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Hybrid inversions of CO_2 fluxes at regional scale applied to network design

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Long term observations of atmospheric greenhouse gas measuring stations, located at representative regions over the continent, improve our understanding of greenhouse gas sources and sinks. These mixing ratio measurements can be linked to surface fluxes by atmospheric transport inversions. Within the upcoming years new stations are to be deployed, which requires decision making tools with respect to the location and the density of the network. We are developing a method to assess potential greenhouse gas observing networks in terms of their ability to recover specific target quantities. As target quantities we use CO_2 fluxes aggregated to specific spatial and temporal scales. We introduce a high resolution inverse modeling framework, which attempts to combine advantages from pixel based inversions with those of a carbon cycle data assimilation system (CCDAS). The hybrid inversion system consists of the Lagrangian transport model STILT, the diagnostic biosphere model VPRM and a Bayesian inversion scheme. We aim to retrieve the spatiotemporal distribution of net ecosystem exchange (NEE) at a high spatial resolution (10 km x 10 km) by inverting for spatially and temporally varying scaling factors for gross ecosystem exchange (GEE) and respiration (R) rather than solving for the fluxes themselves. Thus the state space includes parameters for controlling photosynthesis and respiration, but unlike in a CCDAS it allows for spatial and temporal variations, which can be expressed as $NEE(x,y,t) = \lambda G(x,y,t)\ GEE(x,y,t) + \lambda R(x,y,t)\ R(x,y,t)$. We apply spatially and temporally correlated uncertainties by using error covariance matrices with non-zero off-diagonal elements. Synthetic experiments will test our system and select the optimal a priori error covariance by using different spatial and temporal correlation lengths on the error statistics of the a priori covariance and comparing the optimized fluxes against the ‘known truth’. As ‘known truth’ we use independent fluxes generated from a different biosphere model (BIOME-BGC). Initially we perform single-station inversions for Ochsenkopf tall tower located in Germany. Further expansion of the inversion framework to multiple stations and its application to network design will address the questions of how well a set of network stations can constrain a given target quantity, and whether there are objective criteria to select an optimal configuration for new stations that maximizes the uncertainty reduction.