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Interactive comment on "Sources of variations in total column carbon dioxide" *by* G. Keppel-Aleks et al.

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This paper is one of a pair analyzing modelled and observed variations in total column CO2 (<CO2>) using the AM2 GCM and the Total Carbon Column Observing Network (TCCON). This paper limits itself to analyzing the modelled fields with particular attention to the TCCON sites. as such it is obviously preparing the ground for its companion paper which, with its inclusion of real data, is likely to be of greater scientific interest. However the authors have done the right thing separating the two analyses since this paper is already quite long and detailed.

When coming to this paper I was initially quite sceptical. In particular I wondered why use a GCM to investigate variations in CO2 when there were myriad choices of transport models driven by analyzed meteorology. The question still stands but what

the authors have done within the self-consistent model world nonetheless represents a significant intellectual advance.

What the authors have done is found a way into the problem that has vexed inverse atmospheric studies since the beginning. Leaving aside the statistical framework, these inverse methods compare simulated and observed concentrations in the atmosphere and minimize their disagreement by correcting aspects of the tracer source. Every study has acknowledged the certainty that part of the mismatch will arise from errors in the relationship between fluxes and concentrations (the transport model). Incorporating these model errors into the statistical framework has been difficult although recent work by Miyazaki et al. (JGR, 2011) shows an interesting application of the Kalman Filter for the problem. Worse, though, is our nearly complete inability to characterize such model errors so they can be properly included even when we have the apparatus.

The most interesting part of this paper is to show a relationship between <CO2> and another tracer, potential temperature. For part of the spectrum of <CO2> variations there is a relatively strong relationship between the two tracers. the frequency band in which the relationship is established also overlaps that shown by Law et al. (2002) as useful for constraining fluxes varying on monthly time-scales. If the relationship holds in the real world and our transport model (or the underlying analyses) does a decent job with potential temperature we have part of the <CO2> signal we can use with reasonable confidence. That, of course, is to be established by the companion paper.

Outside the most interesting frequency band the contribution of the paper is less dramatic. The finding that it is the latitudinal structure of fluxes that contributes to the seasonal cycle of <CO2> is confirmatory rather than startling given the rates of mixing around a latitude circle. The role of local fluxes in driving diurnal cycles was less than I might have expected but not much less. I would suggest a better way of establishing this would be more detailed labelling of CO2 molecules so that local vs remote influences on the CO2 field could be more easily seen. It is computationally more expensive but would only need to be run for a few weeks.

Another piece of good news from the paper is the relative insensitivity of <CO2> to the injection height of the tracer. This does, indeed, support the oft-claimed greater robustness of column-integrated measurements although one must keep in mind the results of Chevallier et al., GRL, 2010 who performed a direct test between two models and found considerable sensitivity.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 30569, 2010.