Impact of sea ice

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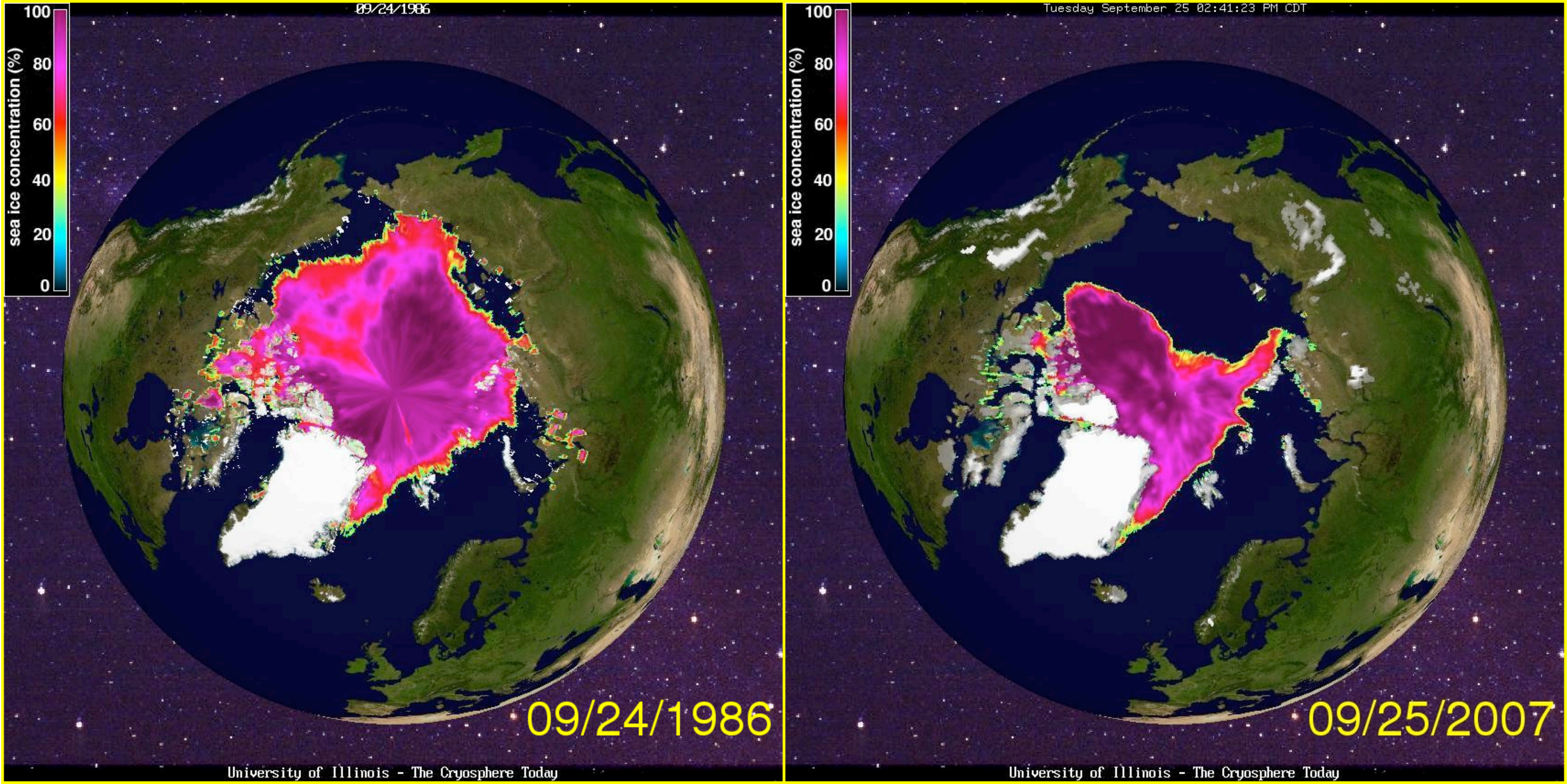
Sea ice concentration September 1986 vs. 2007:

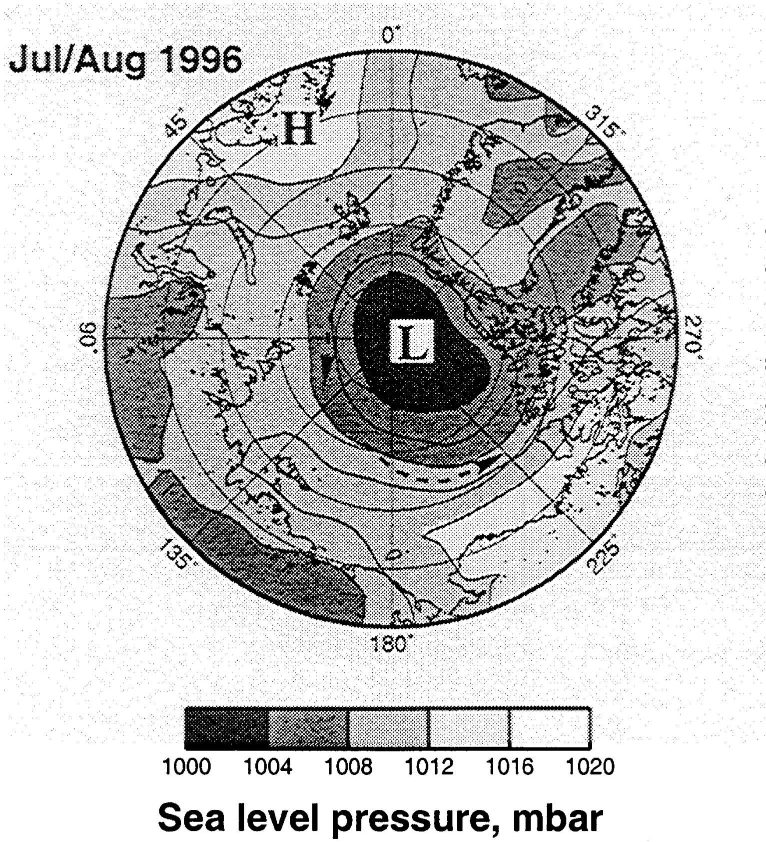


University of Illinois – The Cryosphere Today

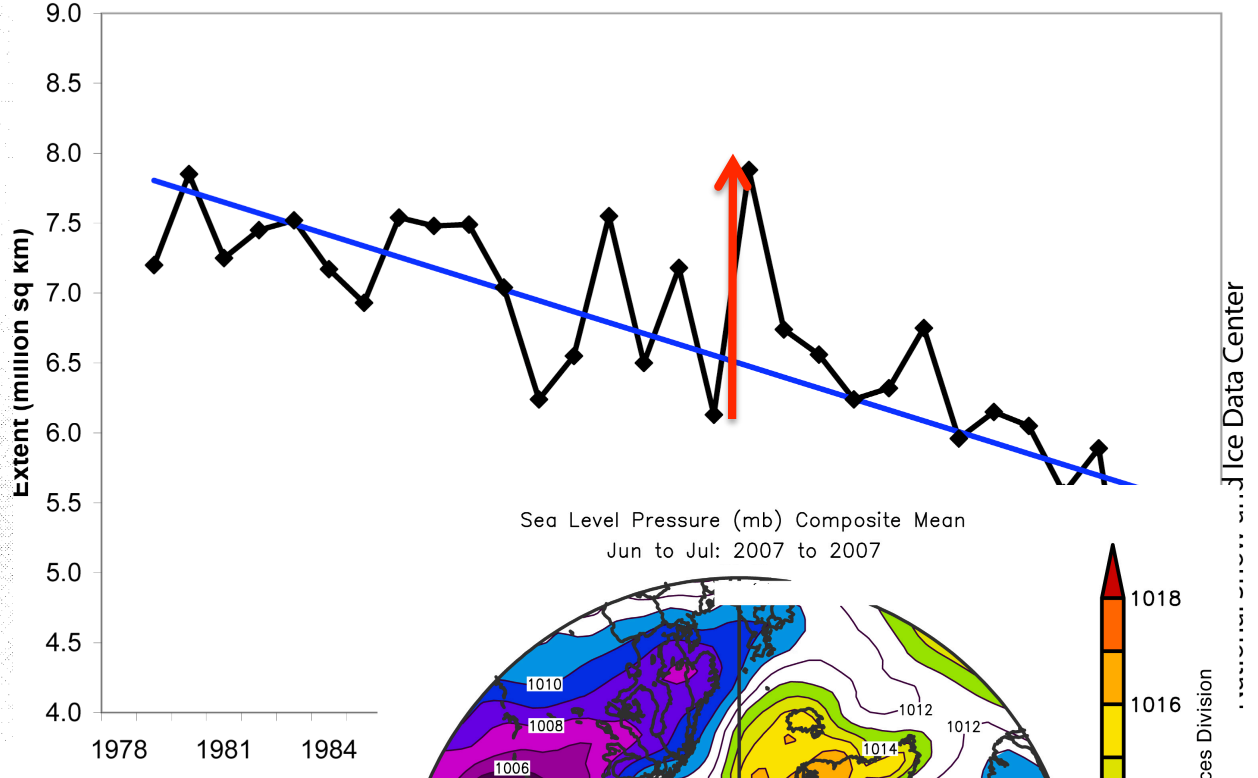
Consequences of less sea ice

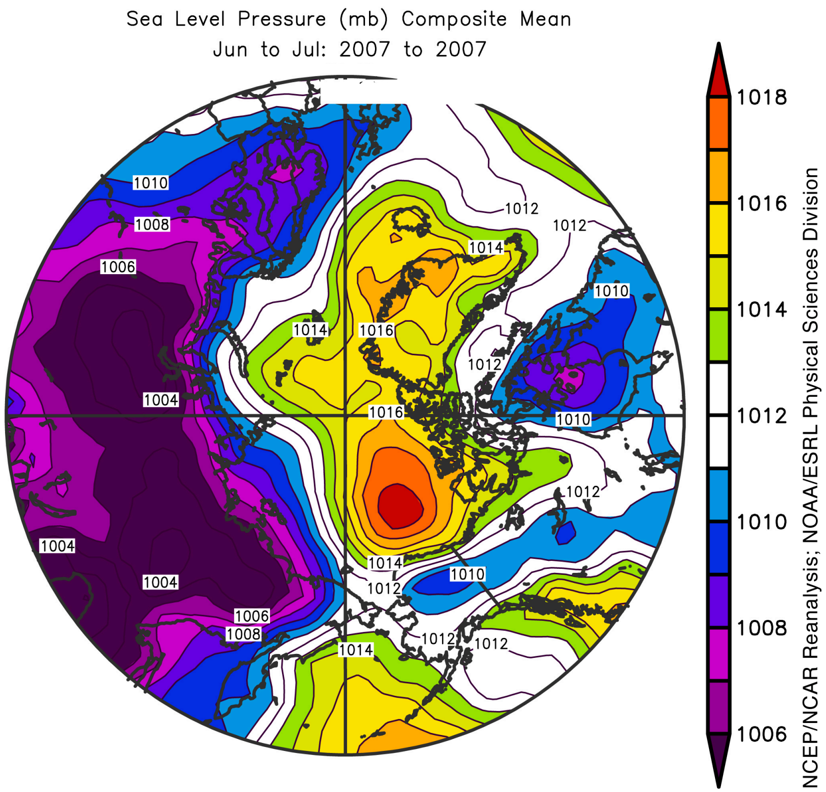

Gammarus wilkitzkii

Sea ice extent experiences strong interannual variability related to atmspheric forcing:

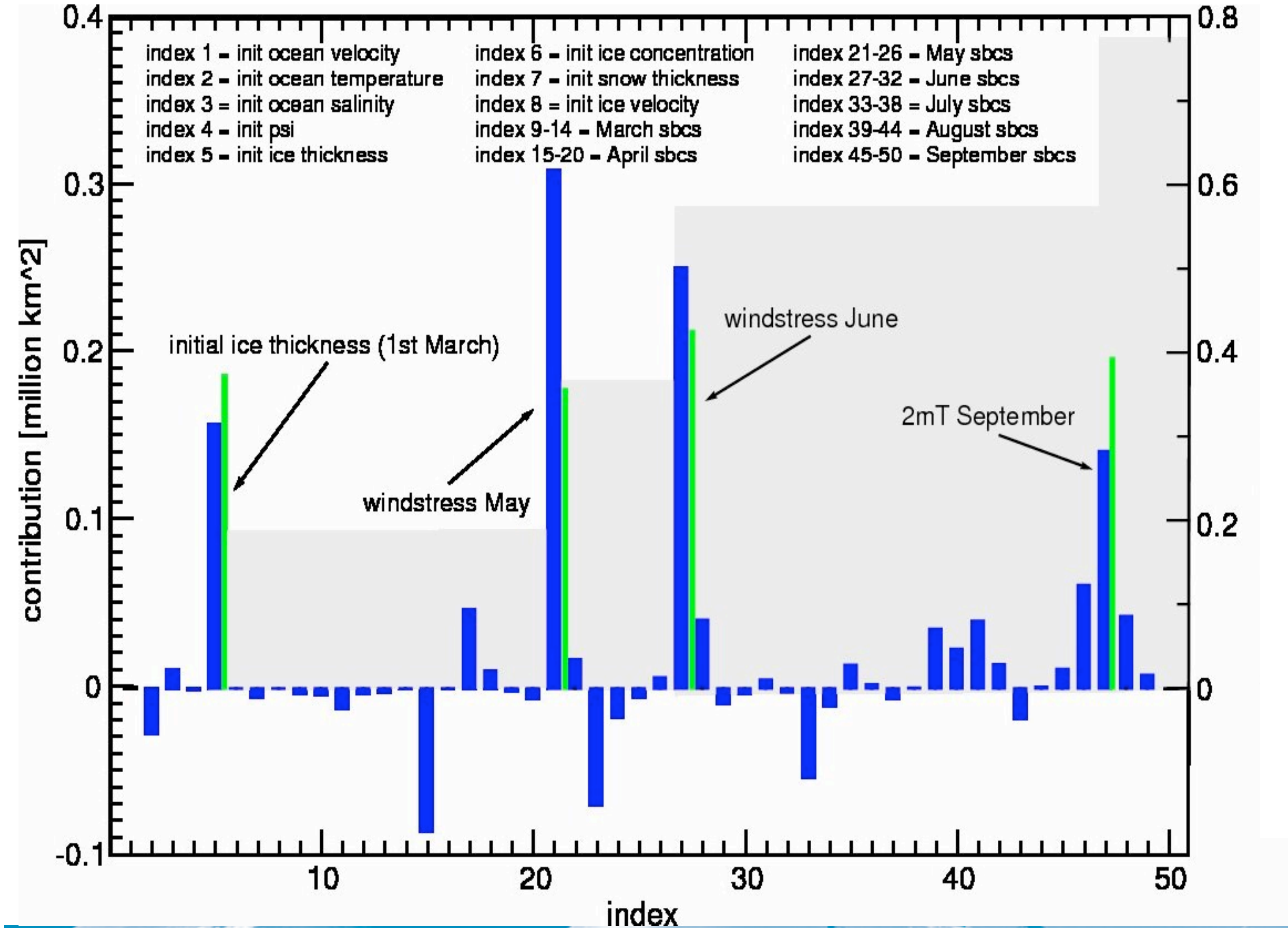


Haas & Eicken, 2001





Adjoint sensitivity: Ice area contributions 2005- 2007



Target variable: Sea ice extent in September 2007, $A_{ice}(t_{end})$.

Model initialized in March 2007.

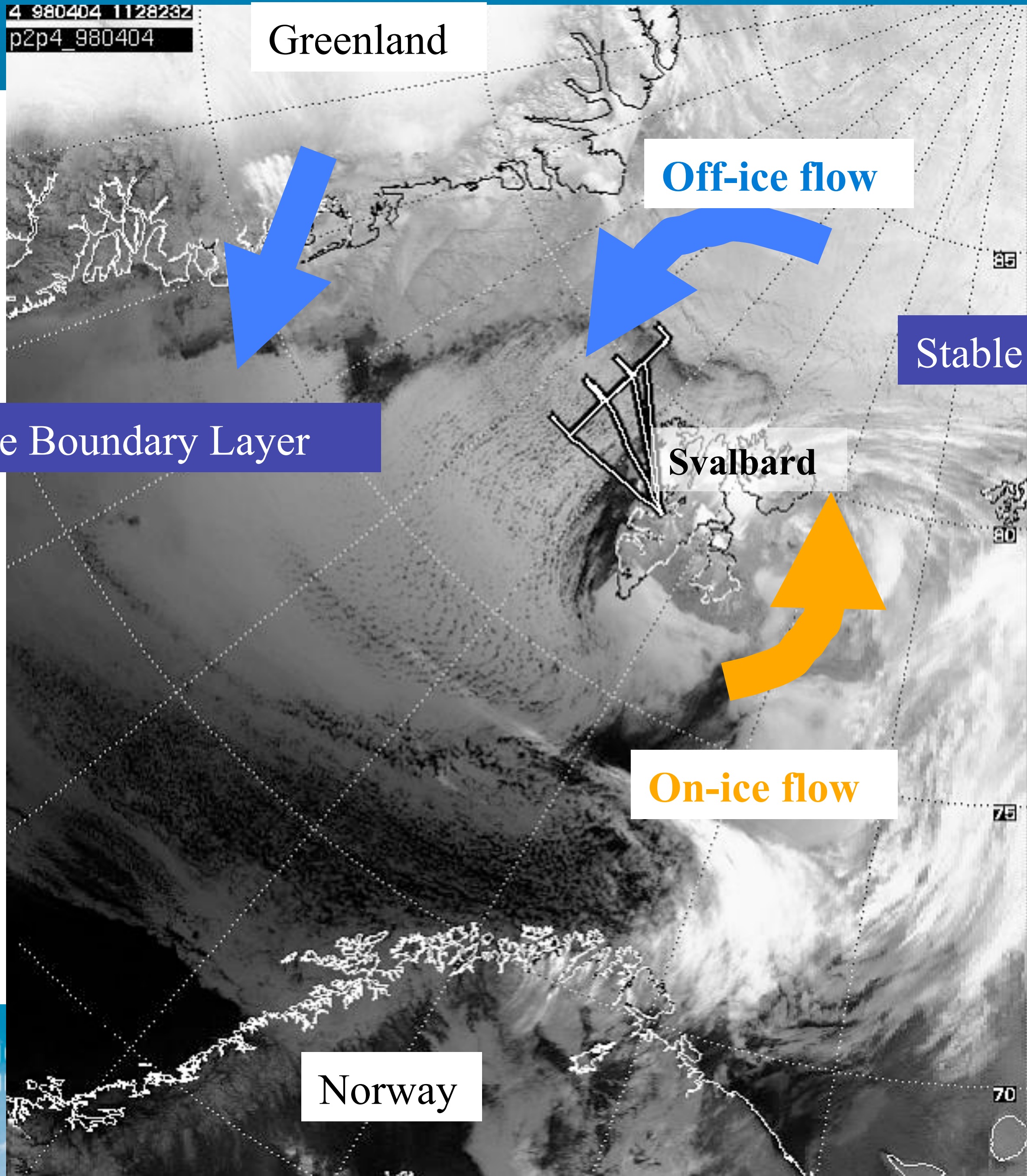
Input: Initial and surface boundary conditions (monthly)

Adjoint sensitivities:

$$\frac{\partial A_{ice}(t_{end})}{\partial x}$$

courtesy Frank Kauker, AWI/OASys

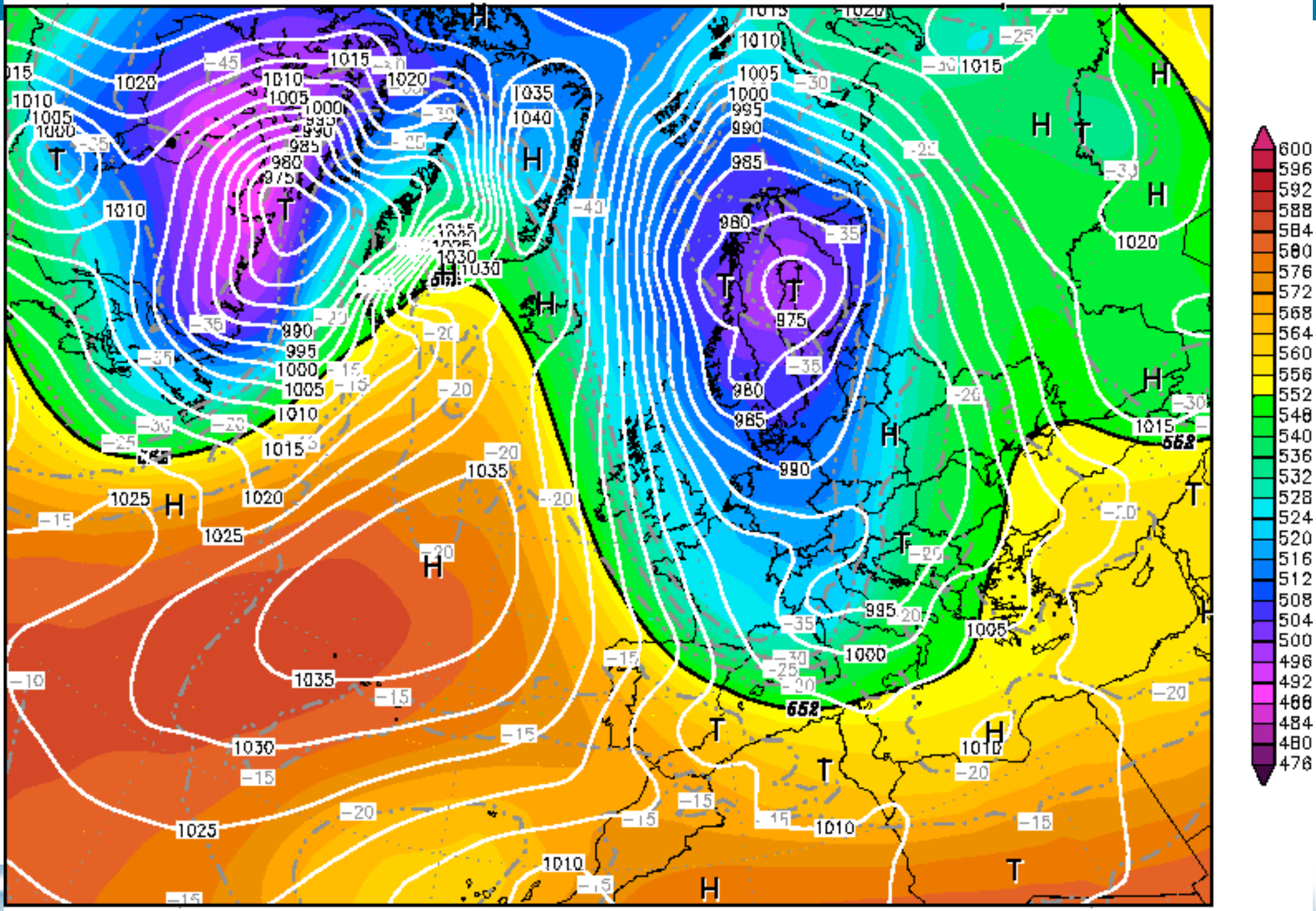
Flow Regimes in the Svalbard/Greenland Region



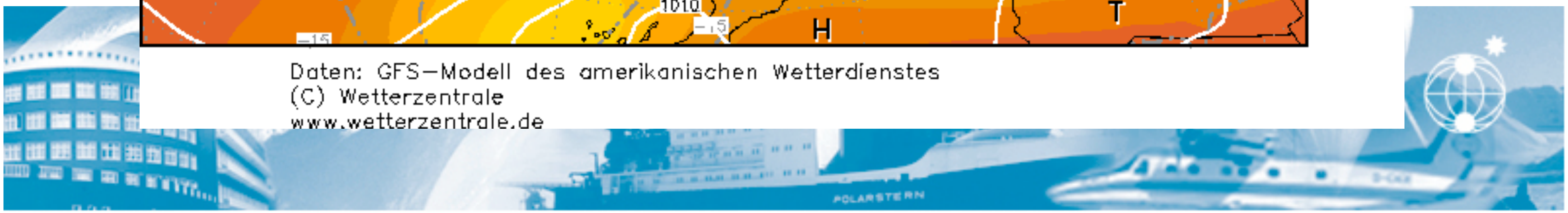
courtesy Christof Lüpkes, AWI

Init : Fri,16MAR2007 06Z Valid: Mon,19MAR2007 18Z

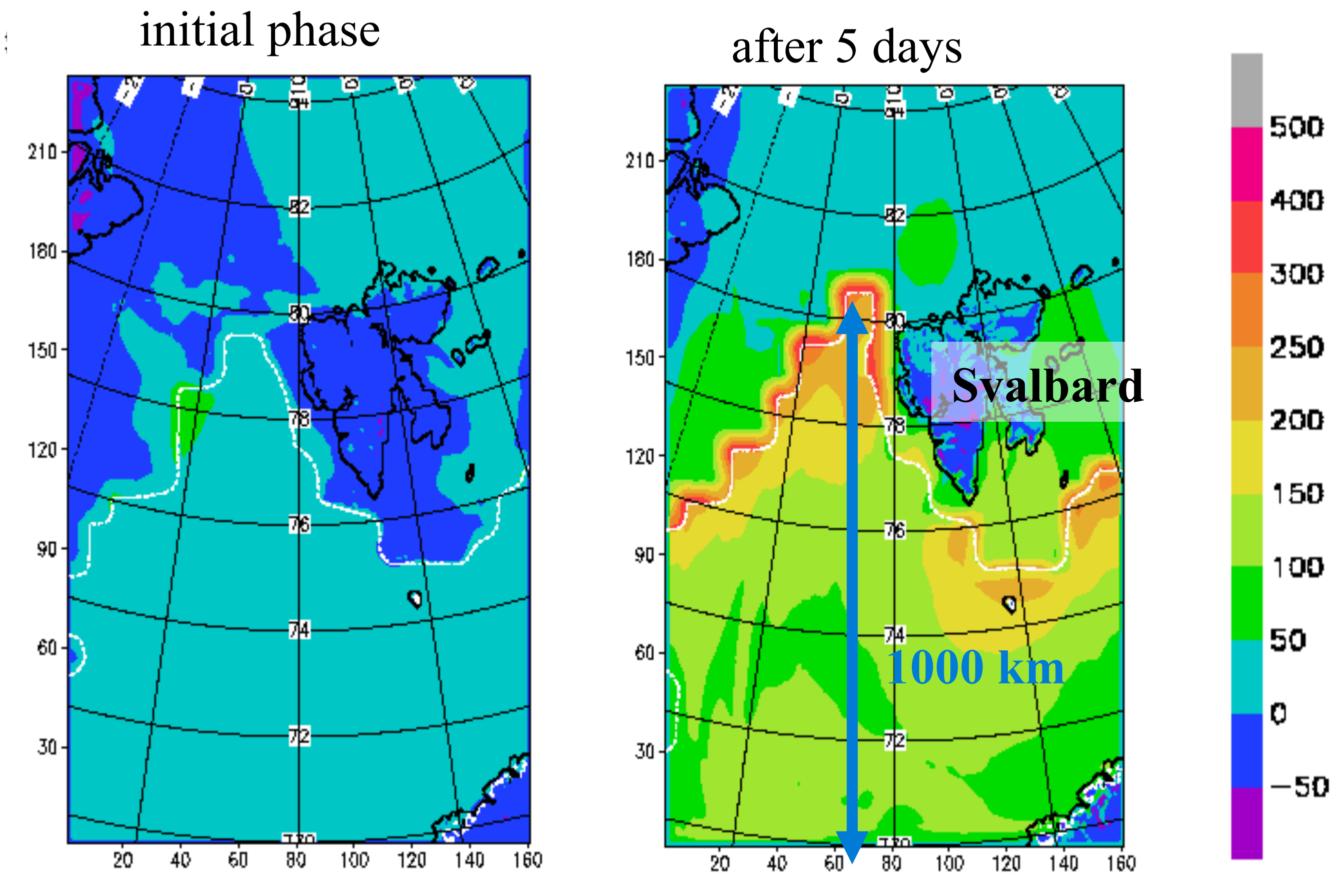
500 hPa Geopot.(gpdm), T (C) und Bodendr. (hPa)



Daten: GFS–Modell des amerikanischen Wetterdienstes
(C) Wetterzentrale
www.wetterzentrale.de



Cold air outbreak, result of the model LM of the German Weather Service
Near-surface heat fluxes (W/m^2)

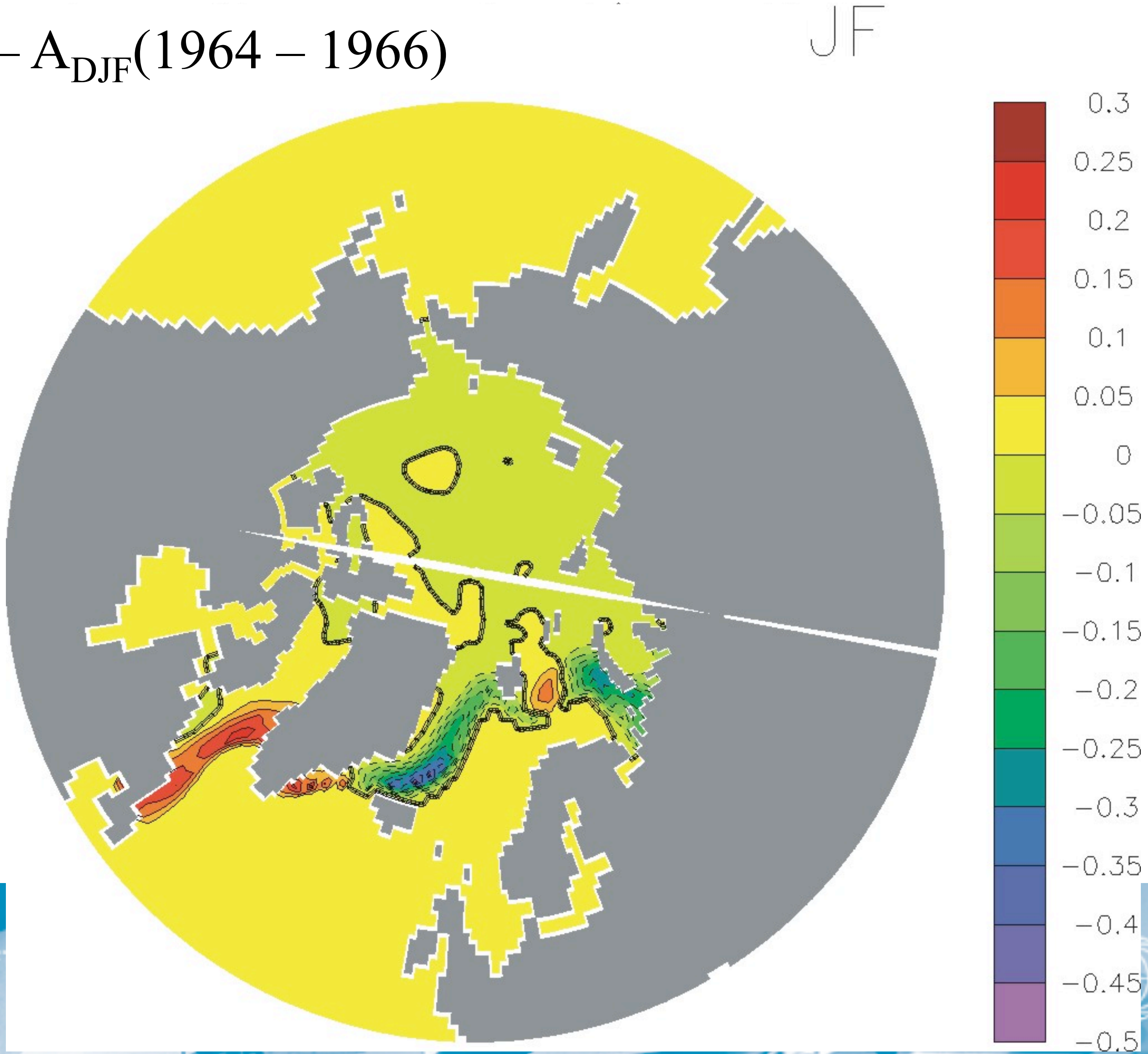


Wacker et al. (2005, BLM)

Response to sea ice concentration anomalies

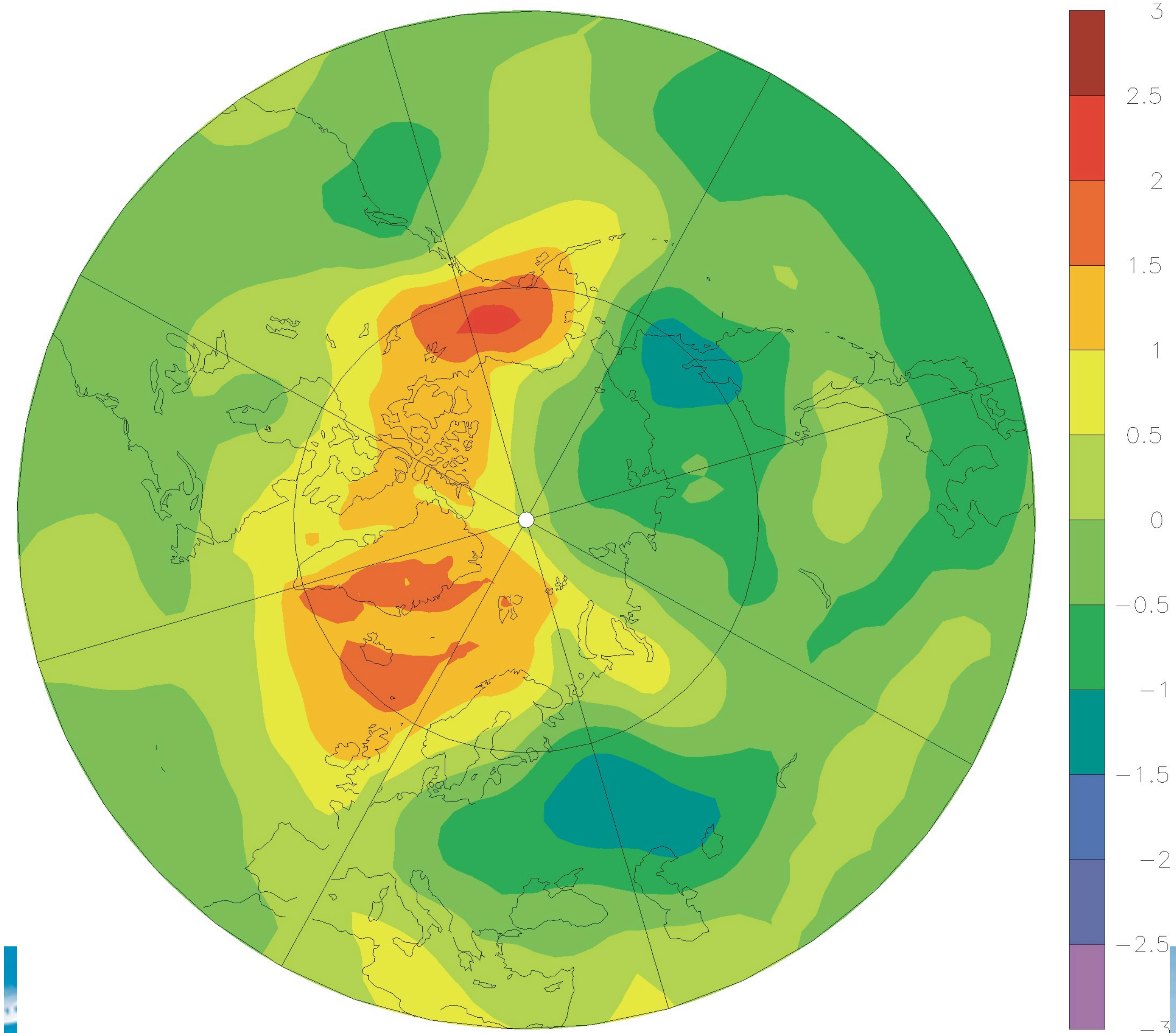
$A_{DJF}(1994 - 1996) – A_{DJF}(1964 – 1966)$

Sea ice concentration from ocean-sea ice hindcast simulation(NCEP forcing) with NAOSIM



Gerdes, 2006

Response to sea ice concentration anomalies



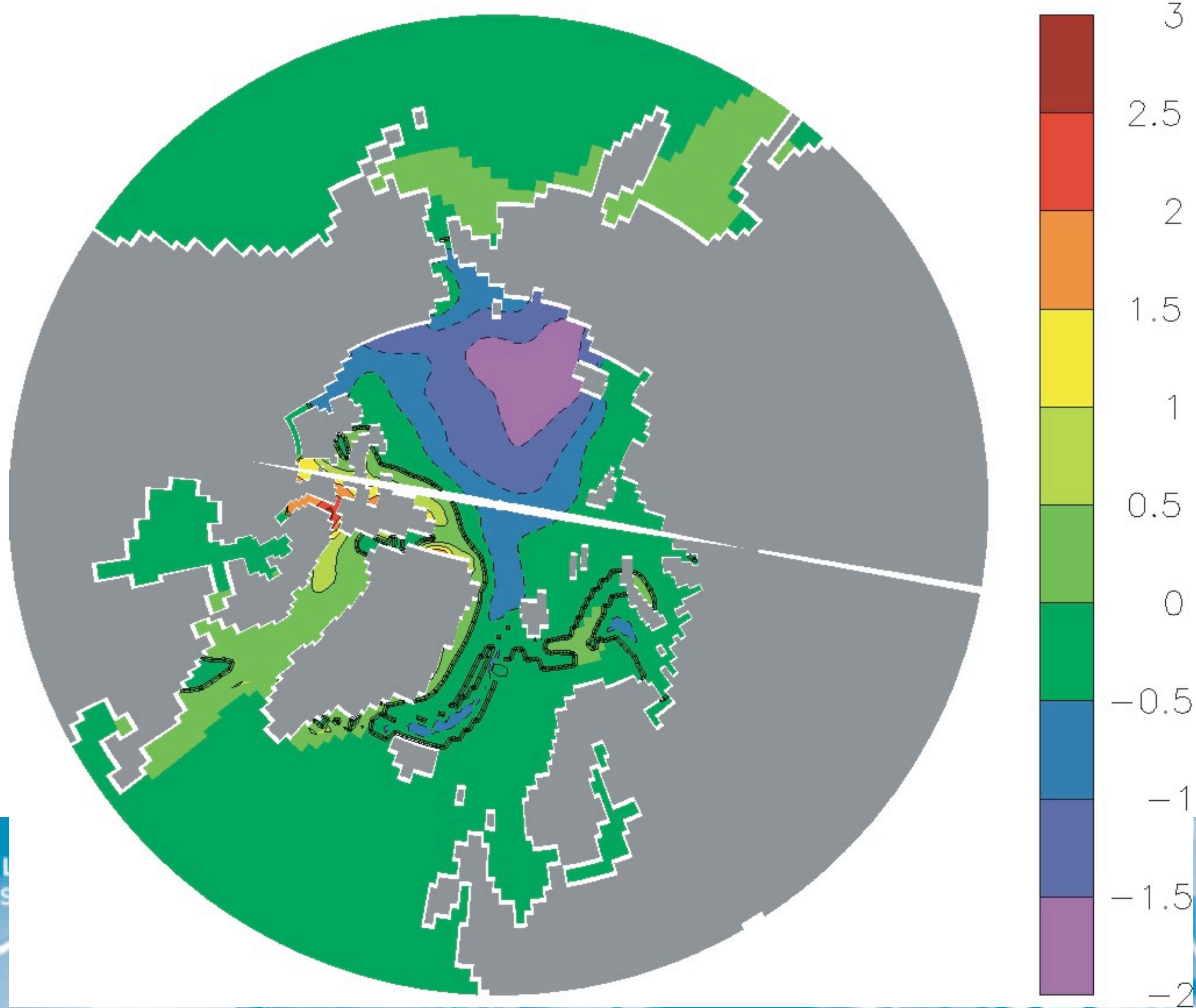
$SLP_{JF}(95) – SLP_{JF}(65)$

Ensemble mean difference from 40 years of GFDL AM1 integration

Consistent with results from Alexander et al., 2004; Deser et al., 2004; Magnusdottir et al., 2004

Impact of ice thickness anomlies

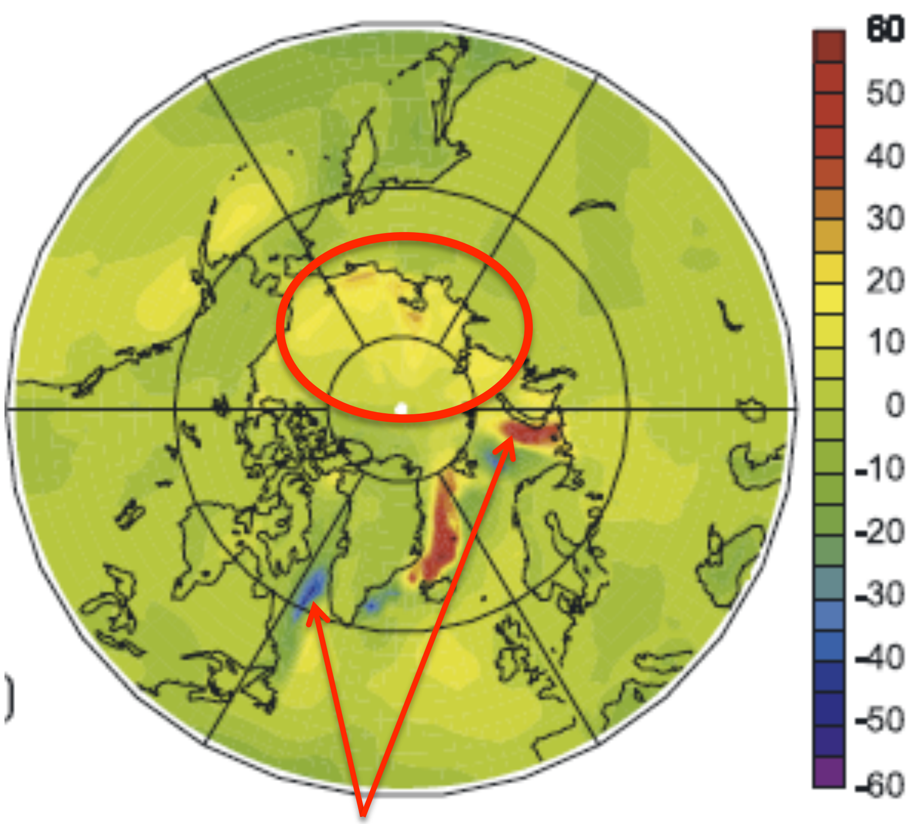
$h_{DJF}(1994 - 1996) – h_{DJF}(1964 – 1966)$



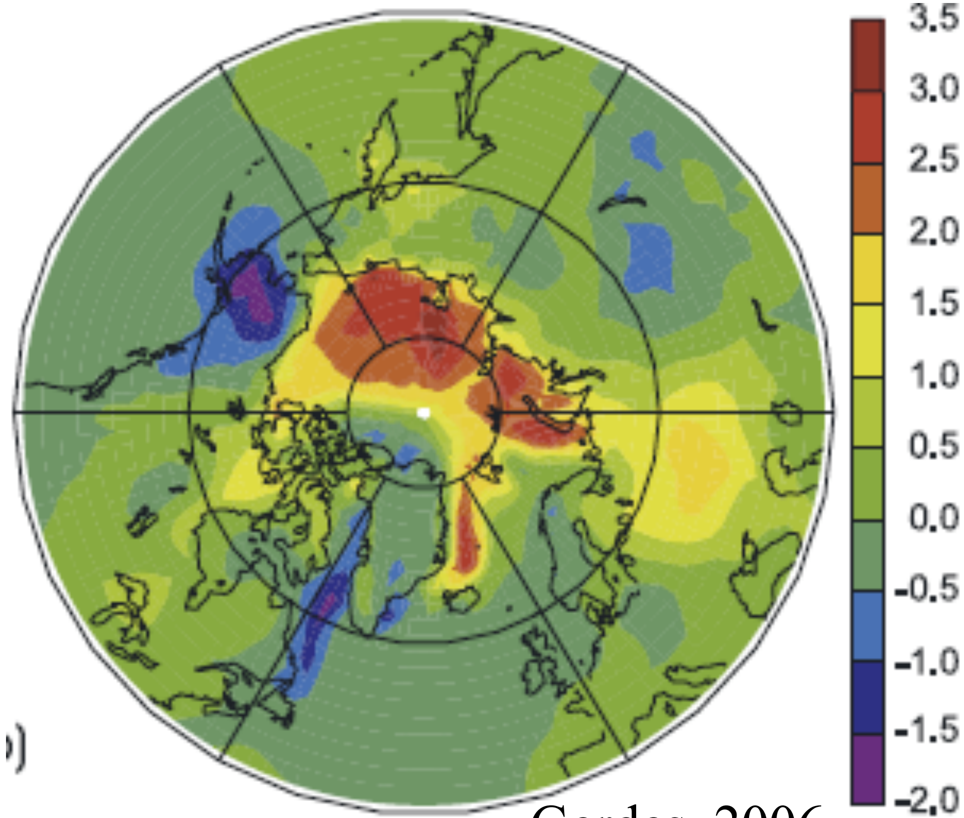
Gerdes, 2006

Impact of ice thickness anomlies

Net upward surface heat flux anomaly

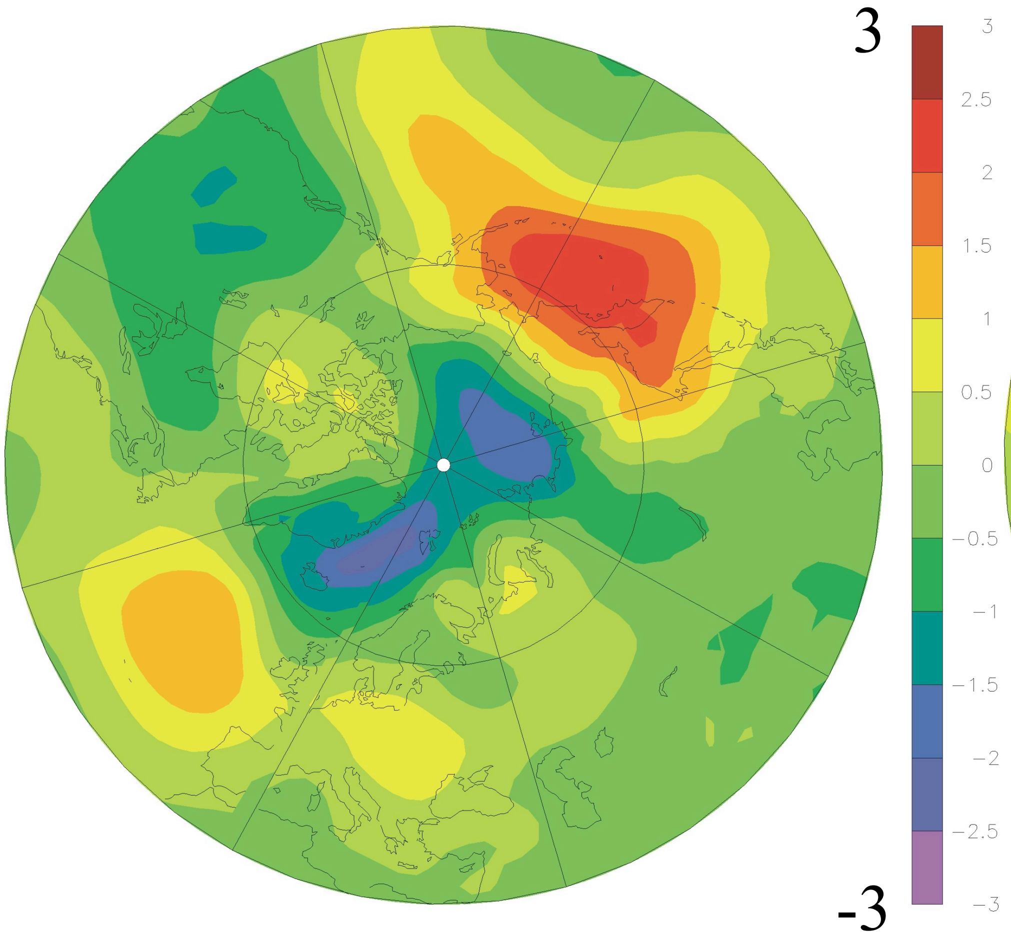


SAT anomaly (thin ice case – thick ice case)

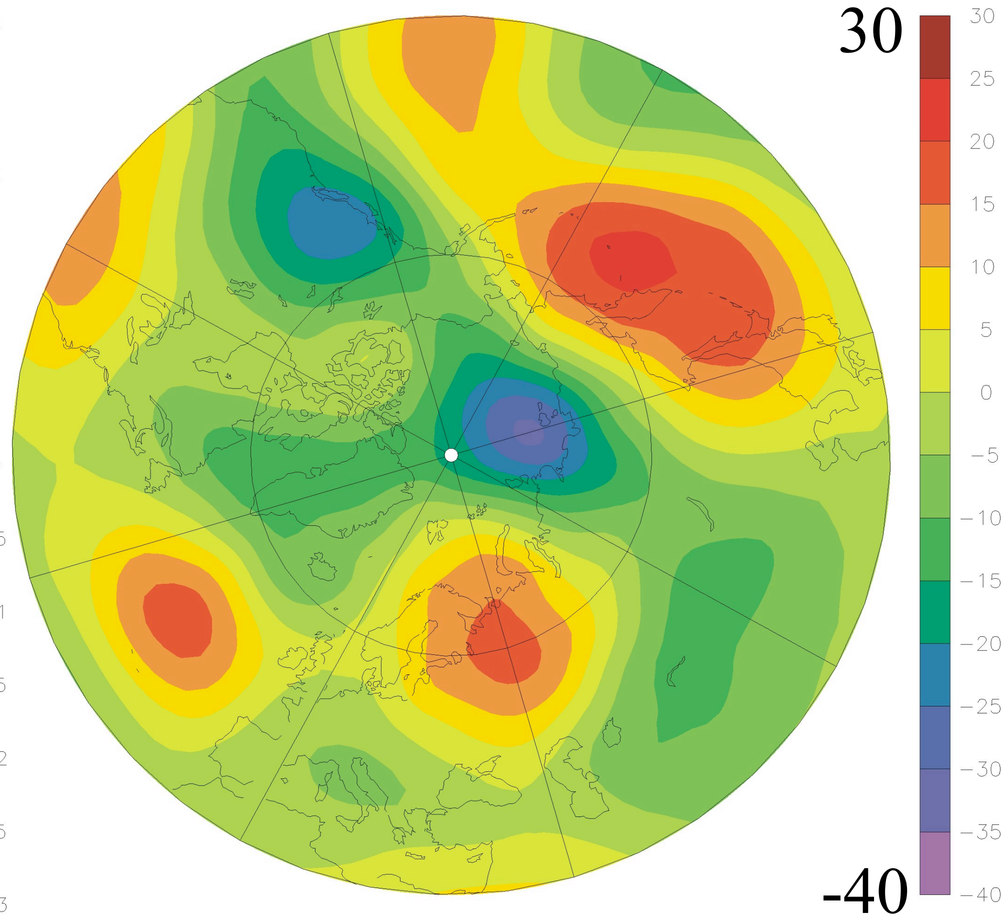


Gerdes, 2006

Impact of ice thickness anomlies



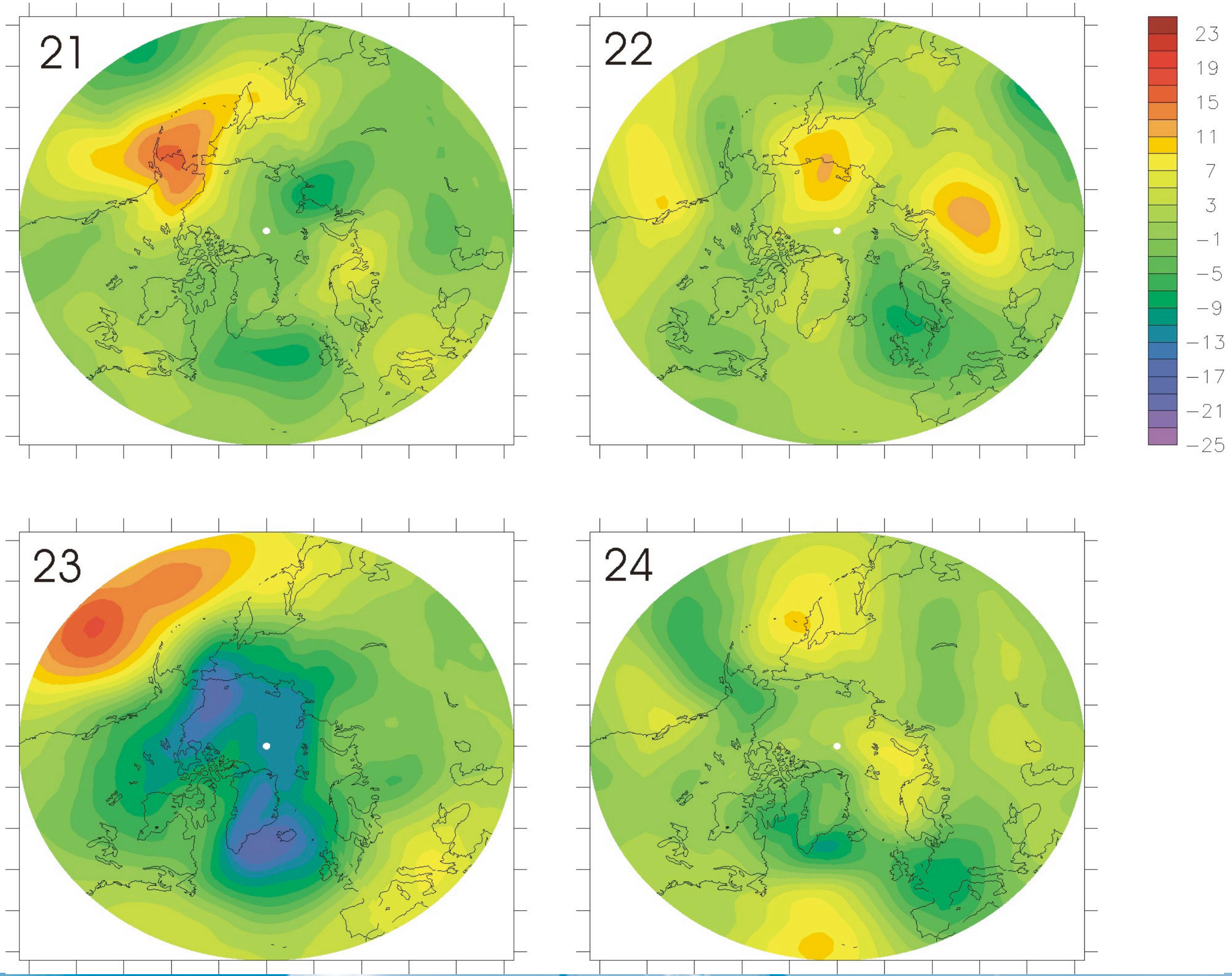
$SLP_{JF}(95) - SLP_{JF}(65)$



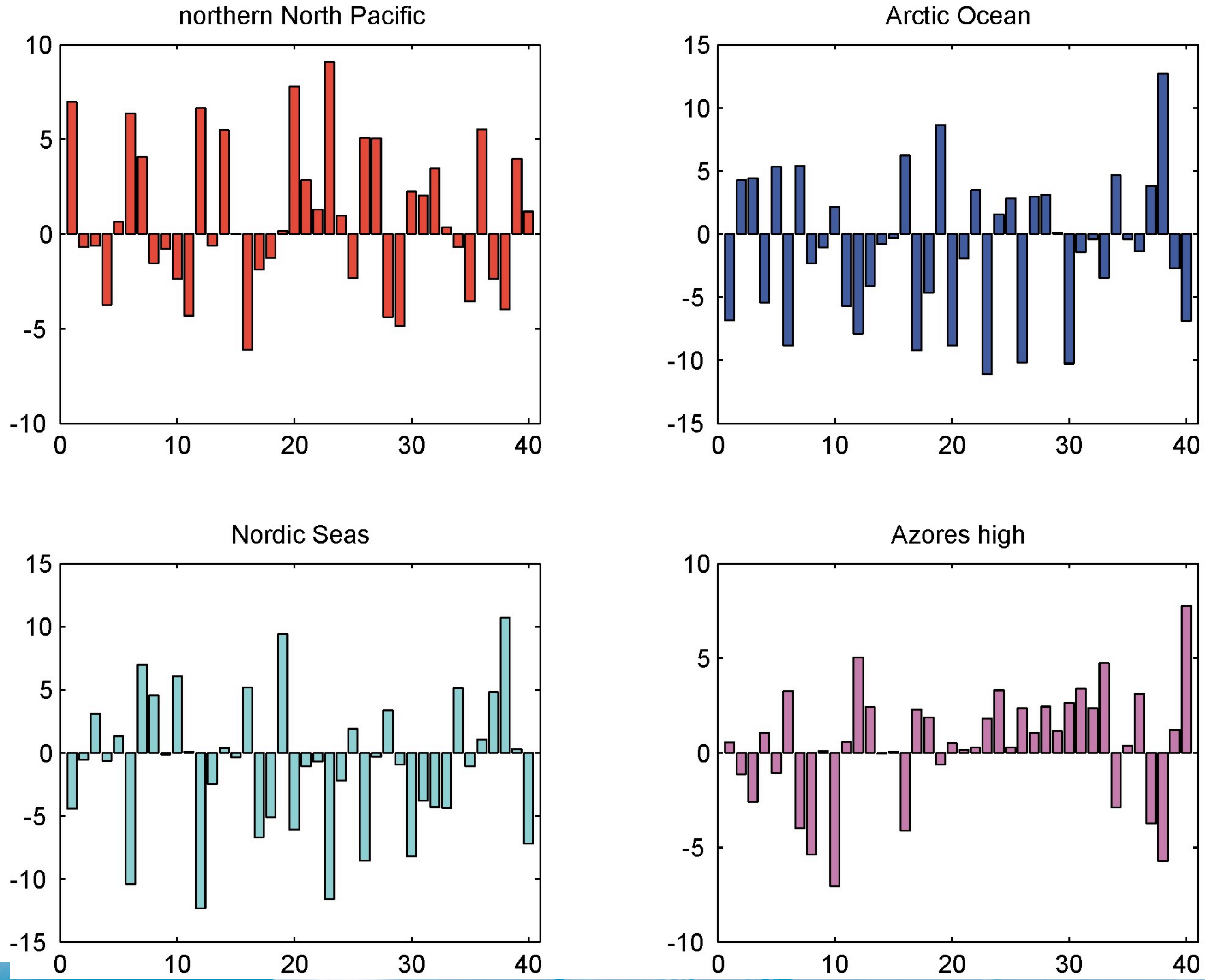
500hPa height 1990s-1960s

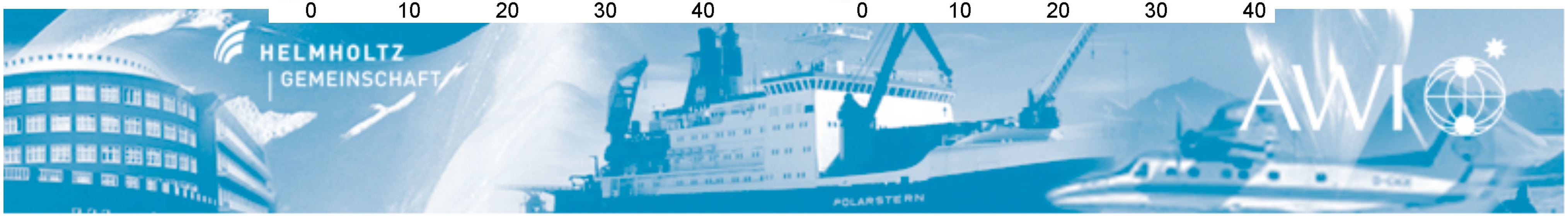
HELMHOLTZ
GEMEINSCHAFT
AWI

No seasonal predictability

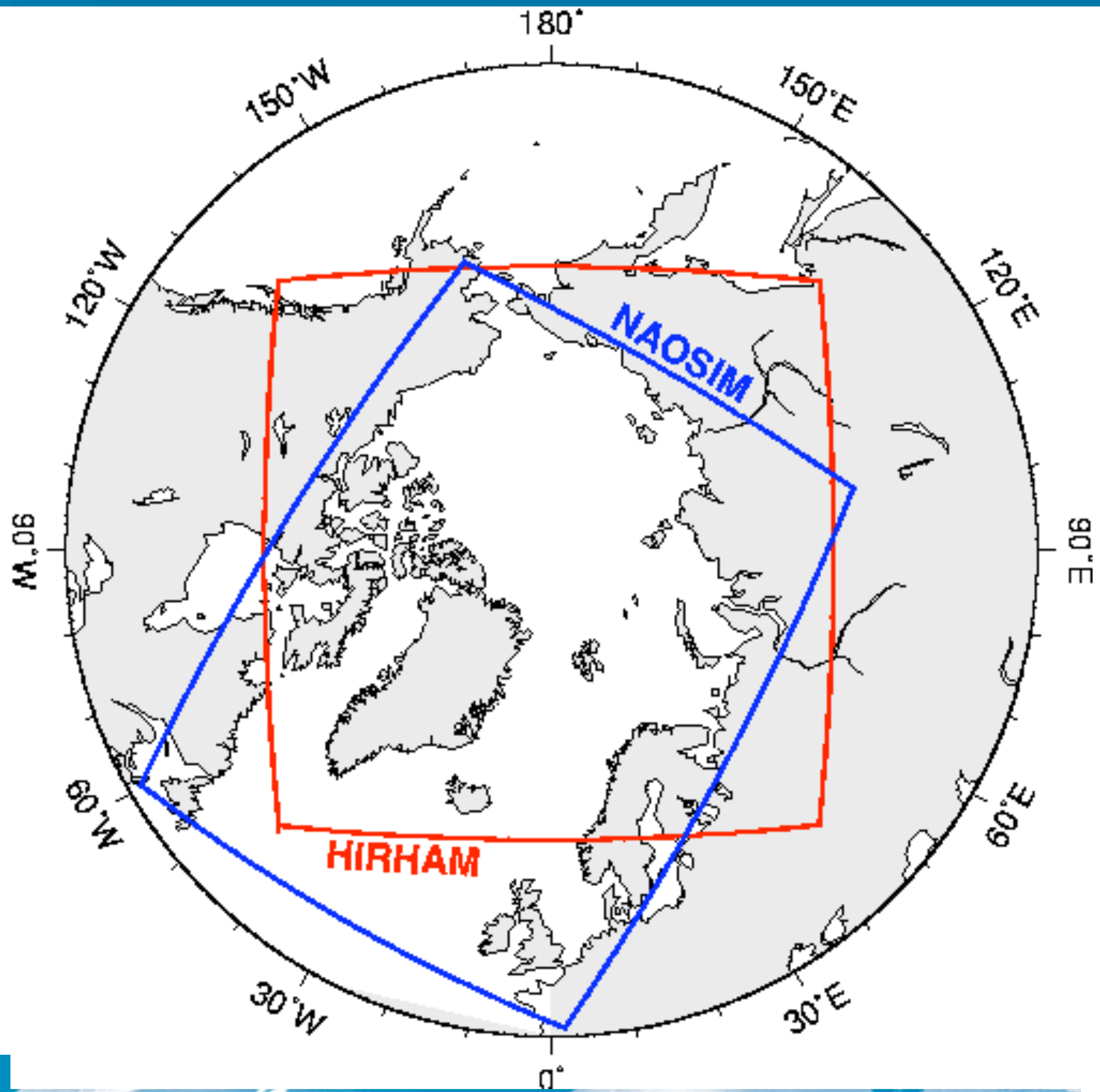


No interannual predictability





Coupled regional Atmosphere-Ocean-Sea Ice Model



Atmosphere model **HIRHAM**

- parallelized version
- 110×100 grid points
- horizontal resolution 0.5°
- 19 vertical levels

Ocean–ice model **NAOSIM**

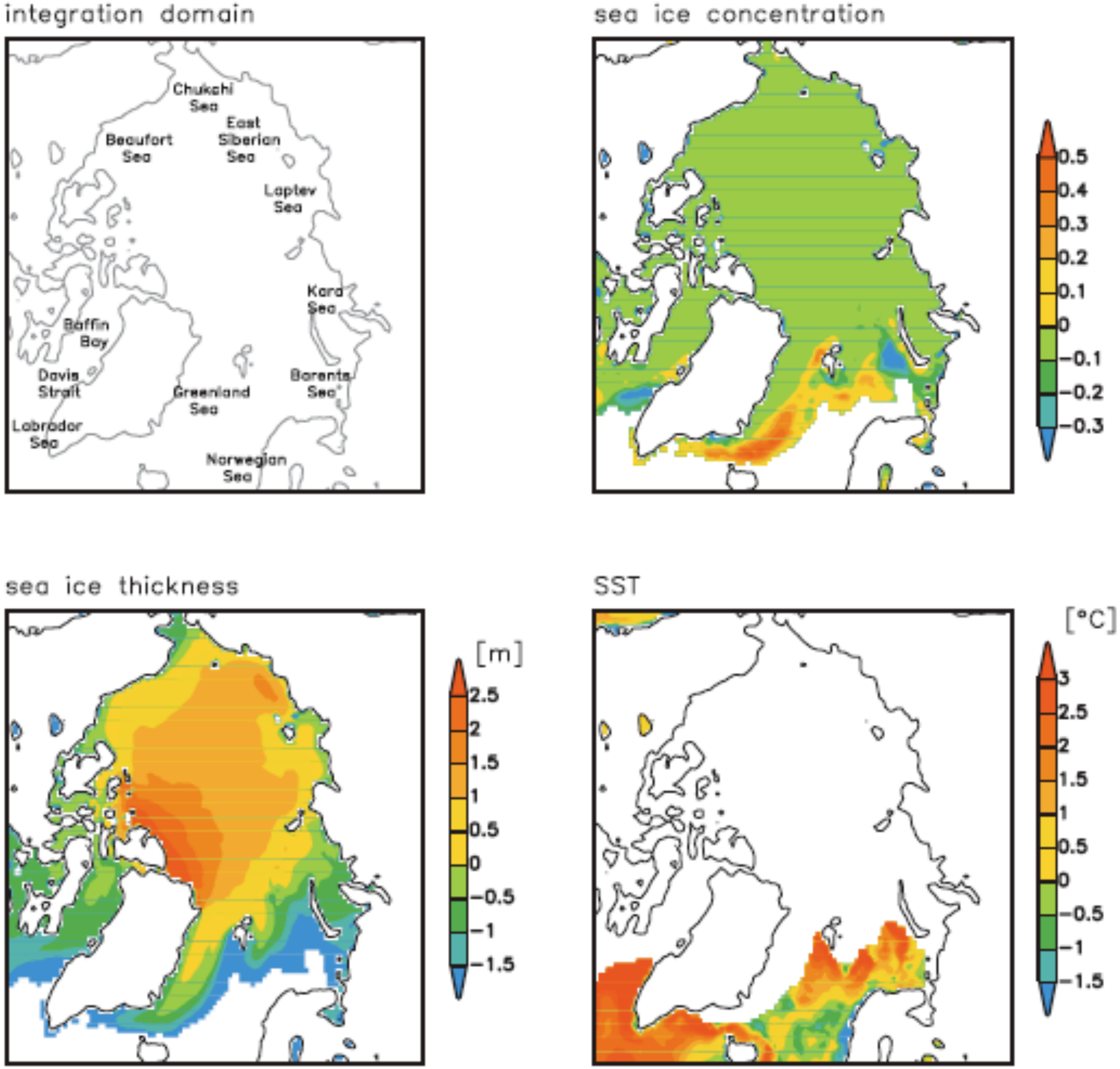
- based on MOM-2 (+EVP)
- 242×169 grid points
- horizontal resolution 0.25°
- 30 vertical levels

Boundary forcing ERA-40

Courtesy Klaus Dethloff

HIRHAM response to sea ice anomalies

RINKE ET AL.: INFLUENCE OF SEA ICE ON THE ATMOSPHERE JGR, 2006



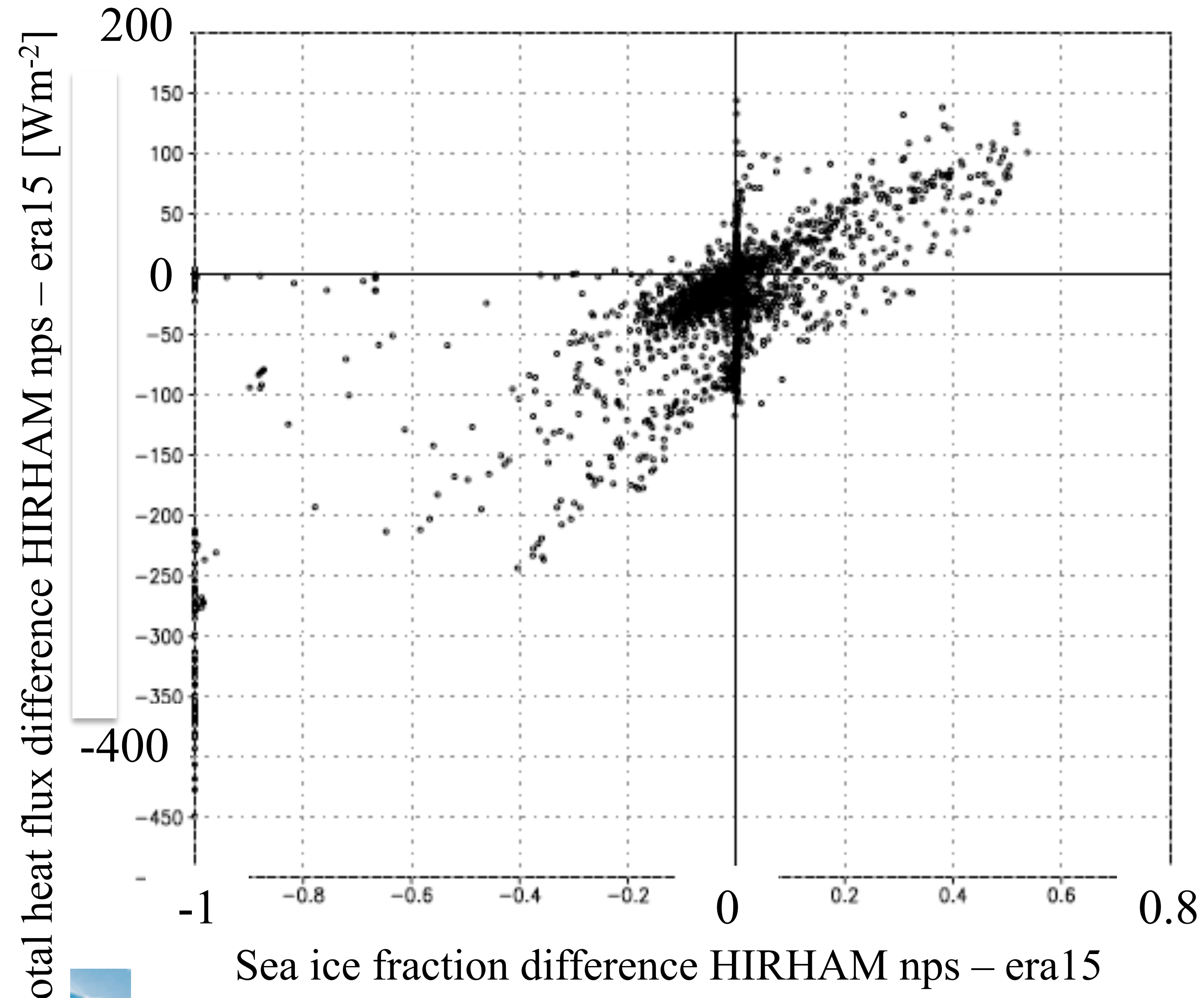
Differences of
sea ice concentration,
sea ice thickness,
sea surface temperature

between the data computed from the Naval Postgraduate School (NPS) ice-ocean model and ERA15 data ("NPS minus ERA15"),

for mean winter (DJF) 1979–1993.

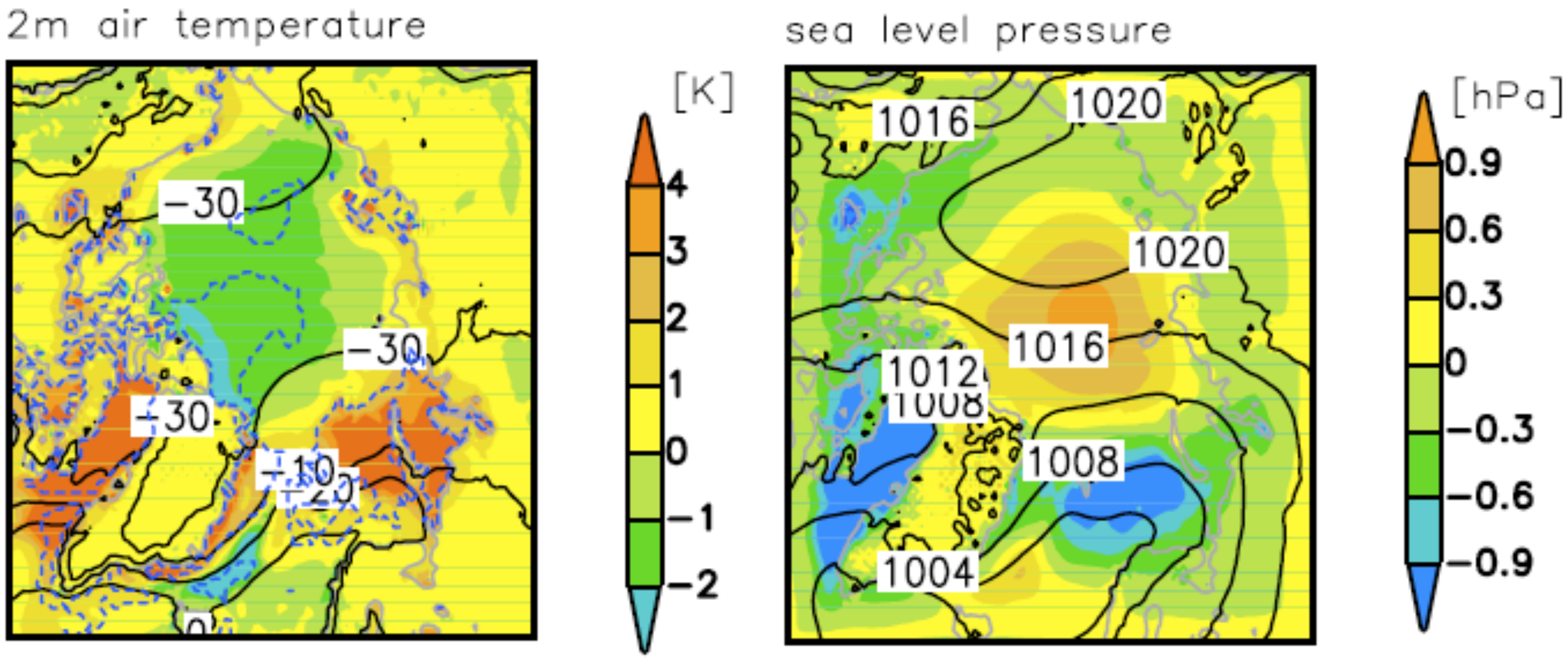
HIRHAM: heat flux vs. ice concentration

Rinke et al., JGR, 2006



Dependency of latent + sensible heat flux change on the sea ice fraction change DJF 1979–1993

HIRHAM: SAT and SLP response

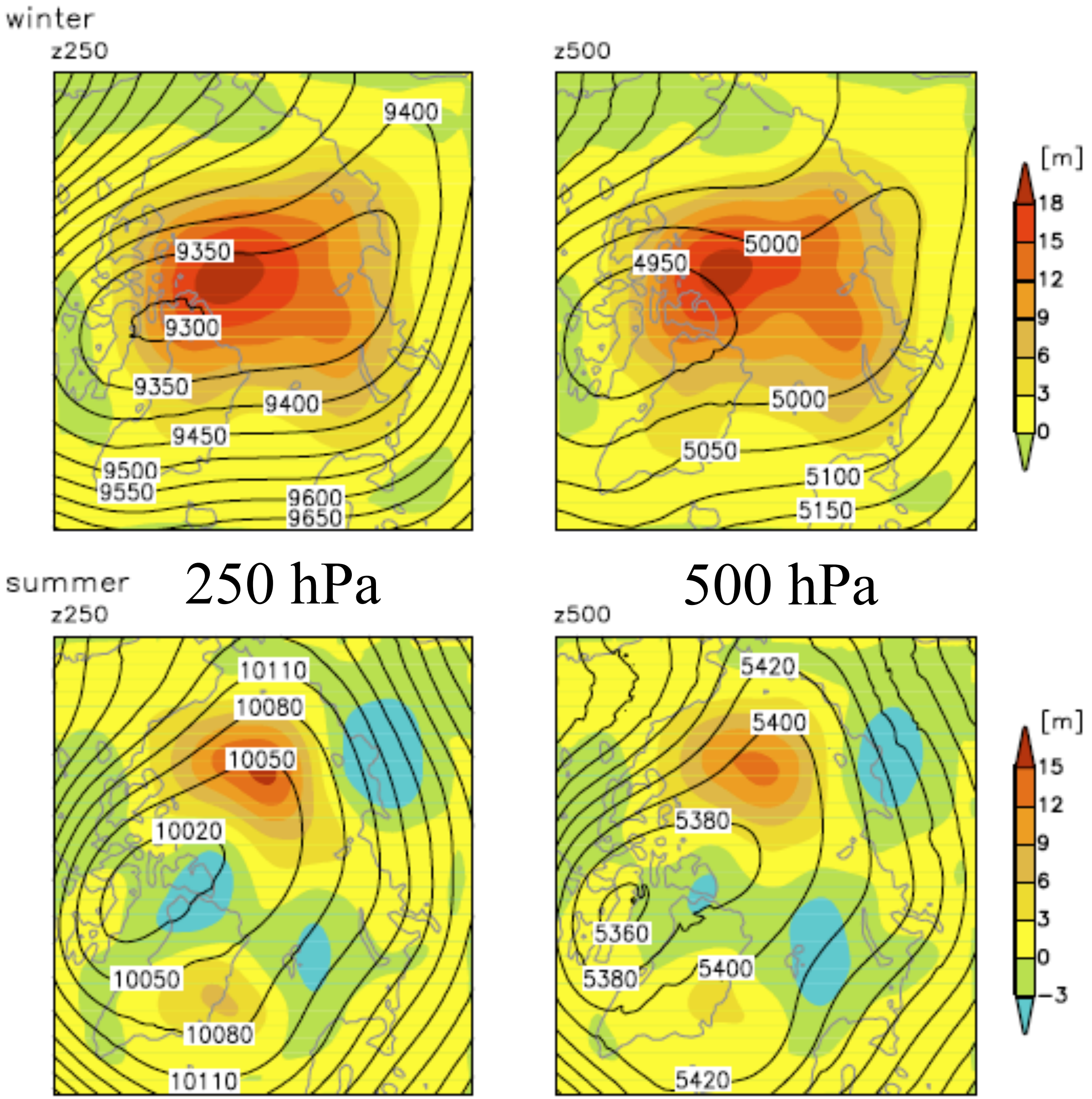


Rinke et al., JGR, 2006

HIRHAM: Geopotential response

winter

summer



Rinke et al., JGR, 2006

Conclusions from HIRHAM experiments

The direct thermodynamic response in winter is limited to about 800hPa. The specification of the winter marginal sea ice zone is important for the simulation of regional circulation patterns and atmospheric temperature profiles.

Ice thickness has an Arctic-wide response in the large-scale circulation.

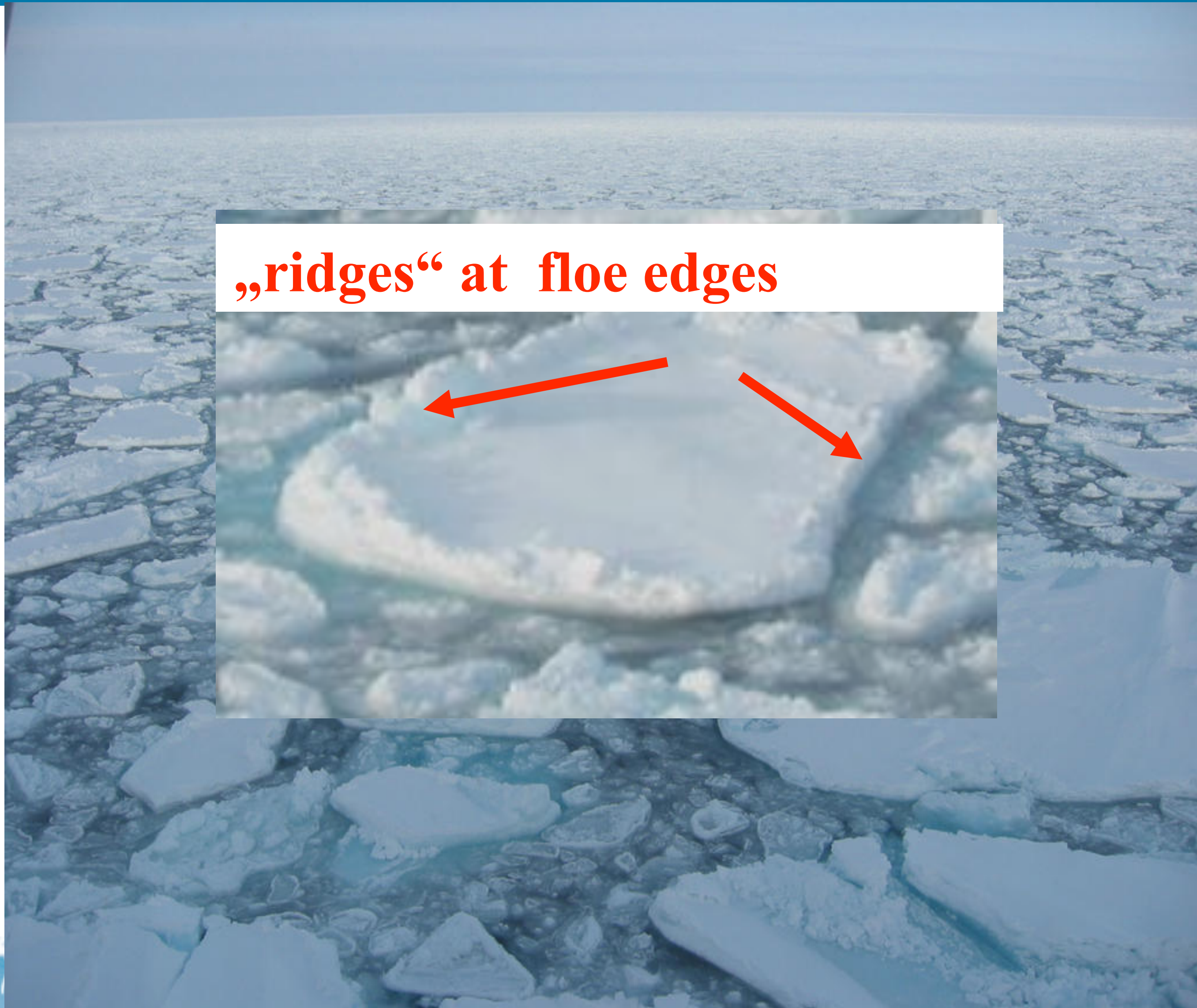
During summer, the thermodynamic effect of sea ice changes is small, but the dynamic response is still important.

Recommend that atmospheric simulations specify the SST/sea ice fraction and the spatial distribution of sea ice thickness realistically, esp. in winter.

Adapted from Rinke et al., JGR, 2006

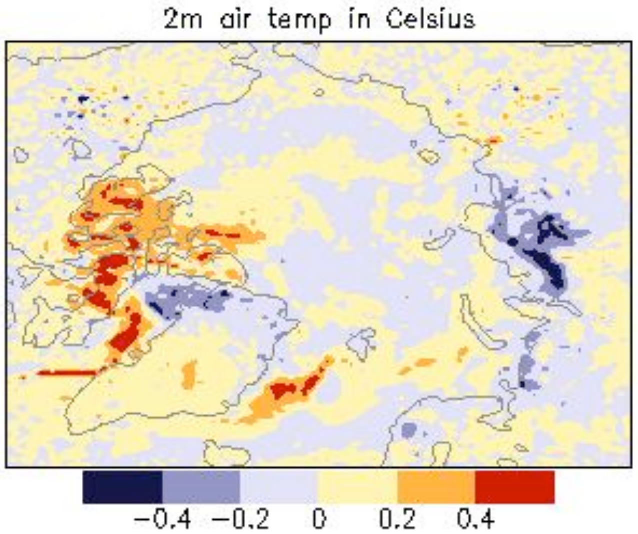
Sea ice is a very inhomogenous surface, both in terms of heat and momentum exchange

Parameterization of atmospheric surfacedrag in the marginal sea ice zone

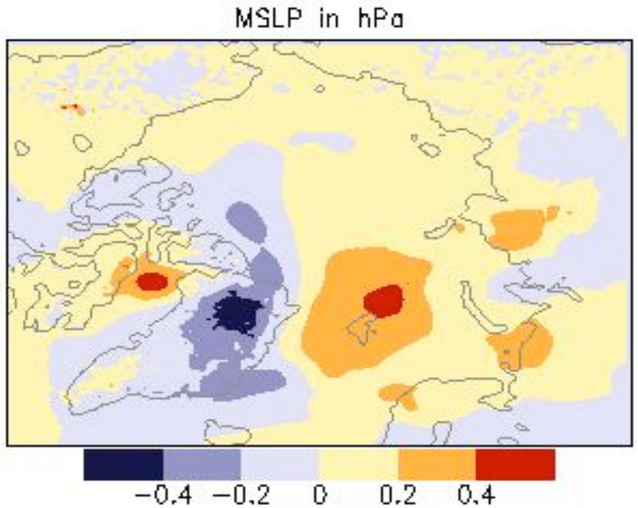


Rinke and Saha, 2005, priv.com.

2m air temperature



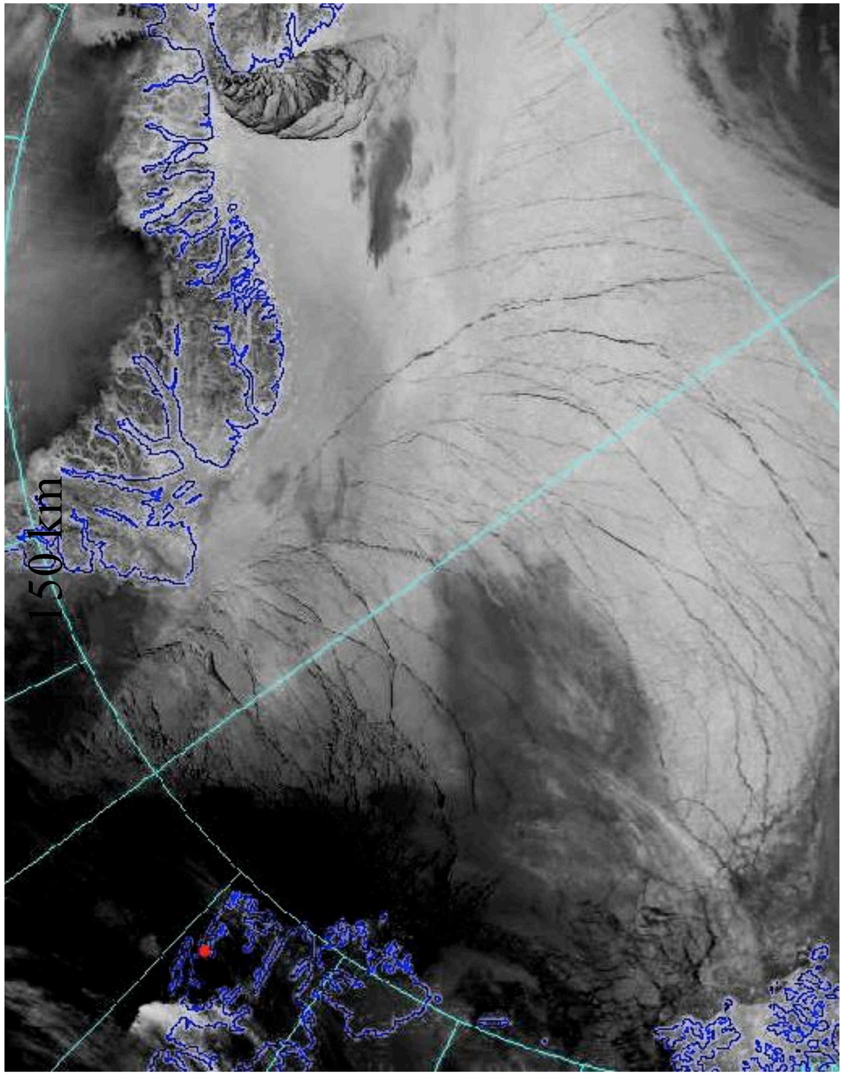
mean sea level pressure



Differences in temperature and SLP.
Model results with new roughness subtracted from model results with old roughness. HIRHAM results for April 2003

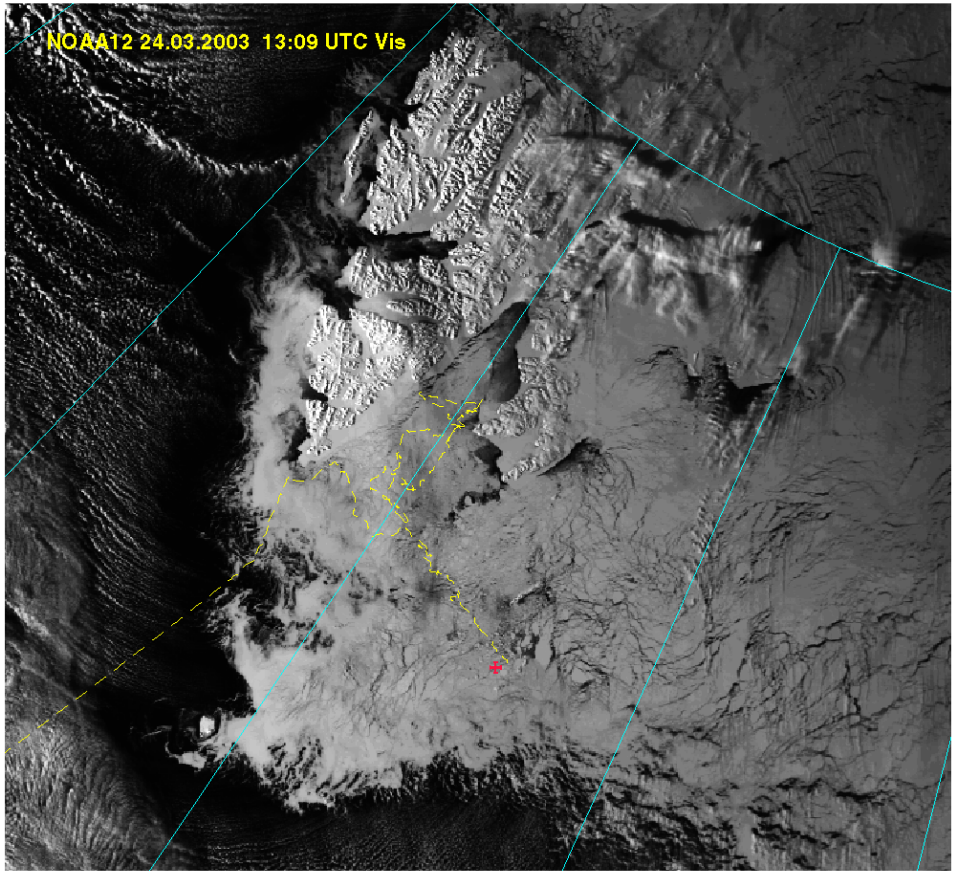
Leads

,organized‘ Arctic leads, April 2003



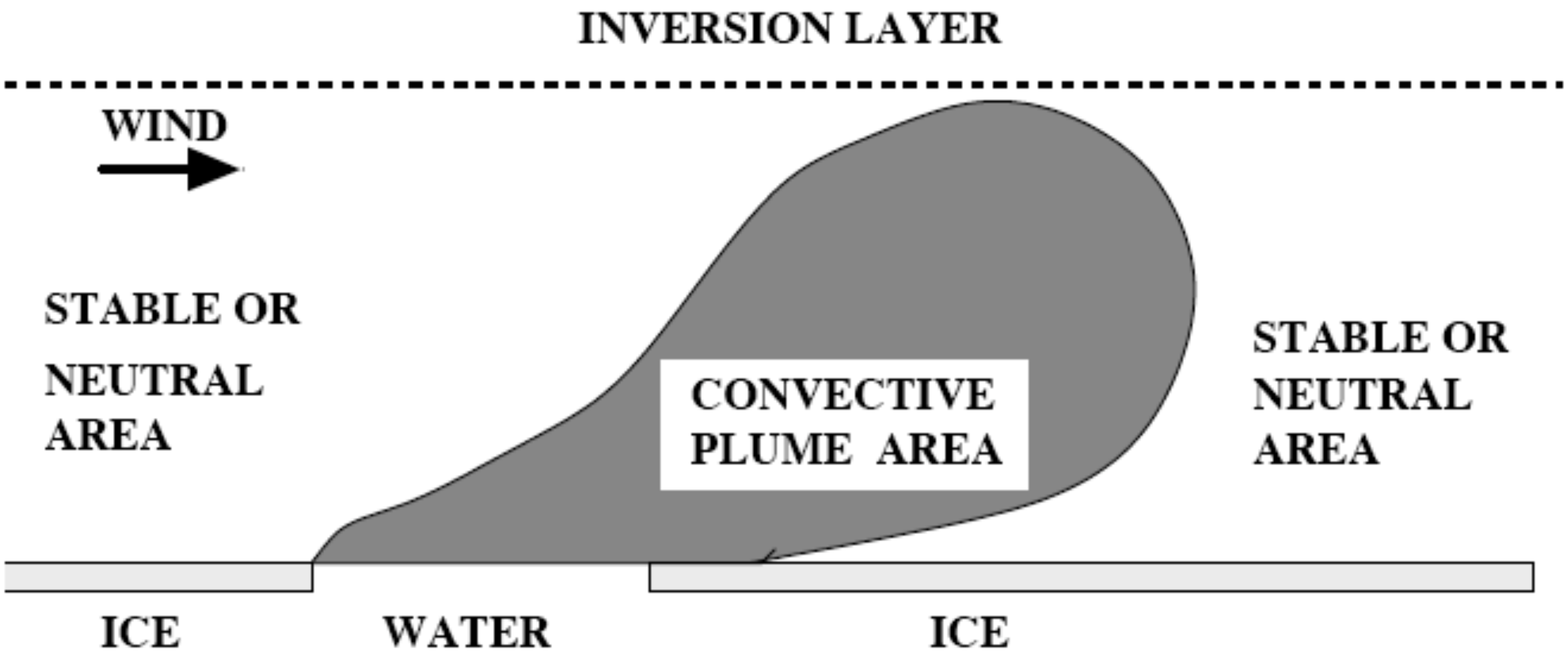
190 km

non-organized‘ leads, Barents Sea, April 2003



Courtesy Christof Lüpkes

HELMHOLTZ
GEMEINSCHAFT
AWI



Lüpkes et al., 2008

Microscale non-eddy resolving model with new turbulence closure

sensible heat flux

pot. temperature

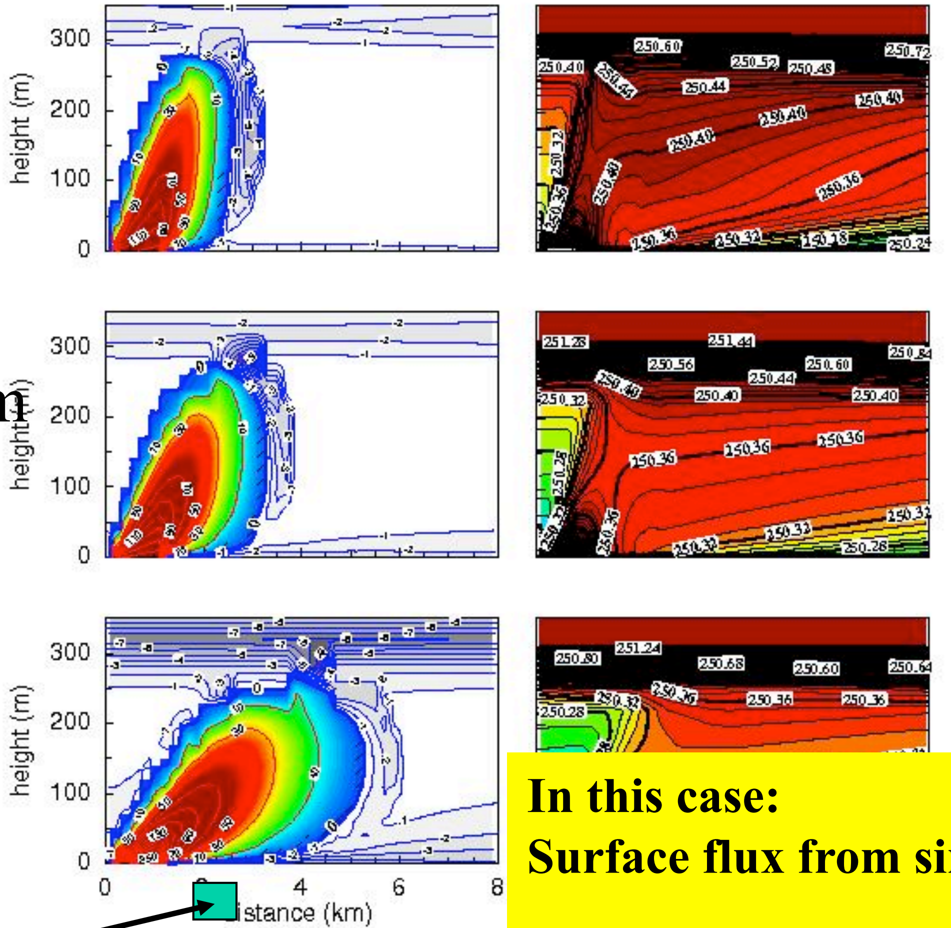
Lüpkes et al., JGR, 2008

surface wind

weak wind

medium wind

strong wind



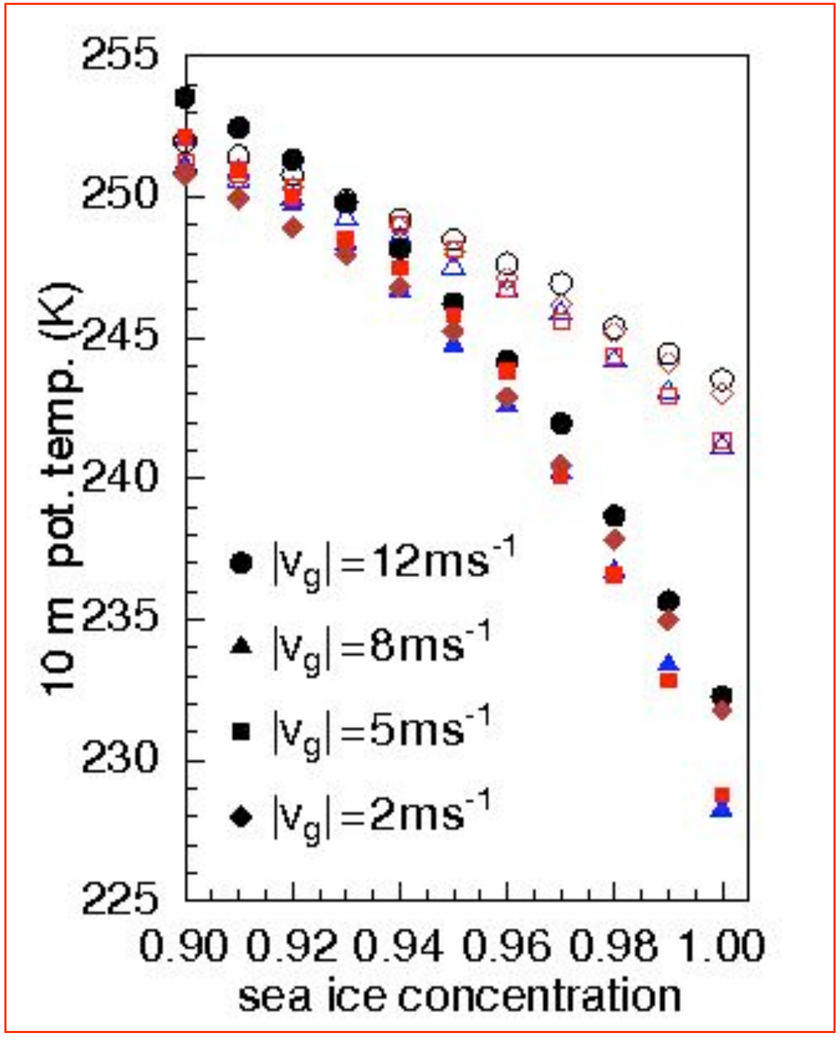
Lead width: 1km

In this case:
Surface flux from single leads: 180 W/m²

Effect on temperature: a few tenth of a degree (agrees with Walter et al., 1995)

Lead contributes to stabilizing of ABL

10 m temperature as a function of sea ice concentration (after 2 days and 12 hours of simulation)



1 % change in sea ice concentration results in 1- 3.5 K change in ABL temperature

Lüpkes et al. GRL, 2008

Summary

- Ice concentration (presence of leads) determines local ocean-atmosphere heat fluxes and stability of ABL.
- Sea ice thickness important over larger areas and for months to seasons (initialization of ocean-sea ice-atmosphere systems).
- Surface structure of sea ice (roughness, albedo, heat capacity) is very variable and enters exchanges of heat and momentum.