Derivation of High Resolution Water Maps from TERRA/MODIS, Suomi-NPP/VIIRS and High Resolution DEM Data

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Introduction

The high temporal resolution and large coverage of coarse- to moderate-resolution satellite imagery, such as EOS-TERRA/MODIS and Suomi-NPP/VIIRS, are very advantageous for flood monitoring, but their coarse spatial resolution hinders their wider application. Overcoming this limitation is an interesting scientific challenge with substantial application potential.

When both the total water area and topography are known, it is possible to locate regional water distribution in small regions, e.g., less than 1 km^2. The water fraction derived from moderate resolution satellite data such as TERRA/MODIS and Suomi-NPP/VIIRS not only provides the water area in 500-m or 375-m pixels, but it also contains geo-location information in each pixel, providing a potential way to derive high-resolution water maps with the use of high resolution DEM data such as SRTM.

Objective

In this study we introduce an integration method to downscale MODIS 500-m and VIIRS 375-m water fraction maps to 30-m or higher resolution water maps with high resolution DEM. As derived from moderate optical satellite data and high resolution DEM data, the final enhanced flood maps can have high temporal and spatial resolutions, and large swath coverage.

Method

Water Fraction Retrieval

Water fraction is key parameter for the whole integration.

Water fraction retrieval from TERRA/MODIS and Suomi-NPP/VIIRS is based on Dynamic Nearest Neighboring Searching method (DNNS) by using short-wave infrared channel (Li et al., 2012).

Inundation machine

Based on basic water fluidity features, the inundation mechanism can be expressed as:

$$A = \int_{min_h}^{max_h} f(h)dh$$

Where, A is the total water area between the minimal surface elevation (min_h) and maximal inundated surface elevation (max_h), and f(h) is the increment of water area with the change of surface elevation h.

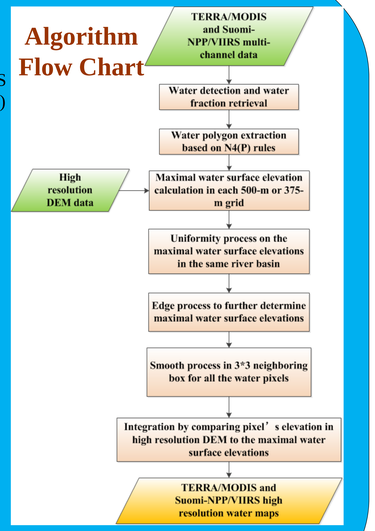
Uniformity Process

Assumptions:

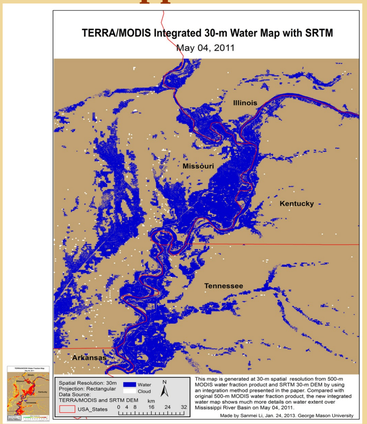
- In the neighboring continuous water area, water level is similar
- Water fraction retrieval errors are with normal distribution
- Pixels which are detected out in a MODIS or VIIRS image are generally with water fractions lager than 18%
- If a cell at DEM data is inundated, then its neighboring cell with similar or less elevation is inundated either

Therefore, max_h is actually the average of a neighboring continuous water body. The uniformity process involves the identification of continuous water bodies and water body splitting with water shed or predefined boxes.

Algorithm Flow Chart

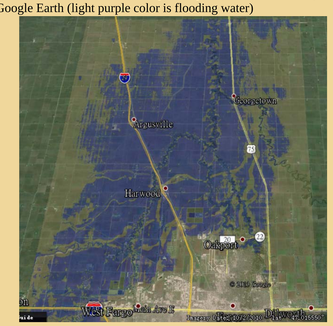


Application



Left: TERRA/MODIS 500-m water fraction map on May 04, 2011; Right: The corresponding TERRA/MODIS 30-m integrated water map on May 04, 2011

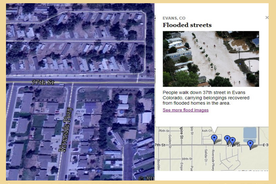
Suomi-NPP/VIIRS 30-m water map on Sep. 17, 2013 near Evans, CO overlapped on Google Earth (light purple color is flooding water)



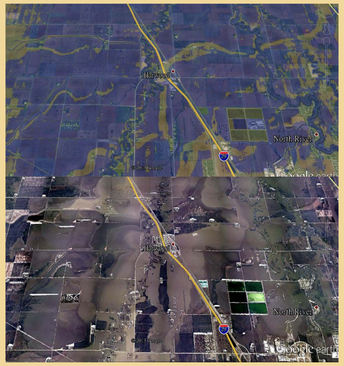
TERRA/MODIS 13-m water map on April 11, 2011 during Red River Flooding overlapped on Google Earth (light purple color is flooding water)

Validation Compare with Ground truth

Left: Suomi-NPP/VIIRS 30-m water map in the 37th St near Evans (light purple is flooding water); Right: a photo map taken on Sep. 16, 2013 covering the same area

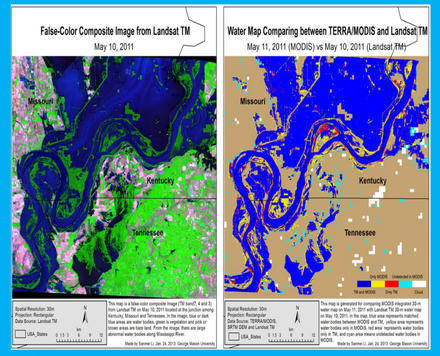


Left: Suomi-NPP/VIIRS 30-m water map in the 37th St of Evans (light purple is flooding water); Right: a photo map taken on Sep. 16, 2013 covering the same area

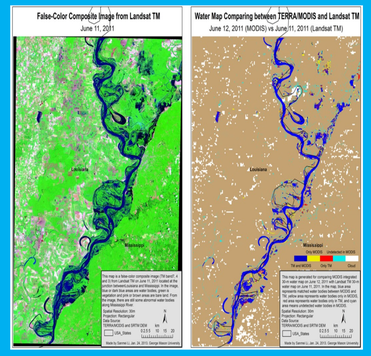


Top: MODIS 13-m water map near Georgetown on April 11, 2011 (light purple is flooding water)
Bottom: Ground truth photo covering the same area on April 11, 2011

Validation- Compare with Landsat/TM



Left: Landsat/TM5 false-color composite image on May 10, 2011; Right: 30-m water map comparing between TERRA/MODIS on May 11, 2011 and Landsat TM5 on May 10, 2011



Left: Landsat/TM5 false-color composite image on June 11, 2011; Right: 30-m water map comparing between TERRA/MODIS on June 12, 2011 and Landsat TM on June 11, 2011

Summary

With the water fraction products retrieved from moderate satellite data such as TERRA/MODIS and Suomi-NPP/VIIRS, and high resolution DEM data, it is highly possible to derive high resolution water maps based on water fluidity features and inundation mechanism.

Because data from TERRA/MODIS and Suomi-NPP/VIIRS have high temporal resolution and large swath coverage, this study shows the possibility to obtain real-time high-spatial-resolution water maps over a large area. The new application in flood detection provides new ways to make better use of moderate-resolution satellite data in natural disaster analysis.

Acknowledgements

We thank NOAA and the NASA JPSS Program for supporting this work through a grant fund to GMU. The contents are solely the opinions of the authors and do not constitute a statement of policy, decision, or position on behalf of NOAA or the U. S. Government.

Reference

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