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Information Fusion and Application Analysis of Multi-Source Precipitation Data in Qinghai under Complex Topography

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Abstract. Precipitation is a key parameter for regional water resources and ecological environment.The Qinghai Plateau is highly sensitive to global climate change due to its special location,complex atmospheric circulation and underlying surface features.As the"Third Pole"of the Earth,its precipitation plays a crucial role in regional river water supply and ecological regulation.However,observation stations on the Qinghai Plateau is sparse,and precipitation data is extremely scarce.This has pose huge challenges to hydrology,water resources,and disaster warning research.This study first evaluate GPM precipitation products on the Qinghai Plateau at different temporal and spatial scales based on"true value"ground station data.Then it fuse the accuracy of daily precipitation at measured stations from precipitation amount,rainy day frequency and probability distribution to correct its bias.

Keywords: GPM, precipitation, Qinghai Plateau, accuracy evaluation, data fusion, spatial downscaling

1. Introduction

Precipitation is the basic link of water cycle and plays a crucial role in regional hydrology,climate research and ecological environment construction.Too much precipitation easily cause floods,debris flows and landslides.Too little precipitation easily cause droughts.In recent years,with the development of satellite remote sensing technology, satellite precipitation products can provide long-term continuous spatial coverage products [1].This make up for the shortcomings of ground stations and weather radar,and are widely used in hydrology,ecology and climate research.However,due to errors of satellite sensors themselves and uncertainties in algorithms for retrieving precipitation physical processes,the accuracy in some regions with complex underlying surface is still not ideal.The spatial resolution is still not high enough,and precipitation details

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cannot be better presented,especially in the Qinghai Plateau with complex climate and underlying surface.

2. An integration algorithm for precipitation attributes

Considering the multiple characteristic attributes of daily precipitation time series in precipitation amount,rainy day occurrence frequency and probability distribution,the correction of precipitation time series at station scale adopt Linear Scaling(LS),Local Intensity Scaling(LOCI)and Gamma probability distribution method.These three methods correct the daily precipitation time series of GPM from precipitation amount,rainy day frequency and probability distribution respectively [2, 3].

The LS method correct the precipitation amount of GPM precipitation products based on the ratio of monthly mean measured precipitation at stations to GPM precipitation data, and the calculation formula is as follows:

$$P_{cor,m,d}=P_{raw,m,d}\times\frac{P_{obs,m}}{P_{raw,m}} \tag{1}$$

pcor,m,drefers to the corrected value of GPM precipitation product on day d of month m， praw,m,d is the raw GPM precipitation product value on day d of month m,， pobs,m and praw,mrepresent the monthly mean of measured precipitation and GPM precipitation product in month m respectively,with units in mm.

Adopting the idea of LS method to ensure the corrected GPM precipitation amount equal to measured precipitation amount,the formula is as follows:

$$S_m=\frac{\mu(P_{obs,m,d}|P_{obs,m,d}>0)}{\mu(P_{raw,m,d}|P_{raw,m,d}>P_{thres,m})} \tag{2}$$

$$P_{LOCI,m,d}=\begin{cases}0,\ \text{if}P_{raw,m,d}<P_{thres,m}\\ P_{raw,m,d}\times S_m,\ \text{otherwise}\end{cases} \tag{3}$$

In the formula:$\mu(P_{obs,m,d}|P_{obs,m,d}>0)$epresents the sum of measured precipitation values greater than 0 on day d of month m;， $\mu(P_{raw,m,d}|P_{raw,m,d}>$pthres,m)represents the sum of daily GPM precipitation greater than the rainy day threshold on day d of month m;P_{LOCI},m,d refers to the corrected value of GPM precipitation product after LOCI method correction on day d of month m [4].

3. The spatial distribution characteristics of precipitation in plateau regions

To analyze spatial distribution of precipitation on the Qinghai Plateau,two cross-sections along N 33°and E 93°were divided.Precipitation variation trends with longitude and latitude on these two sections were calculated and significance analysis was conducted.As shown in Figure 1,annual precipitation change trends with longitude and latitude are obvious.The correlation coefficient R is 0.98 on the longitude section and 0.88 on the latitude section,both at strong correlation level.Annual precipitation show extremely significant increasing trend with longitude increase($P<0.01$),with an increase trend of 476 mm/degree.It also show extremely significant decreasing trend with latitude increase($P<0.01$),with adecrease trend of 1760 mm/degree.

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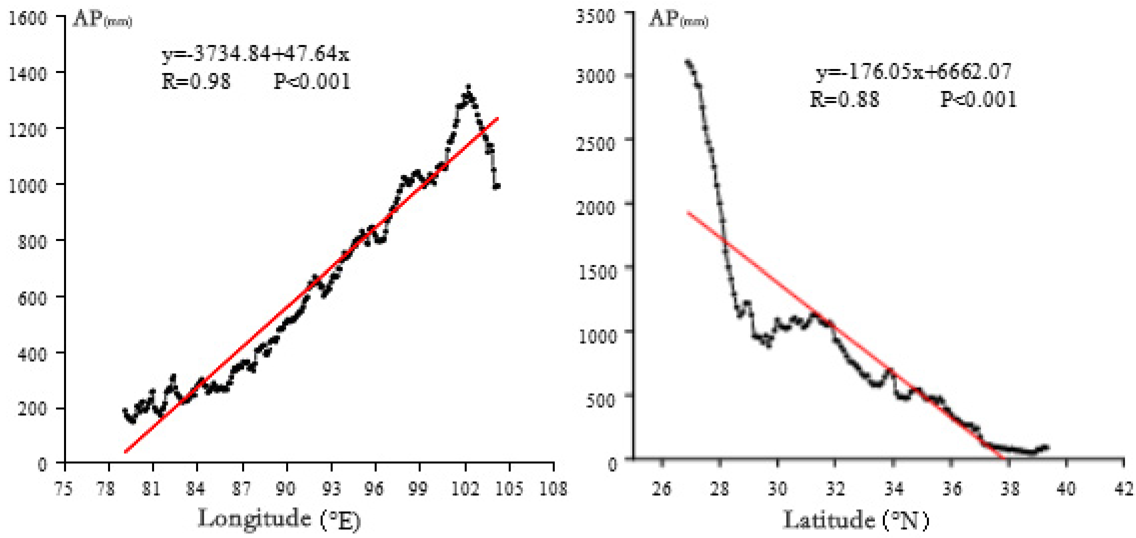

Figure 1. The relationship between longitude, latitude and precipitation

The spatial distribution of precipitation on the Qinghai Plateau change dramatically with longitude and latitude. This quantitatively confirm the spatial distribution pattern that precipitation decrease significantly from east to west and increase from north to south on the plateau.

4. Analysis of the daily-scale precipitation time series

After correction by precipitation attributes of rainy day frequency,precipitation amount and probability distribution of measured precipitation,the corrected GPM products is relatively consistent with measured values in variation trend on time scale.Whether for light rain of 0-2mm,moderate rain of 2-10mm or heavy rain events greater than 10mm,they can be detected relatively accurately. The overall trend between corrected precipitation data and measured data is good [5]. The corrected time series can well retain extreme values and rainy day frequency characteristics in precipitation series.This step is both a correction to original GPM products and a fusion of accuracy attributes of measured station precipitation from another perspective.As shown in Figure 2.

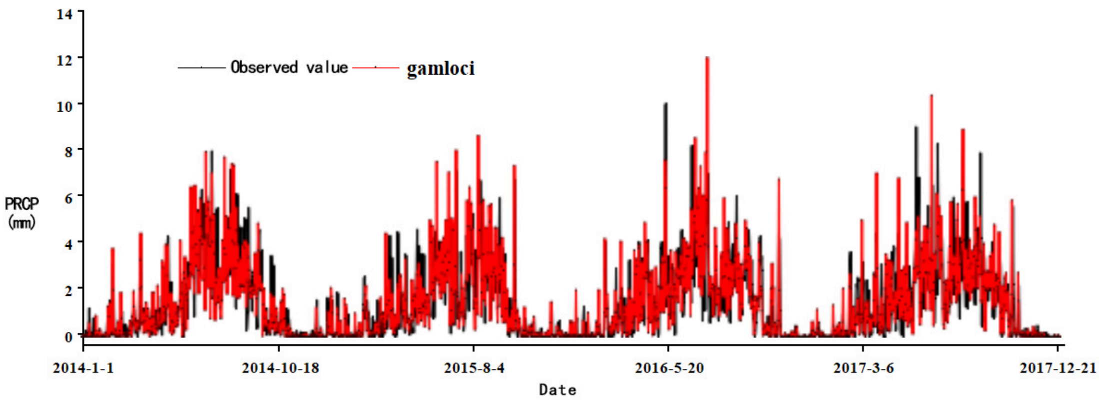

Figure 2. Line graph showing the relationship between precipitation products and the long-term precipitation records from the measured stations

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The residual value between fused precipitation and original GPM products as the dependent variable of geographically weighted regression model has higher accuracy than directly using precipitation products as the dependent variable. Therefore,a geographically weighted regression model between topographic and geomorphological factors and the residuals between station fused precipitation data and original GPM precipitation products is further established,and the model is [6]:

$$P_{fusi0n}=P_{raw}+P_{residual} \tag{4}$$

In the formula:P_{fusi0n} represents the value of GPM precipitation after fusing station accuracy(mm);P_{raw} represents the GPM precipitation value at 10km resolution;$P_{residual}$ represents the residual of precipitation distribution caused by topographic and geomorphological factors(mm).The specific steps are as follows:

5. Application of integrated downscaling results

To evaluate the accuracy performance of original GPM products and downscaled fused GPM products on the Qinghai Plateau, 5 ground representative rain gauge stations randomly selected as precipitation true values were used to evaluate accuracy performance. As shown in Table 1.

Table 1. Basic information of the representative verification site

Site	Province	Latitude	Longitude	Elevation	AP（mm）
Xiaozhaohuo	Qinghai	36.80	93.68	2767.00	26.60
Tashkurgan	Xinjiang	37.77	75.23	3090.10	109.50
Pulan	Xizang	30.28	81.25	4900.00	146.20
Gaize	Xizang	32.15	84.42	4414.90	247.60
Nimu	Xizang	29.43	90.17	3809.40	325.10

VIC hydrological model is a large-scale distributed model. The model divides the region into several small grids. On each grid, based on soil type, soil depth, land cover type, snow elevation band and meteorological forcing mode, it comprehensively integrates water and energy exchange processes between atmosphere, vegetation and soil, and reflects land surface water and heat budget conditions. Due to its independent grid calculation, it calculates surface energy, surface runoff, base flow and other parameters according to corresponding evapotranspiration and saturation-excess runoff formulas, completing runoff and heat generation process calculation on each unit grid [7]. The gridded physical calculation characteristics make VIC couple well with distributed precipitation products. On the basis of runoff generation in each grid, a separate routing model is used to gather routing calculation results through watershed outlet points to obtain corresponding flow processes. As shown in Figure 3.

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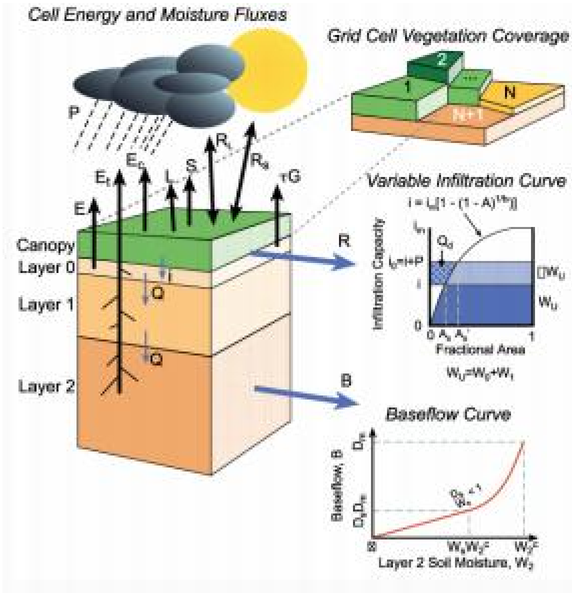

Figure 3. Schematic diagram of VIC model

As a large-scale grid-based hydrological model, because it can consider regional permafrost and snow characteristics to simulate water and heat budget, it has significant advantages in the source region of Yangtze River where permafrost and snow are widely distributed.

6. Conclusion

In the Qinghai Plateau research,the new generation GPM satellite precipitation products have better spatial resolution and accuracy than existing products,but still difficult to meet the demand for high-precision,high-resolution spatial precipitation products.Therefore,based on accuracy evaluation of GPM precipitation products at different temporal and spatial scales on the Qinghai Plateau,this study carry out data fusion research of GPM precipitation products by combining advantageous attributes of measured station precipitation amount,rainy day frequency,probability distribution and spatial distribution attributes under the influence of geographical factors.It use random forest algorithm for spatial downscaling processing,forming a fusion downscaling framework for obtaining high-precision,high-resolution precipitation data on the Qinghai Plateau.This provide new ideas for obtaining precipitation data in areas with scarce data,and also provide data support for regional hydrology,water resources,climate change and ecological research.

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