Climate Forecasting Unit

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

SPECS
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

Ensemble of sea ice initial conditions for interannual EC-Earth climate predictions: Improved forecast quality over the Arctic

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Sea ice predictability

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- **Sea ice area persistence 2-5 months**

- **Re-emergence up the 15 months (Blanchard-Wrigglesworth et al, 2011) : autumn-to-spring (memory in the thickness), spring-to-autumn (memory in the SST)**

- **Spring Arctic sea ice thickness precursor of end-of-summer sea ice extent (Chevallier and Salas-Melia, 2012)**

Potential for skilful interannual sea ice predictions if sea ice volume properly initialized

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Issue for initialization : sparse observational coverage

- **Before 1973 :**

  Arctic : monthly sea ice extent estimates

  Antarctic : climatologies 1929-1937 & 1947-1962

- **From 1973 : quasi weekly estimates of sea ice concentration, US Navy, Canadian, Danish aerial reconnaissance**

- **From 1978 : 2-day frequency later daily, gridded, 1°, satellite microwave imagery**

- **First sea ice thickness dataset in 2010 : submarine, ULS**

Need for consistent sea ice reconstruction over 1960-present

II - Methodology

Sea ice reconstruction

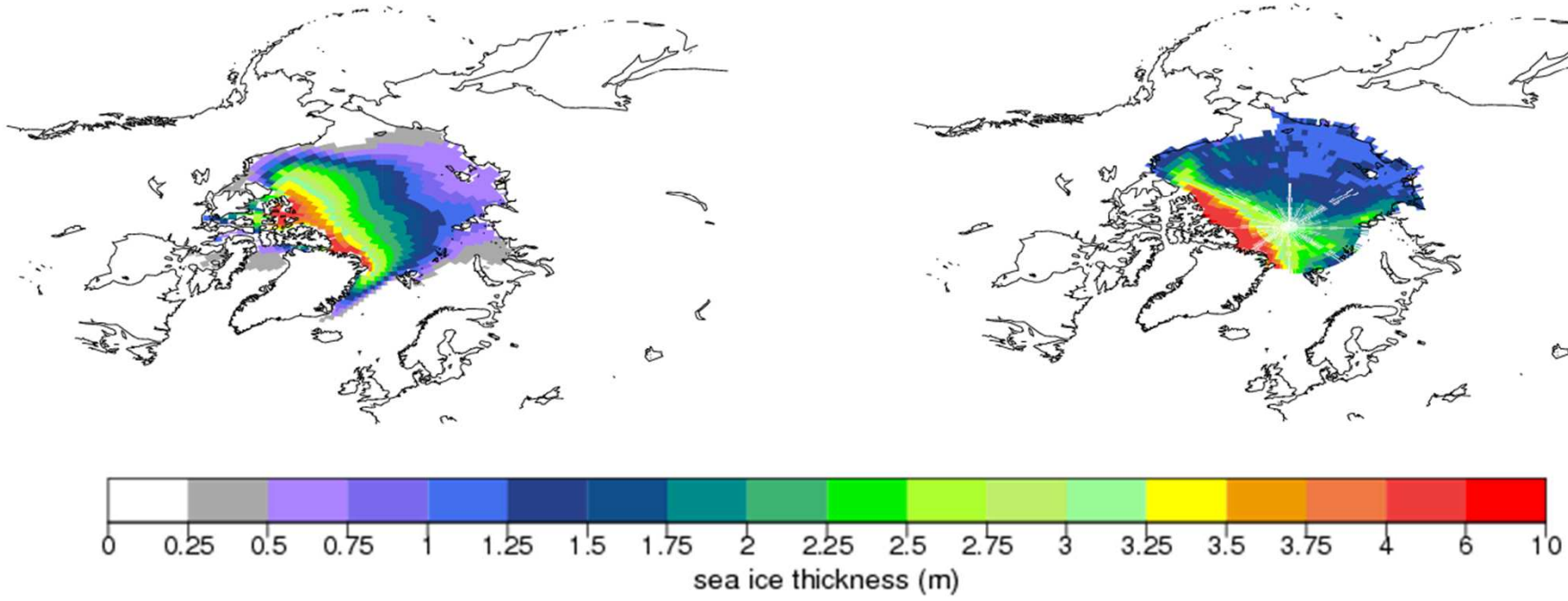
- **NEMO3.2 ocean model + LIM2 sea ice model**
- **Forcings : 1958-2006 DFS4.3 or 1979-2013 ERA-interim**
- **Nudging : T and S toward ORAS4, timescales = 360 days below 800m, and 10 days above except in the mixed layer, except at the equator (1°S-1°N), SST & SSS restoring (-40W/m2, -150 mm/day/psu)**
- **Wind perturbations + 5-member ORAS4 - - - > 5 members for sea ice reconstruction**

5 member sea ice reconstruction for 1958-present consistent with ocean and atmosphere states used for initialization

October-November Arctic sea thickness

Reconstruction

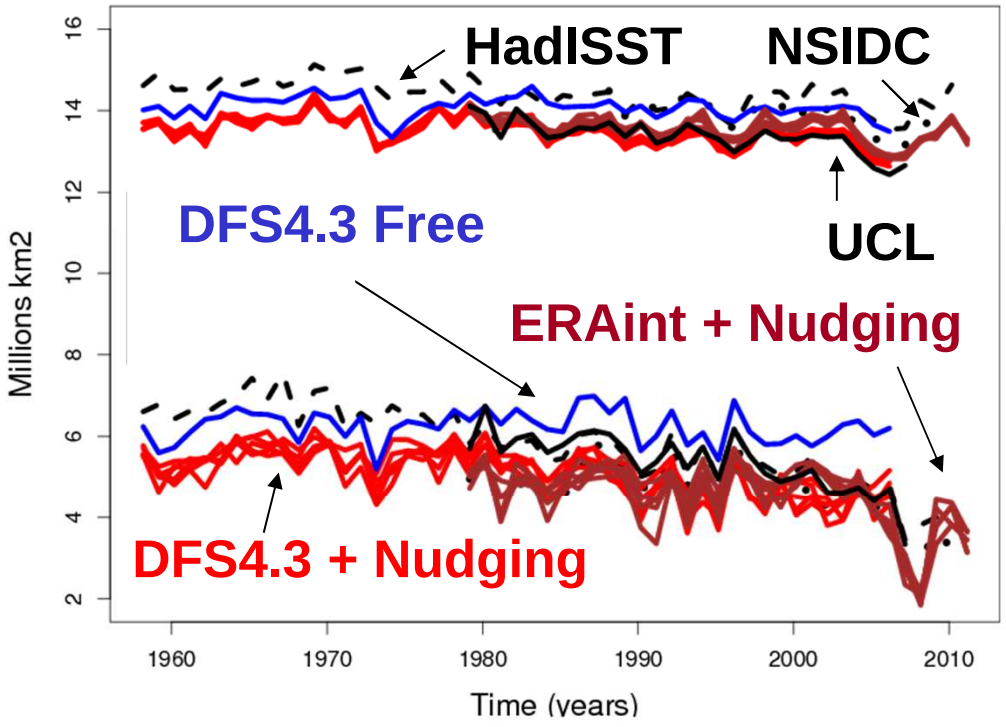
IceSat



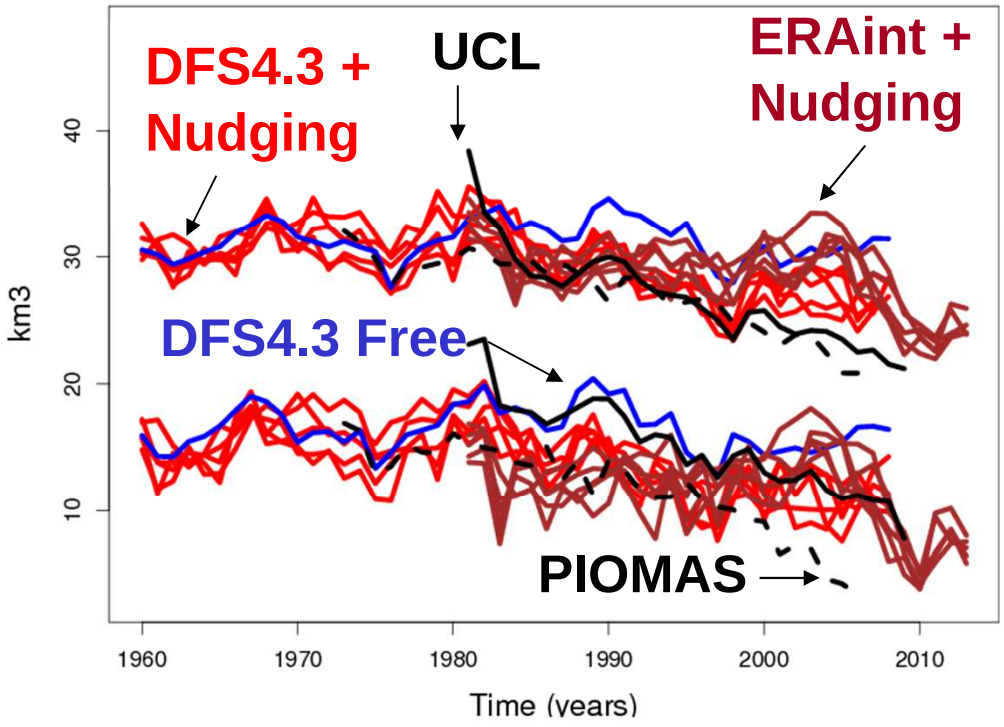
Too much ice in central Arctic, too few in the Chukchi and East Siberian Seas

March and September Arctic sea ice

Sea ice area



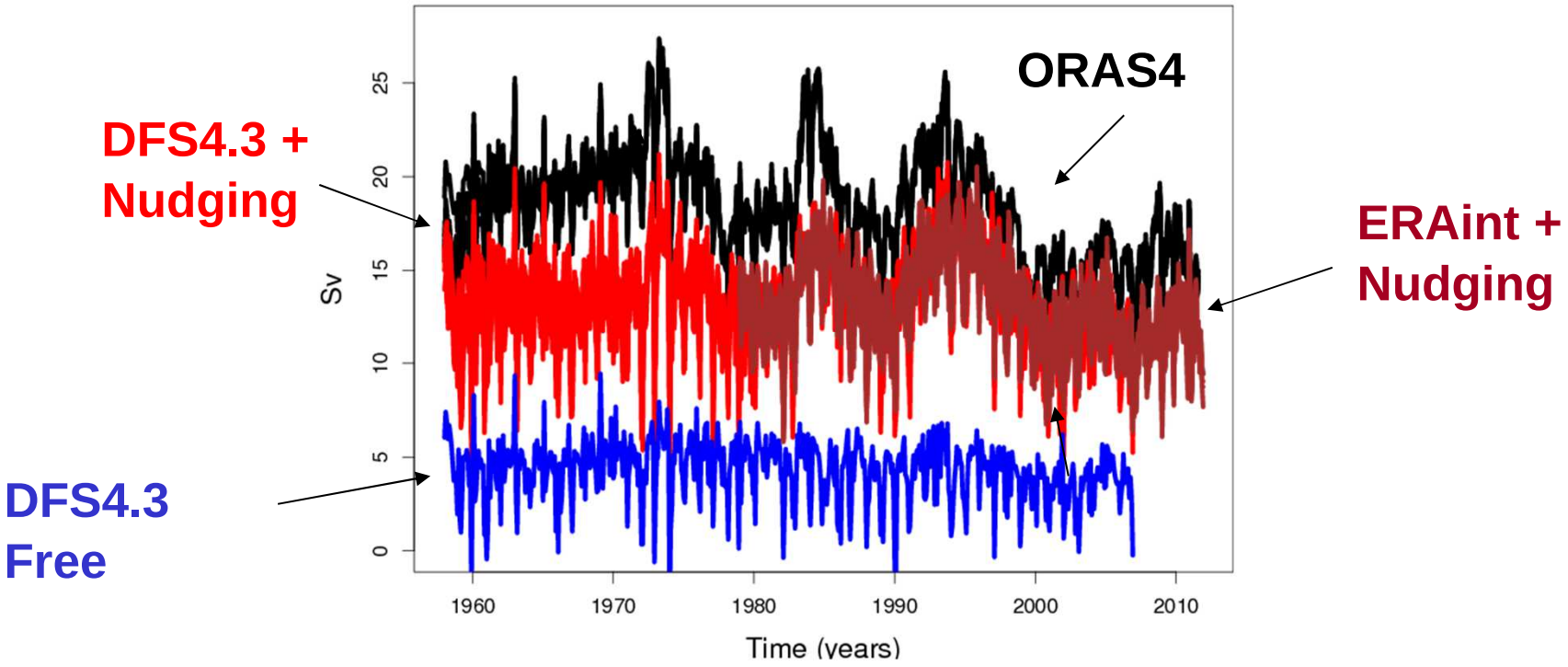
Sea ice volume



Bias but reasonable agreement in terms of interannual variability

Atlantic Meridional Overturning Circulation

Overturning Streamfunction 40-55N, 1-2km



Ocean nudging allows capturing decadal variability in AMOC and warm inflow in the Barents Sea

IV - Forecasts

Climate predictions initialized from those sea ice conditions

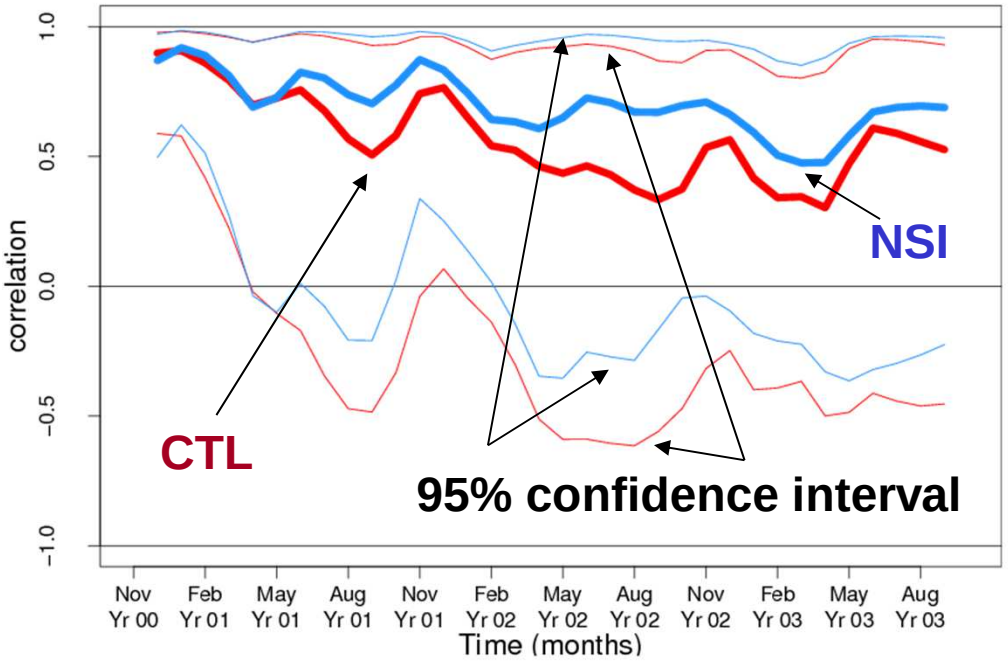
- **Initialization every 2 years from 1960 to 2004 + 1965 + 1975 + 1985 + 1995 + 2005 on 1 November = 28 forecasts**
- **Ocean from ORAS4, Atmosphere from ERA40/ERAInt, Sea ice from our 5-member reconstruction, full-field initialization**
- **3-year forecasts performed with EC-Earth 2.3**
- **Sensitivity experiment with New Sea Ice initial conditions = NSI is compared to previous CMIP5 contribution = CTL initialized from a NEMO2-LIM2 simulation forced by DFS4.3**

Assessment of the benefits of using our new sea ice initial conditions by comparing NSI to CTL

V - Forecast skill

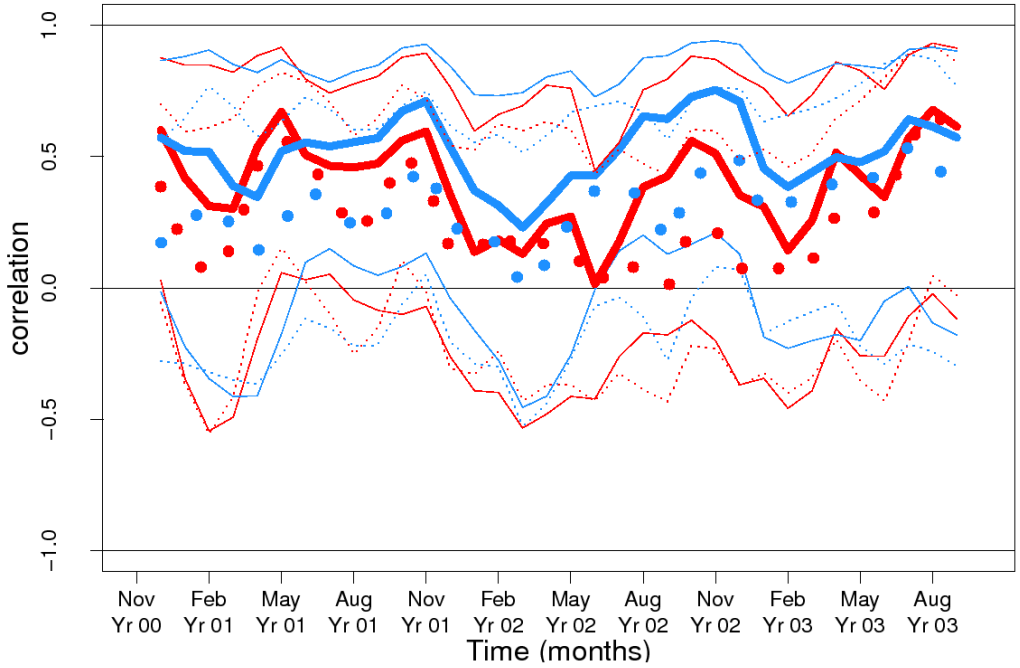
Improved forecast skill in the Arctic

Correlation Arctic sea ice area



Reference: HadISST

Correlation 2m temperature (60-90ºN)



Reference: NCEP (continuous)
ERA40 (dots)

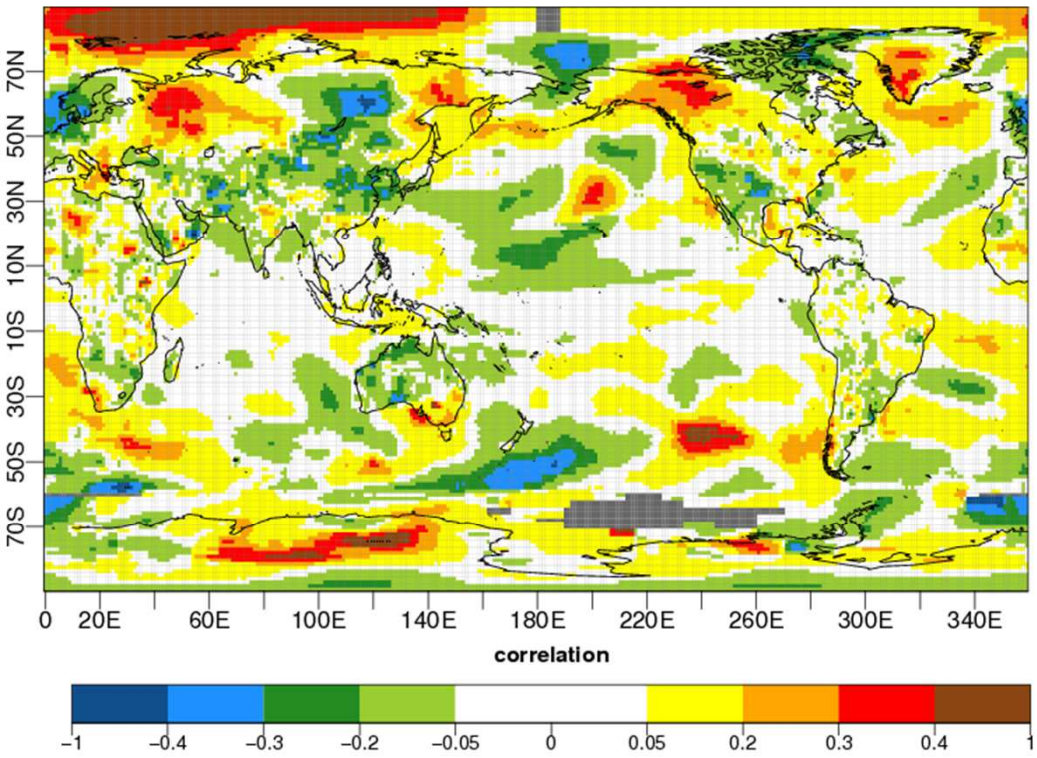
Although not significant, larger correlation in the Arctic region

V - Forecast skill

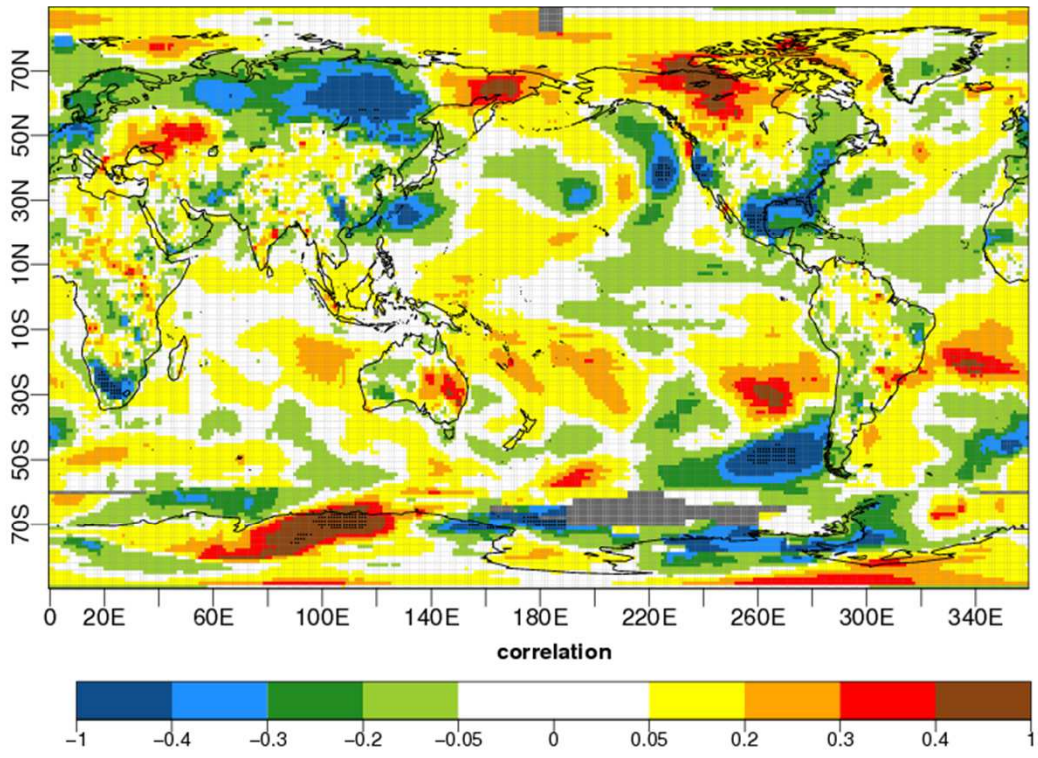
Improvement confined to the Arctic

2m temperature

Correlation NSI minus CTL Year 1



Correlation NSI minus CTL Year 2



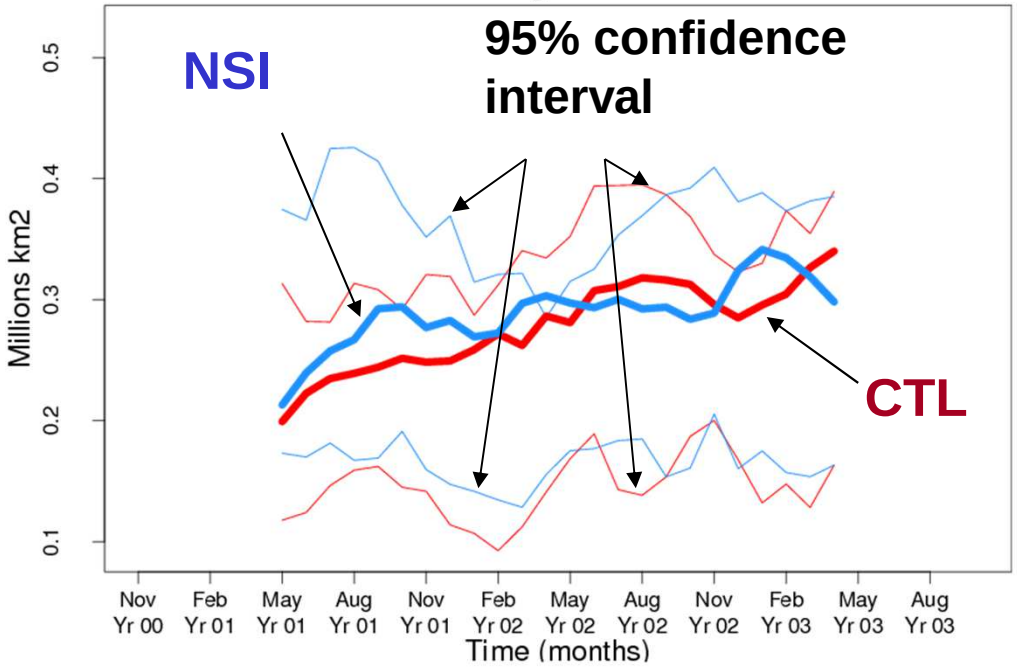
Reference: ERSST over seas + GHCN over land except poleward of 60º GISSTEMP

Nothing significant but improvement all over the Arctic

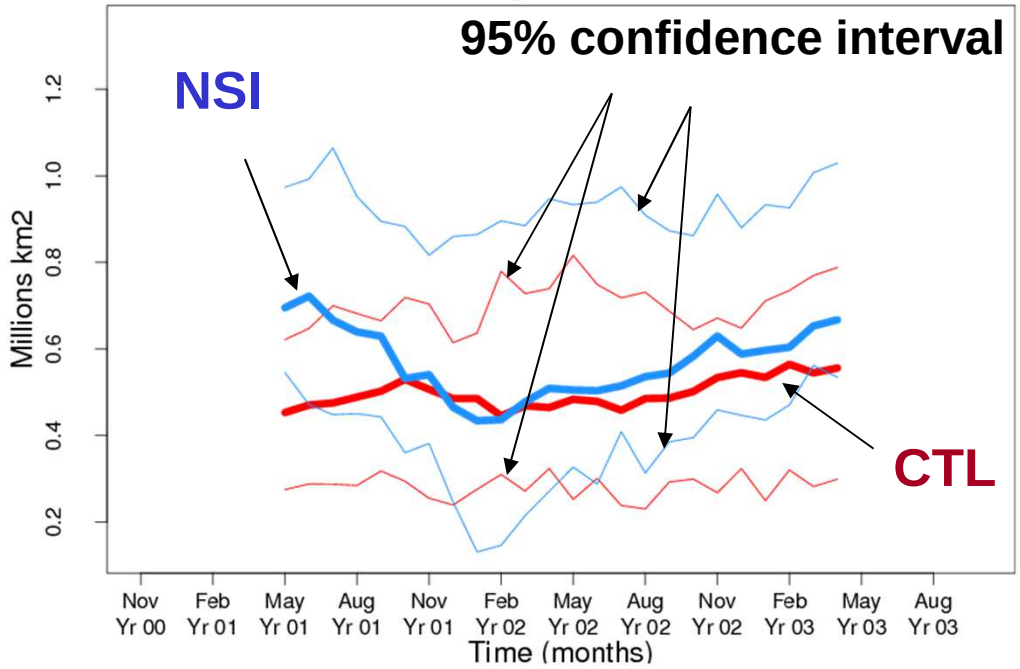
VI - Spread

Interquartile Range of the ensemble members around the ensemble-mean

Arctic Sea Ice Area



Antarctic Sea Ice Area



Larger spread between members for sea ice variables

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Ratio SD (members) / RMSE (ensemble-mean)

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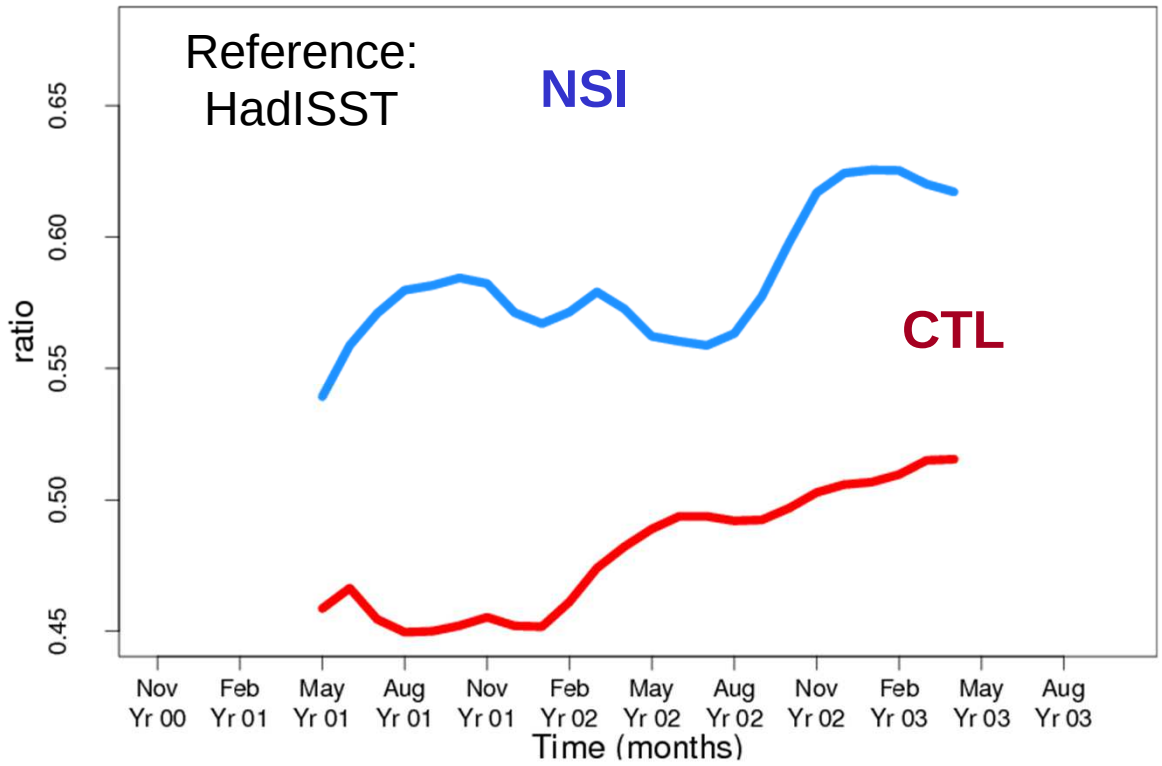
Arctic Sea Ice Area



Spread between the ensemble members closer to RMSE of the ensemble-mean

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Conclusions

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5-member Sea Ice Reconstruction:

- **Sea ice state consistent with ocean and atmosphere states**
- **Too much sea ice in the central Arctic, too few in the Chukchi and East Siberian Seas**
- **Reasonable agreement of the Arctic sea ice interannual variability with observational datasets**

Climate predictions initialized from this 5-member reconstruction:

- **Although the differences are not significant, the correlation is increased for Arctic sea ice area and 2m temperature**
- **The increase in correlation for 2m temperature is confined to the Arctic**
- **The spread between members is larger for sea ice variables, thus more representative of the forecast error**

Thank you very much for your attention

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