



# Sounding Data Products generated at NOAA/NESDIS Using High Spectral Resolution Infrared and Advanced Microwave Sounders (CrIS/ATMS)

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## NOAA Unique Combined Atmospheric (CrIS ATMS) Processing System (NUCAPS) Using SNPP, NOAA-20, IASI/Metop-1, and IASI/Metop-2 Satellites.

The Office of Satellite and Product Operations (OSPO) of NOAA/NESDIS has implemented innovative tools to monitor performance and data quality of the operational sounder and imager products that are being generated using the Cross-track Infrared Sounder (CrIS), in conjunction with the Advanced Technology Microwave Sounder (ATMS). Higher (spatial, temporal and spectral) resolution and accurate sounding data from CrIS and ATMS support continuing advances in data assimilation systems and NWP models to improve short- to medium-range weather forecasts and climate applications. Currently, the NOAA Unique Combined Atmospheric Processing System (NUCAPS) level 2 products from Metop-A/B/C, S-NPP, and NOAA-20 satellites include temperature and humidity profiles; trace gases such as ozone, nitrous oxide, carbon dioxide, and methane; and the cloud cleared radiances (CCR) on a global scale and these products are available to the operational user community. The OSPO tools have been extended to include the CrIS/ATMS SKEW-T (Logarithmic Pressure vs Temperature and Dew Point Temperature) sounding plots over the globe. These plots are updated every hour to show the latest sounding at each grid points (0.5 X 0.5 degrees) over the globe. The last ten soundings are retained to track the changes in the atmospheric conditions. The incorporation of these tools in the OSPO operation has facilitated the diagnosis and resolution of problems when detected in the operational environment. This presentation will include several of these tools developed and deployed for the sounding products monitoring and data quality assurance which led to improving the maintenance and sustainment of the Environmental Satellites Processing Center (ESPC) processing systems. The presentation will include the discussion on the ESPC system architecture involving sounding data processing and distribution for CrIS and IASI sounding products. Discussion will also include the improvements made for data quality measurements, granule processing and distribution, and user timeliness requirements envisioned from the next generation of JPSS and EUMETSAT satellites. There have been significant changes in the operational system due to system upgrades, algorithm updates, and value added data products and services.

**NUCAPS** – Generates (1) spectrally and spatially thinned radiances, (2) retrieved products such as profiles of temperature, moisture, trace gases and cloud-cleared radiances, and (3) global validation products such as globally gridded Outgoing Longwave Radiances and Environment Data Record (EDR) Products.

The thinned radiance products are produced in BUFR format using the NetCDF4 Reformatting Toolkit (N4RT) and are tailored to specifically Numerical Weather Prediction (NWP) centers.

<http://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/index.html>

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### Algorithm Description and Product Baseline

#### CrIS Infrared Sounder

The Cross-track Infrared Sounder (CrIS), provides soundings of the atmosphere with 2211 spectral channels, over 3 wavelength ranges: LWIR (9.14 - 15.38um); MWIR (5.71 - 8.26um); and SWIR (3.92 - 4.64 um). CrIS scans a 2200km swath with 30 Earth-scene views. Each field consists of 9 fields of view, arrayed as 3x3 array of 14km diameter spots (nadir spatial resolution). Each width (+/-5 degrees), scan (with an 8-second repeat interval) includes views of the internal calibration target (warm calibration point), and a deep space view (cold calibration point).

#### ATMS Microwave Sounder

The Advanced Technology Microwave Sounder (ATMS) is a cross-track scanning 22-channel passive microwave radiometer. The channels are bands from 23 GHz through 183 GHz making its measurement capabilities similar to that of the Advanced Microwave Sound Unit (AMSU) and the Microwave Humidity Sounder (MHS).

ATMS makes three scans (a scan set) every eight seconds. Each scan contains a single row of 96 FOVs. The FOV coverage sizes vary for each ATMS channel. ATMS scan sets are synchronized with those of the CrIS instrument. With each scan, the ATMS FOV coverage extends over each end of the associated CrIS scans.

This is done to allow for footprint resampling of the smaller ATMS FOVs into larger AMSU-A like footprints (~40km at nadir).

The retrieved ATMS radiances can be used as input into existing retrieval algorithms like that in NUCAPS.

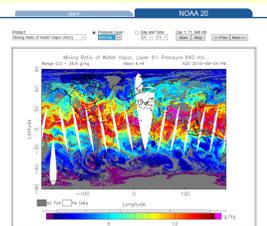
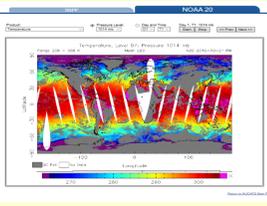
NUCAPS algorithm is used to create the atmospheric temperature and moisture profiles, Infrared Ozone Profile product, trace gases products, and outgoing longwave radiation.

Sounding algorithm is a minimization between observed radiances and radiances computed from the atmospheric state.

### NUCAPS Global Granules Composite Images

The NUCAPS global granules composite images are produced twice a day for AM (0-12 hours) and PM (12-24 hours) for the last seven days at the 15 U.S. standard atmosphere pressure levels or layers. These products are produced by using the NUCAPS retrievals which are derived based on a fixed air pressure levels. The temperature is derived at the fixed pressure levels (1014 mb, 853 mb, 707 mb, 497 mb, 300 mb, 260 mb, 201 mb, 151 mb, 103 mb, 71.5 mb, 51.1 mb, 29.1 mb, 9.5 mb, 1.0 mb). Mixing ratio for the Water Vapor, Liquid Water, Ozone, Methane, Carbon Dioxide, Carbon Monoxide, Sulfur Dioxide, Nitric Acid, and Nitrous Oxide are derived at the layer pressure using the effective air pressure variable (1000 mb, 840 mb, 695 mb, 487 mb, 399 mb, 293 mb, 254 mb, 198 mb, 147 mb, 99.5 mb, 68.8 mb, 49.3 mb, 27.6 mb, 8.82 mb, .838 mb). Each product is computed separately for each granule, and then the global image is generated by combining the data from individual granules based on the granule geographical location. For each image the granules from the preceding 12 hours of observation are used; each image combines the granules of data measured at both ascending and descending nodes.

[https://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/NUCAPS\\_composite.html](https://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/NUCAPS_composite.html)



### NUCAPS Global Gridded Products

Global Gridded 0.5 deg lat x 2 deg lon Images

NUCAPS EDR Global Gridded products include the Temperature (degK), Water Vapor Mixing Ratio (g/Kg), Liquid Water Mixing Ratio (g/Kg), Ozone Mixing Ratio (ppb), Methane Mixing Ratio (ppb), Carbon Dioxide dry mixing ratio (ppm), Carbon Monoxide Mixing Ratio (ppb), Sulfur Dioxide mixing ratio (ppb), Nitric Acid Mixing Ratio (ppb), and Nitrous Oxide Mixing Ratio (ppb). The retrievals are derived based on a fixed air pressure variable grid: temperature is derived at the fixed pressure level (1014 mb, 853 mb, 707 mb, 497 mb, 407 mb, 300 mb, 260 mb, 201 mb, 151 mb, 103 mb, 71.5 mb, 51.1 mb, 29.1 mb, 9.5 mb, 1.0 mb) and mixing ratio variables are derived at the layer pressure using the effective air pressure variable (1000 mb, 840 mb, 695 mb, 487 mb, 399 mb, 293 mb, 254 mb, 198 mb, 147 mb, 99.5 mb, 68.8 mb, 49.3 mb, 27.6 mb, 8.82 mb, .838 mb).

[https://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/NUCAPS\\_gridded.html](https://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/NUCAPS_gridded.html)

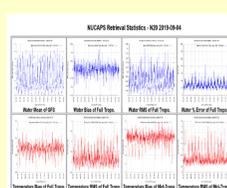
Temperature	SNPP	NOAA-20
Temperature (K)	0.3K	0.3K
Water Vapor (g/Kg)	0.3K	0.3K
Carbon Dioxide (ppm)	0.3K	0.3K
Ozone (ppb)	0.3K	0.3K
Methane (ppb)	0.3K	0.3K
Sulfur Dioxide (ppb)	0.3K	0.3K
Nitric Acid (ppb)	0.3K	0.3K
Nitrous Oxide (ppb)	0.3K	0.3K

Global Gridded 0.5 deg lat x 2 deg lon Images	SNPP	NOAA-20
Temperature (K)	0.3K	0.3K
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Ozone (ppb)	0.3K	0.3K
Methane (ppb)	0.3K	0.3K
Sulfur Dioxide (ppb)	0.3K	0.3K
Nitric Acid (ppb)	0.3K	0.3K
Nitrous Oxide (ppb)	0.3K	0.3K

### NUCAPS Retrieval Statistics

The NUCAPS retrieval statistics are generated for Temperature (Tp) over two layers: average over mid-troposphere (520-790 mb) and average over full troposphere (200-1100 mb); and Water Vapor Mixing Ratio (WVMR) statistics are generated over full troposphere. The NUCAPS retrieval estimates are compared with GFS estimates to compute bias and rmserror over these layers and are plotted for each granule on the 24-hour scale for the day. To generate the temperature bias and rmserror over a large ensemble of K granules one needs to take the bias for a single granule, bias(k), weighted by the number of accepted cases.

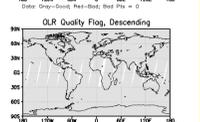
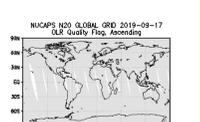
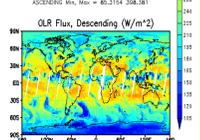
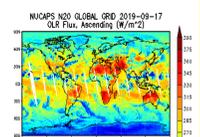
[https://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps\\_stats.html](https://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps_stats.html)



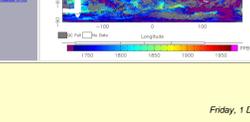
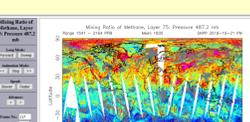
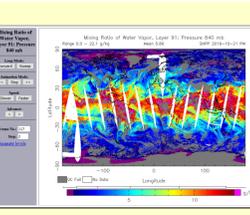
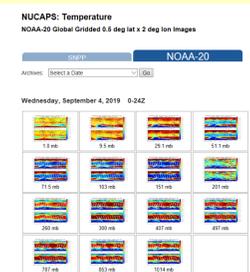
NOAA-20	SNPP	NOAA-20
Temperature (K)	0.3K	0.3K
Water Vapor (g/Kg)	0.3K	0.3K
Carbon Dioxide (ppm)	0.3K	0.3K
Ozone (ppb)	0.3K	0.3K
Methane (ppb)	0.3K	0.3K
Sulfur Dioxide (ppb)	0.3K	0.3K
Nitric Acid (ppb)	0.3K	0.3K
Nitrous Oxide (ppb)	0.3K	0.3K

### NUCAPS Outgoing Longwave Radiation Products

Attribute	Observed
OLR Applicable Conditions	1. Daytime and nighttime, regardless of sky conditions
a. Horizontal Cell Size	14 km at nadir
b. Mapping Uncertainty - 3 sigma	0.5 km at nadir
c. Measurement Range	0 to 500 W/m <sup>2</sup>
d. Measurement Precision	5 W/m <sup>2</sup>
e. Measurement Accuracy	2 W/m <sup>2</sup>
f. Refresh	Two global images for Ascending and Descending per day



	Accuracy	Precision
Ascending	2 Wm <sup>-2</sup>	5 Wm <sup>-2</sup>
Descending	1 Wm <sup>-2</sup>	5 Wm <sup>-2</sup>
All	1.5 Wm <sup>-2</sup>	5 Wm <sup>-2</sup>



# NUCAPS Global Map

<https://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/pskewt/WORLD.html>

