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Mineral dust simulations with ECHAM6.3-HAM2.3 for pre-industrial and last glacial maximum climate conditions with a focus on the Southern Hemisphere

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Mineral dust constitutes an important component of the climate system due to its various direct and indirect effects on the Earth's radiation balance as well as its fertilizing effects on ecosystems. We use the state-of-the-art model ECHAM6.3-HAM2.3, consisting of the atmospheric general circulation model ECHAM and the aerosol model HAM, to provide new global and regional data on the dust cycle consisting of dust emission, transport and deposition for pre-industrial (PI) and last glacial maximum (LGM) climate conditions. Globally, our model simulates a dust emission flux of 5159 Tg yr^{-1} for the LGM, which is 5.8 times higher than for PI conditions. Since we focus in particular on the Southern Hemisphere, we investigate the contribution of the major dust sources South America, South Africa and Australia to the total dust deposition. For both the PI and LGM, over 90% of the dust depositing onto the Southern Ocean and Antarctica is contributed by Australian and South American sources, of which the latter contributes over 50% and thus constitutes the predominant source during PI conditions. Although the strength of both Australian and South American sources increases by a factor of ~15 during the LGM, we find, contrary to other studies (e.g. [1]), that the relative importance of South American dust sources decreases and Australia contributes almost 70% to the total dust deposition south of 60°S. Regional meteorological conditions at the source areas are combined with the detailed information on modal particle sizes provided by the aerosol model in order to investigate the observed and simulated stronger dust cycle during the LGM. We find increased wind speeds, larger emission areas and reduced precipitation over the source areas to be the main causes for the increased source strength as well as the emission and transport of slightly larger particles during the LGM compared to PI conditions. The on average higher particle lifetimes simulated for the LGM can be attributed to a generally drier climate.

[1] Albani, Mahowald, Delmonte, Maggi & Winckler (2011), Climate Dynamics 38, 1731-1755.