Intraseasonal Stratosphere-Troposphere Coupling and Tropospheric Prediction

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.... with material graciously provided by:
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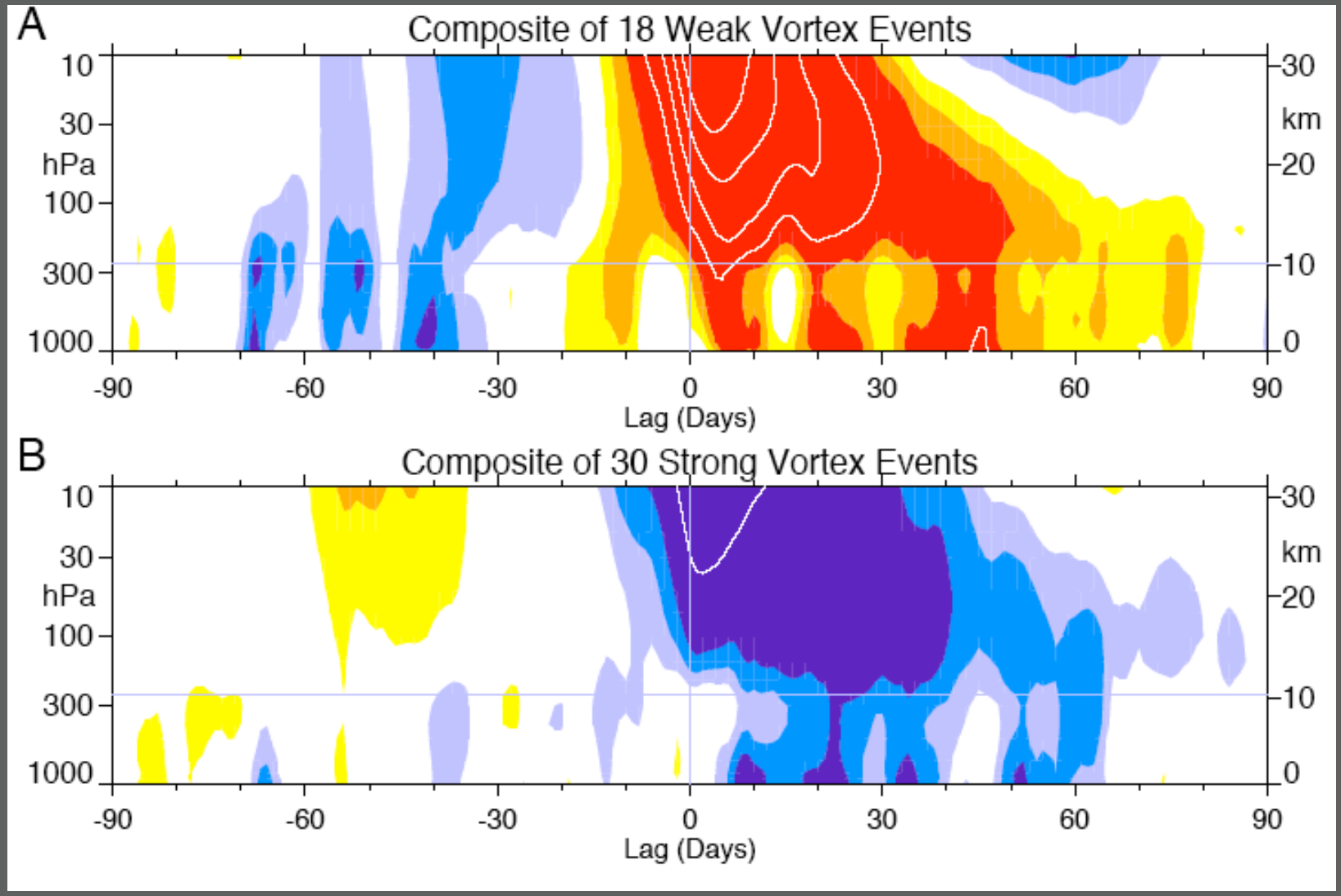
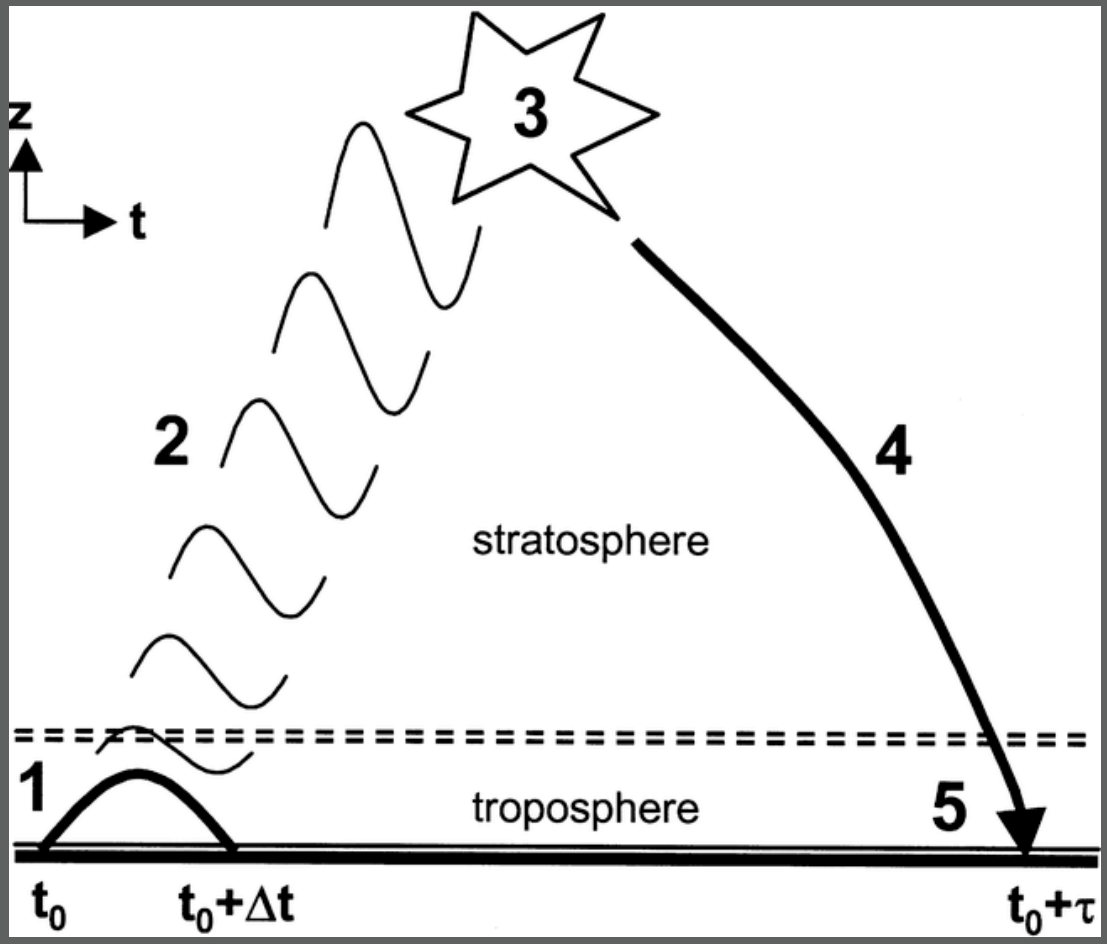


Baldwin & Dunkerton 2001

hope for prediction

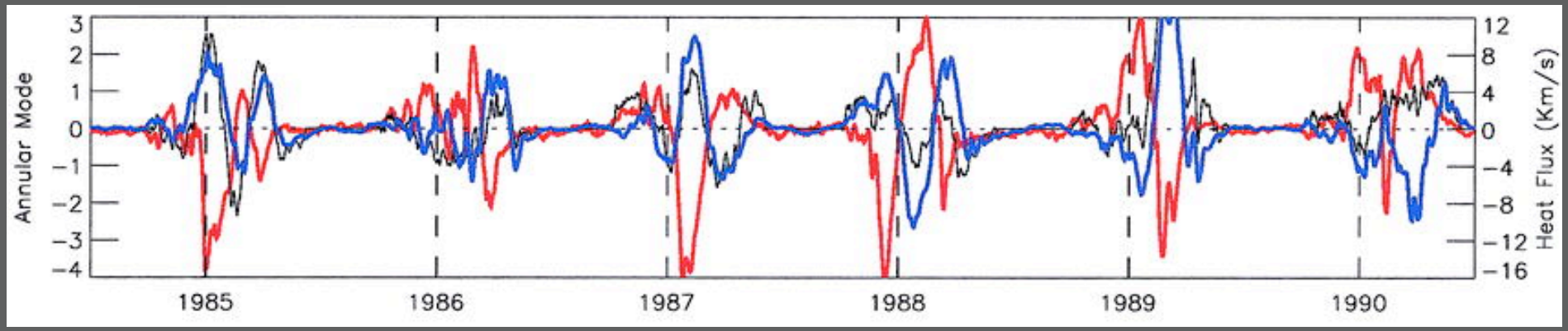


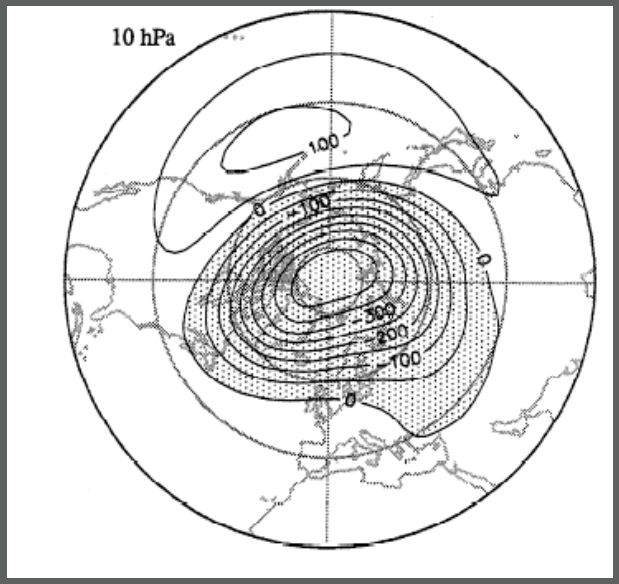
Reichler, Kushner & Polvani 2001

outline

- Upward influence
- Downward influence
- Spring transition
- Value for prediction?

upward influence





Polvani & Waugh 2004

10 hPa NAM
100 hPa [v*T*]
300 hPa [v*T*]

[v*T*] is average over preceding 40 days

Baldwin & Dunkerton 1999

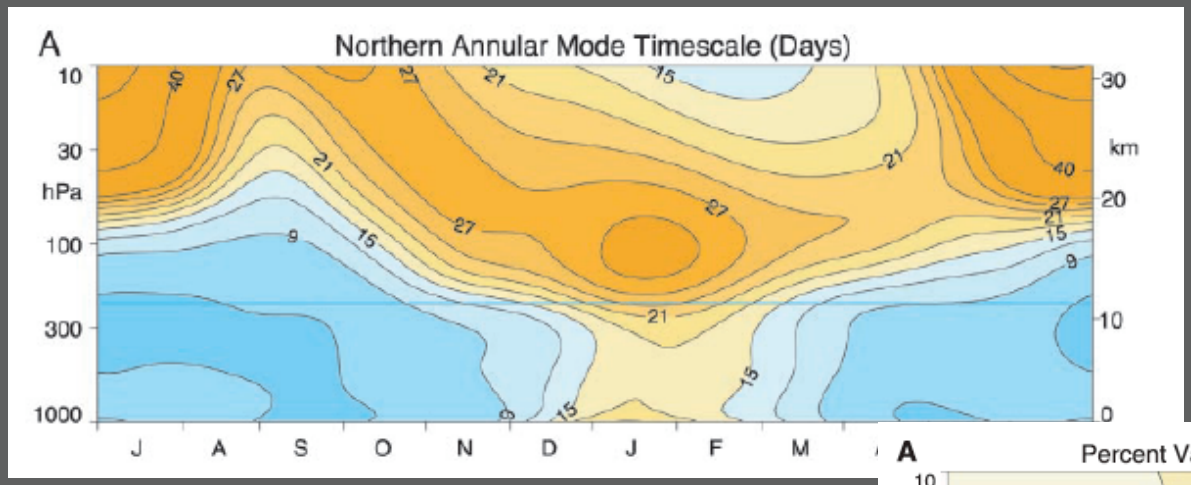
upward influence

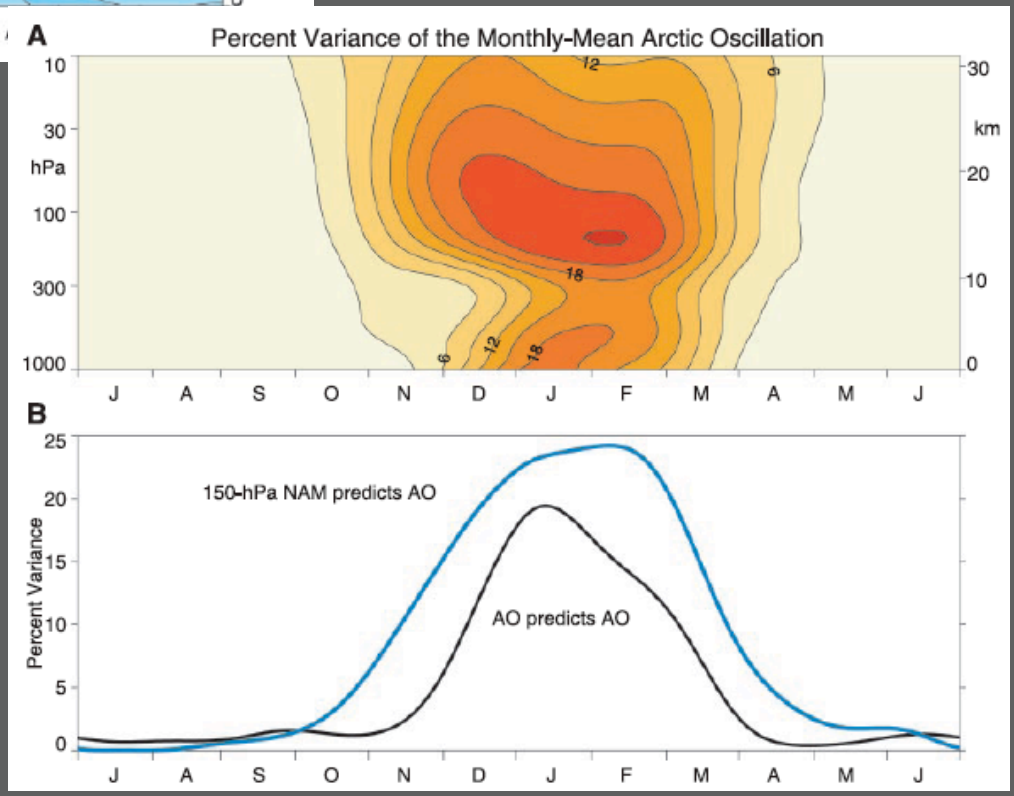
- Polar vortex “flywheel” integrates wave driving from troposphere over ~1 month
- But...
  - Planetary waves are deep structures spanning the tropopause
  - Stratosphere influences its own wave driving
  - Connection is weaker to [v*T*] within troposphere
  - Variations in planetary wave [v*T*] are not fully understood

downward influence

- Statistical evidence
- Idealized models
- Prediction model

statistical evidence

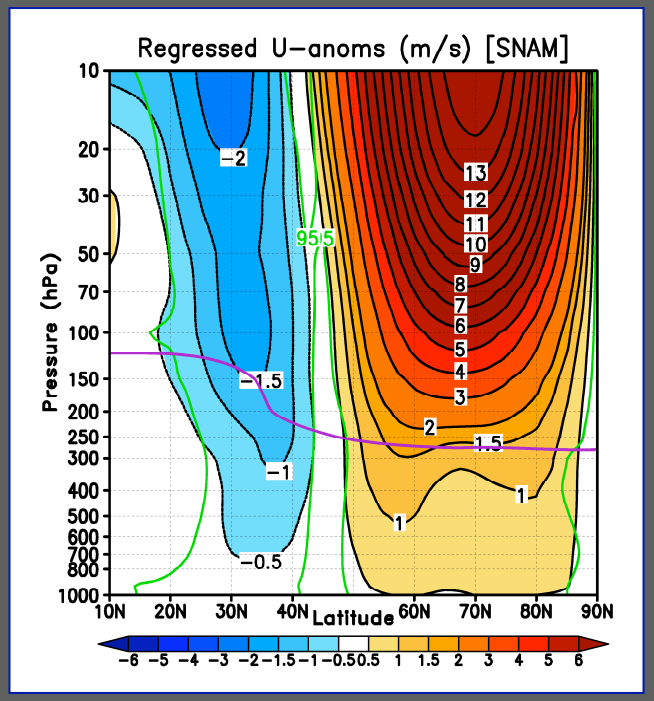


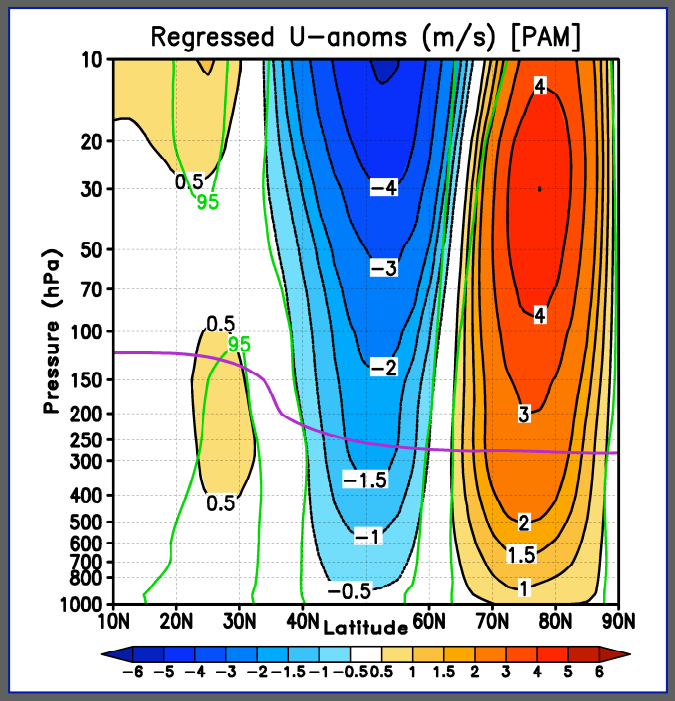


Baldwin *et al.* 2003

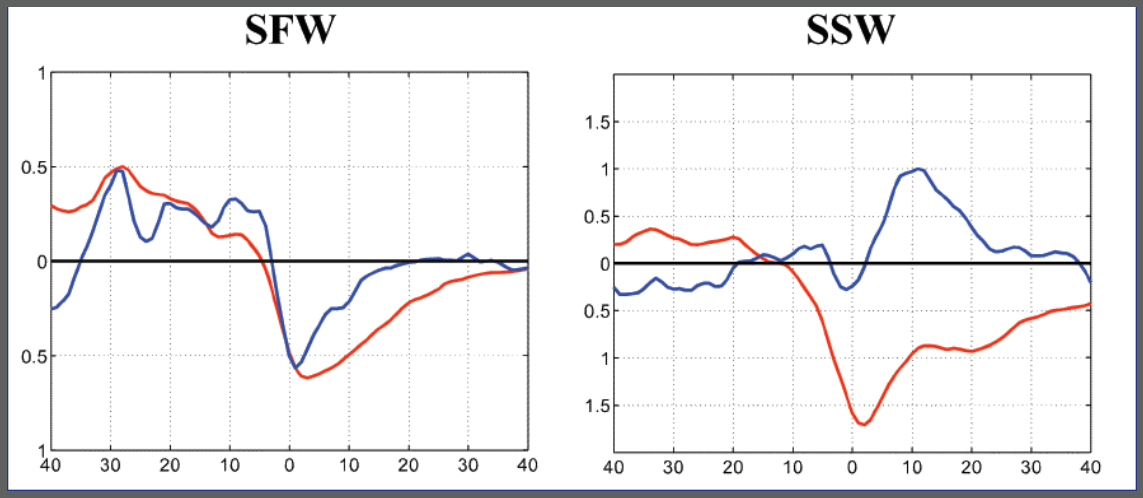
not just the NAM

"SNAM"
EOF1: 71%



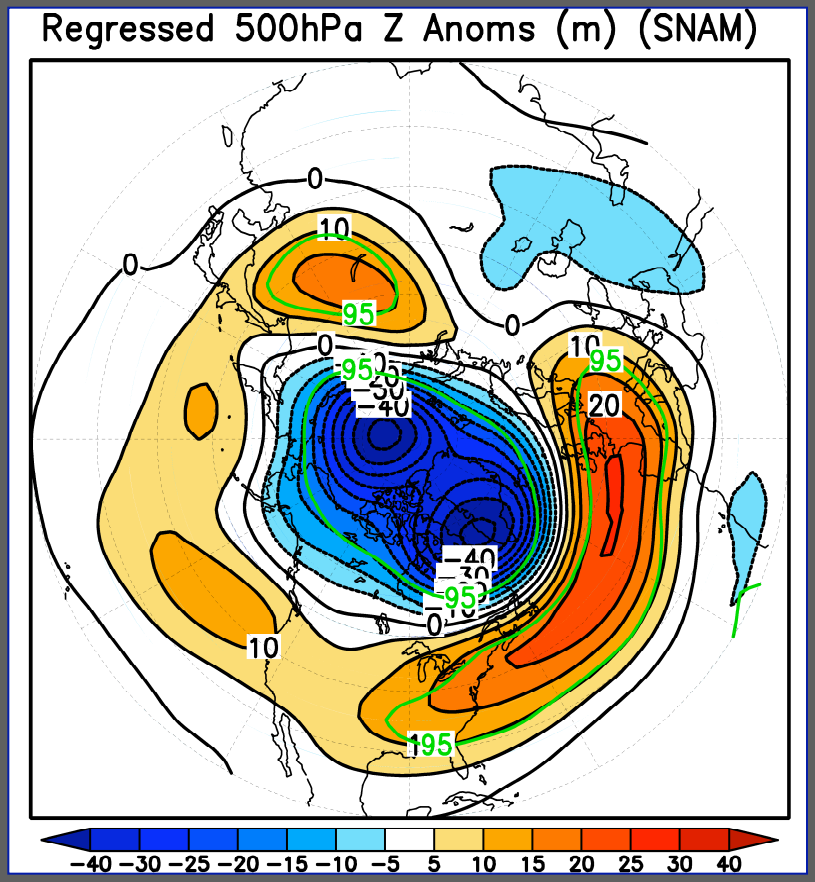


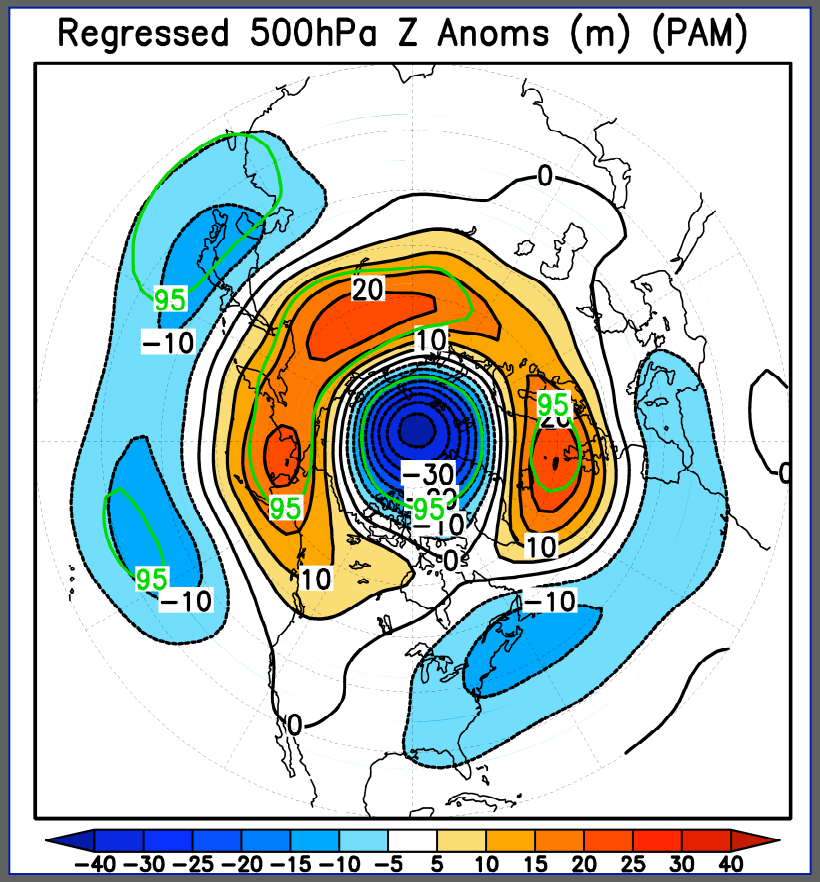
"PAM"
EOF2: 15%



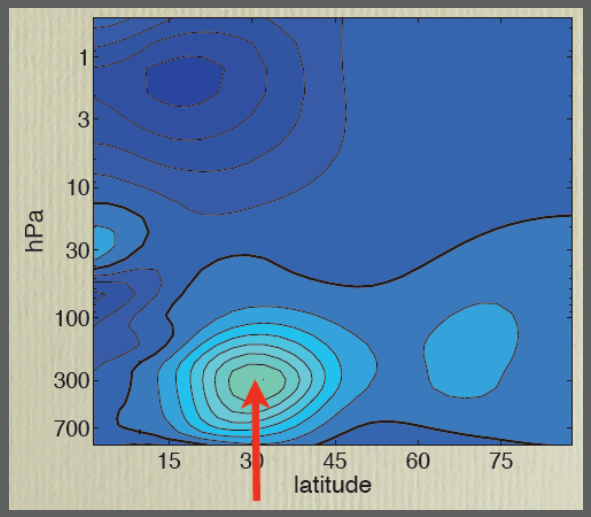
Black & McDaniel 2007

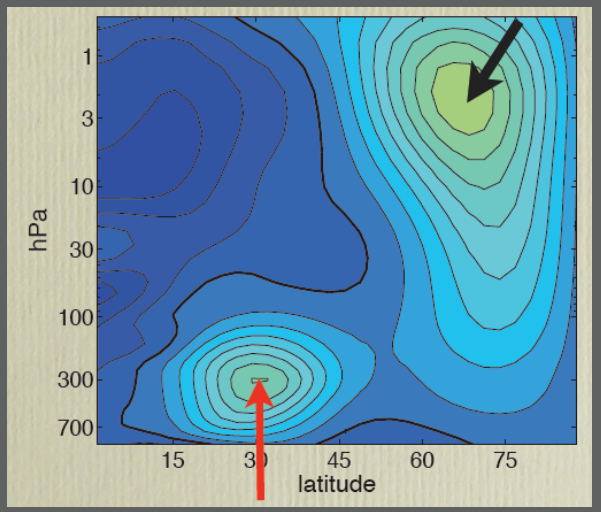
SNAM & PAM (cont'd)

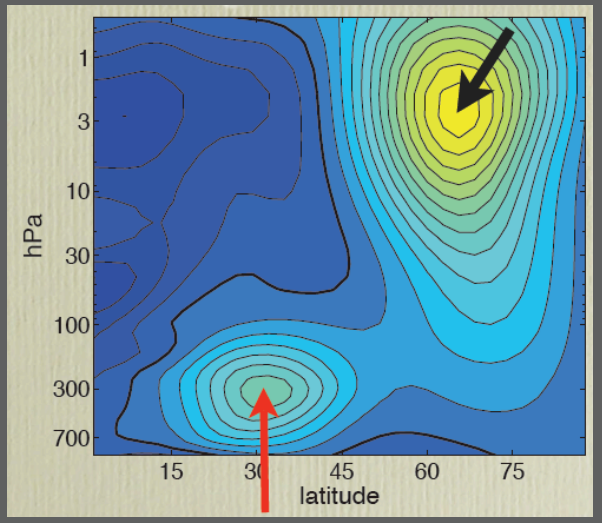


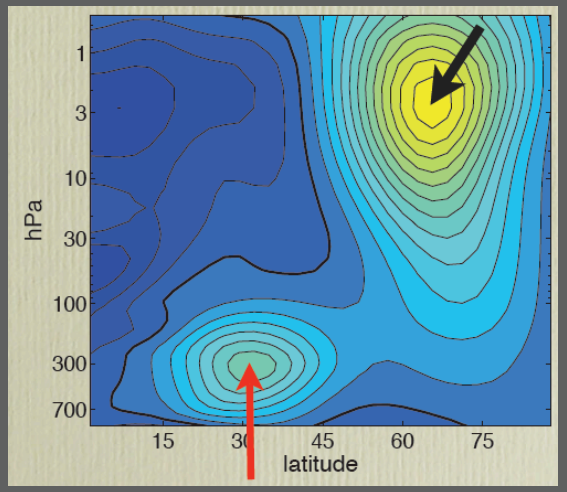


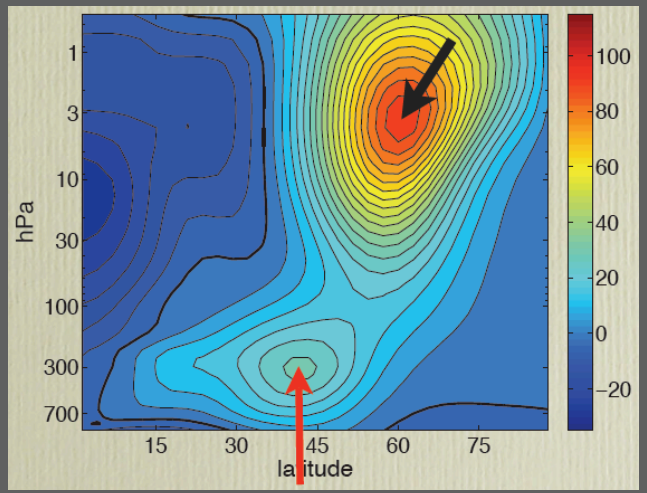
idealized models

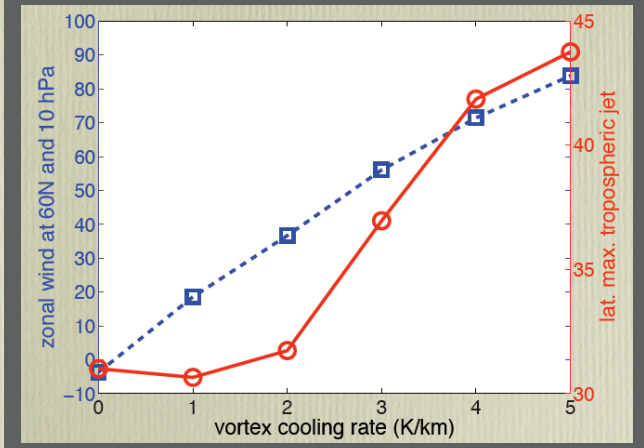






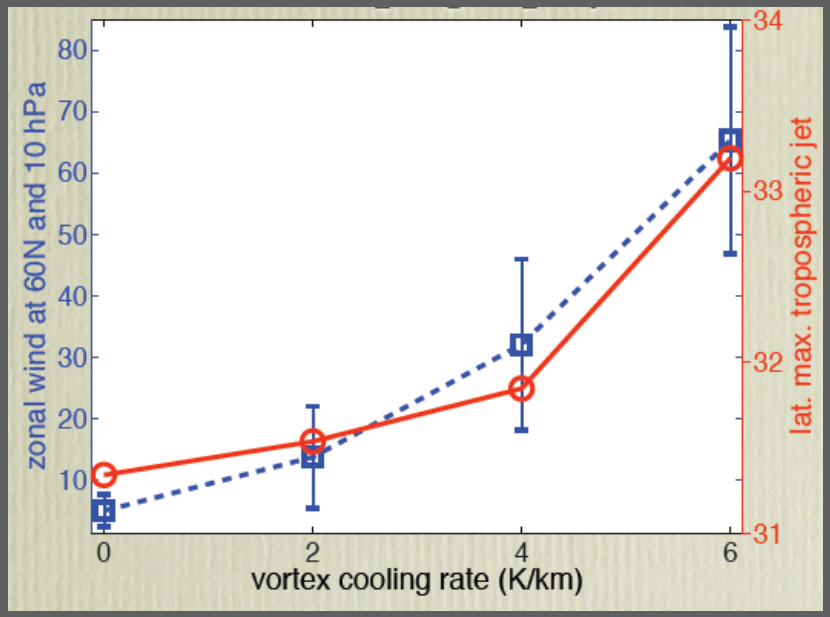




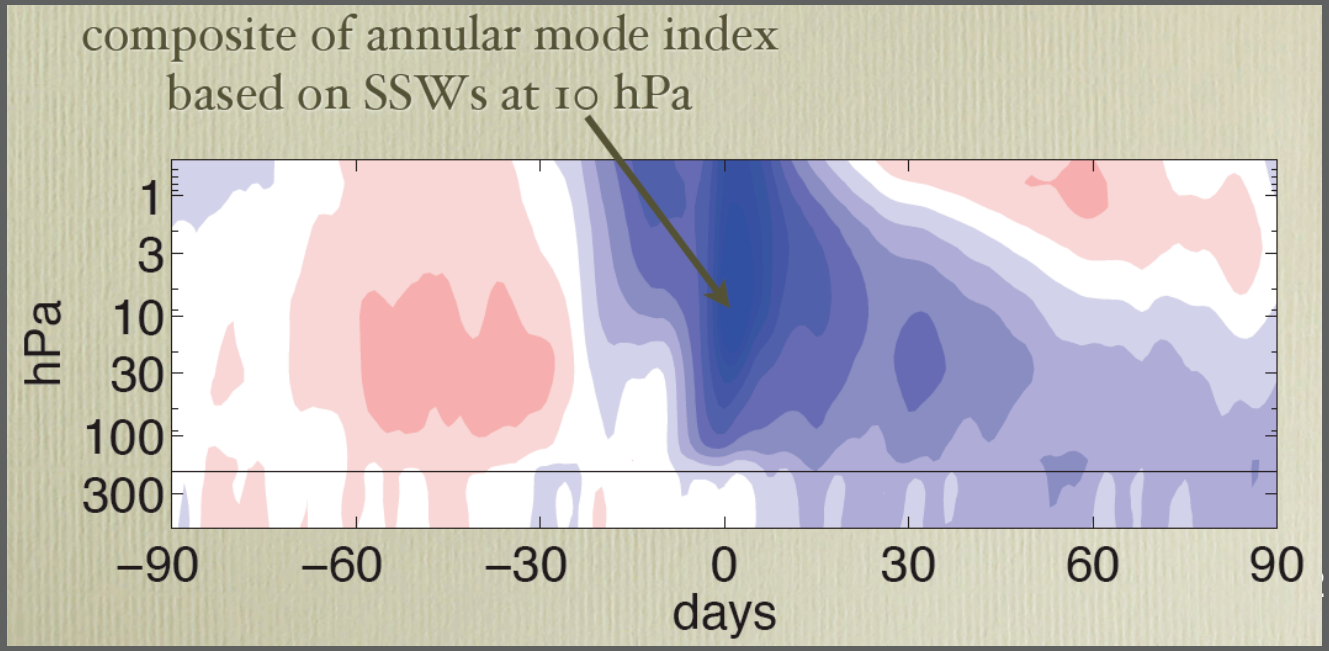


Polvani & Kushner 2002

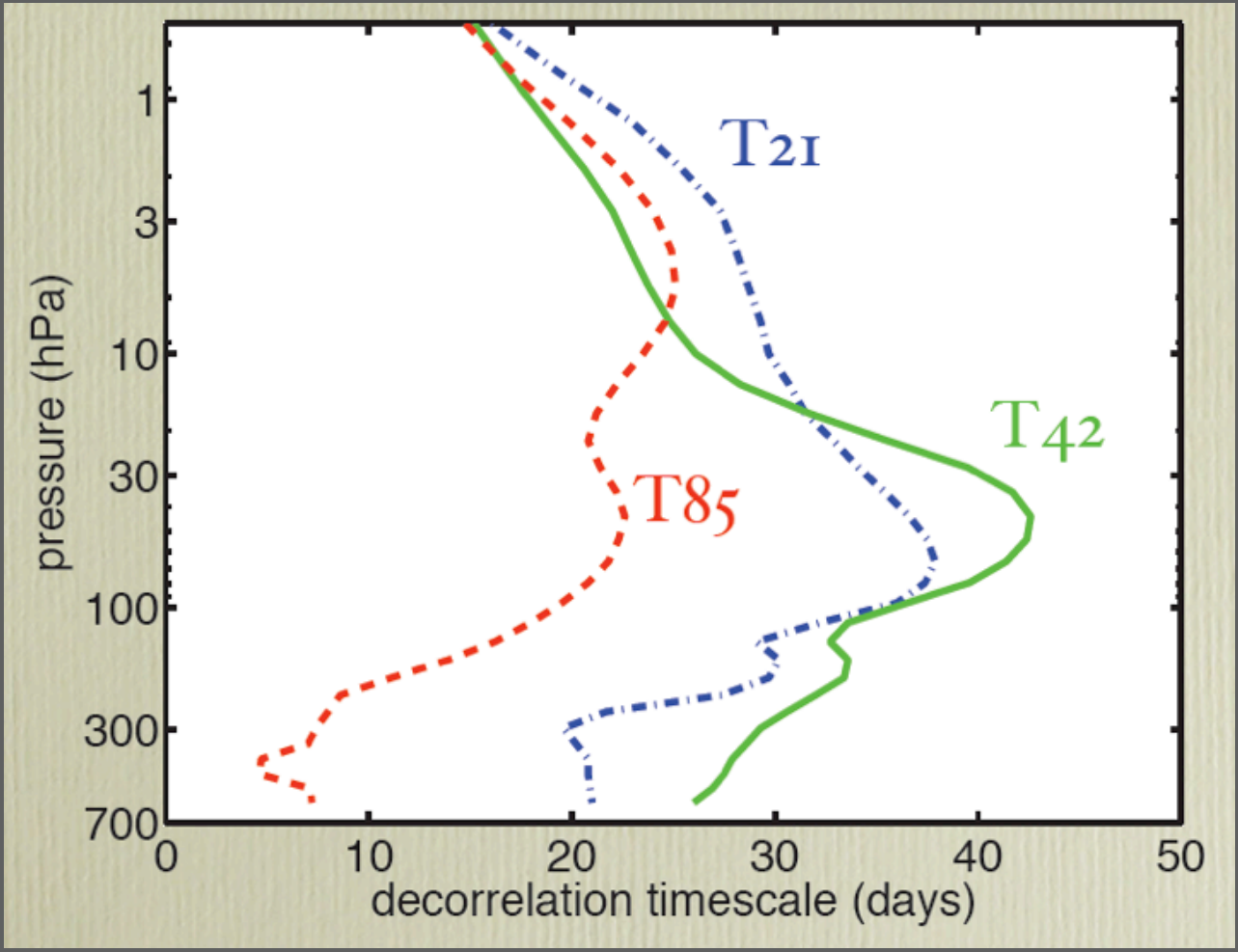
idealized model with topography



Gerber & Polvani *in prep.*



resolution caveat

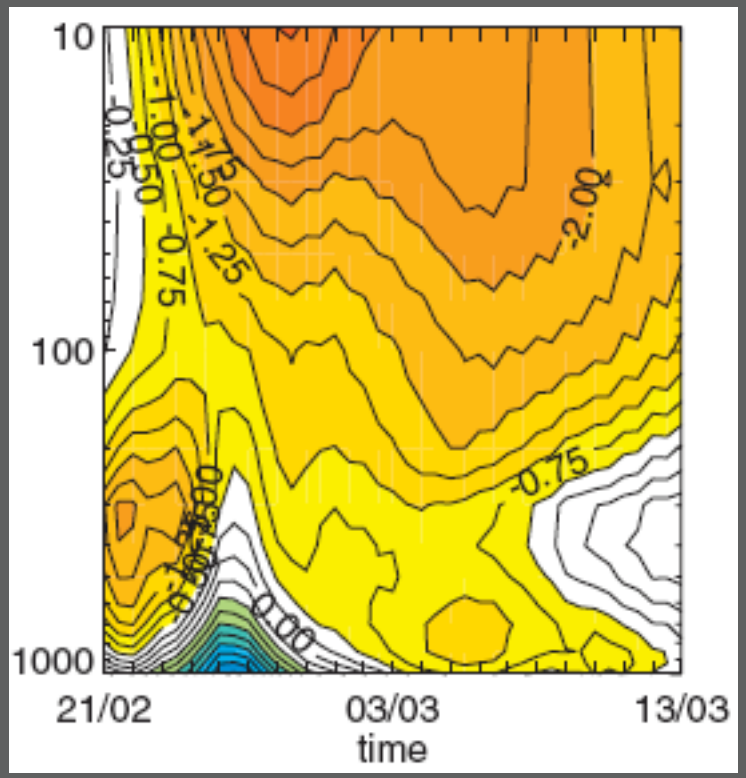


Gerber & Polvani *in prep.*

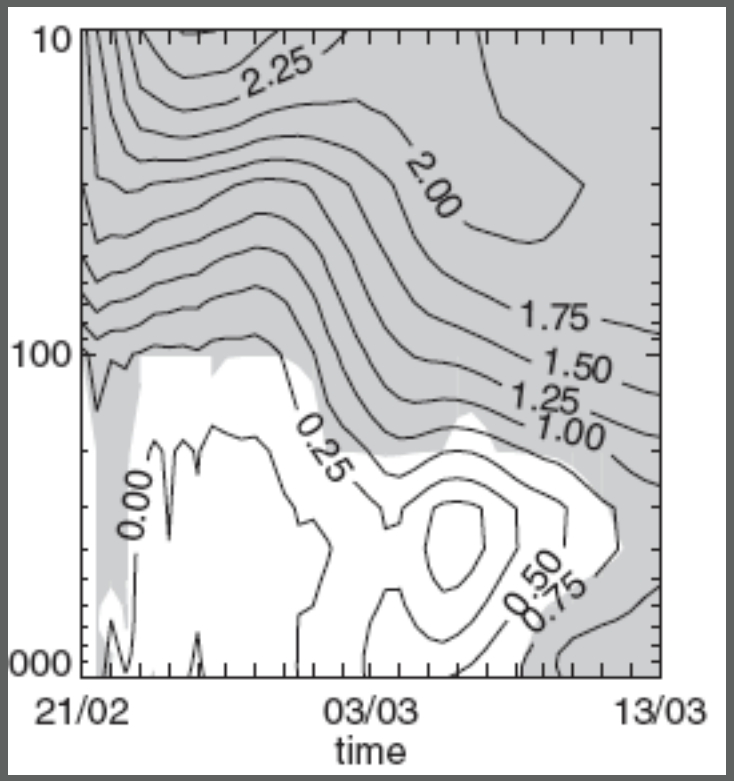
NWP model

- ECMWF T255, L60
- 30 member ensembles: “nature” vs “non-nature” runs

Nature ensemble AOI



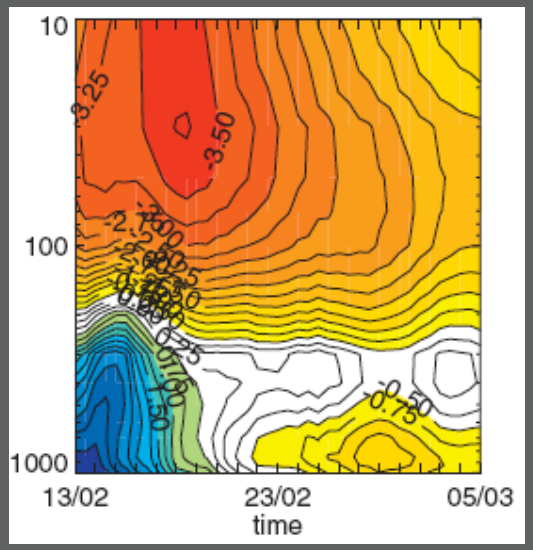
Nature - non-nature



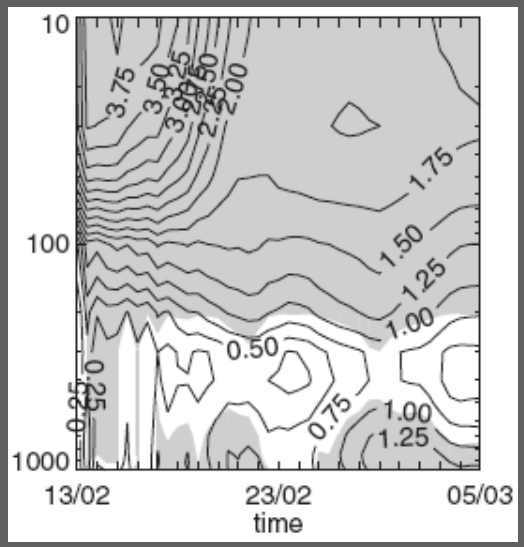
Charlton *et al.* 2004

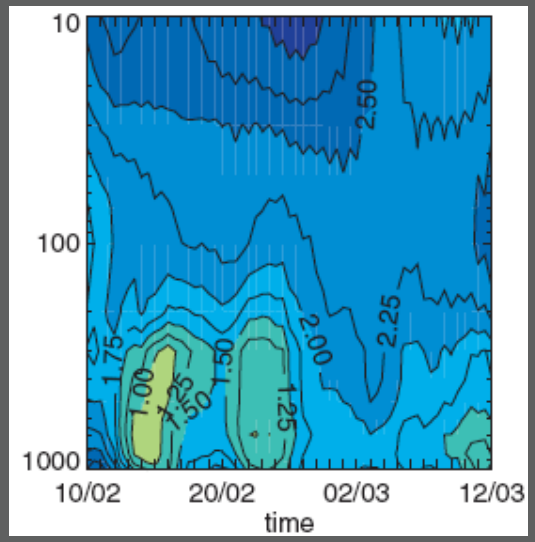
NWP model (cont'd)

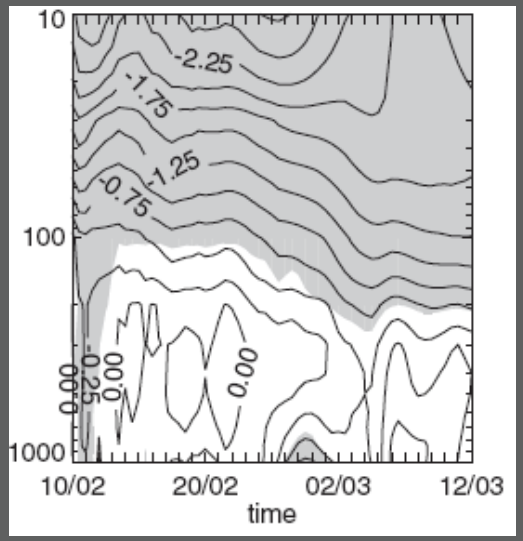
Nature ensemble AOI



Nature - non-nature







Charlton *et al.* 2004

downward influence

- Strong suggestion of downward influence in statistical analyses of observations
  - But correlation≠causality issue persists
  - Focus on NAM may miss key features
- Models show clear downward influence on climate time-scales
  - Though early results were likely exaggerated by weak internal variability and low resolution
- Limited number of intraseasonal experiments show downward influence
  - But these initial conditions were *strongly* perturbed

spring transition

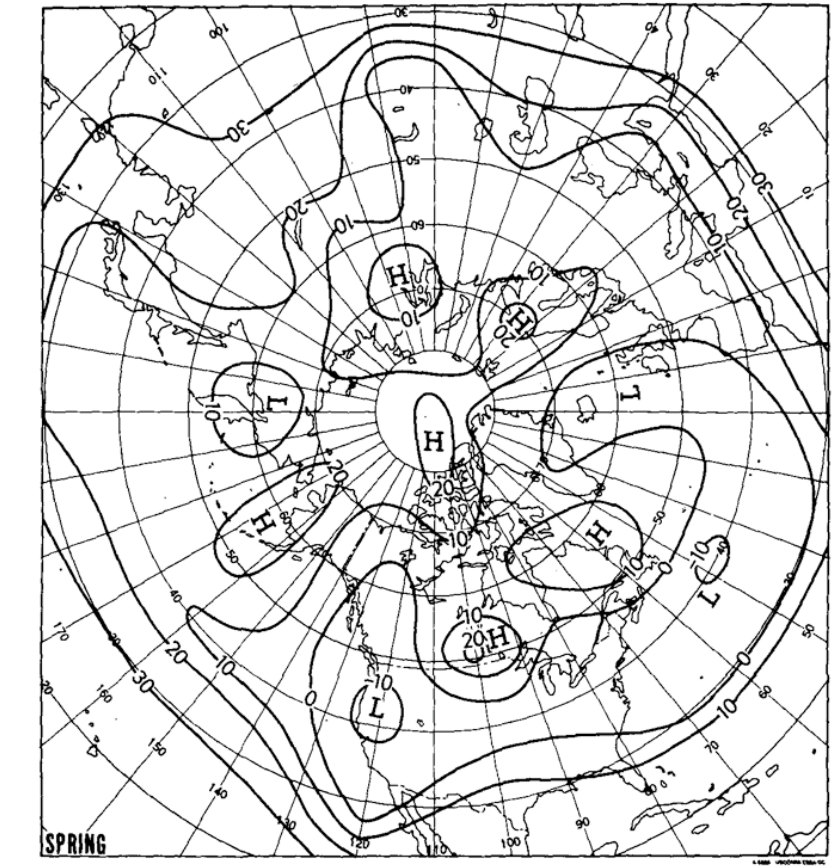
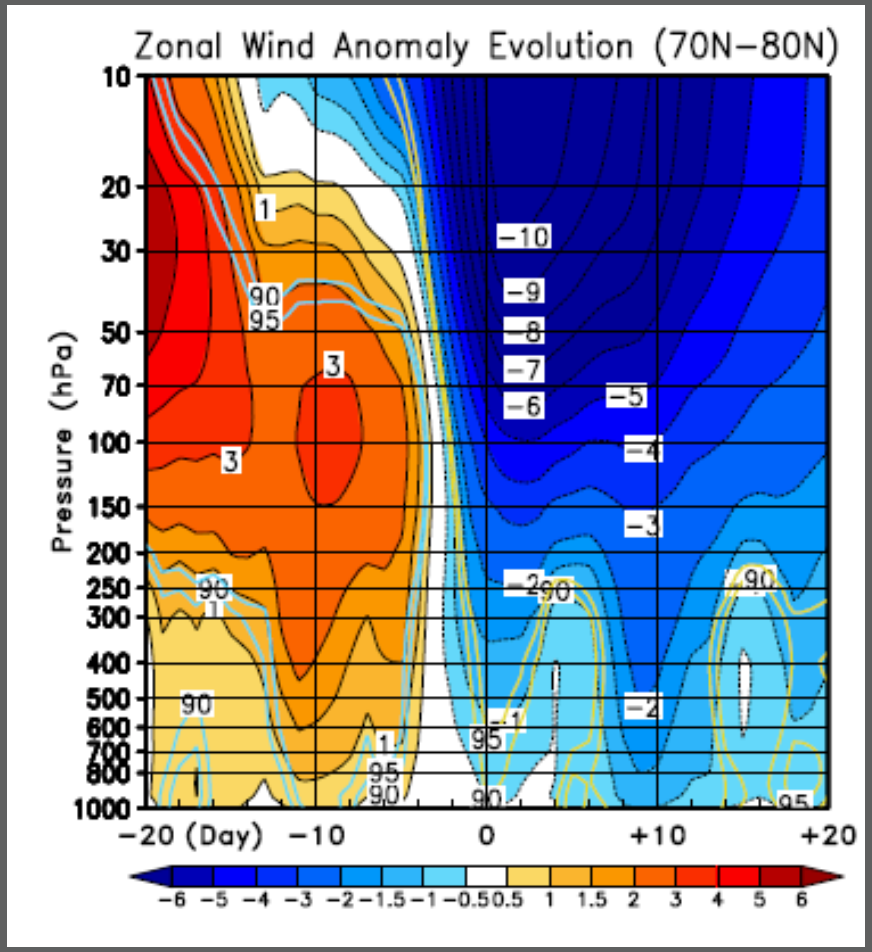


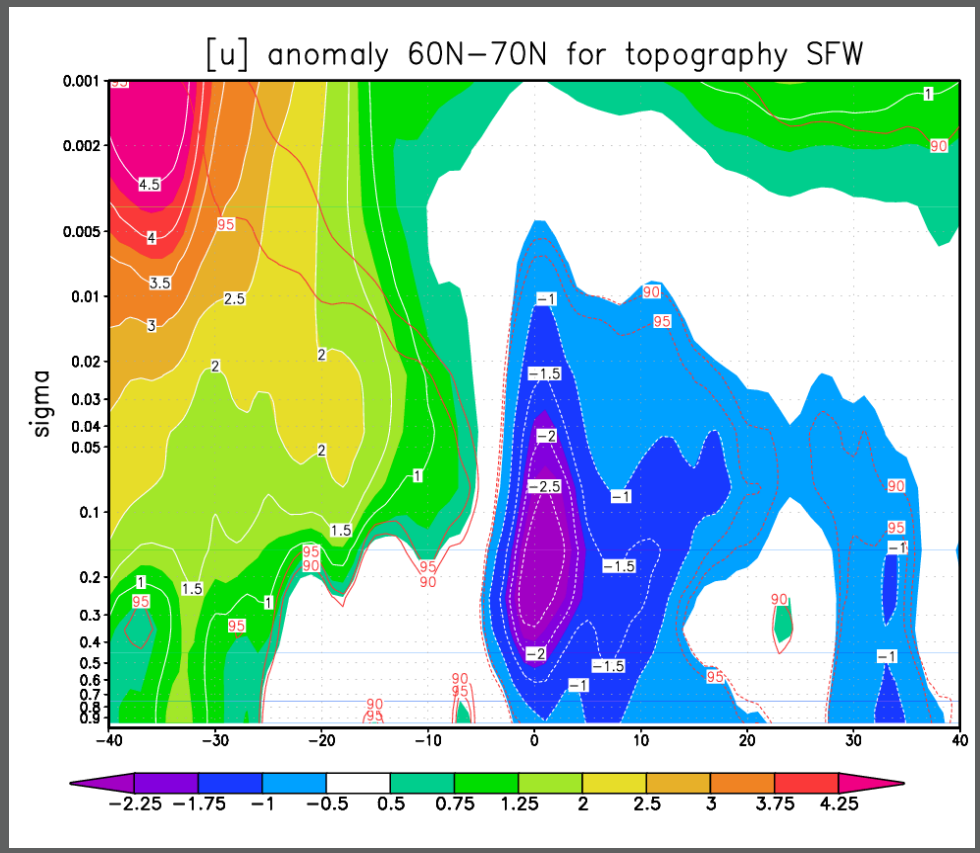
FIG. 2. As Fig. 1, but for spring.

van den Dool & Livezy 1983

observed and modeled SFW

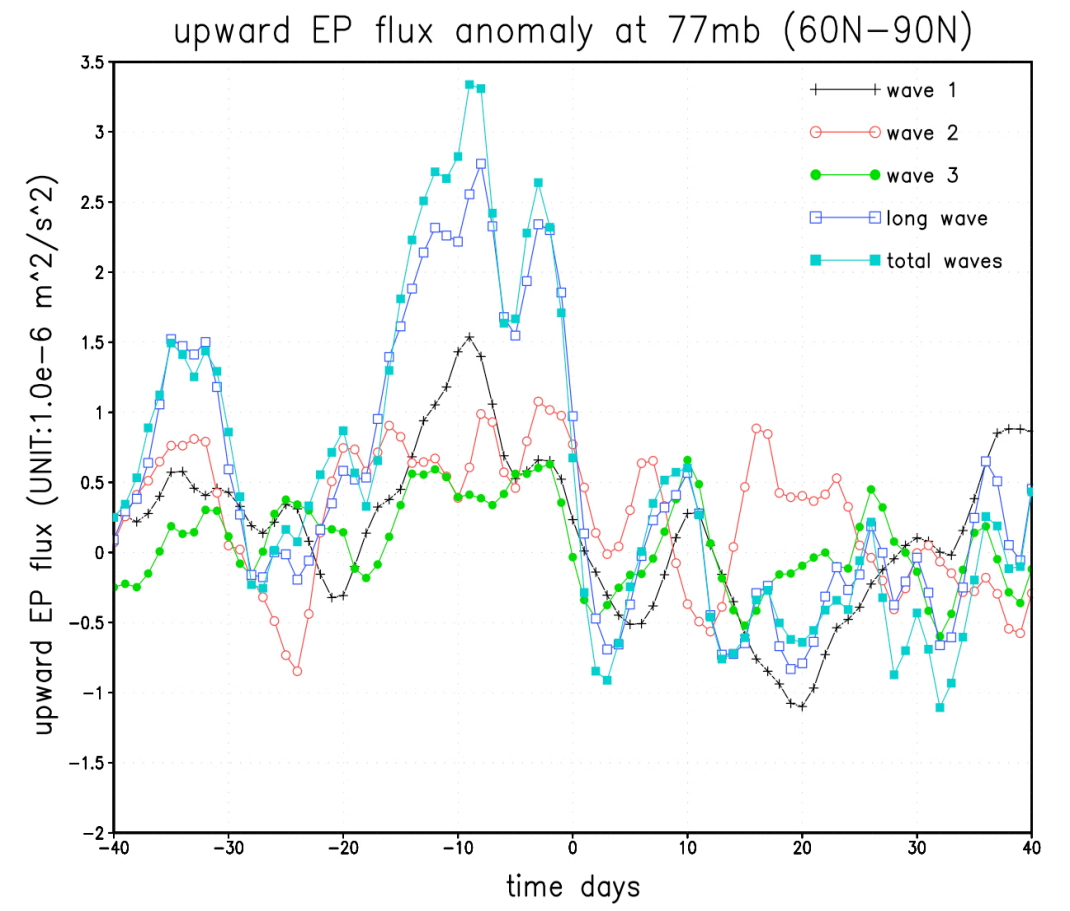


Black *et al.* 2006



Sun & Robinson *in prep.*

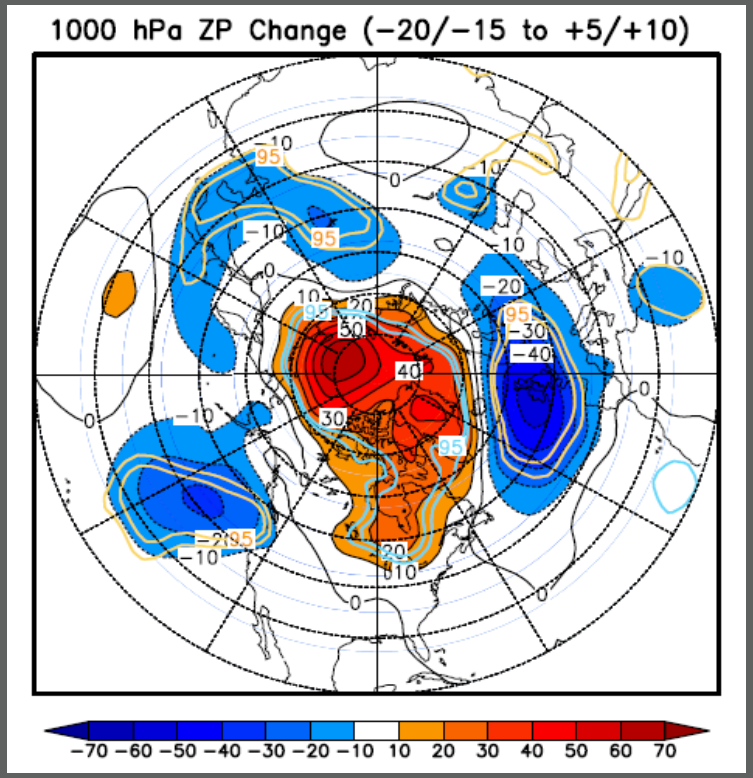
SFW precursors



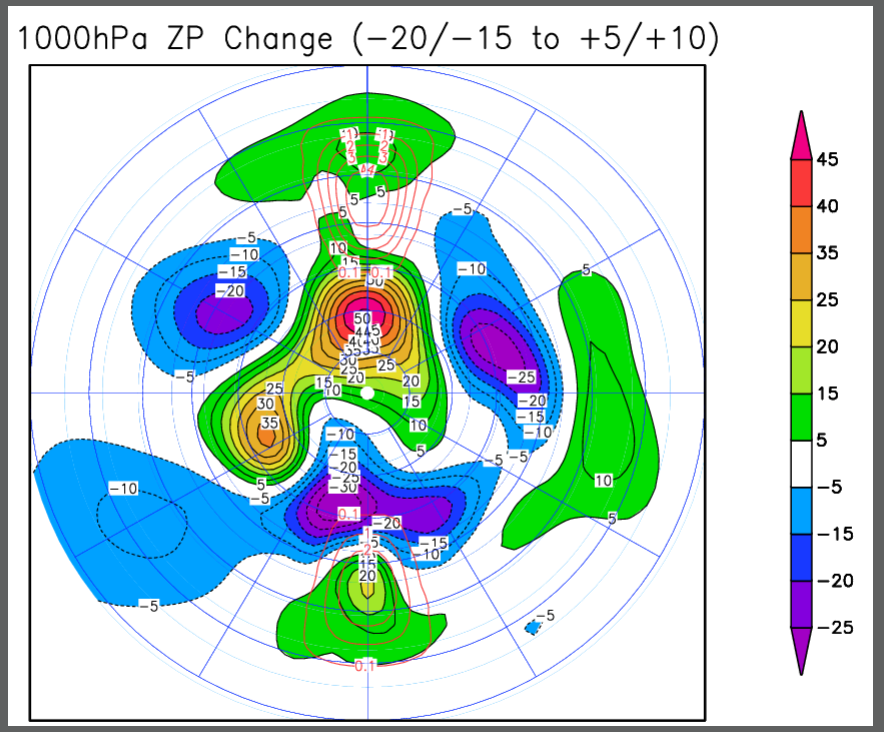
Sun & Robinson *in prep.*

tropospheric circulation changes

NH observations



Black *et al.*



Sun & Robinson *in prep.*

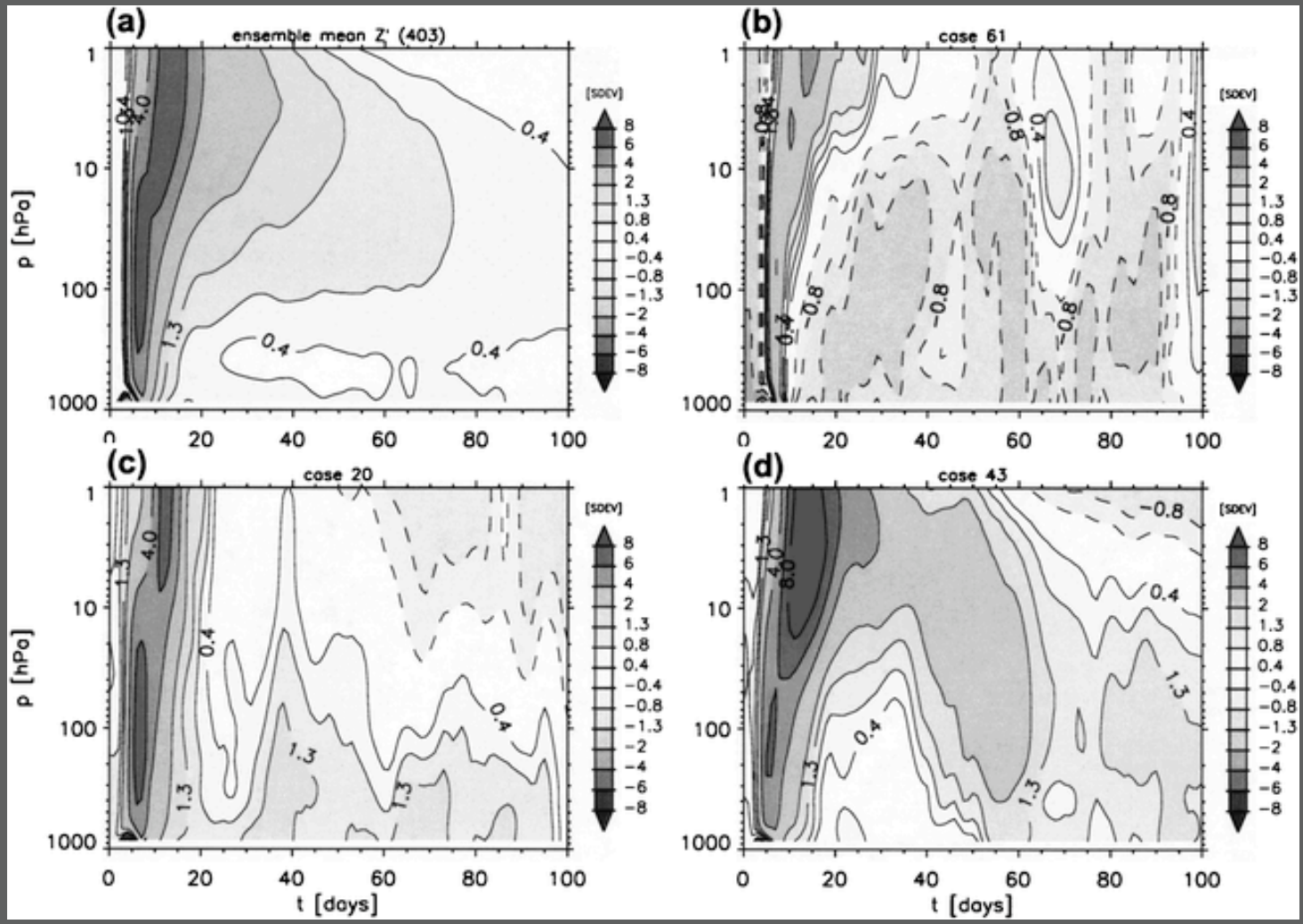
spring transition

- Interesting season with weak tropospheric persistence of anomalies, strong strat-trop coupling
- Final warming contributes to tropospheric transition
- Precursors suggest possibility of predicting SFW

value for prediction?

- An idealized experiment
- Linear inverse model results

idealized experiment - pulse forcing

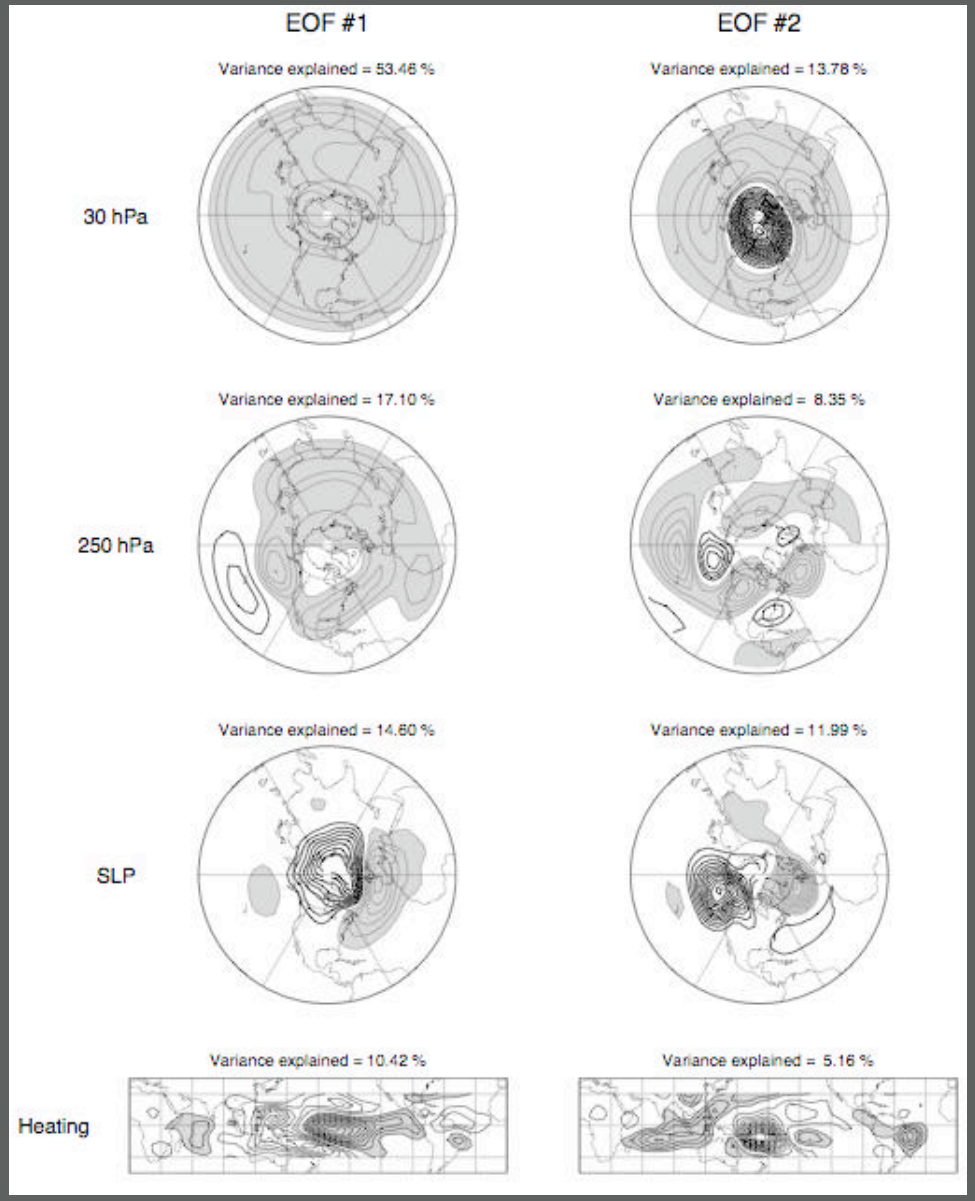


Reichler, Kushner & Polvani 2001

LIM results

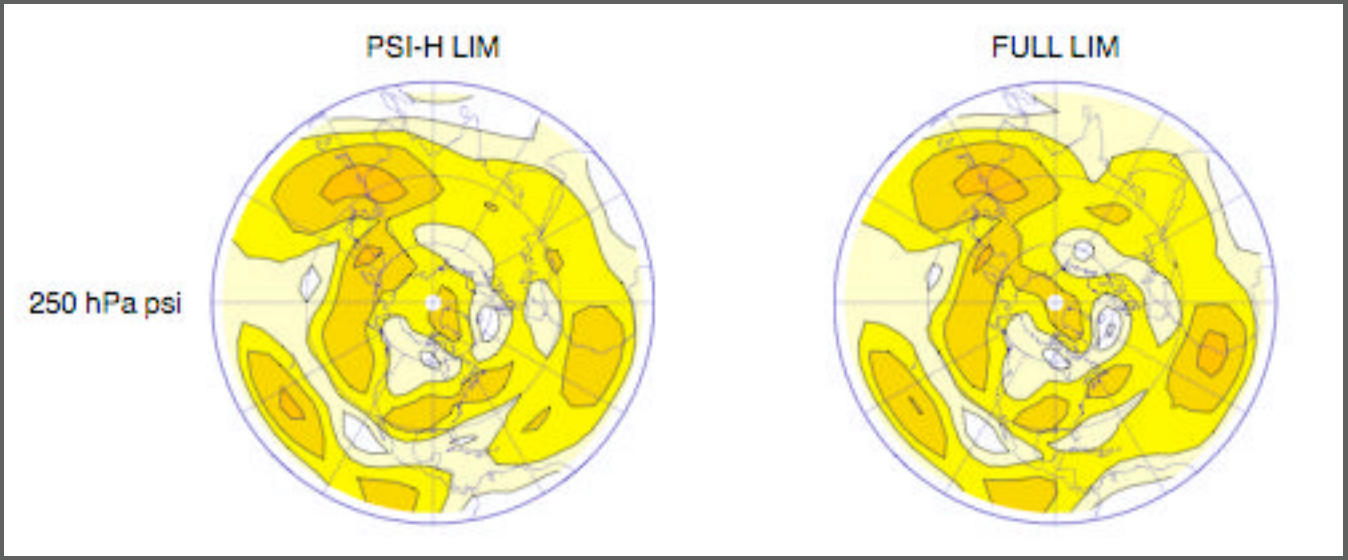
Newman and Sardeshmukh 2007

- Linear inverse model with tropospheric and stratospheric streamfunction, SLP, and tropical heating
- T21, 7-day running means
- Trained on 35 years of obs

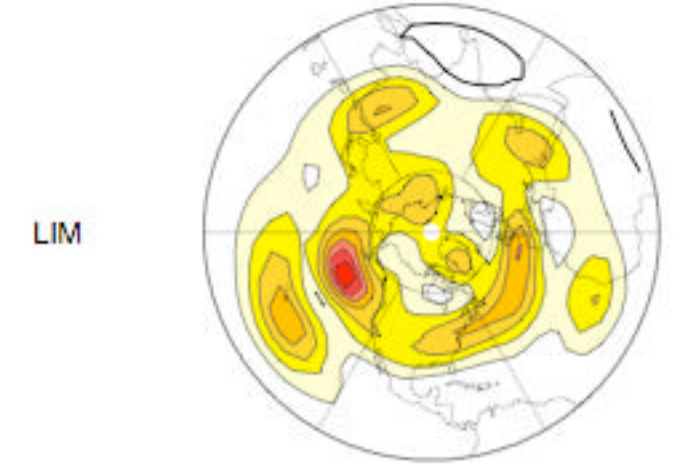


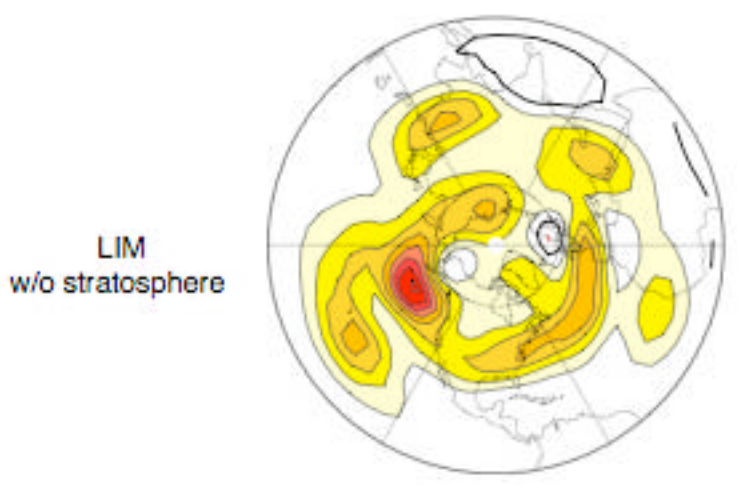
LIM (cont'd)

Day 21 AC



21-day lag covar.





value for prediction?

- Even an idealized forced experiment shows weak predictability
- LIM results suggest limited scope for stratospheric impacts on IS prediction

concluding comments

- Tropospheric influence on stratosphere is indisputable, yet more complex, possibly less predictable, than usually acknowledged
- Stratospheric influence on troposphere:
  - Nearly indisputable on climate time-scales - mechanisms still not clear
  - Appears to operate intraseasonally - pathways are not clear - strongest evidence for strongest events (SSW and SFW)
  - More structurally complex than previously recognized

comments (cont'd)

- Help for IS prediction?
  - LIM results are discouraging
  - Possibly in most dramatic events
  - SFW provides a dramatic event every spring
- Need now for model-twin prediction experiment - many cases and large ensembles - looking at impact on forecasts of modestly degraded stratospheric analyses