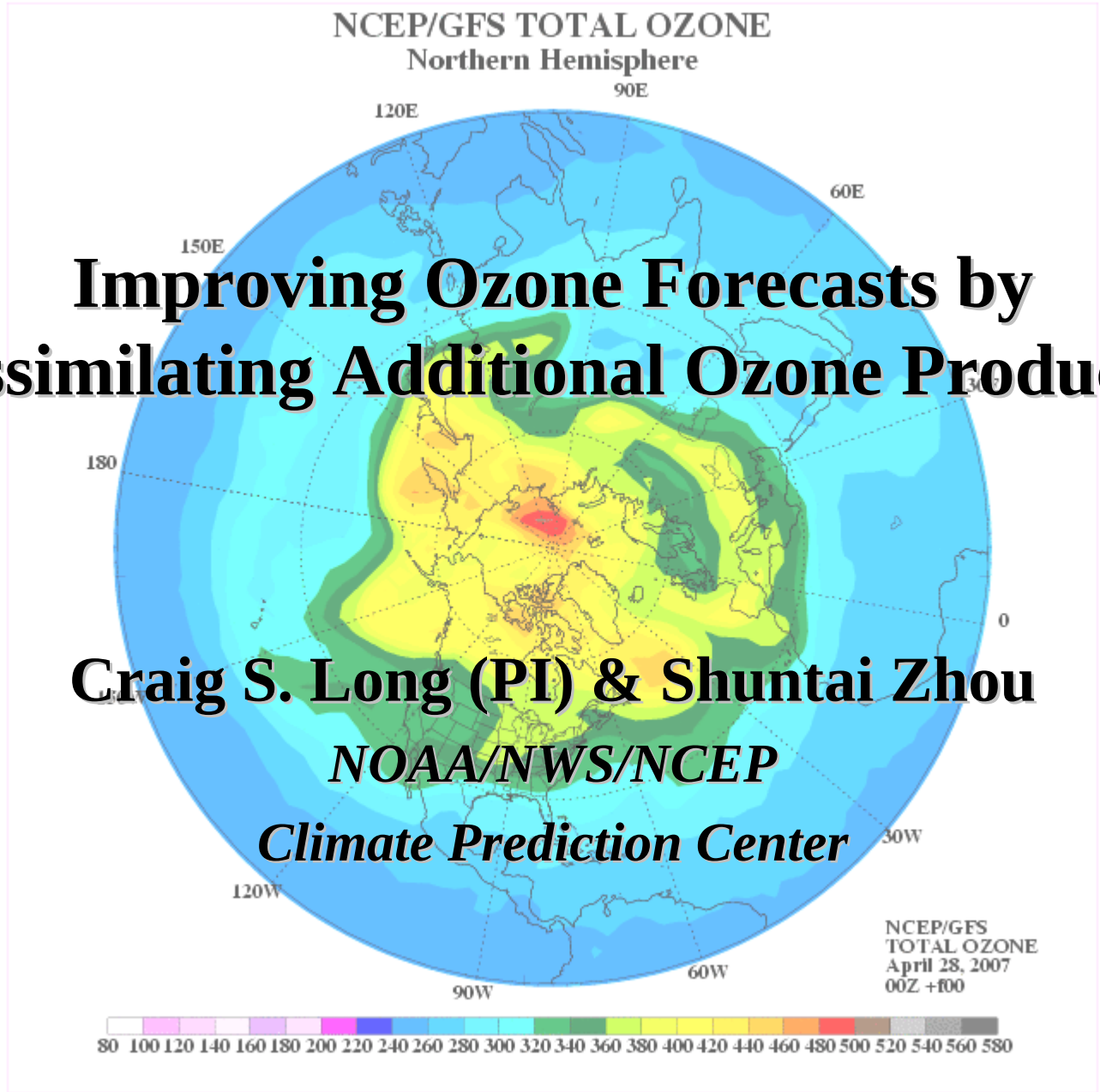

Improving Ozone Forecasts by Assimilating Additional Ozone Products

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NOAA/NWS/NCEP

Climate Prediction Center

Accomplishments

- Implementation of NRL ozone chemistry module into GFS.
- Validated that GSI and SSI give similar analyses wrt ozone.
- Modify GSI code to accept different ozone profile products.
- Access differences between OMI TOMS and DOAS total ozone products.
  - OMI DOAS will be made available as a NRT product.
- Test thinning technique to reduce amount of OMI data used.
  - Without impacting analysis.
- Performed 1 month T62 run assimilating OMI TOMS and a separate 1 month run assimilating OMI DOAS total ozone followed by doing the same at T126.
  - No negative impacts to GFS forecast skill (AC 500 and 1000 hPa).
  - Slight improvement at higher wave numbers in winter hemisphere.

Accomplishments – cont.

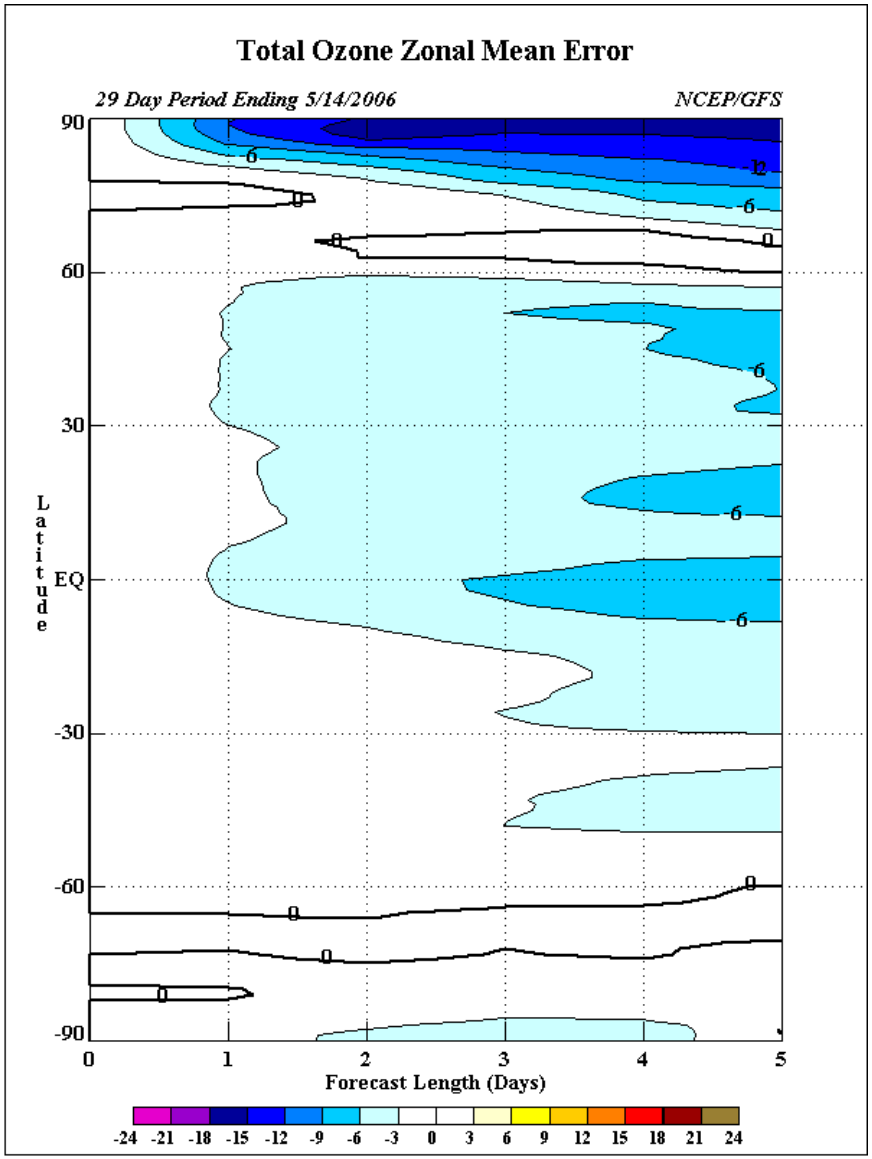
- Performed 10 day T382 test assimilating OMI TOMS to study impact upon ozone hole size forecasts.
  - Improved days 3,4,5 forecasts of ozone hole size.
- Performed tests assimilating ozone profile data from:
  - OMI (NESDIS profile version)
  - MLS
  - HIRDLS
- Performing tests comparing SBUV/2 v8 total and profile products vs operational v6 products.
  - v8 products available operationally from NESDIS now.
  - Addition of NOAA-18 v8 data.
  - NESDIS has calibrated N16, 17 & 18 to produce similar v8 profiles.
  - v6 products will be discontinued in Fall 2007.

Implementation of NRL Ozone Chemistry Module

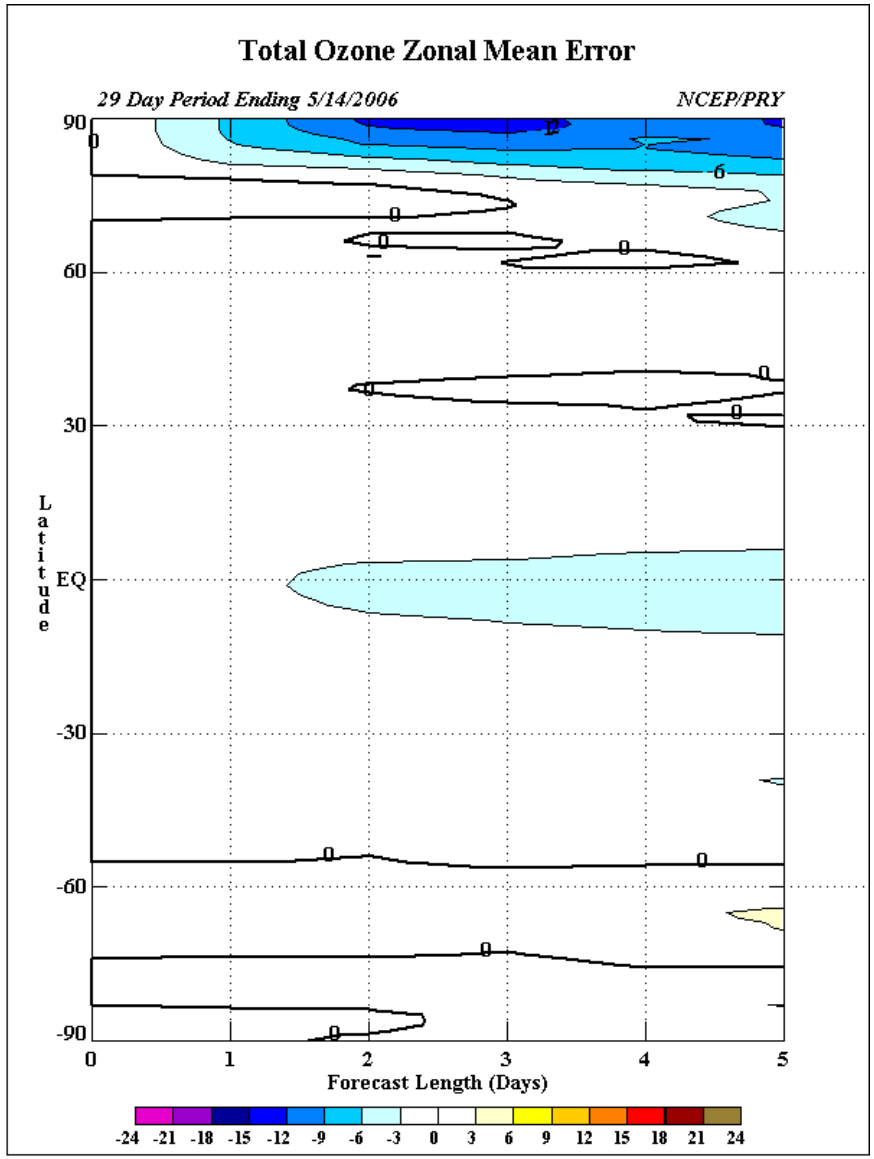
- NRL module corrects GFS tendency to lose ozone in tropics and in polar areas
- Helps GFS produce better ozone forecasts further into forecast cycle.

$$\frac{df}{dt} = (P-L)^{o} + \left.\frac{\partial(P-L)}{\partial f}\right|_{0}(f-f^{o}) + \left.\frac{\partial(P-L)}{\partial T}\right|_{0}(T-T^{o}) + \left.\frac{\partial(P-L)}{\partial c_{O_3}}\right|_{0}(c-c^{o}_{O_3})$$

GFS



GFS w/NRL Chemistry

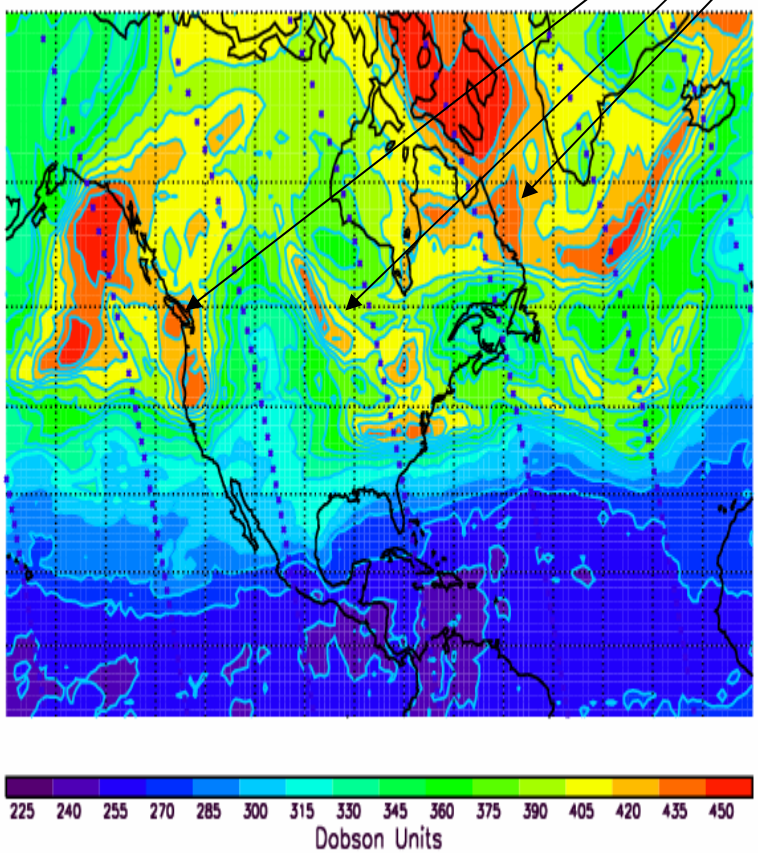


Assimilating Additional Total Ozone Products

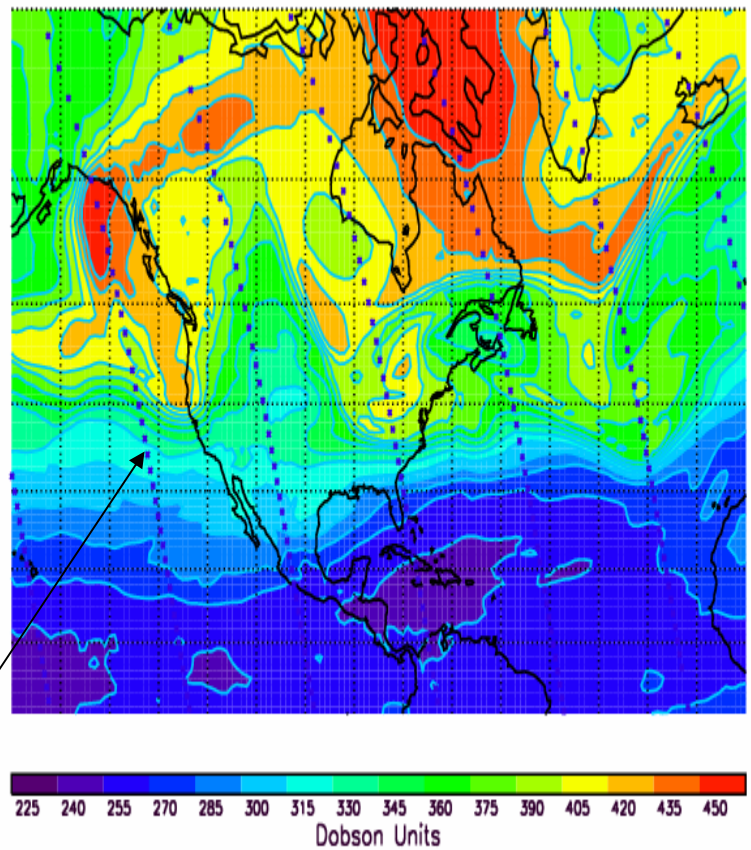
Comparison of NCEP ozone analyses in North America

OMI provides greater detail in between SBUV/2 nadir obs

OMI TOZ



GFS (SBUV/2)

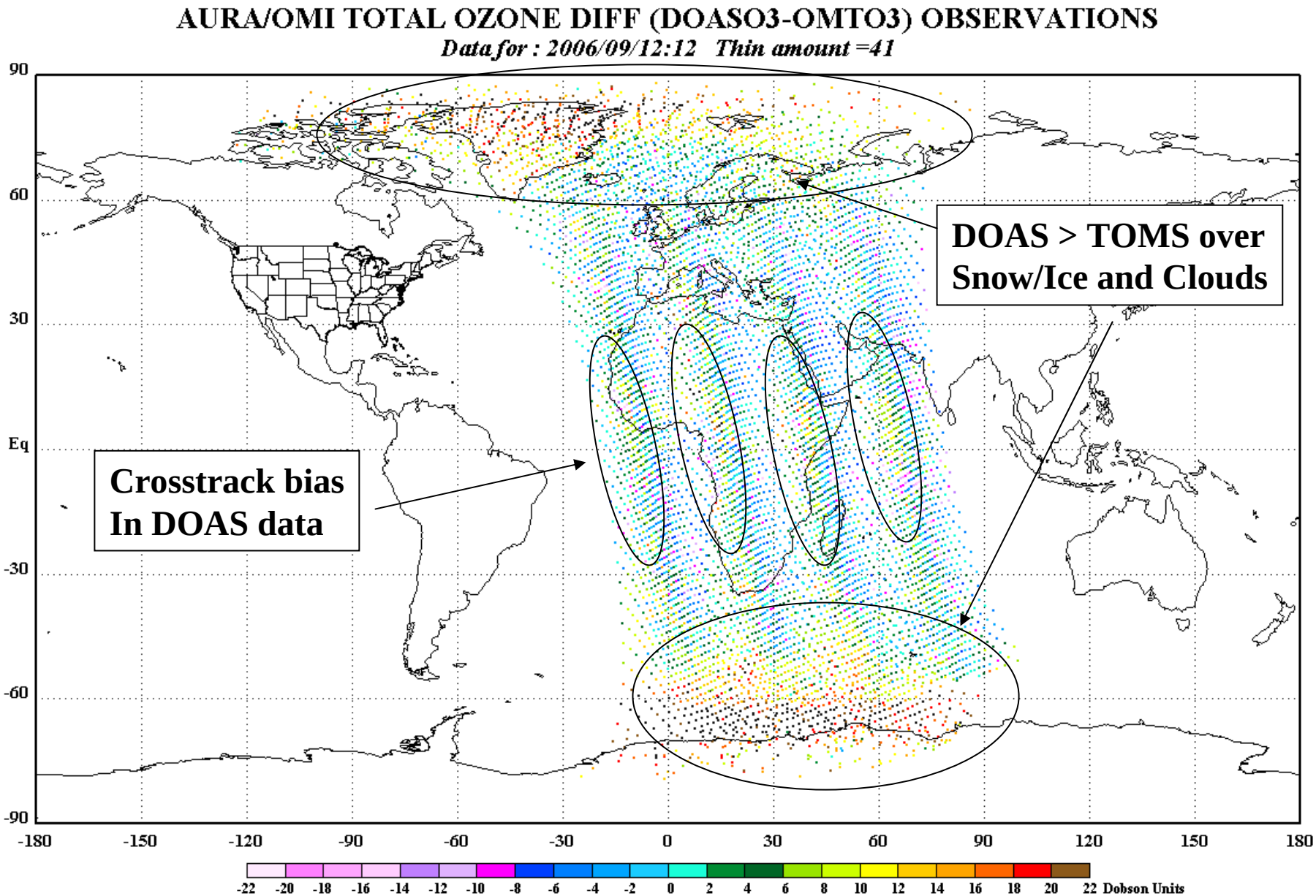


The blue dots indicate SBUV/2 orbital data locations.

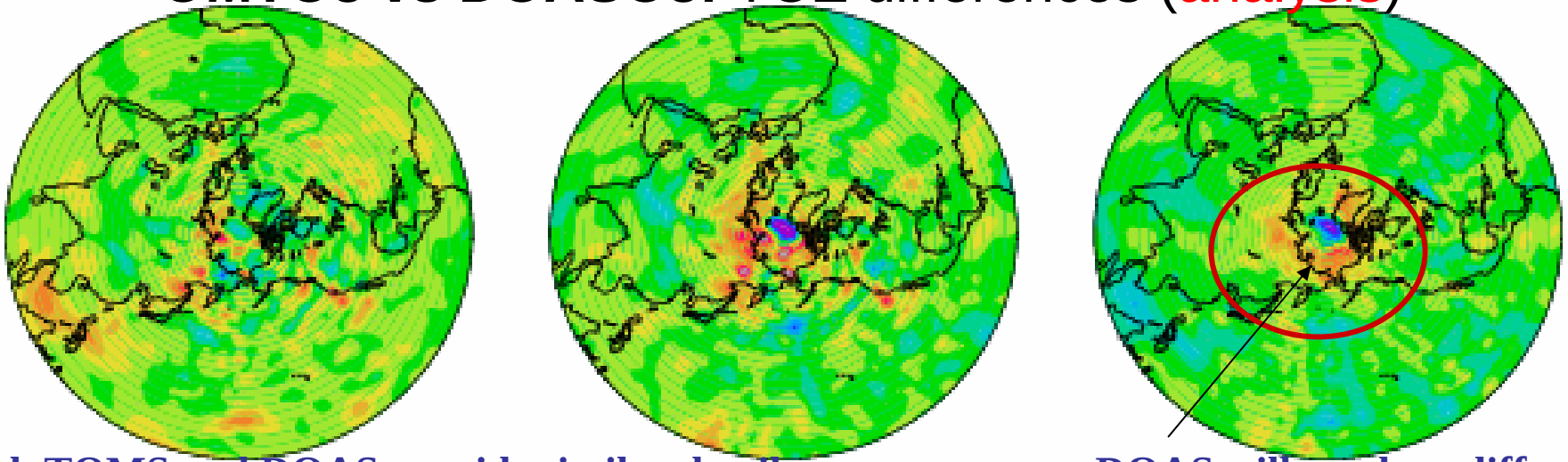
Issues: *OMI TOMS vs DOAS, Thinning*

- Both total ozone products agree in mid-latitudes and tropics.
- Exceptions:
  - Over snow/ice (20+ DU differences)
  - Over clouds (< 10 DU differences)
- Key Points:
  - Agreement with KNMI to have DOAS provided to NCEP in NRT
  - TOMS uses climatological clouds and snow/ice
  - DOAS detects clouds internally and uses latest snow/ice analyses within TO3 algorithm
- OMI provides 60x13 more obs per single SBUV/2 nadir obs
  - Extended latitudinal coverage
- Using 2.5% observation still produces 20 times more obs than SBUV/2
  - Reduction has no impact upon ozone analysis

Differences between OMI TOMS and DOAS Total Ozone values

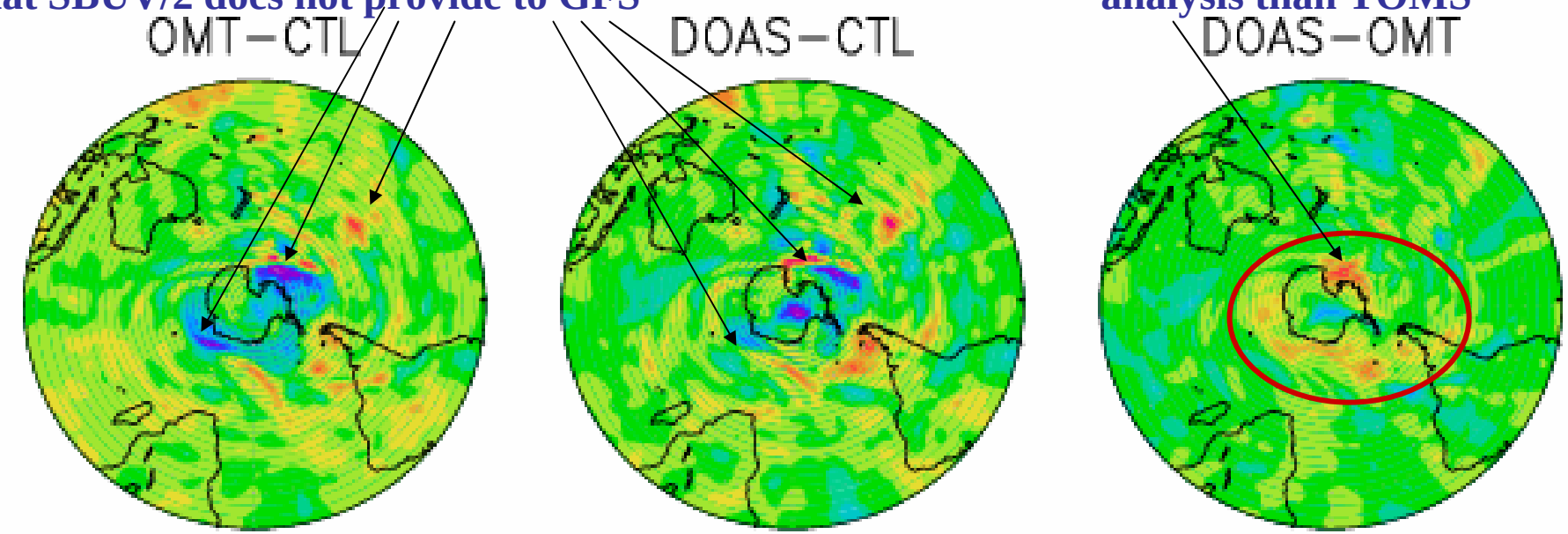


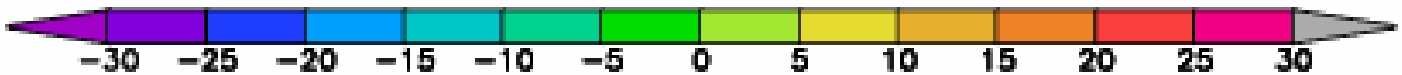
OMTO3 vs DOASO3: TOZ differences (analysis)



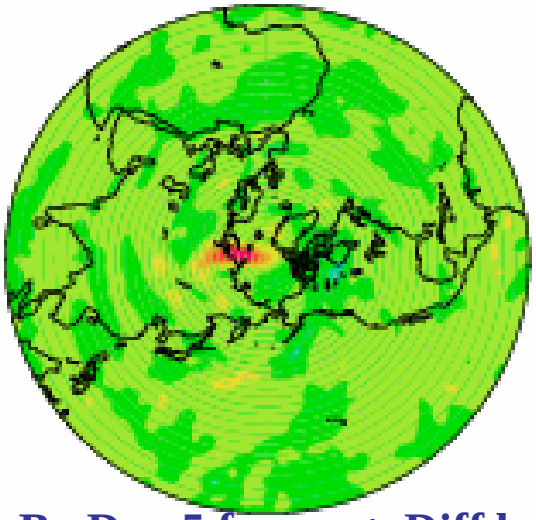
Both TOMS and DOAS provide similar details that SBUV/2 does not provide to GFS

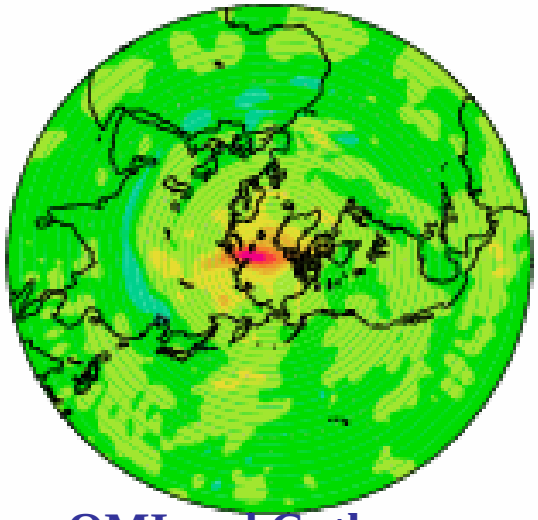
DOAS will produce different analysis than TOMS

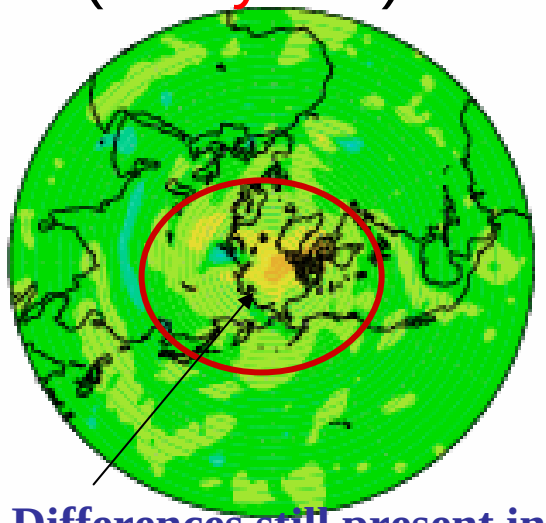




OMTO3 vs DOASO3: TOZ differences (5-day fcst)



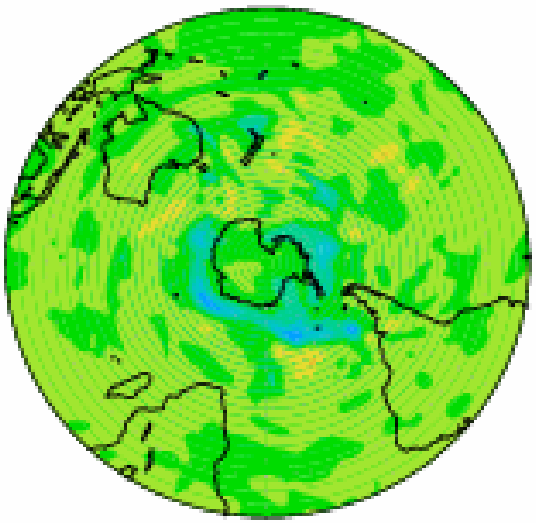




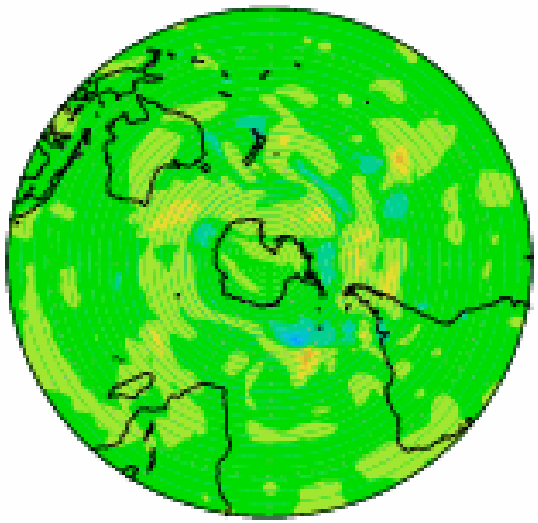
By Day 5 forecast, Diff between OMI and Cntl are minimal in mid-latitudes and tropics.

Differences still present in 5 day forecast

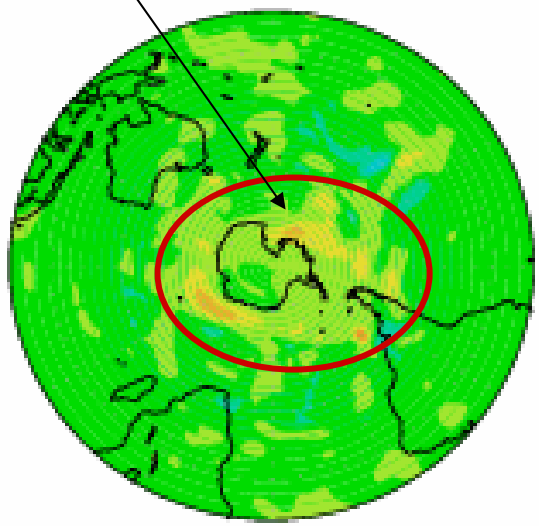
OMT−CTL

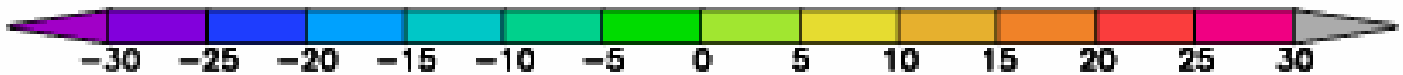


DOAS−CTL

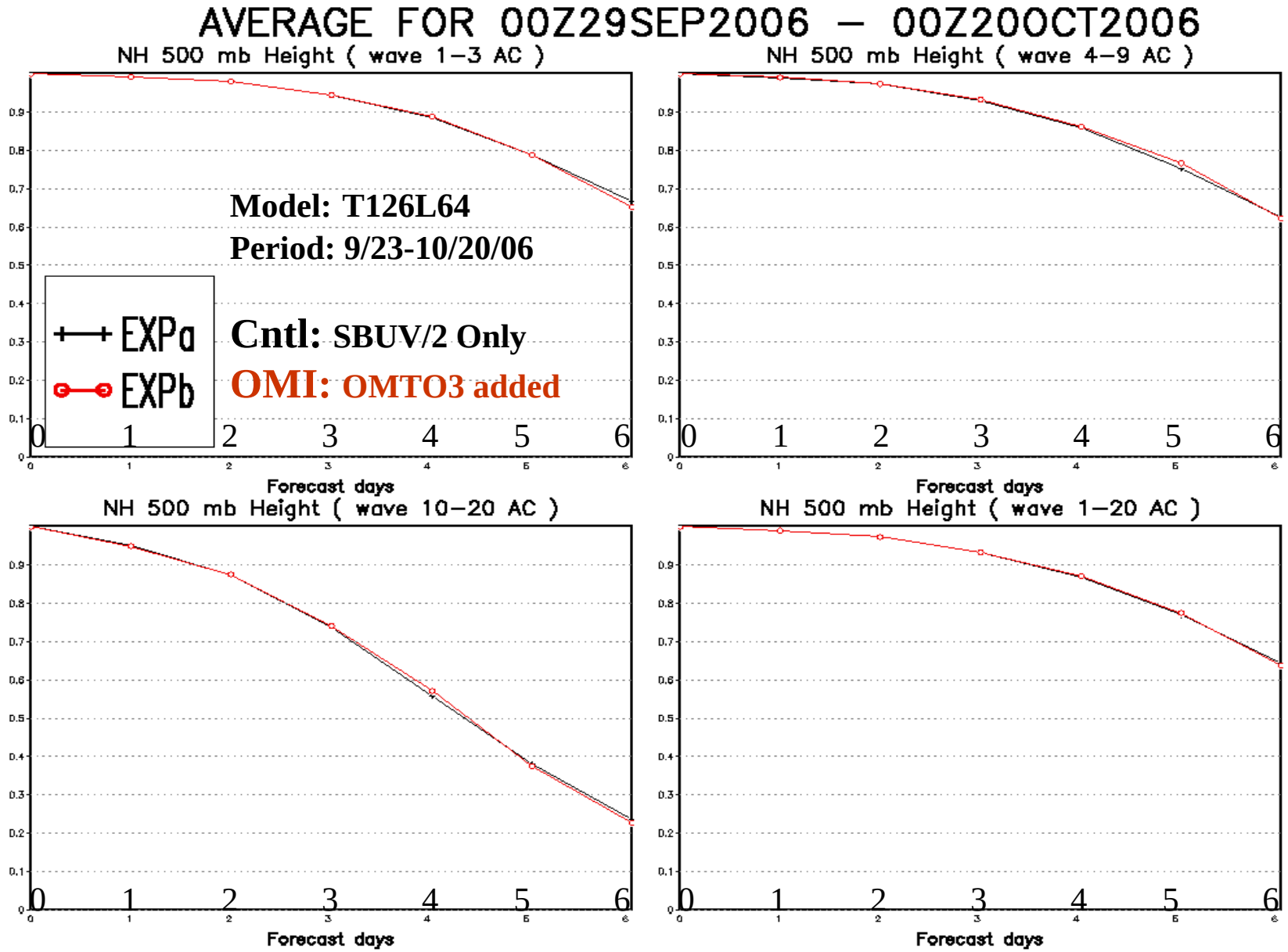


DOAS−OMT

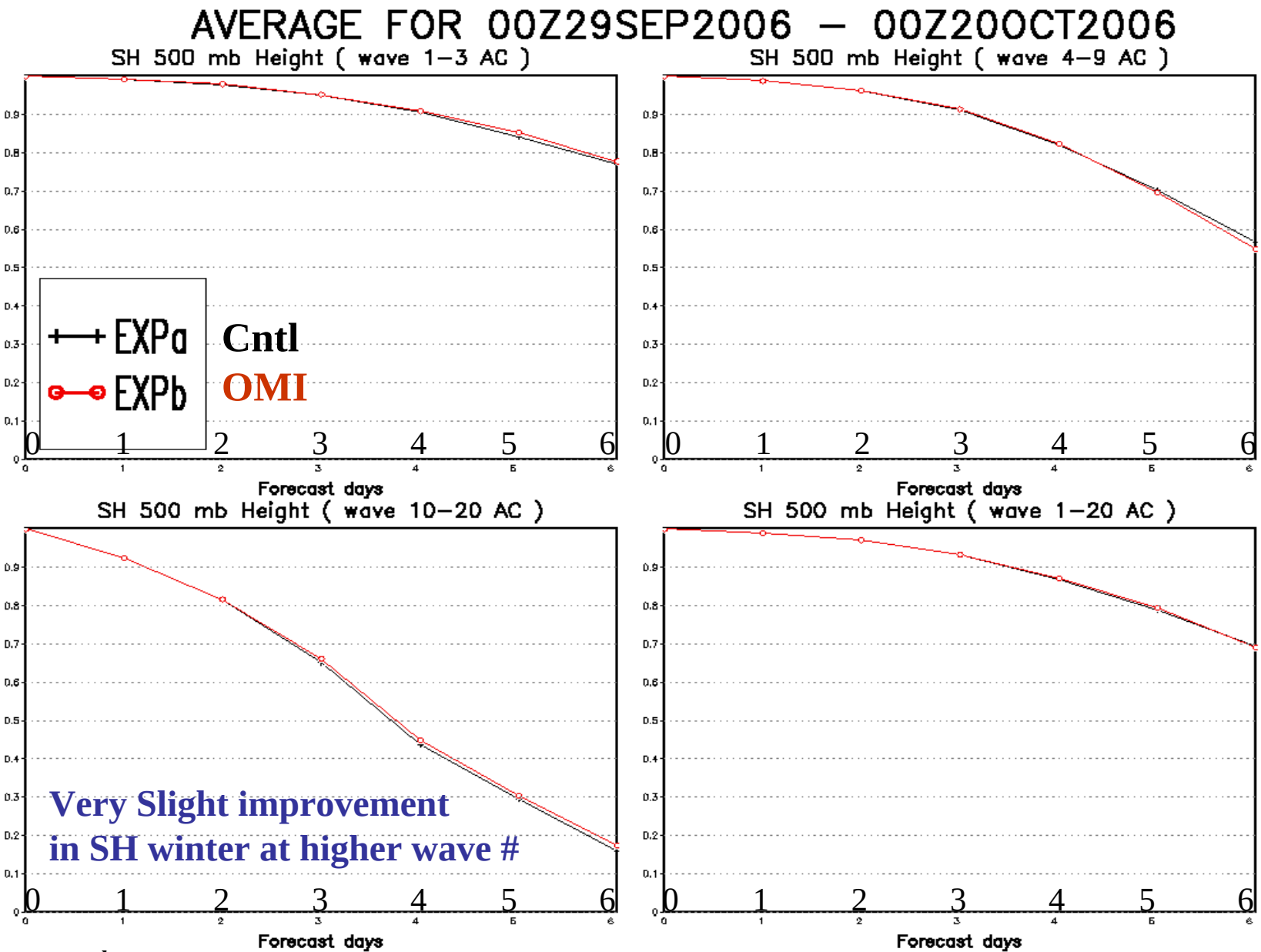




NH 500 hPa height (Z) AC



SH 500 hPa height (Z) AC



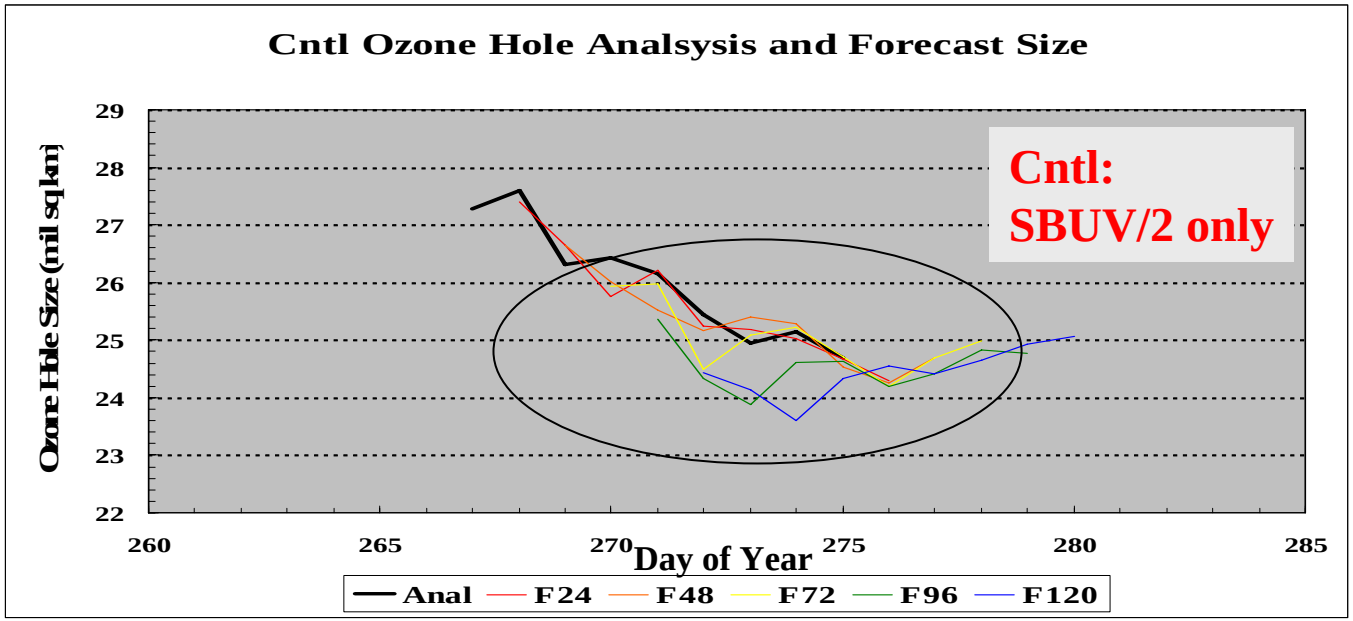
Forecast of the size of the Antarctic ozone hole

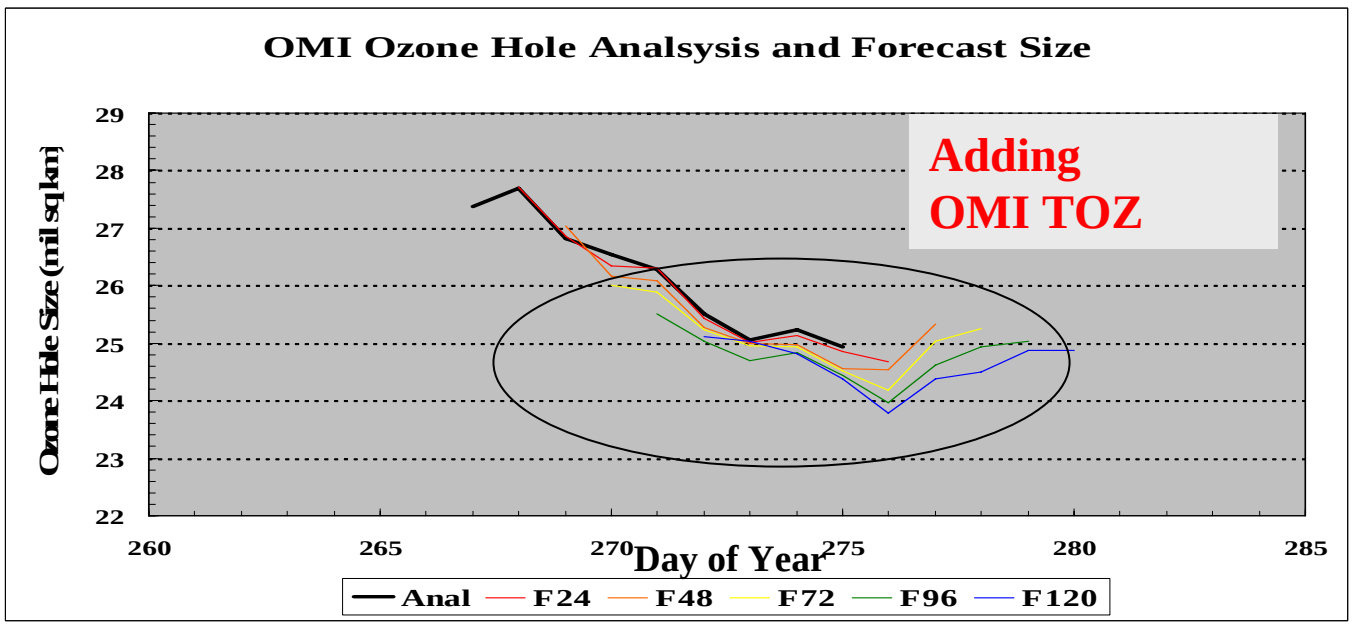
Black: analysis

Color: forecast

Model: T382L64

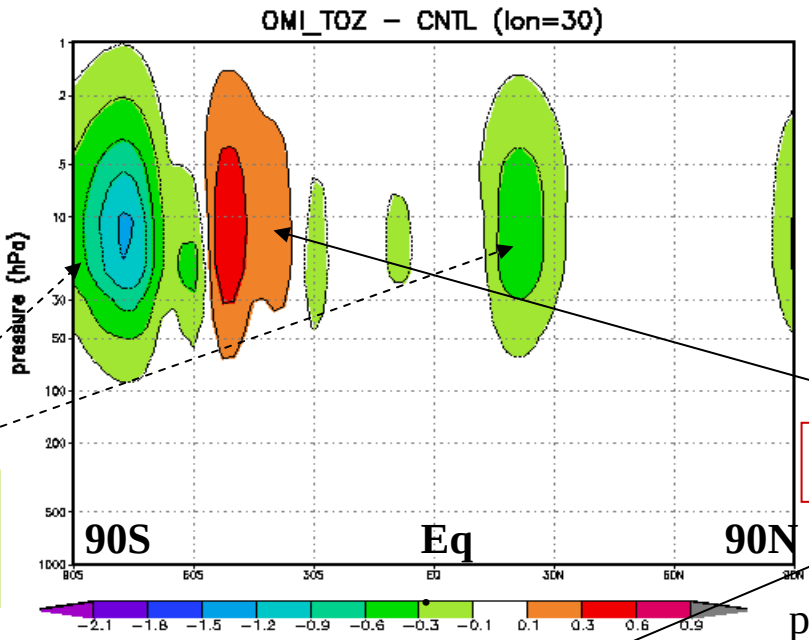
Period: 9/23/06 – 10/2/06 (10 days)





Assimilating Additional Profile Ozone Products

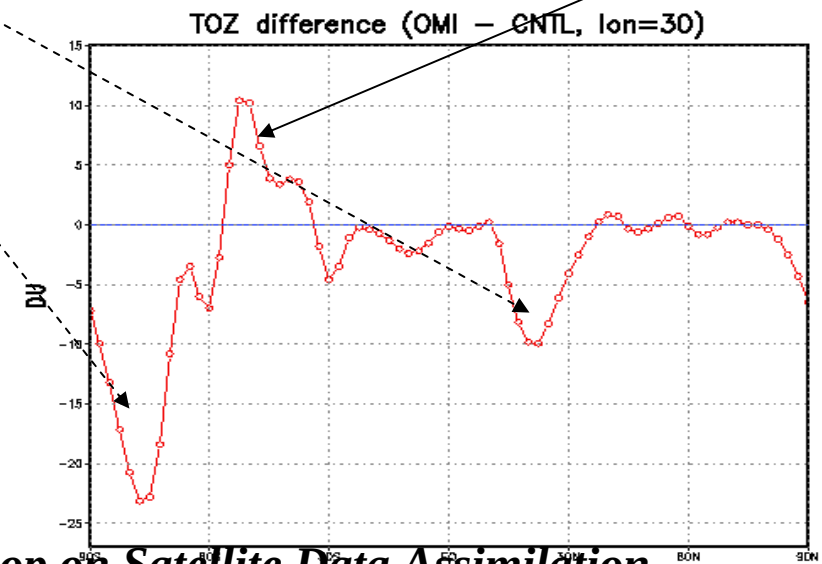
How GSI distributes total ozone changes in vertical profile



O_3 mixing ratio

OMI adds ozone here

OMI decreases ozone here



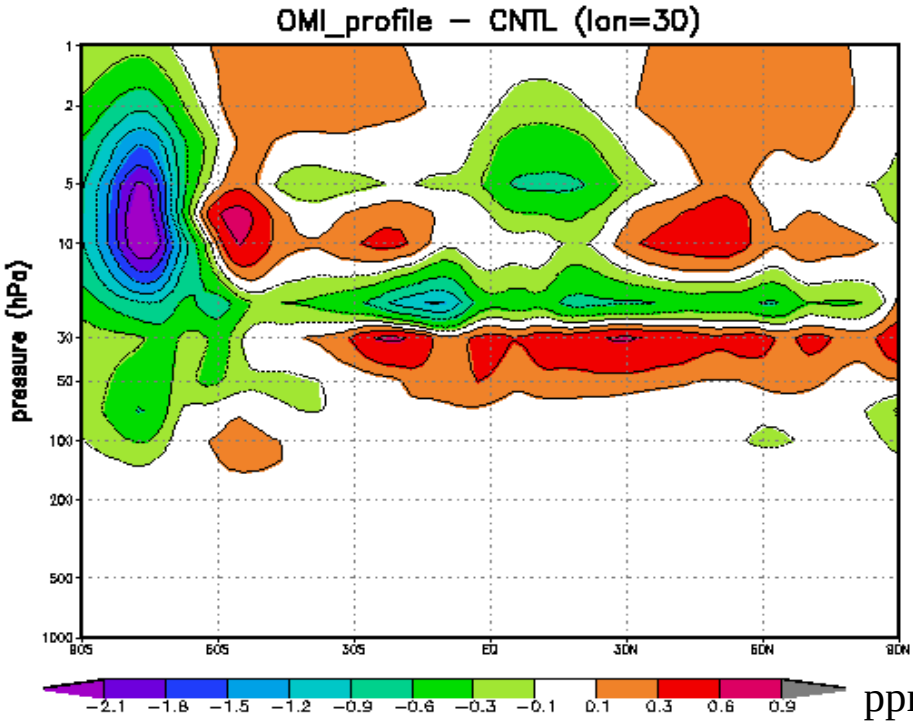
Total column O_3

(2006/09/11/12Z)

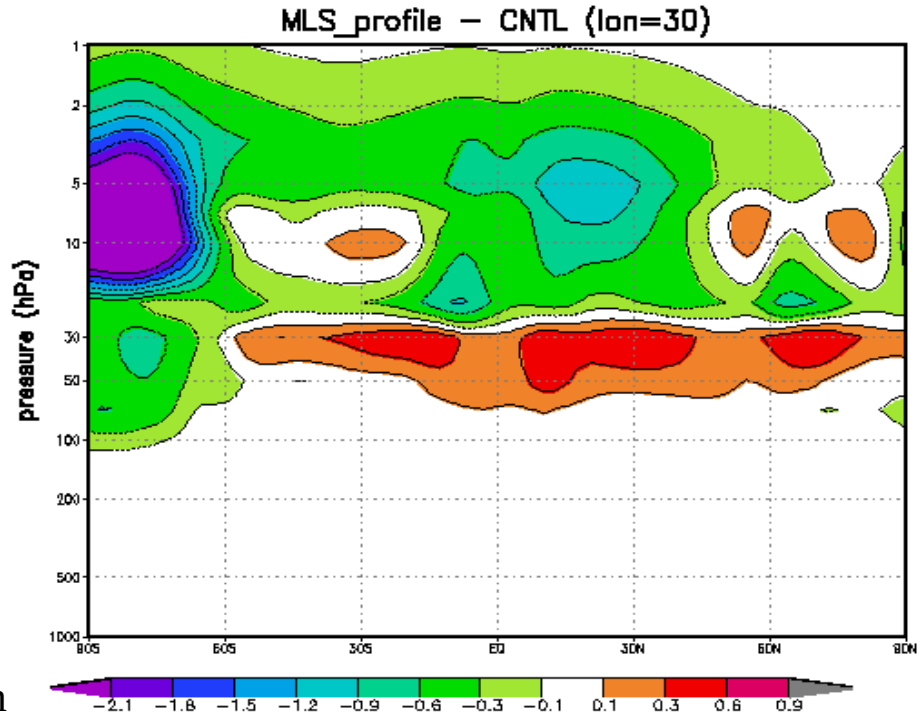
Assimilated ozone mixing ratio differences

OMI and MLS profiles have more ozone in lower stratosphere. Assimilation produces lowering of ozone max below 30 hPa and decrease of ozone above 30 hPa

OMI Profile



MLS



ppm

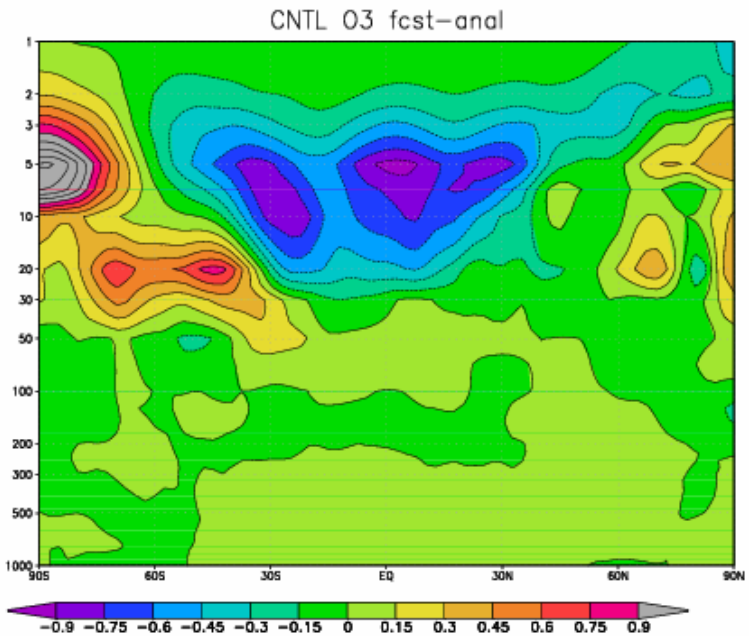
2006/09/11/12Z

MLS has coverage in polar night where as OMI does not.

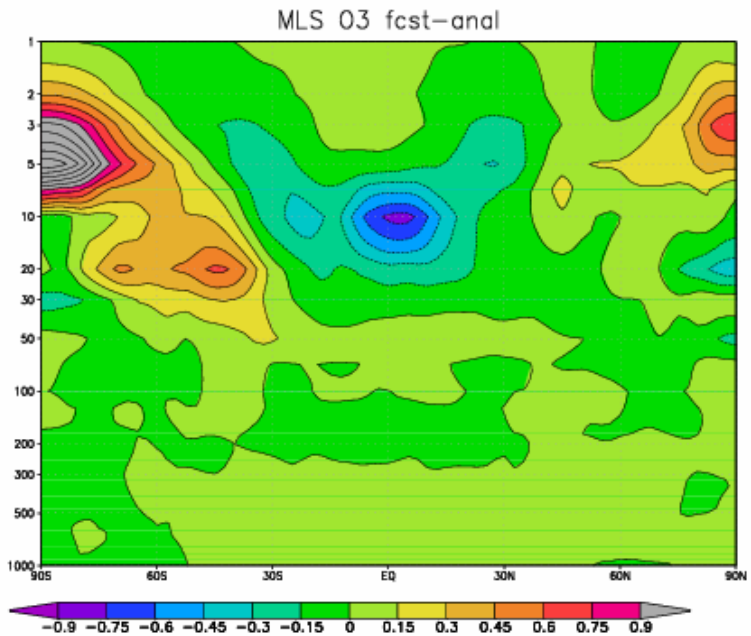
SBUV/2 v8 will produce similar differences from CNTL (SBUV/2 v6) as OMI profile

F-A Differences between CNTL and MLS - 41 day assimilation

CNTL O3 F5-A

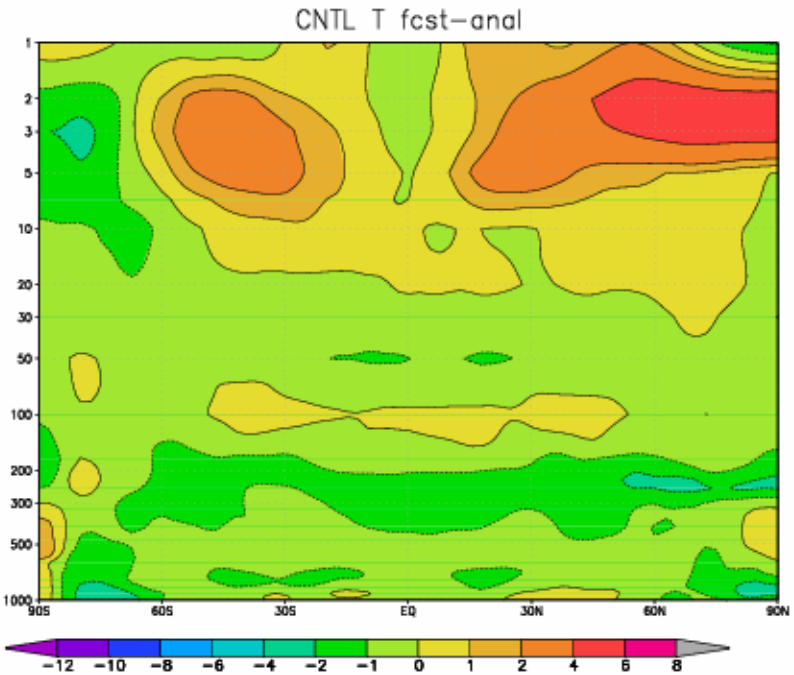


MLS O3 F5-A

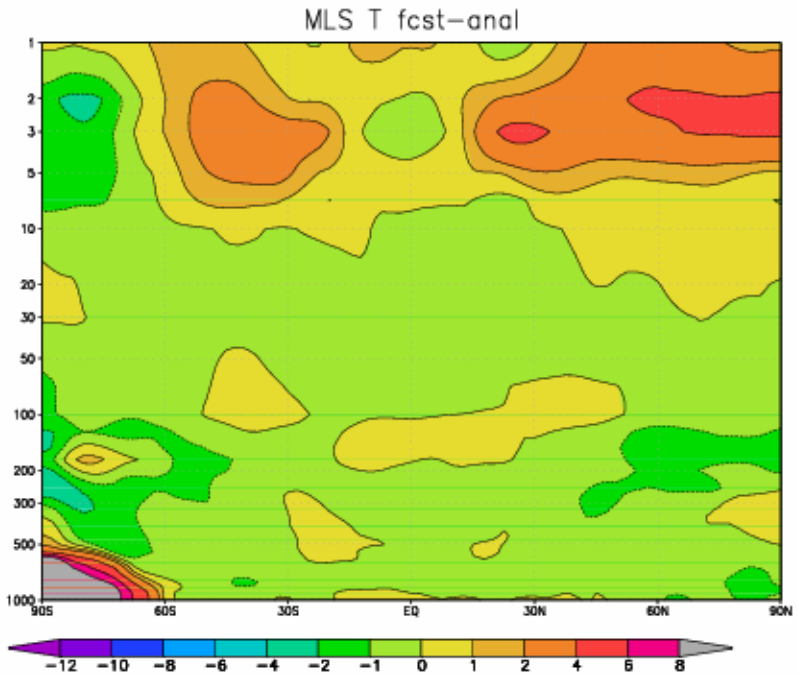


F-A Differences between CNTL and MLS - 41 day assimilation

CNTL T F5-A

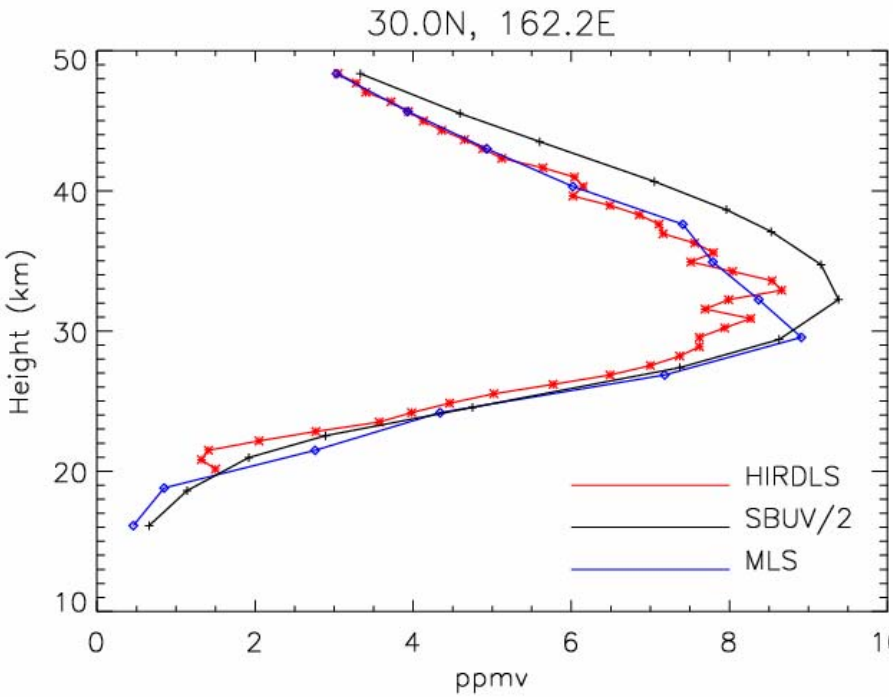


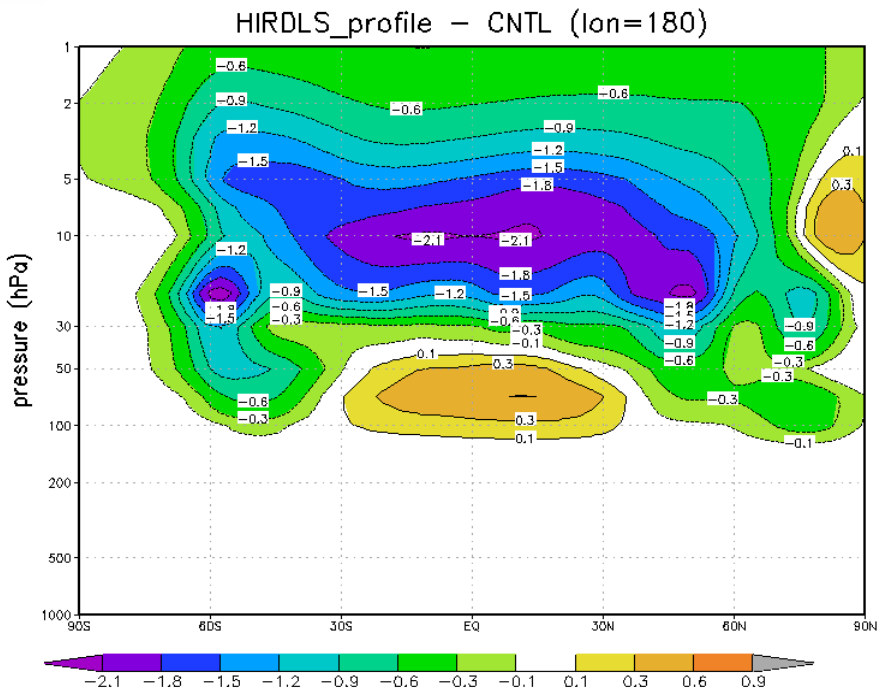
MLS T F5-A



HIRDLS Assimilation Test Results

HIRDLS ozone profile has higher vertical resolution than either OMI or MLS. However, HIRDLS ozone mixing ratios are biased low.



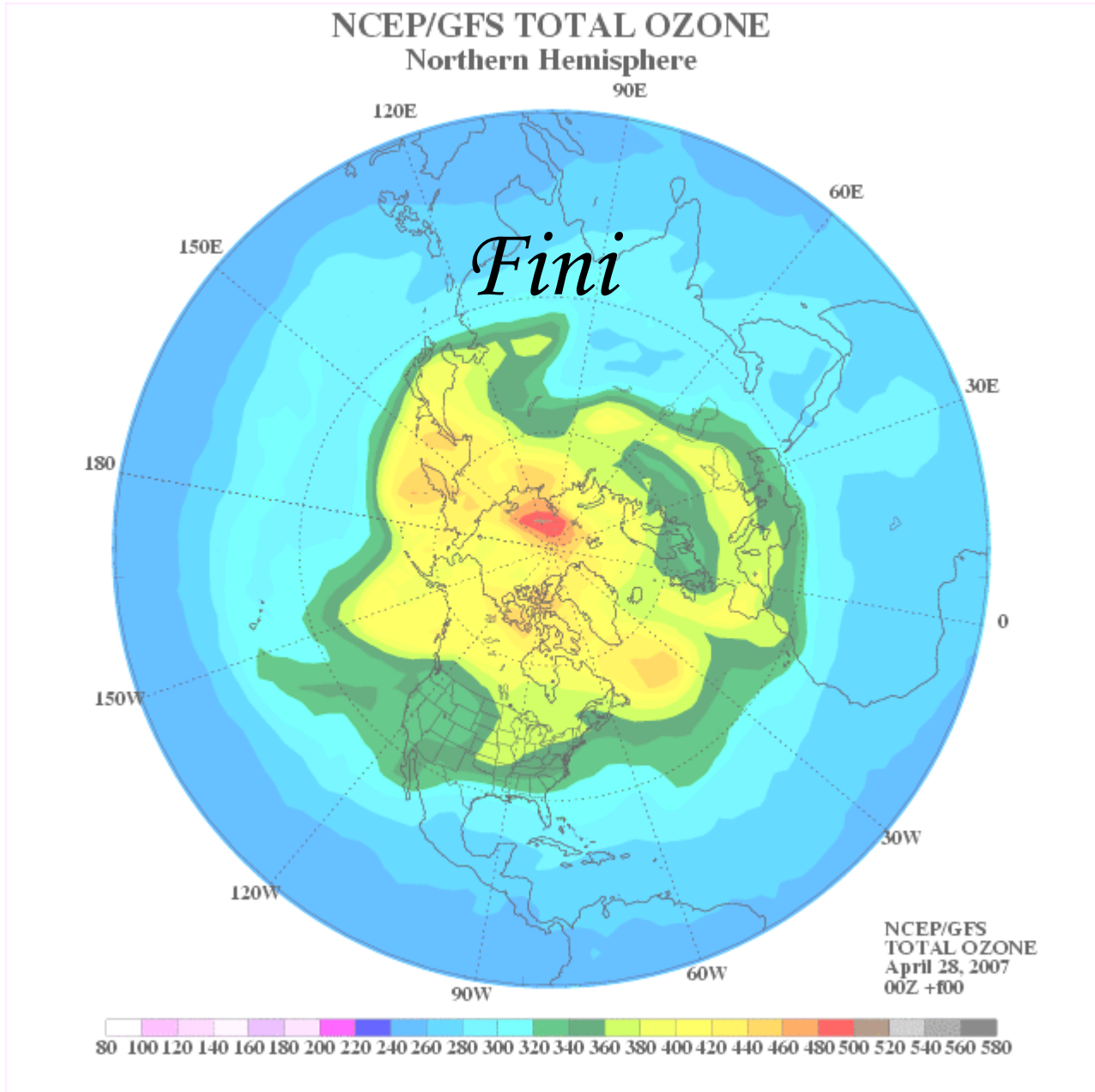


Summary

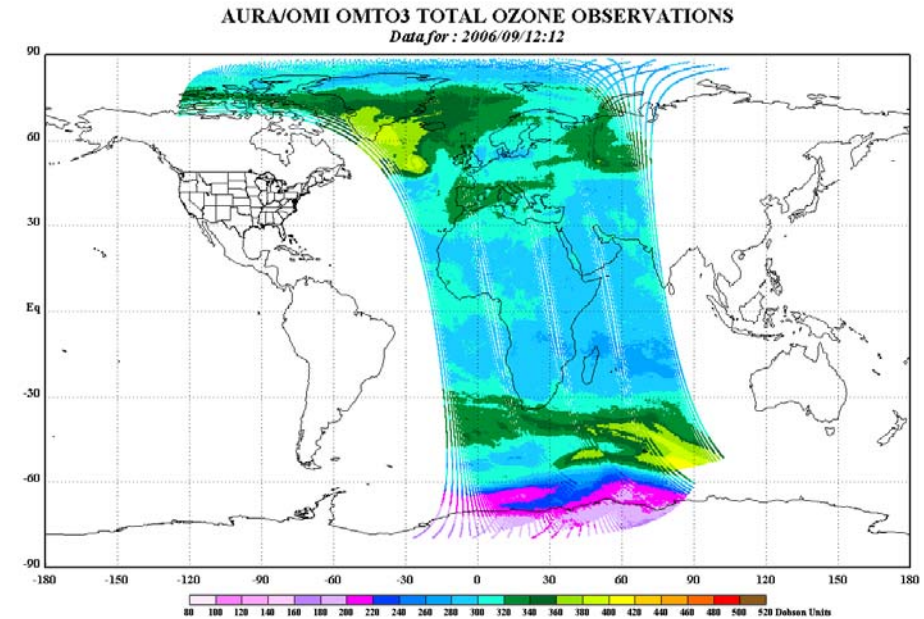
- NRL ozone chemistry improves ozone analyses and fcsts
  - additional work needs to be done with additional coeficients
- Assimilation of OMI TO3 products has been thoroughly tested at T62, T126 and limited at T382.
  - Need to get more information to quality control DOAS total ozone data.
  - Issue over snow/ice and cross-track diff need to be addressed.
  - Thinning scheme seems to work.
  - Assimilation of total ozone products affects ozone profile in a limited way.
  - Does provide greater detailed ozone forecasts – ozone hole size
- Assimilation of OMI and MLS profile data impact ozone and temperature forecasts.
- HIRDLS not 'ready for prime time' yet, although it does have greater detail in vertical.
  - Question is: will model be able to utilize this higher resolution?

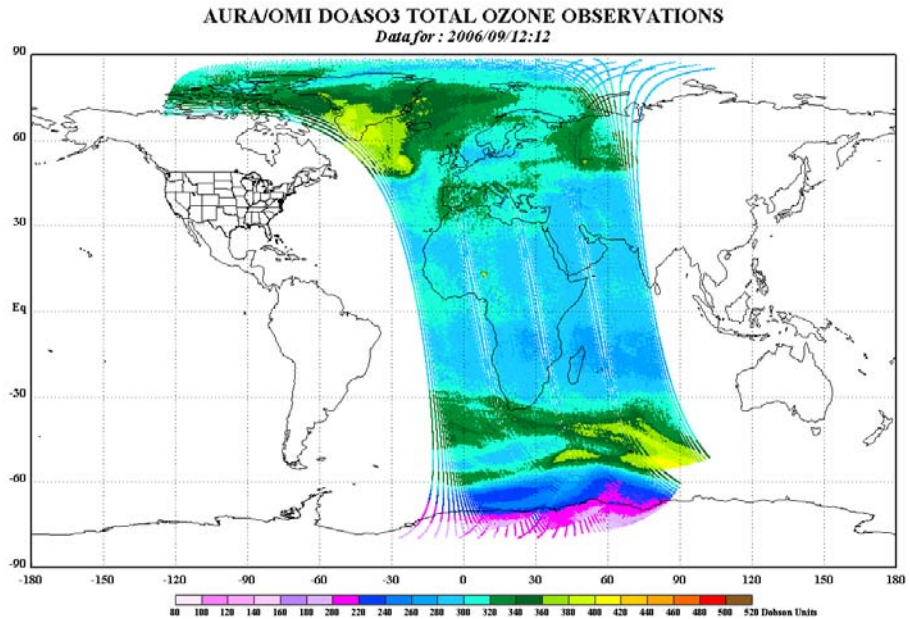
What's Next

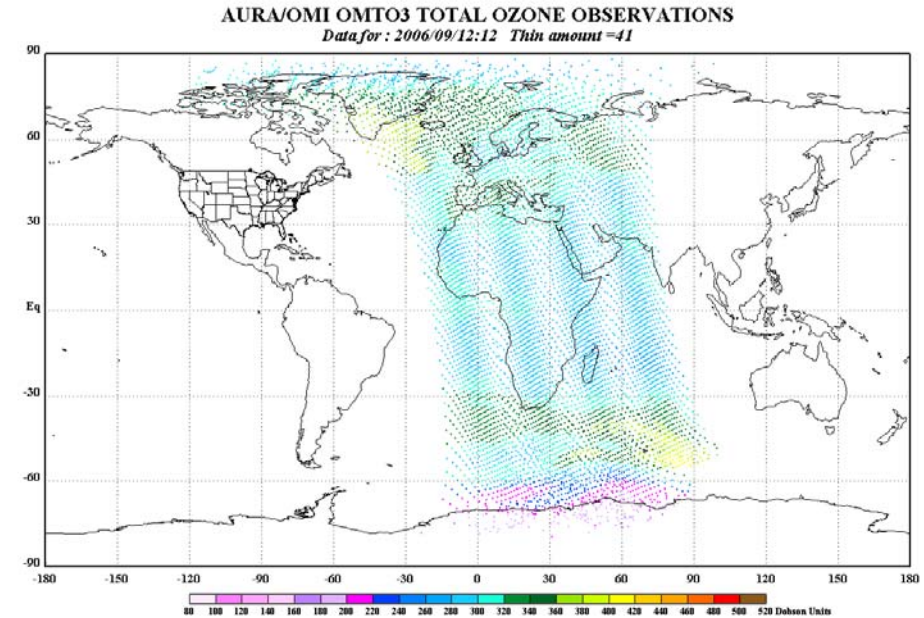
- Complete OMI total ozone tests and prepare for operational assimilation in Fall 2007.
  - Run additional tests at T382
- Complete SBUV/2 v8 profile tests and prepare for operational assimilation in Fall 2007.
- Utilize MLS as ozone validation data set along with ozonesonde and lidar (NDACC).
- Provide feedback to HIRDLS Science Team as new versions of ozone profiles become available.
- Begin tests with MetOp GOME-2 total ozone product.
- Work with KNMI OMI profile ozone product when available.
  - NESDIS version is available but priorities prevent it from implementation.

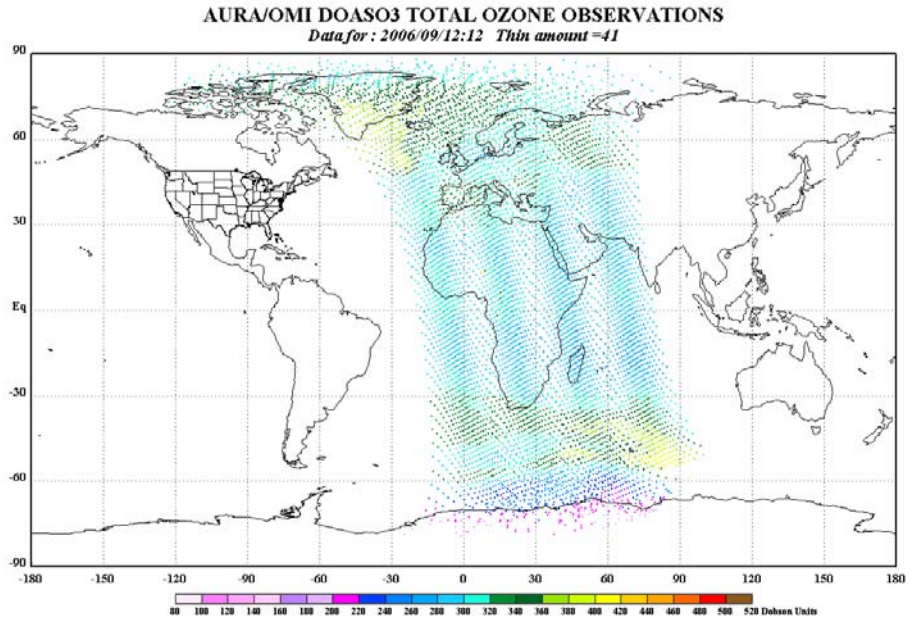

NCEP/GFS TOTAL OZONE
Northern Hemisphere
90E
120E
60E
150E
Fini
30E
180
0
150W
30W
120W
60W
90W
NCEP/GFS
TOTAL OZONE
April 28, 2007
00Z +f00
80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580

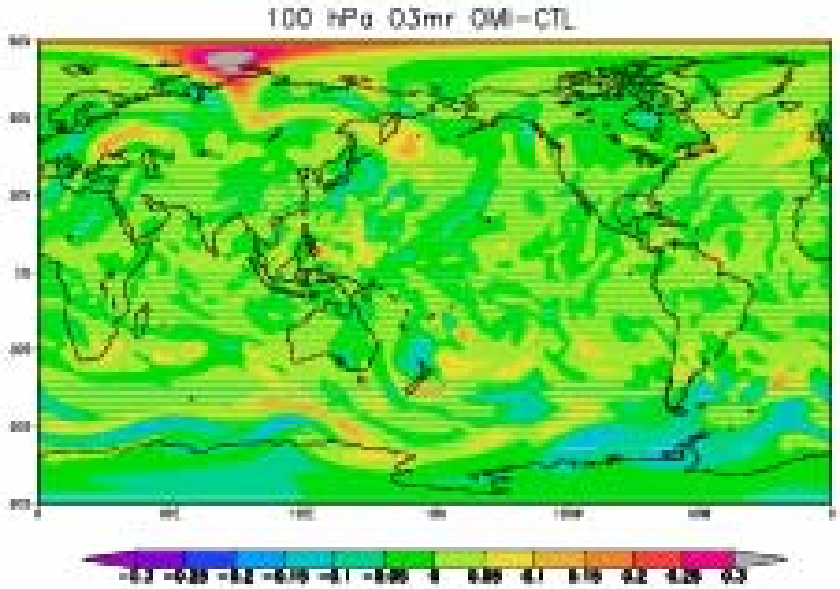
OMI TOMS vs DOAS: All data points *(top)*, thinned *(bot)*

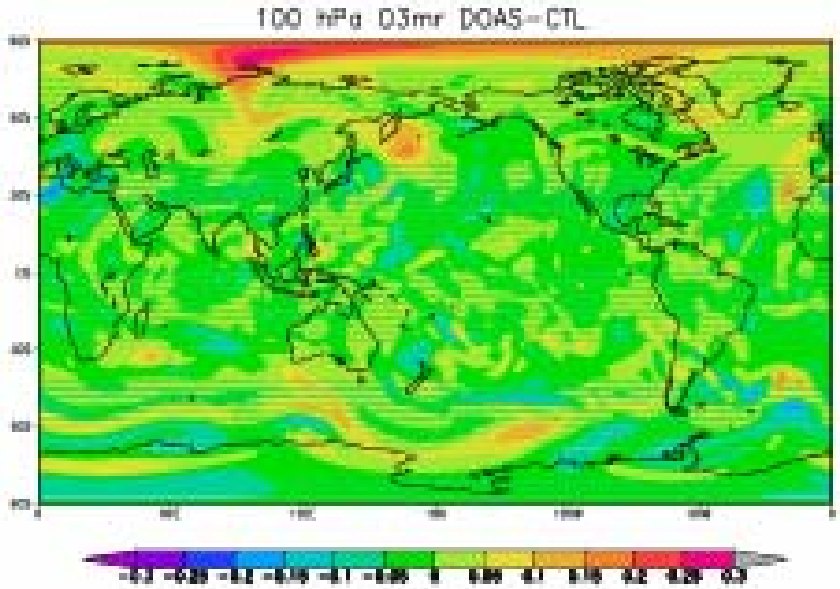












5 day fcsts of OMI data has largest O3MR differences in polar regions.

But largest temperature differences are located in mid latitudes and tropics.