The Feedback Between Aerosols and Climate

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More specifically...

The Feedback Between African Dust and North Atlantic SST
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Our working hypothesis:
SST induces low frequency variability in atmospheric circulation, which drives low frequency dust changes.
The Atlantic Multidecadal Oscillation (AMO)

- With a period about 60-80 years.
- Exists in both instrumental and paleoclimate records.
Dust decrease since the 80’s

Composite Difference in DAOD between 2000s and 1980s

AVHRR based dust AOD change since the 1980s.

Yuan et al., 2016
Data from Evan and Mukhopadhyay (2010)
Dust changes

Dust change dominate over the tropical North Atlantic region and dust AOD changes induced about $1 \text{ Wm}^{-2}$ (highly uncertain) in radiative impact.

Chin et al., 2014

Fossil fuel and biomass burning related

Natural, mostly desert dust, related

E.g. Yoshioka et al. (2007); Ridley et al. (2014); Mahowald et al. (2010); Evan et al. (2009)
Co-variability

Time series of areal average over the tropical North Atlantic.
Co-variability in longer records

AMO index is anticorrelated with dust concentration or proxies
Trade wind response

Regression of wind onto AMO index

Correlation between AMO index and wind speed

Theory: Kang et al. (2008); Chiang and Friedman (2012); Frierson et al. (2012); Schneider et al. (2014)

Yuan et al., 2016
Wind change

GEOS-Chem driven by reanalysis correctly simulate dust trend since the early 1980s. Wind is the dominant factor for changing dust emission.

Ridley et al., 2014; See also Wang et al. (2012)
Wind driven emission

GOCART simulates the trend quite well and dust change is mostly driven by surface wind speed change in this area.

Chin et al., 2014
Time-lagged MCA

Yuan et al., to be submitted

MCA: maximum covariance analysis (see notes by D. Hartmann for short intro)

Czaja and Frankignoul (2002)
Our framework
Our framework

- Warm midlatitude SST Anomaly
- Trade wind speed
- Dust emission

- Low cloud fraction

- Tropical SST

Yuan et al., 2016
Impact: Biogeochemical

Phosphorus in deposited African dust in the Amazon is enough to partially account for loss by river runoff.

Yu et al., 2015
How did the models do?

AMIP style run

CMIP5
The key

Models do not have a correct wind response given SST anomalies.

Model 1

Model 2
Conclusion

• African dust low frequency variability is closely related to surface wind speed changes in the Sahara/Sahel.

• Wind change may be ultimately related to SST changes in the North Atlantic

• Dust changes affect SST, clouds, and biogeochemistry

• Current models could not simulate such low frequency variability