TOPAZ5: An upgraded Arctic coupled ocean and sea-ice forecasting system using the Ensemble Kalman Filter

Jiping Xie[1,3], Achref Othmani[1,3], Alfatih Ali[2], Annette Samuelsen[1,3], and Laurent Bertino[1,3]

1. *Nansen Environmental and Remote Sensing Center, Bergen, Norway*
2. *Norwegian Meteorological Institute, Bergen, Norway*
3. *Bjerknes Center for Climate Research, Bergen, Norway*

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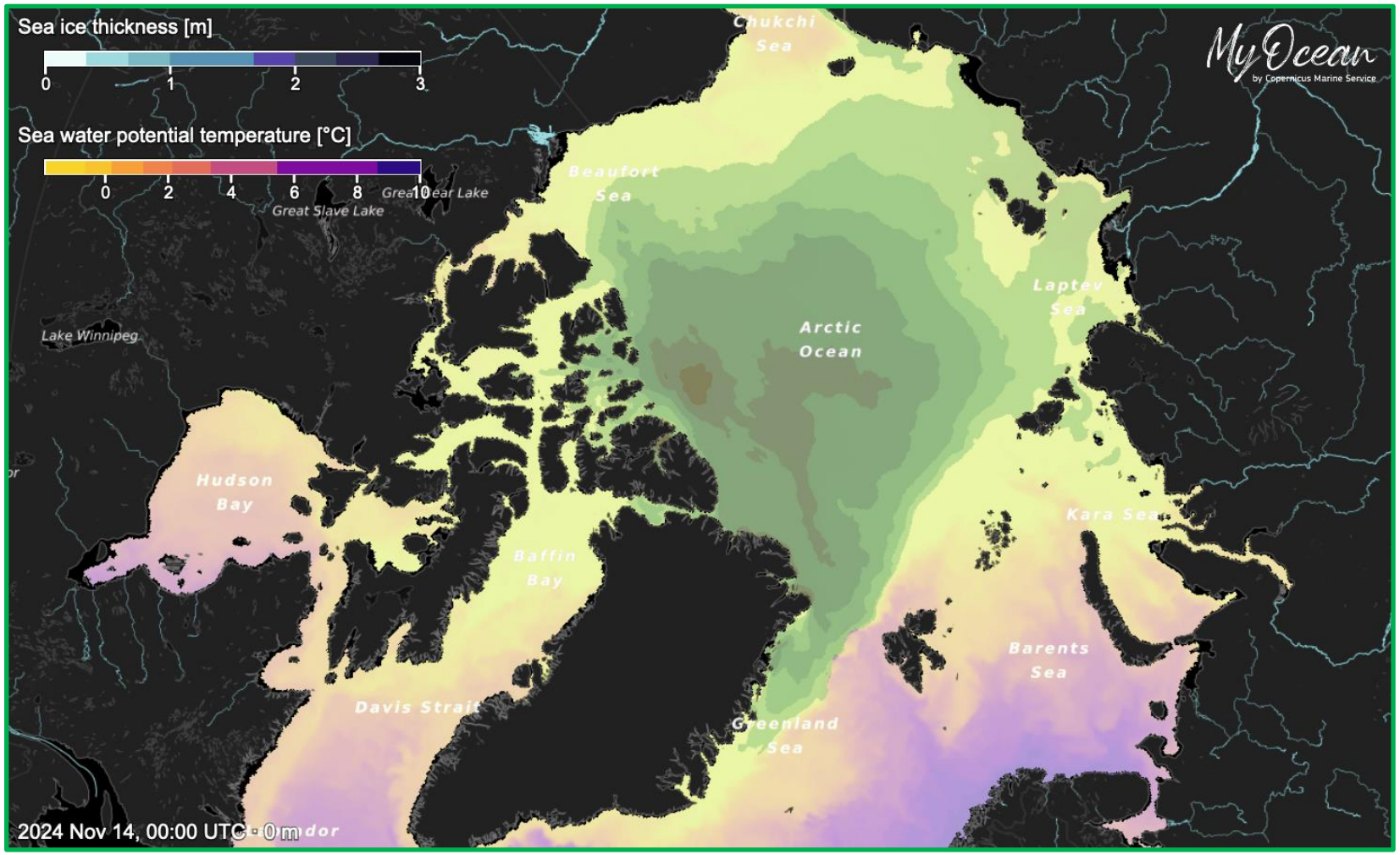


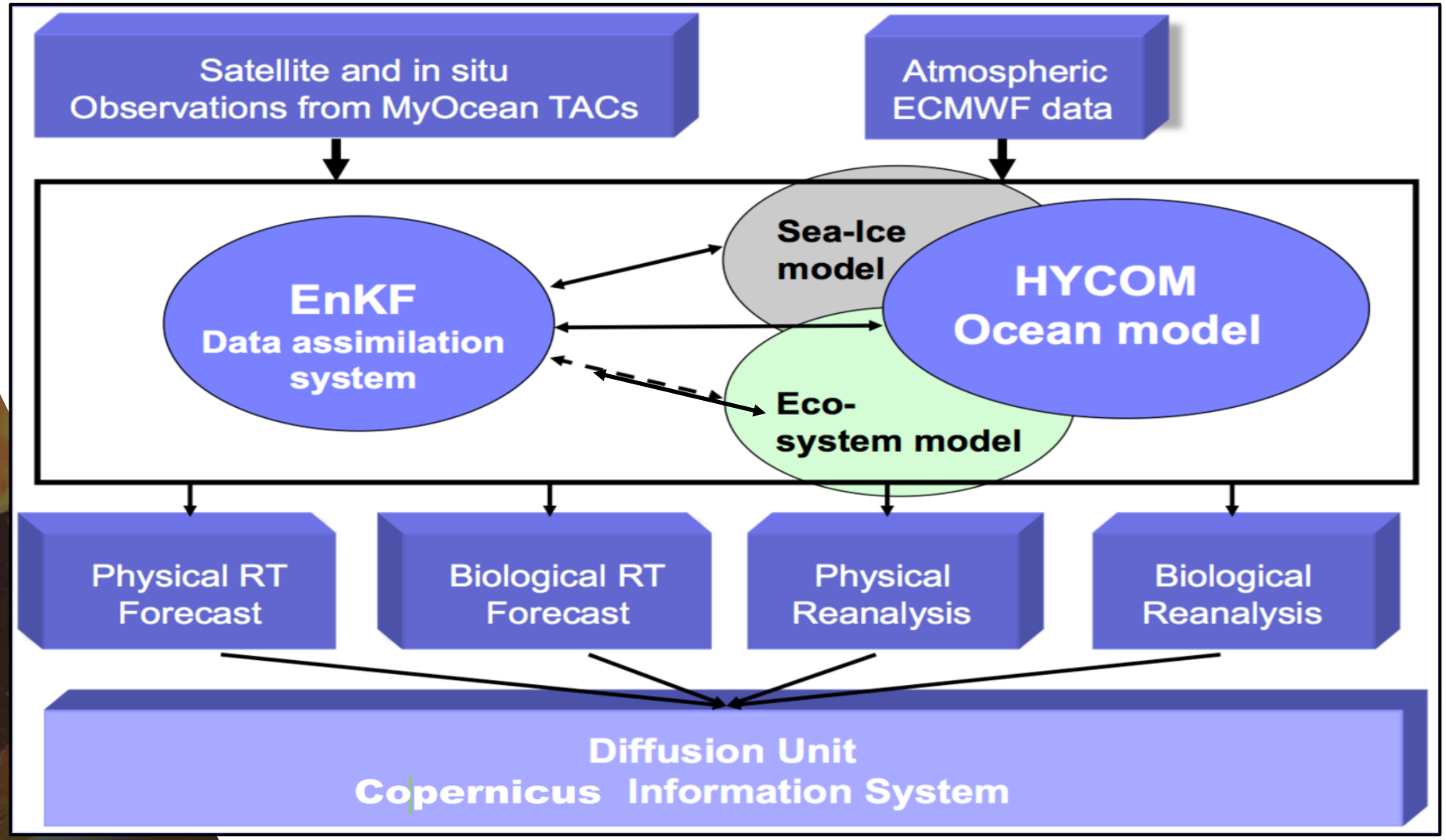
- *Assimilative operational forecast product (arc_phy_anfc_6km) from ARC MFC*
- *Easily shared with https://data.marine.copernicus.eu/-/ok2y9q1pfc*

Outline

- ❑ Model upgrade in the TOPAZ system
- ❑ EnKF sensitivity runs and evaluation
- ❑ Summary and further developments

❑ Model upgrade in the TOPAZ system

The Arctic component in Copernicus marine service:



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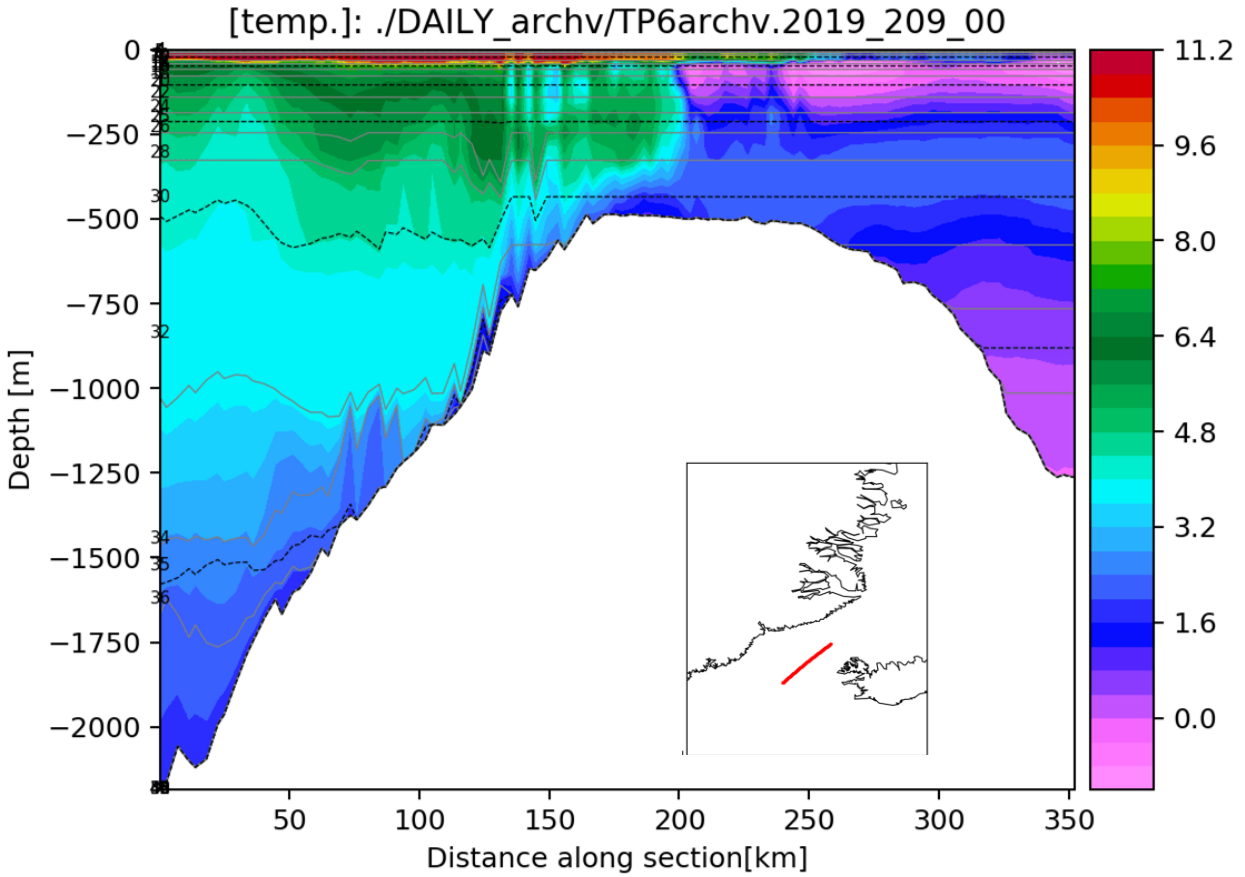
- 3D numerical ocean model: Hybrid Coordinate Ocean Model (HYCOM 2.2.V37 ->2.2.V98)

– Isopycnic in the interior (whole Arctic)
– Z-coordinates near surface
– 28 -> 50 hybrid layers

- Front: warm Atlantic water meets colder Arctic water
- Overflow: well captured as dense Arctic waterfalls

- Hybrid vertical coordinates avoid unphysical mixing



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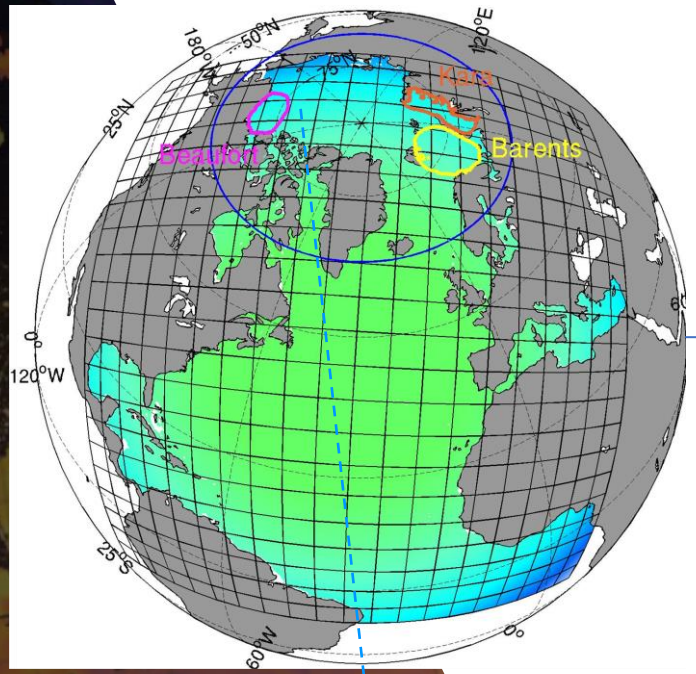
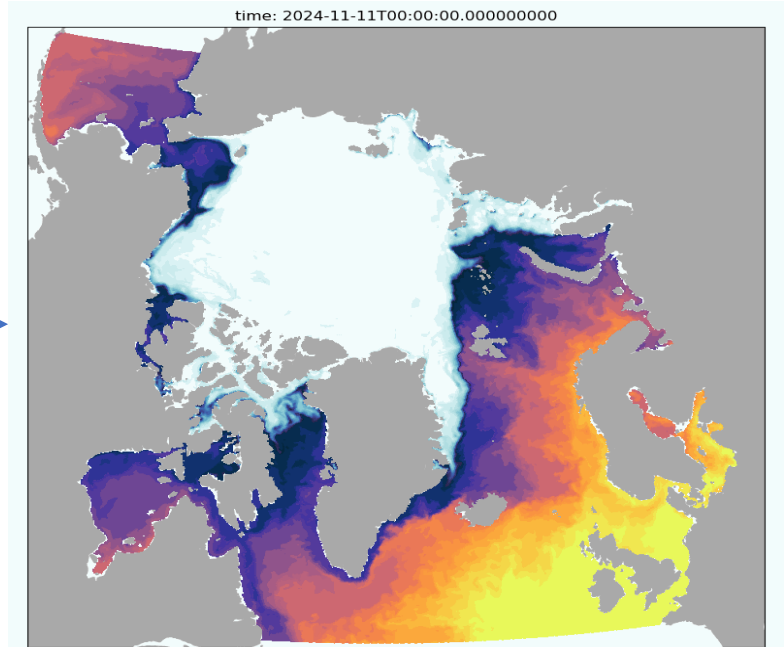
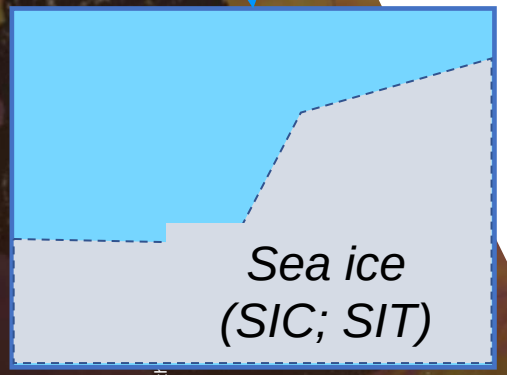
TOPAZ4 -> TOPAZ5



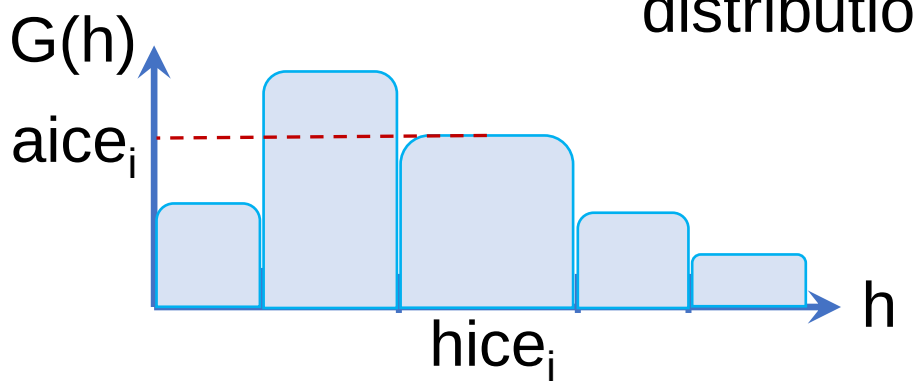


- Resolution: ~6 km;
- Nesting: from the global NEMO
- River: Climatology AHYPE+Greenland glacial melt



CICE v5.1

- Ncat=5;
- Sea ice thickness distribution (ITD) -> SIT



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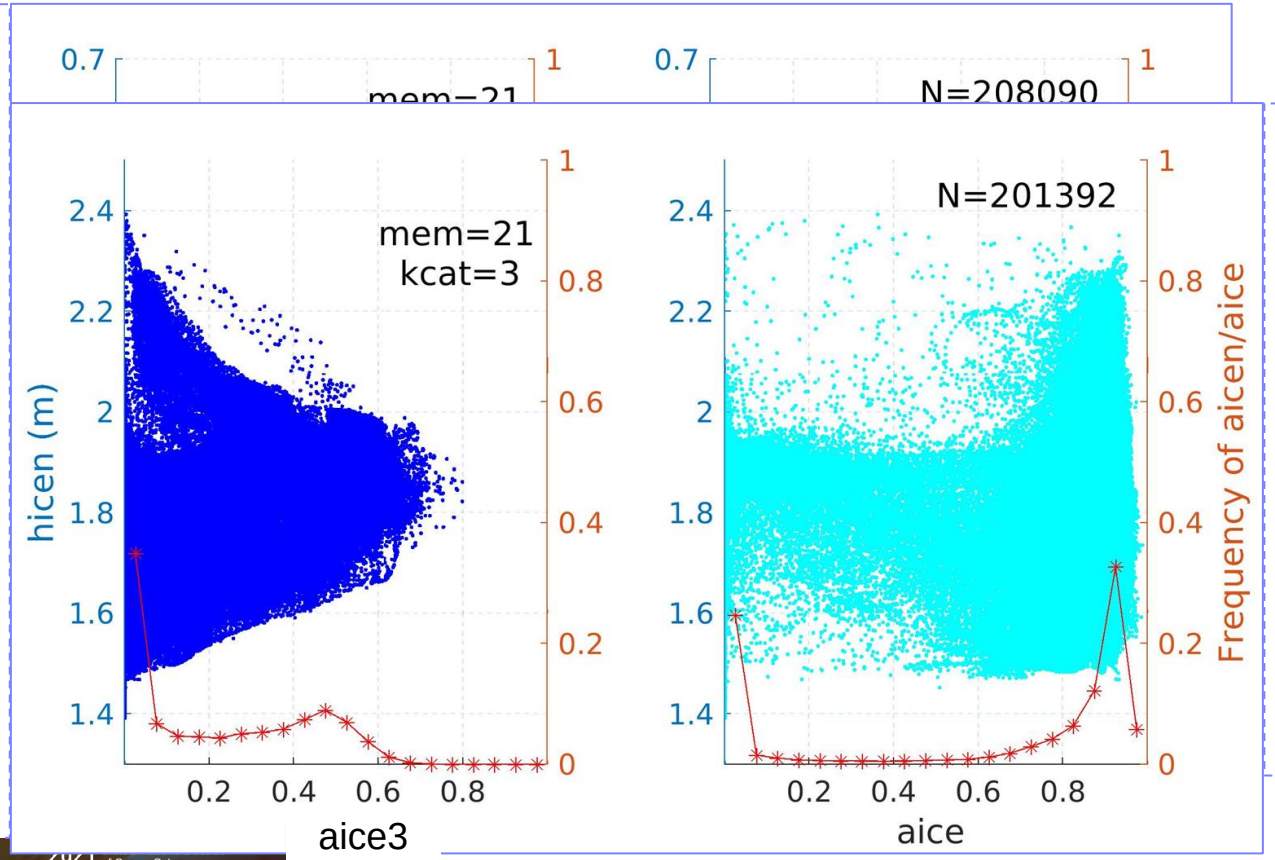
- EnKF: sea ice module adapted to multi-category sea ice
  - Distributions of ice thickness and concentration (vs the aggregated total concentration)

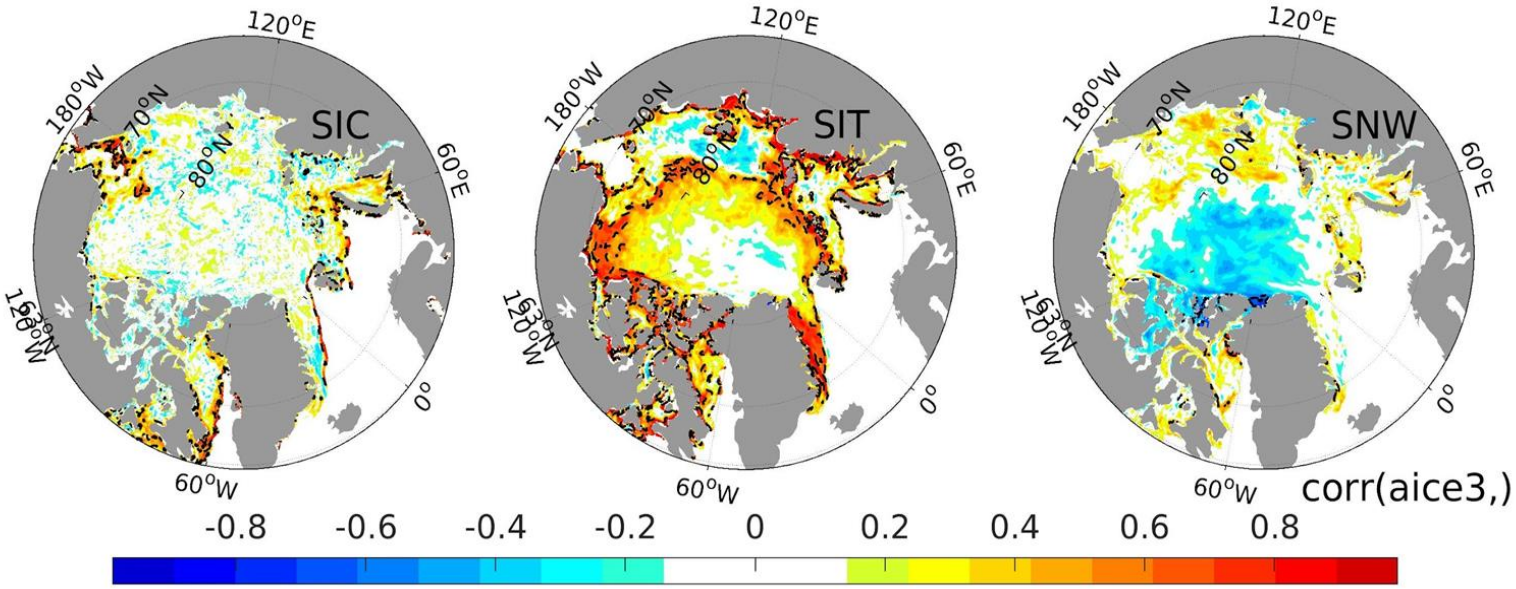
- 1st category ice(<0.64 m)
- In summer: aicen>0 (first histogram <5%)

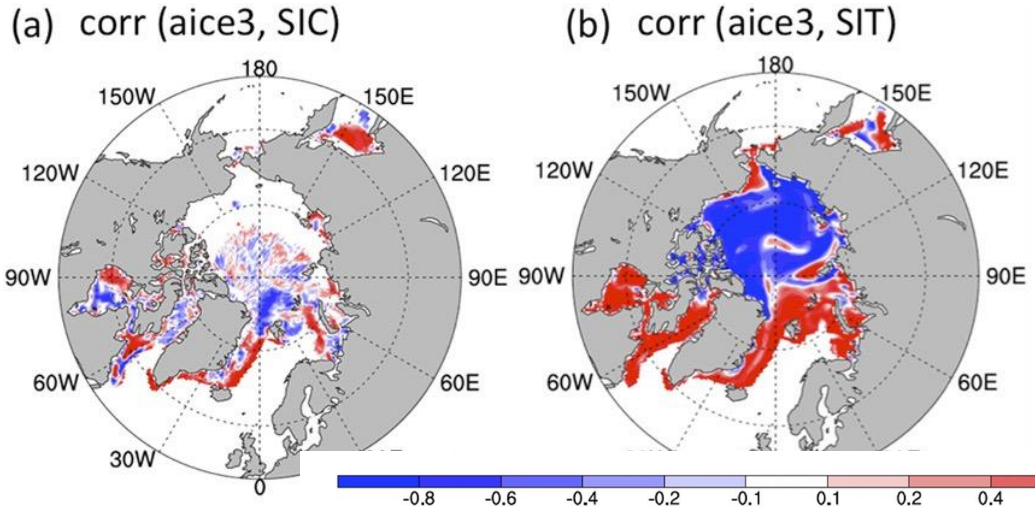


- 3rd category sea ice (1.39~2.47m)
- In summer: aicen>0 (first histogram <5%)

Correlation **aice3** and **SIC** (**SIT**, **snow**) in TOPAZ5 (11th Dec 2019)

- Different categories of sea ice have varied relationships with SIT;
- The thickness distribution varies with seasons and local circulation;
- The aggregated ice concentration scales all categories.





Zhang and Bitz (2018), JC, 10.1175/JCLI-D17-0904.1 (30 ensemble members Mar 2001)

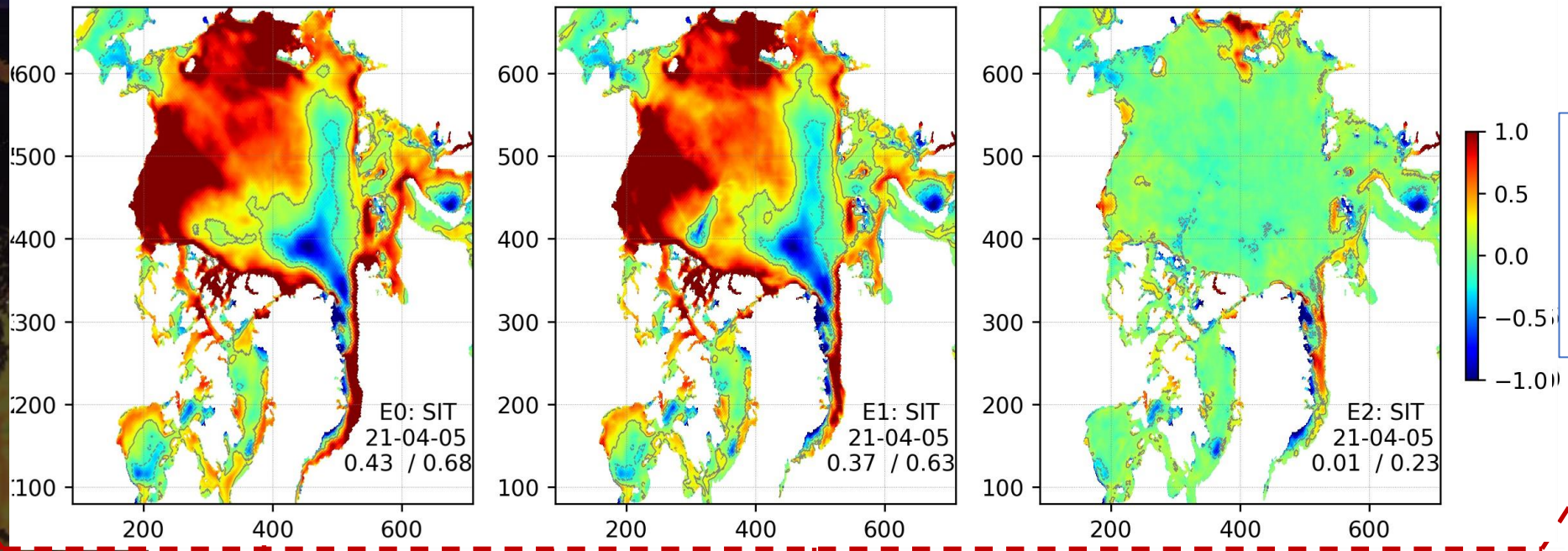
❑ EnKF sensitivity runs and evaluation

Ensemble runs W/WO DA in 2021

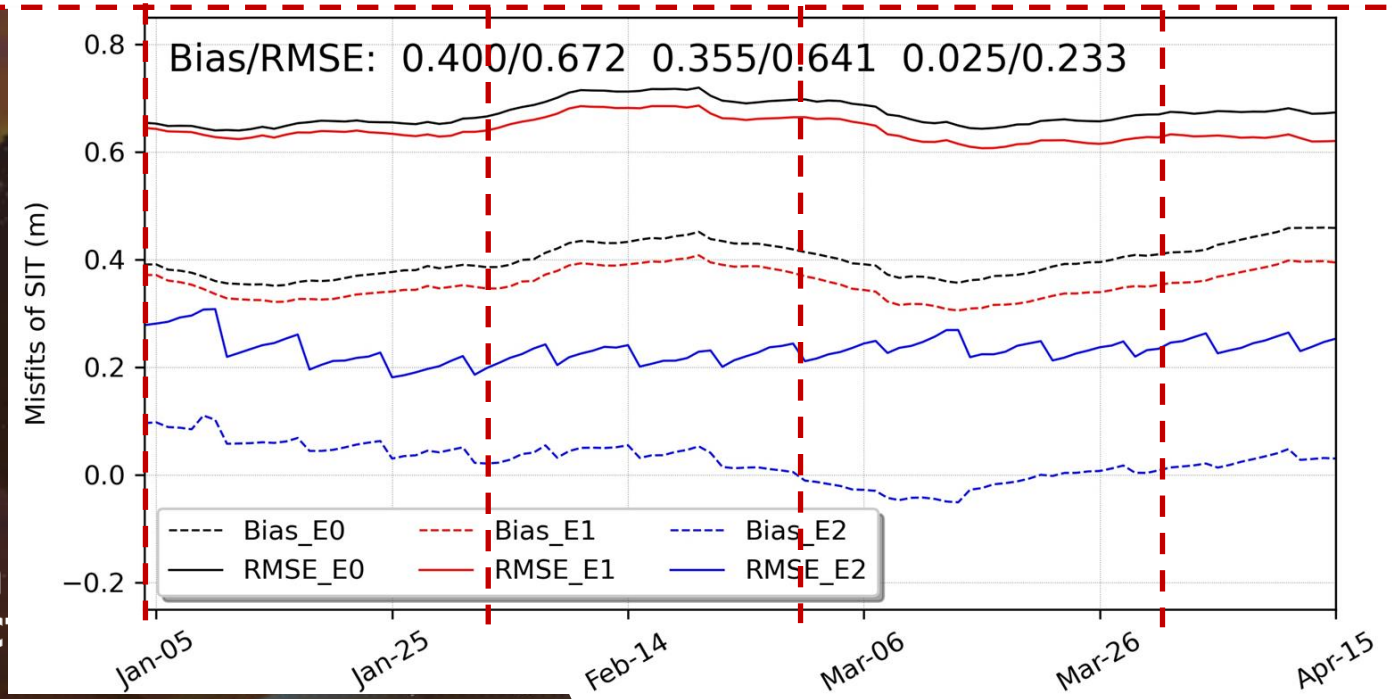
	Time period	Forcing	Nesting	Obs. for assimilation
E0	Jan-July	ERA5	Global NEMO; Daily	No
E1	Jan-July	ERA5	Global NEMO; Daily	TSLA, SST, SIC, TEM/SAL, SID
E2	Jan-Dec	ERA5	Global NEMO; Daily	TSLA, SST, SIC, TEM/SAL, SID, SIT

- 100 members after spin-up during Aug-Dec 2020
- Main data source from Copernicus Marine Service Information (http://marine.copernicus.eu); SIT from CS2SMOS v205 (~25km grided)

- E0: Ensemble mean of 100 model members
- SIT from CS2SMOS v205 from AWI (~25km gridded)
- E2/E3: keeping the same distribution in the forecast ensemble when assimilating SIC/SIT



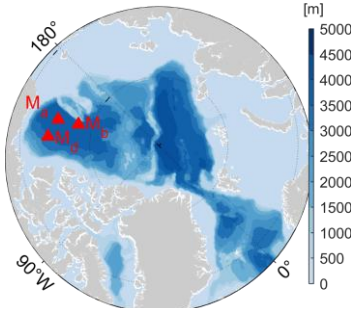
- Validation of sea ice thickness

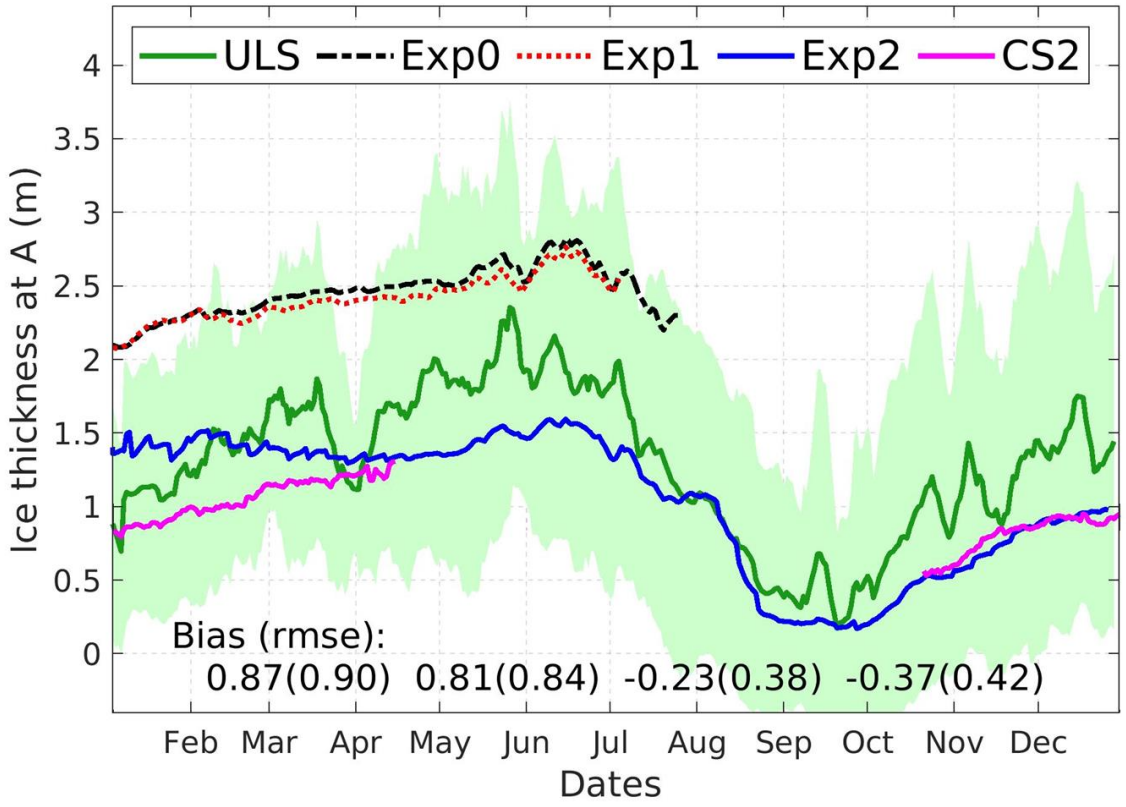


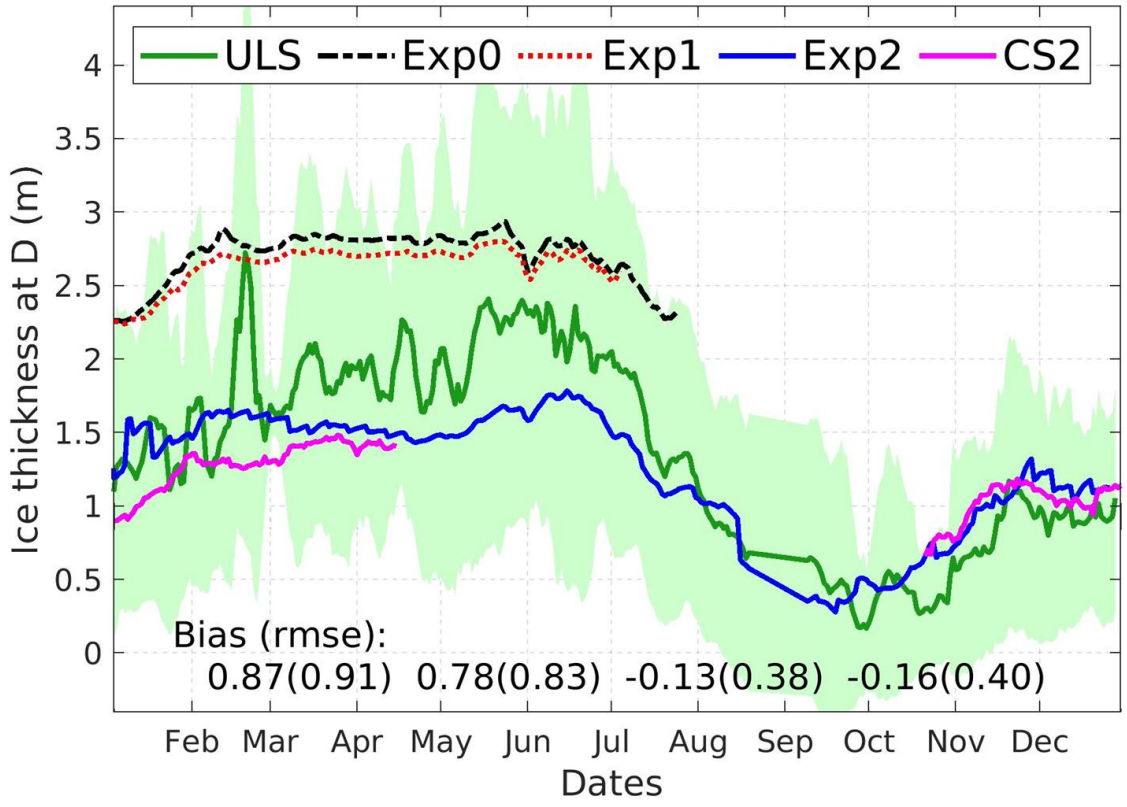
In the first three months:

- Overestimation decreased about 90% in E2 (11% in E1).
- RMSE is reduced >60% in E2 (~5% in E1).

- Validation of sea ice thickness



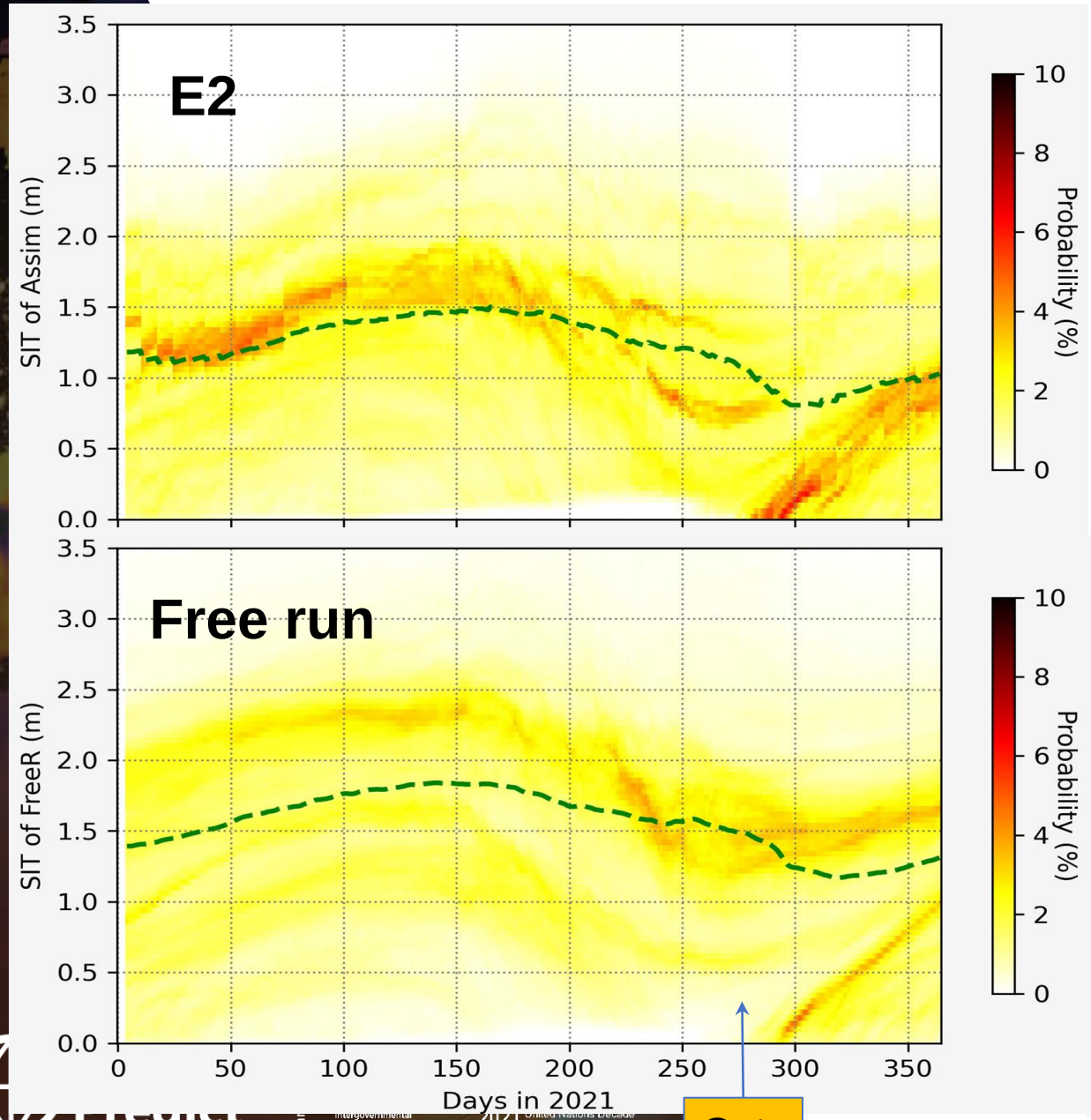


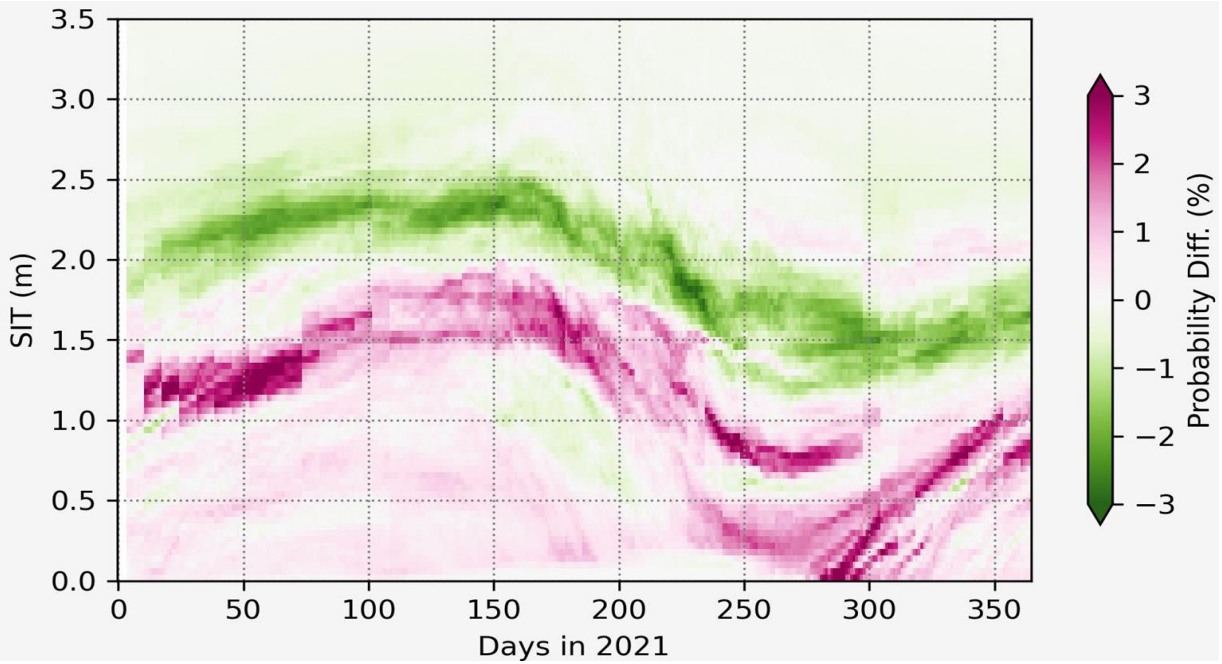


- Thickness time series compared with ULS observation at moorings in BGEP;
- Overestimation reduced remarkably;

Distribution of Arctic SIT

- Frequency of SIT in E2 / Free run
- Their Difference



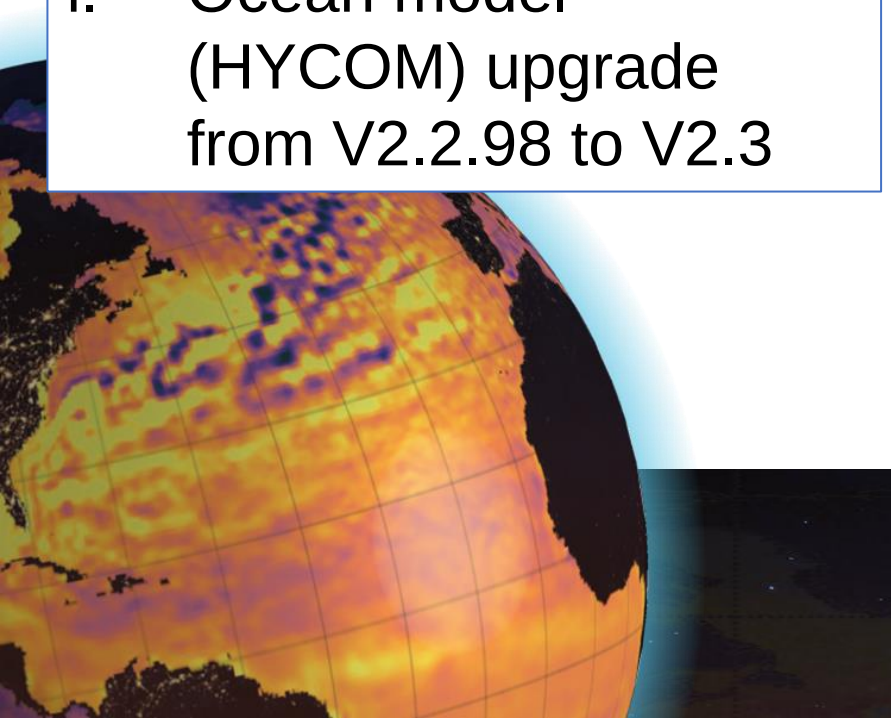


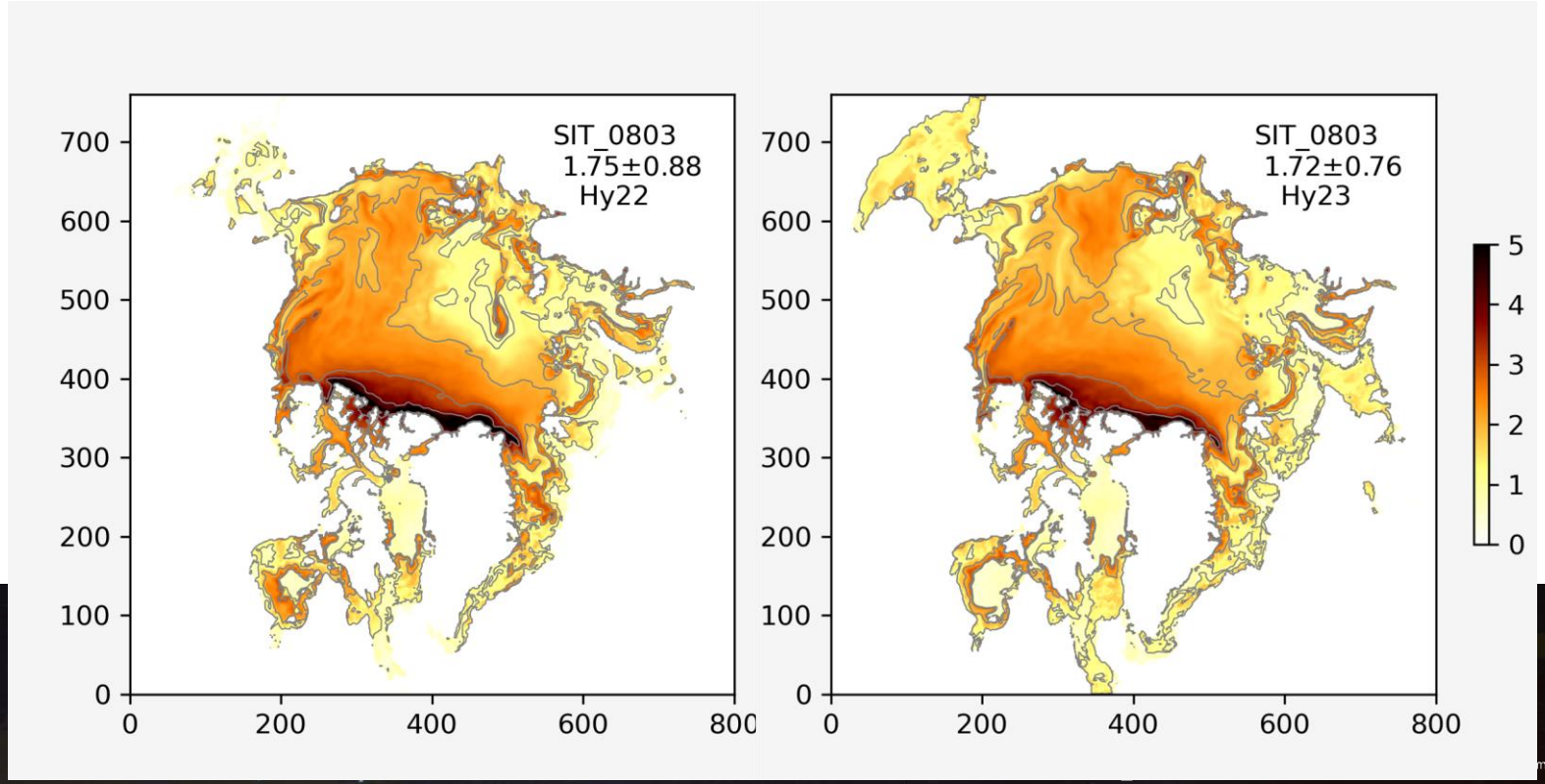
❑ Summary and further developments

- The test DA runs show that multiple types of observations for ocean physical and sea ice can be successfully assimilated, preventing the model bias from increasing
- TOPAZ5 became the main tool for the ARC MFC and related projects (ACCIBERG)

Next development …

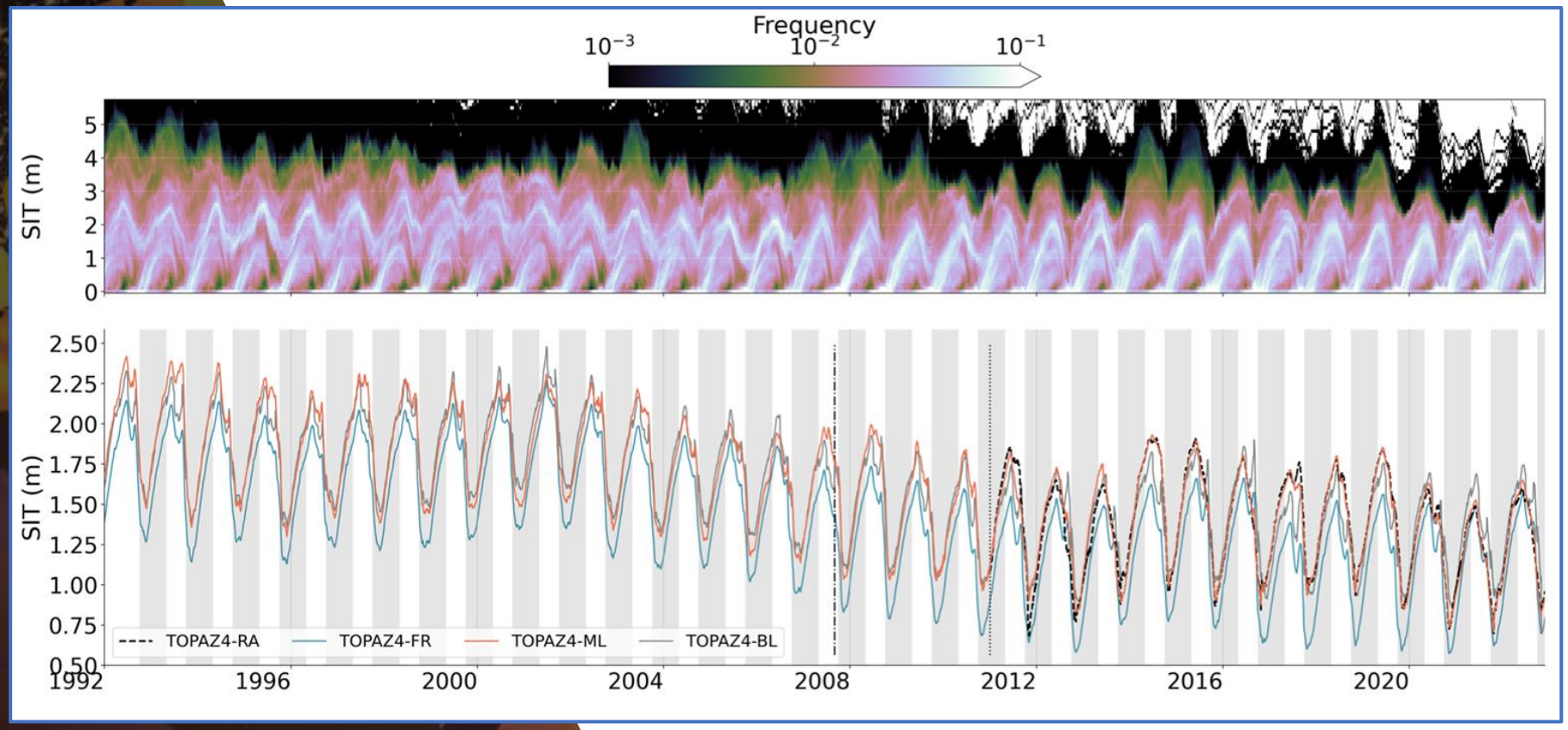
i. Ocean model (HYCOM) upgrade from V2.2.98 to V2.3





II. Next Arctic reanalysis with TOPAZ5

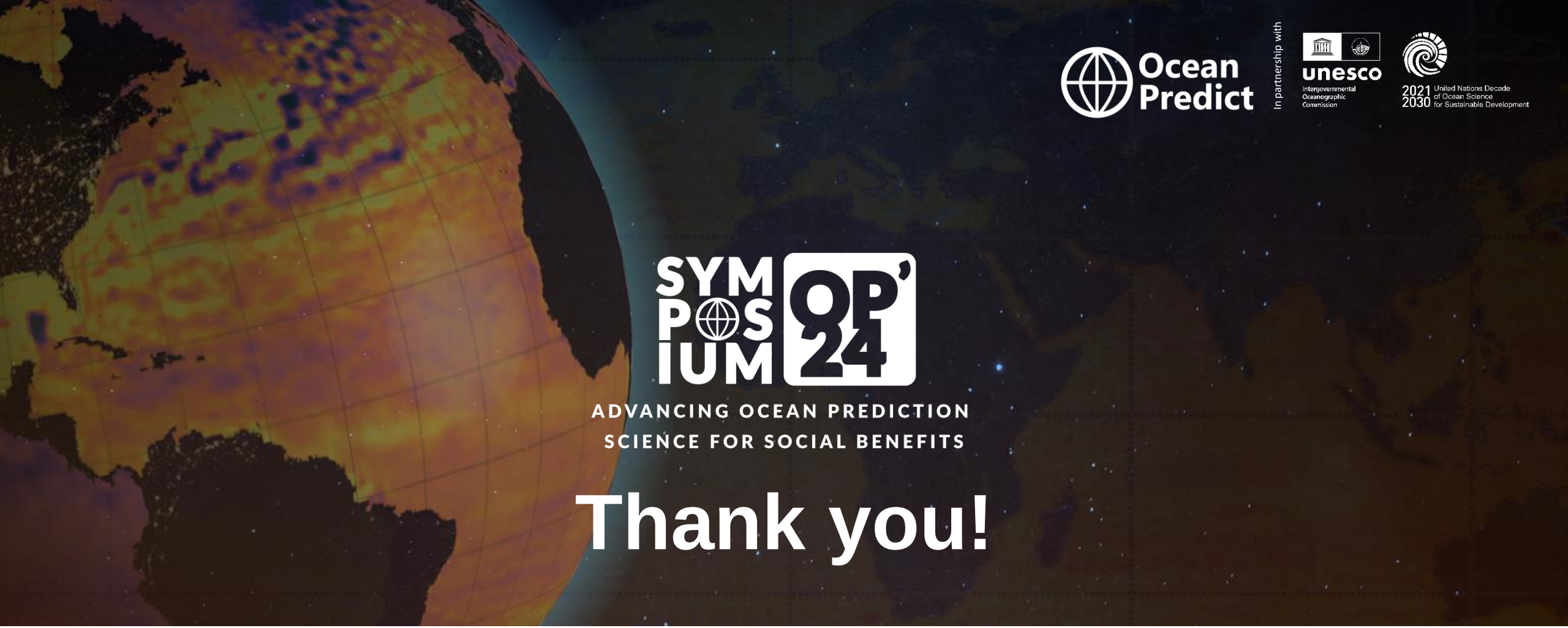
- SIT data in Arctic based on DA and ML by Léo Edel - TARDIS



Top: Distribution of daily SIT (m) from 1992 to 2022.

Bottom: Daily SIT (m) averaged over the Arctic for SIC>15% for the same period.

(https://doi.org/10.5194/egusphere-2024-1896)



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SYMPOSIUM OP'24

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Thank you!

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