Regional Modelling of Arctic Climate
in recent and possible future climates

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Regional downscaling
Coupled climate model setup

Diagram showing the coupling between RCA and RCO models using OASIS as the coupler. The diagram includes a timeline marked with "3 h" intervals and a color scale for the data representation.
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

--- coupled runs
--- ERA40 or sat observation

Döscher et al, 2009
Quantifying Arctic Contributions to Climate Predictability
- summer sea ice thickness -

Sea ice thickness trend and attribution

Döscher et al, 2009

Ice thickness trend: significant and controlled by external forcing
Climate Scenario Experiments
- Dynamic Regional Downscaling -

- GCMs:
  - ECHAM5/MPI-OM
  - BCM

- Greenhouse gas scenario:
  - A1B
Regional model air temperature is more realistic over the ocean.
Sea Ice Concentration
recent climate 1980-2000

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

Sea-ice cover (sic), WINTER (DJF), 55km
Scenario: quality control for recent climate

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

Storm tracks:

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

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

GCM | RCM | near future | RCM | RCM

Local ice thickness increase due to temporal air circulation changes

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

GCM | RCM

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

Königk, Döscher and Nikulin, submitted

Air temperature changes

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

GCM                      RCM                      RCM
near future

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

GCM                      RCM                      RCM

distant future

Königk, 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.
Changes in daily SLP extremes between 2060-2080 and 1980-2000 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.

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.

Königk, Döscher and Nikulin, submitted
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Rapid sea ice reduction events

![Graph showing rapid sea ice reduction events](image-url)
=> 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