

# WACCM and TRODIM

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## TRODIM PROJECT

<http://ephyslab.uvigo.es/trodim/>

**TRODIM is a research project focused on the study of the extratropical tropopause and funded by the Spanish Government with the participation of eight research centres in Spain, Portugal and Cuba**

- Universidad de Vigo, Ourense
- Universidad de Extremadura, Badajoz
- Universidad Pablo de Olavide, Sevilla
- Universidad Complutense de Madrid, Madrid
- Universidad de Barcelona
- CSIS-Laboratory for Atmospheric and Climate Sciences
- Estacion Lidar de Camaguey, Cuba
- Universidad de Aveiro, Portugal

## **RUNNING WACCM-UTLS IN FINISTERRAE (finished):**

**(103 levels – resolution 300 m. between 500-50 hPa)**

- WACCM-UTLS 2.5.48 REFB1
- WACCM-UTLS 3.5.48 – 1999-2007---> 125 chemical species
- WACCM – 1999-2007 125 chemical species (66 vertical levels)
- WACCM-UTLS 3.5.48 – REFB0 ---> AQUAPLANET
- WACCM-UTLS 3.6.54 – grid 0.9x1.25 (tested for 16 months)

## **RUNNING WACCM-UTLS IN FINISTERRAE (in progress):**

WACCM-UTLS 3.6.54 – grid 0.9 x 1.25 + nudged data (2004-2008)

Juan A. Añel, A. Gettelman, J. M. Castanheira (2009), Tropical broadening vs. Tropical rising,, Workshop “The extratropical UTLS: observations, concepts and future directions”, NCAR, 19-22 October 2009. + PAPER IN PREPARATION

A. Gettelman, M. Hegglin, S.-W. Son, M. Fujiwara, S. Tilmes, L. Pan, P. Hoor, H. Lee, G. Manney, T. Birner, G. Stiller, M. Rex, S. Kremser, D. Wuebbles, K. Walker, J. A. Añel (2009) Upper Troposphere and Lower Stratosphere in SPARC CCMVal, SPARC CCMVal Report on the Evaluation of Chemistry-Climate Models, V. Eyring, T. G. Shepherd, D. W. Waugh (Eds.), SPARC Report No. 5, WCRP-X, WMO/TD-No. X

## **Research in Progress:**

- Ability of WACCM to reproduce multiple tropopauses (MT) events
- Comparison to observed MT events (percentages and locations)
- Ability of WACCM to reproduce the observed trend in MT cases over the last three decades
- Ability of WACCM to reproduce the observed tropopause in the nudged simulation
- Study of the tropopause in the Aquaplanet simulation. Is it similar to the other simulations? E.g. are the MT events located in the same regions?

# A comparison of dynamical tropopause pressure from WACCM and ERA-40

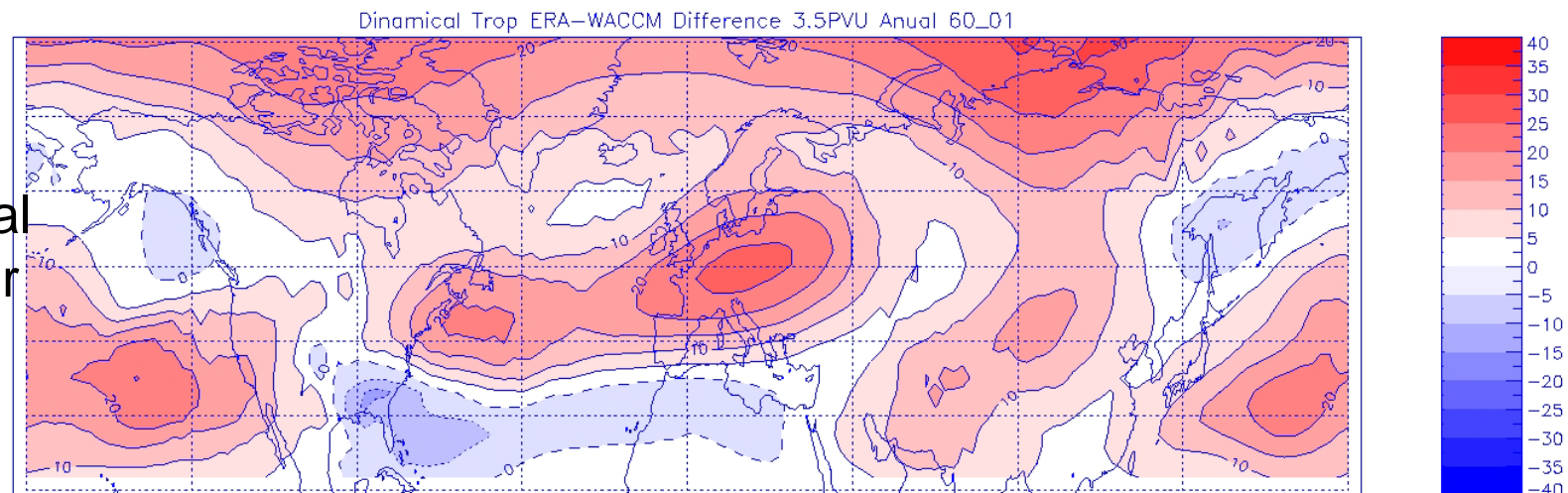
Abstract: Reanalysis data (ERA-40) were used to test WACCM's ability to reproduce realistically the pressure tropopause. Annual and seasonal climatology–mean, meridional profiles and trends of the tropopause pressure of reanalysis and simulations of WACCM were compared.

Data: ERA-40 reanalysis (ECMWF), 42 vertical levels (hybrid coordinates). WACCM REF1.1 (1960-2001).

Methodology: The dynamical tropopause is assigned to the vertical position where the potential vorticity  $PV_{\theta}$  first exceeds a threshold value (3.5PVU)(Hoinka et al., 1998). First the model data were converted into isentropic coordinates by vertical interpolation at  $\theta^{\chi}$  ( $\chi=R/C_p$ ) (Townsend et al, 1985).

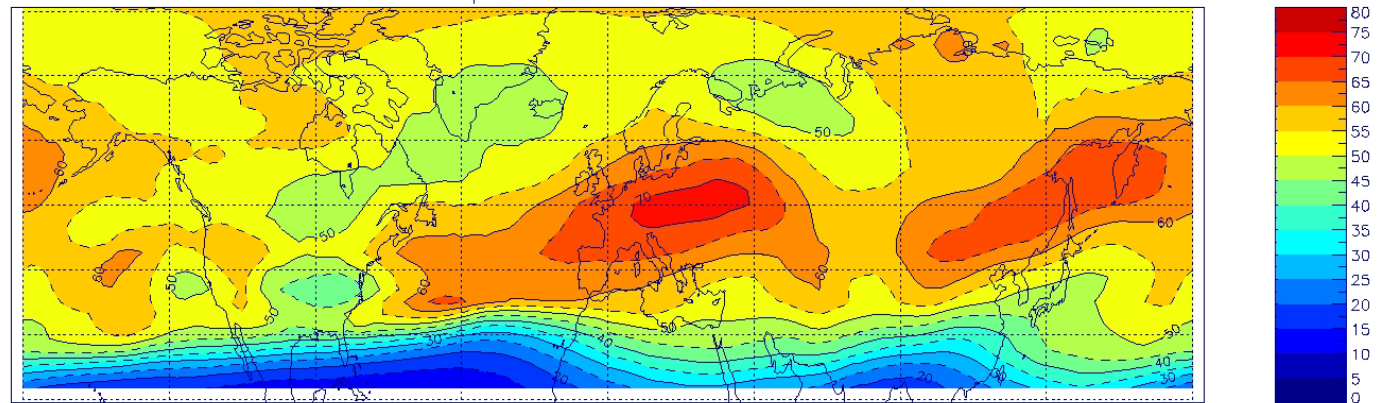
Result:

- ERA-40 dynamical tropopause higher than WACCM on average..



Annual mean of pressure differences (ERA-40 minus WACCM ).  
The pressure increment is 5 hPa.

- Rms was higher over the latitude range 40°-60° N.



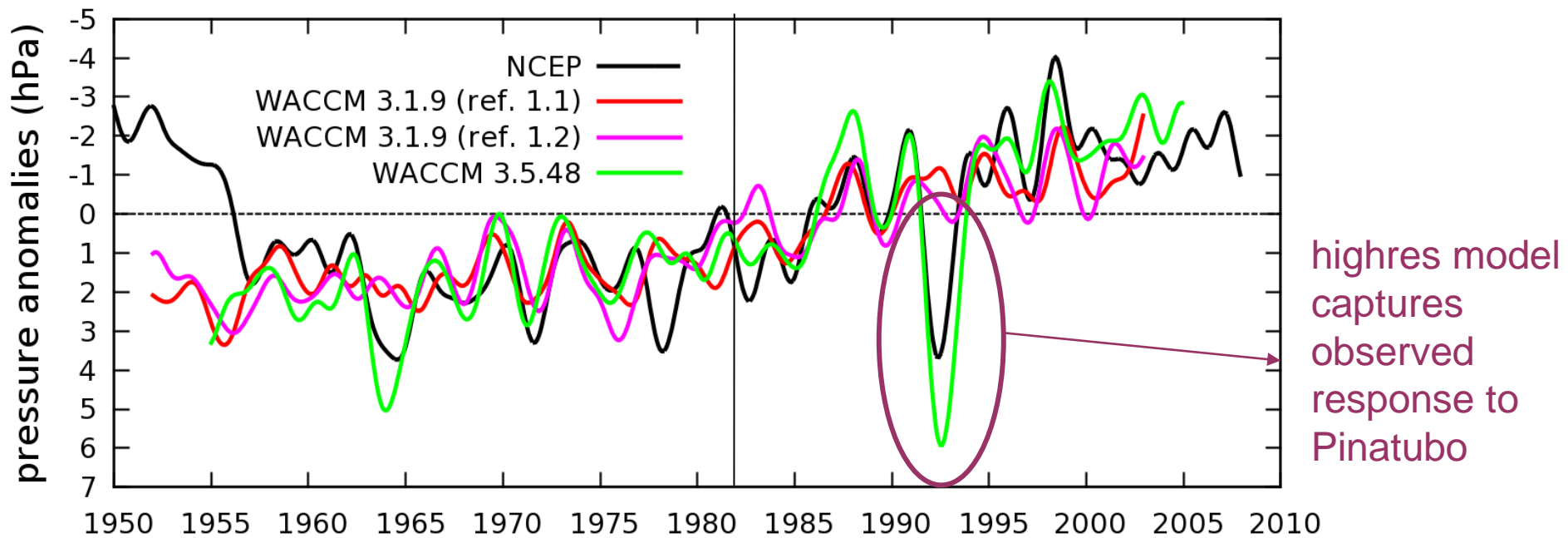
RMS of the mean pressure differences. The pressure increment is 5 hPa.

- The features of the tropopause pressure were reproduced by WACCM and ERA-40.
- Meridional profile shows that WACCM's results are within the range of one deviation from the ERA's results.
- For the recent past, the tropopause pressure (height) has decreased (has increased), for WACCM and ERA-40.

#### Future study:

- ✓ Test WACCM's ability to reproduce results of ERA-40 and MERRA data by application of the definitions dynamical, thermal and chemical tropopause for all globe, by ref 1.1 (present).
- ✓ Study of the chemical tropopause by O<sub>3</sub>, CO and WV profiles obtained from MERRA reanalysis. These results will be checked using the model WACCM.
- ✓ Comparison of results of ERA-40 versus WACCM (ref 1.1), by 66 levels model (standard) and 103 model levels, with resolution higher on tropopause height.

# XX<sup>th</sup> century global tropopause height evolution

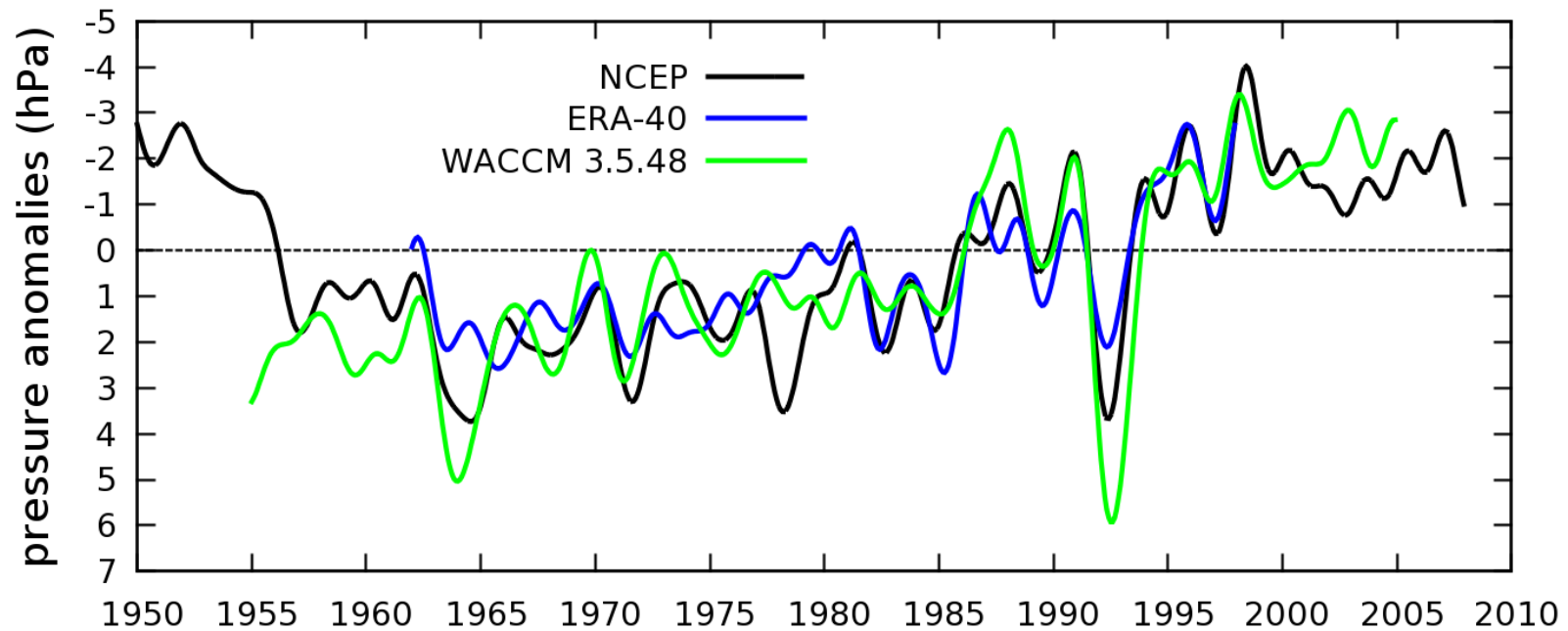


TROPOPAUSE HEIGHT TRENDS (hPa/decade)	1953-2004	1979-2004
NCEP		-1.27
WACCM319 ref. 1.1		-1.24
WACCM319 ref. 1.2		-0.92
WACCM3548		-1.50

simulated trends are of same order of magnitude as observed, but large sampling variability

trends stronger with higher vertical resolution

# XX<sup>th</sup> century global tropopause height evolution

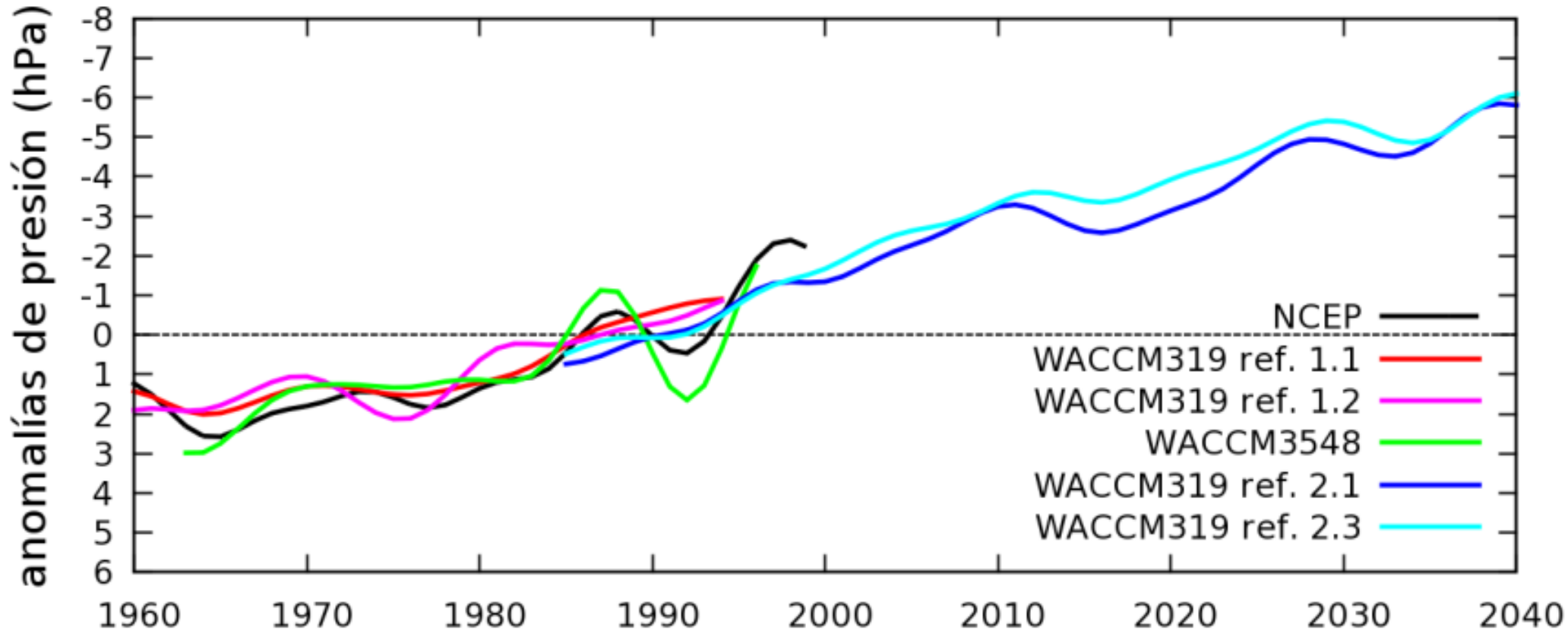


TROPOPAUSE HEIGHT TRENDS CORRELATIONS (1979-1999)	ERA	WACCM 319 ref 1.1	WACCM 319 ref 1.2	WACCM-UTLS
NCEP (unfiltered)	0.66	0.35	0.42	0.72
NCEP (filtered)	0.87	0.33	0.46	0.87

- Interannual variations in ERA40 and NCEP are well correlated (1979-1999)
- Interannual variations in high-res simulation much better correlated with observed



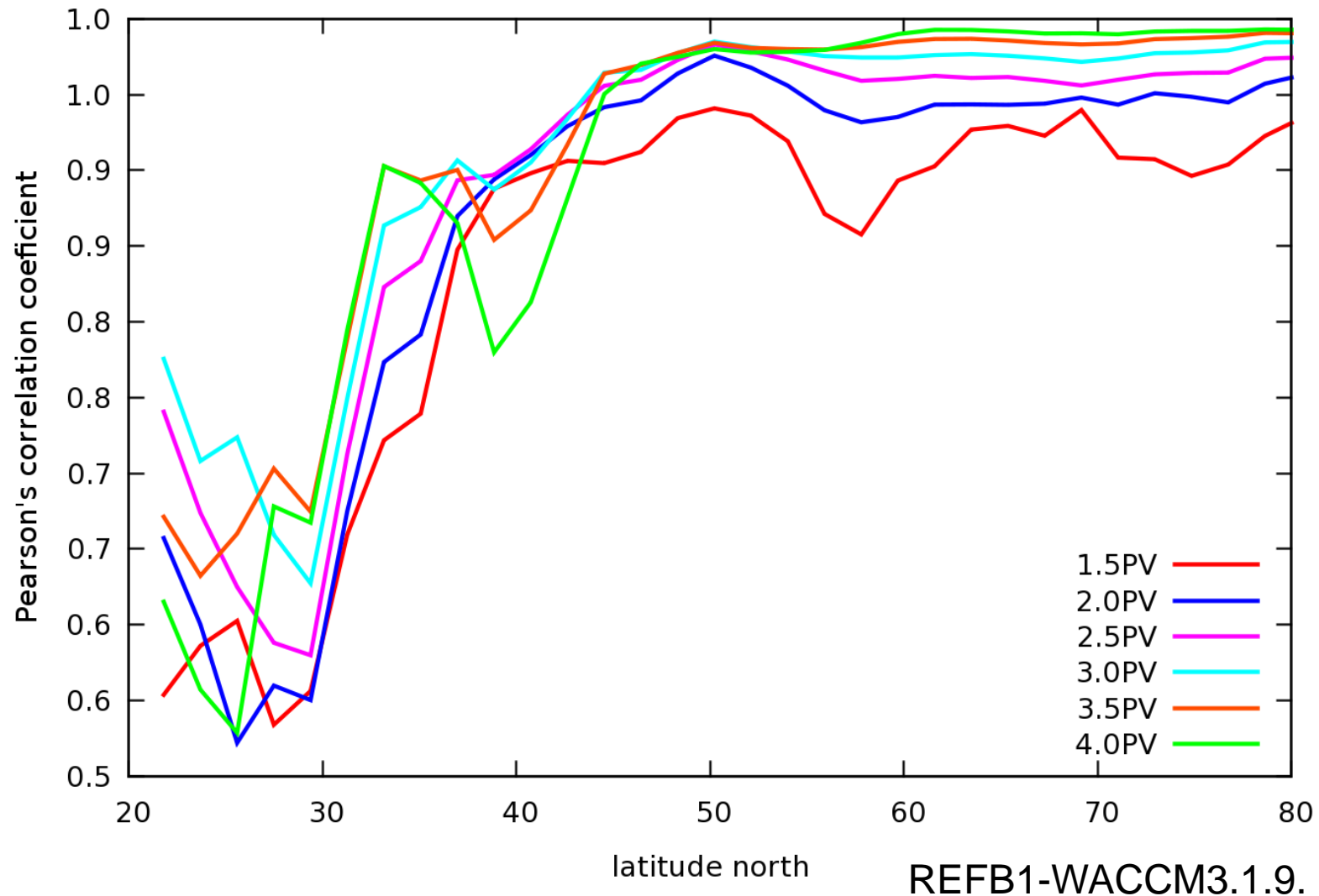
# XXI<sup>st</sup> century global tropopause height evolution



TRENDS	1954-2004	1979-1999	1979-2004	2000-2049
WACCM 2x, 2 member ensemble	-0.80	-1.2	-1.08	-0.98
WACCM 4x, 3 member ensemble (Son et al. 2008)		-1.25		-0.91

Future reduction in tropopause height trend less clear in these simulations

# Lapse-rate versus dynamical tropopause



- Agreement only northwards of 40°N.
- 3.5 or 4 PV surface provides best fit to lapse-rate tropopause.

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### WACCM TEAM



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BARCELONA SUPERCOMPUTING

