Improving Ozone Forecasts by Assimilating Additional Ozone Profile Products

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Introduction

- **NOAA-16 & 17 SBUV/2 ozone profile data are currently used in NCEP GFS. Issues with SBUV/2:**
  - **Vertical resolution is ~6 km,**
  - **Lower stratospheric data are less accurate,**
  - **No data in polar night**
  - **Current status: N16 no SH coverage, N17 loosing coverage,N18 possibly dead**
  - **Last SBUV/2 on NOAA-N' (descending orbit)**

- **Aura MLS**
  - **has slightly higher vertical resolution,**
  - **more accurate lower stratospheric data, and**
  - **polar night coverage**

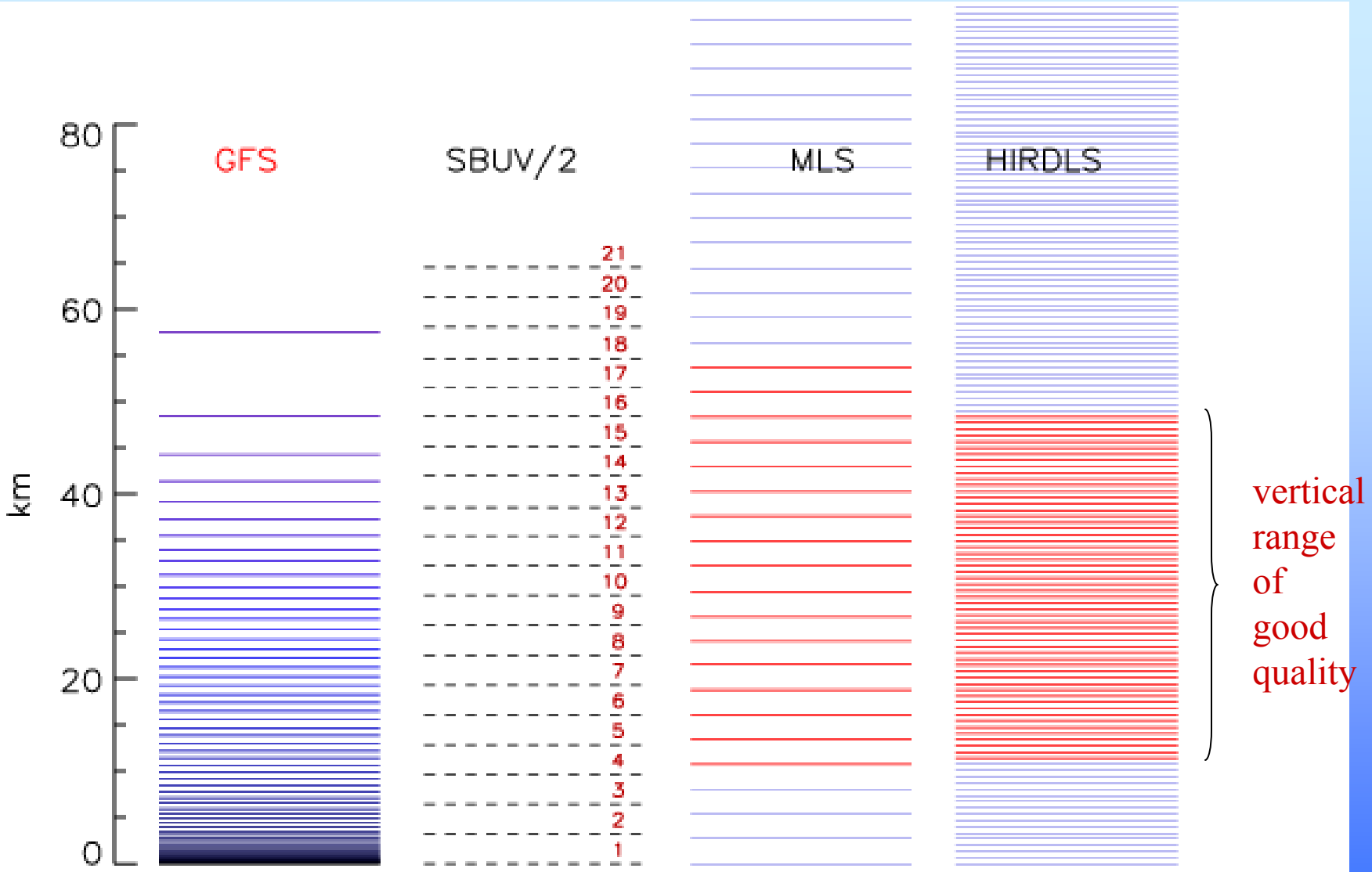
- **Aura HIRDLS**
  - **has much higher vertical resolution and**
  - **nighttime measurements**

Achievements

- **Implemented version 8 SBUV/2 ozone in NCEP operational GFS (replacing version 6)**

- **Conducted assimilation and forecast experiments of Aura MLS ozone profile in the high resolution (T-382) GFS, including version 1.5 and near-real-time (NRT) data**

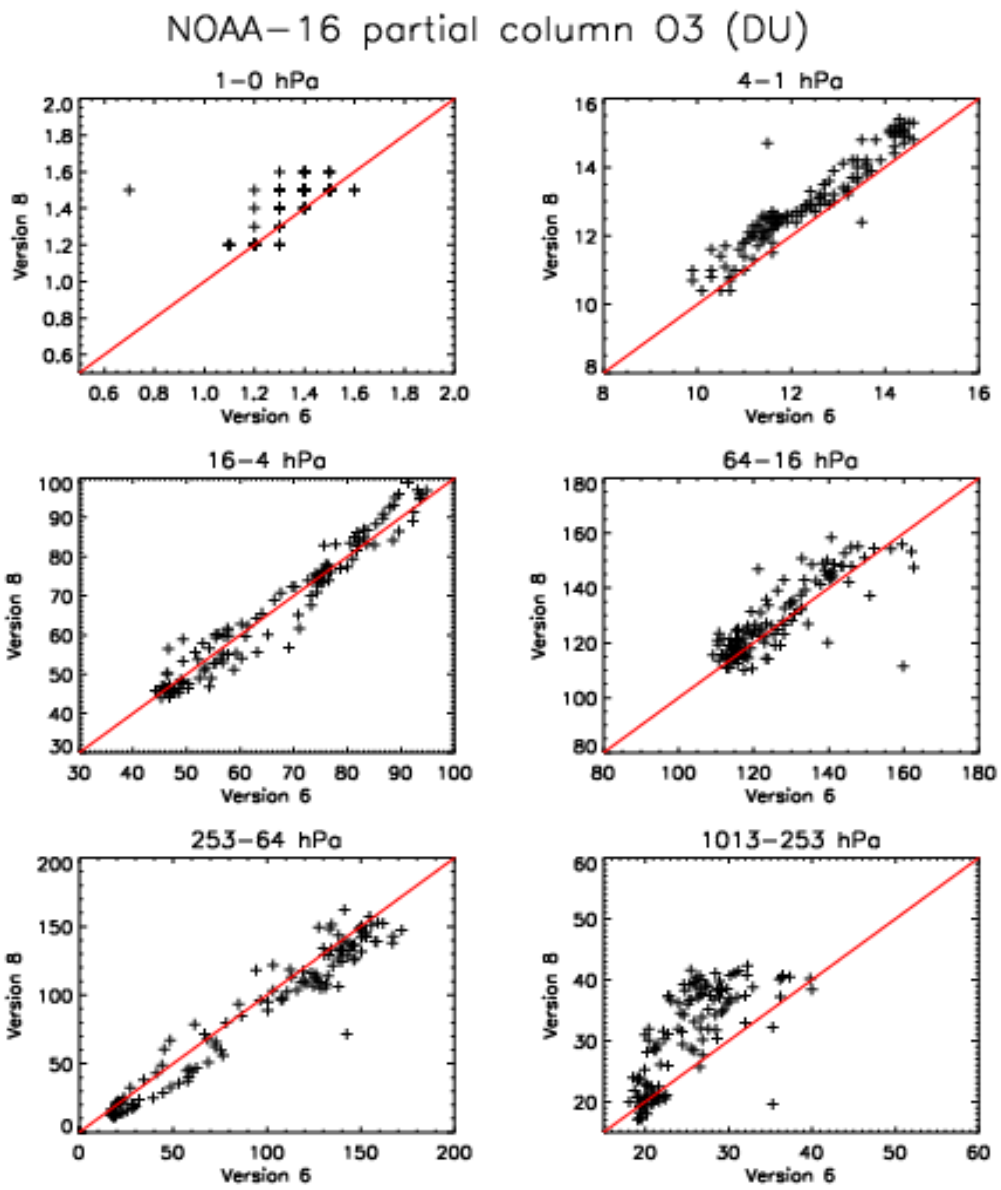
- **Assimilated Aura HIRDLS ozone profile data (version 2 and 3) in NCEP GSI system**



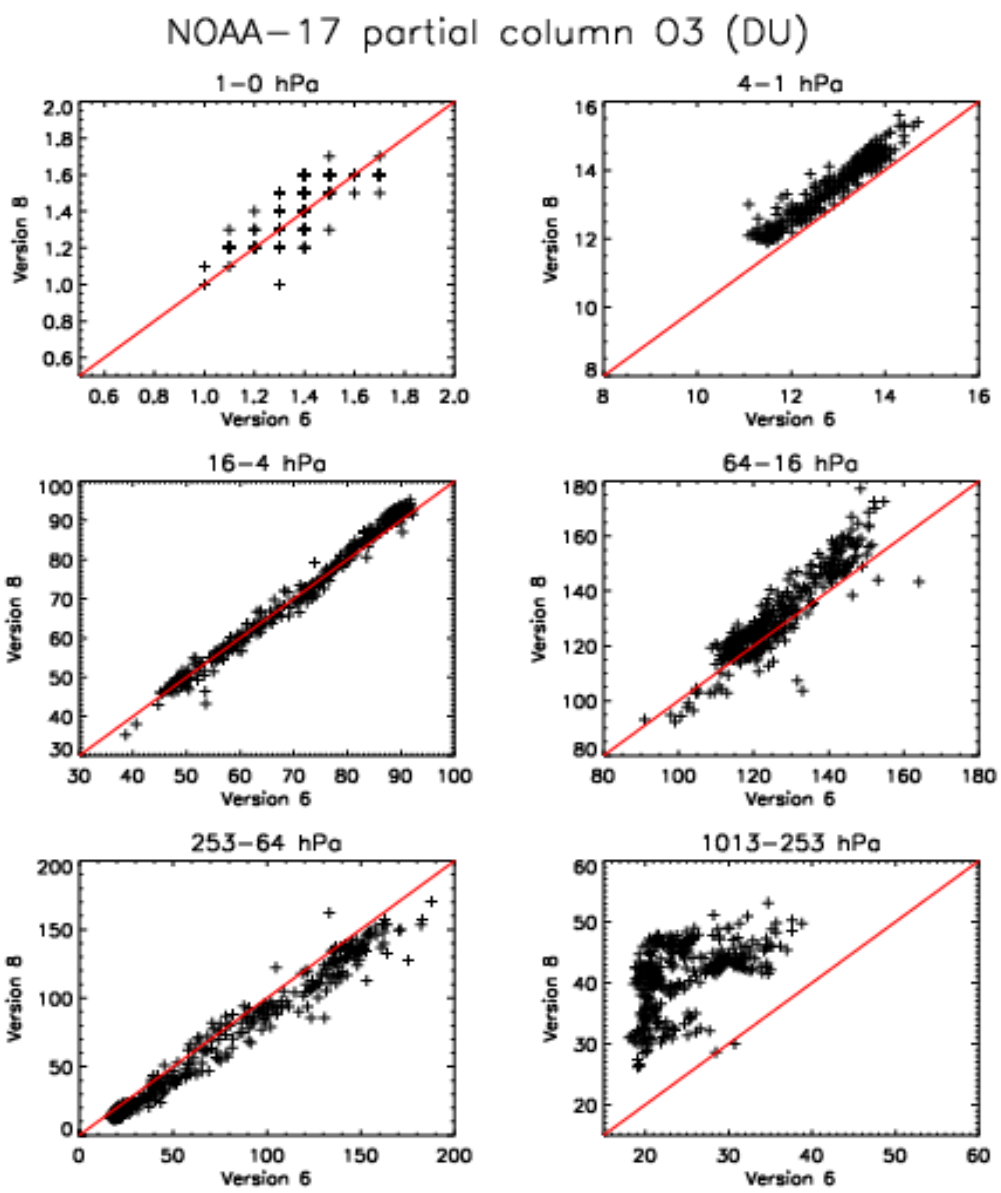
The GFS model layers compared with SBUV/2, MLS and HIRDLS ozone data layers.

SBUV/2 version 8 vs. version 6

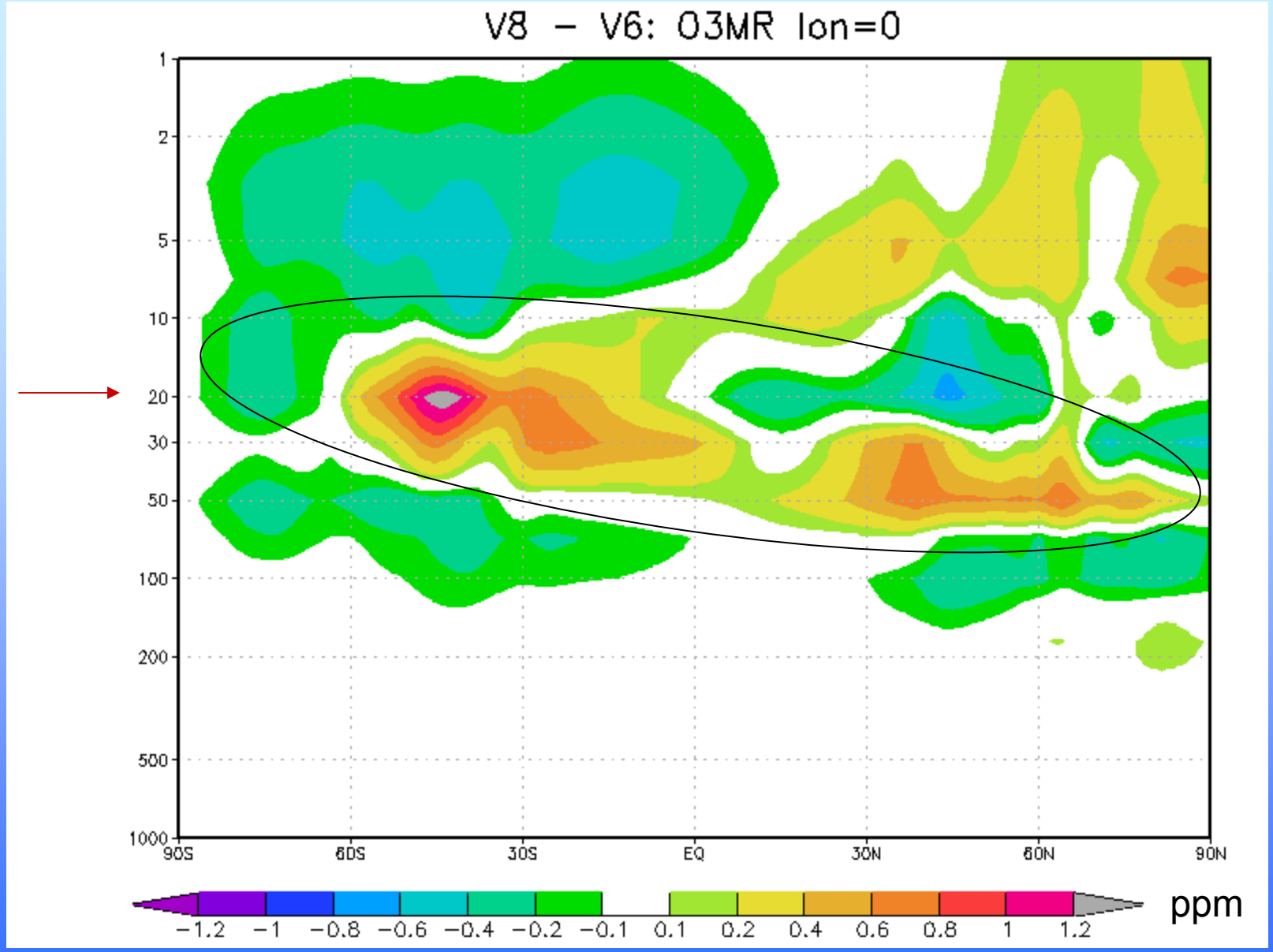
- Layer data comparison
- Differences in analysis (GSI assimilation)
- Differences in forecast (GFS T382L64)
  - -- ozone mixing ratio
  - -- temperature



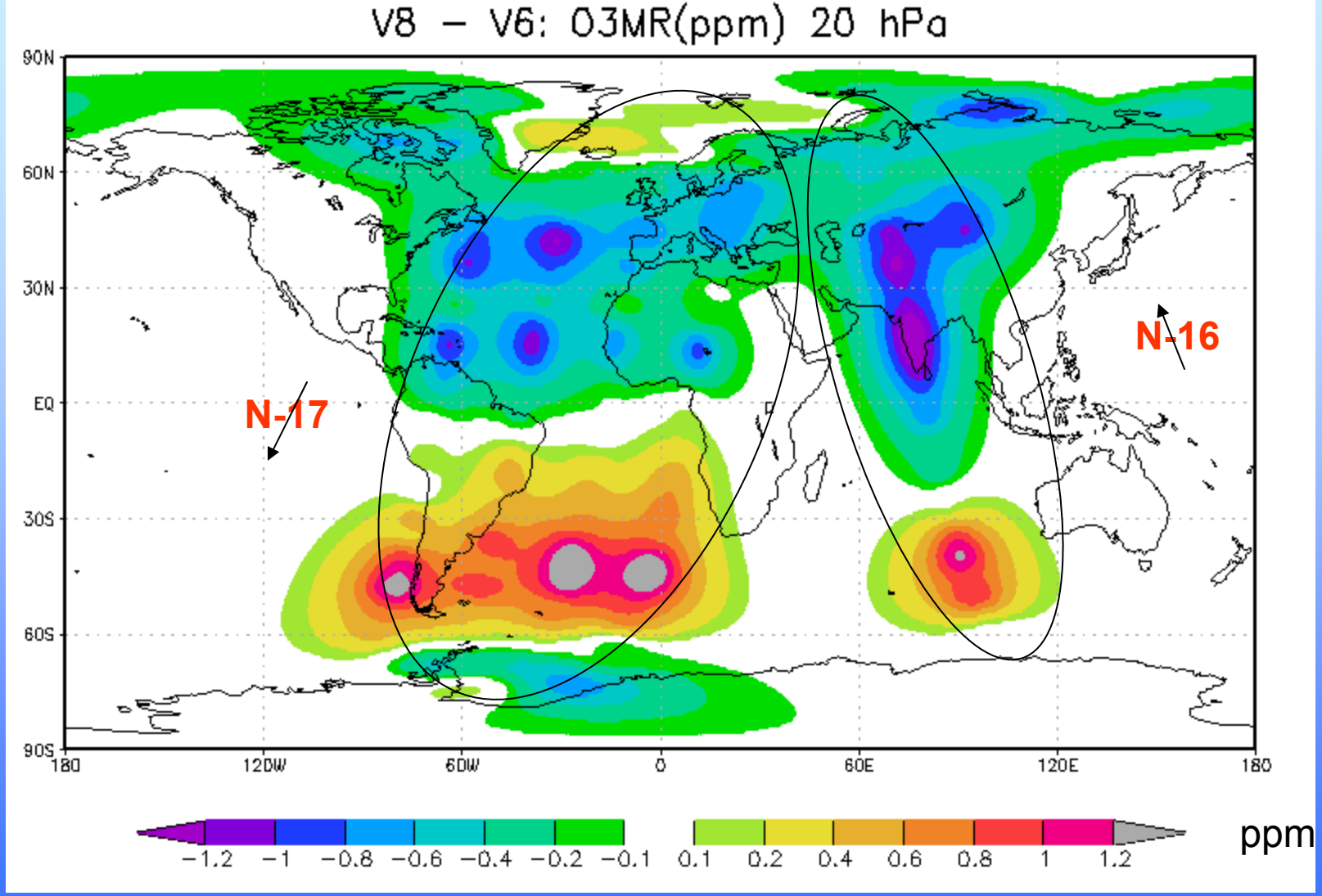
V8 and v6 integrated layer ozone comparison for **NOAA-16** (12Z, April 5, 2007).



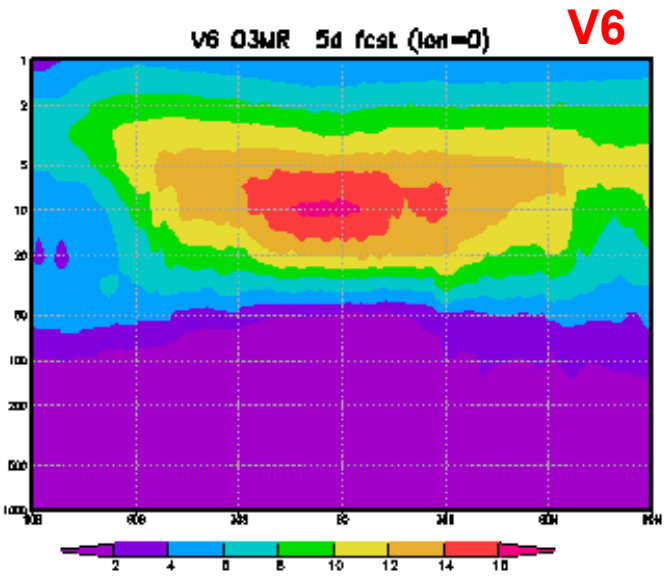
V8 and v6 integrated layer ozone comparison for **NOAA-17** (12Z, April 5, 2007).

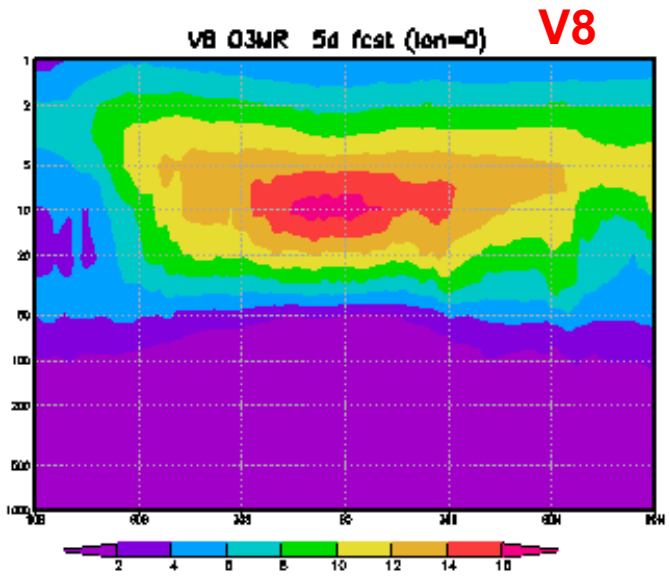


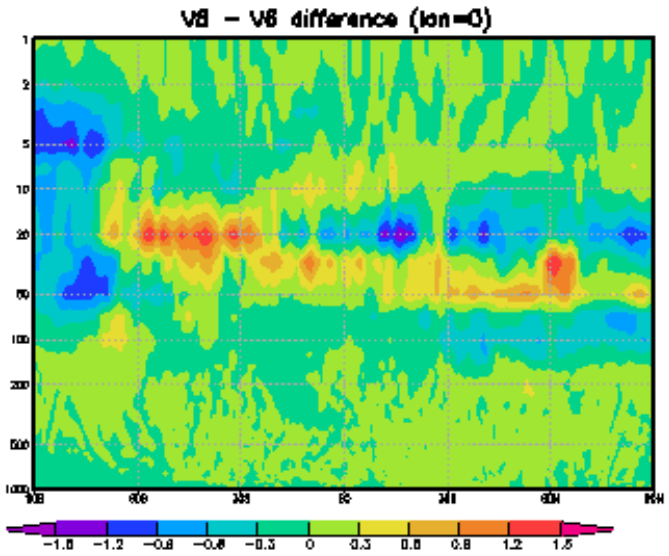
v8 and v6 assimilated ozone mixing ratio difference at longitude 0. It reflects the fact that v8 is larger than v6 in 64-16 hPa layer.



V8 and v6 assimilated ozone mixing ratio difference at 20 hPa (2007040512).

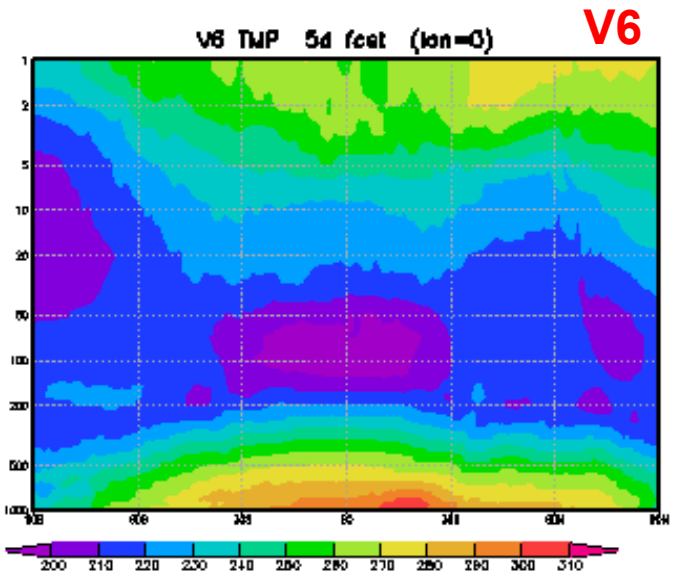


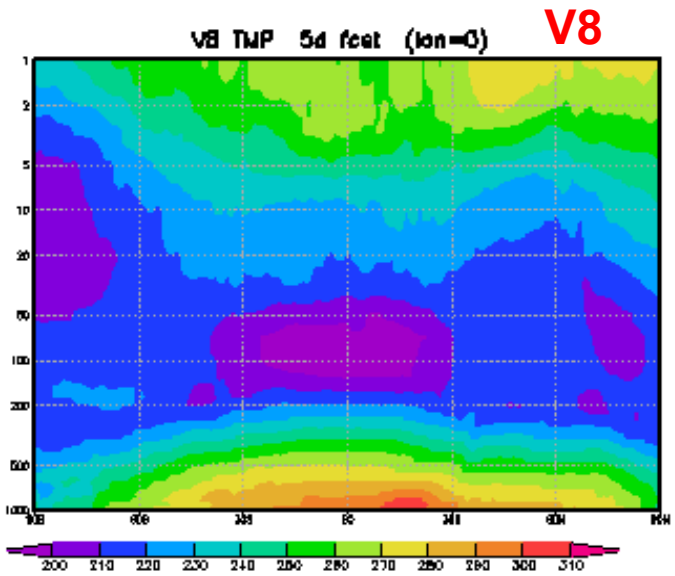


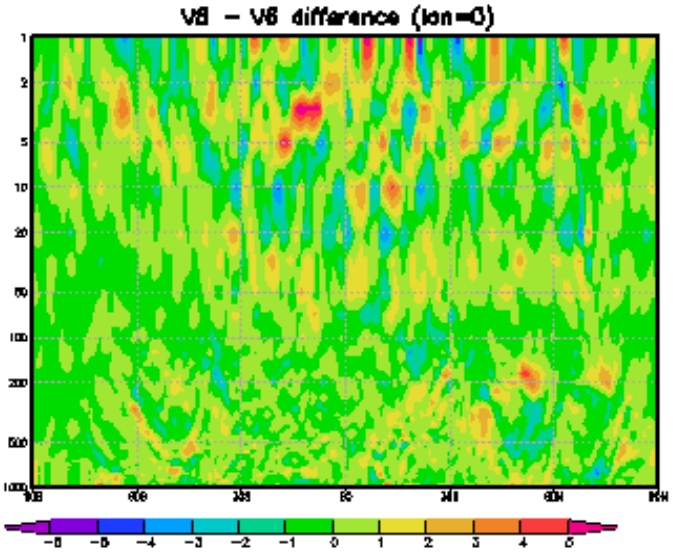


difference

v6 and v8 **ozone mixing ratio** comparison in **5-day forecast**.







difference

Effects on **5-day temperature forecast** by replacing v6 with v8 SBUV/2 ozone.

MLS Ozone Profile

- **Parallel experiments with GFS T382L64**
- **Running period: 09/22/06-10/21/06**
- **Ozone**

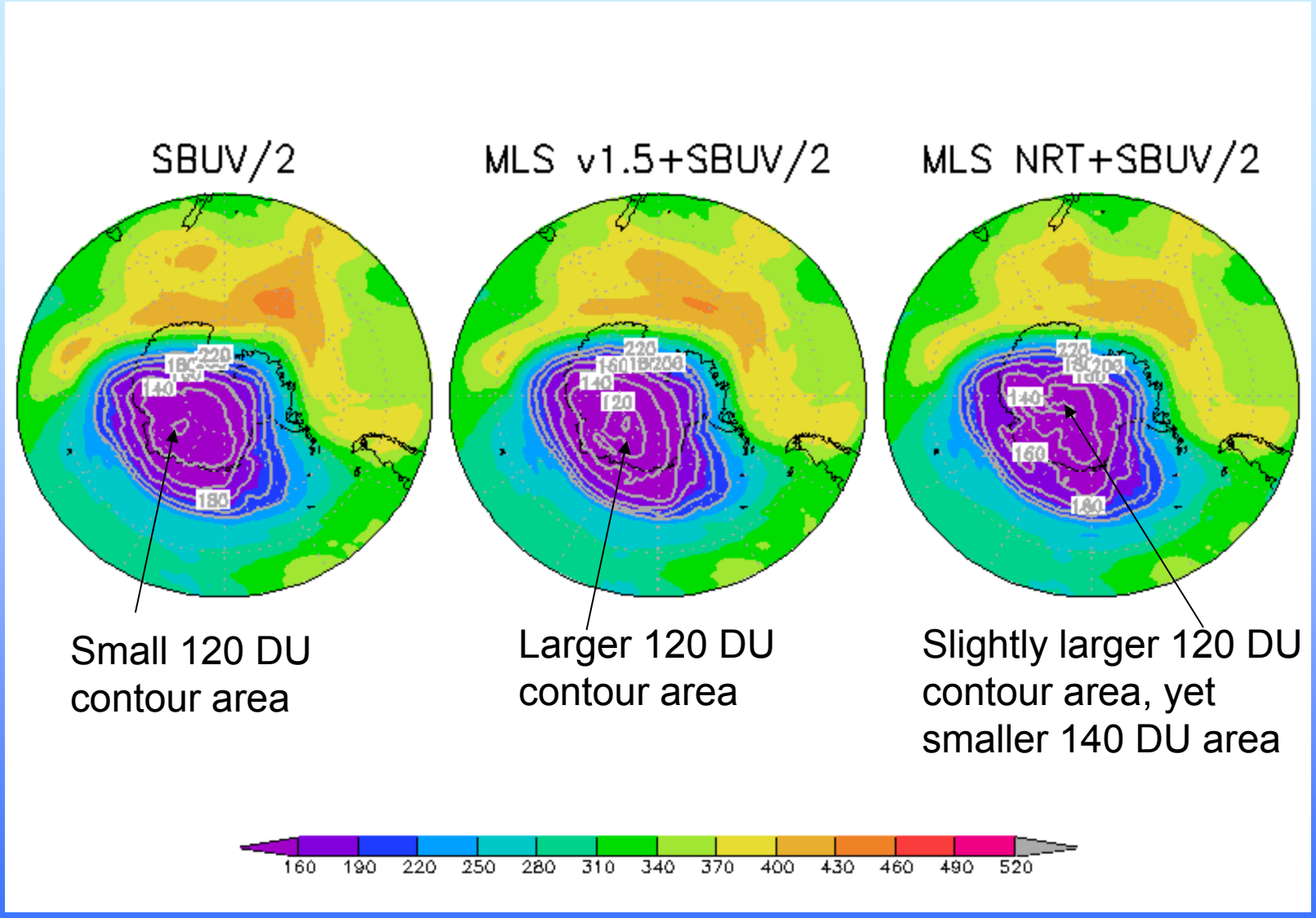
  --- new NRL chemistry

  --- control run uses NOAA-16 and -17 SBUV/2

  --- experiment-1 run adds MLS v1.5 ozone profile from 215 hPa to 1 hPa

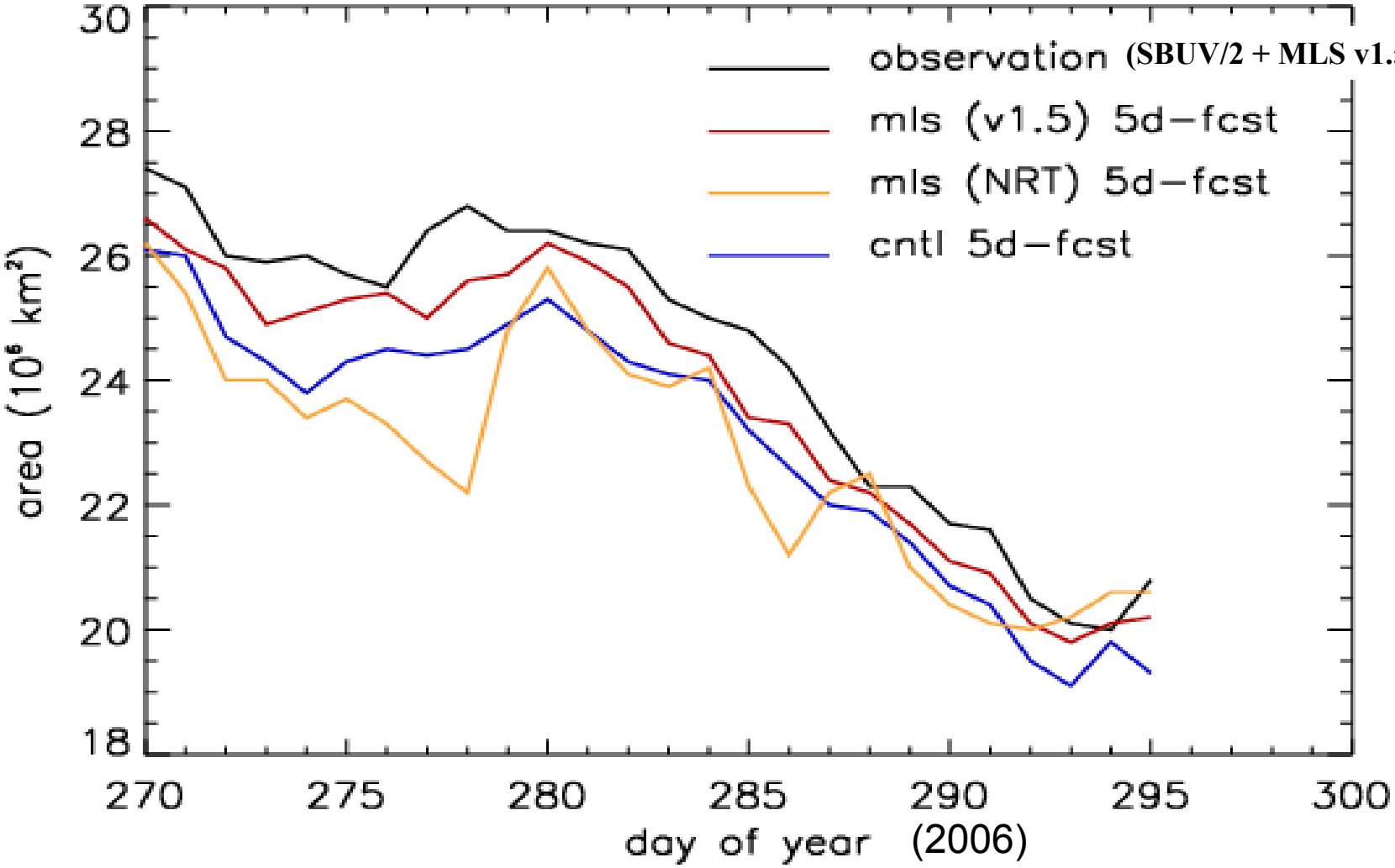
  --- experiment-2 run adds MLS NRT ozone profile from 215 hPa to 1 hPa

Comparison of Ozone Hole Size and Depletion over Antarctica Using 5-Day Fcst

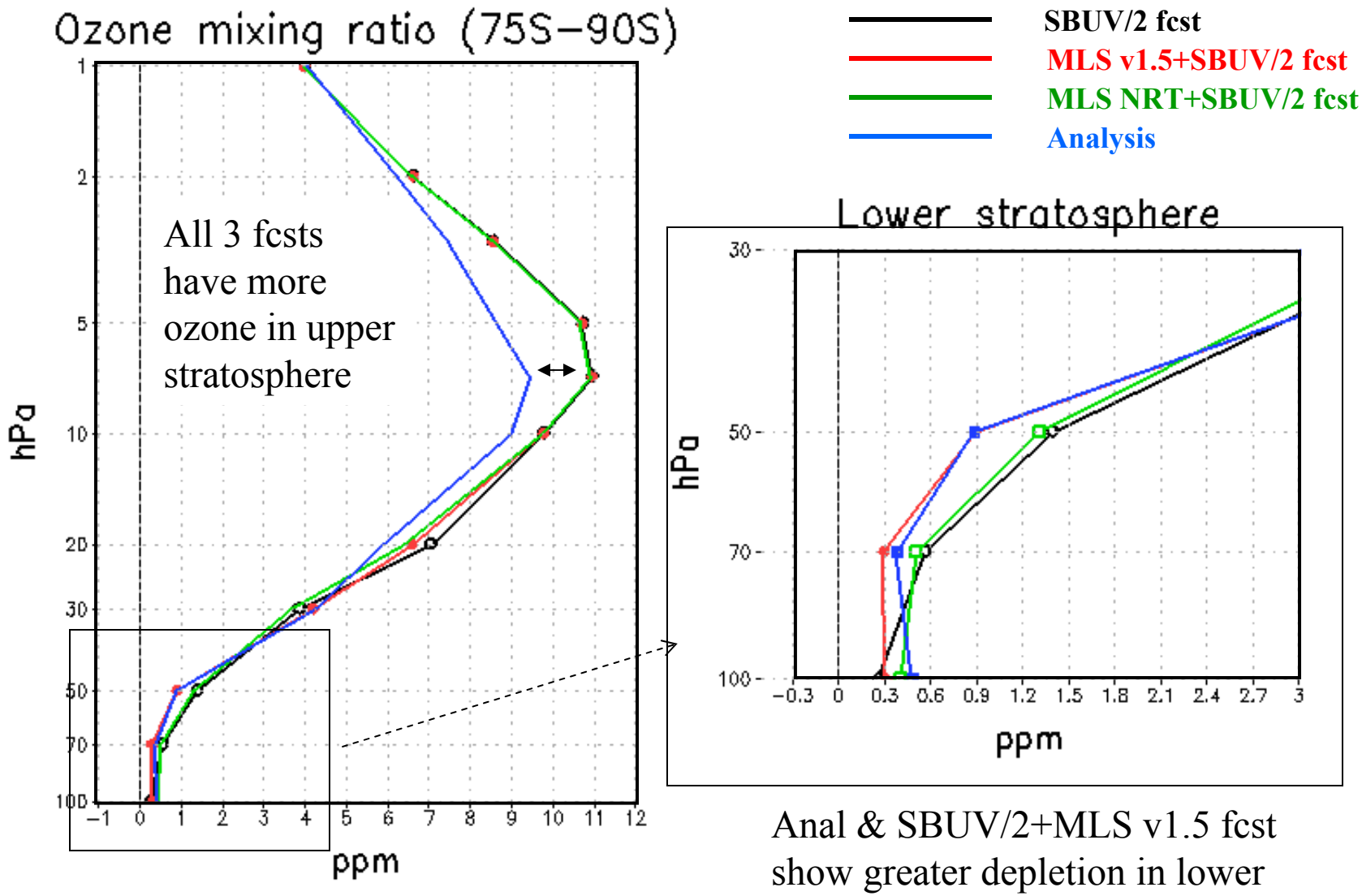


Comparison of 5-day forecast of the Antarctic ozone hole (validated at Oct. 22, 2006). By assimilation of MLS ozone, which has polar night coverage, the experiment runs predict a larger and deeper ozone hole.

Comparison of the Ozone Hole Size between 5-D forecast and Observation

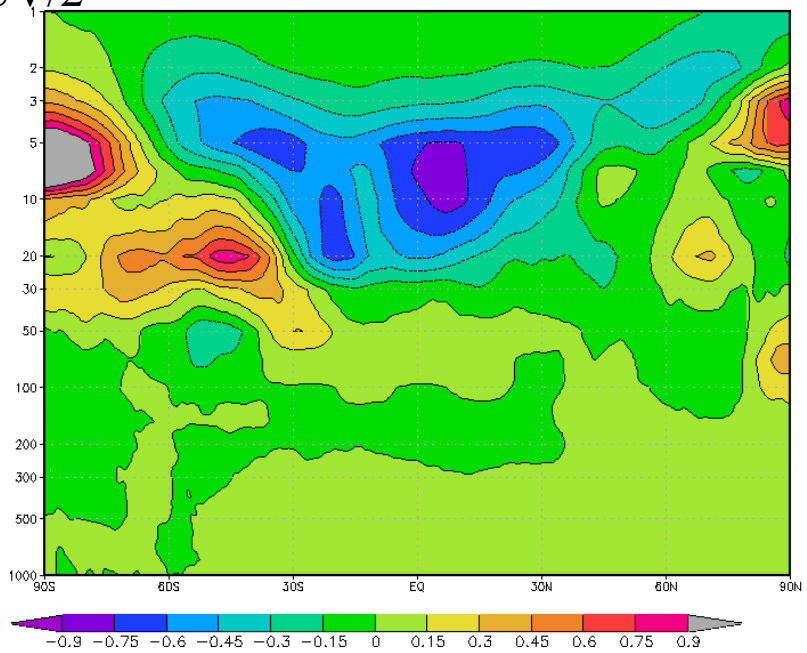


Comparisons of 5-D Fcst of Polar Ozone Profile (75S-90S, valid Oct. 22, 2006).

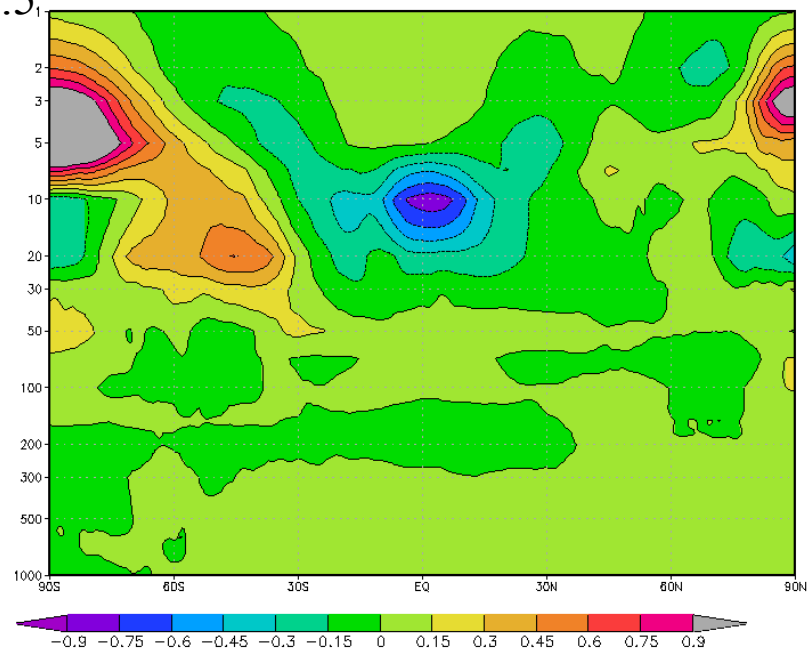


Anal & SBUV/2+MLS v1.5 fcst show greater depletion in lower stratosphere

SBUV/2

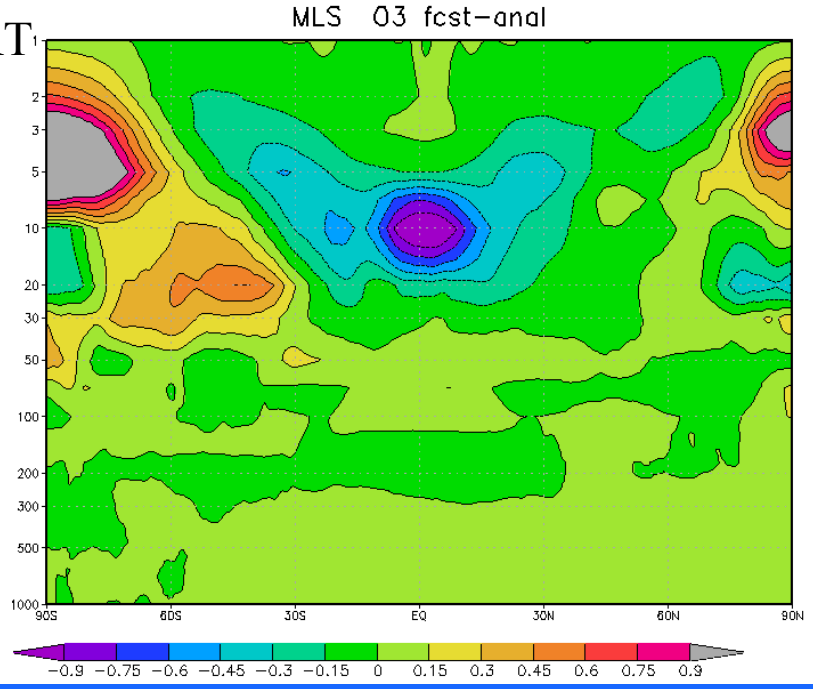


V1.5

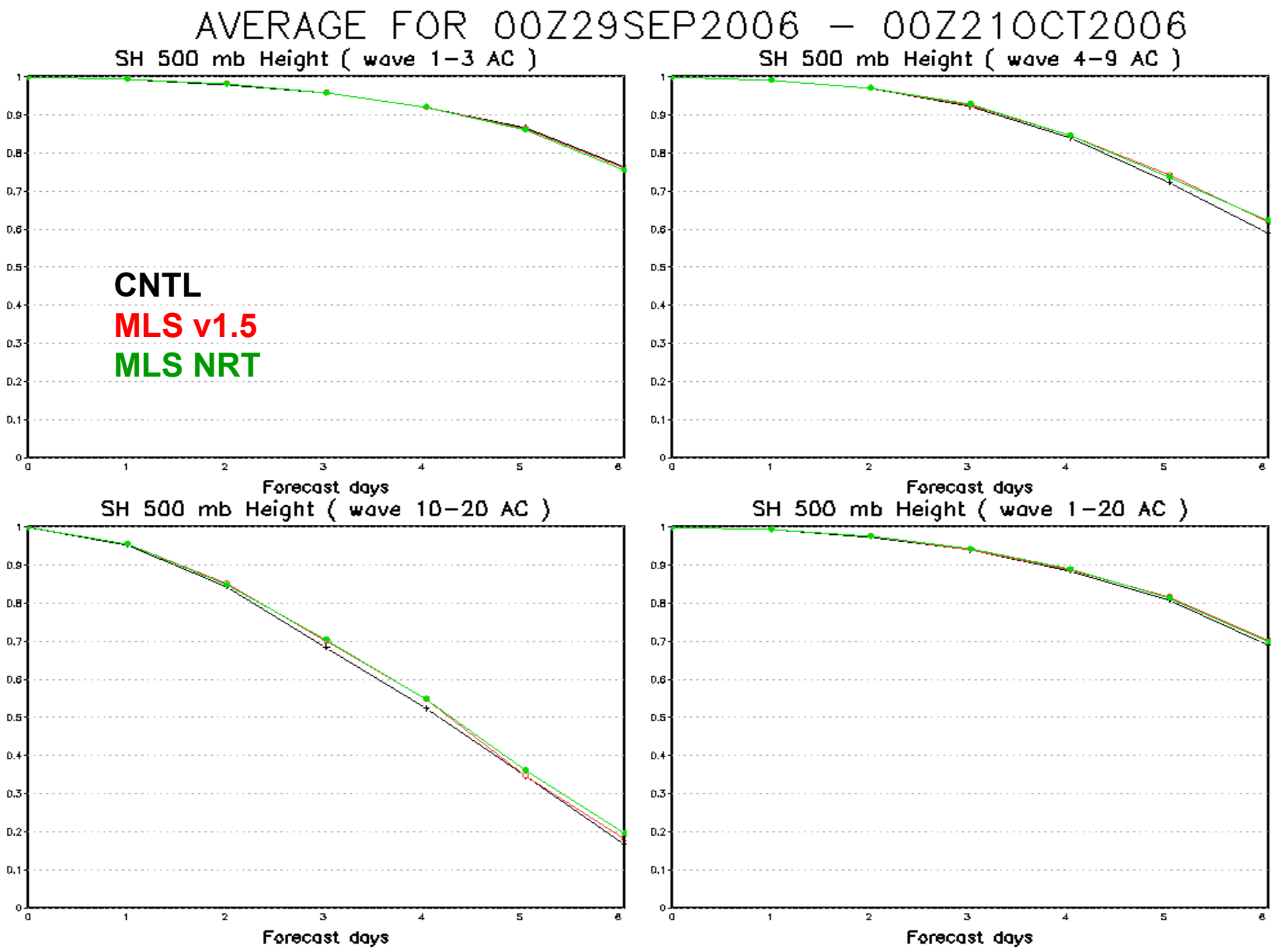


Zonal Mean Ozone Mixing Ration Diff
(Forecast – own anal)

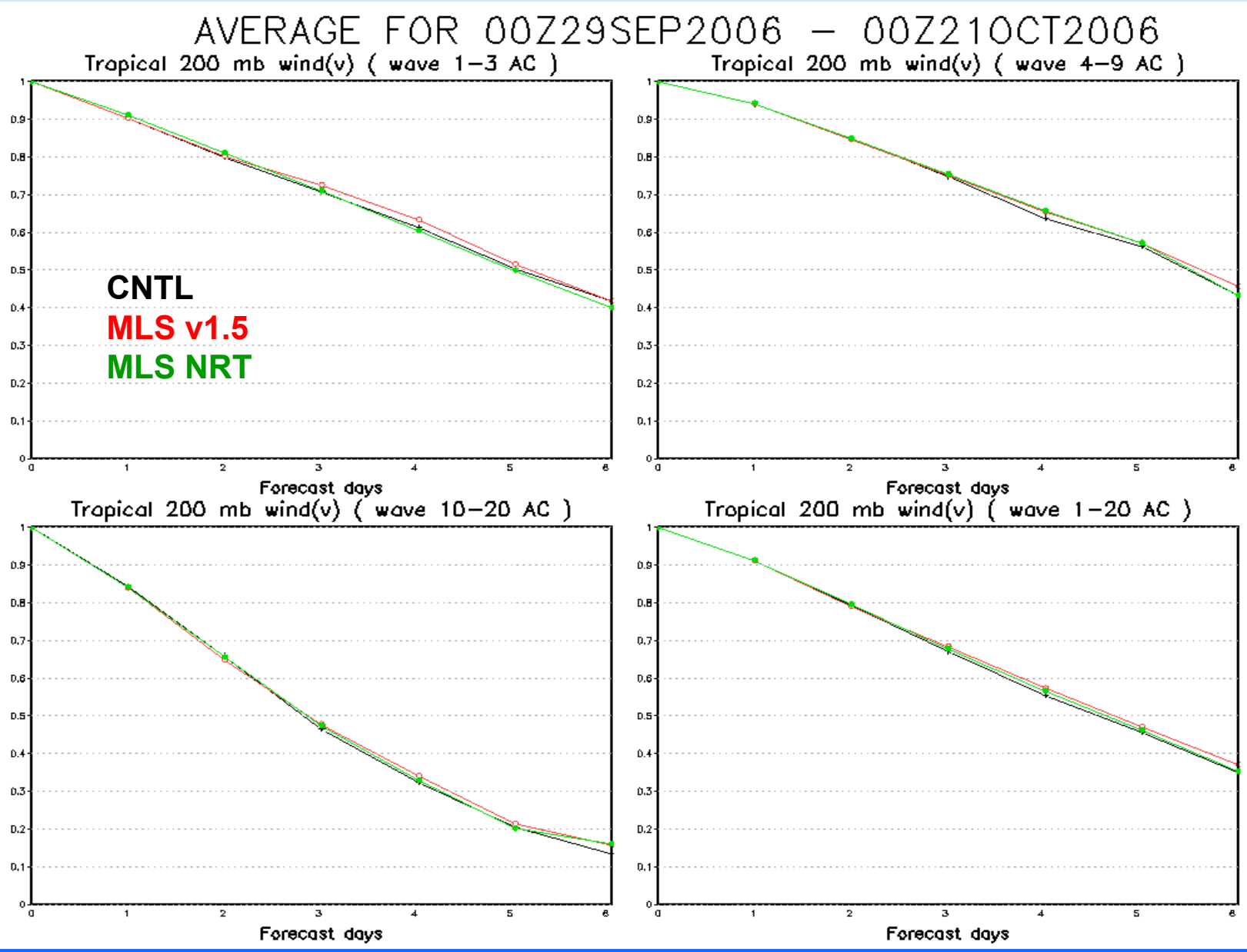
NRT



SH 500 hPa Height (Z) AC



Tropical 200 hPa wind (V) AC



MLS Impact on Forecast Scores (AC)

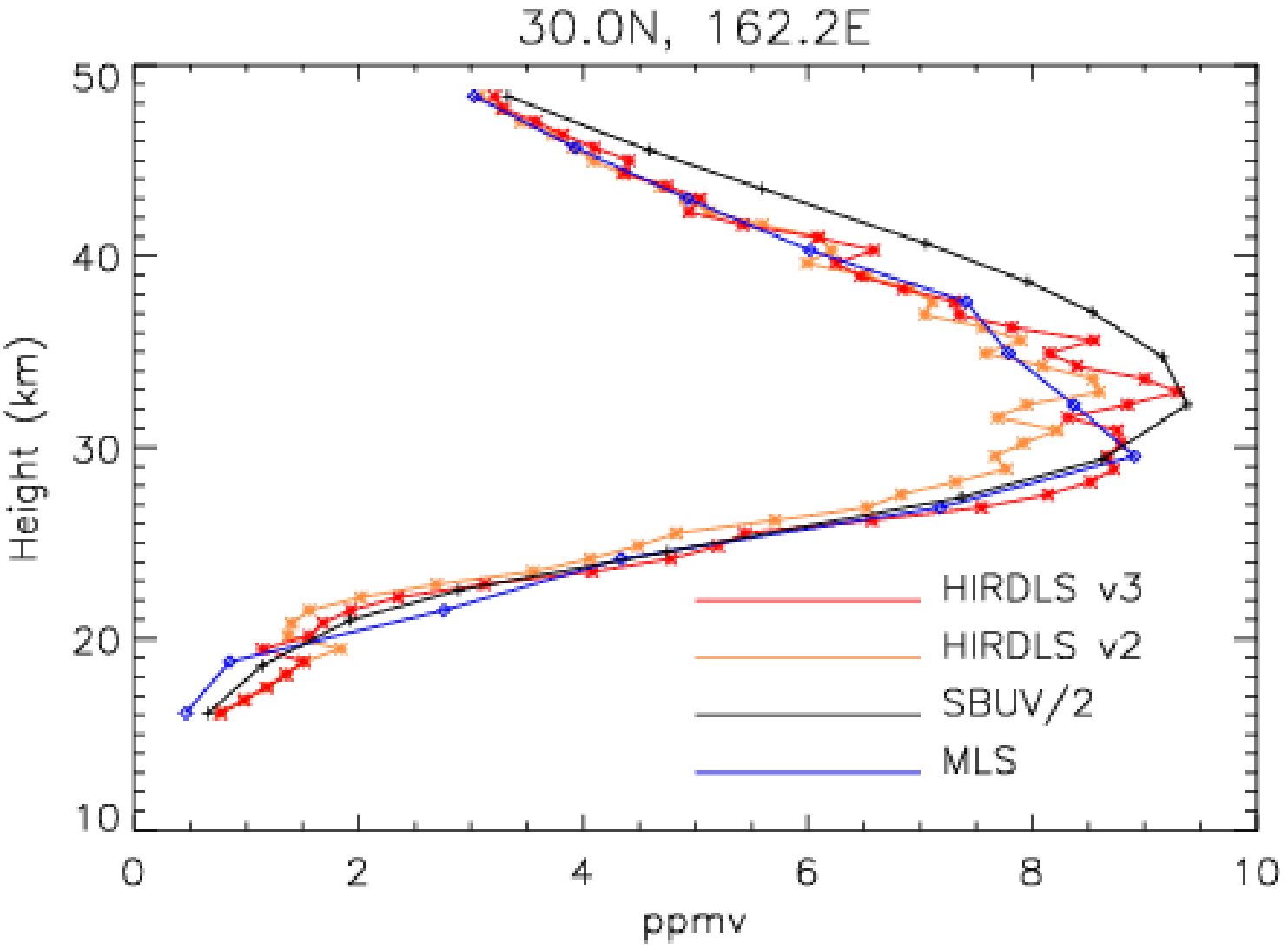
▲ positive ▼ negative neutral

	wave # / variable	1 - 3		4 - 9		10 - 20		1 - 20	
		V1.5	NRT	V1.5	NRT	V1.5	NRT	V1.5	NRT
1	NH 500 Z		▼				▼		▼
2	NH 1000 Z		▼		▼	▲			▼
3	SH 500 Z			▲	▲	▲	▲	▲	
4	SH 1000 Z			▲	▲		▼		
5	TR 200 U						▼		
6	TR 200 V	▲		▲		▲		▲	
7	TR 200 S					▲	▼		
8	TR 850 U			▲		▲	▲	▲	
9	TR 850 V			▲	▲	▲	▲	▲	▲
10	TR 850 S	▲		▲		▲	▲	▲	

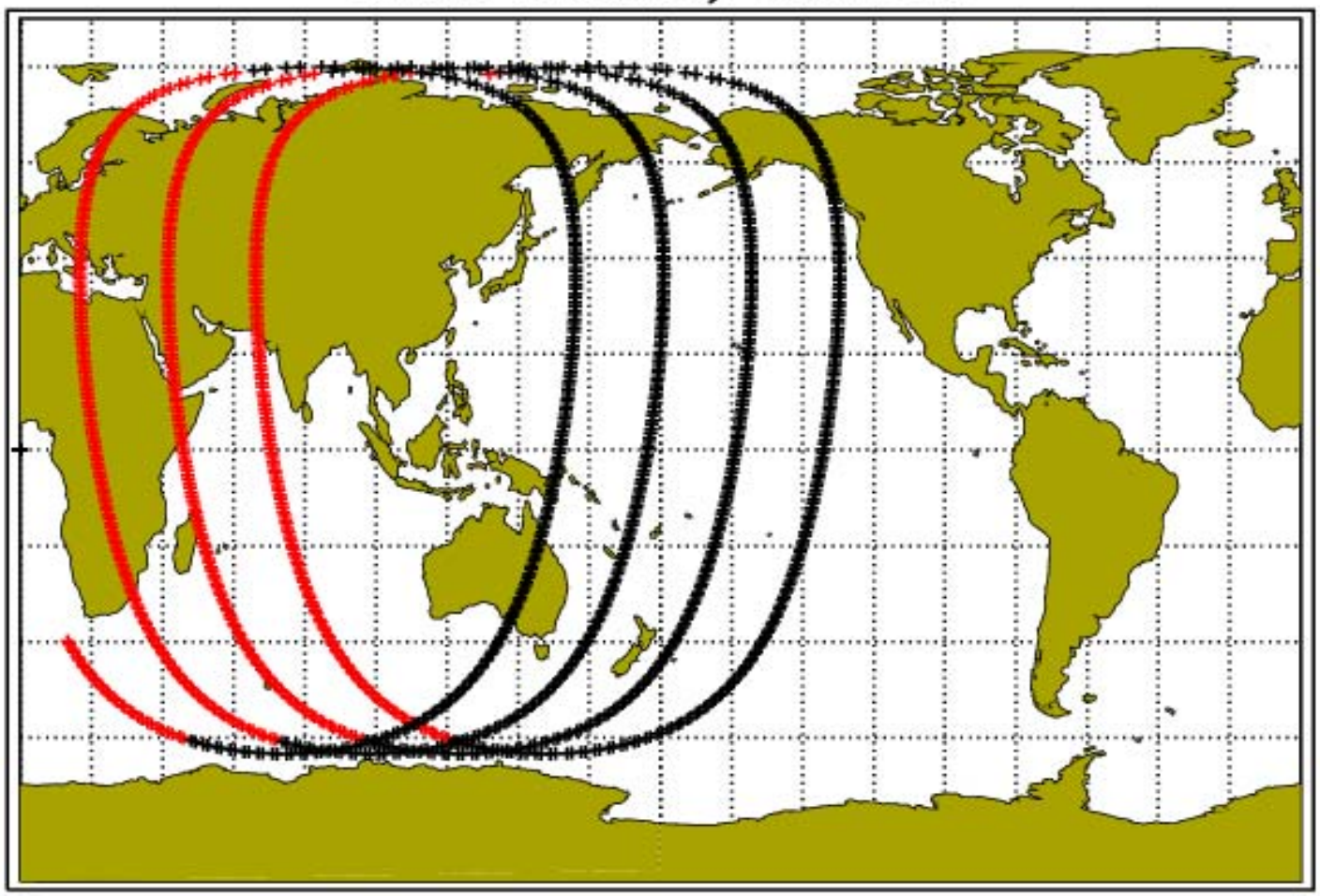
HIRDLS Ozone Profile

- **Comparisons of HIRDLS ozone with MLS and SBUV/2**
- **HIRDLS ozone assimilation experiments**
  - **control: SBUV/2**
  - **experiments: SBUV/2 + HIRDLS (100-1 hPa)**

Coincident observation comparison (lat/lon < 1 deg., t < 1.5 hr) 2006/05/10

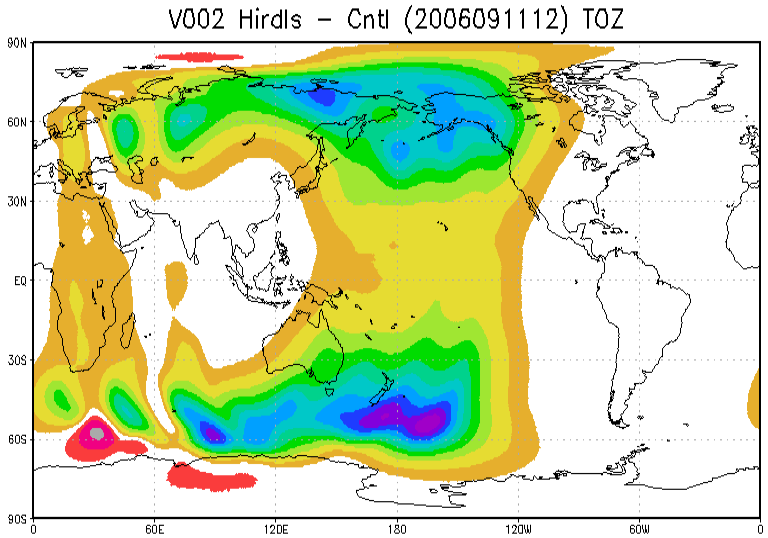


HIRDLS Orbits Day=2006_254 **12Z ± 3 hrs**

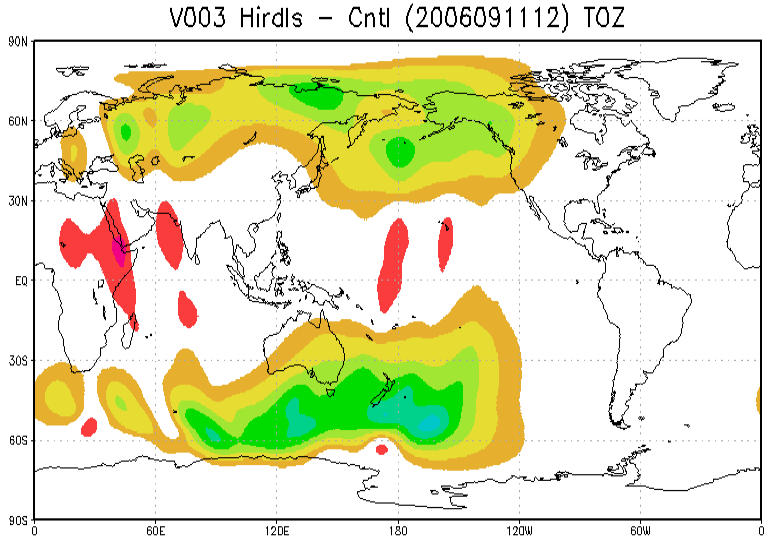


Local day time **Local night time**

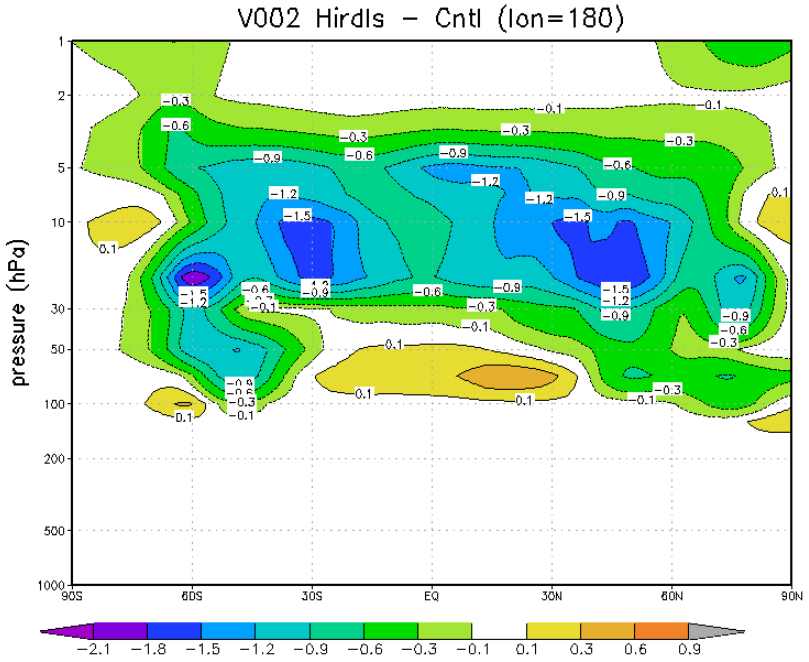
(HIRDLS – CNTL) Total Ozone and Zonal Mean Profile Ozone

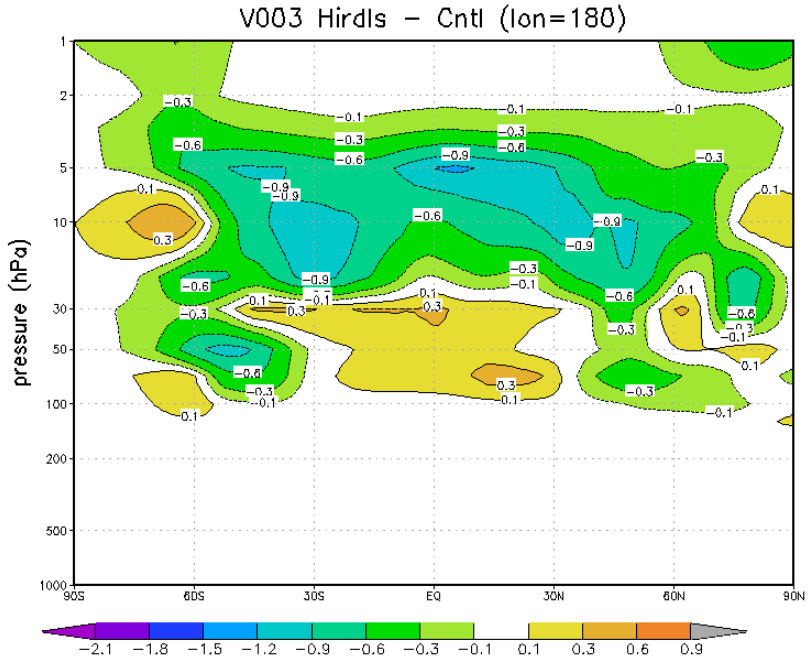


v002



v003





Summary

- Smooth transition in GFS operation from SBUV/2 v6 data to v8.
- Assimilation of MLS v1.5 ozone shows significant improvements in GFS forecast of ozone hole and lower stratospheric ozone. It also has neutral or slightly positive impact on GFS forecast skills. (MLS v2.2 is available.)
- The quality of NRT MLS ozone data is not as good as v1.5 data. MLS Team is working on improving NRT data. We will test it again in GFS when it becomes available.
- The quality of HIRDLS v3 ozone data is much better than v2. It still has a low bias compared to SBUV/2 and MLS. HIRDLS Team is working on it. When the new version is released, we will make parallel runs to see its impact on GFS forecast of ozone and other variables. (Not many days processed)
- With NOAA-16 is drifting away and NOAA-18 SBUV/2 possibly dead, it becomes increasingly important to have additional ozone profile sources for GFS :
  - Aura-MLS, OMI
  - Aqua-AIRS?
  - 2009 – NOAA-N' (descending orbit) SBUV/2
  - 2010 – NPP? OMPS