

# Updates on operational sounding processing systems at NOAA/NESDIS and the exploitation of hyperspectral Sounder and microwaves sounder data from CrIS/ATMS, IASI/AMSU, and ATOVS

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## NOAA/NESDIS Office of Satellite and Product Operations (OSPO)

The current operational polar sounding systems running at the National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite Data and Information Service (NESDIS) for processing the sounders data from the Cross-track Infrared (CrIS) onboard the Suomi National Polar-orbiting Partnership (SNPP) under the Joint Polar Satellite System (JPSS) program, the Infrared Atmospheric Sounding Interferometer (IASI) onboard Metop-A and Metop-B satellites under the program managed by the European Organization for the Exploitation of Meteorological (EUMETSAT), and the Advanced TIROS (Television and Infrared Observation Satellite) Operational Vertical Sounding (ATOVS) onboard NOAA-19 in the NOAA series of Polar Orbiting Environmental Satellites (POES). In an effort to ensure consistent levels of service and quality assurance for the CrIS/ATMS data the NOAA Unique CrIS/ATMS Product System (NUCAPS) data products, the Office of Satellite and Product Operations (OSPO) implemented and have been performing data quality assurance for the operational sounder and imager products that are being generated. The OSPO operation has facilitated the diagnosis and resolution of problems when detected in the operational environment. This presentation includes several of these tools developed and deployed for the sounding products monitoring and data quality assurance which lead to improve the maintenance and sustainment of the Environmental Satellites Processing Center (ESPC) processing systems. The presentation includes the discussion on the ESPC system architecture involving sounding data processing and distribution for CrIS, IASI, and ATOVS sounding products. Discussion also includes the improvements made for data quality measurements, granule processing and distribution, and user timeliness requirements envisioned from the next generation of JPSS and GOES-R satellites. There have been significant changes in the operational system due to system upgrades, algorithm updates, and value added data products and services. User requirements for upcoming satellites sounder data products will also be discussed.



### NOAA Unique CrIS ATMS Processing System NUCAPS (SNPP)

**NUCAPS** - Temperature and humidity profiles at 15 US standard atmospheric levels with vertical accuracies of 1 degree Kelvin and 10 % per 1-km layer respectively, water vapor mixing ratio, Ozone mixing ratio, mixing ratio of CO, CO<sub>2</sub>, CH<sub>4</sub>, trace gases, and the cloud cleared radiances (CCR) on a global scale.

### IASI (Metop-1, and Metop-2)

**IASI** - Temperature and humidity profiles with vertical accuracies of 1 degree Kelvin and 10 % per 1-km layer respectively, water vapor mixing ratio, Ozone mixing ratio, mixing ratio of CO, CO<sub>2</sub>, CH<sub>4</sub>, trace gases, and the cloud cleared radiances (CCR) on a global scale.

### ATOVS (NOAA-19, Metop-A, and Metop-B)

**ATOVS** - Provides near real-time atmospheric temperatures at 42 levels (from surface to 0.1 mb) and water vapor mixing ratios at 19 levels (from surface to 200 mb) with a 40 km horizontal resolution derived from the AMSU-A and HIRS measurements on board the NOAA polar orbiting and European Metop satellites series.

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

NUCAPS

NUCAPS Sounding Products

SNPP Global Gridded 0.5 deg lat x 2 deg lon Images

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Tuesday, April 14, 2015

Product Name	Resolution
Temperature	0.5x2
Mixing Ratio of Water Vapor (H <sub>2</sub> O)	0.5x2
Mixing Ratio of Carbon Dioxide (CO <sub>2</sub> )	0.5x2
Mixing Ratio of Methane (CH <sub>4</sub> )	0.5x2
Mixing Ratio of Nitrous Oxide (N <sub>2</sub> O)	0.5x2
Mixing Ratio of Ozone (O <sub>3</sub> )	0.5x2
Mixing Ratio of Carbon Monoxide (CO)	0.5x2
Mixing Ratio of Sulfur Dioxide (SO <sub>2</sub> )	0.5x2
Mixing Ratio of Nitric Acid (HNO <sub>3</sub> )	0.5x2
Mixing Ratio of Nitrogen Dioxide (NO <sub>2</sub> )	0.5x2

#### NUCAPS Sounding Products

The NOAA Unique CrIS/ATMS Processing System (NUCAPS) was developed to generate (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 radiance matchups and gridded radiances and profiles. The thinned radiances products are produced in BUFR format using the NetCDF4 Reformatting Toolkit (NART) and are tailored to specifically Numerical Weather Prediction (NWP) centers. The NUCAPS Environmental Data Records (EDR) products are archived in Comprehensive Large Array-Data Stewardship System (CLASS) for non-real time users and can be acquired from [www.nasf.class.noaa.gov](http://www.nasf.class.noaa.gov).

#### NUCAPS/SNPP Global Granules Composite Images

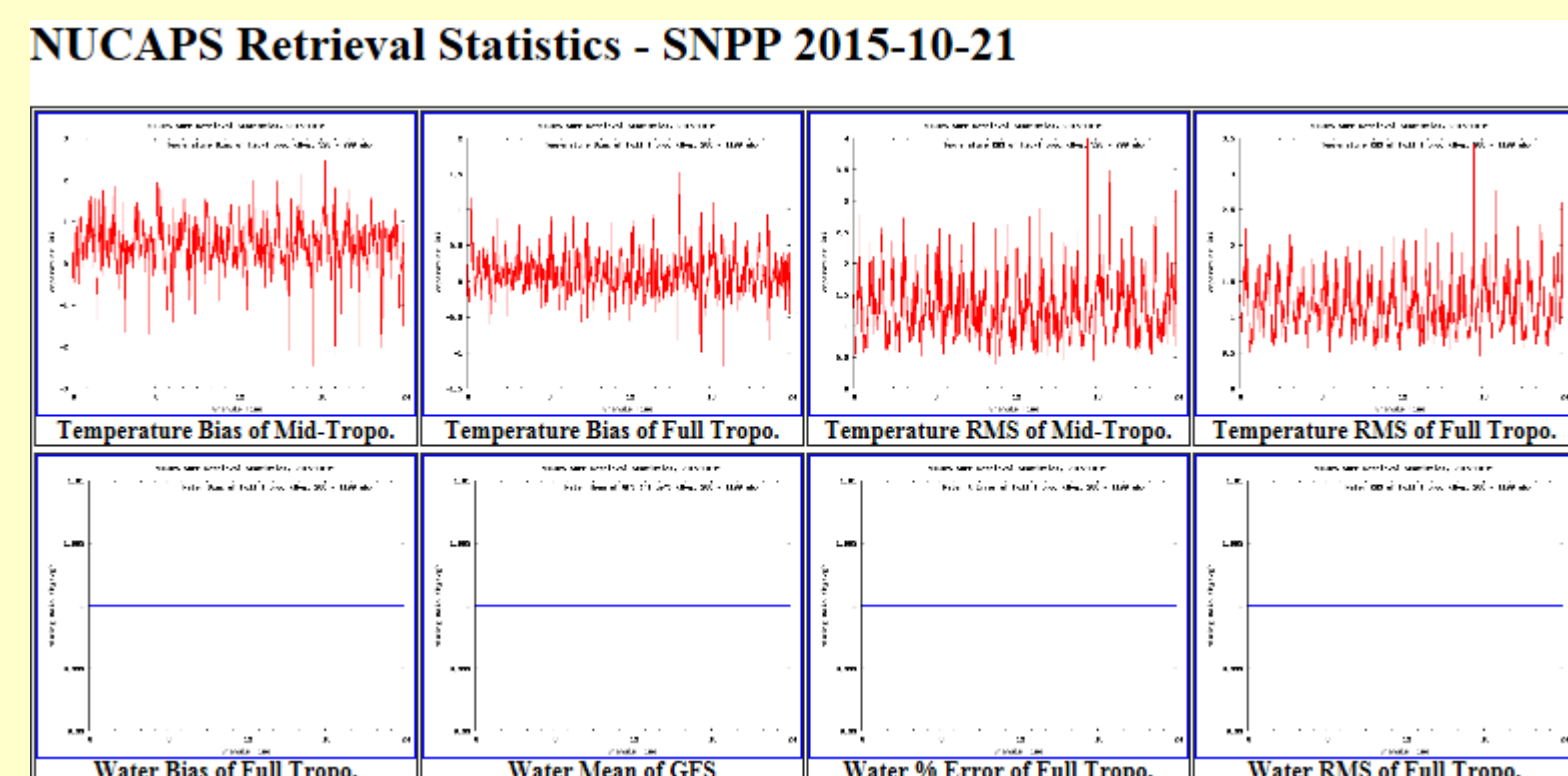
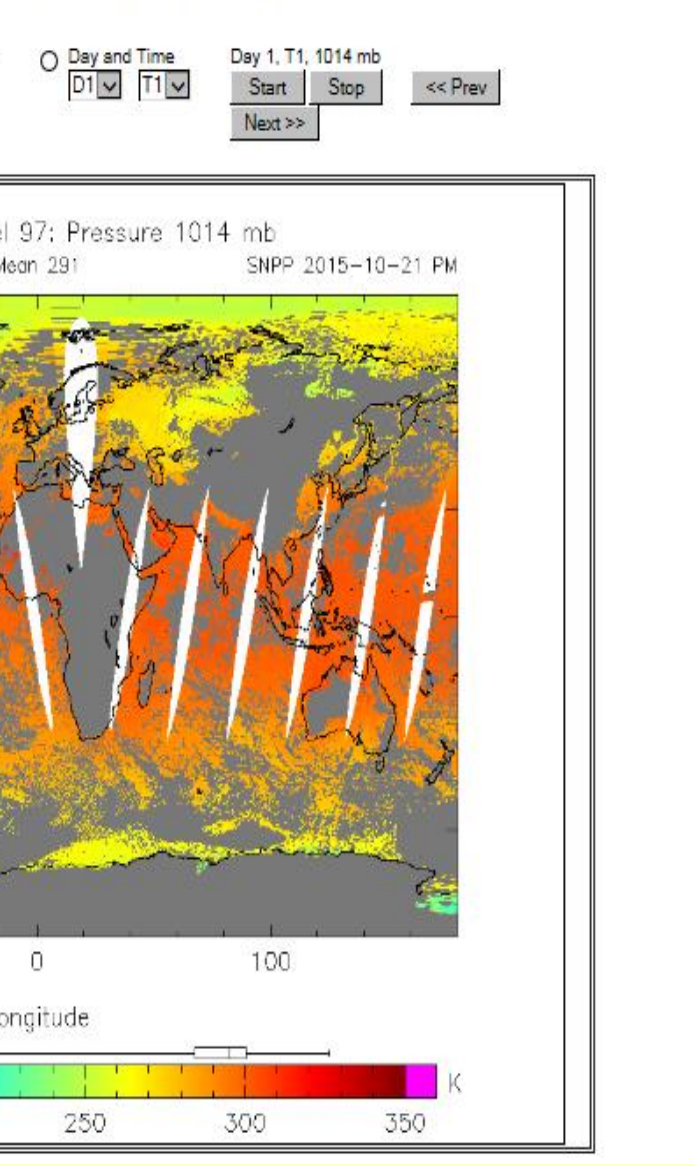
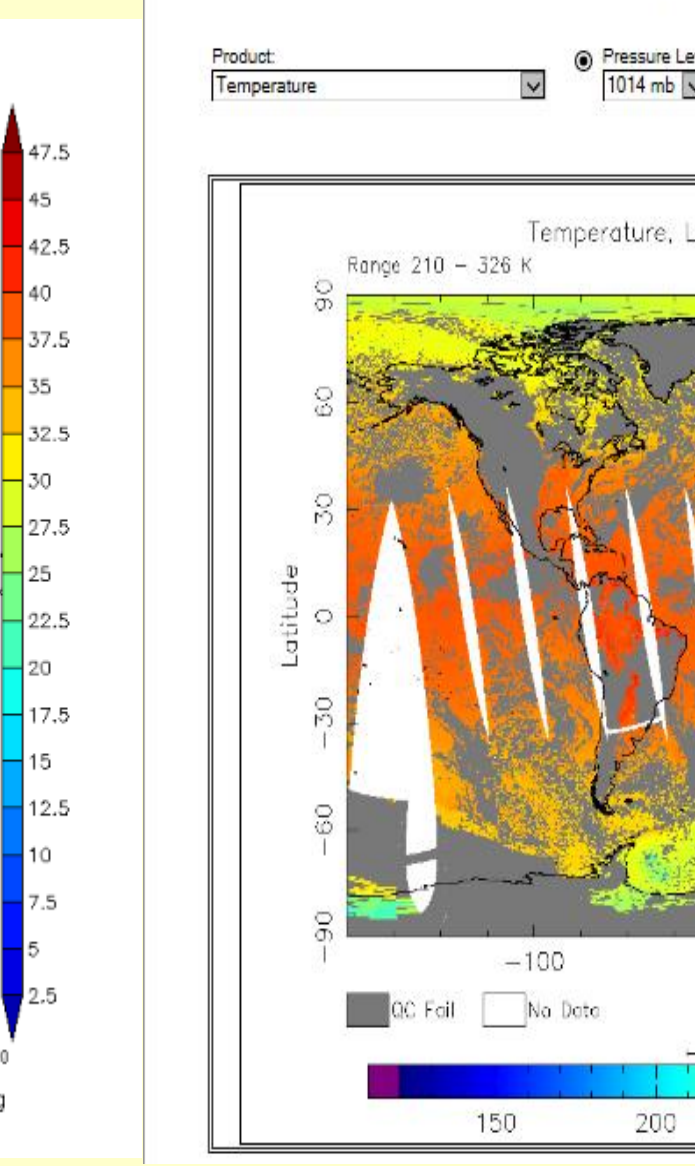
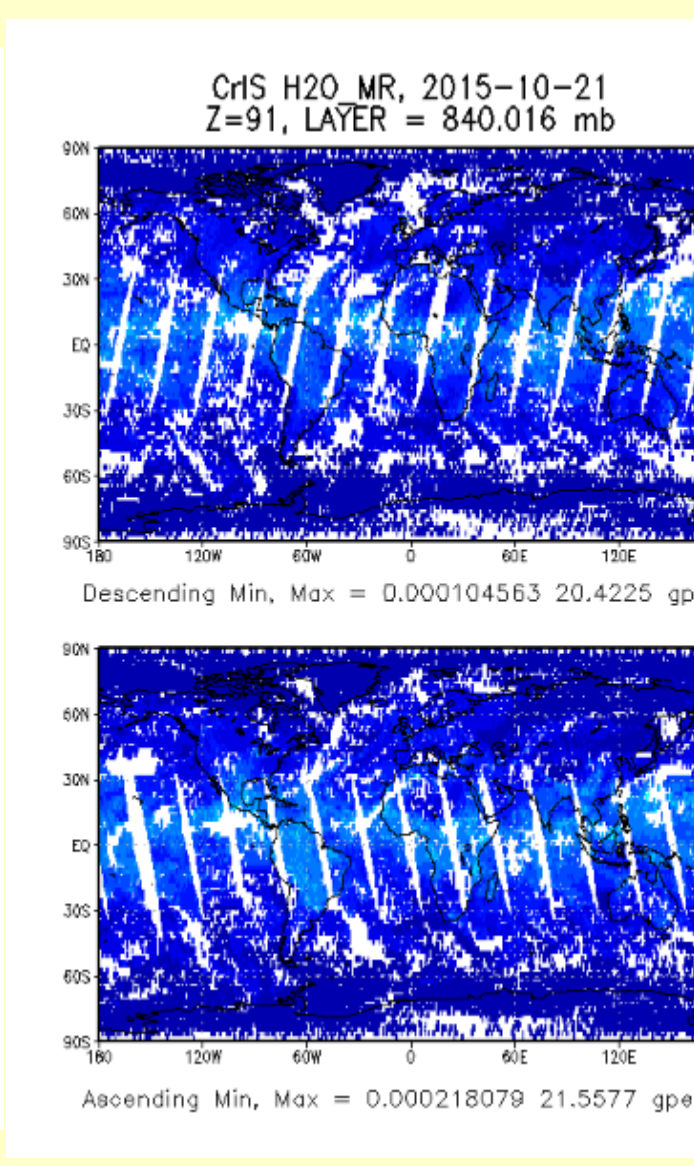
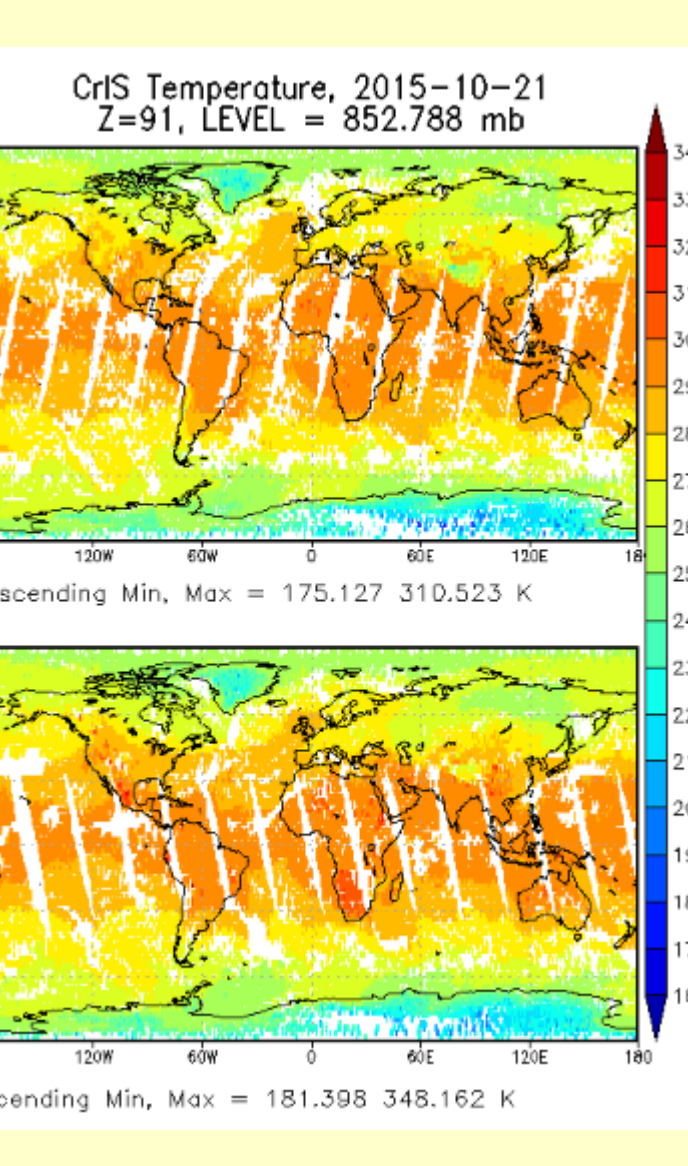
The NUCAPS global granules composite images are produced for the last seven days at the 15 fixed air pressure levels or layers. They are produced by using the NUCAPS retrievals which are derived based on a fixed air pressure variable grid: temperature is derived at the fixed pressure levels (1014 mb, 853 mb, 707 mb, 497 mb, 407 mb, 300 mb, 250 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, 196 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.

#### NUCAPS/SNPP Global Gridded Products

SNPP Global Gridded 0.5 deg lat x 2 deg lon Images  
NUCAPS EDR Global Gridded 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). 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, 250 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, 196 mb, 147 mb, 99.5 mb, 68.8 mb, 49.3 mb, 27.6 mb, 8.82 mb, 838 mb).

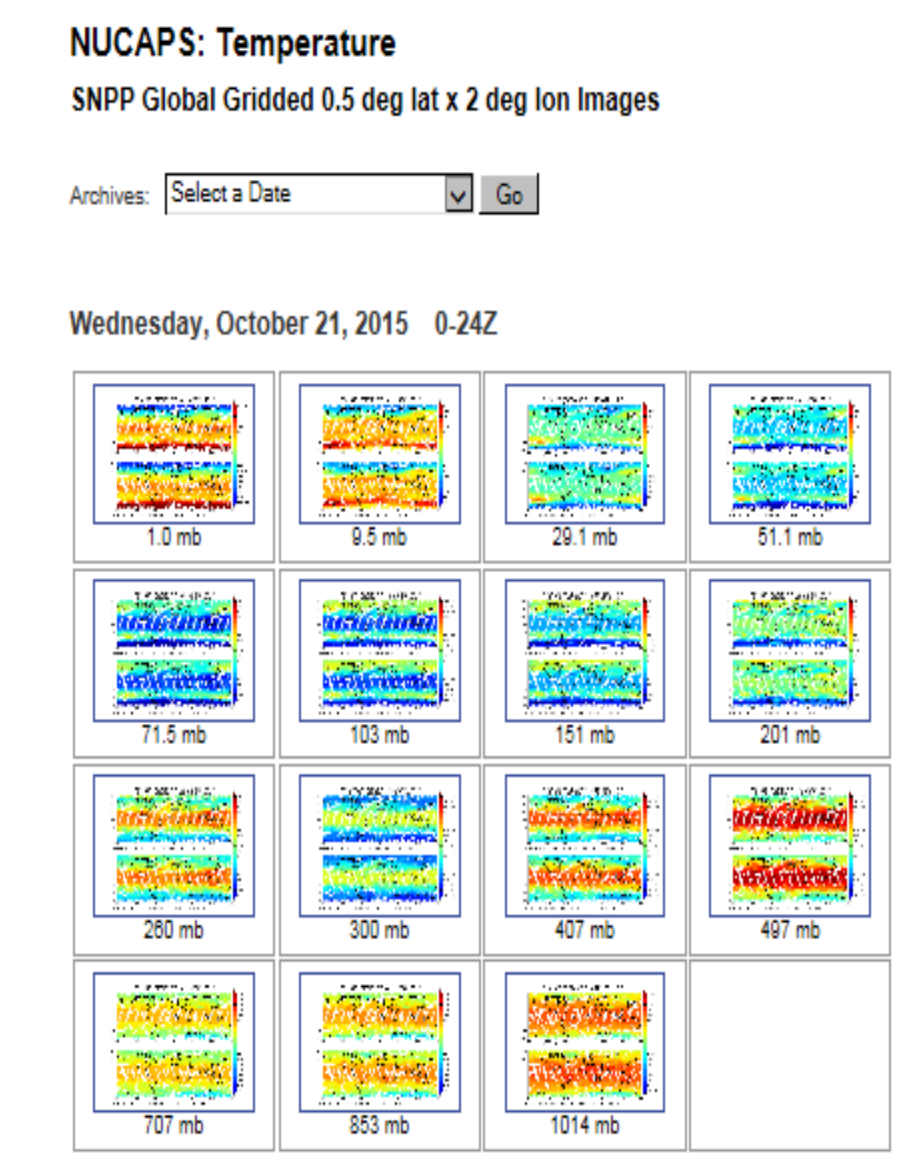
#### NUCAPS/SNPP Retrieval Statistics

The NUCAPS retrieval statistics are generated for Temperature (T<sub>p</sub>) 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. To generate the temperature bias and rms error 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, Nacc(k) such as:  
$$\text{bias} = \text{sum}(Nacc(k) * bias(k)) / \text{sum}(Nacc(k))$$
, where sum is for k = 1, K  
$$\text{rms} = \text{sqrt}(\text{sum}(Nacc(k) * rms(k)^2) / \text{sum}(Nacc(k)))$$
, where sum is for k = 1, K  
To generate the WVMR bias and rms error over a large ensemble of K granules the following formulas are used:  
$$\text{bias} = \text{sum}(gmean(k) * bias(k)) / \text{sum}(gmean(k))$$
, where sum is for k = 1, K  
$$\text{rms} = \text{sqrt}(\text{sum}(gmean(k) * rms(k)^2) / \text{sum}(gmean(k)))$$
, where sum is for k = 1, K



NUCAPS/SNPP Retrieval Statistics

Product	Local	Global
2015-10-21	Local	Global
2015-10-20	Local	Global
2015-10-19	Local	Global
2015-10-18	Local	Global
2015-10-17	Local	Global
2015-10-16	Local	Global
2015-10-15	Local	Global
2015-10-14	Local	Global
2015-10-13	Local	Global
2015-10-12	Local	Global



**IASI**

Temperature profiles  
Water vapor profiles  
Radiances (thinned, cloud  
Principal components  
Stability parameters (CAPE, Lifted Index, Convective Inhibition, Pressure of Equilibrium Level, Temperature Level of Free Convection, etc.)  
Cloud products (Cloud Top Pressure, Cloud Top Fraction)  
Trace gases  
Emissivity

- 100 levels

retrieved temperatures  
First Guess Temperature  
Mixing Ratio of Water  
Mixing Ratio of Ozone  
Mixing Ratio of Carbon Monoxide  
Mixing Ratio of Carbon Dioxide  
Mixing Ratio of Methane  
Surface Properties, Satellite Info, and Retrieval Flags  
Skin Temperature  
First Guess Skin Temperature  
Bottom Level Index  
Microwave Surface Emissivity  
Quality Flag  
Average Carbon Dioxide  
SO2 Anomaly  
Ash Brightness Temperature Differences.

IASI Sounding Products

Surface Properties, Satellite Info, and Retrieval Flags

Parameter	Metop-1 IASI	Metop-2 IASI
Sea Temperature	0.5x2	0.5x2
Sea Surface Temperature	0.5x2	0.5x2
Bottom Level Index	0.5x2	0.5x2
Microwave Surface Emissivity	0.5x2	0.5x2
Quality Flag	0.5x2	0.5x2
Average Carbon Dioxide	0.5x2	0.5x2

Temperature: Metop-2

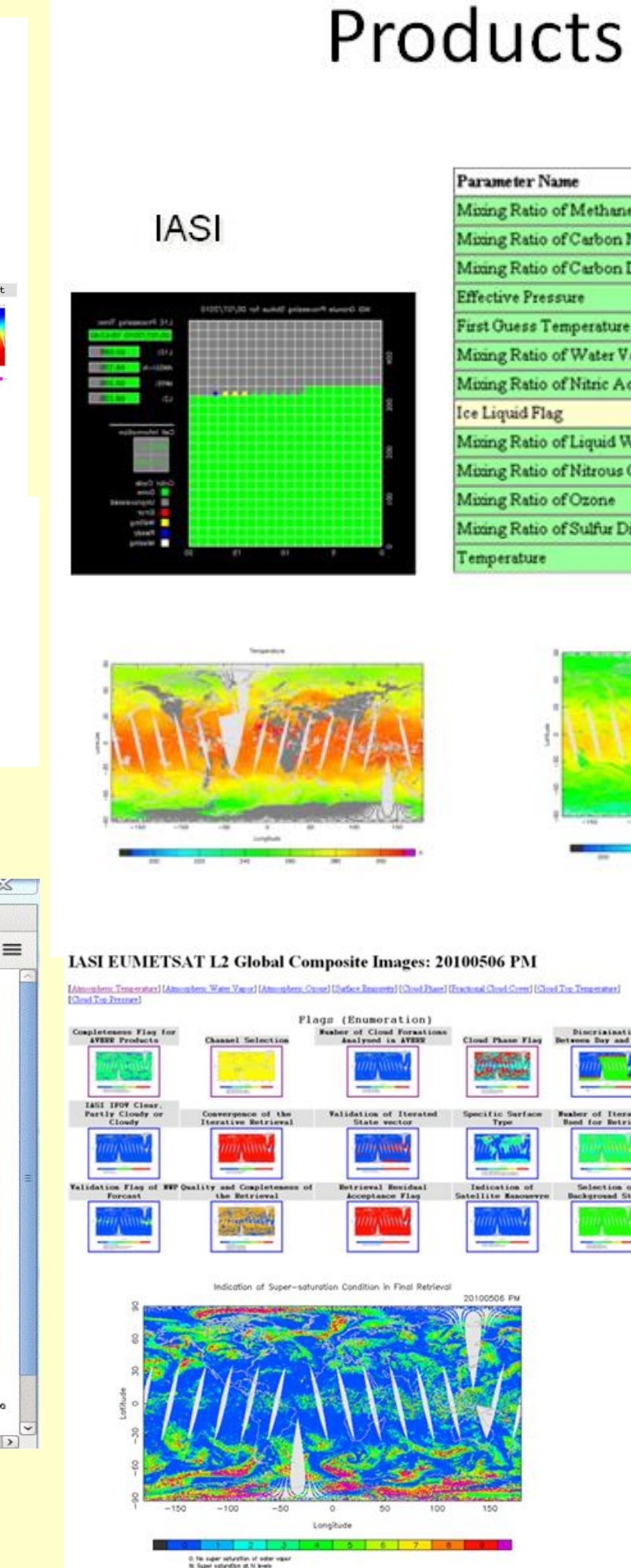
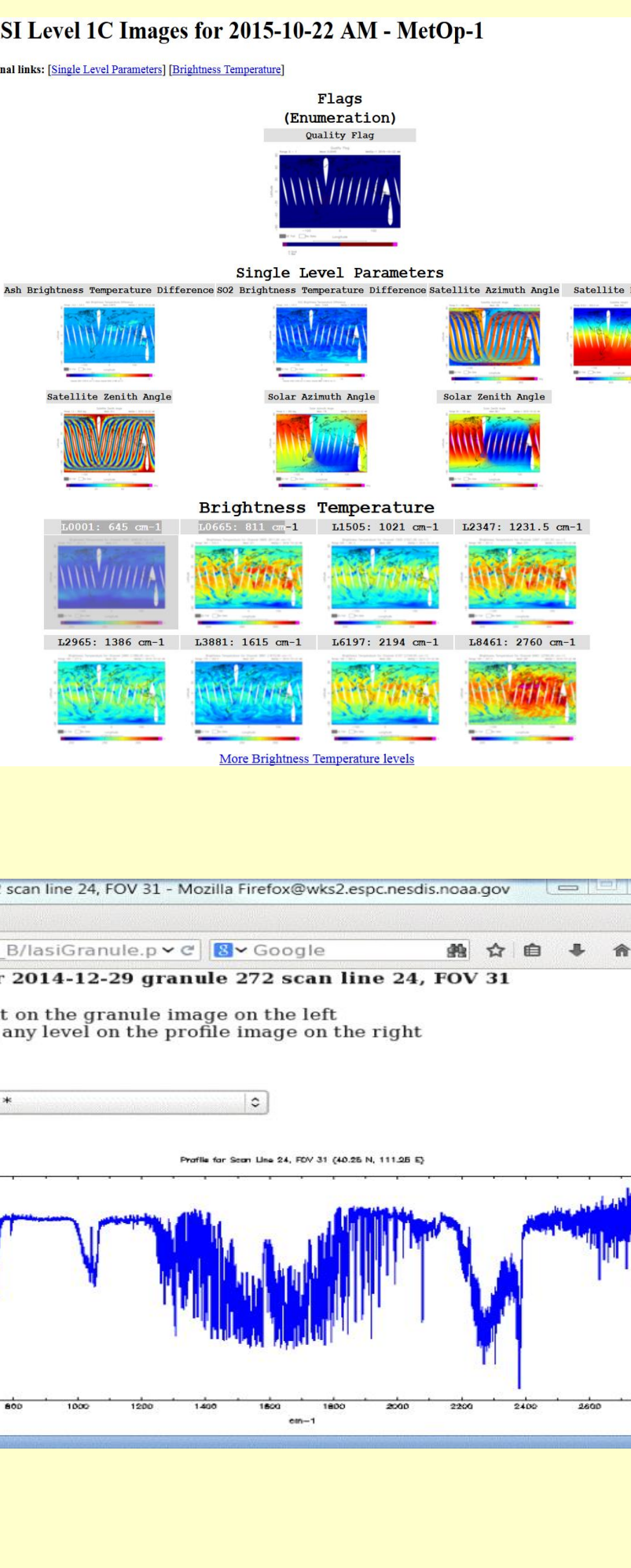
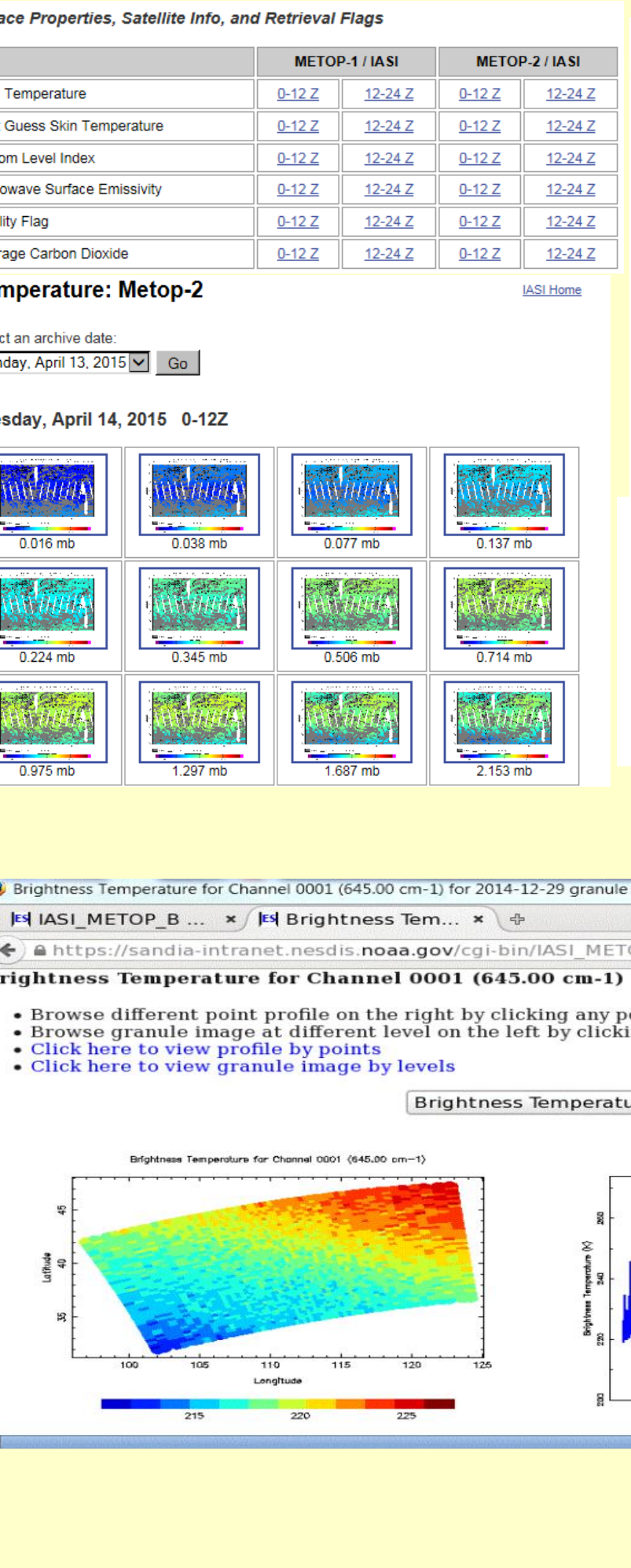
Parameter	Metop-1 IASI	Metop-2 IASI
Temperature	0.5x2	0.5x2
Sea Level Temperature	0.5x2	0.5x2
Sea Surface Temperature	0.5x2	0.5x2
Mixing Ratio of Water Vapor	0.5x2	0.5x2
Mixing Ratio of Ozone	0.5x2	0.5x2
Mixing Ratio of Carbon Dioxide	0.5x2	0.5x2
Mixing Ratio of Methane	0.5x2	0.5x2
Mixing Ratio of Nitrous Oxide	0.5x2	0.5x2
Mixing Ratio of Nitrogen Dioxide	0.5x2	0.5x2
Mixing Ratio of Sulfur Dioxide	0.5x2	0.5x2

Cloud Top Properties

Parameter	Metop-1 IASI	Metop-2 IASI
Cloud Top Fraction	0.5x2	0.5x2
Cloud Top Pressure	0.5x2	0.5x2

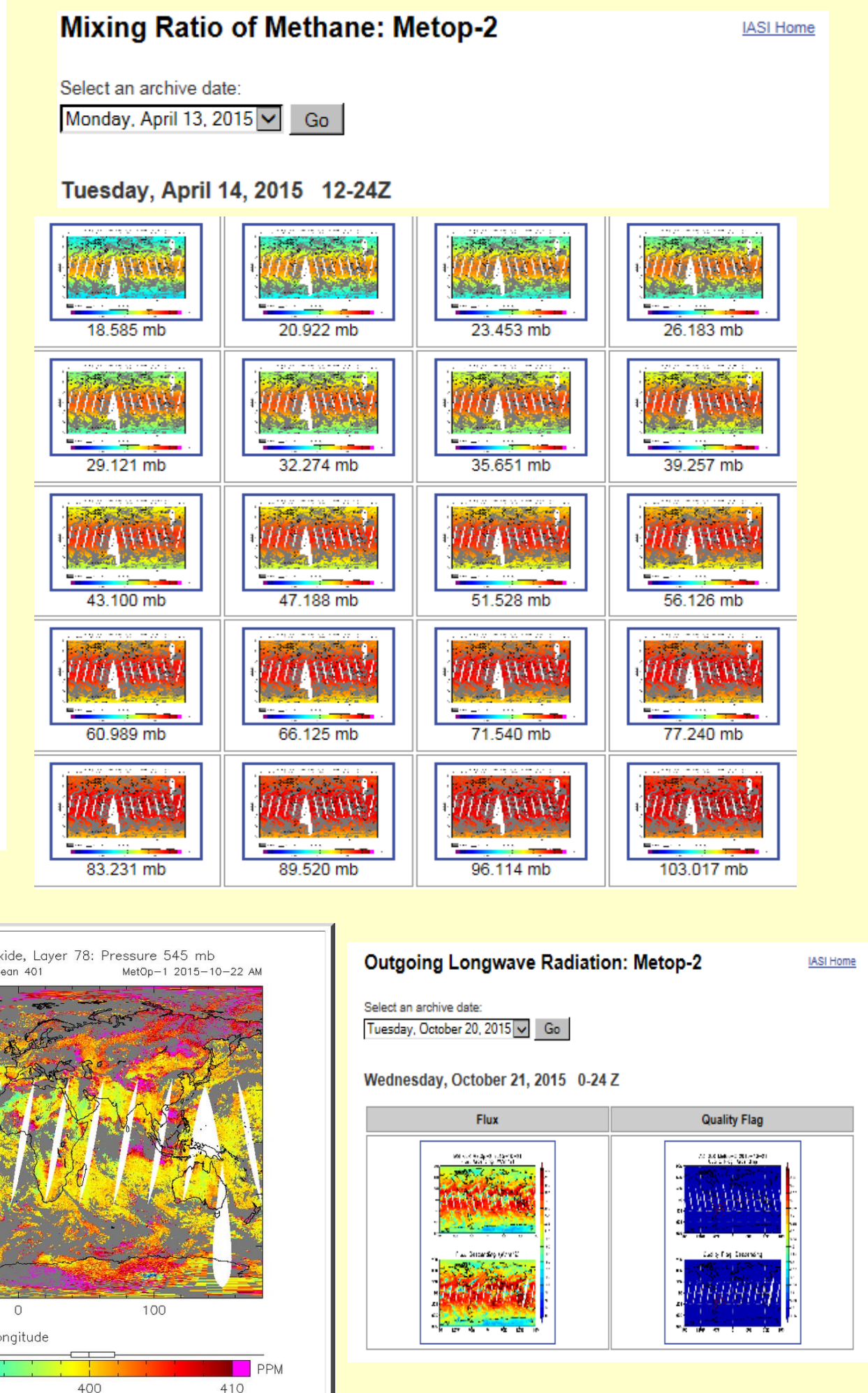
Other Parameters

Parameter	Metop-1 IASI	Metop-2 IASI
Sea Level Index	0.5x2	0.5x2
Sea Surface Emissivity	0.5x2	0.5x2
Sea Level Emissivity	0.5x2	0.5x2
Outgoing Longwave Radiation	0.5x2	0.5x2



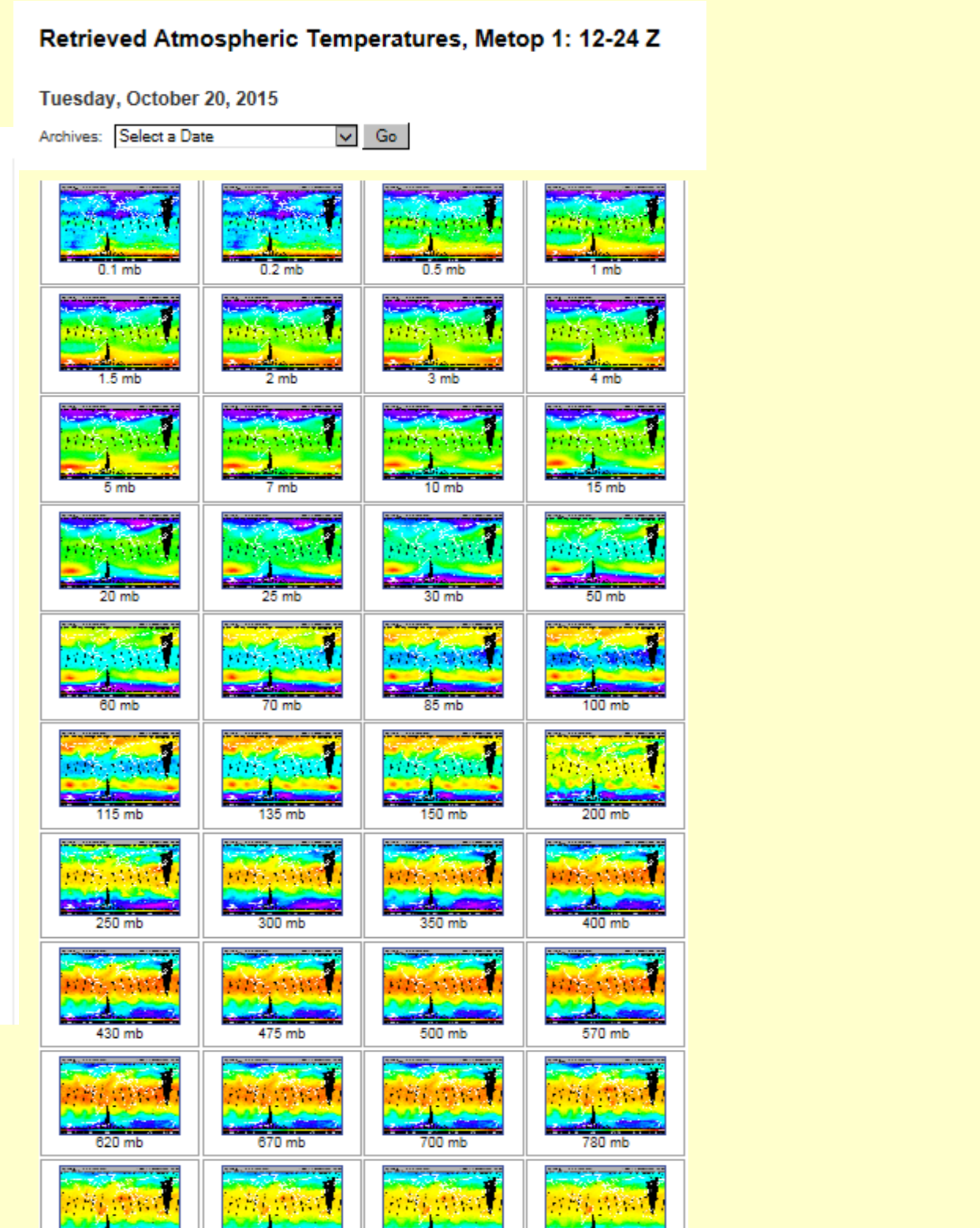
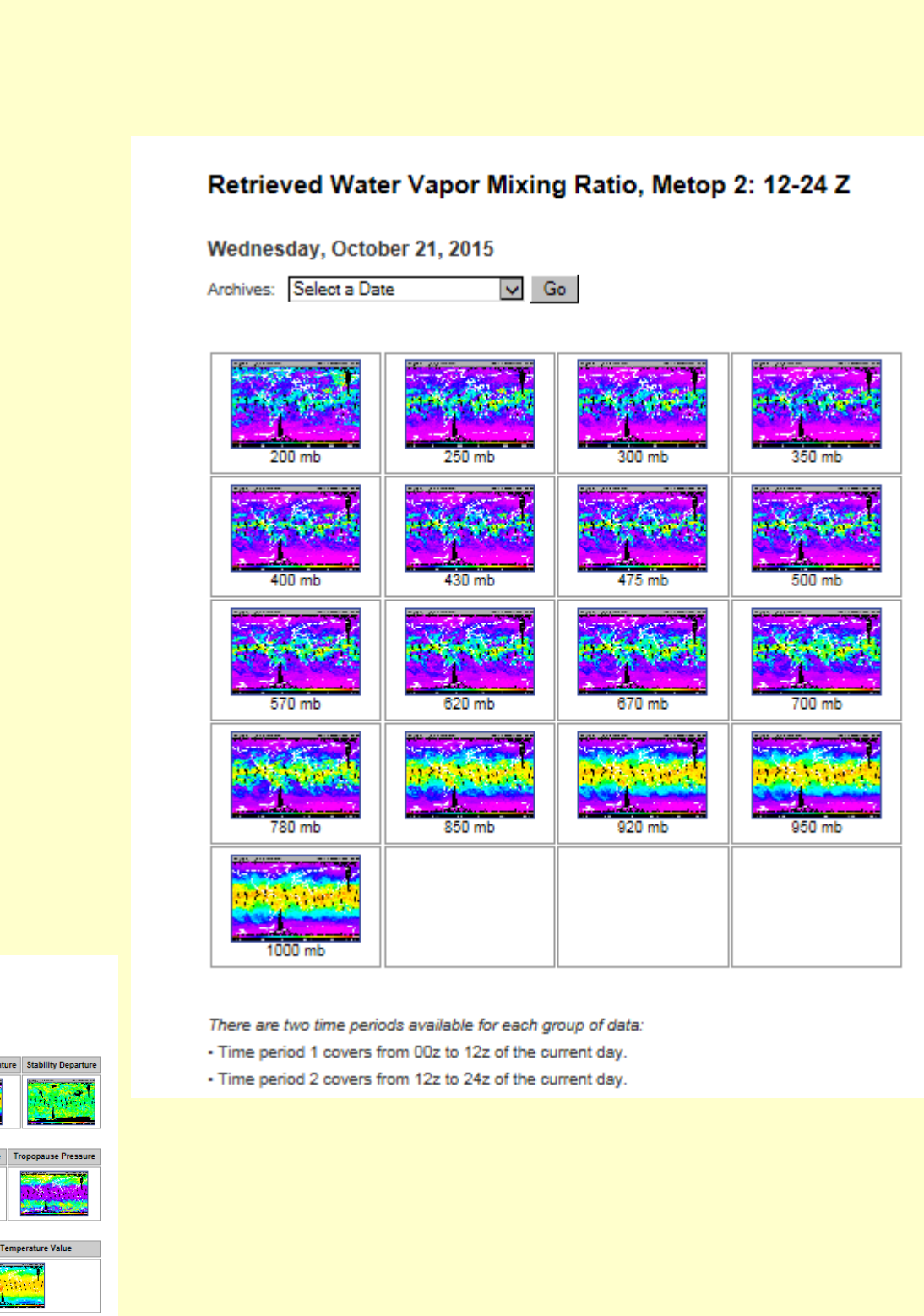
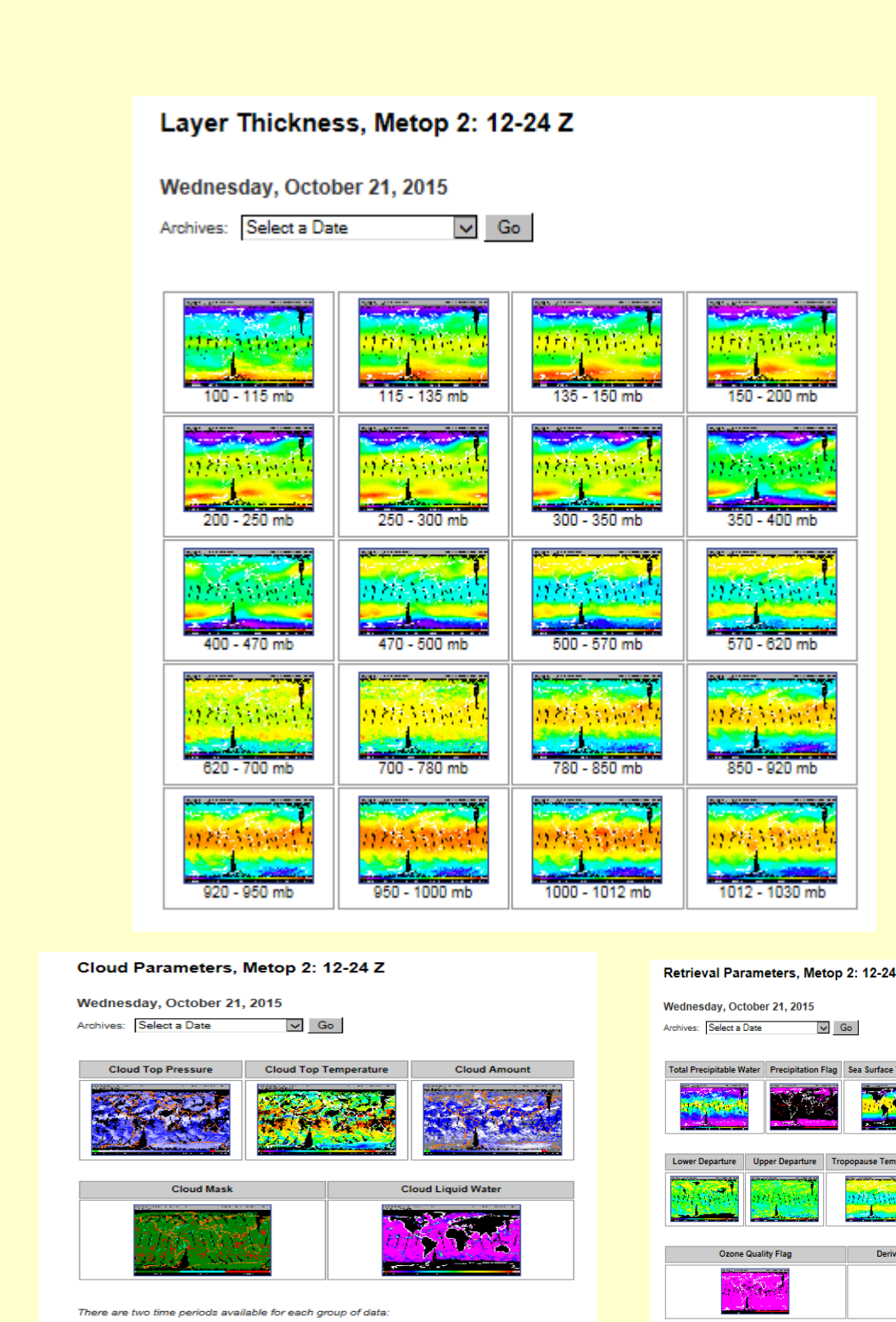
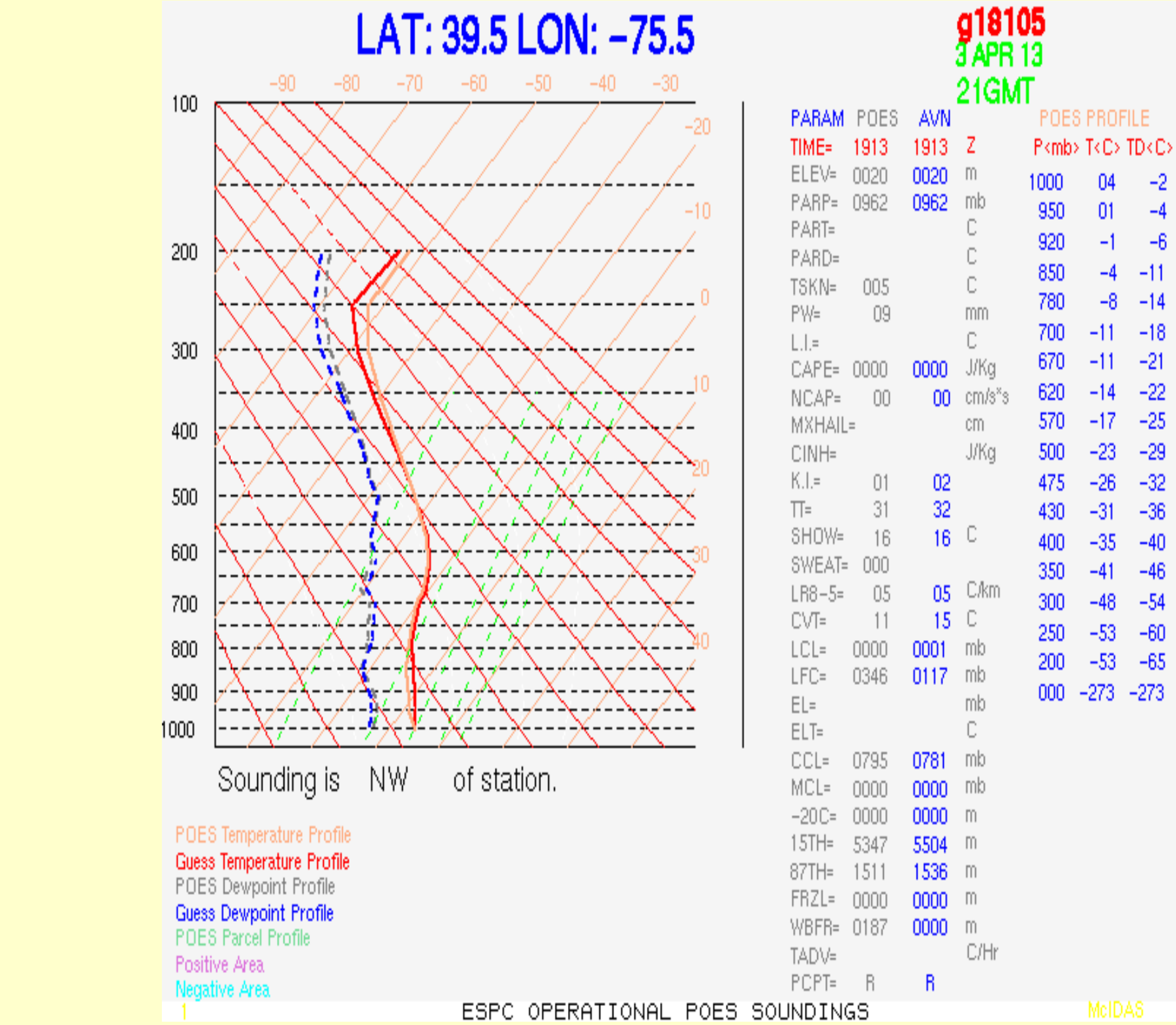
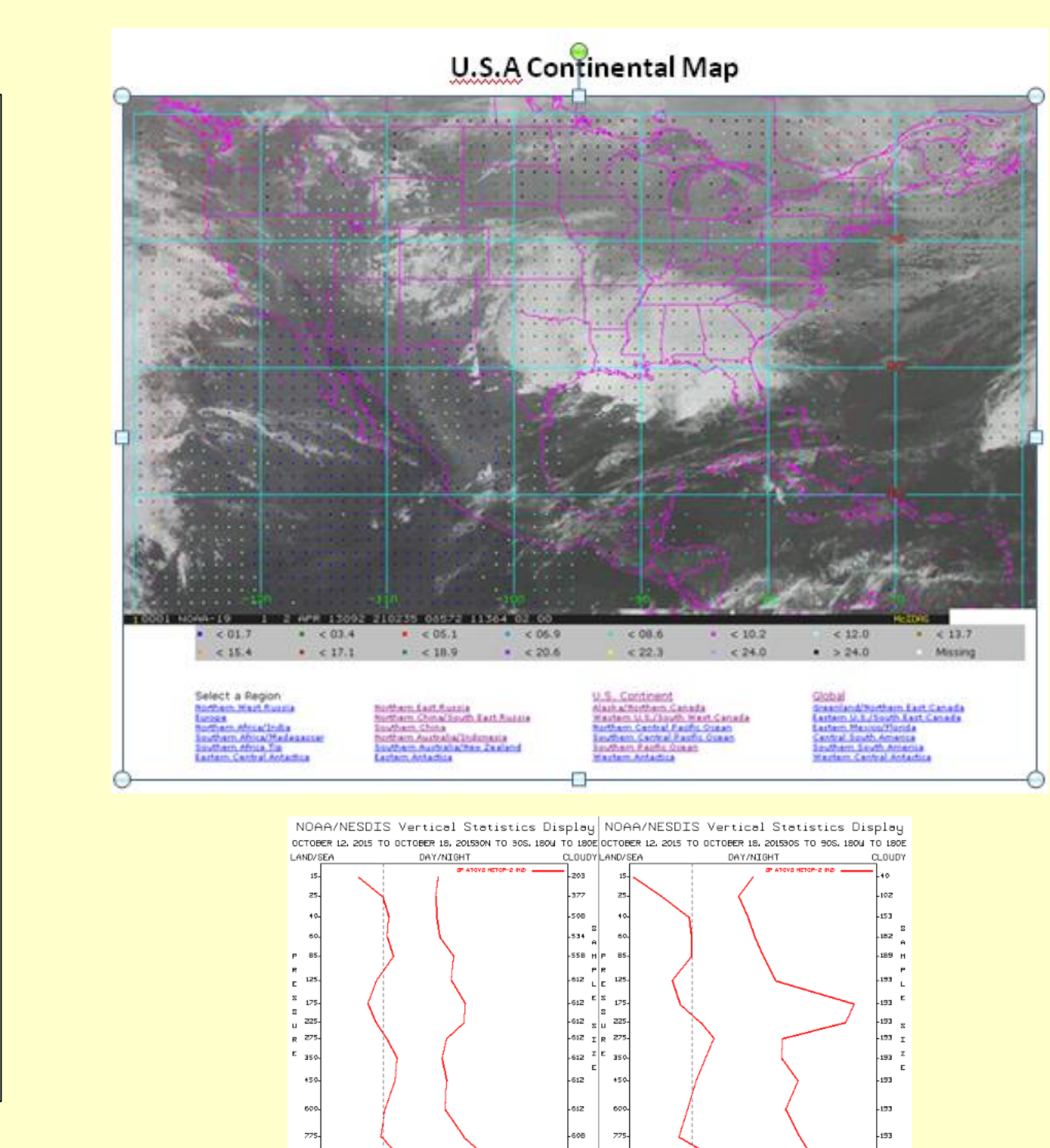
Products Quality Monitoring Cont.....

Parameter Name	Min. Value	Max. Value	Unit
Mixing Ratio of Methane	0	1000	PPB
Mixing Ratio of Carbon Dioxide	370	400	PPM
Effective Pressure	0	1100	hPa
Sea Level Pressure	990	1010	hPa
Sea Level Temperature	190	330	K
Sea Level Humidity	0	10	g/Kg
Mixing Ratio of Water Vapor	0	10	g/Kg
Mixing Ratio of Water Acid	0	1	PPB
Sea Level Wind	0	1	PPB
Mixing Ratio of Liquid Water	0	5400	PPB
Mixing Ratio of Nitrous Oxide	0	300	PPB
Mixing Ratio of Ozone	0	11000	PPB
Mixing Ratio of Sulfur Dioxide	0	0.1	PPB
Temperature	190	310	K



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

ATOVS



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