Evaluation of a Satellite-based Near Real-time Global Flood Prediction System

Koray K. Yilmaz[1,2,*], Robert F. Adler[1,2], Yang Hong[3], Harold F. Pierce[2,4]

[1]ESSIC, Univ. of Maryland, [2] NASA/GSFC, [3]Univ. of Oklahoma, [4]SSAI

*yilmaz@agnes.gsfc.nasa.gov

GPM

OBJECTIVE

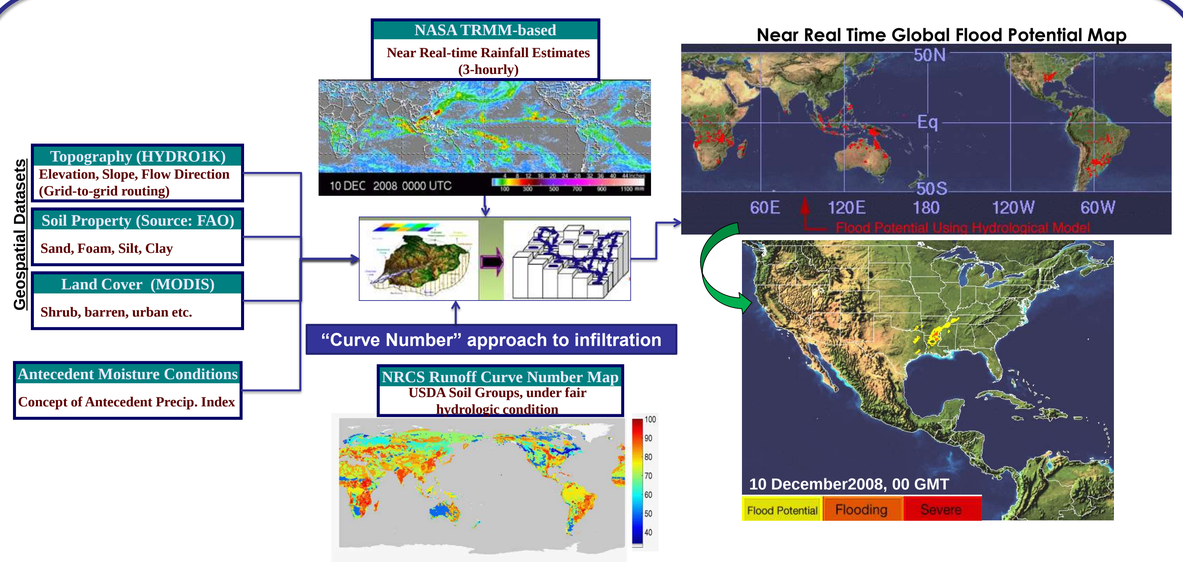
Recently, our group has implemented an initial satellite-based near real-time global flood prediction system that is operationally available. In this study we present a testing/evaluation of this flood prediction system, discuss its strengths and limitations and point toward potential improvements necessary for increasing its near real-time global flood prediction reliability and accuracy. This evaluation study focuses on the severe flooding events and includes comparison of the current product with observed stream flow data at watershed scale, archives of extreme floods, as well as with available remotely sensed inundation products.

APPROACH

Evaluate the current flood prediction system using the following approaches:

1) Location/Extent/Timing of the Flood ➡ Event based qualitative comparison using
   a) Inundation maps obtained from remote sensing analysis
   b) Historical data (e.g. news reports) related to the extreme flooding events
2) Magnitude and timing of floods ➡ Watershed scale comparison using observed stream flow.

OVERVIEW OF THE GLOBAL FLOOD PREDICTION SYSTEM



Hong, Y., et al. (2007), A first approach to global runoff simulation using satellite rainfall estimation, Water Resour. Res., 43, W08502, doi:10.1029/2006WR005739

Hydrological Model Algorithmic Steps:

Step I: Rainfall-infiltration Partitioning (Distributed and Time-variant)
Step 2: Flow Routing using Macro-scale Grid-to-Grid Algorithm
Step 3: Result: Grid Point Hydrographs--Flood Inundation Mapping

Flood Model Running in Real-time in Experimental Mode Globally at 3 hourly time steps, 0.25° lat./long. spatial resolution

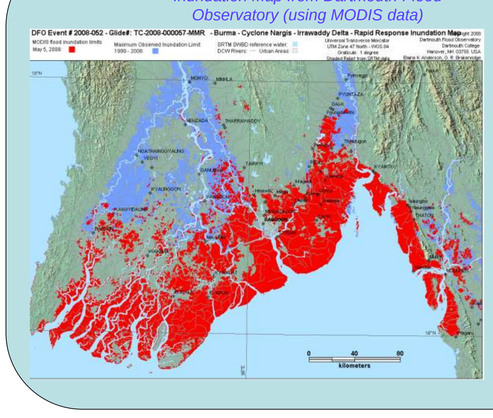
Products Available after 6-9 hours of observation at: http://trmm.gsfc.nasa.gov/publications_dir/potential_flood_hydro.html

EVALUATION USING INUNDATION MAPS

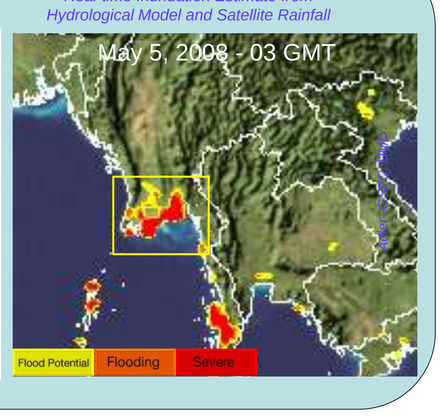
- Dartmouth Flood Observatory uses orbital remote sensing (e.g. MODIS) observations to map the extent of inundation areas.

Burma Flood (May 5th, 2008)

Inundation Map from Dartmouth Flood Observatory (using MODIS data)



Real-time Inundation Estimate from Hydrological Model and Satellite Rainfall



EVALUATION USING ARCHIVE OF EXTREME FLOOD EVENTS

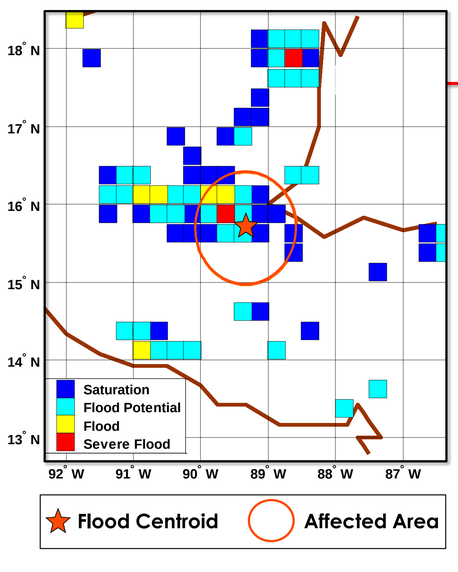
- Dartmouth Flood Observatory provides an archive of extreme flood events derived from a wide variety sources, such as news, governmental agencies and remote sensing data.

- Archive includes the following valuable information for evaluation of global flood prediction model: Begin & End Date, main cause, severity, geographic centroid and approximate area of flooded region (not actual inundated area but affected towns etc.)

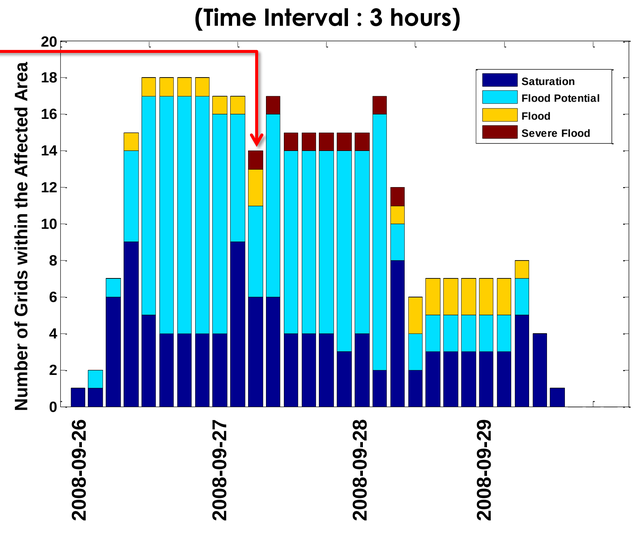
- In a simple analysis we overlay extreme flood information in the archive (centroid & affected area) with flood potential maps from the hydrological model. Both spatial extent and timing of the flood onset can be evaluated. For instance, figures below present the analysis for the recent floods in Guatemala.

GUATEMALA FLOOD
September 27-28, 2008

Real-time Flood Potential Map from the Hydrologic Model September 27th, 2008 -- 06GMT



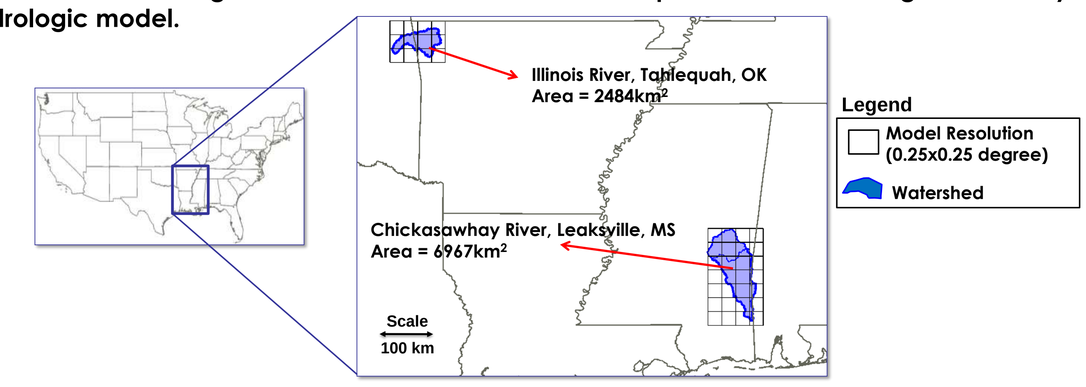
Time Evolution of the Guatemala Flood (Time Interval : 3 hours)



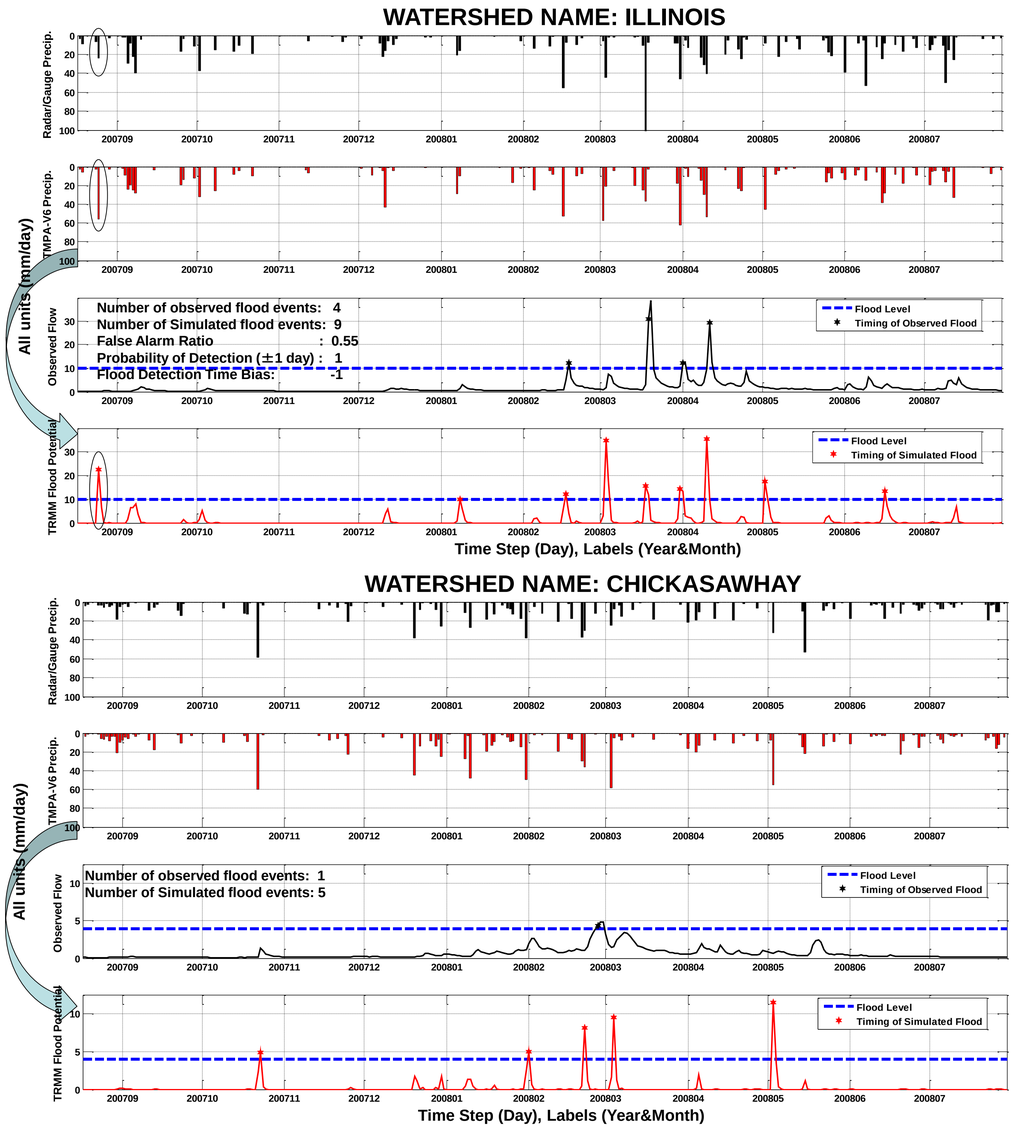
EVALUATION AT THE WATERSHED SCALE

At the watershed scale, magnitude and timing of the model simulated flows were evaluated using observed stream flow at the watershed outlet.

Since satellite-based rainfall estimates from NASA TMPA algorithm is the key input to the model, this product was also compared with rainfall estimates from NEXRAD Stage IV (radar/gauge merged) product. This comparison was performed at the watershed scale (area averaged values). In this study NASA TMPA Version 6 has been used. Of course, any bias in the rainfall estimation algorithm will translate into the flood potential estimates generated by the hydrologic model.



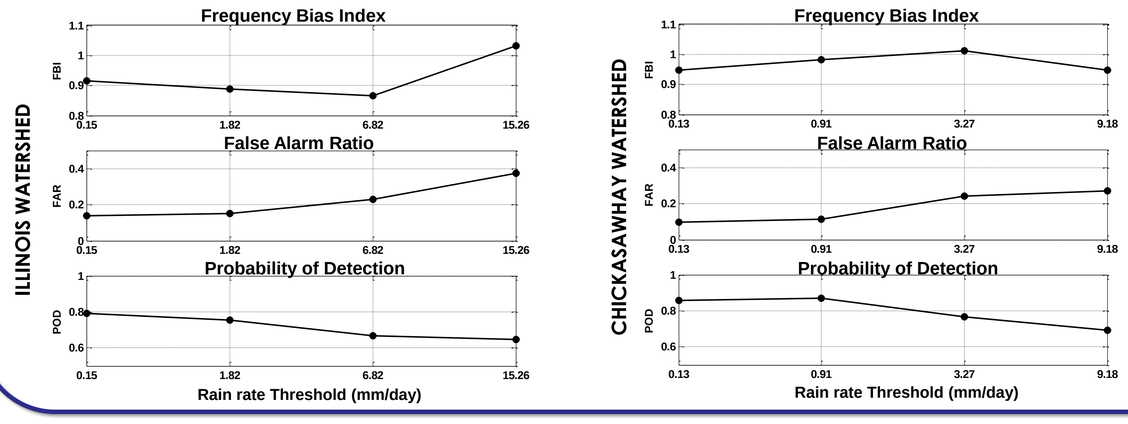
WATERSHED NAME: ILLINOIS



WATERSHED NAME: CHICKASAWHAY

- Watershed-based analysis points out the need for *improvement of the flow routing component* to better simulate flow at the daily timescale.

Evaluation of the Satellite-based rainfall estimates using STAGE IV (Radar/Gauge Merged Product)



CONCLUSIONS & FUTURE WORK

1) Satellite-based precipitation estimations and land surface characteristics have provided new opportunity to develop global flood prediction techniques--results appear promising for global and regional applications.
2) To realize the full potential of global flood prediction system the evaluation needs to be performed for longer time period and for more number of watersheds and inundation cases world wide.
3) Current global near-real time flood predictions provide valuable information related to spatial extent and onset time of extreme flooding events. However the accuracy diminishes in tracking the later stages of flood event.
4) At the current (relatively coarse) resolution, flow routing component of the model is not sophisticated enough to represent the translation and smoothing performed by the river network for the tested medium scale watersheds. One possibility for improvement is a new routing component with a finer spatial scale and that takes advantage of globally available drainage network datasets (e.g. HYDROSHEDS) .
5) Flood predictions are intimately tied to the accuracy of the satellite-based rainfall estimates. Therefore, the current evaluation study will be extended to flood predictions using the new version of the NASA TMPA real time satellite-based rainfall estimates.
6) Currently, Univ. of Oklahoma team lead by Dr. Hong is working on a *suite of alternative hydrological models* (e.g. Xinanjiang model) for improving the global flood prediction system. These models are being tested at scales ranging from global to individual watersheds.
7) In a parallel work, we are working on to incorporate rainfall forecasts from global numerical weather prediction models to increase lead time.
8) We are looking for developing user partners (goverment and non-goverment organizations) to receive feedback and aid in practical evaluations of both global and regional applications.

REFERENCES

Hong, Y, R.F. Adler, F. Hossain, S. Curtis, and G.J. Huffman, 2007, A First Approach to Global Runoff Simulation using Satellite Rainfall Estimation, Water Resource Research, 43(8), W08502, doi: d29/2006WR005739

Huffman, G.J., R.F. Adler, D.T. Bolvin, G. Gu, E.J. Nelkin, K.P. Bowman, Y. Hong, E.F. Stocker, D.B. Wolff, 2007: The TRMM Multi-satellite Precipitation Analysis: Quasi-Global, Multi-Year, Combined-Sensor Precipitation Estimates at Fine Scale. J. Hydrometeor., 8(1), 38-55

ACKNOWLEDGEMENTS

This research is carried out with support from NASA's Applied Sciences Program (Stephen Ambrose) and PMM (Ramesh Kakar) of NASA Headquarters.