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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Mechanisms for synoptic transport of atmospheric CO_2 in the midlatitudes and tropics" *by* N. Parazoo et al.

N. Parazoo et al.

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Thanks to Referee #1 for comments and recommendations. I agree with most of them, in particular that better quantification of the simulated CO2 budget is needed, and feel that addressing them will add much robustness to the paper.

Response to General Comments:

To address the request for better quantification of CO2 tendencies, we have included additional numbers. With regard to budget tendencies, we have extended Table 2 to include the annual mean tendency and standard deviation in addition to percent contributions. This table was originally created for day-to-day variations, but 3-hourly values have also been added, to emphasize the contrast between controls on diurnal and synoptic variations. Differences between budget terms also become clearer in this way. The standard deviations appear to be directly proportional to the mean tendency, indicating that the dominant budget terms experience much fluctuation from day-to-day.

An additional table has been created for comparison of the total tendency to the observed tendency. This table, combined with budget tendencies, suggests that the budget certainty is weaker in the tropics than in midlatitudes. Future budget analysis using additional observations, improved land surface simulations, and improved representation of moist convection will reduce uncertainty in the tropics.

Response to Specific Comments:

1) The Referee suggests sensitivity analysis of global parameters such as vertical diffusion and convective mass flux to help understand the effect of switching off moist convection locally to address interdependency of transport terms such as boundary layer turbulence and convective mass flux. To address this concern, four additional simulations were run in which the moist convective mass flux and vertical diffusion coefficient were varied about their control values. In two experiments, CMF was doubled and halved (holding vertical diffusion at control values) and in two others vertical diffusion doubled and halved (holding CMF at control values). In the original experiment in ACPD, NOCLOUD, CMF is set to zero in 10-degree domains surrounding points in the midlatitudes and tropics. NOCLOUD showed weak sensitivity to moist convective mixing in midlatitudes and strong sensitivity in the tropics. Similar sensitivity to vertical mixing is shown in these new experiments. By varying vertical mixing parameters globally, we find that variations change little in midlatitudes. In the tropics, variations are enhanced by decreasing mixing and suppressed by increasing mixing, with stronger sensitivity to CMF. In all cases, only amplitude of variaiblity is affected, with the shape of the seasonality preserved. Tropical variations, it appears, are strongly sensitive to vertical mixing throughout the tropics, and not just locally or regionally.

2) The Referee also suggests that the effect of surface flux variations (net ecosystem exchange) associated with photosynthetically active radiation and cloud cover on syn-

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optic variations of atmospheric CO_2 are considered. We address this by running additional experiments in which flux calculations in SiB3 are driven by climatological shortwave radiation, thus eliminating any day-to-day variations associated with weather. The motivation is that cloud cover associated with weather systems such as fronts reduces the amount of shortwave radiation reaching the surface, reducing the amount of sunlight available for photosynthetic uptake, which is an important driver for photosynthesis as parameterized in SiB3. To test this sensitivity, we use a 30-day running mean of the shortwave radiation from GEOS-4 to drive SiB3, applied within the 10-degree domains as in the other experiments, couple to PCTM, and compare resulting day-to-day variations to those from the Control simulations. The tests show that, although NEE is sensitive to fluctuations in daily radiation, little sensitivity is seen in atmospheric CO_2, in the tropics and midlatitudes. Magnitude changes in NEE are not large enough to affect atmospheric distributions.

3-4) Our main disagreement with the Referee is with regard to Section 3 and Figure 6 on our discussion of the role of deformational flow. The authors feel that, although the dynamics of cold fronts and its interactions with atmospheric tracers may be well known in the atmospheric science community, it is not necessarily so with the carbon community and merits some discussion in the paper. We agree that our discussion of frontal dynamics is loose and a detailed discussion of frontogenetics and deformations flow is not necessary, with a simple statement that thermal gradients, deformational flow, and natural contrasts in long-lived tracers across the gradients exist is adequate for this paper. We feel, however, that our figure demonstrating the effect of deformational flow on CO_2 has been well received by the carbon community in conferences and workshops and may still come as some surprises to carbon scientists not familiar with atmosphere-biosphere interactions. I believe this Section would be strengthened by a paragraph describing how disturbances in the large scale flow lead to strong CO_2 variations at the surface, and that is important for scientists who use and interpret observed variations to understand this.

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5) The discussion of global circulation in the Introduction is not well placed, and detracts from the focus of the paper. Although this discussion is well known and redundant in the atmospheric science community, again, this is not necessarily true for carbon scientists. It is important to mention but should not be the main focus of the Introduction, and would be better placed if shortened and moved toward the end of the Introduction, with the beginning of the Intro reserved more for motivation.

6) The conclusions have been updated with the additional simulations and budget uncertainty suggested by the Referee. The overall results have not changed and confirm the need for carbon modelers to focus on moist convection and surface flux in the tropics and advection in the midlatitudes to help reproduce observed synoptic CO2 variations.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 12197, 2008.

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