The Effects of Turbulence and Gust on Sand Erosion and Dust Entrainment During Sand Storm

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Abstract

In this paper, we focus on the phenomenon that turbulence and wind gust occur after cold front passage and their effects on sand erosion and dust entrainment in East Asia in spring during sand storm.

First, the ultra-sonic anemometer-thermometer data during the sand storm periods in 2000-2004 have been analyzed. These data are wind velocities with 10Hz frequency, and obtained at three layers of the 325m meteorological tower in Beijing. It is revealed that the air motion during sand storm can be divided into three parts, the turbulent small eddies, the gusty wind which is a kind of coherent structure, and large scale basic flow. Their time scales are 0-1 min., 1-10 min. and larger than 10min. respectively. All they transport horizontal momentum downwards to the ground surface and contribute to the soil erosion and sand-dust emission, hence the friction velocity should consist of their combination. However, in the lower part of atmospheric boundary layer, the descending component of basic flow suppresses the dust particles keeping them within the bottom layers. But the gusty wind has coherent structure, and due to the gusty wind not turbulence, the dust can entrain from lower to upper levels.

Second, we use Lagrangian Stochastic Model to simulate the particle trajectory during sand storm period. The random walk of particles is a Markov process, or a Brownian motion called Wiener type. There are three classical categories of particle motion determined by the diameter of particles: Creep with $d_p \geq 500\mu m$, saltation with $70\mu m \leq d_p \leq 500\mu m$ and suspension with $d_p \leq 70\mu m$. In our calculations, only the dust suspension process is noted. The wind condition in our simulation comes from the observation wind profiles. It includes basic flow profile, gusty wind profile and turbulent intensity. Three kinds of particles are used, which are dust particles, dust and sand particles, sand particles. Every kind of particles has four types of diameters, which are 5μm, 10μm, 20μm and 40μm respectively. The simulation is two-dimension, x direction is 20km and z direction is 500m. By adjusting the wind conditions, it can be seen there are three kinds of particle trajectories. When there are only turbulent fluctuations, particles have random trajectories and can reach 250m height. Once adding gusty wind, particles are carried in the air stream and have the potential to be entrained to great heights (higher than 500m) and over great distances. But if no gusty wind and adding descending component of basic flow, particles are only accumulated in the bottom of layer. The simulation result shows that dust entrainment during sand storm is mainly due to the gusty wind.

Keywords: dust storm, wind gust, coherent structure, Lagrangian Stochastic Model