



Quick tool to enhance temporal resolution of rainfall intensity in data-scarce regions

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This study presents a method to calibrate remote sensing-derived rainfall data adjusted to align with station-measured daily totals. This approach is particularly useful for regions lacking high-frequency rainfall data, and calibrating remote sensing data offers the most practical solution.

1. Introduction

The intensity duration of rainfall in data-scarce regions is restricted to coarse temporal resolution (typically daily total), which hinders the option to run a hydrological model for hazard (scenario) analysis. Although the daily totals would allow rainfall calculation over various return periods based on historical data (Gumbel, 1941). The temporal resolution stays with the daily total and needs correlation over smaller timesteps. Downscaling the daily total intensity into shorter temporal intervals can be achieved by (among other methods) incorporating remote sensing means because of its global availability and better temporal resolution. One example comes as an output of the Global Precipitation Mission (GPM) of NASA, which allows the combination of data acquired over many simultaneously running satellites. Integrated Multi-satellitE Retrievals (IMERG) is one of those algorithms (Huffman et al., 2020) that interpolates (involving recalculations) data from various satellites (mostly on the microwave and infrared spectrum) moving around the globe to publish datasets of rainfall intensity at various temporal and spatial resolutions. The finest spatial resolution available is $0.1^{\circ} \times 0.1^{\circ}$ degree, which within the geographic coordinates (WGS84) would correspond to ~ 11.1 (lat) $\times 9.8$ (long) km for Nepal (28°N). The temporal resolution, however, is available over various datasets that range from every 30 minutes to daily and monthly.

The algorithms used within IMERG are advancing with new versions. Version 7 has been ongoing since mid-2024, having replaced version 6. The data availability within GPM is as early as June 2000. Aimed to address different problems, three sets of data are published 1) early run: intended for immediate disaster operations for first responders, 2) late run: interpolation of the early run aiming to make the dataset more precise, and 3) final run- station calibrated, encouraged for use in research. The final run calibrates the precipitation data with station measurements covering most parts of the world and is thought to have the greatest accuracy over the USA. However, data in the Himalayas needs closer monitoring because of the orographic effect. The IMERG product,

therefore, needs calibration over the mountain catchment based on the station measurements within. The calibration could be crucial depending on the type of assessment it is used in, for example, decisions around relocation of a settlement.

2. Example from a mountain rainfall station

Data from the Tarke Ghyang rainfall station in central Nepal, maintained by the Department of Hydrology and Meteorology, the Government of Nepal, is shown in Figure 1. The station lies at lat long (WGS84) 28.0° N 85.5° E with the station ID- S1058. Data from 1974-2011 was analysed, including the recorded daily total precipitation measurement. The daily data was computed with a Gumbel distribution to calculate the daily total rainfall intensity for return periods of 20 years and 100 years, which were respectively 206 and 268 mm/day. Separately, the IMERG record was downloaded within the Google Earth Engine environment to get output for the calculated intensity within the Tarke Ghyang area for one high rainfall day (2011-07-17). The code for retrieving IMERG V07 is available here¹. IMERG records are shown by the green line in Figure 1 which represents the half-hourly intensity obtained for Tarke Ghyang. The IMERG daily total was summed to be 151 mm, for which the daily total on Tarke Ghyang station measures 82 mm. The IMERG record overestimated the rainfall in this case.

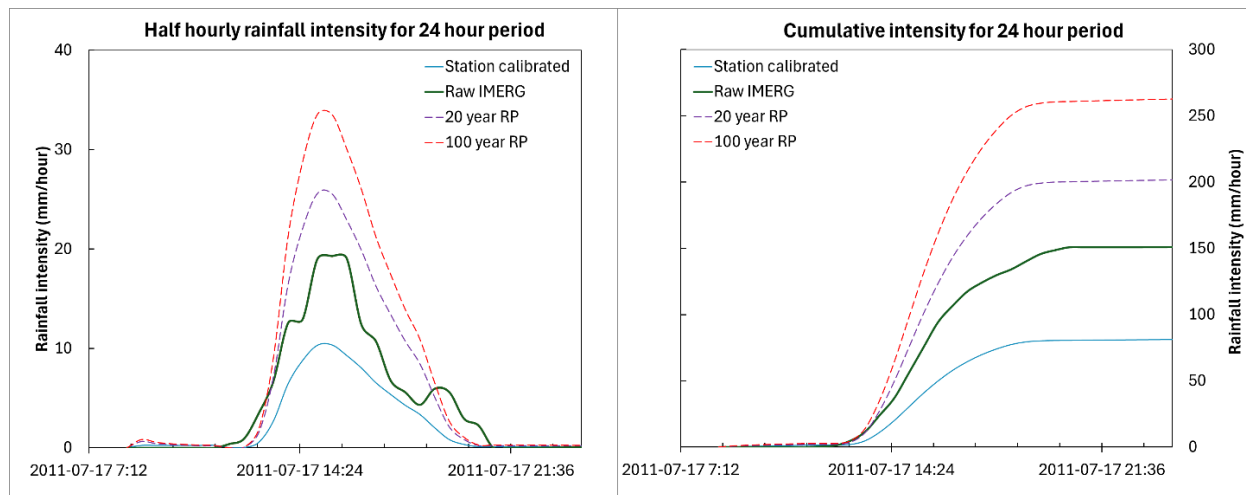


Figure 1 Half-hourly rainfall intensity (left) and cumulative for 24 hours (right) for Tarke Ghyang Station. The green line shows the satellite-measured intensity, and the blue line shows the corrected intensity based on station measurement. The dotted lines show the extrapolation for various return periods of rainfall.

¹ https://developers.google.com/earth-engine/datasets/catalog/NASA_GPM_L3_IMERG_V07



Since the satellite measurement did not match the station measurement and considering the station measurement of rainfall more precise, the rainfall intensity is fitted according to Johnson's SB distribution to obtain the daily total measurement equal to 82 mm for 2011-07-17. Moreover, this rainfall intensity could also be extrapolated into the derived return period values to fit the daily distribution obtained within the IMERG record. The designed intensities are shown in Figure 1. The Johnson SB distribution is used for data fitting as it allows flexibility in the curve fitting with two shape parameters, one scale parameter and one location parameter (Johnson, 1949).

3. Conclusion

This workflow shows the calibration of satellite-measured rainfall intensity with data fitting within a flexible distribution. Upon the time series analysis of historical rainfall records, the workflow also showed how a daily total rainfall could be downscaled with the assumption that the rainfall intensity would be distributed according to the date 2011-07-17. The storm designed here can be meaningful in generating scenario analysis in areas lacking temporal resolution shorter than a day. However, the data should be used with the disclaimer that the results shown for the return period analysis are completely derived from a data extrapolation exercise which should be used with caution.

4. Data

An Excel sheet for data fitting with Johnson's SB distribution is [available to download](#). The fitting would require [Solver add-in](#) on Excel.

References

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