Impact of Sea Ice Thickness Initialisation on Seasonal Forecasting

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Sea Ice thickness constraint using Cryosat2-SMOS (CS2-SMOS)

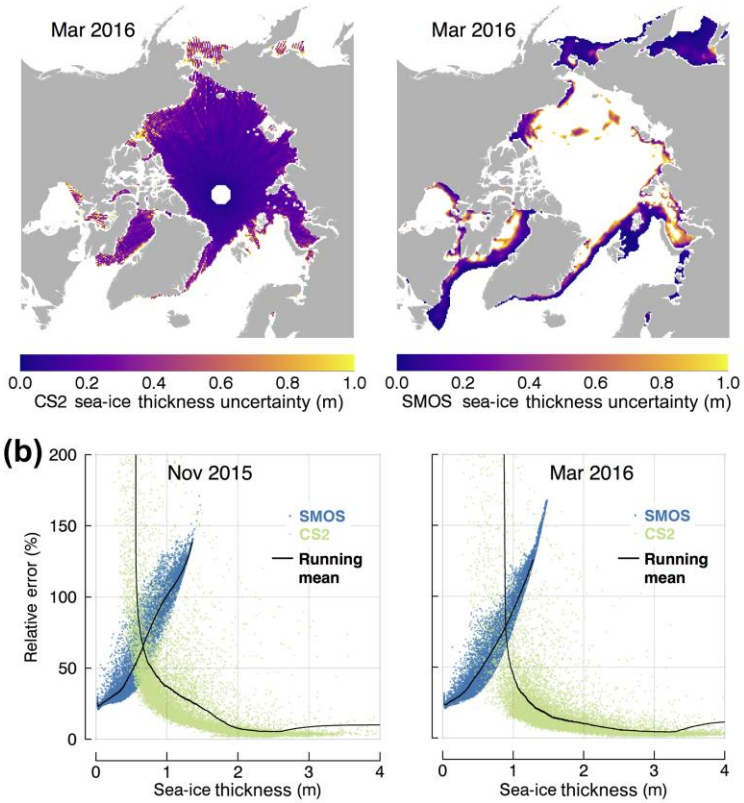
- Currently operational forecasting systems at the ECMWF use a prognostic sea ice model. Ocean-Sea ice initial conditions are from OCEAN5 ocean-sea ice assimilation system. Sea ice (re)analysis assimilates Sea Ice Concentration (SIC) observations.

- Sea Ice Thickness (SIT) assimilation is at its early stage in operational sea ice forecasting (eg. Blockley and Peterson, 2018). Long term memory in winter SIT can potentially improve summer sea ice forecasts (eg. Guemas at al. 2016).

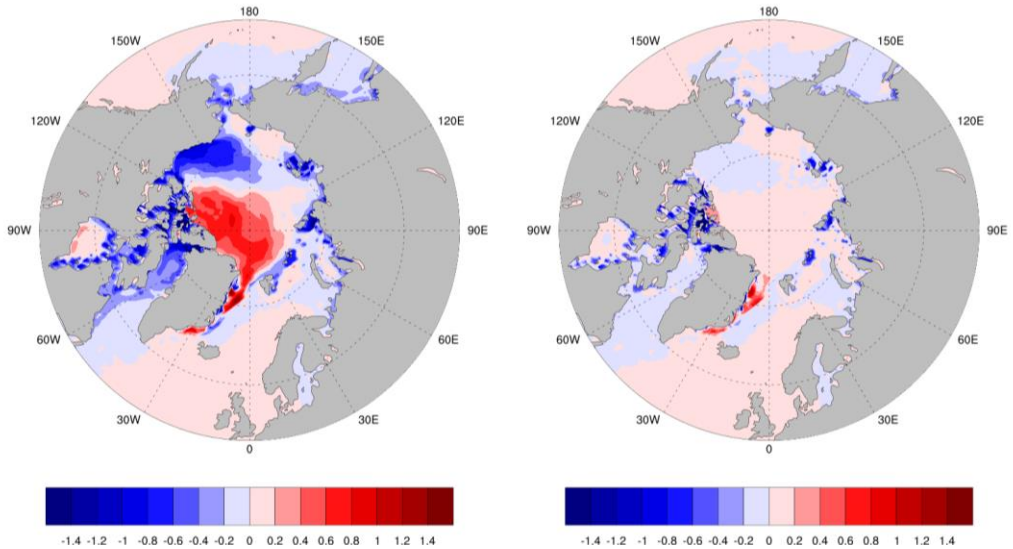
- **new gridded sea ice thickness observations over the Arctic – Cryosat2-SMOS SIT** (Ricker et al. 2018)

→ **Implement thickness nudging to the ocean-sea ice assimilation system with SIC assimilation**

→ **Perform coupled re-forecasts using the new sea ice initial conditions and assess the seasonal forecast skill.**



CS2-SMOS SIT nudging : Impact on Sea ice thickness



Cryosat2-SMOS thickness nudging (with 10-day relaxation time) effective to constrain SIT

Predominant pattern of overestimation (blue) of modelled SIT (m) over ice edge and marginal seas and underestimation (red) over the central Arctic in Jan (left). Huge sea ice thickness biases up to 1.4 m in the ocean-sea ice reanalysis is constrained by thickness nudging (right).

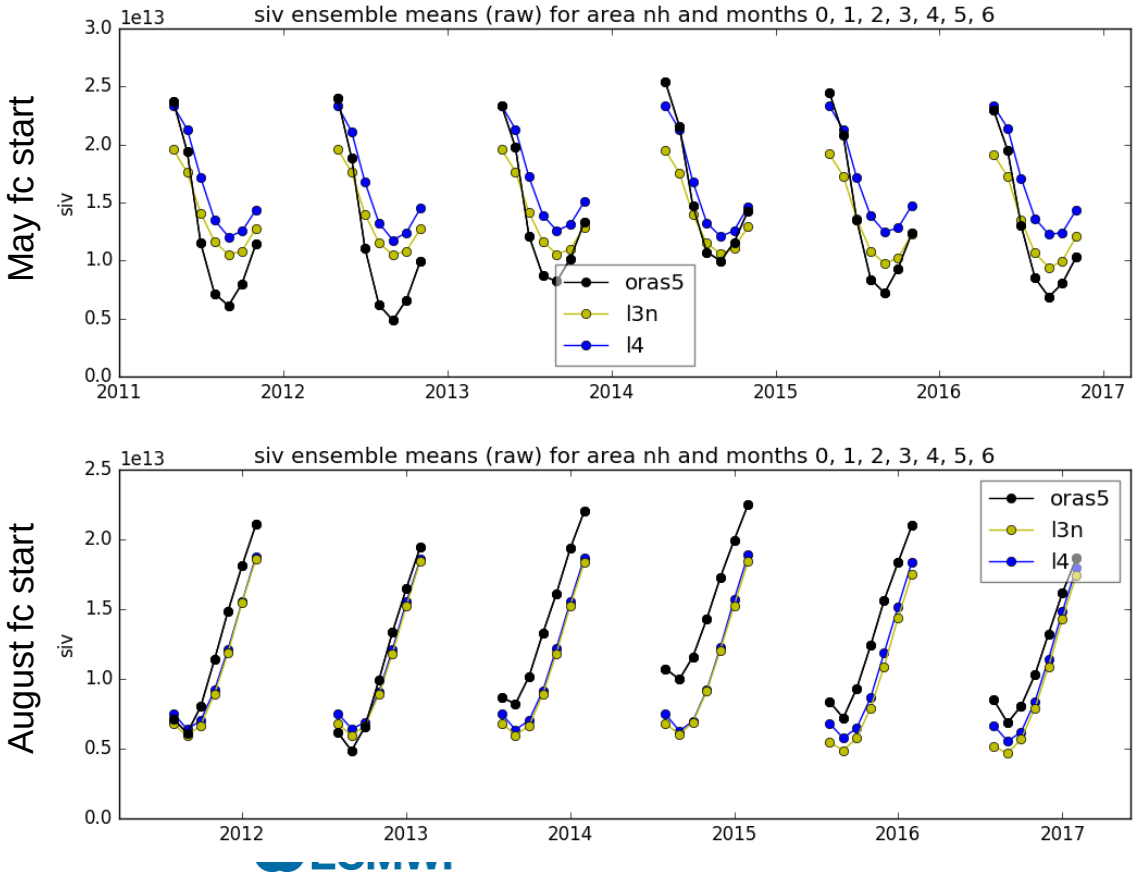
Experiments - Reforecasts

- Two sets of Coupled **Ensemble Seasonal Reforecasts** using low resolution SEAS5 that only differ in the sea-ice initial conditions:

✓ 1. As current operations (**SIC only initialisation**)
✓ 2. **nudging of Sea Ice Thickness to CS2-SMOS** with **10-day relaxation** time (**SIC + SIT initialisation**)

- 25 ensemble members
- All months for 2011-2016 in 1. and 2. to get more robust estimate of CS2-SMOS impact

Impact of thickness initialisation on sea ice volume forecasts



Sea ice volume forecasts for May and August starts:

ORAS5 analysis

Reference forecast (SIC only initialisation)

Experiment forecast (SIC+SIT initialisation)

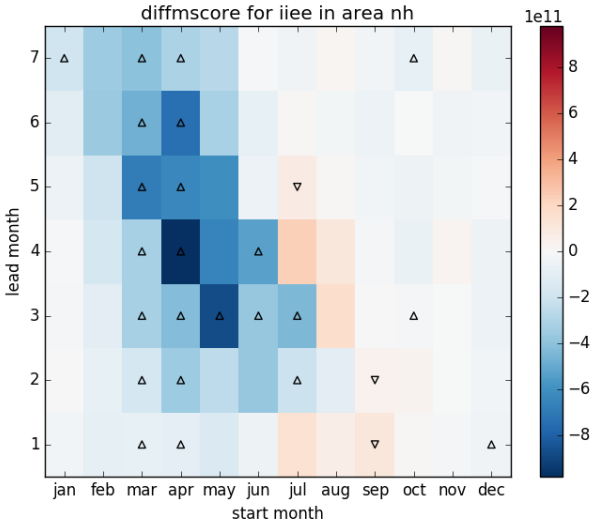
- shape of seasonal cycle preserved, but starting point changed by initialisation

→ improves May starts

→ but deteriorates Aug starts!

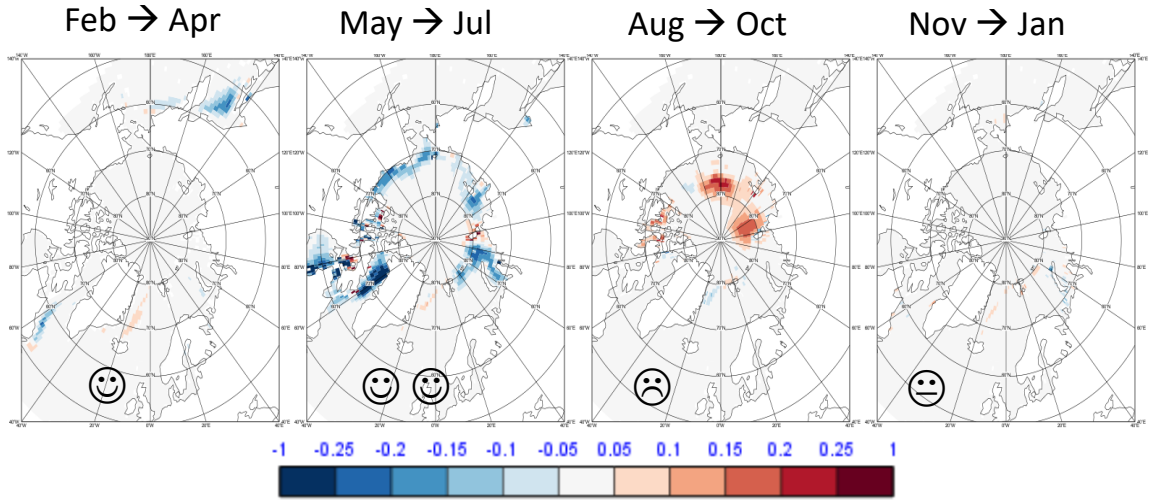
Impact of thickness initialisation on sea ice edge & cover forecasts

IIEE (SIC+SIT) - (SIC only) w.r.t obs



- Blue colours = reduced error in sea ice edge, Improvements for most start and lead months (up to ~30% ice edge error reduction). IIEE = average area in m^2 with false positive or false negative forecast of sea-ice presence (Goessling et al. 2016)

RMSE of SIC (SIC+SIT) – (SIC only) w.r.t obs



+ve impact at lead 3month for forecast initialized in **Feb & May**, **neutral for Nov** and **negative for Aug**

Over all, CS2-SMOS thickness initialisation has positive impact on seasonal forecasts of sea ice fields – Sea ice concentration, thickness, volume and ice edge.

ECMWF

Conclusions and ongoing work

On the impact of Sea Ice Thickness (SIT) for evaluation and initialisation of seasonal forecast
(Balan Sarojini et al. in prep):

- Comparison to newly available Cryosat2-SMOS (CS2-SMOS) SIT observations shows **huge thickness biases** : overestimation of modelled SIT over ice edge and marginal seas and underestimation over the central Arctic in winter.

- **Using SIT from CS2-SMOS observations** to initialise seasonal reforecasts leads to:

❖ drastic reduction of sea ice thickness in the initial conditions and **correction of existing summer biases in SEAS5**

❖ **positive forecast impact** for **Feb & May start dates**, **neutral for Nov** and **negative for Aug** → reduction in SIT by CS2-SMOS initialisation mitigates or enhances seasonally dependent forecast model error as shown by Integrated Ice Edge Error (IIEE).

➢ Impact of ocean observations on the data assimilation and forecasting systems (H2020/ATLANTOS project): Seasonal and Extended range Reforecasts using initialisation from Ocean Observation Denial Experiments (ARGO, XBT/CTD, Moorings etc. globally and over the Atlantic)

H2020 KEPLER

***K**ey **E**nvironmental monitoring for **P**olar **L**atitudes and **E**uropean **R**eadiness*

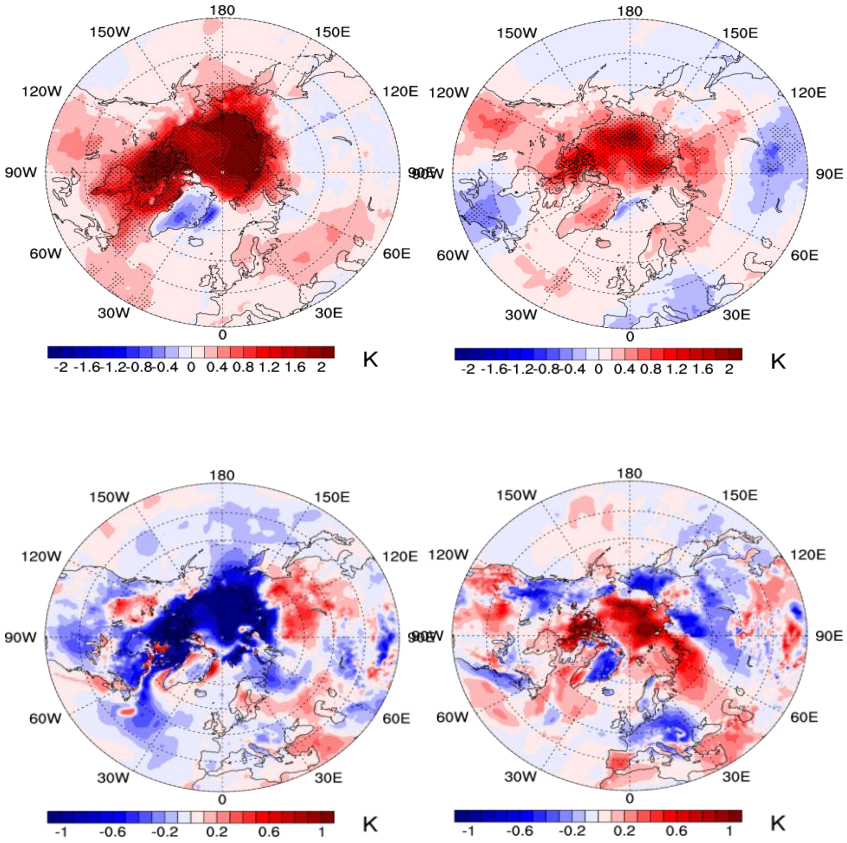
- Mission: to prepare a roadmap for Copernicus to deliver an improved European capacity for monitoring and forecasting the Polar Regions
  → engage with data users, bring together data providers
- Funded with ~3m € from 2019 to 2021 (kick-off meeting in Oslo NOW)
- 14 participants led by METNO (Nick Hughes): BAS, MERCATOR, U Lund, NERSC, ECMWF, ICM-CSIC, and a number of SMEs
- ECMWF lead work package on improved sea-ice mapping and forecasting

More info

- follow @KeplerEU on twitter
- e-mail s.tietsche@ecmwf.int
- check https://kepler-polar.eu/

Thank you!

Impact of thickness initialisation on on 2m temperature forecasts



Change in ensemble mean & RMSE for October:

Positive forecast impact and significant changes in ensemble mean October t2m forecasts initialised in May.
Degradation in autumn t2m forecasts started in August starts