Observing changes in sea-air CO_2 fluxes in the tropical and subtropical Pacific during the strong 2015-2016 El Niño event

Session 4: Societal Challenge #2 Ocean Extremes

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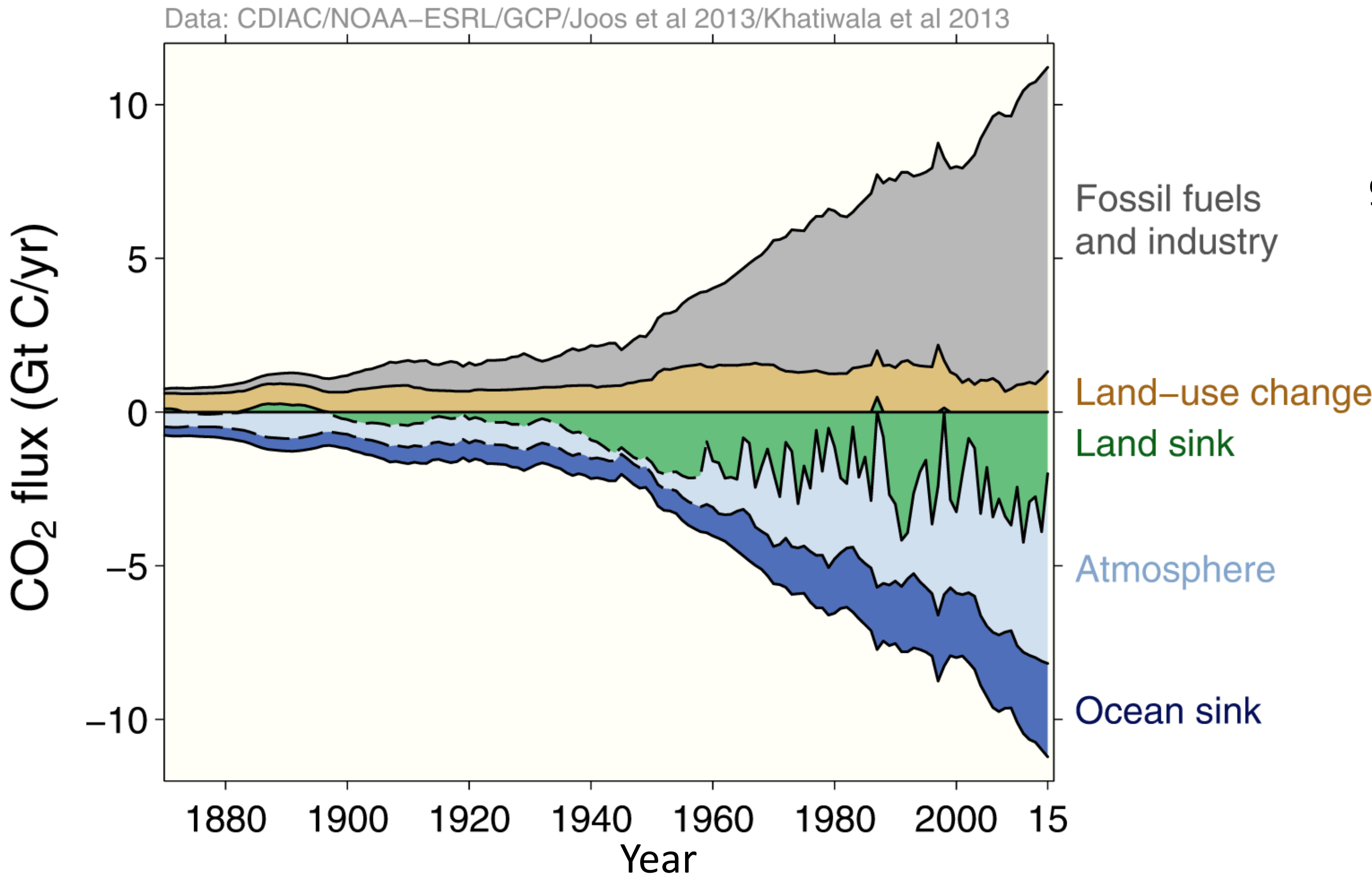
Global Carbon Balance

The carbon sources from fossil fuels, industry, and land use change emissions are balanced by the atmosphere and carbon sinks on land and in the ocean



2006-2015

Sources

9.3 ± 0.5 PgC/yr

0.9 ± 0.5 PgC/yr

Sinks

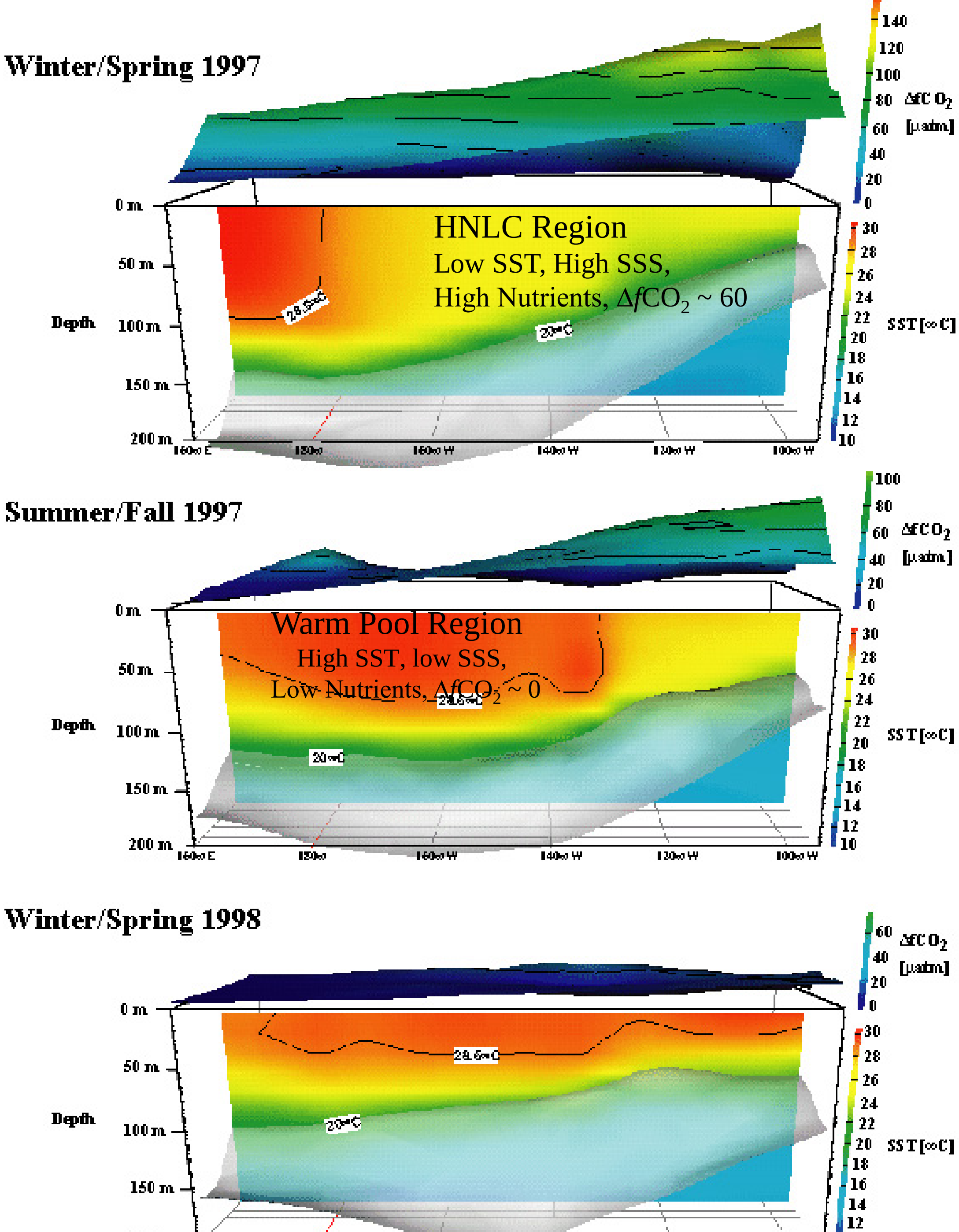
3.1 ± 0.8 PgC/yr

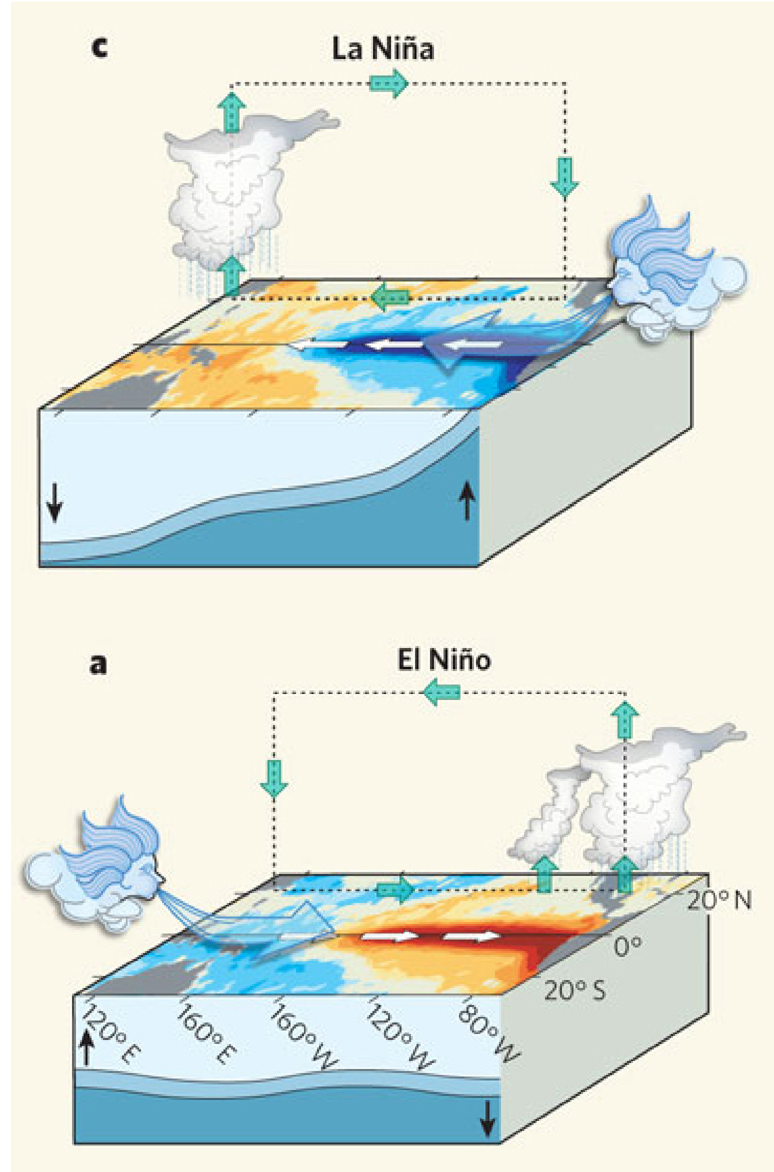
4.5 ± 0.1 PgC/yr

2.6 ± 0.5 PgC/yr

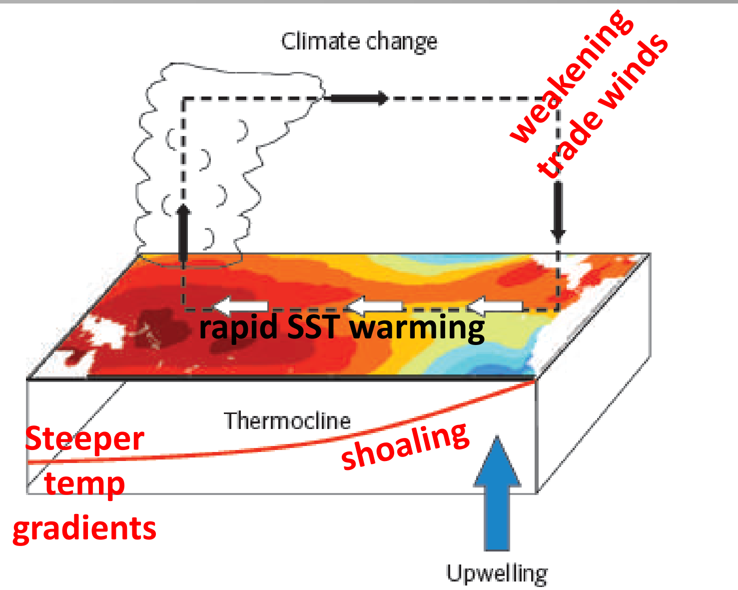
Source: CDIAC; NOAA-ESRL; Houghton et al 2012; Giglio et al 2013; Joos et al 2013; Khatiwala et al 2013; Le Quéré et al 2016; Global Carbon Budget 2016

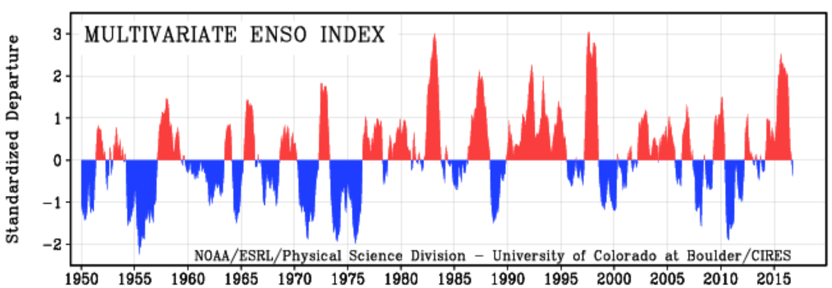
Schematic Diagram of the impact of Strong Eastern Pacific El Niños on the Sea-Air CO_2 Exchange in the Equatorial Pacific

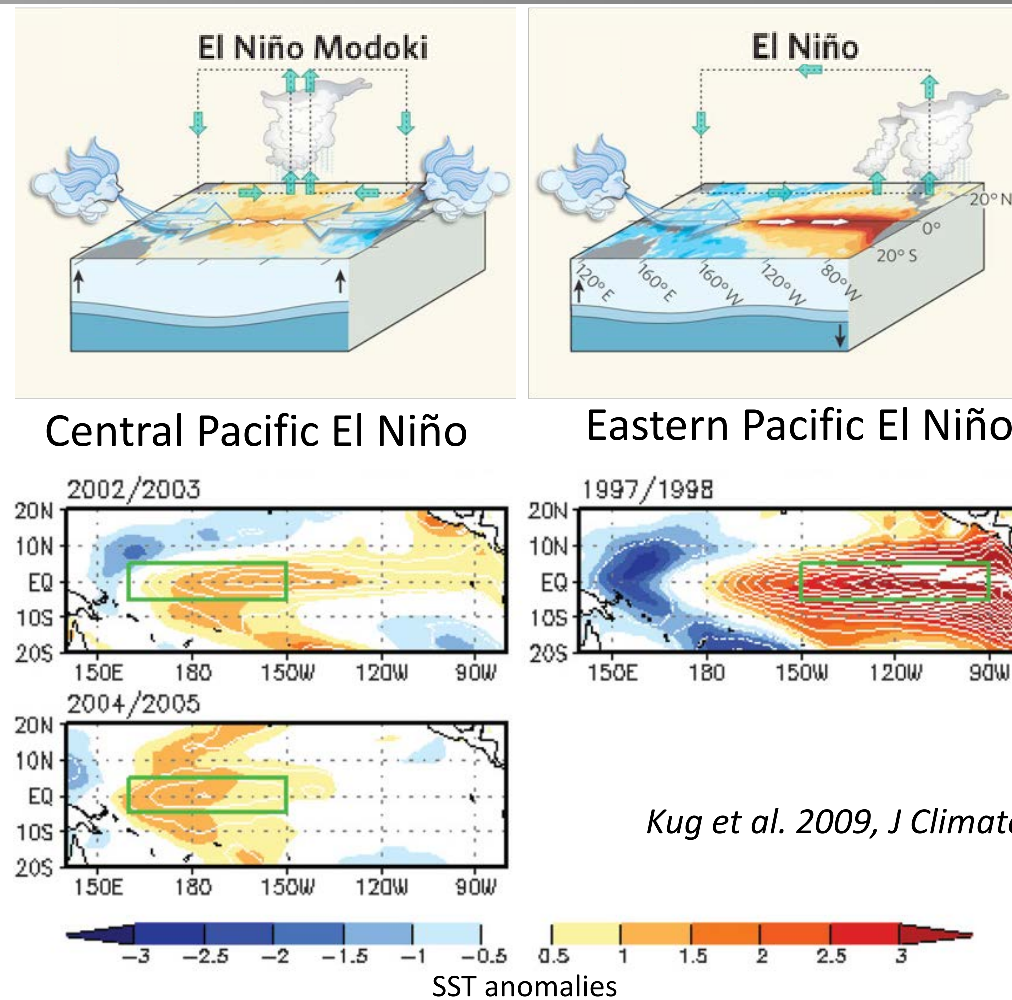




Types of El Niño “Flavors”



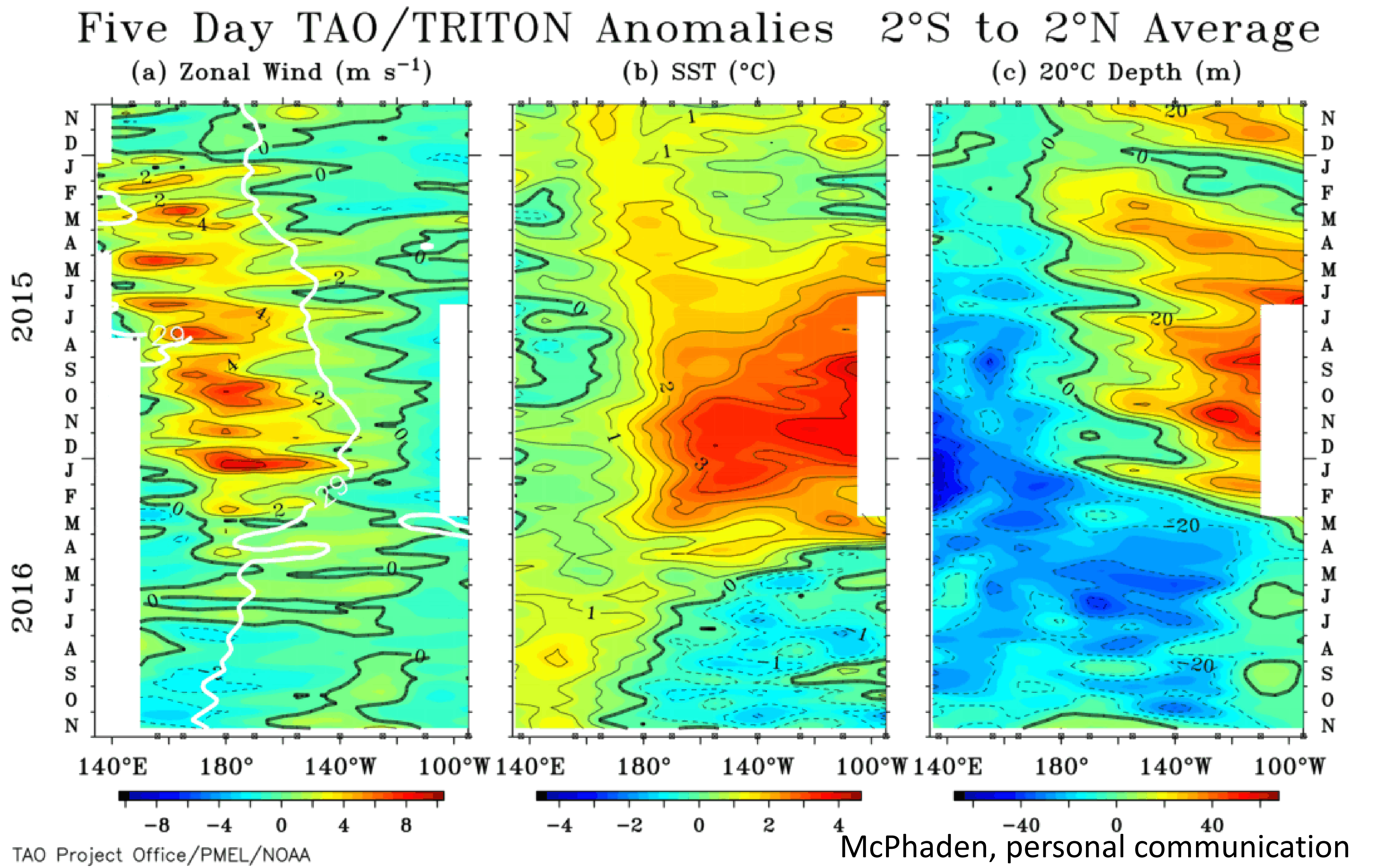




- **A new type of El Nino: maximum warming in the central-equatorial Pacific (CP)**
- **Classical El Nino: maximum warming in the eastern-equatorial Pacific (EP)**

Question: How will climate change will impact physical, chemical, biological, or ecosystem dynamics in the Equatorial Pacific?

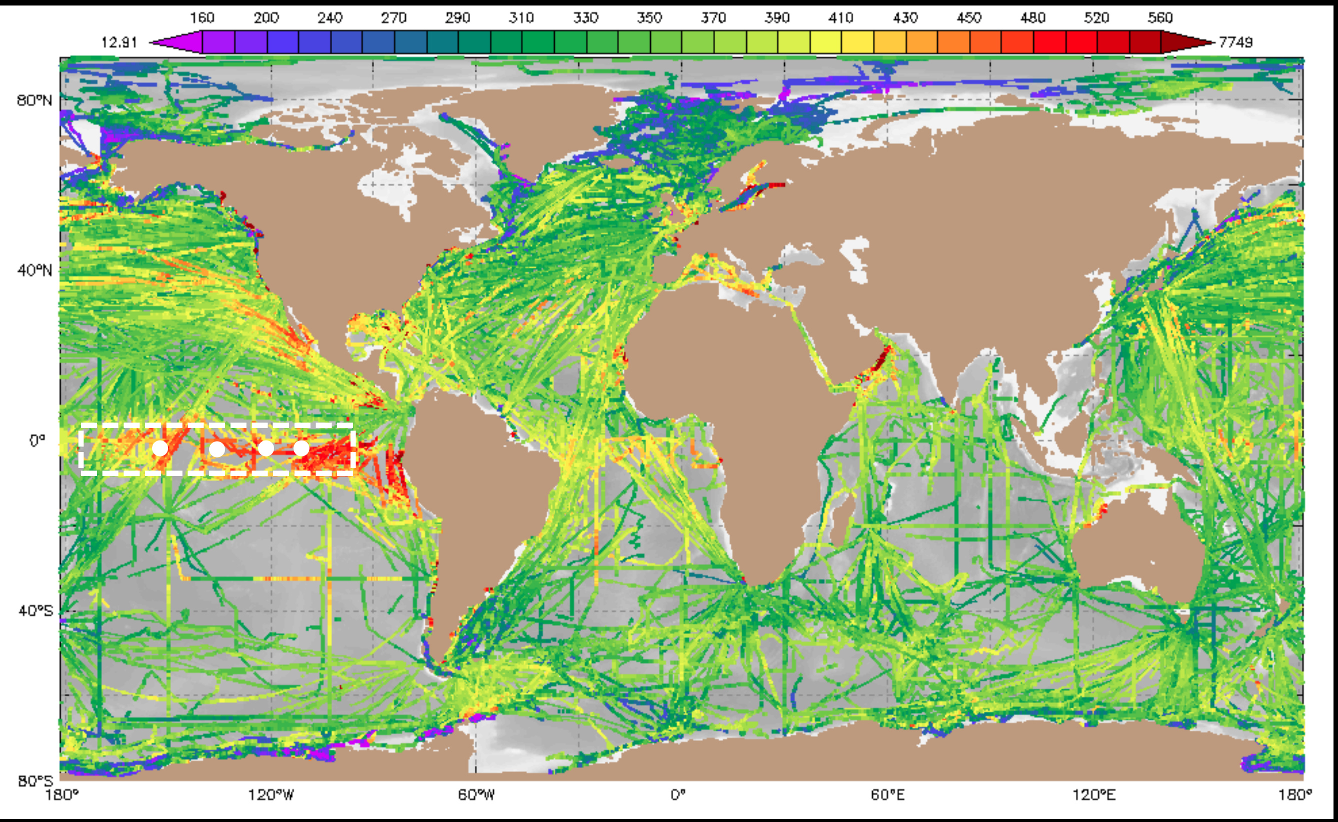
Time - Longitude maps of zonal winds, SSTA, and 20° C isotherm depth (m)



McPhaden, personal communication

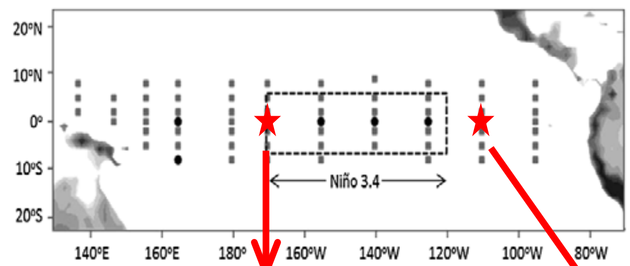
Overview of carbon observing system

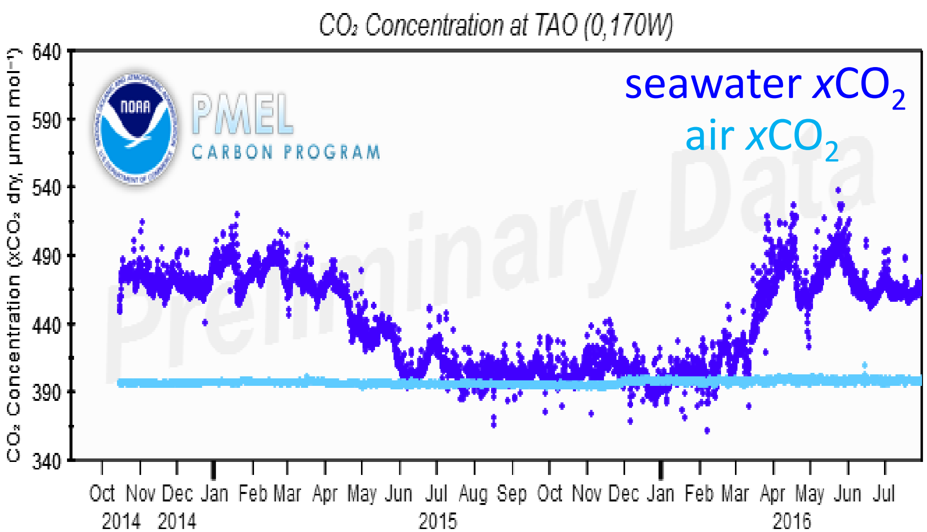
Shipboard and mooring data (1968-2016)

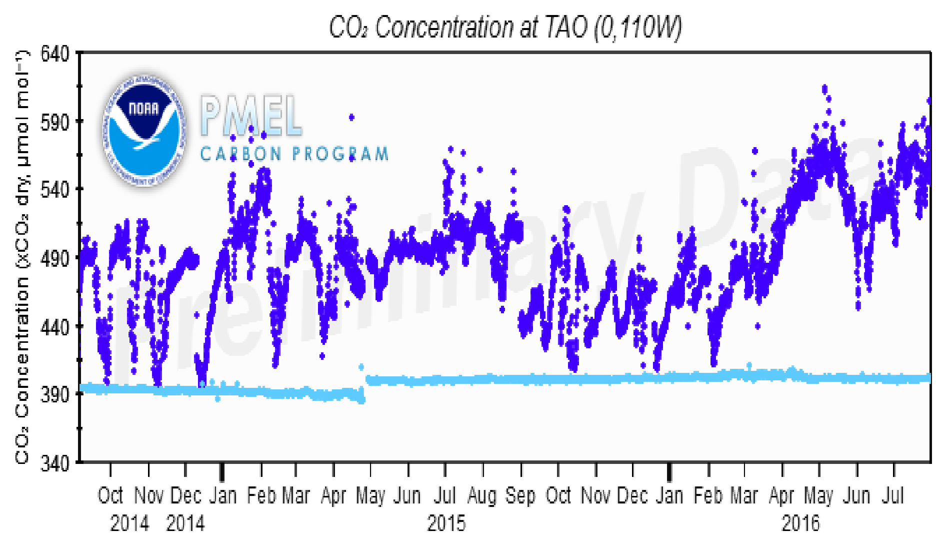


Mooring and underway CO_2 data available at NCEI and incorporated into Version 4 of SOCAT (see Bakker et al., 2016, ESSD)

2014-2016 pCO_2 observations and CO_2 flux from TAO buoys



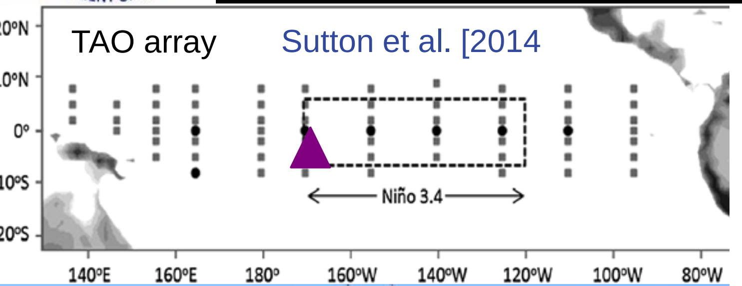


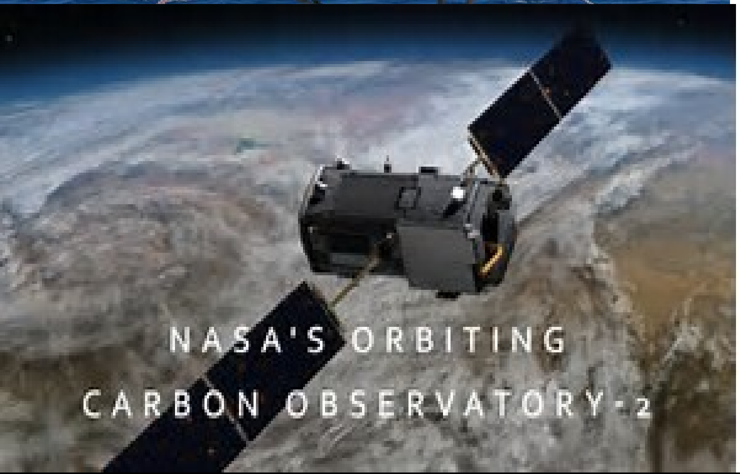


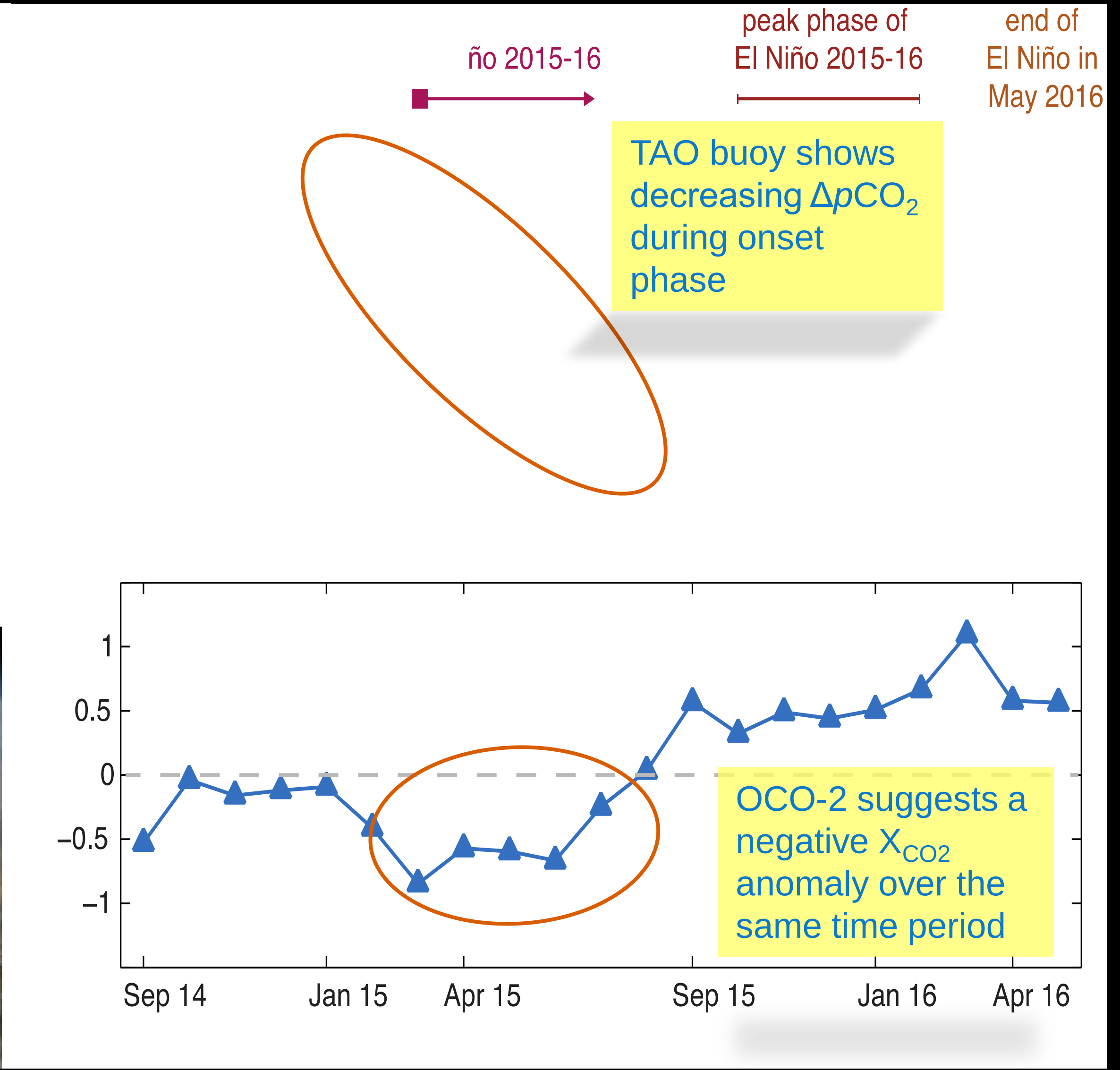
CO_2 time series plots available at www.pmel.noaa.gov/co2/

Corroboration of oceanic signal

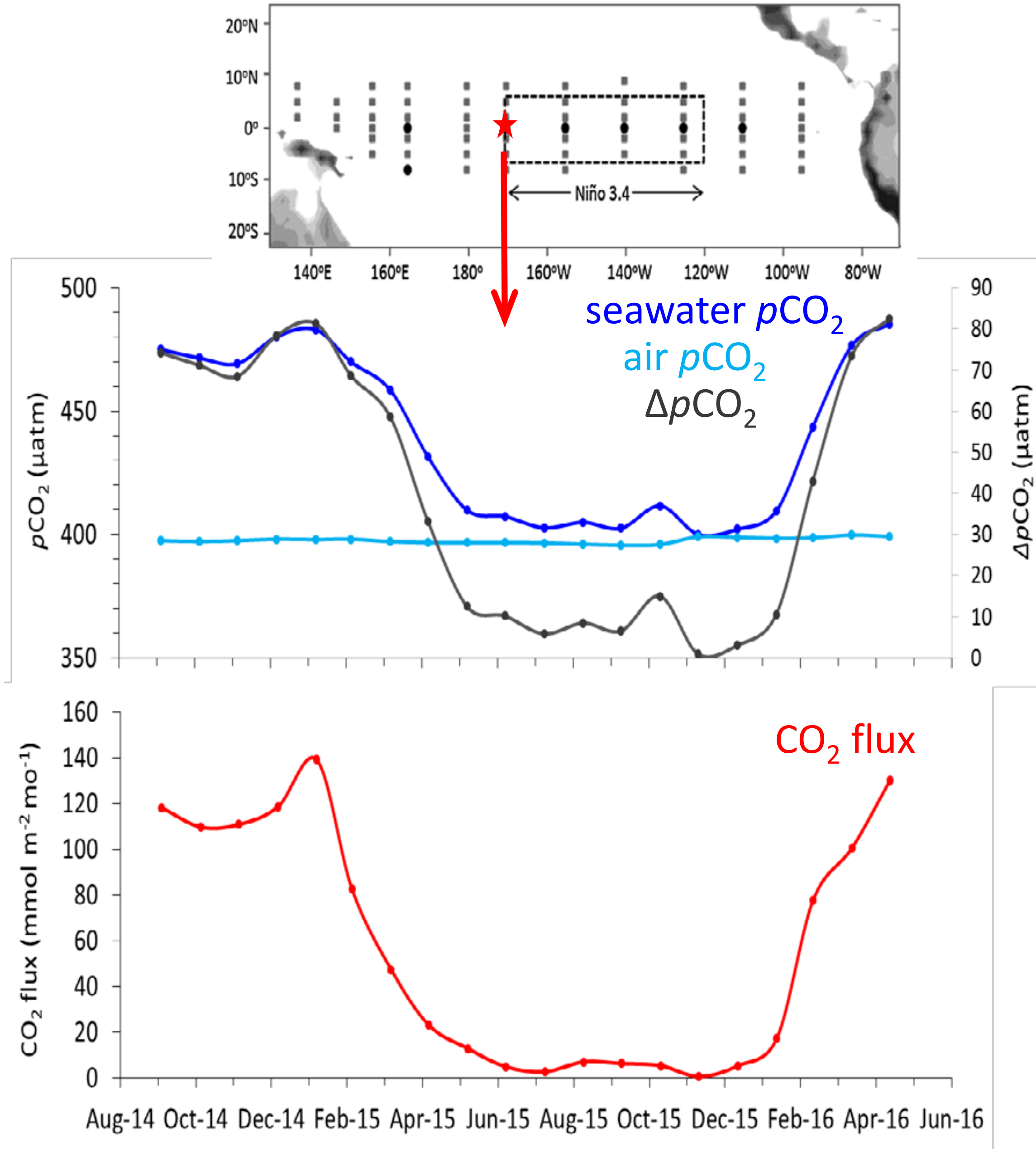
Abhishek Chatterjee et al (Science, in press)







2014-2016 pCO_2 observations and CO_2 flux from TAO buoys



The tropical Pacific CO_2 flux decrease in this region during El Niño (~0.2 - 0.3 PgC yr^{-1}) amounts to an overall CO_2 Flux decrease of approximately 40-60%.

Conclusions

- The tropical Pacific is the major natural source of CO_2 from the ocean to the atmosphere, contributing more than 70% of the global flux to the atmosphere.

- The interannual variability of the sea-air CO_2 flux in the tropical Pacific is also the major source of CO_2 flux variability in the Pacific Ocean (~0.2 - 0.3 PgC yr^{-1}), which is a an overall CO_2 flux decrease of approximately 40-60% in the tropical Pacific during El Niño events.

- With the high-resolution observations available from OCO-2 and TAO moorings, we are able to directly: 1) observe the strong correlations that exist between atmospheric CO_2 concentrations and the El Niño forcing, and 2) track the development of the atmospheric CO_2 anomaly as it switches from a negative phase due to a reduction in CO_2 outgassing from the tropical Pacific Ocean, to a strong positive phase due to a reduction in biospheric uptake and increased fire emissions.

The instrument measures the intensity of three relatively small wavelength bands (Weak CO2, Strong CO2 and Oxygen O2) from the spectrum, each specific to one of the three spectrometers. By simultaneously measuring the gases over the same location and over time, OCO-2 will be able to track the changes over the surface over time. The OCO-2 spectrometers will measure sunlight reflected off the Earth's surface. The sunlight rays entering the spectrometers will pass through the atmosphere twice - once as they travel from the Sun to the Earth, and then again as they bounce off from the Earth's surface to the OCO-2 instrument.