1) Research Motivation & Study Objectives

- Reliable precipitation estimates are crucial for any hydrologic study
- Representation of high spatial-temporal variability in precipitation using rain gauges is challenging especially over complex terrains
- Satellite-based precipitation (SBP) products, with quasi-global coverage and high resolutions, are potentially attractive for hydrologic studies over complex terrains
- However, SBP products have limitations, requiring bias adjustment or merging procedure with other sources to improve accuracy

Study objectives:
1) Evaluate the performance of SBP products against rain gauges over both conterminous US, Turkey which is characterized by complex terrain (Fig. 1)
2) Devise a bias adjustment algorithm for SBP products based on the concept of "physiographic similarity" and evaluate its performance

2) Data Sets

Rain Gauge
Meteorological stations operated by the Turkish State Meteorological Service (TSM)
- 25 AWS type (hourly rainfall)
- 14 pluviometer type (rainfall at 7h, 14h, 21h in a day)
- TRMM (Huffman et al. 2007; 2012)
Spatial resolution: 0.25° x 0.25° (temporal resolution: 3 hourly)

There are two SBP products:
1) Real-time monitoring product (satellite-only; TRMM-RT)
2) Research product – monthly rainfall correction (TRMM-RT+V7)
COSMIC (Joyce et al. 2004)
Spatial resolution: 0.25° x 0.25° (temporal resolution: 3 hourly)

In Region 1 and 2, precipitation products are compared against rain gauge based gridded rainfall dataset (Fig. 3).

Rain gauge-based Gridded Rainfall Dataset
The procedure for gridded rainfall estimation is based on Precipitation-elevation Regressions on Independent Stations (PRISM, Daly et al. 2008) which incorporates the influence of complex topography with the help of physiographic descriptors in the rainfall estimation. Climate-elevation regression function given by

\[ P(E) = \beta_0 + \beta_1 E \]  

Based on physiographic similarity between the observed and estimated station/grid each station is assigned weights. The combined weight W of a station is a function of the following set of physiographic descriptors:

\[ W = f(Z, W, T, \text{m} \text{a.s.l.}, \theta) \]  

3) Evaluation of the SBP Products

Bias Adjustment Based on Physiographic Similarity (BAPS):
- Utilizes "physiographic similarity" concept which is better suited to regions characterized by complex terrain compared to the commonly employed proximity concept.
- Rain gauges located in physiographically similar regions are assigned higher weights rather than the rain gauges in proximity.

Methodology:
For each 0.25° satellite-only SBP grid precipitation is adjusted based on weighted difference between precipitation estimates from rain gauges and their co-located SBP grids. The weights are calculated as follows:

- Select the 0.25° PRISM grids within the 0.25° SBP grid (Fig. 6a).
- Group and sort the weights of each rain gauge used in the PRISM estimation for the selected PRISM grids (Fig. 6b).
- Select a PRISM weight threshold (50th quartile [Q50]) in this case, and assigns bias-adjustment weights (w_i) to each rain gauge based on the frequency of its occurrence within Q50.
- Bias used in SBP product adjustment is the difference (w_i) between rain gauges and their co-located SBP grids (Eqn 3 & 4).

Figure 4. Bias adjustment methodology
(a) Region 1
(b) Region 2

Validation of the Bias Adjustment Algorithm
- Validation is performed using two independent stations ZNG (Region 1) and BOL (Region 2)
- Bias adjustment is based on distance weighted (DW) approach used as a benchmark

For Station ZNG in Region 1, BAPS algorithm generally provided better precipitation estimates compared to IDW method, specifically in cold season (Fig. 7a).
- For Station BOL in Region 2, BAPS algorithm outperforms IDW method. IDW suffers from poor TSS and NRMSE values while providing better CORR statistics compared to BAPS (Fig. 7b).

4) Bias Adjustment of the SBP Products

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Complex topography in the study areas result in a strong N-S rainfall gradient characterized by orographic precipitation.
- All tested SBP products significantly underestimated the precipitation in Region 1 (North) characterized by orographic precip.
- PRISM avoided correction provided superior performance compared to satellite-only SBP products in terms of CORR and NRMSE statistics due to the monthly correction procedure incorporated in its development.
- CPC-V7, CPC-RT and CPC products significantly overestimate precipitation in Region 2 (South, drier) while CPC-MP outperforms all SBP products (especially in cold season) in Region 2 with slight underestimation. High CPC-MP performance in cold season in Region 2 could be attributed to the surface snow and ice freezing process embedded in the algorithm.

The proposed bias adjustment algorithm based on "physiographic similarity" (BAPS) is better suited to complex regions and generally provided better results compared to the benchmark "Inverse Distance Weighted" method of SBP in improving CORR is currently being investigated.

As a natural extension of this work, the precipitation datasets will be used to drive a hydrologic model. The stormtrack observations will then be used as an independent evaluation to evaluate the performance of SBP products.

5) Conclusions

Acknowledgements

This work is supported by a Marie Curie International Reintegration Grant within the 7th European Community framework Programme (Project No. PIRG05-GA-2010-277183, FLOODAOX). The authors are thankful to Turkish State Meteorological Service personnel for providing the rain gauge data.