Wind Relaxations
in the California Current Large Marine Ecosystem

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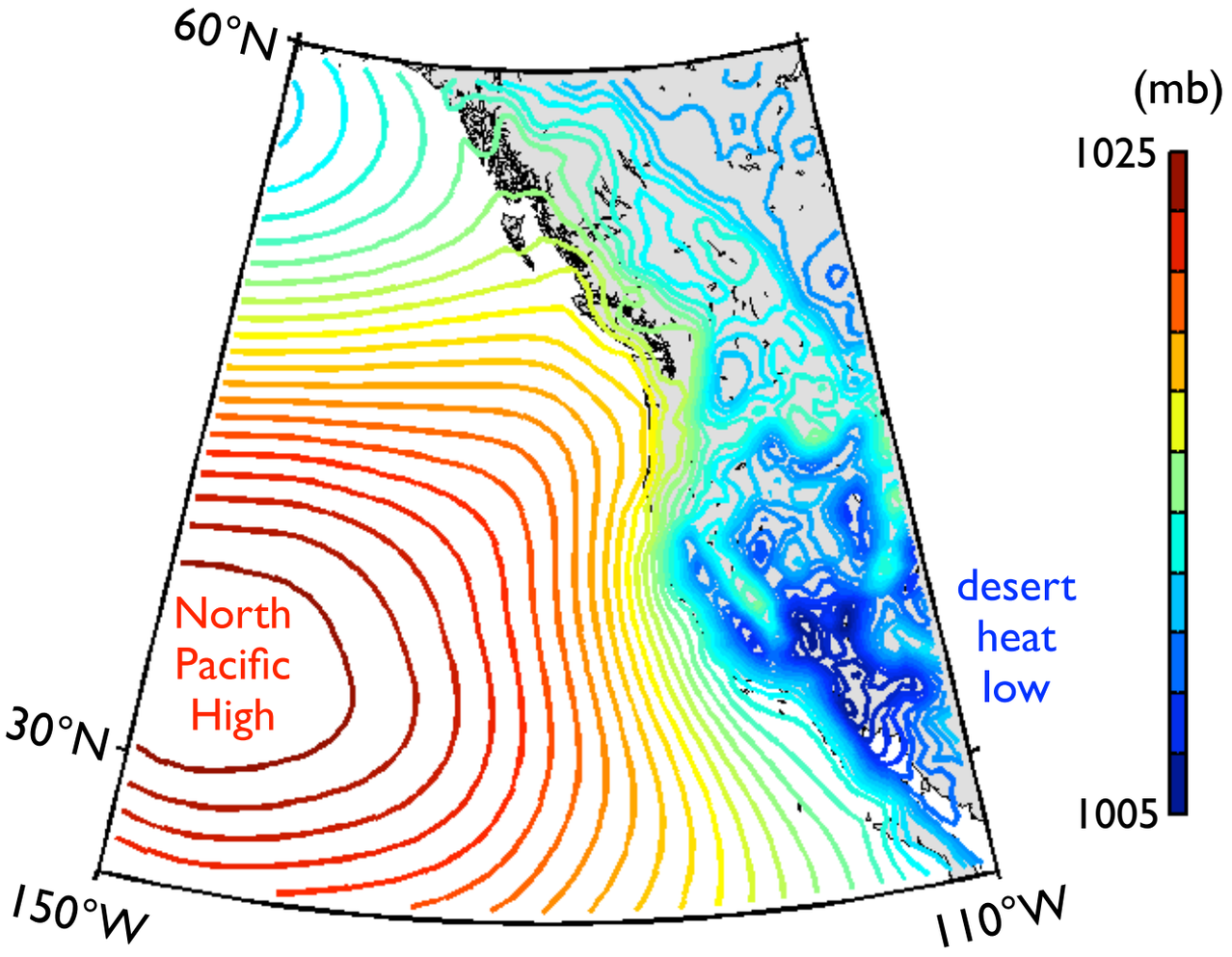
In summer off the West Coast of North America, the prevailing wind is upwelling-favorable and driven by the North Pacific High.

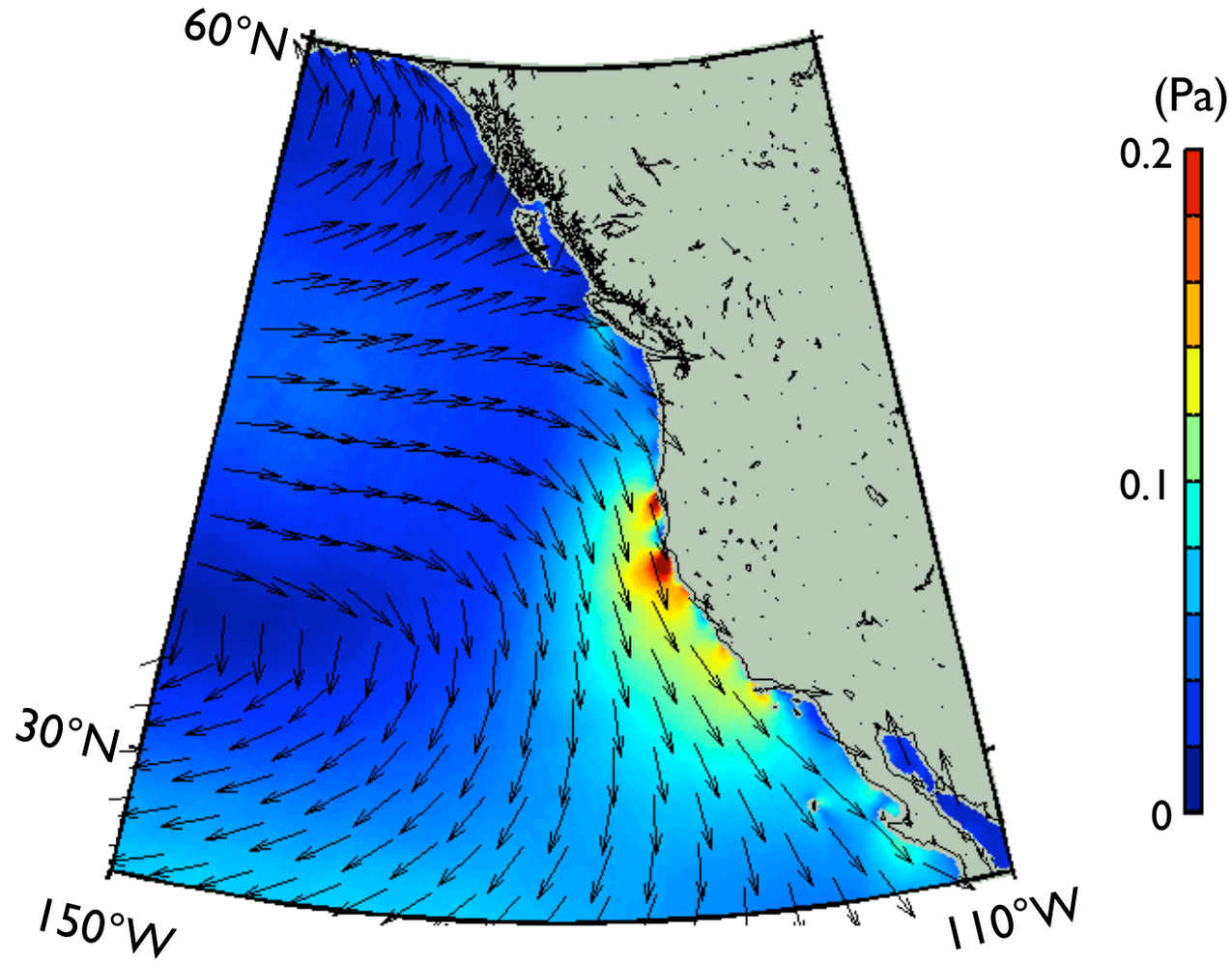
mean sea-level pressure

May–August

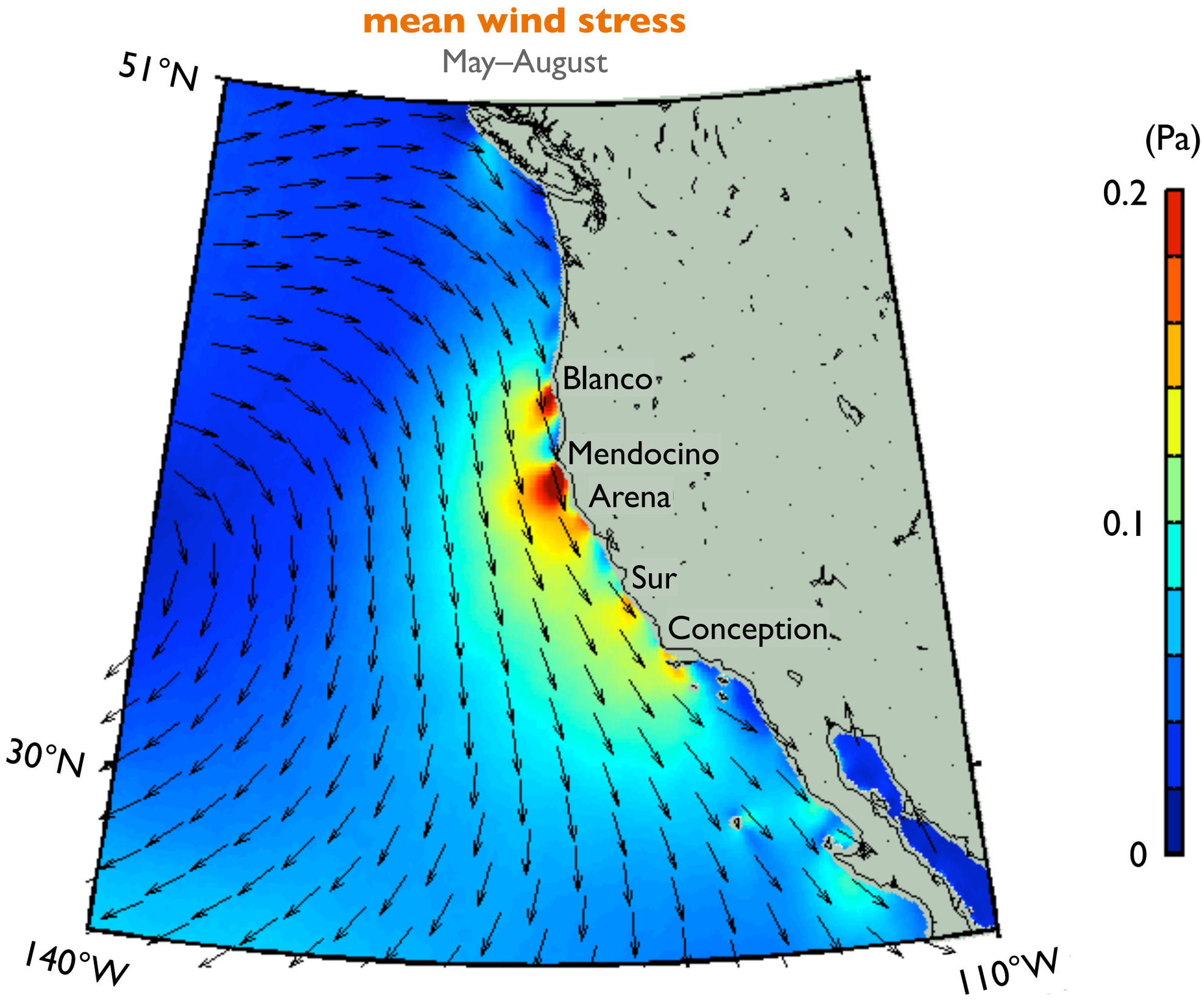


mean wind stress

May–August



The wind stress is enhanced at 5 major capes.



The coastal upwelling brings cold water to the surface.

The upwelled water is **nutrient-rich** but can be **oxygen-poor** and **low pH.**

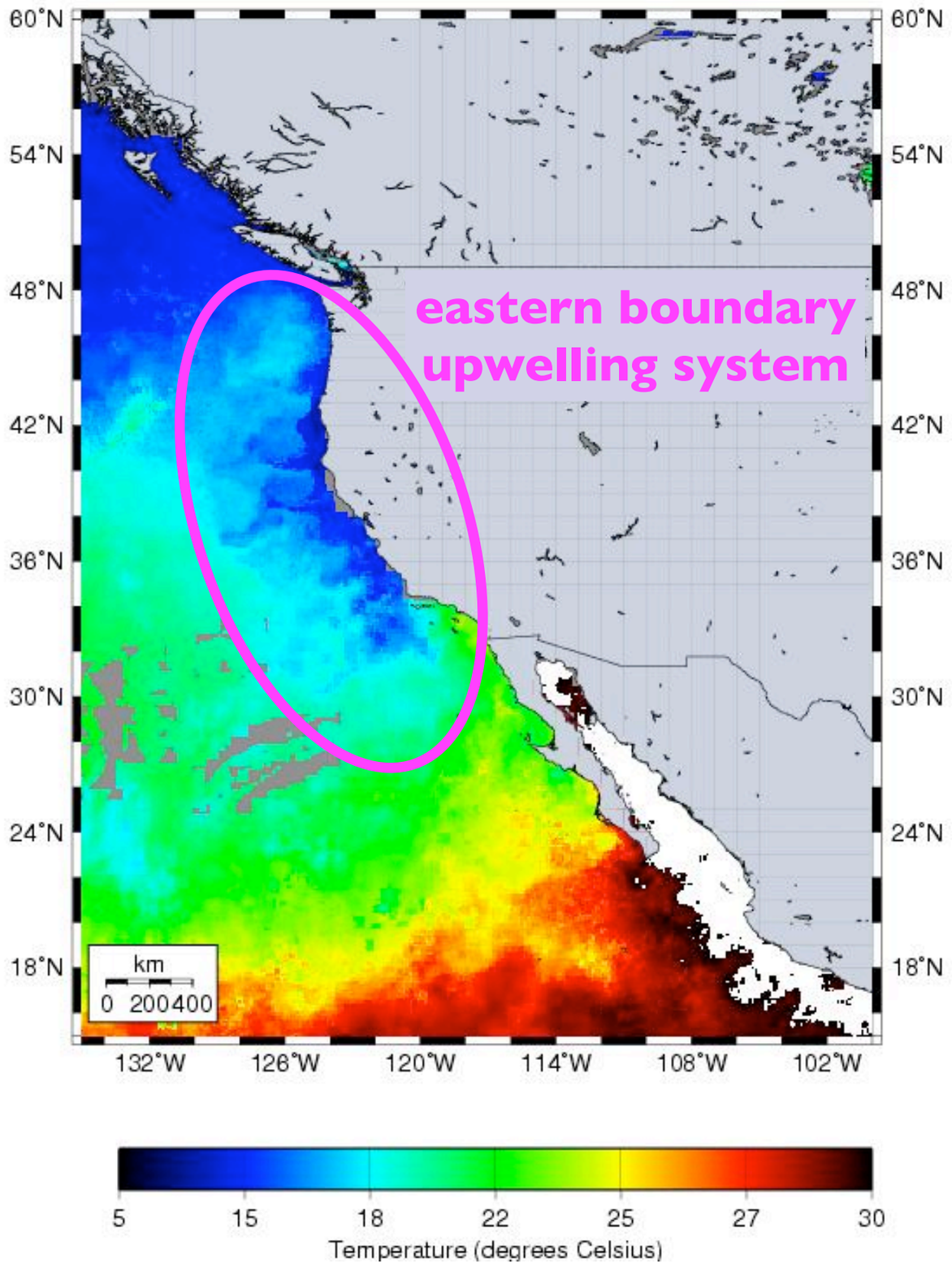
rockfish

spiny lobster

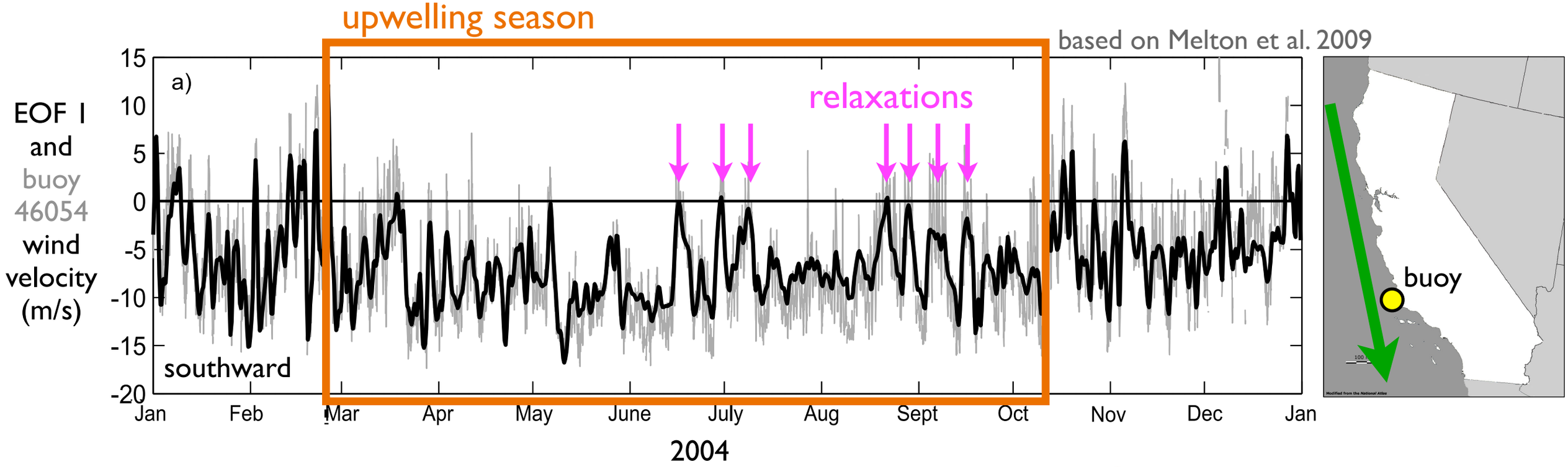
kelp bass

sea-surface temperature

AVHRR-GAC SST from 16 Jul 2006 to 18 Jul 2006



The upwelling-favorable winds periodically weaken or "relax".



note wind rarely reverses direction at Pt. Conception

3 types of wind data:

(1) NDBC buoys

National Data Buoy Center

- hourly, 1982–present

(2) NARR reanalysis

- 32-km grid
- 8x daily, 1979–present
- atmospheric pressure
- 500-mb height

(3) QuikSCAT satellite

- JPL L2 Version 3
- 1999–2009

At Pt. Conception, wind relaxation allows buoyant poleward flow.

- cold upwelled water is replaced by warm water from south of Pt. Conception
- important for larval transport
- similar flows in other upwelling systems

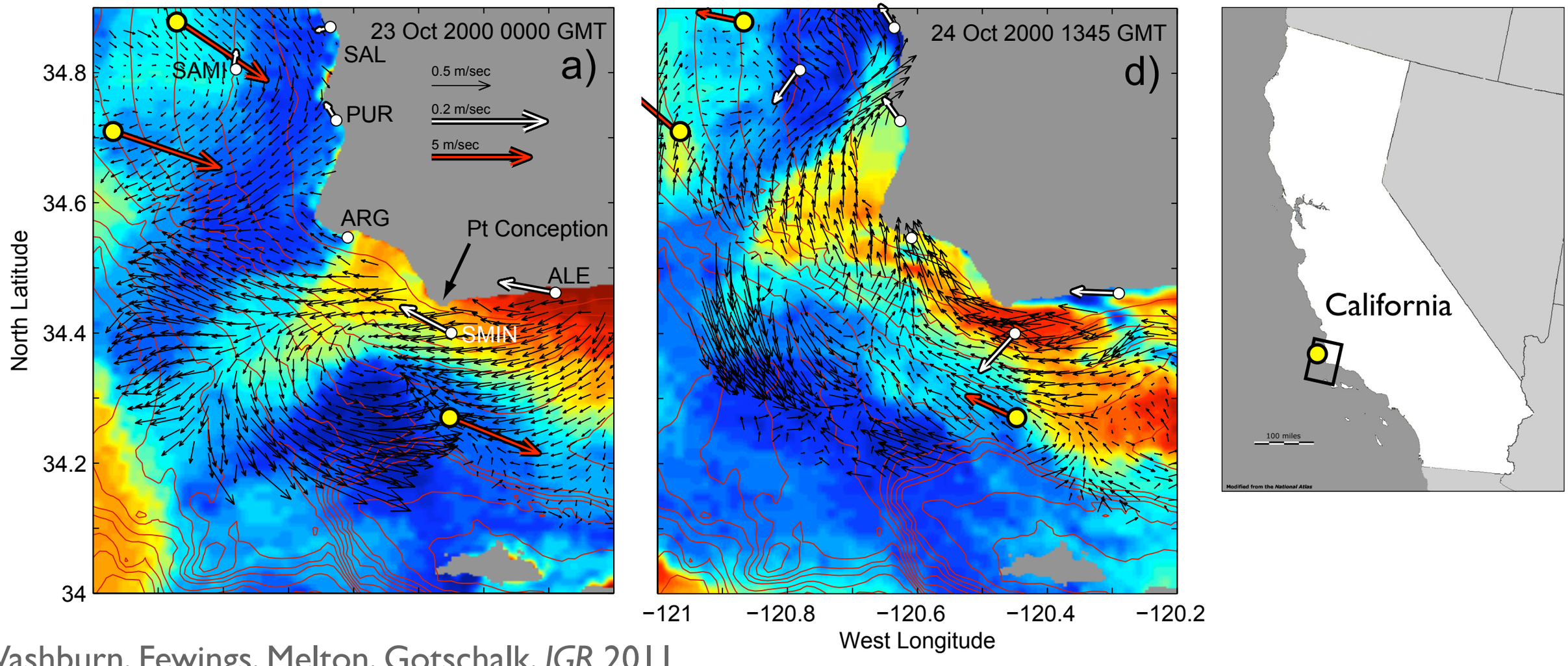
  Iberia:

  García-Lafuente et al, 2006,

  Relvas & Barton, 2002, 2006

  Benguela:

  Fawcett et al. 2008



Washburn, Fewings, Melton, Gotschalk, *JGR* 2011

Questions:

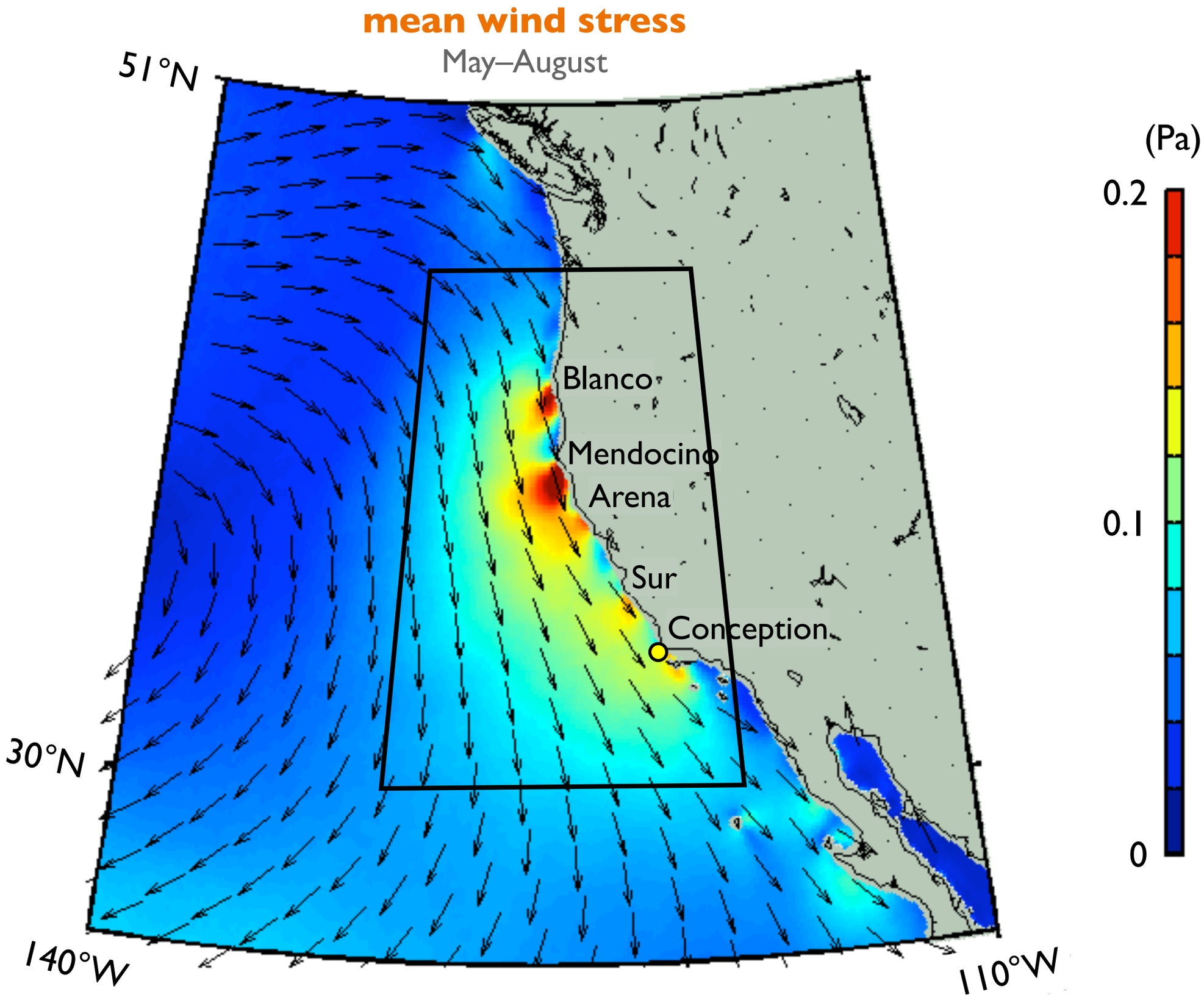
What causes the wind relaxations at Pt. Conception?

How are the Pt. C. relaxations related to relaxations/reversals off N. California and Oregon?

Mass and Bond (1996); Bond, Mass, Overland (1996), Bane et al. 2005, 2007 studied wind reversals but not weak winds

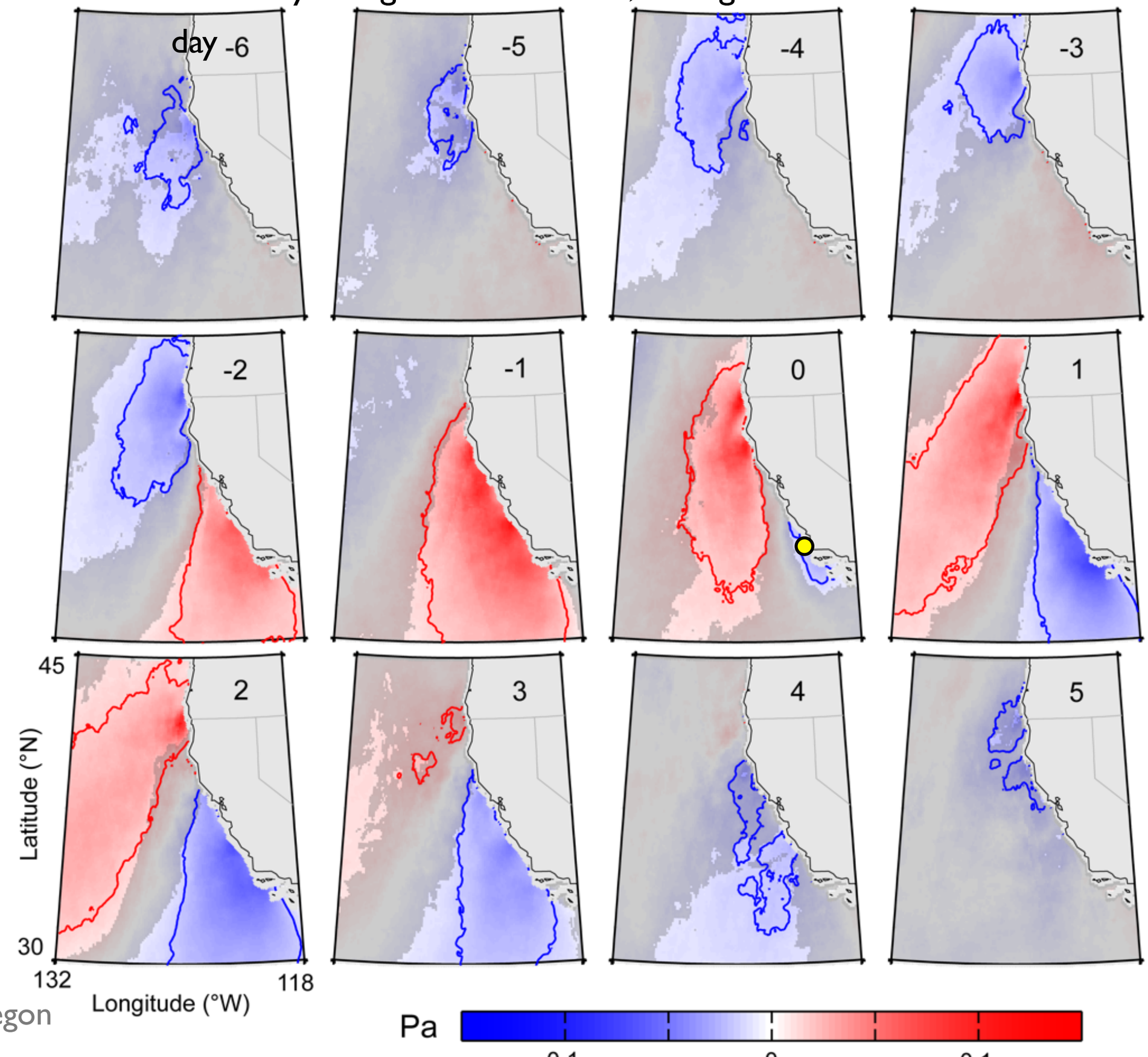
Do the Pt. C. relaxations vary with climate variations and/or jet stream position, like wind reversals off Oregon?

We calculated wind stress anomalies from QuikSCAT, relative to the May-August mean pattern, for ~80 events.



The composite wind relaxation has 3 stages.

wind stress anomaly along mean direction, averaged over ~80 relaxation events



Mass and Bond:
to +48 hr after Oregon reversal

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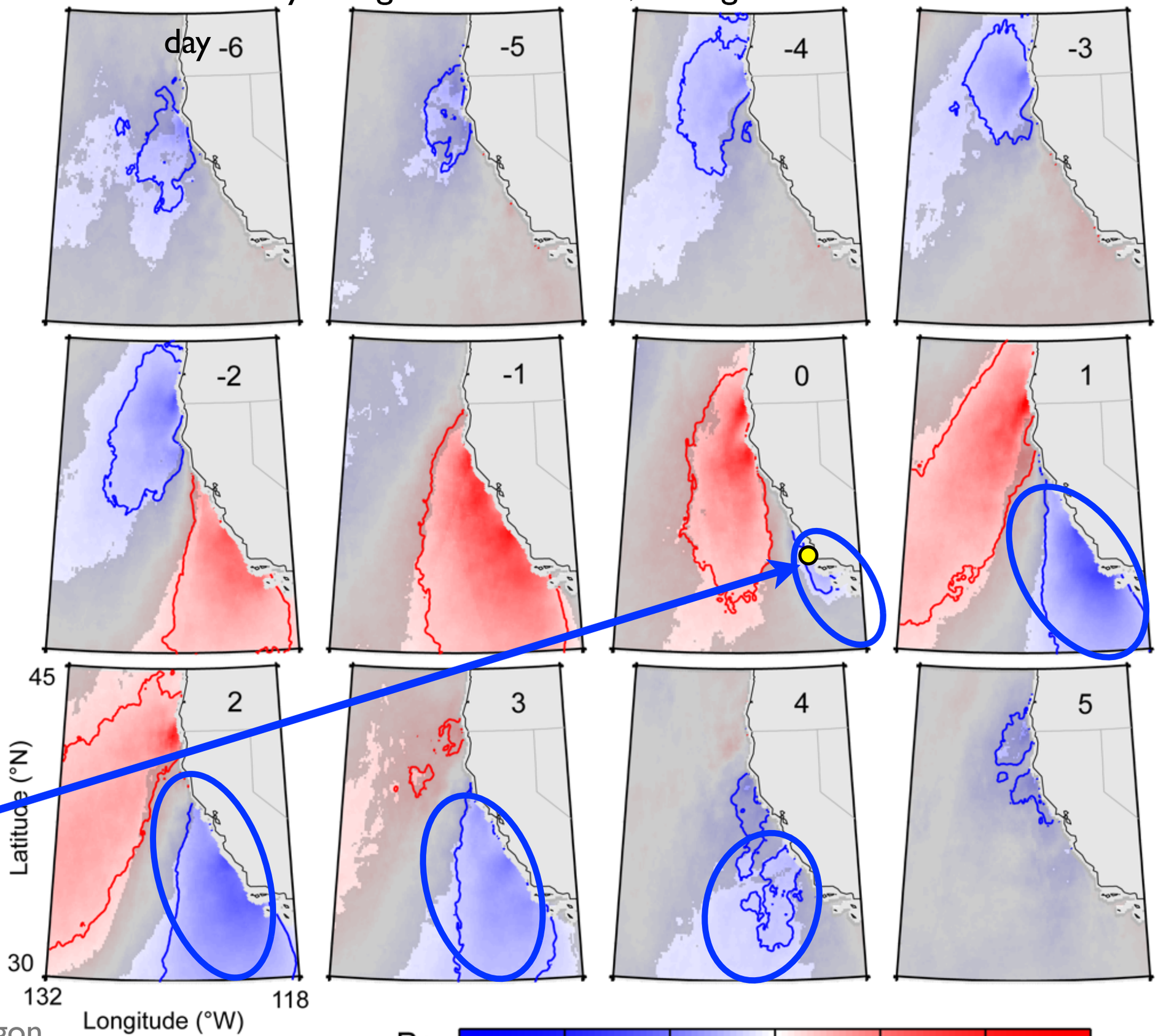

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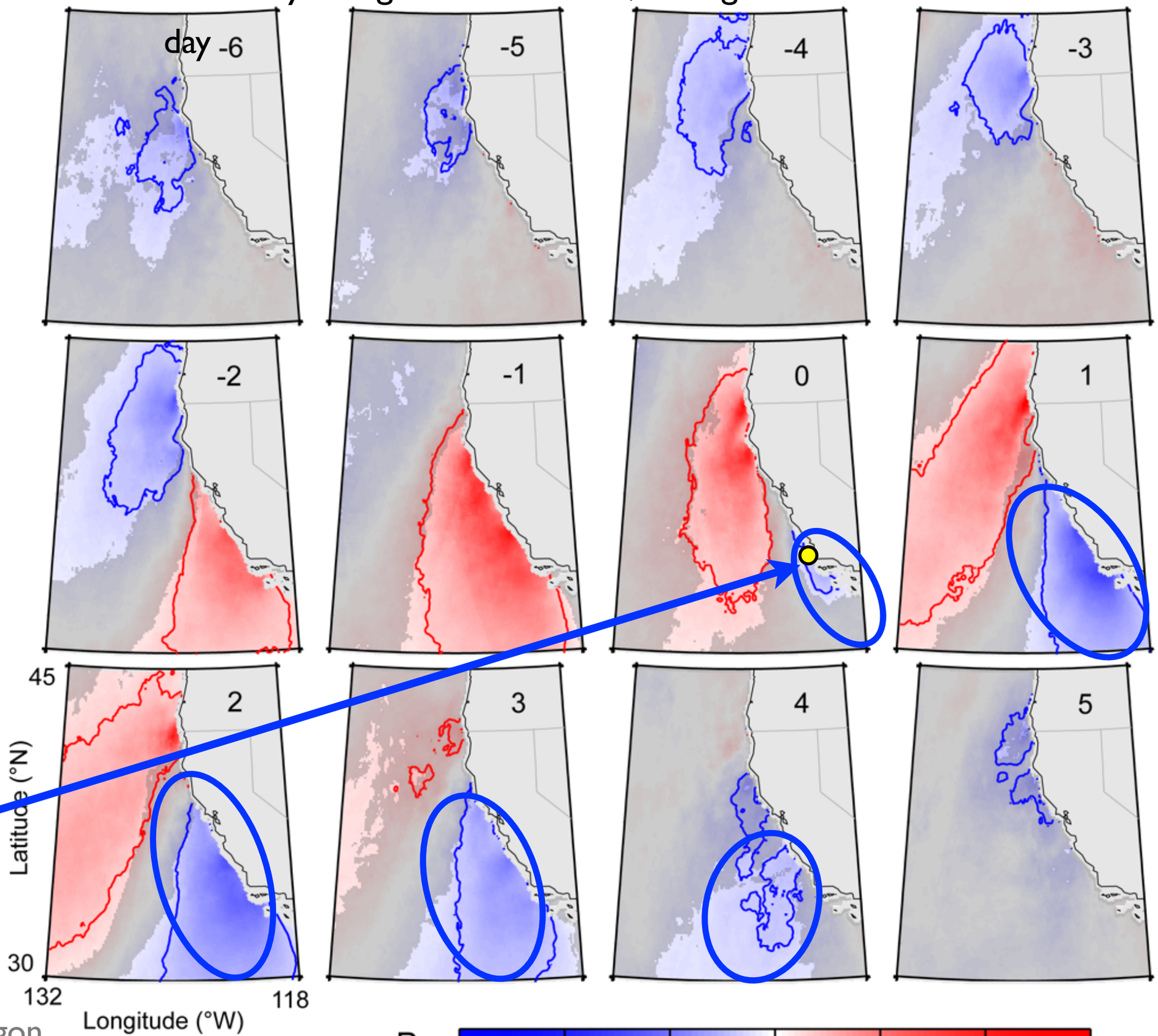


stage 3:
relaxation at
Pt. Conception

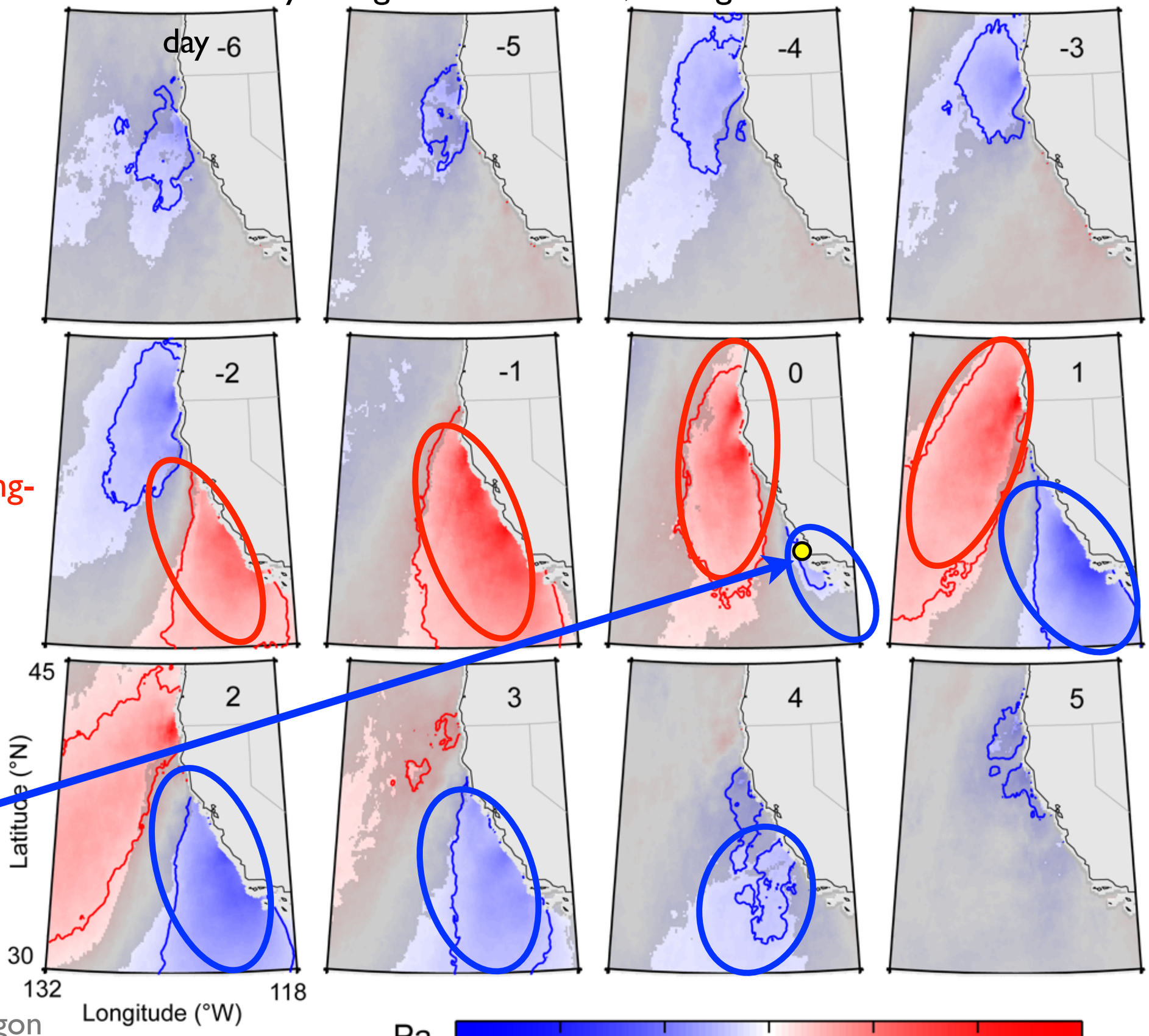
Mass and Bond:
to +48 hr after Oregon
reversal

The composite wind relaxation has 3 stages.

wind stress anomaly along mean direction, averaged over ~80 relaxation events

stage 2:
intensified upwelling-favorable wind

stage 3:
relaxation at Pt. Conception



Mass and Bond:
to +48 hr after Oregon reversal

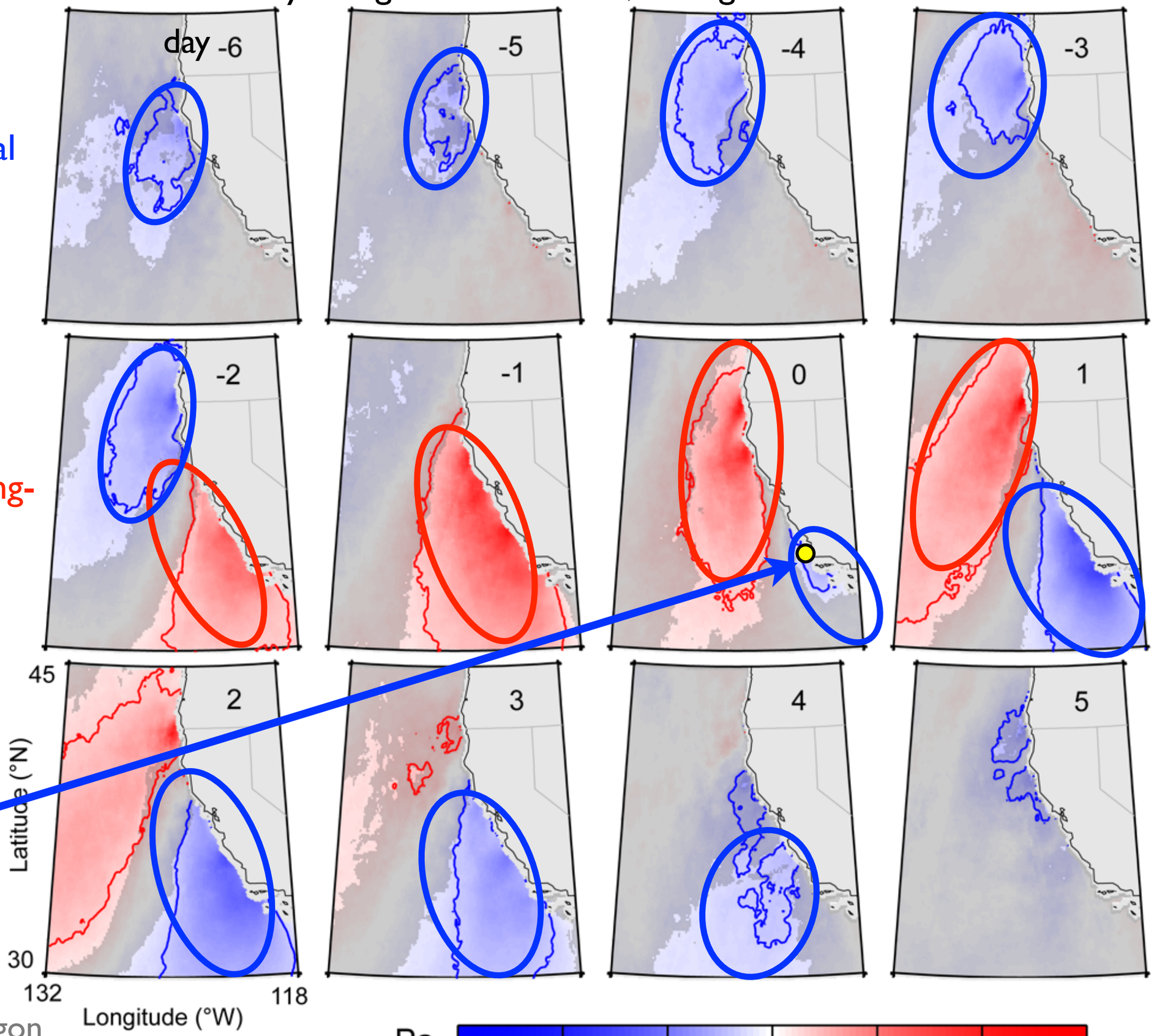
The composite wind relaxation has 3 stages.

wind stress anomaly along mean direction, averaged over ~80 relaxation events

stage 1:
relaxation/reversal
off Oregon

stage 2:
intensified upwelling-
favorable wind

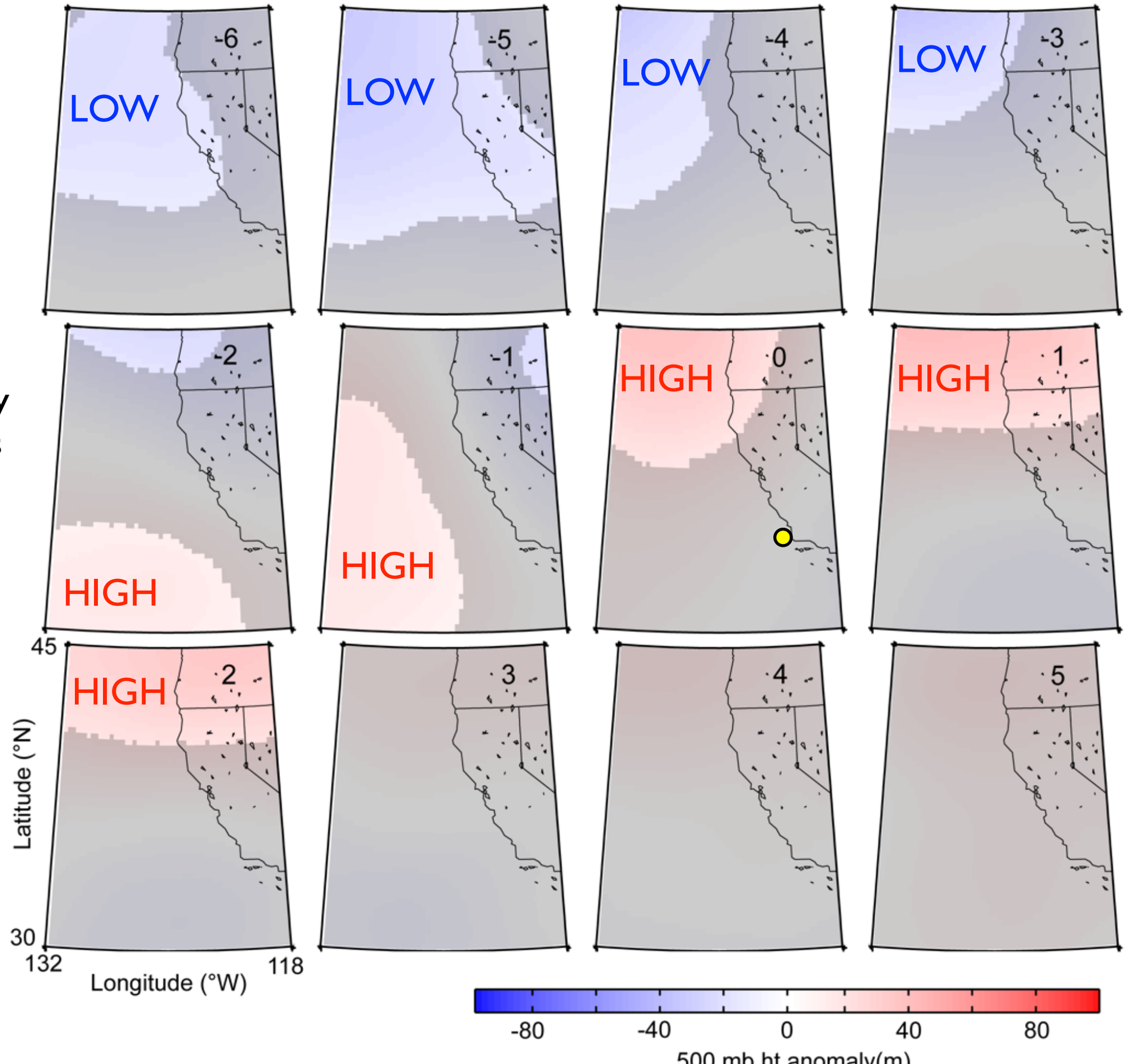
stage 3:
relaxation at
Pt. Conception



Mass and Bond:
to +48 hr after Oregon
reversal

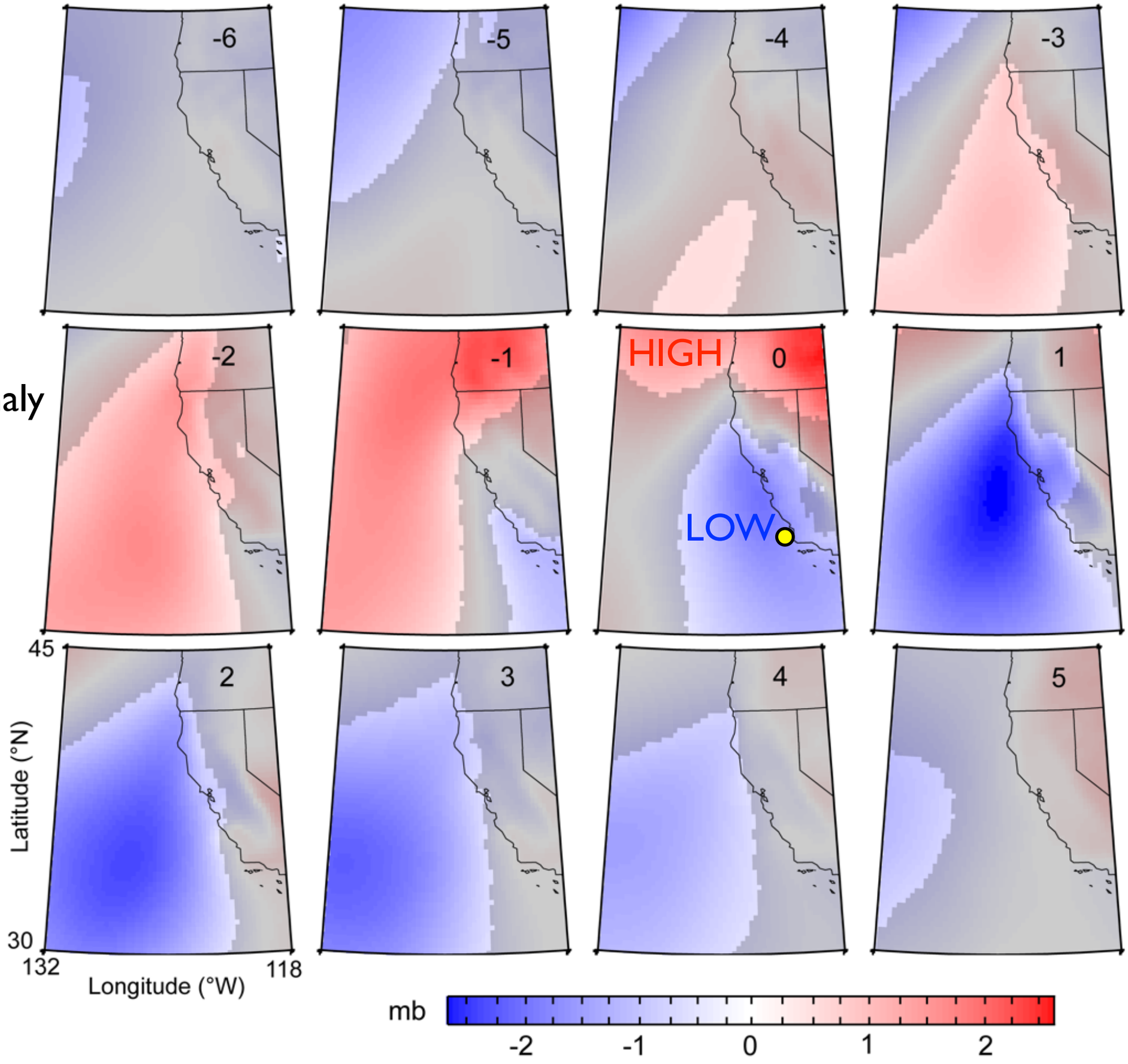
The wind relaxations are preceded by a 500-mb trough in the north...

500-mb height anomaly composite of ~80 events from NARR



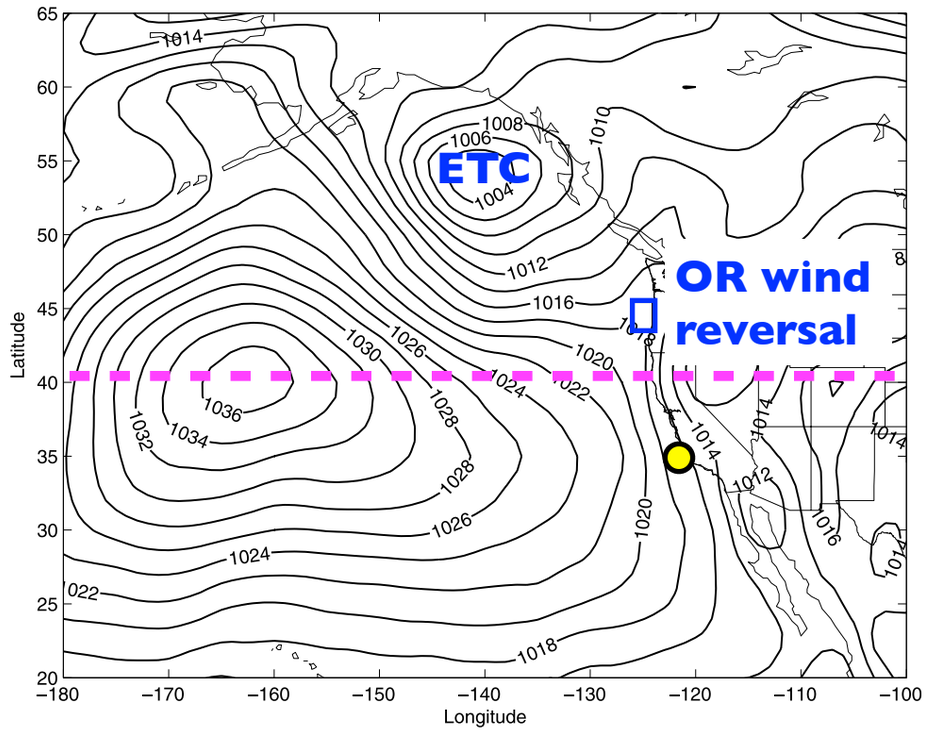
and associated with sea-level pressure anomalies.

sea-level pressure anomaly composite of ~80 events from NARR



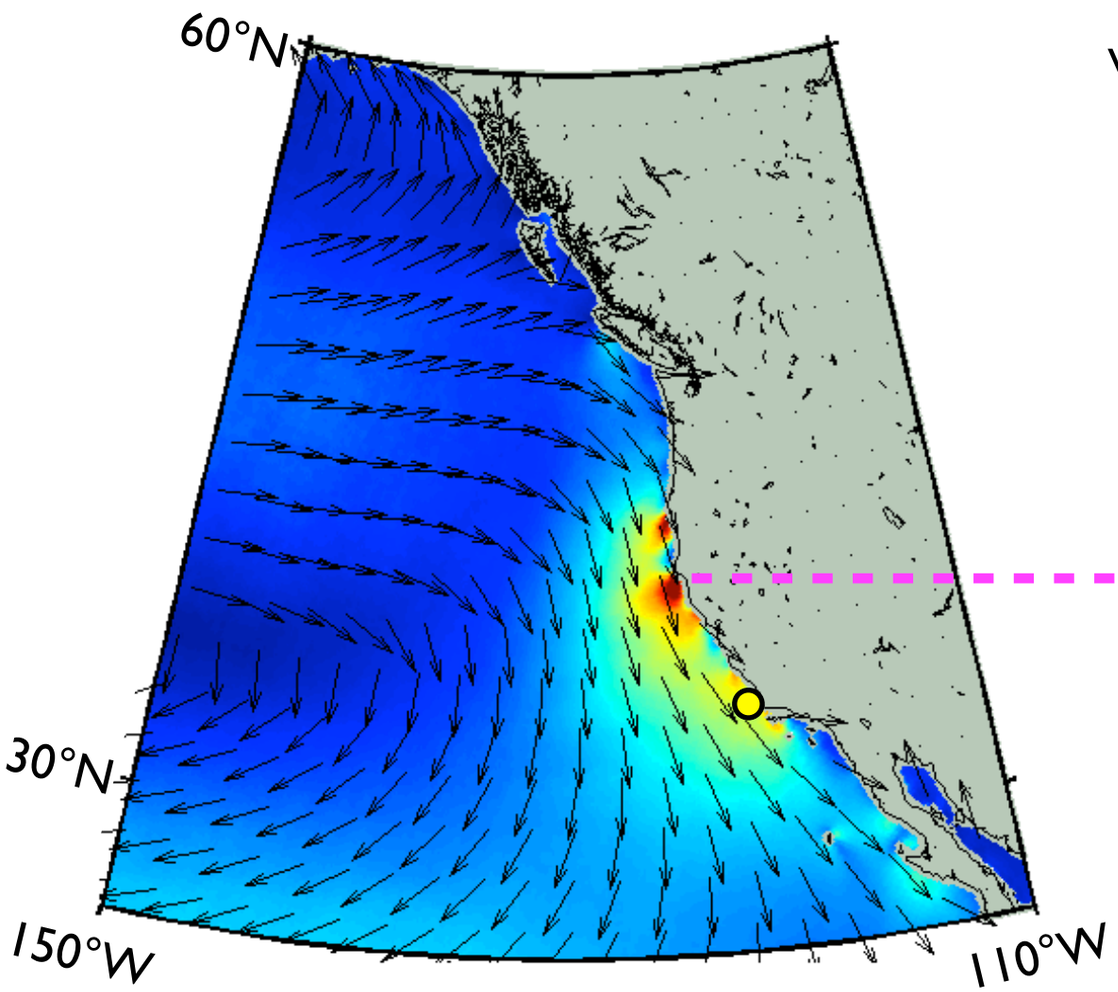
The north and south parts of the upwelling system have different, but linked, wind relaxation dynamics.

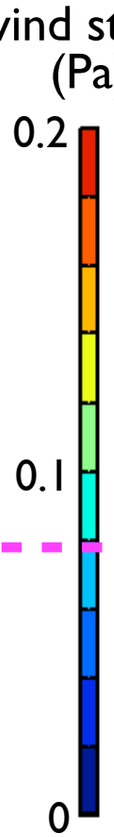
Bane et al. 2001



mean wind stress

May–August





1st, relaxation in north

caused by extra-tropical cyclone & southward shift of jet stream (Bane et al. 2001, 2007)

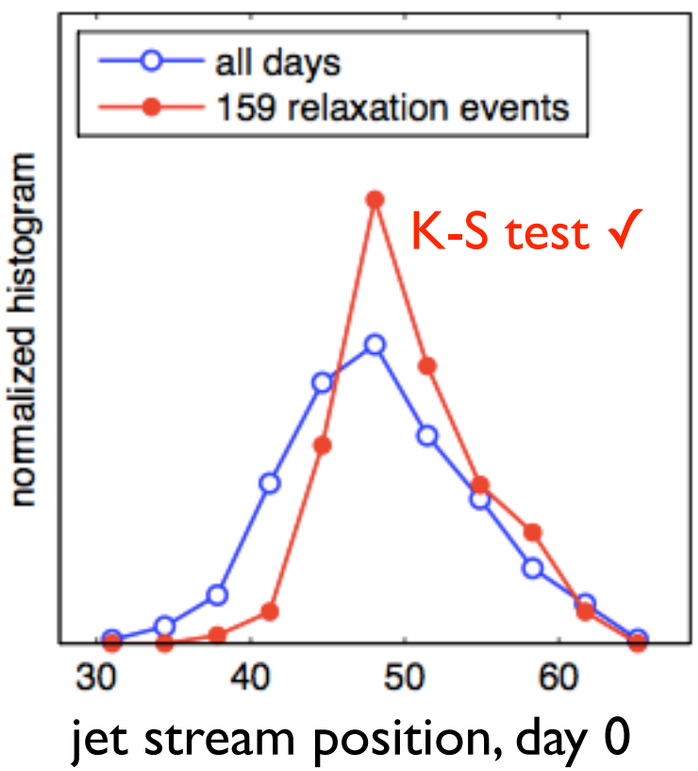
2nd, relaxation in south

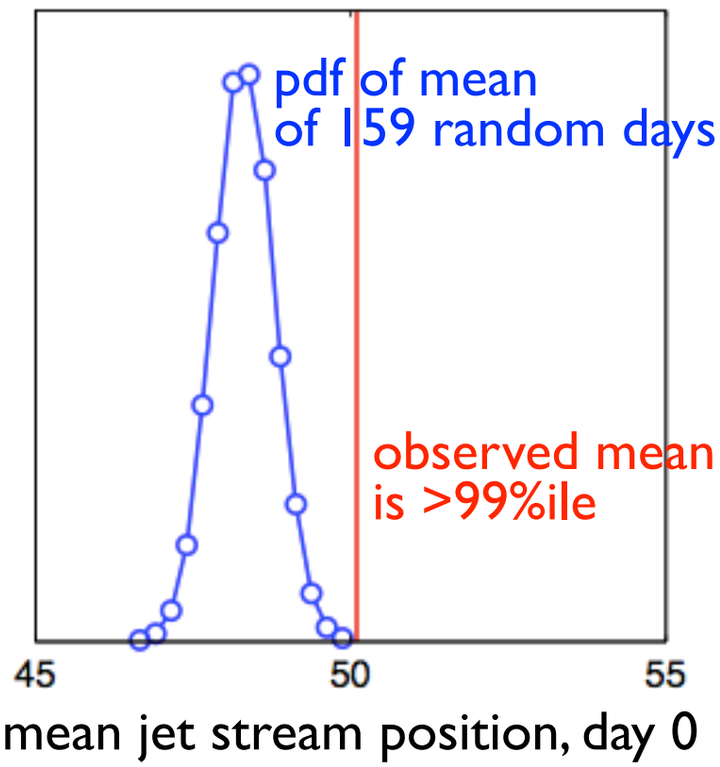
caused by northward movement of North Pacific High

The timing of Pt. C. wind relaxations is related to latitude of the jet stream, and to the North Pacific Gyre Oscillation.

the Pt. C. wind relaxations tend to start when the jet stream is near 50 degrees north

jet stream position, 20-day low pass filtered





NPGO

the Pt. C. wind relaxations tend to occur during positive NPGO

Preliminary ocean response: AMSR-E SST anomalies

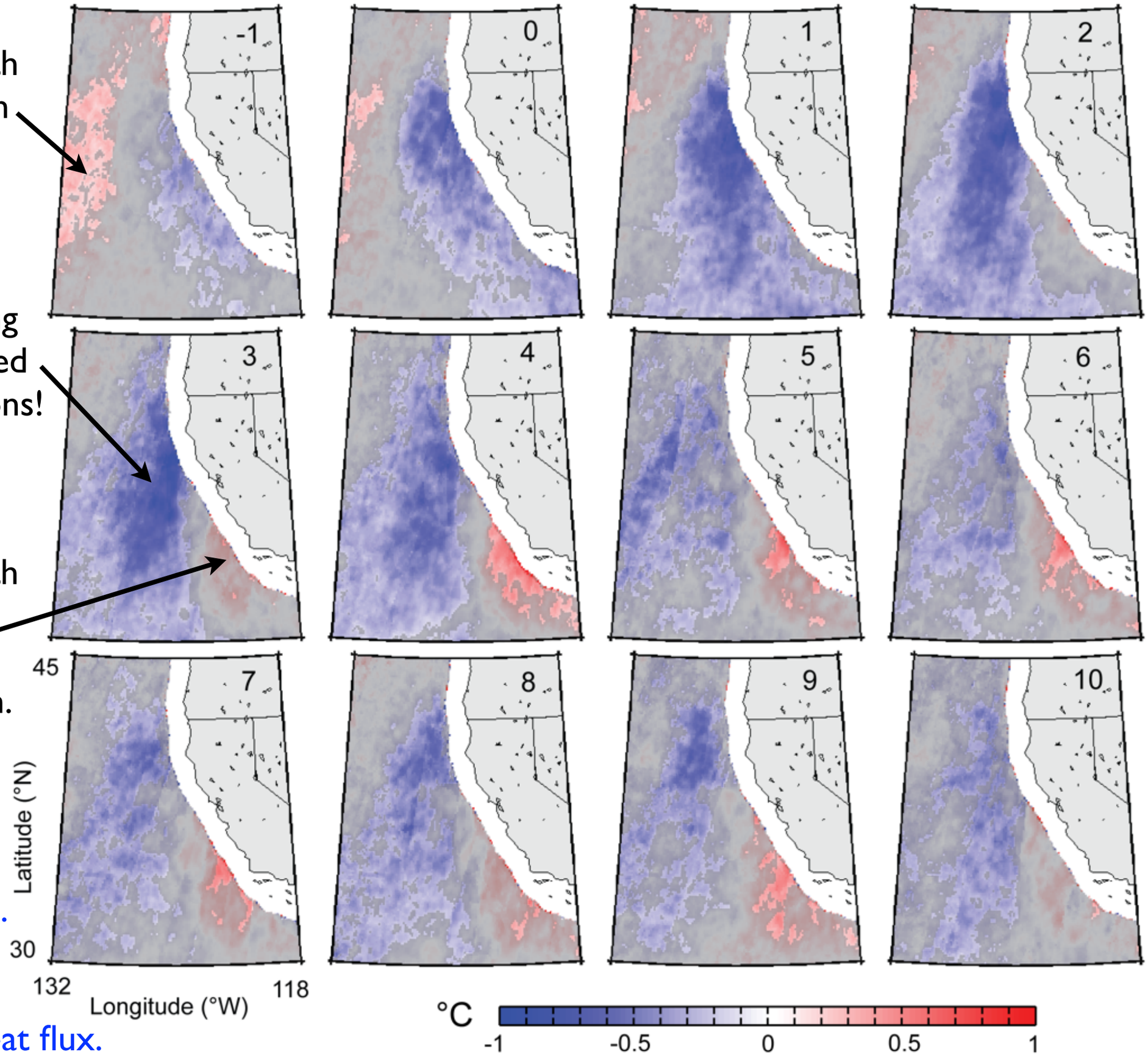
warming associated with Oregon wind relaxation

dominant signal is cooling associated with intensified winds between relaxations!

warming associated with Pt. C wind relaxation; time lag > 1 day and persists after relaxation.

advection of coastal water?
No. Spatial extent too large.

Suggests main signal is vertical mixing & surface heat flux.



Conclusions

What causes the wind relaxations at Pt. Conception?

- A 500-mb trough over Washington State, then a ridge
- Northeast extension of the N. Pacific High
- Sea-level pressure anomalies along the coast that strengthen, then weaken the winds at Pt. C

*** Similar to Mass and Bond (1996) and Bond, Mass and Overland (1996) for Oregon wind REVERSALS, but the Pt. Conception events are weaker

The spatial extent of the Pt. Conception relaxations

is from Point Arena to Baja and ~600 km offshore.

How are the Pt. C. relaxations related to relaxations/reversals off N. California and Oregon?

A series of 3 events affects the West Coast of North America every ~10 days in summer:

1) Oregon wind relaxation/reversal
2) intensified upwelling
3) Pt. Conception wind relaxation

Do the Pt. C. relaxations vary with climate variations and/or jet stream position, like wind reversals off Oregon?

Yes! Stay tuned...

Ongoing Work

Atmospheric momentum balance

what sets the cross-coast scale of the wind relaxations?

30-yr index of relaxations

- trend in number or strength of relaxations
- relation to North Pacific Gyre Oscillation, El Niño, and other climate indices
- relation to jet stream position

Regional ocean response to relaxations

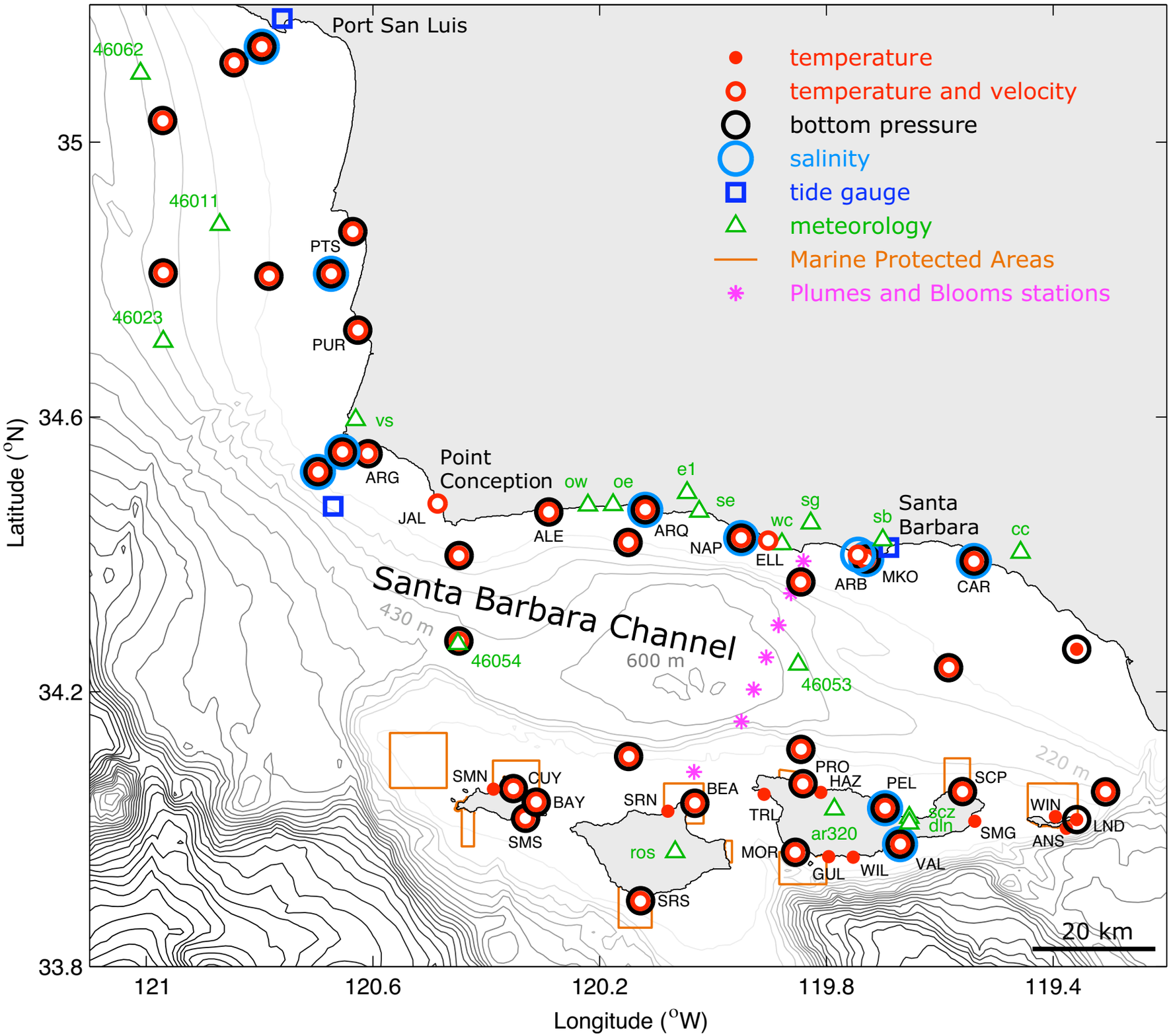
- West Coast scale and local Point Conception scale
- spatial extent, time evolution, ocean-atmosphere coupling dynamics

water temperature, velocity, pressure, chlorophyll

Future Work

Atmospheric wind relaxations and the ocean response in other eastern boundary upwelling systems

New postdoc: Maria Aristizábal
Ocean response on local Pt. C. scale from moorings and HF radar



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Ted Strub (OSU) for advice on coastal applications of QuikSCAT

NOAA/OAR/Earth System Research Laboratory,
Physical Sciences Division, Boulder, Colorado, USA, http://www.esrl.noaa.gov/psd/: NARR output

Brian Emery, UCSB (NARR acquisition)