The 2023-2024 El Niño in the California Current System as observed by the California Underwater Glider Network

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Outline

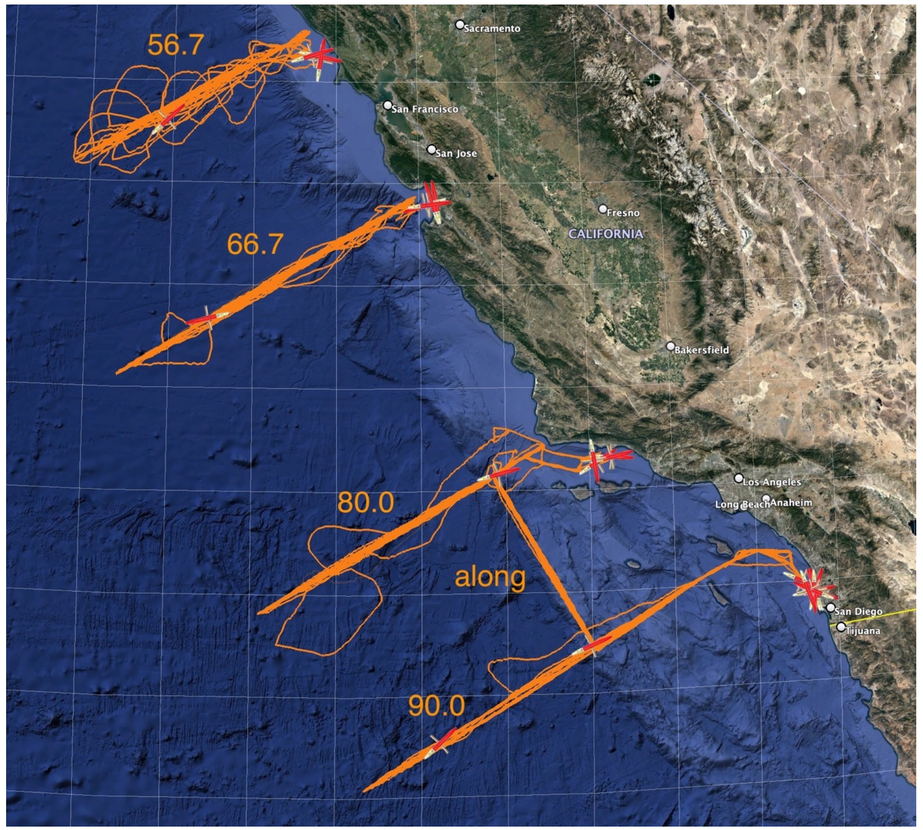
- The California Underwater Glider Network
  - Goal, approach, target phenomena
  - Performance
- The El Niño of 2023-2024 in the California Current System
  - Comparison to El Niños of 2009-2010 and 2014-2016
- El Niños are diverse at the equator and in the CCS

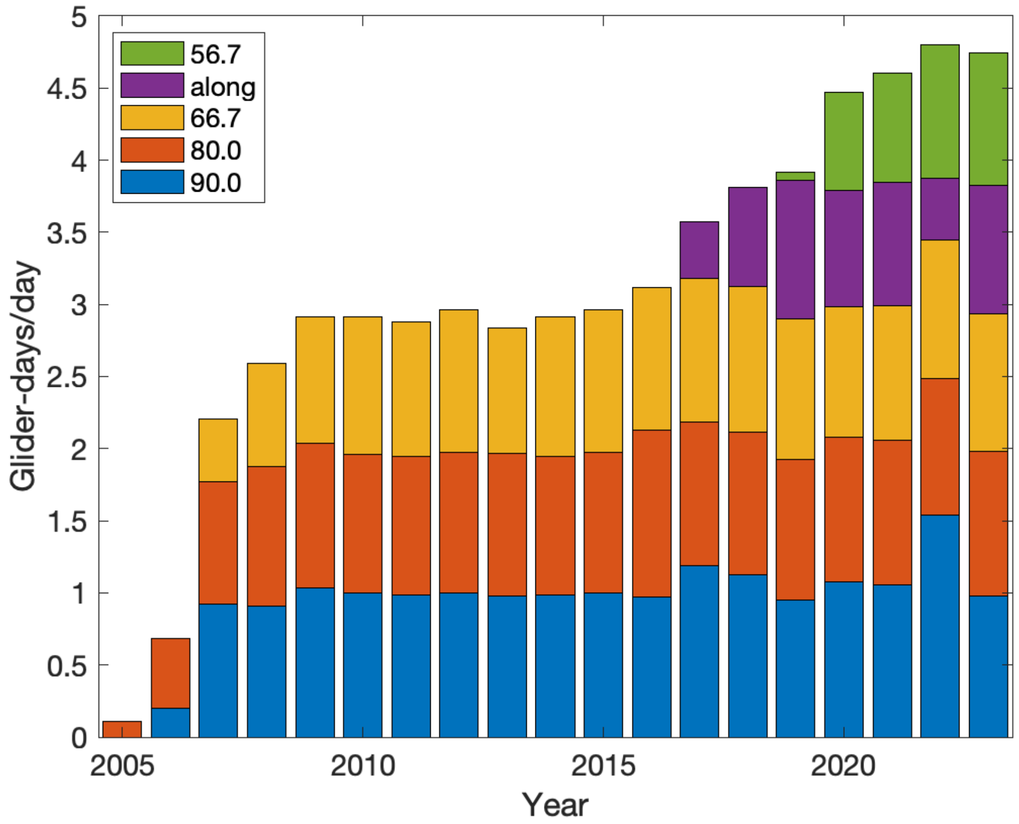
- Activities with Spray underwater gliders

Goal, approach, target phenomena

- Overarching goal of the California Underwater Glider Network is to observe the regional effects of climate variability
- Approach is to make repeated glider sections measuring temperature, salinity, velocity, dissolved oxygen, chlorophyll fluorescence (bulk measure of phytoplankton), and acoustic backscatter (bulk measure of zooplankton).
- Target phenomena
  - Effects of El Niño/La Niña
  - Marine heatwaves
  - Salinity extremes, changes in source waters
  - Ocean acidification, currently measuring oxygen, pH in the future.
  - Building blocks of ecosystem with bulk measures of phyto-, zooplankton
  - Annual cycles, phenology

The California Underwater Glider Network





- Three main sustained lines starting in 2005: 90.0, 80.0, 66.7.
- An alongshore line covered roughly half-time starting in 2017, full-time since January 2019.
- Line 56.7 started in December 2019.

El Niño Diversity

UNDERSTANDING ENSO DIVERSITY

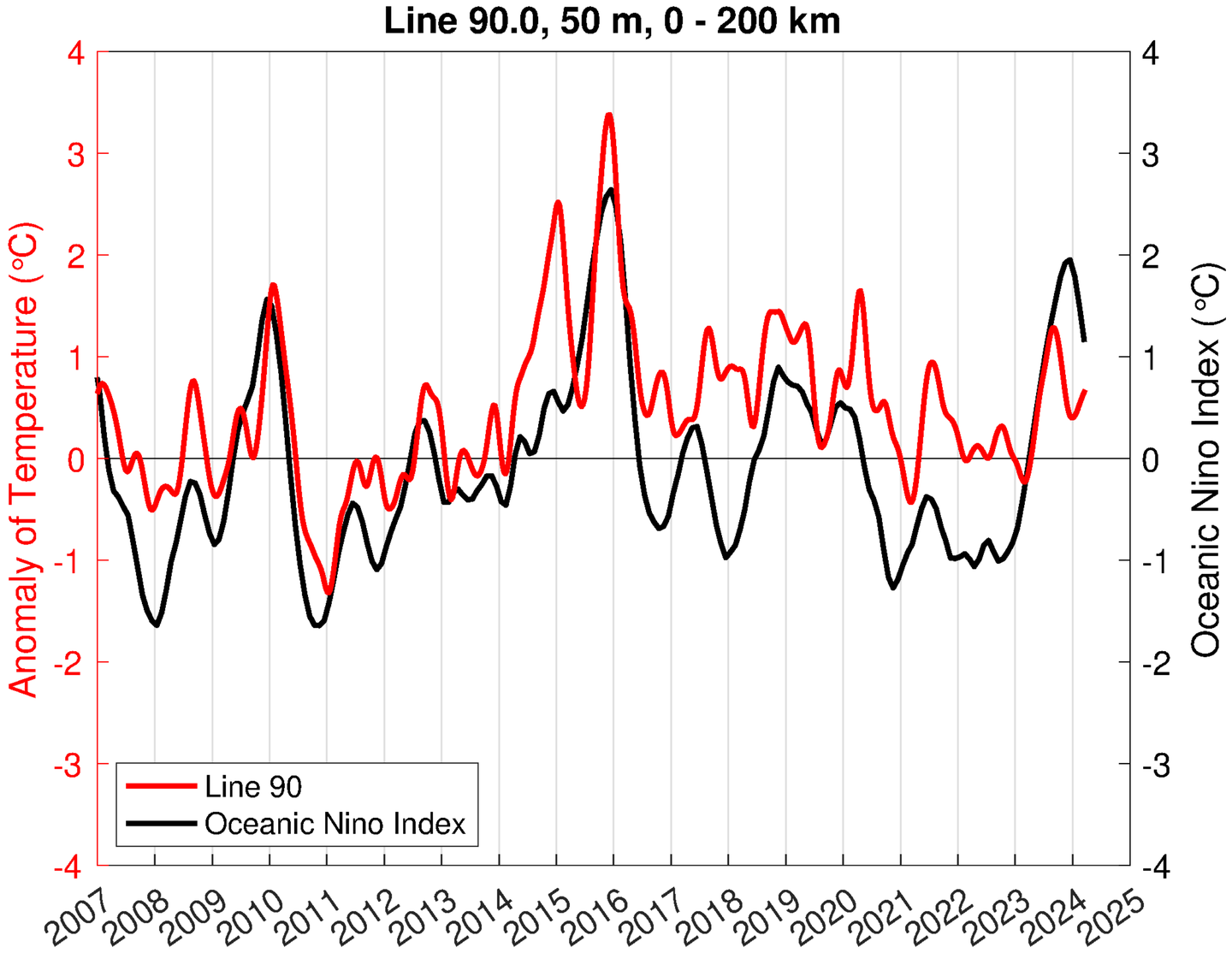
BY ANTONIETTA CAPOTONDI, ANDREW T. WITTENBERG, MATTHEW NEWMAN, EMANUELE DI LORENZO, JIN-YI YU, PASCALE BRACONNOT, JULIA COLE, BORIS DEWITTE, BENJAMIN GIESE, ERIC GUILYARDI, FEI-FEI JIN, KRISTOPHER KARNAUSKAS, BENJAMIN KIRTMAN, TONG LEE, NIKLAS SCHNEIDER, YAN XUE, AND SANG-WOOK YEH

Improved determination of ENSO predictability, teleconnections, and impacts requires a better understanding of event-to-event differences in ENSO spatial patterns and evolution.

BAMS, June 2015

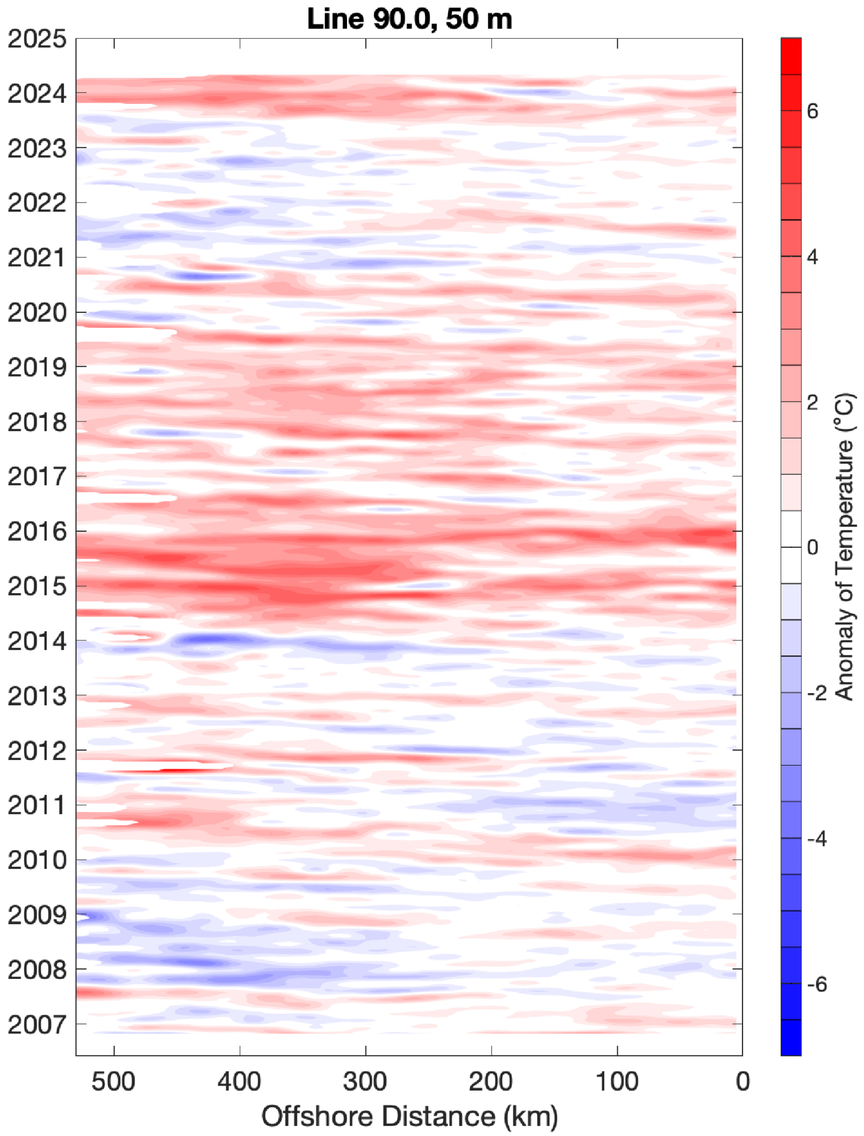
- El Niños
  - 2009-2010: Central Pacific “Modoki”
  - 2014-2016: “Failed” in 2014, strongest of least several decades in 2015-2016
  - 2023-2024: Anomaly started in eastern Pacific

The SoCal Temperature Index



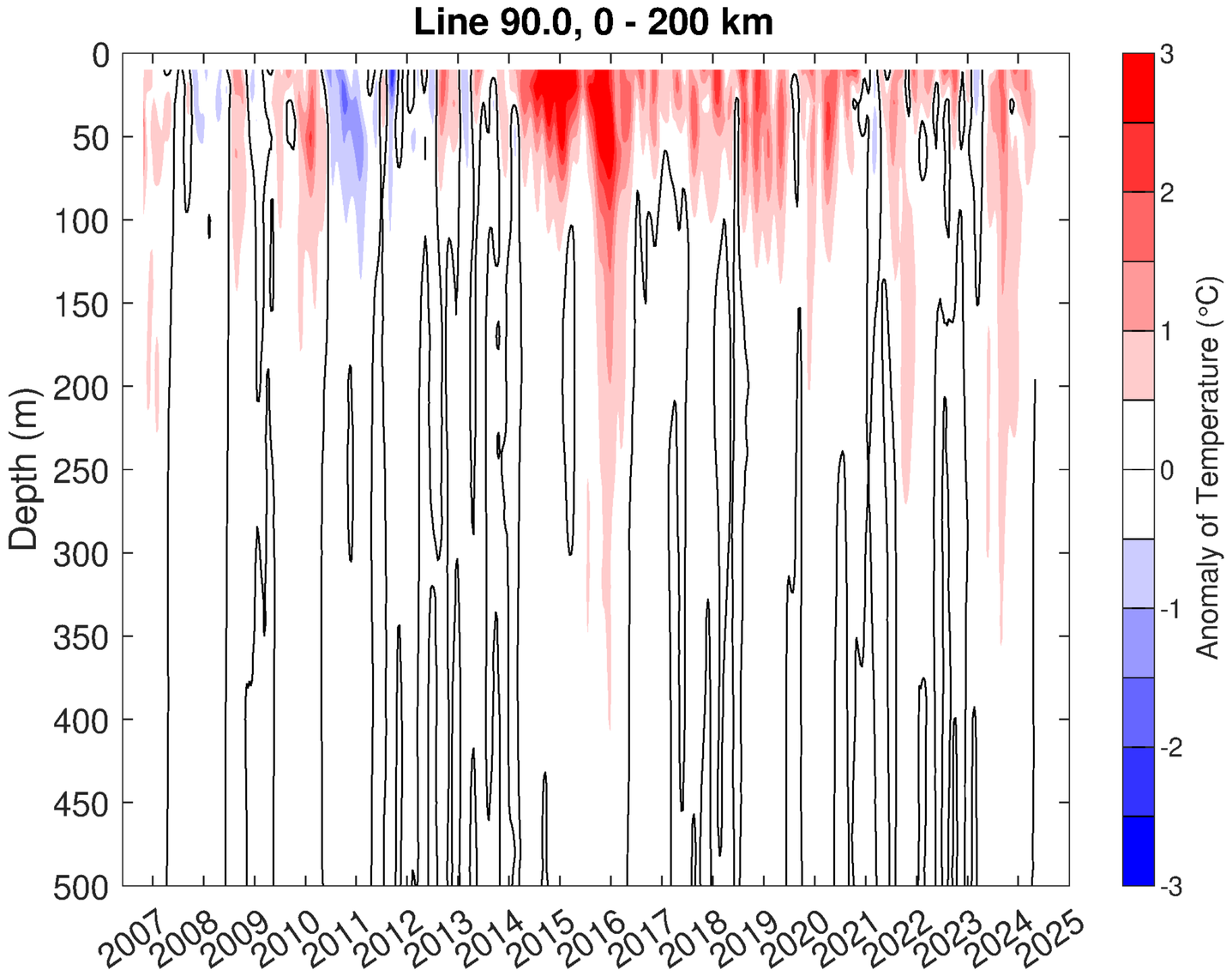
- Temperature anomaly on Line 90 at 50 m, averaged over the inshore 200 km, and filtered with a 90-day running mean
- Chosen after 2009-2010 El Niño as an index:
  - Simple
  - Indicative of thermocline depth
  - Correlated with ONI
- The SCTI was not the best indicator in 2023-2024

Line 90, Temperature at 50 m



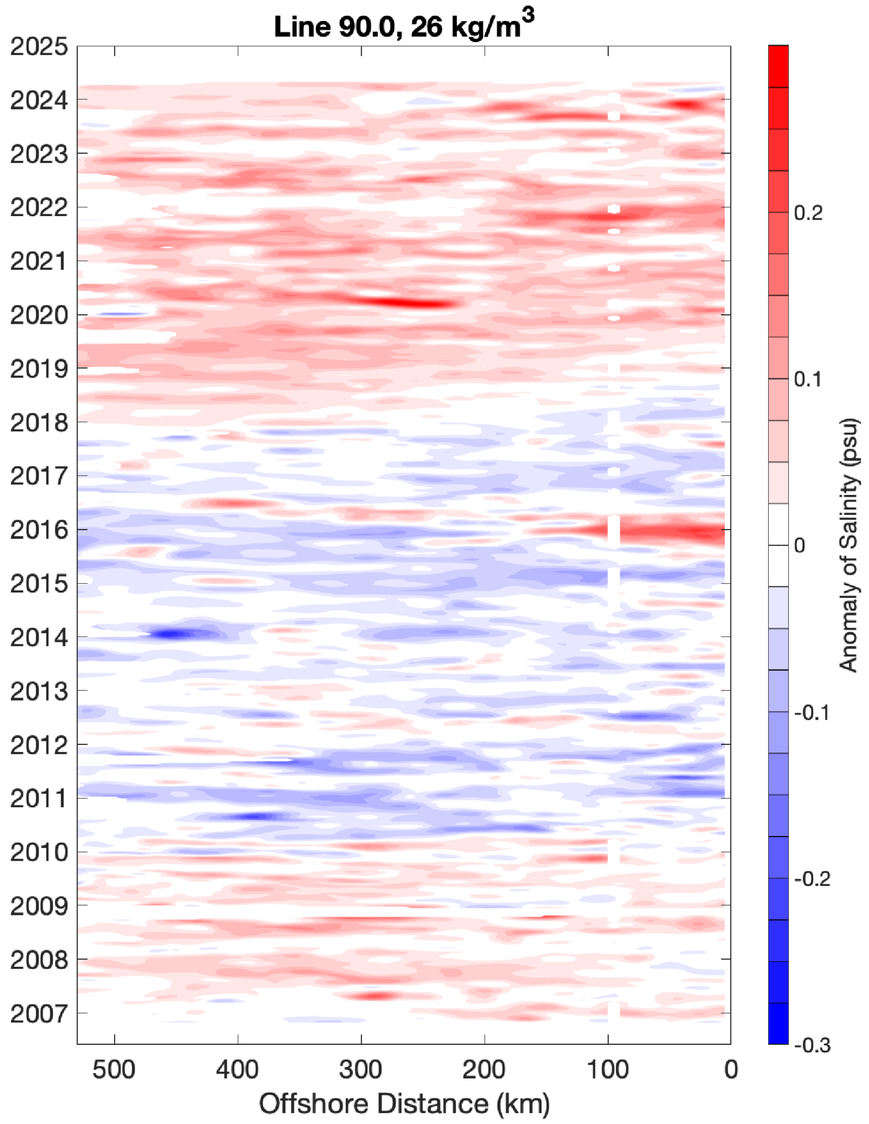
- El Ninos
  - 2009-2010: Appeared first inshore, propagated offshore
  - 2014-2016: “The Blob” followed by strong anomaly and sustained warmth in following years
  - 2023-2024: Moderate anomaly with persistent cold patch 100-200 km offshore

Line 90, Temperature, Inshore 200 km



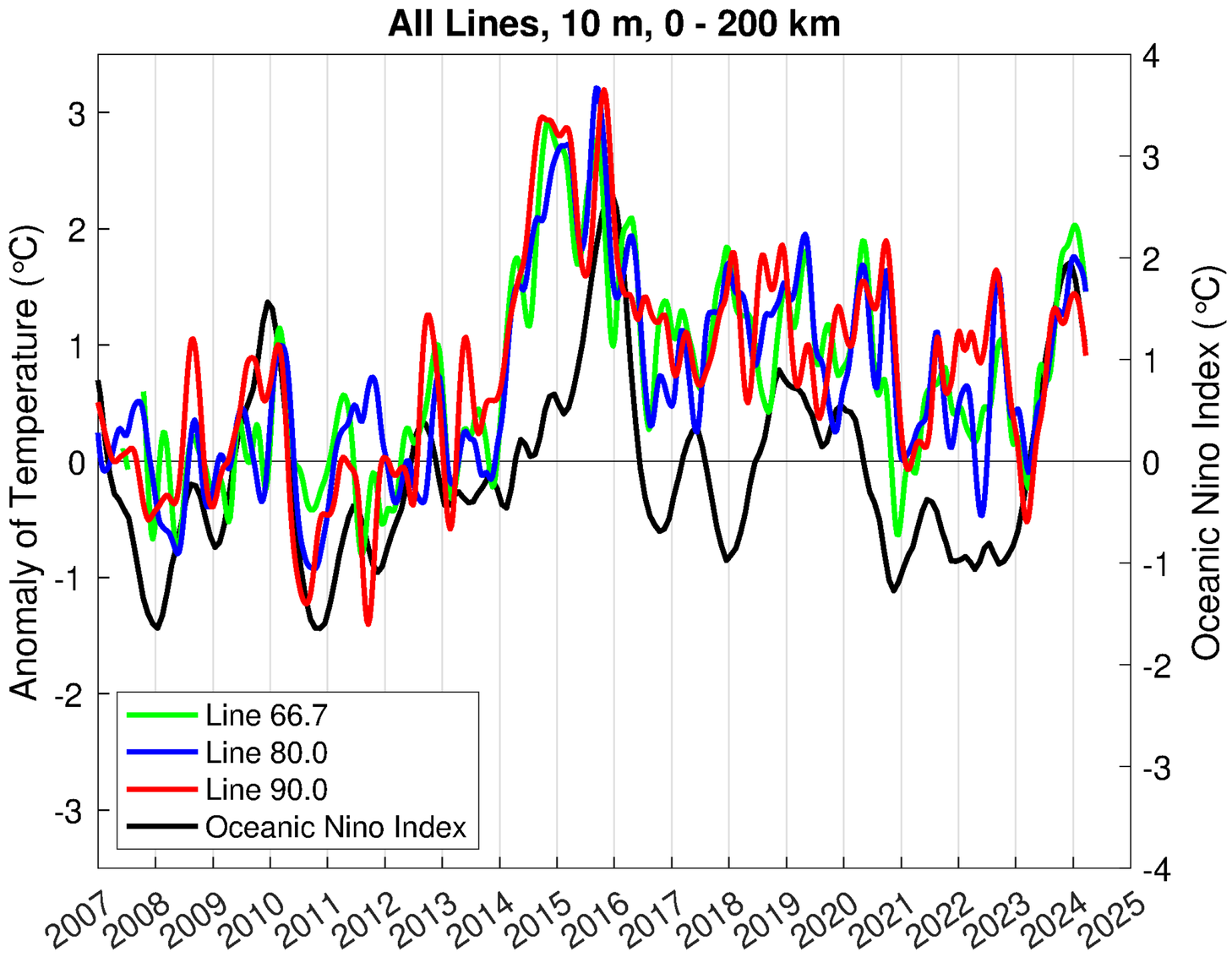
- El Niños
  - 2009-2010: Moderate anomaly followed by La Niña
  - 2014-2016: Shallow “blob” then Deep El Niño
  - 2023-2024: Deep, but with cool patch at 30-50 m (doming thermocline)

Line 90, Salinity on 26 kg/m^3 isopycnal



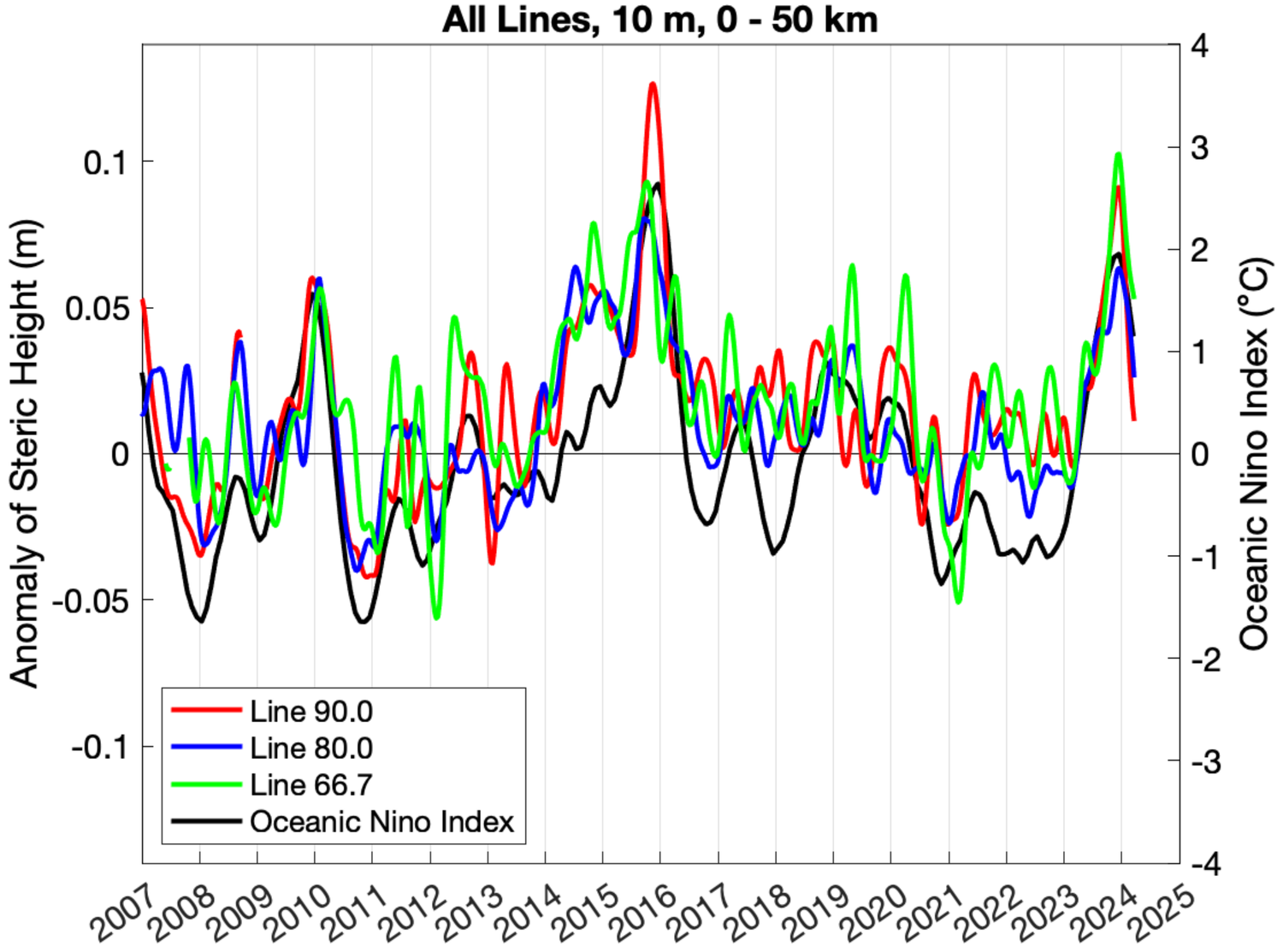
- Strong salinity anomaly in 2015-2016 indicative of southern source water
- Similar to 1997-1998 El Niño
- Decadal variability in salinity suggests larger scale changes in source water

All Lines, Temperature at 10 m, Inshore 200 km



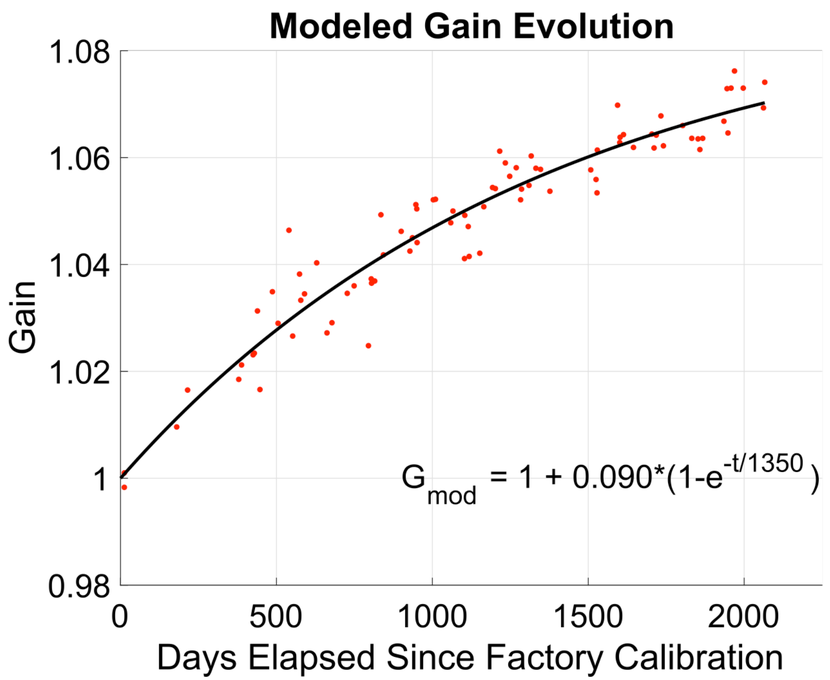
- Wide extent of “blob” in 2014
- El Niño of 2023-2024 apparent on all lines
- 2023-2024 signal not especially strong in shallow temperature

All Lines, Steric Height, Inshore 50 km

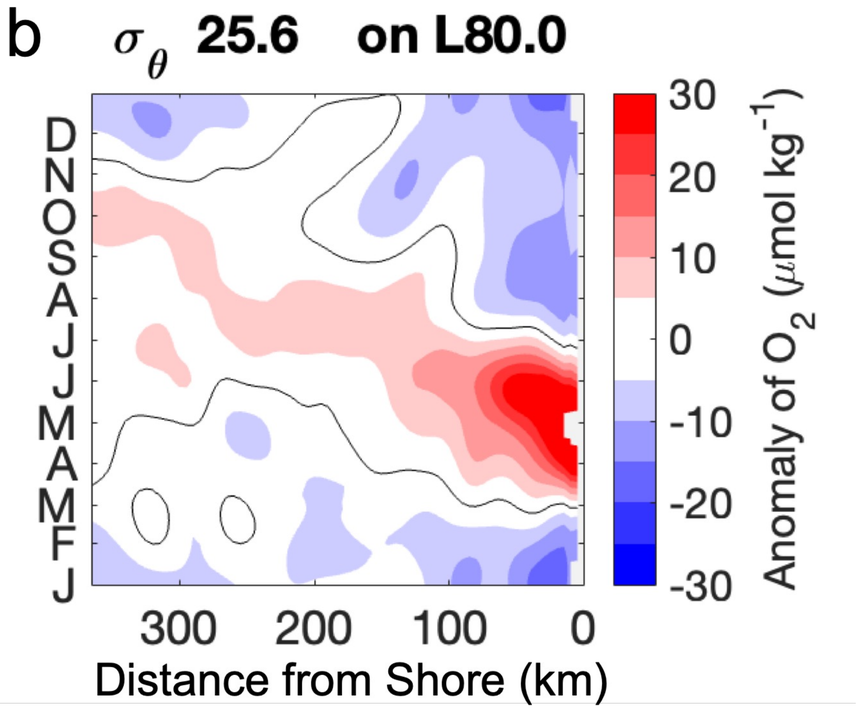


- Steric height at 10 m relative to 500 m.
- 2015-2016: large steric height anomaly of ~0.1 m
- 2023-2024: steric height anomaly also large
- The effect of this year's El Niño extended deep

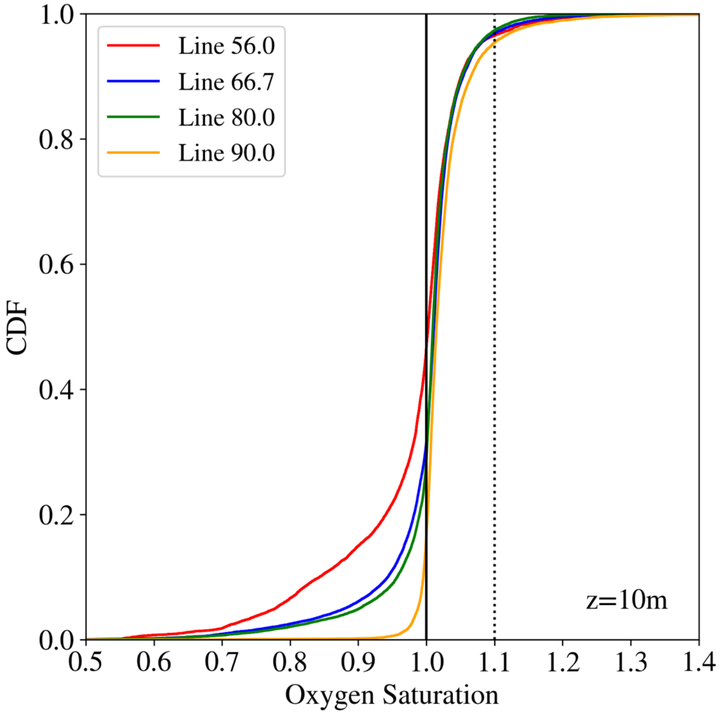
Dissolved oxygen



Calibration
Ren et al. (2023, JTECH)



Annual cycle
Ren et al.
(2024, submitted)

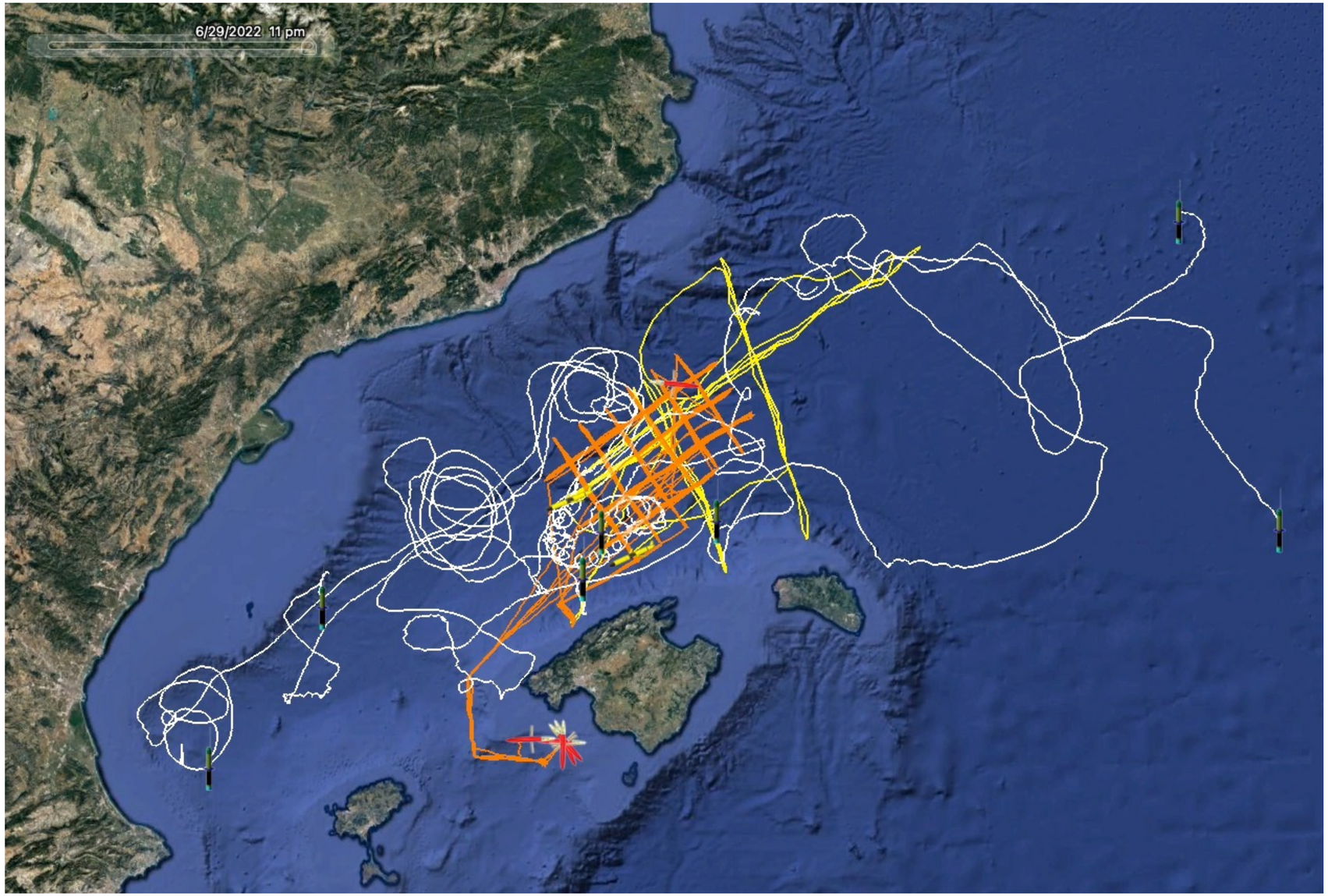


Extrema
Prochaska and Rudnick
(2024, in prep)

Spray2

- Spray2 underwater glider during a field test earlier this year
- Designed for:
  - BGC payload
  - Longer missions
  - Faster speeds
  - Ease of use
- Recapitalizing glider fleet
- Licensed to MRV

CALYPSO



- Collaboration with SOCIB, IMEDEA
- Submesoscale processes, vertical fluxes
- Joaquin Tintoré, NIKOLAOS ZAROKANELLOS, Shaun Johnston
- Three experiments: 2018, 2019, 2022
- Rudnick et al., (2022, JPO)
- Zarokanellos et al. (2022, JGR)
- Garcia-Jove et al. (2022, JGR)
- Zarokanellos et al. (2024, in prep)

Conclusions

- El Niño diversity in the CCS
  - Variability at other time scales
    - Eddies, as in 2023-2024
    - Decadal changes of source water
  - Connection between equator and CCS
    - Failed El Niño of 2014 coincided with “blob”
    - Strong response in 2015-2016 at both equator and CCS
  - Diversity in CCS response to El Niño emphasizes the need for observation