Source attributions of pollution to the Western Arctic during the NASA ARCTAS field campaign

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Supplementary material

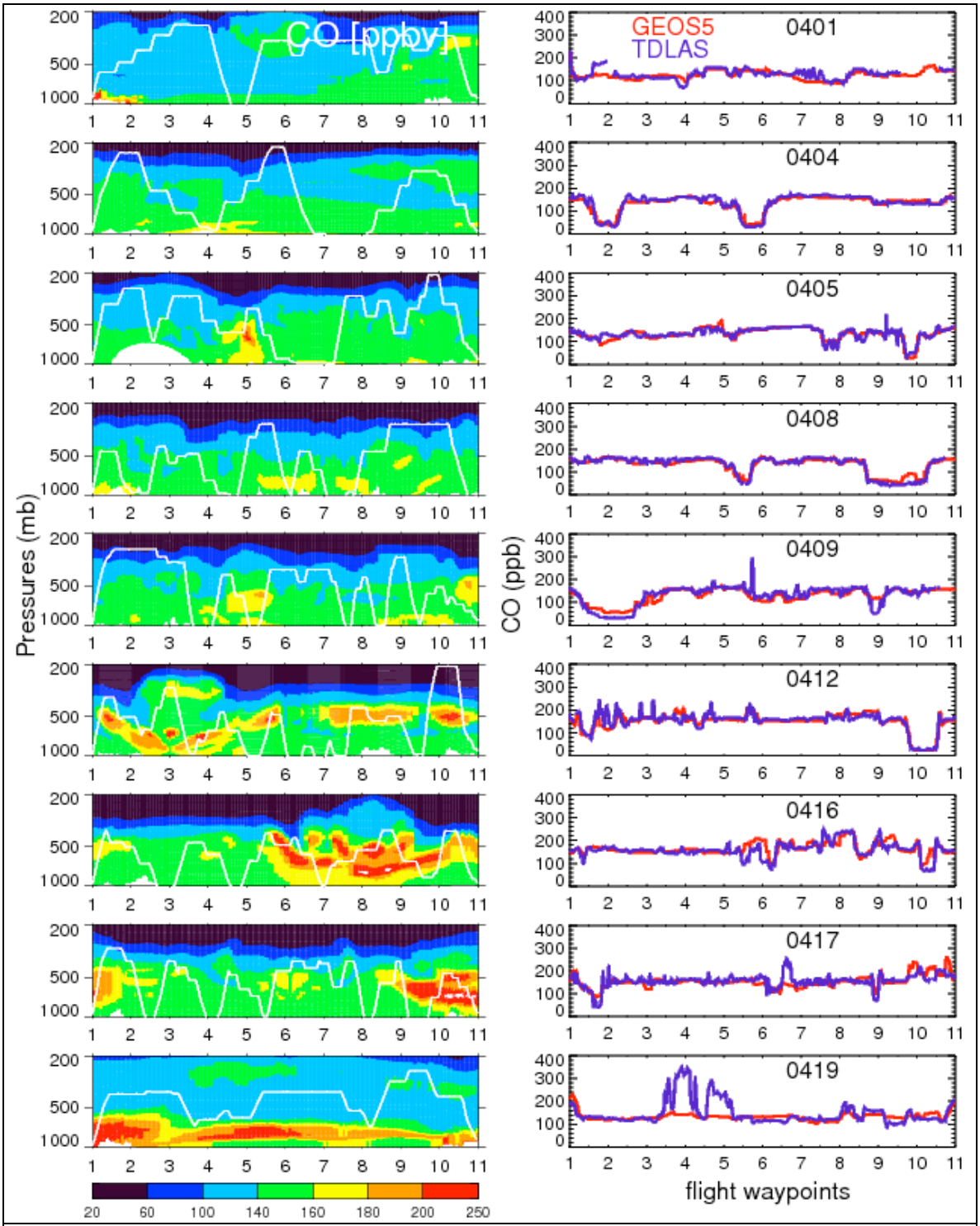
More evaluations for the model simulation are presented in the supplementary material (SM). The tracer concentrations from model and observation along each flight track for CO and BC are shown in Fig. S1 and S2, respectively, for April and in Fig. S3 and S4 for July. The model generally captures the observed CO and BC in both average level and variability. The agreement is better for CO than for BC. This is partially because BC is more spatially and temporally inhomogeneous and the finer BC features observed by aircraft measurements cannot be captured by the model based on its spatial and temporal resolution and partially because BC is more sensitive to local biomass burning emission. The model overestimates the local biomass burning emission on 1 July BC simulation, while underestimates on 4 July. The spike in the measurements on 19 April came from a local source when the instruments onboard the aircraft sampled the boundary layer (PBL). The model misses these spikes in both CO and BC, possibly because the PBL depth is underestimated in the model or because of too coarse vertical resolution in the model around the top of PBL.

A scatter plot of the DC-8 measured CO mixing ratios compared to the total CO mixing ratio simulated by the GEOS-5 model along the flight tracks is presented in

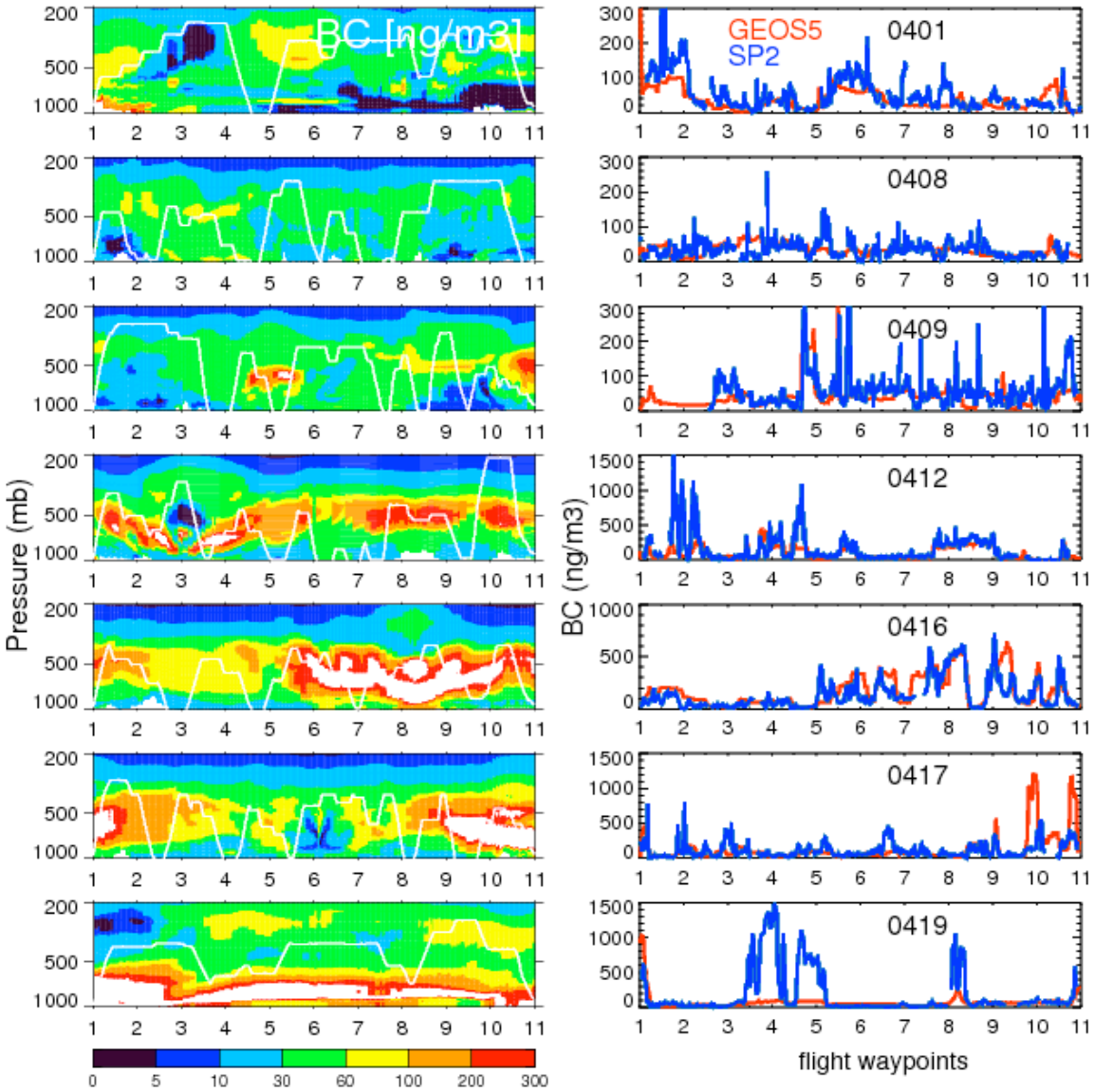
S5 and a similar comparison for BC is done in S6. Here, the model is also sampled at the time and location where the aircraft measurements were made. Each point on the figure represents median values of model and observation within 10 minutes. Separate panels are presented for the spring and summer phases of the ARCTAS campaign, and within each panel the comparison points are color-coded by the particular aircraft flight, consistent with the color-coded flight tracks shown in Fig. 1b-c.

In April, measured and modeled CO values rarely exceeded 250 ppbv, suggesting long-range transport rather than local biomass burning sources as the origin of the observed CO. The model CO is well correlated with the observations (r = 0.88). The ratio of mean modeled CO to mean observed CO is 0.99, indicating an overall good performance of the model. In July, the observed CO mixing ratios sometimes were as high as 800 ppbv. The DC-8 sometimes observed very high CO values that were missed in the model simulation and vice versa. These high CO events not simulated in the model are possibly due to missing sources, the inability of the model to capture fine structure plumes, or plumes simply being misplaced in the model. The correlation of the model with the observations is thus reduced (R = 0.62) although the simulated mean CO is somewhat unchanged (B = 0.98) in July.

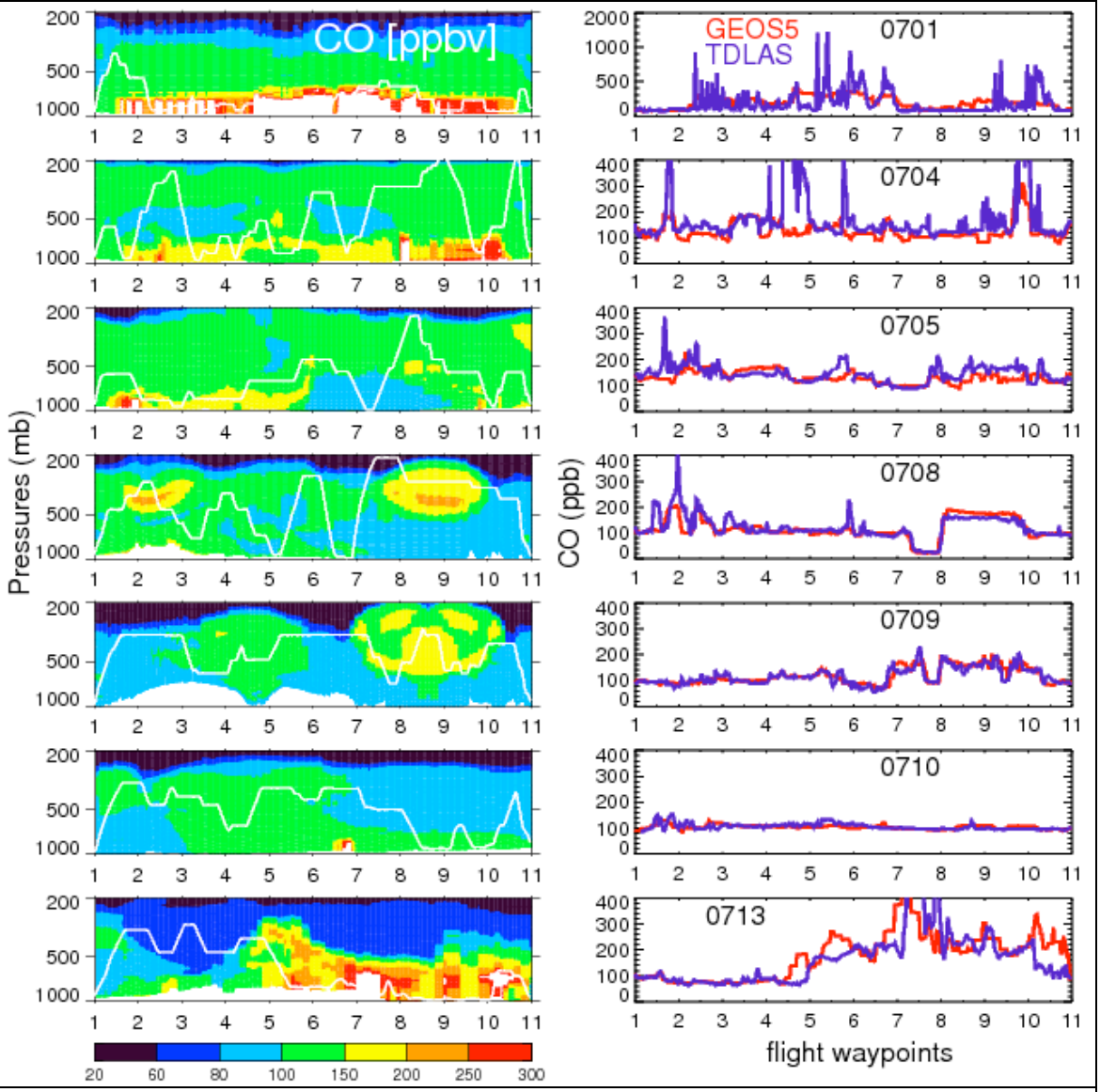
The correlations between modeled and observed BC are higher than 0.5 but lower than those of CO's, consistent with our discussion above. The simulated BC mass concentrations are closer to the observed values in April (B = 0.96) than in July (B = 1.73). The higher bias in July BC simulation is mainly caused by overestimated BC on 1 July when the QFED v2.4 reported a very high local biomass burning.



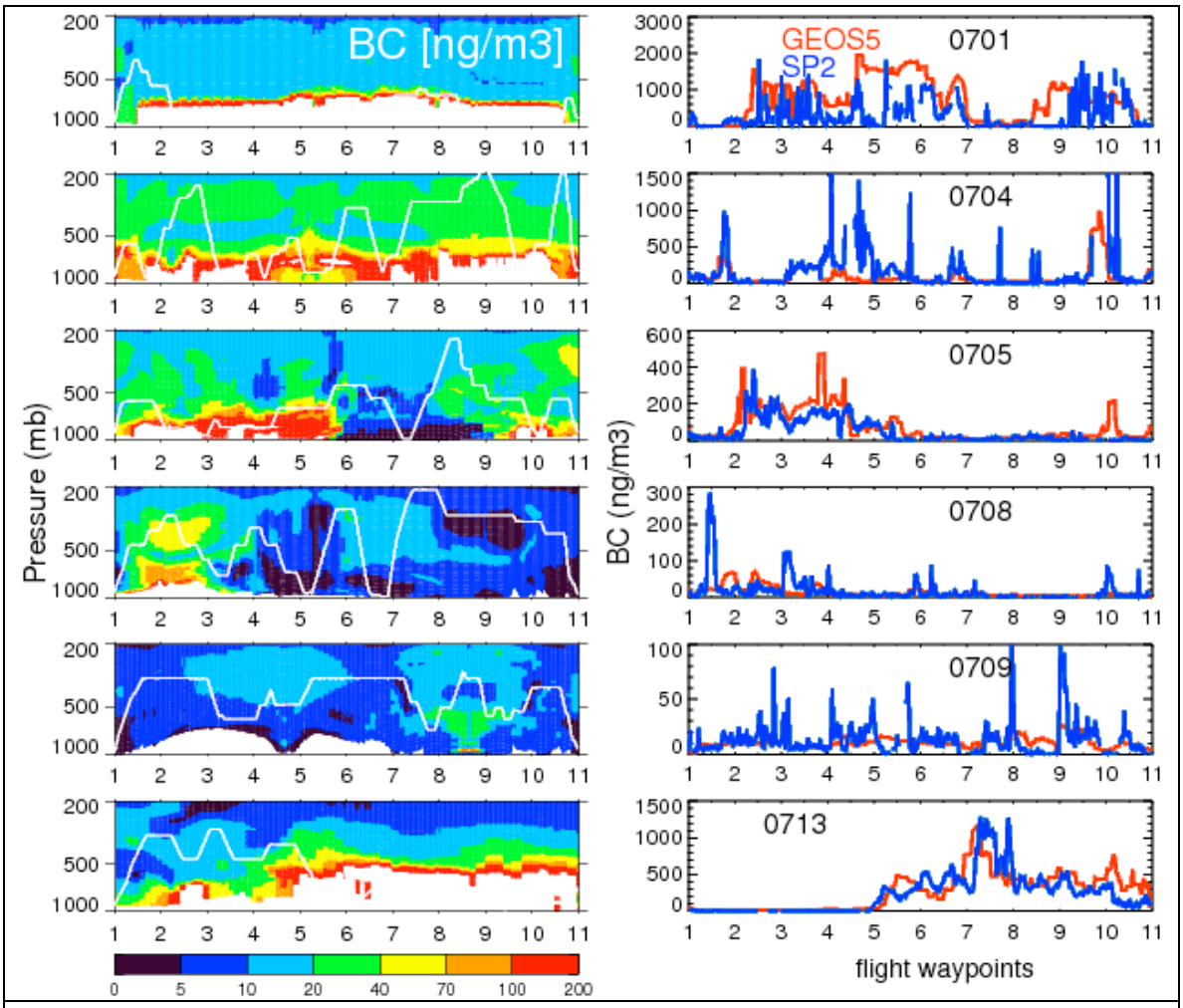
S 1. The modeled and measured CO mixing rations during the ARCTAS A April campaign based over Fairbanks, Alaska. The curtain plots are shown in left column for modeled total CO with the white line representing the flight track. The measured and modeled total CO volume mixing ratios along flight track are shown in right column. The model misses the pollution on 19 April when the aircraft hit boundary layer.



S 2. Similar to S1 but for BC mass concentration.



S 3. Similar to S1 but from ARCTAS B July campaign based on Cold Lake, Canada.



S 4. Similar to S2 but from ARCTAS B July campaign based on Cold Lake, Canada.

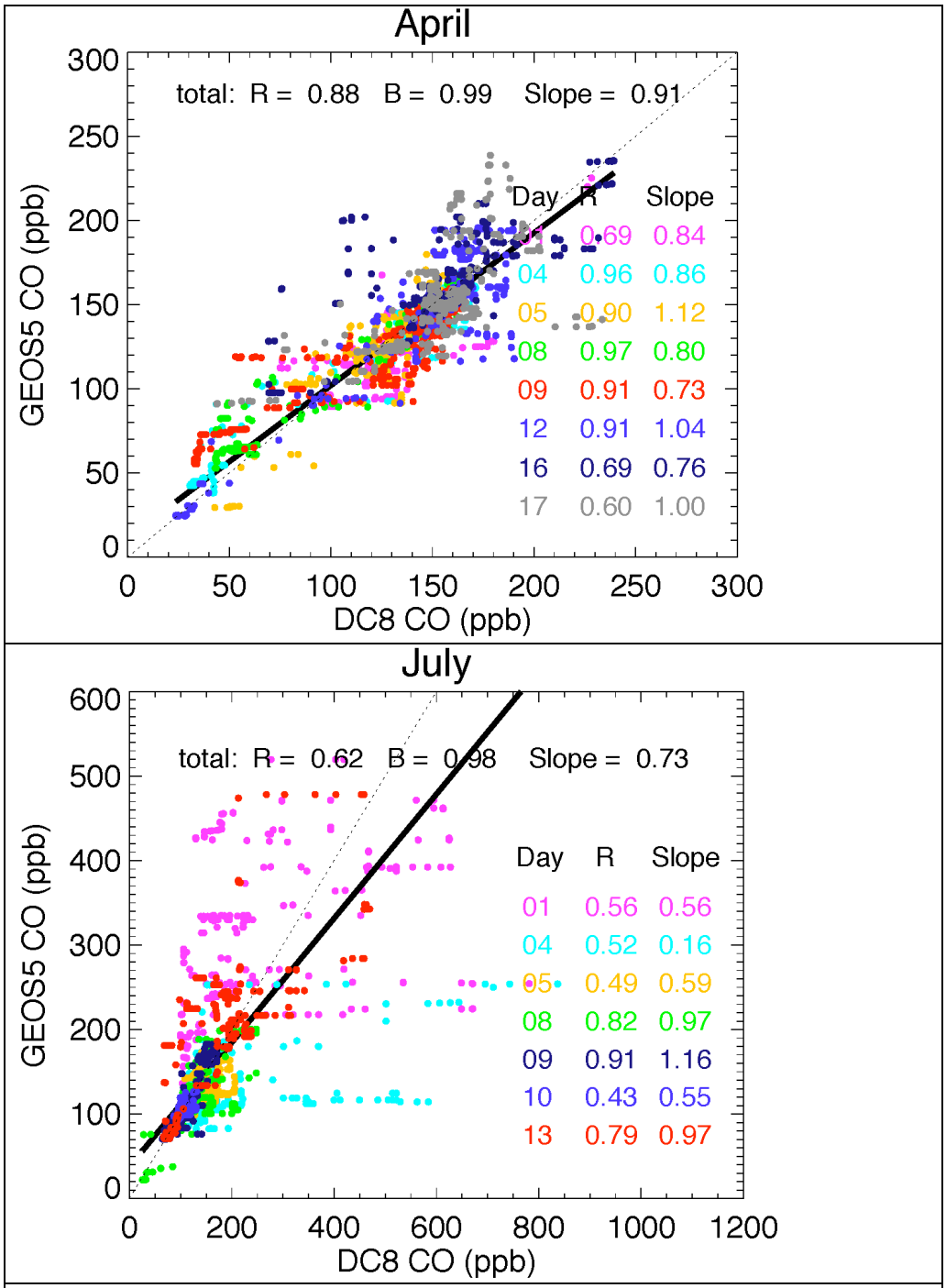


Figure S5. Scatter plot of CO volume mixing ratio (ppb) from the DC-8 aircraft measurements and the GEOS-5 simulation for April and July, with colored dots for different flights. Each scattering point represents median values of model and observation within 10 minutes. The thick solid line is the linear regression line and the thin dotted line is 1:1 line. The data correlation coefficient (R) and bias (B) (ratio between mean model value and mean measurement value) are calculated for each campaign. Note the flight on 19 April is excluded as explained in S1.

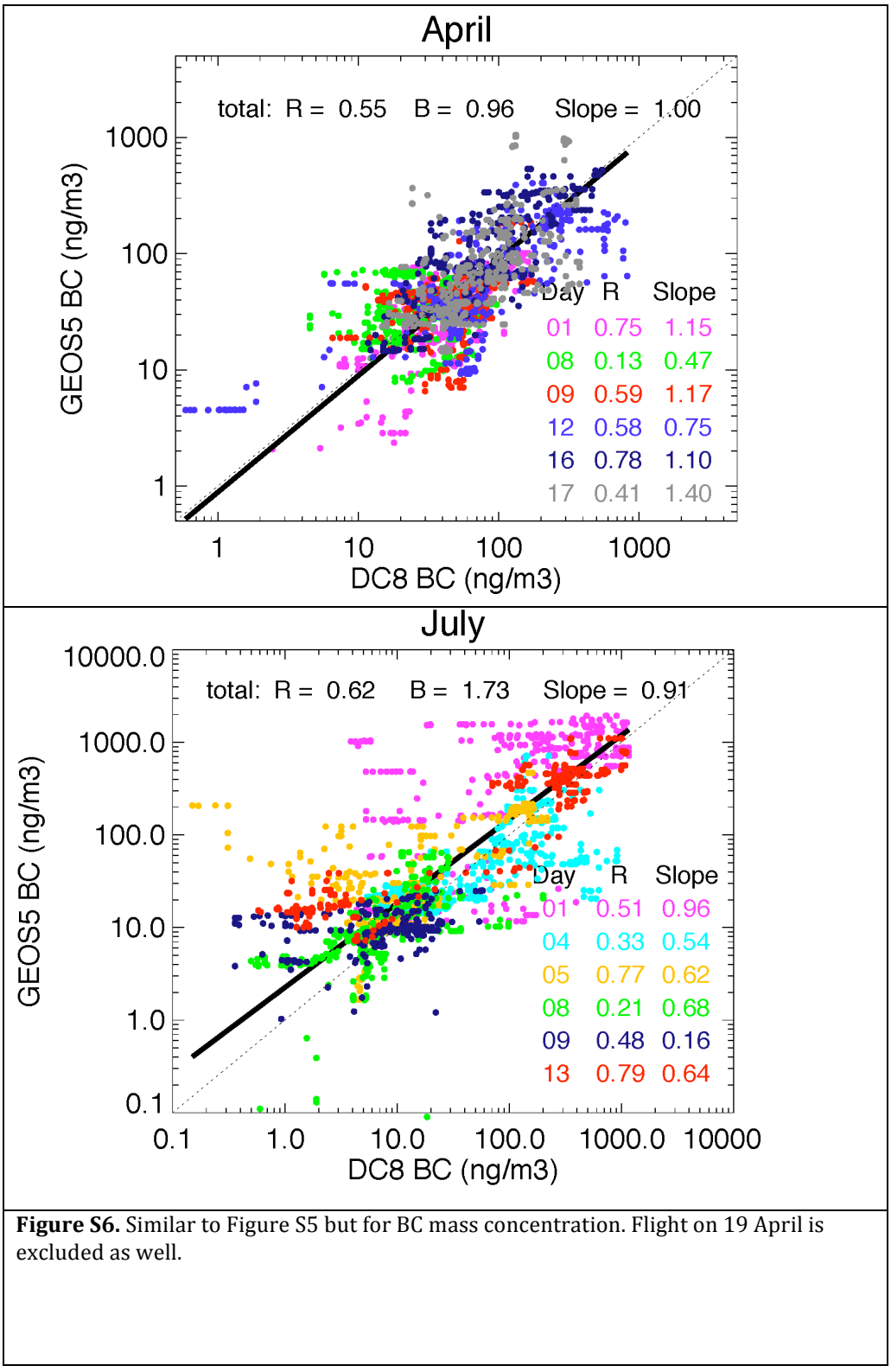


Figure S6. Similar to Figure S5 but for BC mass concentration. Flight on 19 April is excluded as well.