Satellite remote sensing and model forecasting for water-related disaster application

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Content

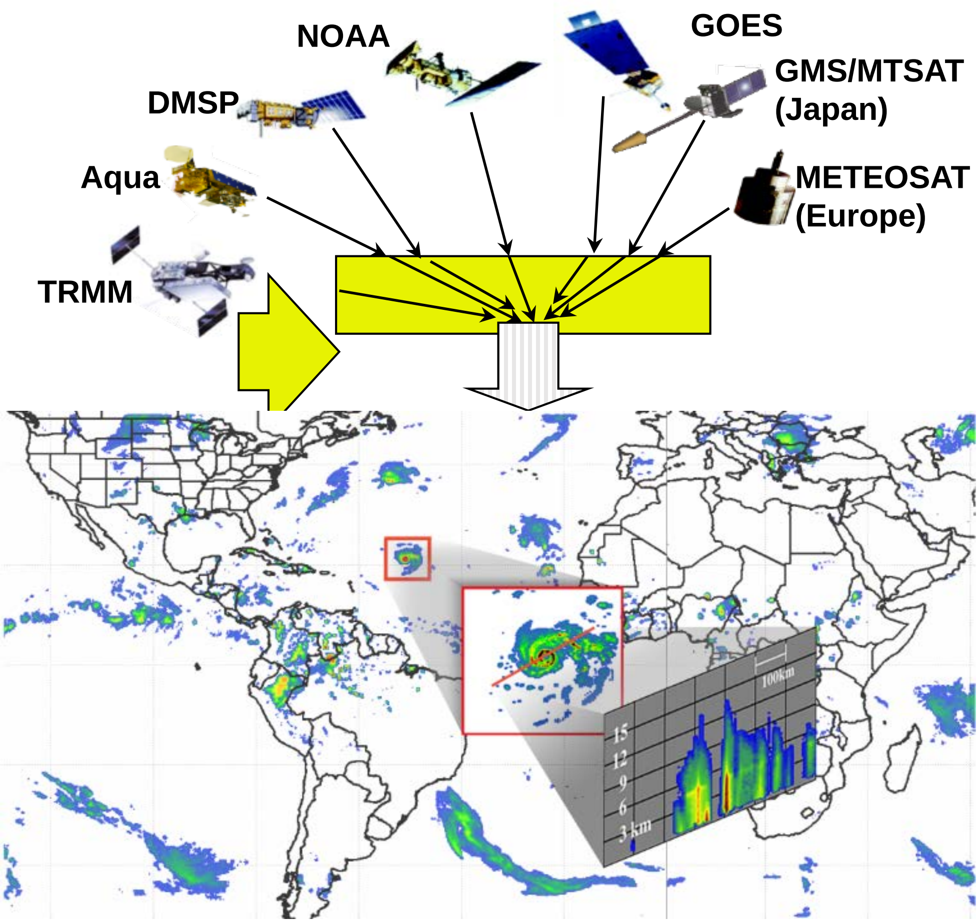
I. Satellite Remote Sensing for Precipitation Monitoring

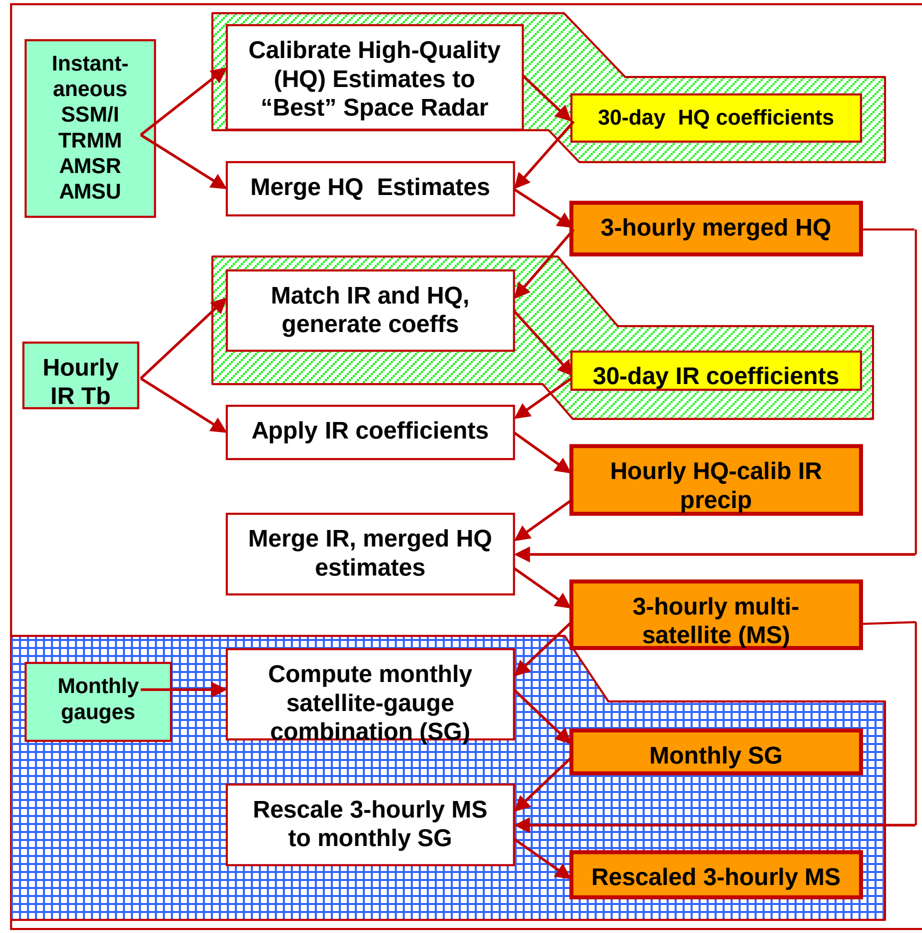
II. Satellite Precipitation Products for Capturing Rainstorms

III. Model Forecasting for Water-related Applications

I. Remote Sensing for Precipitation Monitoring

The main stage: TRMM era (1998-2014) and GPM era (2014-present)





17+ years (‘98-16’) of data; <u>Most requested TRMM product from NASA</u>

Prof. Hong and Huffman et al. 2007 : (3000+ Citation)

Ⅰ. Remote Sensing for Precipitation Monitoring

Satellite-based precipitation data provides its irreplaceable advantages to monitor the precipitation at global and hourly scales. Though the GPM and TRMM provides the state-of-the-art satellite-based precipitation products, the **spatial resolution of these data are still too coarse (0.25°/0.1°)** to meet the demand in various fields(~ 1 km), e.g., hydrology.

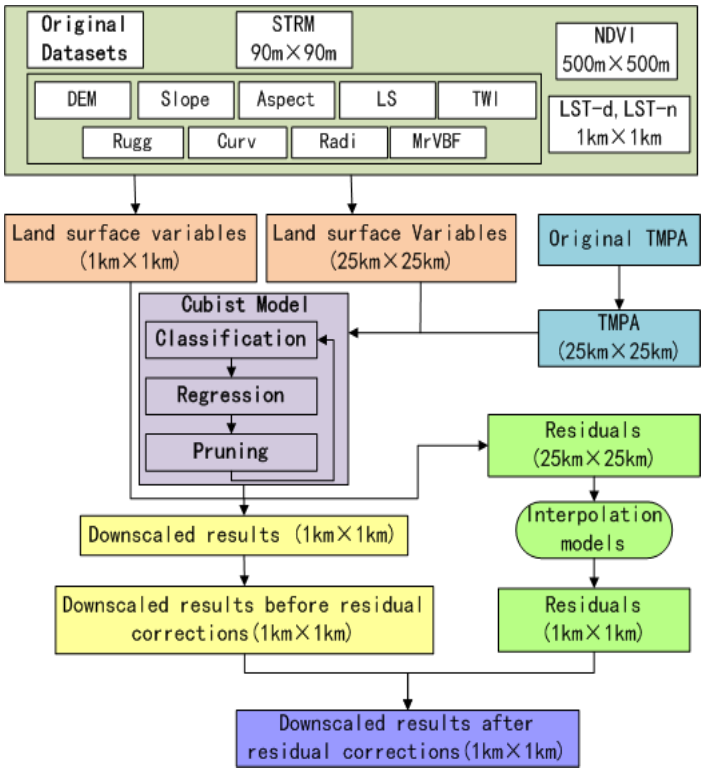


Fig. 6 Flow chart for the Cubist-based downscaling algorithm

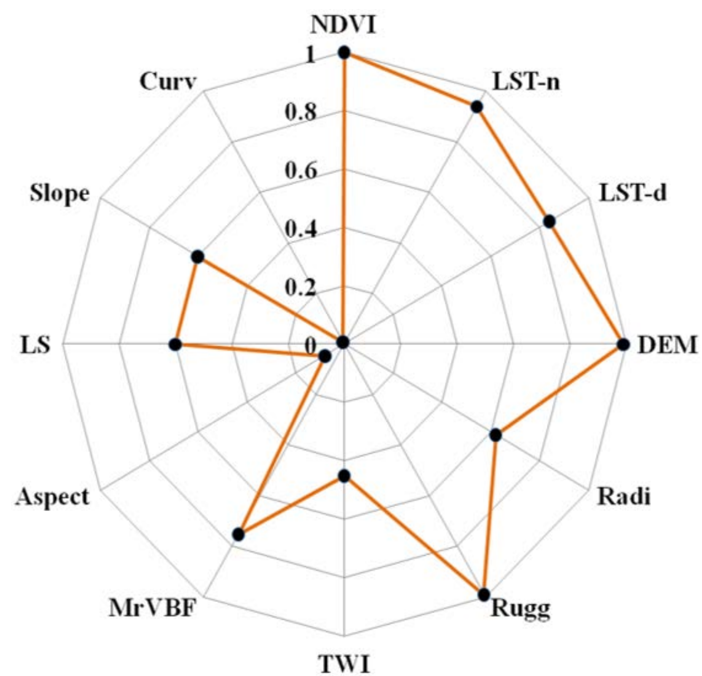


Fig. 8 Contributions of LSC to build the models for downscaling.

Ma et (2017) Introduce a data mining algorithm to downscale the TMPA data with various land surface characteristics. **Ma et al., (2017), *RSE***

Ⅰ. Remote Sensing for Precipitation Monitoring

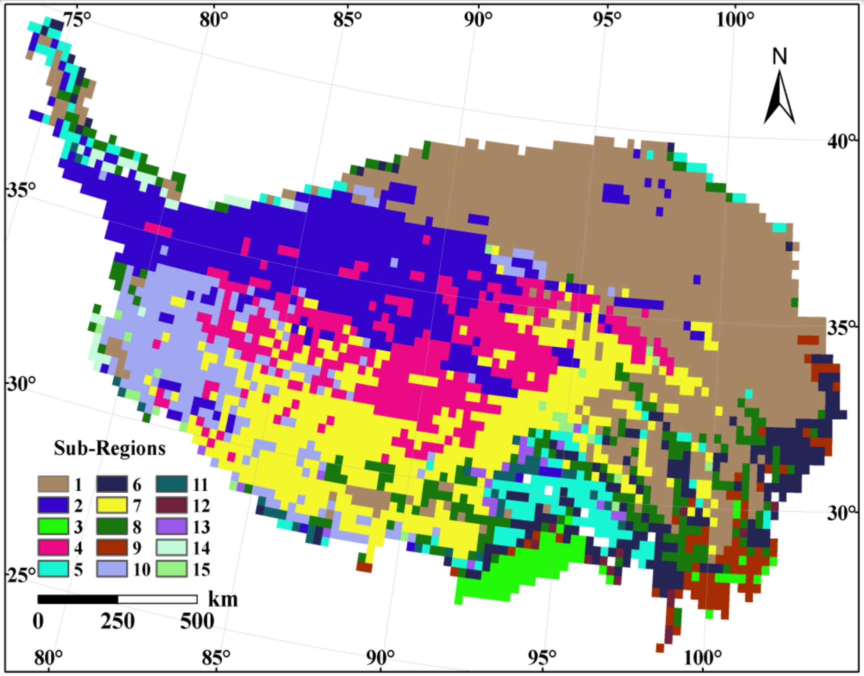


Fig. 9 Classification results and corresponding spatial patterns to show the 15 sub-regions in 2006 at the 0.25° scale

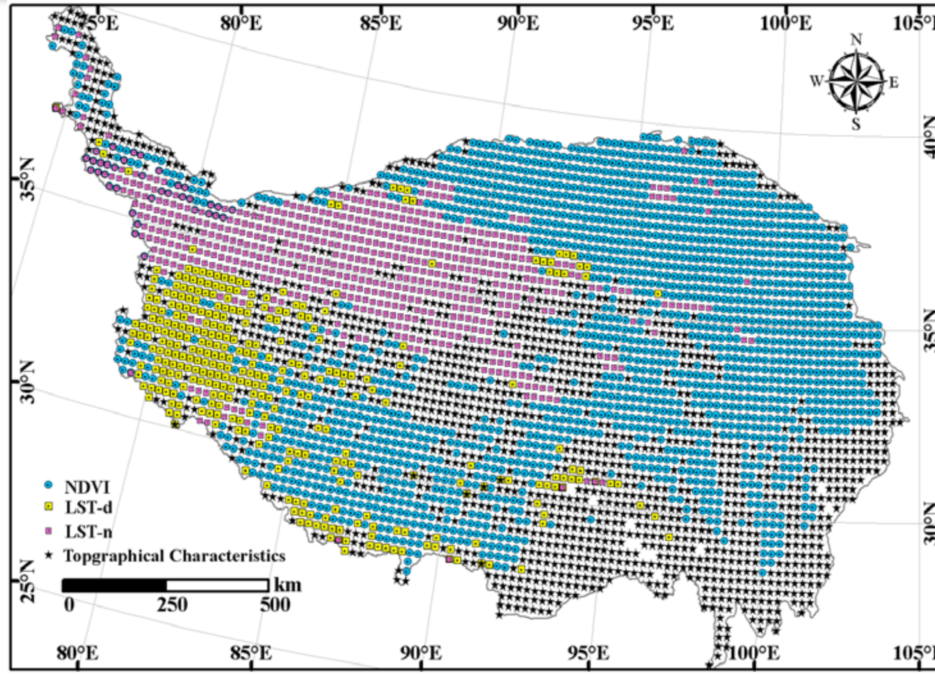


Fig. 10. Spatial distribution of the most important variables for downscaling the TMPA data for 2006 over the Qinghai–Tibet Plateau.

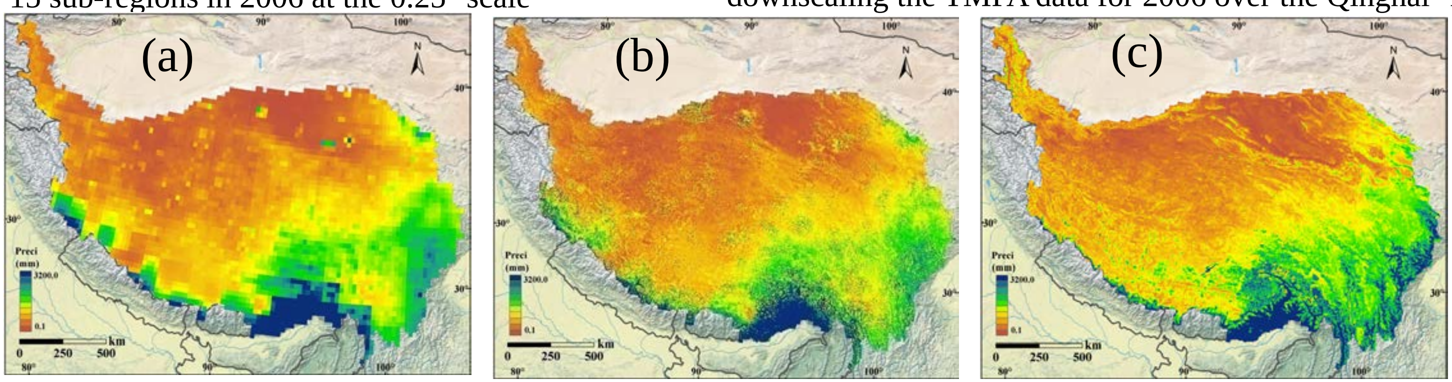


Fig. 11. (a) Accumulated monthly TMPA precipitation data for 2006 at 0.25° resolution. (b) Downscaled results based on GWR before residual correction at 1 km resolution. (c) Downscaled results based on Cubist before residual correction at 1 km resolution.

Ⅰ. Remote Sensing for Precipitation Monitoring

Ma et al., (2017), *IJOC*

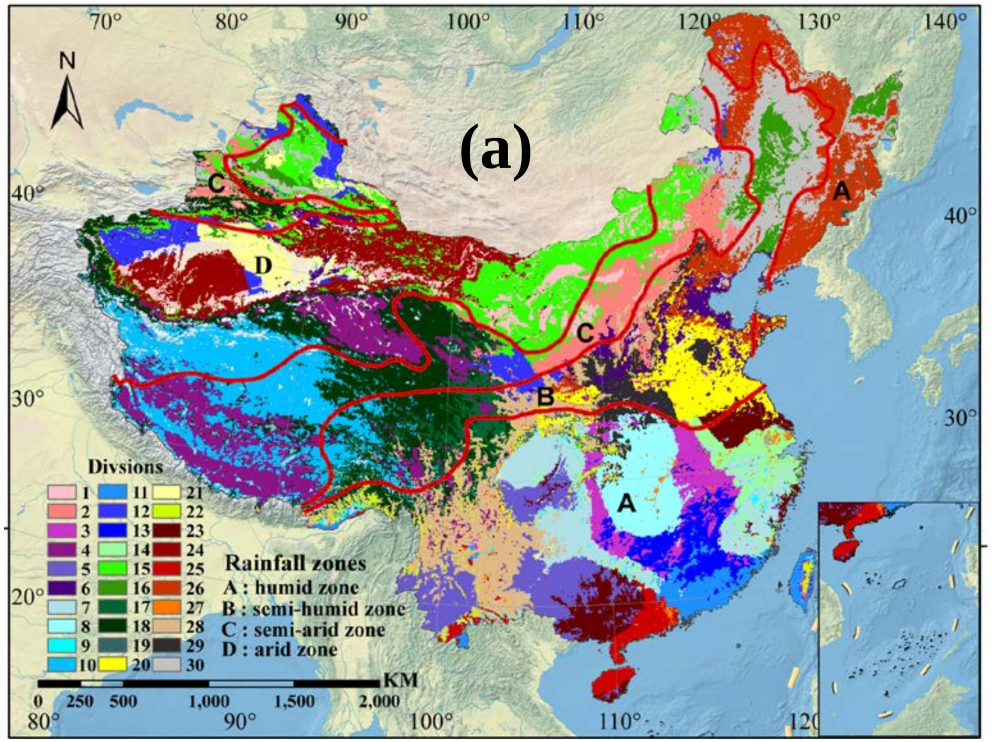
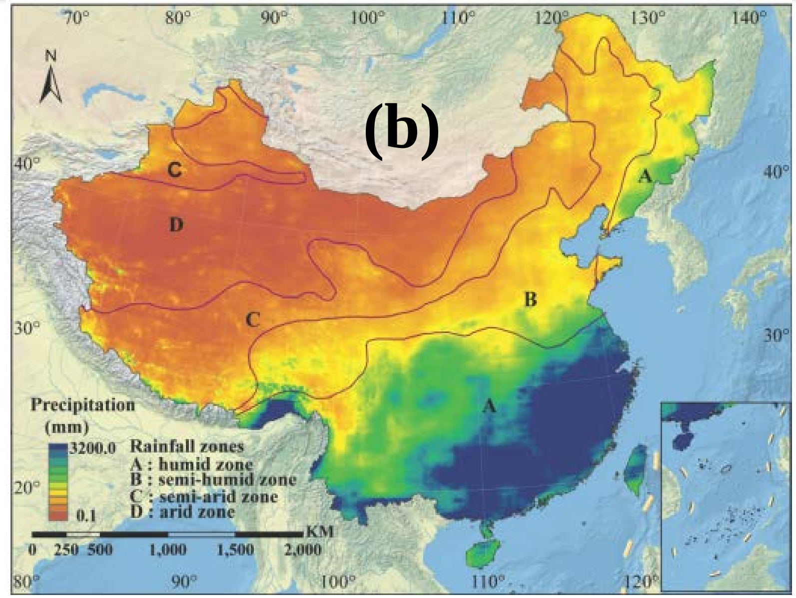
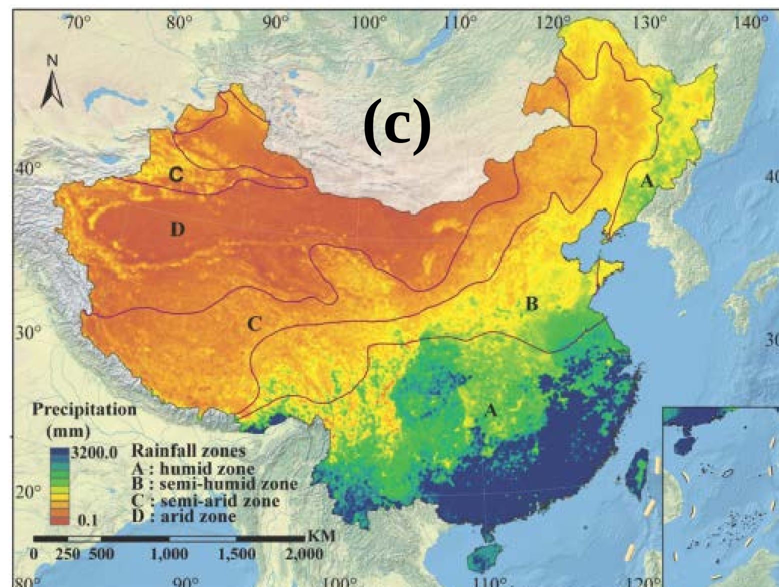


Figure 17. (a) Comparison between Cubist divisions in the downscaling process and those of Chinese rainfall zones; and validation between rain gauges against (b) the TMPA data from TRMM, and downscaled results by (c) the Cubist algorithm over China in 2015.



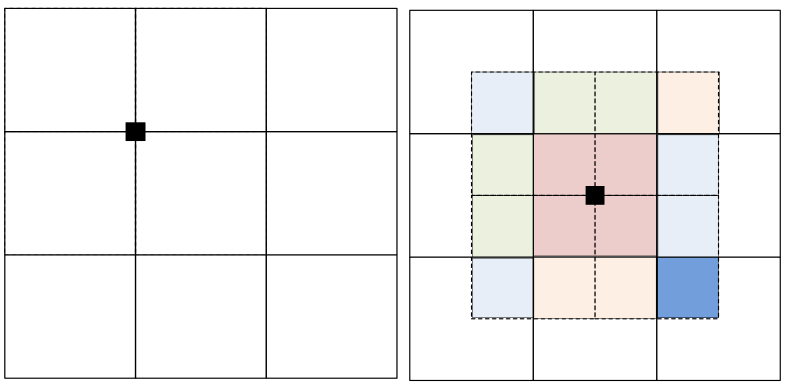


I. Remote Sensing for Precipitation Monitoring

Ma et al., (2019), *IJRS*

$$Fraction(0.25°) = \frac{TRMM_{original,i}}{\sum_{i=1}^{n} TRMM_{original,i}}$$

Where the numerator $TRMM_{original,i}$ represented the precipitation that occurred during the ith month as estimated from the original TRMM 3B43 product, and the denominator was the annual total value.



(*a*) (*b*)

Fig. 18. The number of neighboring TMPA pixels (0.25°) was varying with the with the center of moving window located in (a) the cross of the four TMPA pixels; (b) one of the TMPA pixels.

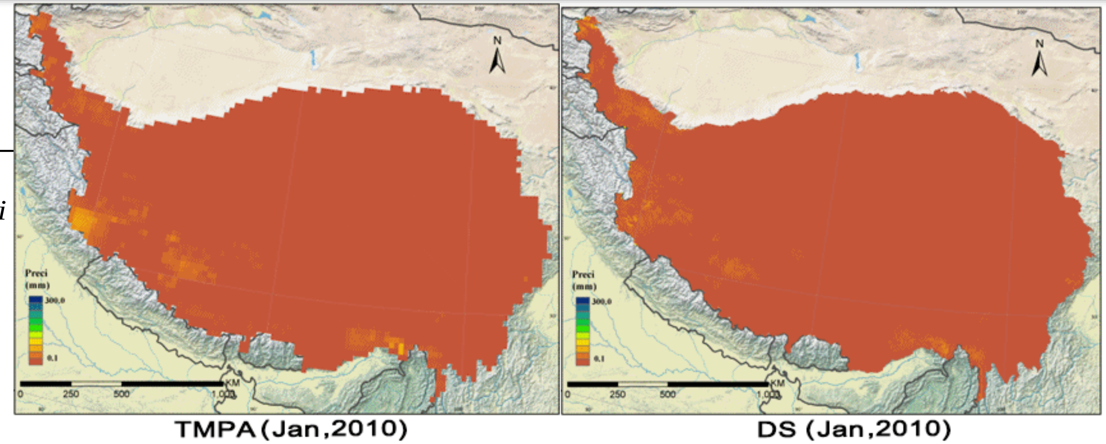


Fig. 19. The spatial patterns of monthly TMPA 3B43 V7 data (0.25°), and corresponding monthly downscaled results at ~ 1 km, from January to December, in 2010 over the TP.

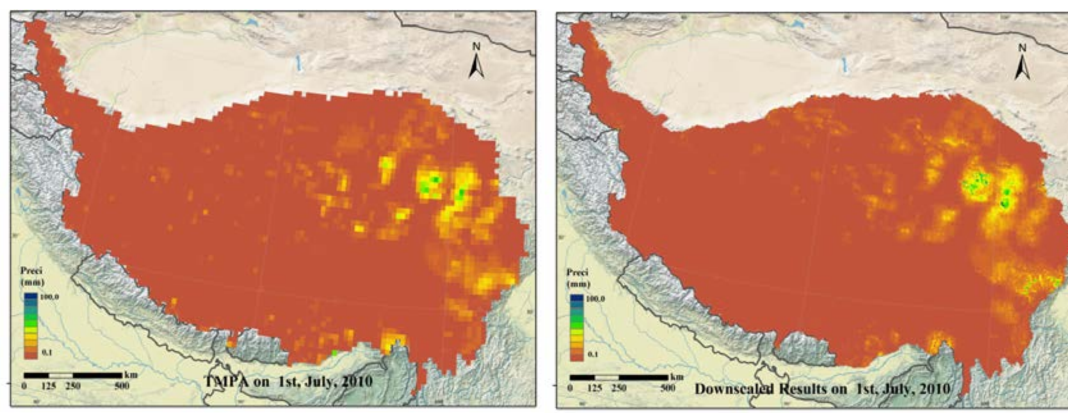


Fig. 20. The spatial patterns of daily TMPA 3B43 V7 data (0.25°), and corresponding daily downscaled results at ~ 1 km, in July, 2010 over the TP.

Ⅰ. Remote Sensing for Precipitation Monitoring

Moving Window Disaggregation Strategy

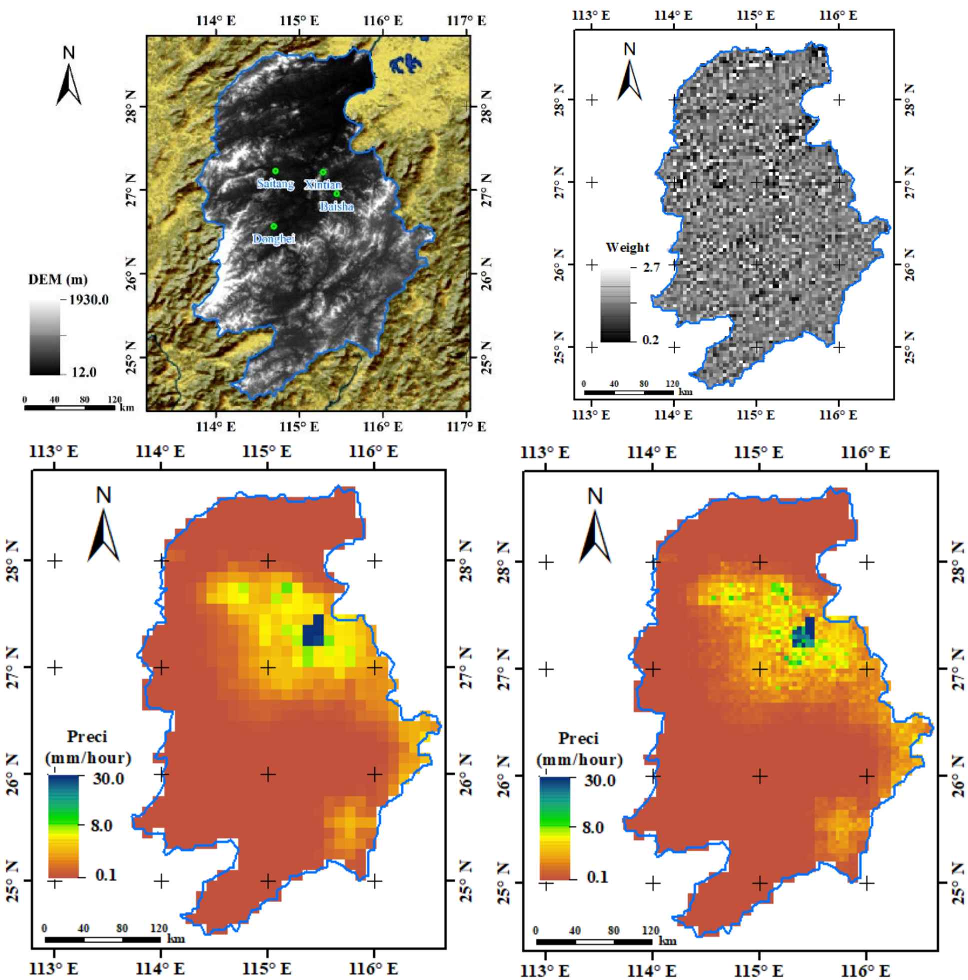


Fig. 21. (a) Study area, (b) Disaggregation Weights based on DEM, (c) IMERG at 14070310, and (d) DS at 14070310 Ganjiang, China.

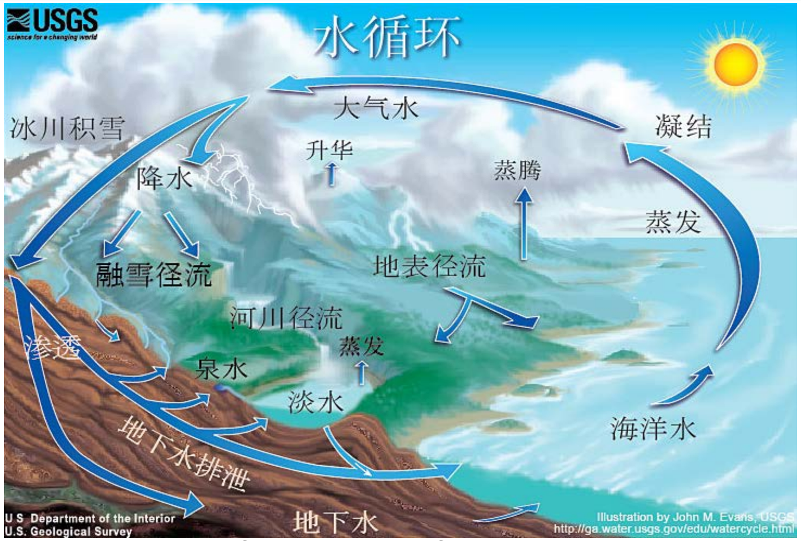
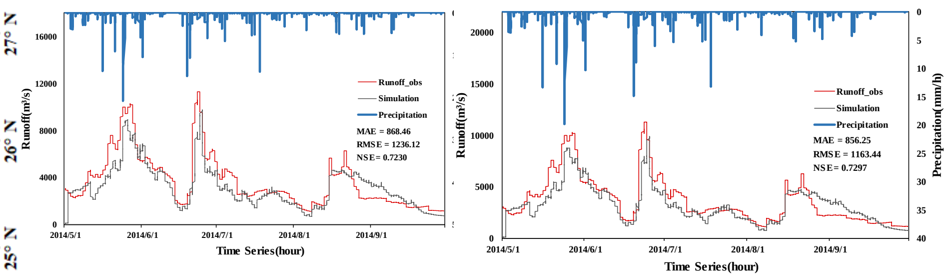


Fig. 22. The flowchart of global water cycling (http://water.usgs.gov/edu/watercyclechinese.html)

Time Period: 2014.5.10-2014.8.5

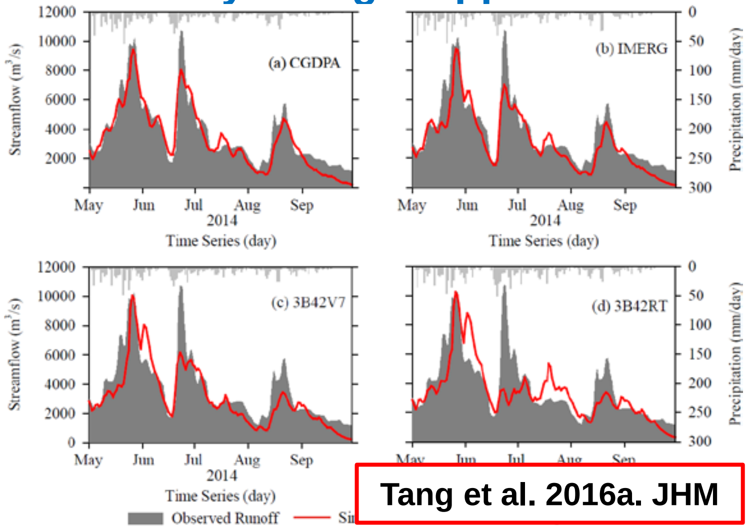


(a) IMERG, Waizhou (b) DS_IMERG, Waizhou

Ma et al., (2018), *Water*

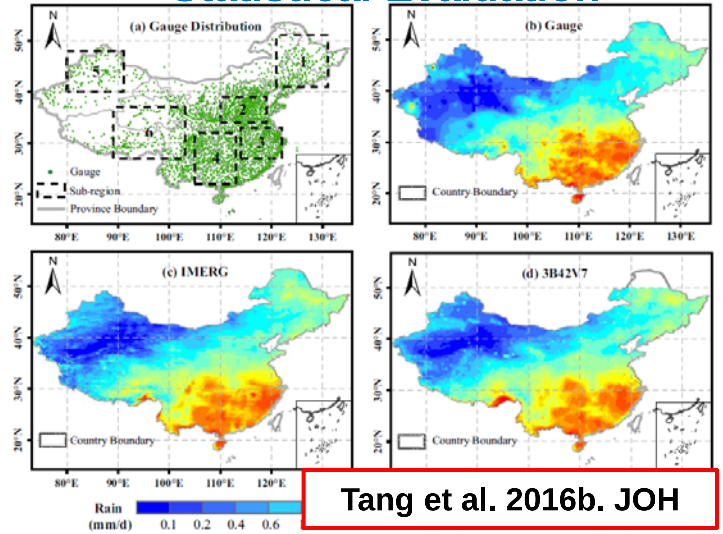
What can satellite precipitation do?

Hydrologic Application



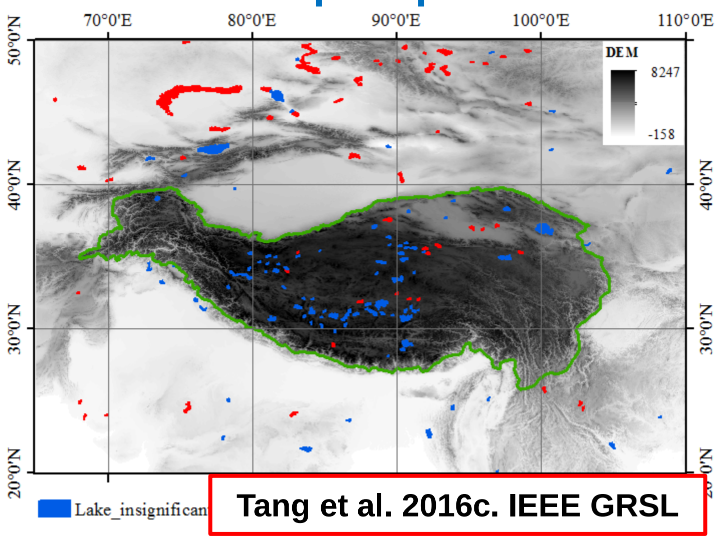
Tang et al. 2016a. JHM

Statistical Evaluation



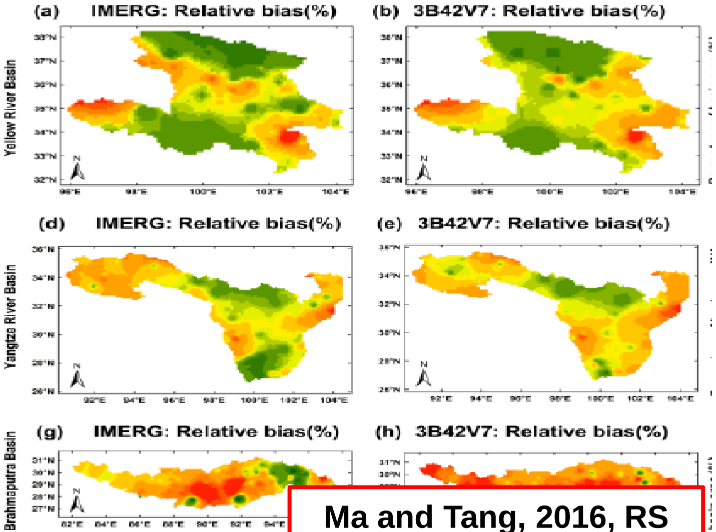
Tang et al. 2016b. JOH

Lake precipitation



Tang et al. 2016c. IEEE GRSL

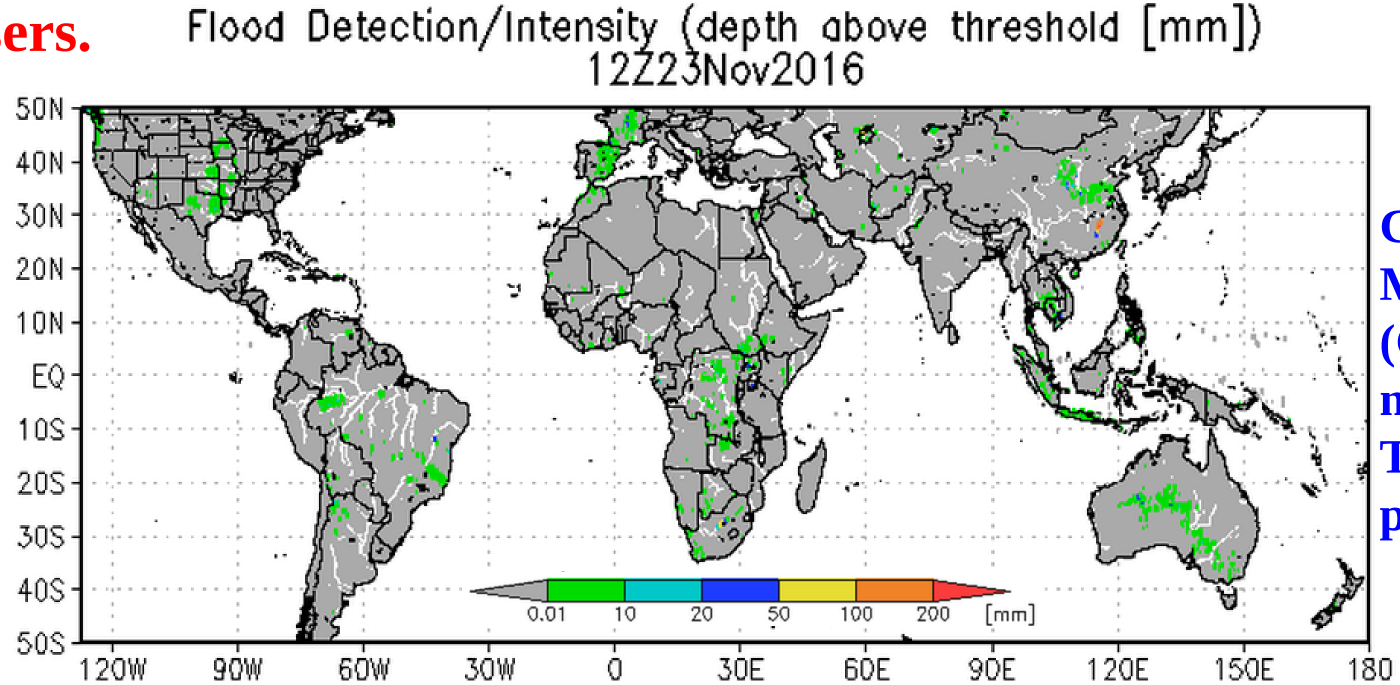
Data source for remote areas



Ma and Tang, 2016, RS

Near-real-time satellite precipitation products

Different sources of precipitation products may be "best" for different users.



Global Flood Monitoring System (GFMS) based on near-real-time TRMM precipitation products.

Near-real-time (NRT) products is totally based on satellite signals without gauge correction. Unlike Final products with higher accuracy but longer lag periods, for real-time hydrological forecasting and natural hazard warning, the NRT products with a time lag of a few hours are more attractive for real-time hydrological forecasting and natural hazard warning.

2. Precipitation Products for Capturing Rainstorms

Can near-real-time satellite precipitation products capture rainstorms and guide flood warning alerts for the 2016 summer in South China?

Satellite precipitation products

- **PERSIANN (hourly)**
- **3B42RT (3-hourly)**
- **GSMAP NRT (hourly)**
- **GPM IMERG (with an algorithm error)**

Validation datasets

- **CGDPA from CMA** （中国气象局） **(daily)**
- **Gauge and satellite merged products from CMA (hourly)**
- **FFG critical precipitation from IWHR** （中国水科院）
- **83 hazard events collected from all open-access materials**

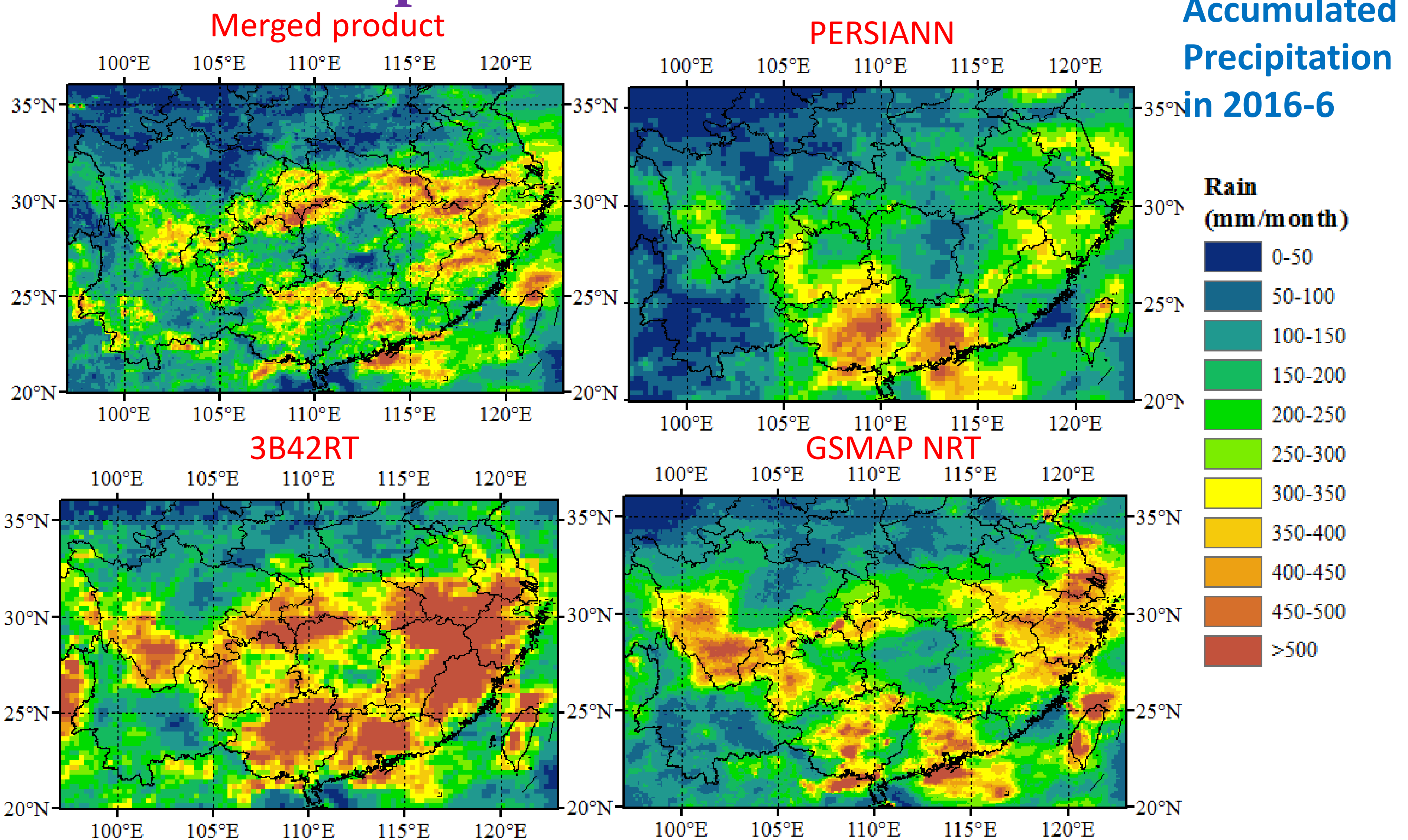
Methods

$$\mathrm{R} = R_0 + \sum_{i=1}^{4} \alpha^i R_i = \sum_{i=0}^{4} \alpha^i R_i$$

A flood hazard is alerted when the effective accumulation precipitation is higher than FFG precipitation and FFPI is higher than a specific threshold (β) in the meantime.

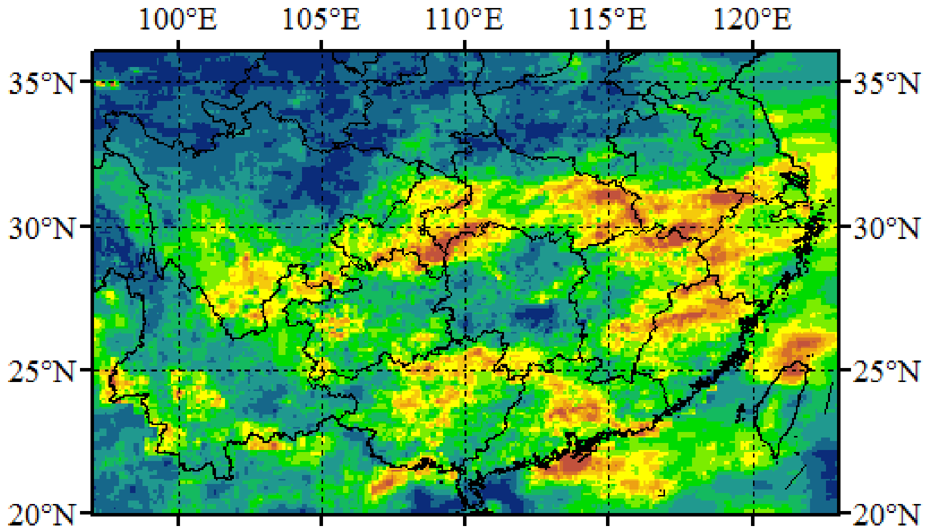
2. Precipitation Products for Capturing Rainstorms

Precipitation Distribution

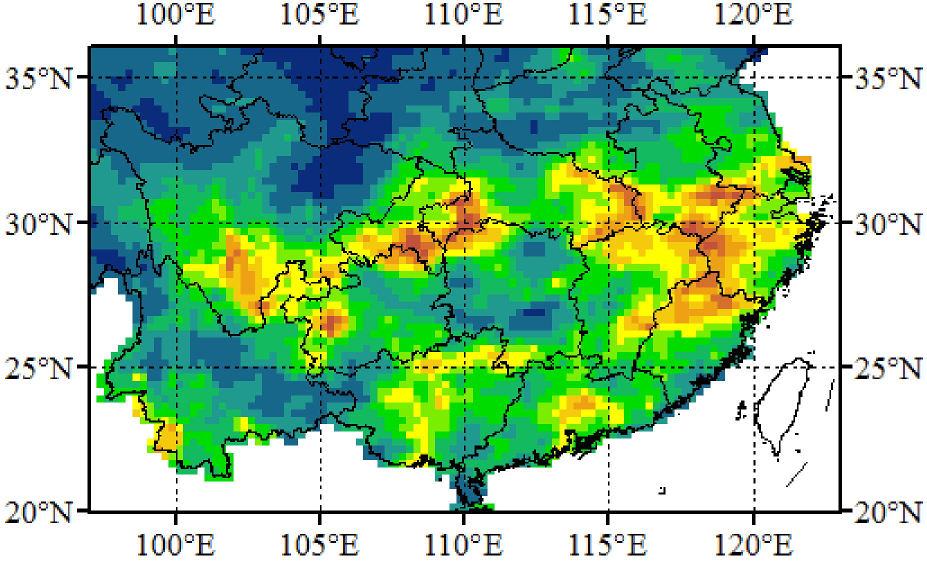


Precipitation Distribution

Merged product



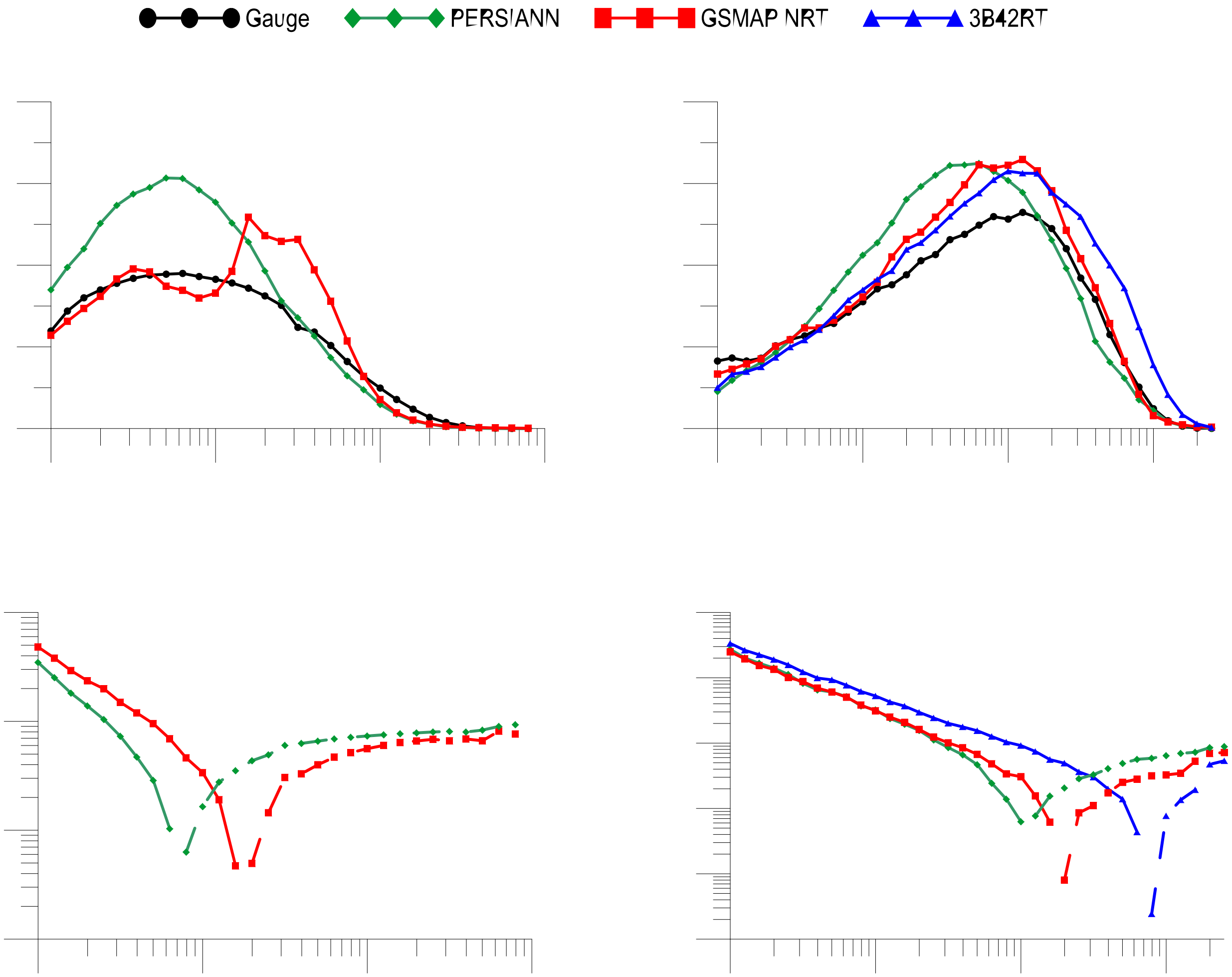
CGDPA



A similar spatial distribution between the merged product and CGDPA indicates that the merged product has reliable quality and can be used to evaluate NRT satellite precipitation products.

2. Precipitation Products for Capturing Rainstorms

Satellite precipitation evaluation

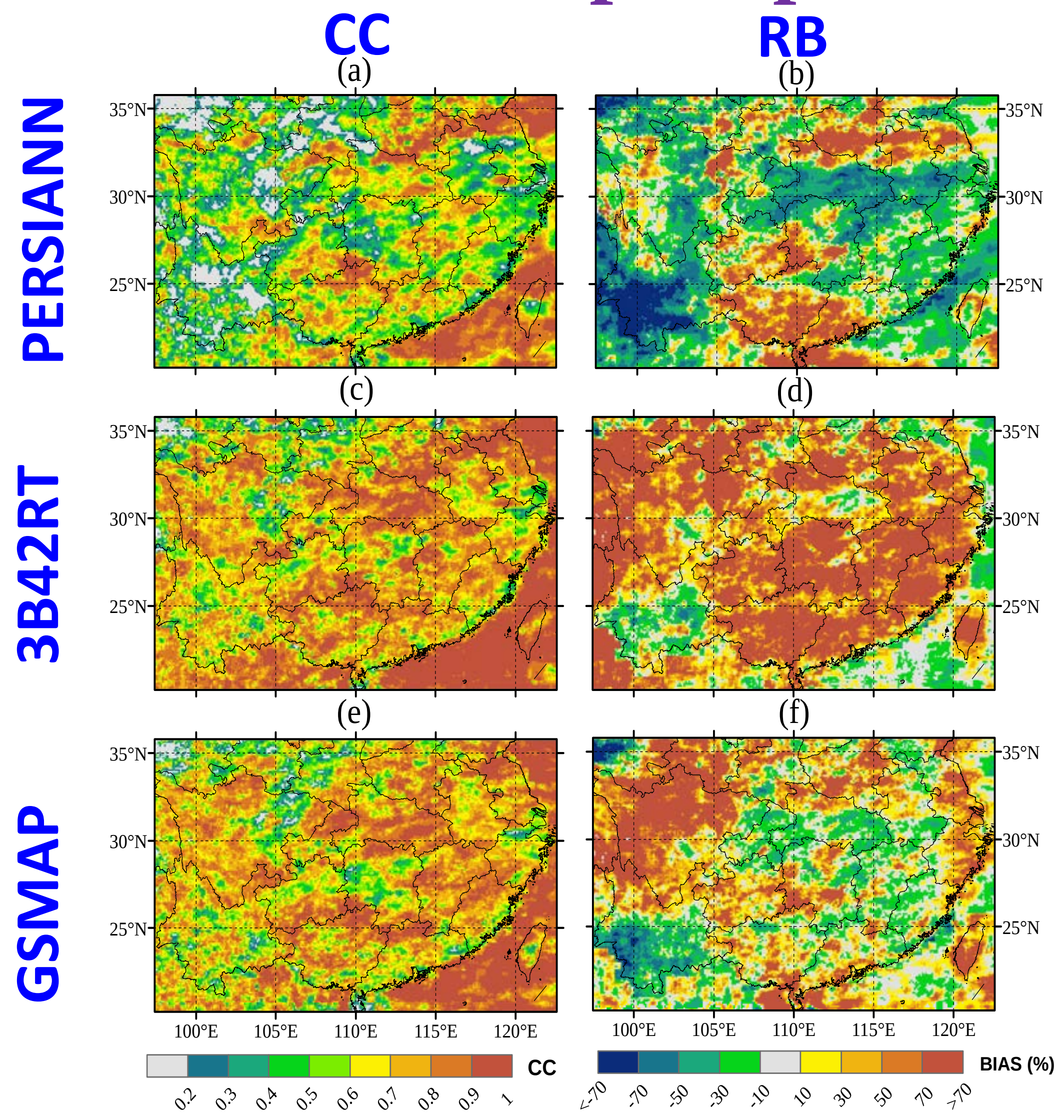


At the hourly scale, PERSIANN deviates far from gauges at light precipitation (<2 mm/h), but GSMAP NRT deviates farthest at moderate precipitation (2-10 mm/h)

At daily scale, satellite products are closer to gauge data, but still show notable overestimation.

2. Precipitation Products for Capturing Rainstorms

Satellite precipitation evaluation

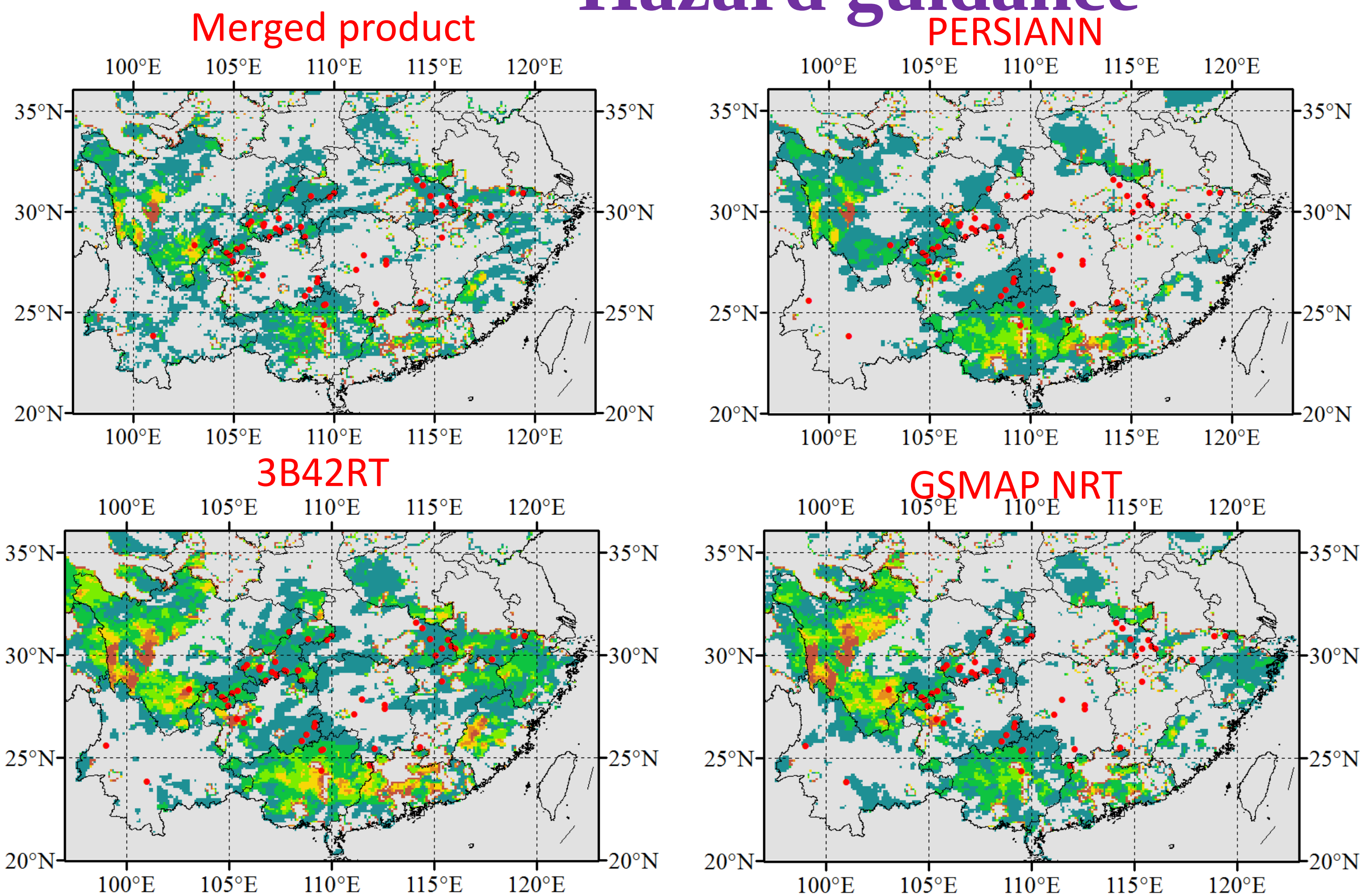


3B42RT and GSMap NRT correlated with the merged product well in most regions of South China. PERSIANN showed degraded performance in the whole South China in terms of CC, particularly in the northwest part where precipitation was the lowest.

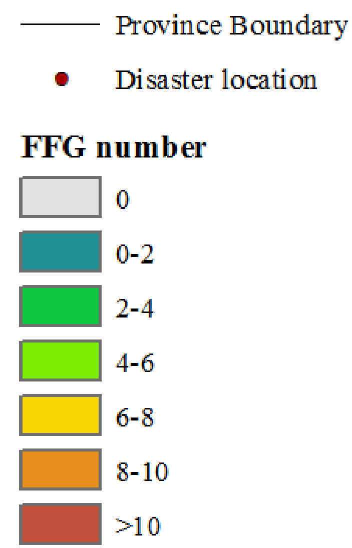
As regards RB, 3B42RT was much higher than PERSIANN and GSMap NRT, indicating that 3B42RT overestimated precipitation significantly in South China.

2. Precipitation Products for Capturing Rainstorms

Hazard guidance



Hazard identification when comparing precipitation with FFG directly.

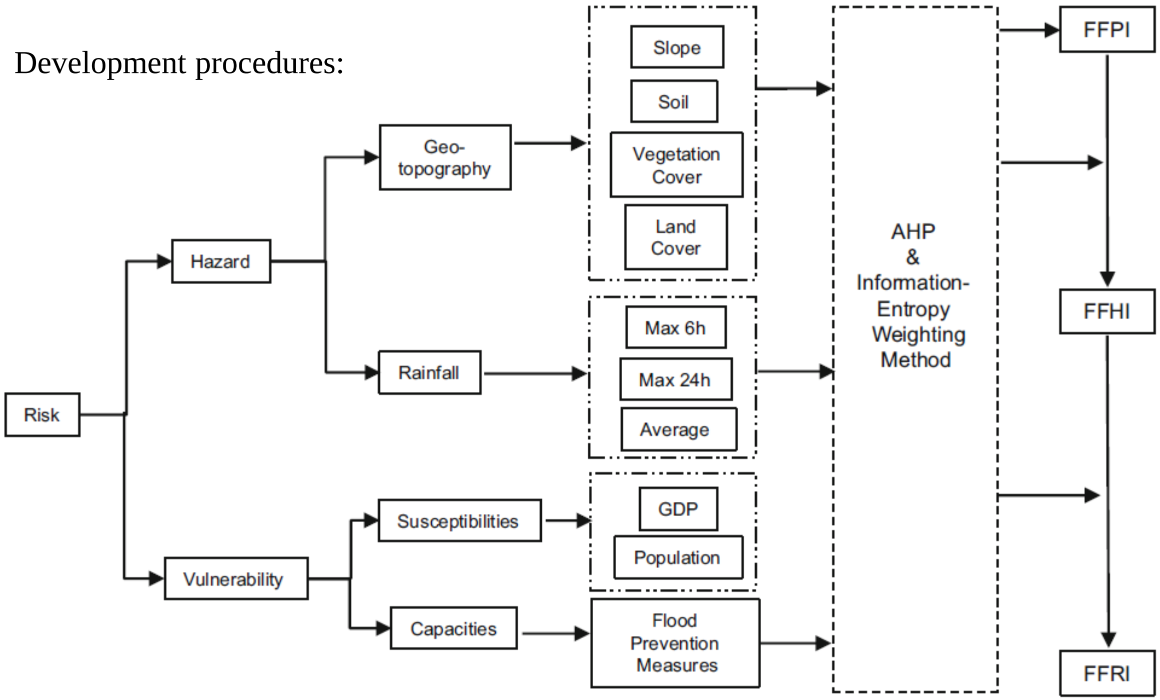


To validate the results of hazards guidance, we collected 83 hazard events from all open-access materials, and we found that most of the events were located in the floods regions identified by the satellite-based precipitation.

3. Model Forecasting for Water-related Applications

- **A cascading flash flood guidance system: development and application in Yunnan Province,**

Development procedures:



Cascading Flash Flood Guidance :

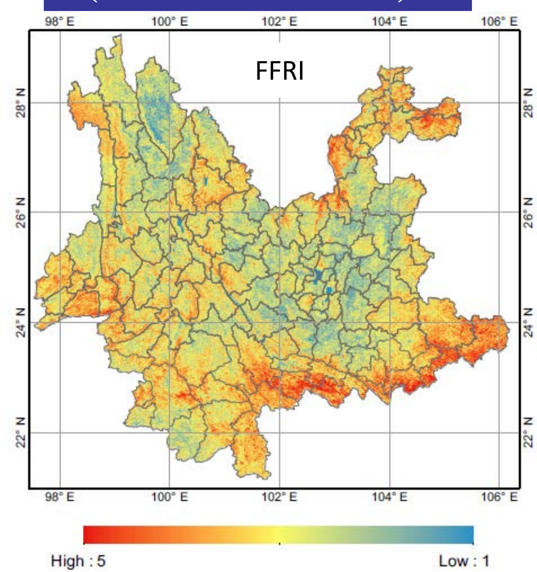
FFPI
(Flash Flood Potential Index)

+ Rainfall Frequency

FFHI
(Flash Flood Hazard Index)

+ Social-economic Data

FFRI
(Flash Flood Risk Index)



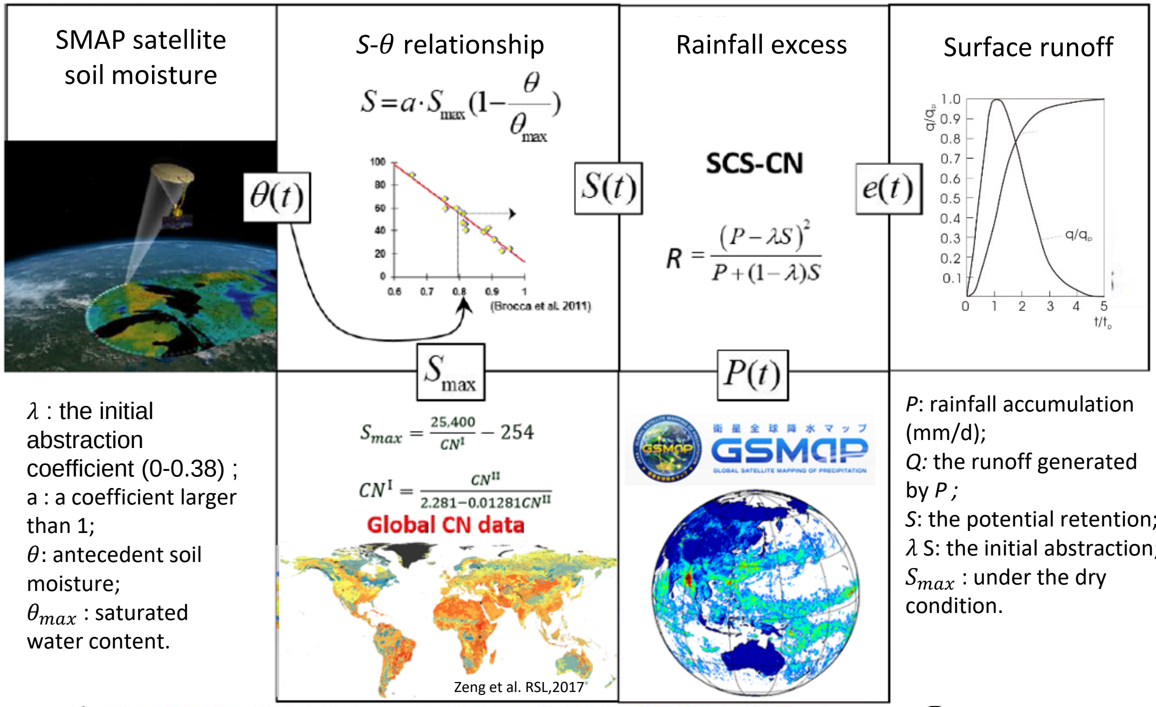
Highlights:

-- The CFFG system demonstrates the possibilities of flash flood occurrence in a fine resolution at a cascading manner (i.e., from potential to hazard and risk)

-- It can provide a useful new tool for research and evaluation of flash flood occurrence in areas prone to flash floods.

3. Model Forecasting for Water-related Applications

- **Surface runoff calculation for flood monitoring and forecasting, based on SMAP soil moisture retrievals (passive, 36 km/daily) and GSMaP_Gauge satellite precipitation product (0.1°/h)**

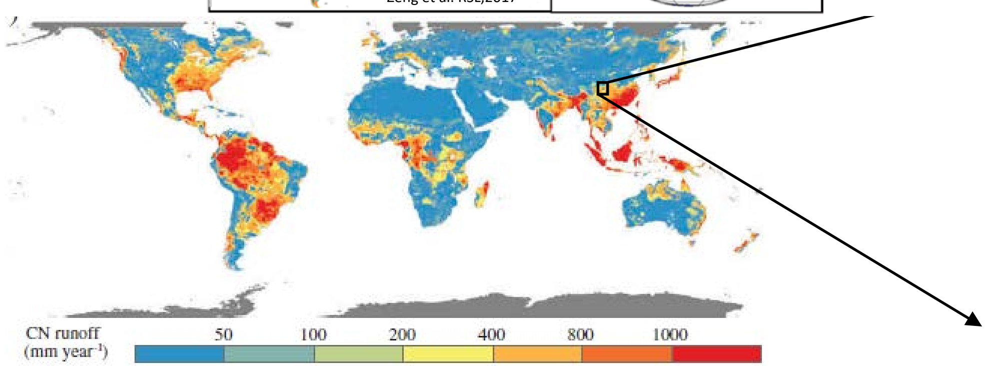


Highlights:

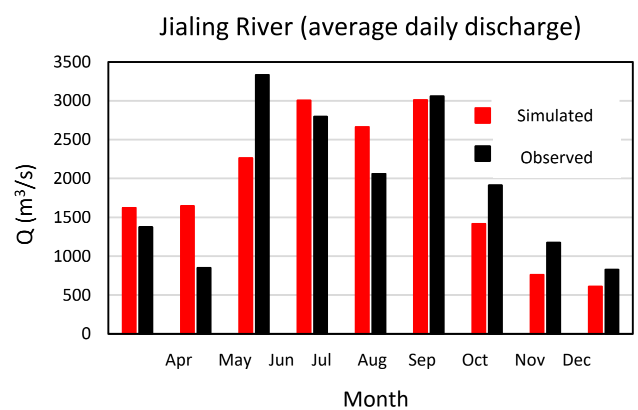
-- Updated the global CN (Curve Number) dataset (~2013, 500 m)

-- The NRCS-CN model, with SMAP soil moisture and GSMaP satellite precipitation, can indicate flood and drought possibility around the world.

-- In Jialing River basin, the estimated runoff can illustrate flood process at monthly scale.

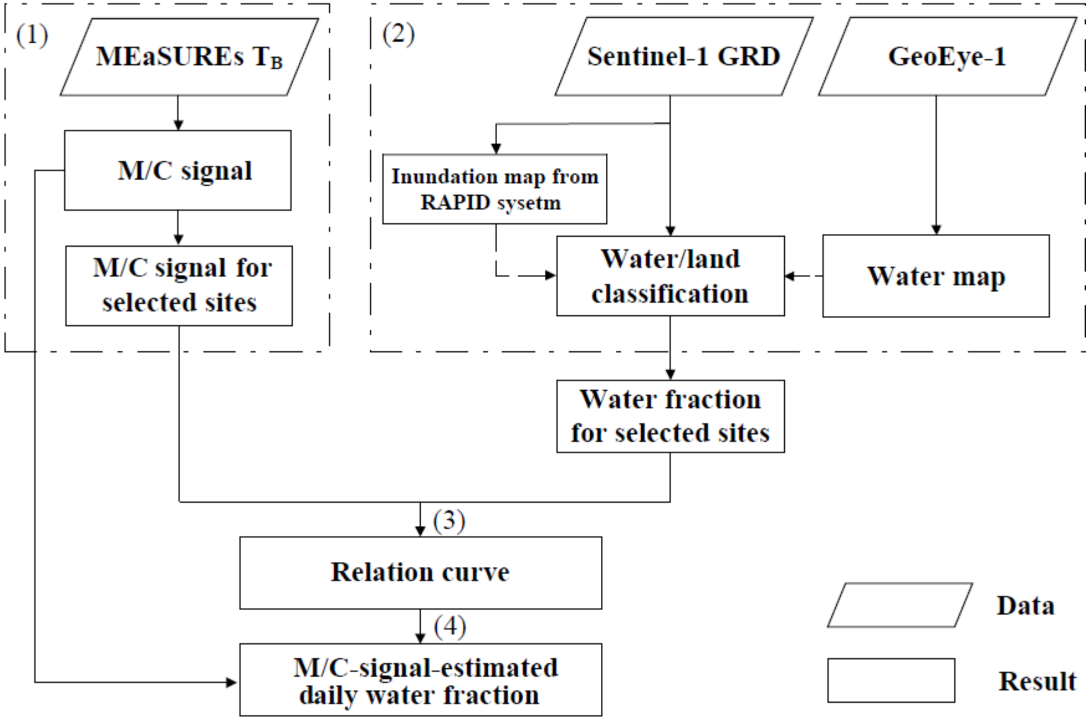


Global annual surface runoff (2015.04-2016.03, 0.1°)

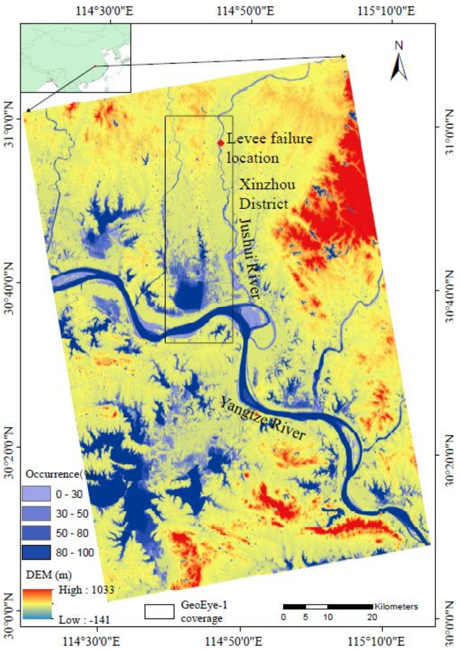


3. Model Forecasting for Water-related Applications

- **Towards high resolution flood monitoring: An integrated methodology using MEaSUREs brightness temperatures and Sentinel-1 synthetic aperture radar imagery**



Flood: 2016-07, Wuhan



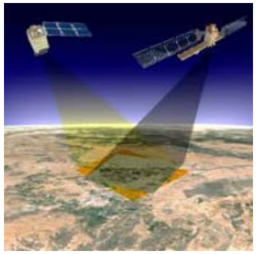
To determine the feasibility of using high resolution T_B to estimate flood extent combined with SAR-based flood mapping information

Data:

-- MEaSUREs CETB product (37GHz, 3.125 km/ twice a day, from 1978)

-- Sentinel-1 SAR imagery (10 m, ~12 days)

-- GeoEye-1 (~2 m, from GBDX, DigitalGlobe)

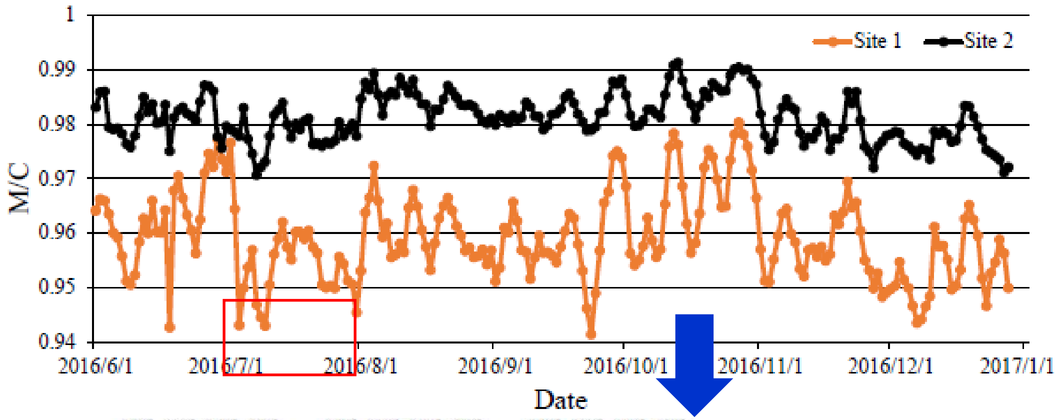


Sentinel

Zoom-in map of a GeoEye-1 image

3. Model Forecasting for Water-related Applications

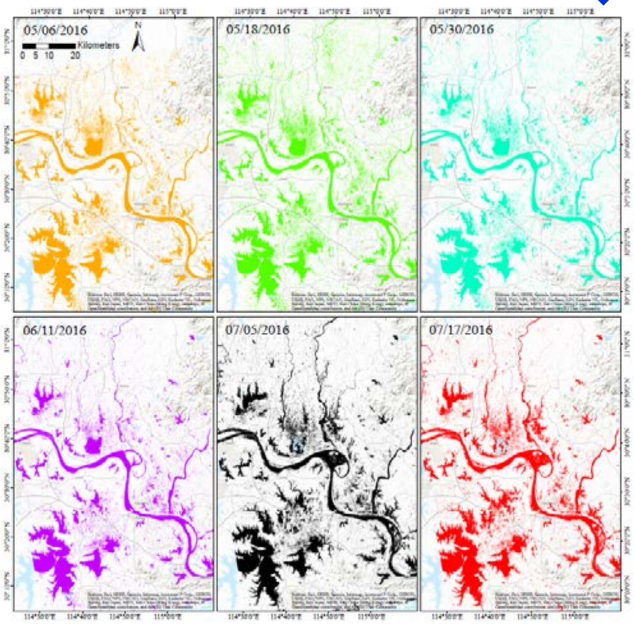
Towards high resolution flood monitoring: An integrated methodology using MEaSUREs brightness temperatures and Sentinel-1 synthetic aperture radar imagery



Flood occurrence signal:

-- M/C signal derived from T_B was propsed by Brakenridge et al (2005)

-- $\frac{\mathrm{M}}{\mathrm{C}} = f(SWF)$



Surface water map derived by a threshold-based method

$$\mathrm{SWF} = 49674(\mathrm{M/C})^2 - 96903(\mathrm{M/C}) + 47270$$

(R^2=0.84)

Highlights:

-- This study proposed a reliable and efficient methodology to monitor floods, which offers continuous information on surface water fraction (SWF) at a high resolution of 3.125 km/day

-- Based on high-resolution microwave remote sensing data, this integrated methodology can be applied to studies on flood monitoring or other hydrological applications in flood-prone regions across the globe

Thank You!

Ziqiang Ma

Sep-11, 2019