Simulation of Stratospheric Intraseasonal Variability with the GFDL Climate Model
A Low-top / High-top Comparison

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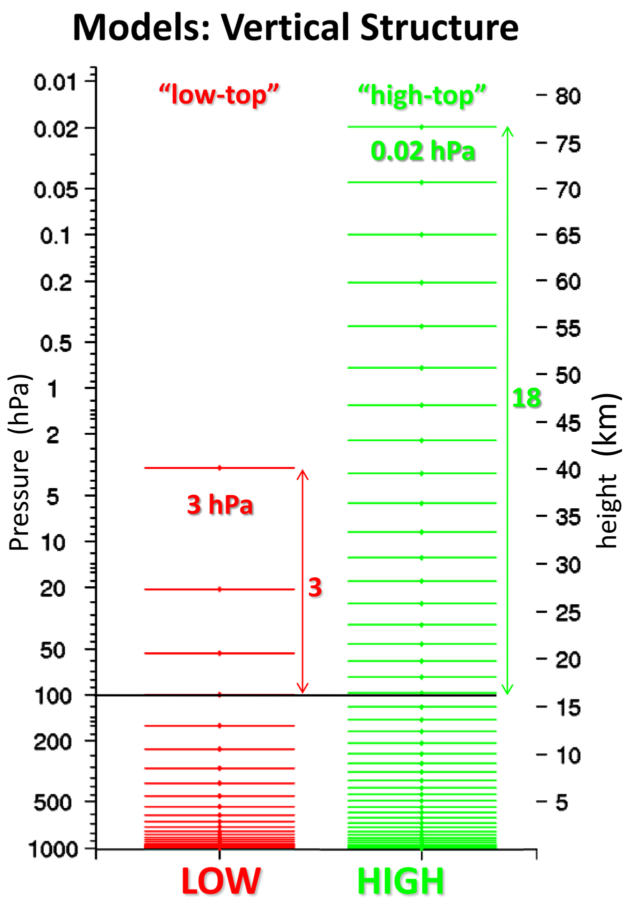
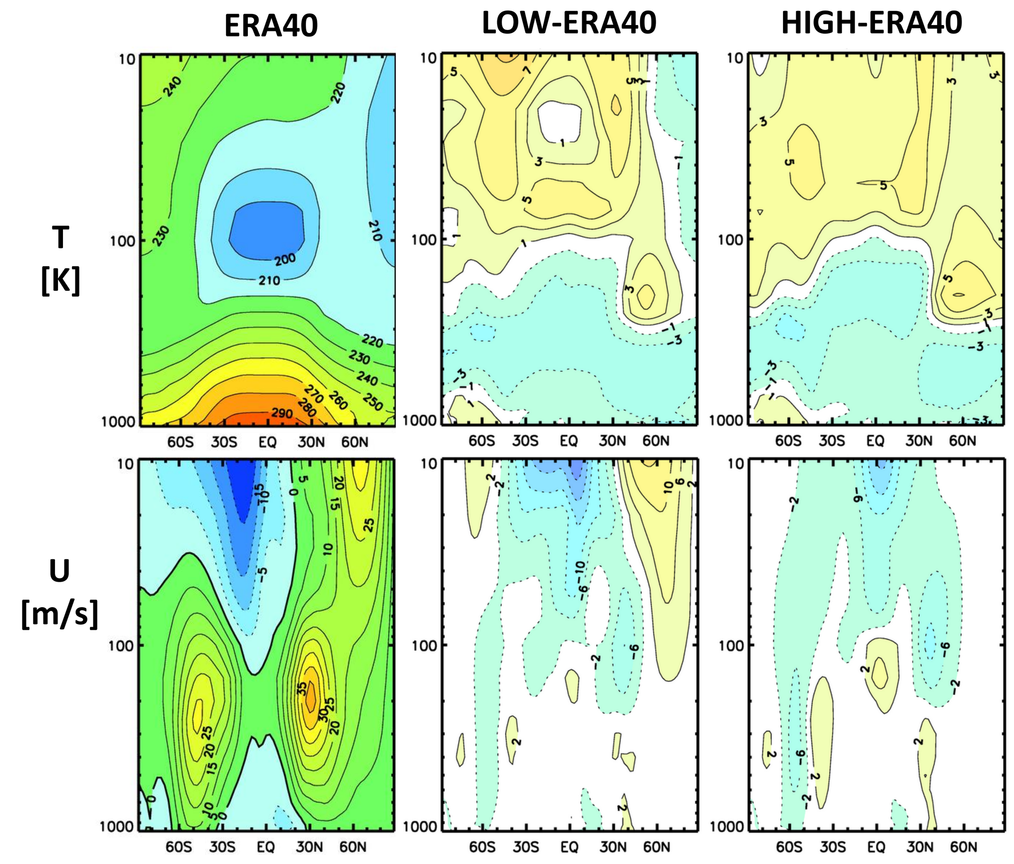
1. Introduction

We examine long (about 500 years) AMIP-type slice experiments performed with the GFDL AM2.1 climate model in a low-top (L24) and high-top (L48) configuration.



2. Mean Climate

2a. Temperature and U-wind (DJF)

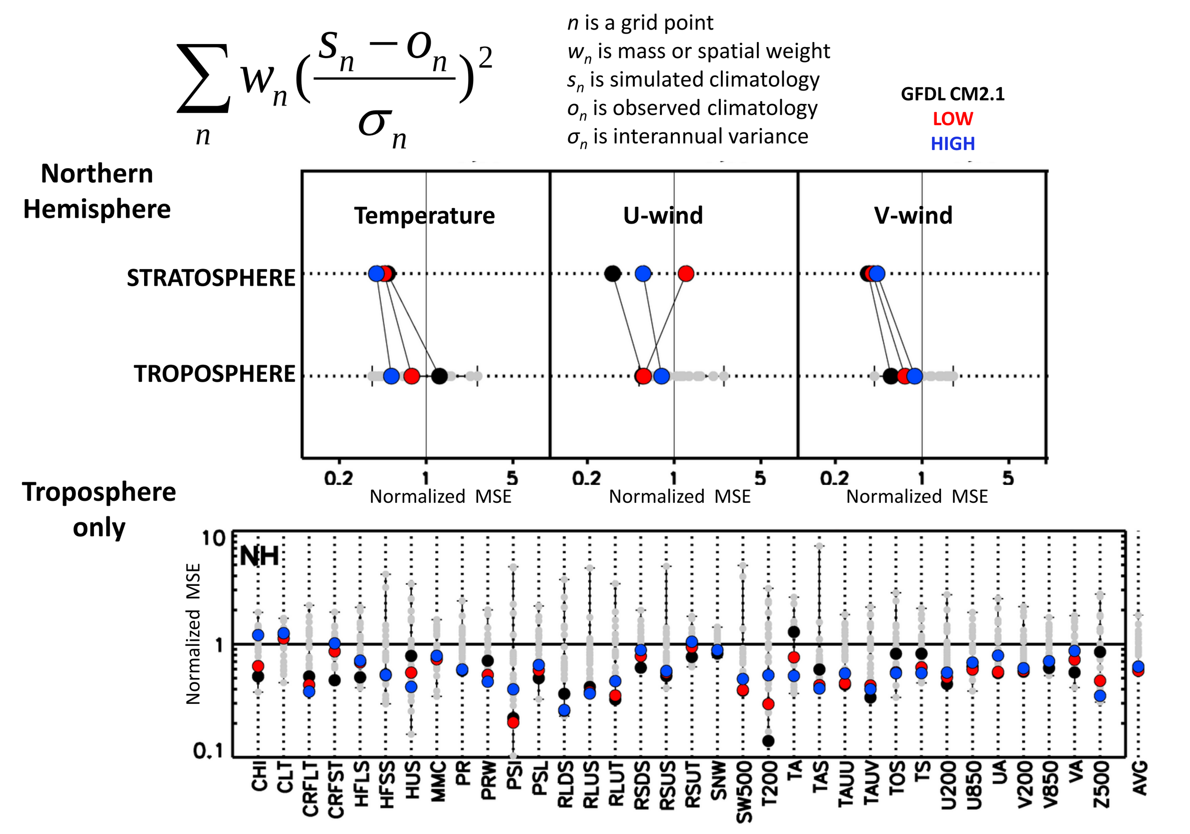


2b. Model Performance Metric

Normalized MSE (suggested by Reichler and Kim, 2008, BAMS)

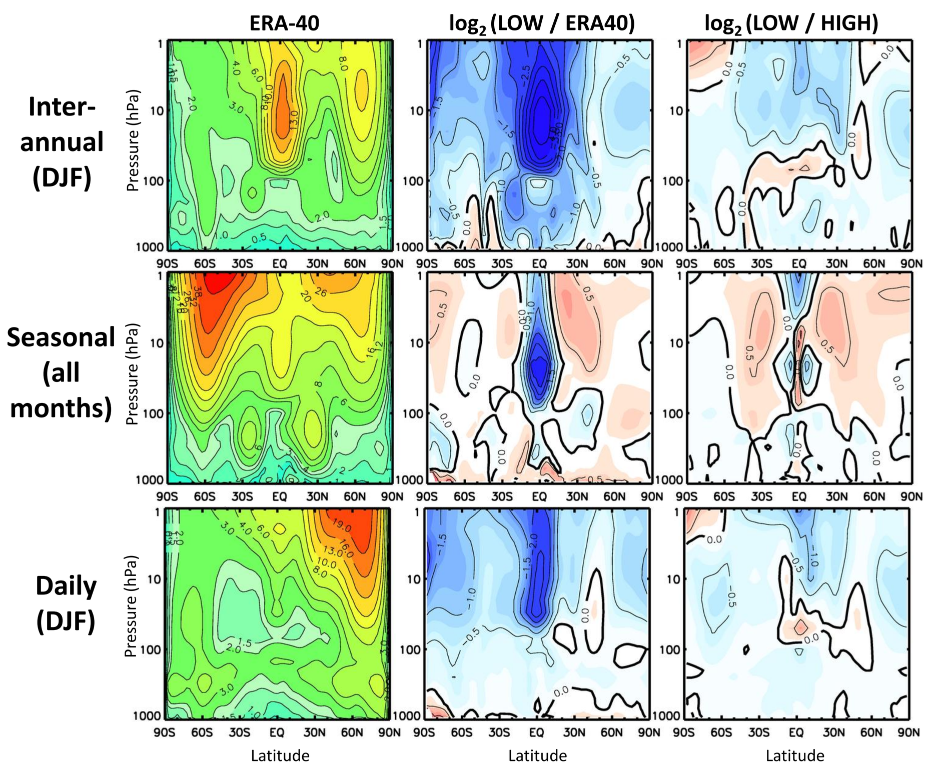
$$\sum_n w_n \left(\frac{s_n - o_n}{\sigma_n}\right)^2$$

n is a grid point
w_n is mass or spatial weight
s_n is simulated climatology
o_n is observed climatology
σ_n is interannual variance

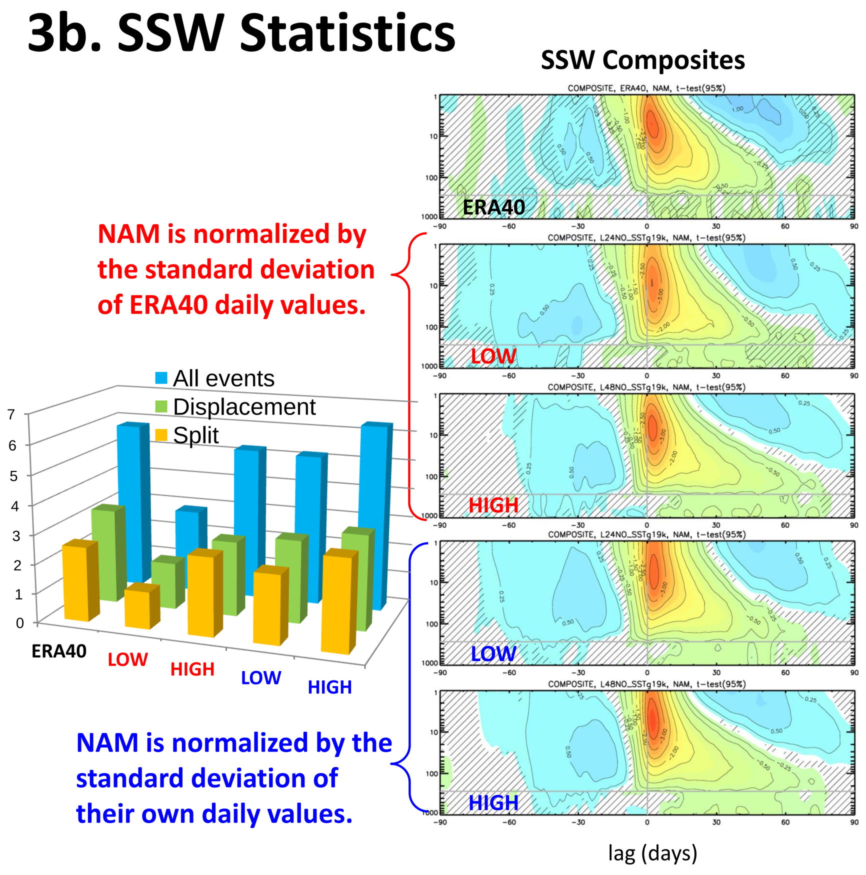


3. Variability

3a. Relative Variability



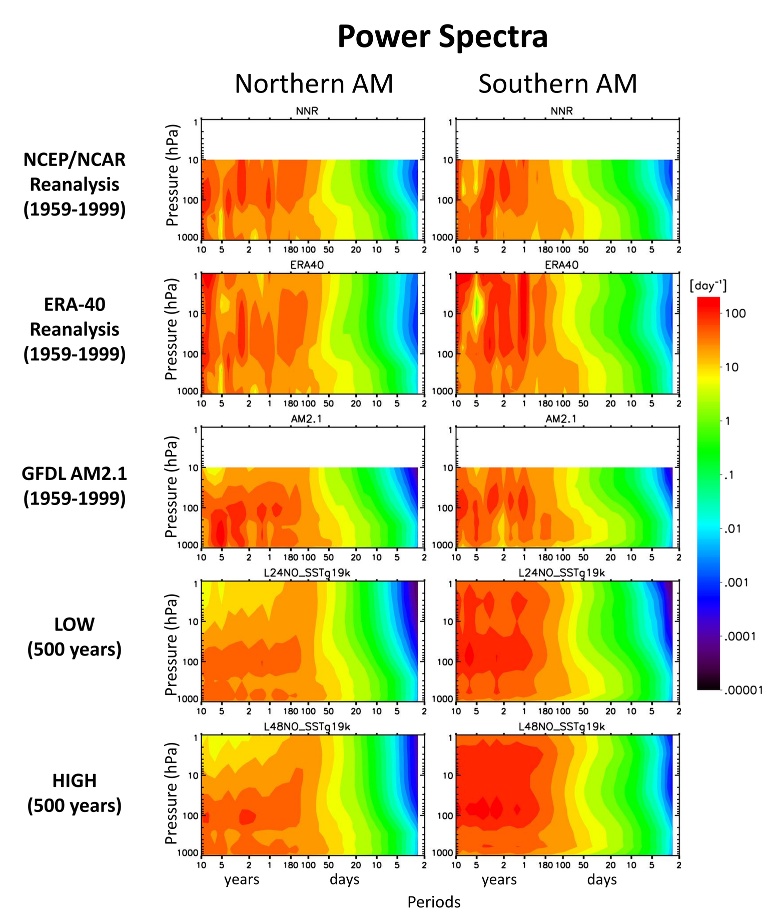
3b. SSW Statistics

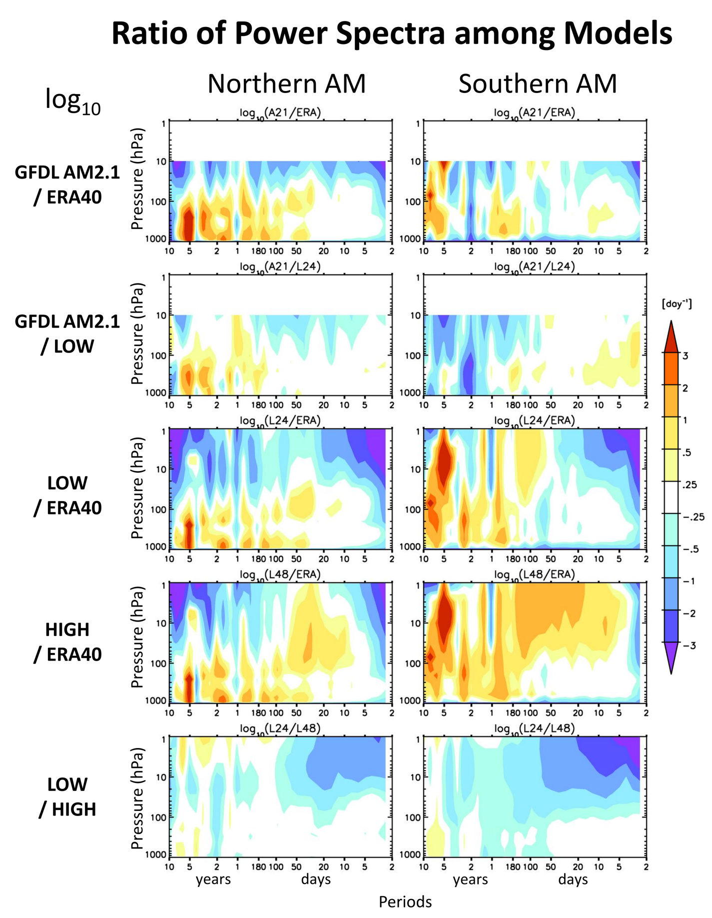


The positive annular mode, on average, happens about 1-2 months before SSW onsets, and it lasts for several weeks. There is strong downward propagating negative annular mode during SSW events. Again, the strong positive annular mode shows up and it persists for several weeks in the stratosphere.

There are smaller numbers of events in LOW models than in HIGH models, when the annular mode is normalized by the standard deviation of ERA40 daily values. This means that the variability in LOW models are smaller than that in reanalysis and HIGH models.

4. Annular Mode Spectrum

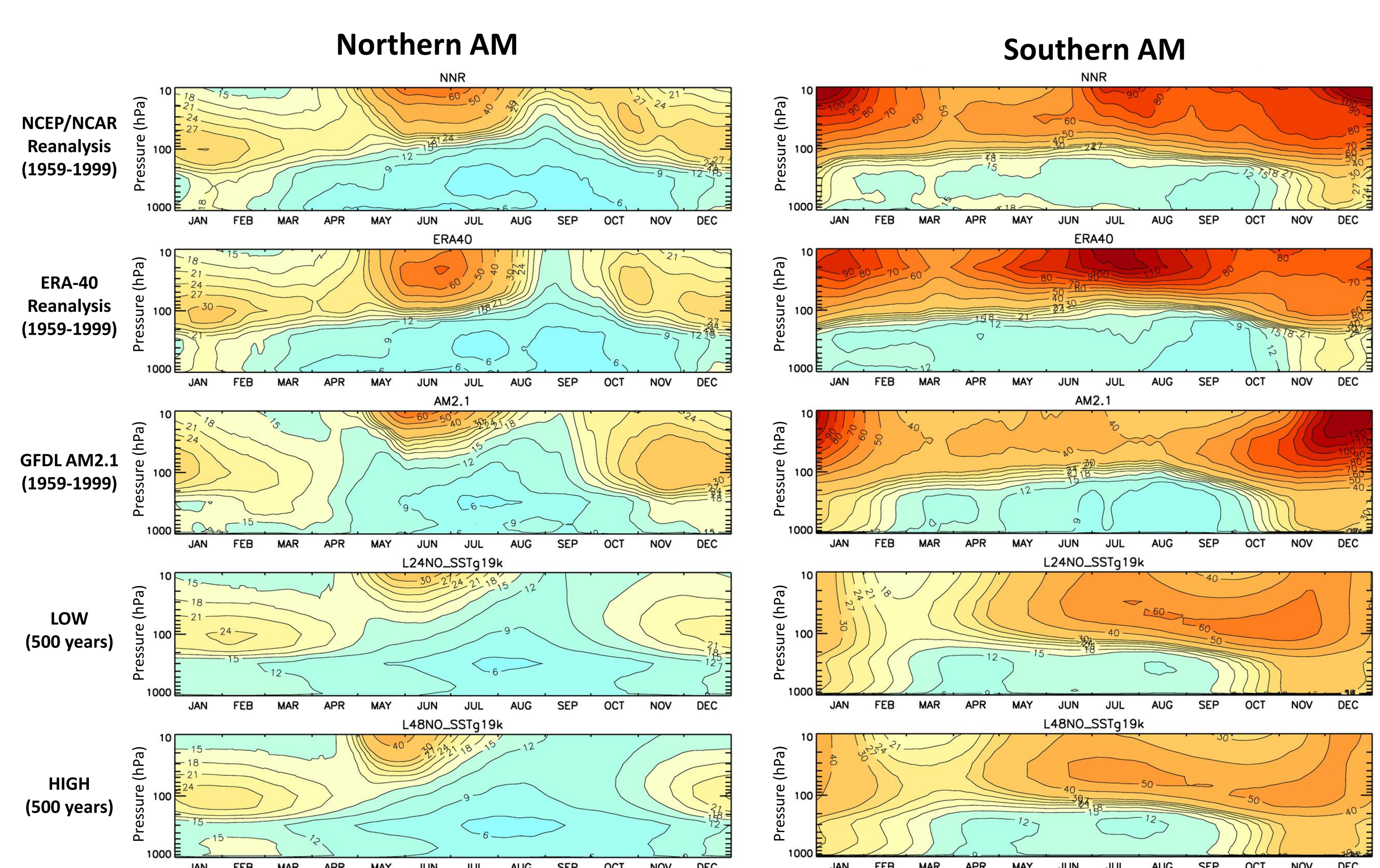




Left panels:
As expected from large winter/spring variability in both hemispheres, the reanalysis power spectra have very prominent annual cycle. In the stratosphere, the power spectra also show a 2.5 year cycle associated with the QBO signal (Holton-Tan Oscillation). We can clearly see the ENSO cycle, too.

Right panels:
Both LOW and HIGH models underestimate NAM power spectra in the stratosphere during longer than half year periods, whereas they overestimate SAM power spectra, compared to ERA40 reanalysis. Since the most different feature between LOW and HIGH models is their difference in the stratospheric resolution, the power spectra show large differences in the stratosphere.

5. Annular Mode Timescale



Figures:
The "e-folding" time scale (days) of the annular mode for the autocorrelation function to drop to e^{-1} exponentially.

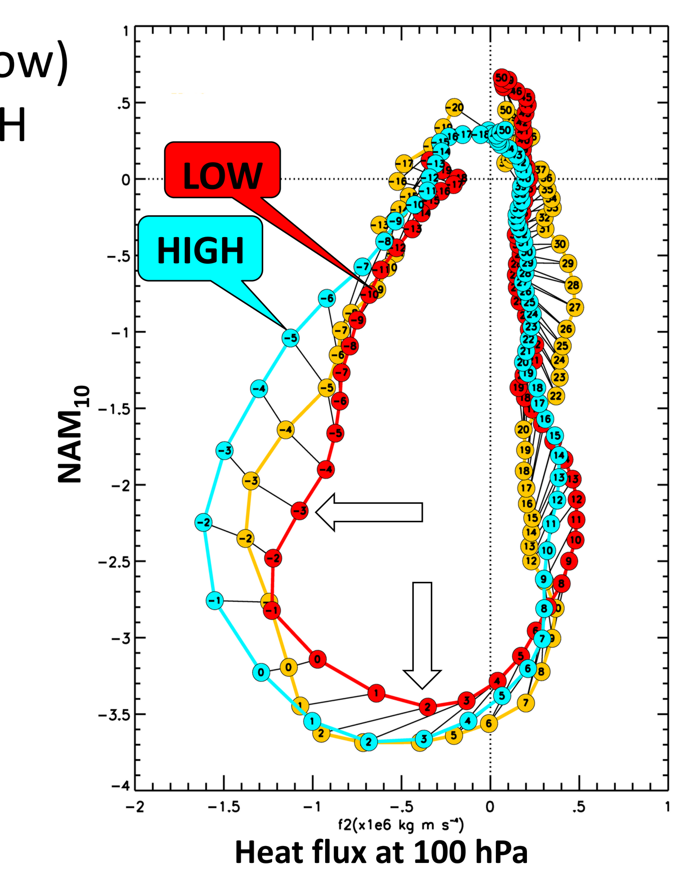
Left panels:
The NAM timescale in the lower stratosphere is longer than that in the troposphere for all seasons. The timescale in the stratosphere is longest during summer because of quiescent conditions. The second longest timescale happens during winter, and its timescale in the troposphere is longest at the same time. This seems to be related to strong persistent stratospheric circulation anomalies such as SSWs.

Right panels:
The timescale of SAM is longer than that of NAM. It has a maximum magnitude in the troposphere during November and December. Although same periods of two reanalyses and GFDL AM2.1 are chosen, the timescale does not show consistent behavior. The stratospheric NAM timescale in the LOW model is generally shorter than that in the HIGH model, whereas the SAM timescale in the LOW model is longer than that in the HIGH model.

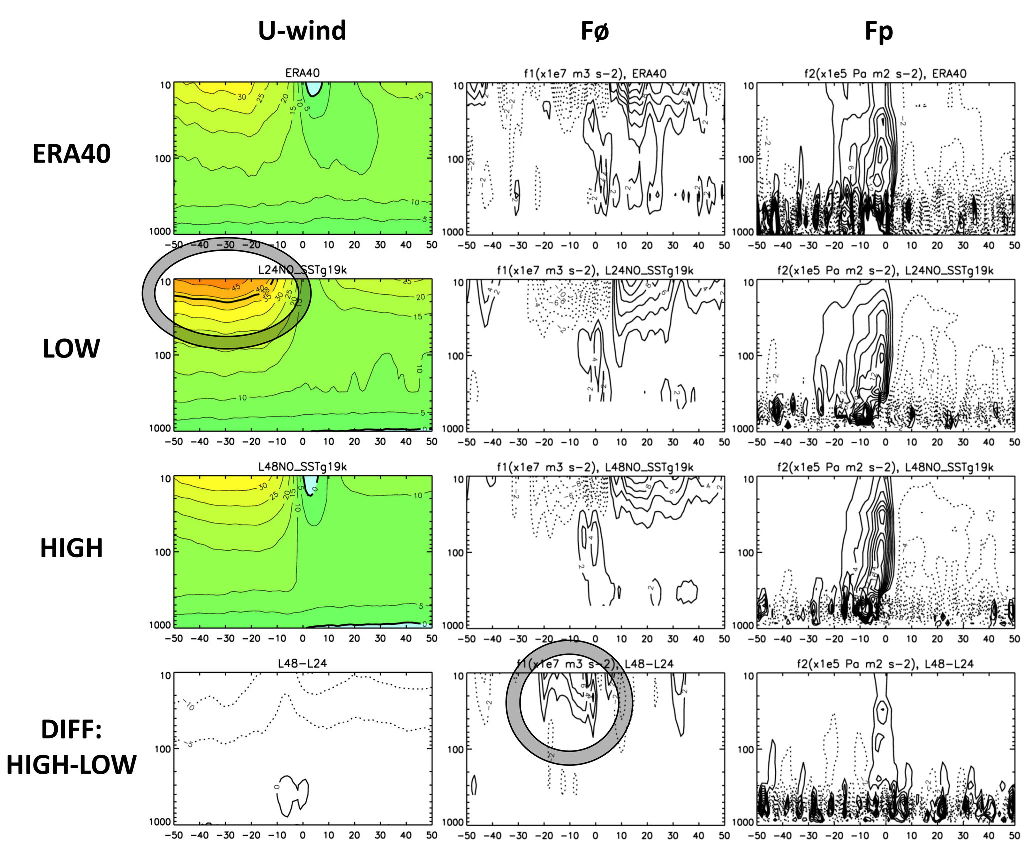
6. SSW Composites

6a. SSW Composites I
NAM_{10} and Heat Flux in Phase Space

- ERA-40 (yellow)
- LOW vs. HIGH



6b. SSW Composites: II
EP-flux Evolution



7. Conclusion

- ➢ The model with a well resolved stratosphere is generally in good agreement with the observations.
- ➢ The troposphere-only model has various deficits in simulating some of basic aspects of stratospheric variability.
- ➢ Having a well-resolved stratosphere does not necessarily guarantee a better troposphere.