AEROSOL-CLOUD INTERACTIONS

TOPICS

- *Current uncertainties in the indirect effect*
- *Process treatments*
- *Climate impacts*

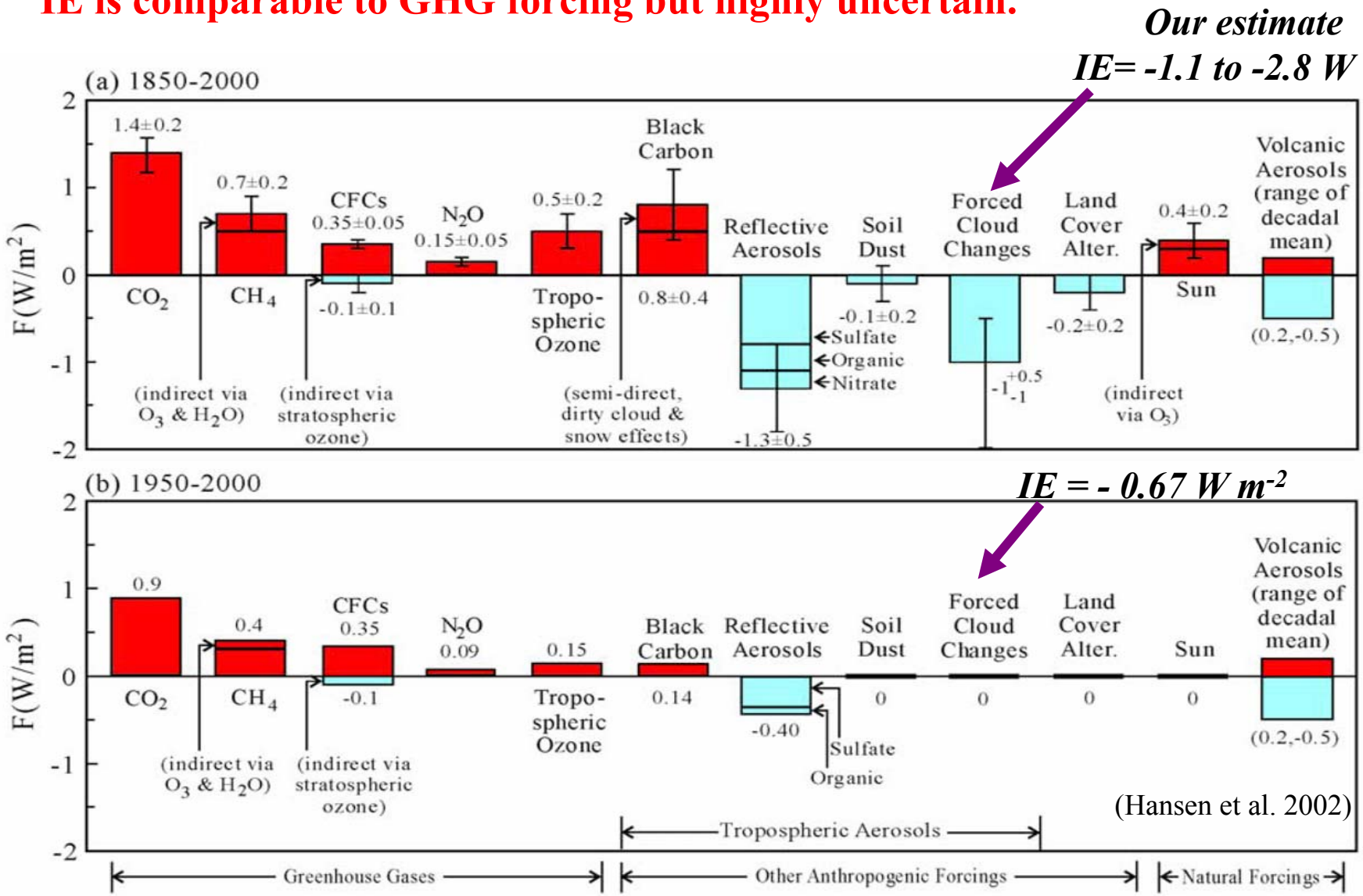
Aerosol-cloud interactions

What are the sources of uncertainty when representing the aerosol indirect effects?

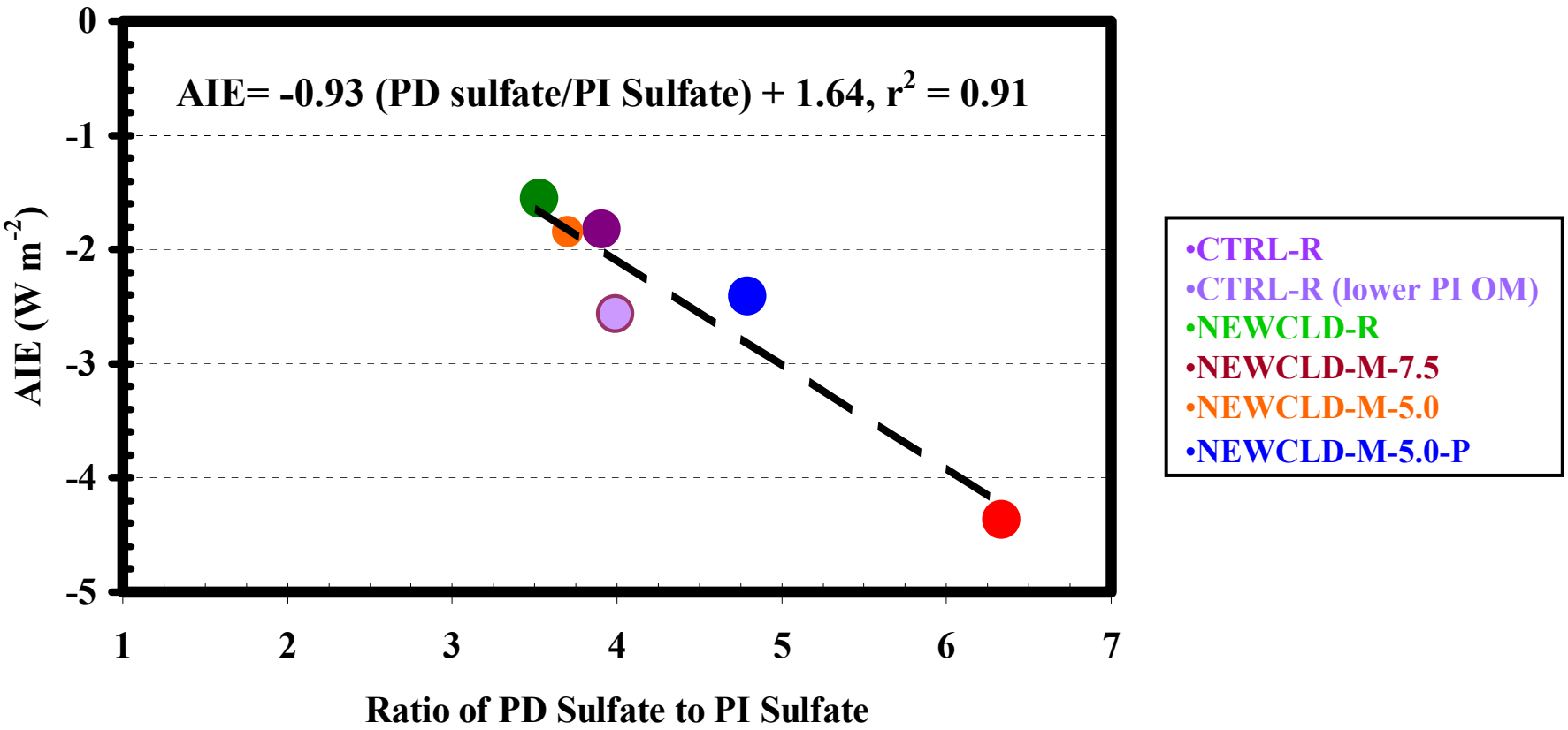
- **Background/total aerosol burdens**
- **Aerosol solubility/mixing state, size distribution**
- **Aerosol - Cloud droplet number relationship**
- **Aerosol/cloud vertical distribution**
- **Precipitation parameterization**
- **Dynamical effects, Associated feedbacks**

Indirect Effect (IE) and Climate Forcings

IE is comparable to GHG forcing but highly uncertain.



Indirect effect versus aerosol burden



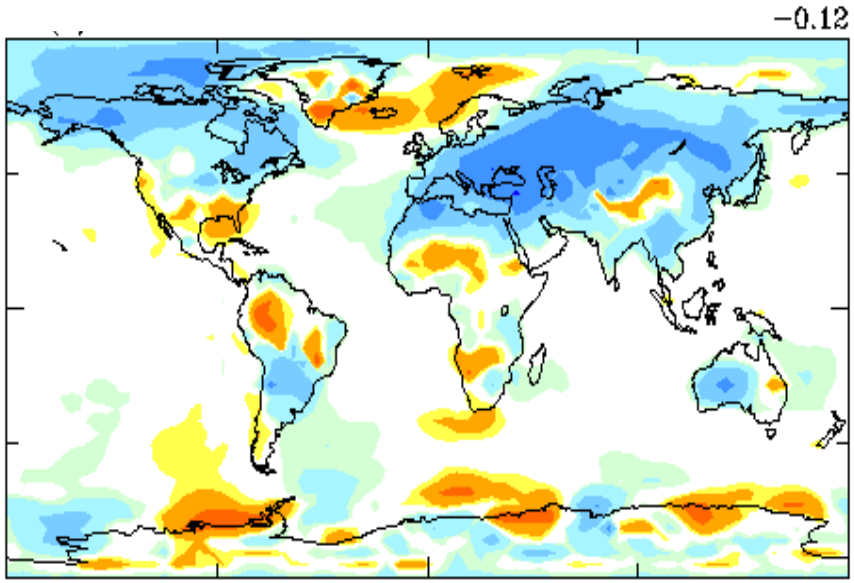
Annual surface temp. changes(K) from 1850 to present

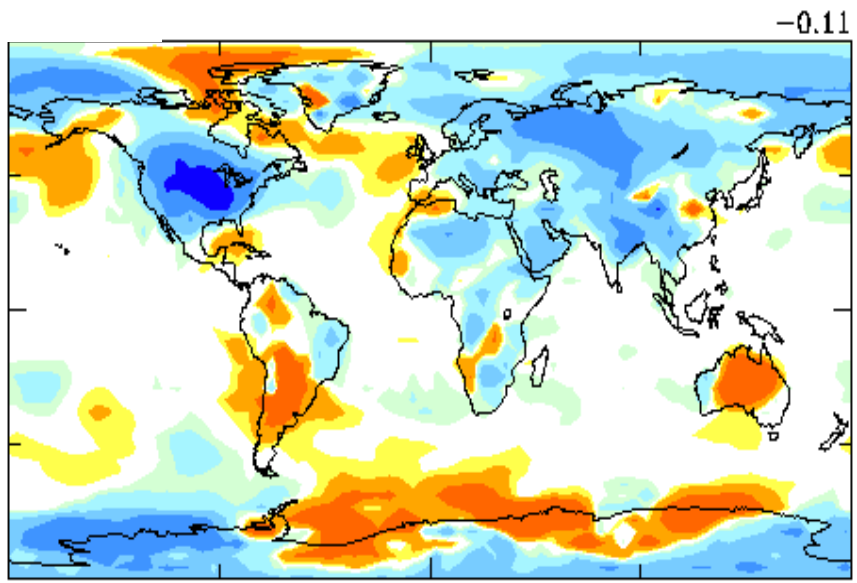
Sensitivity to background concentrations

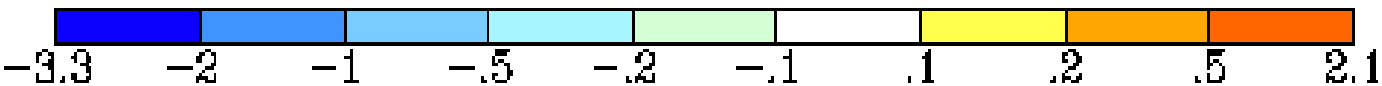
N (cloud droplet number concentration) = f(aerosol mass [Menon et al. 2002], cloud turbulence and cloud cover)

Nmin=10 cm^{-3}, IE= -2.1 W m^{-2}

Nmin=40 cm^{-3}, IE= -1.1 W m^{-2}







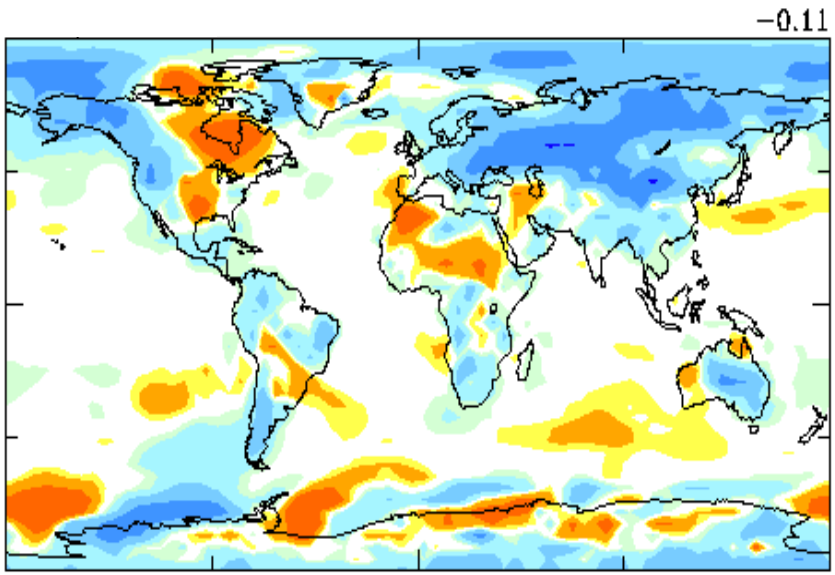
Annual surface temp. changes(K) from 1850 to present

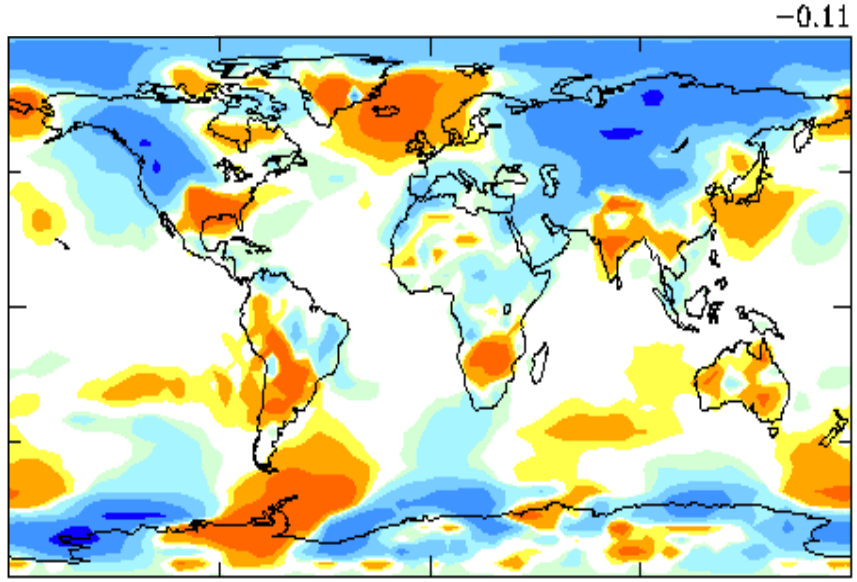
Sensitivity to black carbon absorption

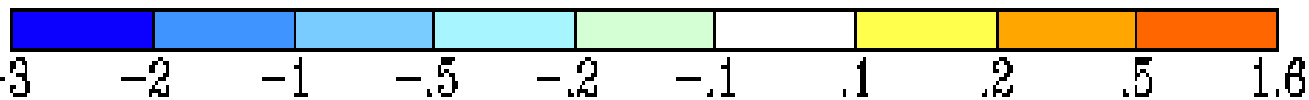
N =f(aerosol number concentration [Gultepe and Isaac, 2000], cloud turbulence and cloud cover)

Without black carbon effects in cloud droplets, IE = - 1.96 W m^{-2}

With black carbon effects in cloud droplets, IE = - 1.73 W m^{-2}







Future Direction

Integration of satellite retrievals, laboratory tests, field programs

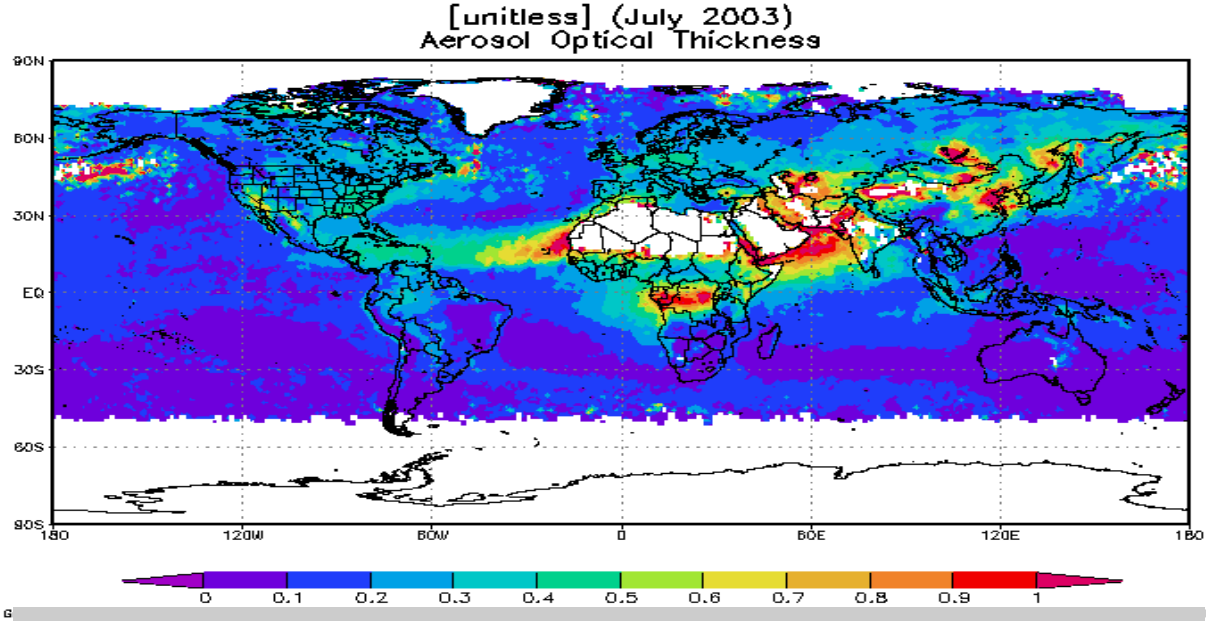
- **Optical and physical properties of internally mixed aerosols**
  Logic of separating BC from OC
- **Aerosol solubility, Aerosol Distribution - horizontal and vertical**
- **Constraining results over last 20 years**
- **Sub-grid aerosol properties**
- **Sub-grid turbulence effects**
- **Sub-grid Precipitation parameterization**
- **Decoupling dynamical and feedback effects**

GISS GCM vs. ISSCP cloud vertical structure

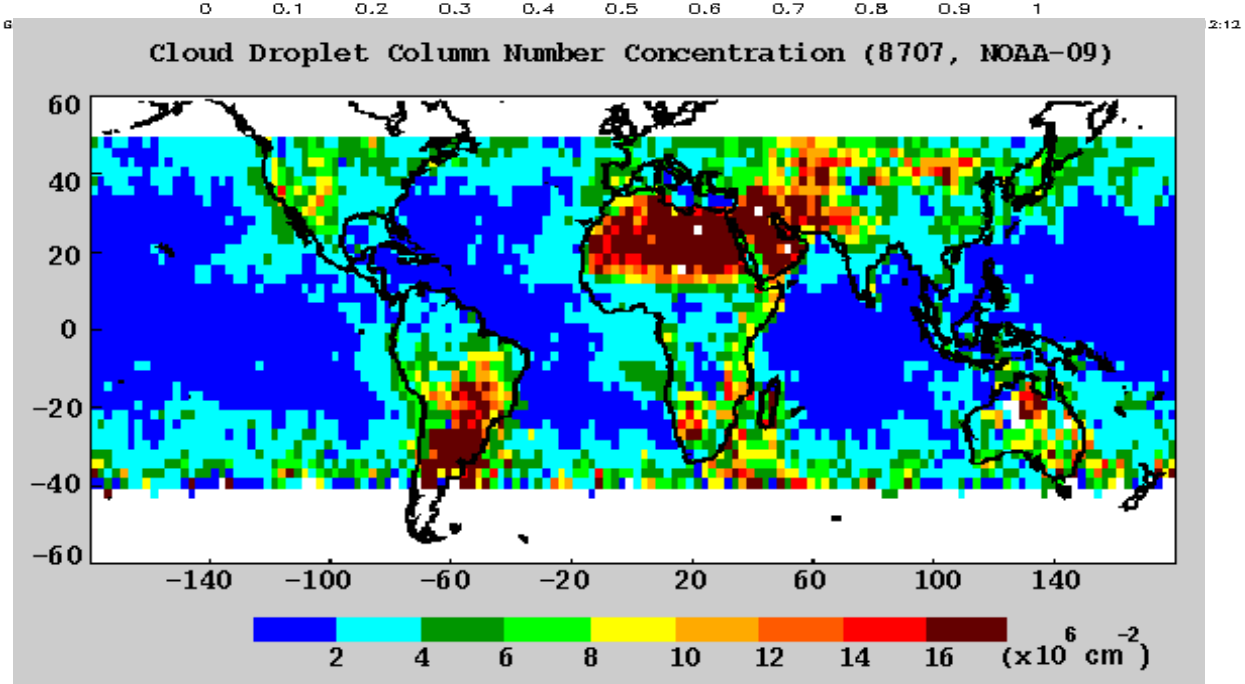
Freq. of occurrence of low-level cld tops (%) for January

Ptop (hPa)	964	934	898	860	805	740	*854*	*720*
CTRL		26					43	31
ISCCP	7	7	13	18	27	29		
R-18	7	10	30	25	18	10		

Satellite Data



MODIS



ISCCP

Things we know we don't know that we would like to know

Using satellite retrievals for model simulations

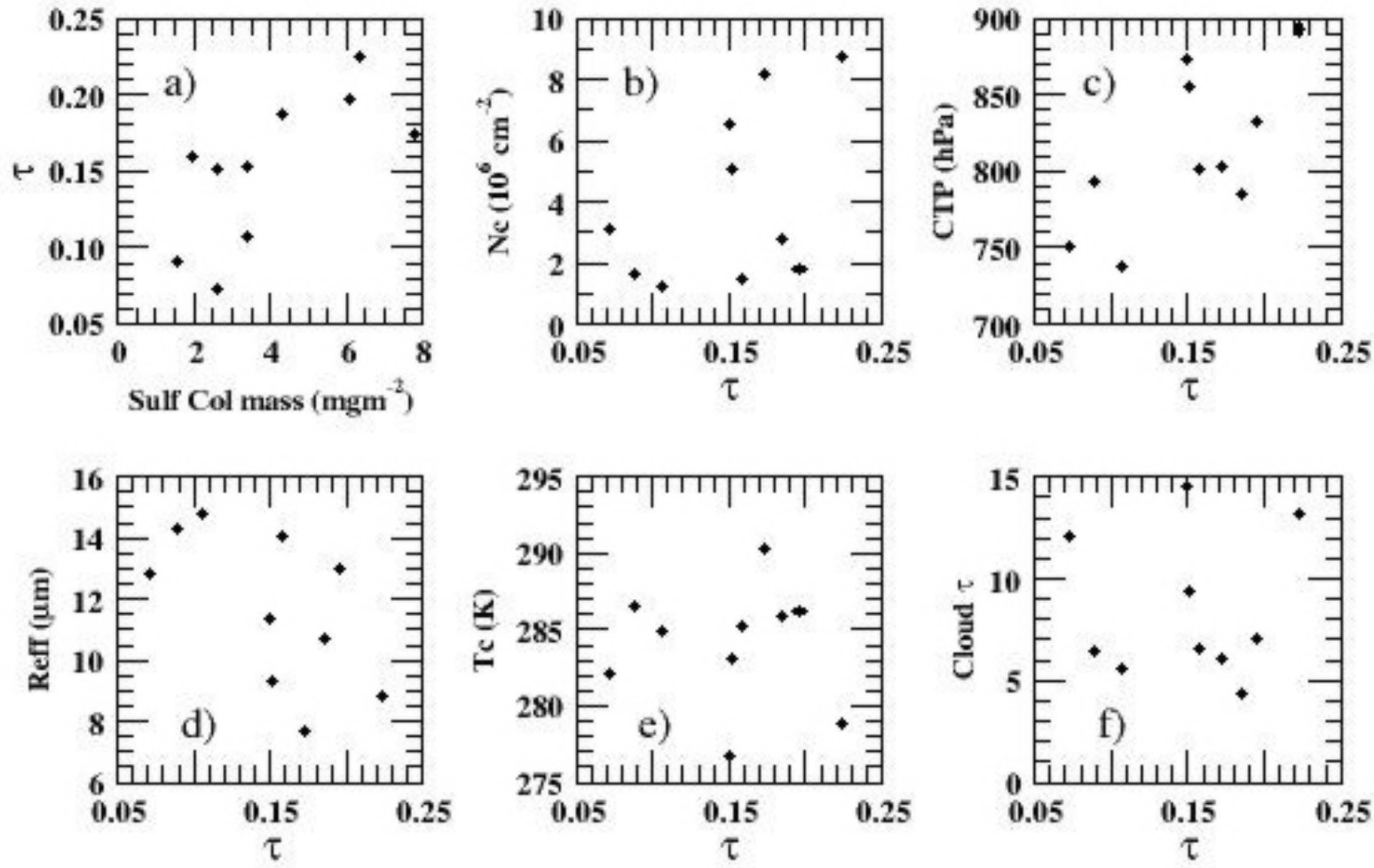
Besides aerosol effects on clouds, cloud properties are controlled by meteorology.

Therefore, for similar dynamical regimes one can look at

Scatter plots of aerosol optical thickness versus

1. **Nc (Col. Droplet Number concentration),**
2. **Cloud droplet radii,**
3. **Cloud top temperatures,**
4. **Cloud top pressure,**
5. **Cloud optical thickness**
6. **Cloud cover**

AVHRR and ISCCP products



Priorities for indirect effect

- **Optical and physical properties of internally mixed aerosols**
  Logic of separating BC from OC
- **Aerosol solubility, Aerosol Distribution - horizontal and vertical**
- **Constraining results over last 20 years**
- **Sub-grid aerosol properties**
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Model simulated column droplet number (10^6 cm^{-2})