Precipitation periodicities in Kurdistan – Iraqi region

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ABSTRACT

Periodicities in the annual precipitation of Sulaimani, Erbil and Duhok cities of Kurdistan, Iraq have been studied visualising the data for 70 years. The three precipitation series, North Atlantic oscillation (NAO) index series and Southern oscillation index series were subjected to spectral analysis by Blackman-Tukey method to investigate the possible periodicities exist that in the rainfall series and their relations to NAO, ENSO and solar cycle. It was found that the cycles of 2, 2.7, 3.6, 4 and 10 years are related to NAO cycles, 5.4 year cycle is related to ENSO cycle and 11.1 year cycle is related to the solar cycle at Sulaimani site. The common rainfall cycles among the three sites were 2.8, 4.8 and 10 years.

***Key Words*:** Precipitation Periodicity, Iraq, NAO, ENSO, SOI

Precipitation is a principal element of the hydrological cycle, the detection of oscillation in precipitation time series yields important information for understanding of climate. These oscillation can be seen as a response of the climate system either external forcing of feed back process. Many researches studied the precipitation time series in Europe and near the study area to estimate the precipitation periodicities. Kalayci (2004) analysed the precipitation pattern in Turkey in the frequency domain, Spectral analysis was carried out to precipitation pattern. It was found a statistically significant periodicities in the 2-6 years band, which assumed to be associated with El-Nino occurrences (Kalayci *et. al.,* 2004). Tosoic and Unkasevic (2005) gave an example of the Belgrade precipitation series (1880-2000) to provide how spectral analysis can provide information on climate variability.

Rodrigo studied Andalusia rainfall time series via a power spectrum, the FFT was calculated a null continuum red noise was adopted peaks above the 95% confidence level indicated possible significant periodicities (Rodrigo *et. al.*, 2000).

The NAO (North Atlantic Oscillation) and ENSO (El-Nino Southern Oscillation) phenomenon are two major source of seasonal to inter-decadal variability in the global scale (Louise and Vladimir, 2007). The NAO refers to redistribution of atmospheric mass between the Atlantic and subtropical Atlantic, and swings from one phase to another to produce large changes in the mean wind speed and direction over the Atlantic, the heat and moisture transport between the Atlantic and the neighbouring countries, and the number of storms their paths, and their weather are directly affected by NAO (Lamb, 2005).

MATERIAL AND METHODS

Spectral analysis

The precipitation times series of 70 year (1941-2010) period of three station (Fig. 1) Sulaimani (Lat. 35^0 33' N, Log. 45^0 27' E and altitude 8848 m amsl) and Erbil (Lat. 36^0 11' N, Log. 44^0 60' E and altitude 420 m amsl) period and Duhok (Lat. 36^0 50' N, Log. 43^0 0.2' E and altitude 57.5 m amsl) were used in this analysis.

The NAO data were obtained from http://www.cru.uea.ac.uk/timo/projpagesnao update.htm while ENSO data were obtained from http://www.bom.gov.au/climate/current/soihtm1.shtml. Most time series like rainfall and temperature series exhibit some periodic patterns that can roughly be represented by some of harmonics (Brooks and Carruthers, 1935). Spectral analysis is the separation of a signal into different frequency components. It's essentially a modification of Fourier analysis so as to make it sutible for stochastic rather deterministic function of time (Afriyie and Adukpo, 2006).

In the present work Blackman-Tukey periodicity spectral analysis was follow.

The correlogram constructs in this spectral method is an estimate of the power spectrum using a windowed fast
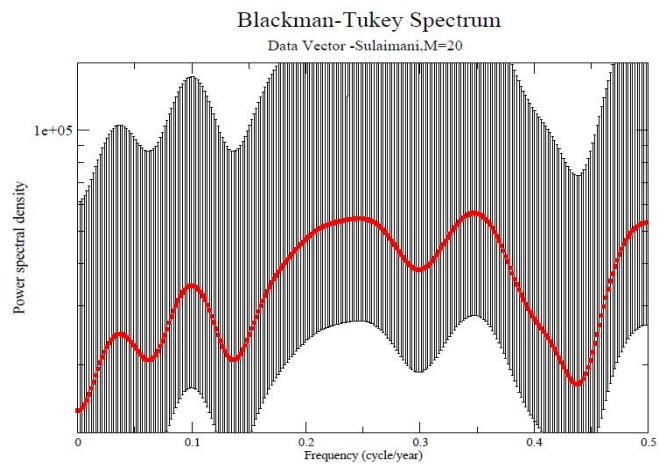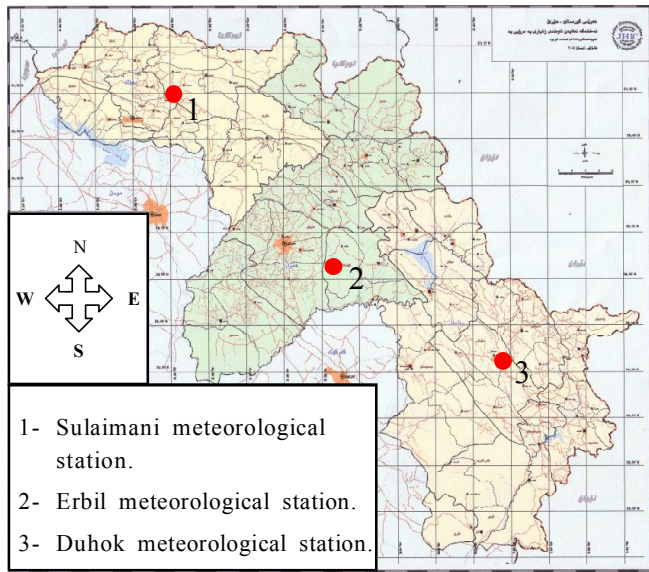
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Fig. 2: Power spectra precipitation series of Sulaimani
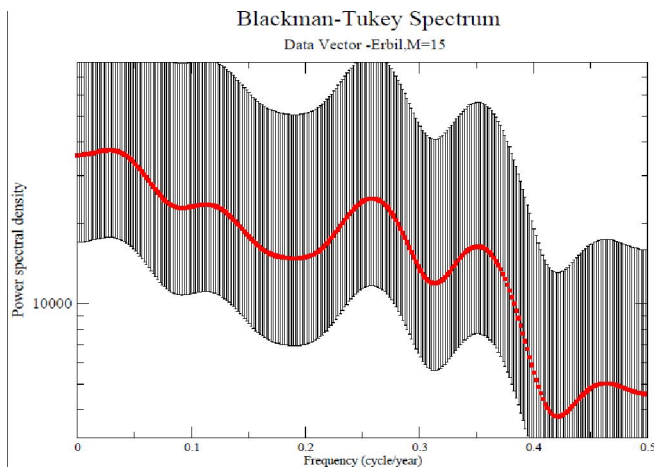

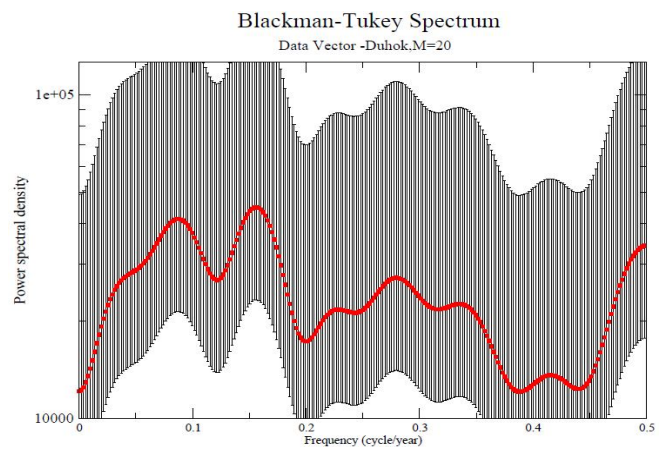**Fig. 3:** Power spectra precipitation series of Erbil

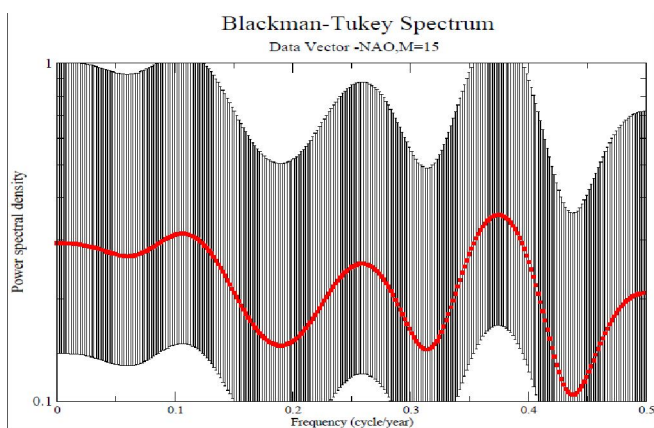

Fig. 4: Power spectra precipitation series of Duhok
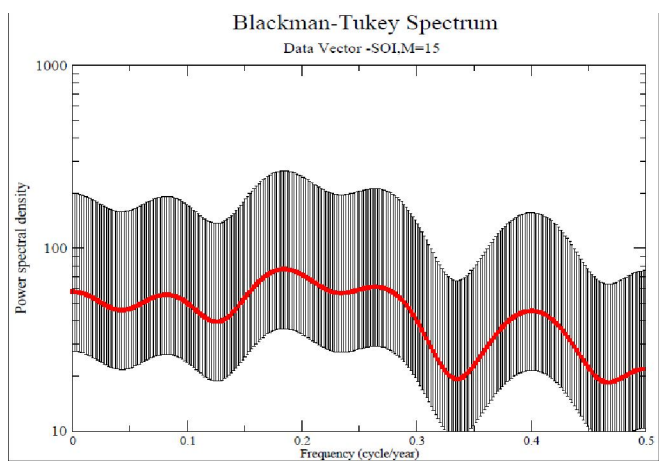

Fig. 5: Power spectra of NAO series

Fig. 6: Power spectra of SOI series

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Fourier transforms (FFT) of the autocorrelation function of the time series(Clays, 2010). The Blackman and Tukey method is based on the Wiener-Khinchin theorem, which states that if the Fourier transform of a series $x(t)$ is $X(t)$, and if the autocorrelation function of the series is R, then the Fourier transform of R yields $P_x = |X(f)|^2$ or the power spectrum of $x(t)$ (Press, 1988) . The resulting power-spectrum estimate is called a correlogram. In Blackman-Tukey approach $P_X(f)$ is estimated by:

$$P_x f = \frac{1}{M} \left| \sum_{j=0}^{M-1} r_j w_j e^{i\omega j} \right|^2 \quad (1)$$

Where r_j is the autocorrelation function, M is the maximum lag considered and window length, and w_j is the windowing function.

The Blackman-Tukey correlogram is the classical method for performing spectral analysis. In this method most of the time sharp features are considerably smoothed, this method also used to estimate cross-spectrum between two time series (Percival and Walden, 1993).

RESULTS AND DISCUSSION

Precipitation cycles

The spectral analysis is applied using. Blackman-Tukey method, to detect the exist periodicities in precipitation time series of Sulaimani, Erbil and Duhok. Fig. 2 shows the spectral analysis (periodogram) of Sulaimani precipitation series. The dominant cycles (frequencies) are 2, 2.8, 4, 10 and 25 years where M=20. Thus the general precipitation periodicities for Sulaimani obtained by the three methods are 2, 2.7, 3, 3.7, 4, 4.5, 5.4, 7-10, 11.1 and 25 years. Fig. 3 reveals the spectrum of Erbil precipitation series. The precipitation periodicities are 2.1, 2.8, 3.8, 8.3 and 25 years choosing M=15 and Duhok station precipitation periodicities obtained by are 2, 2.4, 9, 4.3, 6.4, and 11.1 years using M=20 (Fig. 4). It is found from the spectrum analysis that there is some differences in the periodicities between the spectrum of the three sites because the precipitation is very variable climate element both spatially and temporally at different scales inter-annual and intra-annual.

NAO and ENSO cycles

To examine the source of the periodicities precipitation series a Blackman-Tukey method were subjected to NAO index for the same 70 years selected for precipitation

series .The obtained periodicities (cycles) from Fig. 5 are 2, 2.7, 3.8 and 9 years

From the Fig. 6 the general periodicities for the Southern Oscillation Index (SOI) are 2.5, 3.7, 5.5, 6.32, 10.8 and 12.5 years cycles.

Coincidence between precipitation series with NAO, ENSO and solar cycles

It is found that the periodicities in Sulaimani precipitation series are related to three source of climate oscillations, The 2, 2.7, 3.7, 4, 10 years are related to NAO cycles and 5.4 year cycle is related to ENSO cycles and 11.1 year cycle is related to the solar cycle. Erbil precipitation cycles 2.1, 2.8, 3.8, 4, 9, 10, 20 years are coincidence with the cycles of NAO and 5.5 year cycle is related to ENSO. Finally Duhok precipitation series reveals that 2, 2.7, 3.7 and 10 years cycles are related to NAO where there is no cycles related to ENSO. The 11.1 year cycle is related to 11 year solar cycle. These differences are natural in the climate because a high variability of precipitation both spatially and temporally.

CONCLUSOINS

From the analysis of annual precipitation series of Sulaimani, Erbil, Duhok cities, SOI series and NAOI series, it can be concluded that:

The common rainfall cycles among the three sites were 2.8, 4, 8 and 10 years.

There is coincidence between the cycles of NAO, ENSO, and precipitation of Sulaimani, Erbil and Duhok which reveals the influence of NAO and ENSO on the rainfall of the three sites.

ACKNOLOGMENTS

REFERENCES

Afriyie, K. and Adukpo, D. C. (2006). Spectral characteristics of the annual mean rainfall series in Ghana, *West Africa J. Applied Ecology*., 9: pp. 855.

Brooks, C. E. and Carruthers, N. (1953). Hand book of

statistical methods in meteorology. London: Her majesty's stationary office.

Clays P. (2010). Msc. Thesis, Time series analysis on selected geological sections, a search for cyclicity. Faculty of science and Bio-engineering science, Dep. of geography, University of vrije- Brussel.

Kalayc, S. and et al. (2004). Analysis of El-Nino signals on Turkish stream flow and precipitation pattern using spectral analysis. *Fresenius environmental bulletin,* 13: 719.

Lamb, H. H. (2005). Climate, History and the Modern World''. second edition, Routledge, Taylor & Frances group.

Louise B. and Vladimir C. (2007). Borehole climatology, a new method on how to reconstruct the climate, El-

Sevier.

Percival, D. B. and Walden, A. T. (1993). *Spectral Analysis for Physical Applications.* Cambridge University Press, Cambridge UK, pp. 583.

Press, W. H. and et al. (1988). *Numerical Recipes: The Art of Scientific Computing.* Cambridge University Press. p. 818.

Rodrigo, F. and et al. (2000). Rainfall variability in southern Spain on decadal to centennial time scales, International *J. Climatol.,* 20: 721.

Tosoic, I. and Unkasevic, M. (2005). Analysis of precipitation series for Belgrade, *Theoretical Applied Climatol J.*, 80: 67.

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