Tropical Broadening vs. Tropopause Rising

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- Overview.
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- Conclusions.

- The rising of the tropopause has been verified (Santer et al., 2003, Science, JGR; Schmidt - this workshop)
- The broadening of the tropics has been also pointed out (Seidel et al., 2008, NGEO)
- Additionally the acceleration of the Brewer-Dobson circulation (García and Randel, 2008, JAS) and a positive trend in the number of MT plus the increase of the UTLS baroclinicity (Castanheira et al., 2009, ACPD) complicate the picture.
- Lu et al. (2009, GRL) have obtained that the widening of the tropics is completely attributable to direct radiative forcing (SST forcing alone causes no significant change in the width of the tropics) and the rising of the tropopause is mainly caused by the cooling of the low stratosphere and less related with tropospheric warming.

So, how do we make sense of all these different contributions and effects?

Global Distribution of Potential Vorticity at the tropopause level

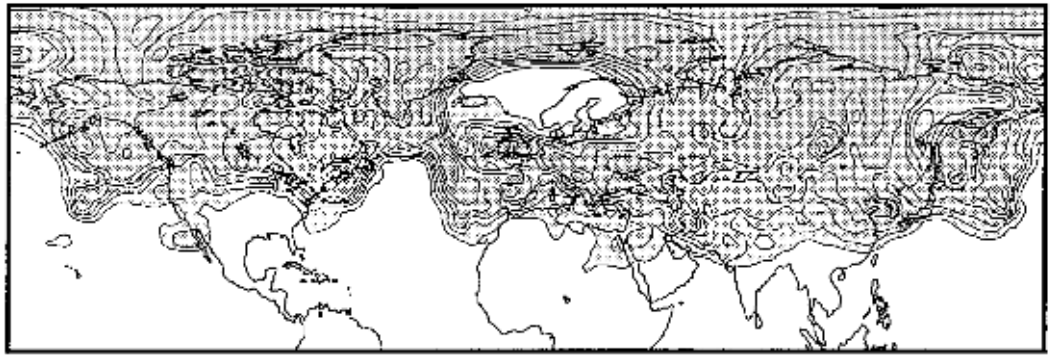

FIG. 1. Potential vorticity on the 320-K isentropic surface at 0000 GMT 15 February 1994, in lat–long projection for the Northern Hemisphere. Isolines are plotted every 1 PVU. Field produced by Dr. P. van Velthoven, using analyzed data from the European Centre for Medium-Range Weather Forecasts.

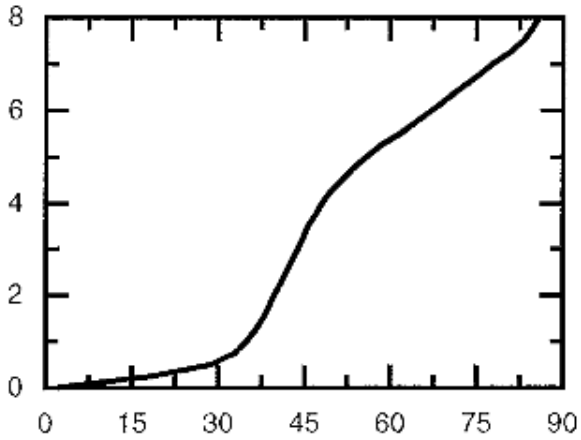

FIG. 2. Potential vorticity (in PVU) for the case of Fig. 1 plotted as a function of the area that is covered by potential vorticity values that are larger than the value at hand. Area is expressed as equivalent latitude, i.e., the latitude of a zonally symmetric contour enclosing the same area.

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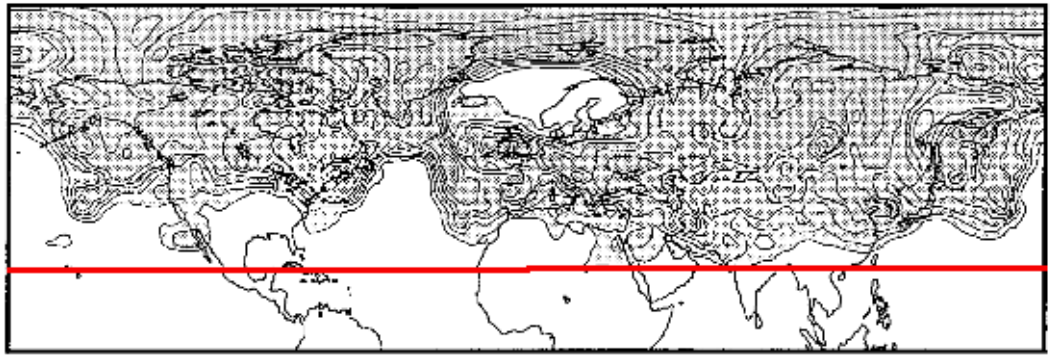

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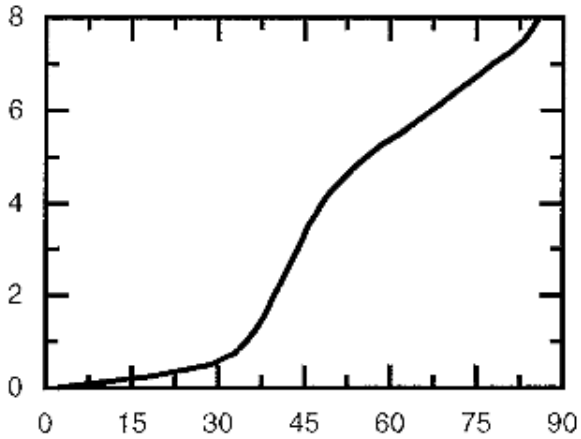

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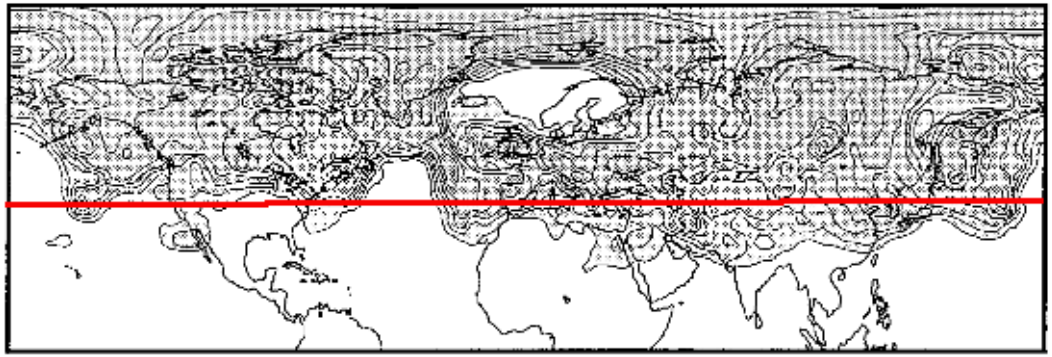

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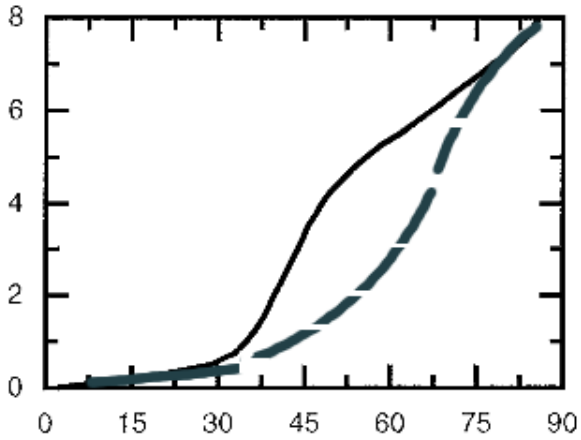

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Questions

Is our planet becoming 'more tropospheric' ?

Could be the observed tropical broadening a single consequence of the tropopause rising?

How can we distinguish the cause-effect relationship of the rising of the global tropopause and the broadening of the tropical one?

How has evolved the global field of potential vorticity at the UTLS in the last decades? Is it as 'expected' from a tropical broadening?

Data & Methodology

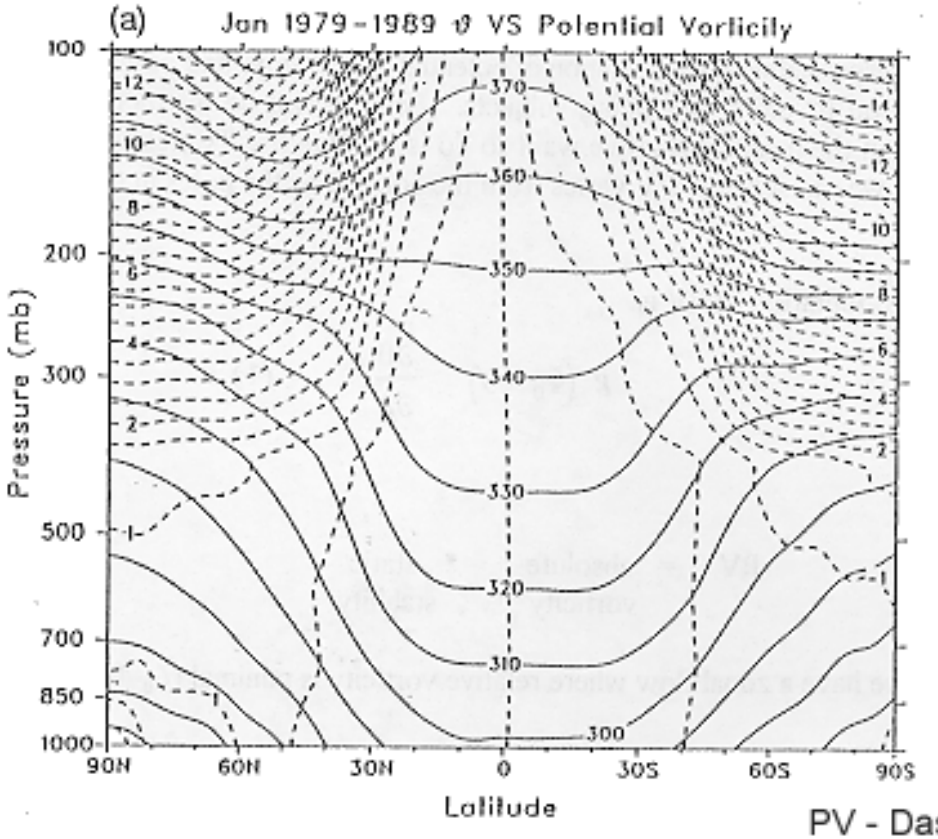


Figure one

Data & Methodology

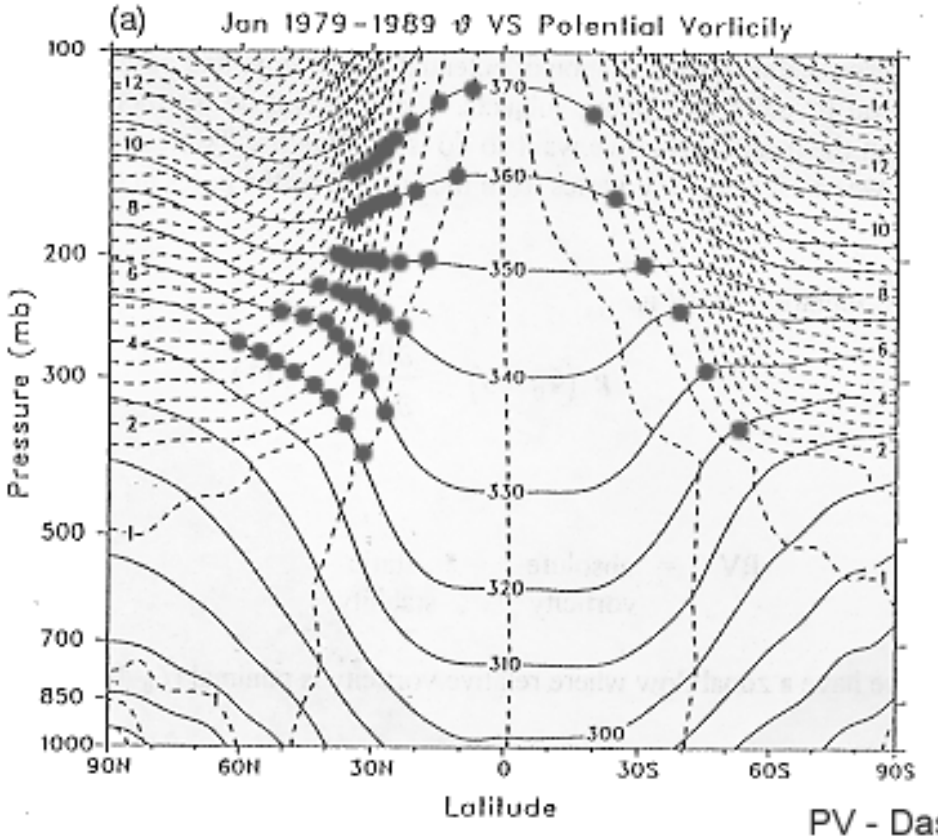


Figure one

Data & Methodology

- Analysis of the pressure leveles between 500 and 50 hPa.
- Datasets used: WACCM, WACCM UTLS, ERA-INTERIM, JRA25, NCEP2

	N levels 500-50 hPa	Horizontal grid
WACCM	14	1.9x2.5
WACCM UTLS	40	1.9x2.5
ERA-INTERIM	14	1.5x1.5
JRA25	7	2.5x2.5
NCEP2	7	2.5x2.5

Data & Methodology

- θ is computed for each grid point

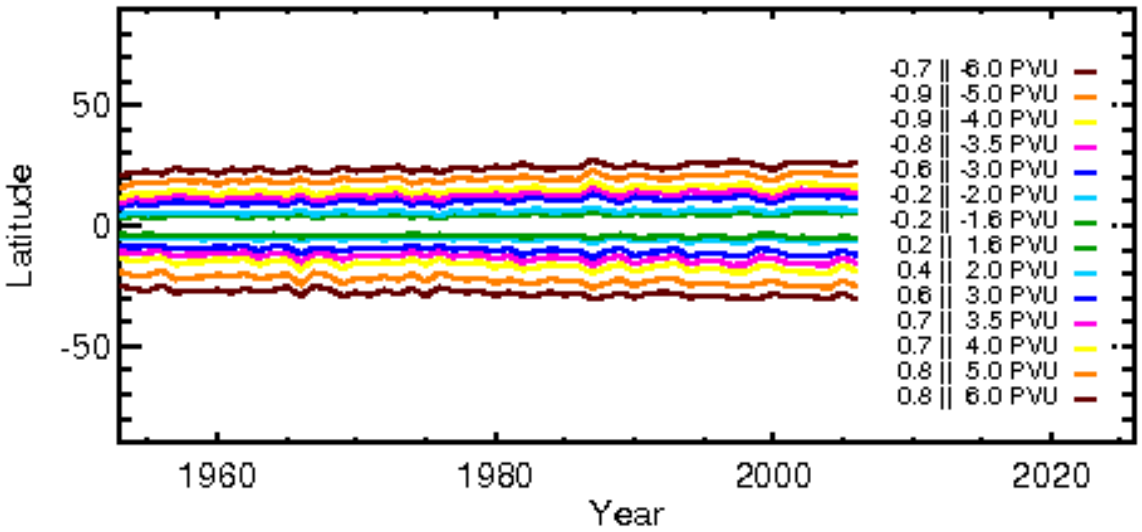
$$\theta(\lambda, \phi, p, t) = T(\lambda, \phi, p, t) \cdot (p_0/p)^{(R/c_p)}$$

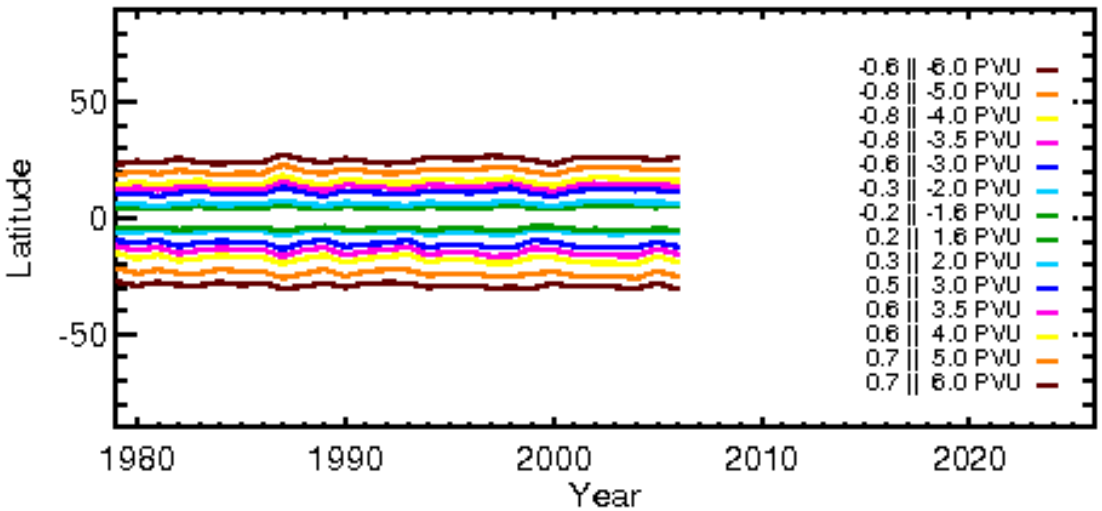
- u, v and z fields are interpoled to the θ levels interesting for our study (from 340K to 420K)
- the isentropic relative vorticity of the air $\xi_\theta$is computed
- then we have the absolute vorticity
- $d\theta/dp$ is computed and then interpoled to isentropic levels.
- then the potential vorticity is computed

$$PV(\lambda, \phi, \theta, t) = -g \cdot (\xi_\theta + f) \cdot (d\theta/dp)$$

- the PV field is interpoled to the desired values (1.6, 2, 3, 3.5, 4, 5, 6 PVU and the subsequent for the Southern Hemisphere).
- the ϕ_e is computed

WACCM 3.5.48 1.9x2.5 - Using different periods of study - 390K

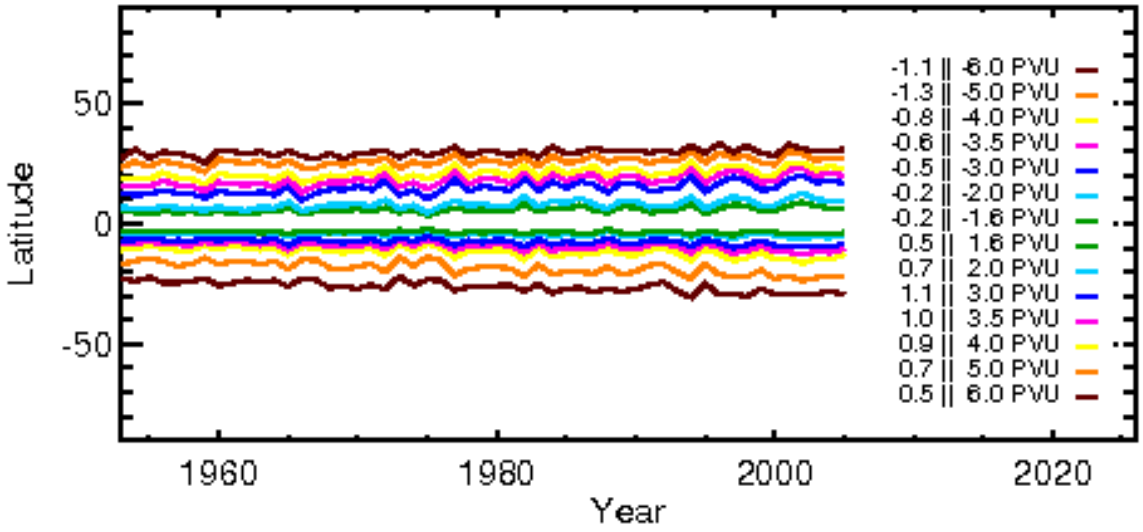




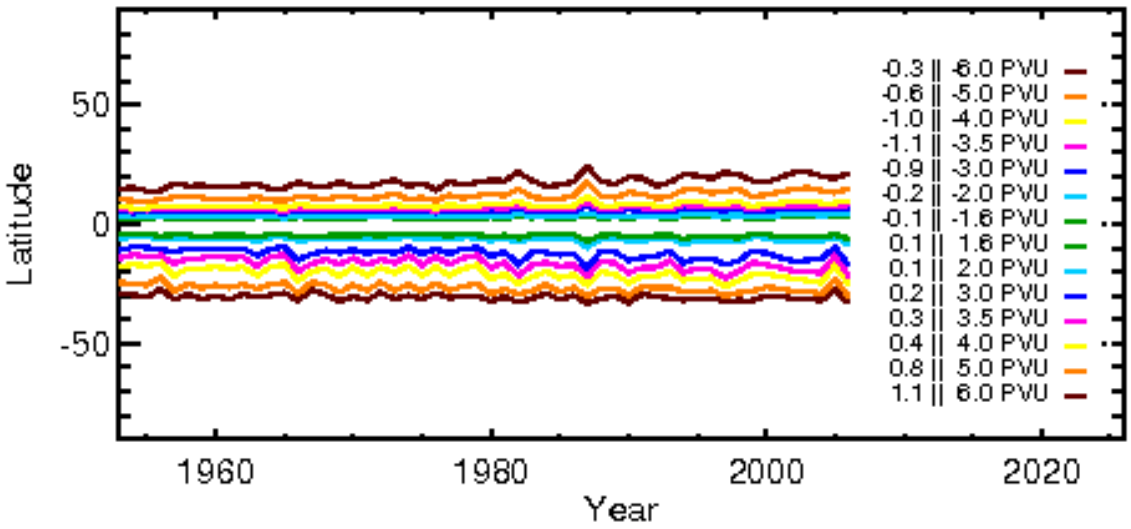
* the diference between the 1953-2006 and 1979-2006 period is a poleward trend 0.1 degrees/decade higher for the first one.

WACCM 3.5.48 1.9x2.5 - Seasonal analysis - 390K

DJF



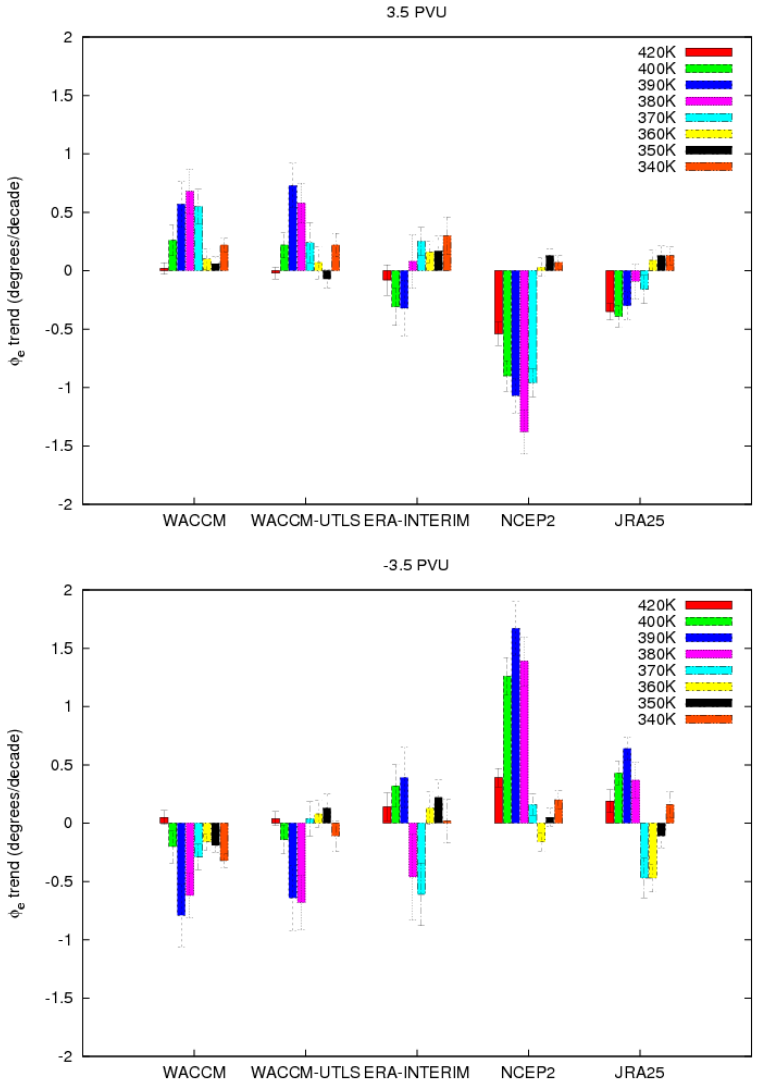
JJA



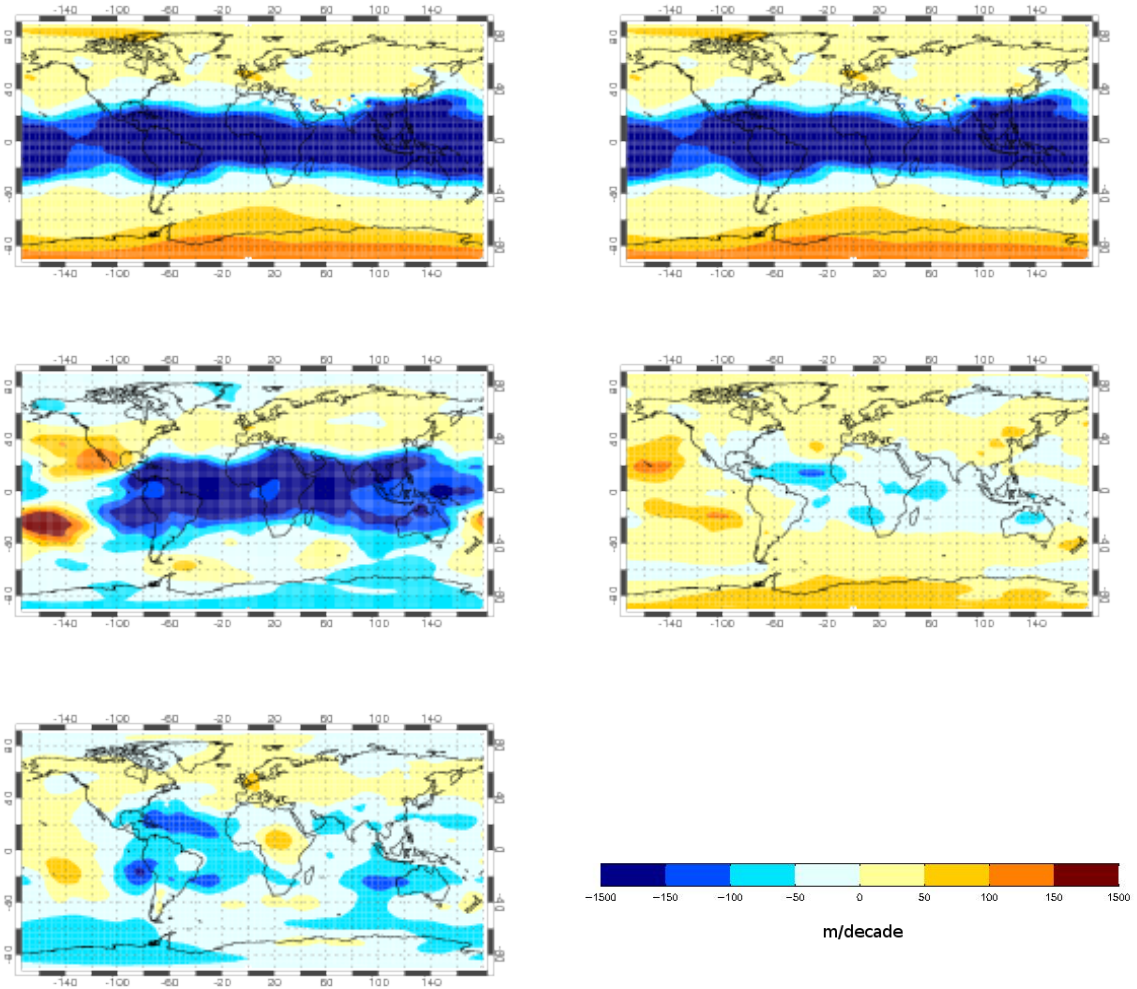
* a poleward displacement of the PV field for the hemispheric winter is found. The main contribution to the final poleward trend for typical PV values of the tropopause in extratropics comes from the winter for each hemisphere.

For the following results keep in mind the period of study:

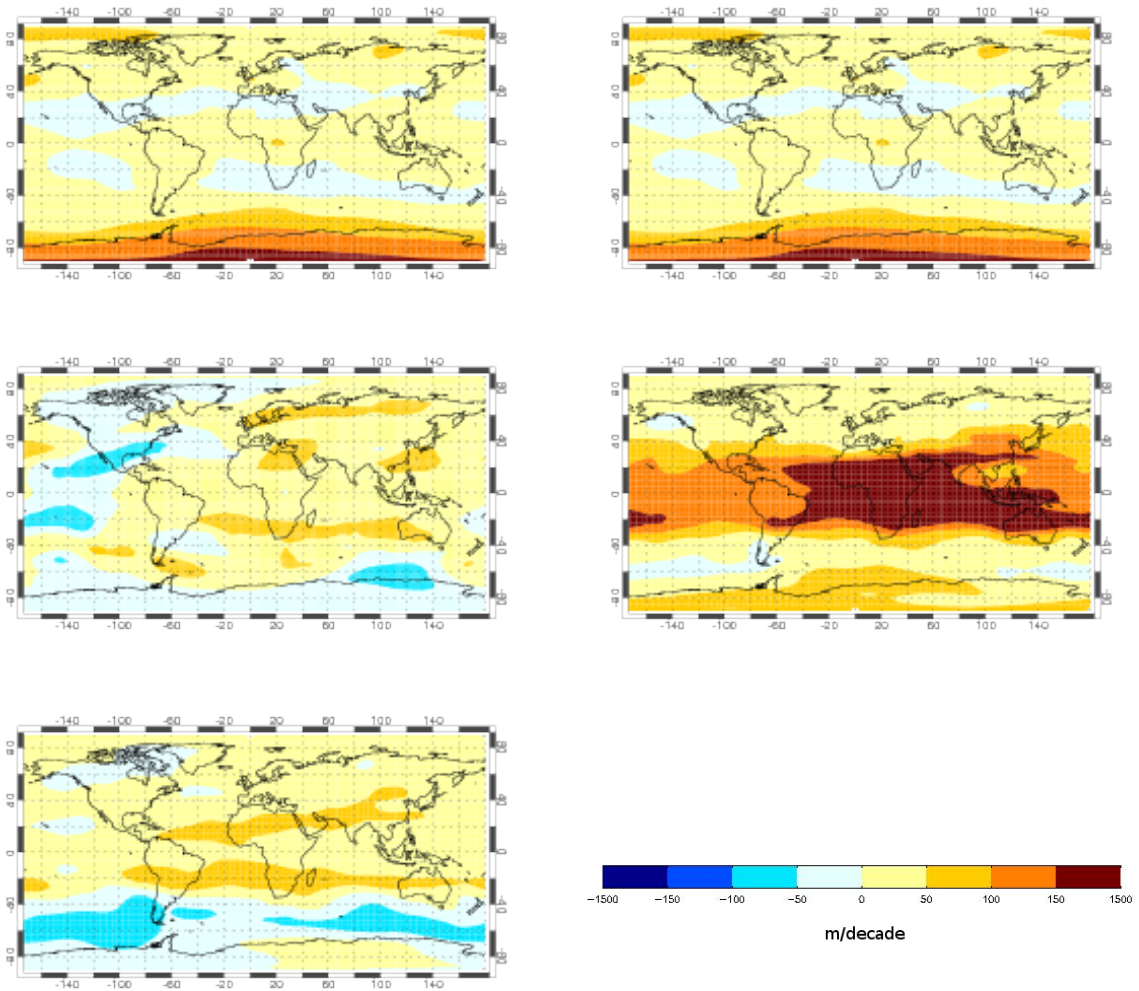
WACCM — 1979-2006
WACCM-UTLS — 1979-2006
ERA-INTERIM — 1989-2008
JRA25 — 1979-2007
NCEP2 — 1979-2008


3.5 PVU
420K
400K
390K
380K
370K
360K
350K
340K
ϕ_e trend (degrees/decade)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
WACCM
WACCM-UTLS
ERA-INTERIM
NCEP2
JRA25
-3.5 PVU
420K
400K
390K
380K
370K
360K
350K
340K
ϕ_e trend (degrees/decade)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
WACCM
WACCM-UTLS
ERA-INTERIM
NCEP2
JRA25

340K



380K



Conclusions

- WACCM gives a clear poleward signal of the movement of the PV field
- The reanalysis give a opposite signal in several cases, but other times are coincident in the isentropic levels more close to the tropopause
- For the reanalysis the signal is opposite for the most tropospheric isentropic levels to the more stratospheric ones and in some cases both of them are opposite to the values in the tropopause
- Why the isentropic levels seem to be going down in the upper troposphere?
- The trends of isentropic potential vorticity in the three reanalysis are pretty coherent:
  - small poleward trends at the isentropes in the isentropes which cut the tropopause
  - greater equatorward trends at the isentropes in the isentropes inside the stratosphere
- we observe two competing phenomena (rising and broadening) with different interaction and contributions in the vertical and with the latitude. Ideas: possibly affected by changes in the static stability and the strength of the polar vortex
- changes in the convective processes affecting the trend of the geopotential height of the tropospheric isentropic surfaces?
- from a quick look there is not too much evidence of a slow down of the widening but it is not a definitive conclusion

Thanks for help, advices and collaboration to ...

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MINISTERIO DE CIENCIA E INNOVACIÓN

TRODIM

... and thank you very much for attending this presentation.