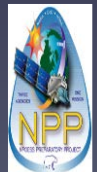


# Real-Time Network for Suomi NPP/JPSS, POES, Metop, EOS, and FY-3 Satellite Reception Across North America and the Pacific

Liam E. Gumley

Space Science and Engineering Center  
University of Wisconsin-Madison

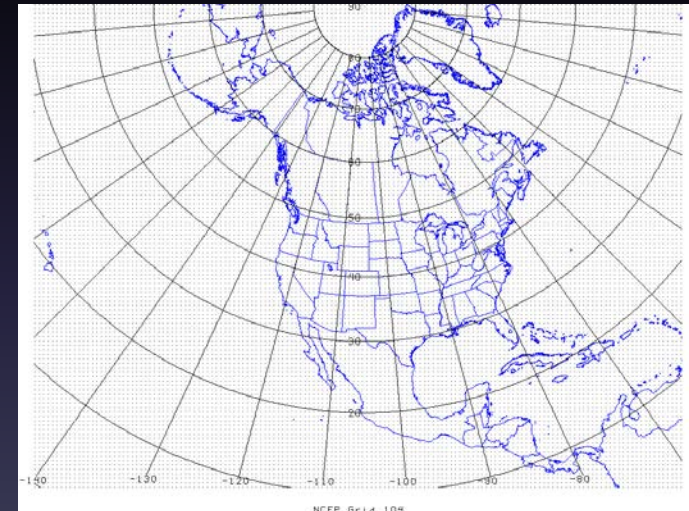
CGMS-41, Tsukuba Japan, 2013/07/11



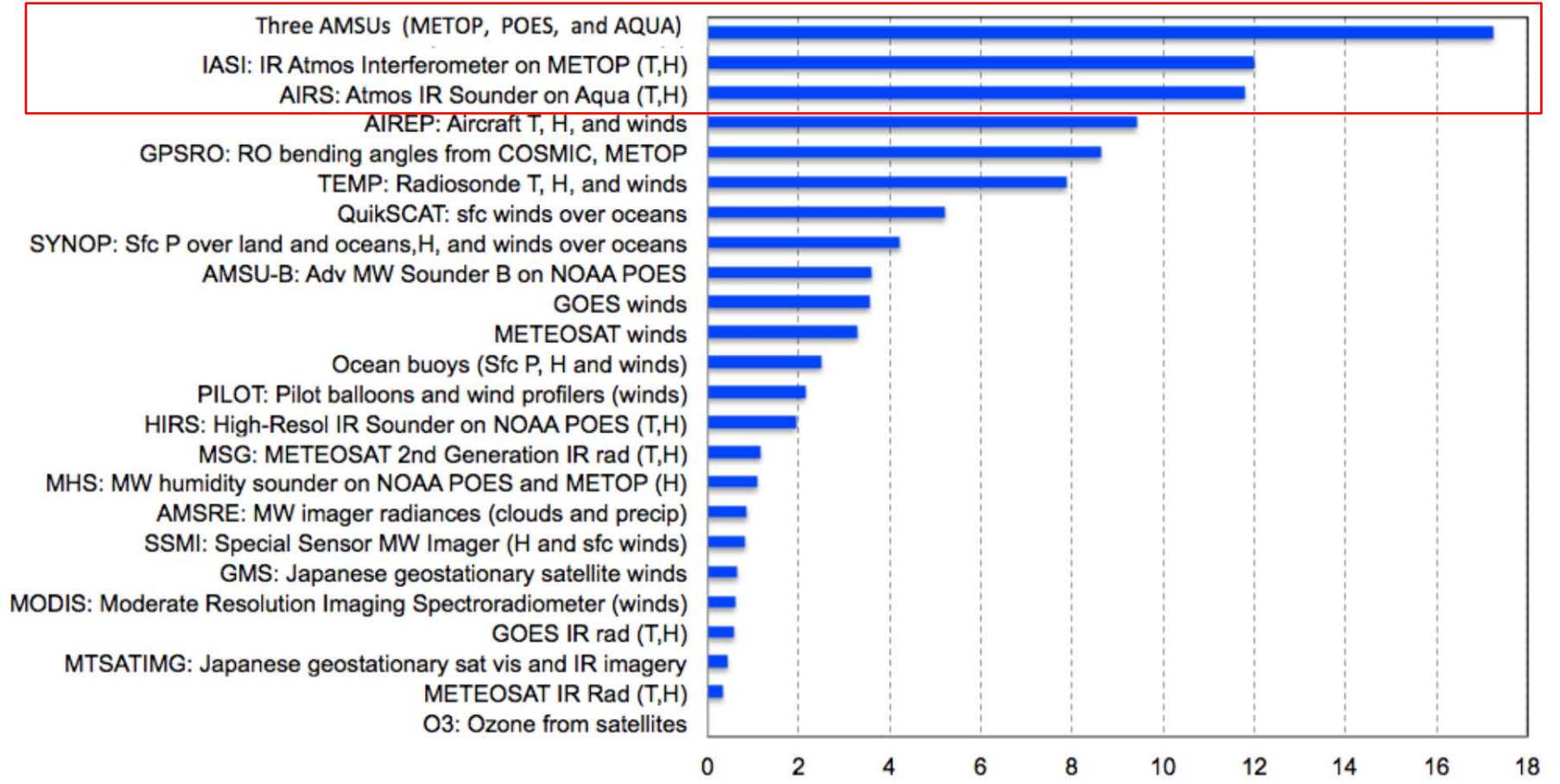
# The Need

- NOAA NWP benefits from timely observations from multiple polar-orbiting meteorological satellites, including Suomi NPP, Metop, FY-3, EOS, and POES.
- Current latency for global Suomi NPP data is 140 minutes: this reduces the percentage of data which can be used for NWP.

NCEP NAM Domain



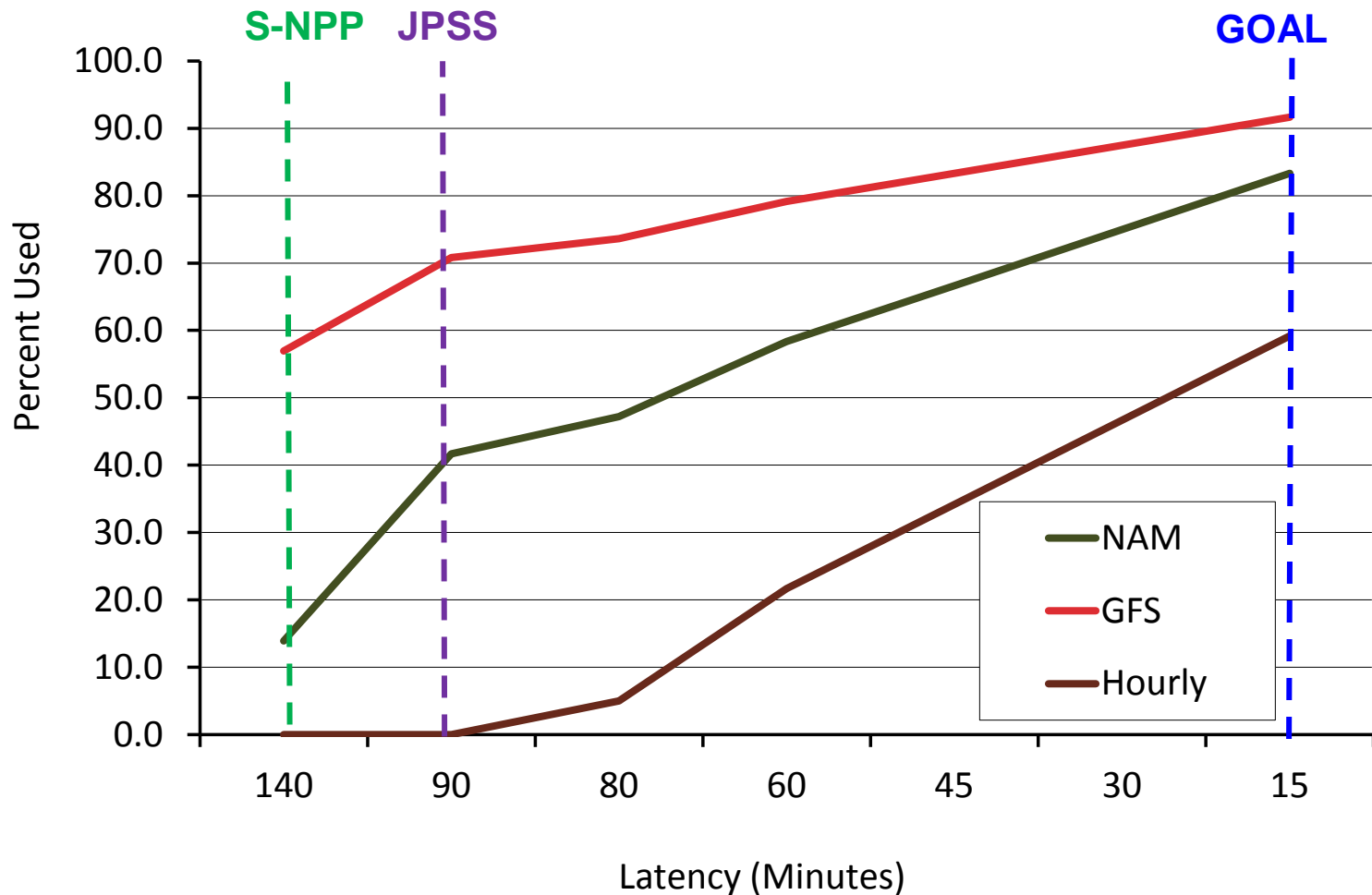
# Forecast Error Reduction as a function of Data Source



From ECMWF

Forecast error reduction contribution (%)

# Percentage of data used in NCEP NWP as a function of Latency





# The Vision

- RARS is very successful at providing regional low-latency data.
- We are planning a complementary service , similar to RARS, to provide low-latency Suomi NPP, Metop, POES, EOS, and FY-3 data to NOAA across the Pacific and North America. Latency goal is 15 minutes.
- In parallel, EUMETSAT and SSEC will work together to make Madison a future EARS reception site.



# About SSEC

Founded by Verner Suomi and located at the University of Wisconsin-Madison, SSEC has supported operational meteorological satellite missions since 1967.

SSEC employs ~ 250 scientists, engineers, programmers, administrators and IT support staff.

SSEC is home to a NOAA Cooperative Institute and the NOAA Advanced Satellite Products Branch.

Real time data are ingested from:

**LEO:** Suomi NPP, Terra, Aqua, NOAA 15/16/18/19, Metop-A/B, FY-3/B

**GEO:** GOES 12/13/14/15; Meteosat 7/9; MTSAT-2; FY-2E/D; Kalpana, COMS



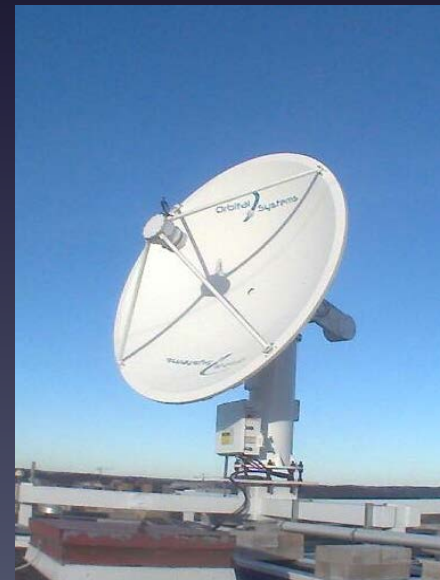
# SSEC Direct Broadcast Reception



SeaSpace 4.4 meter antenna receiving Terra and Aqua.

Orbital Systems 2.4 meter antenna receiving Suomi NPP, Terra, Aqua, Metop-A/B, FY-3B, NOAA 18/19.

Products are delivered to NOAA, National Weather Service, NASA, Canadian Ice Service, and many others.



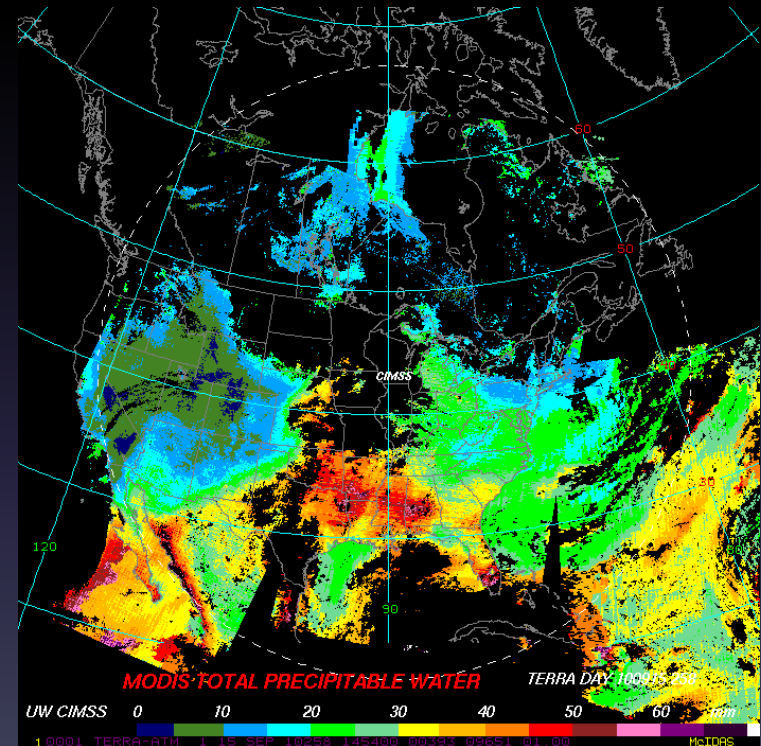
# SSEC Direct Broadcast Software



*International ATOVS Processing Package (IAPP)*  
heritage goes back to 1985. IAPP supports POES  
15/16/18/19.

*International MODIS/AIRS Processing Package  
(IMAPP)* has been available since 2000 (funded  
by NASA). Supports Terra and Aqua.

*Community Satellite Processing Package (CSPP)*  
first released in 2012 (funded by JPSS).  
Supports Suomi NPP, Metop, Terra, and Aqua.



IMAPP MODIS TPW



# CSPP for Suomi NPP

CSPP currently includes software for processing of

- VIIRS, CrIS, and ATMS SDRs (Level 1),
- VIIRS EDRs (Level 2) Cloud Mask, Fires, AOT, SST,
- CrIS single FOV atmospheric profile retrievals,
- VIIRS imagery (AWIPS, GeoTIFF).

Distribution format is executable code and data (ready to run); source code is available from SSEC.

Supported host platform is Red Hat Enterprise Linux 5 (64-bit); fast Intel Xeon hardware is recommended



# Primary Data Sources

For the first phase of this project, we will focus on the following satellites and sensors:

*Suomi NPP: CrIS, ATMS (processed by CSPP)*

*Metop: IASI, AMSU (processed by AAPP)*

*Aqua: AIRS, AMSU (processed by IMAPP)*

*FY-3: MWTS, MWHS (processed by FY3L1PP)*

*POES: AMSU, HIRS (processed by AAPP)*

# Antenna Sites: Partners and Volunteers

*Partner Sites:* Funded by NOAA and operated by NOAA, SSEC, or NOAA-funded partners. Officially part of the network.

NOAA/NWS Honolulu

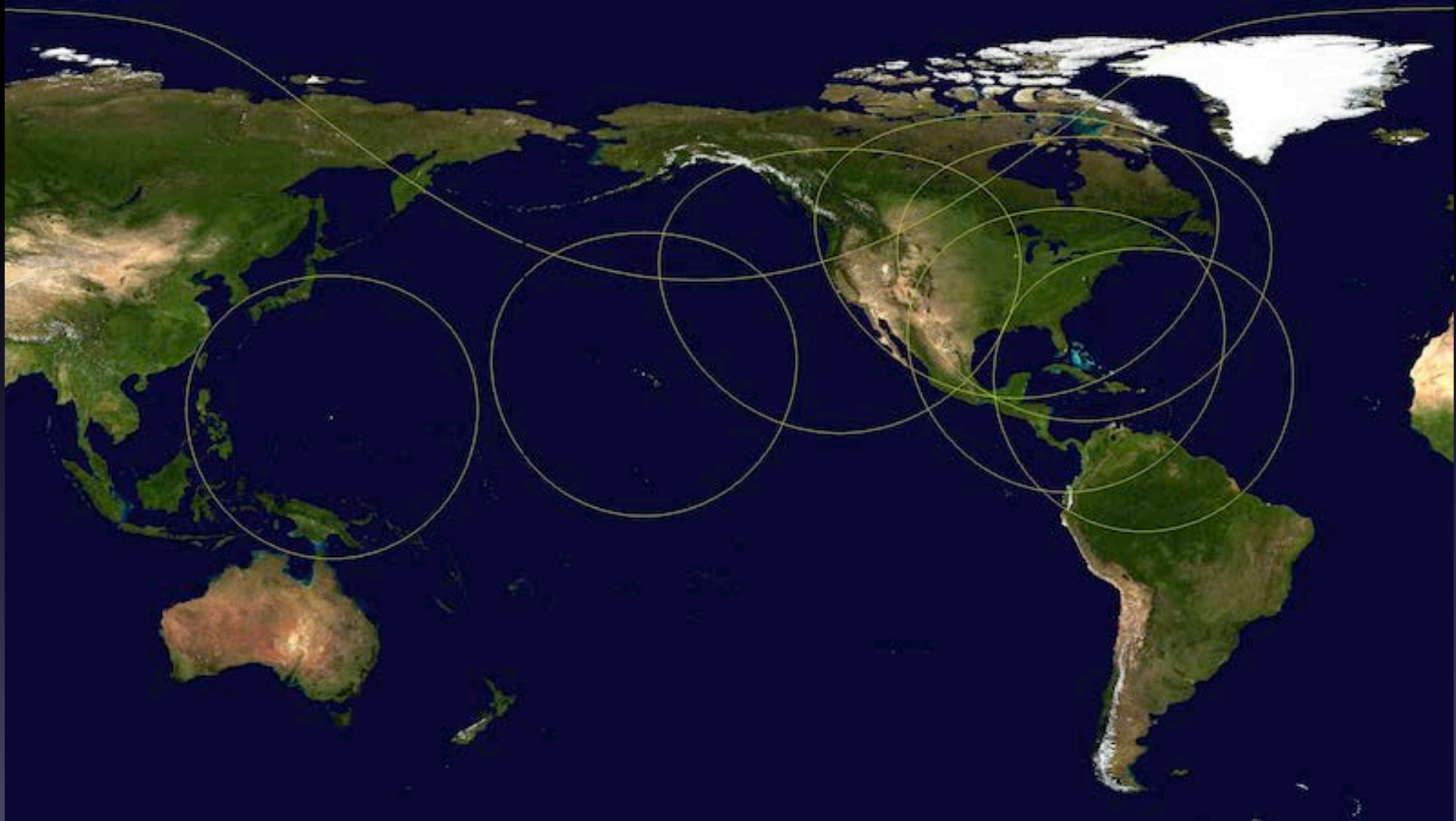


*Volunteer Sites:* DB stations who provide data as a community service. Informal partners in the network.



CSIR Pretoria

# Partner Sites



Guam, Honolulu, Fairbanks, Monterey, Madison, Suitland, Miami, Mayaguez



# Satellite Scheduling Model

- *Partner sites* will schedule satellite acquisitions as directed by NOAA and SSEC.
- *Volunteer sites* will set their own satellite acquisition schedules.
- *In both cases*, acquisition reliability and frequency (as determined by contributed data) will be monitored. Pass predictions for all sites will be generated at SSEC for monitoring purposes.



# Data Ingest Model

- *All contributing sites* will send a notification via HTTPS when a new file is ready for delivery.
- The contributing site will make the file available on a local public download site.
- SSEC will ingest the file automatically as soon as it is notified the file is available.
- SSEC will scan the ingested file, verify it's format, and run a quality check. Metadata will be stored by a DBMS.



# Data Processing Model

- *Partner sites and Volunteer sites* will provide raw data (RDR, CCSDS packets, HRPT) to be processed to L1B at SSEC. Passes from one or more sites may be merged to improve coverage and quality.
- *Partner sites* will have a local processing system to provide local products.



# Enabling Technologies

- Multi-mission antenna systems able to receive data from multiple satellites.
- Freely available software packages (CSPP, AAPP, IMAPP, FY3L1PP).
- Widely available medium bandwidth Internet connectivity (1-2 Mbps) sufficient for transmitting infrared and microwave sounder data.





# Central Processing Facility

*Ingest Subsystem:* ingests RDR/L0 satellite data from antenna sites (including selective logic).

*Processing Subsystem:* processes RDR/L0 satellite data to SDR/L1B.

*Distribution Subsystem:* sends SDR/L1B products to NOAA/NCEP.

*Monitoring Subsystem:* monitors the acquisitions, reliability, latency and quality of each station, and the latency, processing, and distribution of data at the central processing facility.



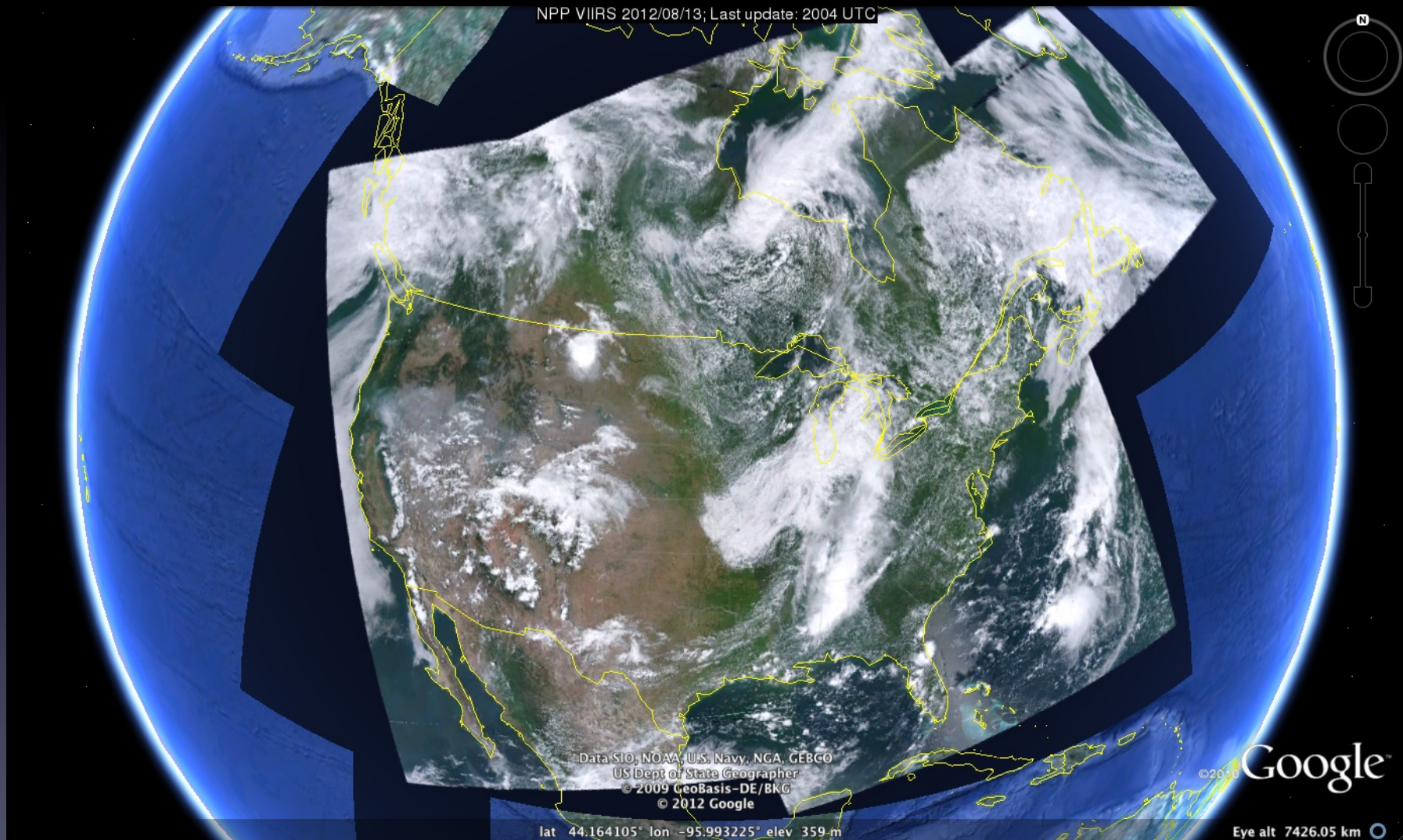
# Local Processing at Partner Sites

- Partner sites will run a processing system developed by SSEC to create local products with low latency.
- Server hardware will either be supplied by SSEC, or tested for compatibility by SSEC.
- Partner sites will have open read-only access to the local products from all sensors (including image products from VIIRS and MODIS).

# SNPP/VIIRS Coverage from SSEC demonstrates large coverage of one site.



NPP VIIRS 2012/08/13; Last update: 2004 UTC



Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
US Dept of State Geographer  
© 2009 GeoBasis-DE/BKG  
© 2012 Google

©2012 Google

lat 44.164105° lon -95.993225° elev 359 m

Eye alt 7426.05 km

# Project Supports Local Applications: VIIRS imagery at Anchorage NWS Office



VIIRS Day/Night Band



Fairbanks DB antenna



VIIRS Imagery at NWS Forecast Desk



# Local Product Suite

## **VIIRS/MODIS/AVHRR/VIRR/MERSI Level 1B Products**

Level 0 quicklook images (JPEG)  
Level 1B radiances and geolocation

## **VIIRS/MODIS/AVHRR Atmosphere Products**

Cloud Mask and Phase  
Cloud Top Pressure and Emissivity  
Cloud Optical Depth  
Aerosol Optical Thickness  
Temperature and Water Vapor Profiles  
Total Column Precipitable Water Vapor  
Total Column Ozone

## **VIIRS/MODIS Land Products**

Corrected Reflectance  
Fire Detection / Thermal Anomalies  
Land Surface Temperature  
Normalized Difference Vegetation Index  
Enhanced Vegetation Index  
Land Surface Reflectance

## **VIIRS/MODIS Ocean Products**

Chlorophyll-A Concentration  
Sea Surface Temperature: 11 micron and 4 micron  
Water-leaving radiance (5 channels, 412- 667 nm)  
Aerosol optical thickness at 869 nm  
Epsilon of aerosol correction at 748 and 869 nm  
Diffuse attenuation coefficient at 490 nm  
Angstrom coefficient, 531-869 nm

## **VIIRS/MODIS/MERSI Image Products**

Atmosphere, land, ocean images (GeoTIFF, JPEG)  
True color images (KML)

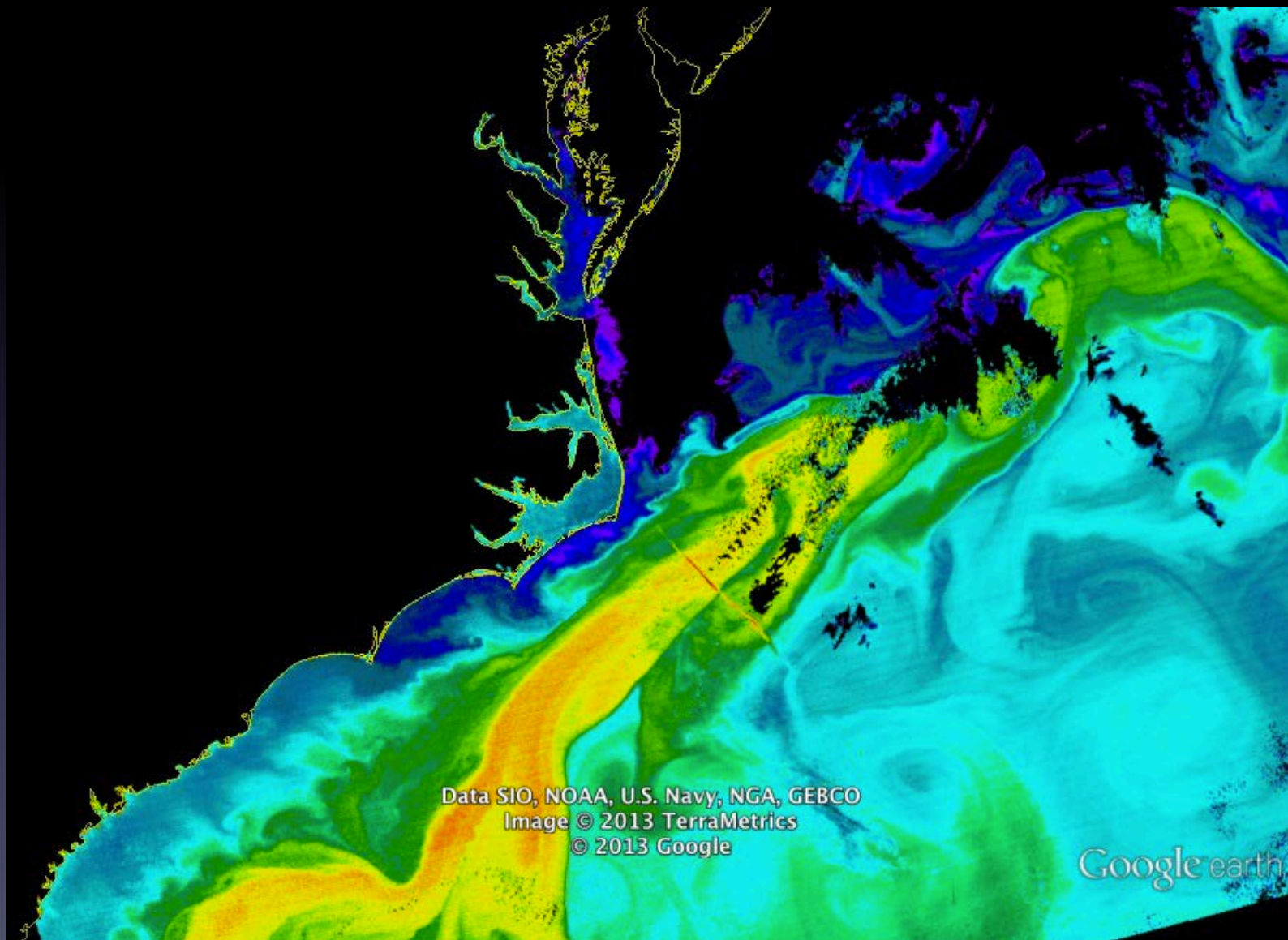
## **CrIS/IASI/AIRS Products**

Level 1B data (including AIRS and AMSU)  
Level 2 retrievals of temperature and moisture

## **ATMS/AMSU/MWTS/MWHS Products**

Calibrated and geolocated antenna temperatures  
Rain Rate, Soil Moisture, Snow Water Equivalent

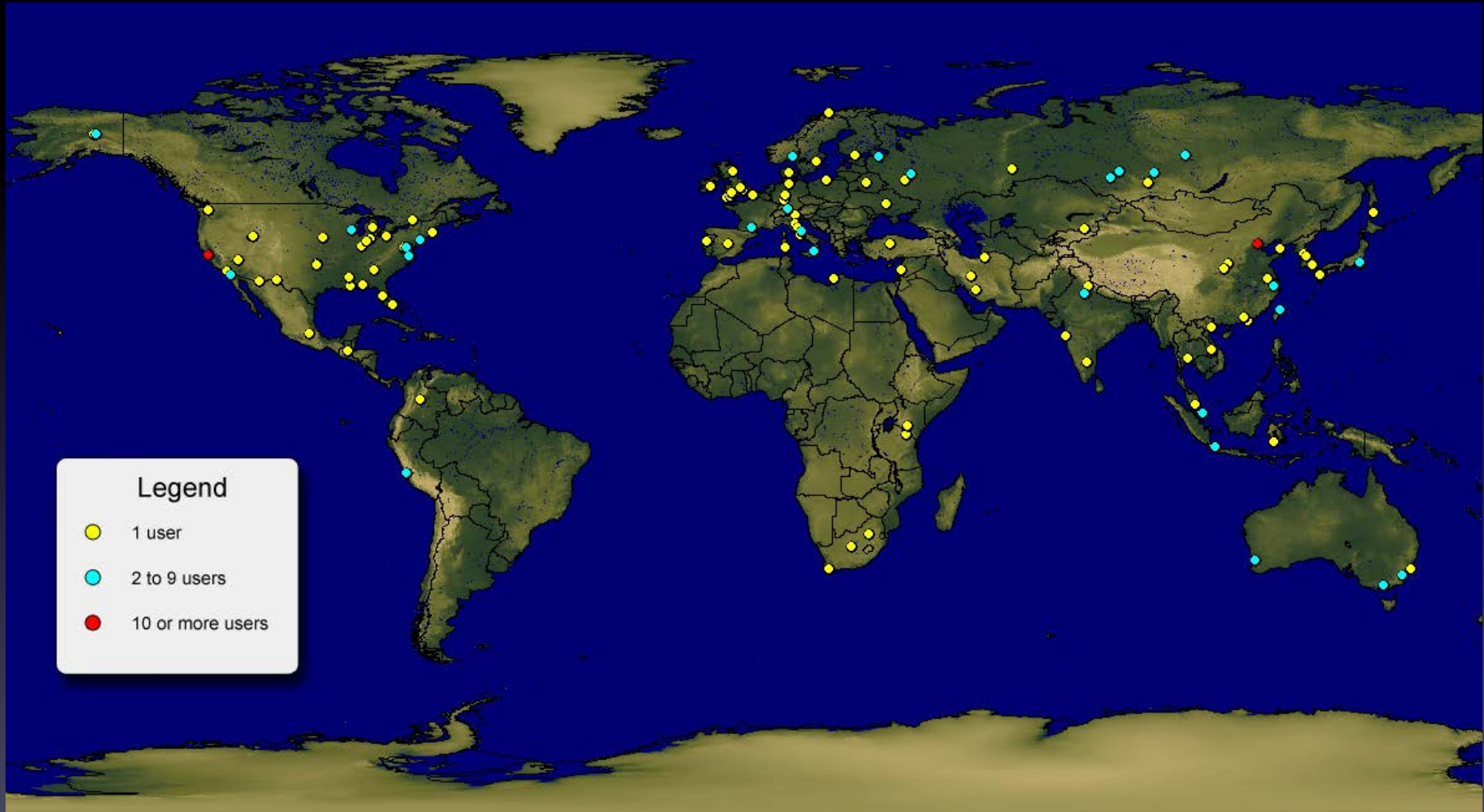
# Local Product: VIIRS SST



# Local Product: VIIRS True Color



# Volunteer Sites (Potential)



More than 200 registered users of CSPP





# Volunteer Sites can contribute with minimal effort

- The only requirement is to (a) install a very small messaging utility, and (b) run the messaging utility a new raw data file (RDR, CCSDS, HRPT) is made available on a local distribution site.
- If no local distribution site exists, files can be uploaded to the SSEC FTP site.
- SSEC ingests the file. SSEC DBMS and associated logic determines which files are ingested. Data rates up to 1TB day are no problem.
- We are already receiving data from 6 DB stations in volunteer mode (newest is CONABIO in Mexico City).



# Product Delivery to NCEP

- Primary delivery format for Level 1B data will be BUFR.
- BUFR converters are provided by AAPP and NOAA (e.g., channel subsetting for CrIS/AIRS/IASI).
- Duplicate data is handled at NCEP as part of assimilation step.
- Product delivery to NOAA/NCEP will be via established secure Internet pathways.
- Product delivery and related latency statistics will be monitored and reported to NOAA.



# Future Milestones

## *By end of 2013*

- SSEC begins producing and delivering real-time L1B products using data from existing partner and volunteer sites (Honolulu, Fairbanks, Corvallis, Madison, GSFC, Mexico City).
- NOAA and SSEC installs new multi-mission antenna systems at Guam, Monterey, Suitland, Miami, and Mayaguez PR.

## *By end of 2014*

- SSEC ingests data from at least 8 partner stations and at least 20 (estimated) volunteer stations.
- All partner stations are creating a full product suite and using it for local applications.



# Thoughts for the Future

- Rebroadcast has not been considered for this project; perhaps it would be a useful future addition.
- Need to ensure that sponsor organizations keep supporting the development and distribution of processing software (ITWG discusses and collaborates on these packages).
- Cloud providers (e.g., Amazon Web Services) may provide a useful processing and distribution capability.
- Support for GEO processing (e.g., Himawari and GOES-R) in CSPP is in the early planning stages.

# Suomi NPP VIIRS True Color Japan 2013/07/09



Data Japan Hydrographic Association

Image Landsat  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

46 mi

Google earth