Satellite Data Support for Hydrologic and Water Resource Planning and Management

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Background: Scientific Problem, Approach

Precipitation estimation with high spatial and temporal resolution is crucial for climate studies, engineering design, verification of regional numerical weather models and environmental applications especially hydrologic processes. Currently, applicability of satellite precipitation products to climate studies and hydrologic applications is limited due to factors such as limitation on record length, and lack of quantitative information about uncertainties in satellite precipitation at the required spatial and temporal scales. This study will focus on addressing these challenges and initiating the development of approaches that can lead to improve utilization of satellite precipitation in hydrologic application and water resources planning and management. This research effort intends to focus on four different thematic areas:

I. Characterization of sub-daily variability of precipitation under climate change;

II. Continue and expand research towards quantitative error and uncertainty analysis of satellite based precipitation estimation in comparisons with gauges and NEXRAD data;

III. Assessment of nonstationarity in extreme precipitation data and spatiotemporal framework to improve regional characterization of return periods with various duration and area extent.

Accomplishments

A significant progress is made toward preparing a White Paper that provides a framework for future research in application of satellite-based precipitation products in hydrometeorological applications. Furthermore, a meeting at the NCDC is scheduled for April 6-7, 2010 to discuss the progress of the work and research scope. As mentioned above, one of the objectives of this study is to use satellite data to support extreme precipitation analysis. In order to validate satellite-based precipitation products with respect to extremes, different satellite-derived precipitation patterns are compared to the Stage II radar-based gauge-adjusted precipitation pattern. Figures 1(a) to 1(c) show three satellite images, occurred on 9/24/05 at 9:00 UTC, with a spatial resolution of 0.25^{o} (1(a): TRMM 3B42; 1(b): CMORPH; 1(c): PERSIANN). Notice that in Figures 1(a) to 1(c), only values above 50 percentile threshold are considered in order to avoid unreliable small rainfall rates. Figure 1(d) displays the corresponding Stage II image. The Stage II data, provide estimates of precipitation using a combination of radar and rain gauge measurements. The data is available on the Hydrologic Rainfall Analysis Project

(HRAP) grid, with a spatial resolution of approximately 4km. The Stage II data are aggregated in space to match the spatial resolution of the TRMM, CMORPH and PERSIANN data (0.25°). Figures 1(e) to 1(h) and 1(i) to 1(l) present similar figures for precipitation values exceeding 75 percentile and 90 percentile, respectively. One can see that satellite products may identify patterns of extreme events significantly differently. Currently, various statistical and geometrical measures are being developed to evaluate extreme precipitation patterns in order to integrate this concept into practical applications.

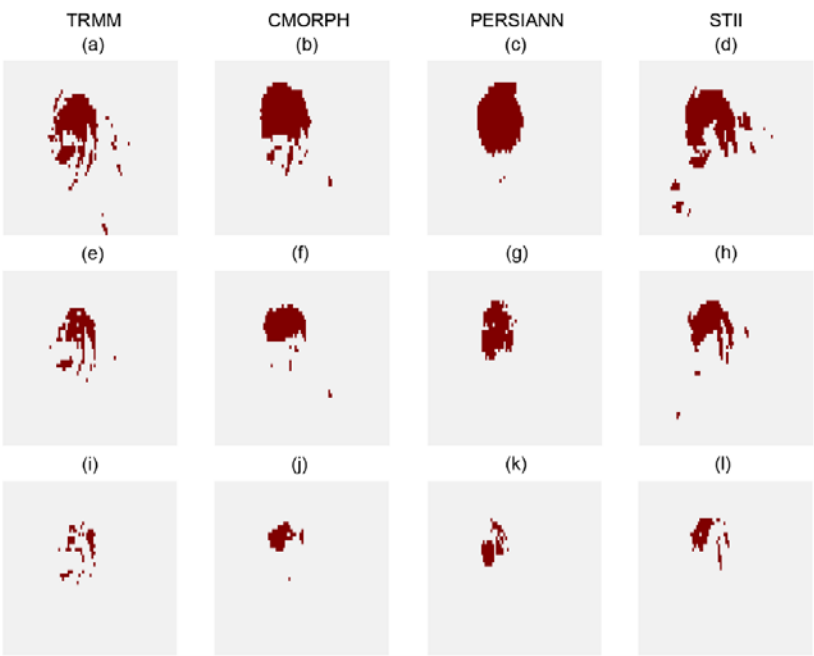

Figure 1: TRMM, CMORPH, PERSIANN and Stage II precipitation patterns for rainfall rates above: 50 percentile ((a)-(d)); 75 percentile ((e-h)); 90 percentile ((i)-(l)).

Planned Work

In addition to data collection and quality control, the planned work involves the following tasks:

(a) Using local gauge/radar measurement to adjust multi-satellite precipitation estimation and extend the precipitation measurements to un-gauged regions using bias corrected satellite data.

(b) Extreme precipitation analysis by examining the trend of extreme storm events at each climate region based on precipitation intensity and frequency (e.g. the annual extreme event, N-largest, peaks over thresholds, % of historical data).

(c) Identify presence of nonstationary in extreme precipitation data.

(d) Validation of satellite precipitation estimates for different thresholds of precipitation (e.g., 95, 90, 75, 50, 25 and 10 percentiles) using NEXRAD radar data and rain gauge measurements. The results will lead to characterization of error, which may result in significant advancements in data assimilation techniques and ensemble generation.

(e) Analysis of multivariate probability distribution of precipitation extremes using advanced statistical techniques (e.g., copulas) at locations where reliable ground reference measurements exist.

(f) Investigation of the dependence structure of satellite precipitation error in space using spatial empirical copulas. These techniques can provide valuable information regarding error and its spatial characteristics.

(g) Utilization of extreme events database to conduct seasonal and regional analysis of heavy precipitation events. Initially, the analysis will focus on characterizing heavy events within given regions in terms of their spatial extent, duration, depth, and storm origin.

Publications & Presentations

A. AghaKouchak, B. Imam, K. Hsu, A. Behrangi, X. Gao, S. Sorooshian, Verification of Extreme Precipitation Events Using Satellite-Based Remotely Sensed Data. Abstract submitted to the Hydrology Conference, San Diego, October 11-13, 2010.

Amir AghaKouchak, Nasrin Nasrollahi, Bisher Imam, Soroosh Sorooshian, 2010: Geometrical Characterization of Precipitation Patterns, Journal of Hydrometeorology, under review.