RETREIVING LAND SURFACE AERODYNAMIC PROPERTIES USING MODIS ALBEDO

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Wind erosion and dust emission models are essential to estimate the lateral and vertical fluxes of carbon and nutrients between terrestrial and marine ecosystems and reduce uncertainty about dust radiative forcing of climate models. Wind erosion models approximate the turbulent transfer of momentum by surface roughness elements using roughness density (lateral cover or the frontal area index, L_c). Instead of using the aerodynamic roughness length (z_0) Raupach et al. (1993) demonstrated using Marshall's (1971) wind tunnel data how the threshold friction velocity ratio R_t could be estimated as $R_t(L_c)$. However, estimation of L_c over large areas (e.g., continents) is difficult and often approximated using classifications of cover (bare surfaces and vegetation type).

When rough surfaces are exposed to the wind, wakes or areas of flow separation are created downwind of obstacles. These sheltered areas reduce the area of exposed substrate and protect the erodible surface and some of the roughness elements from the wind (depending on their size and spacing). These turbulent wakes have been conceptualised using sheltered areas (Raupach, 1992) and shown to be proportional to shadow (Chappell et al., 2010). We made virtual reconstructions of Marshall's (1971) wind tunnel surfaces and applied a ray-tracer to approximate their directional (at-nadir) hemispherical 'black-sky' albedo $\omega_{dir}(\theta, \lambda)$ as a function of waveband (λ) and solar zenith angle (θ) and their diffuse bi-hemispherical 'white-sky' albedo $\omega_{diff}(\theta)$. We normalised the albedo $\omega_n=\omega_{dir}(\theta)$ / ω_{diff} such that it would not depend on (or reduce the influence of) the solar spectrum and estimated $R_t(\omega_n)$ and the friction velocity $U^*(\omega_n)$ without the use of L_c or z_0, respectively.

The Moderate Resolution Imaging Spectroradiometer (MODIS) includes a bi-directional reflectance model of surface roughness which provides a direct beam (local solar noon) ω_{Mdir} and a diffuse ω_{Mdiff} product. Normalising these products ($\omega_{Mn} = \omega_{Mdir} / \omega_{Mdiff}$) was equivalent to the ray-traced estimates and enabled a global estimate of $R_t(\omega_{Mn})$ and $U^*(\omega_{Mn})$ every 500 m and every 16 days consistently using a single holistic framework of albedo. This approach also unifies the source of aerodynamic roughness in the separate erosivity and erodibility components of wind erosion and dust emission models. We illustrate the information content of these new estimates using several spatial and temporal scales at various locations around Australia prone to wind erosion and dust emission.