luence of Aerosols on McRAS-Clouds Employing GOCART lfate-Aerosol Climatology and Specified Aerosol-Activation d Rainout Algorithms in the GEOS-4 GCM

C. Sud, Mian Chin, G. K. Walker, T. Diehl*
d
lliam K. M. Lau

oratory for Atmospheres
ddard Space Flight Center
eenbelt, MD 20771

O U T L I N E

1. Models and Datasets
2. Implementation of the Standard Algorithms into McRAS
3. Design of the Experiment
4. Results
5. Summary

Models and Datasets

AGCM: fvGCM also known as GEOS-4 GCM.

NCAR-Physics but for McRAS Clouds (Sud & Walker, 1999 & 2003) and Chou and Suarez (1998) Radiation.

Sea-surface temperatures, vegetation cover, permanent snow and ice, and **sulfate-aerosols** are prescribed as monthly climatologies, but are interpolated on daily basis.

Everything else, e.g., soil moisture vegetation biology, cloud microphysics are prognostic and interactive

mplementation of the Standard Aerosol-Algorithm

1. Algorithms Water Clouds: Sundqvist (1988) versus K&K (2000)

$$P_r = Com\left\{1 - \exp - \left(\frac{\lambda_c}{\lambda_{crit}}\right)^2\right\}; \quad Com/\lambda_{crit} = C_o/\lambda_o \ (f_1 \ f_2 \ f_3) \ \text{Sundqvis}$$

$$P_r = 1350 .* f_1 \ f_2 \ f_3 * \lambda_c^{1.47} * N_d^{-1.79} \qquad \text{K \& K (2000).}$$

$$\text{where} \quad N_d = A\left(SO_4^{-2}\right)^B \quad \& \quad G_p = P_r \lambda_c$$

2. Algorithms Ice Clouds: Include Sulfate in Ou and Liou, 1995

$$M_{ice} = 4/3\pi\, r_{ice}^3\, \rho_{ice}\, N_{ice}; \quad (r_{ice} \text{ Ou and Liou,1995})$$

$$N_{ice} = f\left(SO_4\right)^B; \quad \text{Assume} \quad B = 1/3\left(\text{round number within}: 0.25/0.48\right)$$

$$\text{Obtain} \quad r_{ice}^{SO4} = r_{ice}^{Sund} * \left[\left(\overline{SO_4}\right)_{zml} / \left(SO_4\right)_{actual}\right]^{1/9}$$

Design of the experiment

1. Initial conditions are from a standard climatological SST run made with the fvGCM-NCAR physics; it is the atmospheric state on Sept 1, of year 47 of the simulation.
2. For adjustment to new formulation of aerosol-cloud interactions, we allow 4 months of adjustment period and then analyze 5-years from Jan 1, yr 48 to Dec 31, yr 52, but with our changes
3. We examine 5-year mean JJA and ANNUAL (mean) climatology for the new aerosol and no-aerosol control simulations. No direct effect is

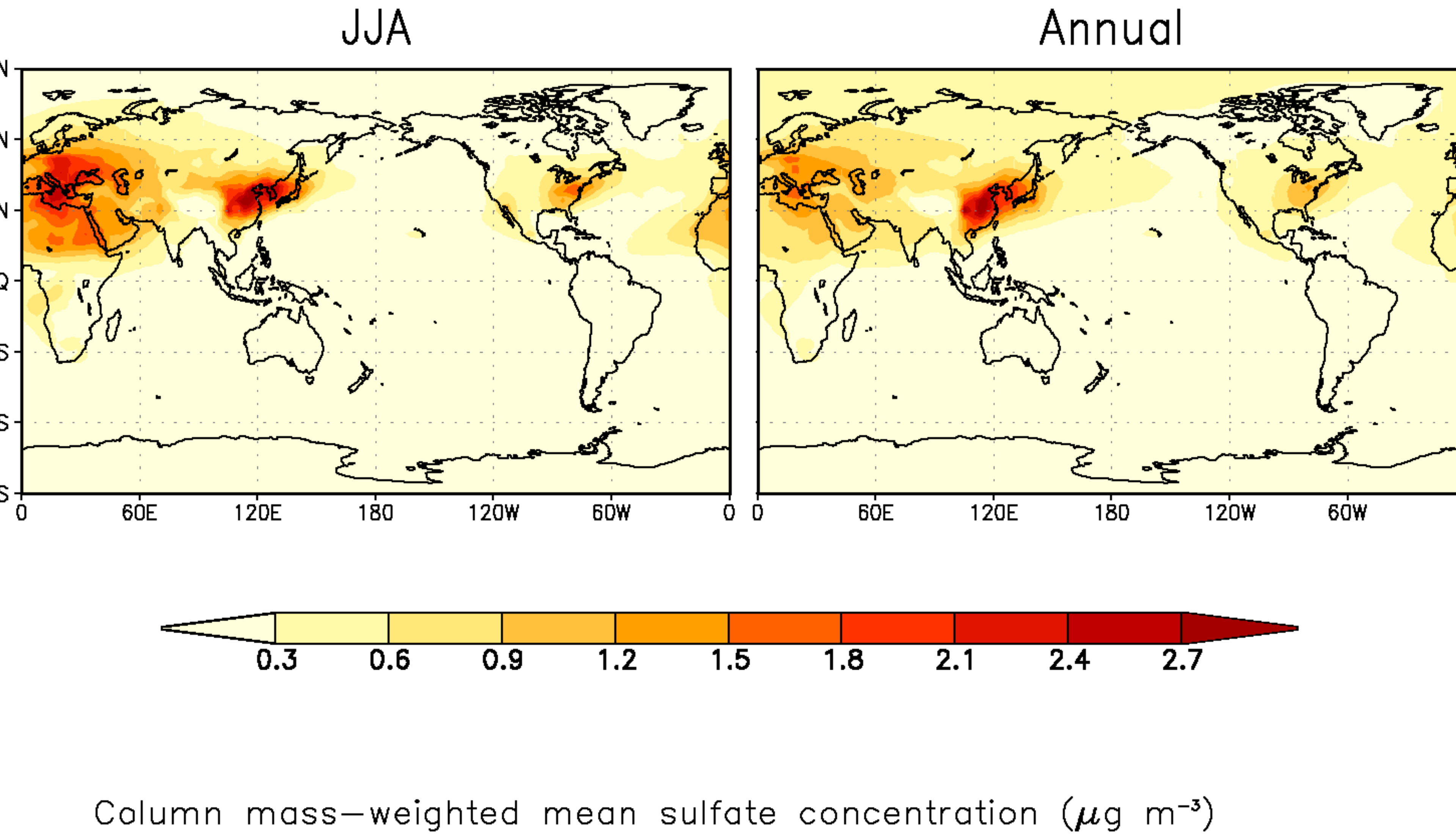
Results

1. Results are shown in the form of **SO4-Anomaly** minus **control** in the 5-year integration in which climatological SST's, vegetation phenology and morphology, permanent snow and ice are prescribed.

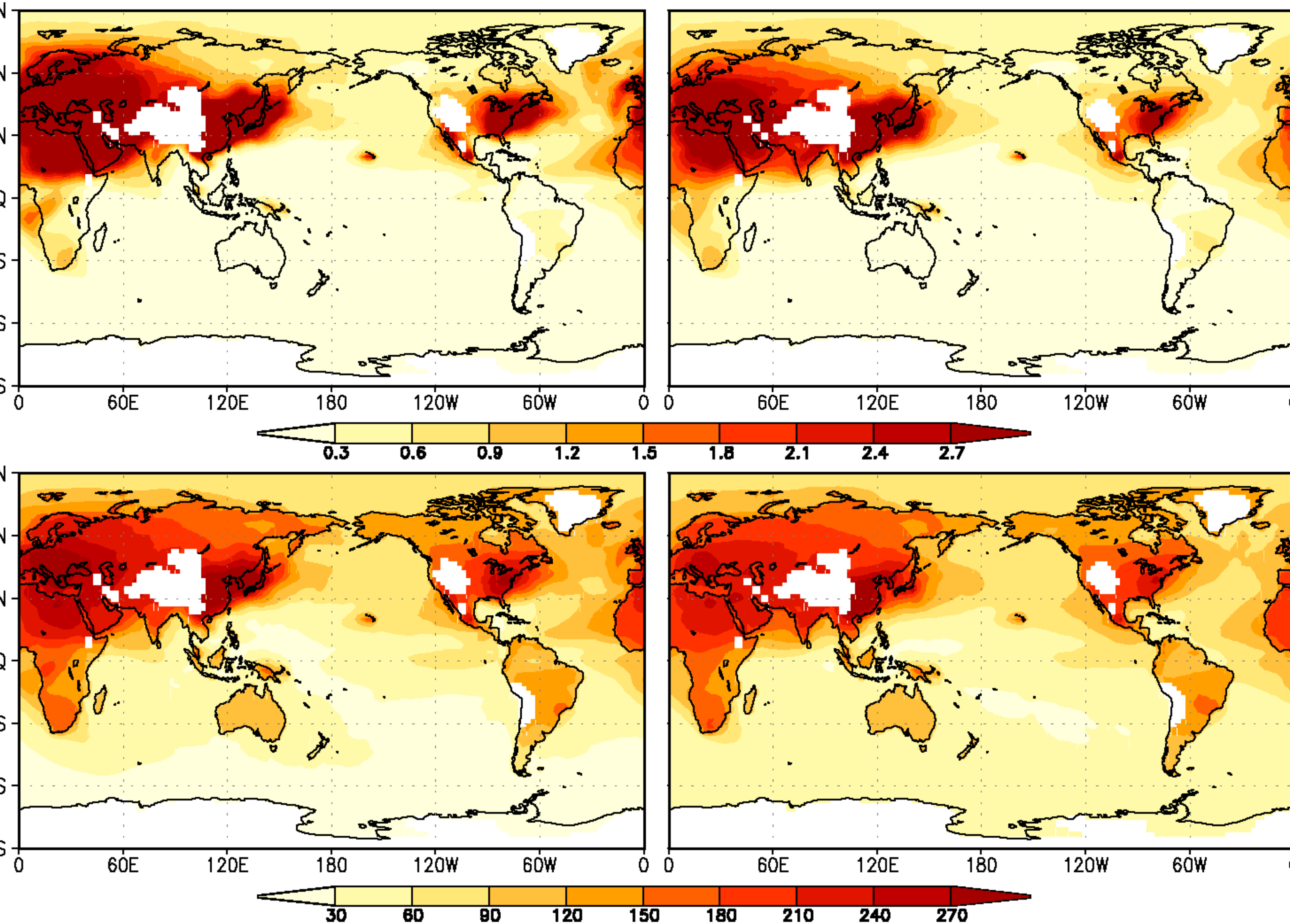
2. The new algorithm was implemented for water clouds; additionally the ice model clouds have been recast to reflect the effect of sulfate aerosols but without zonal biases.

3. McRAS-clouds are fully interactive and fully prognostic. Therefore, the high sulfate content over northern-land areas leads to more cloud water that subsequently advects and increase the cloudiness downstream; these clouds can only turn into rain by the K&K (2000) algorithm.

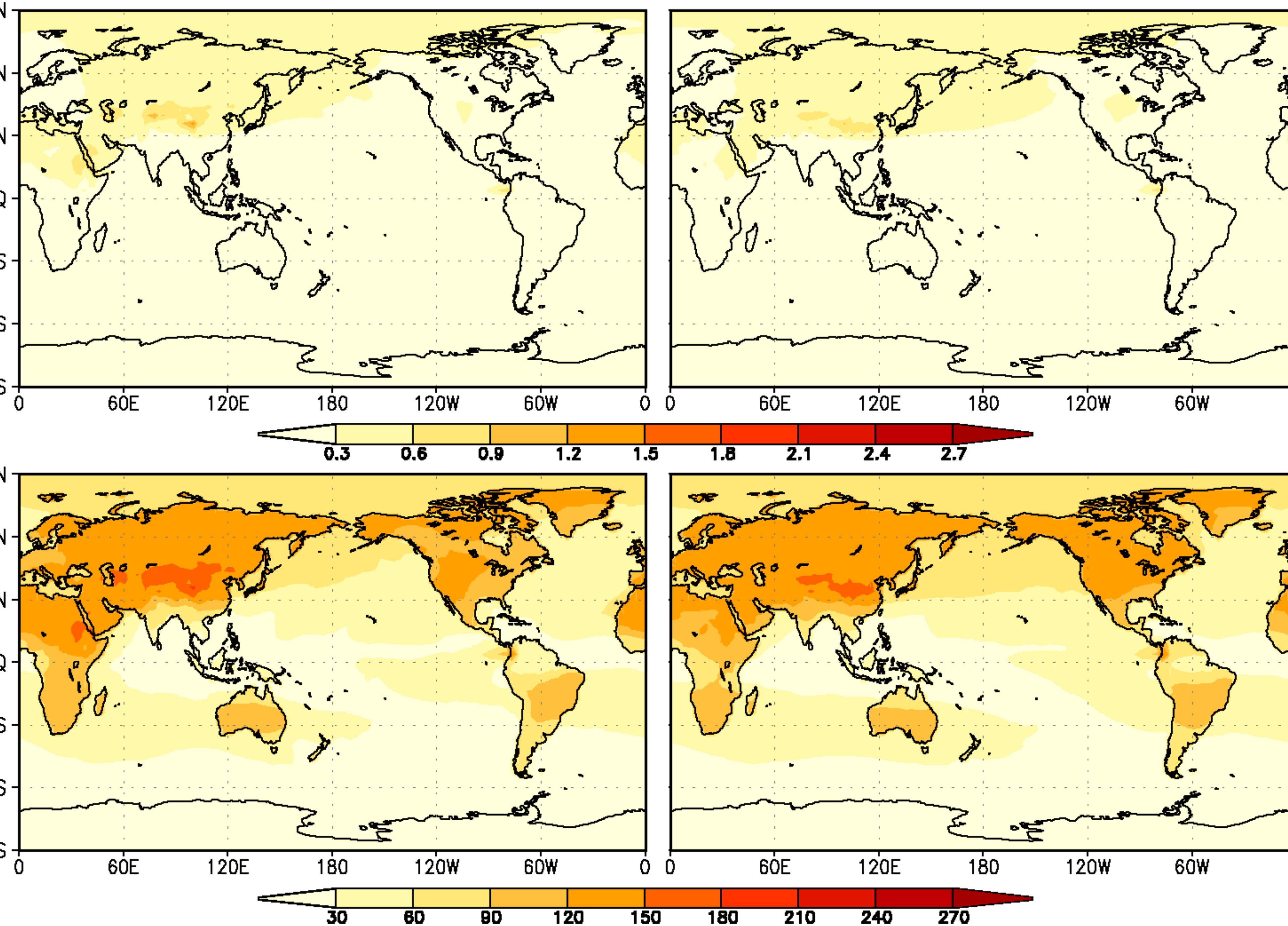
Y C Sud



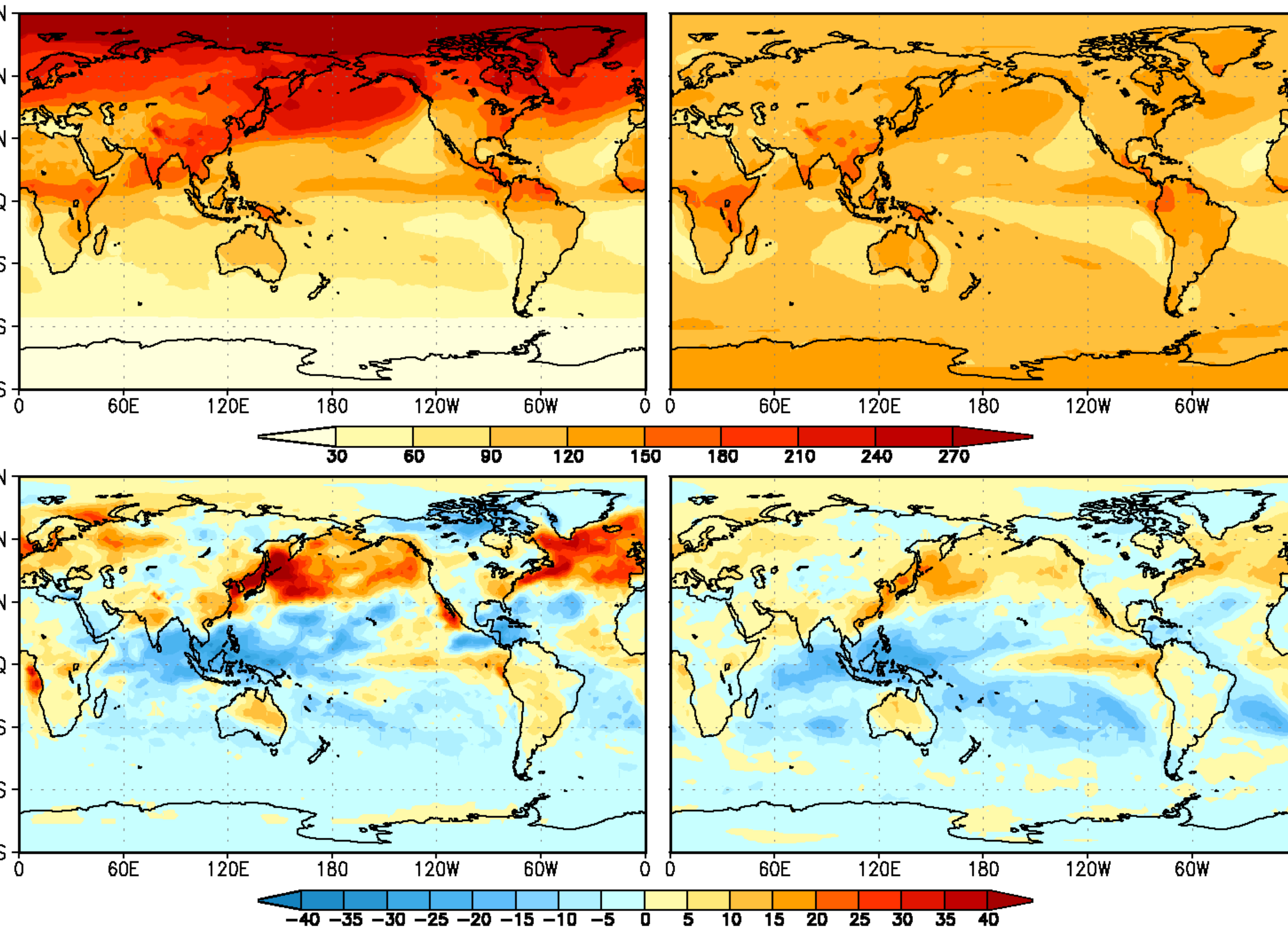
JJA
Annual
0
60E
120E
180
120W
60W
0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
Column mass-weighted mean sulfate concentration (μg m⁻³)



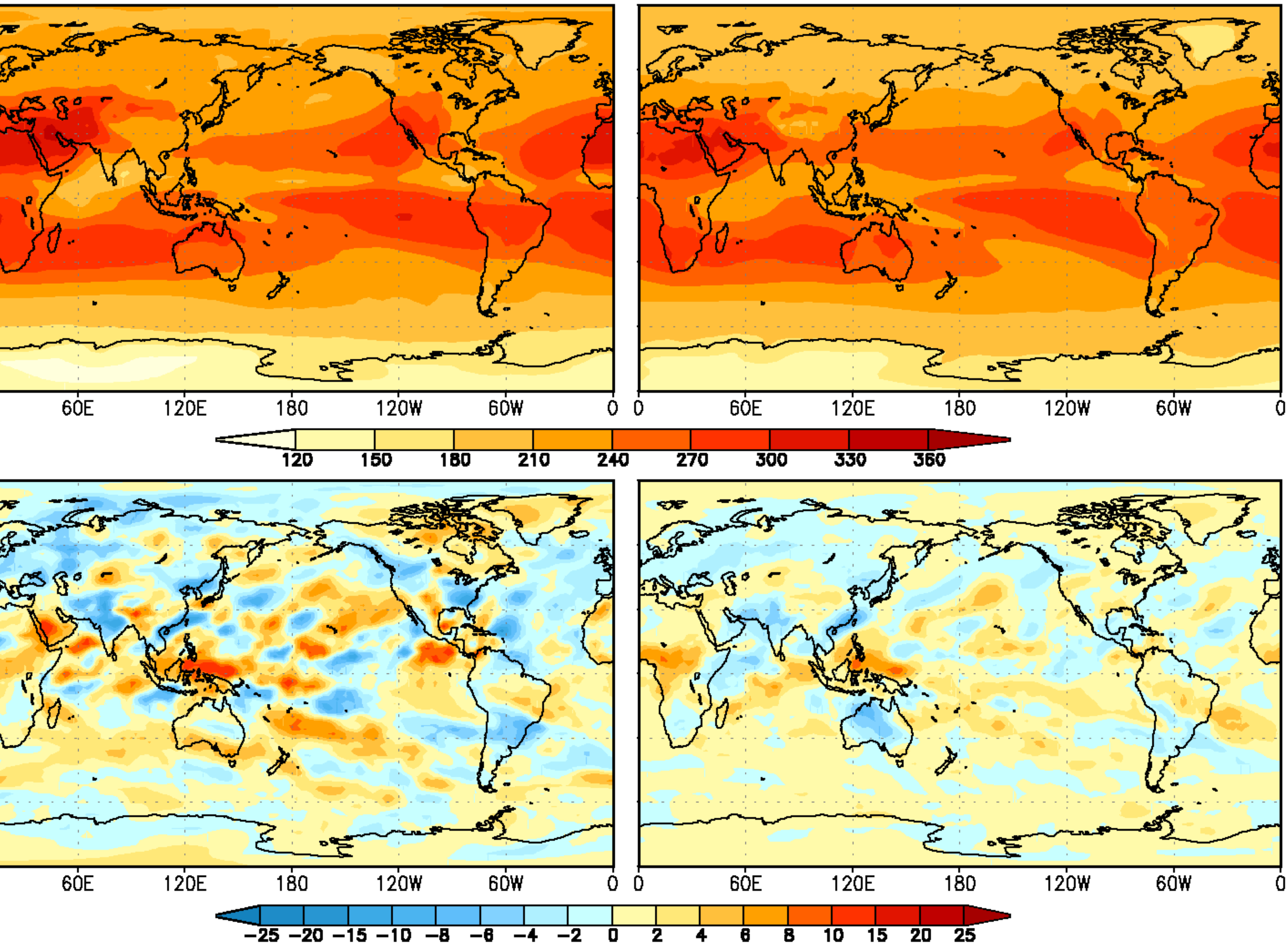
850 hPa sulfate concentration ($\mu g\ m^{-3}$) (top) and number concentration (cm^{-3}) (bottom)



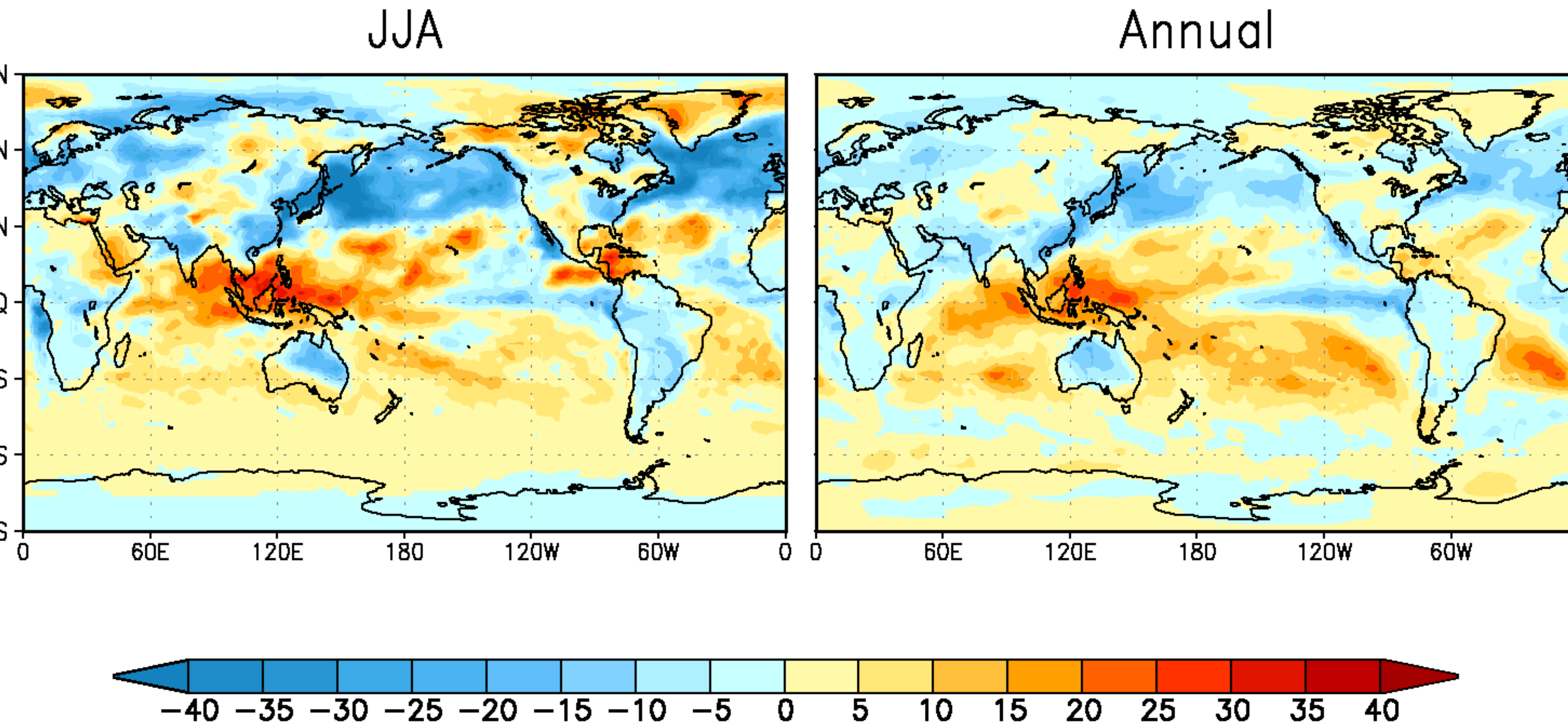
500 hPa sulfate concentration ($\mu g\ m^{-3}$) (top) and number concentration (cm^{-3}) (bottom)



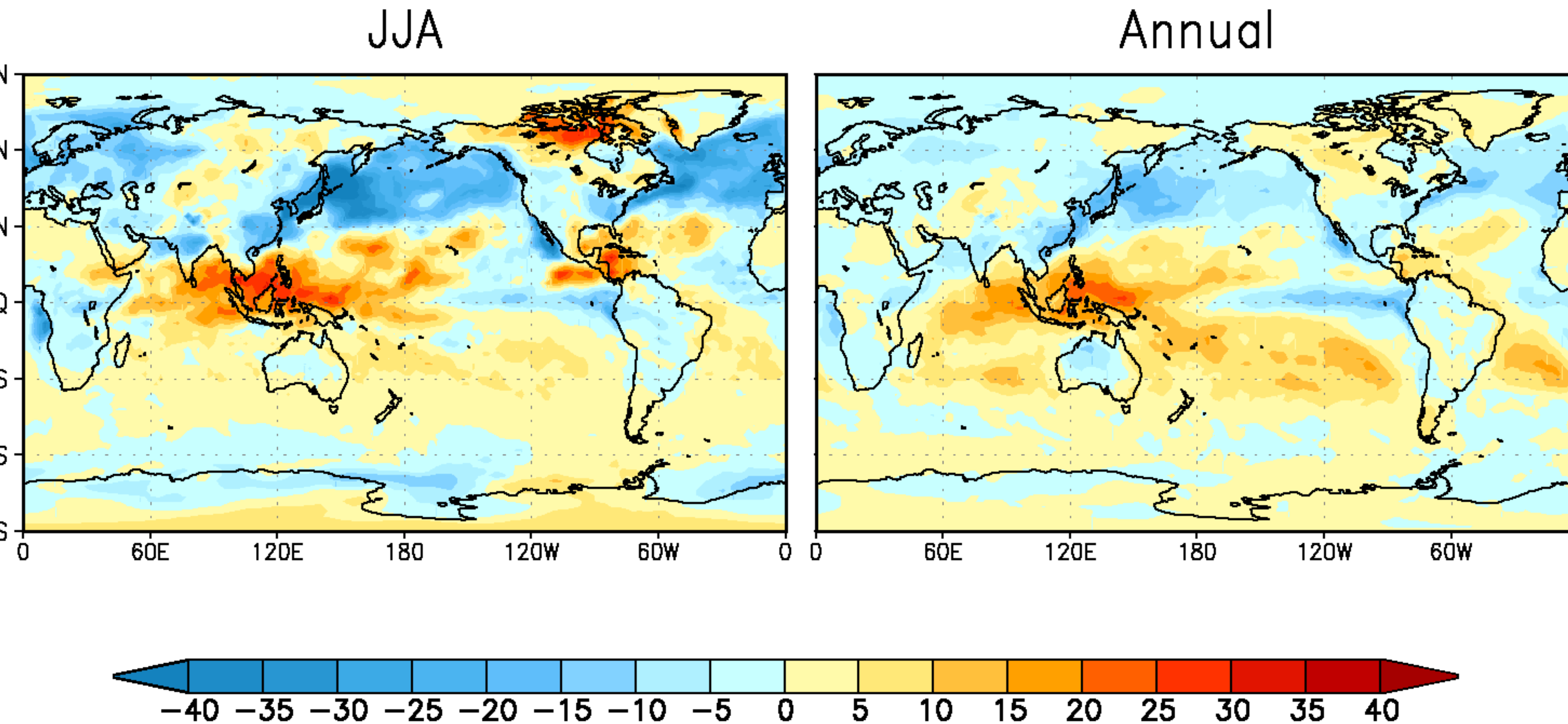
Outgoing shortwave radiation (W m^{-2}) (top) and difference from Control (bottom).



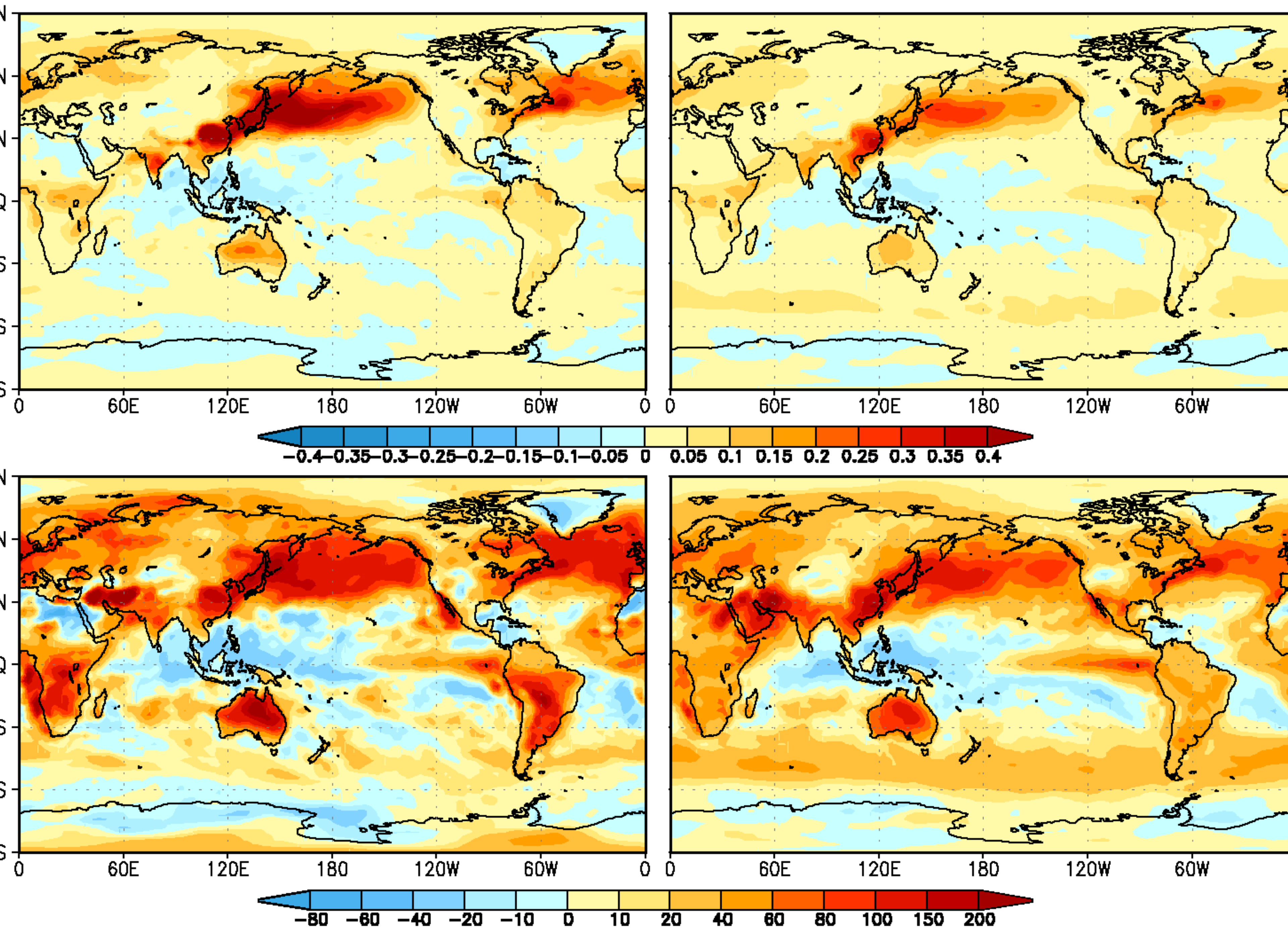
Outgoing longwave radiation (W m^{-2}) (top) and difference from Control (bottom)



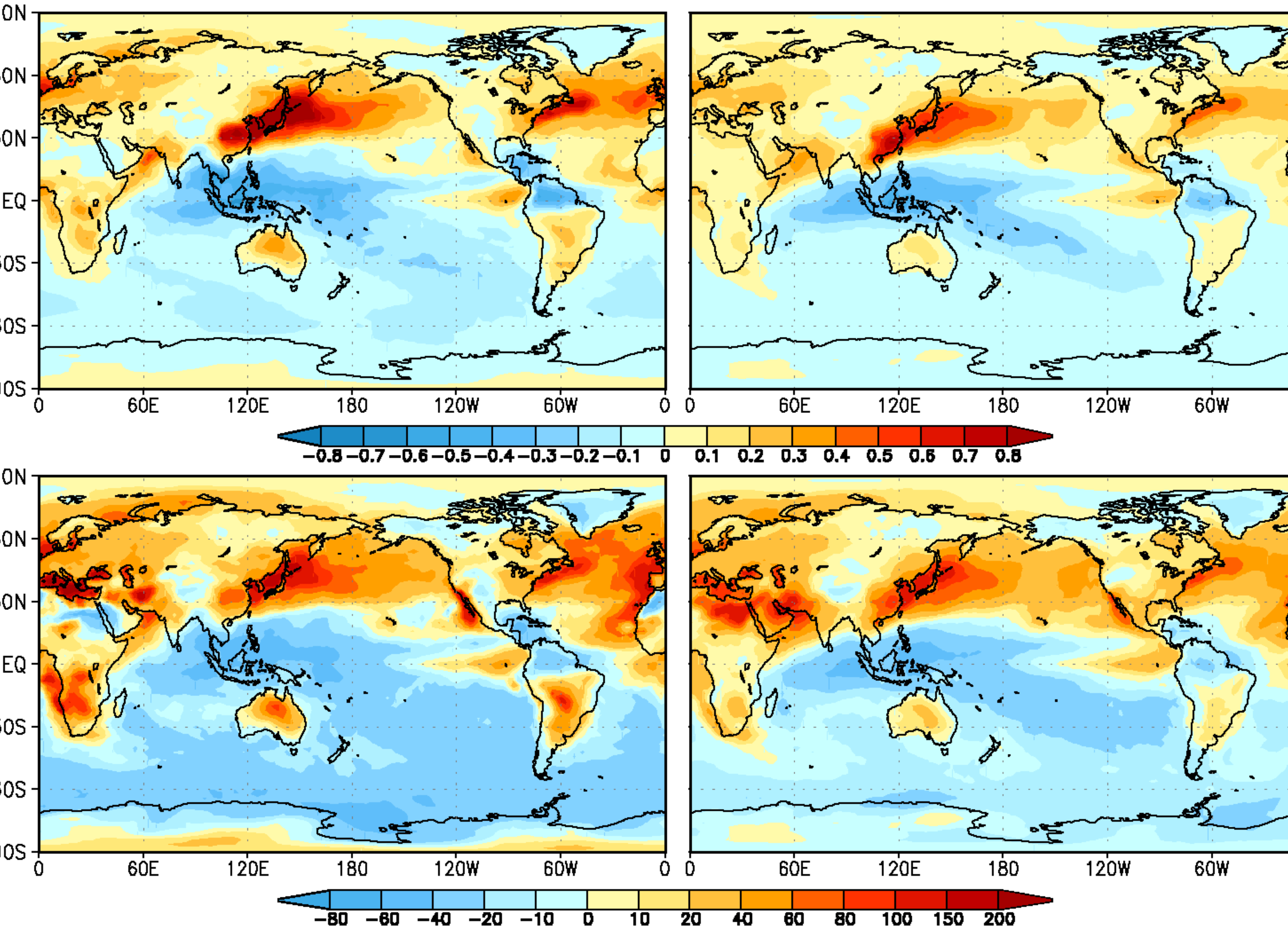
Surface incident shortwave radiation (W m^{-2}) difference from Control.



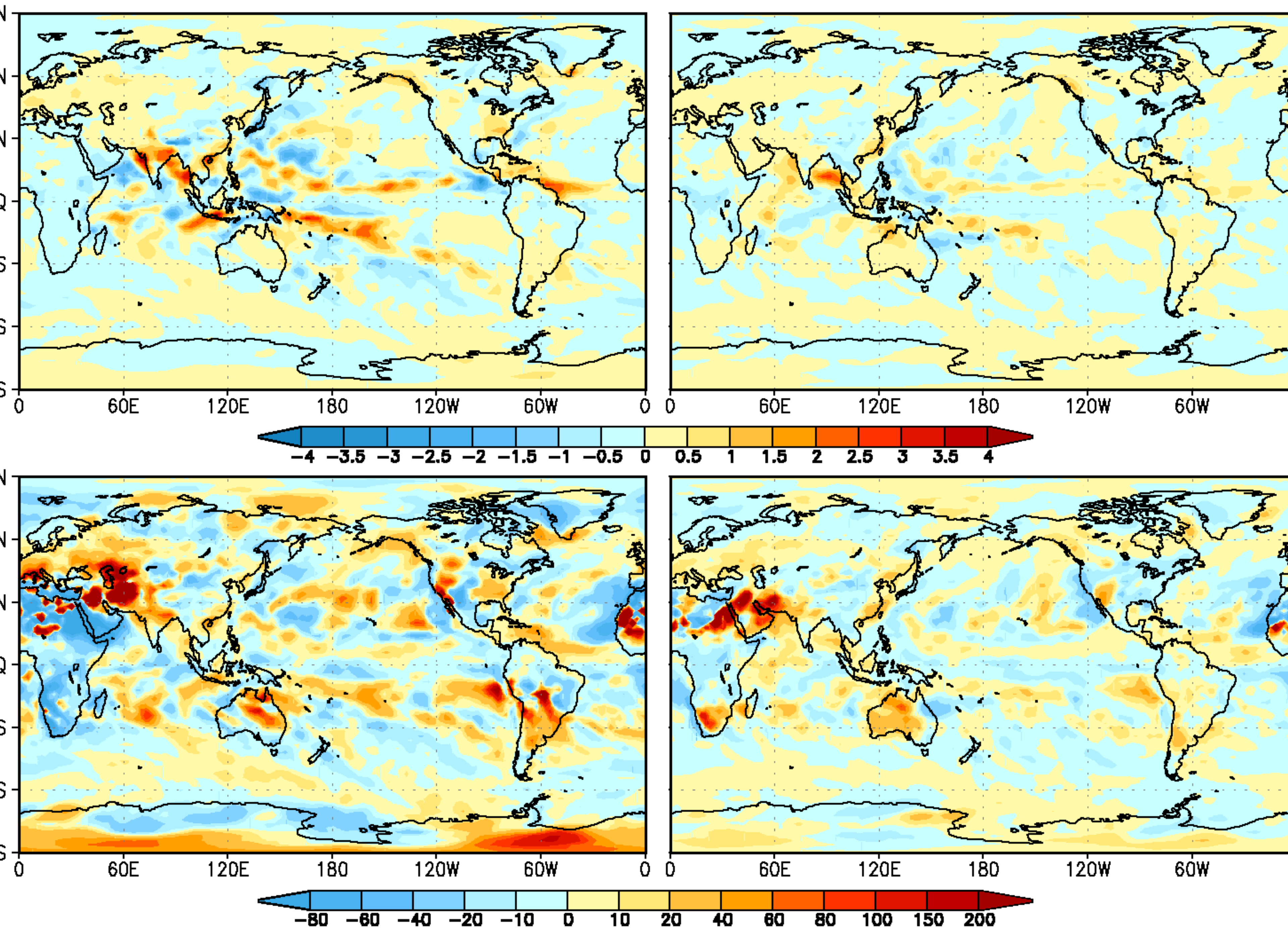
Surface net radiative forcing (W m^{-2}) difference from Control.



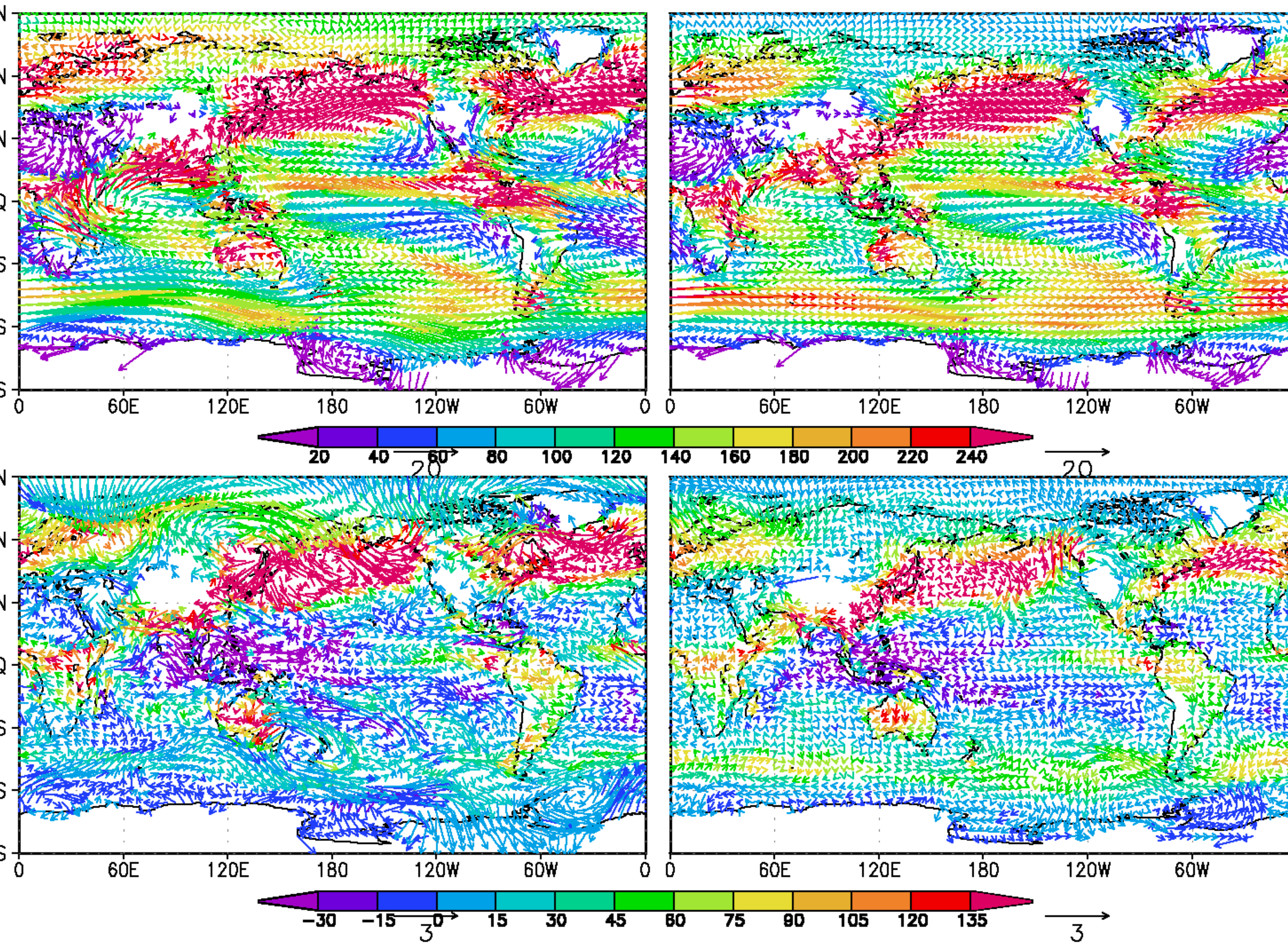
Column cloud water (kg m^{-2}) difference from Control (top) and percent difference (bottom)



Column optical thickness difference from Control (top) and percent difference (bottom).



Precipitation (mm d^{-1}) difference from Control (top) and percent difference (bottom).



850hPa winds (top) and difference from Control (bottom). Color represents column cloud water path (g m^{-2}).

Summary and Comments

1. Clearly, sulfate aerosols are interacting with clouds; we note large cloud water content over North Pacific and Atlantic in response to the sulfates-aerosols.

2. This alters the radiation balance but without interactive oceans, the effect on atmospheric circulation is likely to be muted.

Summary and Comments (2)

3. This is just an exercise in understanding the response of our model to sulfate aerosols; perhaps the only important focus for now is the relative response of our model to other models.

4. We will prepare the data for transmission to pcmdi.llnl, but we are also concerned that everyone is doing the experiment somewhat differently; this might lead to a mixed bag of understanding and confusion(s).