THE ADRIATIC SEA SURFACE TEMPERATURE VARIABILITY VIA EOF/WAVELET ANALYSIS OF THE AVHRR DATA

Milivoj Kuzmic [1] * and Zoran Pasaric [2]

[1] Center for Marine and Environmental Research, Rudjer Boskovic Institute, P.O. Box 180, 10002 Zagreb, Croatia
* kuzmic@rudjer.irb.hr
[2] Geophysical Department, Faculty of Science, Horvatovac bb, 10000 Zagreb, Croatia

Abstract

Fourteen years of five-day averaged medium-resolution (9.3km) Adriatic remotely sensed SST fields is analysed with a view to better discern their spatial and temporal variability. The EOF analysis is employed to derive orthogonal spatial patterns, and continuous wavelet transform (CWT) applied to EOF-derived principal component time series. The first EOF mode revealed dominant spatial patterns, carrying prominent part of the total variance in both time- and space-demeaned cases (98.5% and 66% respectively). The time series of band-integrated principal components has provided revealing insights into intra- and inter-annual variability.

Keywords: Adriatic Sea, surface temperature, wavelet analysis

Introduction

The sea surface temperature dominates the exchange of heat with atmosphere, and exerts influence on the transfer of momentum and moisture affecting a wide range of sea motions. Discerning its spatial and temporal variability using in situ data alone is rarely easy, so spaceborne sensors are welcome to provide much needed repeatability and coverage. LeVourch *et al.* [1], for example, used AVHRR imagery to compile an atlas of the Mediterranean Sea fronts. More recently, Gacic *et al.* [2] used low resolution (18km) weekly averaged time series of AVHRR scenes to study seasonal and inter-annual variability of the Adriatic Sea surface temperature. Their analysis showed an absence of permanent surface thermal features, and revealed basin-scale four-seasonal variability. We report deliberations of an ongoing study better resolving both spatial and temporal variability in a longer (14 years) Adriatic AVHRR SST dataset. Improvement in resolving temporal change is sought by employing the wavelet analysis offering localisation in both time and frequency domains. The analysis is performed on EOF-derived time series of principal components of the surface temperature fields.

Data

The remotely sensed SST data set used in this study is an Adriatic subset of the NASA Seasonal to Interannual Prediction Project AVHRR global pentad SST set (kindly provided by Dr. Kenneth Casey). It was created by extracting the area spanning 12° to 20° East longitude, and 40° to 46° North latitude. The extracted subset comprised 1022 SST fields (14 years [1985-1998] x 73 pentads /year) each consisting of 1556 pixels. Not a single time-series had less than 70 gaps and only 28 series had more than 400 gaps. In order to fill in the gaps simple linear interpolation was performed on residuals after which the removed annual and semi-annual cycles were added back. To validate the subset we looked at 2 northern Adriatic in situ SST series spanning the same period.

Two-variant EOF analysis was applied, one with temporal and the other with spatial mean removed prior to further calculations. The EOF analysis allowed identification of orthogonal spatial patterns. It is tempting although not necessary to interpret the patterns as natural modes of variability of the studied fields. Projected onto those functions, the Adriatic SST fields yielded time series amenable to spectral analysis. For the wavelet analysis we have chosen the Morlet wavelet, well suited to capture the frequency content of a time series. It provides both the modulus measuring the energy density, and the real part commensurate with the intensity and phase of the signal varying in the time-frequency domain.

Results

Removal of the temporal and spatial mean from the original set has allowed pattern ranking by respective residual variance. In both cases the first EOF mode provided dimensionless and timeless dominant spatial patterns carrying respectively 98.5% and 66% of the total residual variance. Related time series of principal components provided temporal variability with two contributions standing out clearly: the annual and semi-annual harmonic, not surprising considering the influence of the annual solar cycle. An example CWT spectrum is presented in Figure 1, for the time-demeaned signal. The absolute value of the real part of the CWT spectrum is plotted. Also plotted is the cone of influence, which maps out the extent of the edge effects. The palette scale is logarithmic. The annual signal dominates the spectrum, but the figure also presents plenitude of other periodicities whose intensity changes with time. For example, removal of the annual and semi-annual harmonics prior to the CWT allows bi-annual component to surface, but also the irregularities near the six-month scale to present themselves. The CWT analysis performed on the space-demeaned series has also yielded spectrum with prominent annual signal.

Other revealing pieces of information can by gained by looking at the time series of band-integrated principal components. In both time-demeaned and space-demeaned cases intra-annual anomalies have been observed in 0-1.5 month band, with pronounced inter-annual variability in some years, e.g. 1989 vs. 1993 in case of time-demeaned series, or the year 1995 vs. 1996, in case of the space demeaned data. The intensity of the integrated signals in this shortest-period band generally reflected relation observed in the original residual series: about five times stronger signal remained after time demeaning than after prior removal of the spatial mean. Consistent amplitude difference was also observed in other bands, the 4 – 18 months in particular. Here the size of the time-demeaned amplitude was about an order of magnitude larger than the one for the space demeaned signal. The time-demeaned signal in this band exhibited more regular oscillation throughout the observed period, whereas the space-demeaned counterpart has shown more provocative irregularities in the second half of the observed period.

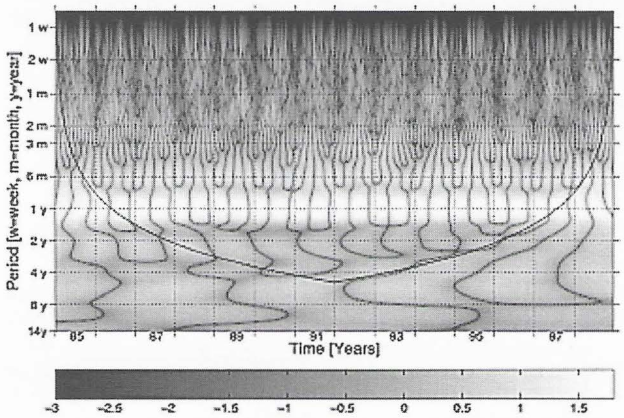

Fig. 1. CWT spectrum of the time demeaned series of principal components.

References

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