

Model Validation of CCCma³ AGCM4

**Knut von Salzen¹, Norman McFarlane¹, Jiangnan Li¹, Cathy Reader¹
Glen Lesins², Ulrike Lohmann², Betty Carlin²**

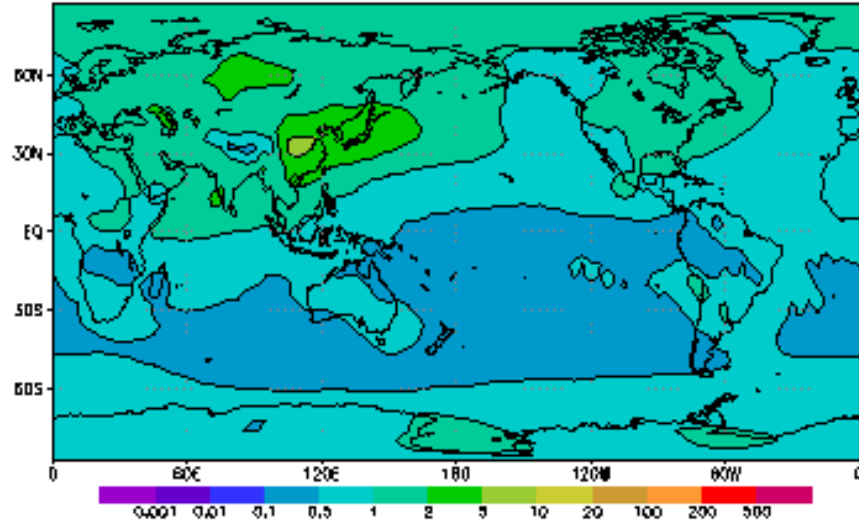
¹ MSC, CCCma, Victoria, British Columbia, Canada

² Dalhousie University, Halifax, Nova Scotia, Canada

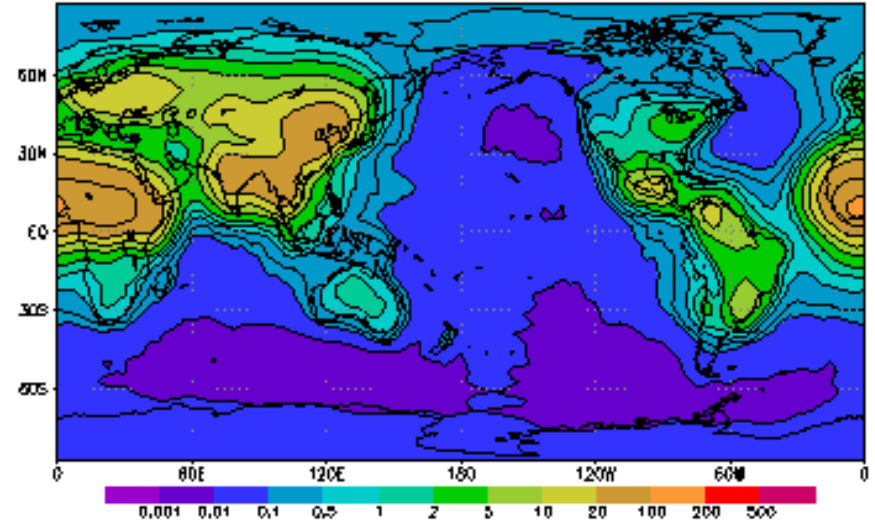
³ Canadian Centre for Climate Modelling and Analysis

January Aerosol Mass Burdens (mg/m²)

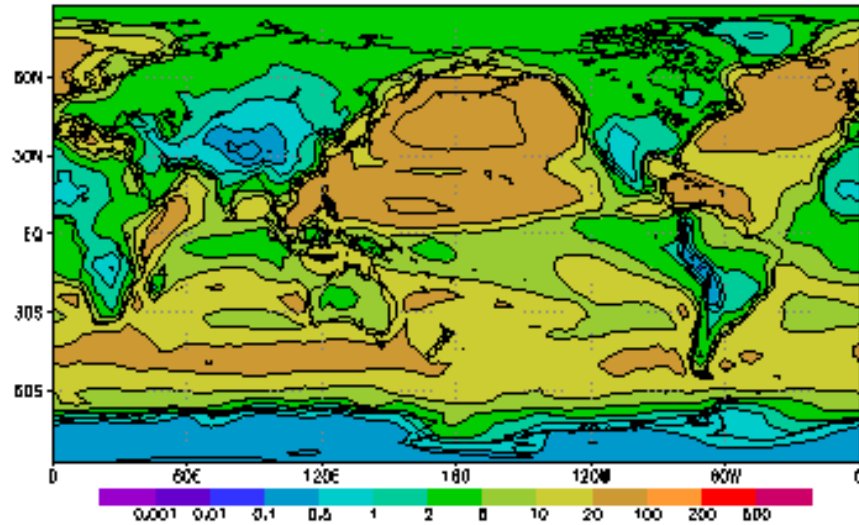
Sulfate



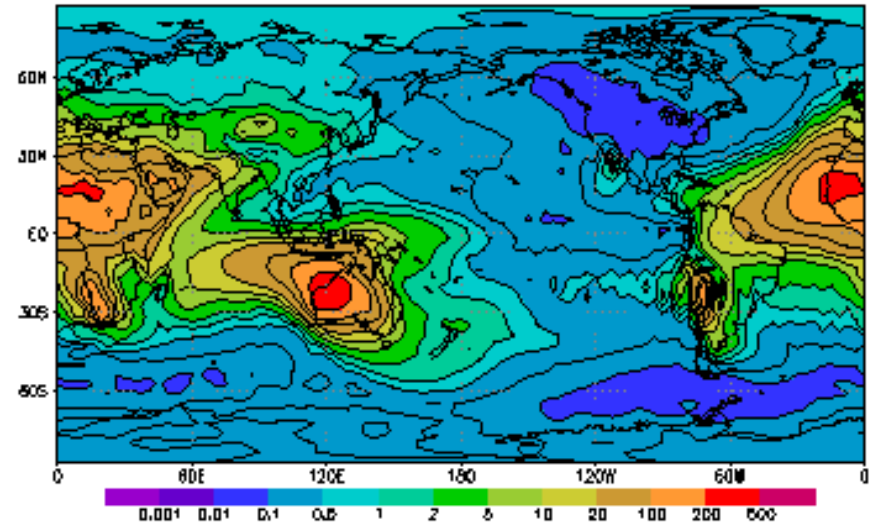
Total Carbonaceous



Total Sea Salt

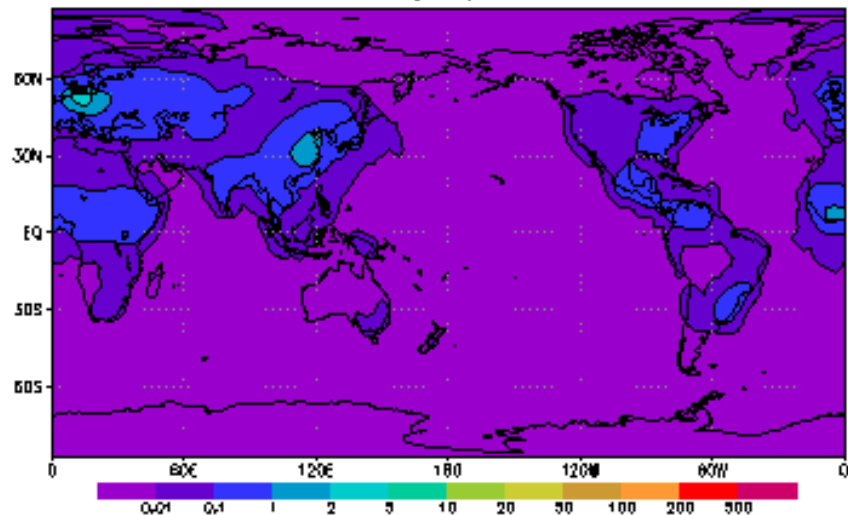


Total Dust

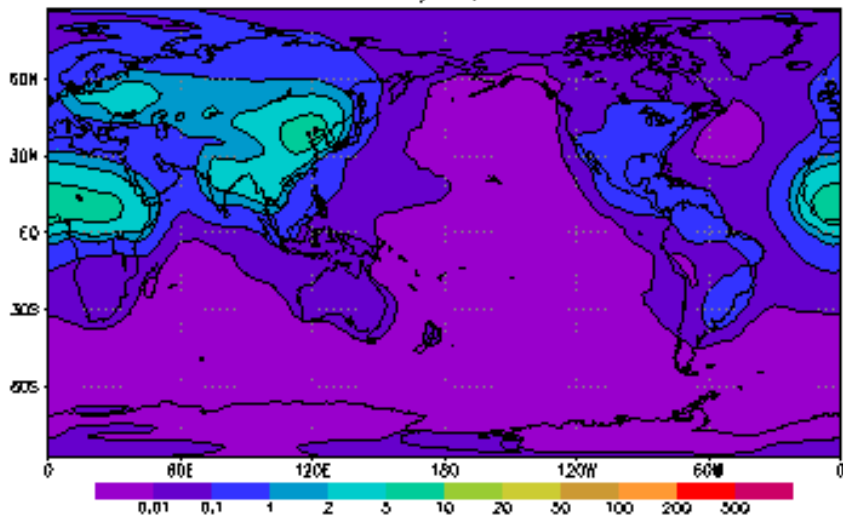


January Aerosol Column Mass Burdens (mg/m^3)

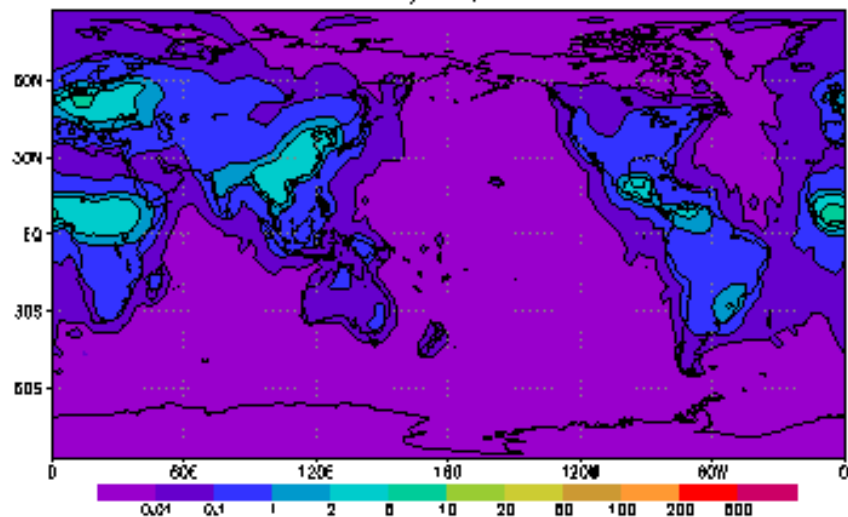
BC Hydrophobic



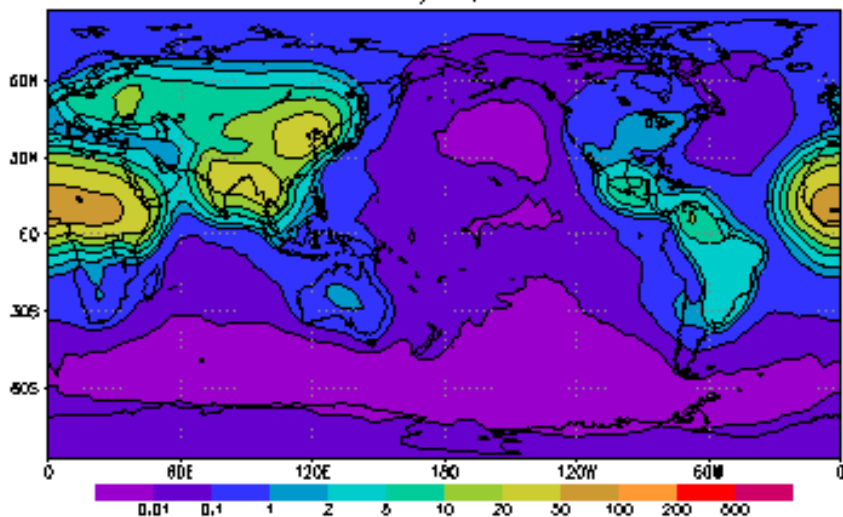
BC Hydrophilic



OC Hydrophobic

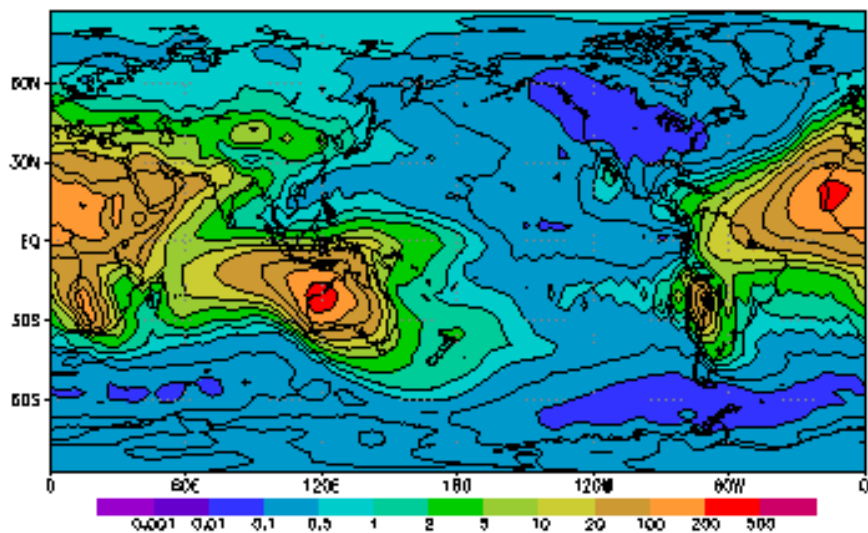


OC Hydrophilic

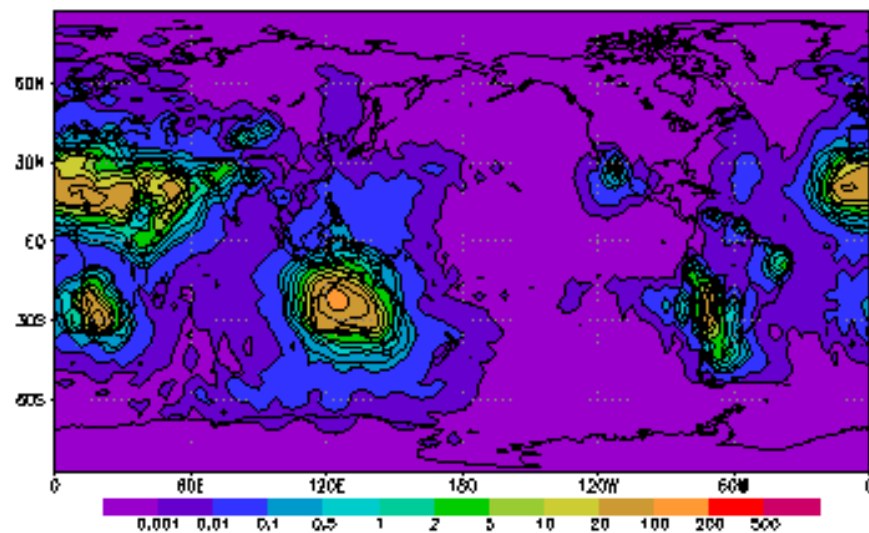


January Aerosol Mass Burdens (mg/m²)

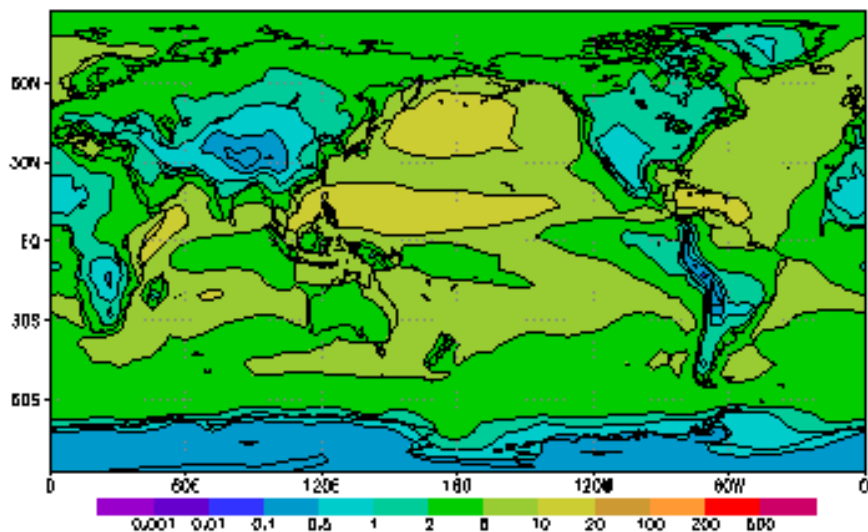
Accumulation Mode Dust



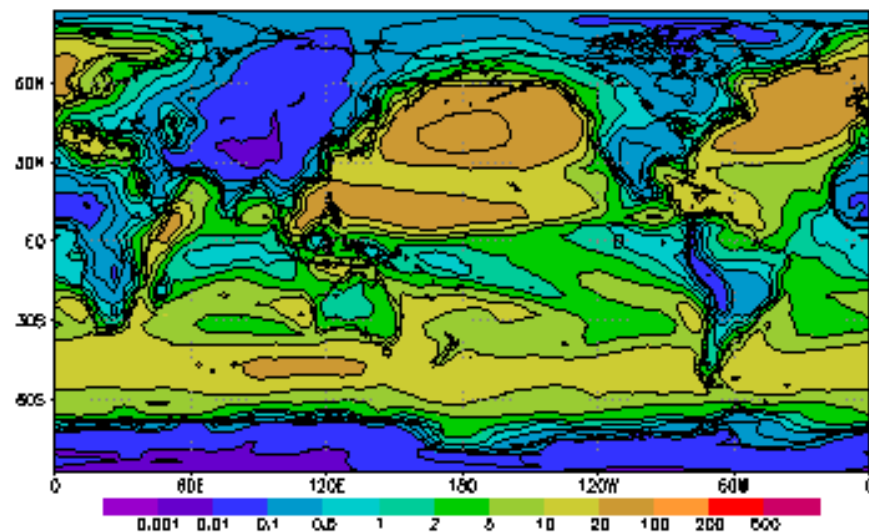
Coarse Mode Dust



Accumulation Mode Sea Salt



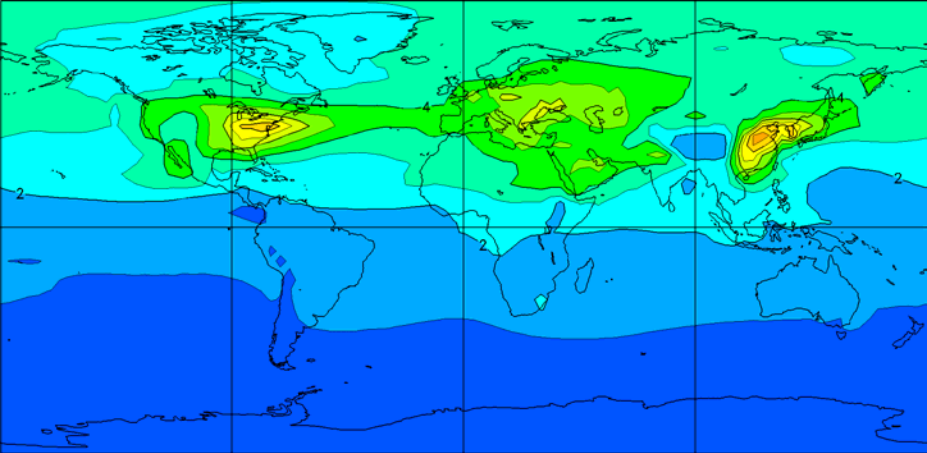
Coarse Mode Sea Salt



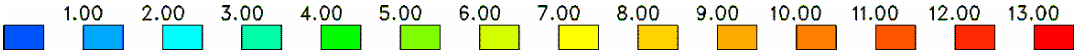
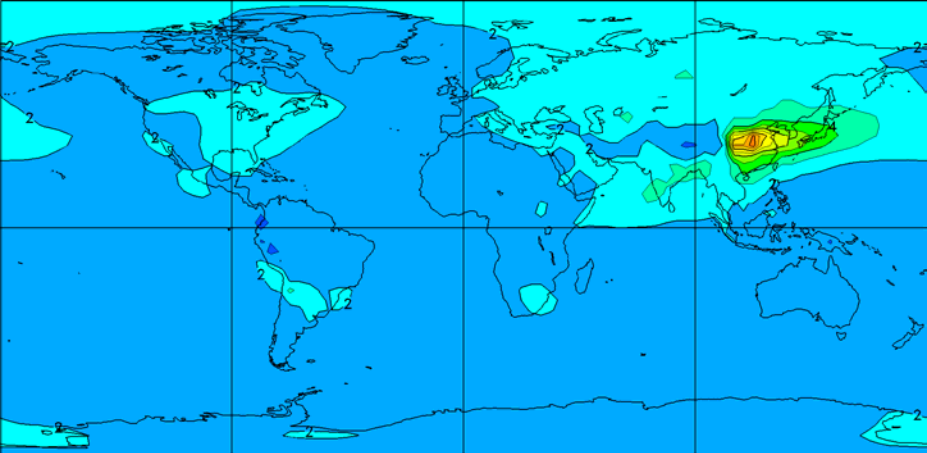
Sulphur Cycle in AGCM4: Results

SO_4^- burden
(in $\mu\text{gS}/\text{m}^2$)

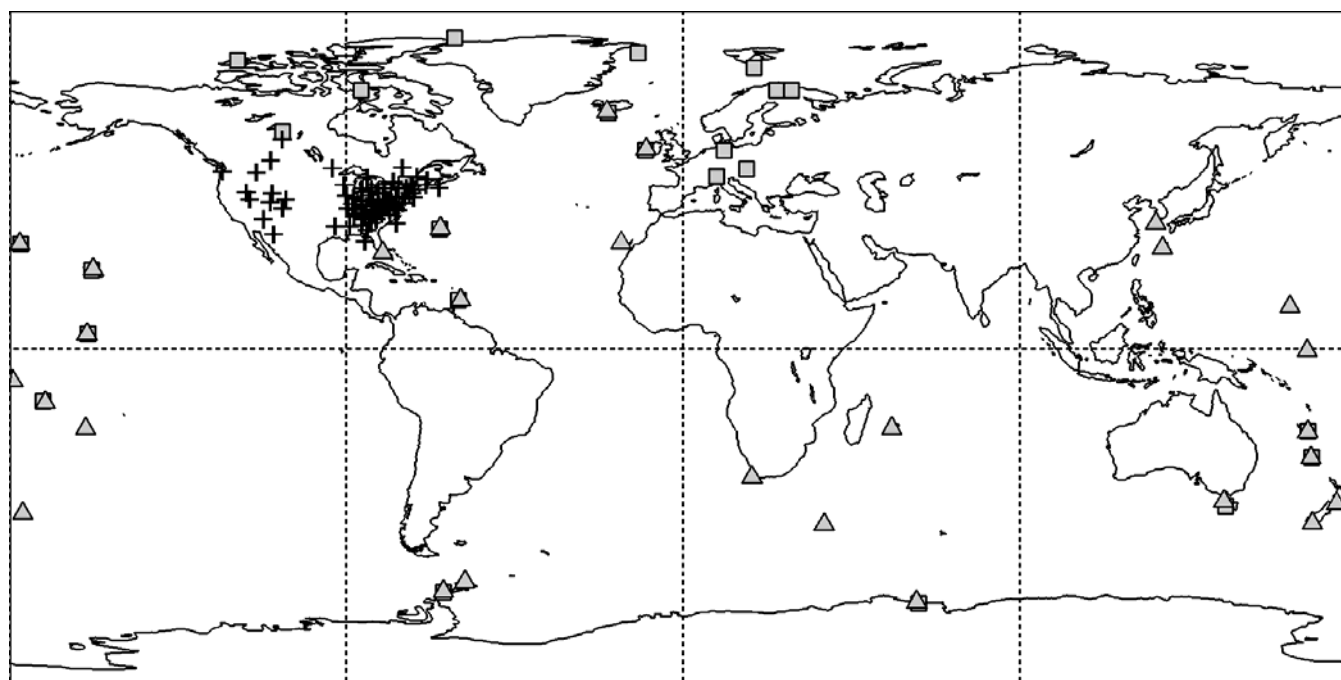
JJA



DJF

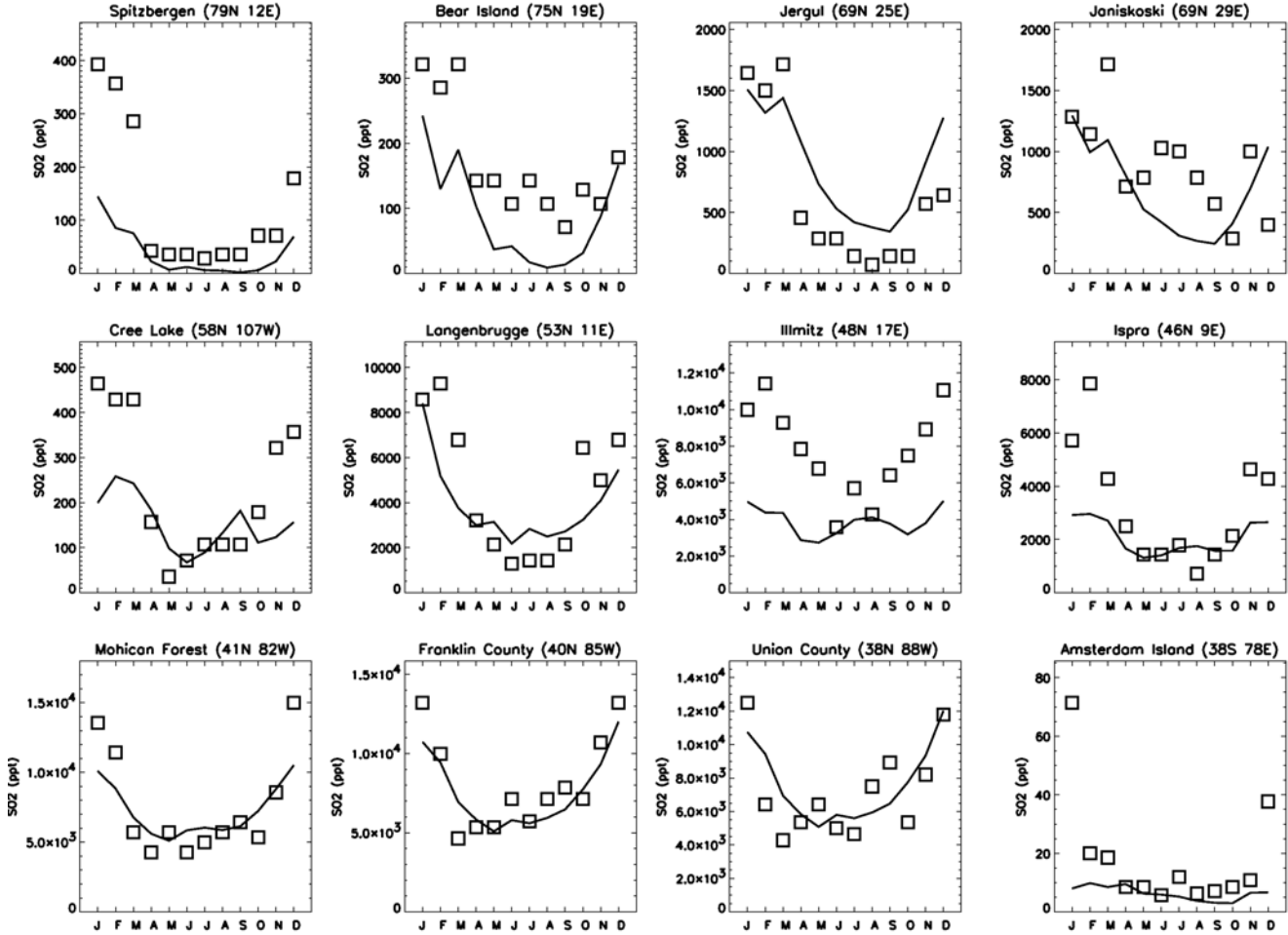


Sulphur Cycle in AGCM4: Comparisons With Observations Near Ground

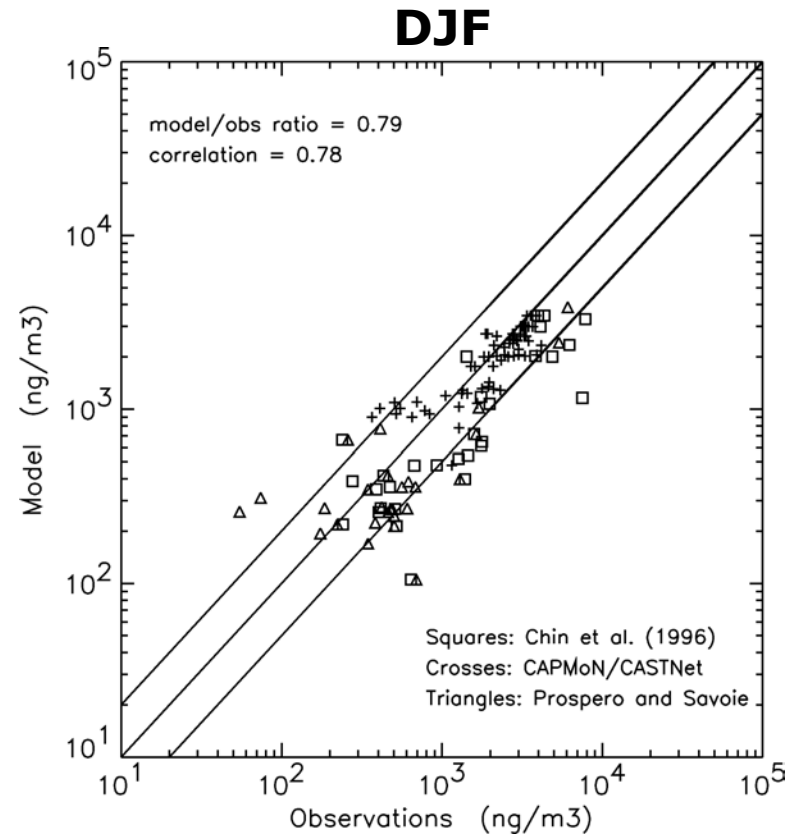
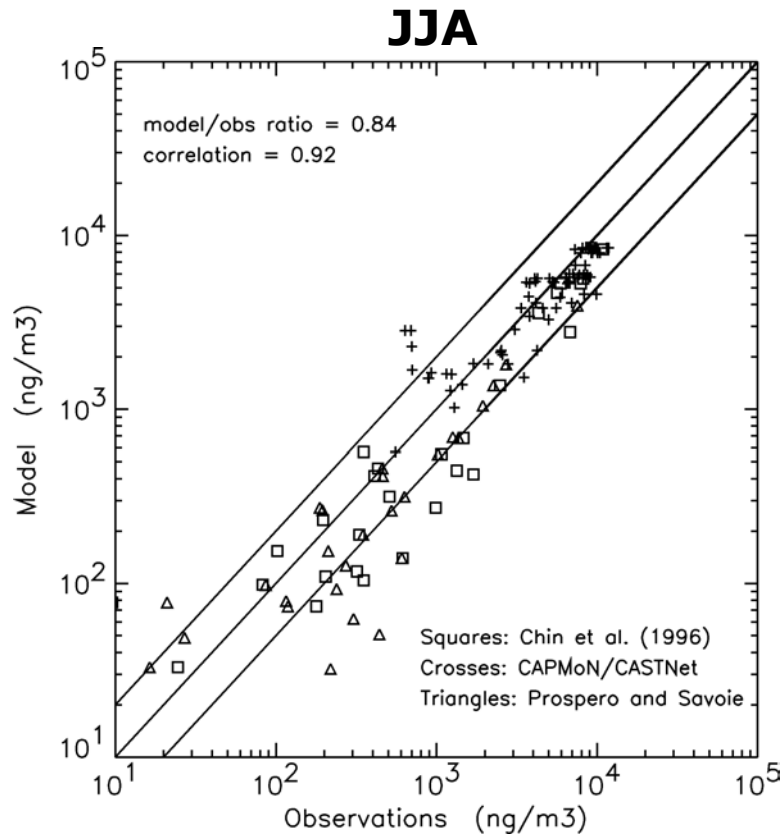


- Chin et al. (1996)
 - ▲ Prospero and Savoie
 - + CASTNet (US EPA)
and CAPMoN (Env. Canada)
- } **131 Sites**

Sulphur Cycle in AGCM4: Comparisons With Observations Near Ground



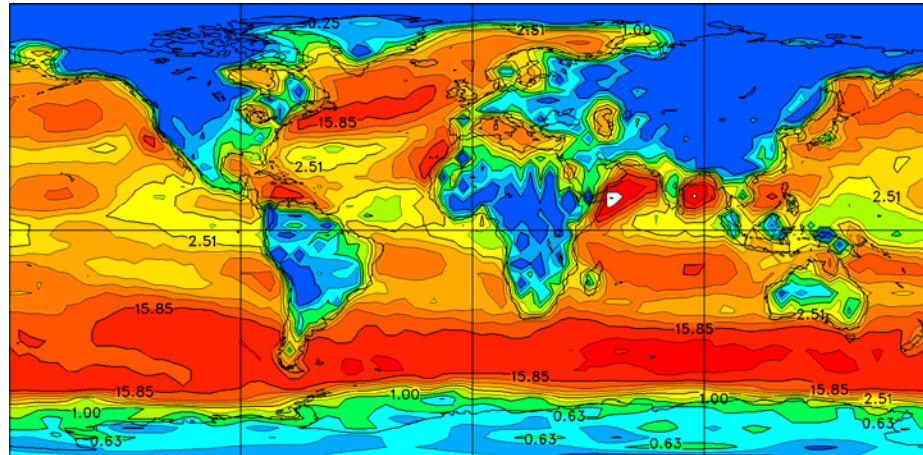
Sulphur Cycle in AGCM4: Comparisons With Observations Near Ground



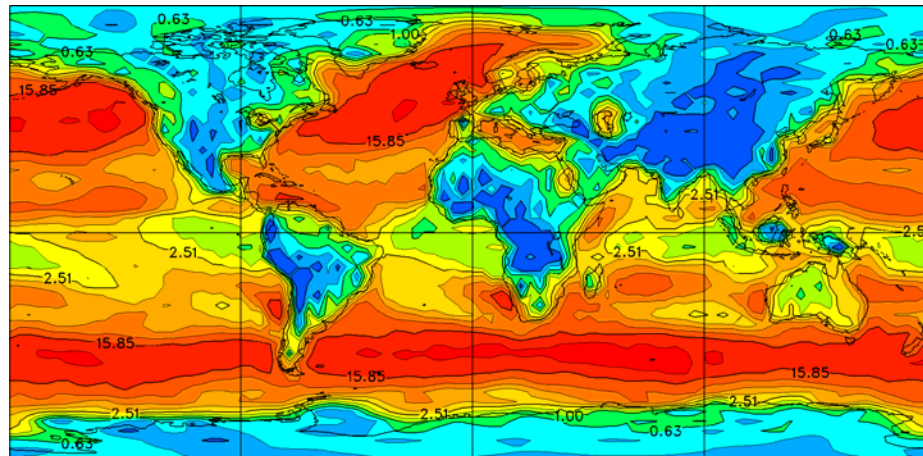
Sea Salt Aerosol in AGCM4: Results

Sea salt concentration
in first model layer
(in $\mu\text{g}/\text{kg}$)

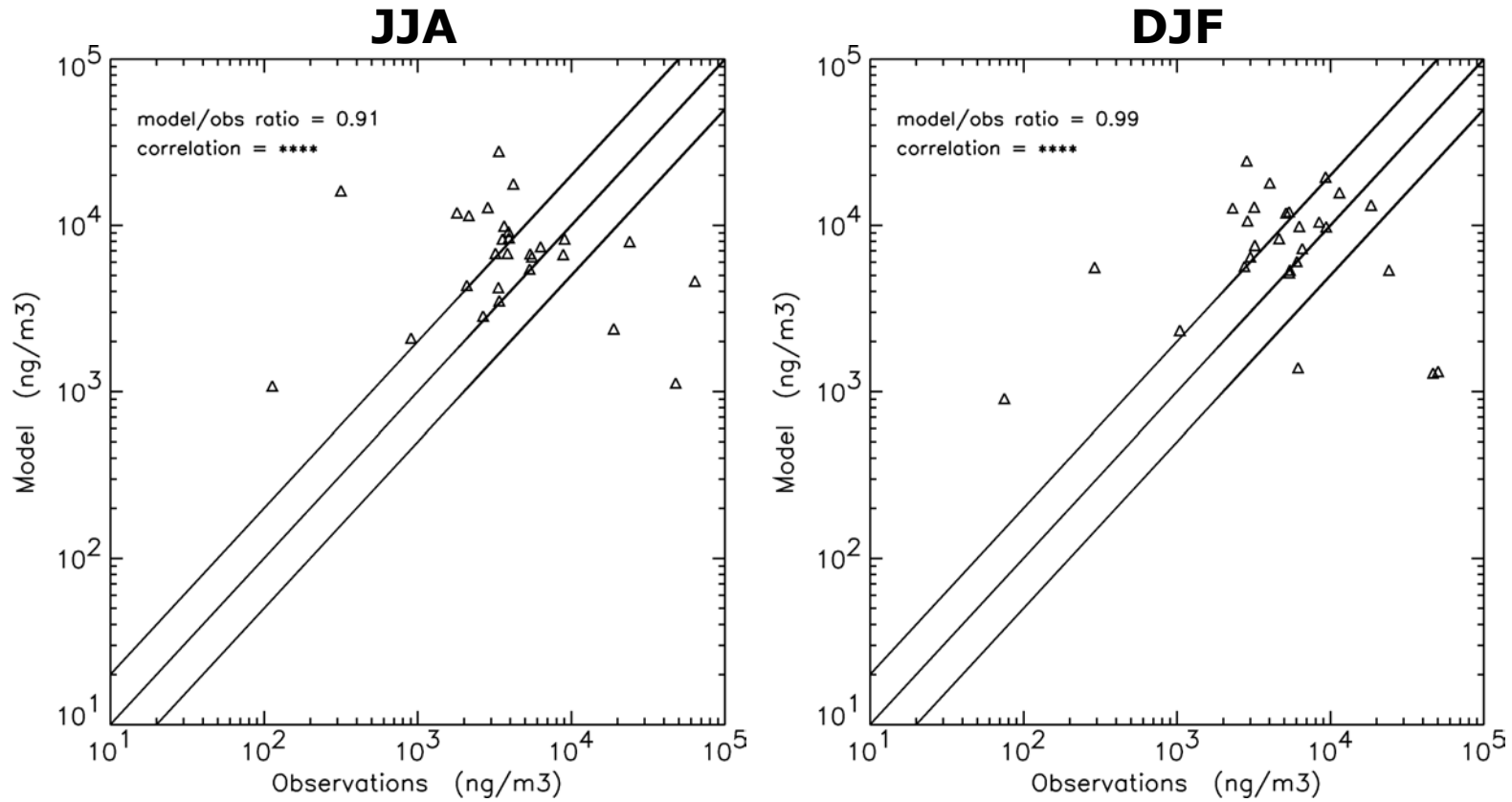
JJA



DJF



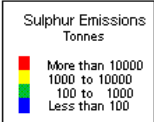
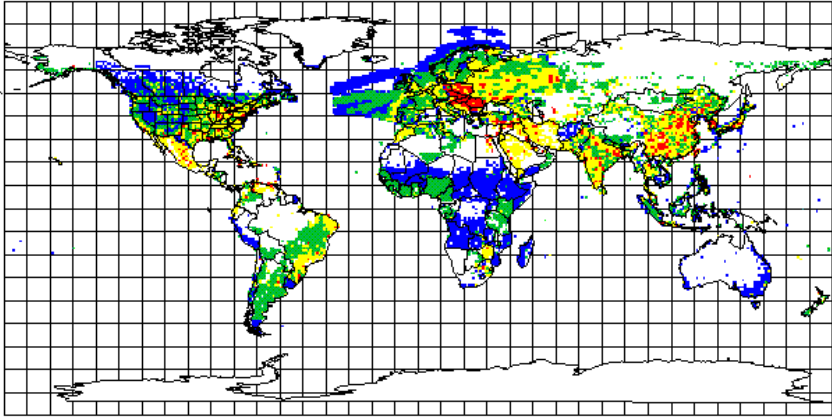
Sea Salt Aerosol in AGCM4: Comparisons With Observations Near Ground



Data: Prospero and Savoie

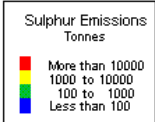
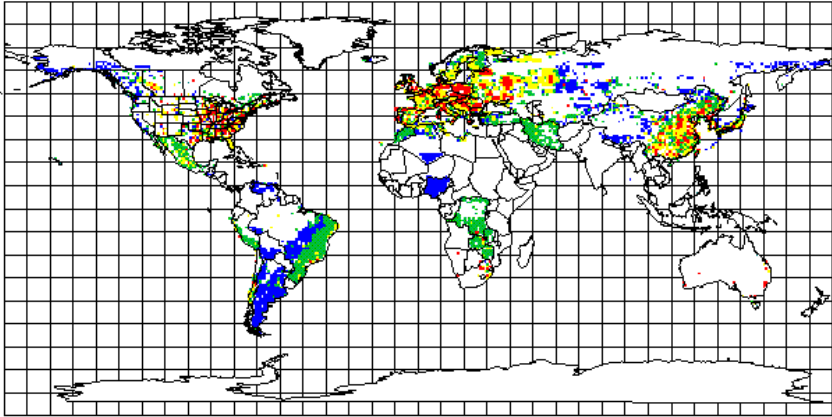
Sulphur Cycle in CCCma AGCM4: SO_x Emissions

Global Inventory Version 1B
Level 1 (<100m) SO_x Emissions as Sulphur
(1 degree x 1 degree Latitude Longitude Grid)



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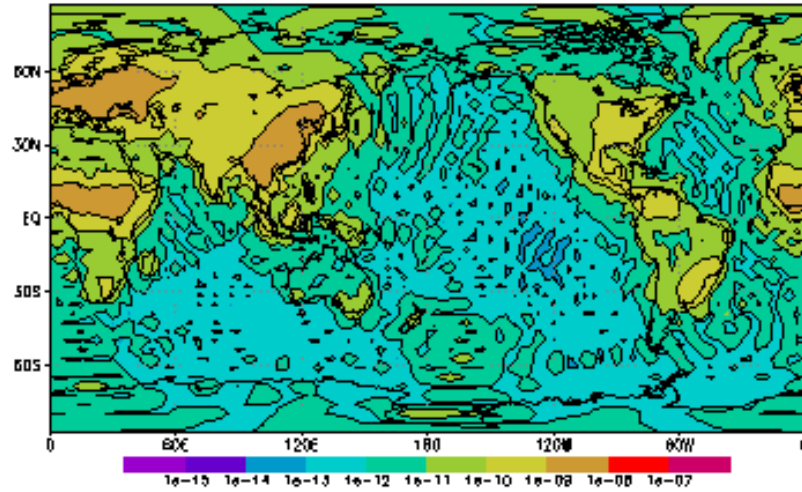
Global Inventory Version 1B
Level 2 (>100m) SO_x Emissions as Sulphur
(1 degree x 1 degree Latitude Longitude Grid)



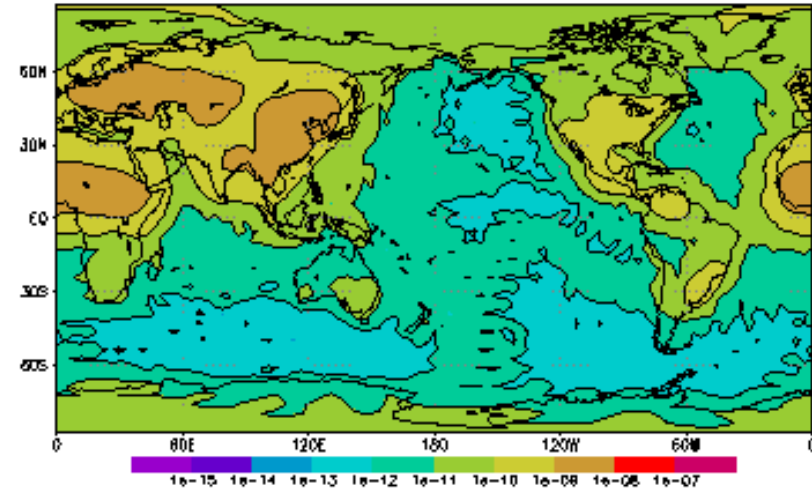
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January Surface Aerosol Mass Mixing Ratios (kg/kg)

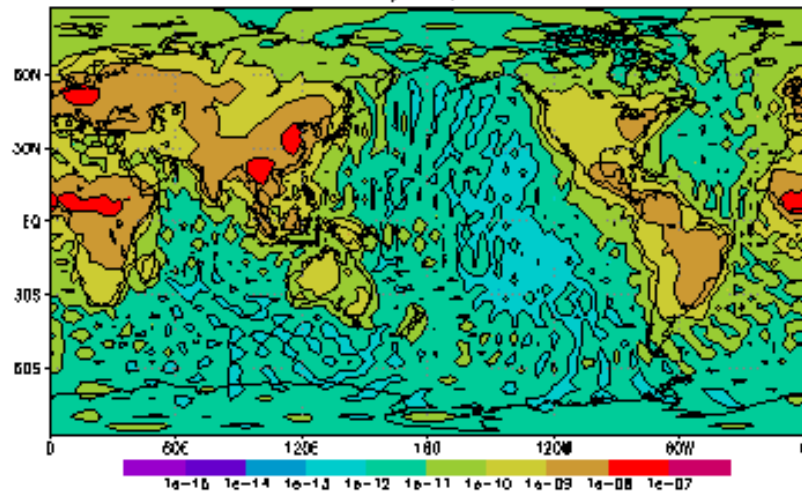
BC Hydrophobic



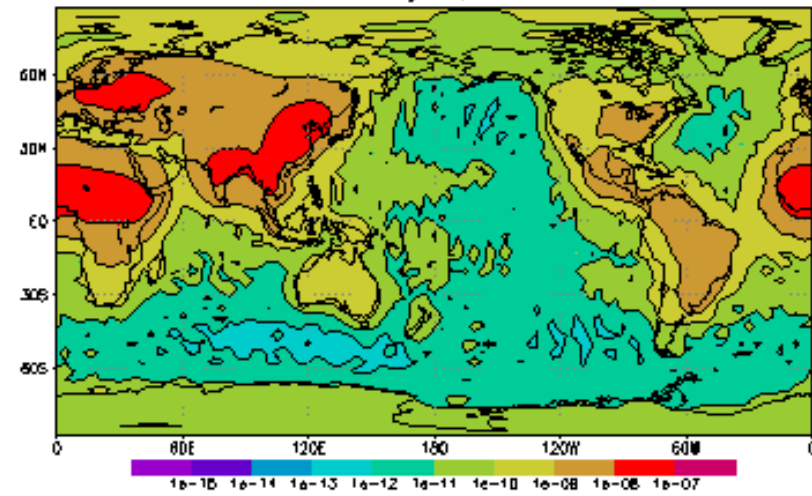
BC Hydrophilic



OC Hydrophobic

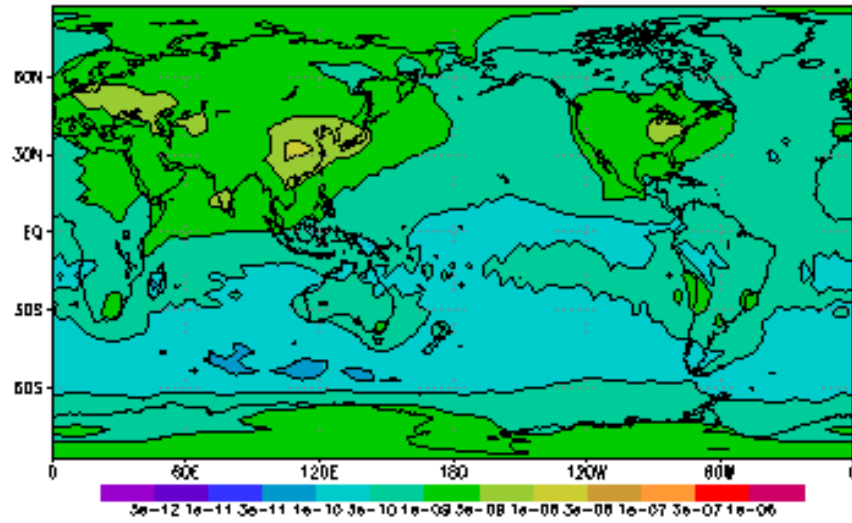


OC hydrophilic

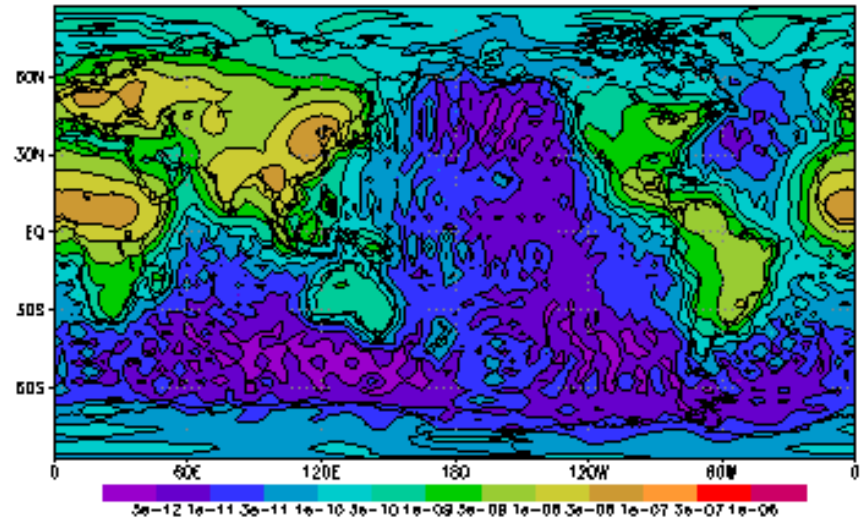


January Surface Aerosol Mass Mixing Ratios (kg/kg)

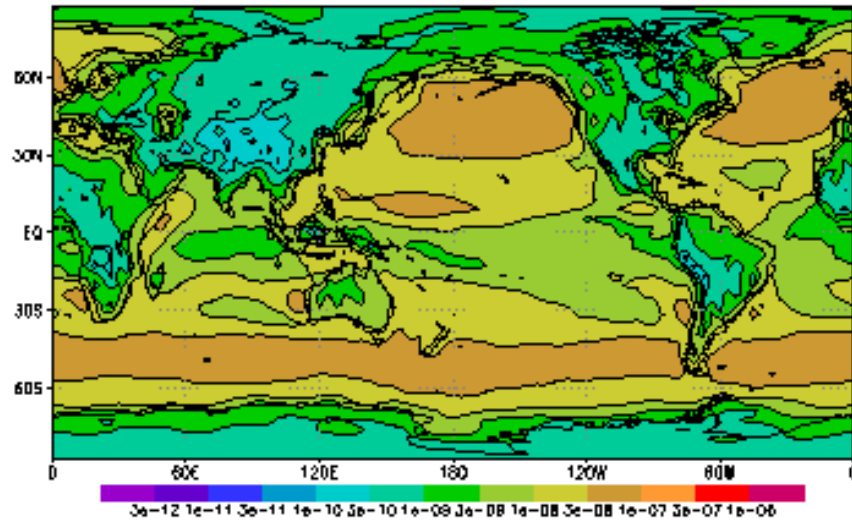
Sulfate



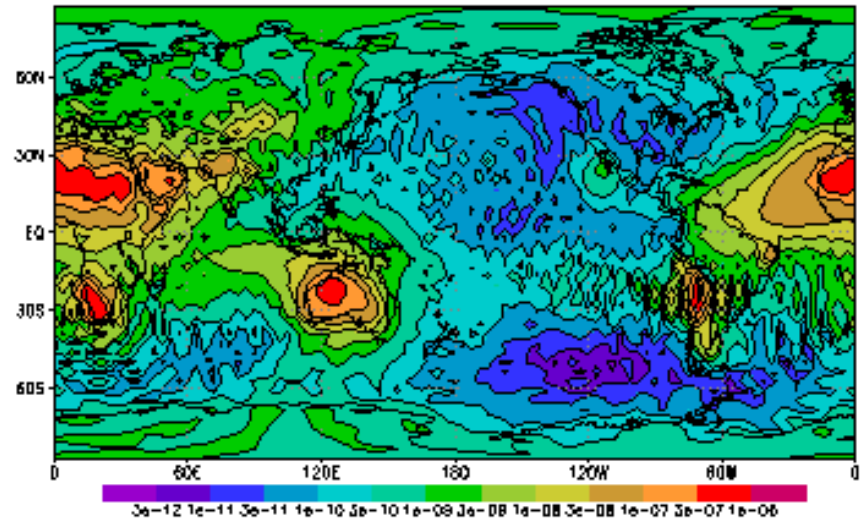
Total Carbonaceous



Total Sea Salt

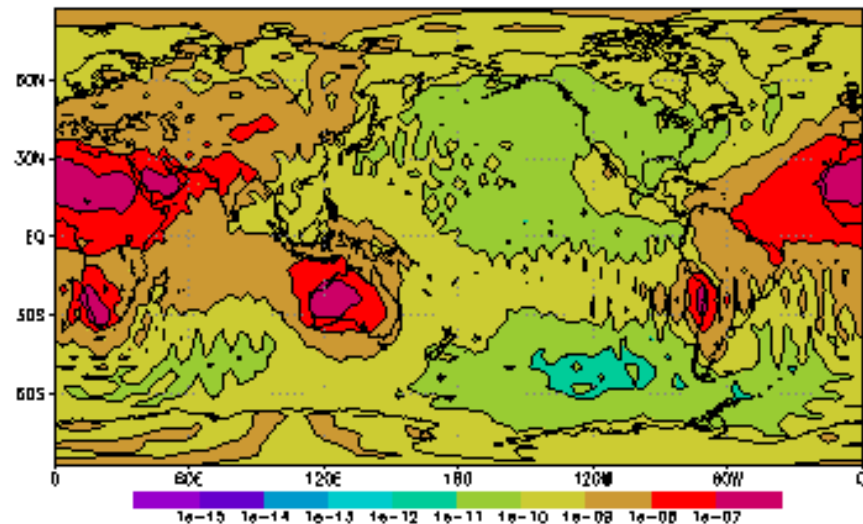


Total Dust

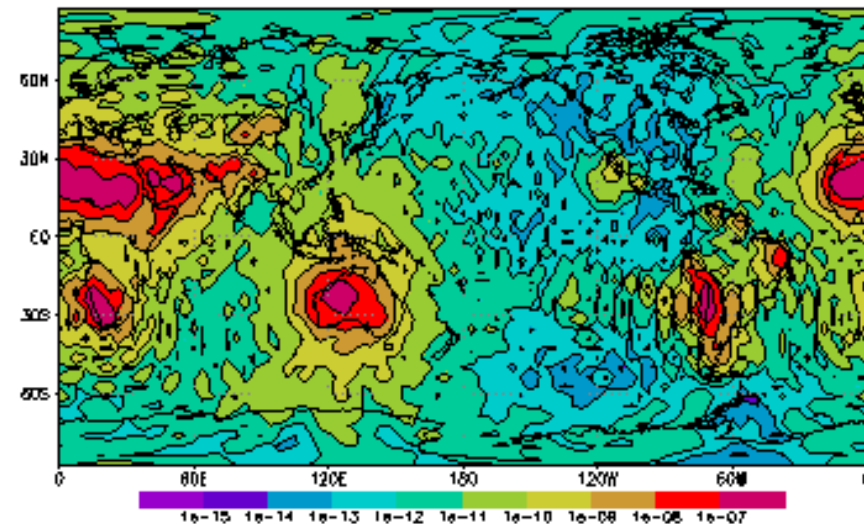


January Surface Aerosol Mass Mixing Ratios (kg/kg)

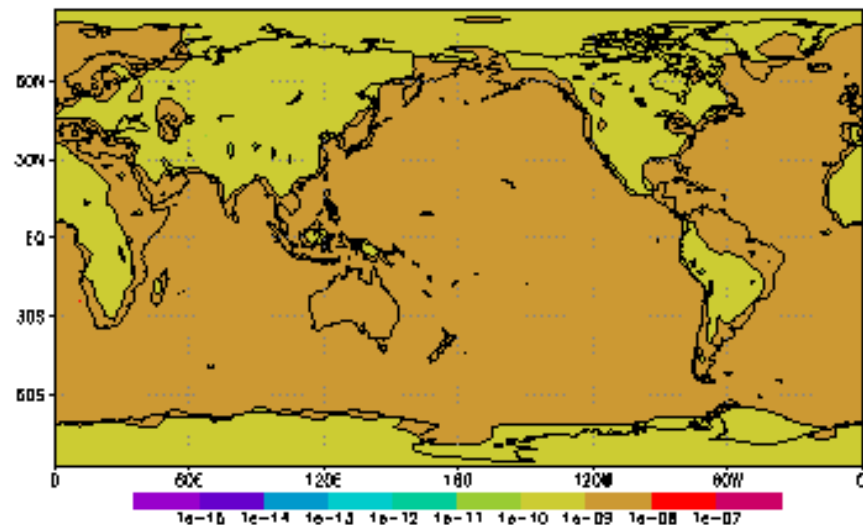
Accumulation Mode Dust



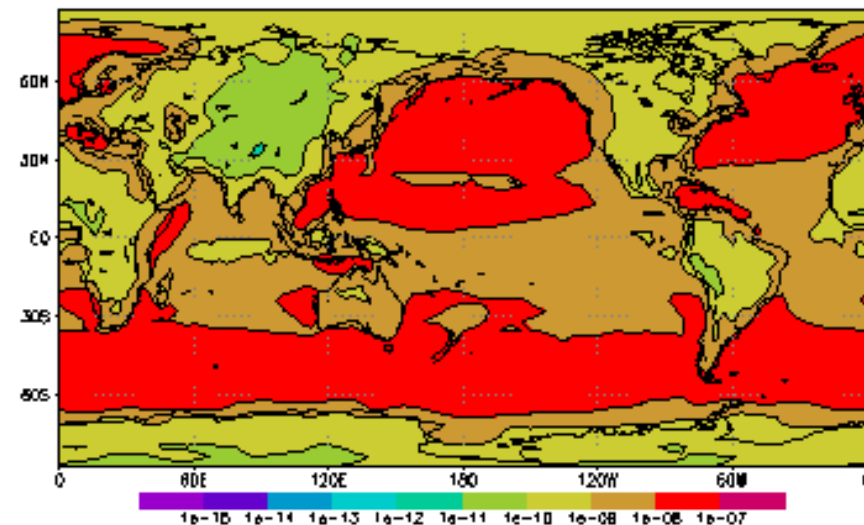
Coarse Mode Dust



Accumulation Mode Sea Salt

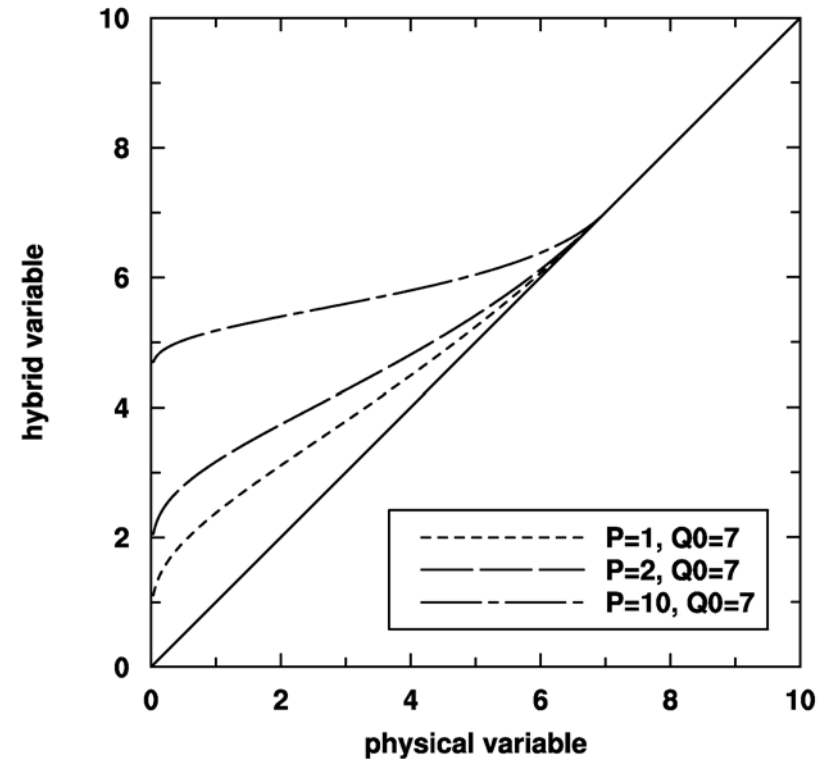


Coarse Mode Sea Salt



Tracer Transport in AGCM4: Methodology

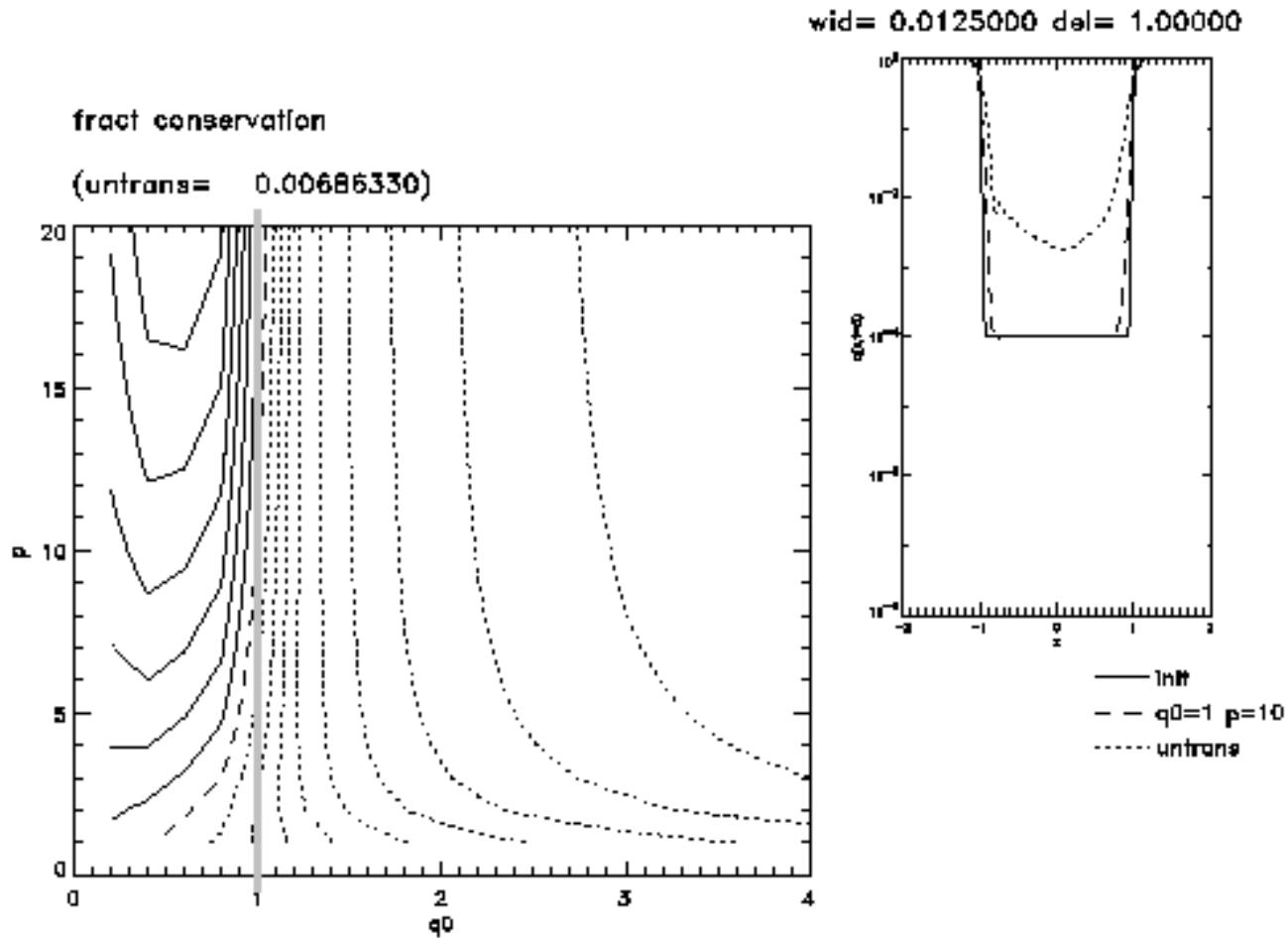
$$s = \frac{q_0}{\left(1 + p \ln \frac{q_0}{q}\right)^{\frac{1}{p}}} \quad \text{for } q \leq q_0$$
$$s = q \quad \text{for } q > q_0$$



Options for tracer advection in AGCM4:

- * Spectral
- * Semi-Lagrangian

Tracer Transport in AGCM4: Idealized Tests

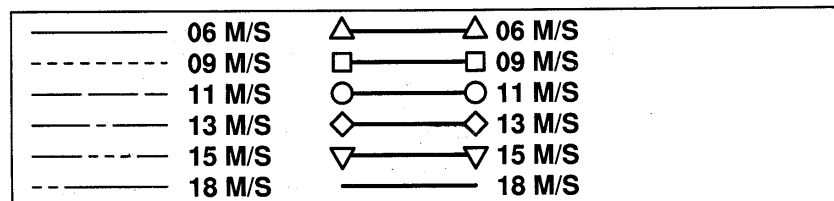
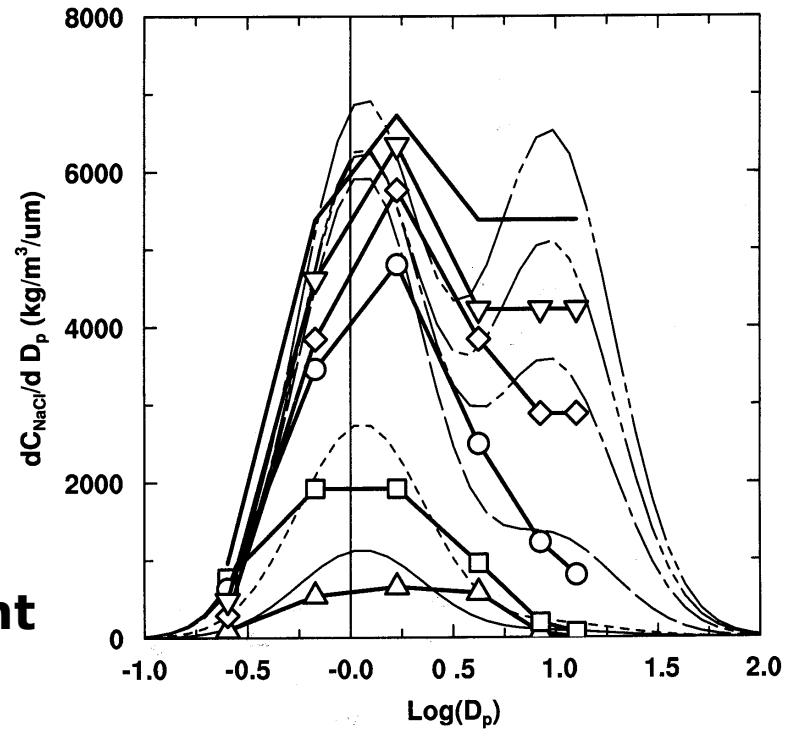


Courtesy W. Merryfield

Sea Salt Aerosol in AGCM4: Parameterization of Mass Size Distribution

NaCl size distribution
in marine
boundary layer

Obs: JASIN experiment
(Fairall et al., 1983)



Parameterization of Convection: Basic Equations

Mass
$$\rho \frac{\partial a}{\partial t} = -\frac{\partial}{\partial z} (\rho a w_c) + E - D$$

Scalars
$$\rho \frac{\partial}{\partial t} (a \chi_c) = -\frac{\partial}{\partial z} (\rho a \overline{w \chi^c}) + E \chi - D \chi_c + \rho a S_\chi$$

Momentum
$$\rho \frac{\partial}{\partial t} (a w_c) = -\frac{\partial}{\partial z} (\rho a \overline{w^2 c}) - D w_c + \rho a \frac{B_c}{1 + \gamma} - \frac{\partial}{\partial z} (a P_c)$$

Parameterization of Cloud-Chemical Processes

Oxidation of S(IV) in cloud liquid water

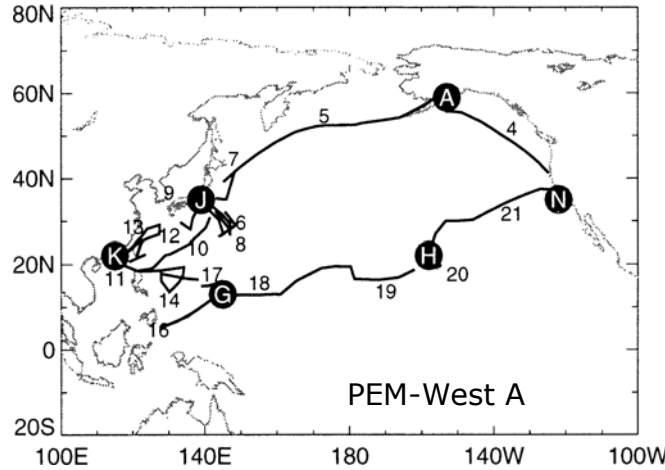


Equilibrium between gaseous and dissolved species

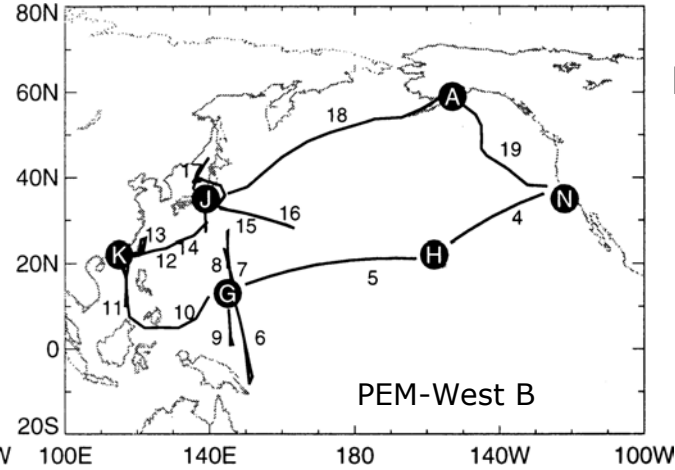


Sulphur Cycle in AGCM4: Comparisons With Observations During PEM

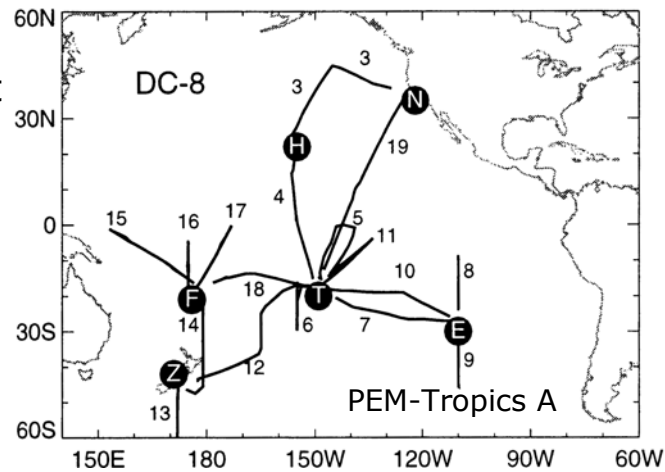
Sept-Oct
1991



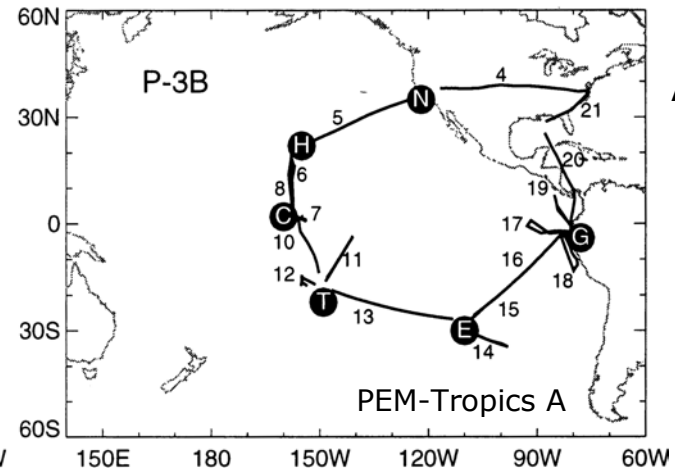
Feb-Mar
1994



Aug-Sept
1996

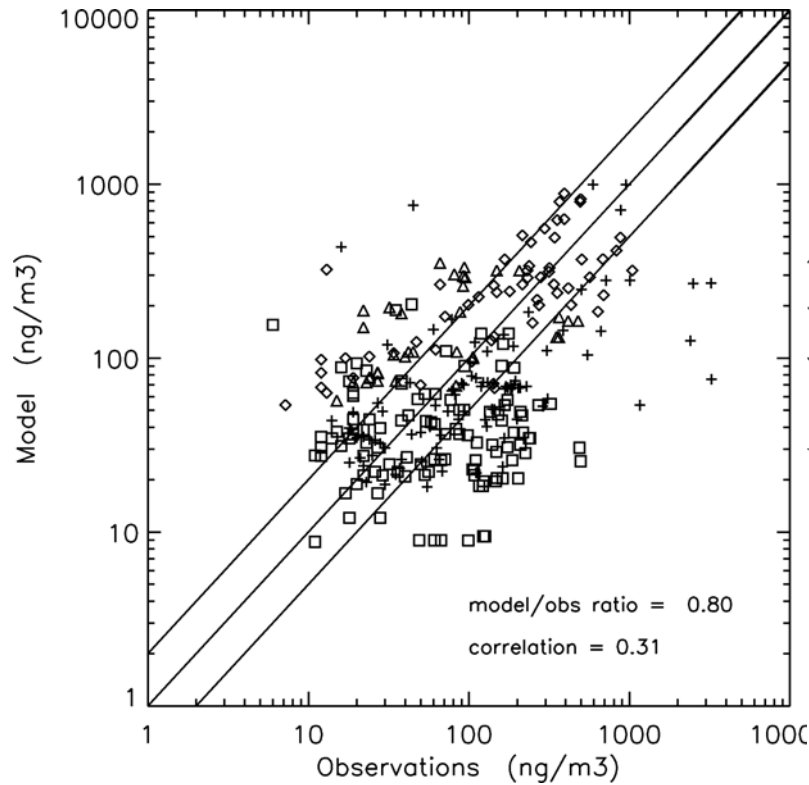


Aug-Sept
1996

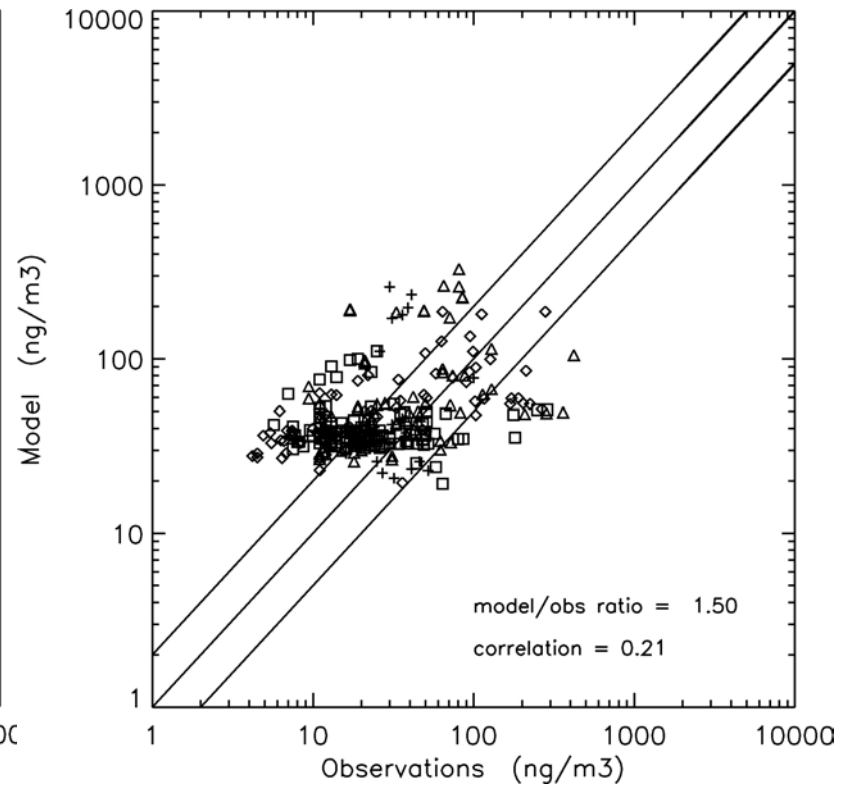


Sulphur Cycle in AGCM4: Comparisons With Observations During PEM - Using Spectral Advection/Hybrid Variable

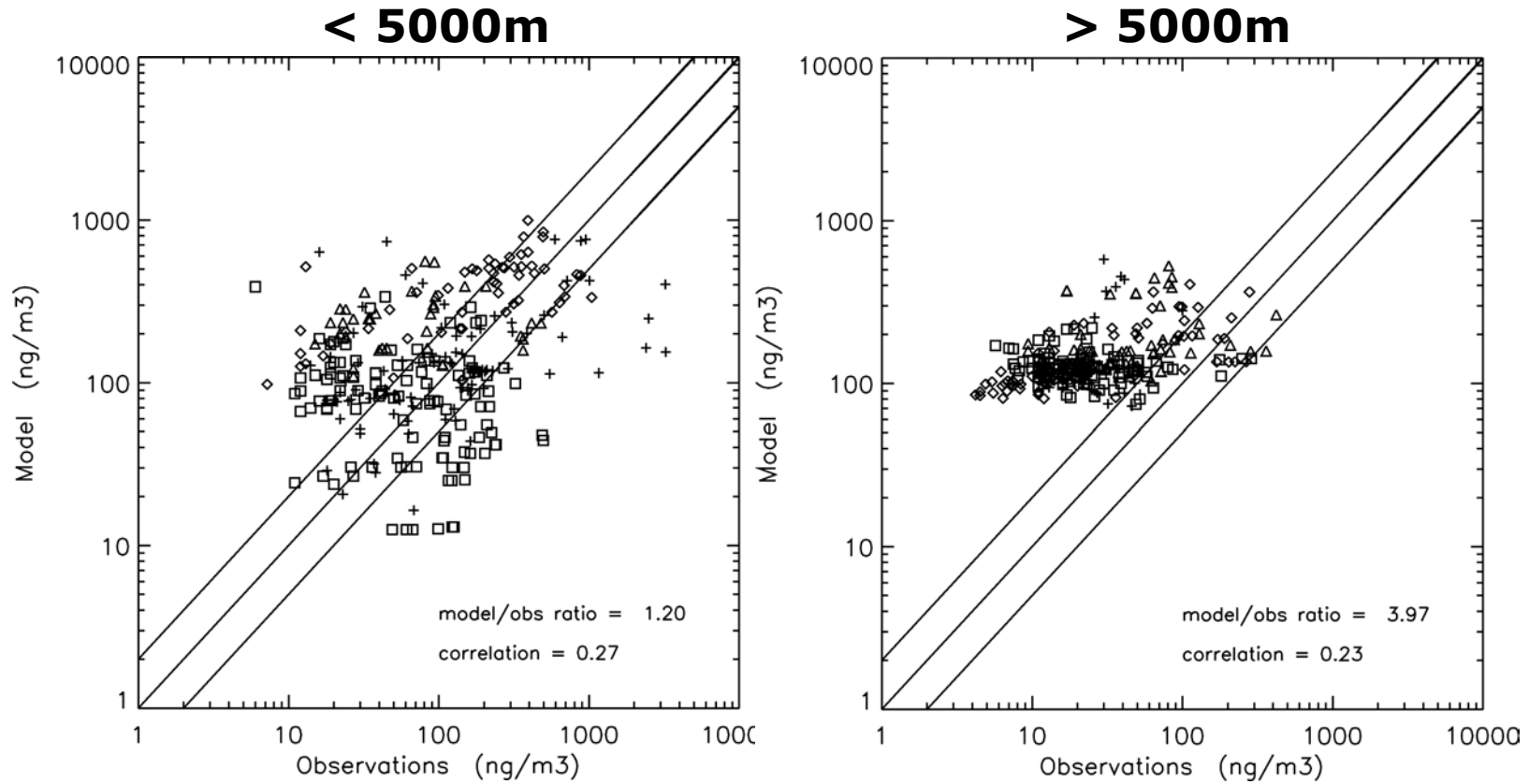
< 5000m



> 5000m



Sulphur Cycle in AGCM4: Comparisons With Observations During PEM - Using Semi-Lagrangian Transport



Sulphur Cycle in AGCM4: Results

Zonal mean
 SO_4^- concentration
(in ppb)

