Geophysical Research Abstracts
Vol. 15, EGU2013-6318, 2013
EGU General Assembly 2013

Large-eddy simulation of turbulent dust emission

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Turbulent dust emission is an important mechanism to be considered in dust models. For example, over a heated desert surface under weak wind conditions, convective turbulence can be highly developed, which generates patches of enhanced shear stresses and entrains dust into the atmosphere. This mechanism of dust emission differs from those considered in existing dust emission schemes, because it does not have to involve the saltation of sand-sized particles. In this study, a large-eddy dust model, WRF_LES/D, is developed by coupling the WRF large-eddy flow model with a new dust mobilization scheme. It is then applied to the simulation of turbulent dust emission under various stability and wind conditions. Our aim is to understand how turbulent dust emission occurs and how turbulent dust fluxes depend on atmospheric control parameters. We show that, due to the complexity of turbulent motion and the dust cohesive forces, turbulent dust emission is a stochastic process which needs to be statistically quantified. With the numerical results, we quantify the large-eddy induced shear stresses on the surface and turbulent dust emissions in terms of probabilistic distributions. For a given soil type, it is shown that these distributions can be described in terms of a few control variables, including the friction velocity, u*, and the convective scaling velocity, w*. The results of WRF_LES/D are implemented in an updated version of the dust emission parameterization of Klose and Shao (2012) for estimating turbulent dust emission in regional dust modeling.