Rainfall spatiotemporal variability relation to wetlands hydroperiods

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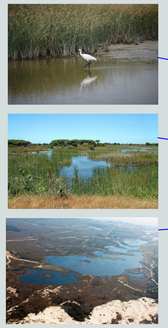
Introduction

Doñana´s Natural Space (southwestern Spain) is one of the most important wetland areas in Europe. In 1982, it was declared a Ramsar reserve as it has an enormous ecological value due to the existence of essential areas for the maintenance of thousands of species that inhabit in Doñana. One of the most important factors affecting the habitat for those species is wetland hydroperiod.

There have been published two different works estimating the hydroperiod of Doñana lagoons with Landsat Time Series images. The principal aim of the present work is the study of the relation between the rainfall spatiotemporal variability and the hydroperiods of wetlands present in Doñana natural space.



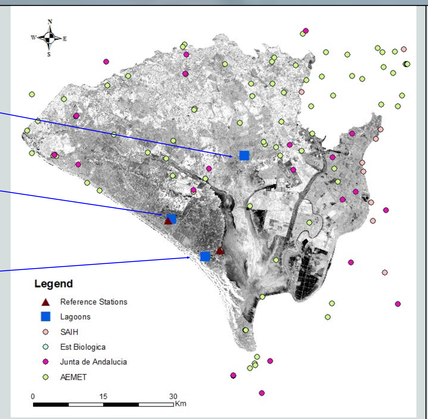


Figure 1: Map of Doñana and the situation of 113 stations, 3 lagoons (Lengua, Acebuche and Santa Olalla) and two station used in the interpolation of reference. Reference rainfall is computed from the two rain gauges shown in this figure.

Photographs taken from Google Earth (Lengua and Acebuche) and Gomez-Rodriguez, C., (2011) Cartografía de lagunas temporales del Parque Nacional de Doñana (Santa Olalla).

Methodology

The rainfall spatiotemporal interpolation has been calculated with the spacetime package implemented in R (Pebesma 2012). It has been used data from 113 stations (graph 1) between hydrological years from 1970 to 2015.

This work is based in hydroperiods which have been previously calculated with Landsat time images (Bustamante, 2016).

A spatiotemporal model variogram has been fitted to daily data available in period 1970-2016. A separable covariance model that assumes separability between the spatial and temporal component has been used.

A cross-correlation was used to study the relation between the interpolated rainfall with the inverse distance method (Bustamante, 2016) and the spatiotemporal variability with hydroperiods.

$$\hat{\gamma}(h,u) = \frac{1}{2N(h,u)} \sum_{N(h,u)} \left\{ \left[Z(s_i,t_i) - Z(s_j,t_j) \right] \right\}^2 \quad Eq.\ 1$$

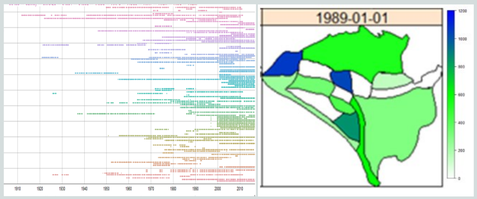
Eq.1: Spatio Temporal variogram of daily rainfall (Sherman, 2011).

$$\gamma_{sep}(h,\mu) = sill\ x\ \left(\bar{\gamma}_s(h) + \bar{\gamma}_t(\mu) - \bar{\gamma}_s(h)\bar{\gamma}_t(\mu) \right) \quad Eq.\ 2$$

Eq.2: Variogram of Separabale Model (Sherman, 2011).

		Type	Range	Partial Sill
Separable Model	**Space**	Spherical	**45000 m**	0.28
	Time	Exponential	760 days	0.7
	2nd Common Structure	Exponential	2.6	0.44
	Total Sill= 36 mm^2			

Table 1: Values of Space and Time in the Separable Model.



Graph 1: Data available of 113 stations.

Figure 2: Annual value per recharge zone with the means of the stations within each zone.

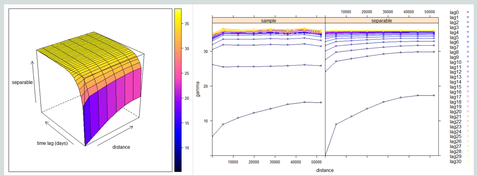
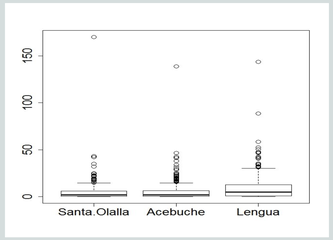


Figure 3: 3D Spatiotemporal Variogram obtained from the adjustment.

Figure 4: 1D Spatiotemporal Variogram.
Left: Experimental. Right: Model.

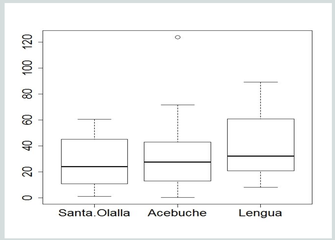
Results



Graph 3: Boxplot of differences between monthly rainfall calculated in each lagoon and reference.

	Santa Olalla	Acebuche	Lengua
Median	2.09	2.04	5.1

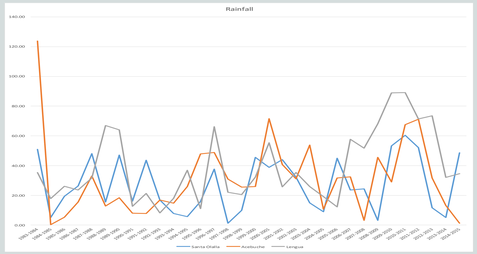
Table 2: Median of differences of monthly rainfall in Lagoons.



Graph 4: Boxplot of differences between annual rainfall calculated in each lagoon and reference.

	Santa Olalla	Acebuche	Lengua
Median	24.0	27.5	32.1

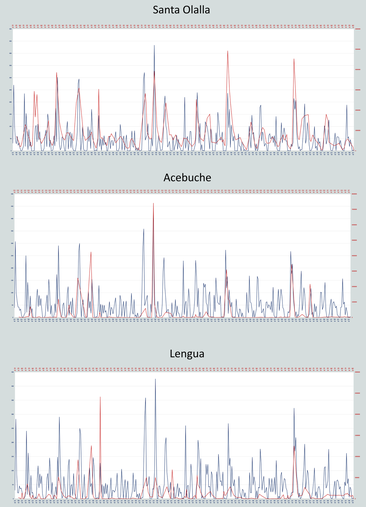
Table 3: Median of differences of annual rainfall in Lagoons.



Graph 5: Differences of annual rainfall interpolated at each lagoon location and the reference rainfall.

	Shift interp.	Shift ref.	Correlation interp.	Correlation ref.
Santa Olalla	2	2	0.56	0.57
Acebuche	1	1	0.44	0.45
Lengua	2	2	0.34	0.33

Table 4: Shift and correlation of graphs .



Graphs of Rainfall correlation analysis between the rainfall of lagoons (Santa Olalla, Acebuche and Lengua) and the hydroperiod of each zones (Peridunares, Abalaria and Coto del Rey).

Low correlation between hydroperiods and rainfall is explained by the influence of other variables as evaporation and groundwater extractions.

Conclusions

- Spatiotemporal variability of rainfall can be quantified through spatiotemporal variography.
- The spatiotemporal fitted model variogram can be used to krige periods where data available are scarce. This will allow to study historic total rainfall in the area.
- Differences in the annual rainfall between the three lagoons locations range between 0.25 and 123.86 mm/year.
- Using interpolated rainfall instead of the values of the nearest rain gauge can change the conclusions about therir relationship with hydroperiod lagoons.

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