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The Challenge of Modelling the Meteorology of Dust Emission: Lessons Learned from the Desert Storms Project

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Mineral dust plays an important role in the Earth system, but a reliable quantification of the global dust budget is still not possible due to a lack of observations and insufficient representation of relevant processes in climate and weather models. Five years ago, the Desert Storms project funded by the European Research Council set out to reduce these uncertainties. Its aims were to (1) improve the understanding of key meteorological mechanisms of peak wind generation in dust emission regions (particularly in northern Africa), (2) assess their relative importance, (3) evaluate their representation in models, (4) determine model sensitivities with respect to resolution and model physics, and (5) explore the usefulness of new approaches for model improvements.

Here we give an overview of the most significant findings: (1) The morning breakdown of nocturnal low-level jets is an important emission mechanism, but details depend crucially on nighttime stability, which is often badly handled by models. (2) Convective cold pools are a key control on summertime dust emission over northern Africa, directly and through their influence on the heat low; they are severely misrepresented by models using parameterized convection. A new scheme based on downdraft mass flux has been developed that can mitigate this problem. (3) Mobile cyclones make a relatively unimportant contribution, except for northeastern Africa in spring. (4) A new global climatology of dust devils identifies local hotspots but suggests a minor contribution to the global dust budget in contrast to previous studies. A new dust-devil parameterization based on data from large-eddy simulations will be presented. (5) The lack of sufficient observations and misrepresentation of physical processes lead to a considerable uncertainty and biases in (re)analysis products. (6) Variations in vegetation-related surface roughness create small-scale wind variability and support long-term dust trends in semi-arid areas.