Global CO_2 source and sink inversions

Product description

The space-time gradients of CO_2 mixing ratios in the atmosphere are determined by CO_2 exchange with the Earth's surface and by atmospheric transport. Thus the joint availability of atmospheric measurements of CO_2 mixing ratios and of numerical models of the atmospheric transport allows the inference of CO_2 surface fluxes over the globe. The present MACC product relies on the flux inversion scheme of Chevallier et al. (2005) that implements Bayesian estimation in the form of the minimization of a cost function. The inversion system computes the Best Linear Unbiased Estimate (BLUE) of the CO_2 surface fluxes given the input information, their Bayesian uncertainty, and the number of degrees of freedom for signal (Chevallier et al. 2007). The BLUE fluxes are simply called inverted fluxes hereafter.

The inversion system has been operated for the period 2000-2010, with surface air-sample measurements as input observations. Fluxes are estimated on a global longitude-latitude grid of regular mesh 3.75ox2.5o at a temporal resolution of 8 days, with day-time and night-time separated. 3-hourly variations within the 8-day segments are prescribed a priori in the inversion. Prior fluxes come from the combination of a flux climatology, of emission inventories and of a model simulation as described in Chevallier et al. (2010). The operator that links the flux space and the retrieval space in the inversion scheme is the general circulation model of the Laboratoire de Météorologie Dynamique (LMDZ, Hourdin et al. 2006), nudged to ECMWF winds. Tracer transport is simulated on the same 3.75ox2.5o horizontal grid as the fluxes with 19 layers between the surface and the top of the atmosphere. The prior initial conditions (i.e. the 3D field of CO_2 at the start of the inversion window) are taken from the global analysis of surface air-sample measurements for the period 1988-2008 made by Chevallier et al. (2010). They are adjusted within the inversion. The present inversion configuration follows the one used by Chevallier et al. (2010) with only minor adaptations to process years 2009 and 2010.

Product validation

The evaluation of this product is based on 1) comparison with the fluxes from other inversions, and 2) comparison of CO_2 mixing ratios calculated from the inverted fluxes with independent aircraft measurements. In particular, the latter test confirms that the inversion has improved the quality (i.e. reduced the uncertainty) of the surface fluxes compared to the assumed or prior fluxes. The product quality is documented by the associated Bayesian uncertainty, that can be provided on demand for any space-time target, from the grid-point weekly scale to the annual global scale. The realism of this uncertainty estimate has been demonstrated with independent data.

References

Chevallier, F., et al. (2005), Inferring CO2 sources and sinks from satellite observations: method and application to TOVS data. J. Geophys. Res., 110, D24309, doi:10.1029/2005JD006390.

Chevallier, F., F.-M. Bréon, P. J. Rayner (2007), The contribution of the Orbiting Carbon Observatory to the estimation of CO2 sources and sinks: Theoretical study in a variational data assimilation framework. J. Geophys. Res., 112, D09307, doi:10.1029/2006JD007375.

Chevallier, F., et al. (2010), CO2 surface fluxes at grid point scale estimated from a global 21-year reanalysis of atmospheric measurements. J. Geophys. Res., 115, D21307, doi:10.1029/2010JD013887.

Hourdin, F., et al. (2006), The LMDZ4 general circulation model: climate performance and sensitivity to parametrized physics with emphasis on tropical convection, Climate Dynamics, 27, 787-813, doi:10.1007/s00382-006-0158-0.

December 2011