Estimating parameters in inversions for regional carbon fluxes

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In recent years, data on the spatial and temporal pattern of atmospheric CO_2 levels together with inverse forms of atmospheric transport operators have been widely applied to deduce the distribution of carbon fluxes and especially to attempt to locate the "missing" CO_2 sink. This approach however has led to widely differing conclusions, particularly for the longitudinal and land-ocean breakdown of the sink. One contributor to this variability has been the choice of such inversion parameters as the relative weighting of different classes of atmospheric measurements and of other, "prior" information on fluxes, and what uncertainties to assume for data at different locations within each class. A variety of methods of estimating such parameters from the data have been employed in inverse problems in other scientific areas. We explore using generalized cross-validation (GCV), which looks for the parameter values that result in the best prediction of any one measurement from the other data, to choose parameter values for atmospheric CO_2 inversions. As an example, we use the TransCom3 annual mean inversion set-up, which solves for net CO_2 fluxes from 22 regions using 1992-1996 mean CO_2 concentrations at ~75 stations. The derived land-ocean and North America-Eurasia distribution of the carbon sink both depend on the extent to which stations are differentially weighted by the station variability and on the relative weighting given to the prior flux estimates. Compared with the published TransCom weighting, optimizing these inversion parameters with GCV results in a similar distribution of solved fluxes in northern regions but in smaller fluxes and greater solution stability in the poorly constrained equatorial and southern regions. We conclude that parameter choice methods such as GCV should be considered as part of the formalism of future inversions.