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Will climate change affect future major stratospheric sudden warmings?

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Major stratospheric warmings (MSWs) are the most prominent events of wintertime variability in the northern polar stratosphere. They also represent one of the clearest examples of the coupling between the troposphere and stratosphere in the Northern Hemisphere. Recent studies have examined a possible impact of climate change on MSWs by analyzing chemistry climate models (CCM), focusing on the frequency and intensity of MSWs. However, they have not reached a clear consensus yet.

In this study, a detailed analysis of future changes of MSWs is carried out in a transient simulation of the period 1960 to 2100 using the EMAC-FUB Chemistry-Climate-Model. The focus is on the development of MSWs and their possible impact on the troposphere. The simulation includes forcings by halogens, greenhouse gases (GHGs) and volcanic aerosols as well as natural solar and QBO variability, according to the specifications for the CCMVal-SCN-B2d scenario. Sea surface temperatures and sea-ice distributions from a coupled climate model integration have been prescribed. The impact of climate change on the future characteristics of MSWs has been assessed by comparing the last 40 winters of the SCN-B2d simulation (2060/61-2099/2100) with the period 1960/61-1999/2000. To isolate the effect of climate change on MSWs from other factors, MSWs in the SCN-B2d simulation have been compared with MSWs in a CCMVal SCN-B2c or "Non-Climate Change" (NCC) scenario simulation that is identical to SCN-B2d except for the GHGs concentrations which are kept constant at 1960 levels.

In contrast to some previous studies, we do not find a statistically significant difference or a trend in the frequency and intensity of MSWs due to the increase of GHGs in the future. However, relevant changes in other characteristics of MSWs have been identified, in particular a decrease in the number of future MSWs in early winter and an increase in midwinter, being consistent with variations in the state of the climatological polar vortex and modifications in the upward planetary wave propagation. Moreover, MSWs in the future have been found to be shorter and to show a decline of the downward propagation of their signal, leading to a weaker impact on the tropospheric circulation due to the concurrent impact of increasing GHGs.