A multi-system evaluation of predictive capacity over the Arctic and mid-latitudes at the seasonal time scale

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OVERVIEW

We evaluate re-forecasts performed in the H2020-APPLICATE project alongside operational seasonal forecasting systems over the Northern Hemisphere mid-latitudes and Arctic region.

Seasonal re-forecast quality is assessed for atmospheric variables with respect to ERA-Interim reanalysis data for JJA (May initialization) and DJF (Nov initialization), looking at grid-point correlation and a fair CRPSS.

For sea ice evaluation, we use sea ice concentration fields and a 0.15 threshold to define the Arctic ice edge. We then evaluate the systems predictive capacity using the IIEE and SPS metrics introduced by Goessling et al. (2016, 2018) according to forecast time. NSIDC data is used as a reference.

In both cases, the possible improvements brought by a multi-model approach are explored.

ICE EDGE ERROR METRICS

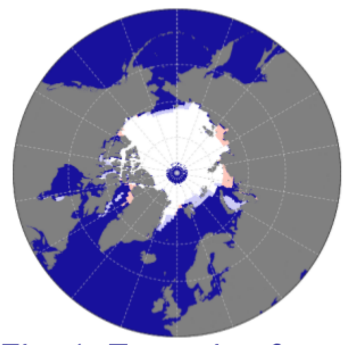

Fig. 1: Example of a sea ice edge forecast for September 1996 and IIEE computation

Integrated Ice Edge Error (Goessling et al. 2016)

IIEE = O + U

Decomposition: IIEE = AEE + ME

with AEE = | O – U | *abs. extent error*

ME = 2 min(O, U) *misplacement error*

Spatial Probability Score (Goessling and Jung 2018)

$$SPS = \int_x \int_y \left(P_{\mathrm{SIC}_f>0.15}(x,y) - \mathbb{1}_{\mathrm{SIC}_o>0.15}(x,y)\right)^2 \mathrm{d}y\mathrm{d}x$$

SEASONAL RE-FORECASTS

APPLICATE stream 1 re-forecasts:

- Initialized 1st Nov. & 1st May over the 22-year 1993-2014 re-forecast period
- 6-month integrations
- CNRM-CM6-1: CMIP6 version of CNRM-CM
- EC-Earth 3.2.2: runs initialized from ORAS4 (ocean) and a standalone NEMO-LIM run with DFS surface fluxes and EnKF assimilation of SIC.
- Compared to operational re-forecasts from C3S: GloSea5 and SEAS5

Model/System	CNRM-CM6-1	EC-Earth 3.2.2	GloSea5	SEAS5
Atmosphere	ARPEGE v6.3	IFS cy36r4	UM v6	IFS Cy43r1
Ocean	NEMO 3.6	NEMO 3.6	NEMO 3.4	NEMO 3.4
Sea ice	GELATO v6	LIM3	CICE 4.1	LIM2
Atm. resolution	Tl127l91r (~1.4°)	Tl255l91r (~0.7°)	N216L85	TCo319L91
Ocean resolution	eORCA1 L75	ORCA1L42	ORCA0.25L75	ORCA0.25L75
Ocean / Sea ice initial conditions	Mercator-Ocean	ORAS4 + EnKF SIC	NEMOVAR	ORS-S5
Ensemble size	30	10	28	25

EVALUATION OF SEASONAL RE-FORECAST SKILL OVER THE NORTHERN HEMISPHERE

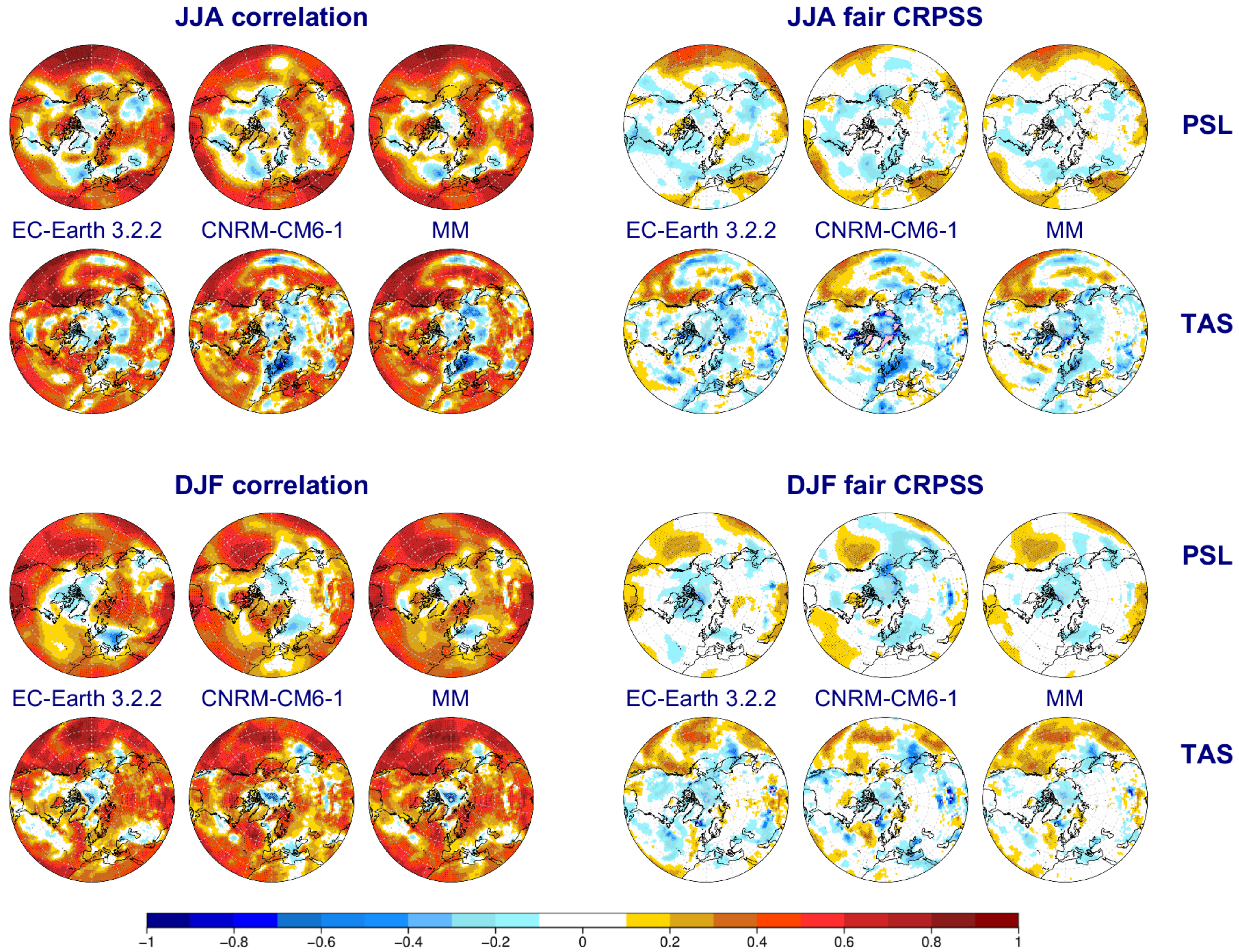

Fig. 2: Correlation (left) and fair continuous ranked probability skill score (CRPSS, right) for mean sea-level pressure (PSL, top rows) and near-surface air temperature (TAS, bottom rows) for JJA re-forecasts initialized in May, and DJF re-forecasts initialized in November 1993-2014 with EC-Earth 3.2.2 (left), CNRM-CM6-1 (10-member subset, center) and a multi-model with both models (right). Reference is ERA-Interim.

SEA ICE RE-FORECAST CAPACITY

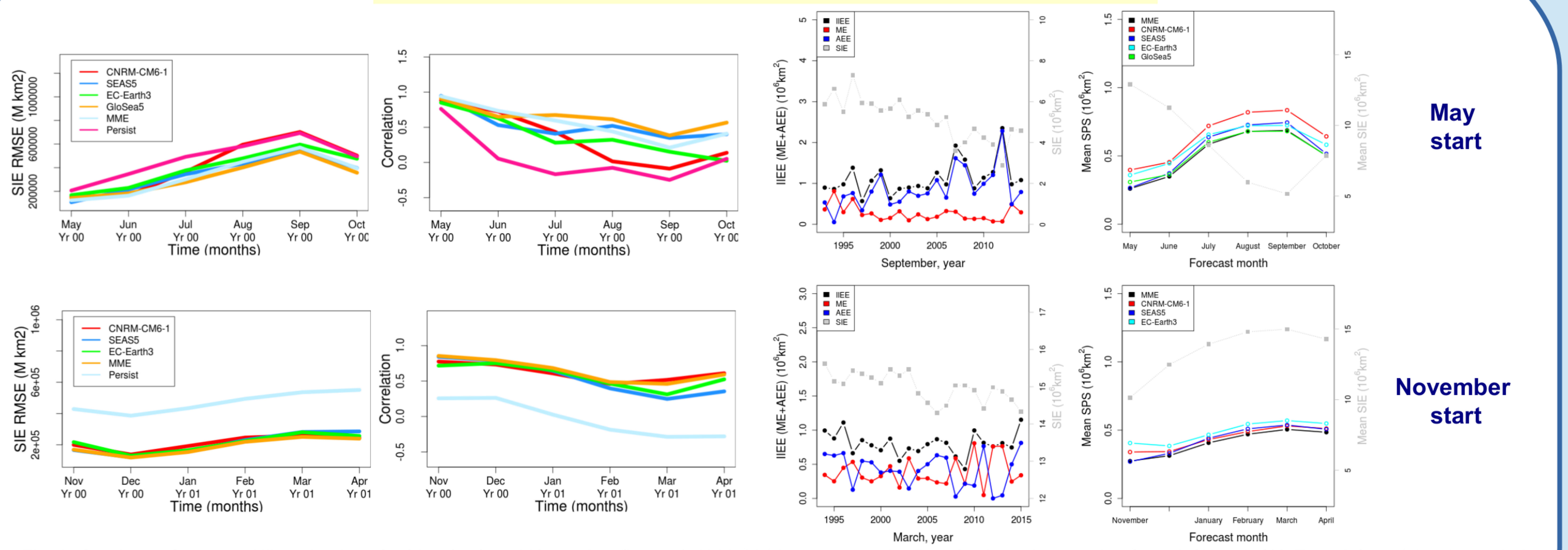

Fig. 3: Sea ice re-forecast skill evaluations for May (top) and November (bottom) 1993-2014 starts over the Pan-Arctic region ranging from 45°N to 85°N. From left to right: detrended sea ice extent (SIE) root mean square error and correlation with NSIDC according to forecast time for each system and a simple multi-model ensemble (MME) forecast; MME IIEE and decomposition in millions of km² for September and March (forecast months 5) of each year of the re-forecast; evolution according to forecast time of SPS for each system. Gray lines show the corresponding SIE (year per year, and climatology) computed in NSIDC v4 data. See the Ice Edge Error Metrics section for more details on IIEE and SPS scores.

CONCLUSIONS AND FUTURE PLANS

EC-Earth 3.2.2 and CNRM-CM6 show limited skill in forecasting atmospheric fields, as shown with the evaluation of TAS and PSL in Fig. 2. Probabilistic skill is particularly small or negative, as often over this region. The multi-model approach does improve some aspects of the forecast but this will be further assessed with all APPLICATE stream 1 re-forecasts *(work in progress).*

Sea ice skill of each of the re-forecasts is better than a persistence approach. However, the multi-model ensemble does not improve skill (for RMSE and correlation) beyond the levels of the best forecast. The IIEE values are similar for each of the systems (not shown), and only slightly better in the multi-model. For the September target month, IIEE peaks during years with the highest anomalies (e.g. 1996, 2007, 2012) primarily due to absolute extent error (all models overestimate SIE for 2007 & 2012). For May starts, CNRM-CM6 has lower skill than other systems beyond forecast month 3. We believe this is due to too thin ice in the initial conditions. Sea ice re-forecasts in November starts are very similar between all systems, therefore limiting the impact of a multi-model approach.

Future plans include introducing user-oriented metrics for the evaluation of the atmospheric re-forecasts (e.g. blocking frequency), and testing the impact of improved representation of sea ice – atmosphere – ocean fluxes or higher resolution on the forecast quality (APPLICATE stream 2 seasonal re-forecasts).

REFERENCES AND ACKNOWLEDGEMENTS

Goessling, H. F. et al. (2016) Predictability of the Arctic sea ice edge. *Geophys. Res. Lett.* 43, 1642–1650, doi: 10.1002/2015GL067232

Goessling, H.F. and T. Jung (2018) A probabilistic verification score for contours : Methodology and application to Arctic ice-edge forecasts. *Q. J. Roy. Meteorol. Soc.*, in press. doi:10.1002/qj.3242

The work described in this poster has received funding from the European Union's Horizon 2020 Research & Innovation programme through grant agreement No. 727862 APPLICATE. ECMWF SEAS5 and MetOffice GloSea5 data were downloaded from the Copernicus Climate Change Service (C3S). NSIDC v4 data was provided by NASA DAAC. Analysis of re-forecast skill was performed using the R library s2dverification (Manubens et al. 2018).

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Horizon 2020 European Union funding for Research & Innovation