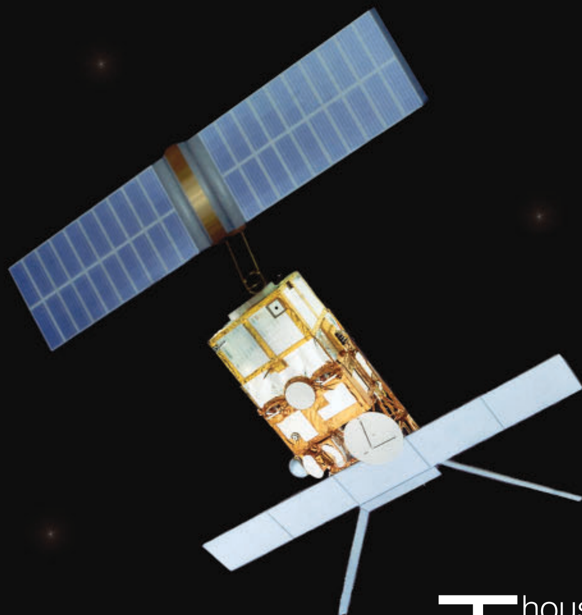
Saving the Earth from Space

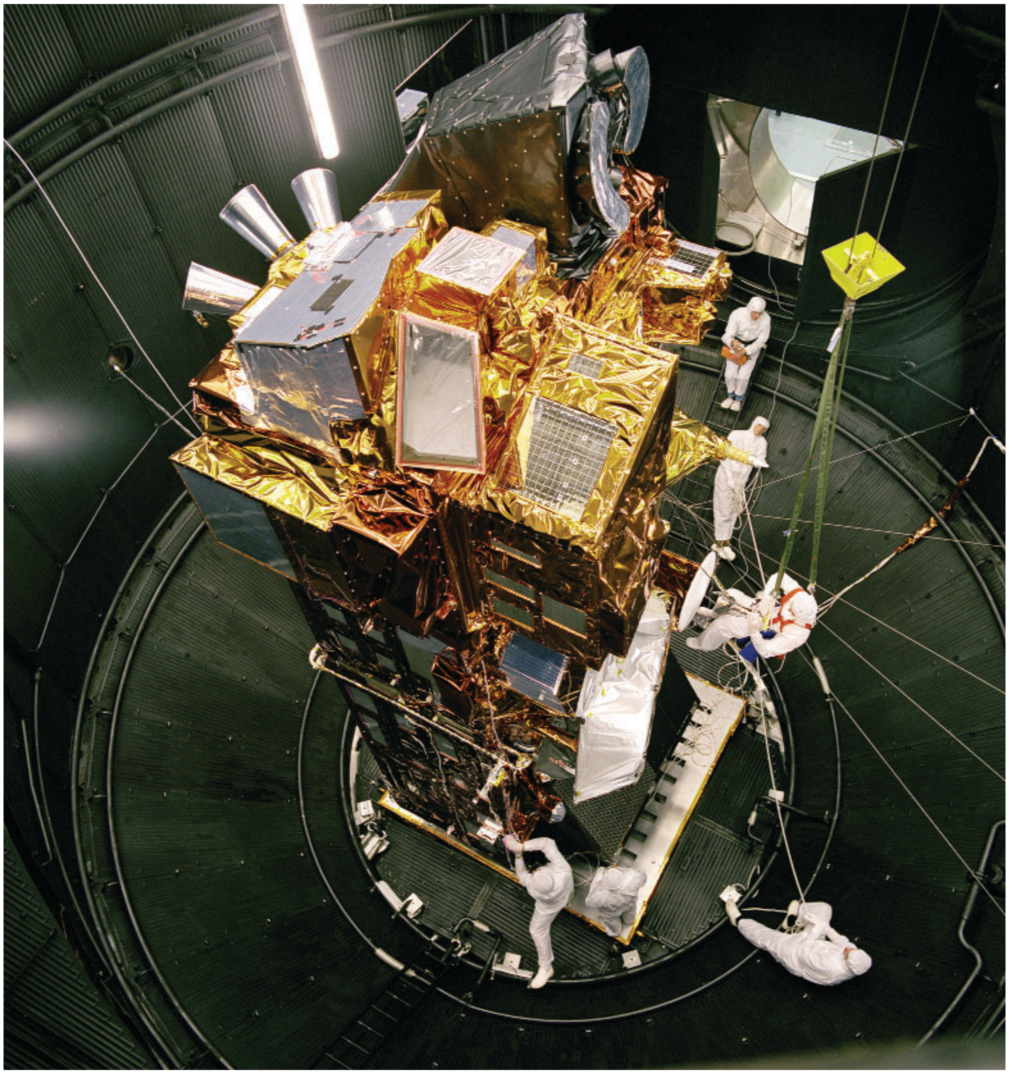
ESA, Christopher G. Reuther/EHP



Thousands of satellites travel above the earth at any given time, performing functions as diverse as monitoring weather patterns and transmitting telephone calls. Some of these satellites also keep an eye on the environment, watching for changes in ecosystems around the world. In April 2001, the Paris-based European Space Agency (ESA), whose members include 15 countries plus Canada (as a “cooperating” nation), announced four initiatives that could help nations better use satellite-gathered environmental data in the implementation and enforcement of international treaties on the environment.

“We’re working with the international environmental treaty organizations to discuss the running of studies using satellite data that would satisfy the requirements of particular agreements,” says Stephen Briggs, head of Earth Observation applications for the ESA. For example, he says, if a convention calls for a reduction in carbon dioxide emissions, how are countries to monitor varying emission levels? What is the best way to measure changes in the environment as called for by new global policies? “Satellites can be highly effective tools in collecting the data linking those policies with the ability to manage the environment,” he says. “They can also have an impact on long-term improvements by providing a feedback loop to the environmental conventions. With the proper data, governments may then take steps to improve their environment.”

Eye in the sky. The ERS-2 satellite (above) monitors the earth day and night under all weather conditions, thanks to its radars, which can pierce cloud cover.



Super satellite. The Envisat Earth Observing satellite, to be launched in January 2002, will use a unique combination of sensors to vastly improve the range and accuracy of scientific measurements of the atmosphere, oceans, land surface, and ice.

ESA

The ESA's four recent initiatives—collectively known as Treaty Enforcement Services Using Earth Observation, or TESEO—focus on the satellite monitoring of changes in wetlands, carbon dioxide levels, marine pollution, and desertification. Earth Observation satellites use an array of remote sensing technologies to collect data on environmental changes caused by a wide range of phenomena, from large storms to human activities. Analyzed by computers, the data can be used to better understand the environment and the earth's processes as well as to forecast the weather and manage natural resources.

This past summer, the ESA contracted with four multinational teams to conduct studies related to each initiative that will last up to 15 months. The teams' principal task is to determine the precise needs of potential users of environmental satellite data, including national and regional government agencies as well as universities and other institutions, in order to help the ESA improve the delivery of those data.

"As a result of the growing concern of the international community about the dramatic environmental problems that affect our planet, some international treaties of primary importance for humanity have been signed during the last decades," says Espen Volden, project manager of TESEO. "These treaties oblige the parties, directly or indirectly, to implement procedures for monitoring and assessing the environment." In addition, he says, the novel capabilities of current and future technologies are opening up new possibilities for developing more advanced and efficient tools. There is therefore a need for assessing these possibilities in relation to the implementation and enforcement of international environmental treaties. "Through TESEO, we hope to spread understanding of the potential of Earth Observation [technology] in the environmental community at large, including the people involved in negotiating, writing, and amending environmental conventions," says Volden. "ESA is now working with many environmental organizations and establishing cooperations that will be very important for the future."

Environmental Treaties Need Data

As international organizations hammer out the details of global policies dealing with environmental issues, Earth Observation satellites are becoming increasingly important tools for gathering the environmental data to verify the scientific bases of these policies. The TESEO initiatives focus on the Ramsar Convention governing the conservation of wetlands, the Kyoto Protocol requiring the reduction of carbon dioxide emissions, the United Nations Convention to Combat Desertification (UNCCD), and the International Convention for the Prevention of Pollution from Ships (MARPOL).

One-half of the earth's wetlands have disappeared during the last century, according to the ESA. The Ramsar Convention therefore requires its signatories to designate wetlands of international importance. The ESA is looking at how Earth Observation technology can help signatory countries monitor the ecology of Ramsar sites.

Signatories to the Kyoto Protocol (not yet in effect) will have to reduce their net emissions of carbon dioxide, widely believed to be contributing to global warming and climate change. One approach is to expand the size and number of forests, which help to absorb carbon dioxide in the atmosphere. Earth Observation satellites can estimate and monitor carbon stocks and help verify compliance with the Kyoto Protocol. Earth Observation technology is also monitoring parts of the world's oceans for any changes, natural or otherwise. One very important measurement of climate change that is measurable by satellite is sea surface temperature, which is a key factor in understanding the degree to which mankind is involved in that change, says Briggs.

Earth Observation technology can also perceive the gradual desertification of land areas. Layers of soil can be blown or washed away in a few seasons and not recovered, especially in arid, semiarid, and dry subhumid areas that cover more than one-third of the earth's surface. The UNCCD aims to develop national and regional programs to combat desertification and diminish the effects of drought. By monitoring how land is used (for instance, for farm or residential development) and land cover such as vegetation and water, Earth Observation technology is expected to help countries fulfill the major objectives of the convention.

Finally, MARPOL calls for monitoring of oil spills in areas exposed to high tanker traffic. "Oil spill pollution is a constant problem in areas of dense shipping, where it's caused by accidents or the deliberate illegal cleaning of tanks," says Briggs. "Detecting contamination is quite simple: satellite radar technology can take an image of the ocean's surface and pick up the presence of patches of oil."

Keeping an Eye on Mother Earth

The ESA has relied on European Remote Sensing (ERS) satellites—both polar orbiting and geostationary—to study the earth's environment and resources for more than 10 years. The ESA launched its first ERS, called ERS-1, in July 1991; it was retired in March 2000. ERS-2, launched in 1995, continues to provide data on a wide variety of environmental changes on earth.

ERS-2 is equipped with synthetic aperture radar (SAR), which has a wide range of practical applications. SAR is able to penetrate cloud cover to detect the most minute changes in vegetation growth, land and forest use, and the earth's surface temperature. It can also observe the seasonal growth of plankton, gauge ocean winds, and measure variations in the thickness of the Greenland and Antarctic ice sheets. In addition, SAR can pick up evidence of deliberate or accidental oil spills on the oceans—the technology is so sensitive that it can detect and track ships from their wakes. In shallow waters, SAR can also map the topography of the ocean floor because the sea bottom relief is reflected on the surface by small variations of the sea surface height.

"By using radar, SAR illuminates the earth's surface and measures the reflected signal," says Olivier Arino, head of the ESA Projects Section. "This generates microwave images of the earth, which can easily penetrate clouds, and allows SAR to acquire images day or night, completely independent of solar illumination or local weather conditions. Because of their long wavelength, microwaves are able to penetrate not only clouds but also soil, sand, snow, or the canopy of a forest, thereby providing information about otherwise hidden features."

The satellite uses a combination of optical and radar instruments to monitor environmental changes on earth. While radar is capable of mapping alterations in the ecosystems, the data can be rough and difficult to interpret, according to Arino. Optical instruments, on the other hand, view the earth as an ordinary camera might from an airplane—they rely on the reflection of sunlight to create an image. The best information is derived from combining data from both sets of instruments.

The Next Generation

In January 2002, the ESA plans to launch Envisat, its most powerful environmental satellite ever. Envisat is an advanced polar-orbiting Earth Observation satellite that will provide measurements of the atmosphere, ocean, land, and ice over a five-year period. Weighing eight tons and measuring ten meters in length, Envisat will pick up at the exact point of data collection where ERS leaves off, and thus is designed to ensure the continuity of data measurements from the ERS satellites. It will be equipped with advanced SAR, an instrument that makes use of recent technologic developments to allow for performance over an extended period of time. The ESA hopes that data collected through advanced SAR will support earth science research and enhance the ability of its member nations in implementing and enforcing international environmental treaties.

Rebecca Clay

Suggested Reading

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