The Use of Remote Sensing-Based Surface Inundation Products in Human Health Applications in Eastern Africa

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Introduction

The potential impact of climate variability and change on the spread of infectious disease is of increasing concern to public health. Newly-available remote sensing datasets may be combined with predictive modeling to develop new capabilities to increase the public health community's capacity to employ appropriate information to mitigate the public health impacts of climate on vector-borne diseases such as malaria, leishmaniasis, and rift valley fever. We have developed new and improved remote-sensing products for monitoring water bodies and inundation dynamics that have potential utility for forecasting risks of vector-borne disease epidemics. These products include daily and seasonal surface inundation for the East African region based on the global mappings of inundated water fraction derived at the 25-km scale. We present validation of this product using high resolution (100m) PALSAR classification of inundated areas in this region, along with analysis of the dynamics of this product with historical malaria occurrence in the east African country of Eritrea. We present a framework for use of these new datasets for prediction of malaria risk.

Methods

Surface Water

Global maps of inundation extent at ~25 km grid spacing are derived from combined passive-active microwave remote sensing data sets from the SSM/I, QuikSCAT and ASCAT instruments. We apply these data with ancillary land cover maps from MODIS to:

1) Define the potential global domain of land inundation

2) Establish land cover driven predictive equations for implementing a dynamic mixture model adjusted to total column water vapor obtained from NASA's Modern Era Retrospective-Analysis (MERRA)

3) Construct a continuous, global record of daily surface water fraction dynamics (July 1999 – Dec 2012)

ScanSAR Classification

We aim to compare our surface water product to classified high-resolution (100m) PALSAR ScanSAR data. We employ a thresholding decision tree to classify open water, inundated vegetation, and non-inundated land cover for 55 PALSAR ScanSAR acquisitions from Dec. 2008 – Nov. 2010. We focus on a test region, UTM Zone 36P in eastern Africa.

Fig 1. UTM Zone 36P

The classified data are resampled to the 25km EASE grid, counting the number of pixels classified as Open Water and Inundated Vegetation and estimating the surface water fraction.

Malaria

We have historical monthly malaria incidence rates (#cases per 1,000 persons) for subzones in the eastern African country Eritrea for 1996-2003, and investigate the spatial and temporal association between surface water fraction and malaria incidence.

SAR Classification and Surface Water Fraction Comparison

Fig 2. Comparison of A) mean backscatter values from PALSAR ScanSAR acquisitions, 2008-2010 (dB), B) decision tree classification (blue=open water, pink=inundated vegetation, grey=urban, green=non-inundated land, white=no data), C) Google Earth image

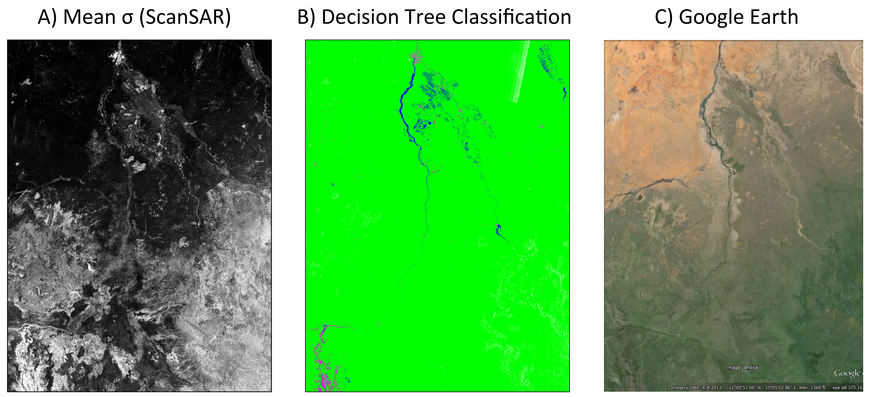
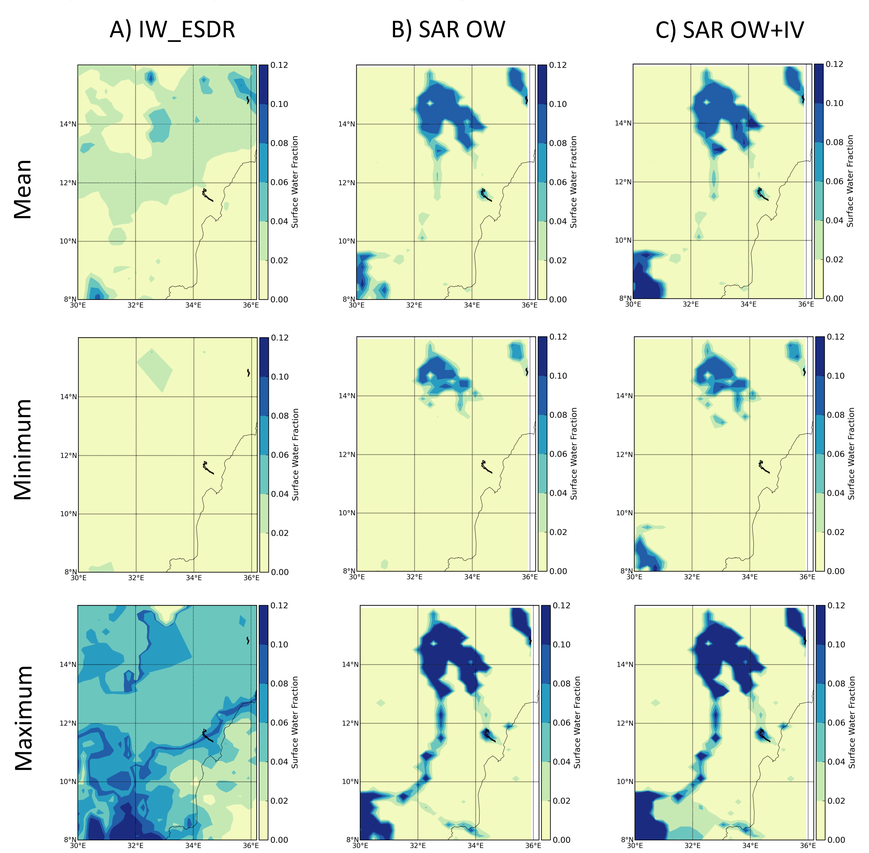


Fig 3. Comparison of mean, minimum, and maximum values for time series of A) surface inundation product (IW_ESDR), B) Resampled ScanSAR Open Water class (SAR OW), and C) Resampled ScanSAR Open Water + Inundated Vegetation classes (SAR OW+IV)



Association with Malaria

Fig 4. Spatial distribution of mean surface water fraction and mean malaria incidence rate across subzones of Eritrea (excluding coastal zones), 1999-2003.

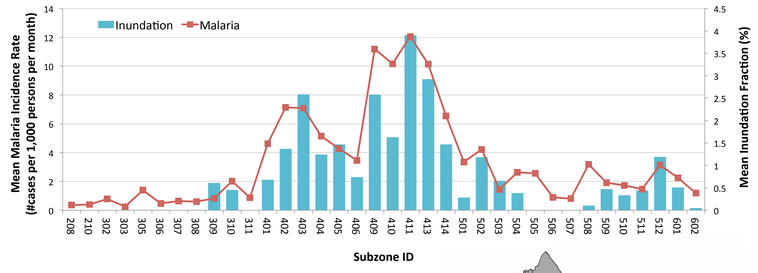
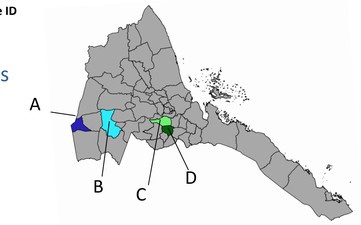
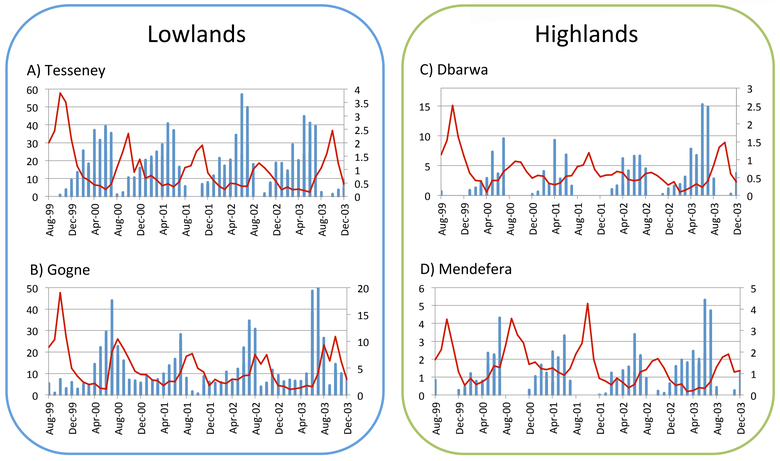


Fig 5. Time series of malaria incidence rates and surface water fraction for districts in lowlands vs. highlands, Eritrea.





Conclusions and Future Work

- IW_ESDR and SAR classification appear to detect a common signal in both mean and minimum inundation; however, significant discrepancies are observed in maximum inundation values (Fig. 3)
- Greater inundation fraction is associated with higher malaria incidence (Fig. 4)
- Appears to a be a lag between peak inundation and peak malaria incidence rates (Fig. 5)
- Difficult to distinguish low backscatter values in microwave satellite data from open water vs. barren land. Land cover classification performance can be improved by incorporating optical inputs such as Landsat
- The creation of these new products allow the user community (UN World Health Organization, Ministries of Health, Doctors without Borders) to better assess the risks of vector-borne epidemics. They are available through the IRI Data Library Map Room on Health and will be integrated into NASA SERVIR and Google Earth, to aid the non-remote sensing specialist community in public health decision processes.

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