The Feedback Between Aerosols and Climate

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Funding from NASA MAP program

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The Feedback Between African Dust and North Atlantic SST

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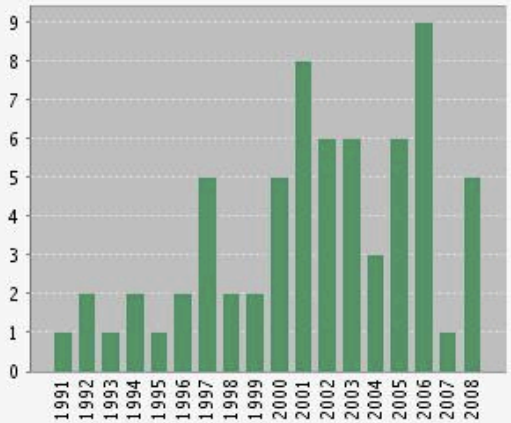

The latest 20 years are displayed.

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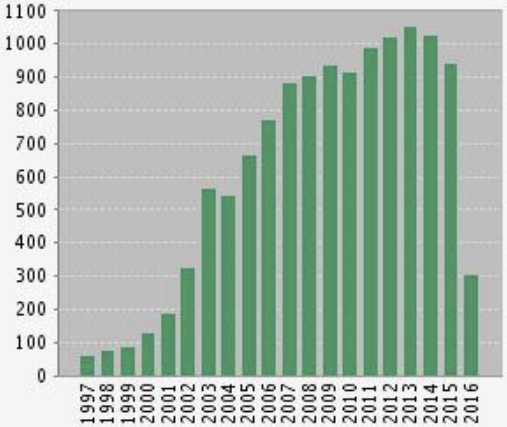

The latest 20 years are displayed.
View a graph with all years.

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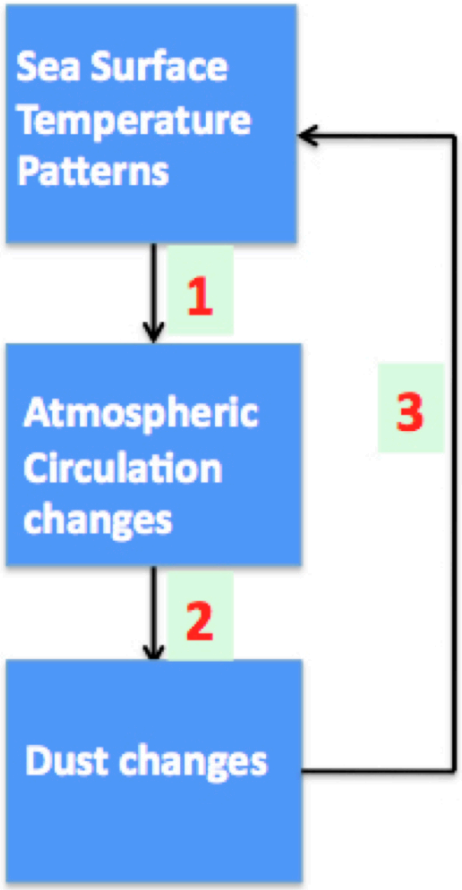
Author: YJ Kaufman

Topic: dust

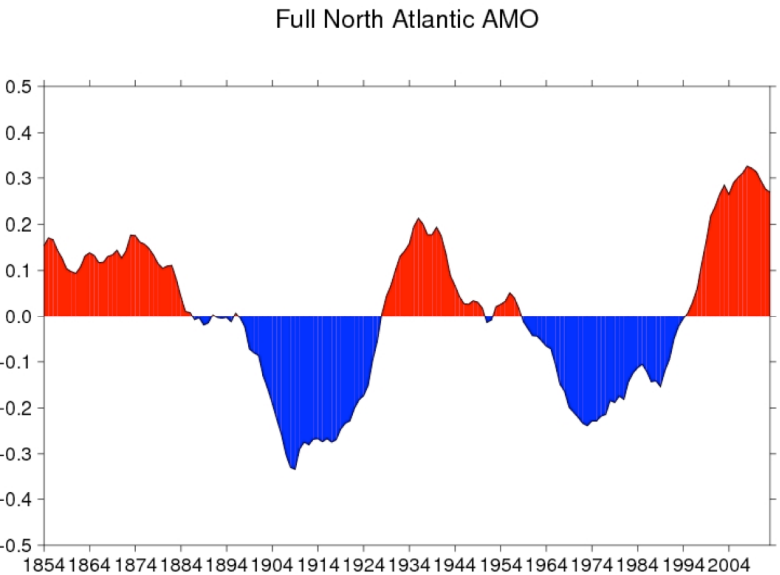
h-index: 46

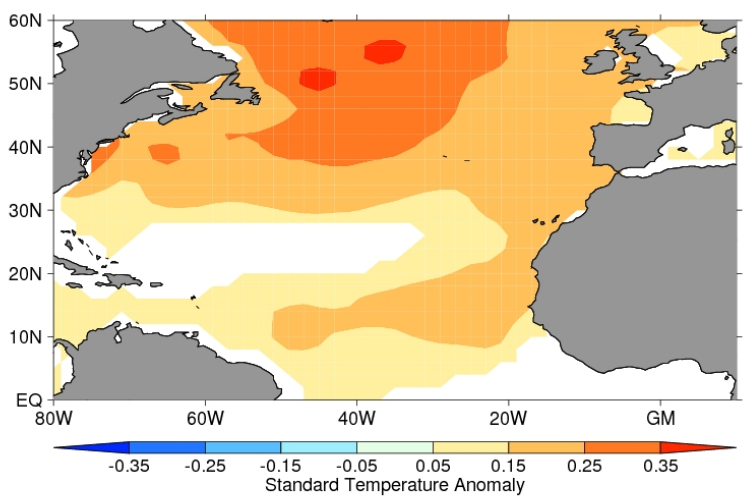
Our working hypothesis:

SST induces low frequency variability in atmospheric circulation, which drives low frequency dust changes.



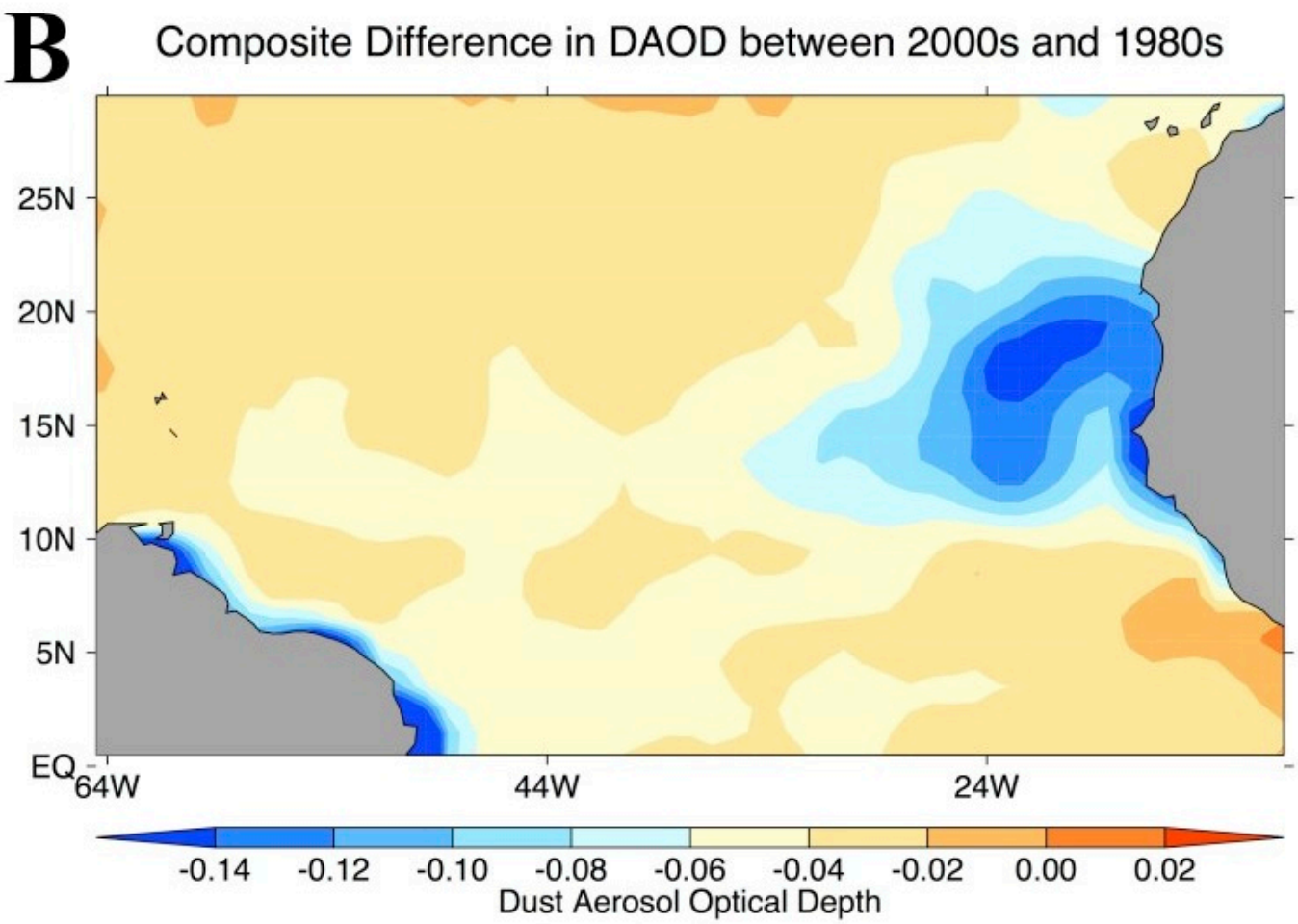
The Atlantic Multidecadal Oscillation (AMO)





- With a period about 60-80 years.
- Exists in both instrumental and paleoclimate records

Dust decrease since the 80's

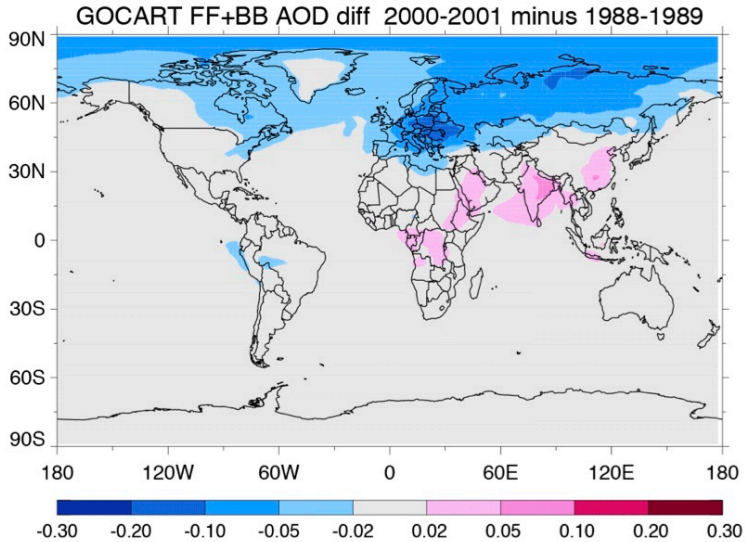


AVHRR based dust AOD change since the 1980s.

Yuan et al., 2016

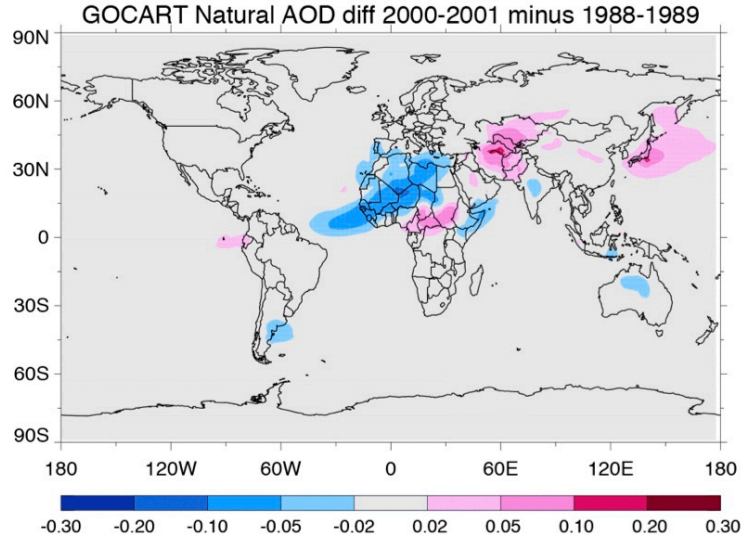
Data from Evan and Mukhopadhyay (2010)

Dust changes



Chin et al., 2014

← Fossil fuel and biomass burning related

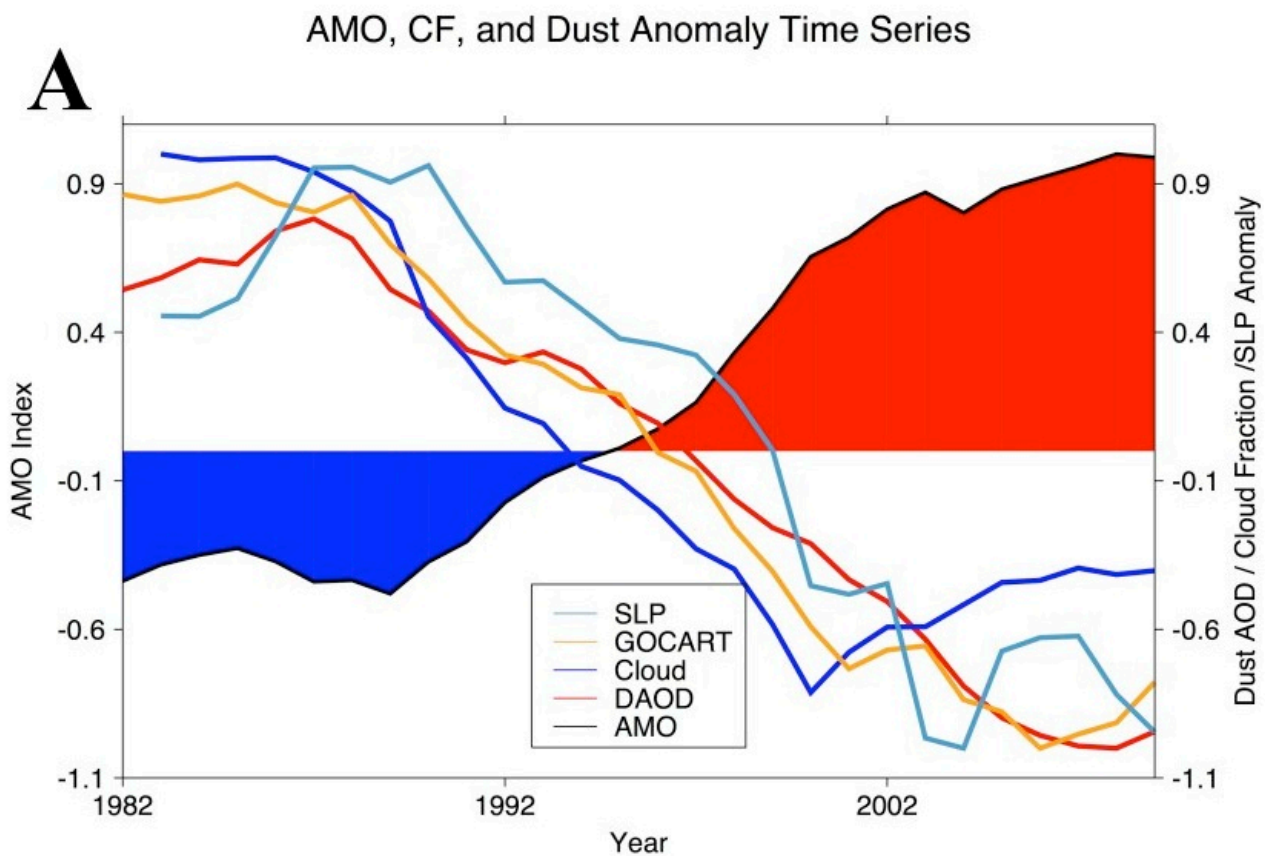


← Natural, mostly desert dust, related

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

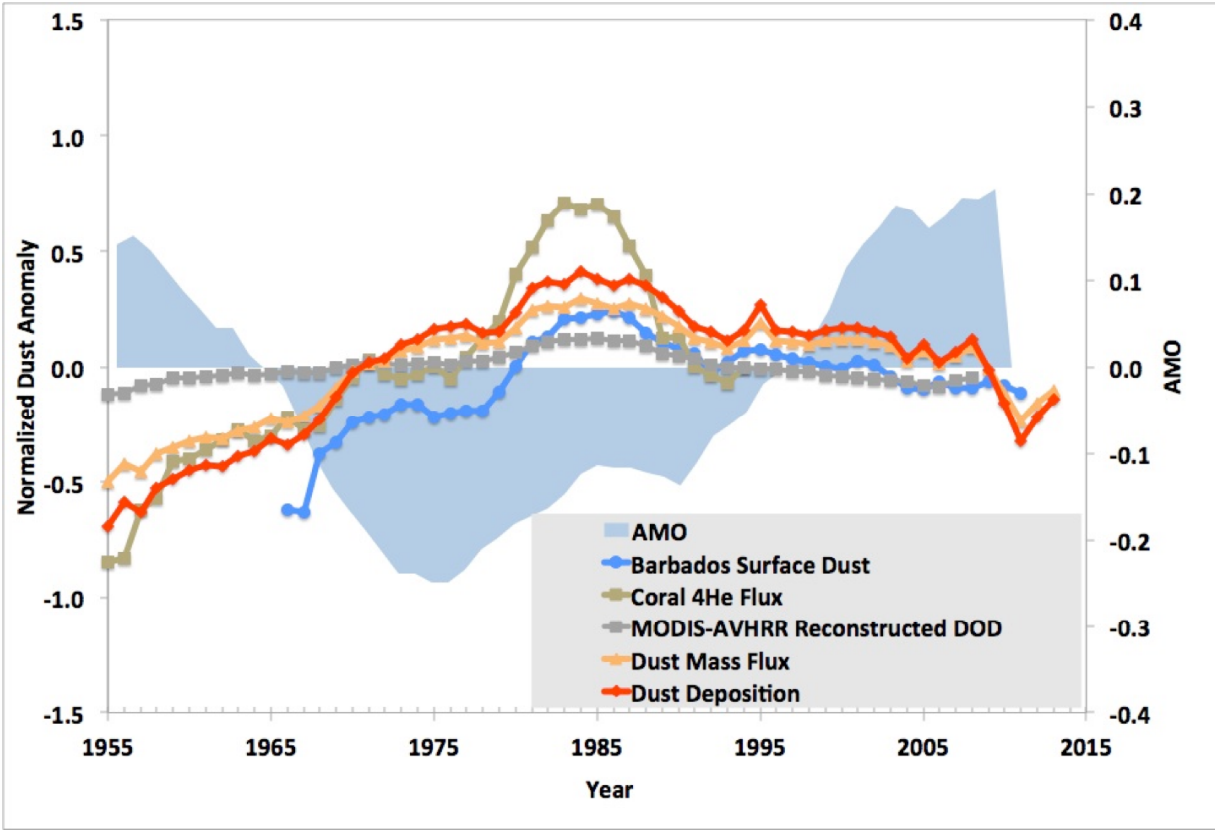
e.g. Yoshioka et al. (2007); Ridley et al. (2014); Mahowald et al. (2010); Evan et al. (2009)

Co-variability

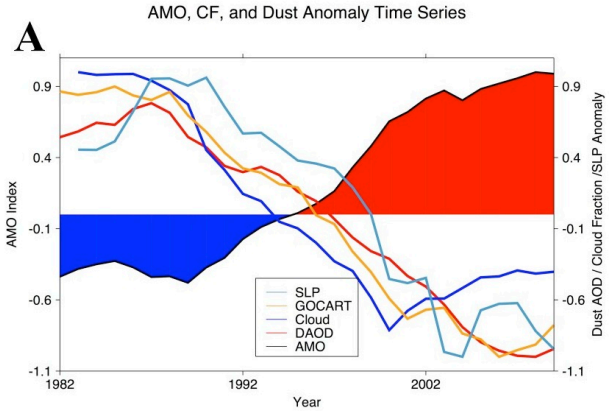


Time series of areal average over the tropical North Atlantic.

Co-variability in longer records



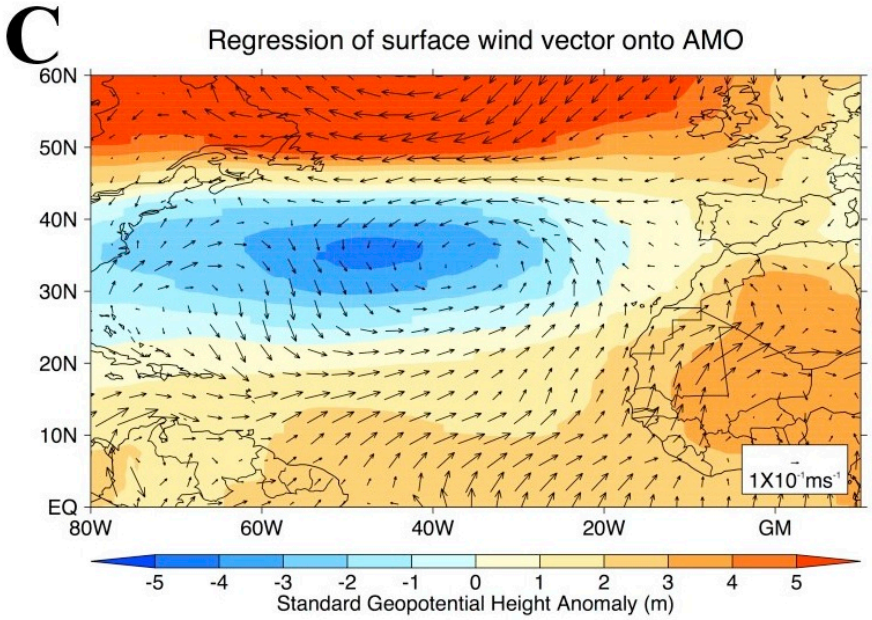
AMO index is anticorrelated with dust concentration or proxies

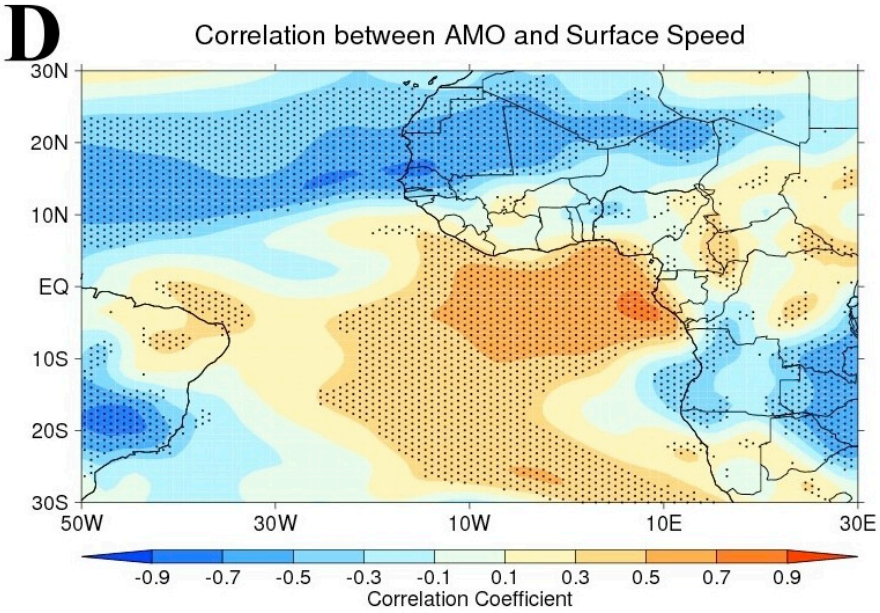


Trade wind response

↓ Regression of wind onto AMO index

↓ Correlation between AMO index and wind speed

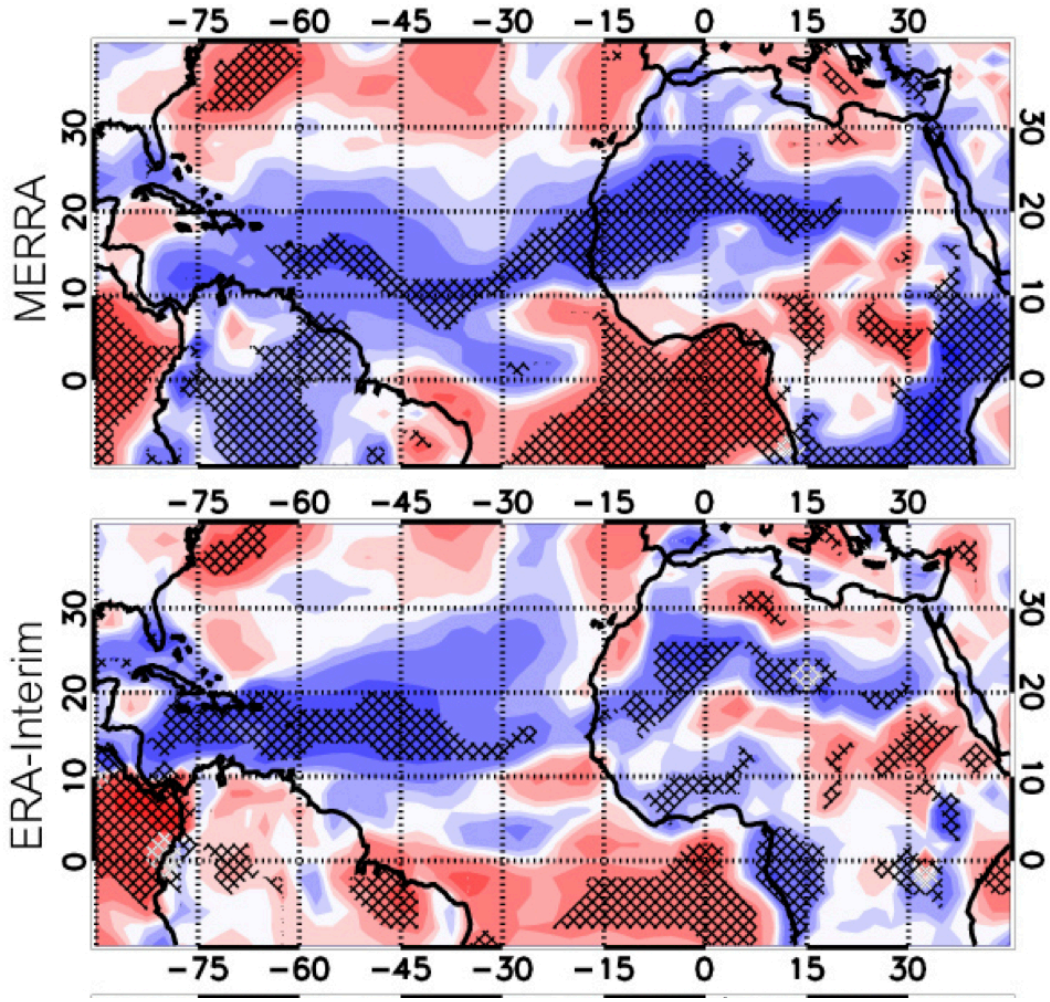




Yuan et al., 2016

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

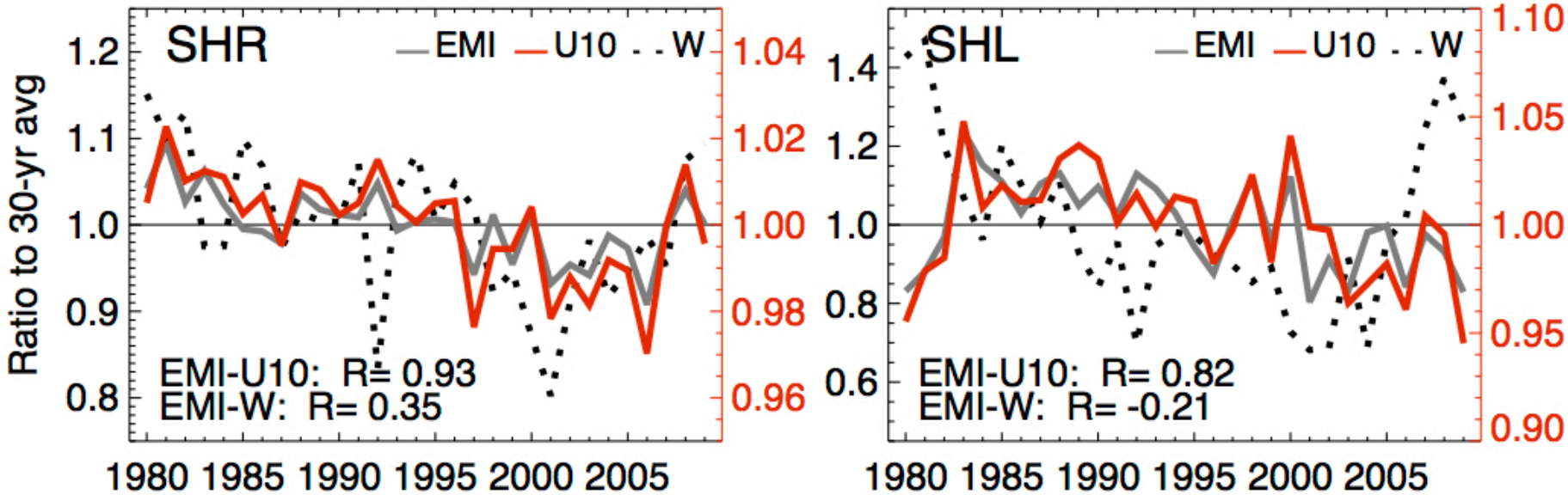
Wind change



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



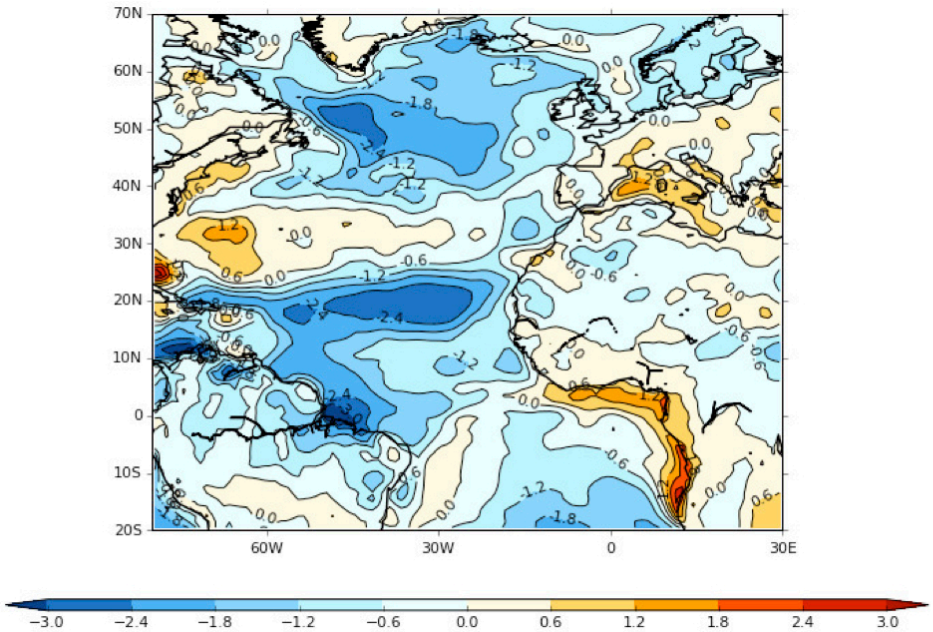
GOCART simulates the trend quite well and dust change is mostly driven by surface wind speed change in this area.

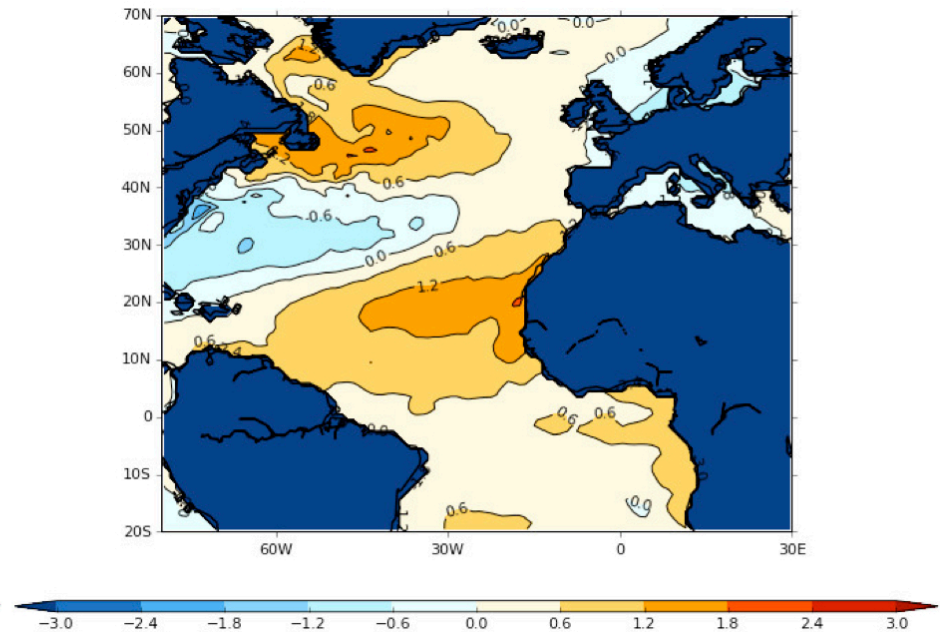
Chin et al., 2014

Time-lagged MCA

↓ Surface wind speed pattern

↓ SST pattern



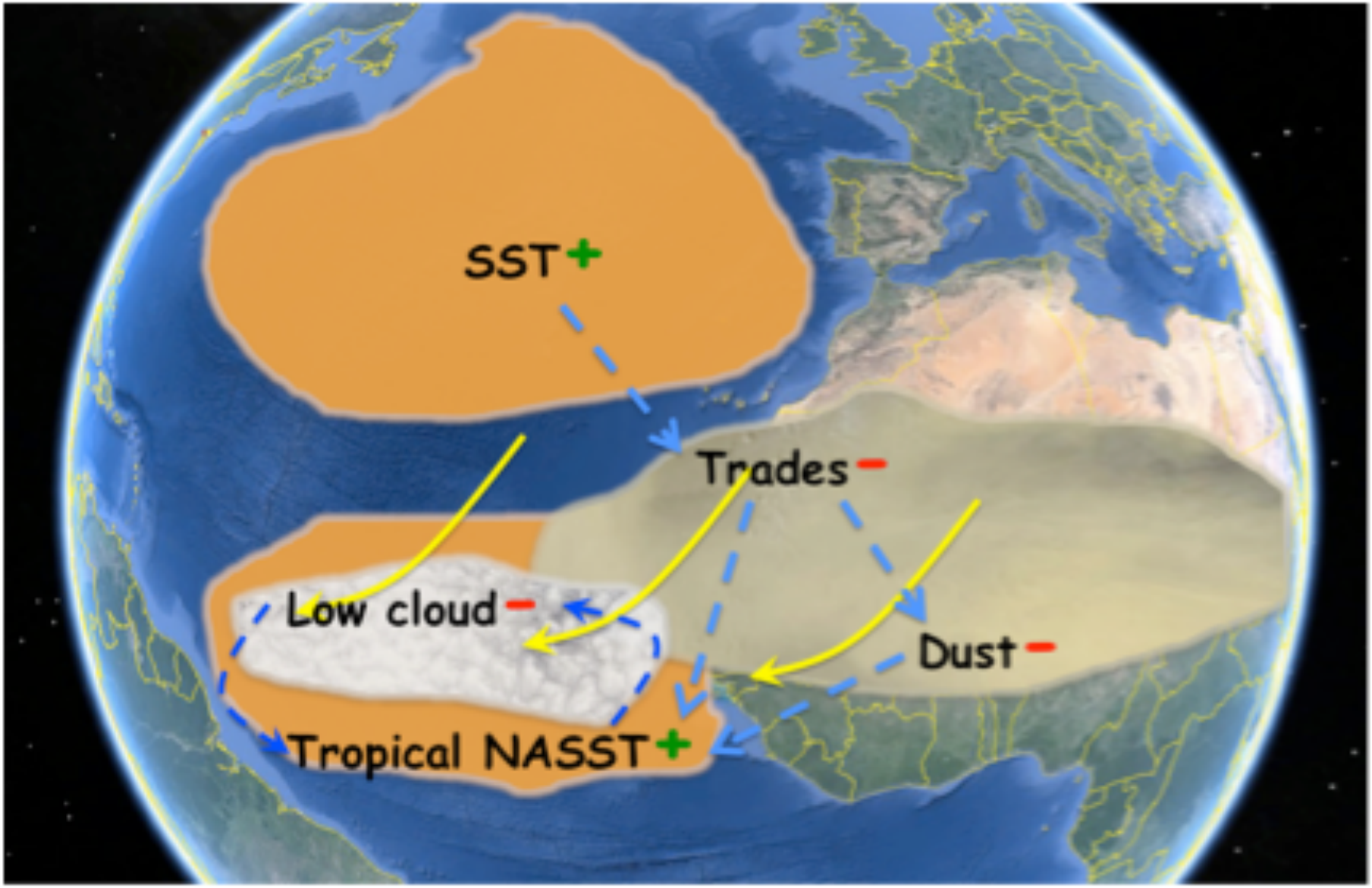


Yuan et al., to be submitted

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

Czaja and Frankignoul (2002)

Our framework

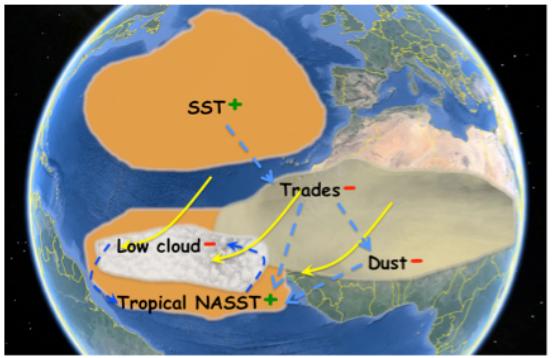


Our framework

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

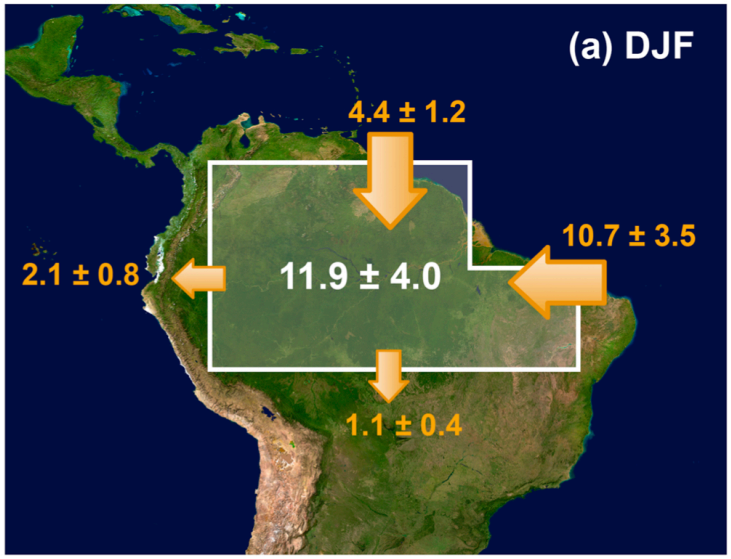
•Low cloud fraction

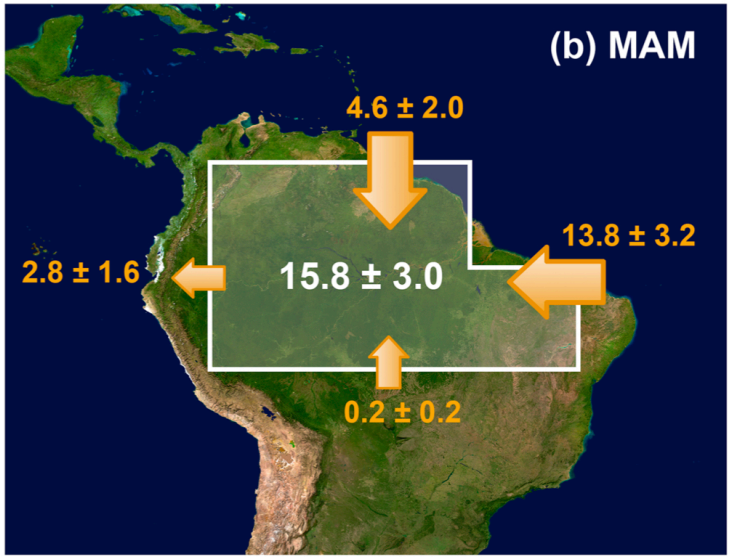
•Tropical SST



Yuan et al., 2016

Impact: Biogeochemical

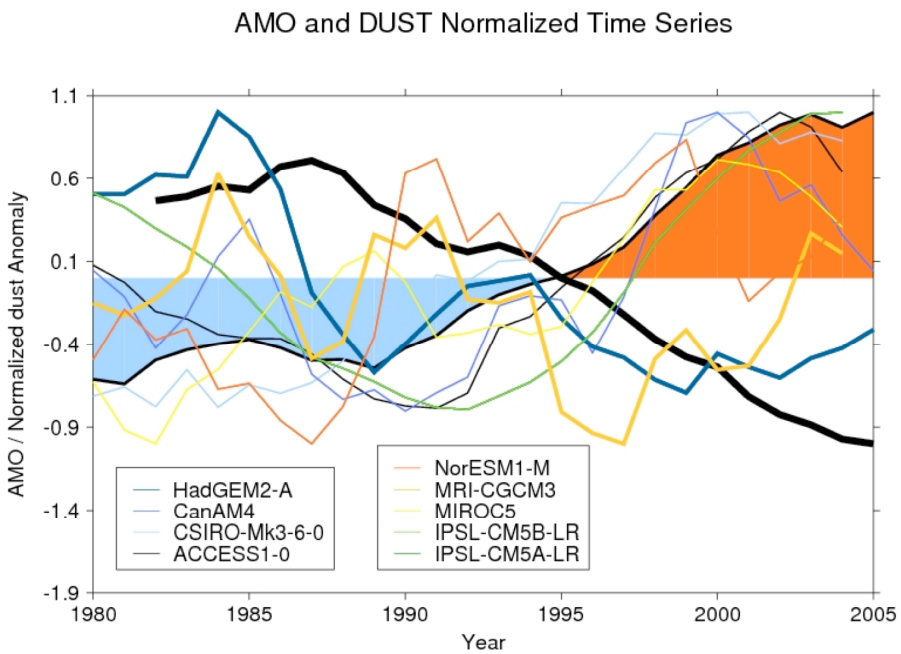


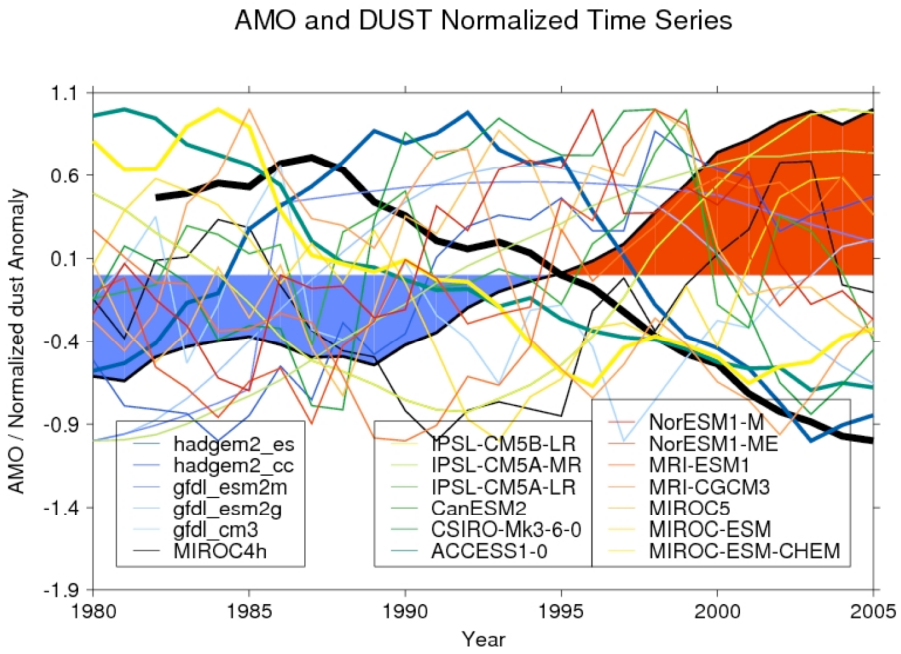


Phosphorus in deposited African dust in the Amazon is enough to partially account for loss by river runoff.

Yu et al., 2015

How did the models do?

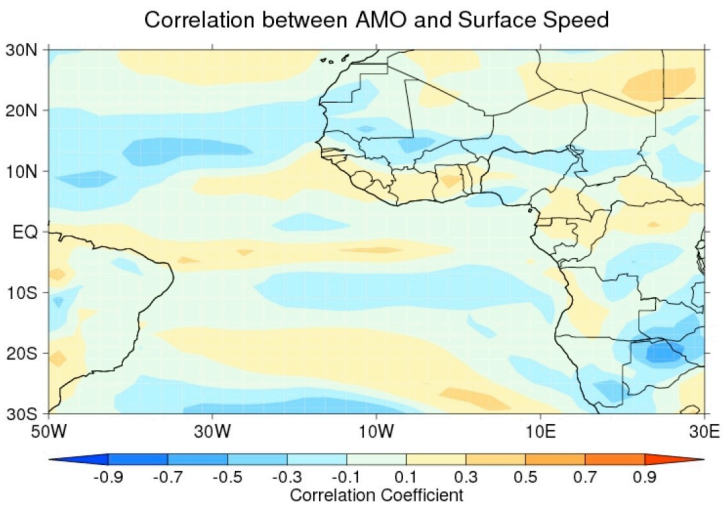




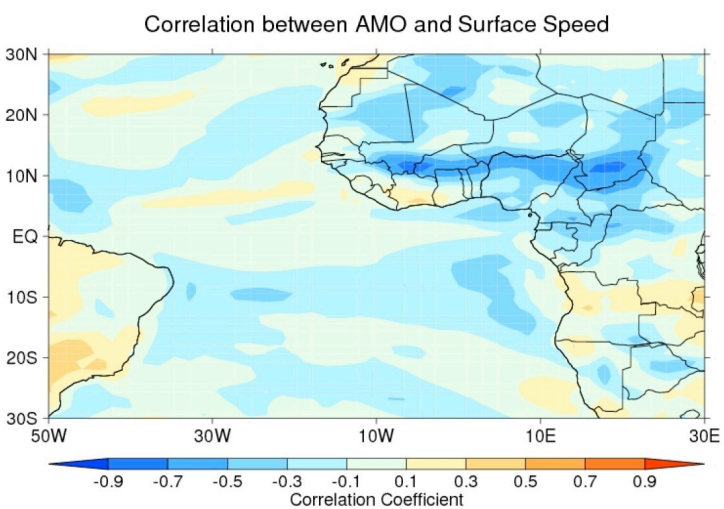
AMIP style run

CMIP5

The key



Model 1



Model 2

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

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