Evaluation and application of satellite-based precipitation measurements for hydro-climate studies over mountainous regions: case studies from the Tibetan Plateau

Soroosh Sorooshian¹, Kuolin Hsu¹, Phu Nguyen¹, Tiantian Yang¹, Hamed Ashouri¹, Zhongwen Yang², Xiaomang Liu³, and Dan Braithwaite¹

Presented by Amir AghaKouchak¹

¹ Center for Hydrometeorology and Remote Sensing, University of California, Irvine, USA
² State Key Laboratory of Environmental Criteria and Risk Assessment, Chinese Research Academy of Environmental Sciences, China
³ Key Laboratory of Water Cycle & Related Land Surface Process, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, China
Research Team: Present and Recent Past

and many more ...

University of California, Irvine
Precipitation Measurement is one of the KEY hydrometeorologic Challenges

Having adequate high resolution (time and Space) observations for model Input, Calibration, Testing, and to capture extremes is crucial.
Precipitation Observations: Which to trust??

Rain Gauges

TRANSMIT Horizontal Pulse

Satellite
Number of range gauges per grid box. These boxes are 2x2 degrees (Source: Global Precipitation Climatology Project)
Satellite Data for Precipitation Estimation

- **Geostationary IR**
  - Cloud top data
  - 15-30 minute temporal resolution

- **Passive Microwave (SSM/I)**
  - Some characterisation of rainfall
  - ~2 overpasses per day per spacecraft, moving to 3-hour return time (GPM)

- **TRMM precipitation RADAR**
  - 3D imaging of rainfall
  - 1-2 days between overpasses (S-35°N-35°)
Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN)

PERSIANN System “Estimation”

Satellite Data
- Global IR (CPC, NOAA)
- MW-RR (TRMM, NOAA, DMSP Satellites)

Ground Observations
- GPCC & CPC Gauge Analysis

Products
- Hourly Global Precipitation Estimates
  - Hourly Rain Estimate
  - Quality Control
  - Merging
- Merged Products
  - Hourly rainfall
  - 6 hourly rainfall
  - Daily rainfall
  - Monthly rainfall

Error Detection
Feedback

Sampling
MW-PR Hourly Rain Rates
(GSFC, NASA; NESDIS, NOAA)
High Temporal-Spatial Res. Cloud Infrared Images

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PERSIANN Extensions: Climate-Related

PERSIANN- CDR
(Climate Data Record)
PERSIANN - CDR

http://www.ncdc.noaa.gov/cdr/operationalcdrs.html

- **Daily Precipitation Data**
- **Data Period:** 1983~2017
- **Coverage:** 60°S ~ 60°N
- **Spatial Resolution:** 0.25°x0.25°

Ashouri, Hsu et al., BAMS, 2015.
PERSIANN Websites and Apps

- CHRS Data Portal
- CHRS RainSphere
- CHRS iRain
- PERSIANN-CONNECT
PERSIANN Extensions: Climate-Related

CHRS RainSphere
An Integrated System for Global Satellite Precipitation Data and Information
CHRS RainSphere

Rainsphere.eng.uci.edu

Watersheds
How Do we Judge the level of accuracy of PERSIANN-CDR??
Many Regional Evaluations of PERSIANN-CDR Have Already Been Reported:
PERSIANN-CDR Evaluation over China

**Gauge data:** daily precipitation over East Asia (EA) (Xie et al., 2007)
- More than 2,200 ground-based stations across China
- 0.5° resolution
- Period 1983-2006

PERSIANN-CDR: up scaled into the same resolution as EA (0.5°)
Results: Entire China

Miao et al., JHM 2015

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\textbf{Miao et al., 2015 conclusion About Tibetan Plateau}

“The results show that PERSIANN-CDR depicts similar precipitation behavior as the ground-based EA product in terms of capturing the spatial and temporal patterns of daily precipitation extremes, particularly in the Eastern China monsoon region. However, the agreement between the data sets in the Tibetan Plateau is not strong. An important factor that may have influenced the results is that the ground-based stations are very sparse.”

\textit{Miao et al., 2015}
The Evaluation was based on the use of a calibrated hydrologic model and using both gauge and PERSIANN-CDR to see which one produced more accurate Streamflow simulation.
Comparisons of the simulated and observed average monthly streamflow driven by the gauge-based precipitation and PERSIANN-CDR precipitation for the two basins from 1983 to 2012.

Liu et al., HESS 2016
Capturing Extreme Precipitation from Hurricane Harvey (Aug 25-27 2017)
How Trust Worthy are Real-Time Satellite Precipitation Estimates??
◆ Study area
Mean elevation > 4000m
Gauge density: 31000 km²/station
Gauge number: 89

◆ Data collection
- Gauge observations
  2003-2013 (daily, 89 gauges)

◆ Satellite data
The PERSIANN-CCS precipitation daily estimates from the University of California, Irvine are collected for 2003-2013 (resolution: 0.04 degree)
● Model Calibration and Validation

To comprehensively test the framework, the bias adjustment approach (step 1) is calibrated using observations for 2003-2009, and the data merging methods (steps 2 and 3) using observations from 81 gauges (about 90%) for 2003-2013 with 8 gauges absent.

Observations from the 8 gauges are used for model validation.

● Results Evaluation

- Precision evaluation
  Gauges observations are used as reference to evaluate the precisions of precipitation estimations

- Hydrological evaluation
  Area: Upper Yalong River Basin (66,000 km²)
  Hydrological model: Soil and Water Assessment Tool (SWAT)
  The model is calibrated with gridded gauge observations, and then used to assess the adjusted and merged precipitation data for streamflow simulation.
  Reference: observed streamflows from the outlet station.
Results - Model calibration

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Zhongwen Yang et al., 2017 (GRA)
Hydrologic Evaluation

Comparison of daily streamflow simulations using different precipitation estimates as forcing data for 2004-2011
Who Uses CHRS Products

CHRS User Statistics

Total Visits: 733,497 since 01-Jan-2010
Countries: 199 countries registered

Data Download

User Visit

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Summary

- Satellite-based precipitation estimates have been evolving and improving in terms of their spatial and temporal resolutions.
- Two of the PERSIANN products (the Climate-Scale PERSIANN-CDR and the Real-Time high resolution PERSIANN-CCS) were introduced.
- Results of their evaluations over several watersheds in the Tibetan Plateau were presented.
- The efficacy of PERSIANN-CDR over two Tibetan watersheds was demonstrated.
- In the case of the real-time high resolutions PERSIANN-CCS, it is shown that even with limited gauge observations systematic corrections of the remotely sensed estimates improves the performance of the algorithm and its accuracy.
Thank You for Listening

Somewhere in New Mexico, USA - Photo: J. Sorooshian
### Evaluation Indices

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<tr>
<th>ID</th>
<th>Definition</th>
<th>Unit</th>
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<tr>
<td>RR95p</td>
<td>The 95th percentile of annual precipitation on wet days (precipitation ≥ 1mm)</td>
<td>mm/day</td>
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<tr>
<td>R10mmTOT</td>
<td>Annual total precipitation when daily precipitation ≥ 10mm</td>
<td>mm</td>
</tr>
<tr>
<td>R10mm</td>
<td>Annual count of days when precipitation ≥ 10mm</td>
<td>Days</td>
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**Extreme precipitation indices used in the analysis**