The Orbiting Carbon Observatory (OCO) Mission

Watching The Earth Breathe…Mapping CO₂ From Space.

OCO-2 Overview

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Units are PgC per year (or GtC per year)

Land is the difference between photosynthesis and respiration

Ocean is the difference between release in warm water and uptake in colder waters

[Le Quere et al., 2013]
Annual combustion of fossil fuels, the largest CO$_2$ source from human activity, increases steadily over time.

The fraction remaining in the atmosphere remains roughly the same.

Fundamental questions:
• Where is the missing CO2 going?
  • In the land or ocean?
  • When does it occur?
• Why does this vary dramatically from year to year?
• Will the nature, the location or the amount absorbed change in the future?

[Le Quere et al., 2013]
Atmospheric CO$_2$ at Mauna Loa Observatory

Scripps Institution of Oceanography
NOAA Earth System Research Laboratory

PARTS PER MILLION


YEAR

Charles Keeling

http://www.esrl.noaa.gov/gmd/ccgg/trends/

Measurement Approach

**Collect** spectra of CO$_2$ & O$_2$ absorption in reflected sunlight over the globe

**Retrieve** variations in the *column averaged CO$_2$ dry air mole fraction*, $X_{CO2}$ over sunlit hemisphere

**Validate** measurements to ensure $X_{CO2}$ precision of 1 - 2 ppm (0.3 - 0.5%)
The OCO-2 Orbit:
- 705 km altitude, 98.2° inclination
- 16-day ground track repeat cycle
- 98.8 minute period: 14.57 Orbits/day
- ~25° longitude offset between consecutive orbits
- 1.5° longitude offset between orbit tracks after 16-days

Latitude Coverage
- Nadir: ±85° Solar zenith angle
- Glint: ±81° Solar zenith angle

Sampling Rate
- 24 samples/second along track
- ~1 million samples per day
- 10-20% of the soundings expected to yield useful \( X_{CO2} \) estimates

OCO-2 is a SAMPLING system, not a MAPPING system.

OCO-2 collects samples continuously along a narrow track with much coarser sampling from track-to-track.
Solar induced chlorophyll fluorescence (SIF) is a direct by-product of photosynthesis (part of the energy goes into SIF) → Found to be a good proxy for gross primary production (GPP)

GPP drives the global carbon cycle as it is the biggest carbon uptake mechanism → SIF (GPP) inversely correlated to CO₂ fluxes, ideal complementarity to OCO-2 primary mission goals!

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SIF Data from OCO-2

OCO2 nadir repeat cycle (16 days), dp<100hPa

- SIF routinely retrieved in L2, as it would otherwise produce a bias in XCO2
- Expected performance reported by Frankenberg et al., RSE, 2014
- IMAP-DOAS product is best for SIF

Figures courtesy of C. Frankenberg
### Data Available to the public at the DAAC

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<th>Type</th>
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<td>OCO-2 spacecraft attitude data for one specific orbit</td>
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<td>Geolocated XCO2 retrieval results for selected soundings for one specific orbit and one specific viewing mode</td>
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</table>

*Lite files at portal….*
Application to Agriculture

Global and time-resolved monitoring of crop photosynthesis with chlorophyll fluorescence

Luis Guanter1,2, Yongguang Zhang3,4, Martin Jung5,6, Joanna Joiner7, Maximilian Voigt8, Joseph A. Berry9, Christian Frankenberg3, Alfredo R. Huete1, Pablo Zarco-Tejada9, Jung-Eun Lee9, M. Susan Moran1, Guillermo Ponce-Campos1, Christian Beer1, Gustavo Camps-Valls2, Nina Buchmann1, Damiano Gianelle1, Katja Klumpp1, Alessandro Cescatti1, John M. Baker9, and Timothy J. Griffiths1

max(SIF) (mW/m²/sr/nm)
0.0  0.9  1.8  2.7  3.6  4.5

Fig. 1. Global map of maximum monthly sun-induced chlorophyll fluorescence (SIF) per 0.5° grid box for 2009. SIF retrievals are performed in a spectral window centered at 740 nm (see Materials and Methods and SI Appendix, SIF Retrievals). This map illustrates the outstanding SIF signal detected at the US CB, which shows the highest SIF return of all terrestrial ecosystems. The maximum SIF over the largest part of the US CB region is detected in July.

- SIF can provide realistic estimates of photosynthetic uptake rates over the largest crop belts worldwide.
- SIF can help us improve current models of global carbon cycle
- OCO-2 and Sentinal 5-Precursor will soon provide SIF-based estimates of crop photosynthesis

Fig. 4. Time series of flux tower-based GPP compared with SIF retrievals (A and B) and the MODIS MOD13C2 EVI (C and D) for the same cropland and grassland sites and spatiotemporal averages as in Fig. 3 (monthly averages in 0.5° grid boxes and the 2007–2011 period). SIF and EVI are plotted with the same vertical scale for cropland and grassland sites.