Interactions between atmosphere and sea ice in the Arctic

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1 Summary

Evaluation and quantification of atmosphere-sea ice interactions

- What are the mechanisms for the rapid Arctic sea-ice loss?
- Which are the involved key regional atmosphere–sea ice feedback mechanisms?
- Are they appropriately described in climate models and how can they improved?

Regional feedback processes arising from (a) interactions between atmosphere and sea ice-ocean and (b) changes in the large-scale atmospheric circulation patterns are critical mechanisms for the Arctic Amplification.

2 Research rationale

Problem

- System-level understanding of critical Arctic processes and feedbacks is still lacking
- Need for better understanding of past, present and future Arctic sea ice changes
- Synthesis of Regional Climate Model (RCM) simulations with integrated observations

Main drivers & feedback mechanisms

- Both atmospheric circulation changes and local feedback processes contribute to sea-ice decline and Arctic Amplification
- Cloud-related processes are important factor for sea-ice loss, but not well represented in climate models
- Poorly understood interactions between cyclones & sea ice (e.g. ice fracturing, riding and ice-edge shift; increased transport of heat & moisture)

Sea-ice and snow data sets

- Available long time series of sea-ice concentration reach only a resolution of 25 km which is not well suited for the evaluation of higher resolution RCMs
- Knowledge of sea-ice thickness and snow depth on sea ice is not comprehensive
- Establishing quantitative uncertainty bounds for observations is still a challenge

3 Research plan

WP 1 Upgrade of the coupled HIRHAM–NAOSIM model

- Atmosphere & ocean components will be upgraded to new versions with improved physical parameterizations and higher resolution
- HIRHAM: 0.25° (~25 km), 40 vert. levels

WP 2 Remote sensing data sets of sea-ice parameters

- Improved high-resolution sea-ice concentration
- Combined sea-ice thickness data set for thin and thick ice
- Improved snow depth on sea ice

WP 3 Model simulations and evaluation

- HIRHAM-NAOSIM ensemble simulations (~1979-present; at least 10 ensemble members with respect to ice-ocean initial conditions)
- Climate-oriented evaluation
- Quantification of the internally generated variability

WP 4 Impact of improved regional feedback processes

- Quantify impact of improved process descriptions by series of sensitivity studies
- Parameterization of transfer coefficients for heat & momentum over sea ice
- Parameterization of clouds
- Parameterization of surface albedo

WP 5 Feedback assessment related to atmospheric circulation

- Analysis of extreme sea-ice events to identify critical mechanisms causing and amplifying sea-ice anomalies
- Feedback processes between cyclone activity and ice-ocean conditions

4 Role within (AC)³ & perspectives

Collaboration within (AC)³

- D03 provides sea-ice data and regional feedback descriptions
- D03 relies on data from (AC)³ for process- and climate-oriented evaluation

WP 1 & WP 3

- RCM simulations & evaluation

WP 4

- Remote sensing

WP 5

- Feedback assessment

WP 2

- Sea ice data

Perspectives

- Model evaluation/improvement and feedback assessment using (AC)³, MOSAIC data
- Detailed analysis of ocean processes and involved feedback mechanisms (e.g., potential impact of enhanced oceanic heat fluxes in Atlantic/Pacific; ocean mixed layer & halocline characteristics)
- Relative contribution of atmospheric & oceanic processes to sea-ice decline
- Interaction with land component (e.g., impact of sea-ice changes on water cycle & terrestrial snow cover) and related large-scale feedback
- Merged satellite retrieval of sea-ice, ocean, atmosphere parameters

Project synergy:

Data use; joint evaluation

Data use; joint evaluation

Process descriptions

Feedback assessment

E01

E02

E04

E01

E02

E01

E04

E04

E02

E01

E04

E04

E01

E02

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E01

E04