

Monitoring Earth Environment from Space

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During the past 25 years, much has been learned about photographing the Earth from space through a series of American, Russian and European satellites. Many useful photographs were acquired by astronauts of the American Gemini, Apollo, Apollo-Soyuz, and Space Shuttle missions, and the Russian Soyuz and Mir missions. In addition, the American Landsat program introduced in 1972 digital imaging from space, where image data were transmitted to ground receiving stations. The technology of these systems provides an advanced new tool for acquisition of data that are necessary for environmental studies of the Earth.

For the acquisition of data necessary for the study of Earth environment, unmanned and manned spacecraft systems are planned to fly in high, medium, or low orbits. The highest orbits are left to the unmanned weather satellites, such as the European Space Agency's Meteosat. These are propelled to a height of 36,000 kilometers above the Earth. At this altitude, their motion is equivalent in speed to the rotation of the Earth about its axis. Such satellites are termed geostationary, and remain above the same point on the Earth to acquire and transmit repetitive images as frequently as hourly. Due to their high altitude, the images they collect cover most of one hemisphere of the Earth at low spatial resolution, which is ideal for studying global phenomena.

The intermediate orbits are those from 5,000 to 2,000 kilometers above the Earth, the region where most unmanned imaging satellites are placed. For example, the polar-orbiting satellites of the National Oceanic and Atmospheric Administration (NOAA) fly at altitudes of 835 to 870 Km; and the near-polar orbits of the American Landsat and the French *System Pour l'Observation de la Terre* (SPOT) reach a maximum altitude of 920 Km above the Earth. Images collected from these altitudes provide greater local detail than is possible from the high-altitude satellites, but the area covered by individual images is significantly reduced. One result of this is that these satellites provide less frequent coverage of the same area than weather satellites (once every 16 days from Landsat, and 28 days for SPOT).

On the lower end, most manned missions are placed in orbits below 500 Km, to a minimum of 150 kilometers above the Earth. For example, the Space Shuttle operational altitude is about 300 kilometers. From this altitude, images show greater detail such as those of the Large Format Camera. Images obtained from most of these satellite systems are useful in the study of environmental parameters of the Earth.

One procedure that has proven very useful in monitoring the Earth environment from space is the utilization of digital images in "change detection". Change detection is the process of identifying differences in the state of an object, a surface or a phenomenon by observing it at different times. The basic premise in using digital satellite images for change detection is that changes in land cover must result in changes in radiance values, and that the latter must be larger than radiance changes caused by atmospheric and other factors. The impact of the other factors may be largely reduced by selecting the appropriate data that will reduce the problems of differences in illumination and season.

Change detection techniques have been successfully applied to the monitoring of changes in the environment due to: (1) land use pattern changes resulting from economic development activities of mankind; (2) vegetation cover changes due to natural seasonal, annual or longer cyclical variations in climate; (3) land degradation due to natural and man-made changes; (4) oil spills in the open ocean and along coastlines; and (5) disruption of the land surface due to military activities such as in the case of the the Gulf War. Examples of these are given to illustrate the utility of space-borne images in monitoring changes to the Earth environment.