THE TROPOSPHERE-STRATOSPHERE CONNECTION IN A SIMPLIFIED MODEL

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Key Questions

- **What are the features of the troposphere-stratosphere coupling in a simple, low-top model ?**
- **What can we learn about the two-way interaction from experiments with a low-top model? Is there a gain coming from simplicity?**

The Model

The model used in this study is the Atmospheric General Circulation Model of the Abdus Salam International Centre for Theoretical Physics (SPEEDY).
It has a spectral core running at T30 horizontal resolution and 8 atmospheric levels (925 hPa-30 hPa).
It includes simplified parameterizations of fundamental physical processes.

1. The wave-forcing

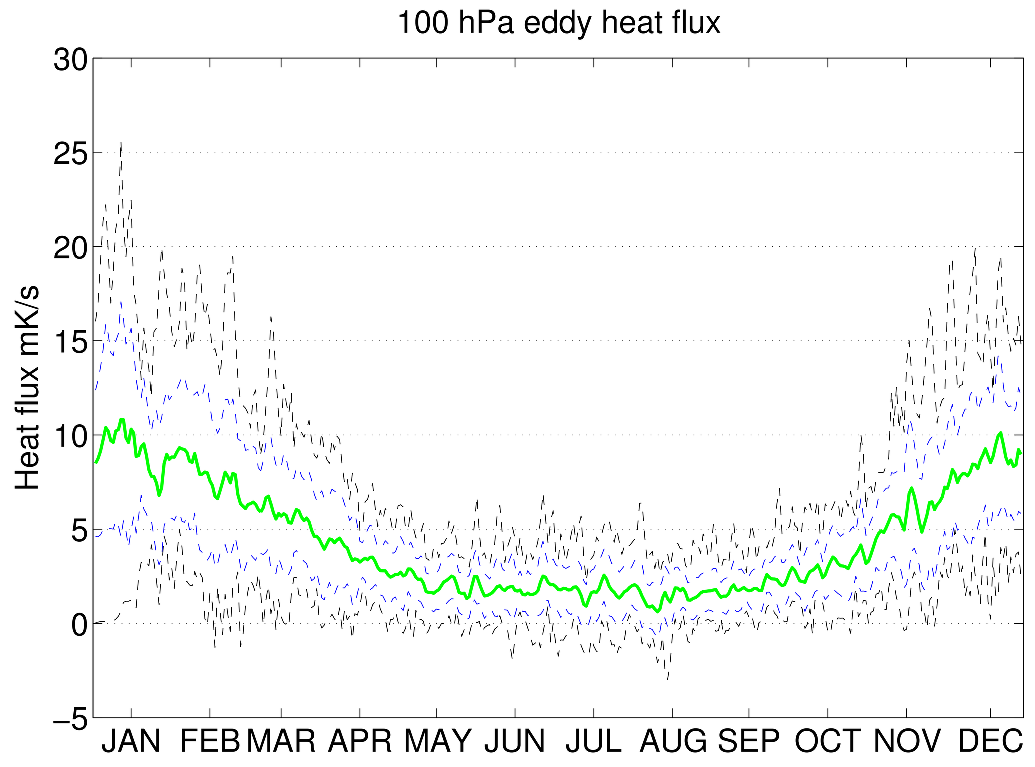

Figure 1: Eddy heat flux at 100 hPa (zonal mean, 40N-80N), the green line is the mean, the blue, dashed line is the mean $\pm$ 1 standard deviation and the dashed, black line is the daily maximun/minimum.

The propagation of planetary waves into the stratosphere has been analysed with the eddy heat flux at 100 hPa. The average correlation of stratospheric temperatures and integrated heat flux is 0.7.

2. The experiment

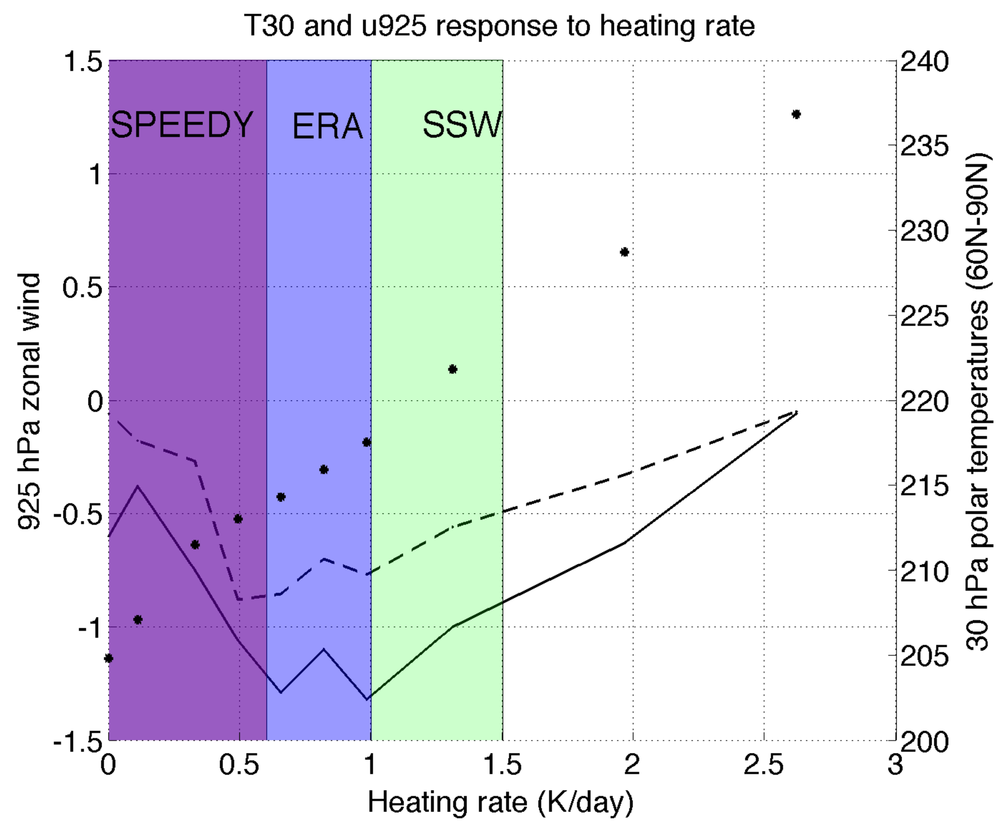

Figure 2: Left Axis: Anomalies of zonal mean zonal wind (dashed line) and average zonal wind over the North Atlantic sector (solid line) in February against the magnitude of the heating rate. Right axis: temperature at 30 hPa (dots).

We performed a set of experiments producing an artificial temperature tendency at 30 and 100 hPain DJF.

3. The near-surface response

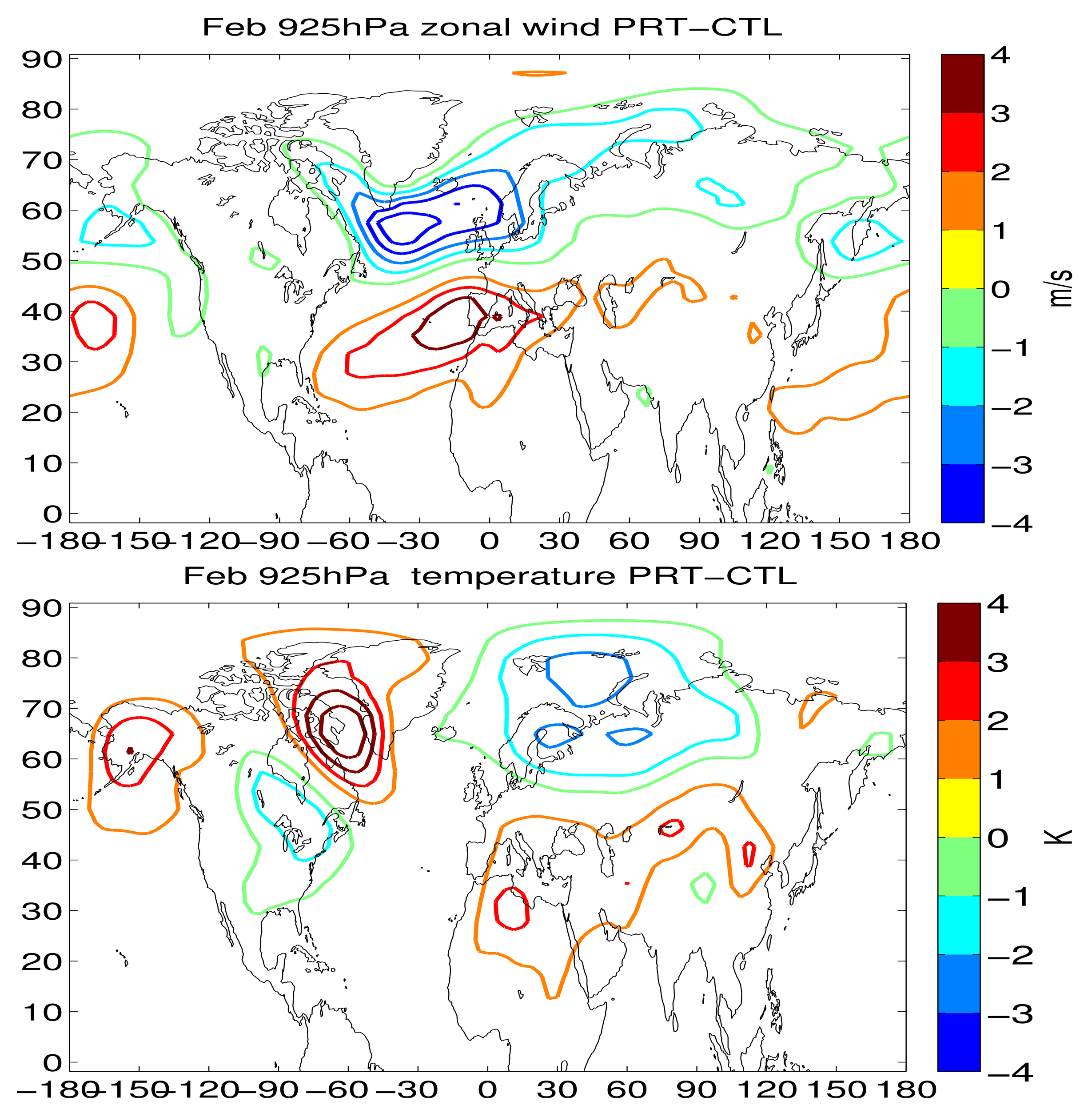

Figure 3: Anomalies of temperature and zonal wind at 925 hPa for a heating rate of 0.9 K/day in February.

We looked at the impact of the stratospheric heating on the temperature and zonal wind at the lowest atmospheric level (925 hPa).
For the zonally symmetric response, the analysys of the Transformed Eulerian Mean tendencies reveals the dominant role of eddies and is in agreement with previous studies with different models.
The zonally asymmetric, near-surface response for temperature and zonal wind is shown in figure 3. It indicates a southward shift of the jet mainly over the Atlantic Ocean and a quadrupolar pattern of temperature anomalies which is quantitatively in agreement with other studies (e.g. Hitchcock and Simpson 2014, JAS).

4. Conclusion and Further Work

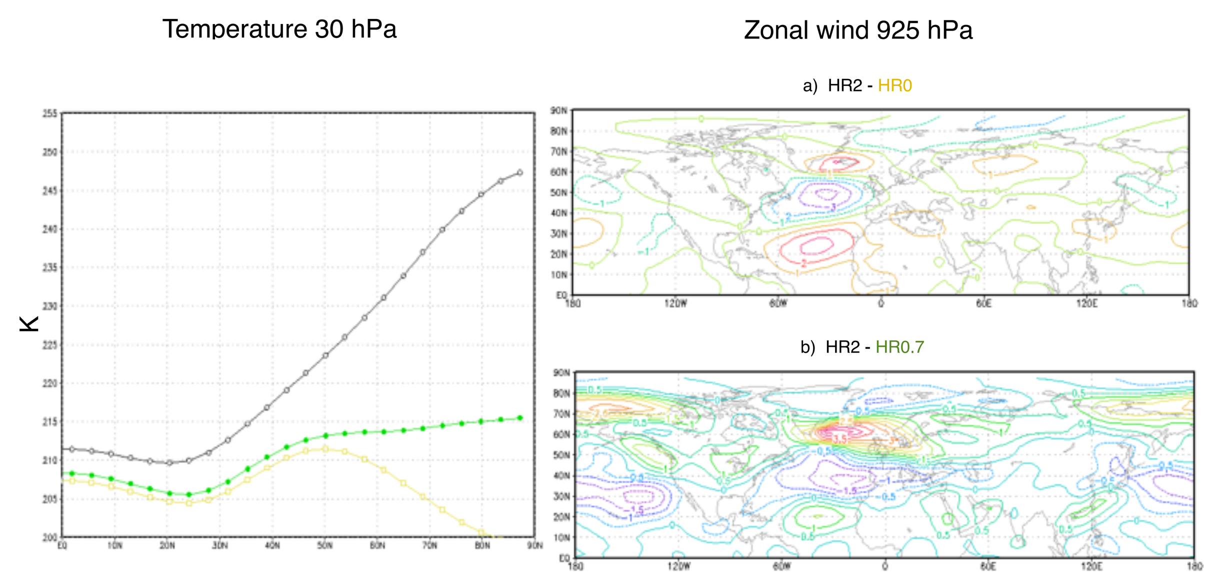

Figure 4: Left : meridional profile of temperature at 30 hPa in February for the control experiment (no heating, yellow), and for the perturbed runs (0.7 K/day - green, 2.0 K/day - black). Right: zonal wind difference at 925 hPa in February (see headings).

We think that the non-linear behaviour of the zonal wind response in figure 2 is due to a warming in the tropical stratosphere for high values of the heating rate (see figure 4). Nonetheless, a deeper analysis suggest that there is room for a physically meaningful saturation of the response and we are currently investigating this.
The troposphere-stratosphere connection in SPEEDY lacks the stratosphere dynamics and this comes along with a misrepresentation of the lower-stratosphere internal variability. **The state of the lower-stratosphere is strongly driven by the troposphere and the downward propagation is reasonable.** It turns out to be a suitable model to investigate **direct and fast tropo-strato exchanges that do not involve stratosphere dynamics.**

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