# The Tropical Pacific Observing System (TPOS) 2020 Project

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TPOS Co-Chairs

# ENSO drove the original TPOS

- - El Niño of 1982-83 – and the failure to recognize it until very late – was the impetus for the TOGA observing system.
- Original TAO designed to detect equatorial waves, then the key issue for diagnosis and prediction.
- TOGA observations led to an explosion of ideas in the 80s-90s that established our understanding of ENSO as an intrinsically coupled, and predictable phenomenon.
- “There are few if any natural climate signals whose prediction would give more benefit for more people than ENSO … but we are not there – yet”

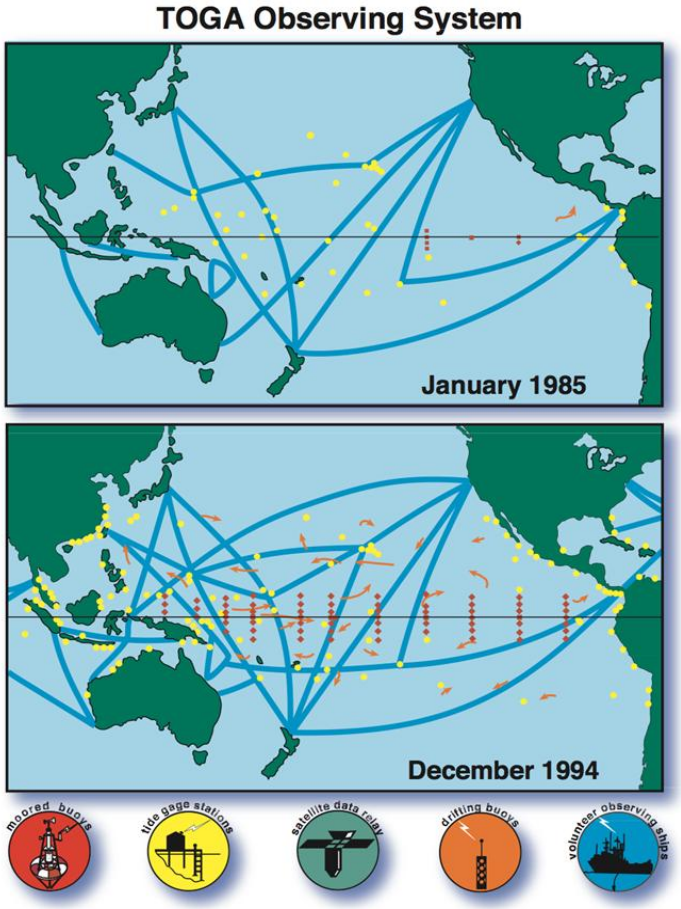
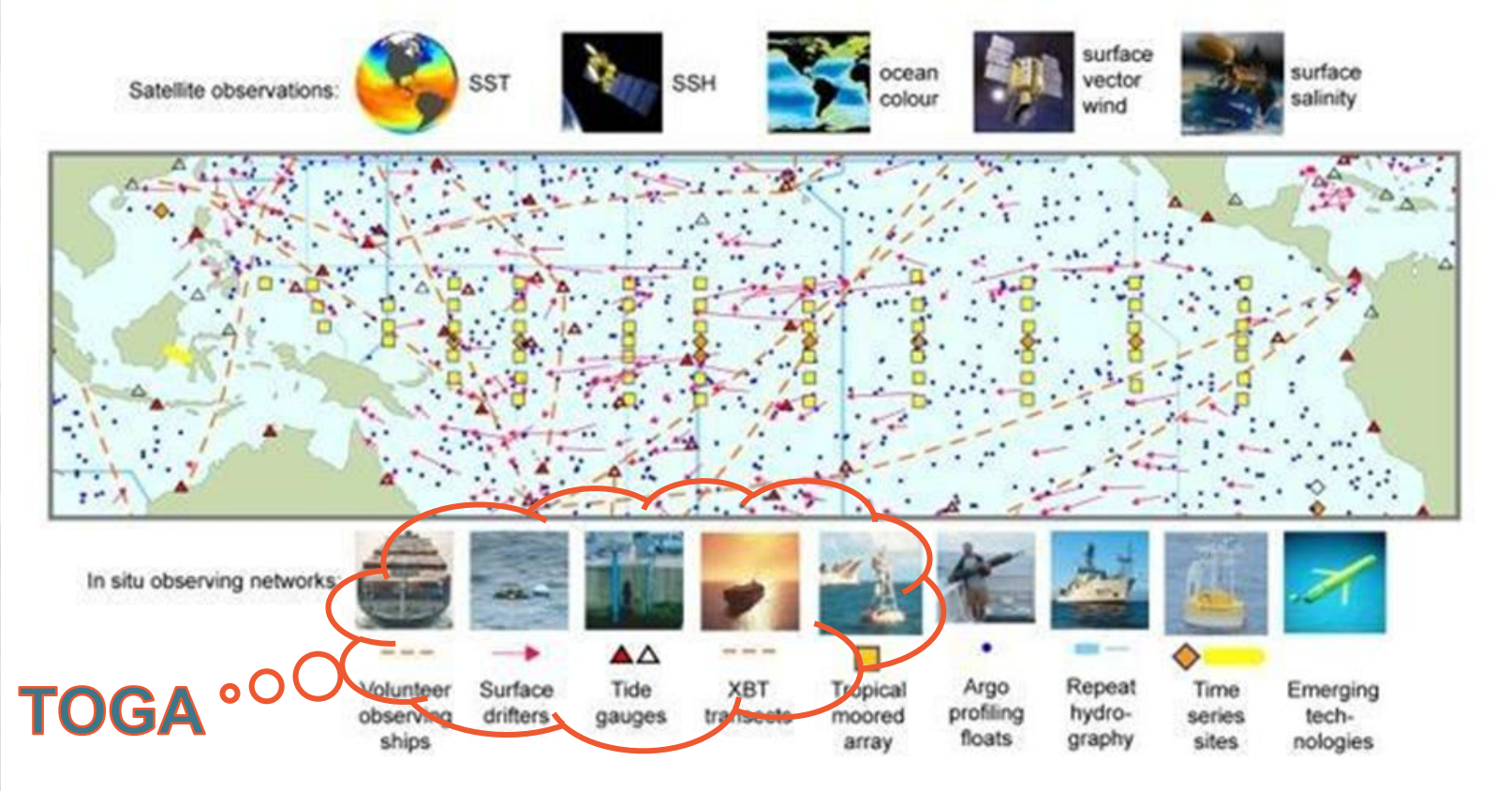



Figure 2. In situ components of the Tropical Ocean Global Atmosphere (TOGA) observing system at (top) the start of TOGA in January 1985 and (bottom) the end of TOGA in December 1994. Color coding indicates the moorings (red symbols), drifting buoys (orange arrows, one for approximately every 10 drifters), ship-of-opportunity lines (blue), and tide gauges (yellow). *After McPhaden et al., 1998*

# TPOS now

- This worked well … until it didn't

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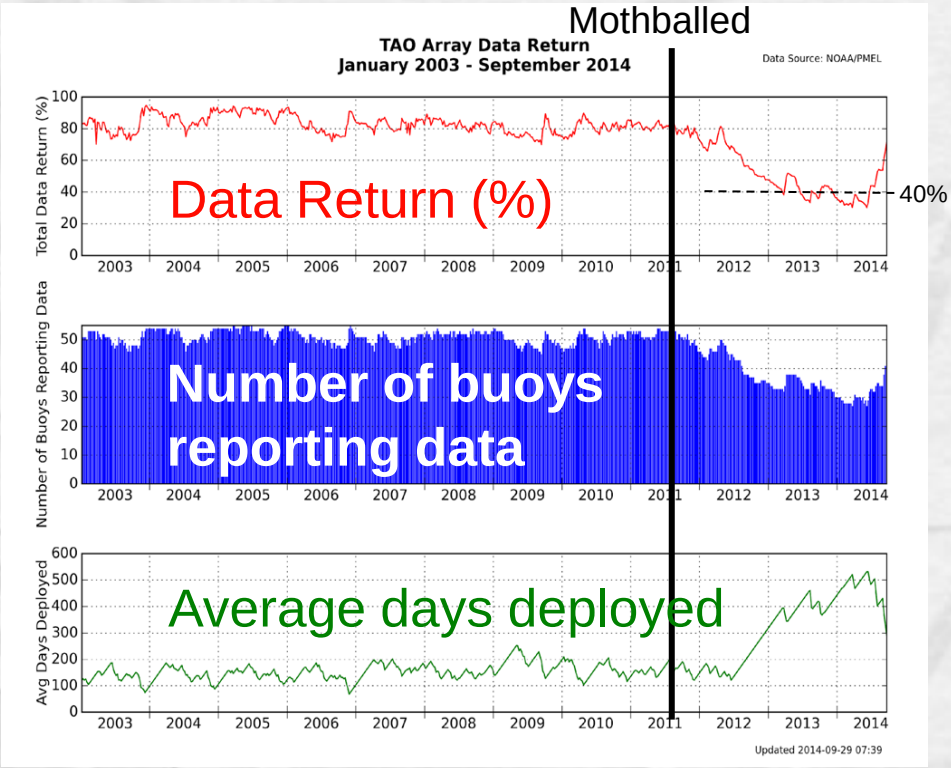
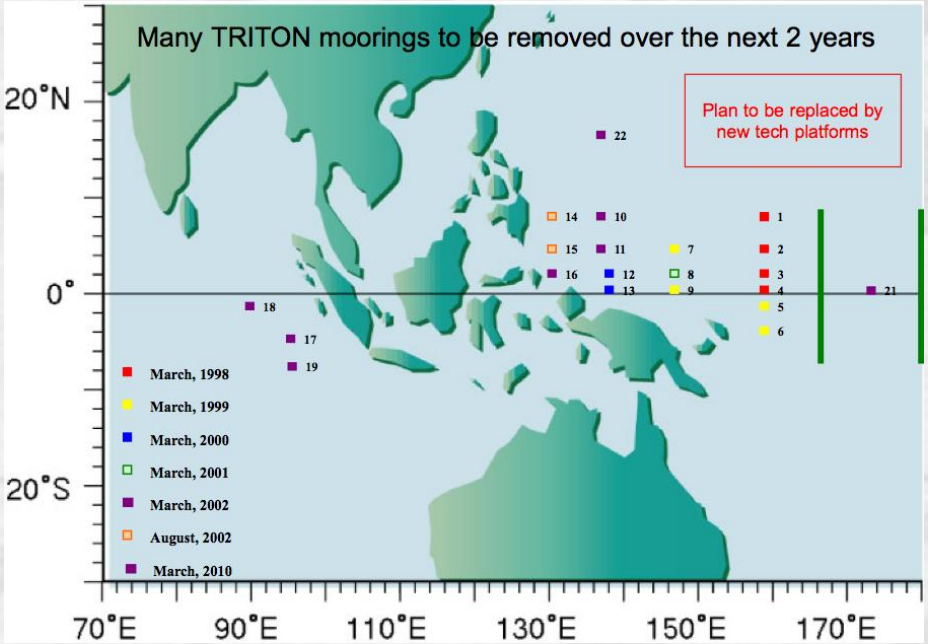
# The TOGA-era system is vulnerable …

Ka`imimoana
Mothballed




*McPhaden, PMEL*




*Ando, JAMSTEC*

- TAO data return fell below 40% in early 2014; since returned to 80%, for now.
- An opportunity to rethink and reframe a better, more robust TPOS.

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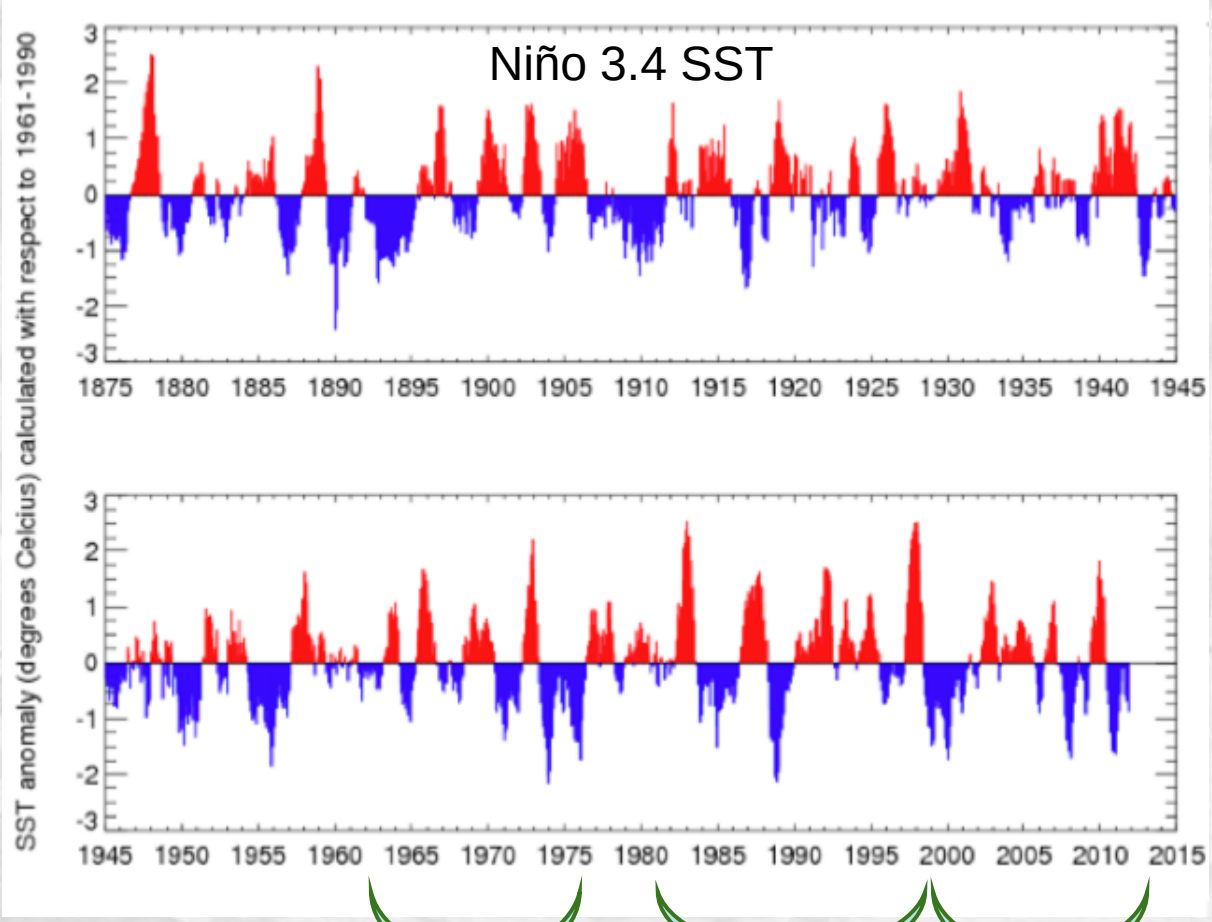
# Some modern context for TPOS 2020

# Diversity of ENSO




Quasi-regular oscillations of the 1960s-70s

El Niño dominance and 2 very strong events of the 1980s-90s

"Central Pacific" or "Modoki" El Niños (and large mean changes)

**The overall story is surprises. Expect more …**

**Lessons:**

- Do not focus only on the challenges of today; tomorrow's will be different.
  - Focus on observing the physical processes that drive the tropical climate.
  - Integrate this understanding into models and data assimilation.
- Build a robust TPOS.
  - Multiple platforms, multiple sources of support. (ENSO is multi-scale)

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# Models need to improve

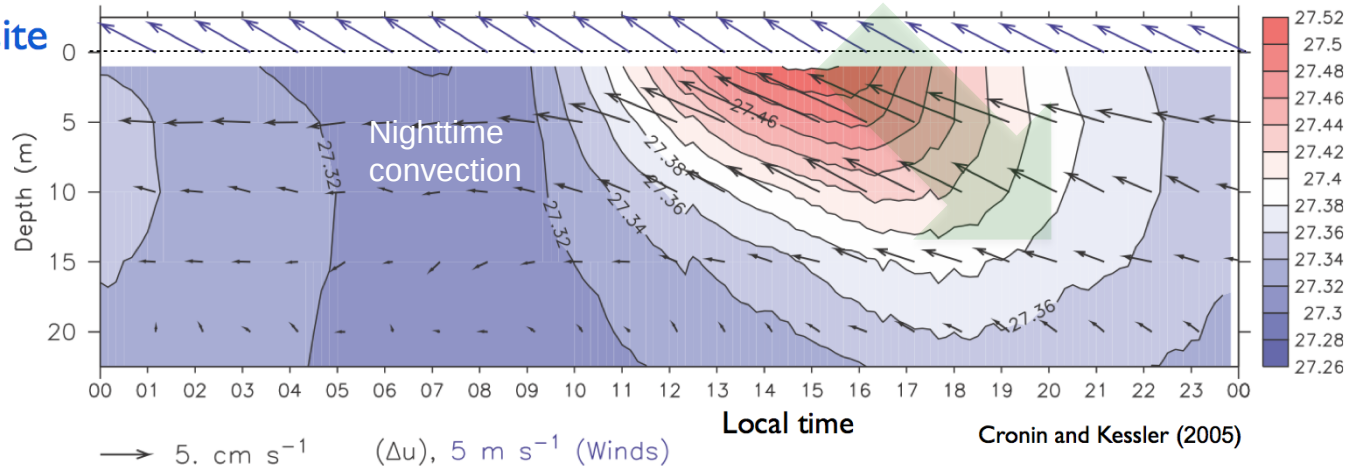
- Much of the impact of TPOS data is through models:
  - Analyses/reanalyses that synthesize diverse data sources, in situ & satellite.
  - Bad (biased) models can and do degrade TPOS data products.
  - TPOS 2020 will support limited-term process studies to support model development

Diurnal cycle composite at 2°N,140°W.

Wind and current vectors,

Afternoon trapping, then downward propagation of T and u (and implied mixing) into the evening.

mixing) into the evening.

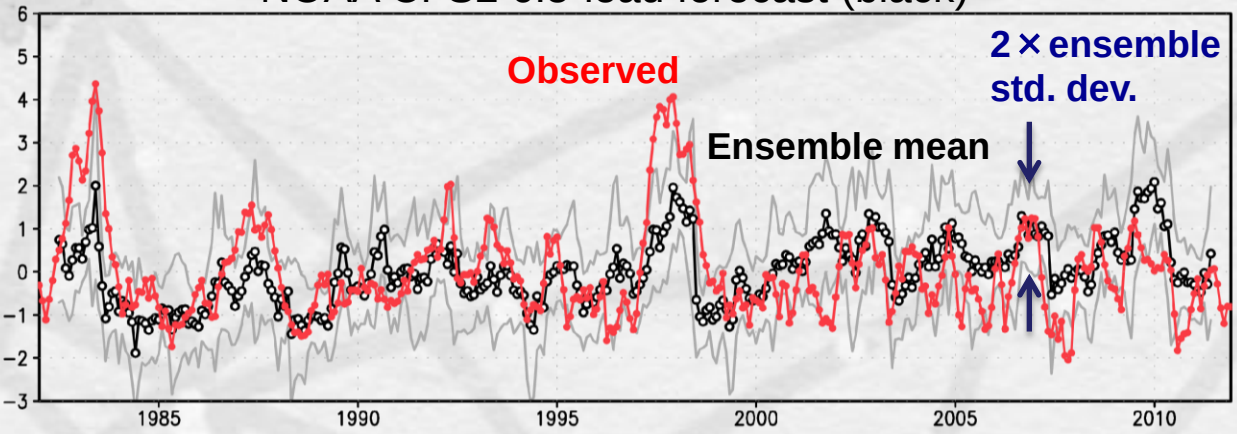



Cronin and Kessler (2005)

FIG. 5. Mean diurnal composite (24 May 2004–7 Oct 2004) of wind (blue vectors), temperature (color shading), and currents relative to 25 m (black vectors). The vector scale is shown at the bottom.

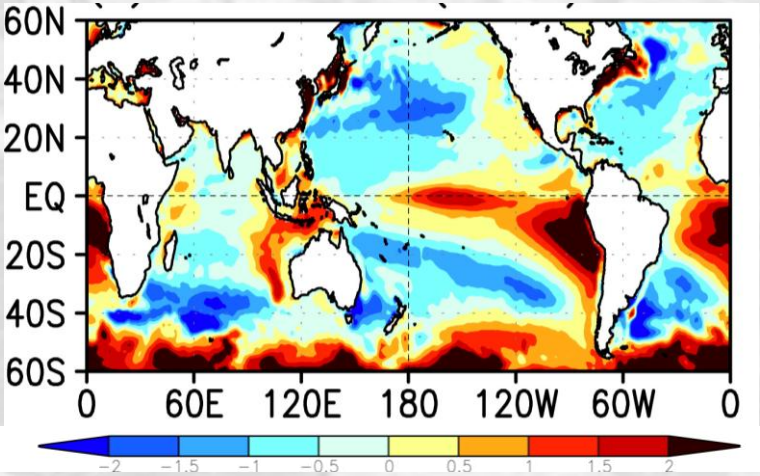
# Boundary regions (west and east)

Niño 1+2 SSTA (° C): Observed (red) and NOAA CFS2 6.5-lead forecast (black)




- Predictive skill beyond 3 months continues to be low in the Eastern Pacific.
- Model biases are likely a dominant factor, but need data and process understanding to improve them.

SST (C) bias in CFSv2 January forecasts initiated in September (1999-2009)




- Long-standing and generalized biases in the eastern Pacific are the warm SST bias and the double ITCZ syndrome.

Kumar et al 2012

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# The TPOS 2020 Project

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# TPOS 2020 Workshop

27-30 January, 2014, Scripps Institution of Oceanography

- Review of observing system requirements and implementation
- Presentations on status of all aspects of system
- Presentations on potential new science and contributions
- Sponsors:

GCOS GLOBAL CLIMATE OBSERVING SYSTEM · The Global Ocean Observing System · NOAA · JAMSTEC · KIOST KOREA INSTITUTE OF OCEAN SCIENCE & TECHNOLOGY

- Chaired by: David Anderson and Toshio Suga
- Report: Published April 2014 (www.ioc-goos.org/tpos2020)

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# TPOS 2020 Workshop outcomes

- The Review recommended the creation of a focussed

  **TPOS 2020 Project**

  - Transition from a loosely coordinated set of activities in the tropical Pacific to a systematic and sustainable TPOS by 2020.

- A project for change, for tomorrow's TPOS:
  - Not business as usual; targeted goals, players, time
  - Of the sponsors; contribution to GOOS/GCOS, JCOMM, CLIVAR, …
  - Managed like a major project
  - Redesign work driven through focused Task Teams

- The Review created a project Steering Committee
  - First meeting: 6-9 October 2014, hosted by KIOST in Seoul, Korea

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# Short Term Actions from SC-1

- Developing advice on the Backbone TPOS (TT)
  - Initially broadscale, now generalised to address all the foundation elements of TPOS, no matter the scale.
  - Advise the elements of the backbone O.S. based on updated requirements, current knowledge base, and existing capabilities.
    - Includes remote sensing as well as in situ contributions
  - Making reasonable assumptions on the sustainability and risks.
  - Prioritisation criteria for time-series climate records (recommendation from La Jolla); OOPC and OceanSites will be consulted.

- Improve Modelling and Data assimilation (TT):
  - Opportunities identified include:
    - **OSE Workshop for improved understanding of sensitivity**
    - A Workshop on systematic errors in tropical models and prediction systems (not likely until 2016)

# Longer Term Actions

- The evolution of the TPOS through design studies for the backbone (by a TT)
- Task Teams for (a) air-sea interaction and the ocean boundary layer, and (b) for biogeochemistry.

- To achieve change in the TPOS, need partnerships within the research/operational groups involved in observation, modelling and prediction.
  - The Western Pacific Project: Writing team to develop regional project plan (drawing on national/regional activities/plans). Potential future TT.
  - The Eastern Pacific (TT) To be formed.
  - Significant process study in the central-to-eastern Pacific, focused on improving understanding of upwelling and mixing, and the interaction with surface processes.

# Specific issues for this Workshop

- The role of salinity
- Changes in predictability
- Evidence from systematic errors
  - To guide design, process studies, etc.
- Frameworks for sensitivity studies

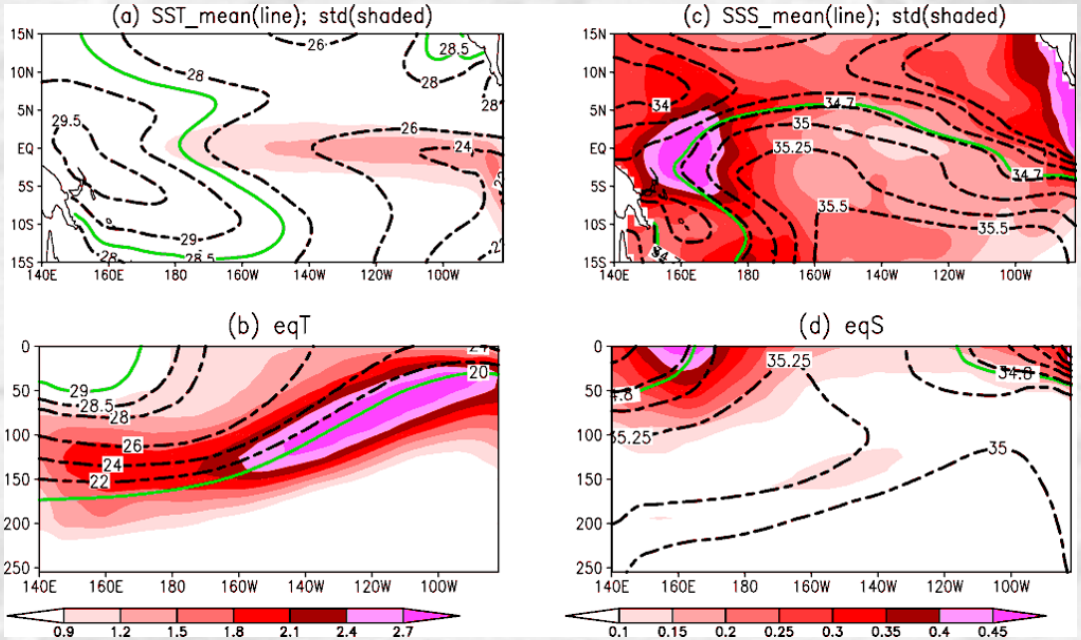
# Freshpool/Salinity variations

Near-surface salinity variability is concentrated on edge of warm pool.

Weak subsurface salinity gradients > long time to adjust to subsurface anomaly

Temperature

Salinity




1981-2013 mean (contour) and standard deviation (shaded)

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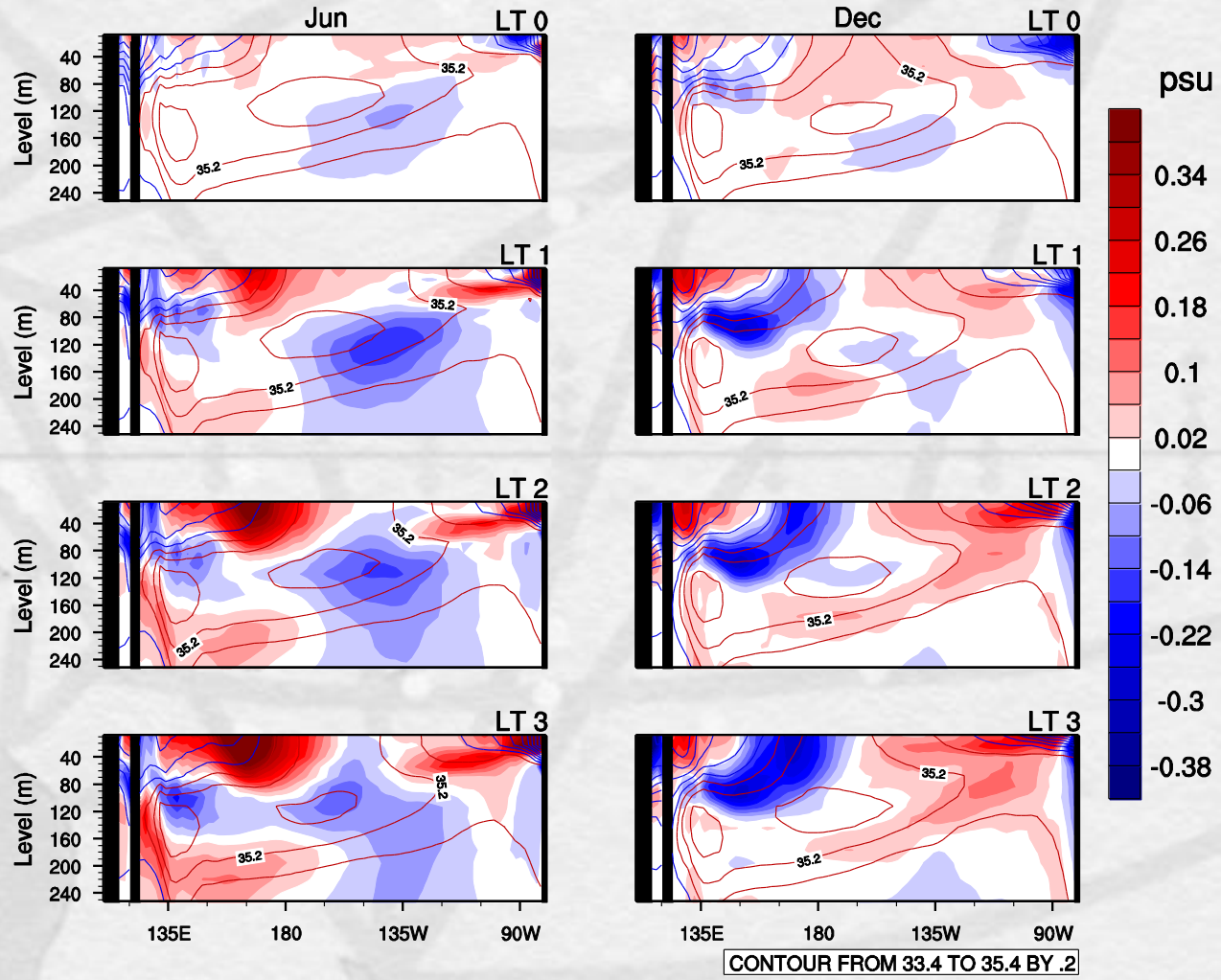
# Mean state salinity bias as function of lead time, eg POAMA

-- Drift is as big as interannual variability: model can't maintain a tight freshpool

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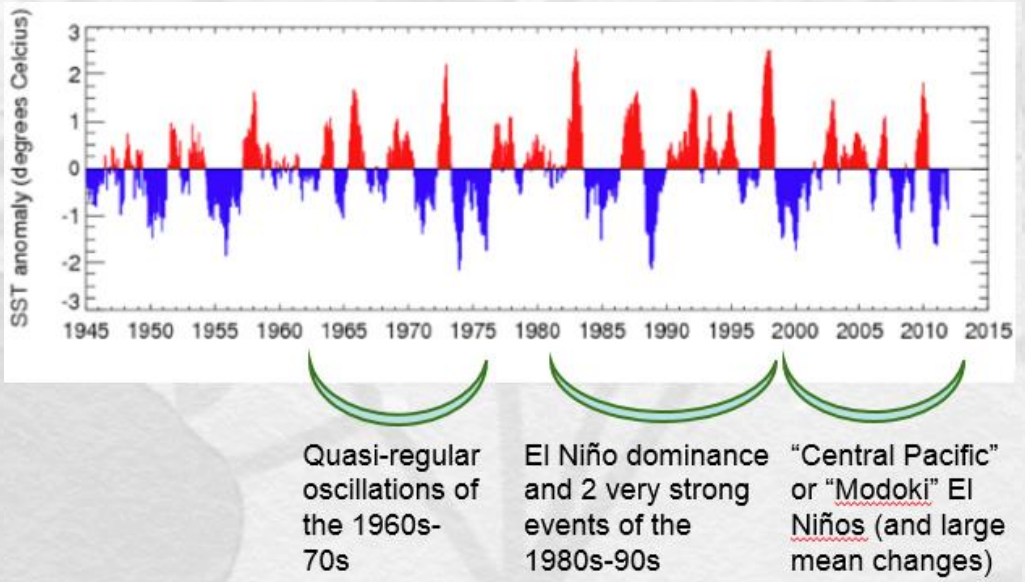
# TPOS 2020 on Salinity

- The role of salinity, its impact on predictability and the degree to which lack of observations and/or poor use of the data might be impacting predictions was debated without firm conclusion.
- The western Pacific 'fresh pool' and the convergence zones were two areas where improved knowledge and simulation skill, especially of precipitation, might have an impact.

- **TPOS 2020 is gathering information of relevant studies and would be interested in diagnostics/analyses that provide guidance on the realism of current simulations/estimates and/or the role of salinity in predictions.**

# Changes in predictability, mean state




- ENSO seems to have changed its character a number of times over the decades we have been able to observe it in detail (roughly 30 years).
  - Changes in mean state will impact bias if models cannot capture modes
  - Changes in predictability imply changes skill, and changes in DA parameterisations

# Changes in predictability?

- Since the 1990's, ENSO predictability seems reduced, likely because SST variability has decreased .
- In principle, decadal changes should be captured in the initial conditions, so why is predictability impacted?
- One line of investigation might be to examine whether there are built-in constraints (e.g. in data assimilation, or intra-seasonal MJO “noise”) that impact the potential of models to capture this diversity.

# Evidence around model systematic errors

- TPOS 2020 has an interest in documenting and comparing patterns in model data assimilation innovations for the tropical Pacific region.
- There are studies underway on systematic errors in standalone ocean models.
  - Such studies and knowledge of assimilation innovations are needed to guide research and process studies to areas/mechanisms that will make the most difference, for the benefit of models, assimilation and the observing system design.
- SC-1 concluded priority should be forward model
  - Points to inadequate parameterisations; understanding of processes
- There is enthusiasm for looking at mixing and upwelling in a number of places and our sense is that the central-eastern Pacific and warm pool (site of convection) might be two candidate places.

# Improved frameworks for sensitivity studies

- Tropical Pacific OSE/OSSE studies are expensive (usually) and often inconclusive
  - Large systematic errors in models and dependence on parameterisation assumptions.
- TPOS sponsors are placing high priority on scientific observing system guidance
  - Multiple perspectives
  - Observations have multiple lives; OSEs may only touch on 1 or 2
- Explore improved frameworks
  - GOV OSEval presentation, particularly community engagement and multiple approaches
  - How do we provide guidance that influences decisions for 2020-2025?
- Interested in exploring improved frameworks for conducting such studies.

# Conclusions

- TPOS 2020 will deliver the following benefits:
  - A refreshed and more effectively designed TPOS, promoting sustainability
  - Greater cooperation and coordination among the international sponsors and contributors to the TPOS, managed risk, greater robustness, …
  - Facilitation of experiments and process studies to guide TPOS design and improve data utilisation: improving forward models is a priority
- Understanding observing system impact and sensitivity is critical
  - OSE/OSSE utility limited in the presence of large biases
  - Advantages in returning to first principles: scales, predictability
- Need access to the wisdom and intellect of OSEval community