Large-scale dynamical mechanisms of Arctic amplification

D01

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1. Summary

Research questions:

Q1: How much are the changes in energy transports impacted by the ocean-atmosphere background state, changing patterns of climate forcing, and stratospheric variability?

Q2: What are the dynamical mechanisms of Arctic-mid-latitude linkages underlying the trends and changes of the horizontal energy transports?

Focus: large-scale atmospheric dynamical mechanisms of Arctic amplification

Tool: ICON global model experiments to study the impact on atmospheric energy transports by

a) ocean-atmosphere variability and background state,
b) the changing geographical patterns of climate radiative forcing, and
c) the stratospheric variability, which is largely determined by planetary and gravity wave driven dynamics and feedbacks between stratospheric dynamics and chemistry.

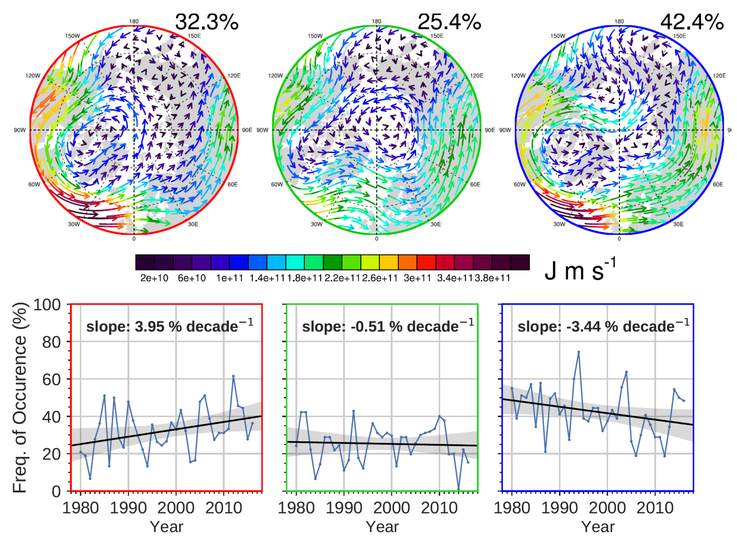
Hypothesis

Atmospheric energy transports critically depend on the ocean-atmosphere background state, changing patterns of climate forcing, and stratospheric variability

2. Achievements phase I

Changes in atmospheric energy transport

- Moist static energy transport patterns for winter (DJF) analysed based on Self-organizing maps (SOM)
- Occurrence frequencies of transport patterns change with time

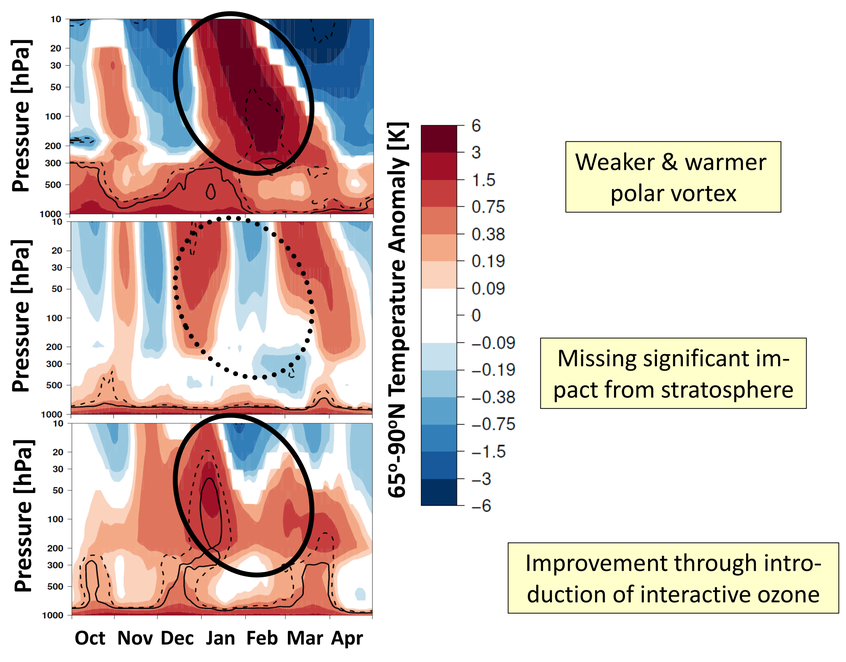


Upper panels: Transport pathways derived from a SOM analysis. Lower panels: Occurrence frequencies of each pathway and their changes with time. From Mewes and Jacobi, 2019, *Atmos. Chem. Phys.*

Arctic-midlatitude linkages

- Improvement of simulated stratospheric pathway for Arctic-mid-latitude linkages by including interactive stratospheric ozone chemistry in global atmospheric model

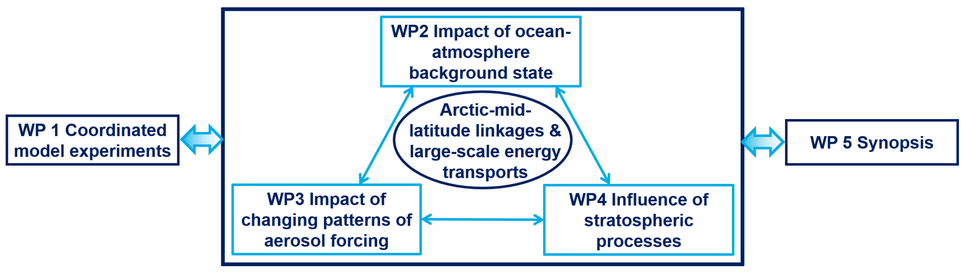
Polar cap mean temperature difference between periods with low and high sea-ice conditions



Jaiser et al. 2016, *J. Geophys. Res. Atm.*; Romanowsky et al. 2019, *Nat. Sci. Rep.*

3. Research plan phase II

- Quantify the relative importance of large-scale processes, which impact the atmospheric energy transport into the Arctic
- Clarify how the related transport changes contribute to Arctic amplification



WP1 Coordinated model experiments & basic evaluation

Time-slice experiments with global atmospheric models ICON-A and ICON-NWP

- ICON experiments with different ocean-sea-ice boundary conditions
- ICON experiments with changed mid-latitude aerosol forcing
- ICON & ICON-SWIFT stratosphere experiments
- Evaluation of meteorological fields and meridional transports with ERA5 reanalysis data, and comparison to CMIP6 multi-model results

WP2 Impact of the ocean-atmosphere background state

- Analysing atmospheric circulation changes
- Investigate mechanisms of Arctic-mid-latitude linkages
- Determine changes of energy transports in dependence on background state

WP3 Modulation of energy transports into the Arctic by changing patterns of aerosol forcing

- Radiative forcing impacts for present-day conditions
- Radiative forcing in a changing climate

WP4 Influence of stratospheric processes

- Effect of interactive stratospheric ozone on the stratospheric pathway
- Impact of interactive stratospheric ozone on energy transport into the Arctic
- Low-latitude gravity wave hotspot effects on Arctic amplification

WP5 Synopsis

- Quantification of energy transports and their impact on Arctic amplification
- Role of meridional transports for lapse-rate feedback

4. Role within (AC)³ & perspectives

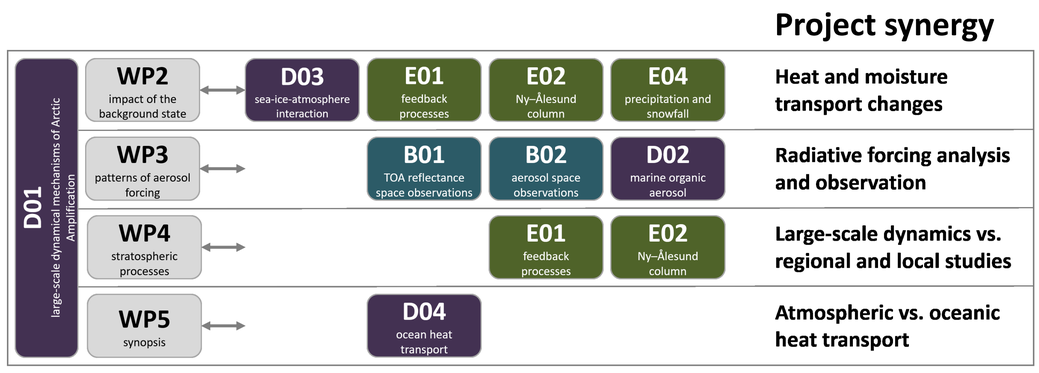
Collaborations within (AC)³

Strong links with other sub-projects, especially:

- Changes in atmospheric circulation and related atmospheric transport studies, D03 and E04
- Impact of changes in aerosol forcing, D02

Contribution to Cross-Cutting Activities

- Lapse-rate feedback (providing characterisations of meridional energy transport)
- Air mass transport and transformation (analysing atmospheric energy transports)



Perspectives

- Focus on large-scale atmospheric processes of Arctic amplification in investigations of climate change scenario
- Investigate possible modifications of Arctic amplification related processes like patterns of ocean energy transport
- Use of coupled atmosphere-ocean climate models

TR 172 TRANSREGIONAL COLLABORATIVE RESEARCH CENTRE

(AC)³ ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms

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