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The whole atmosphere response to century-scale changes in the Earth's magnetic field

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The strength and orientation of the Earth's magnetic field play an important role in the upper atmosphere, for instance through effects on ionospheric conductivity, plasma transport processes, and Joule heating. The overall weakening of the Earth's magnetic field that has taken place over the past century, in combination with changes in orientation, has had a significant effect on the climate of the upper atmosphere, which is fairly well understood. It is much less obvious how magnetic field changes could affect the middle and lower atmosphere. However, simulations with the upwardly extended version of the Whole Atmosphere Community Climate Model (WACCM-X), covering altitudes from 0 to about 500 km, show that the mesosphere, stratosphere, and troposphere do respond significantly to magnetic field changes between 1900 and 2000, based on 38 ensemble members. Responses are most pronounced for December-January-February. In the northern hemisphere (NH), the response consists mainly of a westward extension of the stratospheric polar vortex. The southern hemisphere (SH) shows a poleward shift of the climatological zonal wind pattern throughout the troposphere, stratosphere, and mesosphere, accompanied by a stratospheric warming and tropospheric cooling of up to 2 K at high SH latitudes. The evidence suggests that the responses to magnetic field changes initiated in the thermosphere propagate downward via dynamical mechanisms, most likely through changes in wave-mean flow interactions. In the SH summer, this involves a poleward shift of unstable regions at the top of the mesospheric jet that force planetary waves locally. However, WACCM-X does not reproduce the observed shape of the SH mesospheric jet quite correctly, which means that the obtained responses throughout SH summer may not be realistic. The NH winter response may be more reliable, but further work is needed to pinpoint the exact mechanism for the downward influence of the changes in the magnetic field.