ARM Climate Research Facility

Southern Great Plains Newsletter

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ARM Water Vapor Data Support Severe Weather Forecasting in Oklahoma and Kansas

The ARM Climate Research Facility (ACRF) participates in the international research project SuomiNet (http://www.suominet.ucar.edu/), named after famed weather satellite pioneer Verner Suomi (pronounced "sue me"). The project involves about 100 sites at universities and research institutions in the continental United States, plus a few sites placed in arctic, island, tropical, and ocean climates. In 2001, ARM deployed SuomiNet stations at 15 extended facilities of its Southern Great Plains (SGP) site. Recently, ARM added SuomiNet stations to its Tropical Western Pacific sites at Darwin, Australia; Manus Island, Papua New Guinea; and the island of Nauru.

A SuomiNet station uses the global positioning system (GPS) technology to measure precipitable water vapor in the atmosphere (the total amount in a vertical atmospheric column). Each of the 24 GPS satellites orbiting 12,000 miles above Earth transmits L-band radio signals (in the frequency range 1–2 GHz) to ground-based receivers. A ground-based receiver can determine its distance from a satellite by listening to the radio signal sent by the satellite. When the receiver locates its distance from at least three satellites, it can use mathematical equations to calculate its exact position on Earth, within approximately 100 feet (30 m).

Atmospheric scientists have adapted GPS navigation technology to measure water vapor in the atmosphere. Satellite radio signals transmitted to Earth's surface are bent ("refracted") as they pass through the atmosphere. The refraction causes the signals to travel a longer path and therefore to be delayed in arriving at the ground-based GPS receiver. The amount of bending and the corresponding delay is affected by the amount of water vapor in the atmosphere. By calculating the delay between the arrival of the satellite signal and the expected arrival time (in the absence of intervening atmosphere),

Although GPS was originally developed for military use, its commercial use has grown rapidly. Applications include surveying and mapping, aviation and marine navigation, and tracking vehicles (for example, delivery and transport trucks). GPS receiver costs have decreased in recent years, making the technology affordable for the average consumer. Hand-held GPS receivers are used for navigation in automobiles and also have applications for hikers and boaters and for other recreational and outdoor enthusiasts.

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Figure 1. SuomiNet GPS antenna (foreground) installed at the SGP site. The GPS antenna in the background is part of the National Aeronautics and Space Administration's Jet Propulsion Laboratory network (ARM photo).

scientists can isolate the portion of the delay caused by the presence of water vapor. From this value, the total precipitable water vapor content can be determined.

Water vapor is the most important of the greenhouse gases and one of the most variable. Clouds and precipitation are formed when water vapor in the atmosphere condenses into liquid water or ice. Currently, water vapor data are collected by radiosondes, surface-based radiometers, research aircraft, and weather satellites — the same satellites that gather the cloud images used in daily weather reports. Each of these systems has limitations, ranging from data accuracy and frequency to cost of operation. GPS measurement of water vapor can improve the accuracy and frequency of measurements of atmospheric water vapor content. These improvements benefit not only global climate modeling, but also daily weather forecasts, especially forecasts of severe storms.

Data collected from the ACRF SuomiNet sites have been used by the National Oceanic and Atmospheric Administration (NOAA) Forecast Systems Laboratory (FSL) to investigate ground-based GPS water vapor observing systems. The FSL has performed intercomparisons to evaluate the characteristics of GPS water vapor data and their appropriateness for weather forecasting. The ACRF SuomiNet sites are among some 300 GPS observation stations in the continental United States that transmit hourly data to NOAA for inclusion in weather forecasting computer models. Inclusion of GPS water vapor data has improved the accuracy of short-range precipitation forecasts, in terms of both location and amount of precipitation. Forecasters also use the data to identify changing conditions, to verify other moisture measurements, and to verify the accuracy of model predictions.

ARM is modifying its data communications systems to transfer the SuomiNet GPS data directly to FSL every 30 minutes, within a few minutes of collection. This real-time data availability will greatly benefit operational forecasting at the National Weather Service's Storm Prediction Center in Norman, Oklahoma. Forecasters will now have even more data to use in monitoring and predicting severe weather outbreaks in the SGP region during the coming spring season.

Climate Capsule

"Climate Capsule" is a new monthly feature introducing climate and weather definitions.

Moisture Convergence

: the advection of moist air into a given region. Persistent moisture convergence increases dew points in the lower atmosphere. Areas with persistent moisture convergence are common along cold fronts and are favored regions for thunderstorm development if other factors, such as instability, are also present.