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Stratospheric influence on Northern Hemisphere winter climate variability

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Despite significant improvements in observing and data assimilation systems, long-range dynamical forecasting remains a difficult challenge for the climate modelling community. The skill of operational seasonal forecasting systems is particularly poor in the northern extratropics where seas surface temperature (SST) has a weaker influence than in the Tropics. It is therefore relevant to look for additional potential sources of long-range climate predictability in the stratosphere using ensembles of global atmospheric simulations.
Besides a control experiment where the ARPEGE-Climat model is only driven by SST, parallel simulations have been performed in which an additional control on climate variability has been accounted for through the nudging of the northern extratropical stratosphere towards the ERA40 reanalysis. Though idealized, this original experiment design allows us to compare the relative contribution of the lower and upper boundary forcings on the simulated tropospheric variability. Results show that the stratospheric nudging improves the climatology and interannual variability of the mid-latitude troposphere, especially in winter in the Northern Hemisphere. Major impacts are found in particular on the simulation of the Arctic and North Atlantic oscillations (AO and NAO).
Case studies were carried out for the 1976-1977 and 1988-1989 winters, corresponding to extreme phases of the AO. Results confirm the robustness of the positive impact of the nudging, especially for winter 1976-1977 corresponding to relatively weak SST anomalies in the tropical Pacific. A sensitivity study to the model resolution shows that a well-resolved stratosphere is not necessary for the nudging to be efficient. Besides seasonal mean results, analysis of the day-to-day variability in winter allowed us to better understand the stratospheric polar vortex influence on the tropospheric circulation in the Northern Hemisphere mid-latitudes.