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Simulation of the Earth's paleo-magnetosphere for the late Hadean eon

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Simulations of the Earth's magnetosphere obstacle, including the shape of the auroral oval and related field lines for early stages of the solar system are of particular importance for studying the evolution and mass loss of the Earth's atmosphere. Within this presentation, we will present simulations of the terrestrial paleo-magnetosphere of the Earth for the late Hadean, i.e. for ~4.1 billion years ago. These were performed with an adapted version of the Paraboloid Magnetospheric Model (PMM) of the Skobeltsyn Institute for Nuclear Physics of the Moscow State University, which serves as an ISO standard for the Earth's magnetosphere (see e.g. Alexeev et al., 2003). As an input parameter, the new measurements of the paleomagnetic field strength by Tarduno et al., 2015, are taken. These data from zircons between 3.3 billion and 4.2 billion years old vary between 1.0 and 0.12 of today's equatorial field strength. Available data at ~4.1 billion years ago are among the lowest field strength values. Another input into the adapted PMM is the solar wind pressure, which was derived from a newly developed solar/stellar wind evolution model (Johnston et al., 2015a, b), which is strongly dependent on the rotation rate of the early Sun.

Our simulations of the terrestrial paleo-magnetosphere with the adapted PMM show that for the most extreme case of a fast rotating Sun and a paleomagnetic field strength with 0.12 of today's value, the stand-off distance of the magnetopause $\mathrm{R_s}$ shrinks down from today's 10 $\mathrm{R_e}$ to 3.43 $\mathrm{R_e}$. Even for a slow rotating Sun $\mathrm{R_s}$ would be at only 4.27 $\mathrm{R_e}$. Taking the same magnetic field strength as that of today and a slow rotating Sun leads to an $\mathrm{R_s}$ of 8.23 $\mathrm{R_e}$, which would be the least extreme case for the terrestrial atmosphere. Another outcome of the modelling is that the auroral oval was significantly broader ~4.1 billion years ago than today. As demonstrated by our calculations a good approach of the relationship between auroral oval size Θ_{pc} (Θ_{pc} as oval co-latitude) and magnetospheric subsolar distance $\mathrm{R_s}$ is $sin^2\Theta_{\mathrm{pc}} = \mathrm{R_e}/\mathrm{R_s}$.

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