Weather Satellites – past, present and future

A major feat of modern engineering occurred in October 1957 when Russia launched Sputnik, the first spacecraft to orbit Earth, initiating the space race and igniting innovation worldwide.

University of Wisconsin-Madison researchers Verner Suomi and Robert Parent quickly proposed putting instruments on satellites that could measure electromagnetic energy and monitor Earth's weather and climate, resulting in the birth of satellite meteorology.

October 13th, 1959, marked the launch of the Explorer 7 satellite and the first successful space-based weather experiment. On board Explorer 7, was the radiometer designed by Suomi and Parent to collect data which would ultimately establish the critical role that clouds play in Earth's radiation budget.

Early satellites flew in a low orbit perpendicular to the direction that the Earth spins, traveling from pole to pole above our rotating planet. Today, Polar-orbiting Operational Environmental Satellites, or POES, fly at 17,000 miles per hour in a sun-synchronous orbit at an altitude of 870 km, or 540 miles high and take 102 minutes to complete a full circle around Earth.

The polar orbiting satellites scan the surface in swaths as the Earth rotates, providing high resolution imagery with stunning detail.

Instruments on weather satellites have detectors that measure energy at different wavelengths of the electromagnetic spectrum to determine characteristics of clouds and land. Visible detectors rely on reflected sunlight to produce images that show what our eyes would see as if we were riding on a satellite. Visible images provide valuable information during the day, but not when the sun goes down.

Fortunately, scientists have other detectors measuring energy in the infrared portion of the electromagnetic spectrum. Infrared, or IR instruments, measure outgoing thermal energy emitted from Earth. Warm objects appear dark and cold objects appear gray or white, so it's still easy to track clouds and weather.

Using data from multiple wavelengths, scientists can determine if the thermal energy is being emitted from land, oceans, clouds and even water vapor. Monitoring sea surface temperatures is important as it has a direct impact on the formation and strength of a hurricane or typhoon.

Long-term observations from multiple satellites allow scientists to create climatological records. Comparing current data with the climate records identifies regions of the earth that are warmer and colder than normal. Warmer than average sea surface temperatures in the Equatorial Pacific Ocean indicates the global phenomena El Niño which has been linked to weather patterns causing flooding and droughts.

In 1960, The United States National Aeronautics and Space Administration, or NASA, began development of a geostationary satellite that would fly in a geosynchronous orbit.

Geostationary satellites are located above the equator at an altitude of 35,780 kilometers or 22,233 miles and orbit Earth at the same rate that Earth rotates. This is critical for weather forecasting because geostationary satellites continually monitor the same area on Earth.

The United States Geostationary Operational Environmental Satellite program, or GOES, began in October 1975 with launch of GOES-A which was renamed GOES-1 once it was in its final orbit. This is also when NASA transfers responsibility to NOAA, the National Oceanic and Atmospheric Administration. During the late 1970's and early 1980's other countries including Europe, Japan, India, China and Russia began their own weather satellite programs.

Technological advancements have allowed geostationary and polar orbiting satellites to utilize other parts of the electromagnetic spectrum. Water vapor sensors were added revealing the flow of moisture in our atmosphere. Other sensors and animations have been combined to estimate hurricane intensity, locate fires, detect areas of volcanic ash and measure the coverage of snow, ice, ozone and aerosols.

New next generation geostationary satellites feature even greater advancements, including:

> Three times more spectral information, an increase from 5 to 16 wavelengths,
> four times the spatial resolution, similar to POES and
> scanning five times faster than previous.

The United States next-generation GOES-R satellite series includes a unique Geostationary Lightning Mapper that can measure total lightning activity continuously over the Americas and adjacent ocean regions, creating a new tool for forecasters. Images from GOES-R, as frequent as every 30 seconds, provides increased real-time data to forecasters to detect the initiation and development of severe weather and monitor the changing structures of hurricanes. These new technologies allow for NOAA's National Weather Service to issue warnings and alerts much faster, saving many lives. Aviation and commercial shipping industries will also benefit from more up-to-date weather data by making critical transportation safety decisions.

The GOES-R satellite series is part of a 21st-century constellation of international environmental satellites. Its advancements continue the evolution of satellite remote sensing technology in an ongoing effort to provide a comprehensive, in-depth understanding of Earth's weather, environment, and climate.