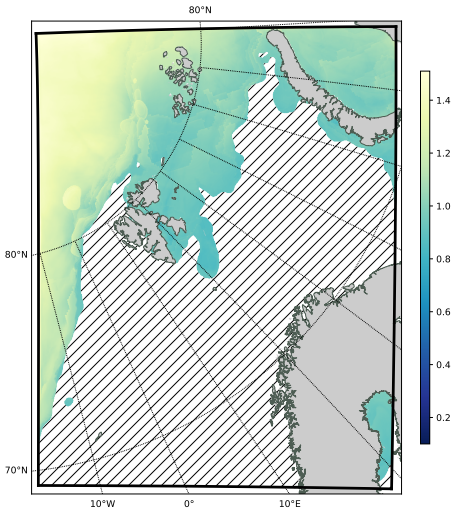
Pseudo-dynamic sea-ice cover in AROME-Arctic

Yurii Batrak (MET-Norway)

XXX·MAR·MMXX

Sea ice in operational AROME-Arctic lacks any dynamics...



Ice thickness on 15 February 2019

- SICE is one-dimensional and the sea-ice grid cells are "pinned" to their locations
- As result ice field show artificial features and unrealistic evolution
- The same problem appears in the snow cover over sea ice

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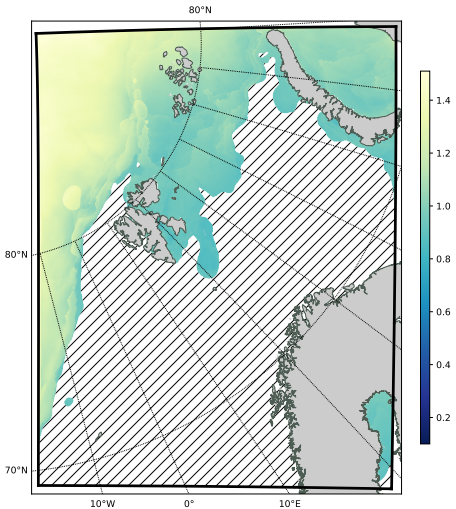

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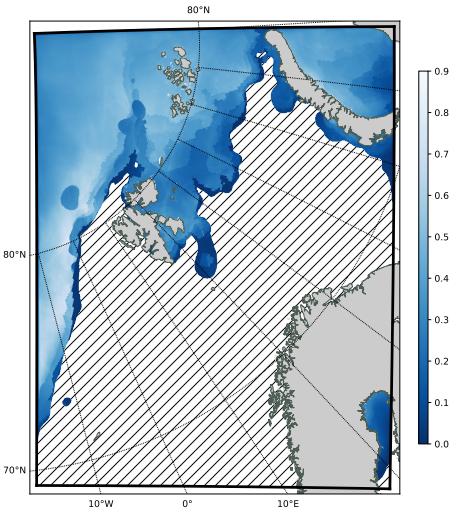
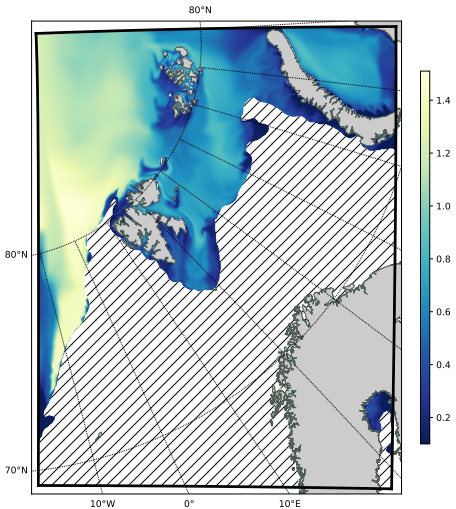


Snow thickness on 15 February 2019

. . . but there should be a way to emulate ice drift



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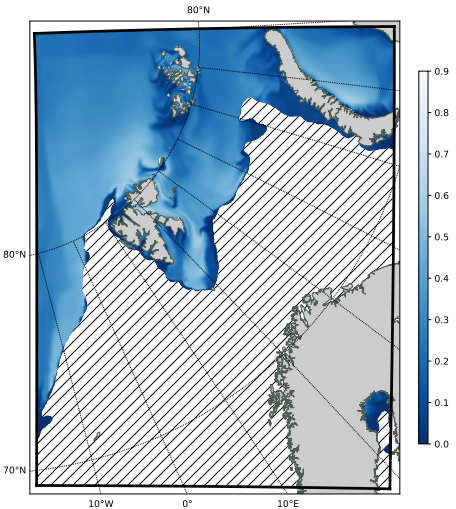
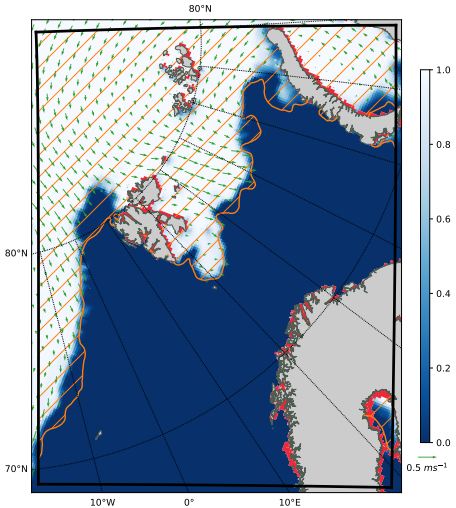


Snow thickness on 15 February 2020

Applying the ice drift from TOPAZ4 seems to be an option



TOPAZ4 and AROME-Arctic sea ice on 1 April 2019

TOPAZ4:

- pan-Arctic 12.5 *km* domain
- 10-day forecasts on daily basis
- EnKF data assimilation system

TOPAZ5 with 6 *km* resolution is on its way and should be available in 2020.

How to apply the external ice drift data?

Eulerian approach

$$\frac{\partial F}{\partial t} + u\frac{\partial F}{\partial x} + v\frac{\partial F}{\partial y} = 0$$

- would work on the AA grid
- should be applied to each variable
- not so straightforward boundaries

or

Lagrangian approach

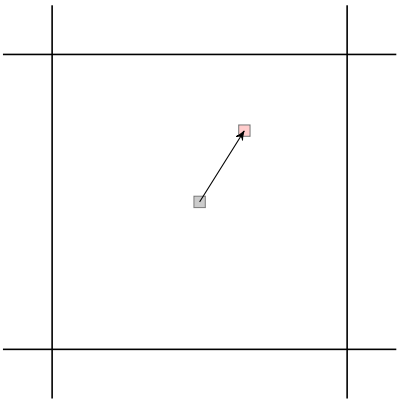
$$\frac{dF}{dt} = 0$$

- more steps to deal with particles
- only one time loop
- straightforward boundary strategy

For this exercise the Lagrangian approach was used to transform the sea-ice cover variables in AROME-Arctic

Why the number of particles matters?

- put a particle in each ice grid cell
- advect it following TOPAZ4 drift
- aggregate particles on the grid



Why the number of particles matters?

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- advect them following TOPAZ4 drift
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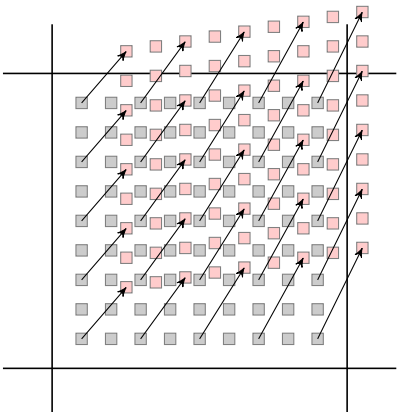
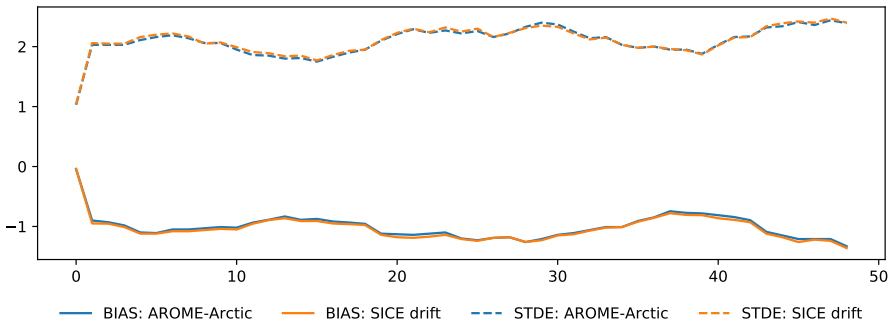
- coarser grid requires more particles
- 10×10 subdivision for AA grid



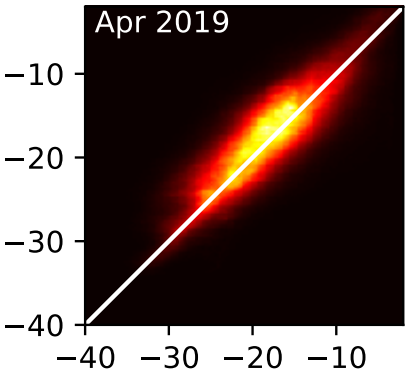
Verification scores from coastal stations are not so impressive

April 2019: T2M verification for Svalbard stations



- experimental setup shows lower T2M for Svalbard stations mainly due to drift of the AA-accumulated thick ice towards the ice edge
- when all old ice is removed, T2M is expected to be higher than in AA

Model ice surface temperature compared to MODIS NRT IST shows potential improvement



Operational AROME-Arctic
x-axis: MODIS, *y*-axis model

- TOPAZ ice and snow covers are generally thinner than in AA
- thinner ice drifts from boundaries inside the domain and reduces the mean ice thickness
- as a result, experiment output shows warmer ice surface than the operational model

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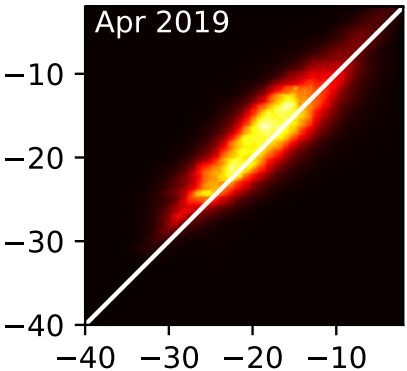

Experimental configuration
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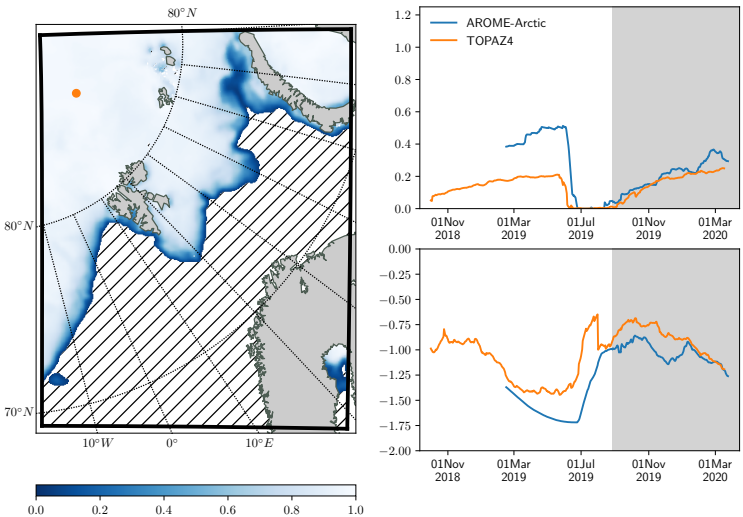
Evolution of the sea ice cover in AROME-Arctic



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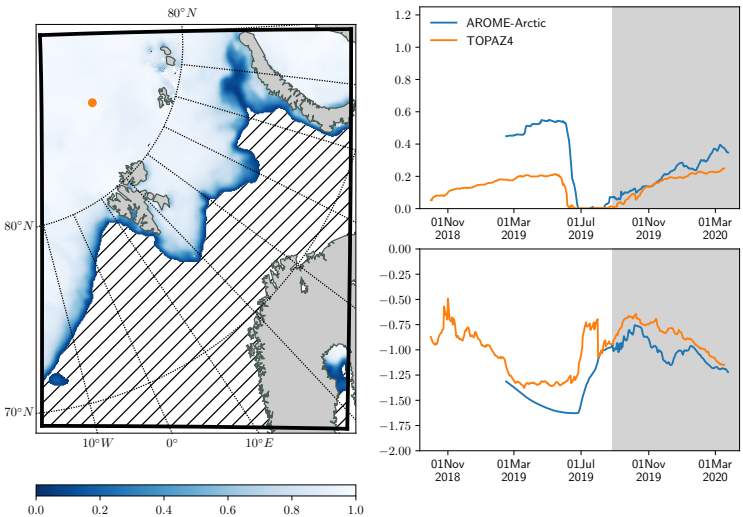

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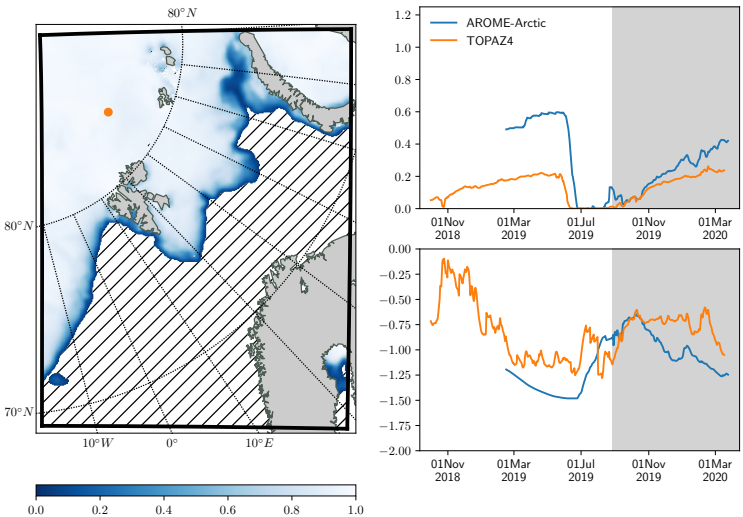

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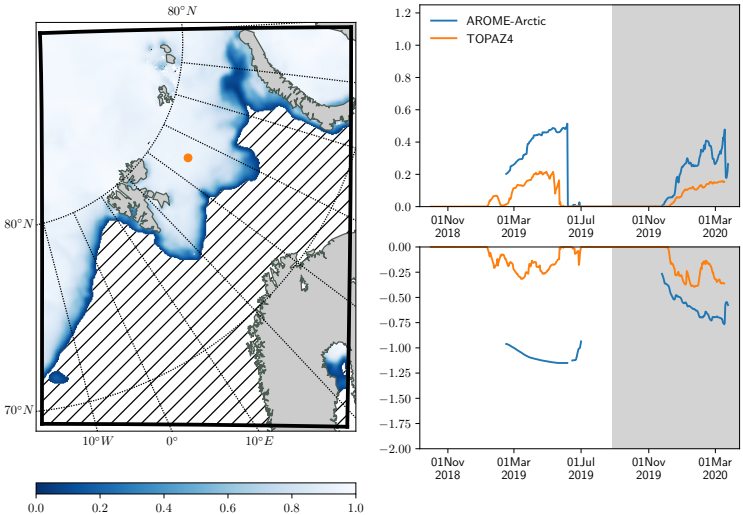

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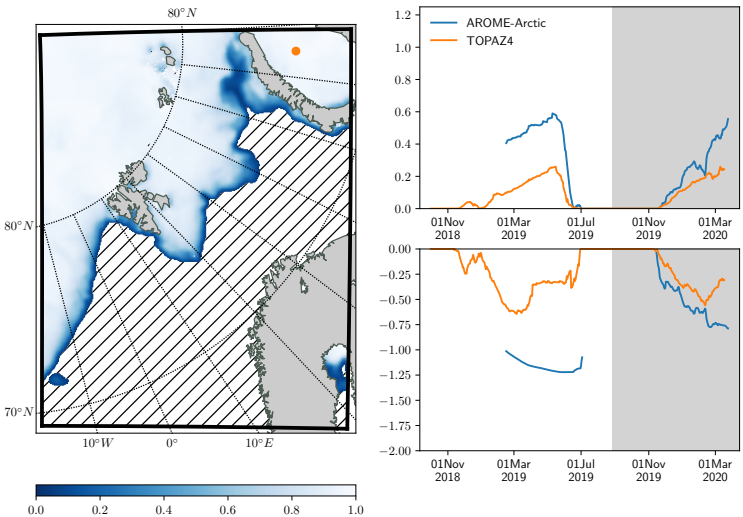

What about the land-fast ice?

- current approach does not take into account the areas of land-fast ice
- and neither TOPAZ nor IFS resolve land-fast ice
- missing land-fast ice could lead to warm bias due to underestimated ice cover in coastal areas

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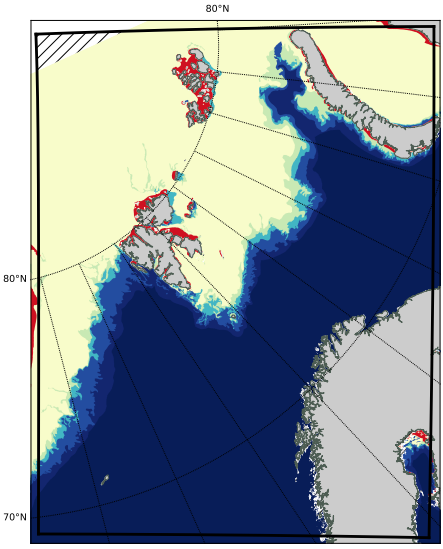
- this problem could be alleviated by using an external dataset which would define the fast-ice areas and updating SIC accordingly

Ice charts as a source of land-fast ice information

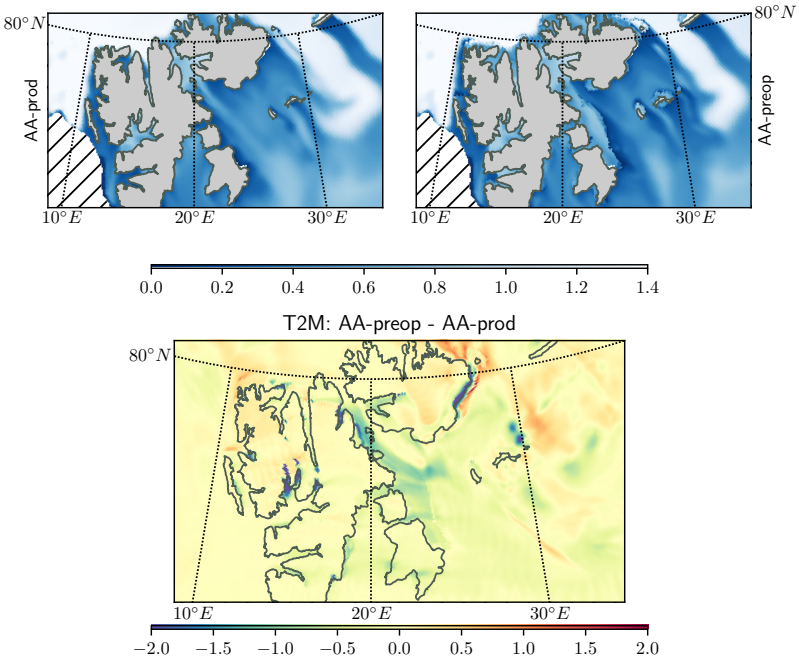
- ice charts are manually produced by the ice service on the daily basis
- no fresh ice charts on the weekends and public holidays, for these days data from the previous available chart are used
- spatial resolution is 1 kilometre

- for the grid cells with ice cover reported as fast-ice according to ice charts SIC is set to 100%
- ice drift speed is also set to zero

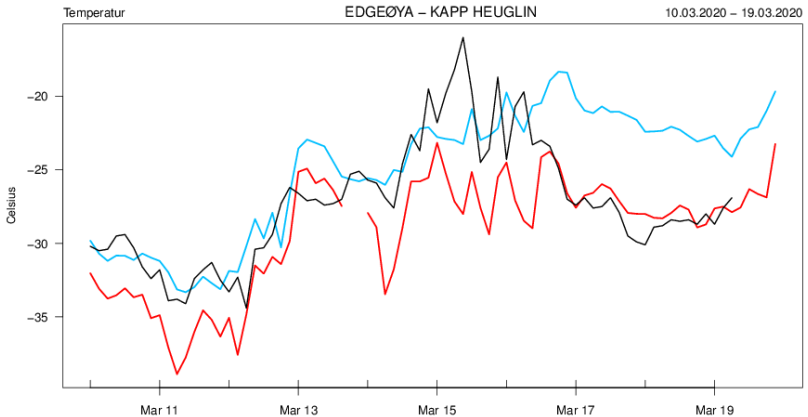


Ice chart from 20 March 2020
with fast-ice areas highlighted

Effect of landfast ice in AROME-Arctic preop…



Effect of landfast ice, well, and XRIMAX



	Min	Middel	Maks	Std	N
synop: 00,...,21 /3	−34.4	−27.3	−16	4.1	75
AA25_preop: 00+12,+15,+18,+21 12+12,+15,+18,+21	−38.9	−29.2	−23.2	3.9	78
AA25: 00+12,+15,+18,+21 12+12,+15,+18,+21	−33.3	−25	−18.3	4.3	80
MEPSctrl:					0

	Middelfeil	Std.feil.	RMSE	MAE	Maks.abs.feil	N
AA25_preop – synop	−2.1	2.9	3.6	2.7	12	73
AA25 – synop	2	3.4	4	3.1	8.6	75

So, what are the benefits?

- new setup removes problematic zones of extensive snow accumulations
- maximum ice age within the domain is limited by the inflow of new ice
- externalized approach, does not require source code modifications

So, what are the benefits and drawbacks?

- new setup removes problematic zones of extensive snow accumulations
- maximum ice age within the domain is limited by the inflow of new ice
- externalized approach, does not require source code modifications

- code requires EPYGRAM to manipulate FA files
- new dependency on TOPAZ4 and ice charts data, and need to transfer these data to HPC from local infrastructure
- external drift is applied at 00, 06, 12 and 18 UTC and this takes about a minute of real time for AROME-Arctic grid and 10×10 subdivisions
- mismatch between TOPAZ4 and AROME-Arctic ice cover could lead to unrealistic drift patterns

Questions?