



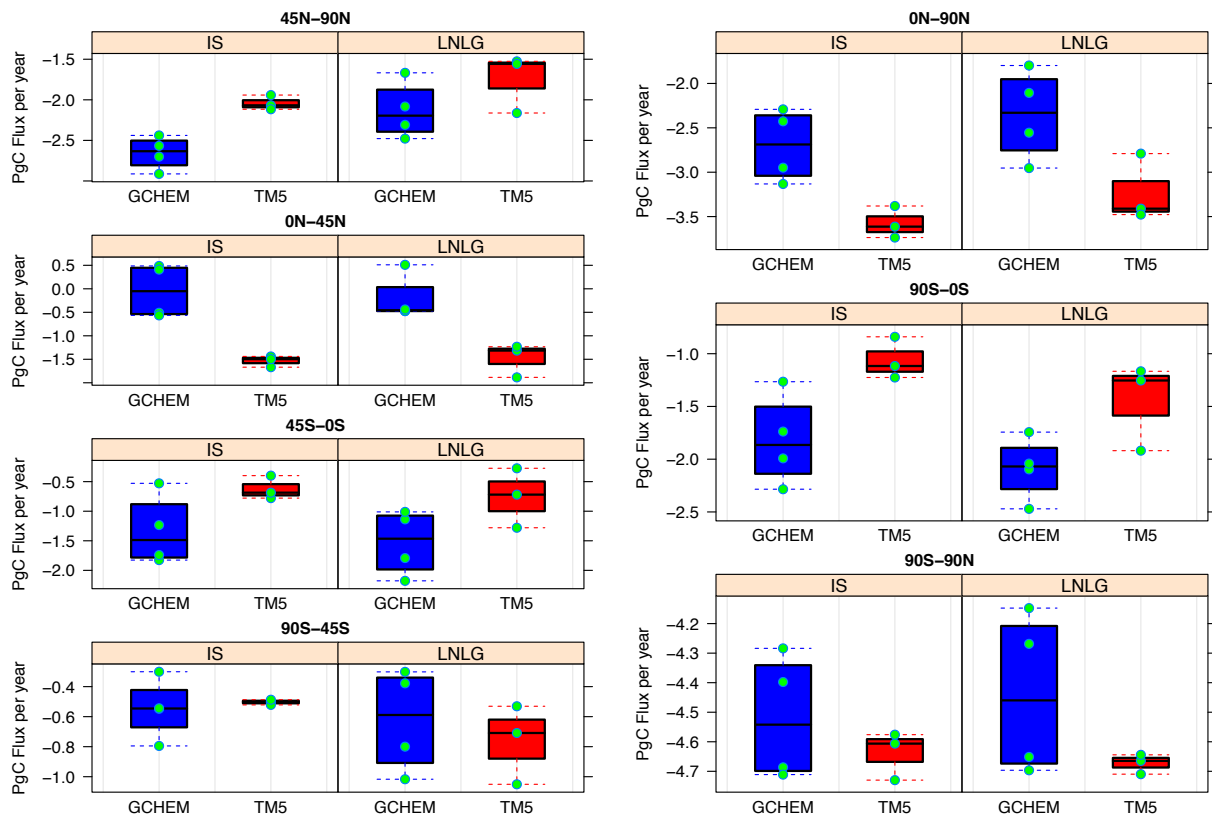
*Supplement of*

## **Uncertainty in parameterized convection remains a key obstacle for estimating surface fluxes of carbon dioxide**

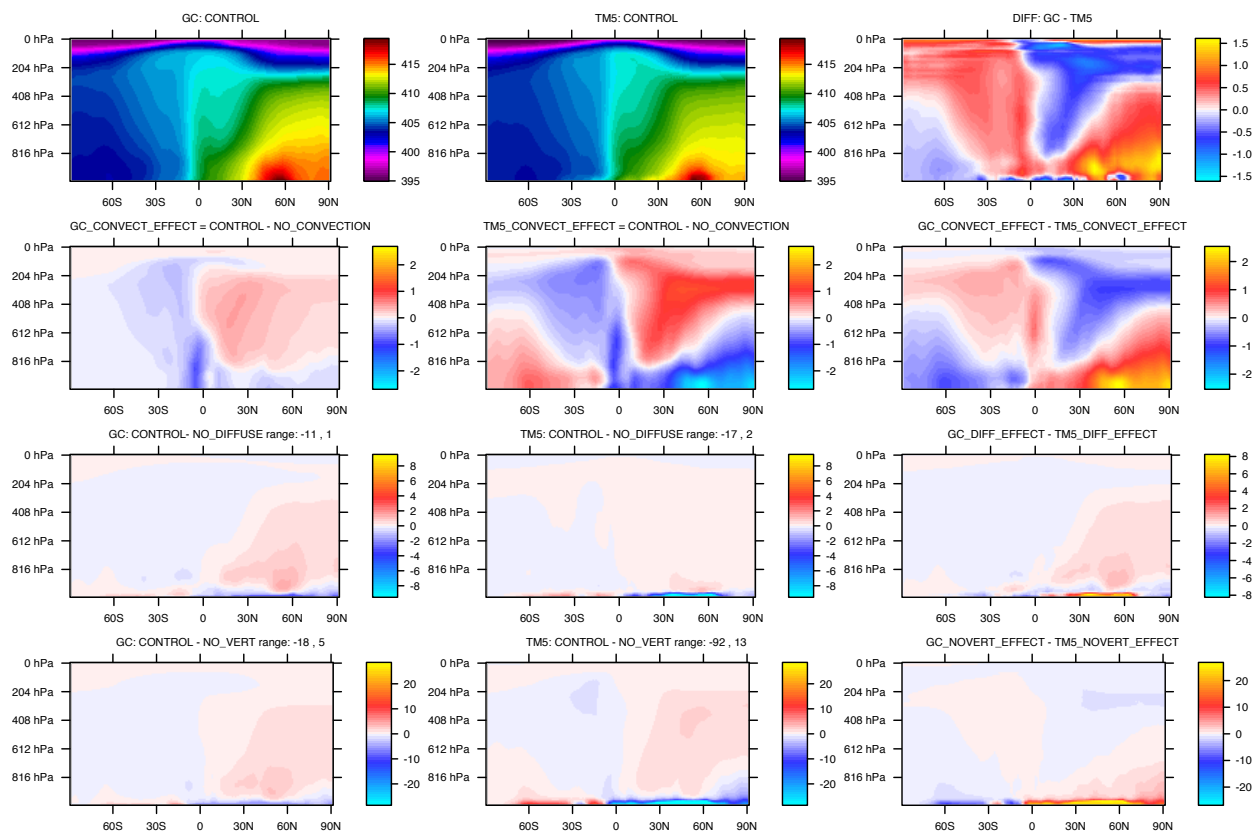
**Andrew E. Schuh and Andrew R. Jacobson**

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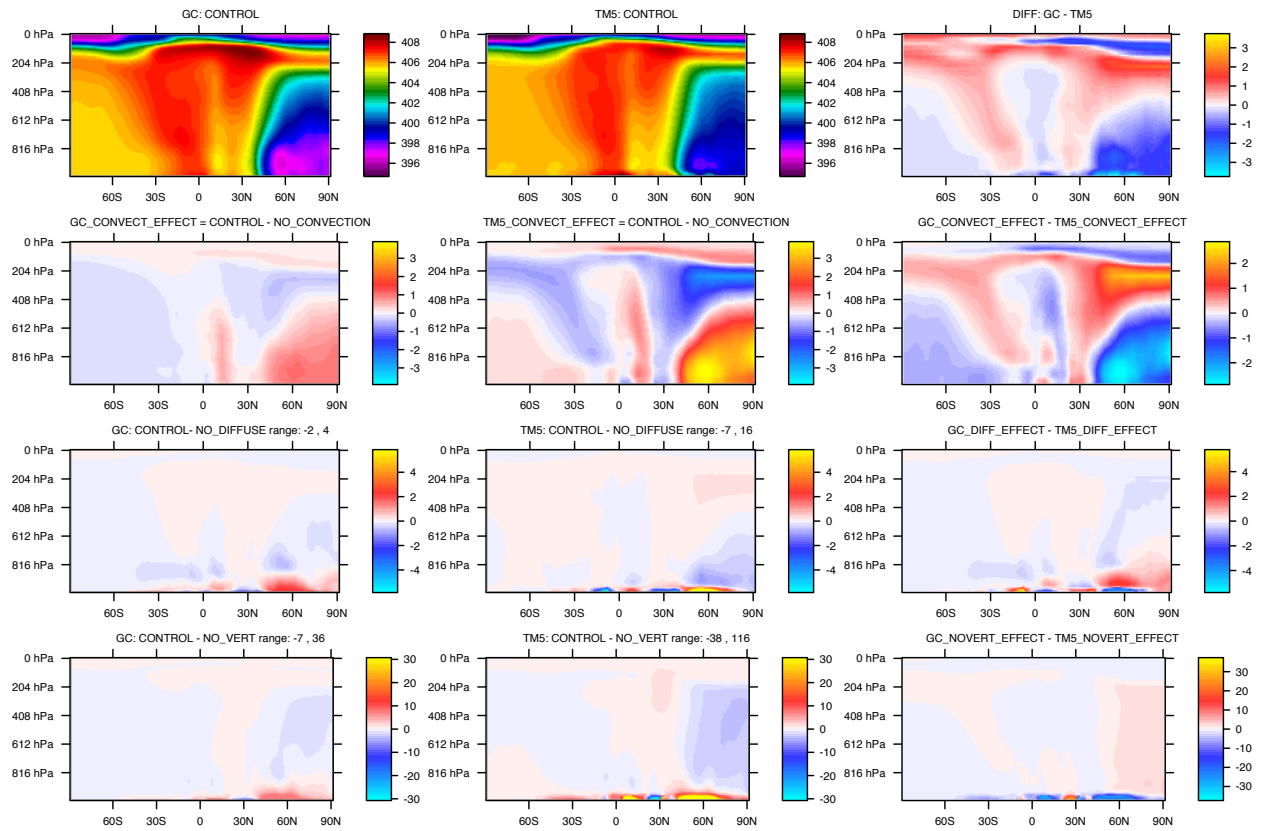
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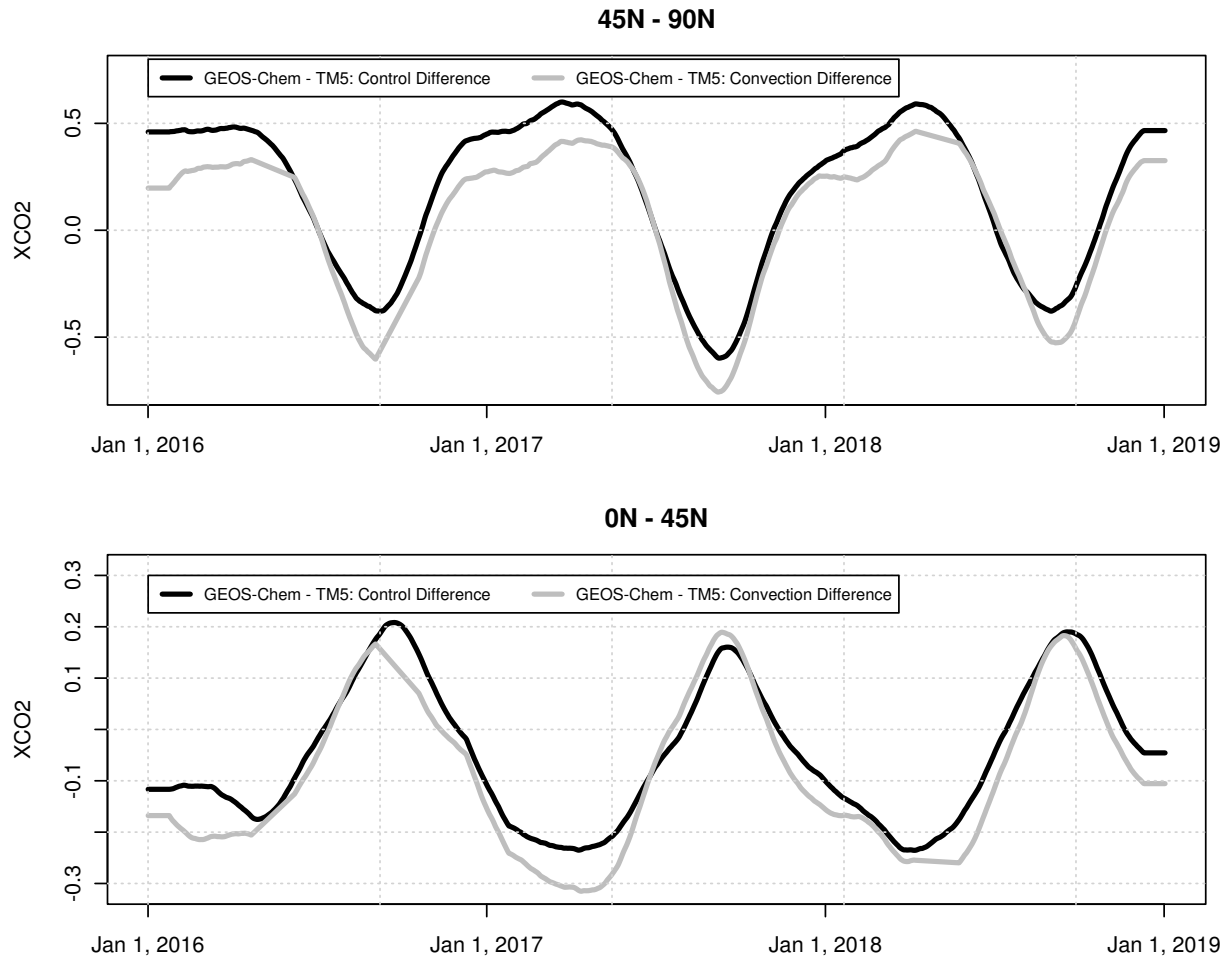
**Figure S1:** Annual flux average (2015–2018) from Orbiting Carbon Observatory-2 model intercomparison project suite. IS refers to inversions constrained with traditional in situ observations, and LNLG refers to inversions constrained with XCO<sub>2</sub> retrievals from Orbiting Carbon Observatory-2 in its land nadir and land glint observing modes. The box and whiskers plot shows a box which roughly approximates the first and third quartiles of the data and whiskers which extend to the most extreme data point which is no more than 1.5 times the length of the box away from the box. This figure is an update of the boxplot image in Schuh et al 2019 (Figure 7) using “version 7” of the OCO-2 Flux MIP. This figure uses version 9 of the ACOS OCO-2 XCO<sub>2</sub> data.



**Figure S2:** Full version of February 2018 effects, top 6 panels show same model data as top 6 panels of Figure 1. Third row of panels show effects of vertical diffusion ( $\sim$ PBL mixing) and fourth row shows “no diffusion and no convection” (no parameterized vertical mixing).

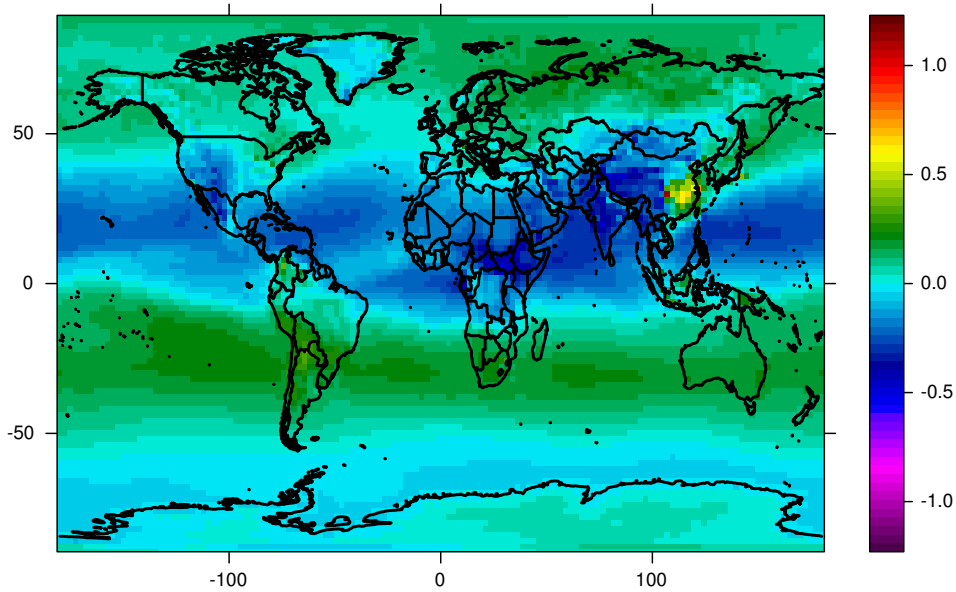


**Figure S3:** Same as Figure S2, but for August 2018.

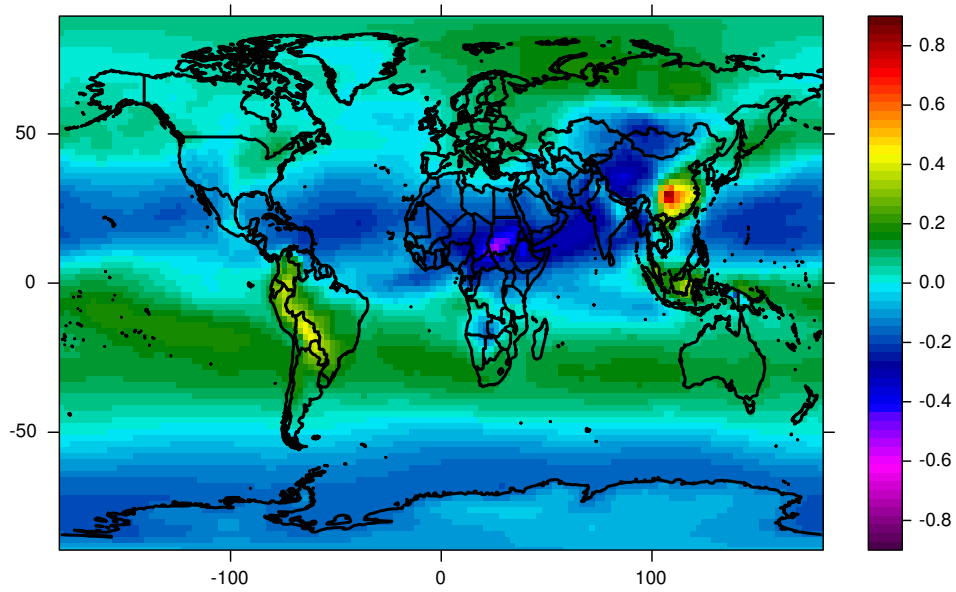


**Figure S4:** This figure is plotting average XCO2 for each of the specified latitude bands. This figure emphasizes the degree to which convective differences drive the overall seasonal difference between the models.

TOTAL CO2: GEOS-Chem minus TM5 XCO2 (ppm)

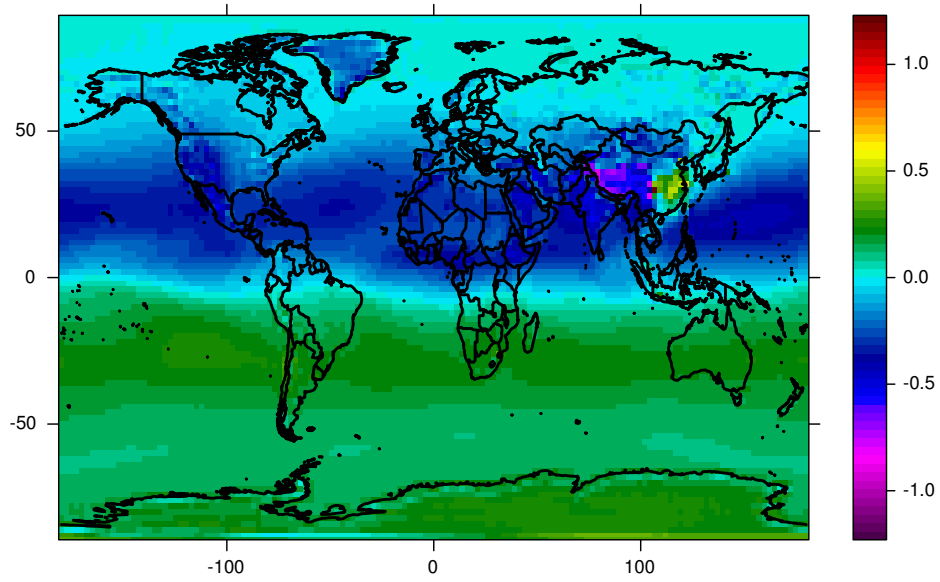


TOTAL CO2: XCO2 MEAN DIFF 2015-2018: GC-TM5 (Convection Effect)

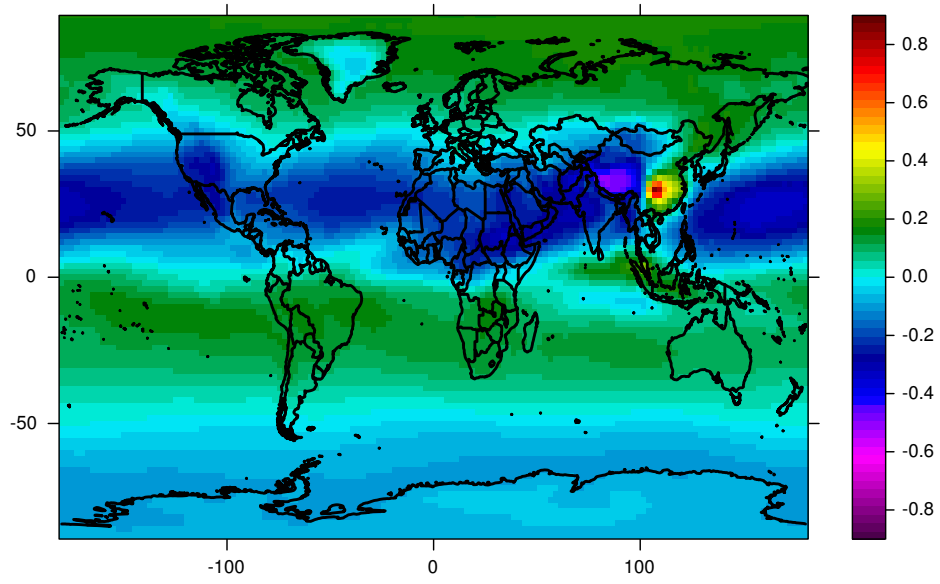


**Figure S5:** The following three figures, S5, S6 and S7 show images similar to the manuscript Figure 3, but for different tracers (total, fossil, and biological).

**FOSSIL CO2: GEOS-Chem minus TM5 XCO2 (ppm)**

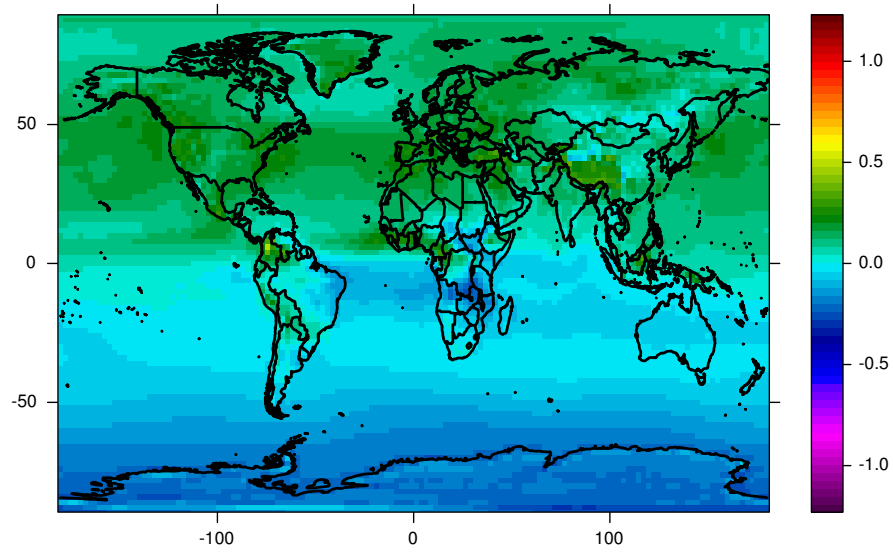


**FOSSIL CO2: XCO2 MEAN DIFF 2015-2018: GC-TM5 (Convection Effect)**



**Figure S6:** See caption for Figure S5.

BIO CO2: GEOS-Chem minus TM5 XCO2 (ppm)



BIO CO2: XCO2 MEAN DIFF 2015-2018: GC-TM5 (Convection Effect)

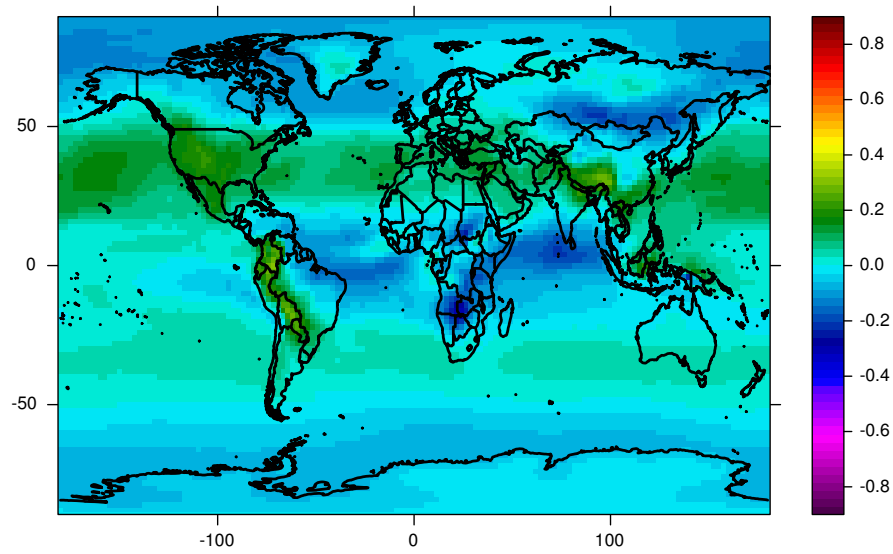
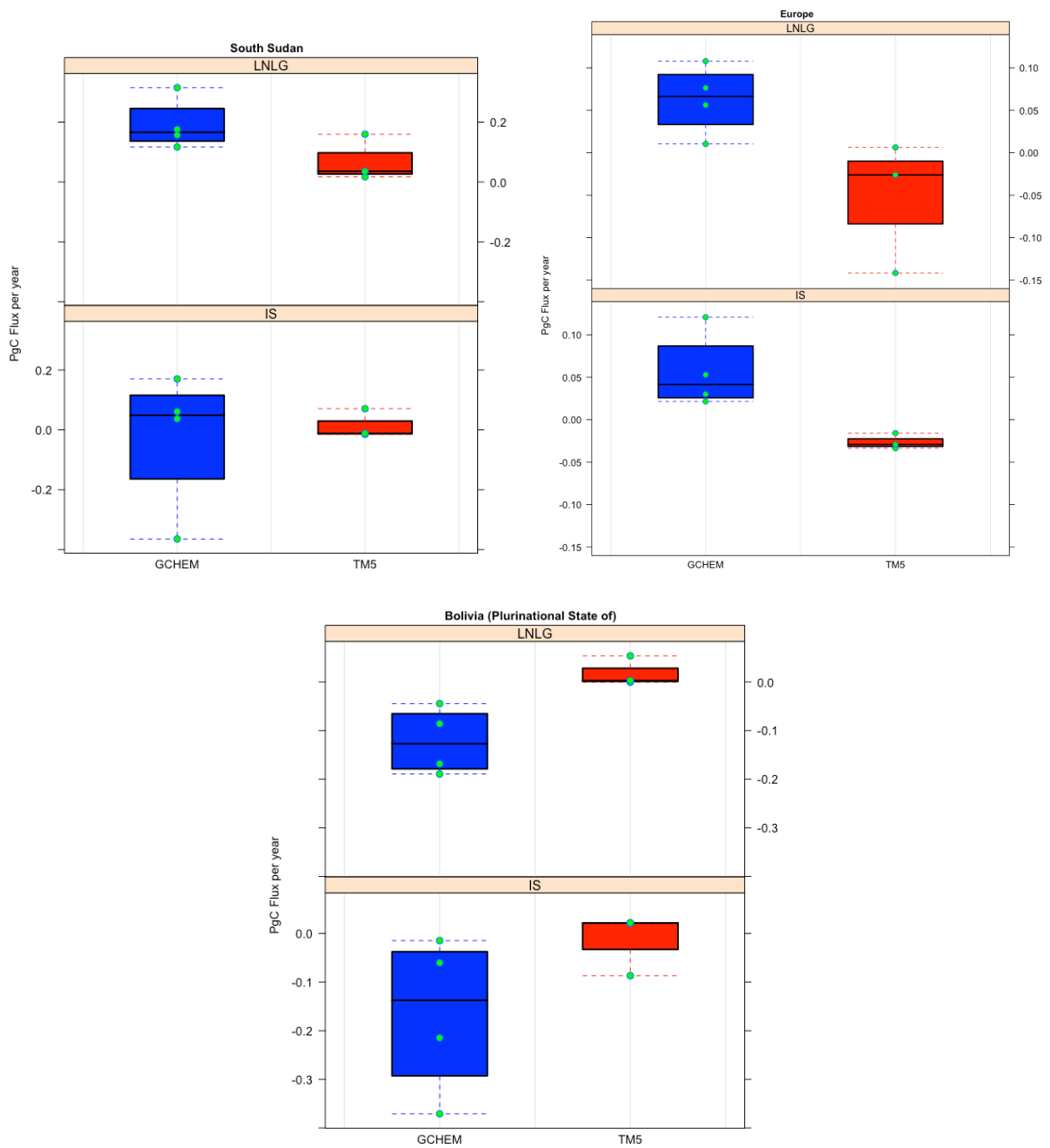
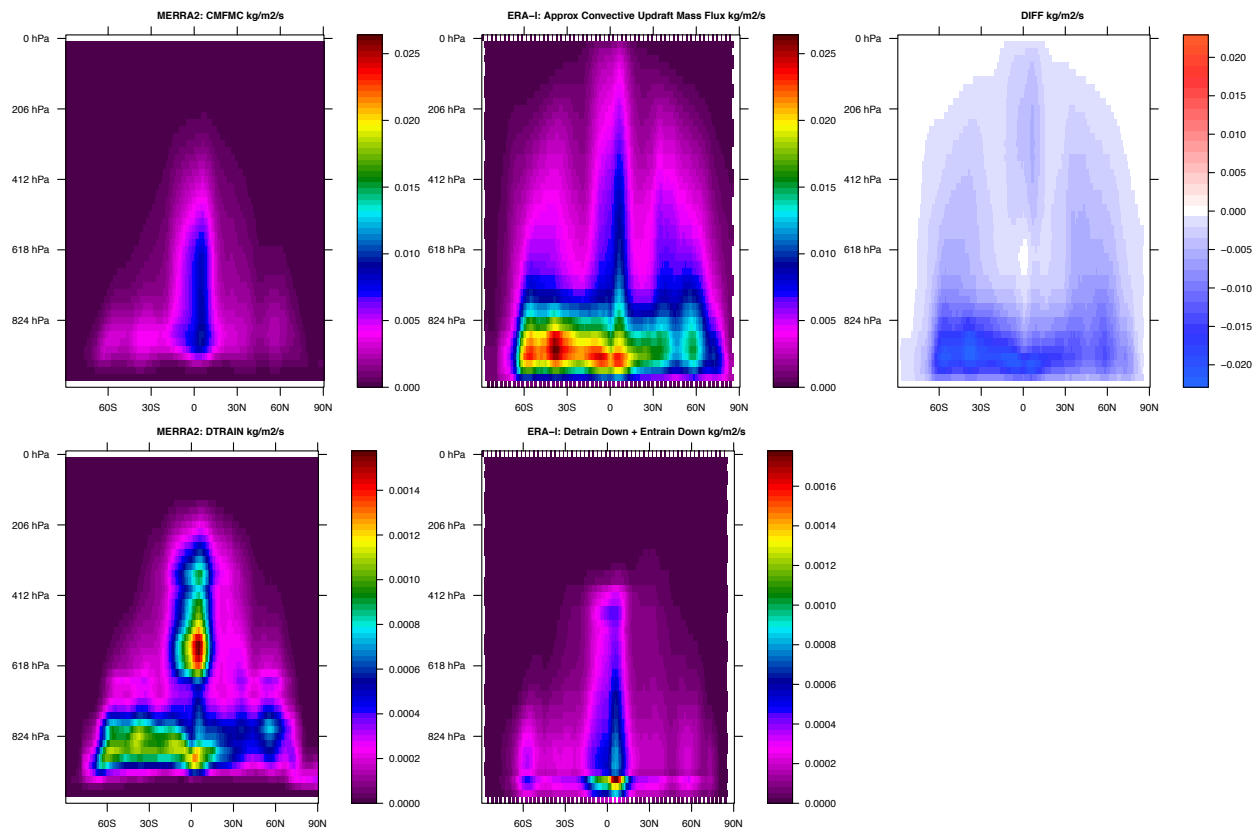


Figure S7: See caption for Figure S5.





**Figure S8:** This image shows area integrated annual carbon flux differences from the v9 OCO2 Flux MIP. This figure is synonymous with what is shown in Figure S1 (and Figure 1 of Schuh et al 2021b), but focuses on countries instead of broad latitude bands.



**Figure S9:** The figure compares zonally averaged annual means upward convective mass fluxes for 2015, from MERRA2 as used by GEOS-Chem (top left panel), ERA-Interim as used by TM5 (top middle panel), and the ERA-interim minus MERRA2 difference (top right panel). MERRA2 convective mass fluxes are taken from the CMFMC field derived from the RAS convection scheme. ERA-interim fluxes are upward cumulative sum of entrainment minus detrainment for the updraft of the Tiedtke (1989) scheme as described in Heiman et al 2003. Due to fundamental differences in the parent model convection schemes, e.g. Tiedtke scheme has a downdraft component not shown, this comparison should be considered approximate. The lower panels are shown for completeness, showing the MERRA2 detrainment fields and the ERA-I downdraft fields. Note the order of magnitude difference between the updraft and downdraft fields in ERA-I.