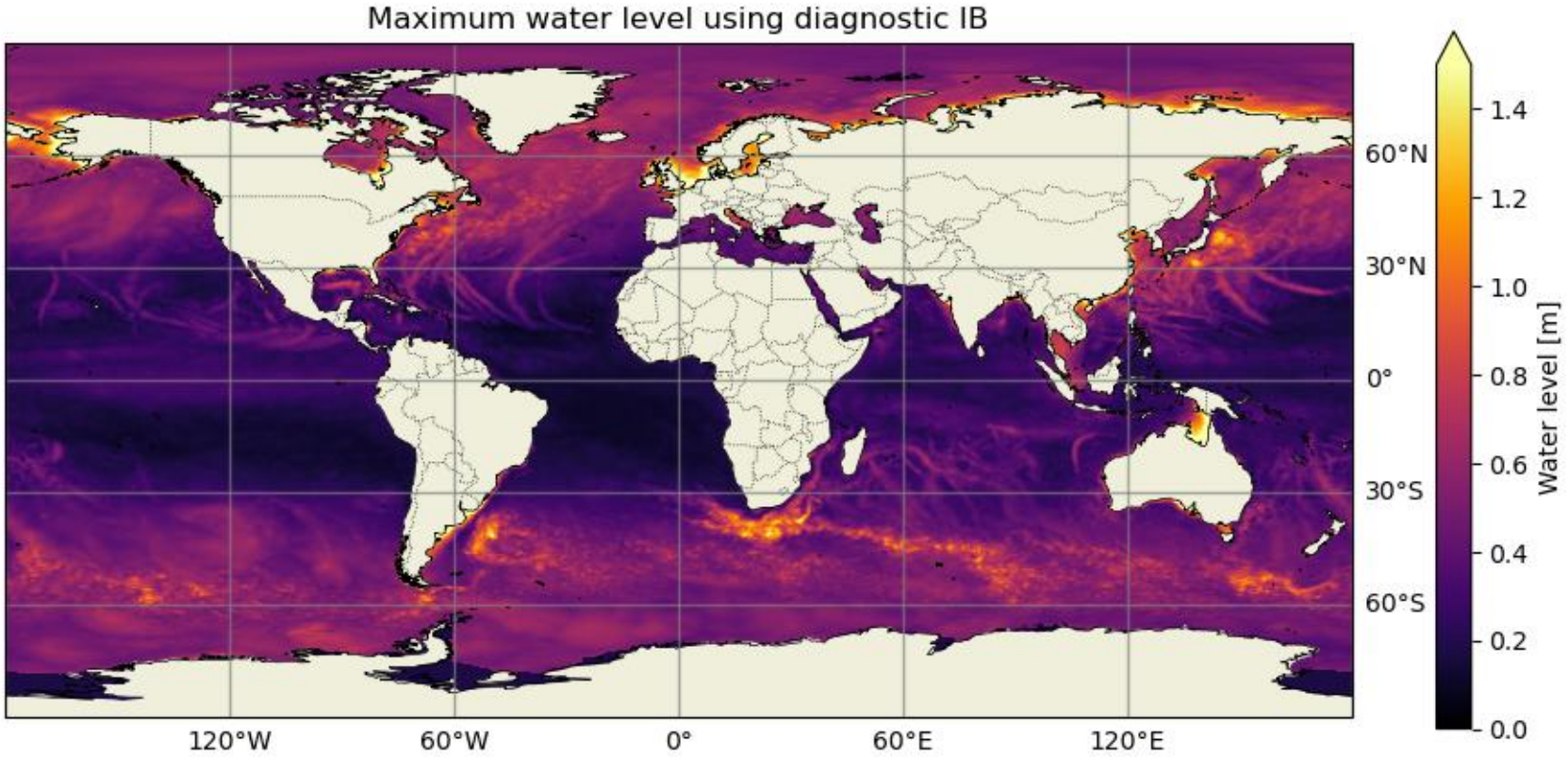
Evaluating two methods for including the inverse barometer effect in a global ocean model



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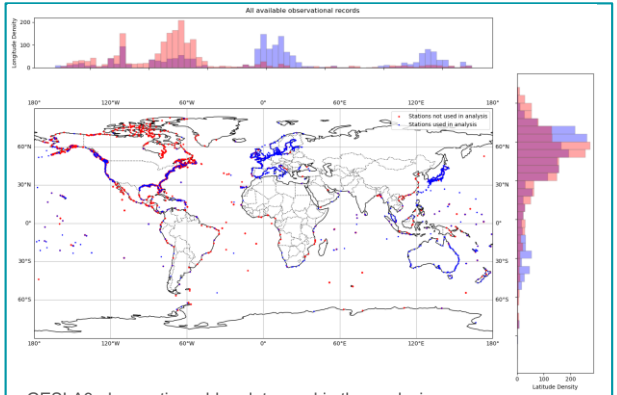
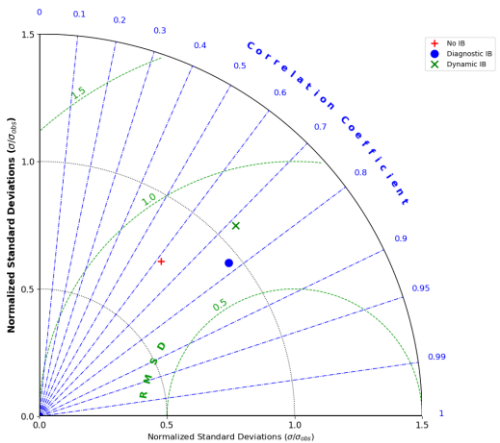


GESLA3 observations, blue dots used in the analysis

Research Question: In a global ocean model, is it better to include the IB effect **dynamically** (calculated during the simulation) or add it **diagnostically** (calculated and added after the simulation)?

Hypothesis: Including the IB effect dynamically will produce more accurate water level forecasts compared to a diagnostic approach, especially in complex coastal regions.



Taylor diagram showing the normalized error statistics.

- Global 0.25° NEMO model was run for 2015-2022, forced by ERA5
- Three “experiments”:
  - *noIB* - a run with no IB effect, WL influence only by wind stress
  - *diaIB* - the *noIB* run, with IB added diagnostically in post-processing
  - *dynIB* - model run with dynamical IB activated

- Results evaluated against GESLA3 global observation dataset
- RMSE reduced by ~1cm when considering all data by including IB
- For extreme cases (storm surge > 2σ), RMSE reduced up to 30%
- Overall performance of *dynIB* and *diaIB* is very similar

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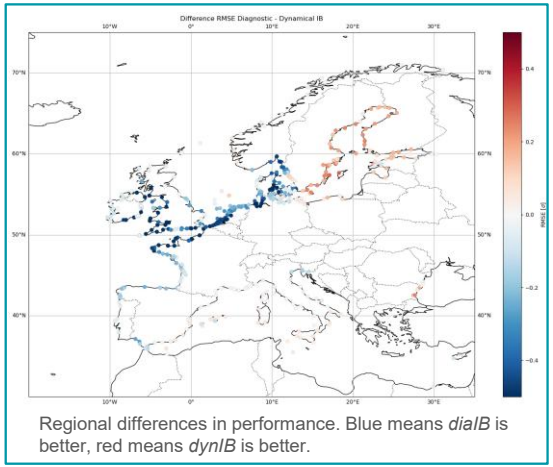

Regional differences in performance. Blue means *dialB* is better, red means *dynIB* is better.

Important regional differences

- European NWS - *dialB* is better
- Baltic, Black Sea (and the Mediterranean) - *dynIB* is better

“Closed” and semi-enclosed basins with limited connectivity to the open ocean ⇒ *dynIB* is better

Conclusions:

- **IB is obviously essential, but …**
- **Diagnostic IB is over all as good as Dynamic, but …**
- **Performance is region dependent, possibly related to the narrowness of the inlets (see the Baltic Sea)**

Implications for Ocean Forecasting

1. **Ease of inclusion:** Ocean models that do not have the capability to include the IB effect dynamically can be **easily and reliably improved** by adding the effect as a simple post-processing step. This provides a low-cost pathway to better forecasts.
2. **Confidence in Global Models:** A global 0.25° model like NEMO, forced with ERA5, can produce realistic storm surge forecasts even in complex coastal areas. This gives confidence in using global ensemble systems like ECMWF's IFS for early warnings of dangerous storm surges.
3. The diagnostic IB is now ready to be added to the water level of the next model cycle (50r1) of the IFS as a separate model variable