

# NOAA Unique CrIS/ATMS Processing System (NUCAPS) Trace Gas Data Products and Access

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CrIS Trace Gas Data

Users Workshop

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# The NOAA Unique CrIS/ATMS Processing System Products

## Retrieval Products

Cloud Cleared Radiances	660-750 cm <sup>-1</sup> 2200-2400 cm <sup>-1</sup>
Cloud fraction and Top Pressure	660-750 cm <sup>-1</sup>
Surface temperature	window
Temperature	660-750 cm <sup>-1</sup> 2200-2400 cm <sup>-1</sup>
Water Vapor	780 – 1090 cm <sup>-1</sup> 1200-1750 cm <sup>-1</sup>
O <sub>3</sub>	990 – 1070 cm <sup>-1</sup>
CO	2155 – 2220 cm <sup>-1</sup>
CH <sub>4</sub>	1220-1350 cm <sup>-1</sup>
N <sub>2</sub> O	1290-1300cm <sup>-1</sup> 2190-2240cm <sup>-1</sup>
HNO <sub>3</sub>	760-1320cm <sup>-1</sup>
SO <sub>2</sub>	1343-1383cm <sup>-1</sup>

gas	Range (cm <sup>-1</sup> )	Precision	d.o.f.	Interfering Gases	Science Code
T	650-800 2375-2395	1K/km	6-10	H <sub>2</sub> O,O <sub>3</sub> ,N <sub>2</sub> O emissivity	100 levels
H <sub>2</sub> O	1200-1600	15%	4-6	CH <sub>4</sub> , HNO <sub>3</sub>	100 layers
O <sub>3</sub>	1025-1050	10%	1+	H <sub>2</sub> O,emissivity	100 layers
CO	2080-2200	15%	~ 1	H <sub>2</sub> O,N <sub>2</sub> O	100 layers
CH <sub>4</sub>	1250-1370	1.5%	~ 1	H <sub>2</sub> O,HNO <sub>3</sub> ,N <sub>2</sub> O	100 layers
CO <sub>2</sub>	680-795 2375-2395	0.5%	~ 1	H <sub>2</sub> O,O <sub>3</sub> T(p)	100 layers
<u>Volcanic</u> SO <sub>2</sub>	1340-1380	50% ??	< 1	H <sub>2</sub> O,HNO <sub>3</sub>	flag
HNO <sub>3</sub>	860-920 1320-1330	50% ??	< 1	emissivity H <sub>2</sub> O,CH <sub>4</sub> ,N <sub>2</sub> O	100 layers
N <sub>2</sub> O	1250-1315 2180-2250	5% ??	< 1	H <sub>2</sub> O H <sub>2</sub> O,CO	100 layers
NH <sub>3</sub>	860-875	50%	<1	emissivity	BT diff
CFCs	790-940	20-50%	<1	emissivity	Constant

# NUCAPS EDR Trace Gas Products

*The EDR product contains the following trace gas profiles calculated on each CrIS FOR:*

- O3 layer column density (at 100 levels)
- O3 mixing ratio (at 100 levels)
- First Guess O3 layer column density (at 100 levels)
- First Guess O3 mixing ratio (at 100 levels)
- CH4 layer column density (at 100 levels)
- CH4 mixing ratio (at 100 levels)
- CO2 mixing ratio (at 100 levels)
- HNO3 layer column density (at 100 levels)
- HNO3 mixing ratio (at 100 levels)
- N2O layer column density (at 100 levels)
- N2O mixing ratio (at 100 levels)
- SO2 layer column density (at 100 levels)
- SO2 mixing ratio (at 100 levels)

# AWIPS NUCAPS Products

*The retrieval product for AWIPS contains the following variables.*

CrIS FOR	Time
Latitude	Longitude
View Angle	Ascending/Descending Status
Topography	Surface Pressure
Skin Temperature	Quality Flag
Pressure (at 100 levels)	Effective Pressure (at 100 levels)
Temperature (Kelvin at 100 levels)	H2O (g/g at 100 levels)
O3 (ppb at 100 levels)	Liquid H2O (g/g at 100 levels)
Ice/Liquid Flag (at 100 levels)	SO2 (g/g at 100 levels)
Stability parameters	

- *Note: This is a subset of the existing set of variables produced by the retrieval. It is our understanding that NDE will extract this subset of variables.*

# NUCAPS Data Access

## NUCAPS data at CLASS (non-real time users)

- Per NOAA JPSS Program office directive, the Interface Data Processing Segment (IDPS) has stopped producing the Cross-track Infrared and Microwave Sounder Suite (CrIMSS) of products as of September 8, 2014.
- The replacement product is the NUCAPS EDRs and can be ordered from CLASS under the data family S-NPP Data Exploitation Granule Data (NDE\_L2). The NUCAPS EDR product consists of retrieved estimates of hydrological variables including temperature, water vapor, cloud fraction and cloud top pressure, along **with trace gas retrievals including ozone (O3), methane (CH4), carbon monoxide (CO), carbon dioxide (CO2), sulfur dioxide (SO2), nitrogen dioxide (N2O), and nitric acid (HNO3)**, and a flag indicating the presence of dust and volcanic emissions. These NUCAPS products are distributed in the **native 32-second granularity in netCDF-4 file format with metadata attributes included.**

[http://www.nsof.class.noaa.gov/saa/products/search?  
sub\\_id=0&datatype=family=NDE\\_L2&submit.x=25&submit.y=11](http://www.nsof.class.noaa.gov/saa/products/search?sub_id=0&datatype=family=NDE_L2&submit.x=25&submit.y=11)

# NUCAPS Data Access Cont...

NUCAPS data at OSPO (Near-real Time Users)

To obtain the near real time NUCAPS data a user needs to fill out the Data Access Request Form located at [www.ospo.noaa.gov/Organization/About/access.html](http://www.ospo.noaa.gov/Organization/About/access.html) and submit it to the Sounding Product Area Lead ([awdhesh.sharma@noaa.gov](mailto:awdhesh.sharma@noaa.gov)) with a copy to [nesdis.data.access@noaa.gov](mailto:nesdis.data.access@noaa.gov).

- Short Term Archive Plan
  - Short Term Archive (STA) located on the ESPC SAN, 96 hours of storage for all data associated with NUCAPS processing. In case of anomaly the STA will be needed for one week for investigating the problems.
  - Long Term Archive (LTA): NUCAPS products archived in CLASS. NUCAPS archive started in April 2014.
- Long Term Maintenance Plan
  - Long term Cal/Val support for NUCAPS products will be starting in FY15 from JPSS funds.
  - OSPO operates NUCAPS operationally and provide users services capability.
  - STAR continues validation and provides resolution to quality issues identified through comparing the retrievals to RAOBS, models, in-situ field campaigns data.
  - STAR provides science related anomaly support capability.
  - STAR continues scientific updates to current and future products.

- JPSS L1RD Supplement Table 5.2.8 - Infrared Ozone Profile (CrIS)

Attribute	Requirement	Observed
a. Horizontal Cell Size	50 km at nadir	
b. Vertical Reporting Interval		
1. TOA to surface	Report on the radiative transfer grid used within retrieval (100 layers). Each layer reports the layer column density (molecules/cm <sup>2</sup> ) within the layer.	
c. Mapping Uncertainty, 3 Sigma	10 km	
d. Measurement Precision		
1. 4 hPa to 260 hPa (6 statistic layers)	20%	
2. 260 hPa to surface (1 statistic layer)	20%	
e. Measurement Accuracy		
1. 4 hPa to 250 hPa (6 statistic layers)	10%	
2. 260 hPa to surface (1 statistic layer)	10%	
f. Measurement Uncertainty		
1. 4 hPa to 250 hPa (6 statistic layers)	25%	
2. 260 hPa to surface (1 statistic layer)	25%	
g. Latency	3 hours	
h. Refresh	At least 90% coverage of the globe every 16 days (monthly average, both day and night)	

**Notes:**

- Ozone retrievals only exist when the CrIS radiances are used in the retrieval (i.e., "partially cloudy" condition in the AVTP and AVMP requirements). For "cloudy" conditions the first guess is reported. Users must use QC to determine if retrieval was performed.
- CrIS measurements are most accurate near the tropopause and statistic layers used to compute performance must mimic standard Umkehr reporting layers of ~5 km per layer (recommend statistic layers = 4-8, 8-16, 16-32, 32-66, 66-125, 125-260 hPa).
- Lower layer statistic is computed on a single thick layer of variable thickness due to surface pressure variability.

- JPSS L1RD Supplement Table 5.2.7 - CH<sub>4</sub> (Methane) Column (CrIS)

Attribute	Requirement	Observed
a. Vertical Coverage	Total Column	
b. Horizontal Resolution	100 km	
c. Mapping Uncertainty, 3 sigma	25 km	
d. Measurement Range	1100 to 2250 ppbv (1)	
e. Measurement Precision	1% (~ 20 ppbv) (2)	
f. Measurement Accuracy	±4% (~ 80 ppbv) (3)	
g. Refresh	24 hours	
<b>Notes:</b> 1. 40 μmoles is equivalent to 1100 ppbv (a more common unit) 2. Experience with AIRS and CrIS simulations suggest we can achieve 1% precision. 3. Experience with AIRS suggests we can achieve an accuracy of 4%.		



# Capabilities Assessment of NUCAPS Infrared Ozone

	<b>Current Capabilities</b>	<b>Requested Capabilities</b>
Satellite Source (s)	<b>Metop-A/Metop-B (IASI)</b>	<b>S-NPP (CrIS/ATMS)</b>
Product Name	<b>IASI-ozone</b>	<b>NUCAPS- Infrared Ozone</b>
Accuracy	<b>20%/5-km near tropopause 10% total column Currently 25%/5-km, 15% total</b>	<b>Meet L1 requirements for JPSS. Output 100 level product, users can average onto their layers. Must be consistent with temperature and trace gas products.  20% precision for ~5 km layers from 4 hPa to 260 hPa</b>
Latency	<b>15 minutes after granule data is available</b>	<b>No change</b>
Timeliness	<b>≤ 3 hours</b>	<b>No change</b>
Coverage	<b>Global – scenes which satisfy cloud clearing assumptions</b>	<b>Global – scenes which satisfy cloud clearing assumptions</b>
Horizontal Resolution	<b>~50 km (Set of 4 IASI FOV's collocated with AMSU FOV)</b>	<b>~50 km (Set of 9 CrIS FOV's collocated with ATMS FOR)</b>
Other attributes	<b>Require vertical weighting functions with O3(p) product.</b>	<b>No change</b>

# Capabilities Assessment of NUCAPS Trace Gas

	Current Capabilities	Requested Capabilities
Satellite Source (s)	Metop-A/Metop-B (IASI)	S-NPP (CrIS/ATMS)
Product Name	IASI CO, CH4, CO2, HNO3	CrIS/ATMS Trace Gases
Accuracy	<p>CH4: 1% mid-trop column                      HNO3: 50% mid-trop column                      * Current accuracy for CO is 25%, CH4 and CO2 is about 2% due to poor cloud cleared radiances.</p>	<p>O3: 20% 5-Km near trop                      O3: 10% total Column                      CH4: 1% Mid-trop column                      CH4: 1% ± 5% / 1% ± 4%                      (precision ± accuracy)                      HNO3:50% mid-trop column</p>
Latency	15 minutes after granule data is available	15 minutes after granule data is available
Timeliness	≤ 3 hours	≤ 3 hours
Coverage	Global – scenes which satisfy cloud clearing assumptions	Global – scenes which satisfy cloud clearing assumptions
Horizontal Resolution	~50 km (Set of 4 IASI FOV's collocated with AMSU FOV)	~50 km (Set of 9 CrIS FOV's collocated with ATMS FOR)
Other attributes	Require vertical weighting functions with all products	No change

Carbon products require high resolution CrIS data

Current accuracy for CO and CO2 is about 2% due to truncated resolution.

# NUCAPS Sounding Products on the Web

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

NUCAPS products include the Temperature (deg K), 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).

## NUCAPS Soundings Products Links

[NUCAPS / SNPP Global Gridded 0.5 deg lat x 2 deg lon Images](#)

[NUCAPS / SNPP Granule Composite Images](#)

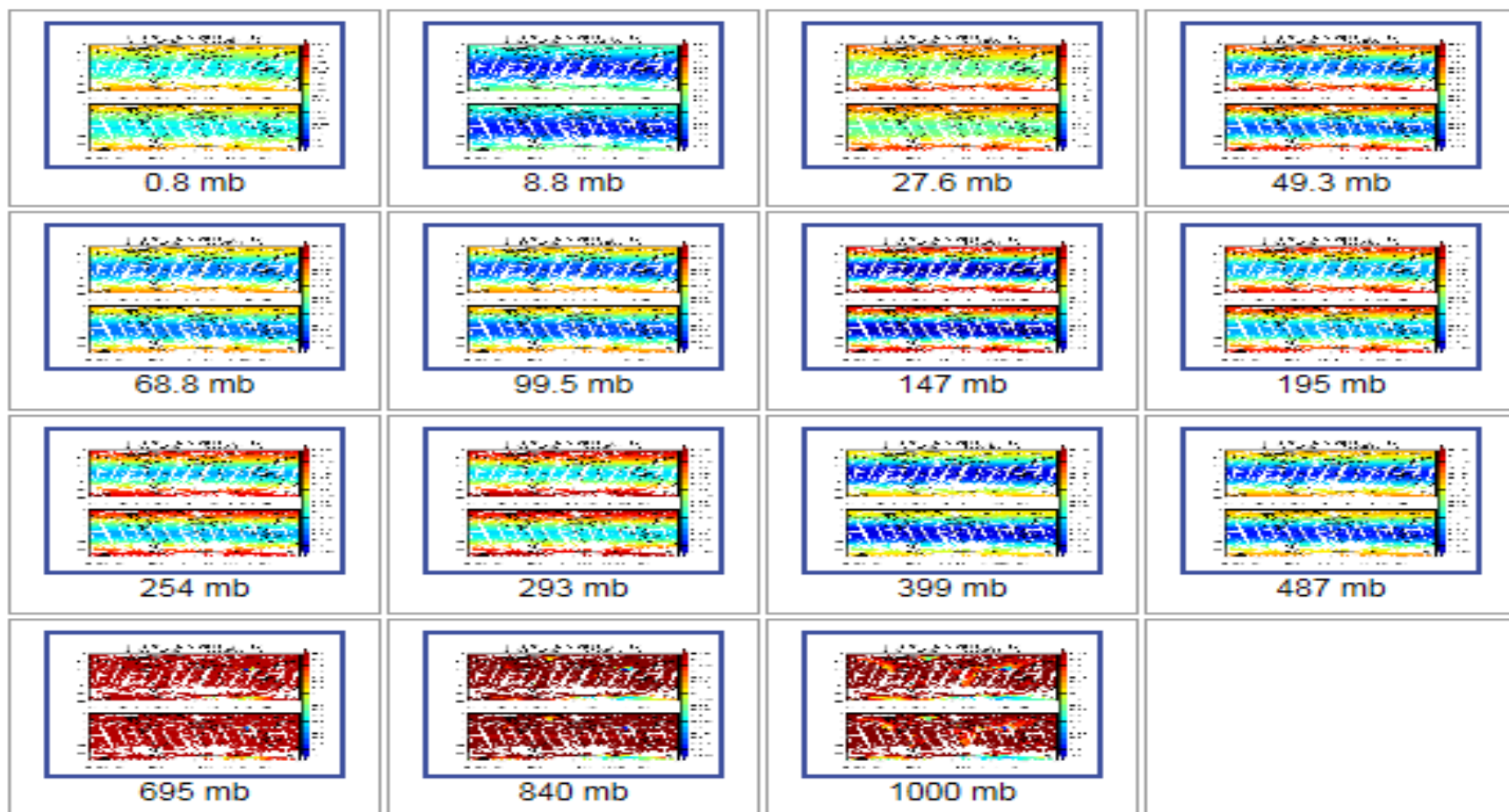
[NUCAPS / SNPP Retrieval Statistics](#)

# NUCAPS: Mixing Ratio of Nitrous Oxide

## SNPP Global Gridded 0.5 deg lat x 2 deg lon Images

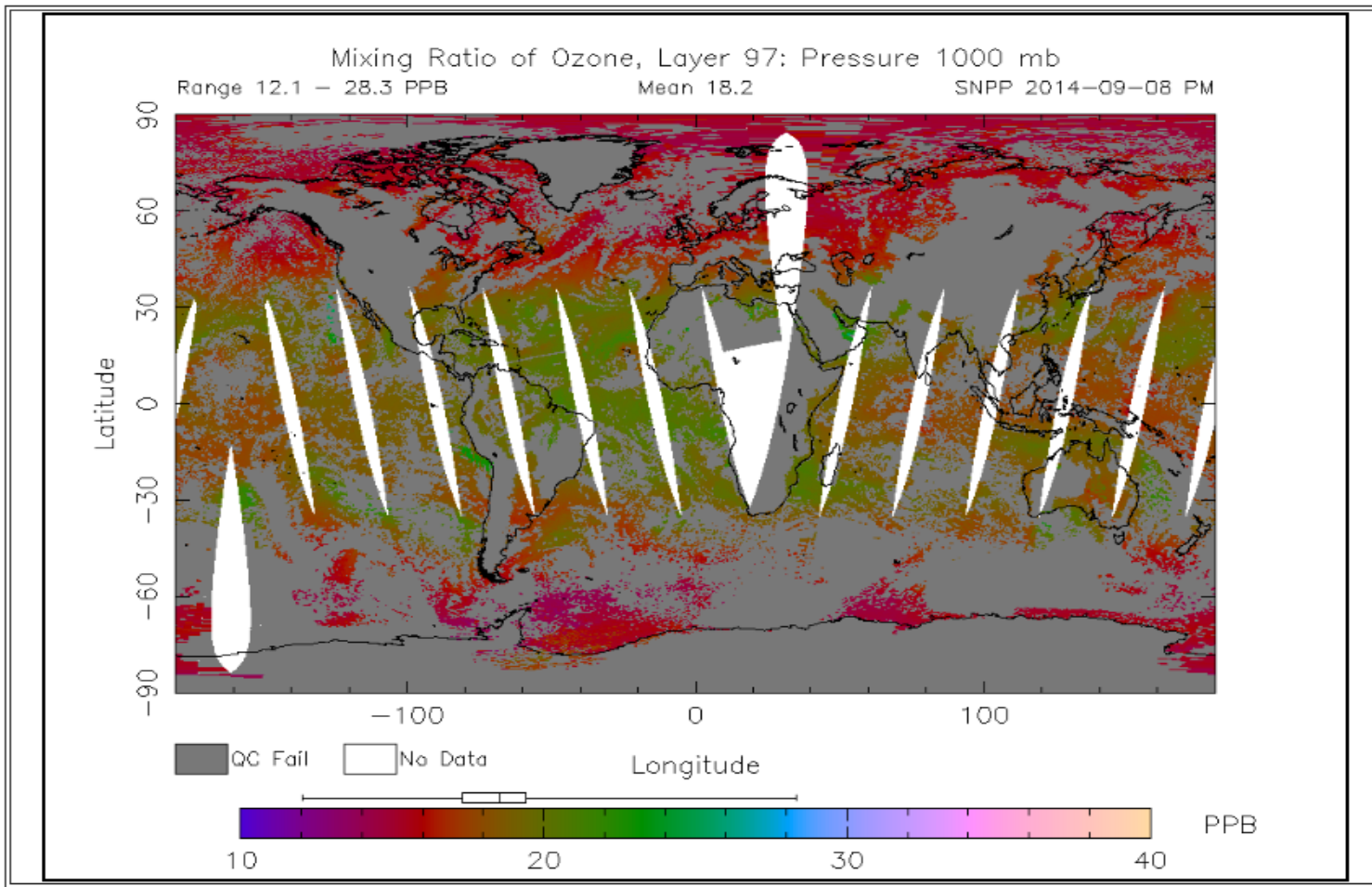
Archives:

Wednesday, September 17, 2014 0-24Z



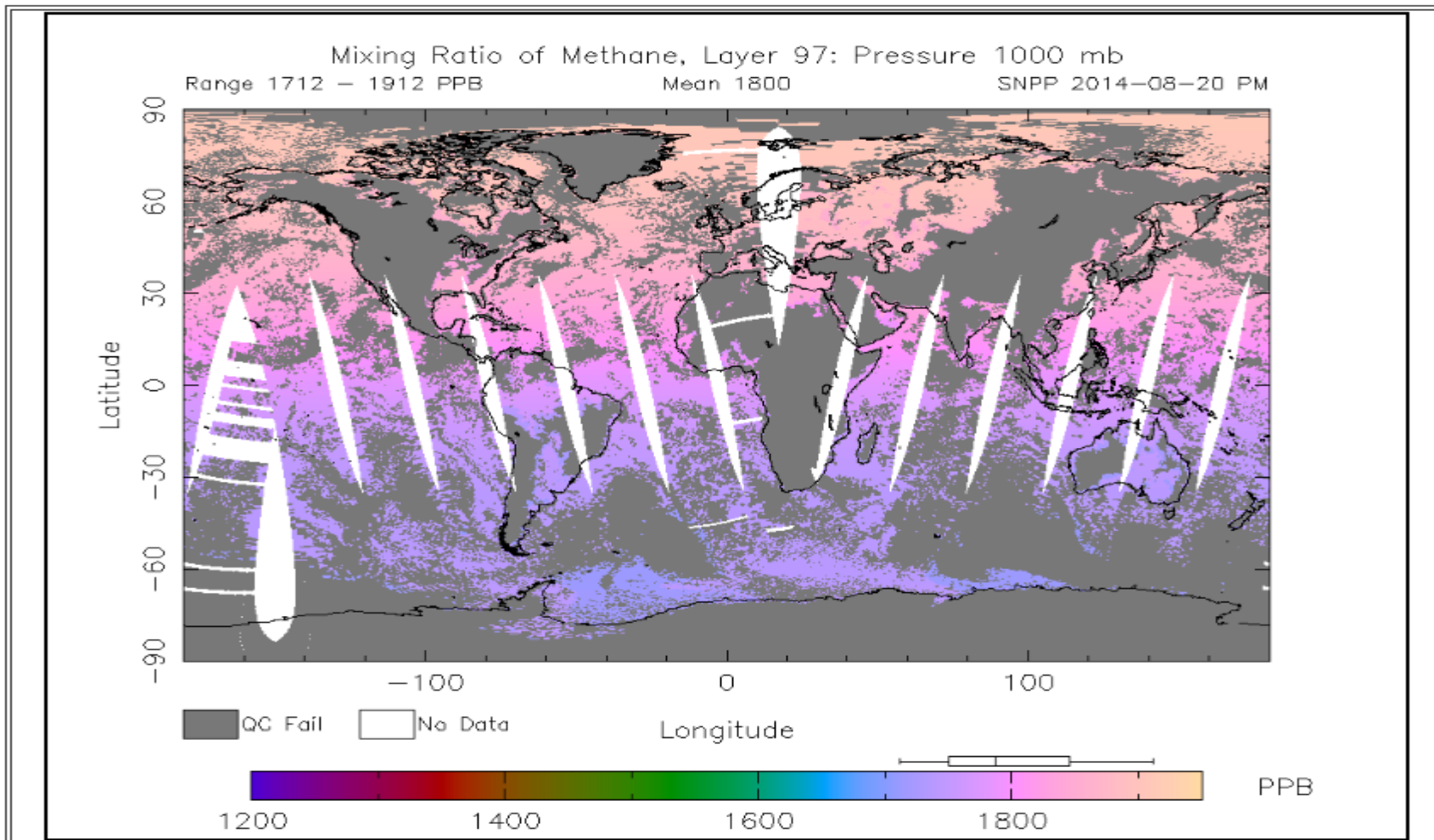
# NUCAPS/SNPP Granule Composite Images

Product:   Pressure Layer:   Day and Time:   Day 1, T1, 1000 mb



# NUCAPS/SNPP Granule Composite Images

Product: **Mixing Ratio of Methane (CH4)**  Pressure Layer: **1000 mb**  Day and Time: **D1** **T1** Day 1, T1, 1000 mb  
**Start** **Stop** << Prev  
Next >>





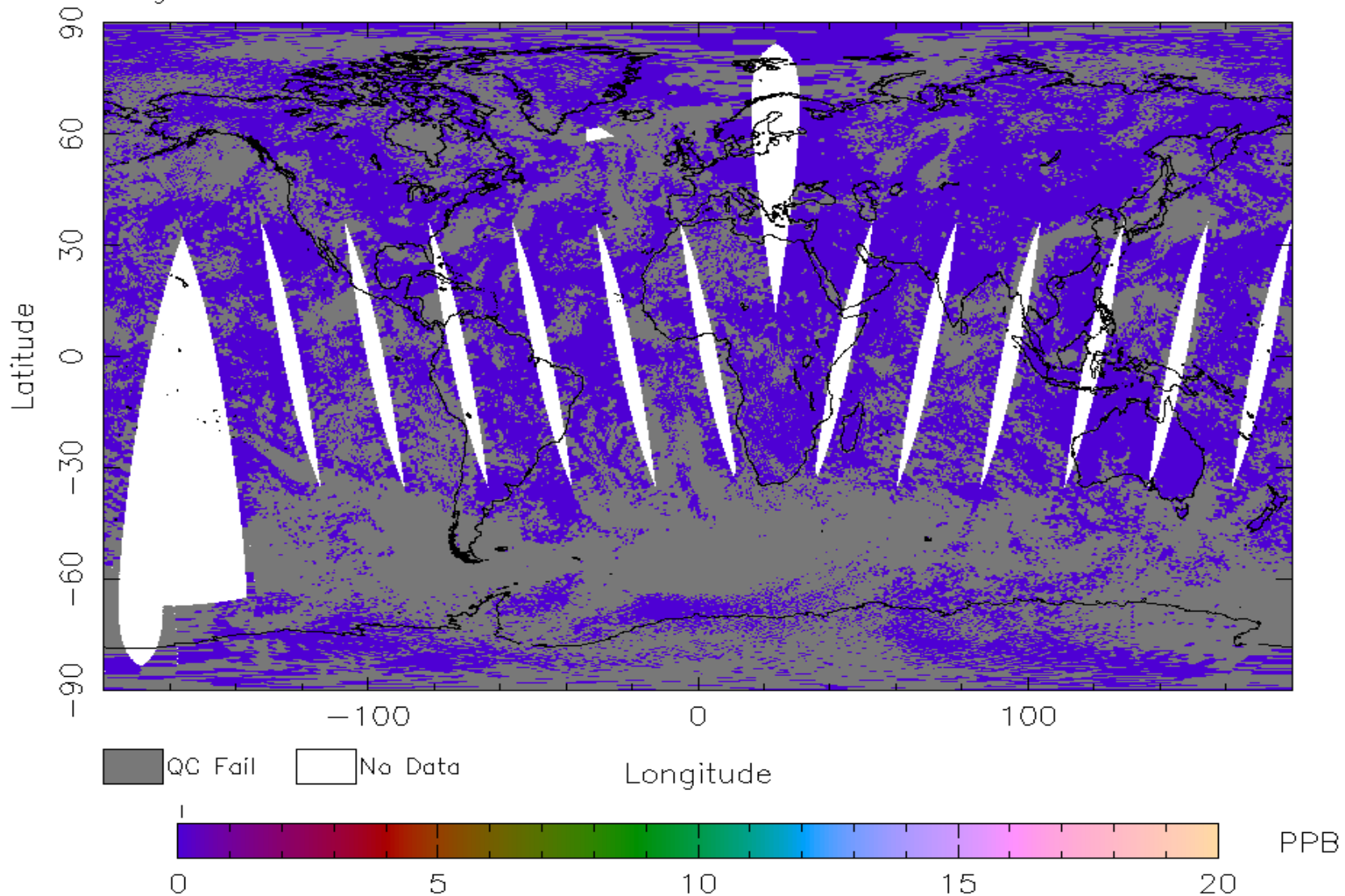
# NUCAPS/SNPP Granule Composite Images Daily Profile

Mixing Ratio of Nitric Acid, Layer 09: Pressure 0.838 mb

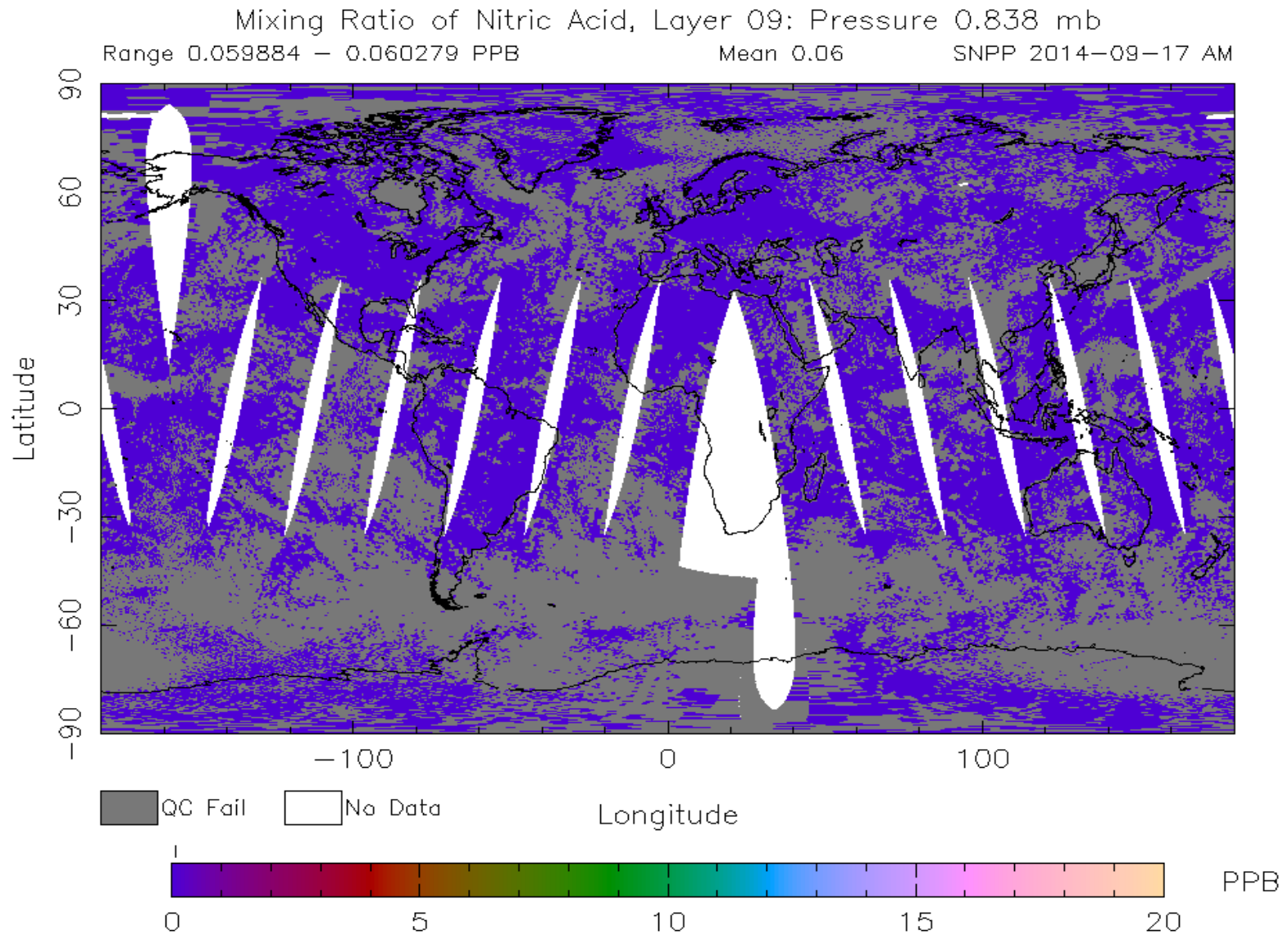
Range 0.059884 – 0.060278 PPB

Mean 0.06

SNPP 2014-09-17 PM



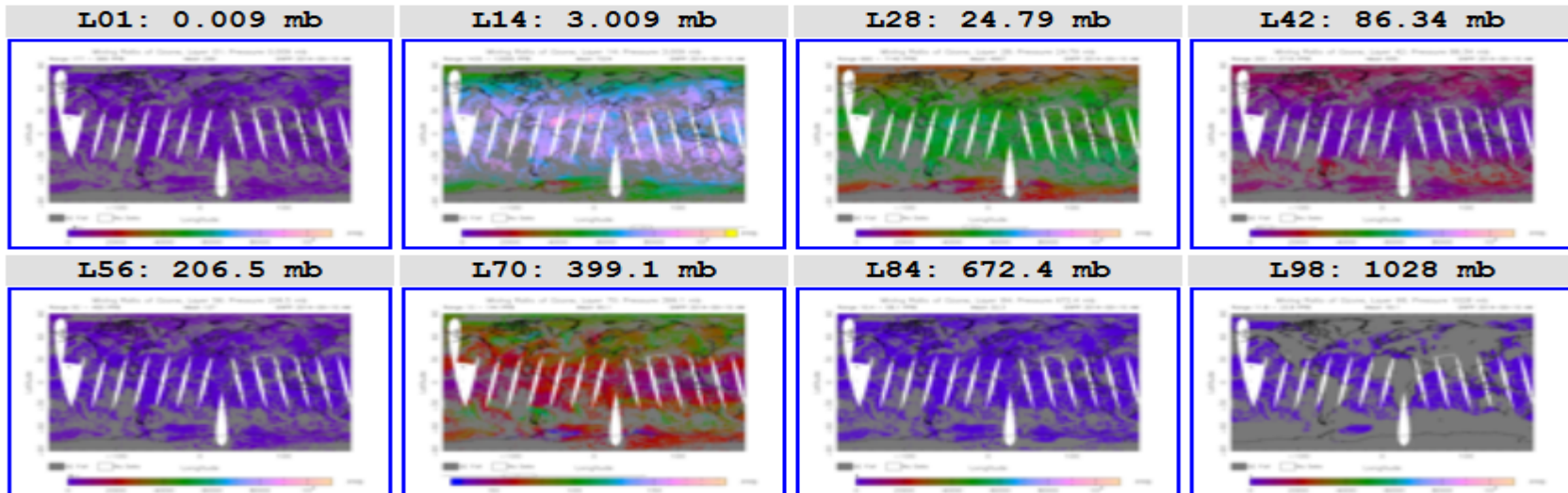
# NUCAPS/SNPP Granule Composite Images Vertical Profile





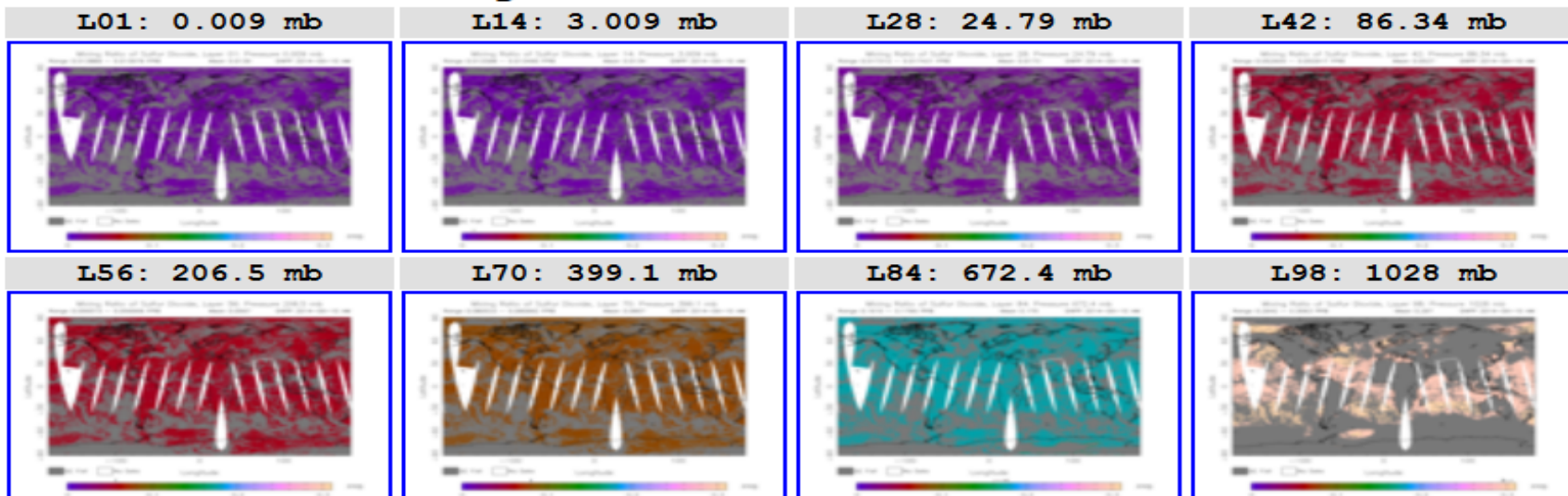
# NUCAPS EDR Images for 2014-09-10 AM - SNPP

## Mixing Ratio of Ozone



[More Mixing Ratio of Ozone levels](#)

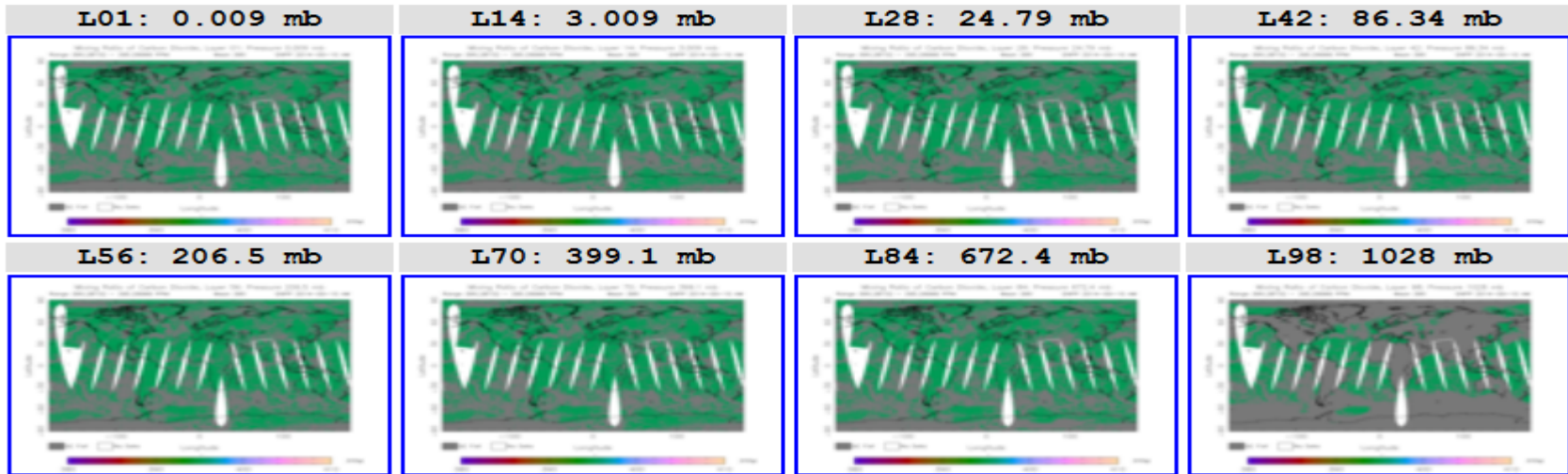
## Mixing Ratio of Sulfur Dioxide



[More Mixing Ratio of Sulfur Dioxide levels](#)

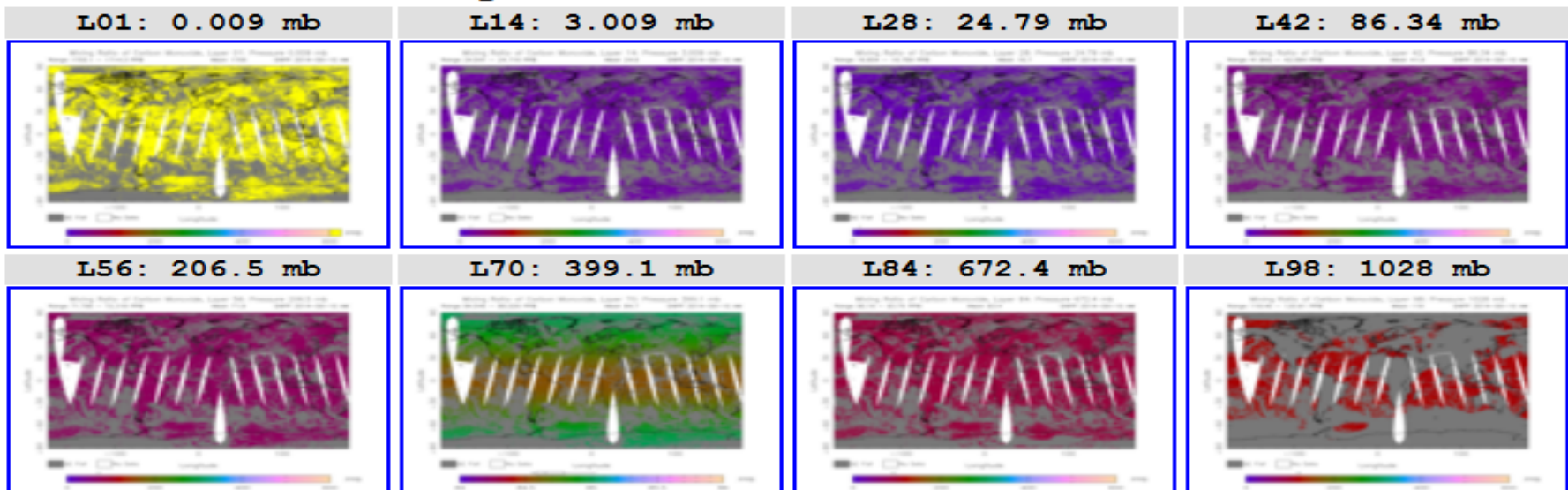
# NUCAPS EDR Images for 2014-09-10 AM - SNPP

## Mixing Ratio of Carbon Dioxide



[More Mixing Ratio of Carbon Dioxide levels](#)

## Mixing Ratio of Carbon Monoxide

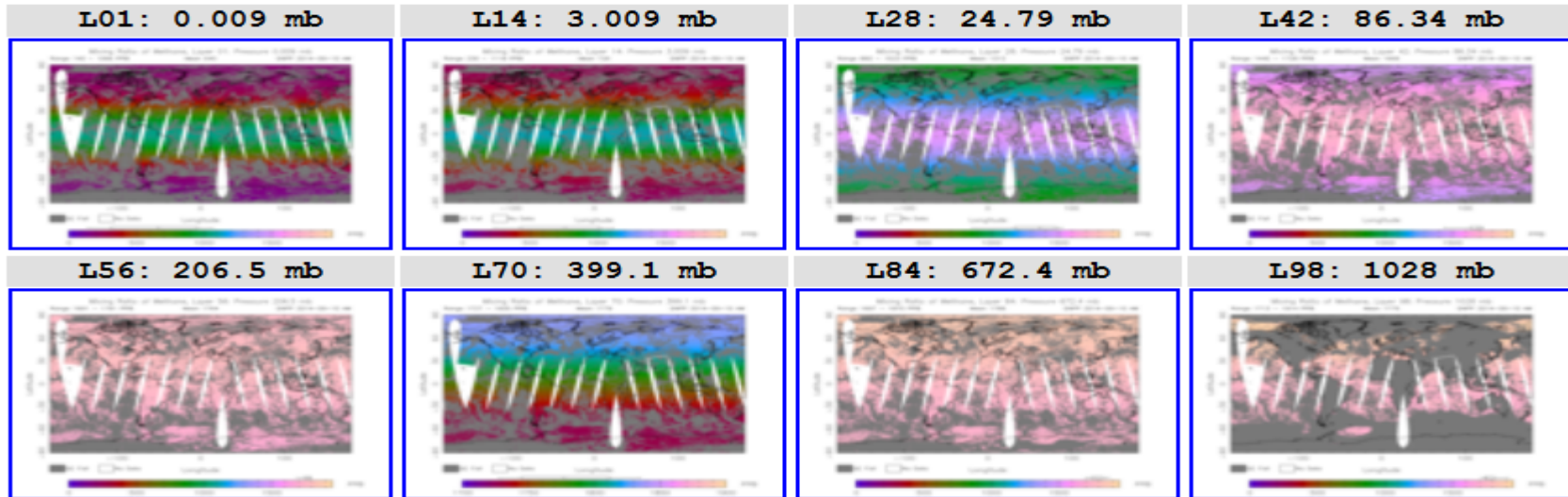


[More Mixing Ratio of Carbon Monoxide levels](#)



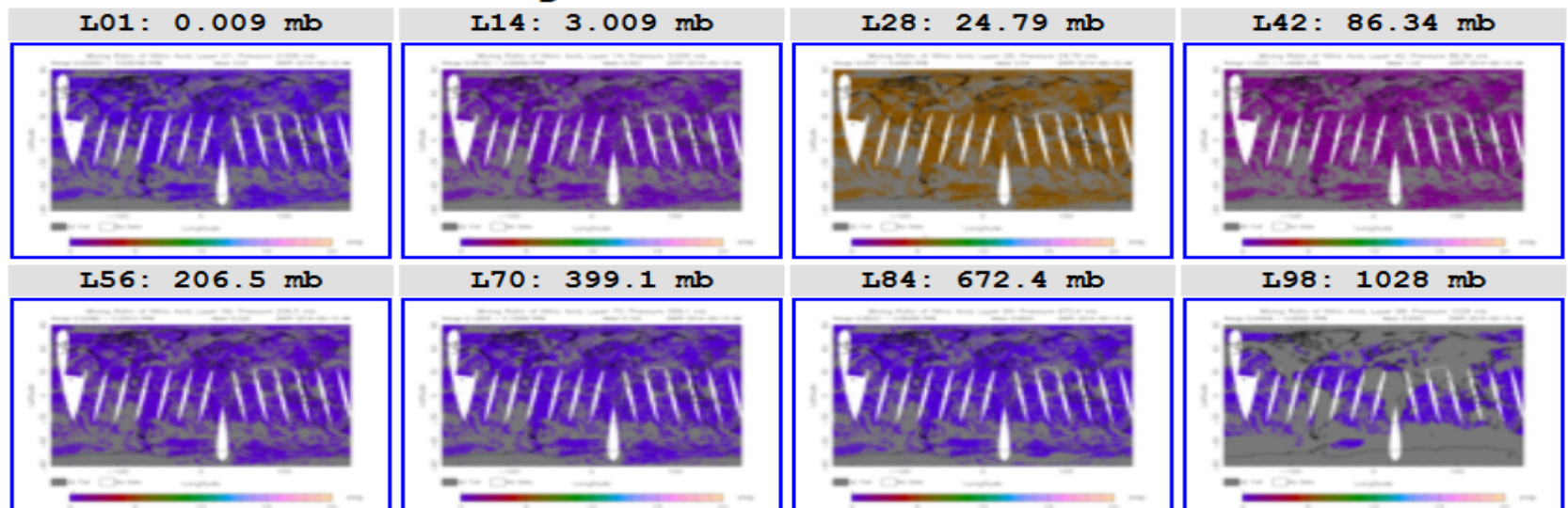
# NUCAPS EDR Images for 2014-09-10 AM - SNPP

## Mixing Ratio of Methane



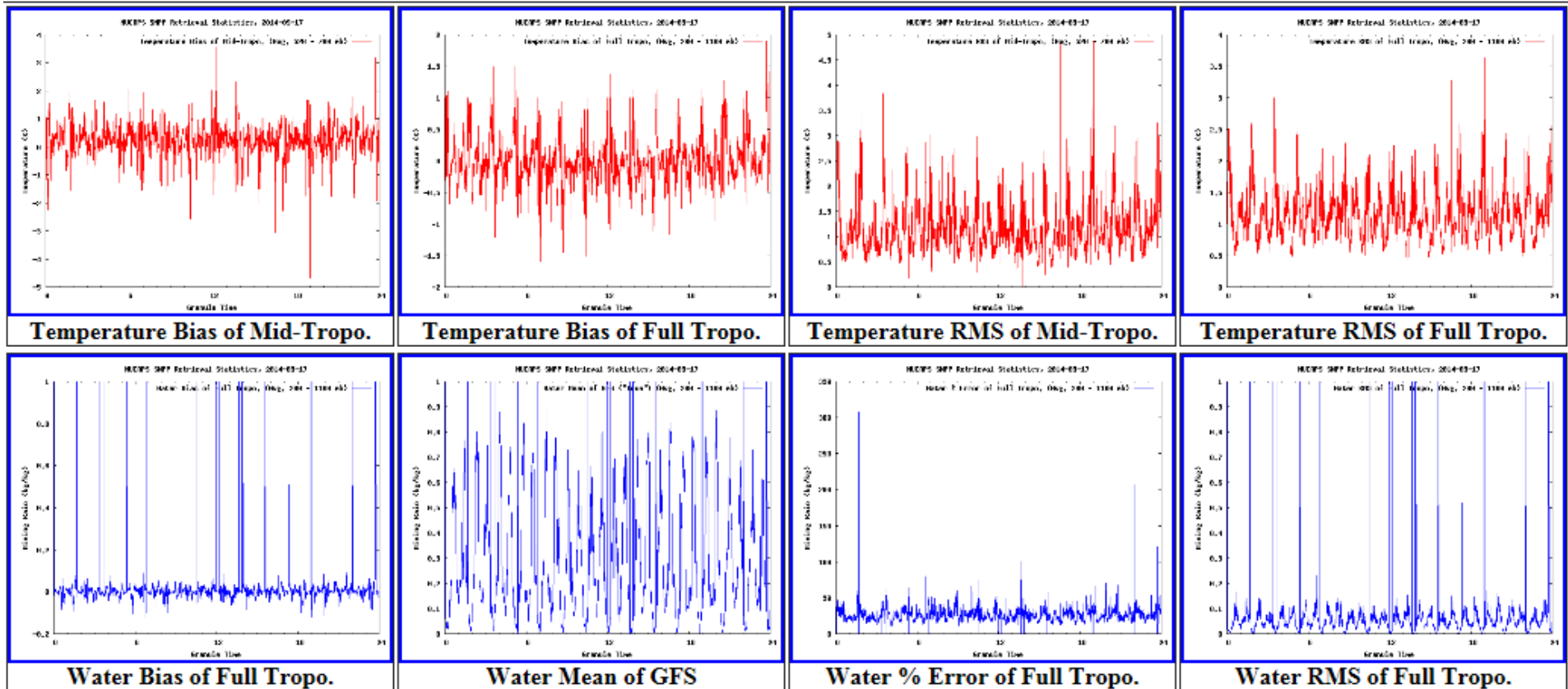
[More Mixing Ratio of Methane levels](#)

## Mixing Ratio of Nitric Acid



[More Mixing Ratio of Nitric Acid levels](#)

# NUCAPS Retrieval Statistics - SNPP 2014-09-17



The NUCAPS retrieval statistics are generated for Temperature ( $T_p$ ) 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 rms error over these layers and are plotted for each granule on the 24-hour scale for the day.

# Summary and Conclusions

- **Acceptance of Product**

- Pending data access requests from Users.
- Trace Gases products from other satellites, such as, IASI Metop that carry similar capabilities and quality, are being used and accepted by its users.
- STAR validating the NUCAPS Trace Gases retrievals (methane, ozone, CO<sub>2</sub>, CO, HNO<sub>3</sub>, N<sub>2</sub>O) based on the current preliminary stage which are compared well in both magnitude and spatial patterns with AIRS trace gas retrievals.

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- **FUTURE WORK**

- Optimize retrieval set up to improve yield
- Improve retrieval a priori and first guess
- Characterize degrees of freedom of the signal
- Determine retrieval error estimates for operational quality
- Prepare to declare NUCAPS for operation