In Situ CO_2 Monitoring Network Evaluation and Design: A Criterion Based on Atmospheric CO_2 Variability

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Inverse modeling methods for estimating fluxes of carbon dioxide (CO_2) rely on networks of atmospheric CO_2 measurements. The network of continuous observations in North America grew from 9 continuous CO_2 monitoring towers in 2004 to approximately 39 in 2008. Despite its growth, the sparseness of the network has been cited as a limiting factor in the effort to constrain CO_2 fluxes at sub-continental scales. Current methods to assess the number and optimal locations for additional monitoring sites either rely heavily on expert opinion, which can be subjective, or on observational system simulation experiments, which are computationally expensive and are sensitive to specific inverse model assumptions. To bridge the gap between these methods we propose a flexible and computationally inexpensive quantitative tool to examine current and future atmospheric CO_2 monitoring network configurations. This tool has been developed to inform the expansion of continuous CO_2 monitoring stations based upon an understanding of the variability in the atmospheric CO_2 signal as represented in modeled CO_2 fields. The spatial variability is quantified through a geostatistical analysis that yields information about the spatial scales over which the CO_2 concentrations are correlated. This information is then used to assess the coverage provided by an existing network and to inform the optimal placement of towers for network expansions. The approach places towers using knowledge of both the location of pre-existing towers, as well as the local variability in the atmospheric CO_2 signal.

Two sample hypothetical networks are created to cover North America with varying degrees of coverage. The less strict coverage regime yields an additional 8 towers relative to the 2008 North American network, while the more stringent regime requires an additional 43 towers. The additional constraint provided by the two hypothetical networks is evaluated relative to the 2008 network using a synthetic data inversion. Overall, the hypothetical networks show marked improvement over the pre-existing 2008 network, and offer insights into addressing the limitations of the current network.

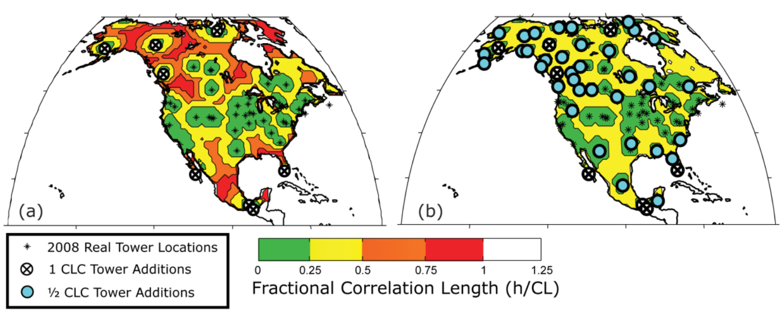

Figure 1. Hypothetical network expansion based on a criterion that a tower must be available within a) one (1 CLC) and b) a half (1/2 CLC) correlation length of CO_2 variability at each location. As per the requirement, the entire continent is covered in red for 1 CLC network and yellow for ½ CLC network.