Improved Assessment of Groundwater Recharge in a Mediterranean Karst Region - Andalusia, Spain

UNI FREIBURG

HYDROLOGY

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Motivation & Objectives

Karst aquifers provide a significant contribution to the drinking water supplies of many countries in Europe. Due to climate change the relevance of groundwater resources will increase in the future. The Mediterranean region is projected to be particularly influenced by the effects of climate change. Estimating the recharge rate of karst aquifers, i.e. the fraction of precipitation that is turned into groundwater recharge, is an essential tool for water management to assess usable groundwater volumes.

The aim of this study is to extend a previously developed GIS based recharge estimation method (APLIS) in order to consider temporally distributed precipitation and evapotranspiration.

Method

The spatially distributed APLIS method (Andreo et al., 2008) to estimate mean annual recharge rates was combined with a temporally distributed soil water routine in order to obtain spatiotemporal recharge estimations. The soil routine consists of 3 steps:

1) $E_a = E_p \cdot \frac{V_{t-1}}{V_{max}}$

2) $V_{temp} = V_{t-1} + P - E_a$

3) $If\ V_{temp} > V_{max}$

$R_{dS} = V_{temp} - V_{max}$

$V_t = V_{max}$

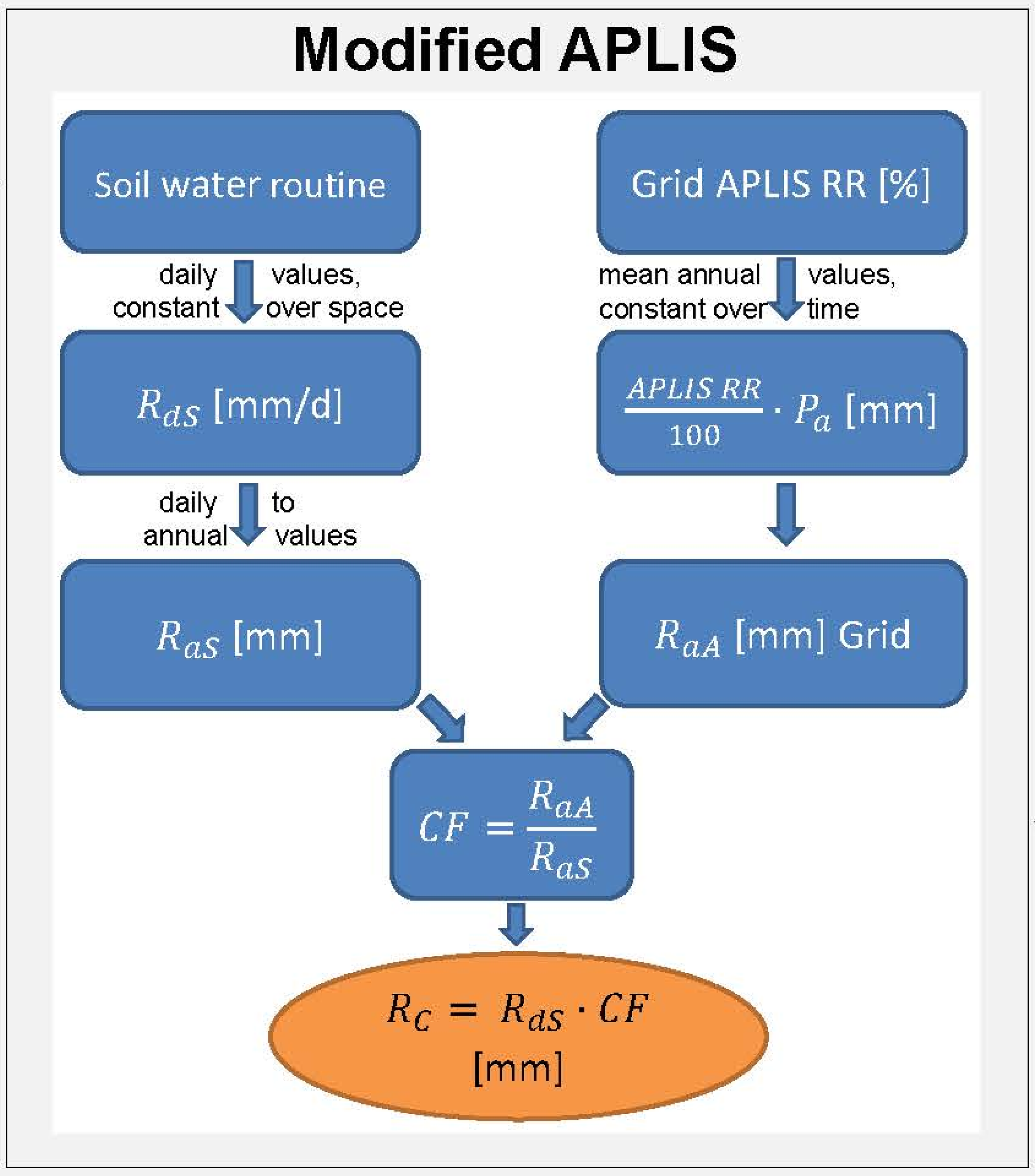
$Else$

$R_{dS} = 0$

$V_t = V_{temp}$

- E_a actual evapotranspiration [mm/d]
- E_p potential evapotranspiration [mm/d]
- V_t water volume in the soil storage at time step *t* [mm]
- V_{temp} temporary storage variable [mm]
- V_{max} maximum water storage capacity of the soil [mm]
- P precipitation [mm/d]
- R_{dS} recharge [mm/d]

Combination of **APLIS** and **soil routine** through correction factor (CF)



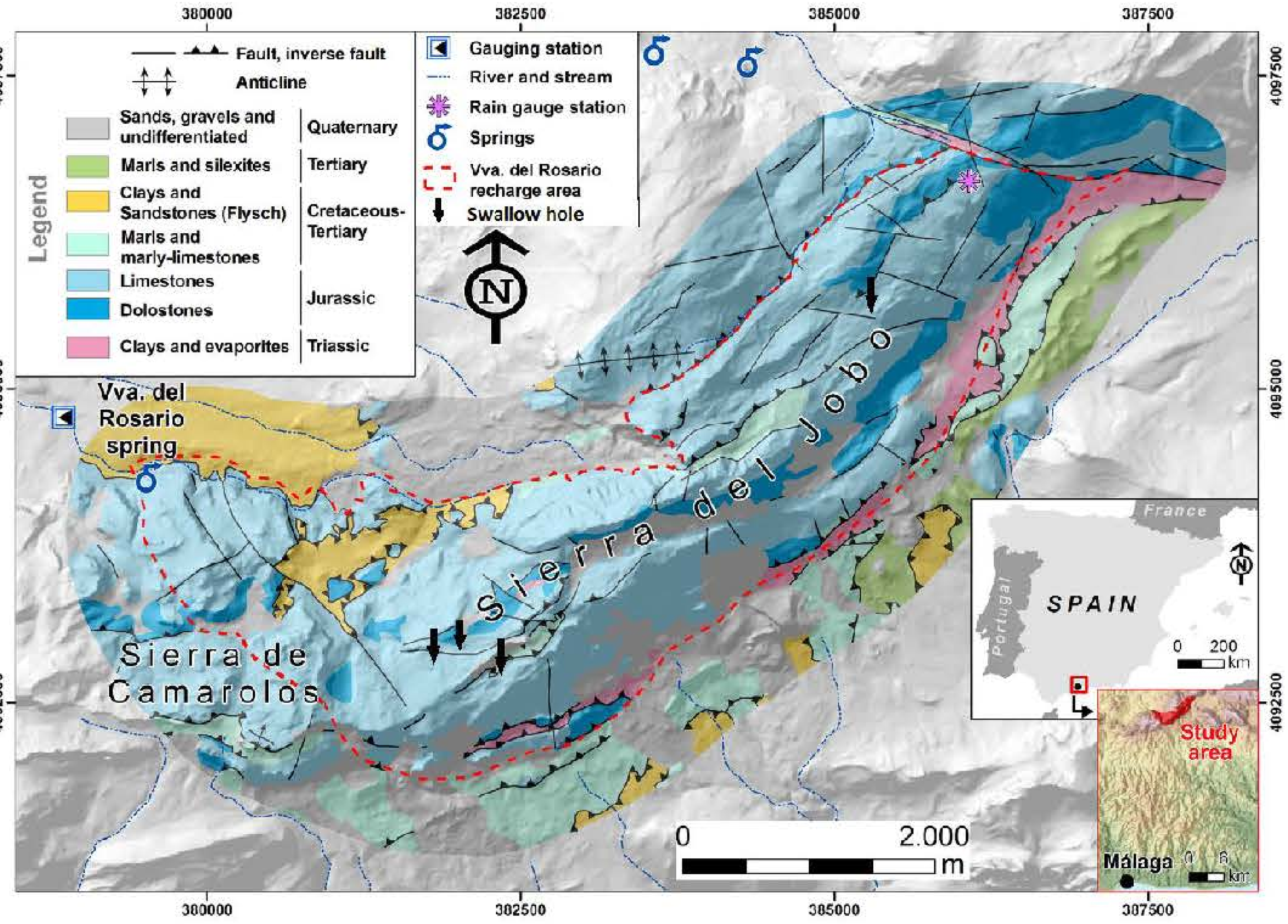
- R_{aS} mean annual recharge
- R_{aA} mean annual APLIS recharge
- P_a mean annual precipitation
- R_C daily corrected spatially distributed recharge

Data

Soil properties were derived from the Harmonized World Soil Database (HWSD) from the FAO. Precipitation, evapotranspiration, spring discharge data, as well as grids with the APLIS recharge rates were provided by the Center of Hydrogeology of the University of Malaga, Spain (CEHIUMA).
For the investigation of future groundwater recharge the climate model data were taken from the Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP). They applied five general circulation models (GCM). Data was available for the time span 1989 – 2099.

Study site

Elevations in the Villanueva del Rosario karst system range from 600 to 1,640 m above sea level. A temperate Mediterranean climate prevails with rainfall occurring mainly in autumn and winter and less during spring time. The mean annual precipitation is 760 mm. The aquifer mainly consists of 400 to 450 m thick karstified Jurassic carbonate rocks. The system has a recharge area of around 14 km^2. Discharge occurs toward Villanueva del Rosario spring.



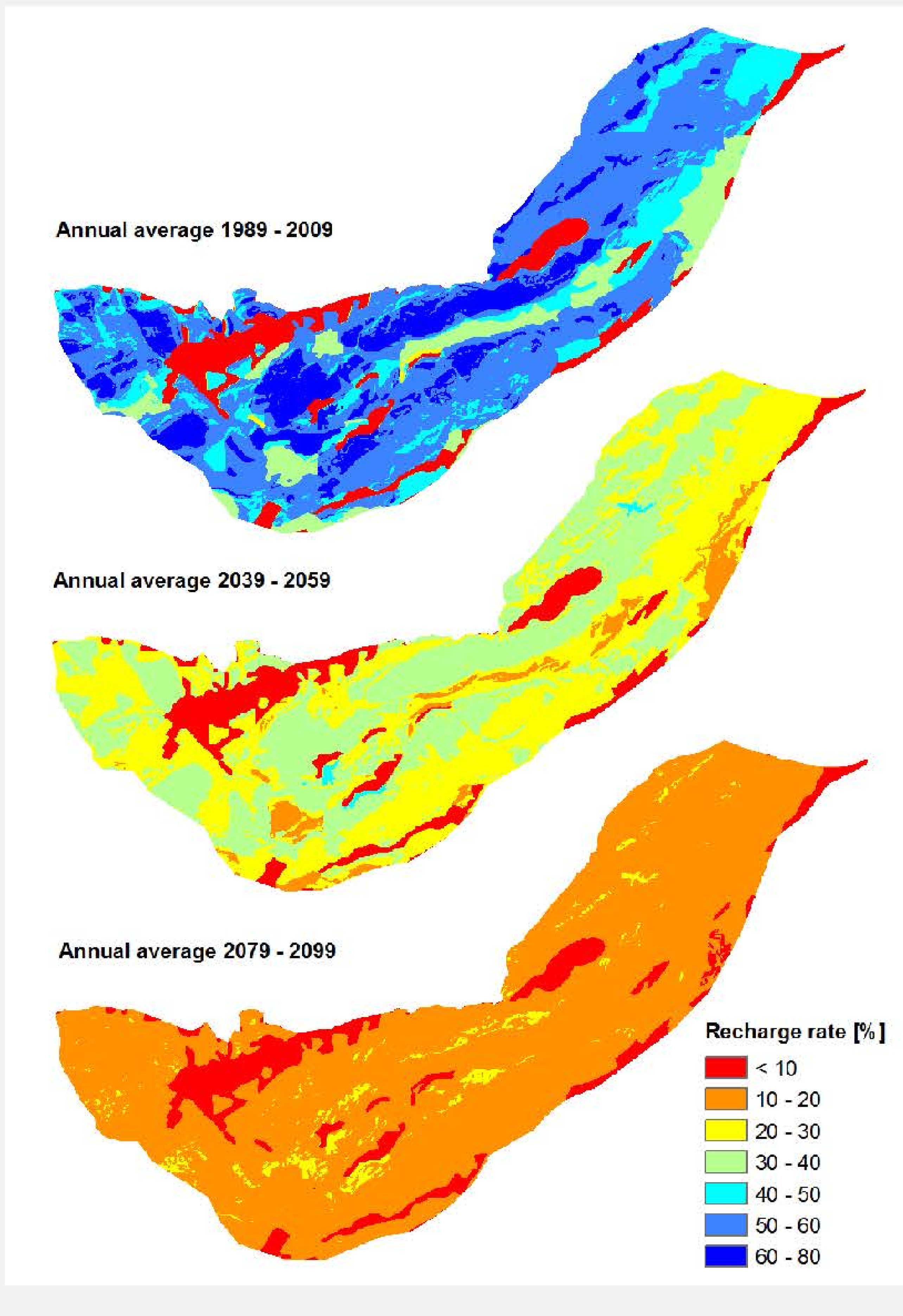
Results

The results were evaluated with spring discharge data from Villanueva del Rosario spring. Comparison of simulated recharge rate (RR) and spring discharge rate (DR) suggested an adequate performance for the new method. APLIS underestimated recharge in wet conditions and overestimated recharge in dry years compared to the new method.

Year	Conditions	P	New method		Observed		APLIS
			R	RR	Q_{spring}	DR	RR
		[mm]	[mm]	[%]	[mm]	[%]	[%]
2008/2009	wet	932.2	603.4	64.7	692.3	74.3	46.6
2006/2007	dry	642.2	209.6	32.6	173.5	27	46.6
2006/07-2008/09	average	752.4	350.8	46.6	391	52	46.6

Applying the 5 climate models all results for the average years suggested a decrease in recharge in the future.

However, large uncertainties of the climate models prohibit a precise quantification of the extent of the decrease as their recharge predictions diverged strongly in the future.



Conclusion

The consequences of considering the temporal variability of meteorological data on the estimated recharge with our new method could clearly be recognized at the study site. The new method was able to reflect much better the differences in climatic conditions between wet and dry years and led to more realistic results.

Those results suggest that small modifications on the APLIS method potentially can enable it to be used for estimating groundwater recharge for climate or land use change scenarios. However, more evaluation with larger data sets of other karst systems is necessary.

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References: Andreo, B., Vías, J., Durán, J., Jiménez, P., López-Geta, J., Carrasco, F., 2008. Methodology for groundwater recharge assessment in carbonate aquifers: application to pilot sites in southern Spain. Hydrogeol. J. 16, 911–925.