Uncertainty of GSMaP and PERSIANN Dataset for Precipitation Estimation in Huai Luang Basin

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ABSTRACT

Huai Luang is one of the important basin in North Eastern of Thailand and flowing to Mekong River, the Main River in Indochina region. Precipitation plays a vital role to trigger to calculate water budget in the basin for planning in watershed management especially early warning to prevent life and property of people. In this study, we want to assess the uncertainty of two precipitation measurement with RS techniques; 1) Global Satellite Mapping of Precipitation (GSMaP) and 2) Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN). With Quantitative precipitation estimation (QPE), Probability of Detection (POD), False Alarm Ratio (FAR), Threat Score (TS), Percent Correct (PC), and Frequency Bias (B) are utilized to verify performance of modification rainfall. Uncertainty comparing between GSMaP and PERSIANN is measured with root mean square error (RMSE), Mean Absolute Error (MAE), bias (BIAS) and Nash-Sutcliffe efficiency coefficient. The final result found that PERSIANN based QPE dataset has less uncertainty than GSMaP, therefore, PERSIANN being very good accuracy for estimate rainfall in our study area, and can be good example for any country of "Lower Maekong Region" for apply QPE technique with related RS precipitation data

1. INTRODUCTION

The traditional idea in remote sensing assume that rain fall estimation made easy by getting data of cloud from remote sensing technology, but not easy as we think. The pioneer researcher found that characteristic of cloud is also be affected to trigger rainfall. (Kidder and Vonder Haar, 1995) In late 20 years rain fall estimation in remote sensing technology has been advance than ever (Zhang *et al.*, 2013) such as apply with artificial neural networks estimation. The widespread unitized RS tools are PERSIAAN, Geostationary, Polar-orbit and Tropical Rainfall Measuring Mission (TRMM). These all RS rainfall estimation tools are Quantitative Precipitation Estimation (QPE) and can enhance Satellite Based rainfalls for more accuracy with ground truth (Rain gauges data)

In 1974, the first Polar-orbit satellite was launched in orbit synchronous with estimation rain fall development emerges. Five years later, TRMM which is the collaboration between US government and Japan government with the interesting property microwave rainfall measurement sensor (Beltrando and Berges, 2014) first open to the public. It can observe rainfall in not only global scale but also local scale. Satellite has outstanding property in detect rain fall in large area which is showing the accurate pattern of rainfall event and quantity accuracy (Fu *et al.*, 2011). In additions, Satellite Mapping of Precipitation (GSMaP) provide data to public in 2002 which has various input data source and measure various wavelength.

PERSIAAN is one of the most famous data set which comprehensive studied, it is estimate precipitation by using Neural Network method with Brightness temperature measured in infrared wavelength sensor in Geostationary satellite as input data. (Brown, 2006)

Developed by The University of Arizona, Artificial Neural Network (ANN) helps estimation rainfall to be the simple data set and user friendly such as adjusting rainfall data with mathematic equation. After successfully utilized infrared wavelength, other wavelengths-Visible light on daytime period have been plan to combine in estimation process in next phase. (Sorooshian *et al.*, 2000)

GSMaP were use in China as following, Zhao's study found that satellite rainfall estimation was slightly improve with with linear correlation in all seasons except summer (Zhao *et al*., 2018). In Hanjing river basin the error between GSMaP and rain gauge were reduce by using quadratic polynomial fitting (Deng *et al*., 2018). Meanwhile PERSIANN were used QPE to downscale rainfall estimation with quadratic parabolic profile model in Yangtze, Yellow, Lantsang river basin showing more reliable than non-QPE (Zhang *et al*., 2018)

Thailand has a plenty of water resource, as being vital role to protect and reserve water to maintain ecosystem for living thing including human. However water hazard (flood and drought) still occurred in many area. Climate is one of the key factor, which trigger water resource problem. Water requirement are increase every year, historical record of food and agriculture organization (FAO) founds that Thailand charts in top ten ranked in water consumption in the world, most of water consumed in food industry for export without suitable water management cause drastic drought occurred frequently (Khaosa`at, 2001).

This study indicates Huai Luang watershed area, located in Thailand northeastern region, belong to three provinces as Khonkaen, Udonthani and Nongkhai. This area is also being Mekong river sub basin, which supplying water to farm area, anyway, but not enough, hence drought occurs frequency. In contrary, flood situation took place in urban area (Vansarochana *et al*., 2016).

2. METHODOLOGY

2.1 Study area

Huai Luang watershed area, has smooth rolling low hill and some parts extremely low land draining to Mekong River. Water hazard occurred frequently including flood in wet season and drought in dry season. Especially in 2011, farm land 215,000 rai encounter flood event above than average record (90,000 rai). Meanwhile, scarce water for consumption still takes place in same area in dry season.

2.2 Data collection

Three data set were used as following

1. GSMaP NOW data provided by Japan Aerospace Exploration Agency (JAXA) is hourly temporal near real time data analyzed satellite image

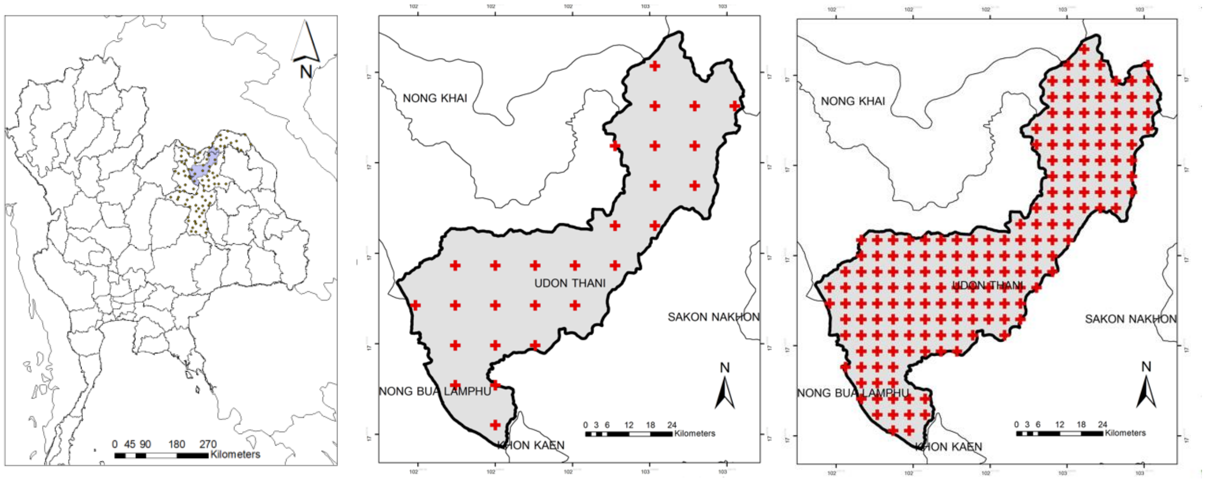
2. PERSIANN provided by University of California, Irvine (UCI) is hourly satellite based rainfall same as GSMaP

3 Automatic rain gauges are provided by Thai Meteorological Department.

All data set time starts at 1 Jan 2016 till 30 August 2018.

2.3 Methods

Rain gauges data were separated in two groups, first groups has 5 station in basin as control group using as ground truth the other 6 stations in basin (showing in figure1) with 53 outer basin stations (figure 2) as quality control by interpolation method and Quantitative precipitation estimation (QPE) process.



a b c

Figure 1. Study area in Huai Luang Basin;
(a) Rain gauge station (b) GSMaP grid points (c) PERSIANN grid points.

First step QPE process using Mean field bias equation (equation 1) adopting delta calculation with rain gauge (G) over remote sensing (R). Multiply slope to adjust rainfall. Next, Inverse distance weight (IDW) calculate weight of rainfall which least distance between station more influence than far one (Mahavik, 2017).

$$C_{MFB} = \frac{\sum_{i=1}^{N} G_i}{\sum_{i=1}^{N} R_i} \qquad (1)$$

QPE satellite rainfall data were compare with satellite data and rain gauge .Scalar Accuracy Measures names as Mean absolute error (MAE), Root mean square error (RMSE) were used. In addition, statistical skill score apply to verify performance of estimation names as Probability of Detection (POD), False alarm ratio (FAR), Threat Score (TS), Percent Correct (PC), and Frequency Bias (B), In term of efficiency of estimation rainfall can be detect by Nash–Sutcliffe model efficiency coefficient (EFF) and bias (BIAS).

3. RESULT AND DISCUSSTION

The Dichotomous Variables (2 –category) evaluation shown that QPE Technique has performance to reduce error and bias. Besides, Misses events are increase cause POD and TS score poorer as shown in table1.

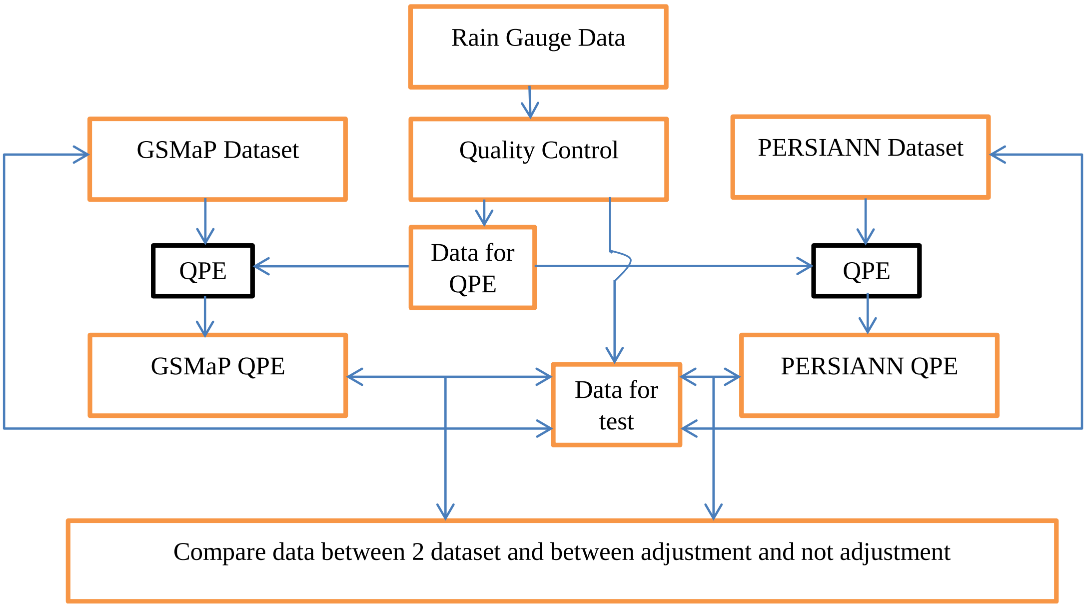


Figure 2. Research work flow

Table.1 category skill score of satellite based rainfall

Dataset	POD	FAR	PC	TS	B
GSMaP	*0.30*	*0.43*	*0.42*	*0.24*	*0.53*
PERSIANN	0.20	0.43	0.45	0.17	0.35
GSMaP-QPE	0.20	0.23	0.46	0.19	0.26
PERSIANN-QPE	0.07	0.38	0.44	0.07	0.11

In case of scalar accuracy and efficiency of rainfall estimation pointed out that uncertainty and efficiency are improved with QPE method as shown in table.2.

Table2. Scalar accuracy and efficiency of satellite based rainfall

Dataset	MAE	RMSE	Eff	BIAS
GSMaP	0.96	3.40	0.22	501.60
PERSIANN	0.81	3.52	0.36	510.59
GSMaP-QPE	0.33	2.68	0.51	61.05
PERSIANN-QPE	0.22	2.25	0.74	0.06

All in all, after considering the statistical method valuation, QPE can be utilized as enhancing method for rainfall to reduce error and build efficiency with more correct negative events. Nevertheless, missing event also detect much more too.

We can conclude that QPE helps to underestimate rainfall causing light rain event change to no rain event as a result, missing event be soar. If only heavy rainfall such as tropical storm event is selected, QPE will show better performance than choosing all rainfall event in study period. Moreover, a few rain gauge stations casus generating error, radar network should solve this problem.

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