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Stratospheric communication of the ENSO teleconnection in European Winter

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1. Introduction

The Reading Intermediate Circulation Model (IGCM) has been used to investigate the role of the stratosphere in the surface response to El Niño-like SST anomalies. Here we firstly investigate the stratospheric response to El Niño and then perform a sensitivity experiment in which the variability of the stratosphere has been degraded. We find evidence to suggest stratospheric variability plays an active role in communicating the ENSO signal to Europe.

2. IGCM + experiments

The IGCM model formulation is as follows:

- spectral dynamical core of Hoskins and Simmons (1975)
- T31L26 resolution (~3.75° lat-long, 1000 - 0.1 hPa)
- intermediate physics parameterisation (Rayleigh friction)

Full stratosphere experiments:

- $CTRL_S$ - climatological SST from ECMWF reanalysis
- $ELNINO_S$ - as control but with additional tropical Pacific SST anomaly derived from the Hadley Centre HadiSST data set, for the El Niño years 1982-83, 86-87, 91-91, 97-98
- 50 years runs were performed and responses ($ELNINO_S$ - $CTRL_S$) are presented

3. Stratospheric response

In the stratosphere we find the response to typical El Niño forcing as:

- a warmer, weaker vortex during NH winter as shown in Figure 1

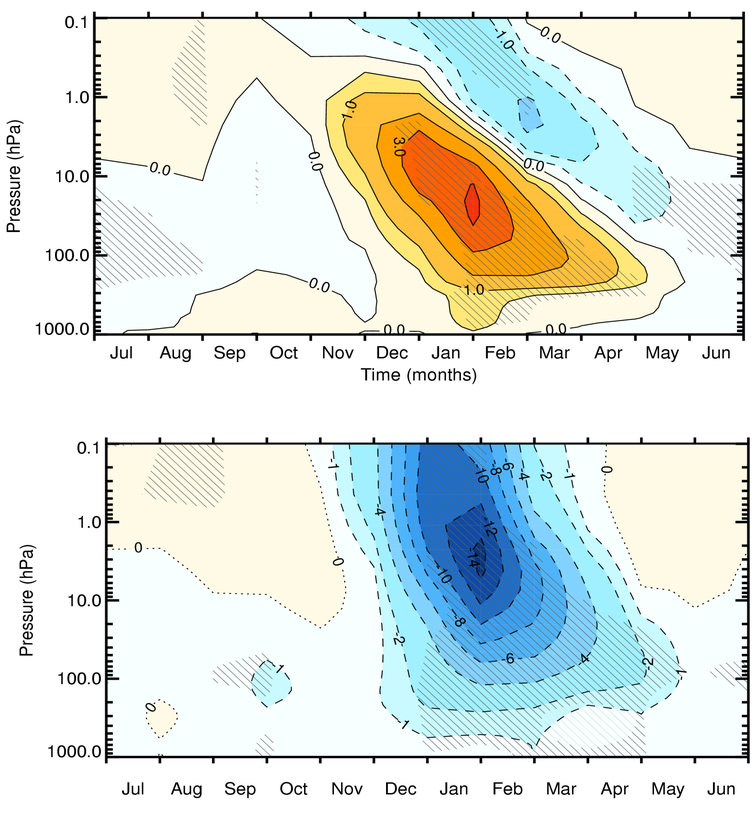


Figure 1: Time-height zonal mean response for area-weighted polar cap temperature (top) and zonal wind at 60N (bottom). Both show a downward propagating signal beginning in early winter and maximizing in Jan/Feb. The signal persists significantly in the lower stratosphere until late winter.

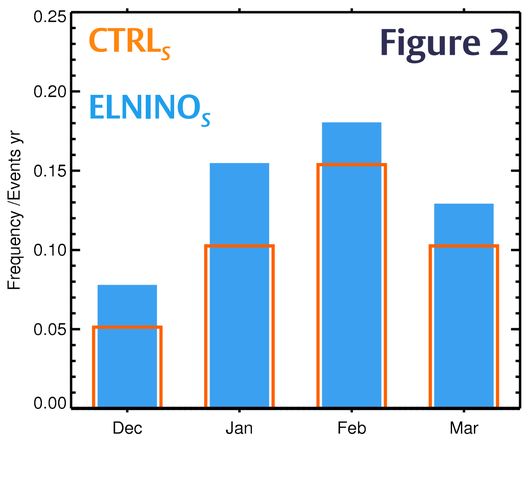


Figure 2

- an increase in SSW frequency (from 0.4 to 0.55 events/yr) as shown in Figure 2.
- a significant increase in variability of the Northern Annular Mode (NAM)
- stronger wave driven Brewer – Dobson circulation

4. European surface response

Following El Niño events, a *canonical* European winter signal has emerged from composite studies of long data sets, appearing as a projection onto a negative NAO-like mode in late winter. The IGCM European winter surface response corresponds well to this *canonical* MSLP signal, shown in Figure 3a below.

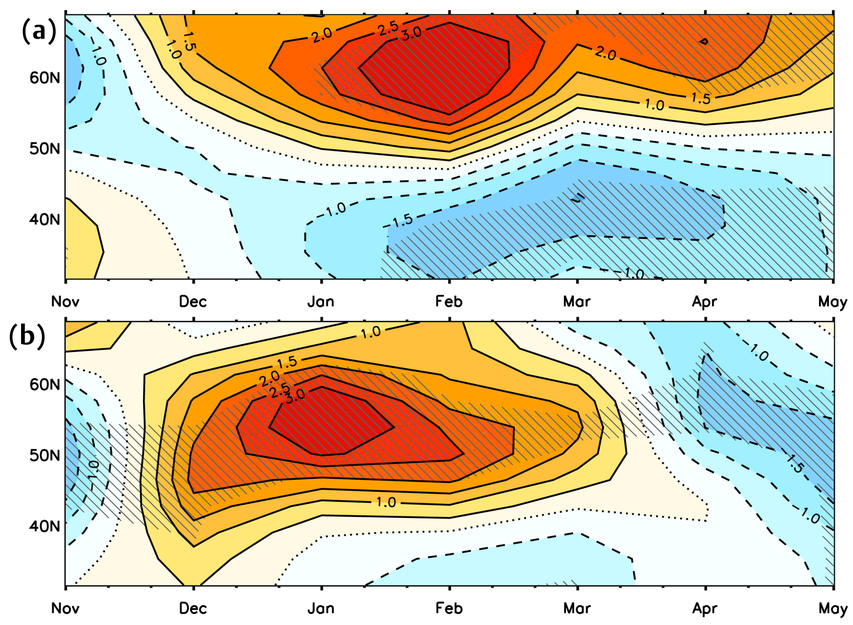
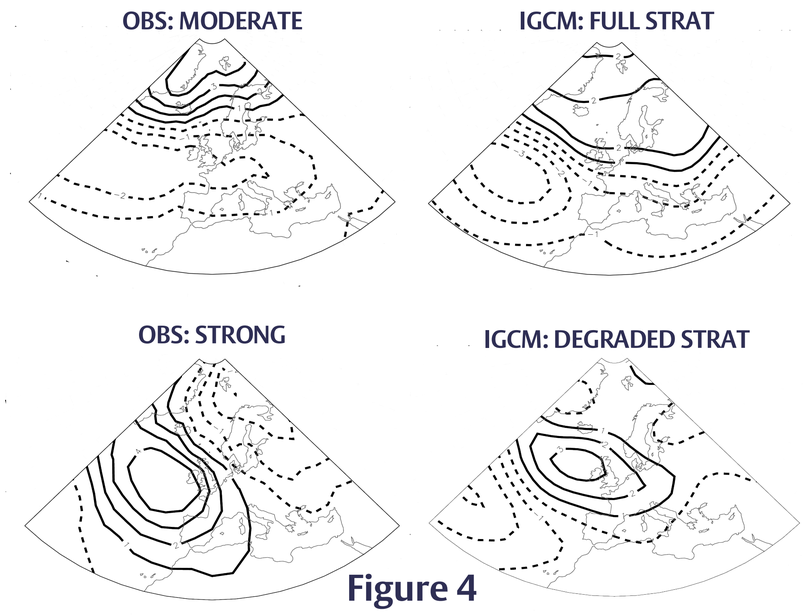


Figure 3: (a) latitude-time MSLP response averaged over the European sector. A significant negative NAO dipole persists into late winter. (b) The same diagnostic from degraded stratosphere runs.

We test whether the El Niño-induced lower stratospheric anomalies influence the surface response by ***removing the stratospheric pathway***:

- Repeat both experiments using a version of the model with a degraded stratospheric mean state and variability (Norton, 2003)
- The expected late winter *canonical* response is NOT found
- Instead, a high pressure signal resides over Europe during DJF (Figure3b)

By stratifying observed El Niño events by the NINO3 index, a clear non-linearity exists in the MSLP pattern over Europe between moderate and strong events (Figure 4 left column; reproduced from Toniazzo & Scaife, 2006)



Observed moderate events → IGCM full stratosphere

Observed strong events → IGCM degraded stratosphere

Suggests that during strong events the tropospheric pathway dominates but for moderate events the stratosphere plays an active role

Figure 4
MSLP anomalies

Conclusions

- During El Niño the NH polar stratosphere is warmer and weaker with a change in mean state *and* variability – increase in frequency of SSW events
- Without adequate representation of the stratospheric response, the observed tropospheric response cannot be accurately reproduced.
- Degraded response is similar to that of strong SST events implying a saturation mechanism involving tropospheric and stratospheric pathways.