

Review of EGU sphere-2025-4879

**Detecting transitions and quantifying differences in two SST data sets using
spatial permutation entropy**

Submitted to Earth System Dynamics

General comment

The authors present a multi-scale approach founded on permutation entropy metrics and change point analysis to identify and characterise changes in spatiotemporal datasets with focus on the Niño 3.4 and Gulf Stream regions for two SST datasets, the ERA5 SST and NOAA OISST v2 products (anomalies SSTA and/or detrended anomalies dSSTA?). They recover known discontinuities or transitions in both datasets indicating that the methodology is potentially capable of discovering potential issues due to 1) changes in the Earth’s observing system with the introduction of new observing platforms (e.g. MeteOp-A to MeteOp-C) and 2) changes driven by modifications of the data analysis workflow (e.g. OSTIA error covariance update). The authors also apply spatial permutation entropy (SPE) to tease out quantitative differences between datasets and compare SPE feature discovery to standard distance metrics (e.g. the average absolute and correlation distances).

Adding SPE to the standard suite of diagnostics to characterise changes in widely used data products is important as it 1) will increase confidence in the data products for specialised use cases such as extreme event detection and regime shift identification, 2) could alert practitioners to potential issues with their workflow if the SPE methodology is part of regular data quality protocols, and 3) may allow potentially new insight in understanding geophysical processes and their impact.

Major issues

1. To make the paper more accessible to practitioners in the weather and climate research, the different methodologies for PE, SPE and SMI should be clearly explained, especially in section 3, where the definition of the Shannon entropy H or PE, Equation 1, should carry all the necessary indices and time dependency, $H_{NS\text{ or }EW}^{L,\delta}(t), \forall t = 1, \dots, n = N - (L - 1)\delta$ and all expressions derived from it. Contrasting the temporal, spatial and spatio-temporal PE approaches and illustrating them with simple examples would also be instructive and would add clarity to the exposé even if these have been shown elsewhere. Clear distinctions between symbol length, total sequence length and the probability of expression of different but a finite number of patterns for each L and δ . Ditto for a precise definition of the joint entropy term in Equation 4.

2. Following on point 1, targeted examples for both El Niño and La Niña snapshots in SSTA or detrended SSTA (or large meander excursions of the Gulf Stream) for example could be valuable. They would show how the metrics presented depend on the different ENSO regimes for example. This may also aid in the physical interpretation of the SPE results if one wish to extend the methodology to the multi-scale characterisation of the dynamics rather than just detecting the spurious changes or artefacts mentioned earlier.
3. Clarifications should also be given regarding how $AAD(t)$ and the Pearson's spatial cross-correlation $r(t)$ are computed for a fair comparison with $H_{NS\text{ or }EW}^{L,\delta}(t)$, when $\delta > 1$. Are $X_{ij}(t)$ sub-sampled according to L and δ to compute AAD and r ?
4. The choice of spatial ordinal pattern orientations, North-South and East-West, for the Gulf Stream box is probably harder to justify than for the Niño 3.4 region, where asymmetries along these directions are relatively well understood given what we know of the equatorial dynamics of ENSO and associated phenomena – Kelvin and Rossby waves propagation, meridional mode and tropical instability waves. Have you tried to check if directions along and across the mean position (approximately SW to NE and NW to SE) of the Gulf Stream current system changes your results? Either by sharpening the points already discovered (i.e. 2007 and 2013) and possibly making the 2021 shift significant!

Minor issues

- Are all the results presented derived from sea surface temperature anomalies only? If so, a clear statement should be made upfront in the data section.
- In Figure 1, the spatial standard deviation could be slightly darker for both Niño 3.4 and the Gulf Stream. Its time evolution and variability as function of ENSO phases may explain some of the behaviour seen in the SPE metrics.
- The parameters L and δ and labels indication the regions should be appear directly on all subplots as this would make the plots more readable, or indicated in left for rows or top margins for columns.
- The symbol length, here $L=4$, should be mentioned in the caption of Table 1 for clarity.
- Line 333, change 'non' to 'none'.

Overall consideration

A more precise mathematical description would make the paper more digestible. Targeted illustrations for ENSO or Gulf Stream phases could be used to illustrate the methodology and make the paper more appealing, the impact of the lag parameter and potential sampling issues clearer.