Seasonal to decadal predictability in mid and high northern latitudes

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Processes with potential for predictability

Persistence: Ice, SST and snow anomalies can persist for several months to a few years and can affect ocean and atmosphere.

Advection of ice and SST anomalies: Anomalies are transported downstream and affect climate conditions downstream.

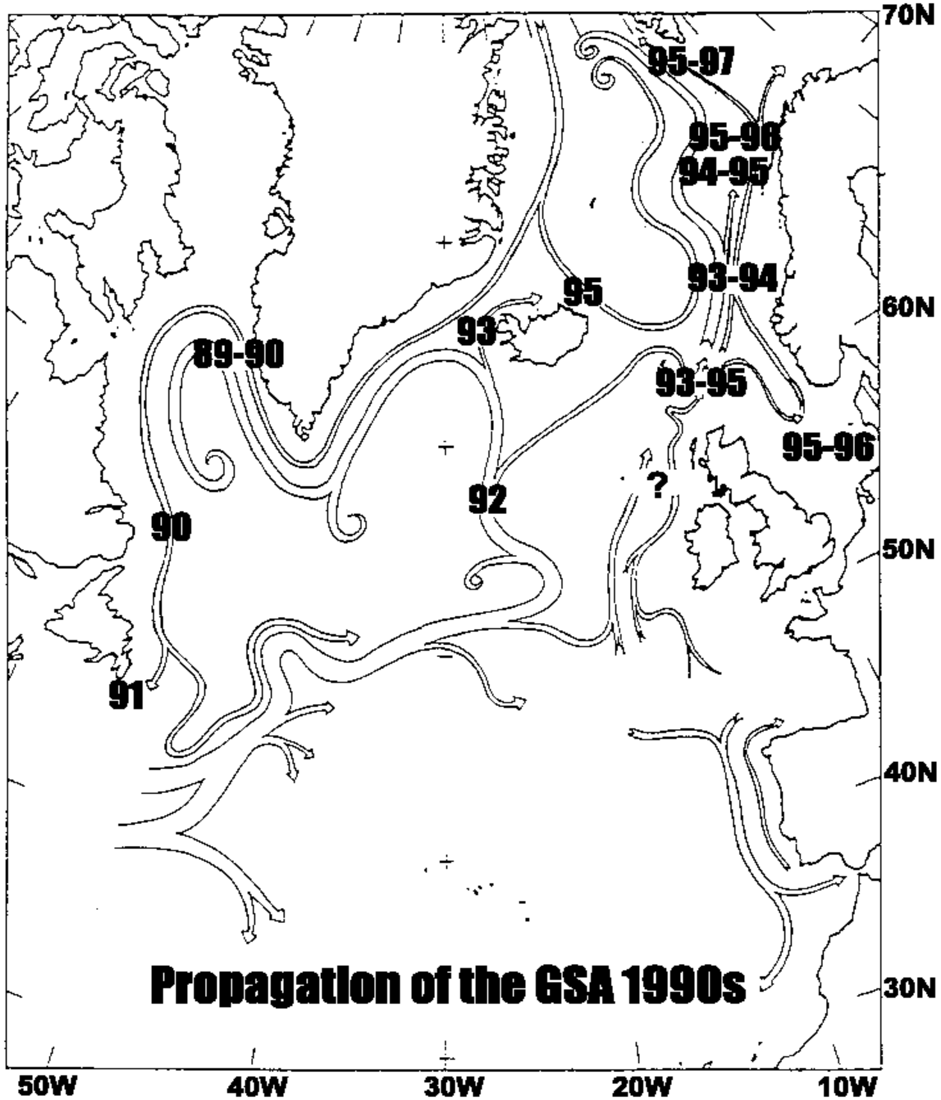
Large scale atmospheric response to ice, snow and SST anomalies

Decadal Arctic processes: variation of sea ice interacting with atmospheric circulation (e.g. Arctic cyclonic/ anticyclonic regimes, AO/NAO)

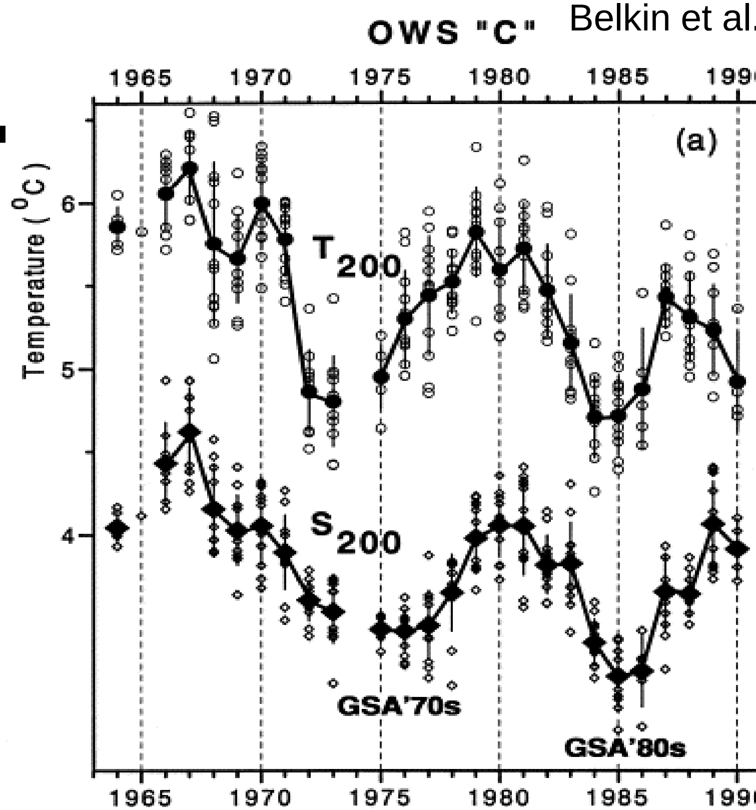
Ocean heat transport/ MOC variations on decadal to multi-decadal scales

Trend: particularly sea ice reductions lead to non-linear responses in atmosphere and ocean

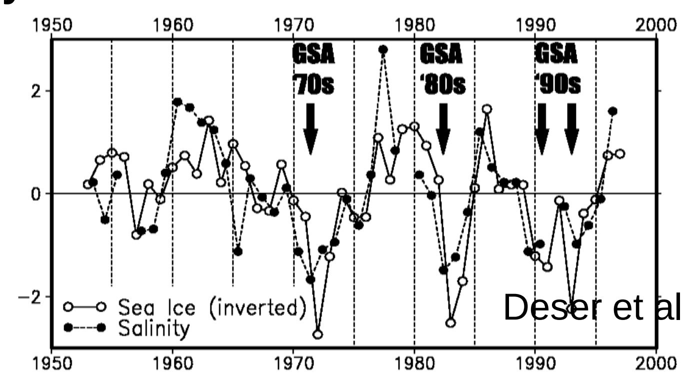
Great Salinity Anomalies



Belkin et al. 2004



Salinity and temperature as observed by OWS BRAVO in the Labrador Sea



Deser et al. 2002

Winter sea ice index and 100m April-July salinity in Davis Strait

Seasonal to interannual predictability

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Perfect ensemble experiments

Model: ECHAM5/MPI-OM:

Atmosphere: T31 /19 vertical levels

Ocean: 30-390 km/40 vertical levels,

300-year control integration

40 ensembles (6 members with a small perturbation) started from different Januaries and Julys of the control integration.

Potential predictability: a measure for the upper limit of predictability

Assumption: we know the initial state almost perfectly.
The model perfectly simulates reality.

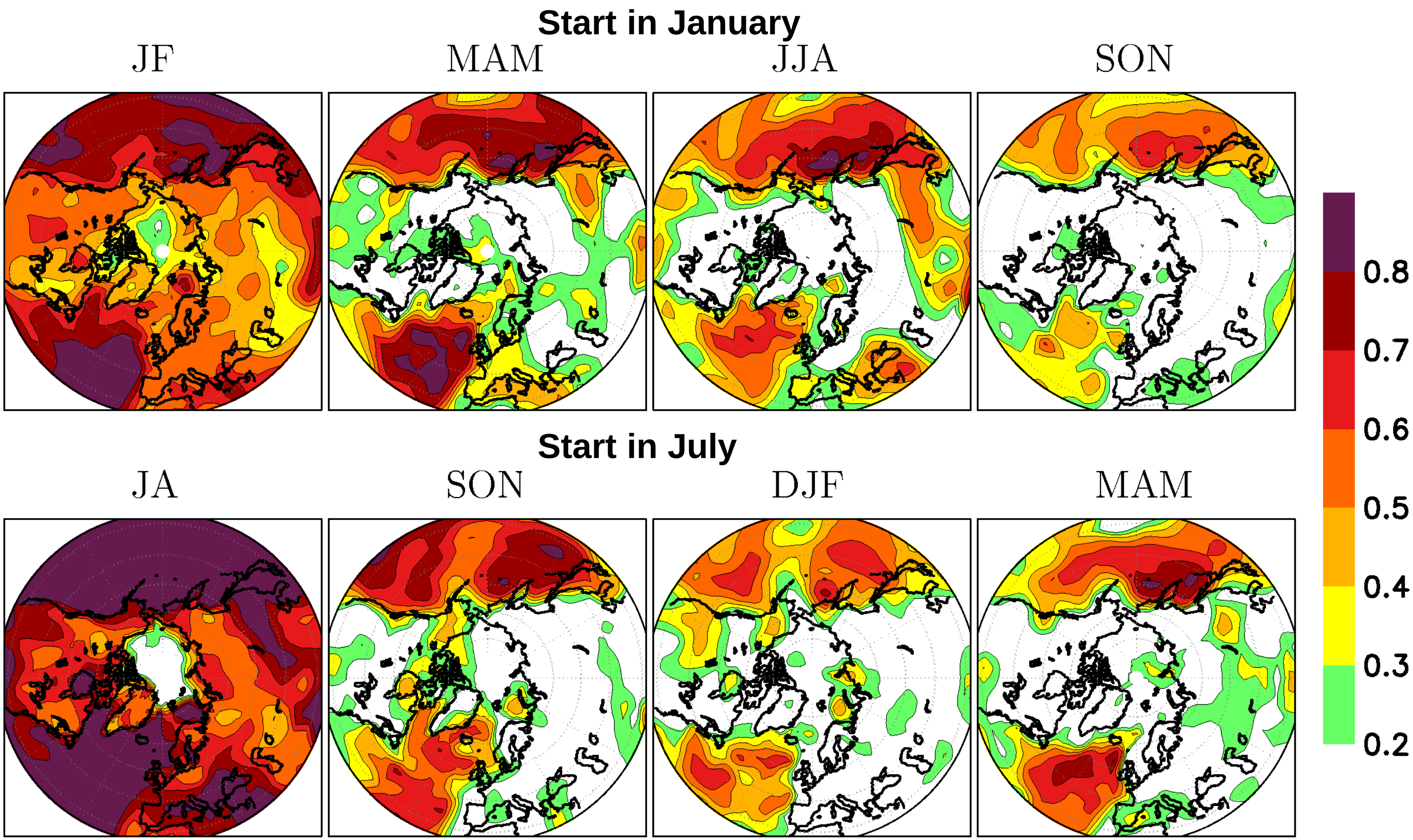
Method: Potential Prognostic Predictability

$$PPP(t) = 1 - \frac{Var_{ens}(t)}{Var_{ctrl}(t)}$$

PPP larger than persistence?

$$PPPa(t) = PPP(t) - r^2_{auto}(t)$$

Seasonal predictability of T2m



Potential predictability of 2 m air temperature for the mean of months 1/2 , 3-5, 6-8 and 9-11.

Seasonal predictability of SLP

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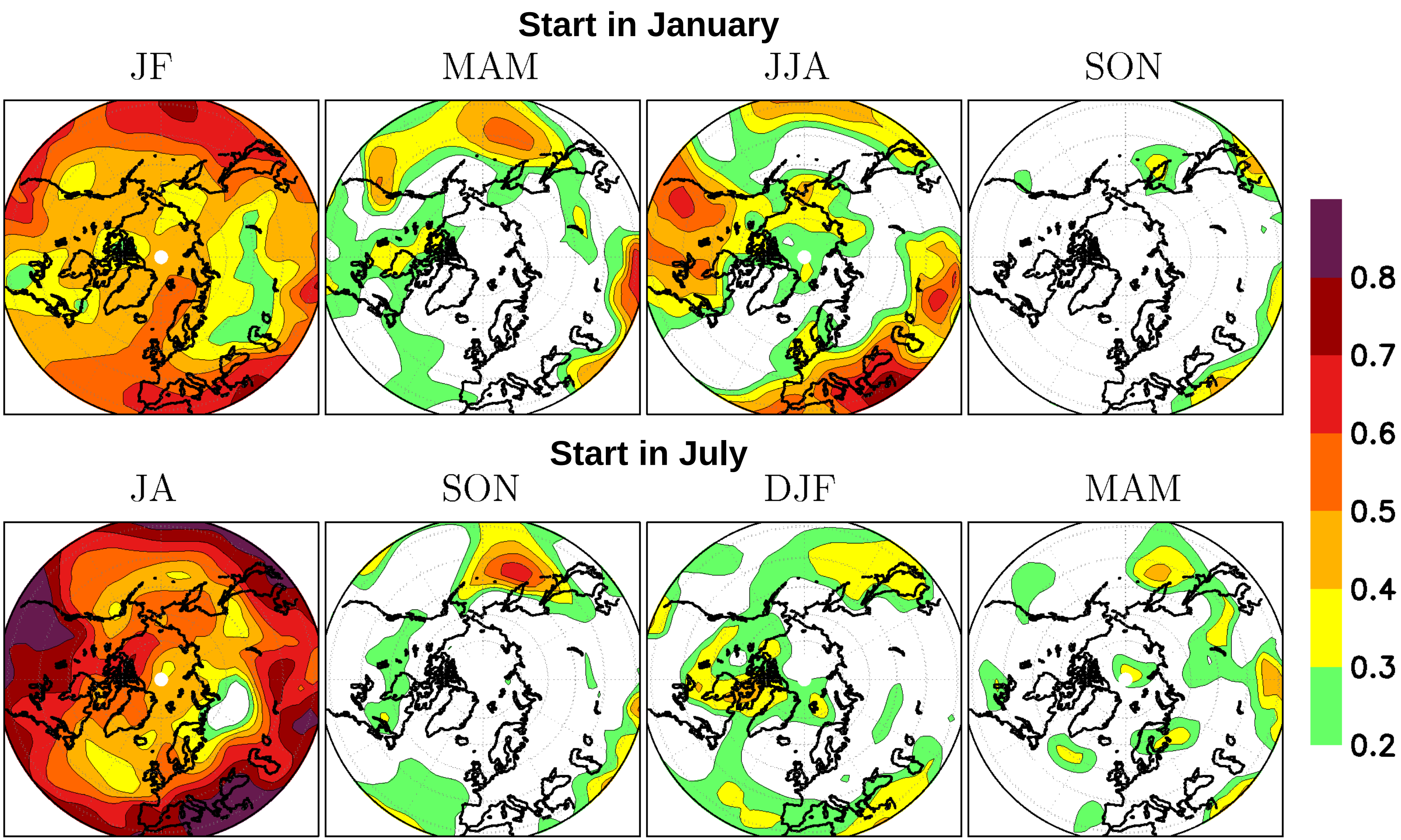
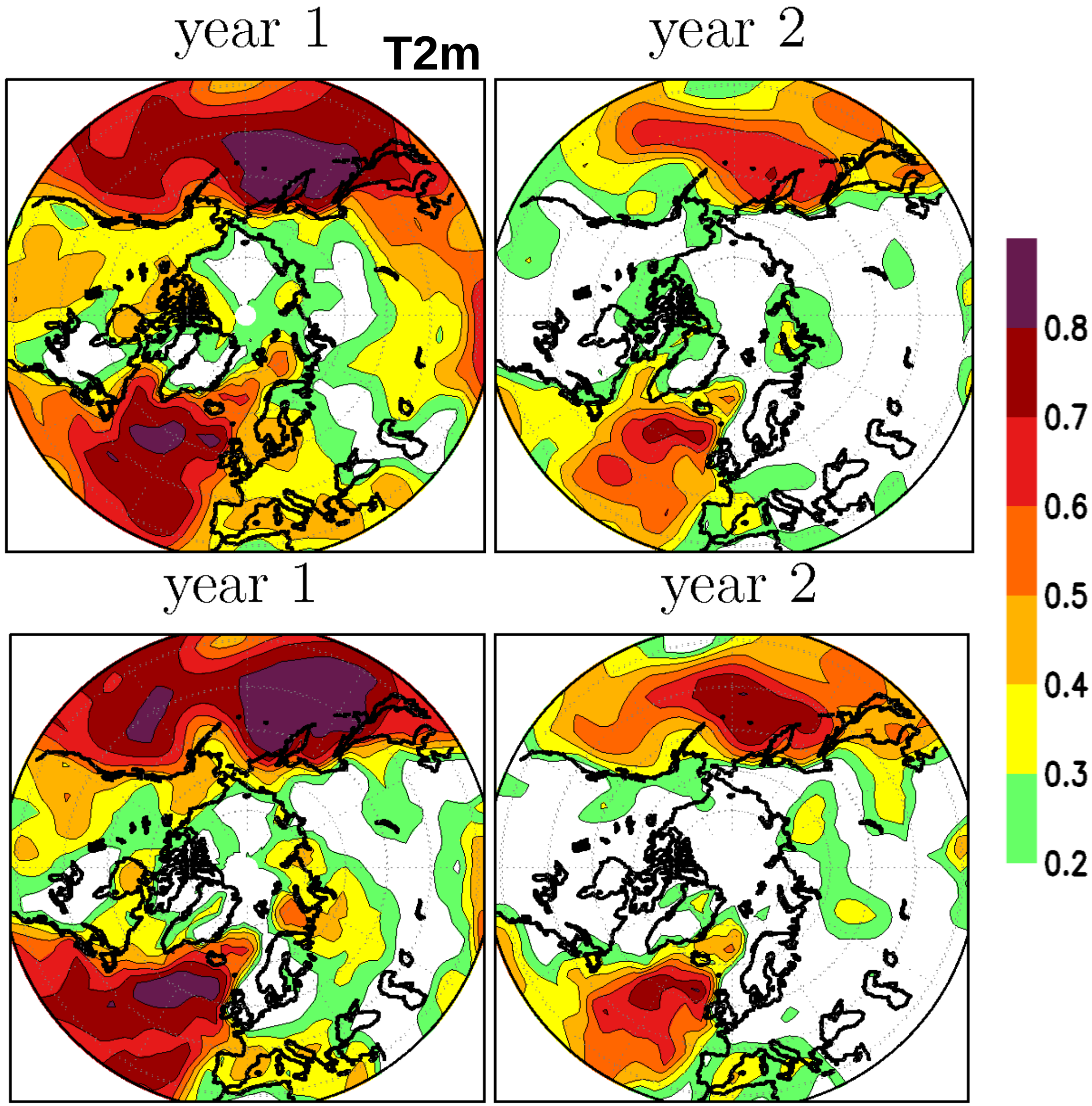


Predictability of SLP for the mean of months 1/2 , 3-5, 6-8 and 9-11.

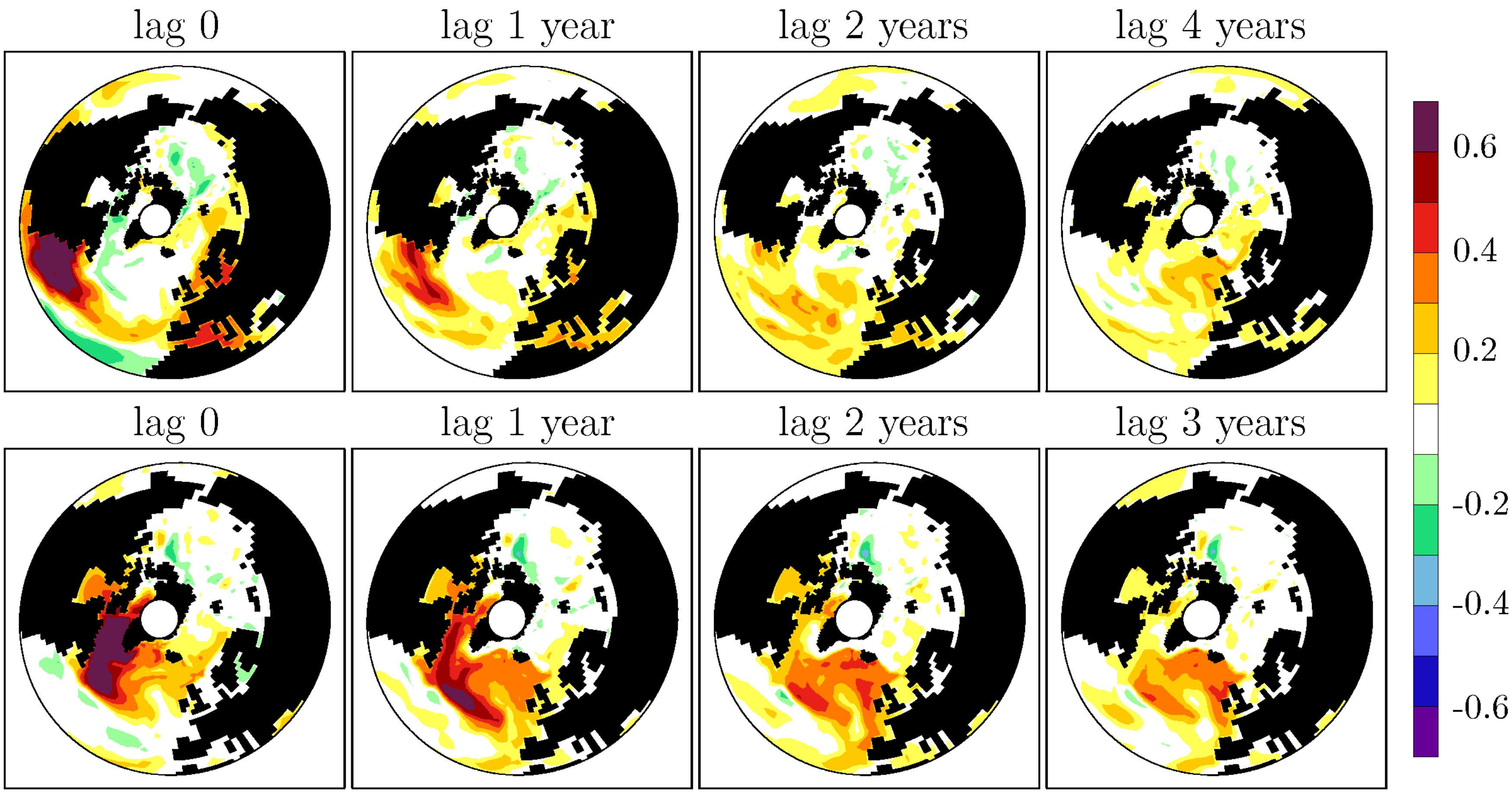
Interannual predictability of T2m

Start in January

Start in July



Advection of SST anomalies



Top: Lag correlation between annual mean 6 m ocean temperature at the North American east coast and 6 m ocean temperature in the 300-year control integration. Bottom: Same for 6 m ocean temperature in the Labrador Sea.

Interannual predictability of sea ice

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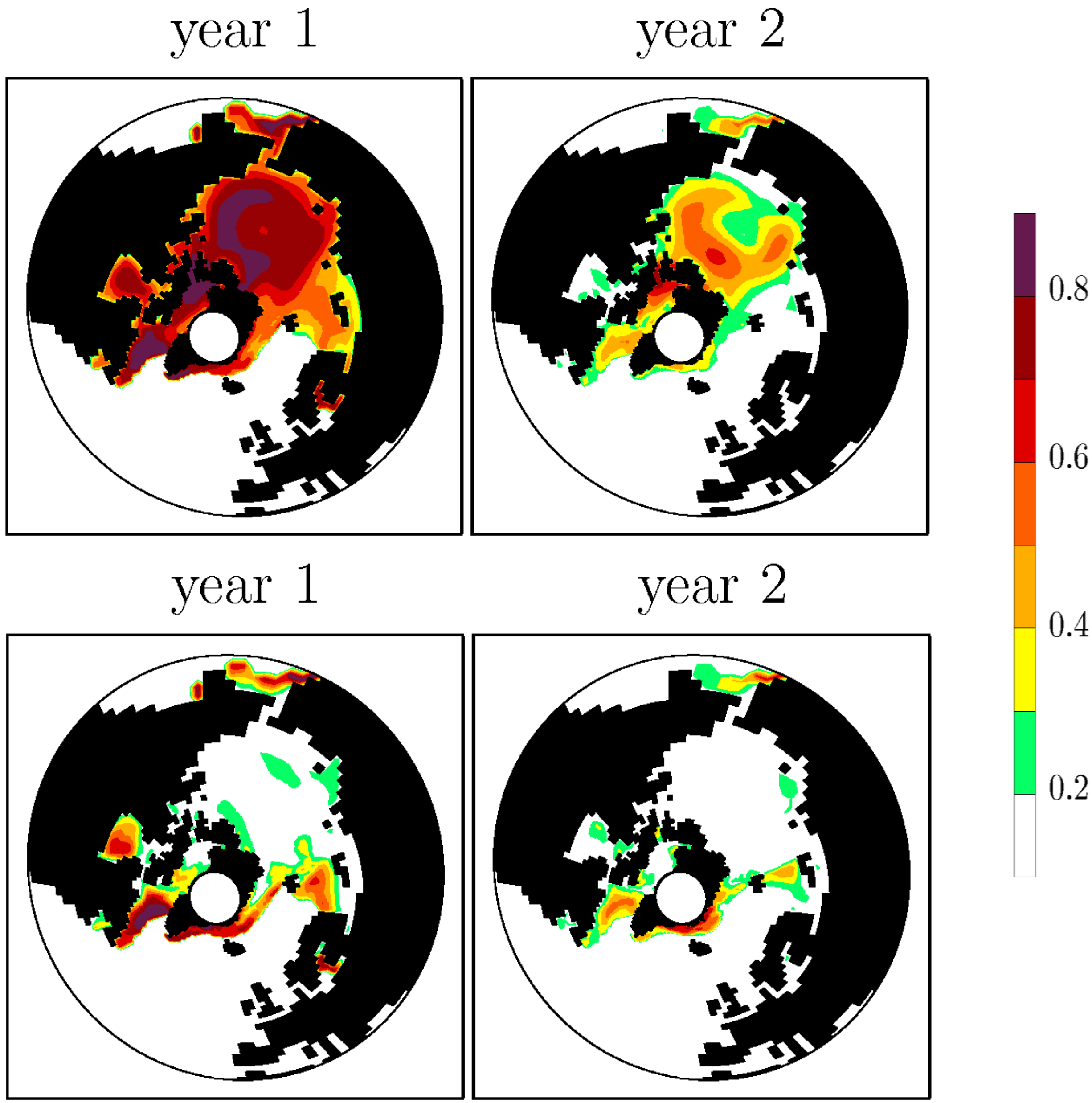
ice thickness

Start in January

ice concentration



Interannual to Decadal Predictability

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EC-Earth version 2.1

Atmosphere: based on IFS cycle 31r1, t159, 62 vertical levels

Ocean: NEMO2 (LIM2), ORCA1-tri-polar grid, 42 vertical levels

Simulations:

CTRL1: 350-year present day control integration

CTRL2: 250-year present day control integration started from year 150 of CTRL1

Reduction in sea ice albedo by 0.03

Perfect Ensemble Experiments:

EXP1: 4 ensembles with 6 members each started from CTRL1

EXP2: 4 ensembles with 6 members each started from CTRL2

Interannual predictability: SLP

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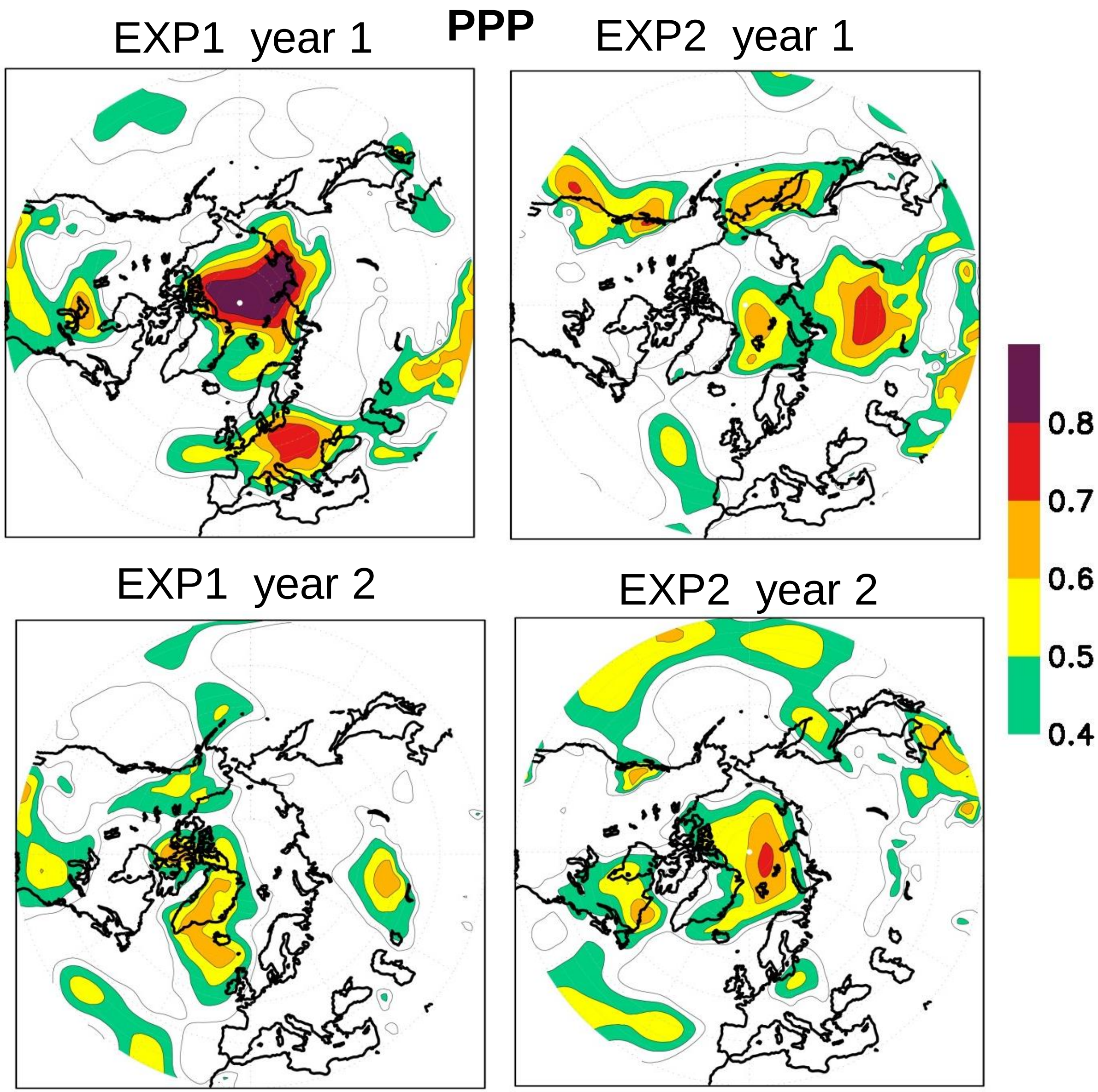
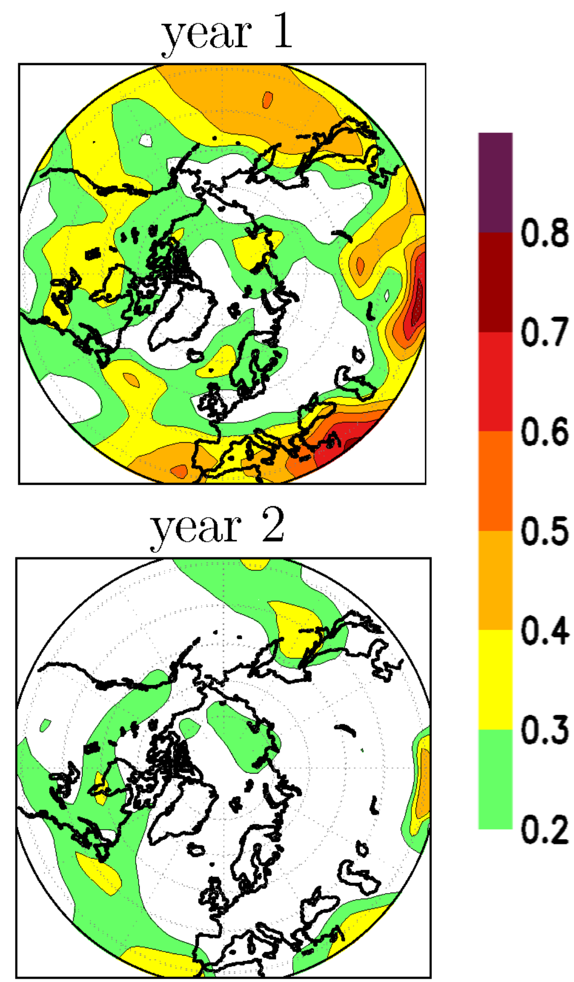
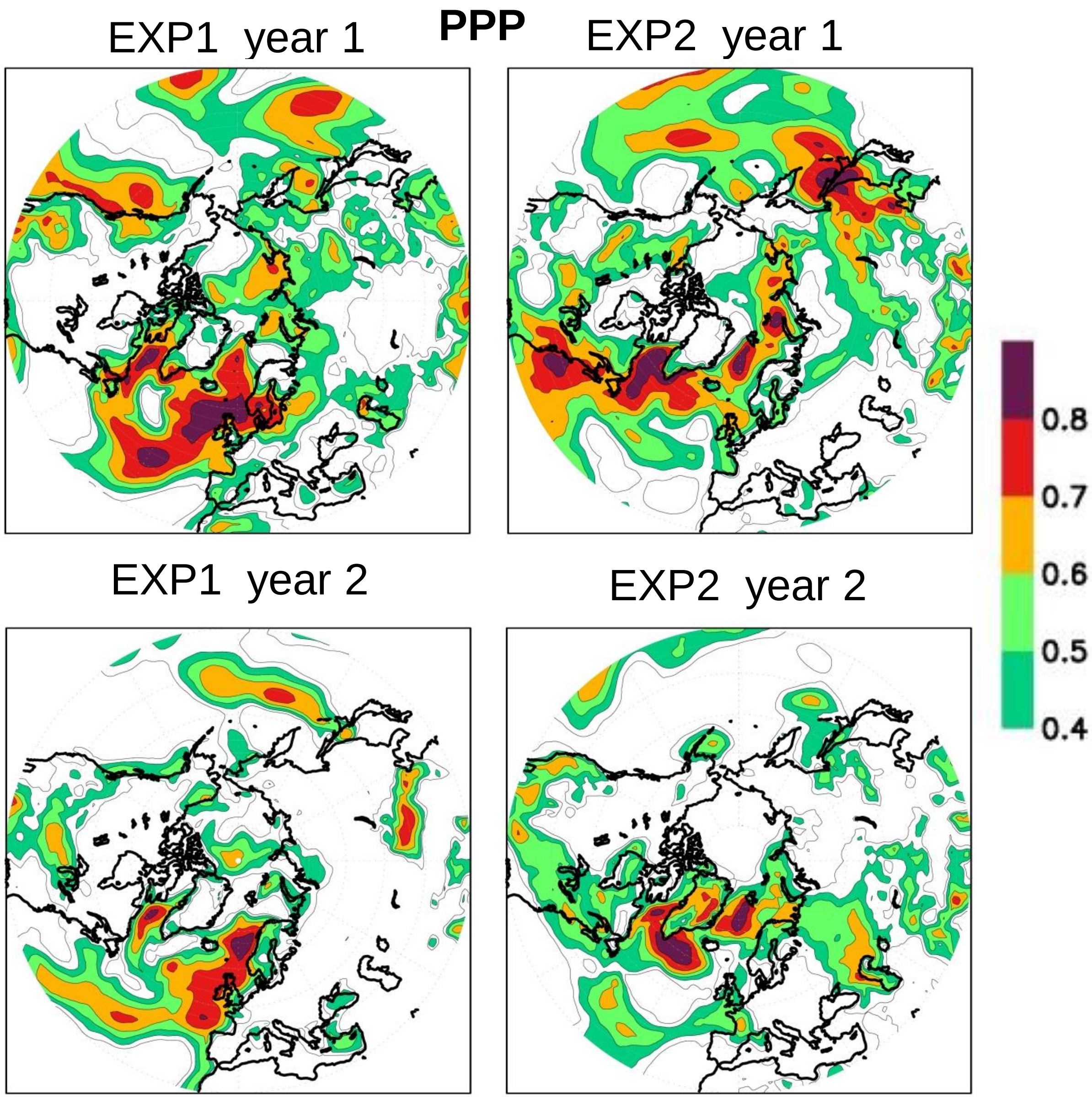


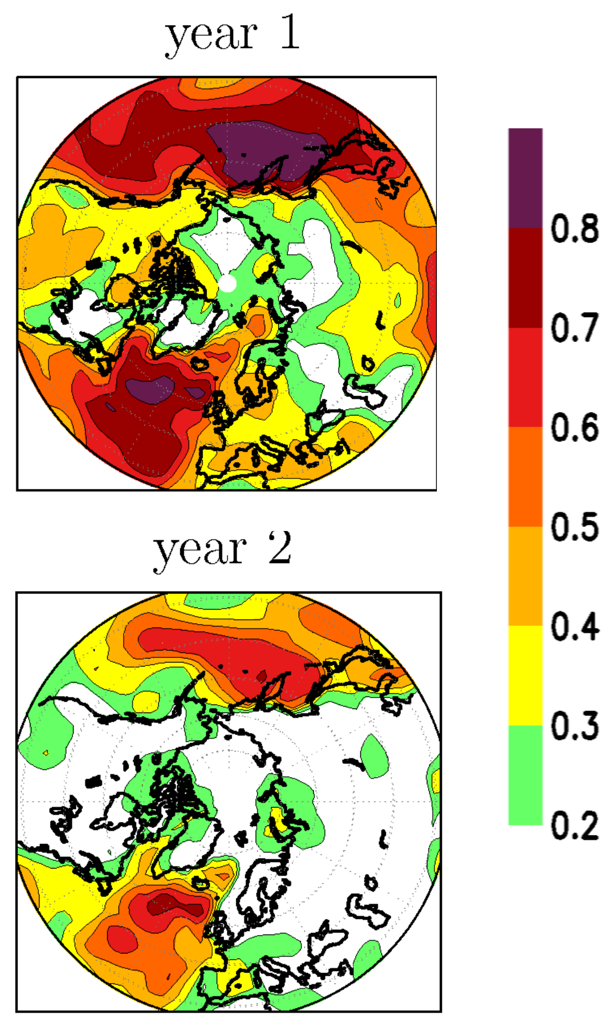
ECHAM5/MPI-OM
Start in January



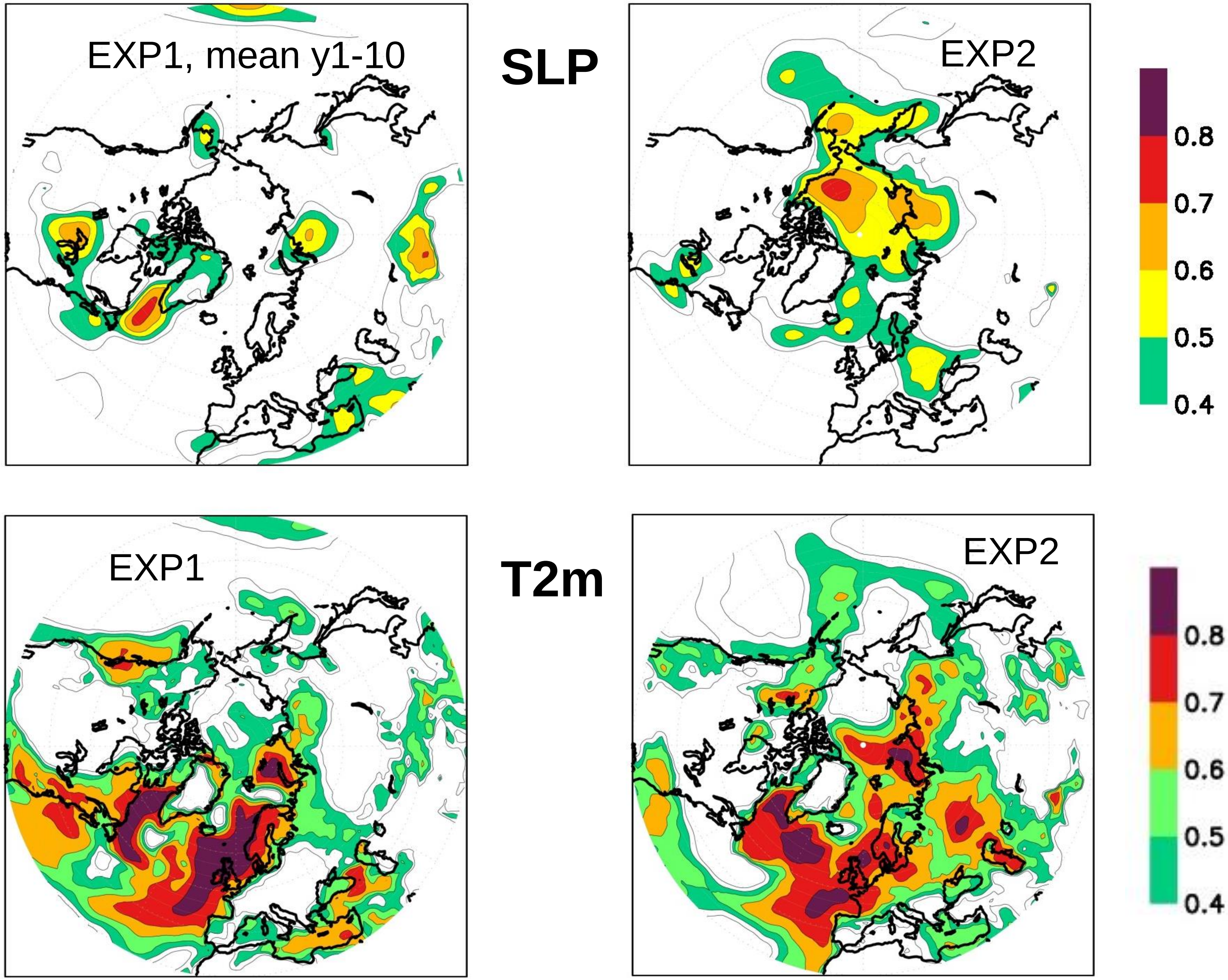
Interannual predictability: T2m



ECHAM5/MPI-OM
Start in January



Decadal Predictability: SLP and T2m



Decadal Predictability: ice thickness

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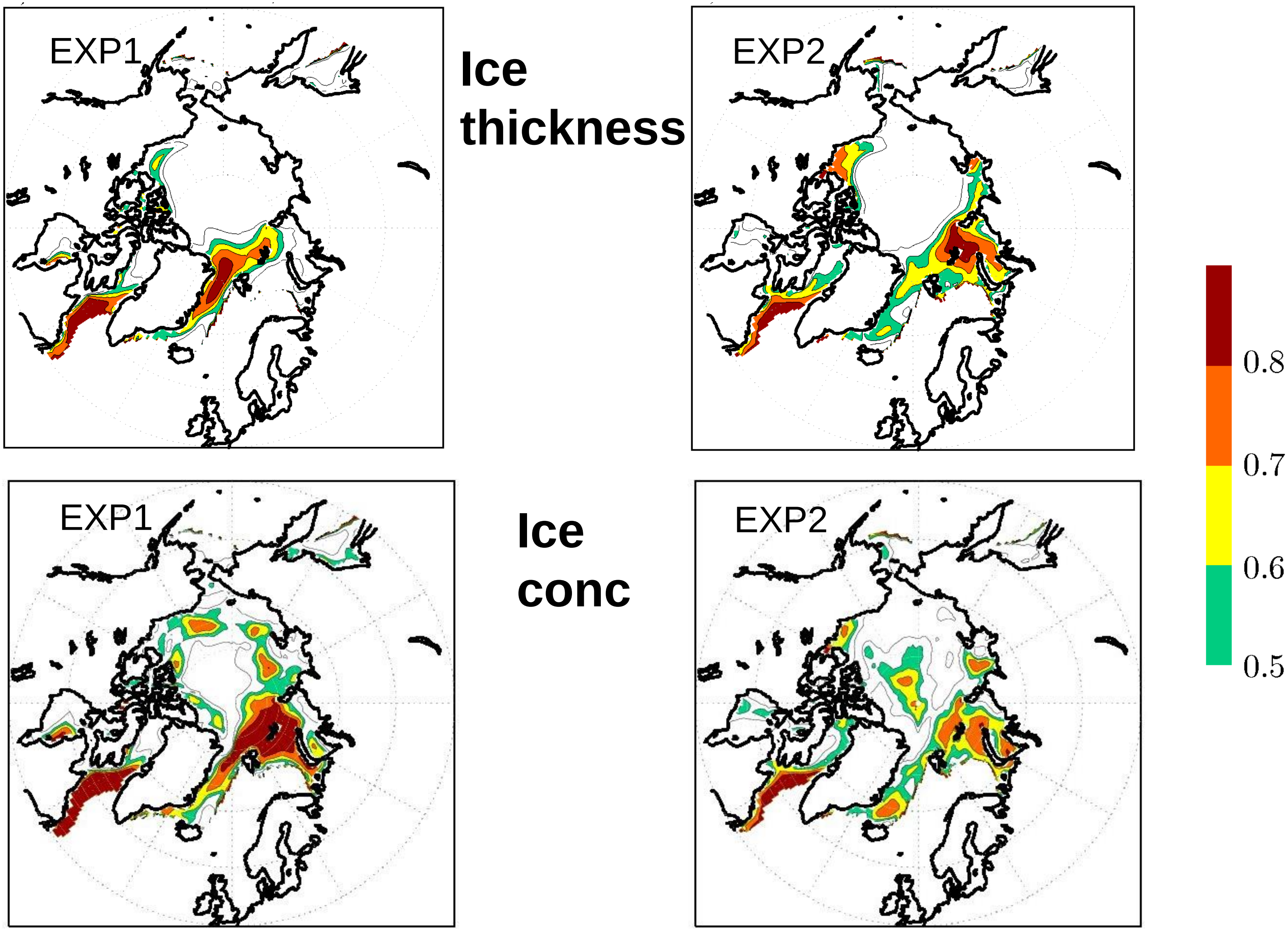
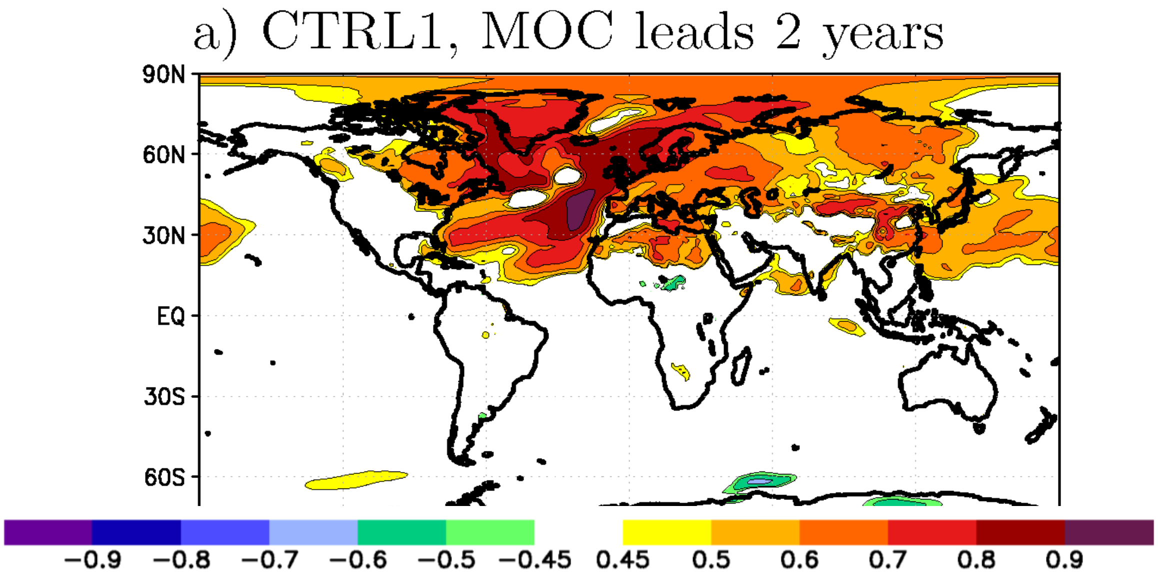
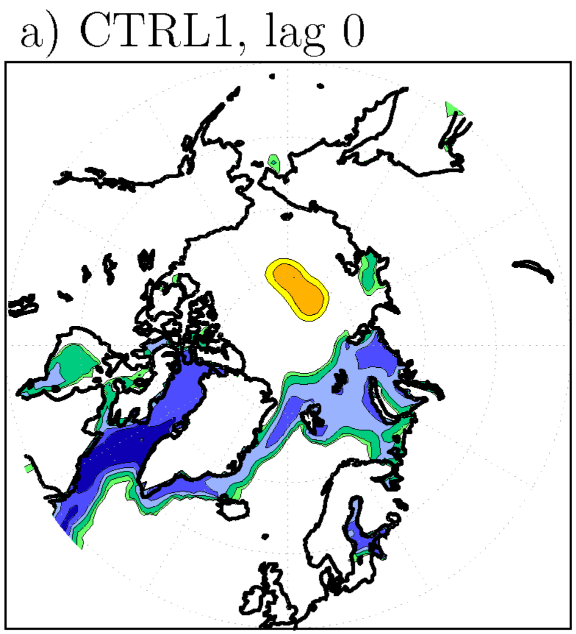


Impact of MOC





Top; Correlation between 10-yr running mean of MOC and T2m in CTRL1.

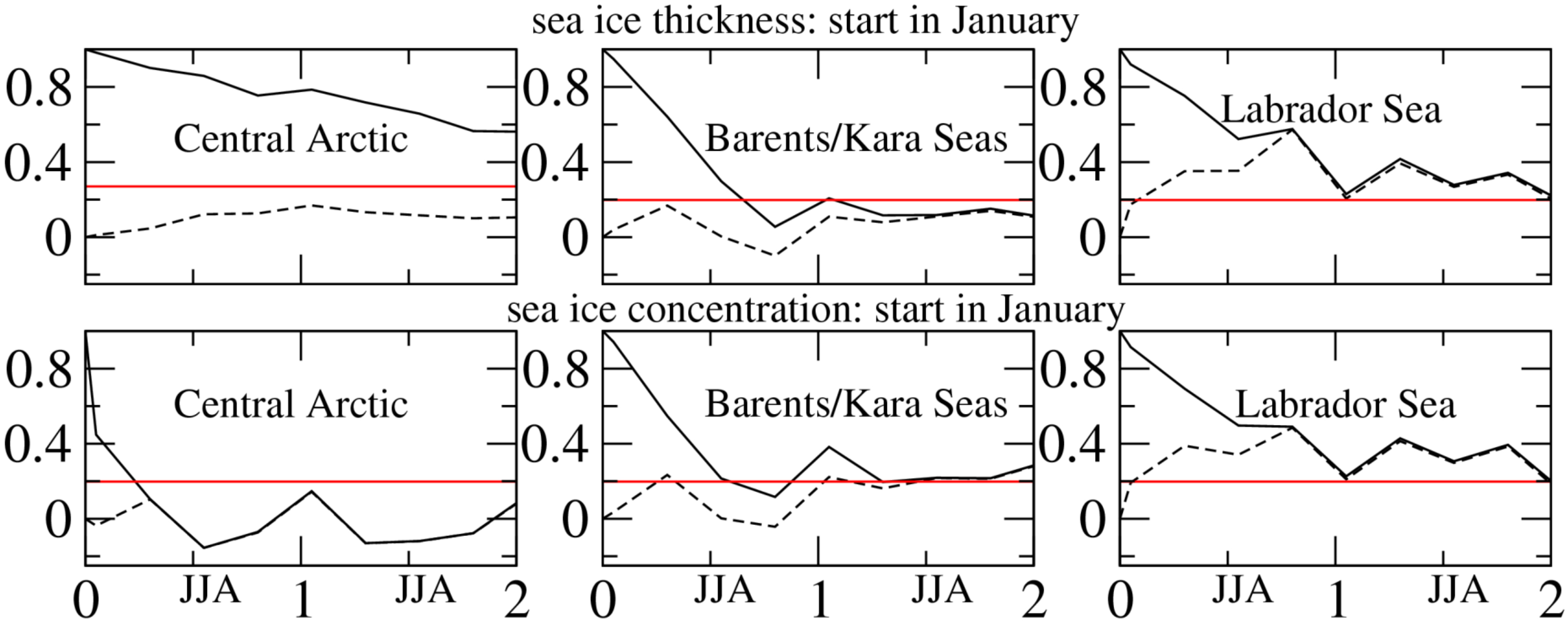
Bottom: The same for MOC and Ice thickness.

Conclusions

- Seasonal predictability depends on season and initial date.
- Sea ice thickness predictability is high in the first two years in the Central Arctic and Labrador Sea.
- Interannual predictability varies among models.
- Persistence and advection of sea ice and SST anomalies govern seasonal to interannual predictability.

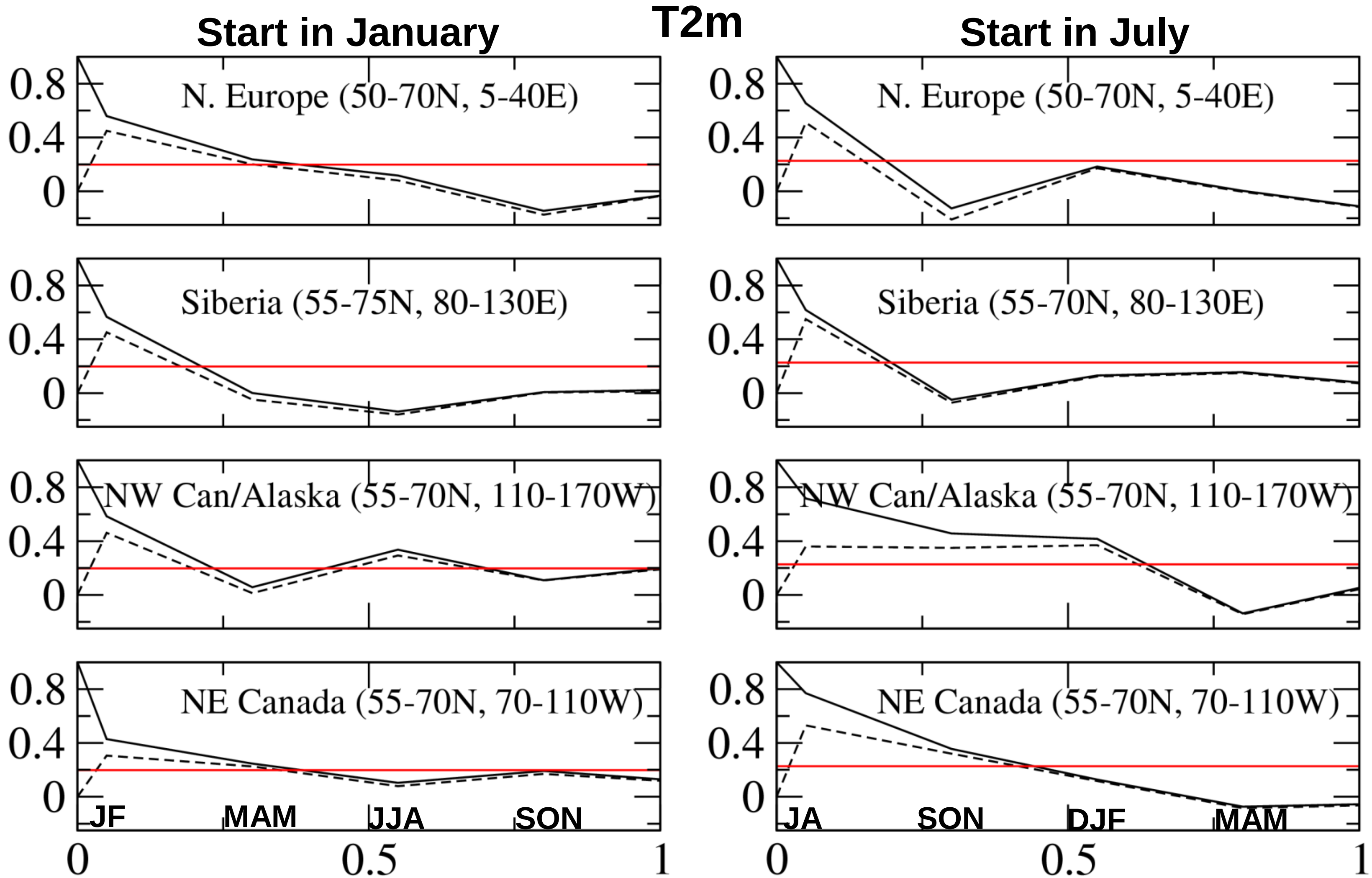
- Decadal predictability of T2m is high over northern North Atlantic and over northwestern Europe.
- Decadal sea ice predictability is high in the Atlantic sector of the Arctic.
- MOC governs most of the decadal predictability in the NH.
- Large scale decadal predictability patterns are similar despite changes in parameterization but differ substantially on regional scales.

Predictability of sea ice



Predictability (solid) and gain of predictability (dotted) of seasonal sea ice thickness and concentration

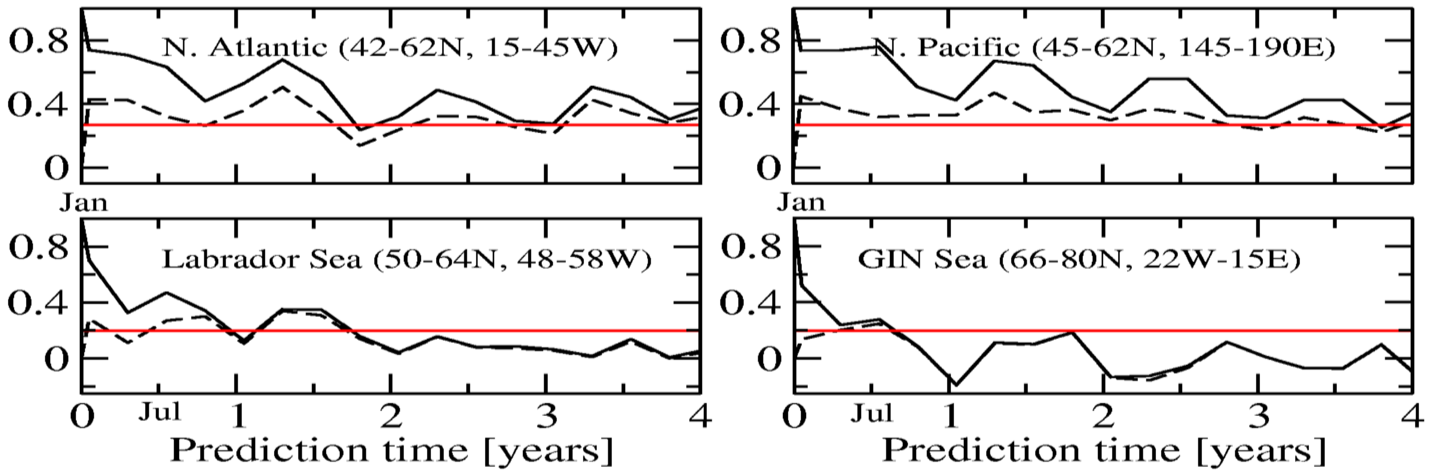
Predictability of air temperature



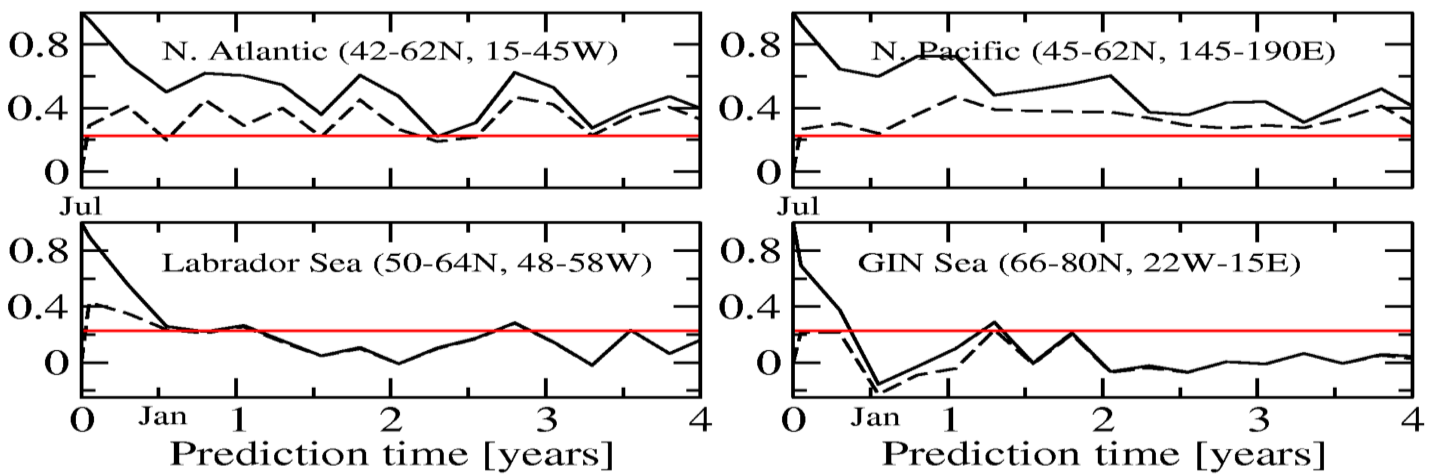
Predictability (solid) and gain of predictability (dotted) of seasonal mean 2 m air temperature, averaged over different land regions in the first year. The red line shows the level of 95 % significance.

Predictability of air temperature

Start in January

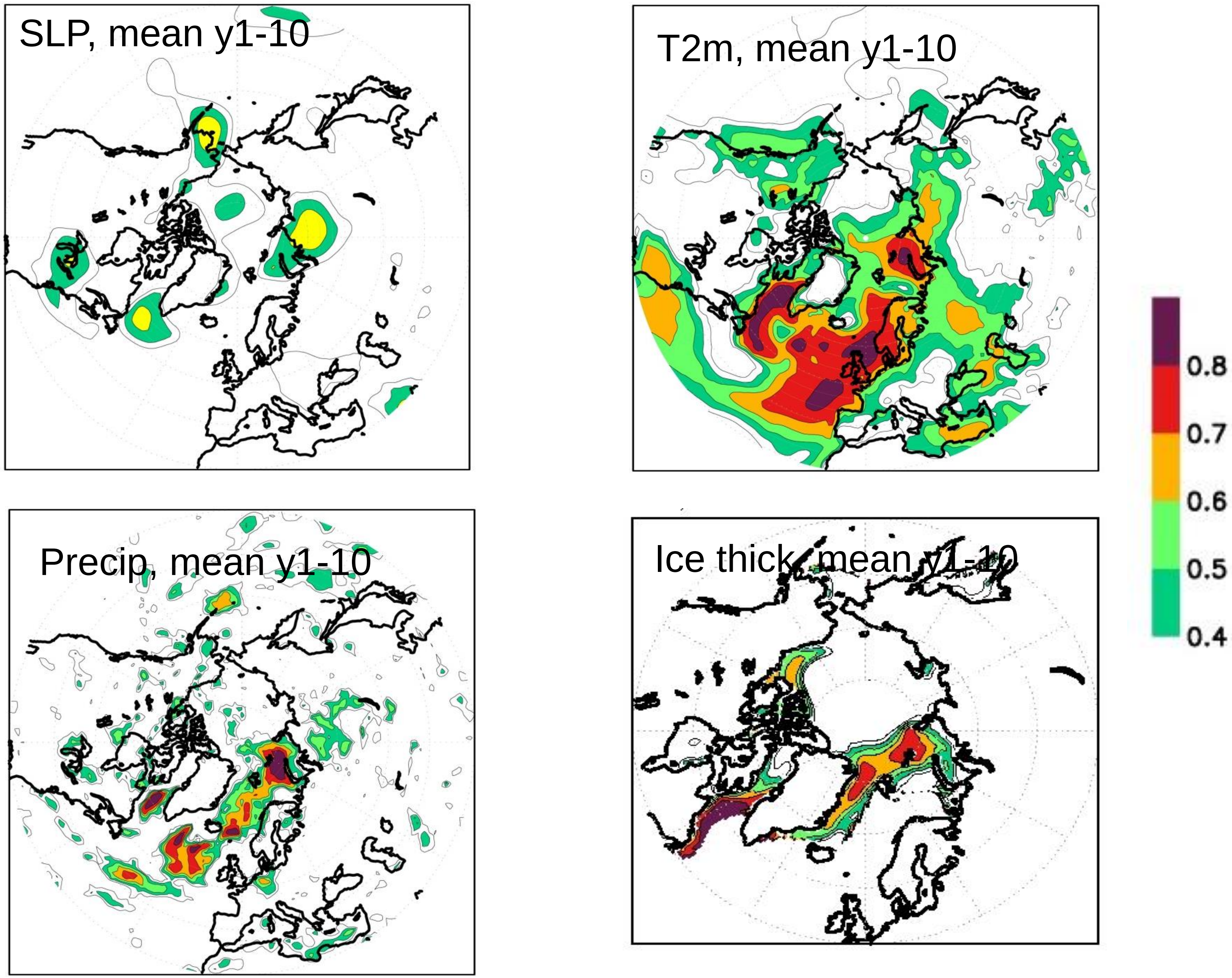


Start in July



PPP and PPPa of seasonal mean 2m air temperature in different ocean regions. The red line shows the 95 % significance level.

Decadal PPP: Combined ensemble



PPP of decadal mean T2m, averages over regions

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Region	PPP EXP1 / Variance CTRL1	PPP EXP2 / Variance CTRL2
North Atlantic (10-60W, 30-60N)	**0.85** / 0.057	**0.83** / 0.037
Europe (0-60E, 30-60N)	**0.72** / 0.041	**0.78** / 0.037
N. Europe (10-40E, 50-70N)	**0.60** / 0.181	**0.69** / 0.130
Africa (10-40W, 30S–30N)	**0.57** / 0.004	0.26 / 0.005
S. Asia (60-130E, 10-40N)	**0.71** / 0.005	0.42 / 0.004
N. Asia (60-150E, 40-70N)	0.39 / 0.062	**0.58** / 0.055
Arctic (0-360E, 70-90N)	**0.77** / 0.264	**0.76** / 0.189
NE N. Atlantic (20E-10W, 45-75N)	**0.82** / 0.164	**0.78** / 0.102
global	**0.85** / 0.004	**0.67** / 0.004