Predicting *Sargassum* Washing Ashore in the Lesser Antilles

Prévoir les Échouages de *Sargasses* dans les Petites Antilles

La Predicción de Encallamientos de los *Sargazos* en las Antillas Menores

JEAN-PHILIPPE MARÉCHAL[1]* and CHUANMIN HU[2]
[1]*Nova Blue Environment, 14 rue Chery Rosette, Fond Lahaye, 97233 Schoelcher, Martinique, French West Indies.*
**marechal.jean@gmail.com*
[2]*College of Marine Science, University of South Florida, 140 Seventh Avenue South, St. Petersburg, Florida 33701 USA.*

EXTENDED ABSTRACT

Since 2011, Caribbean islands are facing major events of pelagic *Sargassum* washing ashore, principally *Sargassum natans* (Børgesen) (Schell et al. 2015). A priority objective for local governments is to detect offshore floating algae and assess the risk of landings on the coastline. Early detection of *Sargassum*, risk assessment and alert releases are key elements in the process of helping the local populations to prepare for *Sargassum* landings. Satellite-based macroalgae detection and tracing can be derived from the Moderate Resolution Imaging Spectrometer (MODIS) (Hu 2009) in detecting macroalgae mats on the surface of the ocean based on the red-edge reflectance of vegetation. The algae-mats appear as slicks in MODIS imagery. In particular, a customised data product (AFAI: Alternative Floating Algae Index) has been generated and distributed in near real-time through a Virtual Antenna System (VAS, Hu et al., 2014) for the Eastern Caribbean (10 – 23ºN, 75 – 60ºW), the Central West Atlantic (22.0°N - 0.0°N, 38°W - 63°W), and other areas in the entire Intra-Americas Sea, since 2011 (http://optics.marine.usf.edu/projects/SaWS.html). Together with surface ocean currents also available in near real-time from a numerical model, the products effectively formed a prototype *Sargassum* Watch System (SaWS, Hu et al., 2016). Local groups used the SaWS on a routine basis to detect and trace *Sargassum* mats. Island authorities and managers expect reliable alerts to anticipate *Sargassum* washing ashore and mobilise technical teams, thus reducing timing and costs of cleaning operations. Here, the objective of this work is to demonstrate and evaluate a simple and fast method for release of early-warning alerts of *Sargassum* risk in the Lesser Antilles, based on the MODIS AFAI products and analyses of surface currents. We present a prediction method to use the SaWS system for near-real-time tracking of floating algae in the central Atlantic. These online products are integrated and made available to users in Keyhole Markup Language (KML) format and uploaded in Google Earth. Using GPS coordinates of *Sargassum* rafts and distance from coast, direction and speed of HYCOM current vectors, we have provided an effective time window of possible washing-ashore in the Guadeloupe archipelago. The method has been used to release daily report to the Guadeloupe local environment agency. We obtained over 60% prediction accuracy between forecast and real events of washing ashore in 2015. The method offers a simple framework for governmental agencies and environmental groups based on existing online resources.

Satellite Images

The Virtual Antenna System (VAS, Hu et al. 2014) has been established at the University of South Florida to download low-level satellite data distributed in near real-time by NASA, and generate and distribute various standard and non-standard data products, which are then distributed on the same day (within 4-6 hours of satellite overpass) through a web portal (Hu et al. 2014). The AFAI images (1 km resolution in reflectance units) detect ocean-surface features such as *Sargassum*, green macroalgae, and cyanobacterial mats.

The AFAI images are derived from MODIS measurements (Hu 2009). The floating algae detected appear as long curved lines (Hu et al. 2015), thus called image slicks, that can be traced over time (Figure 1). The floating algae index (FAI) proposed by (Hu 2009) examines the relative height of the near-infrared reflectance, where macroalgae such as *Sargassum* would show enhanced FAI values. The algorithm was recently updated to an alternative FAI (AFAI) by using band combinations different from those in the original FAI in order to facilitate cloud-masking.

In addition to the MODIS AFAI imagery, surface currents from the Hybrid Coordinate Ocean Model (HYCOM) made available by the National Ocean Partnership Program (NOPP) are obtained, updated nightly, and made available via the VAS. All data products (AFAI, HYCOM currents) can be displayed in GE, thereby facilitating visualisation and navigation.

***Sargassum* Signal Isolation**

Downloaded AFAI images from the Central Atlantic region were processed in ImageJ (Schneider et al. 2012) to isolate the *Sargassum* signal at the surface of the ocean (Figure 2). The final image is uploaded in GE to replace the original AFAI image in the KML file. Surface current vector colours (originally white) are changed in GE for better visualisation of the interactions between floating algae and currents (Figure 3).

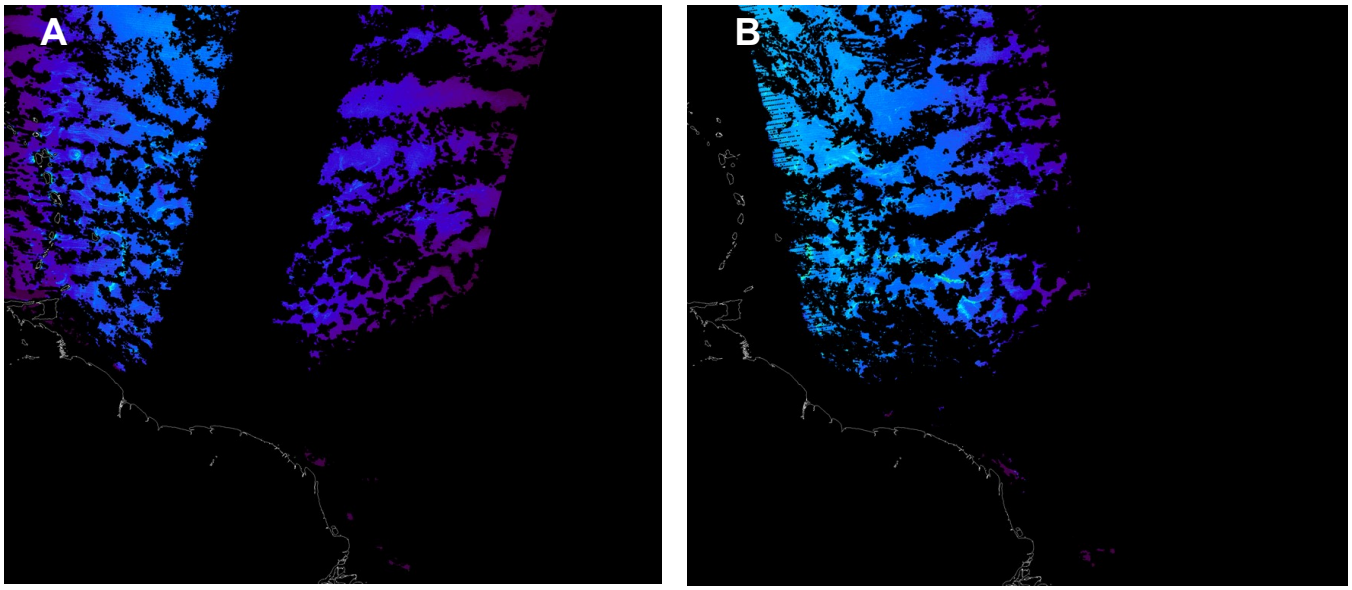

Figure 1. *Sargassum* slicks detected on 7th May 2015 AFAI MODIS images (light green on the picture). (A: 14:15 – B: 17:20).

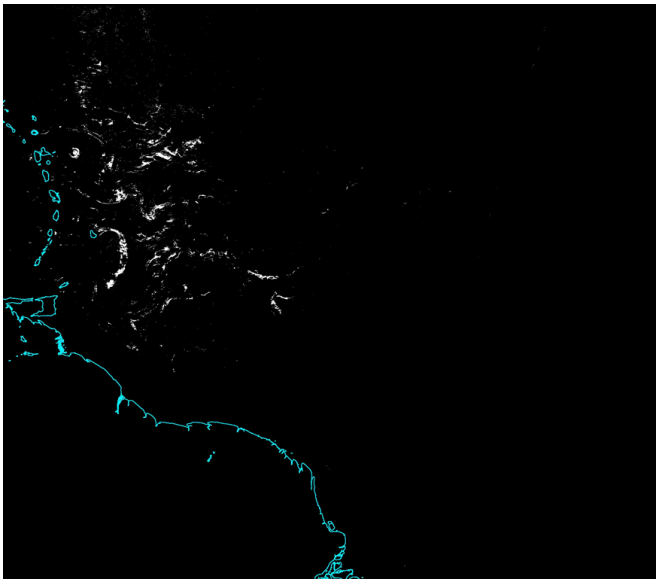

Figure 2. *Sargassum* likely signal isolated from AFAI MODIS pictures composite from Figure 1 images.

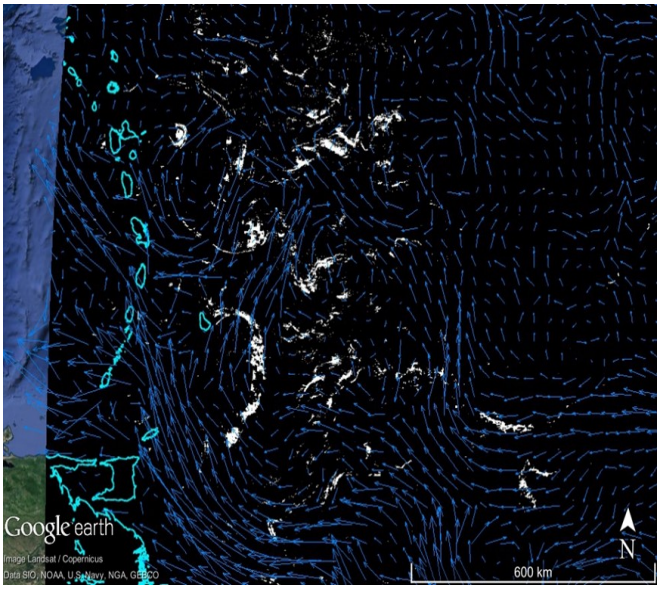

Figure 3. Google Earth final product showing the Sargassum signal isolated from MODIS AFAI image (7th MAY 2015) and combined with HYCOM surface current vectore.

DISCUSSION AND CONCLUSIONS

The use of the method at regional levels reveals a useful tool for local environmental agencies to anticipate *Sargassum* beaching. AFAI and HYCOM forecast data are valuable for short-term prediction as for the year 2015 for the Guadeloupe island. Our protocol is based on simple treatment analyses and basic computing equipment, offering an early-warning operational system. Daily analysis of AFAI permits early detection to alert local authorities. The average uncertainty of the predicted beaching time was less than one day, which gives a good window for managers to prepare locally. While the 62% success rate in the predicted probability of Sargassum beaching does not appear very high, the prediction does provide valuable information for actions. The prediction is limited by three factors:

i) Significant cloud cover and sun glint,
ii) The coarse-resolution (1-km) of MODIS (Wang and Hu 2016), and
iii) The visual interpretation of the HYCOM currents may not be as accurate as a particle tracing model to follow the detected *Sargassum* rafts.

In the future the use of numerical models to trace the observed *Sargassum* rafts may provide a better estimate of *Sargassum* beaching than the simple interpretations here based on HYCOM currents.

The *Sargassum* occurrence in the Caribbean region of the western Atlantic is likely to continue in the future as it is directly linked to general current patterns in the central Atlantic. Near-real-time information on *Sargassum* rafts offshore is required to improve local monitoring capacities. Early detection comes among other aspects of the environmental crisis and will help coordination of networks, effectiveness of the response and rapid action. Thus, the utilisation of *Sargassum*-tracking information improves the efficacy and cost-effectiveness of regional monitoring programs. Efforts have to focus on better, precise early detection, collection at sea and on beaches, and utilisation of biomass.

KEYWORDS: *Sargassum*, Caribbean, early warning, near real-time satellite products

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