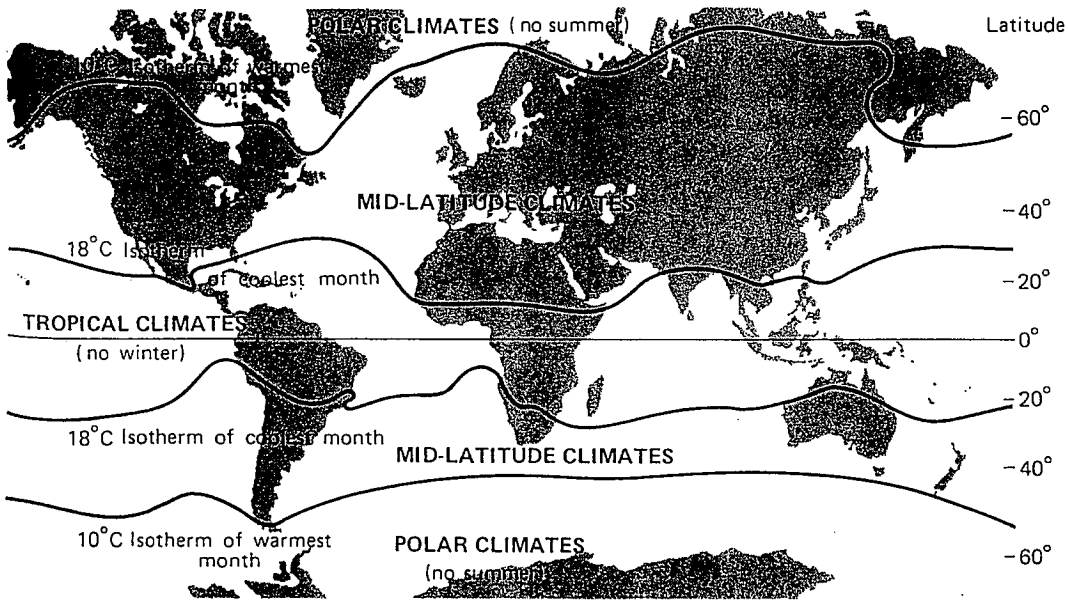
Teacher Background Information: Earth's Climate

When talking about climate, we are referring to the average weather conditions in a region over a period of many years. The two conditions used to describe climate are temperature and moisture: hot, dry deserts, hot, steamy rain forests and cold, snowy polar climates. Since these are the primary factors describing climate, most climate classification systems begin by breaking the Earth's surface into zones according to temperature and moisture patterns.

I. Temperature Patterns and Climate:

To describe the temperature characteristics of a region the average monthly and yearly temperatures must be known. Temperature range is another useful piece of information and is the difference between the warmest average temperature and the coldest average monthly temperature. Average temperatures are highest near the equator and decrease as latitude increases. This information is used to classify climates by dividing the Earth into temperature zones by latitude.



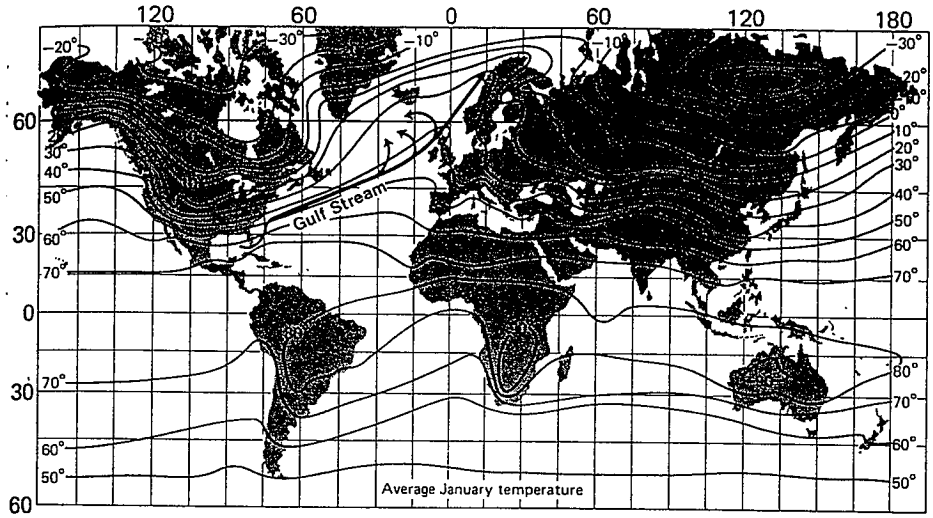
Latitudinal Climate Belts of the World

- The boundary of the cold zones around the poles has been set by places where the average temperature of the warmest month is 10 *C. The line through these places is the 10* C isotherm for the warmest month (July in the Northern Hemisphere and January in the Southern Hemisphere). Average monthly temperatures along this line are never higher than 10*C and at higher latitudes are even colder. These regions are in the **polar climate zone**, in which there is essentially no summer.

- The boundary of the **tropical climate zone** around the equator has been set by temperatures for the coldest month. The 18*C isotherm for the coldest month (January north of the equator, July south of the equator) has been selected. Average monthly temperatures inside this zone are never lower than 18*C and locations there have no winter.

- The zones between the polar zones and the tropical zones are in the mid-latitude climate zone. In these areas there is generally a definite winter and summer.

In drawing the isotherms that are the boundaries of climate zones, the effects of elevation have not been included. The temperature patterns are those that would be found if all the land areas had elevations near sea level. In reality, there are places within the tropical zone that have mid-latitude temperatures, or even polar temperatures because of their high elevations.

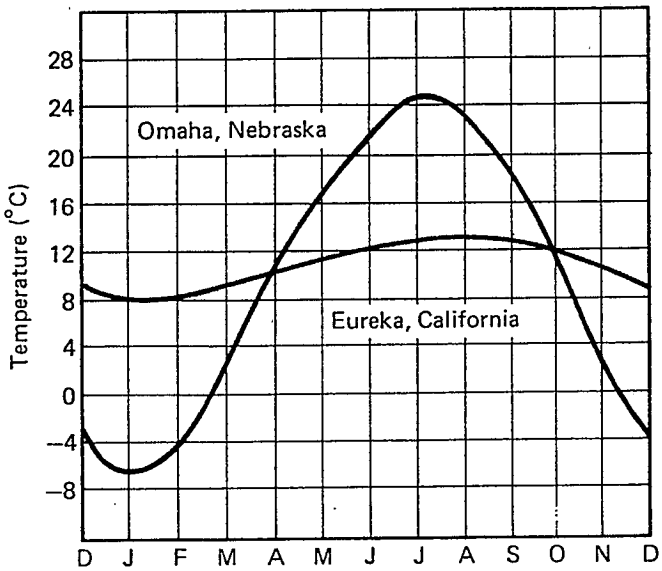


Average global temperatures for January

II. Moisture Patterns and Climate:

A classification of climate based on temperature alone gives only half the picture. It may be helpful to know that a certain area has a tropical climate, but it would be just as helpful to know that it is a desert or a rain forest. Information about moisture must be included for a truly useful picture of any climate

When trying to classify climates according to moisture conditions, it is necessary to consider the *water budget* of the region. The water budget indicates not only how much *precipitation* a region receives, but also how this compares with the natural demand for water - *the potential evapotranspiration.* Two areas may have the same amount of annual precipitation: 500 mm. But one may have tropical temperatures, with a high rate of evapotranspiration - 1000 mm. This area would be considered to have a dry climate - less rainfall than it could use. Another area may have a cold climate, with a potential evapotranspiration of only 250 mm. This area with the same precipitation as the other, would be classified as a wet climate- more water than it can use.



Average monthly temperatures for two cities, both at 41*N latitude

To describe the moisture side of climate, the ***P (precipitation received)*** with the ***E_p (Evapotranspiration potential)***. One way to do this is to express the comparison as a ratio ***(P/ E_p)***. When potential evapotranspiration is greater than yearly precipitation, the ratio is less than 1. When precipitation is greater than evapotranspiration, the ratio is greater than 1. Regions in which P/E_p is much less than 1 are said to have *arid climate*. Where the P/E_p ratio is more than 1, the region is said to have a *humid climate*. Intermediate readings are classified as *semi-arid or sub-humid* climates. A region need not have a great deal of precipitation to be classified as humid. The yearly precipitation rate could be low, but if E_p is lower, the climate would still be lower. The table below shows one system for classifying climates according to P/E_p ratios.

Classifying climate types

P/ Ep	Climate type
Less than 0.4	Arid
0.4 - 0.8	Semiarid
0.8 - 1.2	Subhumid
Greater than 1.2	Humid

Here are two examples using this system:

Example #1: Reno, Nevada

P= 193 Ep =628

P/Ep = 193/628 = 0.3

Climate type: **Arid**

Example #2: New Brunswick, NJ

P = 1183 Ep= 693

P/Ep - 1183/693= 1.7

Climate type: **Humid**

III. Factors affecting Climate Patterns:

The climate of a region is determined by a number of different factors:

- **Latitude** - Latitude is the distance north or south of the equator and is the single most important factor in determining the average monthly and yearly temperatures, as well as the yearly temperature range of a region. (The intensity and duration of insolation received at the Earth's surface varies with latitude; the temperature of a region is dependent on insolation.)

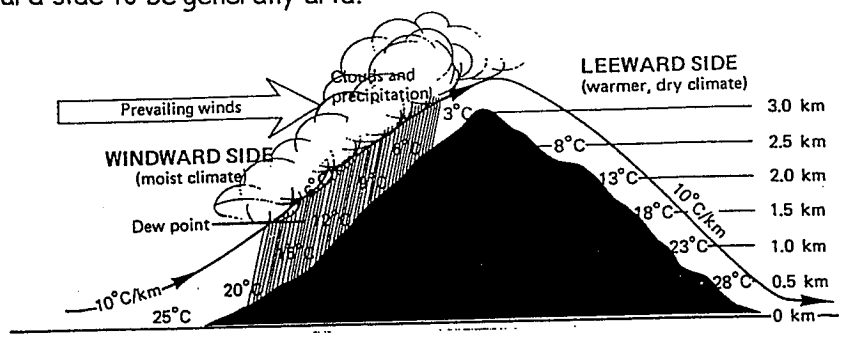
    - **Low latitudes:** angle of insolation and the duration are high throughout the year (12 hours); resulting in high average yearly temperatures and very little variation in temperature.
    - **Mid-latitudes:** angle and duration of insolation is high in the summer (15-16 hrs. daily) but low in the winter; resulting in generally warm summer temperatures and low winter temperatures.
    - **High latitudes:** low angle of insolation in summer, but the Sun shines almost continually; zero for most of the winter; resulting in very low temperatures in winter, but moderating in summer;

- **Elevation**- Because air expands and cools as it rises, elevation (altitude) modifies the climate in the same way as increasing latitude does; as elevation increases, temperatures decrease (10*C/ km); also affects precipitation patterns as air temperature and saturation vapor pressure decrease with increasing altitude; areas of higher elevation generally receive more precipitation than nearby areas at lower elevations;

- **Large Bodies of Water**- Because bodies of water heat up and cool off more slowly than land, lakes and oceans modify the climate patterns shore regions (marine climate) so that they have warmer winters and cooler summers than areas inland (continental climate) and show a narrower annual temperature range than continental climates.

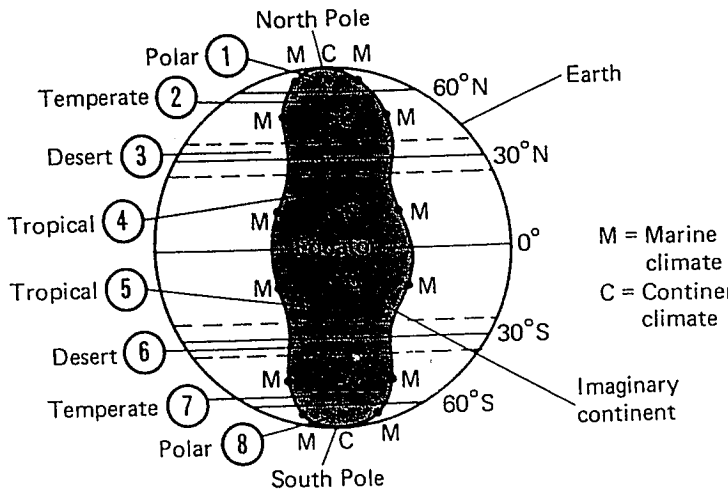
- **Ocean Currents**- The climates of many coastal regions are modified by ocean currents, which can either be warm or cold . For example, some of these current like the Gulf Stream, flow away from the equator to higher latitudes, bringing warmer water and raising the average temperatures of the coasts and islands they pass near (Great Britain and Scandinavia). Others are cold currents (California Current) flowing from higher to lower latitudes, and having the oppostie effect on latitudinal climate patterns.

- **Mountains-** Mountains act as barriers to prevailing winds producing an *orographic effect*. The side of a mountain hit by a prevailing wind is called the *windward side*, the opposite side of the mountain is called the *leeward side*. As air hits the windward side, it is forced to rise, undergoing *adiabatic cooling*. If it cools sufficiently, condensation will occur, clouds form and precipitation occurs; the windward side of the mountain will have a cool, humid climate. On the leeward side, the descending air undergoes *adiabatic warming*, causing it to be warmer than the air on the windward side. Almost all of the moisture will have been lost from the air on the windward side, causing the leeward side to be generally arid.



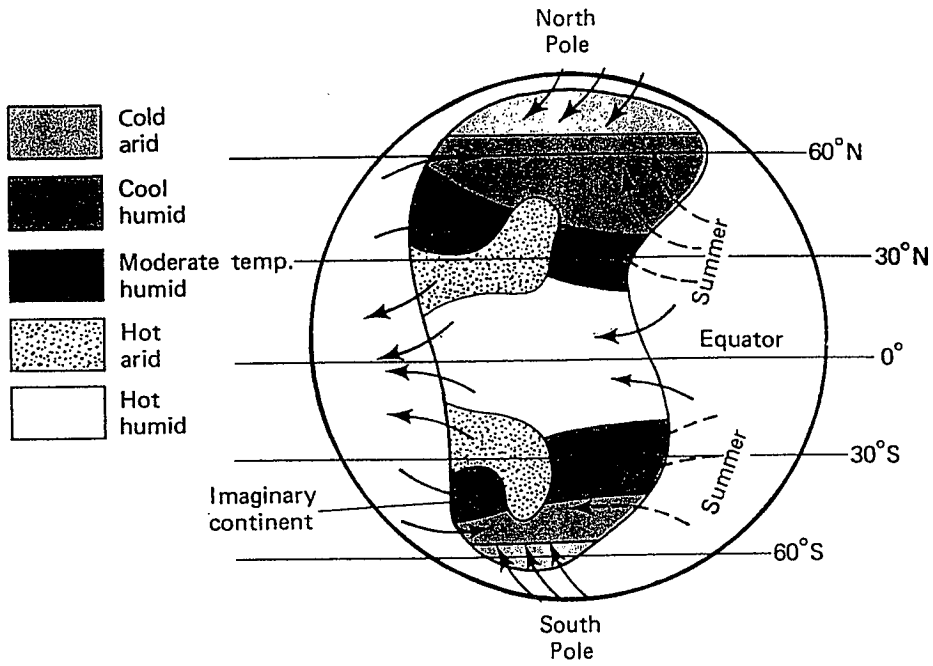
The Orographic Effect

- **Planetary Wind Belts-** The general pattern of atmospheric circulation produces a belt of low pressure around the equator and belts of high pressure at latitudes around 30*N and 30*S, with belts of prevailing winds on either side of these. Rising, low pressure air near the equator results in high precipitation, and high temperatures. In the high pressure areas around the 30*latitudes, the air is generally dry and warm. In the higher latitudes the air generally is more humid with temperatures decreasing as latitude increases. These patterns can be modified by the continental land masses because of the tendency of the land to heat up and cool off to a greater extent than the water, resulting in large scale convection currents between the land and the water which disturb the normal wind patterns. For example, as you move eastward across a hypothetical continent, the arid belt that is expected at around 30* latitudes shifts to higher latitudes and is then cut off, while the humid zone is extended to the lower latitudes in the eastern portions of the continents. This is typical of what happens in the desert climate of the southwestern U.S. (New Mexico/ Arizona) and the humid climate of the southeastern states (Georgia/Alabama) .



CLIMATE TYPE			
Polar	Temperate	Desert	Tropical
Cold, arid, with large temperature variation	Moderate temperatures, humid, with moderate temperature variation	Hot, arid, with moderate temp. variation	Hot, humid, with little temperature variation
1,8	2,7	3,6	4,5

Basic latitudinal climate pattern on an imaginary continent



Modification of a basic climate pattern by prevailing winds-

Notice that the arid belts around 30* latitude do not extend across the eastern regions of the continent. One reason for this is that the heating of the landmass during the summer produces convection currents that draw moist air over the land from the oceans on the east, making the climate more humid. Note also that the central regions of the continent in the mid-latitudes are arid. The reason for this is that the westerly winds in those latitudes have lost most of their moisture as precipitation over the western regions of the continent. High summer temperatures in the central regions also lower the relative humidity and with it the chance of precipitation.