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Quantifying the Benefit of an Active CO_2 Mission Concept in a Terrestrial Carbon Cycle Data Assimilation System.

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Active mission concepts can provide column-integrated atmospheric CO_2 concentration (XCO_2) measurements day and night over all seasons. Compared to passive mission concepts, the signal is less affected by atmospheric aerosol loading and cloud cover. XCO_2 Observations provide an indirect constraint on the processes governing the terrestrial carbon, water, and energy cycles. Assimilation of XCO_2 into a model of the terrestrial biosphere can extend the scope of the observational information beyond the observational period and to quantities beyond the net exchange flux. The procedure is thus suited to retrieve a suite of higher level products. We apply quantitative network design techniques to assess the constraint provided by an active CO_2 mission such as ASCENDS in the Carbon Cycle Data Assimilation System (CCDAS). The system links the observations to the terrestrial vegetation model BETHY via the fine resolution version of the atmospheric transport model TM3. In the modelling process chain the observations are used to reduce uncertainties in the values of BETHY's process parameters, and then the uncertainty in the process parameters is mapped forward to uncertainties
in both long-term net carbon flux and net primary productivity over three regions. The active mission concept yields considerably better reductions in posterior uncertainties than the ground-based GLOBALVIEW station network. This is true for assimilating monthly mean values and instantaneous values, and it is true for two potential vertical weighting functions. The strength of the constraint is high over a range of observational uncertainties.