Extraction of SMOS Soil moisture main features across the Mediterranean over the last decade

Diego Bueso[1], Maria Piles[1], Joaquim Ballabrera-poy[2], Gustau Camps-Valls[1]

(1) Image Processing Laboratory, Universitat de València, Spain

(2) Technologic and physic oceanography Institute of marine sciences, CSIC, Spain

ABSTRACT

Dimensional reduction methods are key to Earth system sciences. They allow dealing with extensive spatio-temporal climatic data sets in terms of individual variables as time series and spatial distributions. Principal Component Analysis (PCA), also called Empirical Orthogonal Functions (EOF) in geophysics, is a simple yet very powerful method to uncover the main geographical patterns at distinct temporal scales present in the data. A variety of PCA extensions have been proposed to deal with specific aspects of the input data, as the complex PCA (CEOF)**[1]**, the rotated PCA (REOF)**[2]** or the nonlinear or Kernel PCA**[3]**. The rotated complex kernel PCA (ROCK PCA)**[4]** was recently proposed to combine these three methods and allow making a physically interpretable spatio-temporal decomposition of extensive climatic variables.

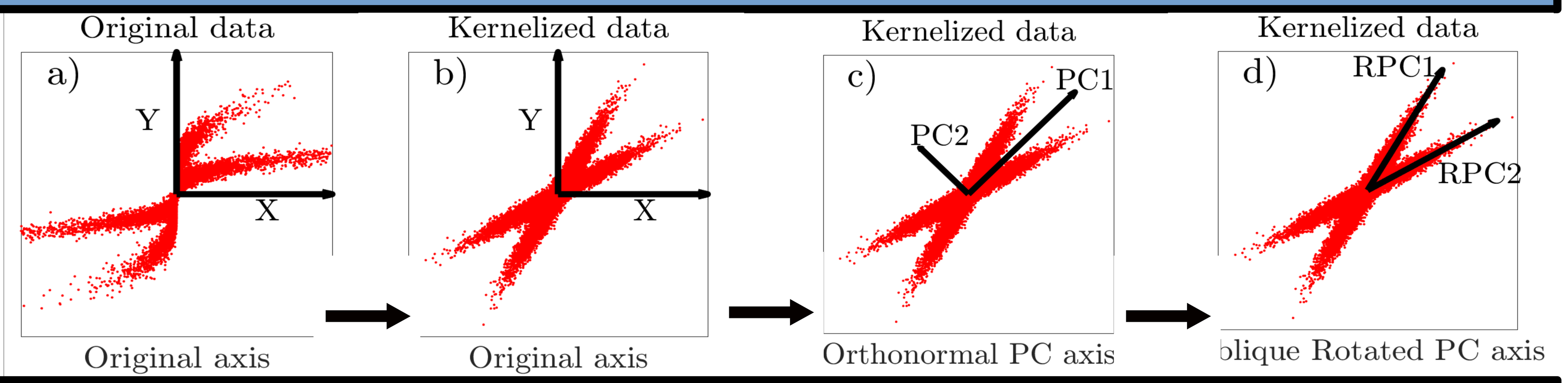
In this work, we apply the ROCK-PCA method to the 8 years of ESA's SMOS Soil Moisture (SM) data available over the Mediterranean region **[5]**. Results show the distribution of the total SM variance among its different components, and indicate dominant modes of variability. The connection of these modes to natural fluctuations as El Niño Southern Oscillation has been explored.

ROCK-PCA

ROCK-PCA is essentially the combination of PCA-based methods:

- **Complex-PCA: phase-modulation decomposition**
- **Rotated-PCA: avoid the orthogonality constraint with Promax rotation**
- **Kernel-PCA: non-linear decomposition**

The method is optimized by maximizing the **kurtosis** to choose the number of components, kernel hyperparameter, and Promax rotation parameter.



DATA AND RESULTS

- **Studied period: from 01/06/2010 to 31/12/2017**
- **5 days average of satelital images.**
- **Latitude lower than 60º.**

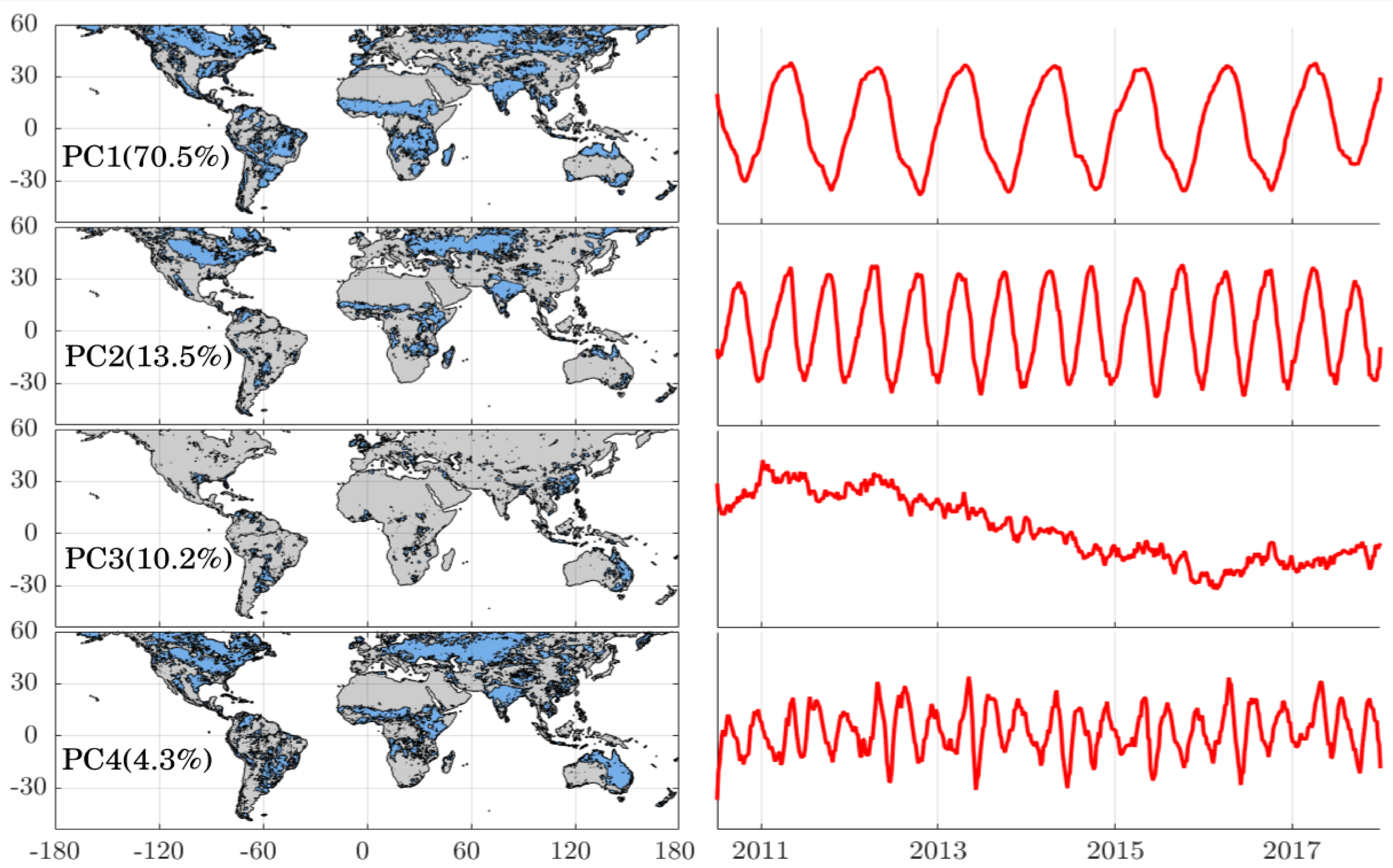


Fig. 1: Global principal varibility components**.** Left: Significant spatial distribution extracted from the amplitude. Right: Estimated time series.

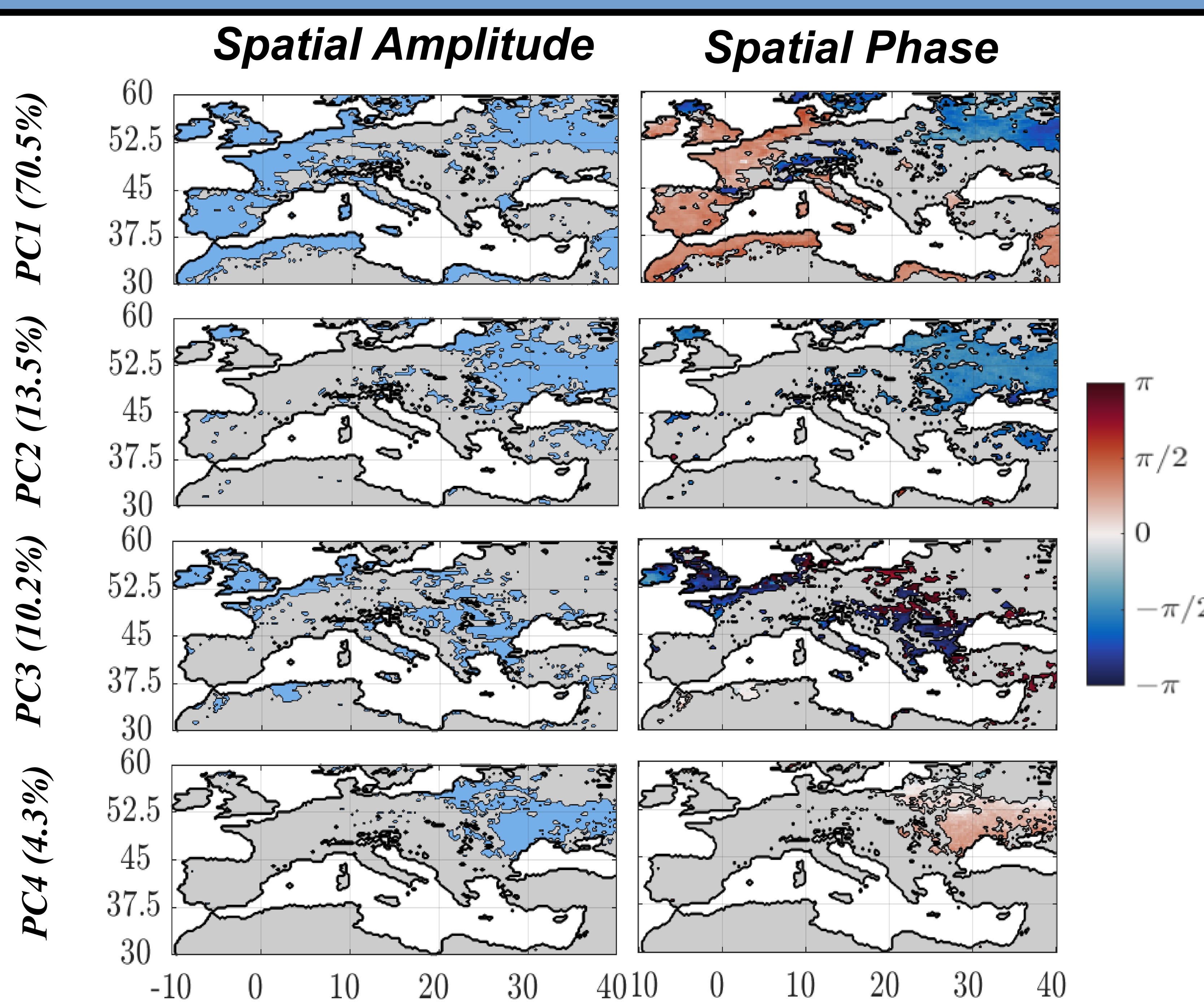


Fig. 2: Mediterranean principal varibility components**.** Left: Significant spatial distribution extracted from the amplitude. Right: Phase maps that define the **spatial distribution of time delay of signal** from each component.

Results: The nonlinear decomposition results in a seven spatio-temporal component subset. The fourth first variability modes acumulate the **98.5%** of the over all **explained variance**. Annual, seasonal and interannual trends are captured as well in widely separate components. Mediterranean main features of Soil Moisture:

- **PC1: Annual signal:** Shows two differenced patterns. The Atlantic region and the hilly lands and west continental lands dynamics are captured with an opposed phase.
- **PC2 and PC4: Seasonalities:** Six and fourth month period signals. Widely distributed over west Europe with an opposed phase.
- **PC3: Interannual trend:** High spatial variavility. Distribution over North Africa, north Atlantic coast and the Balkan peninsula. **Highly related with El Niño Southern Oscillation (ENSO)** event into the studied time scale. **(ρ≈0.8)**

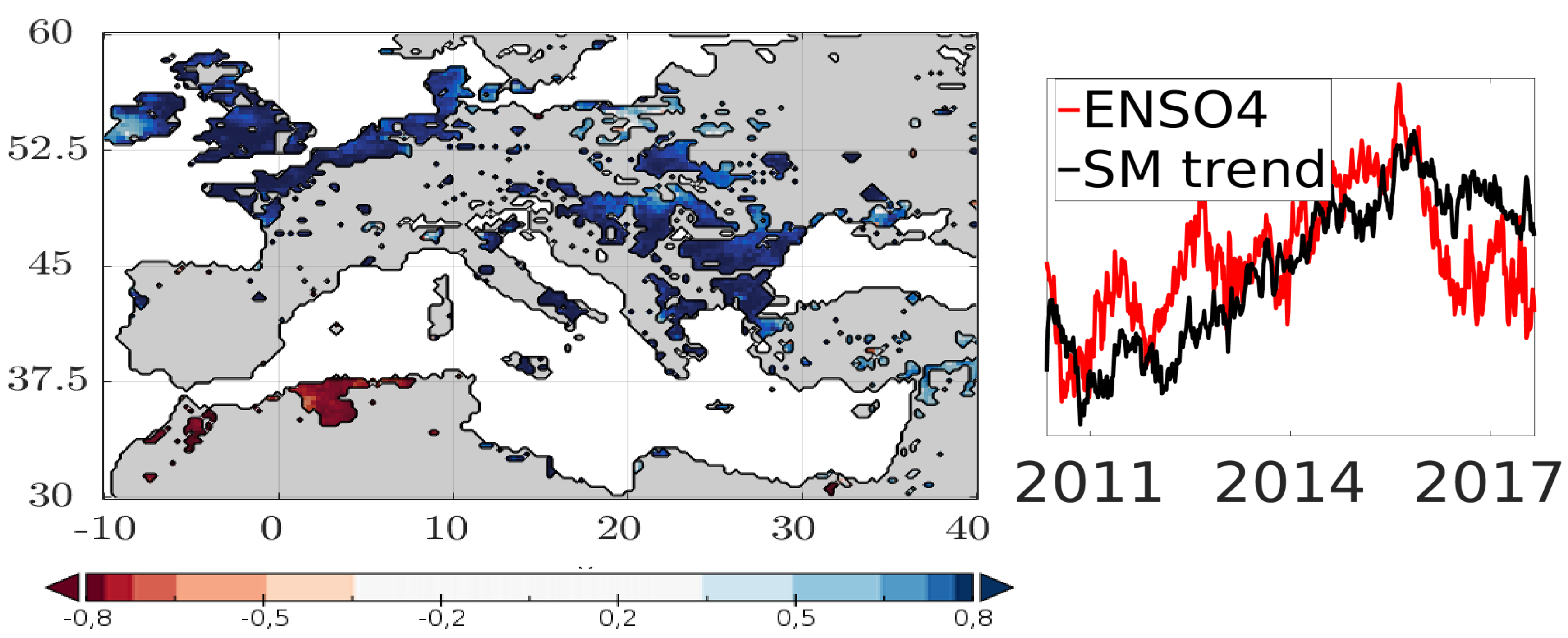


Fig. 3: Mediterranean soil moisture and ENSO4 teleconnection patterns. Phase map allow as to reconstruct the sign and the power of the spatial correlation. Spatial amplitude works as threshold. Different regions are captured. Probably a NAO-ENSO interaction was unraveled.

REFERENCES

[1] J. D. Horel, “Complex principal component analysis: Theory and examples,” Journal of Climate and Applied Meteorology, vol. 23, no. 12, 1984.
[2] T. Lian and D. Chen, “An evaluation of rotated eof analysis and its application to tropical pacific sst variability,” Journal of Climate, vol. 25, no. 15, 2012.
[3] B. Schölkopf, A. Smola, and K.-R. Müller, “Nonlinear component analysis as a kernel eigenvalue problem,” Neural Computation, vol. 10, no. 5, p. 1299-1319, 1998.
[4] D. Bueso, M. Piles, and G. Camps-Valss, “Nonlinear complex pca for spatio-temporal analysis of global soil moisture,” in 2018 IGARSS, July 2018.
[5] BEC team. (2018) Barcelona expert center. [Online]. Available: http://bec.icm.csic.es/

Research funded by the European Research Council (ERC) under the ERC-CoG-2014 SEDAL project (grant agreement 647423) and TEC2016-81900-REDT.
M. Piles is supported by a Ramón y Cajal contract (MINECO).
Main author information: ***Diego Bueso***, e-mail: ***diego.bueso@uv.es***, Tel.: ***+34 627102596***