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The effect of aerosols on northern hemisphere wintertime stationary waves

Anna Lewinschal and Annica M. L. Ekman
Department of Meteorology, Stockholm University, Sweden (anna@misu.su.se)

Aerosol particles have a considerable impact on the energy budget of the atmosphere because of their ability to scatter and absorb incoming solar radiation. Since the beginning of the industrialisation a large increase has been seen mainly in the concentrations of sulphate and black carbon as a result of combustion of fossil fuel and biomass burning. Aerosol particles have a relatively short residence time in the atmosphere why the aerosol concentration shows a large variation spatially as well as in time where high concentrations are found close to emission sources. This leads to a highly varying radiative forcing pattern which modifies temperature gradients which in turn can alter the pressure distribution and lead to changes in the circulation in the atmosphere. In this study, the effect on the wintertime planetary scale waves on the northern hemisphere is specifically considered together with the regional climate impact due to changes in the stationary waves.

To investigate the effect of aerosols on the circulation a global general circulation model based on the ECMWF operational forecast model is used (EC-Earth). The aerosol description in EC-Earth consists of prescribed monthly mean mass concentration fields of five different types of aerosols: sulphate, black carbon, organic carbon, dust and sea salt. Only the direct radiative effect is considered and the different aerosol types are treated as external mixtures. Changes in the stationary wave pattern are determined by comparing model simulations using present-day and pre-industrial concentrations of aerosol particles.

Since the planetary scale waves largely influence the storm tracks and are an important part of the meridional heat transport, changes in the wave pattern may have substantial impact on the climate globally and locally. By looking at changes in the model simulations globally it can be found that the aerosol radiative forcing has the potential to change the stationary wave pattern. Furthermore, it shows that regional changes in the climate occur also where the radiative forcing from aerosol particles is not particularly strong, which would indicate that the large scale dynamical response to aerosol forcing can induce changes in temperature, precipitation and wind patterns outside the region where the forcing is initially located.