Response to Peter Rayner, Referee #2

We thank Prof. Rayner for his thought-provoking comments. Prof. Rayner's comments are italicized for clarity.

- *I am surprised by the weak response of the drawdown to the interannual variability of transport acting on fossil fuel sources, the dynamical effect the authors mention during the description of the fossil results. I suppose my mental picture of the large-scale action of transport on column-averaged CO2 would be some kind of one-dimensional advection-diffusion where changes in the meridional flow would act on the large-scale north-south gradient to "pile up" or deplete CO2 at a given latitude. If that picture made any sense then the dynamical effect on fossil fuel CO2, with its permanent (though changing) north-south gradient might be expected to oppose that of the total CO2 which can have a reversed gradient at this time of year. Perhaps the authors might expand a little on the analysis of the fossil fuel impact.*

  We certainly agree with this mental picture: that the dynamical effects on the fossil fuel emissions of CO_2 ought to oppose the direction of the dynamical effects on the biospheric signal. Because the fossil fuel emissions are primarily in the northern midlatitudes, there should be a negative slope between the fossil fuel component of CO_2 and temperature, driven by dynamics. As a rough scaling argument, if we take ∼8 PgC/yr as the NH fossil fuel emissions and assume all the emissions occur where the biosphere is most active, this becomes ∼2 Pg C source in the growing season (JJA). NEE during the growing season is ∼5 Pg C sink, so this represents about 1/3 of the overall flux. If dynamics controls ∼50% of the temperature sensitivity, you're left with ∼1/6 of the sensitivity overall (a maximum of ∼0.2 ppm/K). This is dwarfed by our current error budget, but certainly an important point which is added to the discussion. The slopes from the CT2011 fossil-fuel module are not inconsistent with this, but they are of varying sign and well within error of 0.

  This effect may be manifest in western Europe where there are intense local fossil fuel emissions that are advected over land where GOSAT observations are currently retrieved. Bremen has a much smaller slope than most of the northern hemisphere in both observations and models. The SiB2009 simulations are particularly noteworthy: the rough difference between Park Falls and Bremen is ∼1.3 ppm/K for the TCCON results and the SiB2009 simulations, suggesting that this difference may reflect the large net efflux from western Europe.

- *Keppel-Aleks et al., 2012 provide a recipe for removing local dynamical noise from the pointwise TCCON data by looking at air mass tracers such as potential temperature. First, what would happen if the authors treated the data and models here the same way? I see one obvious objection, this is aliasing some of the dynamical signal they want to look at but I suspect, provided the averaging was kept fairly local, it might improve signal-noise. It might also be worth looking at the dynamics fields to see whether, indeed, the dynamical response is cleanly explained by this air-mass mechanism. This is genuinely a suggestion; if there's an obvious reason not to do it I recommend the authors deal with it in their response rather than the paper.*

  We have thought about this, and you have exactly described the objection: that of aliasing the dynamic signal. The relationship between CO_2 and mid-tropospheric temperature (e.g., T_{700}) has a relatively constant and robust slope in NH summertime, over all surface temperature conditions we've observed. So, the relationship of these parameters with latitude changes in both CO_2 and T_{700} concurrently. This should (and will) be studied further.