# Progresses in assimilation of EOS MLS observations

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# I. Assimilation of EOS MLS ozone profiles: the experiment for the autumn of 2005

- **Aims of the experiments:**

  **Evaluating impacts of EOS MLS ozone profiles.**

- **Configurations for control and assimilation experiments:**

  **Assimilation scheme:** ECMWF 6-hourly 3DVAR (CY29r3)

  **Model resolution:** T159L60 with top pressure =0.1 hPa

  **Period:** 2005.01.01 to 2005.01.31 (*Winter run*)
  2005.08.13 to 2005.10.31 (*Autumn run*)

  **Ozone chemical model:** Operational ECMWF ozone model (Cariolle scheme, now updated)

  **Operational ozone observations:** SBUV/2 (ozone layer), Sciamachy (TC)

- **EOS MLS ozone data and quality control**

**Version:** 01.51 (retrieved from EOS MLS R3:240 GHz bands

**Coverage:**

Horizontal: 82 S to 82 N

Vertical: 215 hPa to 0.46 hPa

**Resolution:**

Horizontal: ~160 km

Vertical: ~2.7 km from 147 to 0.46 hPa;

**Typical accuracy:** 2%~15 % ( 0.2 to 0.4 ppmv) for 100 to 1 hPa

**Bias correction:** **No**

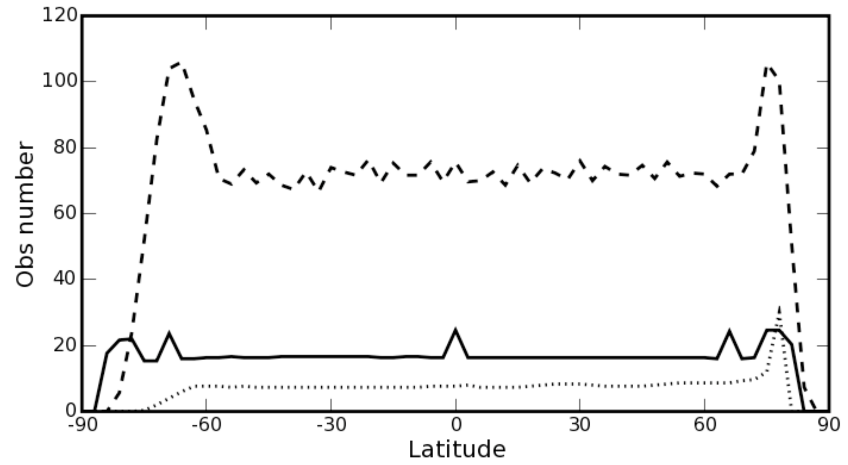
**Quality control:** Besides the variational quality control in the assimilation , quality control is applied to filter out unreliable observations (most in upper troposphere ) at the stage of format conversion.

# Ozone Observation Latitude Coverage in the Autumn of 2005:

The ***Dashed-line*** is the averaged number of the daily assimilated **SCIAMACHY** Total column data within latitude bin of 1 degree: **Very dense, and covers parts of high latitudes**

The ***dotted-line*** is the number of daily assimilated **SBUV/2** ozone during first 10 days of September, 2005 . **No covering on polar night**

**The solid line corresponds to MLS. Good latitude coverage and horizontal dense.**

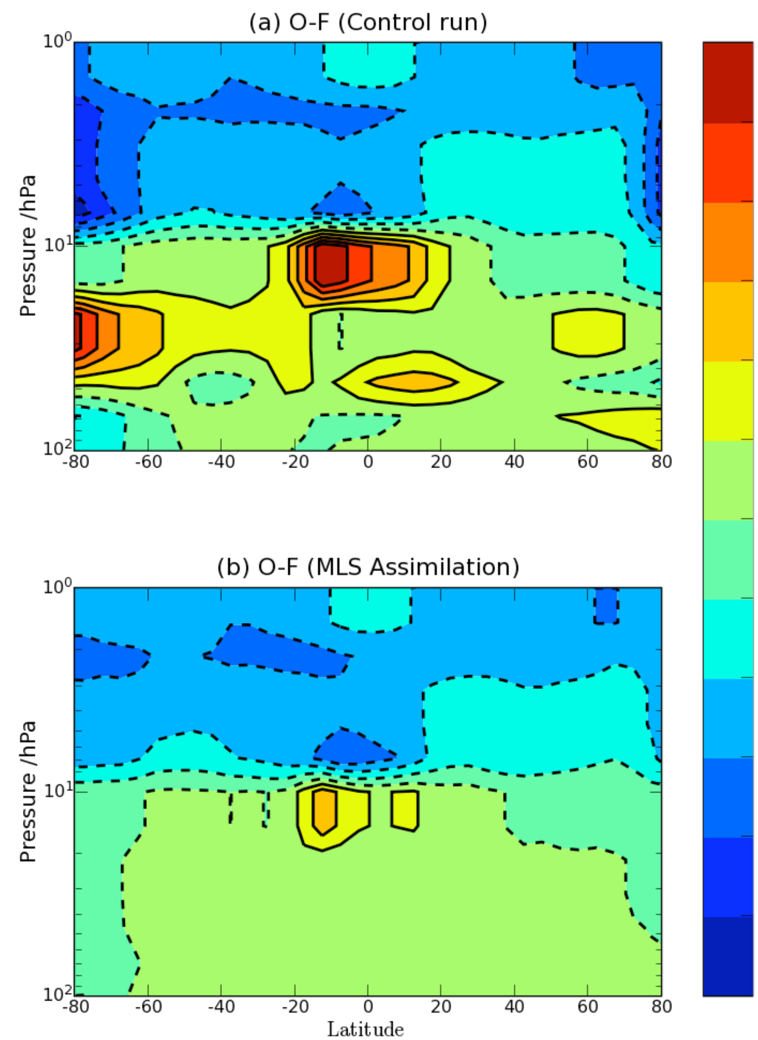


## •Impacts of assimilation of EOS MLS ozone profiles

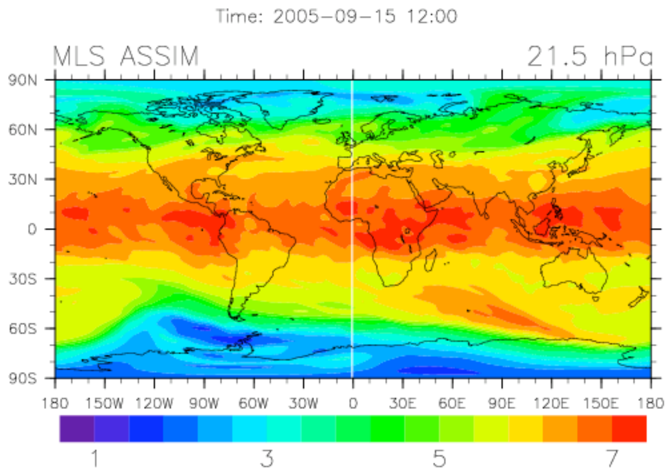
### Impacts on ozone analysis

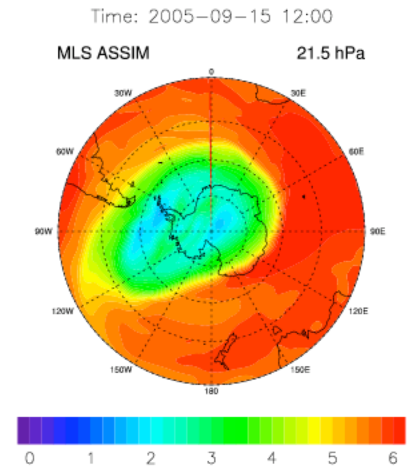
**<u>1. At 100 to 10 hPa</u>: Large positive impacts.**
**<u>2. Above 10 hPa</u>: Impacts are small except at high latitudes**

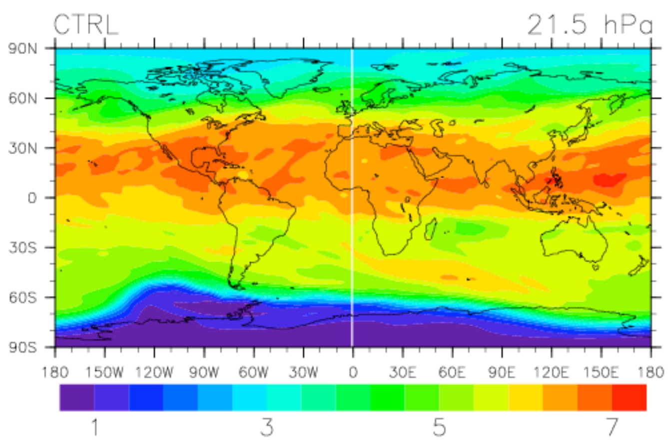
*Example 1---O (MLS)-F for control (**<u>CTR</u>**) and assimilation (**<u>MLS ASSIM</u>**) run.*

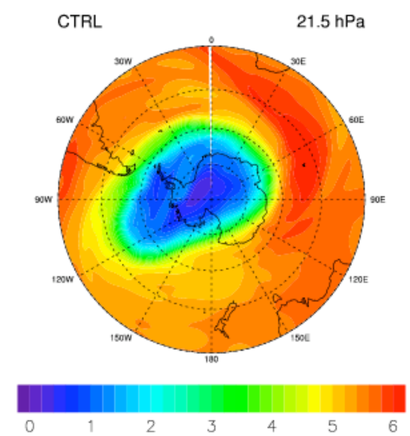


## Example-1 (continue) maps for the control and assimilation run at 21.5 hPa



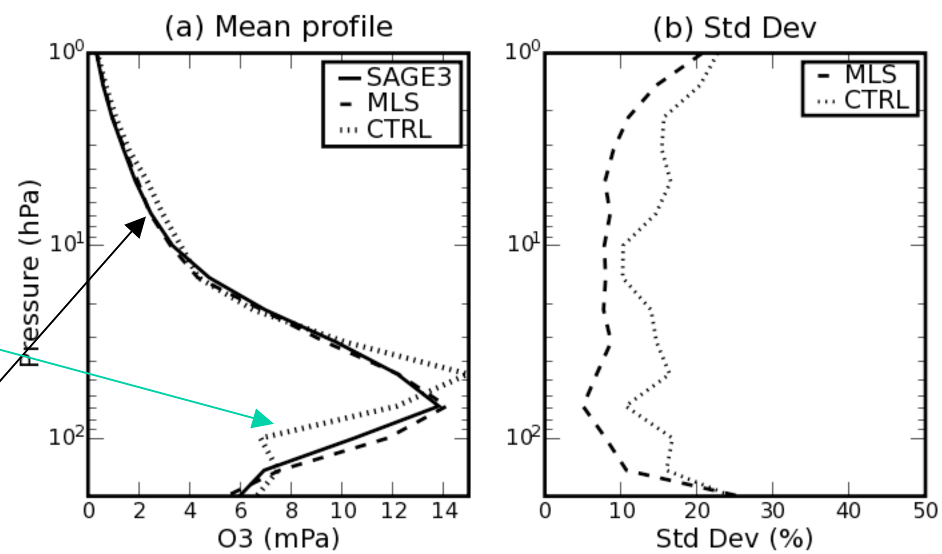

<u>The control run shows less ozone at the southern tropical regions</u>

**At this level**, Too much ozone in the winter vortex **<u>was depleted</u>** in CRTL.

*Example 2---Comparison to SAGE III ozone observations between 60 N to 90 N*

**<u>Assimilation of MLS data lead to</u>**

- General improvement in profile shape in the lower stratosphere.
- Significant reduction of the standard deviation in the whole stratosphere.
- Reduction of the ozone overestimation between 10 to 1 hPa



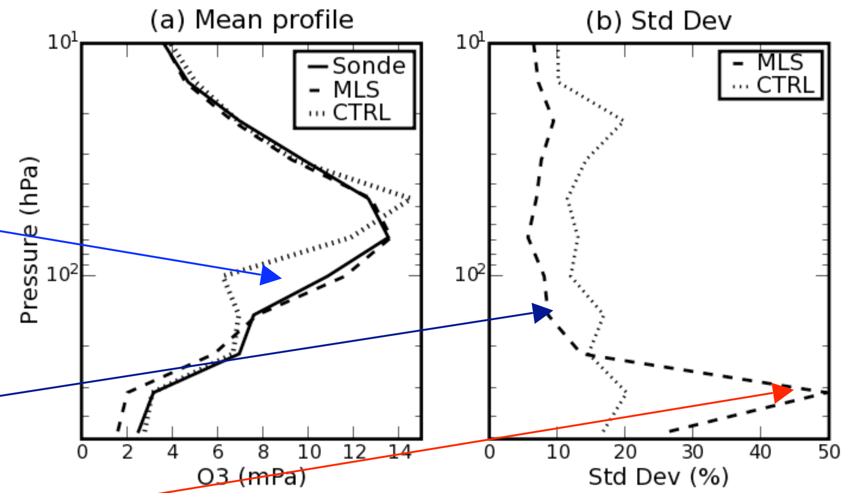
*Example 2 (continue)--- comparison with Ozone sonde between 60 N to 90 N*

1. **The Substantial improvement in the profile shape between 200 to 20 hPa**.

2. **Significant reduction of the <u>standard deviation</u>**

3. *<u>Enlarged negative bias and degraded accuracy seen between 500 to 200 hPa</u>.*
4. *Caused by bias in SBUV/2 layer ozone for surface-16 hPa).*

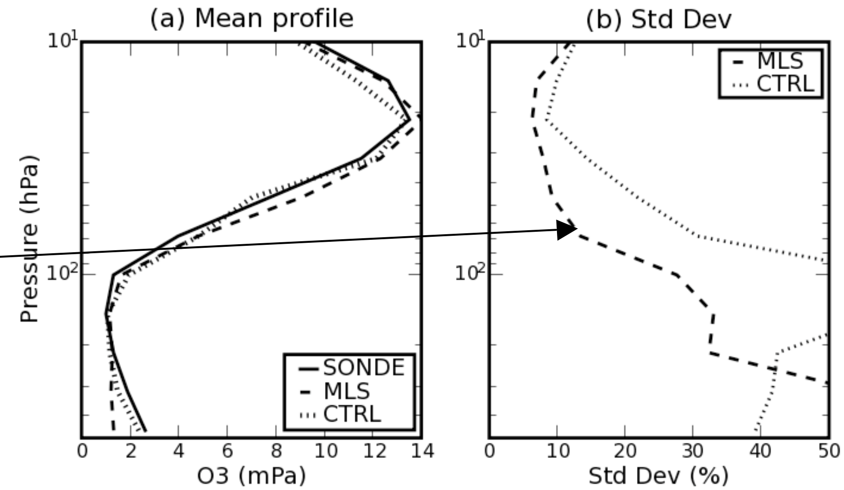
5. **We are trying to retrieve the ozone at 316 hPa using our fast forward model RT-MLS.**



*Example 3---Comparison with ozone sonde data between 30 S to 30 N*

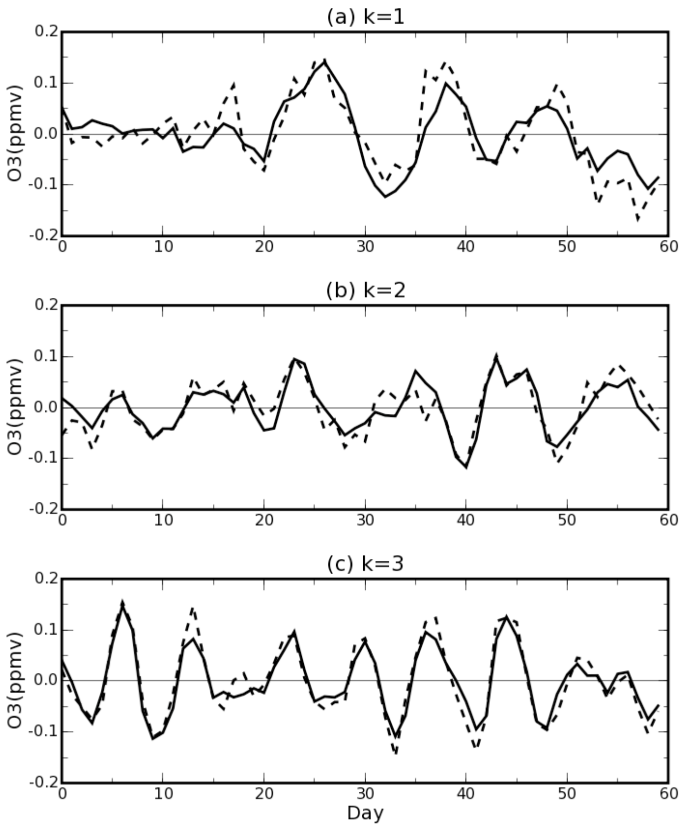
**<u>Assimilation of MLS ozone</u>**

1. Significantly reduces the standard deviation between 200 to 10 hPa
2. Improves the profile shape, and removing some tiny oscillations in the control run.
3. Shows some possible slight overestimation between 100 to 20 hPa.

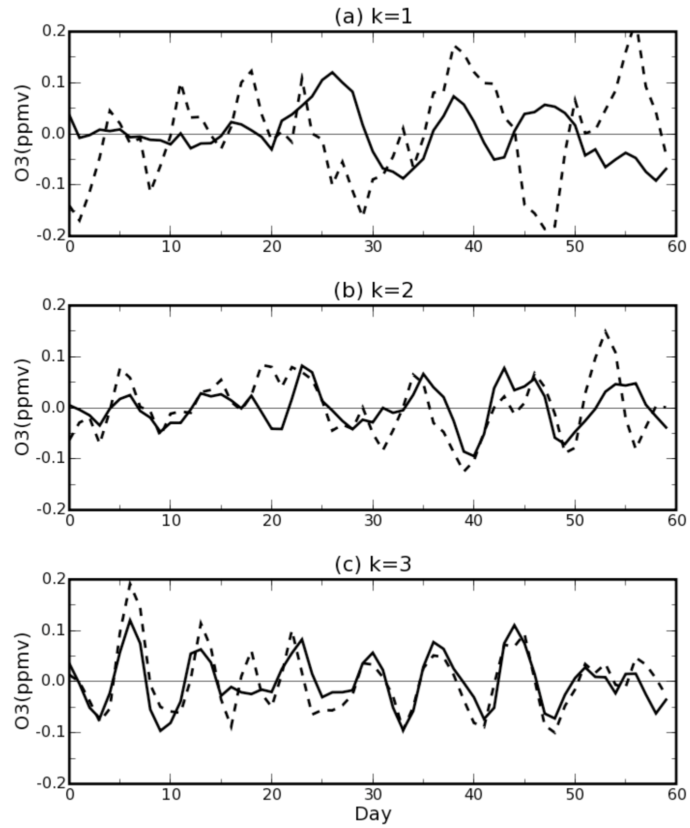


*Example 3---(Continue) More consistent between globe-scale ozone and temperature variations associated with Equatorial Kelvin waves*

MLS ASSIM




CTRL




The comparison of the zonal wave 1-3 components (cosine) of ozone anomalies **(the dashed lines**) at *21.5 hPa* to the ones inferred from temperature perturbations (**the solid lines**) using equations given by Salby et al.

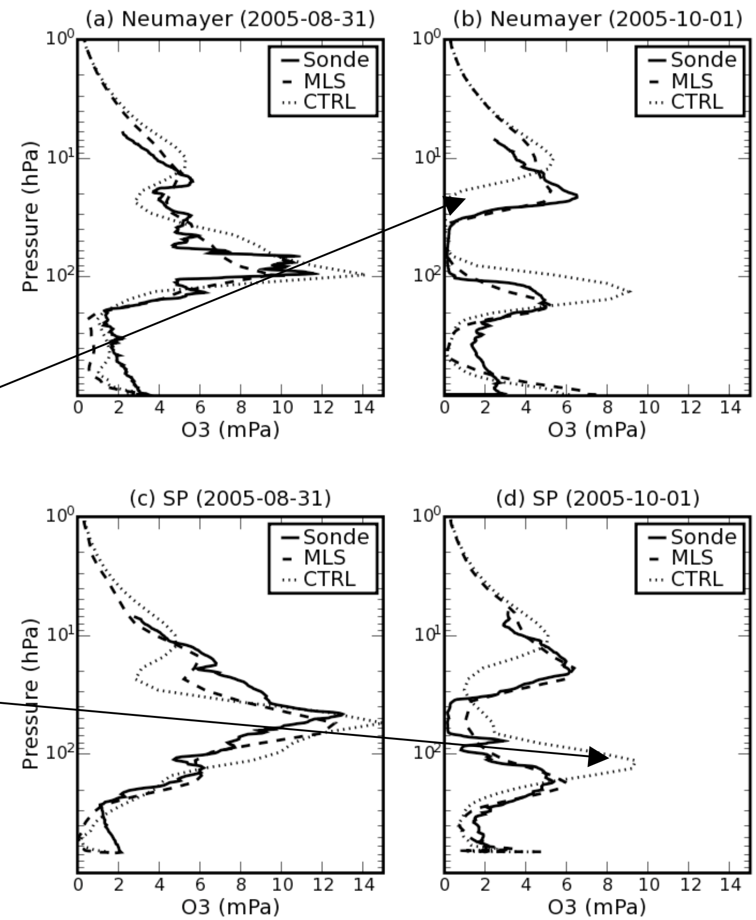
# •Impacts on ozone analysis (continue)

## <u>3. Improved model description of ozone loss in polar vortex</u>

*Example 1----Comparison to ozonesonde over SP and Neumayer (71° S, 8° W)*

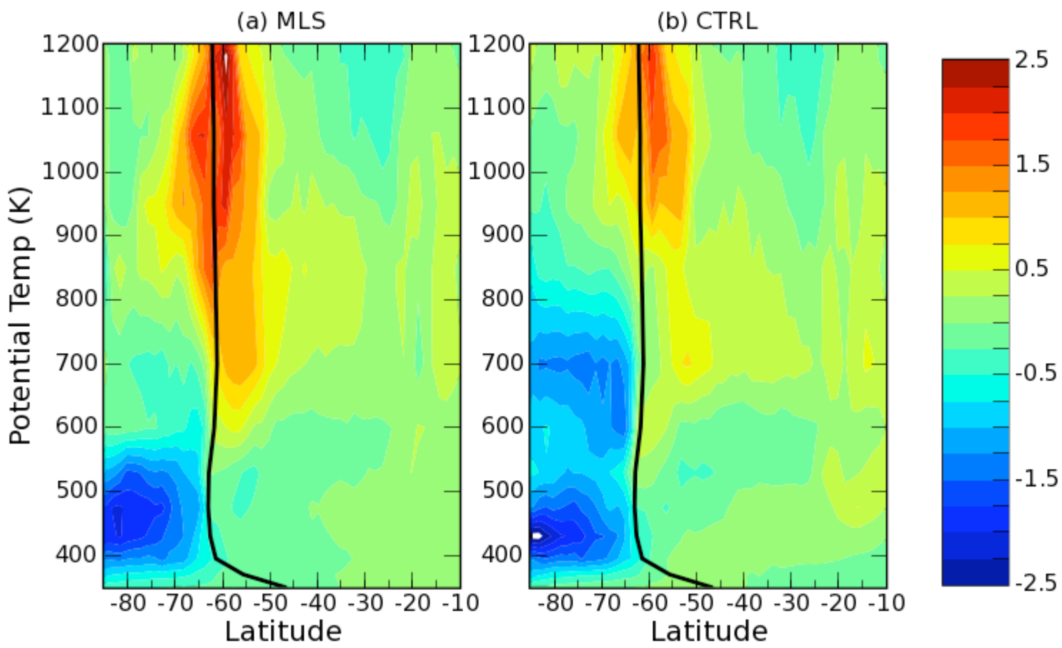
1. The ozone depletion layer is misplaced (shifted towards high altitude) in <u>the control run</u>

2. The control run overestimate the magnitude of the local maximum in the lowest stratosphere.



*Example 2---The net ozone change between Sep.30 and Sep.1 at different equivalent latitudes(Eql).*

- The black line is the vortex edge.
- The control run shows strong ozone depletion above 600 K.
- The assimilation run has much stronger ozone increase around vortex edges (caused by the shrink of the vortex area)

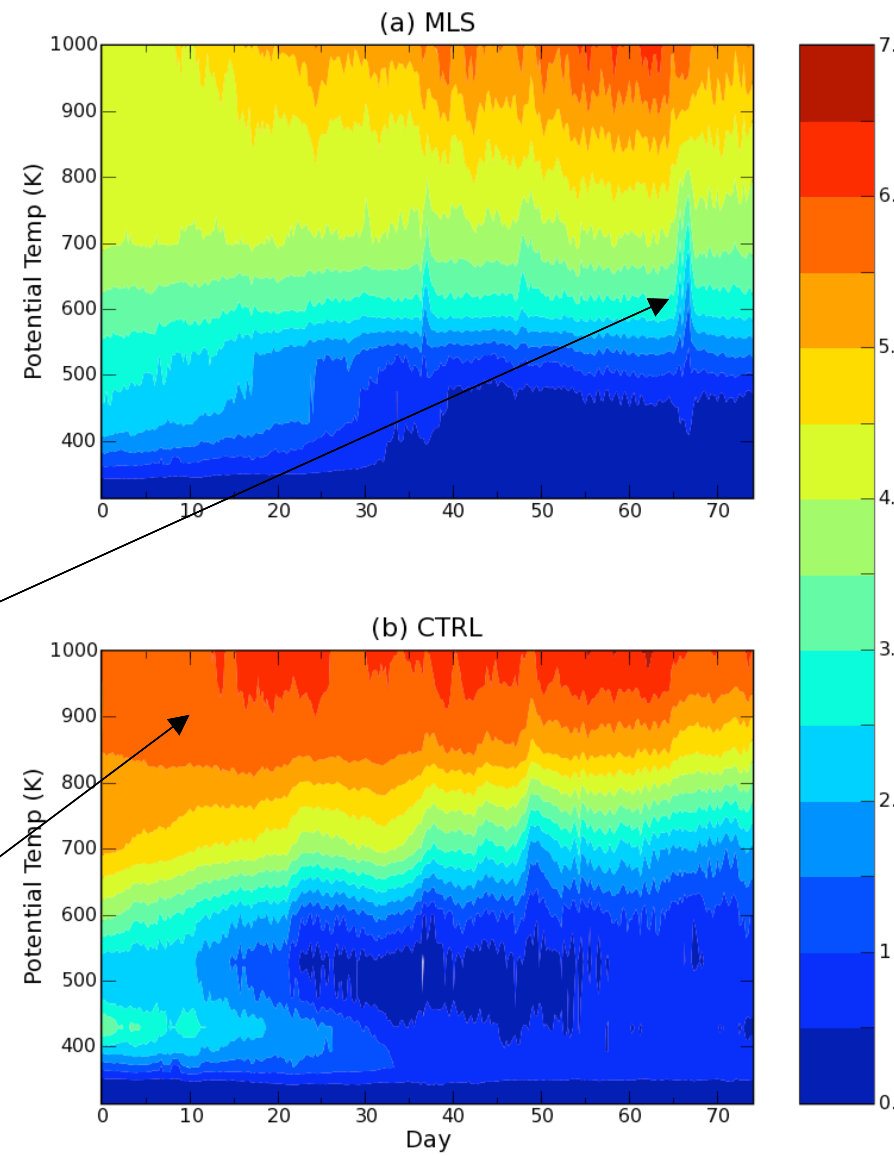


**Example 3---The time evolution of vortex-averaged ozone since 2005.08.15**

1. The complete ozone depletion layer is confined below 580 K in the **assimilation run.**

2. The MLS observation gap may cause some interruptions as shown on day 66 (2005-10-20)

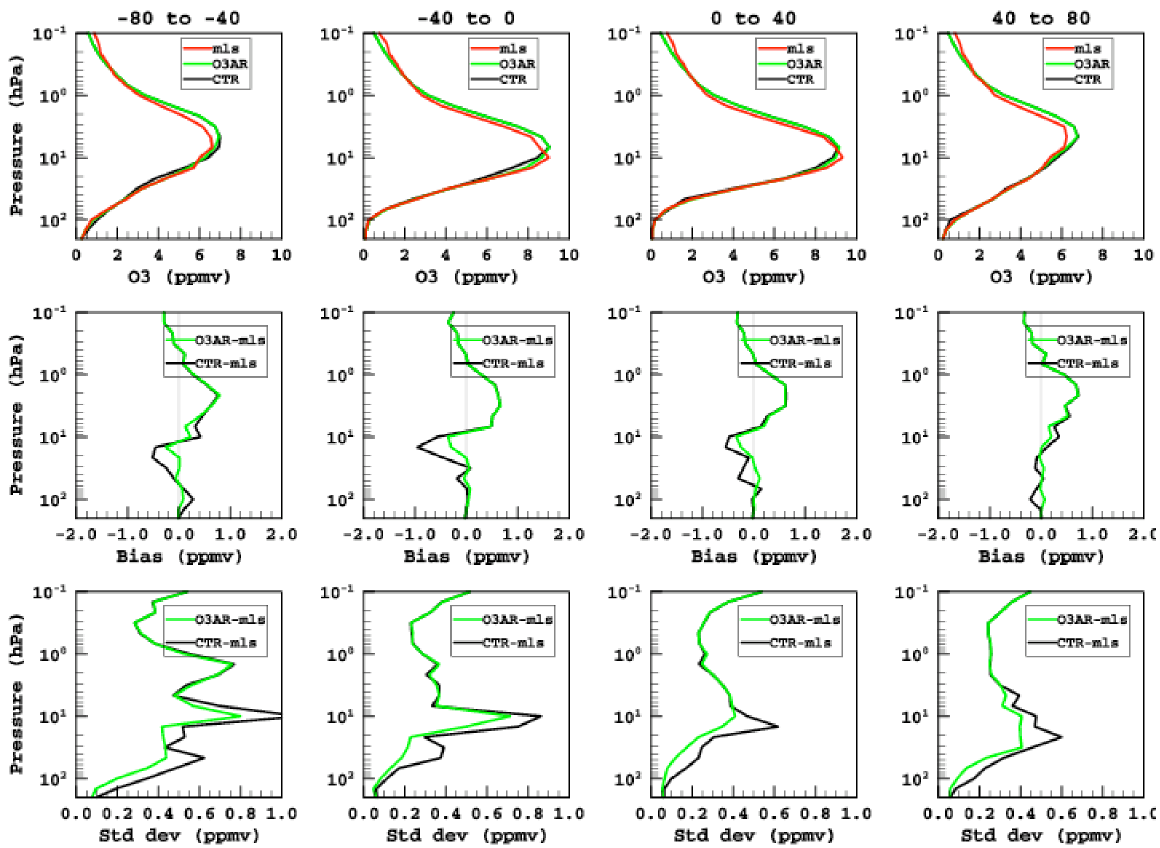
3. The CTRL run has too many ozone between 600 to 1000 K at day 0, followed by un-realistic reduction in the September and October, 2005 (when SBUV/2 observations become available)



# Impacts on ozone forecast

## 1. Better initial conditions help to improve short-term ozone forecasts.

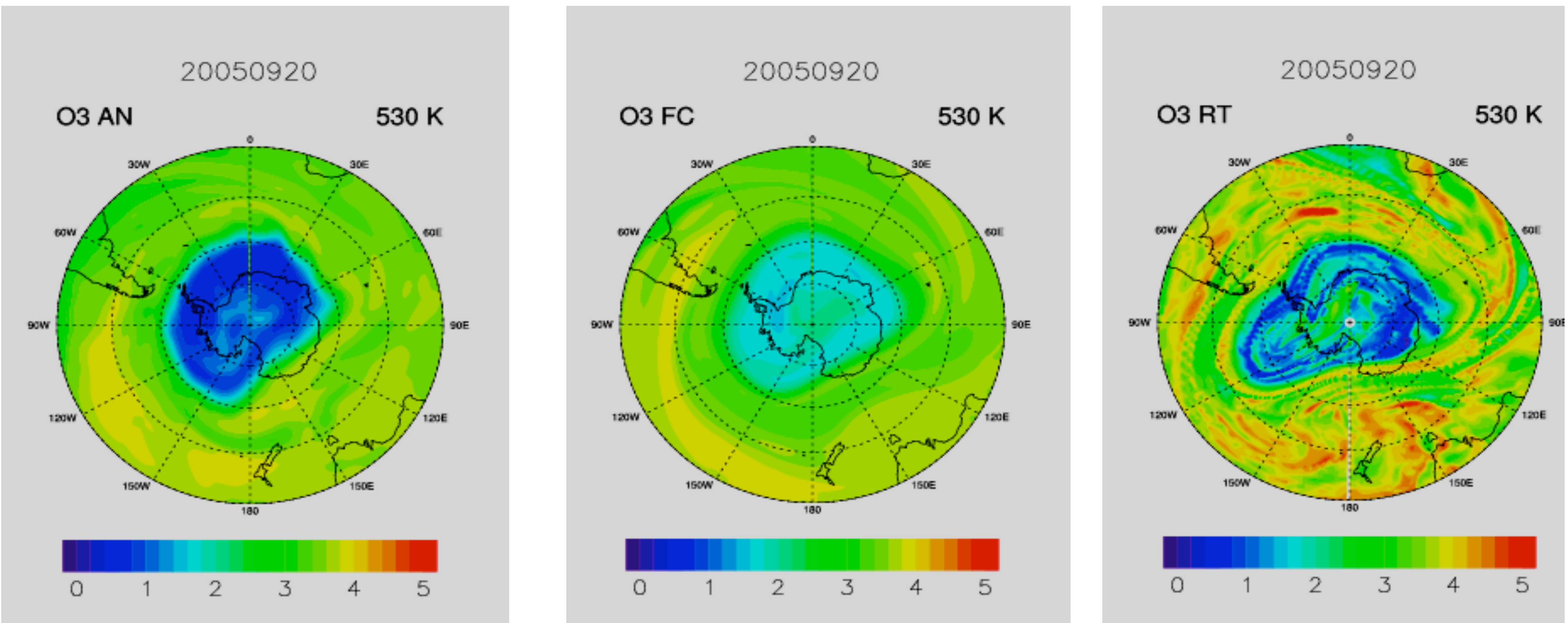
*Example --- comparison of 3-day ozone forecast from analyses of the control (**CTR**) and assimilation run (**O3AR**) to MLS observations at different lat bins*



## • Impacts on ozone forecast (continue)

**2.  Unreliable chemical model prevents us from improving ozone forecast for a longer period, even with a better initial distribution**

*Example --- comparison of 5-day ozone forecasts at 530 K from 2005.09.15 12z with ozone analysis and Reverse trajectory (RT) simulation by (FLEXTRA 3.3) .*

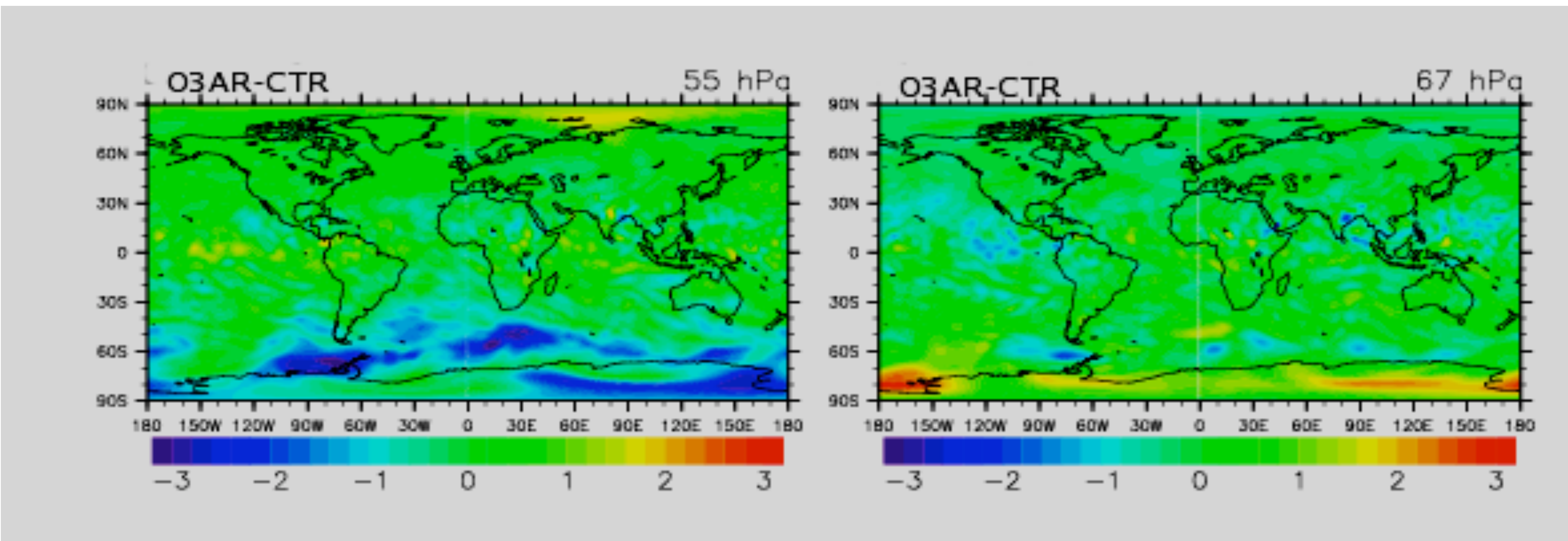


# •Unexpected impacts on temperature field

**•Systematic changes of the ozone field, which are used in radiative transfer model for assimilating radiance of nadir instruments, result in unexpected impacts on temperature.**

*Example --- temperature difference between the ozone assimilation run and control run at 12Z, August 15, 2005 (day 3 since the autumn experiment started)*

**•it may be caused by the interference from assimilating AIRS radiances**



# •Summary

• Assimilation of EOS MLS Ozone profiles have significant positive impacts on ozone analysis at either 100 to 10 hPa or at high latitudes.

• In the middle latitudes, above 10 hPa, many of EOS MLS observations are rejected, possibly because of the biases existing in SBUV/2.

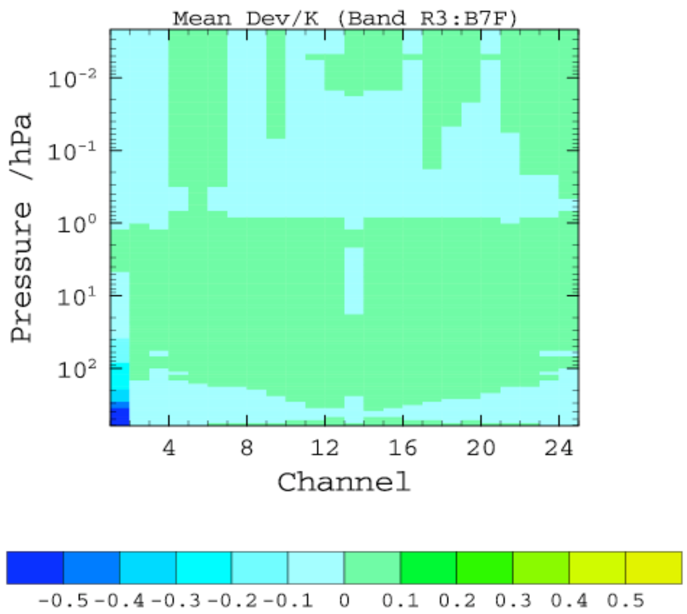
• Improvement on ozone forecast is hindered by the poor chemical model (and by the poor wind forecast as well).

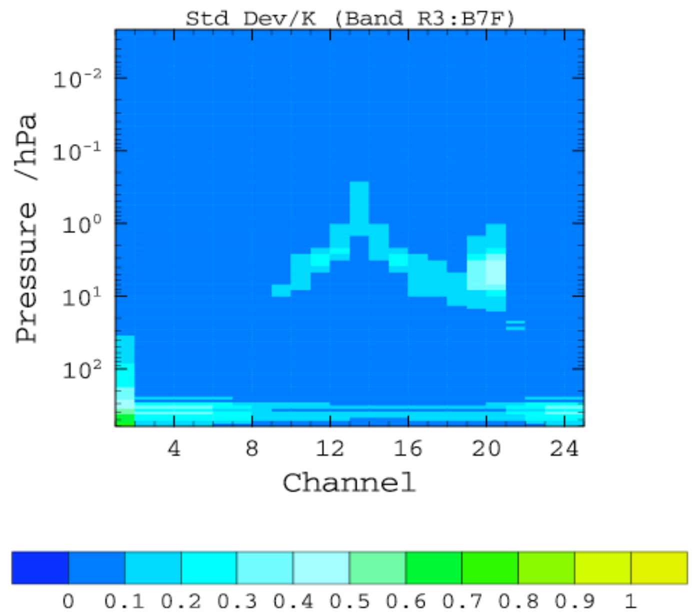
• Interference from radiance assimilation causes some unexpected changes in temperature field, raising questions on the methodology of bias correction.

# II. Progresses in direct assimilation of EOS MLS radiances

1. The fast 2D forward model RTEMLS for direct radiance assimilation is very fast anc in good agreement with the 2D LBL model which is developed from Hugh's forward model .

*Example ---the mean and standard deviation between the LBL model and RTEMLS for the training set of ECMWF 42 diverse profiles.*



2. We are now

- studying the characteristics of the "bias" in observed radiances by comparison to th off-line simulation from ECMWF IFS background.

- choosing appropriate channels for radiance assimilation.

*We need some expertise suggestions here, and we have*

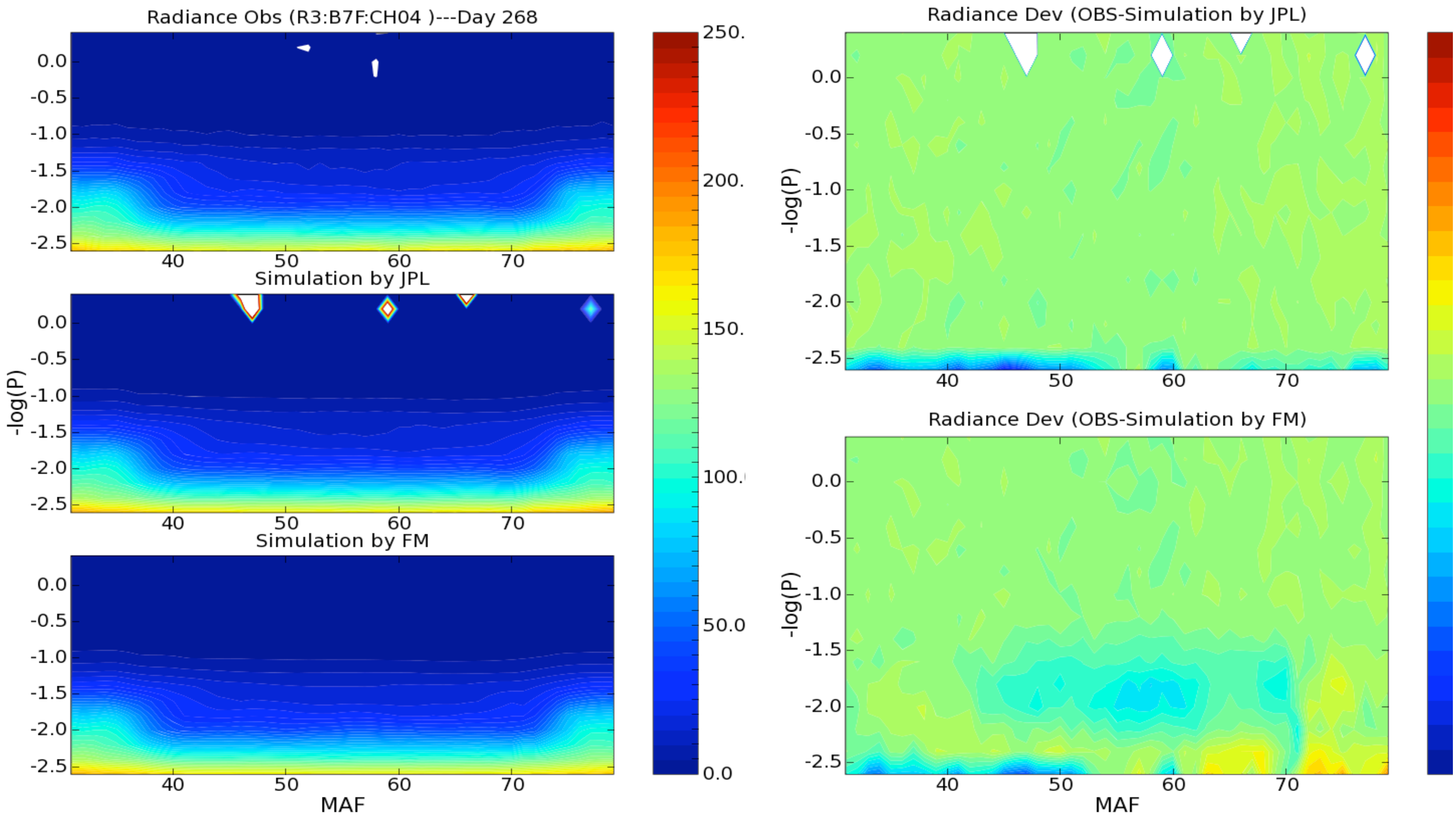
(a) Information concern

(b) Speed concern

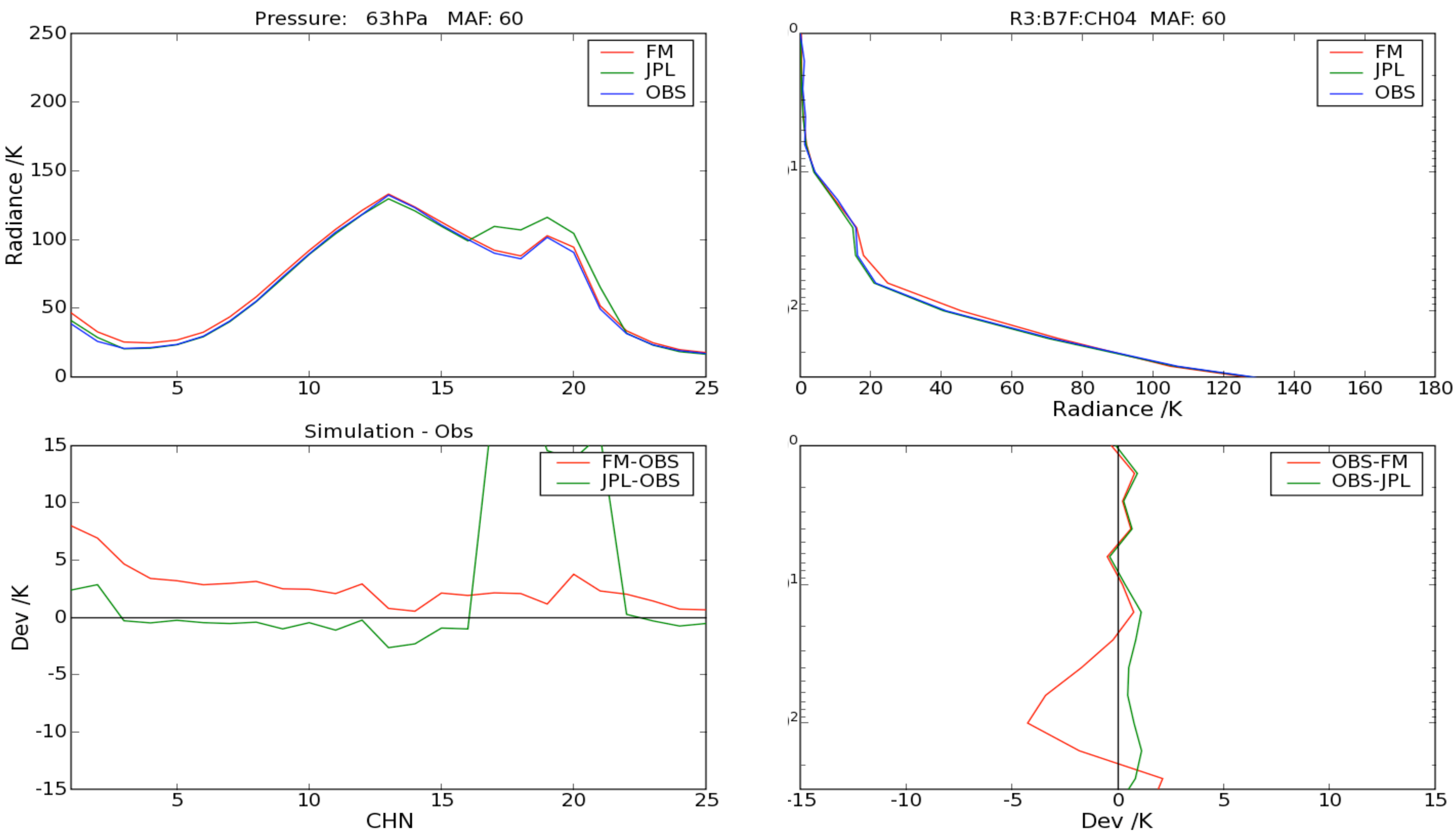
(c) Accuracy concern

In RTEMLS, only T/H2O/O3 are treated as variables, which limits our choice of channels. Indeed, possibly because of the same reason, our 2D LBL model is not always in satisfactory agreement with the JPL forward model as shown in following example where th retrieved T, P, H2O, O3 and Tangent Pressures are used in our LBL forward model calculatic while other trace gases such as HNO3 are taken from climatology

•The chosen 50 consecutive scans on Day 268 (2005.09.25) start from 45º S and pass 82º S before backing to 60º S .



•Plots for the singled-out scans (MAF 60) right inside the vortex.



# III. Outlook

## 1. Continue the experiments for assimilation of EOS MLS retrieved profiles.

- Some short-period experiments for assimilation of MLS temperature and water vapour profiles have already been done.
- Successful assimilation of MLS T/H2O profiles might need:
  (a) significant improvement on H2O background error covariance.
  (b) a flexible or adaptive bias correction scheme for direct assimilation of nadir instruments (Dick Dee et al., 2005).
  (c) more reliable MLS temperature profiles.

## 2. Intend to start some experiments for direct assimilation of EOS MLS radiance in next 6 months.