

Variability
Of the winter
stratospheric vortex
Associated with the
11-year Solar Cycle

Lesley Gray

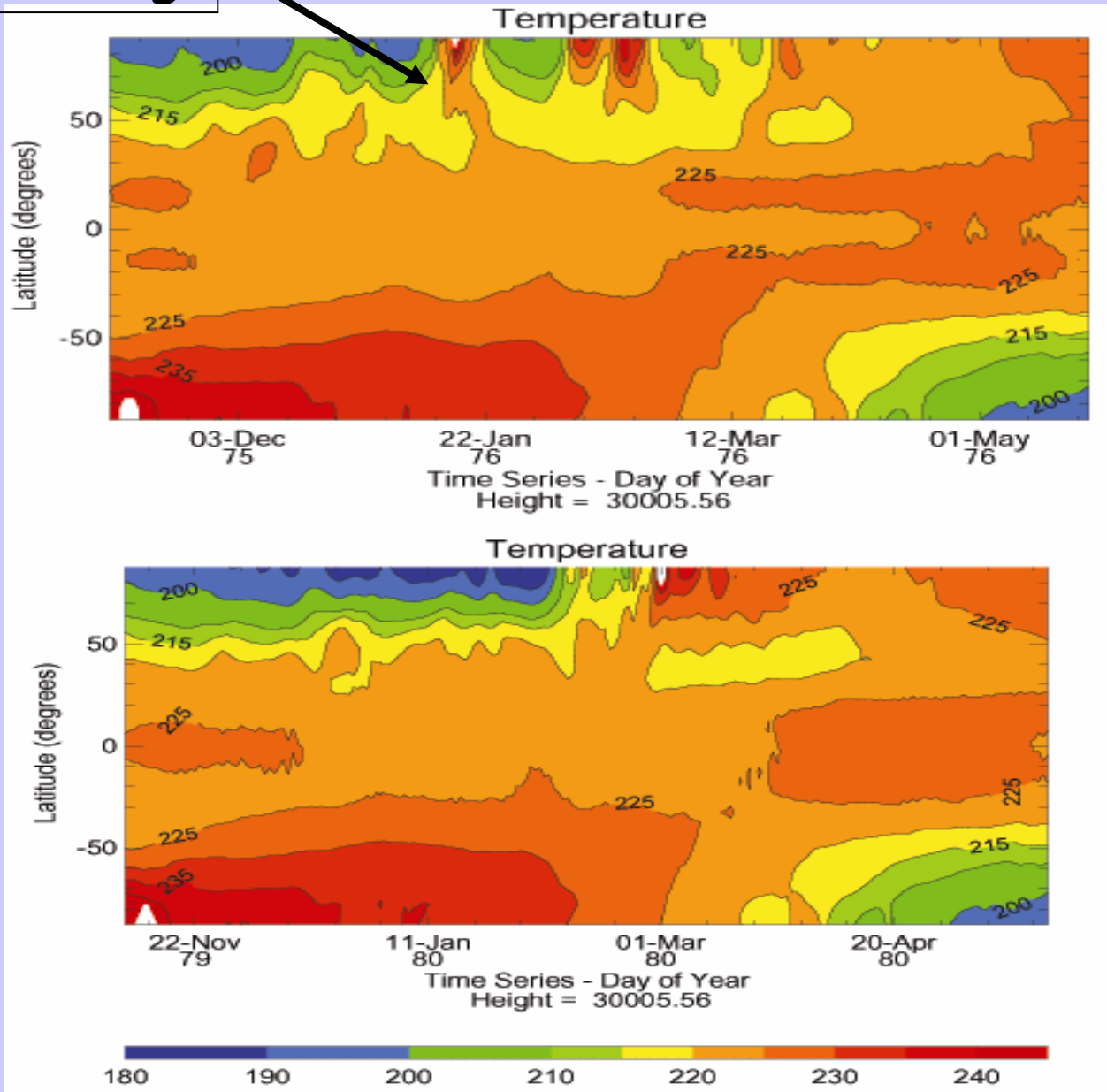
Simon Crooks, Sarah Sparrow, Charlotte Pascoe

Plan of the Talk

- Overview of sudden warmings
- Regression analysis using ECMWF Reanalysis data (ERA-40)
- Some simple model experiments
- Summary / Conclusions
(including possible role of the Quasi Biennial Oscillation - QBO)

'sudden'
warming

Polar Temperatures



Latitude
time-series

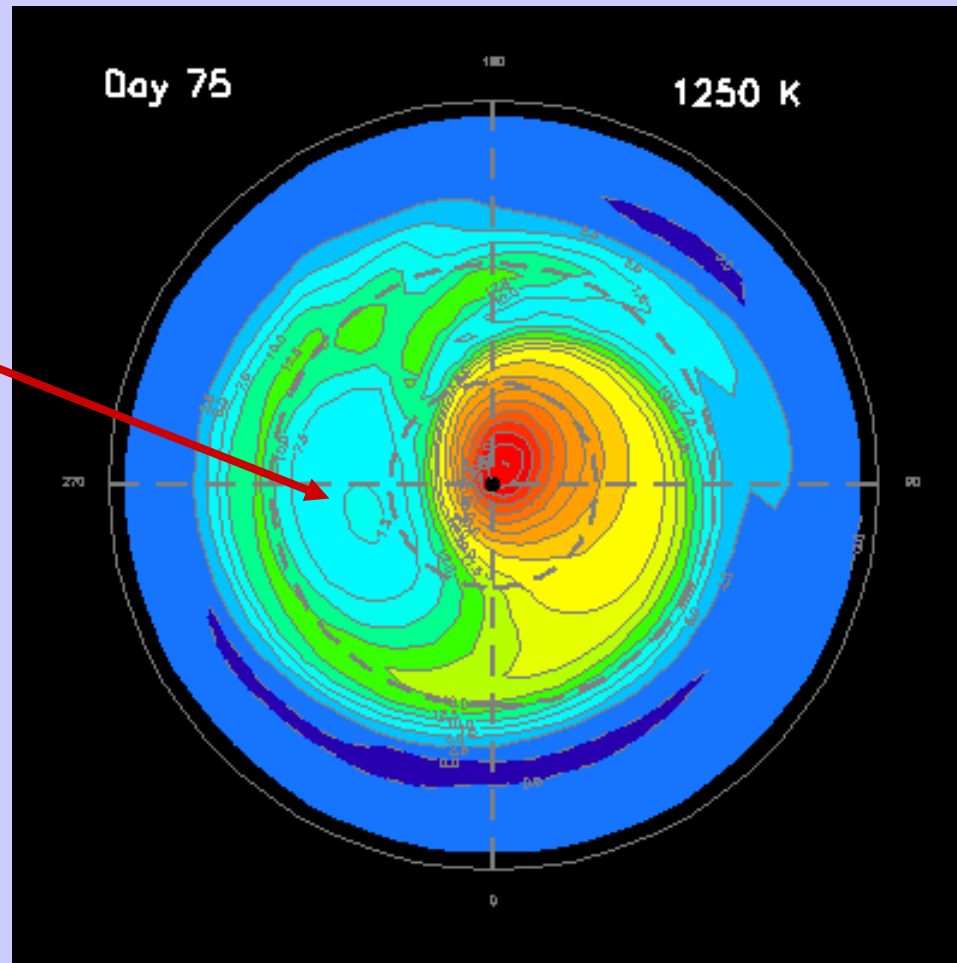
Zonal-averaged
temperatures

NH
winter/spring

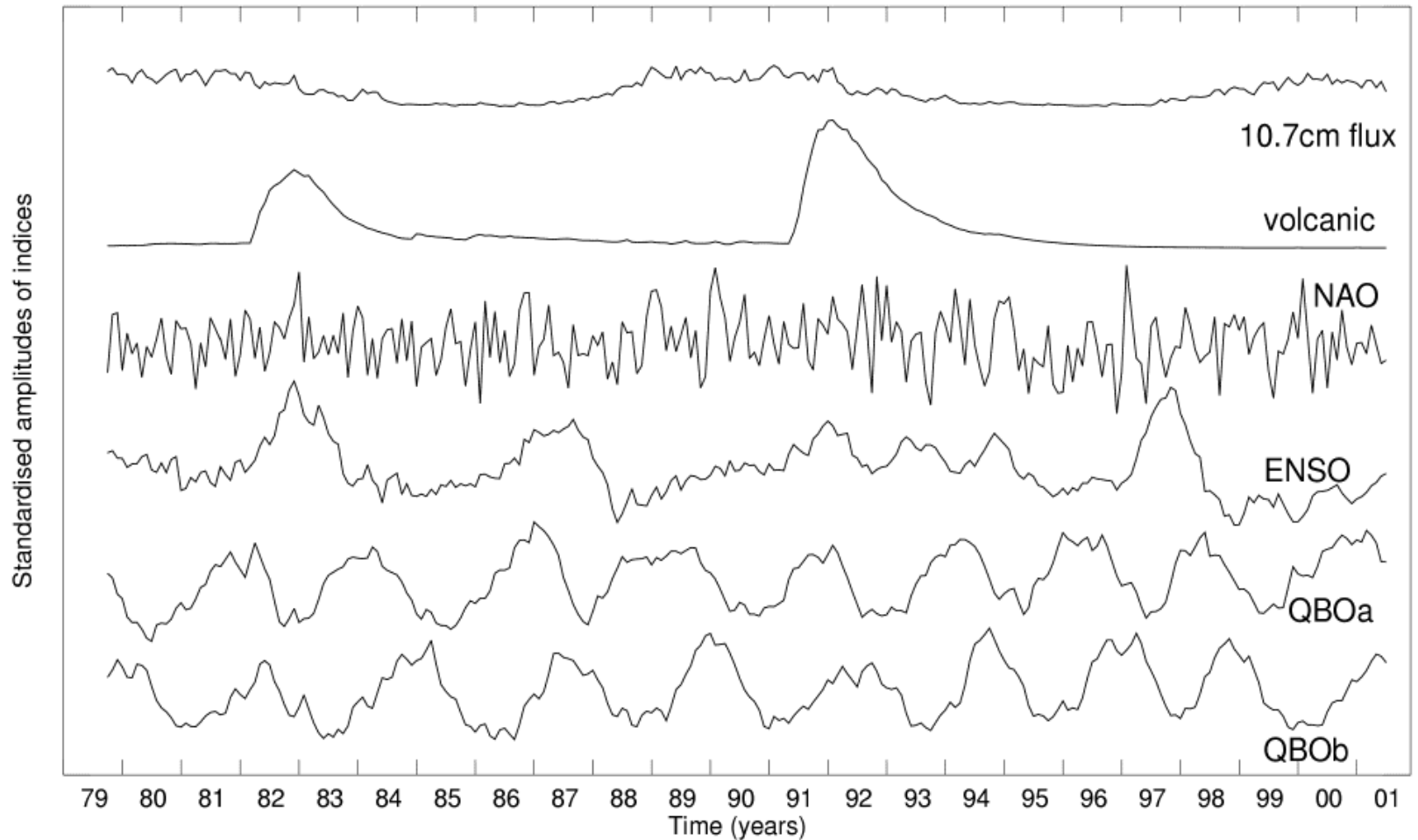
30 km

Example of a Stratospheric Sudden Warming PV on the 1250K isentropic surface (~42 km)

Aleutian High



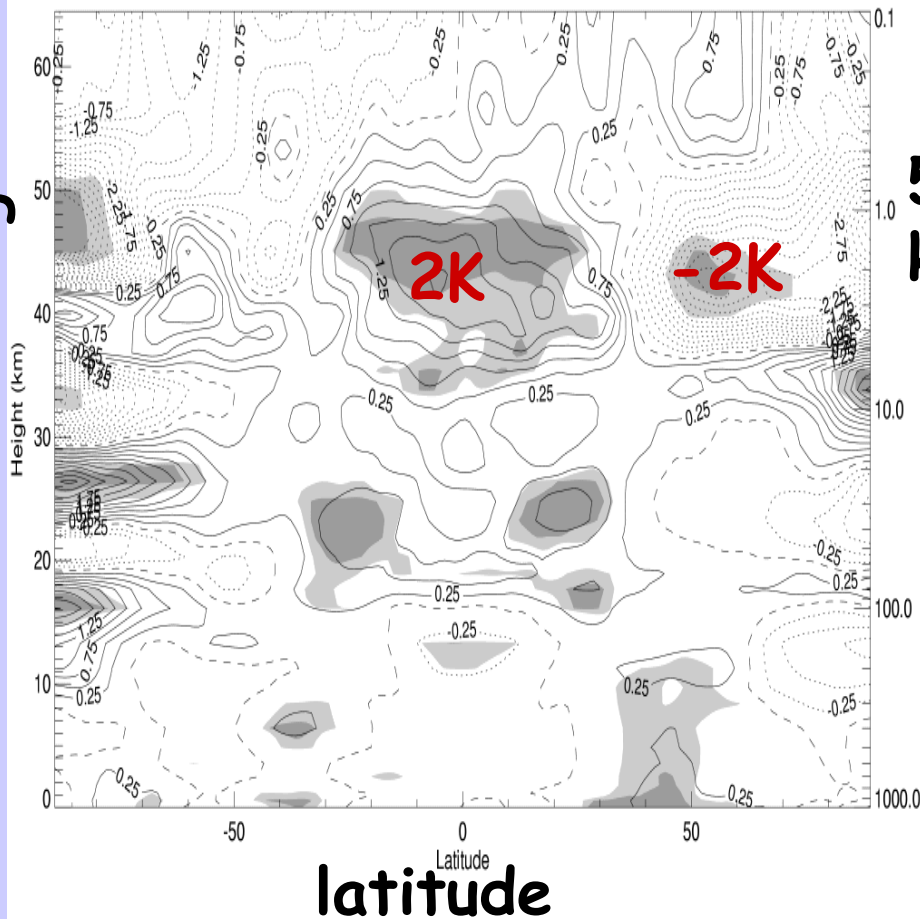
Understanding 11-year Solar Cycle Variability: ERA-40 Multiple Regression Analysis



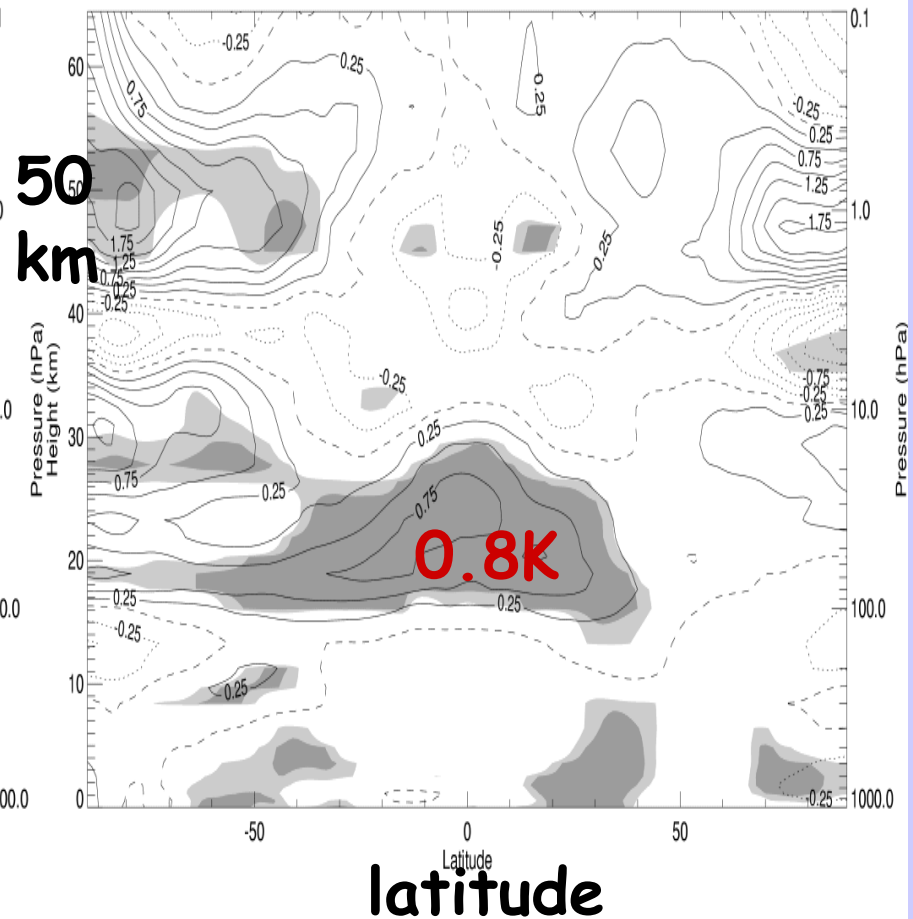
ERA-40 Multiple Regression Analysis Annual Mean **Temperature** Signal

height

**Solar
max - min**

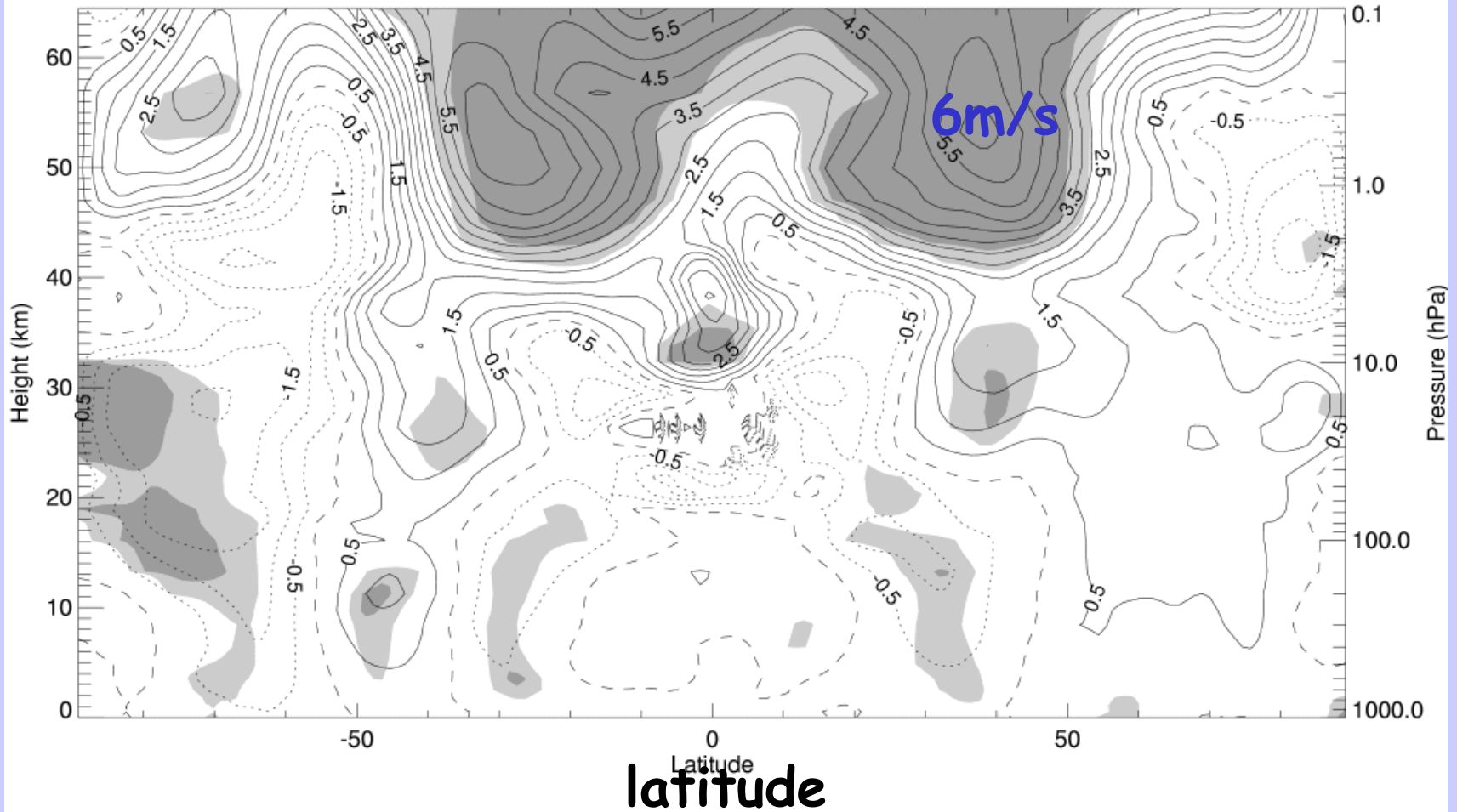


Volcanic



ERA-40 Multiple Regression Analysis

Annual Mean Zonal Wind Signal



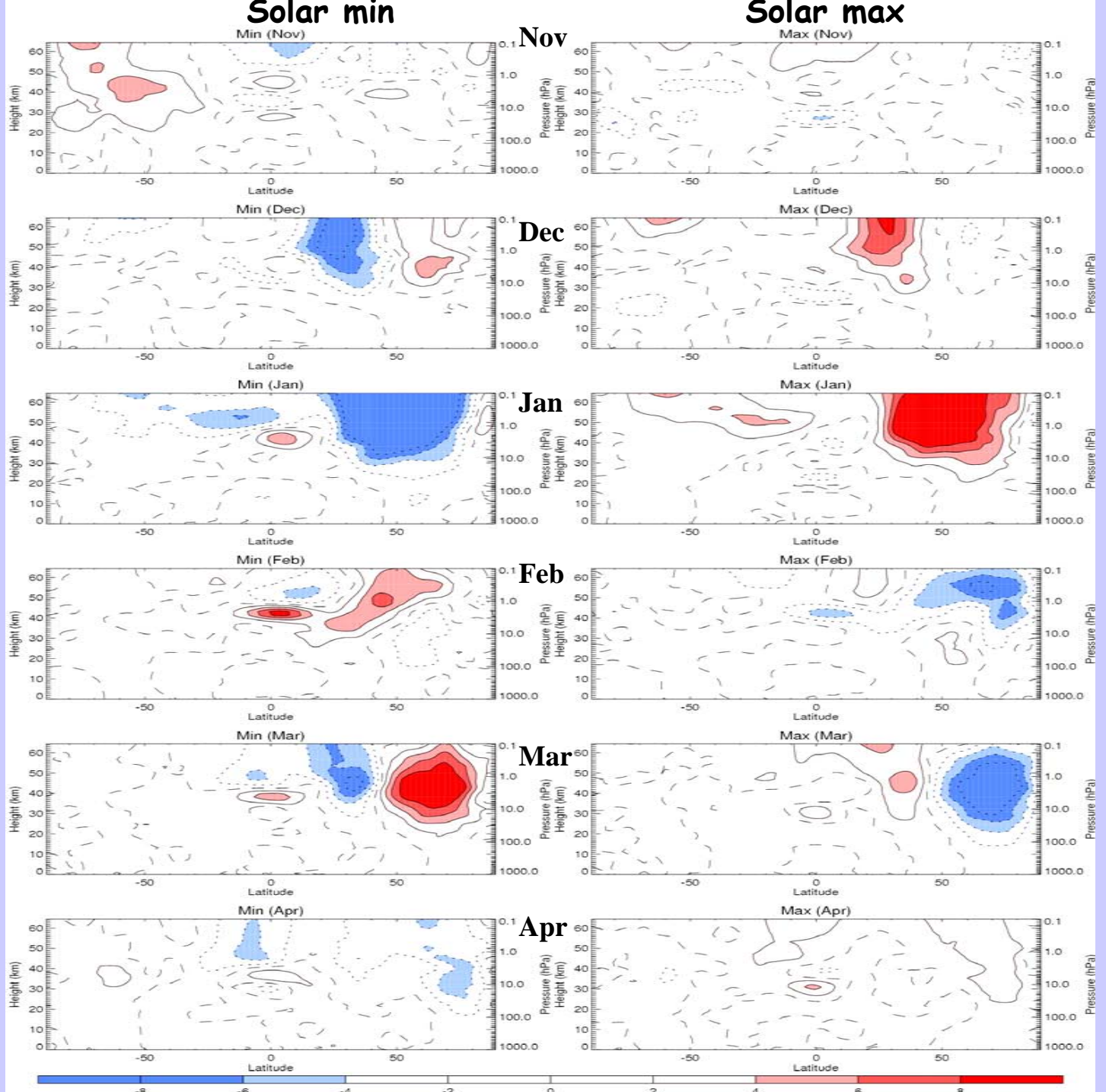
Solar max - min

ERA-40

Solar
Composites
of zonal
mean wind
anomalies

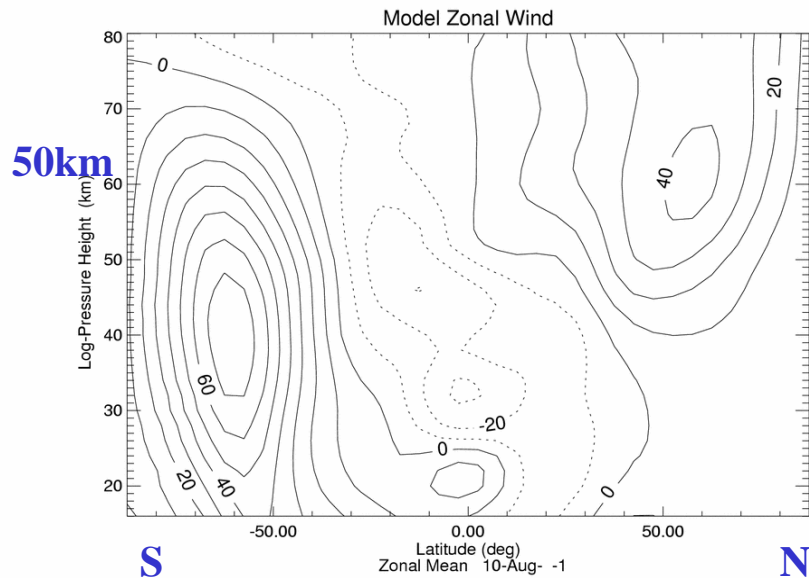
Blue=easterly
Red=westerly

Gray et al.
2004
JAS,
in press

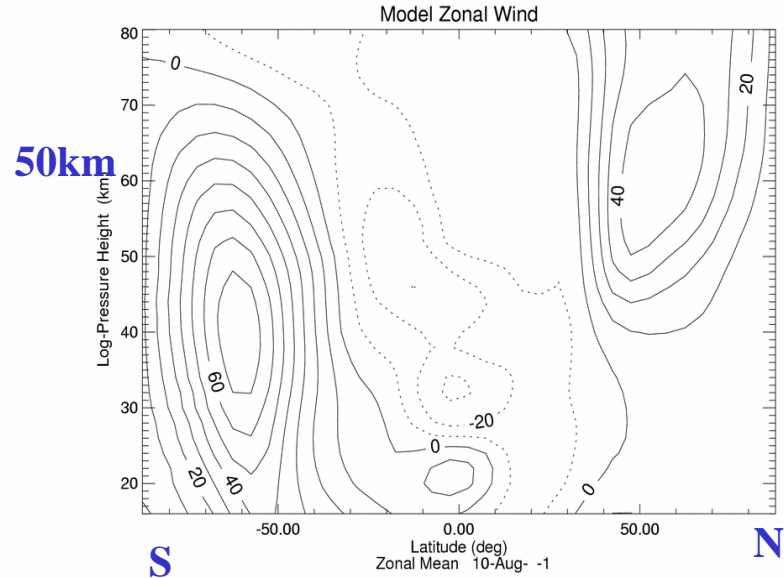


Stratosphere Mesosphere Model Subtropical Forcing Experiment

Easterly forcing applied in subtropics:
10-25N, 40-50 km



control run



subtropical forcing expt

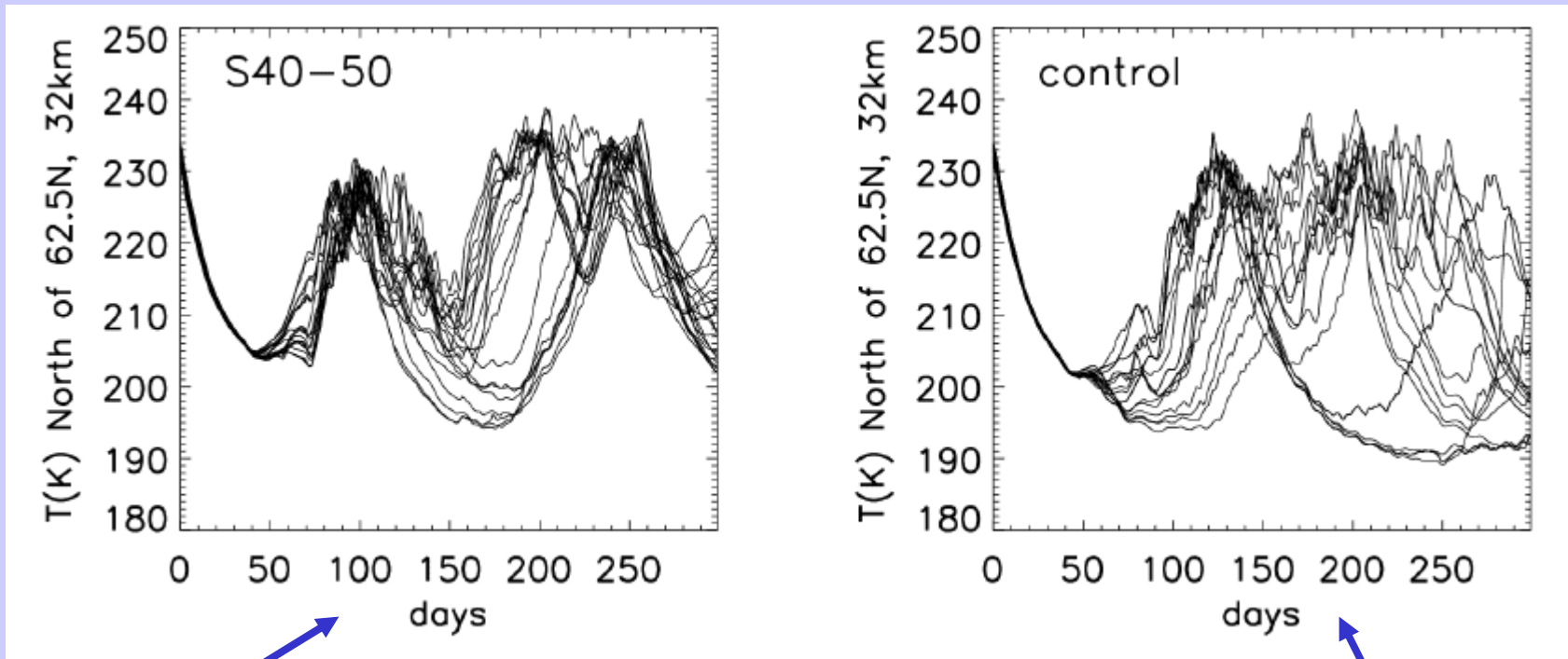
zonal-averaged zonal wind field

in early winter

Stratosphere Mesosphere Model expt

Time-series of polar temperature

20-member ensemble

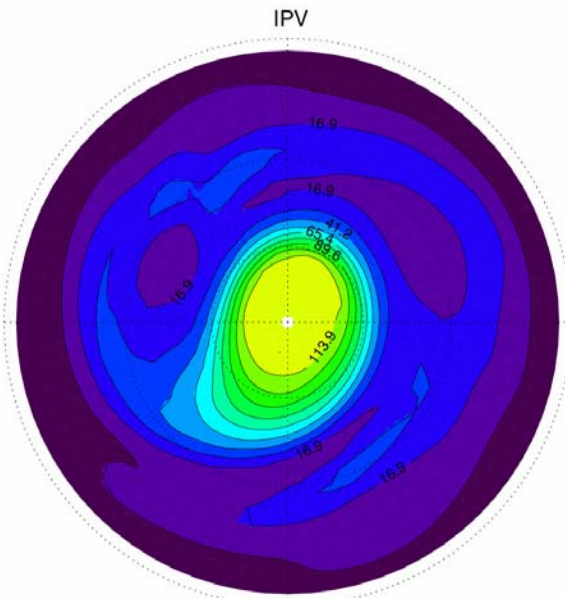


Easterly anomaly imposed in subtropics at 40-50km to mimic a solar minimum anomaly gives consistently earlier warmings

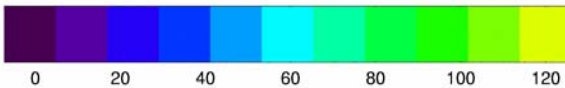
Timing of sudden warmings is very variable in control run

Subtropical relaxation expt

Control run No relaxation



Height = 1650.00 08-Sep- CC1



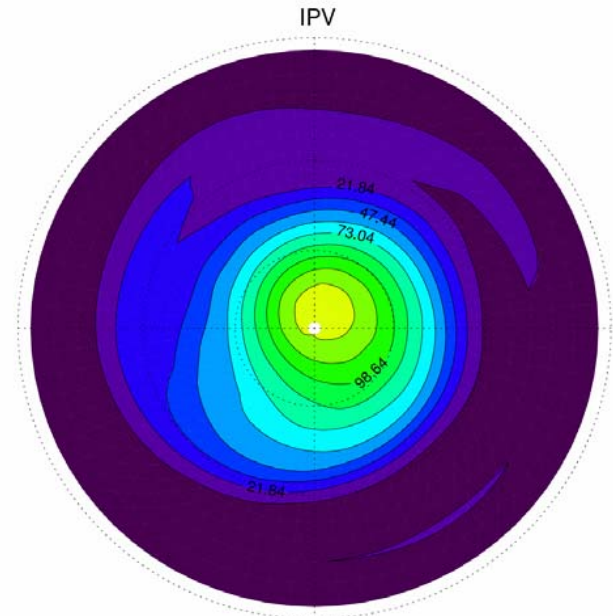
X312D76213.IPV_SMM

V17F_E20 all levels
MAD_JOIN V07-5 22-Nov-01 15:48:28
MAD_VIEW V18-03 [option 35] 01-Jul-03 17:00:50

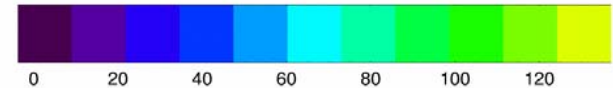
Ensemble member 1
MAD_ISENT V1.50 (Option 3-SF) 22-Nov-01 15:53:21

PV 1650K
(~40 km)

Day 38



Height = 1650.00 08-Sep- CC1



X312D76213.IPV_SMM

V17F_E20 all levels
MAD_JOIN V07-5 24-Aug-01 12:23:26
MAD_VIEW V18-03 [option 35] 01-Jul-03 17:02:11

Ensemble member 1
MAD_ISENT V1.50 (Option 3-SF) 22-Nov-01 16:11:12

Summary of Mechanistic Model Experiments

NH polar variability is sensitive not only to winds in lower equatorial stratosphere (Holton-Tan) where QBO amplitude is greatest but also to winds in the upper equatorial/subtropical stratosphere where the SAO dominates and where both QBO and solar influences are also present

Summary / Conclusions

• Model suggests timing of warmings is very sensitive to wind anomalies in subtropical/equatorial upper strat.

Solar min: easterly anomaly \longrightarrow earlier warmings

Solar max: westerly anomaly \longrightarrow later warmings

• ERA-40 regression / composite analysis supports this

• Solar influence on warmings provides a mechanism for solar signal to extend from upper to lower stratosphere

• QBO : also has anomaly in upper stratosphere hence possible solar / QBO interaction here

• Induced meridional circulation associated with warmings provides mechanism for solar signal in polar lower stratosphere to extend to equatorial lower stratosphere