Ozone measurements from IASI and MLS over Antarctica during 2008 and 2009 austral winters

L. EL AMRAOUI , V.-H. PEUCH, and J. BARRE

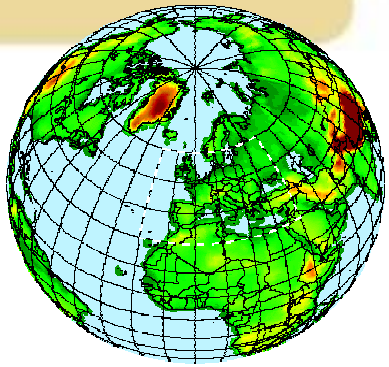
CNRM – GAME, Météo-France, Toulouse

CONCORDIASI WORKSHOP, 29-31 March 2010

Outline

- The data assimilation system: MOCAGE-PALM
- Validation of IASI analyses
- Meteorological conditions during 2008 & 2009 austral winters
- Chemical conditions
- Ozone loss
- Summary

Assimilation tool : MOCAGE



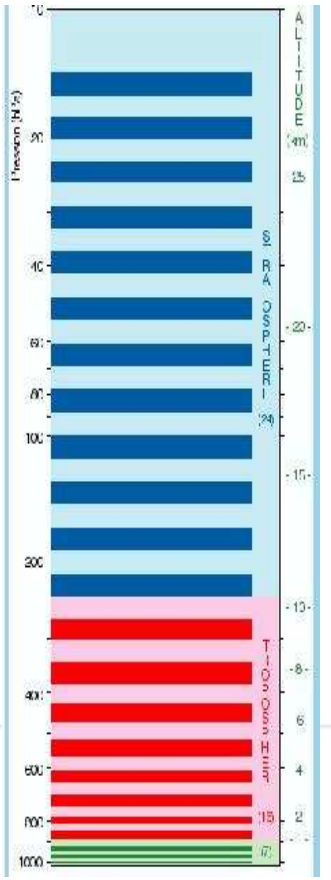
- **Horizontal Configuration :**
  - Global (2° x 2°) ➔ comprehensive schemes
  - Global (0.5° x 0.5°) ➔ Linear chemical schemes (O3, CO)

Vertical configuration :

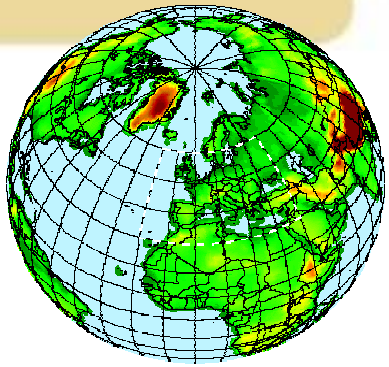
- 47 levels : surface → 5 hPa
- 60 levels : surface → 0.1 hPa

- **dynamical forcing :**
  - ARPEGE (Météo-France NWP)
  - ECMWF

- **chemical scheems :**
  - RACMOBUS: detailed chemical scheme (tropo + strato)
  - CARIOLLE (Linear O3 strato)
  - CARIOLLE (Linear CO tropo + strato)



Assimilation tool : MOCAGE



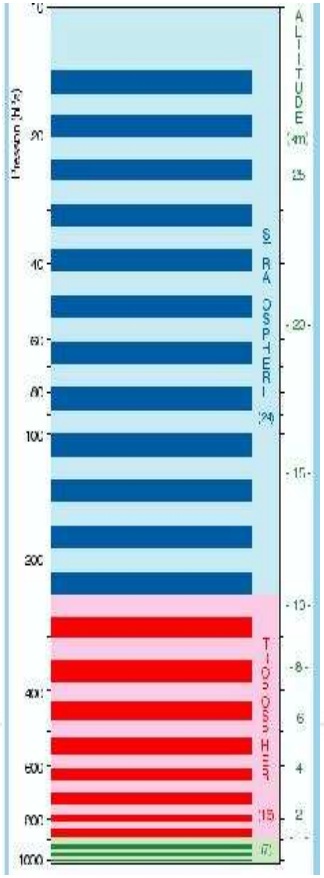
- **Horizontal Configuration :**
  - **Global (2° x 2°) ➔ comprehensive schemes**
  - Global (0.5° x 0.5°) Linear chemical schemes (O3, CO)

Verticale configuration :

- **47 levels : surface → 5 hPa**
- 60 levels : surface → 0.1 hPa

- **dynamical forcing :**
  - **ARPEGE (Météo-France NWP)**
  - ECMWF

- **chemical scheems :**
  - **RACMOBUS: detailed chemical scheme (tropo + strato)**
  - CARIOLLE (Linear O3 strato)
  - CARIOLLE (Linear CO tropo + strato)



Assimilation tool: PALM

- **Method**: Variational : 3D-FGAT (First Guess at Appropriate Time)

→Minimisation of the cost function, J(x) (observations + model)

$$J(x) = \frac{1}{2}\left[x(t_0) - x^b(t_0)\right]^T \mathbf{B}^{-1}\left[x(t_0) - x^b(t_0)\right] + \frac{1}{2}\sum_{i=1}^{p}\left[y(t_i) - H(x(t_i)\right]^T \mathbf{R}_i^{-1}\left[y(t_i) - H(x(t_i))\right]$$

$$J(x) = J_b(x) + J_o(x)$$

- **Advantages of PALM**: Modular Processes

→Flexibility (choice of the parameters)

- **It also takes into account the vertical correlation**

→ Characterization of different layers

→ Assimilation of the total column has a direct impact on the vertical profile

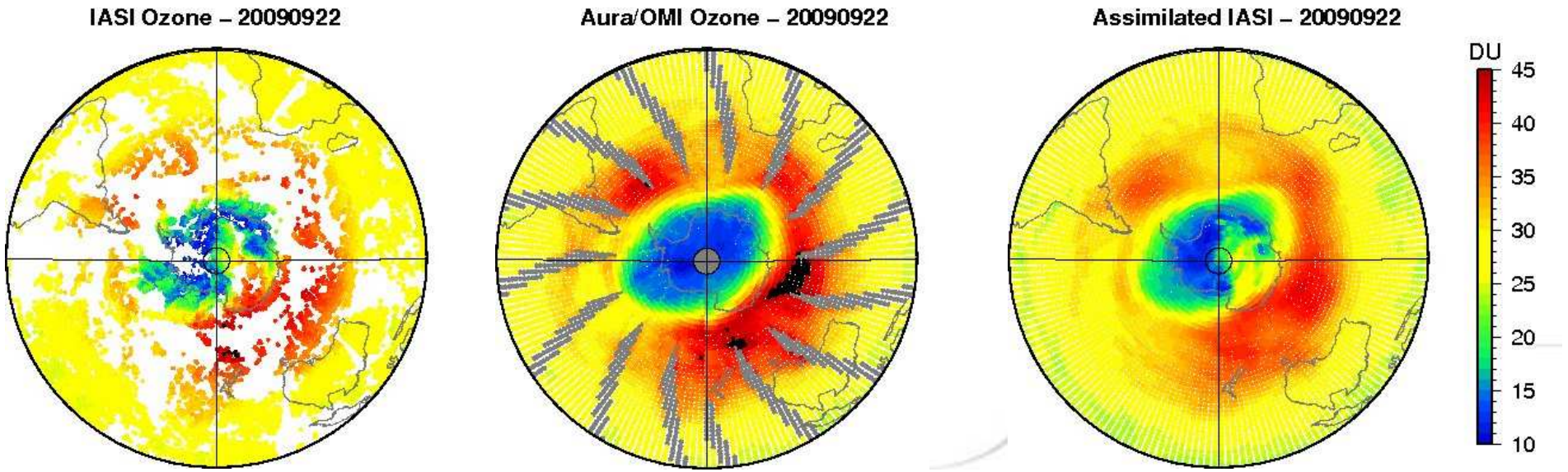
IASI ozone Observations

- The pre-operational product L2 of the total column from EUMETSAT
- The selected pixels are not contaminated by the clouds at all
- **" Neither Averaging kernels, nor covariance matrices are available "** !!!

  ➔ Difficulty to do a realistic assimilation exercise

  characterization of the errors + vertical sensitivity of the measurements

- **Still now, we estimate the errors of IASI on the basis of the a posteriori self-consistency diagnostics (Chi-square) ➔ BIG APPROXIMATION**



Assimilation Results: 2008

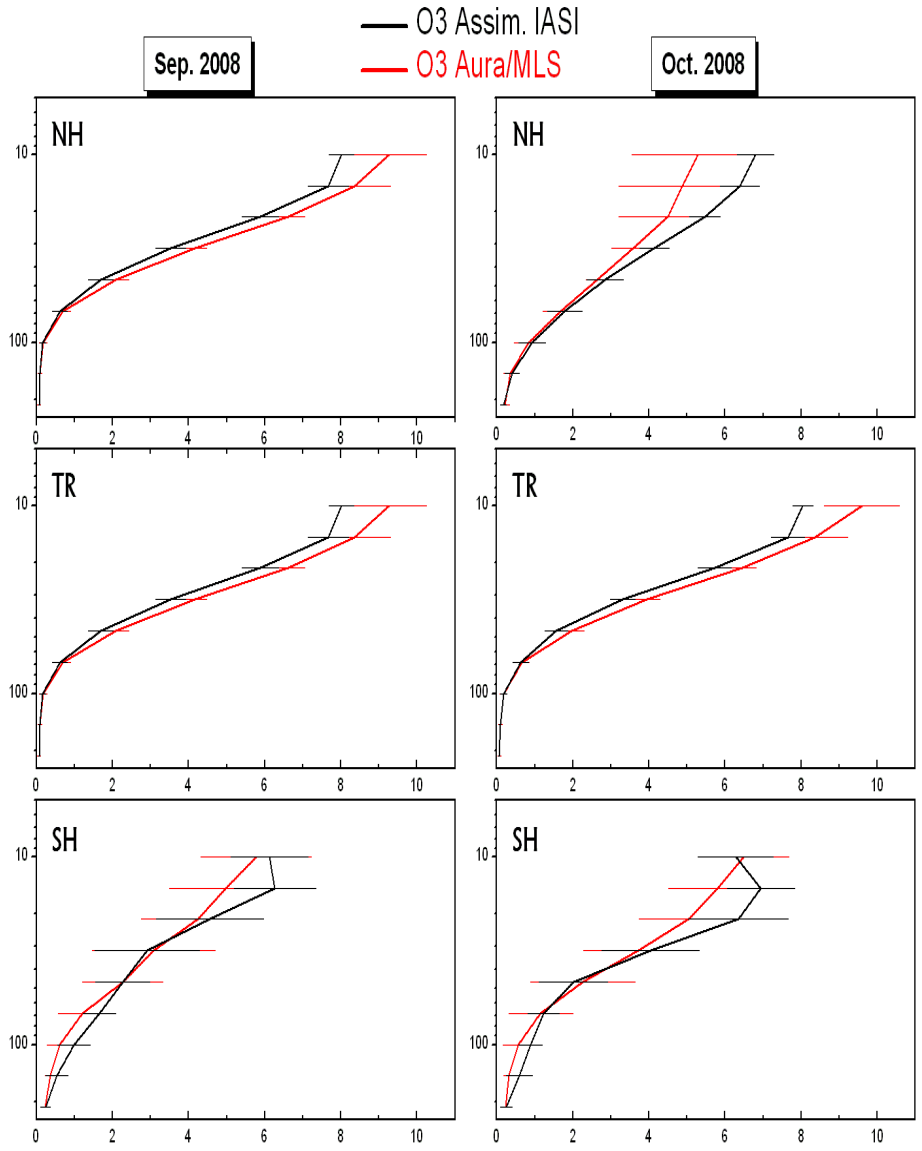
In terms of vertical profiles

➔In the NH, no systematic bias

➔In the TR, MLS overestimates Ozone compared to IASI analyses

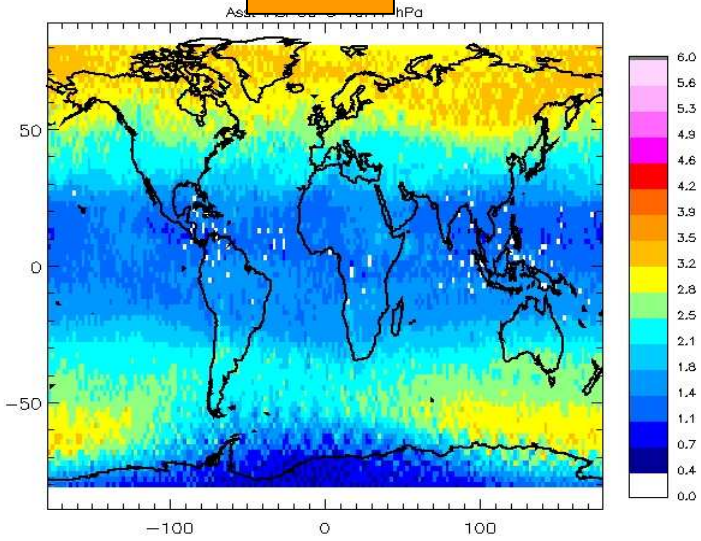
➔In the SH IASI overestimates Ozone

➔ Fairly good agreement between IASI assimilated field and MLS up to 50 hPa

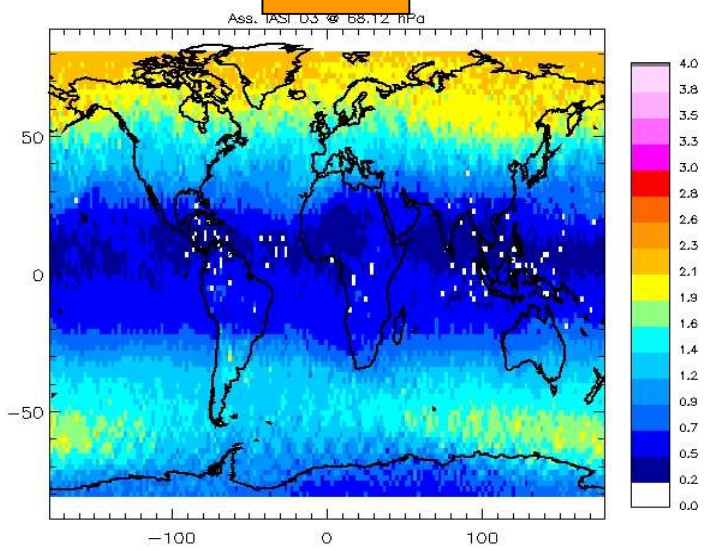


Assimilation Results: 2008

46 hPa

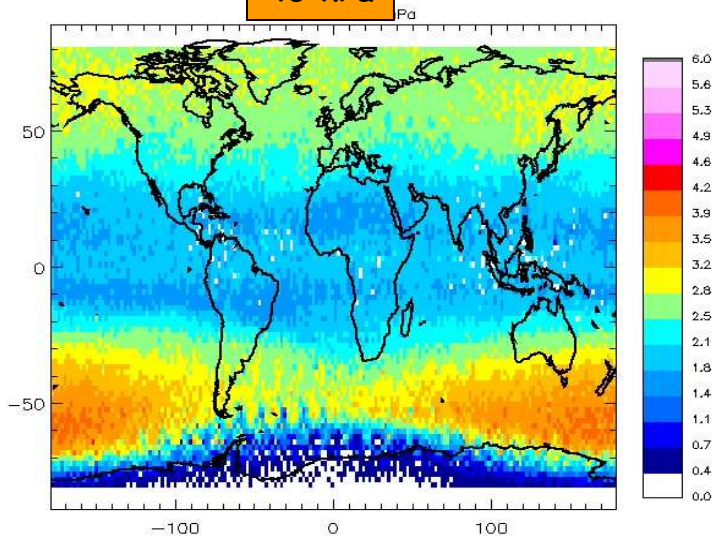


68 hPa

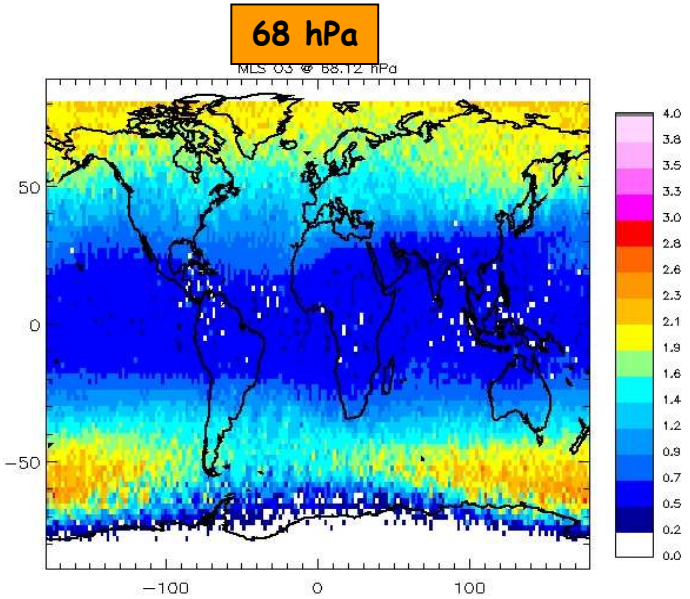


Ass. IASI
(Average of Oct.2008)

46 hPa

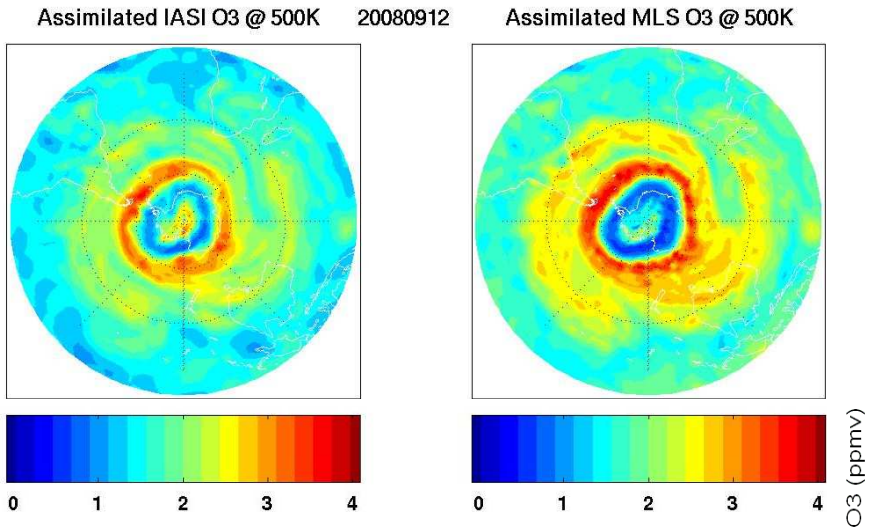


68 hPa

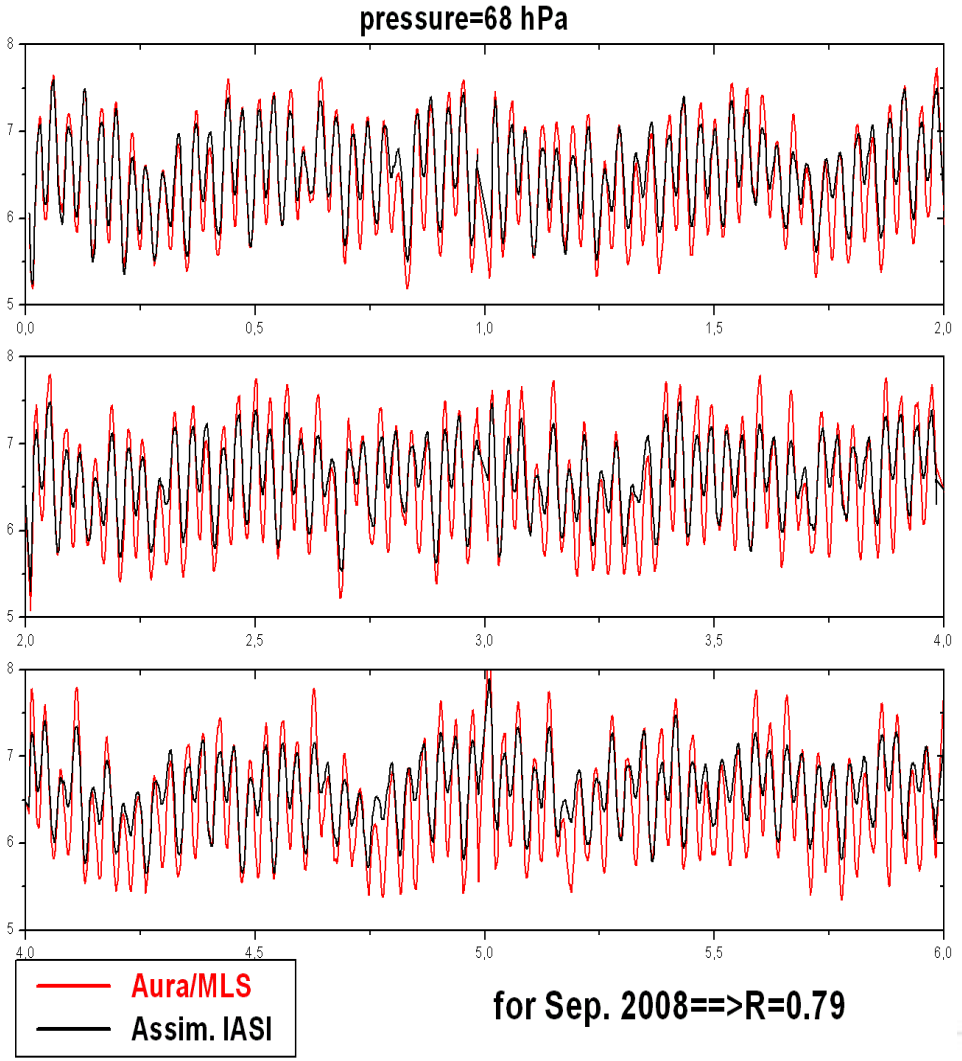


MLS O3
(Average of Oct.2008)

Assimilation Results: 2008



Rabier et al., *BAMS* (2010)

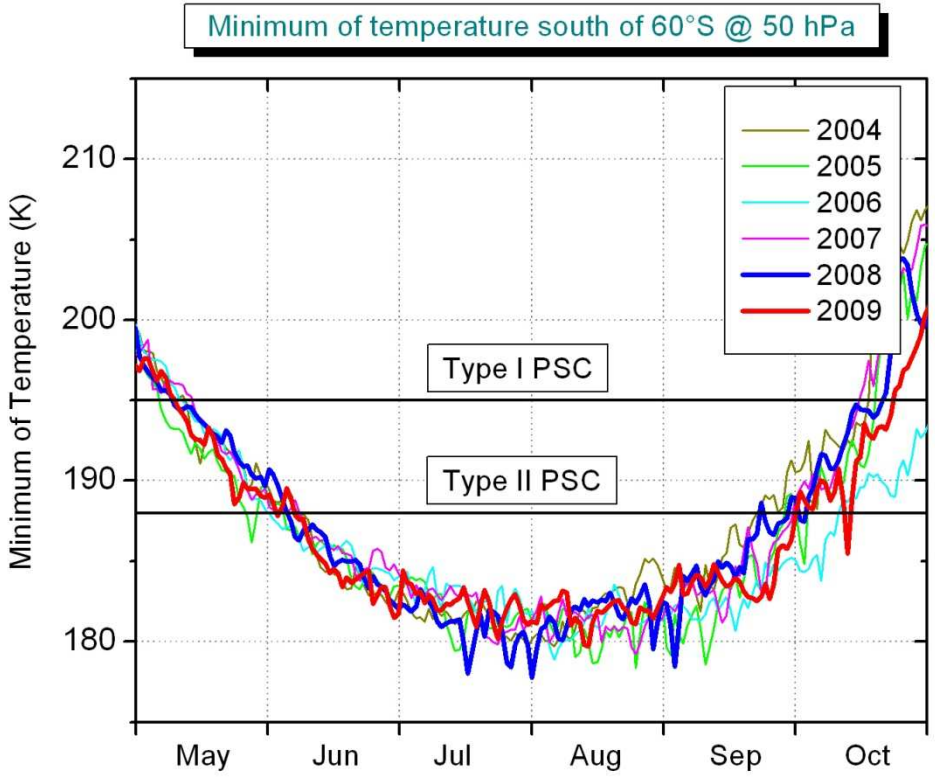


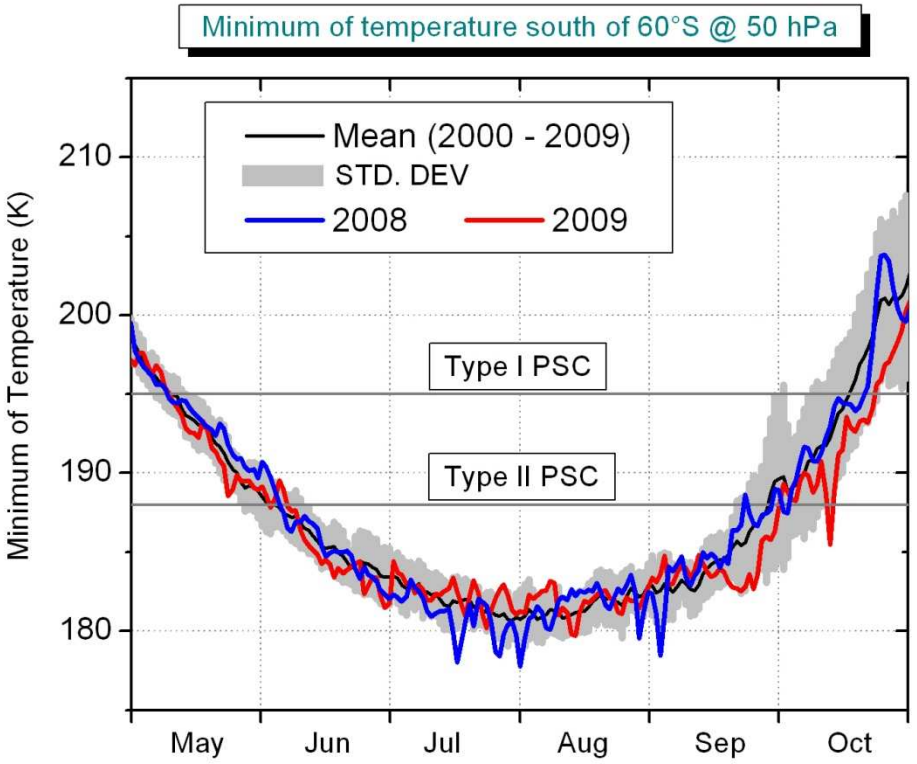
➔ Positive bias in the core of the polar vortex

➔ Negative bias at the edge of the vortex and in mid-latitudes

➔In general fairly good agreement between both fields for all assimilation period

Meteorological conditions: Minimum of temperature



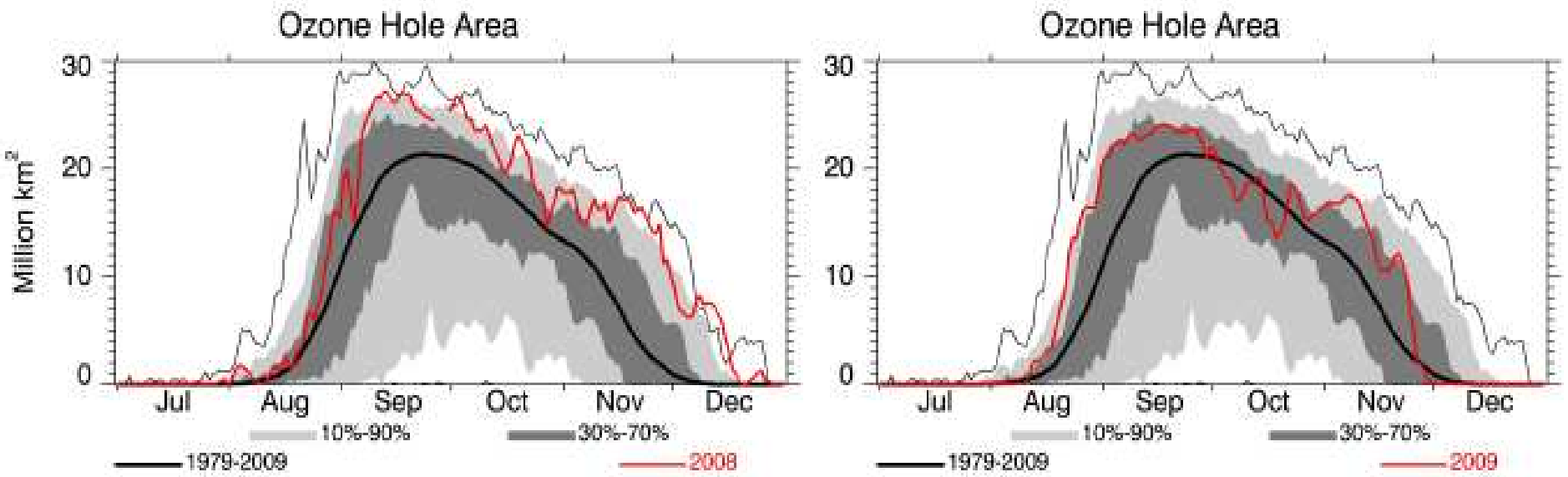


➔ 2008 & 2009 Antarctic winters were quite similar

➔ The daily minimum of temperatures @ 50 hPa are practically of the same order as the 2000-2009 average

➔ No evidence of interannual variability from one winter to another

Meteorological conditions: ozone hole area

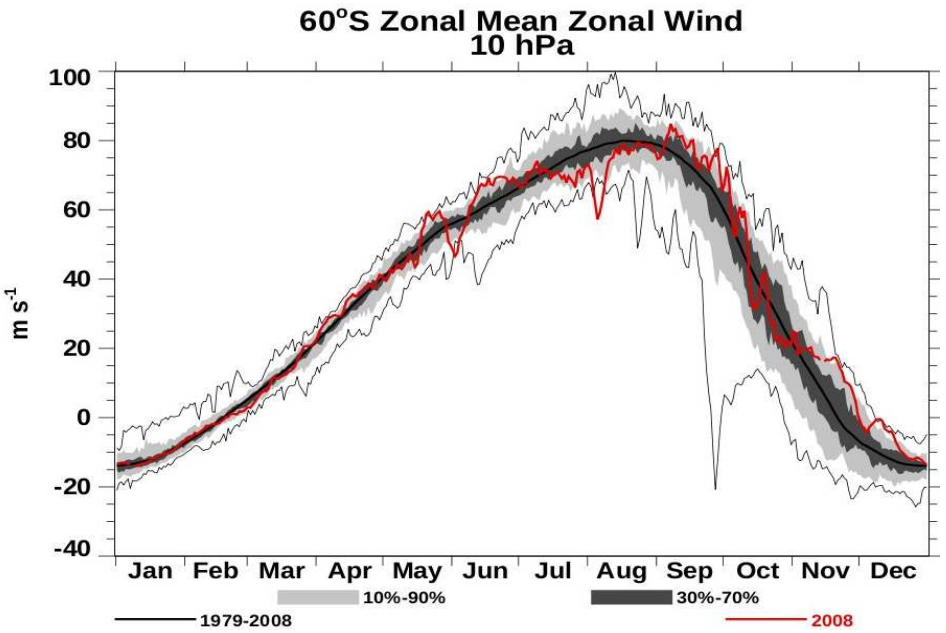


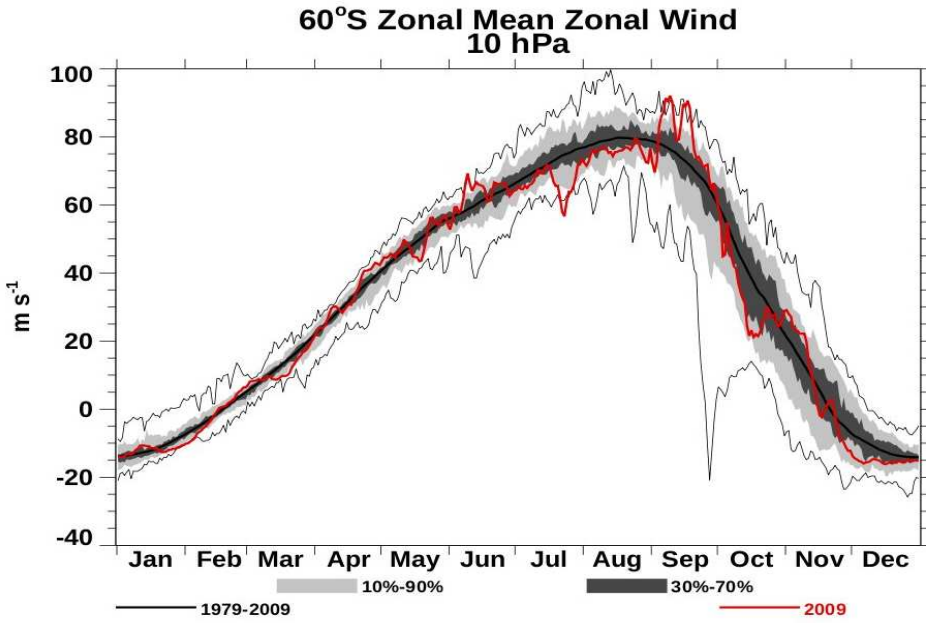
➔ the OHA is maximum during September and persists until the beginning of Dec

➔ 2008: the ozone hole area was greater than the average (1979-2009)

➔ 2009: globally, the polar vortex area was much smaller than that of 2008

Meteorological conditions: zonal wind

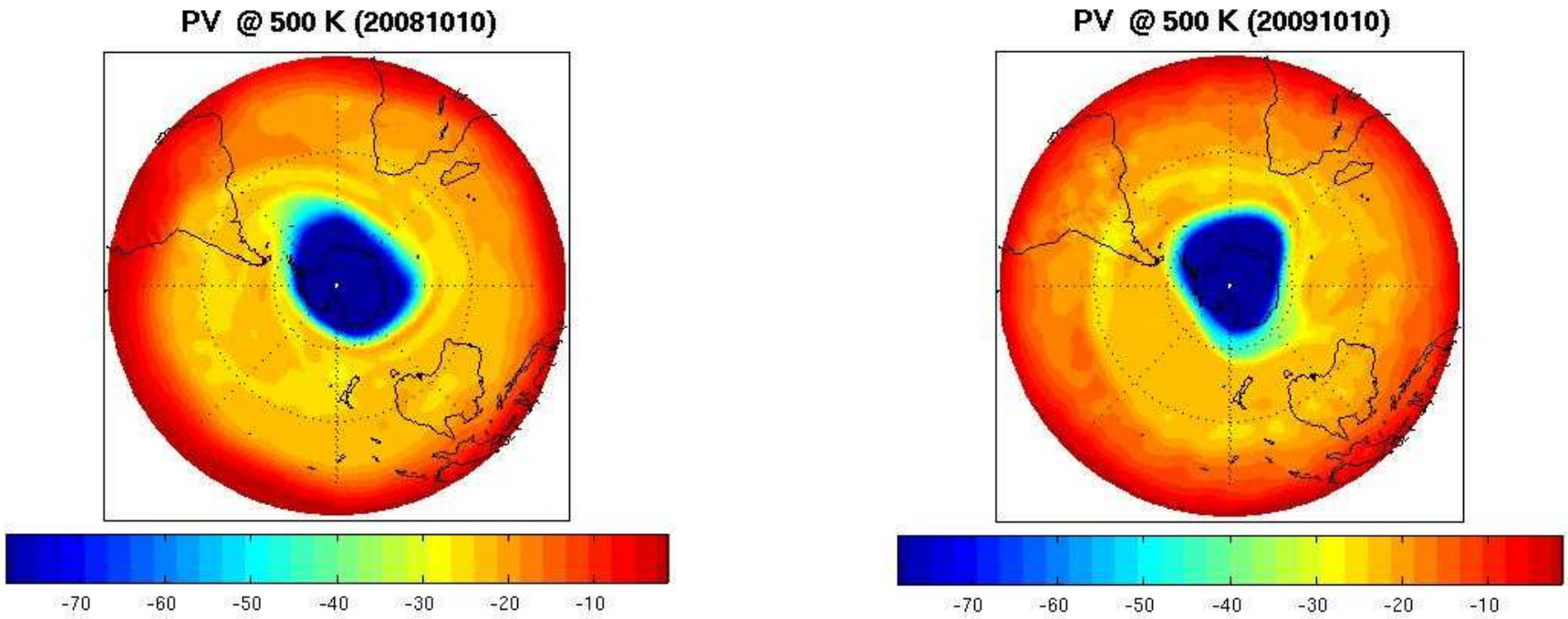




- The zonal means of the zonal wind for both winters are very comparable
- Some decelerations especially during August and October (minor warmings)

➔ No effect on the stability and the strength of the polar vortex

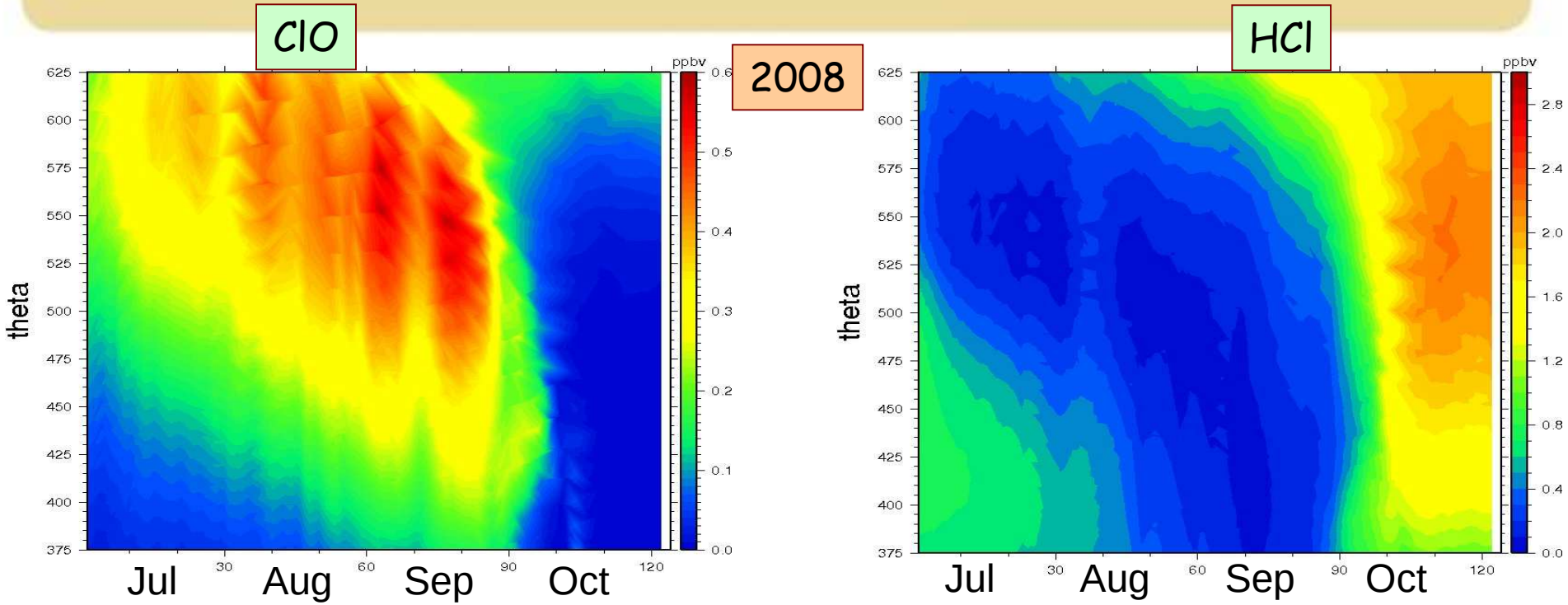
Meteorological conditions: potential vorticity



- The polar vortex is very stable during both winters

- The PV distribution indicate that the polar vortex was more large in 2008 than 2009 (in agreement with the Ozone hole area results)

2008 Austral Winter: chemical conditions

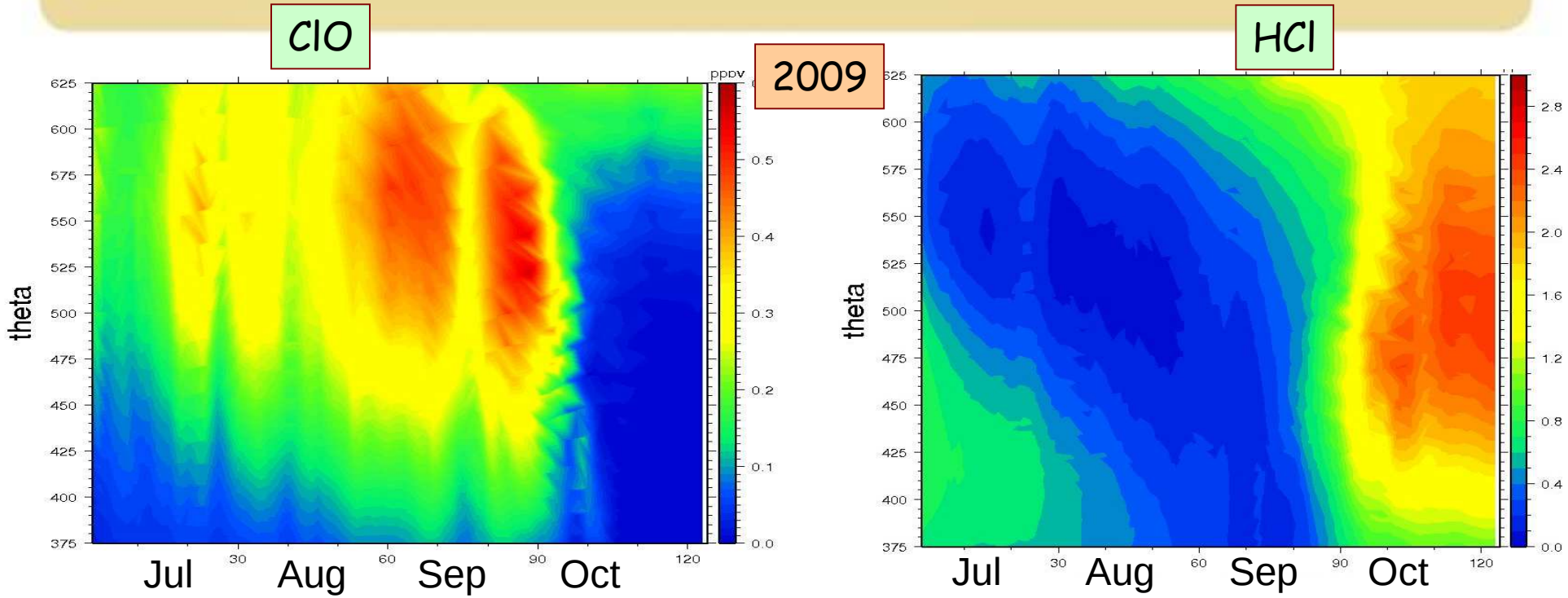


➔ Chlorine activation started in early July until the first week of October

➔ It is maximal during September and extends up to 600 K.

➔ The chlorine deactivation back to Cl reservoirs started in early October (high HCl)

2009 Austral Winter: chemical conditions

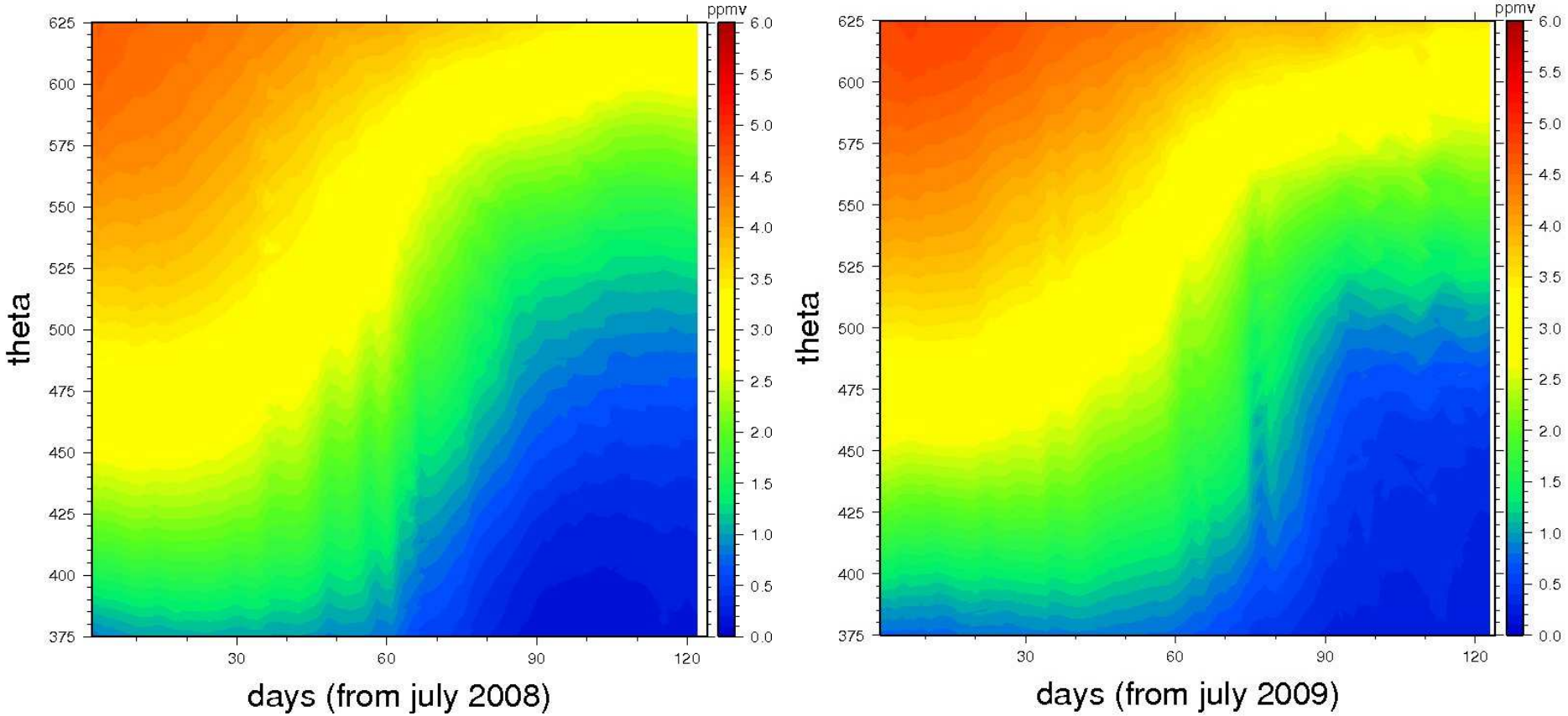


➔ Chlorine activation started in mid-July until the end of September

➔Chlorine deactivation started in the end of September

➔ Generally, chlorine activation was less pronounced compared to 2008

Evolution of the ozone inside the vortex

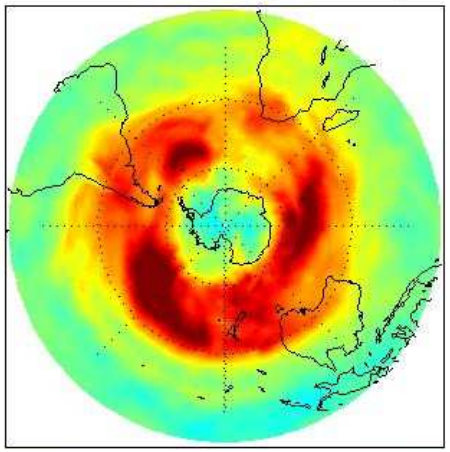


➔ O3 loss: most significant from the beginning of September

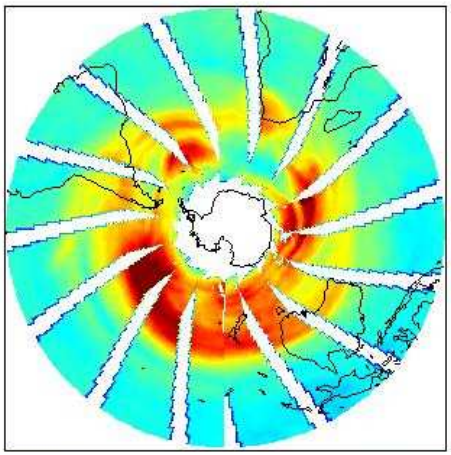
➔ Slightly more pronounced in 2008 than in 2009

Evolution of the polar vortex

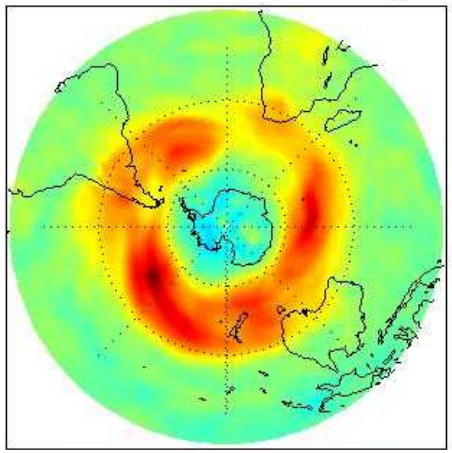
Assimilated MLS (20090731)



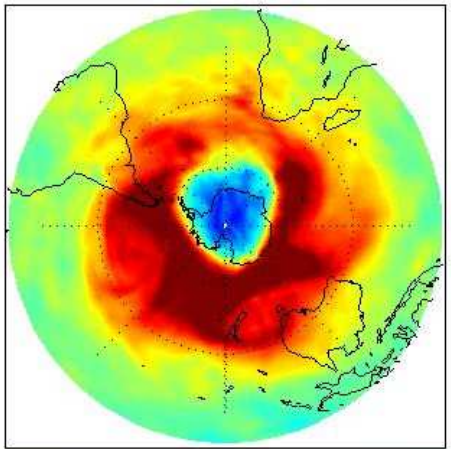
OMI - 20090731



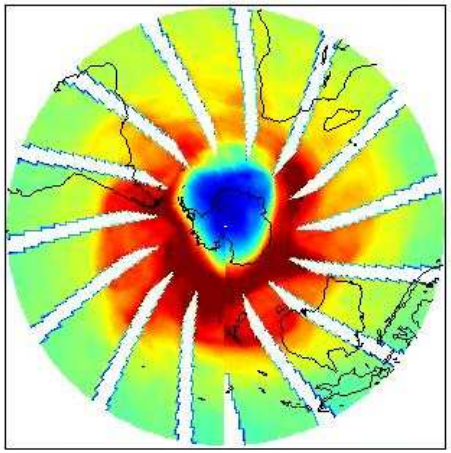
Assimilated IASI (20090731)



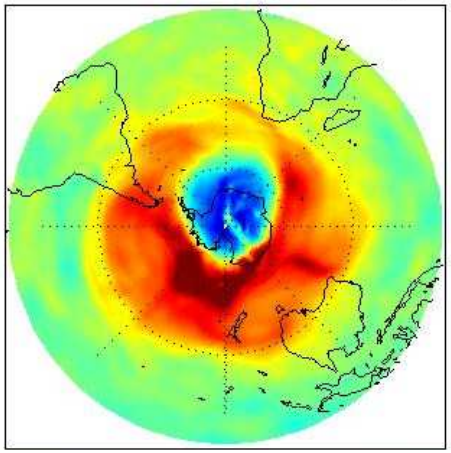
Assimilated MLS (20091010)



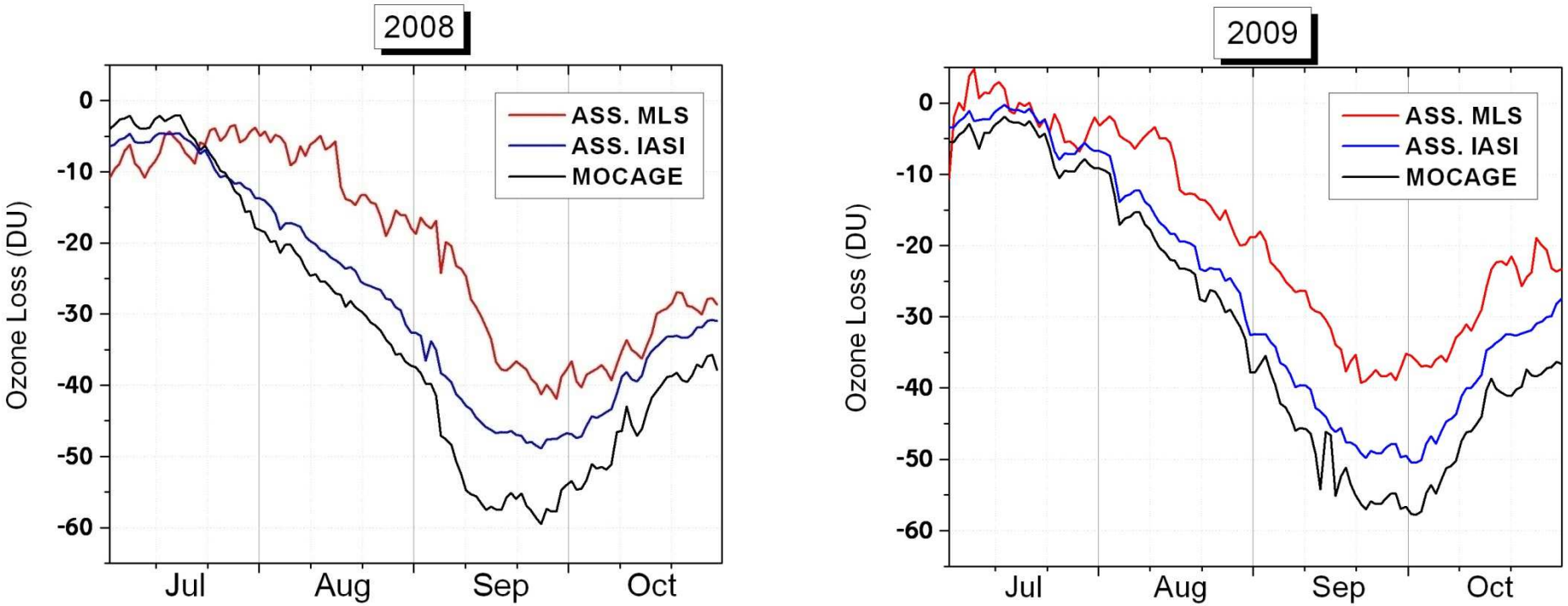
O3 Total Column (Aura/OMI)



Assimilated IASI (20091010)



Chemical ozone loss



➔ The maximum of ozone loss is recorded by the end of September

➔Overestimation of the ozone loss by assimilated IASI / Assimilated MLS

➔ Slightly more important during 2008 than in 2009

Summary

- Need to better characterize the error of IASI ozone measurements (EUMETSAT)

➔ comparison to other retrievals (LATMOS, LISA, LA …)

- Need to validate the IASI ozone analyses over Antarctica (ozonesonde)

In relation with CONCORDIASI:

- Use of ozonesonde measurements within the Assimilation system
- development of a limited domain centred over Antarctica with a high horizontal resolution (0.2° or 0.1°)