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A Improvement Method for Combined Satellite and Rain Gauge of Precipitation over Qinghai

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Abstract. The spatial and temporal distribution of precipitation is needed for a variety of scientific research, obtained usually used two ways, one is rain gauges measurement for using interpolation, another is remote sensing data which retrieval from satellite. But satellite estimates are indirect and need to be calibrated or verified using the gauge observations. In this paper, one method which based on combination of rain gauge and satellite is used to get the distribution of precipitation over Qinghai. Cross-validation tests is carried out to validate the approach. The results show that the method is suitable to produce high-resolution of precipitation over plateau.

Keywords: Remote sensing; Precipitation; TRMM Satellite; Cross-validation; Spatial Distribution

1. Introduction

High temporal and spatial resolution estimates of precipitation are required for many important applications[1], not only to weather forecasters and climate scientists, but also to a wide range of decision makers, including hydrologists, agriculturalists, emergency managers, and industrialists[2-3]. In general, rain gauge observations yield relatively accurate point measurements of precipitation but also suffer from sampling error in representing areal means, is difficult to characterize the spatial distribution of precipitation[4]. Futhermore, rain gauge observations is limited mostly to land areas where raingauges can be deployed, is sparse in many important regions, practically nonexistent over the remote regions. In mountainous regions, the rain gauge is sparse which tend to be in the valleys, seldom in Alpine. The observation data may underestimate the impact of topography on precipitation that occurs in mountainous terrain. In addtion, the interpolation methods used to grid the observations will introduce some degree of smoothing that may or may not be acceptable[3]. Today, because of the lack of finer-scale precipitation data, numerous applications remain stymied. How to obtain high resolution precipitation become an important research topic.

With the advent of meteorological satellites in the 1970s, remotely sensed estimates of precipitation from satellite become a research hotspot. Satellite estimates provide important information about precipitation especially over the remote regions and mountainous regions. Scientists developed techniques to estimate precipitation with advanced infrared (IR) and microwave (MW) instruments from satellites in recent dacades. With the launch of Tropical Rainfall Measuring Mission satellite (TRMM) in the late 1990s, various algorithms have been developed and applied to derive precipitation estimates exploit the high sampling rate of the geostationary satellites, the greater accuracy and more direct precipitation measurement provided by satellite observation.

Many efforts have been focused on the construction of the time series of monthly precipitation from rain gauge observations and remote sensing. The objective of this paper describes a comprehensive assessment of

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a high-resolulion, gauge-satellite-based analysis of monthly precipitation over Qinghai northeastern part of the Qinghai-Tibet Plateau by interpolating gauge observations and satellite observation during 1998-2008.

2. Meterials and Methods

2.1. Study area

Qinghai Province is located in the northeastern part of the Qinghai-Tibet Plateau, covering 721,000 km2 and stretching approximately 1200 km east-west and 800 km north-south(Fig. 1). Its mountain ranges and vast basins have an average elevation of 3000-4000 m.a.s.l.. Its lands are either arid or semi-arid, with frequent windy days. Desertification and soil erosion problems are very serious. The province is one of the five largest pasturelands in China. The surface mean annual temperature is ranging from-5.7 to 8.6℃ and mean annual precipitation of 17-750 mm. Precipitation occurs as rain, snow and hail, with over 80% received in June-September. Due to remoteness and difficult accessibility, the meteorological station is sparse, difficulty to obtained precipitation data.

2.2. Data collection

The monthly TRMM data (3B43 V6) utilized for this study is one of the operational products of TRMM based on rain gauge measurements and satellite estimates of precipitation, a new dataset that continues the trend toward routine computation and distribution of finer-scale precipitation estimates. The algorithm based on the concepts of huffman[5], was developed by the TRMM science team and the data were processed by the TRMM science data and information system. The TRMM best estimates method is a combination of data from the TMI, PR, and VIRS with SSM/I, IR, and rain gauge data. The 3B43 dataset is a combined observation only dataset based on gauge measurements and satellite estimates of rainfll. The gridded estimates are on a calendar-month temporal resolution at a 0.25˚×0.25˚ longtude spacing (50˚S-50˚N). In addition to the satellite data, we utilized station precipitation data measured by the China Meteorological Administration (CMA) observation archives. These datasets were the longest consistent data series available and form the basis analysis described any changes in monthly, seasonal and annual. For several stations missing data have been restructured used the spatial interpolation methods because of trends investigation only homogeneous and complete series covering this period.

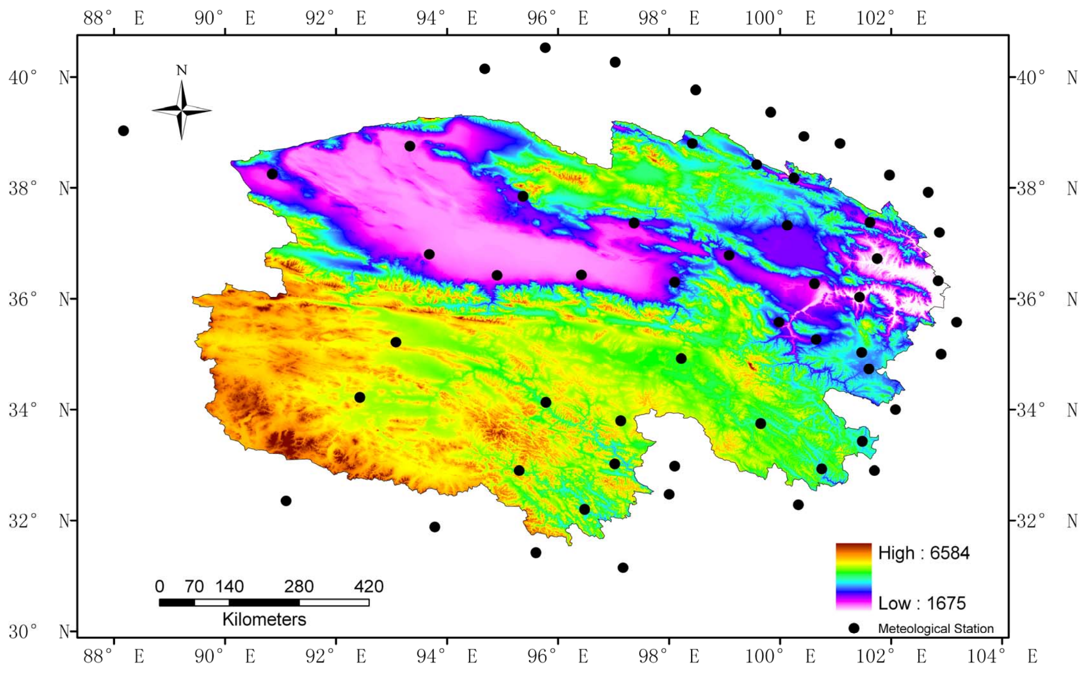

Fig. 1: Location of study area and the distribution of meteorological stations

2.3. Methods

The merging technique has been largely discussed in several papers over the years. Such as the SG estimate is computed on a monthly basis[6]. The Climate Precipitation Center Merged Analysis of Precipitation approach uses a blended technique developed by reynolds[7]. In this study, an attempt has been exploited the technique of Daniel[8] to construction of the time series of monthly precipitation from rain gauge and satellite observations. The proposed schemes uses three steps to combine those two approaches into a single method based on (i) additive and (ii) multiplicative bias correction schemes applied for eah station on a monthly basis. The additive bias correction is defined as follows:

$$r_{add} = r_{sat} + \overline{(r_{obs}^i - r_{sat}^i)}\,, \tag{1}$$

where r_{sat} is the satellite data, $\overline{(r_{obs}^i - r_{sat}^i)}$ is the additive bias between the observed precipitation and satellite retrieval for each station.

Same as above, the ratio bias correction is defined as follows:

$$r_{rat} = r_{sat} \times (\overline{r_{obs}^i} / r_{sat}^i)\,, \tag{2}$$

The precipitation of estimates grid is defined as follows:

$$r_{cor} = \alpha \times r_{add} + \beta \times r_{rat}\,, \tag{3}$$

while r_{cor} is the final estimate precipitation. α and β are the weight factors that satisfied with $\alpha+\beta=1$ for each grid point. This approach takes into account large scale variations and also produce spatially continuous rainfall fields.

Intercomparisons and cross-validation tests are conducted to examine their performance over various parts of the globe where station network densities are different. The Nash-Sutcliffe coefficient(Ens) is used to evaluat the accuracy of the estimate method, expressed as:

$$E_{ns} = 1 - [\sum_{i=1}^{n}(P_i^{obs} - P_i^{ev})^2 / \sum_{i=1}^{n}(P_i^{obs} - P_i^{mean})^2] \tag{4}$$

Where P_i^{obs} and P_i^{ev} are the observed and estimated precipitation respectively; P_i^{mean} is the mean of the observed precipitation; n is the number of observations.

3. Results and Discussion

To investigate the merging technique scheme feasibility, six stations is randomly selected in study area, and calculated the Nash-Sutcliffe coefficient (Table 1). Many month values are the best result obtained for Nash-Sutcliffe coefficient, except individual values of jun, sept, oct and dec(shown red). In addition, the correltation coefficient is analysed of satellte data and rain gauge data, value is between 0.75 and 0.96. Because of its northwest Qaidam desert, scarce precipitation, the Nash-Sutcliffe coefficient and correltation coefficient are lower than other regions. The precipitation is relatively large over southern Qinghai neighbor Tibet, the Nash-Sutcliffe coefficient and correltation coefficient are high, showing excellent consistency. Overall, the results showed that satellite data is consistent with rain gauge data over Qinghai. Thus, the estimates precipitation is depicted the spatial distribution significently by this merging technique.

Table 1 Value of cross-validation test over Qinghai

E_{NS}	Delingha	Xining	Wudaoliang	Tongde	Maduo	Dari
Jan	0.85	0.57	0.63	0.78	0.46	0.79
Feb	0.75	0.70	0.81	0.66	0.60	0.89
Mar	0.69	0.79	0.81	0.71	0.88	0.57
Apr	0.68	0.55	0.35	0.79	0.77	0.43
May	0.51	0.85	0.32	0.42	0.57	0.66
Jun	0.76	0.18	-0.03	0.47	0.71	0.64
Jul	0.76	0.70	0.64	0.62	0.48	0.39
Aug	0.81	0.40	0.57	0.65	0.44	0.56
Sep	0.73	0.27	0.72	0.41	0.23	0.47
Oct	0.58	0.86	-0.18	0.59	0.78	0.23
Nov	0.86	0.92	0.83	0.45	0.58	0.38
Dec	0.69	0.75	0.18	0.54	0.32	0.67
Ann	0.60	0.52	0.30	0.79	0.66	0.36

Figuer 2 shows the spatial distribution of precipitation for rain gauge, satallite and estimation applying the merging technique in january, july and annual. Though the spatial distribution of precipitation is consistency significently in july and annual, some differences are observed in northwestern Qinghai in january. Where the estimation is better matched with the satellite than rain gauge. In southern Qinghai, the spatial distribution of precipitation for three group data is not different significently over southern Qinghai in january. the spatial distribution of precipitation for july is same as annual. Therefore, the TRMM satallite data has a capability for detecting the precipitation in remote region over the pleteau, and provide a feasible aprroach for evaluating the water resources in the study area and performing distributed hydrological models.

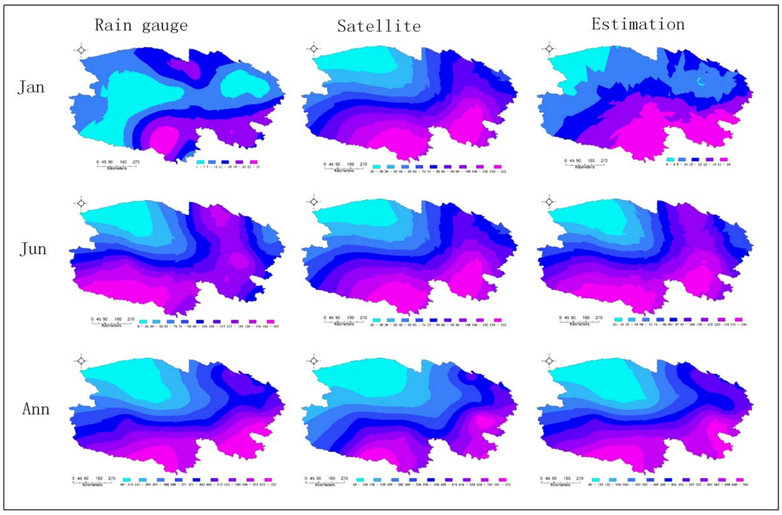

Fig. 2. Spatial distribution of precipitation for rain gauge, satellite and estimation for january, july and annual.

4. Conclusion

A comprehensive assessment has been performed to examine the performance of a new methodolgy by mergeing satellite estimates and observation data, and monthly precipitation have been constructed on a 0.25° latitude/longitude grid over Qinghai from 1998 to 2008. The quality of dataset was evaluted by intercomparisons and cross-validations test. The qulaity of the precipitation estimate degrades as the rainguage being used sparser, and retrieval has almost the same quality based on monthly rainguage data. It is also important to mention that other factors like wind, evaporation, terrain, among other can also affect the precipitation estimation.

5. Acknowledgements

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