Atmos. Chem. Phys. Discuss., 8, S11855–S11858, 2009 www.atmos-chem-phys-discuss.net/8/S11855/2009/ © Author(s) 2009. This work is distributed under the Creative Commons Attribute 3.0 License.



ACPD

8, S11855–S11858, 2009

Interactive Comment

Interactive comment on "Assessing temporal clear-sky errors in assimilation of satellite CO₂ retrievals using a global transport model" by K. D. Corbin et al.

K. D. Corbin et al.

Received and published: 24 March 2009

Thank you again for your comments! We have addressed both remarks stated in the review below.

1) The true annual mean CO2 concentrations that are compared to simulated satellite data are the annual mean total column concentrations at each grid cell including all cloud conditions and all hours. For example, at each grid cell we calculated the total column concentration at every time (which is every three hours for the entire year) and calculated the mean concentration of all modeled values. The true seasonal mean was calculated following the same methodology, so each seasonal mean includes all hours and all cloud conditions.





The two issues discussed in the review, which are diurnal temporal errors from the time of day the satellite samples and clear-sky errors from only sampling in clear conditions, are both included in the resulting error maps displayed. By including both effects, the errors shown are directly comparable to maps produced using the satellite data to represent temporal mean CO2 concentrations on both seasonal and annual timescales. Several studies have previously investigated the diurnal errors, showing that the sampling time of 1300 LST is close to the diurnal mean in total column concentrations (Olsen and Randerson, 2004; Miller et al., 2007; Corbin et al., 2008). These studies also revealed that the synoptic variability in total column concentrations is much greater than the diurnal variability, indicating that the dominate source of errors in using clear-sky samples to represent temporal averages is synoptic variability rather than sampling time.

We have performed sensitivity tests to determine the impact of sampling at a specific time of day. At over 99% of the grid points, the difference in annual mean using all times and the annual mean sampling only at 1300 LST is < 0.1 ppm, with a maximum difference of 0.28 ppm. Looking at the seasonal timescale, over 98% of the grid cells have seasonal means at 1300 LST within 0.1 ppm of the seasonal mean including all hours, and the maximum difference over all seasons is 0.34 ppm. The differences in annual and seasonal means due to sampling time alone are much smaller than the errors seen when the impacts of clear-sky sampling are included. Thus, the conclusion in this paper that satellite concentrations do not represent annual and seasonal averages globally is not sensitive to the time of day sampled but rather is due to sampling only in clear-sky conditions.

To clarify our manuscript, we have added the following paragraph at the end of the methods section: The simulated satellite data are compared to the true annual and seasonal mean total column CO2 concentrations at every grid cell, which are calculated by taking the mean of all time-steps and cloud conditions. By including both diurnal errors resulting from the time of day the satellite samples and clear-sky er-

ACPD

8, S11855–S11858, 2009

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



rors from retrieving data only in clear-sky conditions, the differences shown are directly comparable to errors that will occur in annual and seasonal mean maps produced using satellite data. Sensitivity tests to determine the impact of sampling at a specific time of day reveal that the errors on these time-scales are due primarily to clear-sky sampling. At over 99% of the grid points, the differences in the annual mean between using all time-steps and sampling only one hour per day are < 0.1 ppm. On the seasonal timescale, over 98% of the grid cells have seasonal means calculated using only 1300 LST data within 0.1 ppm of the seasonal mean including all hours, with a maximum difference of 0.3 ppm. Due to the minimal impact of sampling at a specific time of day on seasonal and annual timescales, the results shown in the next section are due primarily to sampling data in clear-sky conditions only.

2) This paper extends previous research by investigating clear-sky temporal sampling errors on a global scale. Comparing simulated satellite CO2 concentrations with modeled true values reveals that spatially coherent patterns of differences between clear-sky and total concentrations emerge on the global scale, which previously has been primarily investigated in regional studies. It is essential that modelers are aware that even including the sampling pattern of satellites, clear-sky differences still occur.

The cause of these differences has been investigated in a study by N. Parazoo et al. [2008], which has now been published. In the mid- and high- latitudes, the differences are due primarily to the covariance of cloud coverage and frontal systems, which advect systematic CO2 anomalies. Various other studies have also investigated CO2 concentration variability associated with mid-latitude synoptic weather systems and fronts (Geels et al., 2004 and Chan et al., 2004). Since satellites cannot retrieve concentrations through clouds, these events, which are generally associated with higher concentration anomalies, are not being sampled. In the tropics, cloud cover is covariant with vertical mixing and convection, which results in a recharge-discharge mechanism that strongly controls boundary layer CO2 and hence alters total column concentrations.

ACPD

8, S11855–S11858, 2009

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



To include insights into the causes of the differences, we have included the following paragraph in the conclusions section: Since differences between clear-sky concentrations and total concentrations are spatially coherent on seasonal and annual timescales, we suggest that the main cause of clear-sky errors is synoptic variability and the covariance of clouds and atmospheric CO2 concentrations. A study by Parazoo et al. [2008] used the same model to investigate mechanisms for atmospheric variability. In mid-latitudes, large synoptic variations in atmospheric CO2 are due to weather disturbances that are associated with cloud cover, such as frontal systems. Due to deformational flow, frontal systems create large horizontal gradients in CO2 that are masked by clouds and thus cannot be sampled by satellites. In the tropics, Parazoo et al. [2008] show that a recharge-discharge mechanism controls variations of atmospheric CO2 concentrations. CO2 anomalies created within the boundary layer are transported to the upper troposphere by vertical mixing and convection, which is covariant with cloud cover. Since these anomalies occur under cloudy conditions, they are hidden from satellite observations.

Although these errors should be investigated for various years using different transport models, it is likely spatially coherent patterns would still exist regardless of model choice due to the covariance between clouds and CO2 concentrations. It is imperative that source/sink estimates from satellite data match the sampling time and location to the observation platform. Further, transport models will need to capture correct placement and timing of convective events and synoptic weather features, including fronts and clouds.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 12887, 2008.

ACPD

8, S11855–S11858, 2009

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

