Inundation Extents and Depths over Lower Mekong Using Synthetic Aperture Radar Data with Machine Learning Techniques

Chi-Hung Chang[1], Hyongki Lee[1], Hanwen Yu[1], Duong Du Bui[2], Luong Duc Nguyen[3]

[1]Department of Civil and Environmental Engineering, University of Houston

[2]Water Resources Monitoring Department, National Center for Water Resources Planning and Investigation, Hanoi, Vietnam

[3]Department of Environmental Technology and Management, National University of Civil Engineering, Hanoi, Vietnam

Motivation and Objectives

In recent years, water resource in the lower Mekong has been facing challenges due to the rapid development of upper Mekong countries and future climate change which may influence livelihood of millions of people (Commonwealth Scientific and Industrial Research Organization, CSIRO, 2014; Kuenzer et al., 2013; Dore et al., 2012; Baird, 2011; Ministry of Natural Resources and Environment, MONRE, 2010; Wassmann et al., 2004). Since the Mekong River is a transboundary river, countries in the lower Mekong such as Cambodia and Vietnam have to rely on upstream countries to provide water usage plan "early" for water resource management. However, sufficient information may not be received early enough to be used for meaningful decision-making.

Satellite remote sensing, regardless of geographic and political boundary, is a perfect technique to address this issue, and to help our local stakeholders in Cambodia and Vietnam build sustainable capacity and independently gather information for water resource management use. In this study, we used synthetic aperture radar (SAR) images which are independent of weather conditions to study inundation extent. Our objectives are to (1) analyze the relation between inundation and hydrological properties (e.g. upstream water level variations, and water discharges), weather forcings, and sea level variations based on empirical orthogonal function (EOF) analysis (Preisendorfer, 1988), (2) forecast inundation extent to provide our local stakeholders with information for water resource management activity.

Dataset and Study Area

In this study, a stack of Sentinel-1A level-1 interferometric wide (IW) mode ground range detected (GRD) intensity images of (Path 26, Frame 33) with VV polarization covering the Cambodian floodplain was used. Figure 1 shows the entire image frame and the study area marked in red rectangle. GRD products consists of focused SAR data that has been detected, multi-looked and projected to ground range using an Earth ellipsoid model. Pixel values represent detected amplitude with no phase information (European Space Agency, ESA). Time span of data we used is from March 13th, 2017 to June 24th, 2018, with 40 image in total due to 12-day revisit cycle of Sentinel-1A.

In order to analyze the relation between variations of inundation extent and upstream hydrological properties, water levels at the Tonle Sap Lake were taken into account using Jason-3 Geophysical Data Record (GDR-D) data (AVISO) and water discharges at Kampong Cham estimated by the Variable Infiltration Capacity (VIC) model (Hossain et al., 2017) with the common time span as SAR images were used as well. See Figure 2 and Figure 3 for Jason-3 water levels at the Tonle Sap Lake and the VIC-estimated water discharges at Kampong Cham, respectively.

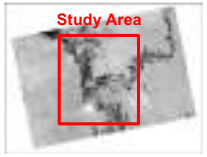


Figure 1. Sentinel-1A GRD intensity image with study area marked in red rectangle.

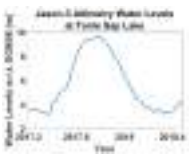


Figure 2. Jason-3 altimetry water levels at the Tonle Sap Lake.

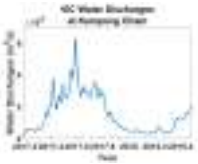
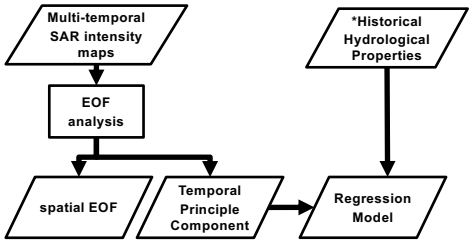


Figure 3. VIC-estimated water discharges at Kampong Cham.

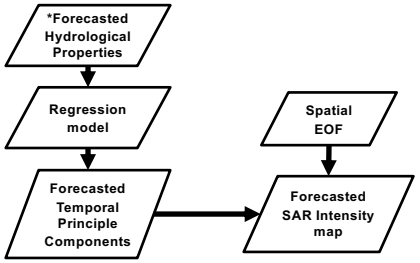
Method

Build Regression Model of one EOF mode



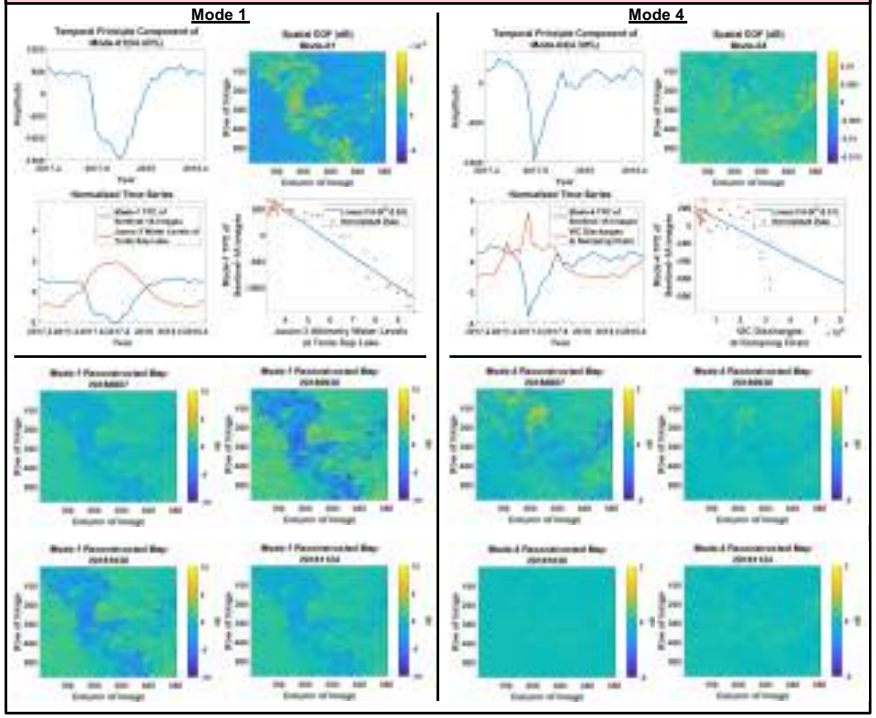
*For mode 1, Jason-3 GDR-D data from cycle 40 to 88 (2017/03/10~2018/06/29) were used, while for mode 4, VIC-estimated water discharges at Kampong Cham from 2017/03/13 – 2018/06/24 were used.

Forecast SAR intensity image of one EOF mode



*For mode 1, Jason-3 Interim GDR (IGDR) data from cycle 92 to 103 (2018/08/07~2018/11/24) were used, while for mode 4, VIC-estimated water discharges at Kampong Cham of the same time span were used.

Preliminary Results



Conclusion and Future Works

- Continue to analyze the relation of temporal principle components of other EOF modes with other hydrological properties, weather forcings, or sea level variations
- Perform classification after combining "forecasted" reconstructed SAR intensity images from dominant EOF modes to obtain forecasted inundation extent
- Combine forecasted inundation extent with digital elevation model (DEM) to estimate water volumes

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