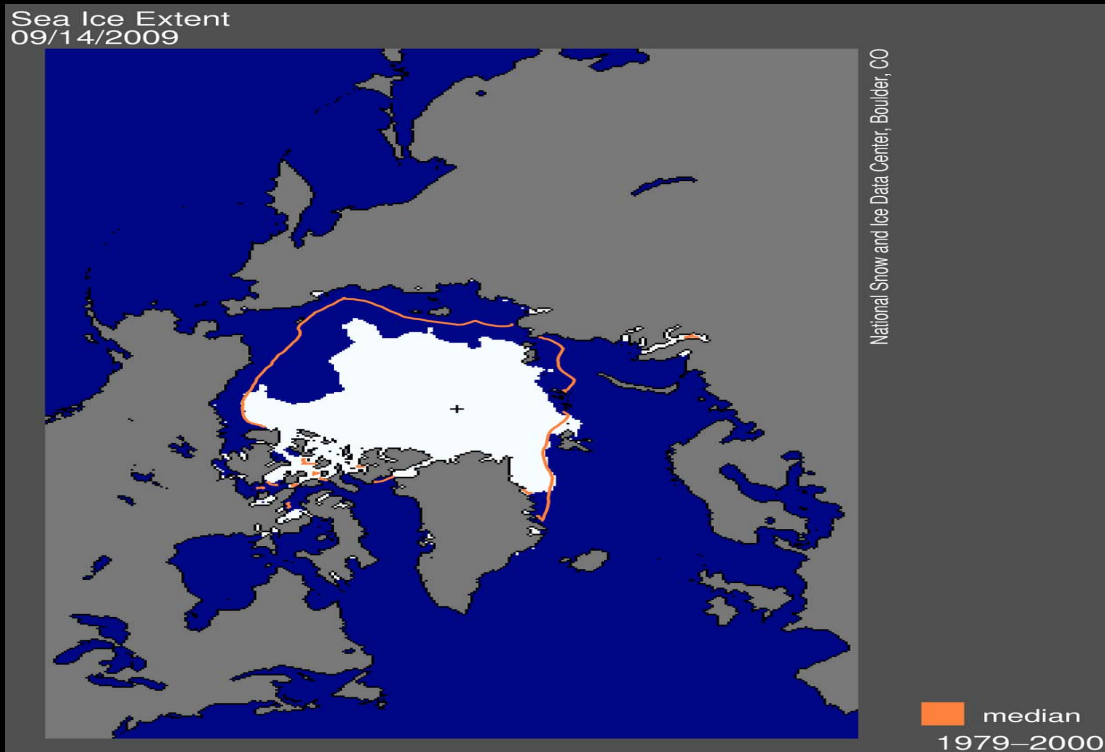
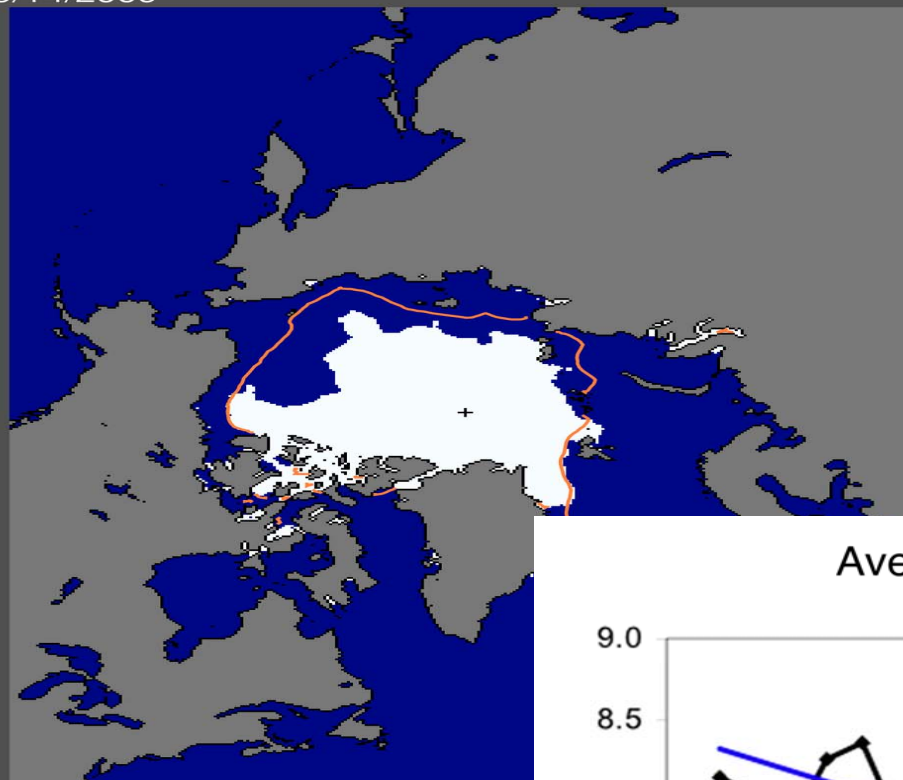


Regional Modelling of Arctic Climate

in recent and possible future climates

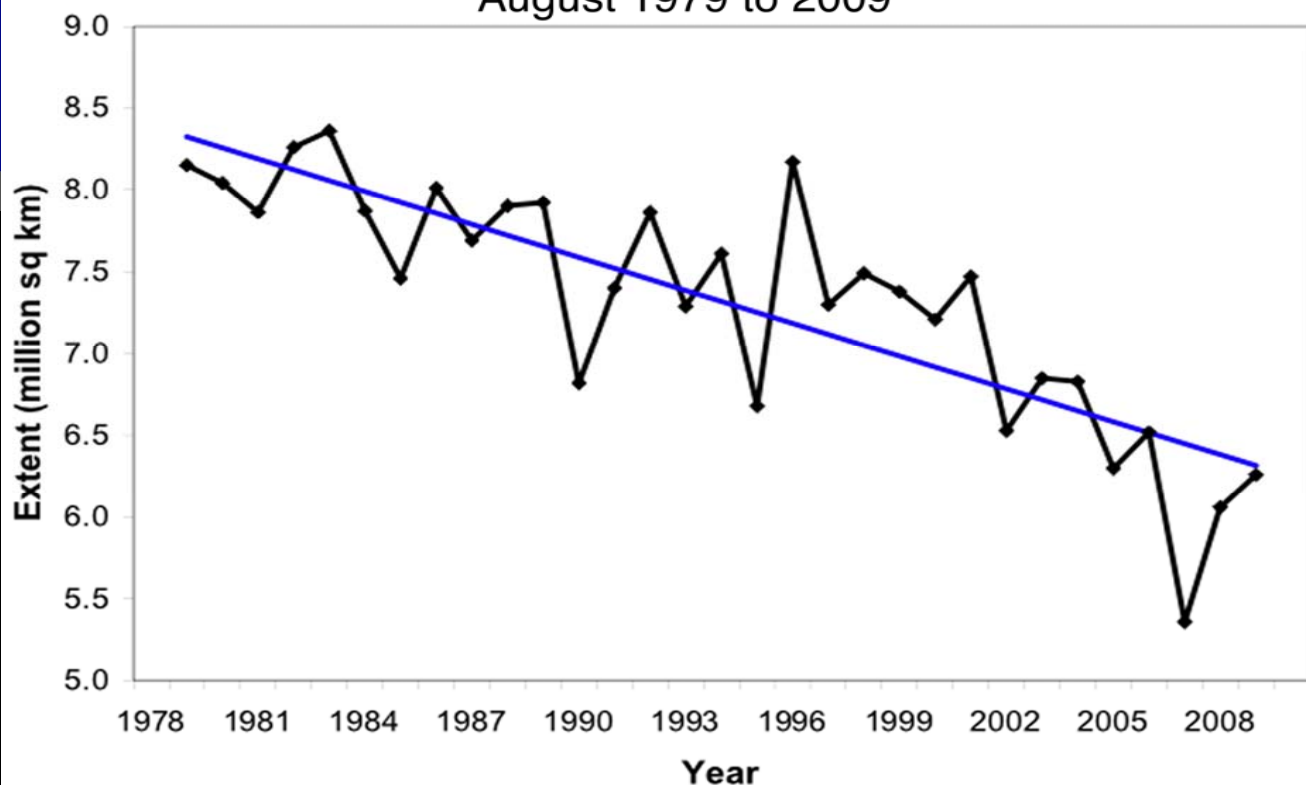
Ralf Döscher, Torben Königk and the Rossby Centre





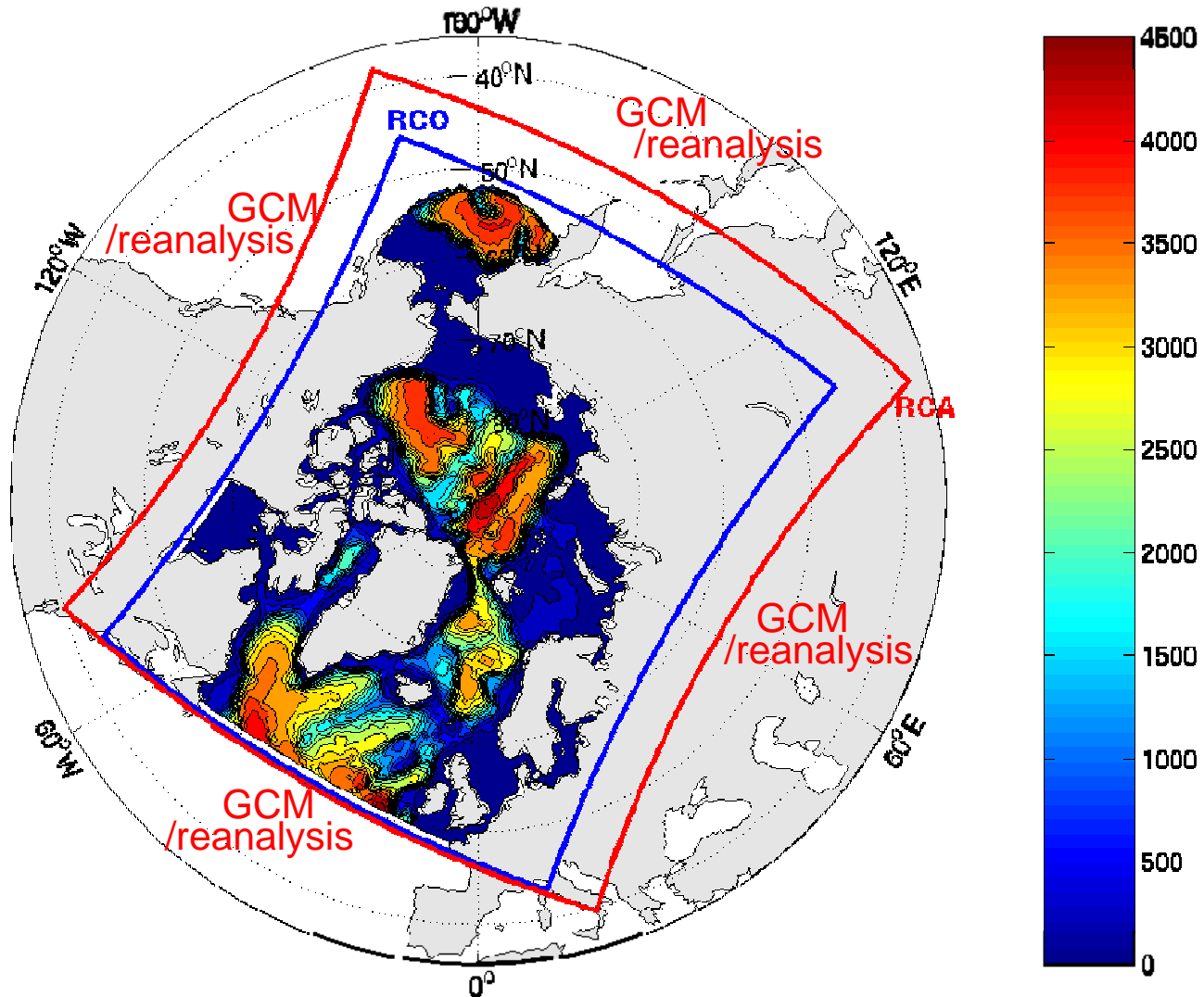
National Snow and Ice Data Center, Boulder, CO

Average Monthly Arctic Sea Ice Extent
August 1979 to 2009

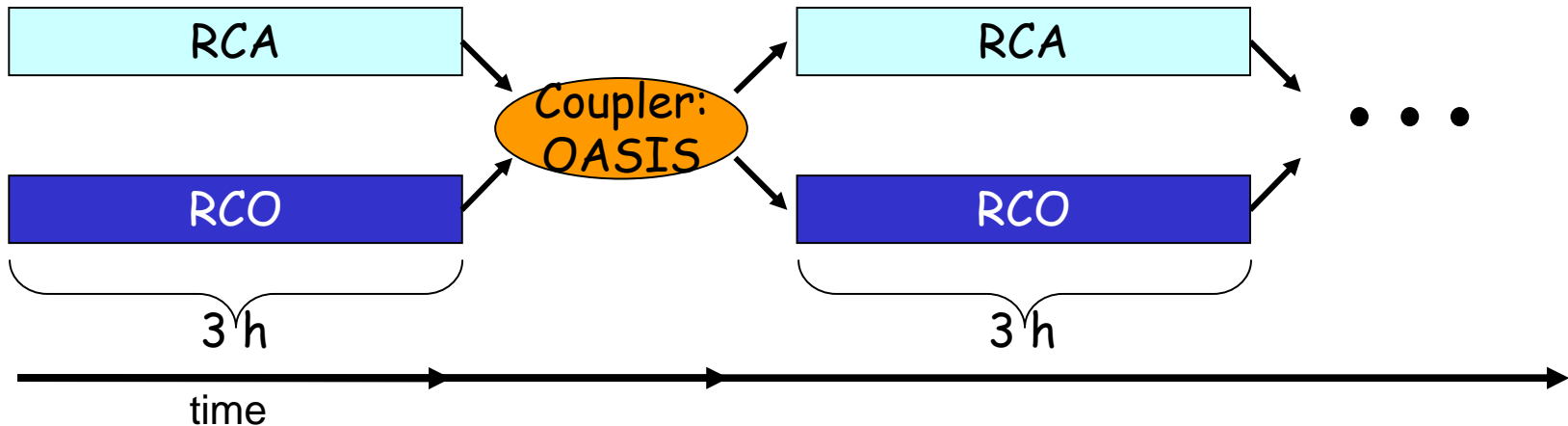
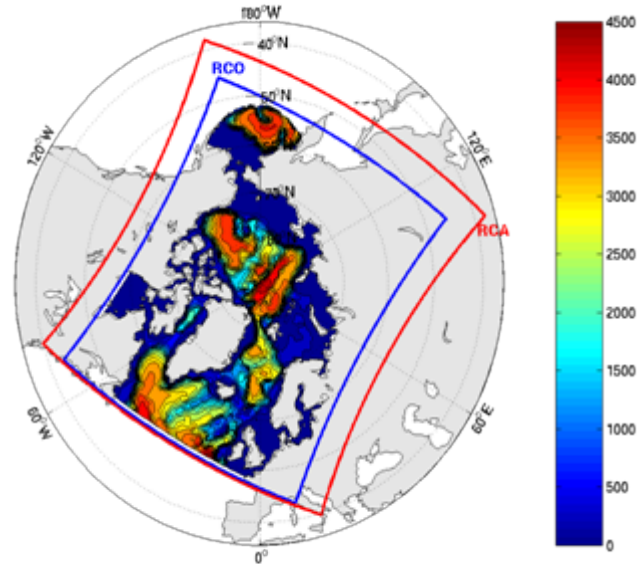


National Snow and Ice Data Center

Regional downscaling

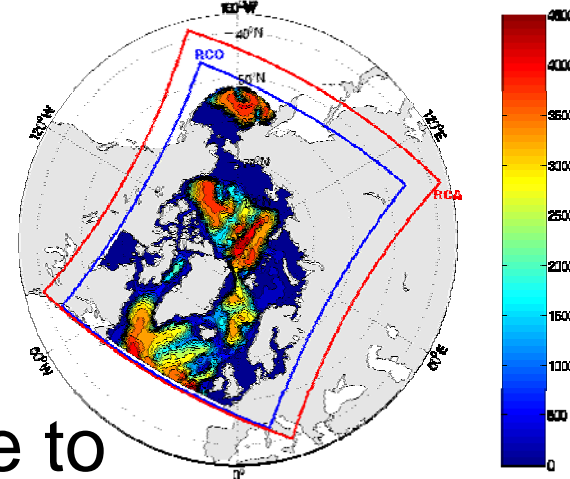


Coupled climate model setup

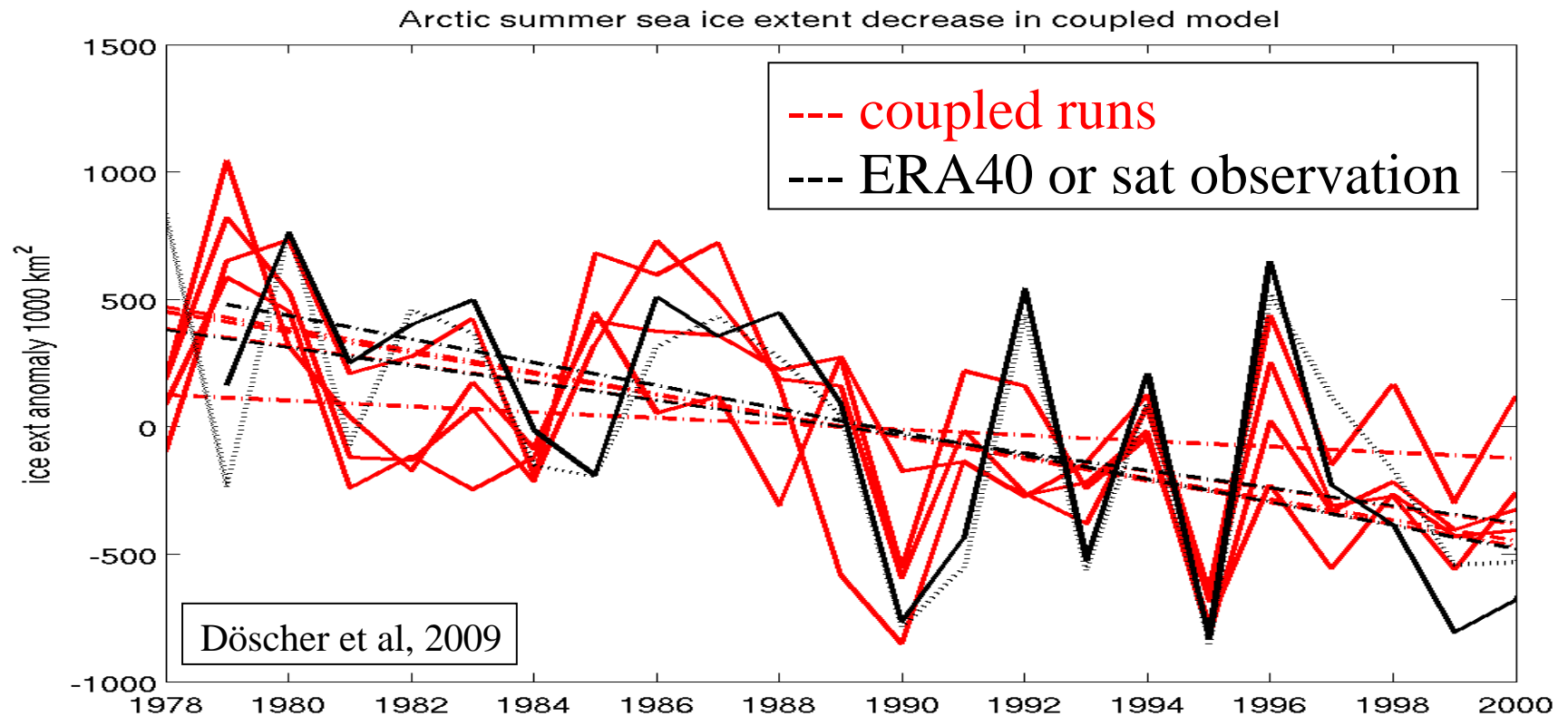
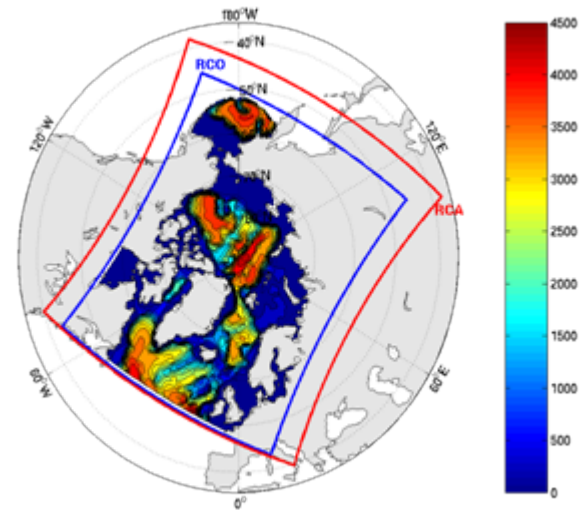


The rationale of regional downscaling

- RCM as a dynamic magnifier due to
 - higher resolution
 - Better representation of orography/topography
 - Regionally better adjusted parameterization (chance to development of more universal parameterizations)
- Process studies under controlled large scale conditions
- Better description of regional conditions together with uncertainties (pdfs)
 - More appropriate input to local impact studies
- Development of parameterizations for the next generation global climate model (GCM)



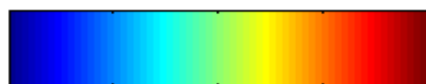
Regional process studies: Simulated summer sea ice extent



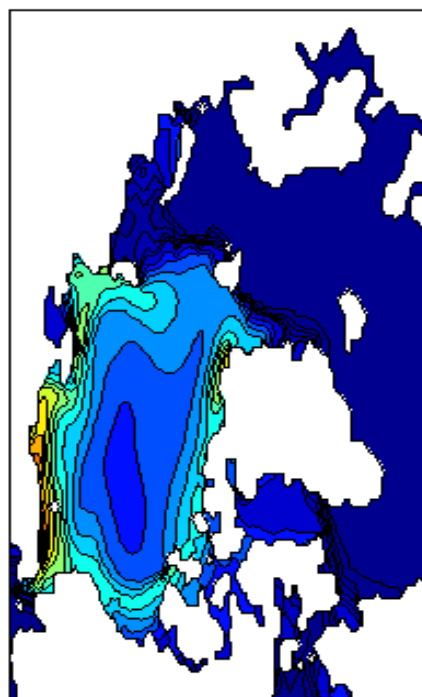
Quantifying Arctic Contributions to Climate Predictability

- summer sea ice thickness -

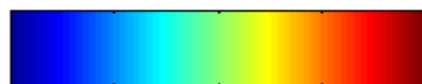
0 20 40 60 80



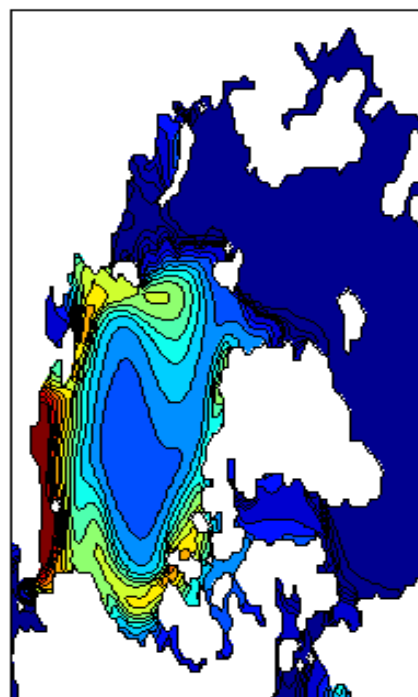
internal 1980 - 2000



0 20 40 60 80



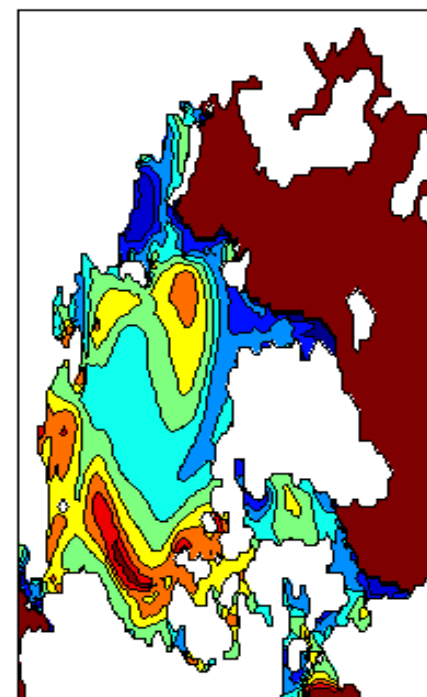
external 1980 - 2000



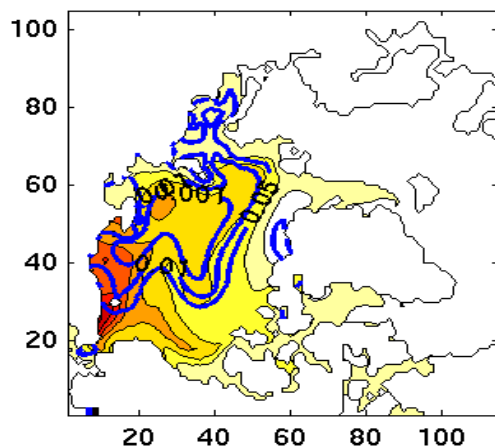
0.5 1 1.5 2



signal/noise 1980 - 2000



Summer thickness trend

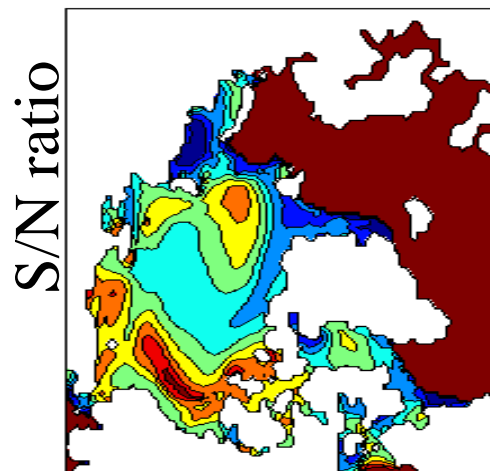


Sea ice thickness trend and attribution

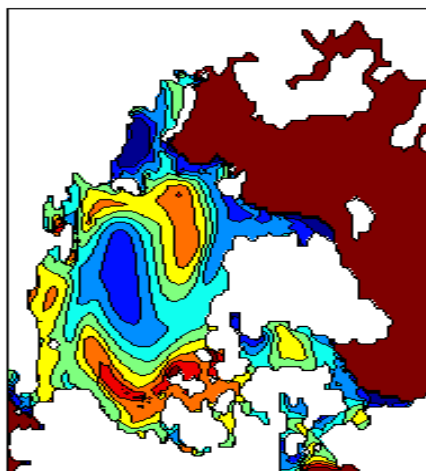
Döscher et al, 2009



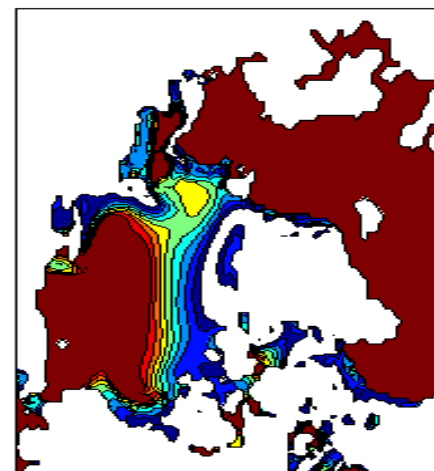
regular summer 1980 - 2000



detrended summer 1980 - 2000

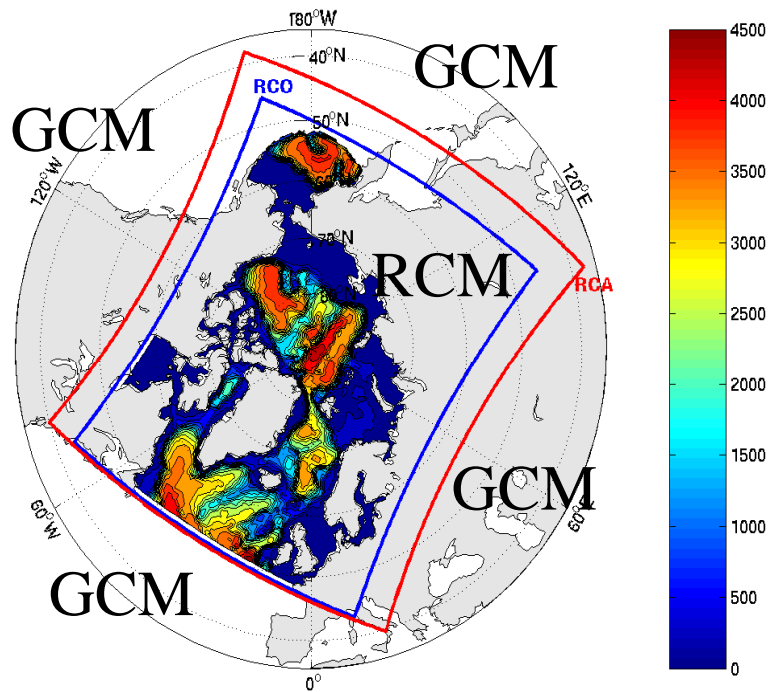


trend summer 1980 - 2000

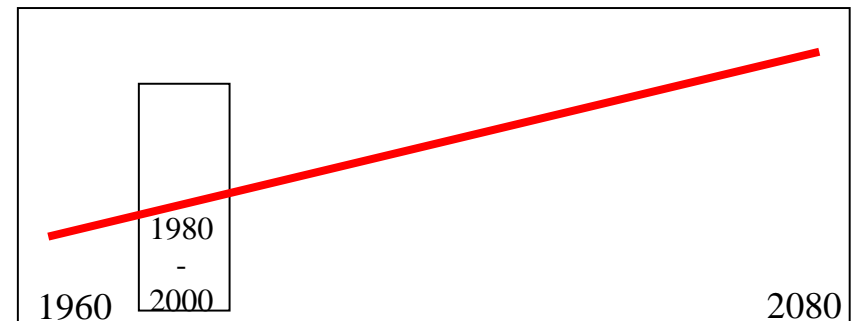


Ice thickness trend: significant and controlled by external forcing

Climate Scenario Experiments - Dynamic Regional Downscaling -

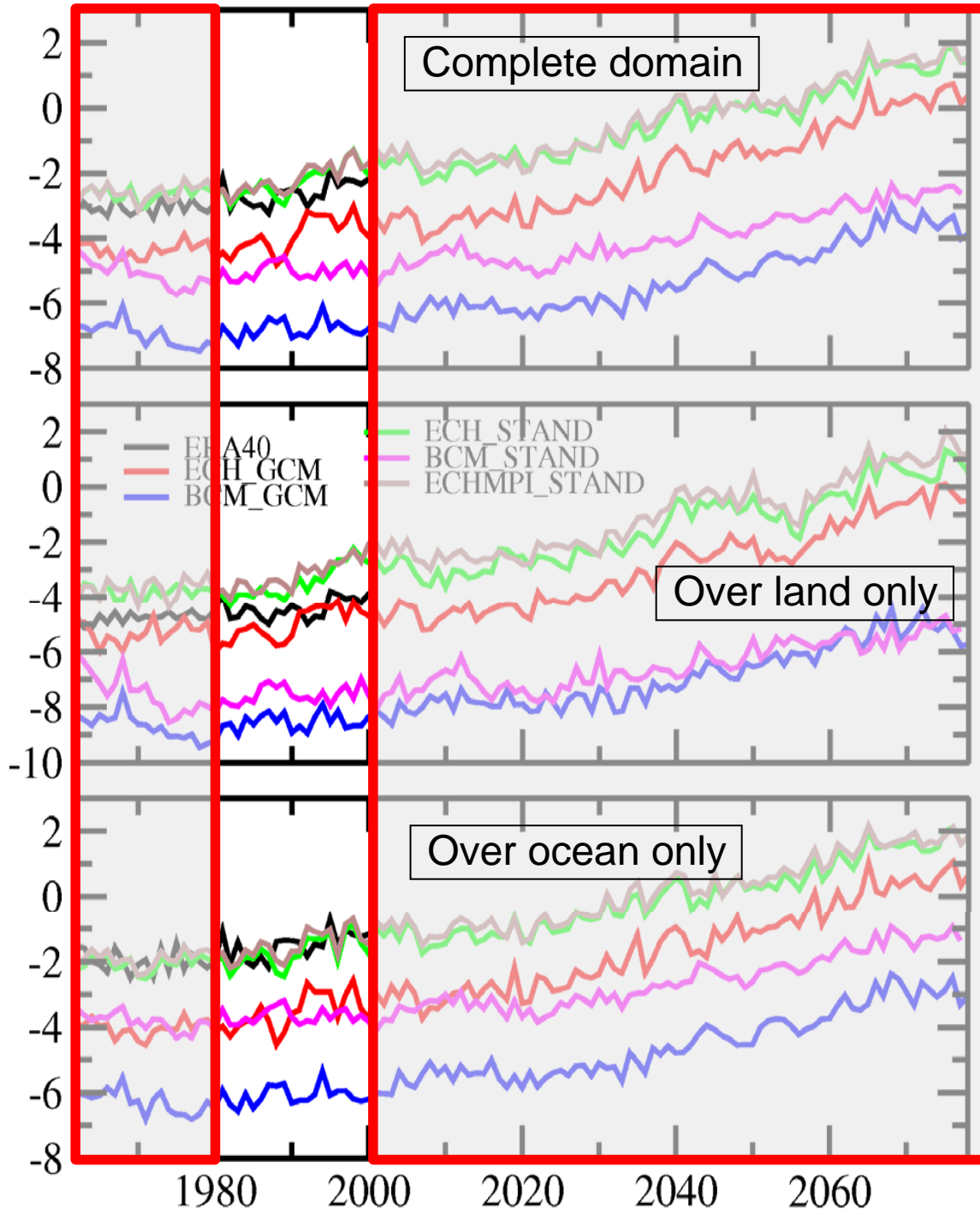


- GCMs:
 - ECHAM5/MPI-OM
 - BCM
- Greenhouse gas scenario:
 - A1B



Annual mean T2m

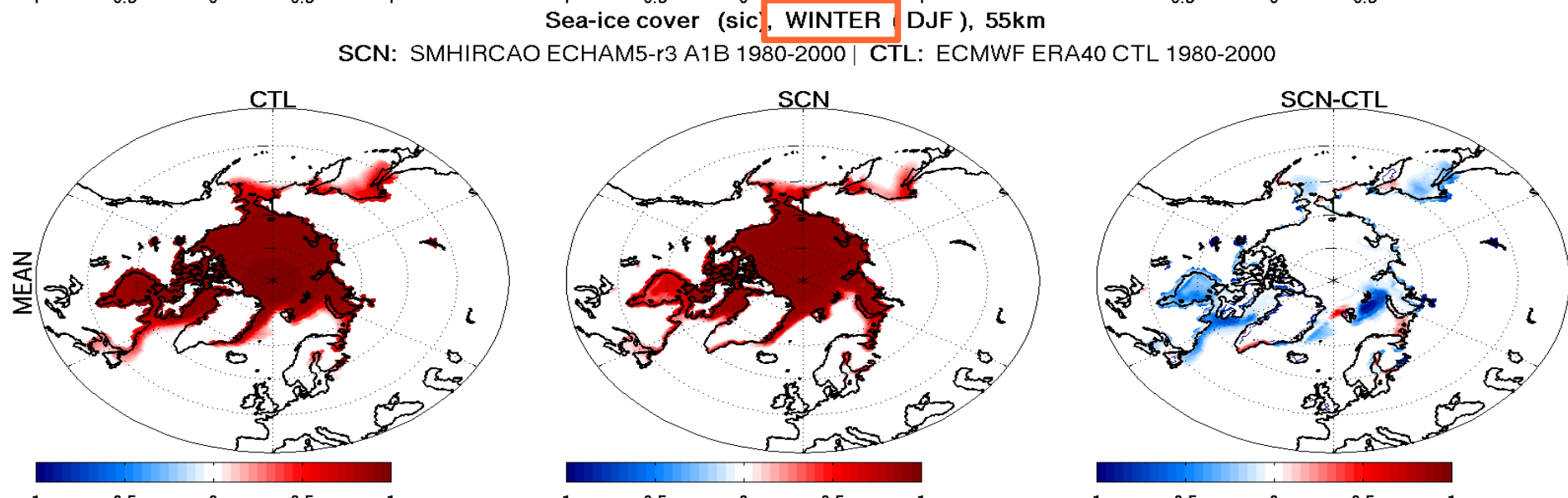
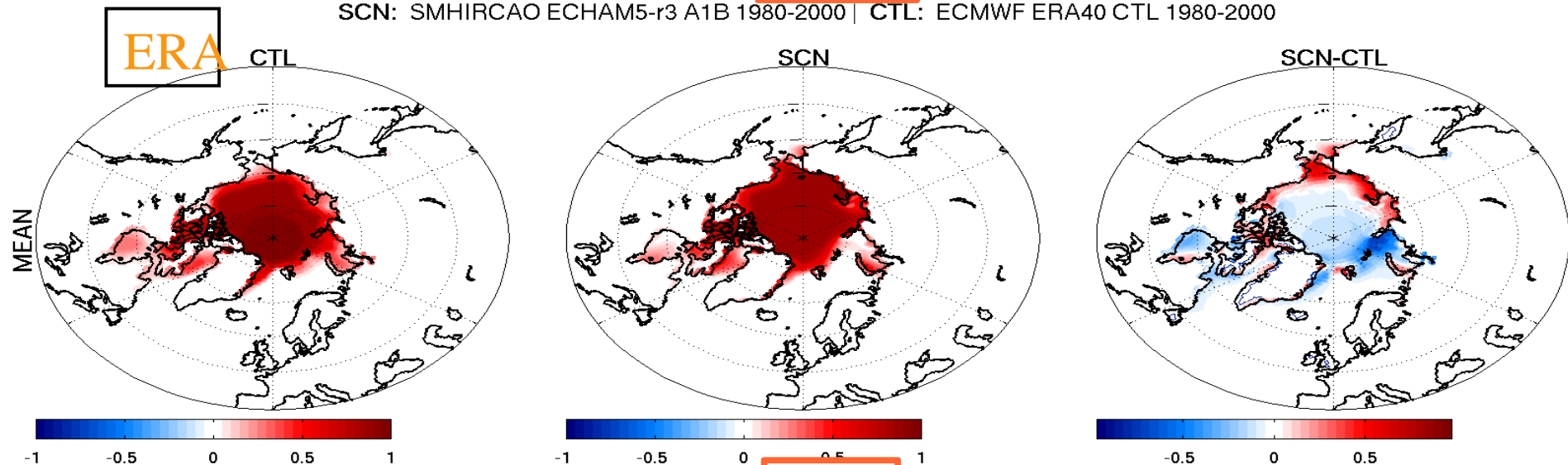
- Regional model air temperature is more realistic over the ocean



Sea Ice Concentration recent climate 1980-2000

Sea-ice cover (sic), SUMMER (JJA), 55km

SCN: SMHIRCAO ECHAM5-r3 A1B 1980-2000 | CTL: ECMWF ERA40 CTL 1980-2000

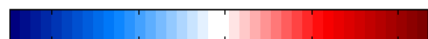
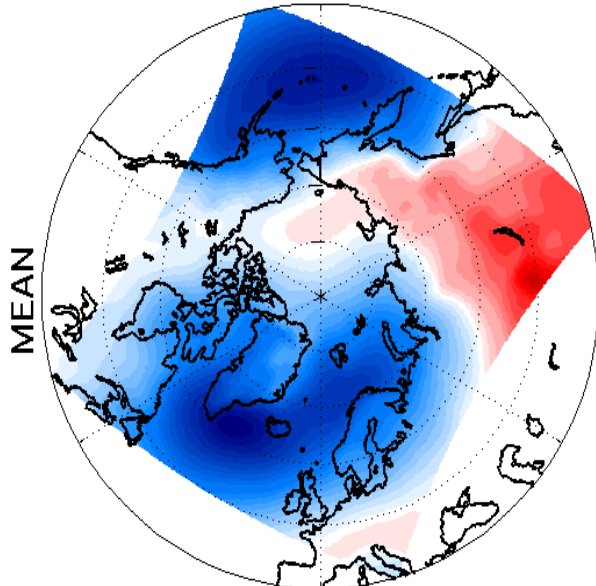


Scenario: quality control for recent climate

Mean sea level pressure (psl), WINTER (DJF), 55km

SCN: SMHIRCAO ECHAM5-r3 A1B 1980-2000 | CTL: ECMWF ERA40 CTL 1980-2000

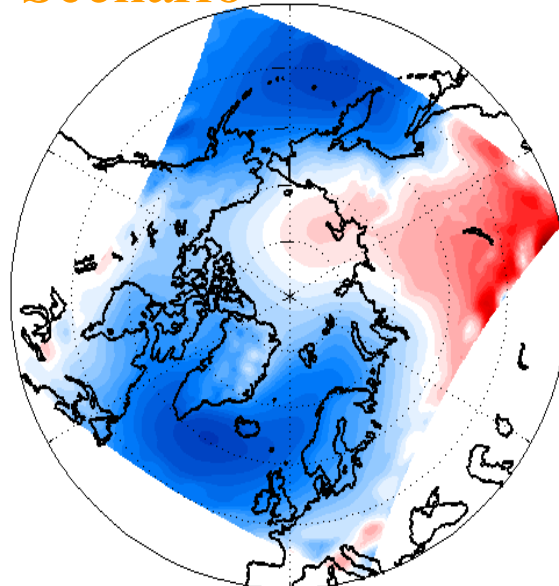
ERA CTL



1000 1010 1020 1030 1040

hPa

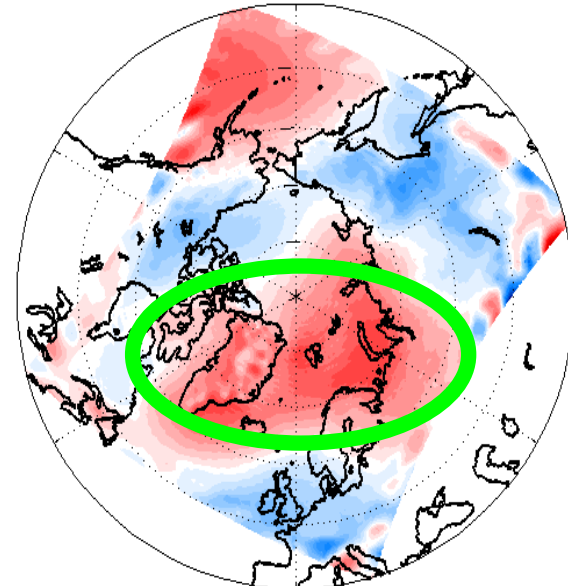
Scenario SCN



1000 1010 1020 1030 1040

hPa

Scenario – ERA
SCN-CTL

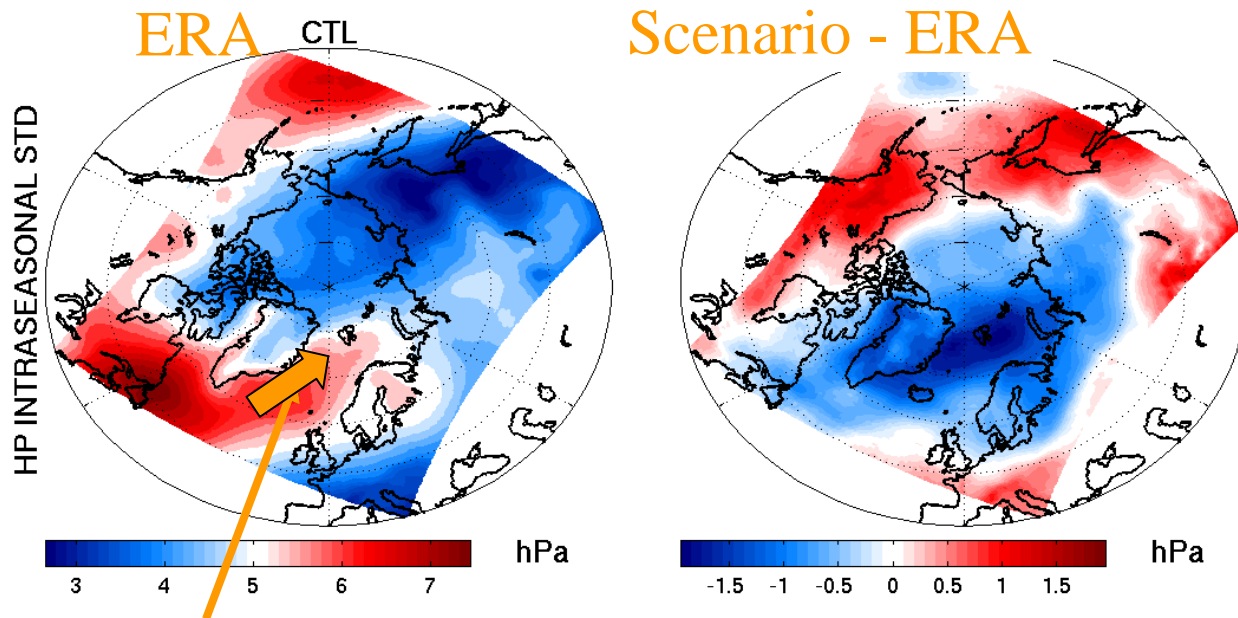


-15 -10 -5 0 5 10 15

hPa

Storm tracks:

standard deviation of HP filtered time series
(1day < T < 7 days)

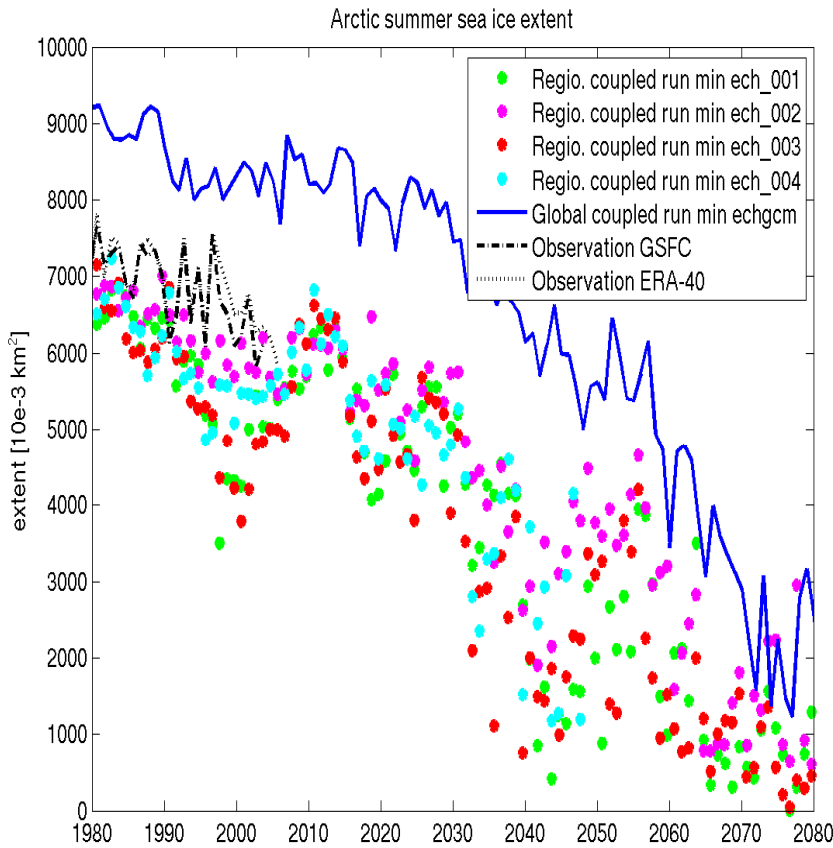


Storm track

High pressure bias can be explained by:

- Lack of low pressure transport into the Arctic via the storm track.
- Lack of transport adds up on longer than synoptic time scales
- Contributions due to over representation of persisting high pressure situations

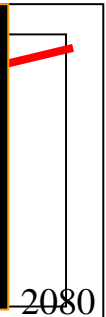
Climate Scenario Experiments - Dynamic Regional Downscaling -



The ensemble:

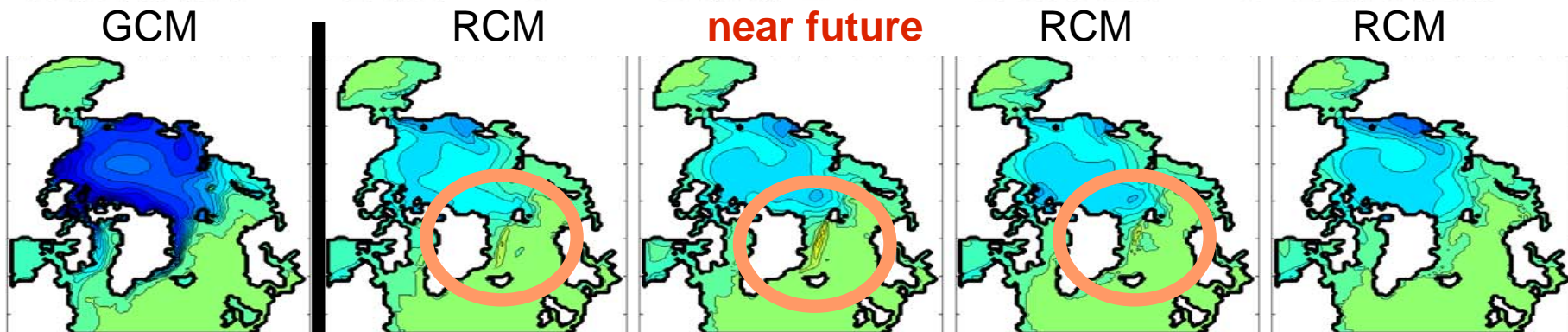
- Configuration with tick/thin ice
- SSS restoring vs salinity flux correction
- Ocean boundary condition climatological vs GCM forced

Rapid change events occur together with recovering
 Strong decadal variability
 Extent from RCM model more realistic than GCM

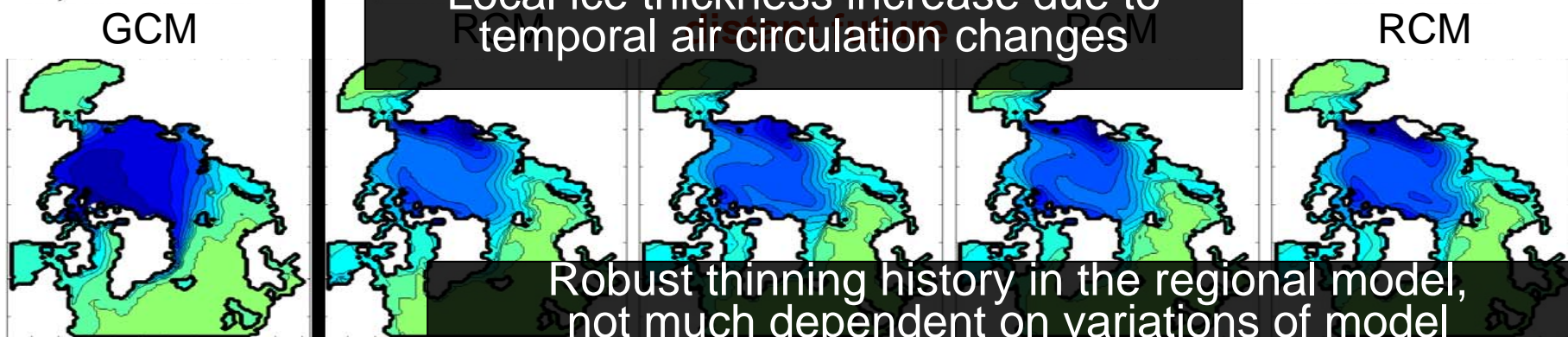


Sea ice thickness changes

a) Ice thickness, annual mean change, 2020-2040 - 1980-2000

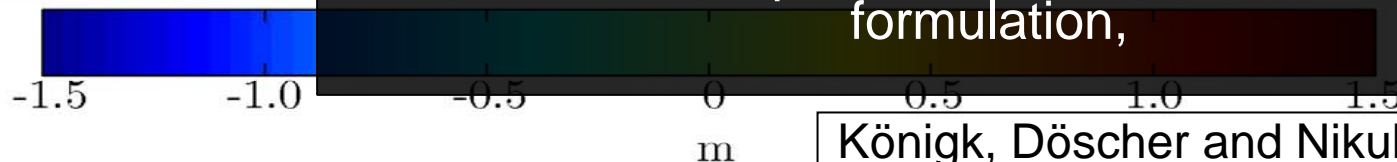


b) Ice thickness, annual mean change, 2060-2080 - 1980-2000



Local ice thickness increase due to temporal air circulation changes

Robust thinning history in the regional model, not much dependent on variations of model formulation,

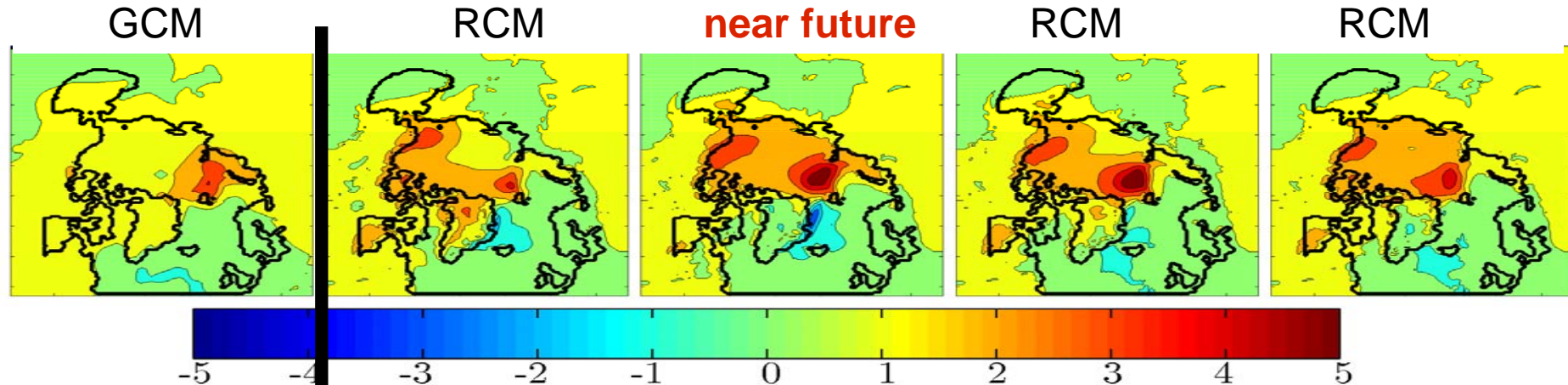


König, Döscher and Nikulin, submitted

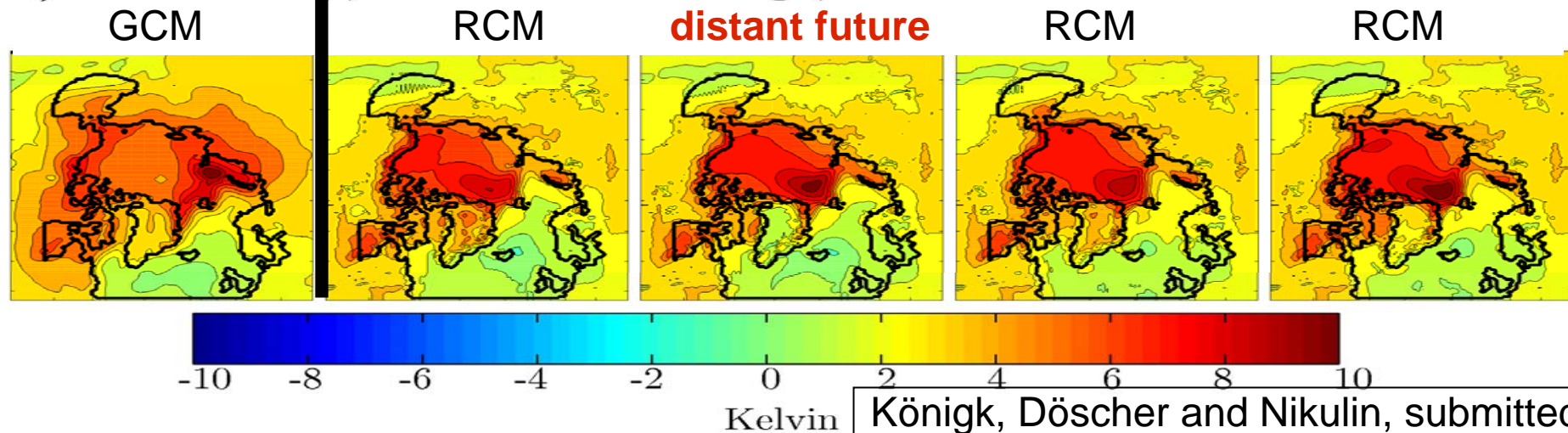
Annual mean ice thickness changes in meters between a) 2020-2040 and 1980-2000 and b) 2060-2080 and 1980-2000 in the regional and global ECH-simulations.

Air temperature changes

a) 2m air temp, annual mean change, 2020-2040 - 1980-2000



b) 2m air temp, annual mean change, 2060-2080 - 1980-2000

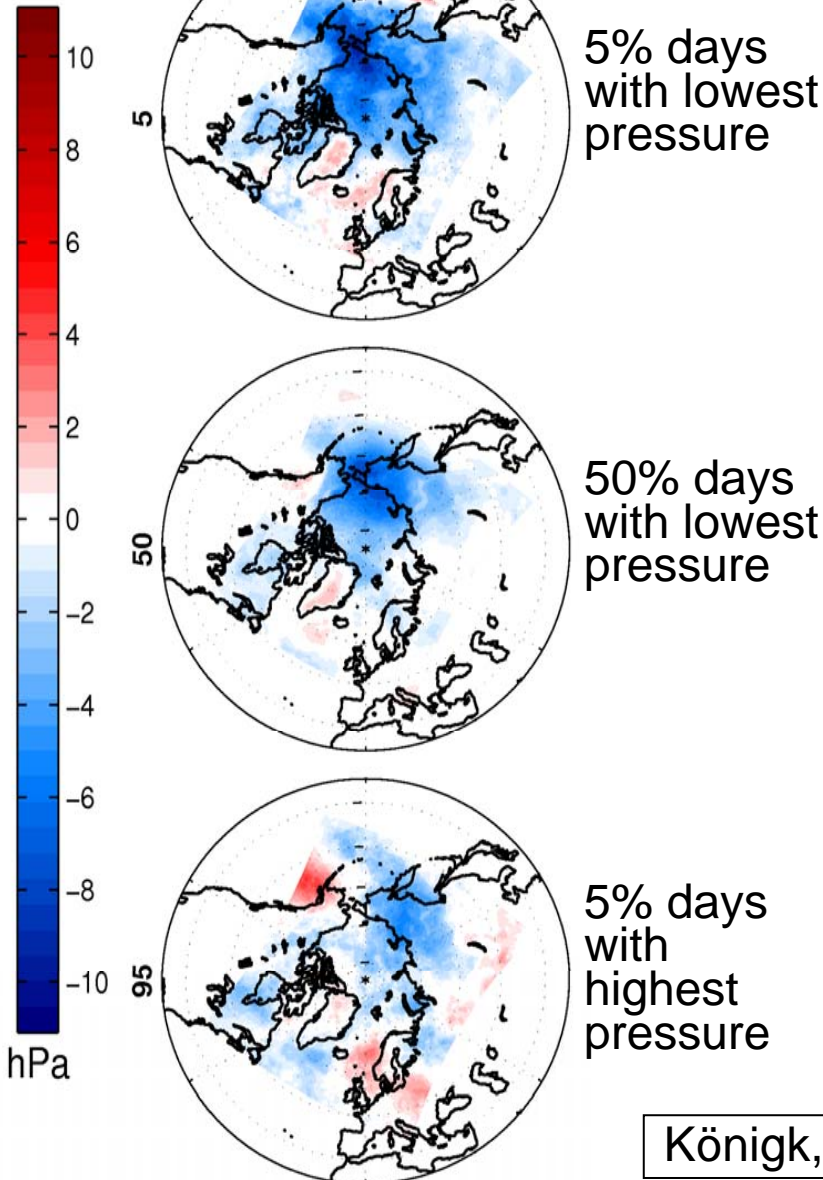


König, Döscher and Nikulin, submitted

Annual mean 2m air temperature changes in Kelvin in the Arctic between a) 2020-2040 and 1980-2000 and b) 2060-2080 and 1980-2000 in the global and regional ECH-simulations.

winter DJF

Extremes



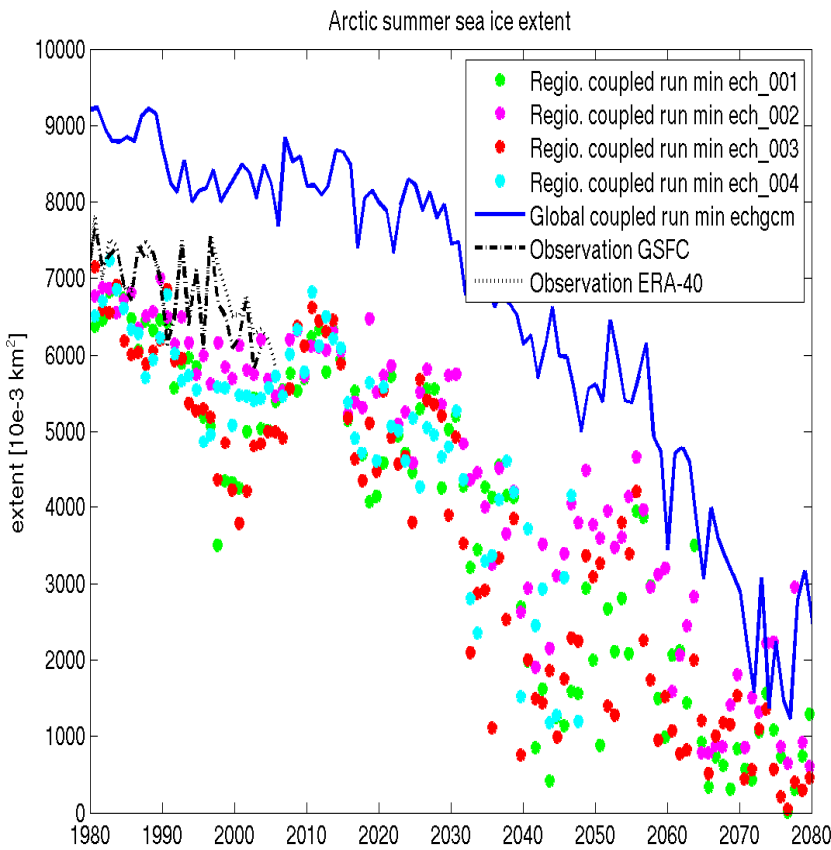
=> For extremely low pressure days, future pressure will be even more reduced: higher frequency of low pressure systems over thinner ice.

=> **increased storminess**

=> **strongest storms get even stronger**




Changes in daily extremes of SLP between 2060-2080 and 1980-2000 in ECHstand in winter and summer: Top: Changes of SLP in the 5% days with lowest SLP, middle: 50% mean change, bottom: 5% days with highest SLP.

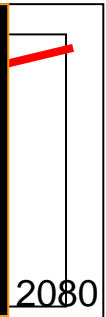
Climate Scenario Experiments - Dynamic Regional Downscaling -



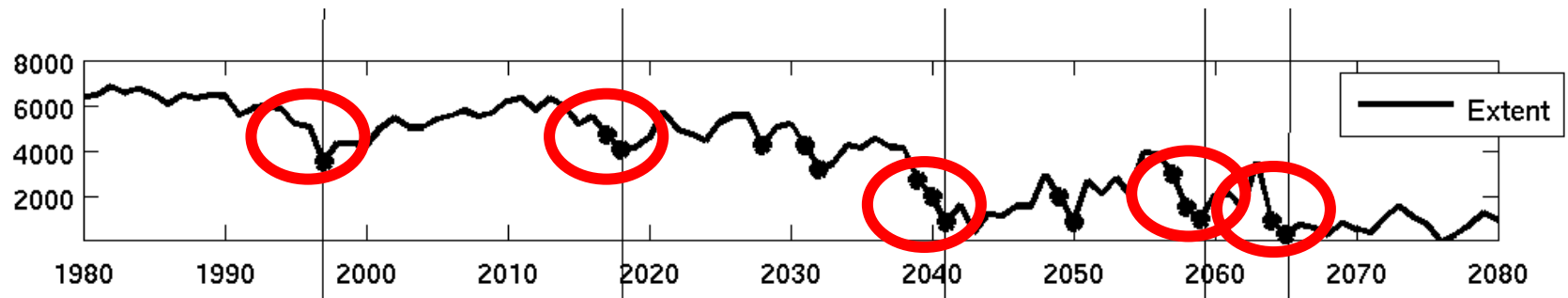
The ensemble:

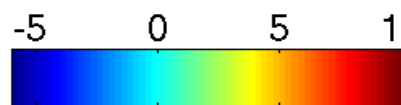
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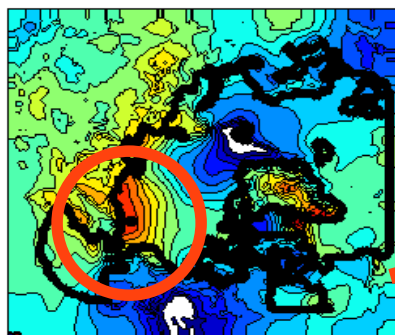


Rapid sea ice reduction events

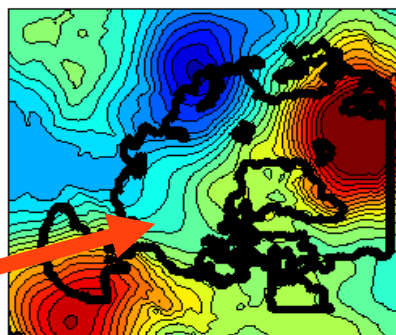




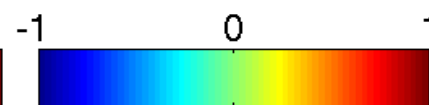
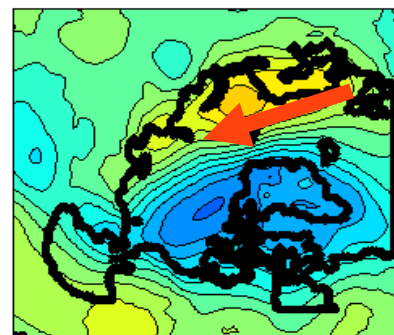
d(T2M) winter



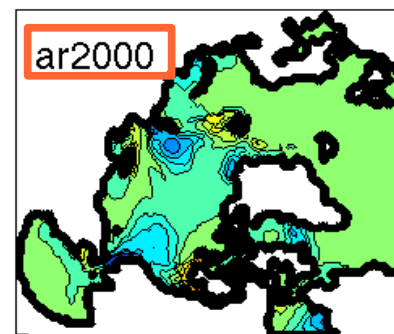
d(SLP) winter



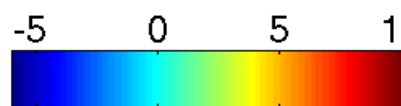
d(SLP) summer



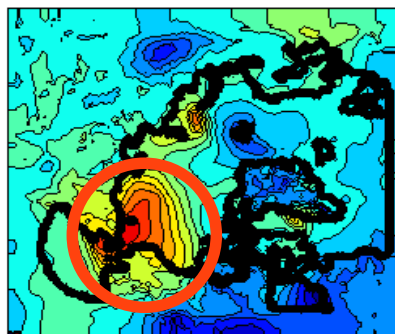
d(ice conc) summer



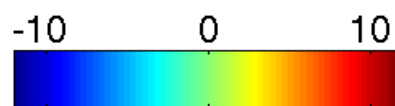
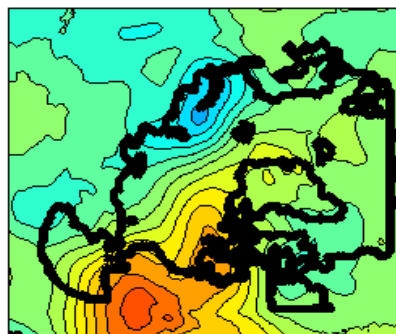
Summer driven



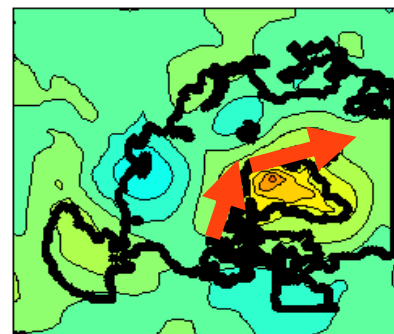
d(T2M) winter



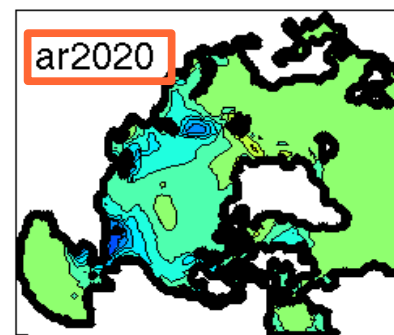
d(SLP) winter



d(SLP) summer



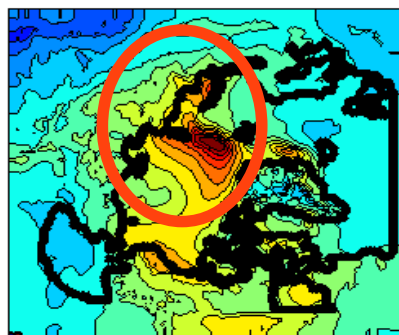
d(ice conc) summer



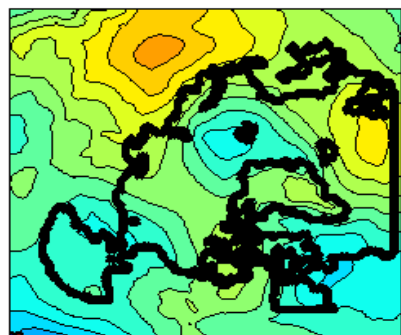
Summer/winter driven



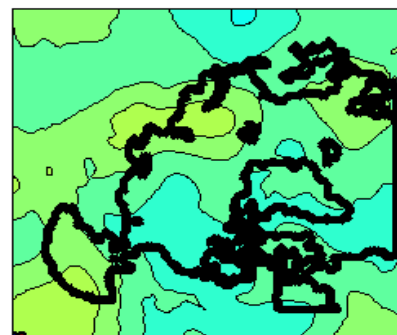
d(T2M) winter



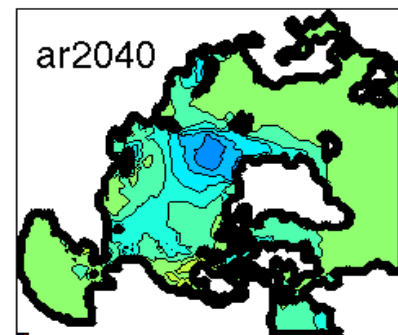
d(SLP) winter



d(SLP) summer



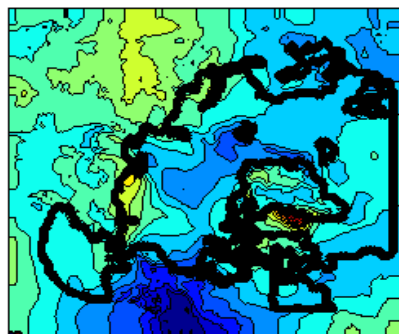
d(ice conc) summer



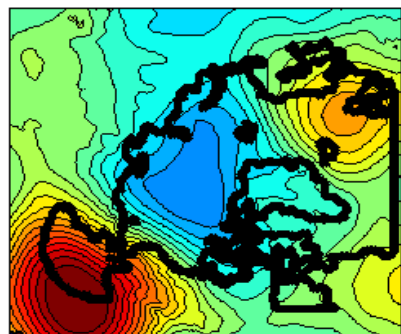
winter driven



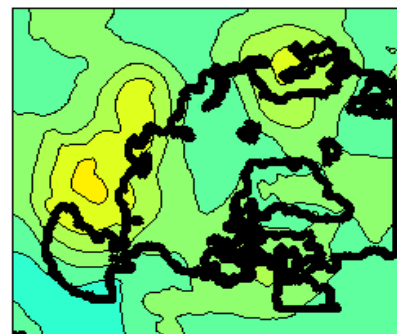
d(T2M) winter



d(SLP) winter

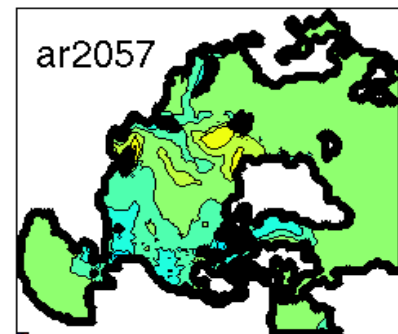


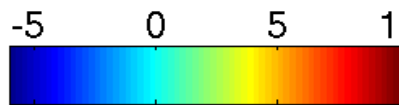
d(SLP) summer



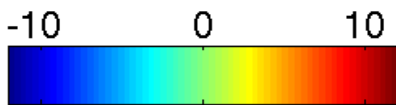
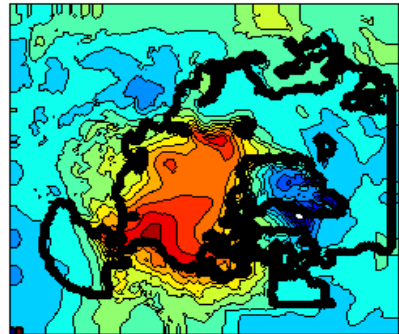
? driven

d(ice conc) summer

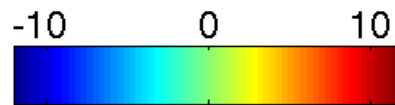
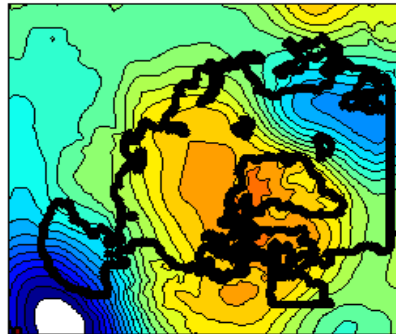




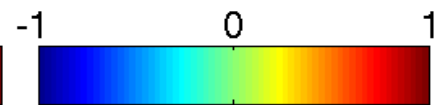
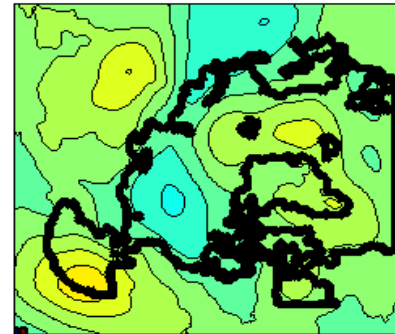
d(T2M) winter



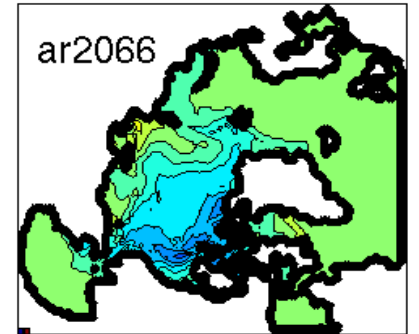
d(SLP) winter



d(SLP) summer



d(ice conc) summer



winter driven

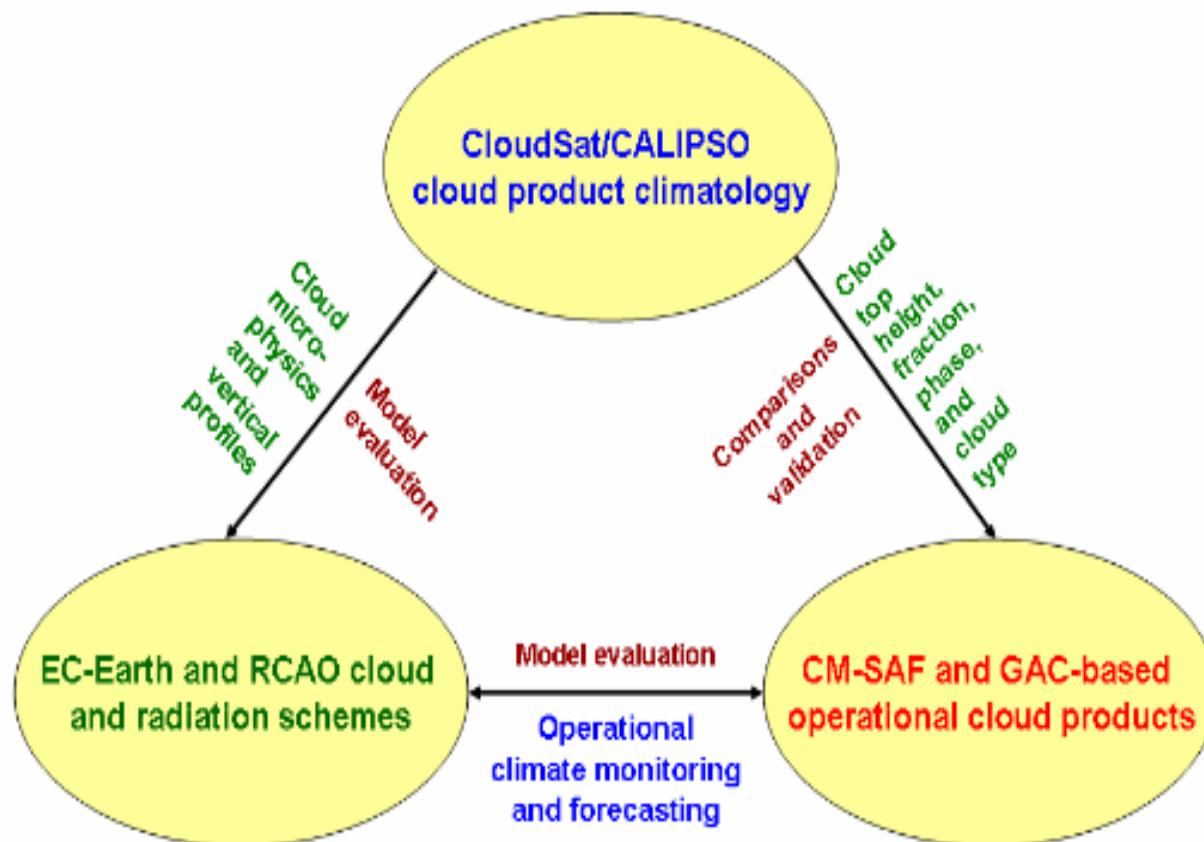
=> Each event is different, little common mechanisms

Scenario conclusions

- Regional scenarios
 - fit better to recent climate observations
 - resolve more processes
 - Rapid Sea ice loss events
 - Temporary local sea ice increase
 - Points out processes responsible for uncertainty
 - robust changes in the regional model
 - allow for statistics in high resolution
- } Added value

Utilisation of Advanced Satellite and In situ Observations in Support of Arctic Climate Modelling

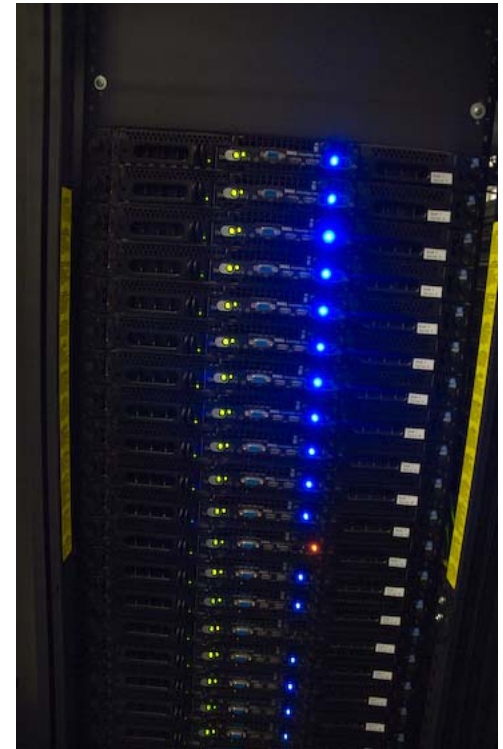
Karl-Göran Karlsson (SMHI) et al.



The End



Linux clusters
at NSC, Linköping



Future applications of Arctic climate scenarios

- Advanced simulations and impact
 - Processes connecting arctic sea ice changes with arctic land surface effects
 - Extreme high resolution for atmosphere and soil for Northern Sweden
 - Effects on permafrost, vegetation, tourism
 - Link to stake holders
- The economy of Arctic change
 - Impact of physical changes on
 - Traffic, exploration, ecology
 - Feedbacks

Coming developments

- Increased resolution in ocean and atmosphere
- Land surface/dynamical vegetation scheme (P. Samuelsson/RC and Lund University)
- A river runoff routing scheme into RCAO (with SMHI-hydrology)
 - Effects of changing hydrology/runoff on ocean currents/sea ice/atmosphere
- Towards an Arctic system model
- Approaching multi-annual prediction