ARCTIC SEA-ICE AND MID-LATITUDE STORM TRACKS

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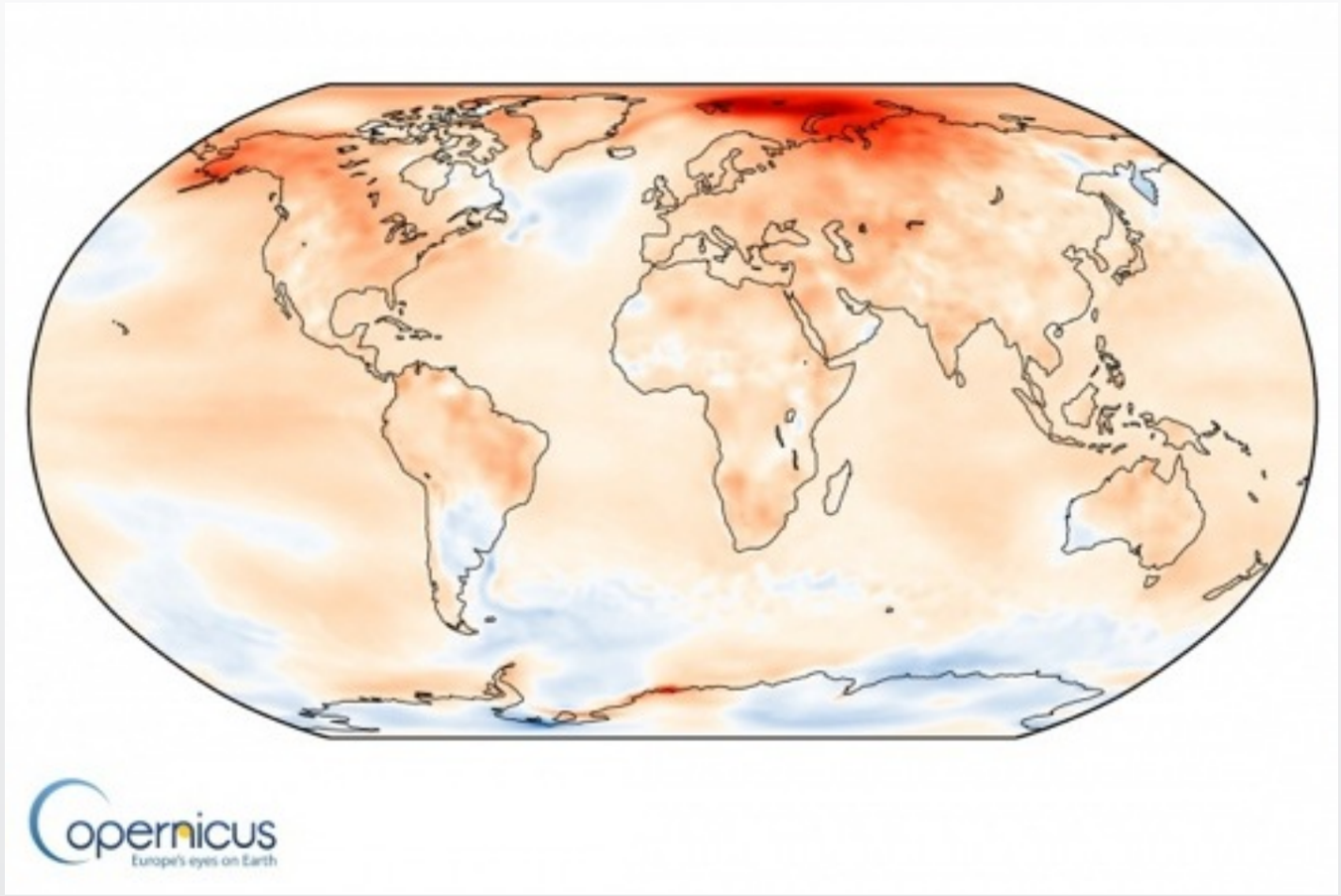
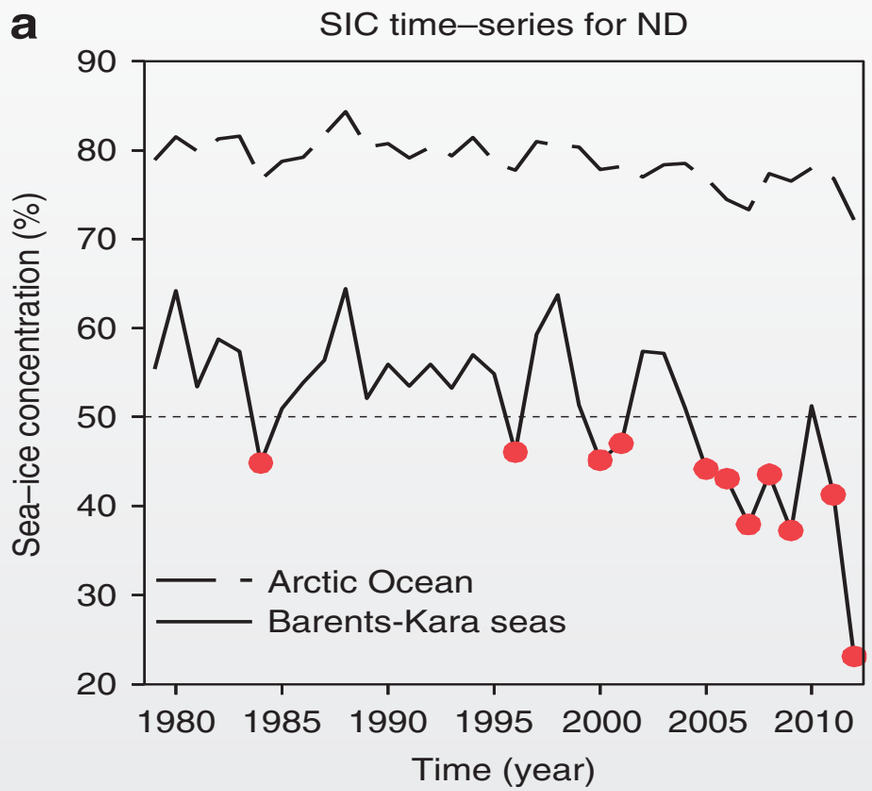
Copernicus Climate Change Service

T2m anomaly (1979-2010) for July 2015- July 2016



SOURCE: C3S website
https://climate.copernicus.eu/



Kim et al. (2014)

MEDIA

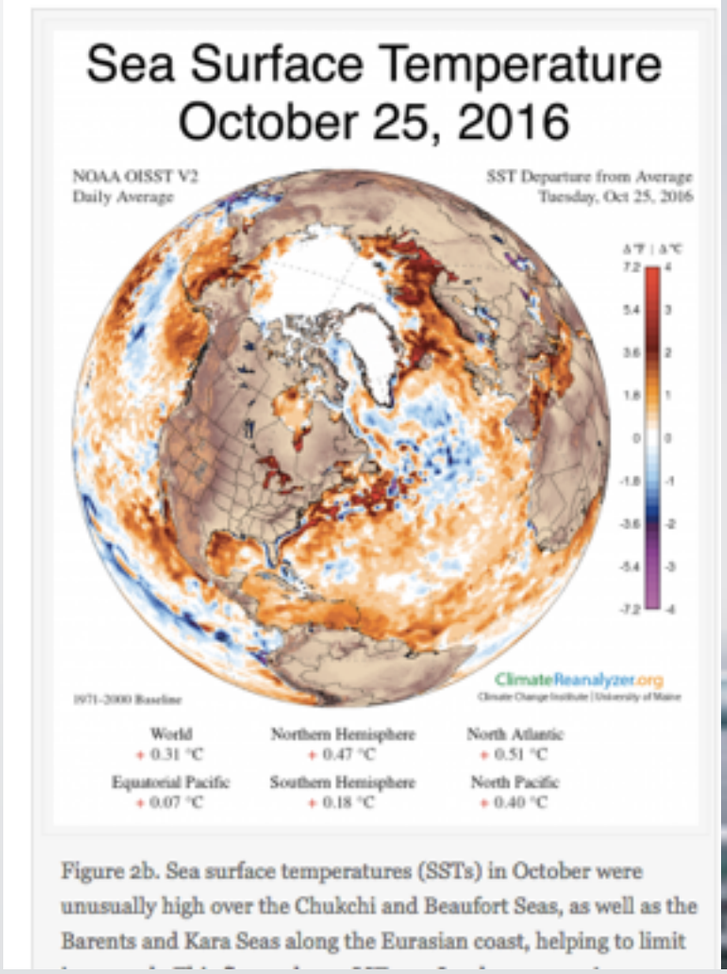


Figure 2b. Sea surface temperatures (SSTs) in October were unusually high over the Chukchi and Beaufort Seas, as well as the Barents and Kara Seas along the Eurasian coast, helping to limit

Geophysical Research Letters

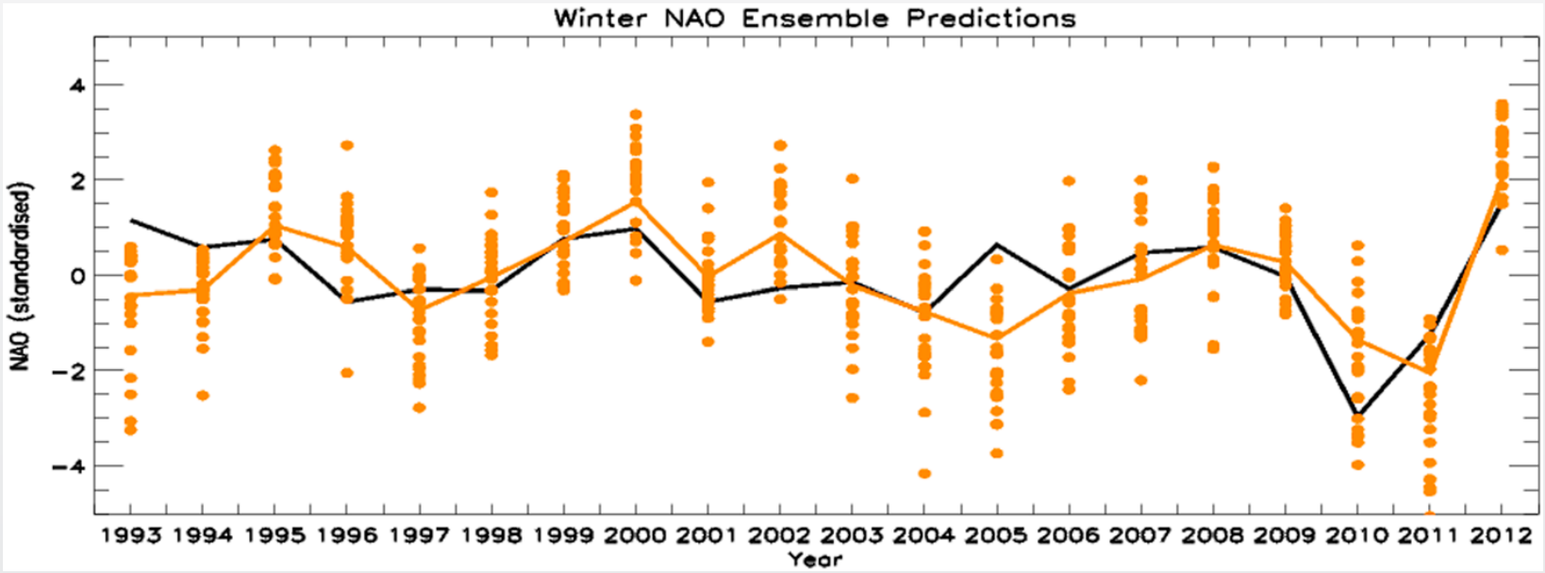
RESEARCH LETTER
10.1002/2014GL059637

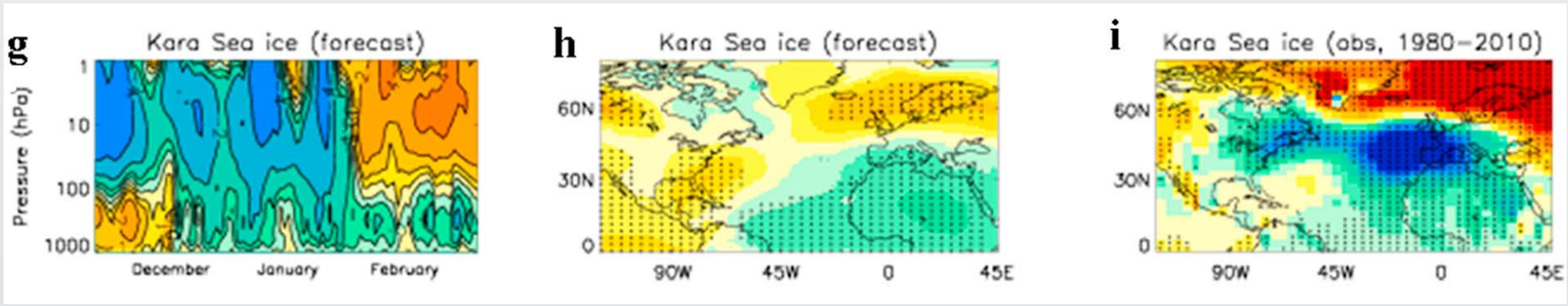
Skillful long-range prediction of European and North American winters

A. A. Scaife[1], A. Arribas[1], E. Blockley[1], A. Brookshaw[1], R. T. Clark[1], N. Dunstone[1], R. Eade[1], D. Fereday[1], C. K. Folland[1,2], M. Gordon[1], L. Hermanson[1,3], J. R. Knight[1], D. J. Lea[1], C. MacLachlan[1], A. Maidens[1], M. Martin[1], A. K. Peterson[1], D. Smith[1], M. Vellinga[1], E. Wallace[1], J. Waters[1], and A. Williams[1]

[1]Met Office Hadley Centre, Exeter, UK, [2]Department of Earth Sciences, University of Gothenburg, Gothenburg, Sweden, [3]Willis Research Network

Key Points:
- The winter NAO can be skilfully predicted months ahead
- The signal-to-noise ratio of the predictable signal is anomalously low
- Predictions of the risk of regional winter extremes are possible





Sea ice source of predictability for NAO

INTRODUCTION

Atmospheric response to sea-ice reduction in the Barents and Kara seas

- Evidence linking sea-ice variability in the **Barents and Kara** seas and circulation in the **North Atlantic**

- A **delayed, non local** link on a sub-seasonal time scale (2 months, e.g. Honda et al. 2009)

- Possible role of **stratosphere** and tropospheric **eddy feedback**

KEY QUESTION: What are the drivers of the response?

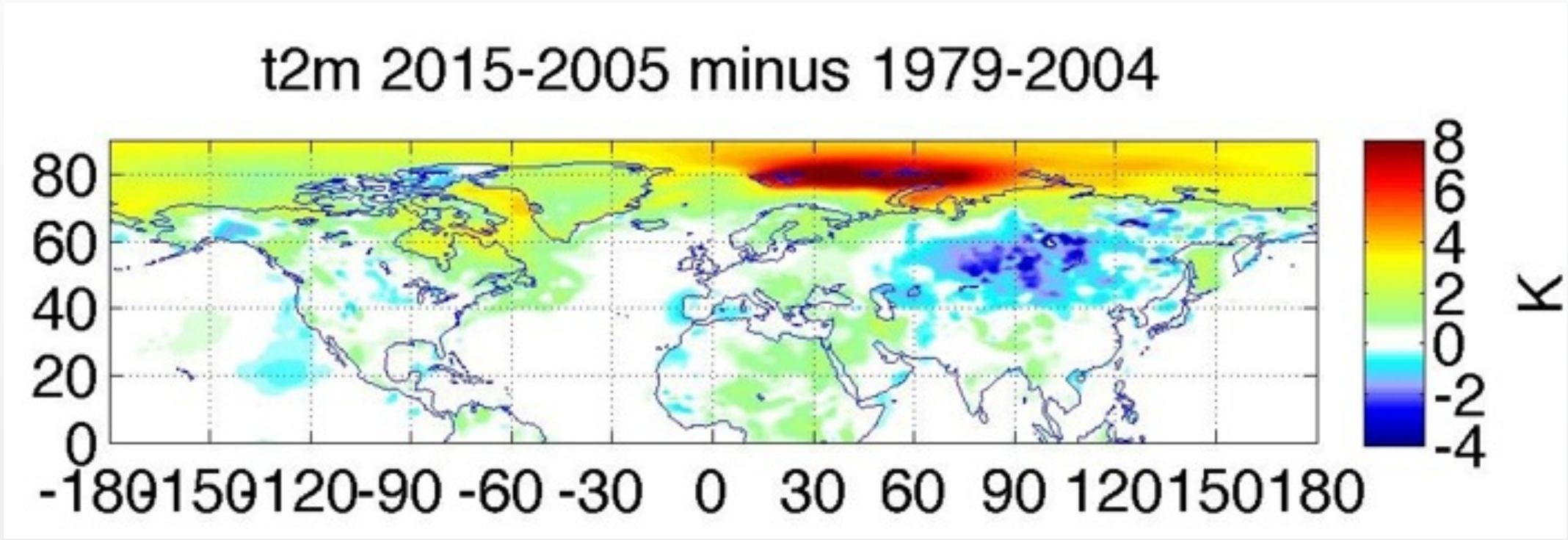
DATA AND METHODOLOGY

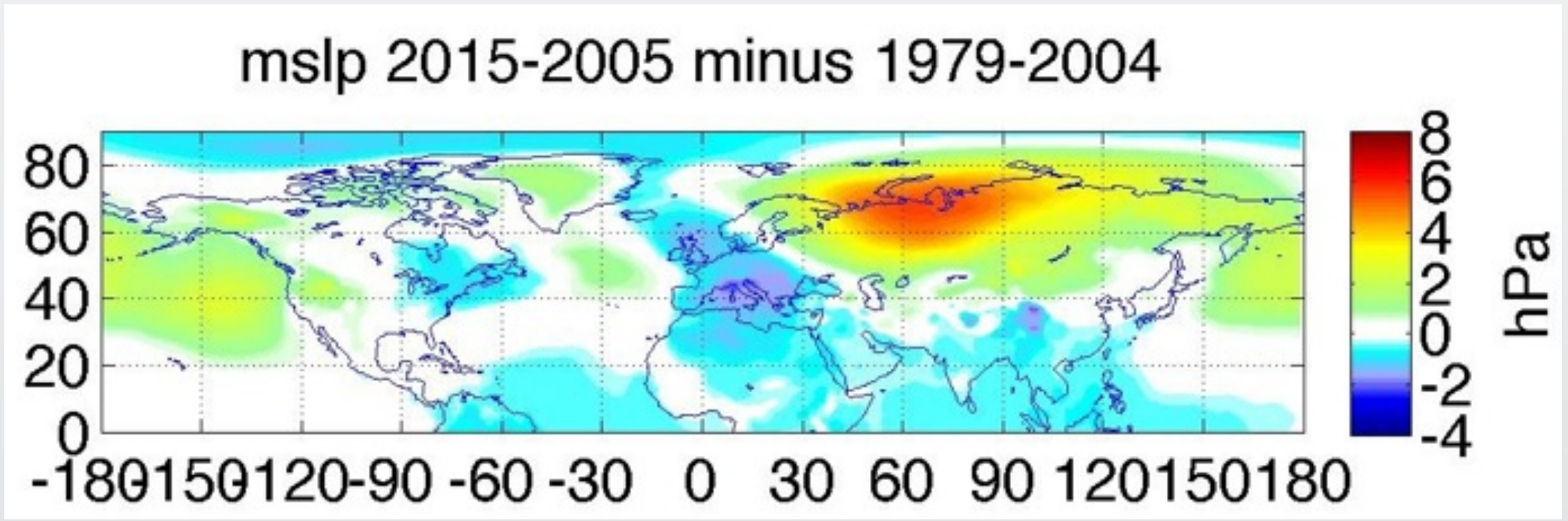
- ERA-INTERIM Reanalysis: Z500, surface fluxes, vT
- Model Experiment: ICTP AGCM prescribed sea-ice reduction
- AQUAPLANET experiment with Idealised Storm Tracks:

OBSERVATIONAL ANALYSIS

WARM ARCTIC COLD SIBERIA

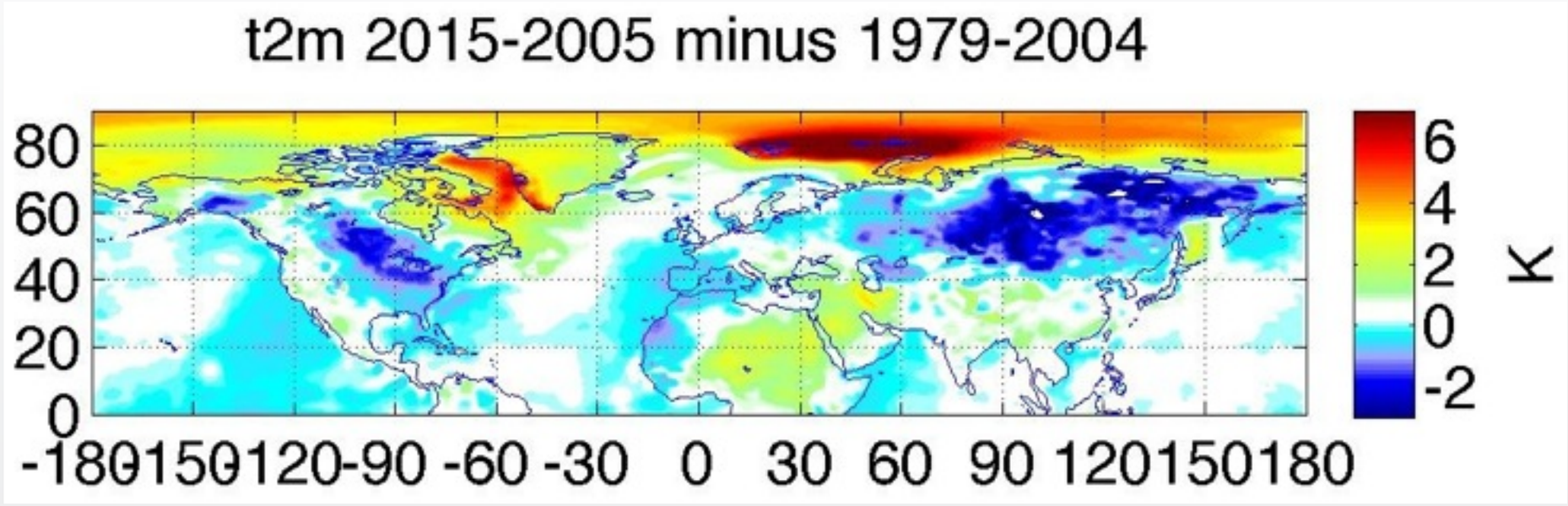
DJF

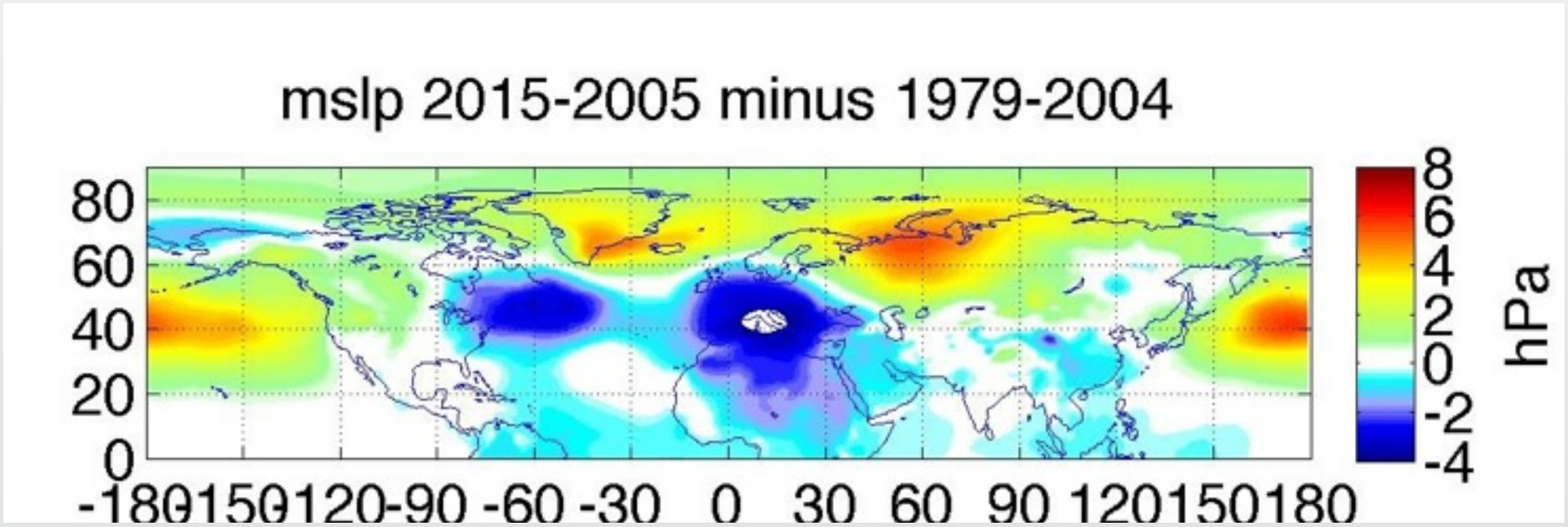




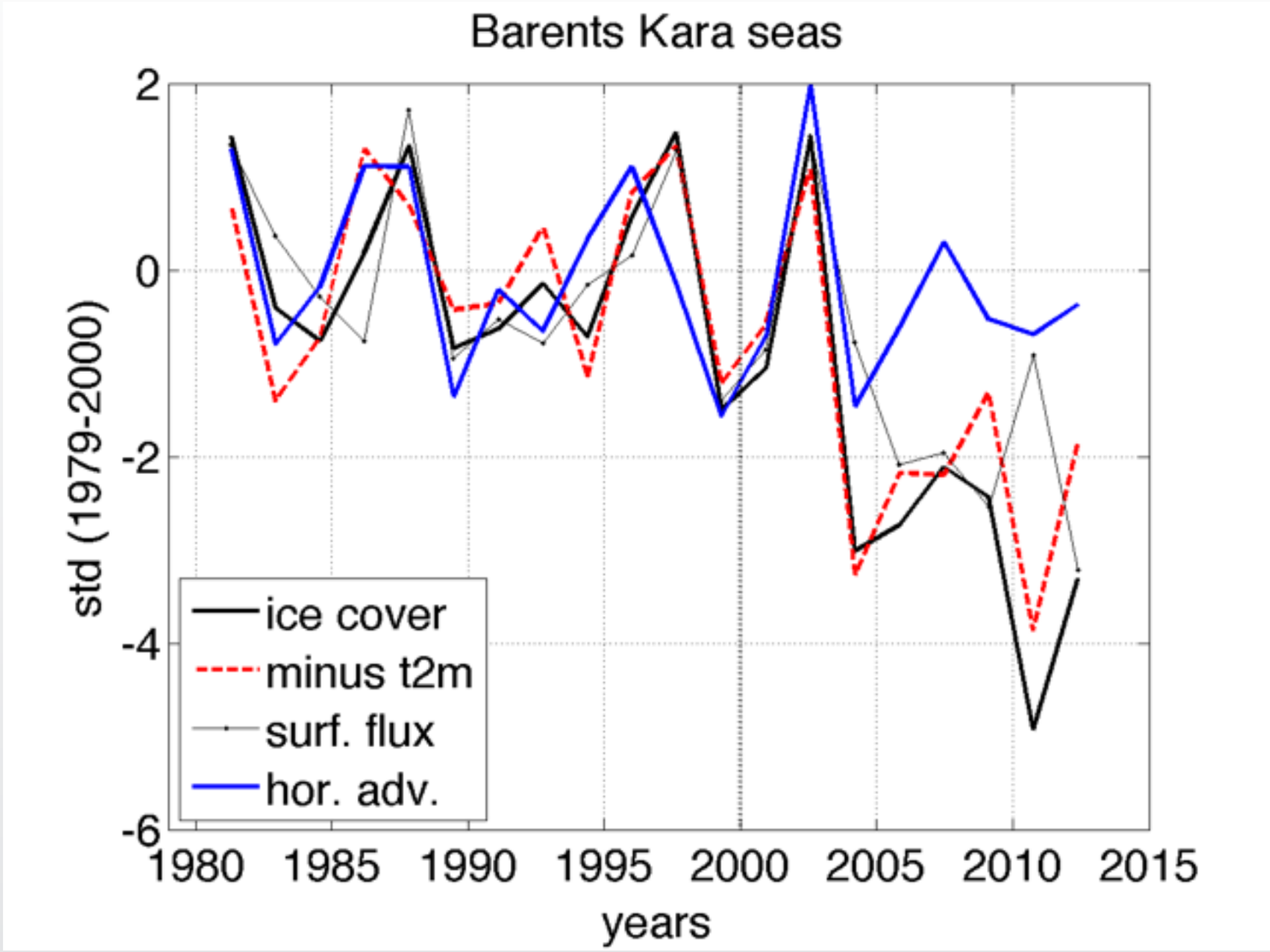
Warm Arctic Cold Continents

FEBRUARY





DJF TIME SERIES



ICE 1979-2015

ICE 1979-1999

Observed Atmospheric Coupling between Barents Sea Ice and the Warm-Arctic Cold-Siberian Anomaly Pattern

SVETLANA A. SOROKINA

Nansen Environmental and Remote Sensing Center, and Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research, Bergen, Norway

CAMILLE LI

Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research, Bergen, Norway

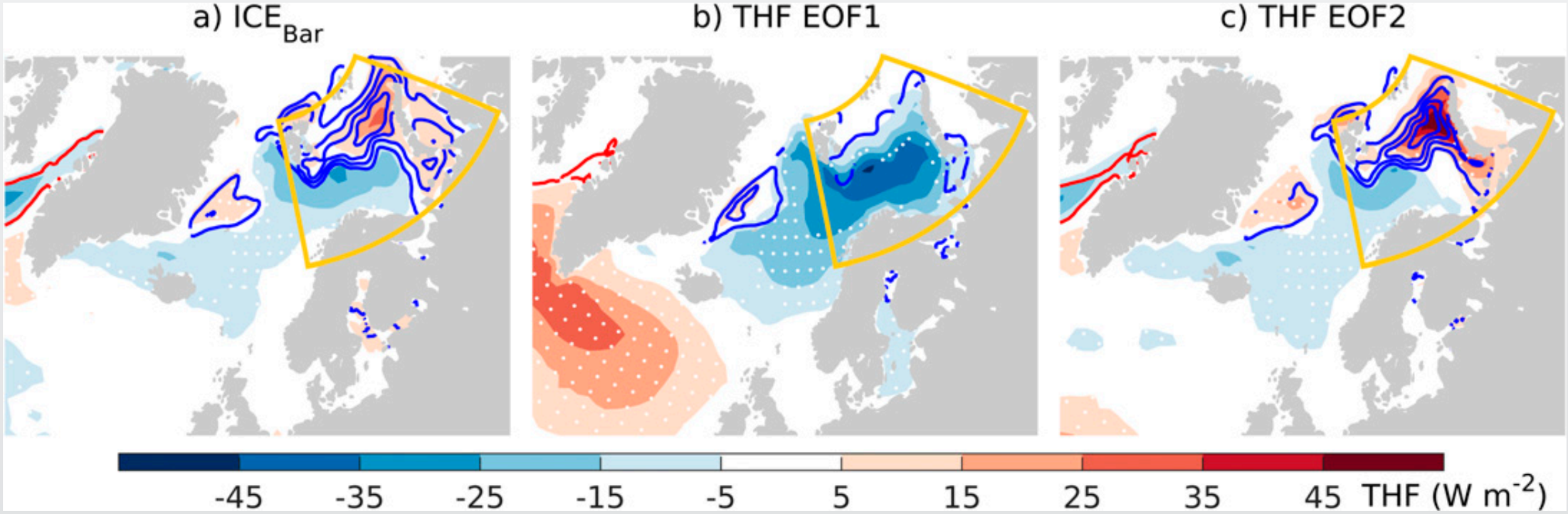
JUSTIN J. WETTSTEIN

College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, Oregon, and Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research, Bergen, Norway

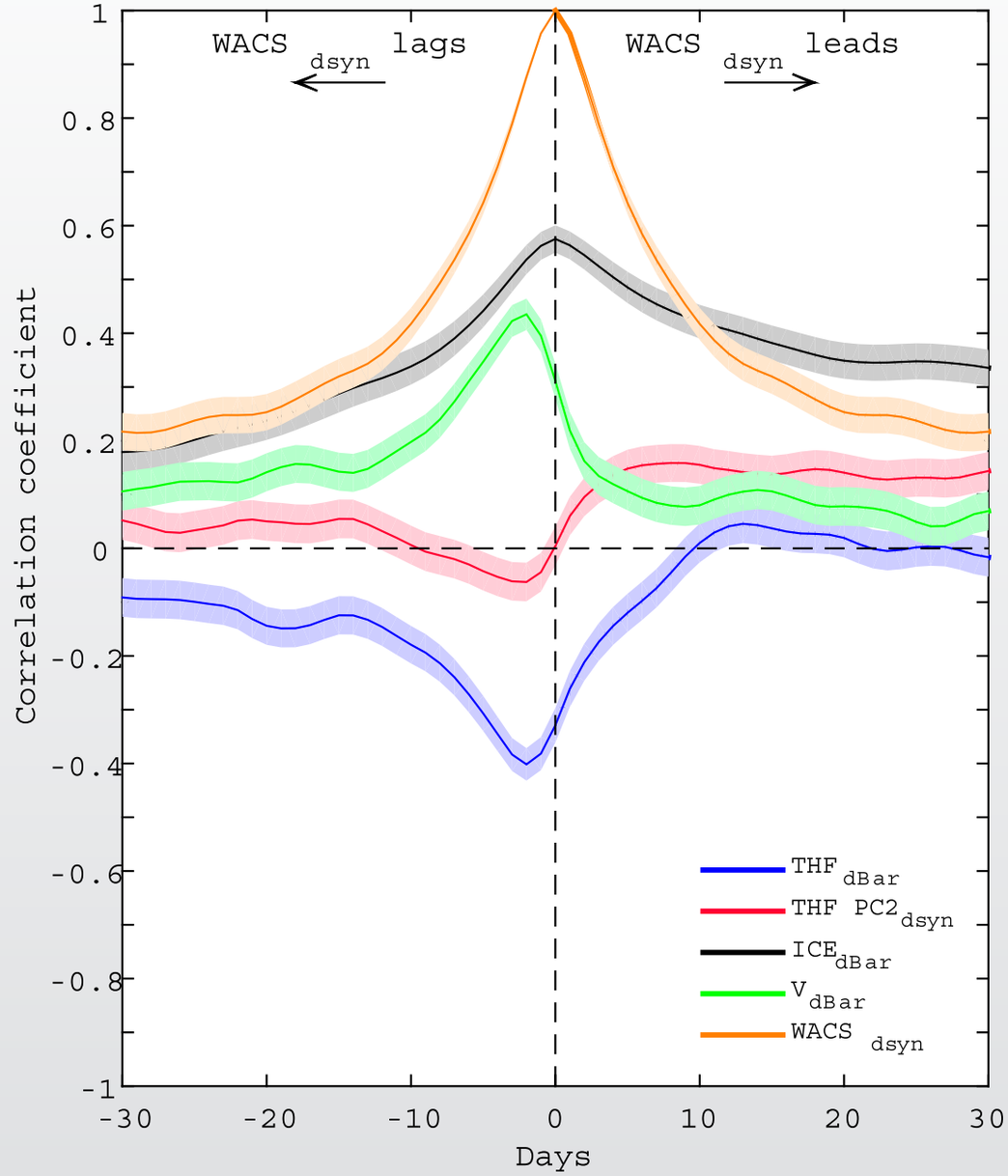
NILS GUNNAR KVAMSTØ

Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research, Bergen, Norway

JCLI 2015



Intraseasonal sea-ice-atmosphere interaction

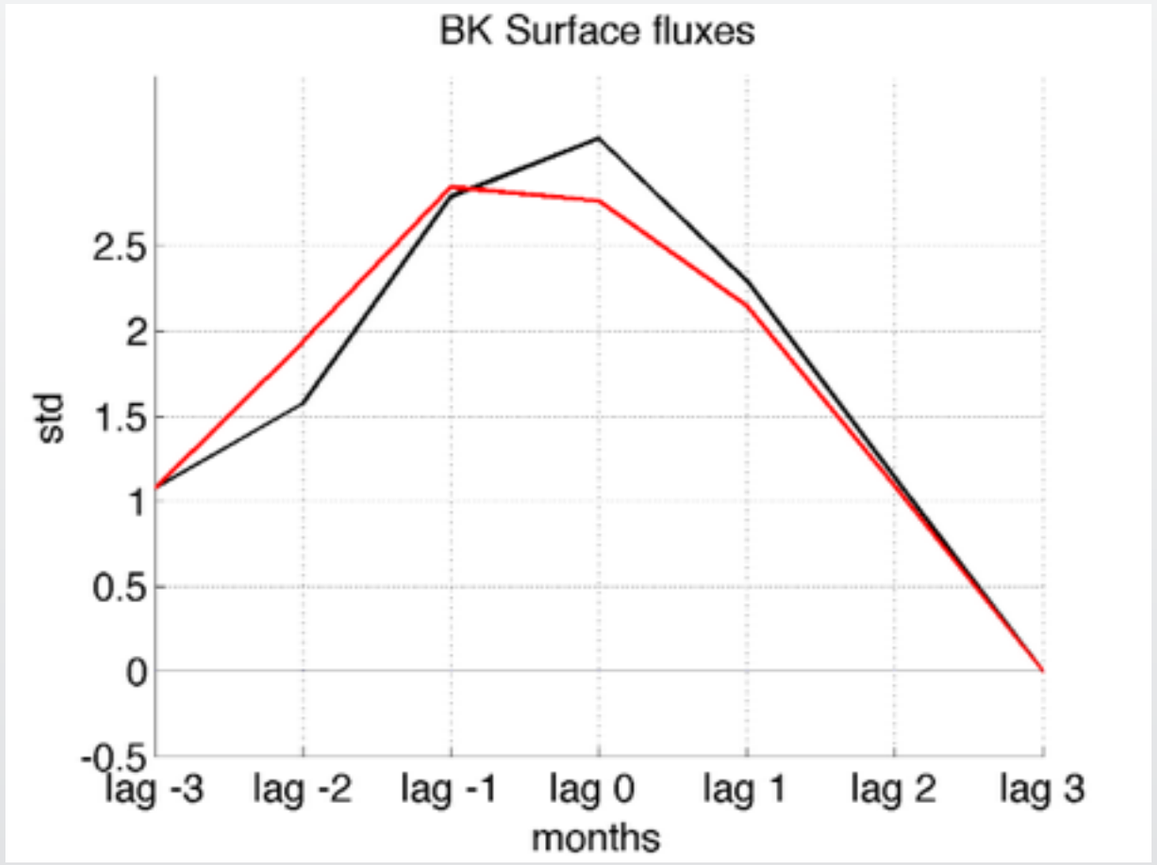


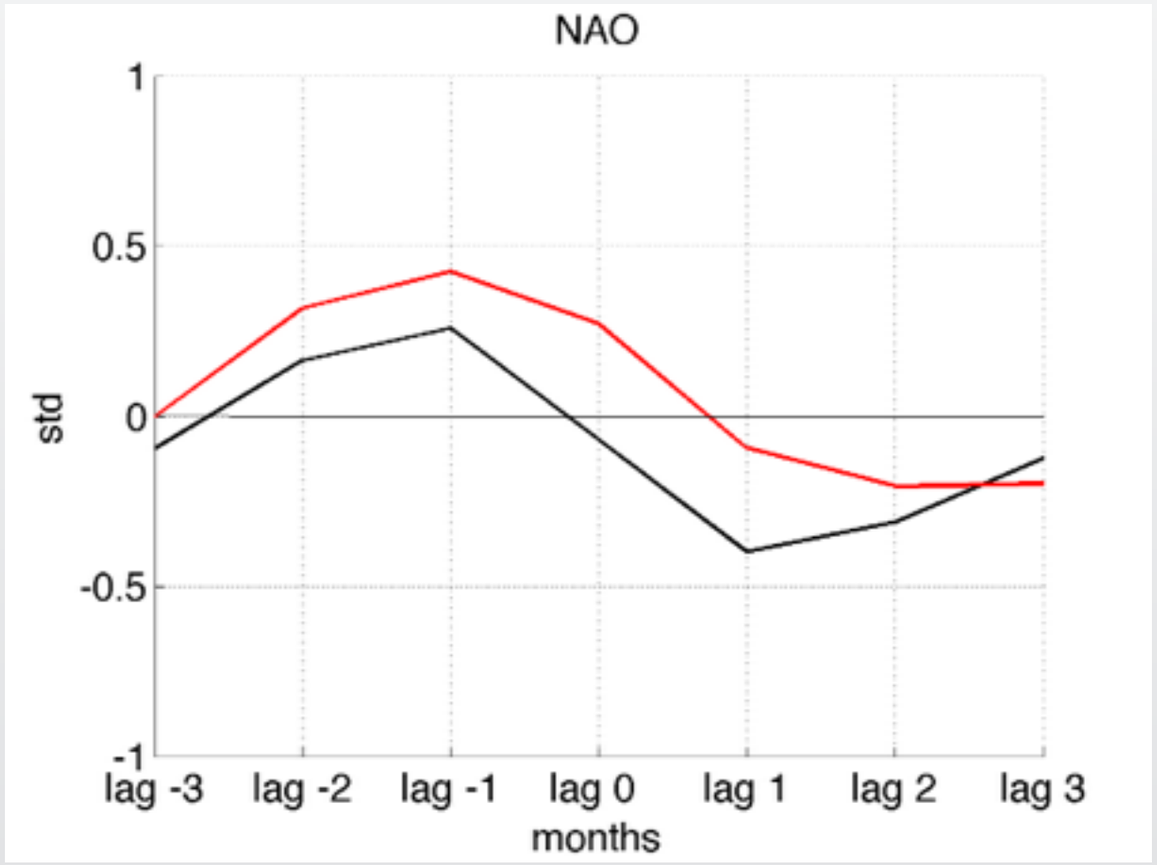
Sorokina et al.

MONTHLY REGRESSION

1979-2015

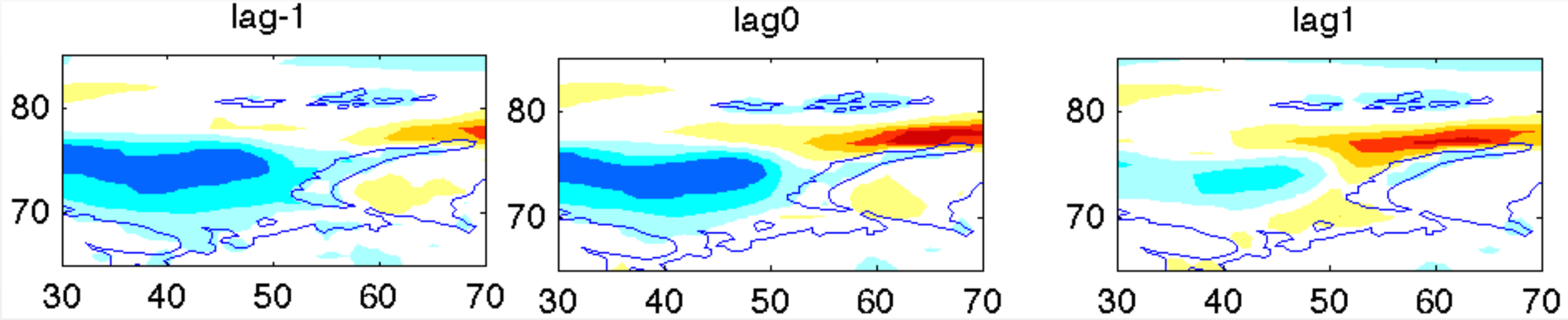
1979-1999



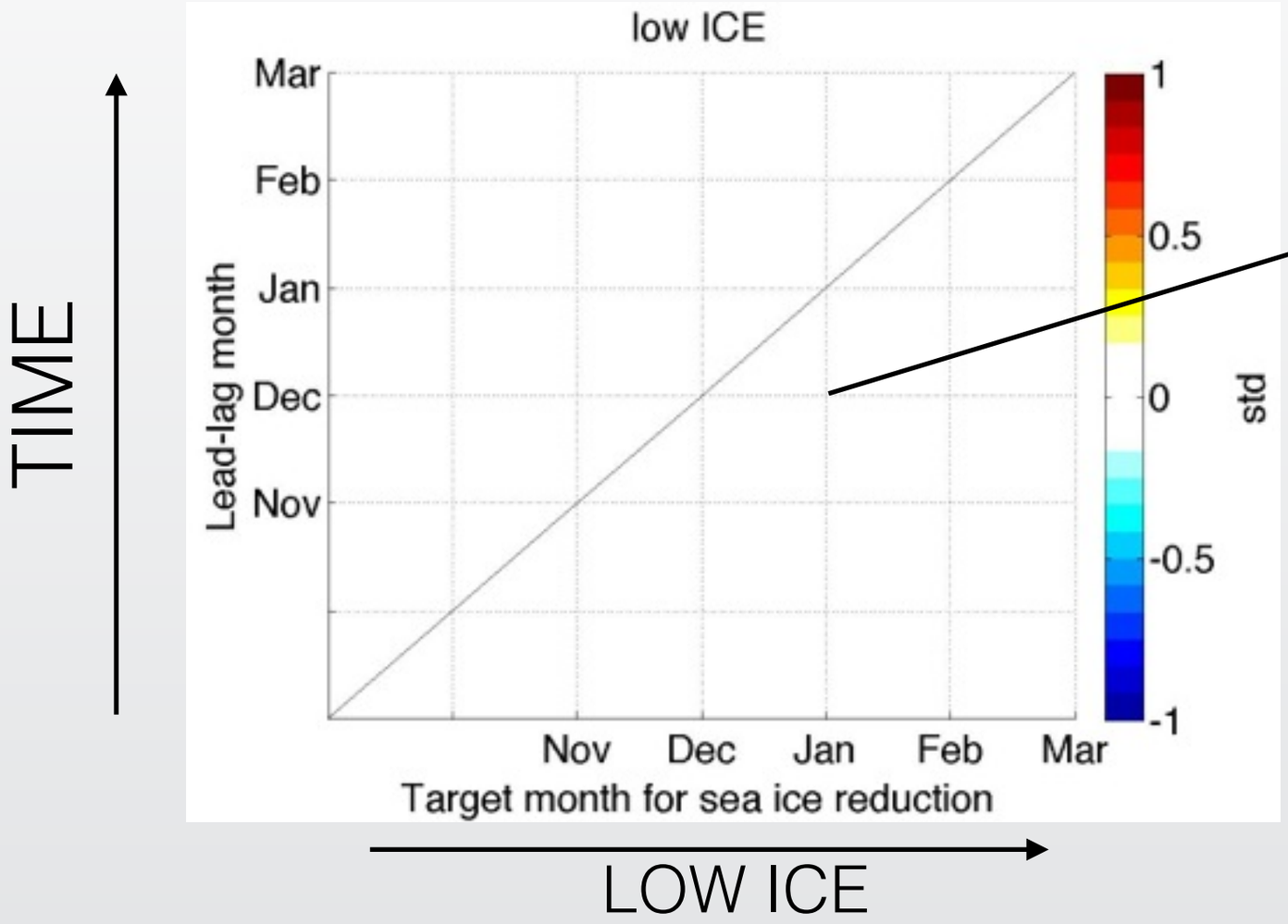


Surface heat flux

ERA-INTERIM



METHODOLOGY

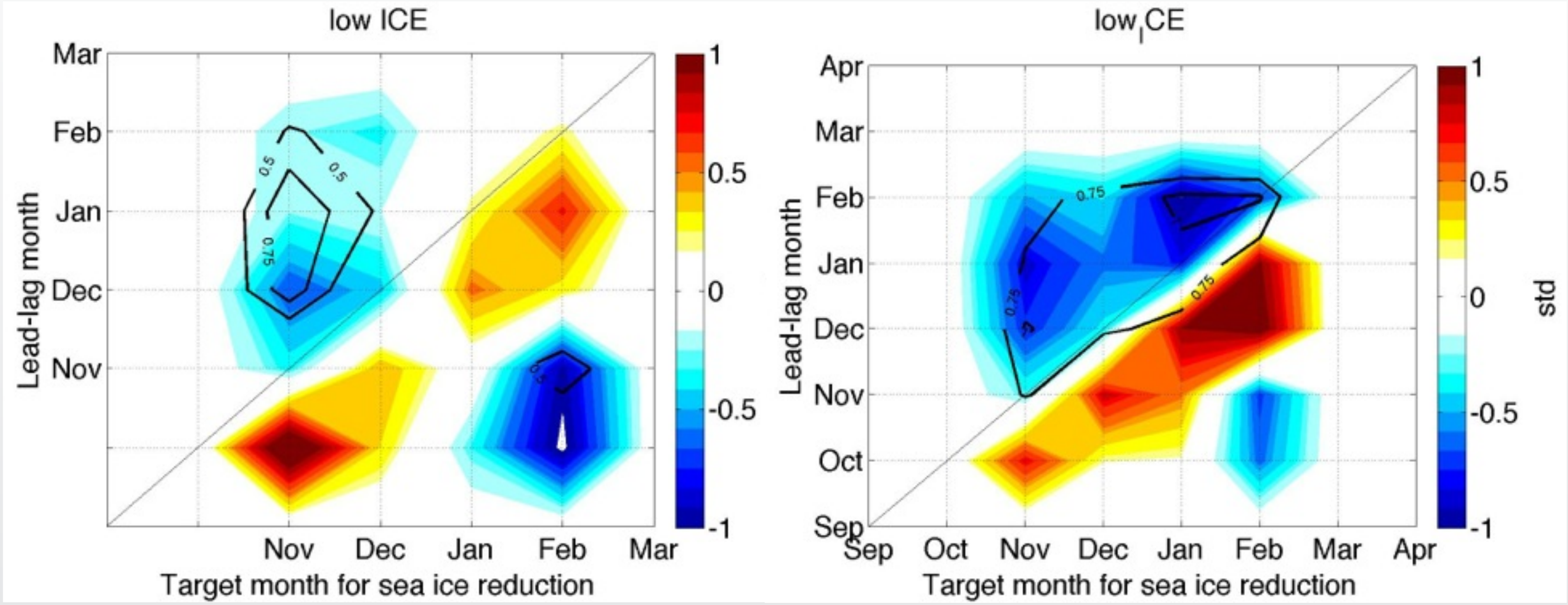


Signal in December associated to low sea-ice in January

METHODOLOGY

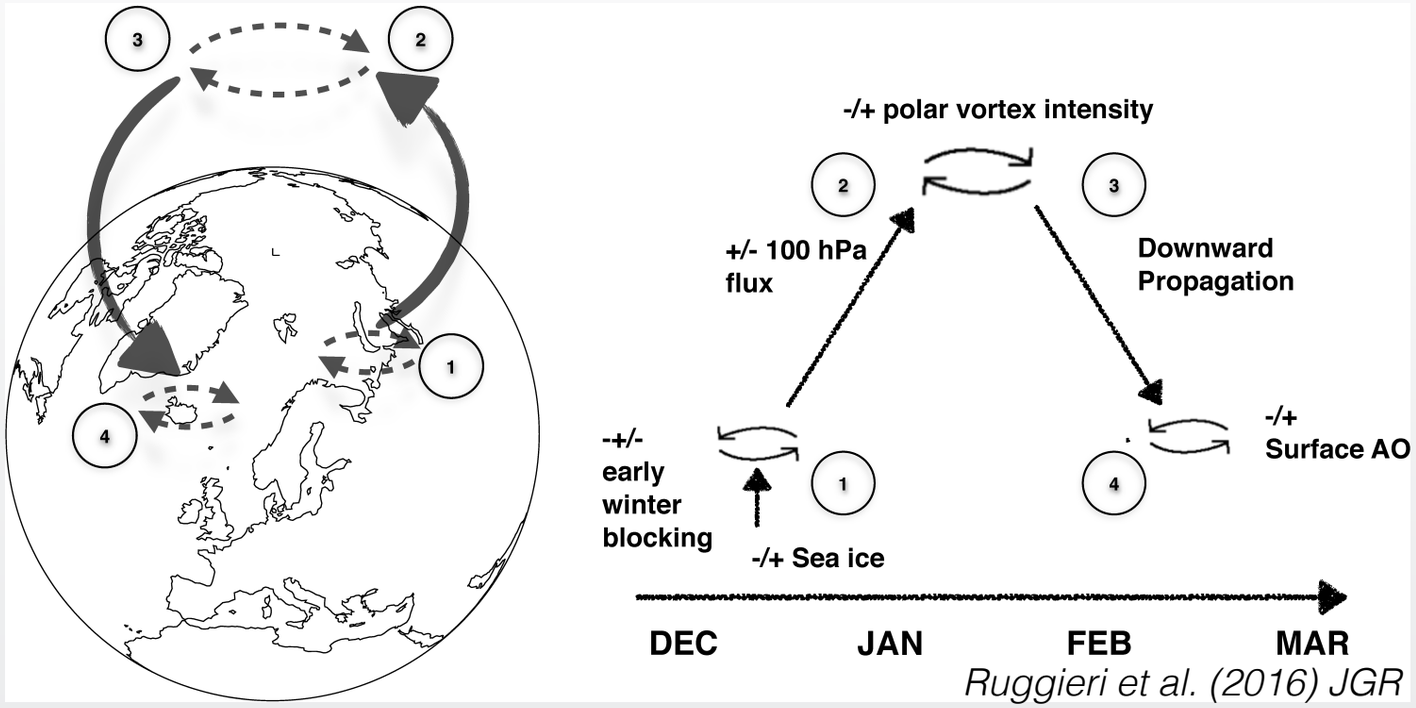
Pre 2000

ERA



RED= WARM ADVECTION in BK, BLUE = HIGH Z 500in BK and NA

A HYPOTHESIS



Ruggieri et al. (2016) JGR

Late-Autumn Early-Winter Sea Ice

↓

Weak stratospheric circulation

↓

Late Winter NAO

Impact of sea-ice on the stratosphere:
Sun et al. (2015, JoC), Kim et al. (2014-NatCom)

Stratospheric pathway to delayed response:
Jaiser et al. (2016, JGR), Ruggieri et al. (2016-JGR)

AGCM EXPERIMENT

MODEL

- Intermediate Complexity **AGCM**: SPEEDY

T 30 , 8 leves , TOA 30 hPa,
simple parameterisations of physical processes

SIMULATION

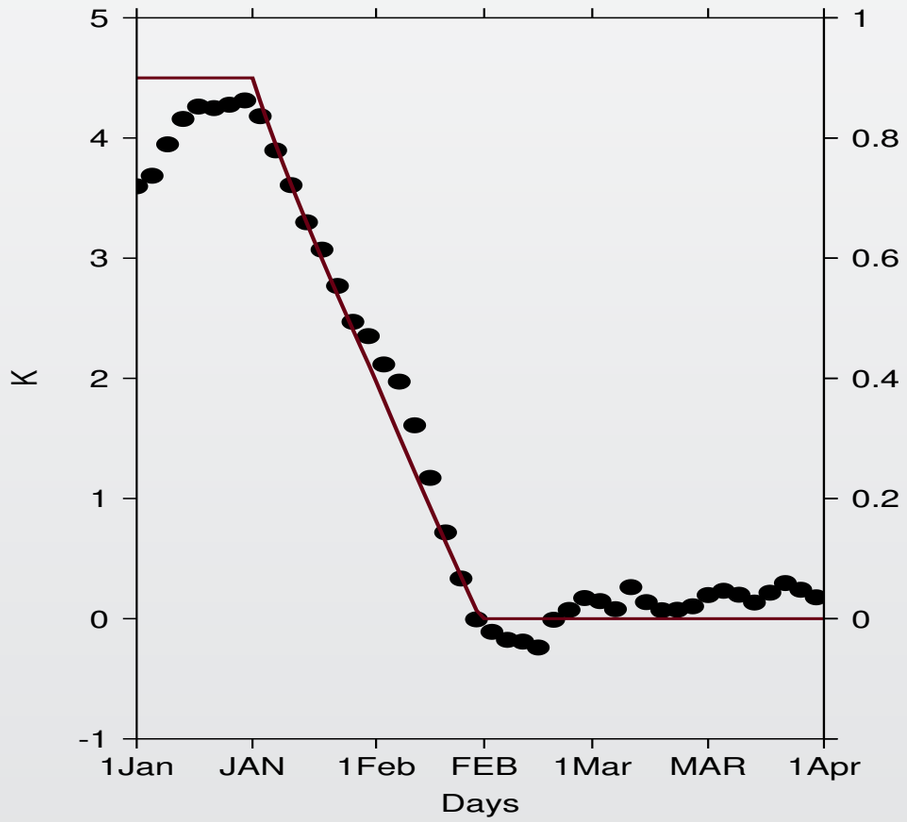
- **100 initial conditions** with clim. sea ice (CTL)
vs reduced sea ice in B-K in January (PRT)

Sea-ice reduction prescribed only
for **2 weeks**

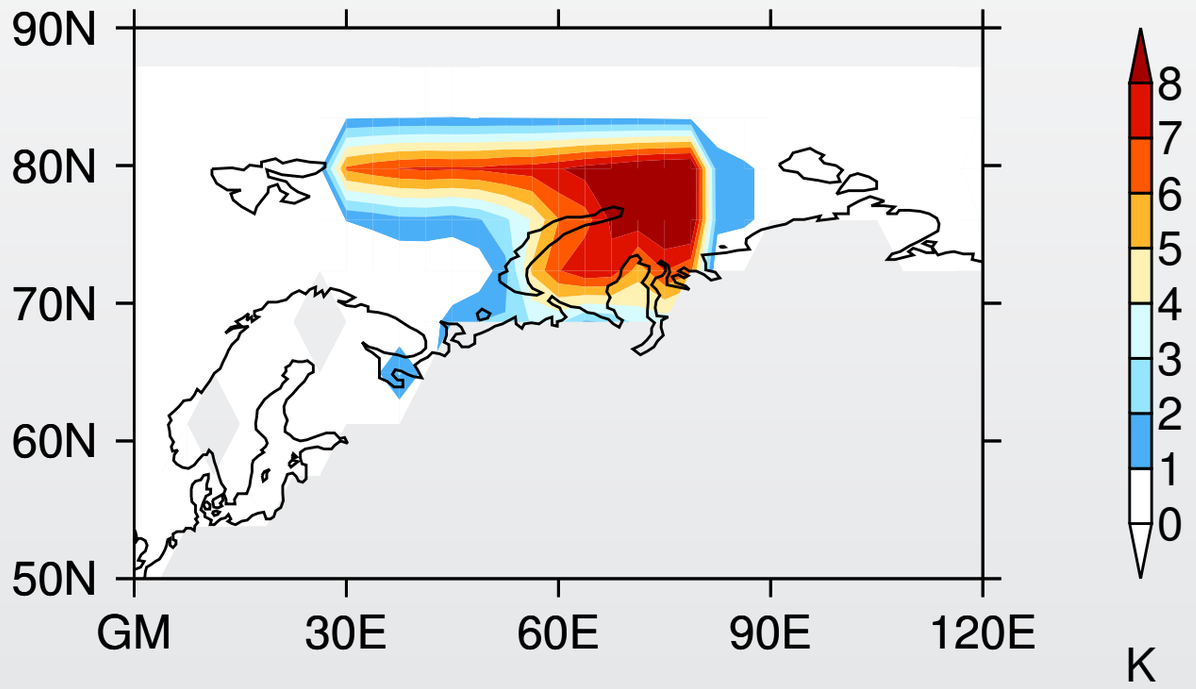
EXPERIMENTAL SETUP

- 100 parallel runs starting on Jan 1st, different atmospheric initial conditions

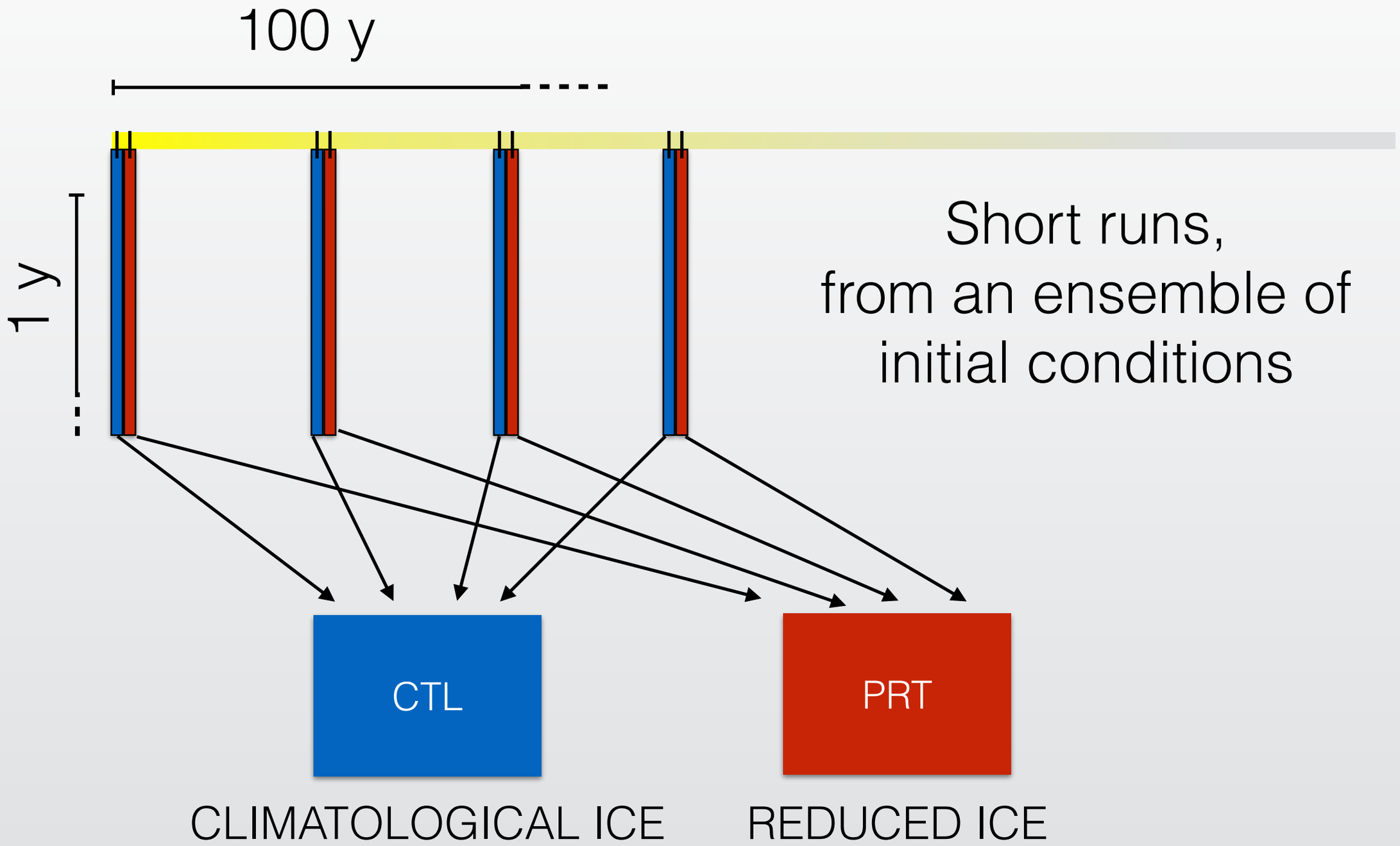
Ice and Surf Temp



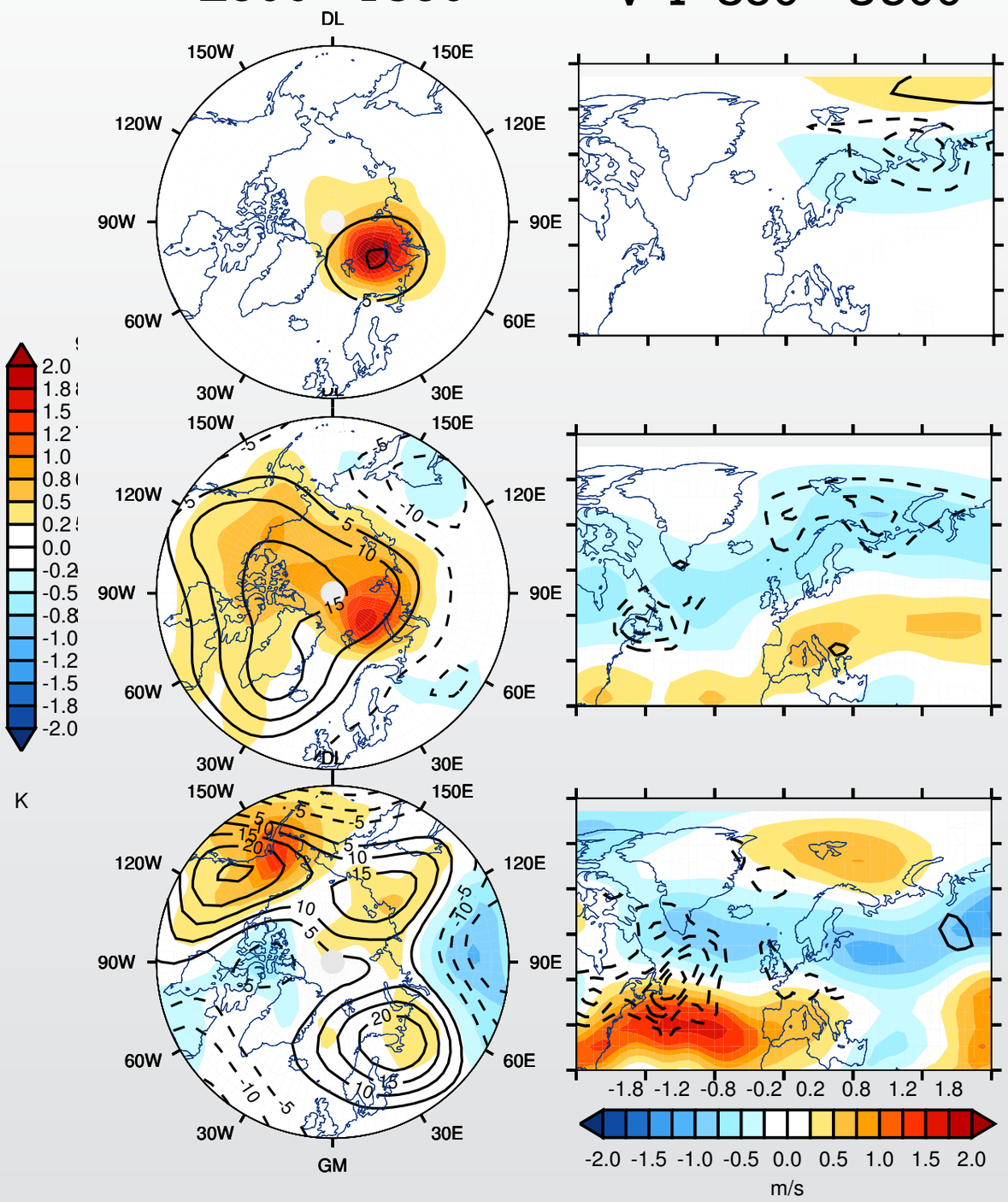
Surface Temperature



EXPERIMENTAL SETUP



REGIMES OF ATMOSPHERIC RESPONSE

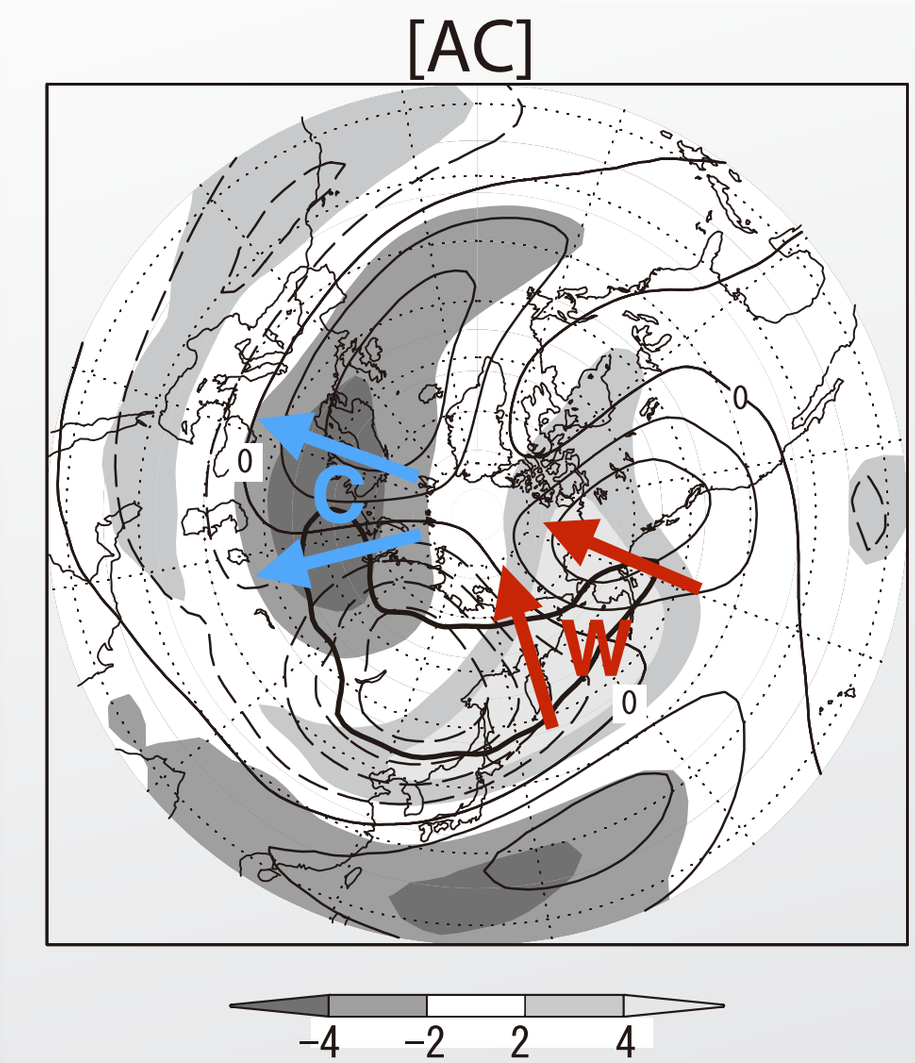


Up to Week 3 — Shallow, local, fast

Week 3-5 — Deep, non-local, fast

Week 5-7 — Deep, non-local, delayed

THE UPPER-TROPOSPHERE



$$Z^* = Z - \langle Z \rangle$$
$$T^* = T - \langle T \rangle$$
$$\longrightarrow \quad \langle v^* T^* \rangle$$

$$\overline{q}_t = -(\overline{v' q'})_y + S$$

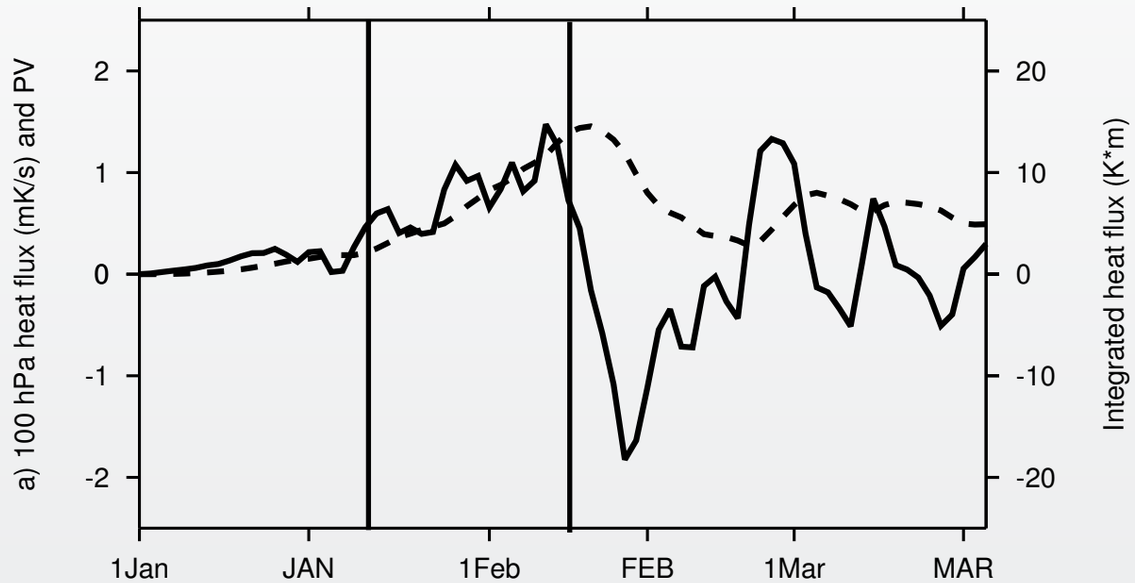
$$\frac{\delta}{\delta t}\langle q(t) \rangle = -A(z)F(t) + \frac{\langle q_r \rangle - \langle q(t) \rangle}{\tau}$$

$$F(t) = \left\{ \overline{v' T'} \right\}_{100}$$

Impact on the upper-tropospheric circulation consistent with observed atmospheric mode of variability in the Barents-Kara region.
(e.g. Takaya and Nakamura 2008, Nishii et al. 2011)

THE UPPER-TROPOSPHERE

100 hPa eddy heat flux (v*T*)



Polar Cap Stratospheric PV-equation

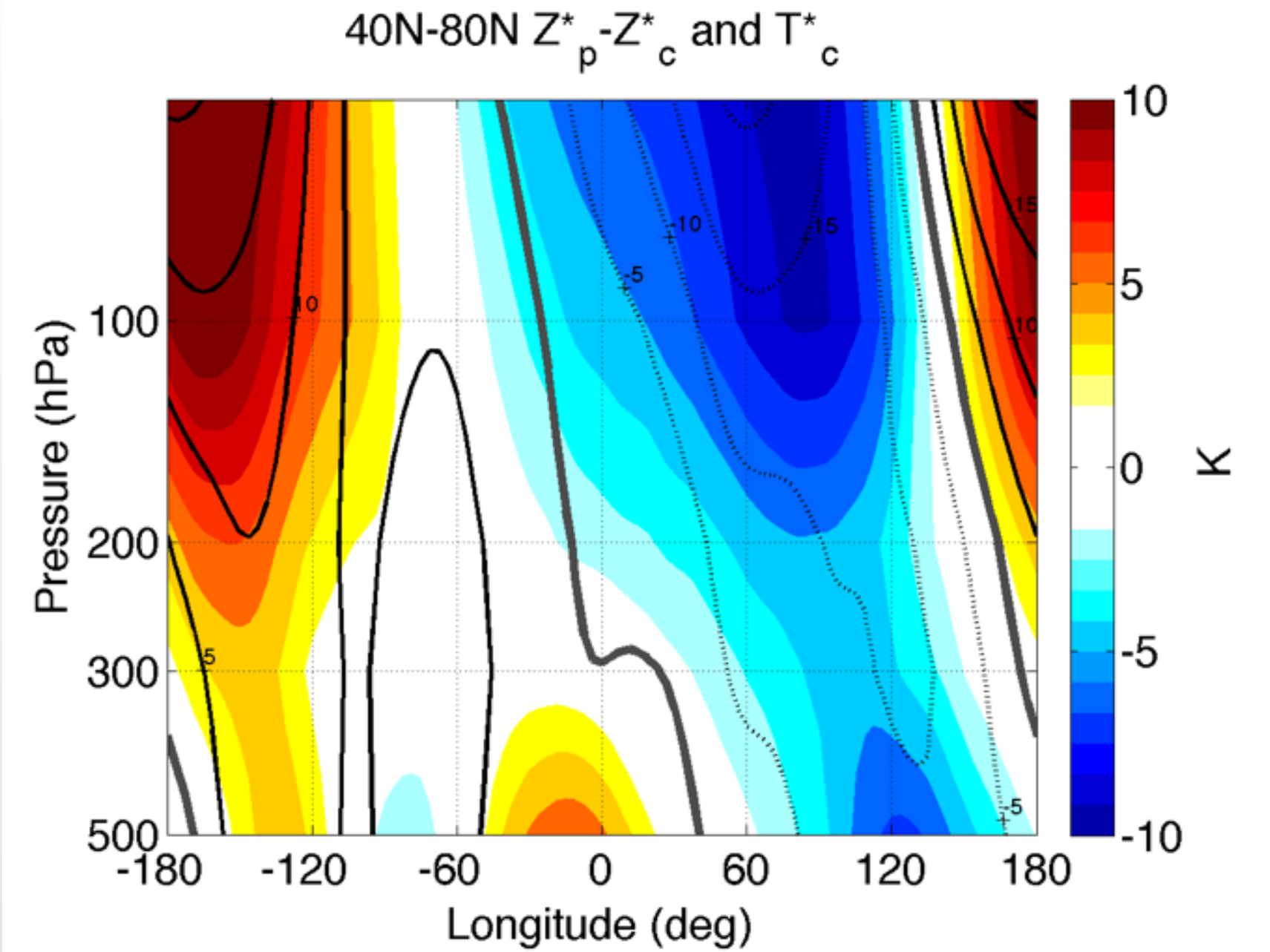
$$\frac{\delta}{\delta t}\langle q(t)\rangle = -A(z)F(t) + \frac{\langle q_r\rangle - \langle q(t)\rangle}{\tau}$$

$$\langle q\rangle(t) = \cancel{q(0)e^{-t/\tau}} + \cancel{\int_0^t \frac{\langle q\rangle_R(t-t')}{\tau} e^{-t'/\tau}dt'} + -A(z)\int_0^t F(t-t')e^{-t'/\tau}dt'$$

HINNSEN and AMBAUM 2011

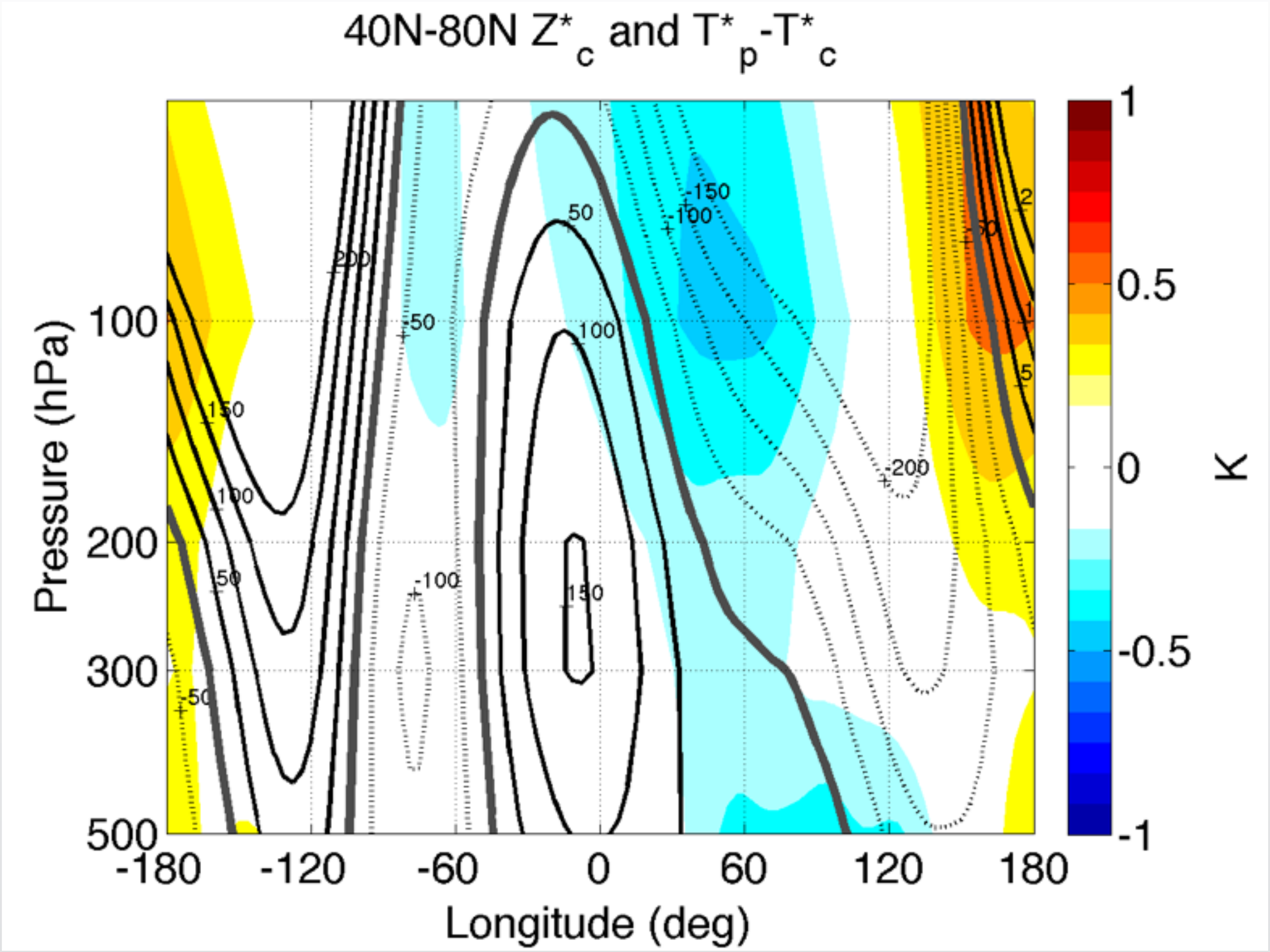
$$\{\Delta v^*T^*\} = \{T_a^* v_a^*\} + \{T_a^* v_c^{*\prime}\} + \{T_c^{*\prime} v_a^*\} + \{\bar{T}_c^* v_a^*\} + \{T_a^* \bar{v}_c^*\}$$

ZONALLY ASYMMETRIC CIRCULATION

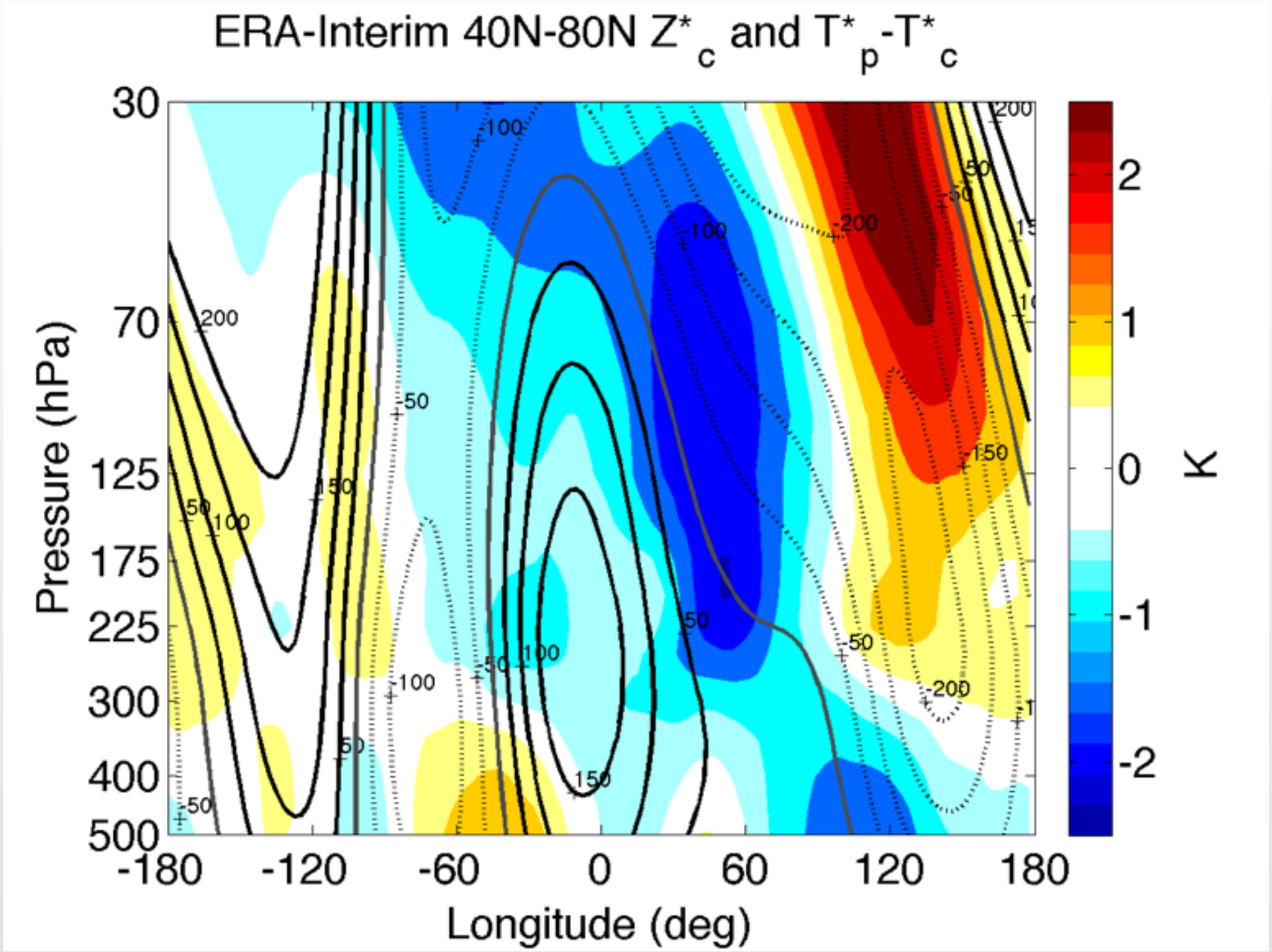


Colors = T, contours= Z

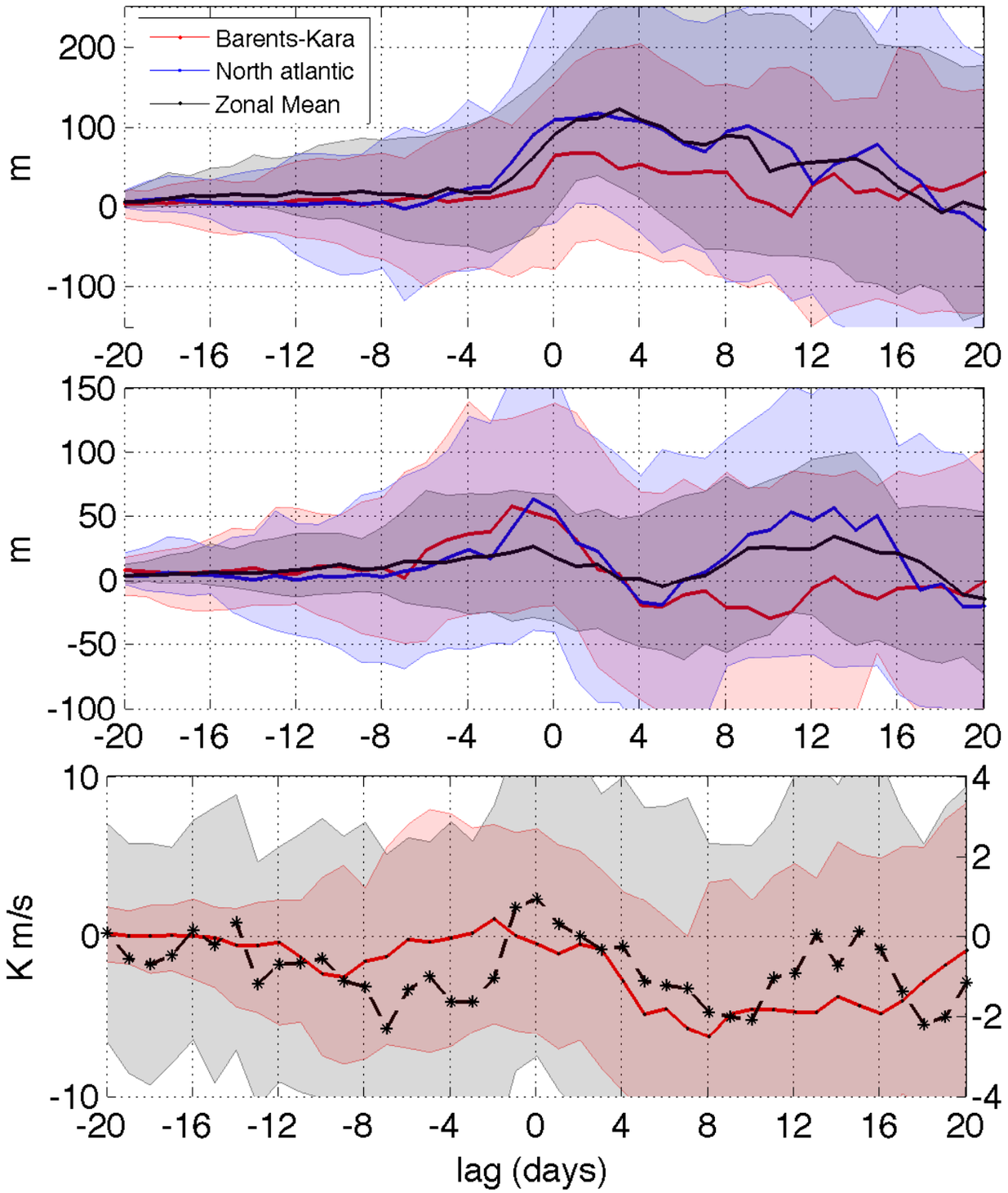
ZONALLY ASYMMETRIC CIRCULATION



ZONALLY ASYMMETRIC CIRCULATION



A UNIFIED VIEW : 1

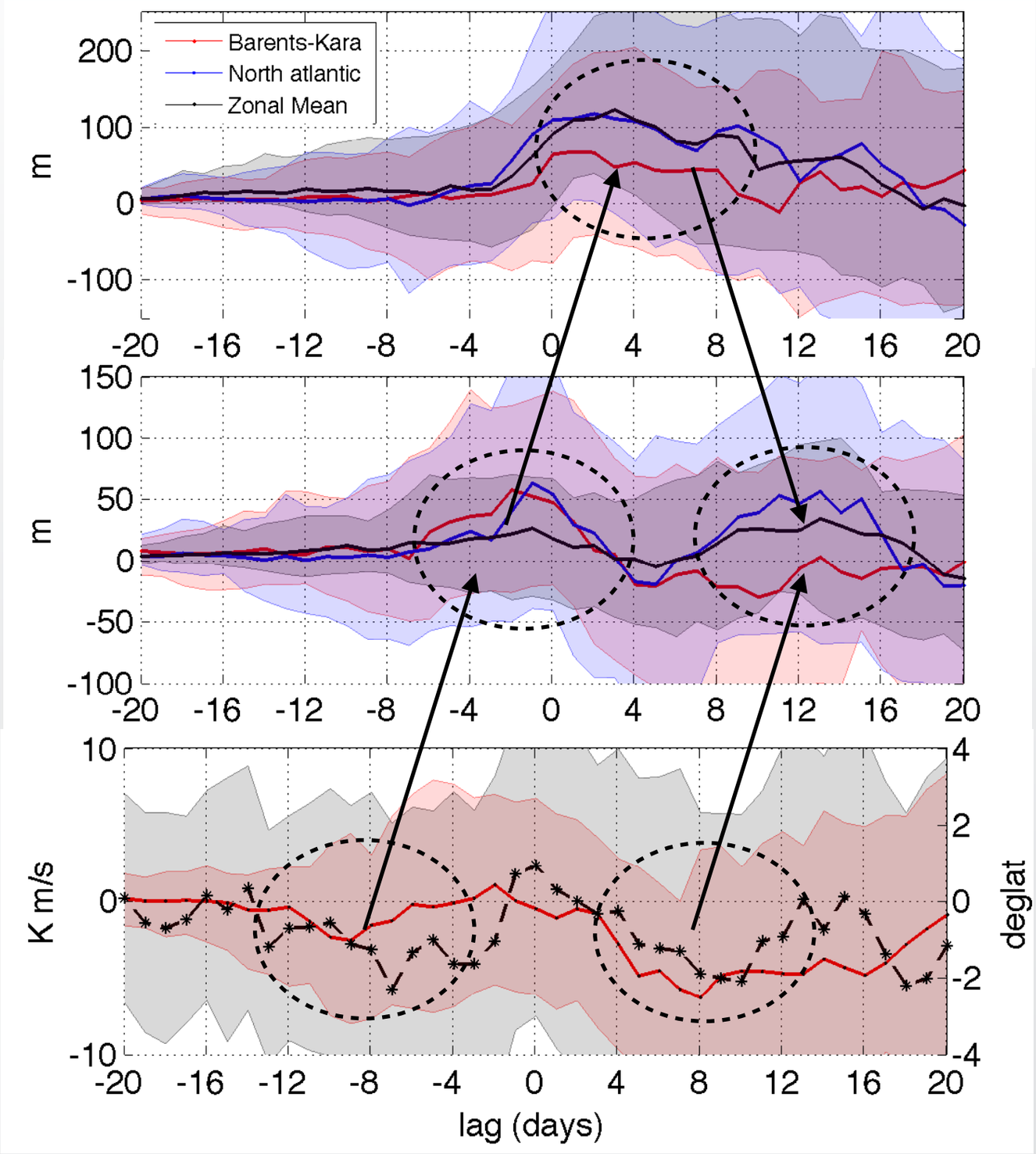


30 hPa, **Geopotential Height**

300 hPa, **Geopotential Height**

850 hPa, Transient **Heat Fluxes** and **Jet Latitude**

A UNIFIED VIEW : 1

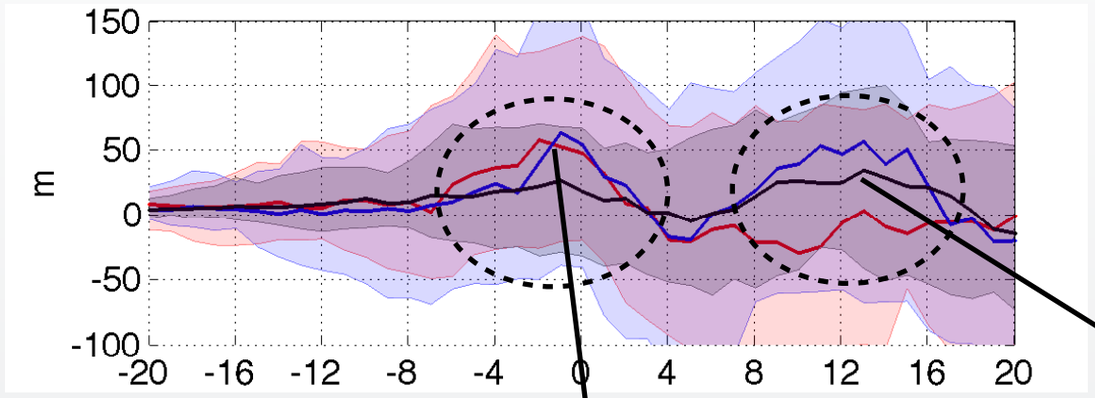


30 hPa, Geopotential Height

300 hPa, Geopotential Height

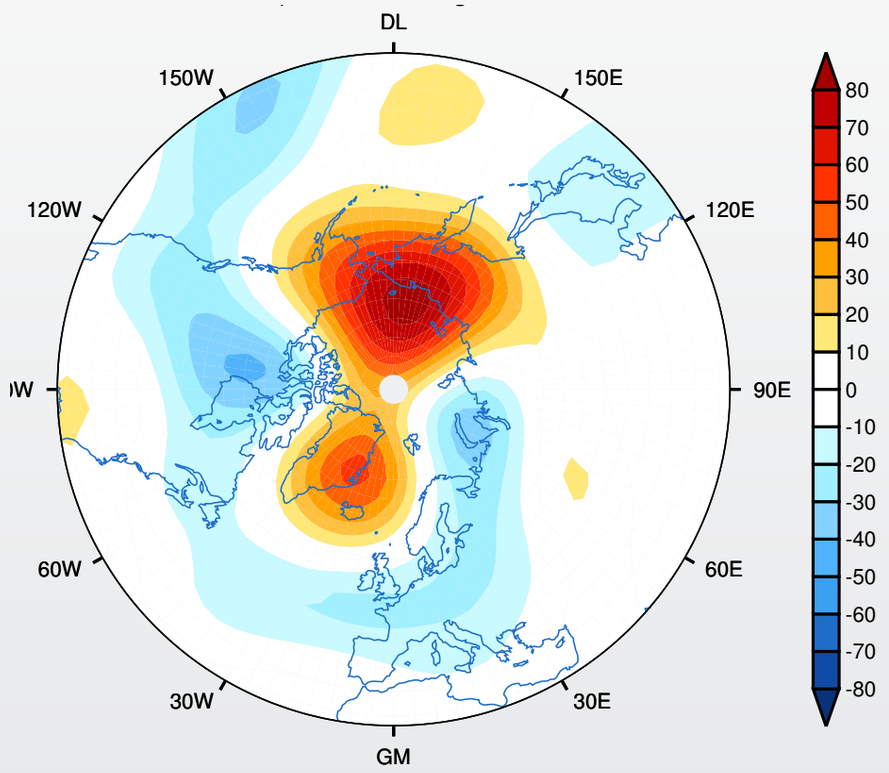
850 hPa, Transient Heat Fluxes and Jet Latitude

A UNIFIED VIEW : 2



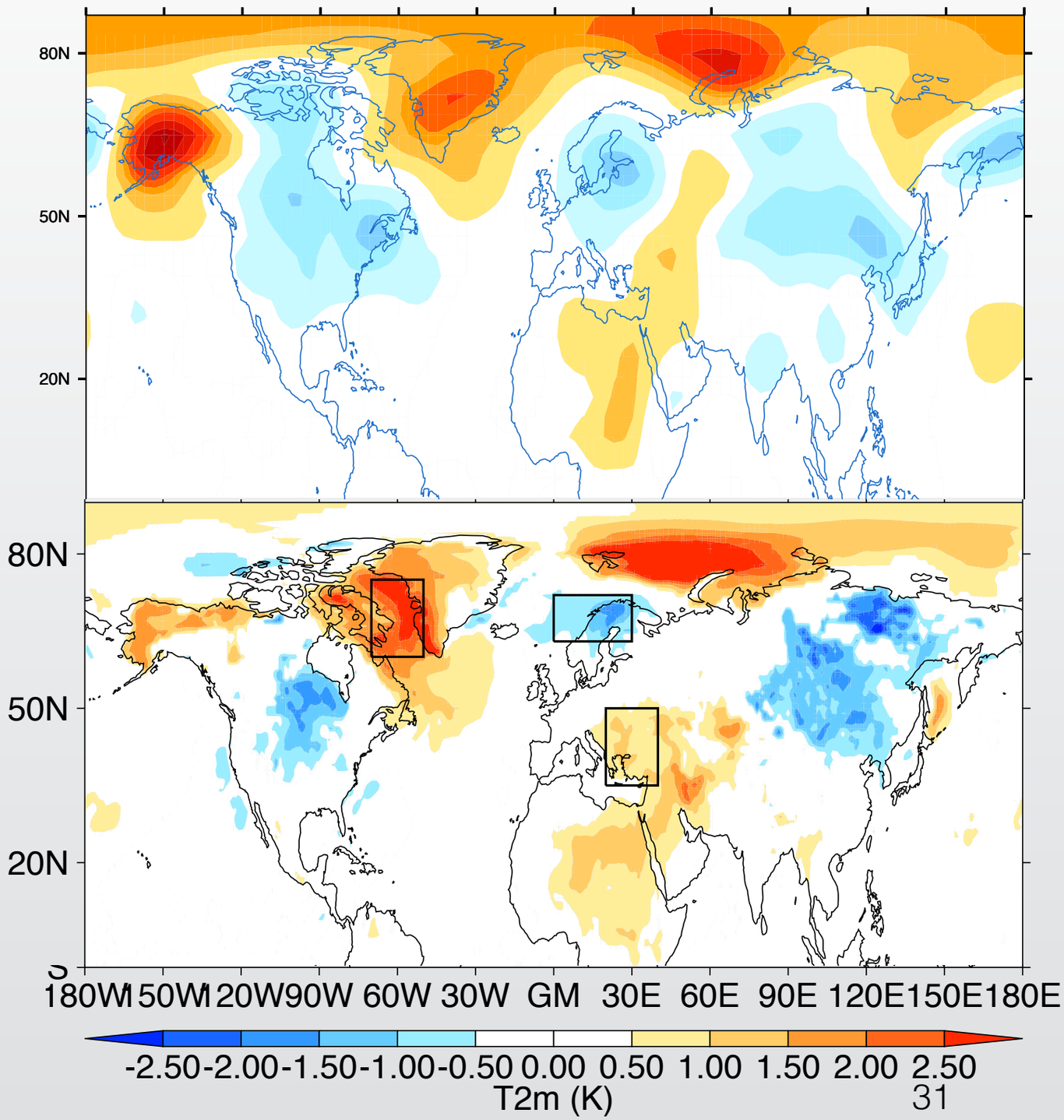
A

B



SURFACE TEMPERATURES

T2m Anomaly February **A+B**



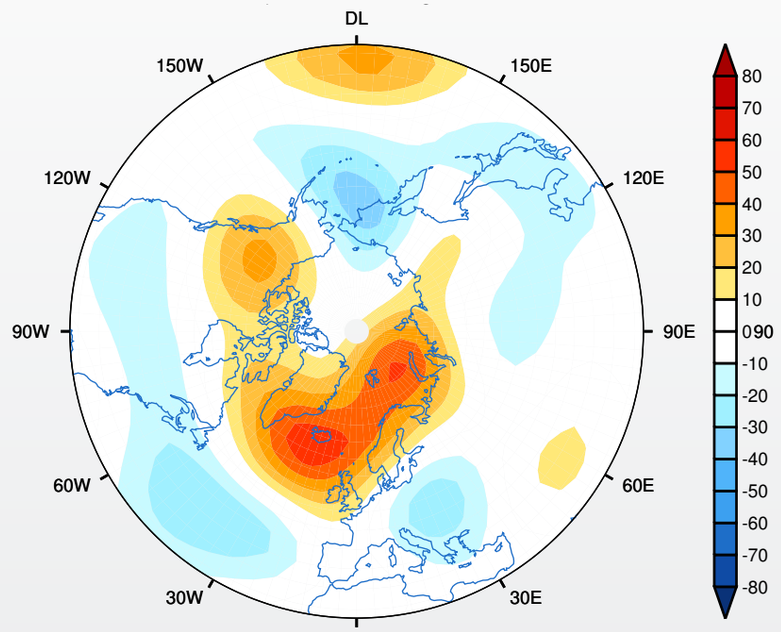
Speedy
Sea-ice Reduction
1-15 Jan

ERA-Interim
Low Sea-Ice
Dec-Jan

FURTHER WORK

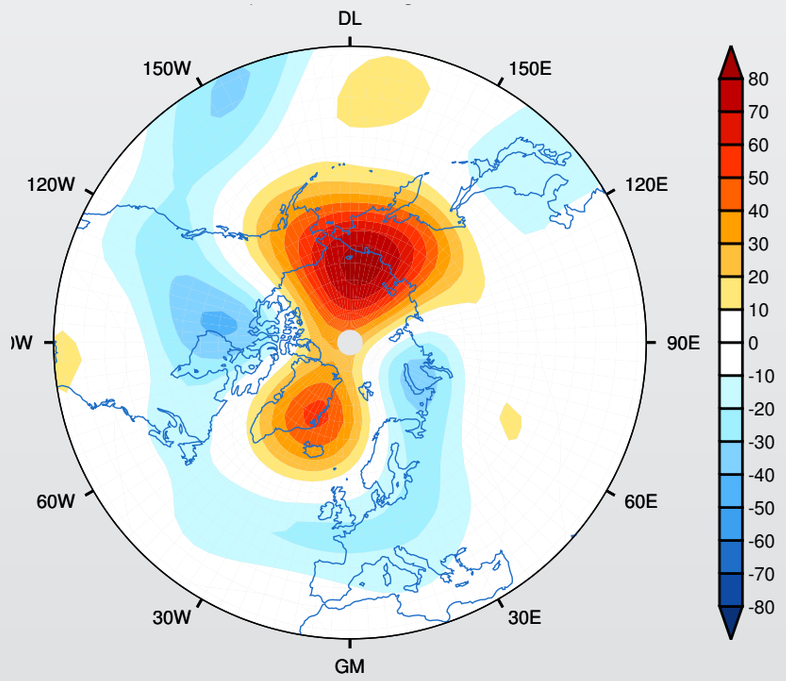
Fast Response

Investigate, in an idealised setup (AQUAPLANET), the dynamical response of **mid-latitude jet** to **high-latitude, near-surface heating.**



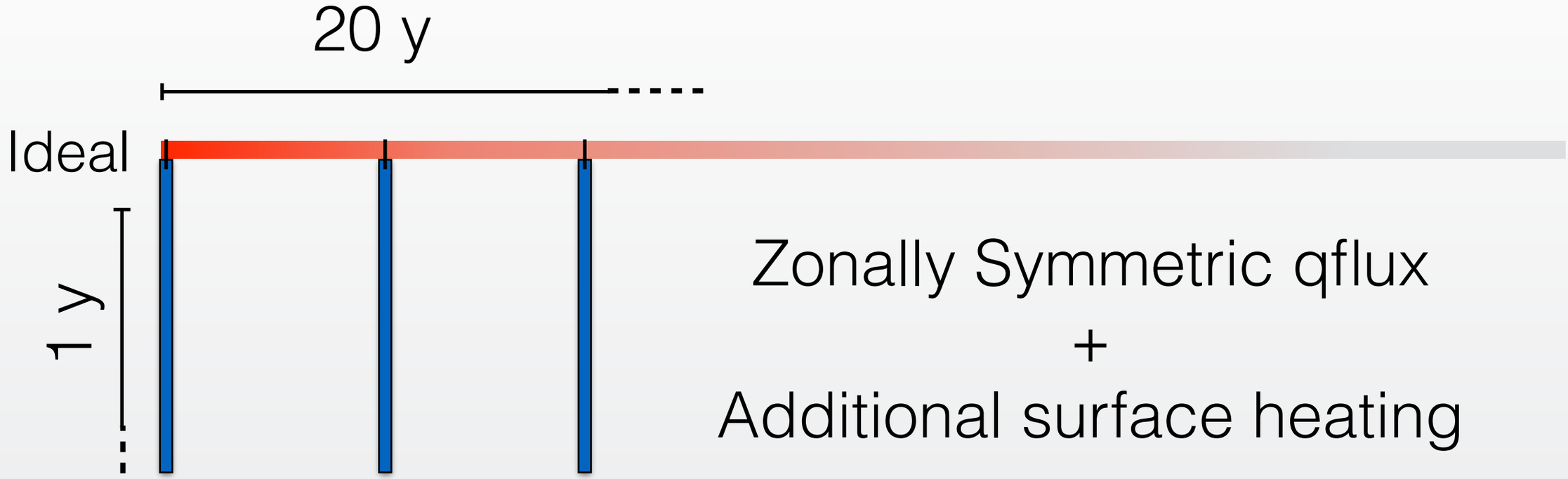
Delayed Response

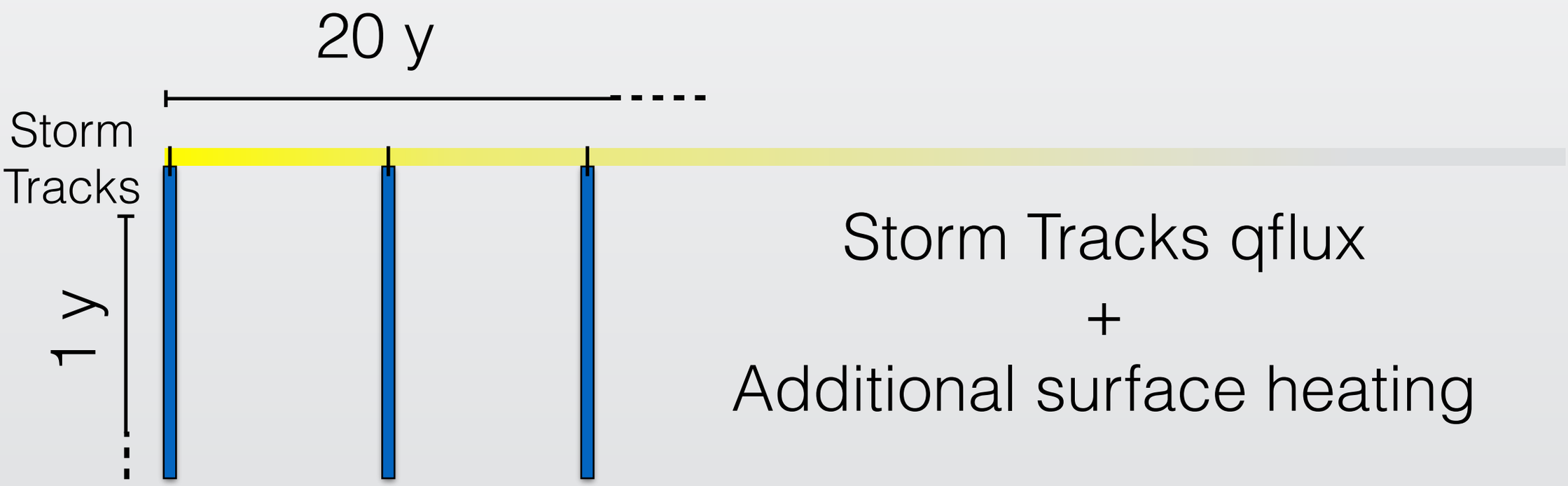
It can be found in a **low-top** model. Can we find it with the same setup in a model which includes complex **stratosphere dynamics**?



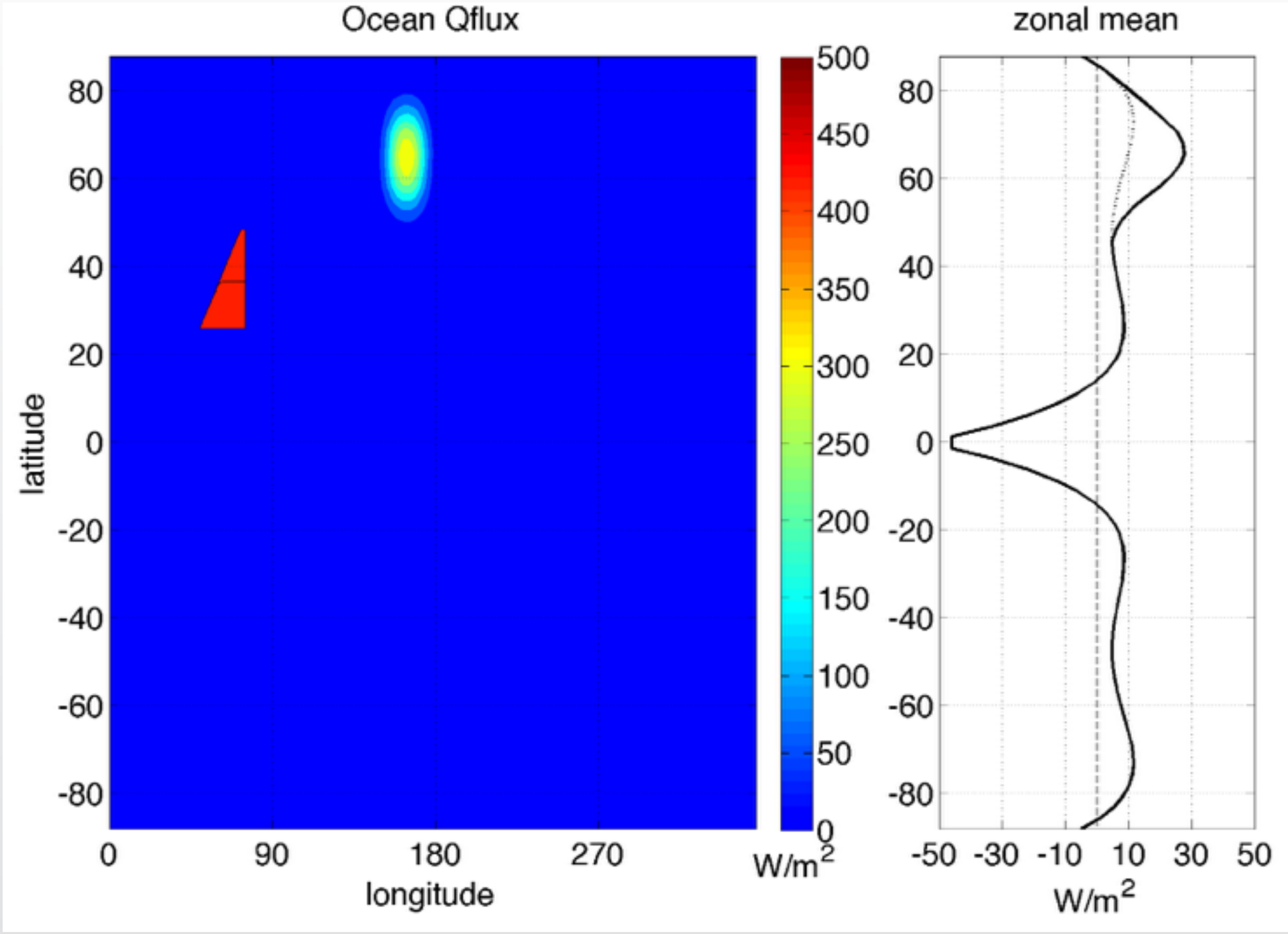
IDEALISED SETUP

AQUAPLANET SETUP

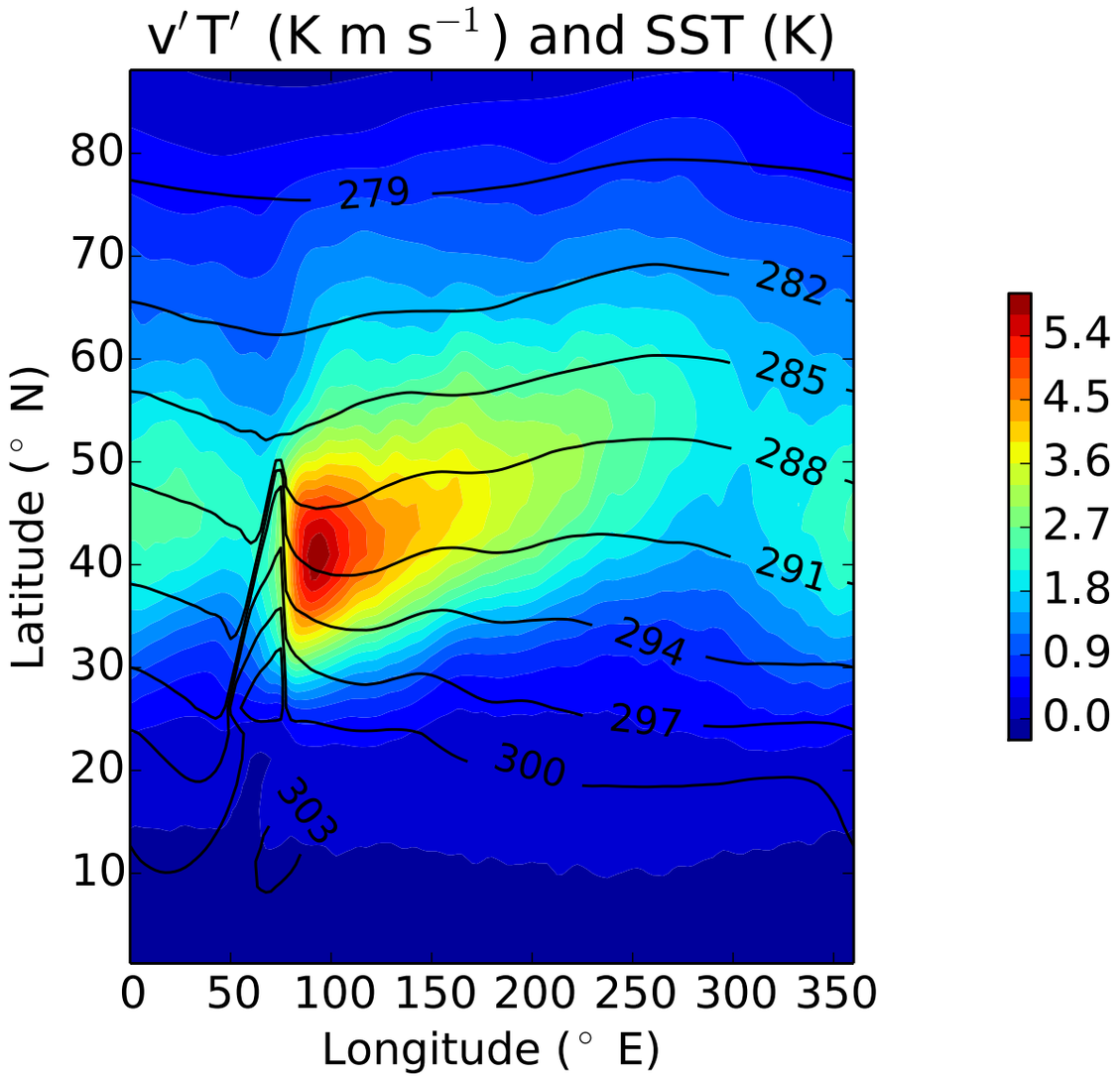


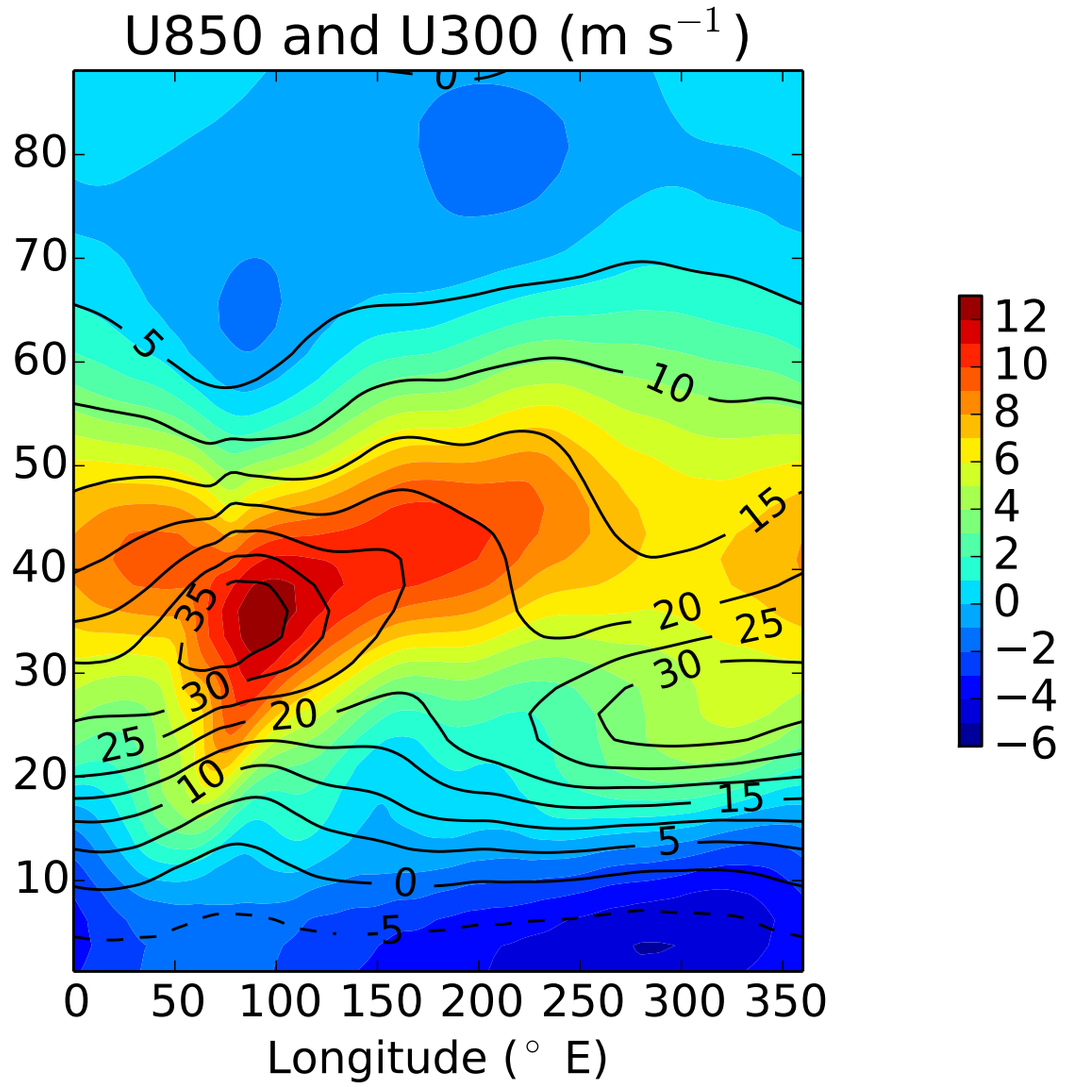


AQUAPLANET POLAR



STORM TRACKS CLIMATOLOGY

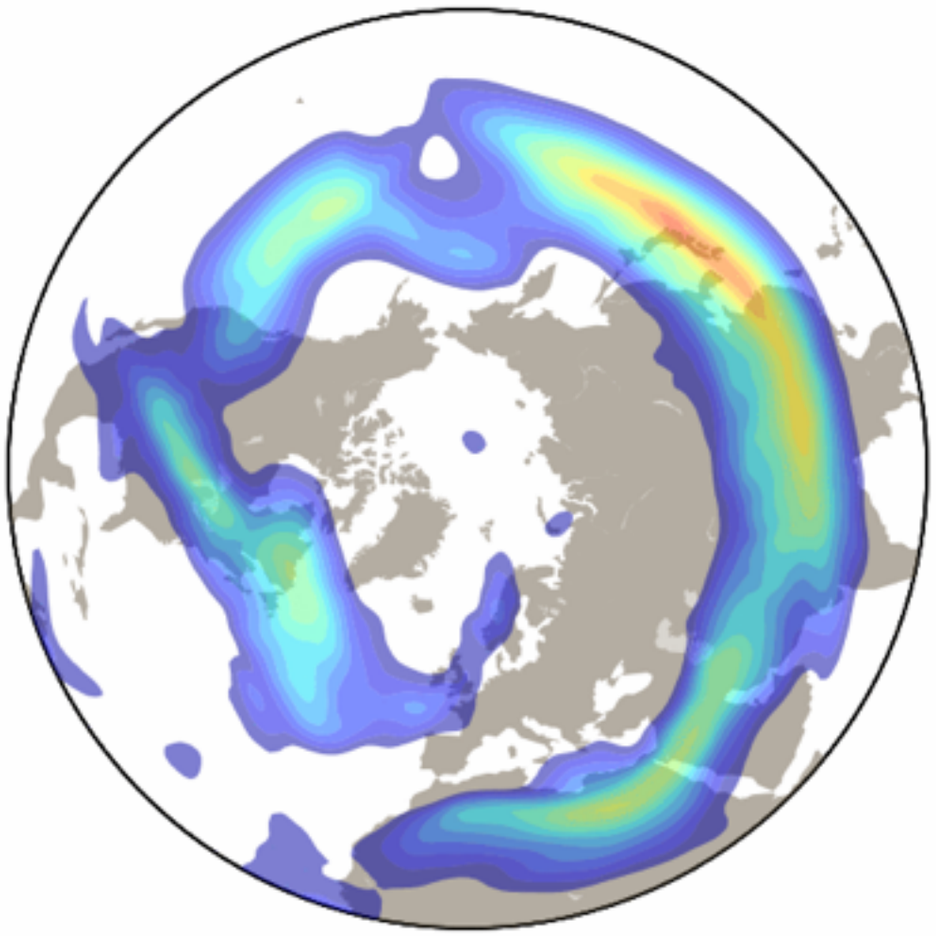




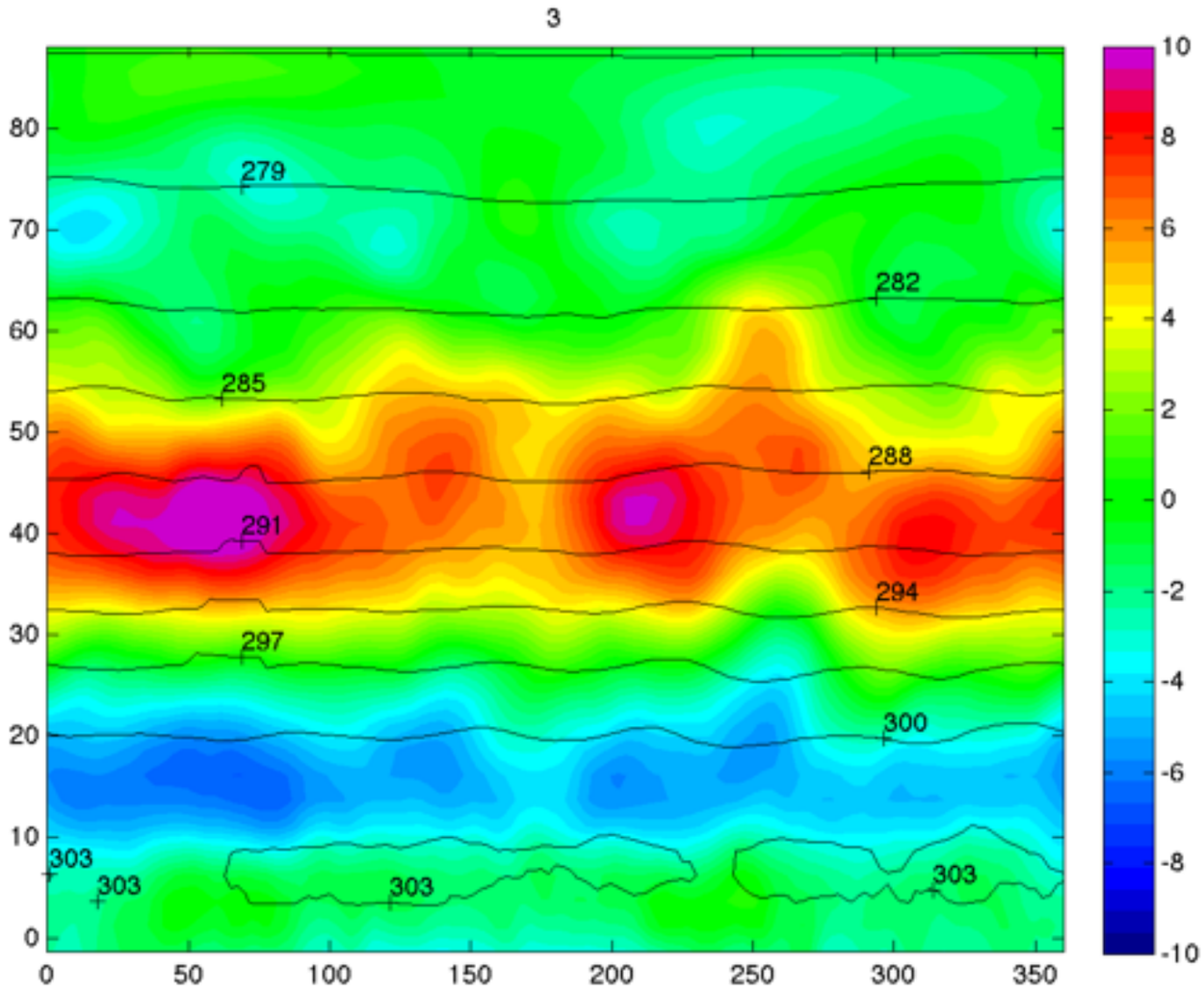
TILTED JET

ERA 40

http://www.met.reading.ac.uk/~bz024837/home/research.php

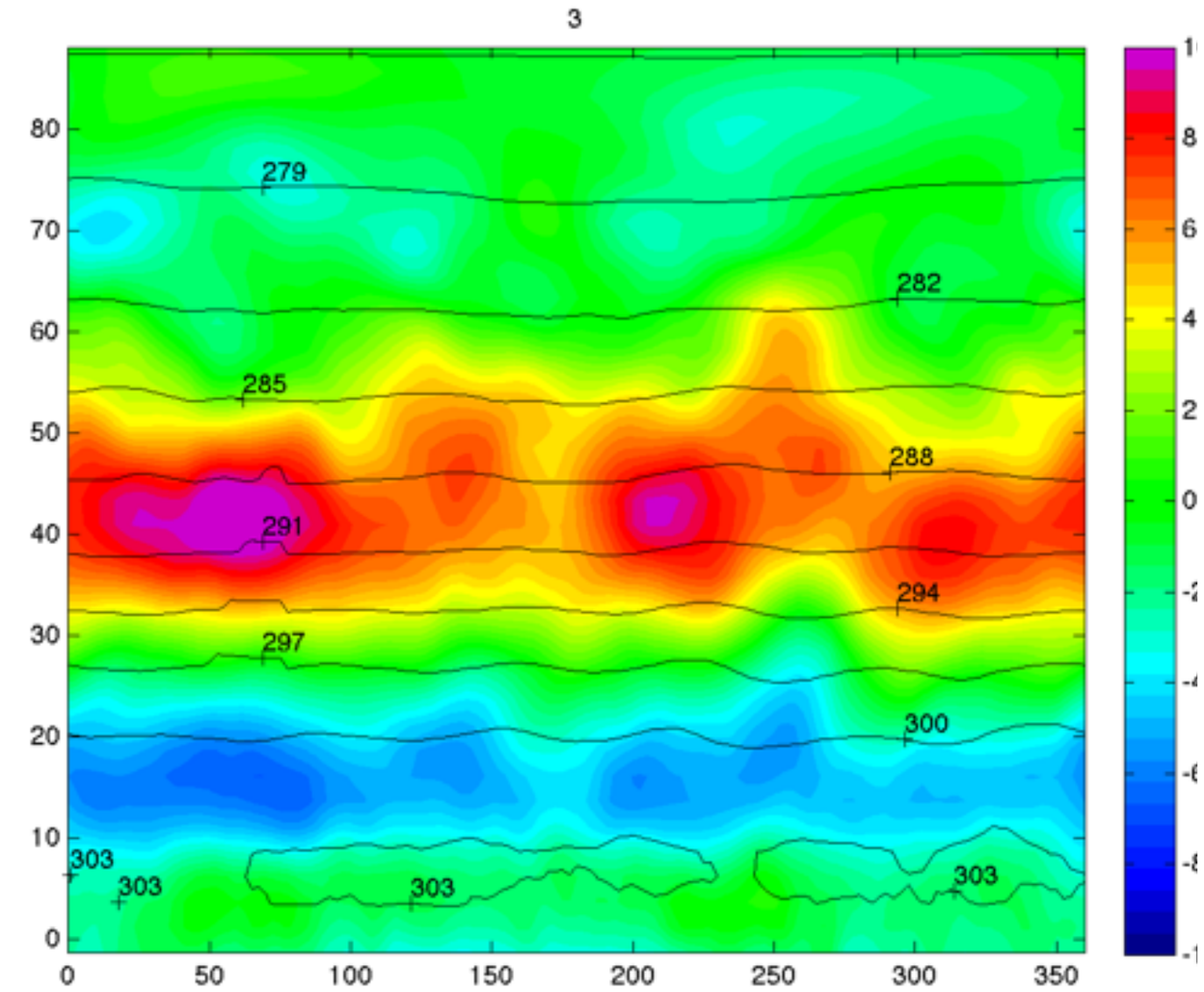


AGCM

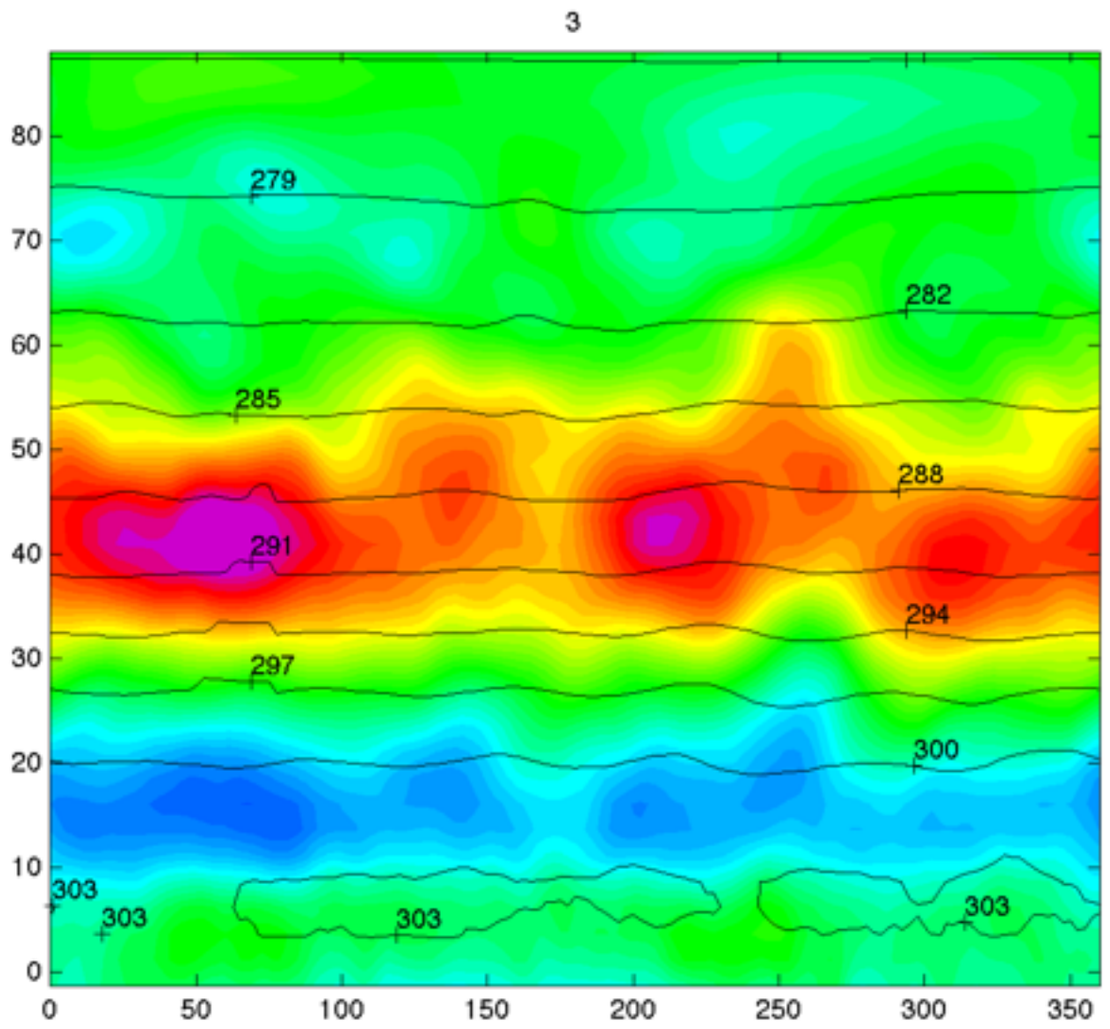


IMPACT OF HIGH LAT HEATING

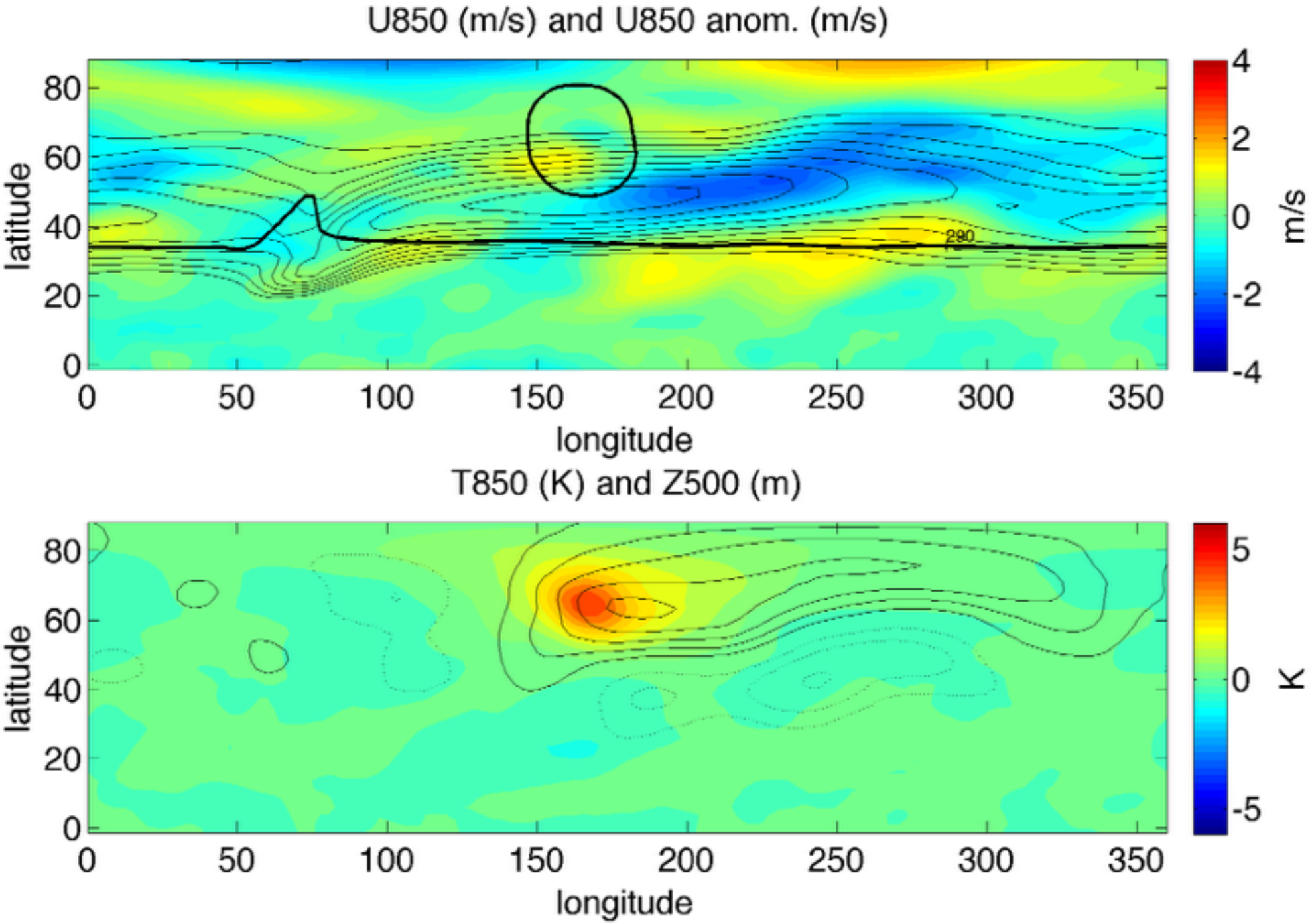
AGCM



AGCM + Heating



PRELIMINARY RESULTS



GRAZIE!!