Seasonal, Spatial, and Long-term Variability of Fine Mineral Dust and Coarse Mass

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4/3/2009 MODIS
Painted Desert, AZ
Fine Dust (FD) and Coarse Mass (CM) \((\mu g \, m^{-3})\)

\[
FD = 2.20[Al] + 2.49[Si] + 1.63[Ca] + 2.42[Fe] + 1.94[Ti]
\]

\[
CM = PM_{10} - PM_{2.5}
\]
Multiple Linear Regression suggests dust is underestimated by ~20%.

Appears to be a shift around 2011 (Panalytical?)
Panalytical XRF- 2011 Changes to Elemental Fractions?

- SiO₂/FD
- FeO/FD
- Si/Fe
Dust sources over North America (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; 4, Black Rock Smoke Creek deserts; 5, Great Basin; 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.
Seasonal mean fine dust and CM (2012-2016)

Spring  |  Summer  |  Fall

Hand et al. (2017)  JGR
Seasonal FD contribution to PM$_{2.5}$ mass (2012-2016)
Seasonal CM contribution to PM\textsubscript{10} mass (2012-2016)
Trends in FD and CM (2000-2016)
2000-2016 Trends in SW Monthly Mean FD

- March: 4.4 % yr\(^{-1}\) (p<0.01)
- April: 1.3 % yr\(^{-1}\) (p=0.4)
- May: 1.3 % yr\(^{-1}\) (p=0.5)

(UT, CO, NM, AZ)
Large Scale Climate Variability

ENSO (El Niño Southern Oscillation)

El Niño: westerly flow shifts southward- storms that travel this branch tap into moisture at low latitudes of the eastern Pacific and bring winter precipitation to the Southwest (SW).

La Niña: Typical flow (northward) resulting in warmer and dryer conditions over the SW (Sheppard et al. 2002).

http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

Pacific Decadal Oscillation (PDO)

Pacific Decadal Oscillation (PDO): leading principal component of monthly SST anomalies in north Pacific Ocean (poleward of 20N):
Negative (or cool): similar impacts as La Nina.

The effects of ENSO and the PDO can amplify each other, resulting in increased annual variability in precipitation over the Southwest.

http://research.jisao.washington.edu/pdo/
Shift to Active and Earlier FD Season Around 2007

SW Regional March Mean FD

FD & Pacific Decadal Oscillation (PDO) \(r = -0.56\)

El Niño Southern Oscillation (ENSO) \(r = -0.40\)

Day of Year Anomaly: half annual total dust

PDO: Washington State University (http://research.jisao.washington.edu/pdo/)

ENSO: NOAA (http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml)

Hand et al. (2016) GRL
2000-2016 Trends in Monthly Mean FD and CM (% yr⁻¹)

FD: Summer

CM: Summer
2000-2016 Seasonal Mean Trends: FD fraction of PM$_{2.5}$

Significance: ▲ p<0.1 △ p>0.1
Visibility Impacts: Trends in Haziest $b_{ext}$

2000-2016 20% Haziest $b_{ext}$

2000-2016 20% Haziest Dust $b_{ext}$

2000-2016 20% Haziest CM $b_{ext}$
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IMPROVE

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4/3/2011 MODIS
To avoid criticism, do nothing, say nothing, be nothing.