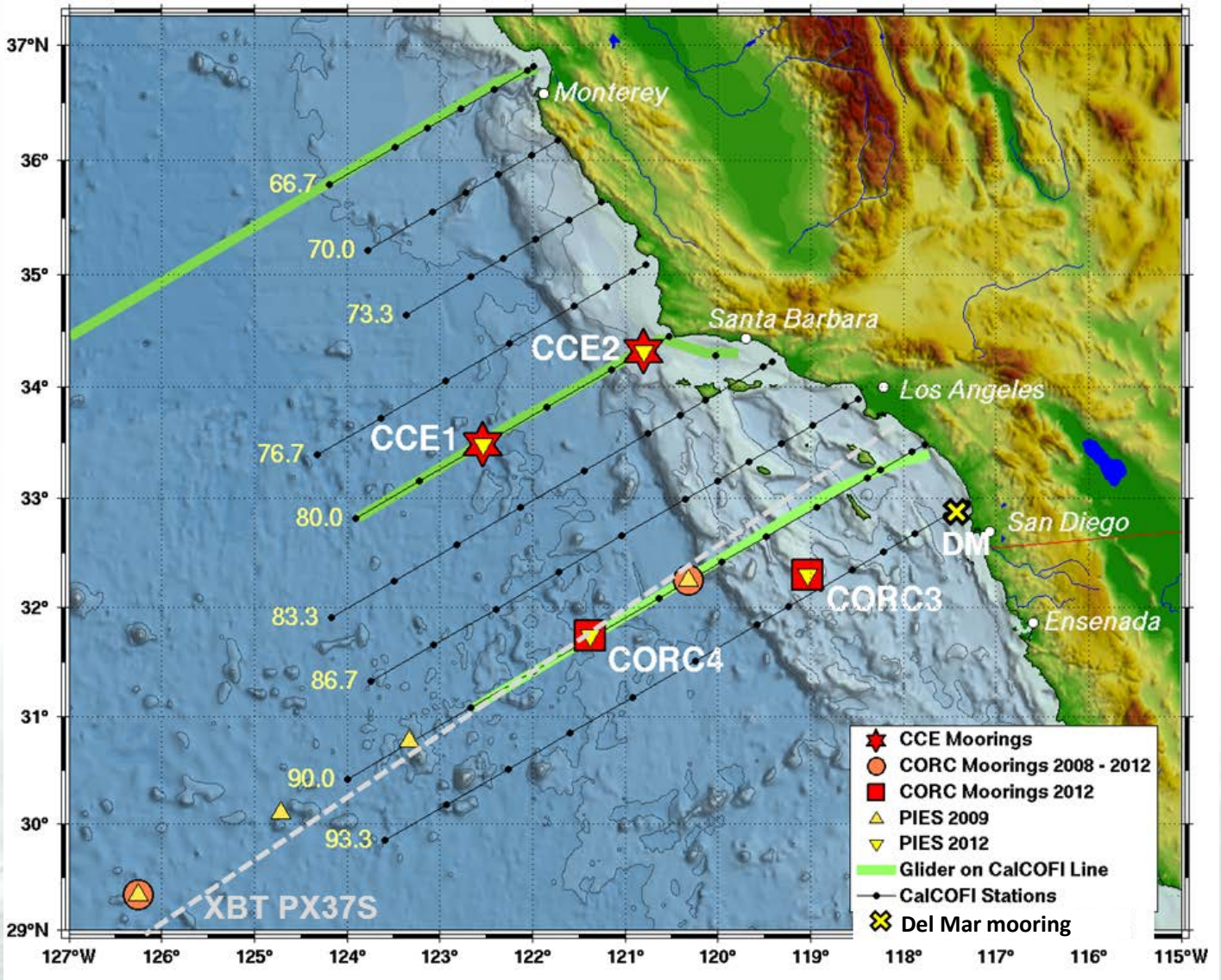
# Southern California in-situ observations

**NOAA CORC and CCE moorings programs**

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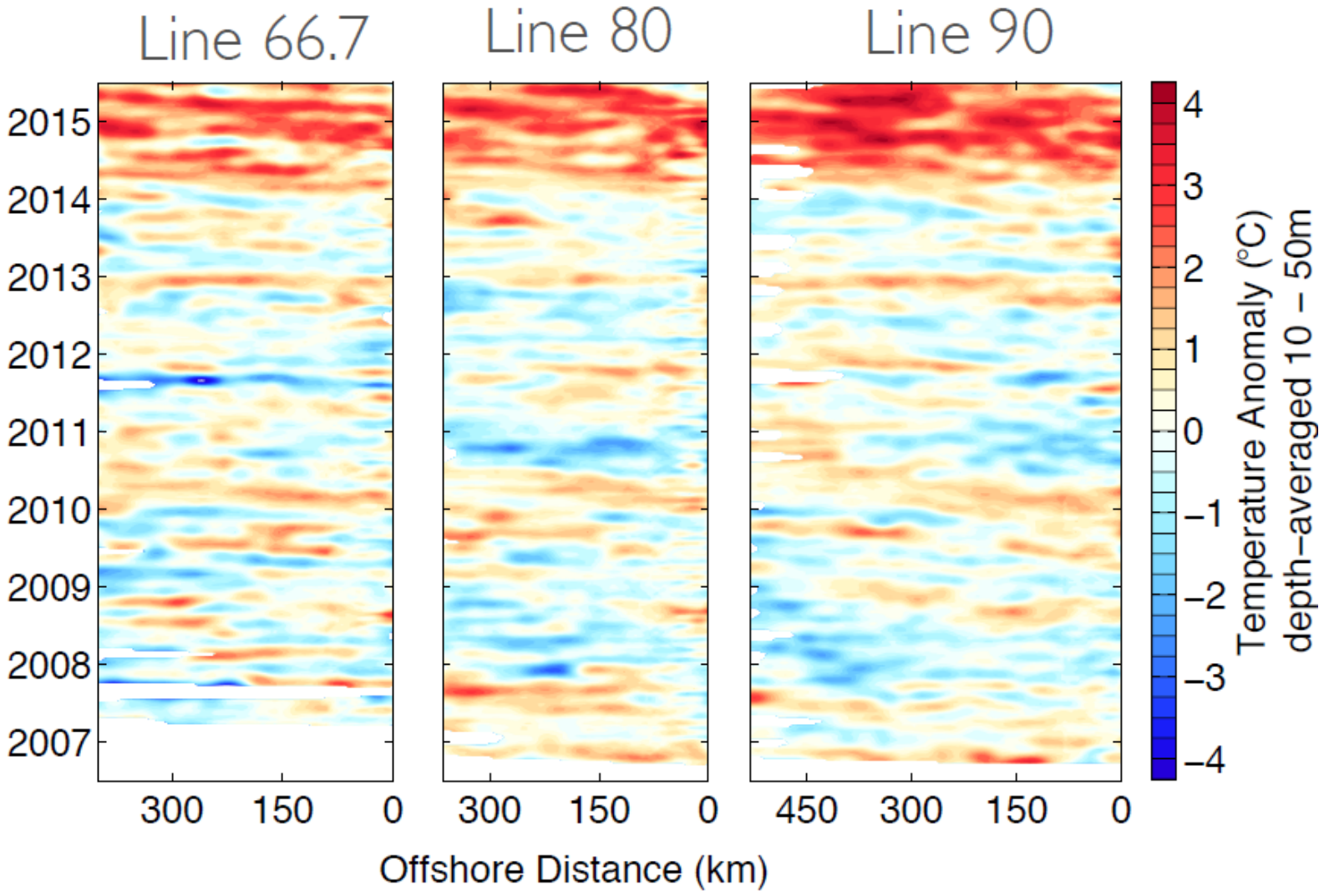
SCRIPPS INSTITUTION OF OCEANOGRAPHY
UC San Diego

NOAA

# Large-scale view from gliders (see also Zaba&Rudnick poster)



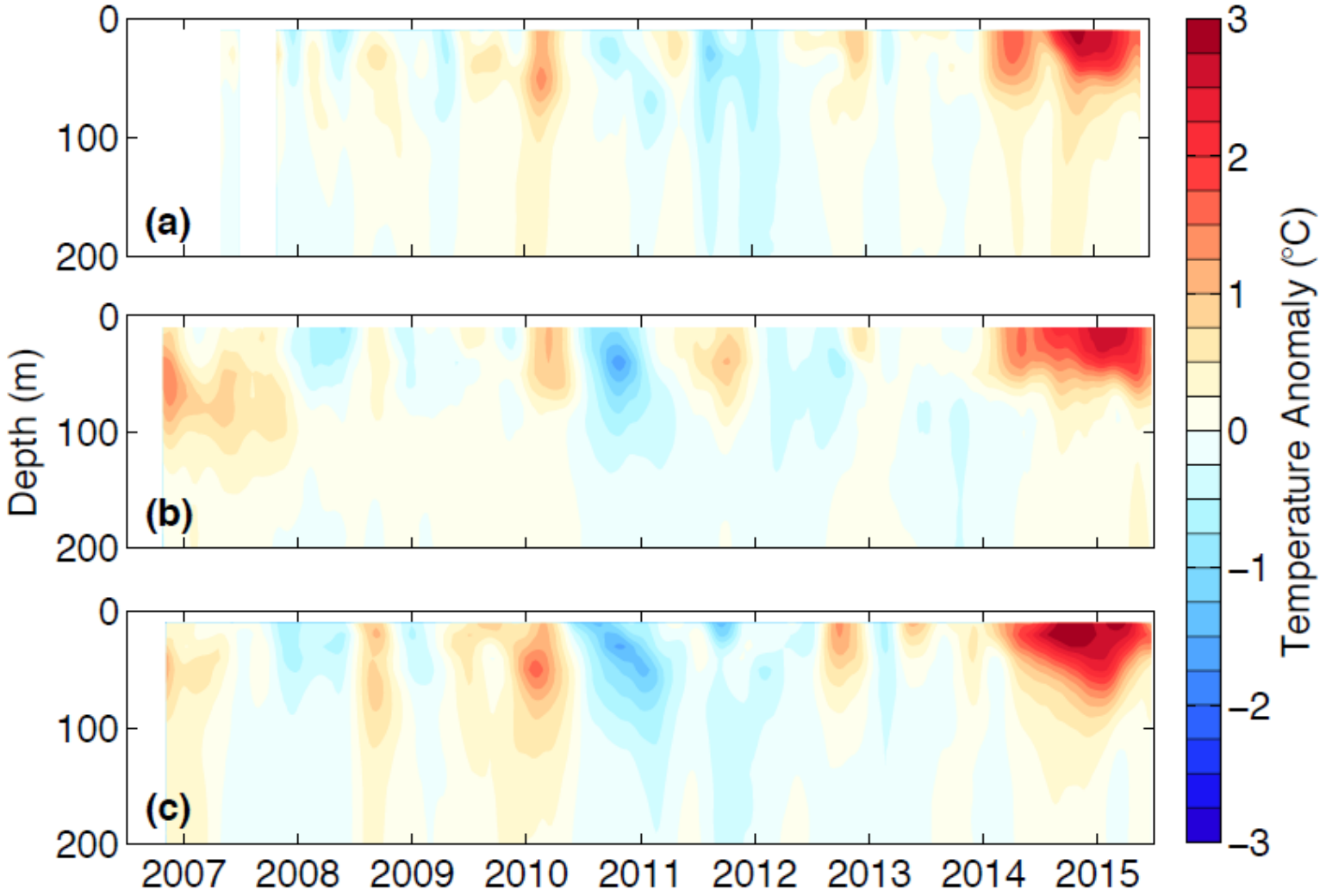

**Anomalous warming starts beginning of 2014, over large region.**

# Shallow / surface-intensified in average over large area off So Cal

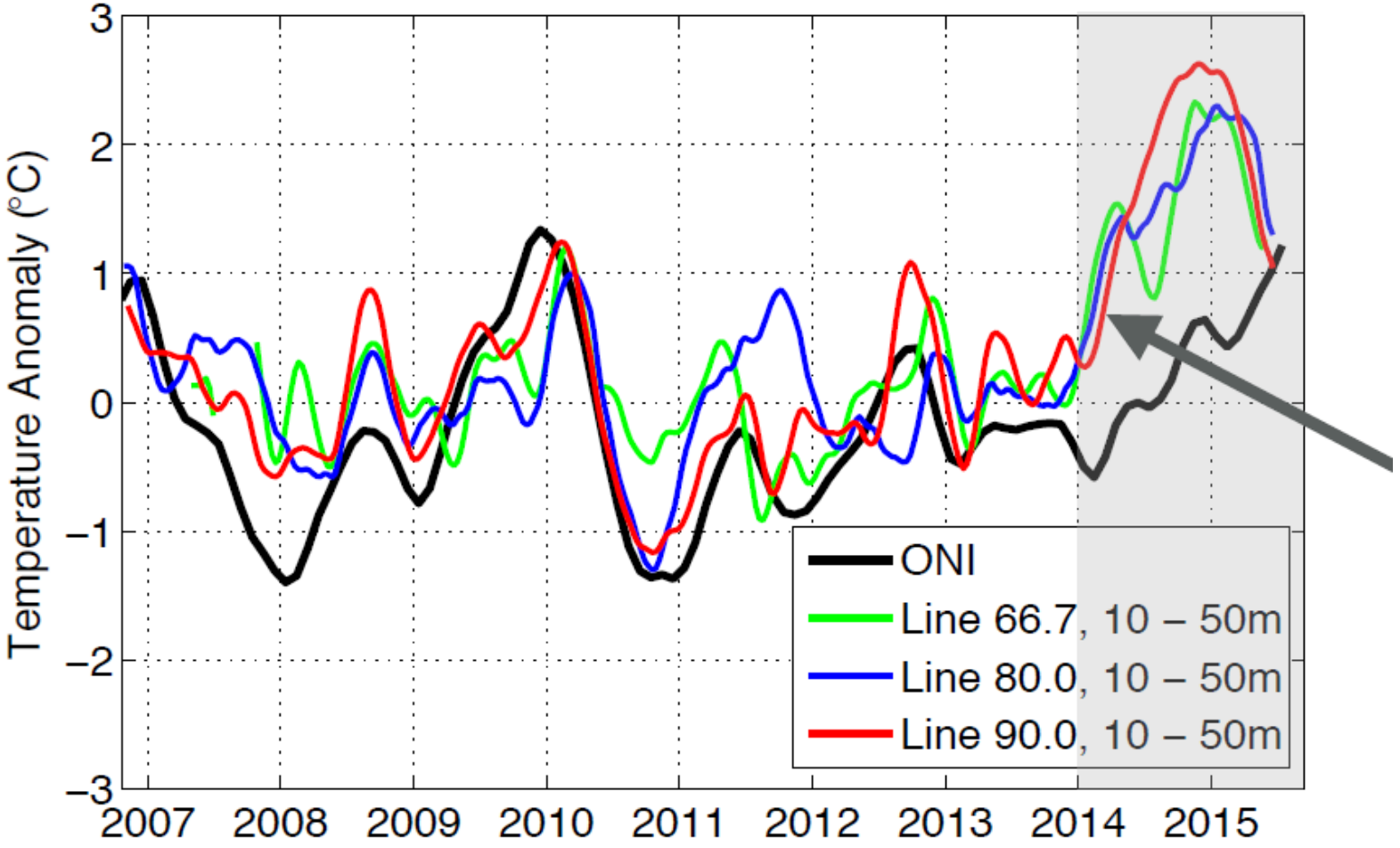
Line 66.7

Line 80

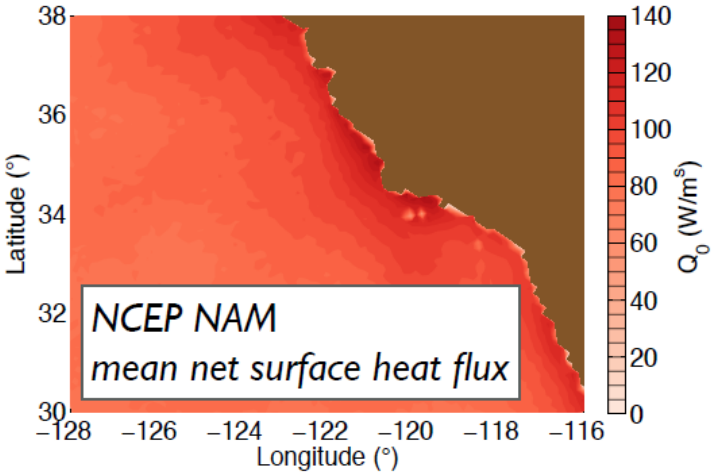
Line 90

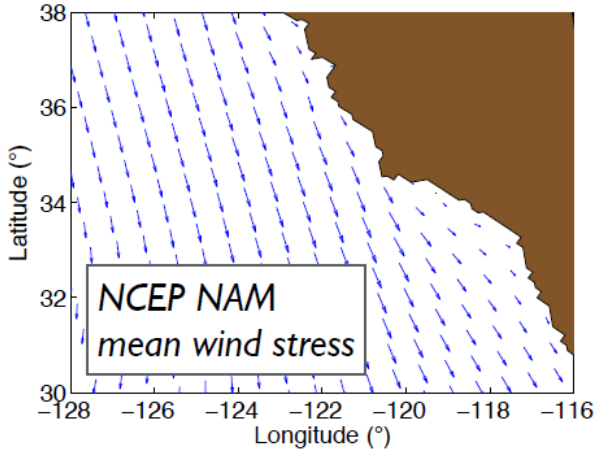


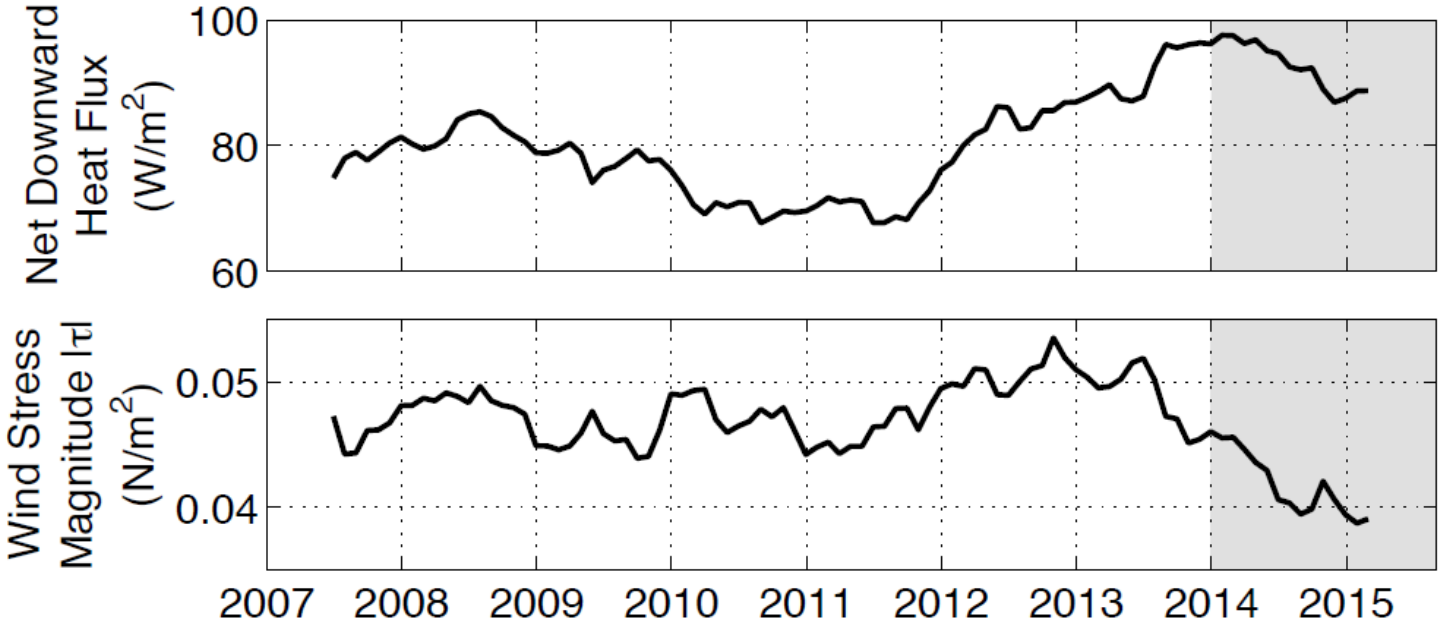
# Warming trend in anomaly may already have started in prior years



# NCEP NAM model: high surface heat flux / low wind stress since 2013

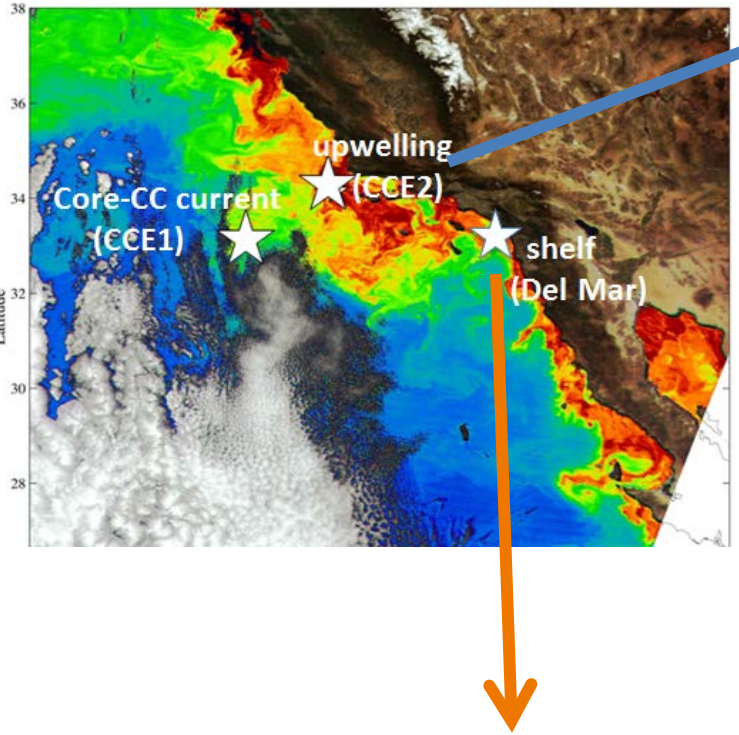


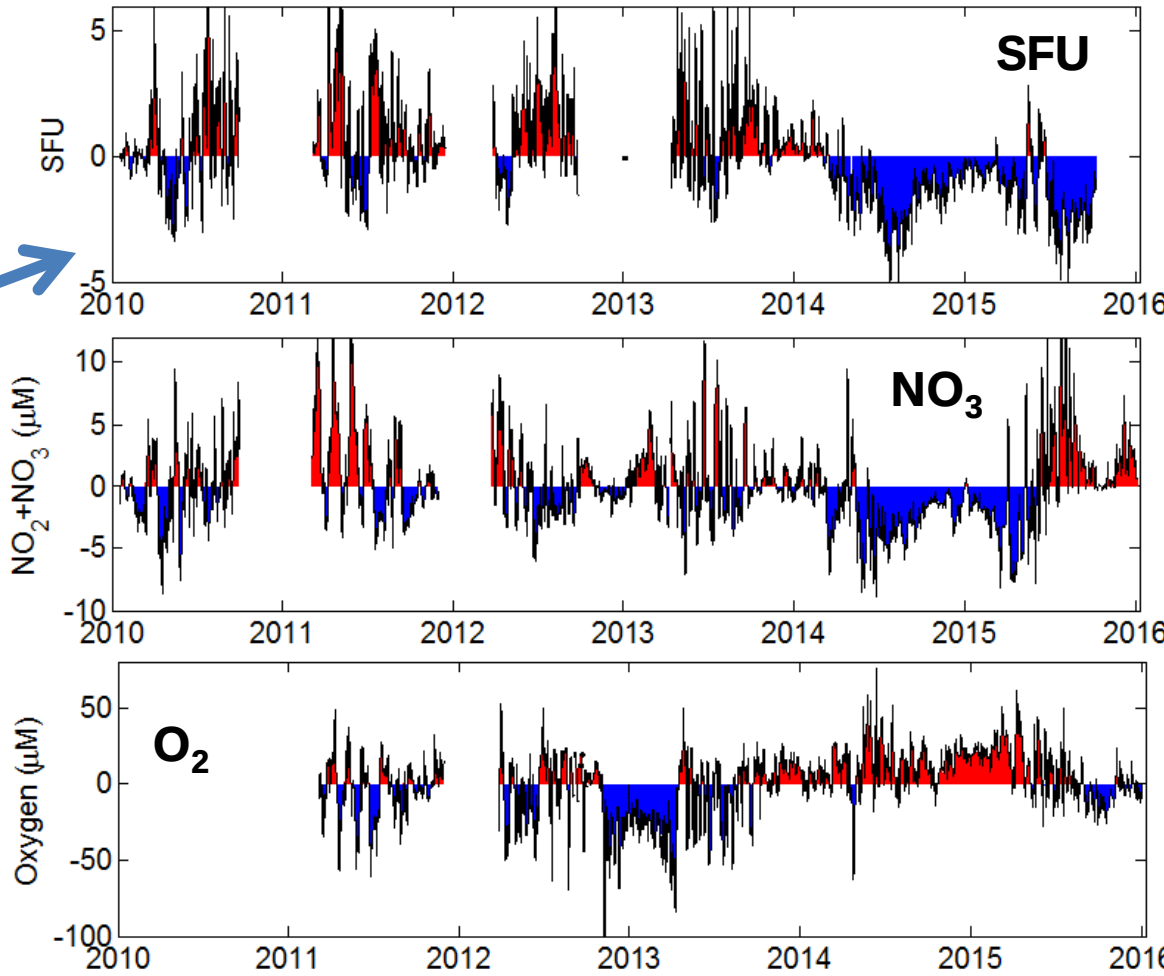



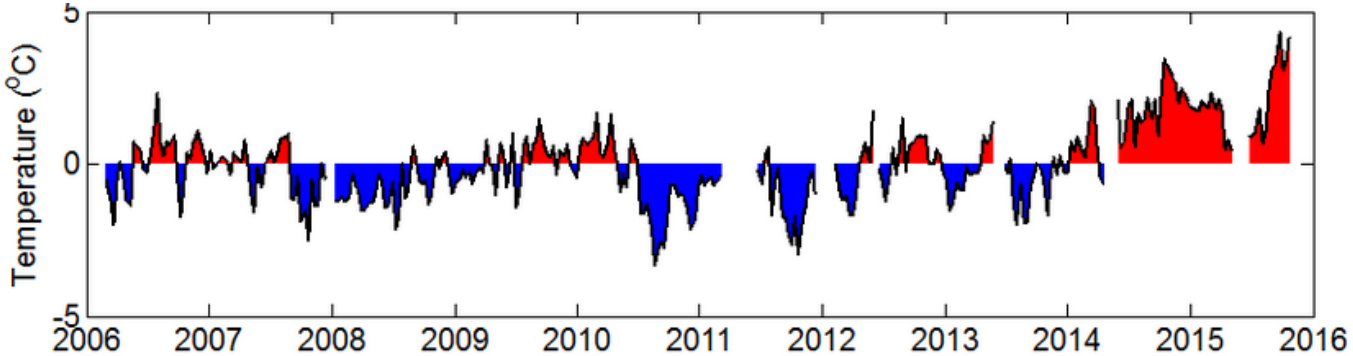

**Suggests warming by anomalous surface heat flux and reduced upwelling**

# Localized views from moorings:




## 15m anomalies at CCE2 mooring



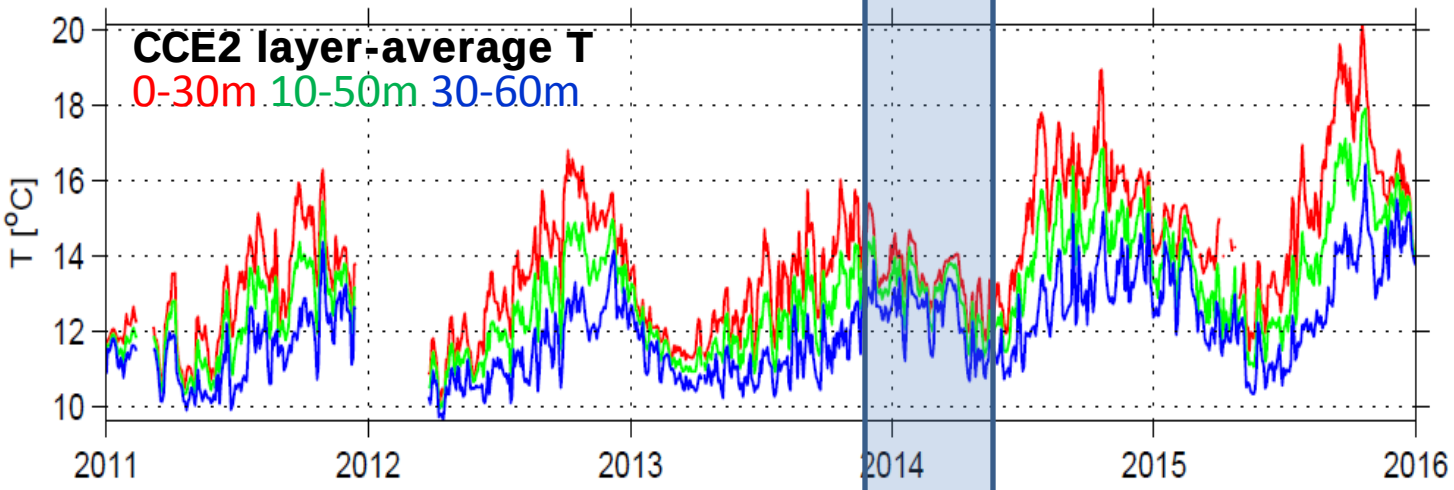



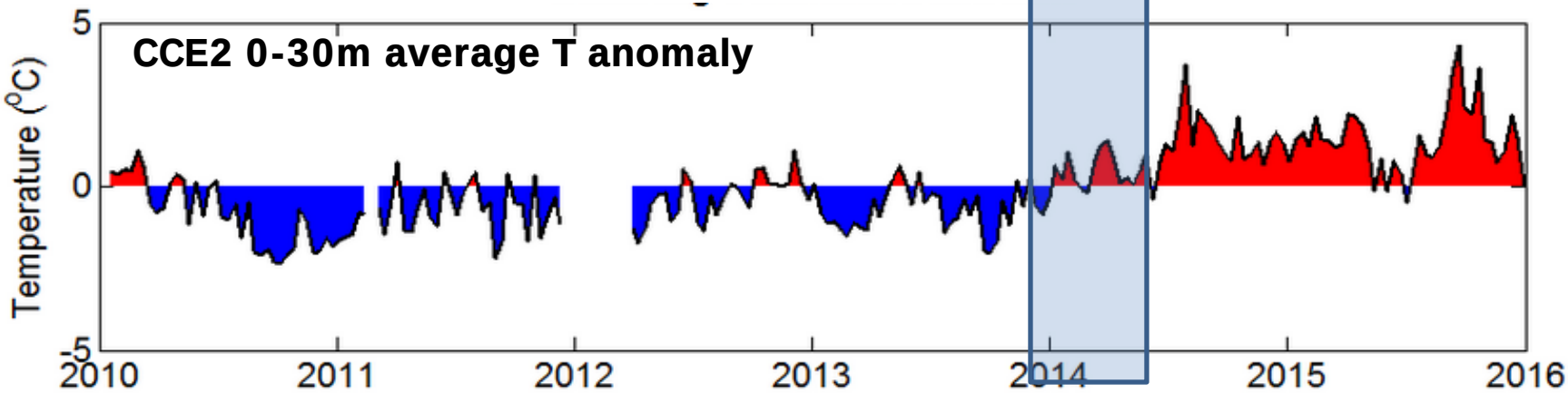

**0-30m T anomalies at Del Mar mooring**

**The warm anomaly developed already during a cooling phase:**

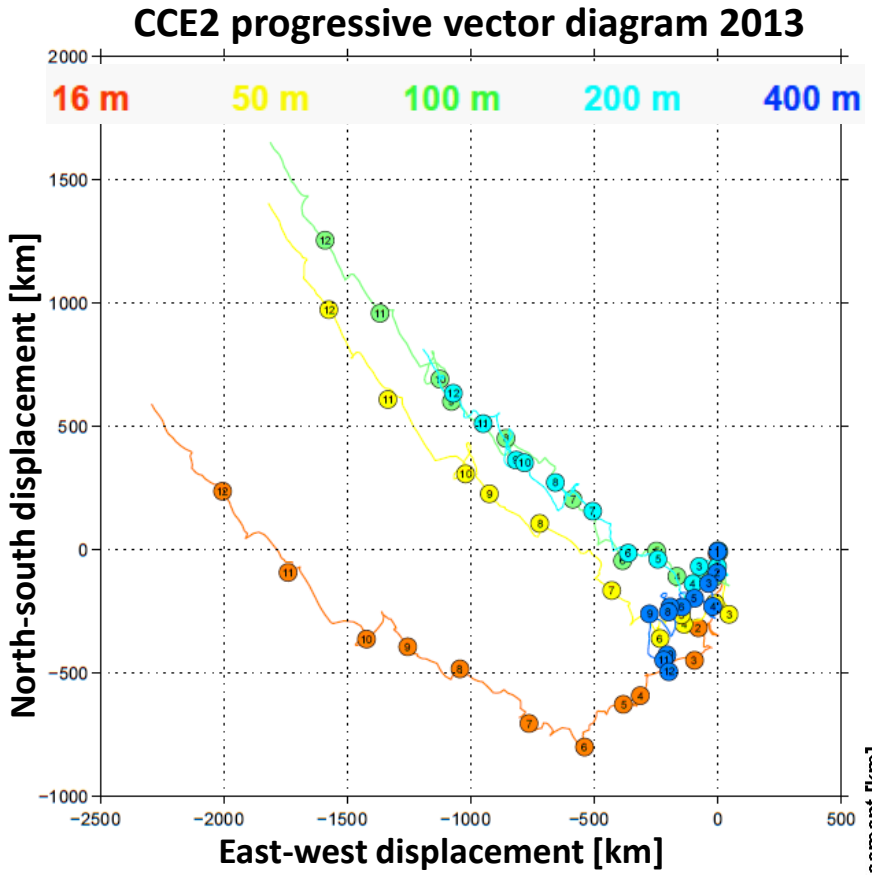
- **Higher surface heat fluxes ?**
- **Reduced upwelling ?**
- **Advection from offshore (downwelling) ?**
- **Increased advection from south ?**

the cooling requires upwelling

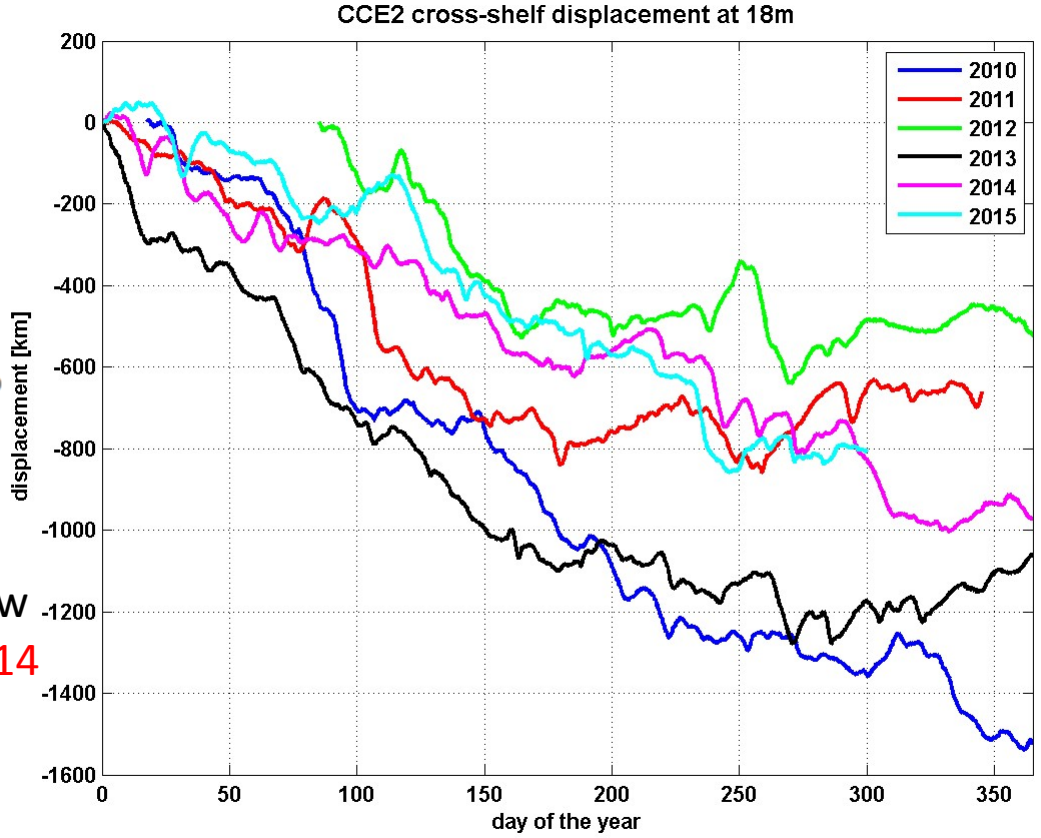


# Moorings can measure the upwelling circulation



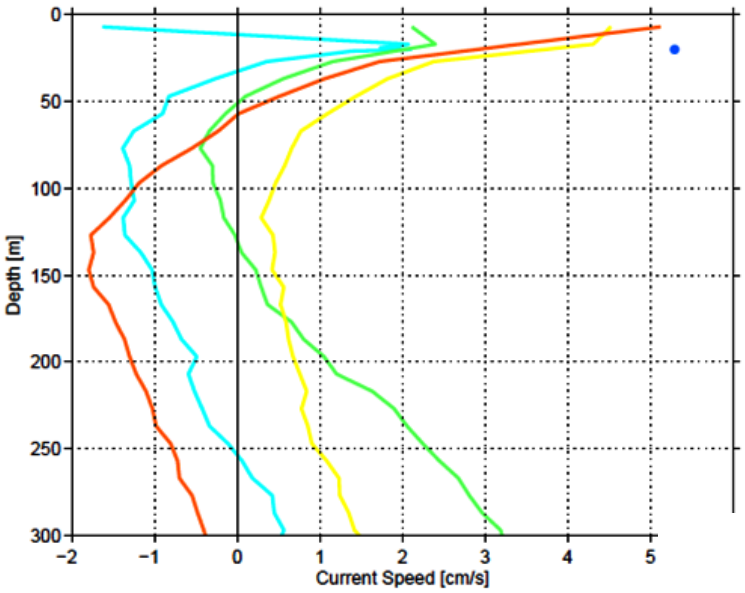

- alongshore/cross-shore well defined
- upper layer offshore for 6 months, then relaxation-like poleward flow
- deeper layers always poleward




- Upper layer nearly always offshore flow
  negligible downwelling, also not in 2014
- Break in slope mid-year
- 2014 had ongoing offshore flow
- Similar at Del Mar mooring

# Cross-shelf shear is highly correlated with wind (2deg to the south)

**CCE2 velocities in offshore direction**




01-Jan-2010 to 28-Oct-2010

01-Jan-2011 to 28-Oct-2011

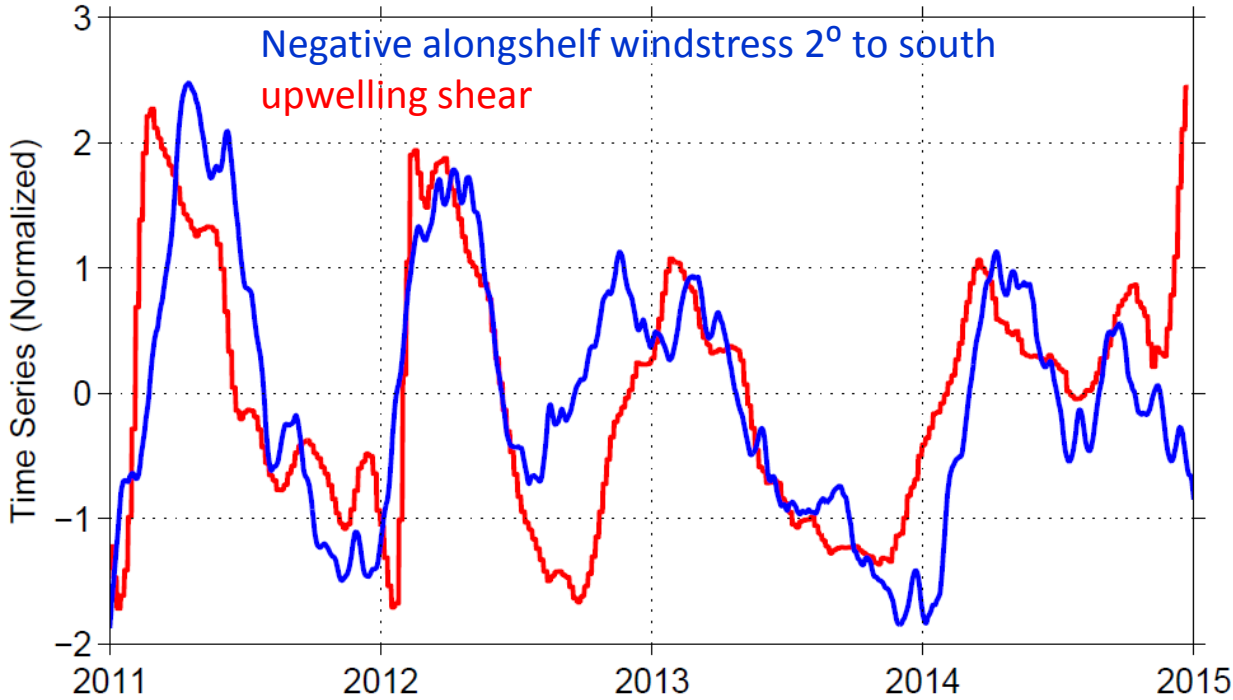
01-Jan-2012 to 27-Oct-2012

01-Jan-2013 to 28-Oct-2013

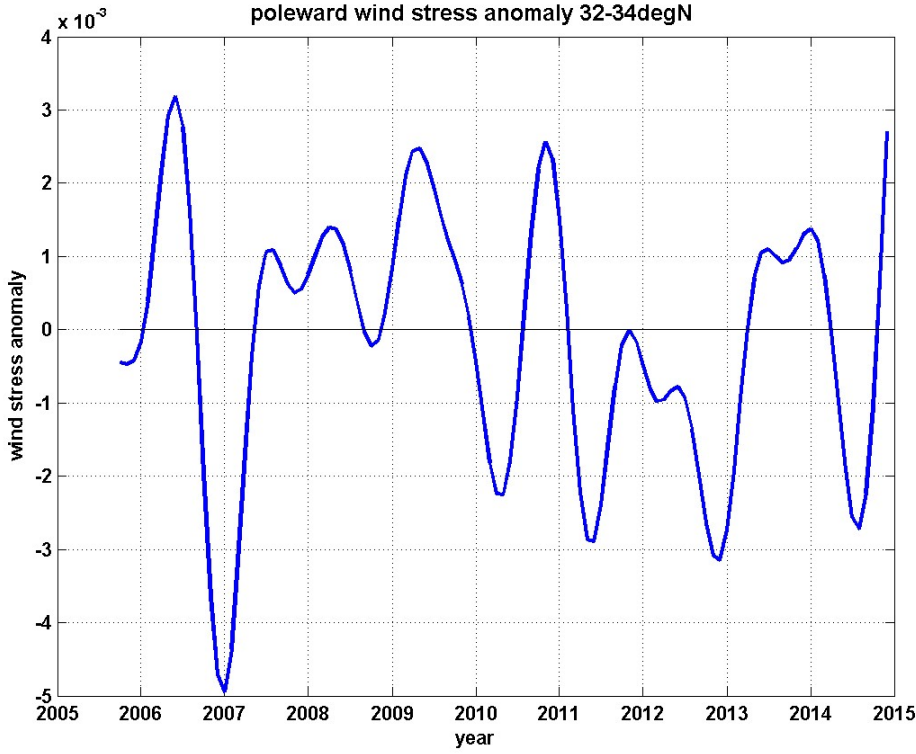
01-Jan-2014 to 28-Oct-2014

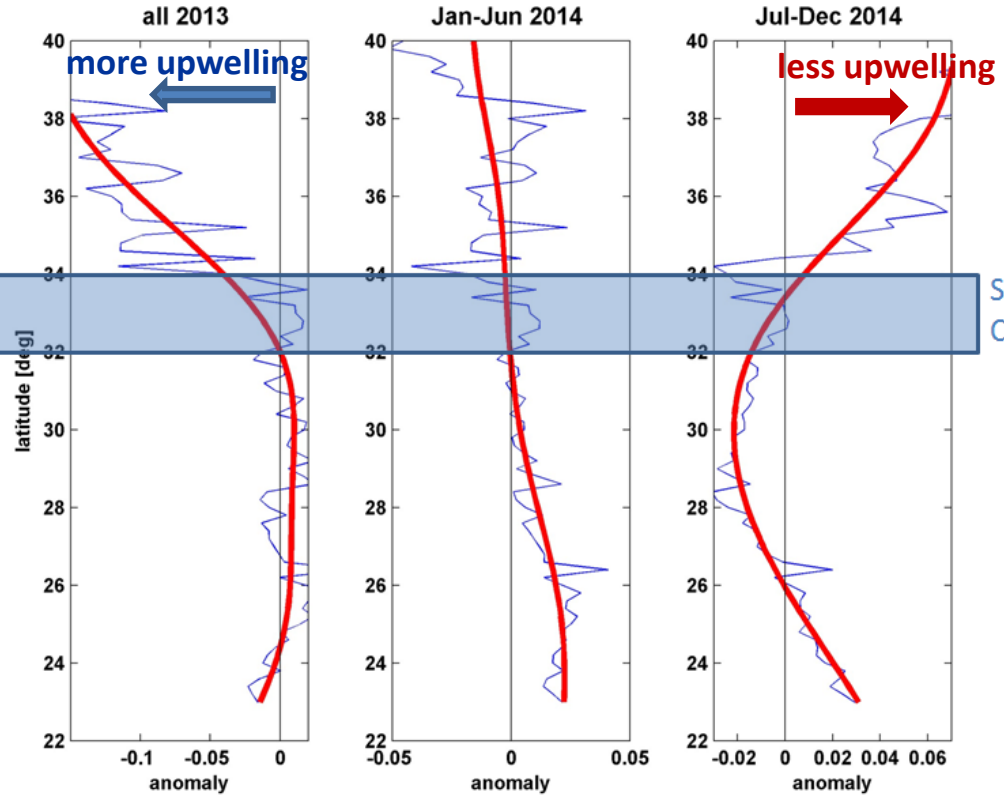
**2014 average of upwelling circulation was not anomalously low**

**CCE2 shear correlation with wind stress**



# NCEP NARR model along-shelf wind stress anomaly 1deg away from the coast

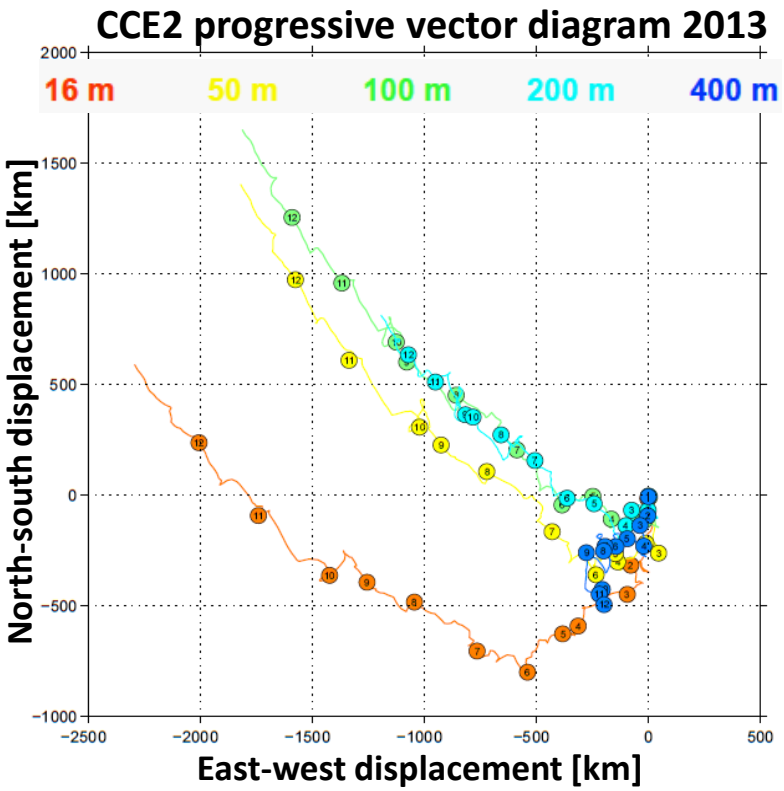


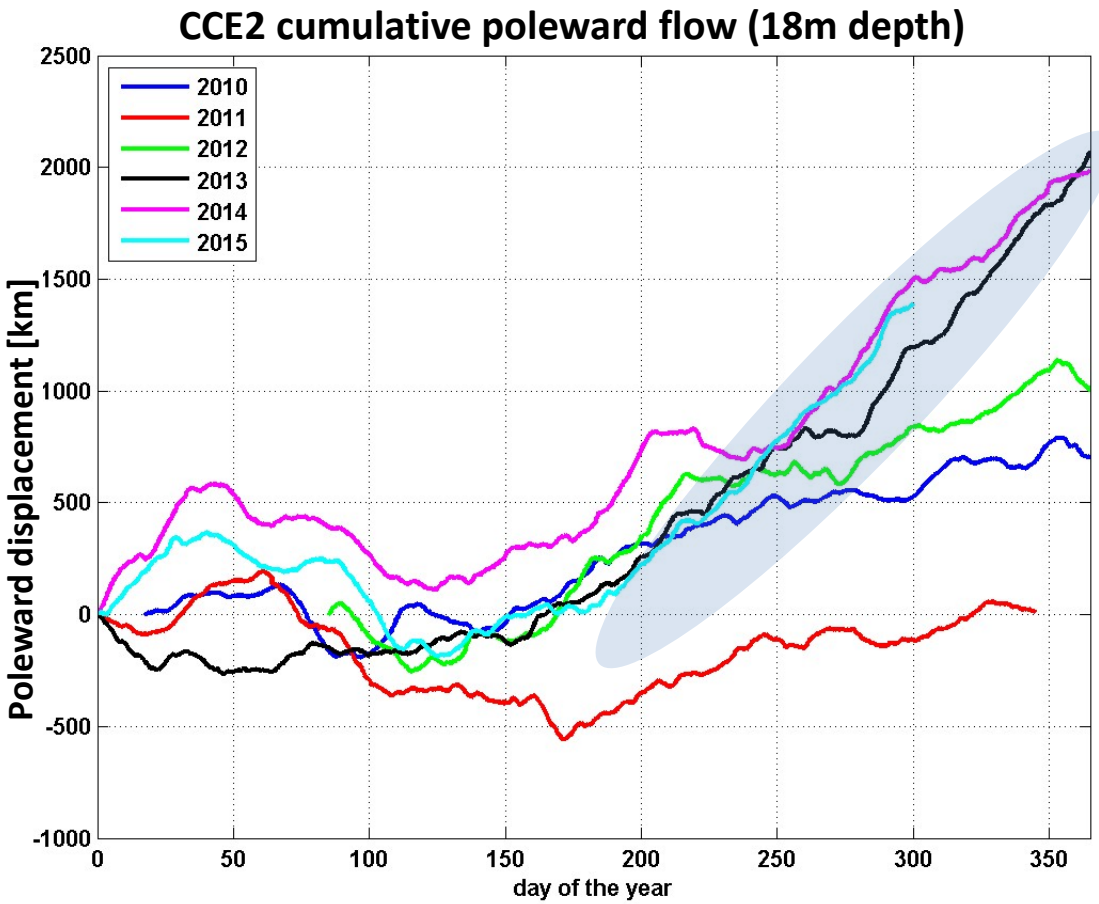




**Upwelling winds in NARR model not anomalously low (except north of Pt. Conception from summer 2014).**

**(confirmed by NDBC buoy south of Pt. Conception)**

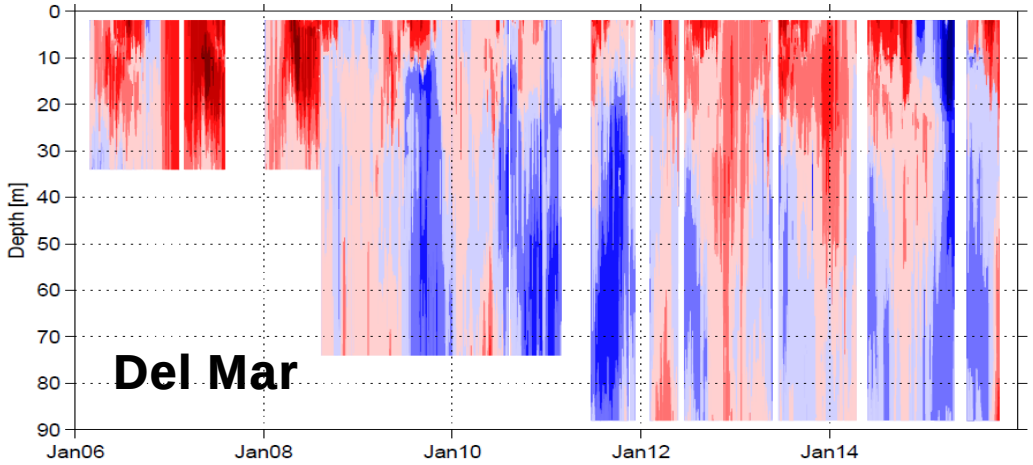
# Integrated upper-layer poleward flow (displacement)

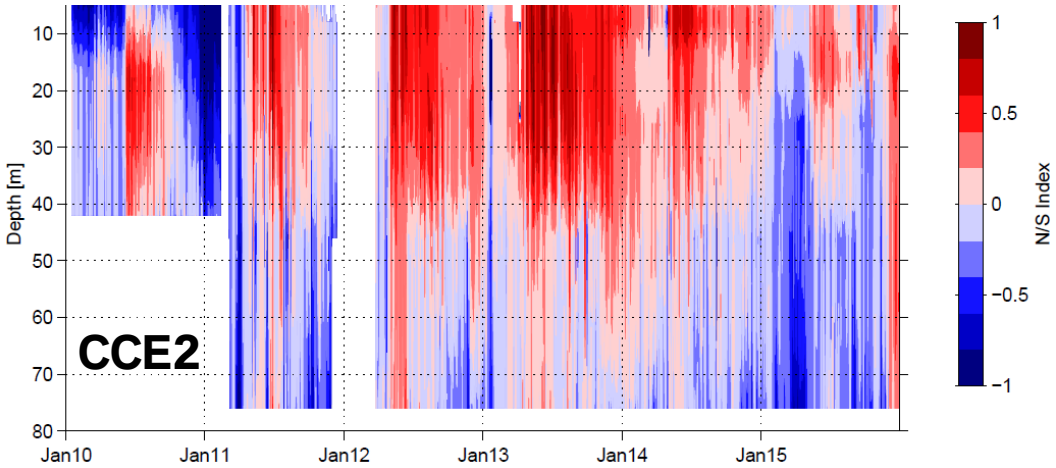


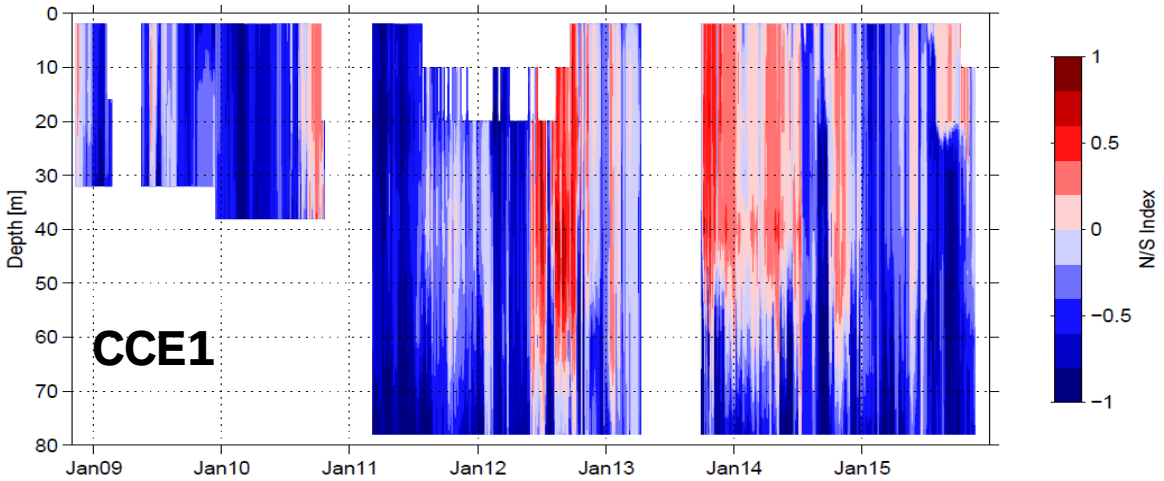




Poleward after end of upwelling season (seasonal relaxation).

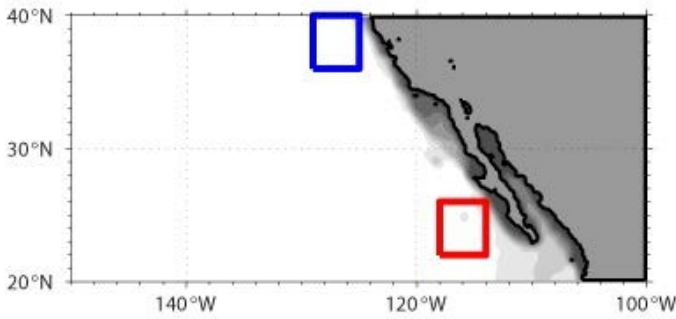
**Large anomalous upper-layer poleward flow in 2013, 2014, 2015**

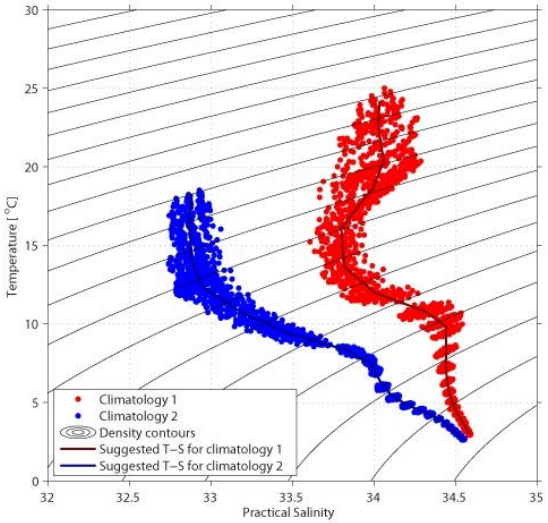


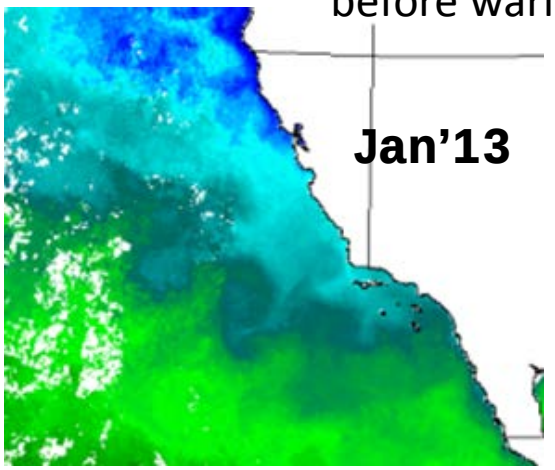



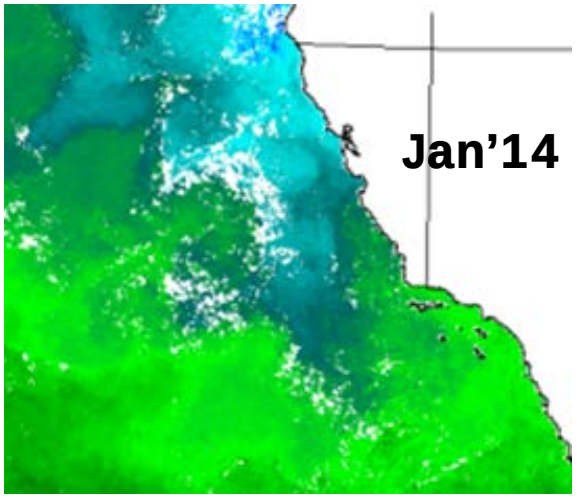

**North-South water mass index shows more southern water in 2012/2013**



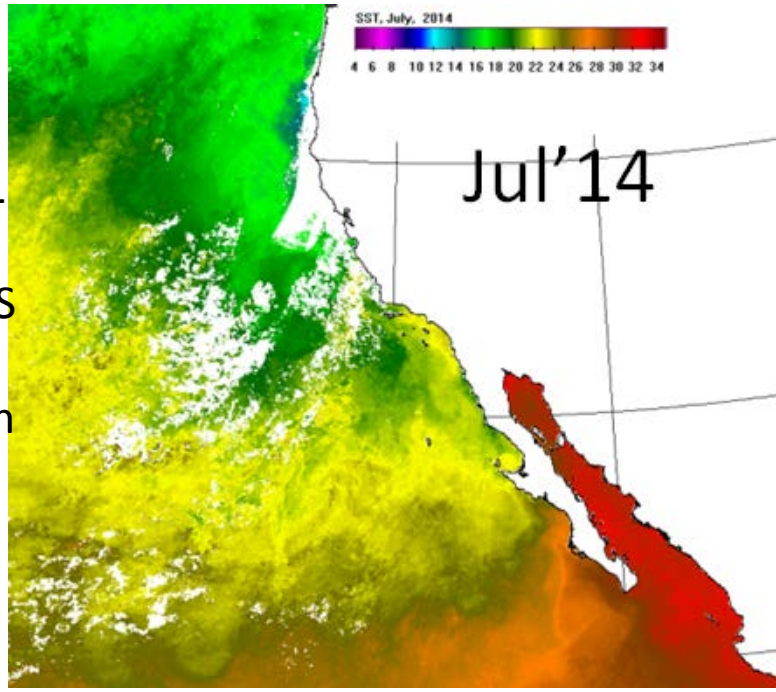



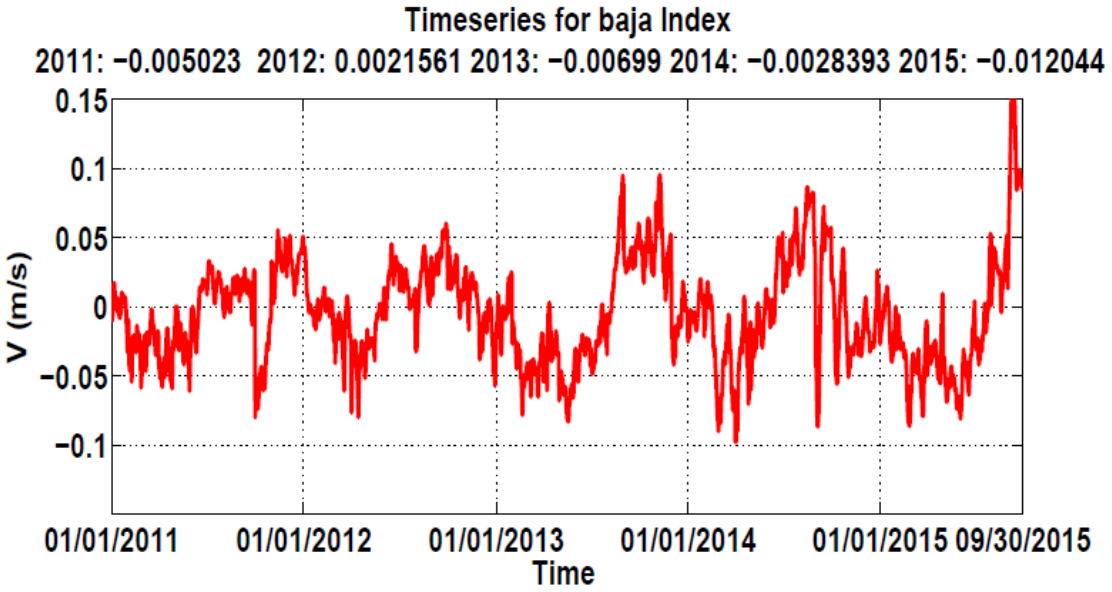
SST suggestive of northward flow before warming




Northward advection WILL bring warmer water. Note N/S and E/W gradients which are lost in anomaly maps.

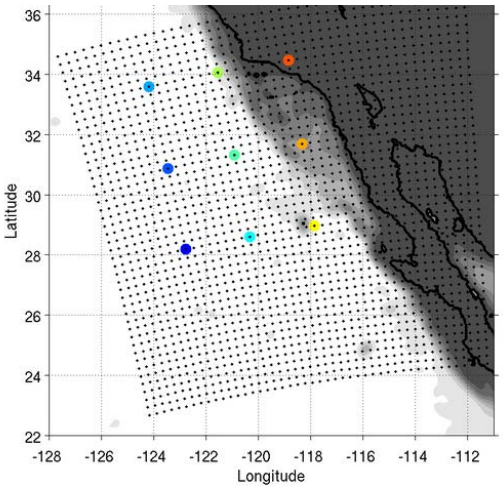


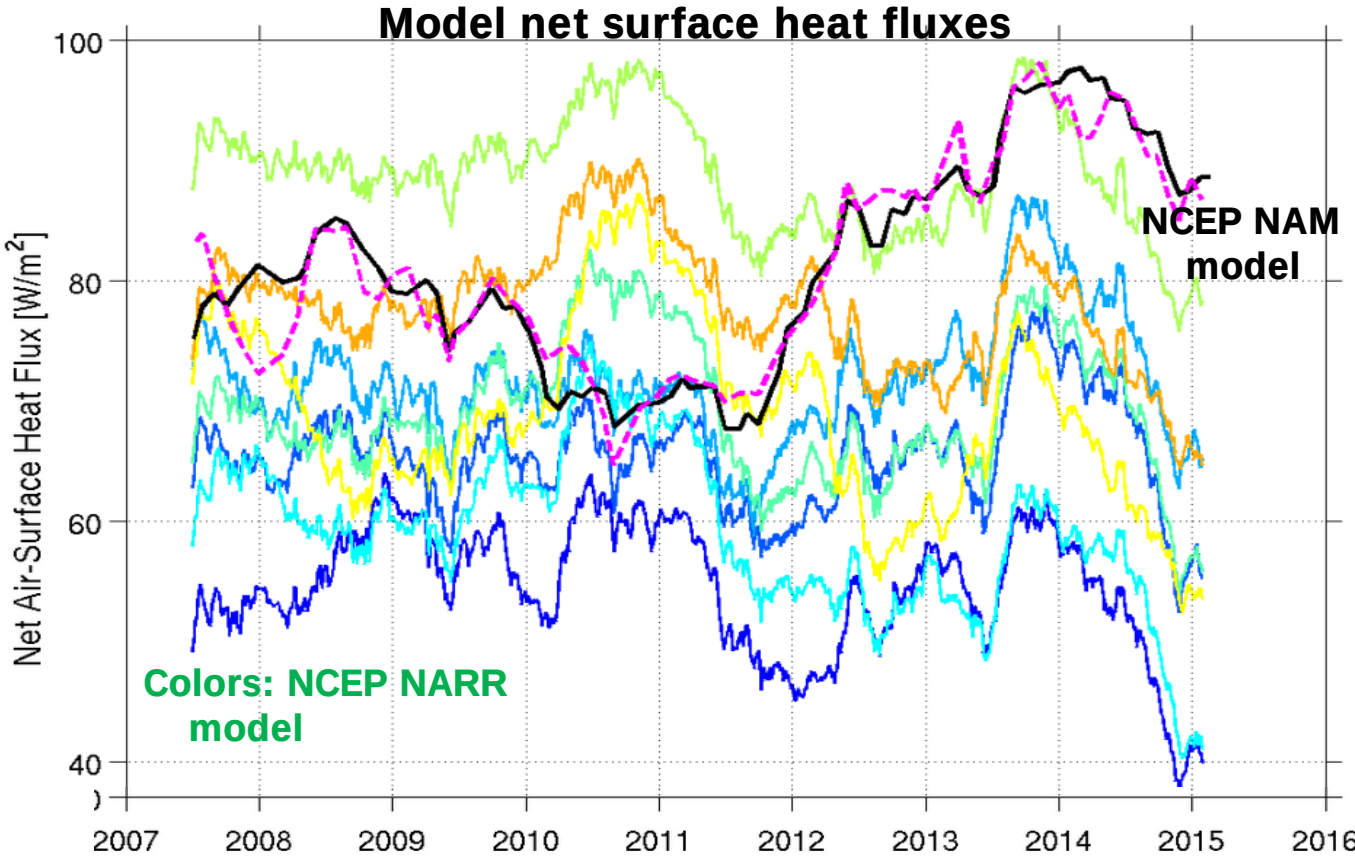




CORC state estimate also shows long enough poleward flow off Baja California to reach Pt. Conception (B.Cornuelle/G. Gopalakrishnan)

**Recap and pressing questions:**

- Upwelling continues during anomalous warming phase (i.e. not warming by onshore flow)
- Upwelling (overturning) circulation (and winds) apparently not weaker in 2014
- Anomalous alongshore advection brings anomalous warm water into region (near the coast), already in preceding years
- Different starting conditions for upwelling season
- Surface heat fluxes probably larger in 2014, but different models give different answers:




If surface heat flux forcing is atmospheric, how did poleward flow propagate/get generated ?