Published article:

Knippertz, P (2013) *Atmospheric science: Dust may cool polar regions.* Nature Climate Change, 3 (5). 443 - 444. ISSN 1758-678X

http://dx.doi.org/10.1038/nclimate1880

CLIMATE

Dust may cool polar regions

Climate change is amplified in polar regions compared to the rest of the globe. A new study describes how dust particles and other aerosols may contribute to this phenomenon.

Peter Knippertz, School of Earth and Environment, University of Leeds, Leeds LS2 9JT, UK; e-mail: p.knippertz@leeds.ac.uk

Tiny dust particles originating from the world's deserts are certainly not the first things that spring to mind for most people when thinking about polar regions. Though it has long been known that dust can be transported over very long distances, the many different roles that these dust particles play in the climate system have only recently been fully appreciated by researchers, reaching from effects on radiation, clouds and precipitation to the fertilisation of ecosystems and associated impacts on the carbon cycle[1]. On page xxx of this issue Lambert and colleagues[2] report that radiative effects of dust may have had a much larger impact than previously thought on the disproportional warming of polar regions during the transition from the Last Glacial Maximum (LGM) to the Holocene, which is underestimated in many climate models.

Polar amplification, the enhanced warming or cooling of high latitudes compared to the rest of the globe in periods of climate change, is evident from many paleoclimatic records and is expected to be an important element of future global warming, but the exact reasons for polar amplification have long been debated[3]. Changes in snow and ice cover and the resulting changes in the amount of reflected solar radiation is a powerful mechanism that is thought to be the main contributor, but many climate models struggle to reproduce the amplitude of the temperature changes in polar regions indicated by paleoclimatic archives. This has raised the question whether significant processes such as those related to aerosols are not sufficiently well represented in our current models and thus whether projections for future polar amplification may be biased low.

Assessing the role of dust particles in polar amplification is a challenge. We have a fairly good record of dust deposition during past climate periods from ice cores (Fig. 1). Such records show a large decrease in dust deposition in high latitudes from the LGM to the Holocene, which is thought to be related to weaker dust sources and more wash-out in the warmer and moister Holocene. Dust models can be "tuned" to represent observed changes in dust deposition on a global scale, but it is not clear how realistic such estimates are for specific regions due to the large uncertainties in emission, transport and deposition processes in the models, even for the current climate[4,5]. This problem is particularly relevant for polar regions because of the long transport paths and the importance of wet deposition, the scavenging of aerosol particles by precipitation. In addition, radiative forcing from dust is sensitive to the vertical profile and dust size distribution and optical properties.

Lambert et al.[2] have followed a new approach to the problem. They conduct simulations with two global dust models for the LGM and Holocene periods, but only retain the vertical profile and the deposition parameters from the models, which are then scaled to match the observed records from ice cores in the Greenland and Antarctic ice sheets to obtain reconstructed atmospheric dust concentrations. A standard one-dimensional radiative transfer model is then used to estimate the surface radiative forcing by the dust. The obtained values amount to –3 to –6 W m^2 in Greenland and –1 to –3 W m^2 in Antarctica, which is of similar magnitude than the radiative forcing due to the reduced LGM CO_2 levels. Dust aerosols tend to cool the lower and warm the higher troposphere, which would increase atmospheric stability and further enhance low-level cooling by supressing vertical turbulent exchange of heat.

This research presents an intriguing fresh look at the potential role of dust in polar amplification, but leaves a number of important questions open. As acknowledged by the authors, the estimated radiative forcing cannot account by itself for the temperature discrepancy between model simulations and observations and, such that additional feedback mechanisms would be required. The analysis is very one-dimensional and does not take into account possible responses in surface fluxes and regional circulations that may well alter the temperature response to the estimated forcing. Despite the attempt to limit the use of model information as much as possible, the disagreement between the two models used for reconstruction is quite large and reveals the substantial uncertainties in our quantitative understanding of the global dust budget. The results are strictly speaking only applicable to the LGM-Holocene warming and may not be directly transferable to other climate periods.

The work of Lambert et al.[2] has demonstrated that increased dust emissions in low latitudes can lead to an amplified relative change of dust concentrations in high latitudes, possibly due to changes in transport and wash-out. The associated radiative forcing can support polar amplification directly and through changes to the atmospheric vertical stability. An improved representation of dust in global climate models may therefore help to cure the underestimation of polar amplification in many models. An important question for future climate predictions is the applicability of this study to current conditions. While dust emissions have increased in some regions over the last centuries[6] and may further increase due to a drying of the subtropics and land-use change, the midlatitude hydrological cycle is projected to intensify, which may offset increased emissions through enhanced wash-out. In addition, reduced sea-ice cover over the Arctic implies a different surface reflectivity than during the LGM, which will alter the resulting dust radiative forcing. The resulting polar amplification will most likely be sensitive to other aerosol types than dust and changes in polar cloudiness.

References

1. Shao, Y. *et al. Aeolian Res.* **2,** 181–204 (2011).
2. Lambert, F. *et al. Nature Clim. Change* **3,** xxx–xxx (2013).
3. Serreze, M. C. & Francis, J. A. *Clim. Change* **76,** 241–264 (2006).
4. Huneeus, N. *et al. Atmos. Chem. Phys.* **11,** 7781–7816 (2011).
5. Knippertz, P. & Todd, M. C. *Rev. Geophys.* **50,** RG1007 (2012).
6. Mulitza, S. *et al. Nature* **466,** 226–228 (2011).

Figure 1 | Dust deposition in ice. A crevasse wall near Weissmies in the Swiss Alps shows annual layering of snow with embedded yellowish layers that mark deposits of Saharan dust. Lambert et al. (2013) use such dust deposition records from Greenland and Antarctica to investigate the potential role of dust radiative forcing in the disproportional warming of polar regions from the LGM to the Holocene. The image was taken from http://www.swisseduc.ch/glaciers/earth_icy_planet/glaciers03-en.html?id=3