

Investigating CO₂ space-time variability in satellite - chemistry transport model differences using aircraft measurements

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Orbiting Carbon Observatory-2 (OCO-2) is providing global spatiotemporal distribution of column average dry-air mole fraction of CO₂ (XCO₂) at finer spatial resolution and covering the globe compared to the high precision surface network and aircraft measurements. This information offers a unique opportunity to the carbon cycle community to utilize satellite retrievals for policy-relevant source and sink estimations through top-down inversion. This study extensively examines CO₂ variability from OCO-2 retrieval, aircraft measurements (Atmospheric Tomography Mission; ATom and Amazon aircraft program), and their representation in the MIROC4-ACTM chemistry transport model, aiming to understand CO₂ difference (model-observation) across measurement platforms, tropospheric layers and regions.

Our results demonstrate the largest mismatch variability of aircraft ($\sim -0.01 \pm 0.4$ ppm) and OCO-2 ($\sim -0.34 \pm 1$ ppm) against ACTM over land in North America and Amazon sites (SAN, ALF, RBA, TEF) likely due to uncertainty in prior land CO₂ flux constrained at lower troposphere (lowest level- 2 km). Additionally, best match of aircraft and OCO-2 against ACTM (mismatch less than -0.04 ± 0.3 ppm; ATom and -0.27 ± 0.4 ppm; OCO-2) is observed over background remote troposphere in Pacific and Atlantic regions. However, in southern ocean ATom measurements showed better concurrency with ACTM (mismatch $\sim 0.06 \pm 0.15$ ppm) as compared to OCO-2 XCO₂ (mismatch $\sim -0.06 \pm 0.7$ ppm). In all the regions, we observe that the aircraft tropospheric column (lowest level-8 km) and OCO-2 XCO₂ pattern matches well with ACTM, but there is more systematic bias in OCO-2 as compared to aircraft in ACTM.

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