Improvements in Aerosol Microphysics, Radiation, and Chemical Interaction in the GEOS Chemistry-Climate Model: Applications to Atmospheric Brown Clouds

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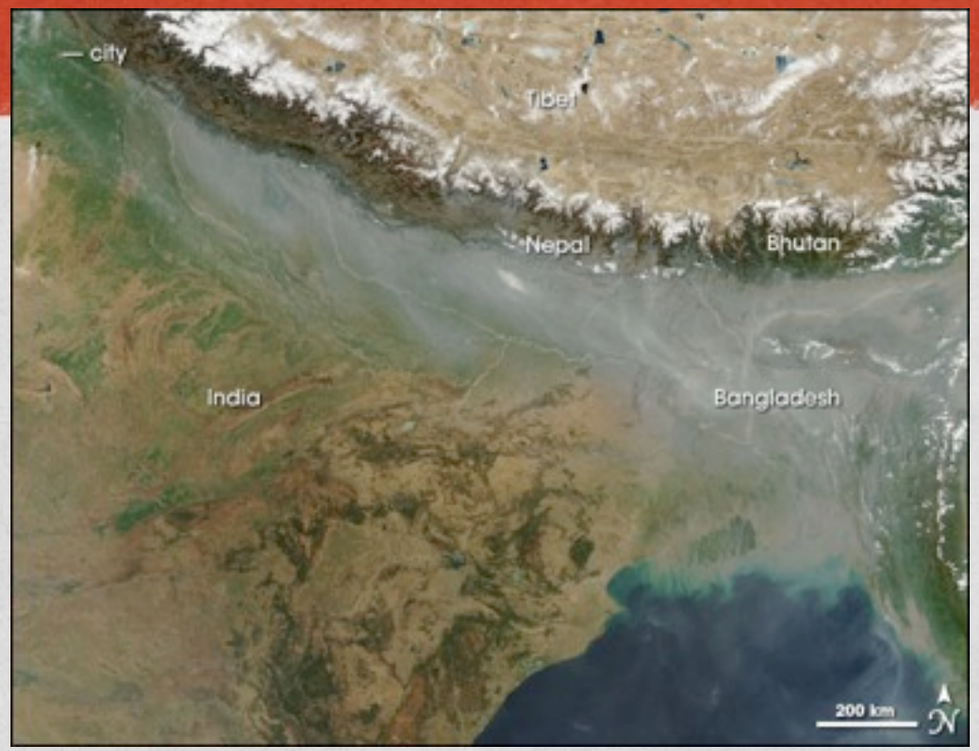
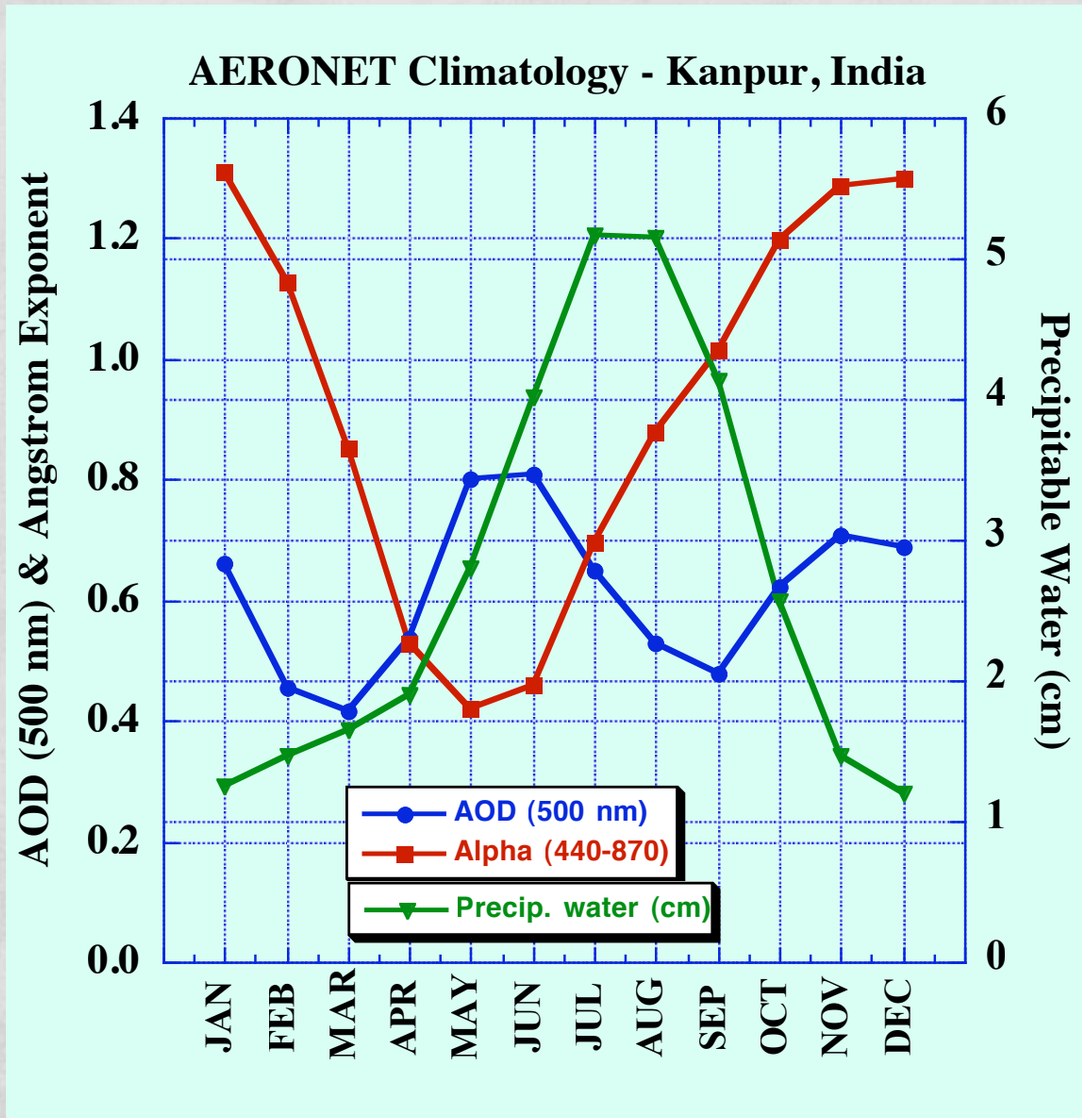
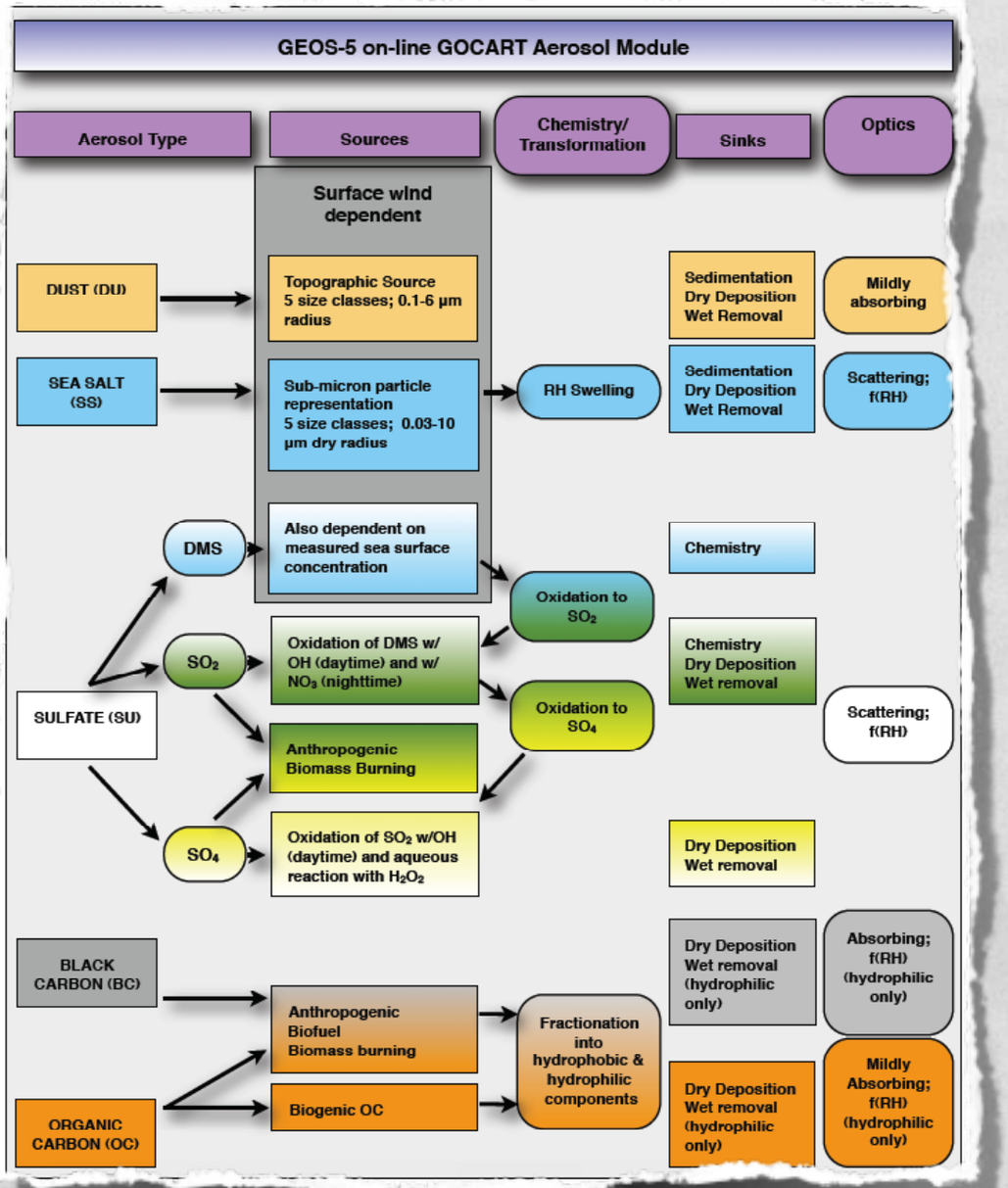
MOTIVATION

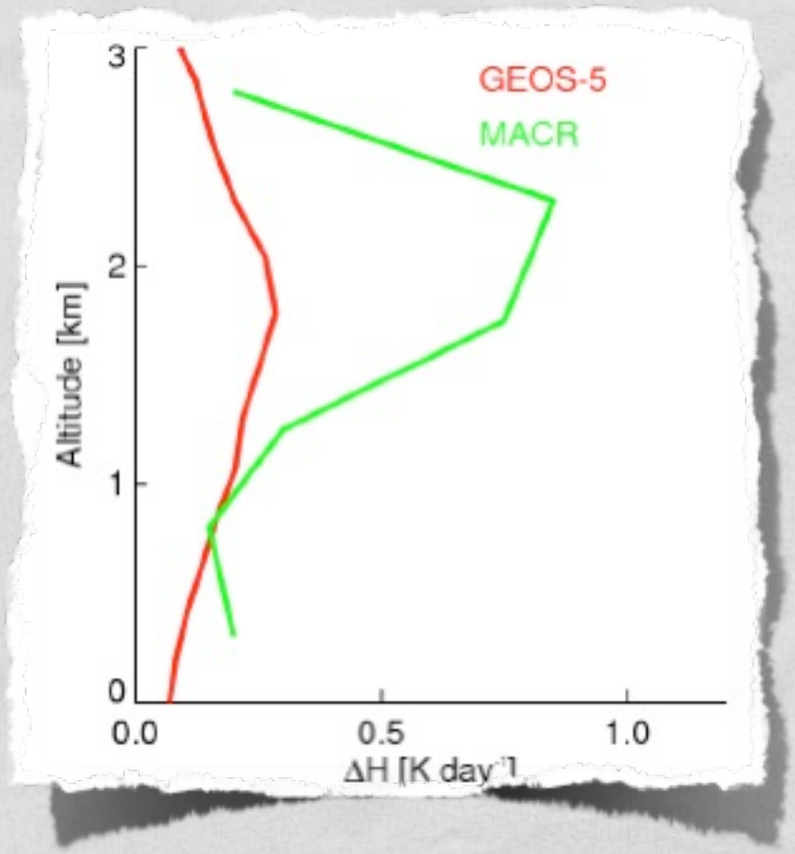


- Understand the nature of Indian aerosol environment
- Elucidate role of aerosol burden and composition in modulating Indian climate
- Improve treatment of aerosol composition and direct effects in CCM
- Introduce aerosol/chemistry interaction in CCM



PREVIOUS WORK





- Implemented online GOCART aerosol module in GEOS-5
- Forcing model with climatological aerosols does not reproduce observed heating rates

AEROSOL DIRECT/SEMI-DIRECT EFFECT

PIESA Experiments

(Preliminary Integrated Earth System Analysis -- http://geos5.org/wiki)

Aerosols[1]	Radiation[2]/ Meteorology[3]	Purpose
climatology	climatology interactive/ non-interactive	Control Run (complete); aerosol direct & semi-direct forcing from prescribed aerosol climatology
GOCART transported (tracer only)	non-interactive/ GOCART interactive	No Aerosol Forcing. What do the climate and aerosol distributions look like if there is no aerosol forcing?
climatology & GOCART transported (tracer only)	climatology interactive/ GOCART interactive	What aerosol distributions are consistent with the forcing (and climate) from the aerosol climatology?
GOCART transported	GOCART interactive/ GOCART interactive	What do the climate and aerosol distributions look like if they are internally consistent?

1. Aerosol forcing (if present) is from (a) a prescribed climatology or (b) on-line GOCART aerosols; note that GOCART aerosols may be run as passive tracers even when climatology forcing is used.

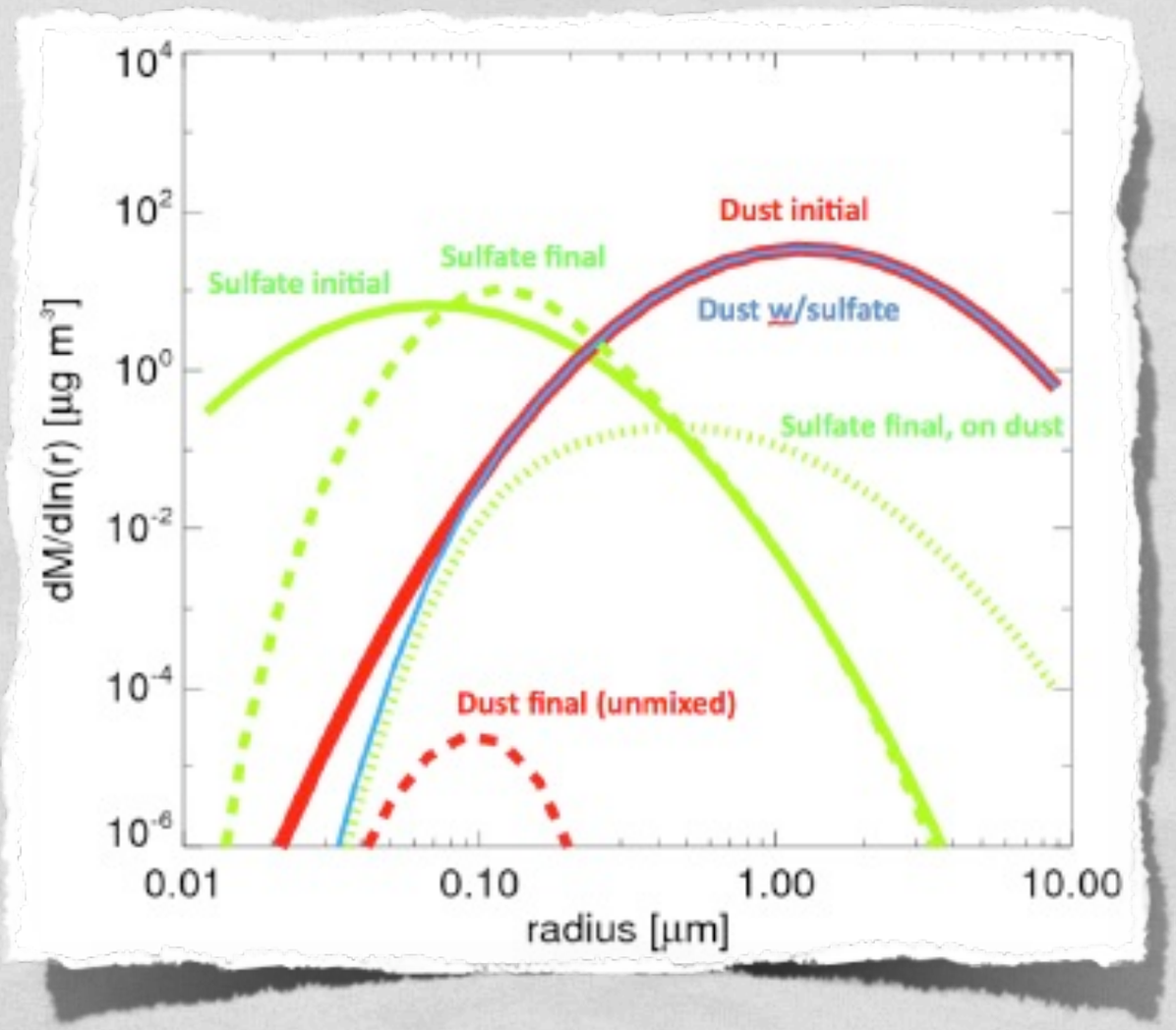
2. In the context of radiation, "interactive" means aerosol direct and semi-direct effects present.

3. In the context of meteorology, "interactive" means model meteorology affects aerosol processes (e.g. wet deposition); this term only applicable to GOCART aerosols. "Non-interactive" applies to the aerosol climatology, which is prescribed from an off-line source.

IMPROVEMENT IN AEROSOL MICROPHYSICS

- CARMA - Community Aerosol and Radiation Model for Atmospheres
  - highly configurable sectional cloud/ aerosol microphysics model
  - treatments of aerosol growth, coagulation, nucleation, sedimentation
  - core/shell Mie scattering code

- Build toward increasing sophistication in CARMA:
  - e.g., how does CARMA dust distribution differ from GOCART?
  - e.g., how does interaction of dust and anthropogenic aerosol influence particle size distribution/lifetime?
  - e.g., how does interaction of aerosol affect optical properties, climate?



CHEMISTRY/AEROSOL INTERACTIONS

- Current GOCART package relies on climatological oxidant fields, e.g., OH, H_2O_2, NO_3
- That climatology of oxidants did not itself come from simulations with interactive aerosols
- Seek to investigate the two-way interaction of aerosols and chemistry:
  - aerosol module (GOCART or CARMA) provide aerosol surface area and optical parameters to chemistry to drive, e.g., photolysis and heterogeneous chemistry
  - chemistry will provide oxidant fields to drive, e.g., sulfate cycle

PROPOSED ACTIVITIES

- Evaluate GOCART in current GEOS-5 (hindcast/replay)
- Complete CARMA integration and evaluate (hindcast/replay)
- Implement chemistry/aerosol coupling
- Evaluate aerosol/chemistry/ climate interactions

Table 1. Proposed simulation scenarios.

Replay scenarios – meteorology from MERRA analyses

#	*Type*	*Period*	*Description*
1	Replay	1999 – 2010	Current GOCART
2	Replay	1999 – 2010	Aerosols as in #1 with chemical interaction turned on
3	Replay	1999 – 2010	GOCART/CARMA simulation with improved aerosol optical tables
4	Replay	1999 – 2010	Aerosols as in #3 with chemical interaction turned on

Climate scenarios – meteorology from model GCM

#	*Type*	*Period*	*Description*
5	Climate	2001 – 2010	Present day run of aerosols setup as in #3 (Control)
6	Climate	2001 – 2010	As in #5, but with chemical interaction turned on
7	Climate	2041 – 2050	Future run with aerosols as in #3 and two IPCC storylines (A2 & B1) for future aerosol emissions, GHGs, and SSTs (see, e.g., Nakicenovic et al., [2000])
8	Climate	2041 – 2050	Repeat #7, but hold aerosol forcings fixed to Control case #5 levels to get at effects of GHG changes only
9	Climate	2041 – 2050	Repeat #7, but hold SSTs fixed to present-day
10	Climate	2041 – 2050	Repeat #7, but forcing from prescribed aerosols to explore the importance of offline versus online aerosol treatment
11	Climate	2041 – 2050	Repeat #7, but use GOCART style aerosols to get at importance of external versus internal mixing of aerosols
12	Climate	2041 – 2050	As in #7, but with chemical interaction turned on

"CORE GROUP" INTERACTIONS

- Evaluations of GOCART aerosol simulations driven with MERRA analyses will leverage work of Chin/GMAO stimulus package
- GOCART/CARMA interaction with chemistry will be with Bian, Duncan, Stolarski, Prather efforts

TIMELINE

- Year 1
  - PIESA experiments
  - Hindcast evaluation of GOCART
  - CARMA Integration
- Year 2
  - Hindcast evaluation of CARMA
  - “Complex” optical models of aerosols
  - Preliminary aerosol/chemistry integration (GOCART)
- Years 3 & 4
  - Coupled chemistry/aerosol/climate simulations (GOCART & CARMA)
  - papers
  - papers
  - more papers