Supplement of Atmos. Chem. Phys. Discuss., 15, 5537–5552, 2015
http://www.atmos-chem-phys-discuss.net/15/5537/2015/
doi:10.5194/acpd-15-5537-2015-supplement

Atmospheric Chemistry and Physics
Discussions
Open Access

Supplement of

Ocean mediation of tropospheric response to reflecting and absorbing aerosols

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Table S1. (a) TOA forcing (W/m2, shortwave + longwave) due to BC (direct radiative forcing, pre-industrial to present-day; not including snow albedo effect), SO4 (direct+indirect effect, so called "adjusted forcing", pre-industrial to present-day) and CO2 (pre-industrial to 400 ppm). The forcing is calculated by running atmospheric model for 5 years (same as Fig S1a). (b) Surface temperature change (℃) in response to different forcings in (a). Surface temperature change is calculated from a 60-year average of coupled model simulation. (c) Cumulative precipitation (cm) change in response to different forcing agents. The relative change of cumulative precipitation in percentage is shown in parenthesis next to the absolute change.

	BC	SO4	CO2
(a) TOA net forcing (W/m2)	0.5	-0.9	1.7
(b) Surface temperature change (℃)	0.21	-0.49	1.15
(c) Cumulative precipitation (cm)	-0.01 (0%)	-2.09 (-2%)	1.73 (2%)

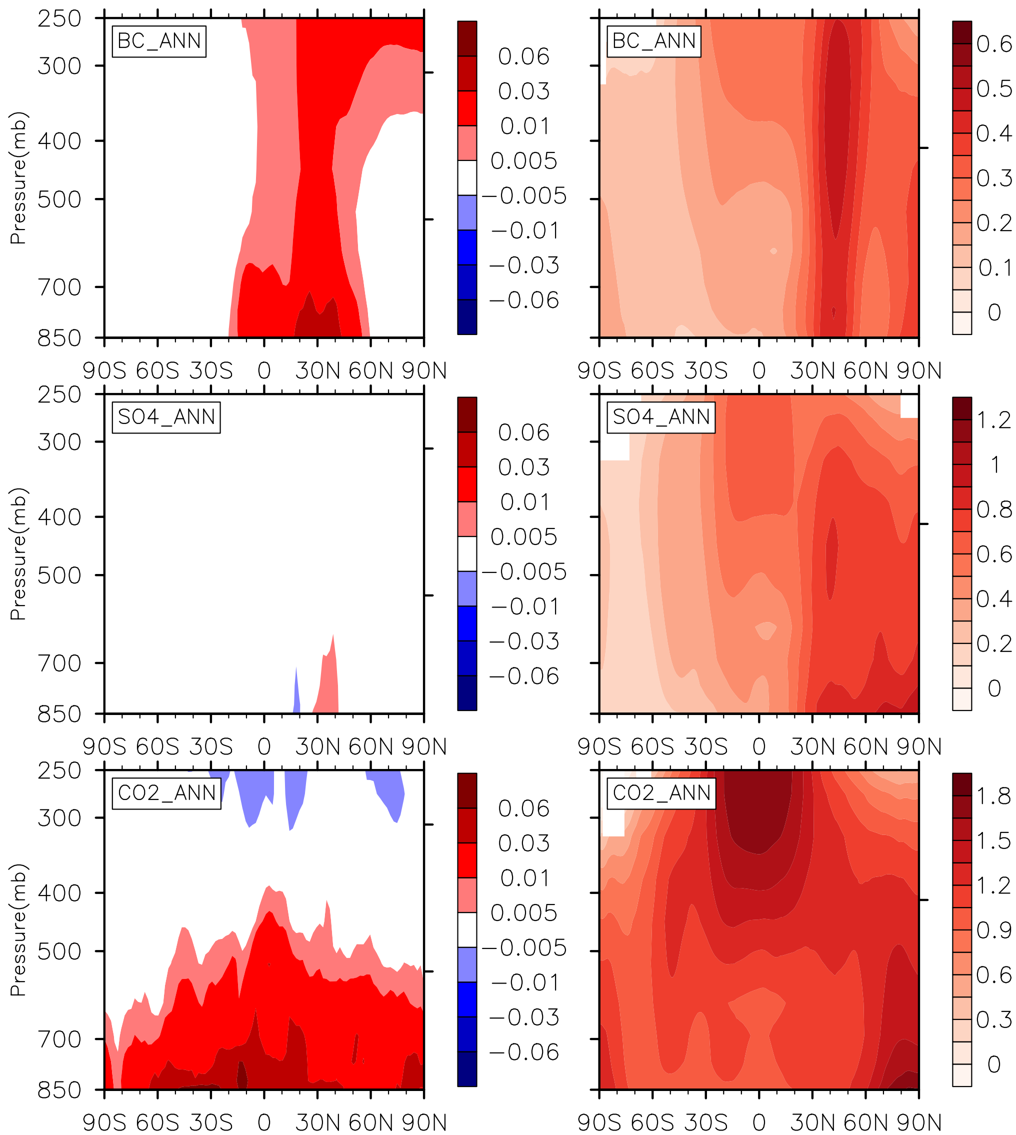

Figure S1. (Left) Heating rate (K/day) due to increase of BC, SO4 and CO_2 atmospheric concentration. The heating rate is diagnosed from 5-year atmospheric-only simulations by calculating the energy flux twice. (Right) Annual averaged atmospheric temperature response due to increase of BC, SO4 and CO_2 atmospheric concentration. SO4 color is reversed. The CO_2 atmospheric response features a structure of amplified upper tropical troposphere warming (maximum at around 300 mb), which is a robust feature due to thermodynamical adjustment of the tropical atmosphere to maintain a moist adiabatic lapse rate there. The lower tropospheric atmospheric temperature over the Arctic also has a larger response, mostly due to stronger snow albedo feedback.

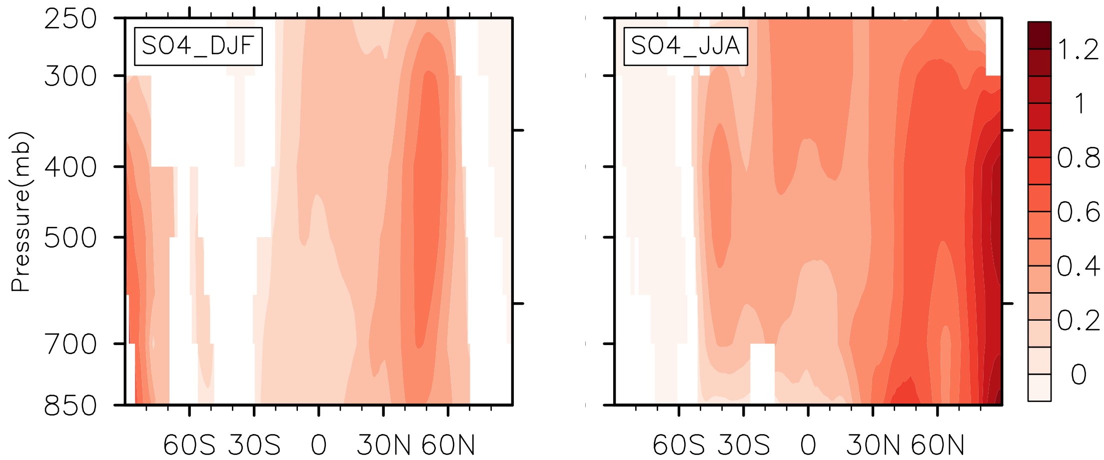

Figure S2. Similar to the 2nd row of Figure 1, but showing the trend of temperature changes (K/decade) during 1940–1970 in the 20th century transient climate simulation using the same model (CESM1) with time-evolving aerosol-only forcing. During this period, SO_2 emissions rapidly increased (Smith et al., 2010). Color scale is reversed to be consistent with Fig 1. GHG forcing is fixed in this simulation. An ensemble of three simulations was conducted.

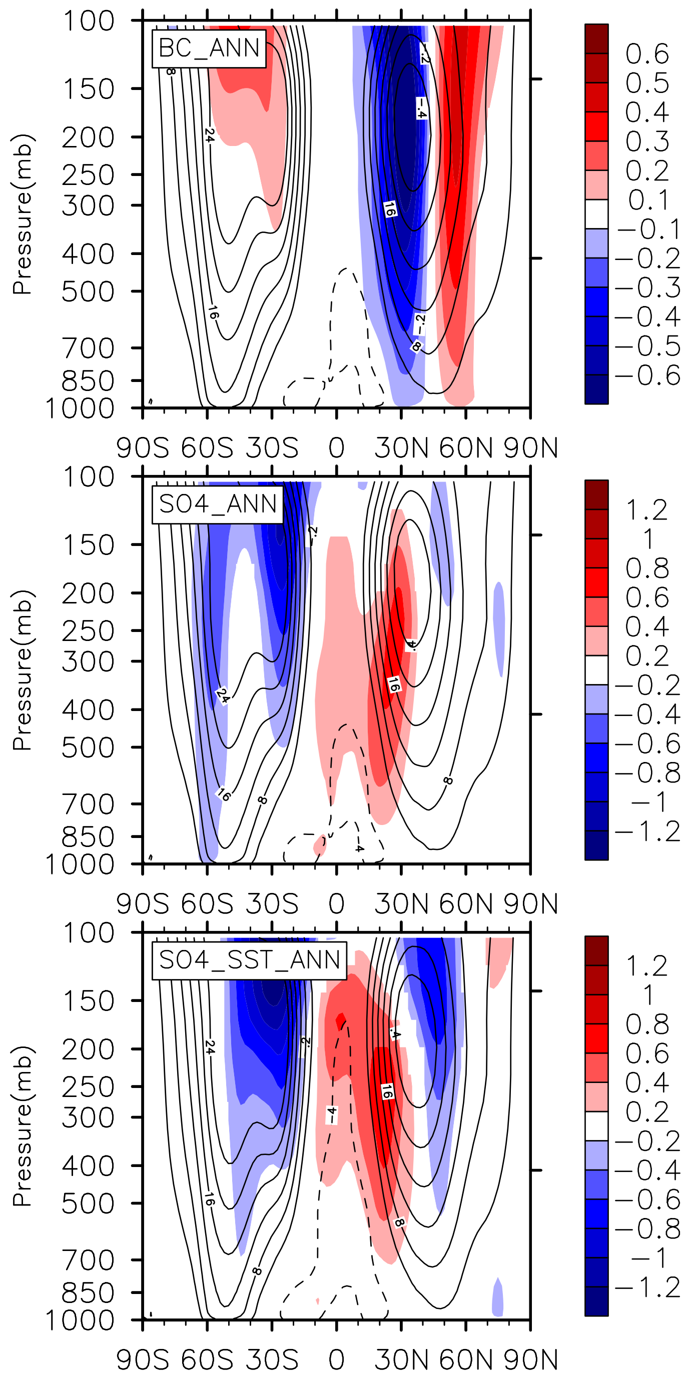

Figure S3. Similar to Figure 3, but showing the zonal mean zonal wind (U) change under various cases. The climatological jet stream is around 30°N to 60°N at 250 mb (line contours). Under SO4 forcing, the NH jet stream shifts significantly equatorward.

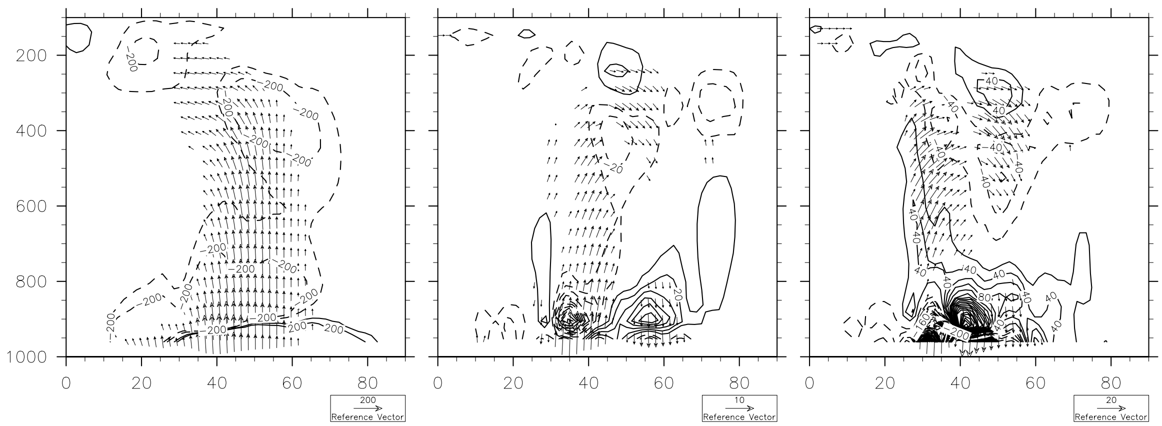

Figure S4. Similar to Figure 4, but (a) shows the climatology, and (b) shows the contributions of the stationary eddy to the change shown in Fig 4. This was calculated using a 10-day average, instead of daily data. Transient eddies are the difference between the total and stationary contribution (not shown). (c) shows the boreal winter (DJF) average, not the annual average that is shown in Fig 4. Note the reference vector changes across the panels (200, 10, 20).

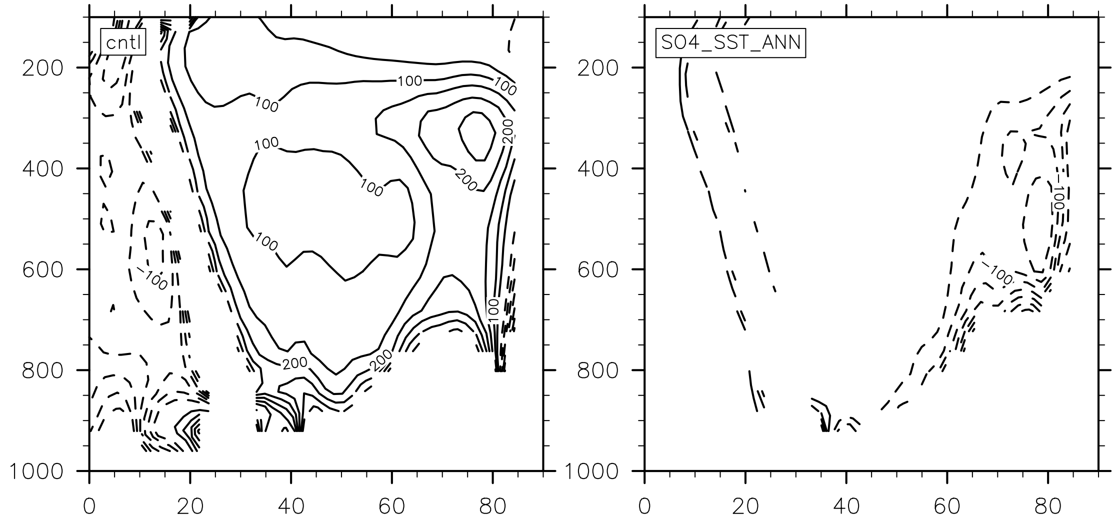

Figure S5. Refractive index in climatology (left panel) and its change due to SO4-induced SST perturbation (right panel). The contour plot is limited to 0–400, following Figure 8 of Limpasuvan and Hartmann (2000), to highlight the contours in the mid-latitude regions where the wave activities are strongest.