Lecture Thirteen
Weather on Other Worlds

Scope: Even the most extreme weather on Earth pales in comparison to the truly astronomical storms found on worlds elsewhere in our solar system. The peaks of heat and depths of cold on our planet are merely average temperatures on other worlds. The forecast on Venus calls for 900° temperatures, constant cloudiness, and a 100% chance of sulfuric acid rain. On Mars, robotic explorers have been caught in planetwide dust storms that last for months. Giant storms that are larger than our entire planet have been raging on Jupiter for centuries. Our complaints about climate seem downright pathetic after exploring the causes and effects of the worst weather known to science.

Outline

I. Temperatures across the solar system extend well beyond the range on Earth.

- **A.** Temperatures on Earth can be understood in terms of the amount of sunlight.
  1. Temperature decreases with latitude, as more sunlight, on average, hits the equator.
  2. The tilt of Earth's axis of rotation produces the seasons during Earth's orbit around the Sun. It is a common, and wrong, idea that Earth's distance from the Sun creates seasonal change.
  3. Even the extremes of temperature in the Sahara (136°F, or 58°C) and the Antarctic (−129°F, or −89°C) can be withstood by life.
- **B.** The thin Martian atmosphere leads to relatively cool high temperatures during the day (0°C to 25°C) and absolutely frigid lows at night (around −75°C).
- **C.** Mercury is close to the Sun, rotates slowly, and has no atmosphere; all of which contribute to the greatest range of temperatures in the solar system (400°C daytime, −180°C nighttime).
- **D.** Due to its thick atmosphere and cloud cover, Venus's temperature is globally constant and extremely high, at about 475°C.
- **E.** The small bodies of the outer solar system receive very little solar energy, have no significant atmospheres, and have temperatures lower than −200°C.

II. Across the solar system, precipitation occurs for several different substances.

- **A.** Earth's extensive oceans dominate its weather.
  1. The hydrologic cycle on Earth consists of evaporation of water into the atmosphere; condensation of water vapor into clouds; and precipitation of rain, sleet, and snow.
  2. Coal-burning power plants release sulfur dioxide into the atmosphere that precipitates out in acid rain.
- **B.** In Venus's middle atmosphere, it is constantly raining sulfuric acid, though it evaporates before reaching the surface.
- **C.** Saturn's moon Titan shows what appear to be lakes and seas of liquid methane as well as evidence of a hydrologic cycle based on methane.

III. Storms are relatively common and can show tremendous power and longevity.

- **A.** Storms on Earth are associated with the seasons. We have summer thunderstorms, and the Atlantic hurricane season goes from late summer to early fall.
- **B.** The giant planets have giant oval storms.
  1. The Great Red Spot on Jupiter is a storm that is larger than Earth and has lasted for hundreds of years.
  2. Astronomers recently witnessed, for the first time, the merging of white ovals to create a smaller red spot on Jupiter.
  3. Saturn can appear rather bland in visible light from Earth, but it reveals many storms when viewed close-up and in infrared light.
  4. Major disruptions in Saturn's atmosphere occur about every 30 years and are as yet not well explained.
  5. The Great Dark Spot on Neptune seen by Voyager 2 had dissipated by the time Hubble observed the planet five years later.
  6. It appears that "storm seasons" exist on Neptune and that they can last for decades because of Neptune's 165-year orbital period.

IV. Dust storms can have both local and global effects.
   A. Earth's dust storms may be gigantic to humans but are generally localized on the planet.
      1. The desert areas of Earth can give rise to giant dust storms.
      2. Dust that is lifted high in the atmosphere can circulate widely and affect weather across oceans and around the globe.
   B. Planetwide dust storms on Mars have been observed many times.
      1. Mars's thin atmosphere allows local disturbances to grow into global systems.
      2. Surface missions to Mars have had to contend with months-long dust storms.

V. From an interplanetary perspective, Earth's most extreme weather is rather mild.
   A. The extremes of temperature in the solar system extend well beyond what humans could withstand.
   B. Giant storms on other planets dwarf our most powerful maelstroms.
   C. It is not a coincidence that Earth's weather is the most hospitable to life.

Suggested Readings:

Beatty, Petersen, and Chaikin, *The New Solar System*, chaps. 13, 15.

Bennett, Donahue, Schneider, and Voit, *The Cosmic Perspective*, chap. 10.

Benson, Michael. *Beyond: Visions of Interplanetary Probes*.

De Pater and Lissauer, *Planetary Sciences*, chaps. 3–4.

Hey, *Solar System*.

McFadden, Weissman, and Johnson, *Encyclopedia of the Solar System*, chaps. 7, 9, 15, 20, 25.

Questions to Consider:

1. As the Sun grows older, it will also get hotter, and Earth's temperatures will slowly increase over billions of years. How far do you think life will be able to adapt to hotter temperatures?
2. What sources of energy are available to power such large and long-lived storms as the Great Red Spot on Jupiter?

3. Uranus is tilted on its side such that each pole sees about 40 years of sunlight followed by about 40 years of darkness. How do you think that orientation affects its weather?