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NASA's Carbon Cycle OSSE Initiative - Informing future space-based observing strategies through advanced modeling and data assimilation

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Satellite observations of carbon dioxide (CO_2) and methane (CH4) are critically needed to improve understanding of the contemporary carbon budget and carbon-climate feedbacks. New space-based observations have provided valuable data in regions not covered by traditional surface in situ measurements, showing examples of the coupling between carbon and climate, and of the ability to observe human emissions under certain circumstances. Next generation satellites will improve coverage in data sparse regions, either through use of active remote sensing, a geostationary vantage point, or a combination of increased swath width and revisit frequency. Observing system simulation experiments (OSSEs) can be used to quantify the relative strengths and weaknesses of the current observing system, identify key gaps, and evaluate the impact that next generation satellites may have. As such, OSSEs are essential tools to guide cost effective implementation of future carbon-observing satellite missions.

To address these needs, a significant subset of the US carbon modeling community has come together with support from NASA to conduct a series of coordinated OSSEs, with close collaboration in framing the experiments and in analyzing the results. Here, we report on advances in the creation of realistic, model-based synthetic CO_2 and CH4 datasets for use in inversion and signal detection experiments. Datasets have been created using NASA's Goddard Earth Observing System Model (GEOS) at global resolutions ranging from 3 to 50 km. These simulations represent the current state of atmospheric carbon as well as best available estimates of expected flux changes. The library of 50-km simulations represents dozens of scenarios that include changes in urban emissions, release of permafrost soil carbon, changes in carbon uptake in tropical and mid-latitude forests, changes in the Southern Ocean sink, and changes in both anthropogenic and natural methane emissions. Global mesoscale CO_2 simulations provide an exciting new tool for mission planning, allowing the complex influence of clouds and aerosols on CO_2 observations to be examined in greater detail than ever before. Statistical analyses of these synthetic datasets provide a simple, objective method for evaluating mission design choices. These datasets will also be made publicly available for use by the international carbon modeling community and in mission planning activities.