Combined effect of the ENSO and 11-year solar cycle signals in the NH polar stratosphere.

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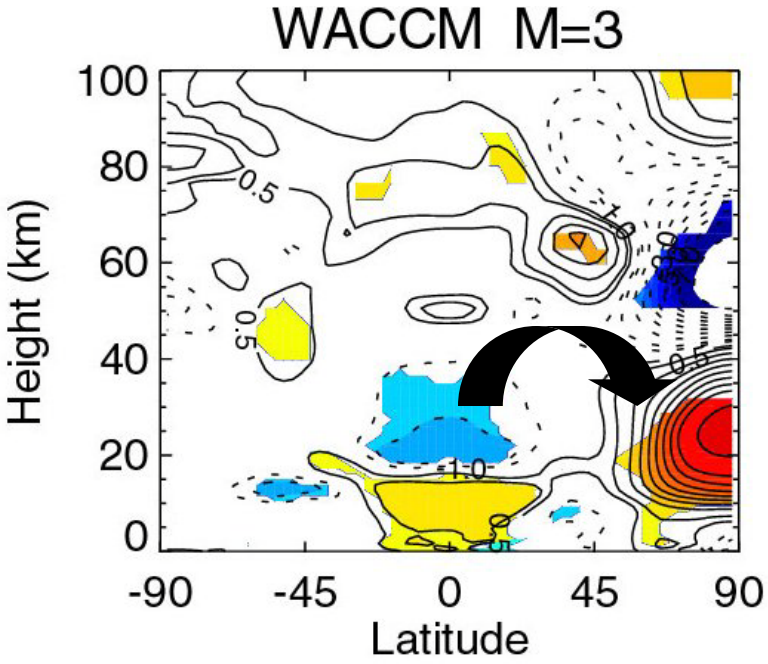
Motivation:

ENSO effects on the polar stratosphere



WACCM1, no solar cycle, no QBO (Garcia-Herrera et al., 2006)

Modeling works: Sassi et al., (2004), Manzini et al., (2006)

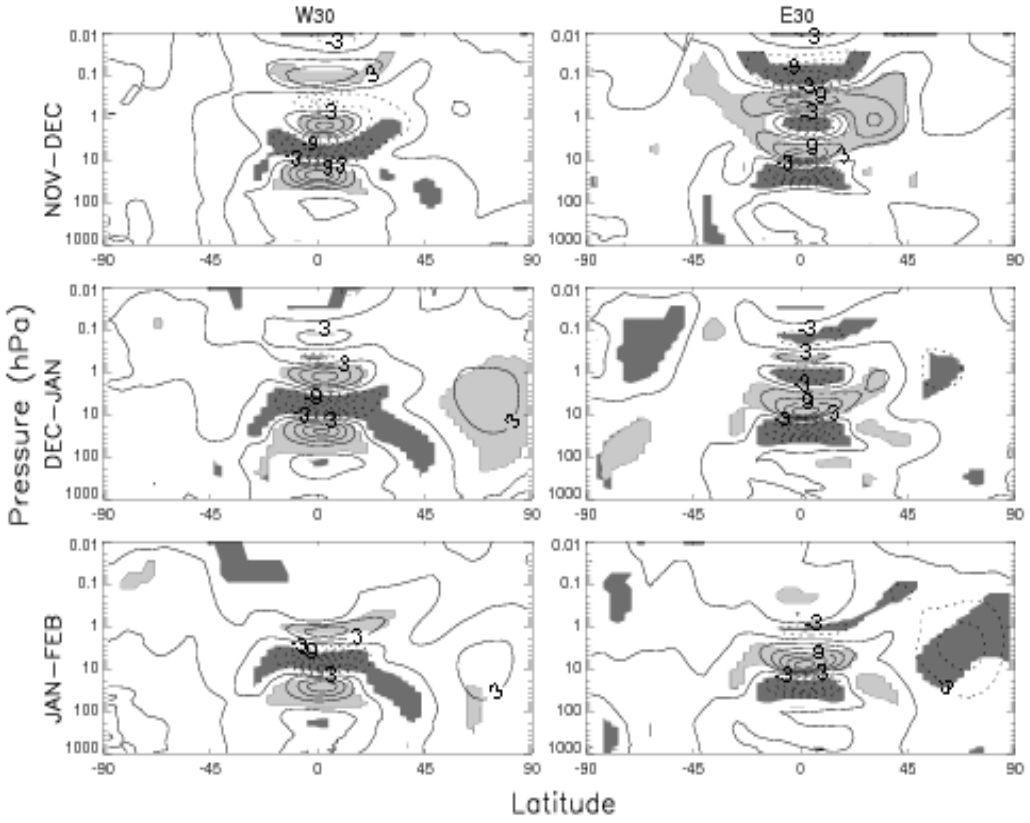
Observations: Garcia-Herrera et al., (2006), Garfinkel and Hartman (2007)

Motivation:

QBO effects on the polar stratosphere (Holton and Tan 1980,1982)

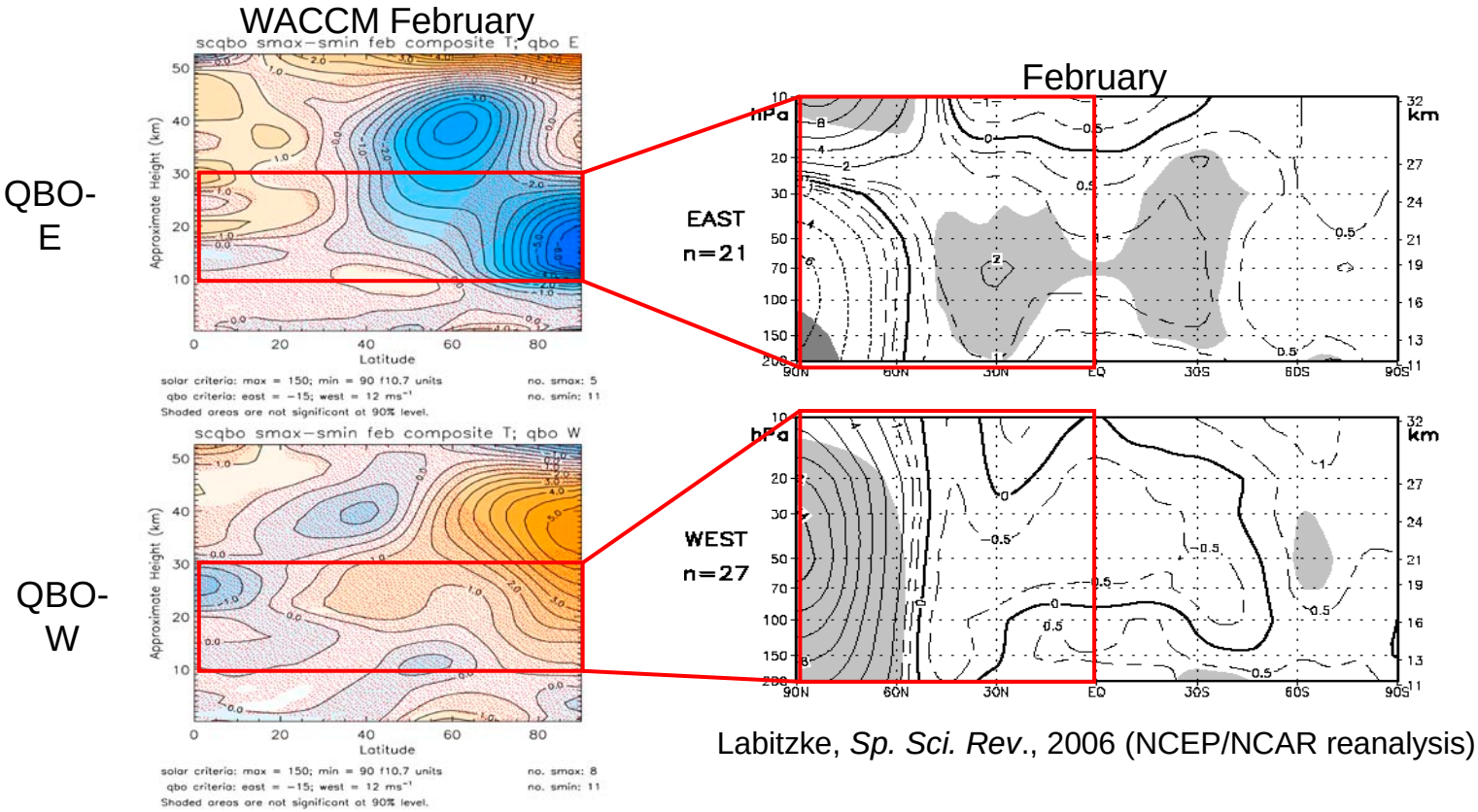
Modeling results from MAECHAM5 with climatological SSTs (Calvo et al., 2007)

QBO/W QBO/E



Motivation:

Solar effects on the polar stratosphere (Labitzke, Matthes)



Labitzke, *Sp. Sci. Rev.*, 2006 (NCEP/NCAR reanalysis)

At high latitudes, a solar cycle signal is found only if the data are separated according to the phase of the QBO (Labitzke and van Loon, 1988; Gray et al., 2001)

Camp and Tung (2007) did not find reversal of the Solar signal from wQBO to eQBO in NCEP/NCAR reanalysis. (Same signal for Smax-eQBO than Smax-wQBO and Smin-eQBO)

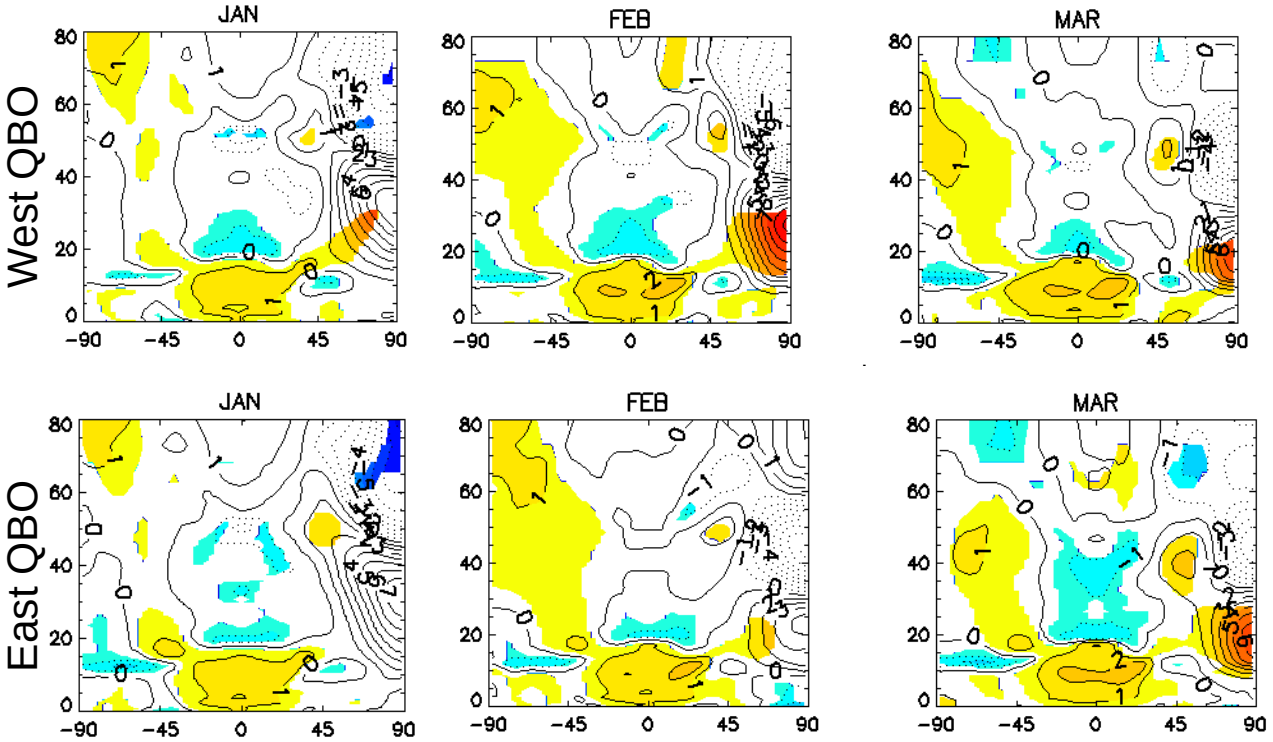
Motivation:

Holton and Tan relationship

Gray et al., (2004): Holton and Tan relationship disrupted or reverse from Smax to Smin? Depending on the month of the winter and the level where the QBO is defined. Significance. (ERA-40 data)

Wei et al., (2007), Calvo et al., (2009): weaker or even reversed Holton and Tan relationship during warm ENSOs in observations and models.

ENSO/QBO effects Calvo et al., (2009), Garfinkel and Hartman (2007)



Motivation:

There are '***strange***' effects when ENSO and QBO are combined

when QBO and Solar are combined

What about the combined effect of the 11year solar cycle signal and the ENSO signal??

WACCM3

Version 3.1.9

Resolution: Horizontal: 1.9° x 2.5° (lat x lon)

Vertical: 60 levels 0-140km
~ 1.0 km in UTLS
1-2 km mid-upper stratosphere
3 km in MLT

REF1: Retrospective simulation of the 20th century (1950-2004)

Observed SST, GHG and CFCs

3 realizations

detrended, deseasonalized, monthly-mean REF1 data

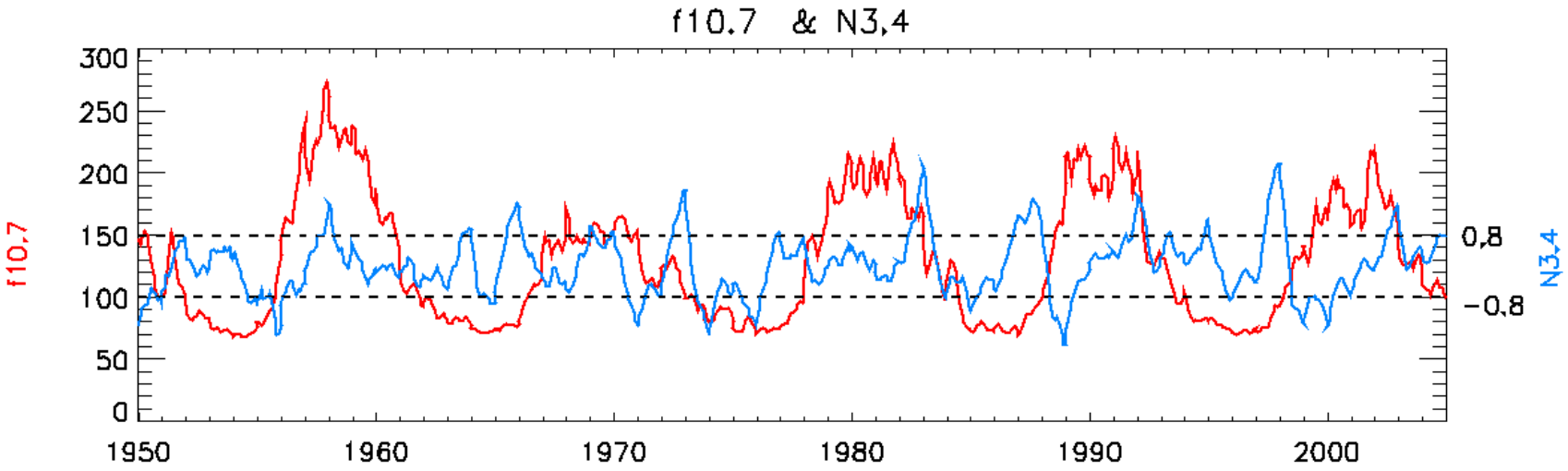
- WACCM3 does not produce a QBO spontaneously. **No QBO** was included in the simulations discussed here
- Interactive chemistry (MOZART, 57 species)

Garcia et al., (2007), Kinnison et al., (2007), Marsh et al., (2007)

Composites

ENSO stratification: N3.4 higher or lower than 0.8

Solar cycle stratification: f10.7 higher than 150 or lower than 100

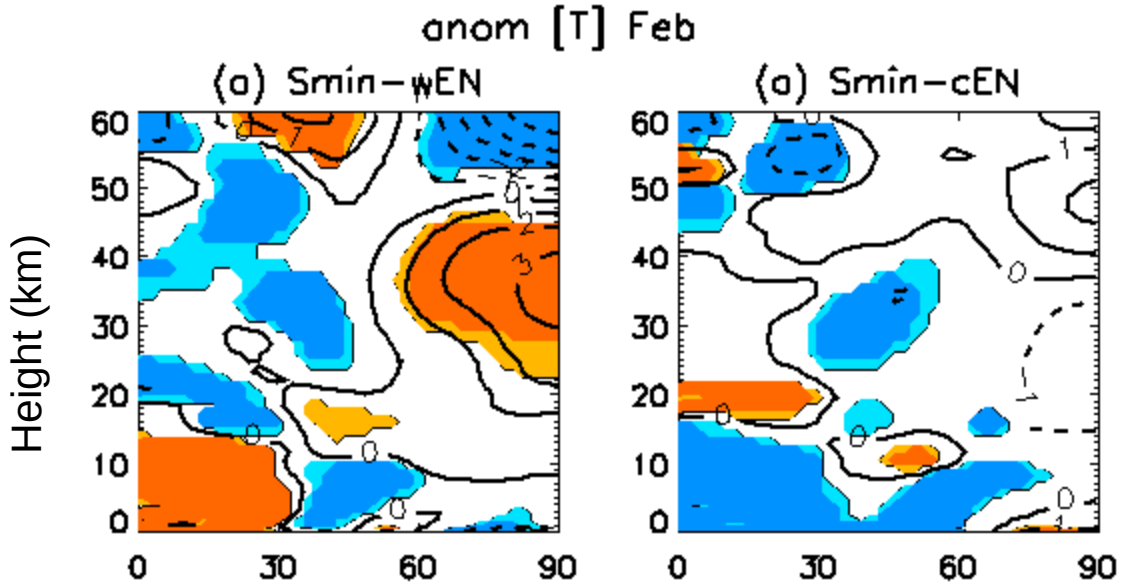


Analysis from 1950 to 2004 in February

4 composites

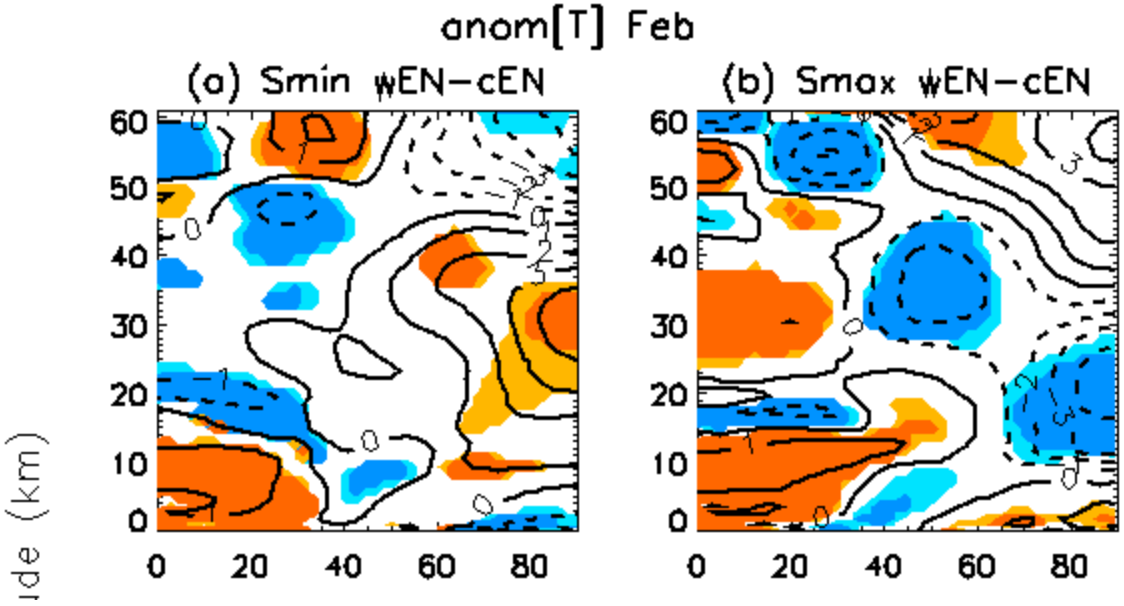
	Smax	Smin
wENSO	9	12
cENSO	9	12

Results



Calvo and Marsh (submitted to GRL)

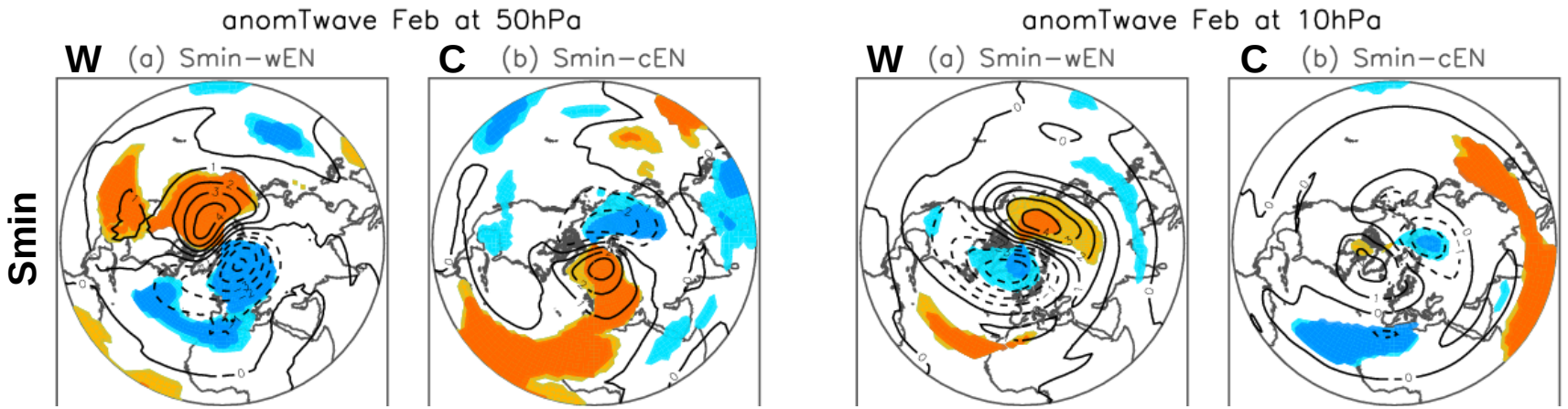
Results



Calvo and Marsh (submitted to GRL)

Results

50hPa **anom T wave** **10hPa**



Calvo and Marsh (submitted to GRL)

Conclusions

During **Smin conditions**, the NH polar stratosphere responds to ENSO in the same way as reported in literature (warm ENSO leads to weaker polar vortex and warmer polar stratosphere)

During **Smax**, the response is opposite. Strong cooling during warm ENSOs.

In both Solar conditions, anomalies reach up to 3-4K.

The **solar cycle effect** also changes sign depending on the ENSO conditions. It is largest and signficant during strong warm ENSO events (up to -6 K)

These changes are mainly related to the state of the atmosphere during **Smax-wEN conditions**, when two forcings act together. In this case, the planetary wave activity observed during Smin conditions and extreme ENSO events is inhibited and thus, the pole becomes very stable and cold.

Need to stratify with respect to ENSO and solar conditions.

Compared to Observations??

Conclusions

Compared to Observations??

ERA-40: Kryjov and Park (2007): Solar modulation of the ENSO effects on NAM

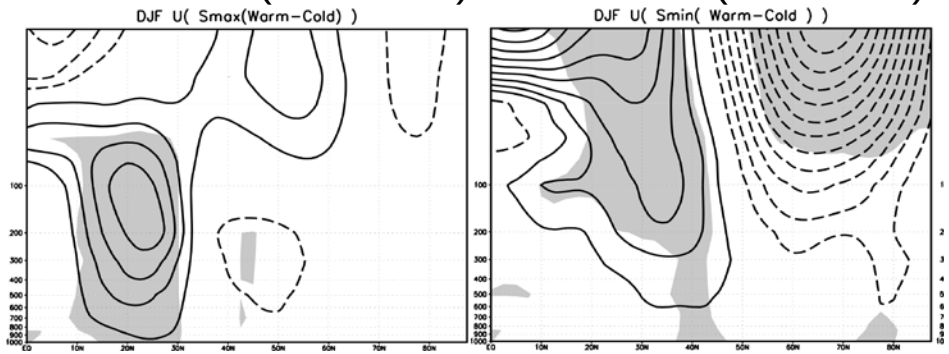
Kuroda (2007): ENSO modulation on the solar cycle signal on NAO

They did **not** find a **reverse but** a **weaker** solar (ENSO) response for different ENSO (solar) conditions.

Smax (wEN-cEN) Smin (wEN-cEN)

100hPa

1000hPa



From Kryjov and Park (2007)

Differences related to QBO effects?

Non linear behavior

Non additive response