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TITLE: WIND AND SALTATION DRIVEN PARTICLE RESUSPENSION IN A WIND TUNNEL

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WIND AND SALTATION DRIVEN PARTICLE RESUSPENSION IN A WIND TUNNEL

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EXTENDED ABSTRACT

To determine parameters of primary importance in wind and saltation driven resuspension of fine particles from surfaces, wind tunnel experiments were conducted to study the resuspension of small polydisperse particles (diameter <10 μm) by monodisperse saltation particles (diameter >80 μm). The experiments were designed to simulate the atmospheric boundary layer resuspension of fine particles.

<u>Wind Tunnel</u>. The tunnel, fabricated of 3 m long aluminum alloy sections, had a rectangular cross section with a hydraulic diameter of 60 cm and was 40 m long. The resuspension bed, which was contained in one 3-m tunnel section, was 2 m in length by 15 cm wide, located symmetrically along the center line of the tunnel floor. Sufficient upstream tunnel length was employed to allow the natural formation of a fully turbulent boundary layer and velocity profile before the airstream passed over the resuspension bed.

<u>Theory</u>. Resuspension rate, Λ, defined as fraction of initial mass resuspended per second, was determined from the relation after Sehmel and Lloyd:[1]

$$\Lambda = A/G\theta \tag{1}$$

where A is total mass/cm^2 passing a plane, 1 cm by 15 cm high, perpendicular to the mean wind; G, the surface concentration of contaminant or material available for resuspension in mass/cm^2; and θ the time.

Vertical flux is a measure of the net mass or number of particles ascending, based on the premise that particles small enough to follow the turbulent eddies, once airborne, will diffuse at a rate proportional to their concentration gradient. To determine the upward diffusion of

particles, we used the method of Gillette and Blifford[2] to obtain the relationship:

$$F_v = -\rho C U_1^2 (n_{i2} - n_{i1})/(U_2 - U_1) \quad , \qquad (5)$$

where F_v is vertical flux in number of particles/cm^{2}s (positive in the upward direction), ρ is air density, C is the Priestley drag coefficient, n_{i1} and n_{i2} are numbers of particles at heights 1 and 2 in the size interval i, and U_2 and U_1 are local mean wind velocities at heights Z_2 and Z_1 where $U_2 > U_1$ and $Z_2 > Z_1$.

Experimental. Resuspension runs were made using beds of small aluminum spherical particles which also contained monodisperse, Eosin-Y (E-Y) dye spheres, 1 μm or 6 μm D_{ae}, deposited as a contaminant simulant by a filtration technique onto the surface of the bed. In runs including saltation, equal numbers of monodisperse 100, 240, or 500 μm spheres were introduced into the tunnel through a vertical drop tube 3 m upstream of the resuspension particle bed, after the wind velocity was established. Thus, four distinct types of resuspension were designated:

a. resuspension from the small particle in-place bed only, with no saltation particles injected (designated Type A),
b. resuspension from the bed, with 0.25 g of 100 μm diameter saltation particles injected (Type B),
c. the bed, with 3.8 g of 240 μm diameter saltation particles injected (Type C), and
d. the bed, with 28 g of 500 μm diameter saltation particles injected (Type D).

Filter samplers with isokinetic inlets at 1, 2, 5, 10, and 15 cm above the tunnel floor were positioned 3 m downstream of the resuspension bed. Total mass and vertical mass distribution were determined gravimetrically. Airborne particle size distributions were determined by photomicrographic methods previously developed,[3] using the filter samples collected at 1 and 15 cm above the surface.

Comparison of the Resuspension of Matrix Particles (aluminum) versus Contaminant Particles (E-Y). Resuspension rates for aluminum and the 6 μm E-Y differ by very nearly a factor of 100, and both Al and E-Y rates increase rapidly as velocity increases or as the saltation particle size increases (Table 1). In contrast, Λ of 1 μm D_{ae} E-Y particles is remarkably constant even though the velocity and saltation type were different for each data point. This is attributed to the limited amount of E-Y at the surface due to the concentration gradient of 1 μm particles down through the aluminum matrix. Thus, the resuspension rate of the 1 μm E-Y was source limited, similar to a weathered natural surface, whereas, the 6 μm E-Y remained on the surface and resuspension was not source limited.

Vertical flux of the 6 μm E-Y was much lower than that of aluminum, due primarily to the low absolute number of these particles resuspended and their larger D_{ae}. The vertical flux of 1 μm E-Y particles was much greater in the few measurements available (Table I). In the only two comparable runs (Type A at 12.8 and 12.7 m/s, Table 1) F_v for 1 μm E-Y was 1000 times greater than that for 6 μm E-Y and about 10 times less than that for aluminum.

Conclusions

1. The resuspension of particles from a bed of loose particles increases generally monotonically with increasing wind velocity and saltation particle size, up to the maximum velocity and saltation size investigated.

2. Λ and F_v of low concentration contaminants in a matrix of similarly sized loose particles may be functions not only of wind velocity and saltation particle size, but also the size of the contaminant particles. The latter dependence may be due to dispersion or percolation of small particles through a larger particle matrix, or to attachment of small contaminant particles to larger matrix particles.

References:

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TABLE 1

RESUSPENSION FROM TWO TYPES OF PARTICLE BEDS

U (m/s) Nom	Run Type	U (m/s) Actual	Resuspension Rates: Smoothed Bed Surface, Aluminum Fraction/s	Smoothed Bed Surface, 6 μm E-Y Fraction/s	Unsmoothed Bed Surface, Aluminum Fraction/s	Unsmoothed Bed Surface, 1 μm E-Y Fraction/s
10	A	10.6	2.6×10^{-7}	$<1\times10^{-5}$	-----	-----
	B	11.4	1.7×10^{-6}	8.4×10^{-5}	-----	-----
	C	10.2	$.4\times10^{-6}$	3.9×10^{-4}	-----	-----
	D	10.1	8.3×10^{-5}	5.9×10^{-3}	-----	-----
12	A	12.2	6.3×10^{-7}	1.6×10^{-4}	-----	-----
		12.8	-----	-----	4.6×10^{-6}	1.6×10^{-4}
	B	12.0	2.5×10^{-6}	2.4×10^{-4}	-----	-----
		12.7	-----	-----	5.8×10^{-5}	2.2×10^{-3}
	C	11.9	8.5×10^{-6}	5.6×10^{-4}	-----	-----
		12.3	-----	-----	3.3×10^{-5}	2.3×10^{-3}
	D	11.9	-----	-----	1.1×10^{-4}	2.0×10^{-3}
14	A	14.6	1.0×10^{-5}	7.9×10^{-4}	-----	-----

U (m/s) Nom	Run Type	U (m/s) Actual	Vertical Flux, F_v: No./cm²s	No./cm²s	No./cm²s	no./cm²s
10	A	10.6	-----	-----	-----	-----
	B	11.4	1×10^{4}	1×10^{0}	-----	-----
	C	10.2	3×10^{3}	2×10^{0}	-----	-----
12	A	12.2	4×10^{2}	7×10^{-1}	-----	-----
		12.8	-----	1×10^{0}	1×10^{4}	-----
		12.7	-----	-----	-----	2×10^{3}
	B	12.0	7×10^{3}	1×10^{1}	-----	-----
		12.7	-----	-----	-----	9×10^{2}
	C	11.9	3×10^{4}	5×10^{1}	-----	-----
14	A	14.6	-----	8×10^{1}	-----	-----