Evaluation of oceanic models in the Gulf of Guinea

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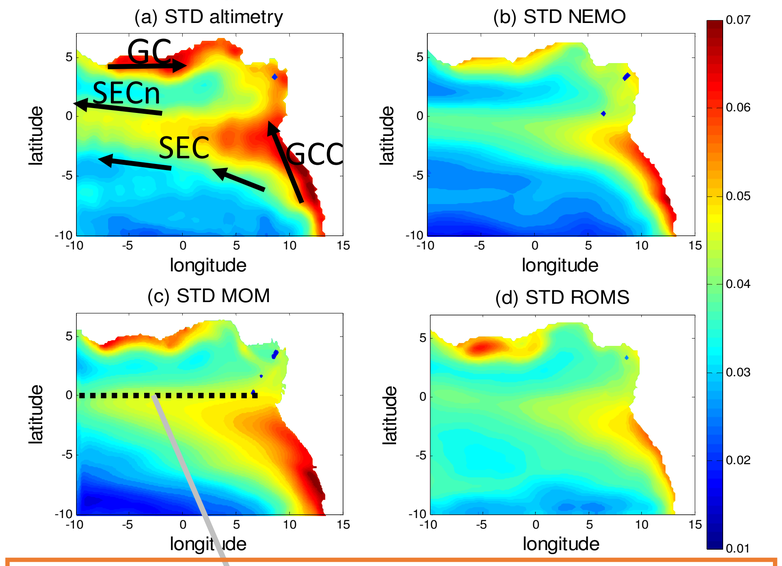
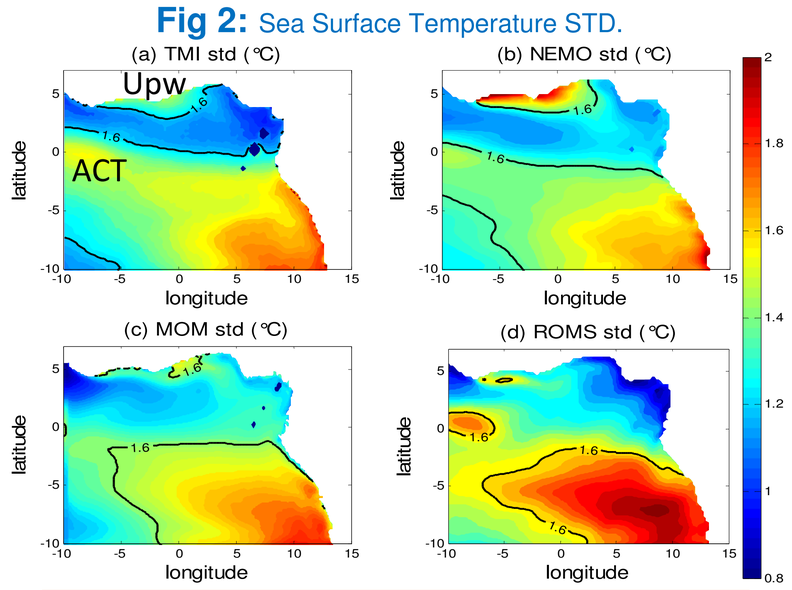
Context: PREFACE aims to improve models in the tropical Atlantic for better climate projections. Climate models show a warm bias on SST in the Gulf of Guinea, a key variable for the West-African Monsoon. Biases are also present (although smaller) in forced oceanic models.
Objectives: To evaluate strengths/weaknesses of 3 high-resolution simulations from the oceanic models NEMO, MOM and ROMS that are used in PREFACE.
Observations: TMI SST (1/4 °, 7 days), Aviso SSH (1/4 °, 1day), T(z) from PIRATA moorings, ADCP currents from PIRATA and EGEE cruises.
Models: - **NEMO** : 1/4 °, z coordinates with 35 verticals levels between 0-300m (Δz = 1m to 30m), 1 day, DFS4.3 (ERA-interim) forcing.
- **MOM** : 1/8°, z coordinates with 53 verticals levels between 0-300m depth (Δz = 3m to 9m), 5 days, ERA-interim forcing.
- **ROMS** : 1/15°, σ coordinates with ~23 verticals levels between 0-300m depth, 2days, Quikscat forcing.
Comparison is done on the common 10°W-15°E, 10°S-7°N region and 1999-2008 period.

Fig 1: Sea Surface Height STD



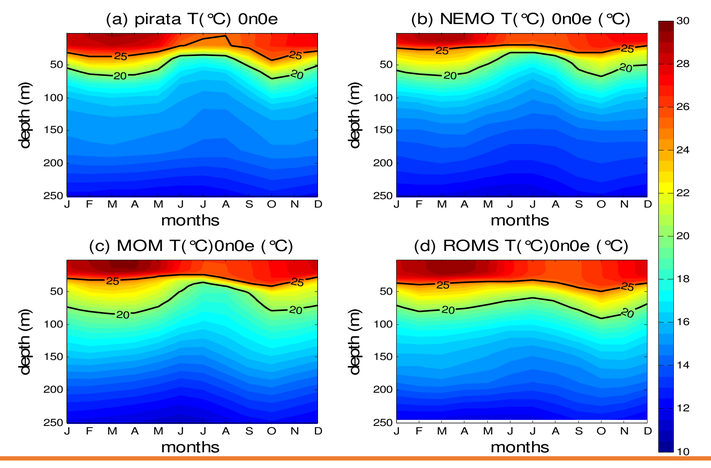
SSH reflects the variability of thermocline depth in upwelling regions (northern GoG, ACT), surface geostrophic currents (GC, GCC, SEC) and equatorial waves. This variability is strong as observed in MOM, in ROMS in the northern upwelling region only, but too weak in NEMO.

Fig 2: Sea Surface Temperature STD.



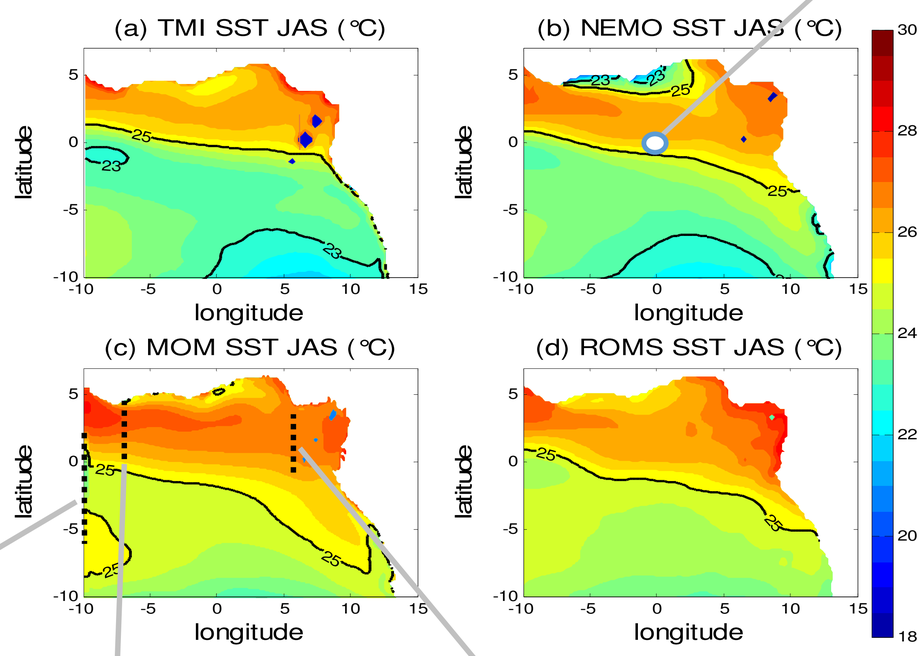
SST variability is strong in upwelling regions. NEMO matches observations better. Variability is weak in MOM in the ACT region, but too strong in the ACT and off Congo in ROMS.

Fig 3: Seasonal climatology of temperature at 0°N, 0°E.



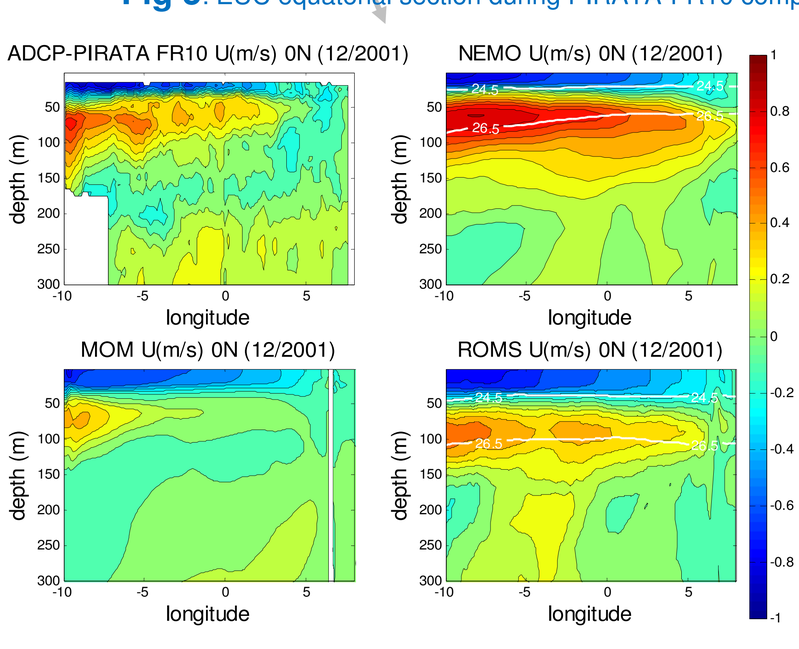
The seasonal cycle of SST shows a maximum in Mar-Apr and a minimum in Jul-Aug (ACT period) related to thermocline depth variations. The latter are realistic in MOM and NEMO but the 25°C isotherm is not shallow enough in summer. Both isotherms are too deep with depth variations too weak in ROMS.

Fig 4: Mean SST in Jul-Aug-Sep.



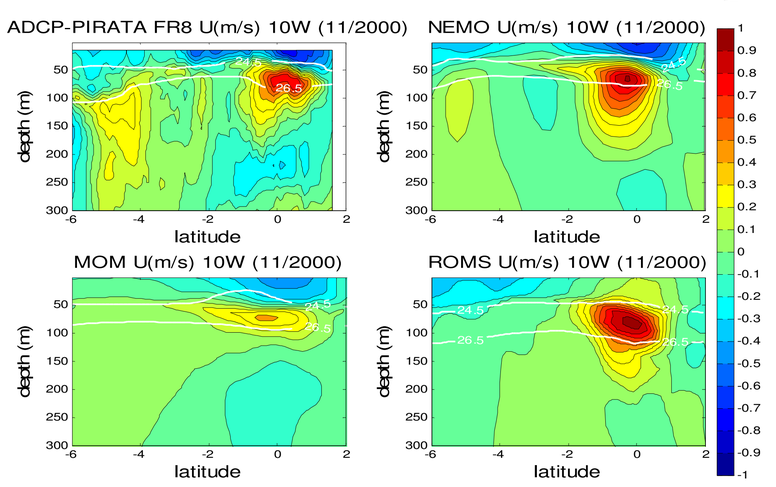
This is the peak season for the ACT and northern upwelling regions. The northern upwelling is colder than observed in NEMO, which is the most realistic model otherwise. However, all models show a warm bias in the GoG and around the ACT : +0,5°C for NEMO, +1°C for MOM, +1,5°C for ROMS.

Fig 5: EUC equatorial section during PIRATA-FR10 compared to models



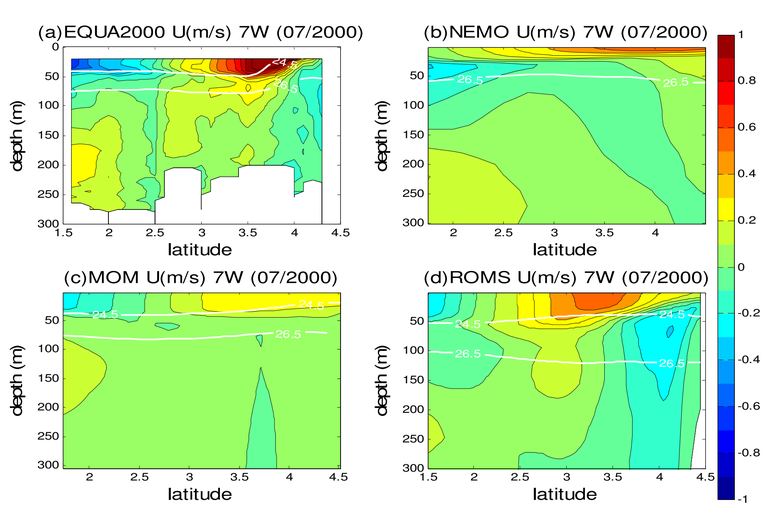
As it flows eastward under the SEC in the GoG, the EUC gets shallower, and its speed (0,8 m/s at 10°W) decreases until it vanishes. It tends to be too strong in NEMO, too weak in MOM, and too deep in both. Its speed is more realistic in ROMS but it is even deeper.

Fig 6: EUC section at 10°W during PIRATA –FR8 compared to models



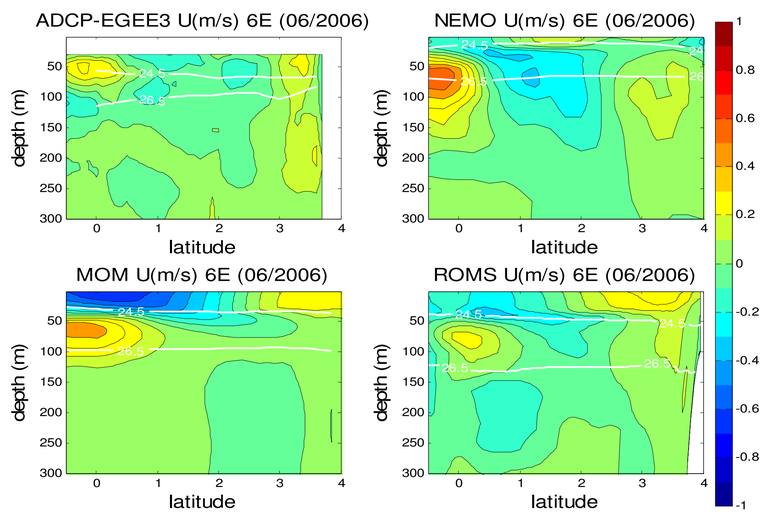
The EUC is too weak and thin in MOM. Its core is thick and wide as observed in ROMS and NEMO, with a speed a bit too high though. The SEC and the shear stress it creates with the EUC are strong enough in NEMO only.

Fig 7: GC section at 7°W during EQUALANT 2000 compared to models



The eastward GC is located around 3.5-4°N, with a speed over 1 m/s, and is related to the coastal upwelling. It is too shallow and weak in MOM and NEMO. The GC is much more realistic in ROMS, which also reproduces the coastal undercurrent.

Fig 8: EUC section at 6°E during EGEE compared to models.



The EUC shifts slightly south of the equator as it approaches the African coast, with a speed about 0,2 m/s. It is too strong in NEMO and MOM, too deep in ROMS. The termination of the GC and overall current structure is better reproduced in ROMS here.

Conclusion

All 3 models show a warm SST bias, ranging from 0.5°C to 1.5°C. ROMS has the stronger bias, but better reproduces coastal dynamics, probably due to its σ coordinates. It is suitable for coastal studies (Djakouré et al., 2014). Despite having the highest vertical resolution among the 3 models, MOM does not reproduce subsurface currents very well, but surface currents and equatorial/coastal waves variability is the most realistic, as suggested by SSH. NEMO simulates a stronger than observed EUC, but the smaller SST bias of all models, which could be due to the realistic vertical gradient of currents and associated mixing (Jouanno et al., 2011). These are preliminary results that will be quantified further using statistical methods. Also, it would be interesting to distinguish models' skills at reproducing variability at different timescales.

NEMO: Nucleus European Model Ocean
MOM: Modular Ocean Model
ROMS: Reginal Ocean Model System
SEC: South Equatorial Current
EUC : Equatorial UnderCurrent
GU: Guinea Current
GCC:Gabon-Congo current
ACT: Atlantic Cold Tongue

References : Djakouré, S., Penven P., Bourlès B., Veitch J, and Konée V. (2014). Coastally trapped eddies in the north of the Gulf of Guinea, *J. Geophys. Res. Oceans*, 119, 6805–6819, doi:10.1002/2014JC01024
Jouanno, J., Marin F., Penhoat Y. D., Sheinbaum J., and Molines J. M. (2011). Seasonal heat balance in the upper 100 m of the equatorial Atlantic *Ocean,J. Geophys. Res.*, 116, C09003, doi: 10.1029/2010JC006912.