

Confidence Levels for the Cycles Found in Air Temperature Data

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Abstract. Recently, new cycles have been observed in air temperature data and proxy series using a wavelet-based methodology. Although many evidences attest the validity of this method applied to climatic data, no systematic study of its efficiency has been carried out. Here, we estimate the confidence levels for this approach and show that the observed cycles are significant.

Recently, two cycles of respectively 30 and 42 months have been observed on the whole planet in temperature time series (at least one cycle is observed in either data set, see Nicolay et al (2009), Mabile and Nicolay (2009)). The methodology leading to these observations is a wavelet-based approach, allowing to study non-stationary signals (see Poster XY306).

However, these cycles are still observed in the associated surrogated data. Therefore, they should be observed in the Fourier transform of the original signals as well. The reason why they are not could be the following:

- the data are subject to trends; unlike the wavelet transform, the Fourier transform is affected by such behaviors,
- these low amplitude cycles are hidden by the dominating cycle of 1 year.

In order, to minimize these influences, the signals have been post-treated as follows:

- the linear trends have been removed,
- for each month, the mean temperature has been computed and subtracted to the original signal.

The Fourier transform of the so-obtained series now displays the expected cycles of 30 and 42 months approximatively (see Fig. 1).

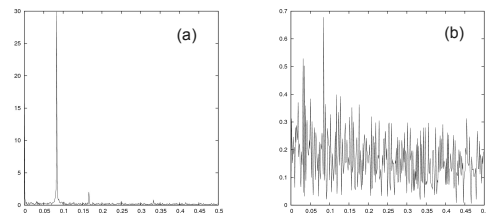


Fig 1. (a) The Fourier spectrum of the Yakutsk weather station (Siberia). The main peak corresponds to the period of 1 year, (b) the Fourier spectrum of the same data modified as described in the text. Although the peak corresponding to 1 year is still visible, a second maximum corresponding to approximately 30 months ($x=1/30$) is also detected.

Such a treatment has been applied to each grid point of the ncep/ncar reanalysis temperature data. The Fourier spectrum allows to check that most of these points display a cycle corresponding to either 30 or 42 months (see Fig. 2). Moreover, the results are very close to the ones obtained using a wavelet-based approach (see Poster XY306, Nicolay et al (2009), Mabile and Nicolay (2009)).

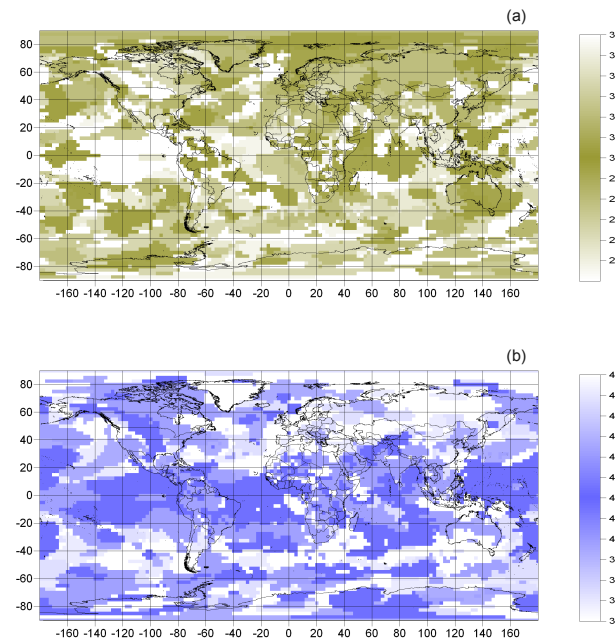


Fig 2. The cycles observed on the planisphere using the Fourier transform corresponding to the period of (a) 30 months and (b) 42 months. The color palette is going from white if no cycle is observed to khaki (resp. blue) if a cycle of 30 (resp. 42) months is observed.

To test the significance of these cycles, the following methodology has been used:

- for each grid point, the monthly means of the data are removed, as well as the linear tendencies,
- the resulting noise is simulated using an AR(1) model:

$$x_n = \alpha x_{n-1} + \sigma \eta_n,$$

where η_n is a Gaussian white noise with zero mean and unit variance,

- $N=10000$ such simulations are computed,
- the distribution of the two highest maxima of the Fourier transform of the data is estimated,
- the probability that a maximum has a higher amplitude than the one observed for the ncep/ncar reanalysis is then computed.

Fig. 3 shows these probability values. Most of the observed cycles are significant.

The same methodology can be applied to the wavelet transform. In this case, the monthly means are added to the AR(1) process and the resulting signal is directly compared to the original data. The results are similar.

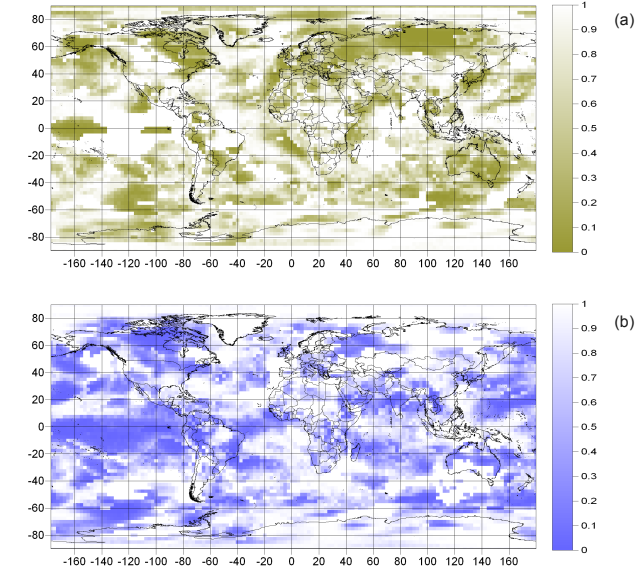


Fig 3. The probability values associated to the cycles of (a) 30 months and (b) 42 months respectively (see text). Cycles observed in zones corresponding to the color white are not significant.

References.

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