Evaluation of multi-annual changes in CO_2 emission from China using tropospheric NO_2 satellite measurements

E.V. Berezin[1], I.B. Konovalov[1], P. Ciais[2], A. Richter[3]

[1]Institute of Applied Physics of Russian Academy of Sciences, Nizhny Novgorod, Russia
[2] LSCE, CNRS -CEA –UVSQ, Centre d'Etudes Orme des Merisiers, Gif sur Yvette, France
[3]Institute of Environmental Physics and Remote Sensing, IUP/IFE, University of Bremen, Bremen, Germany

ABSTRACT

The study is aimed at evaluating multi-annual changes in CO_2 emissions from China by using tropospheric NO_2 satellite measurements. In order to achieve this objective we first obtain estimates of NOx emissions by combining the data for tropospheric NO_2 column amounts derived from the long-term GOME and SCIAMACHY measurements with simulations performed by the CHIMERE chemistry transport model (CTM) and then get annual estimates of annual relative changes of CO_2 emissions in the eastern part of China by applying emissions factors from the EDGAR inventory. The obtained results indicate that CO_2 emissions in China was increasing much more rapidly than it was estimated in international emission inventories in the period from 1996 to 2008.

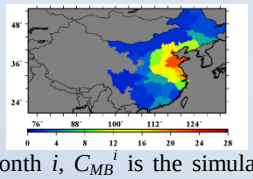
METHOD

Background ideas: •Changes in tropospheric NO_2 column amounts may reflect corresponding changes in NO_x emissions [e.g., 1, 2];
•NOx and CO_2 emissions changes are expected to correlate as they have common sources (fossil fuel burning).

Major points of the method:

1. The data for tropospheric NO_2 columns that have been derived from the GOME and SCIAMACHY measurements in the period from 1996 to 2008 are used.
2. The state-of-the-art CHIMERE CTM is used to evaluate the background level and seasonal variations of tropospheric NO_2 columns for coloured provinces.
3. The CO_2 emissions, $E(CO_2)$, are approximated as

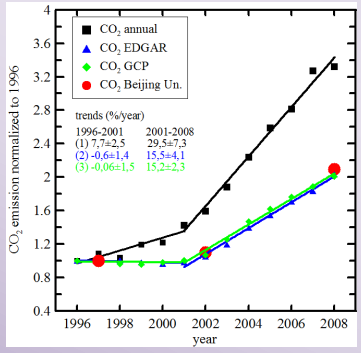
$$E(CO_2) = \sum_{m=1}^{12} \left(\frac{C_O^{\,i} - C_{MB}^{\,i}}{C_M^{\,i} - C_{MB}^{\,i}} \right) \cdot F$$



where $C_O^{\,i}$ is the monthly averaged NO_2 column for a month i, $C_{MB}^{\,i}$ is the simulated "background" NO_2 column which is not related to anthropogenic emissions, $C_M^{\,i}$ is the simulated monthly averaged NO_2 column for a month i, F – the emission factor defined (based on the EGAR inventory) as $F = \frac{[CO_2\ emission]}{[NOx\ emission]}$

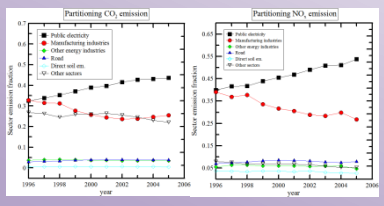
4. Beijing University provincial inventory data (provided by Shu Tao) are used to assess adequacy of the obtained CO_2 emission estimates.

RESULTS



1999-2001: the trend of emissions derived from satellite measurements is strongly positive while the emissions provided by EDGAR and GCP either decrease or remain nearly constant.

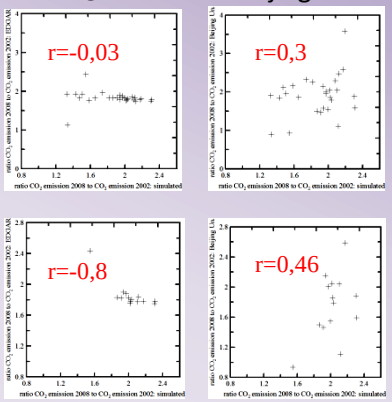
2001-2008: the CO_2 emission growth rate derived from the measurements is much larger than that in EDGAR and GCP.



Monotonous increase of NOx and CO_2 emissions in the period from 2002 to 2008 can be explained by a dominant contribution of the power production sector to the CO_2 and NO_x emissions.

Measurement based estimates vs. emission inventories
(Each point represents the ratio of CO2 emissions in 2008 and 2002 averaged over different provinces in China)

EDGAR Beijing Un.



The fact that the estimated emission changes do not correlate with the corresponding EDGAR data but positively correlate with the national Beijing University data (which are expected to be better than data of global inventories) can be considered as an indication that our estimates are sufficiently adequate.

CONCLUSIONS

We attempted validation of CO_2 emission inventory data for China through the use of tropospheric NO_2 columns amounts derived from satellite measurements. It is found that similar to the EDGAR and GCP data, the "top-down" CO_2 emission estimates demonstrate an accelerating nonlinear trend in the period from 1996 to 2008. However, our results indicate that the changes in CO_2 emissions in China are strongly underestimated in the international emission cadastres.

REFERENCES

1. Richter, A., Burrows, J.P., Nüß, H., Granier, C., and Niemeier, U.: Increase in tropospheric nitrogen dioxide over China observed from space, Nature, 437, 2005.

2. Konovalov, I. B., Beekmann, M., Richter, A., Burrows, J. P., and Hilboll, A.: Multi-annual changes of NO_x emissions in megacity regions: nonlinear trend analysis of satellite measurement based estimates, Atmos. Chem. Phys., 10, 8481-8498, 2010.