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Effects of internal geomagnetic variations on the Earth's space environment and the middle atmosphere

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On geological time scales, variations of the internal geomagnetic field affect the structure and the dynamics of the Earth's magnetosphere and contribute to what may be called space climate and paleomagnetospheric processes. This presentation is going to summarize the paleomagnetosperic research that was carried out in the context of the DFG Priority Programme SPP 1097 Geomagnetic Variations. Structural aspects of paleomagnetospheres were studied using theoretical concepts of magnetosphere formation, a potential field approach to model magnetopause shielding, and magnetohydrodynamic simulations. The types of geomagnetic variations considered here include changes of the dipole moment magnitude and excursions of the dipole axis. Quadrupolar paleomagnetospheres serve as important examples to assess the rich variety of non-dipolar configurations that may arise during geomagnetic polarity transitions. Energetic particles of solar and cosmic origin into the paleomagnetosphere were studied by means of scaling relations for cutoff energies and differential particle fluxes as functions of a reduced dipole moment. We further investigated how higher-order core fields can open the polar caps and even create new particle entry regions in the equatorial region. The resulting particle fluxes into the upper and middle atmosphere during solar particle events were coupled into a numerical model to study ionization, chemistry, and dynamics of the middle atmosphere. In combining magnetospheric and atmospheric modeling, we were able to identify geomagnetic transition field scenarios that could significantly affect the ozone chemistry in the middle atmosphere.