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Estimates of boundary layer CO_2 by combining TCCON and TES data

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Monitoring the global distribution and long-term variations of CO_2 sources and sinks is required for characterizing the global carbon budget. Measurements of the total column CO_2 by ground or by satellite have the potential to estimate global sources and sinks (Rayner and O'Brien, GRL, 2001, Olsen and Randerson, JGR, 2004) but are less sensitive to regional scale sources and sinks because CO_2 is a long-lived gas which makes it challenging to identify local sources from CO_2 transported into the observed air parcel (Keppel-Aleks et al., BGD, 2011). In this study we explore the use of total column measurements with estimates of the free tropospheric CO_2 to distinguish planetary boundary layer (PBL) CO_2 and free tropospheric CO_2 because quantifying the vertical gradient between the free troposphere and boundary layer is critical for estimating CO_2 fluxes (Stephens, Science, 2007) and near surface CO_2 should be more sensitive to local fluxes than the total column CO_2.

Column-averaged concentrations are derived by integrating CO_2 profiles, which are retrieved from the Total Carbon Column Observing Network (TCCON) measurements. These column data agree with aircraft integrated column CO_2 within root mean square (RMS) of 0.7 ppm, consistent with the uncertainties due to measurement noise and temperature. There is a bias of about -5 ppm, agreeing with Wunch et al. (Atmos. Meas. Tech. 2010).

Free troposphere estimates of CO_2 are obtained from the GEOS-Chem model that has assimilated CO_2 measurements from Aura Tropospheric Emission Spectrometer (TES). The PBL CO_2 estimates are calculated by subtracting TES free tropospheric CO_2 from TCCON column CO_2. This estimate of PBL CO_2 agrees well with aircraft data with RMS of 1.30 ppm for more than forty PBL CO_2 estimates we compared. This work shows that total column from NIR measurements (GOSAT, TCCON and OCO-2) and free troposphere measurement from TIR (e.g. TES and AIRS) can be used to profile CO_2 and obtain PBL estimates with precision necessary to capture the atmospheric CO_2 variability. It also shows potential of joint retrieval of NIR and TIR. The CO_2 surface flux can be better quantified by monitoring a long-term boundary layer CO_2.