Sea Ice in the Carra Reanalyses

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with contributions from
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The modern-day Arctic, the climate change and new opportunities
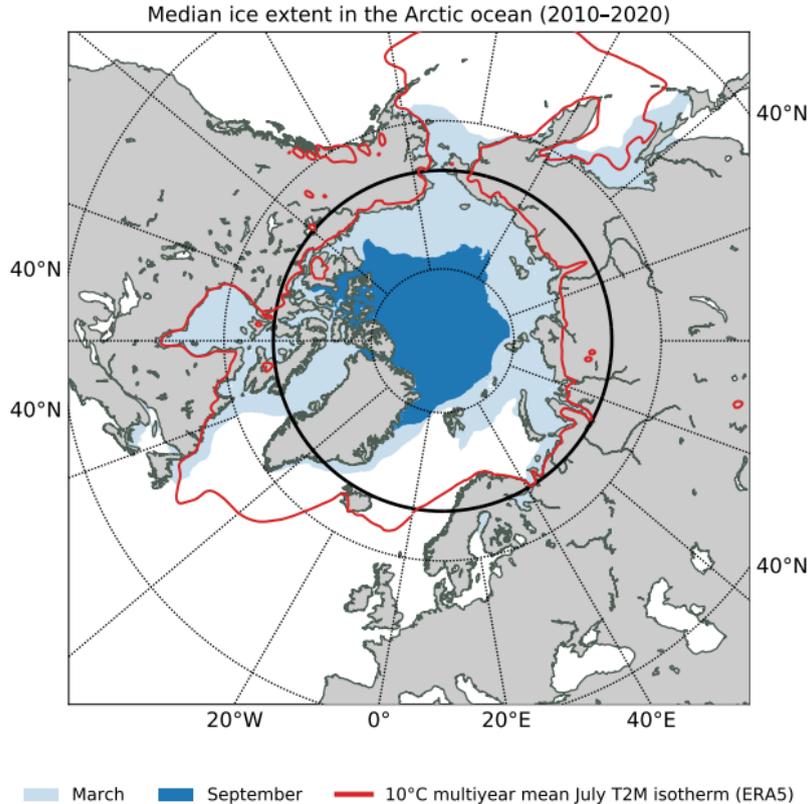
Median ice extent in the Arctic ocean (2010–2020)

March   September   10°C multiyear mean July T2M isotherm (ERA5)

The modern-day Arctic, the climate change and new opportunities

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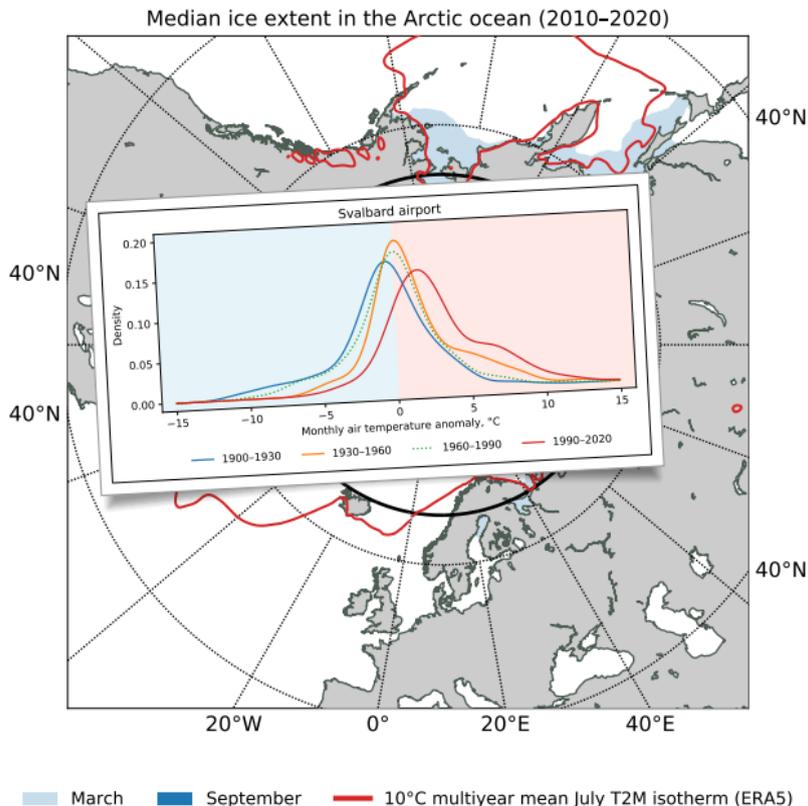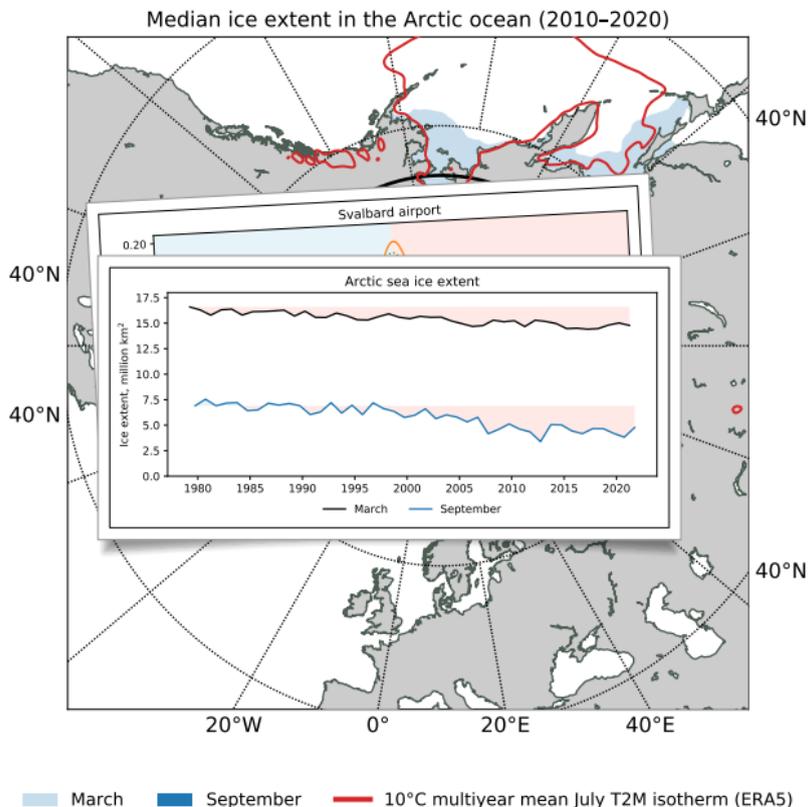
CARRA – Copernicus Arctic Regional Reanalysis
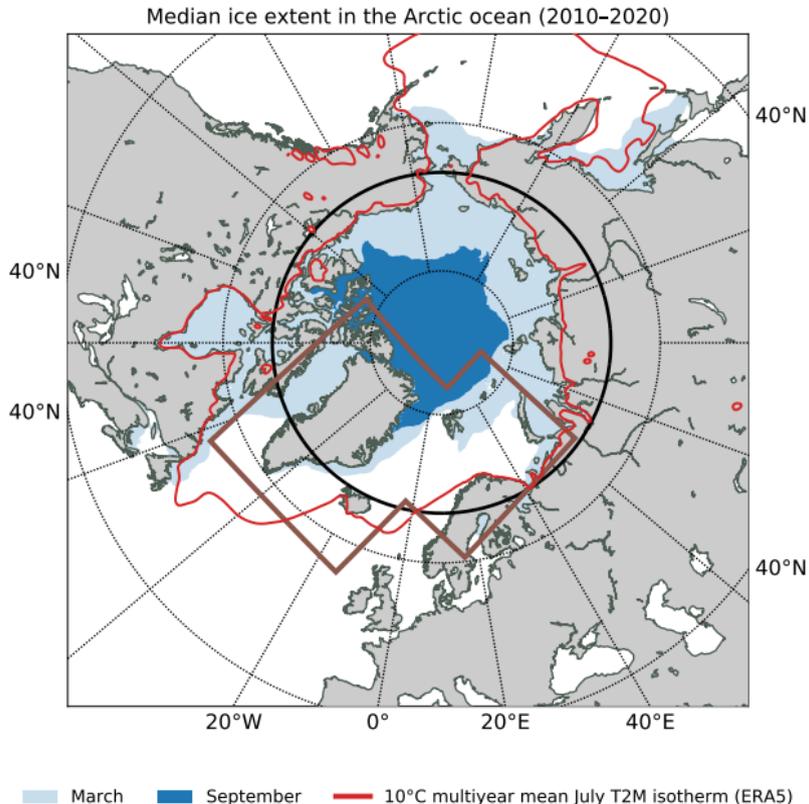
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CARRA and how it handles sea ice

CARRA in a nutshell:

- high-resolution (2.5 *km*) regional atmospheric reanalysis product
- two model domains
- covers the time period from 1990 to the present (2023, at the moment)
- based on HARMONIE-AROME cy40h1, 3DVAR for upper air and OI for surface data assimilation

Sea ice in CARRA

- simple ice model, SICE
- ice thickness evolution
- snow on ice
- external ice concentration
- ice state is not constrained by observations
- snow-free new ice

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ERA5, in contrast, has uniform ice thickness of 1.5 *m* and snow-free ice surface
So, do we do better than ERA5 for sea ice?
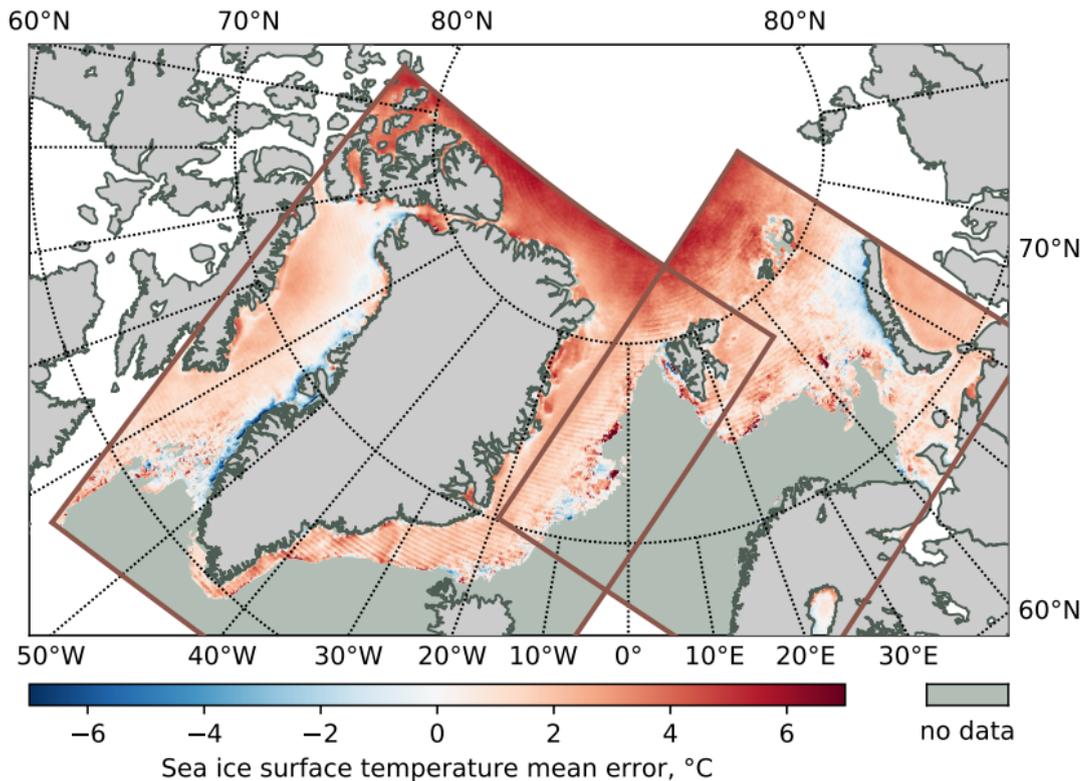
Ice surface temperature – evolution, not revolution

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CARRA

Sea ice surface temperature mean error, °C

no data

Ice surface temperature – evolution, not revolution

Y-axis: ERA5 ice surface temperature
X-axis: MODIS ice surface temperature

Panels: January, February, March, April, May, June, July, August, September, October, November, December

Ice surface temperature – evolution, not revolution

January, February, March, April, May, June, July, August, September, October, November, December
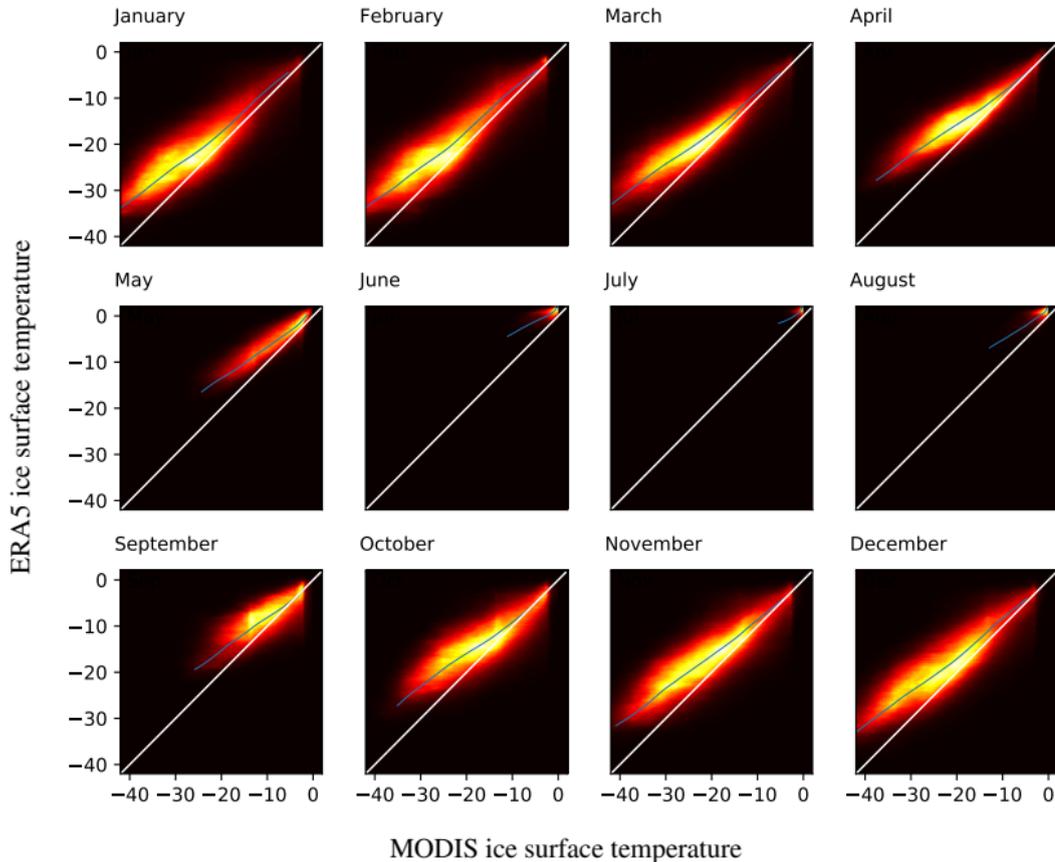
CARRA ice surface temperature

MODIS ice surface temperature

Total ice volume in CARRA and in a satellite product
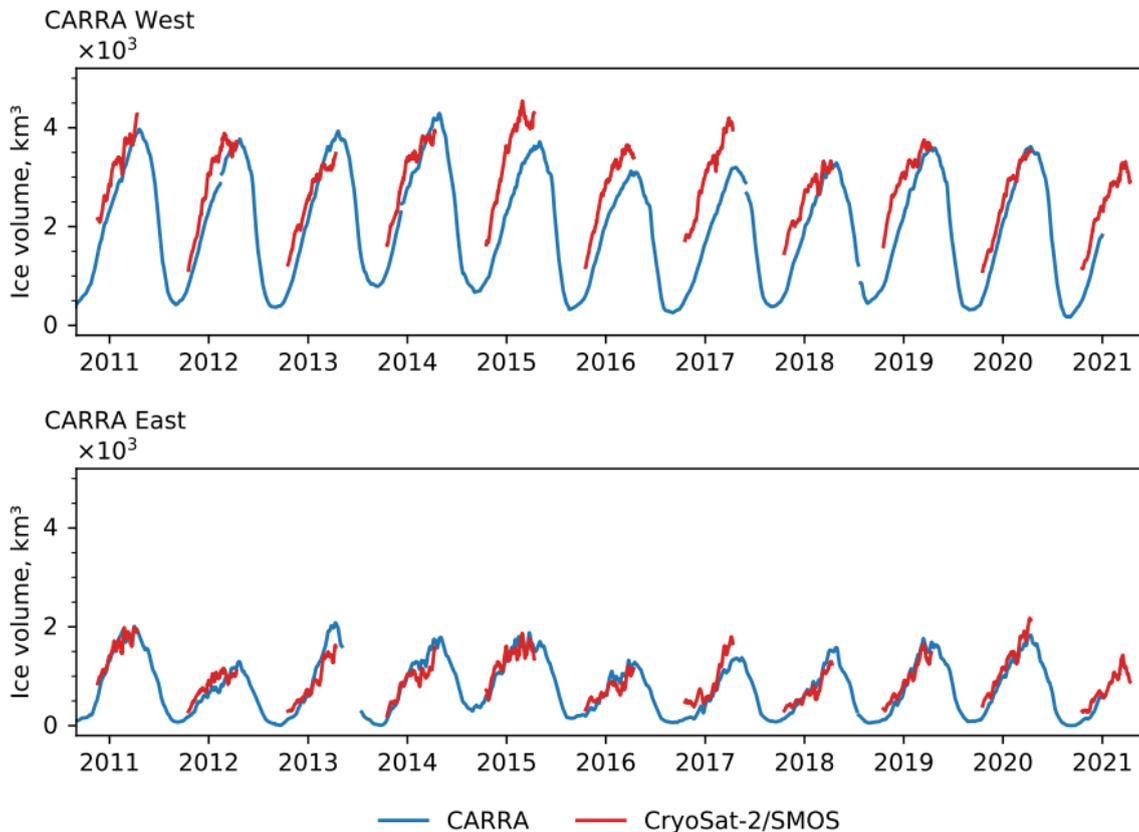
Missing ice dynamics and no external constraints can lead to considerable misrepresentation of the ice cover
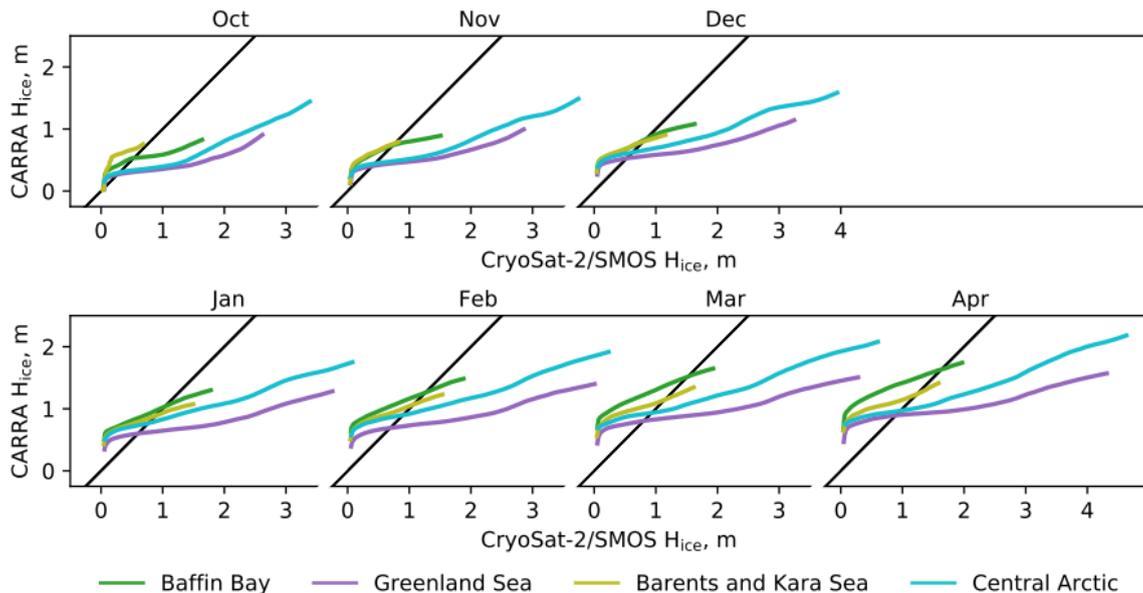
Ice thickness – beware of streams
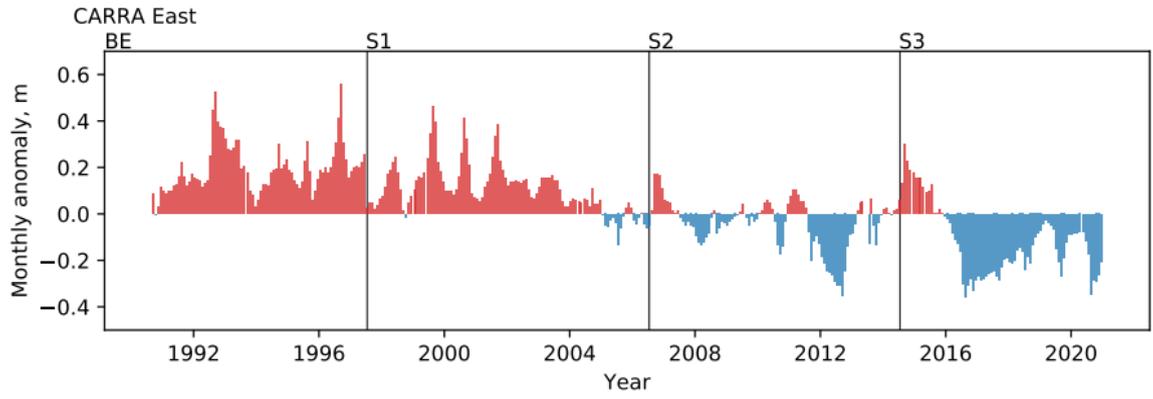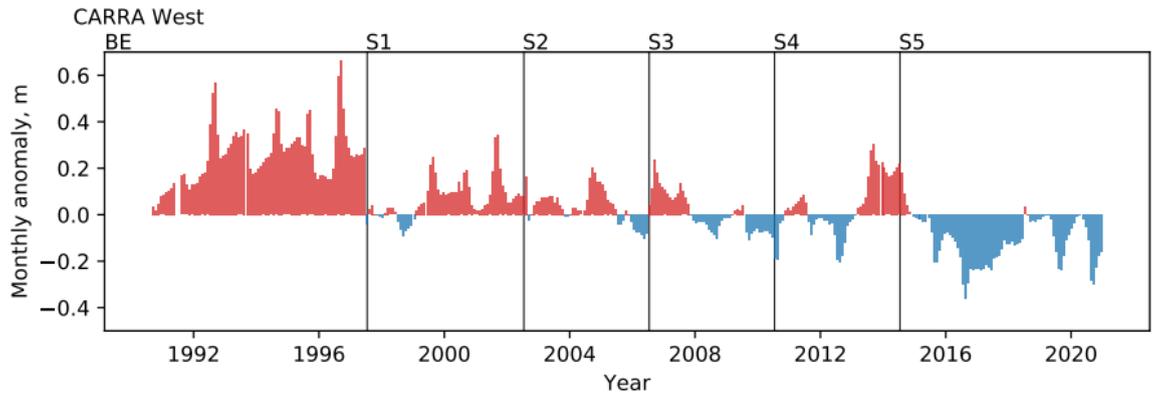
What about snow?

- Verifying snow cover over sea ice in CARRA is tricky
- Due to location of CARRA domains there are few buoys available
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- General indication of overestimated snow depth in the Greenland sea
- Less evident when comparing CARRA against buoy data

Why snow is important?

- Snow layer acts as an insulator which leads to very low surface temperature
- Absence of the snow layer in the model results in a characteristic warm bias of the ice surface temperature forecast, most apparent during clear sky events
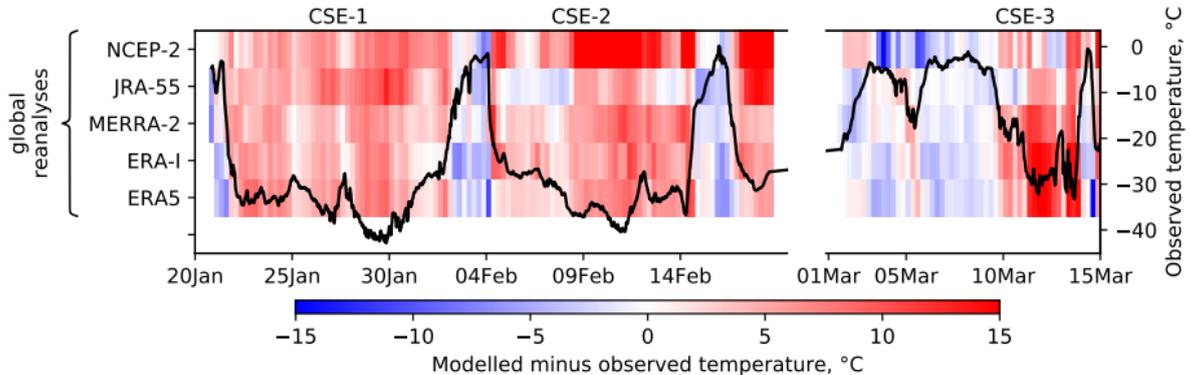
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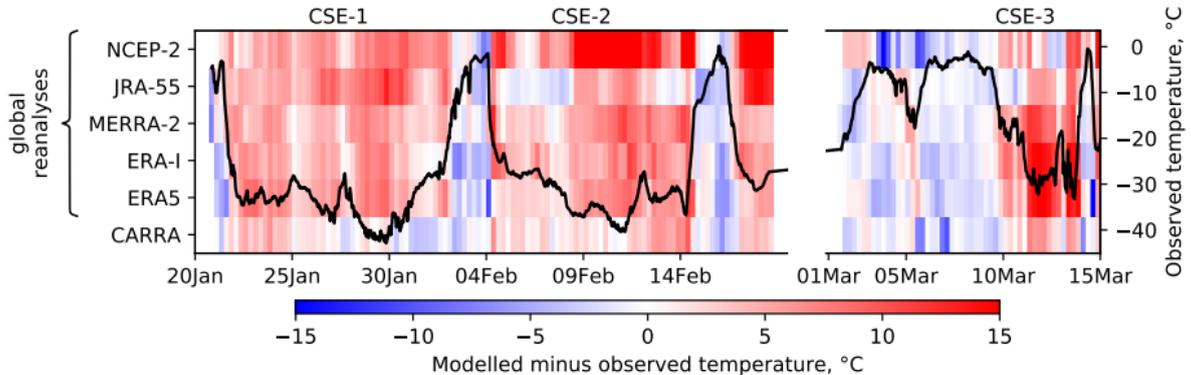
So, is sea ice in CARRA any good?

- Sea ice scheme of the CARRA system is considerably more advanced compared to the ice model applied in ERA5's

- CARRA represents evolution of the ice cover to a reasonable, for a non-constrained 1d thermodynamic scheme, degree

- Ice thickness in CARRA is one of the very few variables with long memory

- Moderate improvements compared to ERA5

CARRA2 – next generation regional reanalysis project
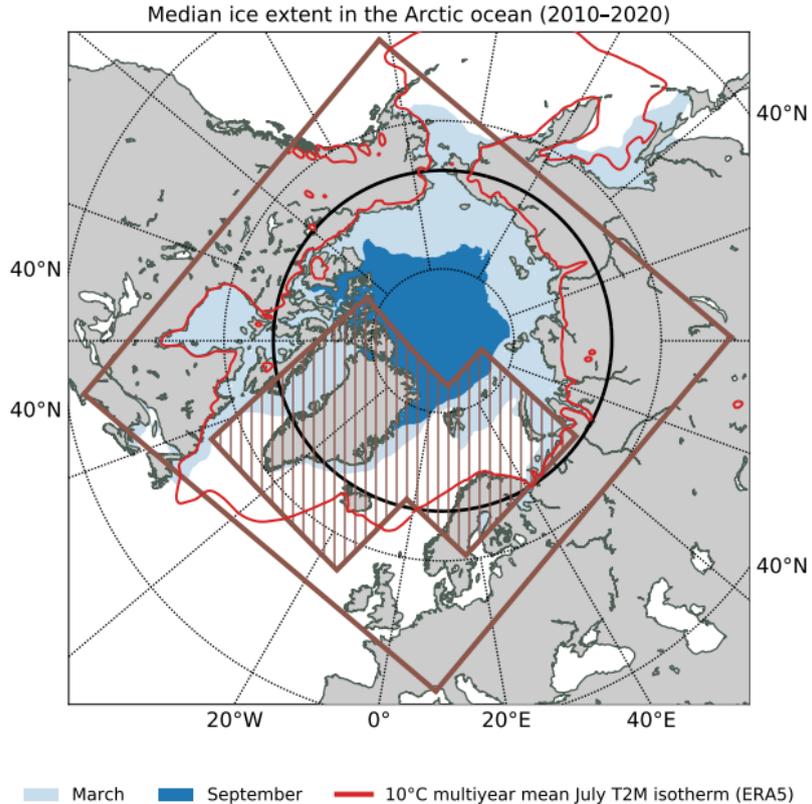
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- The ongoing project which is planned to result in a pan-Arctic atmospheric reanalysis product
- Much more ice within the model domain compared to CARRA

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- Preliminary tests for defining the optimal configuration of the sea ice scheme
- Several alternatives with varying level of complexity

Possible configurations of the sea ice scheme in CARRA2

15 March 2015
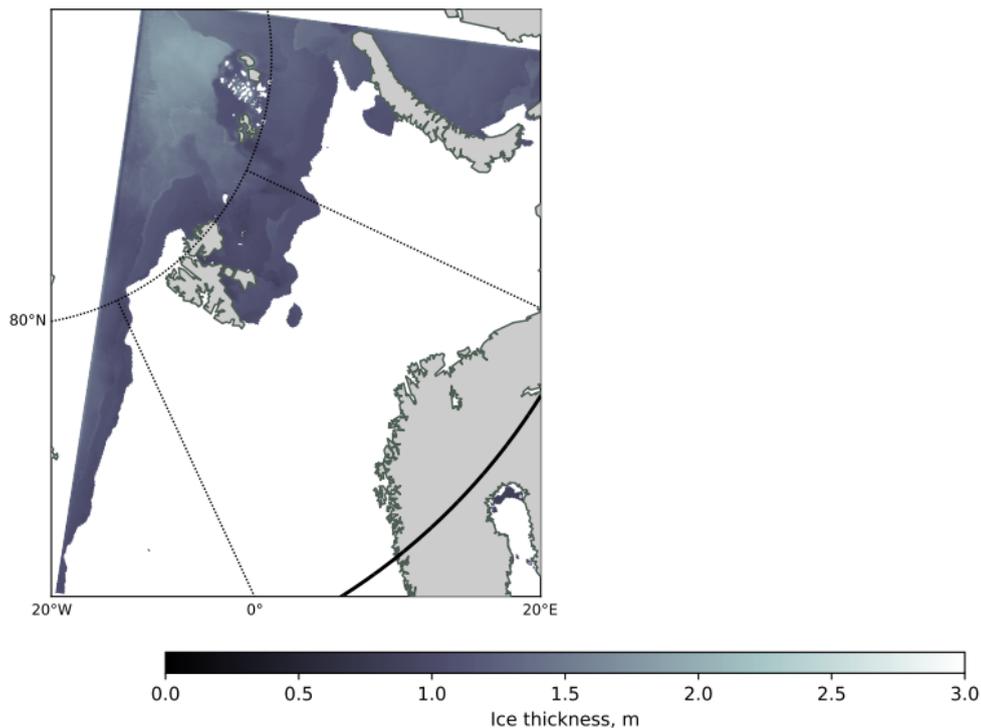
CARRA1 approach

Possible configurations of the sea ice scheme in CARRA2

15 March 2015

CARRA1 approach   HCLIM solution

Ice thickness, m

???

Thank you!