Original TAO designed to do everything

At the time TAO was designed:
- The only routine satellite data was SST (clear skies)
- Subsurface temperature came from volunteer ship XBTs
- Winds came from ship reports
- Island tide gauges defined time scales
- Models were rudimentary

TAO scales chosen primarily to sample equatorial winds, recognized as key to forcing models.
The TAO/TRITON combination lasted 20+ years

But now we have other tools ...
TPOS 2020 integrated strategy

- Complementary “backbone” technologies:
  - Satellites give global coverage, fine 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 and connects to subtropics

- How do these pieces fit together?
  - TAO designed in 1980s-90s. What is the role of moorings in the coming decade?
  - Where can Argo or other autonomous instruments or satellites supplant moorings?
  - New needs: Expanded biogeochemistry and impacts

Assimilating models integrate diverse observations → Users will increasingly rely on gridded products
Array design choices

What variable is the target? → What are its observed scales?
Or
What phenomenon is the target? → What variables characterize it?
→ What are their scales? (x,y,z,t)

Do we know enough to specify the target? (pilot or process study?)
What can be done from the global broadscale arrays (satellites, Argo)?
What in situ techniques can measure the variables at the needed scales?
(Are they mature and well-tested?)
Can a combination of techniques do the needed sampling?
(Or, is the combination needed to constrain assimilation?)
What do they cost? Do any of these fulfill multiple functions?
Are the variables sampled needed for other requirements?
Will proposed changes damage the climate record?
TPOS 2020 Recommendations

• **Reconfigure the moored array**
  
  Use moorings where their special capabilities are needed:
  
  Short timescales, co-located ocean-met, sensitive climate record.
  
  Can thin the array in the broad tradewind zones (consider winds, subsurface T, other?)

• **Reducing TAO requires increasing Argo within 10°S-10°N**

Only 3 of 17 TRITON sites remain

Remove 15 TAO sites, add 10 (plus 4 CM)
Requirements for the backbone

What drives our recommendations?

Example: Vector winds

QuikSCAT rain-flag frequency during 1999-2009.
Over much of the Pacific ~25% of QuikSCAT samples are flagged as potentially invalid due to rain.

This does not mean that scatterometer winds are unusable under rain, but they are in question.
Most importantly wind products from different centers differ significantly.

The global climate is exquisitely sensitive to the equatorial zonal wind, so we must get this right.
Winds with a reduced moored array

TAO was originally designed to map winds, before scatterometry. Now we propose to reduce buoy locations, relying more on scatterometer winds.

Two distinct issues:

1) How well do scatterometers measure winds themselves?

Extensive investigation:
- Only a few ongoing cal/val points are needed in the tropics
- Specific regions need in situ referencing (heavy rain / low winds)
- Equator needs referencing between satellite generations

These considerations were influential in shaping our design:
In situ wind sampling in heavy rain regimes: ITCZ, SPCZ, Warm pool
Maintain full sampling along the equator

2) How well do present analyses produce credible wind fields?

The mapping issues are more difficult:
Products from different centers differ considerably! Work is needed!

TPOS 2020 must provide the in situ observations for adequate referencing of scatterometer winds as wind-gridding improves
Rationale for reconfiguring TAO
Meeting needs for winds and subsurface temperature

• Scatterometer winds (mostly) meet research and operational needs:
  - still need validation/correction under heavy rain (pink dashes)
  - near-equatorial winds are very sensitive (keep all near-eq sites)
    ➤ Can remove some TAO sites in the broad tradewind regions (gray),

• Must replace TAO subsurface temperature with adequate Argo
  - Argo spacing and timing can be adjusted to resolve key processes with fewer TAO
    ➤ Double Argo density (shading)

• Near-equator short meridional scales need focused attention
  - Moorings are (still) the only way to sample this (dark blue dashes)

... (Agonize over surface met) ...
The climate record in an evolving observing system

A “climate data record” is a time series at a point (examples).

A “climate record” is a set of measurements that enable detection and accurate description of an element of climate variability in its longterm context.

Barrier layer thickness (Argo)

Sea Level Pressure anomaly, Darwin (red) and Tahiti (blue)

Salinity at 0°, 156°E (TRITON)
Array design choices

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Or

What phenomenon is the target? → What variables characterize it?
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Do we know enough to specify the target? (need pilot or process study?)
What can be done from the global broadscale arrays (satellites, Argo)?
What in situ techniques can measure the variables at the needed scales?
Can a combination of techniques do the needed sampling?
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Example: LLWBCs
Short spatial scales, but Aviso is useful.
Draw info from previous research, still might need pilot testing.
Different pieces will need different techniques (narrow straits).
Is heat/property transport required?

Example: Winds
Broadscale fields needed.
Scatterometers generally reliable ... but scales vary regionally, and specific foci demand attention.
Moorings are multi-purpose (Met and subsurface T).
Climate record!

Example: Intraseasonal winds
Vital along western equator.
Scatterometers uncertain in crucial situations (rain).
Short meridional, long zonal scales.
Need upper ocean vertical detail, short timescales.
Extra slides below
We view the tropical Pacific as consisting of a broad interior plus four “boundary layers”:

**Surface, Equatorial, Eastern and Western**

The boundary layers are the hard parts.

For the broad interior we can often specify goals and sampling scales.

But many of our pilot and process studies are driven by poorly-known scales or phenomena in the boundary layers.