Object: English Summary of task 3 report
Project: Carib-Coast
Client: IFREMER
Rédacteur: Marc Pavec
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INTRODUCTION

A 3D numerical model has been set-up to describe the currents, temperature and salinity around the islands of Guadeloupe and Martinique. The objective of Task 3 was to validate this model on the main meteo-oceanic processes of the area, in order to have an accurate description of these phenomena. The four dominant processes that have been identified in the area are:

- Barotropic tide

- Regional circulation

- Wind-driven circulation

- Internal tides

3D HYDRODYNAMIC MODEL

PRESENTATION OF THE MODELLING SYSTEM

The modelling system is built using the technique of the nested models: a large model produces boundary conditions for a smaller scale model. The 3 different grids are presented above. The final grid, including both Guadeloupe and Martinique has a spatial resolution of 500m and a vertical resolution of 30 layers. The model MARS 3D developed and maintained by IFREMER has been used for this study.The boundary conditions for currents, salinity and temperature are

obtained from a global Hycom configuration[1]. The meteorological forcing is obtained from CFSv2 database[2].

[1] https://www.hycom.org/ocean-prediction/global-nrl-stennis

[2] https://cfs.ncep.noaa.gov/

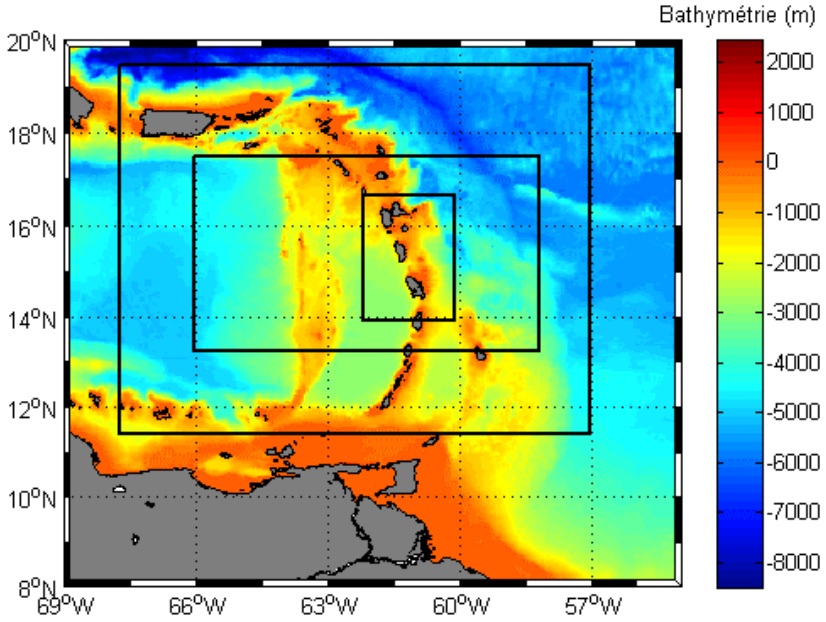

Figure 1 - bathymetry extent of the 3 different ranks

MODEL RESULTS

TIDAL CIRCULATION

The model has been validated in terms of water level against 7 tide gauges in the area. It has then been used to compute the tidal induced current speed in the whole area. Tidal currents remain quite low (always under 1 m/s) and are intensified into the channels between the islands.

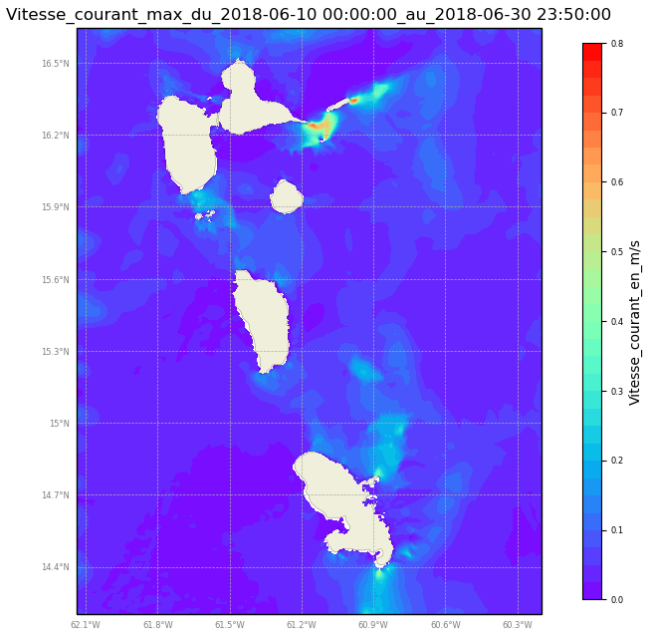

Figure 2 - Maximum tidal induced current from 3D model over a 20-day period in June 2018.

REGIONAL CIRCULATION – SURFACE CURRENT

The general tendency of the surface circulation is a South-North current along the East coast of the islands, penetrating the Caribbean Sea by the channels between the islands. The order of magnitude of the mean current is around 0.5 m/s offshore, and around 0.8 to 1 m/s in shallower areas closer to the coast.

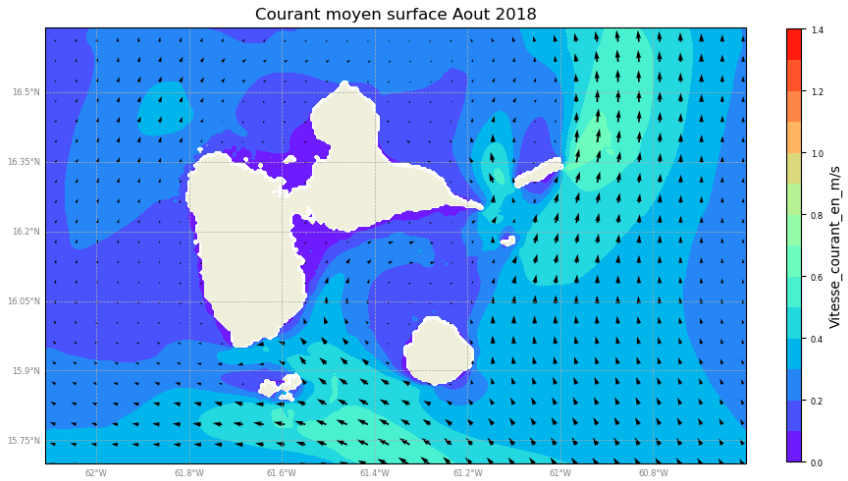

Figure 3 - Mean surface current around Guadeloupe - August 2018

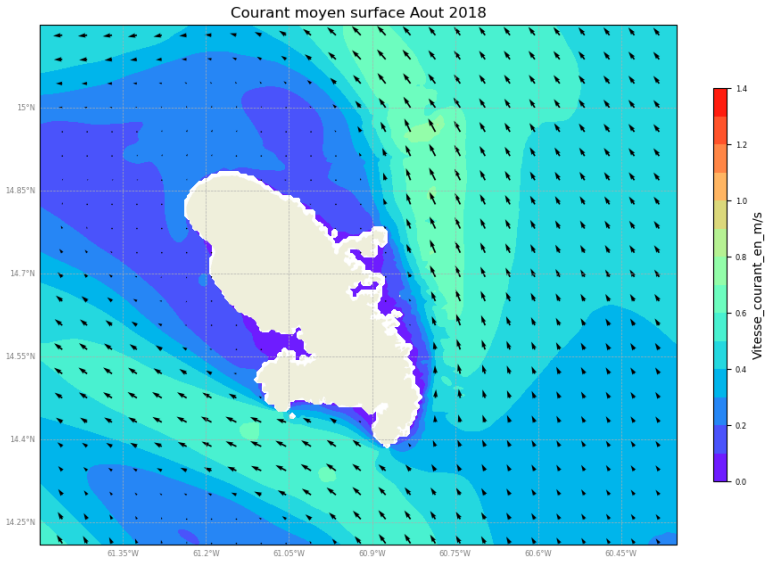

Figure 4 - Mean surface current around Martinique - August 2018

REGIONAL CIRCULATION – DEEP CURRENTS

The main feature of the deep circulation found in the model is an eastward deep current in the North-East of Guadeloupe. It reaches a maximum intensity over 0.5 m/s at 1400m. This current has already been detected in measurements and is known as the “Atlantic Deep Western Boundary Current”.

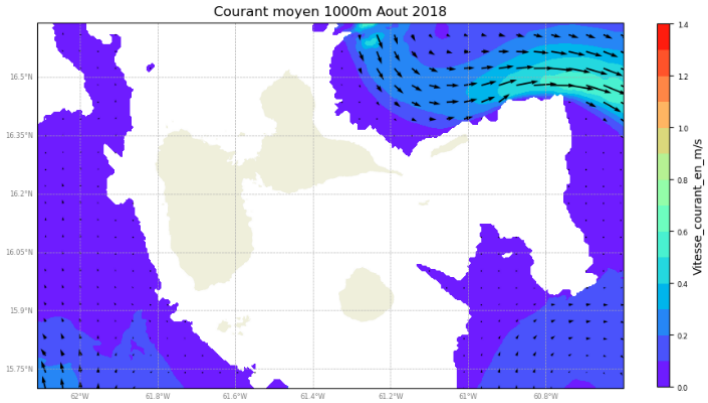

Figure 5 - Current speed at 1000m around Guadeloupe - August 2018

WIND-INDUCED CURRENT

For this part of the study, a simulation including only winds and tidal currents have been launched. The aim of this simulation was to determine the part of the wind induced simulation compared to the regional

circulation. The results show a westward offshore circulation with an intensity of about 0.1 m/s, indicating that the wind-induced circulation is relatively small compared to the offshore regional circulation. Another interesting result is the balance between the regional circulation and the wind and tidal currents, as shown on the following figures. It shows that the regional circulation can be neglected in some parts of the shelf around the islands.

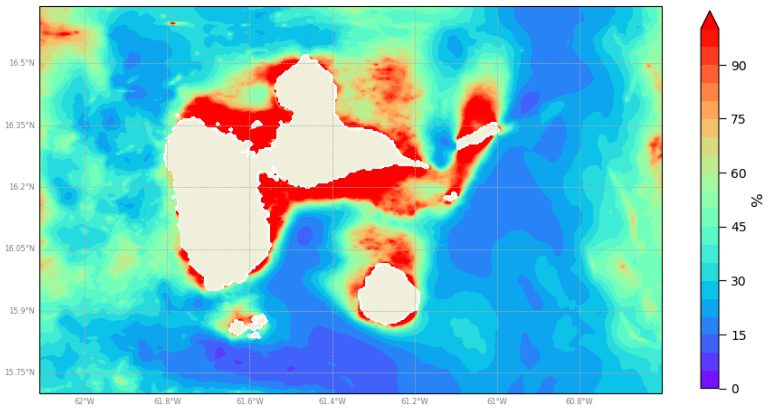

Figure 6 - Importance (in %) of the surface circulation induced by tide and wind in the total circulation in August 2018 around Guadeloupe.

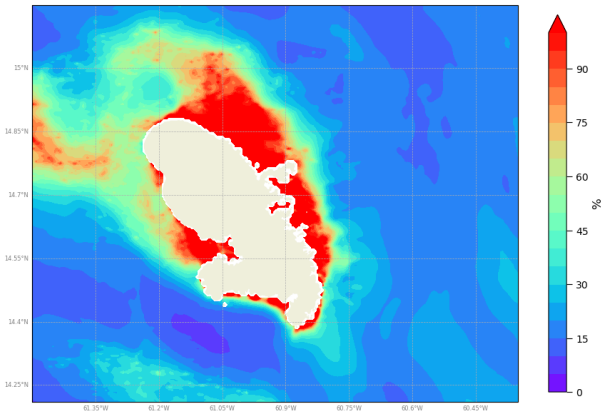

Figure 7 - Importance (in %) of the surface circulation induced by tide and wind in the total circulation in August 2018 around Martinique.

INTERNAL WAVES

To show the evidence of internal waves into the area, a simulation including only the tidal forcing and a stratification has been launched. The apparition of internal waves is detected by the oscillations of isotherms, as shown on Figure 8. Oscillations appear in the whole domain, but are intensified in the South of the area, where the 20°C isotherm shows oscillations with an amplitude greater than 20m.

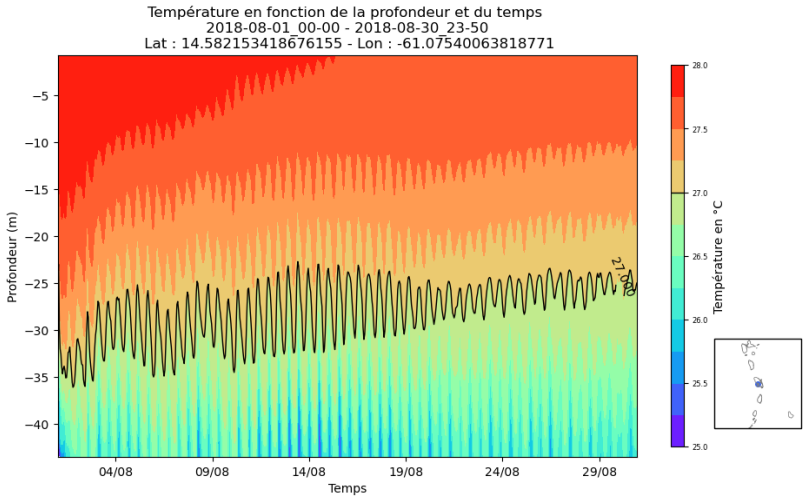

Figure 8 - Temperature profile in the Bay of Fort de France - simulation tide + stratification

CONCLUSIONS

The MARS 3D model was used to build a realistic configuration around the islands of Guadeloupe and Martinique. After various tests, a configuration combining meteorological forcing from CFSv2 and oceanographic forcing from Hycom was selected. This configuration was then used to study four major oceanographic phenomena in the area:

- Barotropic tide: the modelled current velocities agree with the elements known from the literature.
- Regional circulation: the simulations confirmed the known elements on the surface circulation, with a flow coming from South to South-West and flowing into the channels between the islands. A very significant deep circulation in the North-South direction along the Atlantic coast has also been highlighted.
- Wind induced circulation: simulations have shown that wind induced circulation is significant over the entire domain. It represents about 20% of the total offshore current speed, where the regional current is significant.
- Internal waves: the simulations showed large oscillations of the thermocline which may indicate the generation of internal waves, mainly in the southern part of the domain. Martinique would therefore be more concerned than Guadeloupe by this phenomenon