Satellite Data Support for Hydrologic and Water Resources Planning and Management

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Task Code	
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Contribution to CICS Themes	Theme 1: 75%; Theme 2: 25%
Contribution to NOAA Goals	Goal 1: 25%; Goal 2: 75%

EXECUTIVE SUMMARY

Extreme precipitation events have direct impacts to many aspects of our society. Satellite-based precipitation estimation provides a unique way to monitor large precipitation systems with high spatial and temporal resolutions. Our research over the reporting period has contributed to the understanding of precipitation variability at various spatial and temporal scales. Long-term (more than 30 years) satellite-based high-resolution precipitation data is under development. Extreme events relevant to floods and droughts will be processed. The developed high-resolution precipitation measurement can be used for improving our understanding of spatial and temporal variability of precipitation distribution and for documenting the recent trends in extreme precipitation events.

Tasks in this report period are focused on (1) developing a climate data record of high-resolution precipitation estimation, (2) processing a 4-D database of heavy precipitation events from historical precipitation measurement, and (3) evaluating high-resolution precipitation data for hydrologic applications. The work accomplished for the high-resolution data processing, evaluation, and application of the project are discussed.

BACKGROUND

Satellite-based precipitation products provide an excellent data source for hydrometeorological applications and climate studies. One of the main objectives of the project is the development of long-term high-resolution precipitation measurement for extreme event (floods and droughts) studies. Specific tasks are focused on developing of climate data record of high-resolution precipitation estimation and evaluating high-resolution precipitation data for hydrologic applications. Two peer review papers were published and four presentations were presented at AGU and AMS annual meetings.

ACCOMPLISHMENTS

Develop Climate Data Record of High Resolution Precipitation Estimation

The ISCCP (International Satellite Cloud Climatology Project) B1 data are evaluated and used for PERSIANN (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks) rainfall estimation. The PERSIANN precipitation dataset will cover more than 30 years when it is fully processed and completed. PERSIANN precipitation bias is adjusted by GPCP (Global Precipitation Climatology Project) monthly precipitation estimates. The adjusted dataset has monthly rainfall consistent to GPCP estimation while retaining the spatial and temporal features of precipitation estimates from PERSIANN estimation at 0.25^{o} spatial and 3-hourly temporal resolution. This bias adjusted dataset is further up-scaled to 0.5^{o} daily for ex-

treme event analysis. Figure 1 shows the adjustment of PERSIANN bias using GPCP monthly rainfall for Jan 2007. Currently, more than 10 years of GPCP adjusted PERSIANN data are generated. We plan to process more than 30 years of historical data for extreme event analysis.

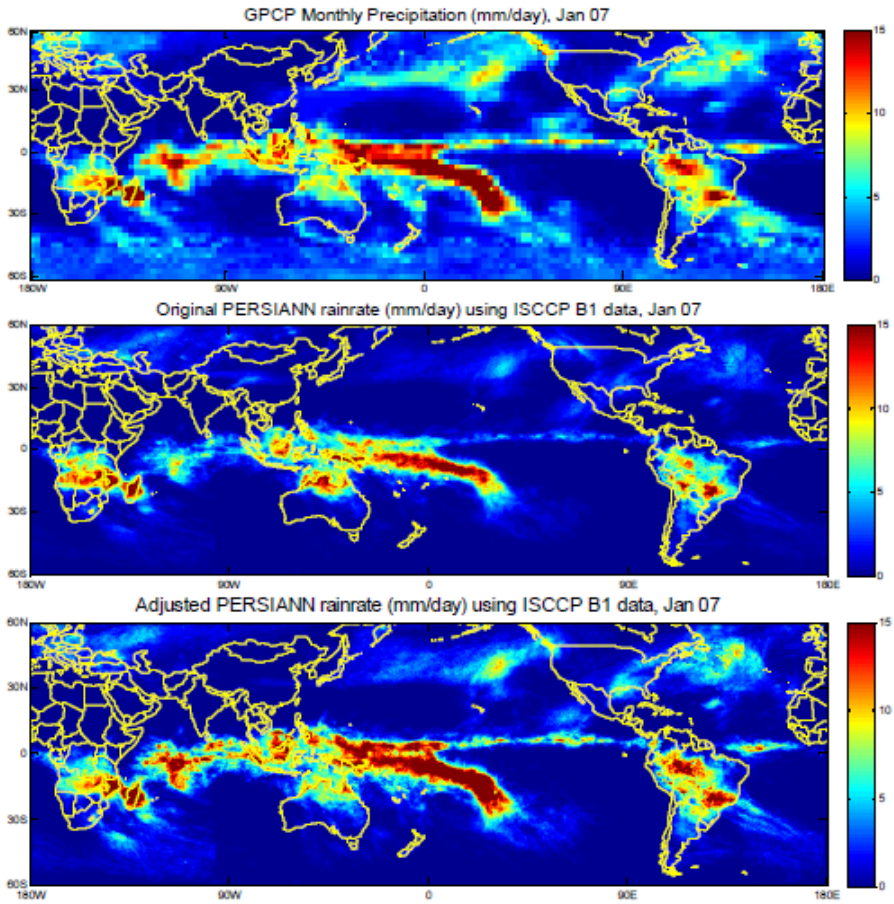

Figure 1: Monthly Bias Correction Method (Top: GPCP Monthly, 2.5°, Middle: Original PERSIANN Aggregated Monthly 0.25°, Bottom: Adjusted PERSIANN Monthly 0.25°)

Process 4-D Database of Heavy Precipitation Events

A fast connected components labeling (CCL) algorithm for extracting large precipitation systems from a consequence of satellite precipitation images has been developed. The CCL algorithm was applied to a 10-year (2000-2009) and global (60° to 60°) PERSIANN dataset, which has the resolution of 0.25^o and 3-hours. To enable easy storing and sharing, a MySQL database was set up to archive all the heavy precipitation events extracted. By implementing a relational database, researchers can obtain a particular set of events based on the temporal and geographical preferences in the studies. Figure 2 illustrates a continuous precipitation event that can be viewed as an object of connecting precipitating pixels in a sequence of continuous satellite images. The CCL algorithm scans over satellite images and extracts the objects based on a user-specified threshold of storm duration and intensity.

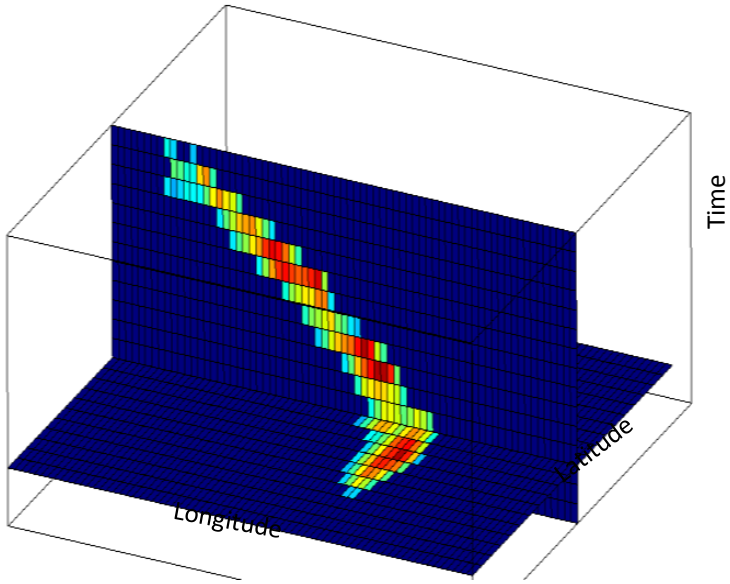

Figure 2: A heavy precipitation event is represented as an object in a 3-D (longitude, latitude, and time) hyper-space from a sequence of continuous satellite precipitation images.

Evaluate and Utilize High Resolution precipitation Data for Hydrologic Applications

The effectiveness of using satellite-based precipitation products for streamflow simulation at catchment scale is evaluated. Satellite-based PERSIANN precipitation products are used as forcing data for streamflow simulations at 6-h time scales during the period of 2003–2008. SACramento Soil Moisture Accounting (SACSMA) model is used for streamflow simulation over the mid-size Illinois River basin (1498 km^2). The results show that by employing the satellite-based precipitation forcing the general streamflow pattern is well captured at both 6-h and monthly time scales. Adding PERSIANN bias-adjustment, satellites products can improve estimation of both precipitation inputs and simulated streamflows substantially (Behrangi et al., 2011). Verification analyses show that, comparing with unadjusted PERSIANN estimation, the GPCP adjusted PERSIANN estimation has improved streamflow simulation.

Figure 3 presents time series of monthly averaged precipitation rates over the Illinois River basin: (a) PERSIANN (unadjusted); and (b) PERSIANN-adj (adjusted version). The grey lines show the monthly averaged multi-sensor radar/gauge-adjusted baseline data. It shows that the PERSIANN algorithm can capture the precipitation pattern and the bias-adjusted version consists of a better agreement with the reference of gauge-adjusted radar multi-sensor data. PERSIANN estimates tend to overestimate the amount of precipitation, particularly during the spring and summer months. The bias-adjusted PERSIANN data shows improvement in capturing both the variation and the total amount of precipitation.

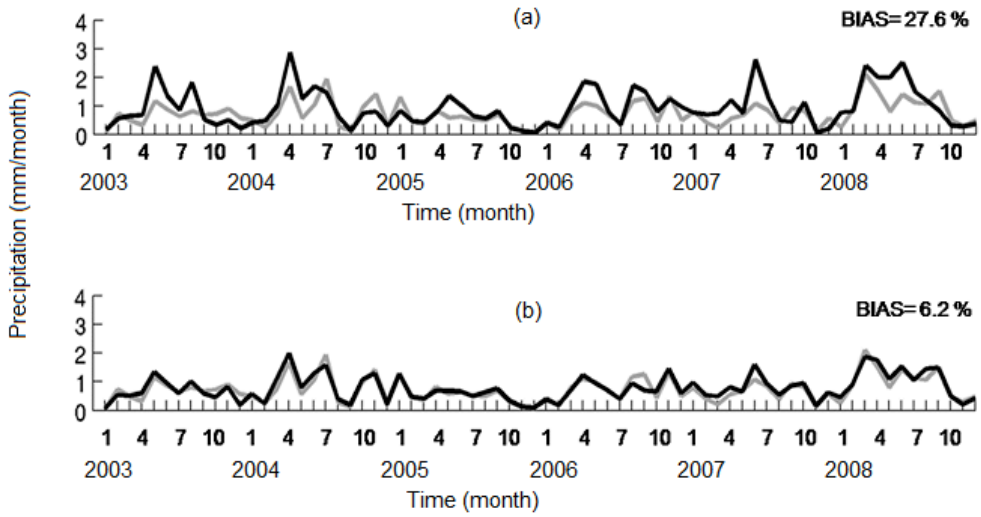

Figure 3: Time series of monthly precipitation estimates over the Illinois River basin based on (a) PERSIANN estimation; and (b) GPCP adjusted PERSIANN estimation. The grey lines show the monthly averaged multi-sensor radar reference data.

PLANNED WORK

- Continue processing high resolution precipitation data and 4-D database of heavy events (location, incremental depth/intensity, and time period)
- Utilize the developed database to conduct seasonal and regional analysis of heavy precipitation events.
- Analyze the pattern and trend of large storm events, including frequency, intensity, duration, coverage, and path.
- Evaluate the satellite data product over effective radar coverage and high-density gauge sites. Storm events from satellite, radar, and gauge observations will be extracted and evaluated.
- Develop a process to steward the framework such that the database can be implemented an operational setting to deliver the processed data to data archive centers.

PUBLICATIONS

Peer Reviewed

AghaKouchak, A., A. Behrangi, S. Sorooshian, K. Hsu, and E. Amitai, 2011, Evaluation of satellite-retrieved extreme precipitation rates across the central United States, *Journal of Geophysical Research*, 116, D02115, doi:10.1029/2010JD014741.

Non-Peer Reviewed

Ali Behrangi, Behnaz Khakbaz, Tsou Chun Jaw, Amir AghaKouchak, Kuolin Hsu, and Soroosh Sorooshian, 2011, Hydrologic Evaluation of Satellite Precipitation Products Over a Mid-size Basin, *Journal of Hydrology*, 397, 225–237.

PRESENTATIONS

Li, J., K. Hsu, A. AghaKouchak, and S. Sorooshian, A Hybrid Framework for Verifica tion of Satellite Precipitation Products, AGU Fall Meeting, 5-9 December, 2011, San Francisco, CA, 2011.

Nasrollahi, N., K. Hsu, S. Sorooshian, Application of CloudSat Cloud Classification Maps and MODIS Multi-spectral Satellite Imagery in Identifying False Rain from Satellite Images, AGU Fall Meeting, 5-9 December, 2011, San Francisco, CA, 2011

Ashouri, H., K. Hsu, and S. Sorooshian, Reconstruction of Daily Precipitation for Climate Trend Detection and Extreme Precipitation Analysis, AMS Meeting, 22-26 January, 2012. New Orleans, LA. 2012.

Hsu, K. (Invited), A Machine Learning Approach for Precipitation Estimation from Multiple Satellite Information. American Meteorological Society Annual Meeting, 22-26 January, 2012. New Orleans, LA. 2012.

OTHER

None