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Surface CO_2 and CH4 fluxes simultaneously inferred from proxy GOSAT XCH4:XCO_2 retrievals

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The Japanese Greenhouse gases Observing SATellite (GOSAT) has collected atmospheric column measurements of CO_2 and CH4 since it was launched in 2009. Observed atmospheric column variations of CO_2 and CH4 can in principle be used to infer the responsible surface fluxes. A major advantage of space-based observations over conventional in-situ measurement networks is their better global coverage. However, to improve our current quantitative understanding of CH4 and CO_2 fluxes from in-situ data, space-borne column measurements have to exceed strict precision requirements. Uncharacterized systematic errors at regional or sub-regional spatial scales can compromise the ability of these data to infer surface fluxes.

Previous work has demonstrated how to infer simultaneously regional CO_2 and CH4 flux estimates directly from the XCH4:XCO_2 ratio retrieved using the proxy approach. The proxy retrieval method fits CO_2 and CH4 gases in nearby spectral windows (at 1.65 μm and 1.61 μm) under the assumption that the ratio between XCH4 and XCO_2 reduces the sensitivity to fitting artefacts common to both gases (e.g. aerosol and clouds). The proxy method is also simpler than the full physics approach, and more robust against scattering, resulting in more useful retrievals over regions, such as the Tropical South America, which currently represent the largest uncertainties in our current understanding of the global carbon cycle. We present monthly regional CO_2 and CH4 fluxes from 2009 to 2014 inferred from GOSAT XCH4:XCO_2 proxy retrievals and NOAA in-situ atmospheric CO_2 and CH4 mole fraction measurements. To improve the spatial resolution as well as the numerical efficiency we use an ensemble Kalman Filter to assimilate each single GOSAT and NOAA observation. We show that the CO_2 and CH4 fluxes inferred from the proxy retrieval have generally much lower posterior uncertainties than using the full physics GOSAT retrievals of XCO_2 and XCH4 or using the NOAA in-situ data. We find particular improvements over tropical land regions, where the proxy retrievals have better coverage than the full physics retrievals. We also find that over tropical regions, CO_2 and CH4 flux estimates inferred from the proxy data have different seasonal cycles and inter-annual variations compared with the emissions inferred from the in-situ data. We evaluate our results by comparing them with independent aircraft measurements, and investigate possible reasons for the differences in inferred seasonal cycles and inter-annual variability.