VARIATIONAL DATA ASSIMILATION OF HIGH DENSITY ATMOSPHERIC CO2 DATA: EVALUATING THE UTILITY OF SATELLITE VS IN SITU DATA

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ABSTRACT
High-frequency atmospheric CO_2 measurements should become increasingly available by the end of this decade from a variety of sources, including low-Earth orbiting satellites. If of sufficient accuracy, these should allow the functioning of the global carbon cycle to be monitored at fine time/space resolutions using atmospheric transport inversions. Since traditional direct inversion methods (e.g., Bayesian synthesis) become computationally infeasible at these resolutions, we use an approximate method, variational data assimilation, to estimate surface CO_2 fluxes at spatial resolutions ranging from 10x10 degrees to 1x1 degrees and at time resolutions ranging from 2 weeks to 1 hour. We assess its performance using simulated data, including the effects of realistic transport and data errors.

Three possible future measurement networks are examined: 1) an expanded version of the current in situ network, with increased numbers of continuous analyzers, aircraft flights, and eddy-flux towers; 2) network #1 plus the column-integrated data from the Orbital Carbon Observatory (OCO), with a 1-ppm measurement accuracy; and 3) a network with spatially-dense column-integrated measurements across the full diurnal cycle. The flux estimation accuracy obtainable from each network is determined, considering realistic data and transport errors, across the range of flux resolutions given above. Computational constraints limit the number of descent steps possible in the method's iterative minimization technique, resulting in a residual convergence error. Here, we terminate the minimization when this convergence error becomes small compared to the transport- and data-induced errors. This criterion allows us to estimate the computational requirements for each network/resolution; for the densest networks, it also sets a limit on how fine a resolution the fluxes may be resolved at.

By comparing the estimation errors for networks #1 and #2, we can directly assess the additional information content of the satellite-based data as compared to that of the *in situ* surface and aircraft data projected to be available at the end of the decade. The accuracy of low-order covariance estimate provided by the technique is also evaluated by comparing it with the true errors obtained in a perfect transport model simulation.