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Assimilation of high-sampling rate altimetry for sea level studies in the Nordic Seas and Arctic Ocean

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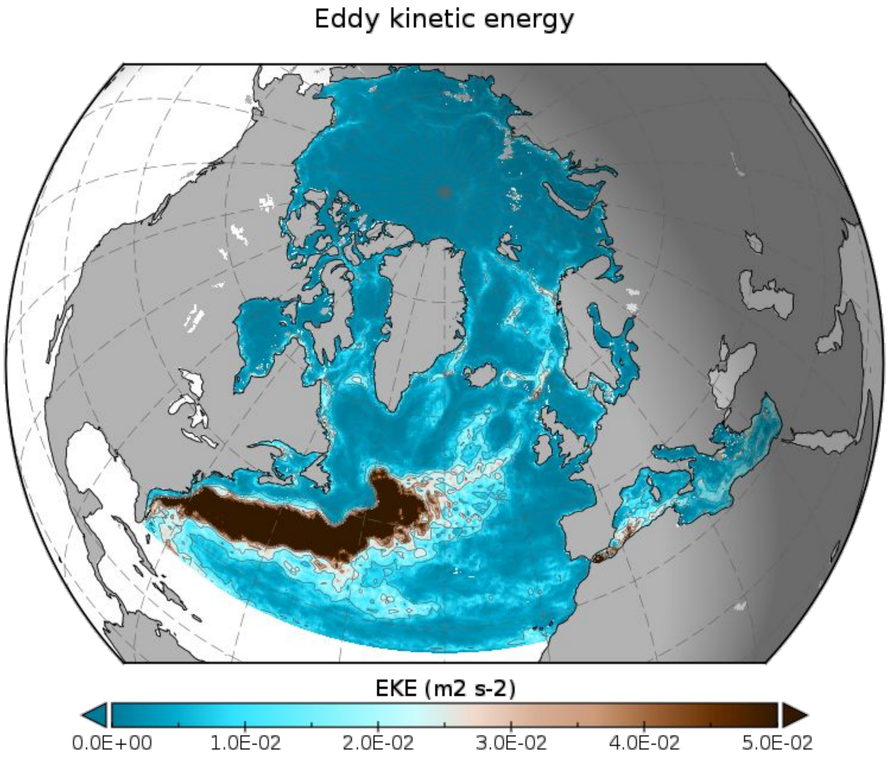
Introduction

Regional ocean models



NEMO 4.0.7
A family of configurations:
CREG025
CREG12
CREG36

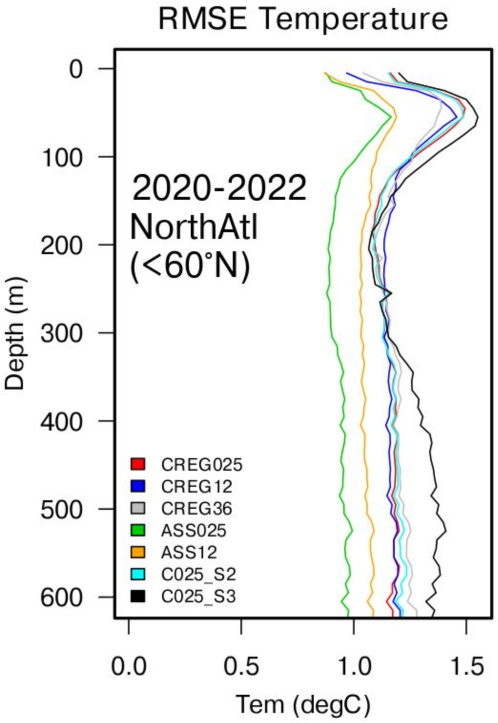
Forced by ERA5/GLORYS12 laterally
JRA55-do discharge

Data assimilation enabled:
Variational DA in the ocean

Applications
Interannual variability in the NA
Atlantification of Arctic
Stochastic physics developments
DA developments (e.g. new obs types)

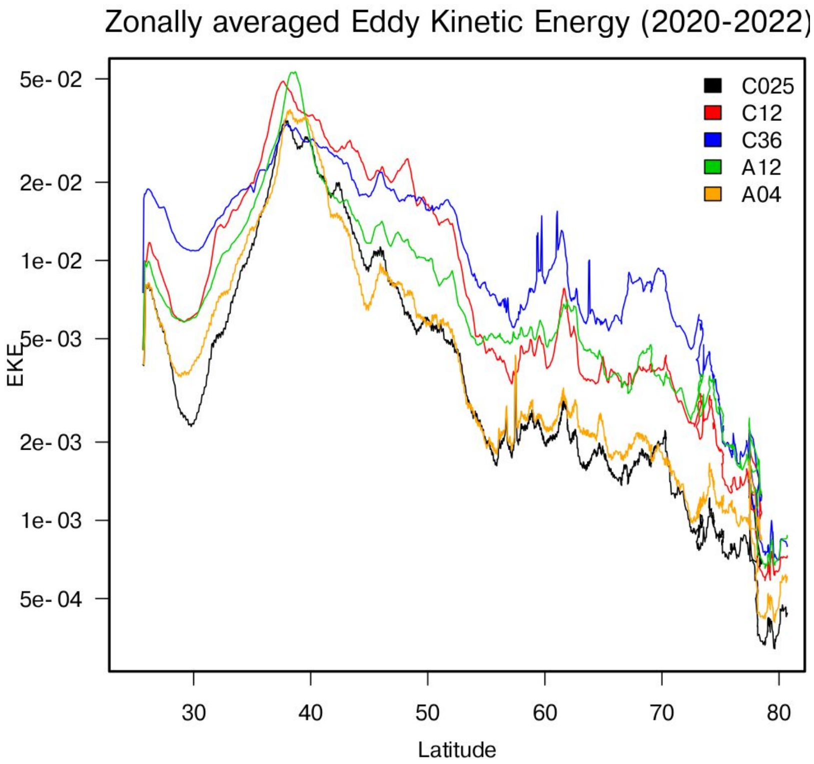
Comparison

<u>Goal</u>: To understand the relative impact of eddy parametrization, stochastic physics, data assimilation and horizontal resolution on the mesoscale activity representation



Impact of DA & resolution

<u>To add:</u>
ReTuned ASS12
STOCH PHYS runs



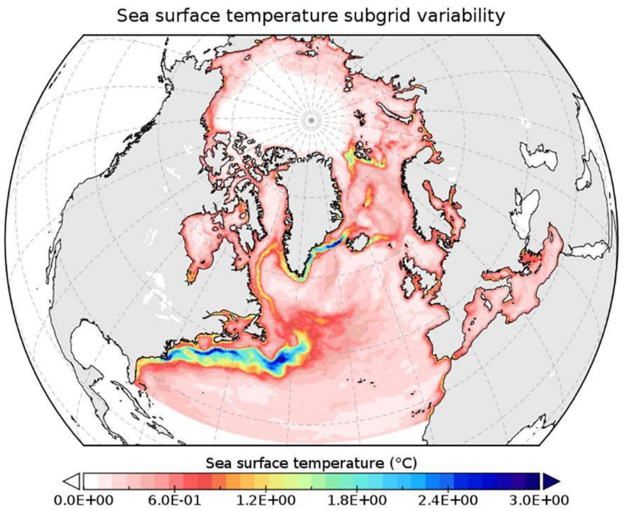
Stochastic physics

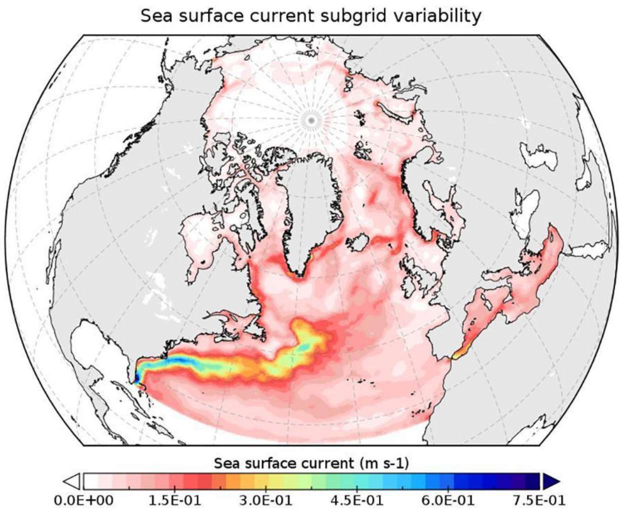
Increasing resolution configuration help assessing the subgrid variability in ~coarse models

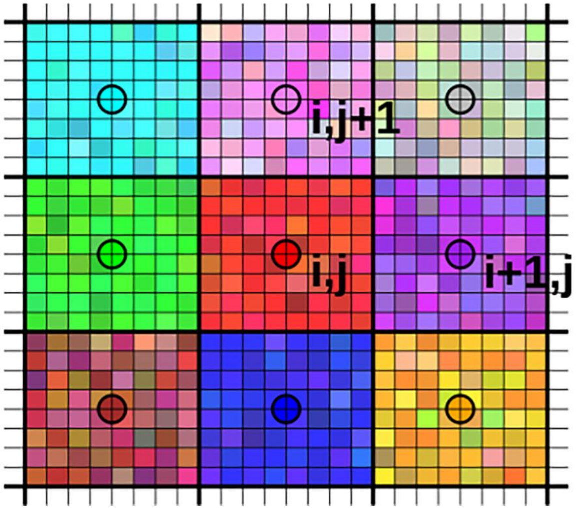
Below: subgrid (submesoscale) variability of the 1/4° assessed using the 1/36° configuration

Stochastic coarse-grained high-resolution bulk formulas:

Stochastically modulate air-sea fluxes through computing their subgrid variations

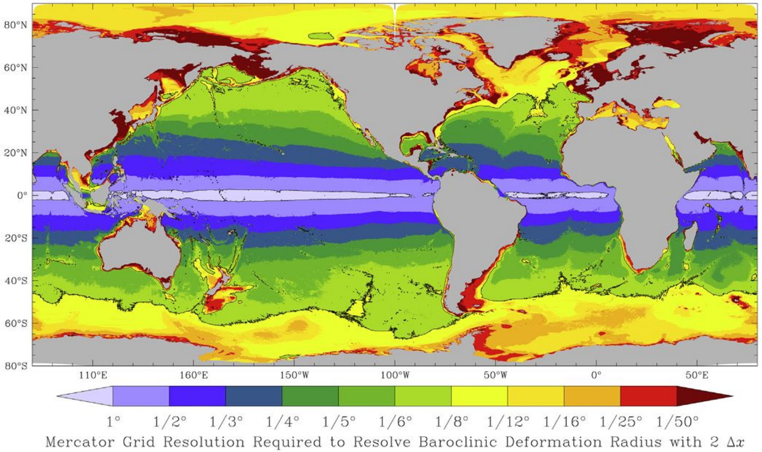




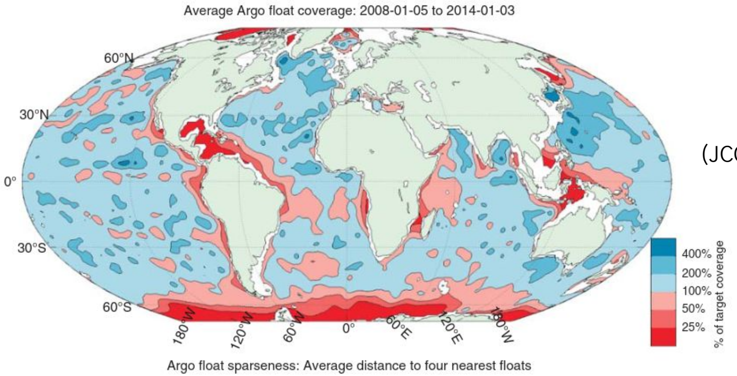


Motivation for altimetry at 5Hz

- The intrinsic challenge of high latitudes:
  - Much less observed (especially subsurface)
  - Much shorter Rossby Radius (even ~1/10° models do not resolve eddies)
  - Meridional transports are crucial to understand the global changes (e.g. sea-ice decline, etc.)
- It is crucial to optimize the current observing network
- Important to investigate networks capable to sense partly ice-covered areas, and altimetry in particular as it contributes to mesocale characterization



(Hallberg, 2013, OM)



(JCOMMOPS)

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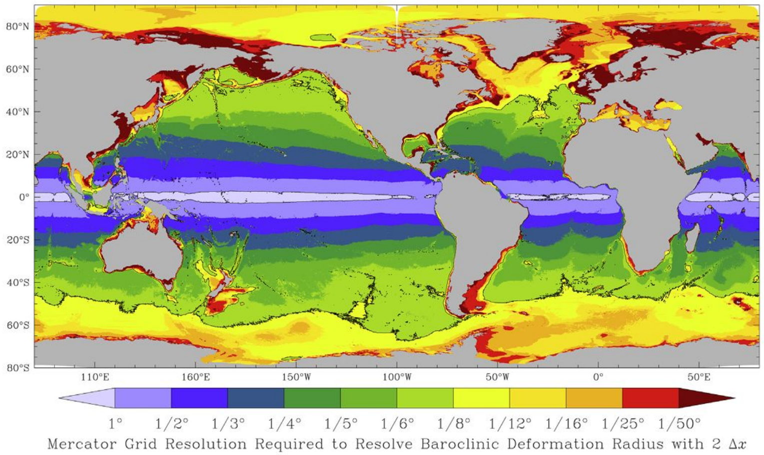

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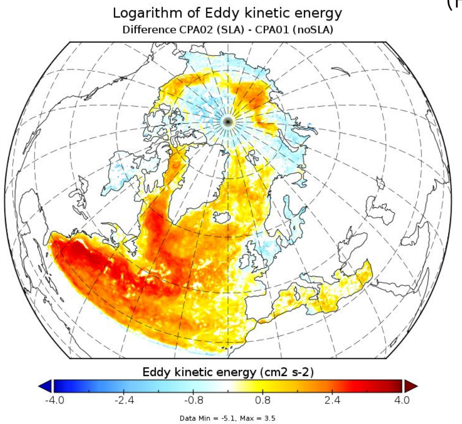
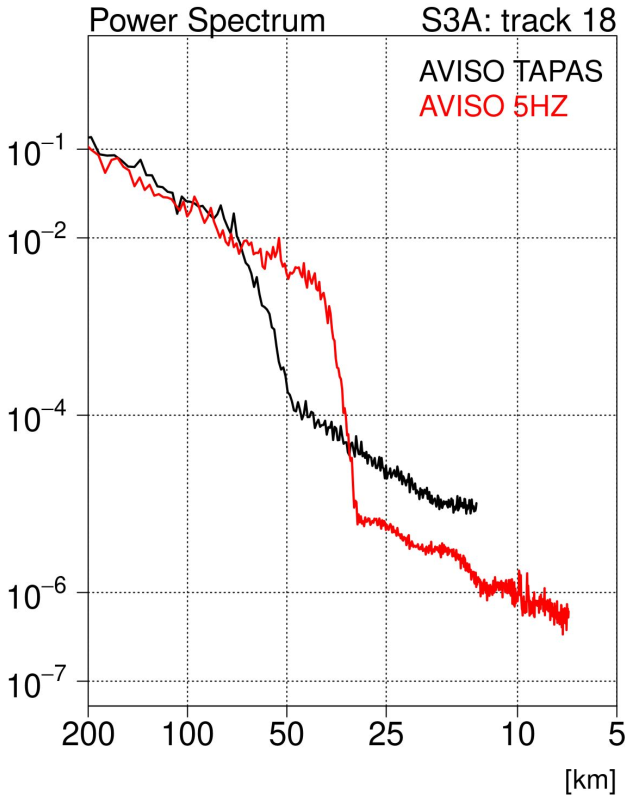
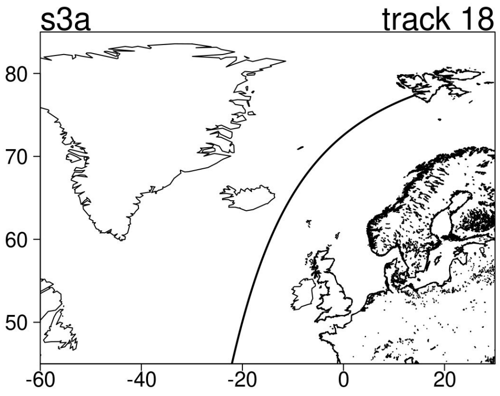


Altimetry dataset





Cryosat−2, Saral/AltiKa and Sentinel−3A reprocessed in order to provide:

- 5Hz dataset (against 1Hz conventional)
- use of new re−tracking for retrievals over leads
- now disseminated within Copernicus (but not updated

(Prandi et al., 2021)

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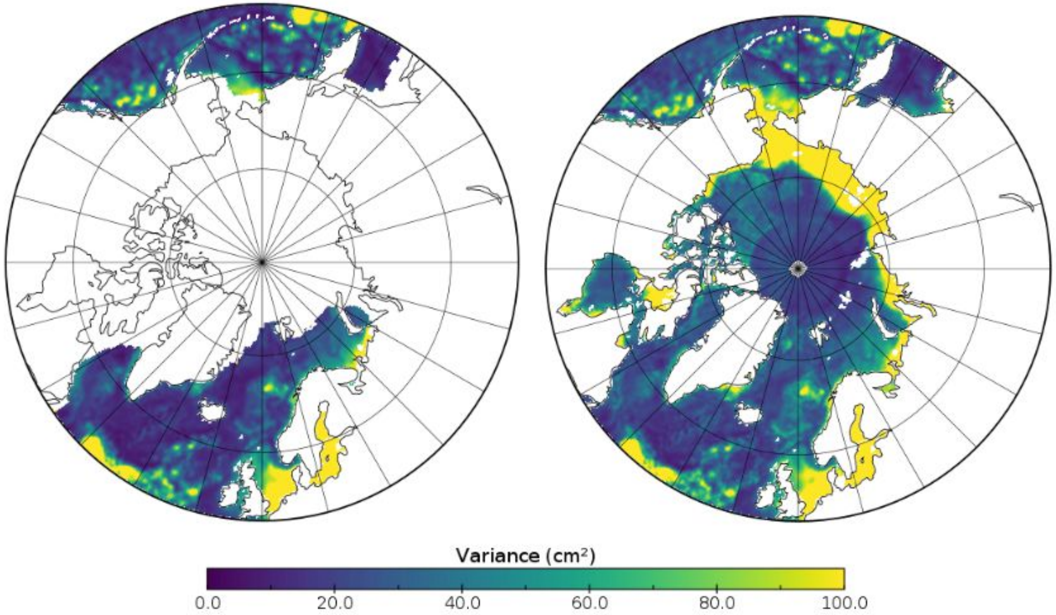

Variance of the sea-level anomaly field (cm^2) obtained considering conventional (left) and enhanced altimetry satellite altimetry maps over the period 2016-2020.

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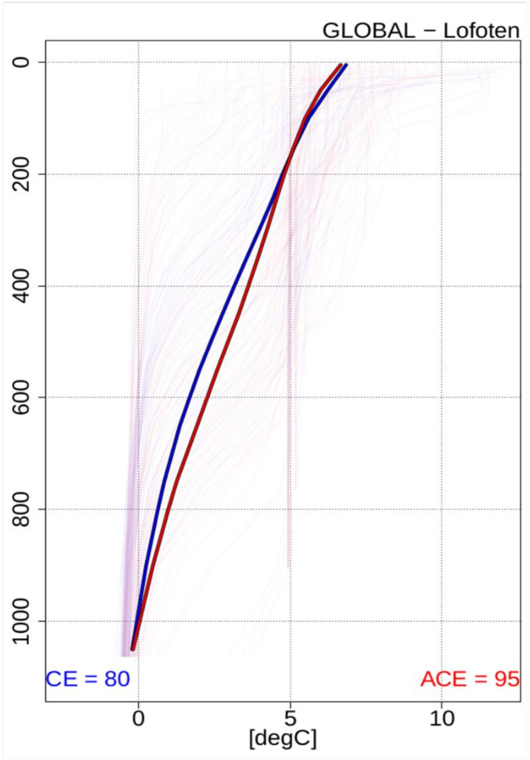
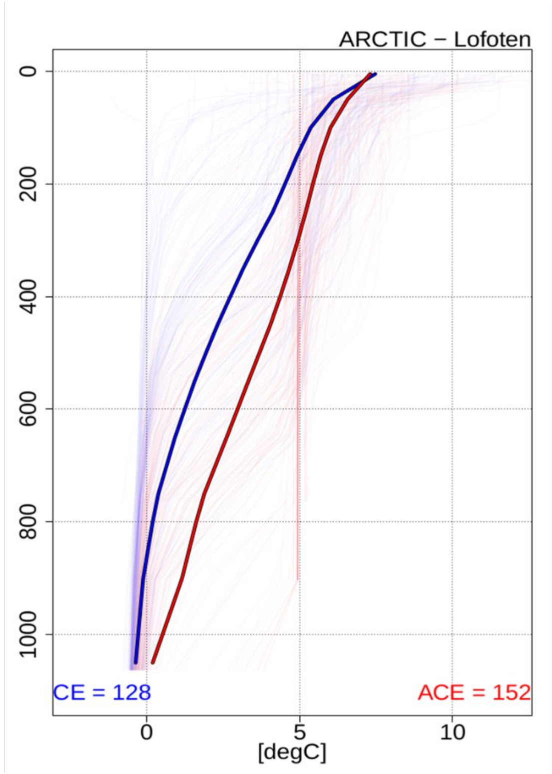




- **Argo profiling floats trapped** by eddies in the Lofoten Basin.

- In-situ temperature profiles collocated with mesoscale features as a function of **eddy size, lifetime (> 1 month) and polarity:** cyclonic (CE; blue lines) and anticyclonic (ACE red lines) features.

Experiments

A01: Only in-situ data assimilation

A02: In-situ + 5Hz altimetry assimilation

A03: In-situ + conventional altimetry (1Hz) assimilation

(A02b: as A02 but with representativeness error augmented) example: $\sigma\sqrt{5}$ for 20 Hz satellite, e.g. S3-A)

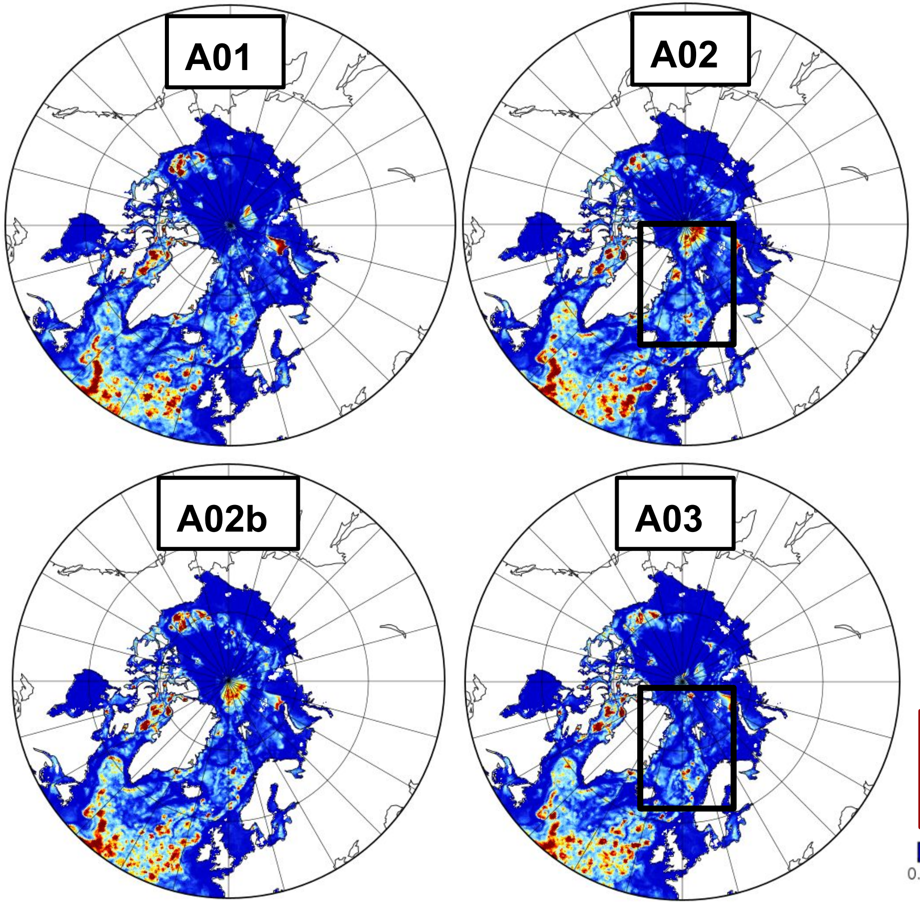
Experimental Set-up

OGCM
NEMO (4.07), TKE vertical mixing, SI^3

Data Assimilation Scheme
- 3DVAR
- Multivariate EOFs
- Obs. Operator SLA based on dynamic height

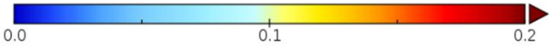
Forcing
ERA5-hourly (SRF)
GLORYS12 (LBC)

Relative EKE

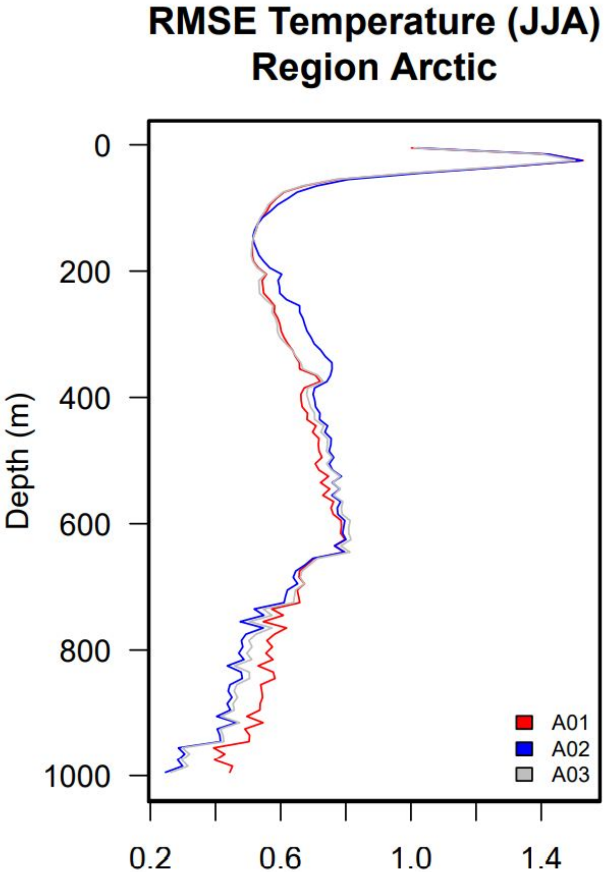


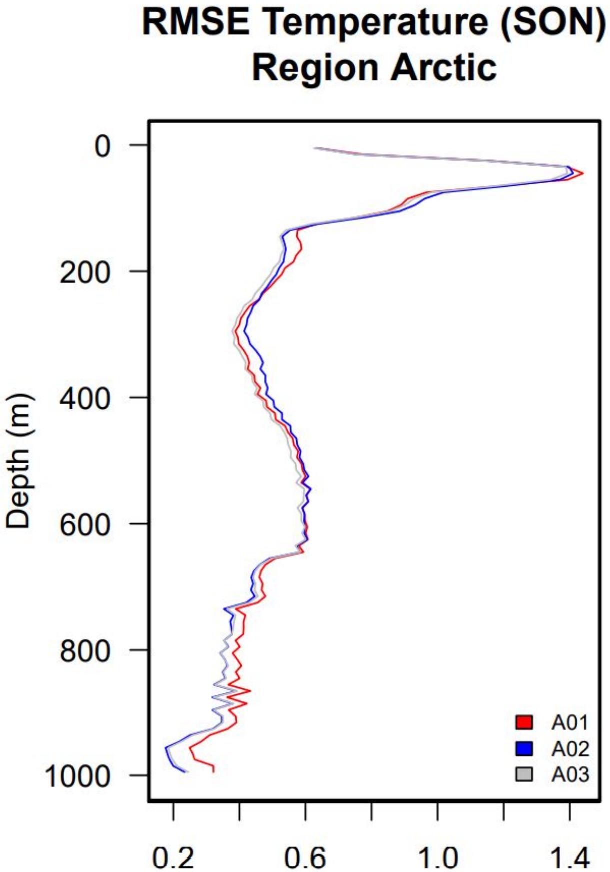
- **REKE** (%) explained by eddies > 14 days lifetime considering **0–200m** depth range
- The impact of enhanced altimetry data shows off at the high latitudes: **energetic mesoscale features** in the Arctic (Nansen basin)
- A02b exhibits no significant difference w.r.t. A02

REKE=fraction of EKE occurring in presence of eddies, i.e. EKE due to eddies in compact form



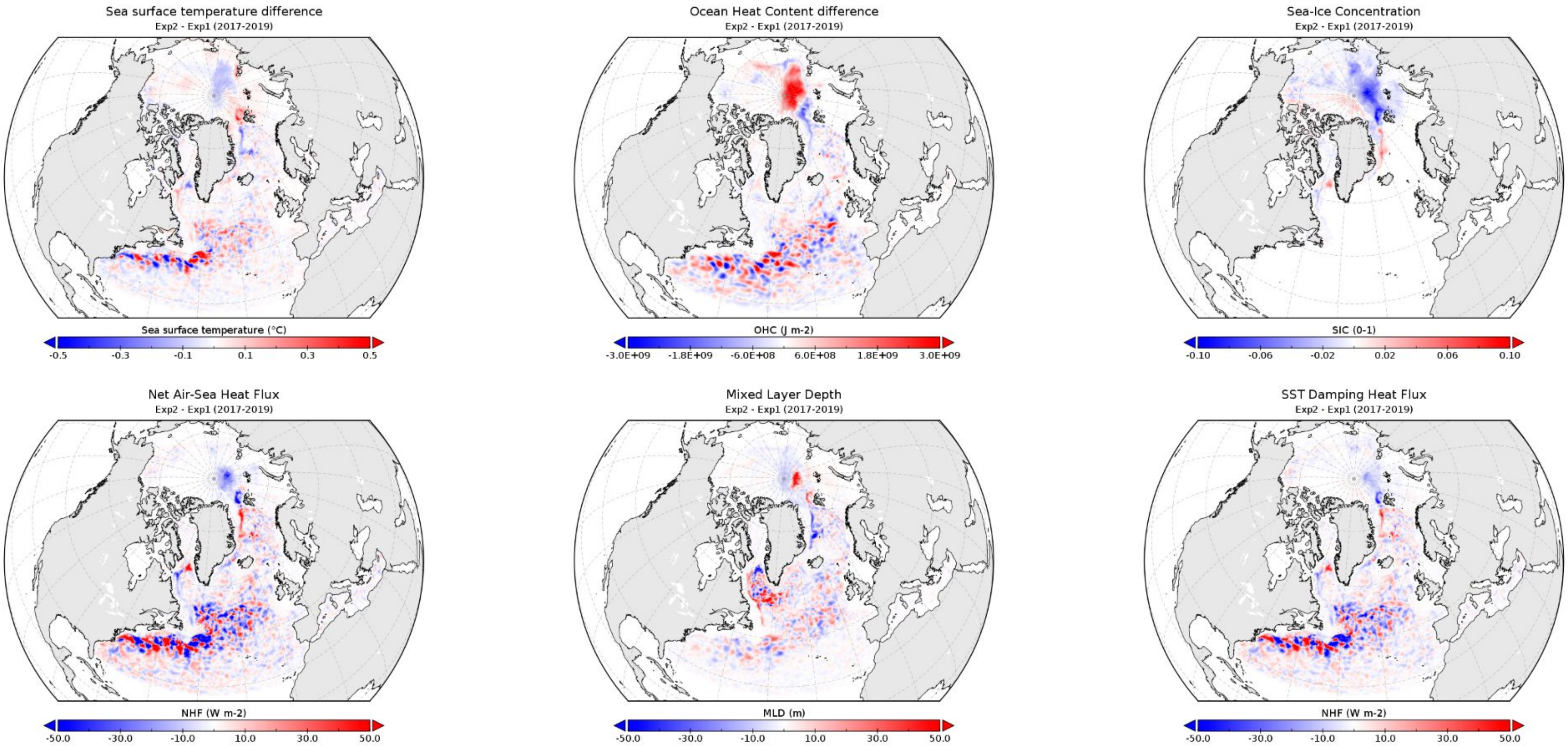
Skill score metrics



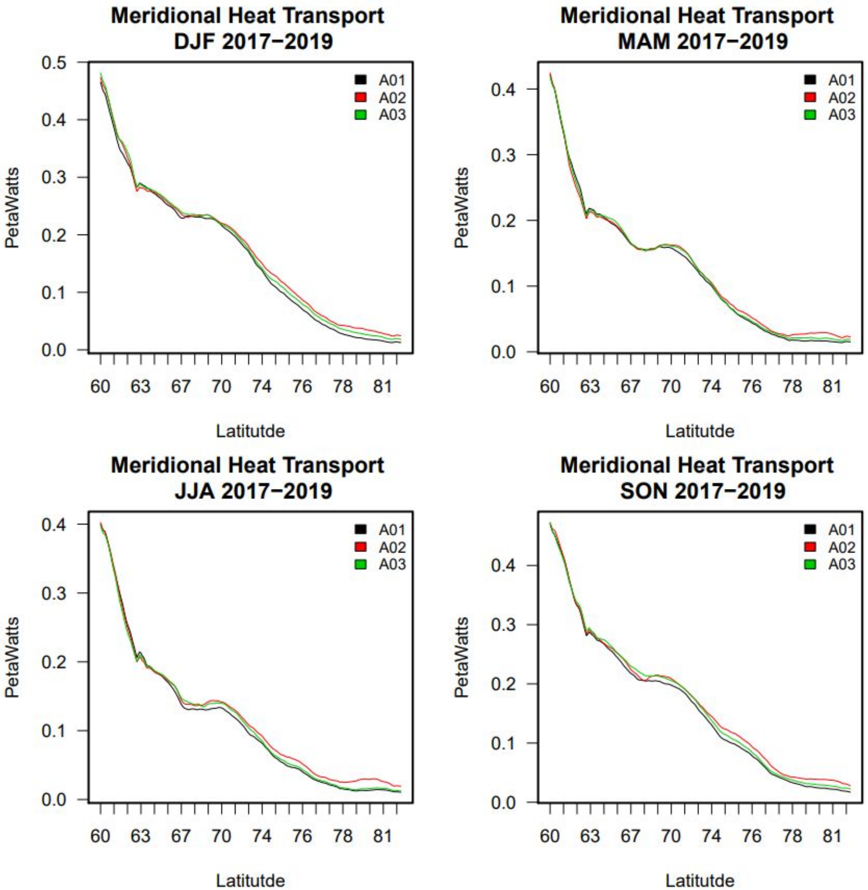


- The **skill** of the experiments is **comparable**
- **Improvements** can be observed **at depth** > 500 m during JJA

Mean differences (A02–A03)



Meridional Transports



- Significant **increase of MHT** at the high latitudes

- The experiment performed ingesting **enhanced altimetry** shows the **largest increase** in all the seasons

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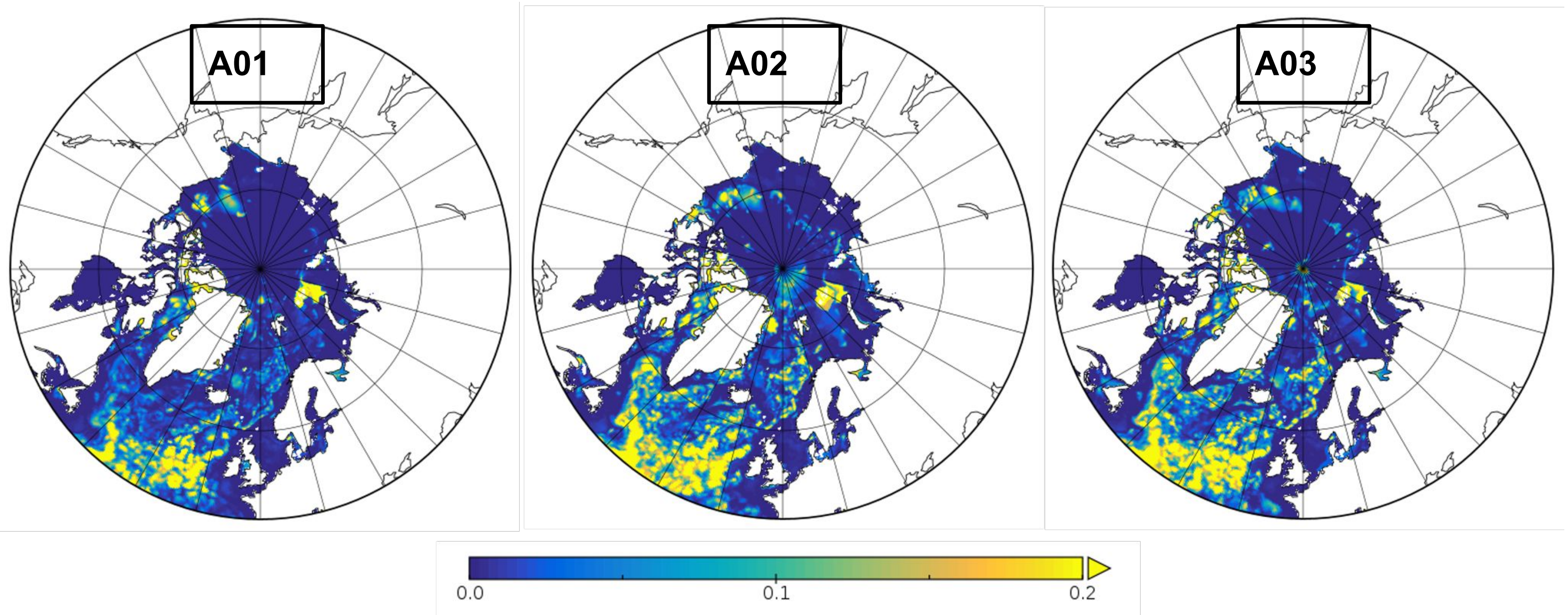
SSH variability



- Percentage of **variance of SSH** explained by eddies as a function of lifetime (>1 month)
- **Mesoscale** features show their **signature in the SSH field** in Nordic Seas and Arctic

Conclusions

- The challenges in the Arctic observing networks call for optimizing the assimilation of the current altimetry missions
- 5Hz altimetry offers an enhanced dataset at higher spatial resolution and capable of sensing sea ice leads
- Its ingestion in an operational-like forecasting system provides some improvements:
    - rather neutral impact on skill scores
    - enhanced mesoscale activities locally (Lofoten Basin, Nansin basin)
    - enhanced meridional heat transports around for $\varphi>70°N$