Tropical Pacific Decadal Variability (TPDV)

A review initiative of the CLIVAR Pacific Region Panel

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Motivation

Decadal Predictions are very important, and the Tropical Pacific plays a key role in the global climate

Long “hiatus” in TPDV research since the early 2000

Activities to date

2 workshops:

Guayaquil, Ecuador, October 2018 (in conjunction with the international ENSO conference)

Paris, France, April 2019

Review Paper in progress

How well can we predict the tropical Pacific climate over the next decade or so?

Decadal predictions in the tropical Pacific is challenging:

- Interannual variations associated with ENSO are a source of noise at decadal timescales. Is TPDV simply a result of decadal ENSO variations?

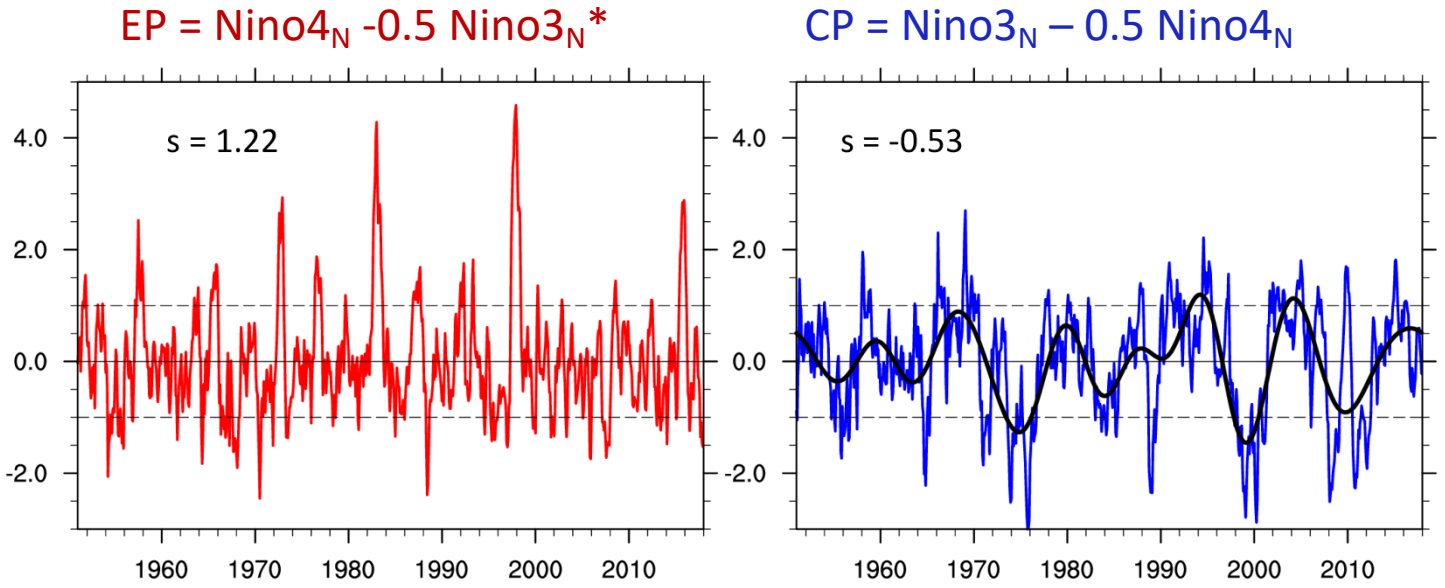
- The influence of climate change on the tropical Pacific is highly uncertain.

“Null Hypothesis”: TPDV is just a ENSO residual

Sampling variability: If, by chance, a decadal epoch has more El Nino events than La Nina events, we can expect the decadal average to be more “El Nino-like”

ENSO asymmetries and diversity

Decadal epochs with more EP events will be more El Nino-like (zonally flatter equatorial thermocline), while epochs with more CP activity will be more likely to exhibit a La Nina-like character (zonally steeper equatorial thermocline). See McPhaden et al. (2011)



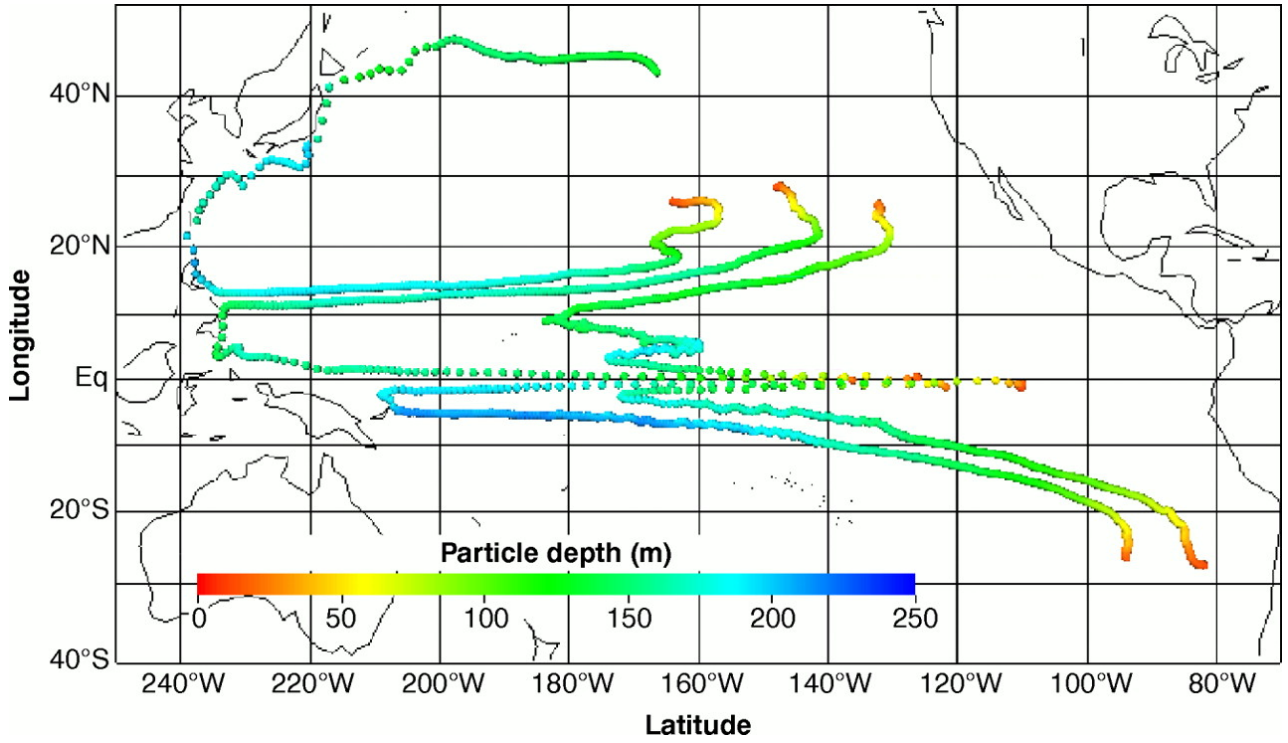
* Sullivan et al. (2016)

If TPDV arises only from random decadal ENSO variations, there would be limited hope for skillful decadal predictions

It is also possible that ENSO decadal modulation is not purely random, but arises from decadal changes in the mean state. Several mechanisms have been proposed.

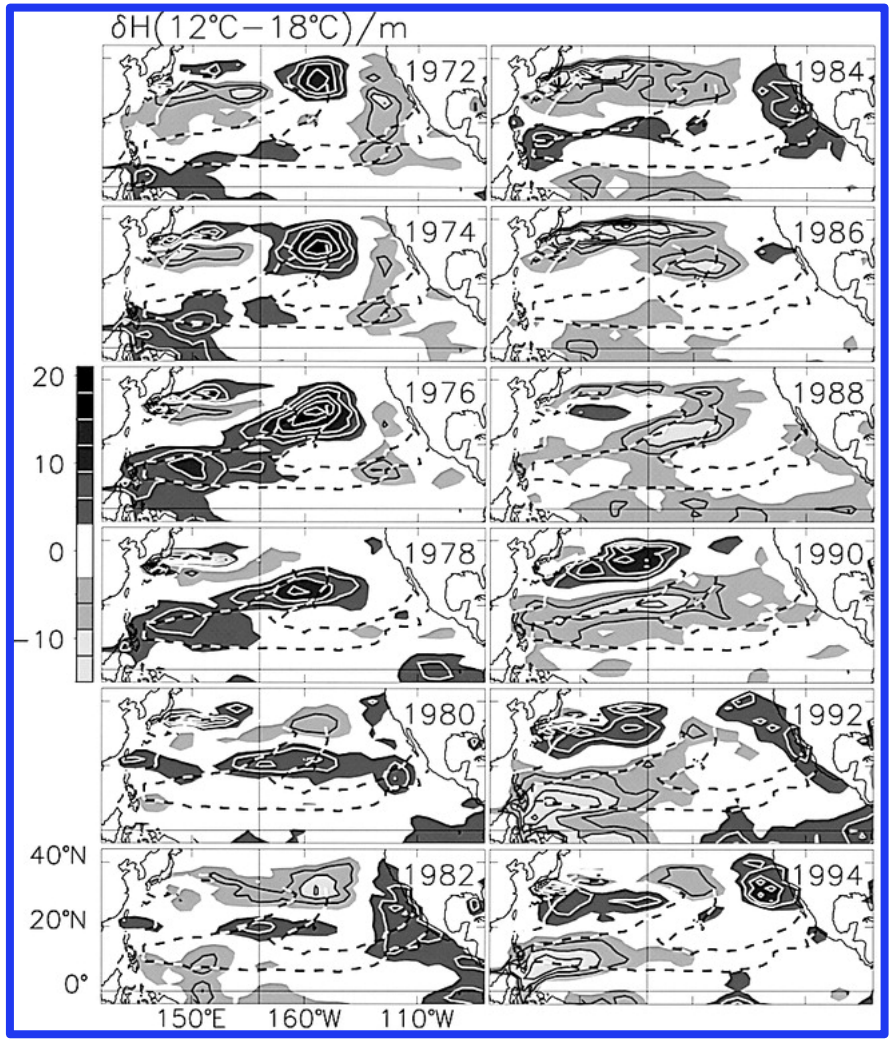
Gu and Philander (1997) mechanism ($\bar{v}$ T'hypothesis)

Temperature anomalies subduct in off equatorial regions and move westward and equatorward following mean isopycnal surfaces.



Path of water parcels subducted off the coasts of California and Peru over a 16-year period, from an OGCM forced by observed climatological winds.

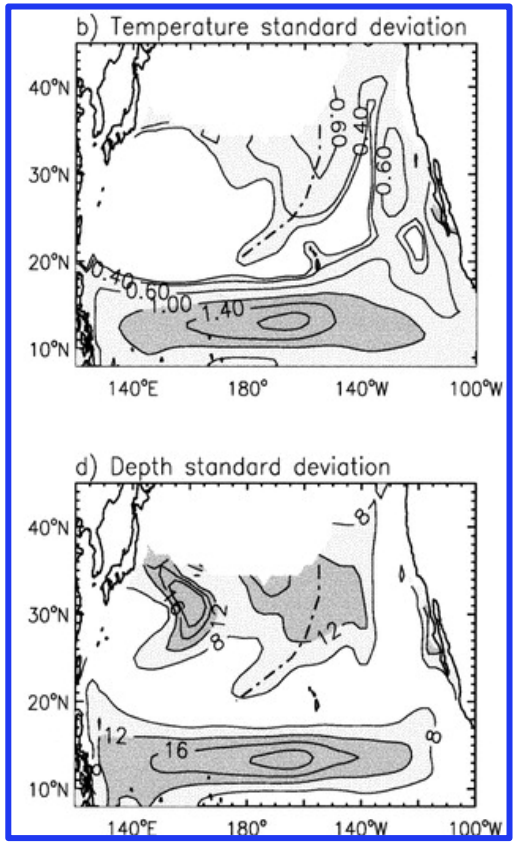
Anomalies subducted in the North Pacific propagate only to 18°N and do not reach the equator (Schneider et al. 1999)



Propagation of warm and cold decadal temperature anomalies (12°-18°C layer) along surfaces of constant potential vorticity.

Although anomalies from the northern extra-tropics decay before reaching the equator, large pycnocline variability is found in the 10º-15ºN band

Standard deviation of temperature and depth along the mean 25.5 σ_θ isopycnal

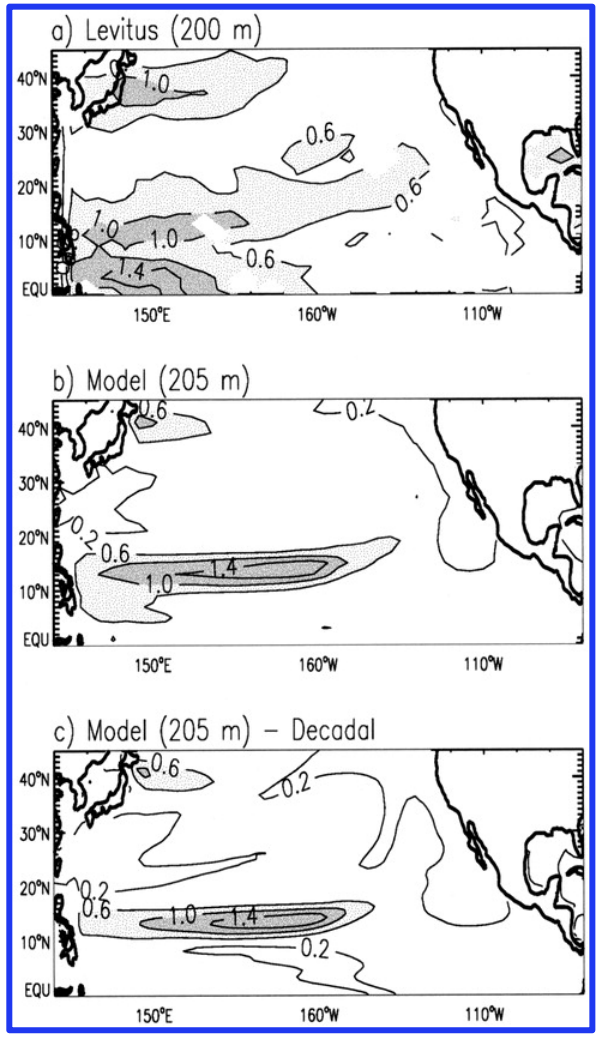


Temperature

Depth

Capotondi and Alexander, 2001

Temperature variance at 200m depth



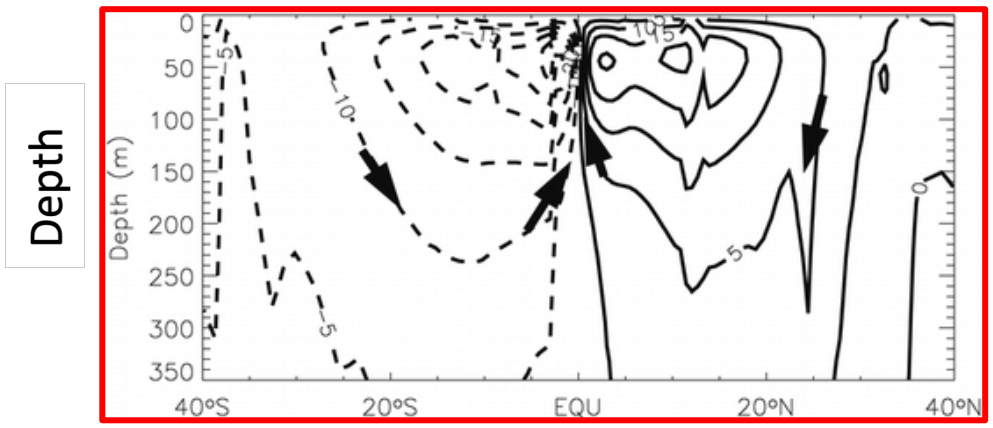
Levitus

Model

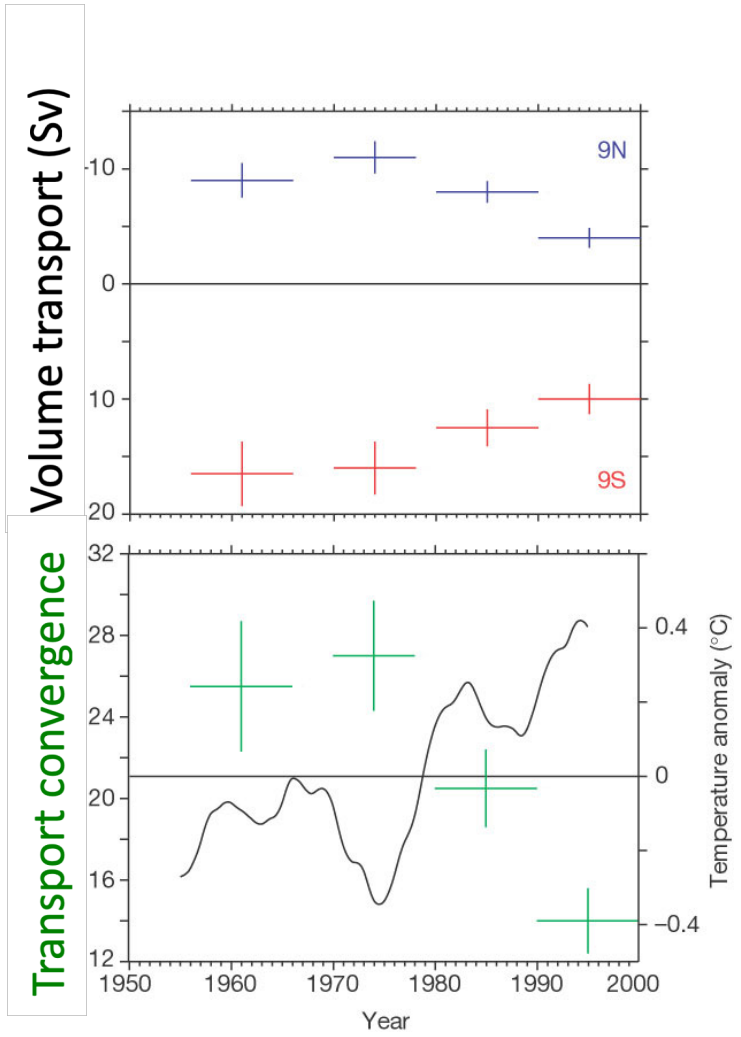
Model – 7-yr low-pass filter

Subtropical-Tropical Cells can influence the tropical ocean at decadal timescales

V' T_{bar} hypothesis



Decrease in interior flux convergence during 1950-2000 was associated with low-frequency equatorial (9°S-9°N) SST increase

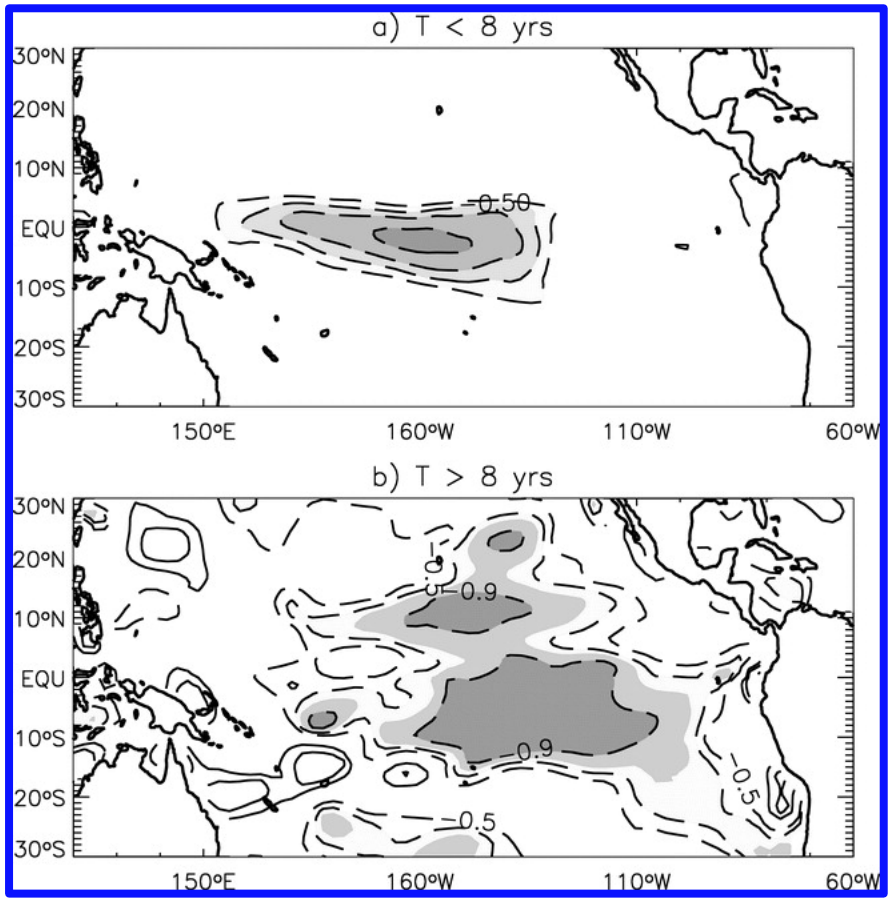


McPhaden and Zhang 2002

Which winds are most important for forcing the STCs

T < 8 yrs

T > 8 yrs



Correlation between upwelling index and zonal wind stress

Capotondi et al. 2005

Mechanisms that involve anomaly propagation along isopycnals

While anomalies cannot propagate all the way to the equator from the Northern Midlatitudes, they may be able to reach the equator from the subtropics. Several mechanisms involving propagation of anomalies from the Southern Hemisphere.

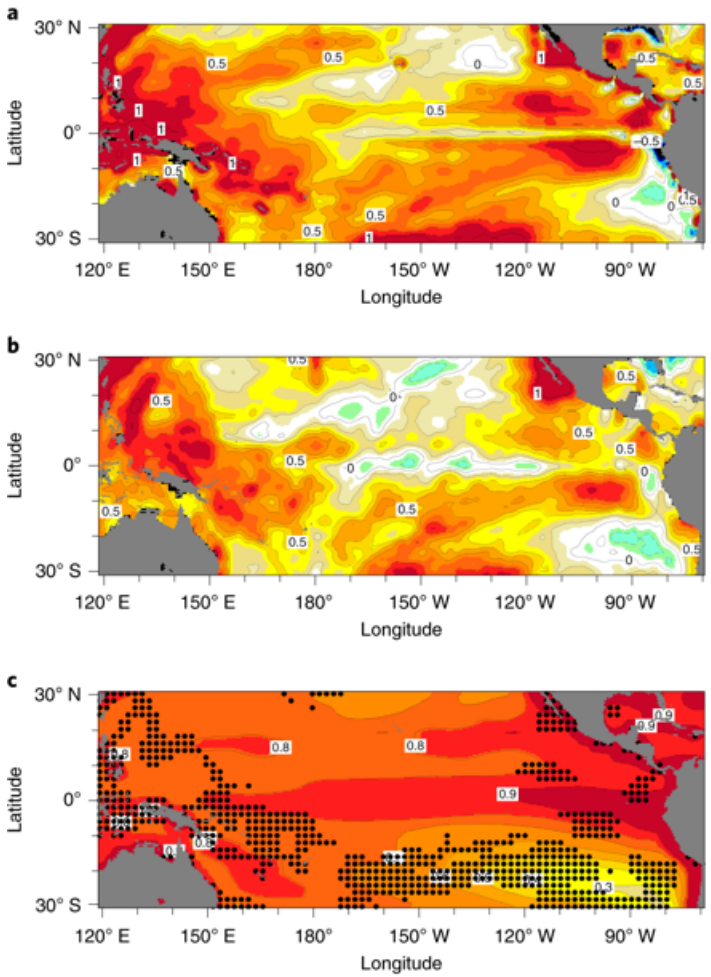
A special class of these mechanisms involves temperature anomalies that are density-compensated ("spiciness" anomalies). Spiciness anomalies are created by wind variations in the subtropics, and can propagate along mean isopycnals to the equator with less dissipation that temperature anomalies alone. (Schneider, 2000)

Schneider et al. (2000) hypothesized that after reaching surface equatorial Pacific these anomalies can feed back to the subtropical winds.

Open questions

- How large is the equatorial signal produced by the above mechanisms?
- What is the relationship between these different mechanisms? Are they acting independently, and if so what is their relative importance?
- Most mechanisms arise from anomalous wind forcing. How are the wind anomalies generated? Are they random? Are they associated to extra-tropical processes, or induced by the influence from other oceans? Or can they be a response to the equatorial Pacific itself?

How will the tropical Pacific change due to global warming?
Trend is a source of predictability, but what is the trend?



ECMWF/ORAS4 reanalysis

HadISST

Multi-model mean

Trends over 1958-2015

Seager et al. (2019)

How well can we predict the tropical Pacific climate over the next decade or so?

- At the moment we are unable to reject the Null Hypothesis that TPDV arises from decadal variations of ENSO, which could themselves happen by chance
- Understanding the effectiveness and relative importance of the mechanisms that rely on ocean dynamics is key to assess the degree of predictability. Origin of the wind forcing needs to be clarified (stochastic, originating from the tropical Pacific itself, from the extra-tropical Pacific, or from other oceans).
- A better understanding of the discrepancy between observed and model trends is fundamental to be able to trust model projection