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Performance Assessment of CHIRPSv2.0 and MERRA-2 Gridded Precipitation Datasets over Complex Topography of Turkey †

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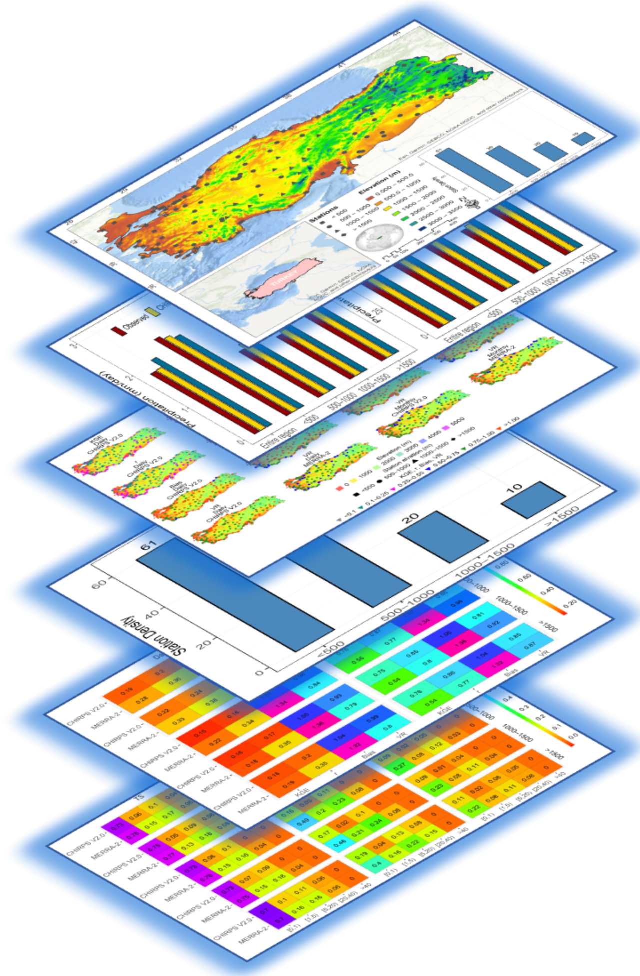
Why Gridded Precipitation Datasets (GPDs) are Important ??!!

- Accurate precipitation estimates with high spatio-temporal resolution are essential for many studies related to water resources on regional and global scales [1,2]. Precipitation monitoring over highly elevated regions and complex topography has been a great challenge in recent years [3,4] , and the lack of precipitation observation usually limits hydro-climatic studies, especially for data-scare regions [5].

- Alternatively, Gridded Precipitation Datasets (GPDs), which take advantage of satellite sensor information and numerical weather prediction model output data, present high spatio-temporal resolution and long-term precipitation estimates [1,6]. However, the validation of GPDs over a particular area may not be applicable for other regions, and a detailed assessment is required to address GPDs performance over time and space.

❖ According to the previously described context, this study aims to evaluate the spatio-temporal consistency of two multi-source Gridded Precipitation Datasets (CHIRPSv2.0 and MERRA-2) over complex topography (distinct elevation ranges) of Turkey considering the daily and monthly precipitation.



Study Area and Station Distribution

- Region: Turkey; Area: 784,000 km^2 ; Location: 36–42° N latitude and 26–45° E longitude; Station No: 130.
- The region is discretized into four elevation ranges where area with elevation less than 500m includes the maximum number of selected meteorological stations (61 station in total) and area with elevation more than 1500m has the lowest number of meteorological stations (10 station in total).

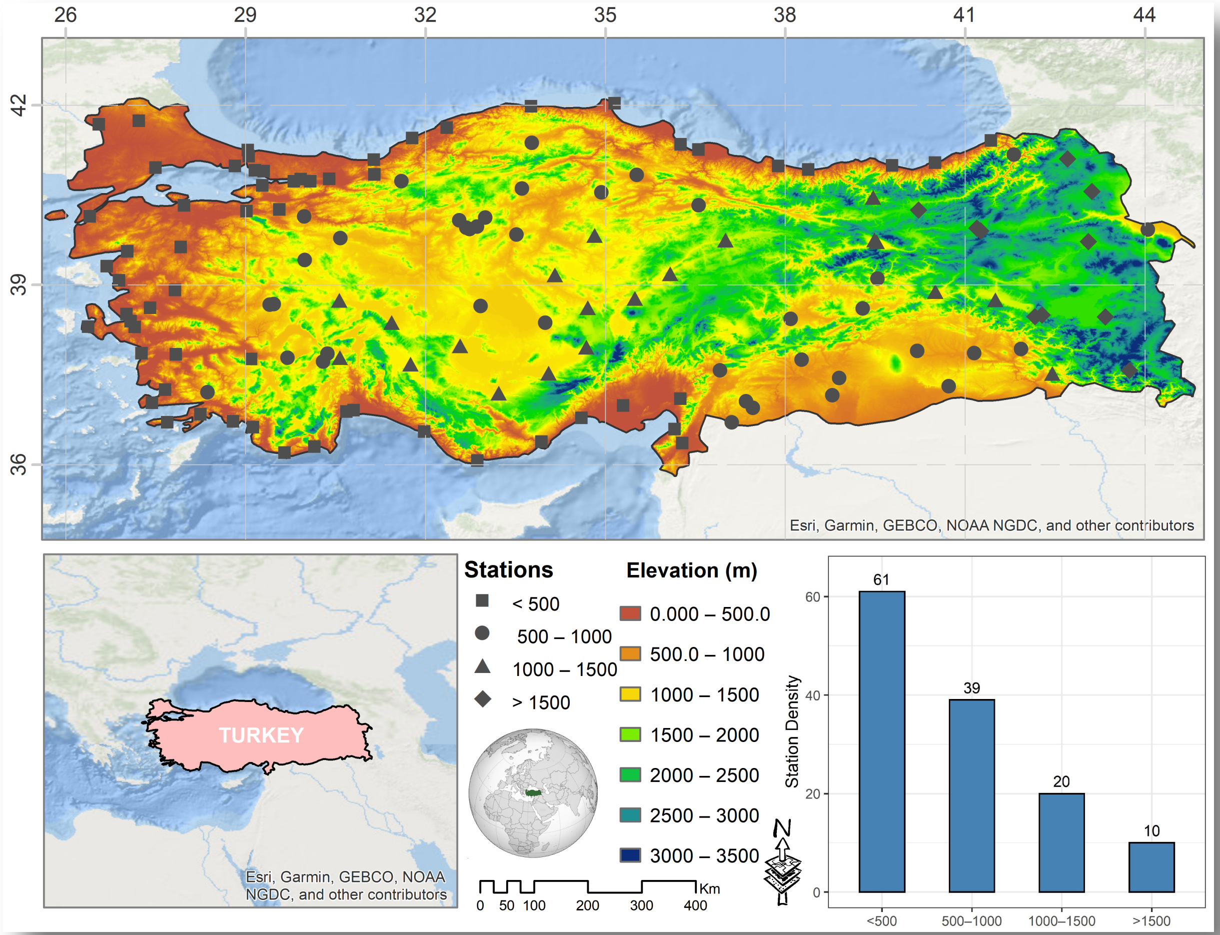


Figure 1. Geographic location of the study area, elevation (m), and station distribution over four elevation ranges.

Gridded Precipitation Datasets and Post Performance Indicators

- The Climate Hazards group InfraRed Precipitation with Stations (CHIRPS) version 2 presents precipitation with a high spatial resolution (0.05°) and spatial coverage within 50° S–50° N from 1981 to the present.
- The Modern-Era Retrospective Analysis for Research and Applications, version 2 (MERRA-2), presents precipitation with global coverage and spatial resolution 0.5° from 1980 to the present.

Table 1. Properties of performance metrics for GPDs evaluation

Metrics	Equation	Remarks
Kling Gupta Efficiency and its correlation, Bais and Variability Ratio components	$KGE=1-[(r-1)^2+(Bias-1)^2+(VR-1)^2]^{0.5}$ $r=\frac{1}{n}\sum_{1}^{n}(o_n-\mu_o)(s_n-\mu_s)/(\delta_o\times\delta_s)$, $Bias=\frac{\mu_s}{\mu_o}$, $VR=(\delta_s\times\mu_o)/(\mu_s\times\delta_o)$	*r* is *Pearson correlation coefficient*, *Bias* is the ratio of estimated and observed mean, *VR (Variability Ratio)* is the ratio of estimated and observed coefficients of variation, μ and δ are the distribution mean and standard deviation, where *s* and *o* indicate estimated and observed. *M (Miss)*; when the observed precipitation is not detected. *F (False)*; when the precipitation is detected but not observed, *H (Hit)*; when the observed precipitation is correctly detected, *CN (Correct Negative)*; a no precipitation event is detected.
Threat Score	$TS=\frac{H}{H+F+M}$	
Peirces's Skill Score	$PSS=\frac{(H\times CN)-(F\times M)}{(H+M)\,(F+CN)}$	
Gilbert Skill Score	$GSS=\frac{H-H_{random}}{H+M+F-H_{random}}$, $where\ H_{random}=\frac{(H+M)(H+F)}{H+M+F+CN}$	

Evaluation of mean daily and monthly precipitation

- Based on observed precipitation, the entire region receives precipitation of around 1.80 mm and 56.25 mm for daily and monthly time steps and Areas with an elevation of less than 500 m, which mostly represent coastal regions, experience higher precipitation amounts (2.37 mm/day and 73.2 mm/month).
- CHIRPSv2.0 shows close precipitation estimates to observed and its perfect records is obtained over areas with elevation more than 1500 m and MERRA-2 only underestimates daily and monthly precipitation in the coastal areas (area with elevation less than 500 m).

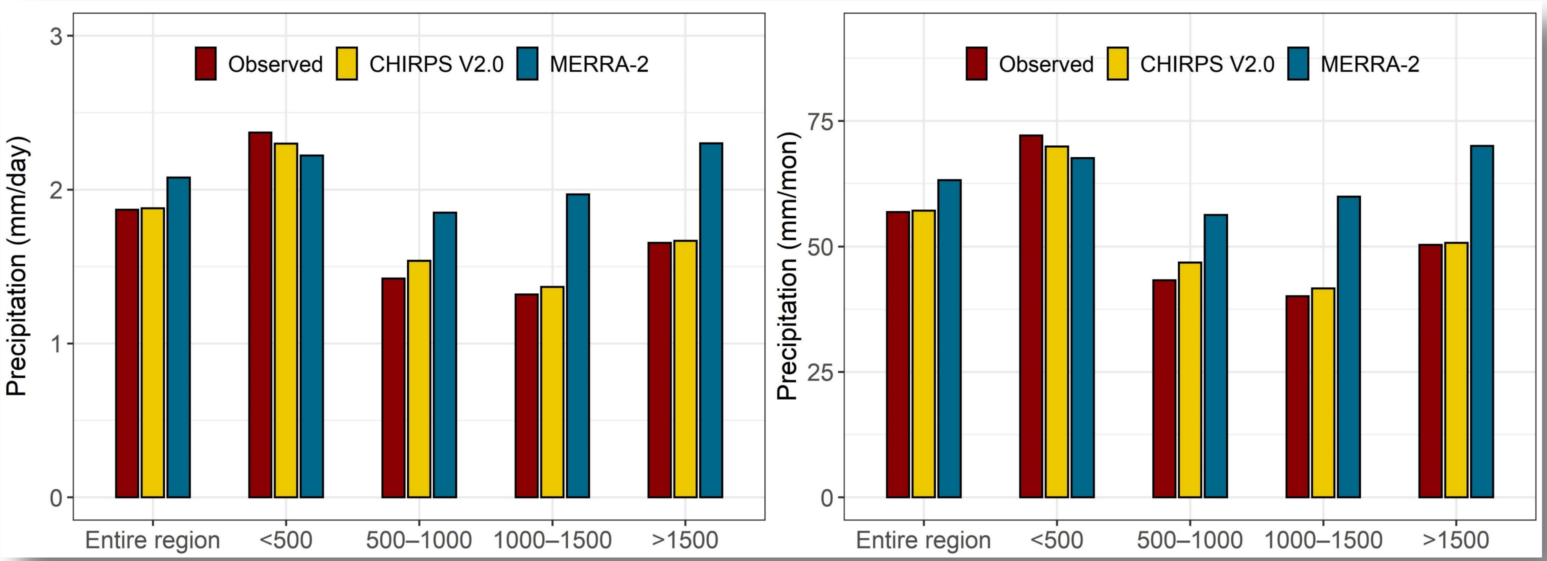


Figure 2. Mean daily and monthly precipitation from observed, CHIRPSv2.0, and MERRA-2 over the entire region and four elevation ranges.

Performance accuracy of GPDs at the station location

- Overall, both CHIRPSv2.0 and MERRA-2 show higher performance for the monthly precipitation than the daily time step.
- Considering daily precipitation, MERRA-2 shows higher performance compared to CHIRPSv2.0 at the grid-point level, which is relatively indicated by higher KGE and correlation coefficient (r) values.
- MERRA-2 shows a larger bias than CHIRPSv2.0, especially in the inner (with an elevation range of 500–1500 m) and eastern parts of the country.
- CHIRPSv2.0 is able to present effective monthly precipitation compared to MERRA-2.

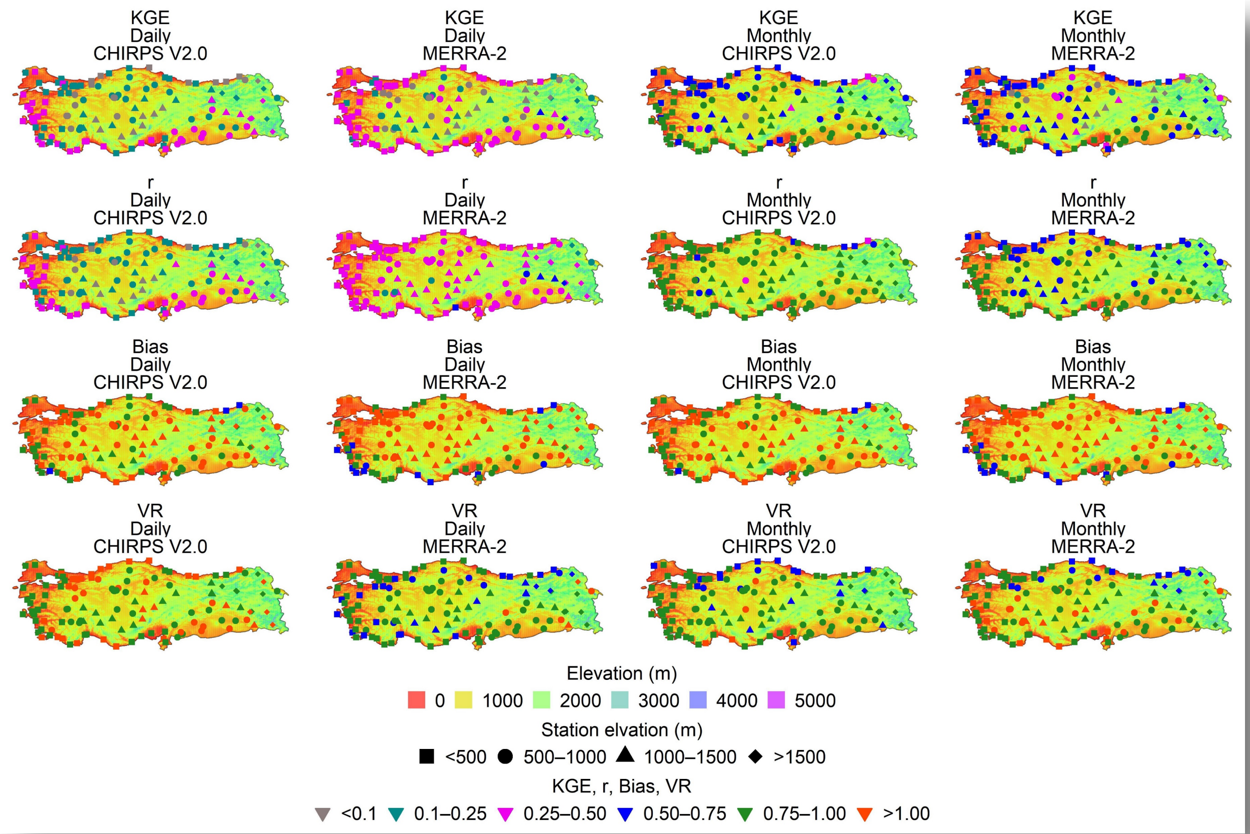


Figure 3. Reliability of CHIRPSv2.0 and MERRA-2 at the station location expressed in the form of KGE and its three components for daily and monthly precipitation.

Performance accuracy of GPDs at the regional scale

- ❖ Considering daily precipitation, MERRA-2 shows higher performance over the entire region (median KGE of; 0.28).
- ❖ In general, MERRA-2 displays lower performance compared to CHIRPSv2.0 when the elevation is increased.
- ❖ Both CHIRPSv2.0 and MERRA-2 show significantly higher performance for monthly precipitation estimates.
- ❖ CHIRPSv2.0 exhibits a stable but lower performance compared to MERRA-2 over different elevation rages (median KGE of; 0.15–0.22) for daily time step.

- ❖ CHIRPSv2.0 outperforms MERRA-2 for the monthly time step. This can be attributed to the fact that MERRA-2 shows a slightly lower correlation compared to CHIRPSv2.0 for the monthly time step.

Figure 4. Reliability of CHIRPSv2.0 and MERRA-2 at the regional scale expressed in the form of KGE and its three components for daily and monthly precipitation.

Detection ability of GPDs for daily precipitation

- The GPD's ability to detect daily precipitation events for five intensities is expressed in the form of Threat Score (TS), Pierce Skill Score (PSS), and Gilbert Skill Score (GSS).
- MERRA-2 shows higher detectability strength compared to CHIRPSv2.0 over different elevation ranges, and CHIRPSv2.0 shows slightly higher detection ability only for extreme (> 40 mm/day) precipitation over areas with an elevation of less than 500 m, which mostly presents coastal regions in the country.
- Generally, GPDs' detection abilities decrease with the increase of precipitation intensities and show the lowest detectability of extreme precipitation.

Precipitatioin event	Intensity (mm/day)
No rain	[0, 1)
Light rain	[1, 5)
Moderate rain	[5, 20)
Heavy rain	[20, 40)
Violent rain	≥ 40

Figure 5. GPDs' skill in reproducing daily precipitation events of different intensities is stated in the form of TS, PSS, and GSS over the entire region and four elevation ranges.

Conclusions

- MERRA-2 shows a higher mean precipitation for areas over 500 m elevation and becomes more observable over areas with an elevation of more than 1500 m, while CHIRPSv2.0 produces effective daily and monthly mean precipitation and it has a perfect match with observed precipitation over areas having an elevation of more than 1500 m.
- Overall, MERRA-2 exhibits higher performance compared to CHIRPSv2.0 for the daily time step, where CHIRPSv2.0 outperforms MERRA-2 considering the monthly time window.
- Considering the performance of GPDs over different elevation ranges, CHIRPSv2.0 presents a relatively stable performance compared to MERRA-2 for both daily and monthly precipitation.
- Overall, MERRA-2 displays relatively higher detectability strength compared to CHIRPSv2.0 for different precipitation intensities, while CHIRPSv2.0 shows detection ability higher than MERRA-2 only for extreme precipitation over areas with less than 500 m. Moreover, both the CHIRPSv2.0 and MERRA-2 detection abilities decrease as the intensity and elevation increase.

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