The TPOS 2020 project

(T.P.O.S. is the observing system, TPOS 2020 the project)

The Tropical Pacific Observing System 2020 project (TPOS 2020) is an international effort to rethink the T.P.O.S.

We now have new tools and new issues ...

What in situ observations do we need for the next decades?

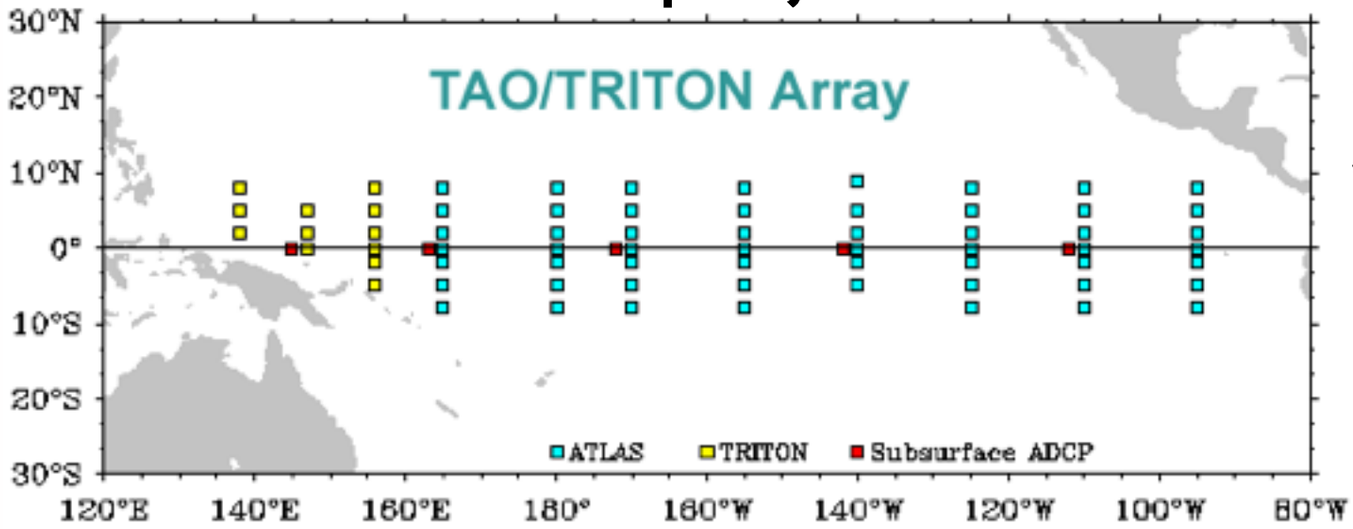
TPOS 2020 was defined by an international workshop in January 2014

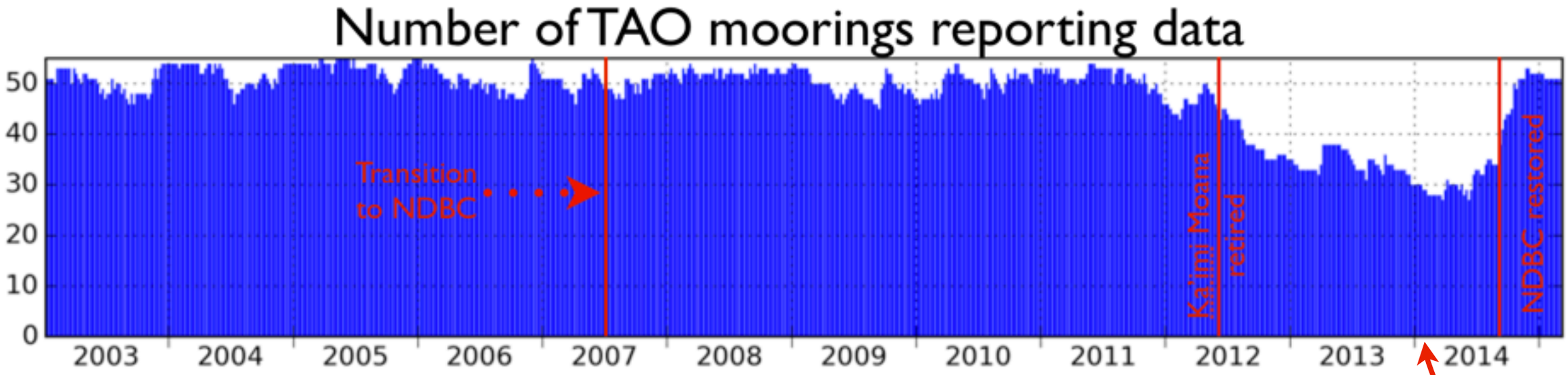
TPOS 2020 Tropical Pacific Observing System

Making an opportunity from a crisis:

Can we build a more effective, modern, robust system?

The TPOS 2020 project arose from the 2012-14 crisis of TAO, and JAMSTEC's coming withdrawal from TRITON, but the time is ripe to reexamine the whole system.

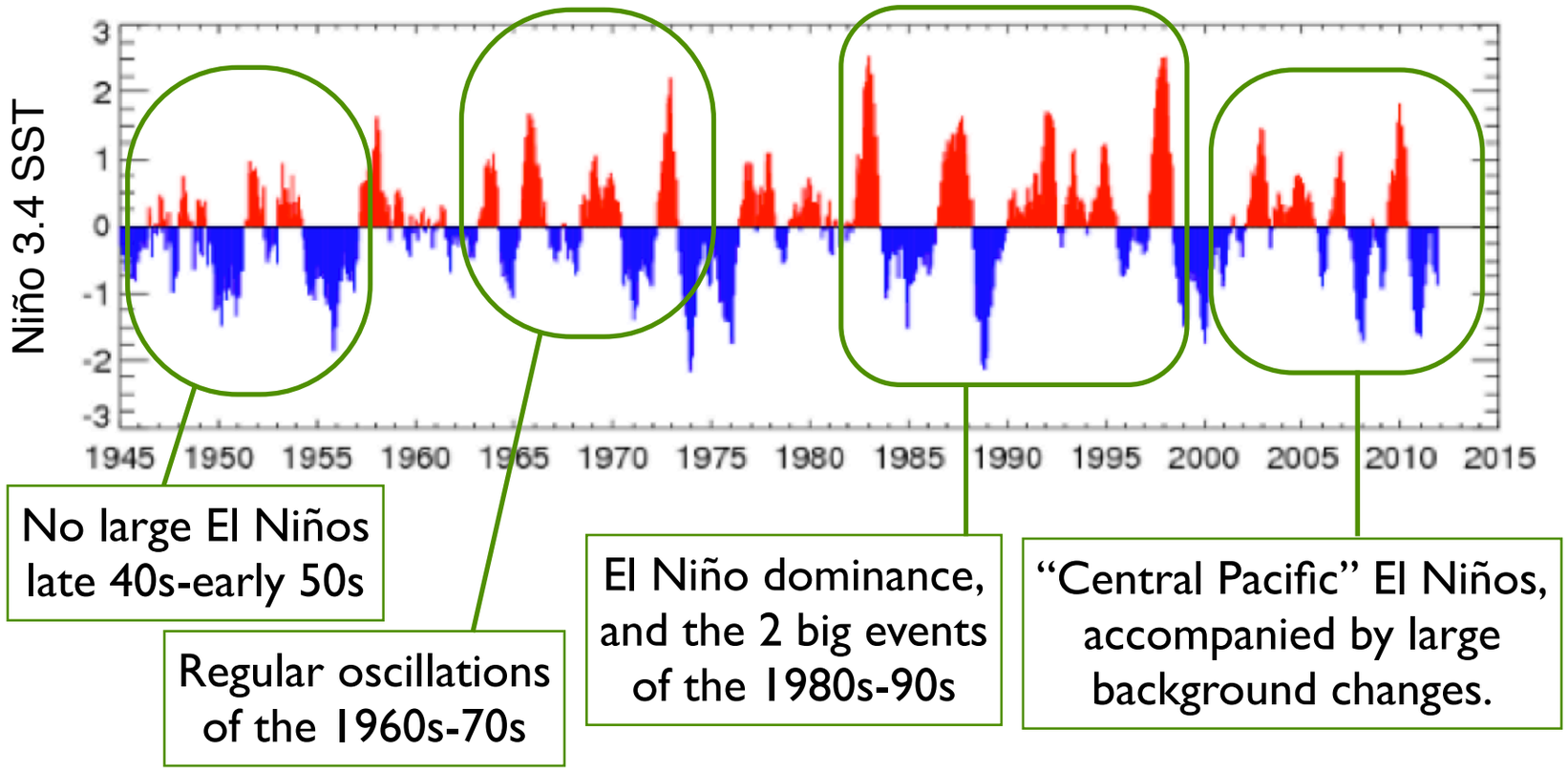




NOAA / JAMSTEC/OOPC workshop, January 2014

TPOS 2020 Tropical Pacific Observing System

ENSO drove the original T.P.O.S in a simpler world. Now we know ENSO is diverse ... and full of surprises



The lessons we take from this are:

Describe the physical processes that drive the tropical climate.

Integrate this understanding into models.

Build a resilient T.P.O.S.

Do not focus only on the challenges/issues of today; tomorrow's will be different:
Looking back from 2030, what will we wish we had started sampling in 2016?

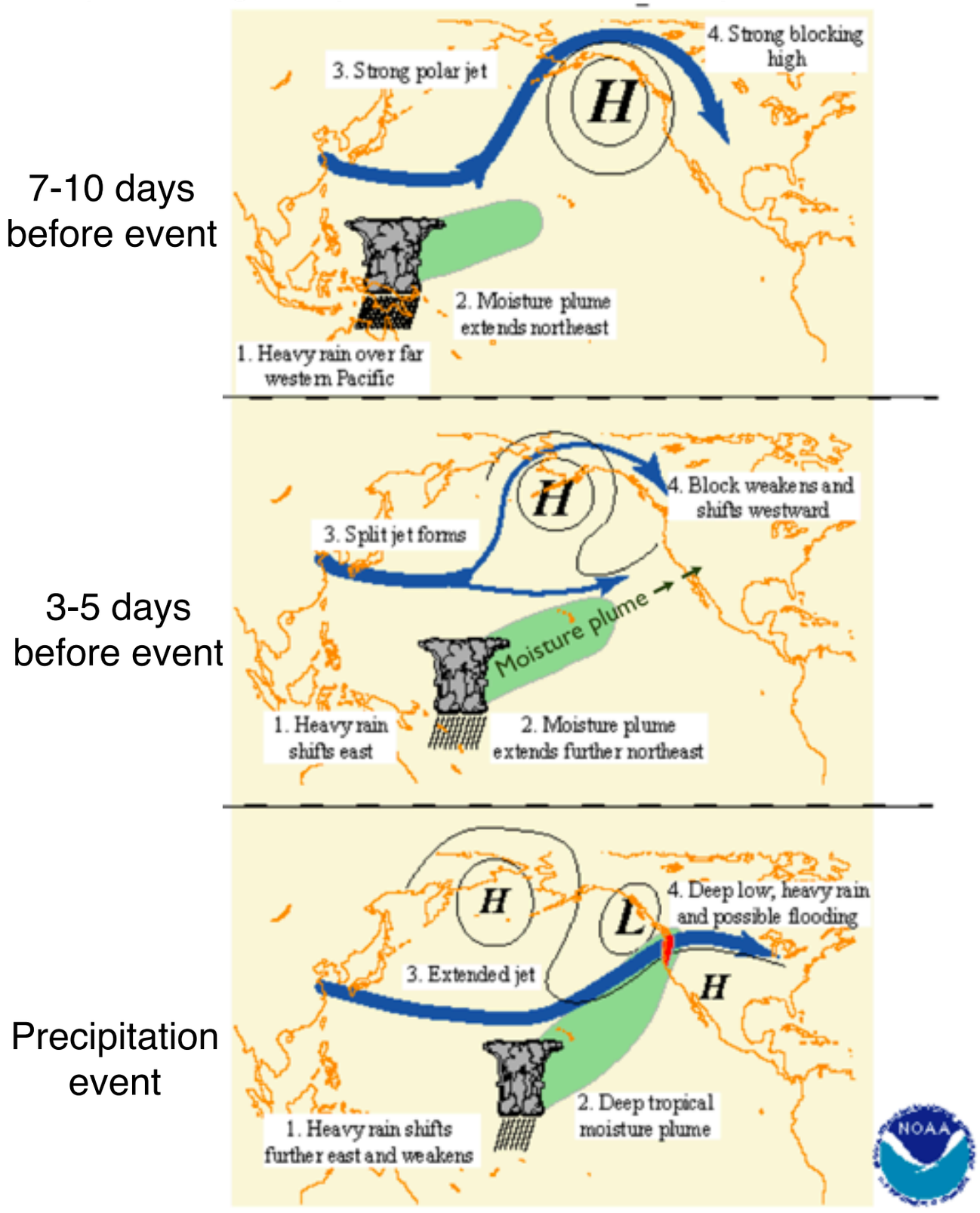
Maintain and build long time series:

High-quality data, detect weak trends
(Three examples ....)

It's not just ENSO ...

Because the atmosphere is so sensitive to changes tropical heating, many kinds of tropical disturbances radiate to the extratropics.

Typical winter tropical Pacific anomalies preceding heavy US West Coast precipitation events



Climate Prediction Center/NCEP/NWS

TPOS 2020 Goals

- To redesign and refine the T.P.O.S. to observe ENSO and advance 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.

TPOS 2020 will provide evidence-based, vetted advice pointing to an intelligent evolution of the observing system.

Evolution is essential ...
for both practical and scientific reasons:

- The ENSO observing system was designed in the 1980s-90s:
  - based on the scientific challenges of that era,
  - and largely on technology from that era,
  - it is an independent collection of pieces.
- The crisis of TAO in 2012-14 showed the risk to this system that underpins our seasonal forecasting and tropical research.
- We are now in a position to improve the system by taking full advantage of present tech (Argo, robotics, satellites), and recent scientific understanding, in a thought-through system.

We will live with what we design for many years, so we will move carefully.

TPOS 2020 organization

TPOS 2020 is an international project under GOOS,
but in fact is effectively appointed by the 2014 workshop.

Steering Committee:

15 members from 6 nations

Co-chairs: Neville Smith (BOM, Australia) and Billy Kessler (NOAA)

Task Teams:

- Planetary Boundary Layers
- Models and data assimilation
- Biogeochemistry
- Eastern Pacific

} Recommendations due early 2016, to feed the design of the Backbone

- Backbone ⟶ Plan due July 2016

Strawmen ideas being developed, done by late summer.

Our first customers are the operational centers

but we will design an array to serve both research and operations

Although TPOS 2020 is mostly about observations, we consider the role of observations in the entire system:

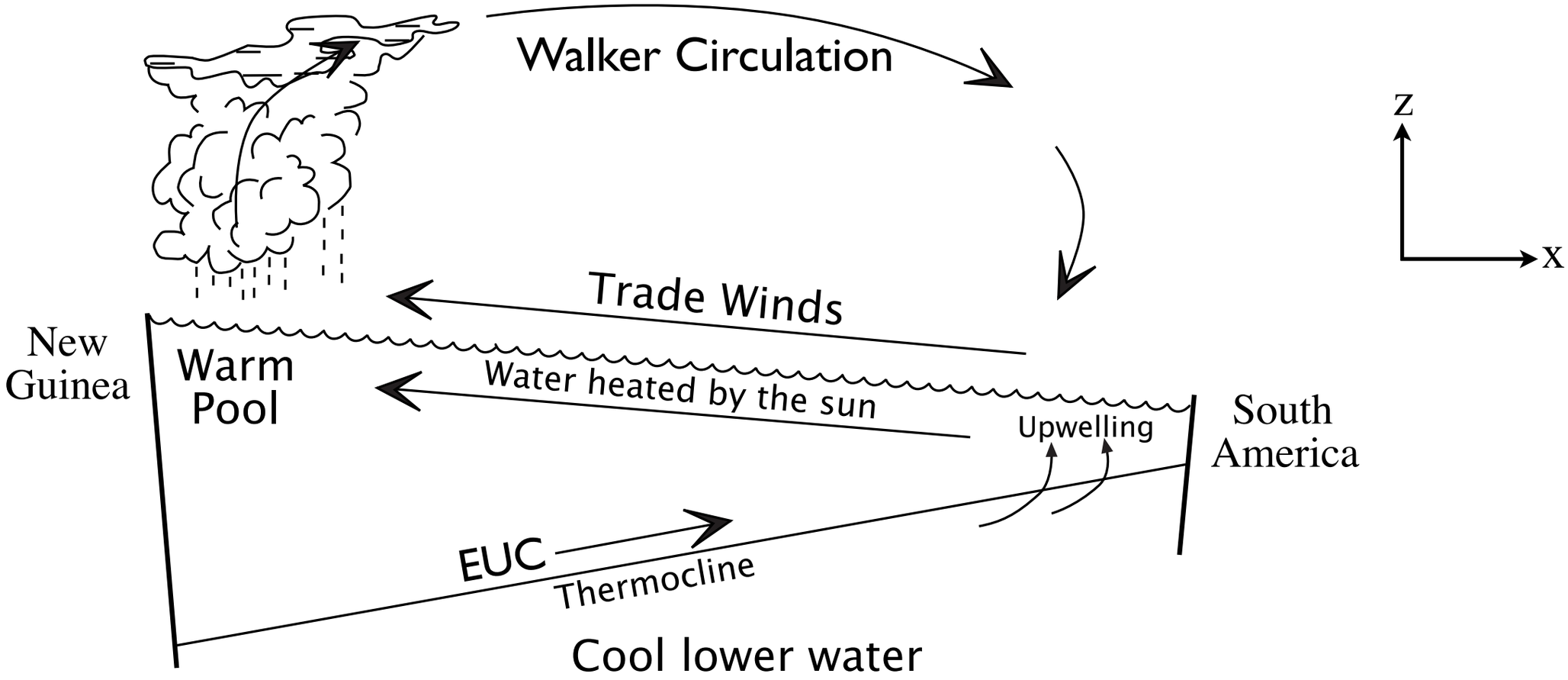
Observations • Analyses • Forecasts

Current-generation assimilation/forecast systems do not make effective-enough use of observations. Thus we aim to:

- ➔ Target sampling where the models and data assimilation systems need guidance for improvements,
- ➔ Improve model representation of unresolved processes,
- ➔ The operational array must provide infrastructure for research, enabling embedded process studies

What will models need in 2030?

The Bjerknes feedback: Fundamental coupling



Positive feedbacks couple thermocline slope, SST, zonal winds.

The coupling depends on communication links:
- between the thermocline and the surface
- between the free atmosphere and the surface stress/fluxes

(The above is glib and vague about how these links operate ... and so are models)

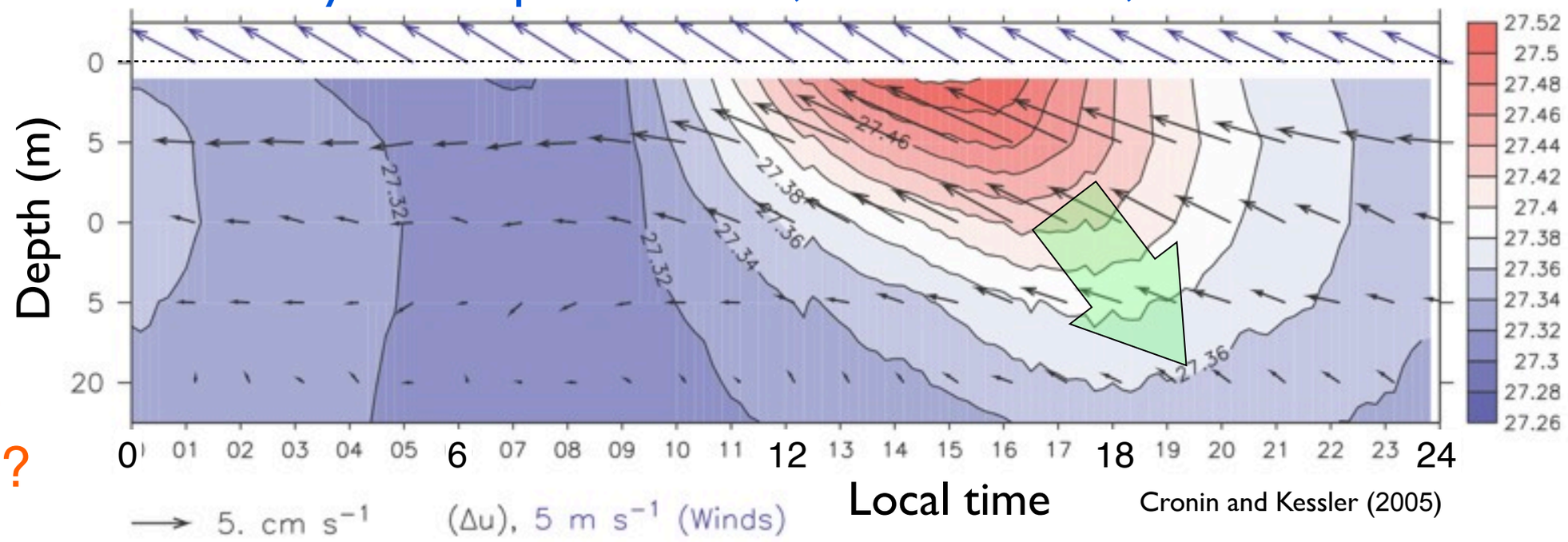
It's time to be more serious about this connection.

How does the thermocline communicate with the atmosphere?

The <u>diurnal cycle</u> is important ... and its effect depends on background conditions.

Can we challenge and guide models?

Diurnal cycle composite at 2°N,140°W: Winds, current shear.

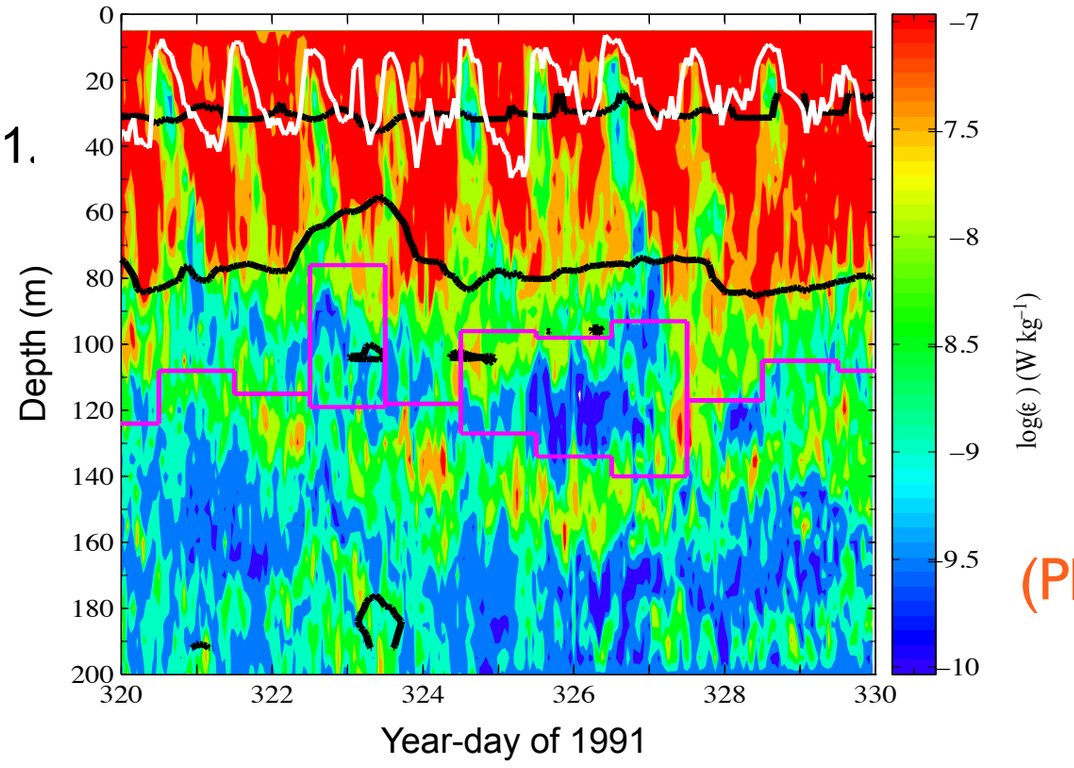


Cronin and Kessler (2005)

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.

Turbulent dissipation during 10 days of 1991.
White = Mixed layer
Red = Turbulent ϵ

TIWE (Lien)

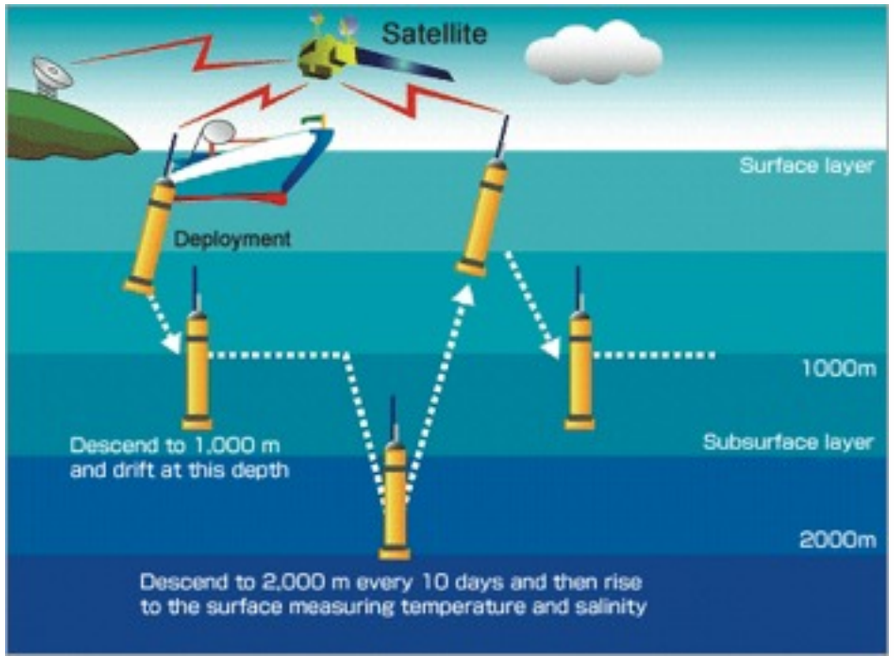


Much of the work of heat and momentum transmission to the thermocline is accomplished by the diurnal cycle.

(Planetary Boundary Layer Task Team)

Take advantage of developing ocean technology

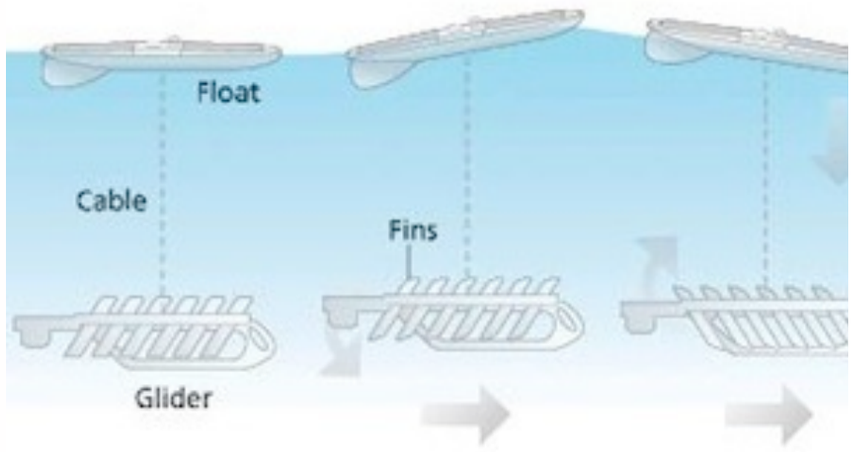
Argo floats make a profile every 10 days
Measure temperature and salinity



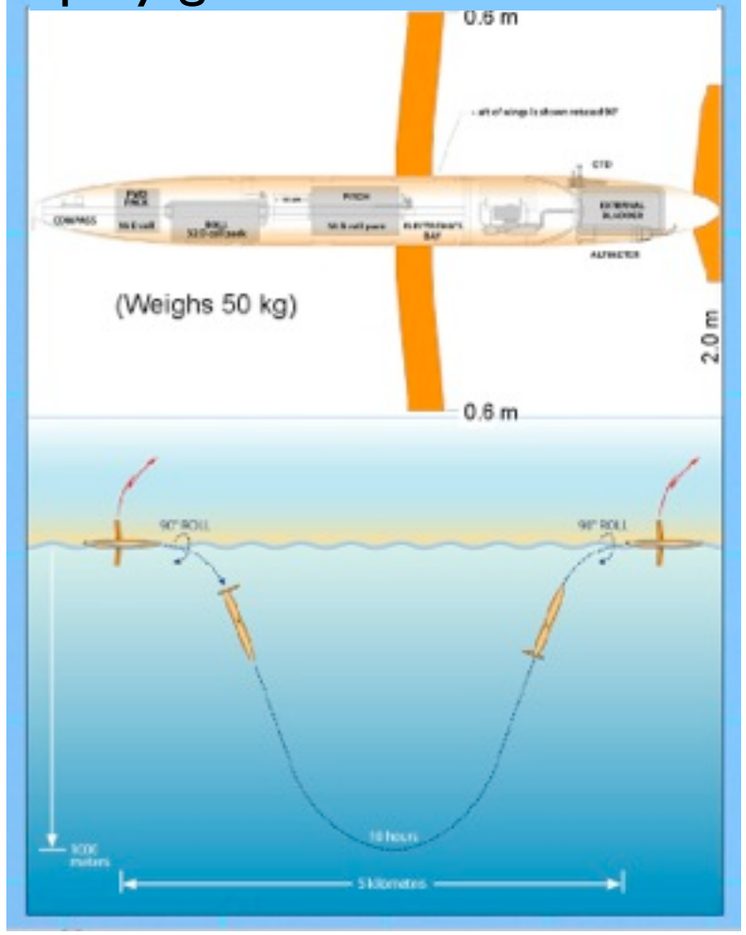
Argo float array:
More than 3800 (~3° x 3°)

(Readiness upper left to lower right)

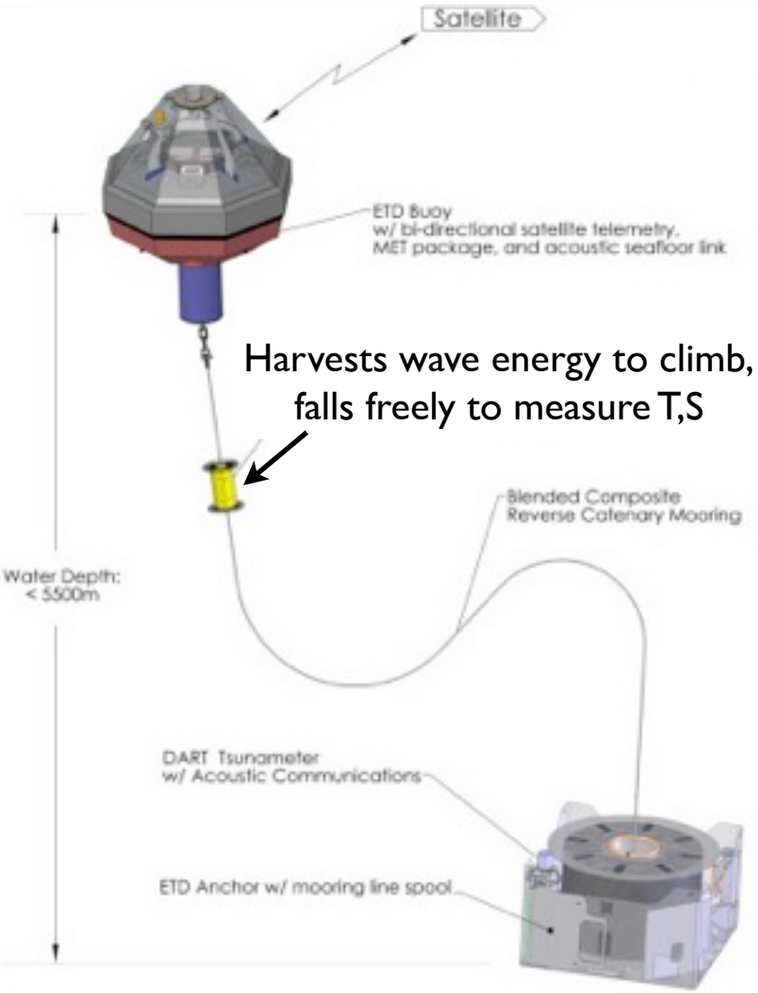
Up and down wave motion creates forward thrust to propel Wave glider: near-surface to 6m



Spray glider: T,S,u to 1000m



Prawler mooring:
T,S, etc to 600m



Saildrone
Surface met

Changes? (premature to say, but …)

Use technology where its capabilities match the needs

It's likely that a moored array will continue to be necessary:

- TAO time series calibrate satellite winds, SST, …
- Near-equatorial current measurements are vital.
- The long records from TAO are a key climate indicator.
- High-frequency sampling aids interpretation of coarser measurements.
- Co-located ocean-atmosphere sampling to diagnose the (poorly-modeled) interaction of the two boundary layers.

Changes? (premature to say, but …) 2: new tools

We have tools that did not exist when TAO was designed:

Argo floats, extensive satellite sampling, other autonomous vehicles.

Argo is improving and complementing existing subsurface sampling:

Argo has better vertical resolution, better zonal spacing, salinity ...

It is a major part of the TPOS 2020 vision.

But Argo can't do the diurnal mixed layer, or the surface met obs.

Satellites complement in situ sampling.

This should be fundamental, but it is not yet clear how to effectively overlap and integrate the two kinds of measurements.

(Backbone Task Team)

Enough arm-waving; what MIGHT we actually do?

A "strawman" is a simple draft proposal intended to generate discussion of its advantages and disadvantages, thus to provoke evolution of new and better proposals.

Key words: → "generate discussion" "provoke evolution" ←

Strawman ≠ What we will eventually propose

Enough arm-waving; what MIGHT we actually do?

In case you didn't get it the first time ....

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Key words: → "generate discussion" "provoke evolution" ←

Strawman ≠ What we will eventually propose

Example strawman ideas (TAO; more topics coming soon):

1. Move all 8°S/N moorings to 1°S/N, increase near-eq velocity sampling.
2. Refocus TAO to the near-surface (short timescales [diurnal], co-located ocean-atmosphere obs [enhance these]). Rely on Argo in the thermocline and below (salinity, vertical resolution, timescales well-matched to phenomena).
3. Rearrange TAO to fewer longitudes, but extend lines across the ITCZ and SPCZ. Double Argo.
4. Shift towards regime-based sampling: a few highly-capable sites.

What in situ observations do we need for the next decades?

Suggestions wanted! Think big and bold, but:

- Must meet the needs of operational forecast systems!
- Backbone technology must be mature or nearly so!
- Must maintain a credible climate record!

Questions for discussion: What in situ sampling is needed?

1) Beyond supporting prediction, the T.P.O.S. is infrastructure that underpins tropical Pacific research.

This infrastructure is both material:

⇒ ships and platforms that make process studies feasible;

and intellectual:

⇒ climatologies and regional context for limited-term studies.

What background sampling will CLIVAR process studies need?

Which variables? Where?

2) Changes made now will be in place for decades.

What in situ data will future models need?

Looking back from 2030, what will we wish we had started sampling in 2016?

3) What is the TAO array for?

- In situ calibration of satellite data (winds).
- Diagnosis of phenomena that need long time series.
- Initialization of forecasts.

Questions for discussion: the future of TAO

1) TAO buoy humidity sampling and ability to estimate evaporation and latent heat fluxes from the buoys is important for subseasonal forecasts and analyses. How can this information be used? How does it complement satellite moisture soundings?

2) What other surface met sampling is needed? (e.g. BP, SW / LW radiation, precip, ...).

3) The geographical shape of the array:
Is the present TAO grid appropriate? Changes to suggest?
Examples: Contract TAO to denser spacing near the equator; extend lines across the ITCZ, SPCZ.
Would a few highly-instrumented sites (e.g. for direct surface flux measurements) be useful?
Where should those be? How would they be used? (realtime assimilation, delayed-mode validation?)

4) What about the near-surface ocean?
We can now make profiles of T,S,velocity at much higher vertical resolution than present TAO for the upper 50m, thus to resolve the diurnal warm layer, its formation and nighttime dissipation. Is this a valuable target?

5) TAO now makes delayed-mode velocity profiles at 4 sites along the equator.
Would more sites be useful? We are considering adding velocity sampling for two additional targets: the ocean mixed layer everywhere (could be realtime), and delayed-mode full-depth profiles at near-equatorial sites which would describe the meridional structure of the EUC and velocity gradients.

6) How do you see the combination of TAO and Argo being used?

7) Since whatever system we design will be in place for decades, we need to think ahead to what future models/forecasts will need. Looking back from 2030, what will we wish we had started sampling in 2016? What observations would guide model improvement?

Extra slides below

Guiding principles

0. Do not repeat the mistake of changing observing systems without adequate overlap and evaluation!

1. Advance by observing the mechanisms connecting the equatorial thermocline and the free atmosphere. Challenge and guide model improvement.

2. Foster a diverse-platform observing system to adequately sample ENSO's rich multi-scale variability. Integrate tools that did not exist when TAO was designed: Satellites, Argo, new autonomous samplers, …

3. Beyond its monitoring capability, TPOS should serve as the backbone for essential ancillary and process studies (allowing others to propose and participate).