

# **Total Ozone from Assimilation of Stratosphere and Troposphere (TOAST) Its past, current and future versions**

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# TOAST objective analysis

- **Basic consideration:**

1. IR obs. possess higher sensitivity to lower atmosphere
2. UV obs. Possess higher sensitivity to upper atmosphere.
3. Mix the IR and UV retrieved O<sub>3</sub> may increase O<sub>3</sub> accuracy
4. Fill in the UV observation gaps

- **Basic procedures:**

1. Convert IR and UV O<sub>3</sub> pressure scale into same pressure scales.
2. Coordinate transform from geographic into stereographic.
3. Objective analysis.
4. Analyzed global ozone data are transformed back to the geographic coordinate with  $1^{\circ} \times 1^{\circ}$  resolution.

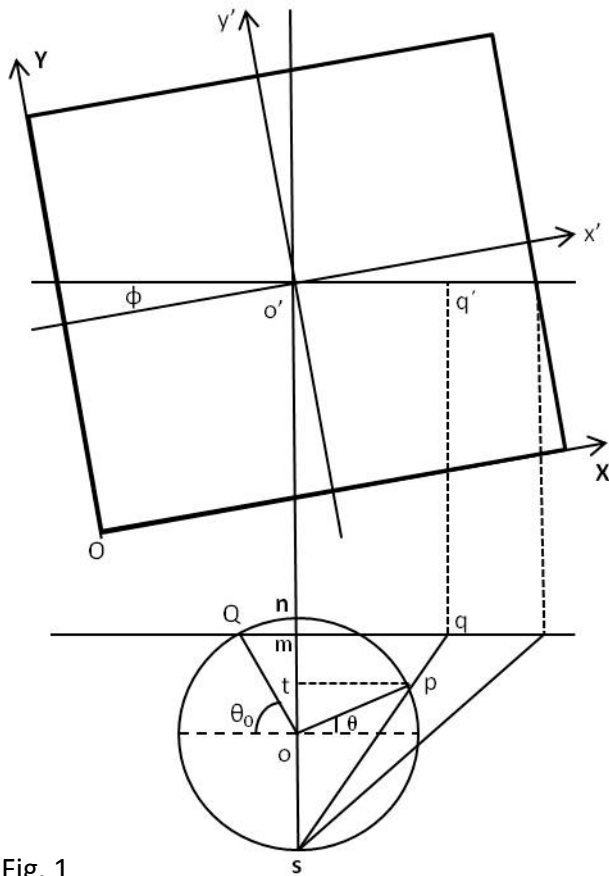


Fig. 1

$$X = \cos \theta \cdot \cos \phi \cdot \frac{\sin \theta_0 + 1}{\sin \theta + 1} \cdot \frac{Re}{mesh} + \frac{N-1}{2} \quad (1)$$

$$Y = \cos \theta \cdot \sin \phi \cdot \frac{\sin \theta_0 + 1}{\sin \theta + 1} \cdot \frac{Re}{mesh} + \frac{N-1}{2} \quad (2)$$

mesh=24,384/(N-1) km,  $\theta_0=60^\circ$ ; N is mesh grid number;

For CrIS N=245; for OMPS N=65

Fig 1. coordinate transformation from geographic to Stereographic.

$$C = WE \quad (3)$$

$$W = \frac{R^2 - d^2}{R^2 + d^2} \quad (4)$$

Any initial value on the grid within radius R and the origin point A determined circle will be corrected by the correction value C, where E is the difference between observation and the initial value at A, W is a weighting factor.

Fig. 2

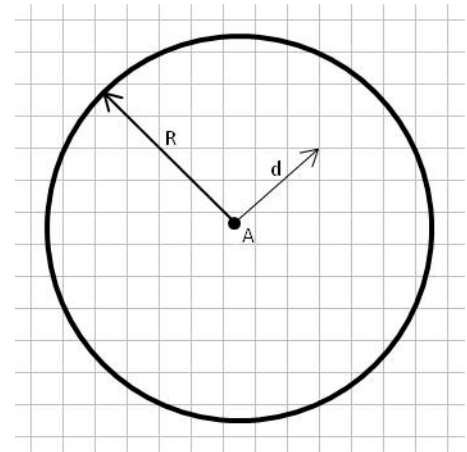
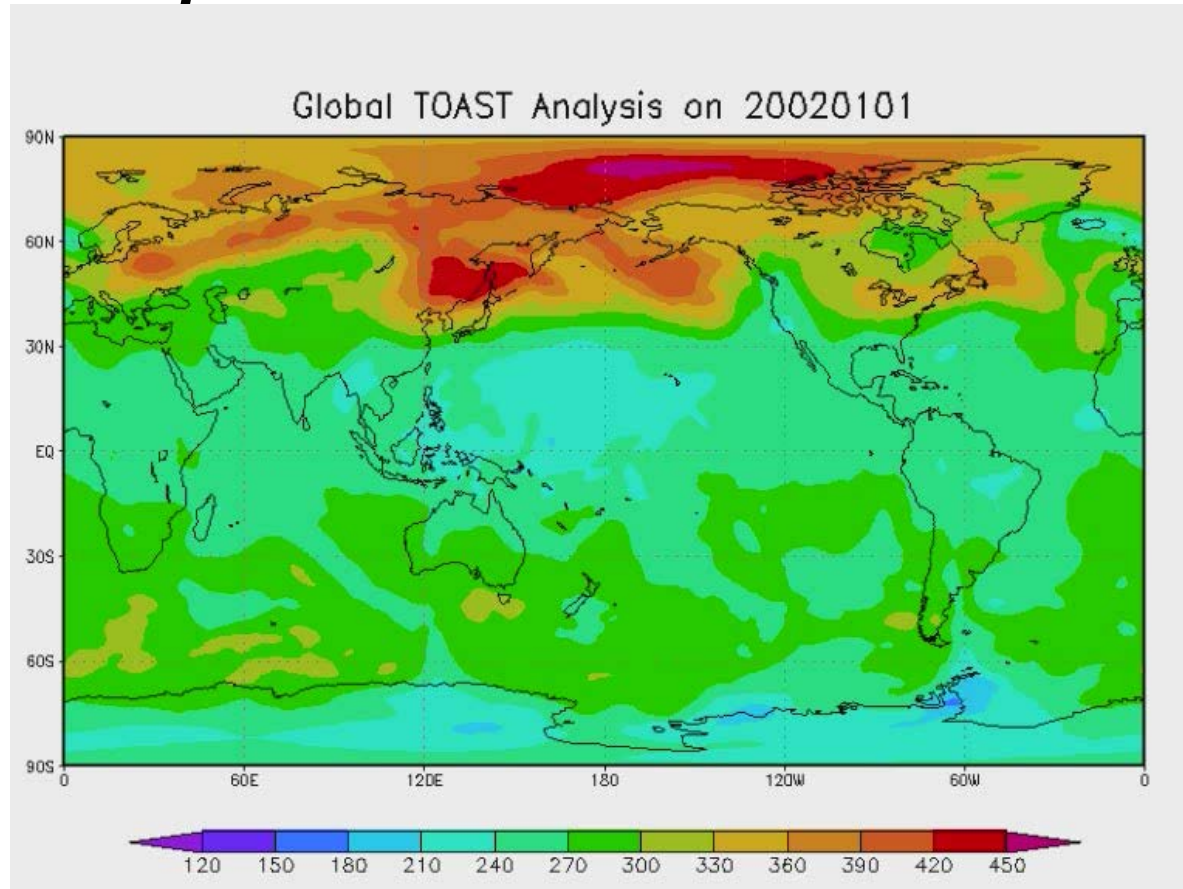


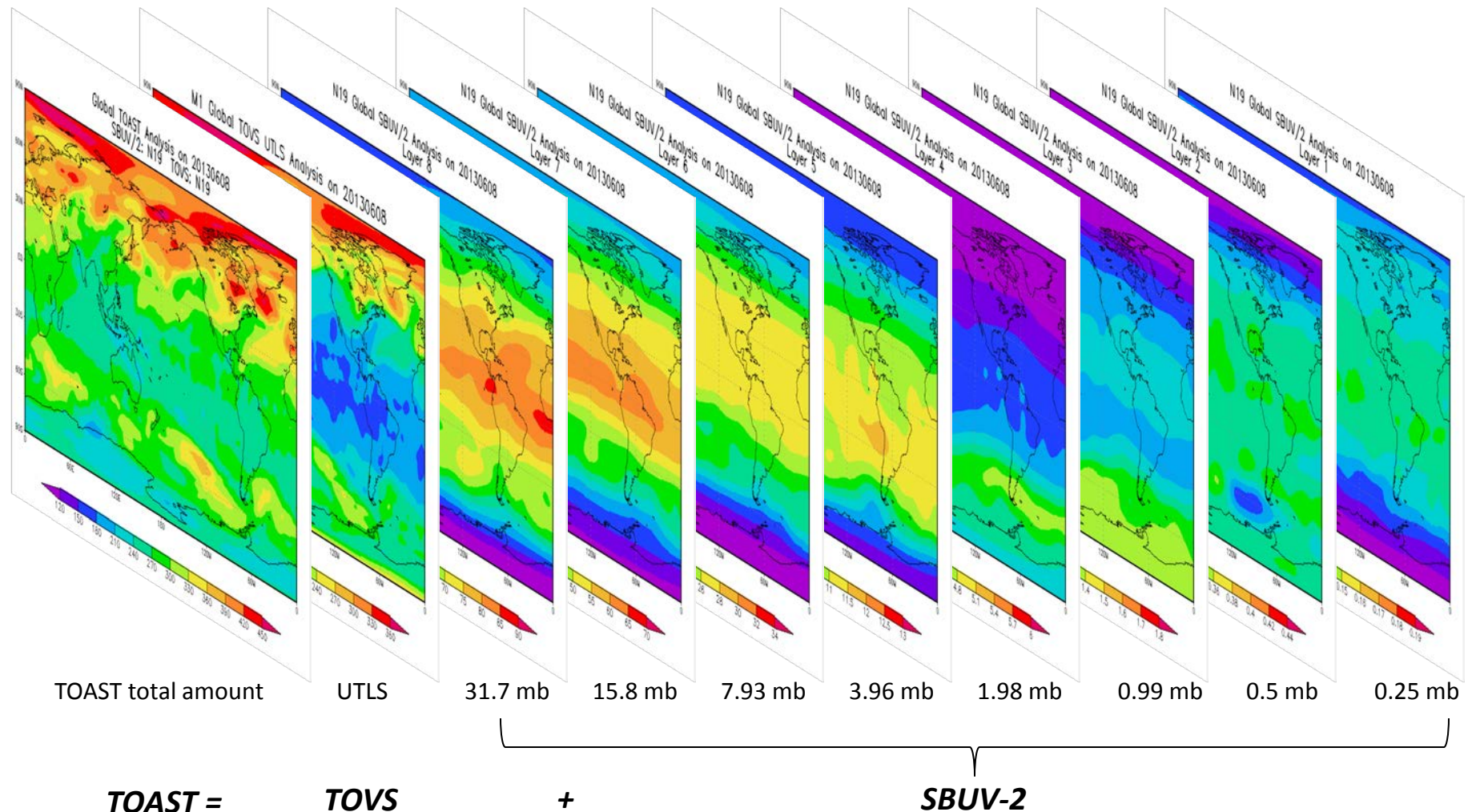
Fig 2. scheme of objective analysis

# *The past TOAST : from 2002 to 2014*



- Started from 01/01/2002 and has accumulated 11<sup>+</sup> years data.
- Provide global 1° × 1° total O<sub>3</sub>
- Provide global 1° × 1° for eight Umkehr layer O<sub>3</sub> at 31.7, 15.8, 7.93, 3.96, 1.98, 0.99, 0.50, 0.25 mb.

# TOAST using TOVS and SBUV-2 (06-08-2013)



## From 2012, S-NPP provided the following ozone sensors

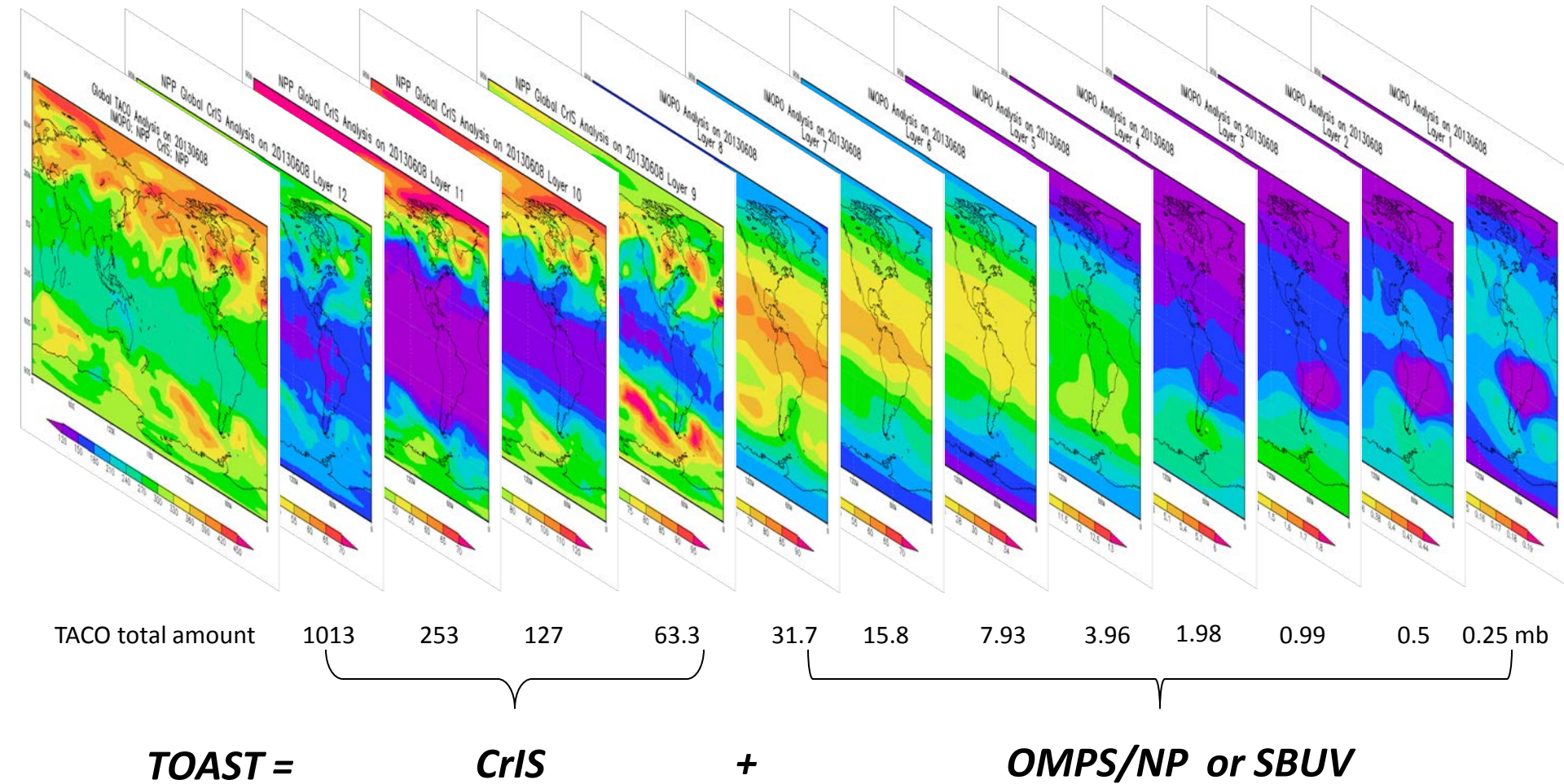
- CrIS IR sensor monitoring global O3 profiles
- OMPS NP nadir view profiler
- OMPS NM nadir mapper
- OMPS limb

### The current TOAST

- **T**otal **O**zone from **A**ssimilation of CrIS and OMPS (NP) or SBUV2 in **S**tratosphere and **T**roposphere
- Current operational **TOAST** is running CrIS + SBUV/2 (N19) until OMPS advances into validated maturity.



# TOAST using CrIS and OMPS/NP (or SBUV-2) (06-08-2013)

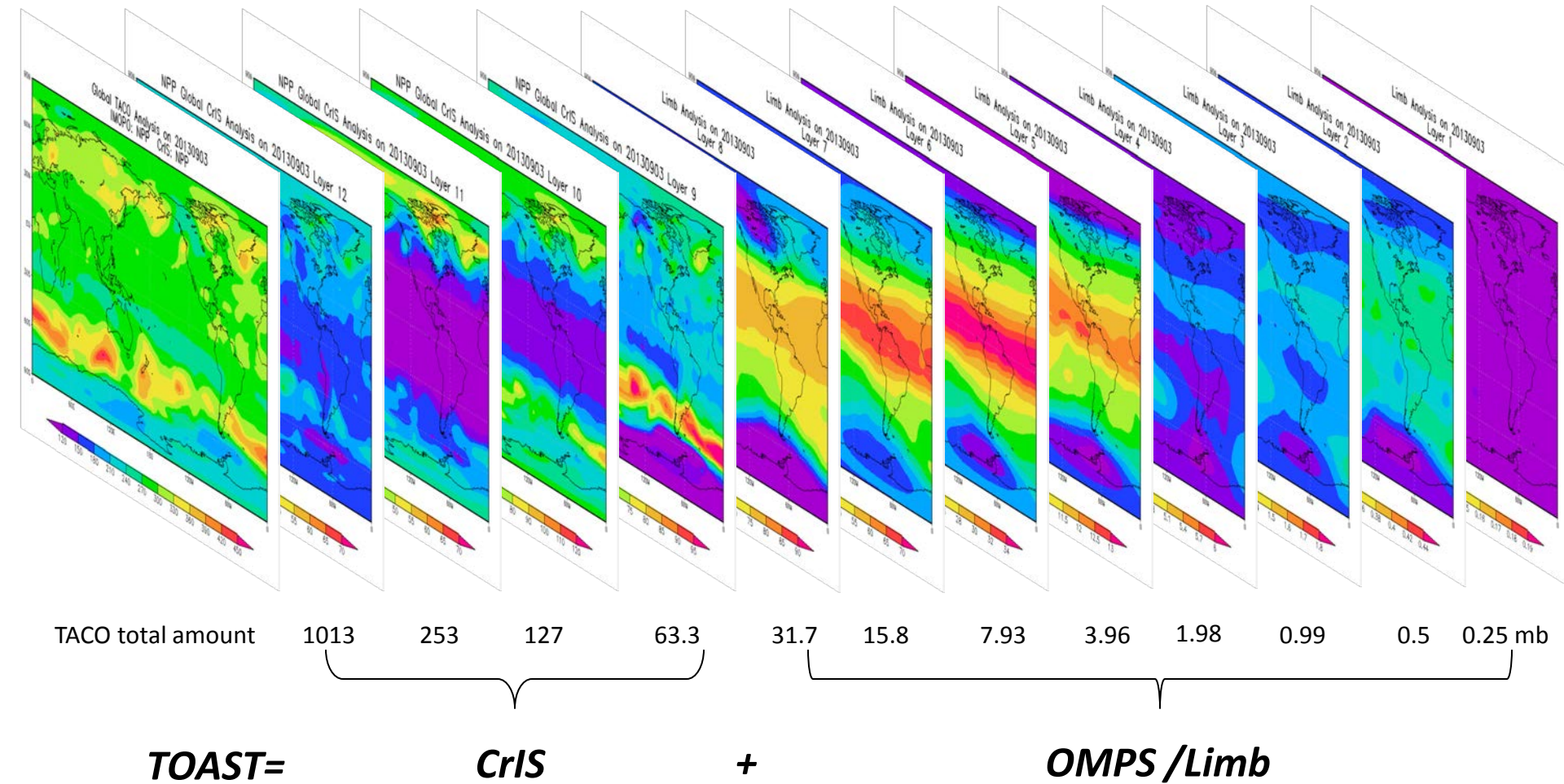


# The upcoming TOAST (CrIS + OMPS/Limb)

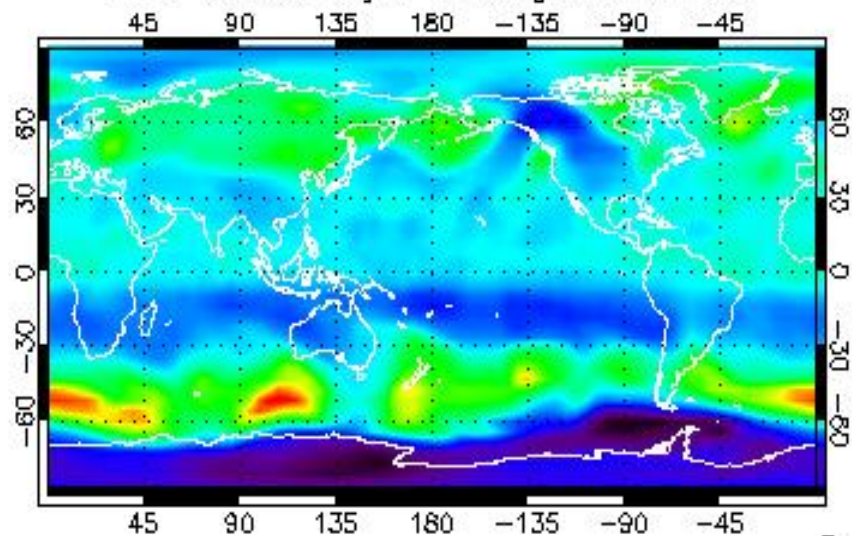
- Using CrIS and OMPS Limb (61 one-kilometer-thick layers)
- Provide global  $1^\circ \times 1^\circ$  total  $O_3$
- Provide global  $1^\circ \times 1^\circ$   $O_3$  maps of eight Umkehr layers at 31.7, 15.8, 7.93, 3.96, 1.98, 0.99, 0.50, 0.25 mb from OMPS Limb objective analyzed maps
- Provide global  $1^\circ \times 1^\circ$   $O_3$  maps of four Umkehr layers at 1013, 253, 127, 63.3 mb derived from CrIS NUCAPS product.
- Intend to provide 21 layer (V8 layers  $\sim 3\text{km}$ ) analyzed maps
- Intend to provide Limb 61 layers analyzed maps



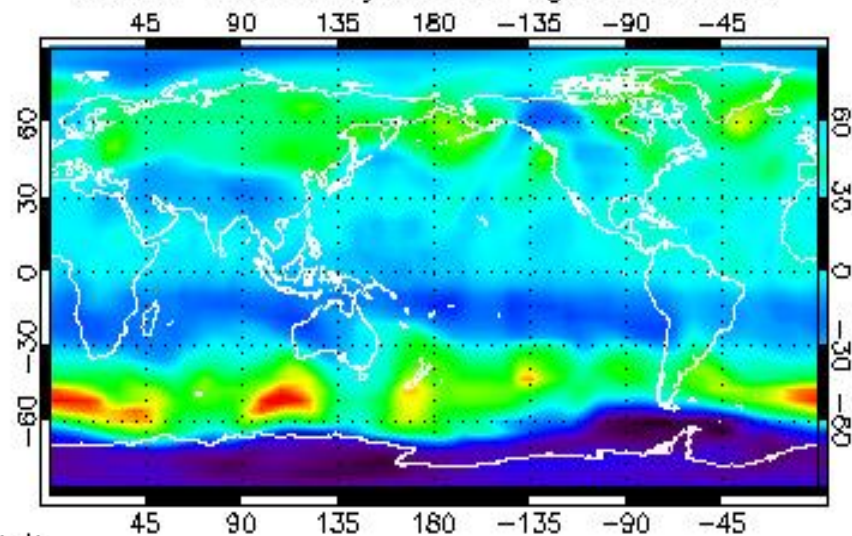
# TOAST using CrIS and Limb (09-03-2013)



Limb-TOAST analyzed total  $O_3$  at 20130903



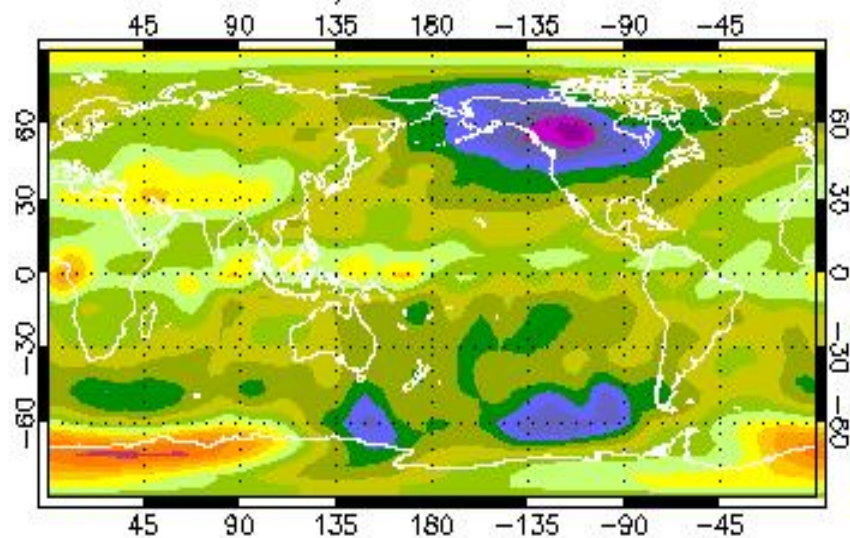
SBUV2-TOAST analyzed total  $O_3$  at 20130903



Dobson Unit

183 252 321 390 459

$(\text{LimbTOAST} - \text{SBUV2TOAST})$  relative to SBUV2TOAST at 20130903



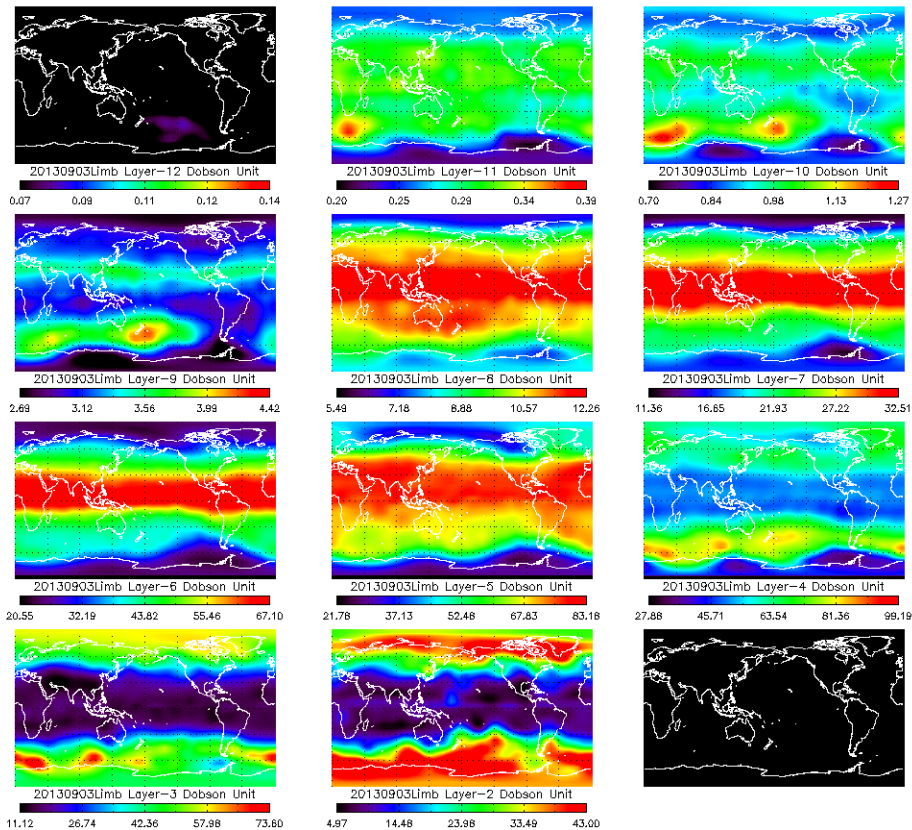
percent relative to SBUV2

10  
5  
0  
-5  
-10

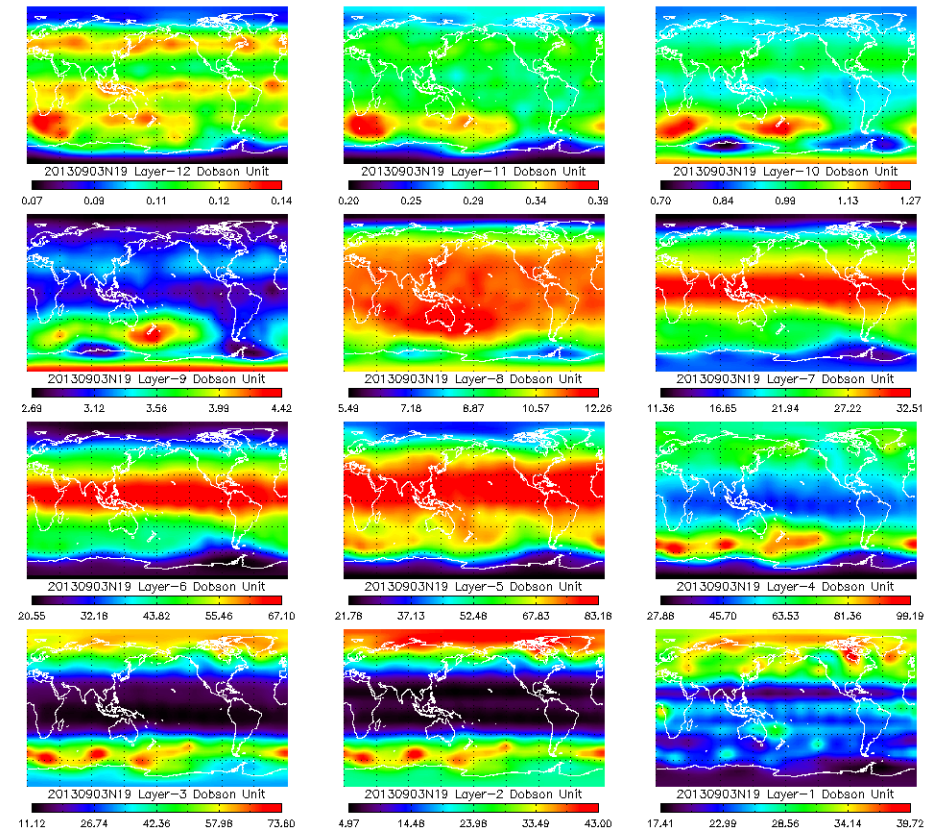


# 12 Umkehr layers analyzed O<sub>3</sub> 09-03-2013

## Limb



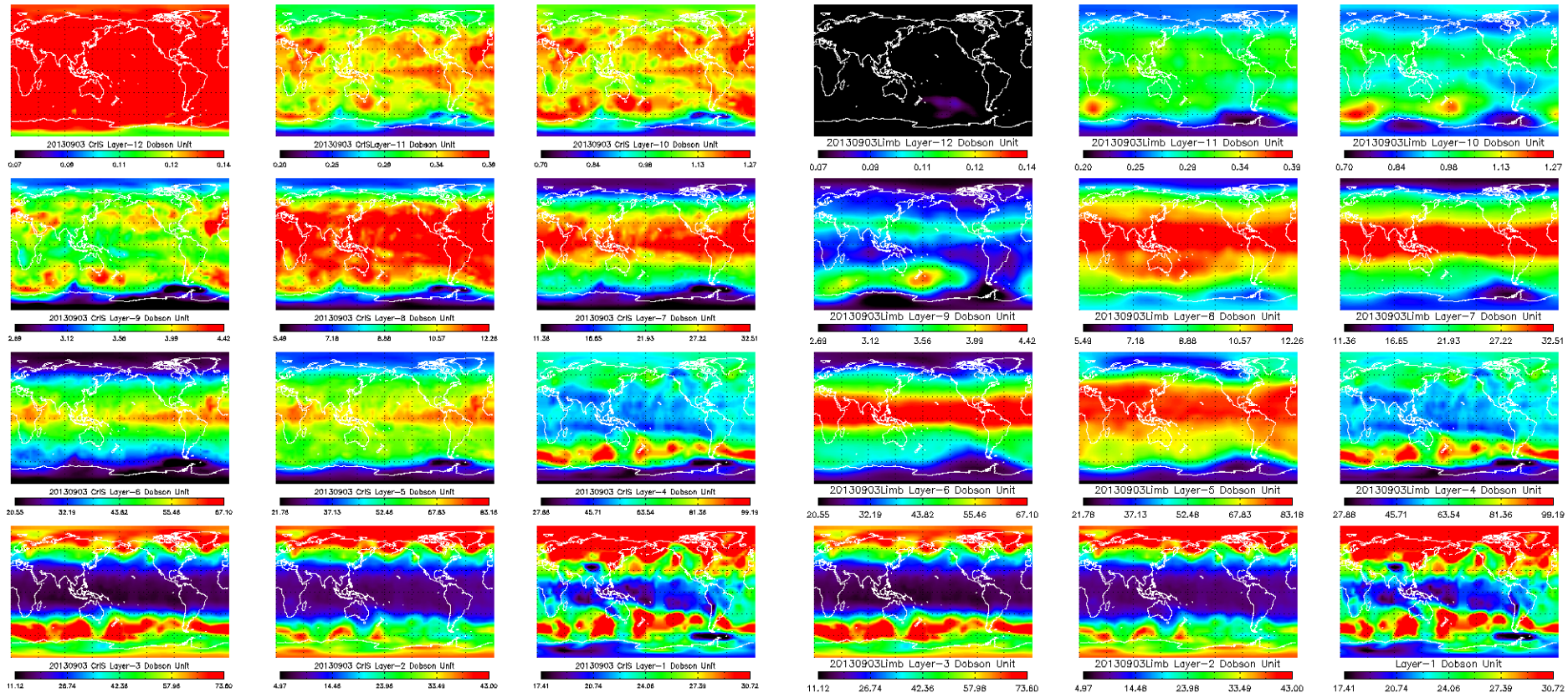
## SBUV



# 12 Umkehr layers analyzed O<sub>3</sub> 09-03-2013

CrIS

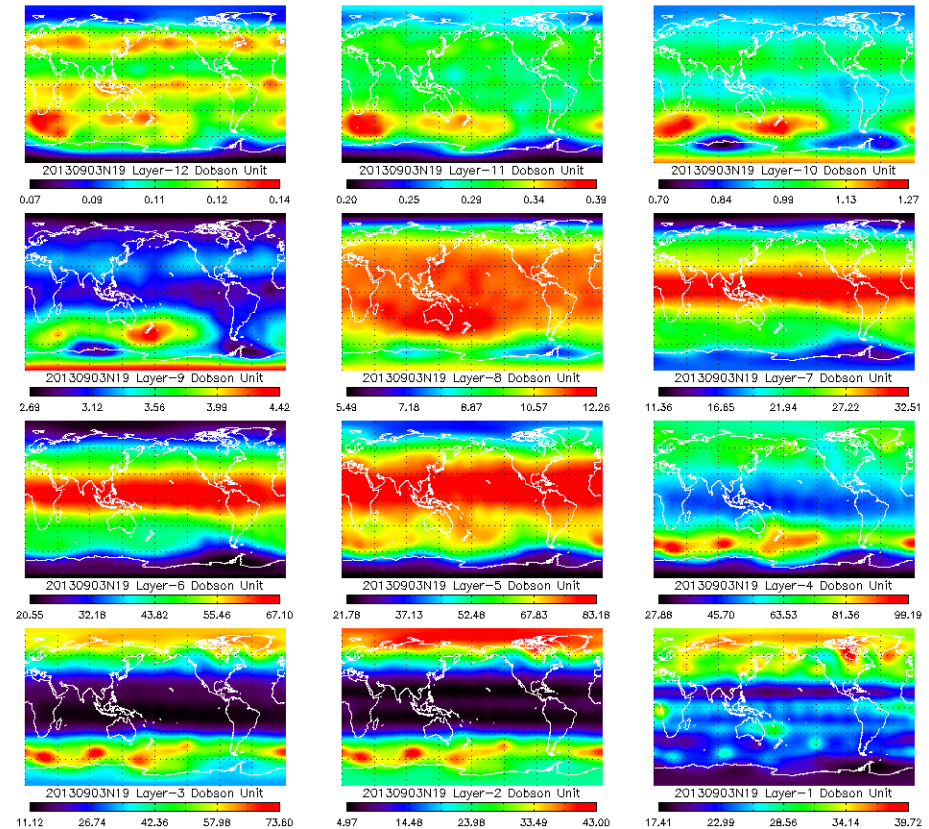
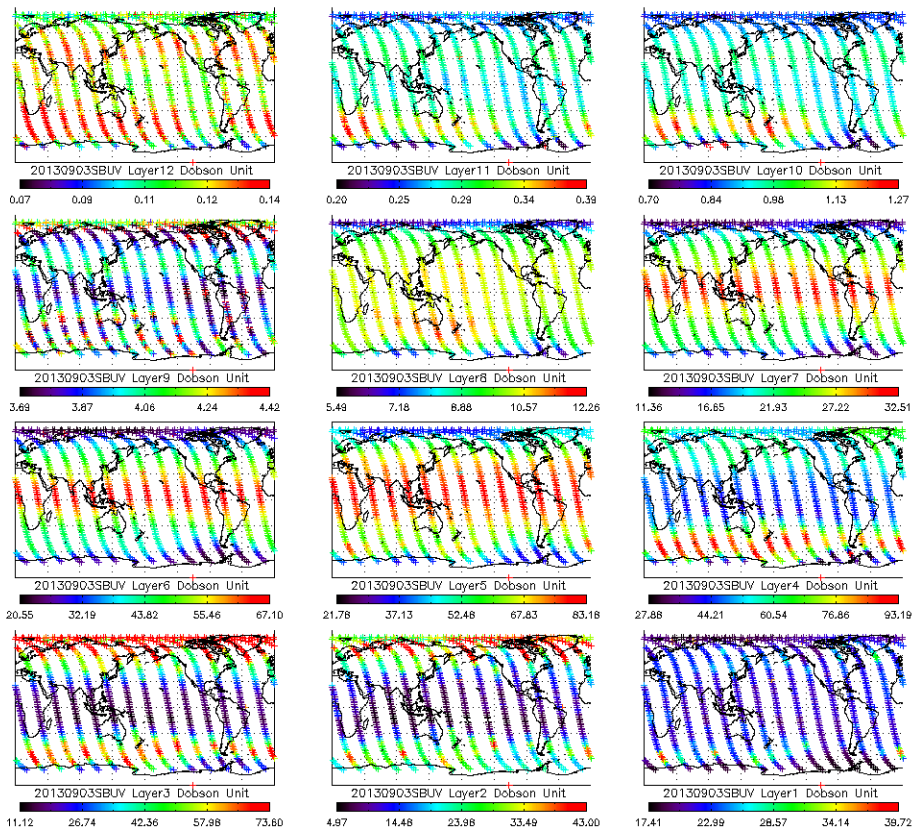
CrIS + Limb



# SBUV 12-layer vs. analyzed 09-03-2013

## SBUV-2 input

## TOAST SBUV-2 analyzed

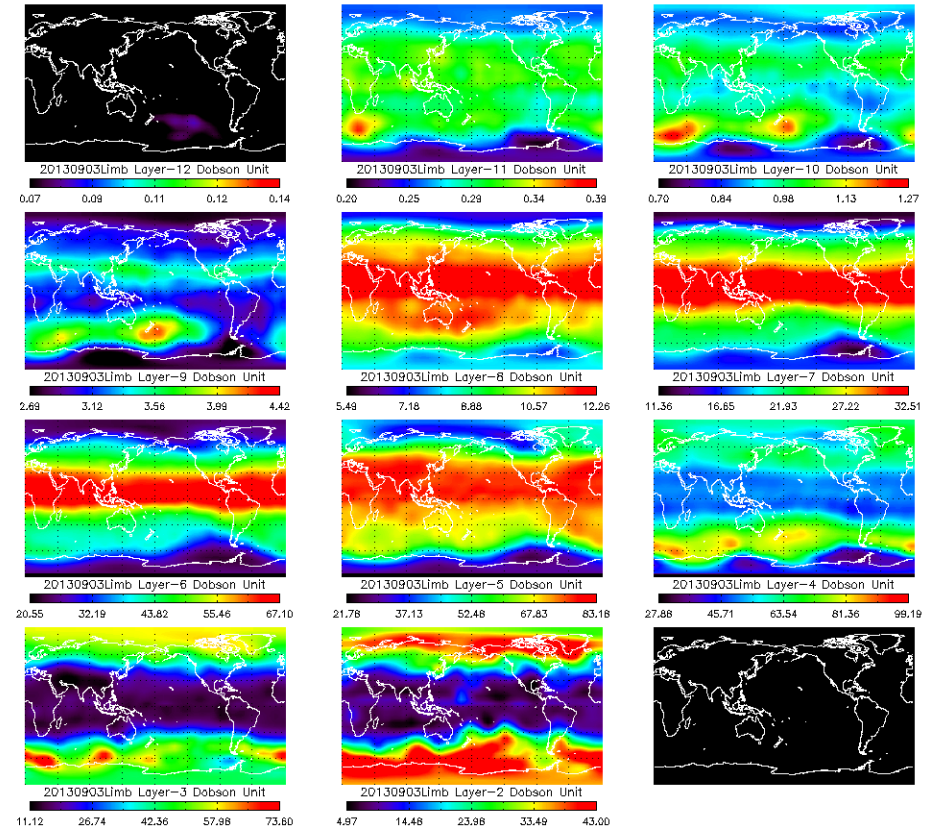
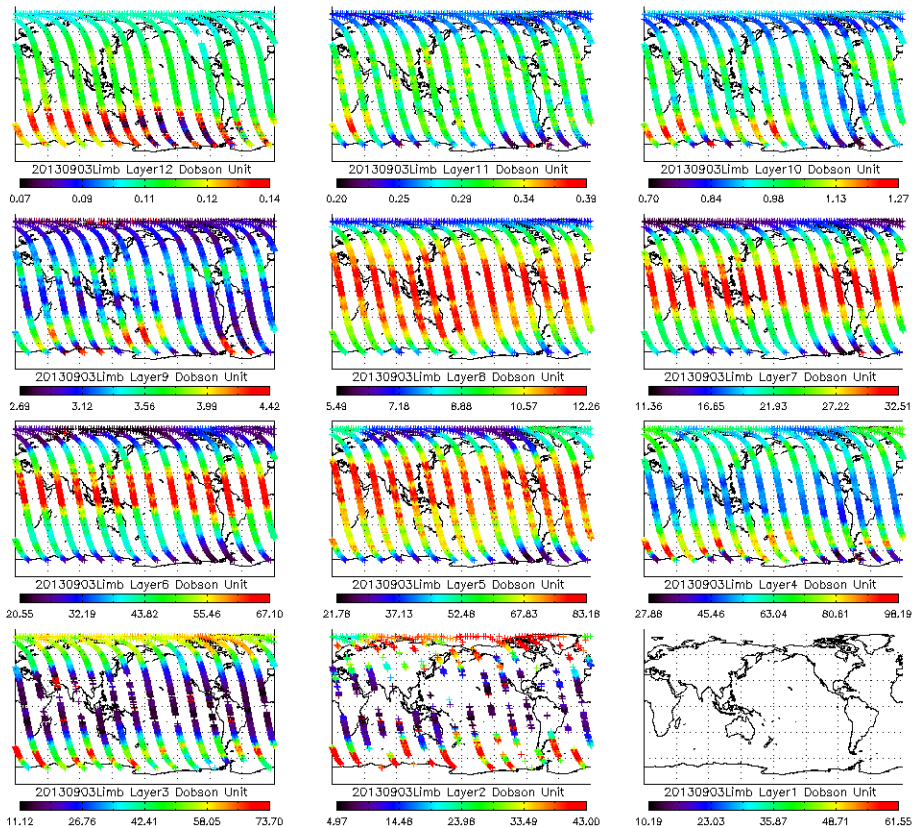




# Limb Layer reformed vs. analyzed

## Layer reformed Limb input

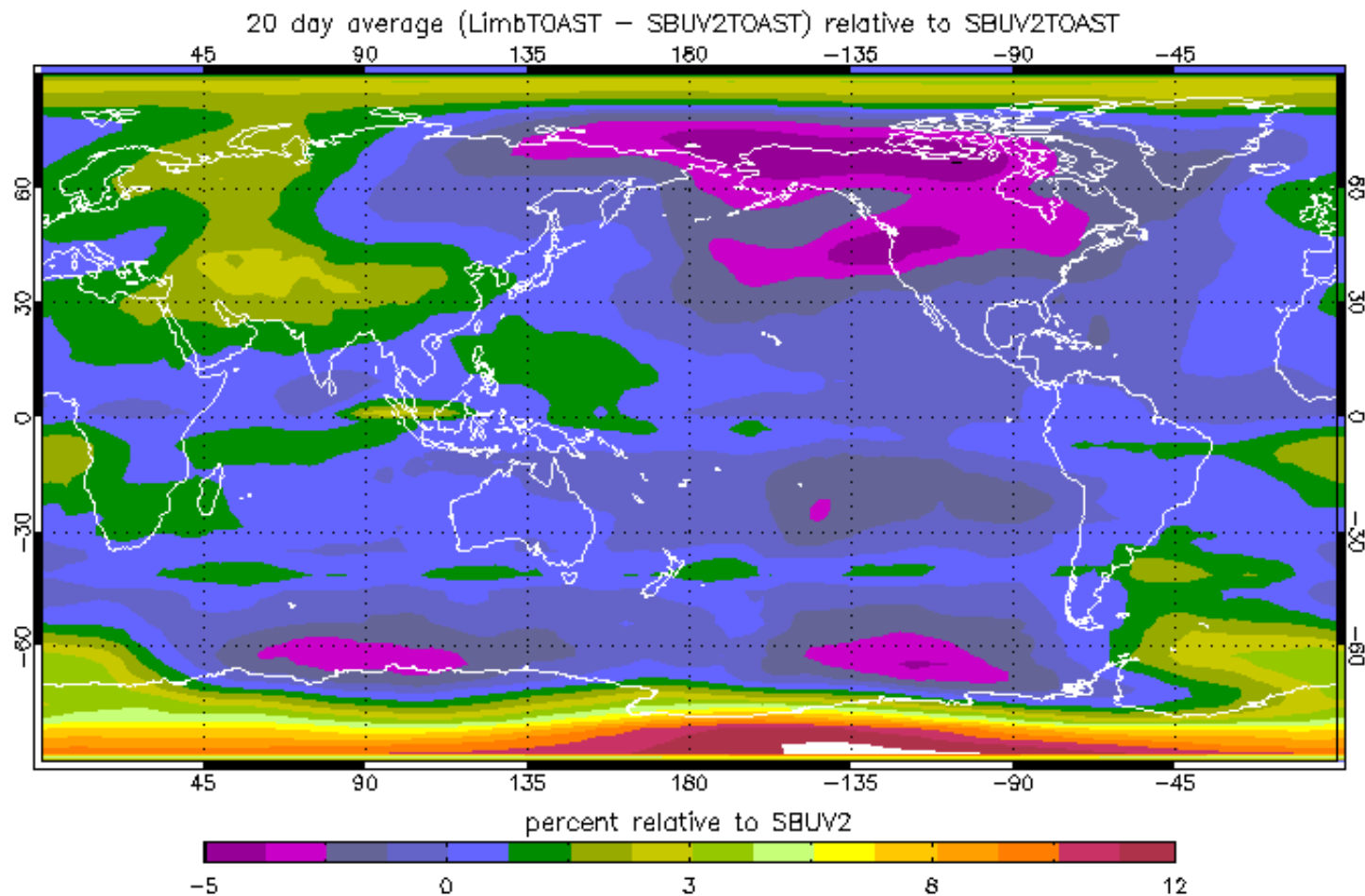
## Limb TOAST analyzed







## 20 day average of the relative differences to current version from 09-03-2013 to 09-22-2013



# What we have achieved

- Limb TOAST and SBUV TOAST show similar global patterns and values in the upper layers (comparison need to introduce retrieval averaging kernels)
- Limb and SBUV2 analysis algorithm functions well from the comparison of the EDR input and analyzed figures
- 20 days of total column Ozone analysis have been conducted
- The averaged relative differences shows Limb TOAST total amount analysis has  $\pm 5\%$  difference relative to current operational version (SBUV2 TOAST).

# Conclusion

- TOAST has provided global one by one degree total ozone product for 11<sup>+</sup> years.
- TOAST using CrIS and SBUV2, as a new version has been in operation and will be shifted to use CrIS + OMPS/NP mode whenever OMPS advances to its validated maturity.
- TOAST using CrIS and OMPS Limb preliminary total column analysis shows promising results.
- TOAST (CrIS+Limb) further work will be on detailed layer analysis by introducing retrieval averaging kernel.

THANKS