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Influence of the Madden-Julian Oscillation on the boreal winter stratosphere

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The Madden-Julian Oscillation (MJO) is the predominant intraseasonal variability pattern in the tropics. Moreover, it can affect the weather in high latitudes and change the stratospheric circulation.

This study concentrates on the response of the boreal stratosphere to the MJO during winter. We utilize the ECHAM/MESSy Atmospheric Chemistry (EMAC) chemistry-climate model with coupled ocean module. Greenhouse gas concentrations are kept constant.

Due to the coupling of the middle atmosphere model with the ocean, EMAC is able to reproduce the interactions between the stratosphere and atmosphere-ocean processes, like the MJO.

The model agrees in strength and frequency of the MJO with the observations. However, there is a tendency for a longer cycle from 40 to 80 days in comparison to observations (about 45 days).

The influence of the MJO on the boreal winter stratosphere highly depends on the position of the convective center (active phase). Studies using reanalysis data show that a MJO induced increase of the deep convection over the Indian Ocean can lead to a more disturbed polar vortex due to enhanced planetary wave propagation into high latitudes.

This could induce or enhance a Sudden Stratospheric Warming (SSW). EMAC reproduces this response and shows a weakening of the polar vortex about one month after a strong active phase of the MJO over the Indian Ocean. More SSWs occur after strong convective activity in this region. During suppressed convection, a less disturbed polar vortex is found due to weakened wave propagation from the troposphere. This leads to a colder and more stable polar vortex with less SSWs.

The analysis shows that the model is able to reproduce the coupling between the MJO and the middle atmosphere. In comparison to observations, the influence of the MJO on the stratosphere can be described quantitatively and qualitatively well.