Chapter 11 Study Guide and Case Studies: The Atmosphere, Weather and Climate

Key Concepts

- Climate describes the long-term average weather conditions at a particular location, while weather describes a short-term anomaly in the atmospheric condition typical of a location.
- The two main factors controlling climate on Earth are insolation (the amount of sunlight received) and the albedo (the fraction of sunlight reflected back to space).
- The insolation depends largely on latitude, but cloud cover can reduce it locally.
- Areas near the equator receive a surplus in insolation, while polar regions have a deficit. This imbalance drives poleward heat transfer, in the atmosphere as well as in the oceans.
- At the top of the atmosphere, Earth receives and reradiates the equivalent of 342 W/m^2 of energy. Absorption and radiation of energy at Earth's surface is also in balance though the surface emits more IR radiation than it receives.
- The tilt of Earth's rotation axis and the location of the axis along Earth's orbit around the Sun determine the seasons at a particular location. The Northern and Southern Hemispheres are at the opposites in the seasonal cycle, i.e. it is summer in the Southern Hemisphere when it is winter in the Northern Hemisphere.
- Astronomical seasons lead the calendar seasons by 1.5 months, i.e. the summer solstice at the peak of the astronomical summer coincides with the calendar start of summer.
- The position of the Sun in the sky at noon changes with the seasons. It is highest at the summer solstice when the Sun is directly above at 23.5º latitude.
- The climate at a particular location is determined not only by the latitude of a location but also by altitude, proximity to water, proximity to warm and cold ocean currents, proximity to orographic barriers, proximity to high- and low-pressure zones.
- Oceans act as climate moderators. They slow both heating and cooling of the atmosphere and Earth's surface compared to areas inland.
- Oceans absorb not only heat and so slow the current heating of the atmosphere. Oceans also absorb CO_2, thereby slowing the increase of the greenhouse effect. At the same time, oceans acidify which may have a negative impact on marine life.
- Earth's atmosphere is mainly composed of nitrogen (78%) and oxygen (21%) with other components present only in trace amounts (such as argon and greenhouse gases).
- Water vapor is the most dominant greenhouse gas in Earth's atmosphere but the increase in CO_2 and CH_4 cause current global warming.

- Earth's atmosphere is transparent to visible light but greenhouse gases trap IR radiation, thereby keeping Earth's surface 34ºC (61ºF) warmer than it would be without the greenhouse effect.
- The relative contribution of a process to global warming or cooling is called radiative forcing.
- The density and of Earth's atmosphere decrease exponentially with increasing altitude. The air pressure at the surface is 1013.25 mbar or 14.7 PSI or 1 atm, which is also referred to as the standard atmosphere.
- The temperature in the atmosphere varies greatly with increasing altitude. The naming of layers approximately follows this variation. The bottom 10 km make up the troposphere which is located below the stratosphere, mesosphere and thermosphere.
- Most clouds and weather form in the troposphere, while the ozone layer that protects Earth's surface from harmful UV radiation is in the stratosphere.
- The relative humidity in the air describes how much moisture (in form of water vapor) the air contains relative to the saturated state. In the saturated state, the air contains the maximum amount of water vapor it can contain in its current condition. Any increase in water vapor leads to condensation.
- The dew point is related to the relative humidity in air and determines how low the air temperature can potentially fall with current conditions before condensation takes place. Frost can occur when the dew point falls below freezing. The broadcast of dew point predictions helps farmers decide if they have to protect frost-sensitive crop.

Key Terms

- climate
- weather
- insolation
- albedo
- heat transfer
- electromagnetic waves
- UV radiation
- IR radiation
- astronomical seasons
- climate zones
- latitude
- altitude
- orographic barriers
- glaciation
- climate moderator
- Gulf Stream
- California Current
- ocean acidification
- aerosols
- greenhouse effect
- radiative forcing
- atmospheric layers
- atmospheric pauses
- aurora (borealis and australis)
- absolute and relative humidity
- saturated air
- dew point
- latent heat
- frost
- Köppen climate classification

Questions for Review

1. What is the principal different between weather and climate?
2. Describe the impact of insolation and albedo on Earth's surface radiation.
3. How do absorbed and emitted radiation relate near the equator vs the poles?
4. Why does Earth have seasons?
5. Describe the location of the Sun in the sky throughout the year at the following locations: Quito, Ecuador; Miami FL; San Diego, CA; Bangor, ME; Fairbanks, AK; Lima, Peru; Adelaide, Australia; Johannisburg, S. Africa.
6. What factors control the climate of a particular location?
7. Describe the climates at the following locations: Quito, Ecuador; Miami FL; San Diego, CA; Bangor, ME; Fairbanks, AK; Lima, Peru; Adelaide, Australia; Johannisburg, S. Africa
8. Contrast the climate of San Diego, CA with that of New York, NY and Colorado Springs, CO.
9. Describe the function of the oceans as climate moderators.
10. What are the major constituents of Earth's atmosphere?
11. What is the standard atmosphere?
12. Describe the greenhouse effect.
13. What is radiative forcing?
14. How does air pressure change with altitude?
15. How does temperature change with altitude?
16. What are the atmospheric layers?
17. Which atmospheric layer contains the ozone layer?
18. Which atmospheric layer is also called the "weather layer"?
19. Explain the concept of absolute and relative humidity.

20. How does the relative humidity in air relate to the range in daily temperatures?

21. How do citrus farmers protect their crop in extremely cold nights?

Case Studies

Case Study 1: The 2007 Western U.S. Freeze

In January 2007, an Arctic low pressure system dipped unusually far west, causing record low temperatures in the western U.S. from Washington to Southern California. The preceding December had brought unusually heavy rain to Washington and Oregon but extremely dry conditions and unusually warm weather with little cloud cover to Southern California. With little moisture in the air, the dew point was very low. Then the Arctic air moved in. Thermometers in the San Joaquin Valley, CA began to drop on January 11, and a day later in Southern California. In Los Baños in the San Joaquin Valley the temperature reached 21ºF (-6.1ºC) on 14 and 15 January (Fig. C11.1), causing major damage to frost-sensitive crops such as citrus, avocados, some flowers and also strawberries. On 17 January, snow fell in Malibu and West Los Angeles, something that is extremely rare. The temperature on 14 January dropped to only 36ºF (2.2ºC), a record for that day. Temperature lows in San Diego also dropped to 36ºF (2.2ºC) and 35ºF (1.7ºC) on consecutive days. Palm trees and other tropical plants died. The total damage to crops in California (mainly the San Joaquin Valley) was estimated at a staggering $1 billion and Governor Schwarzenegger requested federal disaster aid. In San Diego county, the January freeze caused nearly $115 million in crop damages. Losses were particularly high for lemons (> 30%), and most costly for avocadoes ($38 million) (Fig. C11.2).

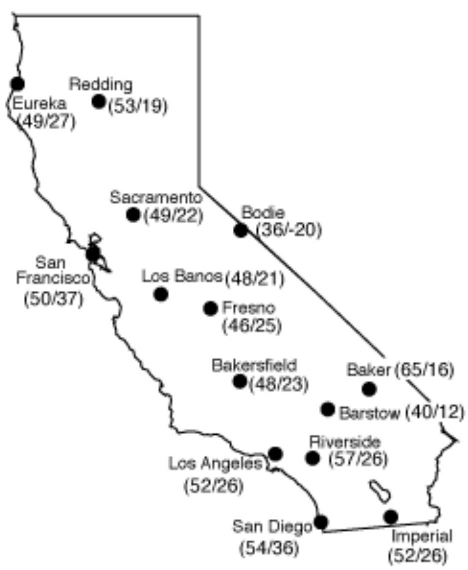

Figure C11.1 Daily high and low temperatures in California on 14 January 2007

Figure C11.2: Avocado damaged by the January 2007 freeze. (source: S.D. Union Tribune)