GRIPS GCM simulated polar vortex intercomparison

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The 4D evolution of stratospheric polar vortex simulations within GRIPS GCM models (Pawson et al, 2000) are compared with analyses (NMC and UKMO) by applying elliptical diagnostics (Waugh, 1997) to daily output over several years. Details of the datasets used are seen in Table 1.

Elliptical diagnostics (Waugh, 1997) provide a concise method to depict the 4D lifecycle of stratospheric polar vortices and are obtained by fitting an ellipse to the Ertel potential vorticity (Epv) contour which defines the edge of the polar vortex on isentropic surfaces. The characteristics of the fitted ellipse (equivalent latitude, centroid latitude and longitude, aspect ratio and orientation of the major axis) are then used to describe the vortex.

Given the time series of daily geopotential height fields the Epv is calculated via Randel (1992). Because the magnitude of Epv increases rapidly with height we use the modified Epv of Lait (1994) and we define the vortex edge as the location of the highest Epv gradient with respect to the equivalent latitude of each Epv contour, constrained by the proximity of a strong westerly jet (Nash et al., 1996).

The time mean, maximum, minimum and standard deviation of the absolute equivalent latitude ($|elat|$) for the southern hemisphere polar vortex for the analyses and model datasets are plotted in Figure 1. The NMC and UKMO analyses plots suggest that the polar vortex is: "S" shaped; centred near 60^o; with a local $|elat|$ maxima near 700K; a rapid increase in vortex size and variability above 1000K; and a local $|elat|$ minima near 1500K with rapid decay of the vortex above.

Most of the model vortices tend to capture some of these main features but the shape of the vortex is greatly affected by model characteristics such as: horizontal and vertical resolution; the presence of sponge layers; gravity wave drag schemes; model top location; radiation schemes and planetary wave characteristics.

References

Lait, L.R., 1994: J. Atmos. Sci., 51, 1754-1759.

Nash, E.R. et al., 1996: J. Geophys. Res., 101, 9471-9478.

Pawson S. et al., 2000: Bull. Amer. Met. Soc., 81, 4, 781-796.

Randel, W.J., 1992: NCAR Technical Note NCAR/TN-366+STR, February, 1992.

Waugh,D.W., 1997: vortices. Q.J.R. Meteorol. Soc., 123, 1725-1748.

Group	Contact	Horiz Resolution no. Lat X Lon	No. of Vert Levels	Top (hPa)	Time Span
NMC analyses, USA	W.Randel	40x36	L17	1.00	21 years
UKMO analyses, UK	BADC	72x96	L22	0.31	9 years
BMRC, Australia	G.Roff	72x144	L34	0.31	10 years
CMAM, Canada	J.de Grandpre	48x96	L50	0.01	10 years
CNRM, France	P.Simon	32x64	L31	0.03	20 years
FUB, Germany	U.Langematz	32x64	L27	0.01	20 years*
MPI, Germany	E.Manzini	64x128	L39	0.01	5 years*
MRI-JMA, Japan	K.Shibata	64x128	L24	0.01	15 months
NASA, USA	S.Pawson	91x144	L55	0.015	10 years
UM-UKMO, United Kingdom	R.Bannister	72x96	L58	0.10	20 years

Table 1: *The group, contact scientist, resolution and reference for the GRIPS GCM models and analyses used in this study. * Note that FUB provided three different model runs and MPI two.*

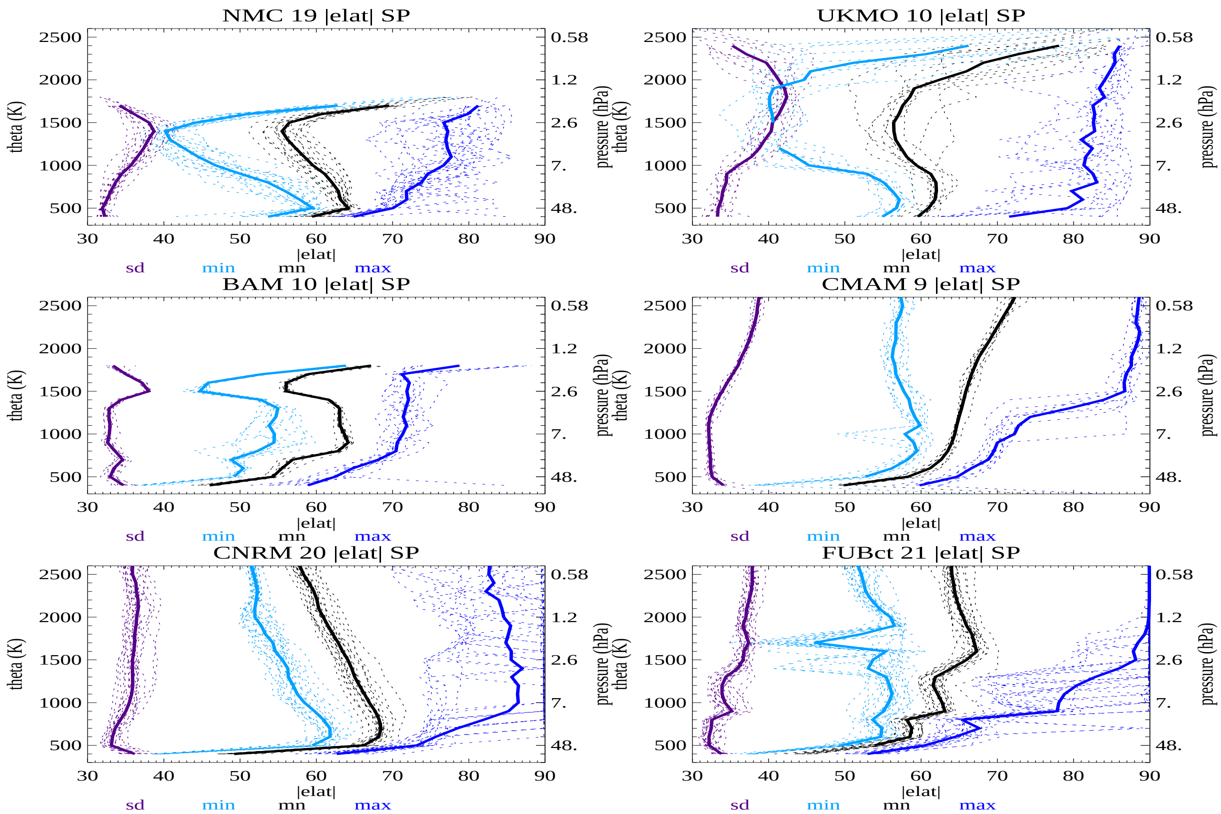

Figure 1: The mean, maximum, minimum and standard deviation (black, dark blue, light blue and purple curves, respectively) of the absolute equivalent latitude (^{o}) for the southern hemisphere polar vortex calculated for daily data from each year (dashed curves) and averaged over all years (solid curves) for 2 analyses and 10 model datasets plotted against potential temperature (K).