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Weather Journeyman

Volume 1. Climatology, Regional Analysis and Forecast Program, and Forecast Reviews

Extension Course Program (A4L)

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Material in this volume is reviewed annually for technical accuracy, adequacy, and currency. For SKT purposes the examinee should check the *Weighted Airman Promotion System Catalog* to determine the correct references to study.

THIS IS the first volume of a three-volume course. This volume has three units. The first unit covers climatological terms and elements, climatic controls, climate classification, and climatological aids. The second unit contains information on the regional analysis forecast program (RAFP). The last unit deals with forecast reviews, studies, and seminars.

After completion of this volume, you will progress to completing the remaining two volumes. Volume 2, *Forecasting Surface Weather and Flight Weather Elements*, provides knowledge on forecasting clouds, precipitation, winds, obscuring phenomena, temperature, and pressure. In addition, it explains important concepts about turbulence, icing, and low-level wind shear. It also presents important information about forecasting severe convective and non-convective weather. Volume 3, *Meteorological Satellite*, contains information on meteorological and non-meteorological features as well as relating satellite data to meteorological events.

A glossary of abbreviations and acronyms is included at the end of this volume.

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This volume is valued at 15 hours and 5 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then do the unit review exercises.

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Unit 1. Climatology

FORECASTERS who limit themselves to short-range considerations of the weather also limit their forecast. In the preparation of a local forecast you drastically reduce the service you perform if you consider only the present synoptic situation and fail to review the large-scale climatic features and seasonal climatic changes. Unfortunately, the relationship among meteorological knowledge, forecasting, and climatology is all too frequently overlooked. Both meteorology and climatology deal with the atmosphere and the processes that take place within the atmosphere, thus we must consider both.

This unit introduces climate and the elements used to assemble climatological data. Additionally, this unit discusses how this data is classified into climatic zones and types. Of course, there are many other publications available that enhance your knowledge of climatology.

1–1. Climatological Terms and Elements

As a forecaster, you'll observe many varying weather conditions. As your duty assignment changes, so do the prevailing weather conditions. You'll greatly improve your skills as a duty forecaster by understanding climatic patterns, factors that govern and regulate weather changes, and the differing weather patterns associated with other regions of the world. Research of climatological variances for different geographical areas enables you to better recognize possible weather hazards.

001. Terms and definitions

We can discuss climatology from several different viewpoints. To understand each aspect of climatology, you must become familiar with common terminology.

Climate

Climate is the average or collective state of the earth's atmosphere at any given location or area within a specified period. While weather is thought of as the day-to-day changes in the atmosphere, the climate of an area is determined over a long period (30 years) and represents the average daily and seasonal weather characteristics for a given region or place. The word climate comes from the Greek word *Klima*—meaning inclination. The ancient Greeks also used the word Klima to signify the prevailing weather and its seasonal changes. They correctly associated these factors with the seasonal variation of solar radiation received from the sun. This we discuss in greater detail later.

Climatology

Climatology is the scientific study of climate and plays a major role in the study of meteorology; most meteorologists consider it a major branch of meteorology. Climatology deals with similarities and variations of weather from time to time and place to place. The three principal approaches to the study of climatology are physical, descriptive, and dynamic.

Physical

This approach to climatology seeks to explain the cause of climate by the physical processes influencing climate and the processes producing the various kinds of physical climates such as marine, desert, mountain, and so on.

Descriptive

Descriptive climatology typically deals with geographic regions and is also called regional climatology. A description of the various types of climates is made on the basis of analyzed statistics from a particular area. An added attempt is made to describe the interaction of weather and climatic elements on the people and the areas under consideration.

Dynamic

Dynamic climatology is the climatology of atmospheric dynamics and thermodynamics; a climatological approach to the study and explanation of atmospheric circulation. Dynamic climatology attempts to relate characteristics of general circulation to the climate.

Climatology as related to other sciences

Climate has become increasingly important in other scientific fields. Geographers, hydrologists, and oceanographers use quantitative measures of climate to describe or analyze the influence of our atmospheric environment. Climate classification has developed primarily in geography. The basic role of the atmosphere in the "hydrologic cycle" is an essential part of the study of hydrology. Both air and water measurements are required to understand the energy exchange between the air and the ocean.

Use one of the three prefixes with the word "climatology." By prefixing either micro, meso, or macro to climatology, you can suggest climatology on a small, medium, or large scale.

Microclimatology

Microclimatological studies often measure climatic contrasts between hilltop and valley, city and surrounding country. They may be of an extremely small scale: one side of a hedge contrasted with the other, a plowed furrow versus level soil, or opposite leaf surfaces. Climate in the microscale may be effectively modified by comparatively simple human efforts.

Macroclimatology

Macroclimatology is the study of the large-scale climate of a large area or country. Climate of this scale is not so easily modified by small human efforts.

Mesoclimatology

Mesoclimatology embraces an indistinct middle ground between macroclimatology and microclimatology. The areas are smaller than those of macroclimatology, larger than those of microclimatology, and they may or may not be climatically representative of a general region.

002. Climatological elements

Climatic elements are the weather elements we use to describe climate. This section includes a discussion of some of these elements. An added discussion of the effects upon some of these elements is provided later.

The condition of the atmosphere at any time or place, the weather, is expressed by a combination of several elements, primarily (1) *temperature* and (2) *moisture* but to a lesser degree by (3) *precipitation* and *clouds* and (4) *winds* as well. These are called the elements of climate because they are the ingredients from which various weather and climatic types are compounded.

Temperature

Temperature is the most important of all the climatic elements. The temperature of an area depends on latitude, or the distribution of incoming and outgoing radiation, nature of the surface (land or water), altitude, and the prevailing winds. The temperature we normally use in climatology is the surface temperature.

Moisture

Moisture (humidity) is a general term referring to the water vapor content of the air. It modifies temperature—the more moist the air, the smaller the temperature ranges (diurnal, monthly, annual). For example, the annual temperature range for Houston, Texas is 53°F and the annual precipitation is 48 inches. At Bismarck, North Dakota, the annual temperature range is 87°F and the average annual precipitation is only 16 inches. You can see the effects of moisture on temperature. The larger the temperature range, the drier is the climate.

Moisture is influenced by temperature. In the low latitudes the amount of water vapor is greater than in the polar regions. Since the average temperature is higher in the tropics, the air can hold more water vapor.

More evaporation occurs in warmer climates. If you put your clothes out on the line to dry, they dry faster in the summer than in the cold season. Although evaporation does not receive much attention, it can be extremely important when we consider it in relation to weather phenomena forming over bodies of water. It can be an important factor in the formation of fog over such areas.

Precipitation and clouds

Precipitation and clouds (hydrometers) are any product of condensation or sublimation of water vapor in the atmosphere. Precipitation has a wide range of variability over the surface of the earth. This variability requires a longer period of observations to achieve an average. For example, two stations could have the same amount of annual precipitation. However, that precipitation could occur in different months or on different days during these months; the intensity could also vary, which is why the average amount of precipitation is not a good way to compare the climate of two stations. For these reasons, it often becomes necessary to include such factors as the average number of days with precipitation, the average amount per day, and other factors.

Precipitation amounts are also directly associated with the amount and type of clouds. The type of cloud is closely related to air mass stability. Cumuliform clouds and showers indicate unstable air, while stratiform clouds and continuous precipitation suggest stable air.

In many studies, hydrometers include all water reaching the earth's surface (by the process of condensation) and falling; either in liquid or in solid state. The most significant forms are rain, snow, and hail. Condensation can also include such deposits as dew, frost, and rime ice. Condensation in this form does not play an important role in regions where there is enough rain to support life. In desert areas, however, these forms of condensation can be important.

Wind

Climatologists are mostly interested in wind direction, speed, and gustiness. Frequently, we express these measurements as *prevailing* wind direction, average speeds, and maximum gusts. Some climatological studies use *resultant* winds, which is the vectorial average of all wind directions and speeds for a given level, at a specific place, and for a given period. We obtain the vectorial average by dividing each wind observation into components, making a summation for a given period, and then obtaining averages and converting components into a single vector.

Determining the prevailing wind direction is part of computing statistical climatic data. In the next section, you will explore how climatological elements are compiled and computed to output statistical climatic data.

003. Computing statistical climatic data

As a forecaster, you must be well acquainted with the many terms used in the discussion of climatology. To a certain extent, climatology has a language of its own. Unless you understand the terms and the methods used to derive these terms, much of the climatological data will have little or no meaning to you. In this section, the most commonly used terms are defined and, where applicable, their usage in expressing climatic elements is explained.

With the invention of weather instruments and the establishment of weather observational networks throughout the world, the climatic record has become much more detailed for the past 100 years. To understand that climatic record, you must become familiar with how to compute statistical climatic data and the terms involved.

Mean or average

The mean is the most commonly used climatological parameter. The term *mean* normally refers to the arithmetic mean, which we obtain the same way as we do the average, by adding the values of all factors or cases and then dividing by the number of items. In analyzing weather data, the terms average and mean are often used interchangeably. For example, to compute the average or mean daily temperature, you would add all the hourly temperatures for the day and divide by 24. The mean, as computed this way, is normally best for both the expected value and the center of the temperature distribution.

However, there is one variation to computing mean temperature. The National Weather Service has for years arrived at the mean temperature for the day by simply adding the maximum and minimum values for the day and dividing by 2. Assume the maximum temperature for a certain day is 75°F and the minimum temperature is 57°F; the mean temperature for the day is 66°F. Unfortunately, the term *mean* has been used in many climatological records without explaining how to compute it. Although called the mean temperature, AFW personnel do not use this method to compute the mean temperature. Instead, AFW personnel use the aforementioned arithmetic method.

Normal

In climatology, we apply the term *normal* to the average value any meteorological element is found to have on a specified date or during specified times. These times may be a particular month or other portion of the year. They may refer to a season or to the entire year. Normal serves as a standard when comparing values occurring on a date or over time.

For example, the National Weather Service computes temperature and precipitation normals for a 30-year period, such as 1961–1990. Recommended international practices are to recompute the normal at the end of every decade, using the preceding 30 years data. This practice considers the slow changes in climate and has the added advantage of adding more recent reporting stations to the list.

Absolute

The term *absolute* usually is applied in climatology to the extreme highest and lowest values (for any given meteorological element) recorded at the place of observations. Assume, for example, the extreme highest temperature ever recorded at a particular station was 106°F and the lowest recorded was –15°F. These are called the absolute maximum and absolute minimum, respectively.

Extremes

The term *extreme* applies to the highest value and the lowest value for a particular meteorological element that has occurred over a particular period. We usually apply the term extreme to months, seasons, or years. (We can use the term for a calendar day only, for which it is particularly applicable to temperature.) We consider the highest and lowest temperature readings for a particular day the temperature extremes for that day. From time to time, *The Weather Channel* reports cities with a record high or low temperature for the day. At times, extremes apply to the average of the highest and lowest temperature and the reporter uses the terms *mean monthly extremes* and *mean annual extremes*.

Ranges

Range is the difference between the highest and lowest values and reflects the extreme variations of these values. Except for very crude work, this statistic is not recommended for use, since it has a high degree of variability. The range is related to the extreme values of record and can be useful in finding the extreme range for the records available.

Frequency

Frequency is the number of times a certain value occurs within a specified period. When an array of values needs to be presented, a condensed presentation of data may be obtained by a frequency distribution. Frequency distributions usually consist of two types, discrete (made up of distinct parts) and continuous.

Discrete

In discrete distributions, the probability density depends on a discrete, random variable or one that varies in steps. (A discrete random variable means its possible values are separated by finite intervals.) The most common discrete climatological variable is frequency, for example, the number of days with a thunderstorm.

Continuous

In continuous distributions, the probability density depends on a continuous, random variable (its possible values extend over a continuous period). Temperature, pressure, precipitation, or any element measured on a continuous scale has a continuous, random variable.

Mode

The mode is the value that occurs with the most frequency or the value about which the most cases occur. It is the point of maximum density or the point of maximum frequency in a frequency distribution or the most common value.

An example of the mode could be seen with a parameter such maximum temperature. For instance, during the week of July 3rd through July 9th the daily maximum temperature varied from 87 degrees Fahrenheit to 110 degrees Fahrenheit. During that week a maximum daily temperature of 99 degrees Fahrenheit occurred on three separate occasions, while the other four days had a maximum temperature of 87°, 90°, 94°, and 110° Fahrenheit (F). The mode would be 99° F due to it being the most frequent value.

We cannot readily determine the mode from unorganized data; therefore, we must group the data in a frequency distribution before we can determine its location accurately. Even so, the mode is not always well defined or possible to locate properly. The maximum density point may be at more than one point, in which case the mode depends upon the judgment of the person interpreting the data.

Generally, you don't use the mode in your work. However, it may be useful in local climatological studies or in finding the most common or most frequently attained value for a prediction technique. For example, in the objective technique, *The Prediction of Maritime Cyclones*, the deepening prediction graph for cyclones has a modal value as well as a maximum value.

Median

The median is the value at the midpoint in an array. For finding the median, arrange all items in order of size. You can then obtain estimates of the median by taking the middle value of an ordered series. However, if there are two middle values, average them to get the median. You can then find the position of the median by using the following formula, where n is the number of items:

$$\text{Median} = \frac{n+1}{2}$$

The median is not widely used in climatological computations. Some writers recommend the use of the median instead of the mean or average. This is because the extremes of these elements are averaged and combined in the mean. This may give a wholly unrepresentative picture of distribution and probability of that particular element. However, a longer period of record might be required to formulate a median. For example, in tropical rainfall analysis, one writer suggests at least 40 years of records would be needed at a particular station to qualify for an accurate representation of the median.

Deviations

In some analyses of climatological data, you need to compute an exact measurement of the average or usual deviation of all items from a central point. This measurement you may acquire from a computation of either the mean (or average) deviation or the standard deviation. We call these measures of dispersion and use them to find whether the average is representative or the extent to which data vary from the average. Deviations better measure the spread of data.

Mean

Obtain the average deviation by computing the arithmetic average of the deviations from an average of the data. First, compute an average of the data. Then find the deviations of the individual items from this average. Finally, compute the arithmetic average of these deviations. Disregard the plus or minus signs. The formula for computation of the average deviation is as follows:

$$\text{Average deviation} = \frac{\sum d}{n}$$

The Greek letter Σ (sigma) means the summation of "d" which are the deviations; *n* is the number of items.

Standard

The standard deviation, like the average deviation, is the measure of the scatter or spread of all values in a series of observations. To compute the standard deviation, square each deviation from the arithmetic average of the data. Next, find the arithmetic average of the squared deviations; finally, extract the square root of this average. This value we also call the *root mean square deviation*, since it is the square root of the mean of the deviations squared.

The formula for computing standard deviation is:

$$\text{Standard deviation} = \sqrt{\frac{\sum d^2}{n}}$$

Σd^2 is the squared deviation from the arithmetic average and *n* is the number of items in the group of data.

Figure 1–1 and the following paragraphs give an example of the computation of both the average deviation and the standard deviation.

Suppose, on the basis of 10 years of data (1954–1963), for January, you needed to compute the average deviation of mean temperature and the standard deviation. First, arrange the data in tabular form (fig. 1–1). Place the year in the first column, the mean monthly temperature in the second column, the deviations from an arithmetic average of the mean temperature in the third column, and the deviations from the mean (column 3) squared in column 4.

January year	Mean temperature	Deviations from mean	Deviations squared
1954	47	–4	16
1955	51	+0	0
1956	53	+2	4
1957	50	–1	1
1958	49	–2	4
1959	55	+4	16
1960	46	–5	25
1961	52	+1	1
1962	57	+6	36
1963	50	–1	1
Totals	510	26	104
Mean	51	2.6	3.2

Figure 1–1. Computation of average and standard deviations.

To compute the average deviation, add all the temperatures in column 2 and divide by the number of years (10 here). Next, compute the deviation from the mean temperature, using column 3 (the mean temperature for the 10-year period is 51°F). Then total the column (disregarding the negative and positive signs). In figure 1–1, this total is 26.

Applying the formula for average deviation:

$$\frac{\sum d}{n} = \frac{26}{10} = 2.6°F$$

The average deviation of temperature during January for the 10-year period is 2.6°F.

To compute the standard deviation, you go one extra step. First, you square the deviations from the mean (column 3). Then, total these squared deviations. Next, apply the formula for standard deviation:

$$\sqrt{\frac{\sum d^2}{n}} = \sqrt{\frac{104}{10}} = \sqrt{10.4} = 3.225 \text{ or } 3.2°F$$

Thus, the standard deviation of the temperature for the month and period in question is 3.2°F (rounded off to the nearest tenth of a degree).

The standard deviation is used more often than the *average* deviation in climatological studies.

Naturally a question arises. What can we use deviations for and how can we apply resultant computations to everyday forecasting? With the standard deviation we just found, it is obvious that the mean temperature range for the month is small. If you had the temperature frequency distribution for this station, you could find the mean temperatures fall within the 6.4° spread (3.2° either side of the mean). From this data you could formulate a probability forecast of the number of days the normal or mean temperature is expected to occur within this range. You could break this study down further into hours of the day.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

001. Terms and definitions

1. Match the climatological terms in column B to the appropriate definition in column A. Items in column B may be used once.

	Column A	*Column B*
____ (1)	A study that measures the climatic contrast between city and surrounding country, or even on a smaller scale.	a. Climate.
____(2)	This approach tries to explain the cause of climate by the physical processes influencing it.	b. Climatology.
____(3)	An average or collective state of the earth's atmosphere at any given location or area.	c. Physical climatology.
____(4)	Attempts to relate characteristics of general circulation to climate.	d. Descriptive climatology.
____(5)	The study of the large-scale climate of a large area or country.	e. Dynamic climatology.
____(6)	The scientific study of climate.	f. Microclimatology.
____(7)	May or may not be climatically representative of a general region.	g. Macroclimatology.
____(8)	Regional climatology.	h. Mesoclimatology.

002. Climatological elements

1. What is the *most* important of all the climatic elements?

2. Evaporation is an important climatic element over which regions?

3. Why is the average amount of precipitation not a good way to compare the climate of two stations?

4. Which element of precipitation includes such deposits as dew, frost, and rime ice?

5. Climatologists are mostly interested in which elements of wind?

6. What is obtained by dividing each wind observation into components, making a summation for a given period, and then obtaining averages and converting components into a single vector?

003. Computing statistical climatic data

1. Match the definitions in column B to the correct statistical terms in column A. Items in column B may be used once.

	Column A	*Column B*
____(1)	The number of times a certain value occurs in a specified period.	a. Normal.
____(2)	The average value that any element is found to have on a specified date or time.	b. Absolute.
____(3)	The highest and lowest values for any given meteorological element that have been recorded at the place of observation.	c. Extreme.
____(4)	The highest and lowest value for a particular element for a particular period.	d. Range.
____(5)	The difference between the highest and lowest values.	e. Frequency.

2. Compute the mean or average temperature below using:

   a. The arithmetic method.

   b. The National Weather Service method.

   0000L - 43° 0800L - 40° 1600L - 52°

   0100L - 42° 0900L - 42° 1700L - 50°

   0200L - 41° 1000L - 44° 1800L - 49°

   0300L - 41° 1100L - 46° 1900L - 48°

   0400L - 40° 1200L - 48° 2000L - 47°

   0500L - 40° 1300L - 50° 2100L - 46°

   0600L - 39° 1400L - 51° 2200L - 45°

   0700L - 38° 1500L - 52° 2300L - 44°

3. Use the following list of yearly mean temperatures and compute the values requested.

   a. Mode.

   b. Median.

Year/Temperature

1956/48°

1957/50°

1958/51°

1959/52°

1960/56°

1961/54°

1962/53°

1963/50°

1964/52°

1965/51°

1966/49°

1967/47°

1968/50°

1969/51°

1970/48°

4. Use the following list of yearly mean temperatures to compute the requested value.

   a. Mean deviation.

   b. Standard deviation.

Year/Temperature

1956/48°

1957/50°

1958/51°

1959/52°

1960/56°

1961/54°

1962/53°

1963/50°

1964/52°

1965/51°

1966/49°

1967/47°

1968/50°

1969/51°

1970/48°

1–2. Climatic Controls

The variation of climatic elements from place to place and from season to season is caused by several factors, called *climatic controls.* The same basic factors that cause weather also determine the climate of an area. These controls, acting in different combinations and with varying intensities, act on temperature, precipitation, humidity, air pressure, and winds to produce many types of weather and, therefore, climate.

This means we can derive climatic conditions from a study of these weather controls. Further, the climatic controls operating together give the earth a general climatic pattern. Remember, in the study of weather controls you must consider their influence throughout at least the four seasons of the year.

Essentially, six factors decide the climate of every ocean and continental region. They are:

- Latitude.
- Land and water distribution.
- Topography.
- Semi-permanent pressure systems.
- Ocean currents.
- Human influences.

Understanding climatic controls helps you understand climate and weather in areas where you are stationed.

004. How latitude affects climatic conditions

Perhaps no other climatic control has such a marked effect upon climatic elements as the latitude, or the position of the earth about the sun. The angle at which the sun's rays reach the earth and the number of *sun* hours each day depends on the distance from the equator and season of the year (fig. 1–2). Therefore, latitude influences the extent to which an air mass is heated. This uneven distribution of heat is responsible for the general pattern of worldwide air circulation. It influences the sources and direction of air masses and the weather that air masses bring with them. The uneven heating of the earth's surface, with other factors, causes a variety of pressure systems and other meteorological systems.

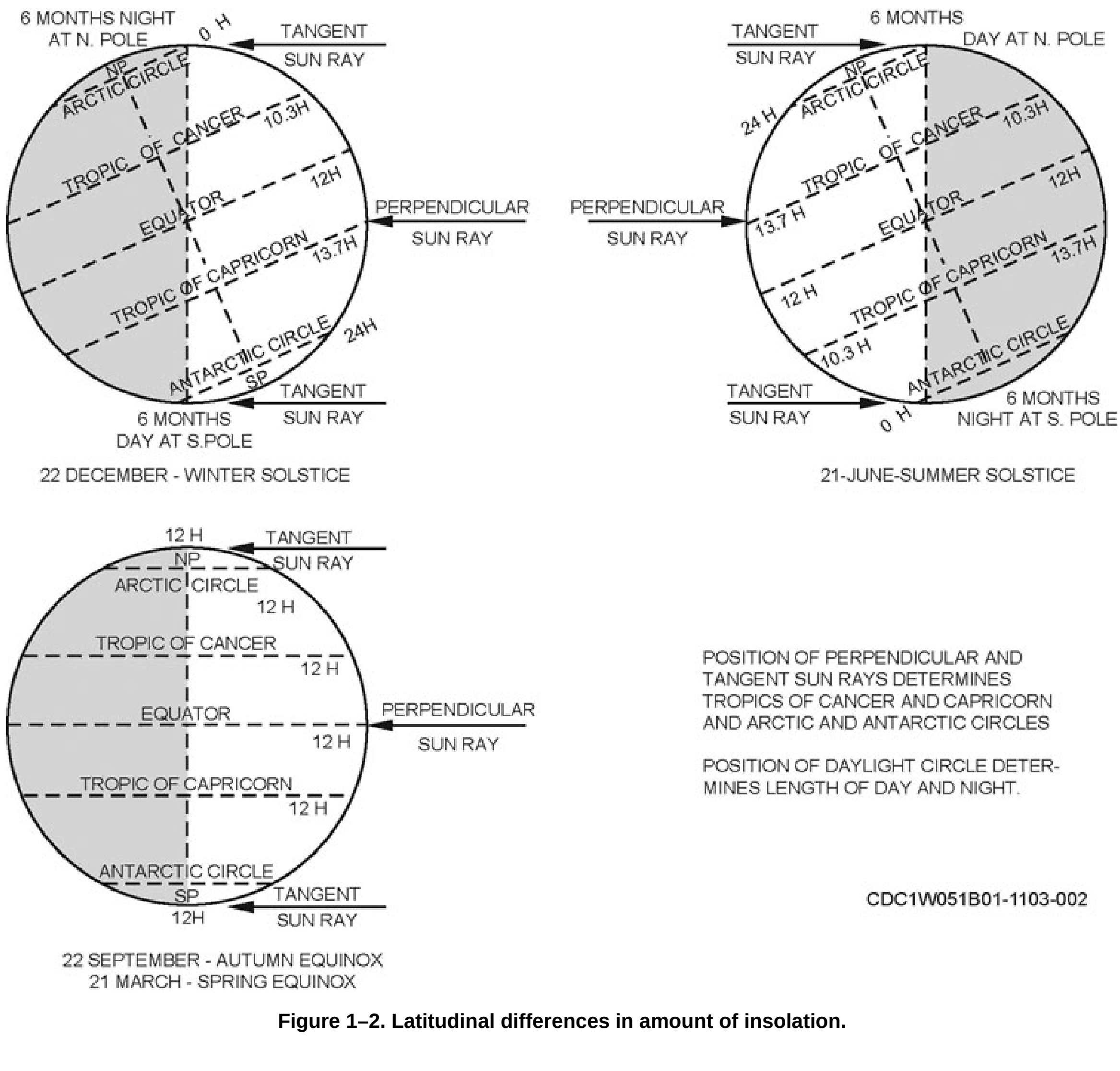


Figure 1–2. Latitudinal differences in amount of insolation.

Influence on air temperature

Regions under direct or nearly direct rays of the sun receive more heat (per unit of time) than those under oblique rays. We can compare the heat caused by the slanting rays of early morning with the heat caused by the slanting rays of winter. Conversely, we can compare the heat that is due to the nearly direct rays of midday with the heat resulting from the more nearly direct rays of summer (fig. 1–3).

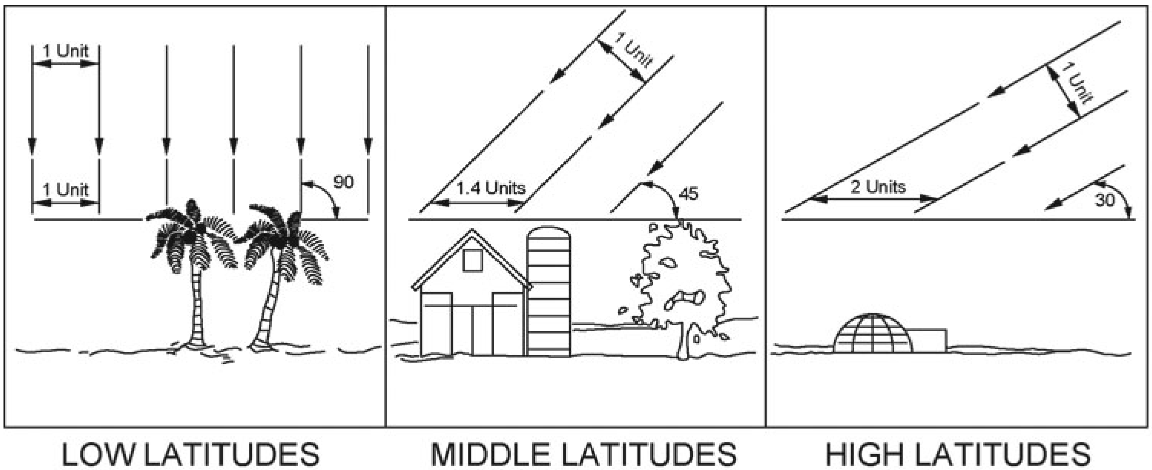


Figure 1–3. Angle of incidence varies with latitude.

The length of the day, like the angle of the sun's rays, influences the temperature. The length of the day varies with the latitude and the season of the year. A place near the equator has about 12 hours of daylight each day of the year. Because of this, and because the sun at midday is always high in the sky (giving nearly direct rays), equatorial regions do not have pronounced seasonal temperature changes.

During summer in the Northern Hemisphere, all places north of the equator have more than 12 hours of daylight. This situation reverses in the winter with such locations receiving less than 12 hours of daylight.

Large seasonal variations in the length of the day and in the angle at which the sun's rays reach the earth's surface cause seasonal temperature differences in middle and high latitudes. In the far north, long hours of winter darkness produce cold temperatures that breed powerful polar air masses. Conversely, the long hours of summer daylight thaw lakes and generally weaken the polar air masses.

The hot and humid climates of equatorial Africa and South America are good examples of the influence that latitude has on climate. Never during the year are the sun's rays at much of an oblique angle. Therefore, there is little difference between mean temperature for the coldest and warmest month and the annual range is smaller than the daily range.

Contrast this picture with the opposite extreme, where the sun is either below the horizon for a good deal of time or is only slightly above the horizon at any time. The sun's rays reaching the earth's surface in polar regions make such a small angle with the earth's surface that the energy received per unit area is extremely small. This reduces the sun's effectiveness though it may shine for days without ceasing.

Figure 1–4 represents the average world surface temperatures on two world products for July and January. Remember, these are mean products and not meant to be an accurate portrayal of the temperatures on any one day. Note that, in general, the temperatures decrease from low to high latitudes. This is the latitudinal factor.

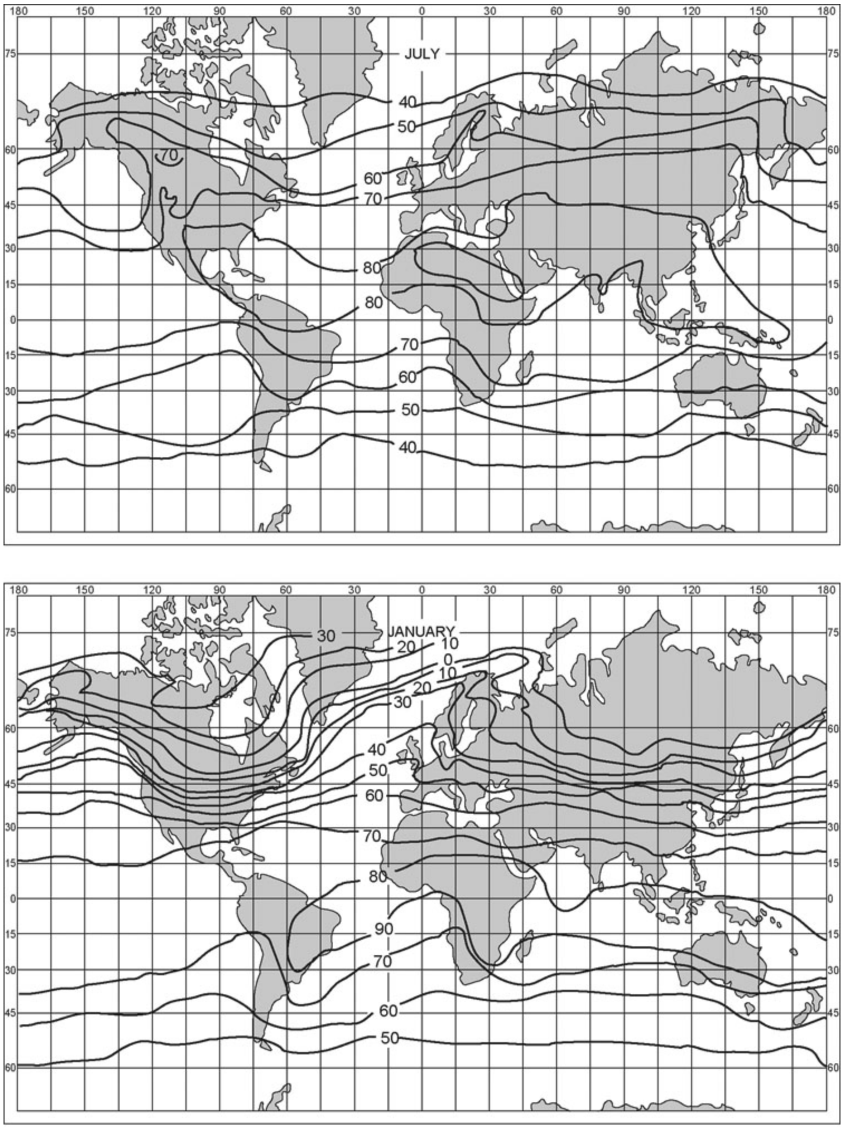


Figure 1–4. Seasonal mean temperatures (degrees Fahrenheit).

Influence on air circulation

Incoming solar radiation is not uniformly distributed over the surface of the earth. Uneven heat distribution causes air to move and the winds blow. The latitudinal difference in the earth's heating sets the air in motion and tends to develop a general pattern of motion all over the earth. Because of the low angle of incidence of solar radiation in polar regions, a given horizontal area in high latitudes receives less solar radiation than an equal area closer to the equator. In low latitudes, the heat from this solar radiation results in increased infrared radiation toward space. This establishes a balance with the heat received from the sun.

Thus, as we proceed from the poles toward the equator, the temperature of the earth and the air near it increases far more than the temperature of the atmosphere as a whole. The air in low latitudes expands vertically, while the cooling in high latitudes results in vertical shrinking (fig. 1–5).

Air, like any fluid, tends to move from high to low pressure. Since the pressure at any fixed level in the upper atmosphere is higher in the tropics than at the poles, the upper atmosphere is set in motion from the equator poleward. This motion raises the sea-level pressure near the poles and reduces it near the equator. As a result, the surface air moves from the poles toward the equator.

The circulation between a heat source in low latitudes and a cold source in the middle and higher latitudes works on the same principle as a simple heat engine. In such an engine, the difference between the heat received at the heat source and the heat emitted at the cold source converts to work. In the atmosphere, it appears as the energy of wind systems.

Unless some forces are applied, the wind must constantly increase in speed. The friction between the wind and the underlying surface provides such a force. Since no appreciable changes are made in the surface of the earth, the frictional energy of the wind steadily converts into heat. The heat eventually radiates back into space. Thus, the total amount of radiation received and given off by the earth is maintained in balance.

The rotation of the earth creates certain frictional stresses on the flow of air near the surface. These stresses set up a three-cell planetary wind system. Assuming the earth has a uniform surface, the final cellular meridional circulation would consist of easterly trade winds from 0° to 30°N and S with prevailing westerlies from 30° to 60° latitude to the poles. However, the surface of the earth is not uniform and we must consider the second factor in climatic control, land and water distribution.

Latitude plays an extremely important role in a resulting area’s climate. Another important influence on climate is land and water distribution.

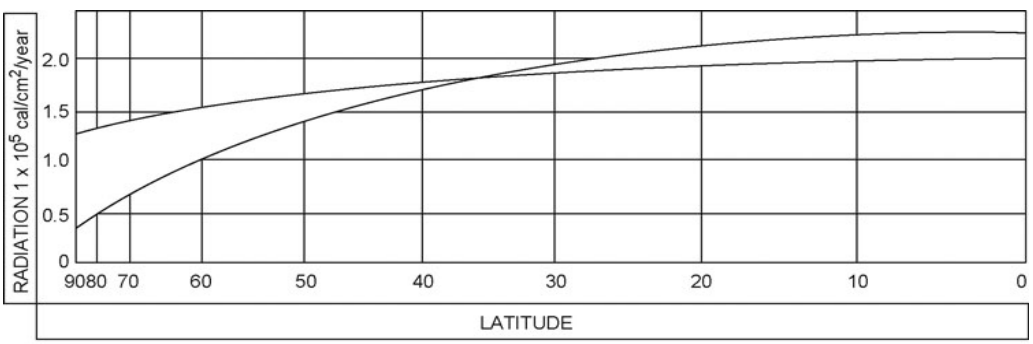


Figure 1–5. Energy absorbed and emitted.

005. Land and water distribution effects on climatic elements

Because land and water heat and cool at different rates, the location of continents and oceans alters the earth’s pattern of air temperature and influences the sources and direction of movement of air masses.

Influence on air temperature

Coastal areas take on the temperature characteristics of the land or water to their windward side. In latitudes of prevailing westerly winds, west coasts of continents have oceanic temperatures and east coasts have continental temperatures. The wind flow determines the temperature.

Since the upper layers of the ocean are nearly always in a state of violent stirring, heat losses or heat gains occurring at the sea surface are distributed throughout a large volume of water. This mixing process sharply reduces the temperature contrasts between day and night and between winter and summer over oceanic areas.

Over land, there is no redistribution of heat by turbulence into the surface and the effect of conduction is negligible. Thus, wider contrasts (between seasons and between day and night) are created in the interiors of continents than over water. During winter, a large part of the incoming solar radiation reflects back toward space due to the snow cover that extends over large portions of the northern continents.

For these reasons, the northern continents serve as source regions for dry polar air. The polar ice cap is no longer symmetrical, but is displaced far to the south, particularly over the interior of Asia.

The large temperature difference between the land and water surface, which reverses between the two seasons, determines, to a large extent, the seasonal weather patterns.

Figure 1–4 shows that in the Northern Hemisphere the temperature gradient is greater in winter than in summer and is more regular in summer. Notice also that the isotherms are more closely spaced and parallel in winter. In the Southern Hemisphere, the temperature gradient does not have as large a seasonal change as in the Northern Hemisphere. This is due to the unequal distribution of land and water on the two hemispheres. Since the Southern Hemisphere has less land and more water surface than the Northern Hemisphere, the change due to the greater water surface is less; therefore, the isotherms are more uniform. The continents of the Southern Hemisphere also taper toward the poles and do not extend as a high latitude as in the Northern Hemisphere.

The nature of the earth’s surface affects local heat distribution. Color, texture, and vegetation influence the rate of heating and cooling. Normally, dry surfaces heat and cool faster than moist surfaces. Plowed fields, sandy beaches, and paved roads become hotter than surrounding meadows and wooded areas. During the day, air is warmer over a plowed field than over a forest or swamp; during the night, the situation reverses.

The distribution of water vapor and cloudiness is another factor influencing air temperature. Figure 1–6 shows the distribution of water vapor in the atmosphere. Although areas with a high percentage of cloudiness have a high degree of reflectivity, the energy that is not reflected is easily trapped in the lower layers due to the greenhouse effect. Thus, expect areas of high annual moisture content to have comparatively high annual temperatures.

The higher mean temperature of the Northern Hemisphere is not only an effect of its greater land cover, but the oceans are also warmer than in the Southern Hemisphere. This is partly due to the movement of warm equatorial waters from the Southern Hemisphere into the Northern Hemisphere, caused by the southeast trades that cross the equator. Another factor conducive to higher mean temperatures in the Northern Hemisphere is the partial protection of its oceans from cold polar waters and Arctic ice by land barriers. There is no such barrier between the Antarctic and the southern oceans.

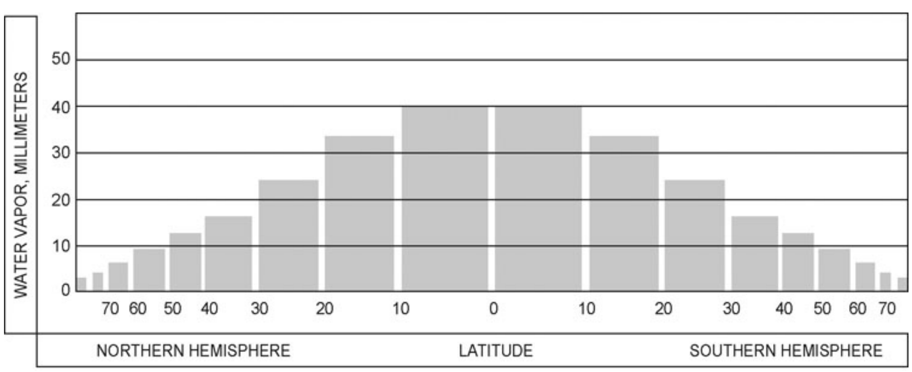


Figure 1–6. Water vapor in the atmosphere.

Influence on air circulation

The Southern Hemisphere, with its practically uniform water cover, is characterized to a large extent by a zonal arrangement of the different wind belts. In the Northern Hemisphere, however, uneven distribution of land and water areas causes high- and low-pressure belts associated with the wind system to break down into separate closed centers of high and low pressure. During winter, we can observe the low-pressure centers (the Icelandic and Aleutian lows) and the semipermanent high-pressure centers (the Pacific and Atlantic highs) in the Northern Hemisphere.

As you can see from this lesson, climate is greatly influenced greatly by the distribution of land and water. Next, you will explore topography's influence on the climate.

006. Topographical effects on climatology

Over land, climates may vary radically within very short distances because of landforms and the variations with altitudes. Let's examine these two general effects.

Altitude

The height of an area above sea level exerts a considerable influence on its climate. For instance, a place located on the equator in the high Andes of South America would have a climate very different from a place located a few feet above sea level at the same latitude. This fact has led some climatologists to classify these areas as a special type of climate.

Weather personnel observe a change of all climatic values as a function of elevation. The exploration of temperature with height above sea level shows that, on the average, temperature decreases with elevation from the earth's surface.

Mountain barriers

A powerful influence on climates is mountainous terrain, especially the long, high chains of mountains that act as climatic divides. These obstacles deflect the tracks of cyclones and block the passage of air masses in the lower levels. If the pressure gradients are strong enough to force the air masses over the mountains, the forced ascent and descent modify the air masses to a large extent. Thus, climate on the windward and leeward sides may differ markedly. Figure 1–7 shows the effect that mountains have on the mean annual precipitation.

The orientation of the mountain range may block certain air masses and keep them from getting to the lee side of the mountains. For example, the Himalayas and the Alps, with an east-west orientation, prevent fresh polar air masses from advancing southward. Therefore, the climates of India and Italy are warmer in winter than other locations of the same latitude. The coastal ranges of mountains in North America, which are generally oriented in a north-south line, prevent the passage of unmodified maritime air masses to the lee side.

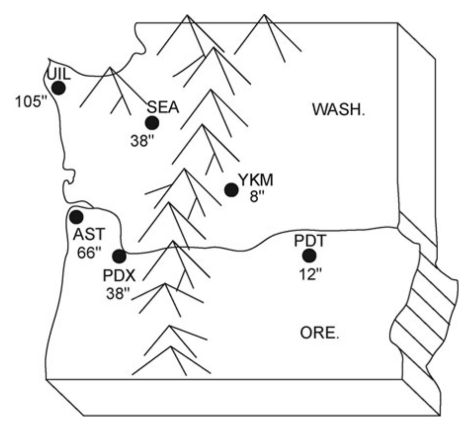


Figure 1–7. Orographic effects on mean and annual precipitation.

Probably the most noted effect of mountains is the distribution of precipitation. Both the windward and the leeward sides show an increase in precipitation over the more level areas in the vicinity. Yet the values are much higher on the windward side.

In regions where a westerly circulation is predominant, the amounts of precipitation increase almost uniformly up to the tops of the mountains to elevations of about 10,000 feet. However, in the tradewind zone, such as at the Hawaiian Islands, precipitation amounts increase only to about 3,000 feet and then decrease gradually. Even with this decrease in amounts, more rain is received at 6,000 feet than at sea level.

From this information, you can see that altitude and mountain barriers are the two topographical features that have the greatest affect on the climate of an area.

007. How pressure systems control climate

The overall effects of the pressure systems are not as large as some previously discussed controls. However, we must consider pressure systems because they cause the winds that move air from one region to another.

The semipermanent pressure centers are the major controls, while the migratory pressure centers are extensions of the semipermanent centers.

Remember, heating of the earth's atmosphere initially causes the general circulation patterns by solar radiation and interaction of the initial pressure systems with the rotation of the earth. There is considerable variation in the intensity and location of the pressure systems between seasons. This variation is especially true in the Northern Hemisphere.

Figure 1–8 shows the mean sea-level pressure for January; figure 1–9 shows this same pressure for July. During January, the Icelandic and the Aleutian lows are extensive and deep. Migratory low-pressure centers develop over the continents and in the semipermanent low-pressure areas and move eastward. Semipermanent lows are often just a reflection of a series of migratory lows moving through a given region on monthly mean charts. To say that a migratory low "moves through" a semipermanent low is misleading.

Figure 1–8 shows the subtropical highs to be small and displaced southward over the North Atlantic and the North Pacific. These high-pressure cells are not dominant during January and are often broken into smaller cells by migratory low-pressure cells. Though broken up at times, the Azores and Pacific high cells modify the climate of areas where they are located.

Figure 1–8 shows that over North America there is a general ridging in January, with several semipermanent high centers. High-pressure cells of varying intensity replace migratory low-pressure cells that develop and move out of North America. The intensity of these high-pressure centers depends on the density of the air involved and whether the air reached its maximum density over the area where the air mass formed.

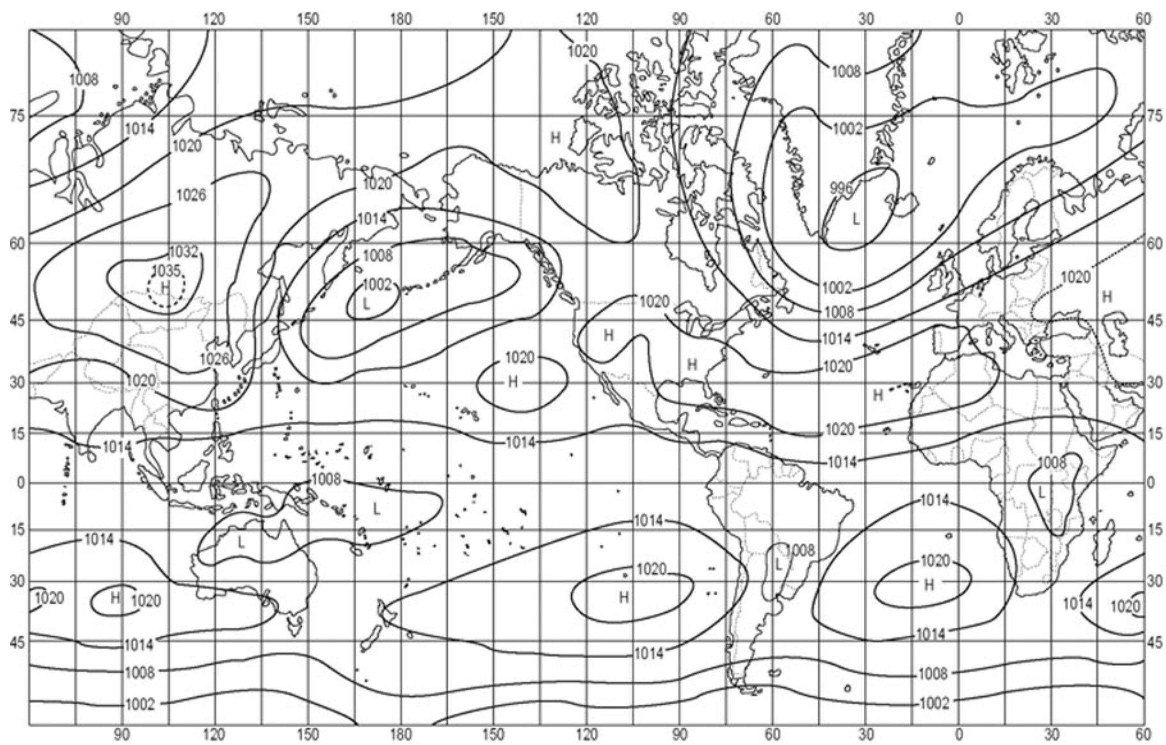


Figure 1–8. Mean sea-level pressure for January.

Figure 1–8 shows Asia dominated by a large high-pressure cell. This high pressure extends into eastern Europe as a ridge. Remember that this massive high-pressure area is also broken up by migratory systems. However, the predominance of extreme high-pressure centers with very cold temperatures gives a mean sea-level pressure system, as shown in figure 1–8.

The tropical low-pressure belt shifts to the south of the equator in January. Figure 1–8 shows semipermanent tropical low centers over southern Africa, southern South America, and Australia.

In the Southern Hemisphere, high-pressure centers are located in the South Atlantic, South Pacific, and the southern portion of the Indian Ocean. Figure 1–8 shows these pressure centers to be of moderate intensity. They are displaced southward during the Southern Hemisphere summer. These Southern Hemisphere highs are more intense during July (winter), as shown in figure 1–9. The Antarctic low-pressure area is larger in July, with the high-pressure areas displaced northward.

Figure 1–9 shows the tropical low-pressure areas displaced northward in July, with a large, low center over southern Asia. In fact, a thermal low dominates much of Asia with very hot temperatures during July. North Africa and northern South America have their warmest temperatures during that time with the northward displacement of the tropical low-pressure areas. The southwest United States and Mexico are also affected by subtropical low pressure in the form of a thermal low.

Figure 1–9 shows the Azores and Pacific high-pressure areas displaced to the north in July and of greater intensity than during January (fig. 1–8). The Aleutian low center is practically nonexistent in July (fig. 1–9) and is shown as a weak trough area. Coincidentally, the Icelandic low is a weak low-pressure area with a center shown between Baffin Island and Greenland.

With this distribution of pressure, you can see that tropical air masses dominate the greater portion of the Northern Hemisphere in summer. Polar outbreaks occur in the most northern latitudes, occasionally reaching mid-latitudes. However, these air masses are usually mild and give only short periods of cool weather.

Although not as strong an influence as other climate controls, pressure systems still exert a certain amount of dominance on the climate. Next, you will see how ocean currents affect climate.

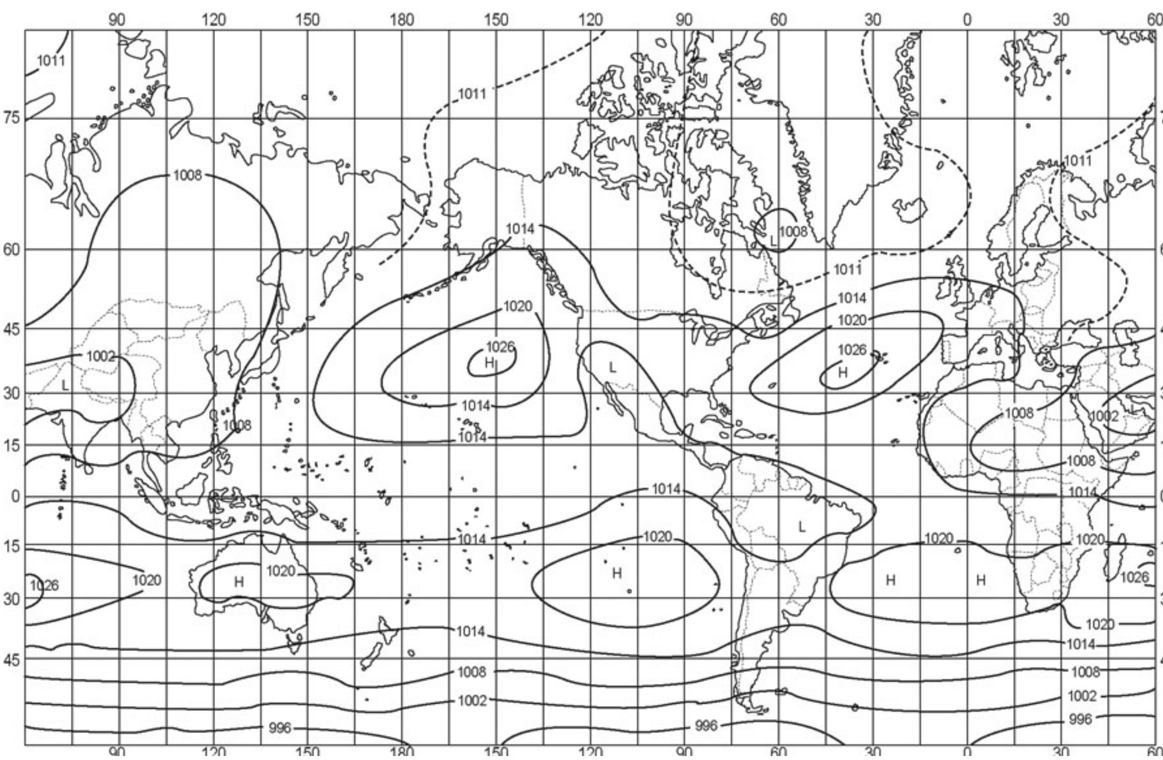


Figure 1–9. Mean sea-level pressure for July.

008. How ocean currents affect climate

The ocean currents are produced mainly by the frictional effect of the wind on the ocean surface. Ocean currents tend to follow the flow patterns of the semipermanent pressure systems. Moving water obeys the same law of deflection as moving air. It is deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. Coriolis force provides the basic cause for this pattern of deflection. A secondary cause is density differences due to variations in salinity and temperature.

The orientation of coastlines often modifies this circulation. Since the air circulation over the oceans in middle latitudes is chiefly anticyclonic, we can expect the oceanic circulation at these latitudes to be the same. At higher latitudes, where the flow is principally cyclonic, the oceanic circulation follows this cyclonic pattern, although not as closely as it does the anticyclonic pattern of the lower latitudes. In regions with a pronounced monsoonal flow, the oceanic currents respond to this flow. We can make the following statements concerning general distribution of ocean currents.

At middle and low latitudes (below 40°, continents have warm currents that flow poleward along their east coasts and cold currents that flow equatorward along their west coasts (fig. 1–10). In monsoonal regions, ocean currents vary with the seasons. The presence of an irregular coastline causes deviation in the general distribution of ocean currents.

The circulation of ocean waters acts to transport heat from one latitude belt to another like the heat transported by the primary circulation of the atmosphere. The cold waters of the Arctic regions move to warmer sections of the earth. Conversely, warm waters of the low latitudes move toward the poles.

An example of this effect on climate is shown by the comparatively mild climate that exists in the area of northwest Europe. The coast of Norway, as far north as it is, is mild enough that its Atlantic ports are usually ice free during the long winter. This is due to the effect of the ocean current that sweeps the Atlantic Ocean from the equatorial regions. Conversely, the cold ocean current off the coast of California is a decisive factor in giving cities such as San Francisco (38° latitude) such cool temperature readings in summer (fig 1–10).

Temperatures near some west coast regions are further lowered by upwelling. Upwelling of ocean water is the process by which the colder subsurface waters are brought to the top of the ocean. This is made possible in areas where the winds parallel the coastline and deflect due to coriolis force. This causes the surface water to be transported away from the coast with the surface water being replaced by the colder subsurface water.

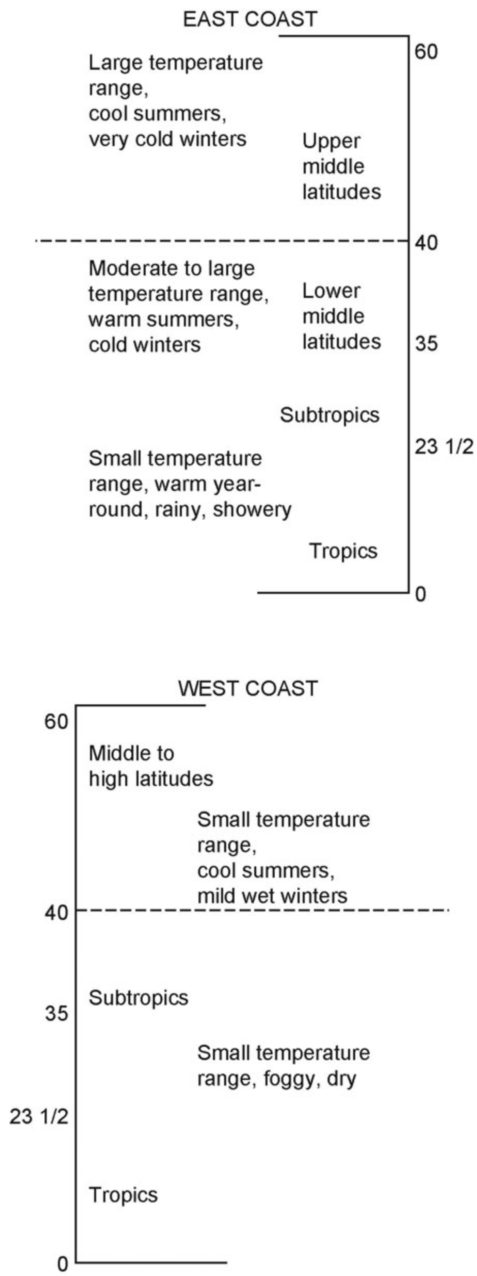


Figure 1–10. Effect of ocean currents on coastal climates.

In the Northern Hemisphere, upwelling is common where a wind blows parallel to the coast, with the coast on the left side of the wind, using Buys Ballot's law. This causes the surface water to be transported to the right and away from the coast. During upwelling, the overturn of water takes place only in the upper layers (usually 400 to 600 ft). Though prevailing winds are the major cause of upwelling, the process is so complicated there may be other factors that contribute to it.

Since ocean currents affect the weather, as a forecaster, you must become acquainted with the prevailing major ocean currents of the earth.

009. The North Atlantic Ocean Currents' effect on world climate

Meteorologists are normally more interested in the effect of the surface temperature of the ocean's water than in how the water arrived at a particular place. Even so, an understanding of the ocean currents in their relationship to the prevailing winds of the weather picture is desirable. Figure 1–11 shows the major surface currents of the oceans during February and March.

The North Equatorial Current and the Gulf Stream System dominate movements of the waters of the North Atlantic Ocean.

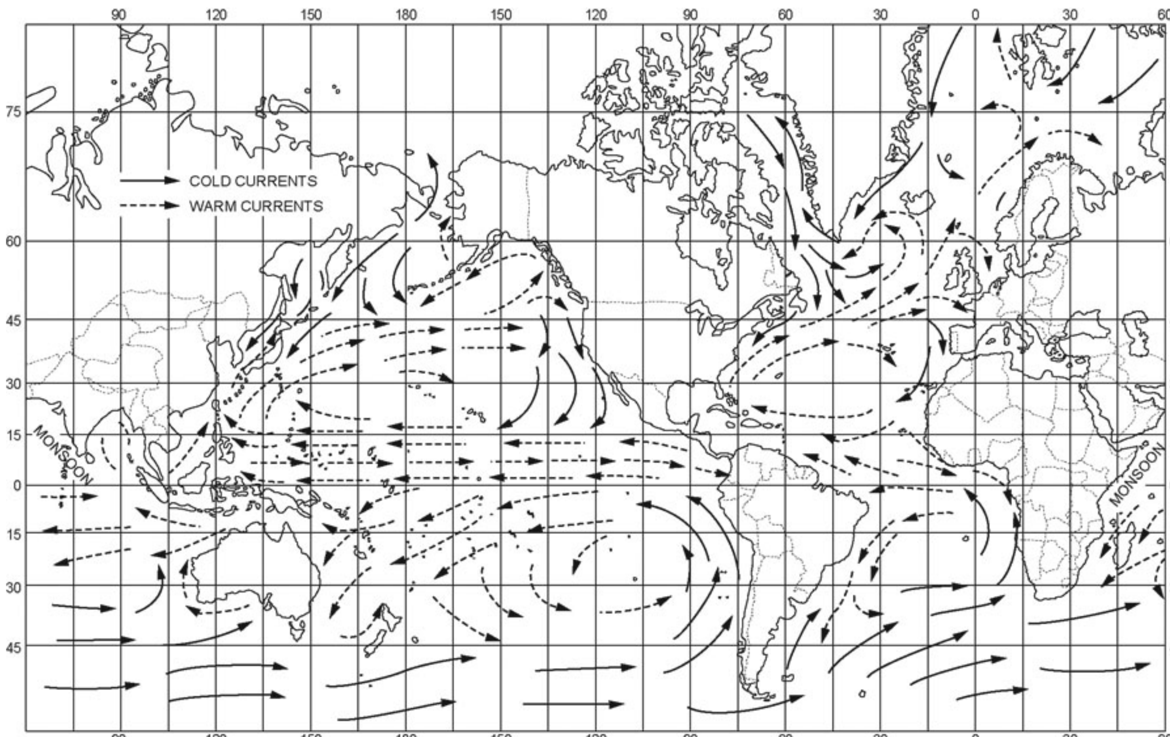


Figure 1–11. Ocean currents (February and March).

North Equatorial Current

The North Equatorial Current is located in the trade wind belt of the North Atlantic Ocean. The chief sources of the flow are the northeasterly currents off the west coast of northwestern Africa. These currents of water of comparatively high density and low temperatures are from the North Atlantic Current. They help cause the temperatures of the northwest coast of Africa to be lower than normally expected. The upwelling of colder water from moderate depths further lowers the temperatures near the coast. The upwelling here is not as pronounced as at other localities.

As the North Equatorial Current flows westward north of the equator, the South Equatorial Current crosses the equator and joins it in the western North Atlantic Ocean. Part of the North Equatorial Current that enters the Caribbean Sea has water that is a mixture of waters from the North Atlantic Ocean and South Atlantic Ocean.

The northern branch of the North Equatorial Current that flows along the northern side of the Greater Antilles is called the Antilles Current. It carries water that is virtually the same as that of the Sargasso Sea (part of the middle North Atlantic Ocean).

Gulf Stream System

The northward and eastward flow of warmer water that begins in the Florida Straits is known as the Gulf Stream System. These waters include all of the various branches of the western North Atlantic Ocean traceable to the region south of the Grand Banks off Newfoundland. This system, along with the Kuroshio System of the western Pacific, is the fastest of all the ocean currents. It moves with speeds of 25 to 75 miles per day or roughly 1 to 3 knots. The Gulf Stream System is made up of three currents: the Florida Current, Gulf Stream, and North Atlantic Current.

The Florida Current

The Florida Current consists of the northward moving water from the Florida Straits to the vicinity of the coast of Cape Hatteras. Much of the flow is derived from the Caribbean Sea by way of the Yucatan Channel. Here, the water from the Yucatan Channel takes the shortest route to the Florida Straits rather than making a long sweep through the Gulf of Mexico. The Antilles Current also feeds the Florida Current.

Energy of the Florida Current is believed to come from the difference in the levels of the water in the Gulf of Mexico and the water next to the Florida Atlantic coast. The difference in the two levels is due to the prevailing trade winds, which result in an accumulation of water in the Gulf.

The Gulf Stream

The Gulf Stream is considered the middle portion of the Gulf Stream System. It begins near Cape Hatteras, a point where the current leaves the continental slope. It continues northward to the vicinity of the Grand Banks off Newfoundland, flowing for a considerable distance off the continental shelf. To the right of the Gulf Stream is the Sargasso Sea portion of the North Atlantic Ocean; to the left are the coastal and slope waters.

The North Atlantic Current

The northern extension of the Gulf Stream System is called the North Atlantic Current. It begins off the Grand Banks, where the Gulf Stream begins to fork. It consists of northerly and easterly currents which end in subsidiary currents. A major subsidiary is the Irminger Current. The Irminger Current flows westward off the southern coast of Iceland. Another subsidiary is the Norwegian Current, which flows beyond the Norwegian Sea into the polar seas. Other branches of the North Atlantic Current which turns southward end in vast eddies off the coast of Europe and in the comparatively cold Canaries Current off the northwest coast of Africa.

The effect of the North Atlantic Current on the climate of northwestern Europe is considerable. Westerly winds carry the warming effects far inland, causing the climate to be much milder than would ordinarily be expected in a region of similar latitude.

010. The North Pacific Ocean Currents’ effect on world climate

The currents of the North Pacific Ocean are very similar to the currents of the North Atlantic Ocean. Even so, there are some distinct differences. These are due mainly to the large amounts of subarctic water in the North Pacific compared to the small amount in the North Atlantic.

North Equatorial Current

The origin of the North Equatorial Current of the North Pacific Ocean is near the western coast of Central America, where the waters of the Equatorial Countercurrent turn northward. As the North Equatorial Current makes its way across the Pacific from the east to the west, other waters are added. They include the California Current, the waters of the eastern North Pacific, and the western North Pacific. Toward the western side of the North Pacific, most of the waters turn northward along the eastern coast of the northern Philippines and Formosa.

Some waters then turn southward and become a part of the Equatorial Countercurrent. The North Equatorial Current takes very warm water to the eastern side of the island system in the western North Pacific.

Cromwell Current

The Cromwell Current is a narrow, swift current that is centered on the equator. It extends from 2°N to 2°S. Its longitudinal dimensions span 140°W to 92°W. At the equator, the easterly flow appears at 20 meters, reaches a maximum speed of 2 to 2.5 knots at 100 meters, and disappears at roughly 250 meters.

Kuroshio System

The Kuroshio System is very similar to the Gulf Stream System of the North Atlantic Ocean. It has its origin in the North Equatorial Current of the North Pacific Ocean and is located in the extreme western portion of the ocean. It flows past Formosa and northwestward in the deep ocean area between the China Sea and the Ryukyu Islands. The system then flows eastward and northeastward along the coast of Japan.

Divided into three branches, the Kuroshio System consists of the Kuroshio Current, the Kuroshio Extension, and the North Pacific Current.

The Kuroshio is similar to the Florida Current of the Gulf Stream System, in terms of flow and climatological influence. It is the portion of the Kuroshio System that flows from Formosa to about 35°N latitude. The salinity of the Kuroshio Current is less than that of the Florida Current. Cold offshore winds have a marked cooling effect on the Kuroshio, causing an annual range in temperature of as much as 9°C in some localities.

The Kuroshio Extension is the continuation of the warm Kuroshio Current. It divides into two branches at 35°N latitude. Most flows eastward as a well-defined current to about 160°E longitude. The other portion flows northeastward to about 40°N latitude, where it turns eastward.

The North Pacific Current is a prolongation of the Kuroshio Extension. Since the current is not well defined, it is difficult to trace its progress across the Pacific Ocean. It appears to extend from about 160°E longitude to about 150°W longitude. Most of these waters turn southward before they reach 150°W longitude and form many of the major whirls that are rather pronounced in that portion of the North Pacific. Temperature and salinity are the two best clues about the location of the current. It is believed that some waters extend east of the Hawaiian Islands before turning south between the island chain and western North America.

Aleutian Current

To the north of the North Pacific Current is a current of waters flowing toward the east. This current is known as the Aleutian Current. One branch of the Aleutian Current flows north of the Aleutian Islands and continues around the Bering Sea in a counterclockwise circulation. It later flows southward to the northern islands of Japan as the Oyashio Current. The Oyashio divides at 40°N latitude; one branch becomes a part of the Kuroshio; the other branch moves south along the coast. In the winter, the Oyashio carries cold waters as far south as Vietnam. In summer, the cold circulation is kept to the area north of 40°N latitude by the summer monsoon circulation.

The other branch of the Aleutian Current flows south of the Aleutian Islands. On approaching the coast of North America, one portion turns to the north and flows into the Gulf of Alaska as a warm current. The other portion turns south and flows along the coast as the California Current.

California Current

The portion of the Aleutian Current that flows into the Gulf of Alaska is considered a warm current since it brings milder winter temperatures to southern Alaska than would normally be expected at that latitude. On the other hand, in the spring and summer, the California Current definitely has a cooling effect on the western coast of the United States. Due to the north-northwest winds during those seasons, there is plenty of upwelling of the subsurface cold waters. In the fall, the upwelling gives way and a countercurrent in the surface waters, known as the Davidson Current, flows northward along the coast to about 48°N latitude.

Where the upwelling is intense, the spring temperatures are lower than the winter temperatures. However, in areas of only moderate upwelling, the winter temperatures are lower. Associated with areas of much upwelling are tongues of water of low temperature that extend in a southerly direction away from the coast. These tongues are separated by tongues of water with a higher temperature; these tongues protrude toward the coast. The tongues of water with lower temperature flow toward the south. The tongues of water with higher temperature flow toward the north.

On a planet dominated by water, in the world's largest ocean it shouldn't be surprising how large an influence the Northern Pacific Currents have on the global climate. Next, you will explore the ocean currents in the Southern Hemisphere.

011. Southern Hemisphere Ocean Currents and their effect on world climate

In the Southern Hemisphere, surface ocean circulations are much the same except that the circulations move counterclockwise in response to the winds around the subtropical highs. In the Indian Ocean, monsoon circulations complicate the general pattern of ocean currents.

South Pacific Currents

The currents of the South Pacific Ocean show the effects of the anticyclonic circulation of the atmosphere. The northern portion of the South Pacific is dominated by the South Equatorial Current, which flows from east to west just south of the Equatorial Counter Current. On reaching the western end of the ocean, the South Equatorial Current turns southward as the East Australia Current and bathes the northern and eastern shores of Australia with warm waters. Turning eastward as it flows past the eastern coast of Australia, it brings warm waters to the northern and western coasts of New Zealand. As a result, the eastern coast of Australia and the western coast of New Zealand are warmer than the opposite coasts.

The West Wind Drift Current dominates the southern portion of the South Pacific. This current completely encircles the Southern Hemisphere and has a marked effect on the equatorward moving currents.

The Peru Current, a branch of the West Wind Current, dominates the coastal waters of western South America. The waters are comparatively cold. There is considerable upwelling off the coasts of Chile and Peru due to the prevailing southerly winds. Coastal fogs and low clouds are characteristic of the area.

South Atlantic Currents

The prevailing anticyclonic wind circulation of the Southern Hemisphere gives the South Atlantic Ocean its characteristic oceanic circulation.

The South Equatorial Current dominates the northern portion of the South Atlantic. It flows from east to west just south of the Equatorial Counter Current. On reaching the eastern shores of South America, one branch turns northward along the northern coast of South America. This branch merges with the waters of the North Equatorial Current to become a part of the Gulf Stream system of the North Atlantic. The other branch flows southward as the Brazilian Current, bringing waters of high temperature and high salinity to the coasts of Brazil and Uruguay.

One branch of the West Wind Drift Current turns northward along the coast of Argentina and is known as the Falkland Current. It brings waters of low temperature and low salinity. Where the Falkland Current and Brazilian Current meet (about 40°S latitude) the two currents turn eastward, developing sizable whirls in the middle section of the South Atlantic.

On the African side of the South Atlantic Ocean, there is one dominant current. It is the Benguela Current. The Benguela Current is another northward flow of waters from the West Wind Drift Current. It brings low clouds and fog along the immediate southwestern coast. In the region of the equator, the Equatorial Counter Current flows eastward to the coast as the Guinea Current, favoring warm, moist air and heavy rainfall.

Indian Ocean Currents

The oceanic circulation of the Indian Ocean shows the influence of the Asiatic monsoon circulation in the northern portion of the ocean and the anticyclonic circulation in the southern portion.

The Equatorial Currents of the Northern Indian Ocean are variable. During the northeastern monsoon season (February and March), the wind aids the North Equatorial Current, causing it to be well developed in its circulation from east to west. During the same season, immediately to the south of the North Equatorial Current, there is a pronounced countercurrent. In August and September, during the southwest monsoon, the North Equatorial Current flows from west to east as the Monsoon Current, and the Equatorial Counter Current appears to disappear.

A large portion of the Equatorial Current that reaches the east coast of Africa turns southward. South of the equator, this branch is known as the Mozambique Current to about 35°S latitude, where it becomes known as the Agulhas Stream. These waters are favorable to warm, moist air masses with moderate rainfall along the southeast coast of Africa.

Some of the equatorial waters make their way to the West Wind Drift Current in the South Indian Ocean and flow eastward toward Australia. On reaching the vicinity of the west coast of Australia, some waters of the West Wind Drift flow northward, bringing comparatively cool sea surface temperatures and the formation of fog and low stratus clouds.

In both the northern and southern hemispheres, it's important to remember the control ocean currents have over the climate. In a smaller role by comparison is the effect on climate by humans and vegetation.

012. The effect of humans and vegetation on climate

Vegetation and human activity, though their roles may be minor in the overall climatic picture, do have an effect on local climate. Evaporation and transpiration (breathing) of plants are very important influences on climate. Falling precipitation caught in trees before it reaches the ground may be evaporated. Precipitation that reaches the ground does not readily evaporate or run off easily, due to the spongy structure of solid forests that can absorb and store considerable quantities of water. Snow in forests is protected from direct radiation by the trees and may stay on the ground for much longer periods than over open, exposed surfaces. Inside forests, temperature maximums are lower and minimums are higher than over open land at the same latitude. Relative humidities are higher in forests and wind speeds are, in great measure, lower than open land areas.

Large human settlements and industrial plants have a noticeable influence on climate. The atmospheric pollution is increased and the radiation balance near the pollution is changed. This affects the daily maximum and minimum temperatures inside cities. High and low temperature extremes are normally warmer in the cities than in the suburbs. The higher concentration of hygroscopic condensation nuclei in the cities results in an increased occurrence of fog. Also, with the larger heat source concentrated over cities, increased convection causes greater amounts of cloudiness with slightly higher amounts and frequencies of rain.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

004. How latitude affects climatic conditions

1. What two factors influence the angle at which the sun’s rays reach the earth and the number of sun hours each day?

2. Typically how much sunlight does a station near the equator receive?

005. Land and water distribution effects on climatic elements

1. Why does the air over land have a wider diurnal range in temperature than air over water?

2. Explain why daytime temperatures are warmer and nighttime temperatures are cooler over a plowed field than over a forest.

3. What is the effect of land and water distribution on air circulation in the Northern Hemisphere?

006. Topographical effects on climatology

1. Do all land areas near the equator have the same climate classification regardless of altitude? Explain.

2. Do mountain barriers influence climate? Explain.

3. Which mountains prevent polar air masses from moving southward?

4. Which sides of mountains (windward or leeward) receive the greatest amount of precipitation?

007. How pressure systems control climate

1. How do pressure systems serve as a climate control?

2. How are high pressures systems displaced in the southern hemisphere during the summer?

008. How ocean currents affect climate

1. What causes ocean currents?

2. What is the basic cause for deflection of ocean currents and air?

3. Explain the difference between the ocean currents along the east coasts and those along the west coasts in the mid latitudes. Why?

4. Define upwelling.

5. What causes upwelling in the Northern Hemisphere and how does it affect the surface water?

6. Where does upwelling normally occur in the Northern Hemisphere?

009. The North Atlantic Ocean Currents’ effect on world climate

1. How does the Gulf Stream system influence the weather along the east coast of the US?

2. How fast do the currents of the Gulf Stream system move?

3. What portion of the Gulf Stream system does the Gulf Stream make up and where does it originate?

4. What is the effect of the North Atlantic Current on the climate of northwestern Europe?

010. The North Pacific Ocean currents' effect on world climate

1. Even though the North Pacific Ocean Currents are very similar to the currents of the North Atlantic Ocean, there are some distinct differences. Describe the main cause of these differences.

2. Where does the North Equatorial Current originate?

3. What North Atlantic current/system is similar to the Kuroshio system?

4. Name the branches into which the Kuroshio system divides.

5. In spring, what effect does the California Current have on the western coast of the US?

011. Southern Hemisphere ocean currents and their effect on world climate

1. What is the atmospheric circulation that influences the ocean currents in the South Atlantic Ocean?

2. What causes the ocean currents in the northern Indian Ocean to reverse directions between the February/March and August/September time frames?

3. Draw a rough picture of the South Pacific Ocean with the main ocean currents labeled as WARM or COOL

4. Draw a rough picture of the South Atlantic Ocean with the main ocean currents labeled as WARM or COOL

012. The effect of humans and vegetation on climate

1. What is the effect of a forest on local temperatures?

2. How is evaporation affected by forests?

3. What is the effect of large settlements on the temperature? Why?

4. What causes a greater amount of cloudiness and slightly higher amounts and frequencies of rain over cities?

1–3. Classification of Climate

The climate of a given region or place is determined by a combination of several meteorological elements. For example, two regions may have similar temperature climates but very different precipitation climates. Therefore, their climatic difference becomes apparent only if we consider more than one climatic factor.

Since we determine the climate of a region by averaging many different elements, including temperature, precipitation, and wind speed and direction, no two locations have the same climate. However, it is possible to place similar areas into a grouping known as a climatic zone.

013. Classification of climates by zones

The basic grouping of climatic zones consists of classifying climates into five broad belts determined by latitude or mean temperature.

Latitude

The five basic regions or zones are the torrid or tropical zone, the two temperate zones, and the two polar zones. The tropical zone is limited on the north by the tropic of cancer and on the south by the tropic of Capricorn (23°N and S latitude, respectively). The temperate zone of the Northern Hemisphere is limited on the south by the tropic of cancer and on the north by the Arctic Circle (66°N latitude). The temperate zone of the Southern Hemisphere is bounded on the north by the tropic of Capricorn and on the south by the Antarctic Circle at 66°S latitude. The two polar zones are regions located poleward of the Arctic and Antarctic Circles and sometimes called the frigid zones.

Mean temperature

A glance at any product depicting the isotherms over the surface of the earth shows that the isotherms do not coincide with latitude lines. At some places, the isotherms parallel the longitude lines more closely than they parallel the latitude lines. We can make a better approach to the understanding of climate if the climatic zones are limited by isotherms rather than by parallels of latitude.

One method of classifying climatic zones by isotherms is by limiting the hot belt, which corresponds to the torrid or tropical zone mentioned before, by the two mean annual isotherms of 68°F. The uneven distribution of land in the lower latitudes of both hemispheres results in an uneven position of the hot belt about the equator. The belt extends farther north than south of the equator. The hot belt increases in width over continents, while there is a tendency toward equalization of the temperature over the oceans (fig. 1–12). The boundary between the temperate and polar zones is fixed by the isotherm of 50°F for the warmest month.

The five belts introduced in this lesson are a very basic climate classification compared to the next classification types that are in the next lesson.

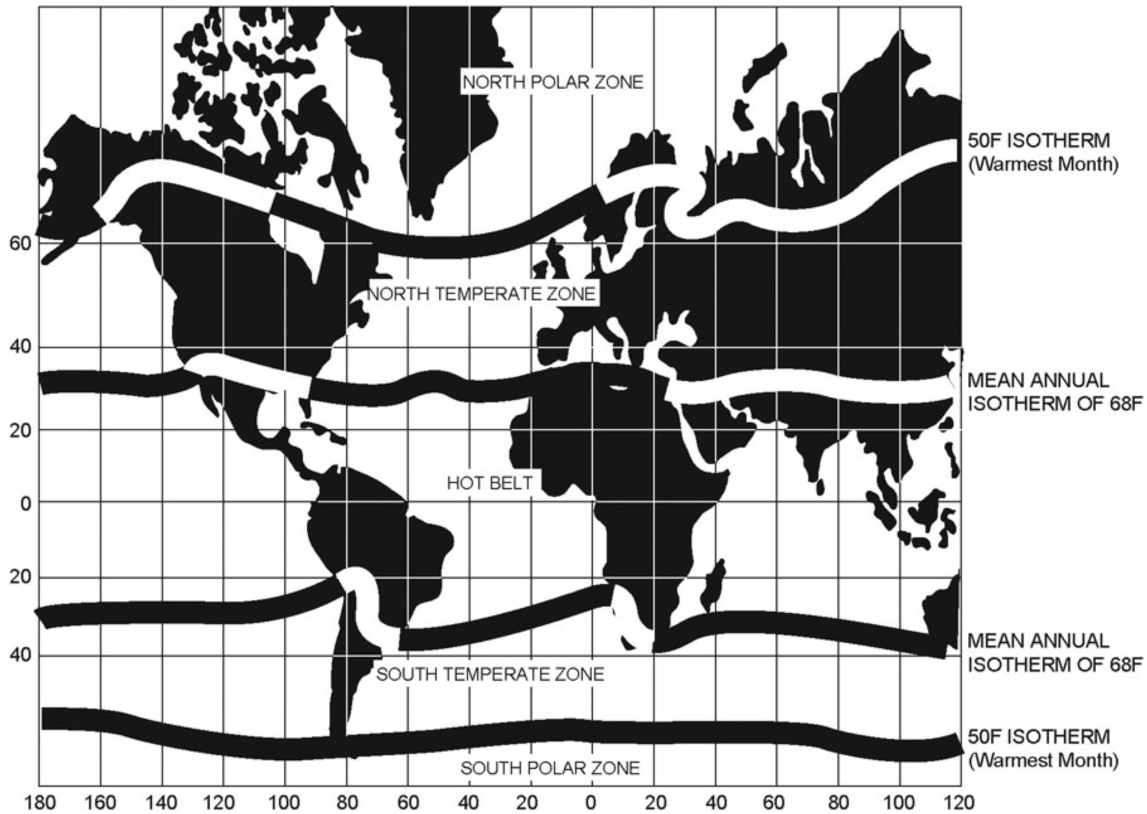


Figure 1–12. Climatic zones using temperature boundaries.

014. Classification of climates by types

Any classification of climate depends to a large extent on the purpose of the classification. A classification separating air stations, with favorable flying conditions, would differ significantly from that used to determine areas favorable for the growing of crops. There are three classifications that particularly merit your attention. They are the classifications of Waldimir Köppen (1846–1940), C. Warren Thornthwaite (1899–1963), and Glenn T. Trewartha.

Köppen's system

Initially published in 1918, the original Köppen classification system has since been modified and refined. In Köppen's original classification, there are five main climatic types: TROPICAL RAIN, DRY, HUMID MESOTHERMAL, HUMID MICROTHERMAL, and POLAR. These main types are further divided into climatic provinces. The tropical rain climate is divided into RAIN FOREST and SAVANNA. The term savanna identifies a region that has a long dry season but a heavy rainy season and continuously warm temperatures. The dry climate consists of STEPPE and DESERT. The term steppe identifies a region that is grass-covered and a generally treeless plains region.

The humid mesothermal climate consists of OCEANIC MODERATE, WINTER DRY MODERATE, and SUMMER DRY MODERATE, while OCEANIC BOREAL and CONTINENTAL BOREAL are the provinces making up humid microthermal climate. Boreal is a term that identifies a region that has a definite winter with snow and a short, generally hot summer. The polar climate is broken down into TUNDRA and ETERNAL FROST.

The Köppen classification is based mainly on temperature, precipitation amount, and season of maximum precipitation. Numerical values of these elements are the boundaries of the above types and were selected primarily according to their effect on plant growth.

Thornthwaite's system

Thornthwaite's classification of climates places a great deal of emphasis on the effectiveness of precipitation. Effectiveness of precipitation means the relationship between precipitation and evaporation at a certain place. Thornthwaite classifies climate into five climatic provinces. They are WET, HUMID, SUBHUMID, SEMIARID, and ARID. Each province is given a precipitation effectiveness rating.

Trewartha's system

Trewartha's climate classification is primarily based upon Köppen's original system. The following explain the Trewartha classification in more detail. This figure is used with permission from the book *An Introduction to Climate*, by Trewartha and Horn, 4th edition, copyright © 1968 by McGraw–Hill, Inc. Figure 1–13 gives a further explanation and breakdown of the different groups and types of climate depicted to include general precipitation. Figure 1–14 provides an alphabetical listing and definition for the small letter symbols (located in the center column of figure 1–13) utilized to further explain the type of climate.

An additional group which is not listed in figure 1-13 is the highland (H) climate group. Mountainous climates are difficult to group climatologically on small scall maps. Due to the added vertical dimension; limitless local effects factor into the climate of the region as atmospheric conditions change markedly with altitude and exposure.

GROUPS OF CLIMATE	TYPES OF CLIMATE	PRECIPITATION
A. Tropical humid	Ar, tropical wet Aw, tropical wet-and-dry	No more than two dry months annually Wet when sun is high on horizon, Dry when sun is low on horizon
C. Subtropical	Cs, subtropical dry-summer Cf, subtropical humid	Summer drought, winter rains Rain occurs in all seasons
D. Temperate	Do, oceanic Dc, continental	Rain occurs in all seasons Precipitation occurs in all seasons with an accent on summer (rain); winter snows and associated snow cover
E. Boreal	E, boreal	Minimal precipitation throughout the year
F. Polar	Ft, tundra Fi, icecap	Minimal precipitation throughout the year Minimal precipitation throughout the year
B. Dry	BS, semiarid (steppe) BSh (hot), tropical-subtropical BSk (cold), temperate-boreal BW, arid (desert) BWh (hot), tropical-subtropical BWk (cold), temperate-boreal	Short moist season Minimal rainfall, most occurs in summer Constantly dry all year Constantly dry all year

Figure 1–13. Explanation of groups and types of climates.

Small Letter Symbol	Definition
A	hot summer
B	cool summer
C	continental, coldest month < 32°F
F	no dry season
H	hot
I	all months < 32°F
K	cold
O	oceanic
R	rainy
S	summer dry
T	tundra, warmest month 32–50°F
W	winter dry

Figure 1–14. Explanation of small letter symbols from figure 1–13.

015. Regional circulations affecting weather

Many regions have unusual local weather phenomena caused directly by the temperature difference between land and water or by local topographical features. It is essential that you know the effects regional circulations have on air and ground operations.

Land and sea breezes

Sea or lake breezes generally occur on a summer afternoon near a coastline. When an air mass is stationary over a coastline and the land surface is warmer than the sea surface because of radiation heating, an onshore breeze is produced at the surface, with an outward drift aloft. At night, the radiation cooling of the land is greater than that of the seas. The horizontal temperature gradient is, therefore, normally reversed. This produces the offshore breeze, or land breeze, which reaches its maximum about dawn. The land and sea breeze phenomenon is purely local. Its influence does not extend far from the coastline and seldom extends above a height of 3,000 feet. A prerequisite for the formation of these circulations is a weak pressure gradient.

Monsoon winds

Monsoon winds are characterized by a tendency toward a reversal in prevailing wind direction between winter and summer. The name *monsoon* comes from the Arabic word *Mausin*, meaning season. Monsoon was first applied to the winds over the Arabian Sea, which blow for approximately six months from the northeast and for six months from the southwest. Monsoons occur because the surface of the earth consists of great land and water areas, which have unequal heating and cooling capacities.

Because of the great size of the continent, the monsoon is most developed over eastern and southern Asia. However, monsoons in modified form, or monsoon tendencies, are characteristic of other regions as well. The Southeastern United States, northern Australia, Spain, and South Africa are regions with monsoon tendencies. These land areas are not extensive enough to cause a complete seasonal reversal of winds, as does Asia, but they produce partial monsoons, which greatly affect the amount of seasonal rainfall.

Regions with strong monsoon tendencies usually are on the eastern sides of continents. This is especially true in the middle latitudes, since the western or windward coasts are distinctly marine in character, with only small changes in temperature from winter to summer. It is, therefore, only on the more continental eastern, or leeward, sides that sufficiently large seasonal extremes of temperature can develop to produce a wind reversal.

Monsoon air, as observed over India and Burma, consists of modified continental polar air during the winter season. The weather conditions during the summer monsoon consist of cloudy weather with almost continuous rain and widespread shower activity. High temperatures and humidities are the rule. Weather conditions during the winter monsoon are dominated by the dry, adiabatically warmed polar air flowing toward the equator. It is during this time that generally pleasant weather prevails over most of the area that is influenced by monsoon conditions.

The reverse of this condition occurs along the east coast of Indochina, particularly the northern coastal sections of Vietnam. During the winter, the continental polar air flowing southward over the East and South China Seas becomes sufficiently modified to produce extensive cloudiness and drizzle in this area. This phenomenon is called the *Crachin.*

Ravine winds

Strong winds often blow along deep valleys or ravines that break across mountain ranges. Some of the highest observed wind velocities have occurred in such valleys. The *mistral* of southern France and the *bora* of Trieste are among the best known of a large group of such winds. All ravine winds are characterized by their potential destructive force. Most of them have a marked seasonal variation, occurring more frequently in winter. They seem to peak in the early morning. It is believed that ravine winds are due to a pressure gradient acting along the ravine. The wind blows directly from high to low pressure along the ravine. The wind speed increases with distance from the source, reaching a maximum as it emerges at the low pressure end of the ravine.

Many examples of ravine winds are found in the Pacific Cordillera and the coastal areas of the United States.

The best known include the following:

- The gales in the Columbia River Gorge across the Cascades.
- The southeasterly winds through the San Joaquin Valley in California.
- The Santa Ana wind in the Los Angeles region.

The Santa Ana blows through the Cajon Pass between the San Gabriel and the San Bernardino ranges. At the high pressure end over the Mojave Desert, speeds are low, but 15 miles farther south, speeds often exceed 50 mph. At the low pressure end, speeds may exceed 60 mph for many hours. The Santa Ana normally blows only in the winter half of the year because the temperature discontinuity responsible for the pressure gradient along the Cajon Pass is statistically absent at other times. This is generally true of the Pacific Coast ravine winds as well.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

013. Classification of climates by zones

1. Name the five basic climatic zones.

2. What are the boundaries of the five zones using the latitudinal boundaries? Using the isothermal boundaries?

014. Classification of climates by types

1. What are the climatic elements upon which Köppen's classifications are based?

2. List the climatic elements on which Thornthwaite's classifications are based.

3. Describe the main difference in the basis of Köppen's and Thornthwaite's climatic classifications.

4. What are Köppen's main climatic types? Thornthwaite's?

5. On what climatic classification system did Trewartha base his own classification system?

015. Regional circulation affecting weather

1. What is the major feature of the land/sea breeze?

2. When and where is the land/sea breeze most likely to occur?

3. What is the seasonal effect of the monsoonal circulation on India and Burma?

4. What type of weather would be expected during the winter monsoon along the east coast of Indochina?

5. What is the cause of the ravine wind?

1–4. Prepare Climatological Aids

As a forecaster, there are several different climatological aids to use in performing your job. These aids provide additional information to the user. The first ones you cover here are the equivalent chill temperature, the heat index, and degree-days. The last part of this unit covers statistical climate data.

016. Temperature indices

Several parameters have been developed using the temperature as a base. The two temperature indexes that forecasters calculate are the equivalent chill temperature and the heat index.

Equivalent chill temperature

The equivalent chill temperature approximates the additional cooling effect of wind on the human body. It is the temperature that causes the same rate of cooling under calm wind conditions. This temperature we obtain from a product shown in figure 1–15. By knowing the temperature and wind speed, we can acquire the equivalent chill temperature from the product. For example, when the temperature is –5°F and the winds are 15 mph, the equivalent temperature is –40°F. Use the most representative wind speed that occurs most of the time. Include gusts if they occur frequently, but omit them if they occur only occasionally.

Many commanders use the equivalent chill temperature for decisions affecting personnel working outdoors, such as security forces or flight-line maintenance crews. When informed that the equivalent temperature is (or is forecast to be) below a predetermined value, the commander may restrict the outdoor activity of these personnel.

Heat index

The National Weather Service implemented the heat index during the summer of 1984. The heat index combines air temperature with relative humidity to find an *apparent temperature*—what the air temperature "feels like" to the average person for various combinations of air temperature and relative humidity. For example, in figure 1–16, an air temperature of 38°C (100°F) and a relative humidity of 60 percent produce an apparent temperature of 54°C (132°F). Heatstroke or sunstroke is imminent when the index reaches this level.

EQUIVALENT CHILL TEMPERATURE CHART (FAHRENHEIT)

WIND SPEED				TEMPERATURE (F)																				
MPH	KM/HR	MPS	KNOTS																					
CALM	CALM	CALM	CALM	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-60
5	6-11	2-3	3-6	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45	-50	-55	-65	-70
10	12-19	4-5	7-10	30	20	15	10	5	0	-10	-15	-20	-25	-35	-40	-45	-50	-60	-65	-70	-75	-80	-90	-95
15	20-28	6-7	11-15	25	15	10	0	-5	-10	-20	-25	-30	-40	-45	-50	-60	-65	-70	-80	-85	-90	-100	-105	-110
20	29-35	8-9	16-19	20	10	5	0	-10	-15	-25	-30	-35	-45	-50	-60	-65	-75	-80	-85	-95	-100	-110	-115	-120
25	36-43	10-11	20-23	15	10	0	-5	-15	-20	-30	-35	-45	-50	-60	-65	-75	-80	-90	-95	-105	-110	-120	-125	-135
30	44-52	12-14	24-28	10	5	0	-10	-20	-25	-30	-40	-50	-55	-65	-70	-80	-85	-95	-100	-110	-115	-125	-130	-140
35	53-59	15-16	29-32	10	5	-5	-10	-20	-30	-35	-40	-50	-60	-65	-75	-80	-90	-100	-105	-115	-120	-130	-135	-145
40	60-67	17-18	33-36	10	0	-5	-15	-20	-30	-35	-45	-55	-60	-70	-75	-85	-95	-100	-110	-115	-125	-130	-140	-150
WINDS ABOVE 40 MPH, 36 KNOTS, 18 MPS, OR 67 KM/HR HAVE LITTLE ADDITIONAL EFFECT.				**LITTLE DANGER**					**INCREASING DANGER (Flesh may freeze within one minute)**							**GREAT DANGER (Flesh may freeze within 30 seconds)**								
				Danger of freezing exposed flesh for properly clothed persons.																				

INSTRUCTIONS

MEASURE LOCAL TEMPERATURE AND WIND SPEED IF POSSIBLE: IF NOT, **ESTIMATE**. ENTER TABLE AT CLOSEST 5F INTERVAL ALONG THE TOP AND WITH APPROPRIATE WIND SPEED ALONG LEFT SIDE. INTERSECTION GIVES APPROXIMATE EQUIVALENT CHILL TEMPERATURE; THAT IS, THE TEMPERATURE THAT WOULD CAUSE THE SAME RATE OF COOLING UNDER CALM CONDITIONS.

Notes

WIND

1. THIS TABLE WAS CONSTRUCTED USING MILES PER HOUR (MPH); HOWEVER, A SCALE GIVING THE EQUIVALENT RANGE IN KNOTS, KM/HR AND MPS HAS BEEN INCLUDED ON THE CHART TO FACILITATE ITS USE WITH APPLICABLE UNIT.
2. WIND MAY BE CALM BUT FREEZING DANGER GREAT IF PERSON IS EXPOSED IN MOVING VEHICLE, UNDER HELICOPTER ROTORS, IN PROPELLER BLAST, ETC. IT IS THE RATE OF RELATIVE AIR MOVEMENT THAT COUNTS AND THE COOLING EFFECT IS THE SAME WHETHER YOU ARE MOVING THROUGH THE AIR OR IT IS BLOWING PAST YOU.
3. EFFECT OF WIND WILL BE LESS IF PERSON HAS EVEN SLIGHT PROTECTION FOR EXPOSED PARTS - LIGHT GLOVES ON HANDS, PARKA HOOD SHIELDING FACE, ETC.

ACTIVITY DANGER IS LESS IF SUBJECT IS ACTIVE. A MAN PRODUCES ABOUT 100 WATTS (341 BTUs) OF HEAT STANDING STILL BUT UP TO 1000 WATTS (3414 BUTs) IN VIGOROUS ACTIVITY LIKE CROSS-COUNTRY SKIING.

PROPER USE OF CLOTHING AND ADEQUATE DIET ARE BOTH IMPORTANT.

COMMON SENSE THERE IS NO SUBSTITUTE FOR IT. THE TABLE SERVES ONLY AS A GUIDE TO THE COOLING EFFECT OF THE WIND ON BARE FLESH WHEN THE PERSON IS FIRST EXPOSED. GENERAL BODY COOLING AND MANY OTHER FACTORS AFFECT THE RISK OF FREEZING INJURY.

Figure 1–15. Equivalent chill temperature chart.

RH	AIR TEMPERATURE °F						
	80	85	90	95	100	105	110
35%	79	85	91	98	107	118	130
40%	79	86	93	101	110	123	137
45%	80	87	95	104	115	129	143
50%	81	88	96	107	120	135	150
55%	81	89	98	110	126	142	
60%	82	90	100	114	132	149	
65%	83	91	102	119	138		
70%	85	93	106	124			
75%	86	95	109	130			
80%	86	97	113	136			
85%	87	99					

°130°F	Heatstroke or sunstroke *imminent*.
105–129°F	Sunstroke, heat cramps, or heat exhaustion *likely;* heatstroke possible with prolonged exposure and physical activity.
90–105°F	Sunstroke, heat cramps and heat exhaustion *possible* with prolonged exposure and physical activity.
80–90°F	Fatigue *possible* with prolonged exposure and physical activity.

Figure 1–16. Apparent air temperature (°F) heat syndrome index.

017. Heating/cooling degree-days

The mean temperature for any day shows the amount of fuel necessary for home or industrial heating. Estimates are that most people use their furnace when the temperature drops below 65°F.

Heating degree-days

Heating degree-days (HDD) is a statistic originally developed for the power companies. It provided them with a sign of how much heat their consumers would require. By comparing current values with past values, power companies could judge the severity of the seasons.

The heating degree-days are simply the difference between the average daily temperature and 65°F. Calculate this by adding the maximum and minimum temperatures together and dividing by 2. Subtract this value from 65. When the average temperature is greater than 65, consider the number of heating degree-days to be zero.

For example, with a maximum temperature of 30 and a minimum of 10, the average temperature would be 20. The heating degree-days would be 65 - 20 = 45. By summing these values every day, we obtain a running total that shows how cold the season is.

Cooling degree-days

Use a similar index, called the cooling degree-day (CDD), during warm weather to estimate the energy needed to cool indoor air to a comfortable level. Convert the forecast of mean daily temperature to cooling degree-days by subtracting 65°F from the mean. The remaining value is the number of cooling degree-days for that day. For example, a day with a mean temperature of 70°F would correspond to 70 minus 65, or 5 cooling degree-days. By summing these values every day, we obtain a running total that shows how hot the season is. High values signal warm weather and high power production for cooling.

Knowledge of the number of cooling degree-days in an area allows a builder to plan the size and type of equipment to install to provide adequate air conditioning. Also, the forecasting of cooling degree-days during the summer gives power companies a way of predicting the energy periods. A composite of heating degree-days plus cooling degree-days would give a practical signal of the energy requirements over the year.

018. Statistical climate data

There are several different climatological products that have been developed from statistical climate data. Statistical climate data consists of meteorological parameters that have been compiled and stored in climatic databases. Data is collected for nearly every spot on the planet. By itself the data is just a series of numbers.

However, when the data is analyzed and formatted into a useful climatological product, it becomes a valuable aid to forecasters and users. The climatological products you will learn about in this lesson are engineering weather data (EWD), modeled diurnal curves (MODCURVES), operational climatic summaries (OCDS), station observation climatic summaries (SOCS), and wind stratified conditional climatology tables (WSCC).

Engineering weather data

Engineering weather data (EWD) is a collection of climatological products that assists professional engineers in the design, construction and maintenance of buildings. Much of the information is geared to the selection and sizing of heating and air conditioning equipment and includes data on wind, moisture, solar radiation, rain rate, snow load and freezing thaw cycles.

As of the spring of 2011, there are over 1200 sites completed and data for other sites can be generated upon request via the 14th Weather Squadron's (14WS) homepage. Since EWDs are a collection of climatological products, their output form can be many pages in length. A large part of the output is statistically computed into variables unfamiliar to forecasters. A professional engineer should easily understand the output data. For example, figure 1–17 is the first page of an EWD produced for Biloxi, MS.

Modeled diurnal curves

MODCURVES provide monthly summaries of temperatures, dewpoint, altimeter setting, relative humidity and pressure altitude changes by hour for stations with available surface observations. The product includes four wind sectors and two sky cover categories displayed in graphic and tabular forms. Figure 1–18 is an example of a temperature MODCURVE for Keesler AFB.

This MODCURVE was specified to begin at 0000 UTC with an initial value of 80° F, as indicated by the legend. Also, notice the legend below the MODCURVE indicates the temperature curve is for southerly winds and a clear to scattered sky condition.

KEESLER AFB/BILOXI MS

Latitude = 30.42N	WMO No. 747686
Longitude = 88.92W	Elevation = 33 feet
Period of Record =1967 to 1996	Average Pressure = 29.98 inches Hg

Design Criteria Data

Dry Bulb Temperature (1)	Design Value (F)	Mean Coincident (Average) Values: Wet Bulb Temperature (F)	Humidity Ratio (gr/lb)	Wind Speed (mph)	Wet Bulb Temperature (NSEW)
Median of Extreme Highs	96	80	128	7.5	N
0.4% Occurrence	93	79	127	8.0	S
1.0% Occurrence	92	79	127	8.0	S
2.0% Occurrence	90	78	127	7.9	SSW
Mean Daily Range	14	–	–	–	–
97.5% Occurrence	39	35	24	7.0	N
99.0% Occurrence	34	30	18	7.7	N
99.6% Occurrence	30	26	14	8.7	N
Median of Extreme Lows	25	22	11	9.3	N

Wet Bulb Temperature (T_{wb})	Design Value (F)	Mean Coincident (Average) Values: Dry Bulb Temperature (F)	Humidity Ratio (gr/lb)	Wind Speed (mph)	Wet Bulb Temperature (NSEW)
Median of Extreme Highs	84	91	164	9.3	SSW
0.4% Occurrence	82	89	152	8.3	SSW
1.0% Occurrence	81	89	147	7.7	SSW
2.0% Occurrence	80	88	141	7.4	S

Humidity Ratio (HR)	Design Value (F)	Mean Coincident (Average) Values: Wet Bulb Temperature (F)	Humidity Ratio (gr/lb)	Wind Speed (mph)	Wet Bulb Temperature (NSEW)
Median of Extreme Highs	168	88	1.11	6.9	SSE
0.4% Occurrence	152	87	1.01	8.8	SW
1.0% Occurrence	147	86	0.97	8.7	SW
2.0% Occurrence	143	85	0.95	6.7	S

Air Conditioning/ Humid Area Criteria		T 93F	T 80F	T_{wb} 73F	T_{wb} 67F
	# of Hours	53	2172	2689	4256

Other Site Data

Weather Region	Rain Rate 100 Year Recurrence (in/hr)	Basic Wind Speed 3 sec gust @ 33 ft 50 Year Recurrence (mph)	Ventilation Cooling Load Index (Ton–hr/cfm/yr) Base 75F–RH 60% Latent + Sensible
10	4.8	130	8.1 + 2.1
Ground Water Temperatures (F) 50 Foot Depth*	**Frost Depth 50 Year Recurrence (in)**	**Ground Snow Load 50 Year Recurrence (lb/ft^2)**	**Average Annual Freeze–Thaw Cycles (#)**
71.1	0	0	6

*Note: Temperatures at greater depths can be estimated by adding 1.5F per feet additional depth.

Figure 1–17. First page of EWD for Biloxi, MS.

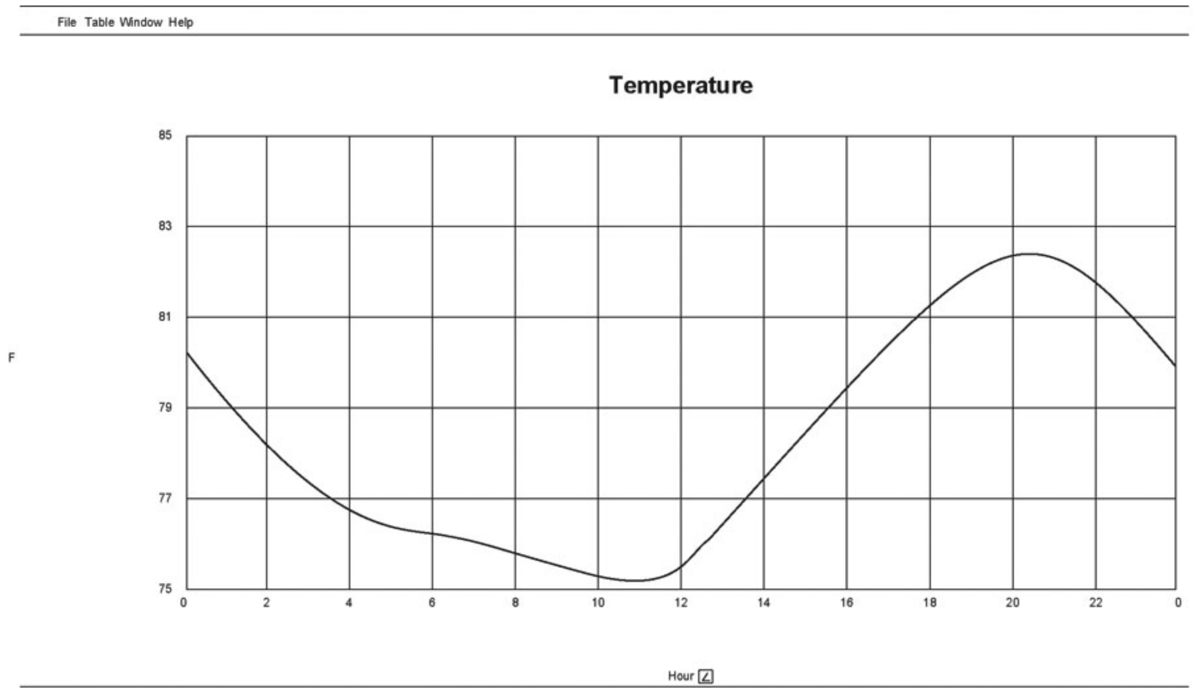


Figure 1–18. MODCURVE for Keesler AFB.

Operational climatic data summary

An operational climatic data summary (OCDS) is a manually prepared summary of monthly and annual climatic data. The summaries are provided by the 14th Weather Squadron. The OCDS displays climatic data for temperature, precipitation, snowfall, humidity, prevailing wind direction and speed, and other meteorological elements in a tabular format. Figure 1–19 is an example of the ceiling portion of OCDS for Keesler AFB, please refer to the 14WS homepage for the full version.

In addition to OCDS, 14WS also provides the OCDS-II web application. The OCDS-II web application allows users to generate tailored climate summary reports by individual and multiple weather parameters. Available formats include a web page hypertext markup language (HTML), comma separated value (CSV) and extensible markup language (XML).

8. % FREQ OF CIG/VIS LT 1500/3 MI (SOURCE NO. 1)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
00-02 LST	25	23	20	15	6	1	#	1	3	6	15	22	11
03-05 LST	27	26	25	18	9	2	2	3	5	11	20	23	14
06-08 LST	27	27	27	18	8	3	2	4	8	13	20	23	15
09-11 LST	21	20	17	9	4	1	1	2	4	6	12	17	10
12-14 LST	16	15	11	6	2	1	2	1	2	3	7	14	7
15-17 LST	16	13	11	6	2	1	2	2	2	3	7	13	6
18-20 LST	18	16	13	9	3	1	1	1	2	2	7	15	7
21-23 LST	22	19	17	13	4	1	#	1	2	4	9	17	9
ALL HOURS	22	20	18	12	5	1	1	2	4	6	12	18	10

Figure 1–19. OCDS for Keesler AFB.

Station observation climatic summary

Each station observation climatic summary (SOCS) summarizes surface hourly observations and "summary of day" data for a given weather station. SOCS output includes observed atmospheric phenomena, precipitation, snowfall, snowdepth, surface wind, ceiling, visibility, sky cover, temperature, and other meteorological climatic data.

SOCS are available for download from the 14WS web site. Figure 1–20 is an excerpt from the SOCS for Keesler AFB. This particular part of the SOCS depicts the percentage frequency of atmospheric phenomena for various hours of the day. The entire SOCS product can be extremely large.

GLOBAL CLIMATOLOGY BRANCH PERCENTAGE FREQUENCY OF HOURS WITH VARIOUS ATMOSPHERIC PHENOMENA
AFCCC, ASHEVILLE NC FROM SURFACE OBSERVATIONS
STATION NUMBER: 747686 STATION NAME: Keesler AFB MS PERIOD OF REPORT: JAN 1973 JAN 1997
UTC TO LST" –6 MONTH: JANUARY

HOURS (LST)	TSTMS	LIQUID PRECIP	FREEZG PRECIP	FROZEN PRECIP	HAIL	ALL PRECIP	FOG	SMOKE &/OR HAZE	BLOWING SNOW	DUST &/OR SAND	ALL OBST TO VSN	TOTAL NO. OF OBS
00–02	0.8	9.8	0.0			9.9	28.7	5.0			36.5	2084
03–05	1.4	11.2		0.1		11.3	29.8	4.5			37.6	2102
06–08	0.8	11.5	0.2	0.1		11.8	34.1	7.7			43.6	2192
09–11	0.3	9.3	0.3	0.4		9.9	25.0	10.4			36.6	2191
12–14	0.3	9.2		0.1		9.4	16.6	10.4			29.1	2189
15–17	0.9	10.6		0.1		10.6	16.3	11.9			30.7	2187
18–20	1.0	12.0		0.0		12.1	20.4	8.8			31.8	2187
21–23	1.4	10.5		0.1		10.6	23.9	5.9			32.6	2164
ALL HRS	0.8	10.5	0.1	0.1		10.7	24.3	0.1			34.8	17296

Figure 1–20. SOCS for Keesler AFB depicting percentage frequency of atmospheric phenomena.

Wind-stratified conditional climatology

The wind stratified conditional climatology (WSSC) product is produced by the 14WS to aid forecasters in the generation of ceiling and visibility forecasts and is available through the 14WS home page. As its name implies, the product employs a conditional climatology approach. Given an initial set of criteria (month, time of day, wind direction, ceiling height, visibility), this product displays the likelihood of a particular threshold based on the selected ceiling or visibility in time. WSCCs can be produced using both standard and specialized criteria.

The *Conditions* section is broken up into current and revised parts. The month and hour choices are automatically set to the current month and hour. The wind sector, ceiling, and visibility choices are updated based on the current observation displayed in the *Sequence Information* section. All parameters can be changed by either clicking on the arrow at the end of the selection or clicking directly in the row itself to pull down the list of choices.

The *Ceiling and Visibility* tables display the historical percentage of time the wind, ceiling and visibility conditions occurred for the month chosen. The highest percentages are bolded and represent the *climatology forecast* for the particular forecast hour.

Each table has several rows of information. At the top are the standard fcst hrs (forecast hours) column headers. Next is the time row in Zulu. This begins with the next hour after what is select in the Hours pull down. Below this are the ceiling and visibility threshold rows.

The last row in the table is an occurrences row. This specifies the number of occurrences a chosen ceiling or visibility condition has happened and is based in the wind sector and hour bin used. The number is color-coded: yellow for occurrences less than 30 and red for occurrences equal to or less than 15. These are cautionary warnings the statistical sample size is less than desired for significance. Where there are yellow values, use with some caution. Where there are red values, use with extreme caution. The WSSC product can be a valuable tool for the forecaster and should be reviewed prior to issuing any forecast. Figure 1-21 is an example of the ceiling and visibility tables derived from WSSC.

CEILING

13 FCST HRS	1	2	3	4	5	6	7	8	9	12	15	18	24
TIME	21Z	22Z	23Z	00Z	01Z	02Z	03Z	04Z	05Z	08Z	11Z	14Z	20Z
200 ft										4		3	
500 ft				3							3	3	3
700 ft	3	3			3	3						3	
1000 ft	3		6	6			6			4	3	6	3
1500 ft	6	11	9	6	11	6	6	3		12	13	12	11
3000 ft	***50***	***40***	23	18	14	14	20	16	7	4	16	18	20
10000 ft	22	26	26	18	26	29	14	22	34	27	23	***32***	20
Unlimited	17	20	***37***	***48***	***46***	***49***	***54***	***59***	***59***	***50***	***42***	24	***43***
OCCURRENCES	36	35	35	33	35	35	35	32	29	26	31	34	35

Total Initial Condition Observations: 1313

VISIBILITY

13 FCST HRS	1	2	3	4	5	6	7	8	9	12	15	18	24
TIME	21Z	22Z	23Z	00Z	01Z	02Z	03Z	04Z	05Z	08Z	11Z	14Z	20Z
0.5 mi													
1 mi													
1.5 mi		***33***	***67***	***67***	***67***	***67***	***67***	***50***					
2 mi	***67***	***33***											
3 mi													
7 mi											***50***	***67***	
Unlimited	33	***33***	33	33	33	33	33	***50***	***100***	***100***	***50***	33	***100***
OCCURRENCES	3	3	3	3	3	3	3	2	1	1	2	3	3

Figure 1–21. WSSC Table for Ceiling and Visibility.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

016. Temperature indices

1. What are the two temperature indexes that forecasters calculate?

2. Using the equivalent chill temperature chart (fig. 1–15), calculate the equivalent temperature for the following cases.

	Temperature	Wind Speed
(a)	10°F	20 mph
(b)	30°F	10 mph
(c)	0°F	15 mph with gusts to 20 mph
(d)	–20°F	15 ph with gusts to 25 mph

3. Using figure 1–16, calculate the heat index for the following cases:

Temperature	Relative Humidity
(a) 90°F	70 percent
(b) 110°F	50 percent
(c) 80°F	80 percent
(d) 85°F	65 percent
(e) 95°F	75 percent

017. Heating/cooling degree-days

1. What temperature value is used to calculate heating degree-days?

2. For the following cases, calculate the heating degree-days.

Max	Min	HDD
(a) 50	30	
(b) 20	0	
(c) 10	–10	
(d) 25	15	
(e) 71	63	

3. What is the total HDD for the days?

4. What temperature value is used to calculate cooling degree-days?

5. For the following cases, calculate the cooling degree-days.

Max	Min	CDD
(a) 70	60	
(b) 83	72	
(c) 94	80	
(d) 82	68	
(e) 102	76	

6. What is the total CDD for the five days?

018. Statistical climate data

1. Match each statistical climate product in column B with the description in column A. The products in column B may be used once, more than once, or not at all.

Column A	*Column B*
___(1) Provides monthly summaries of temperatures, dewpoint, altimeter setting, relative humidity, and pressure altitude changes by hour for stations with available surface observations.	a. EWD.
___(2) Monthly tables that give the frequency of occurrence for specified weather thresholds of ceiling and visibility stratified by wind direction.	b. MODCURVES.
___(3) Summarizes surface hourly observations and "summary of day" for a given weather station.	c. OCDS.
___(4) A collection of climatological products that assists engineers in the design constructions and maintenance of buildings.	d. SOCS.
___(5) Manually prepared summary of monthly and annual climatic data.	e. WSCC.

Answers to Self-Test Questions

001

1. (1) f.
   (2) c.
   (3) a.
   (4) e.
   (5) g.
   (6) b.
   (7) h.
   (8) d.

002

1. Temperature.
2. When considered in relation to weather phenomena forming over bodies of water.
3. Two stations could have the same amount of annual precipitation, but it could occur in different months or on different days during these months, and the intensity could vary.
4. Condensation.
5. Wind direction, speed, and gustiness.
6. The vectorial average.

003

1. (1) e.
   (2) a.
   (3) b.
   (4) c.
   (5) d.

2. (a) 44.9°, (b) 45°.
3. (a) 50 or 51, (b) 51.
4. (a) 1.8°F, (b) 2.3°F.

004

1. The distance from the equator and season of the year.
2. About 12 hours.

005

1. Because the mixing process sharply reduces temperature contrast for layers over water in contrast to the layers over land.
2. The forest provides a greenhouse effect to the underlying ground, while the plowed field is not protected.
3. The uneven distribution of land and water in the Northern Hemisphere causes the high- and low-pressure belts associated with the wind system to break down into separate closed centers of high and low pressure.

006

1. No. A place located in the high mountains on the equator would have a climate different from a place located a few feet above sea level at the same latitude.
2. Yes. Mountain barriers have an important influence on climate—especially the long, high chains that act as divides. These obstacles deflect the tracks of cyclones and block the passage of air masses in the lower levels.
3. The Himalayas and the Alps.
4. The windward sides.

007

1. The major circulation patterns cause the winds that control the movement of air (air masses) from one region to another. The semipermanent pressure centers are the major controls and the migratory pressure centers are extensions of the semipermanent centers.
2. Southward.

008

1. The ocean currents are produced mainly by the frictional effects of the prevailing winds on the ocean surface.
2. Coriolis force.
3. The ocean currents along the east coasts are primarily warm currents and the currents along the west coasts are primarily cold currents. The reason for this is that the primary circulation of the ocean currents in the mid-latitudes is anticyclonic.
4. Upwelling is the process by which the colder subsurface waters are brought to the top of the ocean.
5. Upwelling is caused by wind blowing parallel to the coast with the coast on the left side of the wind. This causes the surface water to be transported to the right and away from the coast.
6. Upwelling commonly occurs on the west coast in the Northern Hemisphere.

009

1. The Gulf Stream system has a warming influence on the east coast of the US.
2. 25–75 miles per day or 1–3 knots.
3. Middle portion. It begins near Cape Hatteras.
4. Causes the climate to be much milder than ordinarily expected.

010

1. The large amount of subarctic water in the North Pacific Ocean versus the small amount in the North Atlantic.
2. It originates near the western coast of Central America.
3. The Gulf Stream system.

4. The Kuroshio Current, the Kuroshio Extension, and the North Pacific Current.
5. Spring temperatures are lower than winter temperatures where the upwelling is intense. Where the upwelling is moderate, the winter temperatures are lower.

011

1. The currents of the South Atlantic Ocean show the effects of the South Atlantic anticyclone.
2. The currents of the northern Indian Ocean are influenced by the monsoonal flow. In February/March the northern Indian Ocean is under the influence of the northeast monsoon; in August/September, it is under the influence of the southwest monsoon. This causes the reversal of the Indian Ocean Current.
3. See figure 1–15.
4. See figure 1–15.

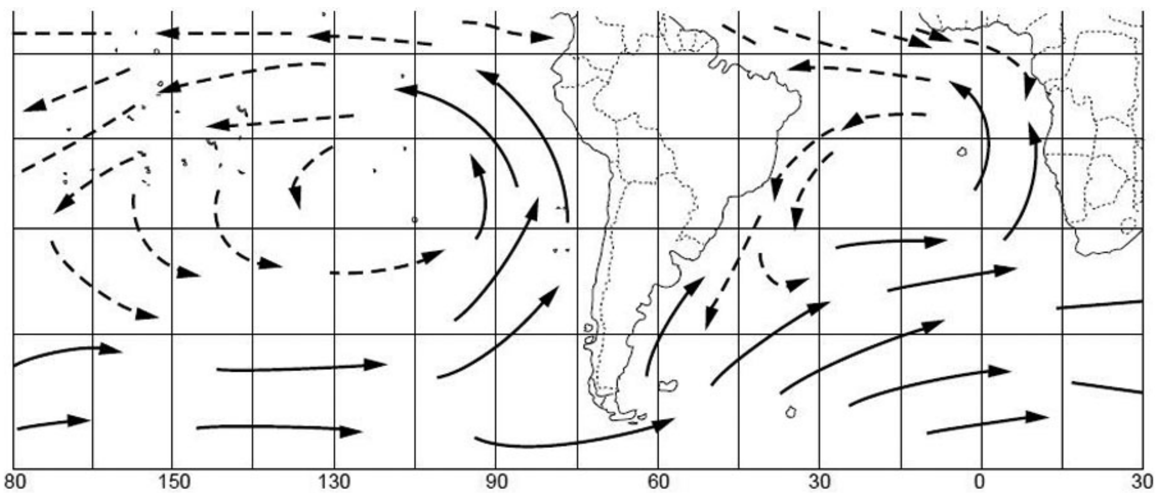


Figure 1–22. Ocean currents of the South Pacific and South Atlantic Oceans (lesson 011, answers 3 and 4).

012

1. Temperature maximums are lower and minimums are higher in forests than the surrounding area.
2. Moisture on trees evaporates readily, while the moisture on the ground does not readily evaporate, nor run off easily.
3. Atmospheric pollution affects the normal radiation balance. Therefore, the daily maximum and minimum temperatures are higher.
4. The larger heat source concentration increases convective currents in these areas.

013

1. The Torrid (or Tropical) Zone, the two Temperate Zones, and the two Polar Zones (or Frigid Zones).
2. The Tropical Zone is bounded on the north by the Tropic of Cancer (23°N) and on the south by the Tropic of Capricorn (23°S). The Temperate Zone of the Northern Hemisphere is bounded on the south by the Tropic of Cancer and on the north by the Arctic Circle (66°N). The Temperate Zone of the Southern Hemisphere is bounded on the north by the Tropic of Capricorn and on the south by the Antarctic Circle (66°S). The two Polar Zones are bounded by the Arctic or Antarctic Circles. Using the isothermal limits, the boundaries between the Tropical Zone and the Temperate zones are set by the two mean annual 68°F isotherms. The boundaries between the Temperate Zones and the Polar Zones are fixed by the two 50°F isotherms for the warmest month.

014

1. Temperature, precipitation amounts, and season of maximum precipitation. The numerical values for these elements were selected primarily on their effect on plant growth.
2. The effectiveness of precipitation, defined by the relationship between precipitation and evaporation.

3. Köppen's classification considers temperatures and precipitation; Thornthwaite's classification does not consider temperature.
4. Köppen's: Tropical rain, dry, humid mesothermal, humid microthermal, and polar. Thornthwaite's: Wet, humid, subhumid, semiarid, and arid.
5. Köppen.

015

1. It is a local feature that causes the wind direction to reverse from night to day.
2. During the summer, near a coastline, under a weak pressure gradient. The sea breeze occurs during the late morning and afternoon hours. The land breeze occurs during the night and early morning.
3. During the summer monsoon, weather conditions consist of continuous rain and widespread shower activity. During the winter, this area is under the influence of modified continental polar air with pleasant weather conditions.
4. The reverse of the weather conditions in India and Burma can be expected along eastern Indochina. The winter monsoon (Northeast Monsoon) is from water to land, and this is the cloudy season in this area. During the winter monsoon, the continental polar air flowing southward over the East and South China Seas becomes sufficiently modified to produce extensive cloudiness and rain or drizzle. This phenomenon is called the Crachin.
5. The pressure gradient acting along the ravine, with winds blowing directly from high pressure to low pressure.

016

1. Equivalent chill temperature and heat index.
2. (a) –25°.

   (c) –30°.

   (d) –60°.
3. (a) 106°, sunstroke, heat cramps or heat exhaustion likely.

   (b) 150°, heatstroke or sunstroke imminent.

   (c) 86°, fatigue possible.

   (d) 91°, sunstroke, heat cramps and heat exhaustion possible.

   (e) 130°, heatstroke or sunstroke imminent.

017

1. 65.
2. (a) 25

   (b) 55.

   (c) 65.

   (d) 45.

   (e) 0.
3. Total = 190 heating degree-days.
4. 65.
5. (a) 25.

   (b) 55.

   (c) 65.

   (d) 45.

   (e) 0.
6. Total = 69 cooling degree-days.

018

1. (1) b.
   (2) e.
   (3) d.
   (4) a.
   (5) c.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to Extension Course Program Field Scoring Answer Sheet.

Do not return your answer sheet to Extension Course Program (A4L).

(001) The average or collective state of the earth's atmosphere at any given location or area within a specified period is known as
a. climate.
b. aerology.
c. climatology.
d. meteorology.

2. (001) Descriptive climatology *usually* deals with
a. geographic regions.
b. general circulation characteristics.
c. the day-to-day changes in the atmosphere.
d. the physical processes influencing the climate.

3. (002) The temperature of an area depends on latitude, distribution of incoming and outgoing radiation, nature of the surface (land or water), altitude, and
a. prevailing winds.
b. vegetation and human activities.
c. annual amount of precipitation.
d. semipermanent pressure systems.

4. (002) Which climatic element is an important factor in the formation of fog over bodies of water?
a. Temperature.
b. Evaporation.
c. Condensation.
d. Precipitation.

5. (002) Which climatic element becomes especially important in desert areas?
a. Winds.
b. Evaporation.
c. Temperature.
d. Condensation.

6. (002) Which is a vectorial average?
a. Maximum wind gusts.
b. The resultant wind.
c. The average wind speed.
d. Prevailing wind direction.

7. (003) The *most commonly* used climatological parameter is the
a. absolute.
b. extreme.
c. normal.
d. mean.

8. (003) The extreme highest and lowest values for any given meteorological element recorded at a place of observation is known as the
   a. mean.
   b. normal.
   c. extreme.
   d. absolute.

9. (003) The highest and lowest value for any given meteorological element that has occurred over a particular period is known as the
   a. mean.
   b. normal.
   c. extreme.
   d. absolute.

10. (003) What are the two types of frequency distributions?
    a. Standard and mean.
    b. Primary and secondary.
    c. Random and probability.
    d. Continuous and discrete.

11. (003) Thunderstorm occurrences are an example of
    a. finite data.
    b. absolute data.
    c. discrete data.
    d. continuous data.

12. (003) The *most* common value in a frequency distribution is known as the
    a. mode.
    b. mean.
    c. median.
    d. standard.

13. (003) The type of deviation used *most often* in meteorological studies is the
    a. mean deviation.
    b. random deviation.
    c. finite deviation.
    d. standard deviation.

14. (004) The climate of a region is impacted *most* by
    a. latitude.
    b. altitude.
    c. ocean currents.
    d. mountain barriers.

15. (004) What sets the air in motion, tending to develop a general pattern of motion all over the earth?
    a. Land and water distribution.
    b. Number of sun hours per day.
    c. Landforms and the variations with altitude.
    d. Latitudinal difference in the earth's heating.

16. (005) Coastal areas take on the temperature characteristics of the land or water
    a. to their leeward side.
    b. to their windward side.
    c. that has the highest average temperature.
    d. that the current air mass was formed over.

17. (005) Why is the mean temperature of the Northern Hemisphere higher than that of the Southern Hemisphere?
    a. There is more land in the Northern Hemisphere.
    b. Oceans in the Northern Hemisphere are warmer.
    c. Oceans of the Northern Hemisphere are more protected from cold polar waters by land barriers.
    d. It is higher for *all* these reasons.

18. (006) Rome, Italy and New York City are at approximately the same latitude, yet Rome has a much milder winter climate. What factor is *mostly responsible* for this?
    a. Prevailing westerlies.
    b. East-west orientation of the Alps.
    c. North-south orientation of the Apennine Mountains.
    d. Mediterranean Sea surrounding Italy on three sides.

19. (006) What two general topographical features have the *greatest* affect on the climate of an area?
    a. Altitude and mountain barriers.
    b. Altitude and proximity to large bodies of water.
    c. Vegetation and proximity to large bodies of water.
    d. Mountain barriers and proximity to large bodies of water.

20. (007) Which pressure centers are the *major* climatic controls affecting climate?
    a. Low-pressure centers.
    b. High-pressure centers.
    c. Migratory pressure centers.
    d. Semipermanent pressure centers.

21. (008) The *principal* cause of the surface ocean currents is the
    a. rotation of the earth.
    b. frictional effect of the wind.
    c. gravitational pull of the sun and the moon.
    d. unequal temperatures of the high and low latitudes.

22. (008) A *secondary* cause of the surface ocean currents is the
    a. topography of the ocean bottom.
    b. gravitational attraction of the moon and sun.
    c. differences in the mean water level of the world's oceans.
    d. density differences due to salinity and temperature variations.

23. (008) Upwelling is the process by which
    a. ocean waters transport heat latitudinally.
    b. subsurface water is displaced toward the surface.
    c. the vertical current components converge and diverge.
    d. water sinks while flowing horizontally until it reaches a density corresponding to its own.

24. (009) What are the two *fastest* ocean currents in the Northern Hemisphere?
    a. Gulf Stream and the Florida Current.
    b. Kuroshio System and the Gulf Stream.
    c. Antilles Current and the Kuroshio System.
    d. North Equatorial Current and the Antilles Current.

25. (009) The Gulf Stream System is made up of the
    a. Gulf Stream, the Florida Current, and the Antilles Current.
    b. Irminger Current, the Gulf Stream, and the Florida Current.
    c. Gulf Stream, the Antilles Current, and the Irminger Current.
    d. Florida Current, the Gulf Stream, and the North Atlantic Current.

26. (009) The northern extension of the Gulf Stream system is called the
    a. Florida Current.
    b. Antilles Current.
    c. North Atlantic Current.
    d. North Equatorial Current.

27. (009) Although it is a high latitude, the climatic region of northwestern Europe has a somewhat moderate temperature in winter. This is due to the
    a. effects of the Gulf Stream.
    b. effects of the North Atlantic Current.
    c. low degrees of cloudiness during the winter.
    d. prevalence of anticyclonic circulation during the winter.

28. (010) Which North Atlantic current is similar to the Kuroshio current in its flow and climatological influence?
    a. Canary Current.
    b. Florida Current.
    c. Irminger Current.
    d. Antilles Current.

29. (010) What are the two *best* clues for locating the North Pacific Current?
    a. Temperature and salinity.
    b. Upwelling and salinity.
    c. Temperature and flow.
    d. Flow and upwelling.

30. (010) In the fall, upwelling along the California coast gives way to a countercurrent that flows northward along the coast to about 48° latitude. What is the name of that countercurrent?
    a. Aleutian Current.
    b. Davidson Current.
    c. California Current.
    d. California Countercurrent.

31. (011) In the Southern Hemisphere, surface ocean circulations are much the same as in the Northern Hemisphere, *except* that the circulations move
    a. clockwise in response to the winds around the tropical highs.
    b. clockwise in response to the winds around the subtropical highs.
    c. counterclockwise in response to the winds around the tropical highs.
    d. counterclockwise in response to the winds around the subtropical highs.

32. (012) Which statement reflects the relationship between open land and forests on wind speed at the same latitude?
    a. Open land wind speeds are higher.
    b. Open land relative humidities are higher.
    c. Forest temperature maximums and minimums are higher.
    d. Wind speeds over large human settlements are higher.

33. (012) What is the effect of large human settlements on temperatures?
    a. Daily maximum and minimum temperatures are lower.
    b. Daily maximum and minimum temperatures are higher.
    c. High and low extremes are normally cooler in the cities.
    d. Daily temperature ranges are almost twice as high as normal.

34. (013) If the boundaries of the hot belt are determined by given isotherms, the width of the zone
    a. increases over the continents.
    b. decreases over the continents.
    c. is the same over continents as over oceans.
    d. shows no consistent variation over continents versus oceans.

35. (014) A climatic province that is classified as humid mesothermal by Köppen is the
    a. WET.
    b. ARID.
    c. SUBHUMID.
    d. OCEANIC MODERATE.

36. (014) Köppen's climate classification is based *mainly* on temperature, precipitation amount, and season of maximum precipitation. These elements were selected *primarily* because of their effect on
    a. plant growth.
    b. human activity.
    c. flying conditions.
    d. annual precipitation.

37. (014) Thornthwaite's classification of climates places a great deal of emphasis on the effectiveness of precipitation, which is the relationship between precipitation and
    a. the amount of absorption by the earth at a certain place.
    b. evaporation at a certain place.
    c. distribution of land and water.
    d. zonal precipitation patterns.

38. (014) Trewartha's climatic classification states that mountainous (highland H) climates are difficult to group climatologically on a small scale map due to the added
    a. vertical dimension and the gradual change in atmospheric conditions.
    b. vertical dimension and the markedly change in atmospheric conditions.
    c. horizontal dimension, atmospheric conditions change gradually.
    d. horizontal dimension, atmospheric conditions change markedly.

39. (015) An area has a stationary air mass over its coastline and the land surface is warmer than the sea surface because of radiational heating. In what direction do local winds blow?
    a. Always from land to water.
    b. Always from water to land.
    c. From water to land during the day and from land to water at night.
    d. From land to water during the day and from water to land at night.

40. (015) What type of modified air mass is observed over India and Burma during the winter monsoon season?
    a. Continental polar.
    b. Continental tropical.
    c. Maritime polar.
    d. Maritime tropical.

41. (016) The equivalent chill factor depends on the
    a. temperature and wind.
    b. temperature and humidity.
    c. wind, humidity, and cloud cover.
    d. temperature, wind, and cloud cover.

42. (016) The heat index depends on the
    a. temperature and wind.
    b. temperature and relative humidity.
    c. temperature, wind, and cloud cover.
    d. wind, relative humidity, and cloud cover.

43. (017) What temperature is used as a constant in the equation for computing cooling degree-days?
    a. 60.
    b. 65.
    c. 68.
    d. 70.

44. (018) What climatological product is produced to provide professional engineers with useful information in the design and maintenance of buildings?
    a. Engineering weather data.
    b. Model diurnal curves.
    c. Surface observation climate summaries.
    d. Winds stratified conditional climatology.

45. (018) As a general rule, which of the following climatological products is reviewed prior to issuing any forecast?
    a. Winds stratified conditional climatology.
    b. Surface observation climate summaries.
    c. Site specific upper air climatologies.
    d. Model diurnal curves.

Please read the unit menu for unit 2 and continue ➔

Unit 2. Regional Analysis and Forecast Program

AT MANY LOCATIONS, the majority of mission-limiting weather is produced by a small number of distinct weather regimes. Understanding regime information—seasonal occurrence, synoptic organization, characteristic weather conditions, and much more—will help you produce more accurate forecasts. Every location on the earth has familiar weather patterns, and each particular system with its own unique features.

Using regime information in the forecast process is the preferred method by Air Force forecasters. Regime based forecasting is not a new process. Forecasters have been using regime information for decades. Every time a forecaster recognizes a weather pattern and makes a forecast based on that pattern, he or she is using regime information. Basically, an application of climatology is using regime information when making a forecast.

In this unit you will learn about the weather regimes. Topics ranging from the basics, such as classification of weather systems, all the way to the application level, such as integrating product analysis into a time efficient forecast process. Armed with this information you will be able to use regime climatology to produce better forecasts.

2–1. Weather Regimes

To properly identify weather regimes it is important to have an understanding of how systems are classified. Classification begins on a large scale then focuses downward, towards the smaller scale. This way you will see how everything ties together; how large and small-scale weather features interact to produce the weather at your location. Essentially identifying the weather regime is a process of putting all the pieces of the atmospheric puzzle together to see the big picture.

019. Classification of weather systems

Weather systems are classified into three different categories according to their size. The classification strategy that is used was born many years ago, but despite its age, it has a strong application in today's regime forecast process. It melds nicely with the regime forecast process because it starts at the largest scale first then, gradually works inward towards the smallest scale. In light of this strategy, it seems fitting we should begin your exploration of the subject with the largest weather system—the macroscale system.

Macroscale systems

The largest systems that you deal with in forecasting are macroscale systems. These systems cover more than 1,500 nautical miles (nm), and their duration is from several days to over a week.

Macroscale systems include long waves, semi-permanent cyclones and anticyclones, as well as seasonal circulations. Macroscale features influence migratory system movement and development. Migratory systems may develop rapidly, or not at all, depending on the long-wave macroscale influence. Furthermore, the long-wave macroscale pattern steers the migratory systems.

Synoptic systems

These vary in horizontal size from 500 to 1,000 nm and have a life cycle of tens of hours to several days. Synoptic scale is defined as the typical weather map scale that shows features such as high and low pressure areas, in addition to fronts over a distance spanning a continent. Synoptic analysis is typically accomplished on a map of that scale, such as a weather map of the North American continent. Synoptic scale analysis is used to identify synoptic weather systems affecting a forecaster's area of operations. These systems include migratory cyclones, anticyclones, and air masses; frontal systems; and tropical cyclones. Synoptic systems influence a station's weather the most. These systems influence advection, vertical motions, and other dynamics.

Mesoscale systems

Mesoscale systems vary in size from 1 to 500 nm and are considered "local effects." They last from tens of minutes to several hours. Examples of mesoscale systems are squall lines, thunderstorms, tornadoes, and land/sea breezes. Mesoscale systems impact the weather by influencing the weather caused by synoptic systems. For example, a location could be under westerly synoptic wind conditions, but receive easterly winds caused by a sea breeze. Local winds, temperatures, and clouds are greatly influenced by mesoscale systems. However, as stated earlier, a station's weather is influenced the most by synoptic systems. It's important to keep in mind the whole chain effect; macroscale systems influence synoptic systems, synoptic systems influence the weather, and mesoscale systems influence the weather caused by synoptic systems. The following table illustrates a comparison of synoptic systems to similar mesoscale systems.

System	Synoptic Scale	Mesoscale
High-pressure system	Anticyclone	Mesohigh
Low-pressure system	Subtropical cyclone Mid-Latitude Cyclone Tropical cyclone Hurricane Typhoon	Mesocyclone Tornado cyclone Mesolow
Frontal system	Warm front Cold front Stationary front Occluded front Dry line	Gust front Radar thin line Arc-cloud line Sea-breeze front

Microscale

Although we classify weather systems down to the mesoscale, you should be aware that weather occurs at an even smaller level. The microscale is the smallest scale used in meteorology. Examples of microscale events are the small circulations in the atmosphere such as localized low level wind shear, a thunderstorm's outflow boundary, or the interaction of the Earth's surface with the boundary layer. Have you ever experienced being near a rain shower but not under the rain shaft? You can see the precipitation at a very close proximity but yet you are completely dry. Examples like these are dependent on your location and the proximity of the weather occurring and depict how weather occurs at the microscale level.

Microscale events should be considered while forecasting. It's important to understand how small features such as terrain can impact the weather for a location. Consider two locations within 5 miles of each other. One of these locations is downstream of a water source while the other is upstream of the same terrain feature. One would expect for the upstream location to experience different weather conditions, a quick look at both of these locations climatology would indicate the differences. Once again, your unit's TFRN and LAFP should include the details of the local features that impact your station's weather. Understanding how these features impact your station will be helpful in developing an accurate forecast.

020. The weather regime

As stated earlier, forecasters have used regime information in the forecast process for some time. However, in the past this application was more of an individual process. Regime information was posted in station literature and read by forecasters on a recurring basis. Then, it was left up to the individual to apply the information. Now, emphasis has moved towards merging regime information with the forecasting process and is considered throughout the forecast funnel, a process you will learn about later in this unit. Forecast checklists are geared towards specific regimes; radar, satellite, and analysis procedures are regime specific; and weather briefing and customer support products are regime oriented. The entire forecast process is linked to regime information. In this lesson we will look at the definition of a weather regime and where the information on them can be obtained.

Definition

In weather terms, a regime is defined as a specific synoptic and/or mesoscale weather pattern that affects the weather at a particular location. Weather regimes affect various sized areas; however, dominant weather conditions are usually associated with synoptic scale weather patterns (highs, lows, fronts, etc.). Regimes are often named after their system type and development region, such as the "Texas Low" in the US, or the "Shanghai Low" in Asia. In some cases, significant local effects (mesoscale regimes) are associated with synoptic regime patterns (low-level jets, cold air damming, upslope conditions, etc.).

Documented regime information

Every forecast unit should have documented regime information for each significant regime affecting their forecast area. This information should be contained in terminal forecast reference notebooks (TFRNs), meteorological technical information programs (MetTIPs), or local analysis and forecast programs (LAFPs). The information will be documented specific to your location, based upon the research from local occurrences. These references have no standard format, so the style in which the information is documented will differ from theater to theater and station to station.

Meteorological Technical Information Program

The Air Force Weather Agency (AFWA) has developed a software program that outputs regime information for weather patterns all over the world. The regime information is viewable in the MetTIPs in a hypertext format, similar to a web browser interface. The original version of the MetTIPS program contains information on CONUS weather regimes. Newer, overseas versions of the program are appropriately named for their region, such as European Theater Meteorological Technical Information Programs (EuroTIP) for the European Theater and Pacific Theater Meteorological Technical Information Programs (PacTIP) for the Pacific Theater.

Figure 2–1 is a sample screen from MetTIPs that illustrates some of the major CONUS regimes. Each map in the figure depicts a characteristic surface analysis of the regime with streamlines representing the upper-level flow superimposed over the image. Users can click, with the mouse, on any of the maps (in MetTIPs) to see more detailed information on the figure.

MetTIPs provide extremely valuable information for the weather forecaster such as knowledge that will be available to you on the unit's computer while you're working a forecast shift.

The MetTIPs regime documentation contains the following information:

1. Regime frequency, duration, and seasons when it most occurs.
2. Description of surface and upper-level features.
3. General weather conditions associated with the regime and potential forecast problems.
4. Special analysis and forecast tools, products, and techniques to use for the regime.

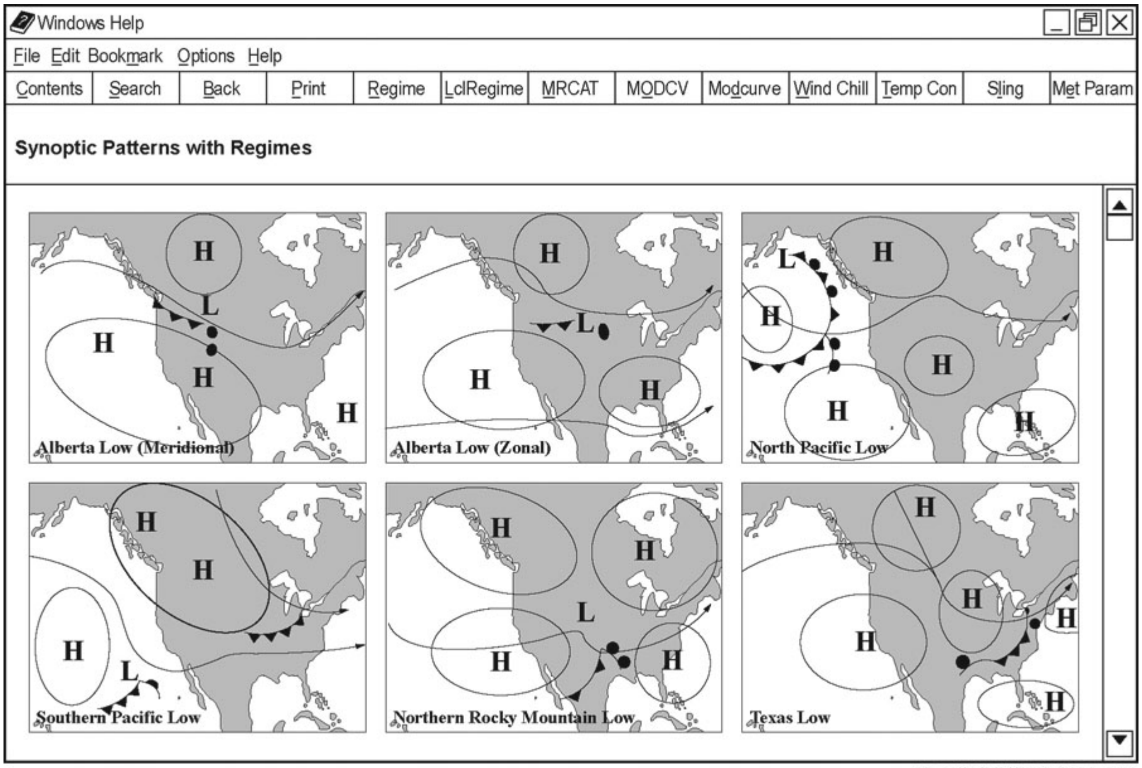


Figure 2–1. MetTIPs CONUS regimes.

Figure 2–2 displays more detailed information on the Central European High regime with accompanying troughing in the Southern Mediterranean. This figure is extracted from the Southern European regimes page of the EuroTIPs program. It includes a broad description along with a more specific synoptic and mesoscale discussion.

Central European High
Troughing in the Southern Mediterranean

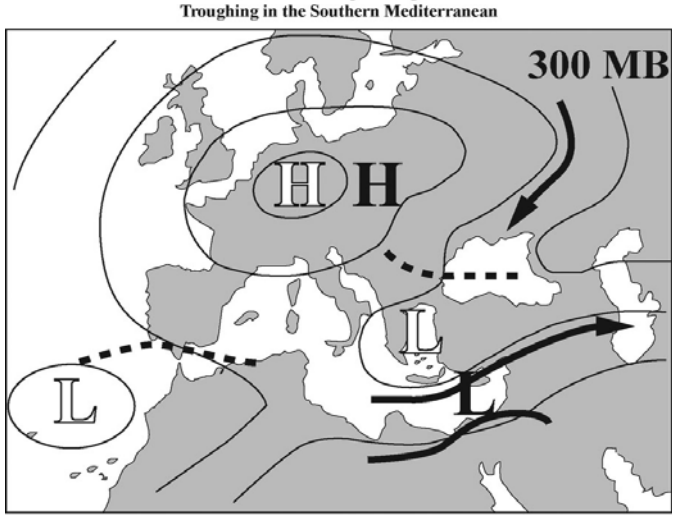


Figure 2–2. Synoptic regime description from EuroTIPs.

As discussed earlier, mesoscale systems interact with synoptic scale regimes. For example, figure 2–3 gives information on a sea breeze, which in this case is a mesoscale regime that can occur within the synoptic Summer Asiatic Thermal Low regime. The EuroTIPs provided the additional information on the sea breeze.

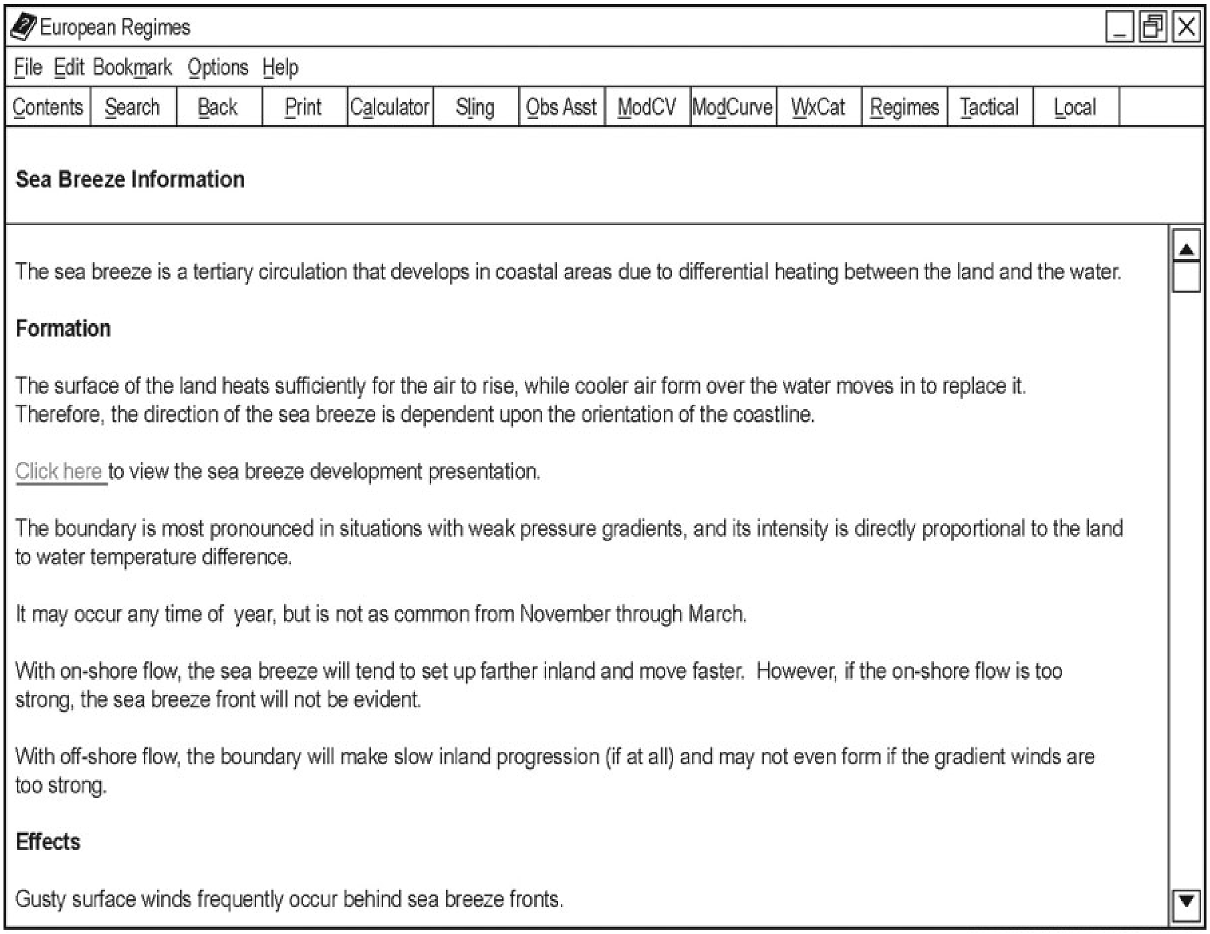


Figure 2–3. Sea breeze information from EuroTIPs.

The MetTIPs programs are valuable tools for a forecaster to obtain specialized climatological information for the weather system influencing your area. However, in order to use the program properly you must be able to identify the weather regime that dominates your weather. The forecast funnel is the process that enables you to correctly identify the regime.

Air Force Weather Knowledge Center

In addition to the previously mentioned resources, you can obtain information about regimes from the Air Force Knowledge Weather Center (AFWKC). AFWKC's vast library includes training tutorials and presentations on weather regimes throughout the world. This information can easily be accessed with a user's account.

021. Forecast funnel

Now that you know how weather systems are classified and the definition of a weather regime, the next step is to learn how that information applies to a process called the forecast funnel. The forecast funnel is a process that allows you to systematically examine your analysis from a broad to narrow perspective to determine the synoptic and/or mesoscale weather regimes in effect.

Forecast funnel

Probably the best way to identify the weather regime is to look at the macroscale first, then the synoptic scale, and finally the local mesoscale. This approach is called the "forecast funnel." A forecaster achieves a clear understanding on the state of the atmosphere by starting with large-scale features first, then focusing downward to the smaller scale.

This process easily narrows down the possible regime choices at each scale in the process. The first step in the forecast funnel process is macroscale analysis.

Macroscale analysis

Macroscale analysis is critical because macroscale features influence migratory (synoptic) system movement and development. They influence the movement because a system's track is dependent upon the long wave pattern. The term "long wave pattern" describes the location of long waves, troughs, and ridges; and the zonal index. The troughs and ridges in the long wave pattern guide the jet stream. Therefore, by knowing their location you are able to predict the systems movement as it's guided by the jet stream. The zonal index, the second part of the long wave pattern, affects a system's speed and its north to south movement.

The zonal index indicates the amplitude of the long wave troughs and ridges. A high zonal index, also known as zonal, means the features have small amplitude; conversely, a low zonal index means a large amplitude. In a long wave pattern with a high zonal index, systems normally speed up and move from west to east. However, in a situation with a low zonal index, also known as meridional, systems move from north to south or south to north and are generally slower. Besides movement, the development of synoptic systems is strongly influenced by macroscale features.

Synoptic scale systems may develop rapidly, or not at all, depending on the systems relative position and the amplitude of the long wave troughs and ridges. The amplitude of long wave features is indicative of their influence on the intensity change of surface systems. For instance, a large amplitude long wave trough deepens a low ahead of the trough due to the strong divergence. All things being equal, a weak amplitude long wave trough will not effectively deepen a low positioned ahead of it. The same holds true for the affect that a long wave ridge has on surface highs. A strong amplitude long wave ridge effectively strengthens a high positioned ahead of it due to the strong convergence. On the contrary, a weak amplitude long wave ridge will not effectively strengthen a high located ahead of it. As you can see, identifying the long wave pattern is a critical step in forecasting, let's look at the process of identification.

Identifying the long wave pattern

Review continuity data from the past several days to get a feel how the pattern is changing. No single "snap shot" in time is good enough to properly identify the regime. Proper regime identification requires an accurate description of the long wave pattern, which depends on continuity and analysis. Some standard products to use are satellite water vapor analysis, 5-wave analysis charts, and 500-MB hemispheric charts. Five-wave charts are especially useful because they eliminate the effects from migratory shortwave troughs, thereby providing a clearer image of the long waves. Analyze the past and current long wave positions to identify any blocks or splits in the flow that may affect migratory systems. Knowing the long wave pattern will help determine the weather regime in affect over the area.

Weather regimes are specific to particular long wave patterns. For example, the Pacific Low only forms when the long wave trough is positioned off the West Coast of the United States. On the other hand, these conditions would not be favorable for the formation of a Gulf Low. Many regime-based forecasting programs document the regime information into categories based on long wave position. This makes it easier to reference the information, because the forecaster needs to only look at the regimes that match the long wave pattern. However, you're not ready to decide on a regime. You are still proceeding through the forecast funnel process and the next step is synoptic analysis.

Synoptic scale analysis

Synoptic scale regimes influence a station's weather the most. They influence advection, vertical motions, and other dynamics. A station's analysis and forecast program should outline standard analysis procedures for the synoptic scale.

As with macroscale analysis, review continuity to see how systems have progressed and gives you a starting point in your analysis. Identify the migratory systems (highs, lows, fronts, etc.) using standard analysis products and tools, such as upper air charts and satellite data. After you have accomplished a synoptic analysis of significant features, you're ready to identify the synoptic regime.

Identifying the synoptic regime

Using documented regime information, match your analyzed synoptic features to a particular regime. Synoptic regime information is categorized by geographical region, long wave pattern, and surface features. You should be able to narrow down the choices to one reigning synoptic regime. However, keep it in mind that different synoptic regimes can affect an area during the same forecast period. For example, Alberta Low regimes can quickly transition into an Alberta High regime shortly after frontal passage. For this reason, it is also important to look at forecasting charts in determining what regime(s) will affect an area during the forecast period. In addition, it's important to know that not all synoptic conditions perfectly match the documented regime information.

The documented regime information is the "classical" scenario for each particular weather pattern. The information represents the climatological norm for each regime. However, many times patterns may represent a mixture of two different regimes. For example, a system may have features in-between a North Pacific Low and an Alberta Low. In situations like this it is important to remember the resulting weather may favor one, both, or some combination of the two regimes. The regime information for both systems must be reviewed. The interaction of the two regimes must be evaluated and considered. By and large, the whole process requires a more in-depth study of the systems and the regime information must be used more subjectively. With the synoptic analysis complete, the next step in the forecast funnel process is mesoscale analysis.

Mesoscale analysis

Mesoscale regimes, such as sea breeze fronts and squall lines, may be shorter lived than those at the synoptic scale, but are no less significant. Documented regime information for the synoptic scale should include details on commonly associated mesoscale regimes that could affect your forecast. This gives you an idea of where to focus your analysis.

Mesoscale analysis should focus on any current or expected mesoscale regime features. These features require detailed analysis to correctly identify and forecast them. As with macroscale and synoptic analyses, previous data (continuity) should be reviewed to give you an idea of what to look for on your analysis and prognosis. Some standard mesoscale products to use include surface and upper air charts focused on the mesoscale, soundings, wind profiler data, and high-resolution satellite. Fine-scale model data can also be helpful in revealing mesoscale features.

With the forecast funnel process complete, you have a clear picture of what weather regimes are influencing your weather. Most weather stations have a regional analysis and forecast program (RAFP) that includes regime-forecasting tools that the forecaster can use for assistance. In the next lesson, you are introduced to some of those tools.

022. Regime forecast tools

After identifying the synoptic regime and/or mesoscale regime, consult the RAFP or other documentation to find documented regime information to assist you in the forecast process. At a minimum, documented regime information should include regime specific weather and helpful forecasting tools.

Regime specific weather

Similar to the MetTIPs program, units are documenting weather conditions common to each regime. However, the regime information at the unit level is not completely similar to MetTIPs (See passage below). The weather conditions listed in MetTIPs are generic and they're written in support of all CONUS installations. The weather conditions associated with each regime in your unit's documentation are specific to your location.

In addition, the information is more detailed. For example, the following statement would be fitting MetTIPs; "… high winds will be experienced in the northeast US with this system." In contrary, the following statement would be suited for your local guidance; "… winds will be greater than 35 knots when the pressure difference between Colorado Springs and Denver is over 8 millibars."

Weather to Expect With This Regime

a) Colorado cyclones are generally responsible for the overwhelming majority of major snowstorms for the Midwest and Great Lakes states. Their effect on the southeast is dependent on the track of the surface low-pressure center. The majority of the cyclones move east out of their source regions before re-curving to the northeast in Kansas or the Texas Panhandle. A significant minority of Colorado Cyclones will track due east from their source region and not re-curve until crossing the Appalachians. Lows taking this "southern track" will significantly impact weather in the LFA. Monitor height change centers at 300-MB and/or 500-MB. Generally, when the HFC supporting the surface cyclone moves east of the front range of the Rockies, it will track towards a height rise center over the Great Lakes or James Bay. If the height rise center is not present in this region, there is a strong likelihood that the surface low will follow the "southern track."

b) Karr patterns are common with the Colorado Low. Monitor the lower tropospheric winds over east Texas and the western Gulf of Mexico for the development of a low-level jet.

c) "Southern track" lows produce significant precipitation and low cloudiness both ahead of and behind the cold front. Thunderstorms with hail and damaging winds are not uncommon in the strongly sheared environment ahead of the surface low. The most significant weather is located in the vicinity of the surface low bounded by the region "swept out" by the –15 through –25 isotherms at 500-MB.

d) Moderate or stronger surface fronts will produce warning class winds in cold air advection post-FROPA. Winds at Hooper, Ech, Brown and Goldberg will be stronger than the base due to terrain effects. If the gradient will support winds of 28 knots or greater, forecast warning class winds for Hooper, Ech, Brown, and Goldberg in northwesterly flow. Winds are strongest at 0800–1100L and again at 1400–1500L. In the morning, winds will be trapped above the nocturnal inversion and reach the surface as the inversion breaks, in the afternoon, winds will spike at the max diurnal pressure fall due to isallorbaric compression of the wind field.

Regime forecasting tools

Most units have specialized tools, products, and procedures outlined in their regime documentation. Regime specific approaches are developed to help forecasters maximize their resources and skills. For example, the WSR–88D RPS list and alert paired products are designed to assist forecaster in regimes conducive to severe convection. More examples are two-degree isotherm analysis at 850 MB and 500 MB, 500 MB height fall analysis, and surface pressure fall analysis (isallobar analysis) to help identify short waves and fronts. There are near endless possibilities to the types of regime forecasting tools that units develop and document.

The table below is an example of a forecast, analysis, and metwatch plan for warm frontal overrunning precipitation. It outlines the use of specific tools and products to help forecasters predict the event.

Warm Frontal Overrunning Precipitation Forecast, Analysis and Metwatch Plan		
Tool	***Product***	***Usage***
OWS website, or other analysis and display systems, i.e. Joint Environmental Toolkit (JET)	Hourly LAWC	Analyze feature positions and precipitation areas and track their movement using previous LAWCs
	Vertical Cross Sections	Generate to help forecast overrunning moisture
	Upper Air Analysis and Progs	Locate areas of: Deep moisture Low-level warm air advection (WAA). Positive vorticity advection (PVA) Cyclonic flow with moisture Support for surface lows/troughs/fronts Low-level convergence and upper-level divergence Cyclogenesis Locate jet stream support Determine position of 700-MB ridge (start of rain) Differentiate between rain and snow using: 1000–500 MB thickness 1000–700 MB thickness 850–700 MB thickness 850, 700, and 500 MB temperatures
Meteorological Satellite	MB Curve Infrared Loop focused over the Midwest	Identify cooling/warming cloud tops as an indicator of increasing or decreasing precipitation. Track cloud areas associated with precipitation.
Radar – RPS List I	Base Reflectivity	Identify echoes > 20 dBZ Track and time precip. Areas
	Base Velocity	Identify overrunning “S” pattern.
	Reflectivity Cross Section	Identify the bright band
	Echo tops (ET)	Determine top of cloud deck

The example shows that hourly LAWCs should be used to identify and track precipitation as part of the forecast/metwatch process. It also shows that the MB satellite curve can be especially useful in showing cloud top temperatures, development, and movement. Furthermore, the example indicates a designated WSR–88D RPS list that should be used to help identify features within the regime.

Assisting in the regime forecast process

It is important to understand that your unit’s regime forecasting programs is never fully developed. The program is ongoing and everyone in the weather unit should take part in maintaining and improving it. If your unit’s regime information is not well organized, you may be able to help by organizing existing documentation into a coherent regime plan. Even if your unit’s RAFP is excellent, you may still help by continually looking for new methods or approaches to add to the program. Examples of improving the regime forecast process are documenting information from forecasting reviews or case studies and disseminating regime information to unit personnel through training seminars.

The RAFP guides an AFW unit's analysis program. By continually improving the program, you ensure that your unit's product analysis is integrated into a time efficient forecast process. In the next lesson, you will see how the RAFP and forecast worksheets play a vital role in the forecast process.

023. Integrate product analysis into a time efficient forecast process (such as forecast worksheets)

The forecast worksheet is a tool that helps forecasters integrate their product analysis into a time efficient forecast process. In this lesson, we explore concepts that are true to most RAFPs and forecast worksheets. Information presented to you ranges from just general concepts about forecast worksheets to using the forecast worksheet itself. Let's begin by looking at some background information on forecast worksheets.

Background information

Combining the analysis techniques specified in your unit's RAFP with a standardized forecast worksheet ensures a time efficient forecast process. Although worksheet blocks are filled out according to RAFP guidance, completing a forecast worksheet is one of the truly creative efforts remaining in the weather career field. Forecasters must weigh and relate centralized and local forecast products to formulate their forecast through the use of deductive reasoning. A worksheet assists apprentice, journeyman, and craftsman forecasters in developing sound judgment by ensuring all information at their disposal is sensibly collected and analyzed. Basically, forecast worksheets lead forecasters through a logical thought process to produce an accurate forecast.

Producing an accurate forecast is challenging for numerous reasons. First, the atmosphere is continually in motion at all scales from macro to micro. Second, forecasts cover a continuous time frame valid for 24 hours for DOD stations, but forecast charts normally provide data in 6- and 12-hour increments. Finally, forecasters must determine if centralized data is reliable. If not accurate, adjustments must be made to the models. However, whether or not the models are correct, forecasters always have to fill in the gap between product valid times. The forecast worksheet is the tool that will assist you in this challenging process.

Forecasters usually have to sort out large amounts of raw data. The goal is to compile this wealth of information using a format to ensure the best possible forecast is produced. This task is not simple. It's nearly impossible for anyone, even experienced forecasters, to keep track of this data. The way to approach this problem is to systematically organize information into an easy to use worksheet. Forecasters can then see at a glance, and begin to understand, the critical synoptic and mesoscale features affecting their forecast region.

There are several key benefits to using a forecast worksheet. The following information summarizes some of those benefits.

Critical factors are not overlooked

Most members of the Air Force are familiar with the checklist procedures followed by pilots for takeoff and landing, regardless of whether they have flown a particular aircraft for more than 20 years. Such a routine assures the pilot does not overlook critical flight safety steps.

The same concept applies to producing a forecast. If factors critical to the forecast are overlooked, then the likelihood of producing an accurate forecast is low. The conscientious use of a worksheet helps ensure significant factors affecting the forecast are not inadvertently missed.

Efficient use of time

Another worksheet advantage is that it allows forecasters to do much of the analysis work during slack times, yet still have the information on paper when it comes time to convert generalized forecast thoughts into specific values and times.

On hectic “bad” weather days, forecasters cannot postpone looking at all the data needed to make a forecast to the last minute. Instead, they must stagger their analysis requirements over the time period between the last forecast and the next one. Forecasters use the worksheet to document analysis results as time progresses, therefore, making the best use of their time.

Continuity

Worksheets provide continuity. If previous worksheets are kept nearby, the present forecaster has a quick reference to those factors affecting the forecast, plus a record of the reasoning and judgment made by the previous forecaster.

Standardized and systematic approach

Worksheets provide a standardized and systematic approach to forecast preparation. Most of us will agree that an organized attack on a problem is better than a helter-skelter approach. A worksheet can embody in an abbreviated form most of the important parameters described in a location’s TFRN and RAFP.

Seasonal application and design

Many weather units use seasonal worksheets. Depending on the forecast station’s geographical location, seasonal worksheets may be applicable. Because weather patterns that produce major forecast problems are often seasonal in occurrence. Another approach often used is to use a generic worksheet supplemented by “regime” specific forms. Remember that a regime is defined as a synoptic and/or mesoscale weather pattern that affects a location. Not all regimes will have a supplemental worksheet.

Most weather locations have two or three regimes that are associated with significant forecast problems such as thunderstorms, fog and stratus, or nonconvective winds. These regime worksheets usually concentrate on asking specific questions that guide the forecaster in recognizing and correctly forecasting the weather associated with that weather pattern.

Your unit will attempt to maximize all the benefits outlined in this lesson by implementing forecast worksheets tailored to their operation, forecast requirements, and weather patterns. Obviously, it is impossible to design a forecast worksheet that can be used for every weather station. However, there are many elements common to a sound worksheet.

Forecast worksheet characteristics

To be effective, a worksheet must address the following elements.

Purpose

Each entry on the worksheet should have a specific purpose on the preparation of your forecast. If it isn’t applicable, it shouldn’t be on the worksheet. A good worksheet is designed around the local forecast problems most often encountered instead around products most routinely used.

Simplicity

A good worksheet is not so detailed that the user gets more involved completing the form than in putting it to practical use. Your RAFP contains a section providing instructions on how to fill out each block on the worksheet, plus how to interpret and use the data effectively. Forecasters must be able to not only complete all entries in minimum time, but also be able to observe and quickly assimilate the information.

Content

A good worksheet follows the forecast “funnel” thought process of looking at macroscale features down to local features. Suggested times spent on interrogating different atmospheric scales are 10 percent macroscale, 30 percent synoptic, and 60 percent mesoscale and local.

Using the forecast worksheet

From your reading thus far, it should be easily apparent how a properly designed forecast worksheet assists you in the forecast process. As you perform different analyses, you enter pertinent information about your analyses onto the forecast worksheet. Most forecasters accomplish this in a staggered process following each individual analysis. Then after the worksheet is complete, the forecaster examines all of the entries and develops their forecast reasoning.

As you go through this part of the lesson it's important for you to remember that this information is generic. Every weather unit you go to, from your first to your last, uses a different form or method to document their analysis and forecast reasoning. For some, it's almost identical to what is portrayed in this lesson. While for others, it's a completely different process. For instance, with the advent of technology some units have gone to using an electronic worksheet that is filled out using the computer. On-the-job training bridges the gap between the generic procedures outlined in this lesson and the specific procedures at your local unit. However, one theme remains constant—*you must integrate your analysis into the forecast process*.

Let's begin the analysis to forecast process by looking at the first entry on most forecast worksheets—the hemispheric analysis.

Hemispheric analysis

Since you are applying the forecast funnel, the first part of most forecast worksheets is documenting the hemispheric or macroscale analysis. Information on the zonal index, longwave amplitude change, and longwave movement is critical to your forecast. By having this information documented, you can quickly apply it to the forecast process.

The illustration below is an example block from a forecast worksheet for entering the hemispheric analysis. Notice in the example, the worksheet provides the choices for the forecaster; therefore, minimizing the amount of time it takes to enter the information and standardizing the choices.

The entries made by the forecaster in the illustration are in bold and underlined. Notice that the zonal index is high, the longwave trough is west and filling, the longwave ridge is east and weakening, and movement is east at 2 knots. As the forecaster goes through the forecast process, this information can be quickly integrated into the forecast process. In the scenario depicted here, the high zonal index should cause systems to move quickly west to east. Plus, with the longwave trough filling and the ridge weakening, rapid system intensification is unlikely.

Hemispheric Analysis
Zonal Index: **HIGH** LOW
LW Trough: **WEST** - OVHD - EAST Amplitude Change: **⇑** - ⇓ - NC
LW Ridge: WEST - OVHD - **EAST** Amplitude Change: ⇑ - **⇓** - NC
Longwave MVMNT: **East @ 2 knots**

Meteorological satellite (MetSAT) analysis

MetSAT analysis is a critical part of any forecast process. In fact, some forecasters would argue that satellite imagery is the most important forecasting tool. Whether or not it's the most important forecast tool, MetSAT imagery provides a wealth of diverse information.

MetSAT information is applicable to all meteorological scales—macro, synoptic, and meso—and it's important to consider all three scales when making comments on the forecast worksheet. You can use the forecast funnel approach to documenting your MetSAT analysis. Your entries on the worksheet can start with the large scale (macro) then focus downward through the smaller scales (synoptic to meso). The MetSAT block on the forecast worksheet is a free text block. You make handwritten entries describing significant satellite features that will affect your area of forecast responsibility.

If you made a list of all the different MetSAT features that could affect your region, the list would be enormous. With such a high degree of complexity and diversity, it's difficult for any one person to remember all the features to monitor. Depending on the weather regime, the RAFP has guidance on certain satellite features to monitor. However, as your knowledge of satellite features and experience level increases, so will your ability to apply the information

In general, you should make comments about your MetSAT analysis for the following features:

1. Significant cloud and non-cloud features (convection, MCC, transverse banding, etc.).
2. Upper level circulation (jet stream, vortices, split flow, etc.).
3. Weather system analysis (baroclinic leaf, fronts, etc.).
4. Local circulation (land/water interface, cloud street orientation).

The illustration below is an example of the MetSAT analysis block from a forecast worksheet for Keesler AFB, MS. The comments documented by the forecaster include most of the information considered important, such as cloud features, jet stream, and weather system analysis. The only thing missing from the four suggestions above are comments about local circulation; however, the advancing cirrus made that analysis impossible.

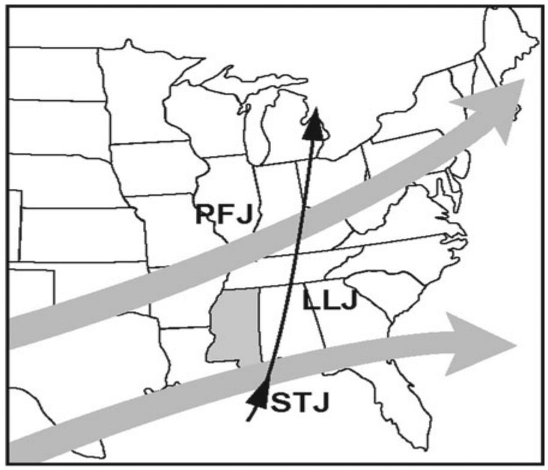
METSAT ANALYSIS
15/12Z – BAROCLINIC ZONE CI INDICATES POLAR FRONT JET IS DIGGING SOUTH OVER WEST TX, THEN RECURVES NORTH OVER LA. UPPER LEVEL LOW IN CENTRAL TX. DEVELOPING BAROCLINIC LEAF AHEAD OF LONG WAVE TROUGH IN WEST GULF MOVING NORTHEAST AT 10 KTS. OVRSHOOTING CB TOPS ABOVE CI CANOPY IN SOUTHERN LA. CI CLOUDS ADVANCE INTO MS.

Synoptic analysis

As stated earlier in this volume, synoptic systems vary in size from 500 to 1,000 nm and have a life cycle of tens of hours to several days. They must be carefully examined during the forecast process because they have the greatest influence on a location's weather. These systems influence advection, vertical motions, and other dynamics that must be carefully evaluated to assess the impact on your forecast. You have already performed your synoptic analysis, so now it's time to extract important information relative to your forecast. This process follows two steps: identification and interrogation.

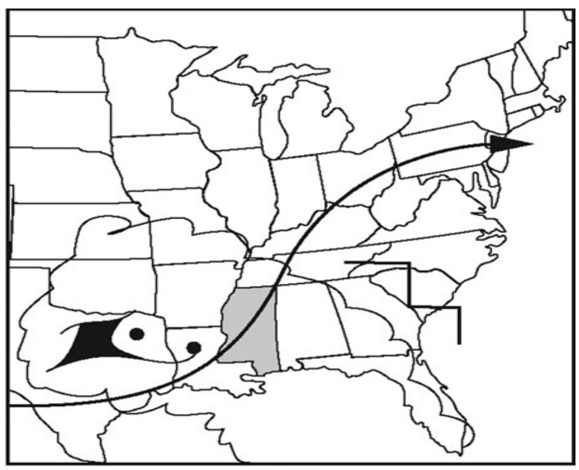
Identification

In the identification process, you are identifying the synoptic features that influence the weather in your forecast area. These features may be migratory cyclones, anticyclones, and air masses; frontal systems; and tropical cyclones. A lot of forecast worksheets use inset maps for you to draw key features from your synoptic analysis. Figures 2–4, 2–5, and 2–6 are examples of using a graphical presentation of your synoptic analysis on the worksheet. It's best to use standard weather symbols and colors when drawing the features.



Jet Locations
(LLJ–PFJ–STJ)

Figure 2–4. Jet Locations.



500mb

Figure 2–5. 500 MB.

SURFACE AND NEPHANALYSIS

Figure 2–6. Surface and Nephanalysis.

Interrogation

Interrogation of the synoptic pattern includes determining how advection, vertical motions, and other dynamics are affected by the pattern. This information should be apparent on your analysis and it's just a matter of summarizing it on the forecast worksheet. The method of entry on the worksheet can take many forms. On some worksheets, entry may be in the form of a free text box in which you enter handwritten or typed comments. On other worksheets, entry may be in the form of circling or checking pre-selected choices. The table below is an example of a worksheet block with pre-selected choices.

Synoptic Pattern			
Level	***Moisture Advection***	***Temperature Advection***	Vorticity **PVA** Neu NVA
500	**M** - N – D	W - N - **C**	Thickness **Warm** Neu Cold
700	**M** - N – D	W - N - **C**	Significant Confluence - **Difluence** Level(s): **500, 700**
850	M - **N** – D	W - **N** - C	
SFC	M - N – **D**	W - **N** - C	

The entries above are depicted as bold and underlined. Notice the forecaster has indicated moist air advection at 500 MB and 700 MB, neutral air advection at 850 MB, and dry air advection on the surface. In the next column over, labeled temperature advection, the forecaster has indicated cold air advection at 500 MB and 700 MB, and neutral temperature advection at 850 MB and the surface. In the last column, the forecaster has indicated positive vorticity advection (PVA), warm air advection on the thickness chart, and difluence at 500 MB and 700MB.

This detailed analysis and documentation of synoptic analysis is important to the forecaster's thought process when developing the forecast. The forecaster has to consider the impact of moist air advection in middle and upper levels on cloud development. The impact of cold air advection on destabilization has to be assessed. In addition, how the combined effects of PVA, WAA, and difluence will influence the weather will be a challenging question for the forecaster to answer.

Vertical analysis (Skew-T)

Vertical analysis of upper-air soundings is an integral part of the forecast process. Information on stability, clouds, turbulence, and icing is essential to formulating your forecast. Below is an example of a worksheet entry for Skew-T. In the example, both the observed and forecasted parameters from the Skew-T are entered in the blocks.

The upper air sounding analyzed by the forecaster was for KLIX, which is the station identification for Slidell, LA. There are numerous factors on both the observed and forecasted Skew-T that are significant to the forecast. For instance, the observed sounding at 1200 UTC has a radiation inversion from the surface to 1,800 feet, an inversion break temperature of 17° C, light turbulence from 3,000 feet to 8,000 feet, and altocumulus and cirrus clouds. Equally important on the forecasted Skew-T for 0000 UTC is the decrease in stability and the increase in the positive energy area as indicated by the lowering of the convective condensation level (CCL) and the raising of the equilibrium level (EL).

Skew-T Analysis						
Sounding: **KLIX** KJAN	OBSVD: **1200** UTC			FCST: **0000** UTC		
Stability: **Conditionally stable**	SSI: **–1**	TT: **42**	LI: **0**	SSI: **–2**	TT: **44**	LI: **–1**
T_1 Gust: **48 knots**	SWT: **134**	KI: **19**	T_C: **22 C**	SWT: **212**	KI: **21**	T_C: **20**
Height of –20° C: **240**	LCL: **042**	CCL: **046**	WBZ: **158**	LCL: **036**	CCL: **042**	WBZ: **136**
1000–500MB ΔZ: **5750**	EL: **165**	CAPE: **12**	BRN: **8**	EL: **210**	CAPE: **86**	BRN: **18**

Inversion: None - **Rad** - Sub – Frontal	Levels: **SFC–018**
Inversion Break Temp: **17 C**	Gradient Level Winds: **250/25KT**
Icing: **None** - Rime - Clear – Mixed	Levels:
Turbc: None - **Lgt** - Mod - Svr – Xtrm	Levels: **030–080**
Cloud levels indicated: **AC/080SCT120 CI/240BKN290**	

Radar analysis

It's extremely important to include radar analysis as one of the entries on the forecast worksheet. It plays a vital role in your forecast reasoning. Analysis provides insight on precipitation type, coverage, and movement. The WSR–88D provides a large number of important products that the forecaster must evaluate depending on the weather scenario. The RAFP also provides some assistance in this matter. Based on the weather regime, the RAFP lists products that the forecaster must evaluate. The RAFP also suggests alert thresholds and routine product set (RPS) lists useful in the weather regime. In addition, the amazing thing about Doppler radar is it can still be used in clear air mode when there are no precipitation echoes.

Since the atmosphere is constantly in motion, so are the images on the radar screen. It wouldn't be prudent to enter information about the radar six hours prior to writing your forecast. It's best to make your radar observation near to the actual forecast transmission time.

The radar analysis block on a forecast worksheet is a free text block. In your own words, enter a description of the radar analysis. The example below is an entry for radar analysis. Here the forecaster has documented comments about all three of the WSR–88D's base products, plus some information from the echo tops product. The base reflectivity product indicated an area of rain located north of Hattiesburg, Mississippi moving southeast at 10 knots. The echo tops product indicated uniform echo tops at 18,000 feet. Base velocity showed southwesterly winds in the low-level veering to northeasterly in the upper-level and there was a maximum wind band of 30 knots at 3,000 feet. Finally, the spectrum widths are low indicating no embedded convection.

Radar Analysis
BASE REFLECTIVITY SHOWS AN AREA OF RAIN NORTH OF HATTIESBURG MS MOVING SOUTHEAST AT 10 KNOTS. ECHO TOPS SHOWS UNIFORM TOPS AT 180. BASE VELOCITY INDICATES SOUTHWEST LOW LEVEL WINDS VEERING TO THE WEST IN UPPER LEVELS. MAX WIND BAND OF 30 KTS AT 3,000. FEET. SPECTRUM WIDTHS ARE LOW. NO SIGN OF EMBEDDED CONVECTION.

Model verification, initialization, and verification (VIV)

The number of meteorological models available to forecasters has increased dramatically over the last 10 years. When a new model is introduced it takes meteorologists and scientists years to determine the model's strengths and weaknesses. They have to take into account a near infinite number of variables, such as terrain, latitude, diabatics, adiabatics, evaporation, condensation, etc. From their research they're able to continually make improvements to the model's algorithms; however, to date, no model has been improved to the point where it can be used blindly. Forecasters are required to analyze the accuracy of the models they're using and document their findings on the forecast worksheet. The most widely used method to analyze models is the VIV process.

Verification

The first step in the VIV process is to verify the previous 12-hr forecast positions against the current 00-hr forecast positions for the same time. This verification helps evaluate consistency of the model solutions from one run to the next. If the model is handling systems well, then there should be little difference between positions. However, if the model is not performing well, then adjustments must be applied to the 00-hr and future forecast positions. Document how the models verified on the forecast worksheet.

Initialization

The next step in the VIV process, initialization, deals only with the 00-hr forecast. Physically compare the 00-hr forecast positions with your analysis (MetSAT, other real-time data) from the same time to see how the 00-hr forecast is doing. If the model's initial placement agrees with the real-time data, then no adjustments are needed. Otherwise if the initial place disagrees, then make adjustments to the 00-hr and subsequent forecasts. Document your findings on the forecast worksheet to use later in your forecast reasoning.

Verification

The final step in the VIV process is to verify the current 12-hr model forecast with real-time data for the same time (MetSAT, surface analysis) to determine how well the model is performing. If the model is performing well, then no adjustments are needed. If the model is performing poorly, then you must make adjustments to the 12-hr chart and future forecast charts. Document the results of your second verification of the forecast worksheet.

The illustration below is an example of a worksheet entry for the VIV process. The first two entries provide information on the models used and the database time. The models used by the forecaster were the weather research and forecast model (WRF), the North American mesoscale model (NAM), and the Global Forecast System (GFS). The database time was 1200 universal time change (UTC).

Model Verification/Initialization/Verification
1. Name which models were used: 1st model: ___**WRF**____ 2nd model: ___**NAM**___ 3rd model: ___**GFS**___
2. Database time: __**1200Z**_____
3. Model discussion bulletins: FXUS10 INDICATES GFS A BIT SLOWER, WRF MODEL MOVING TOO FAST, NAM HAD BEST HANDLE OVERALL
4. Verification: [WRF] OVER FORECASTING UPPER LEVEL MOISTURE, SEA LEVEL PRESSURE FORECASTED TOO LOW [NAM] MOVING FORWARD EDGE OF MOISTURE TOO FAST INTO LA, BETTER HANDLE THAN GFS ON MOVMENT OF MINOR SHORT WAVES [GFS] PREVIOUS RUN MOVED VORT MIN TOO SLOW OVER AL, LOW IN TX DEEPENING MORE AND MOVING SLOWER THAN PROGGED ON THICKNESS
5. Initialization: [WRF] LI –1 COMPARED TO –2 ON SKEW-T, MID LEVEL WINDS TOO STRONG [NAM] LOW IN TX TOO FAR NORTH COMPARED TO WATER VAPOR SHOT [GFS] VORT MAX IN NORTHERN TX ADJUSTED 1 DEG NORTH
6. Verification: [WRF] COMPARED 12Z SKEWT TO 12 HR FCST SFC–050 WINDS DID NOT VEER AS FORECASTED [NAM] LOW IN TX IS DEEPENING FASTER ADJUSTED 2MB LWR, MOISTURE STILL PROGGED TO FAR EAST ADJUSTED EDGE OF 70% RH BACK TO WESTERN LA [GFS] ADJUSTED MOVEMENT OF VORT MAX IN LA BACK TO EAST TX

The third entry, model discussion bulletins, the forecaster summarized the FXUS10 bulletin. It indicated the GFS was moving features too slow, the WRF was moving them too fast, and the NAM model had the best handle on the situation overall.

The fourth entry, verification, the forecaster compared all three models with the previous 12-hr forecast. The 12-hr forecast of the WRF was over forecasting the amount moisture in the upper levels and sea level pressure was too low. The NAM model was moving the forward edge of moisture into Louisiana too fast on the 12-hr.

However, the NAM model had a better handle on the movement of minor short wave troughs as compared to the GFS. On the previous run, the GFS moved the vorticity minima too slow over Alabama. Also, the GFS was not deepening the low enough in Texas and had it moving too fast.

The fifth entry, initialization, the forecaster compared real-time weather data with the 00-hr model forecast. As stated previously, initialization is the act of comparing the placement of meteorological features on model products to their actual position on real-time data. Then documenting this comparison on the forecast worksheet. Referring to the example above, the WRF was off by one on the lifted index and the mid-level winds were too strong compared to the Skew-T. The NAM model had the low in Texas too far north compare to the water vapor shot. On the GFS vorticity chart, the vorticity maxima in northern Texas had to be adjusted one degree of latitude north.

The sixth and final entry, verification, the forecaster compared the 12-hour forecast on the current model with real-time weather data that was valid for the same time. When the WRF was compared to the Skew-T, it was observed that the WRF was forecasting winds to veer more than they actually were. The NAM model was not deepening the low enough and had to be adjusted two millibars lower. On the GFS, the vorticity maxima in Louisiana had to be adjusted west, back into eastern Texas.

Model output

Following the VIV block on the worksheet there is generally a block for you to enter model output data. Your unit may use one particular model or a combination of several. The table below is an example block to enter data from the WRF. The entries made by the forecaster are bold and underlined. The entries are fairly simple; just read the product and enter the data on the worksheet in numeric form. After entering the model output data, the forecaster can quickly assess the model's atmospheric projection. In the table it's rather easy to determine the model is forecasting warm air advection, falling surface pressure, decreasing stability, incoming clouds, and backing surface winds.

WRF Model Output								
Valid time:	6-Hour		12-Hour		18-Hour		24-Hour	
Thickness	**5720**		**5730**		**5740**		**5740**	
Sea Level Pressure	**1012**		**1011**		**1009**		**1008**	
	3-Hour	6-Hour	3-Hour	6-Hour	3-Hour	6-Hour	3-Hour	6-Hour
Lifted Index	**0**	**+1**	**+1**	**0**	**–1**	**–1**	**–2**	**–2**
Precip	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Clouds	-	-	-	-	-	**030–120**	**025–140**	**025–160**
SFC Winds	**3510**		**0210**		**0315**		**0315**	
Temperature	**77**		**78**		**81**		**83**	
Dew Point	**70**		**71**		**73**		**74**	

VIV and ensembles

Conducting VIV is necessary when utilizing model data, but it can also be an inexact and time consuming process. The time requirements and task complexity are compounded when VIV is performed for multiple models; often in an effort to determine a "model of choice" or the "best" model for a given time or situation. Fortunately, recent advancements in computing power and computer affordability have begun to provide an alternative to VIV overload—ensemble prediction systems.

Benefits of ensembles

For an ensemble prediction system, most steps of the VIV process are inherent to the ensemble and automated, while others are rendered superfluous or unnecessary. These efficiencies are made possible by the stochastic information (distributed possibilities) produced by the ensemble. Whereas a single deterministic model will have one 00-hr analysis and one solution for a given time, an ensemble composed of multiple model runs will have a set of 00-hr conditions (slightly different but plausible) and a range of possible solutions for a given time. Assuming each run (or "member") of the ensemble is equally likely to be correct and that reality should be contained within an adequately large number of members, the forecaster's focus can shift from determining which model is right to which ensemble solutions are possible and which are probable.

Accounting for uncertainty

Given the range of previous solutions from an ensemble, consistency of a single member (first "V" in VIV) is less important than checking an ensemble's 00-hr mean or median solution is encompassed by its previous forecast bounds (min/max). Either can be subjectively assessed or precisely calculated from ensemble output.

Additionally, a well-constructed ensemble's set of initial conditions at 00-hr should include at least one solution close to reality, thereby providing initialization ("I" in VIV). Likewise, verification of an ensemble forecast (last "V" in VIV) is inherent in the range of possible outcomes. Recognizing the difficulty in determining the true state of the atmosphere (given observing and analysis errors), the stochastic information provided by an ensemble accounts for uncertainty and provides objective, quantified probabilities helpful to ORM or to measure forecast confidence.

Climatology

Climatology is considered in the formulation of any forecast. As stated earlier in this volume, the WSSC table is a climatology product that must be reviewed before issuing a forecast. The forecast worksheet will have a place for you to enter ceiling and visibility data from the tables. In addition, some worksheets have other pertinent climatological information for you to enter. The table below is an example of an entry for climatological information on a forecast worksheet. Entries made by the forecaster are in bold and underlined.

In the example below, the average high temperature is 87°F and the average low temperature is 68°F. The extreme high temperature for the month was 98°F and the extreme monthly minimum was 49°F. In regards to the WSSC tables, the wind sector used was between 090° and 159°.

The table also lists the ceiling and visibility values for each time frame using the highest percentages from WSSC based on the current observation.

Climatology													
Average High: **87 F**			Extreme High: **98 F**			Average Low: **68 F**		Extreme Low: **49 F**					
Wind Stratified Conditional Climatology Wind Sector: 090 –159													
	1	2	3	4	5	6	7	8	9	12	15	18	24
CIG	**100**	**100**	**100**	**030**	**030**	**015**	**007**	**007**	**100**	**100**	**UNL**	**UNL**	**UNL**
VIS	**UNL**	**UNL**	**UNL**	**3**	**3**	**2**	**1.5**	**1.5**	**UNL**	**UNL**	**UNL**	**UNL**	**UNL**

Climatology is usually the last entry on a forecast worksheet before beginning to write the reasoning for your forecast. Forecasting reasoning is a documentation of your thought process to reach your forecasting conclusions. It is the grand finale to the forecast worksheet. Essentially, it is the final step to integrating your analysis into the forecast process.

Forecast reasoning

The forecast reasoning section of the forecast worksheet is divided into blocks for you to enter information about each of the different weather elements in the forecast. For example, there is an entry block for clouds, winds, pressure, and so forth. Most worksheets are designed for you to enter information about your forecast reasoning in a free text form. The table below is an example of an entry for forecast reasoning.

By breaking up this section into the weather elements, you are required to evaluate each element separately and provide justification for your forecast. If you spent adequate time researching the element and the meteorological data relevant to that element, you will experience no problem entering information about your forecast. In fact, you will probably run out of room. On the other hand, if you really didn't give a weather element much consideration, it will be difficult to write down any worth-while justification. Historically, this is a part of the forecast worksheet that often got pencil-whipped. However, forecasters are just hurting themselves when they don't take full advantage of the worksheet. If you can't give a good reason why you forecasted something the way you did, then what are the odds of it actually happening? The answer is low. In fact, the odds are higher that you will have to make an amendment to your forecast. So please, use the worksheet wisely.

<table>
<tr><th colspan="2">Forecast Reasoning</th></tr>
<tr><td colspan="2">Current synoptic situation: LOW IN NORTHERN LOUSIANA MOVING NORTHEAST, COLD FRONT EXTENDS SOUTHEST ALONG GULF COAST OF TEXAS, WARM FRONT EXTENDS EAST ACROSS MISSISSIPPI AND ALABAMA. LOW LEVEL JET OVERRUNNING WARM FRONT NORTH OF JACKSON. KEESLER LOCATED IN THE WARM SECTOR. WEST GULF LOW WEATHER REGIME.</td></tr>
<tr><td>Clouds: SCT AC AND CI ON OBSERVATION. CONVECTION NORTH OF WARM FRONT INDICATES WARM SECTOR AIR IS UNSTABLE. EXPECT CU TO FORM ABOUT 15Z ACCORDING TO CONVECTIVE TEMPERATURE AND MODCURVE TEMPERATURE TABLES. ISOLATED CB ACTIVITY IN AFTERNOON WITH MAX HEATING AND UPPER LEVEL SHORTWAVE.</td><td>Visibility/Weather: CURRENT RADIATION FOG WITH SCT CLOUD COVER THAT WILL PROVIDE MINIMAL SHELTER FROM SUN. EXPECT BURN OFF TO BE IN LINE WITH WSSC TABLES. THIS AFTERNOON DECREASING STABILITY IN WARM SECTOR AND UPPER LEVEL SHORTWAVE WITH LOW LEVEL JET EXPECT ISOLATED TSTMS FROM 19Z TO 23Z</td></tr>
<tr><td>Wind: LIGHT AND VARIABLE WINDS UNTIL BREAK INVERSION ABOUT 14Z THEN WINDS START SOUTHWEST ABOUT 10 KNOTS PICK UP IN AFTERNOON WITH MAX HEATING TO 12 GUSTING TO 18 KNOTS BASED ON PRESSURE GRADIENT, 80% WINDS SFC–050, AND WRF.</td><td>Pressure: BASED ON MOVEMENT OF SURFACE LOW AND DIURNALS THE PRESSURE WILL DROP ABOUT.40 MB DURING DAY. DURING THE NIGHT DIURNALS WILL OFFSET TO ABOUT.20 MB DECREASE</td></tr>
<tr><td>Temperature: MAX 88F MIN 72F
Δ T between Gulf and Land: 15 F</td><td>Thunderstorms: <u>Yes</u> No
ISOLATED TSTMS IN WARM SECTOR WITH MAX HEATING AND UPPER LEVEL SHORTWAVE. CAPE IS LOW, SWEAT IS LOW, LI AND SSI BOTH –2 WHICH POINTS TOWARD NON-SEVERE</td></tr>
<tr><td>Turbulence: <u>Yes</u> No
LIGHT SURFACE TO 5,000 FT WITH VERTICAL WIND SHEAR ON SKEW-T AND GUSTY SURFACE WINDS. LOW LEVEL JET NOT ENOUGH DIFFERENCE BETWEEN GRADIENT AND SURFACE WIND TO CONSTITUTE LOW LEVEL WIND SHEAR OUTSIDE OF TSTMS</td><td>Icing: Yes <u>No</u></td></tr>
<tr><td>Seabreeze? Y or <u>N</u> Time frame:
Landbreeze? Y or <u>N</u> Time frame:</td><td>Other Hazards: NONE</td></tr>
</table>

Remember it was stated earlier in this lesson that forecast worksheets differ from location to location. It's impossible to develop a worksheet that is useable at all locations. However, you can apply this information in a generic sense to all forecast worksheets. The bottom line is forecast worksheets help you integrate your analysis into a time efficient forecast process.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

019. Classification of weather systems

1. Describe a macroscale system.

2. Describe a synoptic system.

3. Describe a mesoscale system.

4. List five examples of synoptic systems.

5. List four examples of mesoscale systems.

020. The weather regime

1. What is a weather regime?

2. Which AFWA computer program is useful for obtaining information on weather regimes? List the overseas versions of the program.

3. What regime information is available via MetTIPs?

021. Forecast funnel

1. Explain the forecast funnel.

2. How do macroscale systems influence synoptic systems?

3. What affect does the zonal index have on surface systems?

4. Describe the affect that long wave trough and ridge amplitude has on synoptic systems.

5. Name three different types of analysis used to identify the long wave pattern.

6. What must a forecaster do if analyzed weather features represent a mixture of two or more different synoptic weather regimes?

7. What are some standard products to use for mesoscale analysis?

022. Regime forecast tools

1. List at least four examples of regime forecasting tools.

2. Name ways you can assist a unit's regime forecasting program.

023 Integrate product analysis into time efficient forecast process (such as forecast worksheets)

1. Describe three challenges to producing an accurate forecast.

2. Explain how forecast worksheets assist forecasters in efficiently using their time?

3. List three characteristics of an effective forecast worksheet and describe each one.

4. Why is it impossible for AF Weather to use an identical forecast worksheet at all locations?

5. What is the first meteorological entry on most forecast worksheets? Why?

6. Name some significant features on METSAT that should be documented on the forecast worksheet.

7. Describe the two steps for extracting information about the synoptic analysis to document on the forecast worksheet.

8. When is the best time to document a description of your radar analysis?

9. Describe the VIV process.

10. Identify the climatological product that must be reviewed before issuing a forecast.

11. What part of the forecast worksheet is used to enter the justification for your forecast?

2–2. Synoptic Weather Regimes

US Air Force weather personnel are stationed around the world. US military aircraft are constantly in global transit. This combination requires that weather journeymen have a general knowledge of the types of weather and climate encountered during various seasons in regions all around the world. This knowledge also increases insight into atmospheric circulation, weather development and movement, weather effects on the environment, and credibility as a knowledgeable analyst, interpreter, and briefer.

To this point, we have discussed climate and climatic controls in general terms. To relate this knowledge more directly with forecasting, you need to understand the relationship between climate and daily meteorological occurrences. The following section is intended to give you a very general climatological understanding of the world. It is not intended to be a specific guide for climatology. If you require specific information on climatology for a region, obtain or request the information from the sources, services, and data presented in unit 2. While reading the next sections we advise you to use an atlas, such as *Goode's World Atlas*, as a reference to further assist you in understanding the information presented.

We begin by discussing the contiguous United States (the lower 48 states) and Hawaii. Due to their proximity, we discuss Canada and Alaska together. We finish by briefly discussing other prominent countries of the world. For obvious reasons, the United States' discussion is generally in more detail than other countries. The remaining discussions are divided into topography, water bodies, and climatic regions. As we stated previously, these discussions are only intended to give you a general understanding of the climates of the world.

024. The United States

The weather in the United States, with minor exceptions, is typical of all weather types within the temperate regions of the North American, European, and Asiatic continents. The general air circulation in the United States, as in the entire temperate zone of the Northern Hemisphere, is from the west to the east. All closed surface weather systems (highs and lows) tend to move with this west-to-east circulation.

Since this is the average circulation pattern and weather systems move with the general flow, the fronts associated with the migratory lows move southward if they are cold fronts and northward if they are warm fronts. Surface low-pressure centers, with their associated weather and frontal systems, are usually called cyclones. Knowledge of the normal circulation patterns makes it possible to forecast future frontal movement with a reasonable degree of accuracy.

Contiguous United States

Geographical and climatic conditions tend to make certain areas favorable for the development and formation of storm centers. In the United States, these areas are west Texas, Cape Hatteras, Colorado, and the northern portions of the Gulf of Mexico. Once a storm forms, it generally follows the same mean track as the previous storm that formed in that area. We call the average or mean paths storm tracks. Figure 2–7 shows the mean storm tracks for January.

These storms are outbreaks on the polar front or the generation or regeneration of a storm along the trailing edge of an old front. The low pressure along these fronts intensifies in certain areas as the front surges southward ahead of a moving mass of cold air from the polar regions. Much of the weather in the Temperate Zone is a direct result of the effect of these storms (especially in winter).

Added to the weather from these storms is air-mass weather. Air-mass weather is considered all weather other than the frontal weather in the temperate region. Air-mass weather is the net effect of local surface circulation, terrain, and the modifying effect of significant water bodies.

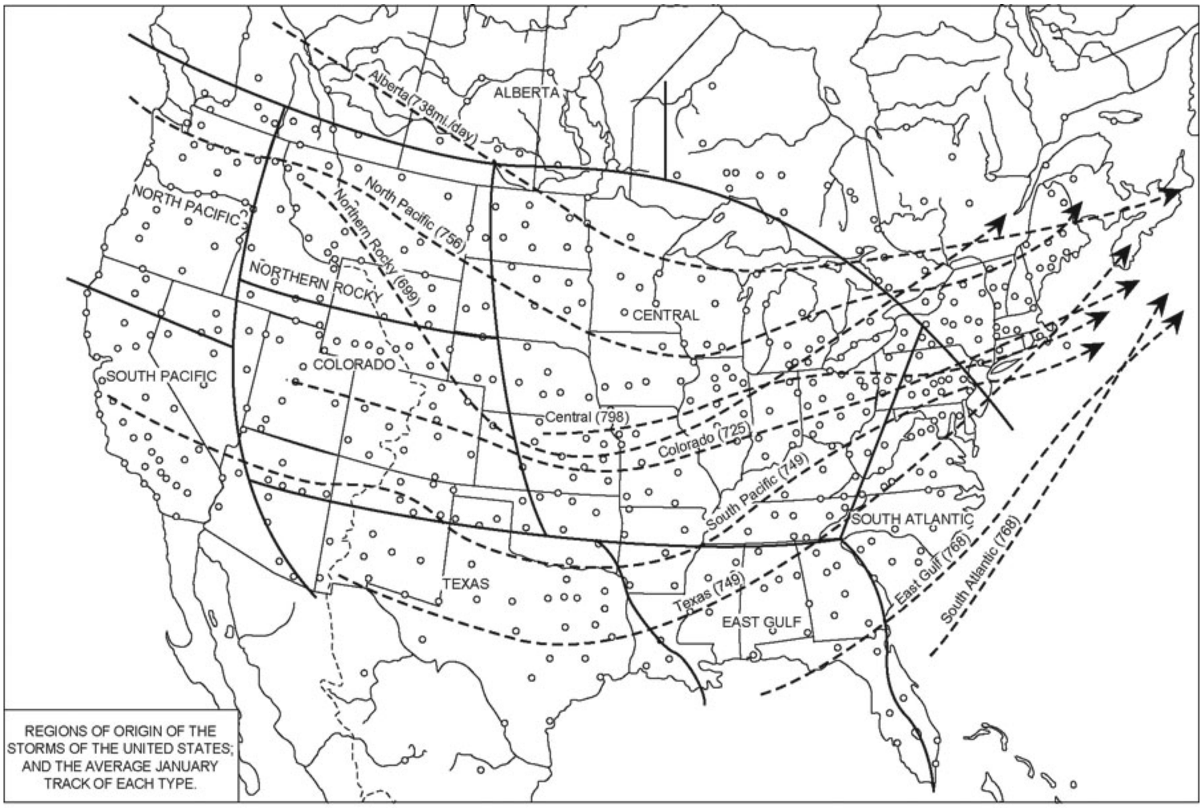


Figure 2–7. Mean January United States storm tracks.

US topographical features

The most prominent topographical features of the United States are the Rocky Mountains of the western US, the Cascades of the Pacific Northwest, the Sierra Nevada Mountains of the west coast and the Appalachian Mountains of the eastern US. The main peaks of the Rockies, Cascades and Sierra Nevada Mountains exceed 14,000 feet while the Appalachian Mountains peaks are generally below 7,000 feet. Regardless of the height of peaks, note that each mountain region plays a major role in the type of weather and climate produced in their respective areas.

US water bodies

The most obvious water bodies and moisture sources influencing the US are the Atlantic and Pacific Oceans along with the Gulf of Mexico. The Gulf of Mexico is especially important during the spring as it provides a moisture source (maritime tropical air) conducive to producing severe weather in the central plains region.

The Great Lakes, which include Huron, Ontario, Michigan, Erie, and Superior (HOMES), and The Great Salt Lake in Utah plays a significant part in producing, modifying, and intensifying the weather in those respective regions. The Mississippi and Missouri rivers, although not water bodies, should be considered as significant sources of moisture when forecasting in the vicinity of these tributaries.

Climatic regions of the US

Now that we have a general idea of where the topographical and moisture source regions of the US are, let's examine the general climatology of the US. There are many subdivisions of weather climatic regions in the United States. For this discussion, we divide the US into the regions shown in figure 2–8.

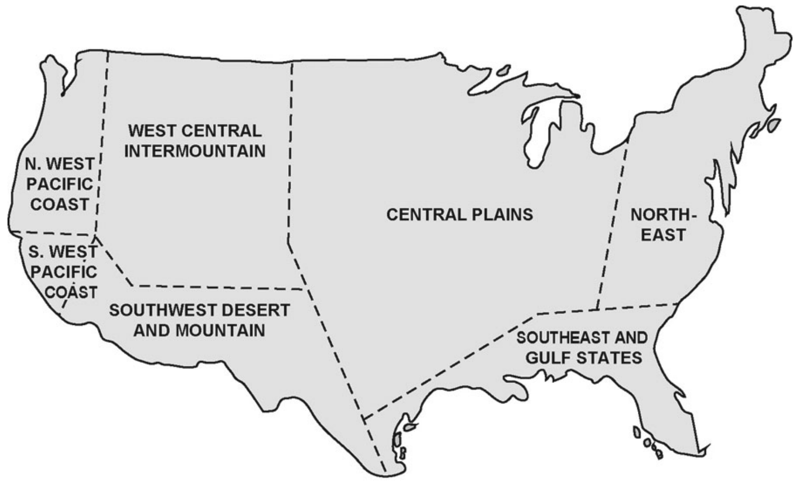


Figure 2–8. Contiguous United States climatic regions.

Northwest Pacific coast area

The northwest Pacific coast area has more precipitation than any other region in North America. Its weather is the result of frontal phenomena, consisting mainly of warm occlusions that move in over the coast from the Aleutian low region. The orographic lifting of these weather systems produces stratiform clouds and fog throughout the year in this region on the windward side of the mountains. However, rainfall is more common in winter than summer. Rainfall amounts decrease significantly on the lee of the mountains. Pacific moisture basically "dries out" through the process of adiabatic warming as the air descends on the lee side of the mountains.

We discuss this drying effect later in the west-central intermountain region section. Mean annual temperatures in this region are < 18°C (64°F).

Southwest Pacific coast area

This region experiences a Mediterranean-type climate, which is distinctively different from any other region of North America. This type of climate occurs in the Northern Hemisphere exclusively in the Mediterranean and Southern California. In the Southern Hemisphere, it occurs only over small areas of Chile, South Africa, and Southern Australia.

The Mediterranean climate is characterized by warm to hot summers, tempered by sea breezes, and by mild winters during which the temperatures rarely fall below freezing. Rainfall seldom occurs during the summer and mostly light to moderate rain occurs during the winter, but heavy rain is possible. This occurs because the flow is more directly from the ocean.

Cold fronts rarely penetrate the southwest Pacific coast region. The weather this region receives is primarily caused by moist Pacific air being forced up the coastal range slope. In summer, the air is more stable, resulting in stratus and fog. During winter, unstable air is forced over the mountain ranges, causing showery precipitation in the mountains.

West central intermountain area

This region is located east of the Cascade and Coastal Ranges, west of the Rocky Mountains, and north of the southwest desert area. The climate is generally cold and dry in winter, hot and dry in summer. Most of the region is semiarid. The western mountain range, which acts as a climatic barrier, has an extreme drying effect on the air in the westerly circulation.

In this region, maximum rainfall occurs in the spring because of the many weather systems moving through the area. In midwinter, a cold high is generally centered in this region, preventing storm systems from entering the region. Thus, annual precipitation is light.

Southwest desert and mountain area

This area includes lower California, parts of Southeast California, all of the southern half of Arizona and New Mexico, and west and southwest Texas. It is an area almost surrounded by high mountains and is either desert or very close to being classified as such. Annual rainfall seldom exceeds 5 inches. Although the northerly sections of this region experiences cold winters, the entire region experiences extremely hot summers.

The chief flying hazard is the predominance of summer and spring thunderstorms caused primarily by maritime tropical air penetrating into the area as the Bermuda high expands in the summer and forces the air aloft at the mountains. Consequently, nearly all significant mountain peaks and ranges have thunderstorms building over them in spring and summer. Although the thunderstorms are generally scattered, they are often severe. They are generally avoided by circumnavigation. Mean annual temperatures in this region are > 18°C (64°F).

Central Plains area

This area includes the continental climatic regions of the Great Plains, Mississippi Valley, and Appalachian Plateau between the Rocky Mountains to the west and the Appalachians to the east and the Gulf States on the south.

In the western section, the climate is rather dry, but moisture increases eastward. The main weather hazards are caused by wintertime outbreaks along the polar front and associated low-pressure center formation. Spring severe weather outbreaks are common in this region as the area from Texas to Iowa is often referred to as “Tornado Alley.” During the summer, air-mass thunderstorms are prevalent over the region. Hot summers with mild winters in the southern areas to cool or cold winters in the northern areas are generally associated with this region.

Both cold and warm frontal passages and their associated weather are common in this area. Thunderstorms are most intense if they develop in maritime tropical air.

Southeast and Gulf States area

This area includes all the states bordering on the Gulf of Mexico and South Carolina and Georgia. A phenomenon known as gulf stratus affects this area. The stagnation of southward moving cold fronts, rapidly moving squall lines, circulation thunderstorms, and the gulf stratus, occurring in various combinations, make this area an especially difficult area for forecasting weather.

You can expect cold frontal passages mostly in the late fall, winter, and early spring. Fronts may be weaker in other seasons, but frontal passage can still occur. In the winter, when the circulation near the surface is southerly, the warm moist gulf air is cooled from below to saturation. When this occurs, you can expect fog and stratus to form and persist for several days. The southerly circulation in summer causes warm moist air to be heated from below; convective thunderstorms are common. Since the air is generally quite moist and unstable, the storms are generally severe. Mean temperatures of the coldest months of winter are < 18°C (64°F) but > –3°C (27°F), whereas mean temperatures of the summer are > 22°C (72°F).

Northeastern area

This is an area of storm track convergence. Cyclonic storm activity is a normal occurrence during the winter. Moreover, this is an area in which these storms are intensified by heating and the addition of moisture over the Great Lakes. The lake effect is largely accountable for the great amounts of snowfall often found over this area in the winter. Generally good weather prevails in summer due to the dominating influence of the Bermuda high. The interior portion does have severe thunderstorm activity during the summer months, mainly associated with squall line activity. Mean temperatures of the coldest months of winter are ≤ –3°C (27°F). The mean temperatures annually are < 22° C (72°F).

025. Canada and Alaska

Another place we need to look is the northern areas of Canada and Alaska. These regions have their own individual characteristic topography and associated weather.

Topography

The western range of the Rocky Mountains is comprised of the British Columbia range and Alaskan range. Peaks in the British Columbia region exceed 18,000 feet while Mount McKinley in Alaska exceeds 20,000 feet. This mountainous terrain has an obvious effect in adiabatically modifying the weather in this region. While Alaska has a lot of mountainous terrain, the remainder of Canada is comprised of generally flat, low-lying terrain east of the Rockies.

Water bodies

The two major bodies of water that affect both Canada and Alaska are the Atlantic and Pacific Oceans. Other significant water bodies that affect Canada's weather are the Arctic Ocean, Baffin, Hudson, James, and Goose Bays, as well as Lake Winnipeg and the Great Bear and Great Slave Lakes. For example, Hudson Bay becomes a source region for deep polar air masses during the winter. Outside of the Pacific Ocean, Alaska's weather is also affected by the Bering and Arctic Ocean.

Climatic regions of Canada

Due to the massiveness of the country, Canada has a number of distinct climatic regions. For our purposes, we divide the country into four regions of east and west coastal regions and northern and southern Canada. The following paragraphs examine these regions.

East coast

The Atlantic Ocean modifies this region of Canada by protecting it from the harshness of winter that is experienced inland. Frequent changes of weather are the norm as the storm track for low-pressure systems is through this region. Therefore, clouds and precipitation (summer rains and winter snows) are prevalent throughout the year. The Atlantic Ocean modifies temperatures of this region by keeping winters warmer and summers cooler than the inland regions. Sea fog occurs quite often, especially during spring and summer as warm air moves over the cold waters of the Labrador Current.

Southern central Canada

This region consists of the provinces of Ontario, Manitoba, Saskatchewan, and Alberta. Winters in this region are long and harsh. Low temperatures here aren't much higher than the temperatures experienced further north towards the Arctic Circle. Winter snowfall is fairly light with strong winds being the norm. Summers are relatively warm with moderate rainfall. The increase of precipitation from winter to summer is primarily caused by the migration of the average storm track northward during the summer months. Cities in Alberta, such as Edmonton and Calgary, may experience warmer temperatures in the winter. This is caused by the air (which flows west to east) in that region being adiabatically warmed as it descends to the east side of the Rockies.

Northern central Canada

This region encompasses the majority of the country but is the least populated since very harsh winters prevail. Although average annual precipitation amounts are low, the very cold air and dangerous wind chill temperatures make this region quite hazardous in winter. Average daily high temperatures are –13°F in winter while summer daily highs average 47°F. The northern portion of this region is considered tundra and is covered with snow eight to nine months of the year. Snow and frost may occur during any month of the year when cold air advances from the north.

West coast

The west coast region of Canada experiences the warmest winters of any region of Canada. The Rocky Mountains act as a barrier to the very cold air masses that traverse the central and eastern portions of the country. The Pacific Ocean also acts as a modifying feature by keeping winters warmer and summers cooler than the mountain and central country region. Precipitation is an annual event associated with onshore flow with maximums occurring during the winter season. Coincidentally, clouds are also dominant throughout the year.

Climatic regions of Alaska

From a climatic standpoint, we can divide Alaska into the coastal and interior climatic regions. The coastal region experiences milder winters in comparison to the interior of the state. A warm ocean current modifies the temperatures along the southern coast significantly. Anchorage, a coastal city, averages daily high temperatures of 19°F in January, while Fairbanks, an interior city, averages –2°F.

Due to the average storm track and an abundance of moisture, the coastal region experiences more changing weather conditions and heavier precipitation than the interior region. Clouds and frequent fog are also associated with the coastal region.

Ironically, the interior region experiences higher temperatures in the summer than the coastal region. Average July daily temperatures at Fairbanks are 72°F while Anchorage averages 65°F. It appears that the oceanic influence along the coast contributes to the cooler temperatures than inland during the albeit short summer. Considering the latitude of Alaska, relatively warm temperatures exist during summer. This summer temperature phenomenon is primarily attributed to the increased hours of daylight (increased solar insolation) and relatively fair weather (decreased amount of clouds) as a decrease in weather systems traversing the area occurs.

026. Europe

Europe is comprised of many countries and has encountered significant changes in territory within the past years (i.e., former Yugoslavia now divided into Slovenia, Croatia, and Bosnia-Herzegovina).

This region is located between 70° and 35°N latitude and 10°W and roughly 30°E longitude. Although it is not landlocked to the continent, we include the United Kingdom in our discussion as one of the European nations.

Topography

In contrast to the North American continent, Europe has no extensive north to south oriented mountain ranges. Generally, the mountains in this region are oriented from west to east. This orientation aids in preventing cold air from interacting with warm air from the south. Let’s now examine the four main mountain (highland) regions of Europe.

1. The Alps. These are the highest European mountains. They extend from southern France to southeastern Austria and branch southward as the Dinaric Alps. Farther east exists a semicircular mountain region that includes the Transylvanian Alps and the Carpathian Mountains. These smaller mountain systems are considerably lower than the main ridge Alps, which has peaks that exceed 10,000 feet.
2. The Pyrenees. This mountain chain, which is again oriented west to east, separates France from Spain. Highest peaks are greater than 9,000 feet and form one of the main mountain chains in Europe.
3. The Apennines. Stretching the entire length of Italy, the Apennines are also considered one of the major mountain chains of southern Europe. The orientation of this mountain chain is from northwest to southeast.
4. The Scandinavian Mountains. This mountain chain is oriented southwest to northeast with the highest peaks rarely exceeding 7,000 feet. These higher peaks are located nearer to the west coast of Norway.

There are a number of lowlands where elevations of large areas of land are located below 1,000 feet. These regions include northern sections of France, Belgium, Holland, Germany, and the countries along the Baltic Sea. The United Kingdom and Hungary are also considered low-level regions.

Water bodies

Many large water body indentations affect the weather regime of Europe, including the Black, Aegean, Adriatic, North, and Baltic Seas, the Gulfs of Bothnia and Finland, and the Bay of Biscay.

Climate

Most of Europe has a relatively mild climate, largely due to its oceanic exposure to the north, west, and south. The east-west orientation of the mountains in Europe normally prevents extremely cold arctic air from penetrating southward to the Mediterranean. As a result, very cold weather is limited to the northern regions. The southern coast and Mediterranean countries enjoy moderate temperatures year round because relatively warm maritime air masses move inland from the Atlantic and because of the moderating influence of the Mediterranean Sea. However, this inflow of maritime air also brings frequent cloudiness, considerable precipitation, and high humidity.

In winter, when continental air masses dominate, Europe is subjected to low-temperature extremes, low humidity, and clear skies much the same as North America. This is especially true north of the Alps. South of this region, somewhat normal migratory pressure patterns do exist. The end result is relatively dry summers and wet winters characteristic of the western coastal region of North America and Canada.

Summer temperatures in Europe average 80°F in Athens, Greece; 77°F in Granada, Spain; 63°F in Greenwich, England; and 65°F in Paris, France. Farther north, summer temperatures average as much as 20 to 25 degrees less. During the winter, the Mediterranean temperatures average in the upper 40°F to low 50°F range while the extreme northern regions of Europe average 10°F or less. The Atlantic coastal countries with their predominantly maritime climates maintain far less temperature extremes between summer and winter.

Precipitation in the form of rain and drizzle is common along the European Atlantic coast and near the Mediterranean Sea. Snow does occur at times in areas east of Spain and north of the Mediterranean Sea. At higher elevations inland, snow is common and frequently abundant. Central Spain and southern Russia, by contrast, experience semiarid and arid climates.

027. The Far East

This huge region includes the two largest countries in the world, the Commonwealth of Independent States (CIS formerly the USSR) and China.

Topography

The Asian continent consists of a vast plateau region containing a number of mountain ranges. The following is a discussion of the major topographical features that affect the weather regime of the Asian continent.

The most prominent topographical feature of Asia, if not the world, is the Himalaya Mountains. These mountains are oriented from the west to the east through northern India and include the highest mountains in the world with elevations reaching 29,000 feet.

The very high plateau of Tibet lies between the Himalayas to the south and the Kunluns to the north. This region gradually slopes downward toward the Arctic Ocean. Associated in Mongolia and Siberia are various mountains such as the Altai and Yablonovoi Mountains. The Hindu Kush and Tien Shan are mountain chains that are a more or less continuous series of mountains that extend from the Arabian Gulf to Mongolia.

A large portion of southwestern Asia exceeds 2,000 feet in elevation and is interspersed with mountain chains. Lowlands exist in the Euphrates and Tigris river valleys. A major portion of the CIS consists of land where the elevation is less than 1,000 feet. The Ural Mountain chain crosses this region with a north to south orientation.

Other prominent highlands of Asia include the series of small mountains along the east coast of the continent, the Japanese Islands, Southern India, and Saudi Arabia.

Bodies of water

The bodies of water of the continent of Asia include the inland seas of southwestern Asia; that is, the Black, Caspian, and Aral Seas, along with Lake Baikal of Russia. The continent also has numerous water body indentations, such as the Persian Gulf, the Arabian, and Kara Seas, the Bay of Bengal, the Gulfs of Siam and Tonkin, and the Sea of Okhotsk. All of these bodies of water play an integral part in the weather regime of the region.

Climate

Asia’s climate is predominately continental. The only exceptions are the heavily populated coastal areas that have tropical and maritime climates during the summer. This primarily continental climate results in limited precipitation and large temperature ranges both daily and seasonally.

Asia is a huge continent with large expanses of land extending far northward. The Himalaya Mountains stretch across the southern portion in an east-west direction; mountains also parallel the eastern coast. These geographical features often contain continental arctic and polar air inlands, resulting in the most extreme temperature ranges found in the Northern Hemisphere. Northeastern Siberia’s temperatures often range from –60°F in the winter to above 60°F in the summer. Extremes range as high as 98°F and as low as –90°F. The large interior of Asia also results in extreme pressure differences. In the winter, the continent is dominated by a cold high-pressure area, and in the summer, by a warm low-pressure area. This accounts for the northeast winter monsoons and southwest summer monsoons.

In winter, the interior is dry, receiving less than one inch of precipitation. Coastal areas under maritime influence receive normal amounts (about 8 inches) of precipitation. In the summer, precipitation is plentiful except well inland. Rain is so abundant in some regions, such as India, that the yearly rainfall average (425 inches or more) is among the highest in the world. This high rainfall in India primarily occurs during the southwest monsoon season as onshore flow from the Arabian Sea inundates regions of the country with precipitation.

The extreme south and southeast regions of Asia differ sharply from its northern neighbors. These southern regions enjoy the tropical and maritime climates that feature only minor seasonal temperature variations. Eastern Asia enjoys a climate very similar to that found along the eastern coast of North America from the Florida Keys to eastern Canada. East and Southeast Asia, like the eastern and southeastern US, is also subject to an occasional tropical cyclone (typhoon) in the summer and in the fall.

028. African tropical regions

Africa is the second largest continent in the world and is located between 38°N and 33°S latitude.

Topography

The African continent is void of any extensive high mountain chains. In the northwest, the Atlas Mountains and plateau of Algeria separate the coast from relatively low-lying desert to the south. The large, immense Sahara Desert varies in elevation with isolated mountains whose peaks exceed 8,000 feet.

The principal mountain regions of Africa are sporadically located between northern Sudan and the Red Sea. Many of these isolated peaks in this region exceed 12,000 feet. Smaller mountainous areas appear in the southeast (Drakensberg Mountains), in southwest Africa (Auaz Mountains), in the Cameroons (Cameroon Mountains), in Madagascar (Ankarata Mountains), and elsewhere.

Bodies of water

Africa has no large indentations of water bodies (similar to those in Europe). Except for Lakes Rudolf, Victoria, and Nyasa, the continent is devoid of inland water bodies. Although not water bodies, the Nile and numerous other rivers play a contributing part in the meso- and microscale weather regimes of Africa. The Atlantic and Indian Oceans as well as the Red Sea and Gulf of Aden also play a major part in the regional weather regimes of Africa.

Climate

Africa's climate is unlike that of any other continent for several reasons; the most important being that the entire continent is within the tropical zone. The equator bisects the continent; therefore, in the areas north and south of the equator, the climates are similar, yet they differ because the region north of the equator is much larger than the southern region. Since the northern area is so broad in the east-west direction, maritime effects inland are minimal. Also, an extensive low-pressure area develops inland due to extreme land mass heating. The southern section, however, with its maritime influences is dominated by a belt of high pressure during winter and by low pressure during summer.

Another factor is the cold currents that exist along Africa's western shores. These currents allow an influx of cool winds and associated weather to the west coast. The final factor involves the lack of high mountains common to other continents. Since there are no prominent mountain ranges, the various climate types in Africa blend together, showing no sharp distinctions.

The most important climatic element in Africa is precipitation. Precipitation is great near the equator (60 to 80 inches to over 120 inches annually in some places). It decreases sharply to the north (less than 10 inches annually) and decreases gradually south of the equator (average of 20 to 40 inches annually). Because Africa is in the tropical zone, the precipitation belt of the near-equatorial convergence zone (NECZ) moves with the seasons. This belt of precipitation moves northward during the Northern Hemisphere's summer and southward in the winter.

Africa does have distinct climatic regions. Air-mass movement and influences allow for a division of eight climatic regions.

Northern Africa

The northern region includes the great Sahara Desert. The desert is a source region for dry continental-type air masses. While maritime air may transit the area, the air masses are highly modified and often exhibit continental properties after moving inland. This desert region is extremely hot during the day throughout the year but is very cool at night due to a lack of moisture; hence, strong radiational cooling occurs (more about radiational cooling later).

Southwestern Africa

The southwestern region is an arid to semiarid area that is known as the Kalahari Desert. The temperatures are not as extreme as in the Sahara because the land area involved is much smaller.

North Central Africa

The north central region is a semiarid area located along the edge of the Sahara. While the temperatures are similar to those of the neighboring desert (50°F in winter to well above 80°F in summer), this area occasionally receives precipitation in the winter. The source of this precipitation for the northern area is maritime air from the Mediterranean; in the south, it is the intermittent rainfall provided by the meandering NECZ.

Sub-equatorial Africa

The sub-equatorial region extends toward the equator from the semiarid region in the north. The region is marked by seasonal rainfall associated with the position of the NECZ. The region is wet for about five months (Nov–Mar), and dry during the rest of the year. Temperatures show little seasonal variation (68°F to 86°F) because of the close proximity to the equator. The only exception to this temperature stability occurs in the western portion, which during the winter is occasionally influenced by cool weather from the north.

Equatorial Africa

The equatorial region includes the southwest tip of northern Africa and the region between 5° north and south latitudes, extending from the west coast to Lake Victoria. It is the wettest climate in all of Africa. These areas have two distinct rainy seasons associated with the northward and southward movement of the NECZ. Rainfall averages over 120 inches annually in some areas. Throughout the rest of the year, precipitation remains plentiful because of the influx of maritime air from the west. There are no significant mountains in the region to prevent this maritime air from migrating inland. Temperatures are moderate year round.

Southeast Africa coast

The southeast coastal region has a humid subtropical climate. This region has rainfall all year (45 inches on the average) and temperatures remain generally moderate all year, ranging from an average maximum of 72°F in winter (July) to 89°F in summer (January).

Southeastern Africa interior

This region has a wet-and-dry type of maritime climate; however, it is considered temperate because of the lower temperatures common to the higher elevations.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

024. The US

1. Match the US climatic regions in column B to the climatology in column A. Items in column B may be used once.

Column A

____ (1) Weather results mainly from occluded frontal phenomena and orographic lifting of moist stable maritime air; rainfall is most frequent in winter.

____ (2) In winter, the main weather hazards are caused by outbreaks along the polar front and associated waves. In summer, the main hazard is convective air-mass thunderstorms that are most violent if they have developed in mT air.

____ (3) This area is a convergence zone where weather systems moving from the west and from the south meet and intensify. Severe thunderstorms are normally associated with squall lines.

____ (4) Conditions are similar to the Mediterranean. Cold fronts rarely penetrate this region. In summer, the air is stable; stratus and fog result. In winter, the air is unstable, causing showers and sometimes snow showers in the mountains. Little or no rainfall occurs in summer and only light to moderate rain falls in the winter.

____ (5) The more northerly sections have cold winters and all parts have extremely hot summers. The area is either very arid or actual desert. The chief flying hazards are thunderstorms forming along the mountains during the spring and summer.

____ (6) This climate is generally cold and dry in the winter and warm and dry in the summer. Most of the region is semiarid. Maximum rainfall occurs in the spring due to the predominance of storm track passages during this season. Annual precipitation is light.

____ (7) Cold frontal passages may be expected only in the late fall, winter, and early spring. The southerly circulation in the summer causes warm moist air to be heated. Severe convective thunderstorms are quite common.

Column B

a. Central plains area.
b. Northeastern area.
c. Southwest Pacific coast area.
d. Southeast and Gulf states area.
e. Southwest desert and mountain area.
f. The Northwest Pacific coast area.
g. West central intermountain area.

025. Canada and Alaska

1. Where is mountainous terrain located in Canada?

2. Describe the effect of the Atlantic Ocean on the east coast of Canada.

3. Why do cities like Edmonton and Calgary experience warmer temperatures than other cities in southern central Canada?

4. Why does the west coast of Canada experience warmer winters, on average, than the rest of the country?

5. Would Anchorage or Fairbanks experience warmer temperatures during the winter? Why?

6. Why does the coastal region of Alaska experience more changing weather patterns than the interior of the state?

026. Europe

1. What can generally be said of the mountain ranges of Europe that has a definite affect on the climate of the region?

2. What kind of air mass is present in Europe that produces low-temperature extremes, low humidity, and clear skies?

3. Where in Europe would you anticipate minimal temperature extremes?

027. The Far East

1. What is the most prominent topographical feature of Asia and what is the orientation of this feature?

2. How would you classify the Asian climate?*

028. African tropical regions

1. Why aren't the African climates north and south of the equator similar?

2. How does the NECZ move with seasonal changes?

3. What causes the Sahara Desert region to become very cool at night when, in contrast, daylight hour temperatures are very high?

4. What is the cause of Sub-equatorial Africa's wet fall and winter?

5. Which region of Africa averages over 120 inches of rainfall annually in some areas?

Answers to Self-Test Questions

019

1. The largest systems you deal with in forecasting. These systems cover more than 1,500 nautical miles (nm), and their duration is from several days to over a week. Macroscale systems include long waves, semipermanent cyclones and anticyclones, and seasonal circulations.
2. Vary in horizontal size from 500 to 1,000 nm and have a life cycle of tens of hours to several days. These systems include migratory cyclones, anticyclones, and air masses; frontal systems; and tropical cyclones. Synoptic systems influence a station's weather the most. These systems influence advection, vertical motions, and other dynamics.
3. Vary in size from 1 to 500 nm and are considered "local effects." They last from tens of minutes to several hours. Examples of mesoscale systems are squall lines, thunderstorms, tornadoes, and land/sea breezes. Mesoscale systems have an impact on the weather, by influencing the weather caused by synoptic systems.
4. Any five of the following: Anticyclone, subtropical cyclone, mid-altitude cyclone, tropical cyclone, hurricane, typhoon, warm front, cold front, stationary front, occluded front, or dry line.
5. Any four of the following: Mesohigh, Mesocyclone, Tornado cyclone, Mesolow, Gust front, Radar thin line, Arc-cloud line, or Sea breeze front.

020

1. A specific synoptic and/or mesoscale weather pattern, which affects the weather at a particular location. Weather regimes are often named for synoptic systems and their development regions, such as the "Texas Low" in the US, or the "Shanghai Low" in Asia.
2. Meteorological Technical Information Program (MetTIPs) is an Air Force Weather Agency (AFWA) developed software program that outputs regime information on weather patterns all over the world. Overseas versions of the program are appropriately named for their region, for the European Theater there is EuroTIPs, and for the Pacific Theater there is PacTIPs.
3. MetTIPs regime documentation may contain the following information: Regime frequency, duration, and seasons when it most often occurs; description of surface and upper-level features; general weather conditions associated with each regime, to include potential forecast problems; and special analysis and forecast tools, products, and techniques to use for the regime.

021

1. The forecast funnel is the process of analyzing at the largest scale first (macroscale), then focusing downward to the smallest scale (mesoscale).
2. Macroscale features influence the movement and development of synoptic systems. They influence the movement because a system's track is dependent upon the long wave pattern. A system's development is dependent upon its relative position and the amplitude of long wave troughs and ridges.
3. The zonal index affects a system's speed and its north to south movement. In a long wave pattern with a high zonal index, systems normally move rapidly west to east. However, in a situation with a low zonal index, systems move more north to south and generally slower.
4. The amplitude of long wave features is indicative of their influence on the intensity change of surface systems. A deep long wave trough (large amplitude) will deepen a low ahead of the trough due to the strong the divergence. A shallow long wave trough (weak amplitude) will not effectively deepen a low positioned ahead of it. A strong amplitude long wave ridge effectively strengthens a high positioned ahead of it. A weak amplitude long wave ridge will not as effectively strengthen a high located ahead of it.
5. Some standard products to use are satellite water vapor analysis, 5-wave analysis charts, and 500 MB hemispheric charts.
6. In situations when the analyzed features represent a mixture of two or more different regimes a forecaster must remember the resulting weather may favor one, both, or some combination of the two regimes. The regime information for both systems must be reviewed. The interaction of the two regimes must be evaluated and considered. By and large, the whole process requires a more in-depth study of the systems and the regime information has to be used more subjectively.
7. Surface and upper air charts focused on the mesoscale, soundings, wind profiler data, and high-resolution satellite. Fine-scale model data can also be helpful in revealing mesoscale features.

022

1. List at least four of the following: WSR–88D RPS lists, alert paired products, two-degree isotherm analysis at 850 MB and 500 MB, 500 MB height fall analysis, or surface pressure fall analysis.
2. Documenting information from forecasting reviews or case studies and disseminating regime information to unit personnel via training seminars.

023

1. First, the atmosphere is continually in motion at all scales from macro to meso. Second, forecasts cover a continuous time frame valid for 24 hours, but forecast charts normally provide data in 6- and 12-hour increments. Third, forecasters must determine if centralized data is reliable. If not accurate, adjustments must be made to the models.
2. Forecasters do the majority of their analysis during slack times. Then document their analysis after it's completed; therefore, making the most efficient use of their time.
3. Purpose – each entry on the worksheet must be significant to the forecast. Simplicity – entries cannot be so complicated that it becomes impractical to complete the forecast worksheet. Content – a good worksheet follows the forecast funnel.
4. Because different units tailor the worksheet to meet their operational needs, forecast requirements and weather patterns.
5. Hemispheric analysis because entries follow the forecast funnel approach.
6. Significant cloud/non-cloud features, upper level circulation, weather systems analysis, and low level circulation.
7. Identification is the process of recognizing significant synoptic features that will influence the weather in your forecast area. Interrogation includes determining how advection, vertical motions, and other dynamic are affected by the synoptic pattern.
8. Near to the actual forecast time.
9. Verification is the act of comparing the previous 12-hr forecast positions with the current 00-hr forecast positions for the same time. Initialization is the act of comparing the 00-hr forecast positions with your analysis for the same time. The second verification is a comparison of the current 12-hr forecast with real time data for the same time to determine how well the model is performing.
10. WSSC tables.
11. Forecast reasoning.

024

1. (1) b.
   (2) c.
   (3) d.
   (4) g.
   (5) e.
   (6) a.
   (7) f.

025

1. British Columbia.
2. It modifies the east coastal region by keeping it warmer during winter, protecting it from the harshness of winter experienced inland.
3. Because air is adiabatically warmed as it descends the east side of the Rockies.
4. Because the Rocky Mountains act as a barrier to the very cold air masses that move down from the north interior of Canada.
5. Anchorage. Because it is located on the coast and the warm current of the ocean modifies temperatures significantly.
6. Because the average storm track is along this region along with an abundance of moisture.

026

1. The main ranges are oriented from west to east. Thus, they prevent cold air from the north from interacting with warmer air from the south.
2. Continental air masses in winter.
3. Atlantic coastal regions.

027

1. The Himalaya Mountains, which are oriented from east to west.
2. Predominantly continental.

028

1. Because the land mass north of the equator is much larger than the southern region.
2. The NECZ moves northward during the Northern Hemisphere’s summer and southward in the winter.
3. Due to the lack of moisture in the air, radiational cooling maximizes.
4. Seasonal rainfall associated with the position of the NECZ.
5. Equatorial Africa.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

46. (019) What size of an area do macroscale systems influence?
    a. 1,000 nautical miles.
    b. 1,500 nautical miles.
    c. 2,500 nautical miles.
    d. 5,000 nautical miles.

47. (019) Which type of analysis covers an area of sufficient size to identify systems affecting a forecaster's area of operation?
    a. Mesoscale analysis.
    b. Macroscale Analysis.
    c. Synoptic scale analysis.
    d. Pseudo Hemispheric Analysis.

48. (019) Which is *false* concerning the classification of systems?
    a. Synoptic systems influence advection, vertical motions, and other dynamics.
    b. Macroscale systems include long-waves, semipermanent cyclones, and anticyclones.
    c. Local winds, temperatures, and clouds are not influenced by mesoscale systems.
    d. Migratory systems may develop rapidly, or not at all, depending on the long wave macroscale influence.

49. (019) Which of the following is a synoptic system?
    a. Mesohigh.
    b. Warm front.
    c. Mesocyclone.
    d. Radar thin line.

50. (019) Which of the following is a mesoscale system?
    a. Mesolow.
    b. Long wave trough.
    c. Short wave trough.
    d. Semi-permanent cyclone.

51. (020) A synoptic or mesoscale weather pattern that affects the weather at a particular location defines
    a. a weather regime.
    b. a standard synoptic regime.
    c. a regional climatic system.
    d. an oscillating weather pattern.

52. (020) What often determines the name of a synoptic weather regime?
    a. Development region and system type.
    b. System type and thermal characteristics.
    c. Precipitation type and speed of movement.
    d. Thermal characteristics and development region.

53. (020) Which of the following information is *not* available via the meteorological technical information program (MetTIPs)?
    a. Description of surface and upper-level features.
    b. Regime frequency, duration, and season when it most occurs.
    c. Specific regime forecasting checklists for every weather unit in the CONUS.
    d. General weather conditions associated with the regime and potential forecast problems.

54. (021) This analytical process involves analyzing at the largest scale first, then focusing downward to the smallest scale?
    a. Forecast funnel.
    b. Synoptic analysis.
    c. Mesoscale analysis.
    d. Macroscale analysis.

55. (021) The affect that the zonal index has on the speed and movement of synoptic systems is a
    a. low zonal index that would cause systems to speed up and move from the north to south.
    b. low zonal index that would cause systems to slow down and move from the west to east.
    c. high zonal index that would cause systems to speed up and move from the west to east.
    d. high zonal index that would cause systems to slow down and move from the west to east.

56. (021) What affect does the amplitude of a long wave trough or ridge have on surface systems?
    a. A small amplitude long wave ridge would cause a high located ahead of it to build due to the strong divergence.
    b. A large amplitude long wave ridge would cause a high located ahead of it to weaken due to the strong convergence.
    c. A large amplitude long wave trough would cause a low located ahead of it to deepen due to the strong divergence.
    d. A large amplitude long wave trough would cause a low to weaken located ahead of it due to the strong convergence.

57. (021) What affect does the amplitude of a long wave trough or ridge have on surface systems?
    a. A small amplitude long wave ridge would cause a high located ahead of it to build due to the strong divergence.
    b. A large amplitude long wave ridge would cause a high located ahead of it to build due to the strong convergence.
    c. A small amplitude long wave trough would cause a low located ahead of it to deepen due to the convergence.
    d. A large amplitude long wave trough would cause a low located ahead of it to fill due to the strong divergence.

58. (021) Which products are considered standard for detecting the long wave pattern?
    a. Local area work chart, Satellite water vapor analysis, and 500 millibars (MB) hemispheric charts.
    b. Satellite water vapor analysis, 5-wave analysis chart, and 500 MB hemispheric charts.
    c. Local area work chart, Satellite infrared analysis, and 500 MB height fall analysis chart.
    d. Satellite water vapor analysis, baroclinic wave analysis chart, and 500 MB hemispheric charts.

59. (021) How is synoptic regime information categorized?
    a. Geographical region, long wave pattern, and surface features.
    b. Long wave pattern, associated weather, and thermal characteristics.
    c. Geographical region, long wave pattern, and thermal characteristics.
    d. Geographical region, associated weather, and thermal characteristics.

60. (022) How do *most* units document regime information in their Terminal Forecast Reference Notebook (TFRN) or Local Analysis and Forecast Program (LAFP)?
a. Regime information will not be documented at the unit level.
b. Documented regime information will be specific to their location.
c. Documented regime information will be generic to all Air Force bases.
d. Regime information will be documented at a continental level in the TFRN and a local level in the LAFP.

61. (022) Which is *not* an example of a regime specific forecasting approach?
a. Performing standard isobaric analysis of surface charts as outlined by routine station procedures.
b. Using WSR–88D routine product set (RPS) lists and alert paired products during episodes of severe convection.
c. Using hourly local analysis work charts (LAWC) to identify and track precipitation as part of the forecast/metwatch process during warm frontal overrunning.
d. Performing two-degree isotherm analysis at 850 MB and 500 MB, 500 MB height fall analysis, and surface pressure fall analysis to help identify short waves and fronts.

62. (023) Suggested times spent on interrogating different atmospheric scales are
a. 10 percent macroscale, 30 percent synoptic, and 60 percent mesoscale and local.
b. 30 percent macroscale, 10 percent synoptic, and 60 percent mesoscale and local.
c. 10 percent macroscale, 60 percent synoptic, and 30 percent mesoscale and local.
d. 60 percent macroscale, 30 percent synoptic, and 10 percent mesoscale and local.

63. (023) What two steps are followed to document your synoptic analysis on a forecast worksheet?
a. Analysis and prognosis.
b. Observing and forecasting.
c. Continuity and extrapolation.
d. Identification and interrogation.

64. (023) Which statement *best* describes the first verification in the verification, initialization, and verification (VIV) process?
a. Verify the previous 12-hour forecast positions with the current 00-hour forecast positions for the same time.
b. Verify the current 12-hour forecast positions with the previous 00-hour forecast positions for the same time.
c. Verify the 00-hr forecast positions with analysis of real-time data for the same time, such as meteorological satellite (MetSAT) analysis.
d. Verify the 12-hr forecast positions with analysis of real-time data for the same time, such as MetSAT analysis.

65. (023) Which statement *best* describes the second verification in the VIV process?
a. Verify the previous 12-hour forecast positions with the current 00-hour forecast positions for the same time.
b. Verify the current 12-hour forecast positions with the previous 00-hour forecast positions for the same time.
c. Verify the 00-hr forecast positions with analysis of real-time data for the same time, such as meteorological satellite (MetSAT) analysis.
d. Verify the 12-hr forecast positions with analysis of real-time data for the same time, such as MetSAT analysis.

66. (023) Which part of the forecast worksheet is used to record forecast justification for each weather element in a forecast?
    a. Climatology.
    b. Model output.
    c. Synoptic analysis.
    d. Forecast reasoning.

67. (024) Which area is favorable for the development and formation of storm centers, due to geographical and climatological conditions?
    a. The Central Plains.
    b. Southern California.
    c. The northwest Pacific coast area.
    d. Northern portions of the Gulf of Mexico.

68. (024) This US weather region is dominated by a cold high in the midwinter that prevents storm systems from moving into it is the
    a. Northeastern area.
    b. Southwest Pacific coast area.
    c. West central intermountain area.
    d. Southwest desert and mountain area.

69. (024) This US weather regions' main weather hazards are caused by wintertime outbreaks along the polar front and associated wave phenomena.
    a. Northeastern area.
    b. Central Plains area.
    c. Northwest Pacific coast area.
    d. Southeast and Gulf States area.

70. (024) Which US weather region is an area of storm track convergence?
    a. Northeastern area.
    b. Central Plains area.
    c. Southeast and Gulf States area.
    d. West central intermountain area.

71. (025) The Atlantic Ocean modifies weather along the east coast of Canada by keeping the east coast
    a. cloud-free during the summer.
    b. cloud-free during the winter.
    c. summers cooler and winters warmer than inland regions.
    d. summers warmer and winters cooler than inland regions.

72. (025) Where would you expect predominantly wet, cloudy, and relatively warm winter weather in Canada?
    a. East coast region.
    b. West coast region.
    c. North central region.
    d. South central region.

73. (025) Relatively warm temperatures exist in Alaska during the summer due to the
    a. increased solar insolation and decreased clouds.
    b. decreased solar insolation and decreased clouds.
    c. increased solar insolation and increased clouds.
    d. increased solar insolation and increased clouds.

74. (026) What mountain chain separates France from Spain and how is it oriented?
   a. Dinaric Alps; oriented north to south.
   b. Dinaric Alps; oriented west to east.
   c. Pyrenees; oriented north to south.
   d. Pyrenees; oriented west to east.

75. (027) India encounters an abundance of precipitation (425 inches or more) annually due to the
   a. northeast monsoon and associated onshore flow.
   b. northeast monsoon and associated offshore flow.
   c. southwest monsoon and associated onshore flow.
   d. southwest monsoon and associated offshore flow.

76. (028) What is the *most* important climatic element in Africa?
   a. Humidity.
   b. Temperature.
   c. Precipitation.
   d. Prevailing winds.

Please read the unit menu for unit 3 and continue ➔

Unit 3. Forecast Reviews, Studies, and Seminars

AT ONE TIME or another in your forecasting career you will be expected to accomplish a forecast review or possibly even a study or seminar. There has been a tendency to think of these tasks as meaningless busy work or even punishment. However, that is far from the truth. Reviews, studies, and seminars are excellent tools to improve the technical health of a unit. They are an excellent means for the unit to hone the weather skills of all its forecasters. Imagine if the only people that ever benefited from significant weather event were the on-duty forecaster. This would cause valuable training opportunities to be missed. Therefore, AF weather units implement policies to ensure weather events are recorded (forecast reviews). Also, when historically significant weather events occur or when faced with complex forecasting problems, weather units conduct an in-depth reanalysis (forecast study). Forecast seminars also prove useful as well, they are used to disseminate weather information to unit personnel. The upcoming unit provides background material and development procedures for forecast reviews, studies, and seminars.

3–1. Background Information

To properly develop forecast reviews, studies, and seminars it is important to know the definition and purpose of each one. The following section provides that information plus other relevant background information.

029. Definitions

This lesson covers the definitions of forecast reviews, studies, and seminars.

Forecast review

A forecast review is an after-the-fact review of the observations, analyses, and forecast aids that were available to the forecaster. They are conducted to determine whether existing unit procedures were adequate and identify ways to correct the forecast. A review normally takes less than an hour to prepare and will focus on a specific part of the forecast process.

Forecast study

A forecast study is sometimes called an in-depth reanalysis. In the course of a study, considerable effort is used to collect and present the data. Compared to a review, a forecast study involves more work analyzing data and the information is documented at greater length. The whole process usually requires several hours of concentrated work and some rewrites over a period of several weeks or more.

Forecast seminar

A forecast seminar is a presentation developed and performed by weather personnel for the purpose of giving or discussing weather information. In the general sense, a seminar may cover a wide range of subject matter. However, for the purpose of this text we limit the subject matter to weather information.

Even restricted to the weather field, seminars cover a wide scope of topics such as the following:

- Forecasts reviews and lessons learned.
- Climatology.
- Terminal forecast reference notebook (TFRN) changes.
- Technical notes and manuals.
- Terminal aerodrome forecast (TAF) worksheets.
- Regional analysis and forecast program (RAFP).
- Observing procedures.
- Doppler radar operation.
- Meteorological satellite analysis.

030. Requirements

Forecast reviews, studies, and seminars will be accomplished following the unit’s guidance. A systematic, effective program provides tremendous potential for improved weather service. To realize this potential, procedures have been established to make the process work. Each unit has unique needs and their programs are written specifically to meet those needs. The upcoming lesson covers the review, study, and seminar requirements similar to most AF weather units.

Forecast review requirements

The purpose of a forecast review is to improve forecasting—plain and simple. They are not punitive. They are learning tools for the forecasters who prepare them and all who read them. The commander or operations superintendent mandates a review to be accomplished either directly or indirectly through policy. The reason for the review generally falls under four categories:

- Forecast evaluation.
- Failed to follow forecast procedures.
- Outstanding forecast.
- Significant weather event.

Forecast evaluation

A forecast review of this type is required when the forecaster did not properly forecast the weather conditions to standard. Forecast evaluation is the process of determining forecast accuracy against the observed weather. Evaluation is a part of the regular duties in a weather unit and you are required to document the results after every forecast you issue. The results will be used to evaluate the forecast, look for trends, and determine what after-the-fact actions (review, forecast study, or nothing) are required. The unit commander and operations superintendent sets the standards of quality to be met. Satisfactory thresholds are set for ceiling, visibility, winds, and any other criterion they see fit. For instance, the standard for wind warnings may be to set a standard of five knots within the warning threshold. If a situation arose, whereas the winds failed to get within five knots of the warning threshold then a forecast review would be required.

The thresholds are chosen to lead towards improvement in their perspective areas of a unit’s operation. The goals are clearly stated and explained to all forecaster personnel. Therefore, the duty forecaster in most cases initiates the review, when required, without notice. Only in a few exceptional cases is it necessary for the operations superintendent to directly instigate forecast reviews of this category.

Failed to follow forecast procedures

Unit management may direct a forecast review when the forecaster failed to follow forecast procedures. Reviews of this type are accomplished to ensure the forecaster does not repeat the errors and to ensure that others do not make the same mistake. The review details the procedures that were not followed correctly and the consequences of those actions. In addition, the review states the proper procedures that should have been followed. Forecast reviews of this type are considered corrective and serve as an excellent method of training.

Outstanding forecast

Sometimes an outstanding forecast merits a forecast review to document how a specific situation can and should be handled. These are probably the most pleasant and rewarding of the various types of reviews to accomplish. Pleasant because the forecast review is for positive job performance, and there is no feeling of negativity such as when a forecasts busts–rewarding because the forecaster can expect to receive public praise for their accomplishment. In addition, unit awards and high performance markings on proficiency reports may also result from a trend of producing outstanding forecasts.

Significant weather event

Occasionally, an event is forecasted satisfactorily but because the weather was so significant it requires a forecast review for documentation. These reviews help forecasters meet the challenges of a similar weather scenario in the future. Reviews of this type commonly are issued to a team of forecasters. For instance, all the forecasters that worked during the weather episode may be charged with the review. This multi-person tasking actually improves the investigative process of the review.

A forecast review team of forecasters makes the investigation more broad ranging. This is because each member of the team adds his or her own personal direction to the investigation. Additionally, the team has effective brain storming sessions to discover effective forecasting methods to apply to future situations. However, when the weather event is of such a magnitude that it requires a lengthy investigation and documentation a forecast study may be more appropriate.

Forecast study requirements

The purpose of a forecast study is to thoroughly investigate a weather scenario, or test and develop new forecast techniques. Compared to reviews and seminars, studies are the less automatic of the three. Seminars and reviews, in most cases, are automatically generated following unit procedures. However, unit management generally assigns studies on a case-by-case basis. Many times they are accomplished after personal initiative, after someone experiences a notable weather event or discovers a new forecasting technique while working shift. For example, if a forecaster was having success using stability indexes from the Skew-T to determine cloud type they should conduct a forecast study to prove their findings and present it to the unit.

Forecast studies can also be an excellent way to investigate and document weather patterns that frequent a location, especially weather regimes. They are an excellent way to illustrate the effectiveness of the regime forecasting tools and procedures outlined in your unit directives. A forecast study for a regime will contain examples of the weather data required by standard operating procedures (SOP). Permitting unit forecasters to see how these products perform during the regime episode.

Forecast seminar requirements

The basic purpose of a forecast seminar is to present weather information to unit personnel. However, forecast seminars have a wonderful side benefit, too. In addition to educating the audience, they also raise the knowledge level of the presenter. Joseph Joubert, a French essayist and moralist, once said, “To teach is to learn twice over”–a quotation fitting the seminar process. While a person presents a seminar, they are solidifying the information in their own mind.

The unit’s seminar program is generally contained in a continuity binder. The program serves to document seminars and schedules future ones. The commander, operations superintendent, or delegated representative schedules seminars on a regular basis. Seminar topics are designated on a seminar roster; however, the seminar assignment roster is not completely restrictive; meaning most units operate in such a way that the assigned seminars are the minimum requirement. Personnel are free to show initiative and volunteer for additional seminars.

Forecast seminars are generally presented at unit meetings. Format and presentation instructions should be maintained in the unit's seminar program continuity binder. Many format and presentation methods are available, due in most part by the advent of new technology. Presentation software such as PowerPoint has introduced color and animation to seminars. In addition, hypertext markup language (HTML) has produced web-based seminars and provides an interactive interface for the audience.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

029. Definitions

1. Describe a forecast review.

2. Explain the use of a forecast study.

3. What is a forecast seminar?

4. List four example topics for a forecast seminar.

030. Requirements

1. State the purpose of a forecast review.

2. List the four reasons a forecast review may be required.

3. Give two reasons why a forecast study may be needed.

4. What is the purpose of a forecast seminar?

5. When are forecast seminars normally presented, and what are some example format presentations?

3–2. Forecast Review, Study, and Seminar Development

For the most part, developing forecast reviews and studies typically follows four logical steps: (1) compiling pertinent data; (2) constructing an event scenario; (3) conducting independent verification of data; and (4) presenting the results in a logical sequence leading to conclusions and lessons learned. The upcoming section covers this development process. In addition, the last lesson in this section briefly covers developing forecast seminars. Let us begin with the first step in the forecast review and study process compile pertinent data.

031. Compile pertinent data

You have just been selected to accomplish a forecast review or study. Questions are soaring in your head. What do I do? Where do I begin? Well, the first step is to start by compiling the data you need to accomplish your reanalysis. Pertinent data is the most important and urgent step in developing a forecast review. Having the proper types and amount of data sets the tone for the rest of the project. It enables you to thoroughly investigate the scenario and arrive at sensible conclusions. In addition, time is critical in this process.

Urgency is a fundamental concept in the compilation of data. If you wait too long, you may miss the opportunity to save and copy data because it purges itself from your systems. Speed now saves you enormous time later. It is possible to get data once it has purged from your systems. However, that process involves getting data from weather archives or outside sources that wastes time and effort. The following lesson covers the types of data to compile and how they may be used.

Upper-air charts

It is important to get the copies of the upper-air analysis package used to make the forecast. In addition, it may also be helpful to get the continuity sets for the last couple of chart sets. The continuity sets depict how the weather pattern has evolved over time, plus aids in determining long-wave pattern. Then, the analysis package is used to detect the synoptic pattern that was in effect for the forecast.

Make sure to compile as many upper-air charts as possible; you can always eliminate what you don't need later. If possible save as many forms of the data as you can, from electronic copy to paper. Having an electronic copy gives you the ability to print charts on an as needed basis and not waste paper. Besides saving data to storage device, performing system archives is useful too. Most weather systems have the ability to archive (save) information on a storage device based on a time period that you specify. If you have this ability, perform it before the files are purged from the system.

Meteorological models

You need to copy at least a complete run of the meteorological model that was in effect for the forecast period. Having the complete run gives you the ability to pick and choose the charts you want to include as attachments to the documentation. If accomplishing a major review or forecast study, more than likely you will have to include a complete model package with the review. For a minor review, possibly only significant or referenced charts need to be included. Regarding saving model data, getting a complete run is the easy part; the hard part is determining what model to use.

The number of meteorological models available to the forecasters has increased dramatically over the last 10 years. Most CONUS forecasters have access to the following models:

- Global forecast system (GFS).
- Weather research and forecasting (WRF).
- North American mesoscale (NAM).
- Global ensemble forecast system (GENS).
- Rapid update cycle (RUC).

The five models listed only represent a few of the models used today. There are many more models out there, available to you. More than likely you will concentrate your efforts on saving the model data your unit prefers. However, this should not preclude you from compiling data from all the other models available. Recall that one of the reasons to write a review is for an unsatisfactory forecast (forecast evaluation). Many times the reason a forecast fails is a result of using poor model data. By investigating how the other models perform, you may find new forecasting techniques to use in the future. The Internet will assist you in compiling all the model data. With the Internet, it is possible to save the model data on a storage devise for later printing and analysis.

Surface charts

The surface chart is a vital product used in the forecast process. As a result, it is also a vital product to include in the compilation of data. Gather surface charts relevant to the forecast period, to include copies that occurred as the weather unfolded. The continuity and current surface charts, relative to the forecast time, are used to describe the synoptic and mesoscale patterns for the forecast period. Then, the subsequent surface charts depict how the pattern evolved over time. It’s important to remember that if the charts are already analyzed, a reanalysis is required to determine its accuracy.

Meteorological satellite images

Meteorological satellite (MetSAT) images are another vital product in the forecast process. Compile all the MetSAT images available to the forecaster before and after the forecast. This includes both visual and infrared, and in the various enhancement curves available. The MetSAT pictures are used to identify jet support and longwave location. In addition, they are also used to illustrate the cloud development and general synoptic circulation.

These files can be saved in paper copy or electronic form. If possible, perform a data archive on your system to cover the complete forecast period. In addition, do not restrict yourself to gathering still images. Loop data is available from many sources and may be beneficial to the review or study.

Radar images

You need to compile radar pictures for the time period in question. Gather as much possible because you can always eliminate extras later. Some units make it a common practice to start a data archive on the radar whenever significant weather affects their area. If indeed this is the case, you need to use the recorded images to make paper copies. If a WSR–88D data archive was not automatically accomplished it may be necessary to perform your own archiving before the files are purged. In addition, search the Internet for any radar images worth saving, either on a storage device or paper copy.

Surrounding observations and forecasts

Compile all the surrounding observations and forecasts that were received during the forecast period. If possible, conduct a data archive on your weather systems to save all alphanumeric products. Then, if necessary, make copies of the data as you need it. An important consideration when gathering forecasts (especially if you’re doing a review for an inaccurate forecast) is to search for stations that have issued accurate forecasts. If you find one, open a line of communication with the responsible forecast agency and try to get the information that led to their accurate forecast.

Skew-T Log P diagram

The Skew-T is another important product to include in the compilation of data. At a minimum, you should gather Skew-T data from the stations referred to on the TAF worksheet. In addition, investigate other upstream stations to determine if their Skew-T data is worthy of copying. The Skew-T is a valuable resource; it is used to show stability, clouds, turbulence, icing, and many more phenomenons. If you obtain an already analyzed Skew-T, it may be necessary to reanalyze some of the indices.

Other meteorological data

There are many other products available that you might find worthy to be included in your data save. The Internet in particular is an excellent source of meteorological data. Meteorological data has been manipulated in so many different forms it is impossible to list all the data that is available today. Therefore, it is left up to the individual to decide the relevancy of the new information out there. The purpose of the review will largely dictate what additional data you may need. For example, a review of severe convective activity would require a different approach than a review for a radiation fog episode.

032. Construct an event scenario

Now that you have compiled the data you are now ready for the next step—constructing an event scenario. In this part of the process you're a detective, much like Sherlock Holmes putting all the pieces of a mystery together. In your case, the data you have compiled are the pieces to your puzzle. And, it's your job to put all the pieces together into a useable order and make it possible to determine what happened and why. This lesson covers the steps involved in constructing an event scenario.

Reanalysis

Before using all the compiled data you must first reanalyze it. The reanalysis is done to correct mistakes or find features that were originally missed. You should place an emphasis on finding those features relevant to the purpose of your review or study. In addition, it may be useful to perform a hand reanalysis of the data.

Most of the analysis that you perform today is done on computers, either automated or manual. A problem with computerized analysis is it can "smooth out" features thereby making it difficult to detect fine scale phenomena. By performing a reanalysis, you can catch these subtle features missed by the computer analysis. After you have reanalyzed the data, it is time to organize it.

Organizing your reanalysis

The next step is to organize your reanalysis to identify all the key meteorological elements. The reanalyzed data is used to construct a logical three-dimensional description of the atmosphere. To accomplish this you follow the forecast funnel approach to analysis. First, you begin at the macroscale level to determine the longwave pattern and zonal index. Next, you apply this information to the remainder of the reanalysis to determine the synoptic scale regime that was in affect. Lastly, you concentrate at the mesoscale level to determine if any mesoscale regimes were influencing the weather. During this whole process use the old analysis and the new reanalysis.

It is okay to use the information from the previous analysis or forecast worksheet as a guide but use it prudently. The reason for your review may be due to an incorrect analysis or improper reasoning. Once you're completed, you have an accurate description of the atmosphere and are ready for the next step, which is constructing an event scenario.

Construct an event scenario

An event scenario is a chronological list of weather events and their potential causes. The way you construct it is by beginning at the zero hour, then follow the weather as it progressed over time. At each significant weather event, document what occurred and its potential causes. The reason the causes are termed "potential" is because they have not been thoroughly investigated yet. Follow this approach through the whole weather episode. Place the greatest emphasis on documenting the events responsible for the review. Figure 3–1, which is used in the next lesson, is an example excerpt from an event scenario. Once the event scenario is complete, you are ready to conduct verification of the data.

033. Conduct independent verification of the data

At this point you have a sound description of the atmosphere and an event scenario that lists the potential causes of the weather episode. However, you have not isolated the "potential causes" to determine which ones are the "root causes" of the weather episode. To do this you must know the role that each potential cause played in the weather scenario. In the next step each potential cause will be investigated to determine its significance in the weather event.

Investigate the potential causes

The event scenario is used to investigate each potential cause and determine its contribution to the weather episode. The goal of this procedure is to let you know how all the weather elements behaved, so you can eventually determine which ones were chiefly responsible. To illustrate the investigation procedure, let's go through a plausible example of the process.

Using figure 3–1, the example event scenario, the following paragraphs takes you through the process.

Event Scenario		
Time (UTC)	***Event***	***Potential Causes***
1428	Fog Thickened on station—visibility decreased to 1 ¼ miles	Frontal overrunning, positive vorticity advection (PVA), warm air advection (WAA), moist air advection
1446	Started raining	Frontal overrunning, PVA, WAA, moist air advection
1455	Ceiling decreased to 1,200 ft and visibility decreased to ¾ mile in rain and fog	Frontal overrunning, PVA, WAA, moist air advection, and rain
1548	Thunderstorm started on station	Embedded cumulonimbus (CB), Low-level jet, increased instability, PVA, Upper-level thermal trough and cold air advection (CAA), WAA
1555	Ceiling raised to 1,500 ft and visibility improved to 2 ½ miles in a thunderstorm, rainshower, and fog	Embedded CB, Low-level jet, increased instability, PVA, Upper-level thermal trough and CAA, WAA

Figure 3–1. Example of event scenario.

The event scenario in figure 3–1 was produced for a forecast that failed evaluation. This occurred at 1555 universal time change (UTC) when the ceiling and visibility improved to an unforecasted level. Prior to the weather's improvement, the forecast called for a 1,200 ft ceilings and ¾ mile visibility in rain and fog. The original forecast reasoning contributed the weather to frontal overrunning, PVA, WAA, and moist air advection. Finding the reason your forecast failed involves investigating all the factors you uncovered in the event scenario. Let's begin to investigate the problem by starting at 1555 UTC when the ceiling and visibility increased.

The first potential cause at 1555 UTC is the embedded cumulonimbus, which was first detected at 1548 UTC. This brings the question to mind, "How would an embedded CB have caused the ceiling and visibility to raise?" After some thought, it is concluded that the updrafts associated with the CB raised the ceiling by incorporating all of the low-level moisture vertically into the storm. The drawing of the surface moisture from the low-levels caused the ceiling and visibility to improve. In addition, it's deduced that the downdrafts associated with the storm resulted in stronger surface mixing that thinned the fog out. So we have arrived at one of the principal causes behind the ceiling and visibility improvement. However, what caused the CB to form? Possibly, the answer to that is in the next potential cause–the onset of a low-level jet.

Analysis of the WSR–88D Doppler VAD wind profile data indicates that a low-level jet, approximately 40 knots at 3,000 ft, was evident above the station on the 1536 UTC volume scan. You recall that the interaction of a low-level jet with frontal overrunning is considered a thunderstorm trigger. A fact especially true when unstable, moist air is being rapidly forced over a frontal boundary.

The low-level jet that was detected by the radar at 1536 UTC was the forcing mechanism responsible. However, observations reported continuous rain and fog earlier, which is conducive to stable conditions. What then caused the airmass that was being pushed over the frontal slope to become unstable? A question that brings us to your next potential cause: increased instability.

To answer the question what causes instability, you must determine what factors lead to instability and if any were present. A couple of factors can cause instability; they include low-level heating, upper-level cooling, and mid-level dry air advection. Looking back at your potential list of causes, upper-level CAA was occurring associated with a thermal trough. This would have increased the size of the positive energy area, therefore making it easy for convection to form. The increased positive energy area would have increased the thunderstorm updraft and in-turn entrained more low-level moisture in the storm. The loss of low-level moisture would have then raised the ceiling and surface visibility. Let us recap what you have learned.

You know that an unforecasted CB formed and through its updraft incorporated a significant amount of the low-level moisture vertically into the storm. You also know that the radar picked up a low-level jet just prior to the CB's appearance. In addition, you know the instability was caused by an upper-level trough and associated CAA. However, which of these causes were responsible for your forecast bombing? The next step is to use this information to determine the root causes.

Determine the root causes

At this point you know all the contributing factors to the weather event. It's time to determine which of the factors were chiefly responsible. This procedure can differ depending on whether you are conducting a forecast review or a study. For a forecast review you have to determine the causes that were missed from your original reasoning and which ones were principally responsible for the unforecasted weather event. However, in the case of a forecast study you have to present all the causes of the weather episode in your documentation. Therefore, you are not as focused on finding one specific cause, or set of causes, instead you are concentrating on all of them. To illustrate this process, let's go back to your failed ceiling and visibility forecast to determine the root of your problem.

The ceiling and visibility improved because of a decrease in low-level moisture. The decrease was caused by an embedded thunderstorm and CB in the stratiform precipitation. The low-level jet rapidly forced unstable air over the frontal slope thereby causing the thunderstorm. The unstable air resulted from upper-level trough and associated CAA. You now know what caused the weather episode. But, which of the contributing factors was left out of your original reasoning?

You were already forecasting low ceilings and visibility due to continuous rain and fog. The rain and fog conditions you contributed to overrunning, PVA, WAA, and moist air advection. However, you did not forecast the onset of a low-level jet nor did you expect an upper level thermal trough. These two forces resulted in the formation of a CB, which raised the ceiling and visibility. Congratulations! You have arrived at the root cause of the weather event—the low-level jet and upper level trough with CAA.

034. Present the results

At this point you have all the data collected and reanalyzed, a good description on the state of the atmosphere, an event scenario, and know the root cause of the forecast scenario. Now it is time to present the results in a logical sequence leading to conclusions and lessons learned. Most weather units have a formatted forecast review worksheet. Quite often the weather units have different worksheets for minor or major reviews. A standard operating procedure outlines the procedures for documenting the review and the method for disseminating it throughout the unit.

Forecast study format is generally less regimented than forecast reviews. The format is generally left up to the author to choose. However, using the forecast review worksheet as a guide is good starting point to documenting studies. This lesson covers the general presentation procedures you can be expected to follow.

Synoptic description

Documenting the synoptic description is part of the presentation form. Briefly describe the synoptic situation prior to the valid time of the forecast. Key charts should be attached and referenced in this portion of the review or study. Ensure that the written description complements the charts. It is not necessary to describe the location of each feature when it can be readily seen on a map. For example: “A high pressure area with center located over Southeast Indiana was dominating the Scott AFB area.” This sentence, alone, is an adequate description. “A cold front extended from eastern Montana to central Nevada. Weak southerly flow existed throughout the Mississippi Valley.” The last two sentences are not necessary because they contain information readily apparent from the attached maps.

The purpose of the description is to provide an introduction and rough guide to synoptic classification. It should include a statement telling readers the synoptic or mesoscale regimes that are in effect. A regime statement paints a picture in the reader’s mind to the location of fronts, airmasses, and pressure systems. The statement provides a frame of reference that makes it easier for weather personnel to understand the subsequent comments and discussion.

Reasoning used

Provide a summary of the reasoning used when the forecast was prepared. These statements should summarize your forecast worksheet, with concentration placed on the key forecast guidance used. Attach a copy of the forecast worksheet and any other referenced products to the review. Examples include:

- Global forecast system (GFS) indicated strong PVA in the next 12 hours.
- National Weather Service (NWS) discussion bulletin indicated the low would move east.
- Weather research and forecast (WRF) model indicated pressure rises after 1800Z.

Including the original reasoning is important because it can indicate better ways to do the job as well as define any misinterpretations of existing guidance. Your investigation of the event has most likely indicated better reasoning that you could have used, but it’s crucial you remain open. No ridicule or adverse feedback will occur from any statements made. Many times a review is a learning device, for you and others. If you do not indicate your initial reasoning, then others cannot recognize when they are going down the wrong path.

Verification

In general, a summary of the forecast and the verifying observations or charts is required. This data will usually be in the form of attachments. You should attach copies of the forecast and observations. Include a copy of the event scenario you constructed earlier, this helps to relate the occurrence of events with their causes. In cases where the subject is timing of a synoptic control, such as a front or upper-level trough, include charts showing the extrapolated positions of the feature and verifying analysis.

Results

This discussion contains the results of the post-analysis, with emphasis on why the weather occurred as it did, and the factors responsible. In this section of the review you will present the root causes to the weather event. It may not always be possible to identify the real causes or to specify a foolproof way to prevent reoccurrence.

Nevertheless, a painstaking effort is required. When the causes of the weather that occurred are imperfectly known, the purpose of the forecast review is to help build a data base (several different descriptions of a forecast event) that can be used to improve the knowledge and understanding of the event.

Lessons learned

No review or study is complete without a summary of lessons learned, as well as suggestions, which could aid forecasters in future, similar conditions. This is the most important part of the documentation because this is the payoff for all your hard work. The bottom line is you are attempting to improve forecasting at your unit. Ideally, the best way to do this is by formatting suggestions in such a way that they are easily incorporated into unit procedures.

For example, a proper statement would be, “an analysis should be performed to determine 500 MB height falls in this synoptic regime.” This way if unit management approves your suggestion then you’re guaranteed future encounters will be met with your improved methods.

Figure 3–2 is an example of a forecast review; it deals with the weather episode you investigated when constructing an event scenario.
Discussing the synoptic description, forecast reasoning, verification, results, and the lessons learned should be considered the minimum standards for a forecast review. Your unit might have more rigorous documenting procedures that are tailored to its operating style. However, the steps to arriving at the point of documentation should be the same.

In summary, they are (1) compile the data, (2) construct an event scenario, (3) conduct independent verification of the data, and (4) present the results in a logical sequence leading to conclusions and lessons learned. These procedures should be generic to developing forecast reviews and studies. By contrast, the next lesson covers developing forecast seminars, which has a more varied method of preparation.

Name	***Forecast***	***Reason for the Review***
TSgt John Raincraft	***1212***	***Out of Category***
Synoptic Description Texas low synoptic regime existed as identified on surface chart (Atch 1). Warm front was located approximately 120 miles south.		
Forecast Reasoning Initial observation was a ceiling 3,000 ft and visibility 4 miles in fog (Atch 2). Warm front was approaching from the south at 5 knots, and southern stations were reporting low ceilings with reduced visibility in rain and fog (Atch 3). Forecast was for ceiling and visibility to lower to less that 1,500 ft and 1 mile by 1500Z as warm front moved closer. Rain was also forecasted at that hour the result of PVA, frontal overrunning, WAA, and moist air advection. The onset of rain would aid in the lowering of the ceiling by adding low-level moisture and evaporative cooling. The Conditions were stable SSI/LI were +5 (Atch 4) and radar indicated uniform tops at 20,000 ft (Atch 5), no convection was expected.		
Verification Forecast: By 1500Z SCT005 BKN012 OVC030 ¾ -RABR; By 1700Z BKN005 OVC012 ¾ -RABR (Atch 5) Observations: 1500Z SCT007 OVC012 ¾ -RABR; 1548Z SCT007 BKN012 OVC015CB ¾ -RABR; 1555Z SCT007 SCT012 BKN015CB OVC030 2 ½ -TSRABR (Atch 6)		
Results The ceiling and visibility raised out of category at 1555Z as a result of an embedded CB that moved on station. The updrafts associated with the CB raised the ceiling and visibility by incorporating all the low-level moisture vertically into the storm. And, turbulent mixing on the surface associated with the CB helped thin the fog out. The rapid overrunning of moist unstable air over the frontal boundary caused the embedded CB.		

At 1536Z radar indicated a low-level jet at 3,000 ft of 40 knots (Atch 7). Post analysis of the upper air charts indicated an upstream 500 MB thermal trough with CAA that was missed on the original analysis (Atch 8). Also, the 850 MB chart showed a 35 knot band of winds upstream in the warm sector (Atch 9). The air became unstable when the upper-levels cooled as a result of the trough, and then the stronger overrunning associated with the low-level jet formed an embedded CB.
Lessons Learned When making a forecast for overrunning conditions a careful analysis must be made for conditions that could result in the development of embedded convection. Recommend that statements be included on the overrunning regime checklist to perform an upper-level analysis for thermal troughing and other destabilizing features (such as dry air intrusions and upper-level diffluence). Also, recommend that the 850 MB command sequence be modified to show wind speeds equal to or greater than 35 knots in bright red. Also, for future episodes when confronted with the potential for embedded convection consider using a TEMPO condition for the occurrence of a thunderstorm. During this forecast period it's important to consider CB's effects on the ceiling and visibility.

Figure 3–2. Example of forecast review.

035. Developing a forecast seminar

Developing a forecast seminar is similar to developing a speech. Essentially, you're making an extemporaneous presentation to give to fellow forecasters. An extemporaneous presentation is one carefully prepared but delivered without extensive notes. The presenter will use an outline to help them flow from one idea to the next. The next lesson covers the five steps in making a forecast seminar. In order, the steps are the following: (1) research the subject, (2) support your ideas, (3) develop an outline, (4) construct audio-visual aids, and (5) set-up and present the seminar.

Research the subject

The first step in researching a subject involves determining what you already know about it before looking elsewhere. The topic of forecasting reviews and studies deal with some aspect of weather. Since you are a graduate of the weather forecaster apprentice course you may already have some of the information you need stored in memory. Personal knowledge may also suggest a tentative organization to your seminar. On the contrary, determining what you already know about the subject will point out gaps in your knowledge where you need further research.

The second step in the research process is to draw on the experiences of others. An excellent place to start is with people who have greater experience than you do in the weather field. Ideally, the best source of information is often an expert who can clarify your thinking, provide facts and testimony, and suggest sources for further research.

Your library can also provide you with valuable resources, such as newspapers, magazines, and encyclopedias. While these periodicals cover a wide variety of subjects, they do not usually cover a topic thoroughly as a book on the subject. Depending upon your subject and purpose, you may find one type of reference material more useful than another. In addition, it may not be necessary to physically go to the library for information; many libraries are posted on the Internet.

The Internet is a great medium for information of all types. The ability to perform searches using a search engine across the World Wide Web (WWW) is one of the most astounding features. Most likely you will receive thousands of hits in which to peruse for valuable information. However, a word of caution, just because it's on the net doesn't make something factual. Verification of the data through multiple sources increases the likelihood of the data's authenticity.

Remember to take careful notes; inexperienced researchers start organizing before they have enough facts. Effective research takes an extra effort to write down every idea that is related to the subject. As a result, you are able to review all the compiled information before you start organizing the seminar.

Support your ideas

Weak support is one of the principal reasons for a seminar to fail. During the seminar you present ideas and facts related to your subject. People are hesitant to believe what you say without backing up the information with credible support. There are five potential cures for weak support: examples, statistics, testimony, comparison and contrast, and explanation.

Examples

Examples are specific instances chosen to represent or indicate factual data. Good examples are appropriate, brief, interesting, and attention getting. Quite often they are presented in-groups of two or three for impact. An example would be, displaying PowerPoint slides that depict surface charts of a weather regime, from formation to end.

Statistics

Statistics are an excellent means of support if you keep them simple, and easy to read and understand. Remember to round off your statistics when possible and tell your audience the exact source of your statistics. An example would be displaying statistics on the number of thunderstorm days for each month of the year.

Testimony

Testimony is a means of supporting your opinion with the comments of recognized authorities. These comments can take the form of a direct quote or paraphrases, but direct quotations tend to carry more weight. As an example, you could say, "… the Director, National Hurricane Center said, 'the number of named hurricanes is anticipated at 45 this year.'"

Comparison and contrast

Use comparison to dramatize similarities between two objects or situations, and use contrast to emphasize differences. For instance, you could use this technique in a seminar on the East and West Gulf Lows to explain the similarities and differences between them.

Explanation

Explanation may be used in three ways:

Definition

This is simple explanation in understandable terms of what you are discussing.

Description

This is similar to "definition," but usually more personal and subjective.

Analysis

This is the division of your subject into small parts and discussion of the questions: Who? What? Where? When? and How? The acceptance of your information depends on the strength of your support material. Keep it simple, relevant, and accurate.

Develop an outline

Once you have the information gathered for the seminar through your research and developed strong support for your ideas it's time to make an outline. Most communication follows a three-part arrangement: introduction, body, and conclusion. The introduction must capture your audience's attention, establish rapport, and announce your purpose. The body must be an effective sequence of ideas. Finally, the conclusion must summarize the main points stated in the body and close the seminar smoothly. The whole process of developing an effective outline relies on staying focused on the main purpose of the seminar.

Determine your bottom line

Your purpose is your bottom "one liner." It is the message you are conveying to the audience. For instance, the purpose a forecast seminar may be to instruct fellow forecasters on a new forecast regime checklist. Therefore, every element of your outline should be focused at meeting that objective.

List your main and supporting ideas

Main ideas and facts represent the major divisions or points you expect to develop. They are so vital to your purpose that the omission of one would leave the seminar unbalanced. For example, you could be giving a seminar on supercell thunderstorms. Your main points may be divided into three principal characteristics of a supercell thunderstorm: mesocyclone, rear flank downdraft (RFD), and bounded weak echo region (BWER). Your supporting ideas would describe each one of these characteristics and what distinguishes them as a supercell feature.

Pick a pattern

Your next step is to select a pattern that enables you and your audience to move systematically and logically through your ideas from the beginning to the conclusion. Either your purpose or the nature of your material dictates the pattern of your seminar. Most forecast seminars are presented in three particular formats: topical, chronological, or geographical.

Topical pattern

This pattern presents the information in divisions based on key elements of the subject matter. A topical pattern of presentation often springs directly from the subject itself. For instance, a forecast seminar on forecasting precipitation may be divided in terms of forecasting liquid precipitation and frozen precipitation. In another example, you could arrange a seminar on the forecast duties in the weather unit according to day shift, swing shift, and night shift.

Chronological pattern

This pattern discusses events, problems, or processes in the sequence of time in which they take place or should take place. Chronological pattern is especially useful in presenting a seminar on a weather episode or frequent weather regime. This is because you would present the weather events associated with the episode or regime as they occur in chronological order. For example, giving a forecast seminar on the Texas Low regime that follows the system through its evolution in time.

Geographical pattern

This pattern is useful in weather because information may be divided in the presentation according to geographical region. For instance, you could use this pattern giving a forecast seminar on world ocean currents and arrange the information by the five oceans.

Construct audio-visual aids

The next step is to develop audio-visual aids that are attention getting and assist in getting your message across to the audience. It is not absolutely necessary to have audio-visual aids but without them your presentation can be dry. If you’re not a dynamic speaker, as few of us are, it can be difficult to keep your audience enthused for the whole course of the seminar. Audio-visual aids can help overcome your shortcomings as a speaker. However, words of caution–do not make audio-visual aids just for the sake of having them. Audio-visual aids should have a purpose.

The underlying purpose of audio-visual aids is to help you relay your message. To accomplish this they should be informative and centered around the most important information. Construct audio-visual aids with the most important topics of your seminar. Many times the audio-visual aids will display the key points of your outline. Then, you will communicate the remainder of the subject verbally to the audience. Besides having purpose, audio-visual aids must meet a certain standard of quality.

Quality audio-visual aids that gain the attention of the audience are appealing to the eye, easy to read, and appropriately timed in your presentation. Appealing to the eye means more than just using one-font, black and white slides. Try adding color to the presentation, and mixing the font and pitch for emphasis. Applying these techniques should also help the readability of the slide. However, readability does not only apply to being able to see the words but also understanding them. Your audio-visual aids should be thought provoking not mind numbing, so keep the words in easy to understand English.

Lastly, they should be appropriately timed in the presentation to avoid adding distracters for your audience. For instance, if you were giving a seminar on satellite interpretation and you kept all the photos out in the open it could be distracting. The audience may look at all the photos during the seminar and not pay attention to you. After you have your audio-visual aids developed, then you are ready to set-up for the seminar and give your presentation.

Set-up and present the seminar

It is approaching time for the unit meeting and your seminar is the first item on the agenda, after the operations superintendent's comments. You have all the material you need—an outline, audio-visual aids, and the knowledge of the subject—except you're missing a key part of the seminar process you must set the stage. "Setting the stage," means essentially preparing the room beforehand for the briefing. Imagine if you were watching a presentation where the speaker fumbled around on stage for 30 minutes trying to get computer equipment to work. More than likely you would be turned off as an effective listener. The same thing could happen to your audience if you don't have essential equipment prepared beforehand. Essential equipment includes lights, computers, audio-visual aids, and any other items you will need during the seminar. Also, if you have a degree of uncomfortableness speaking in front of people you may rehearse the seminar to get comfortable. Don't end up wasting all the time you spent developing the seminar by screwing up the delivery. Follow this advice and present an effective forecast seminar.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

031. Compile pertinent data

1. State the first step in accomplishing a forecast review.

2. What is the most important and urgent step in developing a forecast review?

3. What can happen if you wait too long before compiling data for a forecast review or study?

4. How can upper air charts help your review or study?

5. Is it necessary to verify the NWS analysis on the surface charts? Why?

6. How can MetSAT pictures be used in the review or study?

7. Is it helpful to look at the forecasts from other stations when accomplishing a review? Why?

8. How can a Skew-T diagram be used for a study or review?

032. Construct an event scenario

1. State the importance of conducting a reanalysis.

2. What analysis approach should be used to construct a logical three-dimensional description of the atmosphere?

3. Describe an event scenario.

033. Conduct independent verification of data

1. What is the purpose in investigating the potential causes of a weather episode?

2. How is the event scenario to be used in the process of independently verifying the data?

3. How may the process of determining the root causes to a weather event differ in the forecast review and study development?

034. Present the results

1. List the five general topical areas of a documented forecast review.

2. What is the purpose of the synoptic description?

3. Why is it necessary to include your original reasoning in the documentation of a forecast review?

4. What is the purpose of a forecast review if the causes of the weather are imperfectly known?

5. What is the most important section of forecast review?

6. What is the best way to format suggestions provided in the lessons learned?

035. Developing a forecast seminar

1. List the five steps in developing a forecast seminar.

2. What is the first step in researching a subject?

3. List the five potential cures for weak support.

4. Name the three-part arrangement that most communications follow.

5. Explain the topical pattern.

6. Explain the chronological pattern.

7. Explain the geographical pattern.

8. What is the underlying purpose of having audio-visual aids in a forecast seminar?

9. List some of the essential equipment you should set-up prior giving a forecast seminar.

10. What is the best way to overcome being uncomfortable speaking in front of people?

Answers to Self-Test Questions

029

1. An after-the-fact review of the observations, analyses, and forecast aids that were available to the forecaster. They are conducted to determine whether existing unit procedures were adequate, and identify ways to correct the forecast.
2. It is sometimes called an in-depth reanalysis. In the course of a forecast study, considerable effort is used to collect and present the data.
3. A presentation developed and performed by weather personnel for the purpose of giving or discussing weather information.
4. Any four of the following: Forecasts reviews and lessons learned, Climatology, TFRN changes, technical notes and manuals, terminal aerodrome forecast (TAF) worksheets, LAFP, observing procedures, Doppler radar operation, or meteorological satellite analysis.

030

1. To improve forecasting—plain and simple. They are not punitive. Instead, they are learning tools for the forecasters who prepare them and all who read them.
2. The reason for a forecast review will generally fall under four categories: (1) If, after a forecast evaluation, a forecast fails to meet satisfactory standards; (2) after a forecaster improperly follows forecast procedures; (3) after a forecaster issues an outstanding forecast or (4) after the occurrence of a significant weather event.
3. Case studies are generally written to thoroughly investigate a weather scenario, or test and develop new forecasting techniques.
4. To present weather information to unit personnel.
5. They will generally be presented at unit meetings. Presentation formats include the following: PowerPoint slides, hypertext markup language, and overhead slides.

031

1. Compile pertinent data.
2. Compiling pertinent data.
3. If you wait too long you may miss the opportunity to save and copy data before its purged from your weather systems.
4. Upper air charts will aid in determining the long wave and synoptic patterns that were in effect for the forecast.
5. Yes. Because the analysis needs to be checked for accuracy.
6. MetSAT imagery will be used to identify longwave location, jet support, cloud development, and general synoptic circulation.
7. Yes. Because you could find a unit's forecast for the event that was accurate and open a line of communication with them to get the information they used.
8. Skew-T will be used to show stability, clouds, icing, turbulence, and many more phenomenon.

032

1. To correct mistakes or to find features that were originally missed.
2. The forecast funnel.
3. It is a chronological list of weather events and their potential causes.

033

1. Each potential cause should be investigated to determine its contribution in the weather episode and eventually lead to the determination of which were chiefly responsible.
2. To investigate each of the potential causes to a weather episode and determined its contribution.
3. Developing a review requires you to determine the root causes that were missed in your original reasoning, while a study requires you to present all the causes of a weather episode in your documentation.

034

1. Synoptic description, reasoning used, verification, results, and lessons learned.
2. To provide an introduction and rough guide to the synoptic classification.
3. It can indicate better ways to do the job as well as define any misinterpretations of existing guidance.
4. To help build a database that can be used to improve the knowledge and understanding of the event.
5. Lessons learned.
6. To format suggestions is in such a way that they are easily incorporated into unit procedures.

035

1. Research the subject, support your ideas, develop an outline, construct audio-visual aids, and set-up and present the seminar.
2. Determine what you already know before looking elsewhere.
3. Examples, statistics, testimony, comparison and contrast, and explanation.
4. Introduction, body, and conclusion.
5. This pattern presents the information in divisions based on key elements of the subject matter.
6. This pattern discusses events, problems, or processes in the sequence of time in which they take place or should take place.
7. In this pattern the information in the presentation is divided according to geographical region.
8. To help relay your message.
9. Essential equipment includes lights, computers, audio-visual aids, and any other items you will need during the seminar.
10. Rehearse.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Extension Course Program Field Scoring Answer Sheet.

Do not return your answer sheet to Extension Course Program (A4L).

77. (029) What is a forecast review?
 a. A presentation developed to disseminate weather information to unit personnel.
 b. An in-depth reanalysis whereas considerable effort is used to collect and present the data.
 c. A before-the-fact review of observations, analyses, and forecast aids available to the forecaster.
 d. An after-the-fact review of the observations, analyses, and forecast aids that were available to the forecaster.

78. (029) What is the difference between a forecast study and a review?
 a. A study is required for significant weather events and a review for minimal ones.
 b. A study requires more work analyzing data and the information is documented at greater length.
 c. A review requires more work analyzing data and the information is documented at greater length.
 d. Information contained in a review may be hypothetical, but information documented in a study must be proven by scientific method.

79. (029) What is a forecast seminar?
 a. A written periodical issued monthly to unit personnel that covers new forecasting procedures.
 b. A presentation by forecasters in training to discuss unit procedures that are giving them the most difficulty.
 c. A presentation developed and performed by weather personnel for the purpose of giving or discussing weather information.
 d. An informal discussion given at station meetings in which unit forecasters are free to bring up points of conversation that interests them.

80. (030) What is the purpose of a forecast review?
 a. Improve forecasting.
 b. Punish forecasters for issuing bad forecasts.
 c. Ensure bad forecasts are documented for inspection purposes.
 d. Improve forecasting and punish forecasters for issuing poor forecasts.

81. (030) Forecast reviews will generally fall under the following four categories:
 a. forecast evaluation, failed to follow forecast procedures, outstanding forecast, and a significant weather event.
 b. forecast evaluation, outstanding forecast, a significant weather event, and operations involving one or more flying squadrons.
 c. forecast evaluation, network media worthy weather events, failed to follow forecast procedures, and outstanding forecast.
 d. forecast evaluation, failed to follow forecast procedures, agreement with civilian forecasts, and a significant weather event.

82. (030) What is a forecast evaluation?
a. The process of determining forecast accuracy against civilian forecasts.
b. The process of determining forecast accuracy against the observed weather.
c. A subjective determination of forecast accuracy accomplished by the unit commander.
d. A subjective determination of forecast accuracy accomplished by the operations superintendent.

83. (030) A review accomplished for failing to follow forecast procedures should include
a. a formal apology to the operations superintendent and unit commander.
b. the reason you didn't follow forecast procedures and why your methods were superior.
c. only the forecast procedures you failed to follow that resulted in a poor forecast evaluation.
d. the forecast procedures that were improperly followed, the consequences of those actions, and the procedures that you should have followed.

84. (030) Which would be useful for testing and developing new forecast techniques?
a. Forecast study.
b. Forecast review.
c. Forecast seminar.
d. Forecast evaluation.

85. (031) What is the *first step* in developing a forecast review or study?
a. Compile pertinent data.
b. Construct an event scenario.
c. Conduct independent verification of data.
d. Present the results in a logical sequence leading to conclusions and lessons learned.

86. (031) When accomplishing a forecast review or study, what type of meteorological model data should you compile?
a. The meteorological model your unit prefers.
b. All the meteorological models available to the forecaster.
c. The meteorological model data that supports your original forecast.
d. Meteorological model data should only be included in forecast studies, not reviews.

87. (031) Why is it important to scan forecasts from the surrounding area when accomplishing a forecast review or study?
a. To give credibility to your original forecast.
b. If more than 50 percent of the forecasts agree with your original forecast a review is not required.
c. If more than 75 percent of the forecasts agree with your original forecast a review is not required.
d. To search for accurate forecasts in an effort to open a line of communication with the responsible forecasters and get the information that led to their accurate forecast.

88. (032) The purpose of reanalyzing the compiled data is to
a. teach you to do it correct it the first time.
b. adjust the analysis to meet your findings.
c. make the charts look neat for the unit commanders review.
d. correct mistakes and find features that were originally missed.

89. (032) After reanalyzing the data for a forecast review or study, what analysis approach should be used to construct a logical three-dimensional description of the atmosphere?
a. Forecast funnel.
b. Mesoscale analysis.
c. Macroscale analysis.
d. Synoptic scale analysis.

90. (032) A chronological list of weather events and their potential causes would *best* define what?
    a. Storyboard.
    b. Event scenario.
    c. Event description.
    d. Observation fact sheet.

91. (033) How can the process of determining the root causes of a weather episode differ for a review versus a study?
    a. The root causes must have more substantial documentation in a review compared to a study.
    b. There is no difference between a review and a study in determining the root causes of a weather episode.
    c. Developing a review requires you to determine the root causes missed in your original reasoning, while a study requires you to present all the causes in your documentation.
    d. Developing a study requires you to determine the root causes missed in your original reasoning, while a review requires you to present all the causes in your documentation.

92. (034) In documenting a forecast review, the purpose of providing a synoptic description is to
    a. provide a thorough detailed description of the state of atmosphere.
    b. provide an introduction and rough guide to the synoptic classification.
    c. provide an introduction and background information to non-meteorologists.
    d. point out all the synoptic influences during the forecast period regardless of how readily apparent they are on the attached maps.

93. (034) When documenting a forecast review, why is it necessary to include your original reasoning?
    a. It is not necessary to include your original reasoning it is irrelevant to your conclusion.
    b. It can indicate better ways to do the job as well as define any misinterpretations of existing guidance.
    c. To clarify your reasoning to the unit commander for further punitive action that may be required.
    d. It can indicate better ways to do the job and assist the operations superintendent in determining if retraining is required.

94. (034) What is the purpose of a forecast review if the causes of the weather are imperfectly known?
    a. Weather is a science and the cause of the event should always be perfectly determined.
    b. To help build a database that can be used to improve the knowledge and understanding of the event.
    c. To document an attempt to improve the unit's technical health and preclude any adverse inspection findings.
    d. To forward the review to higher headquarters for their assistance in determining the responsible weather phenomena.

95. (034) What is the *most important* section of the documented forecast review?
    a. Results.
    b. Verification.
    c. Lessons learned.
    d. Synoptic description.

96. (035) Which is *not* one of the steps in developing a forecast seminar?
    a. Develop an outline.
    b. Support your ideas.
    c. Research the subject.
    d. Construct a manuscript.

97. (035) What is the first step in researching the subject?
    a. Gather information from published sources.
    b. Drawing from the experience of others is the first step.
    c. Determine what you already know before looking elsewhere.
    d. Determine what unit forecasters know before looking elsewhere.

98. (035) What is the three-part arrangement that *most* communication follows?
    a. Beginning, middle, end.
    b. Beginning, theme, conclusion.
    c. Introduction, body, conclusion.
    d. Introduction, theme, conclusion.

99. (035) What is the underlying purpose of having audio-visual aids in a forecast seminar presentation?
    a. To make the allotted time.
    b. To help relay your message.
    c. To keep the audience’s attention.
    d. To add excitement to your presentation.

100. (035) What is the *best* way to get over being uncomfortable speaking in front of people?
    a. Planning.
    b. Rehearsing.
    c. Vocalization.
    d. Silent reading.

Student Notes

Glossary of Abbreviations, Acronyms, and Terms

Abbreviations and Acronyms

AF	Air Force
AFCCC	Air Force Combat Climatology Center
AFW	Air Force weather
AFWA	Air Force Weather Agency
AFWKC	Air Force Weather Knowledge Center
AVN	aviation model
AWDS	automated weather dissemination system
AWDS	automated weather distribution system
AWRDP	automated weather regime dissemination program
BWER	bounded weak echo region
CAA	cold air advection
CB	cumulonimbus
CC	conditional-climatology
CCL	convective condensation level
CDD	cooling degree-days
CIS	Commonwealth of Independent States (formerly the USSR)
CONUS	contiguous United States
CSV	comma separated value
dBZ	decibel
DoD	Department of Defense
EL	equilibrium level
EMC	Environmental Modeling Center
ET	echo tops
EWD	engineering weather data
EuroTIPs	European Theater Meteorological Technical Information Program
GENS	global ensemble forecast system
GFS	global forecast system
GOES	geostationary operational environmental satellite
GSM	global spectral model
HDD	heating degree-days
HOMES	Huron, Ontario, Michigan, Erie, and Superior
HTML	hypertext markup language
ITCZ	intertropical convergence zone

LAFP	Local Analysis and Forecast Program
LAWC	local area work chart
LAWC	local analysis work chart
LLJ	low-level jet
LLWS	low-level wind shear
MB	millibar
MCC	mesoscale convective complex
MetSAT	meteorological satellite
MetTIPs	meteorological technical information program
MM5	mesoscale model, version 5
MODCURVES	modeled diurnal curves
MODCV	modeled ceiling and visibility
MSL	mean sea level
NAM`	North American mesoscale
NCDC	National Climatic Data Center
NCEP	National Centers for Environmental Prediction
NECZ	near-equatorial convergence zone
NEXRAD	next generation weather radar
NGM	nested grid model
nm	nautical miles
NVA	negative vorticity advection
NWS	National Weather Service
OCDS	operational climatic data summary
PacTIPs	Pacific Theater Meteorological Technical Information Program
PIREPS	pilot reports
POR	period of record
PVA	positive vorticity advection
RAFP	regional analysis and forecast program
RAOB	radiosonde observation
RAREPS	radar reports
RFD	rear flank downdraft
RH	relative humidity
RPS	routine product set
RUC	rapid update cycle
RUSSWO	revised uniform summary of surface weather observations
SOCS	surface observation climate summaries
SOP	standard operating procedure

SPCZ	South Pacific convergence zone
SSUAC	site-specific upper air climatologies
TAF	terminal aerodrome forecast
TFRN	terminal forecast reference notebook
UGDF	uniform gridded data fields
URL	universal resource locator
UTC	universal time change
VAD	velocity azimuth display
VIV	verification, initialization, and verification
WAA	warm-air advection
WRW	weather regime web
WSCC	winds stratified conditional climatology
WSR-88d	weather surveillance radar – 1988 Doppler
WRF	weather research and forecast model
WWW	World Wide Web
XML	Extensible markup language
Z	Zulu time

Terms

adiabatic process—A thermodynamic change of state of a system in which there is no transfer of heat or mass across the boundaries of the system.

advection—The process of transport of an atmospheric property (i.e., moisture, temperature, etc.) solely by the mass motion of the atmosphere.

angle of incidence—The angle at which a ray of energy impinges upon a surface.

anticyclonic—Clockwise rotation in the northern hemisphere, counterclockwise in the southern hemisphere.

baroclinic—When contours and isotherms are out of phase, advection is occurring and the atmosphere is described as baroclinic. In a baroclinic system, the axis tilts with height.

bounded weak echo region—Radar signature within a thunderstorm characterized by a local minimum in radar reflectivity at low levels which extends upward into, and is surrounded by, higher reflectivities aloft. This feature is associated with a strong updraft and can be detected on the WSR-88d radar.

Buys Ballot's law—Scientific law which states that "If you stand with your back to the wind, lower pressure will be to your left in the Northern Hemisphere." In the Southern Hemisphere, the relation is reversed.

climatology—The scientific study of climate.

condensation—The physical process by which a vapor becomes a liquid.

condensation nuclei—A particle, either liquid or solid, upon which condensation of water vapor begins in the atmosphere.

coriolis force—Created by the rotation of the earth that acts on any body moving above the earth's surface. This force causes objects in motion to be deflected to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.

cumuliform clouds—The principal characteristic in which clouds develop vertically in the form of rising mounds, domes, or towers.

cyclonic—Counterclockwise rotation in the Northern Hemisphere, clockwise rotation in the Southern Hemisphere.

diurnal—Daily.

downdraft—A small-scale column of air that rapidly sinks toward the ground, usually accompanied by precipitation as in a shower or thunderstorm.

evaporation—The physical process by which a liquid is transformed into a gaseous state.

extrapolate—To predict by projecting past experience or known data.

extrapolation—Forecasting a weather pattern feature based solely on recent past motions of that feature.

gradient—Denotes the magnitude of the winds of a horizontal pressure field. Normally, the tighter the spacing of the isobars or contours, the stronger the wind speeds. Conversely, the less tight the isobars or contours are, the weaker the wind speeds.

high zonal index—Upper-level flow characterized by a strong west to east flow.

hygroscopic—Pertaining to a marked ability to accelerate the condensation of water vapor.

inversely—Directly opposite.

inversion—In meteorology, the departure from the normal decrease of temperature with altitude. Instead of the temperature normally decreasing with height, it increases.

isallobar analysis—Analyzing lines of equal pressure change.

Karr pattern—Mesoscale regime that commonly occurs in the northeast US ahead of advancing polar fronts, typically associated with Colorado or Texas Lows. Dense morning stratus and fog is common in the early morning, and in most cases thunderstorms prevail throughout the evening.

lapse rate—The amount of change in temperature with height. If the temperature decreases with height through a region, it is said to have a positive lapse rate. If the temperature increases with height through a region, it is said to have a negative lapse rate.

leeward—The side or part away from the wind.

long wave—A wave in the major belt of westerlies which is characterized by large length and significant amplitude. Long waves are classified as barotropic.

low zonal index—Upper-level flow characterized by a north to south flow.

macroscale systems—The largest systems dealt with in forecasting. These systems cover more than 1,500 nautical miles (nm), and their duration is from several days to over a week. Macroscale systems include long-waves, semipermanent cyclones and anticyclones, and seasonal circulations.

meridional flow—Flow parallel to the meridians (longitude lines).

mesocyclone—A storm-scale region of rotation, typically around 2-6 miles in diameter and often found in the right rear flank of a supercell.

mesoscale—Scale for weather systems that vary in size horizontally from 1 to 500 nautical miles and have a duration from tens of minutes to several hours.

mesoscale system—Vary in size from 1 to 500 nm and are considered "local effects." They last from tens of minutes to several hours. Examples of mesoscale systems are squall lines, thunderstorms, tornadoes, and land/sea breezes.

microscale—Smallest scale weather systems that have a duration from a few seconds to a few minutes and have a horizontal extent of generally less than 1 nautical mile.

millibar—One one-thousandth of a bar; equal to the force of 1,000 dynes per square centimeter.

nephanalysis—Analysis of the field of cloud cover and/or type.

nocturnal—Pertaining to, or occurring in the night.

occlusion—A composite of two fronts, formed as a cold front overtakes a warm front.

orographic lifting—Lifting due to mountainous or "hilly" terrain.

polar-front jet—Jet stream that is associated with the polar front of the middle and upper-middle latitudes.

rear flank downdraft—A region of dry air subsiding on the backside of, and wrapping around, a mesocyclone.

semipermanent systems—Areas of high pressure and low pressure that tend to persist at a particular latitude belt throughout the year.

short wave—A progressive wave in the horizontal pattern of air motion that moves in the same direction as the prevailing basic current in the troposphere. Short waves are classified as baroclinic.

stratiform clouds—Clouds that have extensive horizontal development, as contrasted to the vertically developed cumuliform clouds.

stratus—A principal cloud type in the form of a gray layer with a rather uniform base.

sublimation—The transition of a substance from the solid phase directly to the vapor phase without an intermediate liquid phase.

subtropical jet stream—Jet stream that is located south of the polar front jet stream and is normally observed between 25°N and 30°N extending from the Hawaiian Islands eastward to southern Florida.

supercell—An enormous severe thunderstorm whose updrafts and downdrafts are nearly in balance, allowing it to maintain itself for several hours. It can produce large hail and tornadoes.

symmetrical—Correspondence of opposite parts in size, shape, and position.

synoptic scale—The scale of the migratory high and low-pressure systems of the lower troposphere, with wavelengths of 1,000 to 2,500 km.

terrestrial—Of the earth.

thickness—A type of synoptic product showing the thickness of a certain physically defined layer in the atmosphere (i.e., 1,000 to 500 mb thickness product).

topographical—Term often used to denote elevation characteristics particularly orographic features.

transpiration—To give off vapor or moisture.

updraft—A small-scale current of rising air. If the air is sufficiently moist, then the moisture condenses to become a cumulus cloud or an individual tower of a towering cumulus or cumulonimbus.

veering winds—A change in wind direction in a clockwise manner with height.

wind shear—The local variation of the wind vector or any of its components in a given direction.

zonal—In meteorology: latitudinal; easterly or westerly, opposed to meridional.

Student Notes

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