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A method to fill-in discontinued daily precipitation series from nearby stations.

By:

Manolis G. Grillakis[1,2], Christos Polykretis[2,1], and Dimitrios D. Alexakis[1,2]

grillakis@hydrogaia.gr; polykretis@ims.forth.gr; dalexakis@ims.forth.gr;

[1]Lab of Geophysical-Remote Sensing & Archaeo-environment, Institute for Mediterranean Studies, Foundation for Research and Technology Hellas, Rethymno 74100, Crete, Greece;

[2]School of Environmental Engineering, Technical University of Crete, Chania 73100, Crete, Greece;

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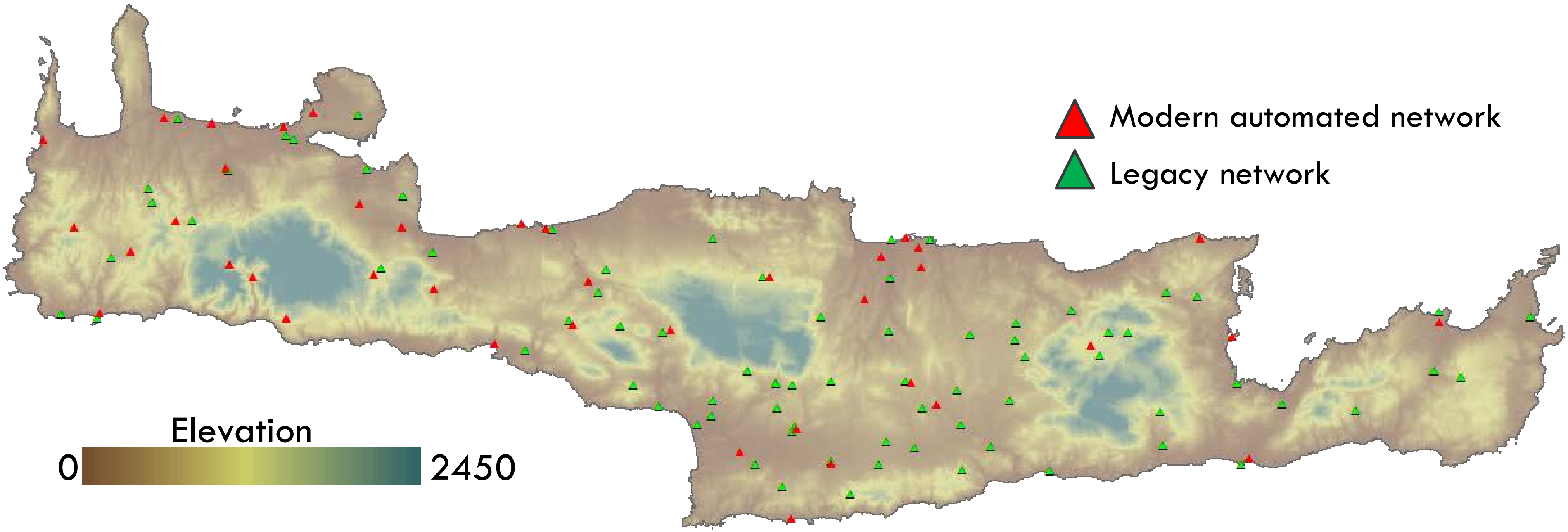
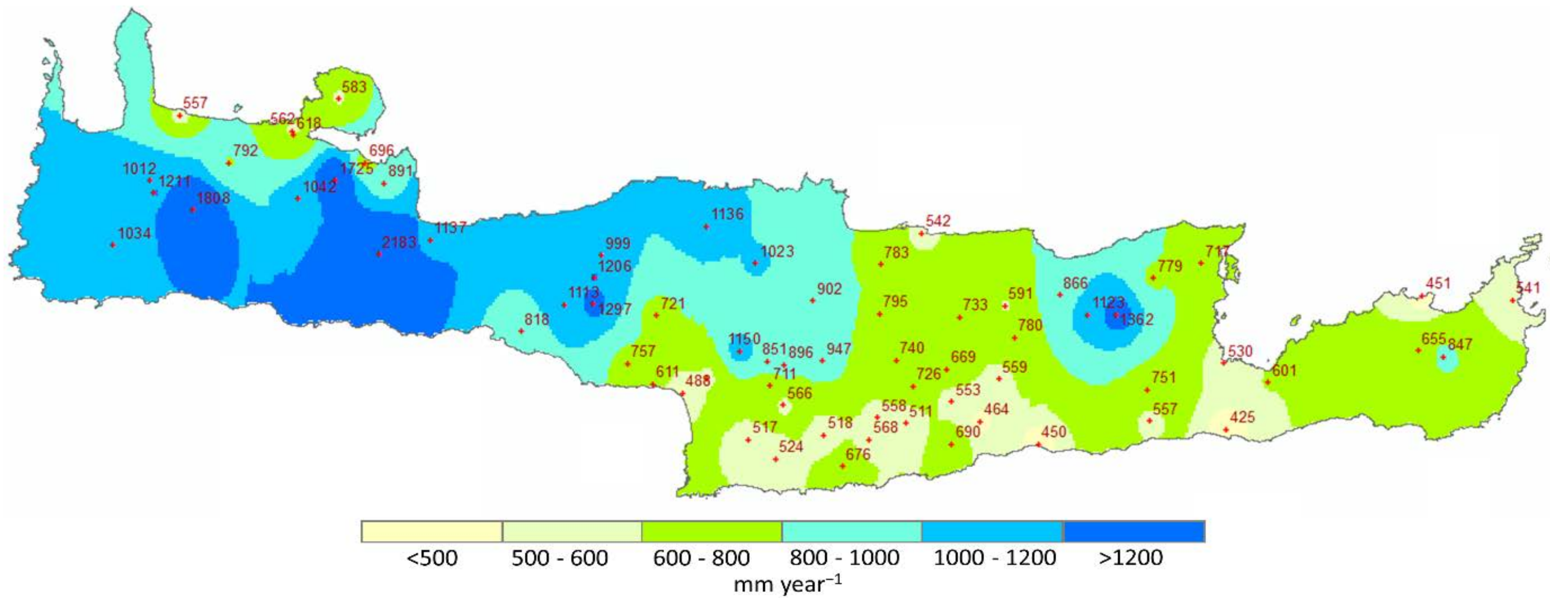
Cornerstone of the meteorological and climatological science is the quality measurements of the precipitation. Large instrumentation gaps occur due to network destructions (fires, wars) or even technical limitations that dictate network reorganizations. This is a difficult to tackle issue as there are legacy networks that provide decades of valuable data, but for various reasons have been discontinued. A method to work out such problems is to include only part of the data to the analyses, or to use methods to fill the measuring gaps from nearby stations, such as interpolation techniques, regression techniques. In this work, we present and assess a method to estimate missing values in daily precipitation series based on a quantile mapping approach, originally used for bias correction of climate model output.

On the island of Crete – Greece, there have been two major precipitation gauging station networks. The one has been mostly put out of service (~1970 - 2010), while a second one that uses automatic station has been developed in the recent years (~2007 - today). The ultimate goal would be to fill-in the voids of both networks in daily timestep.



The island of Crete exhibits Mediterranean climate. The topography of Crete follows the typical Greek landscape consisting mainly of mountainous terrain with a mean elevation at 460 m, with an average rainfall of 878 mm per year[1,2]. Orographic precipitation effects tend to increase both frequency and intensity of winter precipitation in Crete, having resulted to various disastrous and highly erosive flood events in the past[3].



Rainfall climatology 1981 – 2010 for Crete estimated on 69 daily station data[3]. Numbers indicate the mean annual rainfall in mm.

[1] Polykretis, C., Grillakis, M.G., Alexakis, D.D., 2020. *Exploring the Impact of Various Spectral Indices on Land Cover Change Detection Using Change Vector Analysis: A Case Study of Crete Island, Greece. Remote Sens. 12, 319. doi:10.3390/rs12020319*
[2] Grillakis, M.G., Polykretis, C., Alexakis, D.D., 2020. *Past and projected climate change impacts on rainfall erosivity: Advancing our knowledge for the Eastern Mediterranean island of Crete. Catena, in press.*
[3] Tsanis, I.K., Seiradakis, K.D., Daliakopoulos, I.N., Grillakis, M.G., Koutroulis, A.G., 2013. *Assessment of GeoEye-1 stereo-pair-generated DEM in flood mapping of an ungauged basin. Journal of Hydroinformatics, 16(1), 1-18.*

The methodology tested here is based on a three-step procedure.

- The first is to assess the missing values from nearby stations using inverse distance weighting interpolation method or Nearest neighbor methodology (both methods were considered and tested here).
- Then, as a second step, the wet day fraction is adjusted to fit the respective fraction of the target point existing data.
- The third step is to adjust the biases in the probability density function of the filled values towards the target point existing data, using the Multi-segment Statistical Bias Correction methodology (MSBC[1,2]).

1 Grillakis, M. G., Koutroulis, A. G., & Tsanis, I. K. (2013). *Multisegment statistical bias correction of daily GCM precipitation output. Journal of Geophysical Research: Atmospheres, 118(8), 3150–3162.*
2 Grillakis, M. G., Koutroulis, A. G., Daliakopoulos, I. N., & Tsanis, I. K. (2017). *A method to preserve trends in quantile mapping bias correction of climate modeled temperature. Earth System Dynamics, 8(3), 889.*

In order to assess the efficiency of the proposed methodology, we used all the stations from both networks with data over 10 years and with at least 95%-year data completeness (68 stations).

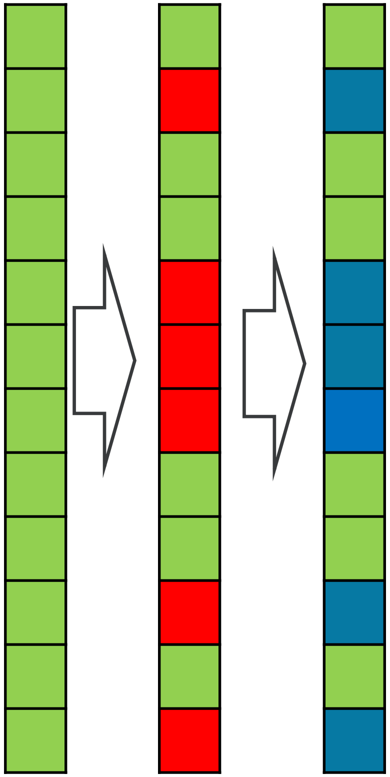
A random set of 50% of each station's years with available data were artificially removed to be used latter as validation.

The three-step procedure was then applied, and the estimated daily precipitation data were compared against the validation data.

The procedure was repeated 10 times (folds) per station in order to eliminate the effect of the random artificial data removal.

The “three step procedure”

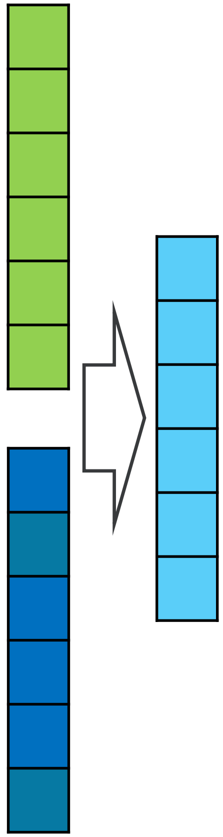
For each of the 68 stations



Randomly remove 50% of the data.

Then estimate the gaps from nearby stations using interpolation.

Step 1



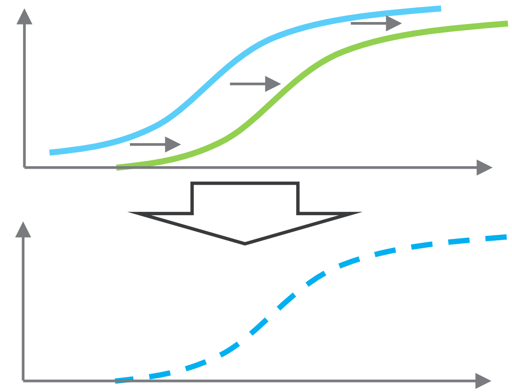
Adjust the number of dry days in the estimations by zero-ing the right amount of the smallest precipitation values.

The resulted estimation data has the same fraction of zero values with the observations

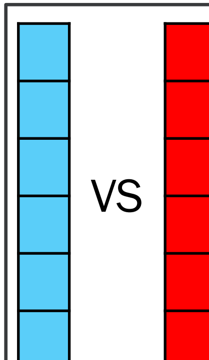
The procedure is performed in a calendar month basis

Step 2

Match Cumulative density functions (CDFs) using the MSBC statistical bias correction methodology

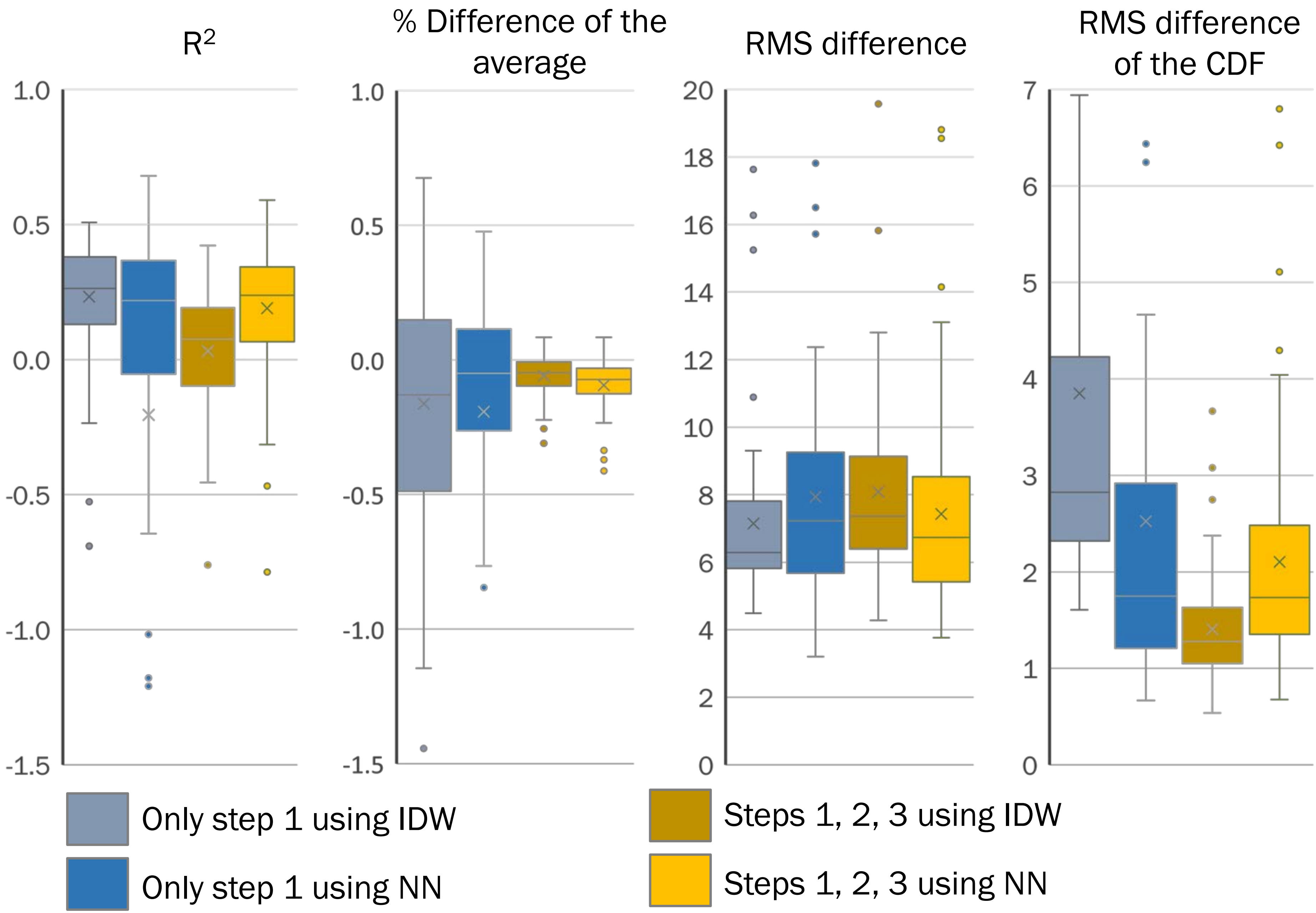


Step 3



Comparison of the results to the initially removed data

Results



R^2
1.0
0.5
0.0
-0.5
-1.0
-1.5
% Difference of the average
1.0
0.5
0.0
-0.5
-1.0
-1.5
RMS difference
20
18
16
14
12
10
8
6
4
2
0
RMS difference of the CDF
7
6
5
4
3
2
1
0
Only step 1 using IDW
Only step 1 using NN
Steps 1, 2, 3 using IDW
Steps 1, 2, 3 using NN

The methods tested, provide useful insights about the use of quantile correction in the interpolated precipitation:

- NN provides better R^2's than IDW but only when CDF matching is used.
- IDW is better than NN when the CDF of the filled data is important.
- CDF adjustment largely improves the remaining average bias (% difference in the average) and the RMSD of the CDF but does not improve the timeseries RMSD or the R^2.

Nearest neighbors is probably better for filling in precipitation data for Crete with the CDF correction to add value to the procedure.

BUT:

- The presented evaluation of the three-step method to fill-in the data is based on the artificially removal of the ~50% of the data that were used for the evaluation.
- However, when the data to be filled are much less than the already existing for a specific location, hence the CDF matching operation would largely distort the filled-in data.
- Hence what is needed to be added is a procedure to adjust the exceedance probability of the target CDF depending on the amount of data to be adjusted – which is the next step of the method development.
- Also: the CDF adjustment assumes stationarity of the rainfall climatology.