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Comparison of the New High-resolution Solar Radiation Data with Observation and Reanalysis Datasets over Central Asia

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Solar radiation is a fundamental driver of energy exchange at the Earth's surface and plays a critical role in hydrological modeling and earth observation. It drives essential processes such as evapotranspiration, snow melt, which are integral components of the water cycle. Accurate modeling of solar radiation contributes to a better understanding of energy fluxes, improves the performance of climate models, and supports sustainable water and land resource management. It helps for estimating potential evapotranspiration, a critical parameter in water balance studies and irrigation management (Monteith, 1965). Incorporating solar radiation into models significantly enhances the accuracy of climate simulations, watershed management, and assessments of climate change impacts on natural and agricultural ecosystems (Sorooshian et al., 2011).

In hydrological modeling, the correction of input data for energy balance is especially needed to ensure accurate simulations. For example, Sadyrov et al. (2024) highlighted the importance of improved solar radiation datasets in modeling glaciated basins and accurately assessing river discharge, highlighting the sensitivity of the high-altitude hydrological systems modelling to solar radiation.

This study utilizes a newly developed high-resolution dataset of downward shortwave flux at the surface, based on an algorithm developed by Takenaka et al. (2011) and subsequently updated for application on MSG (Meteosat Second Generation) remote sensing signals provided by EU METEOSAT satellites. The system includes several advancements to address signal transfer and analysis challenges, enabling the creation of output results with a resolution of 1 km. Such high-resolution datasets offer significant improvements over traditional methods, allowing for more detailed and accurate modeling. With the newly available dataset, it will be possible to conduct high-resolution simulations with improved accuracy, particularly in mountainous regions where terrain complexities often challenge traditional models.

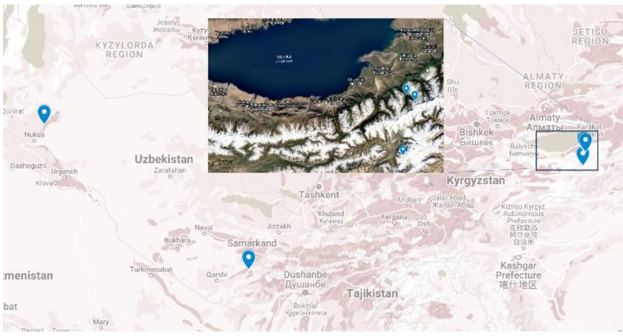

Fig. 1. Locations of the observation sites.

This study validates the dataset using observation points distributed across Kyrgyzstan's high mountainous areas and the plains of Uzbekistan (fig. 1), ensuring evaluation across diverse topographical and climatic conditions. The validation process included a comparison with widely used reanalysis datasets, such as ERA5 and JRA-3Q, to assess the relative performance of the new dataset.

The results (fig. 2) of the comparison demonstrated a strong correlation between the newly created dataset and observed data, particularly during the summer months across all observation stations. The new dataset successfully reproduced the distribution of shortwave radiation, surpassing the limitations of reanalysis datasets, which often rely on Gaussian normal distribution patterns.

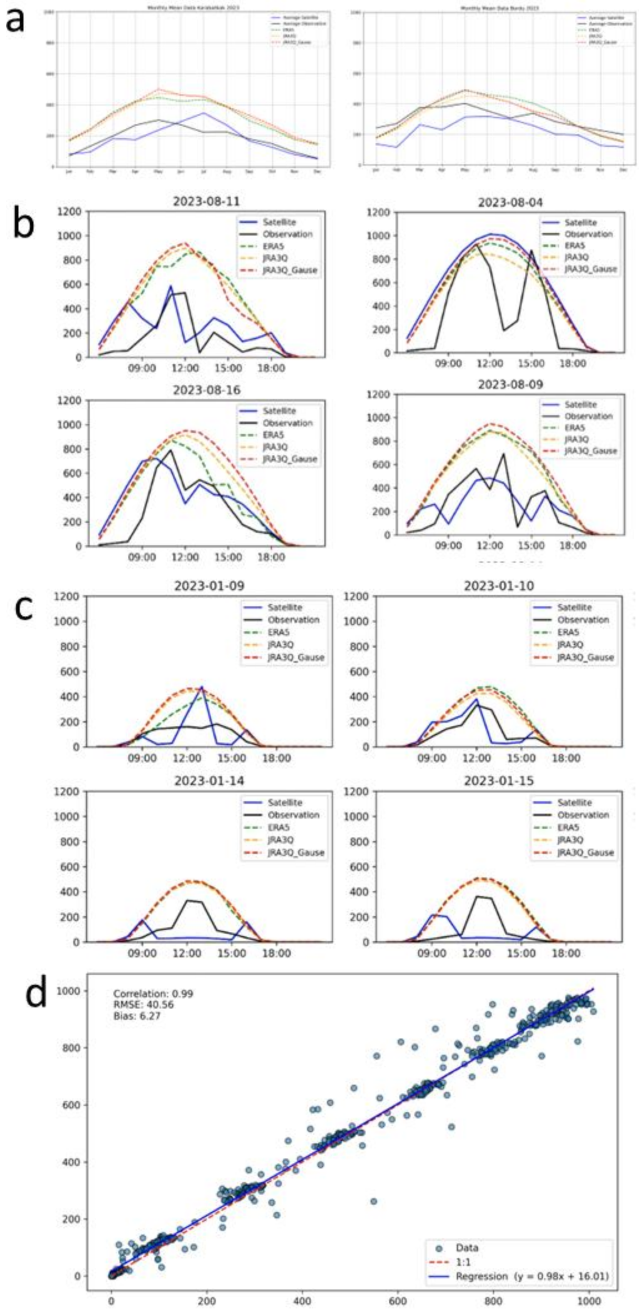

Fig. 2. Comparison of the reanalysis and observation results with satellite composite**.** a) Monthly mean; b) Daily mean for august; c) daily mean for January; d) correlation scatterplot for June

Unlike reanalysis datasets, the new dataset captured and reproduced daily intensity fluctuations more accurately, especially during summer (fig.2 b). However, results for the winter months were more mixed. One potential explanation is the challenge of distinguishing snow from clouds in the prepared images, which may have introduced some discrepancies. Despite this, the dataset performed well in high mountain areas, providing results much closer to observed data compared to reanalysis datasets, which tend to significantly overestimate radiation values in these regions.

The primary focus of this study was to evaluate how effectively the newly prepared dataset captures solar radiation over glaciated areas. Overall, the newly developed dataset demonstrated its capability to provide more reliable radiation estimates in complex terrains, particularly during the critical summer months when accurate solar radiation data is essential for modeling snowmelt and glacier dynamics. These improvements offer promising potential for enhancing hydrological modeling accuracy in mountainous and glaciated regions.

Reference

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