Advancing Extreme Precipitation Modeling Using Data Fusion and Machine Learning

Muhammad Umar Nadeem[1], Koji Dairaku[1]

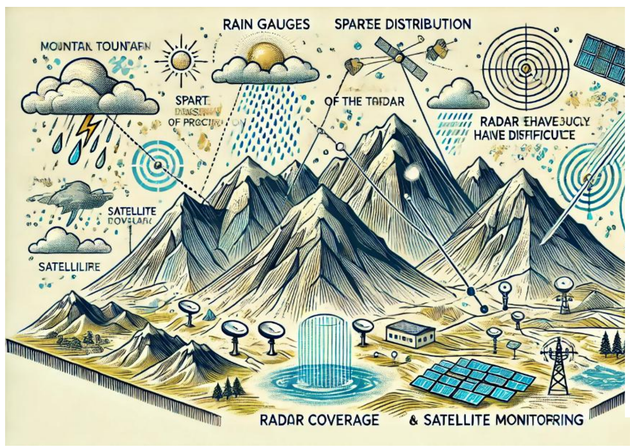
1. Department of Engineering Mechanics and Energy, Graduate School of Science and Technology, University of Tsukuba, Tsukuba, Ibaraki, Japan

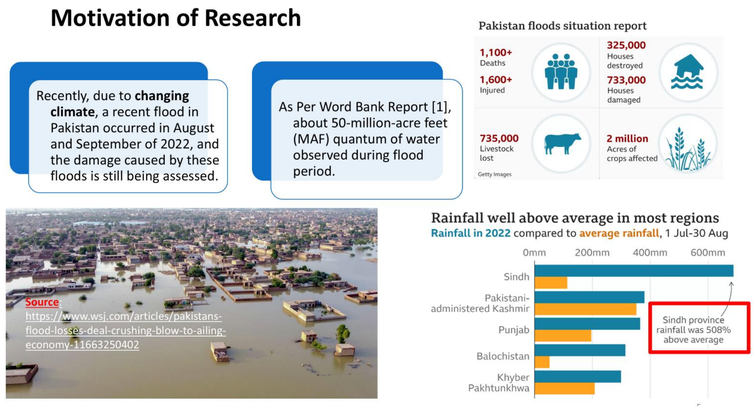
(email: s2330212@u.tsukuba.ac.jp)

Poster Number: **P-76**

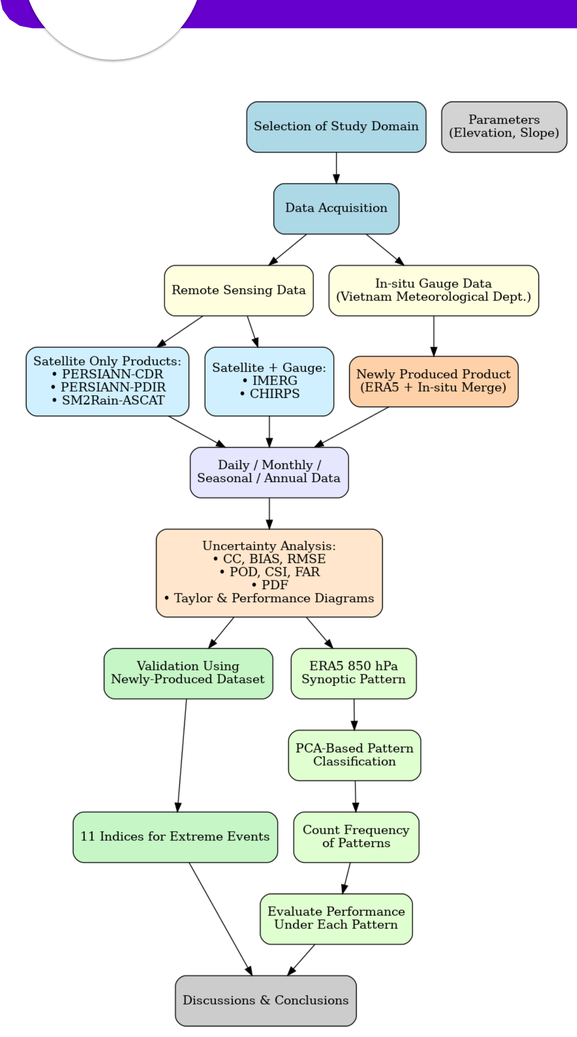
1 Background and Motivation

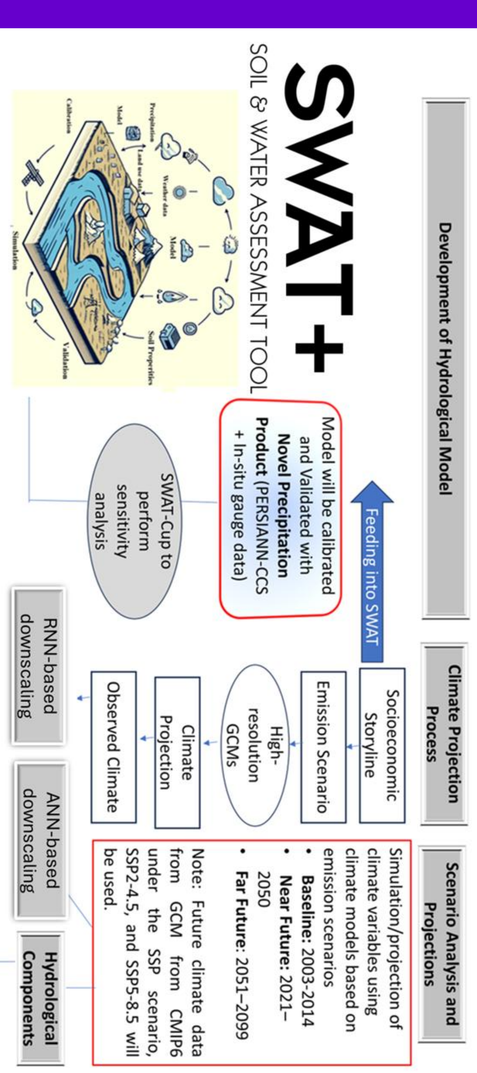
- Extreme precipitation is a major driver of flooding in Pakistan and is challenging to accurately capture in complex mountainous terrain, including Vietnam.
- Climate Change is intensifying extreme precipitation.
- Existing precipitation products cause large uncertainty in precipitation Modeling.
- Machine-learning models lack reliable reference precipitation data.





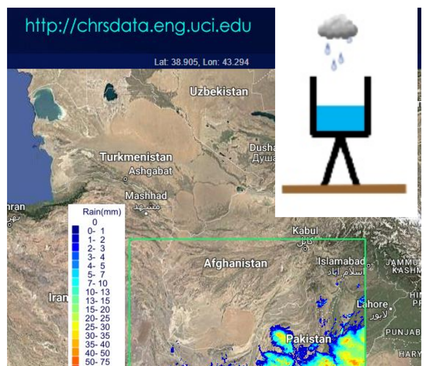
2 Materials and Methods





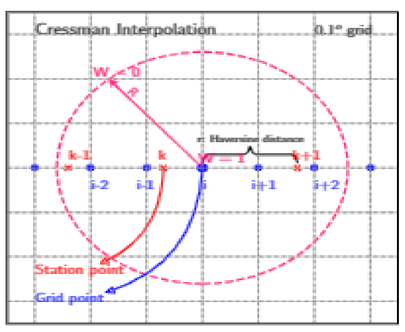
ERA5-Land reanalysis data
a global land-surface by ECMWF
0.1°× 0.1°; hourly; 1981—2019

In-situ data
128 and 63 stations for precipitation and T2m, respectively; daily; 1981—2019



Cressman interpolation method (Cressman, 1959)

$$fo_i = fb_i + \frac{\sum_{k=1}^{K} W_{ik}(o_k - fb_k)}{\sum_{k=1}^{K} W_{ik}}$$



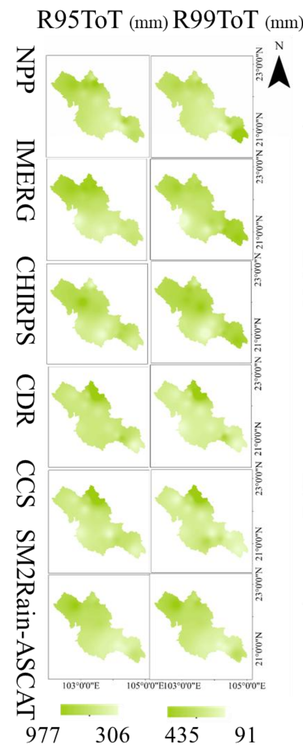
- fo, fb, o_k, and W_{ik}: output, background observed data, and weighted coefficients, respectively.
- i, k: indices for locating grid cells.
- K: number of calculated grids.

$$W_{ik} = \frac{R^2 - r_{ik}^2}{R^2 + r_{ik}^2}, r_{ik}^2 \le R^2$$
$$W_{ik} = 0, r_{ik}^2 > R^2$$

- R: the influent radius; r_{ik}: the distance of the grid point to the located station.
- Stations located closer to the grid point have the greater weight and conversely, the greater the distance, the less weight the stations carry.

Figure 1: Salient features of data fusion methods to produce new precipitation products (**NPP**).

3 Results



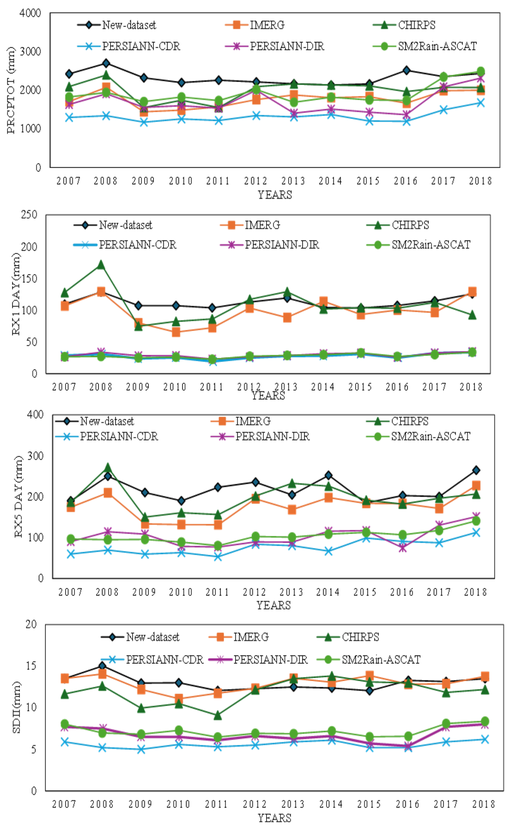


Figure 2: Spatial-temporal performance of NPP against leading SPPs over the complex terrain of Vietnam.

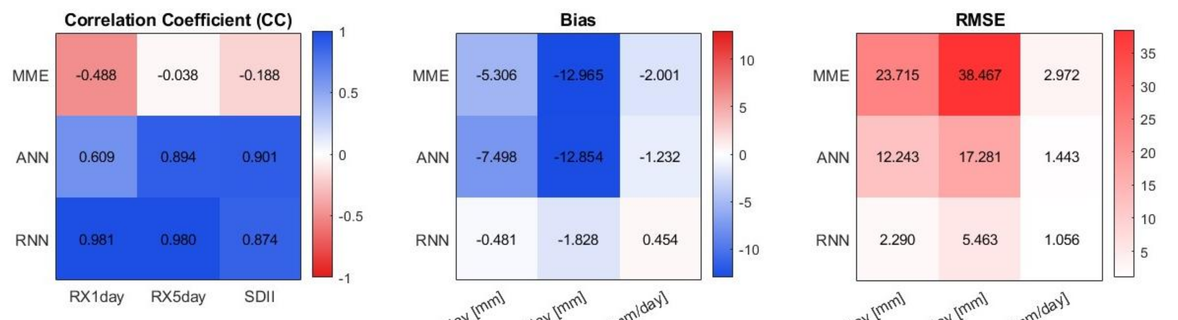
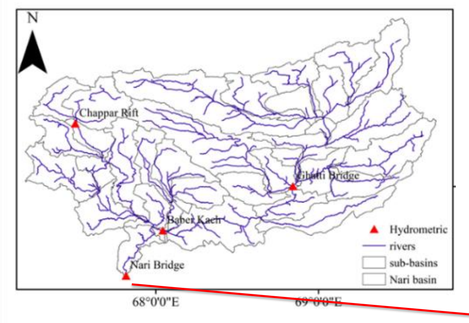


Figure 3: Machine-learning models (ANN, RNN) show clear added value in capturing extreme precipitation over flood-affected regions of Pakistan.



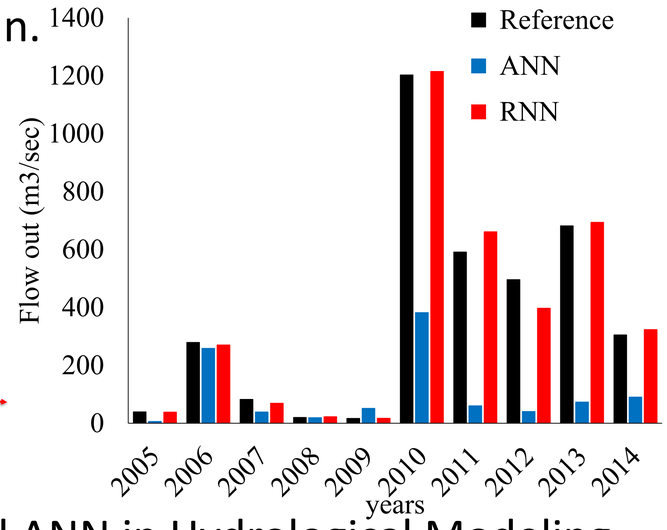


Figure 4: Added value of RNN and ANN in Hydrological Modeling over flood-affected regions of Pakistan.

4 Key finding

- **Combining data fusion, machine learning, and physically based hydrological modeling significantly enhances the representation of extreme precipitation and flood simulations.**

❖ Acknowledgement

SAT TECHNOLOGY SHOWCASE 2026 2026年 1月22日(木) テクノロジー・ショーケース つくば国際会議場

筑波大学 University of Tsukuba

文部科学省 MEXT Scholarships