Joint Workshop of the OS-Eval TT and CP-TT and SynObs Kick-Off
15 November 2022

Tropical Pacific Observing System
-synergy with modeling and assimilation activities-

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TROPICAL PACIFIC OBSERVING SYSTEM

OceanPredict
Advancing the science of ocean prediction

Background of TPOS2020 project (1/2)

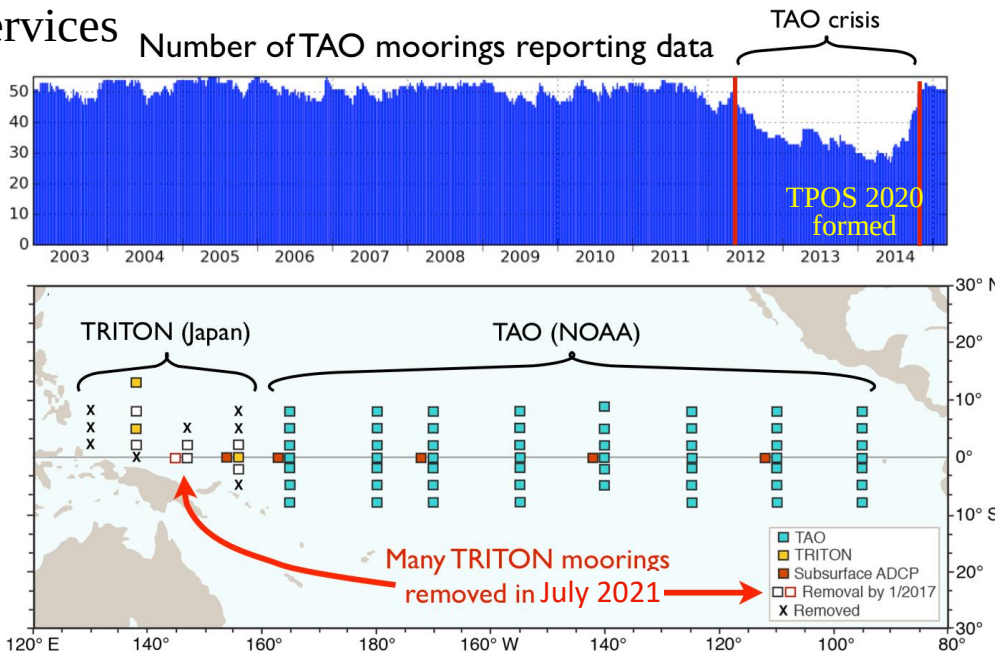
The main driver of the project is an identified significant risk to El Niño–Southern Oscillation (ENSO) predictions and associated services due to the deterioration of the tropical moored buoy array (TMA) in the Pacific in 2012-2014.

The project aims for enhanced effectiveness for all stakeholders, informed by the development and requirements of the operational prediction models that are primary users of TPOS data.

The scientific objectives of the project were as the followings:

- To redesign and refine the TPOS to observe ENSO and advance scientific understanding of its causes,
- To determine the most efficient and effective observational solutions to support prediction systems for ocean, weather and climate services
- To advance understanding of tropical Pacific physical and biogeochemical variability and predictability

We rethought the system in light of its many functions.



Background of TPOS2020 project (2/2)

We reinvigorated work on the tropical Pacific across multiple disciplines, and mobilized our community through workshops and conferences.

As results, we published three reports, which contain recommendations for redesign and enhancement of TPOS.

The TPOS2020 redesign aims to take full advantage of the diverse remote and in situ techniques available today, fitting them together as an integrated system.

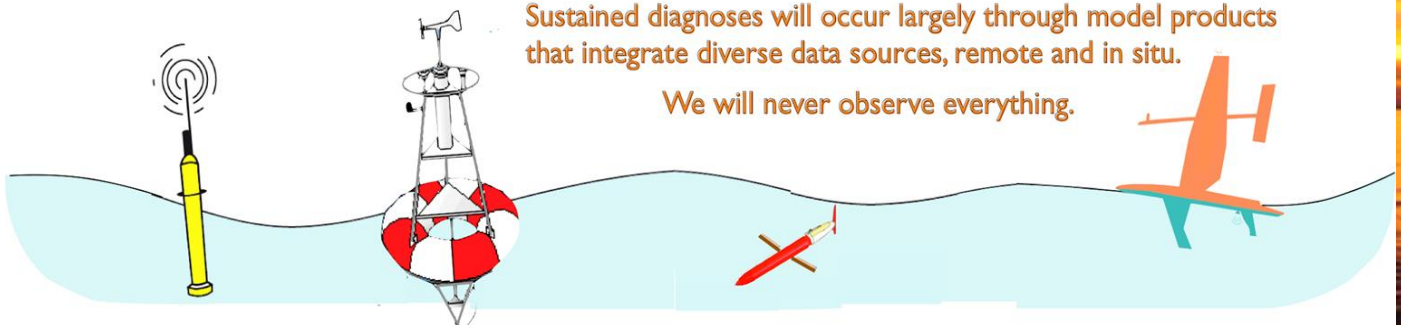
An integrated vision

Complementary "backbone" technologies:

- Satellites give global coverage, horizontal detail
- Moorings sample across timescales, allow co-located ocean-atmosphere observations, velocity sampling
- Argo resolves fine vertical structure, adds salinity, maps subsurface T and S, connects to subtropics

Sustained diagnoses will occur largely through model products that integrate diverse data sources, remote and in situ.

We will never observe everything.



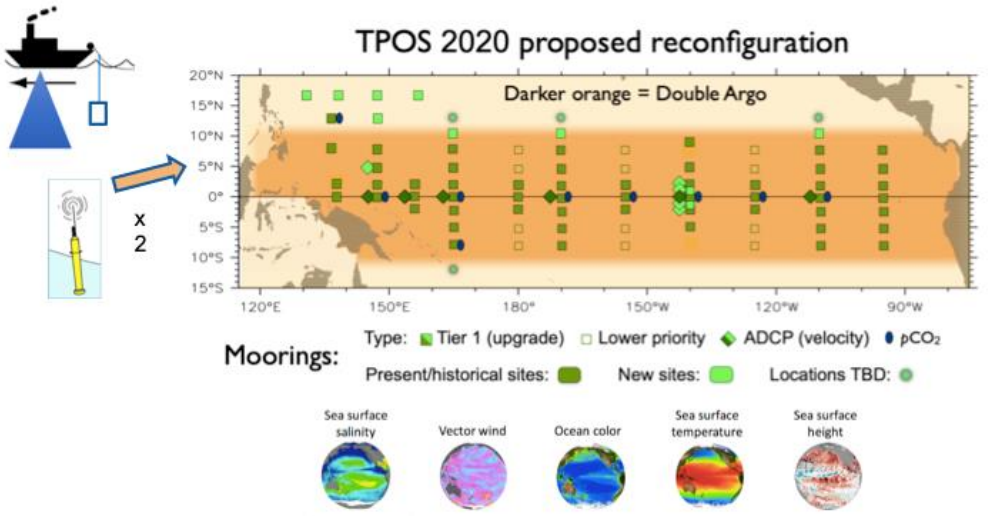
The new configuration of backbone

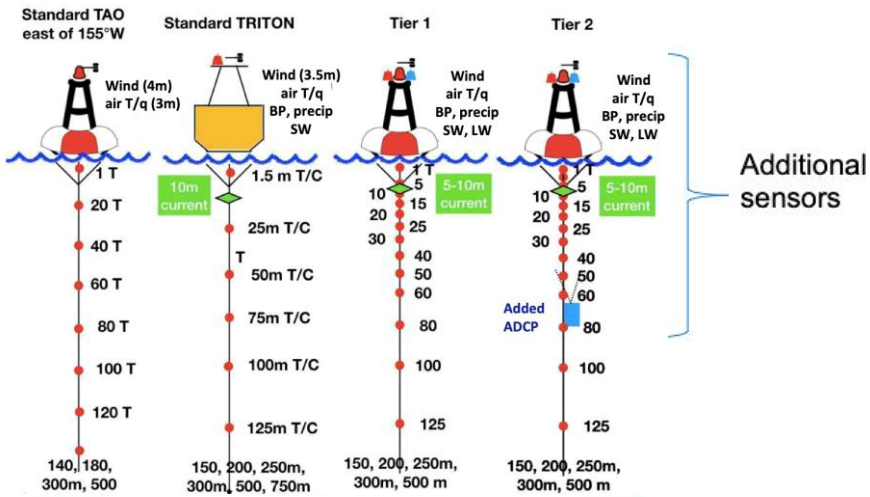
The new TPOS will be exploited the complementarity among observational platforms; Argo floats, hydrographic crises, drifters, USVs, satellite retrievals, and newly emerging, to drive forward a major advance in our capability to monitor the tropical Pacific Ocean and lower atmosphere.

The new TMA will comprise more highly instrumented and capable moored systems than used at present and will return hourly or better data of a larger and more complete parameter set.

As an actual configuration, we envisage 3 tiers of moored sites; a widely deployed enhanced base level (Tier 1) that will include more measurement capability than the present standard mooring configuration, a velocity-enhanced mooring that will be less widely deployed (Tier 2), and very highly instrumented "Super Sites" (Tier 3).

Basically enhancement will be done for ML observation and meteorological sampling.
Also BGC measurements will be intensified.





Data Assimilation and weather & climate prediction relevant issues (1/3)

The redesigned and refined new TPOS were also strongly connected to improvements for model-based prediction systems, including data assimilation.

Thus, to benefit from the sustaining and improving TPOS, it is essential

(a) to improve the modeling infrastructure, and

(b) monitor the efficacy of observations that are being utilized in season to interannual prediction systems

TPOS2020 related activities for DA and prediction;

- A review of present models, especially for S2IP
- Efforts for establishment of routine and regular real-time and off-line system evaluation
- Conducting several OSEs to identify observations that constrain models most effectively and have high impact on forecasts.

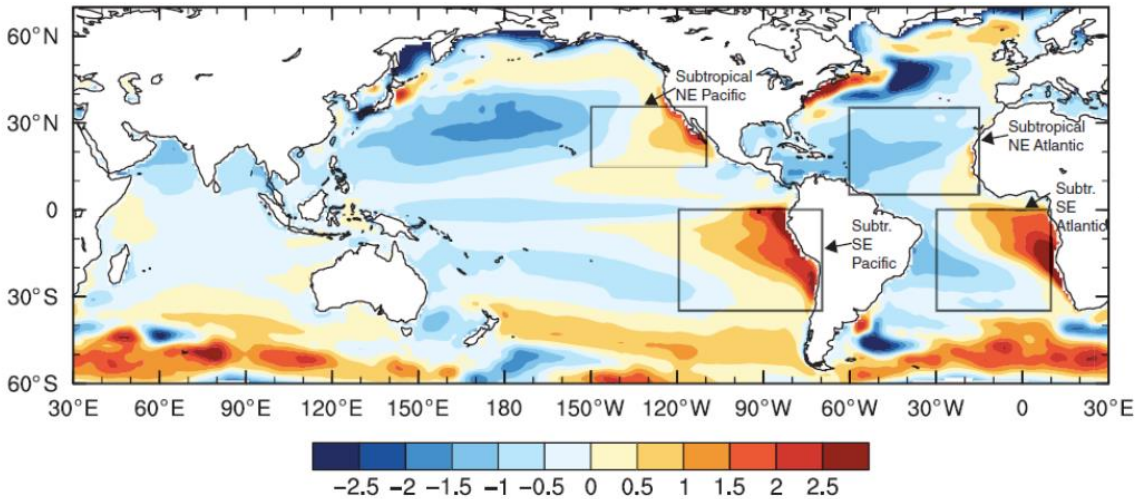


Figure 2.2 in 2nd Rep.
Annual mean SST bias of a CMIP5 ensemble relative to observations (from Richter, 2015)

Data Assimilation and weather & climate prediction relevant issues (2/3)

Larger uncertainty N&S of equator during TMA failure

Xue et al. (CD 2017)

Abstract: *"The **uncertainties in anomalous temperature** remained much higher than the pre-2012 value, probably due to uncertainties in the reference climatology. This highlights the **importance of long-term stability** of the observing system for anomaly monitoring."*

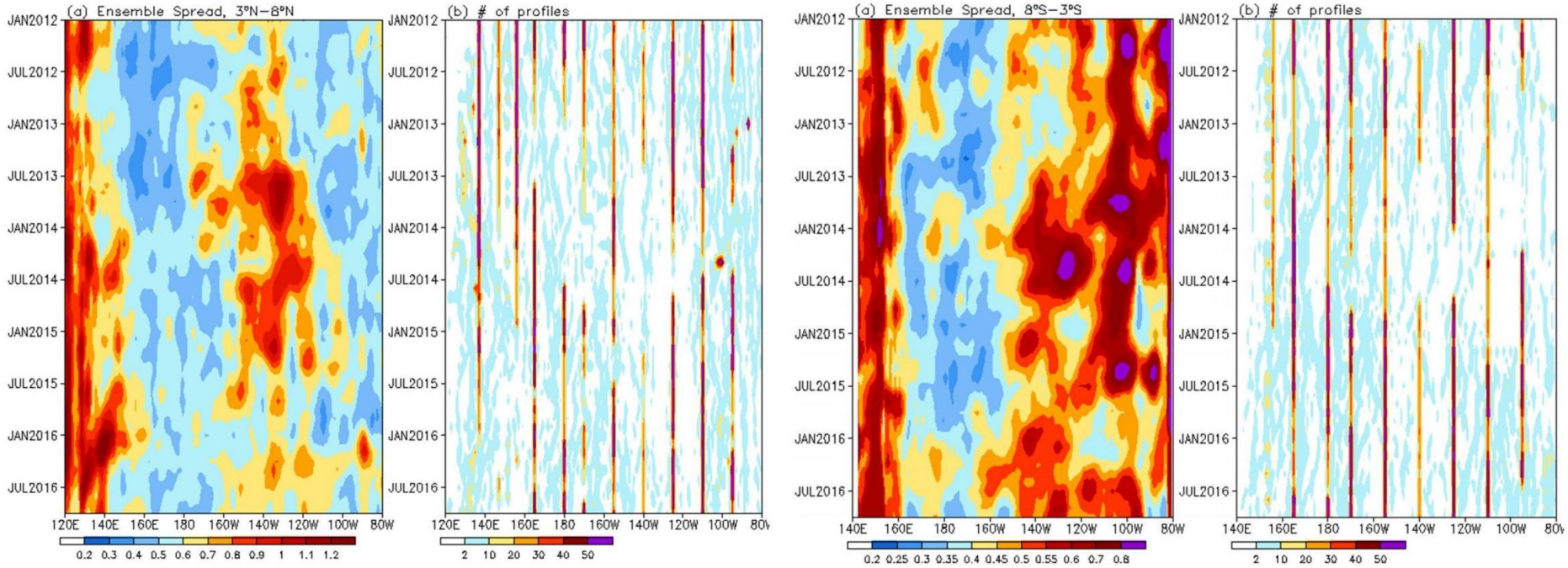


Figure: (a) Longitude-time plot of 3-month running mean of the ensemble spread of total temperature (˚ C) from seven ORAs (with NCFSR and MET removed) calculated in the top 300 m and 3˚ N-8˚ N from January 2012 to October 2016. (b) The number of daily temperature profiles accumulated in each month and in the north equatorial belt **3˚ N-8˚ N** from January 2012 to October 2016. (c-d) Same as (a-b) but from **8˚ S–3˚ S**.

Xue, Y., Wen, C., Kumar, A., Balmaseda, M., Fujii, et al. (2017). A real-time ocean reanalyses intercomparison project in the context of tropical pacific observing system and ENSO monitoring. *Climate Dynamics*, *49*(11-12), 3647-3672.

Data Assimilation and weather & climate prediction relevant issues (3/3)

Impact of removing mooring data on ocean assimilations

Fujii et al. (QJRMS 2015)

OSEs: Removing moorings **increases RMS differences** among heat content estimates during 2004-2010 – not just near the equator, but over the entire TMA region.

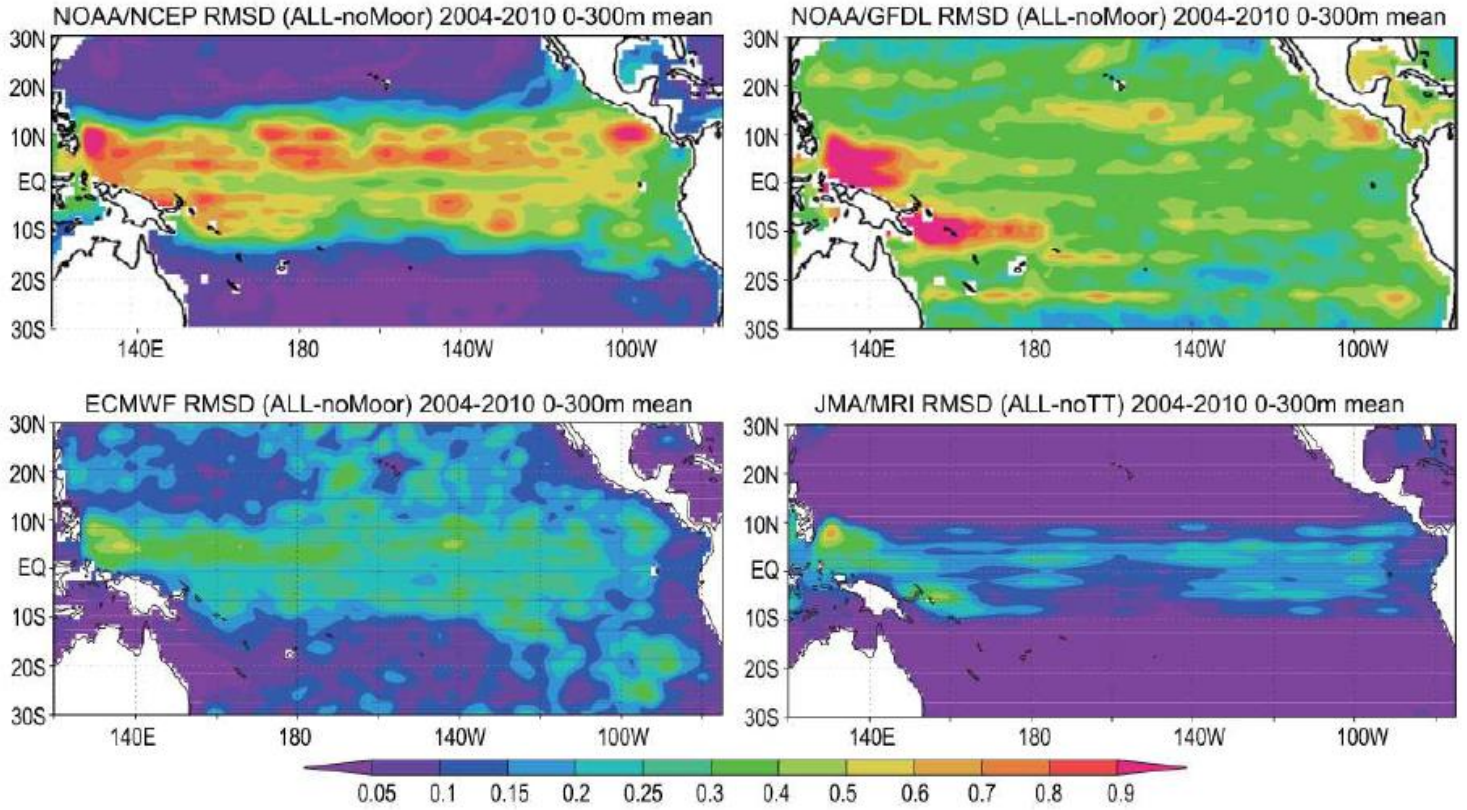


Figure: 0-300 m averaged RMSD of temperature (°C) between ALL and noMoor/noTT in 2004-2011 (2004-2010) for NCEP and GFDL (ECMWF and JMA/MRI).

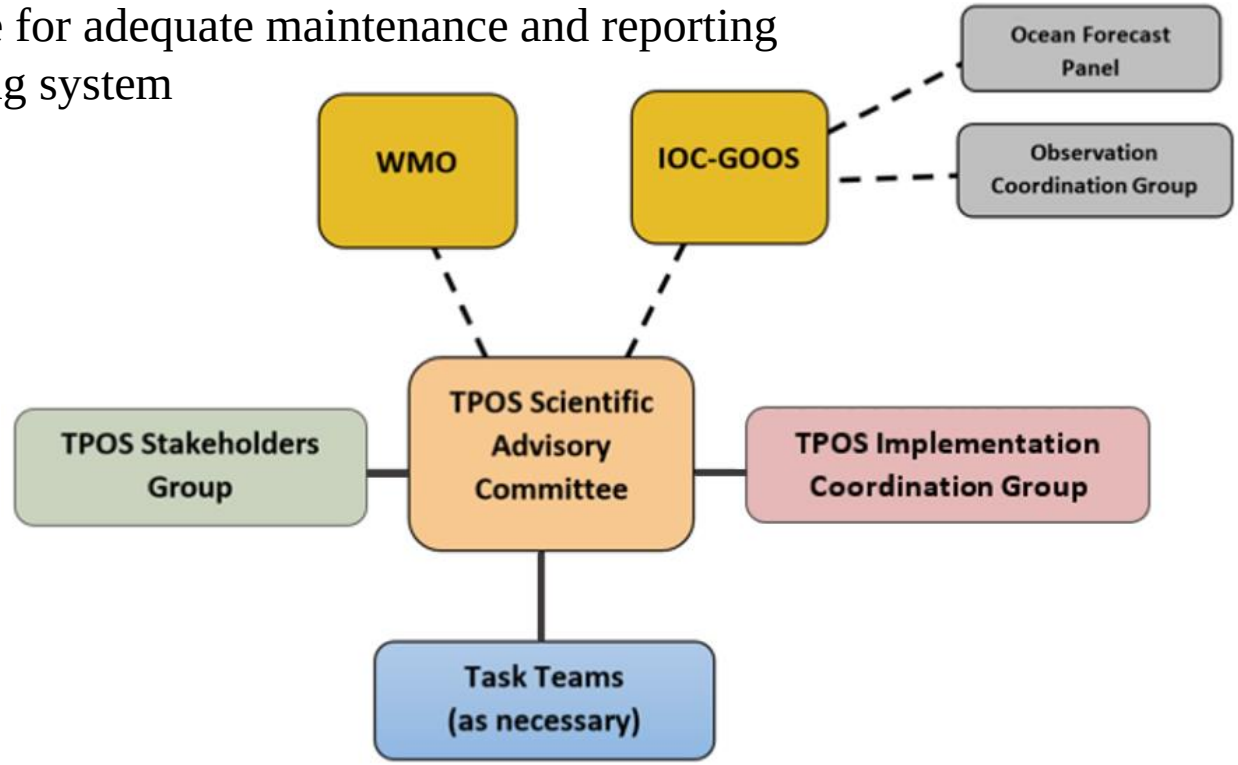
Fujii, Y., Cummings, J., Xue, Y., Schiller, A., Lee, T., Balmaseda, M. A., ... & Cornuelle, B. (2015). Evaluation of the Tropical Pacific Observing System from the ocean data assimilation perspective. *Quarterly Journal of the Royal Meteorological Society*, *141*(692), 2481-2496.

Ongoing new TPOS - Governance -

→ TPOS SCIENTIFIC ADVISORY COMMITTEE (SAC)

→ TPOS IMPLEMENTATION COORDINATION GROUP (ICG)

- Oversee the design and assessment of the TPOS backbone and ensure better integration across the value chain
- Implementation by addressing observational recommendations from TPOS 2020 and advancing integration of new capabilities
- Monitor and advocate for adequate maintenance and reporting for the entire observing system



Ongoing new TPOS - several updates -

Moorings:

NOAA has accepted our recommendations for TAO almost entirely.
Beyond refocused sampling, TAO is being rebuilt: improvements to all systems beginning this year.

MNR's Ding has begun initial deployments. Part of a second round has also been conducted in this year.

JAMSTEC's mooring is being rebuild as a Tier 3 (super sites) at 13˚N 137˚E.

Argo:

MNR deployed 28 new Argo floats in the west in 2021, along with 8 new BGC floats.

NOAA is also increasing its Argo work, both core and BGC. (+ France and …)

=> Aside from pandemic disruptions, we are closing in on double Argo and our BGC Argo goals

Others:

NOAA and JAMSTEC funded pilot studies with useful results.
Process studies are under way: Pre-field modeling happening now, fieldwork expected in 2024-2025.

Nations in western South America are stepping towards better cooperation in regionals (EBUS).

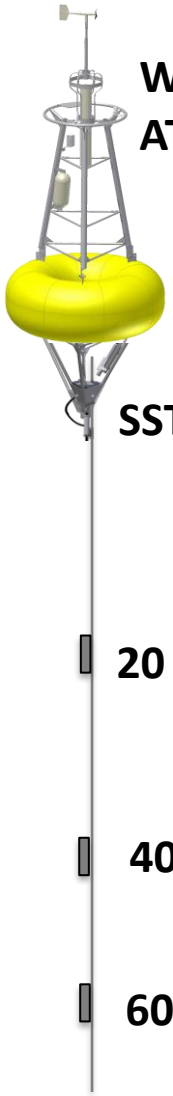
TPOS declared a "WIGOS Regional Pilot" under WMO (entree to Met Services).

International assimilation/evaluation experiments being developed (ECMWF-NOAA-JMA).

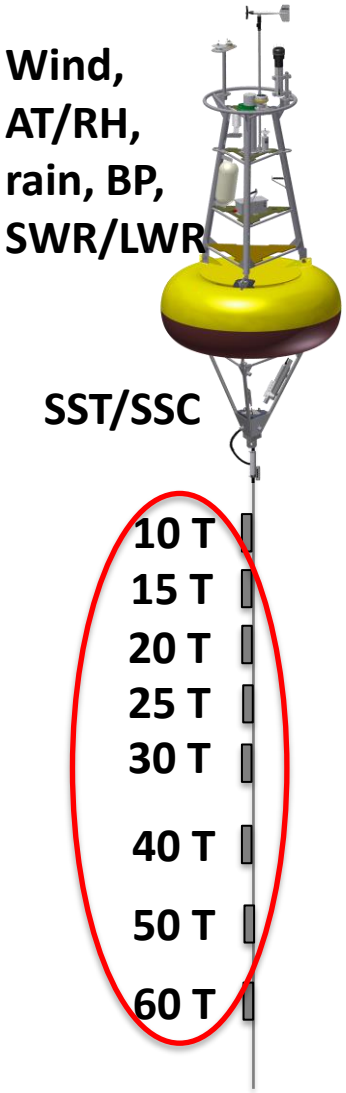
TAO update by NDBC (ML enhancement)

The mooring configuration will be redesigned to adequately describe the rapidly varying near-surface layer of the ocean through enhanced vertical resolution in the mixed layer.

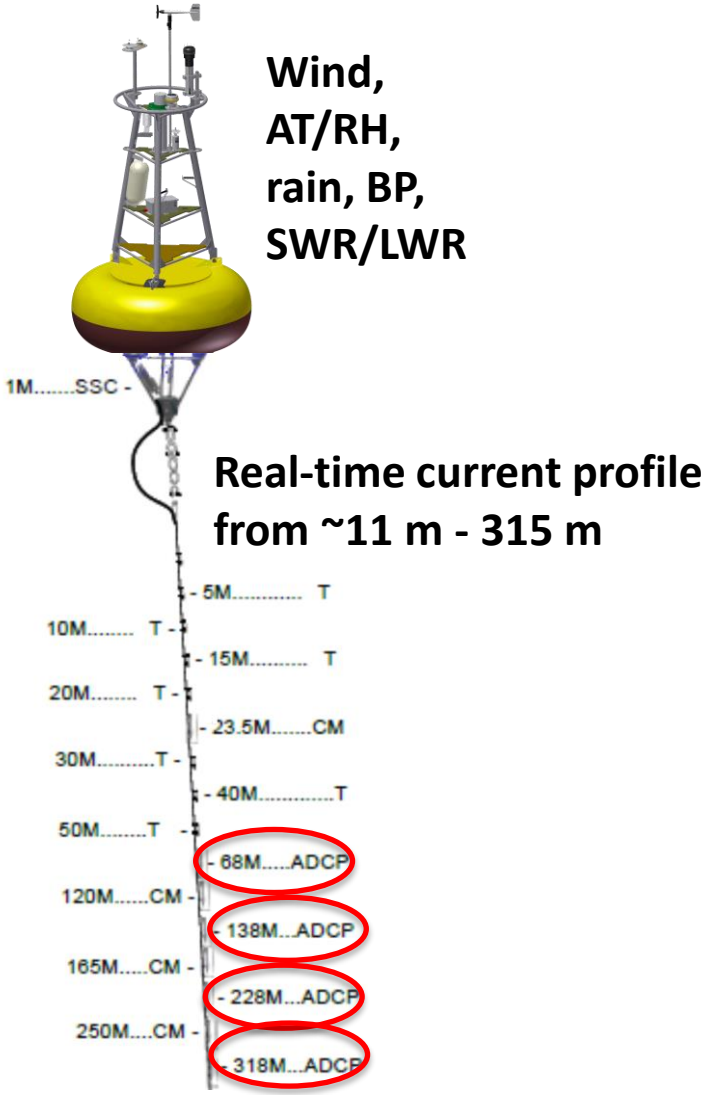
Basic TAO Refresh



Basic TAO Recap



TAO Recap (ADCP)



TAO update by NDBC (Met sensor enhancement)

The new mooring configuration will include the full suite of surface meteorological variables needed for bulk heat and water flux estimation.

Rain

[Vaisala WXT531]

Solar Radiation

[Kipp & Zonen SMP10]

[Kipp & Zonen SGR4]

[Hukseflux SR20-D2]

Barometric Pressure

[Setra 278 Pressure Transducer]

[Druck 8000 series pressure sensor]

[RMY 61402 pressure sensor]

OSE for SLP

AFES-LETKF experimental reanalysis

Enomoto et al. (Data Assim. for Atom. and Ocean 2013)

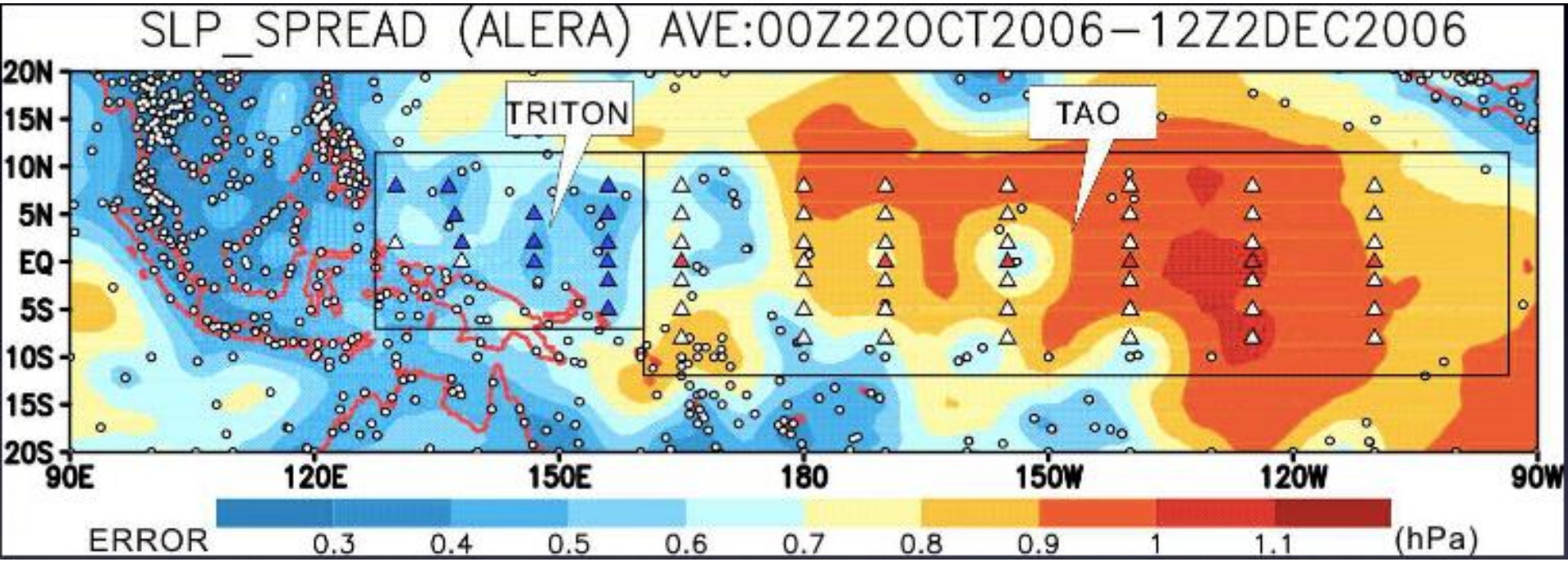


Figure : The analysis ensemble spread of the se-level pressure averaged between 00z 22 October and 12z 02 December 2006 over the equatorial Pacific. Circles indicate surface observations and triangles indicate buoys. Filled triangles denote buoys equipped with a barometer.

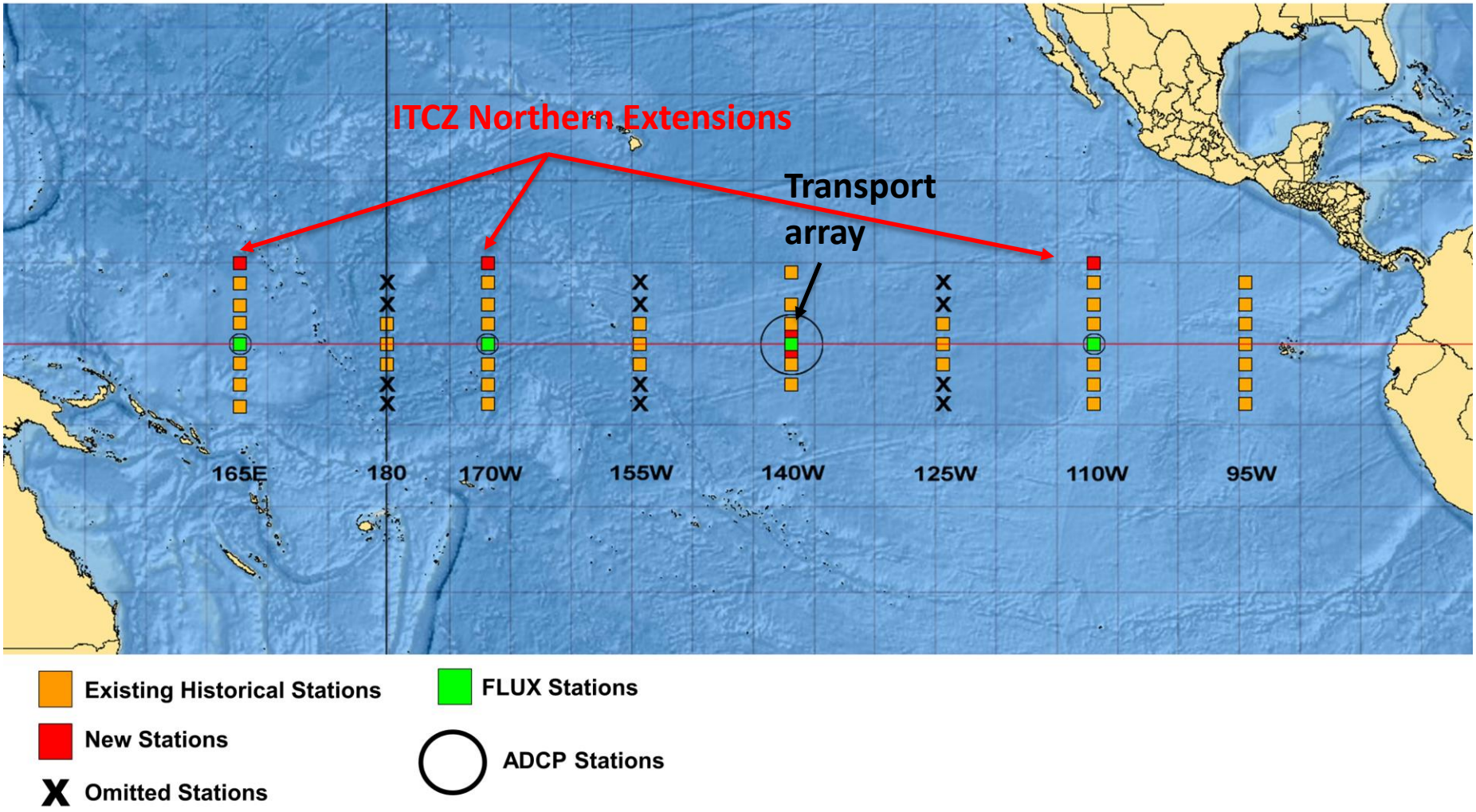
ALERA: specifications

- Observations used in NWP at JMA
- AFES T159L48M

Enomoto, T., T. Miyoshi, Q. Moteki, J. Inoue, M. Hattori, A. Kuwano-Yoshida, N. Komori, S. Yamane, 2013: Observing-system research and ensemble data assimilation at JAMSTEC. In Data Assimilation for Atmospheric, Oceanic and Hydrologic Applications (Vol. II), S. K. Park and L. Xu (eds.), chapter 21, pp. 509–526, Springer, doi:10.1007/978-3-642-35088.

TAO update by NDBC (Northern Extension)

1. Fewer but more capable moorings
2. Meridional expansion



Encourage Collaboration with the EPAC Region

WMO-TPOS Regional Workshop on October 4, 2022

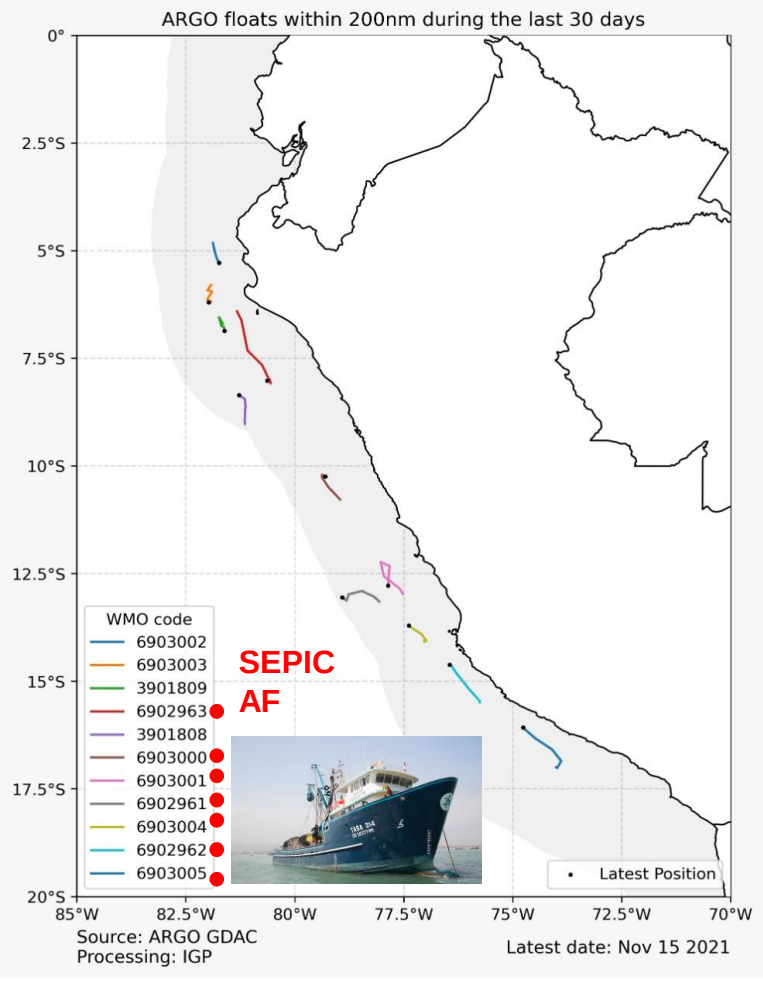
Objectives:

- To review the existent efforts and identify areas of collaboration among national and international institutions of the southeastern Pacific countries; Peru, Colombia, Ecuador, Chile
- To agree on the main steps forward and a potential road map for regional collaboration
- To explore the possibilities of raising this discussion to foster political and institutional support for a long-term initiative

Potential for TPOS associated activities

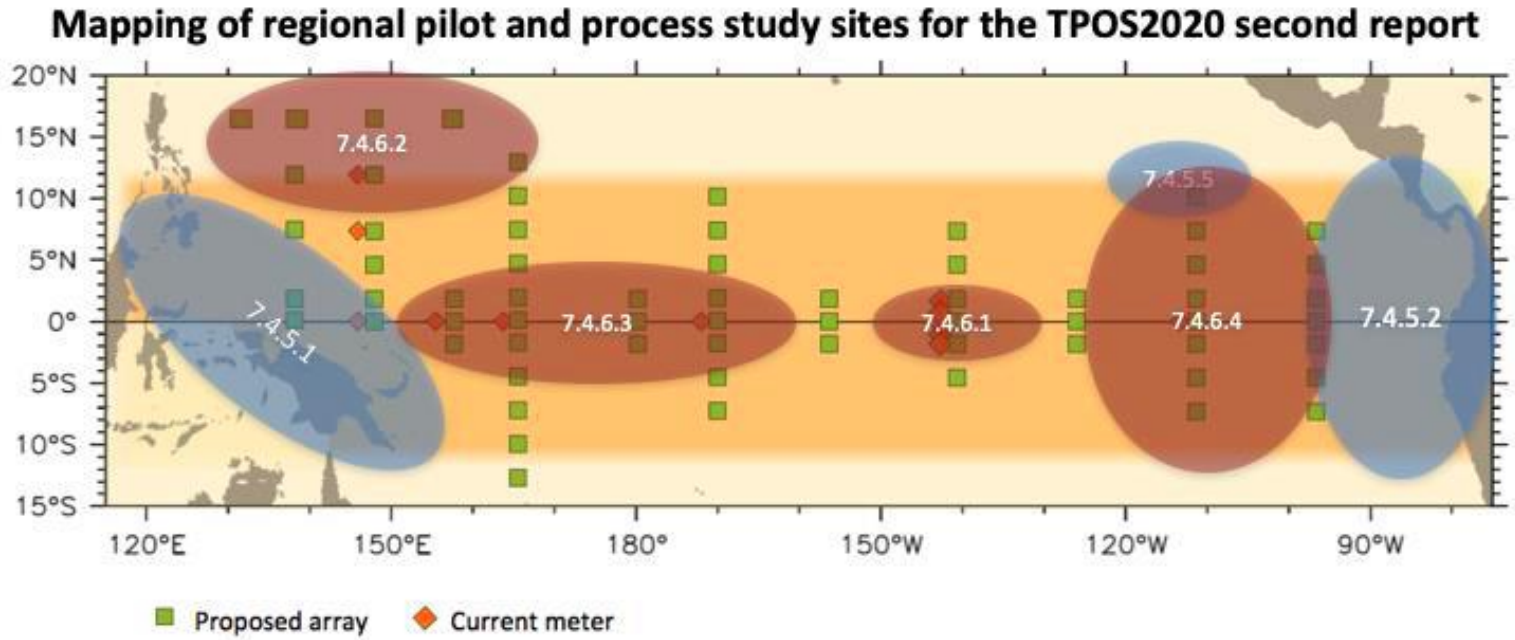
- New regional observations; Island stations, Argo…
- Ocean data exchange and collaboration among regional institutions
- Regional reanalysis - with international partners (Mercator and others)
  1/36˚, 12˚ N-45˚ S; 95˚ W-70˚ W

17 Argo floats were deployed off Chili and Peru in 2021 through the SEPICAF project.
A SEPICAF follow-on (SEPICAF2) will be submitted in this year (November 2022).
SEPICAF2 will involve Ecuador (ESPOL, INOCAR).



Encourage process studies

Under the TPOS2020 project, several pilot and process studies have been conducted. These kind of process studies should be continuously encouraged to seek further update of observing system and representation of key processes.



Regional pilot studies and process studies

7.4.5.1 Observing Western Boundary Current systems
7.4.5.2 Eastern Pacific equatorial-coastal waveguide and upwelling system
7.4.5.5 Pilot climate observing station at Clipperton Island for the study of East Pacific ITCZ
7.4.6.1 Pacific Upwelling and Mixing physics
7.4.6.2. Air-Sea interaction at the northern edge of west Pacific Warm Pool
7.4.6.3 Air-sea interaction at the eastern edge of the Warm Pool
7.4.6.4 East Pacific ITCZ/cold tongue/stratus system

Basin scale pilot studies

7.4.5.3 Determining the critical time and space scales for biogeochemistry in TPOS
7.4.5.4 Direct measurements of air-sea fluxes, waves and role in air-sea interaction
7.4.5.6 Assessing the impact of changes in the TPOS backbone
7.4.5.7 Comparison of analyses and utilization of TPOS observations

Summary

- Implementation of TPOS has been started gradually, referring TPOS2020 recommendations.
- NOAA is planning to enhance meteorological and mixed layer observations on TAO moorings with new technologies.
- MNR started deployment of several moorings in the western part of TPOS with installation of core and BGC Argo floats.
- Discussion with Eastern Pacific community, which is one of the key regional partners, has been started.
- We encourage key process studies continuously for further improvement of TPOS.

Implementation of the redesigned TPOS, which contains enhanced air-sea flux related observations and stable dissemination of uncertainty added data, will be a basis of data assimilation and prediction activities.
TPOS needs continuous collaboration with DA and weather and climate prediction community.

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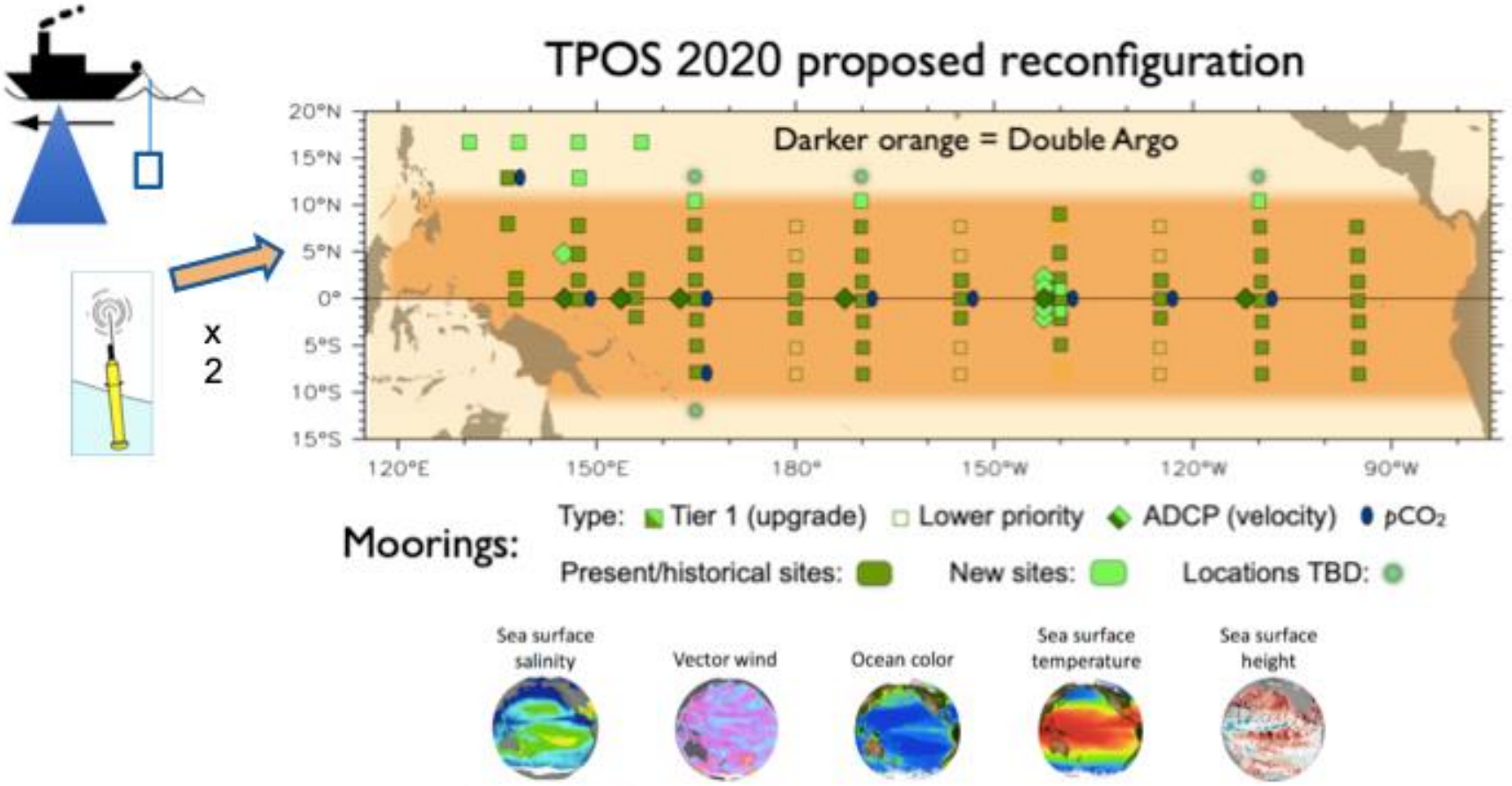
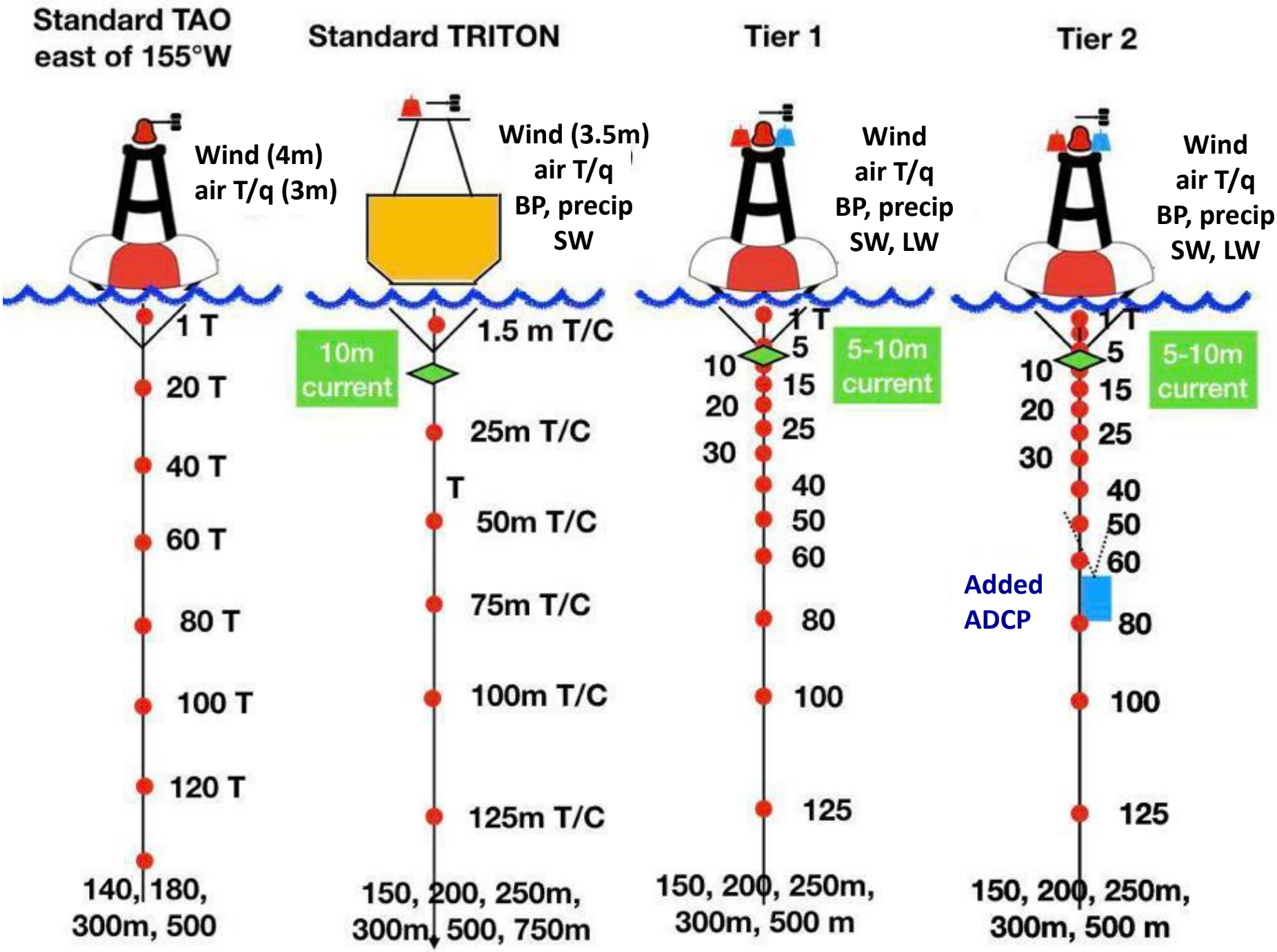
Thank you.



TROPICAL PACIFIC OBSERVING SYSTEM

Back up


Standard TAO
east of 155°W
Standard TRITON
Tier 1
Tier 2
Wind (4m)
air T/q (3m)
Wind (3.5m)
air T/q
BP, precip
SW
Wind
air T/q
BP, precip
SW, LW
Wind
air T/q
BP, precip
SW, LW
1 T
20 T
40 T
60 T
80 T
100 T
120 T
140, 180,
300m, 500
10m
current
1.5 m T/C
25m T/C
T
50m T/C
75m T/C
100m T/C
125m T/C
150, 200, 250m,
300m, 500, 750m
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10
15
20
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125
150, 200, 250m,
300m, 500 m
5-10m
current
Added
ADCP