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Could influence the increase in radiative forcing, of scenarios of the IPCC 5th Assessment Report, in useful rain? Case study: Segura river basin.

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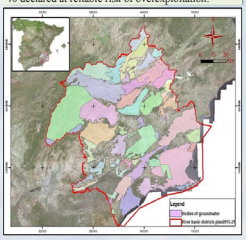
1. INTRODUCTION

The current climate change can be defined as an alteration of the climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and it adds to the natural variability of the climate observed during comparable time periods. Today Science has demonstrated, with a 95% security, that human activity is the dominant cause of the warming observed since the mid-20th century.

In addition, it has been shown that global climate variations may affect specific systems of water resources. In this study, we analyze these climatic variations on useful rain (surplus of runoff Ti) of the Segura river basin, which currently has the highest rates of overexploitation of aquifers in Europe. Specifically, the Statement of Hydrological Planning sets the natural water provisions in the Segura river basin will be reduced by 11% due to climate change.

2. LOCATION

63 bodies of groundwater in the Segura river basin. 40 declared at reliable risk of overexploitation.

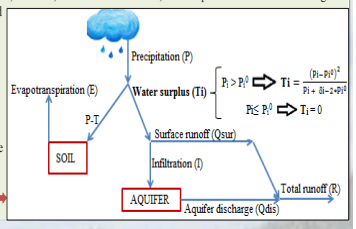


3. MATERIAL AND METHODS

1st- The series of monthly data of the hydroclimatic variables that determine the useful rain or surplus of runoff Ti were exported from the Integrated Information Water System (on MAGRAMA website), in the period 1940-2010 and for the Segura river basin. Then, the correlation between these variables using the software, based R, "Gnu Regression, Econometrics and Time-series Library (Gretl)" was showed.

2nd- These variables were extracted from "KNMI Climate Explorer" database, for the climate change scenarios set by the fifth report of the Intergovernmental Panel on Climate Change (IPCC), the RCP2.6, RCP4.5, RCP6.0 and RCP8.5, in the period 2005-2050 entering the coordinates of the Iberian Peninsula. These variables were exported as maps that we geo-referenced with the software "ArcGIS10" to indicate therein the groundwater bodies of the Segura river basin.

3th- We estimate the average monthly variation of surplus of runoff Ti, over the Segura river basin in the period 2010-2050 under these scenarios of climate change. First, we exported from "KNMI Climate Explorer" data of precipitation and temperature for the four scenarios. From them we found certain hydrological variables needed to calculation of the surplus Ti. Then, we calculate the potential evapotranspiration (ETP), from temperature, using Hargreaves and Samani (1982). Finally, we calculated the surplus of runoff Ti with the hydrological model of Témez (1977).



4. RESULTS

4.1. Analysis of the main components related to the surplus of runoff (Ti)

Correlation between monthly average total runoff (surplus of runoff) and certain hydroclimatic variables in the Segura river basin (period 1940-2010). The used specifications were quadratic, cobb-douglas, semi-logarithmic quadratic, logarithmic quadratic, linear and saturated quadratic. Best results (looking at p-value and R-squared) in the saturated quadratic with this setting:

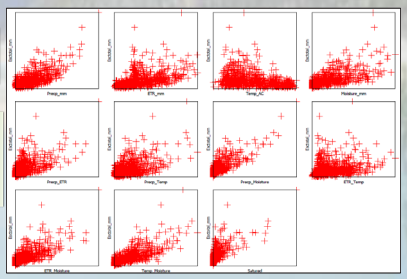
$$\text{Total.runoff} = b_0 + b_1 (P) + b_2 (ETR) + b_3 (P \cdot ETR) + b_4 (P \cdot T) + b_5 (ETR \cdot T) + b_6 (ETR \cdot Mo) + b_7 (T \cdot Mo) + b_8 (P \cdot ETR \cdot T \cdot Mo)$$

P: precipitation; ETR: real evapotranspiration; T: temperature; Mo: Moisture.

Dependent variable: average total runoff (mm) or surplus Ti					
Independent variables	*Coefficient*	*Std. Error*	*t-ratio*	*p-value*	
constant	2,1782	0,1578	13,8063	<0,00001	***
P	0,1674	0,0108	15,4986	<0,00001	***
ETR	-0,1628	0,0180	-9,0398	<0,00001	***
P · ETR	0,0004	0,0002	2,5769	0,01014	**
P · T	-0,0136	0,0010	-13,2793	<0,00001	***
ETR · T	0,0132	0,0011	11,7455	<0,00001	***
ETR · Mo	-0,0012	0,0003	-4,0064	0,00007	***
T · Mo	0,0089	0,0010	9,2148	<0,00001	***
P · ETR · T · Mo	$1,3383^{-06}$	$1,6296^{-07}$	8,2121	<0,00001	***
R-squared					0,7266

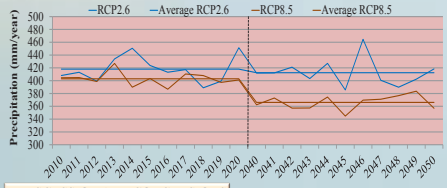
Principal Component Analysis (removing variables with p-value > 0,05). Final setting:

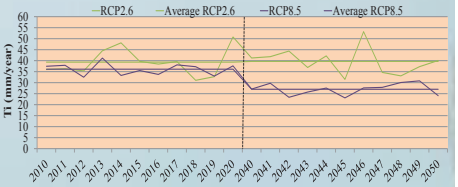
Total.runoff = 2,18 + 0,17 (P) - 0,16 (ETR) + 0,0004 (P · ETR) - 0,014 (P · T) + 0,013 (ETR · T) - 0,001 (ETR · Mo) + 0,009 (T · Mo) + $1,34^{-0.6}$ (P · ETR · T · Mo)



4.2. Modification of precipitation, temperature and ETP due to different radiative forcing (of climate change scenarios)

Changes in the hydroclimatic variables which define the surplus of runoff Ti in the Segura river basin. Period 2005-2050. Scenarios of the IPCC 5th Assessment Report: RCP2.6, RCP4.5, RCP6.0 and RCP8.5.





5. DISCUSSION AND CONCLUSIONS

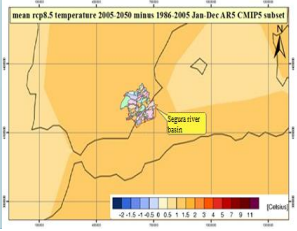
-Better correlation between hydroclimatic variables and useful rain or surplus of runoff Ti: saturated quadratic specification.

-In Iberian Peninsula: increase of average (up to 2ºC) temperatures in the scenario with higher radiative forcing (RCP8.5), and decrease in average rainfall, with respect to the current, 36 mm/year (even in RCP2.6 scenario).

-In the Segura river basin over the next 35 years: rainfall would range between the 418 and 366 mm/year according to different climate change scenarios. ETP between the 1024 and 1107 mm/year (likely overestimation using Hargreaves and Samani,1982).

-Surplus of runoff Ti in Segura river basin (period 2010-2050): lower values in the scenarios RCP4.5, RCP6.0 and RCP8.5. This could affect the recharge of aquifers and worsen the overexploitation of aquifers➡ Difficult to meet environmental objectives of Directive 2000/60/EC (for the years 2021 and 2027).

-Future research: regional climate change models to scale daily or hourly and rainfall-runoff models distributed as SWAT or RENATA to calculate the reduction in the surplus of runoff Ti (in the Segura river basin) and the recharge of aquifers.



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