Supplement of Earth Syst. Dynam., 9, 647–661, 2018
https://doi.org/10.5194/esd-9-647-2018-supplement

Earth System Dynamics
Open Access

Supplement of

Interannual variability in the gravity wave drag – vertical coupling and possible climate links

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Figure S1 gives illustration of how well the CMAM-sd simulation itself captures the different climatological patterns (SO, QBO). While there are some differences between the CMAM-based time series and their observational counterparts, the similarity is generally strong, and the Pearson correlation (i.e., a correlation measure best suited for quantifying the links explored by linear regression analysis) between them is high.

Figure S2 gives illustration of how well the CMAM-sd simulation reflects spatial relations observed in real climate system. As with all model-based frameworks, the issue of reliable reproduction of the observed climate is quite complex and many statistics can be considered for validation. Our tests concentrated primarily on the ability of CMAM to reproduce the spatial patterns of response of lower tropospheric characteristics to the phases of the oscillation considered in our analysis; the results suggested high degree of match between the CMAM-based and observational data (the sample of our results in Fig. S2 summarizes the 850 hPa temperature response to SO and NAO).

Figure S3 illustrates response of the non-orographic GWD. Although it would be very interesting to look at NOGWD variations connected with variability of jets, fronts etc, the CMAM NOGWD scheme (Scinocca, 2003) is based on launching a globally uniform isotropic NOGW spectrum in four cardinal horizontal directions at approximately 125 hPa. The aim is to produce reasonable seasonal evolution of the zonal mean zonal temperature and winds in the mesosphere and the zonal and meridional asymmetry stems from propagation effects only. Regarding NOGWD, we have produced the same analysis as for the OGWD but due to the above mentioned reasons the resulting fields are highly zonally symmetrical and weaker in magnitude compared to the OGWD. We expect the NOGWD interannual variability in the upper troposphere-lower stratosphere region to show highly zonally asymmetric behavior (storm track shifts, distribution of convection, etc.) and in our future research we would like to analyze a dataset that would at least roughly capture this.

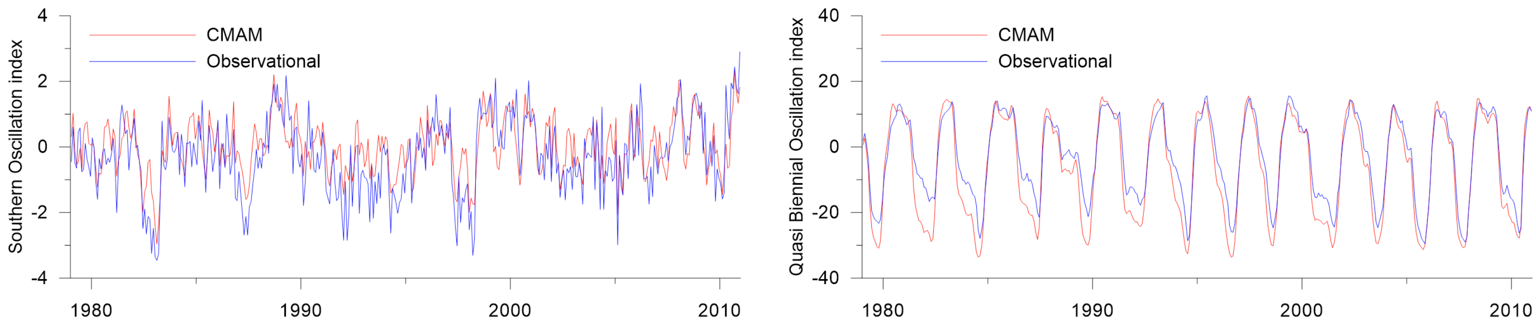

Figure S1. Indices of Southern Oscillation and Quasi Biennial Oscillation, derived from CMAM data (red line) and from direct observations (blue line; observational indices provided by Climate Research Unit at https://crudata.uea.ac.uk/cru/data/soi/ and NOAA at https://www.esrl.noaa.gov/psd/data/correlation/qbo.data).

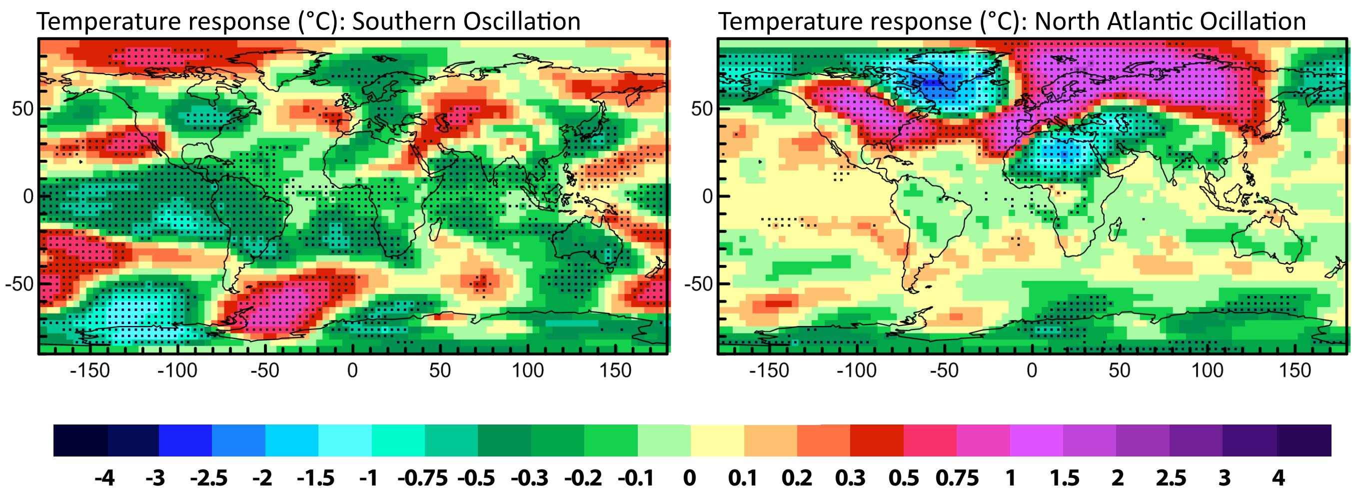

Figure S2. 850 hPa temperature response (°C) to Southern Oscillation (left) and North Atlantic Oscillation (right) change from highly negative to highly positive phase (increase of the respective index by 4x its standard deviation), evaluated through multiple linear regression. Dots represent locations with response statistically significant at the 95% level (moving-block bootstrap). For comparison with results obtained for near-ground temperature in various observational datasets see Miksovsky et al. (2016; Earth System Dynamics 7: 231-249, DOI:10.5194/esd-7-231-2016).

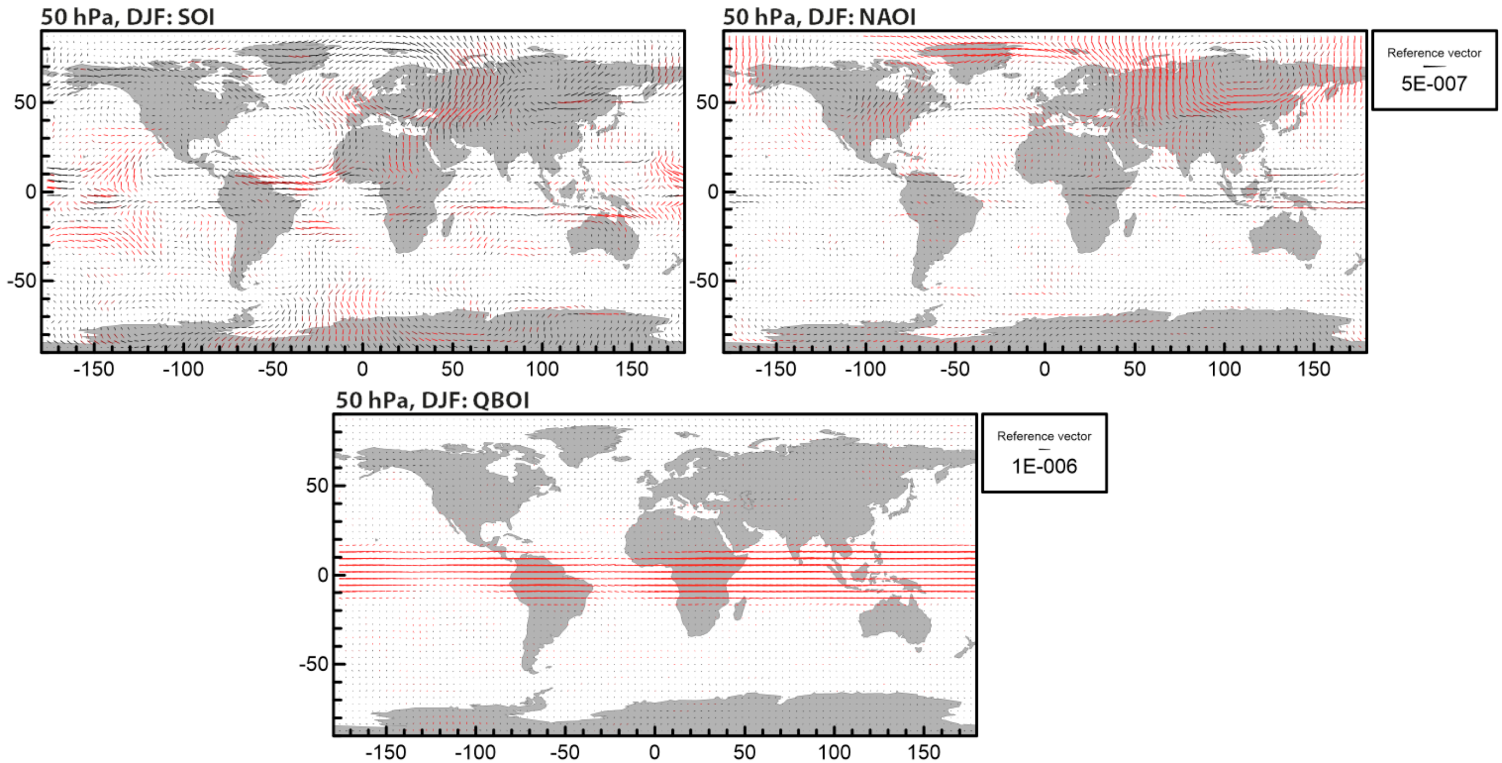

Figure S3. Response of the non-orographic GWD [m/s/s] at the 50 hPa level related to the activity of the Southern Oscillation (left), North Atlantic Oscillation (right) and Quasi-Biennial Oscillation (bottom); responses statistically significant at the 95% level shown in red.