Lesson II. Satellite Images from the Space Shuttle

In this program, students will learn how man-made satellites are used to provide images from space. These uses include: cartography, water turbulence, and tide reporting and tracking.

Key words: *AVHRR, Atmosphere, False Color Image, NASA, JPL, and Shuttle Image Radar*

General Discussion

The most obvious ocean boundary is between land and sea. From whatever vantage point – land, sea, air or space – coastlines encompass such a variety of forms that they have always intrigued the viewer. From space, the shores of the ocean offer scenes and provide information not available to Earth-bound investigators. It is fortunate, therefore, that astronauts have taken the opportunity to acquire many photographs of the land-sea boundary.

There are some 440,000 kilometers of coastline around the landmasses of the world. In 1980, the United Nations estimated that two-thirds of the world's population lived within a few kilometers of the sea. Though such a percentage may at first boggle the mind, it is probably a significant decrease from the percentage of coastal populations in all the preceding millennia of human history.

With the growth of transportation, communications, engineering, and modern agricultural practices, many inland areas can support habitation that was impossible only a few decades ago. Consider, furthermore, the fact that tens of thousands of kilometers of coastline are not habitable, such as those in Antarctica, Tierra del Fuego, Greenland and the Arctic coasts of Canada and Siberia. For most of human history, much of the population has crowded the world's coasts.

There are an innumerable variety of shapes of coasts. They have vistas and forms that have stirred the emotions and piqued the interest of humans from the earliest times: the stately

White Cliffs of Dover; the awe-inspiring grandeur of the fjords of Norway, Chile, and New Zealand; the brilliant heights of the Cote d'Azur; the muddy marshes of the Mississippi, the Irawaddy and the Yangtse; the dunes of the Red Sea, Brazil, and the Diamond Coast of southwest Africa; and the coral sands of Tahiti, the Bahamas, Tarawa, Waikiki and Funafuti.

About half of the world's coastline has cliffs. To those who live along the coastal plains of the Gulf of Mexico or Bangladesh, or beside the North Sea shores of Germany and the Netherlands, coastal cliffs may be difficult to imagine. On the other hand, the inhabitants of Scotland, Norway, Italy, New Zealand, and Alaska might wonder, "What other kinds of coasts are there?"

As spectacular as the great sea cliffs seem, from space they cannot compare with the splendor of the estuaries, lagoons, and deltas that grace the shores of the world. All are coasts of deposition, where the land is winning from the sea, in contrast to the cliffed coasts, where soil is not deposited.

Around the world, these coastal depositional features present themselves in an endless parade of shapes, colors, and sizes: the Ganges; the Yangtse; the red Rio de la Plata; Cook's Botany Bay; the braided Betsiboka estuary; cuspate bars in Lagoa de Patos and the Po Delta, expanding its sands to protect that pearl of all cities, Venice. Each of these impressive coasts has its place in history, and each has been created in the last 6,000 years.

Source: **http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/OCDST/shuttle_oceanography_web/oss_4.html**

Human Observation of Oceanographic Phenomena from Space

The sun's reflection from the surface of the sea, referred to as sun glitter, has proven to be the most valuable tool in the visual observation of the ocean from space. Not only can the fine details of near-shore turbulence be examined, but it is the only method by which dynamics in the open ocean and around islands can be seen.

In the golden center of the sun's reflection, a smooth sea surface reflects brighter than a sea roughened by waves. The sun is reflecting directly to the observer as it would from a mirror. This "forward reflection" permits observing and photographing the ocean's surface.

Sea slicks, or water moving with the wind reflect brightly, whereas water flowing against the wind, producing choppy waves on the surface, has a diffuse, dull reflection. Not only are these reflective differences easily seen, but they photograph well. They have been recorded also by weather satellites and **synthetic aperture radar**.

On the edge of the sun's reflection, the golden colors change to blues. In this part of the glitter pattern, smooth water has a dark color and roughened water has a light blue color. The glare into the lens, of both eye and camera, is far less on the edge of the reflection than in the very center. As a result, fine details of sea-surface turbulence can be lost in the central glare of the sun's reflection.

Source:
http://eosdata.gsfc.nasa.gov/CAMPAIGN_DOCS/OCDST/shuttle_oceanography_web/oss_194.html

Gravity

The fact that the Earth is not perfectly spherical in nature but rather shaped as an oblate spheroid creates an asymmetric potential in Earth's gravitational field. The cyclical characterization of this perturbation requires a rather high level of degree and order in the spherical harmonic expansion representation in order to predict precise effects on the satellite orbit.

Atmospheric Drag

The effect of Earth's atmosphere at orbit altitude is calculated using empirical relationships for air density, together with the known shape and orientation of the satellite.

Geoid Model

As indicated previously, current geoid models have relatively low orders of degree and order upon which their spherical harmonic expansions are based. These discrepancies combine to perturb the satellite's estimated orbit away from the true orbit.

Troposphere

As discussed in propagation medium corrections above, the signal delay caused by water vapor content and other gases present in the troposphere must be accounted for in satellite tracking theory and perturbation analysis. Typically, satellite laser ranging (SLR) techniques are involved which use frequencies in the visible portion of the electromagnetic spectrum and thus are not as susceptible as the radio frequency ranging methods to the delays listed.

Station Location

Station position, i.e. the inability to know the precise location of the tracking stations relative to the center of the Earth, used to be the dominant problem in this category. However, with satellite laser ranging (SLR), extremely accurate measurements are now common-place, the only exception being in cases of severe weather conditions in which data outages can and do last indefinitely. Station distribution is also a significant hindrance, with most SLR's concentrated in the Northern Hemisphere and on continents rather than being evenly dispersed around the globe. With the advent of the DORIS tracking system, these too may no longer pose a concern. Another, smaller in magnitude yet still present, discrepancy is that the coordinate system used to determine the station positions is not precisely known because of polar motion and the variations in the length of the day.
Source: University of Texas Web Site http://www.csr.utexas.edu/tsgc/topex/orbit.html

Cool Web Sites:

http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/OCDST/shuttle_oceanography_web/oss_4.html
http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/OCDST/shuttle_oceanography_web/oss_introduction.html
(NASA)

Activities

Activity II-1. Satellite Resolution --How Well Can a Satellite See?

Image resolution describes how large an object must be in order to be resolved by a satellite sensor. In a four-kilometer resolution APT image, each pixel is 4 km x 4 km; in a 1 km resolution HRPT image, each pixel is 1 km x 1km. The smaller the area in each pixel, the more detail in the image.

Use your artwork to demonstrate differences in resolution.

1. Have students draw any multicolored picture they like on the graph paper that has the smaller squares.
2. Then have students lightly draw lines on the graph paper that mark off squares the size of the larger graph paper's grids. Thus each larger square should have four smaller squares contained within it.
3. Students then determine the average color represented in each larger square. Have them draw that color on a new piece of graph paper with the large squares. Is the new drawing recognizable? What is the resolution of each pixel in the drawing?
4. Using the original artwork, the students then determine the average color represented in each of the smaller squares. Have them draw that color on a new piece of graph paper with the smaller squares. Now are the drawings recognizable? What is the resolution of each pixel in the drawing? What features are still not represented in the pixel drawing?

Resolution in Satellite Imagery

To compare resolutions, take a photograph of the same person or object at a distance of two feet, 10 feet, 20 feet, and a 100 feet. Then look at archival images of the same view of Earth at different resolutions.

Materials

- Crayons
- colored pencils,
- graph paper with two different sized grids.

Student Information Lesson II
Space Shuttle Photography

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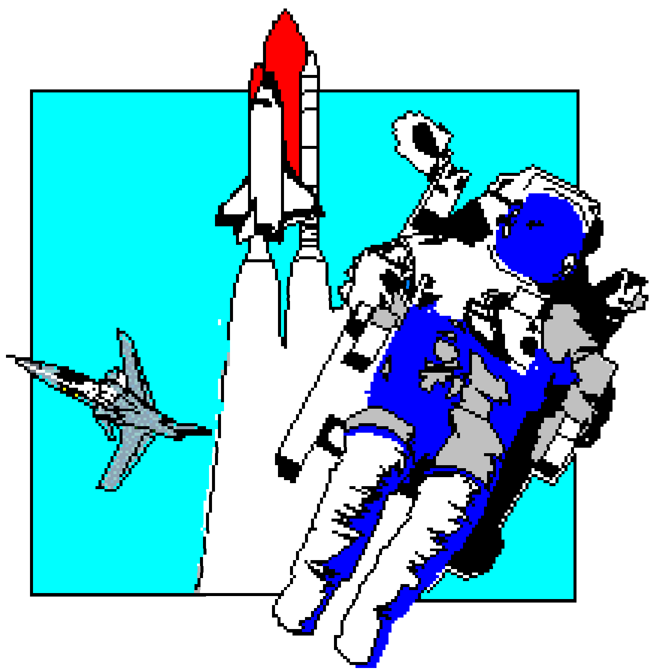

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