MODELING OF THE SENEGALESE UPWELLING SYSTEM

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The wind-driven circulation in the Senegalese upwelling system is investigated using ROMS. The model is initialized and forced at its lateral boundaries with the ECCO model decadal outputs (horizontal currents, temperature, salinity, sea surface height), at the surface with QuikSCAT daily winds over 2000-2004 and WRF wind for one experiment. The model is forced with climatological heat and salinity fluxes from COADS. The Cap Vert peninsula subdivides the Senegalese ecosystem into two distinct regions. When there is upwelling, the structure of the surface water on each side of the Cape differs. To its north the structure of the upwelling is classical with low SST at the coast and increases offshore whereas at the south the upwelling core is in the middle of the continental shelf with lowest SST, increasing in both offshore and onshore. The ROMS model outputs are in good agreement with MODIS sea surface temperature observations and reproduce the seasonal cycle rather well. Using high regional atmospheric models seems to improve the results on local scales.

1. Regional scale

The figure 1.1 shows the first configuration with a 5 km resolution grid embedded into a 15 km resolution grid using the AGRIF refinement method (Blayo and Debreu, 1999). Initial and boundary conditions are provided by ECCO model, surface fluxes (heat and salinity) from COADS and wind stress forcing from QuikSCAT.

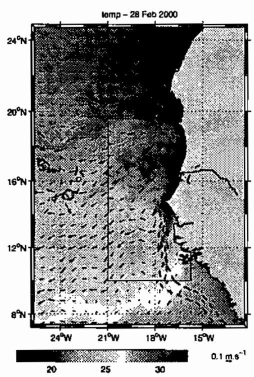

Figure 1.1 – AGRIF refinement method

The outputs of the second grid are validated using satellite sea surface temperature data provided by MODIS. The comparison shows the Roms model ability to simulate large and mesoscale structures in the Senegalese system like the coastal upwelling with the difference between north and south of the Cape, warm waters in the south, cold water filaments around the Cape and further towards Saint Louis in the northern part of the continental shelf.

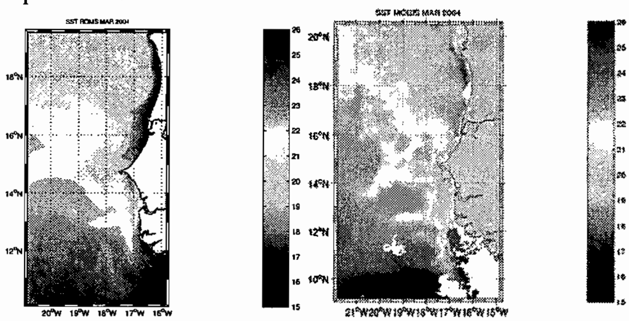

Figure 1.2 – Sea surface temperature from ROMS outputs (left) and Modis satellite data

2. Local scale

A second experiment is realized using both QuikSCAT and WRF wind forcing on ROMS to study the impact of local scales on the upwelling. Initial and boundary conditions are still from ECCO and surface fluxes from COADS. On average, WRF forcing provides coastal waters less cold than the QuikSCAT forcing particularly in the southern part of the continental shelf where WRF winds are much weaker and a positive wind stress curl is generated. Comparison of the SST provided respectively by QuikSCAT forcing and WRF forcing with MSG data at Mbour, a coastal station in the southern region shows that the cold biais introduced with QuikSCAT forcing seems to be improved with WRF forcing, however according to MSG data, coastal waters get warmer during upwelling events and only WRF model reproduces that.

The increase of coastal SST during upwelling events is unusual but can be explained in that, according to the Sverdrup balance, the positive coastal wind stress curl generated in the WRF wind south of the Cape, produces an inshore current which carries warm waters in the upwelling region whereas for QuikSCAT forcing, coastal wind is probably overestimated and generate the classical upwelling jet with cold waters.

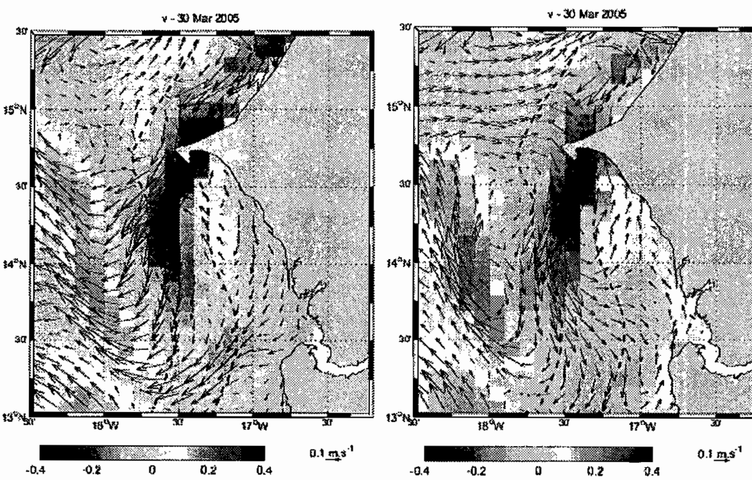

Figure 2.1 – Meridional surface currents generated with QuikSCAT wind forcing (left) and WRF wind forcing (right)

MODELISATION DE L'UPWELLING SENEGALAIS

La circulation forcée par le vent dans le système d'upwelling sénégalais est étudiée en utilisant ROMS (Regional Ocean Modeling System), un modèle régional tri-dimensionnelle haute résolution. Le modèle est initialisé par des champs décadaires (vitesse horizontale, température, salinité, hauteur de la mer) du modèle ECCO (Estimating the Circulation and Climate of the Ocean) et forcé par des vents journaliers QuikSCAT entre 2000 et 2004 et des flux climatologiques COADS (Comprehensive Ocean Atmosphere Data System).

L'analyse des résultats montre que la péninsule du Cap-Vert divise le système d'upwelling sénégalais en deux régions; au nord la structure de l'upwelling est classique avec un minimum de température à la côte alors qu'au sud la température de surface présente des signes distinctifs avec un minimum de température au milieu du plateau continental.

La SST du modèle ROMS est comparée à différents produits satellitaires (Pathfinder 9km, Modis 4km) et reproduit assez bien le cycle saisonnier. Un indice d'upwelling saisonnier égal au gradient de température de surface entre la côte et le large est calculé pour le modèle et semble en accord avec la variation saisonnière du vent.

Notre étude met l'accent sur la sensibilité du modèle d'océan côtier au forçage atmosphérique et les processus dynamiques qui contrôlent la circulation sur le plateau continental.

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Convective wind system with aerosols, named “haboob”, Hombori in Mali, West Africa.