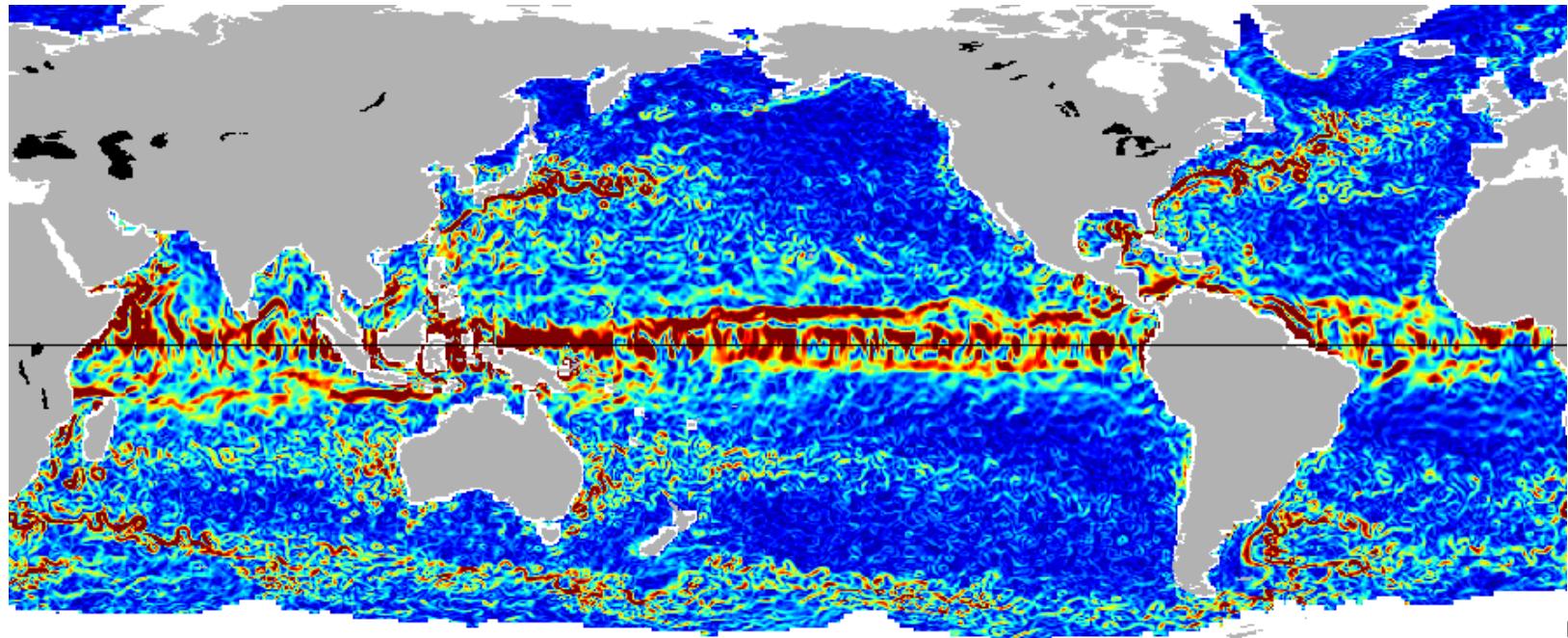


# Surface Currents as an Early ENSO Index

Kathleen Dohan  
Gary Lagerloef

Earth and Space Research  
Seattle, WA

- OSCAR surface currents description
- Validation against drifters
- Equatorial Pacific
- Surface currents as an ENSO index
  - Simple, robust, early indicator of shifting dynamics



## OSCAR Surface currents from satellite fields

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- Ocean Surface Currents Analyses-Realtime processing system (OSCAR) is a satellite-derived surface current database provided in near-real time based on a combination of quasi-steady geostrophic and locally wind-driven dynamics (Bonjean and Lagerloef, 2002).
  - geostrophic term is computed from the gradient of SSH fields (merged gridded AVISO/CLS MDT)
  - wind-driven velocity components are computed from an Ekman/Stommel formulation with variable eddy viscosity using QuikSCAT vector winds (FSU/COAPS) and NCEP winds
  - thermal wind using Reynolds OI SST data.

Similar: Mercator/SURCOUF (Larnicol et al., 2006, [www.mercator-ocean.fr](http://www.mercator-ocean.fr)) and the Centre de Topographie des Oceans et de l'Hydrosphere (CTOH, (Sudre and Morrow, 2008), [ctoh.legos.obs-mip.fr/](http://ctoh.legos.obs-mip.fr/))

## OSCAR Surface currents from satellite fields

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- OSCAR is an analytical solution to quasi-steady linear flow with turbulent mixing parameterized by a constant vertical eddy viscosity. The simplified equations of motion are averaged over the top  $h=30$  m. Frontal model: buoyancy term is a function of horizontal gradients of SST only.

$$if \bar{\mathbf{U}} = -g \nabla \zeta + \frac{h}{2} \nabla \theta + \frac{\tau_0 - \tau(-h)}{h}$$
$$\tau = \nu \frac{\partial \mathbf{U}}{\partial z}$$

where:  $\mathbf{U} = u + iv$ ,  $\tau_0$  is surface wind stress,  $h = 30m$ ,  $\zeta$  is SSH,  $\theta$  is buoyancy, based on SST ( $\theta = g\chi_T SST$ ), and  $\nu$  is a vertical eddy viscosity, calculated as a function of wind

$$\nu = a \left( \frac{|\mathbf{W}|}{W_0} \right)^b.$$

Stommel model boundary conditions:

$$\frac{\partial \mathbf{U}}{\partial z}(z = 0) = \tau_0 / \nu$$
$$\frac{\partial \mathbf{U}}{\partial z}(z = -H) = 0.$$

- Optimal choice for  $a$  in OSCAR blends from  $8 \times 10^{-5} \text{ m}^2 \text{s}^{-1}$ ,  $b = 2.2$  at the equator as in Santiago-Mandujano & Firing (JPO 1990), to  $2.85 \times 10^{-4} \text{ m}^2 \text{s}^{-1}$ ,  $b = 2$  for the global value.

# OSCAR Surface currents from satellite fields

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- Near-real-time, approximately 1 day time lag
- 5-day timebase, updated every day
- Best data used and currents recalculated
  - DT over RT
  - ERA/I or ASCAT will replace NCEP
  - SST: higher resolution, fronts, GHRSSST
- Smoothed in time and space
  - 10-day timescale smoothing
  - 1/3 degree grid spacing
- Areas of development:
  - Time-dependent wind-driven dynamics
  - Turbulent mixing scheme
  - Vertical variation
  - Coastal processes
  - Lagrangian dynamics

# OSCAR Surface currents from satellite fields

- Data is freely available at  
<http://podaac.jpl.nasa.gov> and <http://www.oscar.noaa.gov>.

**Jet Propulsion Laboratory**  
California Institute of Technology

**PO.DAAC**  
PHYSICAL OCEANOGRAPHY  
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2011-06-27 | Edinburgh, Scotland  
IOWW Science Team Meeting  
2011-05-09 | Annapolis, Maryland  
EUMETSAT/ESA Scatterometer Science Conference  
2011-04-11 | Darmstadt, Germany  
[+ MORE](#)

**ANNOUNCEMENTS**  
PO.DAAC Reminder:  
Transition to new interfaces  
Tuesday, April 26, 2011  
Recent Update to New  
Coastal High Resolution  
QUACCAST Dataset  
Thursday, April 14, 2011  
Transition to new web portal,  
[http://podaac.jpl.nasa.gov](#)  
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**FUN FACT**  
The highest tides in the world  
are at the bay of Fundy, which  
separates New Brunswick from  
Nova Scotia.

**DATASET HIGHLIGHT**  
Jason-1 Enhanced Jason Microwave Radiometer Product  
February 27, 2011  
The Jason Microwave Radiometer (JMR) Enhanced Product provides an improved  
rain and sea ice flag valid for the radiometer data products and applies a recently  
developed coastal processing algorithm to provide wet tropospheric Path Delays (PO) near  
land, where the data were previously flagged as bad in the Geophysical Data Records  
(GDR). The use of satellite altimetry for coastal studies has steadily increased over the  
past several years, but some of the science processing algorithms used to produce the  
data products on the GDR are either tuned for the open ocean or only valid in the [MORE](#)

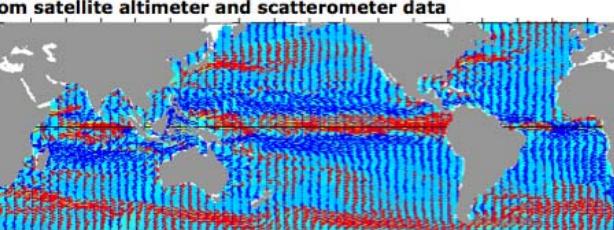
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National Oceanic and Atmospheric Administration

**OSCAR** Ocean Surface Current Analyses - Real time

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**Near-realtime ocean surface currents derived from satellite altimeter and scatterometer data**



5-Day Interval Surface Current, April 27, 2011   Latest realtime data

**• Global Dataset for Display and download**  
**• Peer-reviewed scientific publications using OSCAR data**  
**• OSCAR data available through OPeNDAP/DODS**

Pilot project for a NOAA/NESDIS  
Operational Surface Current Processing and Data Center  
[National Ocean Partnership Program \(NOPP\)](#)

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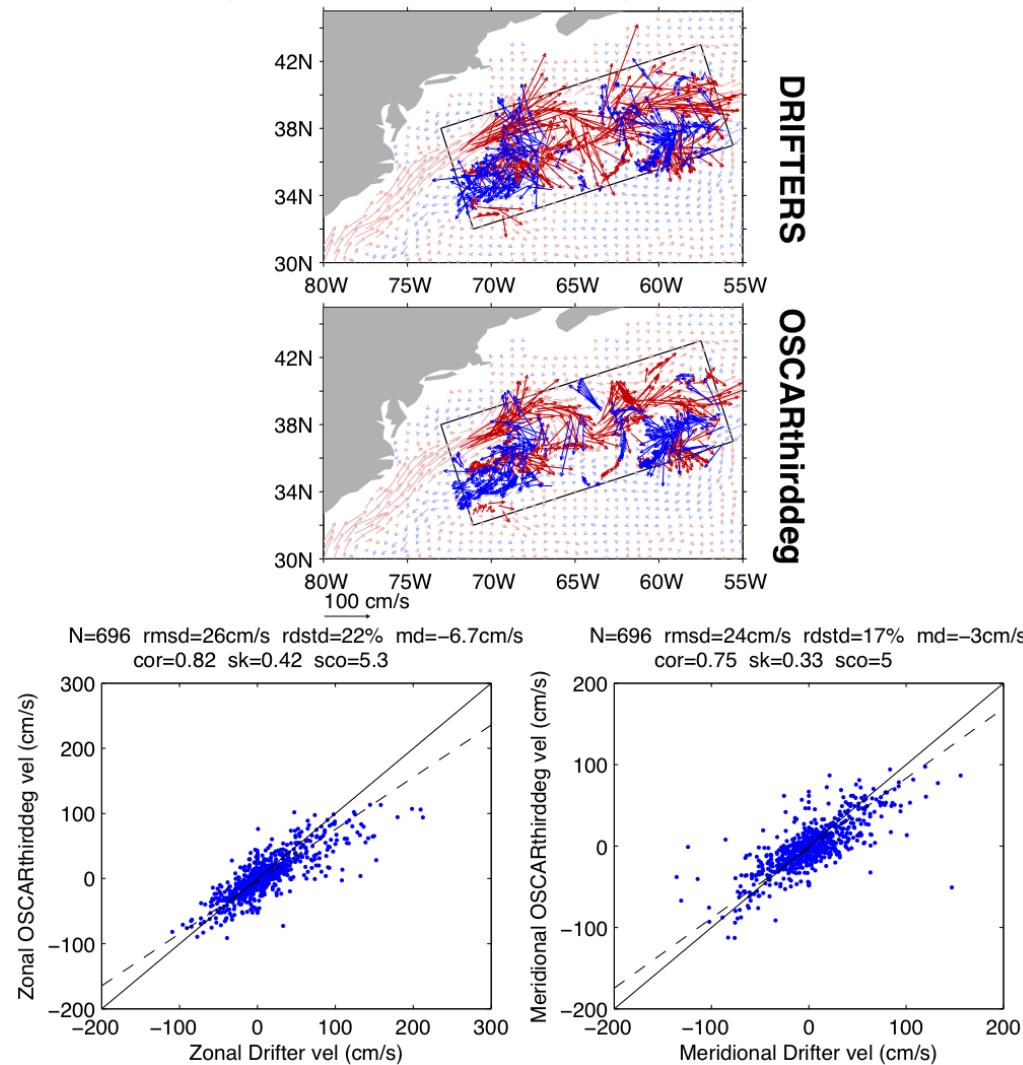
OSCAR Project Office  
Earth and Space Research  
2101 Fourth Ave, Suite 1310  
Seattle, WA 98121, USA

[webmast.oscar@noaa.gov](#)  
[Credits](#) | [Disclaimer](#) | [Privacy Policy](#)

# Validation against drifting buoy velocities

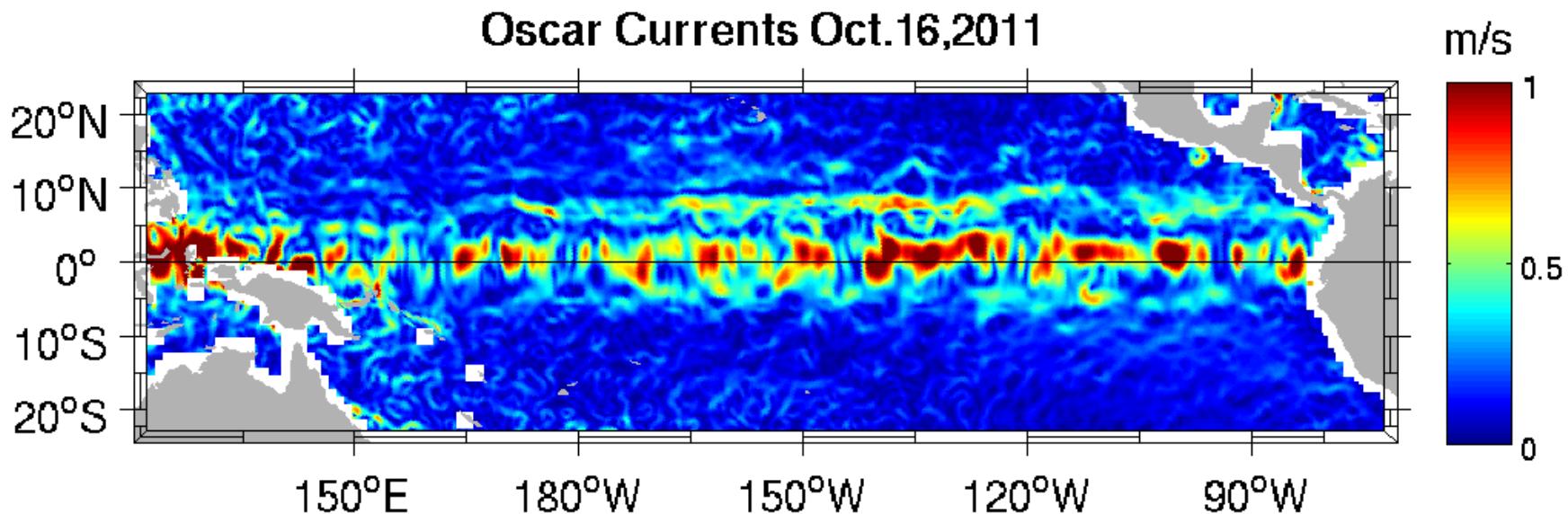
- OSCAR surface velocities are interpolated onto drifter locations (which have been averaged over 1 day). Zonal and meridional currents vs drifter velocities are plotted on the scatter plot.
- Drifter data distributed by NOAA/AOML  
[www.aoml.noaa.gov/phod/dac/gdp.html](http://www.aoml.noaa.gov/phod/dac/gdp.html)
- Good performance in dominantly geostrophic areas, such as the Gulf Stream.

OSCARthirddeg & DRIFTER DATA: Jun.01,2006–Sep.01,2006  
Background field: OSCARthirddeg monthly mean



## Focus of this talk: Surface Currents as an ENSO index

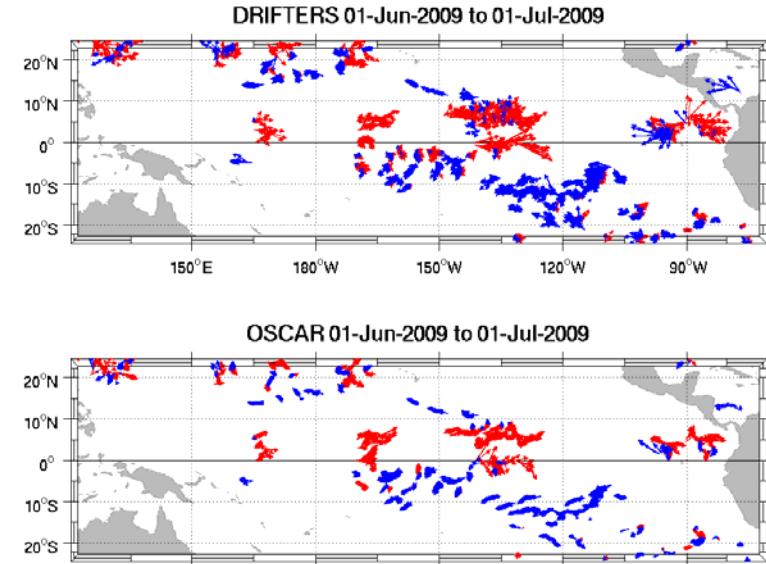
- Follows Lagerloef et al. 2003<sup>1</sup>: surface current index for ENSO.
- Based on the first EOF of OSCAR currents in the Equatorial Pacific



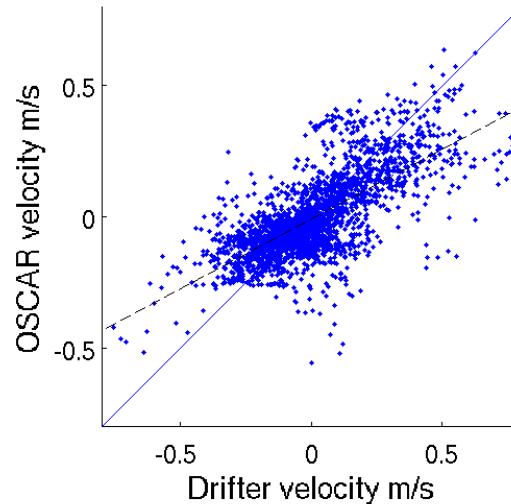
<sup>1</sup>Lagerloef, Gary, Roger Lukas, Fabrice Bonjean, John T. Gunn, Gary T. Mitchum, Mark Bourassa, Antonio J. Busalacchi, 2003. El Niño Tropical Pacific Ocean surface current and temperature evolution in 2002 and outlook for early 2003. *Geophysical Research Letters*, **30(10)**, 1514, doi:10.1029/2003GL017096.

# Validation against drifting buoy velocities

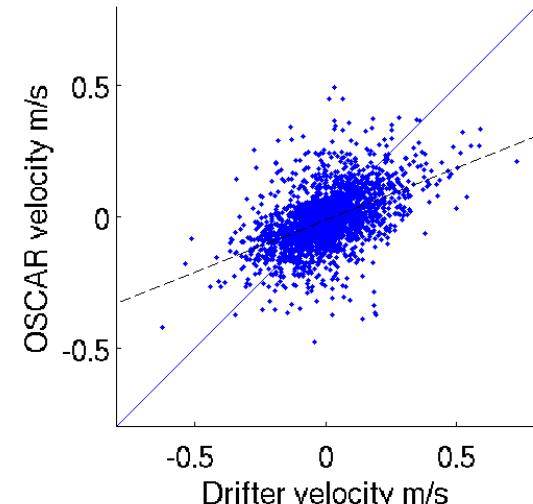
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[www.aoml.noaa.gov/phod/dadp.html](http://www.aoml.noaa.gov/phod/dadp.html)



Comparison of Zonal velocity  
N=2611 Cor=0.7 Slope= 0.5

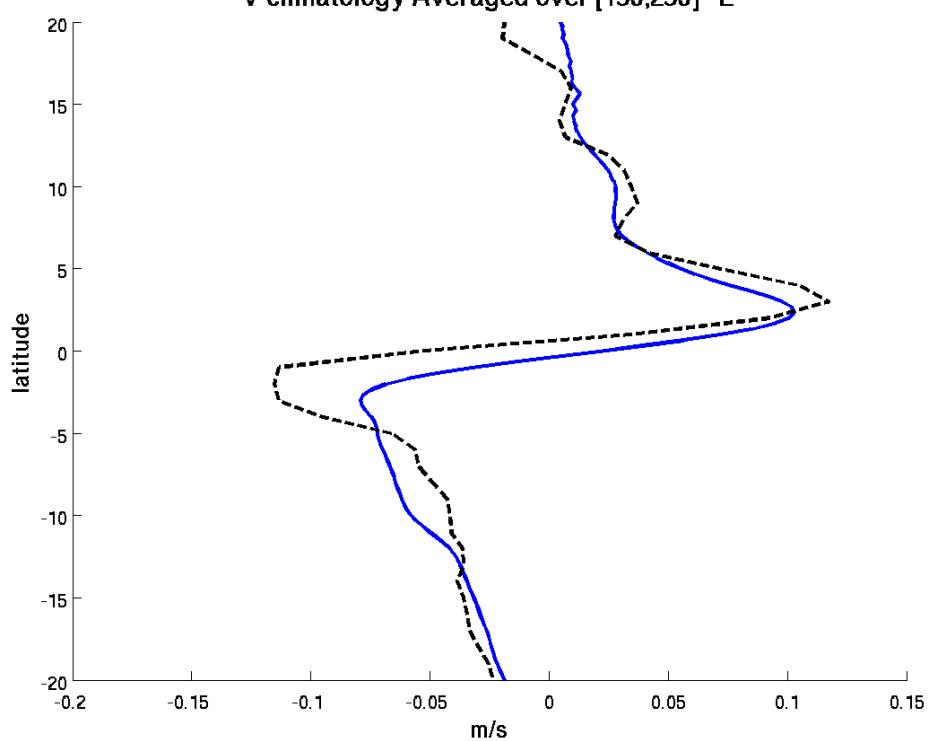
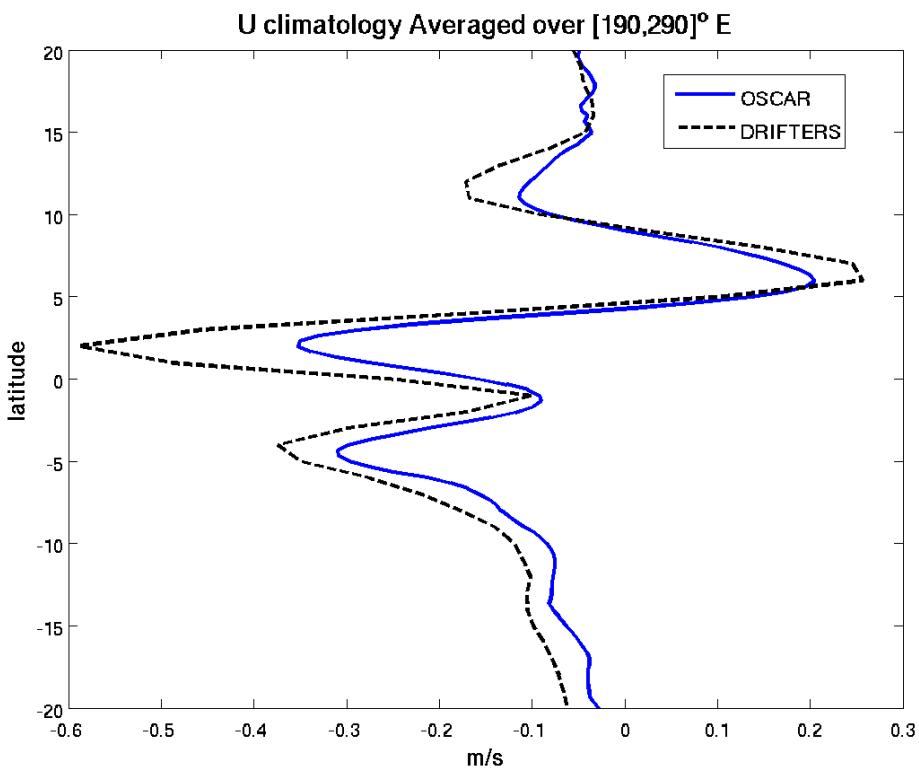
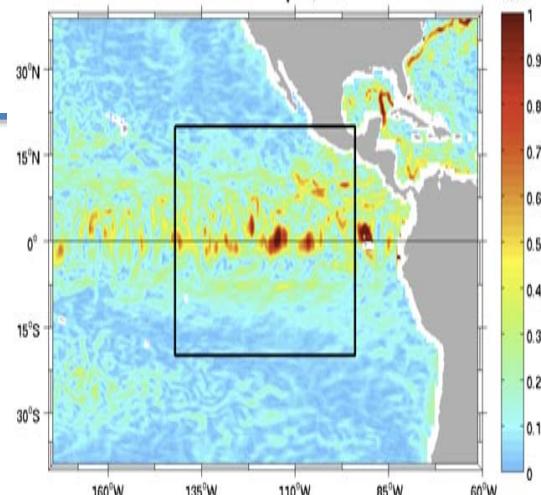


Comparison of Meridional velocity  
N=2611 Cor=0.5 Slope= 0.4



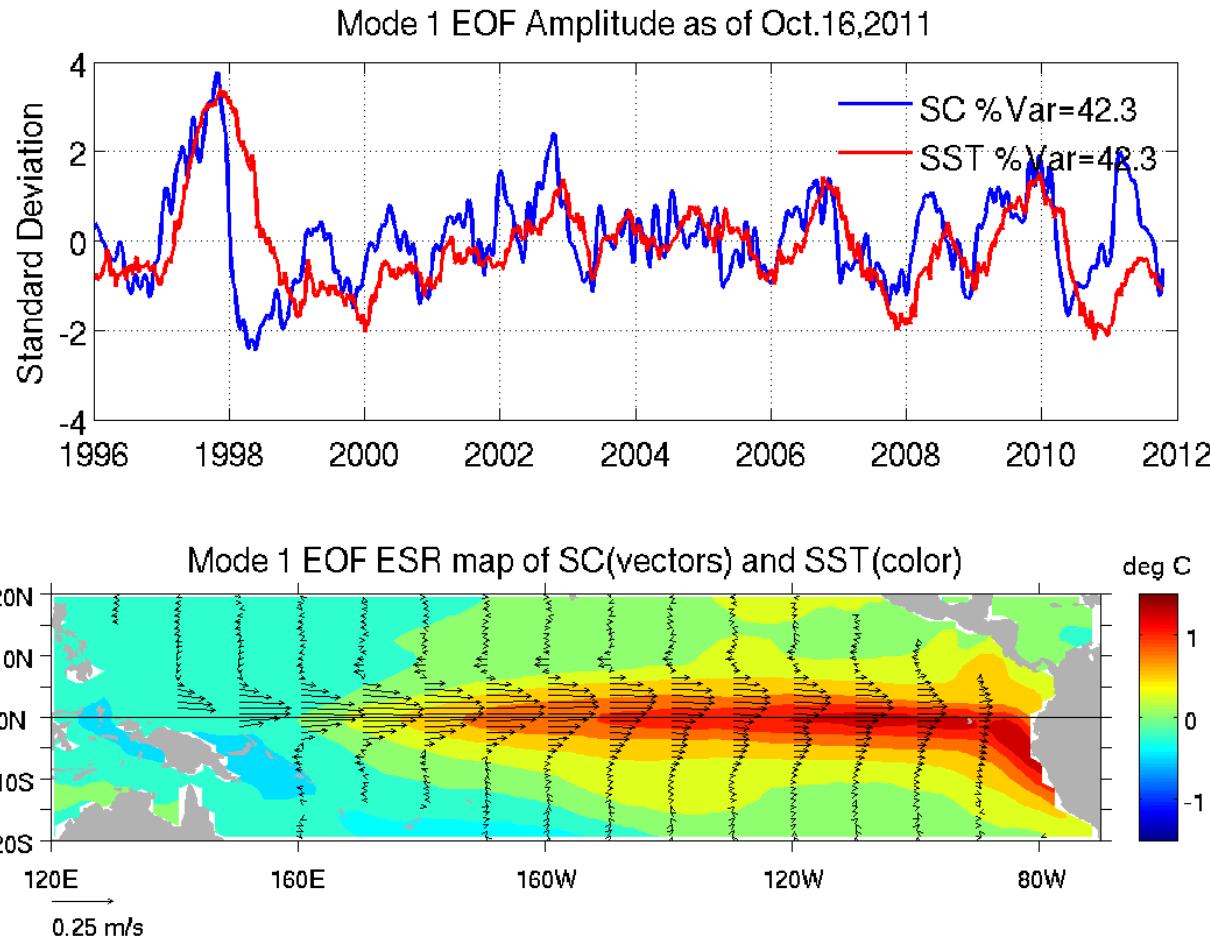
# Validation: Equatorial Pacific Climatology

- Drifter climatology dashed line, OSCAR averaged over 1993:2007 blue line.



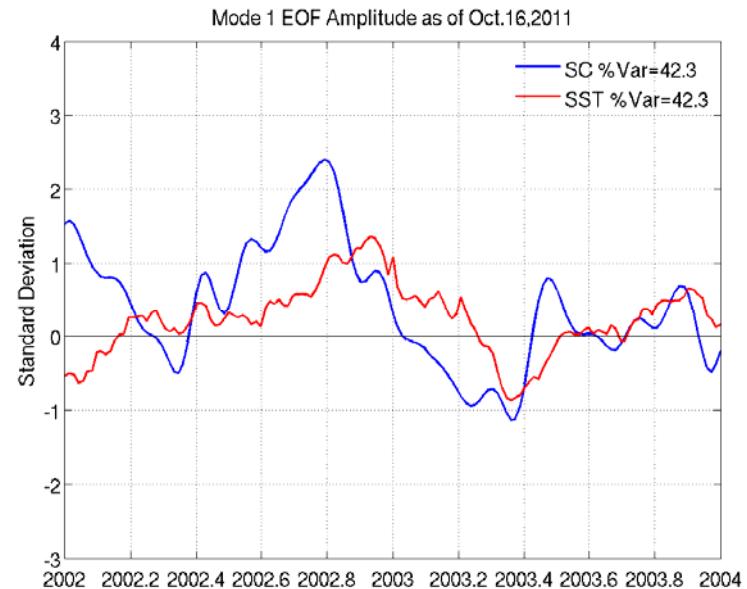
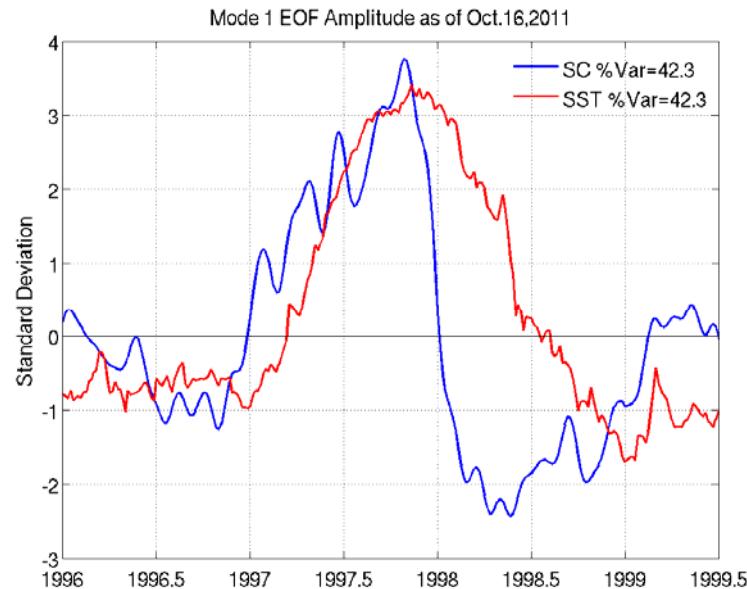
## Application: ENSO index

- [www.esr.org/enso\\_index.html](http://www.esr.org/enso_index.html)

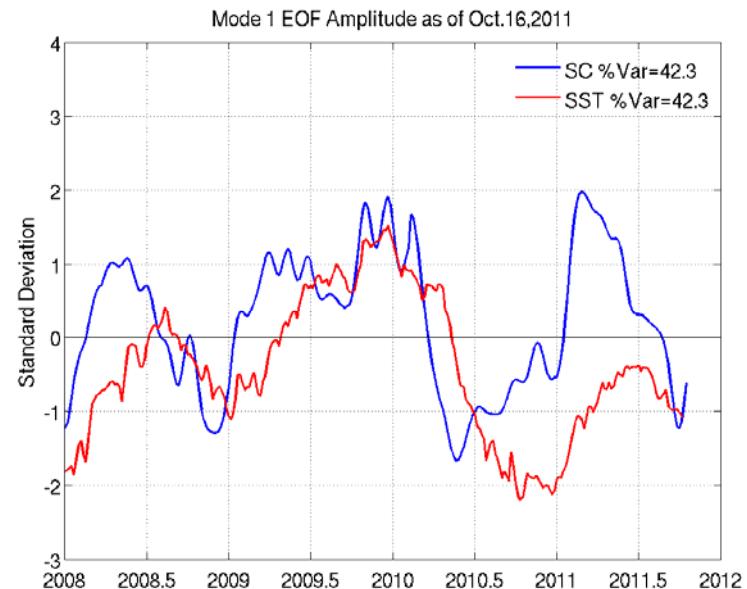


- Principal empirical orthogonal functions (EOF) of surface current ("SC") and of SST anomaly variations in the Tropical Pacific (anomalies from 1993:2002 climatology) from OSCAR. Top: amplitude time series of the EOFs normalized by their respective standard deviations. Bottom: spatial structures of the EOFs.

# “ESR” index 2011



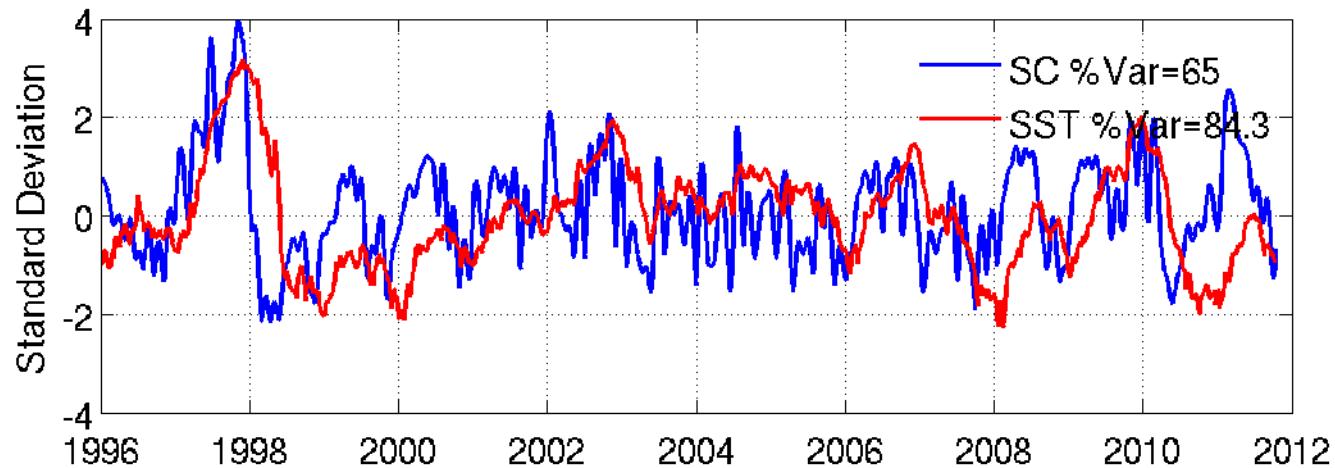
- Surface current (SC) index precedes SST (red)
- Zero crossing denotes SST maximum



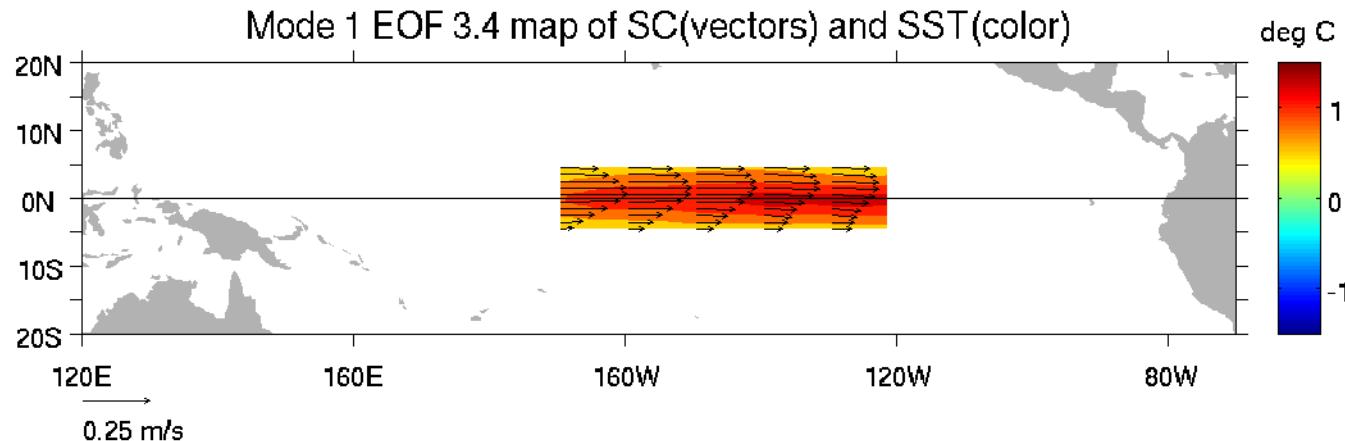
## Application: ENSO index

- El Nino Region 3.4

Mode 1 EOF Amplitude as of Oct.16,2011



Mode 1 EOF 3.4 map of SC(vectors) and SST(color)

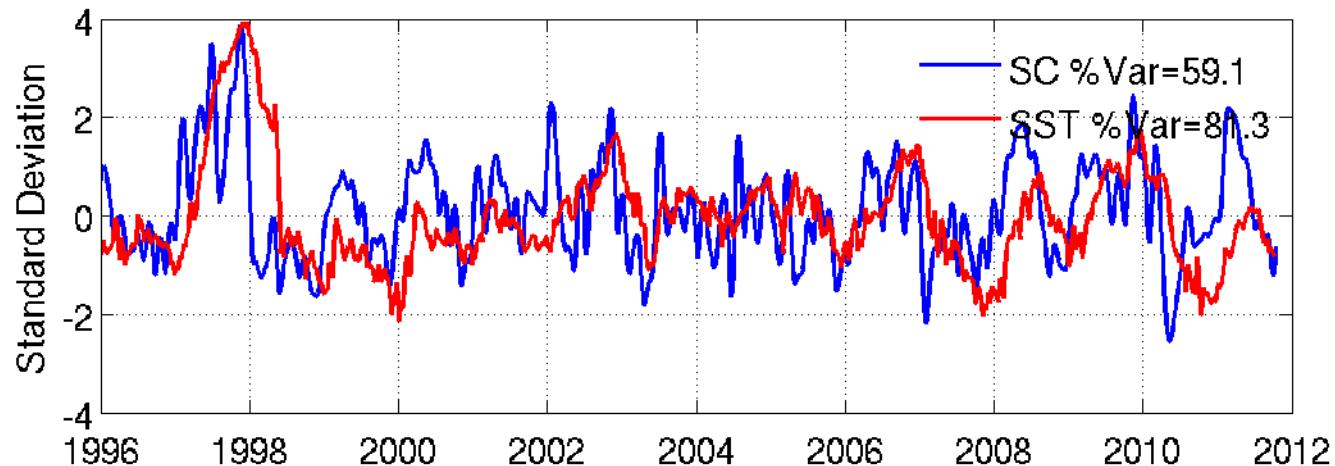


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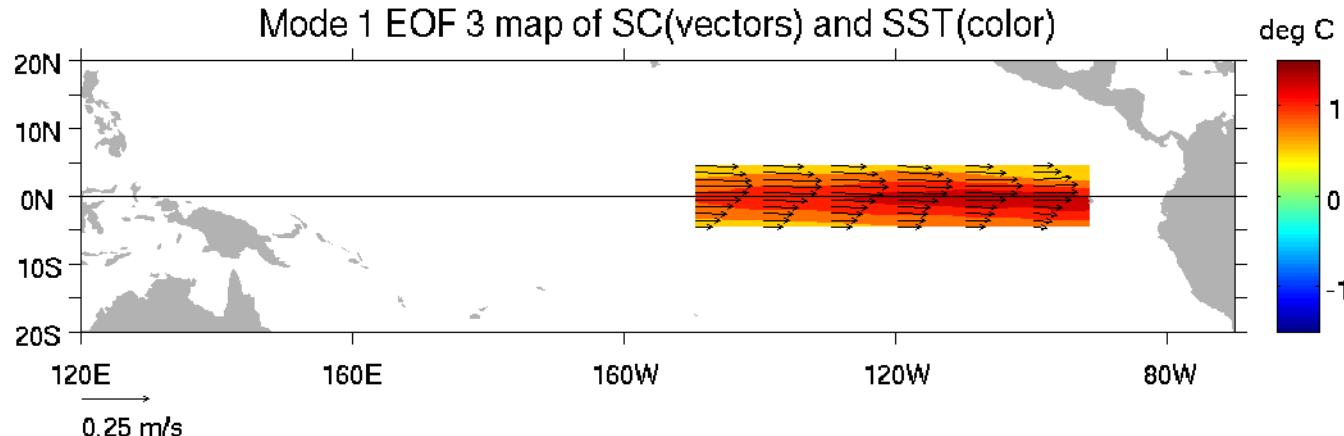
## Application: ENSO index

- El Nino Region 3

Mode 1 EOF Amplitude as of Oct.16,2011



Mode 1 EOF 3 map of SC(vectors) and SST(color)

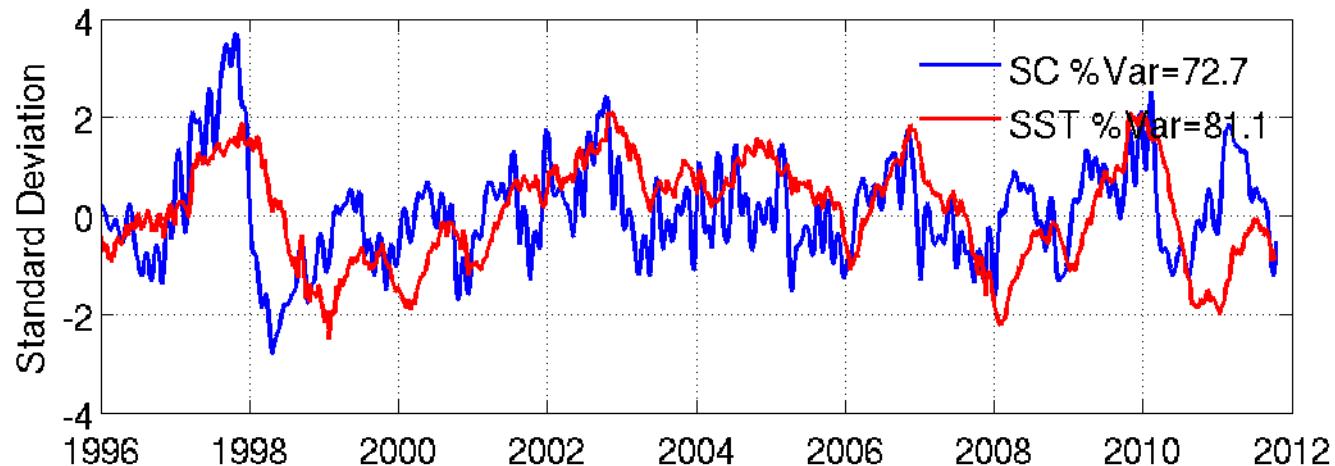


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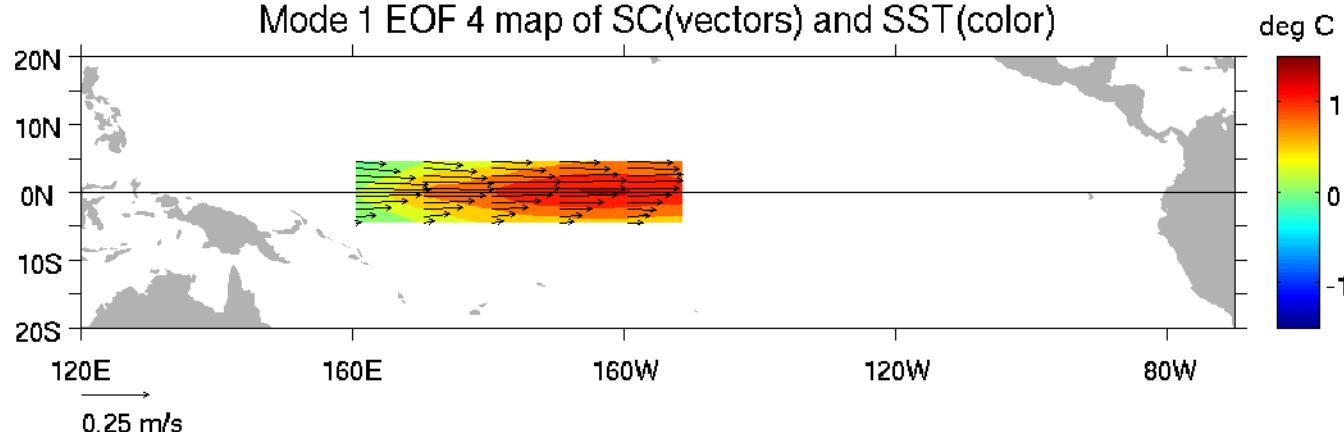
## Application: ENSO index

- El Nino Region 4

Mode 1 EOF Amplitude as of Oct.16,2011



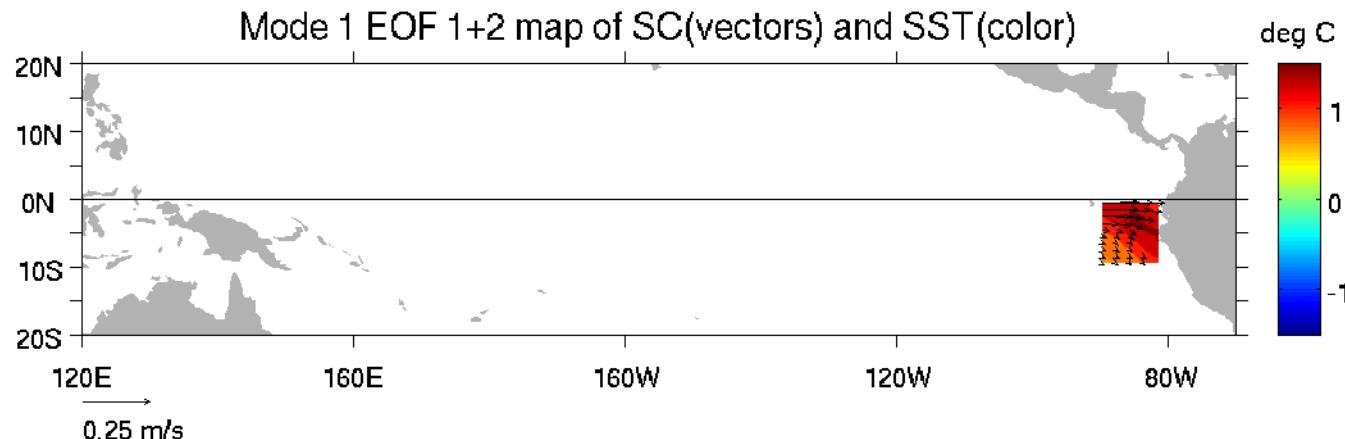
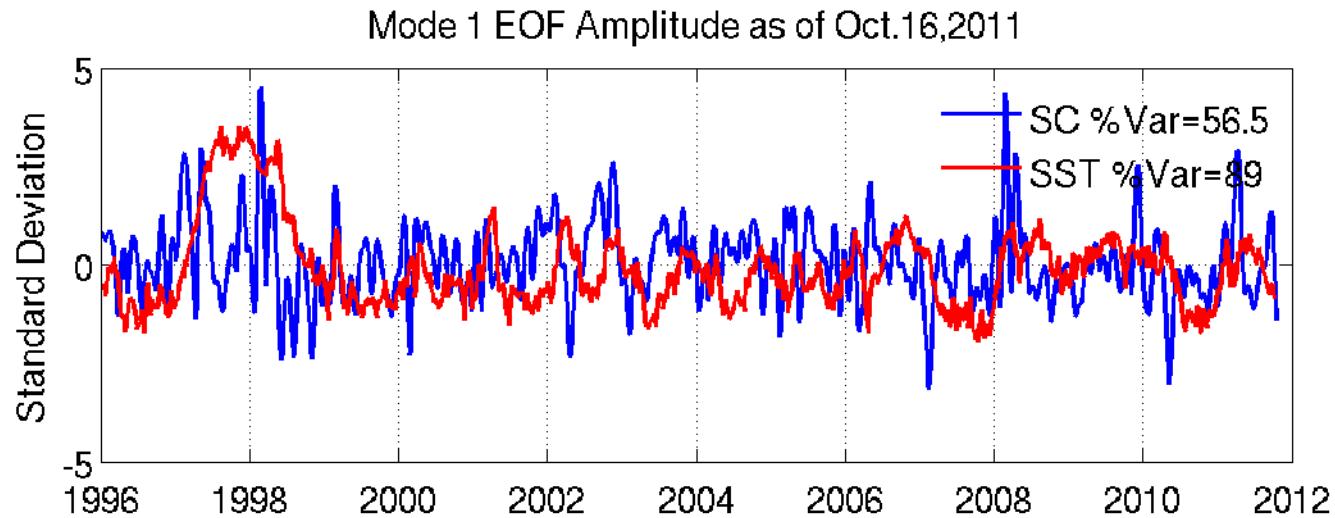
Mode 1 EOF 4 map of SC(vectors) and SST(color)



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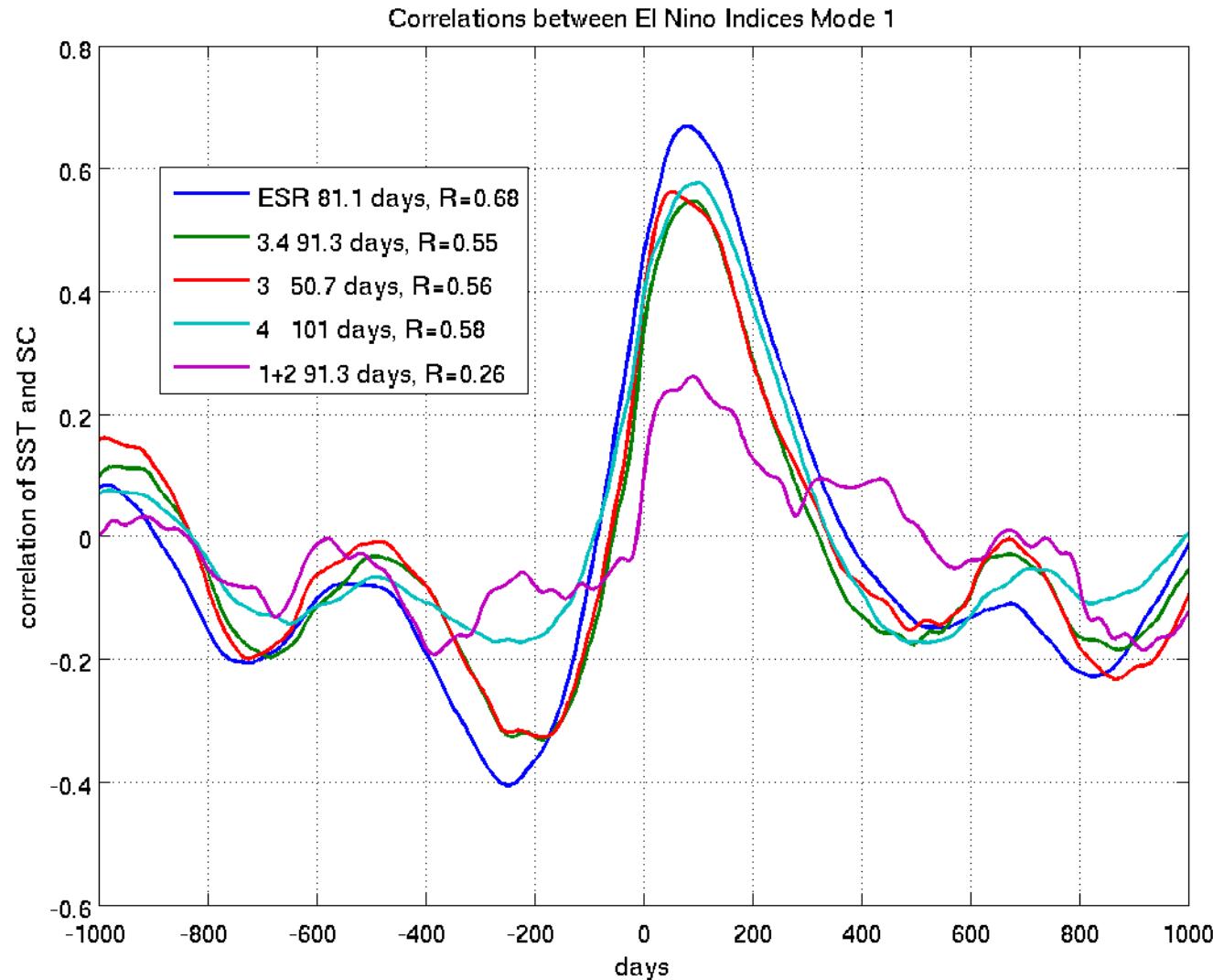
## Application: ENSO index

- El Nino Region 1+2



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# Correlations and lags between El Nino indices and SST indices

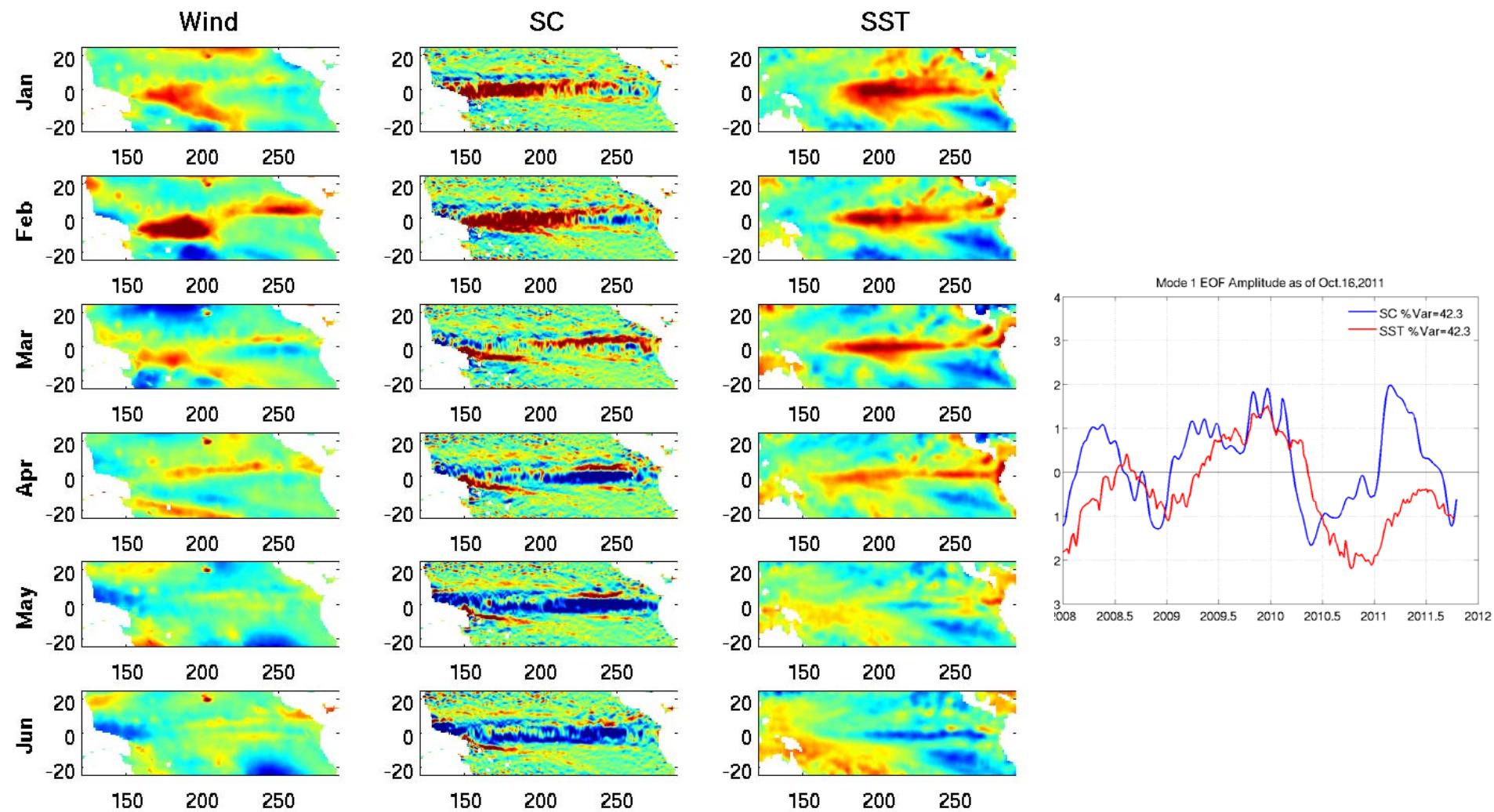


## Summary: Surface Currents as ENSO index

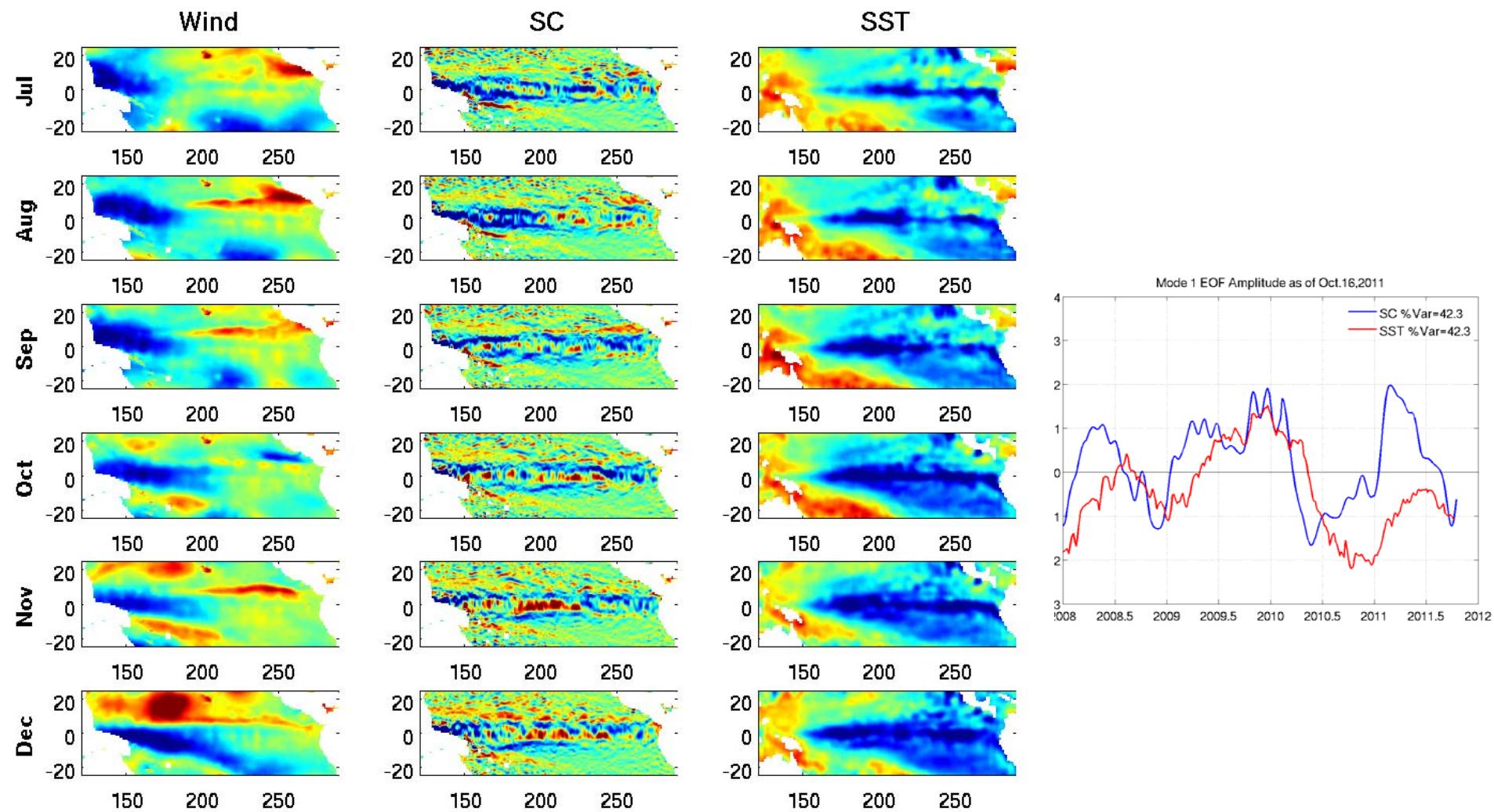
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- Obviously not the whole story
  - Trade Winds relaxation
  - Southward shift of wind anomalies
  - Kelvin waves
  - Surface heat exchange, precipitation, clouds
  - Thermocline shifts
  - Warm pool, heat storage, barrier layers
  - MJO, SO
  - ...
  - As well as the type of response: (CP, EP)
- Surface currents in Equatorial Pacific region are a reliable integrated response
  - Surface current anomalies precede SST anomalies by several months
  - Zero crossing remains a strong indicator of SST maximum
  - Horizontal surface advection plays an important role in ENSO evolution

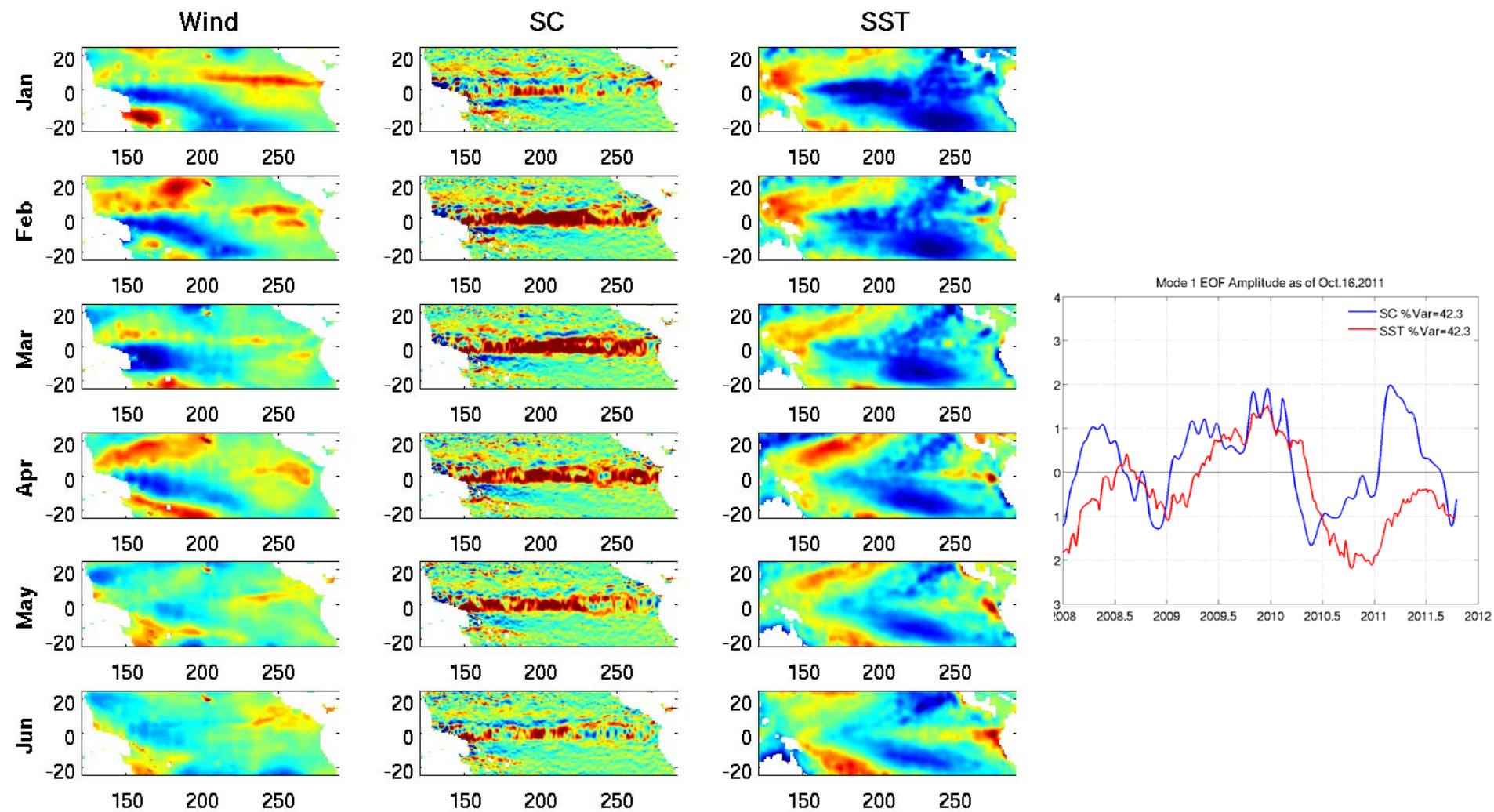
# Monthly Anomalies red=positive ( $\leftarrow \rightarrow$ )



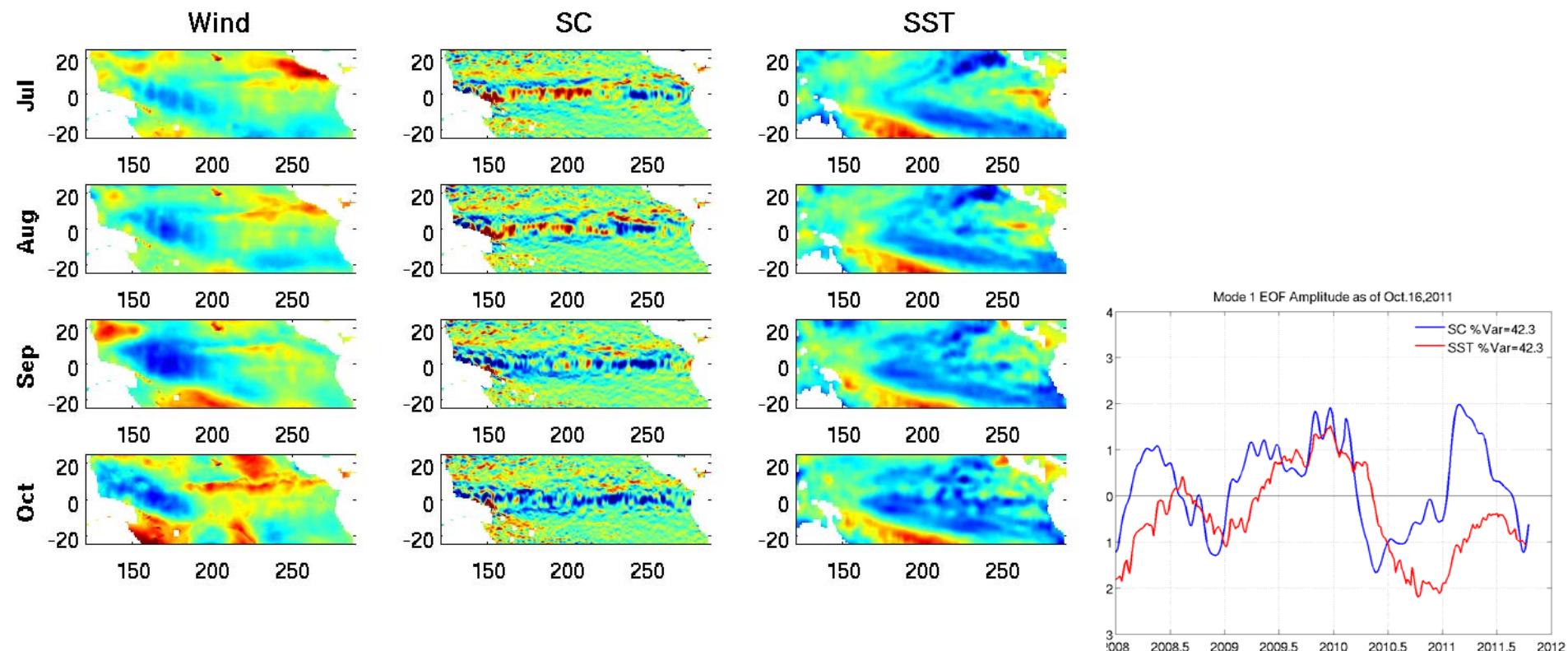
# Monthly Anomalies red=positive ( $\leftarrow \rightarrow$ )



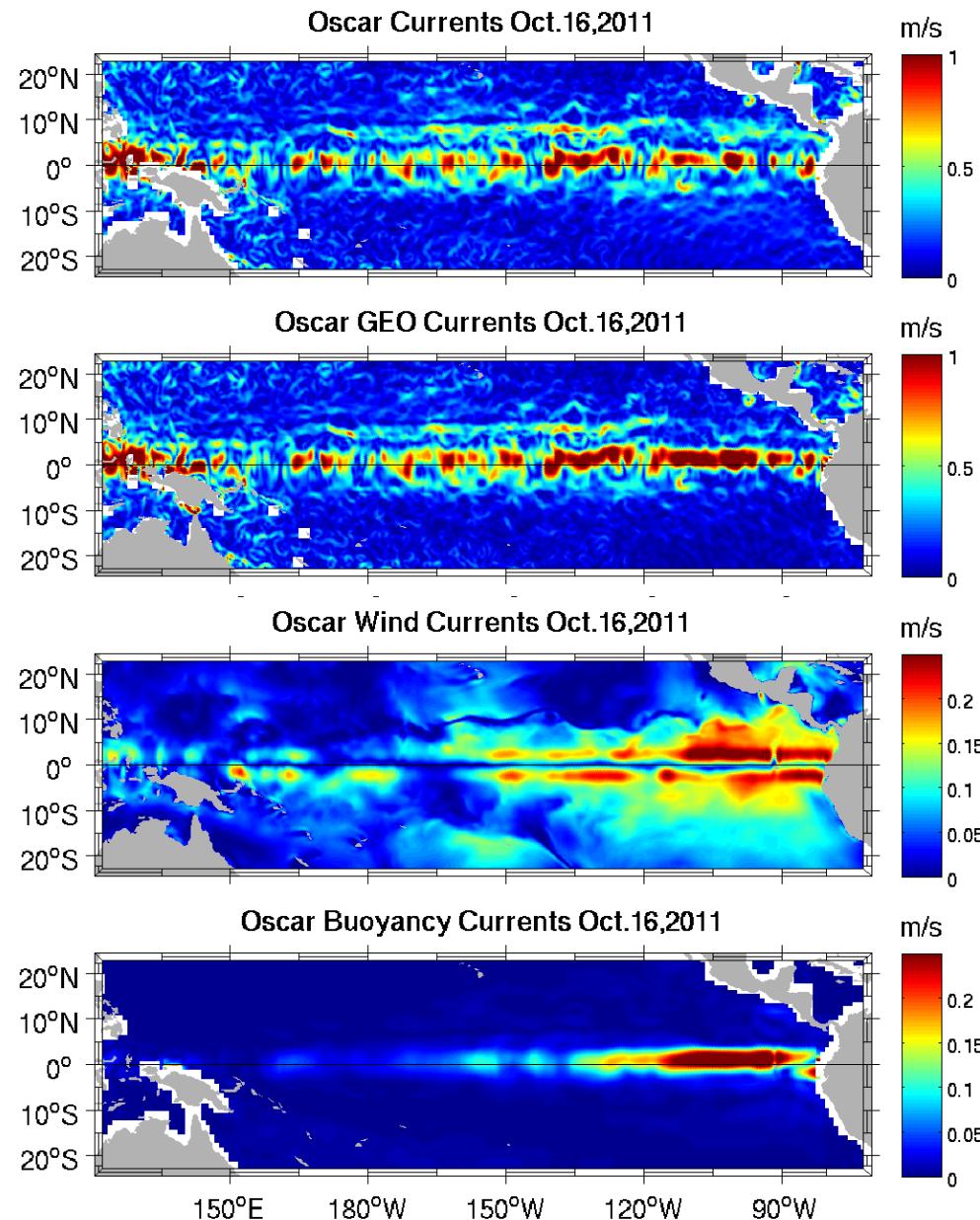
# Monthly Anomalies red=positive ( $\leftarrow \rightarrow$ )



# Monthly Anomalies red=positive ( $\leftarrow \rightarrow$ )



# OSCAR components EQ Pacific



OSTST Oct 20, 2011