

Extended Triple Collocation for Enhanced Precipitation Analysis: Evaluating and Integrating GSMaP ISRO Rain, GSMaP, CHIRPS, and ERA5 Rainfall Data

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1. Introduction:

- Background and Objective:** GSMaP ISRO Rain, a collaborative product by ISRO and JAXA, corrects GSMaP using IMD gauge data from March 2000. This study aims to assess GSMaP ISRO Rain's accuracy compared to GSMaP over India.
- Statistical Method:** Triple Collocation (TC) and Extended Triple Collocation (ETC) allow estimation of error variances and correlation with unknown truth without ground truth data. These methods also enable development of a merged product with reduced error variance and improved correlation coefficient (CC). [4]
- Challenge:** TC and ETC methodologies require independent errors between datasets, which constrains direct comparison between the related products GSMaP ISRO Rain and GSMaP.
- Proposed Solution:** To overcome this limitation, ERA5 reanalysis and CHIRPS are incorporated due to their independent measurement methodologies. The study analyzes two triplets: (GSMaP ISRO Rain, CHIRPS, ERA5) and (GSMaP, CHIRPS, ERA5) using TC and ETC techniques.
- Outcome:** This approach enables indirect comparison of GSMaP ISRO Rain and GSMaP through their relationships with ERA5 and CHIRPS. Additionally, the resulting merged products from each triplet potentially offer enhanced precipitation estimates for India, featuring reduced error variance and improved CC with true unknown precipitation.

2. Study Area:

India was divided into seven climatic zones according to the Köppen-Geiger climate classification [2, 3]. Here, we discuss the (Aw) Tropical, savannah region as it covers major portion of peninsular India.

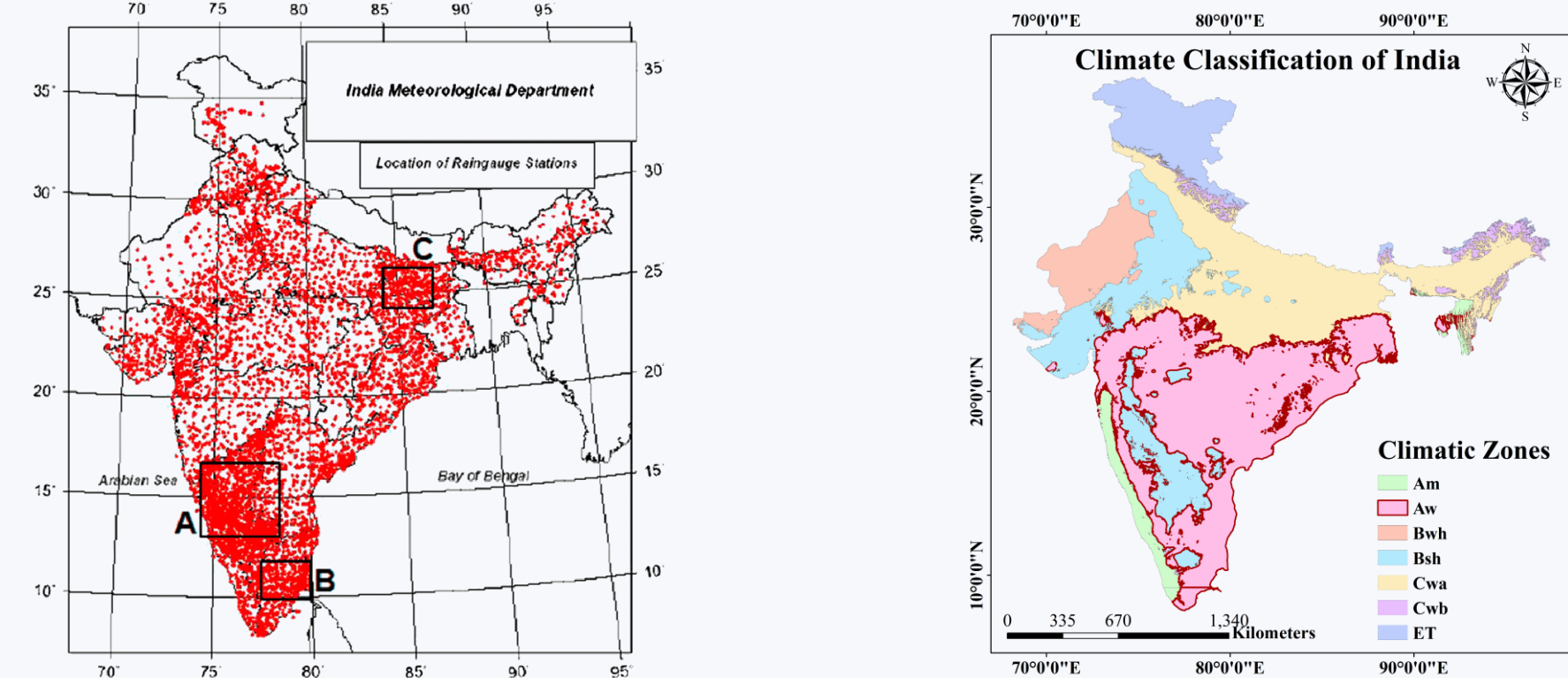


Figure 1: IMD Gauge locations [1] Figure 2: Climate Classifications (India)

3. Data Used:

Table 1: Data and their sources

Dataset	Spatial Resolution	Temporal Resolution	Units	Source
GSMaP	0.1°x0.1°	Hourly	mm/hr.	JAXA
ERA5	0.25°x0.25°	Hourly	mm	ECMWF
CHIRPS	0.05°x0.05°	Daily	mm/day	UCSB
GSMaP ISRO	0.1°x0.1°	Hourly	mm/hr.	ISRO

- Data Download Time period: 2018 to 2022 (JJAS).
- All data were spatially resampled to 0.25° and temporally to daily.

4. Methodology:

I. Assumptions Considered:

- Linear relation between unknown true precipitation and each dataset.
- Errors in input are independent.
- Errors in the three input measurements are uncorrelated.
- Expected value of errors is zero.

II. Triple Collocation (TC) & Extended Triple Collocation (ETC):

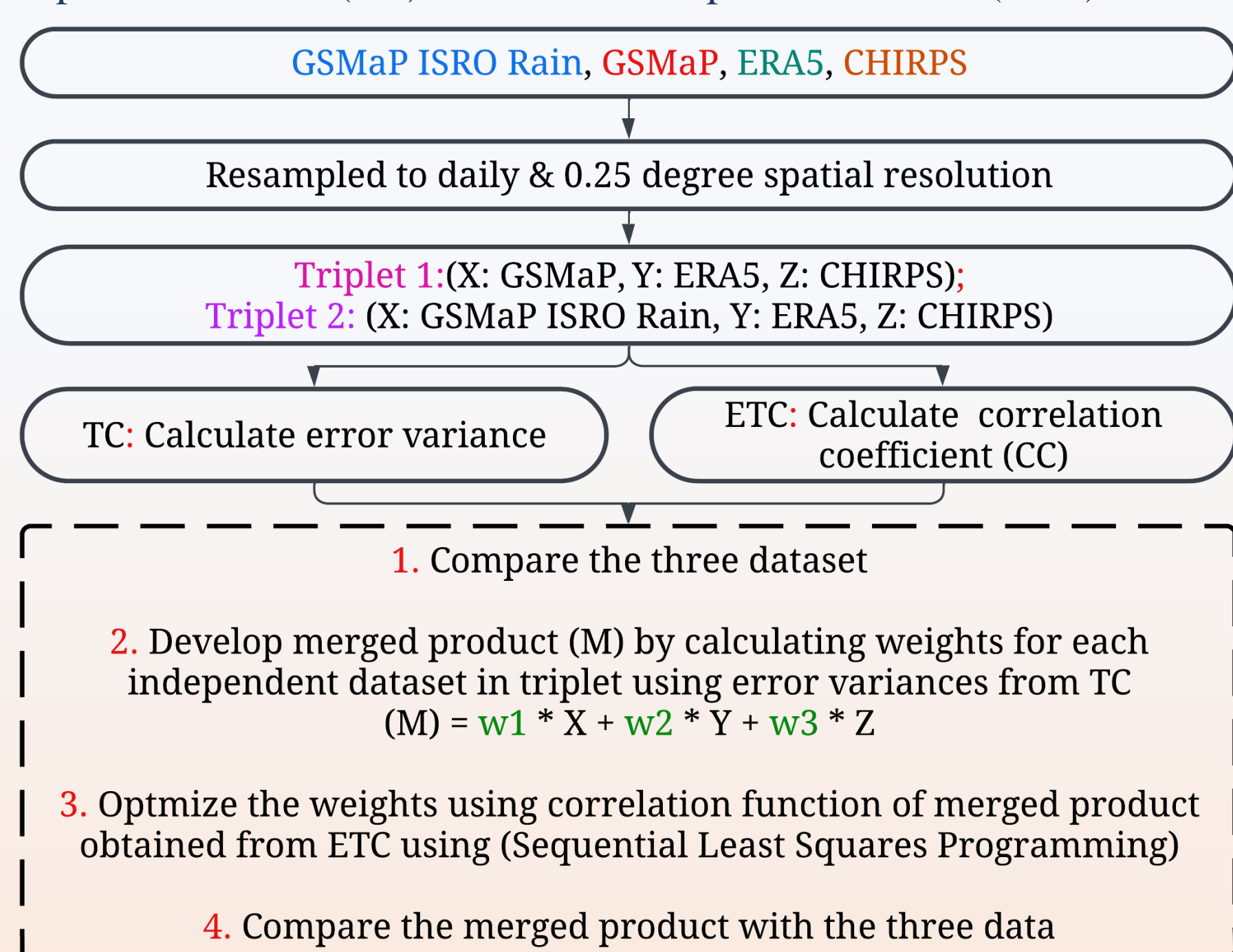


Figure 3: Flowchart of work

5. Results:

a. Extended Triple Collocation with Triplet 1 (GSMaP, ERA5 and CHIRPS):

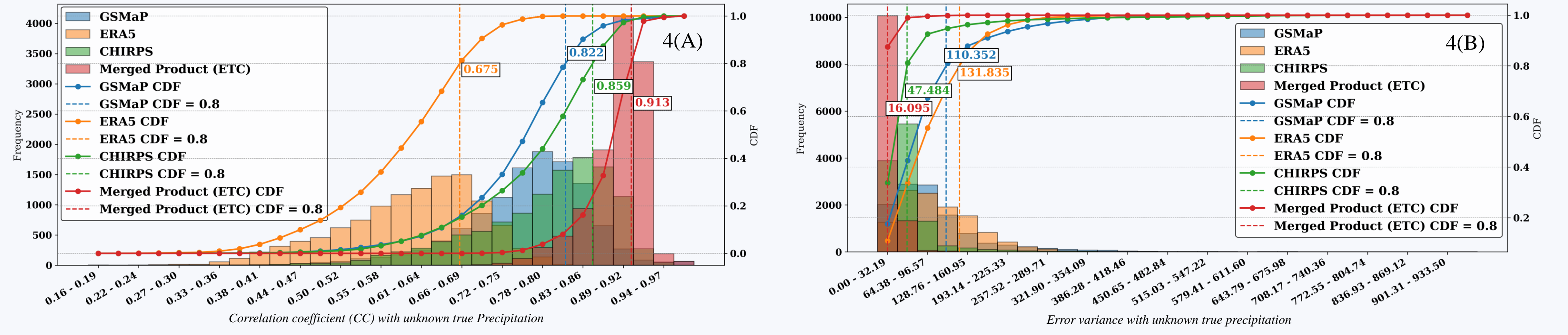


Figure 4: Histogram with CDF of CC (A) and error variance (B) of Triplet 1 & merged product with unknown true precipitation

Comparing (GSMaP, ERA5 and CHIRPS):

- Error Variance:** CHIRPS had least, while ERA5 had highest.
- Correlation:** CHIRPS had highest, while ERA5 had least.
- Performance:** CHIRPS > GSMaP > ERA5

❖ Merged product using ETC had least error variance and the highest Correlation CC.

b. Extended Triple Collocation with Triplet 2 (GSMaP ISRO Rain, ERA5 and CHIRPS):

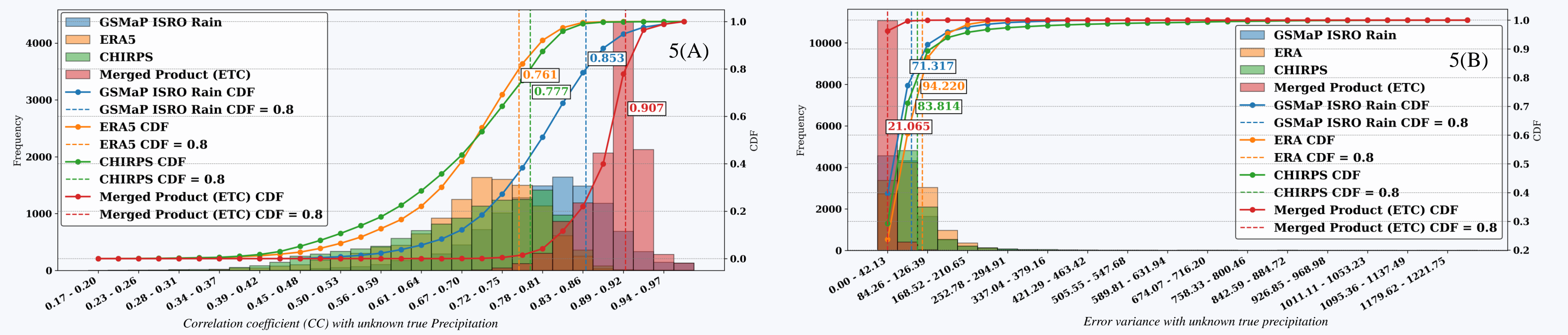


Figure 5: Histogram with CDF of CC (A) and error variance (B) of Triplet 2 & merged product with unknown true precipitation

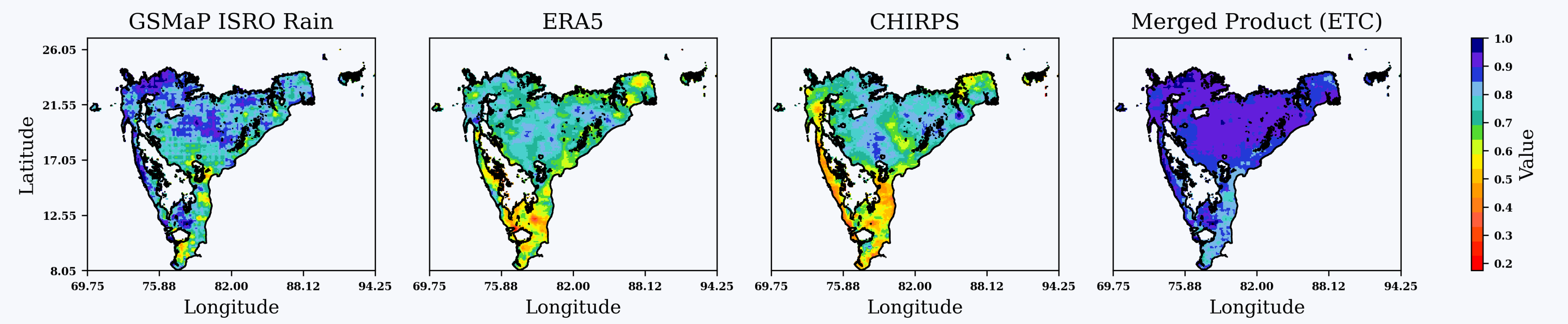


Figure 6: Scatter plot of CC of Triplet 2 & merged product with unknown true precipitation

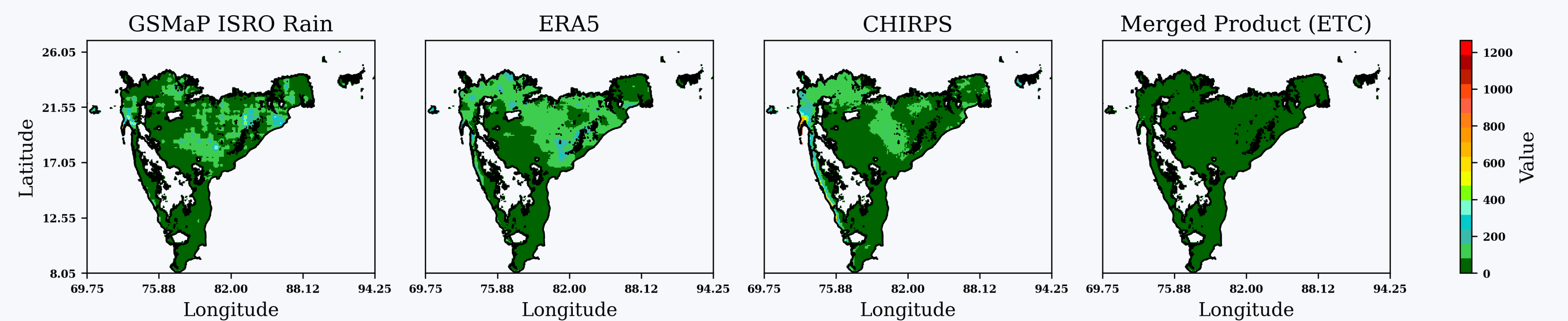


Figure 7: Scatter plot of error variance of Triplet 2 & merged product with unknown true precipitation

Comparing (GSMaP ISRO Rain, ERA5 and CHIRPS):

- Error Variance:** GSMaP ISRO Rain had least, while ERA5 had highest.
- Correlation:** GSMaP ISRO Rain had highest, while ERA5 had least.
- Performance:** GSMaP ISRO Rain > CHIRPS > ERA5

❖ Merged Product using Extended Triple Collocation had least Error Variance and the Highest Correlation Coefficient

6. Conclusion:

- GSMaP ISRO Rain > CHIRPS > GSMaP > ERA5.**
- ETC enabled comparison of satellite precipitation products without ground data, indirectly assessing GSMaP ISRO Rain versus GSMaP.
- Merged product developed through ETC methodology outperformed individual datasets in CC and error variance with unknown true precipitation.
- The best merged product combines GSMaP ISRO Rain, CHIRPS, and ERA5.
- GSMaP ISRO Rain generally outperforms GSMaP in (Aw, Am, Bsh, Cwa, Cwb), but results are mixed in the Bwh and ET climatic regions.

7. References:

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