

30 years of African dust: From emission to deposition

Using GEOS-Chem and MERRA to determine the
causes of variability and trends

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**Toward resolution-independent dust emissions in global models:
Impacts on the seasonal and spatial distribution of dust**

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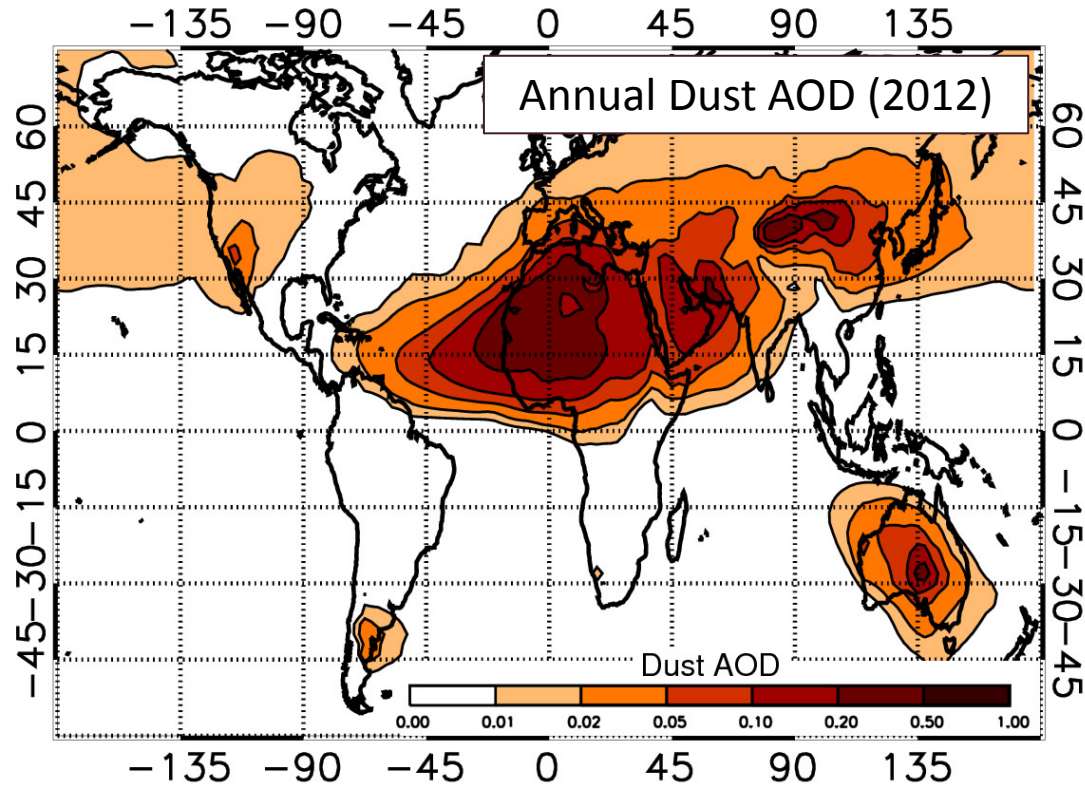
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Motivation



- African dust accounts for half of global emissions (Huneus et al., 2011)
- Wintertime dust emission and transport highly variable (Propero et al., 2013; Doherty et al., 2012; Ben-Ami et al., 2012)
- Land-use changes often cited as possible cause of change in dust emission over recent decades (Chiapello et al., 2005; Evan et al., 2011; Mulitza et al., 2010)

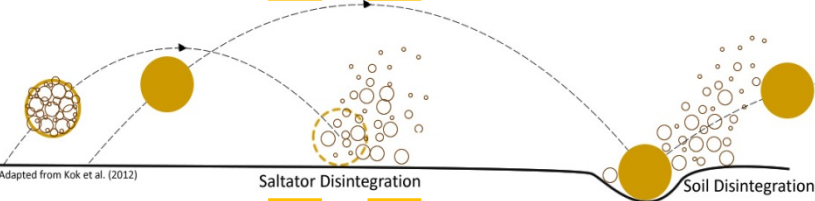


Two Questions:

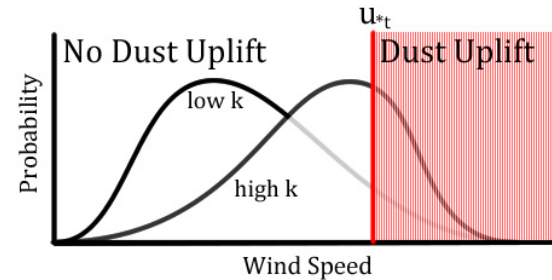
1. Can GEOS-Chem capture the emission and long-range transport of African dust over decadal timescales?
2. What drives the inter-annual variability in winter African dust emissions?
Are land-use changes important??

Modelling Dust Emission

- DEAD dust scheme
(Zender et al., 2003)
- TOMS AI dust source map
(Ginoux et al., 2001, Prospero et al., 2002)



- Solving the resolution issue...
- Dust emission proportional to 10m-wind cubed
- Wind threshold must be exceeded for emission



- Weibull PDF used to represent sub-grid winds in GEOS-Chem

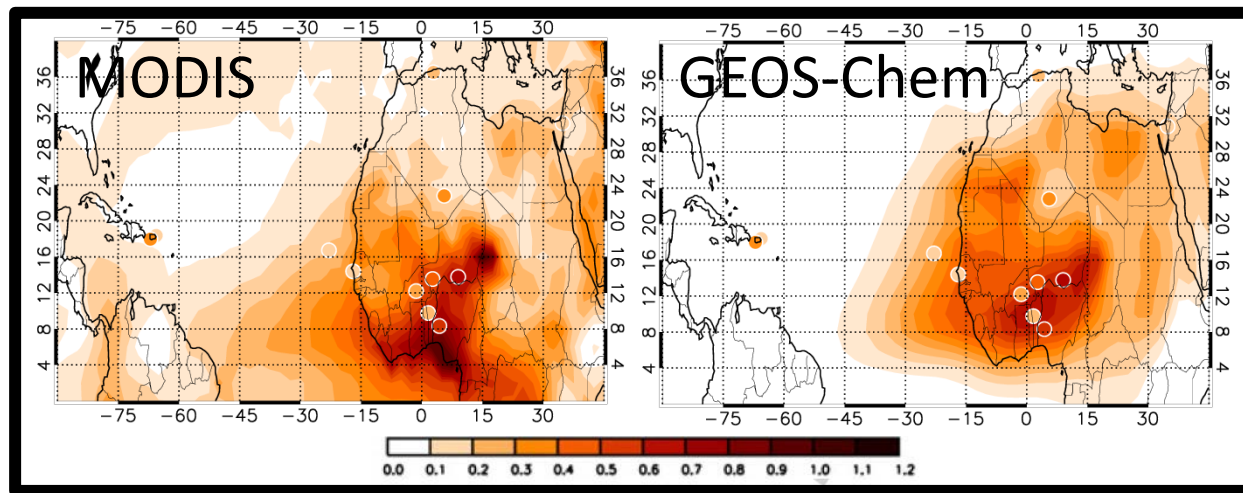
- Reduction in resolution-dependence of emissions

Ridley et al. (2013)

Winter (DJFM) Dust AOD

- Comparison with observations (AERONET, MODIS, MISR & surface concentration at Barbados) shows seasonality is captured.

(Ridley et al., 2012)



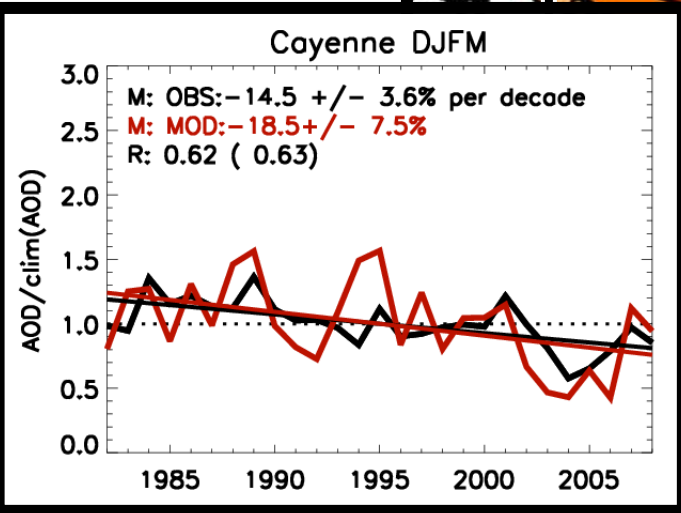
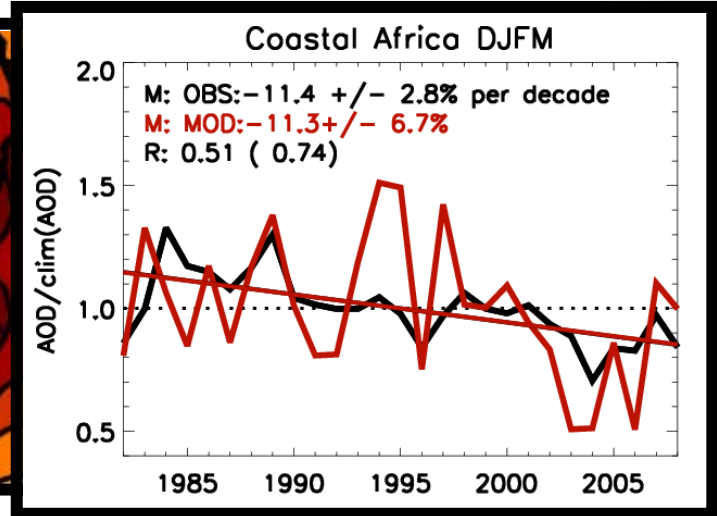
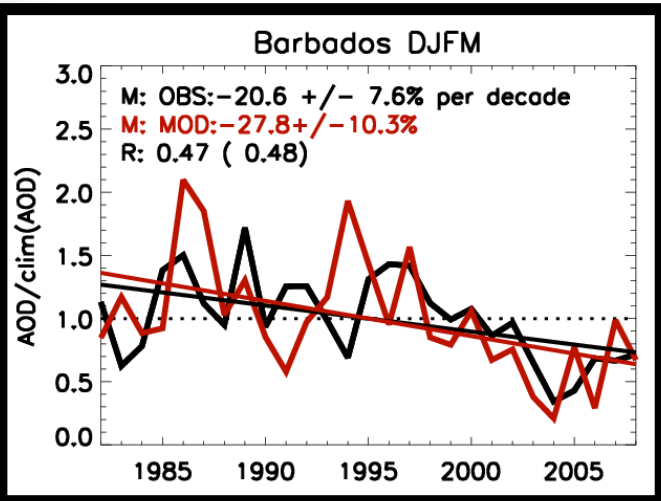
(MODIS dust AOD derived using Eq. A3 from Kaufman et al., 2005)

- Daily comparison (2000-2008) with AERONET and MODIS yields good spatial and temporal correlation in winter.
- Most events captured, however model underestimates peak AOD ($R = 0.60 - 0.80$ at key AERONET sites)



Inter-annual variability downwind

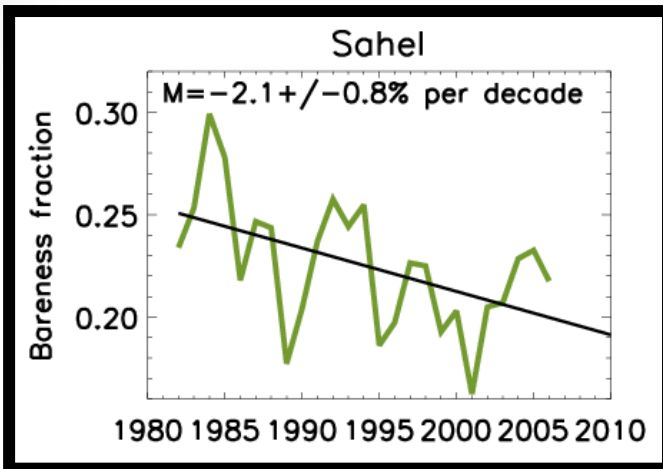
- Using 26 years of dust AOD (DAOD) derived from AVHRR & MODIS satellite data
(Evan & Mukhopadhyay, 2010)



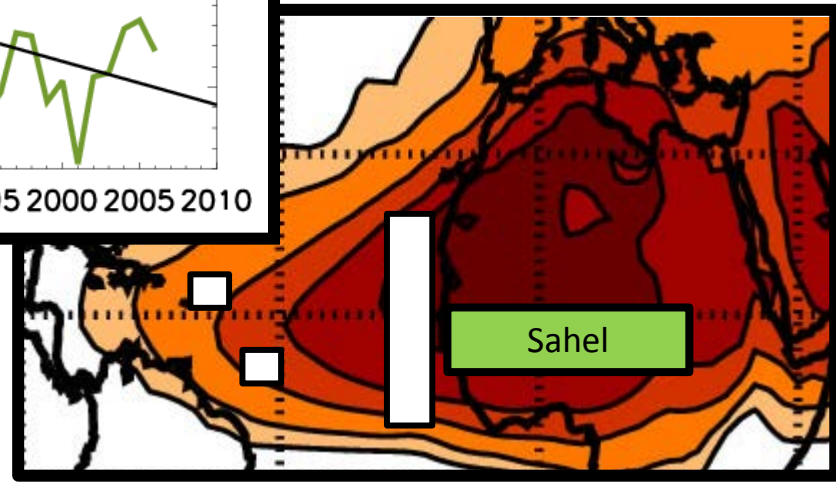
- Significant decrease in dustiness of 11-20% per decade in both observations and model



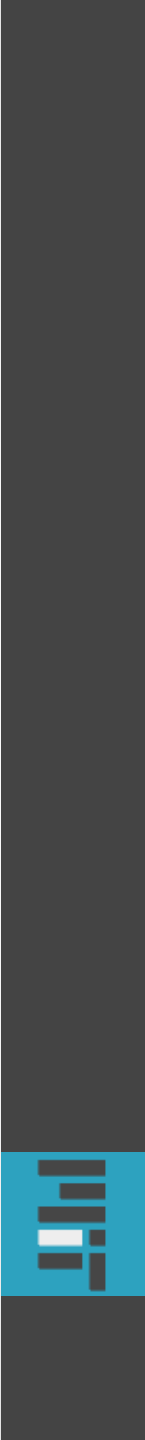
Is Land-Use Change Important?



- Using a relaxed source map modulated by surface bareness from AVHRR NDVI (Koven et al., 2006; Kim et al., 2013)

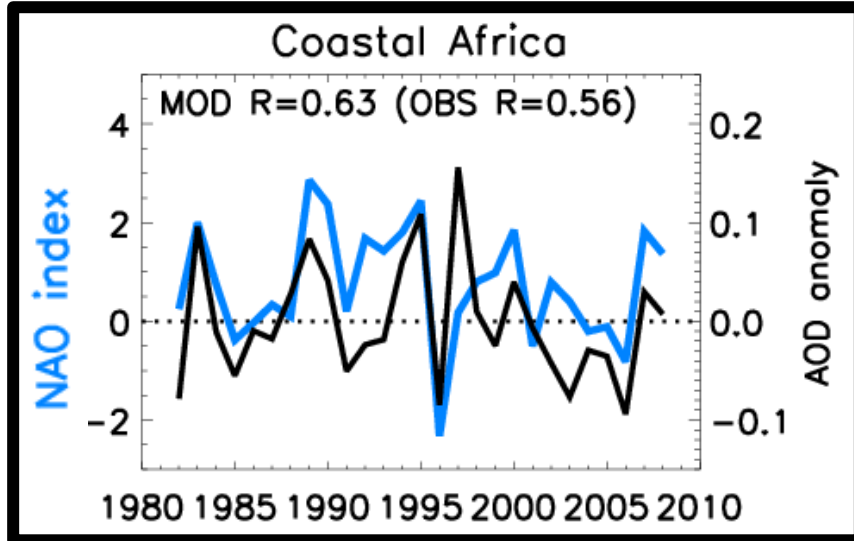


- A greening of the Sahel over the past 30 years observed from AVHRR
- Varying vegetation alters emissions by only 1-5%
- Accounting for dynamic vegetation may be more important in other regions



What causes the variability?

- North Atlantic Oscillation (NAO) shown to correlate with Atlantic dust AOD and concentration (Moulin et al., 1997; Ginoux et al., 2004)
- GEOS-Chem coastal Africa dust AOD correlates with NAO ($R=0.63$)



Cause of variance in winter dust AOD	
Region	Source 10-m wind speed
Coastal Africa	31%
Barbados	32%
Cayenne	26%

- Large scale changes in source wind account for a 30% of the variance in AOD downwind



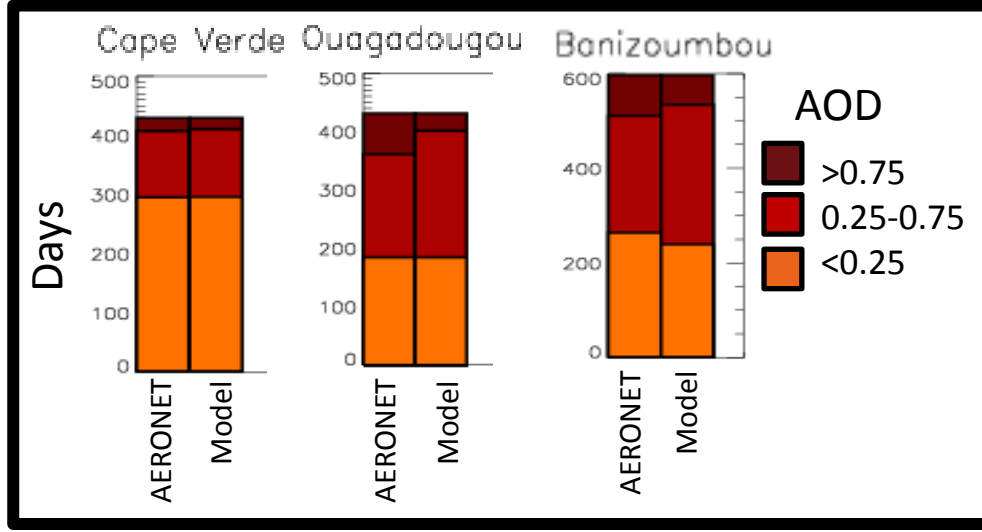
Two Answers:

1. GEOS-Chem captures the trend and variability in wintertime AOD downwind
2. Land use changes do not seem to drive changes in dust (dust variability is primarily controlled by meteorology)



What about summer?

Winter



Summer

