CSPP LEO: Status and Recent Enhancements

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CIMSS/SSEC
University of Wisconsin-Madison, USA

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Outline

- Overview of CSPP LEO
- Software packages, sensors, and satellites supported by CSPP LEO
- Recent enhancements
- New features coming soon
What is CSPP LEO?

- The Community Satellite Processing Package (CSPP) is a collection of freely available software for processing data from Low Earth Orbit (LEO) meteorological satellites.
- CSPP LEO supports the creation of calibrated observational data, geophysical derived products, and images from visible, infrared, and microwave sensors.
- CSPP LEO is funded by NOAA JPSS Program Office.

https://cimss.ssec.wisc.edu/cspp/
Who uses CSPP LEO?

CSPP registration database on 2019-06-16 comprises 2235 registrants in 94 countries
Typical LEO DB reception system

2.4-m X/L-band Antenna
Kwajalein Atoll

X-band and L-band demodulators
Control computer and Processing server
Features of CSPP LEO

The CSPP software

- Is freely available,
- Includes up-to-date algorithms,
- Ready to run on 64-bit Intel Linux (CentOS 6/7),
- Is easy to install and operate,
- Includes test data for verification,
- Runs efficiently on modest hardware,
- Has prompt expert user support.
NOAA-20

Launched November 18, 2017
Main updates since last CSPP Meeting

• Support for NOAA-20 and Metop-C
• Imagery for SST and Cloud Products (VIIRS, MODIS, AVHRR)
• Fire detection for VIIRS
• Flood detection for VIIRS
• Combined infrared/microwave retrievals for IASI/AMSU
• Updated microwave retrievals for ATMS, AMSU/MHS
• Updated infrared/microwave retrievals for CrIS/ATMS and IASI/AMSU
• Aerosol, snow, cloud, ice, and volcanic ash for VIIRS
CSPP LEO satellites and sensor

Supported satellites and sensors:

• NOAA-20 and Suomi NPP (VIIRS, CrIS, ATMS)
• Metop-A/B/C (IASI, AMSU-A, MHS, HIRS, AVHRR)
• NOAA-18/19 (AMSU-A, MHS, HIRS)
• Terra and Aqua (MODIS, AIRS)
• GCOM-W1 (AMSR-2)
• FY-3B/C/D (VIRR, MERSI-2)
CSPP LEO Products

Supported products:

• Geolocated and calibrated reflectances and brightness temperatures
• Georeferenced imagery
• Cloud properties
• Sea Surface Temperature
• Temperature and Moisture Profile Retrievals
• Flood and Active Fire Detection
• Aerosol, Snow, Ice, and Volcanic Ash Properties
• Interactive Visualization
## CSPP LEO Software Packages

<table>
<thead>
<tr>
<th>CSPP Software Package</th>
<th>Product Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDR</td>
<td>VIIRS, CrIS, and ATMS geolocated and calibrated earth observations (NOAA algorithm).</td>
</tr>
<tr>
<td>Polar2grid</td>
<td>Reprojected imagery (single and multi-band) in GeoTIFF and AWIPS formats.</td>
</tr>
<tr>
<td>Hydra</td>
<td>Interactive visualization and interrogation of multispectral imagery and hyper spectral soundings.</td>
</tr>
<tr>
<td>VIIRS ASCI</td>
<td>VIIRS imager aerosol optical depth, cloud properties, sea ice, and volcanic ash (NOAA algorithm).</td>
</tr>
<tr>
<td>VIIRS Active Fires</td>
<td>VIIRS imager wildfire detection (NOAA algorithm).</td>
</tr>
<tr>
<td>VIIRS Flood Detection</td>
<td>VIIRS imager flood detection (NOAA algorithm).</td>
</tr>
<tr>
<td>HSRTV</td>
<td>Hyperspectral infrared sounder retrievals of temperature and moisture profiles, cloud properties, total ozone, and surface properties.</td>
</tr>
<tr>
<td>MIRS</td>
<td>Microwave sounder retrievals of temperature and moisture profiles; surface properties; snow and ice cover; rain rate; and cloud/rain water paths (NOAA algorithm).</td>
</tr>
<tr>
<td>CLAVR-x</td>
<td>Multispectral imager retrievals of cloud properties; aerosol optical depth; surface properties; ocean properties (NOAA algorithm).</td>
</tr>
<tr>
<td>NUCAPS &amp; NUCAPS-IASI</td>
<td>Combined hyperspectral infrared sounder and microwave sounder retrievals of temperature and moisture profiles, cloud cleared radiances, and trace gases (NOAA algorithm).</td>
</tr>
<tr>
<td>IAPP</td>
<td>Combined infrared sounder and microwave sounder retrievals of temperature and moisture profiles, water vapor, total ozone, and cloud properties.</td>
</tr>
<tr>
<td>ACSPO</td>
<td>Multispectral imager retrievals of sea surface temperature (NOAA algorithm).</td>
</tr>
<tr>
<td>Sounder Quicklook</td>
<td>Projected 2D maps of temperature and water vapor retrievals, and Skew-T profiles for individual atmospheric profiles.</td>
</tr>
</tbody>
</table>
## CSPP LEO Supported Sensors

<table>
<thead>
<tr>
<th>CSPP Software</th>
<th>SNPP</th>
<th>NOAA-20</th>
<th>Metop-A/B/C</th>
<th>NOAA-18/19</th>
<th>Terra</th>
<th>Aqua</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDR</td>
<td>VIIRS, CrIS, ATMS</td>
<td>VIIRS, CrIS, ATMS</td>
<td>Provided by AAPP &amp; OPS-LRS</td>
<td>Provided by AAPP</td>
<td>Provided by SeaDAS</td>
<td>Provided by SeaDAS</td>
</tr>
<tr>
<td>Polar2Grid</td>
<td>VIIRS, CrIS, ATMS</td>
<td>VIIRS, CrIS, ATMS</td>
<td>AVHRR, AMSGU, MHS</td>
<td>AVHRR, AMSGU, MHS</td>
<td>MODIS</td>
<td>MODIS, AIRS</td>
</tr>
<tr>
<td>Hydra</td>
<td>VIIRS, CrIS, ATMS</td>
<td>VIIRS, CrIS, ATMS</td>
<td>AVHRR, IASI</td>
<td>AVHRR</td>
<td>MODIS</td>
<td>MODIS, AIRS</td>
</tr>
<tr>
<td>VIIRS ASCI</td>
<td>VIIRS</td>
<td>VIIRS</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>VIIRS Active Fires</td>
<td>VIIRS</td>
<td>VIIRS</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>VIIRS Flood Detection</td>
<td>VIIRS</td>
<td>VIIRS</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>HSRTV</td>
<td>CrIS</td>
<td>CrIS</td>
<td>IASI</td>
<td>N/A</td>
<td>N/A</td>
<td>AIRS</td>
</tr>
<tr>
<td>MIRS</td>
<td>ATMS</td>
<td>ATMS</td>
<td>AMSU, MHS</td>
<td>AMSU, MHS</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>CLAVR-x</td>
<td>VIIRS</td>
<td>Coming soon</td>
<td>AVHRR</td>
<td>AVHRR</td>
<td>MODIS</td>
<td>MODIS</td>
</tr>
<tr>
<td>NUCAPS &amp; NUCAPS-IASI</td>
<td>CrIS, ATMS</td>
<td>CrIS, ATMS</td>
<td>IASI, AMSU</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>IAPP</td>
<td>N/A</td>
<td>N/A</td>
<td>HIRS, AMSGU, MHS</td>
<td>HIRS, AMSGU, MHS</td>
<td>N/A</td>
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<td>ACSPO</td>
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<td>Sounder Quicklook</td>
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<td>AMSU, MHS</td>
<td>N/A</td>
<td>AIRS</td>
</tr>
</tbody>
</table>
CSPP SDR (Sensor Data Record) creates calibrated and geolocated earth observation products (Level 1B).

<table>
<thead>
<tr>
<th>Heritage</th>
<th>Developed by Raytheon and released as part of Algorithm Development Library (ADL).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellites/ Sensors</td>
<td>NOAA-20, Suomi NPP (VIIRS, CrIS, ATMS).</td>
</tr>
<tr>
<td>Products</td>
<td><strong>VIIRS</strong>: M-band, I-band, and Day/Night Band SDR calibrated sensor data and geolocation files in HDF5 format. <strong>CrIS</strong>: Calibrated spectra and geolocation in HDF5 format. <strong>ATMS</strong>: Calibrated antenna temperatures and geolocation in HDF5 format.</td>
</tr>
<tr>
<td>Features</td>
<td>• Multi-core support for faster processing.</td>
</tr>
<tr>
<td></td>
<td>• Optional product aggregation and compression.</td>
</tr>
<tr>
<td></td>
<td>• Automated download and installation of calibration LUTs.</td>
</tr>
<tr>
<td></td>
<td>• Quicklook images</td>
</tr>
</tbody>
</table>
CSPP SDR v3.1 Features

- Supports multi-core processing for reduced runtimes (e.g., 13-minute VIIRS pass processed in 8 minutes using 8 cores). **Critical for low latency.**

- CrIS can be processed at Normal Spectral Resolution (NSR) or Full Spectral Resolution (FSR).
  - Default mode for SNPP CrIS is NSR.
  - Default mode for JPSS-1 CrIS is FSR.

- Supports offline downloads of required ancillary data and calibration lookup tables.

- Users’ Guide includes information on BUFR conversion for DBNet station operators.
CSPP SDR Examples

NOAA-20 Direct Broadcast data from Miami antenna 2019/06/21

VIIRS DNB

VIIRS True Color
CSPP SDR Examples

NOAA-20 Direct Broadcast data from Madison antenna
2018/06/18 07:10 UTC

CrIS 1600 cm\(^{-1}\)  
ATMS 89 GHz
HSRTV (High Spectral Resolution Retrieval) creates temperature, moisture, and trace gas profiles, and cloud products.

<table>
<thead>
<tr>
<th>Heritage</th>
<th>Developed at CIMSS/SSEC by Bill Smith, Elisabeth Weisz, and Nadia Smith.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellites/ Sensors</td>
<td>NOAA-20 and Suomi NPP (CrIS); Metop-A/B/C (IASI); Aqua (AIRS).</td>
</tr>
<tr>
<td>Products</td>
<td>Temperature, moisture, and ozone at 101 pressure levels; surface skin temperature and emissivity; total column water vapor and ozone; CO$_2$ amount; cloud mask; cloud top pressure and temperature; and cloud optical thickness in HDF5 format</td>
</tr>
<tr>
<td>Features</td>
<td>• Common multi-sensor algorithm.</td>
</tr>
<tr>
<td></td>
<td>• Single field of view retrievals.</td>
</tr>
<tr>
<td></td>
<td>• Fast regression algorithm.</td>
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</tbody>
</table>
**HSRTV Examples**

**CrIS**
- Temperature
  - 850 hPa

**CrIS**
- Mixing ratio
  - 850 hPa

**IASI**
- Temperature
  - 850 hPa

**IASI**
- Mixing ratio
  - 850 hPa
MIRS (Microwave Integrated Retrieval System) creates atmospheric profile, precipitation, and surface products from microwave sounder data.

### Heritage
Developed at NOAA/NESDIS by Sid Boukabara, Chris Grassotti, et al.

### Satellites/Sensors
- NOAA-20 and Suomi NPP (ATMS); Metop-A/B (AMSU, MHS);
- NOAA-18/19 (AMSU, MHS).

### Products
- Temperature and moisture profiles, total precipitable water, surface skin temperature and emissivity, rain rate, cloud liquid water, rain water path, ice water path, liquid water path, sea ice concentration, snow water equivalent, and snow cover.

### Features
- Multi-sensor common algorithm.
- Physics-based retrieval.
- Retrieves land and ocean products in all sky conditions.
- Extensively validated and documented.
MIRS Examples

NOAA-20
2019/06/24
07:54 UTC

Atmospheric Temperature
840 hPa

NOAA-20
2019/06/24
07:54 UTC

Water vapor Mixing ratio
840 hPa

Metop-B
2019/06/24
03:32 UTC

Atmospheric Temperature
840 hPa

Metop-B
2019/06/24
03:32 UTC

Water vapor Mixing ratio
840 hPa
NUCAPS and NUCAPS-IASI

NUCAPS (NOAA Unique CrIS/ATMS Processing System) retrieves atmospheric temperature, moisture, and trace gases from combined infrared and microwave observations.

<table>
<thead>
<tr>
<th>Heritage</th>
<th>Developed at NOAA/NESDIS/STAR by Chris Barnet, Antonia Gambacorta, Tom King, Walter Wolf, Mark Liu et al.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellites/</td>
<td>NOAA-20 and Suomi NPP (CrIS, ATMS); Metop-A/B (IASI, AMSU)</td>
</tr>
<tr>
<td>Sensors</td>
<td></td>
</tr>
<tr>
<td>Products</td>
<td>Temperature, water vapor, and ozone profiles; trace gas profiles including ozone, carbon monoxide, methane, carbon dioxide, nitrous oxide, sulphur dioxide; infrared and microwave surface emissivity; cloud cleared radiances.</td>
</tr>
<tr>
<td>Features</td>
<td>• Multi-sensor common physical retrieval algorithm.</td>
</tr>
<tr>
<td></td>
<td>• NUCAPS is the official NOAA sounding product for JPSS.</td>
</tr>
<tr>
<td></td>
<td>• Future version will support Metop-C (IASI/AMSU).</td>
</tr>
</tbody>
</table>
NUCAPS Examples

NOAA-20 2019/06/20 18:55 UTC

Temperature at 852 hPa

Water Vapor Mixing Ratio at 852 hPa
NUCAPS-IASI Examples

Metop-B 2018/08/02 01:02 UTC

Temperature at 852 hPa

Water Vapor Mixing Ratio at 852 hPa
VIIRS flood detection

Algorithm developed by Sanmei Li at George Mason University

- Daytime algorithm using VIIRS I-bands at 375 meter resolution.
- Includes built-in tests for detecting clouds, snow, ice, and shadows from clouds and terrain.
- Uses static global water database to identify “normal water”.
- Supports SNPP and NOAA-20 VIIRS
VIIRS flood detection

SNPP VIIRS Flood Detection 2018/09/27 CAMBODIA
## VIIRS ASCI

VIIRS Aerosol, Snow/Ice, Cloud and Volcanic Ash.

<table>
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<tr>
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<th>Developed at NOAA/NESDIS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Satellites/ Sensors</strong></td>
<td>NOAA-20 and Suomi NPP (VIIRS)</td>
</tr>
<tr>
<td><strong>Products</strong></td>
<td>Cloud Mask, Cloud Top Properties, Cloud Phase, Cloud Base Height, and Cloud Optical Depth; Aerosol Optical Depth and Aerosol Detection Product; Snow Mask, Snow Fraction, Ice Age, Ice Thickness, Ice Concentration, and Ice Surface Temperature; Volcanic Ash Confidence, Ash Height, Ash Top Temperature, Ash Effective Radius and Ash Optical Depth.</td>
</tr>
</tbody>
</table>
| **Features**      | • Multi-core acceleration  
                     • Automated download of ancillary data |
VIIRS ASCI Examples

SNPP 2019/06/01 18:58 UTC

Cloud Mask

Aerosol Optical Thickness

SNPP 2019/06/02 07:15 UTC

Ice Concentration
Algorithm developed by Ivan Csiszar and Wilfrid Schroeder at NOAA.

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<tbody>
<tr>
<td>Satellites/Sensors</td>
<td>NOAA-20 and Suomi NPP (VIIRS)</td>
</tr>
</tbody>
</table>
| Products       | • I-Band (375m) and M-Band (750m) resolutions.  
                  • Fire Mask, Detection Confidence, Fire Radiative Power.  
                  • netCDF and text file product formats. |
| Features       | • Multi-core acceleration |
VIIRS Active Fires Example
New features coming soon in CSPP LEO

- VIIRS SST support for NOAA-20
- Cloud product support for NOAA-20, Metop-C, FY-3D
- GAASP microwave products
- Polar2Grid imagery from FY-3D MERSI-2, FY-3B/C VIRR, VIIRS Flood, VIIRS Fires
- VIIRS Land Surface Reflectance and Land Surface Temperature
Metop-C & FY-3D Cloud Products (CLAVR-x)

Cloud Mask

Metop-C
2019/06/15
16:41 UTC

Cloud Type

FY-3D
2019/05/31
08:00 UTC
GAASP for GCOM-W1 AMSR2

GCOM-W1 AMSR2 Algorithm Software Package (GAASP) was developed at NOAA/NESDIS/STAR.

GAASP products include:

Precipitation Rate (PR), Sea Surface Temperature (SST), Sea Surface Winds (SSW), Total Precipitable Water (TPW), Cloud Liquid Water (CLW), Soil Moisture (SM), Surface Type (ST), Snow Cover (SC), Snow Depth (SD), Snow Water Equivalent (SWE), and Sea Ice Cover (SIC).
GAASP Example: Sea Ice

GAASP Ice Concentration 2018-11-04 to 2018-11-05
Polar2Grid Examples

FY-3B VIRR
2019/06/19

FY-3D MERSI-2
2019/03/12
Summary

• CSPP LEO continues to support the global DB community with updated software and new products.

• Support for NOAA-20, Metop-C, and FY-3D has been added.

• We look forward to supporting JPSS-2 launch in 2022.

https://cimss.ssec.wisc.edu/cspp/

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