Inferring CO_2 Fluxes at Regional Scale by Inverse Modeling and Using Backward Atmospheric Tracer Transport

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1. Purpose

The limitation of the atmospheric concentration of carbon dioxide (CO_2) and other greenhouse gases is seen as a major issue in the next years. A first step is to fully understand and quantify the exchanges between the atmosphere and the other reservoirs of these gases. To do this, several methods exist among which the so-called inverse methods. In thus methods CO_2 atmospheric concentration measurements are used to infer the distribution of CO_2 fluxes in time and space. The CO_2 concentration has been monitored all over the world for more than 50 years what brings us global information on CO_2 fluxes. Some regional networks of continuous measurement stations have been also developed as in Siberia by NIES. Indeed, since 2005, CO_2 concentration is continuously measured at five different sites. Using all these measurements in an inverse model, we intend to infer daily fluxes at our atmospheric model grid resolution over Siberia for the year 2005.

2. Method

To represent the atmospheric transport, we used the global circulation model LMDZ whose grid can be nested. We used this property to enhance the spatial resolution of the grid over Siberia up to 50x50 km^2, therefore improving atmospheric transport modeling over this region. In the chosen inverse technique, we need to calculate the sensitivity of each measurement to each flux by the chosen atmospheric model. The self-adjoint property of atmospheric transport of passive tracers has been implemented within LMDZ to limit the computing cost. The work on the Siberian region began few months ago; we thus decided to illustrate the abilities of the method with a previous study realized over Europe for the year 2001. This study was based on synthetic data as constraints of our problem to study the potential of the European network. These data were simulated by forward atmospheric transportation of daily CO_2 fluxes from the biogeochemical model ORCHIDEE for the year 2001.

3. Results

In this study, we analyzed the results to estimate at which minimal scales, in space and in time, fluxes should be aggregated to compare the best with true fluxes from ORCHIDEE model. We based this comparison over two statistics: the correlation of the retrieved fluxes with the true fluxes and the ratio of the standard deviations of the retrieved and true fluxes. We showed the daily fluxes at grid cell resolution were hardly improved after inversion in a statistical sense. But after aggregating fluxes weekly and over a region of 700x700 km^2 at least, they compare very well to the true fluxes and much better than the fluxes used before inversion.