

SPATIAL-TEMPORAL VARIABILITY OF THE GROUNDWATER LEVEL

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1. INTRODUCTION

The spatial-temporal characteristics of annual series of groundwater levels have been studied in a great region of the Argentinean plains, by means of several techniques of temporary and spectral analysis with the purpose of detecting fluctuations, changes of trends and oscillation modes. The studied region is located on Santa Fe Province, in the north region of the Argentinean "Pampa Húmeda", between 27° and 34° of South latitude and between 59° and 63° of West longitude, covering a surface approached to the 250000 square kilometers.

The authors have a reasonable expectation because they believe that those characteristics will provide a valuable information for the evaluation of the climatic evolution and the detection of variations in this evolution that suggests a climatic change.

It was assumed that the information about the water table levels is the precipitation spatially and temporally integrated and filtered within the region, and that they are representative of the regional hydrologic behaviours (despite being specific records). Moreover, the relationships between them are presumptively strongly not lineal.

This extensive region shows a spatial-temporal similar behavior. The periodicities linked with ENSO are always present and the structures of the series are similar for the period analyzed

A positive trend exists in the whole analyzed region. The spectral analysis presents significant periodicities between 2.0 and 7.5 years, that they show a possible linking with the quasi-biennial oscillation and with the ENSO phenomenon.

2. METHODOLOGY AND DATA

The used methodology responds to a hypothetical conception of the temporary series like that of a signal formed by aleatory components, with characteristics of white noise. By the way, reliability information of the water level gauging stations was considered and that the variability in the water table levels is only due to natural causes.

There were five water table level gauging stations with simultaneous records of water table levels and long precipitation records, and they were used (Table 1).

This paper tries to associate the temporal and space climatic variability to the variability of the water table levels. Venencio (2000) and Venencio and García (1998, 1999) have found that the relations between precipitation and the unconfined aquifer in the "Pampa Húmeda" plains (Argentina) are non-lineal, and so could the significant

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precipitation fluctuations in the freatic levels also be reflected. These studies aimed at a method for the prediction of groundwater availability.

TABLE 1

Estation	Lat.	Long.	Altitude	Period
R.S. Peña	26°52'S	60°27'W	90 m	1956/2000
Reconquista	29°06'S	58°36'W	53 m	1977/2000
Rafaela	31°11'S	61°33'W	100 m	1969/2000
Oliveros	32°33'S	60°51'W	27 m	1960/2000
M. Juarez	32°41'S	62°07'W	110 m	1970/2000

A spectral analysis was used for the study of the relationships between precipitation and the freatic levels at five stations representative of the region during the period 1979-2000. This period was selected since it was the only one with simultaneous information on both variables.

3. RESULTS

The unconfined aquifer behaviour is uniform in all the region, and the first five harmonics are significant in all the stations, accounting for more than 80% of the total variance (Figure 1). Precipitation shows a greater variability, and in average, the first five harmonics account for only 50% of the variance (Figure 2).

FIGURE 1

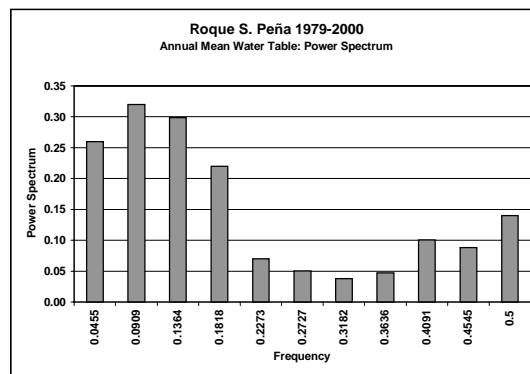
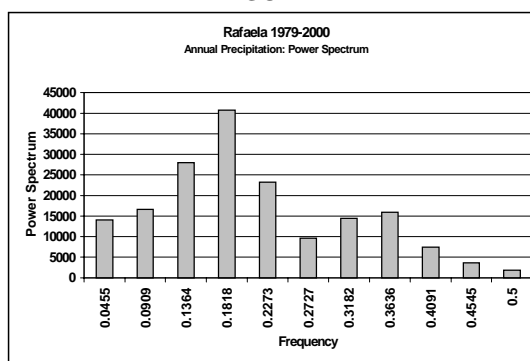


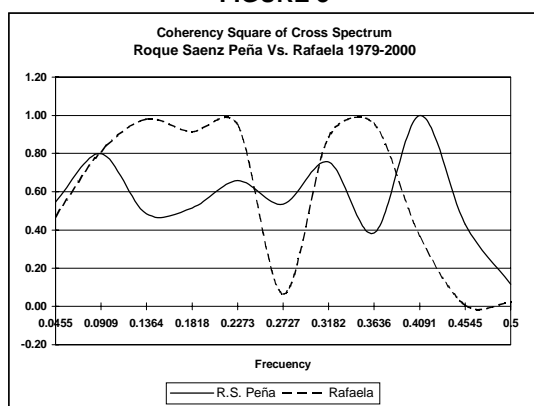
FIGURE 2



The lineal correlation coefficient between the significant accumulated harmonics of freatic levels and precipitation was calculated with different results. The best correlation (0.94) corresponds to the central region of the Santa Fe Province, the north showed a coefficient of 0.78 and the southern only reached a coefficient of 0.64.

Considering the results, the authors tried to analyse the coherence function of cross spectrum. Rafaela y Roque S. Peña gauging station showed similar behavior, but the most important coincidence is in 0.2727 (3.6 years) and 0.2273 (4.3 years) frequencies. This frequencies are coincident with the frequencies of the EL NIÑO phenomenon (Figure 3).

FIGURE 3



In other cases the function values were too low or non existent. These results seem to be originated in the differences between the intensity of the signals. While precipitation has well-defined variabilities, the freatic levels present small periodicities and the data series is practically non-stationary at the station with the lowest correlation coefficient.

This was evident on analysing the series with a Singular Spectrum Analysis, which allows considering components in any way, and not necessarily sinusoidal. In the southern region, the first two main components reach 78% of the variance of the whole record, and besides, those components are not cyclic (non stationary). Evidently, there must be oscillations in the record, but they are present in the remaining 22% of the variance, i.e. in the residual series resulting from subtracting the first two main components to the original series.

The results are interesting due to very important reasons:

- Firstly, it was observed an association between internal variabilities of each individual system (precipitation and freatic levels) when they were tried individually.
- Secondly, the atmospheric climatic impact is shown to be almost completely filtered by the non-saturated physical environment.

4. CONCLUSIONS

The main contribution of this study is the detailed characterization of the spatial-temporal structures of the relationships between precipitation and water table levels in a highly productive agricultural and stock breeding region, where the groundwater hydric resource is essential during the drought episodes.

Precipitation and unconfined aquifer levels present dominant temporal patterns of 3.6, 5.5 and 7.3 years in interannual scale in all cases. This could be associated to the ENSO phenomenon frequencies.

The high frequencies are not appreciable in the water table levels. However, they are in precipitation.

The data series of water table levels constitute a good representation of low frequencies of regional precipitation variability.

5. REFERENCES

- * Venencio, M.V. & García, N.O., 2000: About the Impacts of the ENSO over the Unconfined Aquifer in the "Pampa Húmeda" (Argentina). Preprints 15th Conference on Hydrology, 80th AMS Annual Meeting, Long Beach, CA, 10-15 Jan, pp 142-144.
- * Venencio, M.V., 2000: Climate Variability and Groundwater Resources. Preprints Sixth International Conference on Southern Hemisphere Meteorology and Oceanography, Santiago, Chile, 3-7 April, pp 308-309.
- * Venencio, M.V. & García, N.O., 1998: On the Droughts in the "Pampa Húmeda" (Argentina) and its Relations with Alternative Water Resources". Proceeding Special Symp. Hydrology, 78th AMS Annual Meeting, Phoenix, Arizona, 11-16 Jan, pp 230-233.
- * Venencio, M.V. & García, N.O., 1999: Predictability of Water Table Level from the "EL NIÑO/Southern Oscillation" (ENSO) Phenomenon in the "Pampa Húmeda" (Argentina). Preprints 14th Conference on Hydrology, 79th AMS Annual Meeting, Dallas, Texas, 10-15 Jan, pp 363-366.