High resolution brings global DRAKKAR ocean simulations closer to AVISO at large time/space scales

OST/ST supports DRAKKAR to develop various synergies between ocean observations, simulations, and theories. This includes atmospheric forcing, OSSEs, process studies from observations and models, and simulation Conte experiments. In the present study, we compare four 1958-2004 global ocean simulations (2°, 1°, 1/2°, 1/4°) against the 1993-2004 AVISO database to demonstrate that increasing model resolution largely improves sea-level variability properties, not only at eddy scales as already known, but also at climatic (large-scale & slow) scales. We describe the impact of model resolution on the realism of:

1. Magnitude and Distribution of interannual variabilities (Global)
2. Spatiotemporal modes (EOFs) of interannual variability (North Atlantic)
3. Phase of local interannual variabilities (Global)

The DRAKKAR ocean Modelling Group is led by scientists from France, Germany, and the UK with several collaborations in the operational and research oceanographic communities. This group continuously develops, upgrades, and integrates a hierarchy of global and regional ocean-atmosphere models over the period 1958-present, making continuous use of available observed datasets (forcing, validation, OSSEs). http://www-mmm.iemmg.mpg.de/Projekte/DRAKKAR/

### 1. Magnitude of interannual variabilities (Global)

#### SLA standard deviations (cm) $\sigma^i(\lambda)$ and $\sigma^o(\lambda)$

- Strong enhancement of interannual variability at eddy-admitting resolution.
- This is particularly clear where mesoscale eddies are present (i.e. Southern Ocean).
- High resolution strongly enhances the LARGE-SCALE (L>6° or 12°) interannual variability as well, involved in ocean-atmosphere coupling.
- Still room for improvements at 1/4° higher resolution + finer/stronger surface forcing

#### Sea Level Anomaly standard deviation maps of AVISO and DRAKKAR (fields were first collocated in time and space)

#### 1.1 Distribution of interannual variabilities (Global)

- Strong improvement of SLA interannual variability maps with increasing resolution, especially at high latitudes.
- Like for standard deviations, both laminar models yield very similar variability maps. The 1/2° and 1/4° models yield successive improvements.
- High resolution largely improves the geographical distribution of the LARGE-SCALE (L>6° or 12°) interannual variability as well, involved in ocean-atmosphere coupling.

#### 2. Spatiotemporal modes of interannual variabilities in the North Atlantic

### 3. Phase of local interannual variabilities

#### SLA temporal correlations $C_i(\lambda)$

- Zonally-averaged SLA standard deviations are shown on the right. The red line corresponds to a 14° global simulation forced by the seasonal cycle only. Away from the tropics, 4% (Northern hemisphere) up to 9% (Southern hemisphere) of the total SLA variability (black) emerges without direct forcing of interannual variability (compare red & black lines)
- Strong eddy-driven interannual ACC variability

Conclusions

The AVISO dataset is essential for model assessment. We use it here as a reference to compare 4 simulations:

- Model resolution does not only improve mean & eddy flows, but also interannual & large-scale variabilities
- Interannual variability gets stronger, better distributed. Eddy-driven interannual variability emerges from the resolved ACC variability.

### References

- Improved 0.5° resolution. DRAKKAR ocean simulations closer to AVISO at large time/space scales

### Figures

- Figures on the right show zonally-averaged correlation coefficients between observed and modelled interannual SLA (local timeseries), Increased resolution yields a slight but systematic decrease in these terms, especially in the Southern Ocean. This is consistent with higher resolution letting an intrinsic (eddy-driven) interannual variability emerge.
- Is this hypothesis plausible?
- Zonally-averaged SLA standard deviations are shown on the right. The red line corresponds to a 14° global simulation forced by the seasonal cycle only. Away from the tropics, 4% (Northern hemisphere) up to 9% (Southern hemisphere) of the total SLA variability (black) emerges without direct forcing of interannual variability (compare red & black lines)
- Strong eddy-driven interannual ACC variability

Step 1: compute the leading EOFs of the interannual AVISO SLA(x,y,t)

The first EOF of the observed SLA in the North Atlantic exhibits the well-known “intergyre gyre” circulation anomaly (Marshall 2001). This mode’s Principal Component is shown in green in the figure below, along with the NAO index (blue), which is known to drive this intergyre gyre.

Step 2: project model SLA(x,y,t) on these observed interannual spatial modes

The four models can mimic the observed (green) interannual intergyre variability, which legs the NAO by 6-9 months (left figure below). Differences:

Step 3: compute the observed interannual EOFs with the 4 simulations projected onto them

Increased model resolution from 2° to 1/4° improves the spatiotemporal NAO-related source response in the North Atlantic. NAO-based trends toward observed value - interannual variability get enhanced. Improvement even clearer in the Gulf Stream.