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

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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.
Forecast Error Reduction as a function of Data Source

From ECMWF

<table>
<thead>
<tr>
<th>Data Source</th>
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<tbody>
<tr>
<td>Three AMSUs (METOP, POES, and AQUA)</td>
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<tr>
<td>IASI: IR Atmos Interferometer on METOP (T,H)</td>
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<tr>
<td>AIRS: Atmos IR Sounder on Aqua (T,H)</td>
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<td>AIREP: Aircraft T, H, and winds</td>
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<td>GPSRO: RO bending angles from COSMIC, METOP</td>
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<td>TEMP: Radiosonde T, H, and winds</td>
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<tr>
<td>QuikSCAT: sfc winds over oceans</td>
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<tr>
<td>SYNOP: Sfc P over land and oceans, H, and winds over oceans</td>
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<td>AMSU-B: Adv MW Sounder B on NOAA POES</td>
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<tr>
<td>GOES winds</td>
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<tr>
<td>METEOSAT winds</td>
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<tr>
<td>Ocean buoys (Sfc P, H and winds)</td>
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<td>PILOT: Pilot balloons and wind profilers (winds)</td>
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<td>HIRS: High-Resol IR Sounder on NOAA POES (T,H)</td>
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<td>MSG: METEOSAT 2nd Generation IR rad (T,H)</td>
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<td>MHS: MW humidity sounder on NOAA POES and METOP (H)</td>
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<tr>
<td>AMSRE: MW imager radiances (clouds and precip)</td>
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<tr>
<td>SSMI: Special Sensor MW Imager (H and sfc winds)</td>
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<tr>
<td>GMS: Japanese geostationary satellite winds</td>
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<tr>
<td>MODIS: Moderate Resolution Imaging Spectroradiometer (winds)</td>
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<td>GOES IR rad (T,H)</td>
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<tr>
<td>MTSATIMG: Japanese geostationary sat vis and IR imagery</td>
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<tr>
<td>METEOSAT IR Rad (T,H)</td>
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<td>O3: Ozone from satellites</td>
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</table>
Percentage of data used in NCEP NWP as a function of Latency

- **S-NPP**
- **JPSS**
- **GOAL**

Latency (Minutes)

Percent Used

- **NAM**
- **GFS**
- **Hourly**

Data usage percentages for different latency times, with S-NPP, JPSS, and GOAL indicating specific points on the graph.
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.
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.
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.

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