JRC AeroCom Meeting Ispra, March 12, 2004

# **AEROSOL-CLOUD INTERACTIONS**

# **TOPICS**

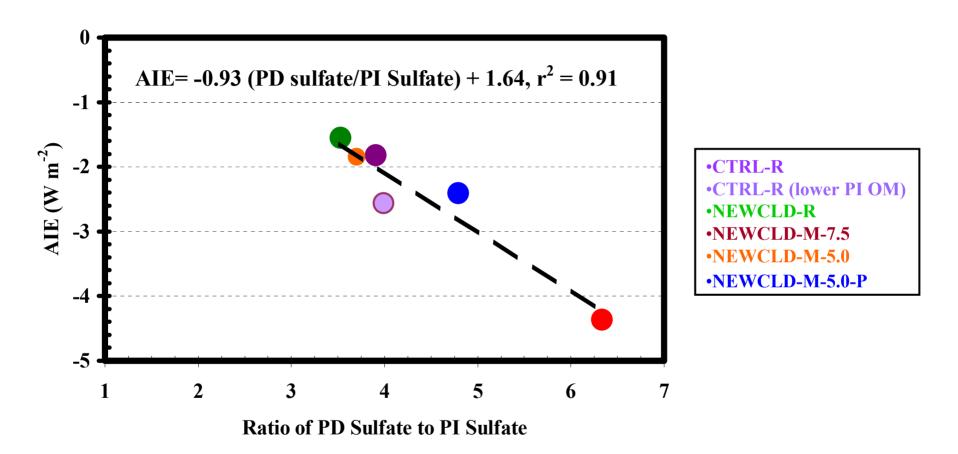
- Current uncertainties in the indirect effect
- **Process treatments**
- Climate impacts

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. Our estimate $IE = -1.1 \text{ to } -2.8 \text{ W m}^{-2}$ (a) 1850-2000 2 $1.4 \pm 0.2$ Black Volcanic Carbon Aerosols 0.7±0.2 1 (range of 0.5±0.2 CFCs Land Forced N<sub>2</sub>O $0.4 \pm 0.2$ decadal $0.35 \pm 0.05$ Cloud Reflective Soil Cover $F(W/m^2)$ 0.15±0.05 mean) Changes Alter. Aerosols Dust + Sun CH<sub>4</sub> CO, Tropo- $0.8 \pm 0.4$ $-0.1\pm0.1$ $-0.1\pm0.2$ spheric $-0.2\pm0.2$ (0.2, -0.5) ←Sulfate Ozone ←Organic -1 -1<sup>+0.5</sup> < Nitrate (indirect (indirect via (indirect via (semi-direct. 0, & H,O) stratospheric dirty cloud & via O<sub>3</sub>) snow effects) ozone) $-1.3\pm0.5$ -2 $IE = -0.67 W m^{-2}$ (b) 1950-2000 2 Volcanic Aerosols 0.9 1 (range of Forced Land **CFCs** decadal Soil Cover $F(W/m^2)$ 0.4 0.35 N<sub>2</sub>O Black Reflective Cloud mean) Carbon Aerosols 0.15 Dust Changes Alter. Sun 0.09 CO<sub>2</sub> CH<sub>4</sub> -0.1 Tropo-0.14 0 0 0 0 spheric -0.40 (0.2, -0.5)Ozone Sulfate (indirect via (indirect via -1 Organic O2 & H2O) stratospheric (Hansen et al. 2002) ozone) Tropospheric Aerosols -2 → **k** Other Anthropogenic Forcings ≯ ← Natural Forcings → Greenhouse Gases



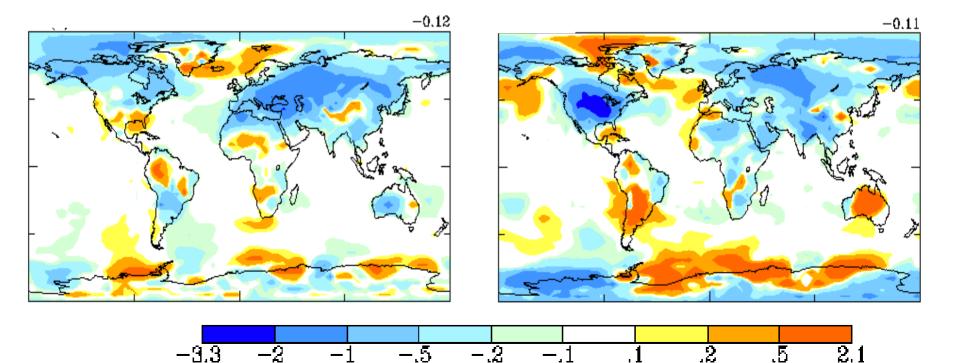
## Annual surface temp. changes(K) from 1850 to present

#### Sensitivity to background concentrations

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

#### Nmin=10 cm<sup>-3</sup>, IE= -2.1 W m<sup>-2</sup>

Nmin=40 cm<sup>-3</sup>, IE= -1.1 W m<sup>-2</sup>

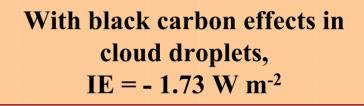


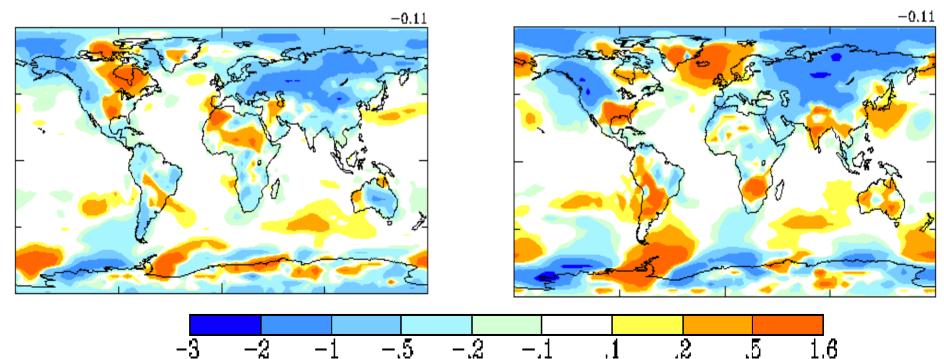
## Annual surface temp. changes(K) from 1850 to present

#### 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<sup>-2</sup>





# **Future Direction**

#### Integration of satellite retrievals, laboratory tests, field programs

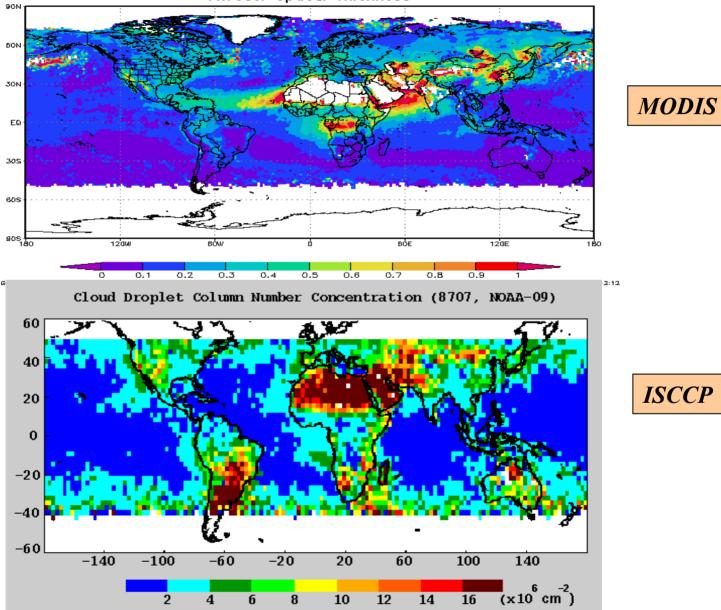
- Optical and physical properties of internally mixed aerosols Logic of separating BC from OC
- Aerosol solubility, Aerosol Distribution horizontal and vertical
- Constraining results over last 20 years
- Sub-grid aerosol properties
- Sub-grid turbulence effects
- Sub-grid Precipitation parameterization
- 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 8	<b>805</b> 54	740	720
CTRL	26 43					31	
ISCCP	7	7	13	18	27	29	
<b>R-18</b>	7	10	30	25	18	10	

## **Satellite Data**

[unitless] (July 2003) Aerosol Optical Thickness

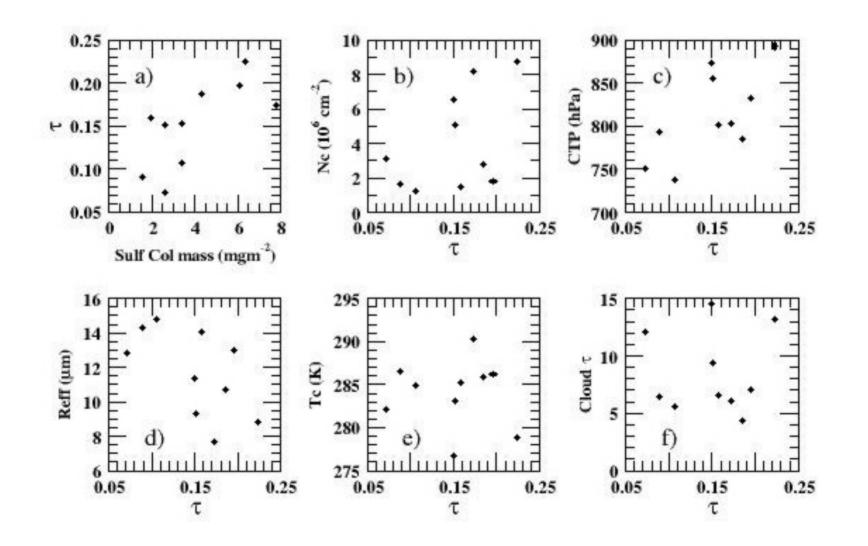


#### Using satellite retrievals for model simulations

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



## **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
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## Model simulated column droplet number (10<sup>6</sup> cm<sup>-2</sup>)

