How well does OCO-2 capture the Seasonal Cycle of Carbon Dioxide?

Matthäus
Kiel
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
Hannakaisa Lindqvist, Finnish Meteorological Institute, Sodankylä, Finland
Christopher O'Dell, Colorado State University, Fort Collins, CO, USA
Joshua Laughner, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
Saswati Das, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
Gregory Osterman, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
Vivienne Payne, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

Poster

The seasonal cycle of carbon dioxide (CO2) plays a crucial role in the terrestrial carbon cycle, with variations in atmospheric CO2 concentration peaking in winter and reaching a minimum in summer. This cycle is an indicator of the dynamics of CO2 uptake and release in terrestrial ecosystems, making it an important quantity for testing the accuracy of CO2 measurements from space. In this study, we focus on the quantitative evaluation of the CO2 seasonal cycle using data obtained from the Orbiting Carbon Observatory-2 (OCO-2). OCO-2 is NASA's first satellite dedicated to measuring sources and sinks of CO2 in Earth's atmosphere. Its data are analyzed using the latest ACOS Version 11.1 retrieval algorithm, which provides estimates of column-average dry-air mole fractions of carbon dioxide (XCO2).

In our analysis, we compare the average regional seasonal cycle characteristics of XCO2 from OCO-2 with those measured directly by the Total Carbon Column Observing Network (TCCON). We assess key parameters such as the mean seasonal cycle amplitude (SCA), the start and end date of the carbon uptake period (CUP), and the half-drawdown date (HDD). Our results show that the SCA is accurately captured within 0.5ppm over 12 out of 15 TCCON sites located in the northern hemisphere. On average, OCO-2 captures the start of the CUP two days earlier and the end of CUP three days later than TCCON. We observe the largest differences over European continental sites, where the end of the CUP from OCO-2 is delayed by up to two weeks compared to TCCON. These differences are primarily driven by a seasonal bias, especially noticeable during the summer months, between OCO-2 and TCCON at these specific sites.

Additionally, comparisons against a suite of models that assimilate in situ measurements of CO2 show qualitative agreement between the models and satellite observations at latitudes 0-70°N. However, model-to-model SCA differences appear generally larger than the differences between the models and satellite observations at most latitude bands. In the mid- to high-northern latitudes, the SCA derived from OCO-2 measurements appears shallower by 1ppm compared to the median SCA of the model suite. In this region, OCO-2 indicates an earlier end of the CUP and HDD (~ 7 days) compared to the models. In contrast, over the subtropics and tropics, the OCO-2 SCA appears larger by 1ppm compared to the models, and the end of the CUP and HDD are delayed (~ 4 days) compared to the models. This discrepancy is likely due to the limited availability of in-situ measurements over land in this region, which affects the constraints on the models.

In general, our findings suggest that with near-global coverage and a data record of more than nine years, OCO-2 ACOS V11.1 retrievals of the XCO2 seasonal cycle are a valuable resource to assess trends and changes in the terrestrial carbon cycle over time.

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