Assimilation of EOS Aura ozone data at the Global Modeling and Assimilation Office

Kris Wargan, I. Stajner, L.-P. Chang,
H. Hayashi, S. Pawson, L. Froidevaux,
N. Livesey, and P. K. Bhartia

Topics

- Assimilating ozone data at GMAO
- Some validation
- Springtime Antarctic ozone loss in 2005
- Defining the tropopause

Assimilation of Aura ozone data into NASA's GEOS-4

- **DATA**
  - The Microwave Limb Sounder (MLS): ozone profiles:
    - 20 levels 216 – 0.14 hPa
    - ~ 3,500 profiles a day, near global coverage
- Ozone Monitoring Instrument (OMI): US retrieved ozone total column
  - Reflectivity < 15%
- Data input and analysis output every 3 hours

- **MODEL**
  - transport within GEOS-4 **general circulation model** constrain by meteorological analyses
  - parameterizations for stratospheric photochemistry and heterogeneous ozone loss
  - a parameterization of the tropospheric chemistry (for year 198

- TIME PERIOD: January 2005 to March 2006

A quick glance

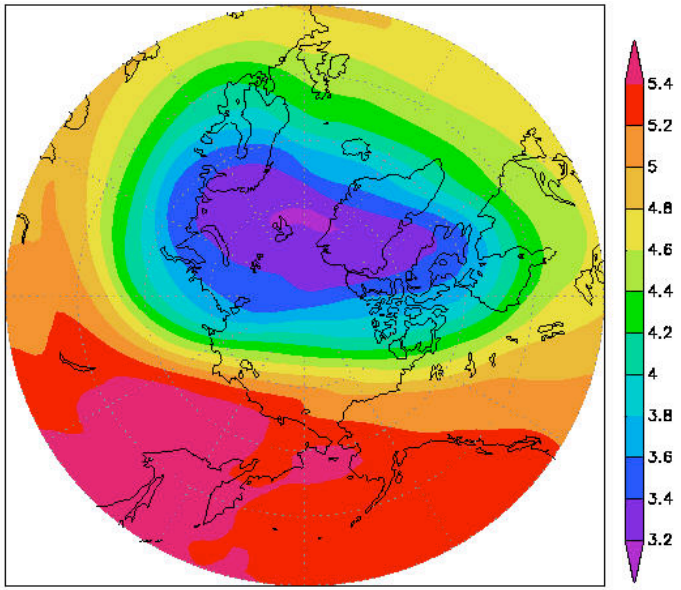
February mean ozone in 2005 vs. 2006

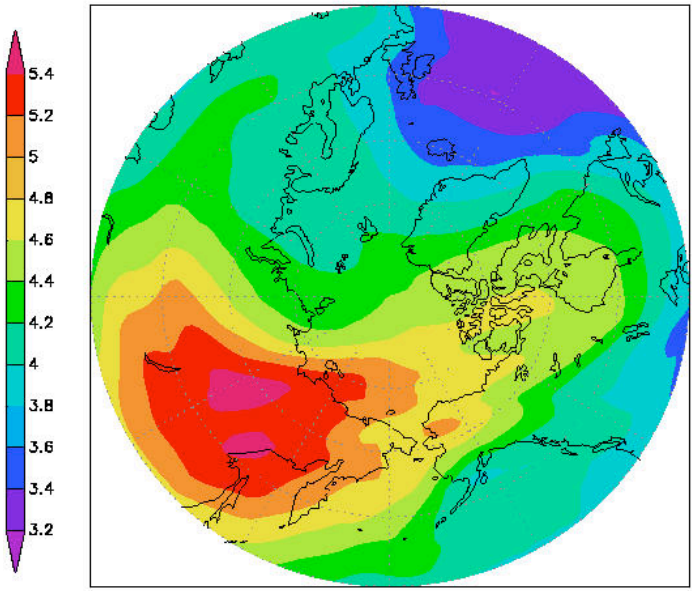
30 hPa

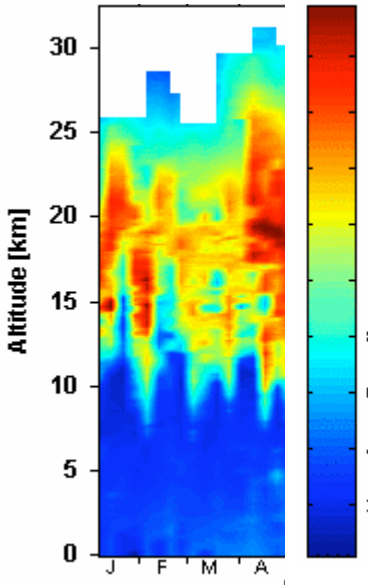
70 hPa

Sodankyla
67.4N 26.6E

2005



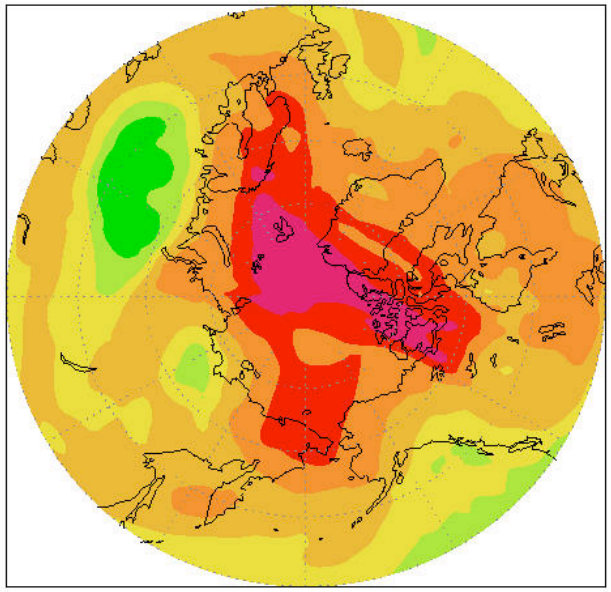


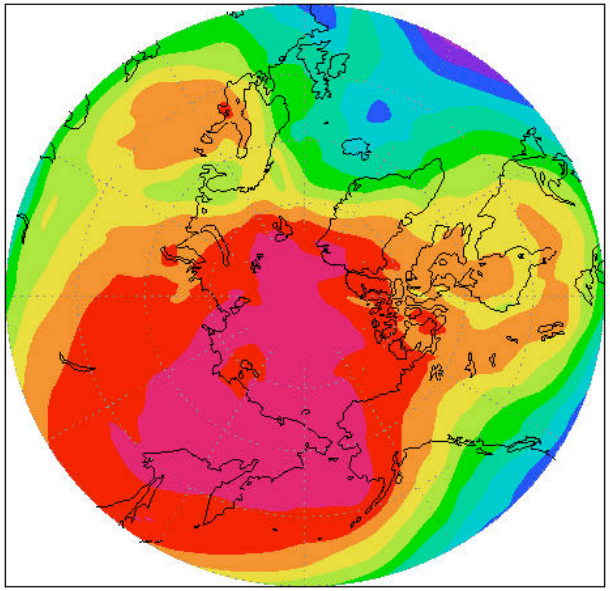


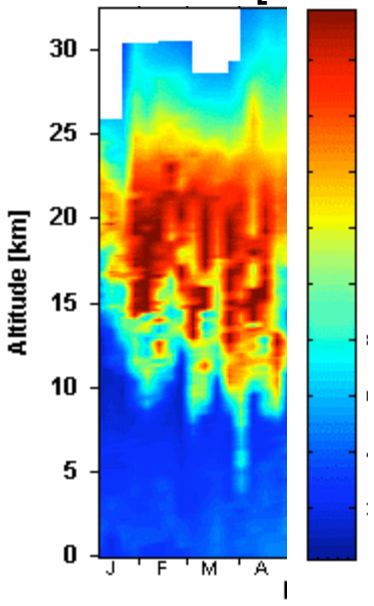
[ppmv]

[mPa

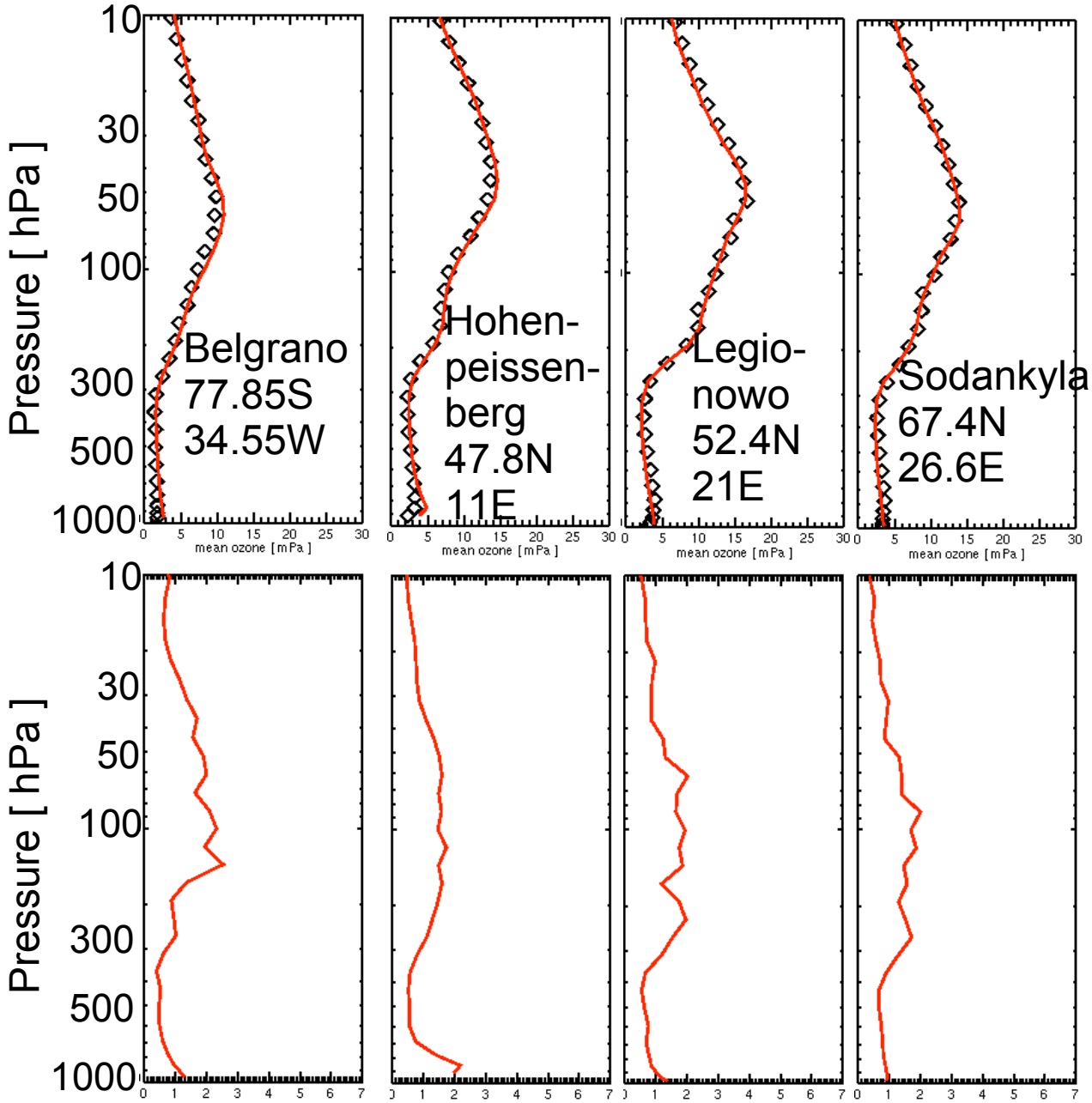
2006







Validation against sonde measurements



2005 mean ozone [mPa]
radiosondes and assimilat

Mean difference between
analysis and **sondes** with
10% above 300 hPa

RMS difference, sonde mi
analysis.

Up to 50% in the upper
troposphere,

- Within 40% above 10(
  at Belgrano
- within 20% above 100
  at other locations

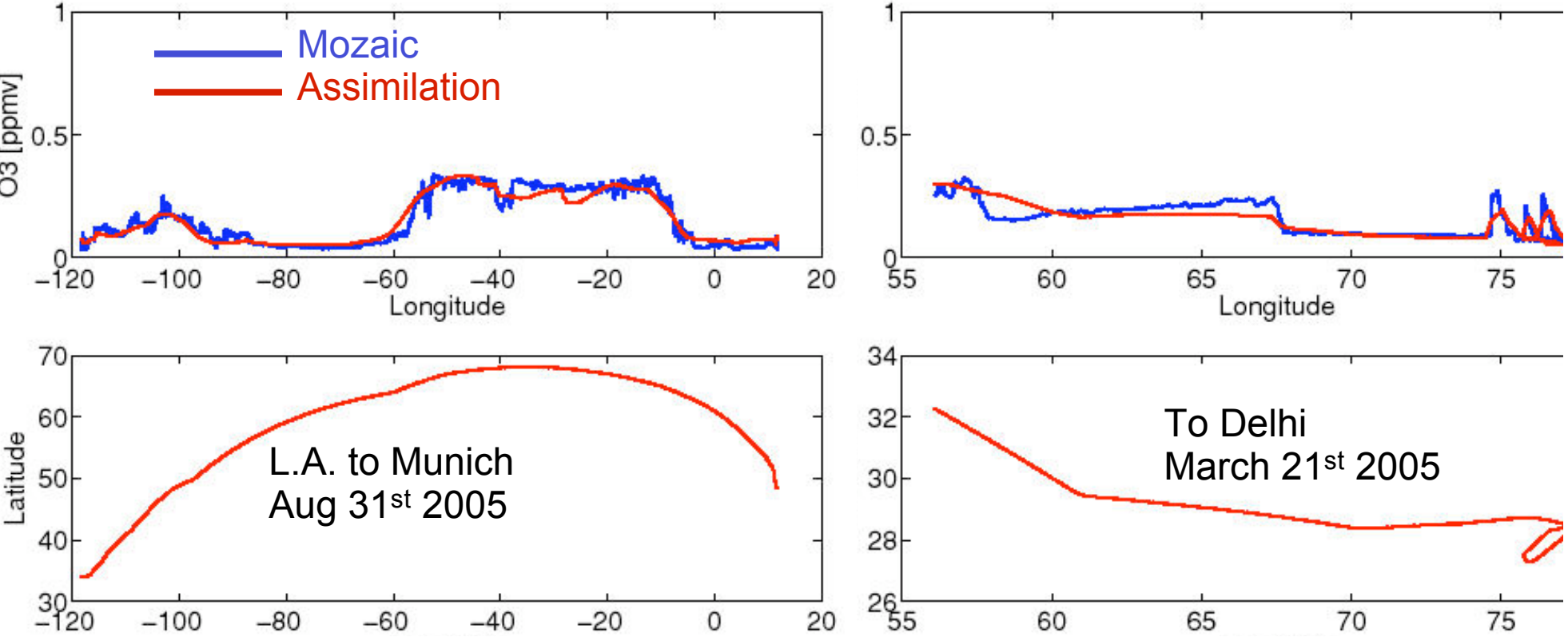
Validation against measurements from Mozaic

Aircraft ozone measurements

- Frequency approx. every 10 seconds
- Pressure at cruising altitude ~220 hPa

Comparisons with two sample flights

- No obvious systematic bias
- Small features often not resolved due to limited temporal resolution (analysis output every

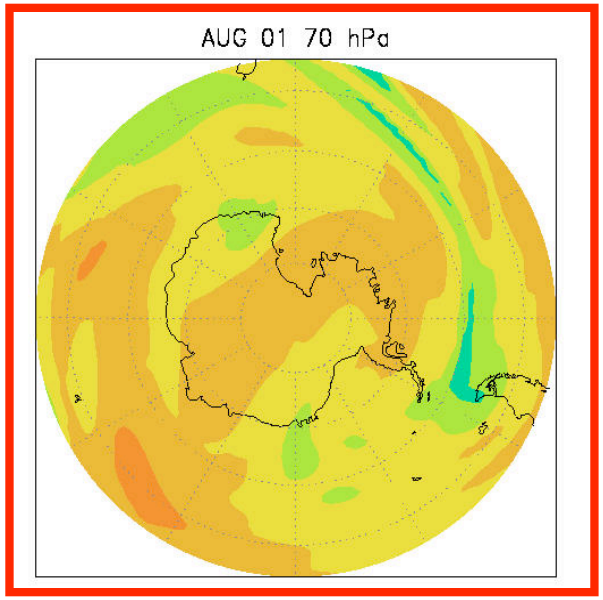


Antarctic Spring, ozone depletion

Our previous work with data from solar occultation instruments (POAM 3, ILAS) demonstrated considerable positive impacts of assimilating even a small number (e.g. 15 daily of high vertical resolution profiles in the southern polar region

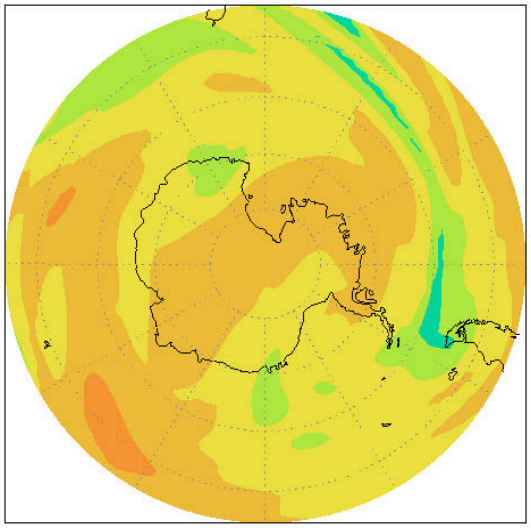
Evolution of the ozone field at 70 hPa

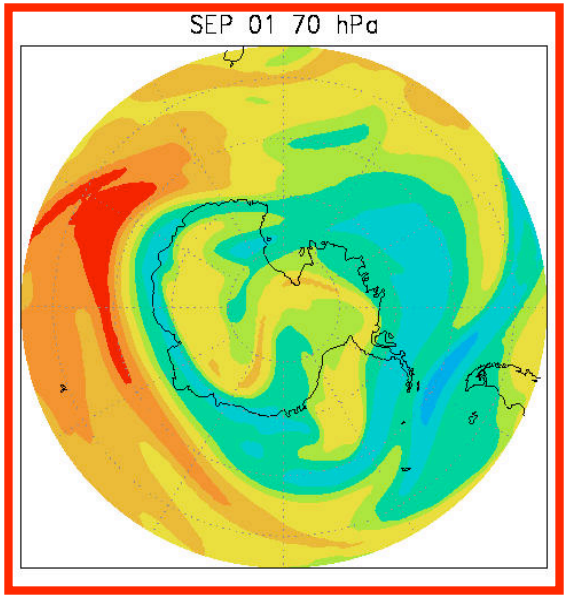
A slow descent within the polar vortex leads to accumulation of ozone in the lower stratosphere



Evolution of the ozone field at 70 hPa

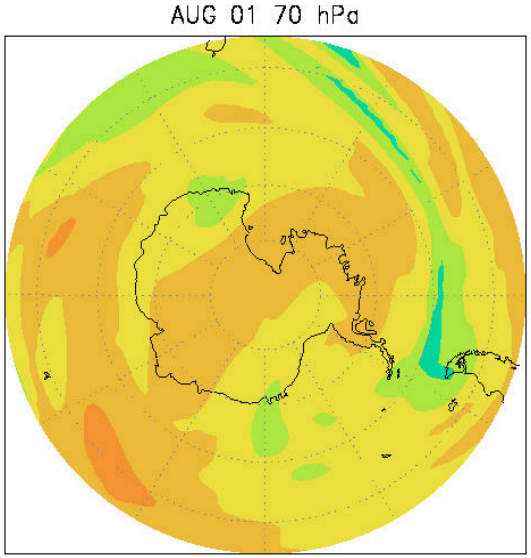
Ozone depletion due to activated chlorine and bromine compounds begins in the sunlit region near the vortex edge

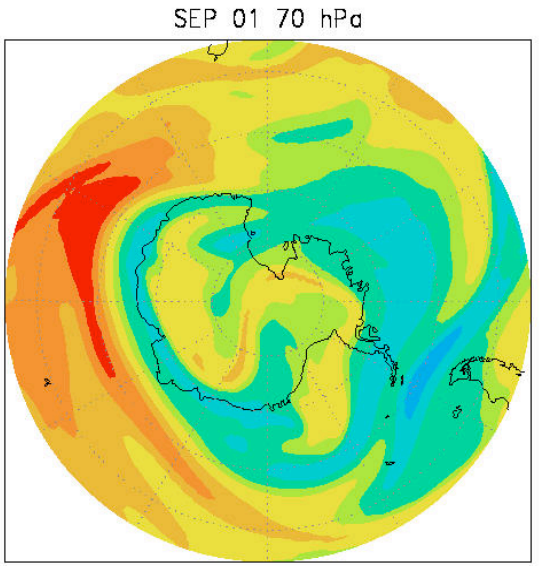


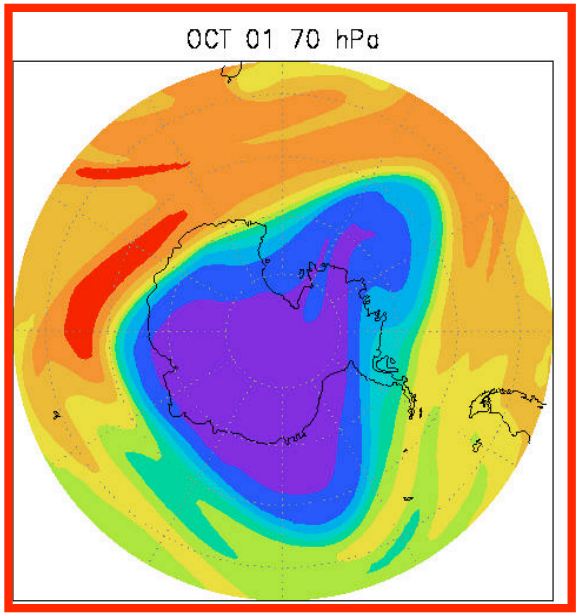


Evolution of the ozone field at 70 hPa

Almost complete ozone loss within the vortex

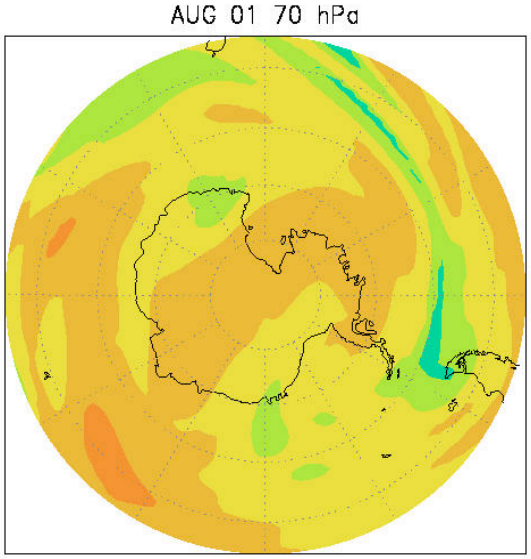


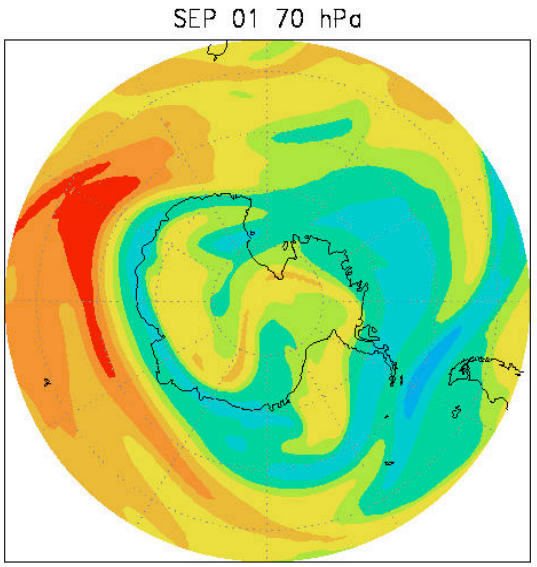


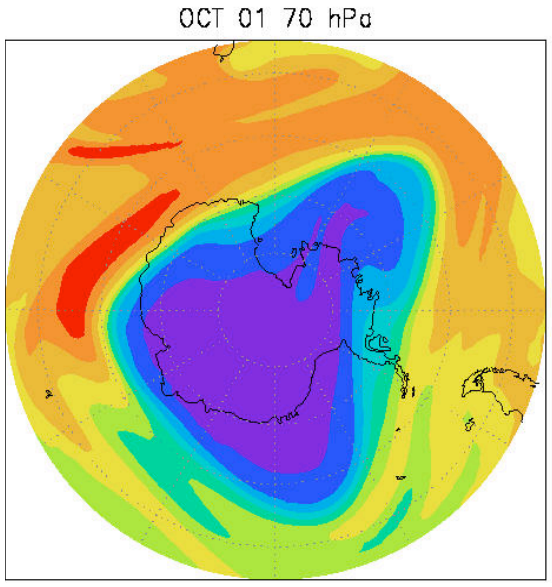


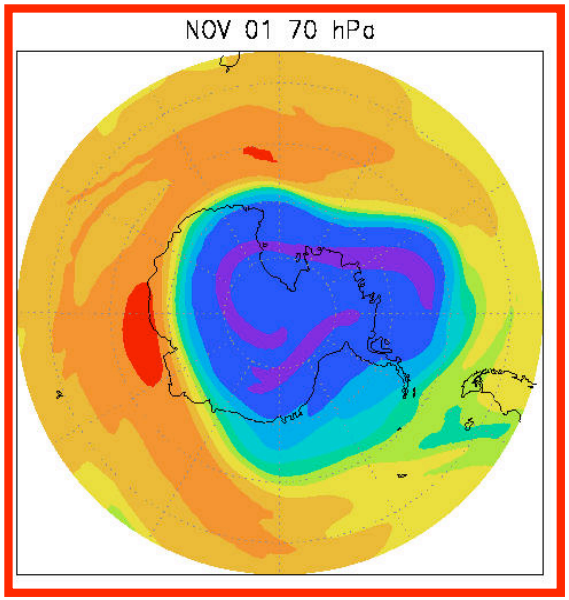
Evolution of the ozone field at 70 hPa

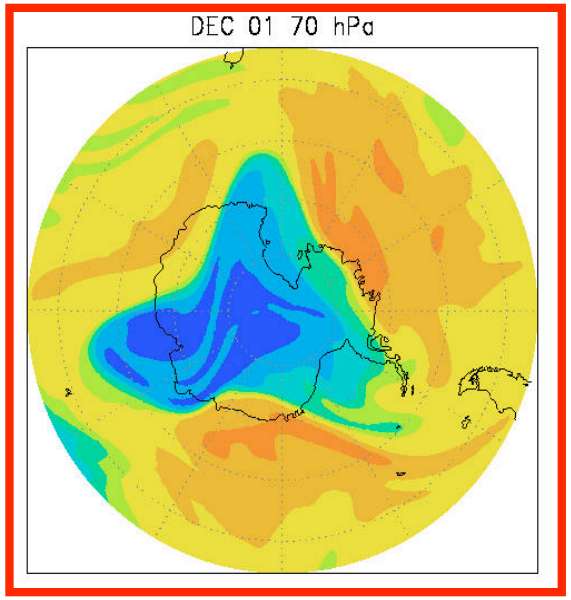
Weakening and dissipation of the polar vortex allows mixing of the air masses.





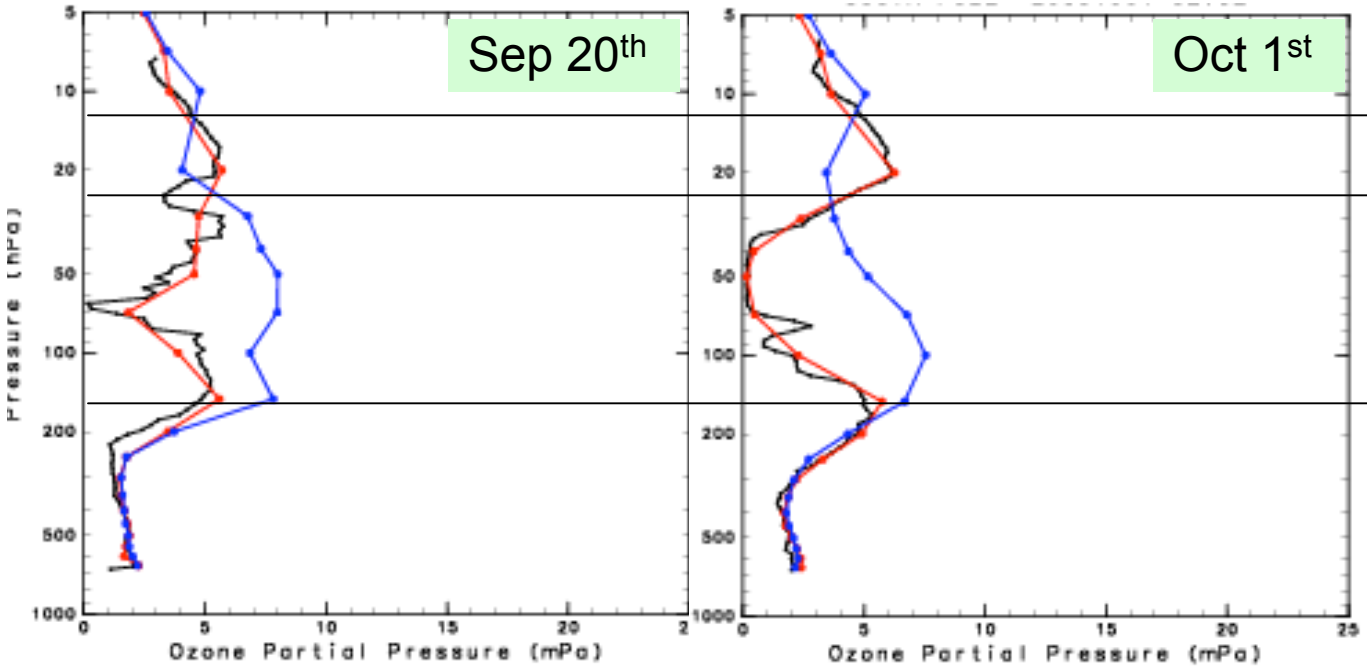






Antarctic Spring.

Correcting a systematic model bias



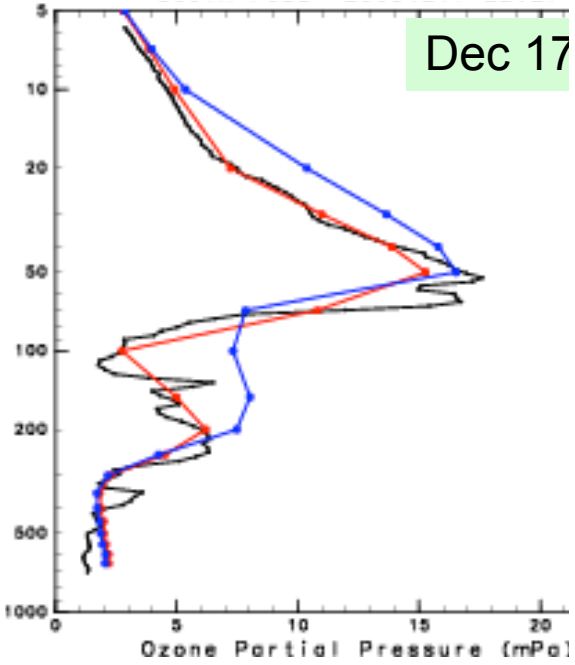
Excessive loss, 30 – 20 hl

Insufficient loss in the low stratosphere

South Pole ozone sonde

Assimilation

Transport and chemistry (no ozone data, run initialized on Jan 2nd 2005)



Defining the tropopause

Different definitions of tropopause

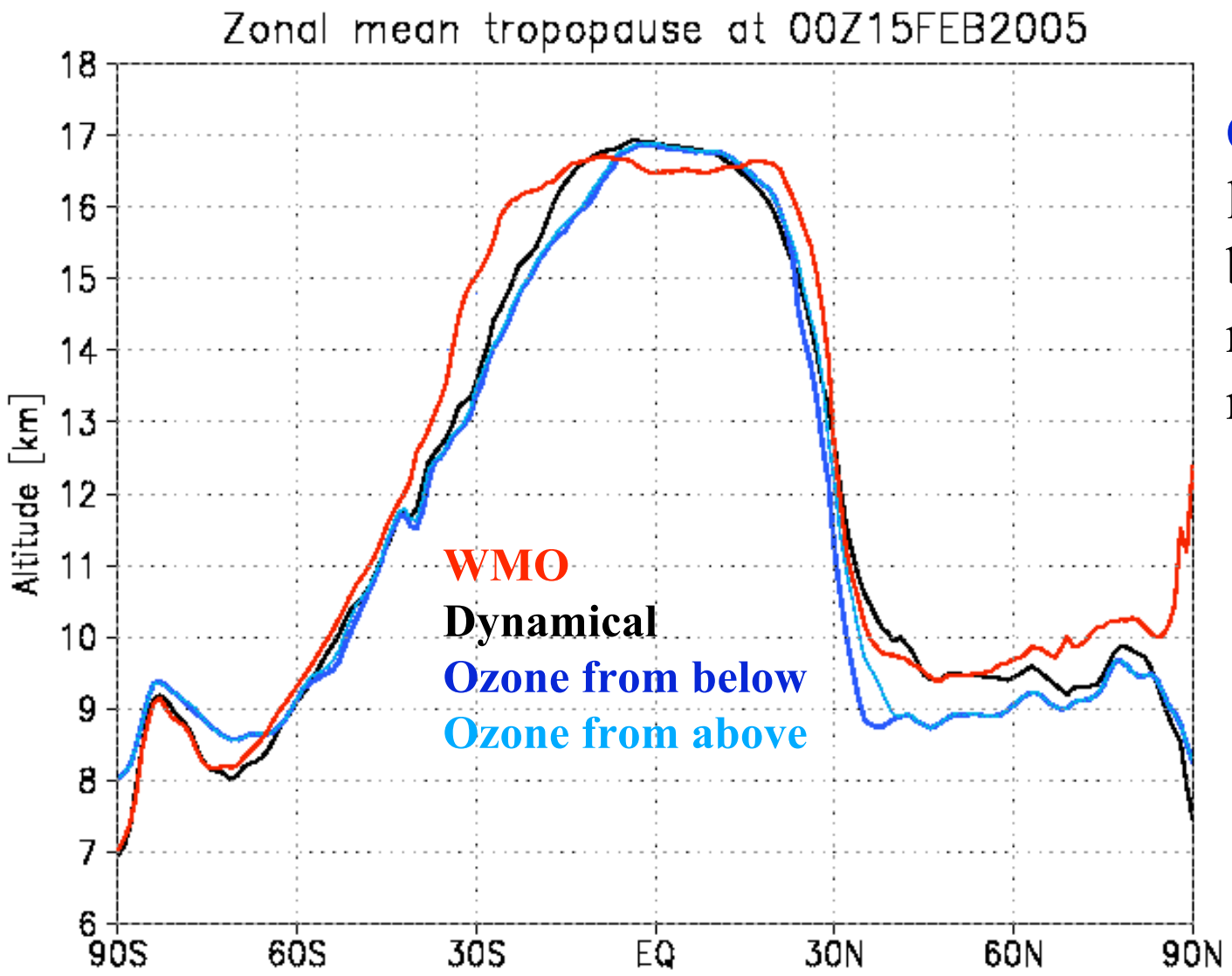
- Temperature lapse rate (WMO)
- Dynamical
- Chemical

Tropopause definition	*Criterion*	*Pressure search range*
WMO (algorithm by Reichler et al 2003)	Lapse rate < 2K/km and does not exceed 2K/km for 2 km above	550 to 75 hPa
Dynamical	Lower of: |PV|=3.5 PVU or θ = 380 K	> 51 hPa
Ozone from below	Ozone = 0.1 ppmv	< 500 hPa
Ozone from above	Ozone= 0.1 ppmv	> 51 hPa

Comparing the different tropopauses

- In terms of distance ([km], [hPa])
- In terms of mutual correlations
- In terms of tracer (ozone) content

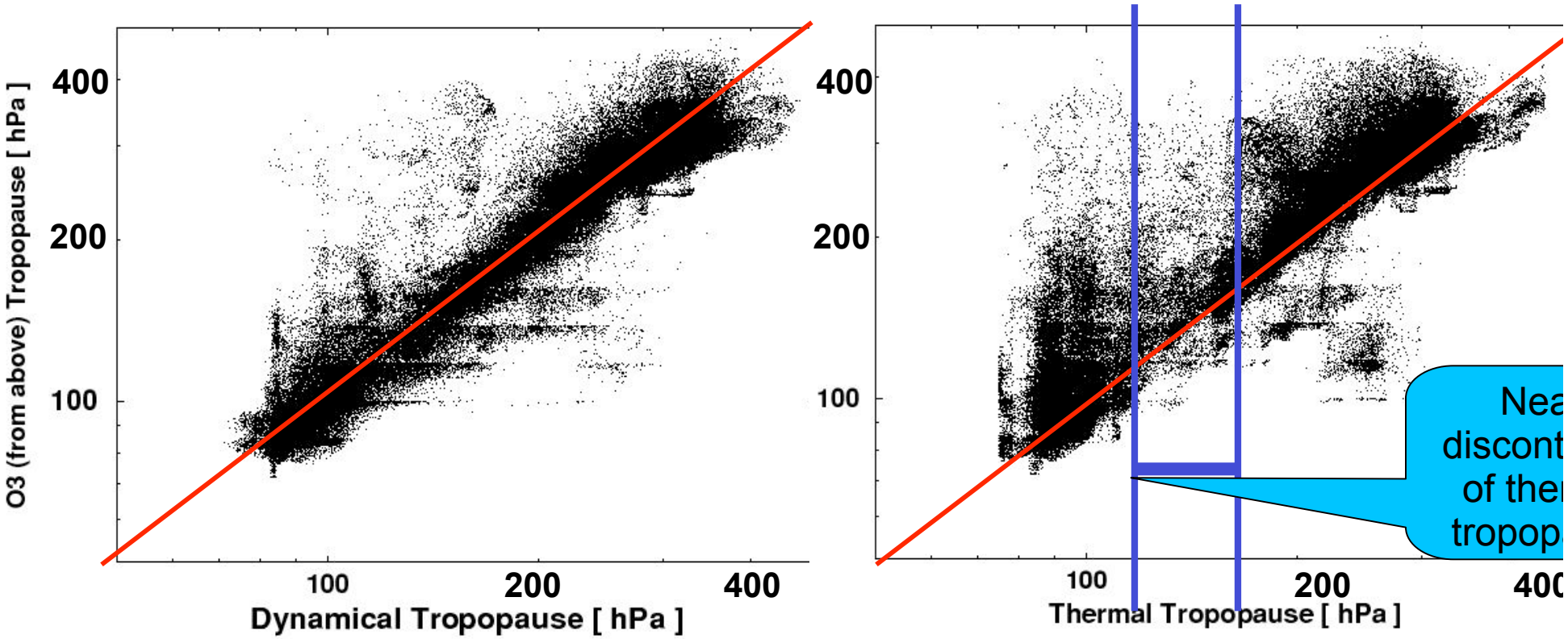
In terms of distance



Ozone tropopause lower than WMO by 0.7 to 1 km in northern midlatitudes

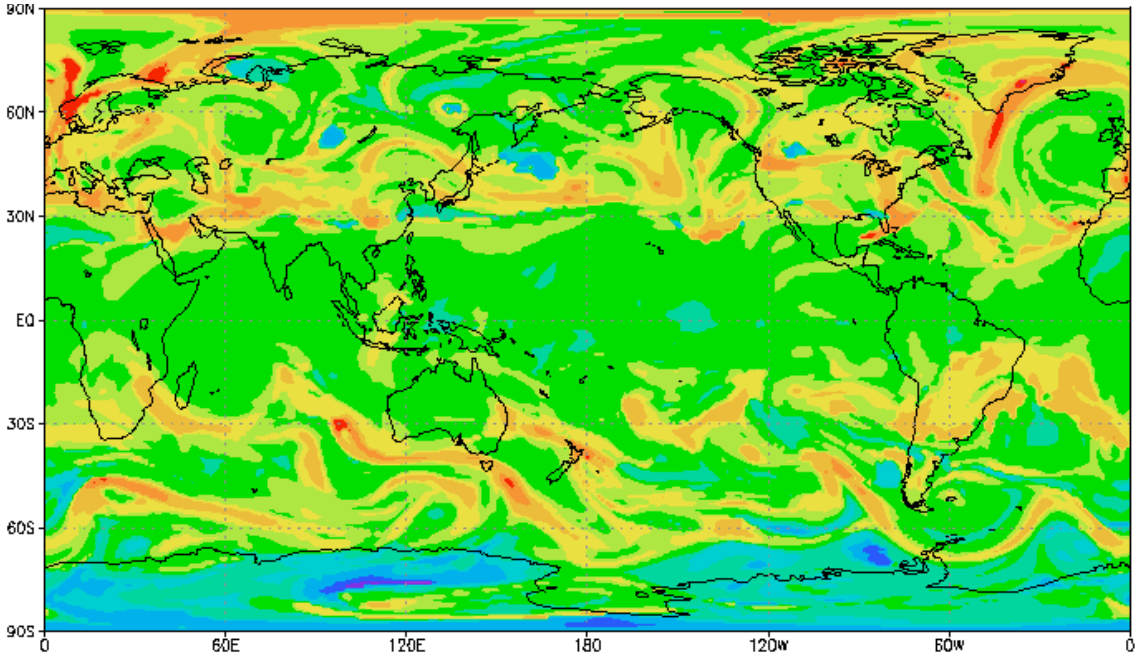
In terms of correlations between tropopauses

February 15th 2005

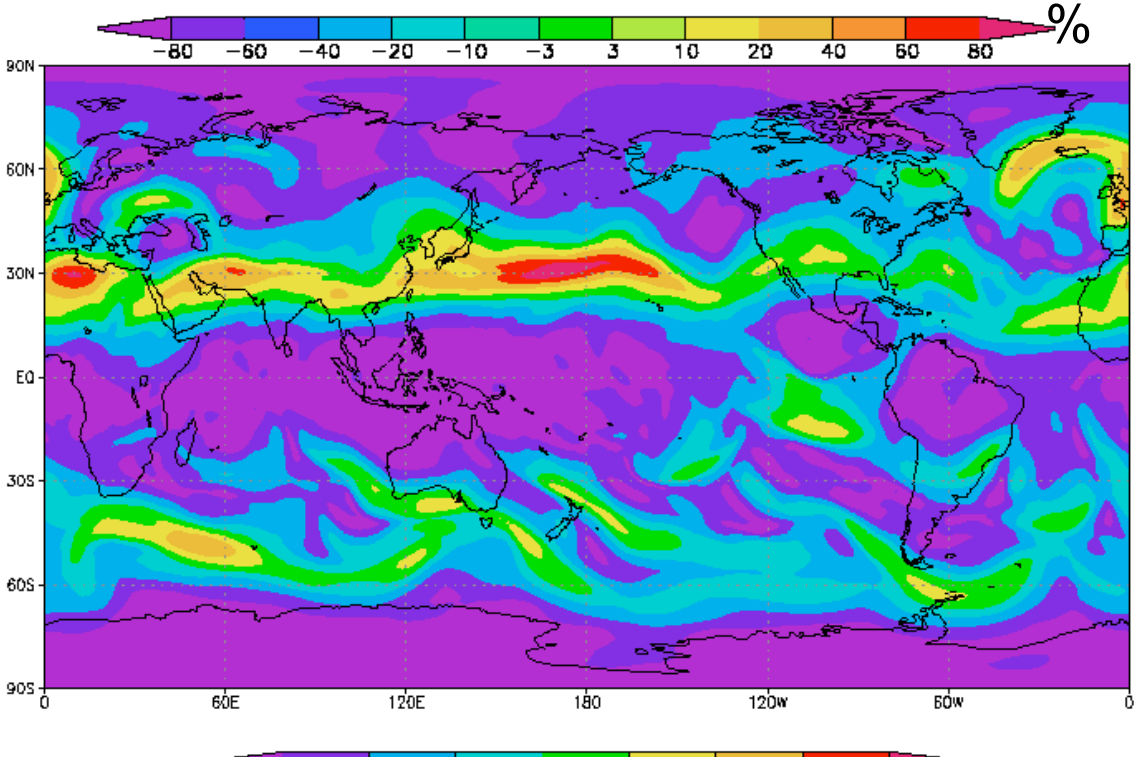


- Ozone tropopause seems better correlated with the dynamical one than with the thermal one
- At most locations the thermal tropopause lies above the ozone tropopause

In terms of ozone content in between

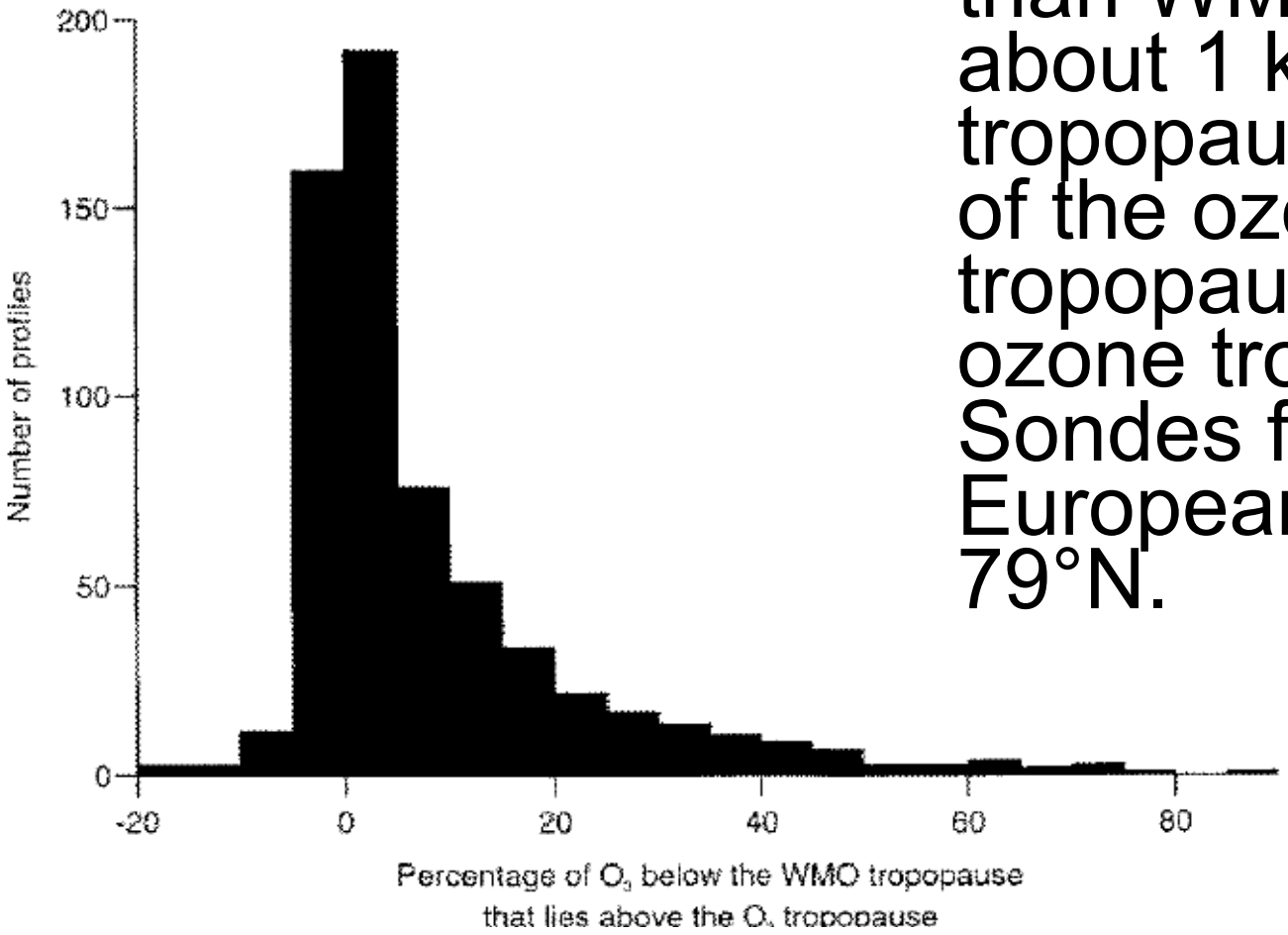


Percentage of ozone colu
below WMO tropopause
that lies above ozone
tropopause at 00Z15FEB2



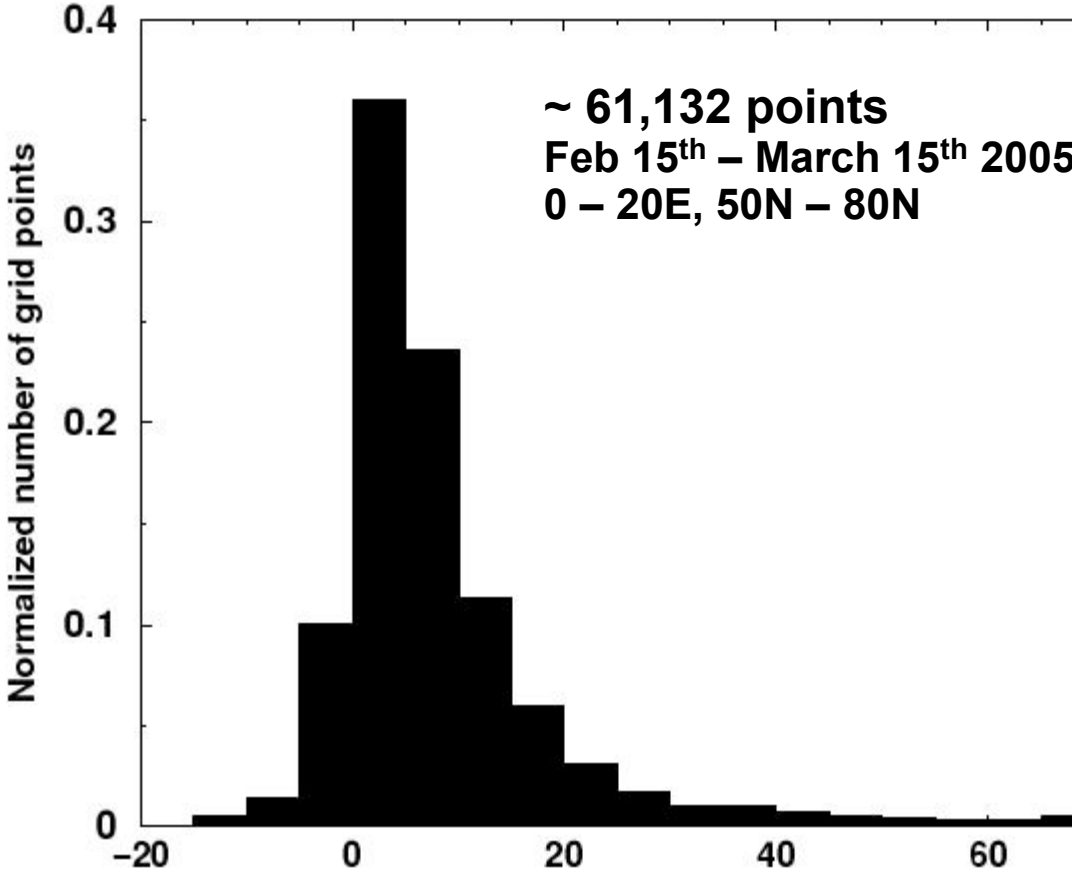
Wind magnitude at 200
hPa at 1:30Z15FEB2005

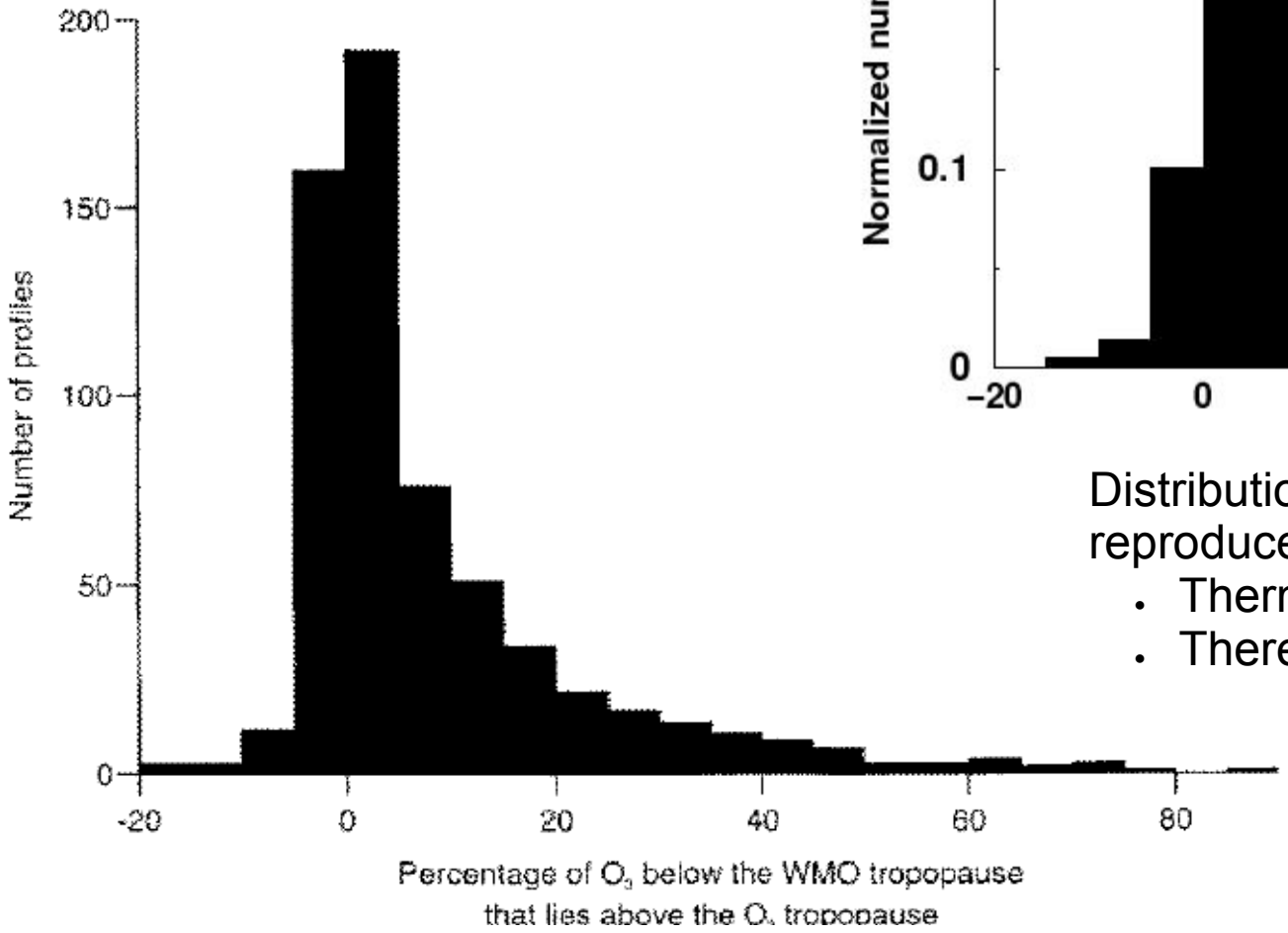
In terms of ozone content in between



- *Bethan et al 1996*: ozone defined tropopause lower than WMO tropopause by about 1 km. When WMO tropopause indefinite, 27% of the ozone below WMO tropopause lies above ozone tropopause. Sondes from four European stations 51°N-79°N.

Percentage of ozone column below WMO tropopause that lies above ozone tropopause

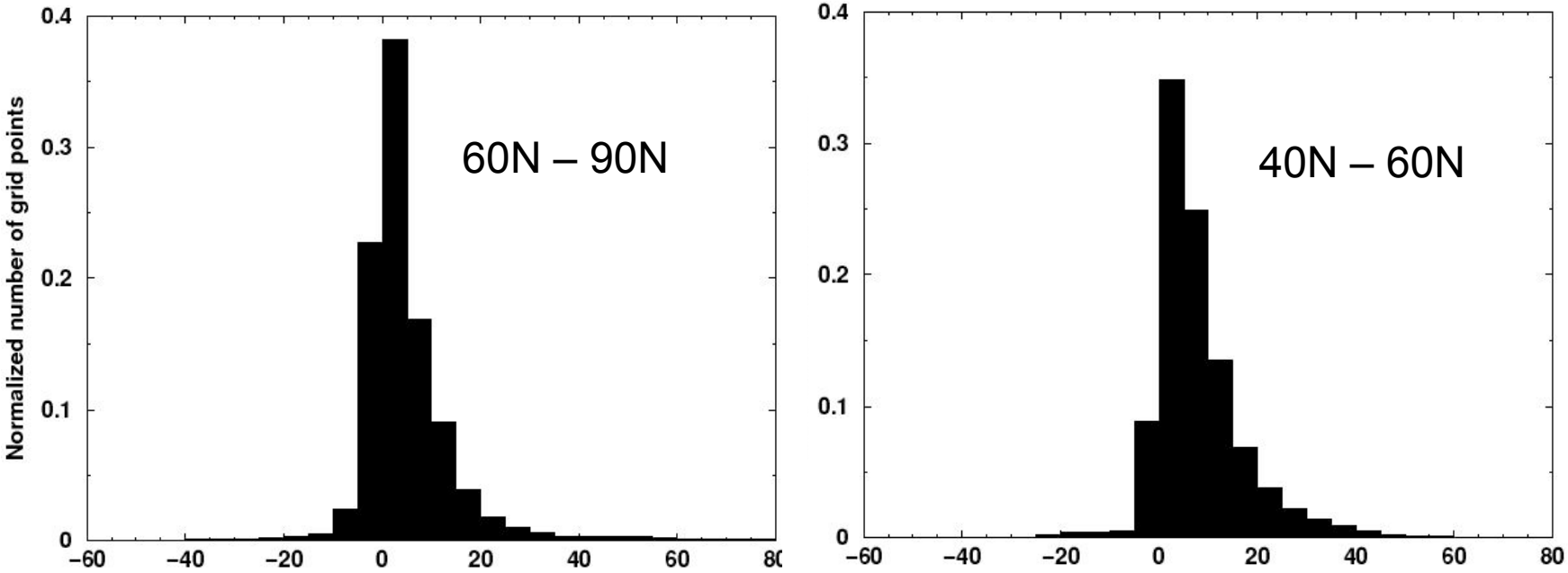




Distribution obtained from the analysis reproduces some of the features

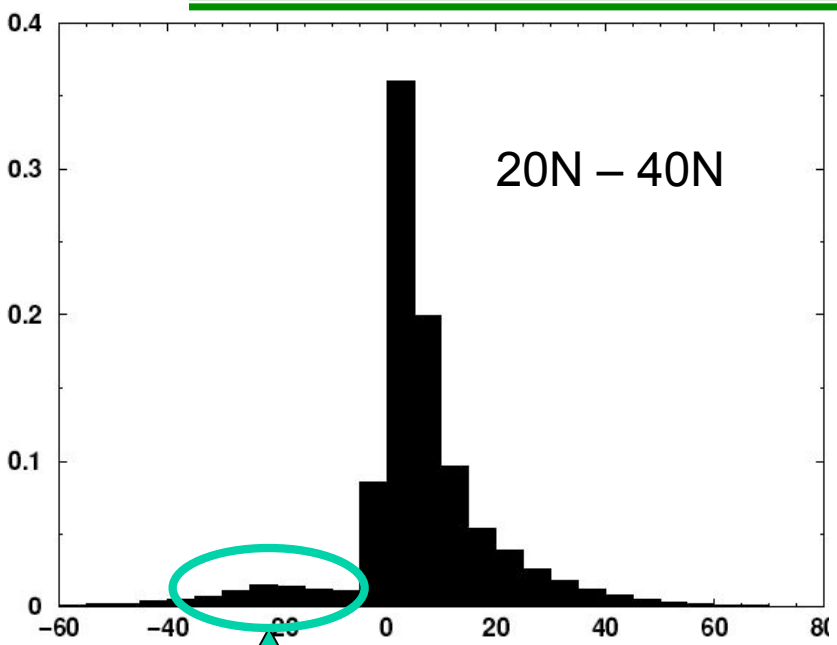
- Thermal tropopause is higher on av
- There are outliers (70 – 80%)

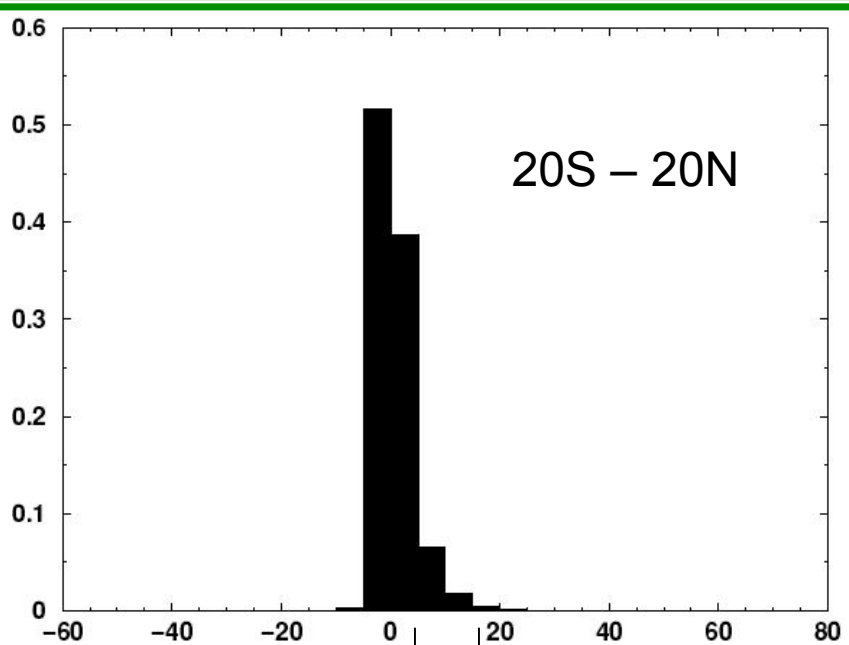
Percentage of ozone column below WMO tropopause t
lies above ozone tropopause Feb 15th – March 15th 200



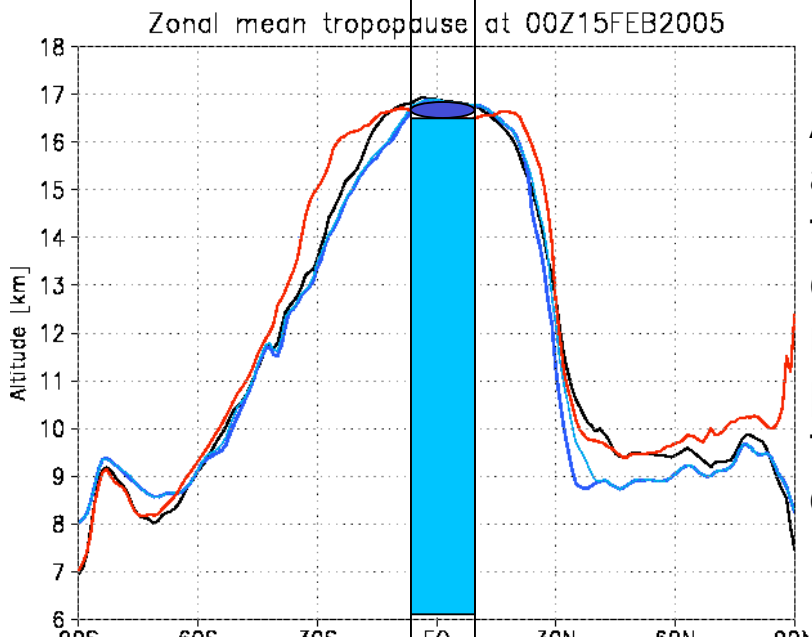
Distributions obtained using all gridpoints in latitude bands

Percentage of ozone column below WMO tropopause f
lies above ozone tropopause Feb 15th – March 15th 200





Thermal tropopause can be found at either ‘top’ or ‘bottom’ of the jet. Parts of the ozone tropopause lie above the WMO one

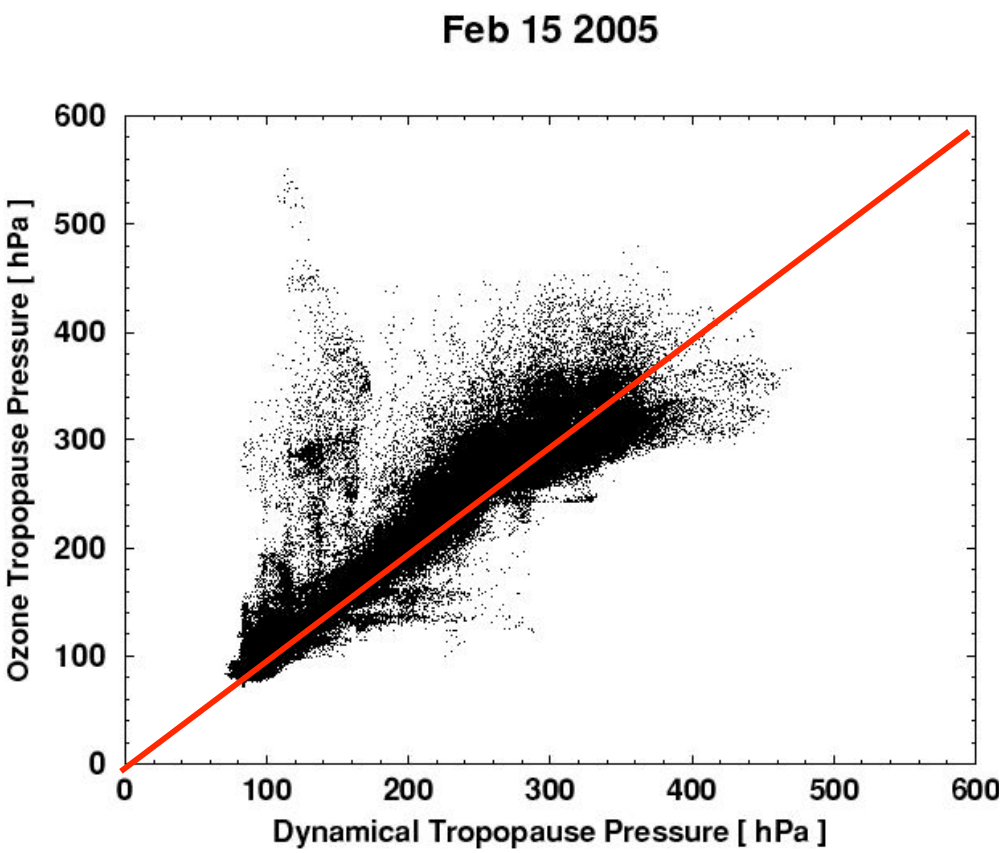


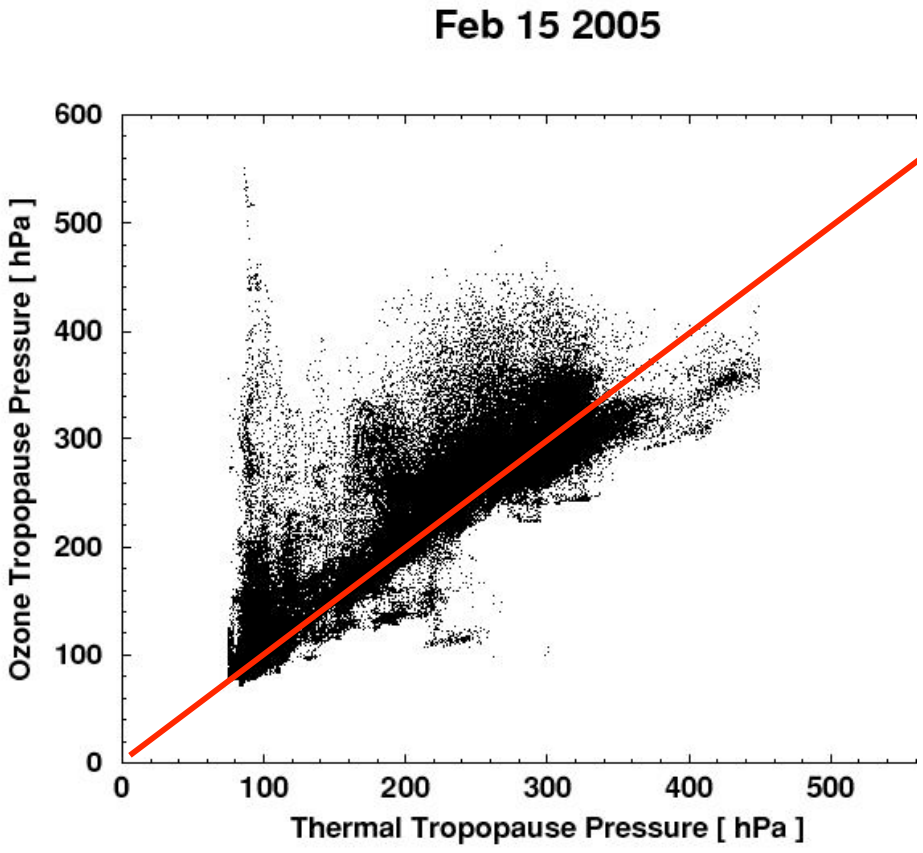
At high alti
air betwee
those surfa
contains
relatively s
portion of
troposphe
ozone

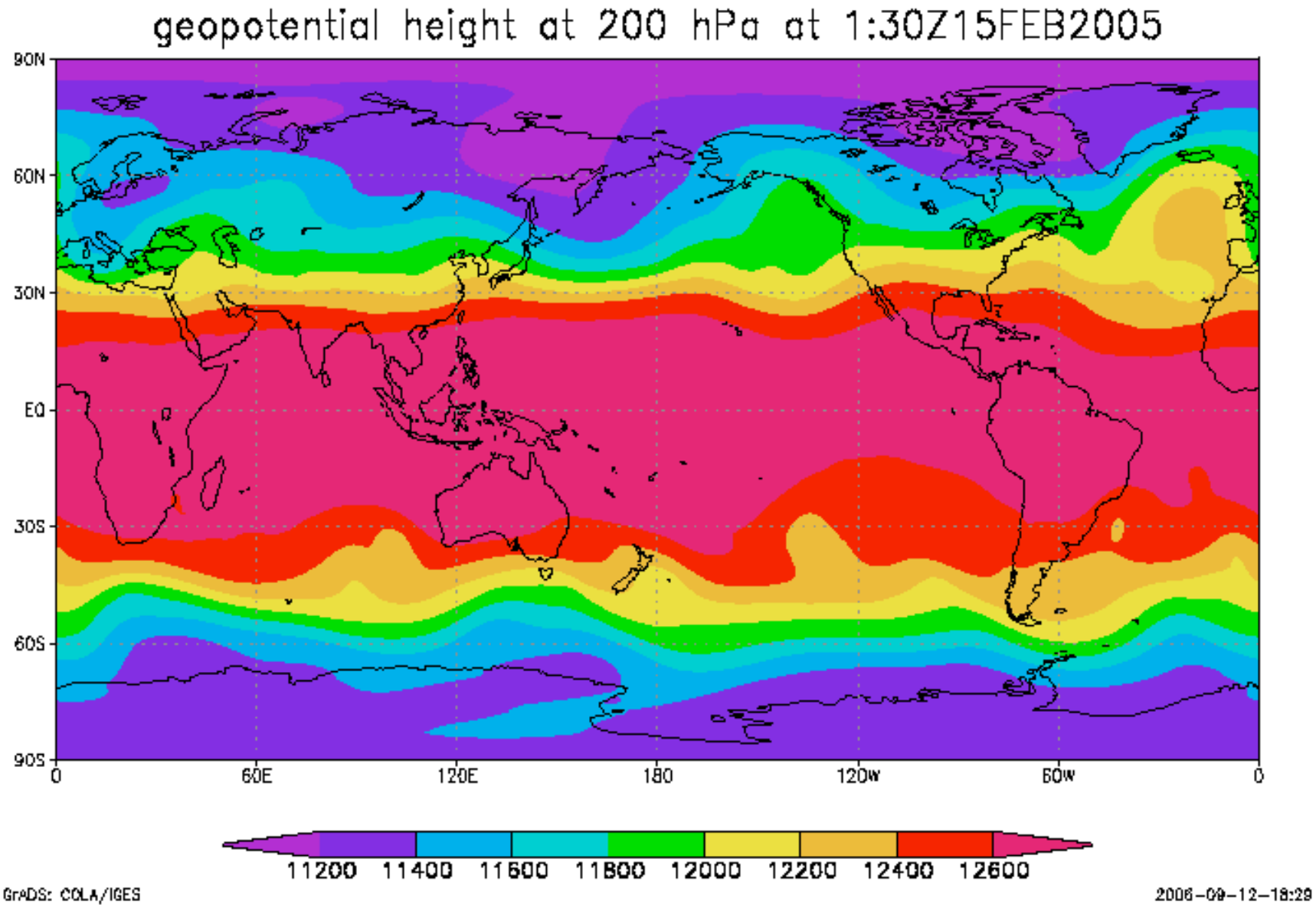
Summary

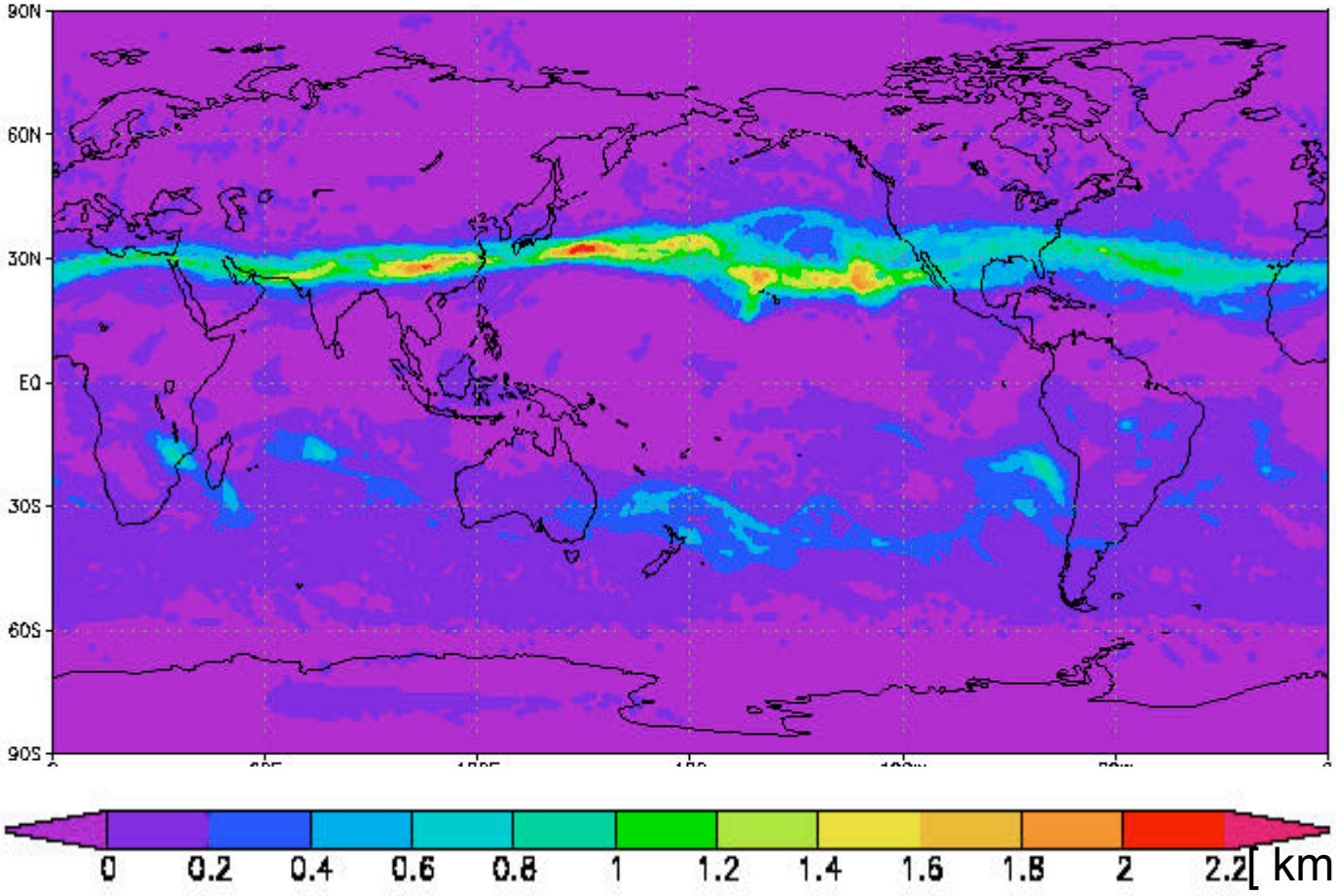
- Retrieved ozone data from OMI and MLS (onboard EOS Aura) were assimilated in a 15 month long run
- Mean agreement with sonde data within 10% in the stratosphere
- Significant reduction of model bias is observed during Antarctic spring 2005
  - Morphology of the Antarctic ozone depletion is captured accurately
- Relationships between thermal, dynamical and ozone tropopauses are studied:
  - Assimilated global ozone fields allow extension of previous studies which rely on insitu data
  - Applications to studies of stratosphere-troposphere exchange are planned.

Backup


Feb 15 2005
Ozone Tropopause Pressure [hPa]
Dynamical Tropopause Pressure [hPa]
0
100
200
300
400
500
600

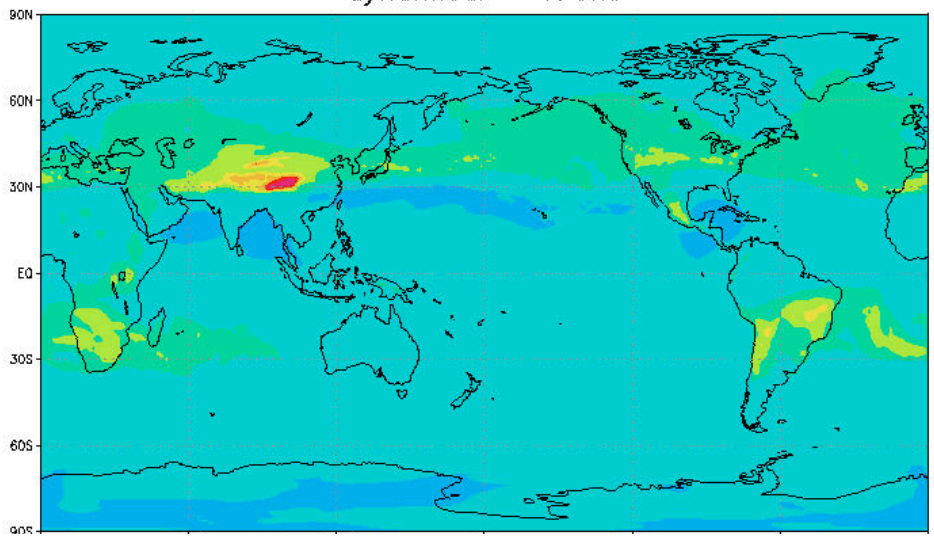

Feb 15 2005
Ozone Tropopause Pressure [hPa]
Thermal Tropopause Pressure [hPa]
0
100
200
300
400
500
600


geopotential height at 200 hPa at 1:30Z15FEB2005
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
0
11200
11400
11600
11800
12000
12200
12400
12600
GrADS: COLA/IGES
2006-09-12-18:29



Mean February approxima
distance between the two
‘ozone tropopauses’

dynamical – ozone



thermal – ozone