Geophysical Research Abstracts
Vol. 20, EGU2018-10813, 2018
EGU General Assembly 2018

Lake-Dust-Snow dynamics "from source to sink" in the semi-arid Bonneville Basin, Utah USA

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The Great Basin physiographic province is the largest desert region in the USA, and a known source area for windblown dusts, including aerosols, black carbon, nutrients, and mineral particles. However, surprisingly little is known about dust composition, atmospheric loading and fluxes from sources to sinks. Within this semi-arid region, intermountain cyclonic storms and aeolian dynamics are important drivers of dust entrainment and transport. Since the 1930s, Utah newspapers have reported spring cold front passages after dust storms that caused it to "rain mud." Various studies on the prevailing winds and synoptic meteorological conditions relate seasonal development of strong intermountain cyclones with elevated wind speeds and dust storm events. The peak frequency of dust event days (DEDs) typically occurs during the spring months when 'Hatu winds' blow from the south. The highest frequencies of dust storms occur in March and April, with a secondary peak in September.

Key source areas providing dust for transport downwind to the populated regions of Utah were identified by assessing 51 DEDs that affected air quality in Salt Lake City over the period from 2004-2010. Among the recurrently active "hotspot" areas prone to dust emission are: barren and sparsely vegetated land; fallow fields; playa lake (ephemeral lake) surfaces relict from Pleistocene Lake Bonneville (as defined by G.K. Gilbert); and areas that have been disturbed by wildfire, agriculture, vehicular traffic, and military activities. Some "hotspots" are subjected to intensified winds due to location downstream of mountain gaps, or along fetches with higher wind speeds from terrain contouring. Dust production was significantly enhanced after severe drought and/or disturbance by wildfire, agriculture, and military activity. For example, the 2007 Milford Flat Burned Area (Utah's largest wildfire) actually generated more dusts after revegetation procedures, including drilling, chaining, and herbicide application.

Dust storms depositing materials on montane snowpack (Dust-On-Snow (DOS)) affects the surface albedo and radiative properties; dust may increase melt rates, causing an earlier "snow-free" date and higher peak streamflows. Dust-forced changes in hydroclimatology might adversely impact Salt Lake City, which relies on seasonal snowpack in the Wasatch Mountains as their main water supply.

An intense intermountain cyclone affecting the region on 14-15 April 2015, provided an occasion to study a specific dust event from inception to deposition of dusts on montane snowpack. Analysis of the "Black Tuesday" storm event is the first "cradle to grave" or "source to sink" real-time documentation of storm development, point correlated dust-source emission and associated dust deposition on snow (DOS) in the Wasatch Mountains. While prior studies have assessed aggregate dust accumulations over a season, we have resolved the particle size, elemental composition, albedo and radiative properties of a single specific dust storm event layer sampled within a day of the storm. Plumes observed on MODIS imagery indicate that dust mobilized from known point sources in the Escalante Desert, Sevier Lake region and other modern playas within the Paleolake Bonneville Basin. Snowpack dust included heavy metals (Cu, Pb, As, Cd, Mo, Zn) that are common in regional mine operations.