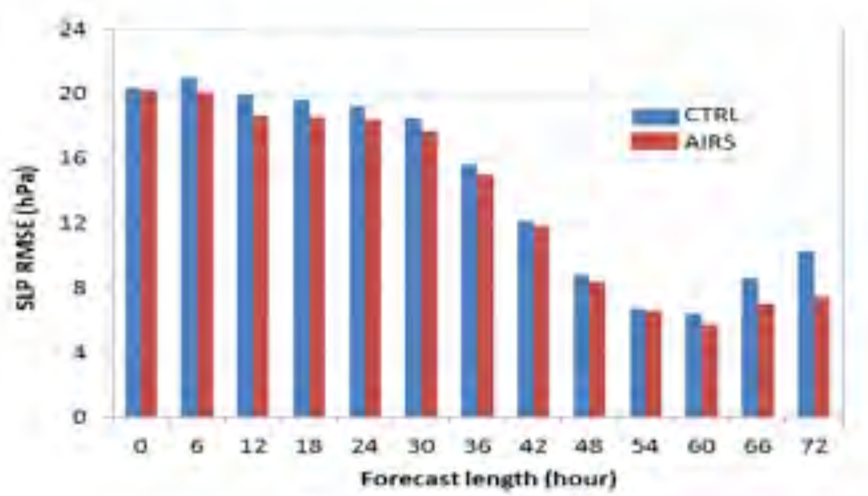

Figure 2. Tropical Cyclone Irene (2011) central sea level pressure (SLP) forecast RMSE for 0-h (analysis), 6-h, to 72-h forecasts. Every 6 hours between 06 UTC 23 and 00 UTC 25 August 2011 the data are assimilated with WRF/DART followed by a 72-hour forecast. The SLP RMSE is calculated from comparisons with the best track observations from National Hurricane Center.

IR sounder temperature and water vapor information from satellites for forecasting hurricane tracks and intensity.

AVHRR Transitions to VIIRS

With Suomi NPP's successful launch and the current NOAA satellite series transitioning to the new JPSS series, AVHRR is transitioning to a more capable visible and infrared imager called the Visible Infrared Imaging Radiometer Suite (VIIRS). VIIRS will be better calibrated than the AVHRR, with higher spatial resolution and 22-channel spectral capability.

HIRS is being replaced by the Cross Track Infrared Sounder (CrIS), a Michelson interferometer that is designed to enable retrievals of atmospheric temperature profiles at a much higher degree of accuracy. This accuracy is accomplished by the CrIS working together with the Advanced Technology Microwave Sounder (ATMS), the replacement for AMSU. A comparable sounding capability has been realized by the Infrared Atmospheric Sounding Interferometer (IASI) on the European Metop-A satellite in conjunction with the advanced microwave temperature sounding units (AMSU-A) and microwave humidity sounders (MHS). CrIS/ATMS is flying on the ascending afternoon orbit and IASI/AMSU is flying on the descending morning orbit.

SSEC's work in sounding and retrieval science covers both polar and geostationary platforms. CIMSS scientists are currently preparing Suomi NPP VIIRS, CrIS, and ATMS data for state of the art soundings aimed at advancing our capability to understand and predict severe weather. The CIMSS hyperspectral IR Sounder Retrieval (CHISR) algorithm has been developed to retrieve atmospheric temperature and moisture profiles from advanced IR sounder radiance measurements in clear skies and some cloudy sky conditions on a single field-of-view (SFOV) basis (Li and Huang 1999; Li et al. 2000; Weisz et al. 2007).

The algorithm is forecast independent and consists of three steps. The first step is the IR sounder sub-pixel cloud detection using a high spatial resolution imager cloud mask product (for example, the AIRS cloud detection can be derived from the MODIS cloud mask, and the CrIS cloud detection can be derived from the VIIRS cloud mask (Li et al. 2004)). The second step is to perform an eigenvector regression on the hyperspectral IR radiance measurements as the first guess of temperature and moisture profiles. The final step is to update/improve the first guess by performing a one-dimensional variational (1DVAR) retrieval algorithm with a Quasi-Newton iteration technique.

Radiance measurements from all IR channels are used in the sounding retrieval process. The CIMSS research product provides IR soundings with higher spatial resolution of approximately 12-14 km than the operational sounding product which is based on the AMSU or ATMS cloud-clearing algorithm (Susskind et al. 2003). The operational sounding product has a spatial resolution of approximately 45 km at nadir, which is much coarser than the resolution of most regional forecast models. CIMSS temperature and moisture soundings, retrieved from an advanced IR sounder at single FOV resolution, soundings in hurricane's environmental region can be assimilated in hurricane models for track and intensity forecasts. The single FOV soundings has also been used in the rapid refreshed model and has shown positive impact in forecast experiments (Li et al. 2012).

Building on decades-long research, CIMSS scientists continue to advance and refine the possibilities of advanced IR soundings from geostationary and polar orbit.

Jun Li
Paul Menzel

Community Satellite Processing Package Transforms Data from Suomi NPP

The Suomi National Polar-orbiting Partnership (NPP) satellite is the first of a new generation of sentinels in low earth orbit for observing the atmosphere, land, and oceans. Suomi NPP carries sensors for detecting wildfires, measuring the temperature structure of the atmosphere, and mapping ocean productivity, among other applications. The data acquired by these sensors are transmitted to a ground station in Svalbard, Norway. From there, the data are sent to NOAA/NESDIS in Washington DC, where it is analyzed and processed on large computer systems. While these data cover the whole globe and span many different uses, users must wait two or more hours for them to be available. For anyone needing to make decisions in "real-time," this may take too long. Fortunately Suomi NPP has the capability to instantaneously transmit everything it observes to ground stations on Earth. With the appropriate receiving equipment, anyone can receive these data in real-time, process them on their own computer, and in less than 30 minutes, use the products to make decisions. This process is known as "direct broadcast" (DB), and it enables government agencies, research centers, and universities in the US and around the world to benefit from Suomi NPP observations of the Earth in real time.

U.S. weather satellites have had this capability since the 1970s, starting with the TIROS-N weather satellite and continuing with the POES and EOS Terra and Aqua satellites of today. SSEC has supported the worldwide DB community since 1985 with software packages for processing real-time data from these polar-orbiting satellites. These "Processing Packages" (ITPP, IAPP and IMAPP) were the forerunners in transforming the DB signal into data products and images, and a new set of software from SSEC named the Community Satellite Processing Package (CSPP) continues this tradition.

Figure 1. Image of Florida, Cuba, and the Bahamas on 21 November 2011, from the VIIRS imaging sensor onboard the Suomi NPP satellite.

To acquire direct broadcast (or DB) from Suomi NPP, a tracking antenna with a movable reflector is needed. The antenna tracks the satellite as it rises above the horizon and flies overhead. Typically the satellite will be visible from a mid-latitude location 2-3 times during daytime, and 2-3 times during nighttime. As the satellite flies overhead, specialized electronics and computer systems convert the radio waves received by the antenna into digital signals (or "raw data") that are stored on a computer hard drive.

Specialized computer software is then needed for decoding, geolocating, and calibrating the raw sensor observations. This software converts the raw data received by the antenna to physical quantities such as reflectance and temperature, and also assigns a geographic location to each observed data point. SSEC/CIMSS is playing an important role in providing this software to Suomi NPP DB users around the world.

The operational Suomi NPP software was originally developed to run on the large computer systems at NOAA/NESDIS in Washington DC. SSEC is funded by the JPSS Program to adapt the software to run on modest computer hardware in real-time. In April 2012, SSEC released the first version of the Community Satellite Processing Package (or CSPP) for Suomi NPP VIIRS, ATMS, and CrIS data to more than 40 different users representing government agencies and educational institutions around the world. The CSPP project provides the global DB community with a simple and reliable way to start using the data from Suomi NPP as soon as possible.

To introduce new users to Suomi NPP DB, SSEC/CIMSS scientists often travel far and wide. Recently scientists Kathy Strabala and Jordan Gerth traveled to Alaska and worked with members of the Geographic Information Network of Alaska (GINA) to install CSPP and trained National Weather Service (NWS) forecasters on how the VIIRS image products can be useful for weather applications. For the Alaska region, CSPP automates the processing and distribution of Suomi NPP VIIRS data for display in the Advanced Weather Interactive Processing System (AWIPS) at the National Weather Service (NWS) forecast office in Anchorage.

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Figure 2. Jim Nelson, Science and Operations Officer (SOO) at the NWS Forecast Office in Anchorage, Alaska, examines the first image of the VIIRS Day/Night band as displayed in AWIPS. The data was captured using the DB antenna at GINA in Fairbanks, AK, automatically processed using CSPP software.

“The first step was to install CSPP,” Strabala says. “Then we remap, colorize, and convert the VIIRS Science Data Record (SDR) files into the format required for display in the National Weather Service’s AWIPS software. The next step is to introduce the NWS forecasters to the imagery and its applications. VIIRS data from the Suomi NPP offers new value to forecasters because of its new day/night band, its larger swath size, and its more consistent spatial resolution. Making these new data available in AWIPS will provide the NWS forecasters with better information to do their job.”

In the the lower 48 states, NWS forecasters will use real-time VIIRS imagery for detecting water temperature in the Great Lakes, which has a strong influence on the air temperature for cities including Chicago and Milwaukee, as well as providing information for recreational and commercial users of the lake and coastal regions. The NWS will also use real-time VIIRS data at night for detecting fog close to the surface, which can be a hazard for transportation including airlines and highway travellers.

The VIIRS sensor onboard Suomi NPP also offers a new capability to capture images of clouds and the land surface at visible wavelengths at night, using only the illumination from the moon, or from surface and atmosphere features that emit light when there is no moon. This new feature of Suomi NPP will have an immediate impact in applications such as transportation safety by detecting low fog over highways at night, and also will provide new capabilities for detecting fires, smoke and snow cover at night.

SSEC operates its own X/L-band ground station on the UW-Madison campus, which captures DB data from Suomi NPP in real-time (Figure 3), as well as DB data from the Terra, Aqua, and NOAA POES satellites. Data processed with CSPP at SSEC/CIMSS are now distributed to users including the NWS, the US Naval Research Laboratory in Monterey CA, NASA Marshall Spaceflight Center, the US Forest Service, and the Canadian Ice Service. SSEC/CIMSS facilitates NWS users of polar-orbiting satellite products supplying data to AWIPS in real-time. Starting with the NWS Forecast Office in 2006, SSEC/CIMSS now supplies real-time image products from Suomi NPP, Terra, and Aqua to 57 NWS forecast offices around the United States.

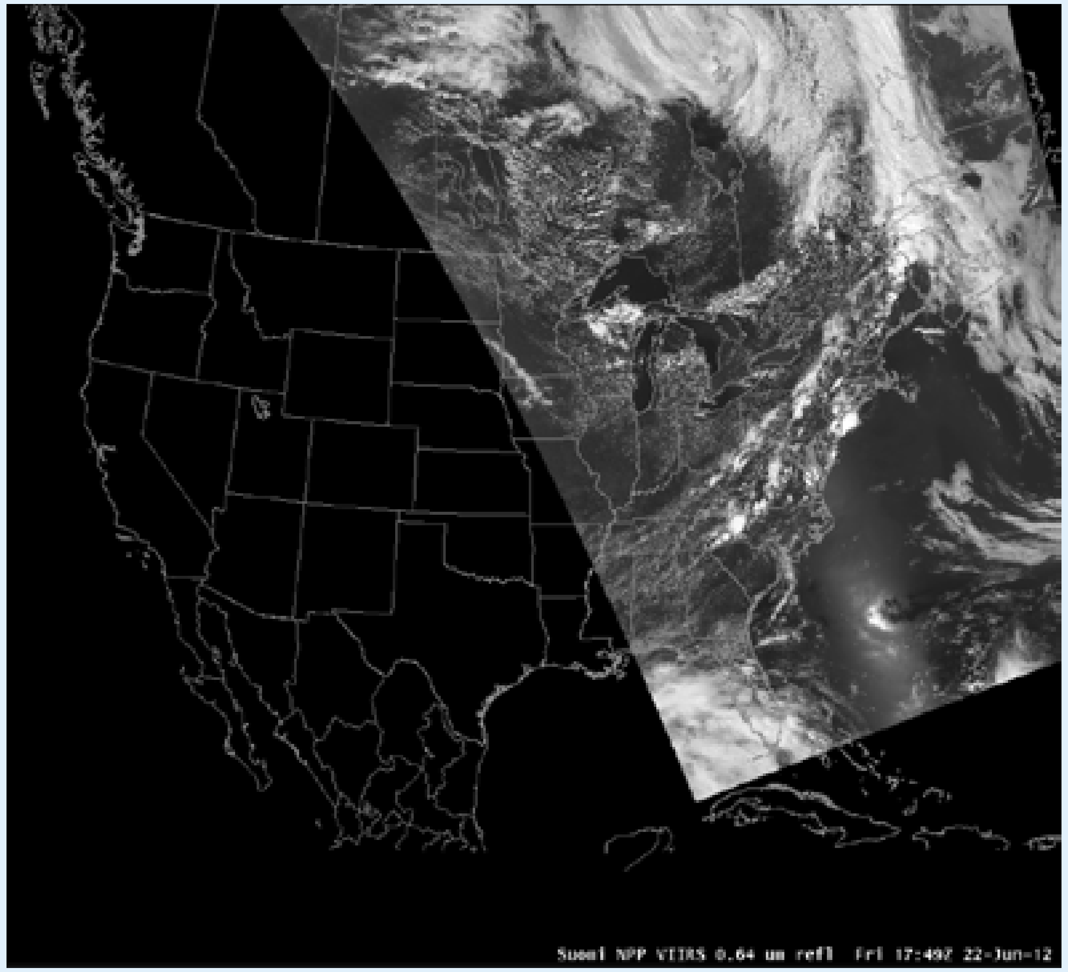
Figure 3. Installation of the SSEC X/L-band Direct Broadcast antenna on the UW-Madison campus in September 2011.

The Community Satellite Processing Package continues a 25-year tradition of supporting the US and international DB communities with free access to software for processing of data from polar-orbiting satellites. When combined with the relatively low cost of DB antenna systems, the opportunity to acquire data in their region of the world in real time, and the demonstrated value of polar-orbiter products, CSPP is promising a great future for those involved in weather forecasting and environmental monitoring.

Liam Gumley
Kathy Strabala
Tom Achtor

Important Disclaimer: CSPP is providing Suomi NPP processing functionality using preliminary algorithms and data to prepare users for real-time direct broadcast applications. Official algorithms are pending and the Suomi NPP calibration/validation checkout has not been completed.

SSEC Partners with NWS to Support AWIPS



A swath of VIIRS visible imagery from 17:49 UTC (12:49 PM CDT) on 22 June 2012, in AWIPS.

Since 2006, SSEC has maintained a relationship with the National Weather Service (NWS) to foster the distribution of satellite imagery and science products to the Advanced Weather Interactive Processing System (AWIPS) at field offices. This collaboration began with the Milwaukee NWS office receiving MODIS imagery collected using an antenna atop SSEC and has since expanded to over 50 NWS offices nationwide.

One significant advantage of the polar-orbiting imagery from MODIS over traditional geostationary imagery is the higher spatial resolution and greater number of spectral bands, which allows for the production of more meaningful science products. For example, the sea surface temperature product provides water skin temperature for the Great Lakes and has been widely used to forecast coastal weather conditions.

VIIRS imagery continues the spatial and spectral legacy of instruments like MODIS in the polar-orbiting orbit with one significant addition, the day/night band. The day/night band is a high-gain visible band which is sensitive to reflected solar light from the moon cast upon clouds. The day/night band also is capable of sensing city lights, lightning, auroras, and fires. SSEC’s NWS partners are looking forward to receiving this imagery to solve a myriad of forecast problems where forecasters are literally “in the dark” during the overnight hours.

SSEC introduced this imagery to NWS Anchorage in May 2012. NWS Honolulu is receiving assistance from SSEC in preparing their antenna for collecting VIIRS imagery over the Pacific Ocean beginning in August 2012.

These demonstrations are known as proving grounds, which have been widely useful for supporting NWS operations.

Jordan Gerth