Satellite remote sensing has a number of potential applications across a broad range of environmental disciplines. This Information Brief outlines those potential applications.

**Environmental Enforcement**

The U. S. Environmental Protection Agency (EPA) [1] conducts four types of satellite and aerial remote sensing projects to support the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as the Superfund Act), the Resource Conservation and Recovery Act (RCRA), and in other EPA regulatory programs and investigations. [2]

The projects are: (1) emergency response to hazardous material release that requires rapid site assessment; (2) single-date analysis to update old data on the current conditions of the site; (3) intensive site analysis of current and historic images, to obtain an understanding of changing conditions over time; and (4) waste site inventories over large areas to locate possible disposal sites. [3]

Images from these projects can standalone or be used in conjunction with topographic maps, [4] digital elevation data, and other features stored in GIS databases. [5]

Further use of remote sensing (both satellite and aerial photography) as a tool in environmental forensics is discussed in a two-part paper by Brilis, et al. [6] The paper outlines the general approach to be followed when planning the use of remote sensing in environmental forensics. [7]

The accuracy of locational data and the use of metadata are identified as two critical items to ensure that a final image can withstand veracity issues when used for courtroom presentation. [8]

Recently, interest has developed in using satellites to monitor and enforce multilateral environmental agreements (MEAs), such as the Kyoto Protocol. [9]

Remote sensing data may be used in the future to ensure compliance with MEA requirements by both direct enforcement and by more indirect means, such as deterring non-compliance through high levels of transparency. [10]

**Land Use Planning and Change**
Passive sensors, including those on the NOAA, IKONOS, Landsat, Terra, and SPOT satellites, are used in a broad range of forest and land use applications. These applications include estimations of primary production, biomass, crop yields, and to chart, vegetation type, deforestation, desertification, forest boundaries, forest harvest, soil erosion, and bush or forest fires. Landsat 7’s EMT+ sensor is especially useful in studying land use change because its data has been archived since the first Landsat mission in 1972. Passive sensors have also been used to observe and monitor changes associated with storm, flood, and fire damage.

Forestry
Forestry applications for passive remote sensors include tree species surveys, monitoring clearcut operations, planning and observing burn areas, and studying successional forest growth. The U.S. Forest Service (USFS) relies primarily on the data from Landsats 5 and 7 for forest monitoring because of the low cost and large scene size. Landsat data is particularly applicable to forest change monitoring because data from previous Landsat missions is archived and available for accurate comparison with data from the current Landsat mission. The USFS also uses SPOT data in conjunction with Landsat data to increase the level of detail in sensitive areas.

Active sensors, carried on the RADARSAT and ERS satellites, are capable of making course scale distinctions between cover types such as late successional forests, newly planted forests, clear cut forests, burn areas, agricultural areas, and deserts. Active sensors are valuable tools for monitoring crop regulation compliance, forest clearing, and for taking general inventories of world forest densities.

Agriculture
The United States Department of Agriculture (USDA) is conducting research to determine the potential uses of remote sensing (both aerial and satellite) in
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the agricultural sector. Promising applications include measuring leaf area indices (LAI - a quantitative indicator of leaf stress), identifying soil properties by their spectral signals, evaluating crop productivity, and providing a valuable data source for crop simulation models. [14] A high-tech type of farming known as “precision agriculture,” uses satellite data to characterize specific sections of a field by certain variables (such as water or nutrient levels). Once the characteristics

and geographic coordinates of the field section are in a computer, additions such as water, pesticides, and fertilizers can be efficiently controlled in response to the specific needs of each section thereby reducing the amount of pollutants introduced to the environment while producing healthier crops. [15]

Water Resources and Fisheries
SeaWiFS is designed to monitor oceans and track water indicators such as turbidity, sediment load and transport, primary production by marine phytoplankton, algal blooms, chlorophyll content, dissolved oxygen, and pH. [16] Other applications include managing coral reefs, monitoring pollution and oil spills, and characterizing and monitoring short-term and long-term fish habitat. Terra’s MODIS and AVHRR sensors record observations of sea surface temperature, which is directly relevant to fisheries due to individual species’ temperature requirements for survival and propagation. The sensor may also help predict migration routes. [17]

Active sensing technologies are capable of measuring sea level, wave height, surface wind speed, current fronts, eddies, and surface temperature, as well as locating ocean floor features such as trenches and seamounts. Active sensors have also been used to track oil spills, effluent discharges, and algal blooms.

Wetlands and Watersheds
Wetlands monitoring may employ a combination of land-observation and
Ocean-observation satellites. ETM+ data can be used to delineate wetland areas, make topographical observations, and to detect illegal development. [18] Active systems can provide consistent and accurate observations of dynamic wetland parameters such as tidal and seasonal patterns, climate, hydrology, topography, vegetation, and soil type. [19]

Satellite data and images can also be used to delineate the flow of water through watersheds, and can even be used to track pollutants. Furthermore, using algal productivity as an indicator, scientists are able to monitor whether high levels of nutrients pollute areas of a watershed. [20]

**Climate Activity**

In the past decade, various ozone-monitoring sensors have been launched to study global climate cycles. These include the TOMS sensor and many of the sensors on Terra, Aqua, and future EOS satellites. AVHRR data from NOAA's POES satellites is used in conjunction with RADARSAT to monitor the polar ice sheets and iceberg movements. The EOS satellites, beginning with the Terra, were designed specifically for monitoring climate conditions, including the observation of aerosols, cloud cover, fires, ocean productivity, pollution, solar radiation, sea ice, and snow cover. [21]

**Disaster Management and Emergency Response**

Remote sensing technologies can provide the government with the ability to avoid much of the damage caused by unforeseen natural disasters. While weather satellites have monitored hurricanes and tornados since the 1960s, other satellite sensors, such as ETM+ and MODIS, have potential applications for disaster management and response. Scientists have used ETM+ data to monitor patterns in floods, droughts, beach erosion, and volcanic activity over time. MODIS and ASTER data can forecast severe weather with a great degree of reliability, potentially saving states millions of dollars in unnecessary evacuation and emergency response. [22]
For forest fire emergencies, TOMS data can identify and monitor the occurrence of forest fires, especially in remote areas,

while AVHRR data can create maps denoting fire-susceptible areas.

NOAA-POES and NOAA-GOES (Geostationary Operational Environmental Satellite) are used to make weather observations including predicting local weather, tracking weather in real time globally and locally, understanding and predicting hurricanes and other severe weather, studying phenomena such as El Niño, La Niña, the Gulf Stream and other global current patterns, and observing the dynamics between the land temperature, ocean processes, and the atmosphere.

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[1] The EPA’s National Exposure Research Laboratory (NERL) is headquartered in Research Triangle Park in North Carolina. It is one of the three national laboratories that conducts research for the EPA’s Office of Research and Development. The NERL conducts research that leads to improved methods to predict human and ecosystem exposure to harmful pollutants.


[3] Id. (discussing all four of the listed project types).

[4] Author’s note: A topographic map is one that is defined by displaying elevation and landform information, usually in the form of contour lines.


[7] Id.

[8] Id.

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[12] One of the most important features of Landsat is its Data Continuity Mission. Archived Landsat data from MSS and TM can be accurately used with current Landsat ETM+ data because the data has been calibrated to ensure that the earlier data represents the same values as the current data.


[19] Id.


[25] A geostationary satellite is one that is always in the same position (appears stationary) with respect to the rotating Earth. NASA Earth Observatory Glossary