October 09, 2002

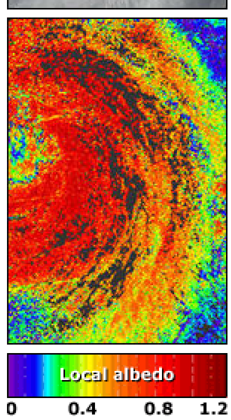
Tune in to the evening weather report on any given day, and you'll no doubt see satellite images of clouds. For years, experts have used cloud observations to predict the weather, from forecasting extreme weather events, such as tornadoes and hurricanes, to simply telling people whether they need to take an umbrella or sunscreen on their afternoon picnic.

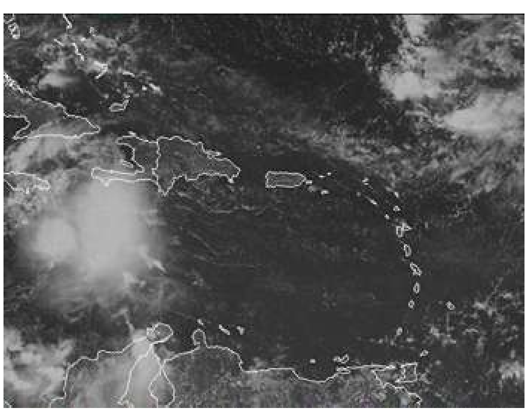
Viewing the sunlit Earth simultaneously at nine widely spaced angles, MISR collects global images with high spatial detail. It captures these images in four colors at every angle.

Weather experts monitor clouds with the help of satellite data, and they use cloud height and motion data to calculate wind speed and height. Although these calculations have proven useful in predicting the path and severity of developing storms, existing satellite instruments are limited in their coverage of vast ocean expanses and higher latitude regions, the common birthplaces of many storms.

Currently, the cloud motion data used to derive wind measurements are observed from geostationary satellites. These instruments orbit the equator, obtaining images of the Earth's surface below to roughly 55 degrees north and south of the equator. Any farther north or south and the satellite image becomes distorted due to the curvature of the Earth. Consequently, wind data predictions based on cloud motion have been most accurate at latitudes lower than 55 degrees.

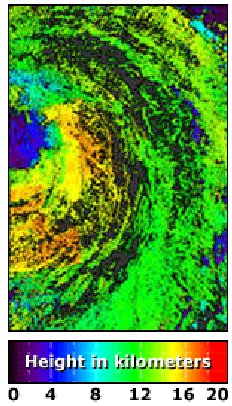
Geostationary satellites measure reflected sunlight in only one direction for any given point on the surface or in the atmosphere. So to determine a cloud's height, scientists either need measurements from more than one satellite, or they must indirectly calculate the cloud's height based on assumptions about the relationship between temperature and altitude. (Generally, the higher the cloud, the colder its temperature.) Moreover, data collected from geostationary satellites can only classify wind heights as low, middle, and high, rather than at precise altitudes.





GOES captured this image of clouds over the Puerto Rico region on September 17, 2002.

A new instrument and remote sensing technique, however, may improve the accuracy of cloud motion and height data over many areas of the Earth, boosting the accuracy of weather predictions. “We’re still testing the new technique for calculating cloud height and motion, but it looks like a very promising addition to future weather forecasting tools,” said Roger Davies, a principal scientist at NASA’s Jet Propulsion Laboratory and a specialist on clouds and climate modeling.



Typhoon Sinlaku forced hundreds of thousands from their homes in the 2002 summer storm season. MISR captured these images of Sinlaku over the Okinawan island chain on September 5, 2002. The top image is true color, the middle image shows local albedo (sunlight reflected back into space), and the bottom image shows cloud height.

NASA’s Multi-angle Imaging SpectroRadiometer (MISR) instrument, launched in 1999 on the Terra satellite, is the first satellite instrument to simultaneously provide directly measured cloud height and motion data from pole to pole.

As the MISR instrument orbits the Earth, it uses cameras fixed at nine different angles to view reflected light and collect global images. The cameras capture images of clouds, airborne particles, and the Earth’s surface, collecting information about each point in the atmosphere or on the surface from nine different angles.

“Originally, the cloud motion data from MISR were intended to provide input to cloud height calculations, and to more precisely identify the location of each cloud,” said Davies.

Cloud heights are important in modeling cloud properties for long-term climate studies, but they are only useful if accurately related to the exact position of the cloud. Davies and his team developed a pattern recognition algorithm that uses MISR data to recognize the same cloud from different angles. The algorithm then derives the cloud motion and height and uses these data to calculate the position of the cloud.

For more information, visit the Langley Atmospheric Sciences Data Center and MISR Web sites. (A new browser window will open.)

Although the pattern recognition technique was intended as a way to pinpoint the location of clouds, the team discovered that the wind speed measurements were better than expected, providing wind values accurate to within 3 meters per second at heights accurate to within 400 meters. “We realized that we were getting extremely accurate cloud motions that could drastically improve weather prediction,” said Davies.

Winds crossing the Pacific Ocean are difficult to monitor with current satellite instruments because there are no landmarks to show the exact location of the clouds. The MISR cloud data may be able to provide more accurate wind speeds and heights over the Pacific Ocean, increasing the warning time for severe weather events threatening the west coast of North America.

“Weather tends to come in from over the ocean, and there’s a general shortage of satellite data over oceans, meaning that MISR data promise to improve short-term weather prediction,” said Davies. In addition, wind-based storm activity near the poles will also be easier to monitor, since MISR collects data from pole to pole.

Initial validation efforts have proved promising, according to Davies. The team compared data from the National Oceanic and Atmospheric Administration’s (NOAA) current geostationary satellites (GOES-W) with the MISR data distributed by the Langley Research Center (LaRC) DAAC. The two matched well enough to verify the accuracy of MISR’s preliminary data.

MISR captured this image of atmospheric vortices near Guadalupe Island on June 11, 2000. Click here for larger image.

In fact, MISR data proved more accurate than the GOES-W data for the wind heights, especially where more than one layer of clouds existed. “Most of the time we get very good agreement between the two instruments, and when we don’t, it’s usually because the two satellites are looking at different clouds,” said Davies.

In addition to improving short-term weather forecasting, the cloud height and motion data will benefit long-term climate studies. “Clouds are the weakest link in our whole understanding of the climate system, as they affect albedo [the amount of solar radiation reflected into space from Earth’s surface, atmosphere, and clouds] and have a stronger greenhouse effect than all the other gases put together, so they’re incredibly important,” said Davies.

Once Davies and his team fully develop and validate the technique to provide accurate cloud height and motion measurements, they expect that wind experts from around the world will continue to explore the best way to apply the MISR technique to real time weather forecasting.

Most likely, they will expand the instrument’s coverage to obtain the most useful wind information, according to Davies. “I can imagine a fleet of small satellites with a simplified version of MISR onboard that would provide us with accurate global wind data and greatly improved weather prediction abilities.”

Horvath, A. and R. Davies. 2001. Simultaneous retrieval of cloud motion and height from polar-orbiter multiangle measurements. *Geophysical Research Letters* 28:2915-2918.