The Role of Surface Wind Forcing on the Movement and Distribution of *Sargassum* in the North Atlantic Ocean and Caribbean Sea

Influencia del Viento en Superficie en el Movimiento y Distribución de *Sargazo* en el Atlantico Norte y el Mar Caribe

Le Rôle du Forçage par le Vent sur le Déplacement et la Distribution des *Sargasses* dans l'Atlantique Nord et la Mer des Caraïbes

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EXTENDED ABSTRACT

During 2011, many Caribbean islands as well as western equatorial Africa and Brazil experienced the most widespread coastal accumulations of *Sargassum* (the "golden" pelagic seaweed of the Sargasso Sea) ever reported for these regions. The resulting negative socioeconomic impacts to their tourism, fishing, and dive industries spurred interest in the likelihood of similar events in the future, and in the prediction of such events for planning and mitigation strategies. Diverse hypotheses were put forward by scientists as to the cause of the *Sargassum* inundations, but no physical connection was found with the Sargasso Sea.

We used a combination of NCEP/NCAR reanalysis fields of winds and surface currents, satellite-tracked surface drifter data from NOAA's Global Drifter Center (separated into drogued vs undrogued data), and high-resolution surface currents from the global HYCOM numerical model to examine in detail the winds and currents of the North Atlantic before, during, and after the 2011 *Sargassum* phenomenon. Particular attention was given to examining the extreme negative phase of the NAO during the winter of 2009 - 2010. Overall, the NAO was found to have caused a southward shift of the typical wind pattern over the Sargasso Sea, strengthening the westerlies and weakening the trade winds, and thereby changing the dynamics of the subtropical gyre.

The key to understanding the connection between the NAO and the *Sargassum* phenomenon was how direct wind forcing on the sea surface ("windage") affects the movement of floating or partially-floating objects. Studies have shown that windage can be simulated by the addition of 1 to 3% of the surface wind speed, in the direction of the wind, to modeled ocean surface currents. We compared climatological February currents (computed for the years 2008-2015) and February 2010 surface currents, both computed with a 2% windage factor. The result was an extension of the gyre to the east, and increased southward flow along the coast of Africa.

The climatological currents (Figure 1) show the typical subtropical gyre circulation. The flow in the eastern North Atlantic and along the African coast north of 30°N is to the south and originates north of the Sargasso Sea. Under this scenario, *Sargassum* located in the subtropical gyre would remain trapped within the gyre, as had been the case prior to 2010.

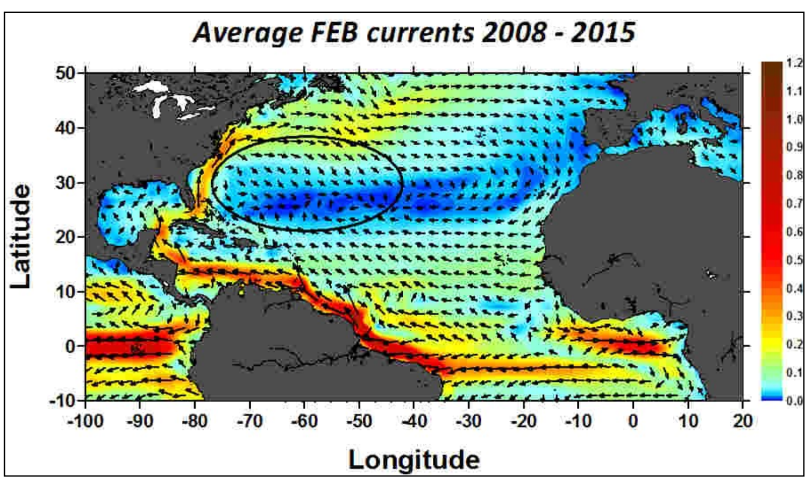

Figure 1. Atlantic gyre circulation.

In contrast, the February 2010 currents (Figure 2) show that the circulation has shifted well to the south from its climatological pattern. The flow north of 30°N is to the east, extending all the way to Gibraltar and beyond. The southward flow along the African coast now begins farther south, and originates in the Sargasso Sea. Under this scenario, there is a clear mechanism for *Sargassum* to join the tropical Atlantic circulation, after which the typical seasonally-varying winds and currents would allow it to reach the coasts of western Africa and Brazil, and eventually enter the Caribbean.

These surface wind effects, which are not explicitly accounted for in the NCEP reanalysis or HYCOM fields, and which do not play a major role in the movement of drogued surface drifters (although they are important to the movement of undrogued drifters), are nevertheless very important to take into consideration. They explain not only the typical climatological *Sargassum* distribution, but also the role of the extreme NAO-related large-scale wind anomaly that occurred during the winter of 2009 - 2010 in dramatically (but perhaps temporarily) altering the usual *Sargassum* pattern.

KEYWORDS: *Sargassum*, winds, surface currents, Atlantic, Caribbean

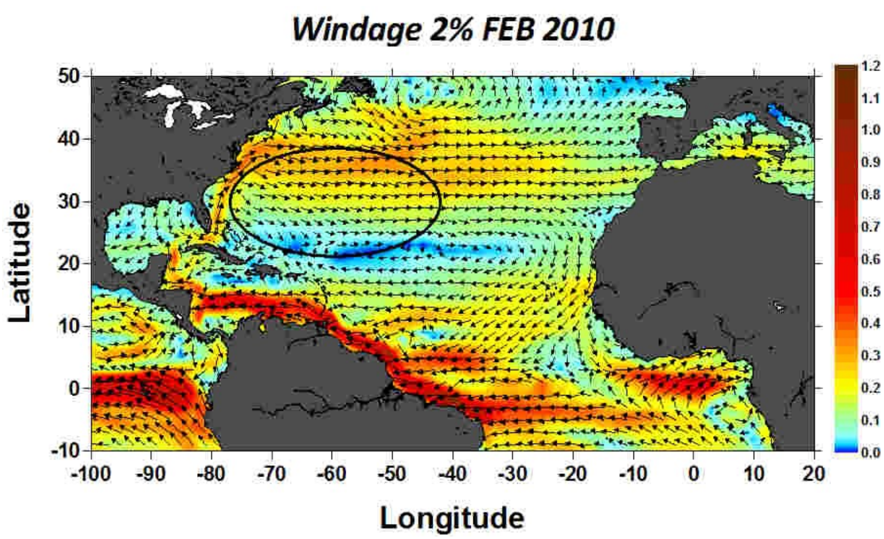

Figure 2. Atlantic gyre circulation in February 2010 indicating a southward shift.