Back Trajectory and Meteorological Factors in Spring Dust Trends in the Southwestern U.S.

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ABSTRACT: Fine soil (<2.5 µm dia.) in the Interagency Monitoring of PROtected Visual Environments (IMPROVE) network in the southwestern U.S. has increased about 5%/year during March 1995-2014, while remaining stable during other months (Hand et al., 2016). Concentrations typically peak in spring and early summer so the March increase is interpreted as an earlier onset of the dust season. The increase is ubiquitous over a large four-state region so is not likely due to local sources or small scale meteorological fluctuations. There are implications for ecosystems, human health, the hydrologic cycle and visibility.

March trends are correlated with the Pacific Decadal Oscillation (PDO) which, like El Niño and La Niña, is related to sea surface temperatures in the Pacific Ocean, though with a longer periodicity. The PDO is believed to influence the position of storm tracks around the world. To further investigate how the PDO influences meteorology and ultimately fine soil concentrations, hourly Automated Surface Observing System (ASOS) and Remote Automated Weather Station (RAWS) meteorological data were examined for the southwestern U.S. and back trajectories were generated for the IMPROVE sites for 1995-2014. The surface based data were examined for trends in wind speed, wind direction, temperature, precipitation, and humidity. The back trajectory endpoints, which track transport patterns, were grouped by the known dust source regions (Ginoux et al., 2012) that they traversed. Then meteorology associated with the endpoints in each source region was examined for number of endpoints (indicating transport direction), wind speed, temperature, precipitation, humidity, solar radiation, mixing depth, and transport height.

The most significant findings are that during the second half of March, in the later years the transport patterns shifted so that IMPROVE sites in the Four Corners states received more air masses from the Sonoran and Mohave Deserts, the Colorado River Basin, and the San Joaquin Valley. Later years were drier than the earlier years as indicated by both lower average relative humidity and lower amounts of and less frequent precipitation. Wind speeds were somewhat higher.

REFERENCES
Ginoux, P., J. M. Prospero, T. E. Gill, N. C. Hsu, M. Zhao (2012) "Global-scale attribution of anthropogenic and natural dust sources and their emission rates based on MODIS Deep Blue aerosol products" *Rev. Geophys.*, 50, RG3005, doi:10.1029/2012RG000388.

Hand, J.L., W.H. White, K.A. Gebhart, N.P. Hyslop, T.E. Gill, B.A. Schichtel (2016) "Earlier onset of the spring fine dust season in the southwestern United States" *Geophys. Res. Lett.*, 43, doi:10.1002/2016GL068519

Boxy Source Regions Based On This

From Ginoux et al. (2012)

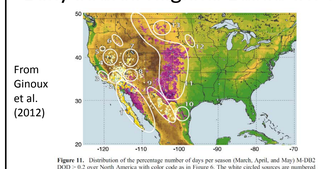


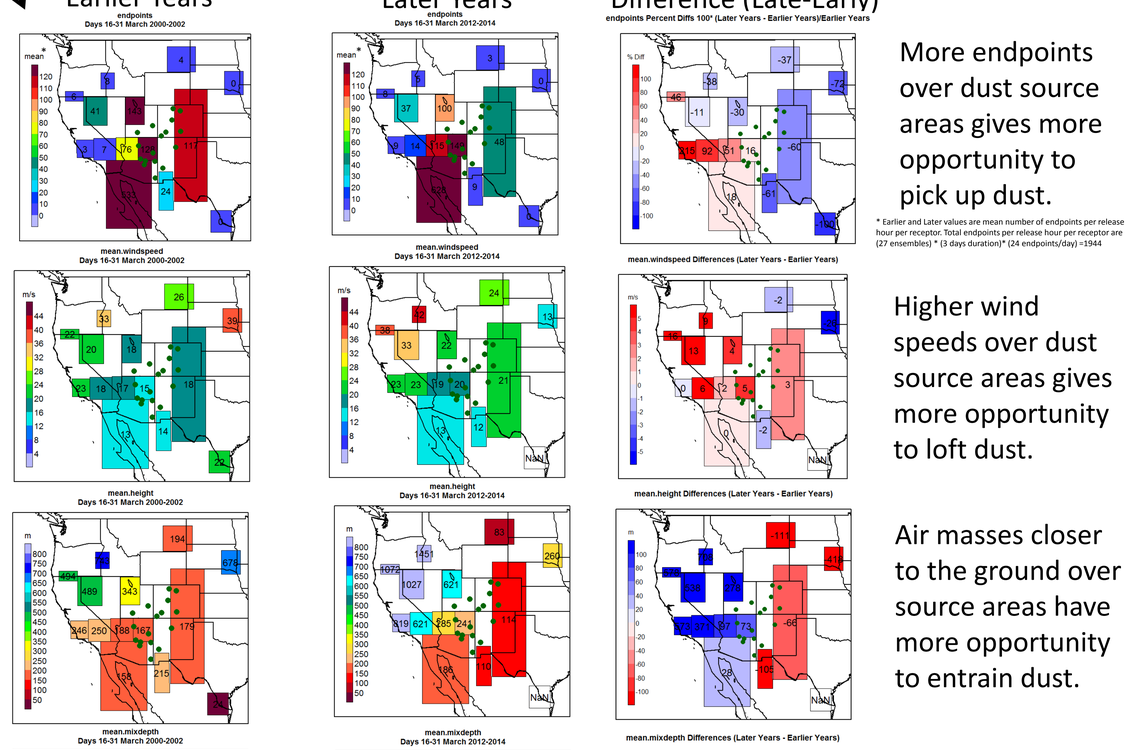
Figure 11. Distribution of the percentage number of days per season (March, April, and May) M-DB2 DOD = 0.2 over North America with color code as in Figure 6. The white circled sources are numbered as follows: 1, Sonoran Desert; 2, Mojave Desert; 3,San Joaquin Valley; 3, Black Rock-Smoke Creek deserts; 4, Goose Lake; 6, Snake River; 7, Great Salt Lake Desert; 8, Colorado River; 9, Chihuahuan Desert; 10, Rio Grande; 11, High Plains; 12, Big Sioux River; and 13, lower Yellowstone Valley.

Transport Frequency (Wind Direction)

3D Transport - Back Trajectory Endpoints over Dust Source Regions

Red = More Conducive to Dust, Blue = Less Conducive to Dust

Green Dots are IMPROVE Sites Where Trajectories were Started



More endpoints over dust source areas gives more opportunity to pick up dust.

* Earlier and Later values are mean number of endpoints per release hour per receptor. Total endpoints per release hour per receptor are (27 ensembles) * (3 days duration)* (24 endpoints/day) =1944

Higher wind speeds over dust source areas gives more opportunity to loft dust.

Air masses closer to the ground over source areas have more opportunity to entrain dust.

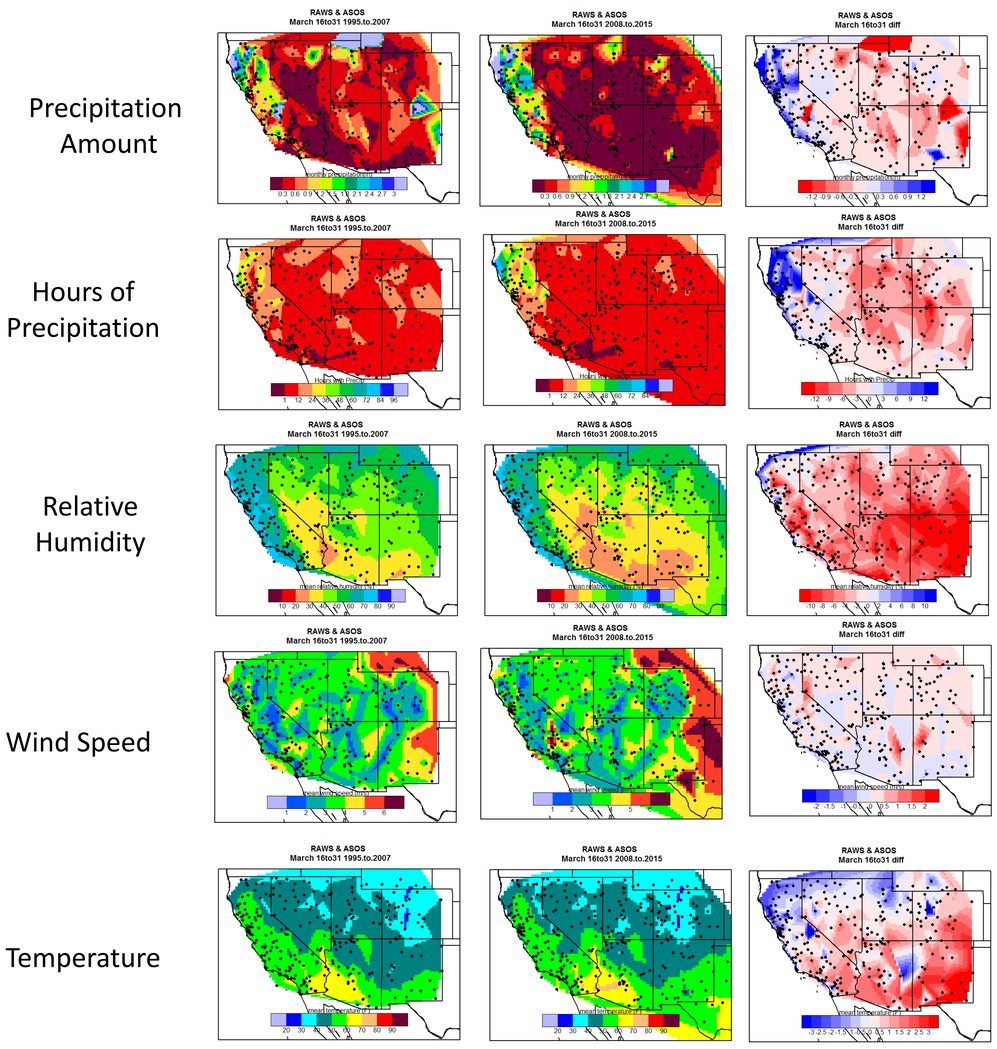
Deeper mixing depths allow entrainment of dust to higher heights, less stagnation.

Lower humidities dry the soil making it easier to be blown away.

Lower precipitation reduces land cover, dries ephemeral wetlands

Surface Meteorology

Red = More Conducive to Dust, Blue = Less Conducive to Dust



Transport Wind Speed

Transport Height

Mixing Depth

Relative Humidity

Precipitation