

Geophysical Fluid Dynamics Laboratory Review

June 30 - July 2, 2009



Aerosol-Cloud-Climate Interactions

Presented by

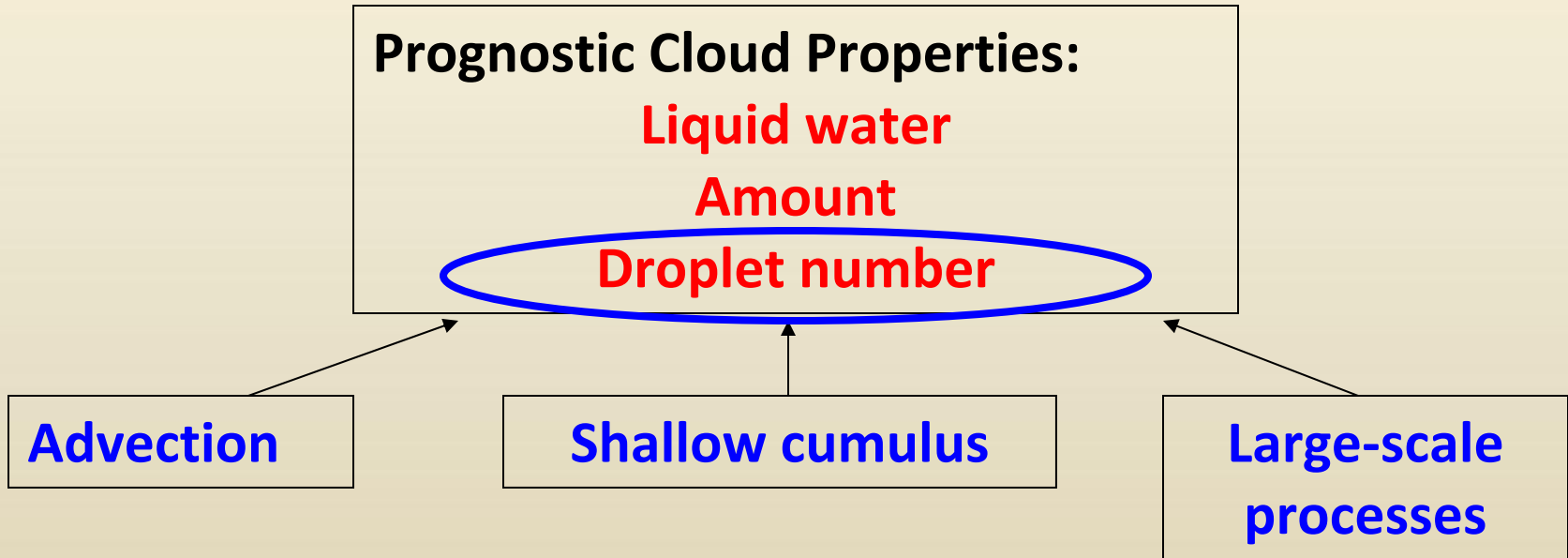
Yi Ming

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A prognostic treatment of aerosol-liquid cloud interactions

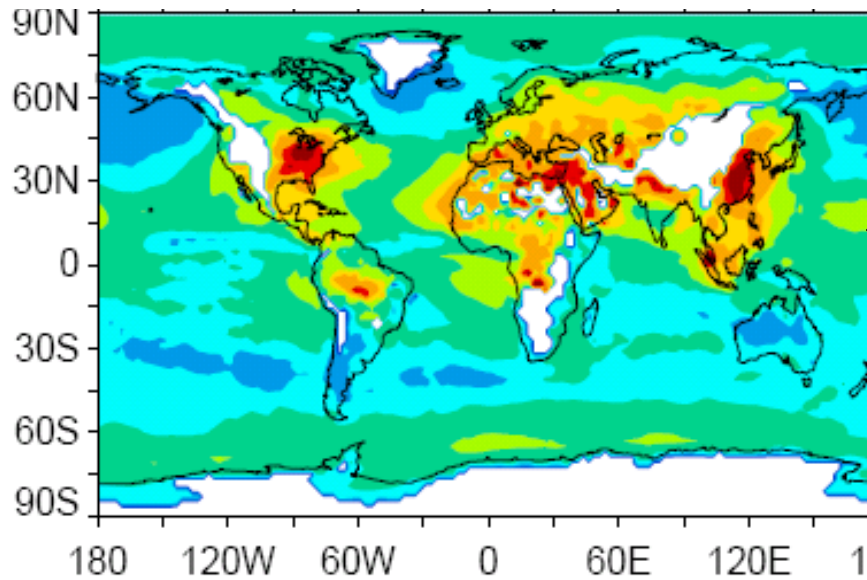


- Source and sink terms are fully consistent
- Multiple aerosol species (i.e., sulfate, organic carbon and sea salt) are activated
- Droplets evolve freely with model meteorology

Ming et al. JAS (2006, 2007)

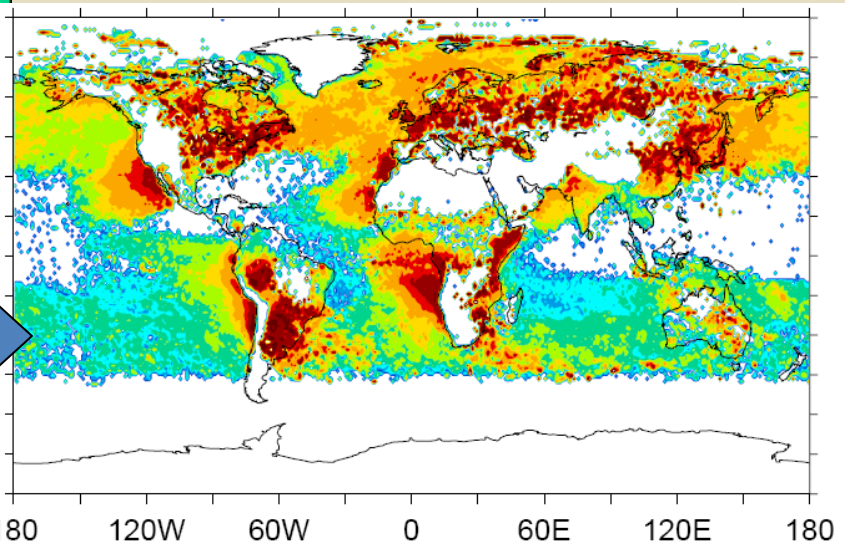
Comparison of AM3-simulated droplet number distribution with satellite data

Cloud droplet number concentration (cm^{-3}) in July at 925 hPa

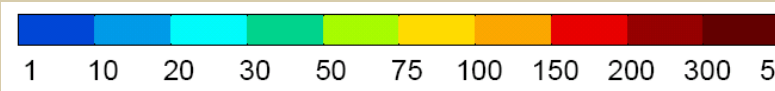


← **AM3**

Derived from MODIS-retrieved cloud effective radius and optical depth



Bennartz (2007)



An evolving understanding of aerosol climate impacts

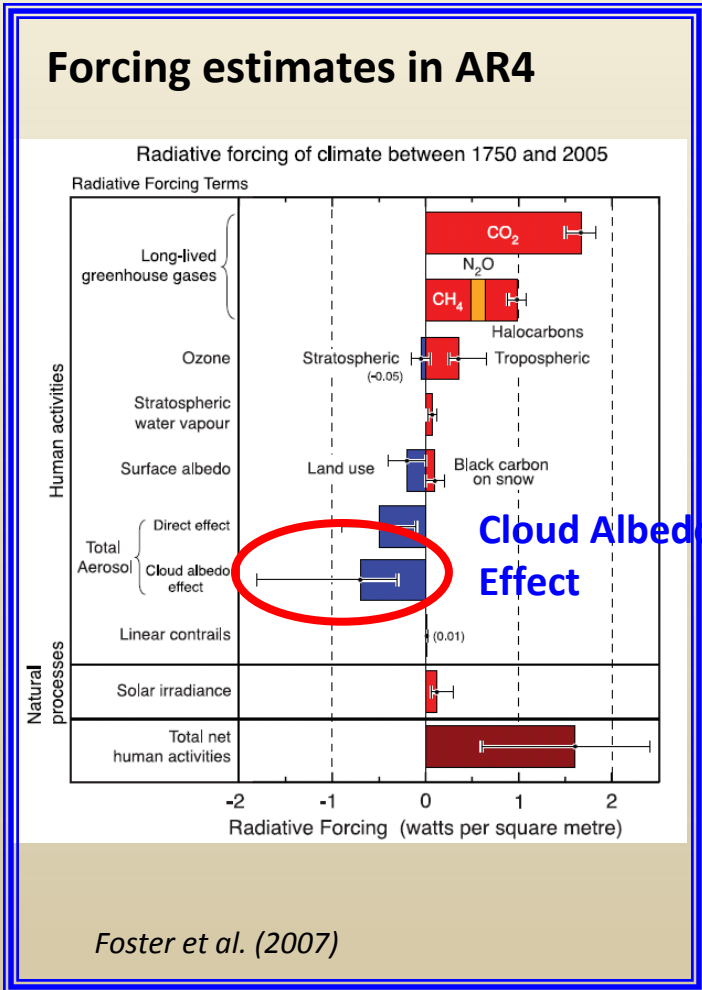
Anthropogenic aerosol radiative flux perturbation (RFP, $W m^{-2}$) at TOA from pre-industrial to present-day

	AM3 (to be used for AR5)	AM2 (used for AR4)
Direct effects – Sulfate and organic carbon	0 (assuming internal mixing of sulfate and black carbon)	-1.3 (external mixing)
Direct effects - Black carbon		0.5 (external mixing)
Indirect effects	-1.3	Not included

An approach to narrowing down the uncertainties in aerosol indirect effects

Dissecting indirect effects on the process level

Forcing estimates in AR4



Emissions

GCM Dynamics & Physics

Wet Removal

Dry Aerosols

Activation

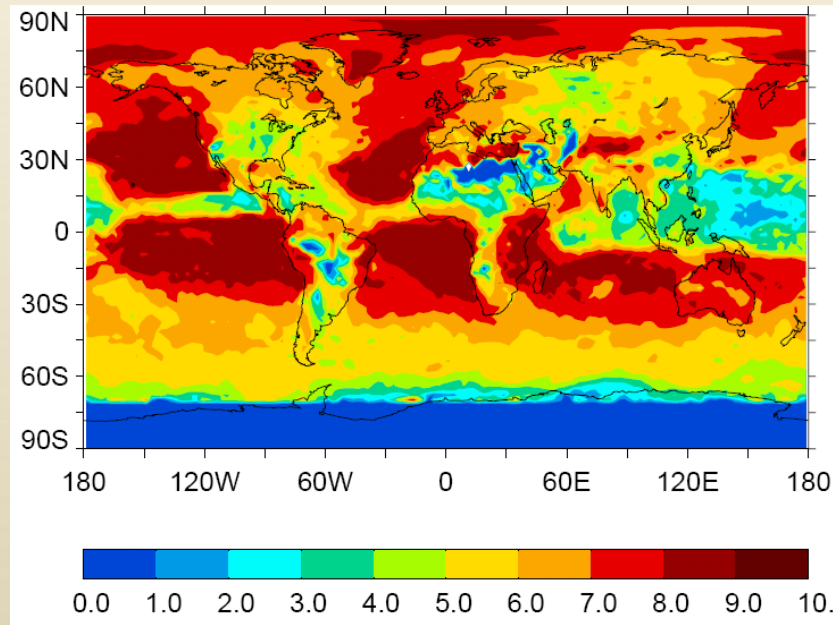
Cloud Droplets

Albedo Susceptibility

Cloud Albedo

Comparison of AM3-simulated cloud albedo susceptibility with satellite data

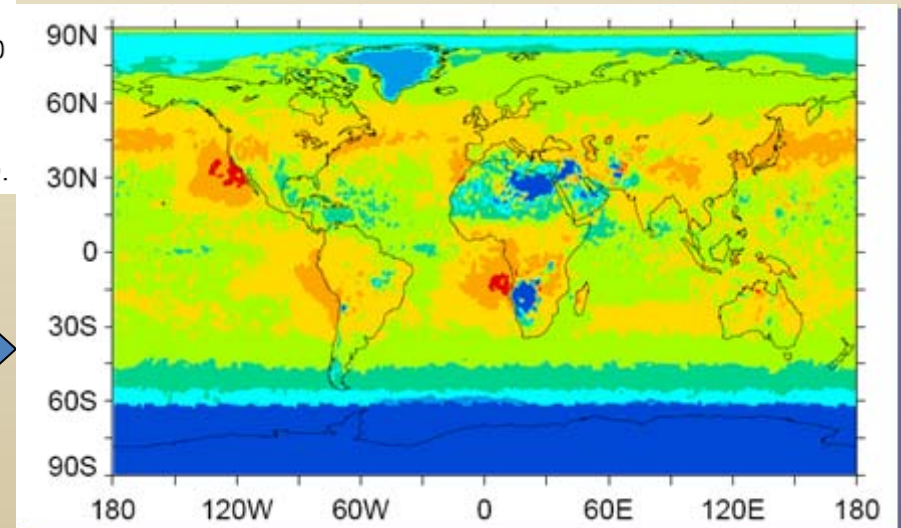
Difference in cloud albedo (x1000) caused by a uniform 10% increase in droplet number in July



← **AM3**

MODIS →

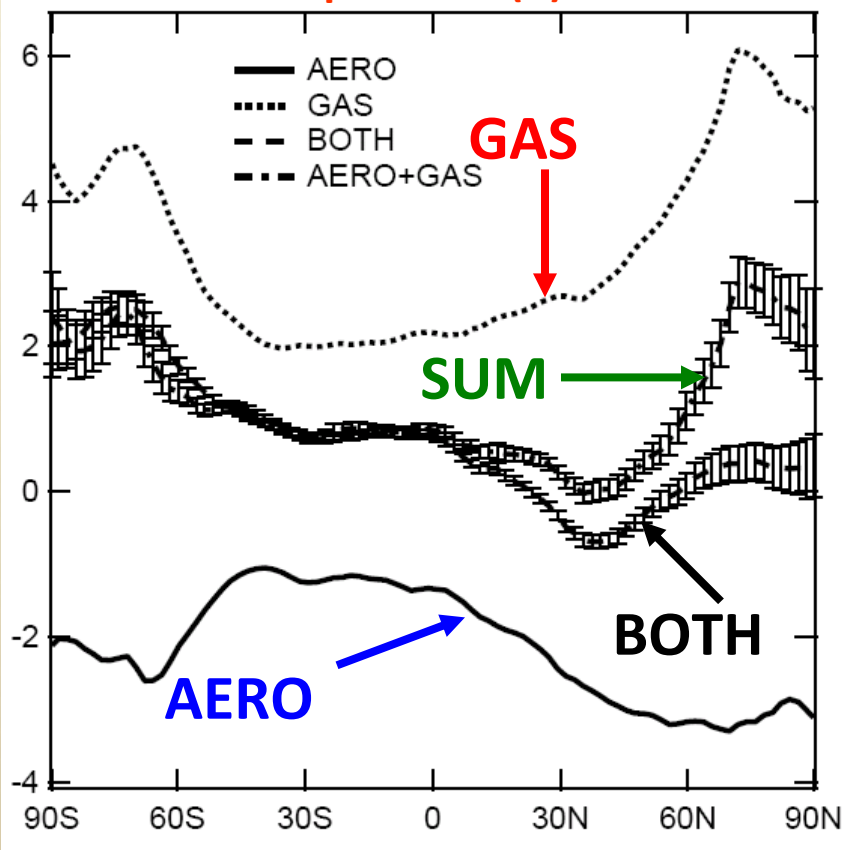
Oreopoulos and Platnick (2008)



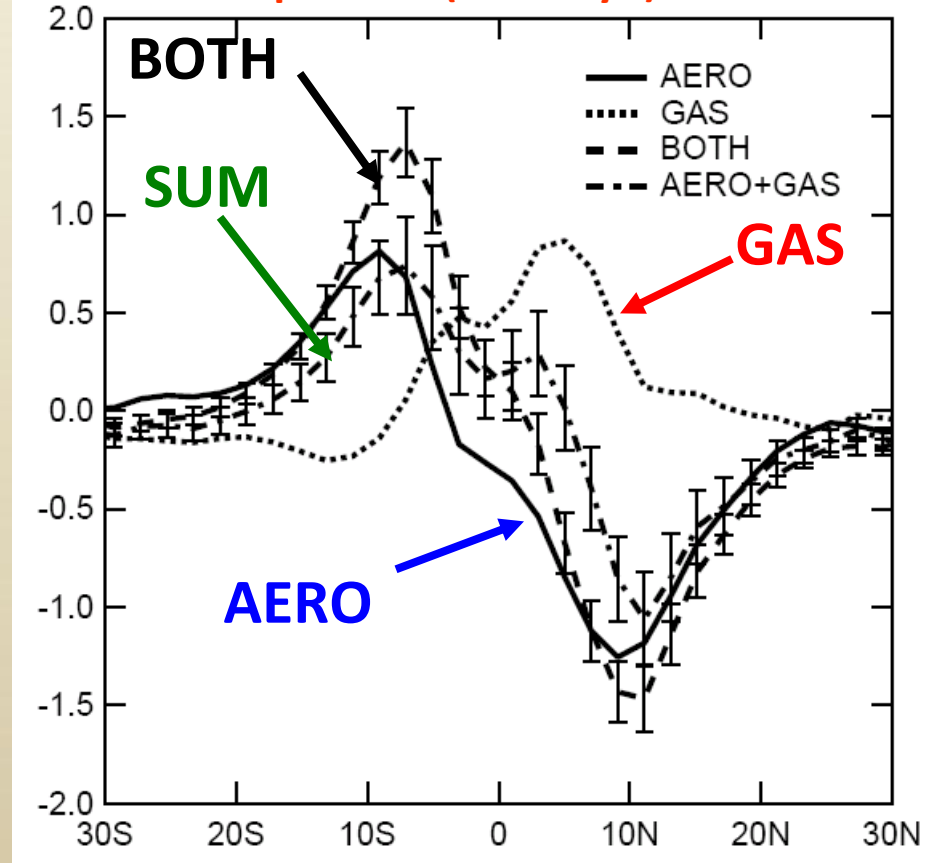
Aerosols are important for understanding regional climate change

Zonal-mean responses to aerosol direct and indirect effects simulated with a modified AM2.1 coupled to a slab ocean model

Surface temperature (K)



Precipitation (mm day⁻¹)



Ming and Ramaswamy (2009)

- **In AM3, a prognostic scheme of droplet number establishes a physical link between aerosols and clouds;**
- **Strong cooling caused by anthropogenic aerosol indirect effects is present at TOA;**
- **Theories, models and measurements are used to better constrain indirect effects;**
- **Aerosol-induced circulation changes need to be studied more thoroughly.**

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