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Influence of El Nino on atmospheric CO_2: Findings from the Orbiting Carbon Observatory-2

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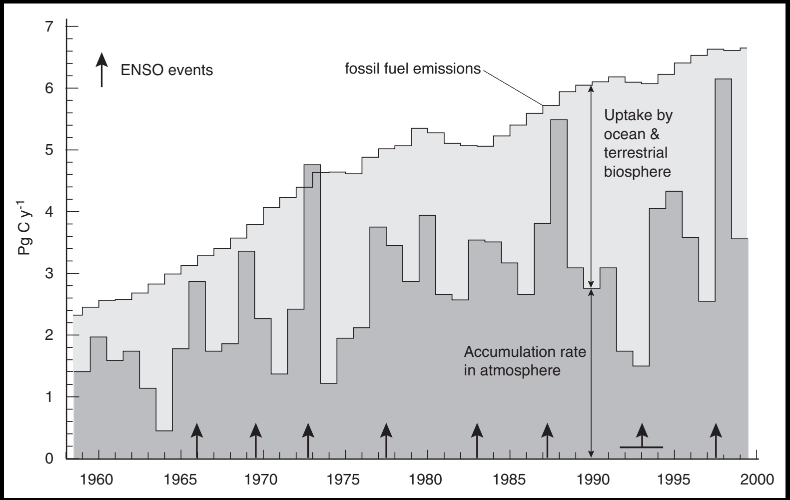
Key Messages

- OCO-2 is providing us with real data constraints on the magnitude and phasing of ENSO-CO_2 relationship
- Oceans do contribute to the ENSO CO_2 effect
- We find this effect to be consistent with observations from sparse in situ data

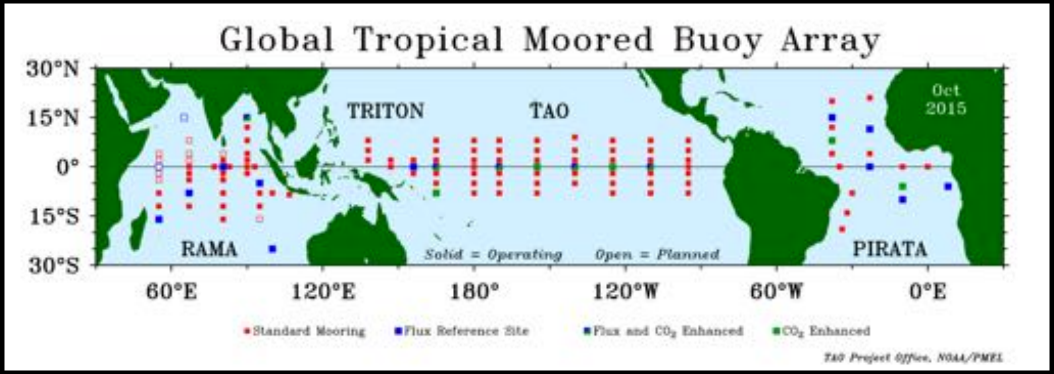
Background

- Correlations between atmospheric CO_2 growth rate and ENSO activity have been reported since the 70s (see Bacastow 1976)
- Studying the response of CO_2 → how feedbacks between the physical climate system and global carbon cycle operates



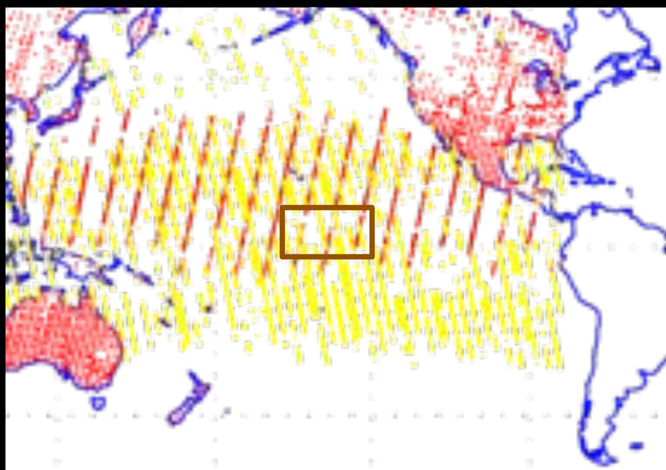
Source: Sarmiento and Gruber [2006]

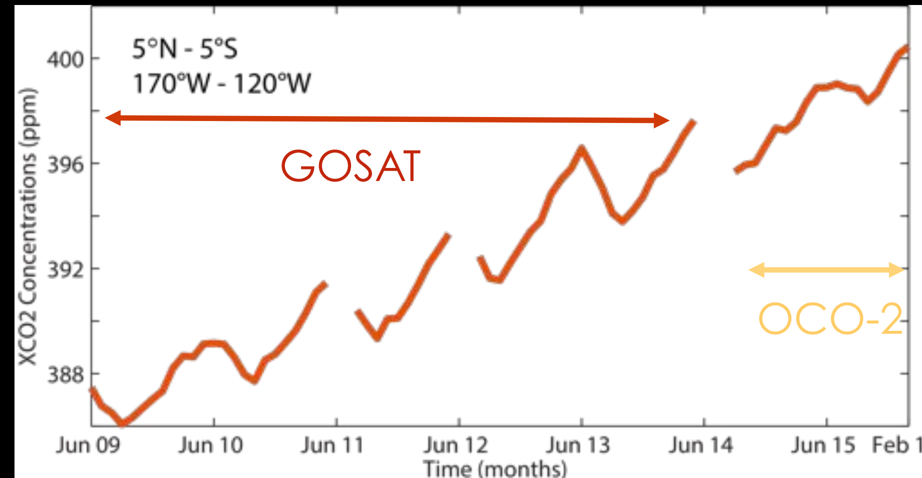
Does OCO-2 observations provide insight on the relationship between ENSO and the carbon cycle?

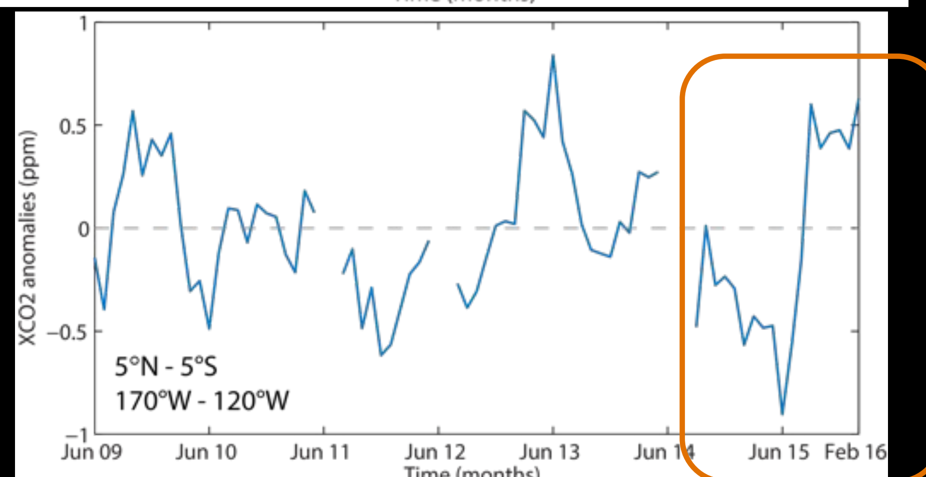


GOSAT-ACOS and OCO-2 era

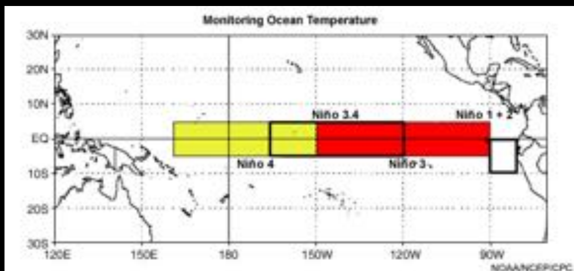
Coverage over Pacific ocean for a generic month
GOSAT-ACOS (2010) and OCO-2 (2015)





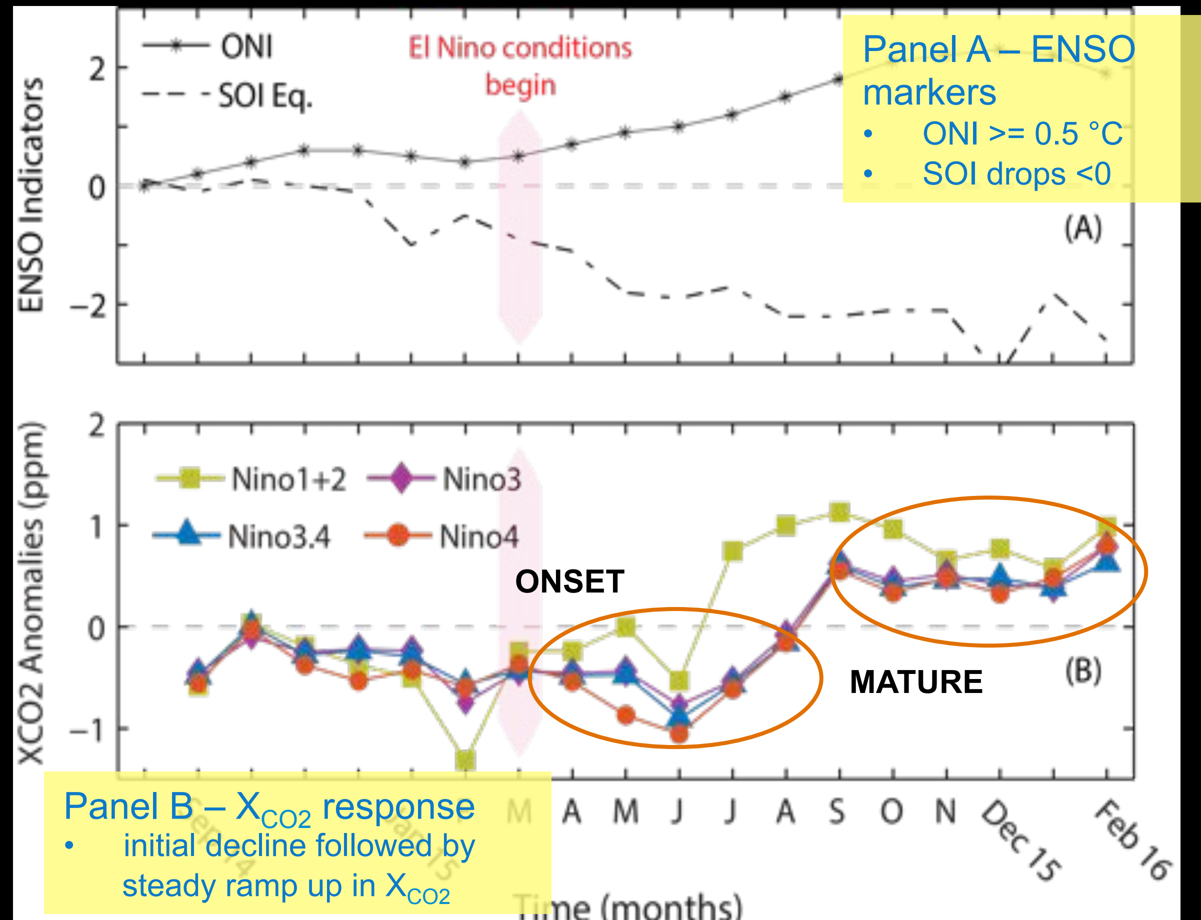


Observable trends in 2015-2016

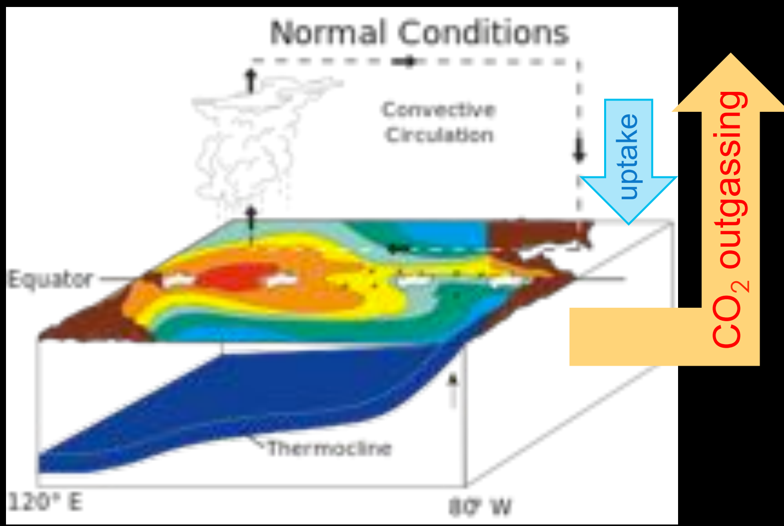


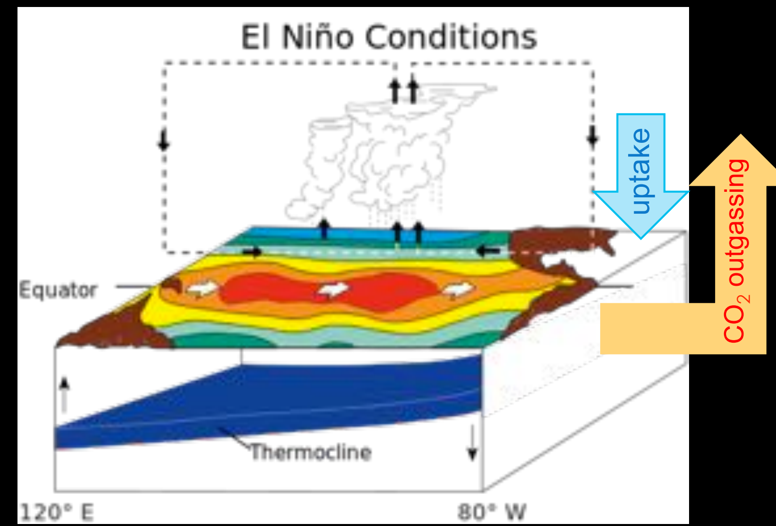
- Time-series showing the temporal evolution of X_{CO2} anomalies

Sep 2014 – Feb 2016



Carbon system in the eq. Pacific





- Normal conditions: strong upwelling of cold subsurface waters that have high potential pCO_2 + inefficient biological pump → high CO_2 outgassing
- El Nino conditions: deepening of thermocline, reduction in upwelling + more efficient biological pump → decreases CO_2 outgassing

Putting it all together: Two phases of CO_2 response

- Development Phase of ENSO: Spring-Summer 2015
  - Typical reduction in CO_2 outgassing over the Tropical Pacific – negative CO_2 anomalies throughout Nino 3 and 4
  - This hypothesis is supported by TAO data

- Mature Phase of ENSO: Fall 2015 onwards
  - Increase in CO_2 anomalies registered over much of Nino 3 and Nino 4 - due to enhanced burning over SE Asia, reduction in biospheric activity
  - Impact of biomass burning emissions is supported by MOPITT CO observations

Ocean vs. Terrestrial contribution

GEOPHYSICAL RESEARCH LETTERS, VOL. 26, NO.4, PAGES 493-496, FEBRUARY 15, 1999

The relationship between tropical CO_2 fluxes and the El Niño-Southern Oscillation

Peter J. Rayner[1] and Rachel M. Law
CRC for Southern Hemisphere Meteorology, Monash University, Clayton, Australia

Roger Dargaville[2]
School of Earth Sciences, University of Melbou

Abstract. This paper summarizes some fe

Rayner et al. [1999]

Jones et al. [2001]

VOLUME 14 JOURNAL OF CLIMATE 1 NOVEMBER 2001

Climate–Carbon Cycle Model Study

COX, AND STEVEN A. SPALL
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oncentration of carbon dioxide (CO_2) even
his variability is well correlated with the El
ral carbon cycle provides a valuable mech-

Biogeosciences, 8, 2493–2506, 2011
www.biogeosciences.net/8/2493/2011/
doi:10.5194/bg-8-2493-2011

Biogeosciences

Does terrestrial drought explain global CO_2 flux anomalies induced by El Niño?

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Received: 24 March 2011 – Published in Biogeosciences Discuss.: 2 May 2011
Revised: 23 August 2011 – Accepted: 24 August 2011 – Published: 9 September 2011

Abstract. The El Niño Southern Oscillation is the domi- tegrated responses from –1.15 to +0.49 Pg C yr^{-1}. Despite

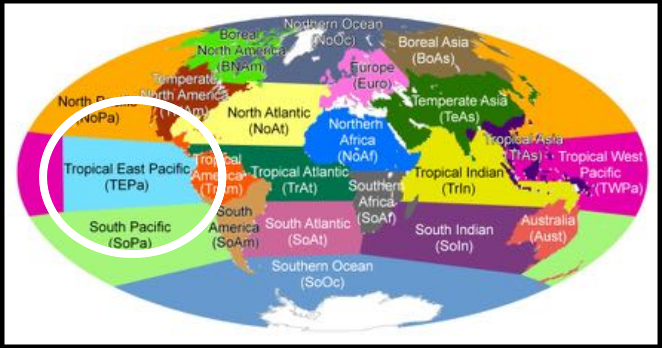
ylin et al. [2005]

Schwalm et al. [2011]

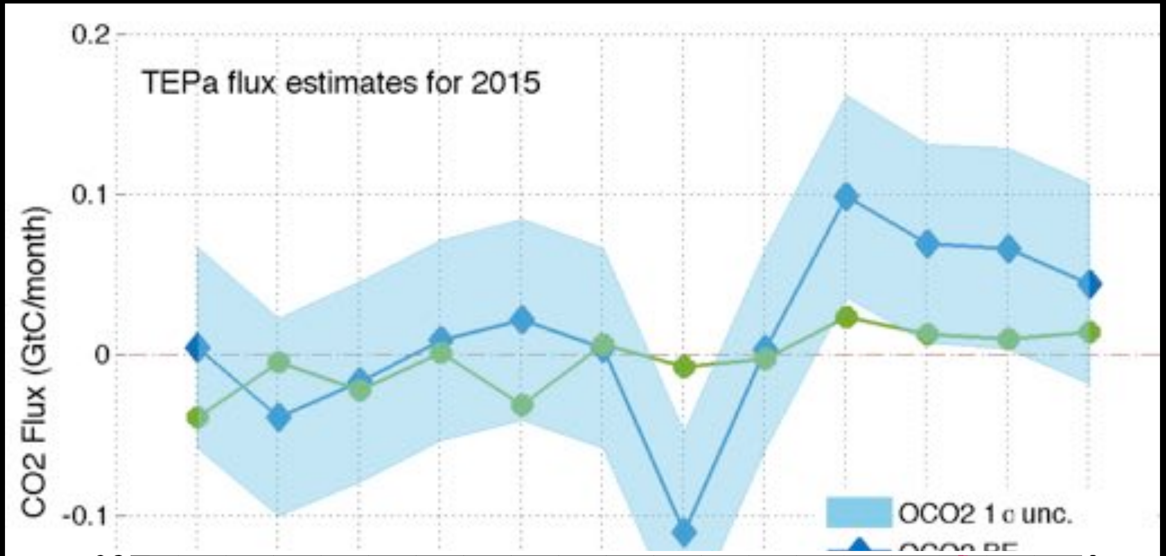
Causes of uncertainty

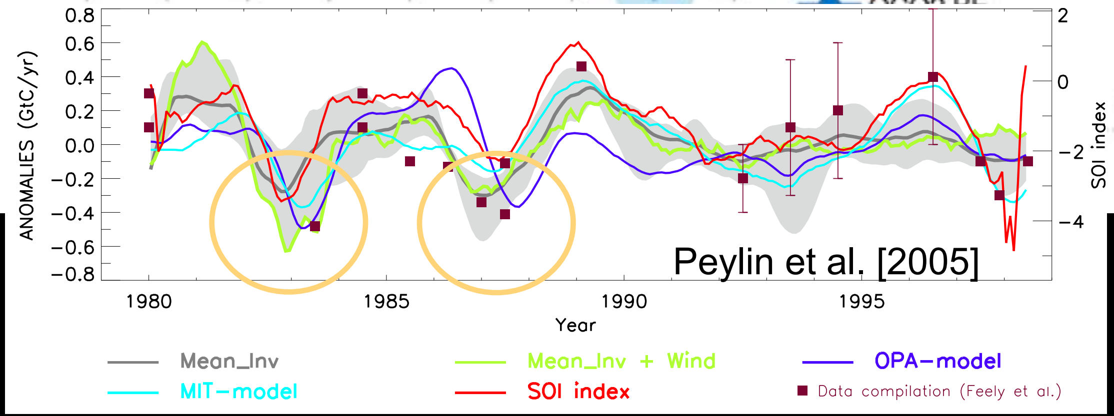
- Signals captured in the X_{CO2} anomalies
  - can X_{CO2} represent local effects?
  - or are the anomalies representative of a global trend and simply responding to global patterns?
- Stitching together two disparate data sources, i.e., GOSAT-ACOS and OCO-2 datasets
  - changes in sampling density, observation strategy
  - changes in instrument type
  - data gaps

What do OCO-2 inversions tell us?



- We see a robust and credible pattern of flux behavior well synchronized with ENSO
- Geostatistical inversions to keep the estimates as data driven as possible





Key Messages

- OCO-2, with its unprecedented coverage over the Pacific Ocean, provides us with actual data constraints on the magnitude and phasing of ENSO-CO_2 relationship

- Oceans do contribute to the ENSO CO_2 effect
  - suppressed outgassing from the oceans happen early, followed by a larger (and lagged) response from terrestrial land masses
  - if it weren't for the reduction in outgassing from the ocean, the impact from terrestrial sources would be larger

- We find this effect to be consistent with observations from sparse in situ data

Acknowledgements

- GOSAT Project, ACOS and OCO-2 team, esp. D. Crisp, A. Eldering, M. Gunson, C. O'Dell, among others

- P. Wennberg (Caltech), J. Worden (JPL), S. Wofsy (Harvard Univ.), among others

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QUESTIONS?

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