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Estimation of the ecosystem CO_2 flux uncertainties over the Europe from ICOS atmospheric CO_2 measurement network

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We present the utility assessment of Integrated Carbon Observing System (ICOS) atmospheric observation network in constraining the biogenic surface CO_2fluxes over the Europe through the atmospheric inversion. A mesoscale inversion system was used to find uncertainties in the 6 hourly Net Ecosystem Exchange (NEE) fluxes with 0.5^o spatial resolution for two week period and to estimate the uncertainties of monthly CO_2 fluxes when assimilating synthetic hourly observations from ICOS observation sites. The estimations of the inverted flux uncertainties are analyzed on the model grid scale, country level and for the whole European domain. The sensitivities of the results to inversion parameters were tested. We checked the dependency of potential flux uncertainty reduction on the extension of observation network and on the different parameters of the inversion setup such as background covariance matrix parameterization and observation error reflecting uncertainties in the ecosystem models used as a prior knowledge and in the atmospheric transport model. The experiments were conducted for July and December of 2007 showing heterogeneous seasonal structure of the uncertainty reduction. We find that assimilating the data from the network with 23 observation sites significantly reduces the uncertainty of the European biogenic two-week fluxes from the biogenic ecosystem model by 50% to the value of $\sim$ 0.51PgC yr^{-1} (over the land area of 6.8*10^6 km^2) for July 2007. The error reduction for December 2007 is found to be higher and estimated as 66% with the value for posterior error $\sim$ 0.31PgC yr^{-1}. The expansion of ICOS network to 66 atmospheric sites further reduce the uncertainties of two-week fluxes by 64% ($\sim$0.39 PgC yr^{-1}) and 79% ($\sim$0.18 PgC yr^{-1}) relative to the prior errors for July and December, respectively. The inversion shows good performance reducing the prior flux uncertainties up to 65 % on the grid scale in the vicinity of the station both for summer and winter fluxes. Having dense ICOS atmospheric observation network we should be able to effectively reduce the monthly CO_2 flux uncertainties on the country scale up to 50-80 % for specific country and significantly improve our knowledge about European CO_2budget.