ENSO diversity explains the interannual variability of the SST pattern effect.

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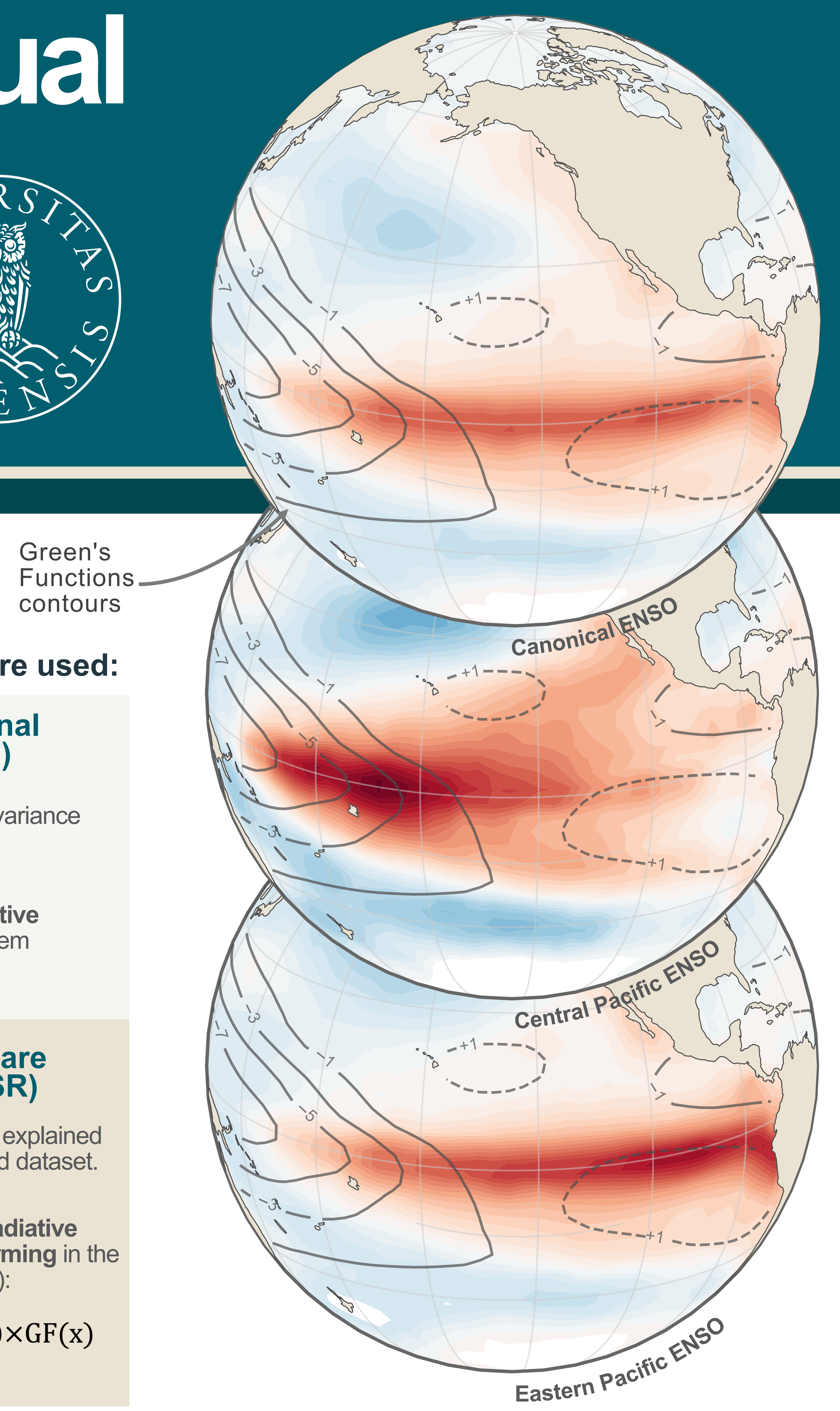


Context

The pattern of sea surface temperature affects the global energy budget of the planet. This is known as **the pattern effect.**

Sea surface temperature evolves either through a forced change from radiative forcing, or through **internal variability**.

Modes of variability affecting **areas sensitive for the pattern effect** (e.g. Eastern Pacific low cloud area, Western pacific warm pool, ...) can interact with the global energy budget through the pattern effect.

Objective

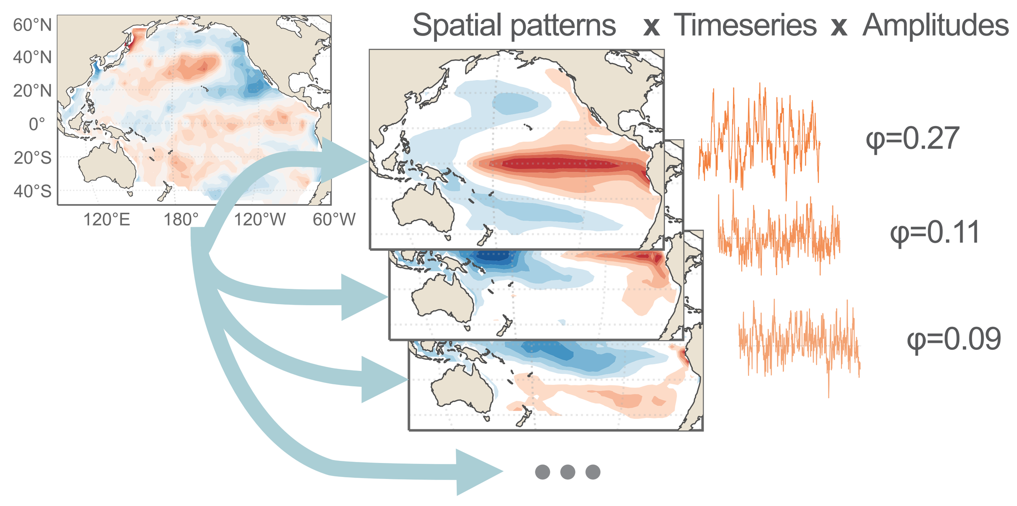
Here, we conduct an **objective analysis** to determine which modes of Pacific sea surface temperature variability are the most associated with the pattern effect in historical observations.

Data and Methods

3 SST products: HadISST, COBE2, ERSSTv5

7 Green's functions: From GFMIP CAM4, CAM5, GFDL-AM4, ECHAM6, HadCM3, CanESM5, "Mean" GF

We decompose the SST anomaly field into a sum of recurring patterns



Two different methods are used:

Empirical Orthogonal Functions (EOFs)

Maximise the spatio-temporal variance explained by the data

SSTAs are **weighted by radiative Green's functions** to make them relevant for the pattern effect.

Partial Least Square Regression (PLSR)

Maximise the cross-covariance explained between SSTA and a predictand dataset.

The predictand dataset is the **radiative response to non-uniform warming** in the Pacific (Meyssignac et al. 2023):

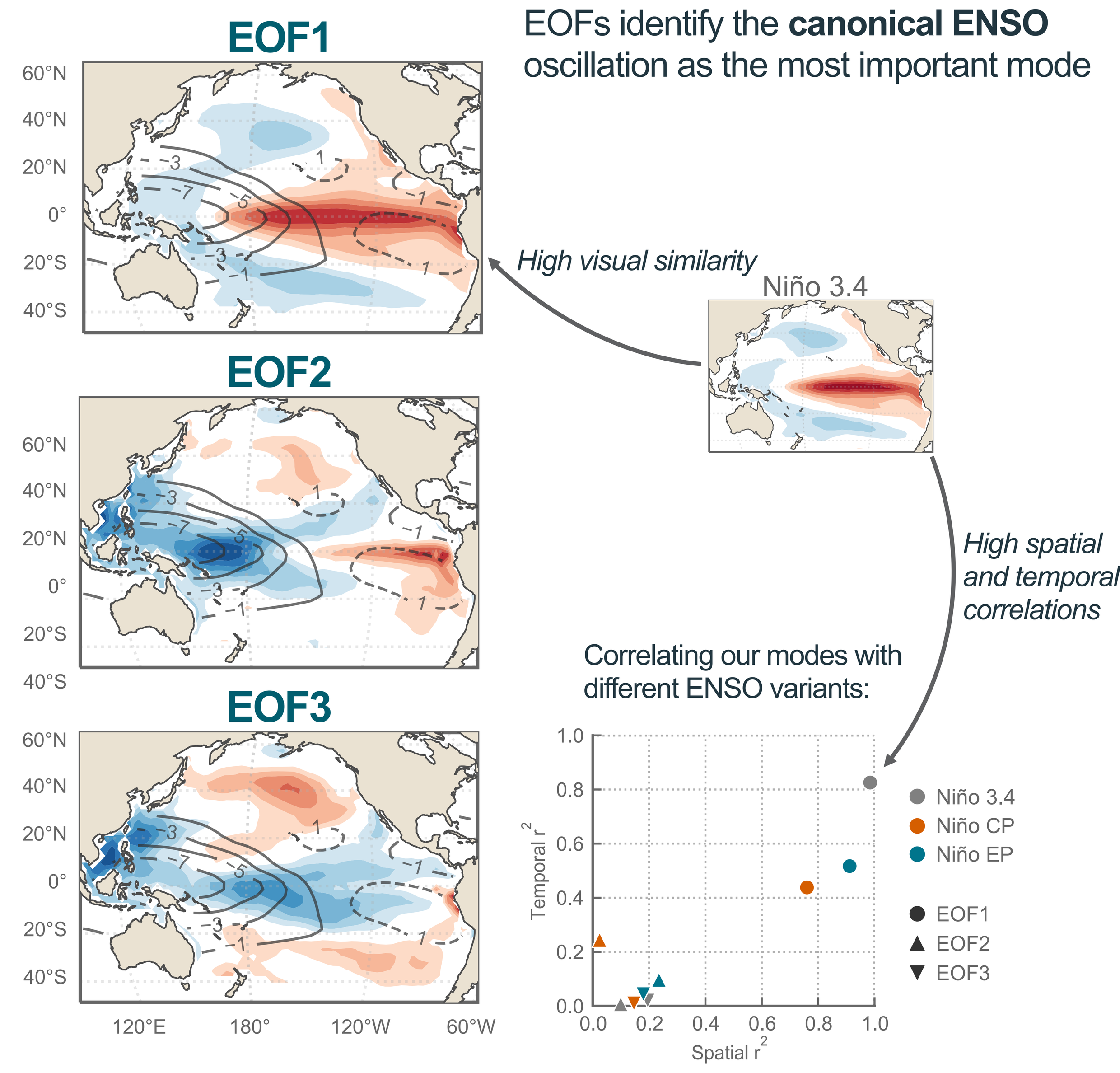
$$R_P(t) = \sum_{x \in \text{Pacific}} \text{SSTA}(x,t) \times \text{GF}(x)$$

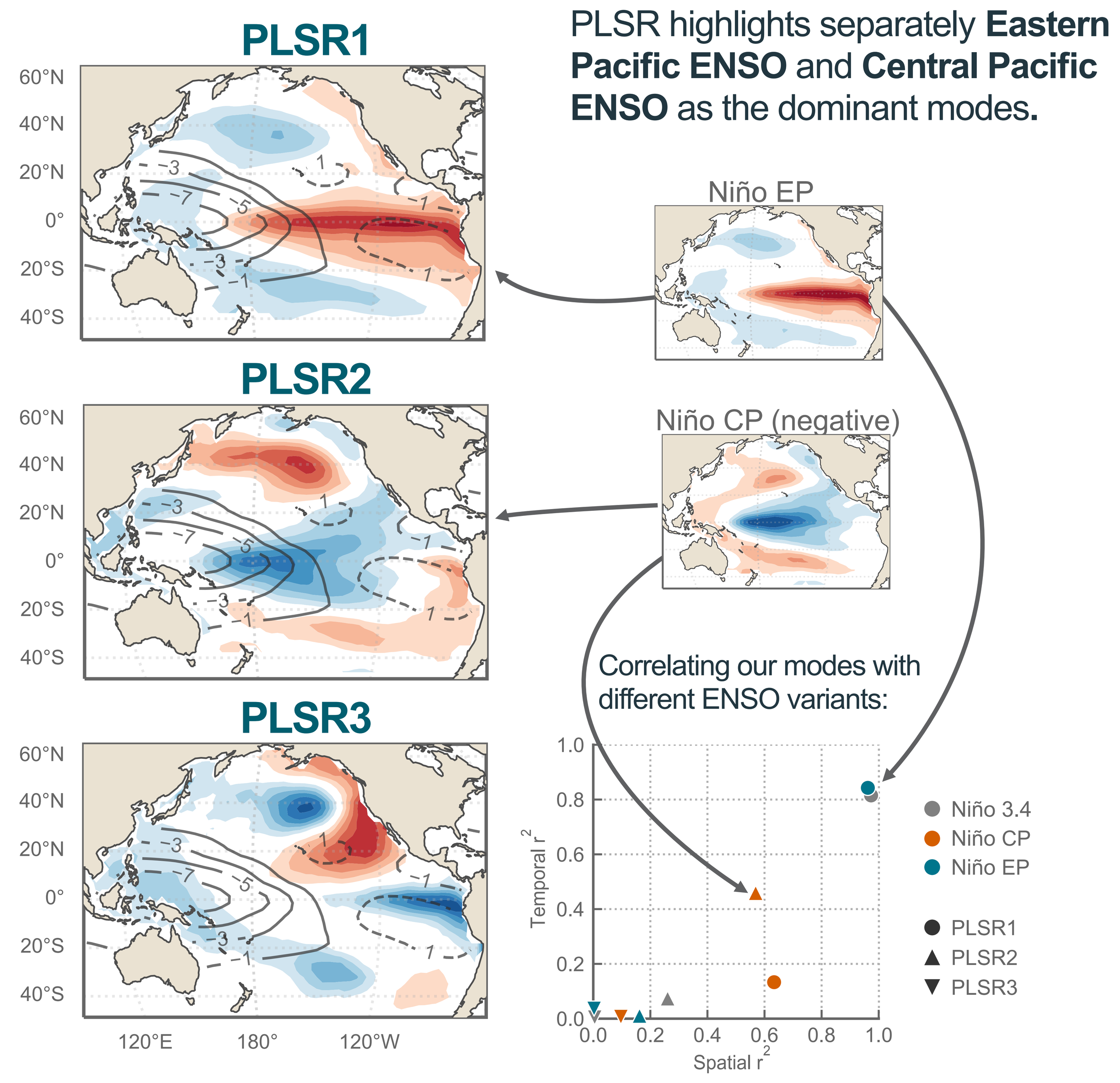
Results:

I: What are the modes identified ?

EOFs identify the **canonical ENSO** oscillation as the most important mode

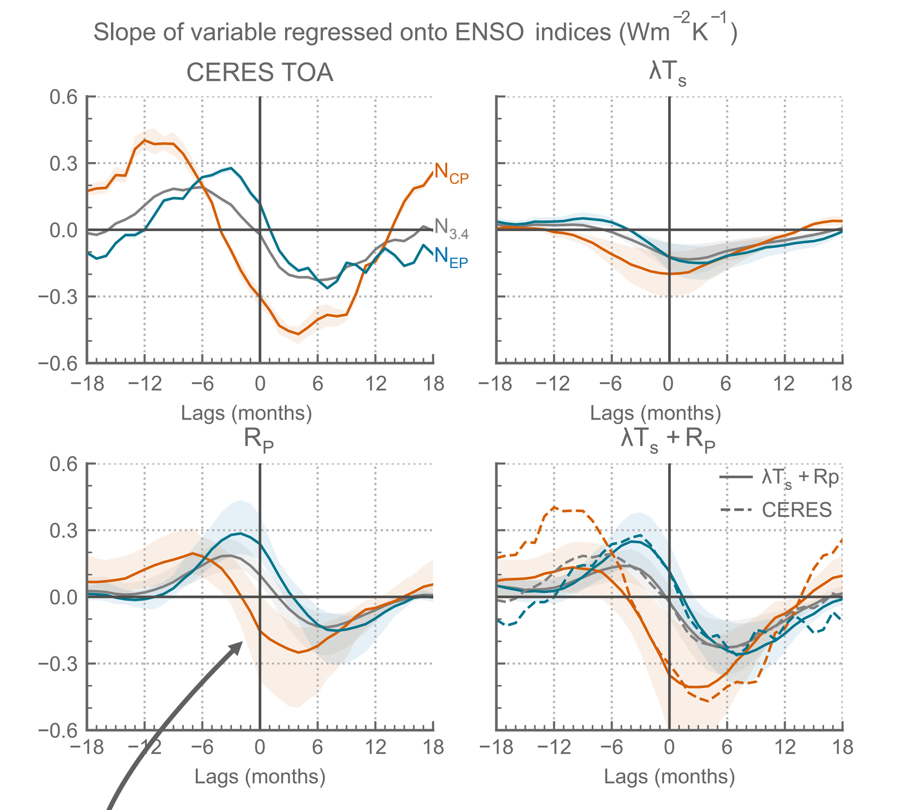
PLSR highlights separately **Eastern Pacific ENSO and Central Pacific ENSO** as the dominant modes.





III: Are these modes relevant for observations?

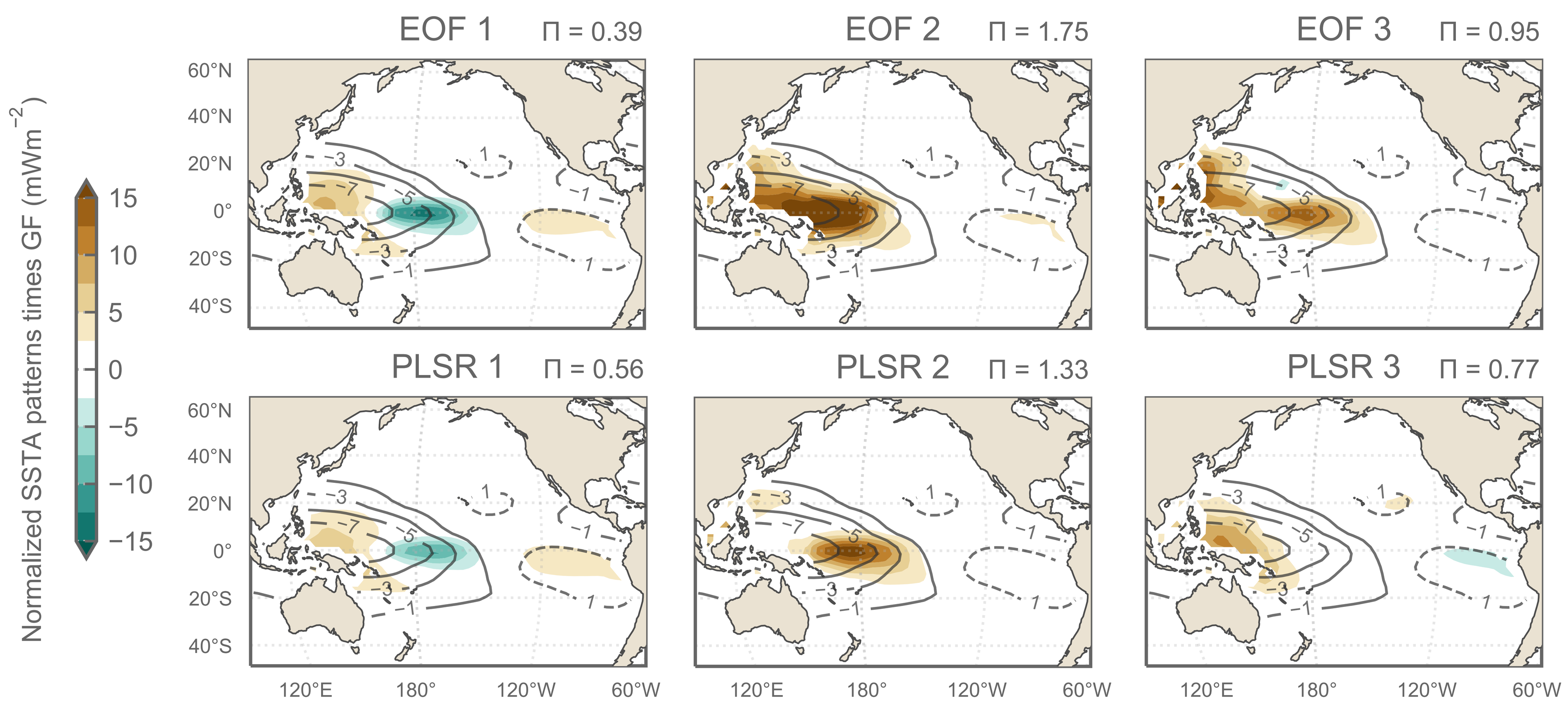
We regress the **observed CERES TOA** radiative budget onto the three different ENSO indices, and explain the slope by a **uniform warming contribution** and **the pattern effect**.

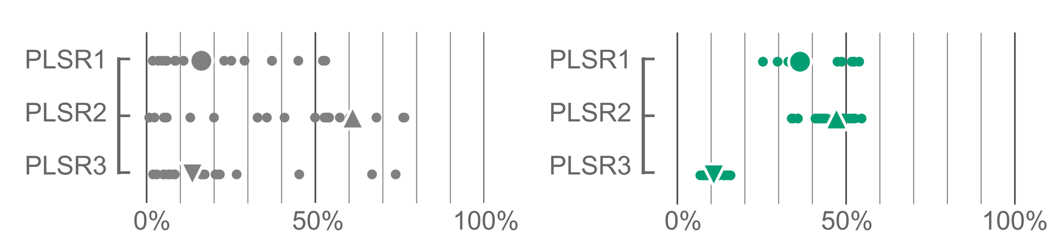


Eastern Pacific ENSO and Central Pacific ENSO both have a **stronger pattern effect** than the Canonical ENSO, and they have opposite sign.

II: How much do they contribute to the pattern effect ?

Multiplying the temperature patterns associated with the identified modes by the Green's Functions allows to determine their contribution to the pattern effect.





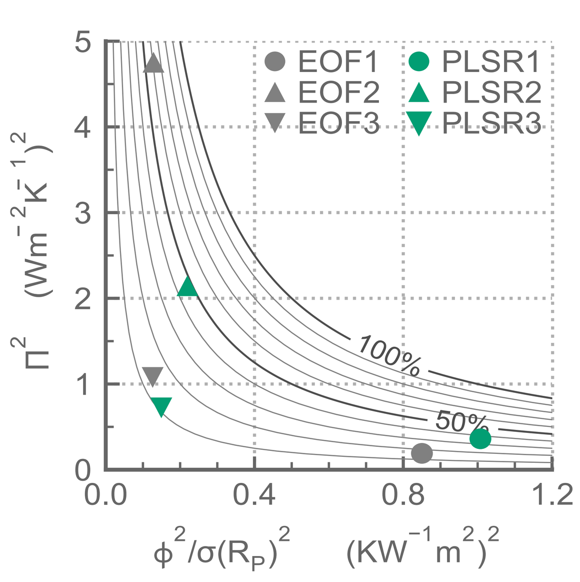
Percent of Pacific R_P variance explained by each mode (individual members and ensemble mean)

The contribution of a given recurring pattern to the pattern effect is explained by two variables: **φ** and **π**

φ is the pattern amplitude: It corresponds to the amplitude of the oscillation, when the pattern is normalized to have a spatial standard deviation of 1K.

π is the pattern effect efficiency: It corresponds to the TOA radiative anomaly associated with the pattern effect for a given recurring SST pattern of standard deviation 1K.

The induced TOA radiative variance is $(\varphi \times \pi)^2$

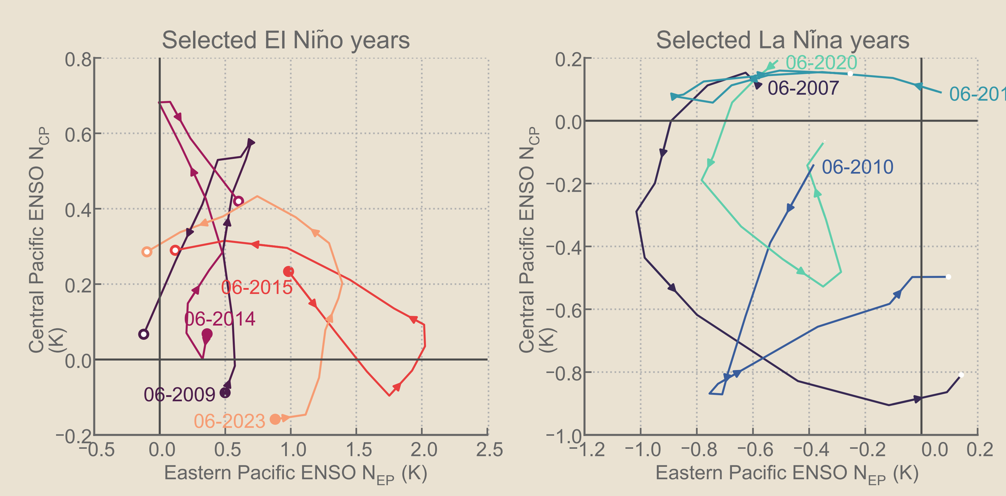


Key points

We apply **objective dimensionality reduction** to identify the dominant modes of Pacific sea surface temperature variability linked with the SST pattern effect.

Eastern Pacific and **Central Pacific ENSO** dominate the inter-annual pattern effect but their contributions have opposite sign.

Because of the pattern effect, each ENSO event has a **unique radiative signature** depending on the temporal evolution of the spatial SST patterns



Considering **ENSO diversity** is crucial to study how sea surface temperature variability impacts the Earth energy budget.

Do you want to know more? Find our preprint on ESS Open Archive: *Robin Guillaume-Castel, Paulo Ceppi, Joshua Dorrington and Benoit Meyssignac. ENSO diversity explains interannual variability of the pattern effect. ESS Open Archive.*

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