Estimating Probable Maximum Precipitation From IMERG Satellite Dataset

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1. Introduction

The Integrated Multi-Satellite Retrievals for Global Precipitation Measurement (IMERG) is a new dataset that provides global precipitation measurement (Guo et al., 2016). This research identifies data gaps peculiar to data scarce regions and attempts to fill those gaps, by extracting 20-years of precipitation record from IMERG and computed their PMPs at different durations. The computed PMPs were validated using station PMPs from NOAA-Atlas-14 55-gauge sites, randomly selected across Kansas. The overall goal were to ascertain the reliability of IMERG computed PMP for applications in water resource management especially as pertaining precipitation extremes which could lead to flood. Key concerns addressed by the study were basically, how well IMERG PMPs compared with station PMPs, influence of precipitation regions and variability on IMERG PMPs, how total accumulated precipitation and maximum precipitation influences PMP errors at different durations. in addition.

2. Data and Study Site

- Satellite Precipitation Dataset (Final Run-GPM_3IMERG V06)
- Rain Gauge Based PMP (NOAA-Atlas-14 station PMP)

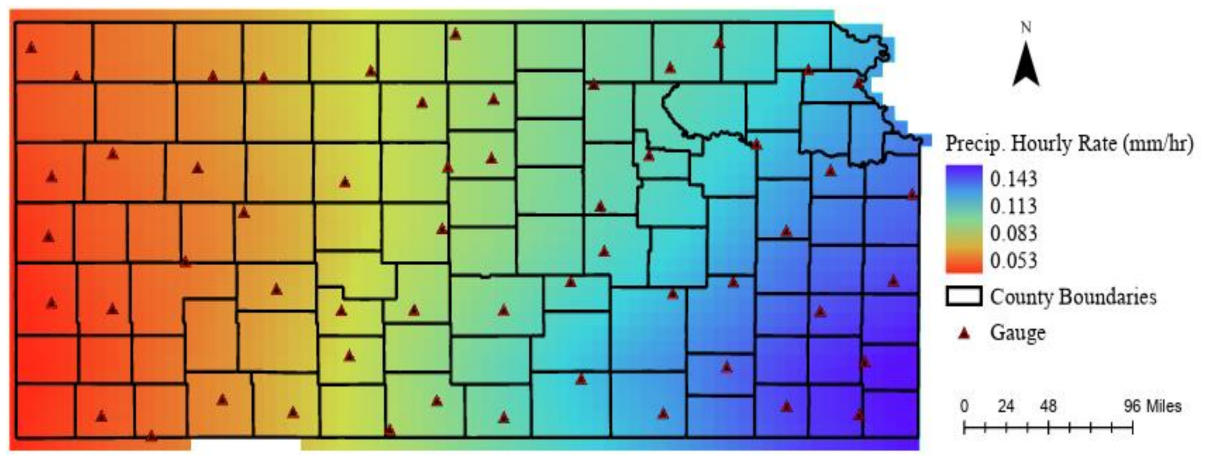

Figure 1. Rain gauge locations used for evaluating IMERG derived PMP, county boundaries in Kansas, and the hourly precipitation rate (mm/hr) between 2000 and 2020.

3. Methods & Workflow

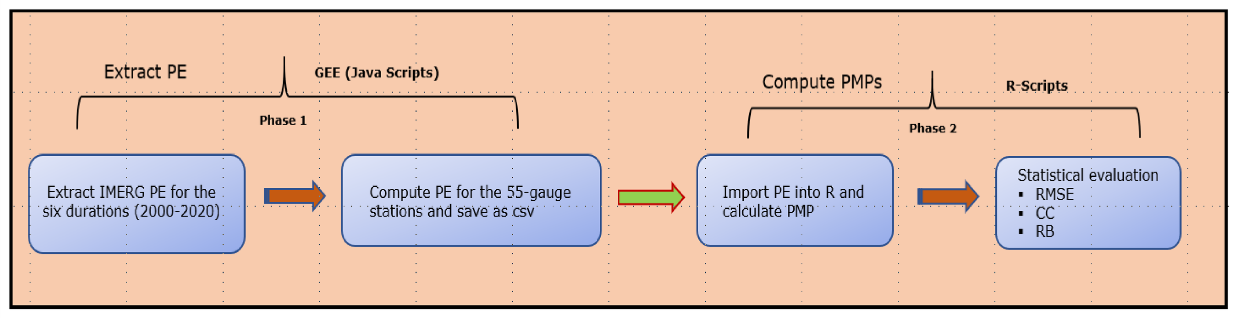

Figure 2. Summary workflow

The frequency factor (K_m) can be calculated using the equation below:

$$K_m = \frac{Rmax - \overline{R_{n-1}}}{S_{n-1}} \quad (1)$$

where R_{max} is the highest value in the series, $\overline{R_{n-1}}$ is the mean of the series excluding the largest value, and S_{n-1} is the standard deviation of the series excluding the largest value. With K_m calculated, the PMP for a given duration of T (PMP_T) can be calculated using the equation below:

$$PMP_T = \overline{X} + K_m \times S_n \quad (2)$$

where $\overline{X}$ is the Mean of the precipitation data, K_m is the frequency factor, and S_n is standard deviation of the precipitation record.

Figure 3. Hershfield PMP Calculation setup

4. Results

4.1 IMERG PMP Evaluation at Durations

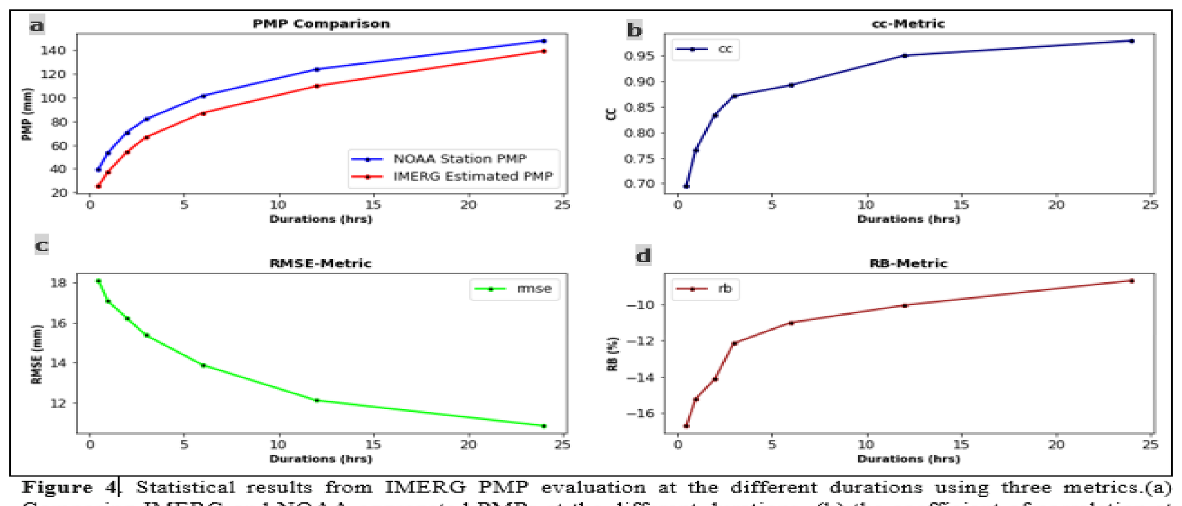

Figure 4. Statistical results from IMERG PMP evaluation at the different durations using three metrics.(a) Comparing IMERG and NOAA aggregated PMPs at the different durations (b) the coefficient of correlation at different intervals of PMP. cc increases with increase in duration (c) the root mean square error in mm at different intervals of PMP decreases as duration increases. (c) the relative bias (%) at different intervals of PMP, showing highest underestimation at shorter durations.

4.2 IMERG PMP Error Interpolation at Durations

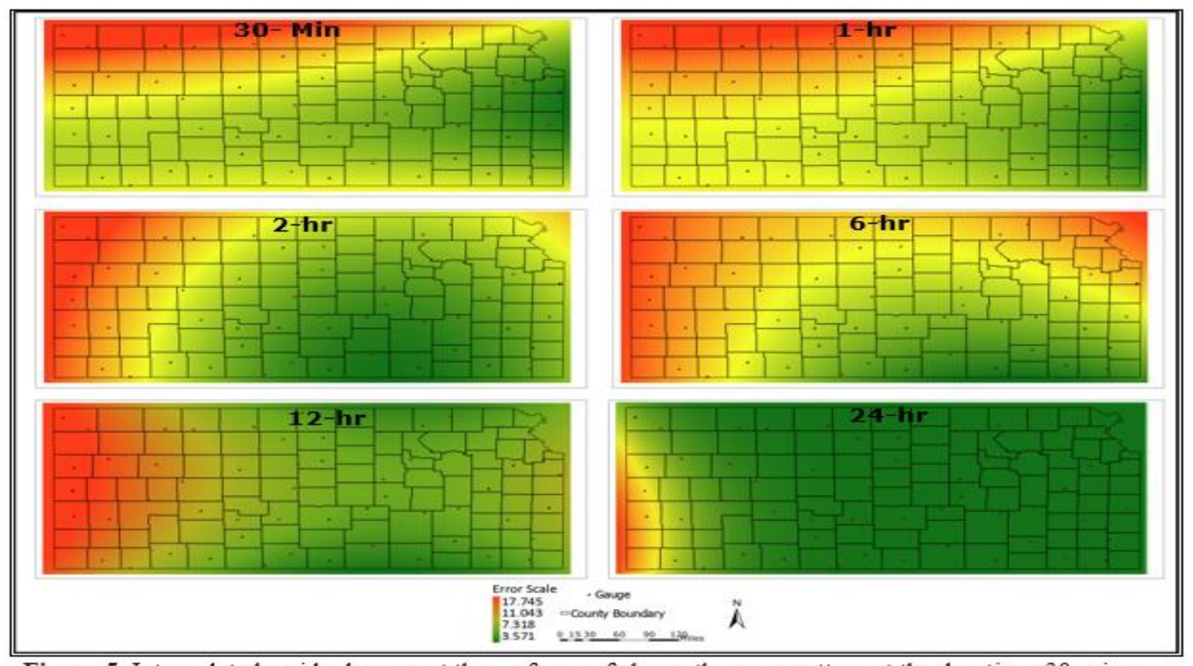

Figure 5. Interpolated residual errors at the surface. a-f shows the error pattern at the durations 30-mins, 1-hr, 2-hr, 6-hr, 12-hr, and 24-hr respectively.

4.3 IMERG PMP Assessment at the 90% confidence Interval

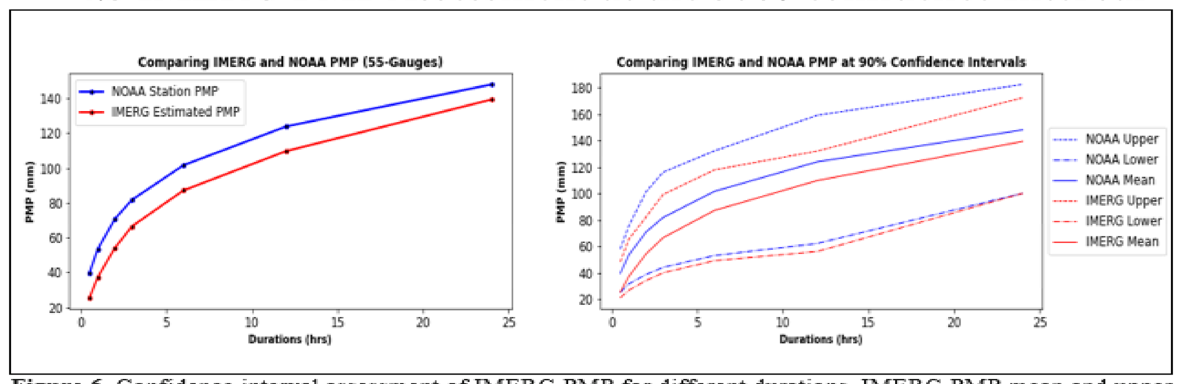

Figure 6. Confidence interval assessment of IMERG PMP for different durations. IMERG PMP mean and upper limits fell within 90% confidence interval of NOAA PMP. However the lower limits fell out of range and must be used with caution.

4.4 Influence of Precipitation Amount on IMERG PMP

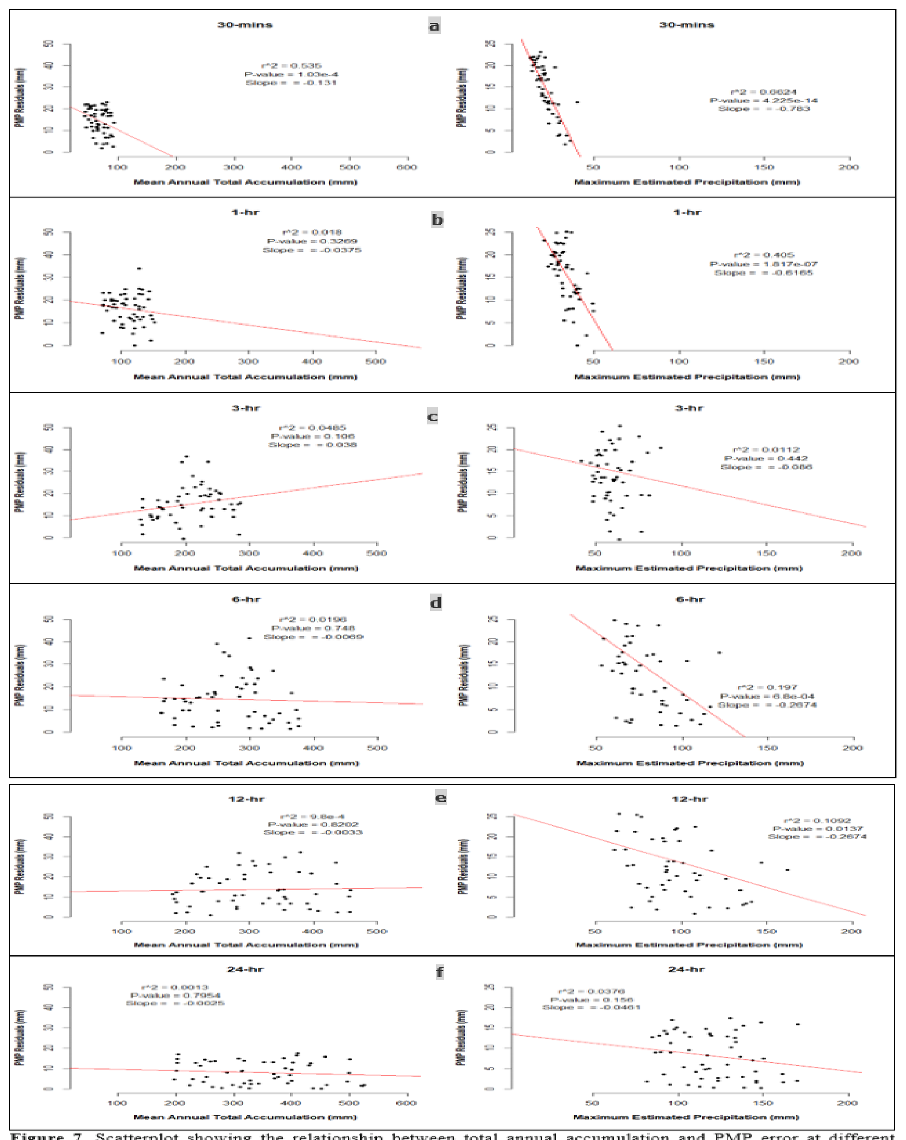

Figure 7. Scatterplot showing the relationship between total annual accumulation and PMP error at different intervals. (a-f) shows the relationships and correlation at the durations 30-mins, 1-hr, 3-hr, 6-hr, 12-hr, and 24-hr respectively. The statistical results (P-value and R-squared) suggests that IMERG annual total accumulation and IMERG maximum estimated precipitation influences IMERG PMP error most at the short duration (30-min) than the long duration (24-hr).

4.5 IMERG PMP Assessment at the zones

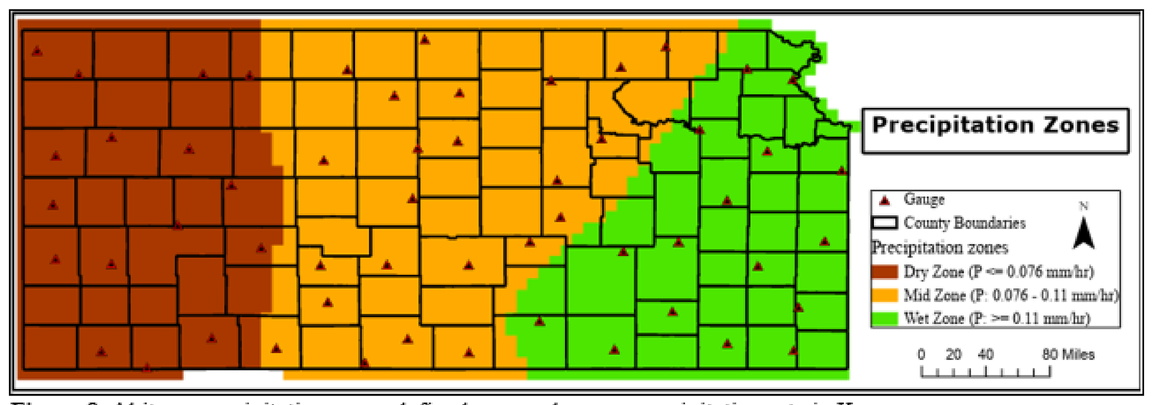

Figure 8. Abitrary precipitation zones define by annual avrage precipitation rate in Kansas.

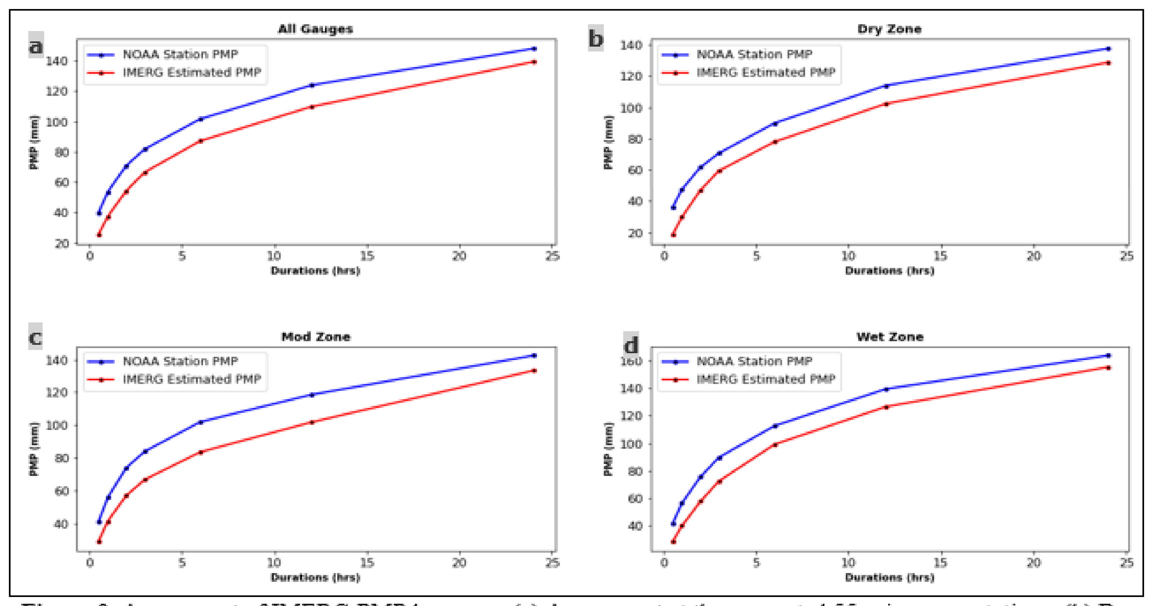

Figure 9. Assessment of IMERG PMP by zones, (a) Assessment at the ggregated 55-rain gauge stations, (b) Dry zone, (c) Moderate zone, (d) Wet zone. The vertical axes represent the PMP depths why the horizontal axes are the durations.

4.6 IMERG PMP Validation at the zones

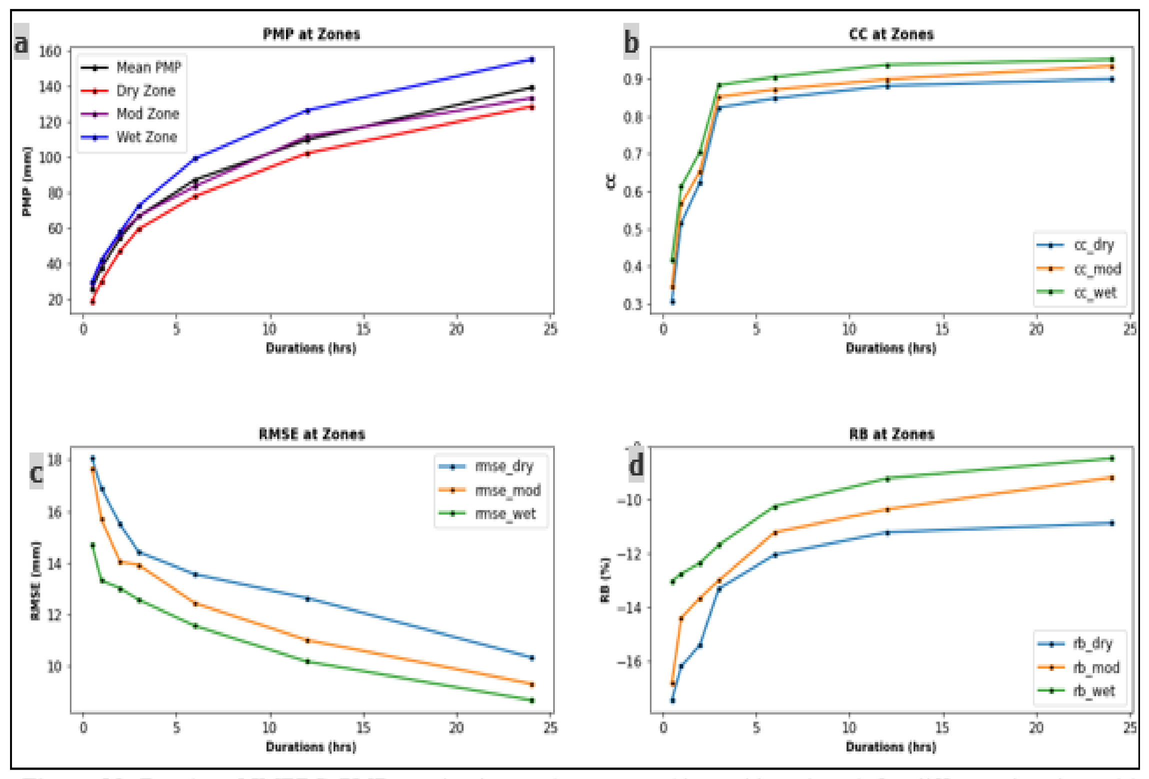

Figure 10. Results of IMERG PMPs evaluation at three zones (dry, mid, and wet) for different durations. (a) average PMPs at the zones, (b) coefficient of correlation at different zones (b) root mean square error in mm (c) relative bias in %. The horizontal axes show the durations while the vertical axes present the statistical metrics.

5. Findings & Conclusion

- The method advanced in this study show great promise for estimating PMP from IMERG satellites.
- IMERG estimates PMP better at longer durations (e.g., 24-hr) with lesser error than shorter duration (e.g., 30-mins)
- IMERG PMP are better in wet zones with less error compared to dry zones. The more the precipitation the better the PMP.
- IMERG PMPs are more underestimated at short duration (e.g., 30-min)
- The study recommends improving the Hershfield frequency factor (km)

References

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