Coastal upwelling limitation by salinity-driven onshore geostrophic flow in the northern Gulf of Guinea

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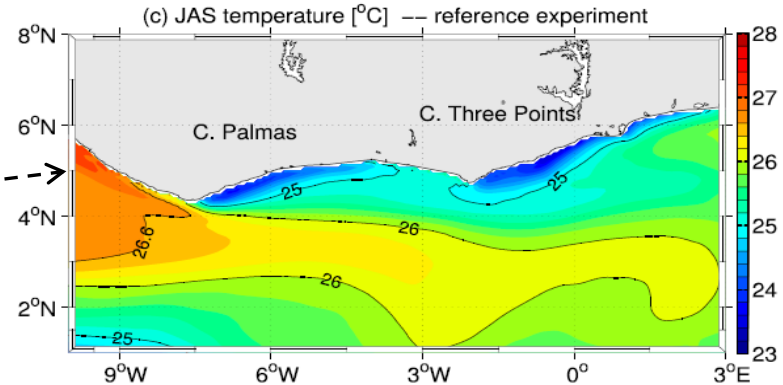
Regional context



- Summer upwelling off Côte d'Ivoire/Ghana driven by detachment of the eastward Guinea Current from the coast east of Cape Palmas and local wind east of Cape Three Points (*Djakouré et al., 2014, 2017*)
- Possible compensation by geostrophic downwelling (*Marchesiello & Estrade, 2010*) due to Niger river plume in the east?

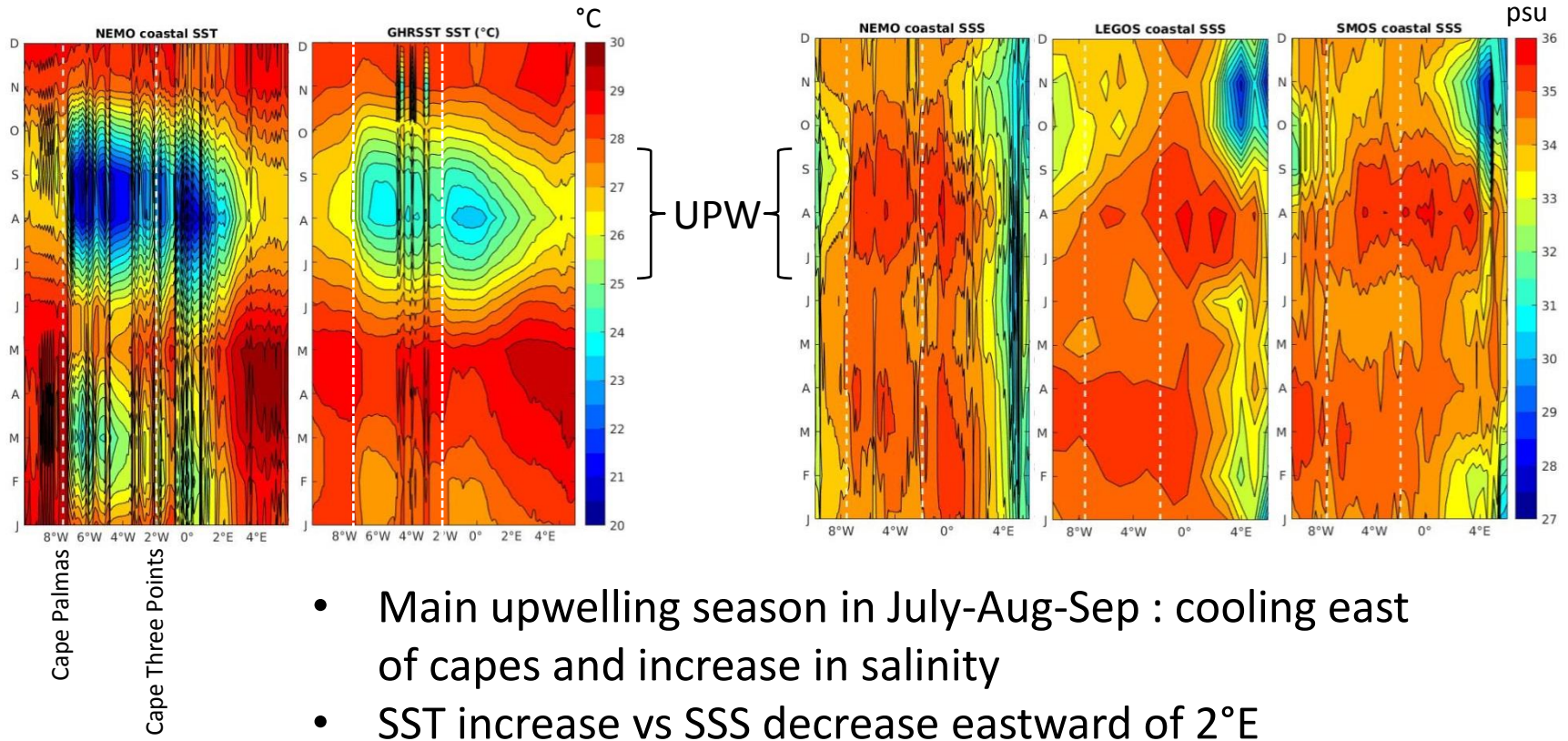
Data, model, methods

- SST from GHRSST 1/20° 2006-2016
- SSS LEGOS 1° 1970-2016, SMOS ¼° 2010-2017
- SSH AVISO ¼° 2006-2016

- Currents from NOAA drifters, GEKCO satellite product 1993-2017
- NEMO 1/12° model tropical Atlantic configuration 2008-2015
- Forcing: ERAi fluxes + *Dai &Trenberth* climatological runoff
- Reference simulation + test simulation without rivers

- Climatological seasonal cycle analysis + focus on summer (JAS) season
- Ekman coastal upwelling index from *Bakun (1973)*
- Geostrophic coastal upwelling index from *Marchesiello & Estrade (2010)*

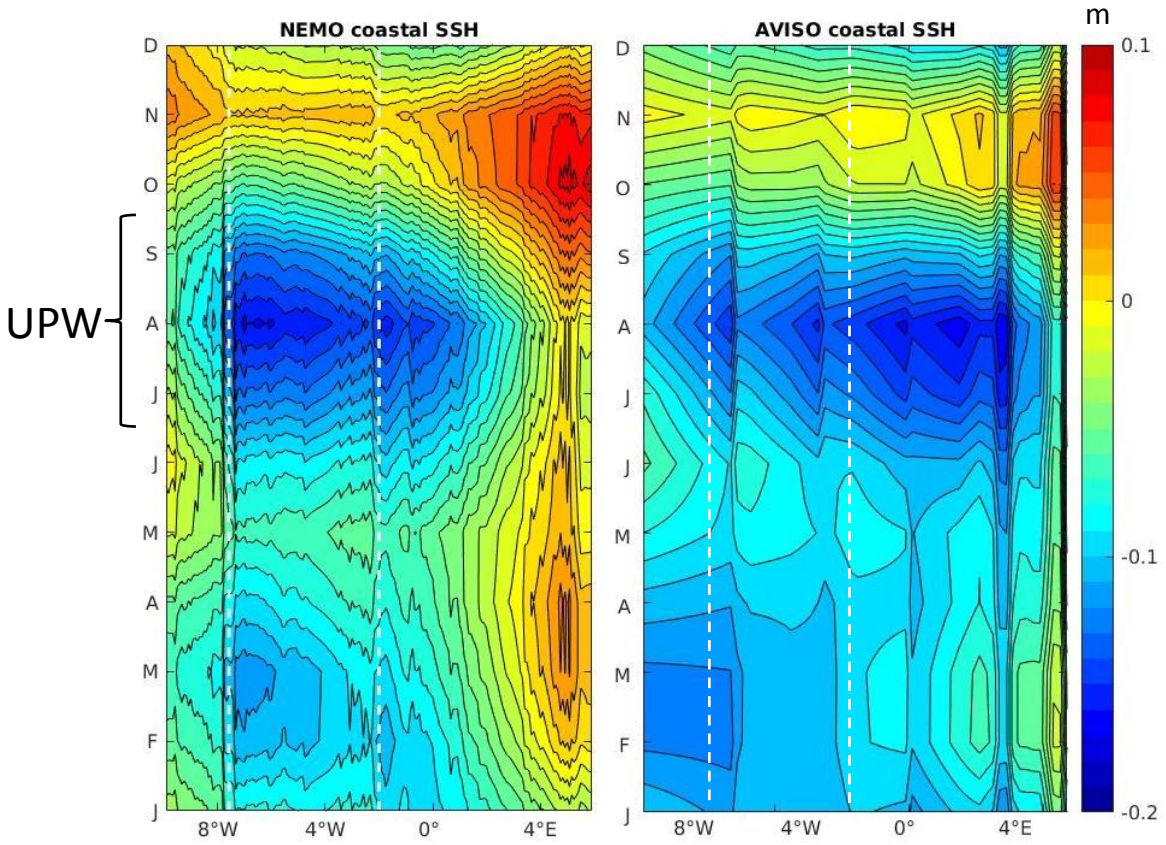
Coastal SST & SSS seasonal cycle



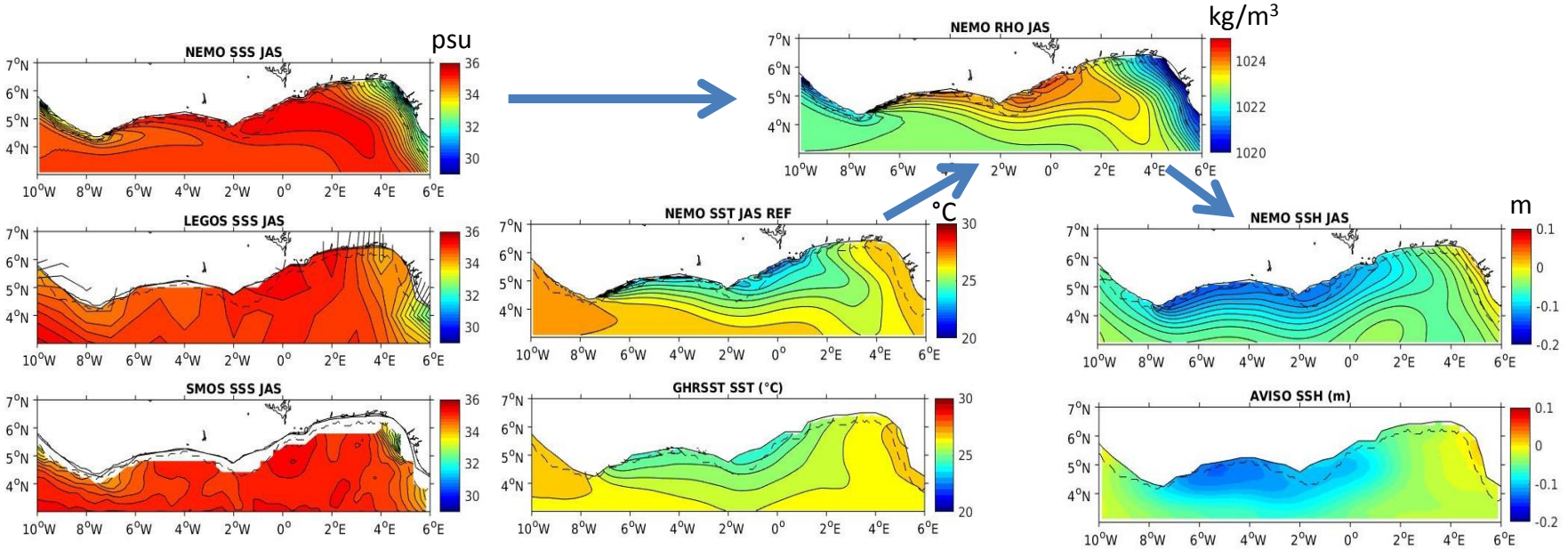
- Main upwelling season in July-Aug-Sep : cooling east of capes and increase in salinity
- SST increase vs SSS decrease eastward of 2°E

Coastal SSH seasonal cycle

- Both cooling and increase in salinity during upwelling season contribute to sea level decrease
- Alongshore sea level slope likely to create cross-shore geostrophic flow

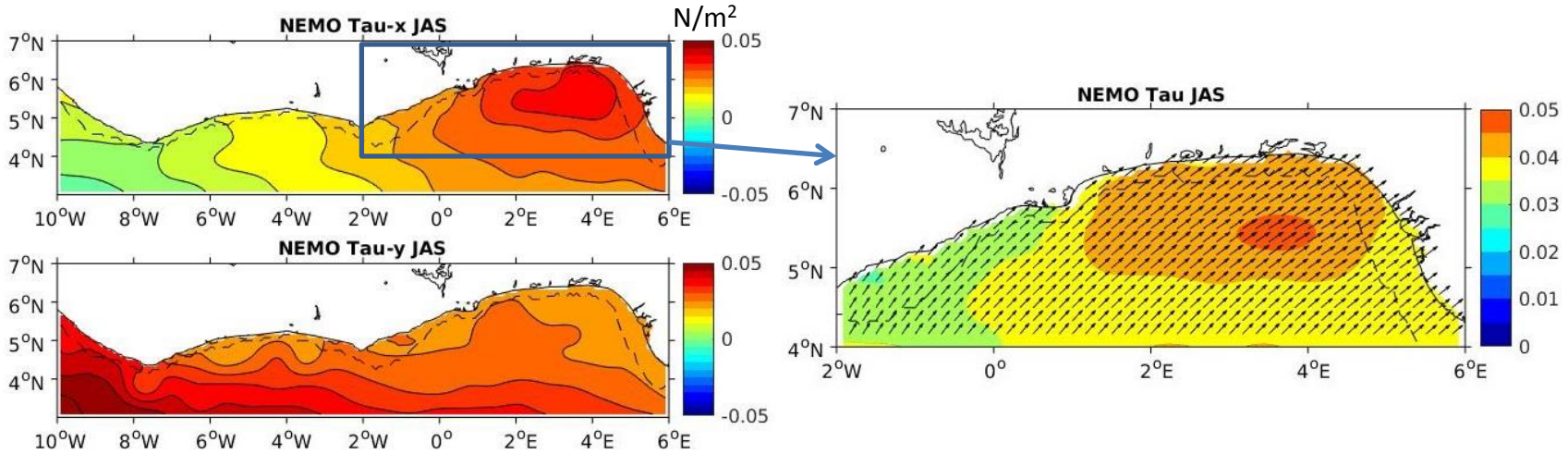


Upwelling surface signature



- Upwelling creates a cool, salty, high-density tongue that extends southeastward and imprints on sea level

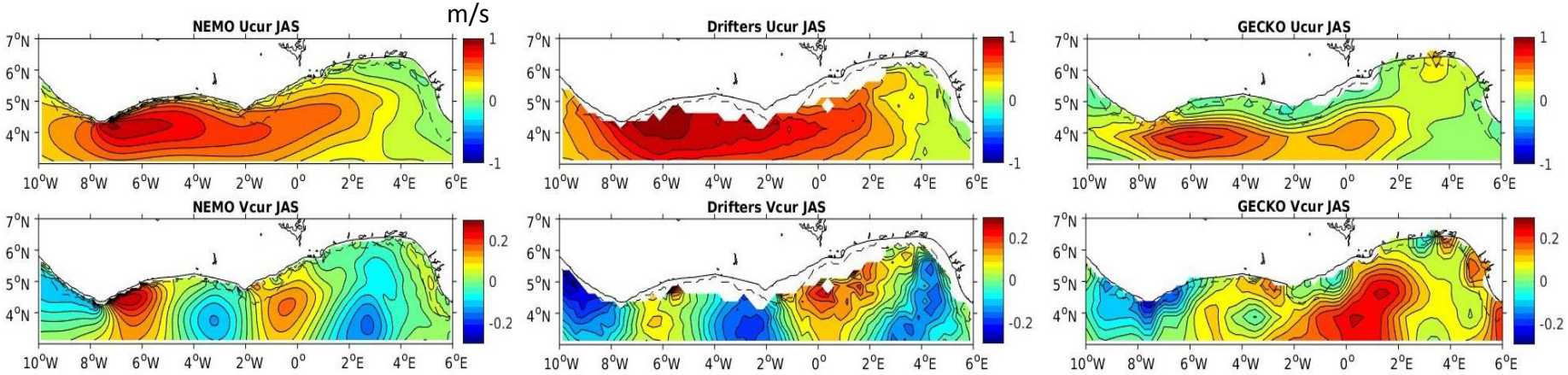
Upwelling dynamics : wind



- Wind stress shifts clockwise from west to east, with strong alongshore projection east of 2°W favourable to upwelling
- Ekman Coastal Upwelling Index : $ECUI = \frac{\tau_{\text{alongshore}}}{\rho_o f L_u}$

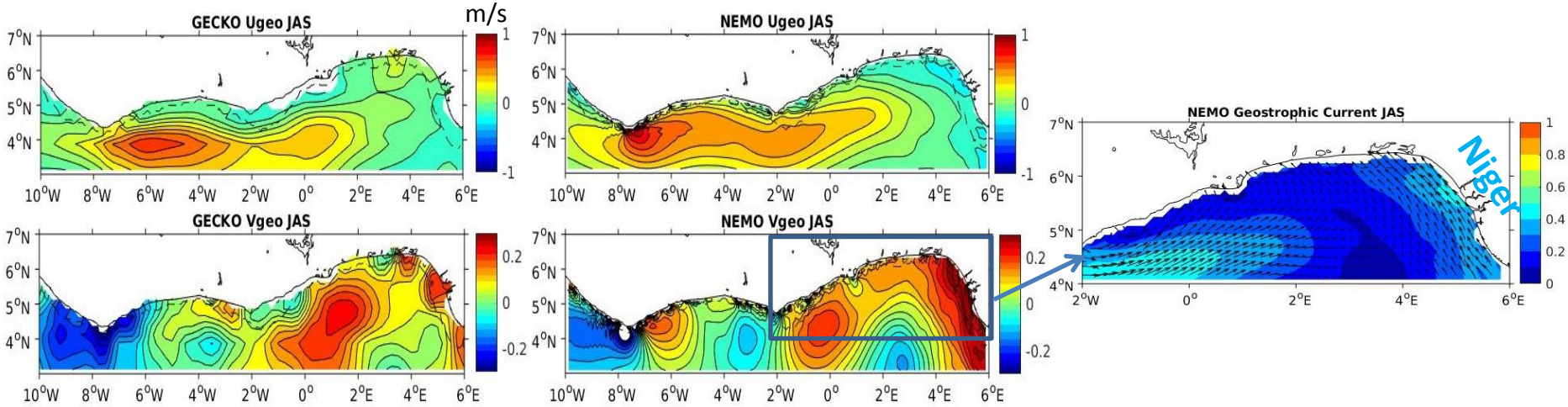
L_u : upwelling width (12 km)

Upwelling dynamics : current



- Main feature of regional circulation: eastward Guinea Current
- Meridional deviation by coastal capes
- Model currents closer to *in situ* rather than satellite currents

Upwelling dynamics : geostrophic current

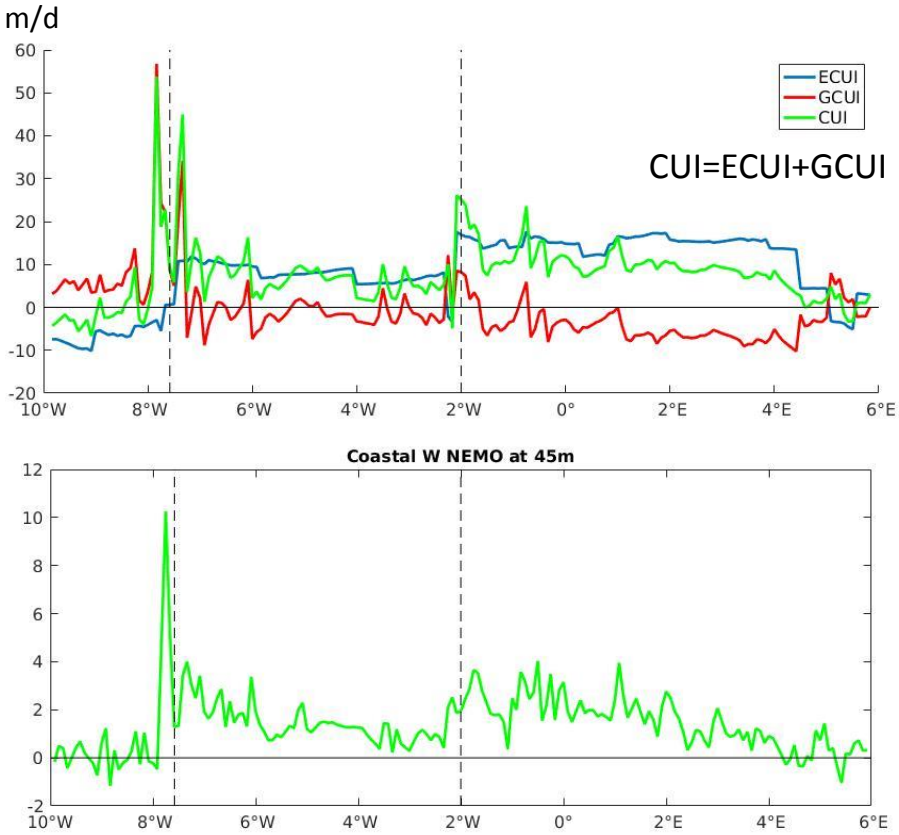


- Open ocean currents largely geostrophic
- Strong coastal geostrophic currents off Niger river towards northern coast
- Geostrophic Coastal Upwelling Index : *GCUI* = $-\frac{u_G D}{2L_U}$

u_G : cross-shore

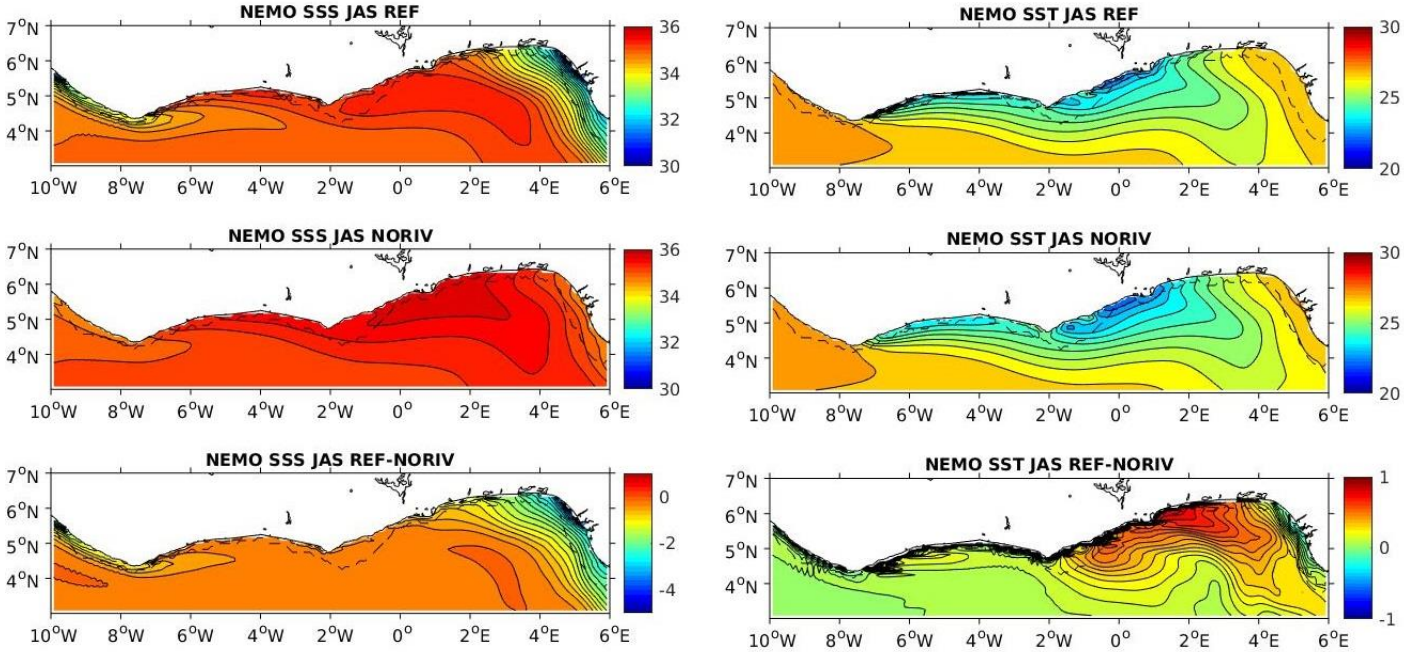
D : mixed layer depth (12 m)

Upwelling vertical dynamics



- ECUI gets stronger east of 2°W
- From 1°E to 5°E, GCUI compensates ECUI by 30% or more
- CUI in good agreement with model coastal vertical velocity

Niger river influence on upwelling



- Niger river is largely responsible for eastern SSS gradient
- It warms upwelling tongue by up to 1°C in model

Conclusion & perspectives

- Coastal upwelling in the eastern part of northern Gulf of Guinea (Togo/Benin/Nigeria coasts) is weakened by more than 30% due to geostrophic compensation driven by Niger river

- Subsurface upwelling dynamics will be investigated deeper using the test experiment
- Quantification of thermosteric and halosteric contribution to sea level coastal gradient
- Similar processes in other upwelling regions next to large river plumes?