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Data in a Flash [1]

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A new global change research tool detects lightning day and night.

It was a year of firsts for lightning detection. In 1996, the world's first satellite sensor capable of daytime lightning detection finished its inaugural year in orbit. A valuable global change research tool, the Optical Transient Detector (OTD) delivers data that form the foundation of the world's most complete global lightning database.

Motivated by concerns about the lightning hazards associated with aerospace activities, lightning research accelerated in the 1960s. Until OTD was launched in April 1995, however, no space-based system had been able to globally detect lightning with high resolution both during daytime and at night.

Daytime detection is important because most lightning and land mass thunderstorms occur in the late afternoon, said Hugh Christian of the Global Hydrology and Climate Center, the former Marshall DAAC in Huntsville, Alabama. But, daytime detection is difficult because lightning must compete with sunlight shining off cloud tops for the attention of a satellite sensor such as OTD.

The Optical Transient Detector is a sophisticated optical imaging system that works much like a fast camera. It looks down at clouds and registers changes in luminosity that occur with lightning flashes. "Because there's lots of scattering in the cloud, what we see in daytime is a puddle of light, not a discrete channel. What we're looking for is a small change in light compared to the constant background," said Christian, OTD's Principal Investigator.

Christian and his colleagues have perfected a technique whereby they are able to record cloud top changes in light intensity well enough to discern signals left by lightning. By constantly running a routine to account for background illumination, and by taking 500 images per second, OTD is now accurately locating and measuring the intensity of more than half the lightning within its field of view.

High resolution daytime detection is a primary advantage OTD has over older satellite-based networks. OTD also offers advantages over land-based systems: it detects more types of lightning over the entire globe with greater, more uniform efficiency and accuracy. Unlike ground-based systems, which detect only cloud-to-ground lightning (about one quarter of all lightning activity), OTD also detects cloud-to-cloud and intracloud lightning events. Intracloud lightning detection is especially important, Christian said, because it is highly correlated with intense atmospheric convection and thus, hazardous and severe weather.

In recent years, Christian and his colleagues have learned how to use lightning as a proxy for storms with strong updrafts and much "mixed phase" precipitation (mixed rain, ice, and snow). "We believe that by observing lightning from space, we can now estimate both the distribution of intense convection around the globe and the amount of mixed phase precipitation being processed," said Christian.

The close coupling of lightning activity with storm convection dynamics lends the OTD database its value as a global change research tool. With a lightning database compiled over time, scientists can map the spatial distribution and temporal variability of global lightning and thunderstorm activity. Moreover, in their search for important indications of global climate change, scientists will be able to compare the lightning database with other global climatological data sets, Christian said. For example, comparisons of temporal (seasonal, annual, and interannual) variations in global lightning activity with coincident variations in global rates and amounts of convective precipitation will further illuminate the relationship between lightning activity and intense convection.

With such research potential in mind, scientists at NASA's Marshall Space Flight Center began exploring the concept of OTD in the 1980s. A decade later, OTD was selected for development as part of NASA's Earth Observing System (EOS), and in less than a year the OTD development team designed, built, calibrated, and delivered the instrument. "We've got mankind's first truly global, detailed, high resolution lightning database now because of this fast-track approach," said Christian. "We're delighted that we were able to get to orbit so rapidly and that the system has worked so well since it's been in orbit."

Designed to fly on a small spacecraft for only two years, the OTD sensor is approaching the end of its life expectancy. OTD will be succeeded by the EOS Lightning Imaging Sensor (LIS), with Christian as its Principal Investigator. LIS will be launched in November 1997 on the Tropical Rainfall Measuring Mission (TRMM), a joint effort of NASA and Japan's National Space Development Agency.

LIS will fly with a suite of other TRMM sensors measuring multiple geophysical processes and parameters. Because LIS will make simultaneous measurements with radars, microwave radiometers, visible and infrared imagers, Christian said, his team will be able to relate lightning data with storm dynamics and precipitation as measured by the other instruments. "The simultaneous measurements will be extremely valuable to us," he said.

Additionally, because TRMM will fly in a lower inclination orbit than OTD, LIS will be better suited for studies of the tropics, said Christian. LIS will be a higher performance instrument, he added, thanks in part to the pathfinding and intellectual heritage provided by OTD. In the end, the world's most complete lightning database, launched with OTD, will grow with LIS lightning data and increase in value as a global climatological record.

Lightning Detection in Real Time

In addition to its value as a global climate change research tool, OTD and LIS technology holds much potential for hazards assessment. This will be realized in the form of real-time lightning observations if the technology is put into "geostationary" orbit on the next generation of operational weather satellites. (A geostationary orbit is one in which satellites remain stationary above a fixed point on the Earth's equator as the Earth moves.)

Real-time lightning data would be of value to people involved in many diverse areas, from aviation safety to space launch support, to severe weather prediction and forest fire management. At the American Meteorological Society's February 1997 annual meeting, Steven Goodman of the Climate Center Global Hydrology and (GHCC) (of which the Global Hydrology Resource Center is a part) presented the conclusions of Florida field research begun in the summer of 1996 to explore the value of adding real-time lightning detection capabilities to existing weather forecast technologies.

The results of the field research reveal that weather forecasters would especially benefit from a real-time ability to detect intracloud lightning, which ground-based systems do not detect. Knowing that cloud-to-ground activity increases only after storms develop -- and with early OTD data showing that severe storms generate intracloud lightning mostly as they build -- scientists could use real-time satellite detection of lightning to provide more advance warning of hazardous and severe storms.

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