

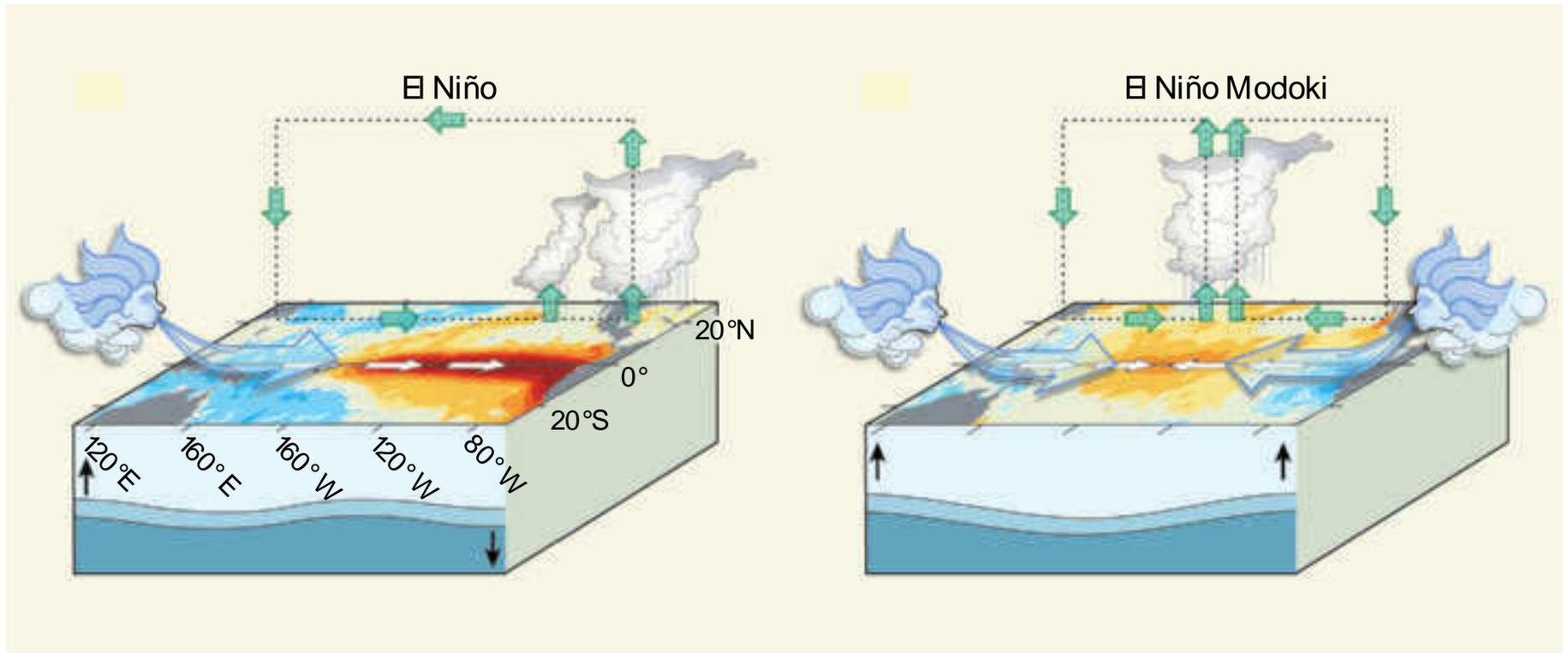
Biological Response in the Tropical Pacific to ENSO Diversity

Michelle Gierach and Tong Lee*
NASA Jet Propulsion Laboratory

Background and Motivation

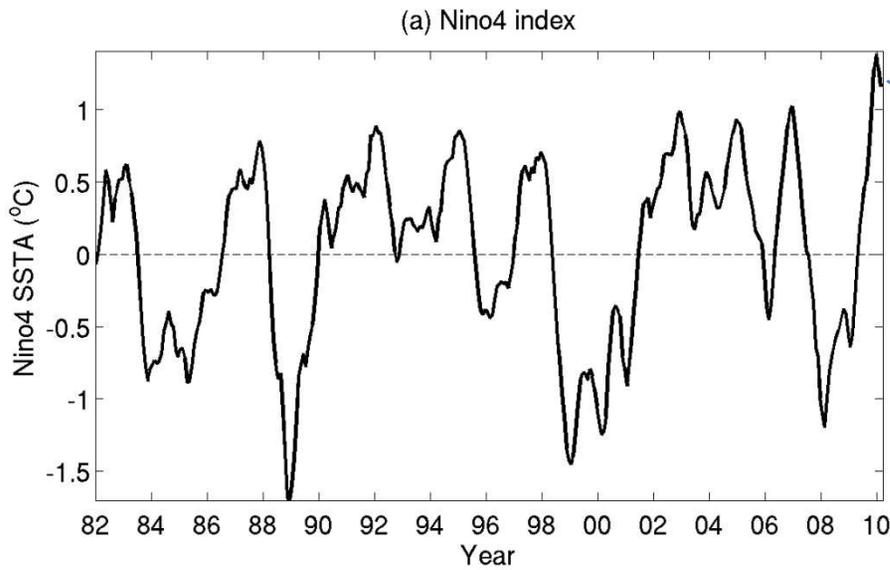
- El Nino has a significant impact on biology and ecosystem in the tropical Pacific.
- Increasing need to use ocean data assimilation products to study physical processes affecting related biological response.
- Previous studies on biological response to El Nino focuses on the classical eastern-Pacific (EP) El Nino.
- But El Nino is changing, with more frequent occurrence of central-Pacific (CP) El Nino.
- How does CP-El Nino affects biological response differently than EP-El Nino?

A New Flavor of El Niño – CP-El Niño

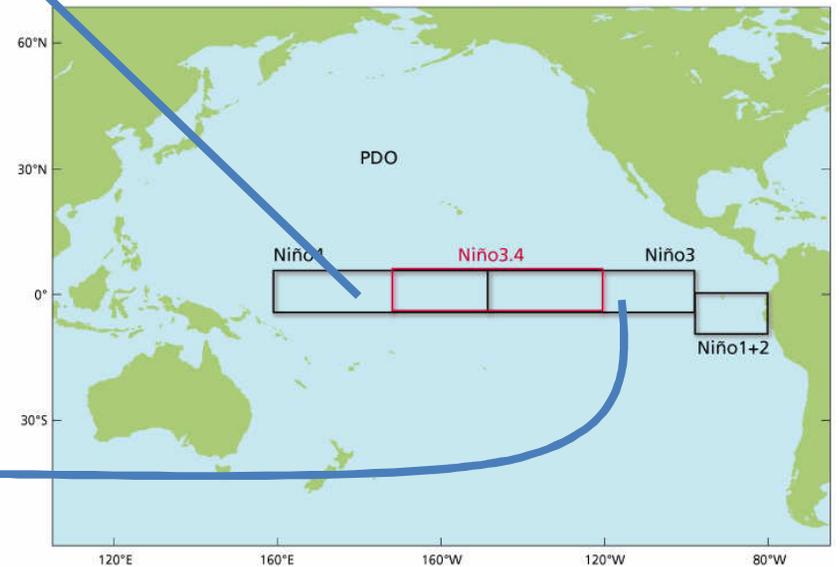
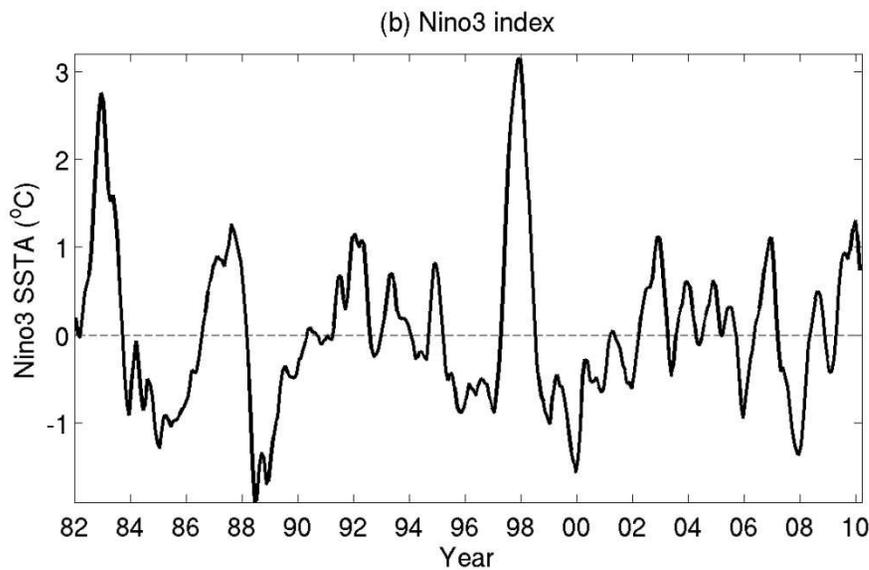
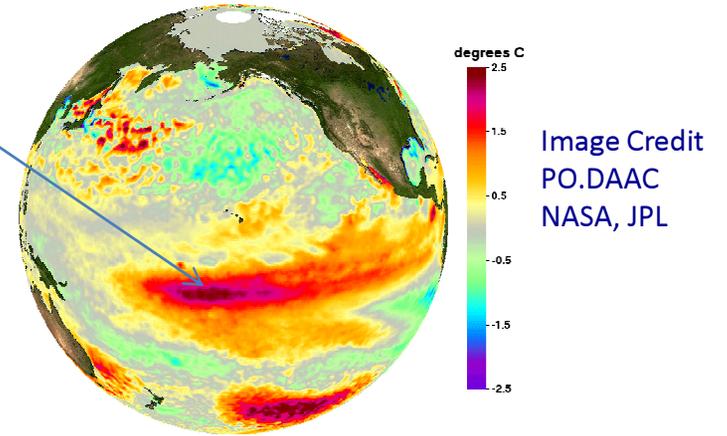


El Niño Modoki, Central Pacific (CP)-El Niño, warm-pool El Niño, or dateline El Niño

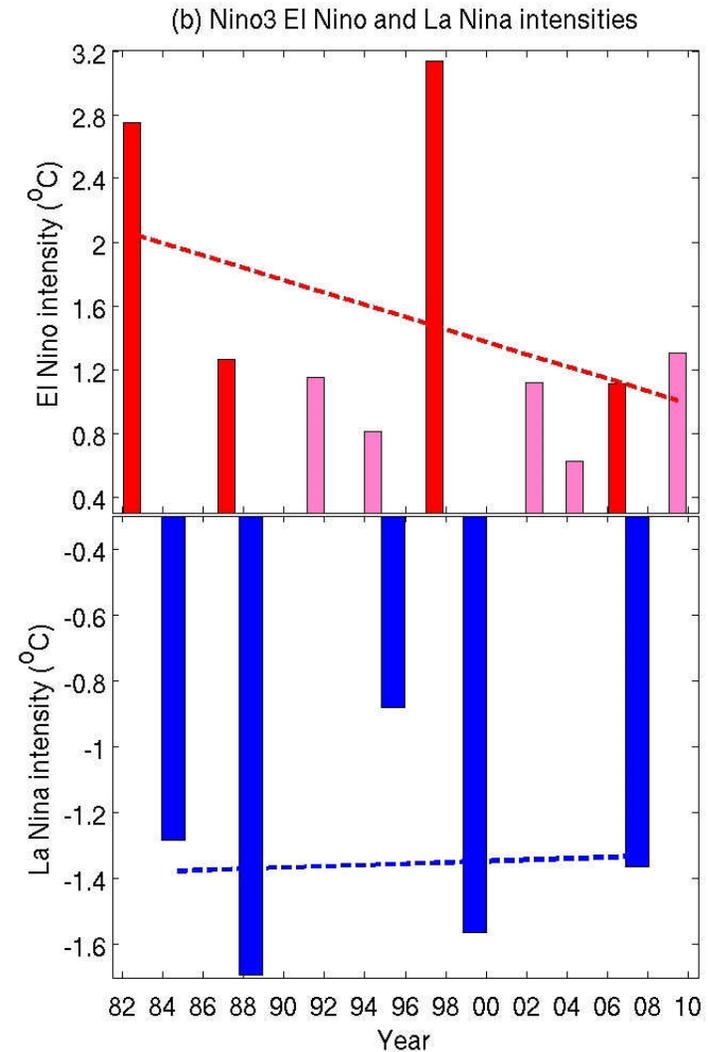
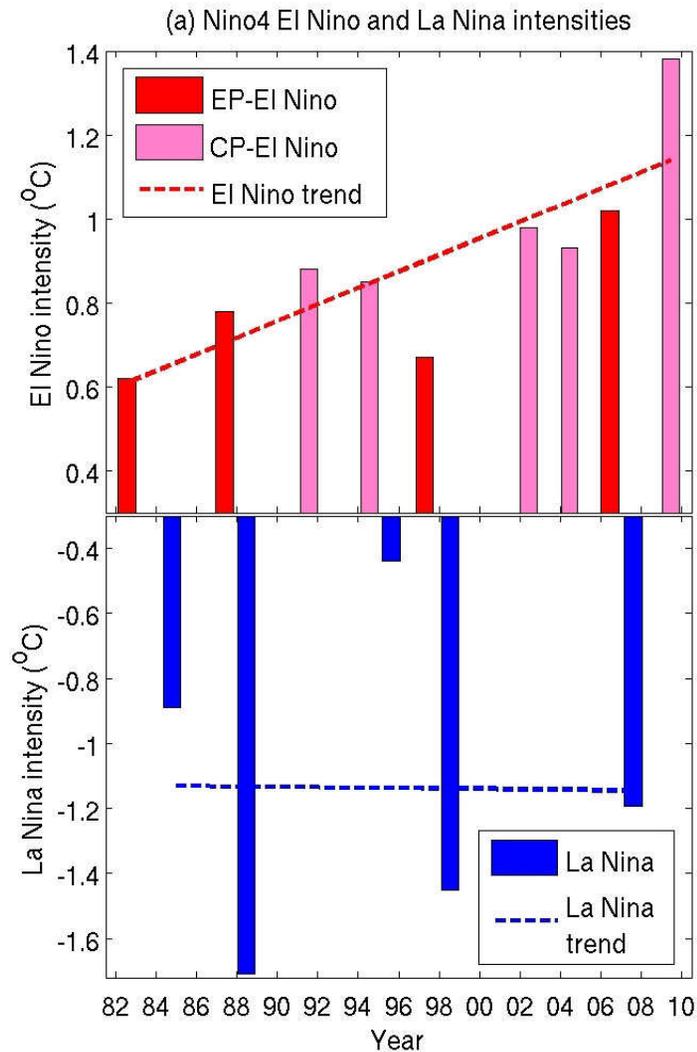
Nino4 (Nino3) index to describe CP-El Nino (EP-El Nino)



Reynolds et al. (2007) 1/4-deg. OISST



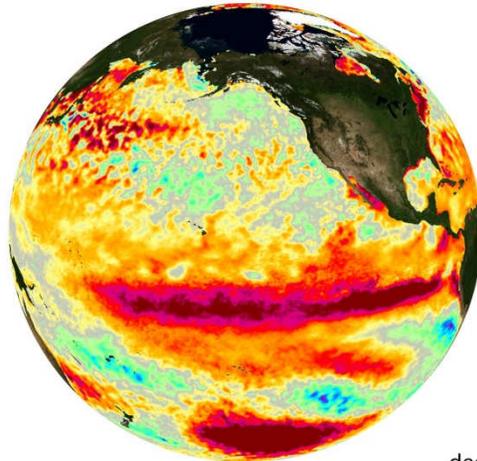
El Nino & La Nina amplitudes in the CP (Nino4) & EP (Nino3) regions



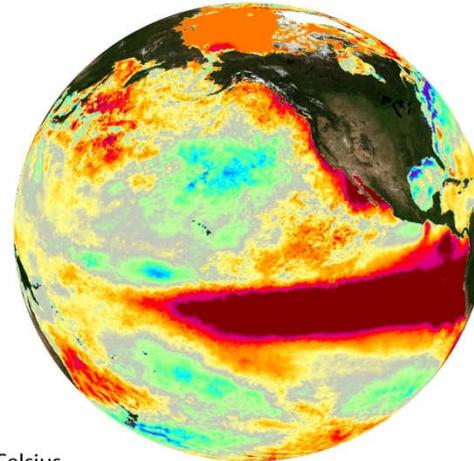
- More frequent occurrence of CP-EI Nino
- Increasing amplitude of El Nino in the CP region (Lee & McPhaden 2010)

The Largest CP- and EP-El Nino events

December 2009
Blended AMSR-E and MODIS SSTA

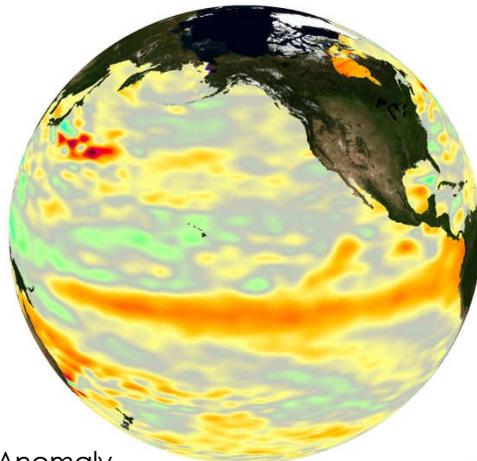


December 1997
Pathfinder AVHRR SSTA

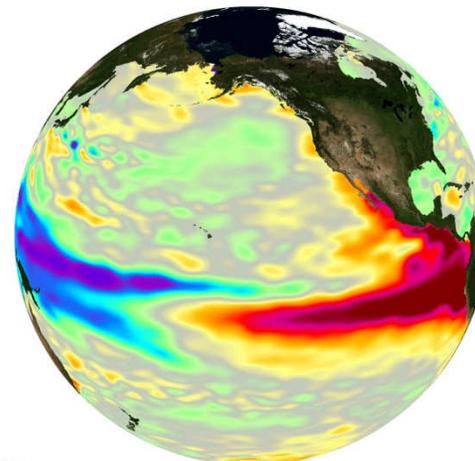


degrees Celsius
-2.5 0.0 2.5

December 2009
Jason-1 SSHA



December 1997
Jason-1 SSHA



millimeters
-300.0 0.0 300.0

SSTA : Sea Surface Temperature Anomaly
SSHA : Sea Surface Height Anomaly

A case study

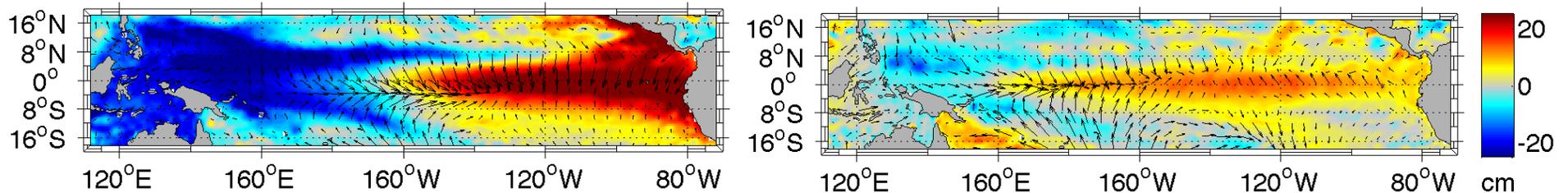
contrasting the biological responses and related physical processes associated with the 1997-98 and 2009-10 El Nino, the largest EP- and CP-El Nino observed by satellites

Physical state associated with the two El Niño events

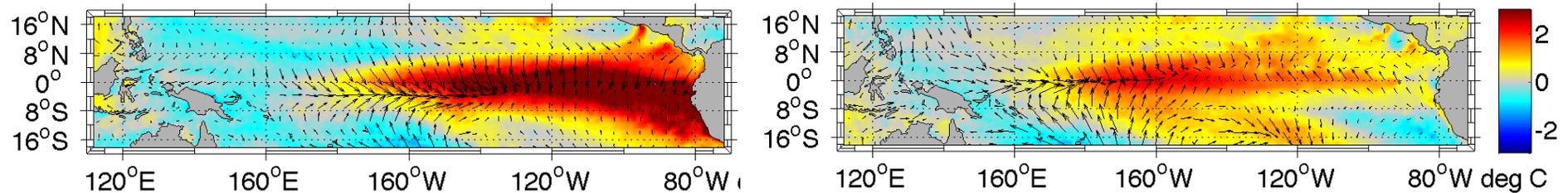
1997-98 Eastern Pacific El Niño

2009-10 Central Pacific El Niño

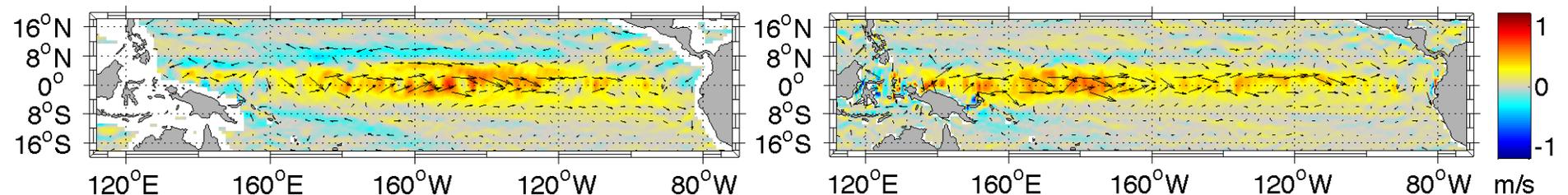
Sea Surface Height



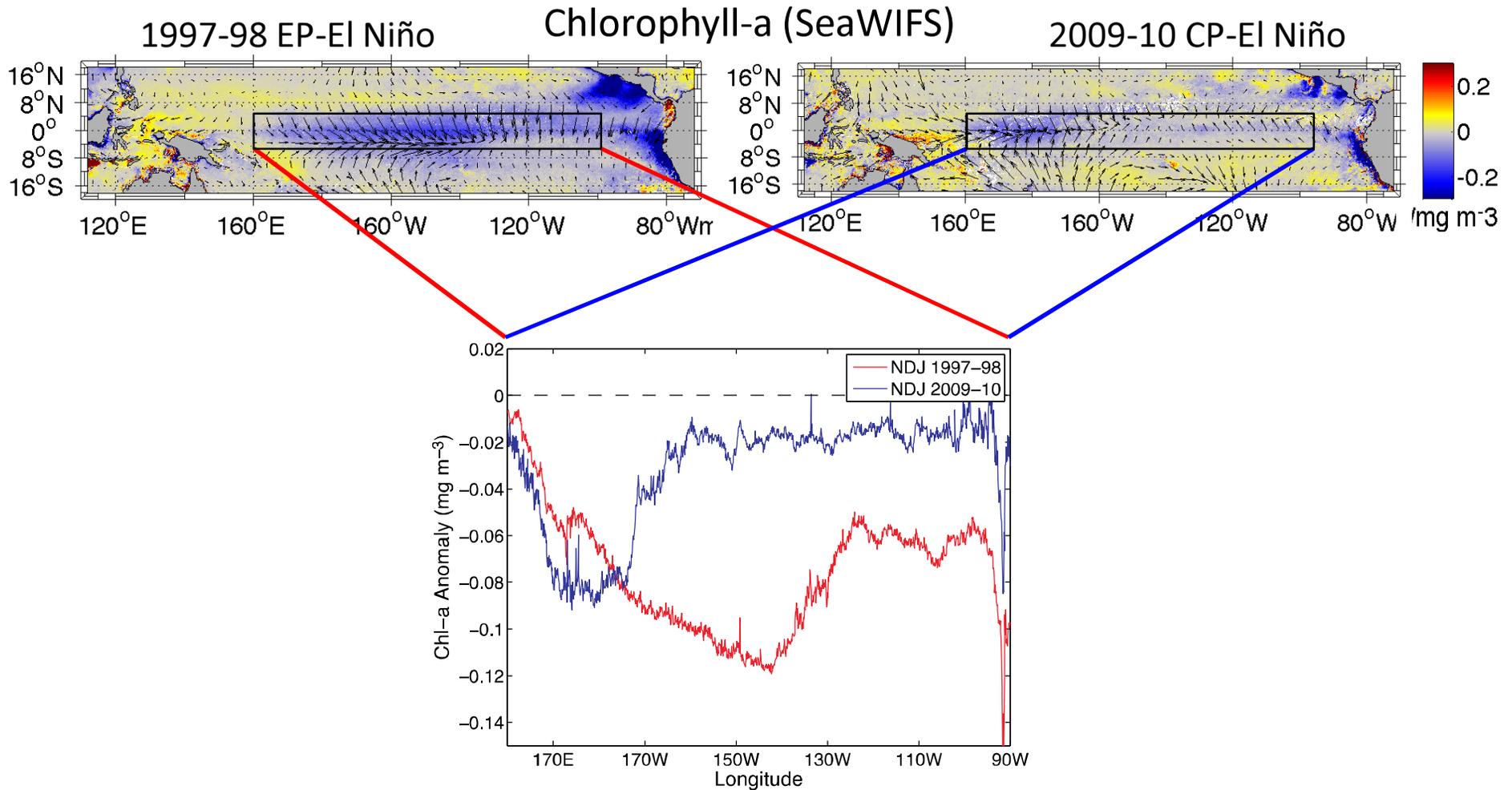
Sea Surface Temperature



Zonal (Eastward) Surface Currents



Different biological responses to the two El Niño



Chl-a reduction is large in the EP region during the 1997 EP-El Niño, but is more confined and large in the CP region during the 2009 CP-El Niño (Gierach et al. 2012).

Using ECCO to investigate physical processes that cause difference in biological responses

- Tropical Pacific is nutrient limited.
- The physical state controls nutrient supply effectively.
- Use passive tracer adjoint based on ECCO state estimation to investigate related physical process (see Fukumori et al. 2004 and Wang et al. 2004 for method & applications).

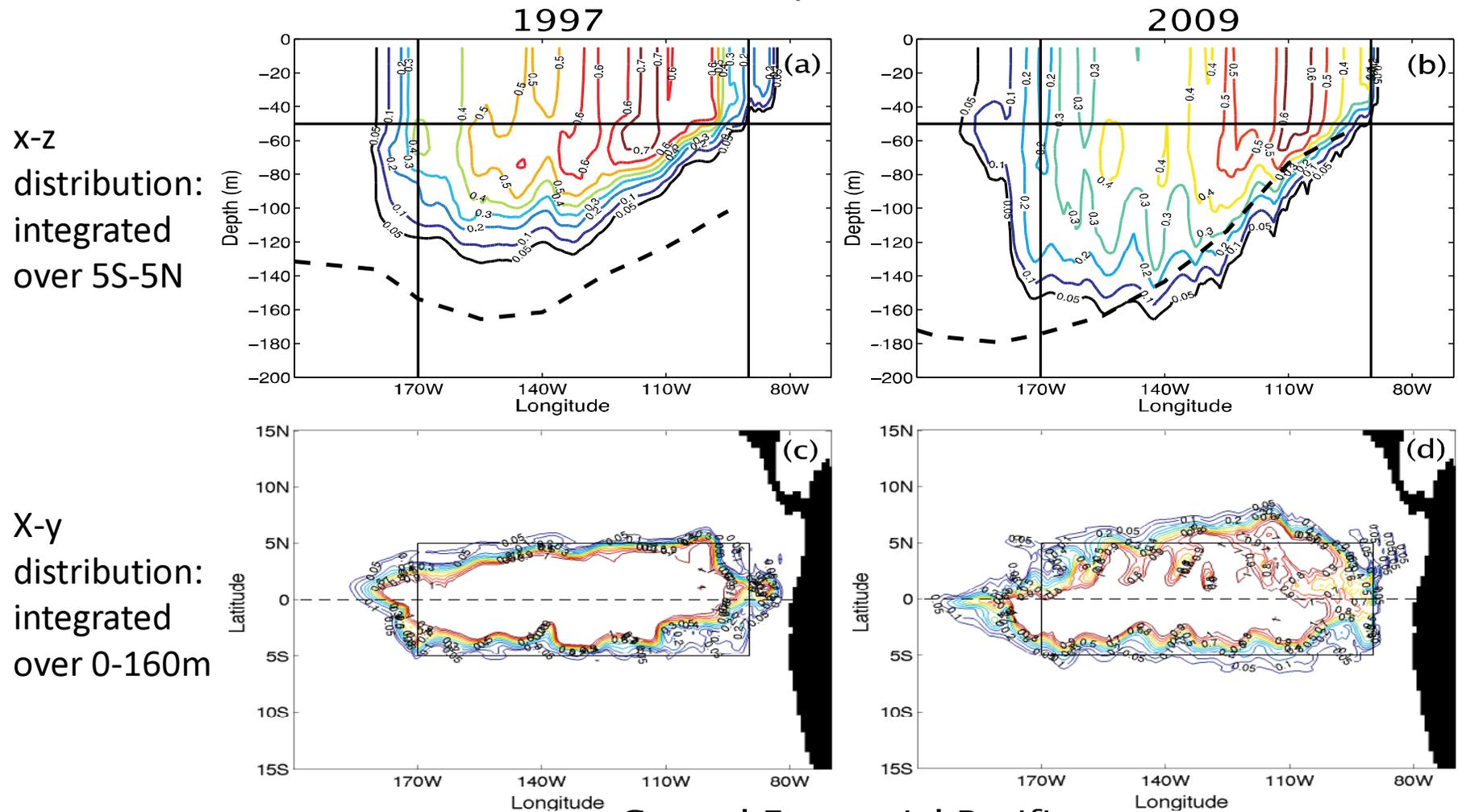
How to apply the ECCO adjoint tracer tool?

- Initialize a uniform tracer in Dec. 1997 & 2009 in the top 50m of the EP region (where the largest chl-a reduction occurred during the 1997 EP-El Nino).
- Integrate the tracer backward in time using the adjoint to trace where water mass (nutrient supply) came from.
- Repeat the procedure by initializing uniform tracer in Dec. 1997 & 2009 in the top 50m of the CP region (where the largest chl-a reduction occurred during the 2009 El Nino).
- Examine the difference in water mass movement and thus nutrient supply (bear in mind: subsurface has higher nutrient; w. Pac. is nutrient poor).

EP region: adjoint tracer distribution in October

(3 months after the backward tracing)

Eastern Equatorial Pacific



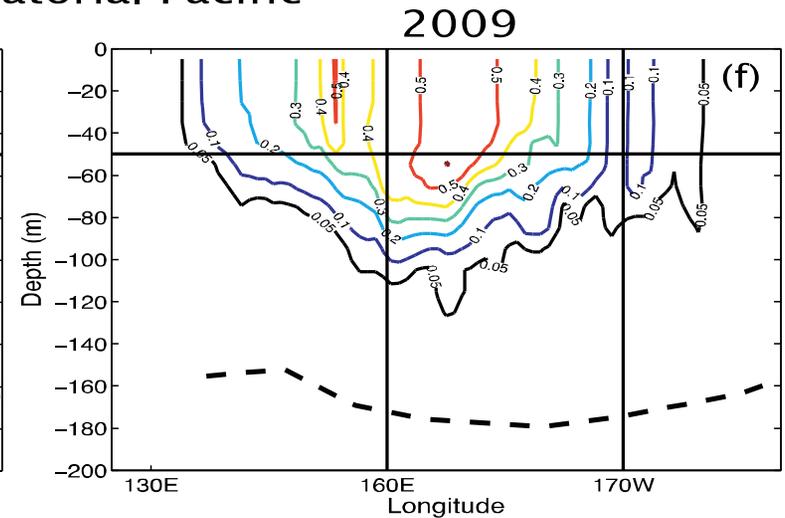
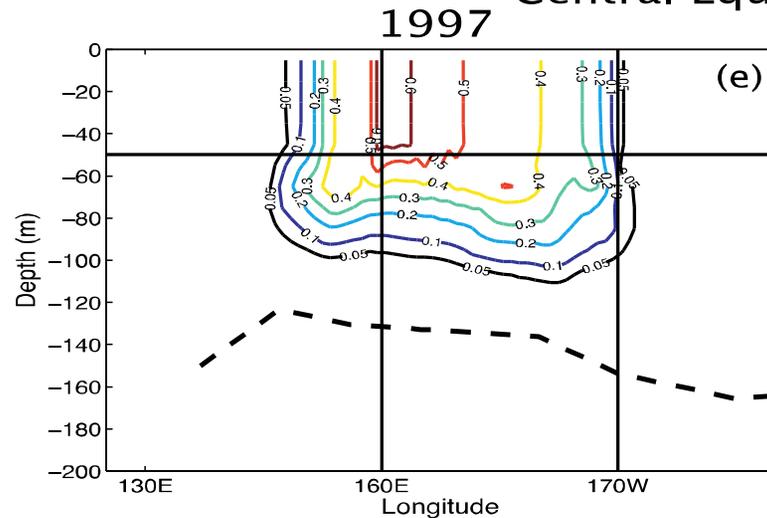
Main difference: the 1997 event has less nutrient-rich subsurface waters due to a larger reduction of wind-driven upwelling & vertical mixing (vertical processes)

CP region: adjoint tracer distribution in October

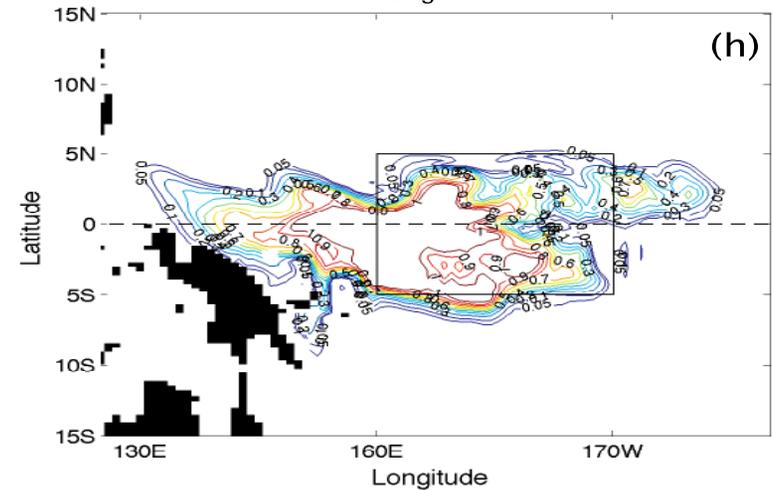
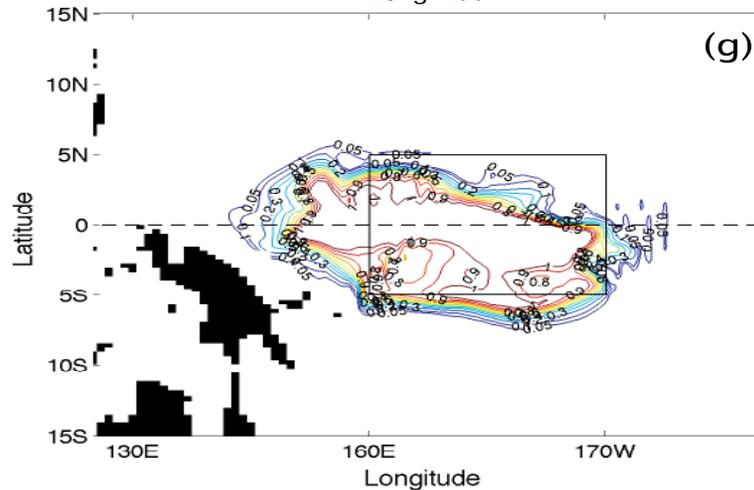
(3 months after the backward tracing)

Central Equatorial Pacific

X-Z
distribution:
integrated
over 5S-5N



X-y
distribution:
integrated
over 0-160m



Main difference: more nutrient-depleted water from the western Pacific advected to the CP region during 2009 by anomalous surface current (horizontal process)

Summary

- **Chl-a reduction is large in the EP region during the 1997 EP-El Nino because of the large decrease in wind-driven upwelling & vertical mixing that inhibited the subsurface nutrient supply.**
- **Chl-a reduction is large in and more confined to the CP region during the 2009 CP-El Nino because of stronger eastward anomaly of surface current brought more nutrient depleted waters.**
- **Realistic vertical and horizontal processes of the physical state, in particular, property conservation, is important to the interpretation of biological response.**