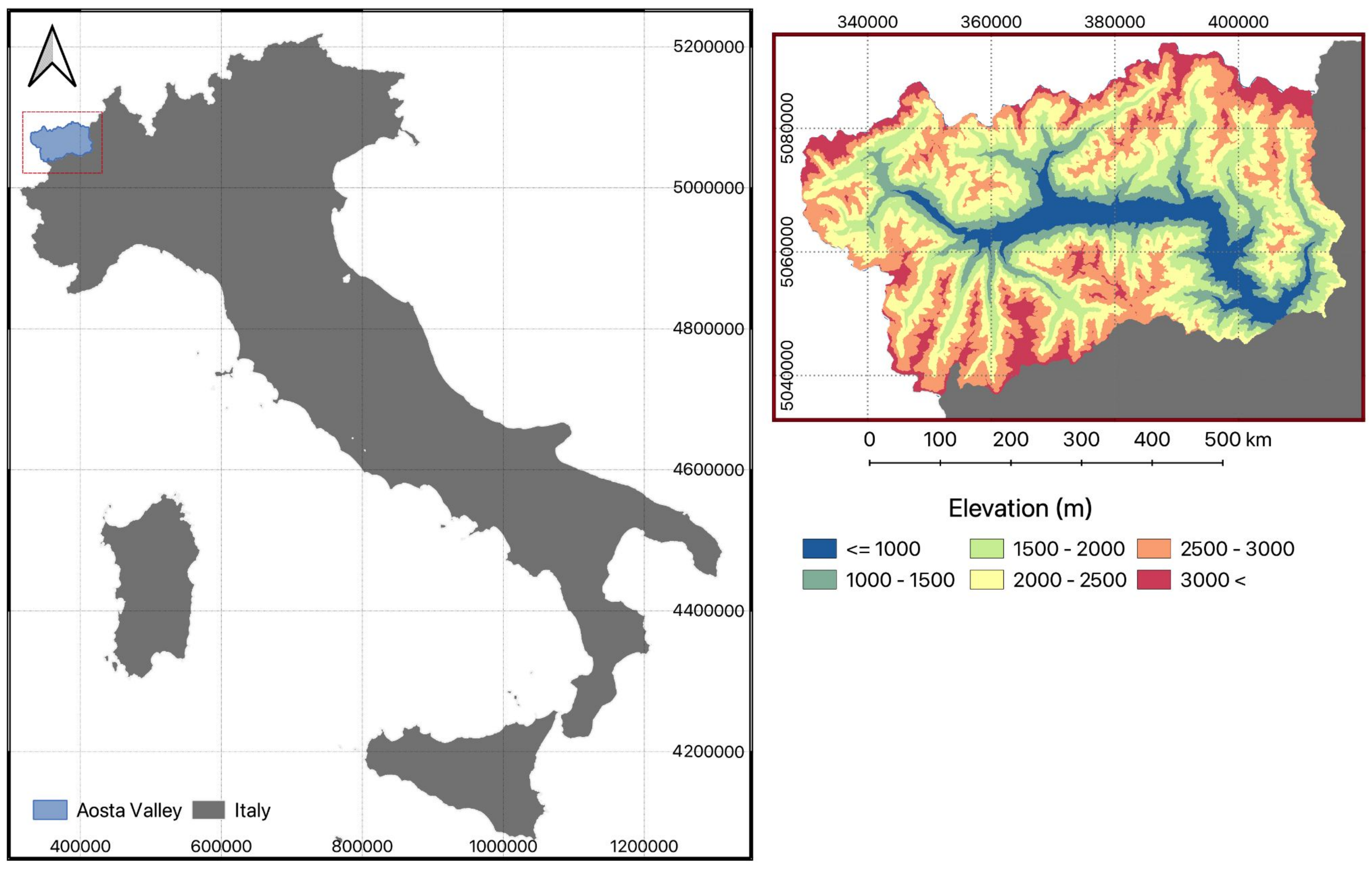

Figure 1. The study area and digital elevation model

Assessment of the Precision of Precipitation and Temperature Reanalysis Data (EMO) in the Aosta Valley Basin: A Sub-Basin Analysis at Daily Time Scale

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Abstract

Integrated and high-resolution Earth Observation (EO) data are essential for water resource management and flood prediction, especially in high-altitude regions with limited data. The European Meteorological Observations (EMO) dataset provides a high-resolution, multi-variable gridded meteorological dataset based on historical and real-time observations. This research aims to evaluate the accuracy of daily precipitation and temperature estimates in the EMO dataset using ground data in the Aosta Valley basin (AVB) in northwest Italy. The average Kling Gupta Efficiency (KGE) and Root Mean Square Error (RMSE) values of 0.6 and 5.8 millimeters, respectively. There was no clear correlation between elevation and precipitation accuracy, though temperature accuracy did show such a correlation. A finer analysis revealed that as elevation increased, KGE values decreased and RMSE values increased, indicating greater inaccuracy at higher elevations. The study investigates these discrepancies and provides explanations for them.

Introduction

High-resolution global climate data are essential for understanding weather patterns, assessing climate change, and improving disaster preparedness, particularly in remote and mountainous areas. These datasets are crucial for studying the hydrological cycle and water availability in river-fed regions. The European Meteorological Observations (EMO) dataset, with detailed climate variables like precipitation and temperature, is vital for analyzing climate change impacts in complex terrains. This study evaluates the EMO dataset's precipitation and temperature data in the Aosta Valley basin (AVB), enhancing our understanding of high-altitude areas and highlighting the importance of reliable data for environmental management and policy.

Study Area

AVB in the Alps encompasses Mont Blanc, Monte Rosa, Gran Paradiso, and the Matterhorn, with Mont Blanc at 4,810 meters as the highest peak. The region has a cold continental climate above 1,600 meters with long-lasting snow and misty summers. January temperatures range from -7 to -3 °C, while July sees 20 to 35 °C. Areas between 2,000 and 3,500 meters experience tundra climates with temperatures below 10 °C. Plateau Rosa's station records Italy's coldest average temperatures, with -11.6 °C in January and 1.4 °C in July (Gobiet et al., 2014).

Evaluation method

In this study, the EMO data were initially interpolated for each sub-basin and then evaluated using the reference data (Figure 2). Precipitation data were evaluated using two sets of statistical indices: continuous indices including Correlation Coefficient (CC), Root Mean Square Error (RMSE), Kling-Gupta Efficiency (KGE), Percent of Bias (PBias), and precipitation detection indices such as: Probability of Detection (POD), False Alarm Ratio (FAR), Critical Success Index (CSI), and Frequency Bias Index (FBI).

Datasets

EMO is a high-resolution European meteorological dataset providing daily data on total precipitation, temperatures, wind speed, solar radiation, and water vapor pressure. It combines historical and real-time observations, processed through quality controls and interpolated using SPHEREMAP and Yamamoto methods to estimate values and uncertainties for each grid cell. For evaluating EMO data, data interpolated from ground stations using the kriging method for each sub-basins (Figure. 2) were selected as the reference.

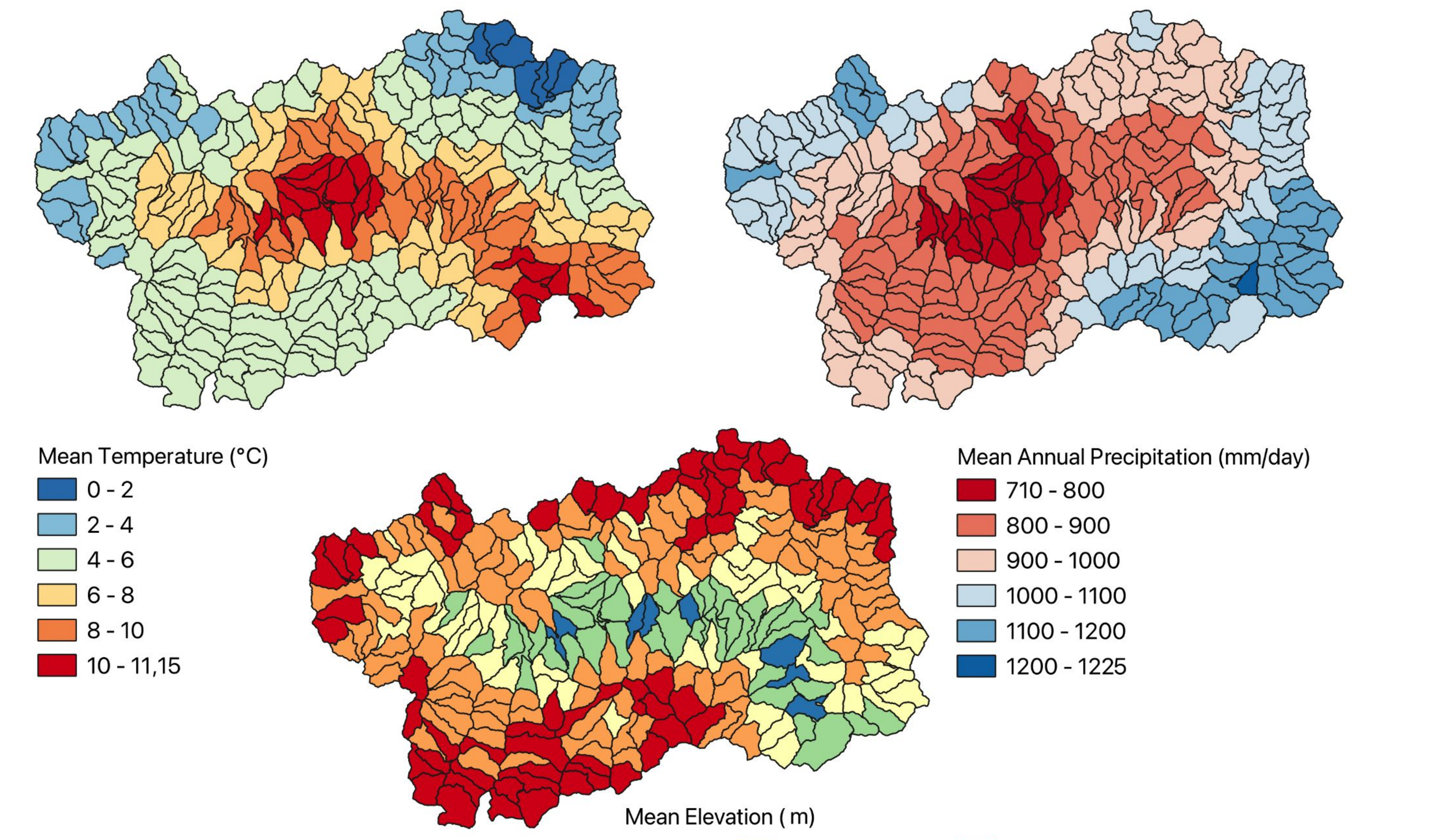

Figure 2. Average daily temperature, precipitation and elevation in each sub-basin based on reference data

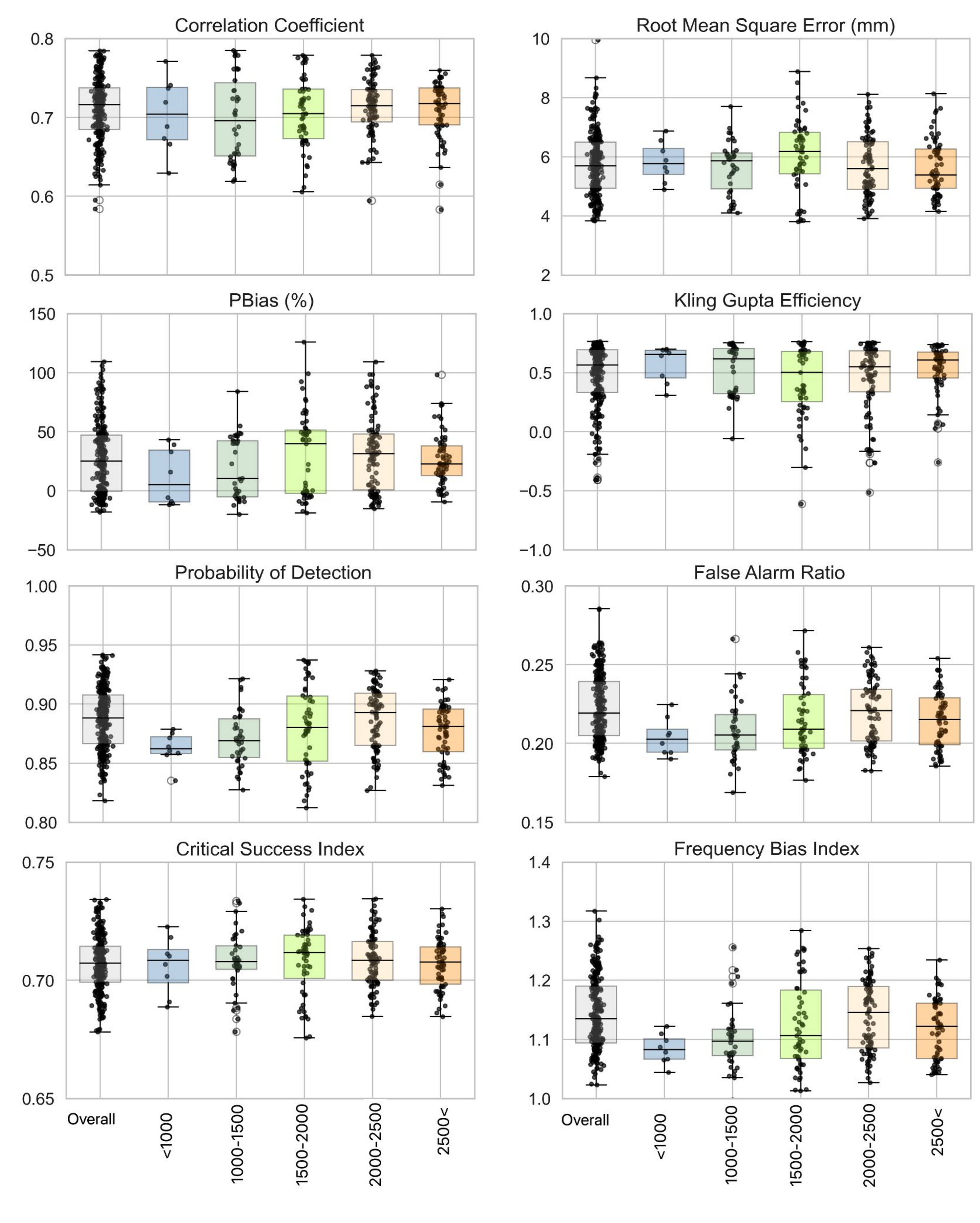

Figure 3. Box plots of overall and different bands of elevation of indices for precipitation of EMO dataset

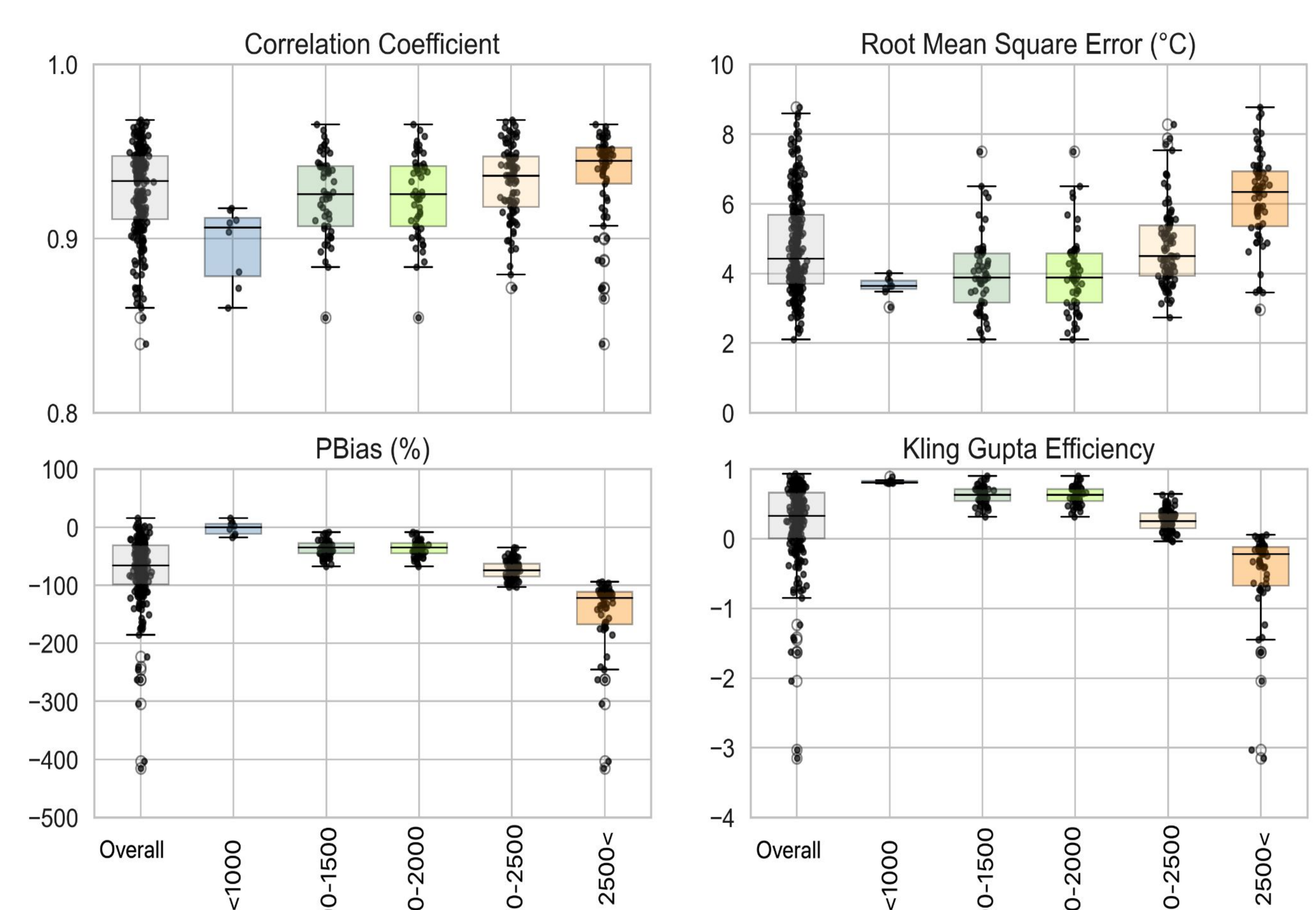

Figure 4. Box plots of overall and different bands of elevation of indices for temperature of EMO dataset

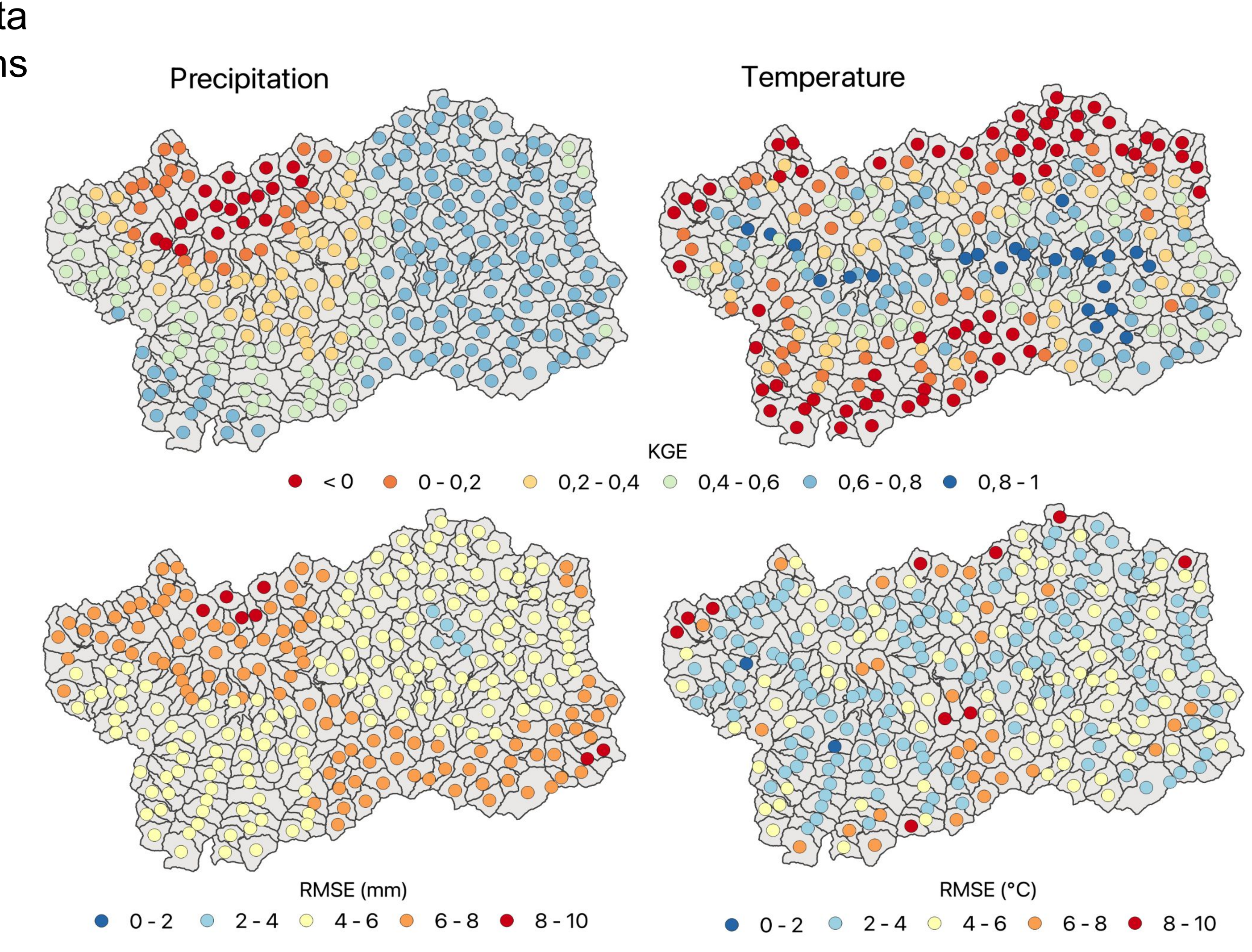

Figure 5. Spatial distribution of KGE and RMSE for precipitation and temperature data of EMO

Results and Discussion

Based on Figure 3, the average values for the CC, KGE, PBias, and RMSE indices for EMO precipitation data are 0.71, 0.48, 27%, and 5.75 mm, respectively. This figure indicates that the correlation between EMO data and Ground Truth (GT) data is independent of elevation. The PBias, ideally close to 0, is usually positive, with a median sometimes nearing 50%, which is significant. This implies an overestimation of water at all elevations, leading to higher discharge and evapotranspiration rates in hydrological simulations using EMO data. If hydrological models are calibrated with EMO data, parameters may vary, suggesting that the increased water content either contributes to evapotranspiration or is lost to groundwater. This could result in inconsistencies in water budget estimations. A KGE value around 0.5 indicates poor agreement overall. Some points have highly negative KGE values, reflecting significant disagreement between ground measurements and EMO data. This indicator also appears to be independent of elevation.

The evaluation results of precipitation detection indices indicate no clear correlation between precipitation detection and elevation. The EMO dataset correctly identifies approximately 90% of precipitation events, demonstrating its accuracy. However, 20% of its precipitation detections are false positives, with an overall success rate calculated at over 70%. Given the POD and FAR values, it can be inferred that the FBI is greater than one, indicating that this dataset reports more events than the GT dataset. It can be inferred that with increasing elevation, both correct and incorrect detections increase, indicating that elevation does not significantly impact the reliability of this dataset.

According to Figure 4, the average values for the CC, KGE, PBias, and RMSE indices for temperature data are 0.92, 0.19, -78%, and 4.76 mm, respectively. Evaluation in different elevation bands shows that the accuracy of the temperature data in the EMO dataset decreases with increasing elevation. KGE shows a strong variation with elevation, indicating disagreement between GT and EMO. The accuracy of this dataset is unacceptable above 2000 meters. Considering the PBias, which is generally negative, it should be noted that this dataset underestimates temperature.

Figure 5 demonstrates acceptable agreement in the East and poor agreement in the West. The worst agreement is observed near the divides. This discrepancy might suggest that if the GT data is interpolated and there are few stations in those areas, the GT data may be inaccurate while the Earth Observation data remains reliable, particularly for precipitation. However, the observed East/West separation does not support this hypothesis. Additionally, the RMSE values indicate that in areas with higher rainfall (northwest and southeast), the error is greater compared to other areas.

The spatial distribution of temperature estimation accuracy shows that the agreement is greater in the valley and worst on the mountain tops. This observation lends some credibility to the conjecture that EMO data may be more accurate than GT data. It should be considered that areas with high elevation and low average temperatures have lower accuracy.