Assimilation of EOS Aura ozone data for NWP and air quality applications

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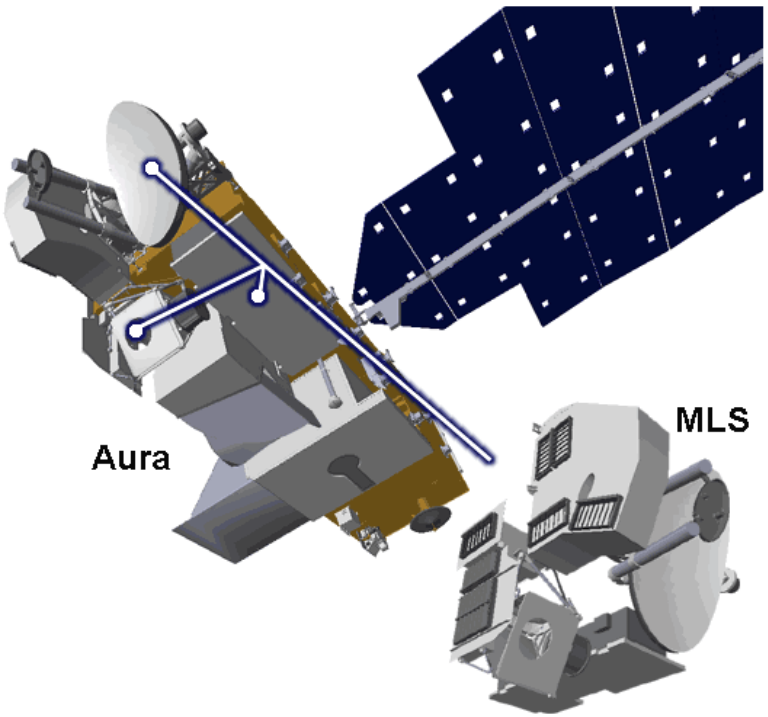
Outline

- MLS characteristics (vs. SBUV)
- Impact of MLS assimilation in GEOS-5
  - September 2004 ozone hole
- Evaluation of ozone in GEOS-5
  - sondes, SAGE II
- Impact on AIRS O-A residuals for ozone channels
- NWP forecast skill
- Summary and plans

MLS – Microwave Limb Sounder

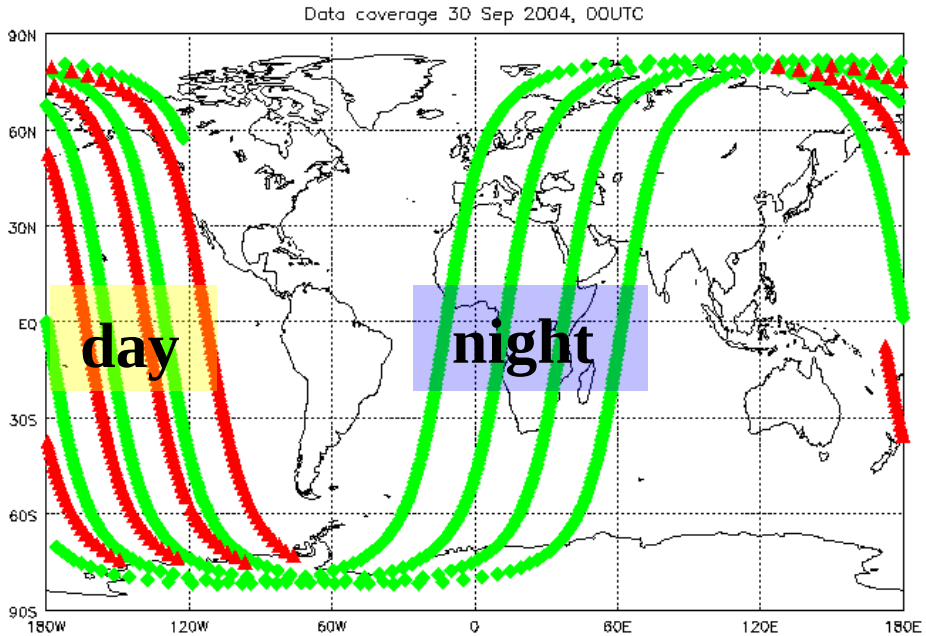


- One of four instruments on **EOS-Aura** spacecraft
- Seven microwave radiometers observing emissions in 118GHz,190GHz, 240GHz, 640GHz and 2.5 THz ranges
- MLS **products** include retrievals of temperature, BrO, ClO, CO, H_2O, HCl, HCN, HNO_3, HO_2, HOCl, N_2O, **O_3,** and OH
- Heritage from UARS-MLS (early 90's)

Implementation of MLS ozone assimilation in GSI

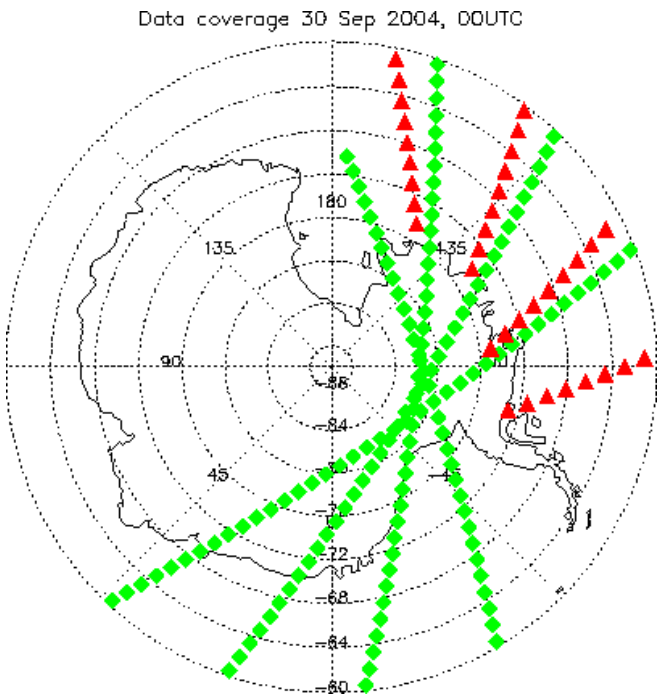
- '**Observation operator**', penalty and gradient terms for ozone mixing ratio, handled like T, q
  - MLS ozone assimilated as point measurements
  - Background ozone assumed to vary linearly with logarithm of pressure
- **Arbitrary pressure level** input – applicable to ozone profile data from other satellites
- Work with current GSI ozone analysis – analysis solution in Dobson units.

Data coverage



NOAA 16 SBUV

MLS



SBUV daytime only – no data near South Pole due to high solar zenith angle

MLS orbital limit ±82º

Comparison of SBUV and MLS ozone measurements

SBUV

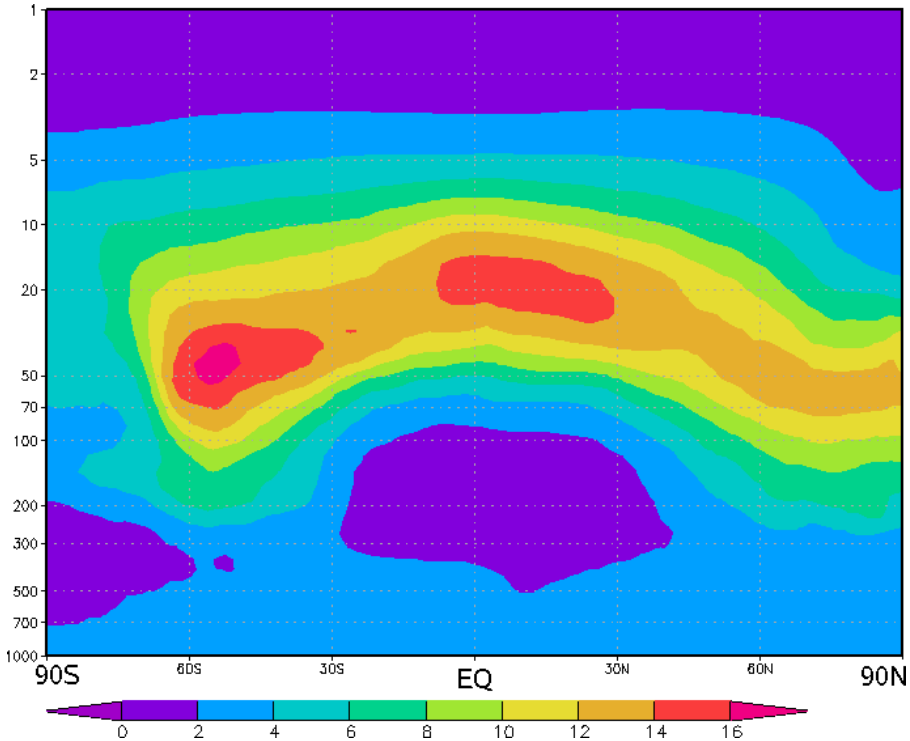
- Solar Backscatter Ultraviolet Instrument uses reflected sunlight – measurements only in daylight
- Assimilate 12 integrated layers (~5 km thick) plus integrated total ozone
- Version 8 used

MLS

- Microwave Limb sounder with measurements both day and night (including polar night)
- Assimilate 20 levels from 215.4 hPa to 0.146 hPa. Vertical resolution higher than for SBUV
- Version 1.5 used

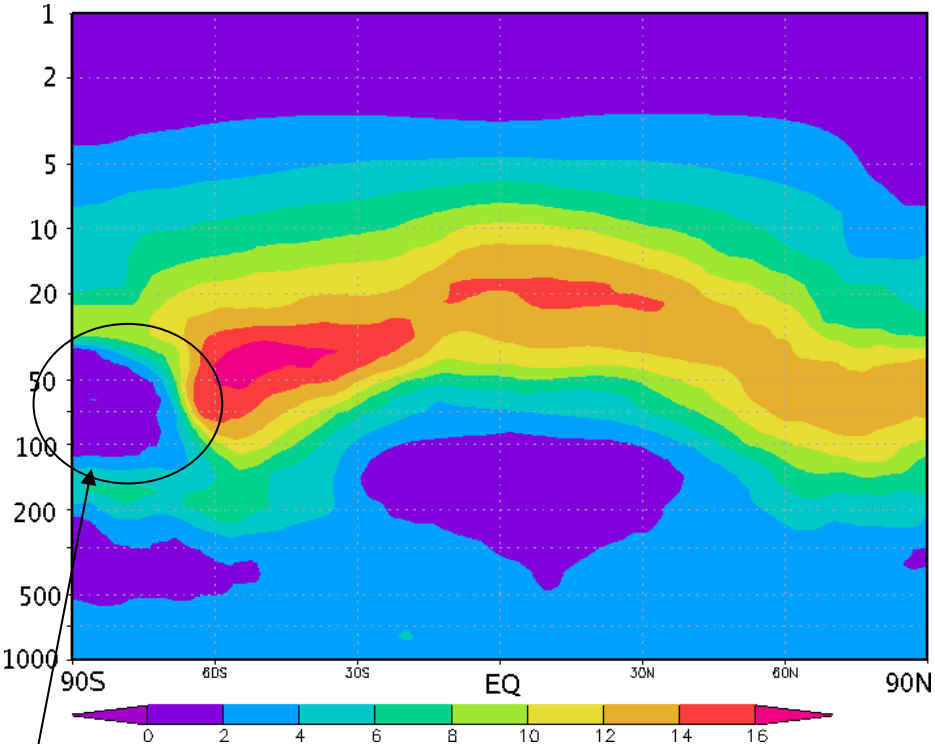
GEOS-5 zonal mean ozone on 9/30/2004

SBUV assimilation



Ozone partial pressure (mPa)

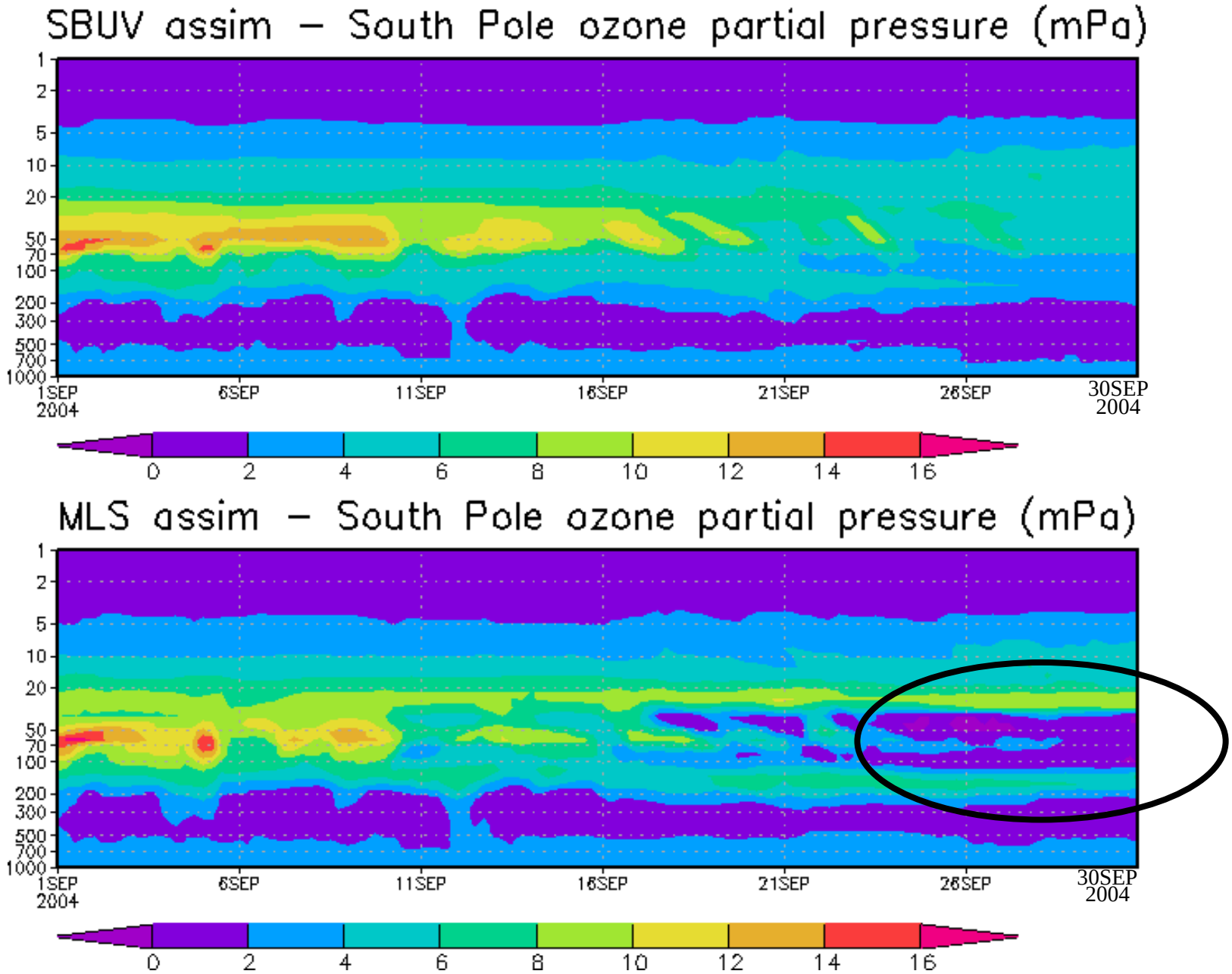
MLS assimilation



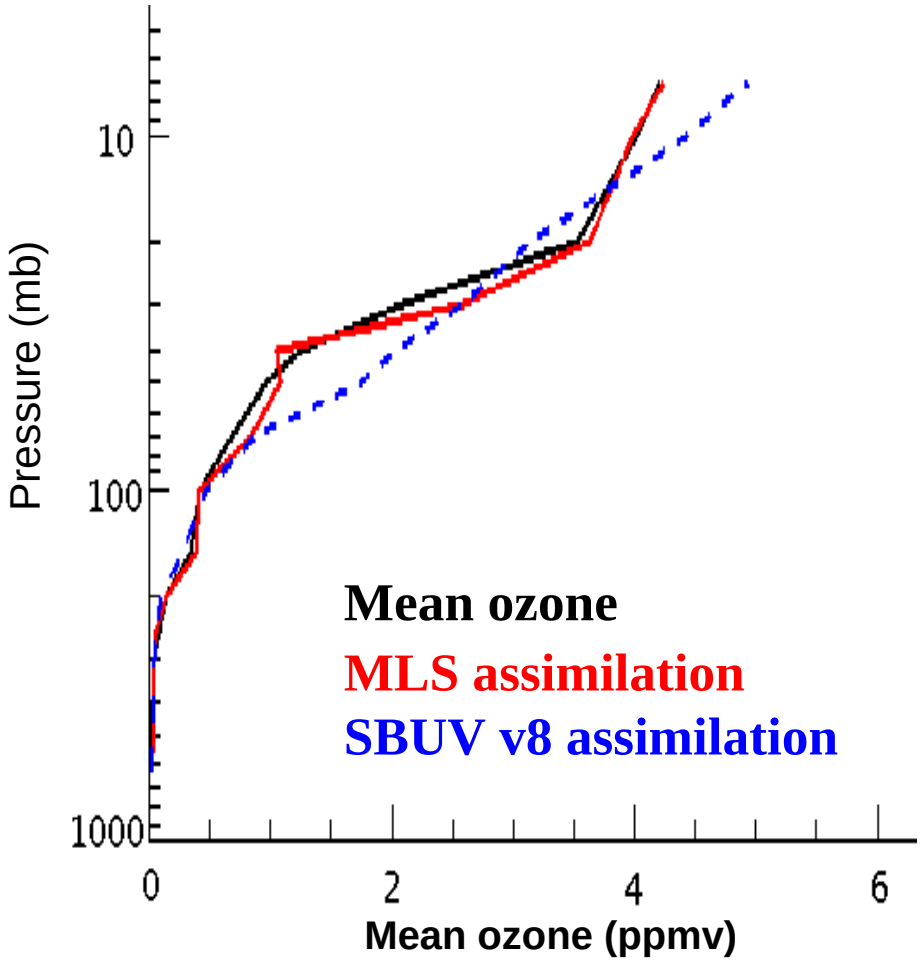
Ozone partial pressure (mPa)

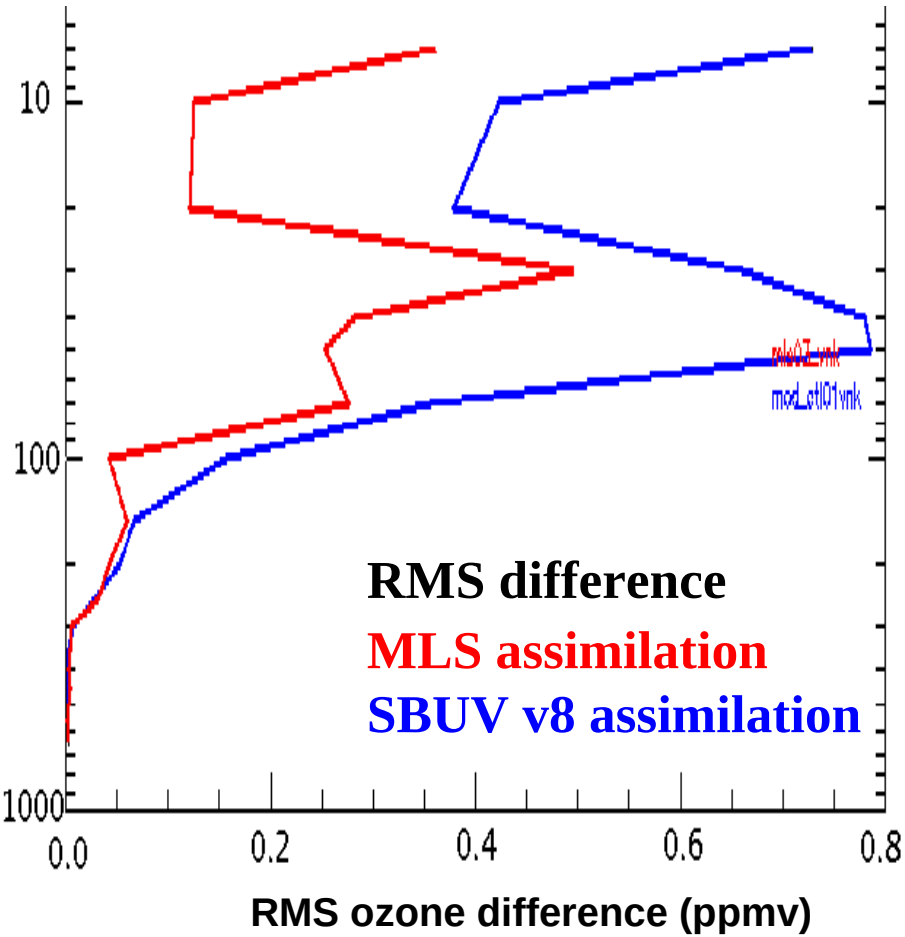
NOAA 16 SBUV/2

Ozone hole in MLS assimilation

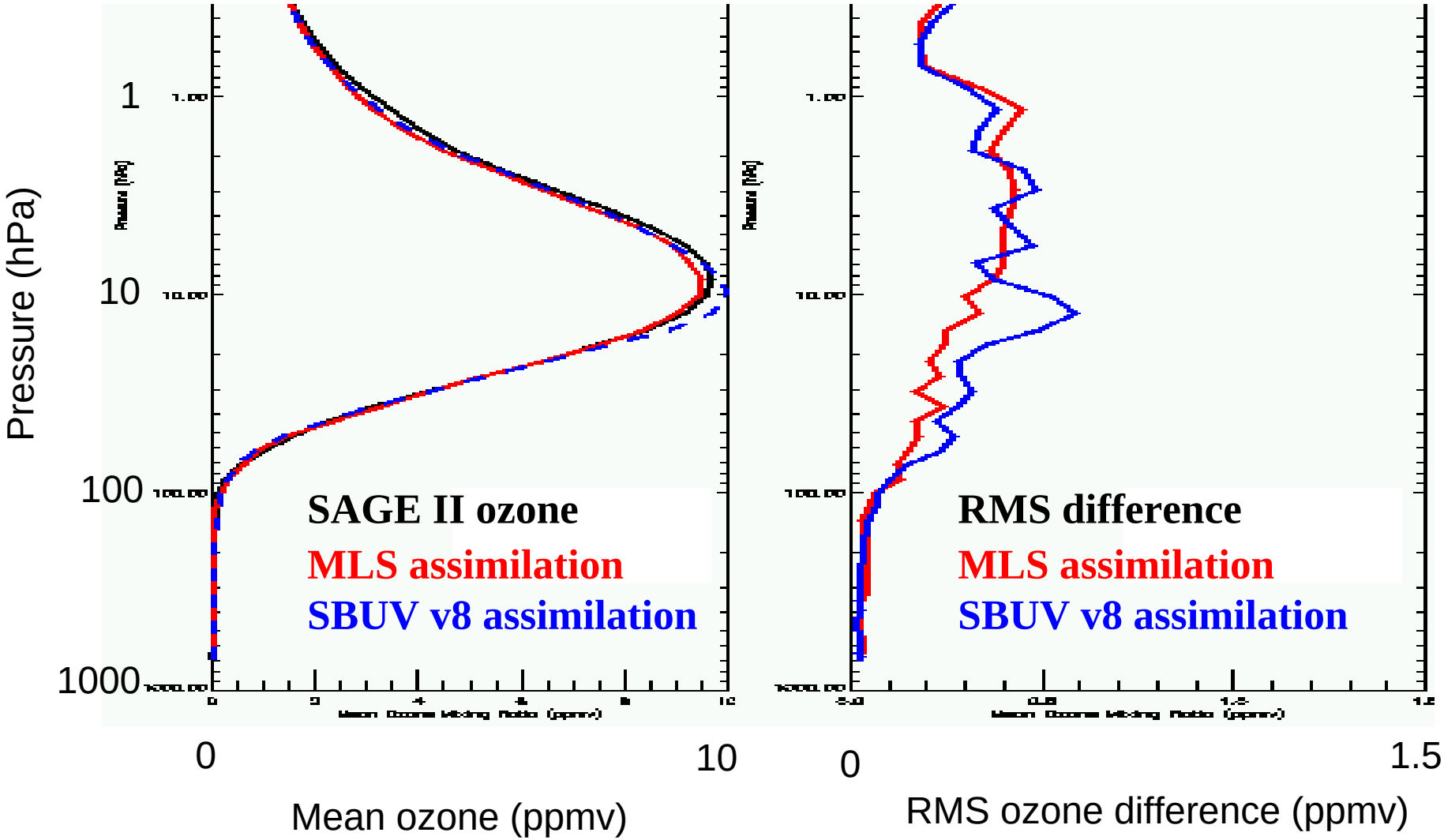

SBUV assim – South Pole ozone partial pressure (mPa)
1
2
5
10
20
50
70
100
200
300
500
700
1000
1SEP
2004
6SEP
11SEP
16SEP
21SEP
26SEP
30SEP
2004
0
2
4
6
8
10
12
14
16
MLS assim – South Pole ozone partial pressure (mPa)
1
2
5
10
20
50
70
100
200
300
500
700
1000
1SEP
2004
6SEP
11SEP
16SEP
21SEP
26SEP
30SEP
2004
0
2
4
6
8
10
12
14
16

Comparison with independent South Pole **ozone sondes**

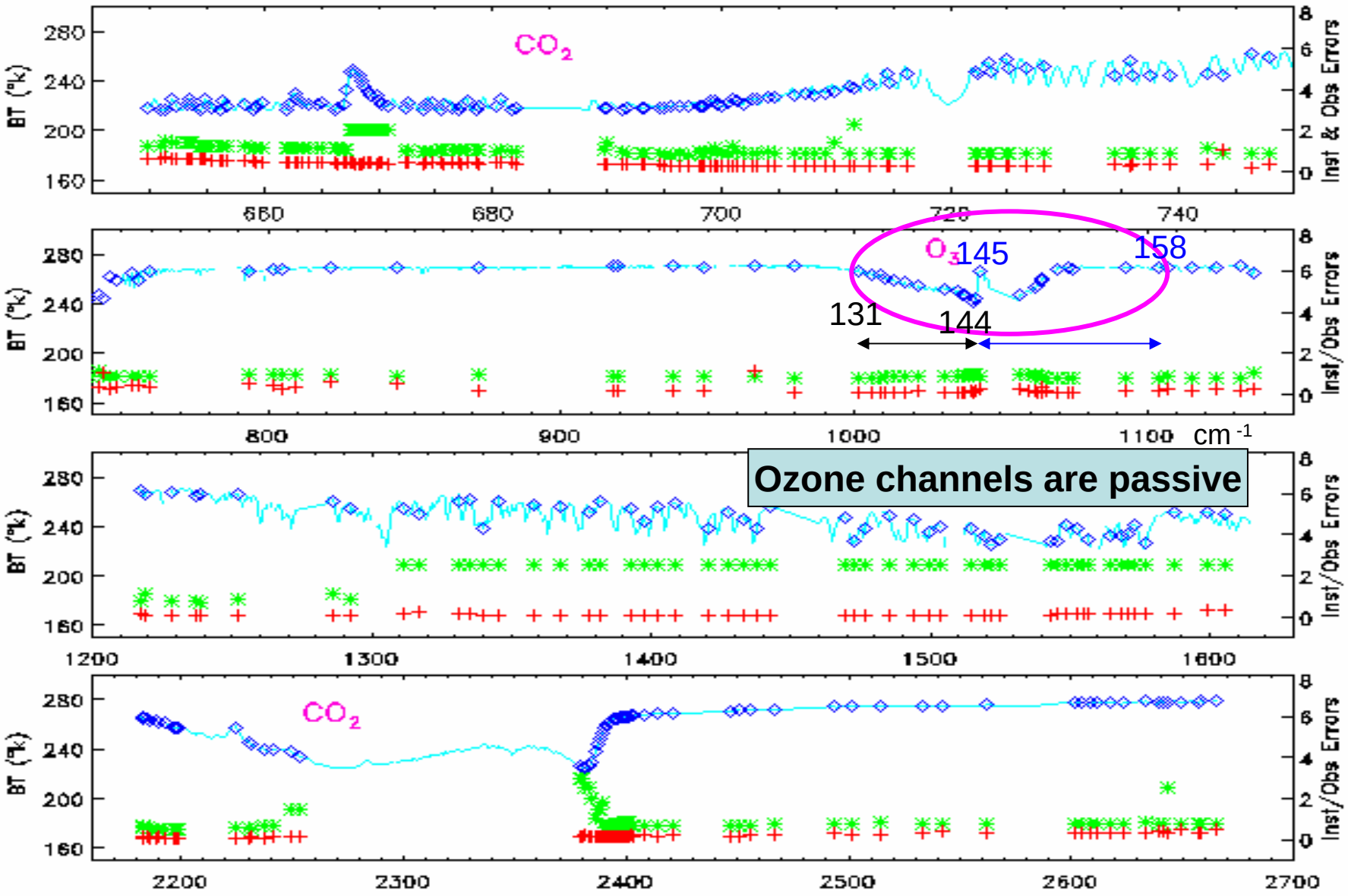




Ozone comparison with **SAGE II** in the Tropics



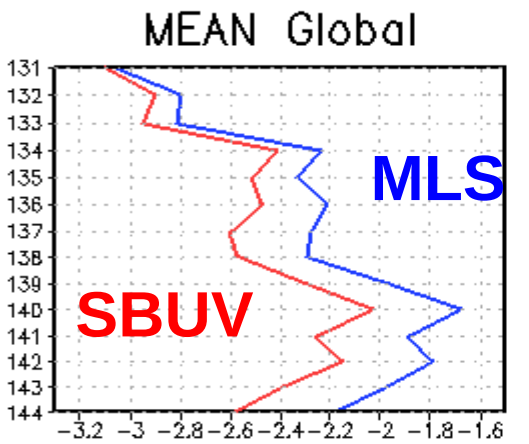
AIRS channel errors and selection

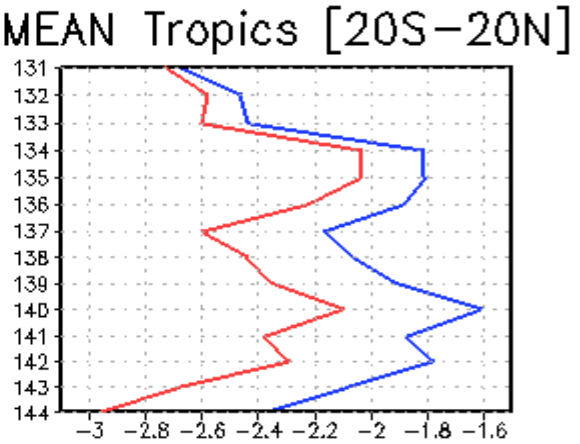


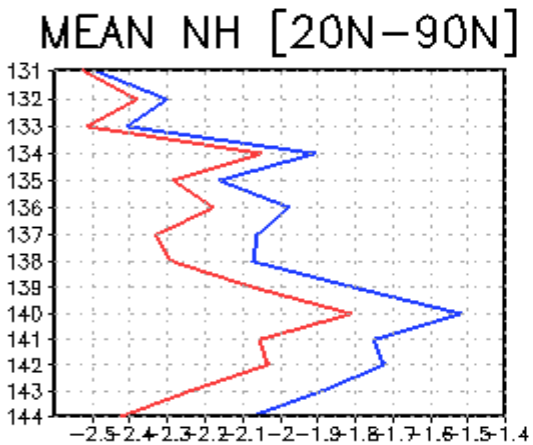
◇ 281 channels + instrument errors * observation errors

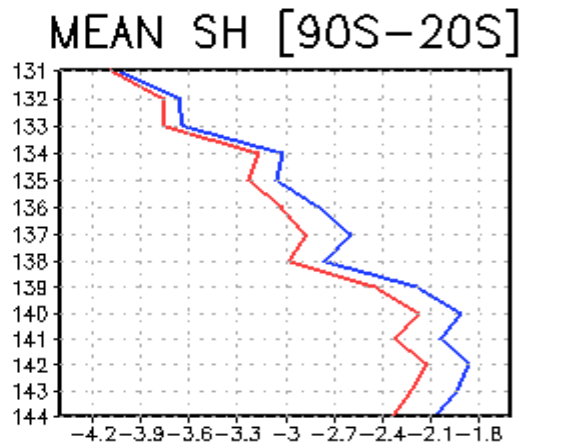
AIRS O-A mean

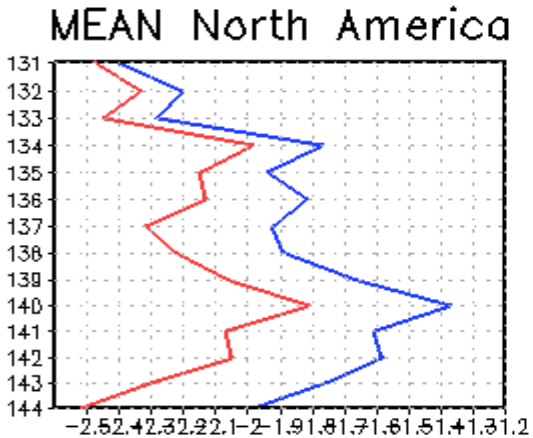
- AIRS observation-minus-analysis (O-A) residuals for September 2004
- Mean for ozone channels 131-144 (1001.4 - 1041.1 cm^{-1})
- Smaller bias with MLS, especially in channels more sensitive to ozone (e.g. 144)

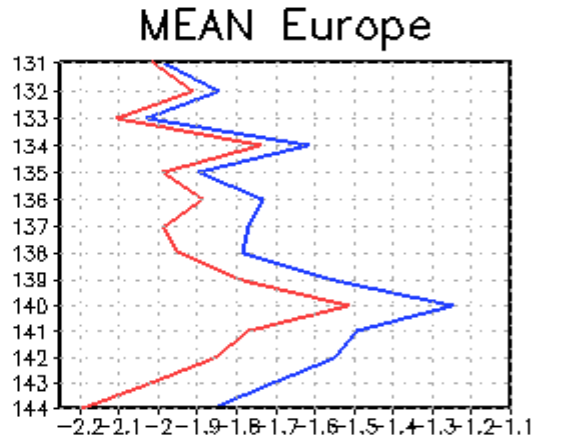






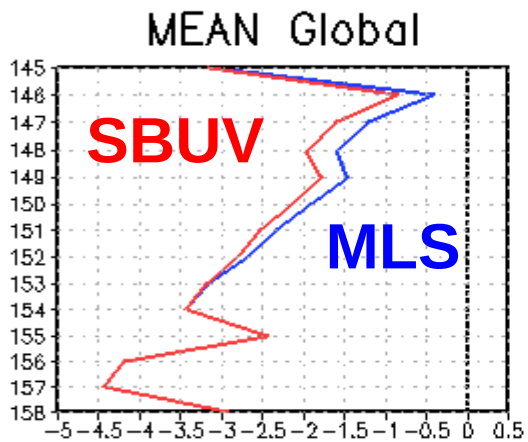


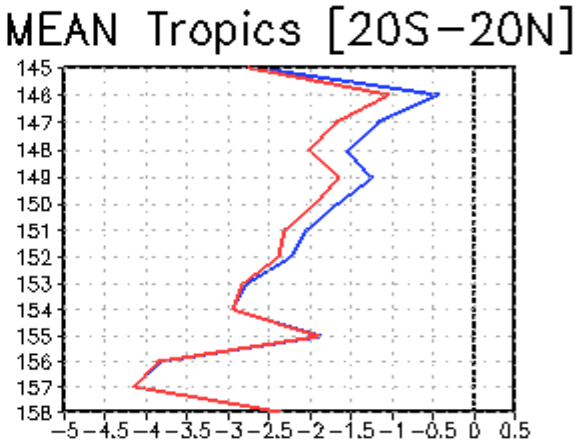


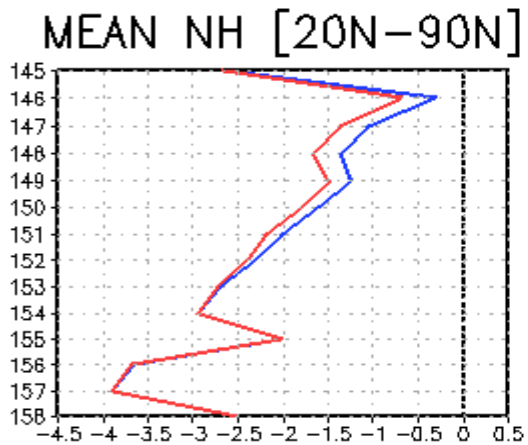


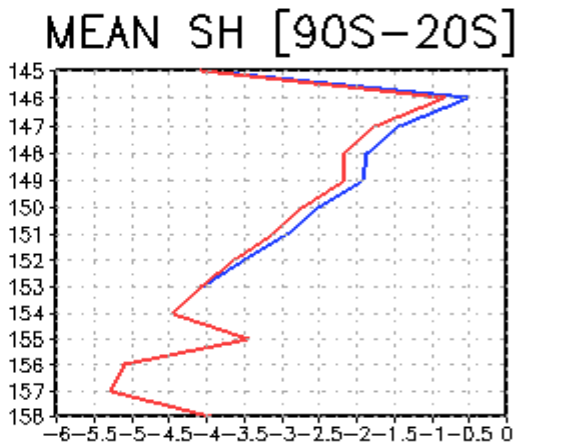
AIRS O-A mean

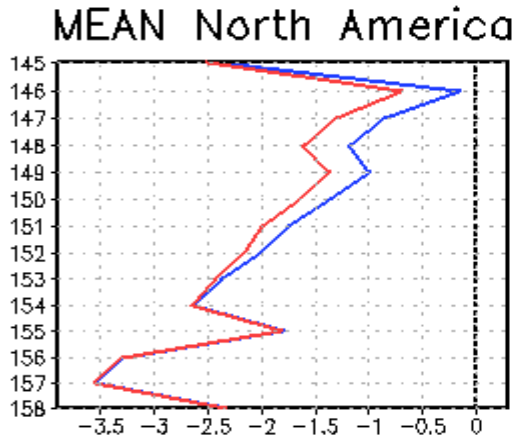
- AIRS O-A residuals for September 2004
- Mean for ozone channels 145-158 (1042.5 - 1106.8 cm^{-1})
- Smaller bias with MLS; especially in channels more sensitive to ozone (e.g. 146)

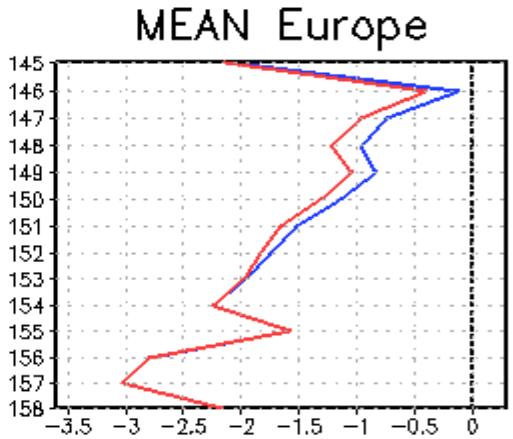






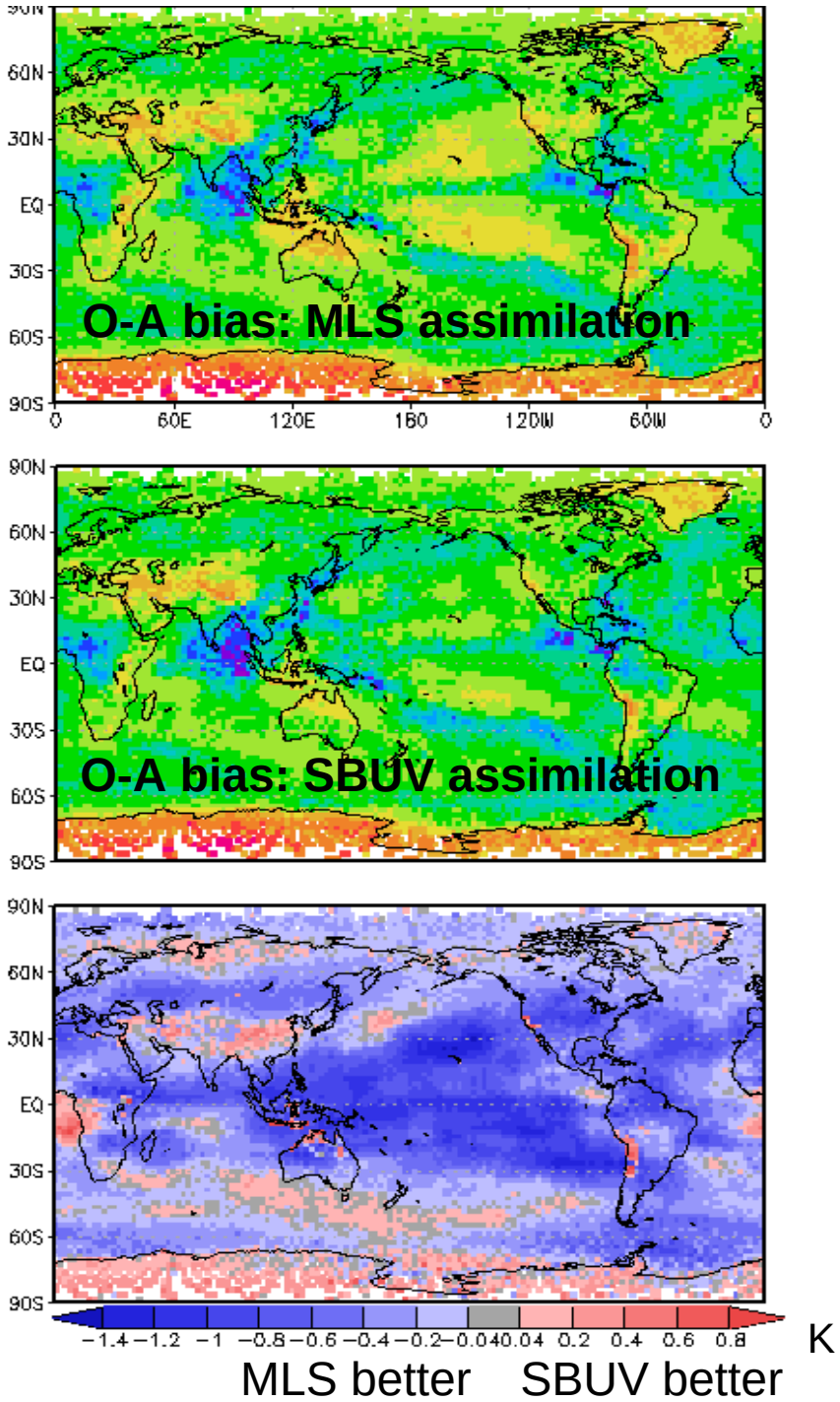






AIRS O-A mean

- O-A bias for channel 144 at 1041.1 cm^{-1}
- September mean
- Smaller bias in MLS assimilation, especially in the Pacific

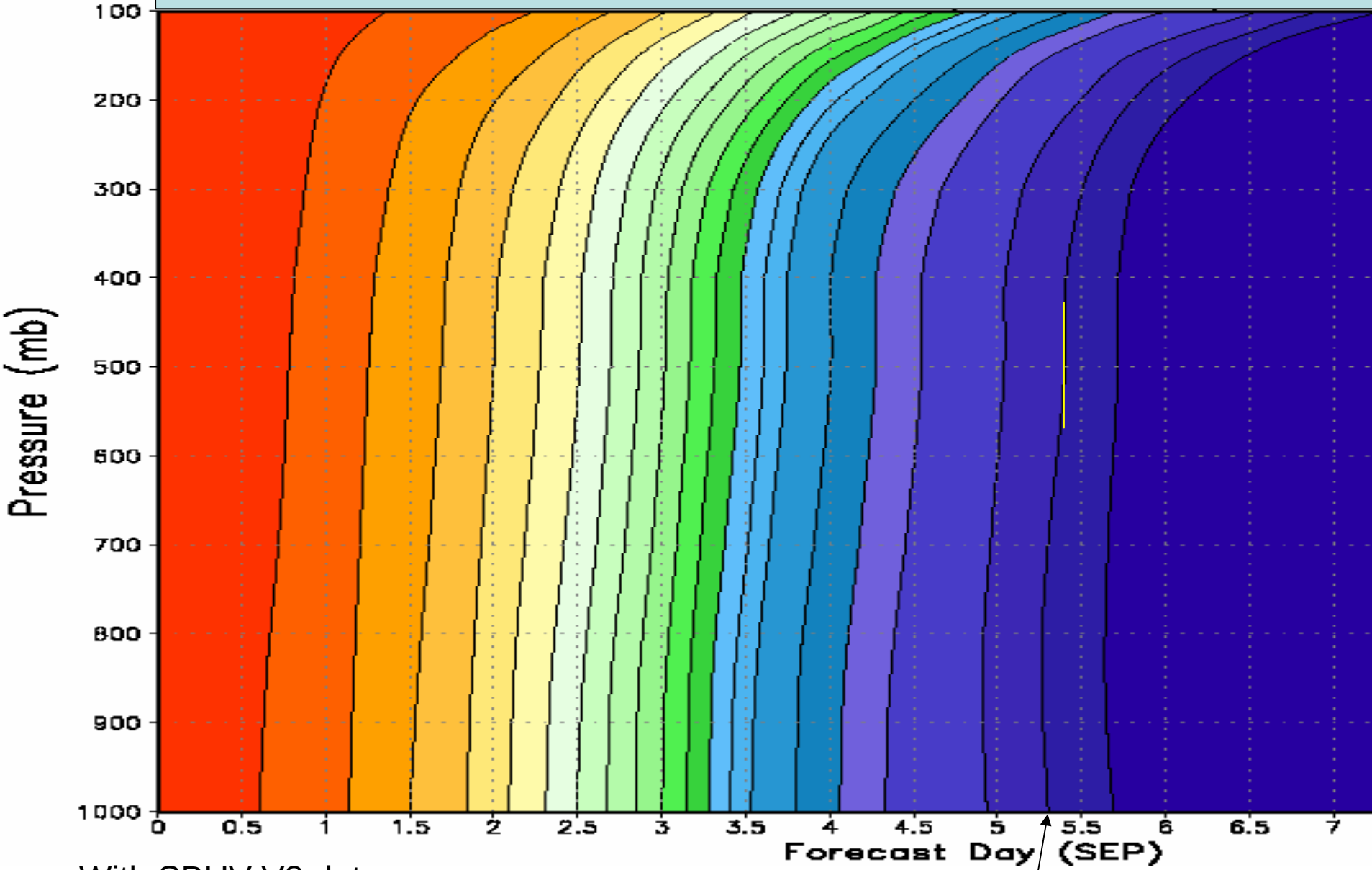


Assimilation of MLS ozone data:

- Improves the ozone field in GEOS-5
- Bias in O-A residuals for AIRS ozone channels is reduced

- What is the impact on the NWP skill?

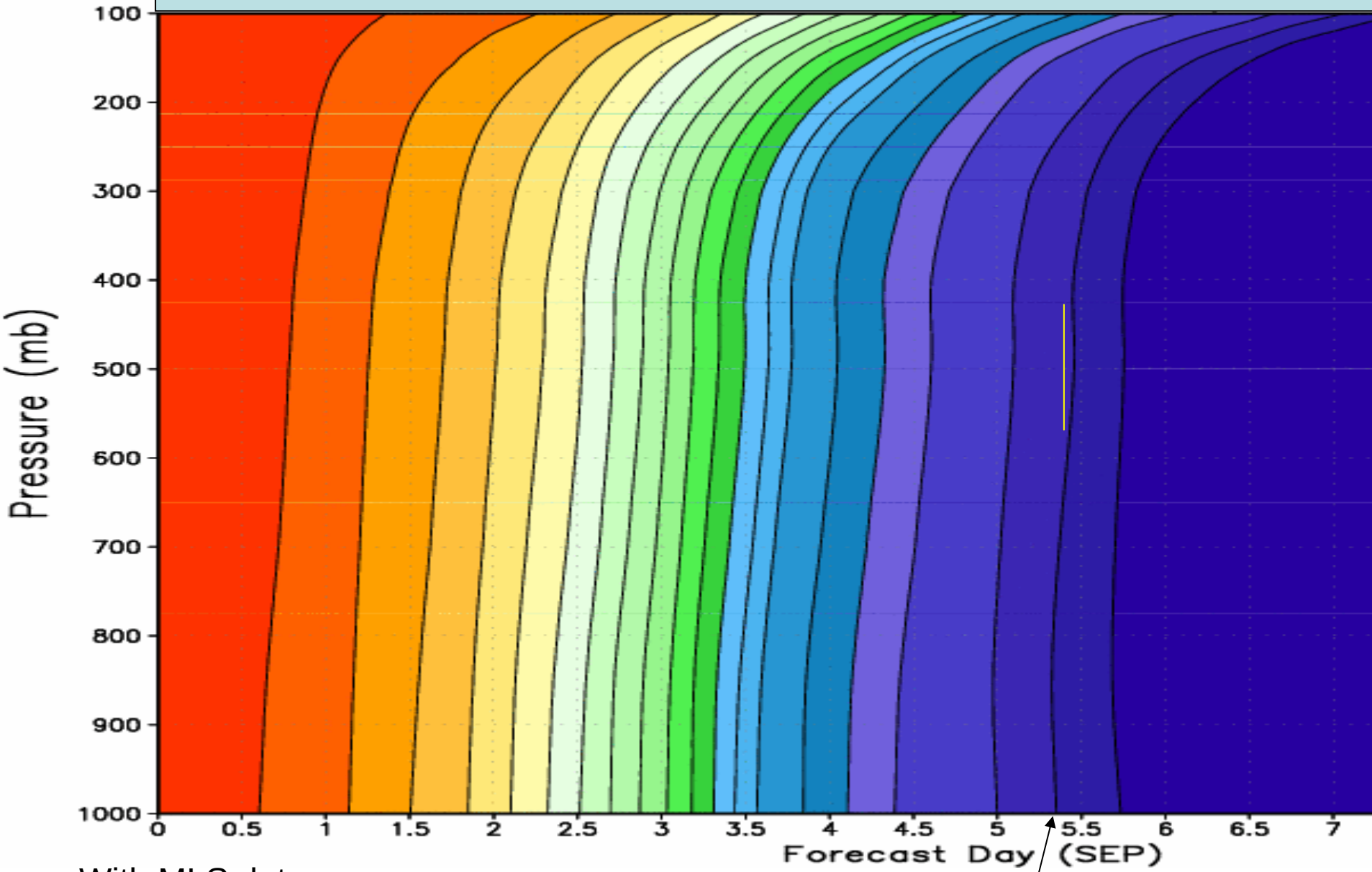
Anomaly Height Correlations – Southern Extratropics



With SBUV V8 data

0.73 contour

Anomaly Height Correlations – Southern Extratropics



With MLS data

0.73 contour

Summary and plans

- **MLS** assimilation implemented **in GSI**
- MLS assimilation reproduces **ozone hole** in September 2004 in GEOS-5
- MLS assimilation is in better agreement with **sondes** and **SAGE II** (e.g. South Pole, Tropics)
- Magnitude of mean **AIRS O-A residuals** for ozone channels is **reduced** in MLS assimilation compared to SBUV assimilation
- Small impact on NWP forecast skill
- Forecast skill and tropospheric ozone from OMI + MLS assimilation need to be evaluated