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Constraints of Satellite Derived CO_2 on Carbon Sources and Sinks

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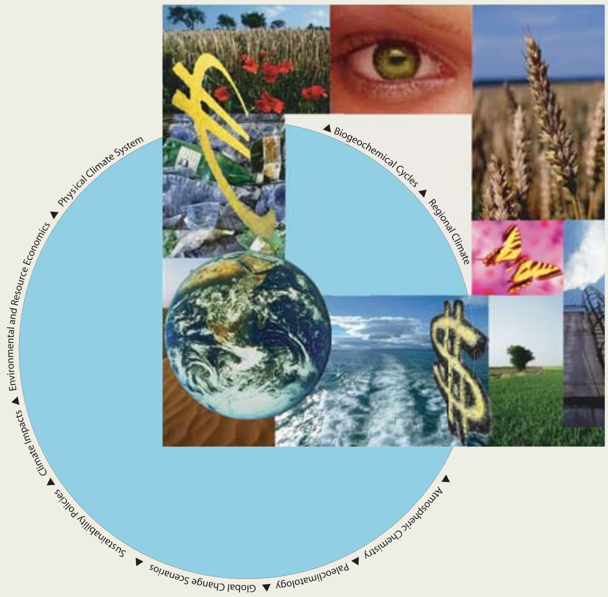

Abstract

This study aims to establish the understanding required to use the satellite derived CO_2 concentration data to constrain surface sources and sinks using inversions of atmospheric transport combined with atmospheric concentration data. CO_2 mixing ratio estimates have recently been derived from space-borne measurements with the TOVS instrument on-board NOAA-11 satellite during 1987-1991 and with the AIRS instrument on the recently launched AQUA satellite during January 2003 to December 2003. Here these satellite retrievals are evaluated through a comparison against modeling results, using two different transport models with surface fluxes optimized to fit surface CO_2 observations.

The TOVS model CO_2 comparison reveals that the RMS (Root Mean Square) difference between retrieval and simulation is around 2 ppm whereas it is only 0.3 ppm between models and is ~0.5 ppm between model and in-situ comparisons when tropics are excluded. In the tropics surface data are very sparse and thus fluxes quite uncertain. Based on a limited set of airborne observations and model simulation, the estimated error (random and bias) in the TOVS monthly product is found to be roughly six times larger than the accuracy needed for improving surface CO_2 flux estimates using an atmospheric approach. The TOVS-model prediction comparison study suggests that confrontation with independent upper air concentration data would be useful to assess more precisely the performance of the models and to exclude unrealistic model transport as reason for model retrieval differences.

The AIRS-model comparison study reveals that simulations of atmospheric CO_2 with both models are much closer to each other than the retrievals. Again there are many features in the retrievals that are difficult to explain from process understanding. This study also raises the question about lower-to-upper troposphere transport pathways and its representation in transport models to rule out biases in model transport as cause of the differences.

As both comparisons suggest to verify model predictions in the upper troposphere with upper air in-situ observations we performed such a study using upper air CO_2 measure-

ments from aircraft campaigns. The comparison shows that model predictions are in good agreement with the long term upper troposphere CO_2 airplane observations. Even short-term transport events as well as longer-term anomalies are well captured. Vertical structures of observed profiles agree also well with simulations but in the tropics absolute magnitudes are often underestimated – the region where surface fluxes used in the model predictions are particularly uncertain.

Overall the study reveals that remotely sensed CO_2 using channels in the thermal infrared exhibit large biases and thus cannot be used to constrain carbon sources and sinks at this stage. However upcoming dedicated missions which focus on the near-infrared region may be more promising. Transport models successfully validated for lower-to-upper troposphere transport are now ready for this purpose.