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Assessments of in situ and remotely sensed CO2 observations in a Carbon Cycle Fossil Fuel Data Assimilation System to estimate fossil fuel emissions

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The Paris Agreement establishes a transparency framework that builds upon inventory-based national greenhouse gas emission reports, complemented by independent emission estimates derived from atmospheric measurements through inverse modelling. The capability of such a Monitoring and Verification Support (MVS) capacity to constrain fossil fuel emissions to a sufficient extent has not yet been assessed. The CO_2 Monitoring Mission, planned as a constellation of satellites measuring column-integrated atmospheric CO_2 concentration (XCO2), is expected to become a key component of an MVS capacity.

Here we provide an assessment of the potential of a Carbon Cycle Fossil Fuel Data Assimilation System using synthetic XCO2 and other observations to constrain fossil fuel CO_2 emissions for an exemplary 1-week period in 2008. We find that the system can provide useful weekly estimates of country-scale fossil fuel emissions independent of national inventories. When extrapolated from the weekly to the annual scale, uncertainties in emissions are comparable to uncertainties in inventories, so that estimates from inventories and from the MVS capacity can be used for mutual verification.

We further demonstrate an alternative, synergistic mode of operation, which delivers a best emission estimate through assimilation of the inventory information as an additional data stream. We show the sensitivity of the results to the setup of the CCFFDAS and to various aspects of the data streams that are assimilated, including assessments of surface networks.