FLOOD AND DISCHARGE MONITORING OVER UPPER MISSISSIPPI WATERSHEDS DURING THE 2008 IOWA FLOOD USING AMSR-E DATA

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Abstract

The objective of this work is to demonstrate the potential of passive microwave data in monitoring flood and discharge conditions. The study case is the recent flood in Iowa in summer 2008. Major floods have been recently observed in the Upper Mississippi Watershed. Several regions in Iowa were particularly affected by a 500 year flood which was classified as the worst in the history of the region (http://www.flood2008.iowa.gov/). Major damages and large inundated areas related to these floods have been recorded. The study area is located in Iowa and part of the Upper Mississippi watershed. The selected area is drained by the Iowa River toward the Mississippi River. It has a surface area of about 2084601 sq mile stretching east to the Mississippi River and west to the center of the state of Iowa. It corresponds to the portion of the state area directly drained by the Mississippi River through the Iowa River which is critical to establish the connection with discharge observed downstream. Discharge observations have been taken around 350 mile downstream at the Saint Louis station. Missouri and Illinois rivers steam flow as well as the upstream Mississippi River discharge at Clinton station have been subtracted from the St Louis station discharge observations to exclusively assess the Iowa watershed contributions.

Remote sensing data and particularly passive microwave images have shown an interesting potential in monitoring these extreme events. Three main raisons foster the use of passive microwave data which are namely their high temporal resolution, their large spatial coverage and their all sky capabilities. AMSR-E 37 GHz data have been used to calculate a Polarization Ratio Variation Index (PRVI). This new index uses the classic Polarization Index with the mean and the standard deviation to detect any increase in soil moisture and/or flood extent. The RAT (Robust AVHRR Technique) approach (Tramutoli (1998)) has been applied to the PR index similarly to the Lavaca et al. (2005) study in which a soil wetness index has been used. The approach implemented in this work aims at detection PR anomalies using a differential Polarization Ratio variation Index. (PRVI) written as:

$$PRVI = \frac{PR - \mu_i}{\sigma_i} \quad (1)$$

Where, μ_i and σ_i are the average and the standard deviation of the PR respectively for a given month i. The average and the standard deviation were estimated on a monthly basis to account for the changing surface conditions (i.e soil roughness and vegetation density) which might affect the microwave signal. The PRVI therefore exclusively reflects soil moisture anomalies.

The PRVI have been used to delineate inundated areas in Iowa. The obtained flooded areas maps have been compared with MODIS cloud free composites acquired over the same area during this flood event. Then the surface area of the inundated regions has been compared with downstream discharge observations taken at Saint Louis station after subtracting Missouri and Illinois contributions. A rating curve has been developed to assess the relationship between the extent of the flooded area and the magnitude of the discharge downstream. A time lag term has been introduced to account for the delay between the extent of the inundated areas and the stream flow. Time lag values showed that this parameter is a good proxy of the drainage time and the time of concentration of the watershed (i.e. the flood wave propagation time plus the longest runoff time in the watershed.) suggesting that passive microwave image can be use to measure a key watershed hydrologic parameter.

Finally, a Kalman filter has been used to update the parameters of the rating curve. The introduced time lag has also been updated by applying a cross correlation function. The temporal variability of these parameter shows that they reach a constant value suggesting that passive microwave images have also an interesting capabilities in monitoring river discharge as well as flood extent.