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Bolin Centre for Climate Research

Airmass transformations and clouds in the Arctic

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and
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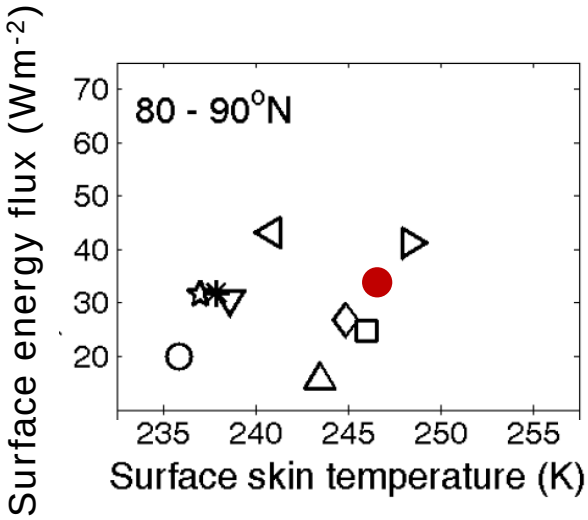
with contributions from Johannes Karlsson, Anders Engström, Cian Woods, Felix Pithan, Rodrigo Caballero…

CMIP3 models

Wintertime (DJF) over sea-ice

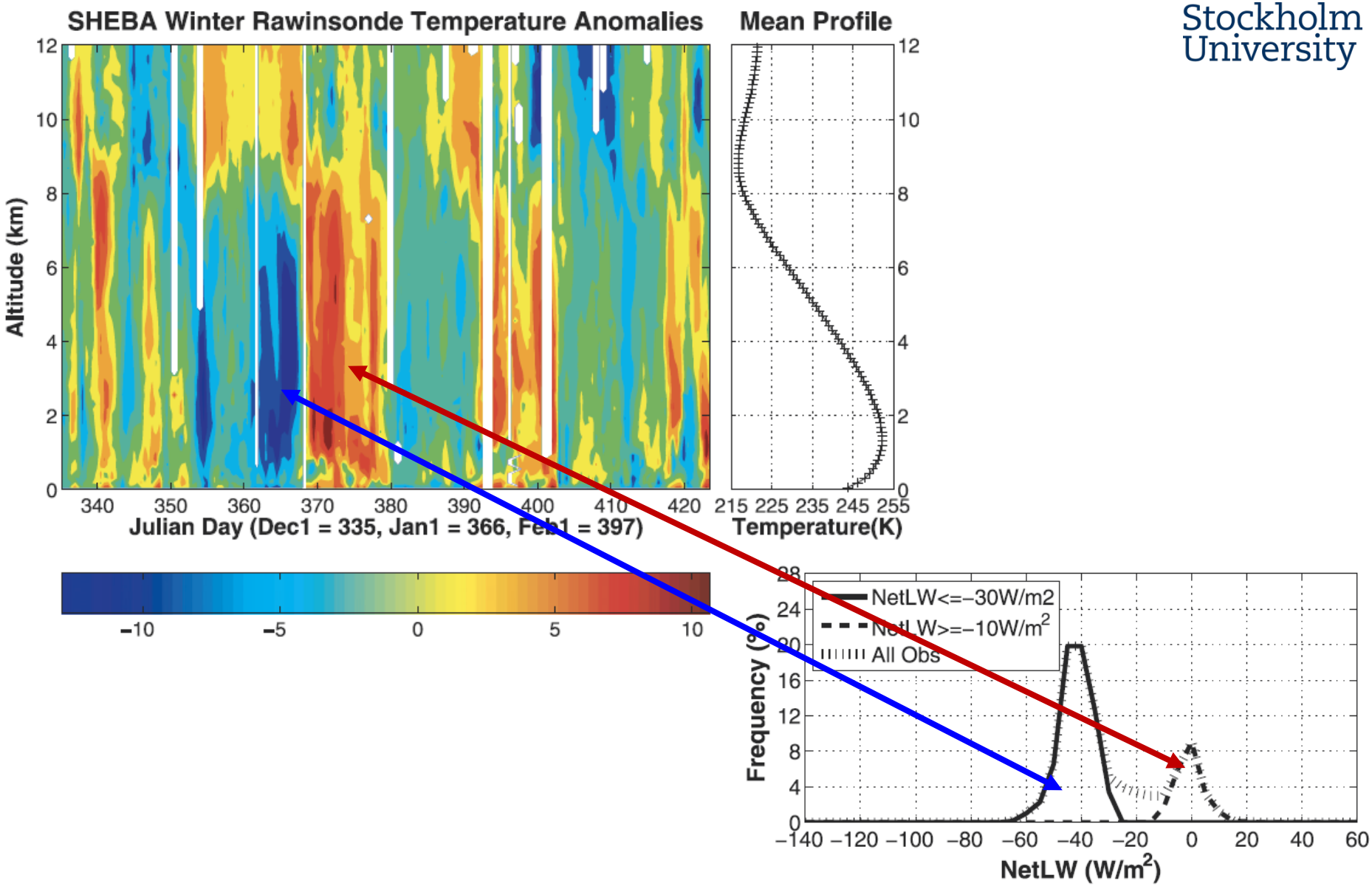


- Climate models are generally too cold during winter with too strong inversions
- Too little downwelling long-wave radiation
- Turbulent heat fluxes are small but important
- Arctic wintertime CRE is underestimated with about 10 Wm^{-2}

e.g. Svensson and Karlsson, 2011

SHEBA data

Stockholm University



Stramler et al., 2011

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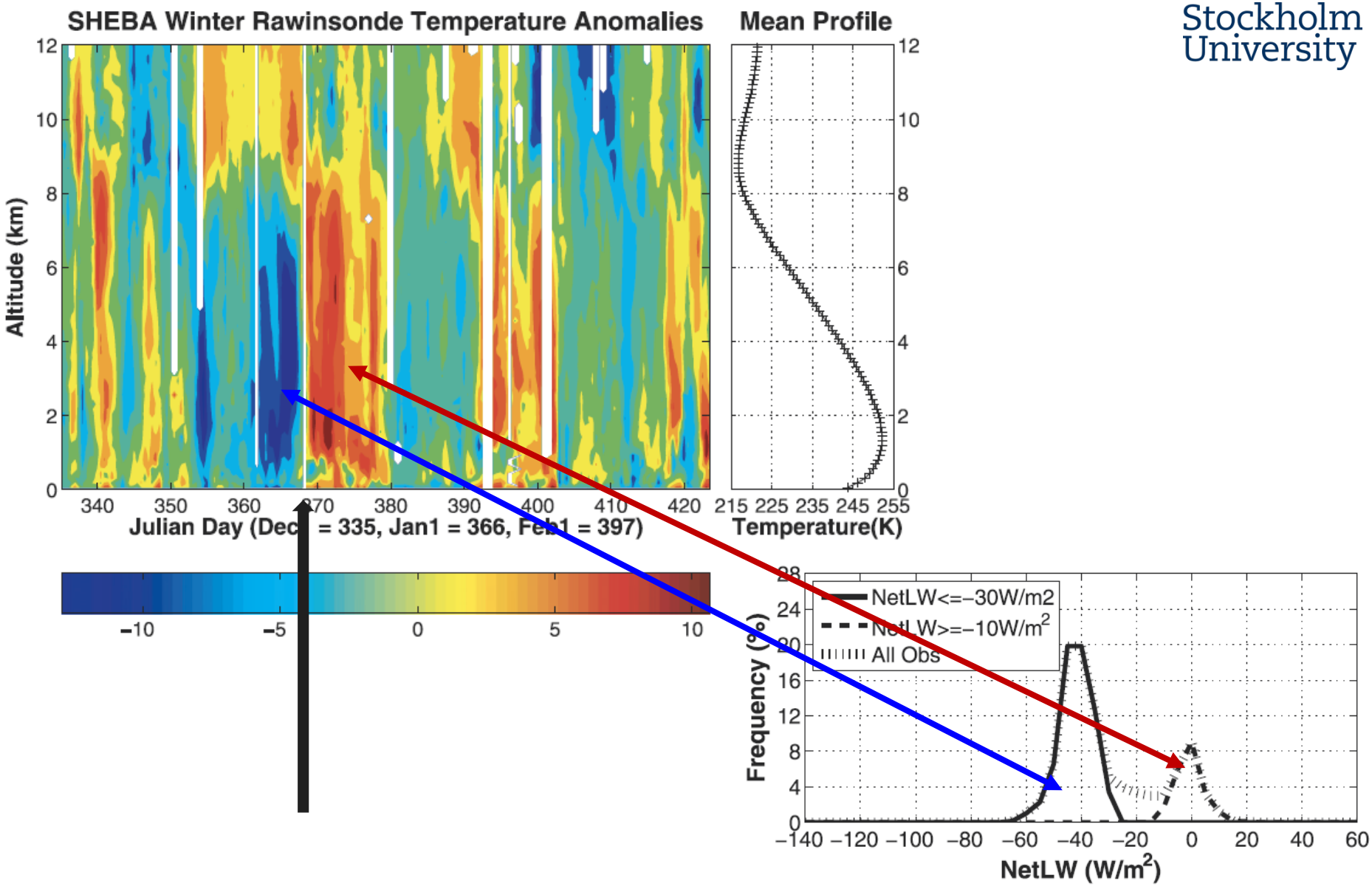

Stramler et al., 2011

Moisture transport to the Arctic

ERA-Interim (1989-2010) SHEBA year

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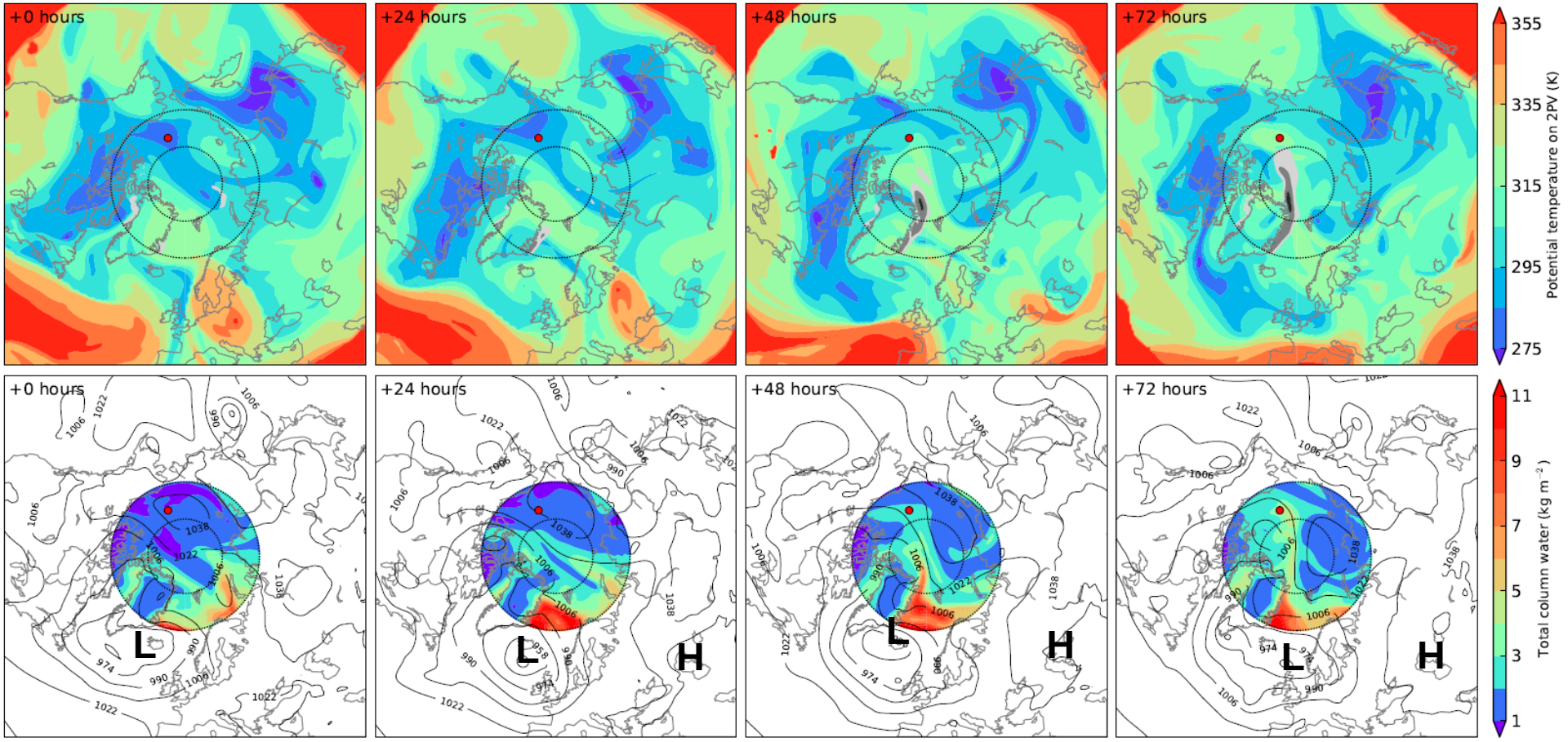
Potential temperature on 2PV



Sea level pressure and precipitable water

Woods, Caballero and Svensson 2013

Impact of the intrusions on surface temperature

ERA-Interim (1989-2010) SHEBA year

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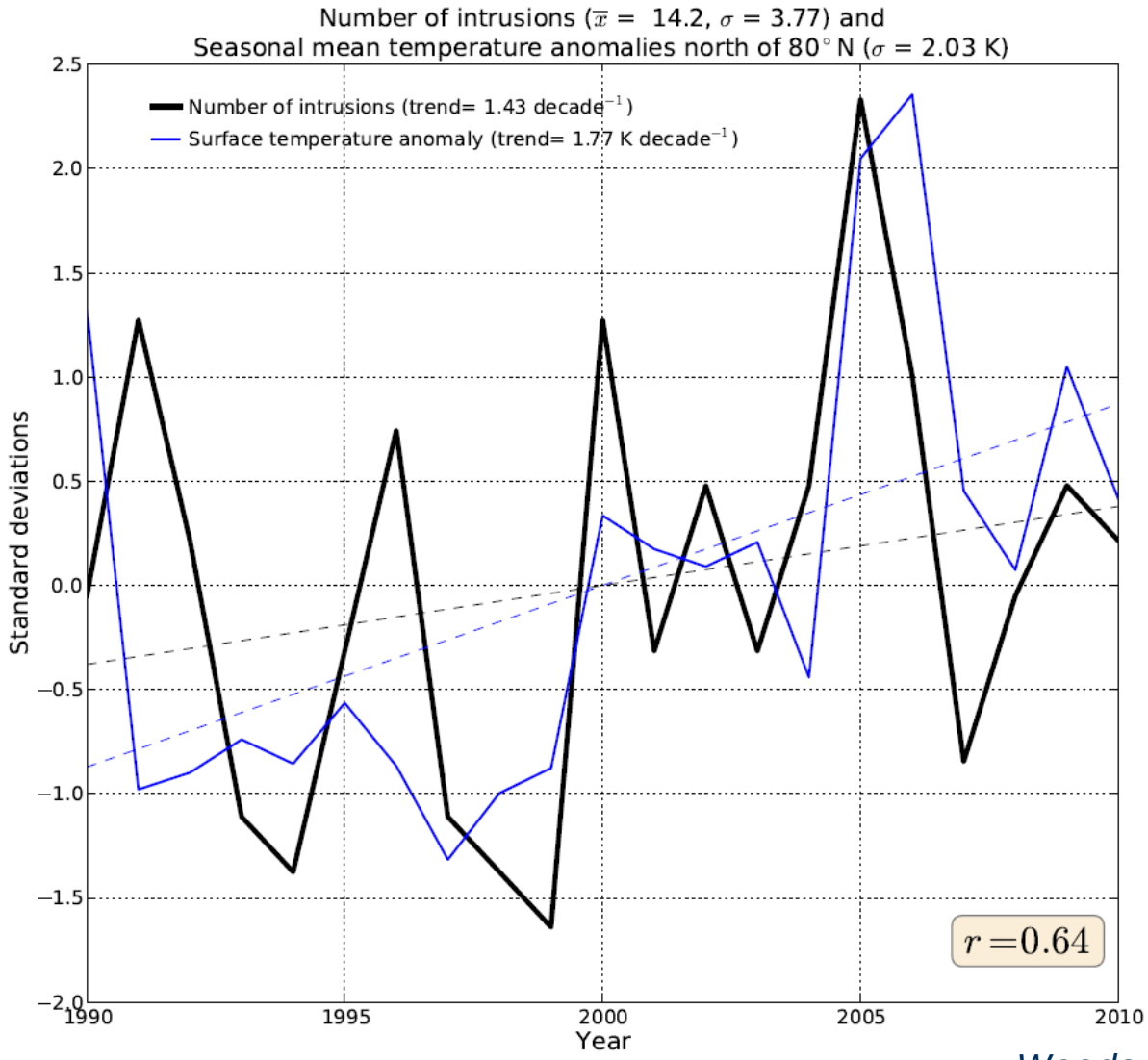

14 events per winter season are classified as strong moisture intrusion events

28% of total moisture transport

Trend in number of intrusions

Intrusions correlate with surface temperature

Woods, Caballero and Svensson 2013

Impact of the intrusions on surface temperature

CMIP5 models

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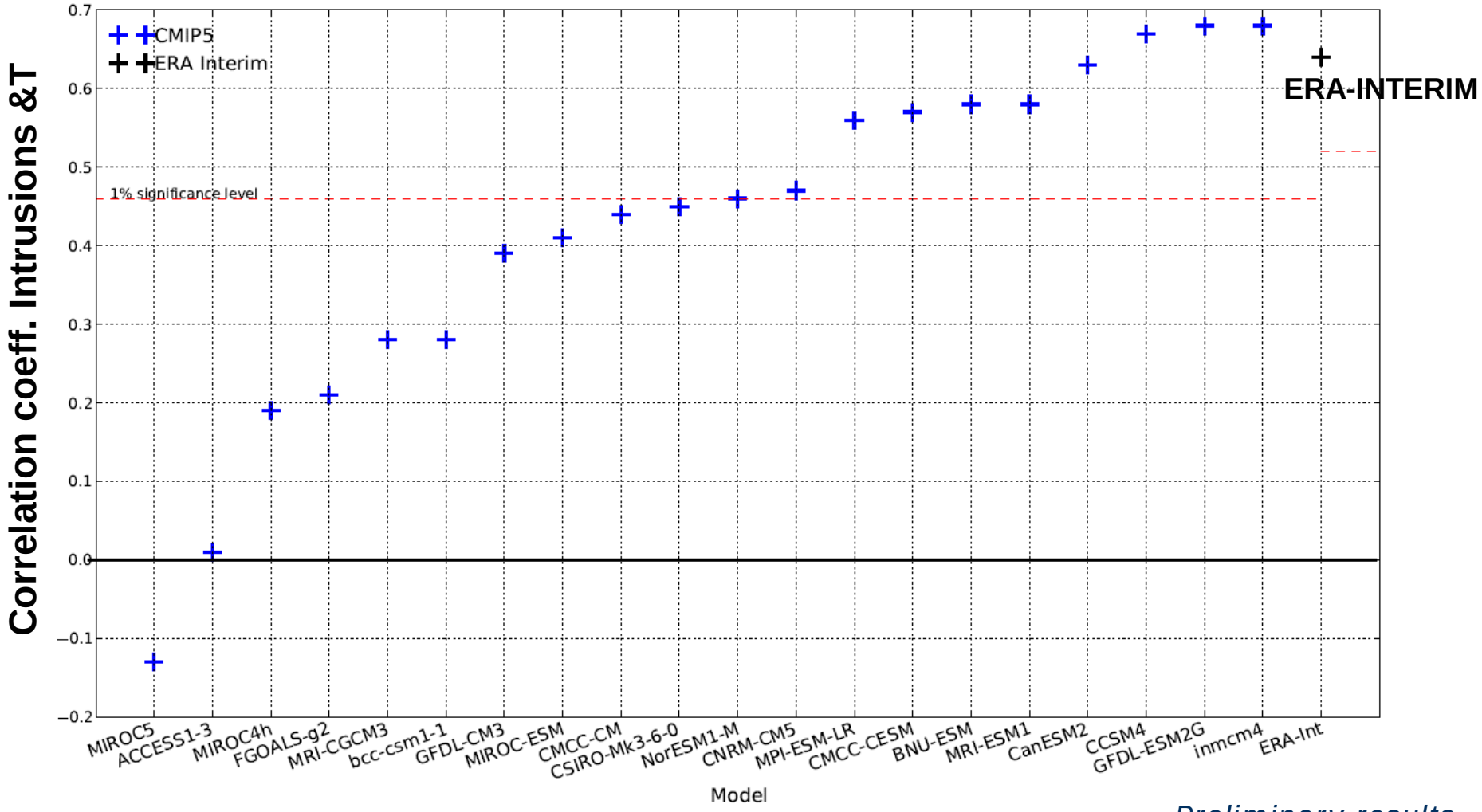

Preliminary results

CMIP5 (and CMIP3) models

sea-ice covered points north of > 66.7°N

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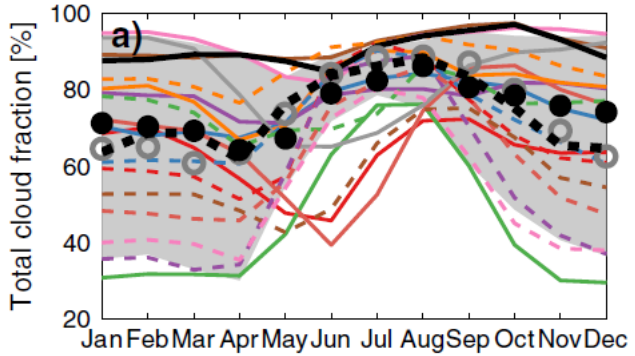

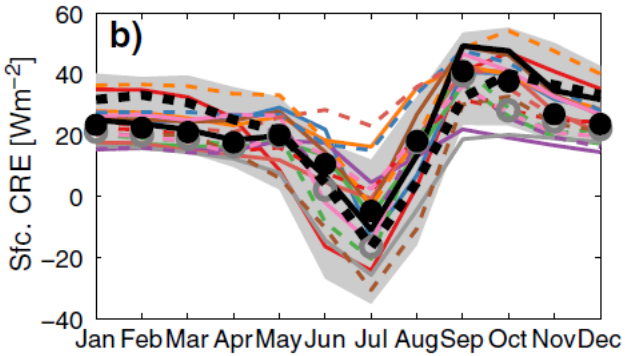

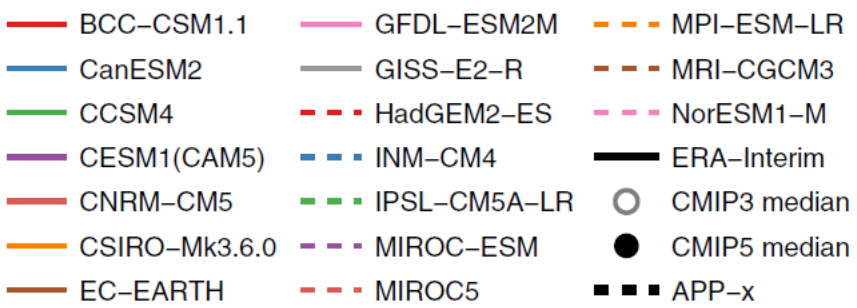

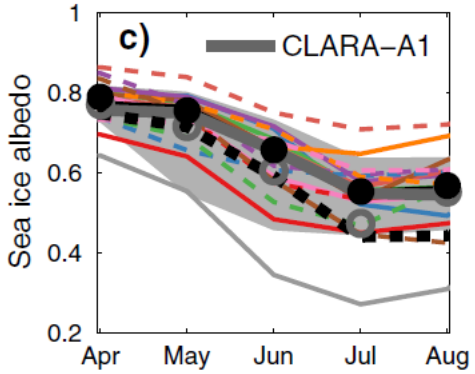

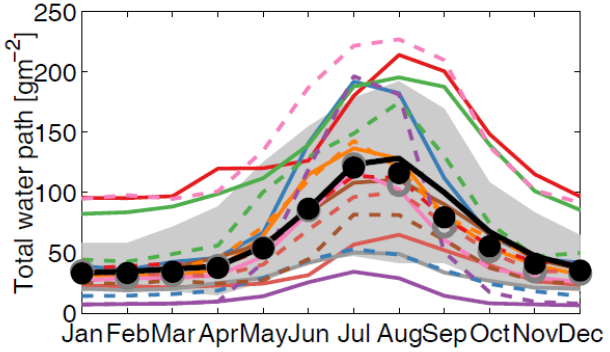

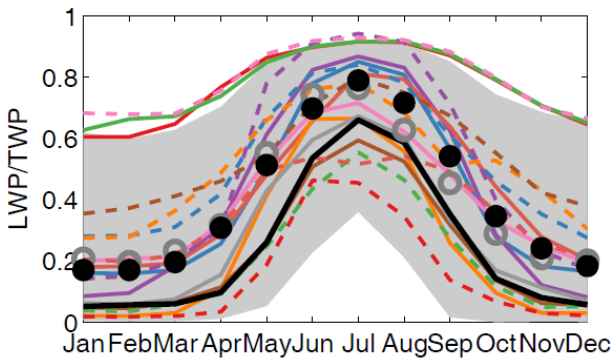

Karlsson and Svensson, 2013

Vertical structure in the CMIP5 models

DJFM, sea-ice points, > 80°N

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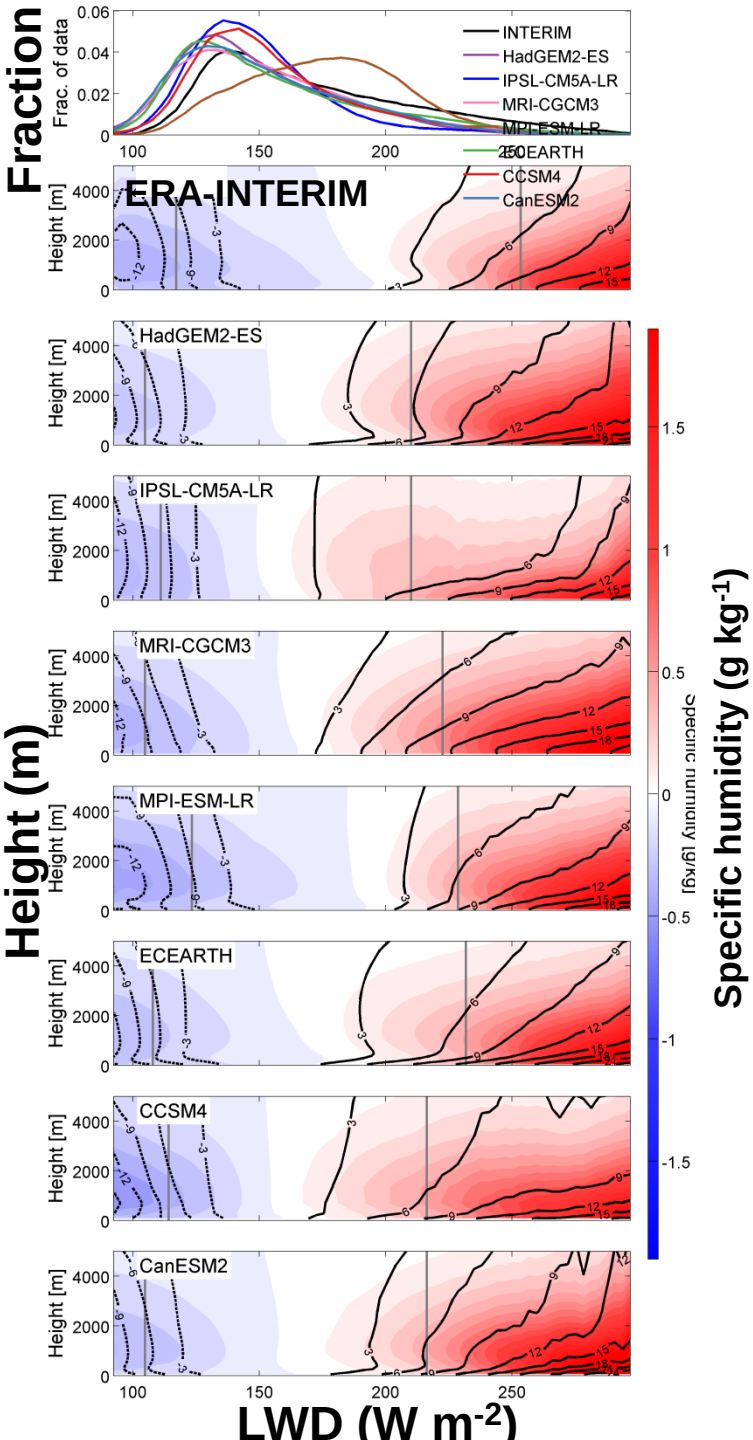
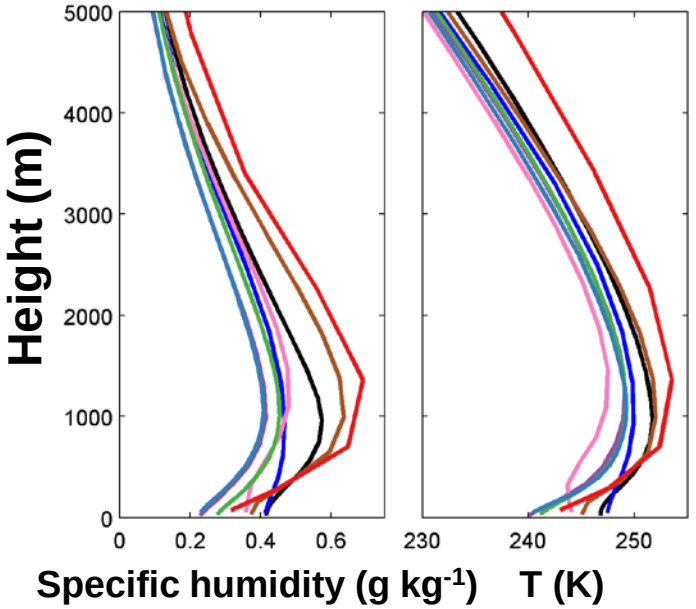
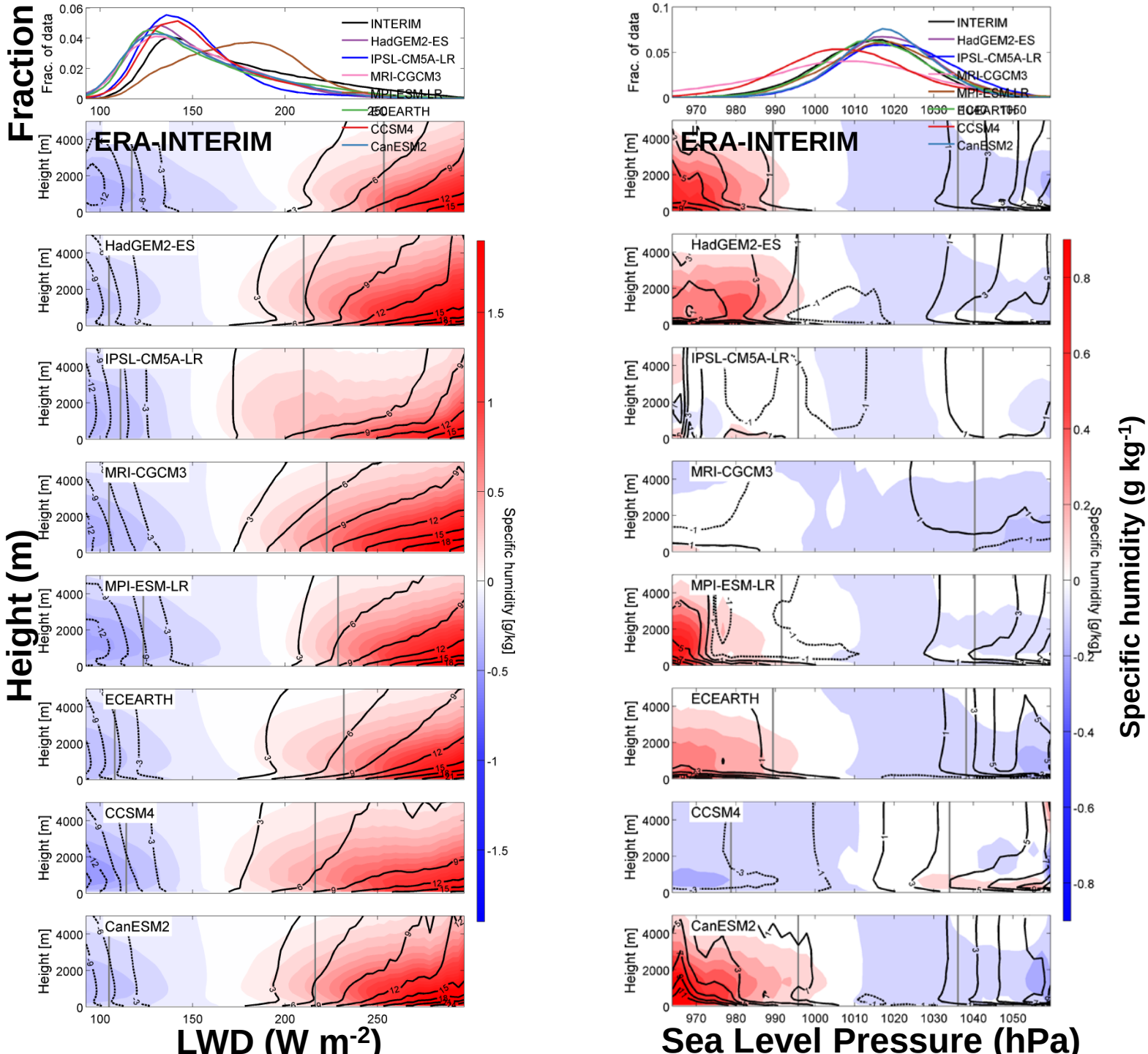




A climatological (1980-2004) seasonal cycle for each grid point and each variable is derived (with daily resolution)

Anomalies are derived as the difference between the raw data and the climatological seasonal cycle



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Importance of microphysic
ERA-Interim (1990-2010)

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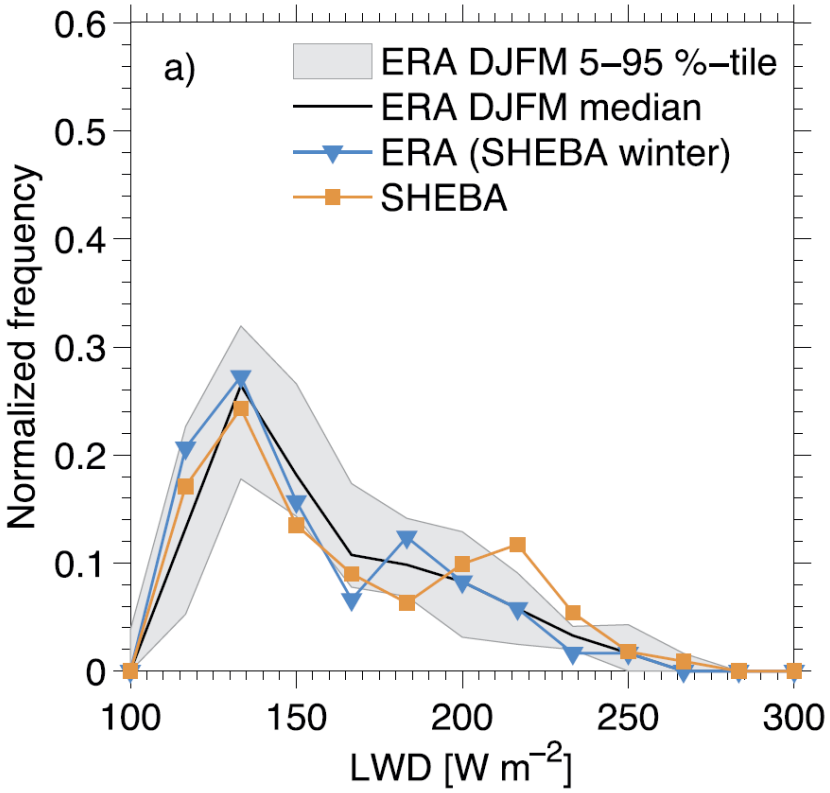

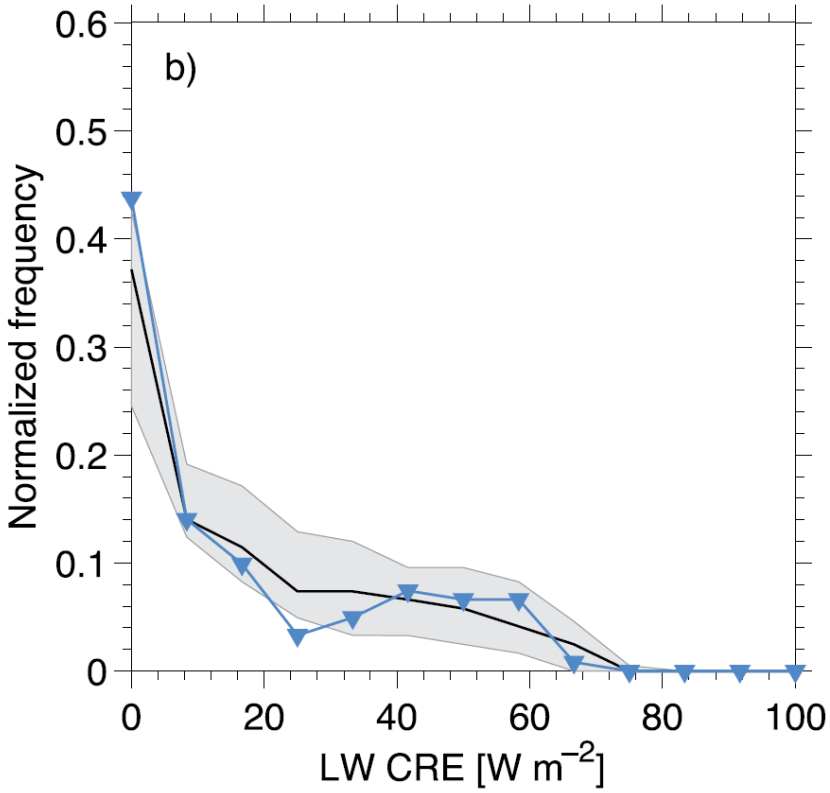

Engström, Karlsson and Svensson 2013

Importance of microphysics

Tuning glaciation efficiency

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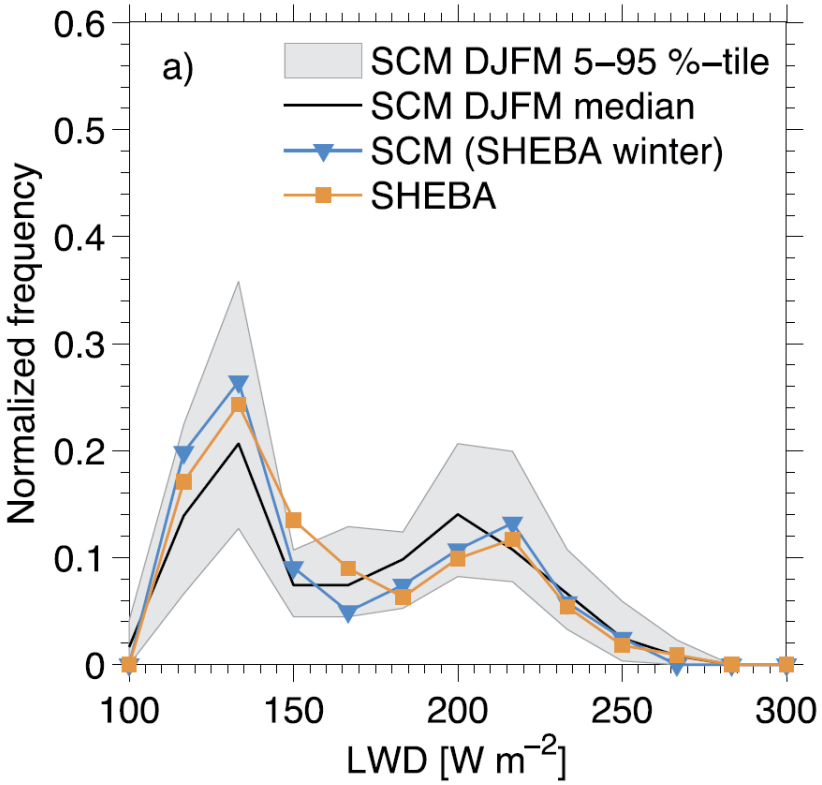
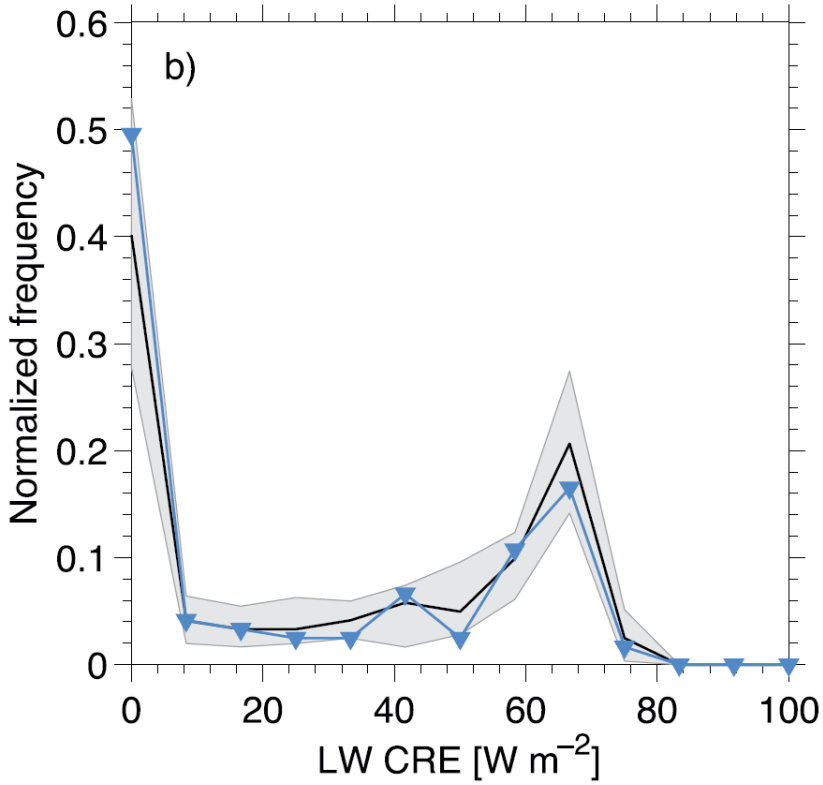
Single column version of EC-EARTH V3, forced with INTERIM data

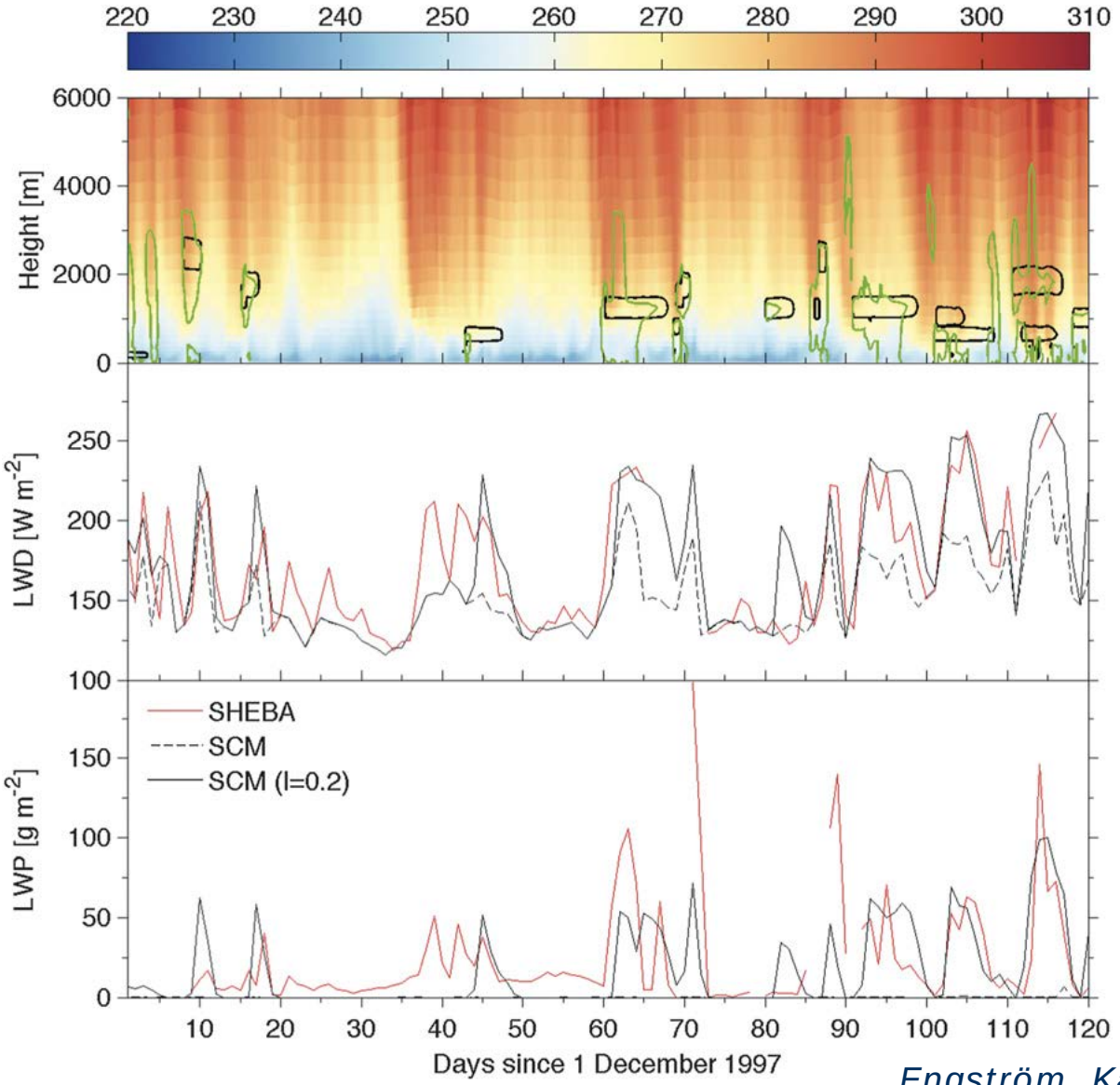




Engström, Karlsson and Svensson 2013

SHEBA data

Observations and EC-Earth SCM



Engström, Karlsson and Svensson 2013

Airmass transformation

Transport in over sea ice

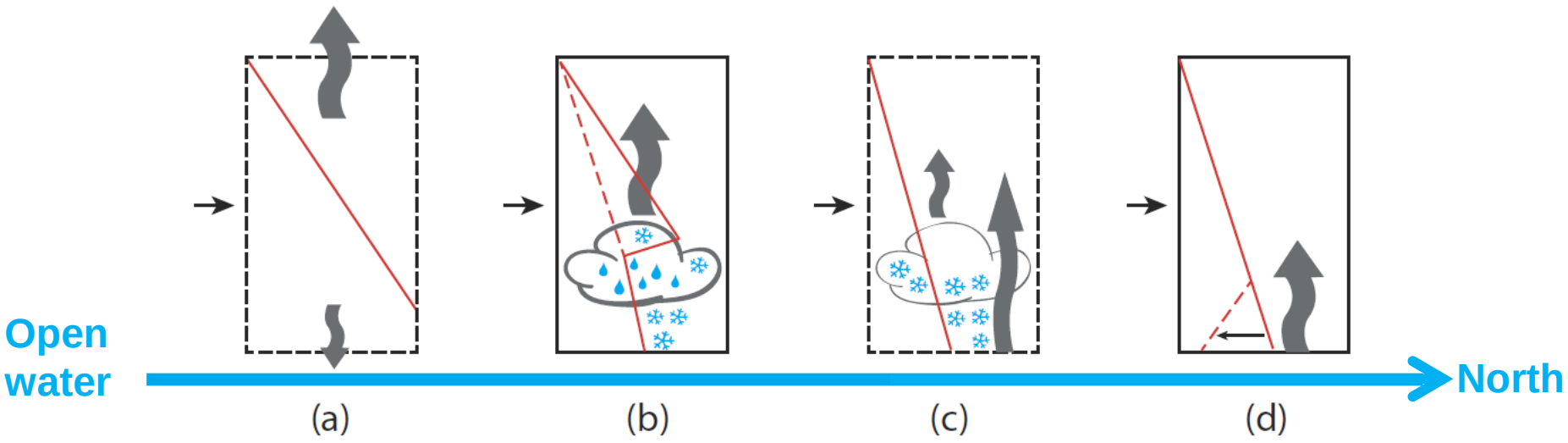


Fig. 6 Sketch of the formation of Arctic air. Dashed boxes mark unstable transition states.

Pithan et al., 2013

Airmass transformation

Transport in over sea ice

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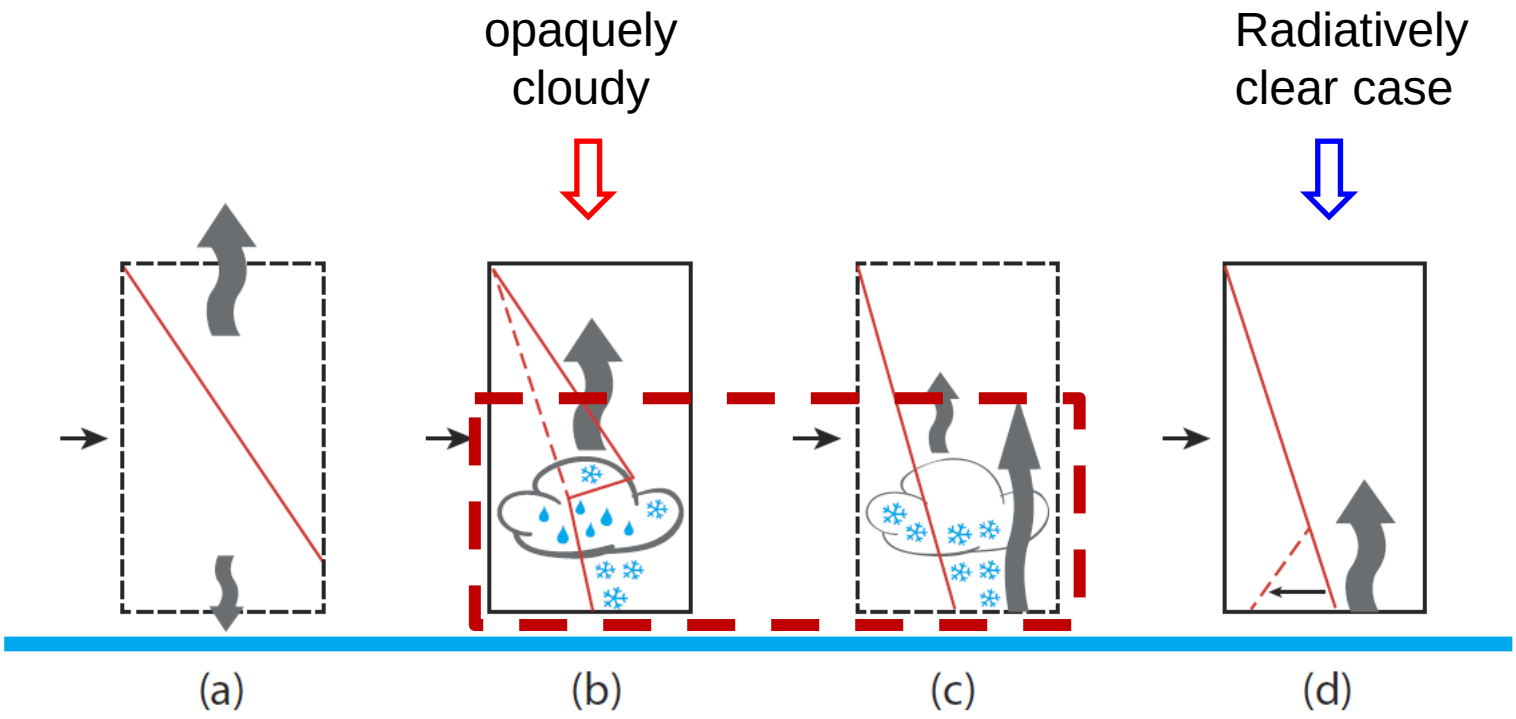

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Transport in over sea ice, a SCM experiment

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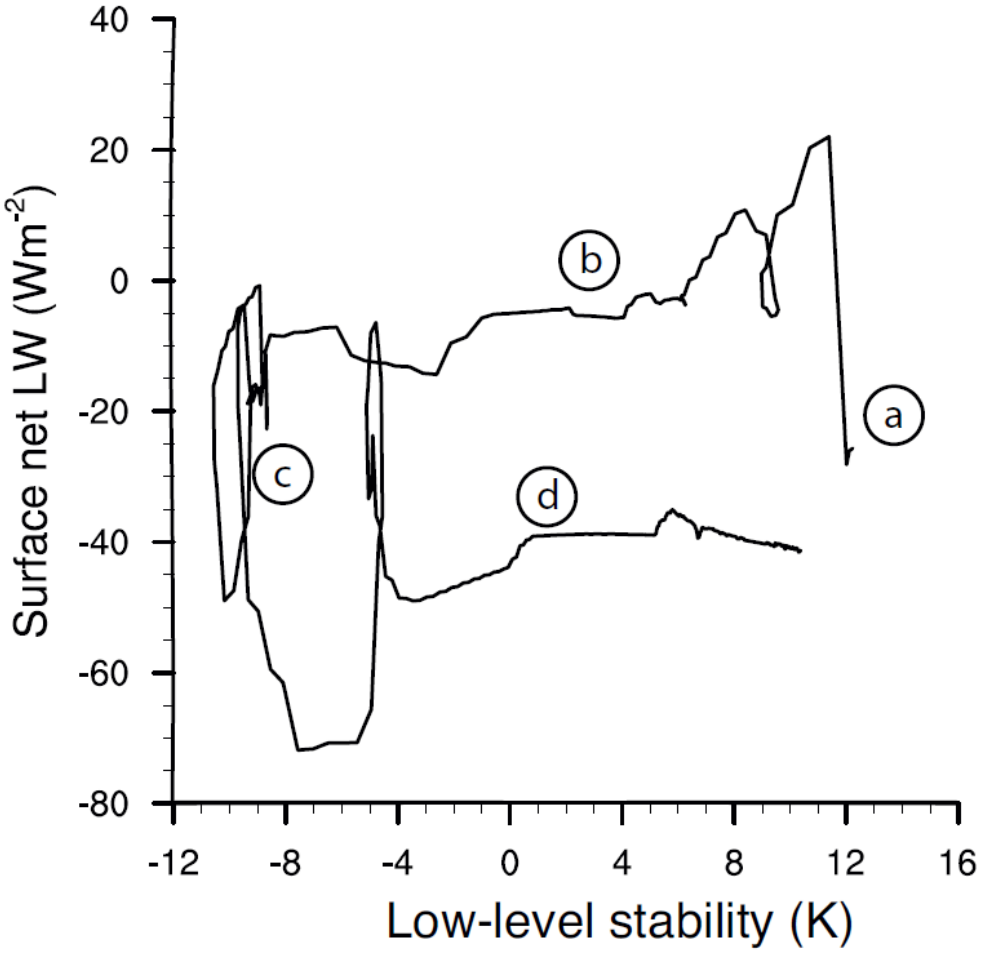

Fig. 7 Trajectory of low-level stability against surface net longwave radiation in idealized SCM experiment of Arctic air formation (section 2.1), hourly averages.

Pithan et al., 2013

Airmass transformation

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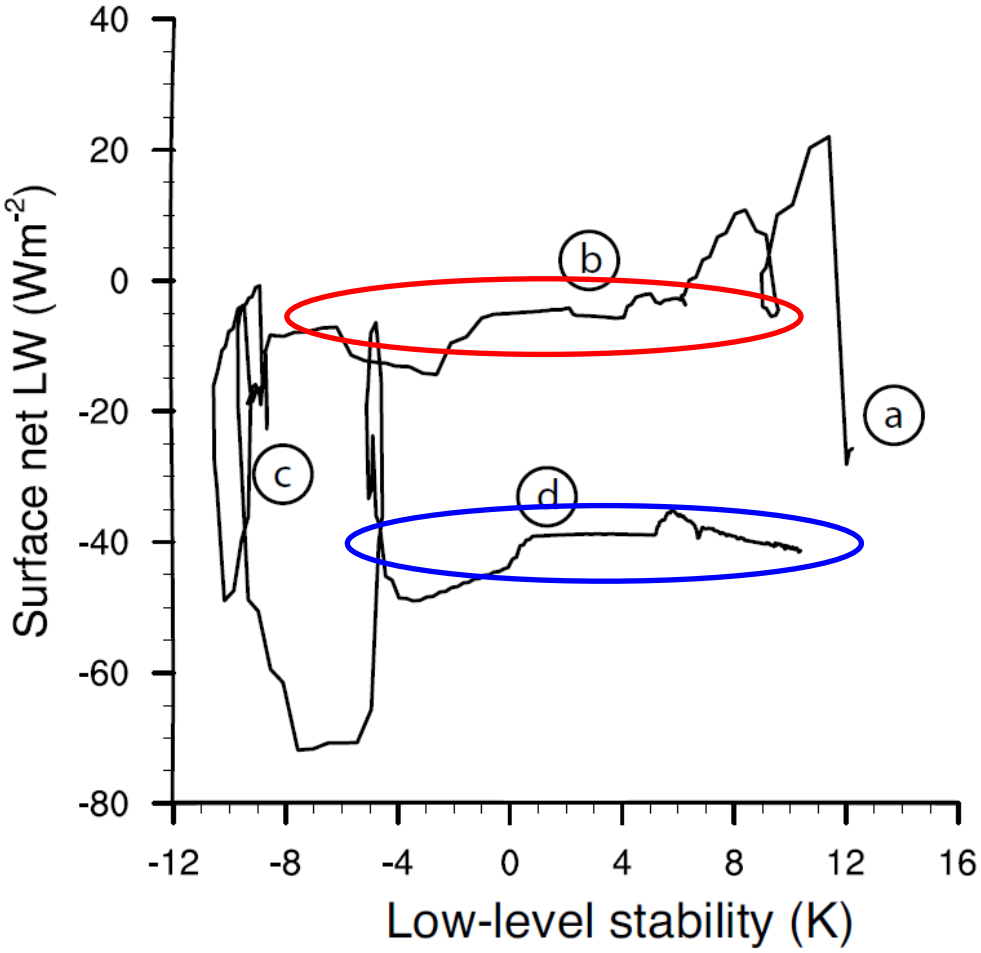

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Pithan et al., 2013

Polar airmass transition

Ongoing Proto-GASS SCM model intercomparison

Coordinated by Felix Pithan

(http://www.mpimet.mpg.de/en/staff/4960/arctic-air-scm-intercomparison.html)

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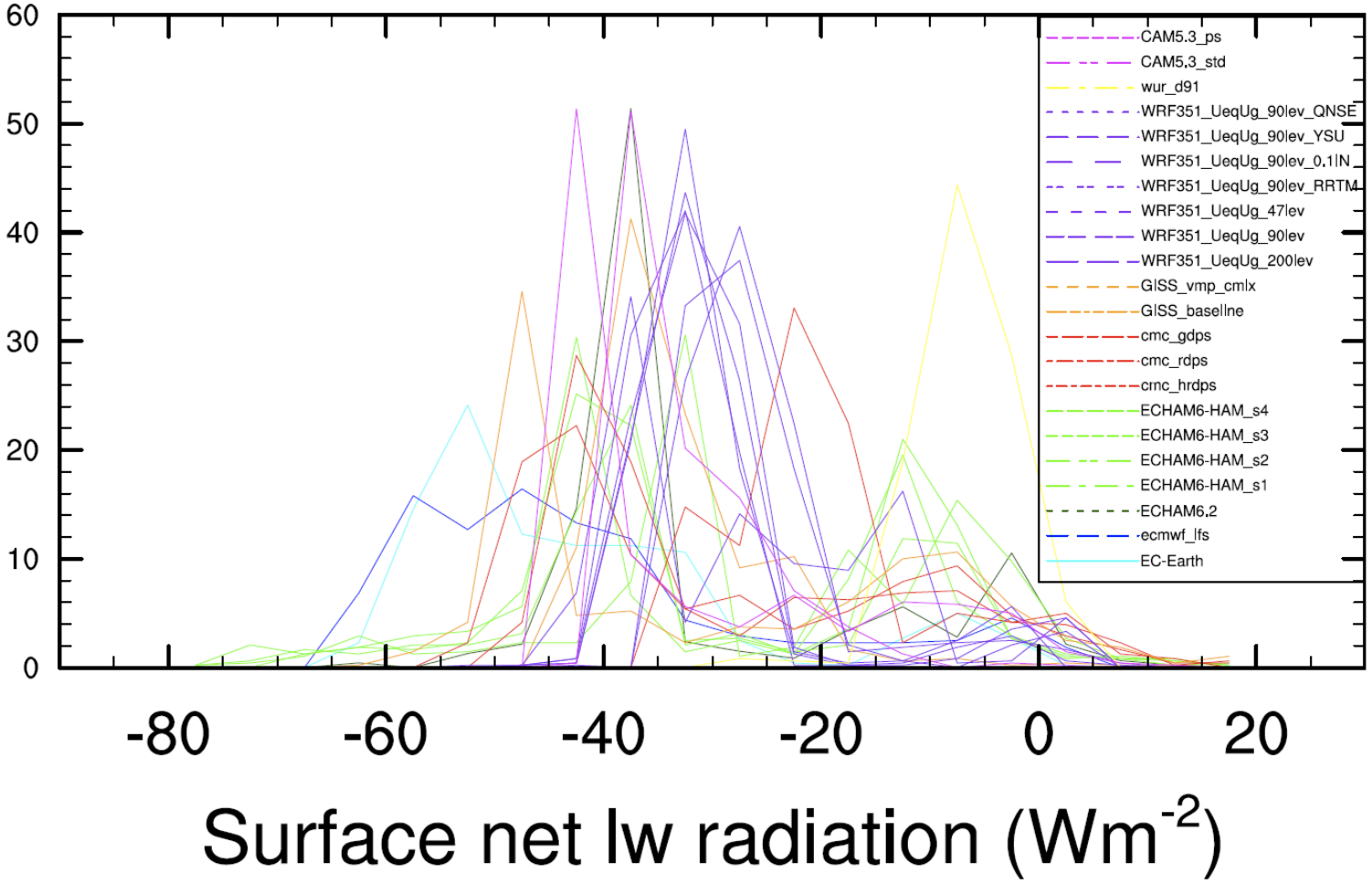

Preliminary results

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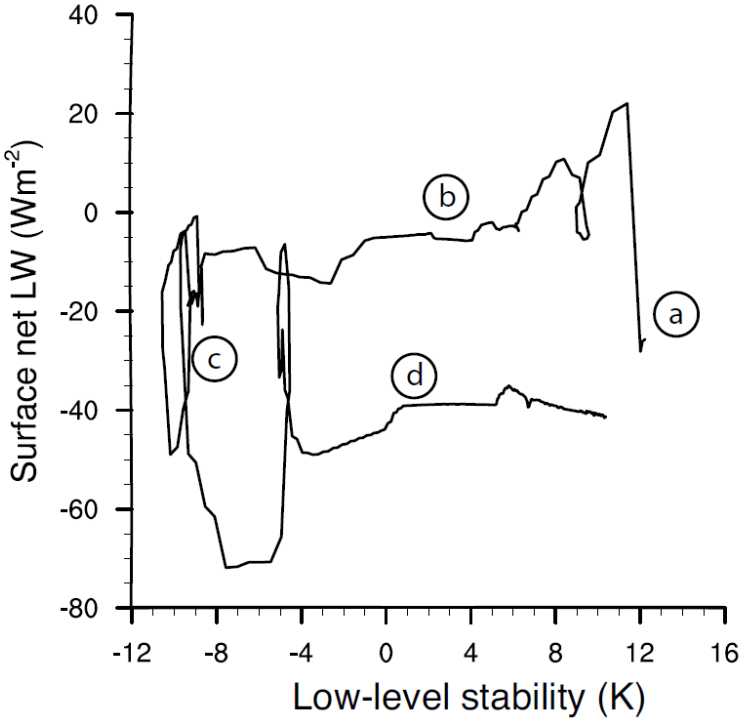

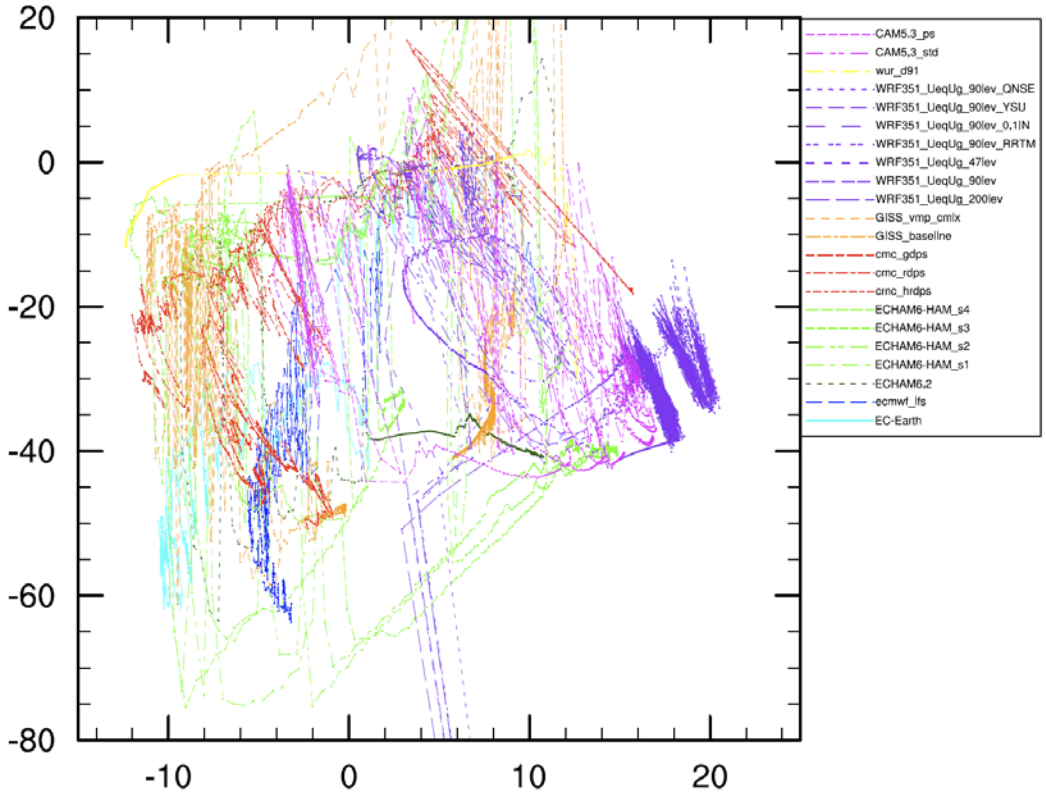

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Pithan et al., 2013

Preliminary results

Summary

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- CMIP3 and CMIP5 models show large variations in surface temperature, vertical structure and clouds
- Large-scale moisture intrusions are important for winter surface temperature, a feature captured by most CMIP5 models
- But, model world lack super-cooled liquid clouds, thus likely underestimate the importance of the moisture intrusions
- Microphysical changes in EC-Earth SCM give an increase of 15 W m^{-2} in winter (DJFM) LWD
- But, models lack low-level mixed-phase clouds important for the Arctic airmass formation, very challenging to model


Questions?
Photo: M. Tjernström