MODELLING STRATOSPHERIC OZONE CHEMISTRY IMPACTS ON SOUTHERN HEMISPHERE CIRCULATION

R.J. Dargaville[1] , D.J. Karoly[1] and O. Morgenstern[2]
[1]School of Earth Sciences, University of Melbourne, Parkville 3010, Australia
[2]National Water and Atmospheric Research, Lauder, New Zealand

THE UNIVERSITY OF MELBOURNE

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Outline

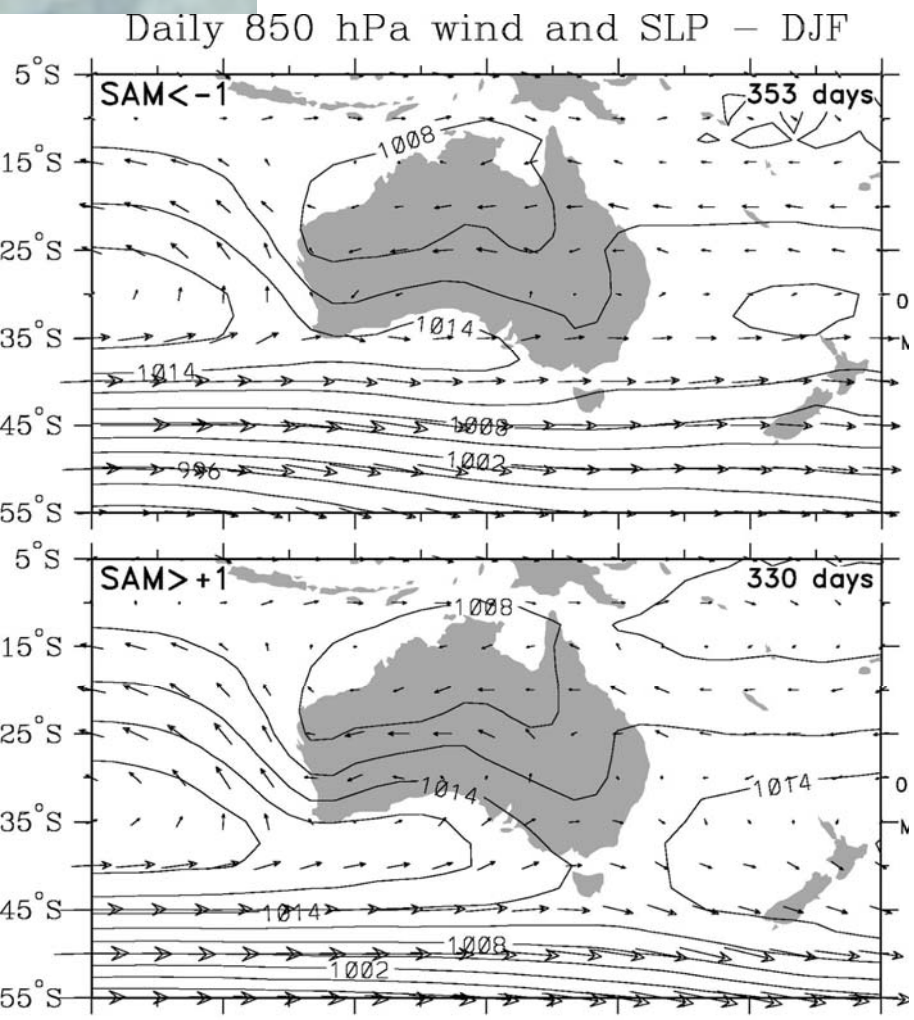
- Why do we care about ozone
- SAM and ozone
- Ozone chemistry
- ACCESS model and preliminary results

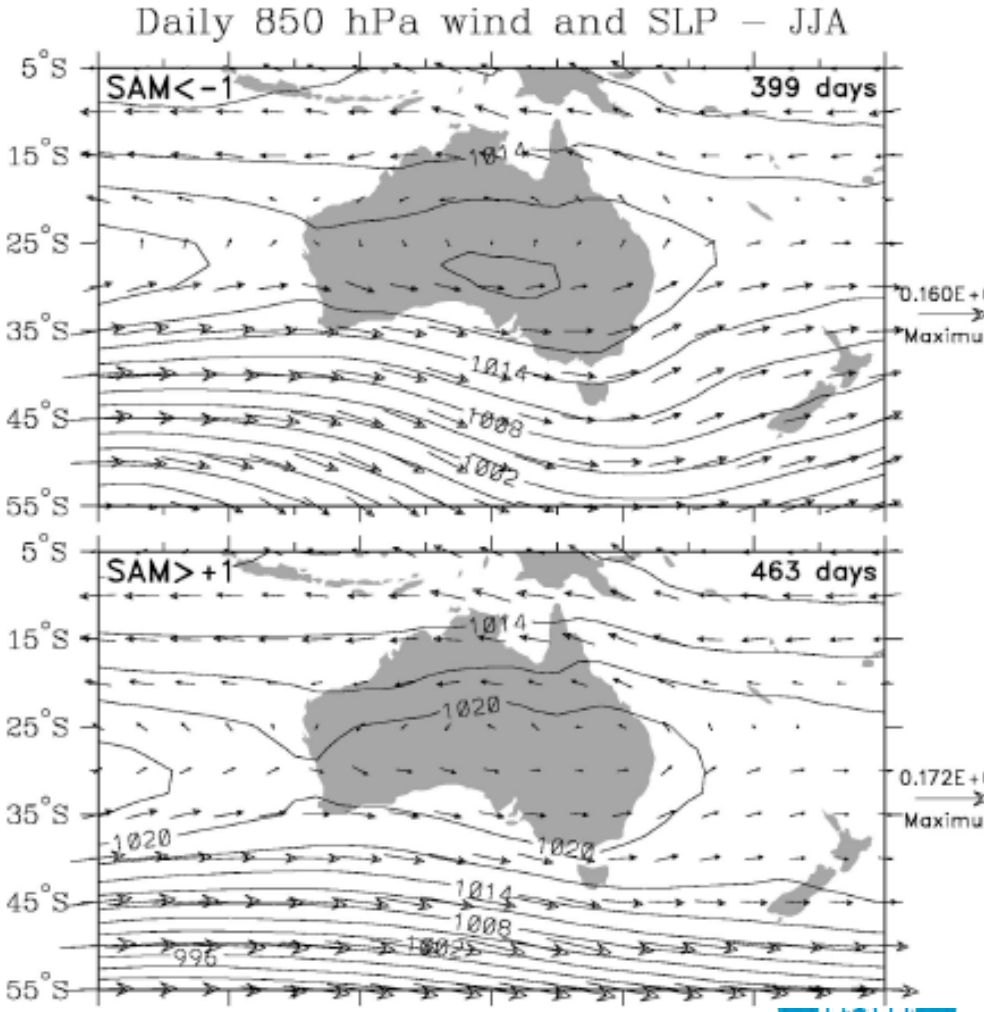
Why are we interested in ozone?

- Ozone protects us from harmful UV radiation
  - The discovery of the ozone hole led to fears that widespread ozone destruction would result in dangerous amounts of UV reaching the surface in populated areas
- Ozone concentrations affect temperature structure of the stratosphere
  - Hypothesis that the ozone hole and cooling of the stratosphere has increased the intensity of the polar vortex which has impacts on storm tracks in the southern hemisphere

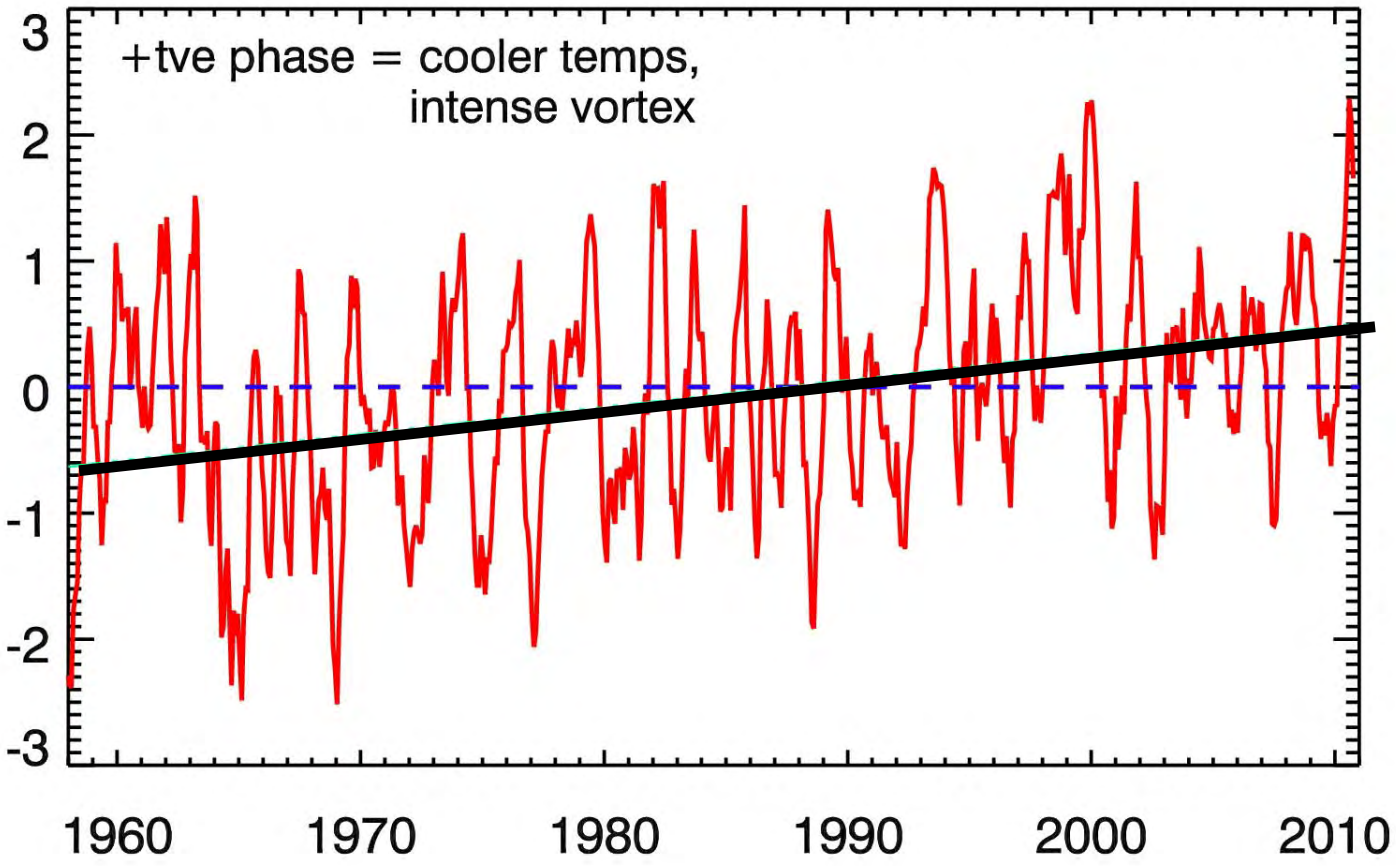
SAM, SLP and 850hPa winds

(Hendon et al. 2007)

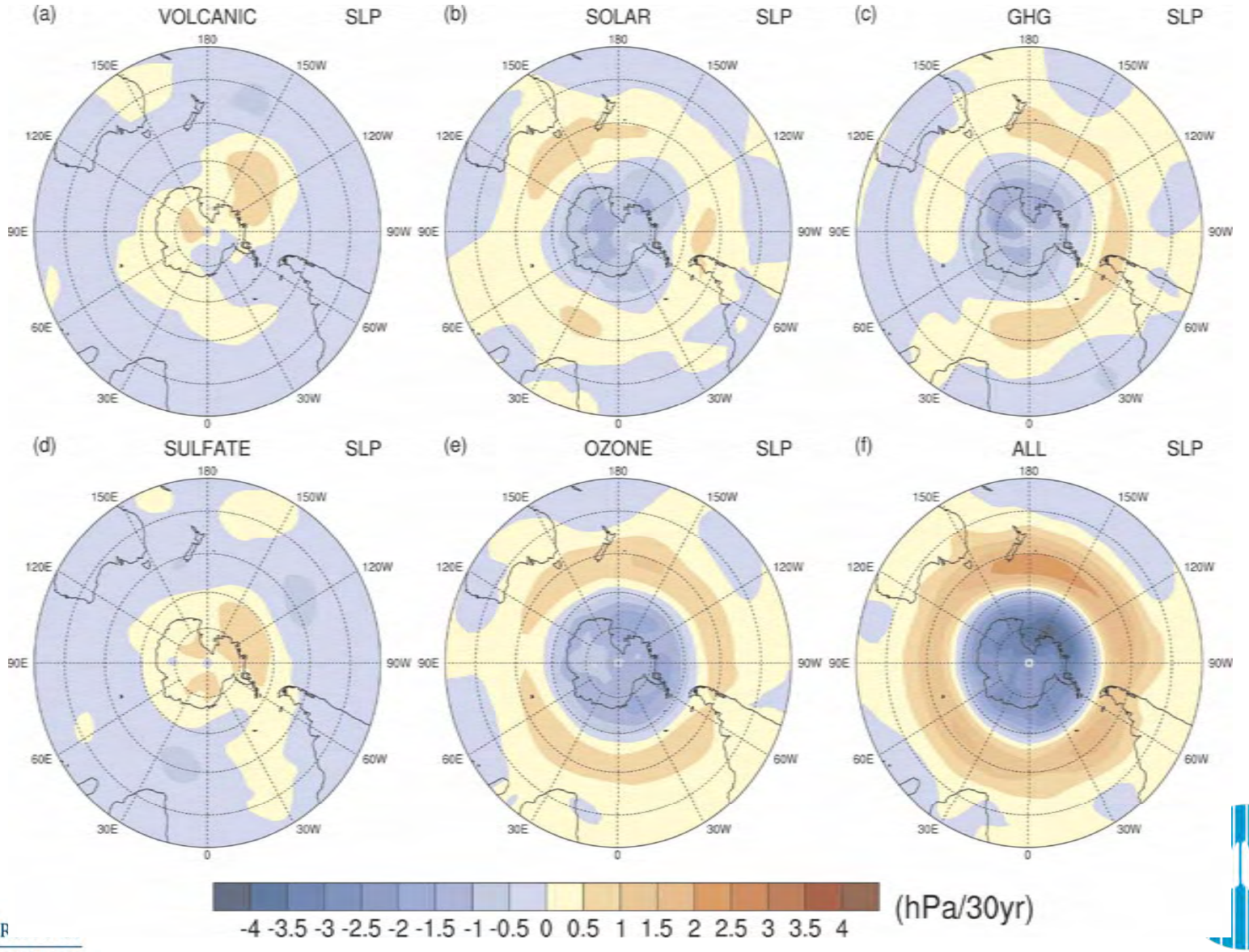




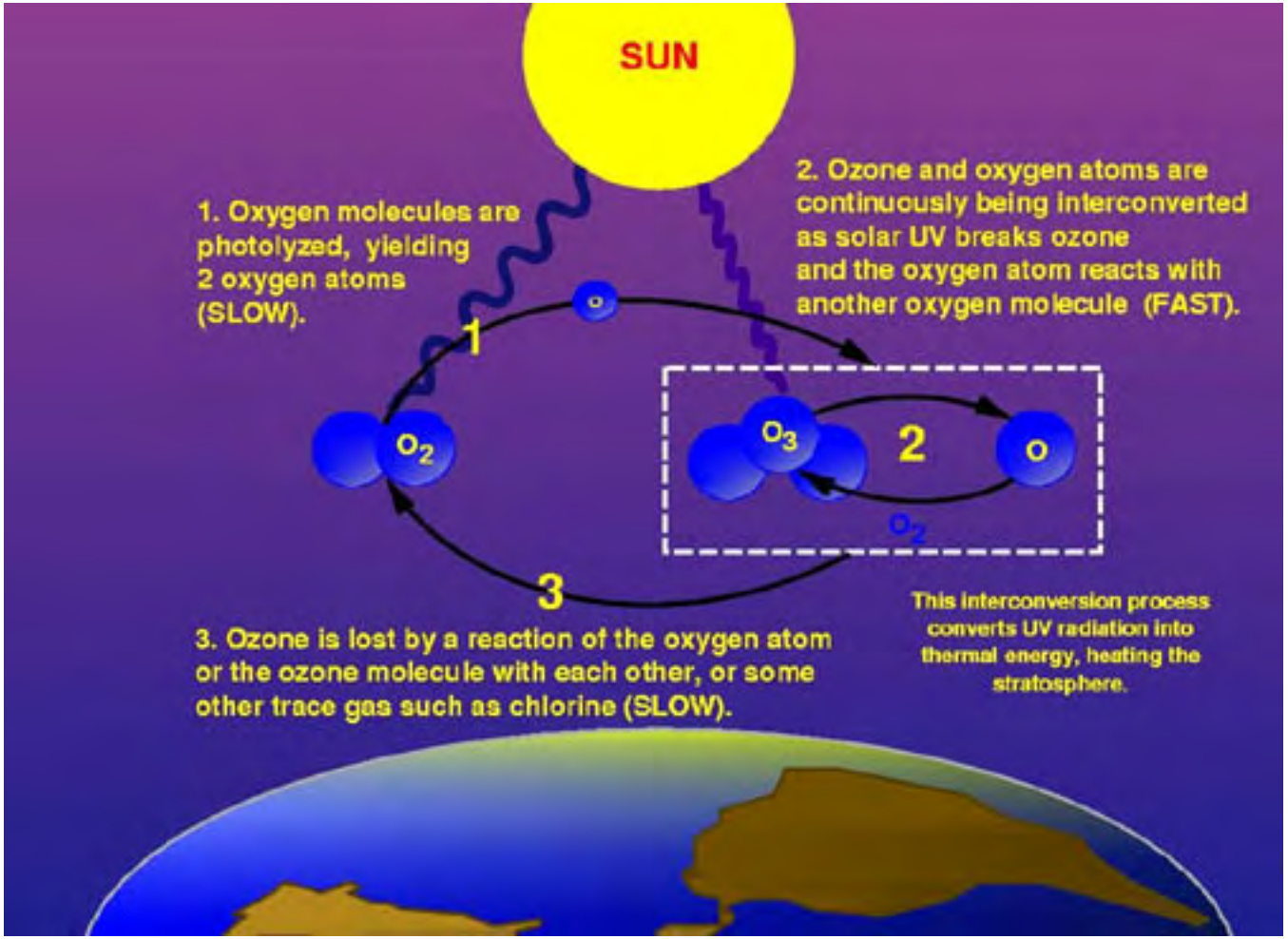
SAM index


+tve phase = cooler temps,
intense vortex
3
2
1
0
-1
-2
-3
1960
1970
1980
1990
2000
2010

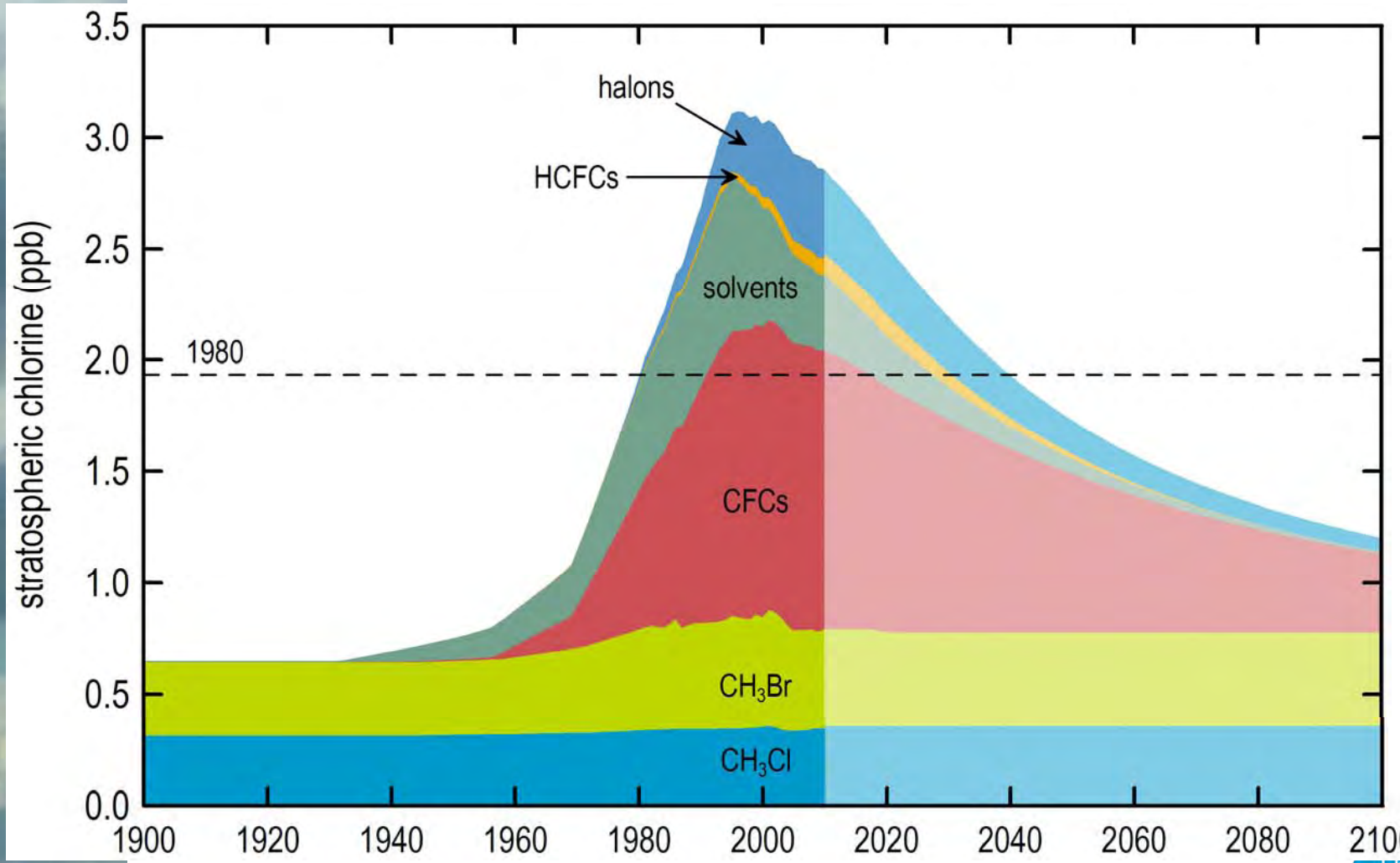
SLP trends 1958-1999 in NCAR CCSM
Arblaster and Meehl, 2006



"Normal" O_3 chemistry



Ozone Depleting Substances & the Montreal Protocol



Chlorine-catalyzed ozone depletion

$2 \times [Cl + O_3 \rightarrow ClO + O_2]$

$ClO + ClO + M \rightarrow Cl_2O_2 + M$

$Cl_2O_2 + hv \rightarrow Cl + ClO_2$

$ClO_2 + M \rightarrow Cl + O_2 + M$

Net: $2\ O_3 + hv \rightarrow 3\ O_2$

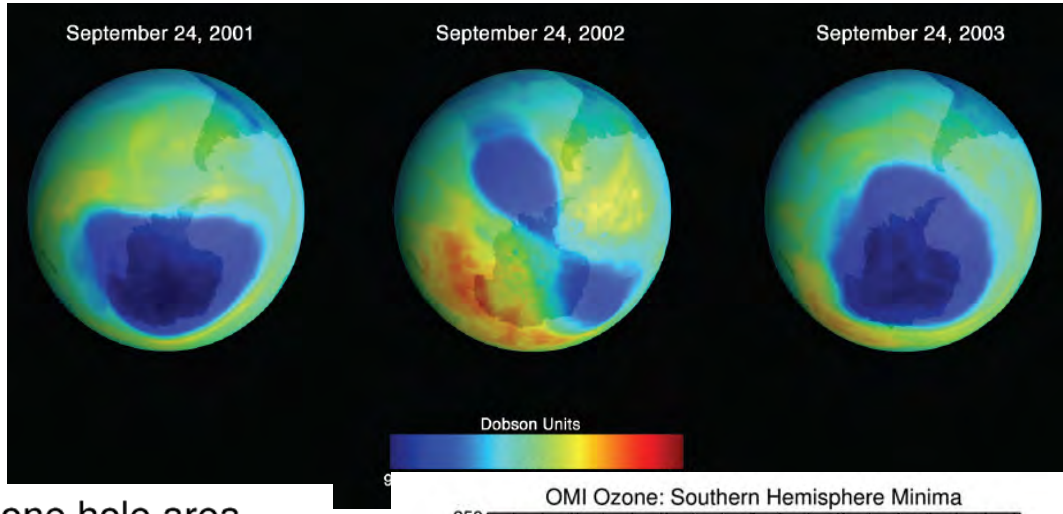
This is the dominant ozone-depleting cycle responsible for the Antarctic ozone hole.

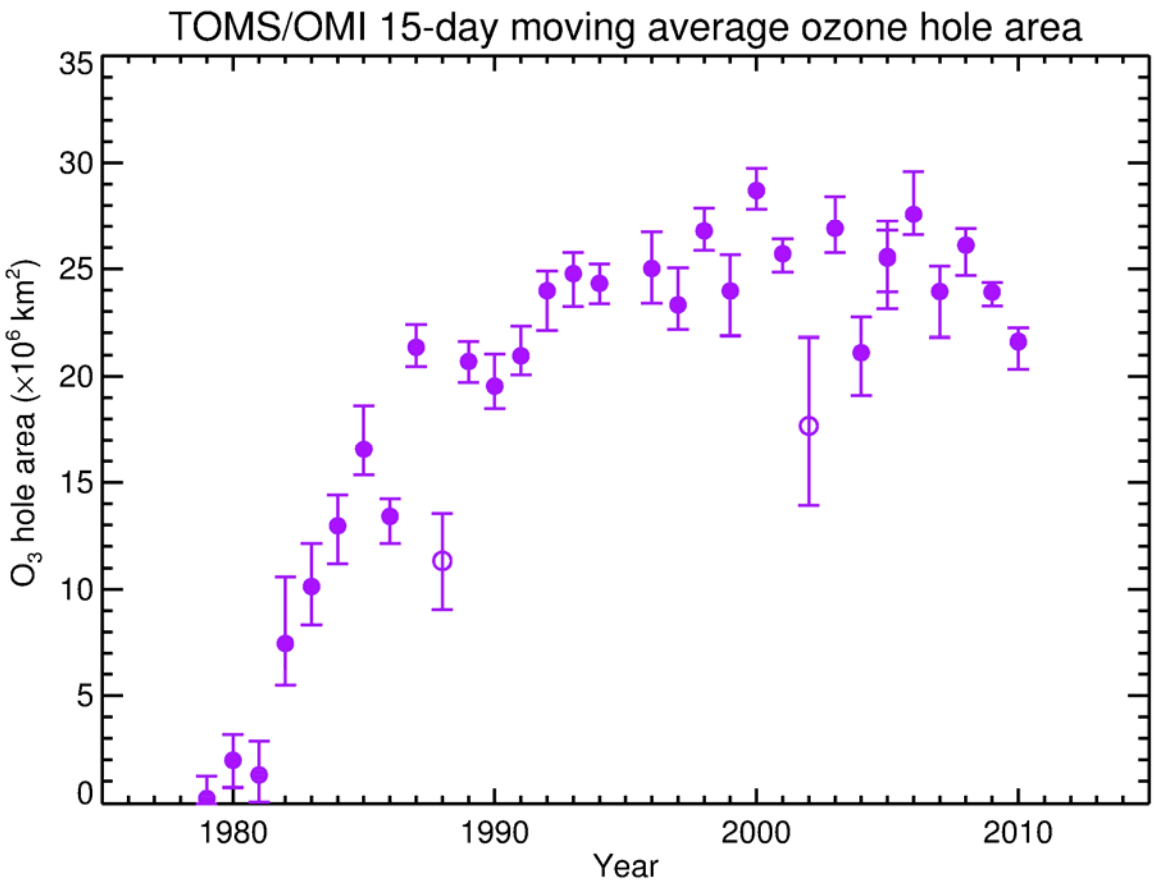
Chlorine is activated from HCl, $ClNO_3$ on PSCs, and deactivated by $Cl + CH_4 \rightarrow HCl$

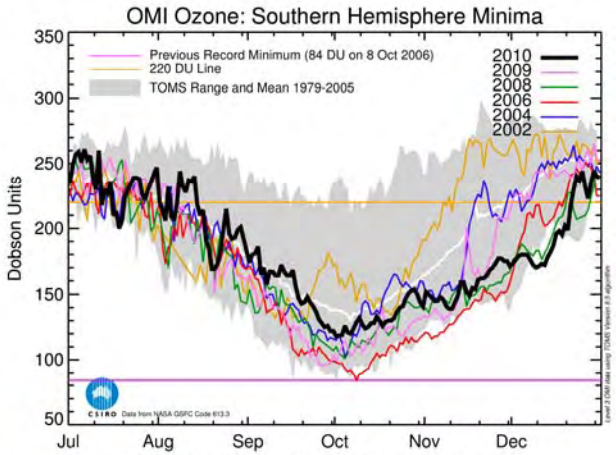
Need for light means ozone hole occurs in spring.

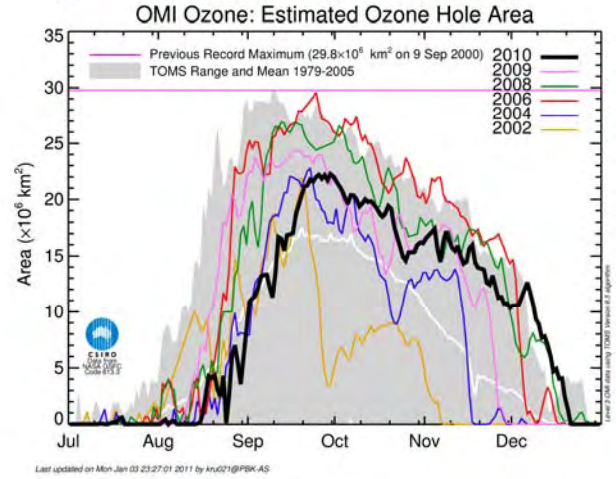
Evolution of the Ozone Hole

http://ozonewatch.gsfc.nasa.gov





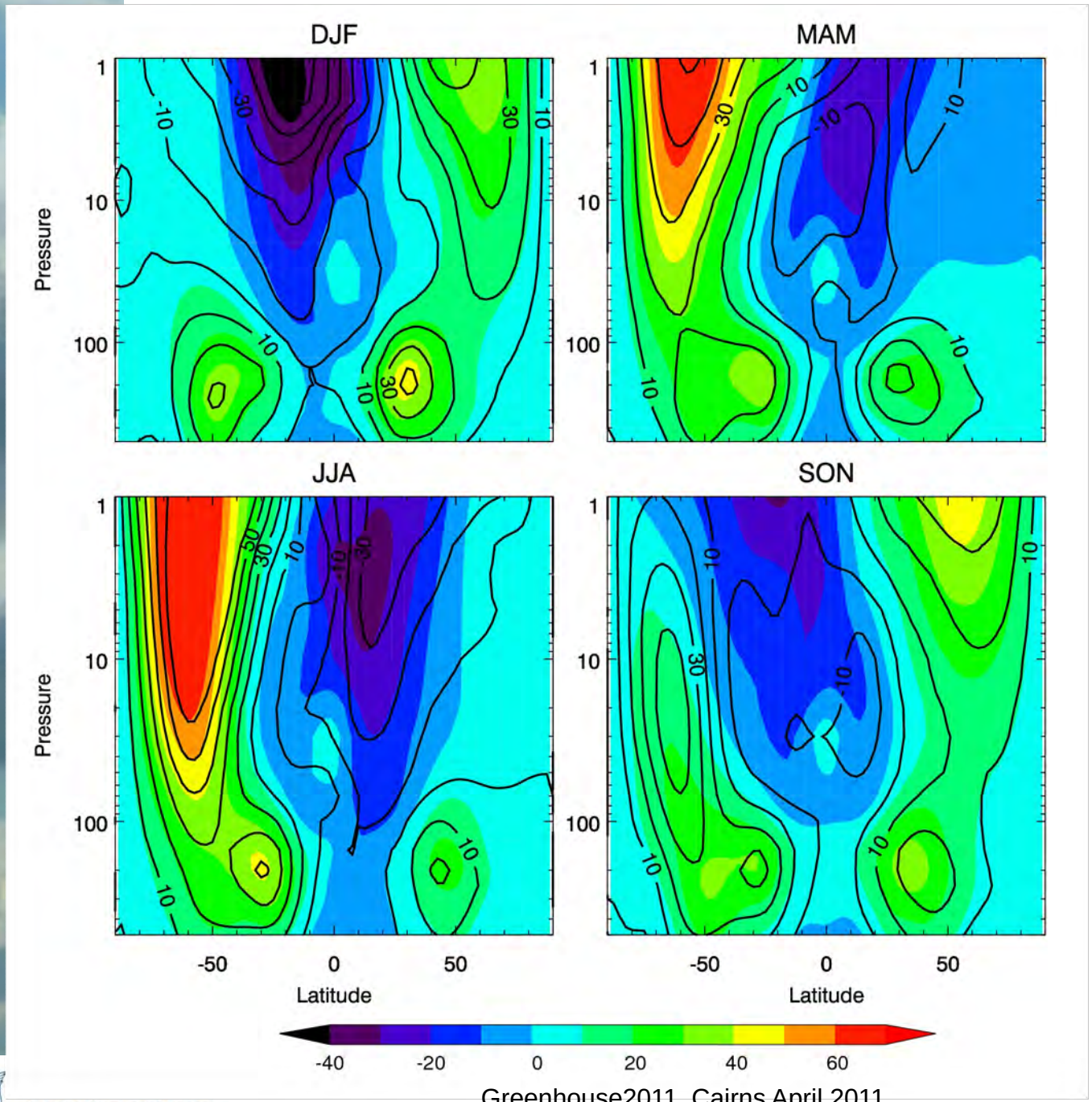




UK Chemistry and Aerosols Model (UKCA)

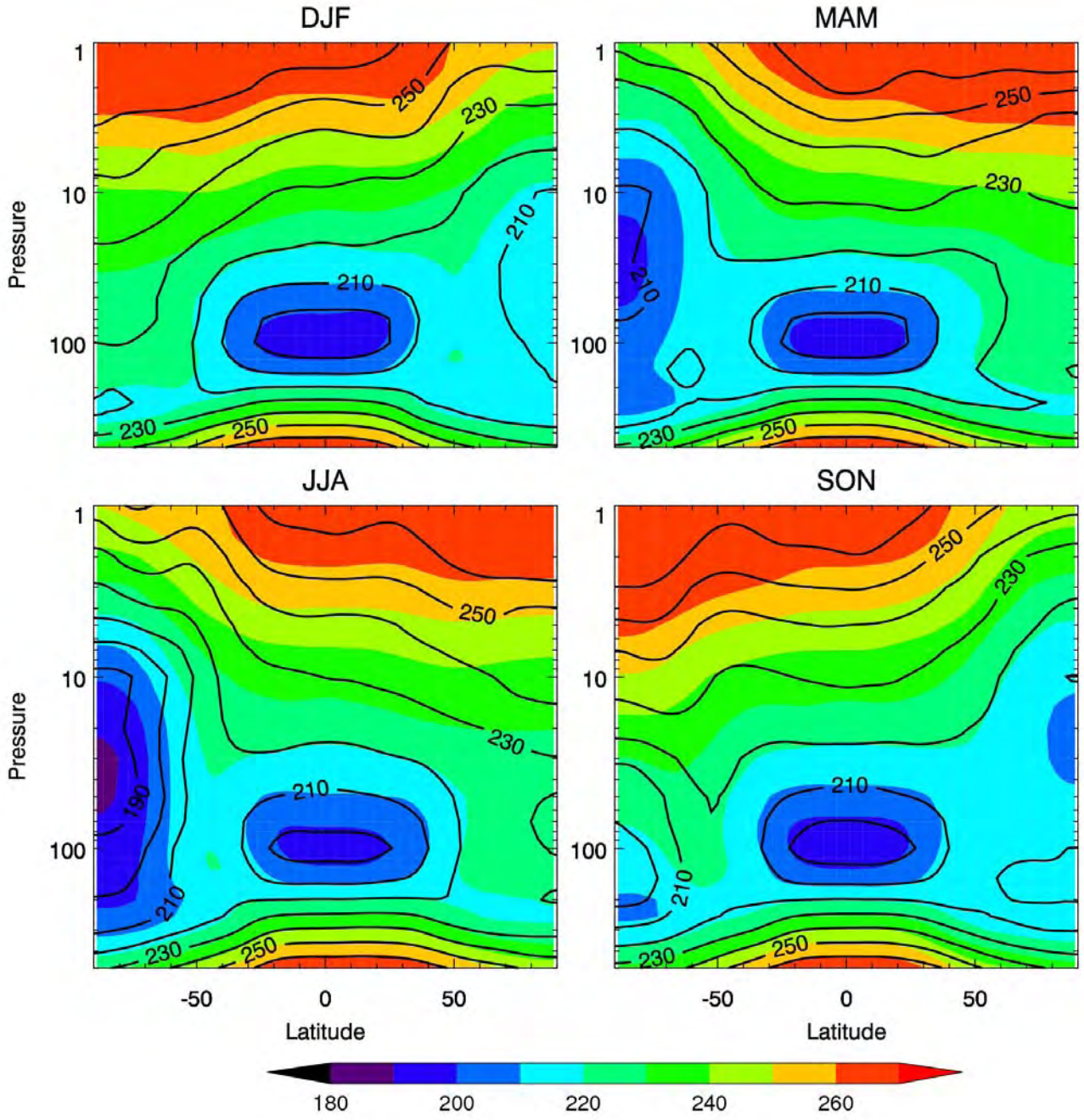
- Comprehensive stratospheric chemistry with chlorine and bromine chemistry including heterogeneous processes on PSCs
- Flexible non-family compiler with Newton-Raphson solver
- 35 species and over 150 reactions
- Radiation feedbacks for O_3, CH_4, $CFCl_3$, CF_2CL_2, H_2O and CO_2
- L60 and N96/N48 horizontal resolution

Zonal Wind



Tropospheric features mostly well resolved

Polar vortex is too weak in spring



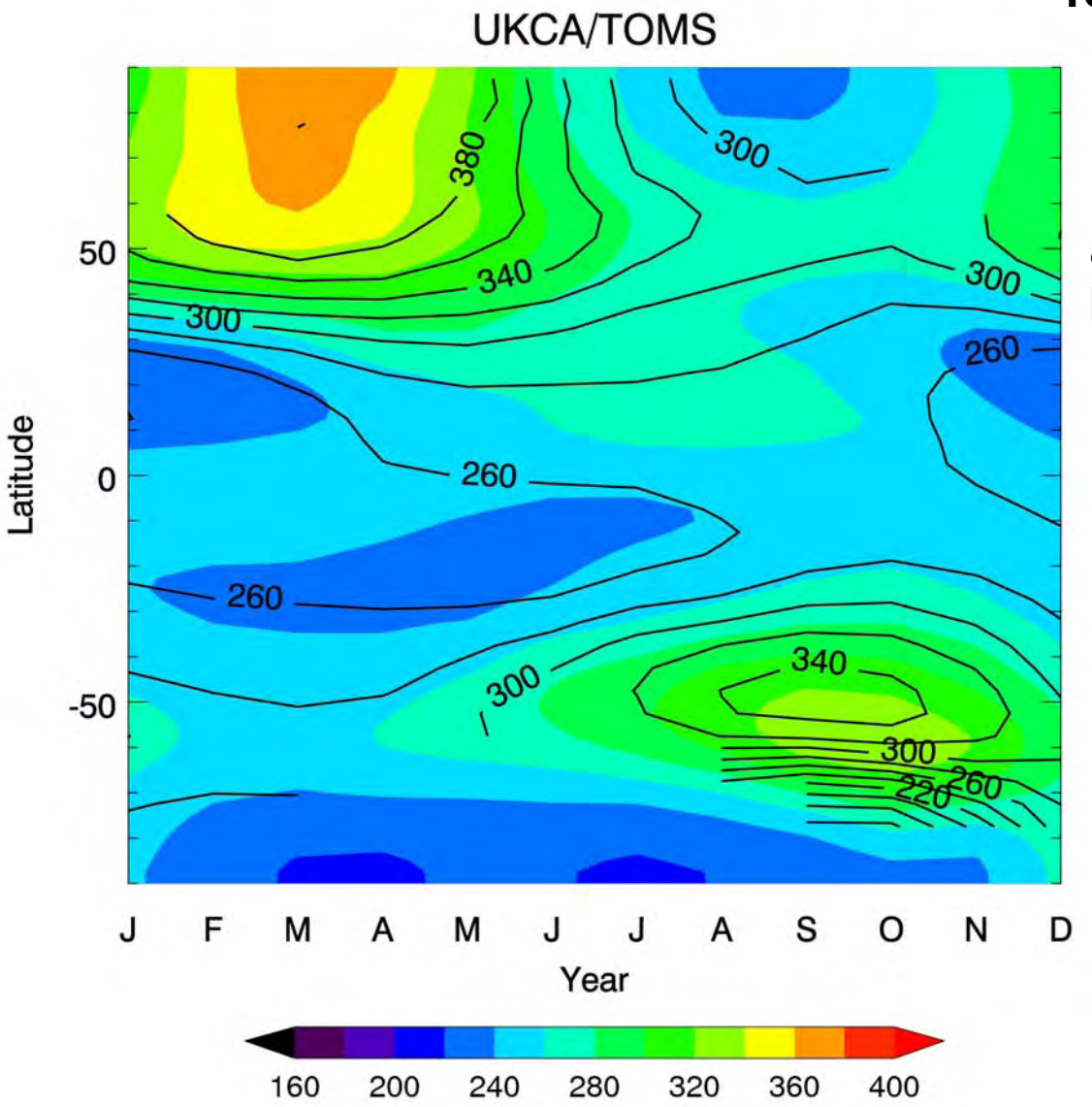
Temperature

Tropospheric T looks very good.

Stratospheric isolines in model too flat – too much B-D circulation

S Pole is too warm in winter and spring

Total column O3 (DU)



Northern Hemisphere and tropical ozone too low.

Antarctic ozone hole too early and not nearly deep enough.

Summary

- Stratospheric ozone has an impact on Southern Hemisphere circulation, but the resultant effect on climate is poorly understood
- Coupled Climate-Chemistry model is required, and we are on our way to having this capability in the Southern Hemisphere