COMPARISON OF MULTI-SATELLITE NASA GPM IMERG AND ERA5 REANALYSIS, CROSS- EVALUATION WITH ORDINARY CO-KRIGING AND GROUND-BASED DATA IN SW AFRICA.

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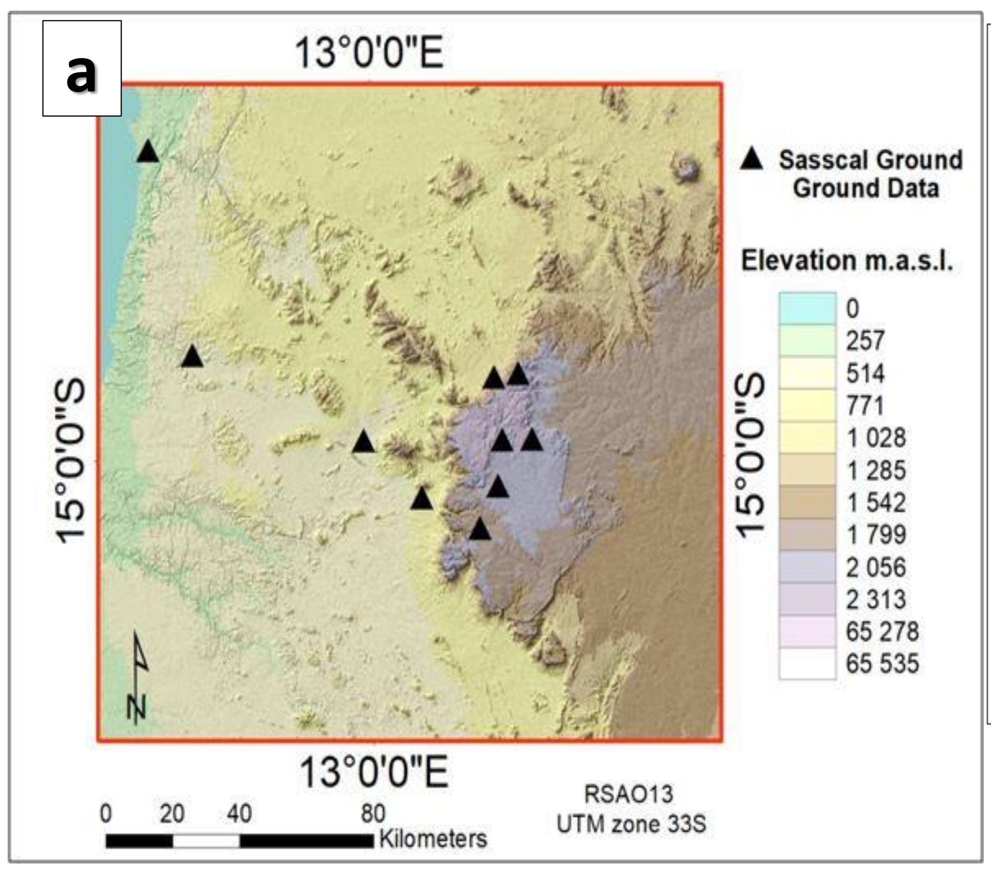
1. Introduction

Most of sub-Saharan countries are profoundly dependent on agriculture, as it serves as a major economic and food-source for populations that usually suffer from diseases and malnutrition [6]. Southwest African countries are good examples regarding this problem, as climate-change scenarios project widespread warming and reduces total surface freshwater availability in south-west Africa [2,5,10,11]. The region is characterized by arid to semi-arid climates [8], with most of the rainfalls occurring from October to March [4] (Figure 1b). Rainfall gradients are large, varying from very little annual rainfalls near the coast, to copious precipitations over the continental plateaus [4]. Until the end of XX century and after the colonial era, SW Africa was severely affected by civil wars where most of the existing weather and hydrological stations were destroyed [1]. As a result, there is still a critical lack of climate data across SW Africa [7,9]. Therefore, some EU-funded programs, such as FRESAN[1] or SASSCAL[2], have been investing in weather and climate research over SW Africa, installing or repairing WS across those places. The main goal of this work was to develop an interpolation methodology to better represent rainfall distributions over a small region of SW Angola, using local WS, as well as reanalysis and satellite data to surpass the lack of WS. This study was done under the scope of the ongoing FRESAN project based in southern Angola.



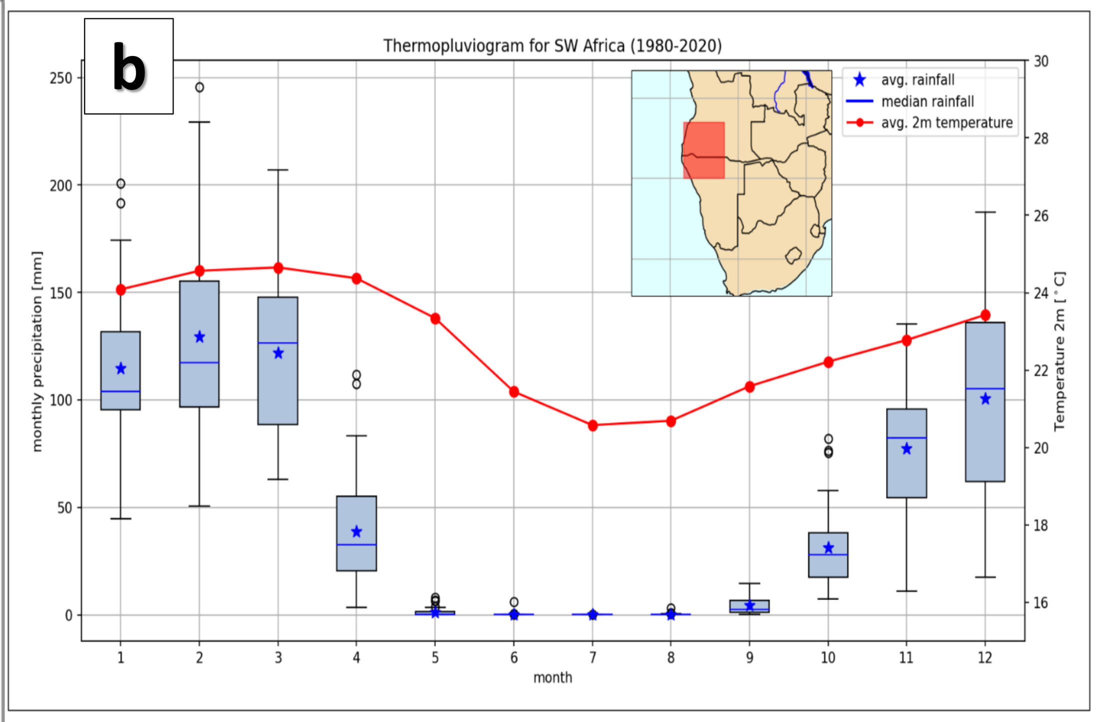


Fig. 1. (a) Locations of used SASSCAL WS over elevation from SRTM (Shuttle Radar Topography Mission) for the FRESAN region **(b)** termopluviogram for SW Africa using 1980-2020 monthly averaged data from ERA5. Rainfall and temperature data used in this figure represents average values over the red box on the inset map [13º-20ºS; 12º-18ºE] - region of interest. Boxplots represent precipitation variability and red line stands for monthly average temperature values.

2. Methodology

The applied methodology involved the use of OCK (Ordinary CoKriging)[3] to model monthly precipitation in SW Angola. Four OCK models were generated, incorporating two distinct spatial supports and two different temporal supports (4 OCK).

As a primary variable, 11 SASSCAL WS were used, with two different time frames, January and February of 2015-2018 (http://www.sasscalweathernet.org/).The different spatial supports were used as a secondary variable, one from NASA GPM IMERG (NASA's Global Precipitation Measurement mission), (30x30km/px), and another from ERA5 (ECMWF's 5th reanalysis generation), (10x10km/px). ERA5 can be retrieved using FRESAN's online-platform, where monthly rainfall, temperature and soil moisture data are available (https://clim2as.ipma.pt/).

To assess significant differences between the two spatial supports (IMERG and ERA5), cross-validation techniques were applied to OCK models.

It is worth noting SASSCAL has a total of 45 weather stations installed in Angola, but only five are currently active. Unfortunately, due to limitations, the study was only able to gather data from 11 weather stations for short time periods. Consequently, the temporal and spatial coverage of the sample was insufficient. As seen in Figure 1a, among the 11 selected stations, only two were located on the coastline and were situated more than 100 km apart from each other. In the mountainous region, there was a cluster of eight stations confined to an area of 3000 km^2, resulting in an unbalanced distribution of weather stations.

[2] SASSCAL - Southern African Science Service Centre for Climate Change and Adaptive Land Management

3. Results

OCK - monthly average total precipitation – January (2015/2018)

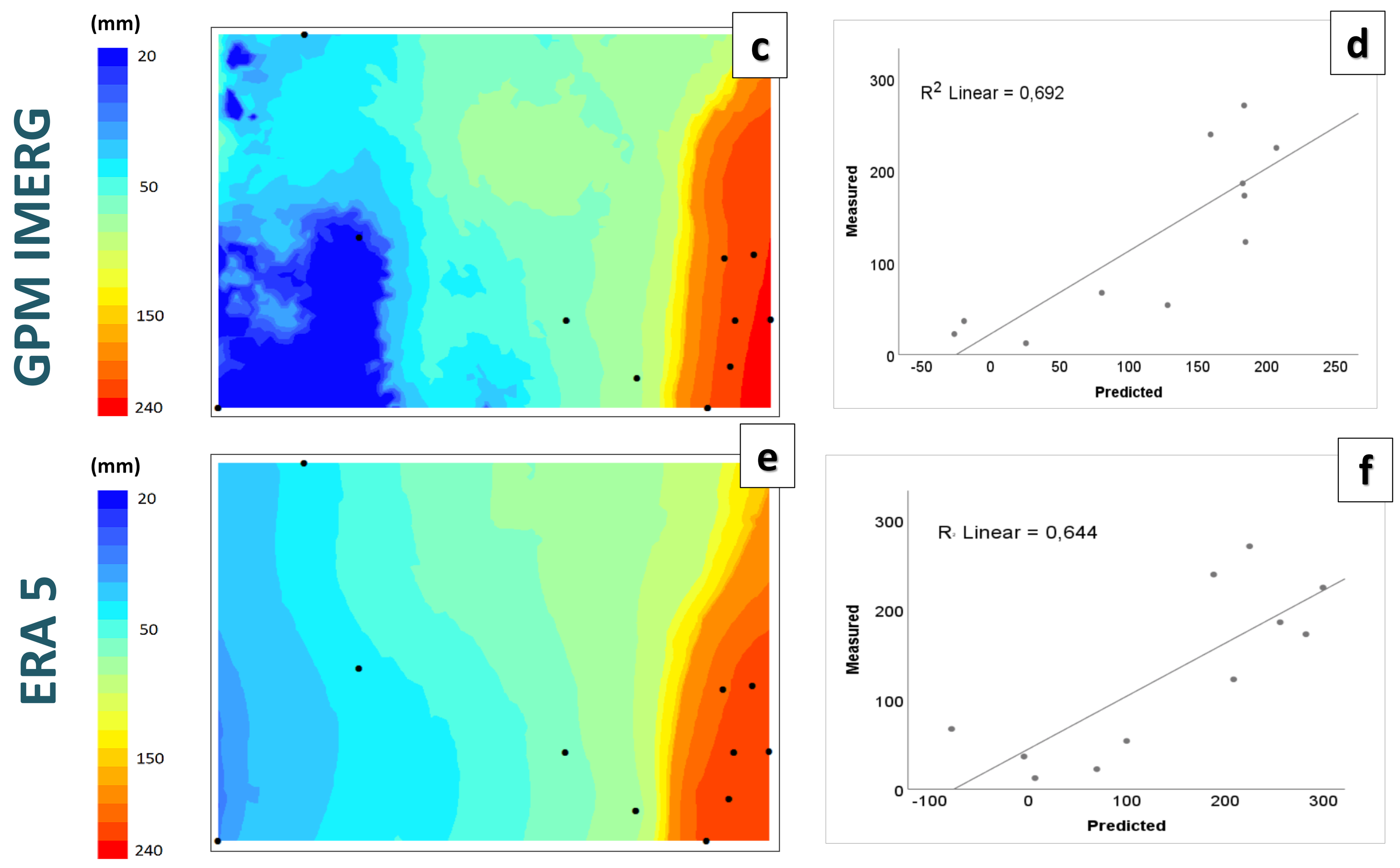


Fig.2. OCK, January gauge data and IMERG **(c)** ERA5 **(e)**, IMERG has visible higher resolution effect on the OCK. Cross validation scatterplots, IMERG **(d)** and ERA5 **(f)**, overall the center on mass from the samples indicate underestimated values in both models.

OCK January	Omnidirectional cross-variogram				(LOOCV) Leave-One-Out Cross-Validation Statistics				
	Model	Nugget	P. Sill	Range	Mean Error	RMSE	Mean Standardized E.	SE Avg.	RMSES
GPM IMERG	Spherical	3213.8	11130.4	114882	-10.76	52.00	-0.154	65.50	0.830
ERA5	Spherical	3291.5	12020.5	119968	13.32	74.98	0.215	62.33	1.223

OCK - monthly average total precipitation – February (2015/2018)

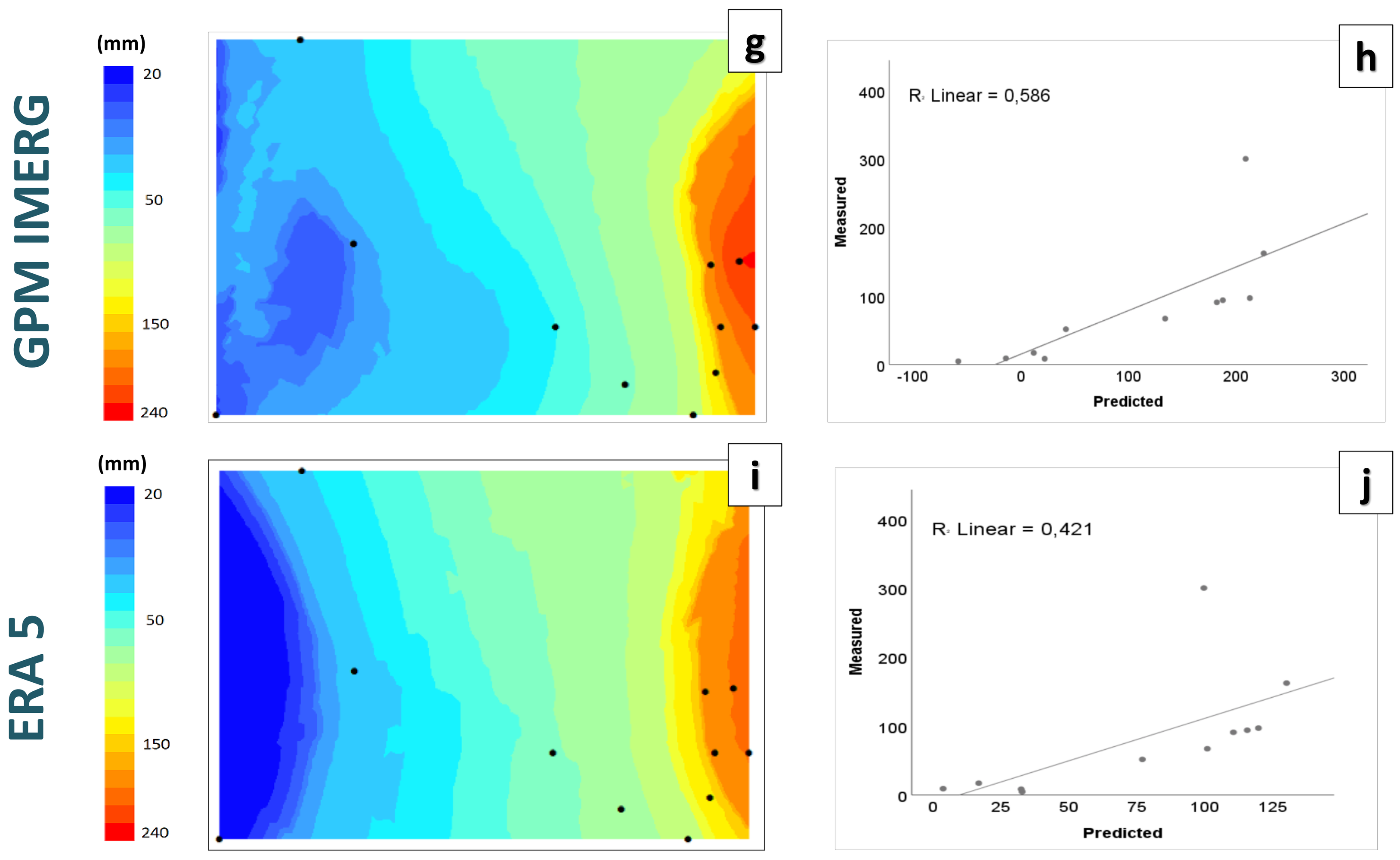


Fig.3. OCK February gauge data and IMERG **(g)**, ERA5 **(i)**. Cross validation scatterplots, IMERG **(h)** and ERA5 **(j)**, **)**, the precipitation values underestimation is heightened in February, one outlier is largely overestimated causing poor fits for this month.

OCK February	Omnidirectional cross-variogram				(LOOCV) Leave-One-Out Cross-Validation Statistics				
	Model	Nugget	P. Sill	Range	Mean Error	RMSE	Mean Standardized E.	SE Avg.	RMSES
GPM IMERG	Spherical	4202.8	5817.7	123261	-5.563	64.5	-0.075	79.34	0.837
ERA5	Spherical	4711.4	6506.5	339803	23.121	68.9	0.283	83.60	0.838

- Scarcity and dispersion of WS + high variability of precipitation leads to high nugget effects,
- Overall underestimated values! - February has low auto-correlation in the WS data

4. Conclusions

- The crucial conclusion of the study is that the available ground data (both in terms of spatial and temporal coverage) in the southwestern region of Angola is insufficient for the validation of models or remote data (OCK) or possibly others geostatistical methods. The FRESAN project has taken steps to improve this situation by installing 6 additional weather stations in the region. Lack of WS is a well-known and persistent scientific and technological problem in Africa, compromising studies over the continent.

- While the measure of errors obtained through cross-validation does not permit a significant comparison between the two spatial supports (IMERG and ERA5), it was observed that the errors were greater in February averages for both supports. This observation is in line with the fact that February is the month with the greatest variability in precipitation levels (see Figure 1b). Moreover, the OCK method resulted in slightly smaller errors for both January and February, when IMERG support was used.

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Acknowledgments

This work was developed as part of the the [1]FRESAN project – "Fortalecimento da Resiliência e da Segurança Alimentar e Nutricional em Angola", founded by the European Union and managed by Camões, I.P.