The impact of ecosystem change on dust emission in North America

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An estimated 50 Mt yr⁻¹ of dust is emitted from North American landscapes, with profound regional impacts (Shao et al., 2011). Dust emission flux in North America is controlled by wind speed and land surface (aerodynamic) roughness that are variable in both space and time. Vegetation growth, form and spatial distribution characterise different ecosystem regimes and protect the soil surface from the shearing stress of the wind. In the dry western US, diverse land use and management drivers create disturbance regimes that produce diverse ecosystem responses that could be drastically impacting rates of wind erosion and dust emission (Ravi et al., 2010). Resolving the impacts of ecosystem change on aeolian processes is needed to quantify anthropogenic-induced dust loads and identify management options as environmental solutions (Webb and Pierre, 2018).

Currently, erosion surfaces in North America are derived from satellite imagery, either by spatial analysis of mean aerosol optical depth concentrations (e.g. Ginoux et al., 2012) or point source identification through subjective analysis of individual daily multispectral images (e.g. Lee et al., 2012; Kandakji et al., 2020). In either approach, the results are subjected to spatial and temporal bias caused by a lag in emission-to-observation period and loss of data during cloudy (dust and meteorological) periods. To complement these approaches we produced the first moderate (500 m) resolution daily maps of dust emission across the dry western United States. These maps were based on estimates of soil surface wind friction velocity ($u_*$) derived from MODIS albedo data (Chappell and Webb 2016) using a commonly applied model (Marticorena and Bergammetti, 1995).

The North American dust emission climatology from 2001-2018 was compared with the $u_*$ data volume to identify the spatio-temporal occurrence of three key disturbance regimes: i) land clearing for energy infrastructure, ii) invasion of shrublands by exotic annual grasses that alter fire regimes, and iii) replacement of grasslands by invasive shrub species. Against this background we examine the state and transition of ecosystem change across these landscapes to understand the impact on current dust emission. We use these findings to comment on the implications for future dust emission and to encourage the development of this modelling approach in Earth System Models.

**How to cite:** Hennen, M., Webb, N., and Chappell, A.: The impact of ecosystem change on dust