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Discussions

Interactive comment on "The 2009–2010 step in atmospheric CO_2 inter-hemispheric difference" *by* R. J. Francey and J. S. Frederiksen

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It is the concurrent timing of irregularities in the measured atmospheric CO2 inter-hemispheric gradient (IHG) and irregularities in Rossby wave propagation plus changes in the turbulent kinetic energy in the equatorial upper atmosphere (equatorial duct) that prompted our paper. This co-variability is demonstrated at sub-annual time frames in 2009/2010, but also on multiple occasions annually over the last 50 years. The conditions for exchange via the duct are determined from NCEP re-analyses of global winds in the upper troposphere. It suggests a strong connection between the CO2 behaviour and interhemispheric transport via the duct.

In response, Prabir Prata has provided brief details of unpublished simulations (Saeki et al., in prep. 2015) of the 2009/2010 CO2 inter-hemispheric gradient (IHG) step. It

is difficult to respond to unpublished work, however our interpretation of the available information suggests possible circularity in his arguments. The IHG "ACTM simulations are prepared using. . .. . .interannually varying. . ..fluxes of the terrestrial biosphere and ocean exchange". However, these fluxes are obtained from inversion of the atmospheric CO2 measurements, including the observed disturbance to CO2 seasonality around 2009/2010, using the ACTM atmospheric transport parameterisation (also based on NCEP reanalyses).

If the ACTM model transport does not adequately describe the duct processes (which requires parameterisation of equatorial vertical convection, changes in Rossby wave propagation and diffusion due to changing turbulent kinetic energy in the duct), then any CO2 variations due to inter-hemispheric exchange (IH) by the duct processes will, because of global budget balance, inevitably be attributed to changes in terrestrial exchange, the most volatile and least well-constrained of available processes. By distributing the signal widely enough over the available, mainly northern hemisphere, terrestrial reservoirs, bottom-up verification becomes impossible. Prabir's brief response has not identified specific surface reservoirs where this might have occurred.

The ACTM relies on SF6 measurements to support the transport parameterisation. Our early examination of such synthetic species with respect to the 2009/2010 event was inconclusive (and not included in the original submission). While we can demonstrate a considerable degree of systematic behaviour in the variation in baseline monthly CO2 IHGs, by comparison the synthetics were found to have much larger scatter. Furthermore, over the period of most concern, we found little agreement in month-to-month, or inter-annual variability about the long term increase in IHG, between the HATS SF6 data, and equivalent data from the AGAGE network (https://agage.mit.edu/). The use of SF6 to calibrate the inter-hemispheric transport may well be adequate for the long-term model mean transport, but fail to adequately constrain past irregular periods such as 2009/2010, or the similar historic events.

There are other aspects of our paper that Prabir did not address and would imply

additional coincidences. These include the stability of the post 2009 IH CO2 differences and the coordinated changes in other long-lived trace gases, particularly hydrogen (less linked to biological processes than CO or CH4 for example).

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