TOAST versions, improvements and validation

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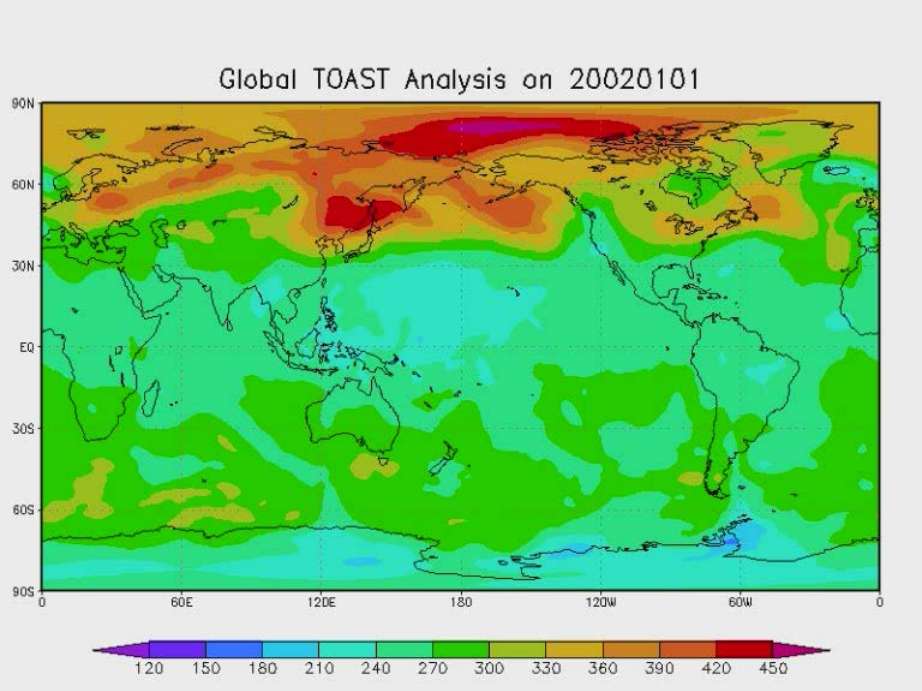
TOAST : Total Ozone Analysis using SBUV/2 and TOVS

- purpose: combining IR ozone at lower atmosphere with the UV ozone at higher atmosphere to derive a new ozone product better than the product from a single sensor.
- Reason:
  1. UV observations are sensitive to the ozone variations in the upper atmosphere.
  2. IR observations are sensitive to ozone variations in the lower atmosphere

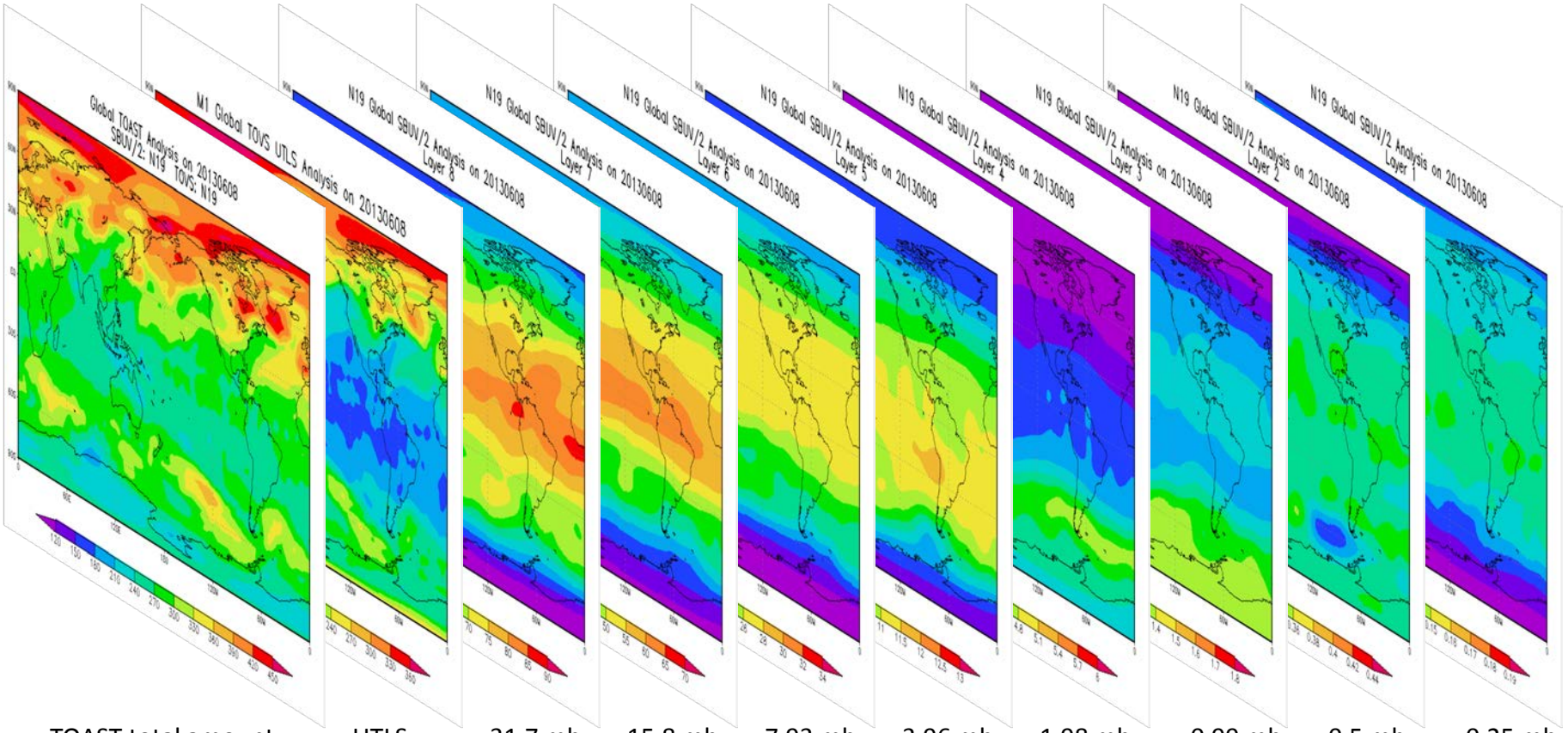
TOAST : Total Ozone Analysis using SBUV/2 and TOVS



2002 2003 2004 2005 2006 2007 2008 2009 2010 2012 2013 2014 ....

- Started from 01/01/2002 and has accumulated 11^{+} years data.
- Provide global $1^{\circ} \times 1^{\circ}$ total O_3
- Provide global $1^{\circ} \times 1^{\circ}$ for eight Umkehr layer O_3 at 31.7, 15.8, 7.93, 3.96, 1.98, 0.99, 0.50, 0.25 mb.

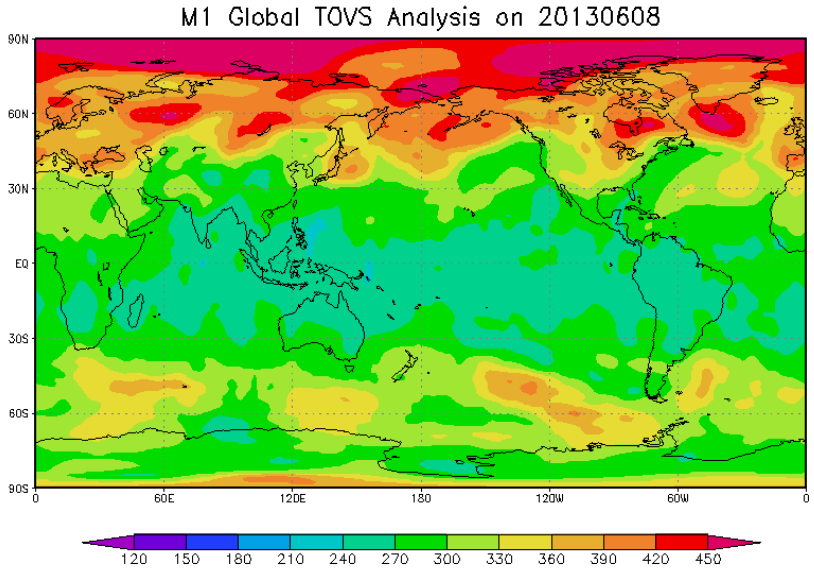
Composition of TOAST total ozone product

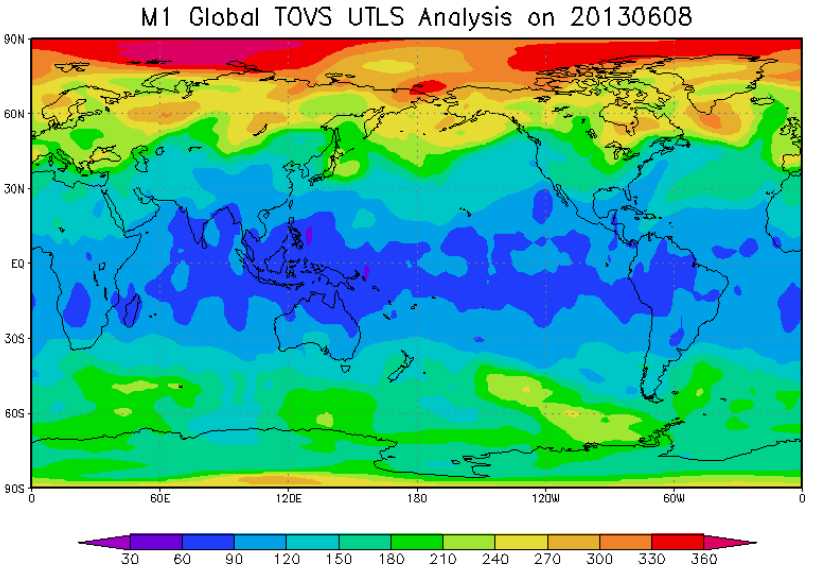


TOAST total amount | UTLS | 31.7 mb | 15.8 mb | 7.93 mb | 3.96 mb | 1.98 mb | 0.99 mb | 0.5 mb | 0.25 mb

TOAST = ***TOVS*** ***+*** ***SBUV-2***

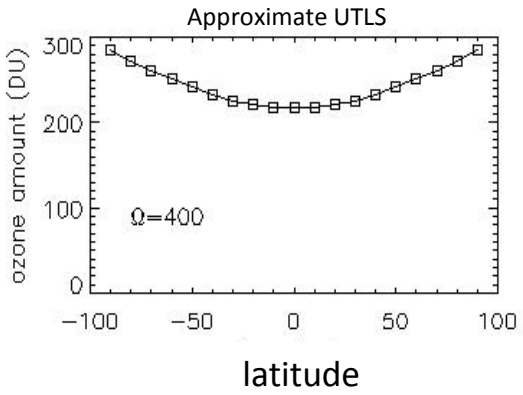
TOAST UTLS: upper troposphere lower stratosphere O_3





$$UTLS = [0.85 + 0.05 \times (0.9 + 1.1 \times \cos\theta)] \times \Omega - 81.6 \times (0.9 + 1.1 \times \cos\theta)$$

θ : Latitude; Ω : total amount of ozone



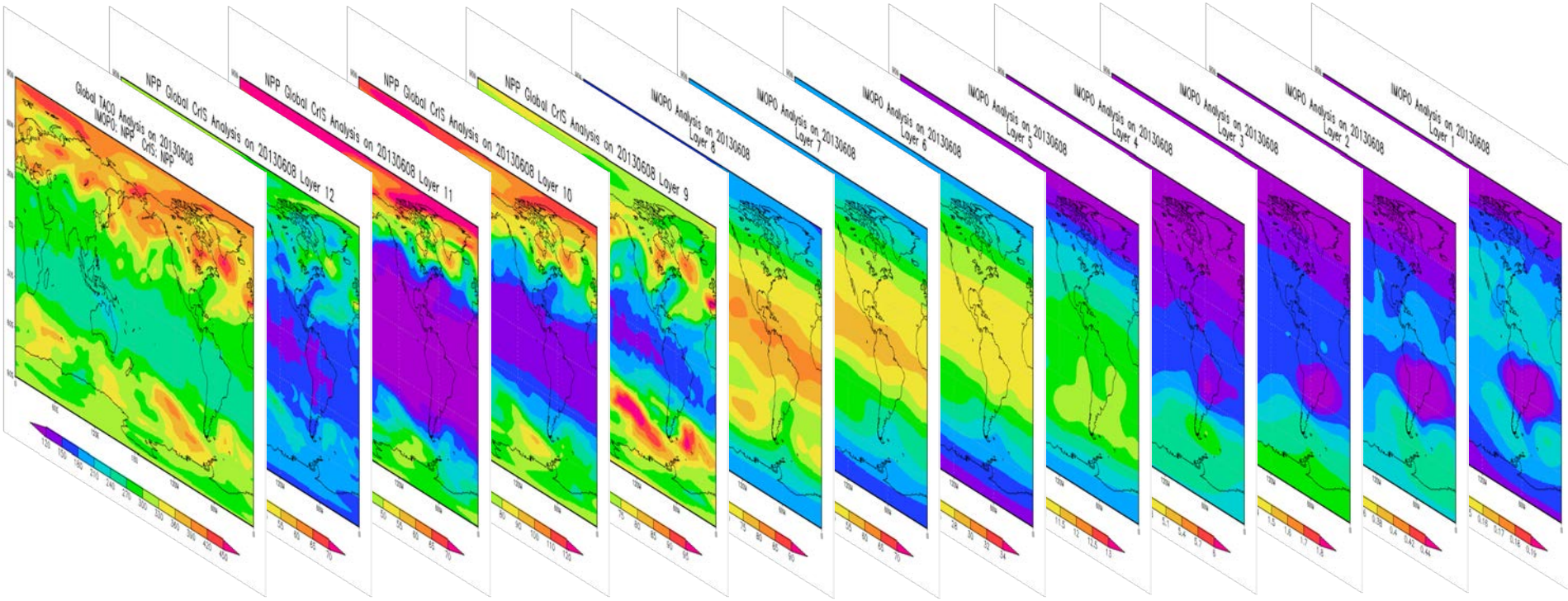
TOAST data sources

	SBUV/2	TOVS/HIRS
Jan. 1, 2002	N16	N16
Dec. 16, 2006	N16, N17	N16
Dec. 4, 2007	N16, N17	M2 (MetOp-A)
July 30, 2008	N16, N17, N18	M2 (MetOp-A)
Oct. 20, 2008	N17, N18	M2 (MetOp-A)
Dec. 19, 2012	N17, N18, N19	M2 (MetOp-A)
Feb. 5, 2013	N17, N19	M2 (MetOp-A)
Apr. 11, 2013	N19	M2 (MetOp-A)
Apr. 22, 2013	N19	M1 (MetOp-B)
Now in test running	N19	CrIS
After OMPS validated	OMPS/NP	CrIS

TACO: a new version of the TOAST

- ***TACO***: **T**otal ozone **A**nalysis of **C**rIS and **O**MPS
- Provide global 1˚ × 1˚ total O_3
- Provide global 1˚ × 1˚ 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 NP (or SBUV/2) observation
- Provide global 1˚ × 1˚ O_3 maps of four Umkehr layers at 1013, 253, 127, 63.3 mb derived from CrIS NUCAPS product.

Composition of TACO total ozone product



TACO total amount	1013	253	127	63.3	31.7	15.8	7.93	3.96	1.98	0.99	0.5	0.25 mb

TACO = CrIS + OMPS or SBUV-2

TACO objective analysis

- **Basic consideration:**
  IR measurement is sensitive to the ozone variation in the lower atmosphere and UV is sensitive to the ozone variation in the upper atmosphere.
- **Basic procedures:**
  1. convert CrIS O_3 pressure scale into OMPS Umkehr scale.
  2. coordinate transform from geographic into stereographic.
  3. improve an initial ozone distribution by incorporating the currently available satellite measurements.
  4. analyzed global ozone data are transformed back to the geographic coordinate with 1˚× 1˚ resolution.

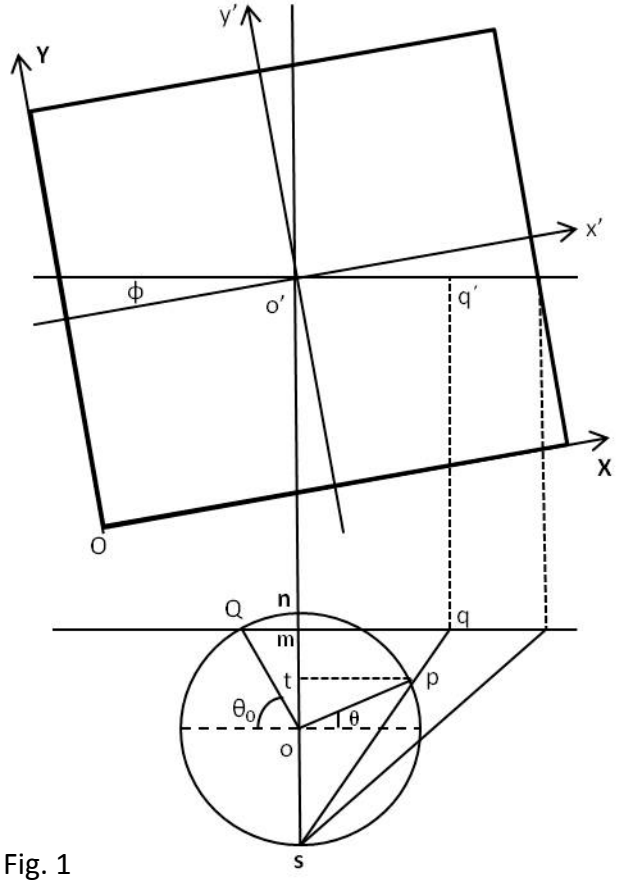


Fig. 1

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

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

mesh=24,384/(N-1) km, θ_0=60˚; N is mesh grid number;
For CrIS N=245; for OMPS N=65

Fig 1. coordinate transformation from geographic to Stereographic.

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

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

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, W is a weighting factor.

Fig. 2

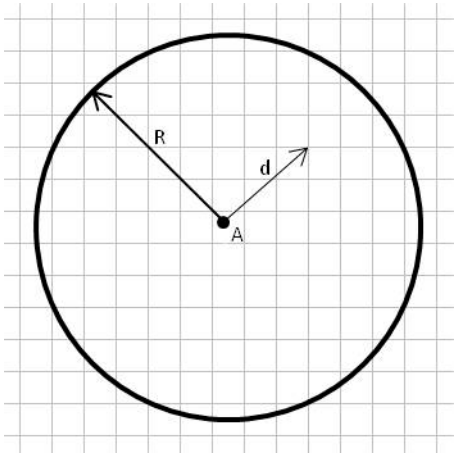
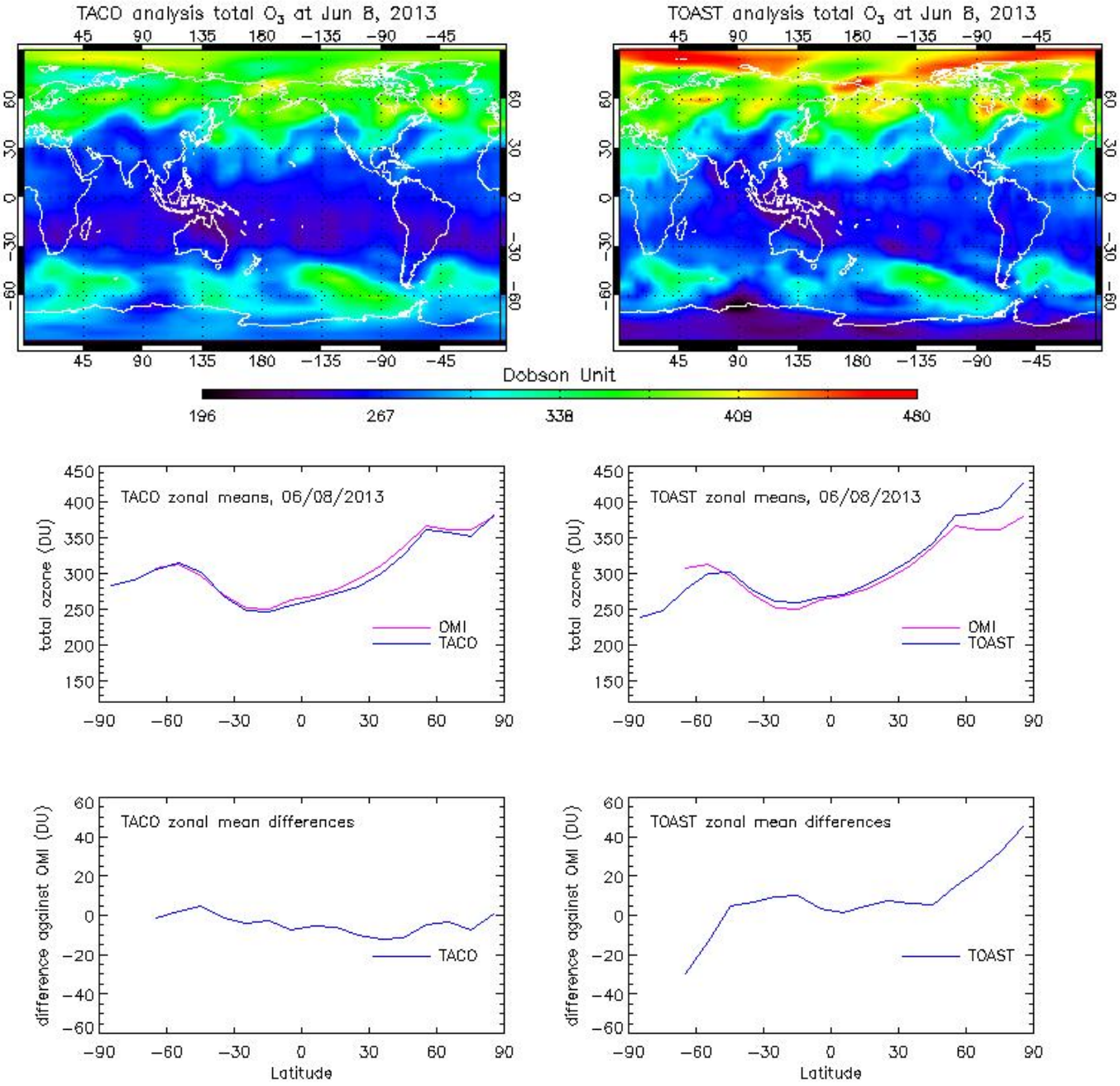
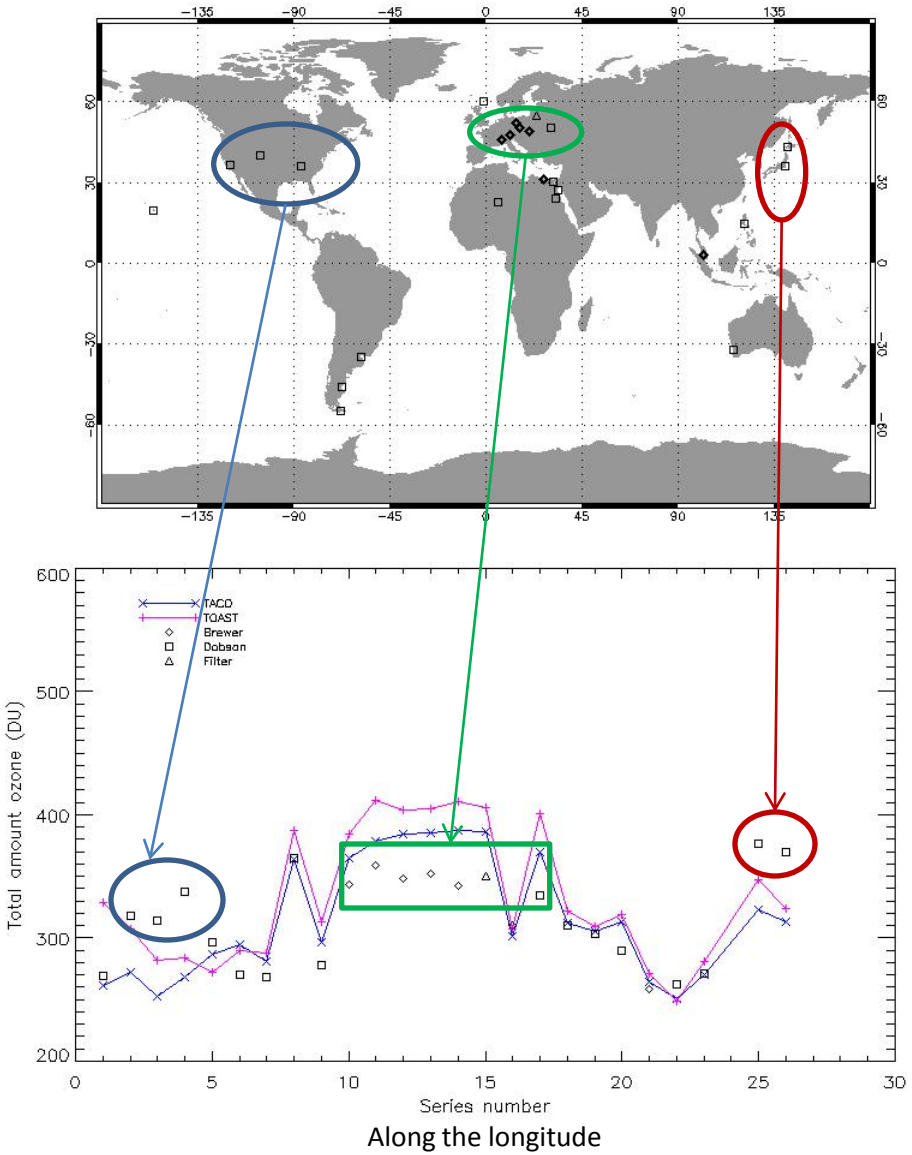


Fig 2. scheme of objective analysis


TACO analysis total O3 at Jun 8, 2013
TOAST analysis total O3 at Jun 8, 2013
Dobson Unit
196
267
338
409
480
TACO zonal means, 06/08/2013
TOAST zonal means, 06/08/2013
total ozone (DU)
OMI
TACO
TOAST
TACO zonal mean differences
TOAST zonal mean differences
difference against OMI (DU)
Latitude

Comparison with ground based station on June 8, 2013



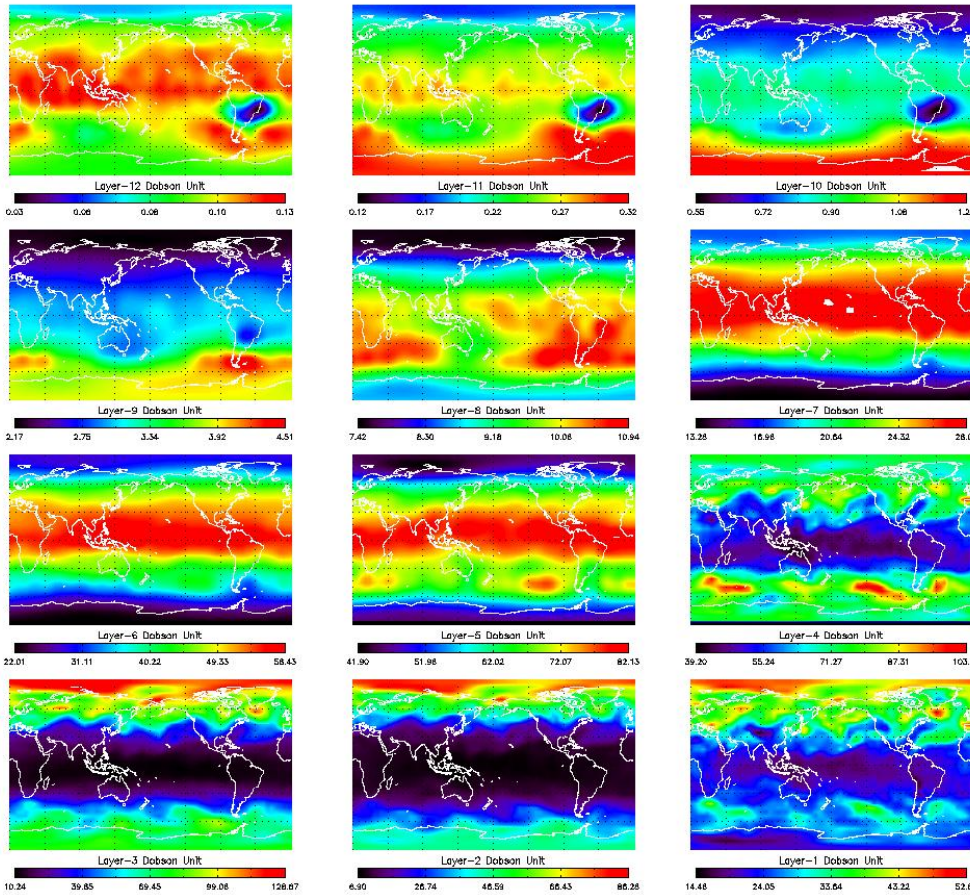
1. Differences of TACO relative to the ground station are mostly less than 10% , and have only 4 locations larger than 15%.

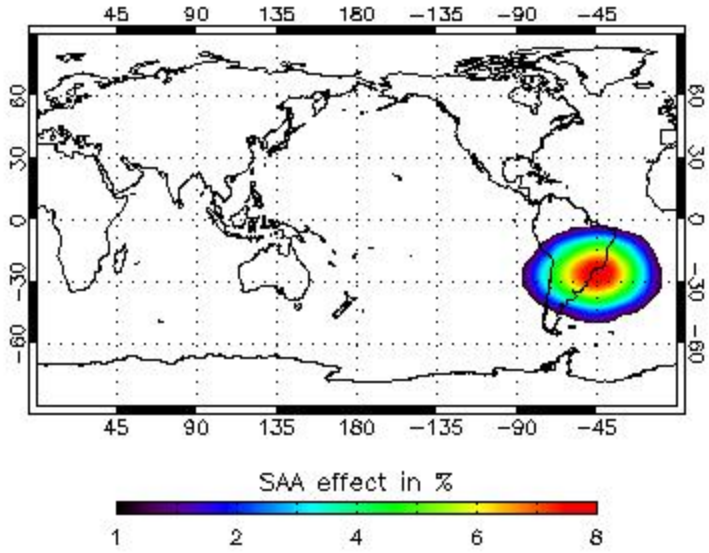
2. The average difference is 7.8%

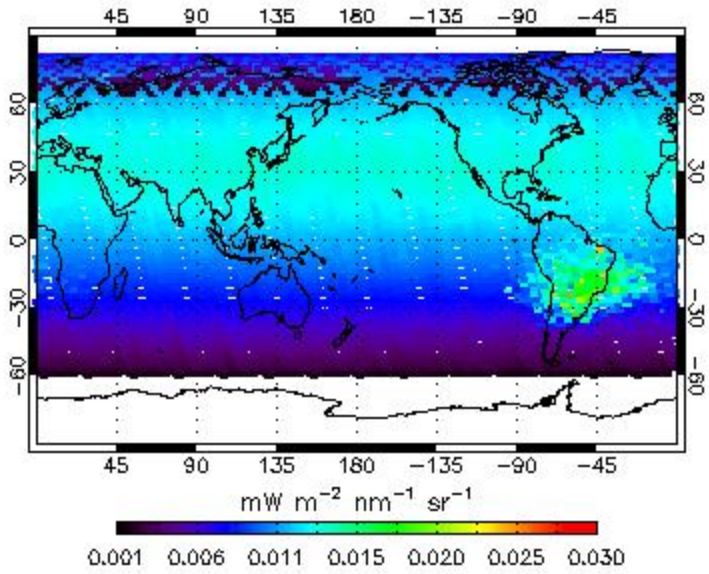
Total ozone and validation

- TACO and TOAST give similar O_3 global pattern.
- TACO zonal mean are similar to OMI's
- TACO gives improve estimates for the high latitude regions in both southern and northern hemisphere.
- TACO replaced approximate estimation of UTLS ozone by using CrIS layer products

12 layers TACO analysis on June 8, 2013

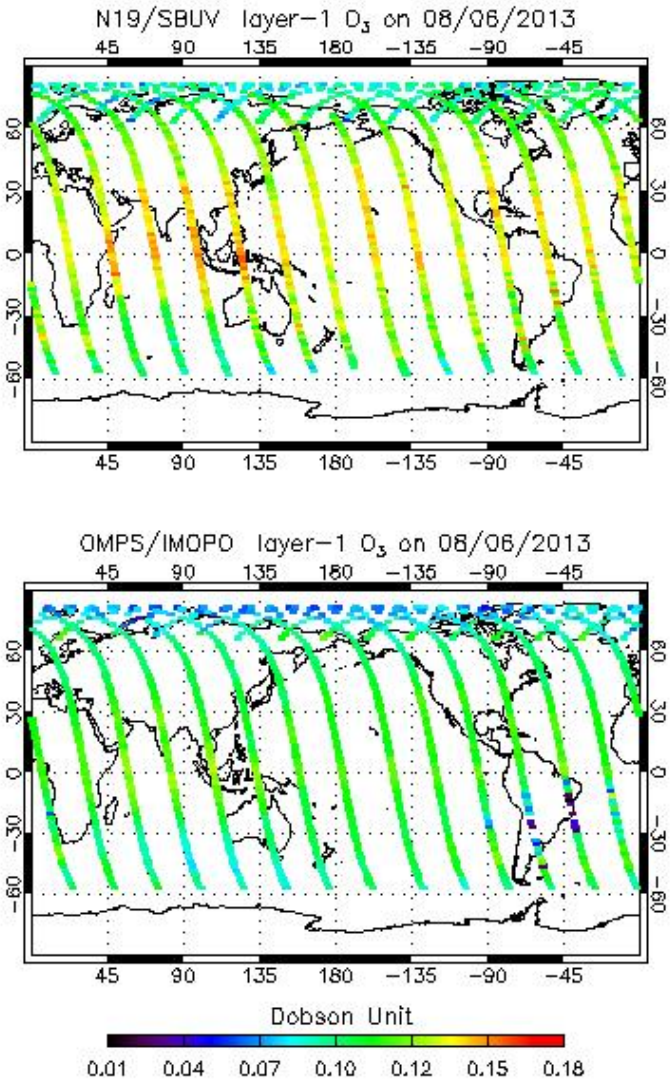






South **A**tlantic **A**nomaly

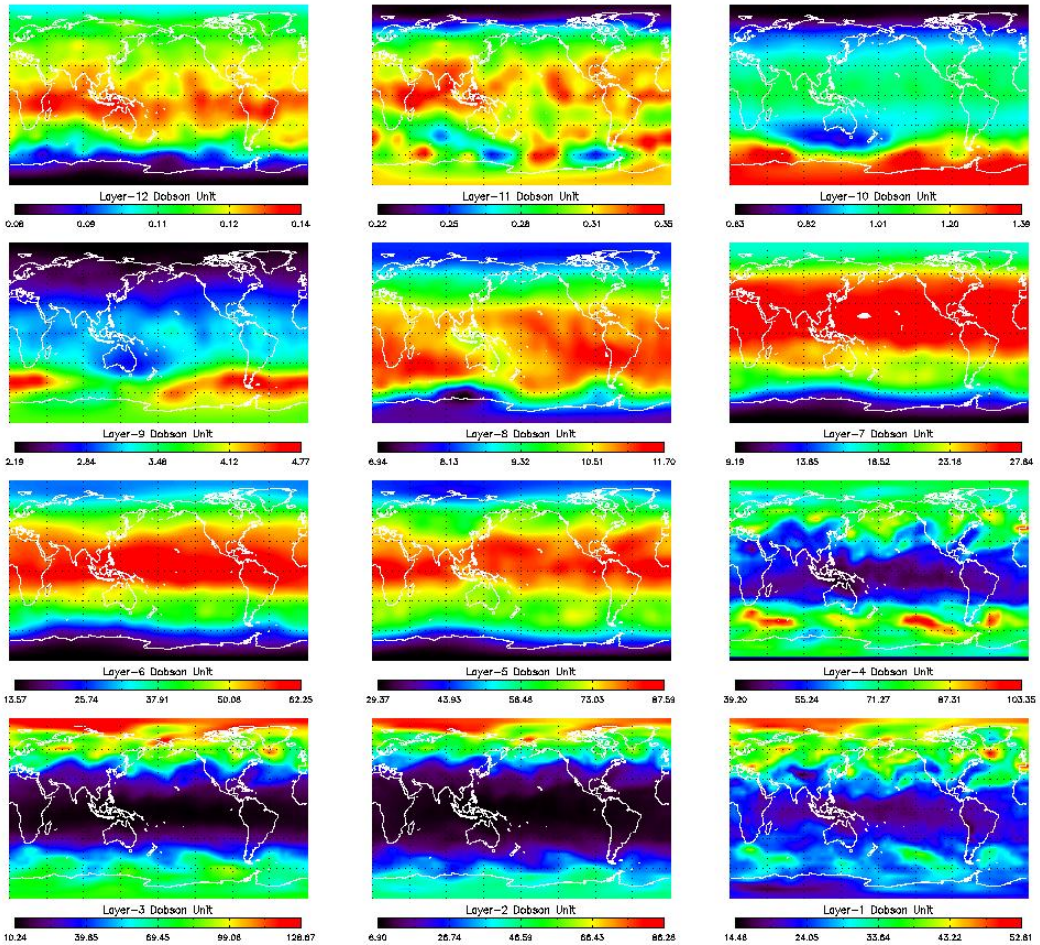
Current OMPS/NP retrievals are systematic lower than SBUV/2



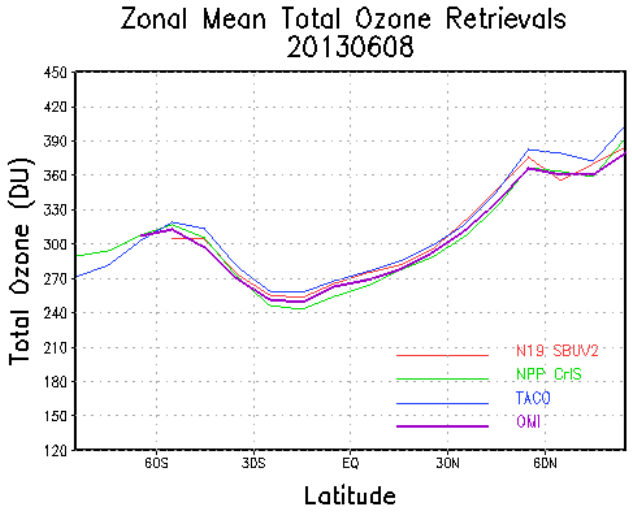
- TACO provide 12 layer ozone maps.
- Current NP retrieval values are systematic lower than SBUV/2 at higher layers
- This can be corrected by soft calibration.
- SAA effect has not been eliminated.
- Elimination of SAA effects are expected on the future hardware improvement.

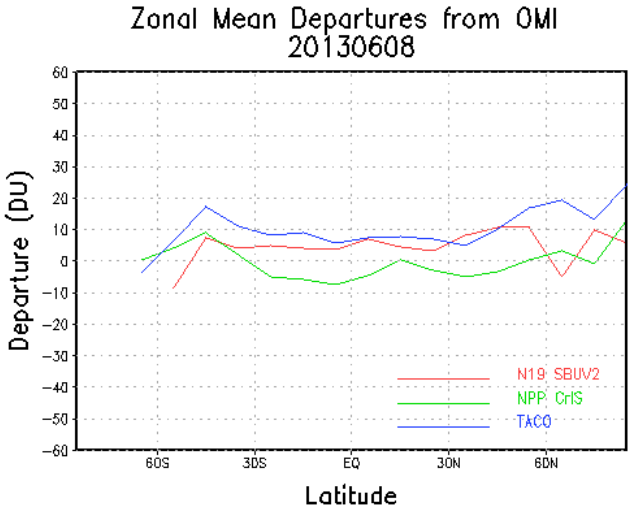
TACO intermediate version: SBUV/2 + CrIS

SBUV/2 + CrIS



Comparison with OMI





Conclusion

- TOAST has provided global one by one degree total ozone product for 11^{+} years.
- TACO, as a new version, will continue the contribution by using new IR and UV instruments.
- New CrIS sensor provide better estimation of the tropospheric and lower stratospheric ozone values.
- Prior to the OMPS nadir profiler advancing to validated maturity, TACO will be created from (SBUV/2 + CrIS) intermediate version by OSPO.

Future work:

- More validation work are expected.
- We planed to replace OMPS SAA ozone values by a zonal mean average.
- It is possible to run TACO algorithm in near real time manner combining the real time OMPS and CrIS profile orbitally to create products with less latency.
- We are investigating using the OMPS profile analysis fields as CrIS a priori profiles for NUCAPS retrieval. This may improve the CrIS retrieval accuracy in upper layers.
- There is a proposed project in NASA to create retrievals using the OMPS and CrIS measurements together as have been developed for use with OMI and TES.

THANKS