Surface Currents as an Early ENSO Index

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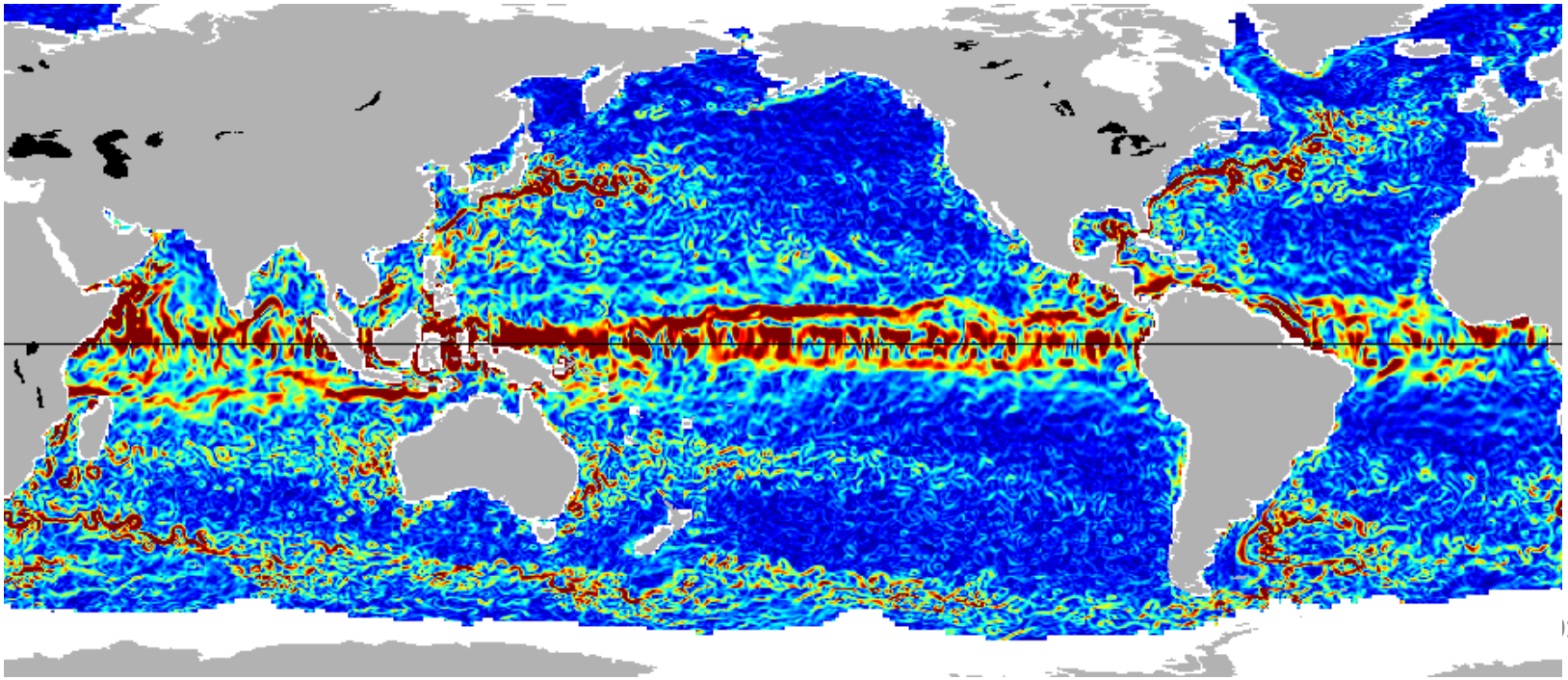
- OSCAR surface currents description
- Validation against drifters
- Equatorial Pacific
- Surface currents as an ENSO index
  - Simple, robust, early indicator of shifting dynamics



OSCAR Surface currents from satellite fields

- 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 MADT)

  - 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) and the Centre de Topographie des Oceans et de l'Hydrosphere (CTOH, (Sudre and Morrow, 2008), ctoh.legos.obs-mip.fr/)

OSCAR Surface currents from satellite fields

- 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.

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

$$\tau = \nu \frac{\partial \mathbf{U}}{\partial z}$$

where: $\mathbf{U} = u + \mathbf{i}v$, τ_0 is surface wind stress, $h = 30m$, ζ is SSH, θ is buoyancy, based on SST ($\theta = g\chi_T SST$), and ν is a vertical eddy viscosity, calculated as a function of wind

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

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 x 10^{-5} m^2s^{-1}, b = 2.2 at the equator as in Santiago-Mandujano & Firing (JPO 1990), to 2.85 x 10^{-4} m^2s^{-1}, b = 2 for the global value.

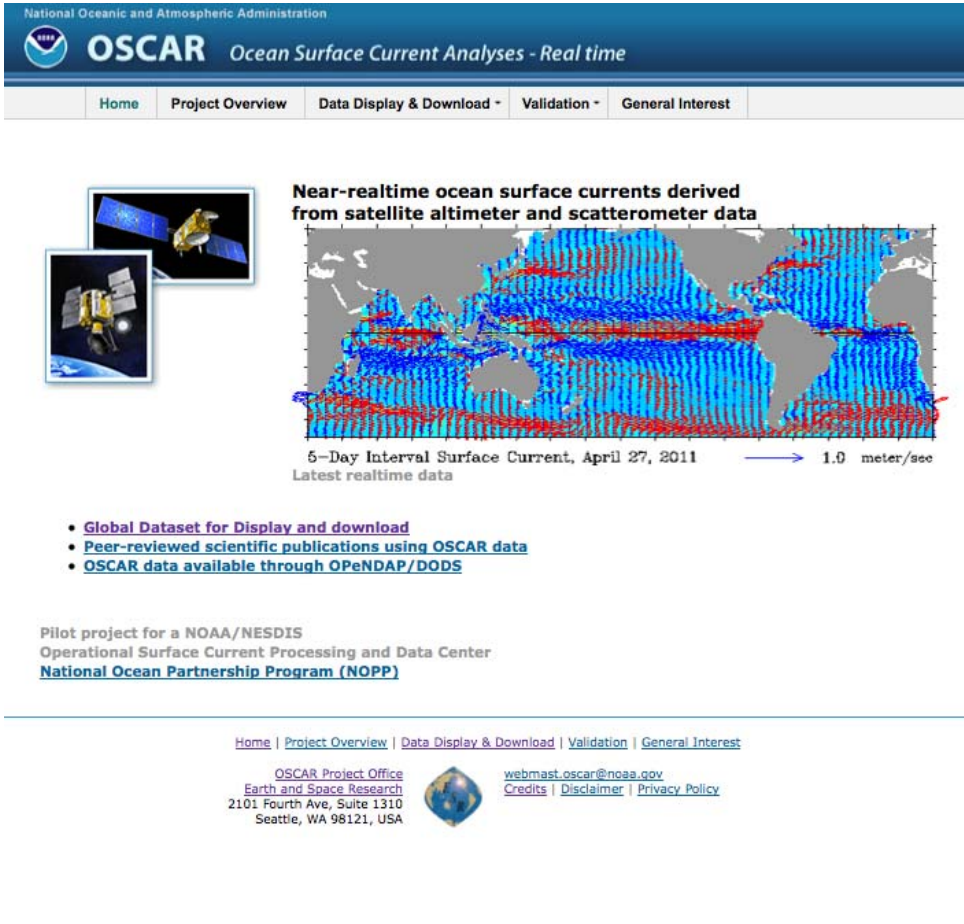
OSCAR Surface currents from satellite fields

- 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, GHRSST
- 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

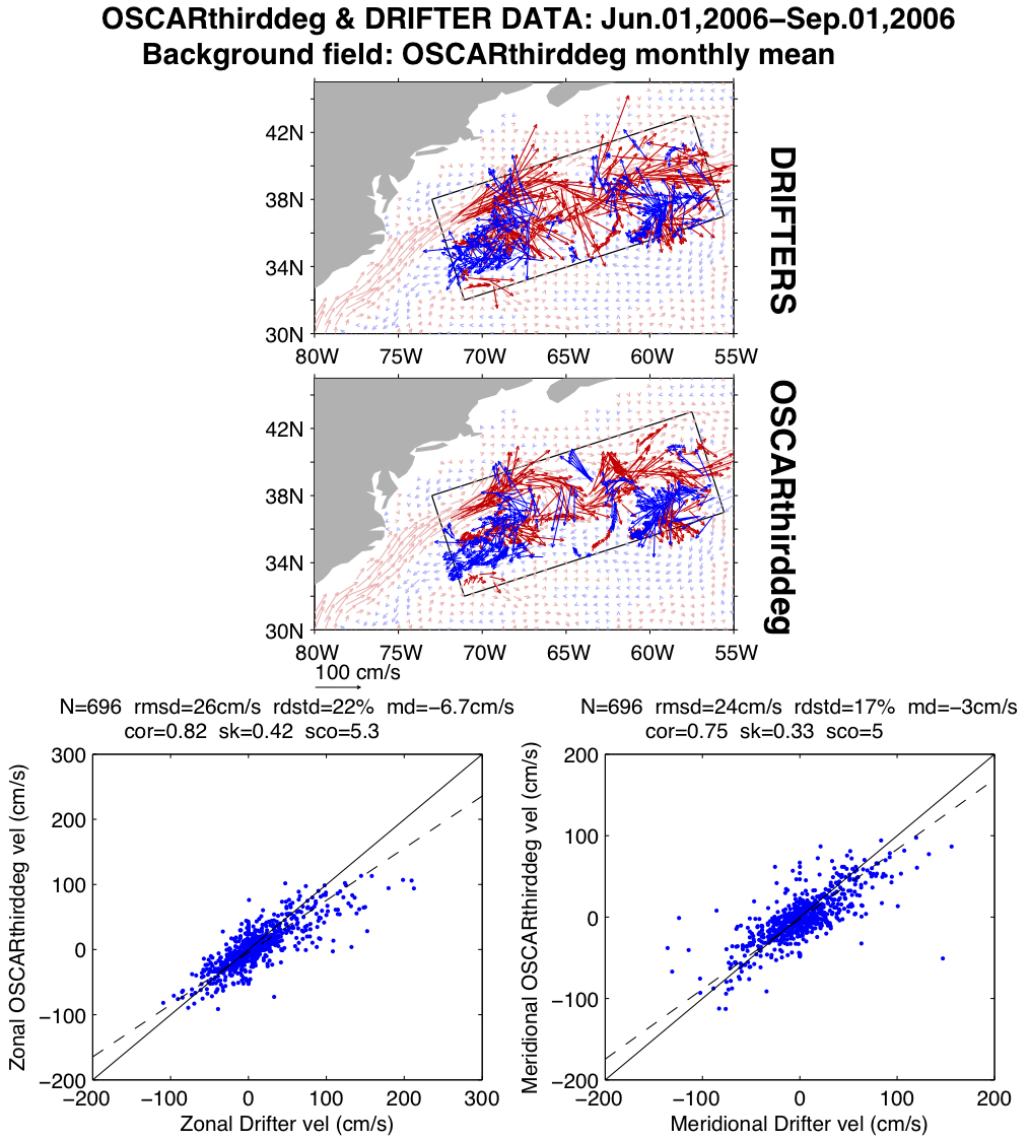
OSCAR Surface currents from satellite fields

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



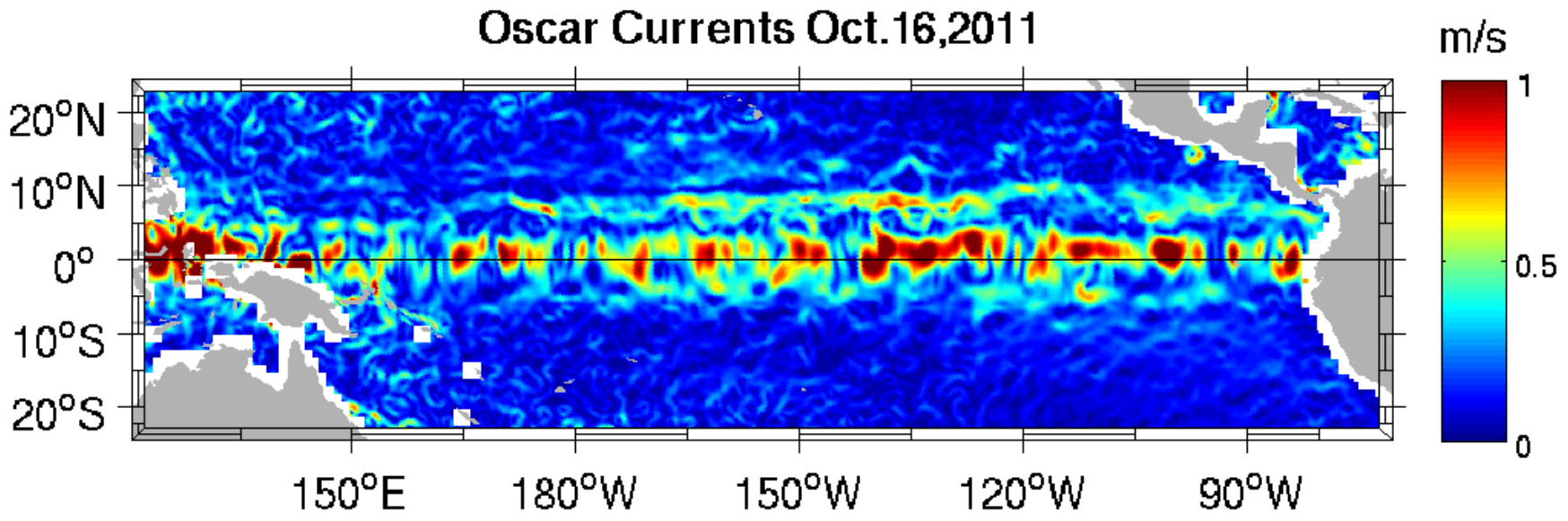
Validation against drifting buoy velocities

- 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
- Good performance in dominantly geostrophic areas, such as the Gulf Stream.



Focus of this talk: Surface Currents as an ENSO index

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



[1]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.

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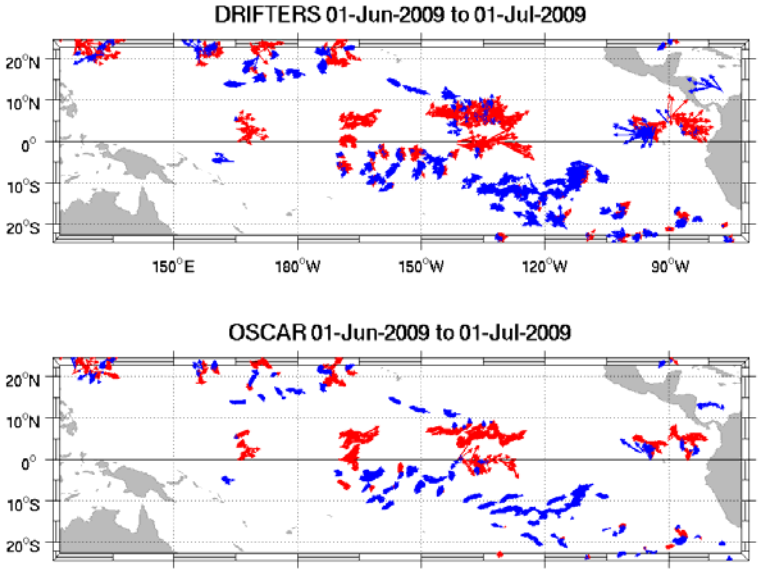
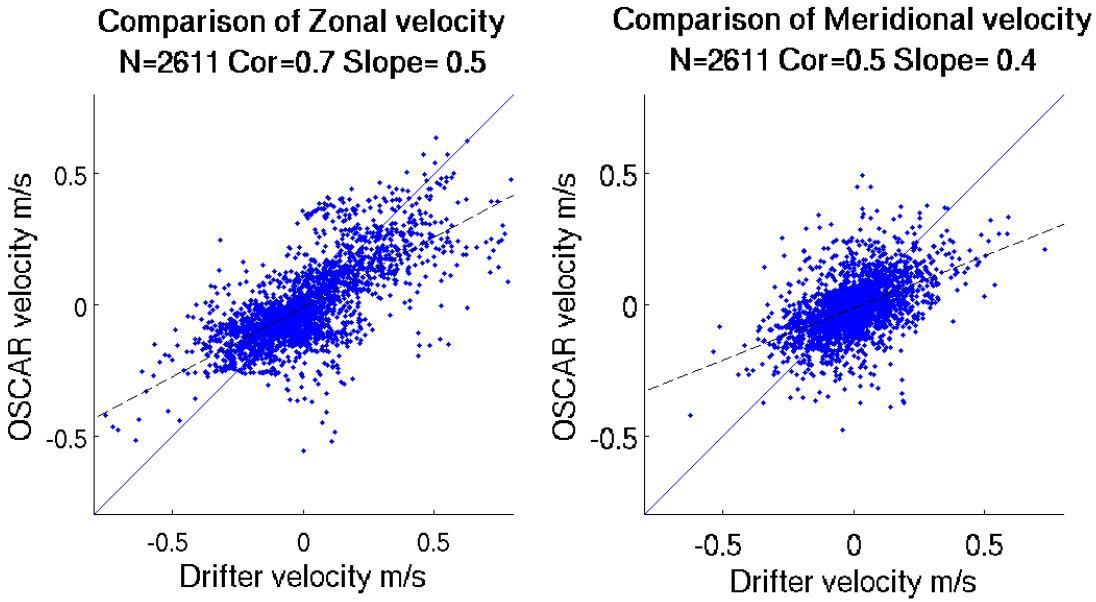
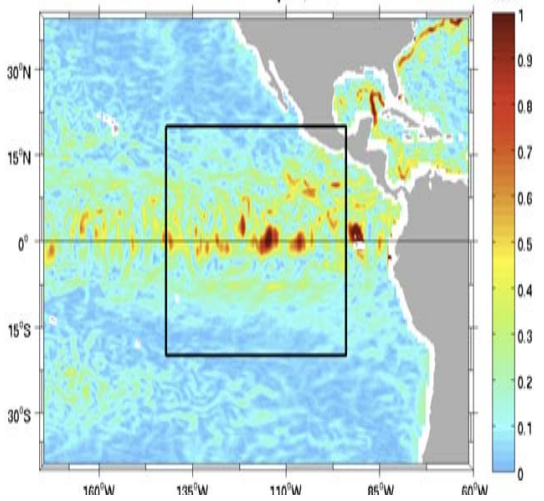
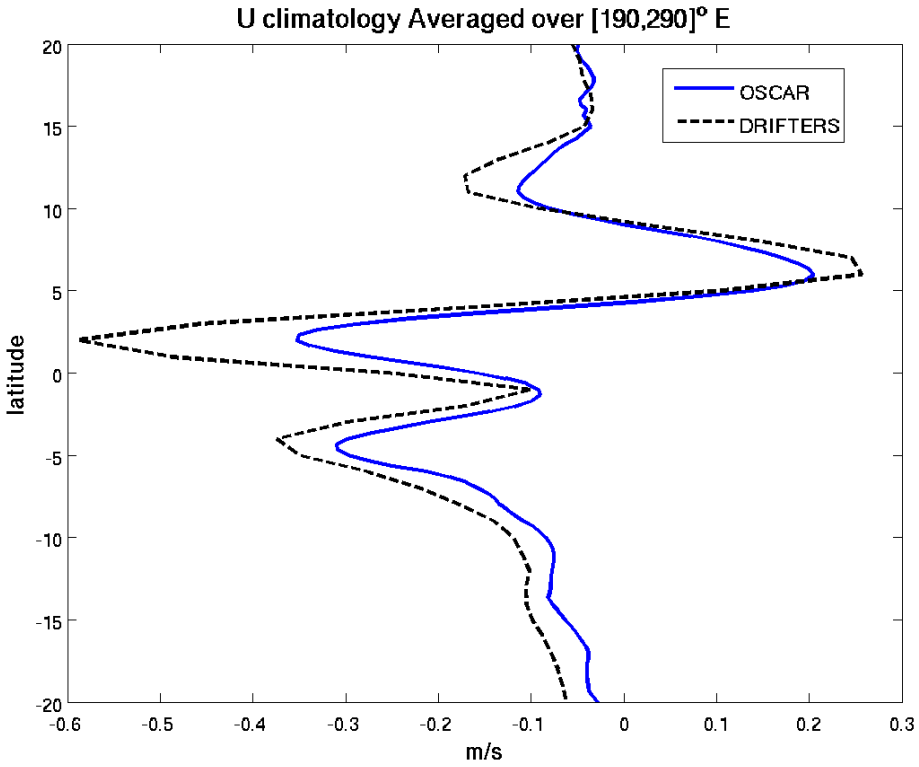


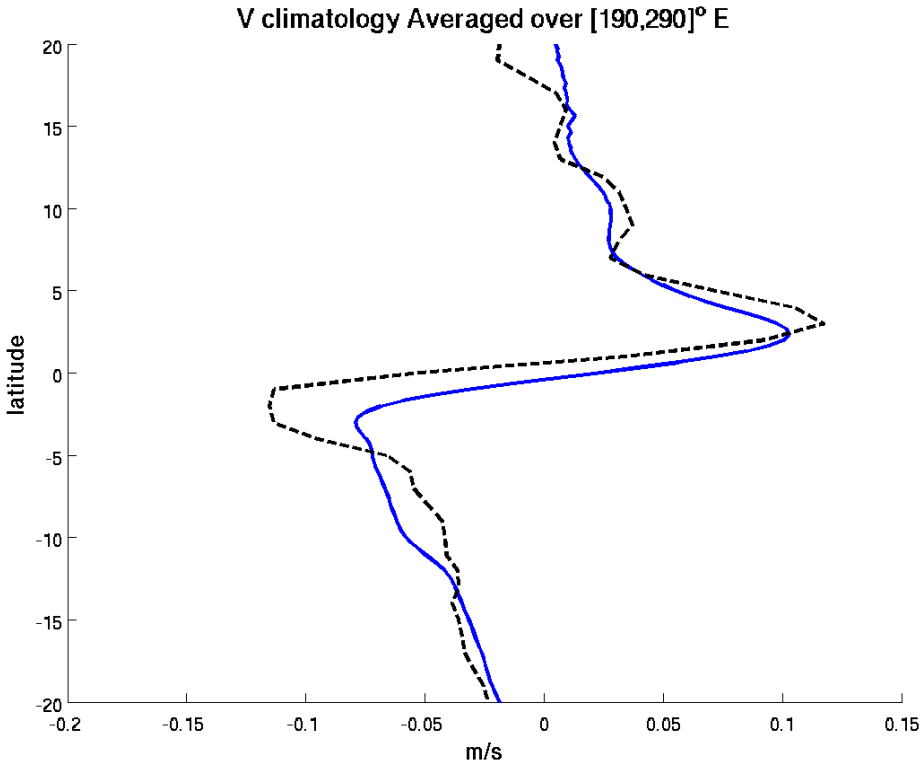


Validation: Equatorial Pacific Climatology

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

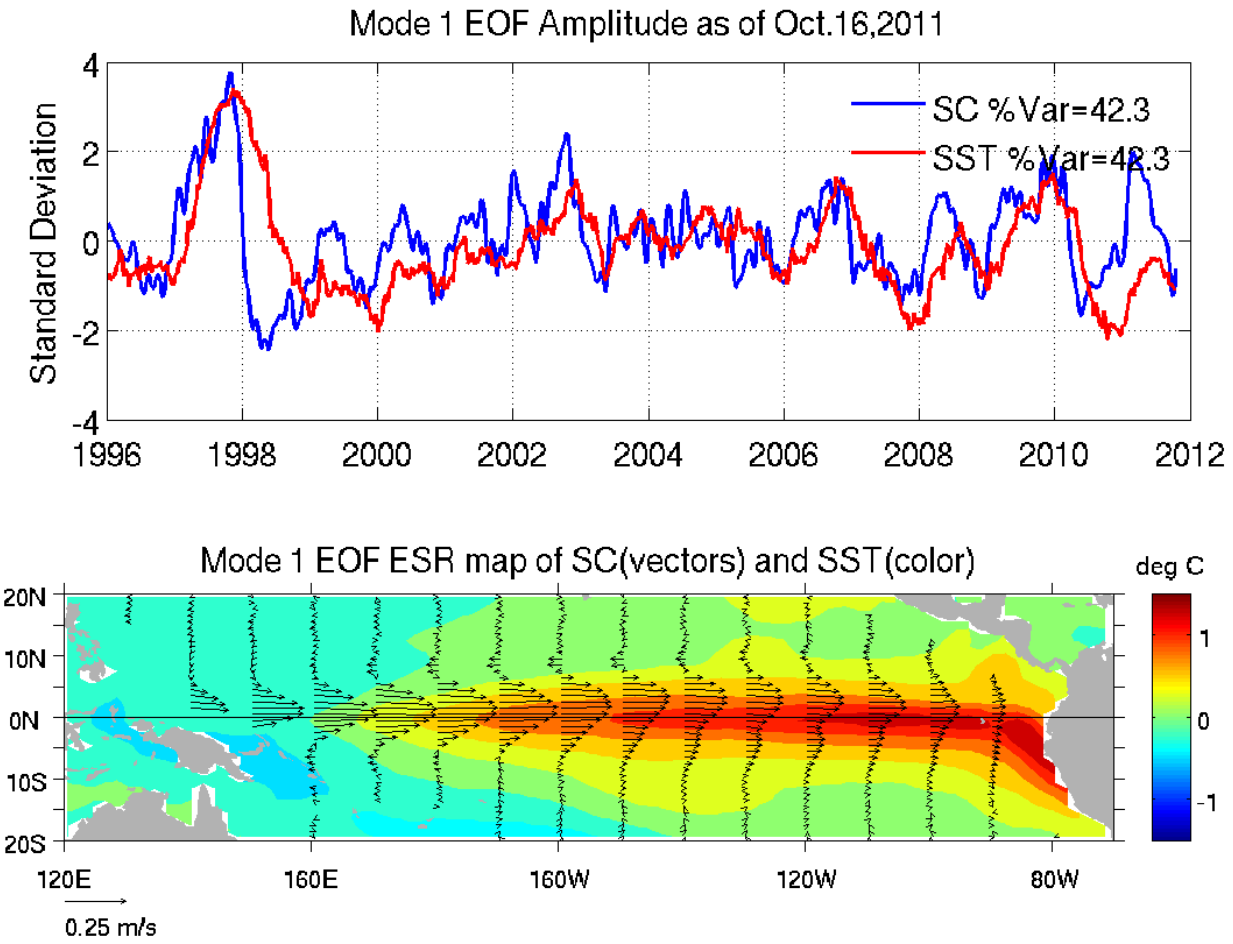






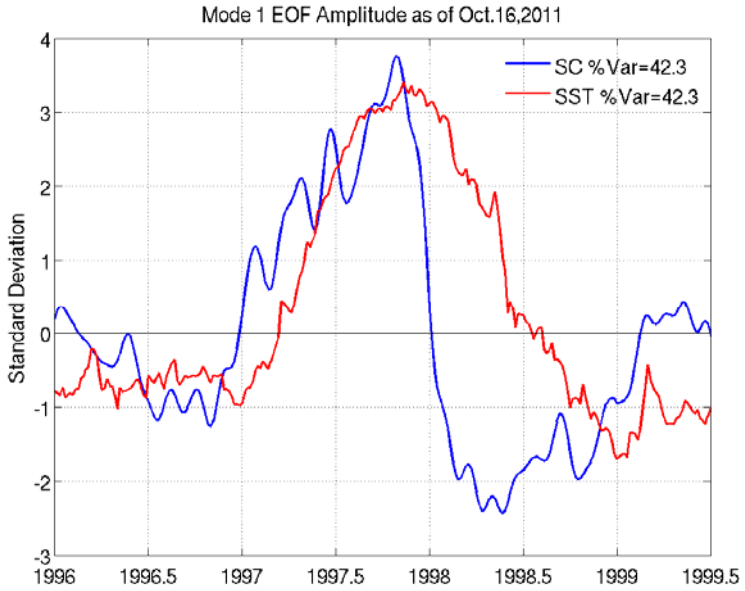
Application: ENSO index

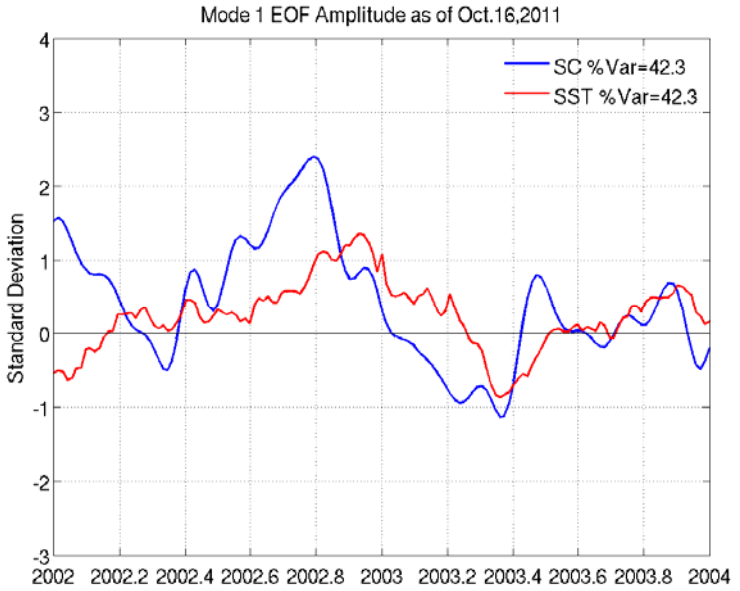
- www.esr.org/enso_index.html



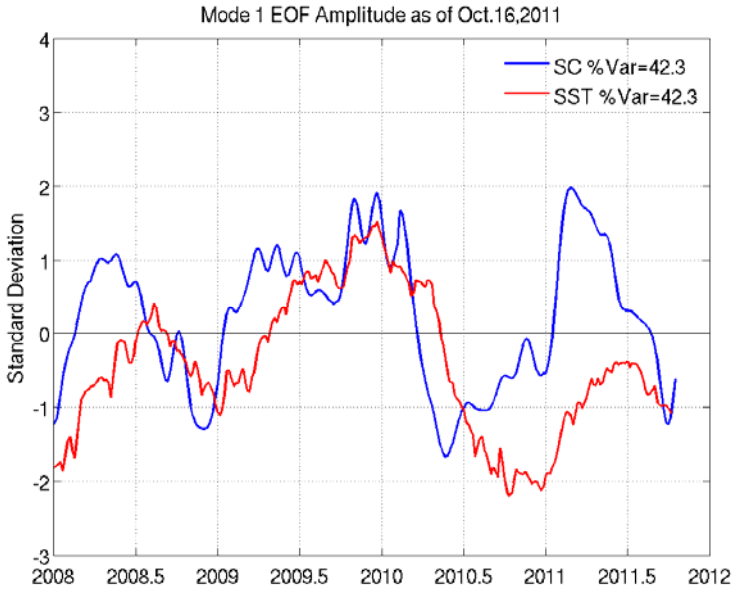
- Principal empirical orthogonal functions (EOF) of surface current ("SC") and of SST anomaly variations in the Tropical Pacific (anomalies from 1993:2002 climatology) from OSCAR. Top: amplitude time series of the EOFs normalized by their respective standard deviations. Bottom: spatial structures of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

“ESR” index 2011



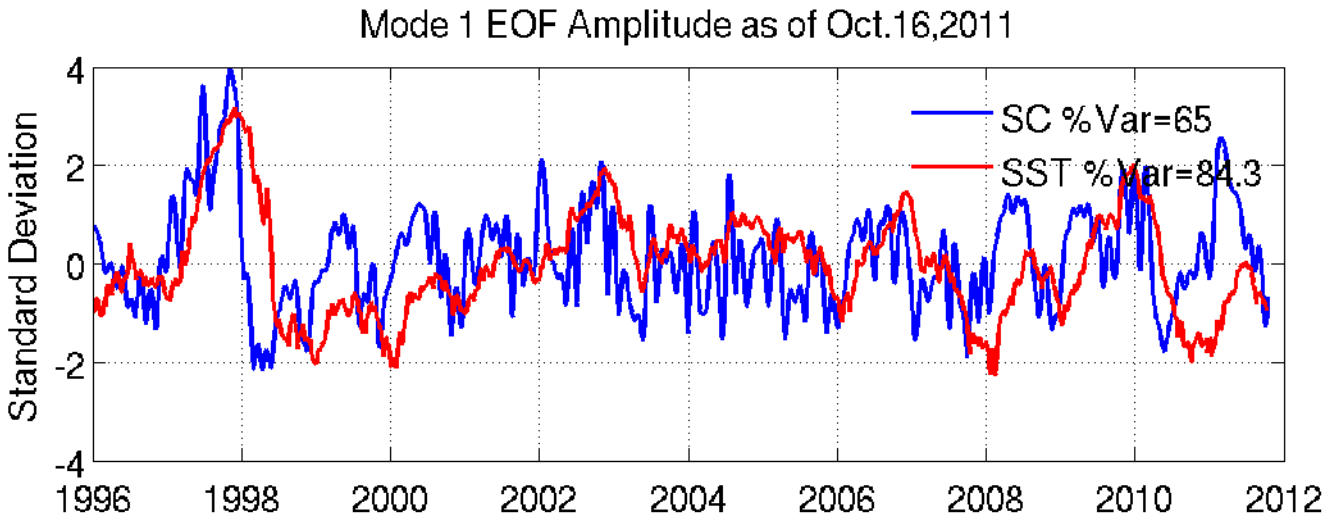


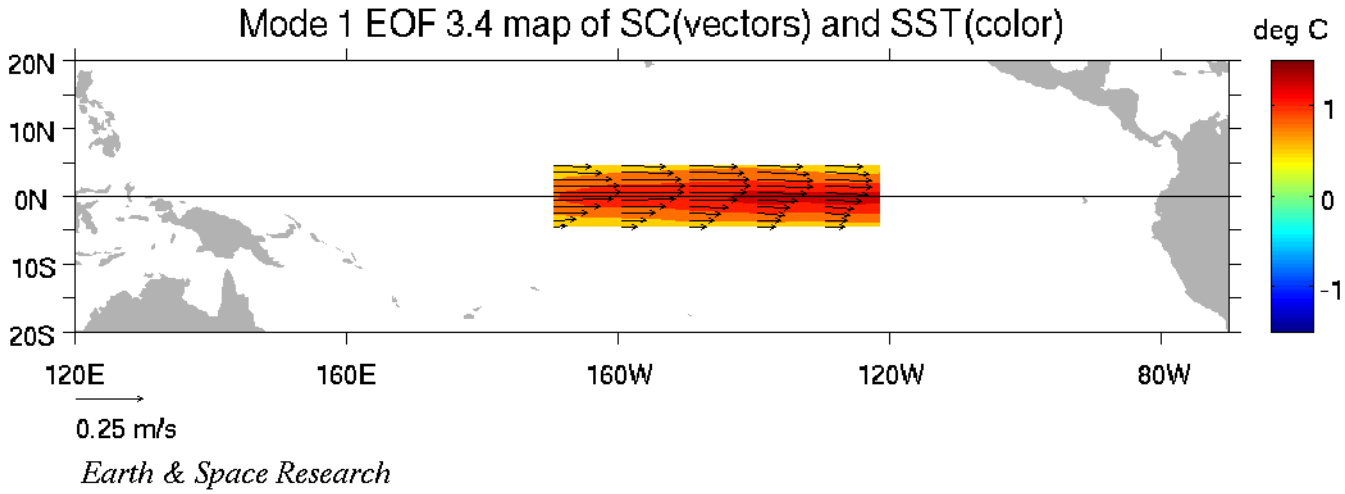
- Surface current (SC) index
  precedes SST (red)
- Zero crossing denotes SST maximum



Application: ENSO index

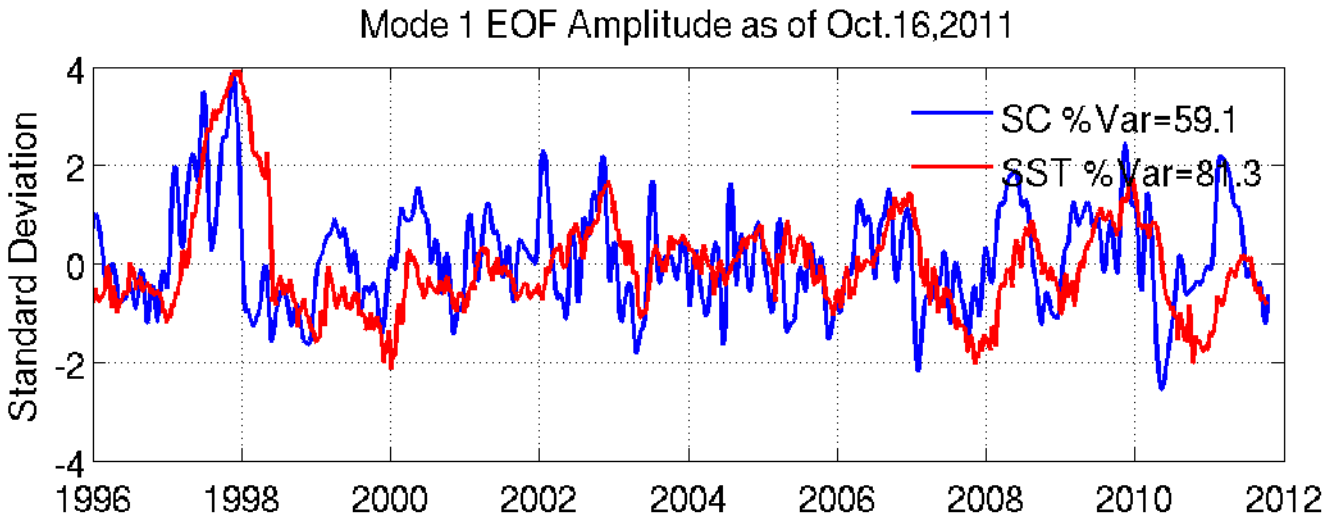
- El Nino Region 3.4

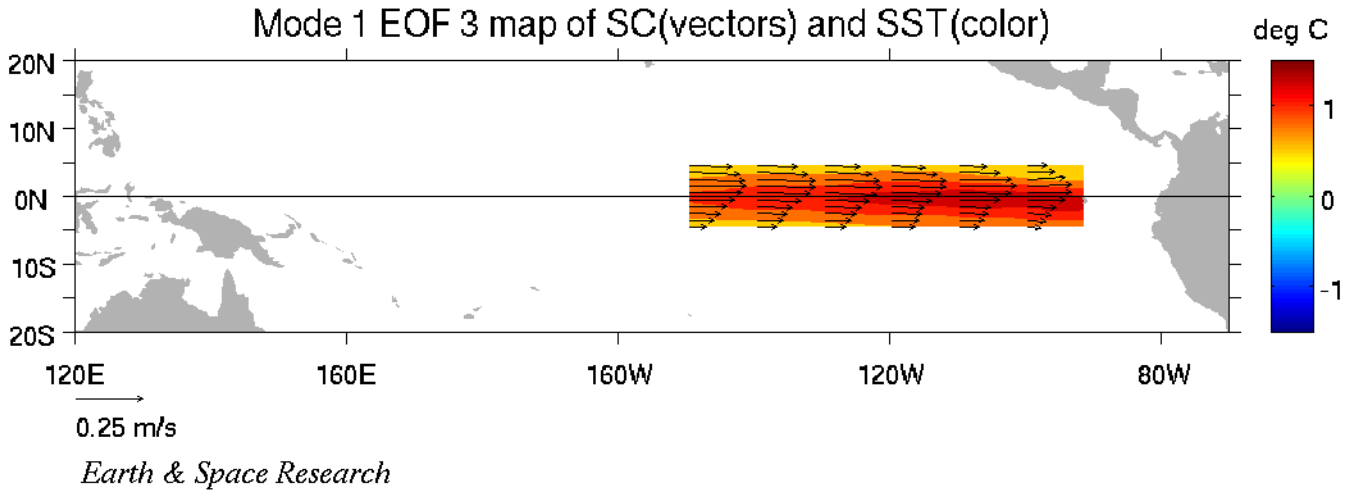




Application: ENSO index

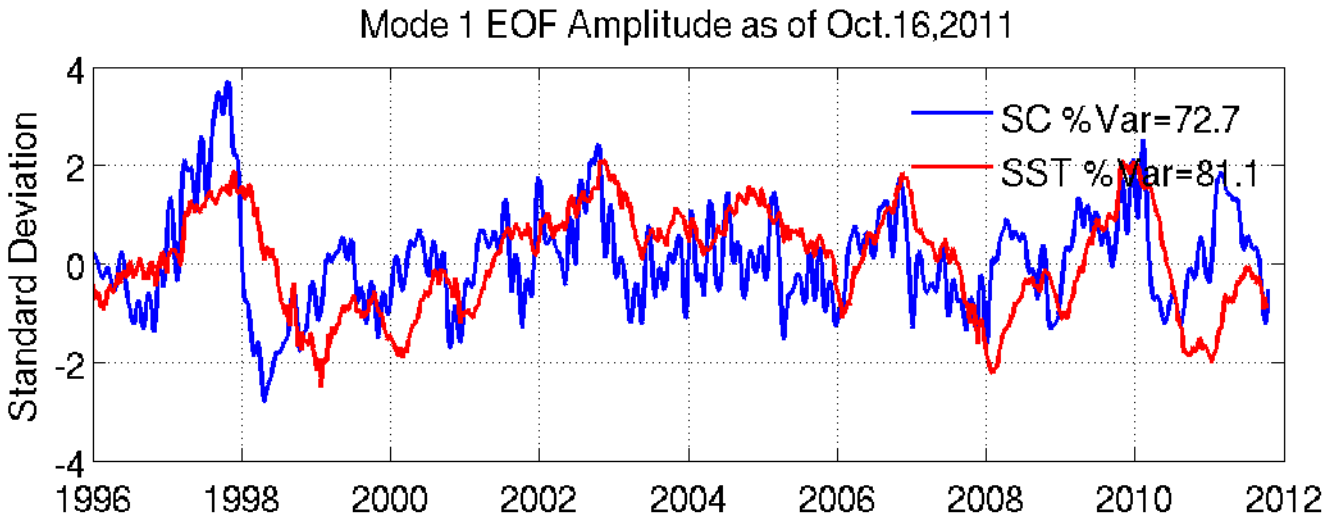
- El Nino Region 3

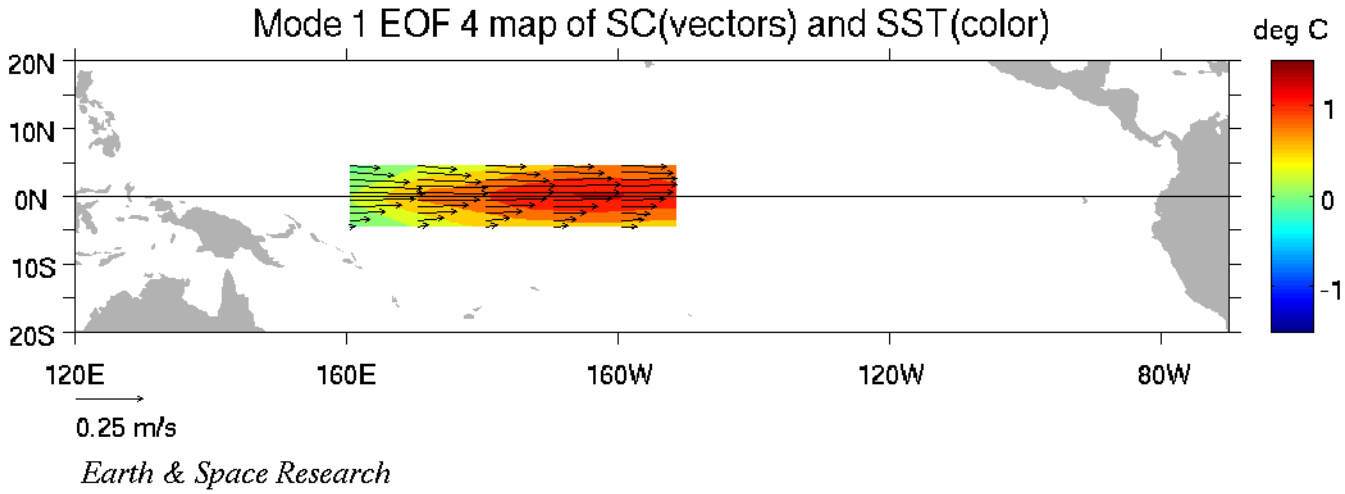




Application: ENSO index

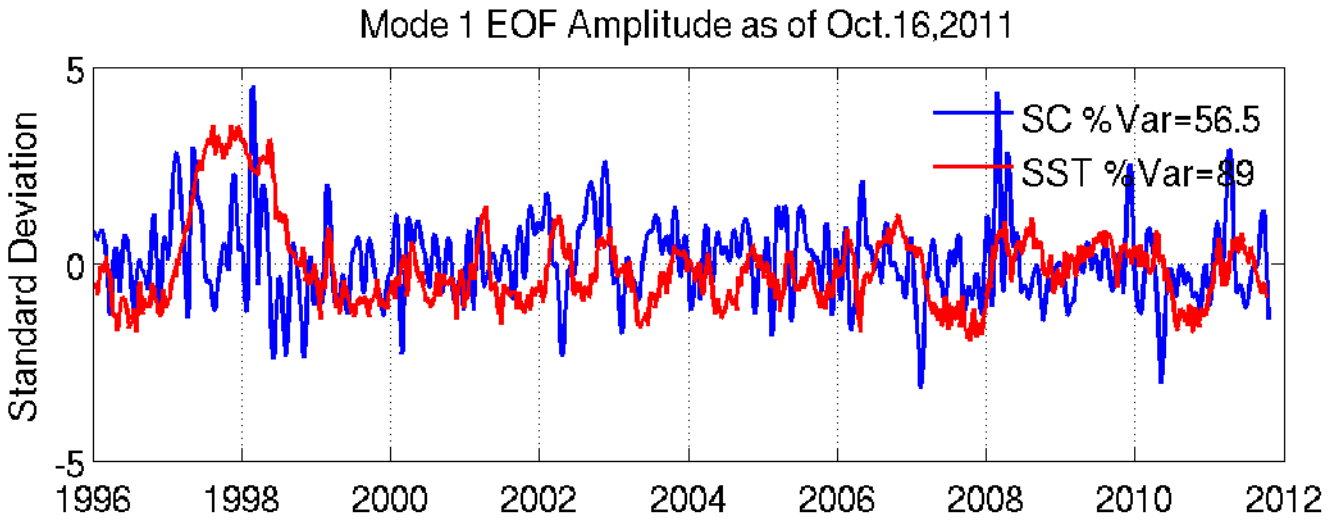
- El Nino Region 4

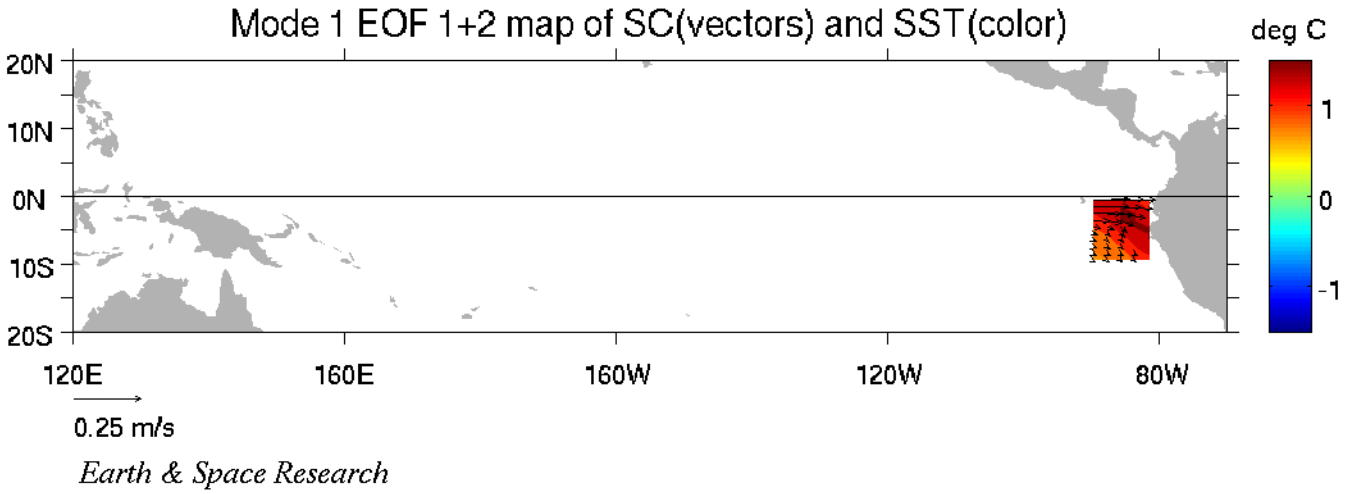




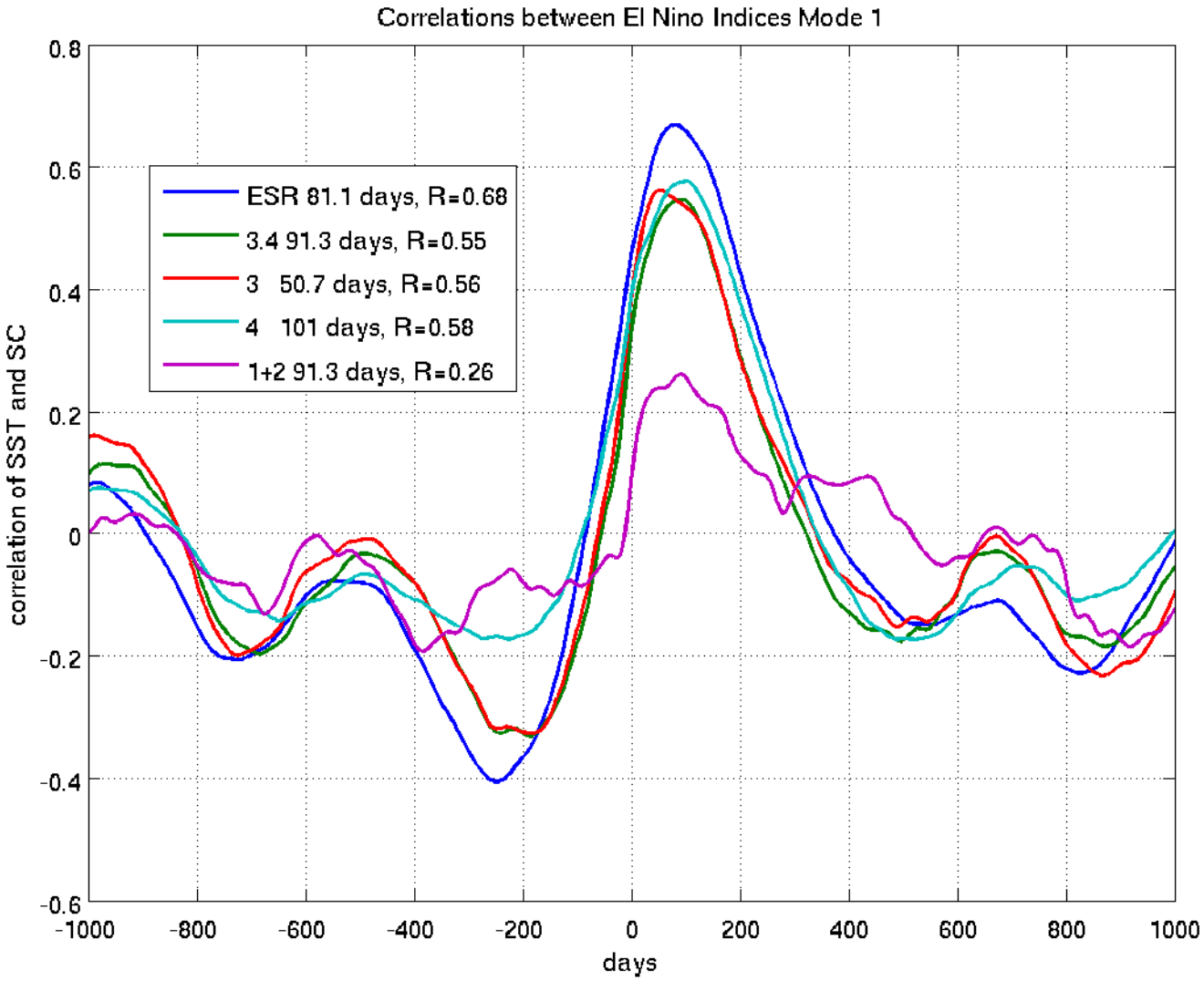
Application: ENSO index

- El Nino Region 1+2





Correlations and lags between El Nino indices and SST indices



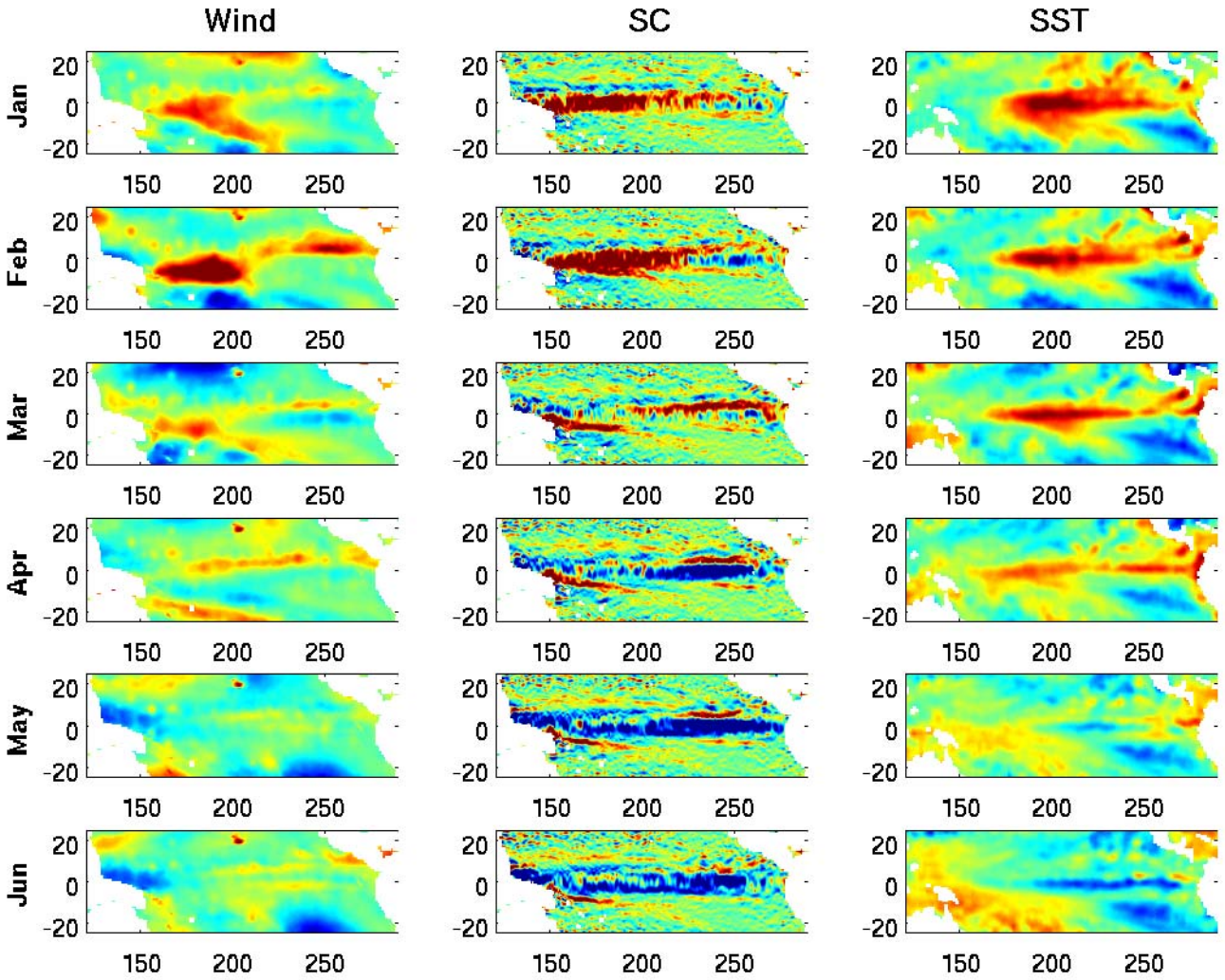
Summary: Surface Currents as ENSO index

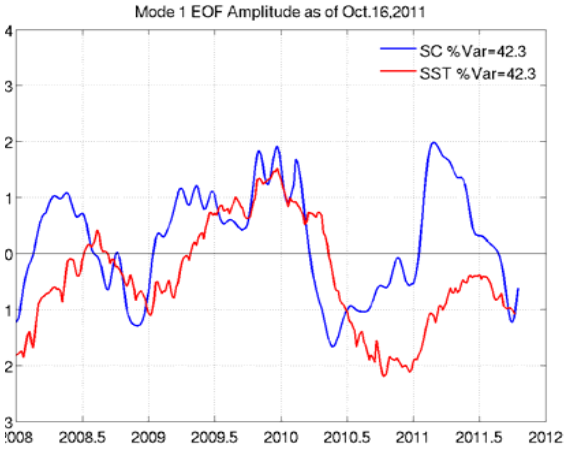
- Obviously not the whole story
  - Trade Winds relaxation
  - Southward shift of wind anomalies
  - Kelvin waves
  - Surface heat exchange, precipitation, clouds
  - Thermocline shifts
  - Warm pool, heat storage, barrier layers
  - MJO, SO
  - …
  - As well as the type of response: (CP, EP)

- 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 (←→)





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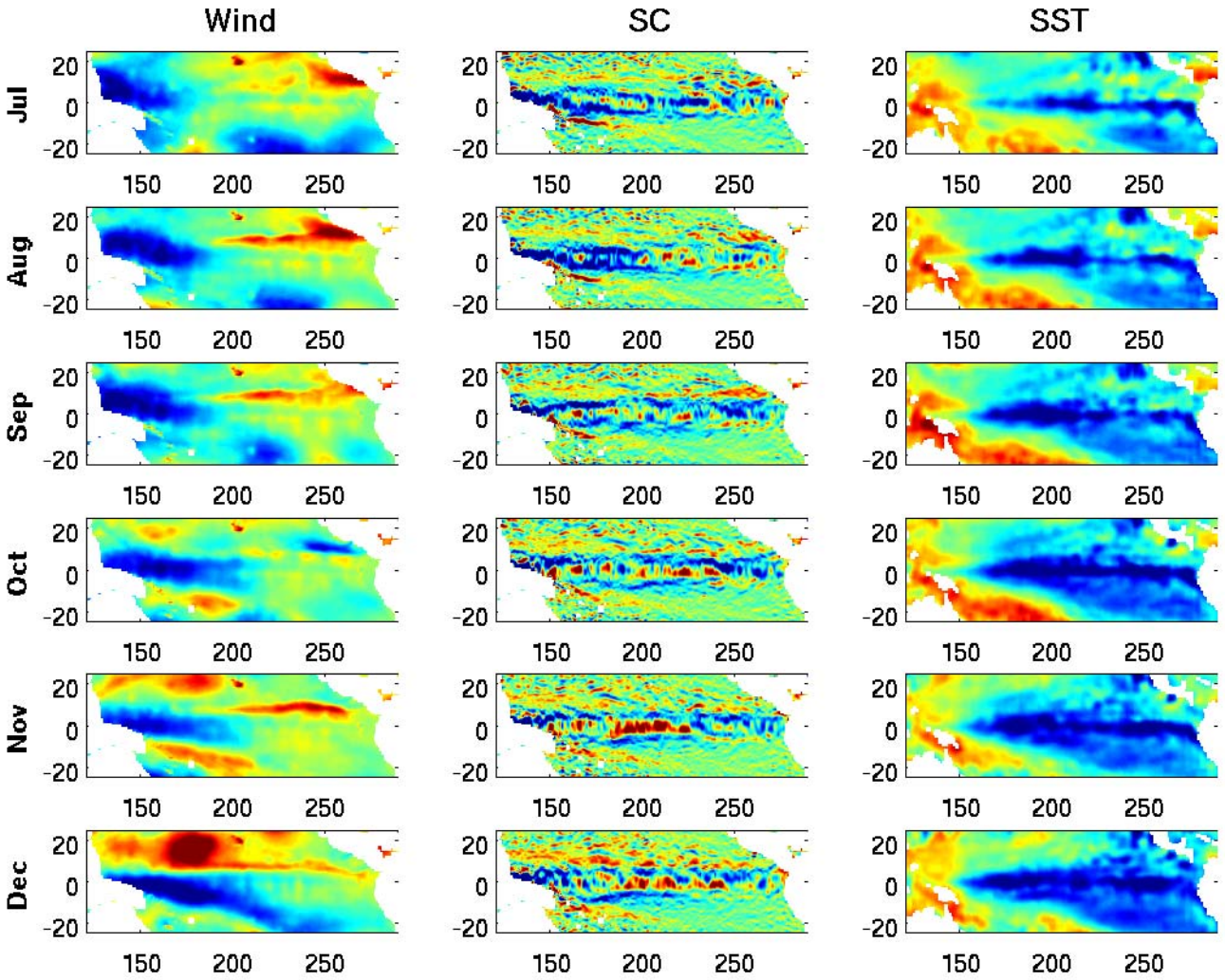

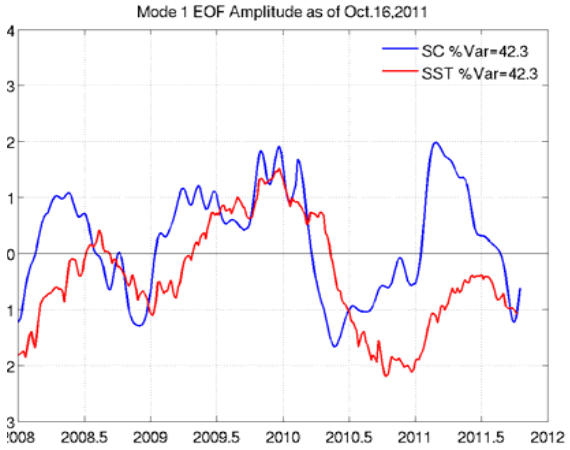

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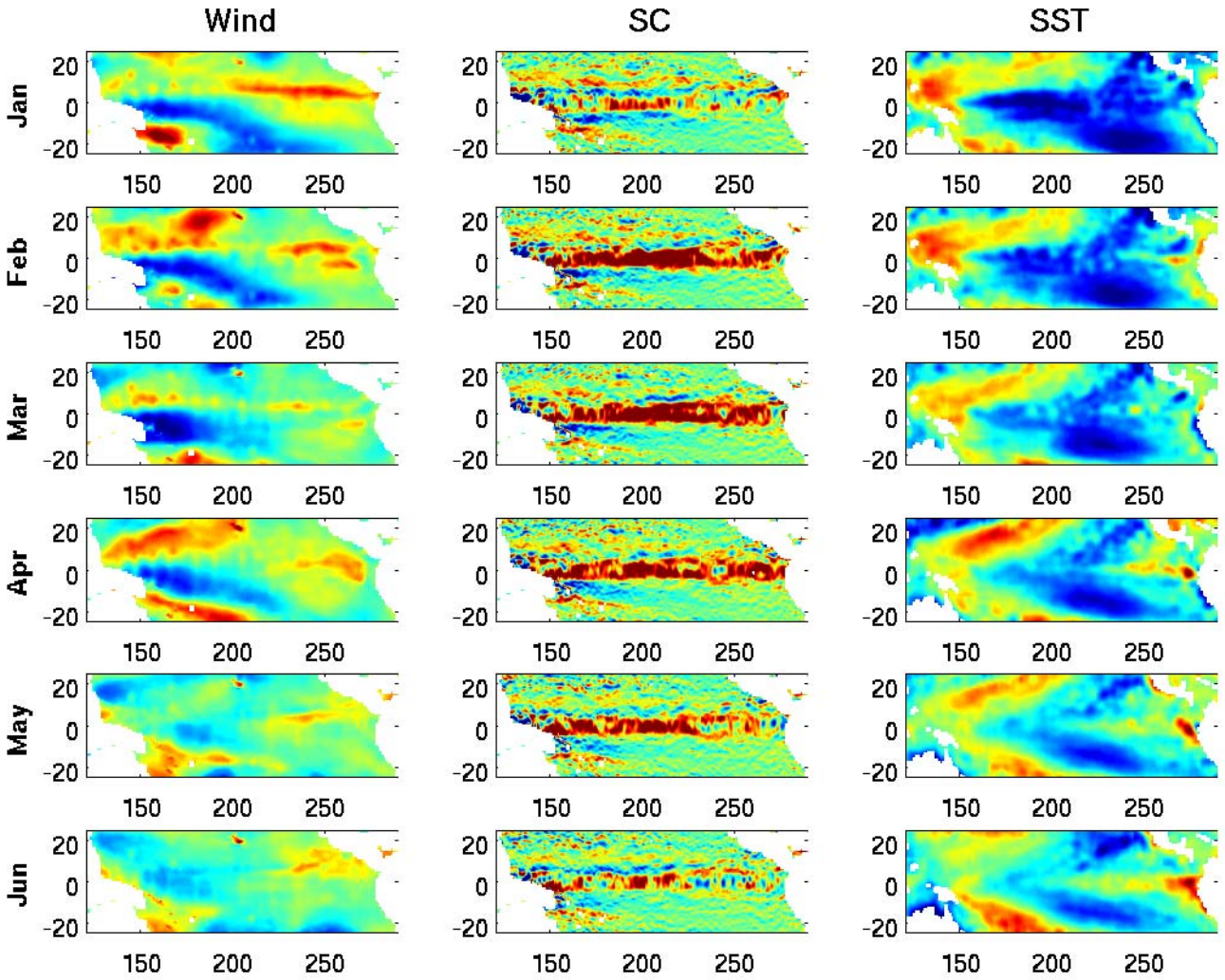

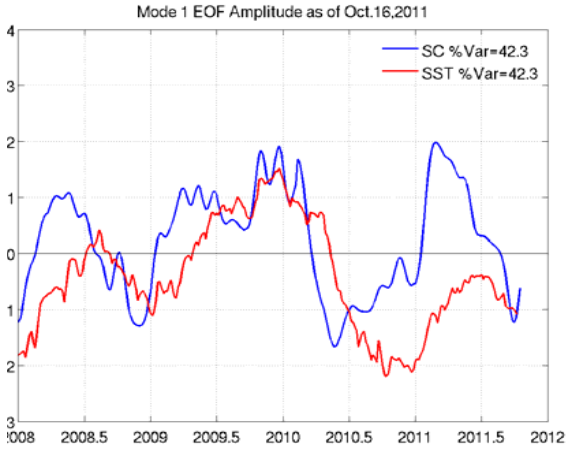

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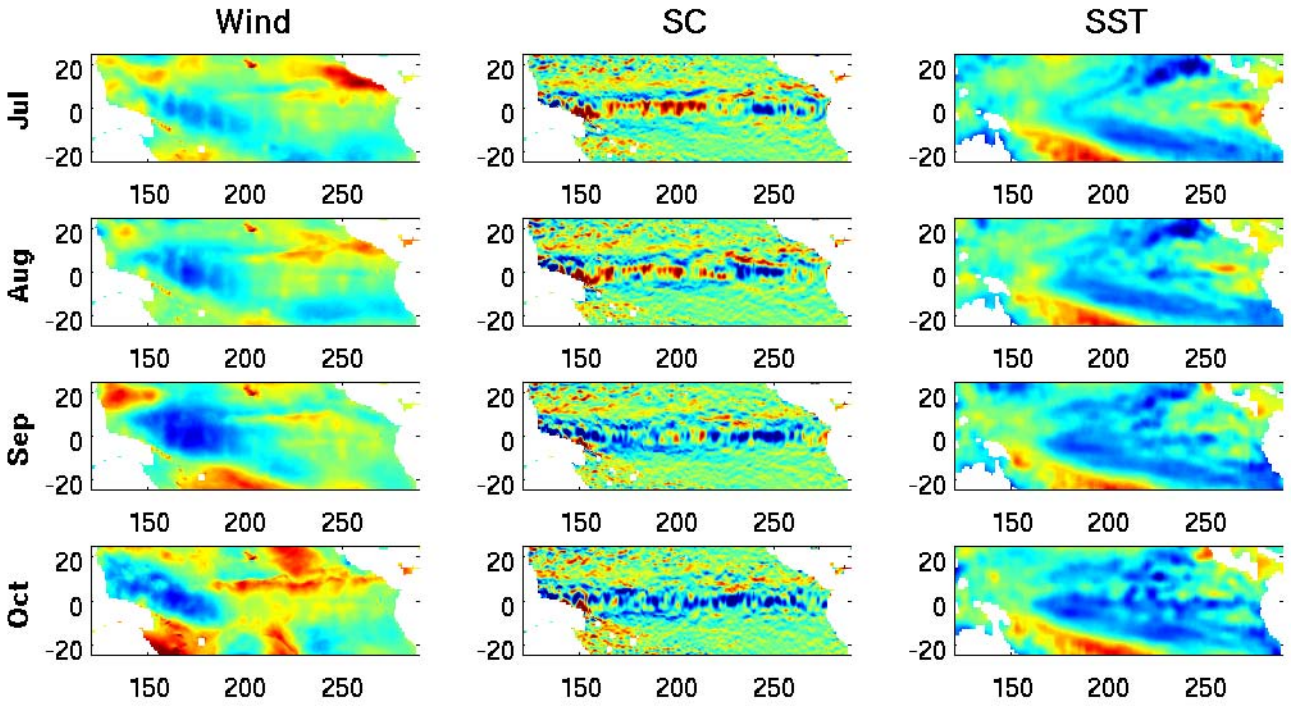
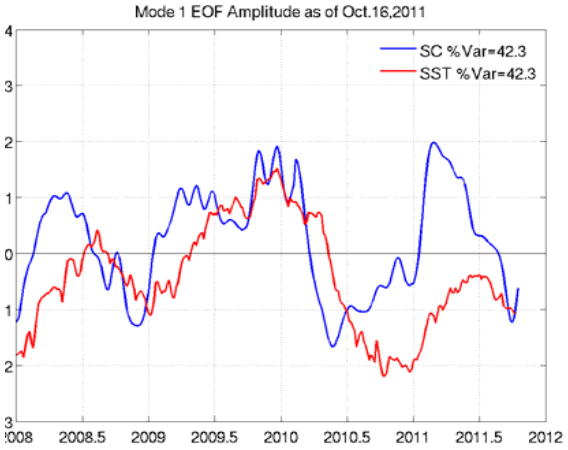
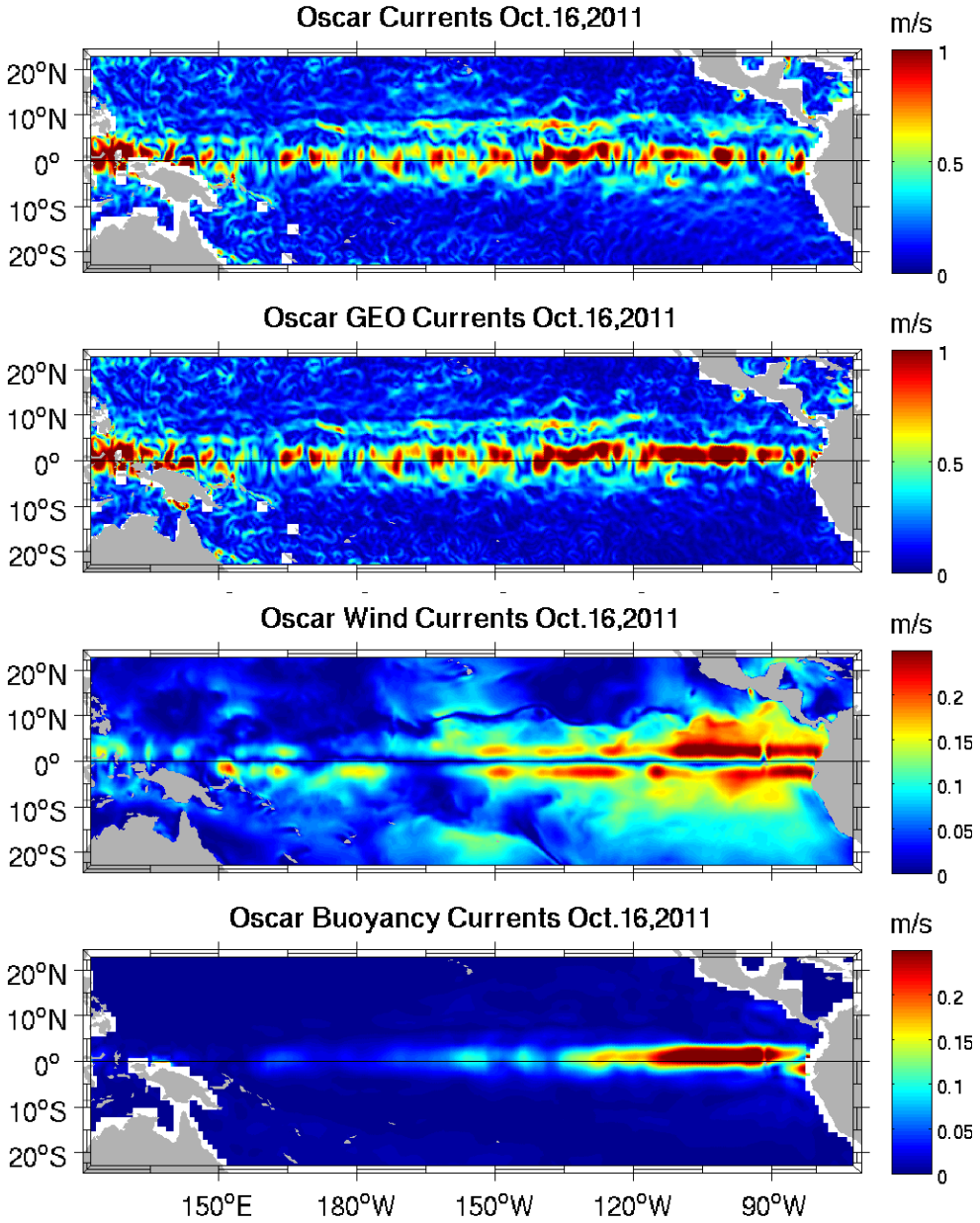




OSCAR components EQ Pacific



OSTST Oct 20, 2011