Monitoring Land Surface Type Changes Using Satellite Observations from Suomi-NPP/JPSS VIIRS and GCOM-W1 AMSR2

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ABSTRACT

Land surface type plays an important role in controlling Earth's environment: altering surface roughness, albedo and exchange rates of heat, water vapor, CO_2 and other green house gases between land surface and the atmosphere, and consequently affecting major components of the water, energy and carbon cycles of the weather and climate systems. Depending on time scale, monitoring land surface type changes is also increasingly important for natural disaster assessment and natural resources management. The literature has demonstrated that rapid and slow land surface type changes could be detected using daily observations of optical and microwave satellites of various national space agencies such as NASA, ESA, NOAA, EUMETSAT and JAXA. This study explores the feasibilities of detection major land surface type changes, such as active fire and burned areas, active flooded areas, urban expansion and deforestation, using daily observations from the Visible Infrared Imaging Radiometer Suite (VIIRS) on current Suomi National Polar-orbiting Partnership (SNPP) and future Joint Polar Satellite System (JPSS) and the second Advanced Microwave Scanning Radiometer (AMSR2) on the 1st Global Change Observing Mission (GCOM-W1). The all-weather observations from AMSR2 can be used to detect possible significant changes of surface soil moisture (SM) or vegetation water content (VWC) at course spatial resolution which may indicate biomass burning, flooding or deforestation within a time period from a day to multiple years. Once a potential surface type change is detected at the coarse resolution in a region, data from VIIRS are collected and processed for the region to find out the specific surface type change and location (e.g. flooded areas at 375m spatial resolution). The simple change vector approach is applied to these satellite data. Testing results for the flooding occurred in early October of 2015 in South Carolina of United States will be presented as a prototype. Implementation of the approach to operationally detecting the major land surface type changes will be discussed and demonstrated with examples.

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VIIRS Surface Type EDR

To provide near real time information surface type for downstream VIIRS data product generation (e.g. land surface temperature), numerical weather prediction models, and natural disaster assessment and resources management, the VIIRS Surface Type (ST) Environmental Data Record (EDR) has been generated since early 2012. The ST EDR contains the **static** surface type label for each 750m pixel of the whole globe as well as **current day** active fire and snow conditions. Figure 1 shows the three data layers of the ST EDR for April 25th, 2016.

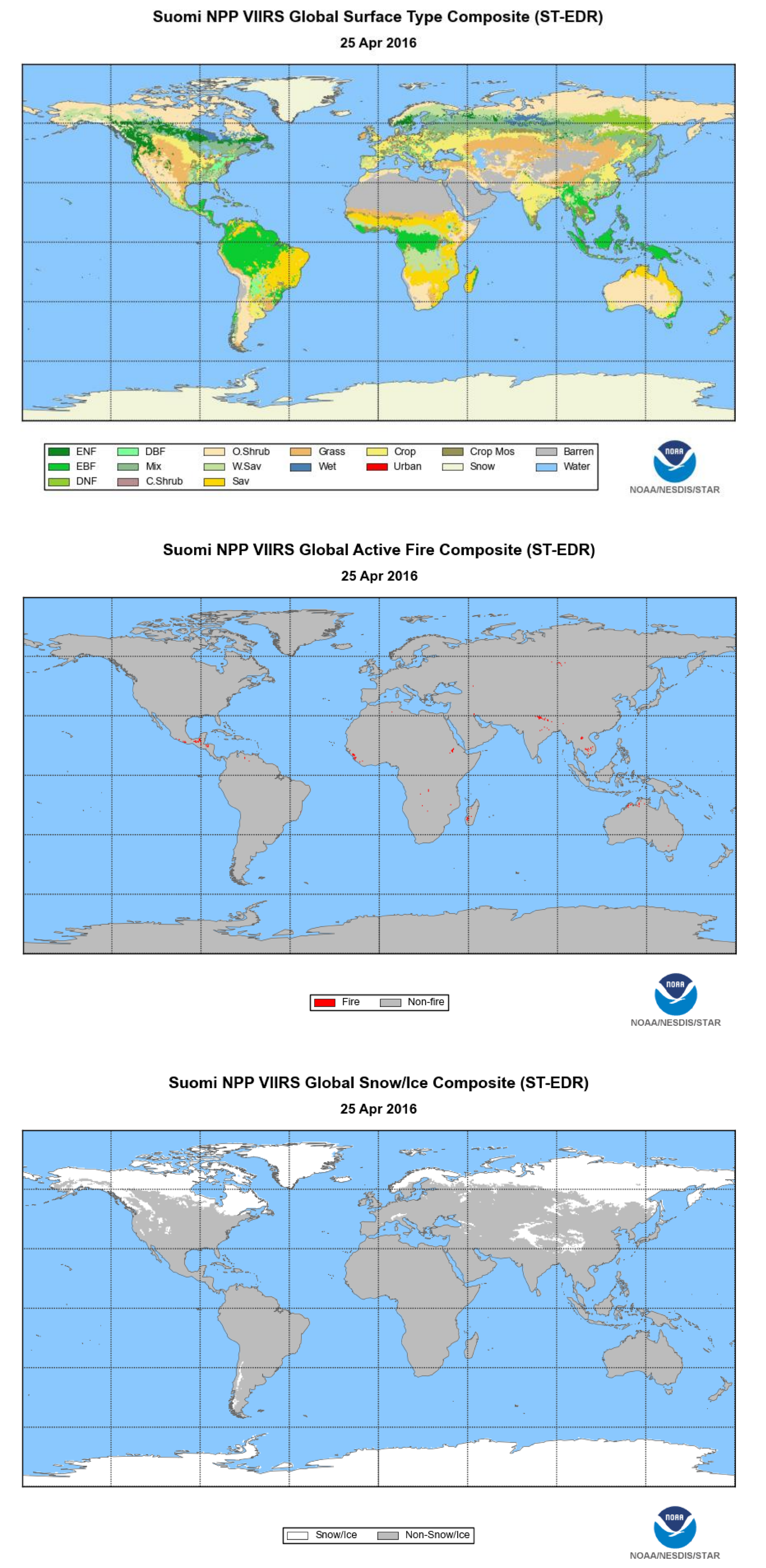

***Figure 1**. Surface type and change data layers in Suomi-NPP VIIRS Surface Type EDR*

Daily Gridded Surface Type Product

NOAA-NESDIS is planning to add more surface type change information into a daily surface type product in order to provide current day information of burned areas, flooded areas, deforested/urbanized areas, and crop-harvested areas in addition to the active fire and snow covered areas.

Change Detection Methodology

For detecting burned areas, deforested/ urbanized and crop-harvested areas, the 375m VIIRS surface reflectances and the change vector algorithms introduced in Zhan et al (2000 & 2002) are implemented. For identifying flooded areas, a two-step approached is employed.

Step 1: Flood region detection using Ka-band microwave sensing and the brightness temperature ratio algorithm used by De Groeve 2012). The GCOM-W1 AMSR2 observations are used in this exploration. The Ka-band emissivities of water and dry soil can be less than 0.5 and larger than 0.75 respectively. Assuming that at least one dry pixel can be identified within a 3x3 window pixels of the AMSR2 36.5GHz v-pol channel observations and the skin temperatures (T_s) are similar for all of these pixels if they are all dry soil, then the ratio of the brightness temperature (T_b) of a pixel with a *w* fraction flooded over the brightness temperature of the dry soil pixel (selected as the maximum of the 3x3 pixel window T_{bx}) is

$$
\begin{aligned}
s &= T_b/T_{bx} = [T_s*E_s*(1-w) + T_s*w*E_w]/(T_s*E_s) \\
&= 1-w+w*E_w/E_s = f(w)
\end{aligned}
$$

where E_s and E_w are Ka-band emissivity for soil and water respectively. A high value of s indicates the pixel is flooded and vice versa. The anomaly of the *s* value of a pixel from its multi year climatology would indicate the severity of the flood. Thresholding the anomalies (*m*) of s gives regions of possibly flooded areas. GCOM-W1/AMSR2 was launched in May 2012 and has accumulated >3 years T_B data.

Step 2: Once the possibly flooded regions are identified, the details of the flooding situation are identified with a change vector algorithm using VIIRS 375m surface reflectance data on two clear days of the regions (Zhan et al. 2000 & 2002).

RESULTS

A severe flood was brought by Hurricane Joaquin in early October 2015. Figure 2 shows the flooded areas near Columbia city of South Carolina State of US. Thresholding the anomaly (*m*) of the flood indicator (*s*) indicated a potential flood region in South Carolina state on October 4th, 2016. The time series of m and s also indicated the flooding around October 4-5, 2015 (See Figure 3). This large scale flood detection result then could be confirmed by detection flood details with high resolution image from Suomi-NPP VIIRS daily surface reflectance data using the Change Vector algorithm. Figure 4 is a preliminary result of the flood detail detection overlaid on the time 2 image of the region. The result can be integrated to VIIRS ST EDR.

***Figure 2**. The October 2015 South Carolina flood caused by Hurricane Joaquin is depicted on a high resolution image acquired by the Advanced Land Imager of NASA EO-1 satellite on Oct 8th, 2015 (right), compared with an image obtained by Operational Land Imager of Landsat 8 on Oct 14th, 2014 (left). (Courtesy: NASA Earth Observatory http://earthobservatory.nasa.gov)*

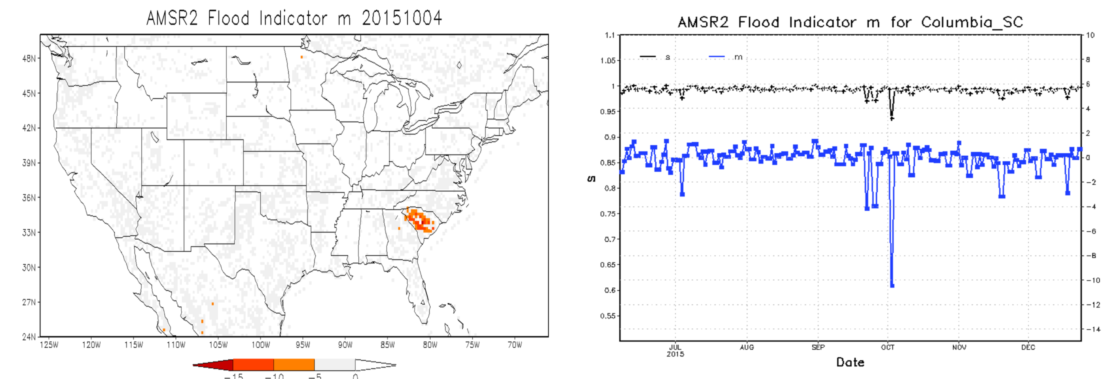

***Figure 3**. A map of the anomaly (m) microwave flood indicator s over CONUS (left) indicated the potential flood region in South Carolina on Oct 4th, 2015. The time series of m values over Columbia, SC showed large anomaly of s value occurred around Oct 4th, 2015. High resolution flood detection will focus on the South Carolina region.*

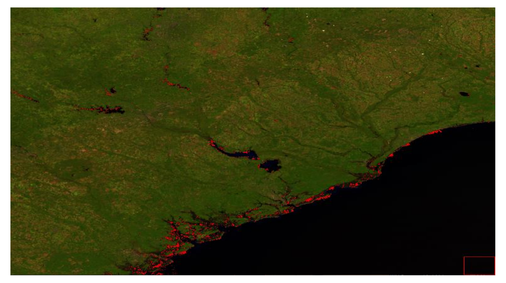

***Figure 4**. Flood detailed detected with Suomi-NPP VIIRS images acquired before and after the rainfall of Hurricane Joaquin passing over South Carolina in early October 2015.*

Conclusion

Using Microwave observations from AMSR2 could provide guidance for high resolution flood detection with VIIRS for a Surface Type Change data product.

References

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