2023-24 El Niño Development – Courtesy of Climate Reanalyzer

Are El Niño Precursors Captured by SMYLE?

Emily F. Wisinski[1], Maria J. Molina[1,4], Michelle L. L'Heureux[2], Meghan F. Cronin[3], Dongxiao Zhang[3], Stephen Yeager[4], Sasha Glanville[4], and Nan Rosenbloom[4]

[1]The University of Maryland, College Park, MD
[2]NOAA/NWS/NCEP Climate Prediction Center, College Park, MD
[3]NOAA Pacific Marine Environmental Laboratory and Cooperative Institute for Climate, Ocean, and Ecosystem Studies (CICOES), Seattle, WA
[4]National Center for Atmospheric Research (NCAR), Boulder, CO

The Seasonal-to-Multiyear Large Ensemble (SMYLE), created using the Community Earth System Model Version 2 (CESM2), consists of 20 ensemble members initialized four times per year (Feb, May, Aug, Nov).

The Seasonal-to-Multiyear Large Ensemble (SMYLE), created using the Community Earth System Model Version 2 (CESM2), consists of 20 ensemble members initialized four times per year (Feb, May, Aug, Nov).

SMYLE predicted a 'Super El Niño'* event (2.2-2.4° C) for DJF 2023 in February, May, and August initializations. What conditions caused this?

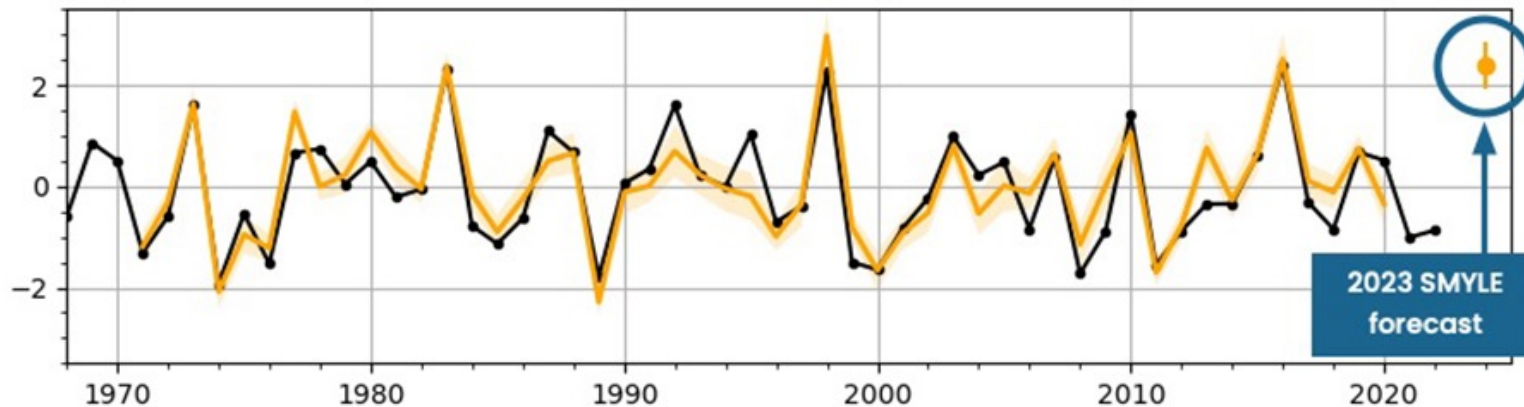

Average Niño 3.4 Index for December, January & February
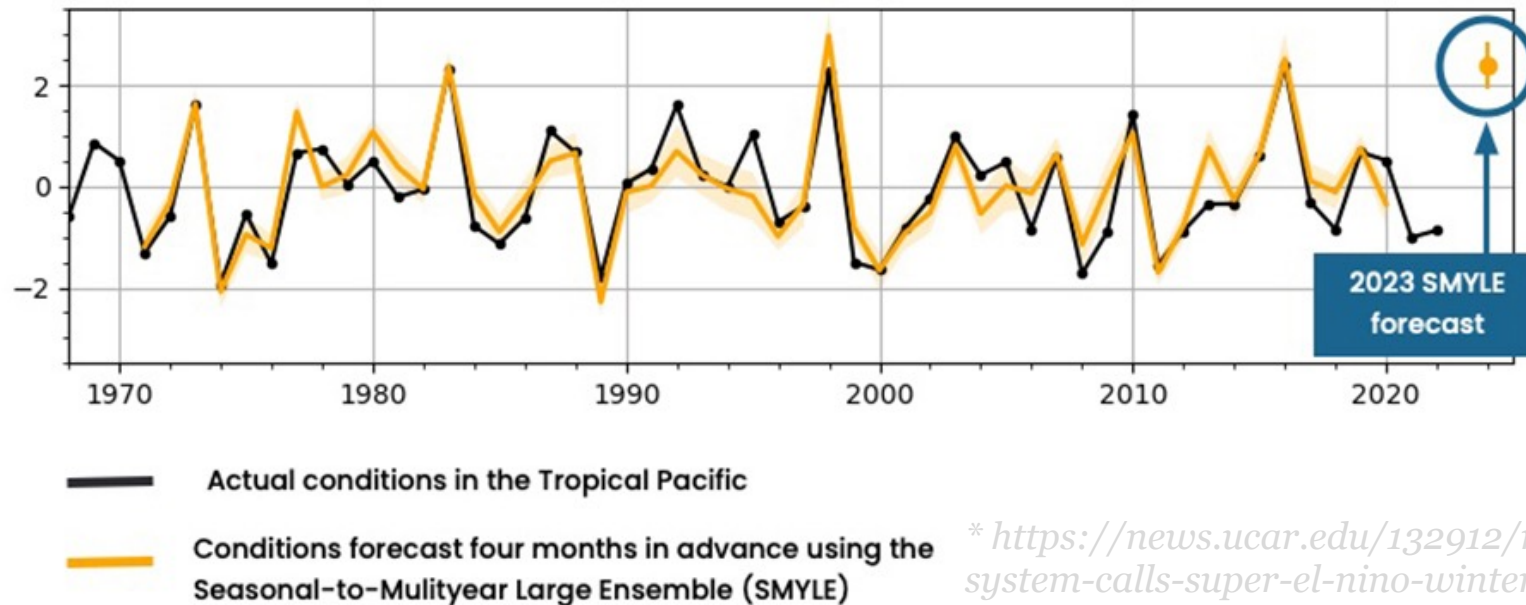
2023 SMYLE forecast

Actual conditions in the Tropical Pacific

Conditions forecast four months in advance using the Seasonal-to-Mulityear Large Ensemble (SMYLE)

* https://news.ucar.edu/132912/ncar-experimental-prediction-system-calls-super-el-nino-winter

The Seasonal-to-Multiyear Large Ensemble (SMYLE), created using the Community Earth System Model Version 2 (CESM2), consists of 20 ensemble members initialized four times per year (Feb, May, Aug, Nov).

SMYLE predicted a 'Super El Niño'* event (2.2-2.4° C) for DJF 2023 in February, May, and August initializations. What conditions caused this?

However, peak amplitude fell short for DJF

Average Niño 3.4 Index for December, January & February

2023 SMYLE forecast

Actual conditions in the Tropical Pacific

Conditions forecast four months in advance using the Seasonal-to-Mulityear Large Ensemble (SMYLE)

*https://news.ucar.edu/132912/ncar-experimental-prediction-system-calls-super-el-nino-winter
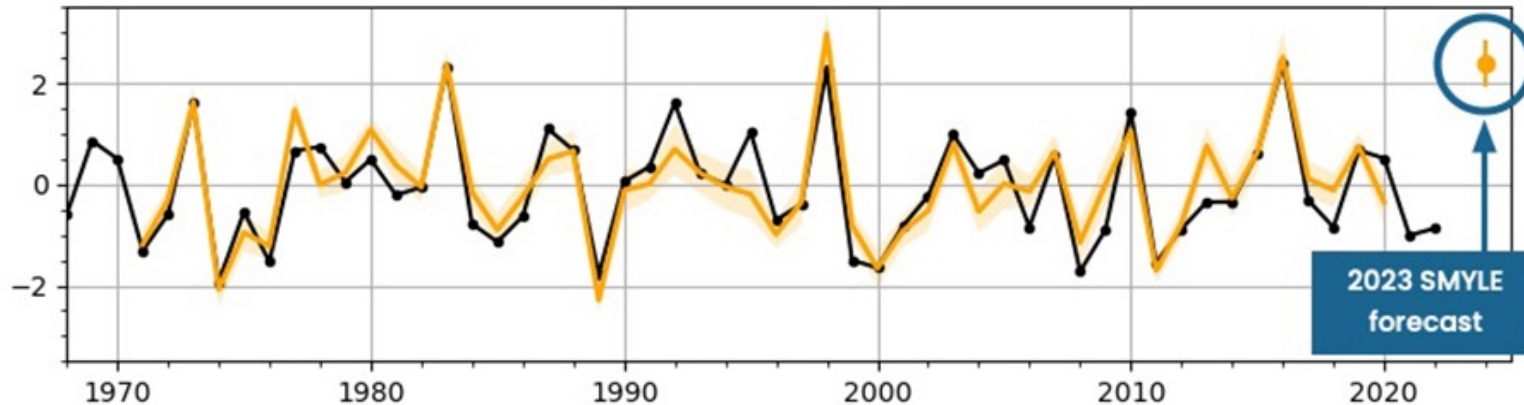
The Seasonal-to-Multiyear Large Ensemble (SMYLE), created using the Community Earth System Model Version 2 (CESM2), consists of 20 ensemble members initialized four times per year (Feb, May, Aug, Nov).

SMYLE predicted a 'Super El Niño'* event (2.2-2.4° C) for DJF 2023 in February, May, and August initializations. What conditions caused this?

El Niño precursors were apparent from observational platforms as early as February 2023. Was SMYLE able to resolve precursors?

Peak amplitude fell short for DJF.

Average Niño 3.4 Index for December, January & February

2023 SMYLE forecast

Actual conditions in the Tropical Pacific

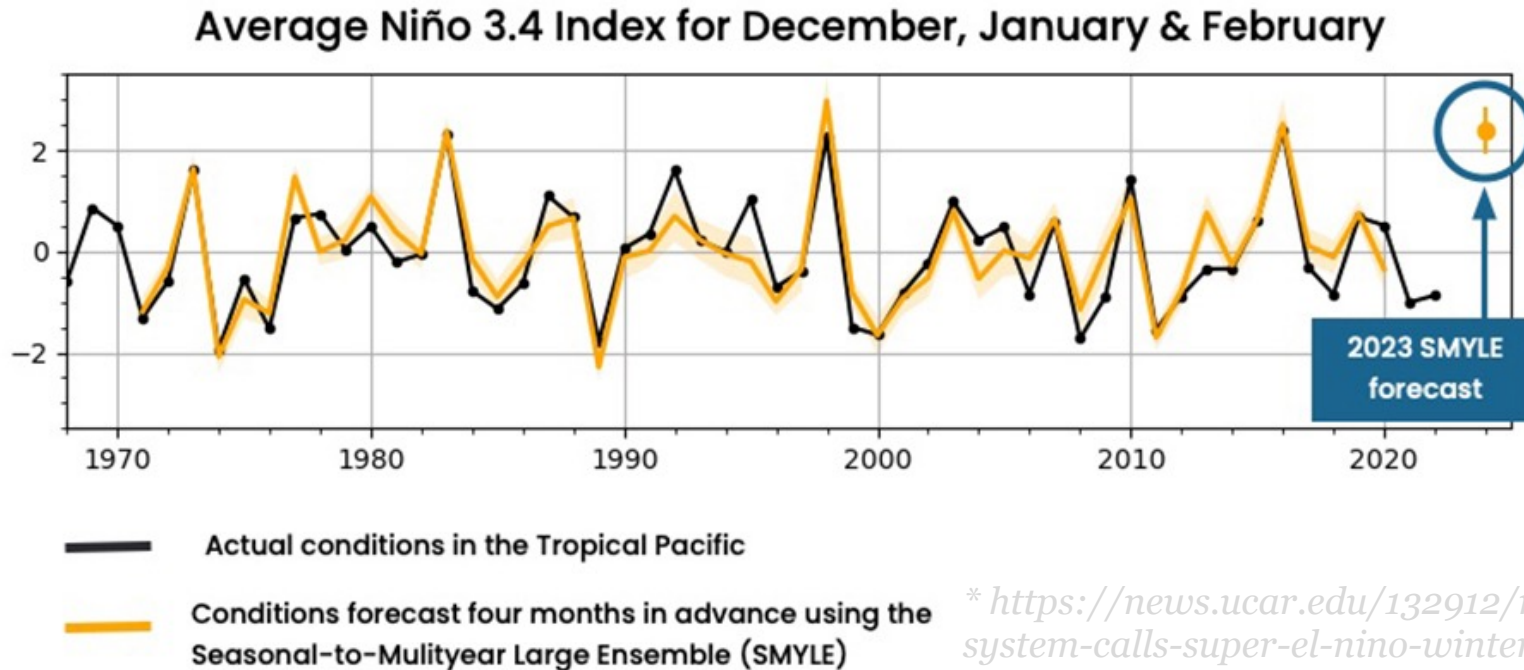Conditions forecast four months in advance using the Seasonal-to-Mulityear Large Ensemble (SMYLE)

https://news.ucar.edu/132912/ncar-experimental-prediction-system-calls-super-el-nino-winter

The Seasonal-to-Multiyear Large Ensemble (SMYLE), created using the Community Earth System Model Version 2 (CESM2), consists of 20 ensemble members initialized four times per year (Feb, May, Aug, Nov).

SMYLE predicted a 'Super El Niño'* event (2.2-2.4° C) for DJF 2023 in February, May, and August initializations.
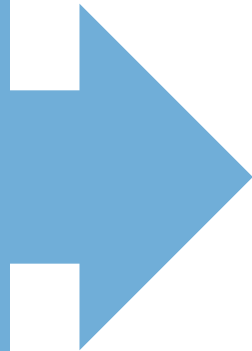
What conditions caused this?

El Niño precursors were apparent from observational platforms as early as February 2023. **Was SMYLE able to resolve precursors?**

Focusing on Research Objective #2

Peak amplitude fell short for DJF.

Average Niño 3.4 Index for December, January & February

2023 SMYLE forecast

1970   1980   1990   2000   2010   2020

— Actual conditions in the Tropical Pacific

— Conditions forecast four months in advance using the Seasonal-to-Mulityear Large Ensemble (SMYLE)
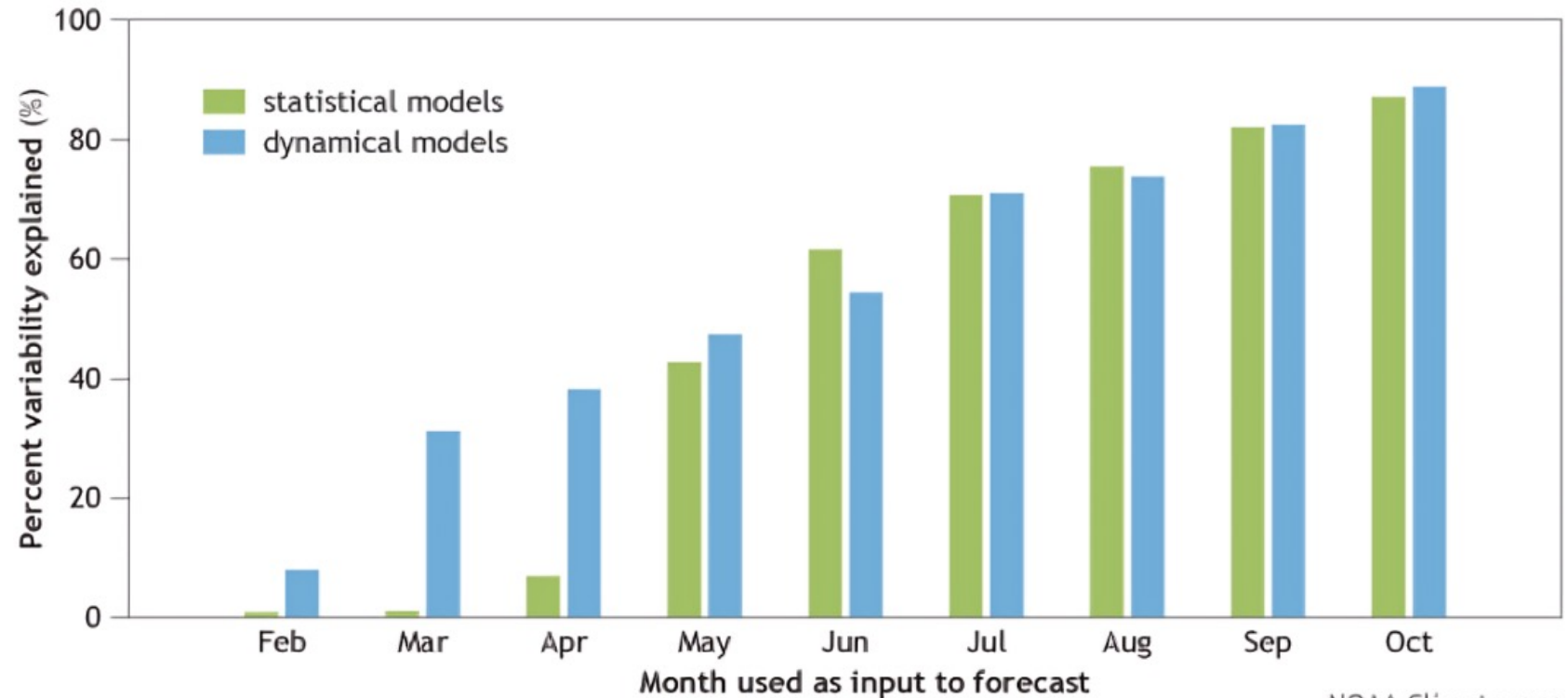
https://news.ucar.edu/132912/ncar-experimental-prediction-system-calls-super-el-nino-winter

The spring predictability barrier (SPB) is referred to as decreased model forecast skill when initialized from February to May

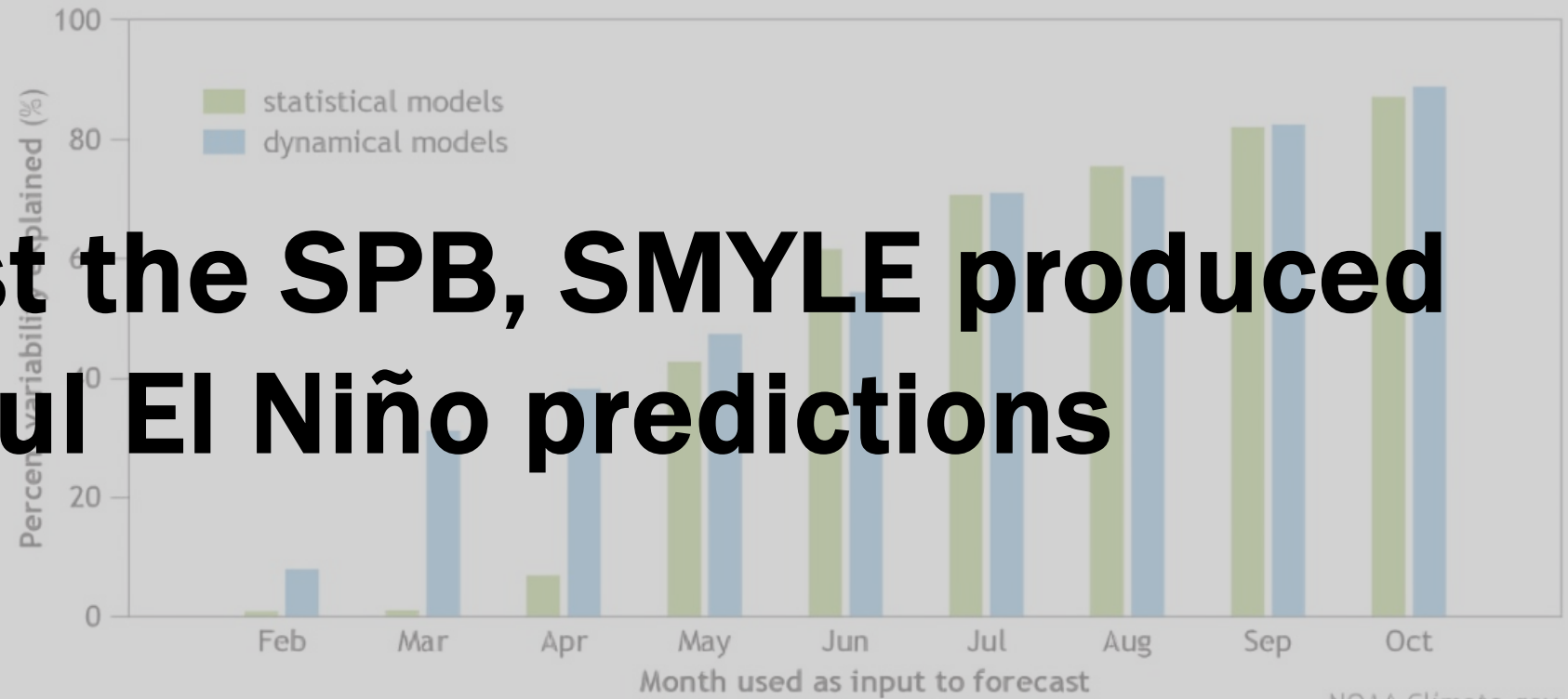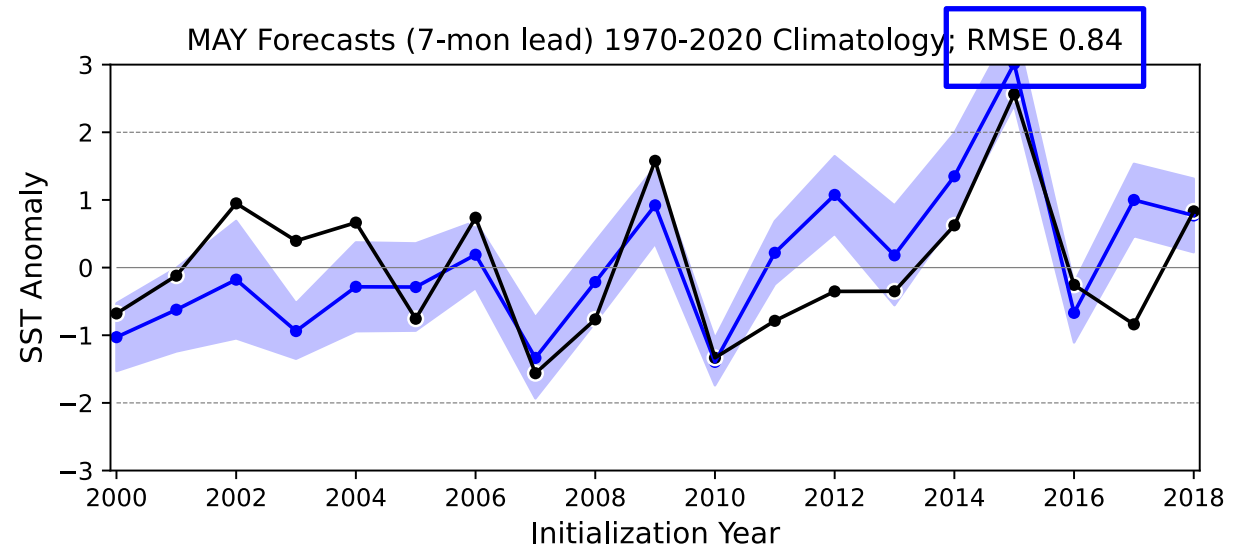How much ENSO variability can be predicted for Nov–Jan forecast?

statistical models
dynamical models

Percent variability explained (%)

Month used as input to forecast

Feb Mar Apr May Jun Jul Aug Sep Oct

NOAA Climate.gov

The spring predictability barrier (SPB) is referred to as decreased model forecast skill when initialized from February to May

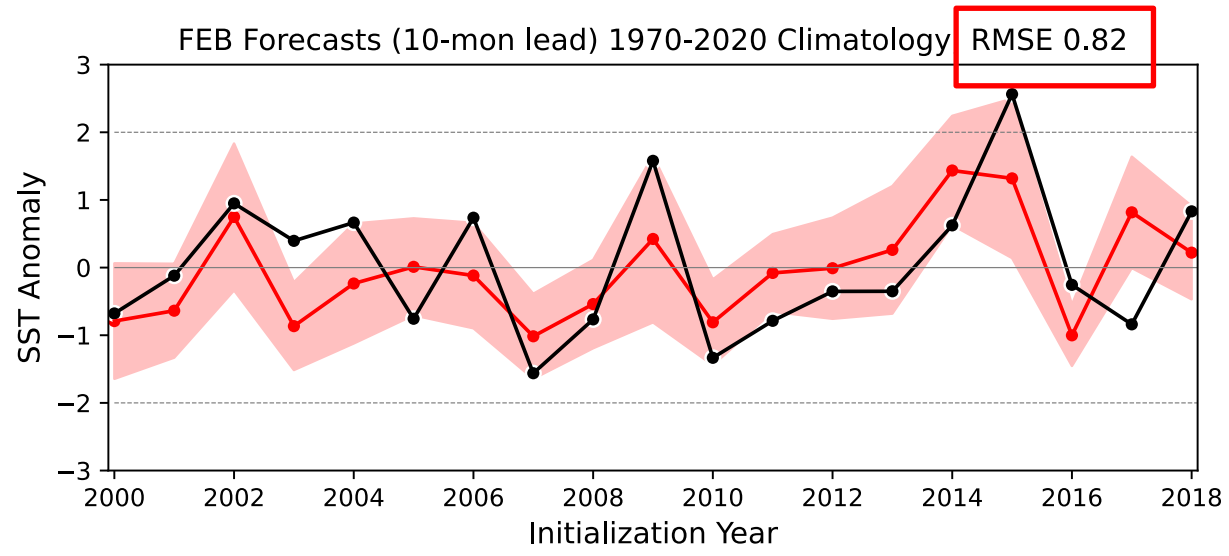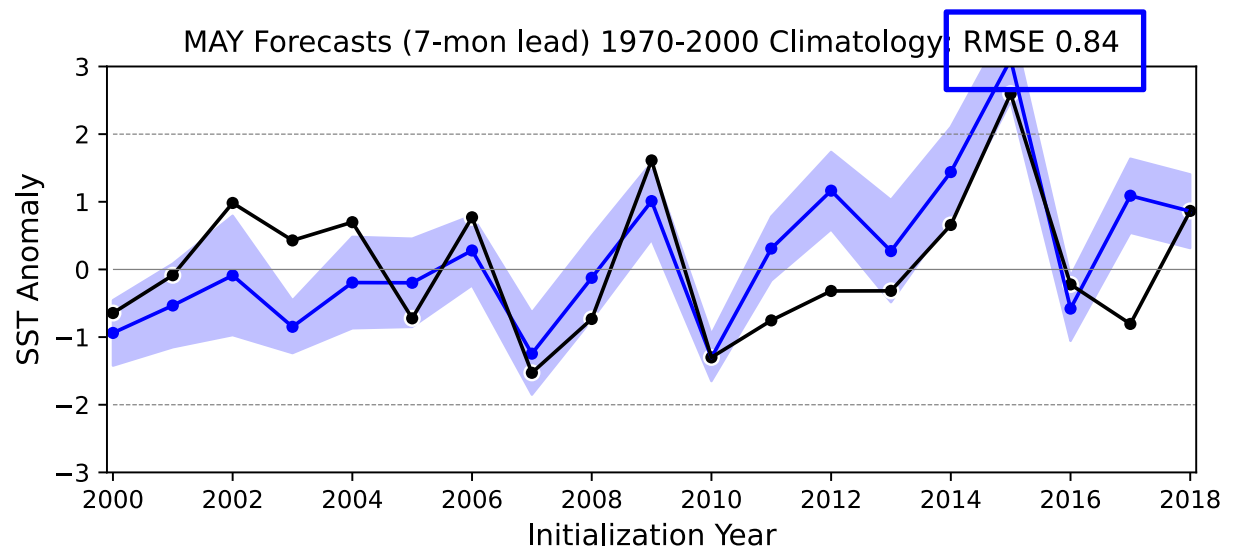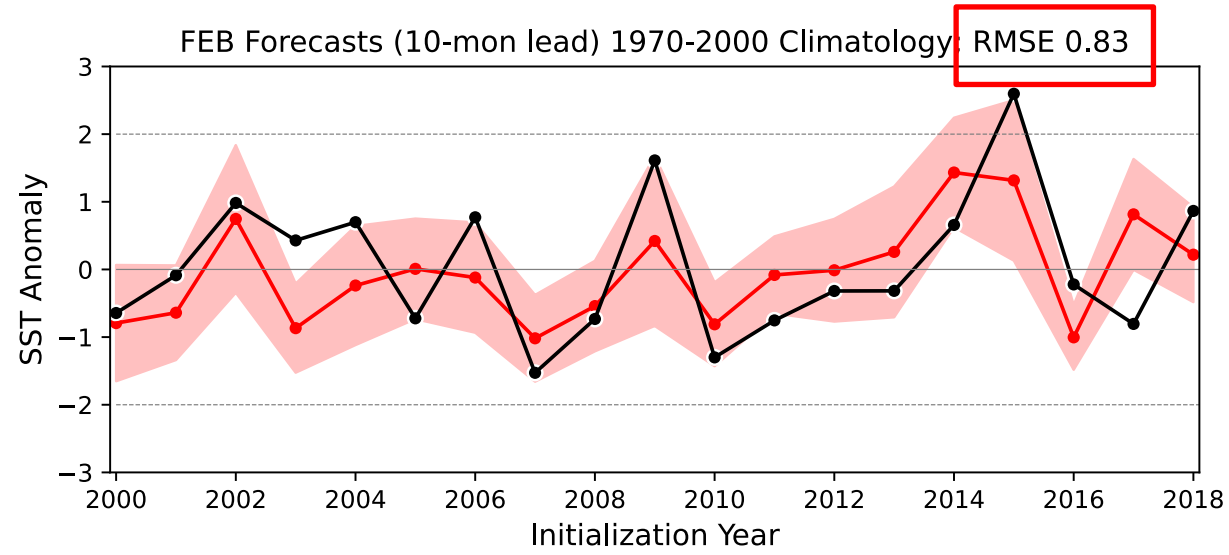**Even amidst the SPB, SMYLE produced skillful El Niño predictions**

Risbey et al. 2021 states that hindcasts may have unrealistic skill because they use data that would be unavailable during real-time forecasting, specifically the climatology to derive anomalies
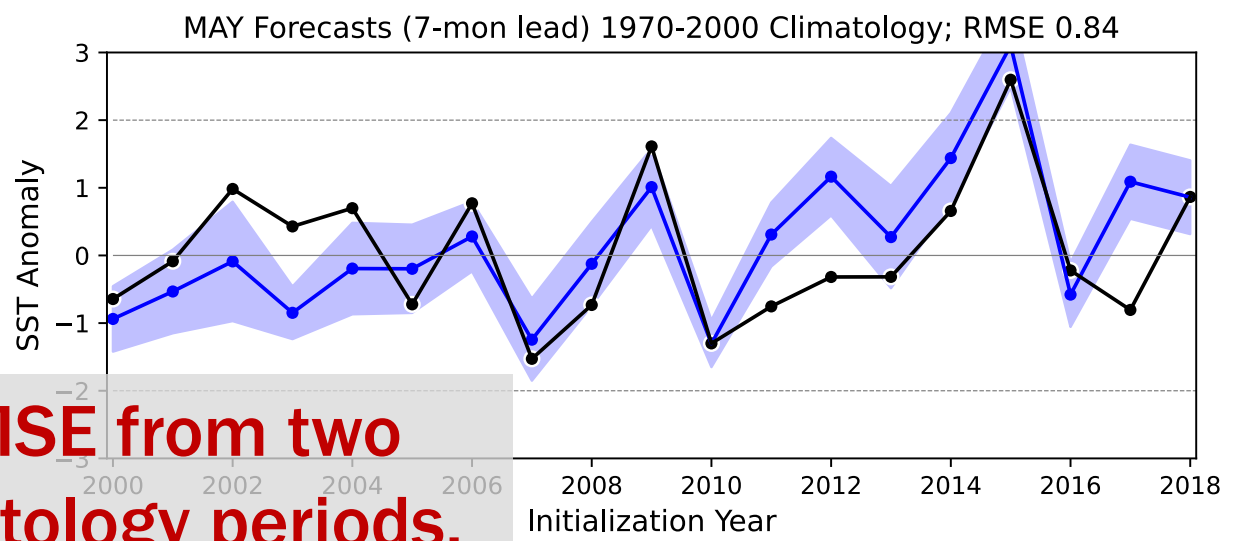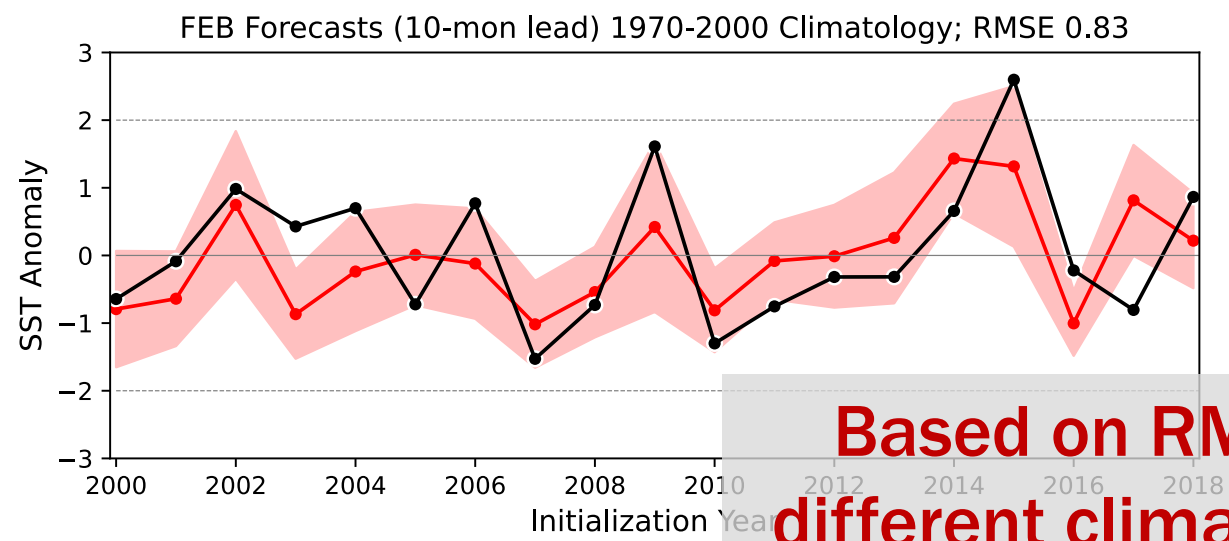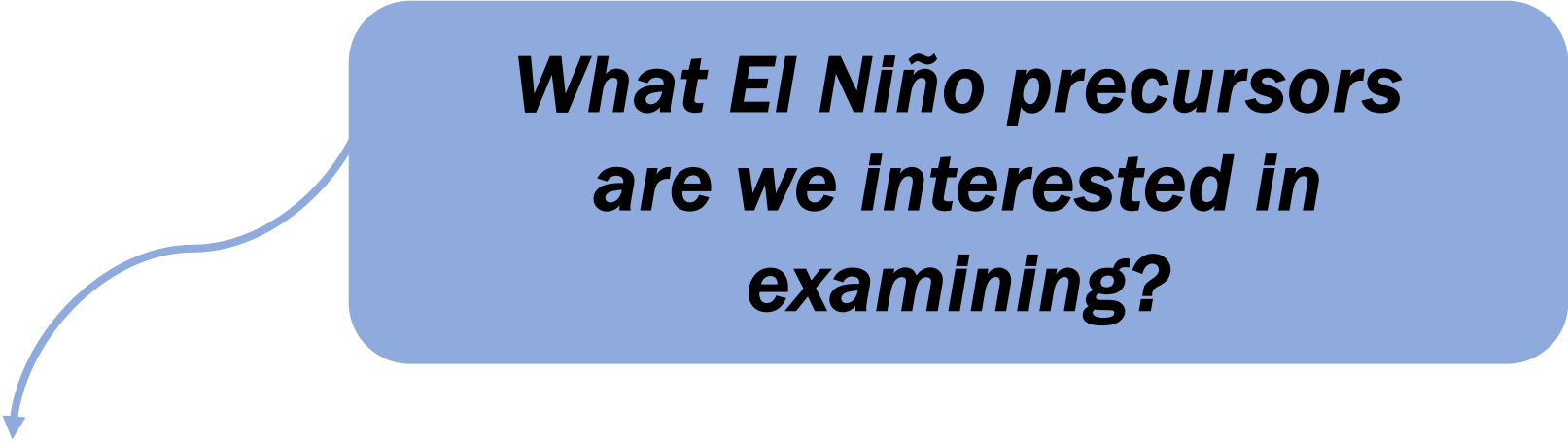
Risbey et al. 2021 states that hindcasts may have unrealistic skill because they use data that would be unavailable during real-time forecasting, specifically the climatology to derive anomalies

FEB Forecasts (10-mon lead) 1970-2000 Climatology; RMSE 0.83

MAY Forecasts (7-mon lead) 1970-2000 Climatology; RMSE 0.84

FEB Forecasts (10-mon lead) 1970-2020 Climatology; RMSE 0.82

MAY Forecasts (7-mon lead) 1970-2020 Climatology; RMSE 0.84

Based on RMSE from two different climatology periods, SMYLE does not show substantial artificial skill
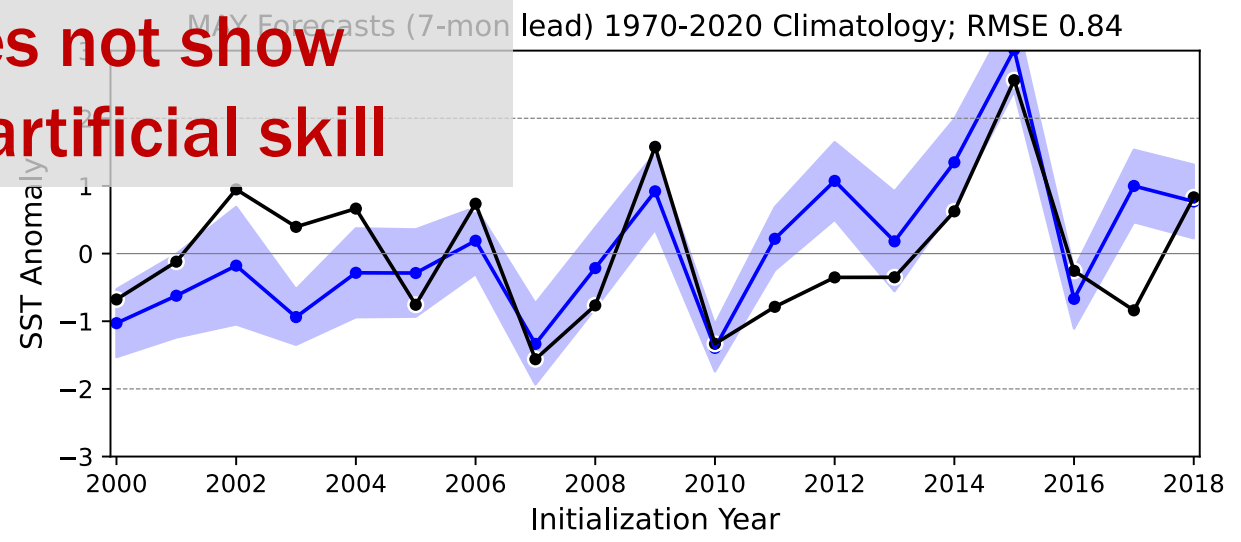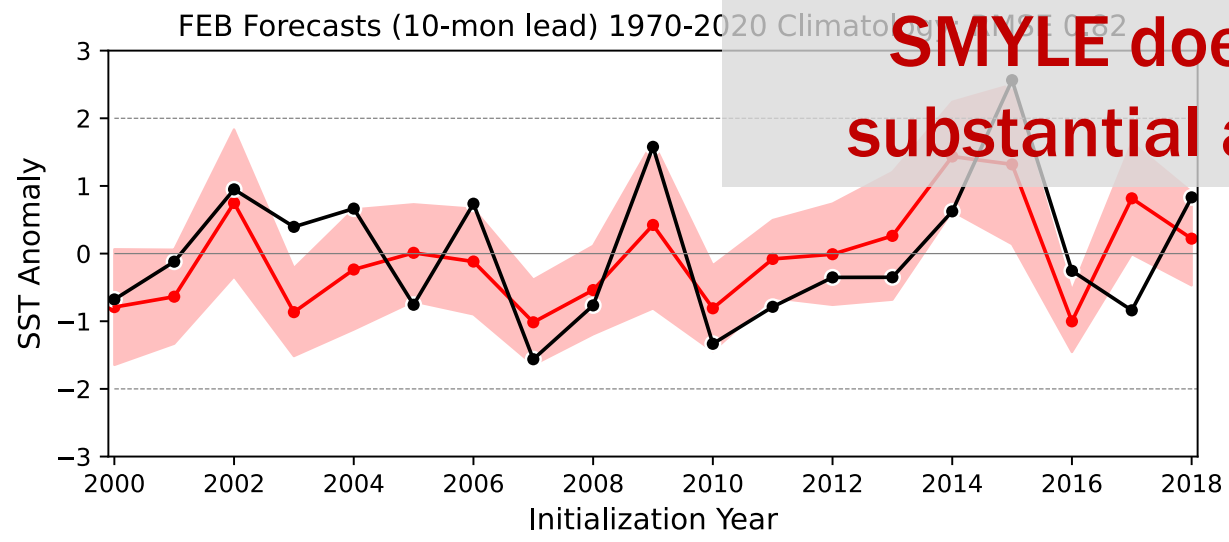
What El Niño precursors are we interested in examining?

Integrated Warm Water Volume

- Proxy for equatorial Pacific heat content
- Integration boundary is the 20° C isotherm

Data for WWV courtesy of the Bureau National Operations Centre (BNOC) at the Australian Bureau of Meteorology and the Pacific Marine Environmental Laboratory

What El Niño precursors are we interested in examining?

ROI: Region of Interest

Integrated Warm Water Volume

- Proxy for equatorial Pacific heat content
- Integration boundary is the 20° C isotherm
- Western Pacific encompasses -5 ° S to 5 ° N and 120 E ° to 155 ° W
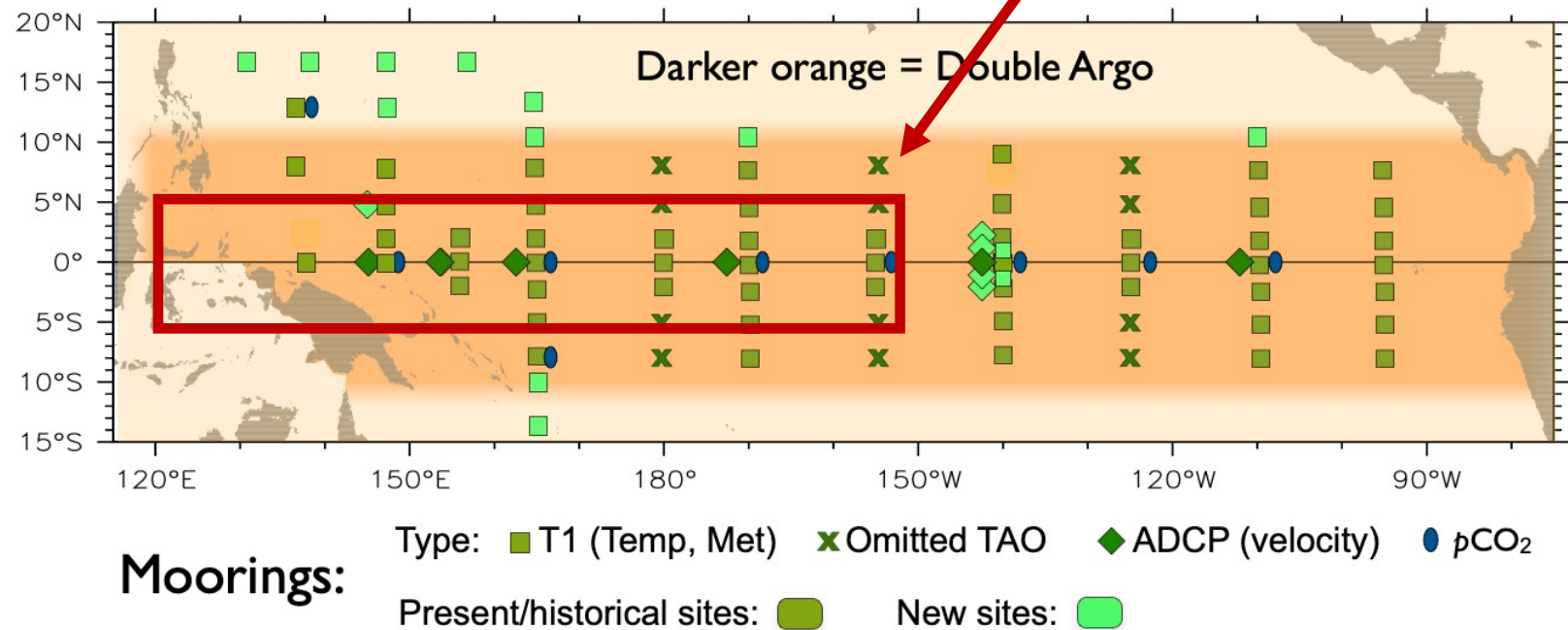

TPOS 2020 proposed reconfiguration

Darker orange = Double Argo

Moorings:

Type: ■ T1 (Temp, Met) ✕ Omitted TAO ◆ ADCP (velocity) ● pCO_2

Present/historical sites: ■   New sites: ■

Image courtesy of tropicalpacific.org

Warm Water Volume Anomalies 2000 – 2024, why are they important?
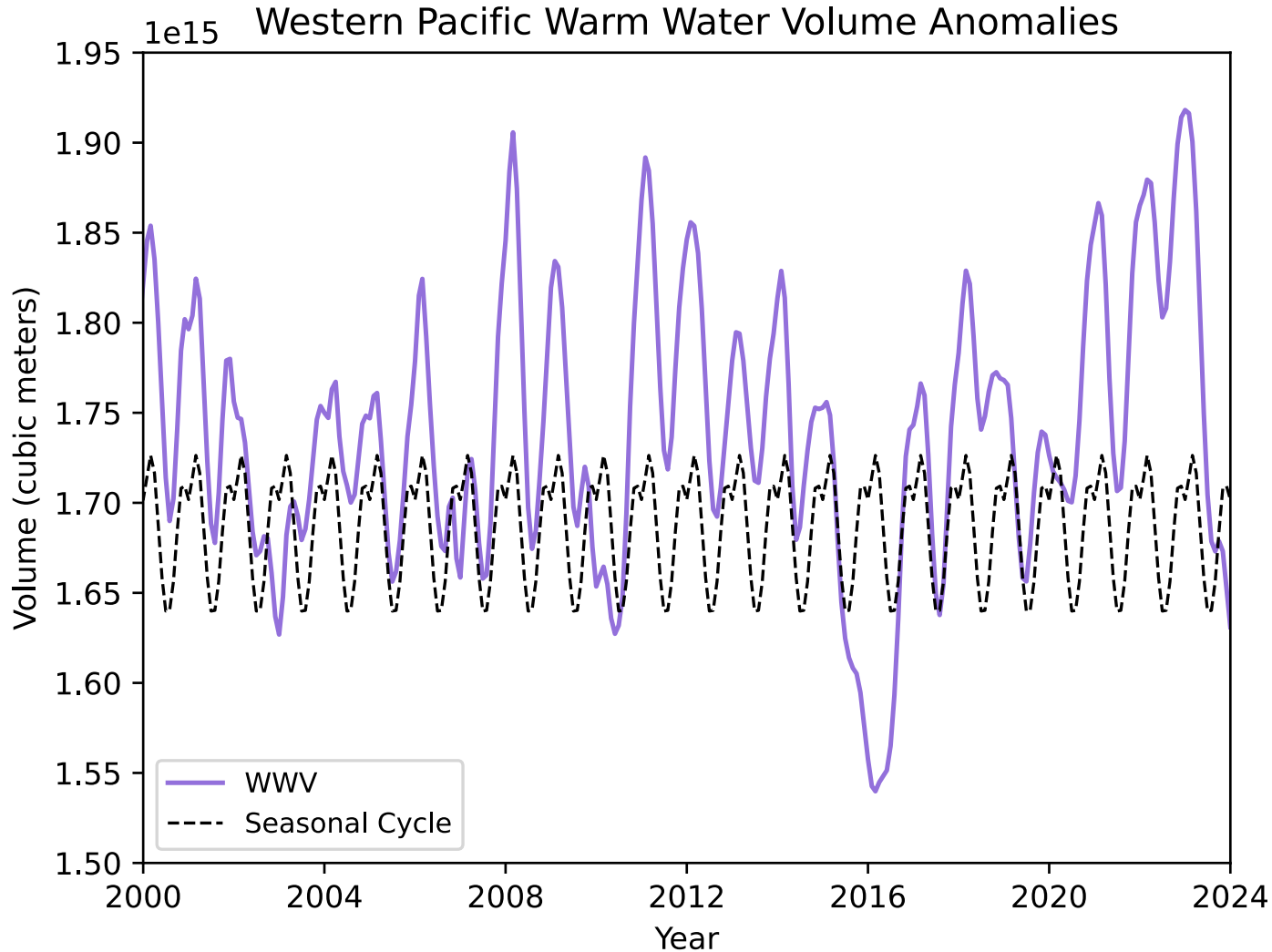
Western Pacific Warm Water Volume Anomalies

- Recharge-discharge oscillator ENSO theory (Jin 1997, Mantua and Battisti 1994, Sheinbaum 2003, Wyrtki 1985)

- ENSO prediction skill increased once ocean heat content (OHC) was included in models (Clarke and Van Gorder 2003, Ji et al. 1998, McPhaden 2003)

Warm Water Volume Anomalies 2000 – 2024, why are they important?
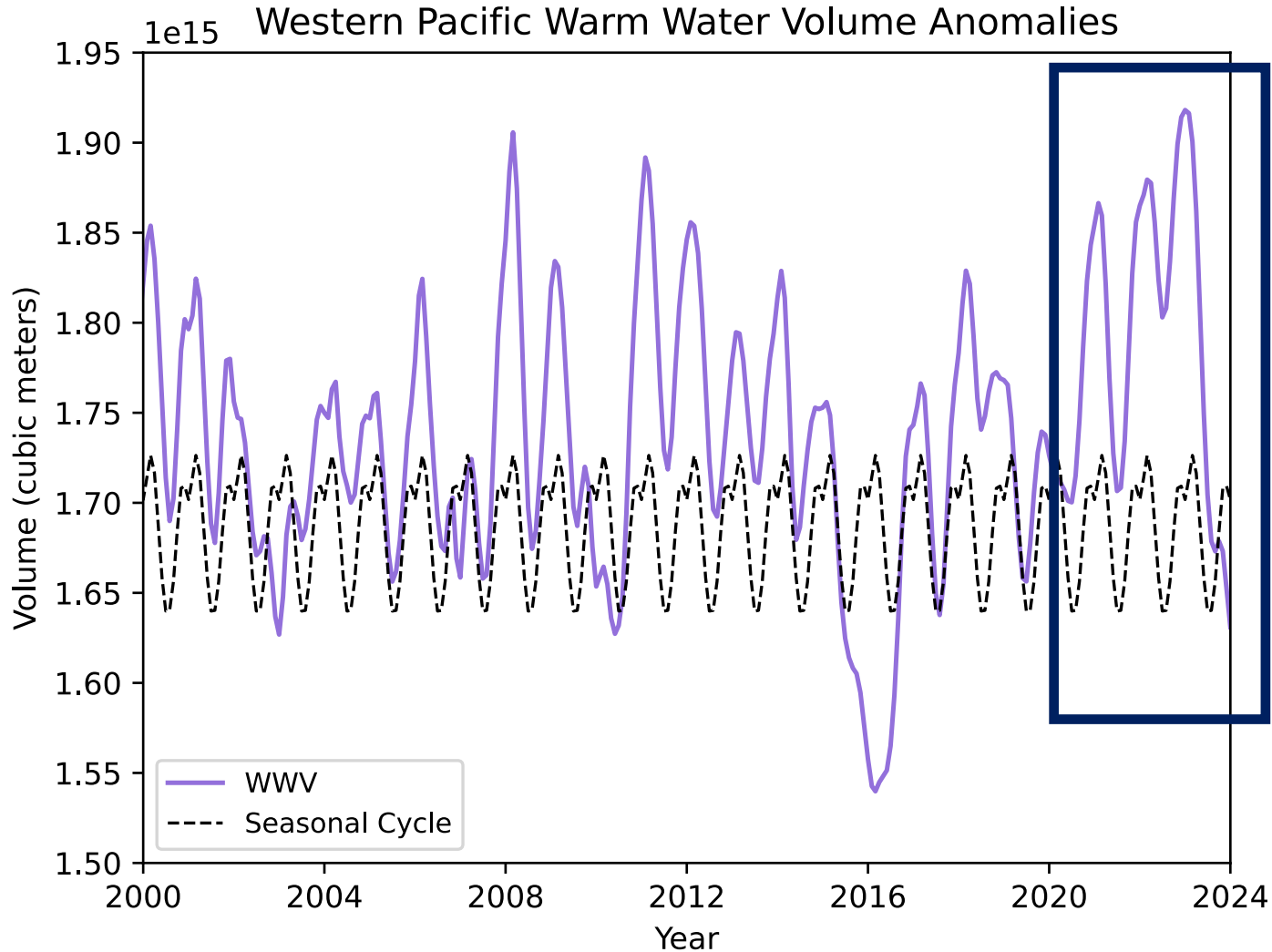
Western Pacific Warm Water Volume Anomalies

- Recharge-discharge oscillator ENSO theory (Jin 1997, Mantua and Battisti 1994, Sheinbaum 2003, Wyrtki 1985)
- ENSO prediction skill increased once ocean heat content (OHC) was included in models (Clarke and Van Gorder 2003, Ji et al. 1998, McPhaden 2003)
- **Multiyear La Niña gave ample WWV/OHC buildup for El Niño onset and materialization**

What El Niño precursors are we interested in examining?

Integrated Warm Water Volume

- Proxy for equatorial Pacific heat content
- Located above the 20° C isotherm
- Western Pacific encompasses -5 ° S to 5 ° N and 120 E ° to 155 ° W

Westerly Wind Bursts

- Zonal wind perturbations that cause a weakening or reversal of the equatorial trade winds
- 'Trigger events' to El Niño due to large, localized accelerations (Cronin and McPhaden 2002)
- Misunderstood, lack of long observational record

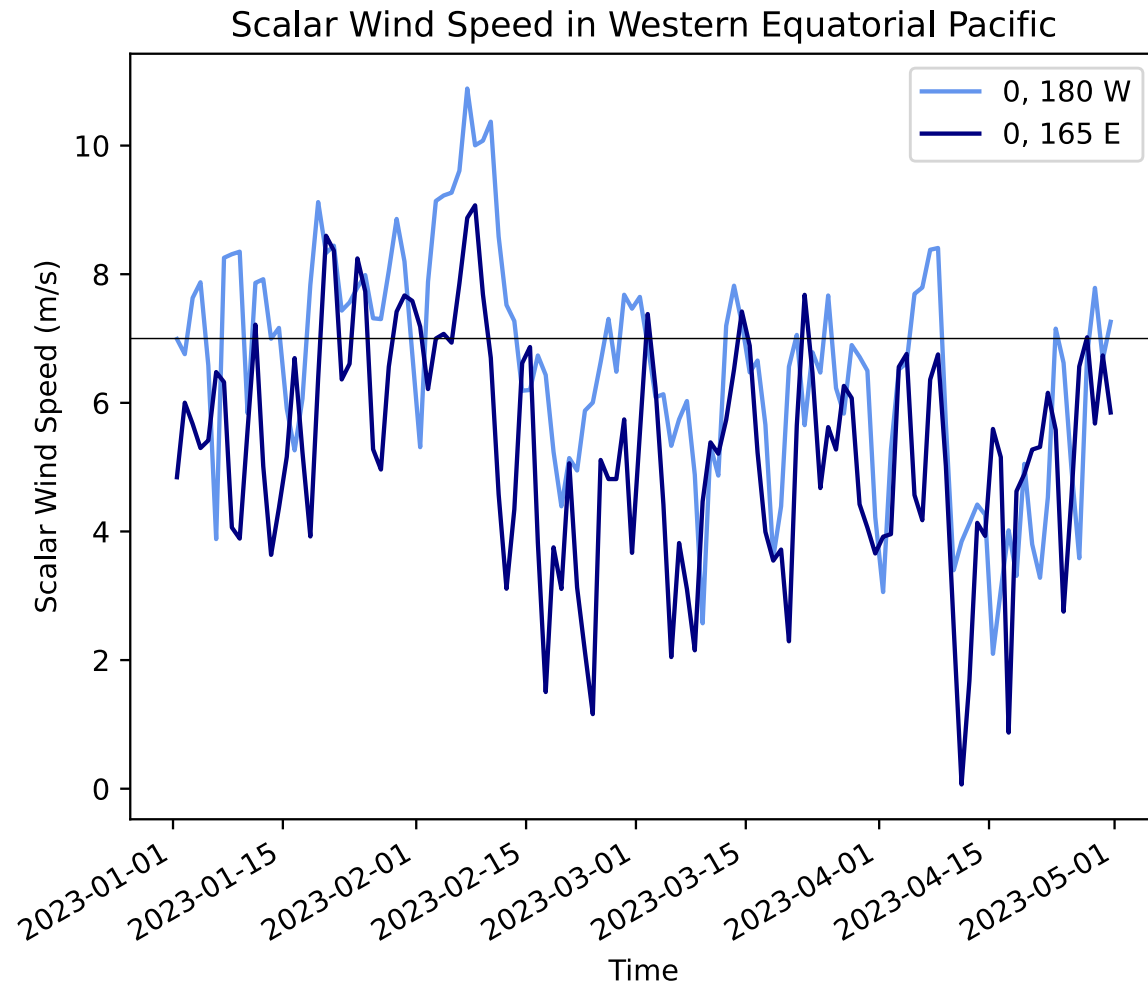# ***Westerly Wind Bursts → Seen from TPOS Moored Array***
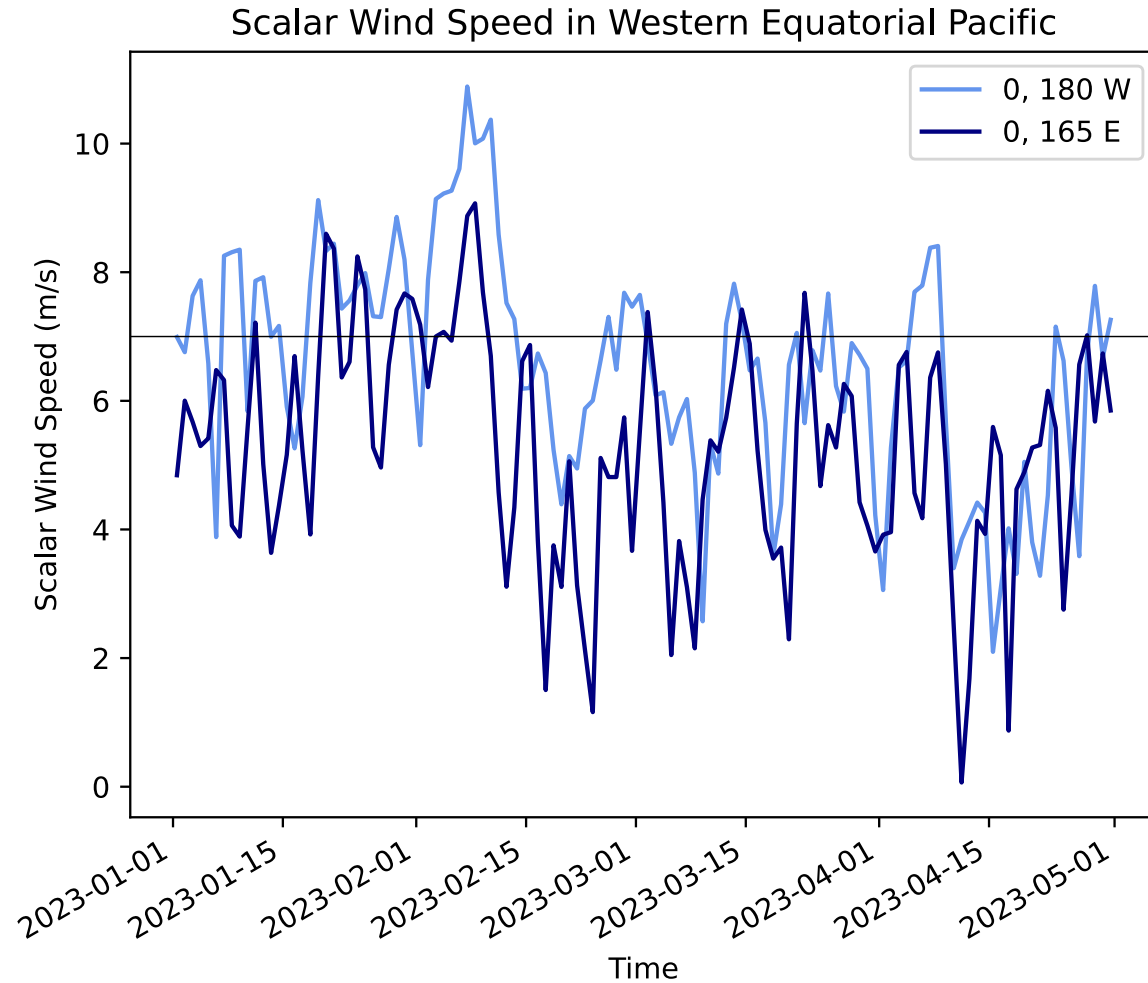
Scalar Wind Speed in Western Equatorial Pacific

Potential WWB event at the beginning of February

- 0, 180 W max wind speed of 10.89 m/s
- 0, 165 E max wind speed of 9.07 m/s

Westerly Wind Bursts → Seen from TPOS Moored Array

Scalar Wind Speed in Western Equatorial Pacific

Potential WWB event at the beginning of February

- 0, 180 W max wind speed of 10.89 m/s
- 0, 165 E max wind speed of 9.07 m/s
- *Note: scalar wind speed reported, not indicative of westward movement … however →*

Westerly Wind Bursts → Seen from TPOS Moored Array

Potential WWB event at the beginning of February

- 0, 180 W max wind speed of 10.89 m/s
- 0, 165 E max wind speed of 9.07 m/s
- *Wind direction shows a westerly shift after wind speed increase*

Wind Direction in Western Equatorial Pacific
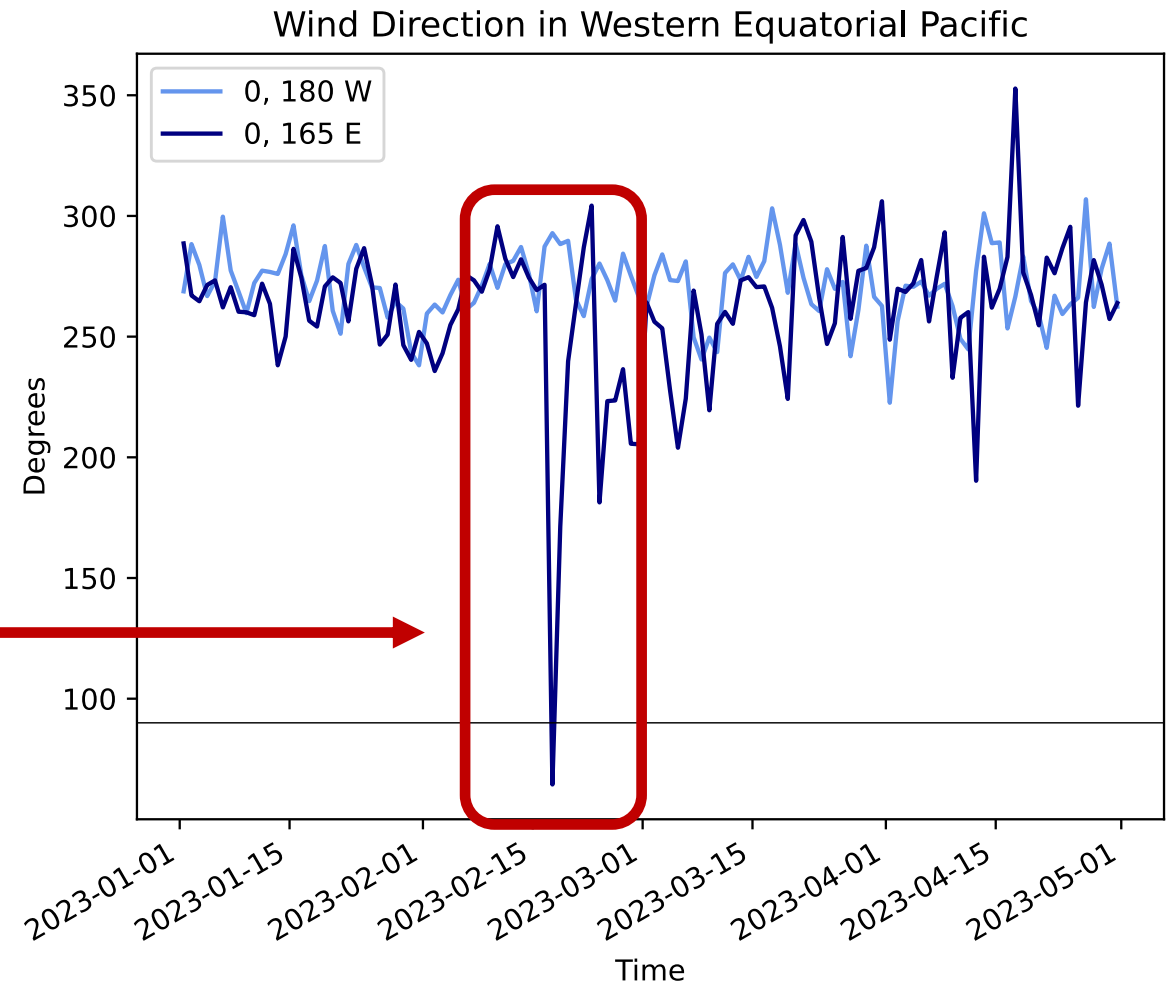
Does SMYLE predict an El Niño event during the Feb initialization?

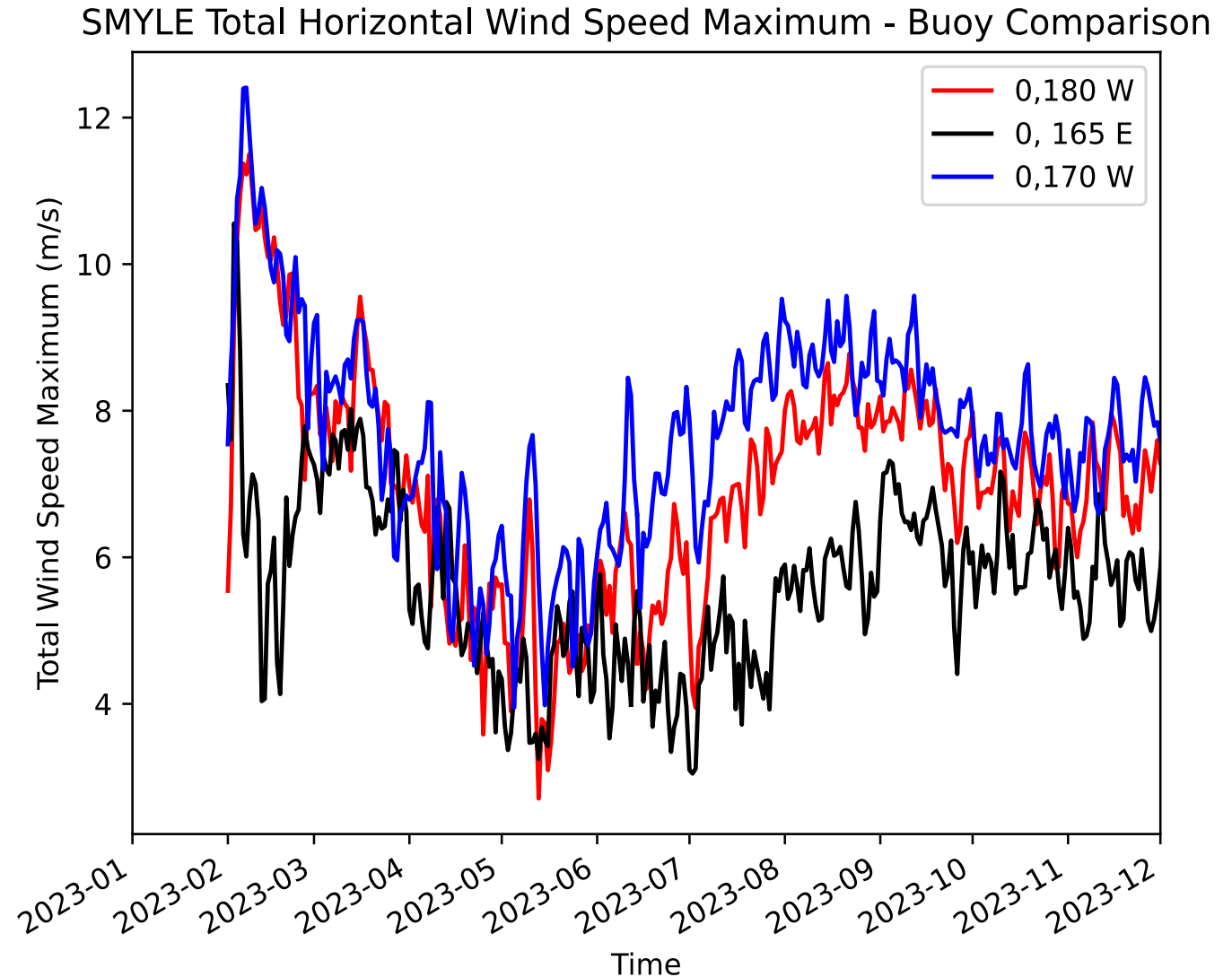**Does SMYLE predict an El Niño event during the Feb initialization?**

- Yes – SMYLE predicted a max SSTA of 2.2° C
- A quick transition from La Niña to El Niño conditions occurs from boreal winter to summer
- *A secondary increase in SSTA from July to October 2024?*

SMYLE02 Sea Surface Temperature Anomaly Niño 3.4 Region
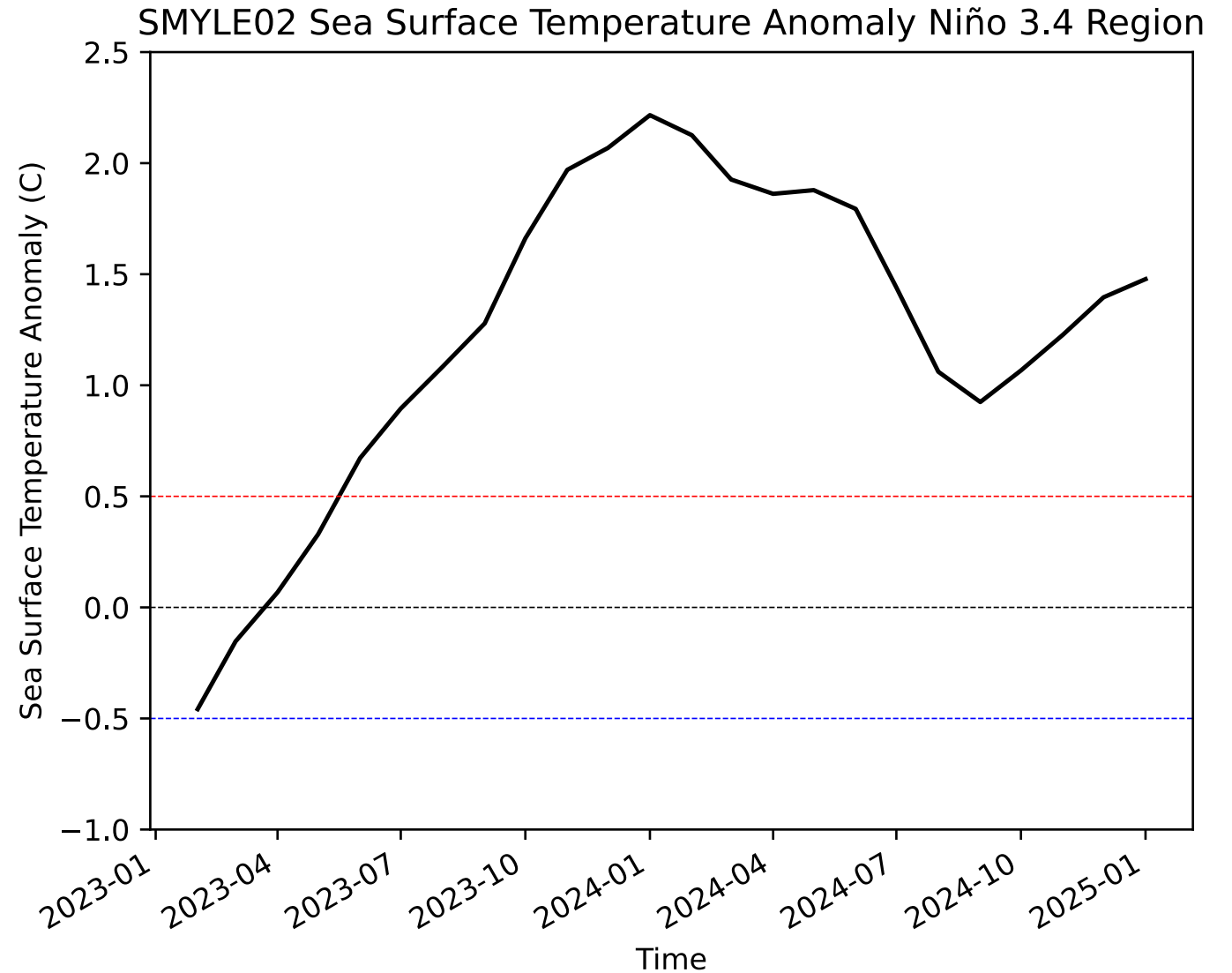
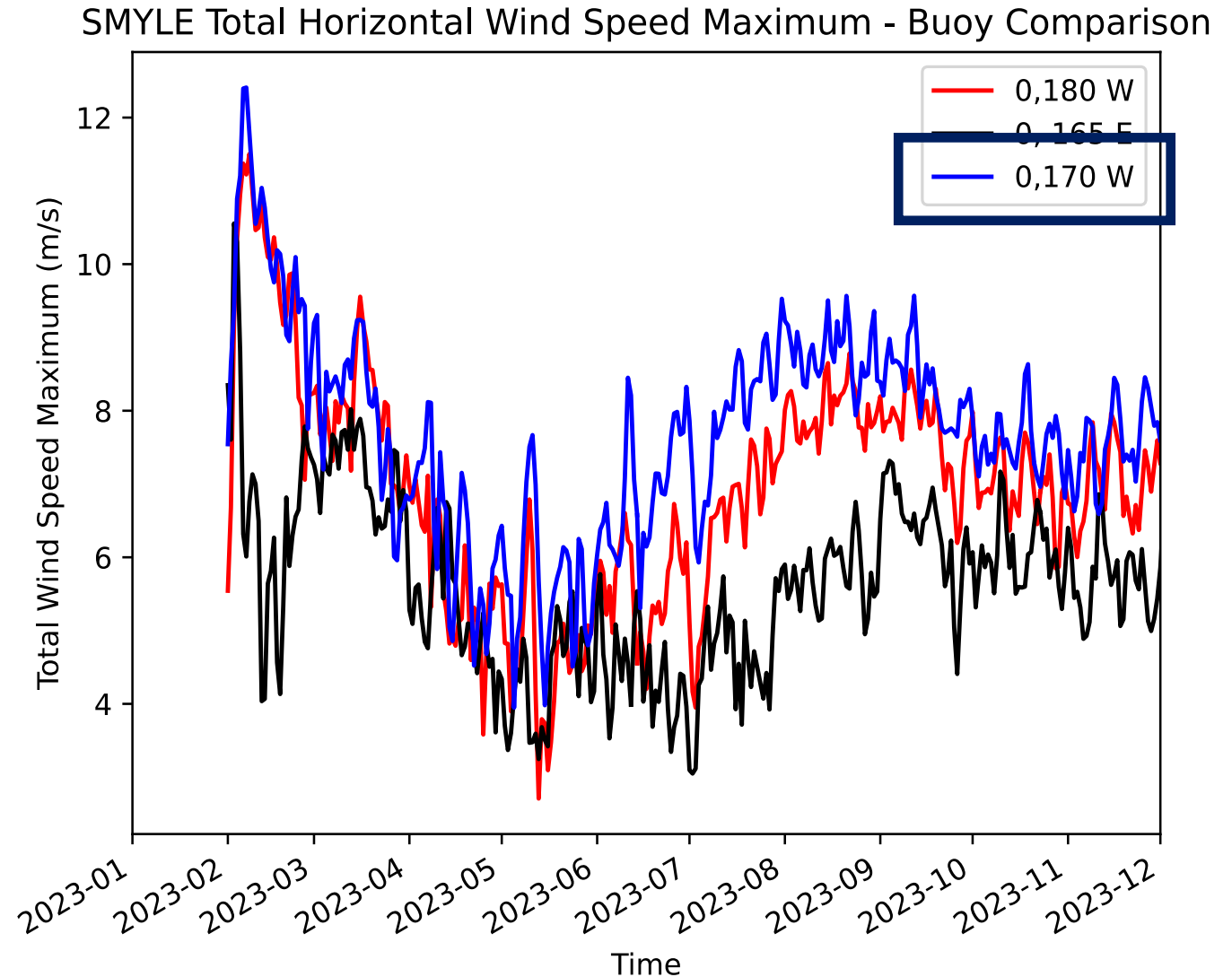# Does SMYLE resolve El Niño precursors during the February initialization?

SMYLE Total Horiz. Wind Speed with Buoy Proxy – Mean Ensemble

- Increase in horizontal wind speed in western Pacific

SMYLE Total Horizontal Wind Speed Maximum - Buoy Comparison

- Increase in horizontal wind speed in western Pacific
- SMYLE peak at 0, 170W and buoy peak at 0, 180 W

SMYLE Total Horizontal Wind Speed Maximum - Buoy Comparison

- Increase in horizontal wind speed in western Pacific
- SMYLE peak at 0, 170W and buoy peak at 0, 180 W
- Wind speed peak of 12.4 m/s, larger than buoy observations
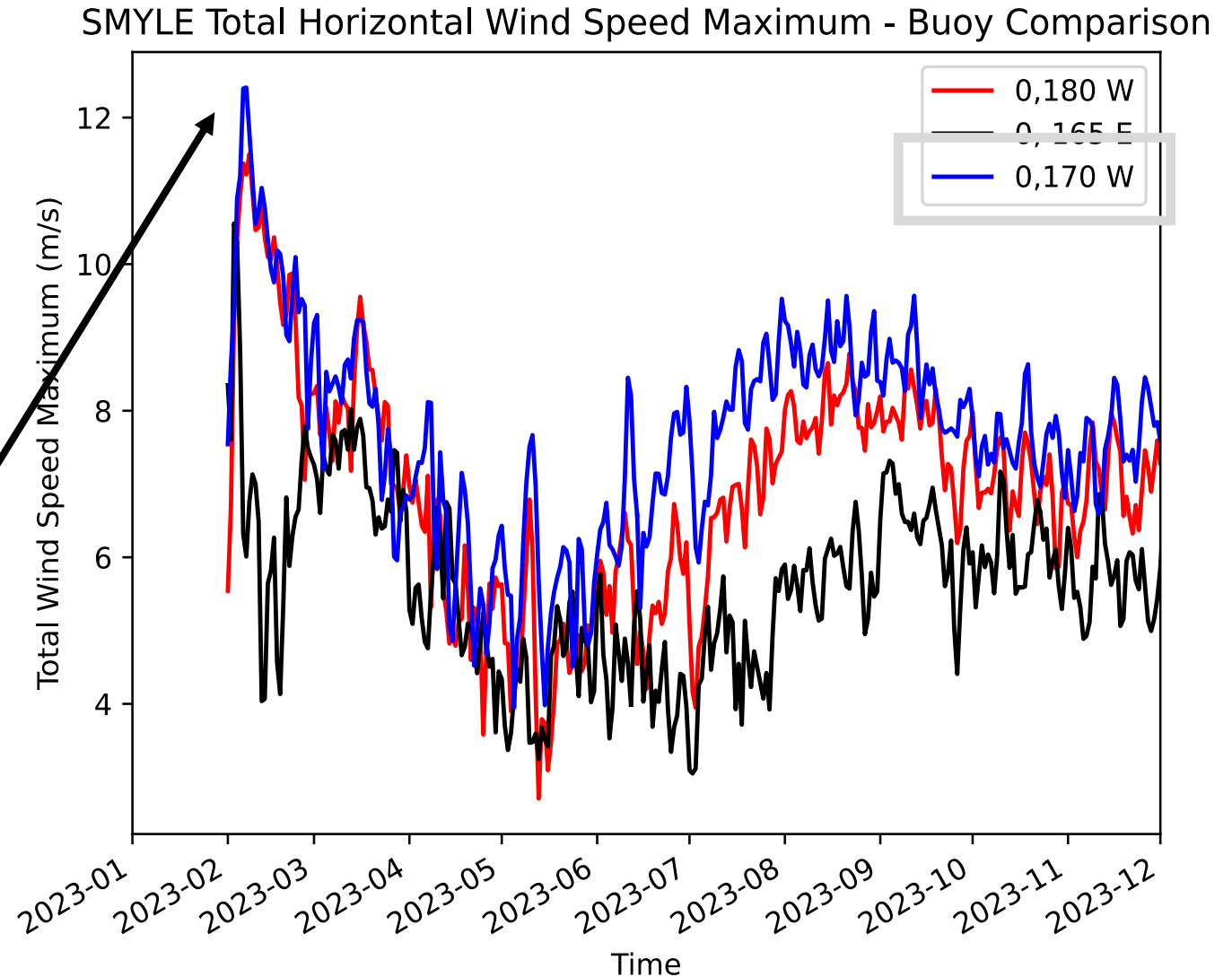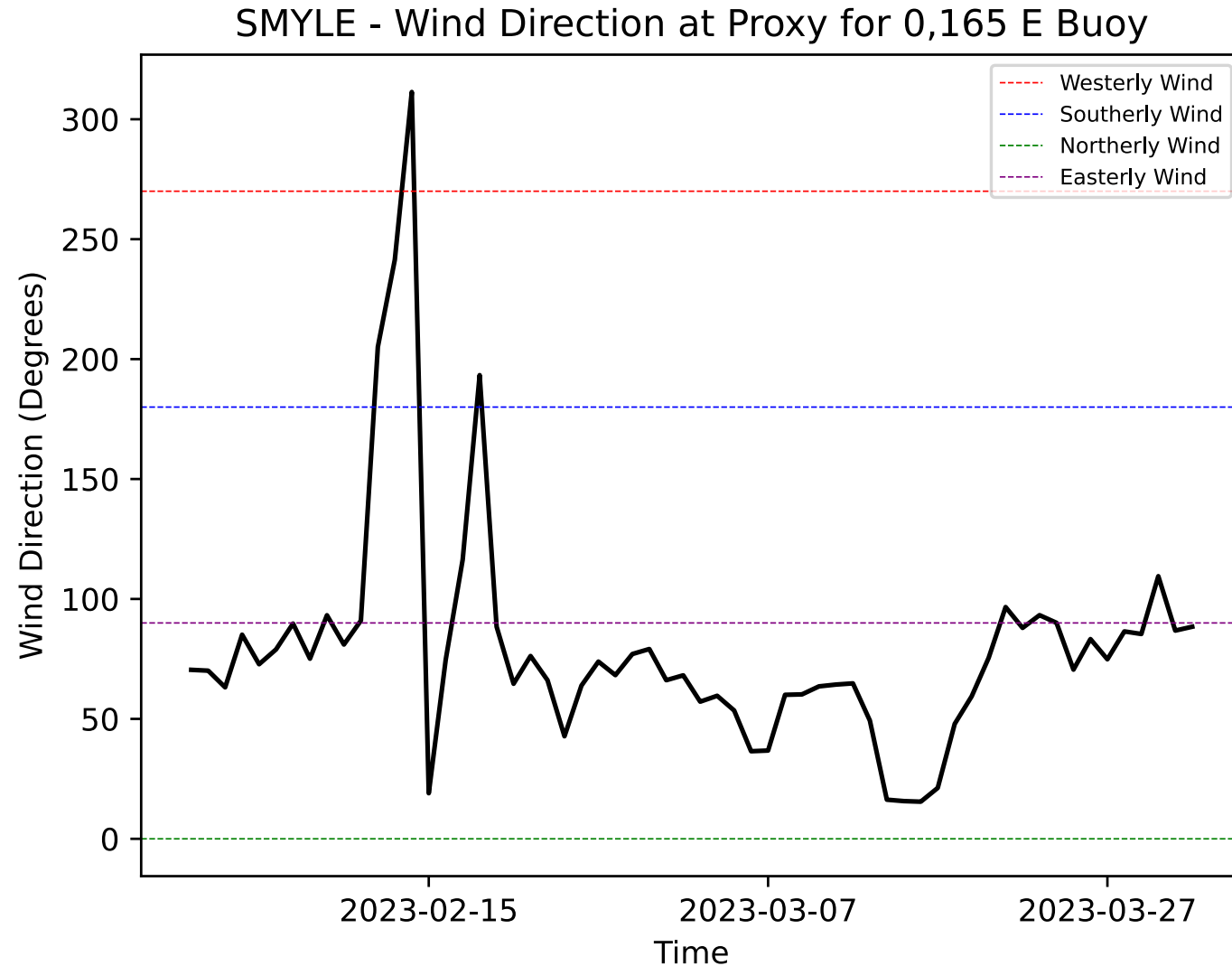
SMYLE Total Horizontal Wind Speed Maximum - Buoy Comparison

Derived SMYLE Wind Direction with Buoy Proxy

Preliminary work – SMYLE02 initialization with 1 ensemble member

SMYLE - Wind Direction at Proxy for 0,165 E Buoy

Derived SMYLE Wind Direction with Buoy Proxy

Preliminary
work –
SMYLE02
initialization
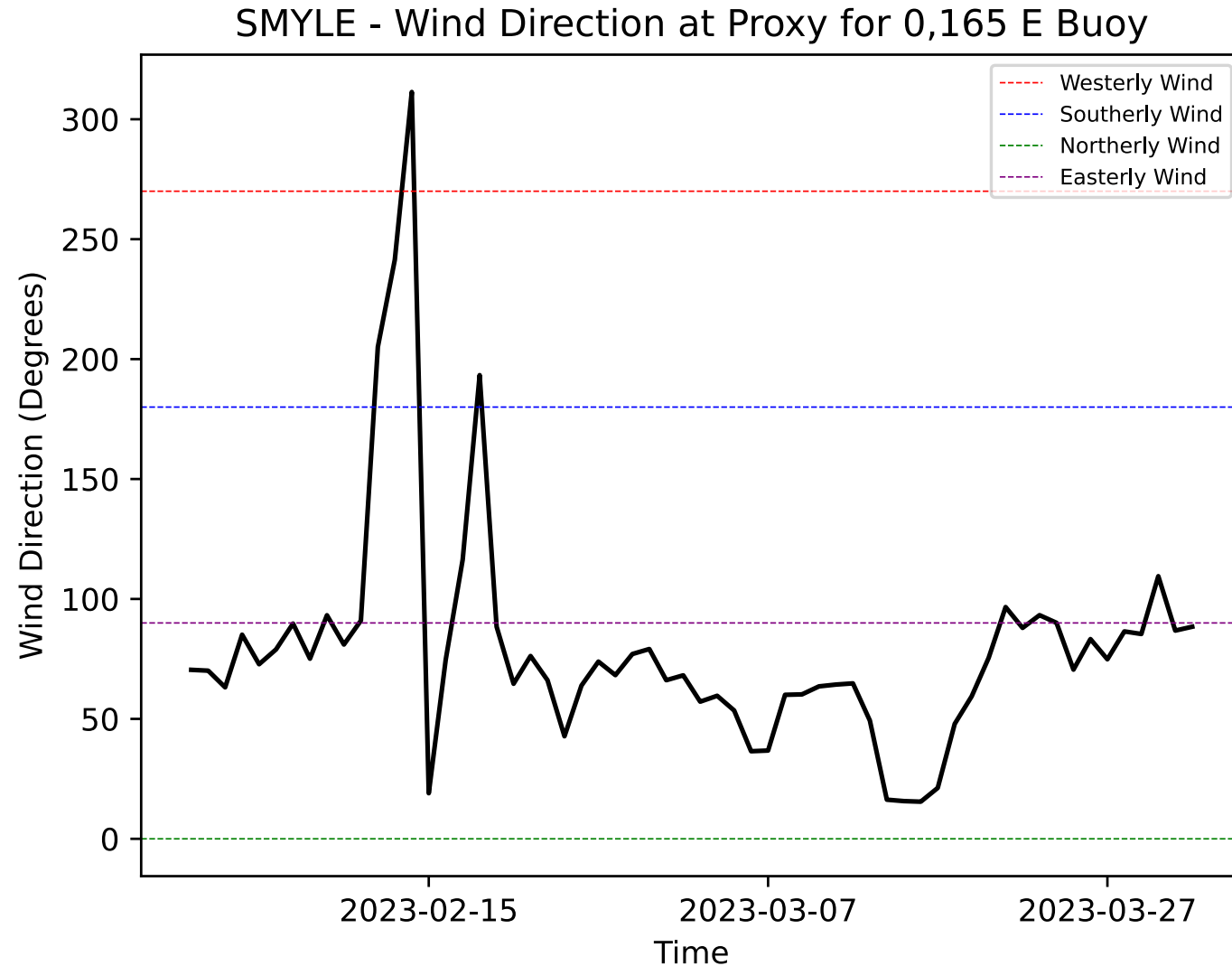with 1 ensemble
member

SMYLE - Wind Direction at Proxy for 0,165 E Buoy
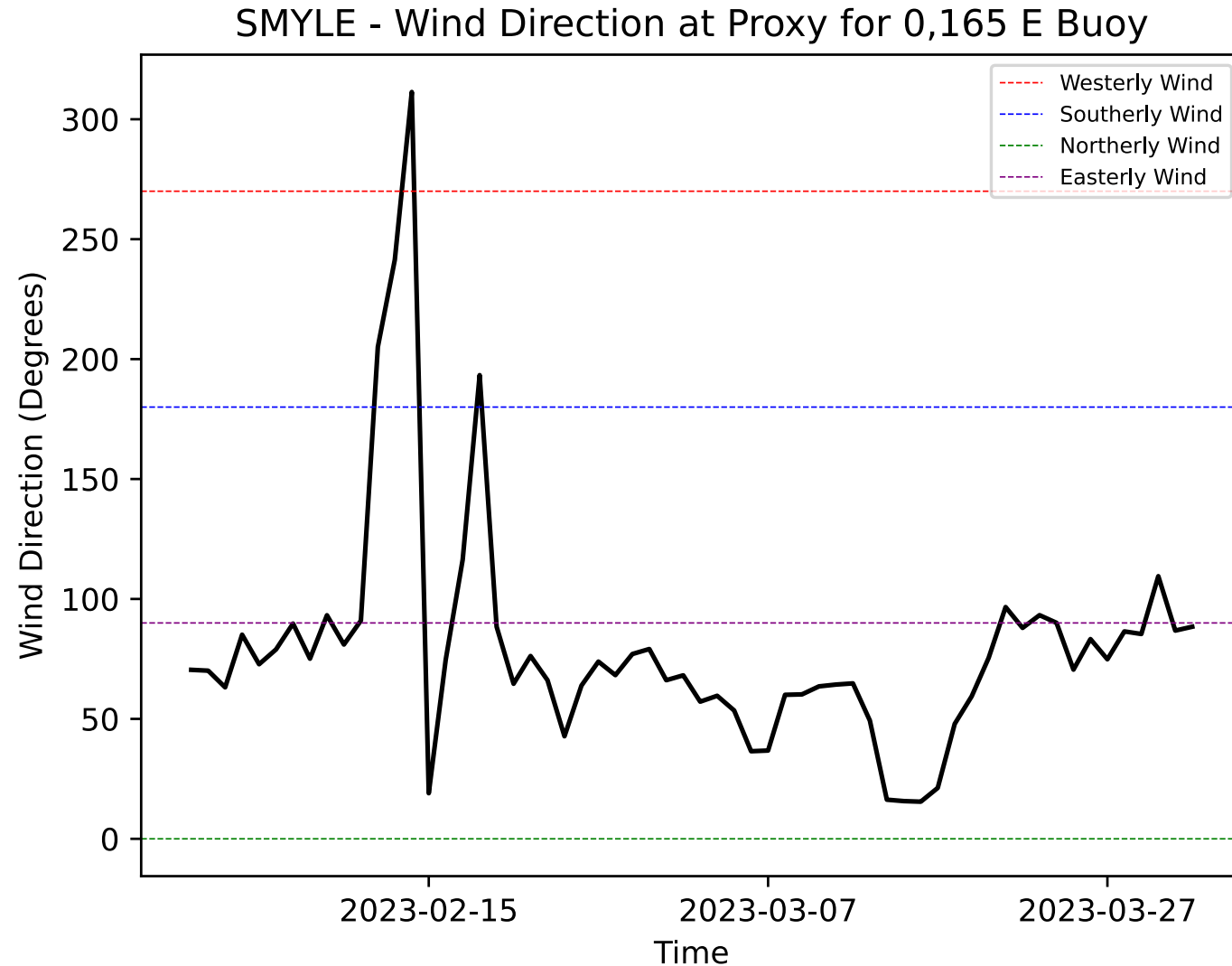
Westerly wind
captured in
February
SMYLE
initialization

Derived SMYLE Wind Direction with Buoy Proxy

SMYLE - Wind Direction at Proxy for 0,165 E Buoy

- - - - Westerly Wind
- - - - Southerly Wind
- - - - Northerly Wind
- - - - Easterly Wind

Wind Direction (Degrees)

300
250
200
150
100
50
0

2023-02-15   2023-03-07   2023-03-27

Time

Feb WWB captured in Feb, is it resolved in Nov 2022? Or Before?
→ <mark>Future work!</mark>

Future Work

Compute SMYLE ocean heat content and wind direction across ensemble members

Future Work

Compute SMYLE ocean heat content and wind direction across ensemble members

Compare February and May initializations to determine skill differences during the SPB

Future Work

Compute SMYLE ocean heat content and wind direction across ensemble members

Compare February and May initializations to determine skill differences during the SPB

Investigate how far back SMYLE predicts El Niño onset, materialization, and magnitude (i.e., SMYLE initialized in 2022)

Future Work

Compute SMYLE ocean heat content and wind direction across ensemble members

Compare February and May initializations to determine skill differences during the SPB

Investigate how far back SMYLE predicts El Niño onset, materialization, and magnitude (i.e., SMYLE initialized in 2022)

Questions?

*Emily Wisinski –
ewisinsk@umd.edu
Dr. Maria Molina –
mjmolina@umd.edu*

Extra Slides

Any questions on WWV:
https://www.pmel.noaa.gov/elnino/upper-ocean-heat-content-and-enso

What El Niño precursors are we interested in examining?

ROI: Region of Interest

Integrated Warm Water Volume
- Proxy for equatorial Pacific heat content
- Located above the 20° C isotherm
- Western Pacific encompasses -5 ° S to 5 ° N and 120 E ° to 155 ° W
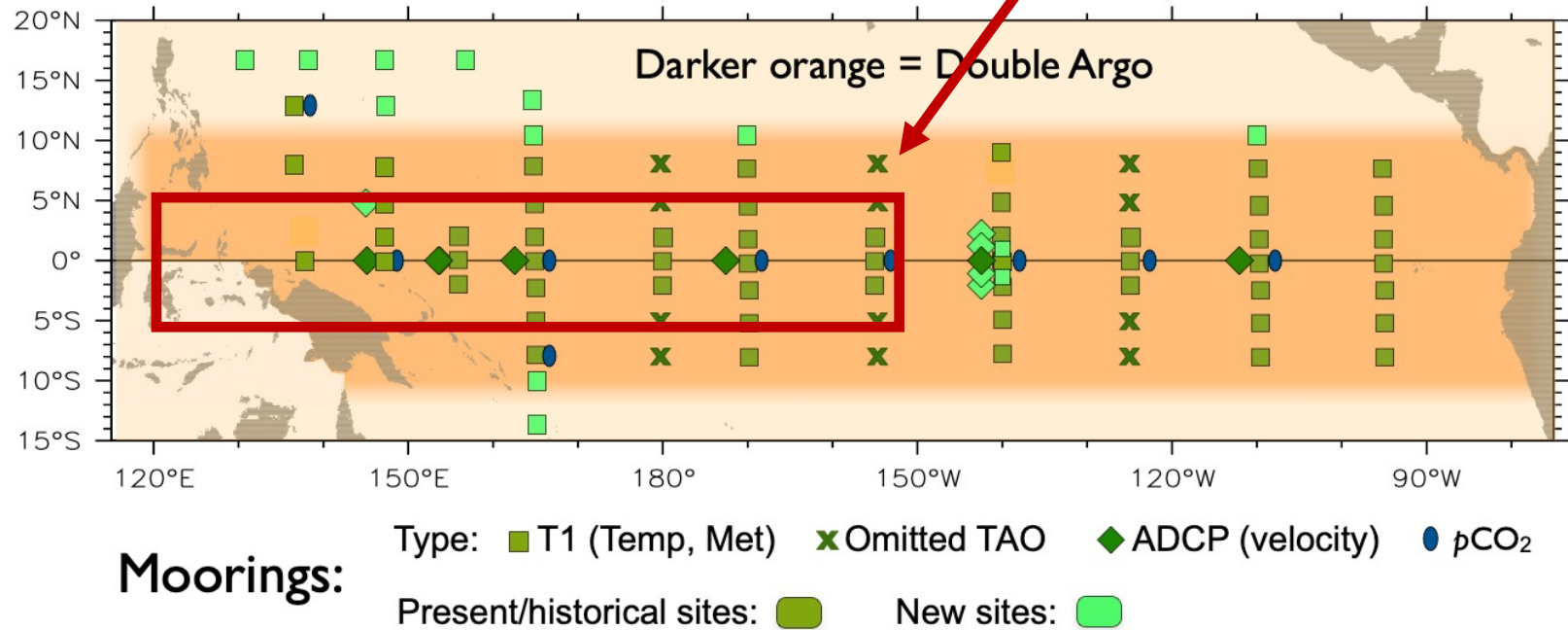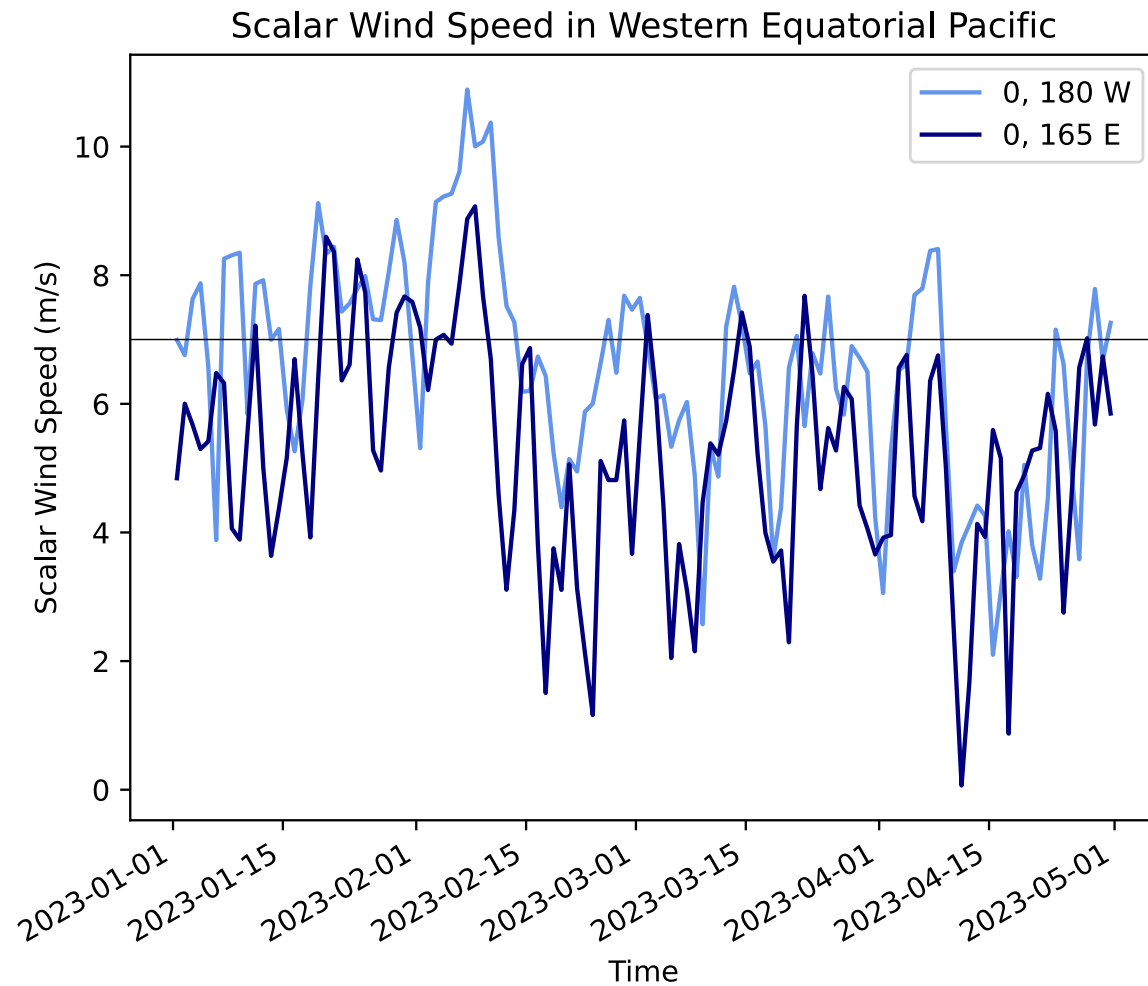
TPOS 2020 proposed reconfiguration

Darker orange = Double Argo

Moorings:

Type: ■ T1 (Temp, Met) ✕ Omitted TAO ◆ ADCP (velocity) ● pCO_2

Present/historical sites: ■ New sites: ■

Image courtesy of tropicalpacific.org

Westerly Wind Bursts → Seen from TPOS Moored Array

Scalar Wind Speed in Western Equatorial Pacific

Potential WWB event at the beginning of February
- 0, 180 W max wind speed of 10.89 m/s
- 0, 165 E max wind speed of 9.07 m/s

WWB Definition (not standardized):

- Must last 5-20 days
- Extending at least 10° in longitude
- Average intensity over the western tropical Pacific higher than 5 m/s and longer than 2 days
- Daily zonal wind anomaly > 0.5 m/s