Island's topography effects on the meso-to-large scale circulation of the Gulf of Guinea

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1. Introduction

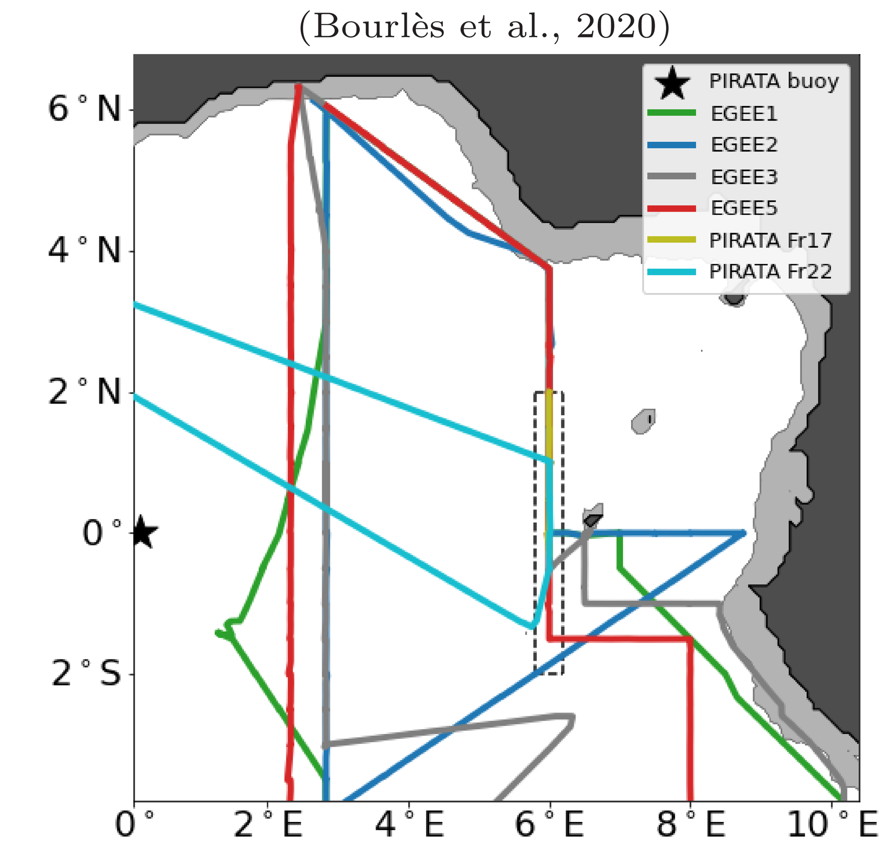
- The eastern Gulf of Guinea is marked by the presence of several islands (e.g., Bioko, São Tomé, Príncipe) which may locally interact with the flow, possibly affecting the Atlantic circulation at larger scales.
- The subsurface circulation the Gulf of Guinea is dominated by the eastward-flowing Equatorial Undercurrent (EUC) centered at 0°, identified by its high salinity core (Kolodziejczyk et al., 2014);
- Centered at about 2°N and 2°S, westward flows (Bourlès et al, 2002, Kolodziejczyk et al., 2014) are consequence of recurrent westward-traveling low potential vorticity (PV) mesoscale eddies, generated in the eastern portion of the Gulf of Guinea (Assene et al. 2020);
- Data from the PIRATA array and related cruises (PIRATA/EGEE) are available for the area surroundings.

2. Objectives

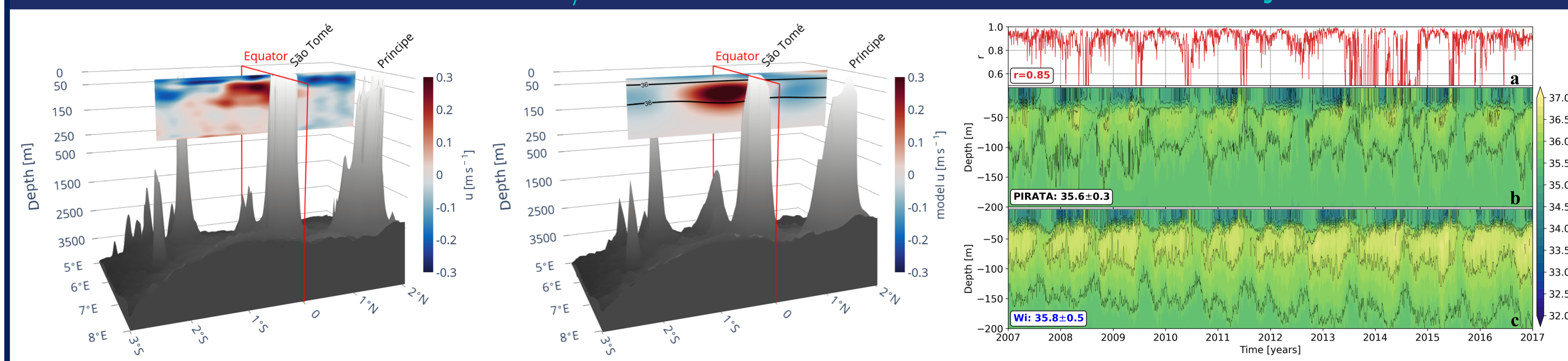
Study the impact of the Gulf of Guinea islands in the meso-to-large scale circulation of the EUC.

3. Gulf of Guinea

Data available at https://www.seanoe.org/data/00335/44635/ (Bourlès et al., 2020)



4. PIRATA/EGEE cruises, PIRATA moored buoy, and NEMO modeling



- NEMO 10-year mean transect (right) shows good agreement with PIRATA objectively mapped sADCP section (left);
- ↑ Velocity, position, and thickness. ↓ Core depth deeper in the model.
- ↑ Salinity structure, mean and maximum values consistent between NEMO and PIRATA;
- ↓ Salinity overestimation at the model EUC.

EUC keys: u: zonal velocity, thick: thickness, wflow: latitude of the westward flows, sal: salinity, and core: core depth.

EUC	PIRATA sADCP	PIRATA buoy	NEMO
u [m s^{-1}]	0.32	—	0.38
thick [m]	120	—	130
wflow [°N]	1.8	—	1.4
wflow [°S]	1.8	—	1.8
sal [mean]	—	35.8	35.6
sal [max]	—	36.7	36.8
core [m]	60	50	87

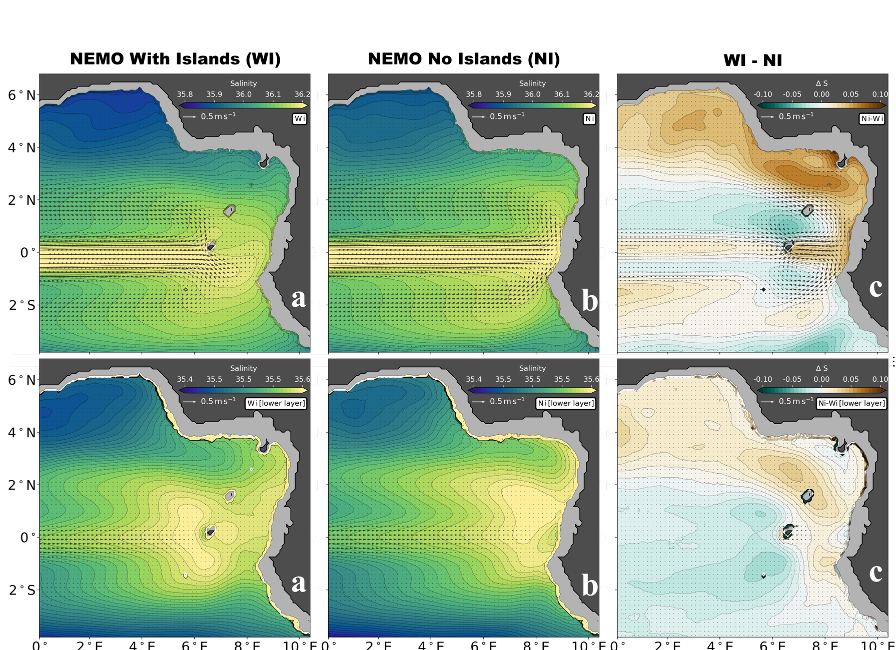
5. Salinity and Potential Vorticity

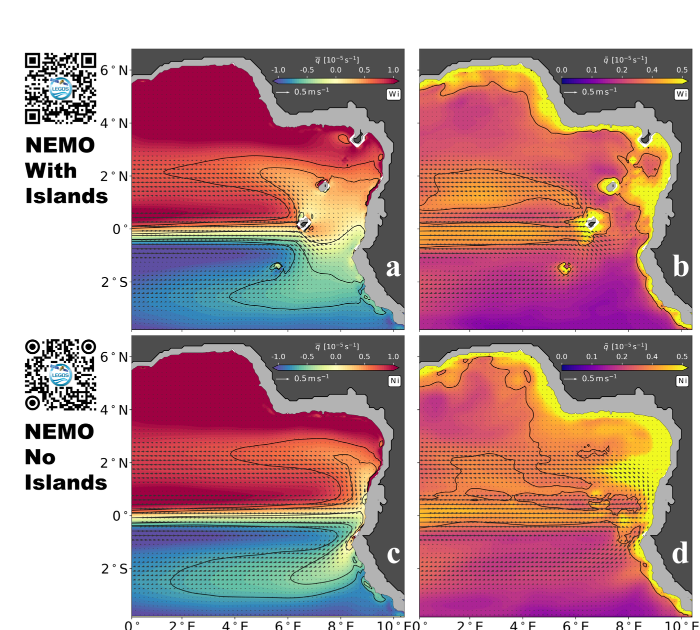
Salinity (Kolodziejczyk et al. 2014)

- EUC layer (top); lower layer (bot);
- Bifurcation, return flows, and shadow area downstream the islands marked by salinity signatures;
- Salinity of the EUC imprint in the lower layer around the islands.

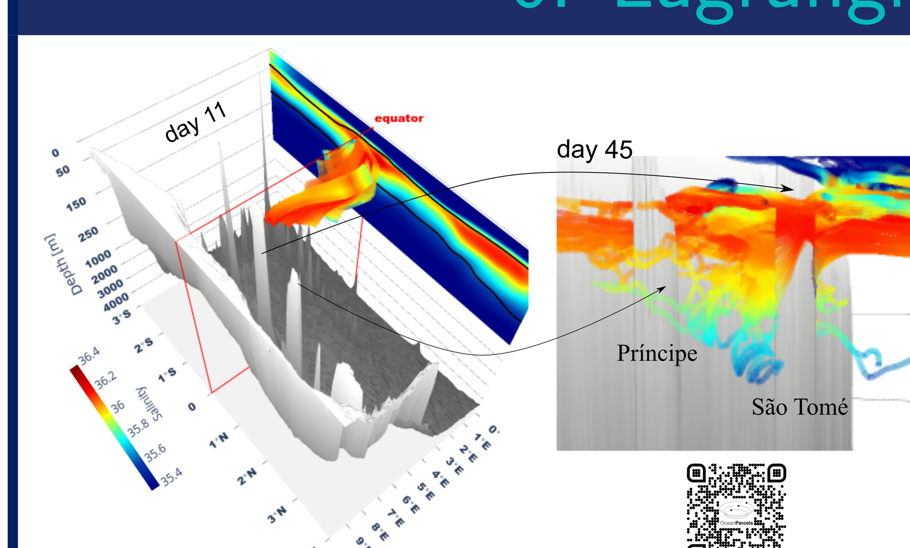
PV (Assene et al. 2020)

- Recaled PV (Morel et al., 2019); $-div((\nabla \times \mathbf{u} + f)Z_\rho)$;
- Mean PV and variability indicate the pathways and changes at the EUC;
- Low PV spreads near the islands, with PV tongues extending westward.





6. Lagrangian study case

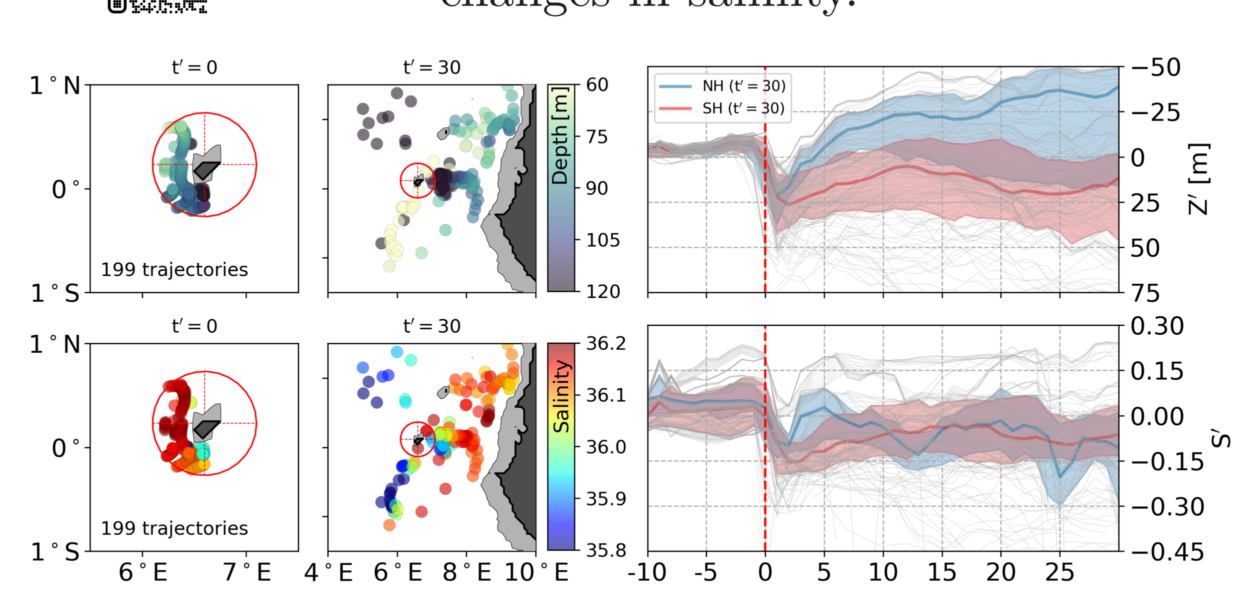


Parcels (Lange & van Sebille 2017)

- 450 seeds (45-day advection);
- Thresholds: z, vel, salt, PV;
- After ~10 days the EUC bifurcates, with particles wrapping São Tomé island, followed by downwelling and changes in salinity.

Traj. diagnostics

- Min(dist): t′ = 0;
- Particles change salinity and depth immediately downstream the island;
- Region of subduction and freshning.



Z′ = z - z(t′ = 0) and S′ salt - salt(t′ = 0).

7. Final Remarks

- The circulation of the Equatorial Undercurrent is influenced by the islands of the Gulf of Guinea, particularly by São Tomé island, responsible for the EUC bifurcation around 6.5°E.
- The bifurcation of the EUC is asymmetric towards the northern hemisphere, dividing the EUC flow at about 40% to the NH and 20% to the SH. The eddy train flows along westward jets, transporting the EUC high salinity mainly through the northern hemisphere.
- In the smaller-to-meso scale picture, islands reveal hotspots of tracer variability, such as salinity and PV, as well as depth. In particular, subduction regions help exporting the EUC salinity to lower layers which may promote diabatic mixing.

References

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