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Estimation of CO_2 emissions from fossil fuel burning by using satellite measurements of co-emitted gases: a new method and its application to the European region

Evgeny V. Berezin (1), Igor B. Konovalov (1), Philippe Ciais (2), and Gregoire Broquet (2)

(1) Institute of Applied Physics of the Russian Academy of Sciences, Nizhny Novgorod, Russian Federation (e.berezin@appl.sci-nnov.ru, konov@appl.sci-nnov.ru), (2) Laboratoire des Sciences du Climat et l'Environnement (LSCE / IPSL), CNRS–CEA–UVSQ, Centre d'Etudes Orme des Merisiers, Gif sur Yvette, France

Accurate estimates of emissions of carbon dioxide (CO_2), which is a major greenhouse gas, are requisite for understanding of the thermal balance of the atmosphere and for predicting climate change. International and regional CO_2 emission inventories are usually compiled by following the "bottom-up" approach on the basis of available statistical information about fossil fuel consumption. Such information may be rather uncertain, leading to uncertainties in the emission estimates. One of the possible ways to understand and reduce this uncertainty is to use satellite measurements in the framework of the inverse modeling approach; however, information on CO_2 emissions, which is currently provided by direct satellite measurements of CO_2, remains very limited.

The main goal of this study is to develop a CO_2 emission estimation method based on using satellite measurements of co-emitted species, such as NO_x (represented by NO_2 in the satellite measurements) and CO. Due to a short lifetime of NO_x and relatively low background concentration of CO, the observed column amounts of NO_2 and CO are typically higher over regions with strong emission sources than over remote regions. Therefore, satellite measurements of these species can provide useful information on the spatial distribution and temporal evolution of major emission sources. The method's basic idea (which is similar to the ideas already exploited in the earlier studies [1, 2]) is to combine this information with available estimates of emission factors for all of the species considered. The method assumes optimization of the total CO_2 emissions from the two major aggregated sectors of economy. CO_2 emission estimates derived from independent satellite measurements of the different species are combined in a probabilistic way by taking into account their uncertainties. The CHIMERE chemistry transport model is used to simulate the relationship between NO_x (CO) emissions and NO_2 (CO) columns from the OMI (IASI) measurements, respectively. Uncertainties in the CO_2 emission estimates are evaluated by means of the Monte-Carlo experiment.

In this study, our method is applied to the case of fossil fuel CO_2 emissions from the European region. Taking into account that the uncertainty in available bottom-up estimates of the total CO_2 emissions from that region is believed to be rather small, the case considered enables validation of our method, understanding its advantages and limitations, as well as examination of feasibility of its application to the world's regions with potentially much larger uncertainties in CO_2 emissions.

References:

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