Sources of Systematic Differences in Global CO_2 Inverse Model Results

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Current estimates of the global carbon budget are informed by surface flux estimates from atmospheric inverse models. It is essential to quantify the uncertainty in inverse flux calculations through comparison with independent observations. We have compared a suite of state-of-the-art inverse flux estimates [MACC (v14r2), Jena (s04_v3.8), CT2016, CTE2016, ACTM (with IEA or CDIAC emissions) and TM5-4DVar] to carbon dioxide (CO_2) concentration profiles from the HIAPER Pole-to-Pole Observations (HIPPO) aircraft campaigns (2009-2011, Wofsy et al. 2011), to assess the dependence of their results on differences in vertical mixing and to identify other drivers of remaining model spread. To reconstruct annual and seasonal distributions for different altitudes and latitudes, we have sampled the models along the HIPPO flight tracks and fitted the binned values with a combination of an offset from a prescribed trend and 2 harmonics. The modelled CO_2 fields agree well with HIPPO observations, in particular for annual mean vertical gradients in the Northern Hemisphere. Although the models differ in inverse approaches, assimilated observations, prior fluxes, and transport, their large-scale fluxes are in closer agreement than in the previous TransCom3 experiment where only the transport model varied. The dependence of northern extratropical annual fluxes on northern hemisphere vertical mixing appears less important than in TransCom3.

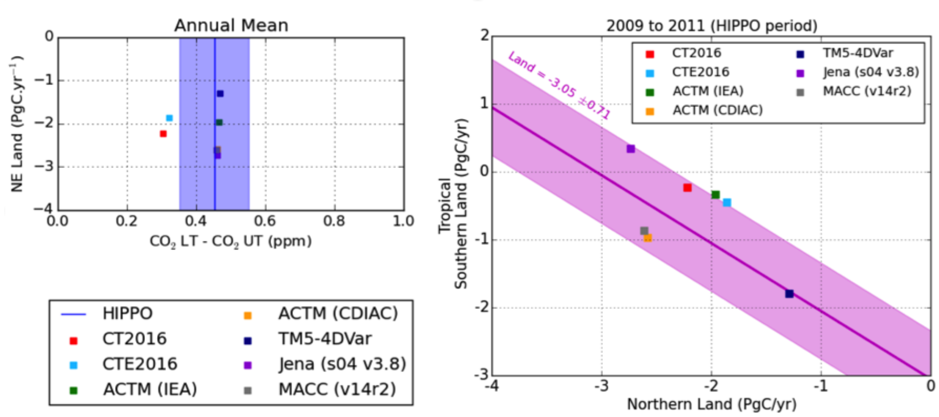

Figure 1. Left panel: Annual mean vertical gradient of CO_2 between the lower troposphere (LT, surface to 700 hPa) and upper troposphere (UT, 700 to 400 hPa), measured by HIPPO (blue line) with an uncertainty range of 0.1 ppm and for each inversion (square). The Northern Extratropical land net flux (2009 to 2011) is plotted on the Y axis. Right panel: this same quantity is shown on the X axis and the remaining land net flux (tropics and southern hemisphere) is shown on the Y axis. The pink line shows the Global Carbon Project 2016 estimates for the same period with reported uncertainty.