2nd Workshop on Parameterization of Lakes in NWP and Climate Modelling, Norrköping 2010

GKSS FORSCHUNGSZENTRUM

Can the Baltic Sea be parameterized as fresh or salt water lake?

First results from COSMO-CLM FLake simulation

Frederik Schenk, Burkhardt Rockel
Sebastian Wagner, Eduardo Zorita

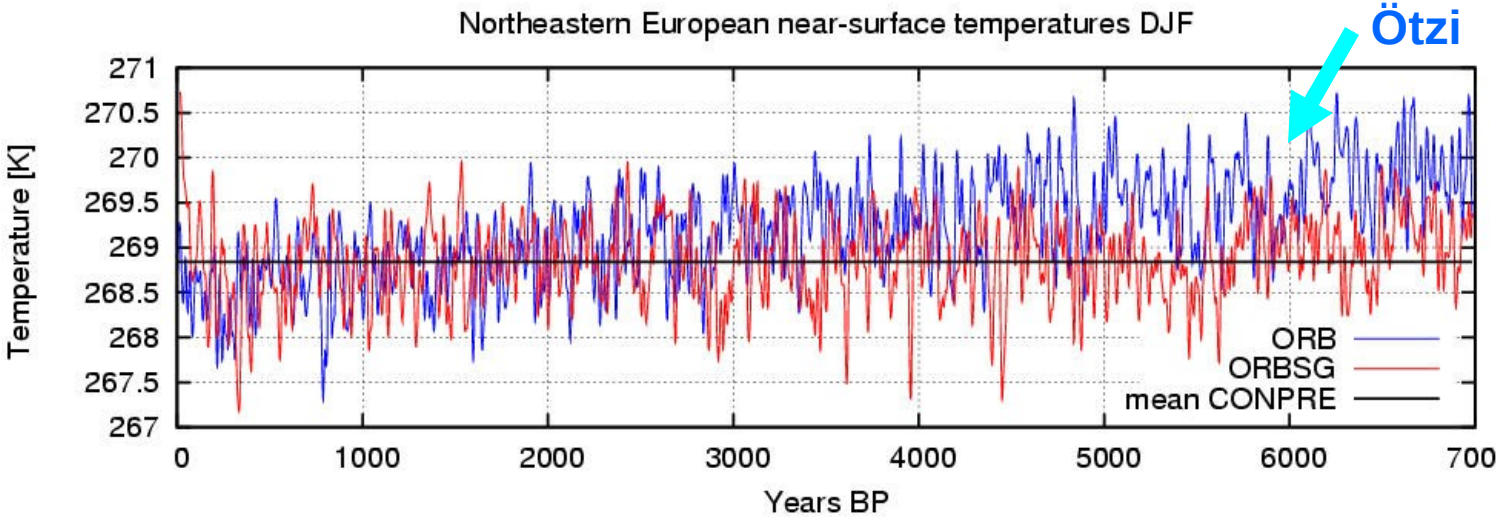
HELMHOLTZ ASSOCIATION

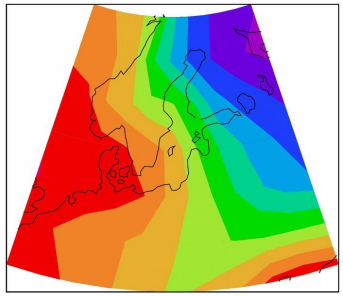
Motivation

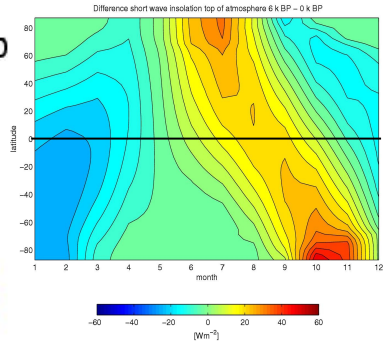
Our Task:

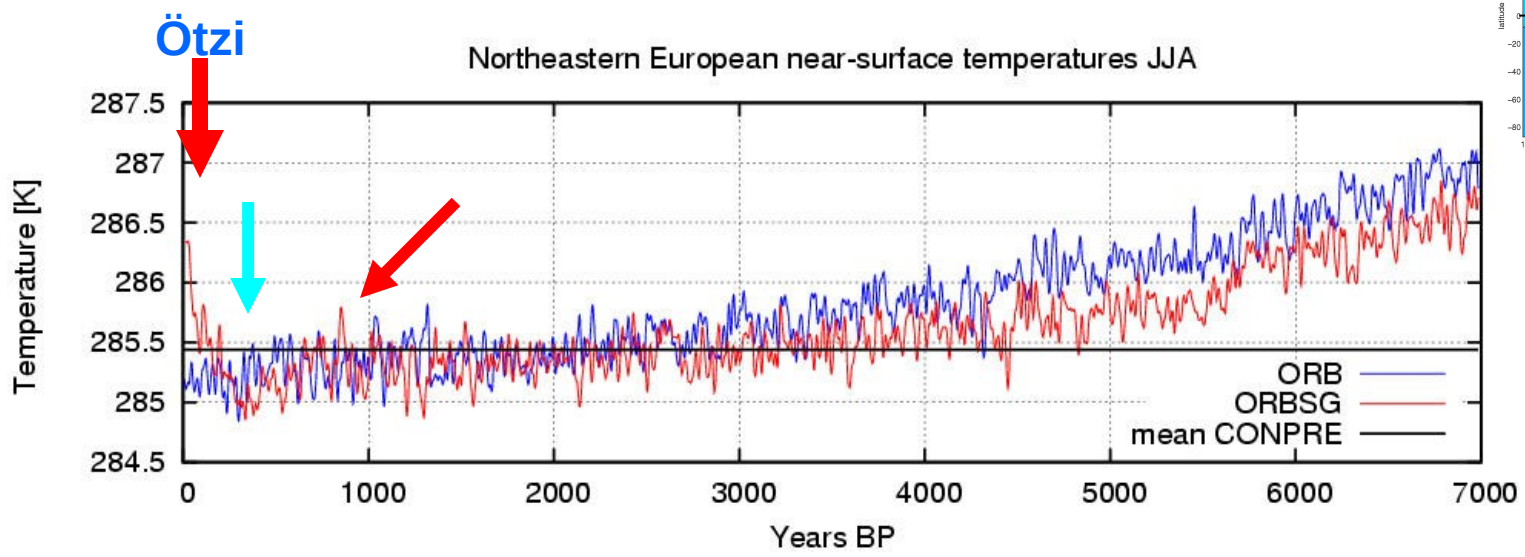
- **CCLM paleoclimate simulation: 880 – 1990 AD**
  - **Europe with 0.44°** (INTERDYNAMIK → PRIME)
  - **NE-Europe with 0.25°** (GKSS / BALTEX / ECOSUPPORT)
- **Forcing: MILLENIUM runs / ECHAM5**
  - external forcing:
    - orbital + GHC + Volc. + solar + Δ land use
  - **CLM paleo-routine**: dito (Sebastian Wagner, GKSS)

NE-European T2M since 7000 BP



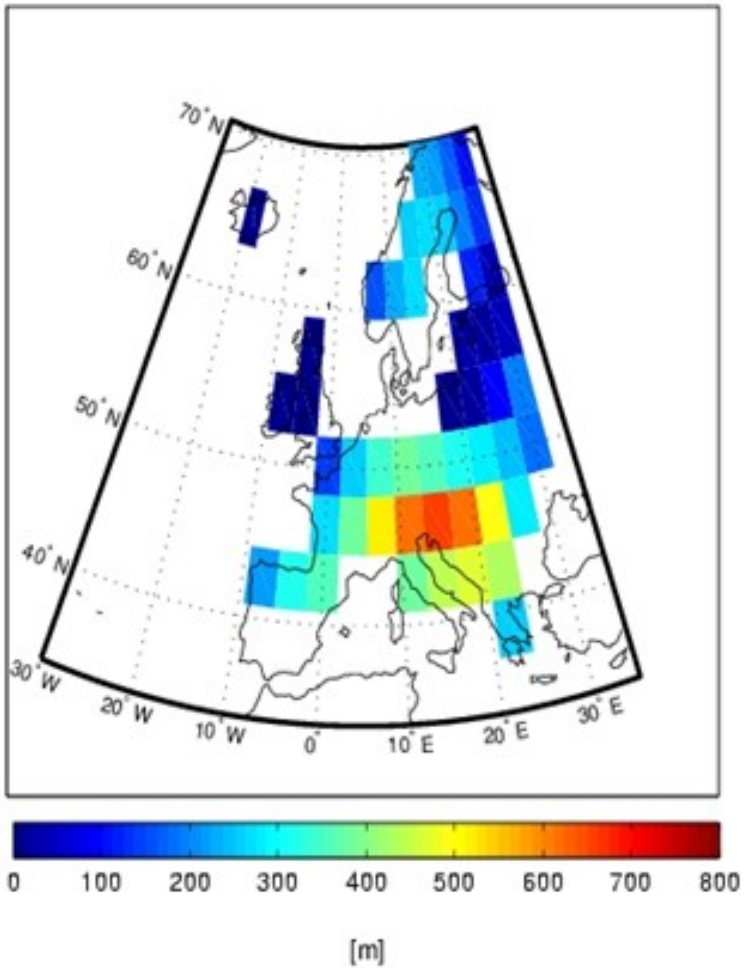






OETZI simulations

ECHAM T30 Orography



Downscaling using SST:

- **Baltic Sea:**
- **DJF: always too warm**
  - **i.e. no sea-ice**
- **JJA: always too cold…**

- Ocean-coupling too time consuming for regional paleoclimate simulations…

GKSS FORSCHUNGSZENTRUM

FLake instead of prescribed SST for Baltic Sea

Changes in COSMO-CLM

Modifications

External fields:

- option for Baltic Sea to be **fr_lake**
- introduction of Baltic Sea bathymetry **depth_lk**
- implementation of external field for salinity **salt_lk**

Physics/Code:

- conversion of constants to 2D fields as F(salt_lk)
  - freezing point (**tpl_T_f**)
  - temperature of max. density (**tpl_T_r**)
  - max. density (**tpl_rho_w_r**)

GKSS FORSCHUNGSZENTRUM

A sensitivity study with COSMO-CLM using FLake with(out) mean salinity

(a) Baltic Lake: fresh water vs. 7 PSU ☺

(b) validation with new 2D-fields ☹

HELMHOLTZ ASSOCIATION

Sensitivity study

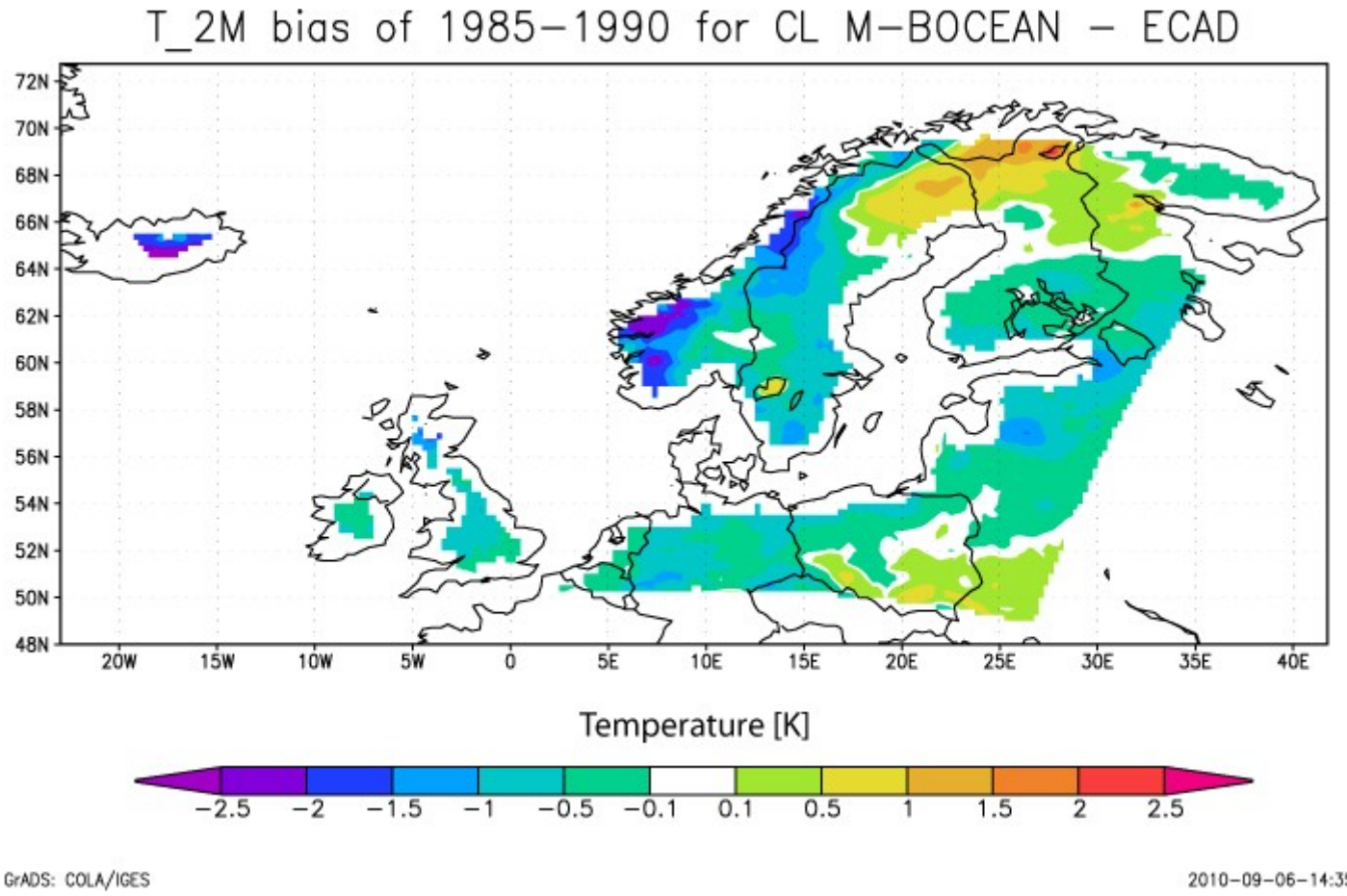
CLM4.8 driven by ERA40 for 1985-1990

- „best“ settings according to CLM Community…

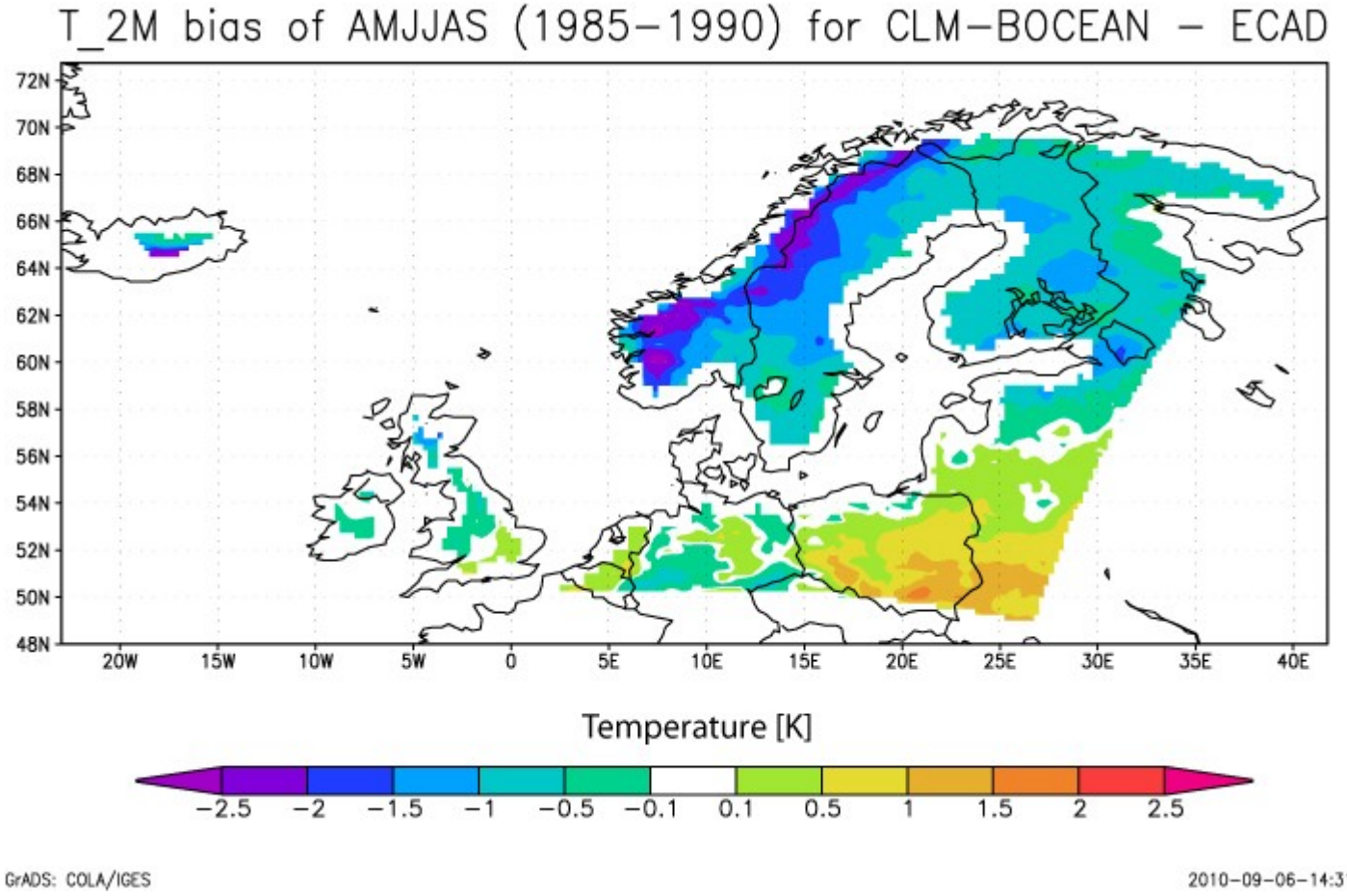
  → **Sensitivity experiment independent from bias**

  - **(1) bocean: llake = .FALSE.**
  - **(2) bflake: llake = .TRUE.**
  - **(3) bs7psu llake = .TRUE. using mean salinity**
  - **[(4) bslake llake = .TRUE. with new 2D-fields]**

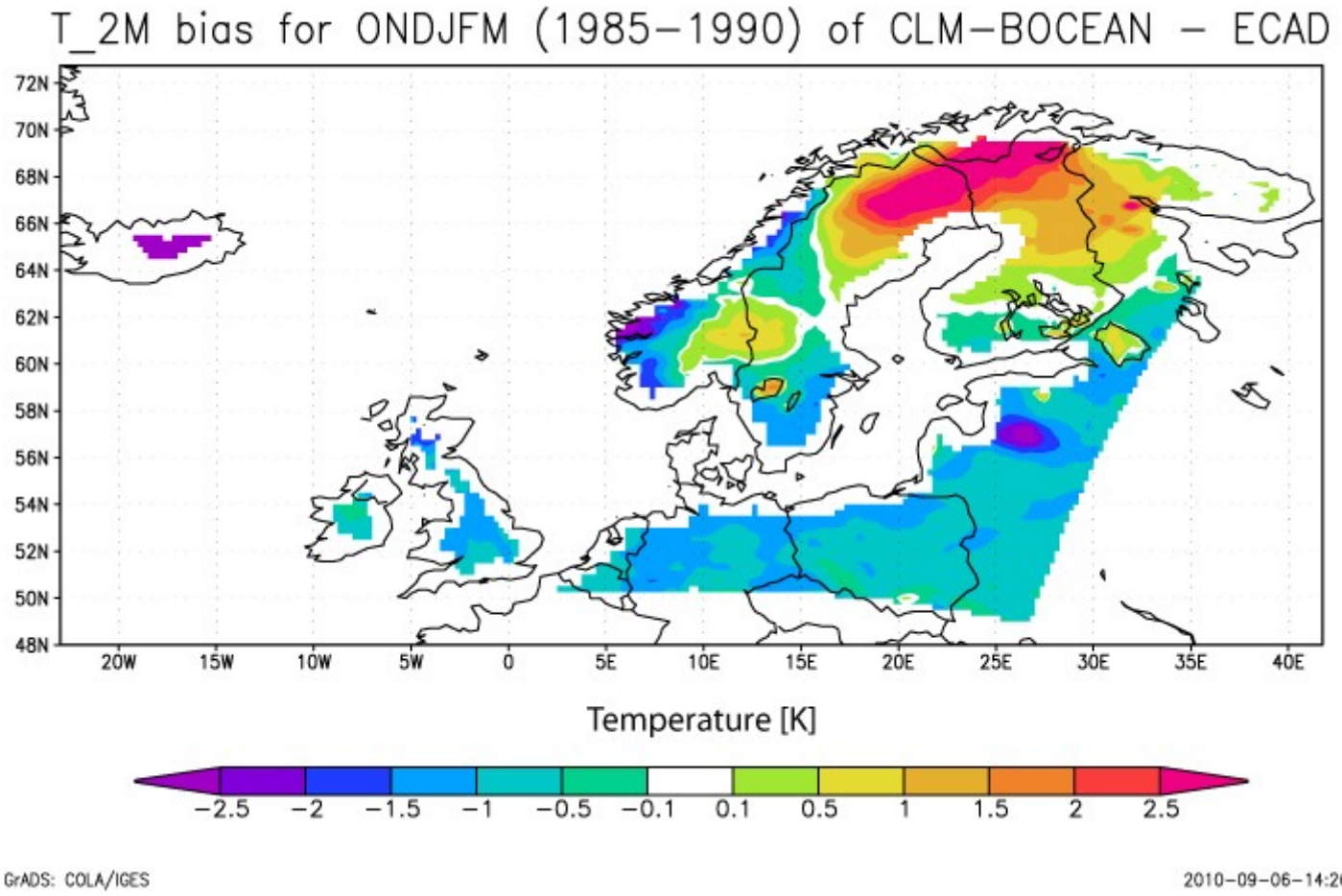
General Model Bias



General Model Bias



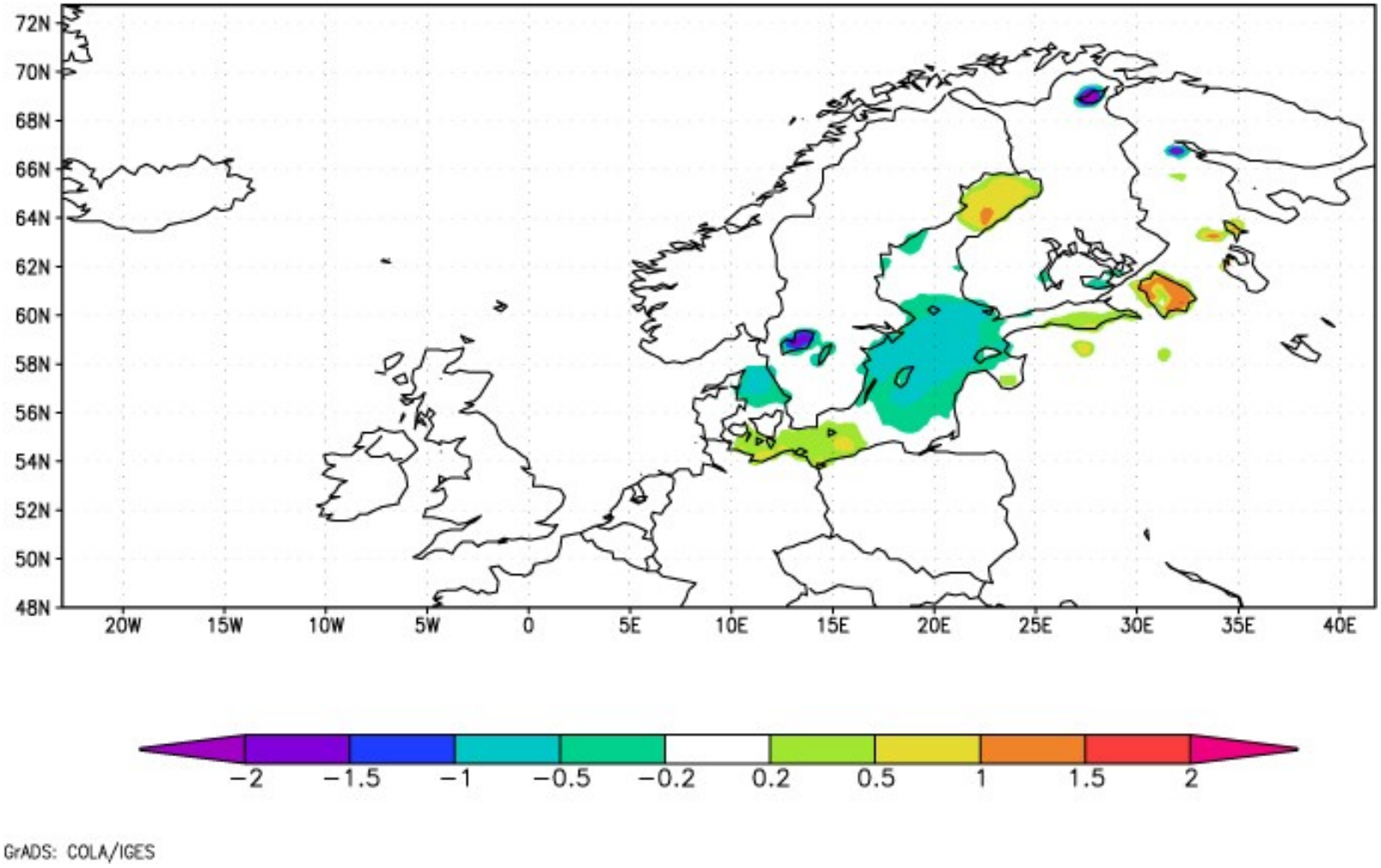
General Model Bias



Sensitivity Study for Surface Temperature

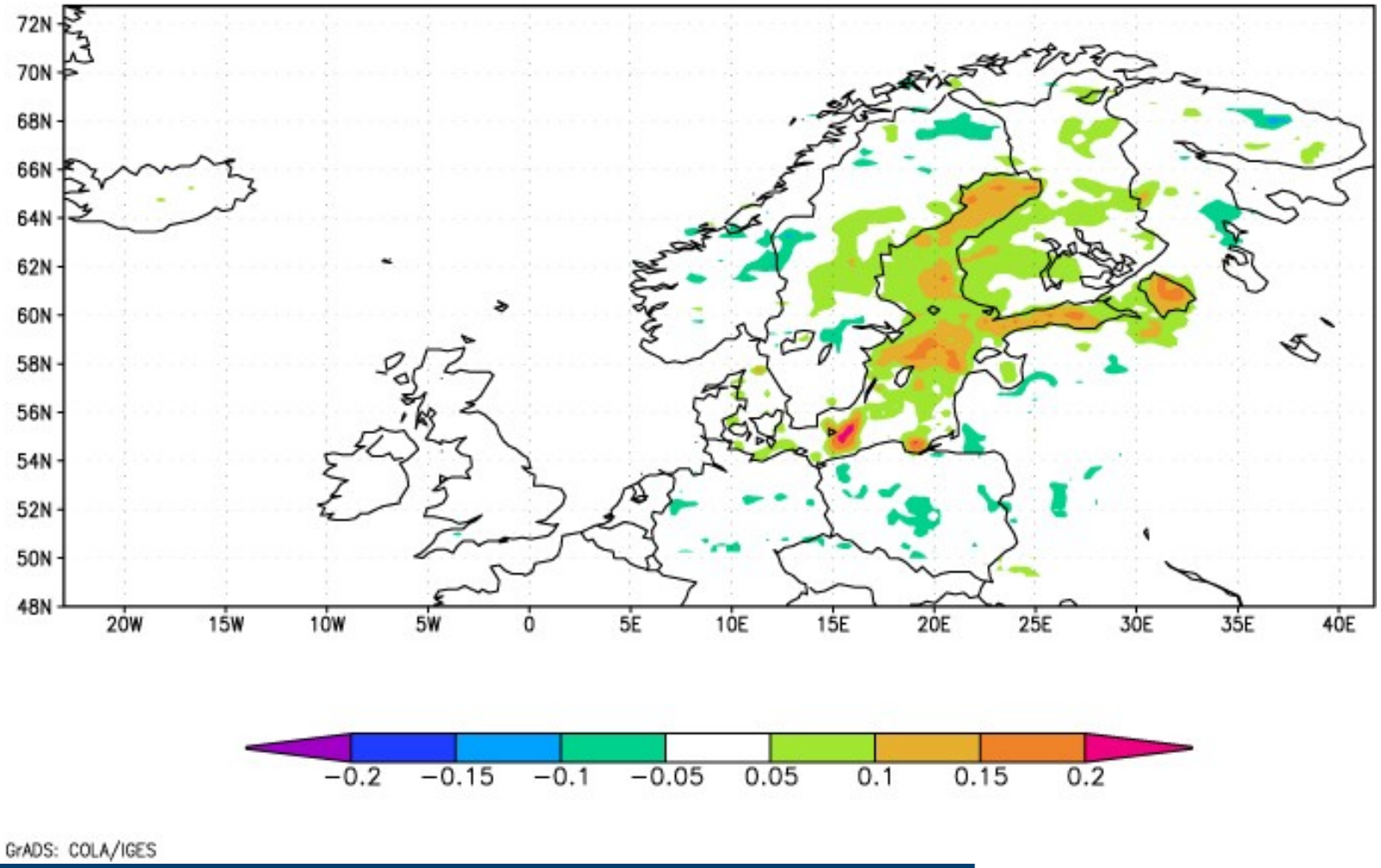
T_S [K]

ΔT_S bs7psu – bocean



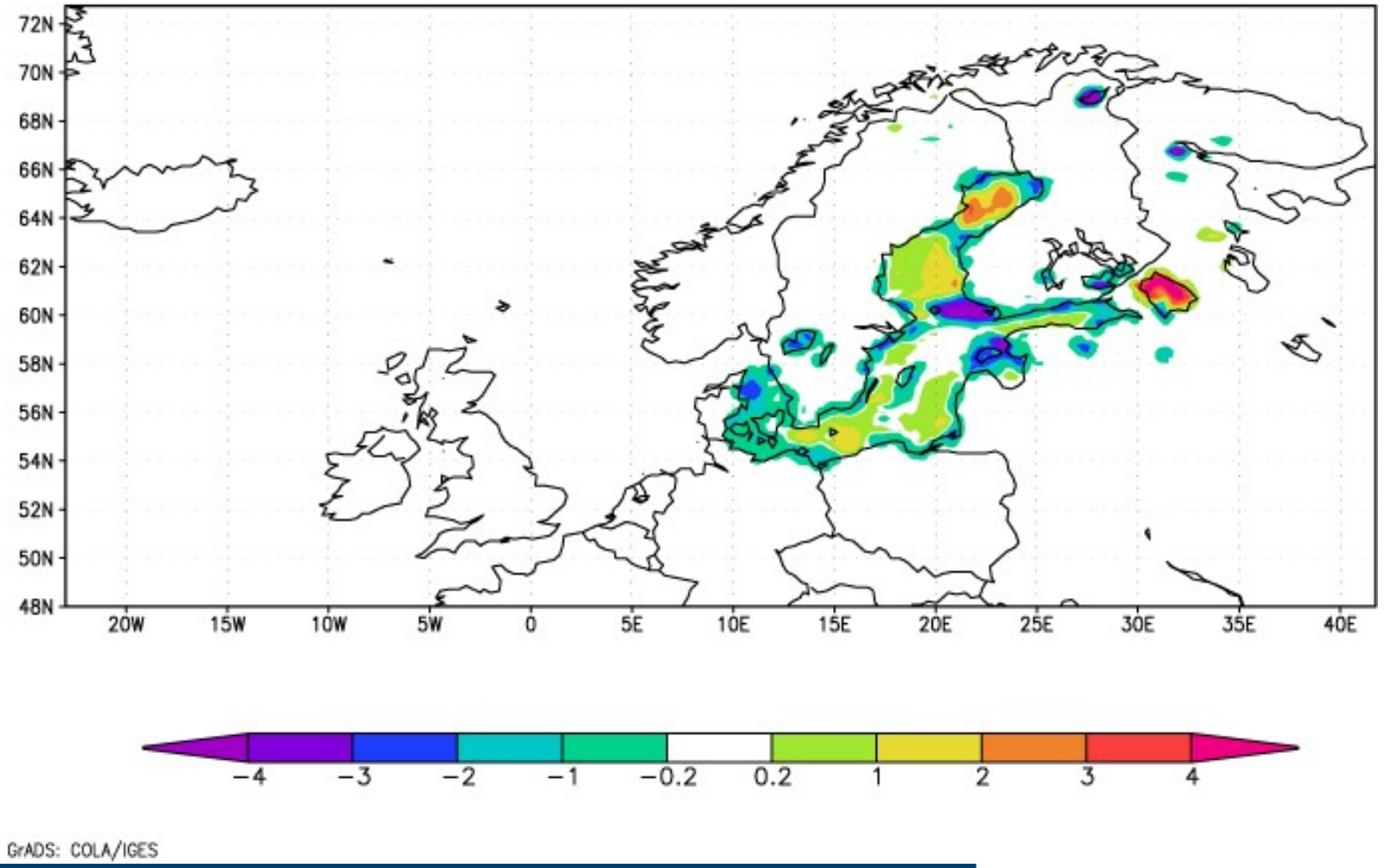
Mean over 1985/07 – 1990/08

ΔT_S bs7psu – bflake



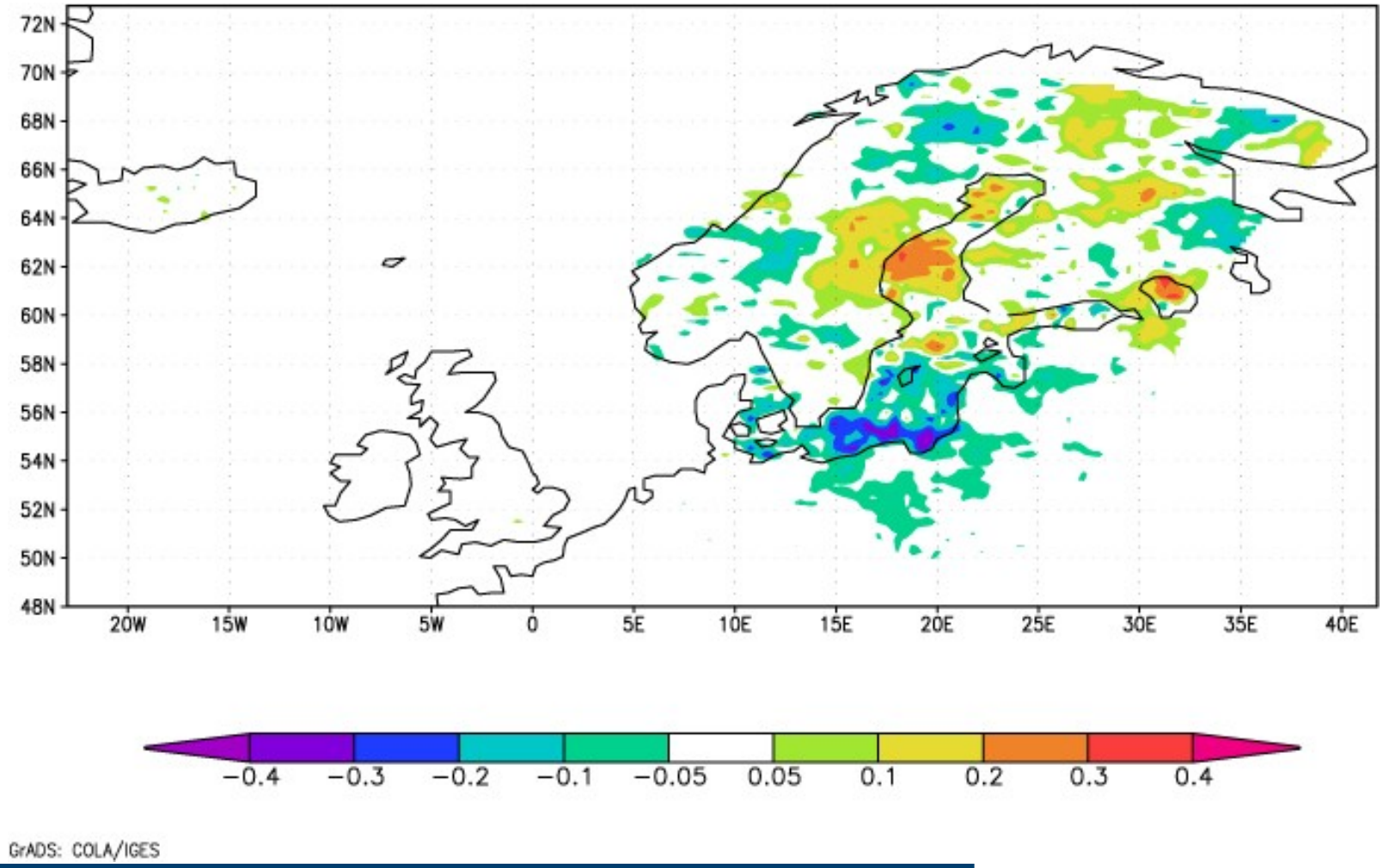
Mean over 1985/07 – 1990/08

ΔT_S bs7psu – bocean



ONDJFM over 1985/07 – 1990/08

ΔT_S bs7psu – bflake

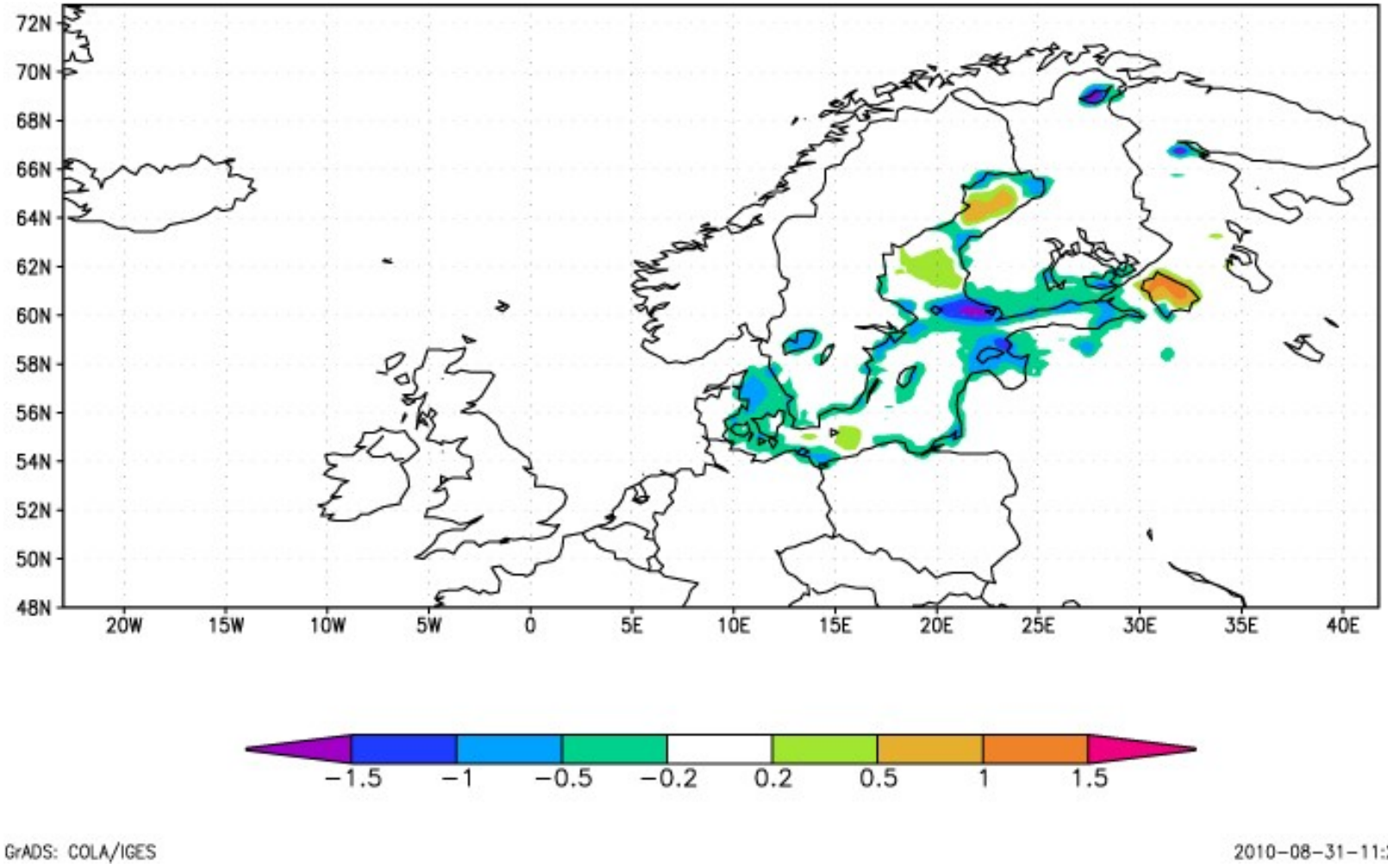


ONDJFM over 1985/07 – 1990/08

Differences for Near-Surface Temperature

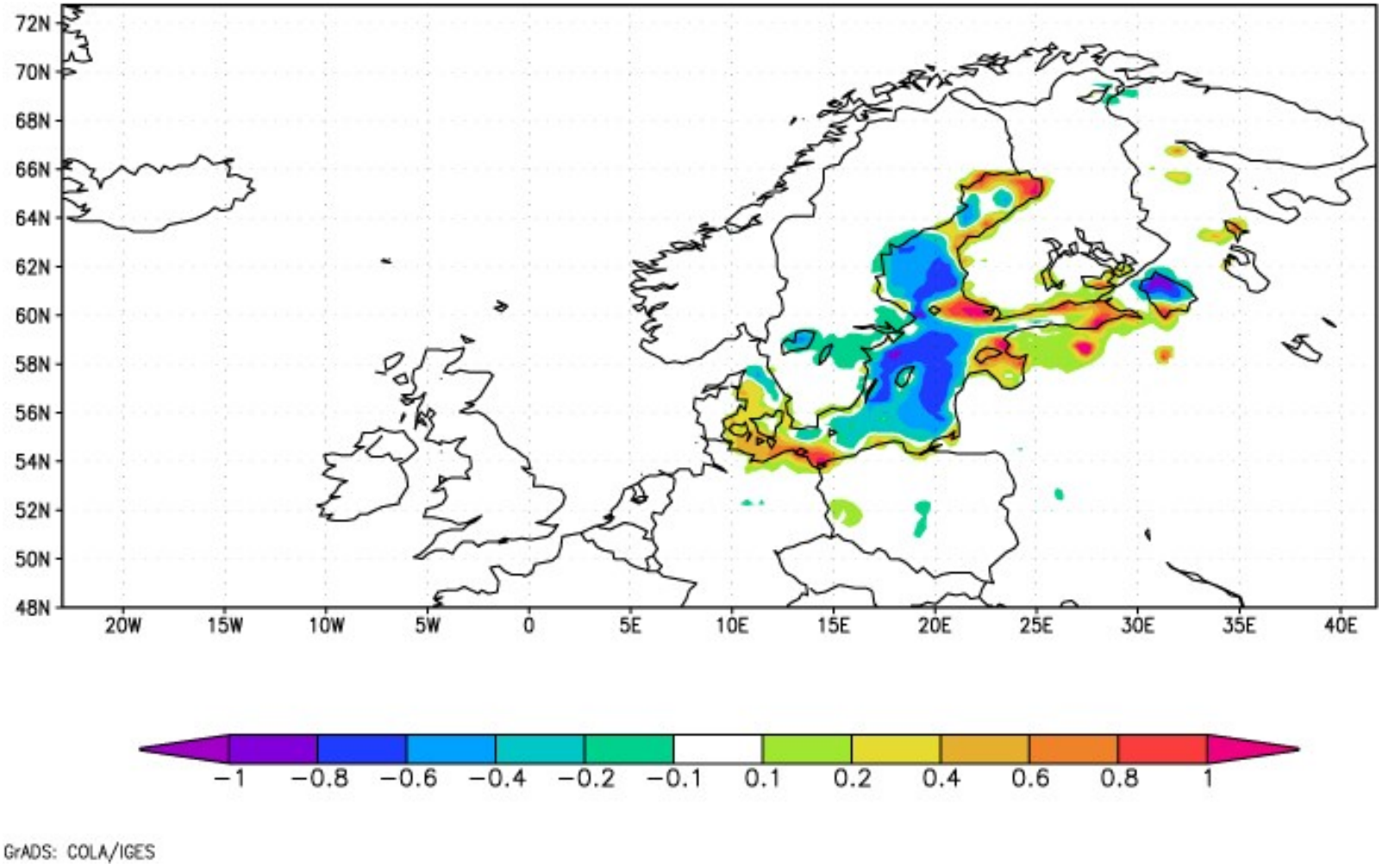
T_2M [K]

ΔT_2M bs7psu – bocean



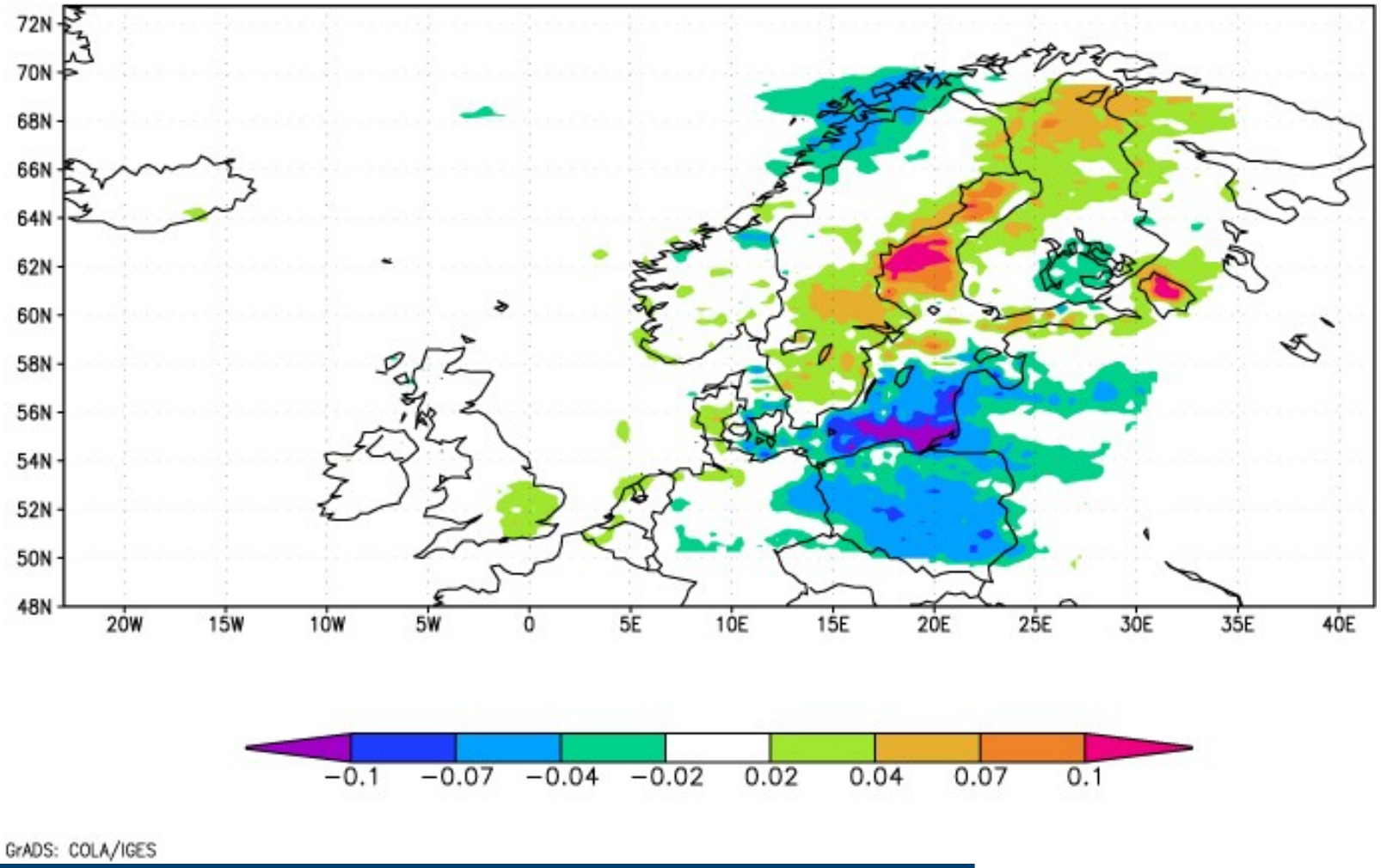
ONDJFM over 1985/07 – 1990/08

ΔT_2M bs7psu – bocean



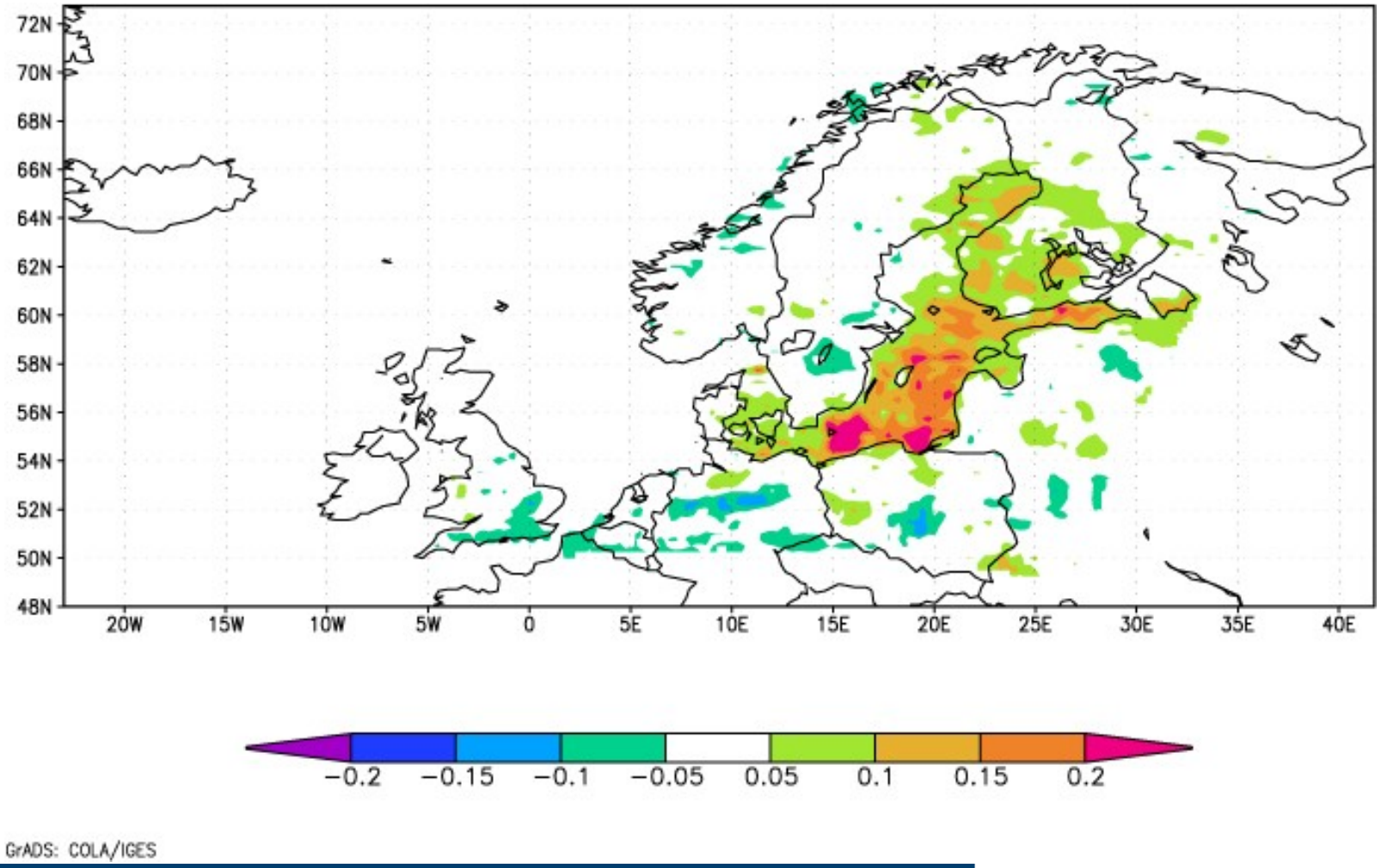
AMJJAS over 1985/07 – 1990/08

ΔT_2M bs7psu – bflake



ONDJFM over 1985/07 – 1990/08

ΔT_2M bs7psu – bflake



AMJJAS over 1985/07 – 1990/08

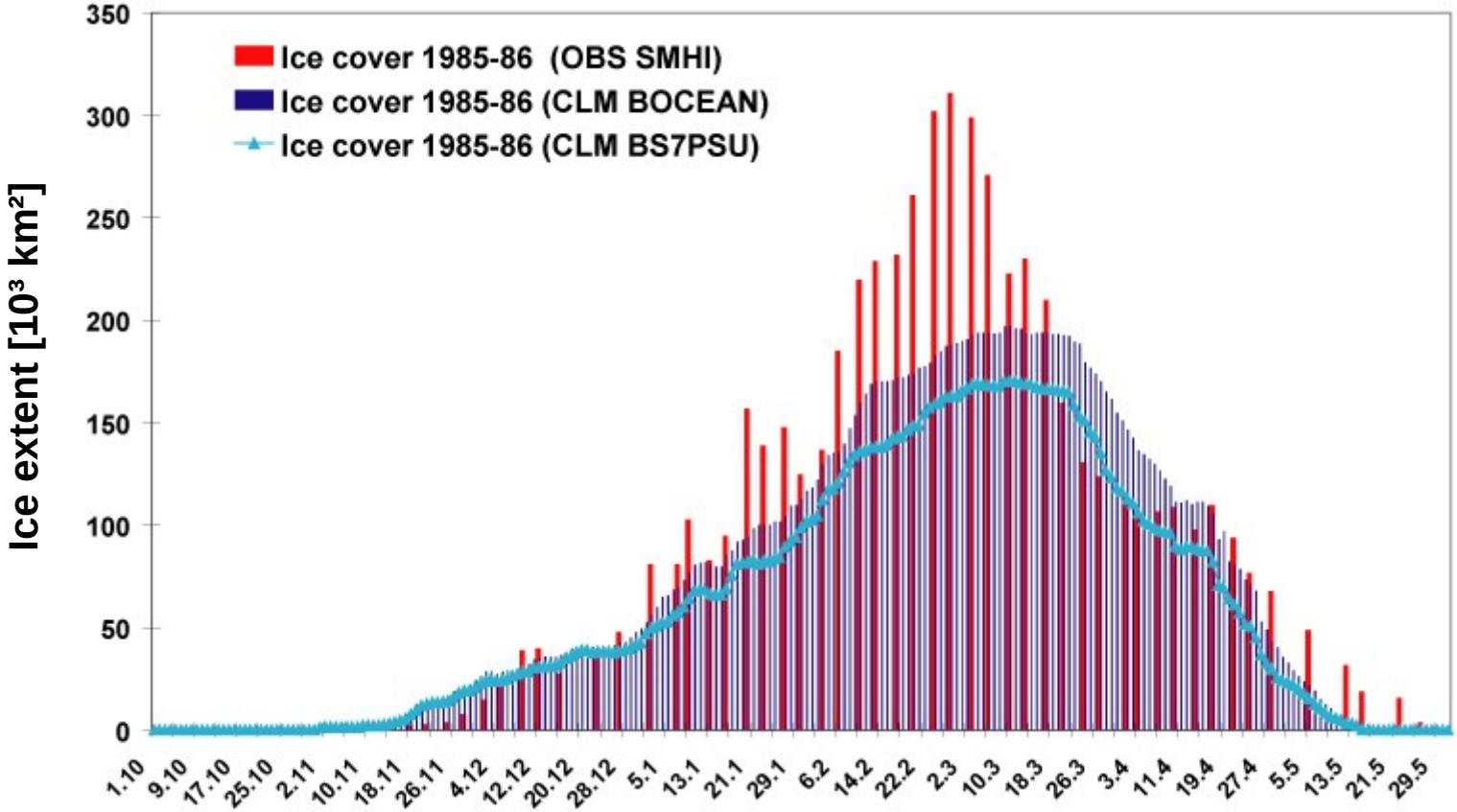
Sea-Ice of the „Baltic Lake“

H_ICE [m]

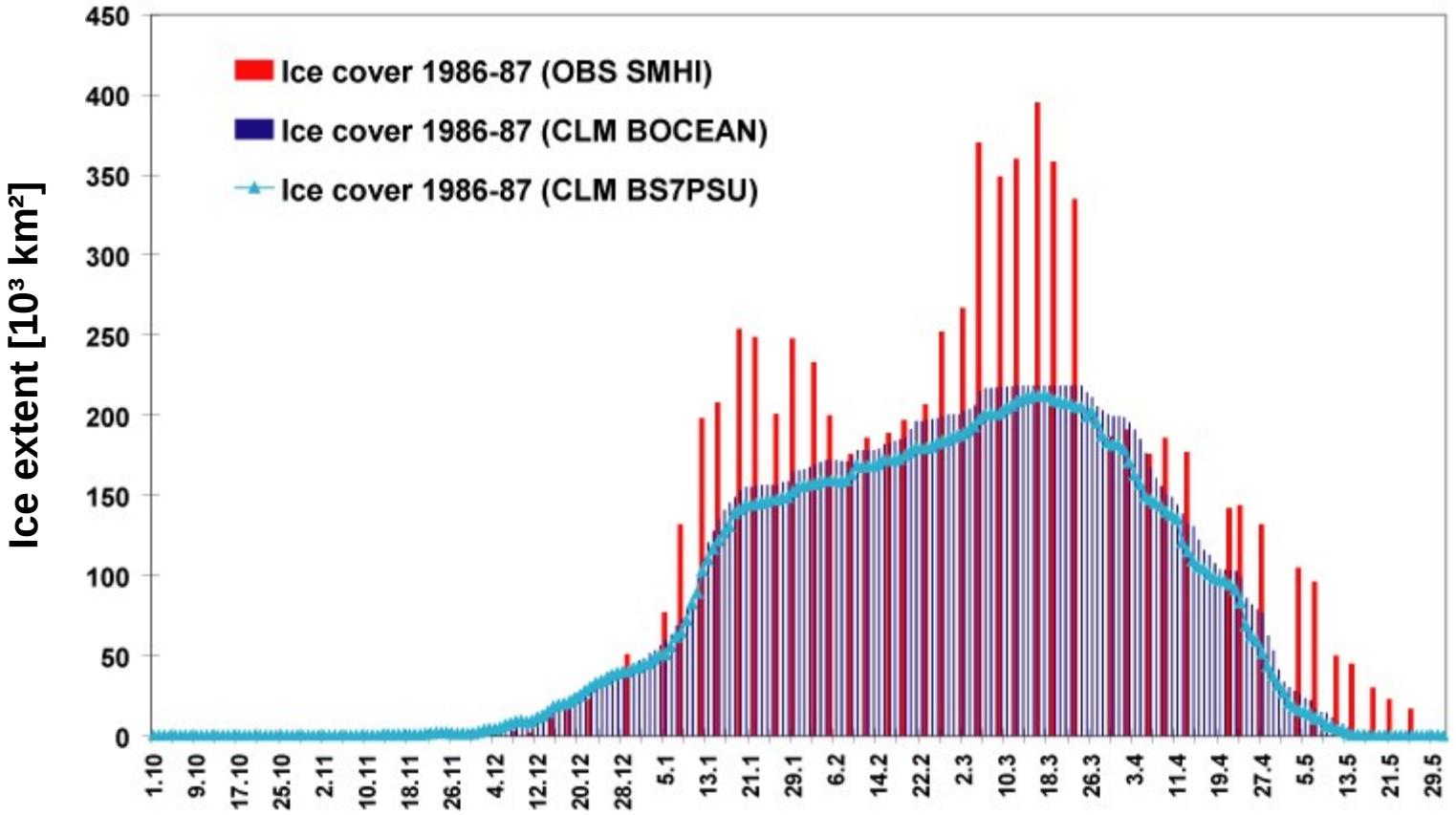
start/end of ice season

max. ice extent

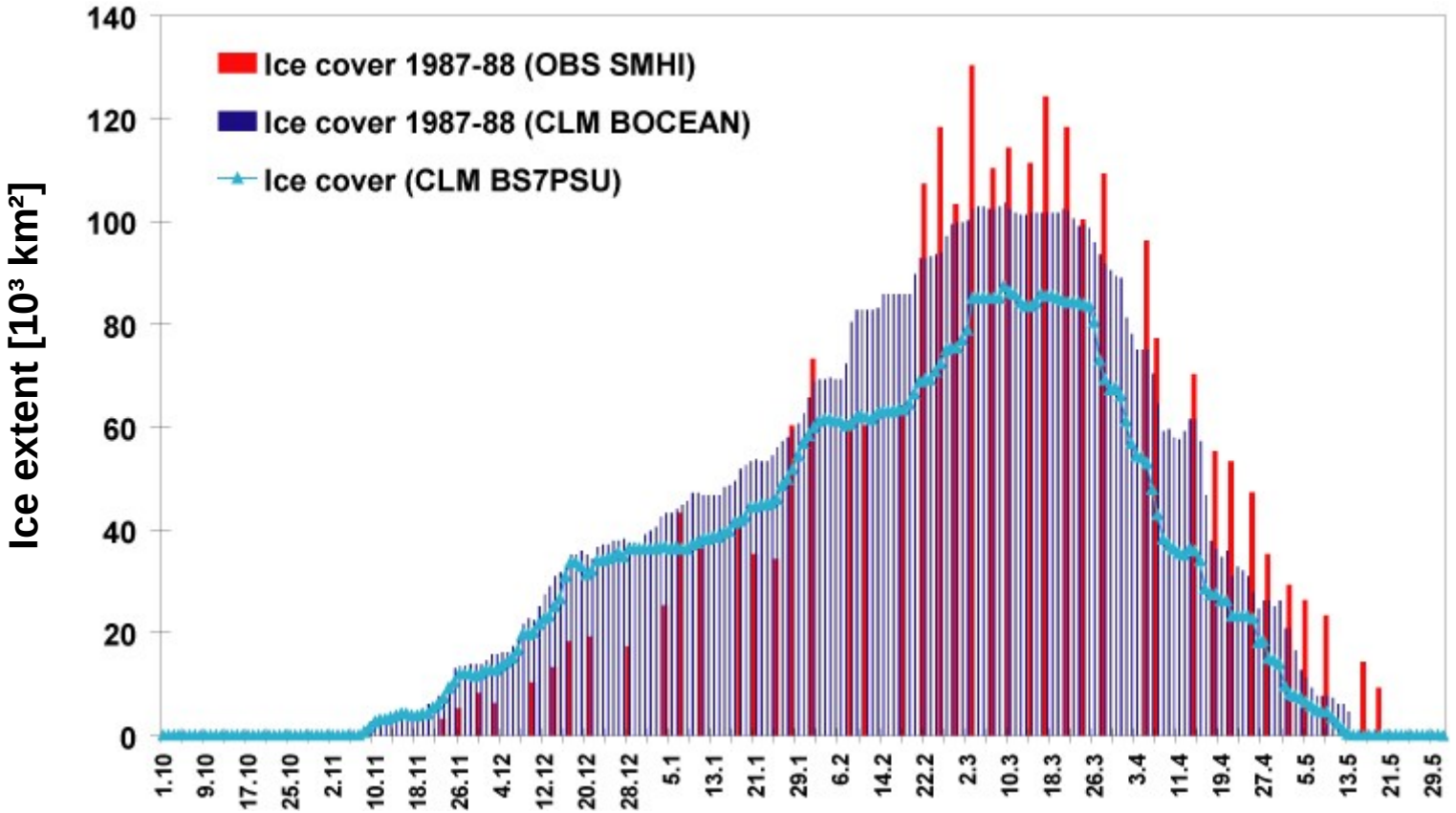
Severe winter 1985/86



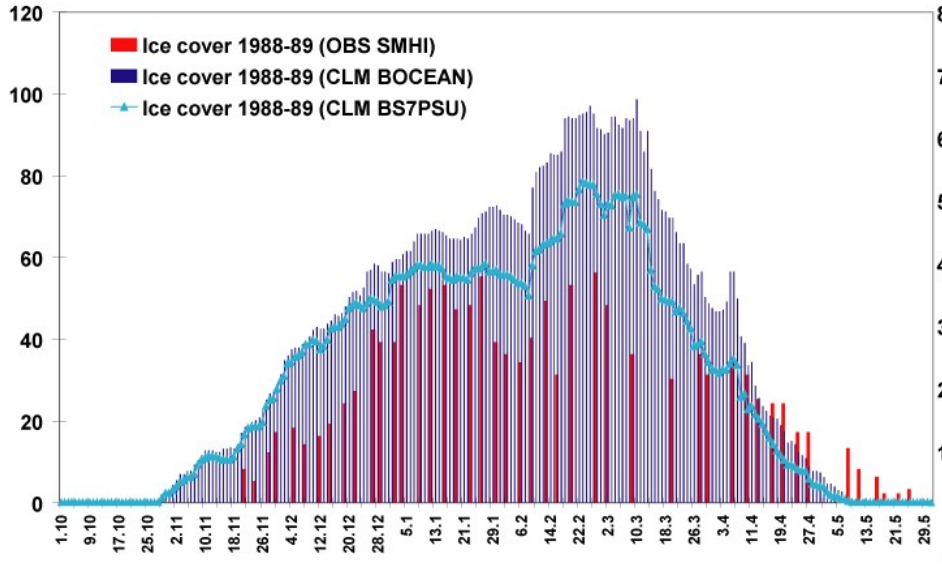
Very severe winter 1986/87

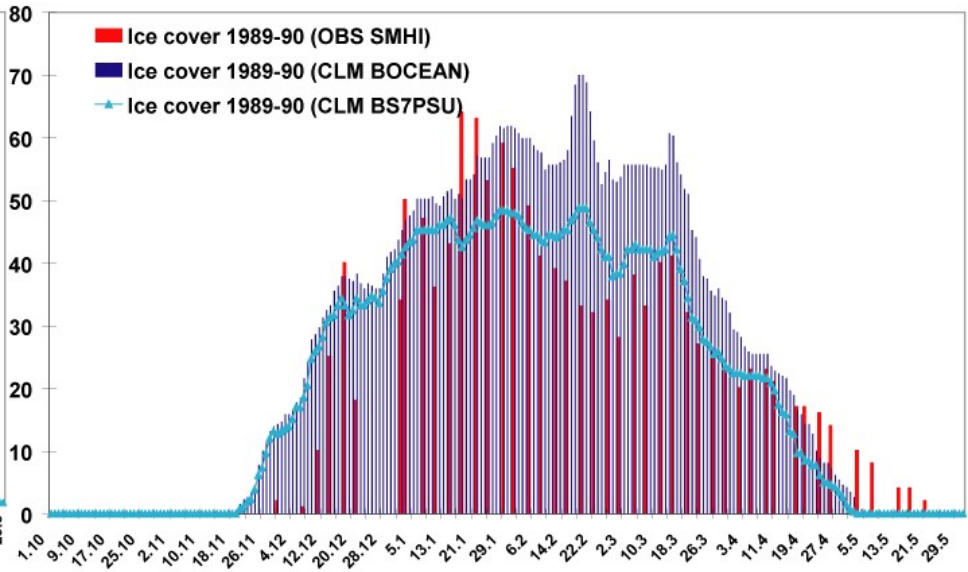


Average winter 1987/88



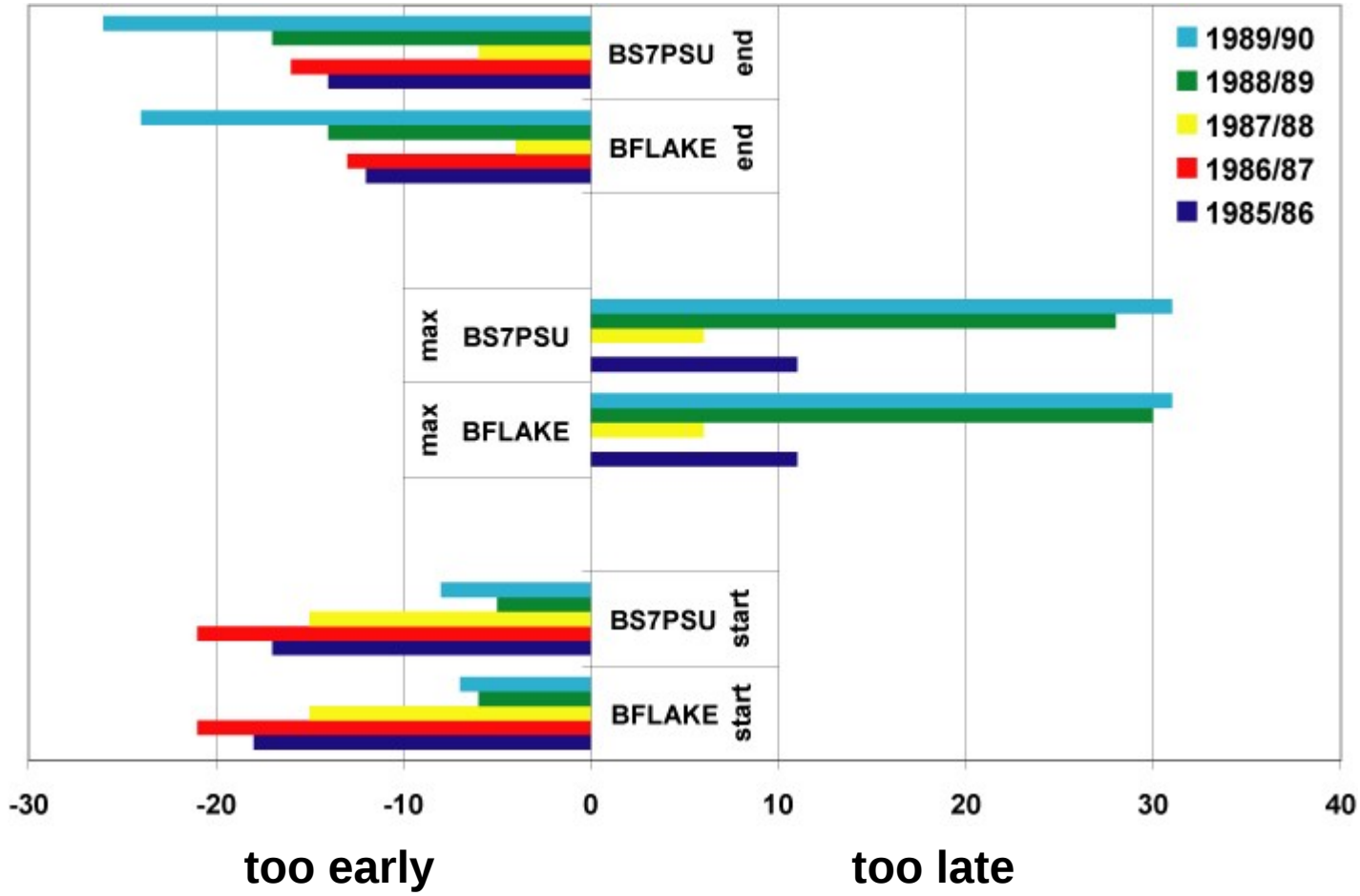
Very mild winters 1988-1990





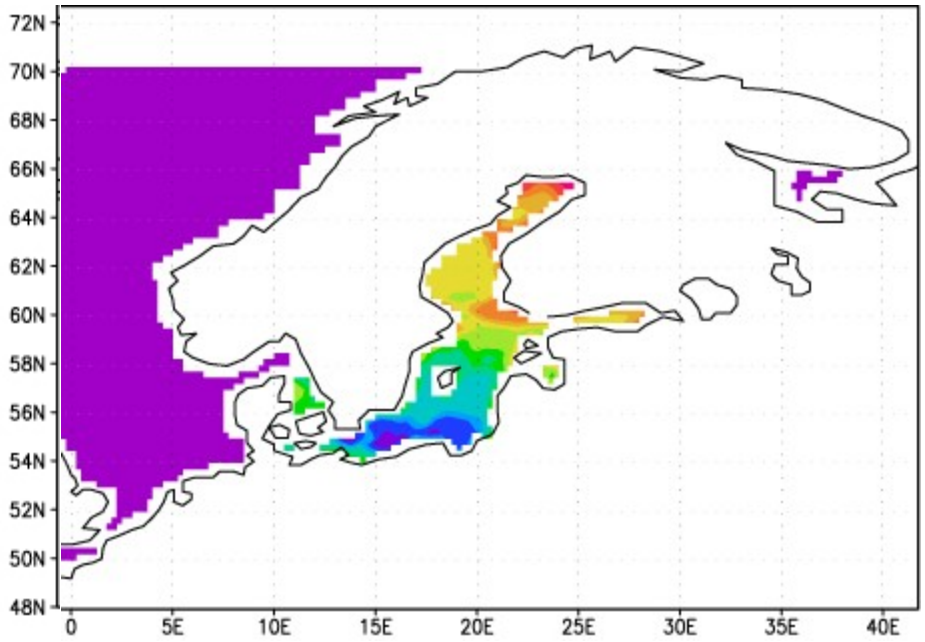
- underestimation of severe conditions (i.e. no peak)
- very close to average ice conditions
- small cold bias in very mild winters

Dates of ice season

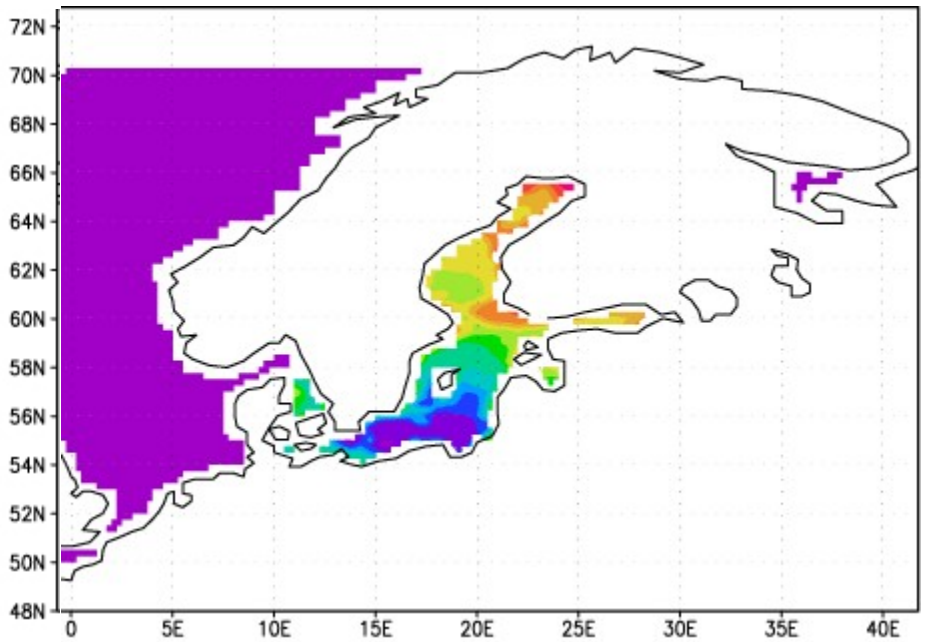


Exact dates of first/last sea-ice quite uncertain…

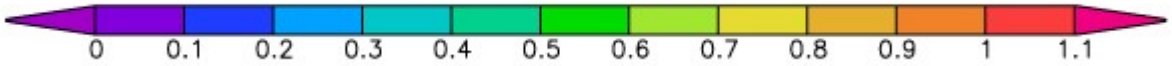
Spatial ice-cover (max.)



Bflake (fresh water)



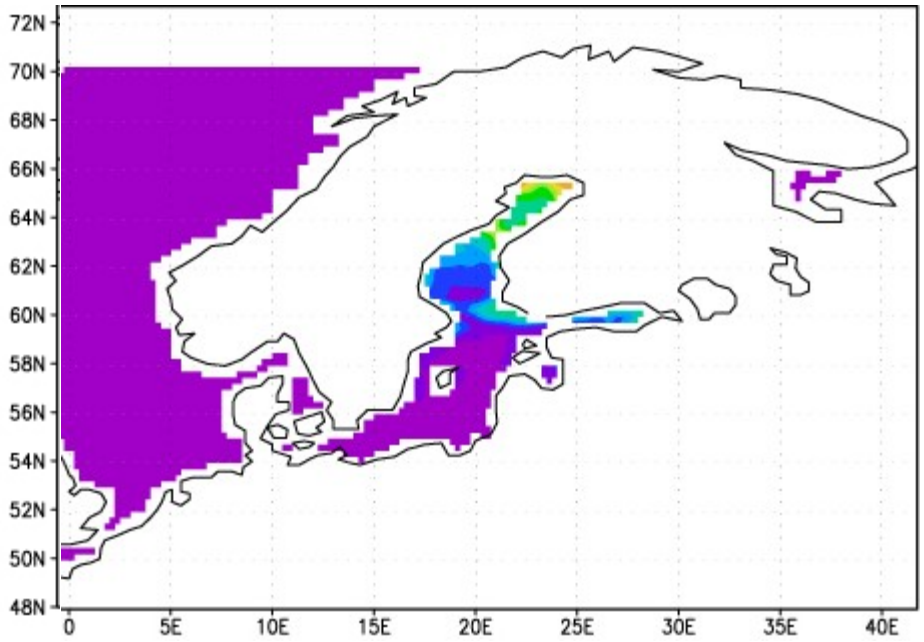
bs7psu (salt water)



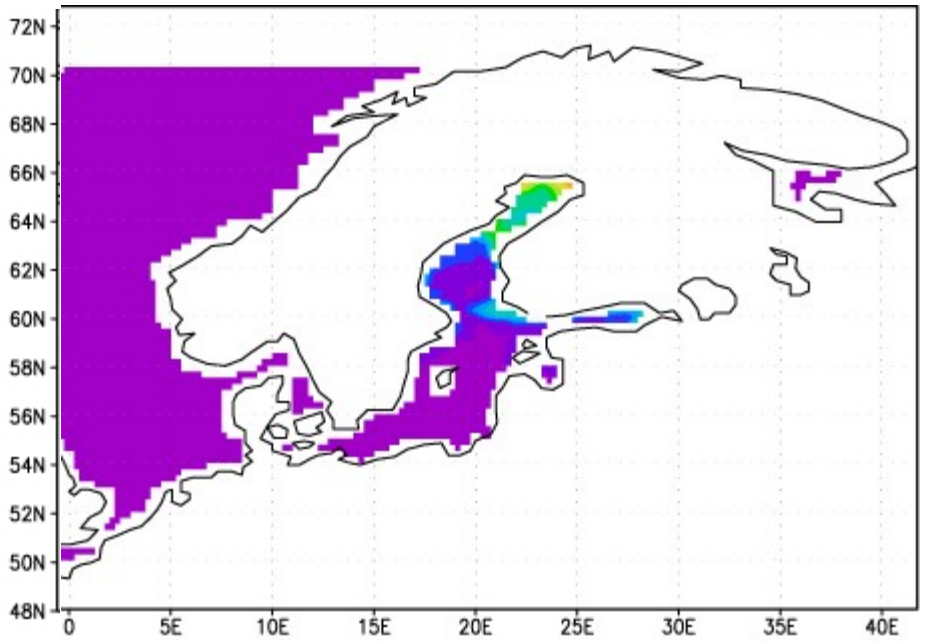
H_ICE [m]

Very severe ice winter 1986/87 (max. 1986-03-12/17)

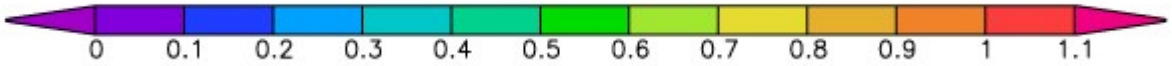
Spatial ice-cover (max.)



Bflake (fresh water)



bs7psu (salt water)



H_ICE [m]

Very mild ice winter 1988/89 (max. 1989-03-23/25)

Discussion

Further improvements:

- better sea-ice, i.e. Western Baltic Sea due to SSS?
- systematic tests for best settings
- comparison with ECHAM5/CLM
  - CLM standard (global SST)
  - CLM FLake, CLM SLake

Open Questions:

- extended changes in FLake necessary for salinity?
- i.e. strong stratification, vertical mixing, sea-ice…

GKSS FORSCHUNGSZENTRUM

To be continued…

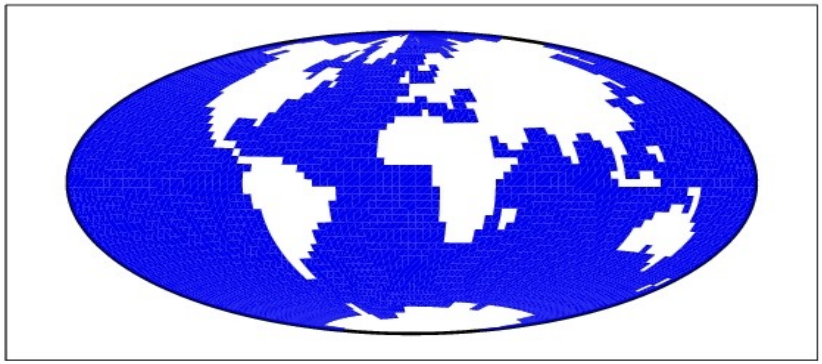
Looking forward to your expertise!

Thanks for your attention!

Hamburger Klimamodell

Atmosphere: ECHAM4

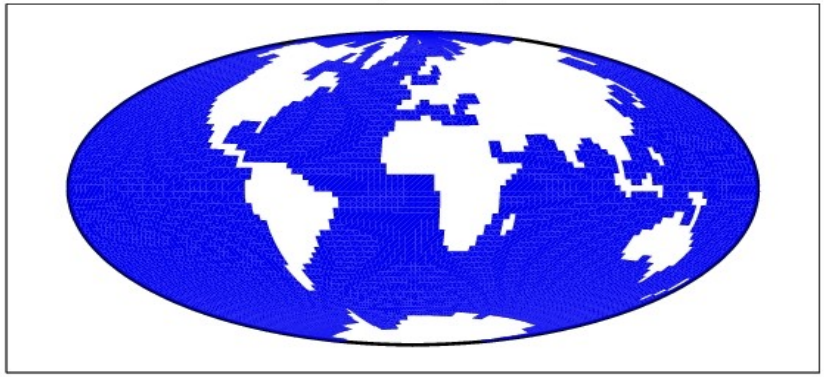
T30 (ECHAM4)



T30 (3.75° x 3.75°)
19 vertical layers

Ocean: HOPE-G

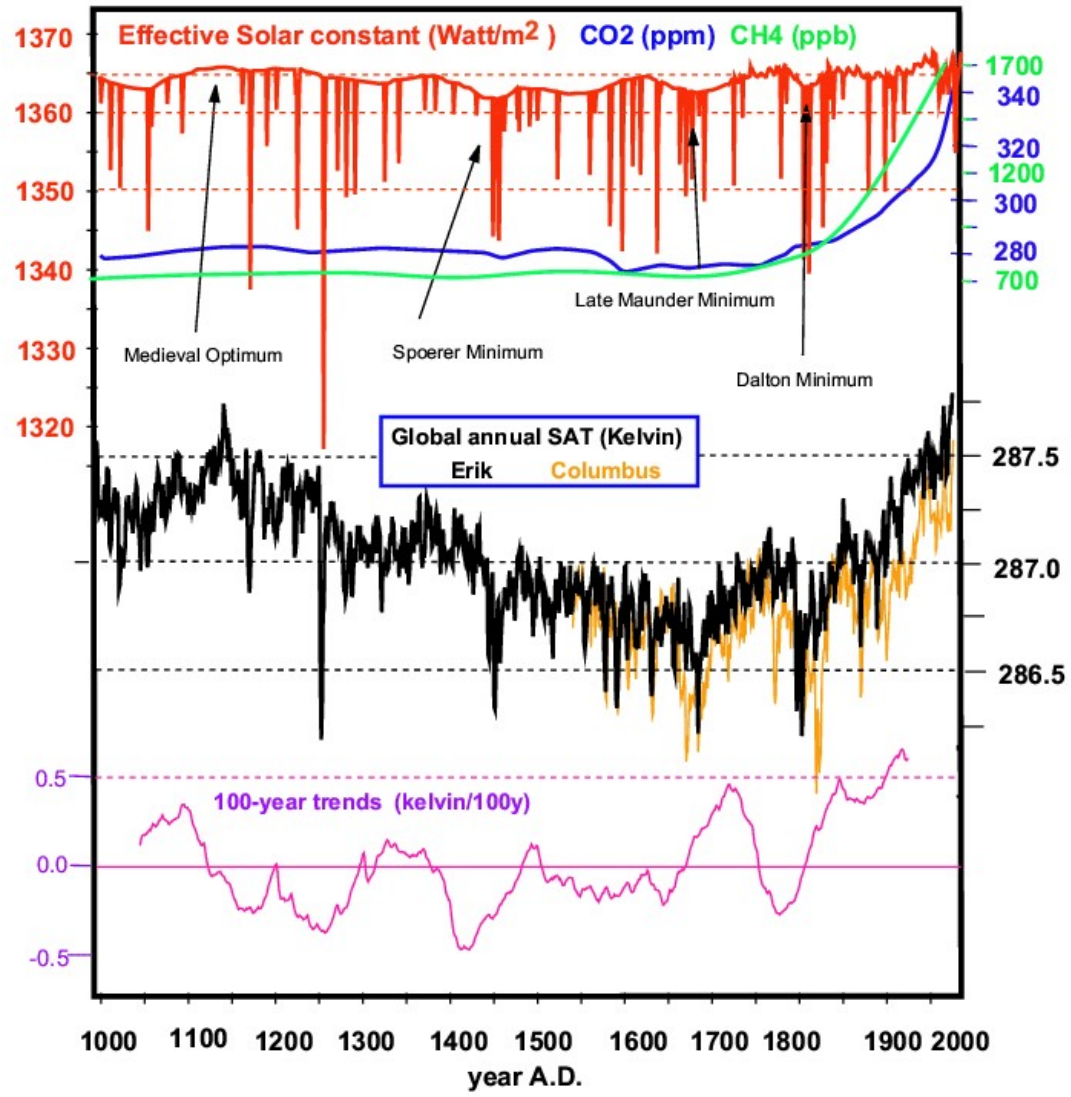
(HOPE–G)



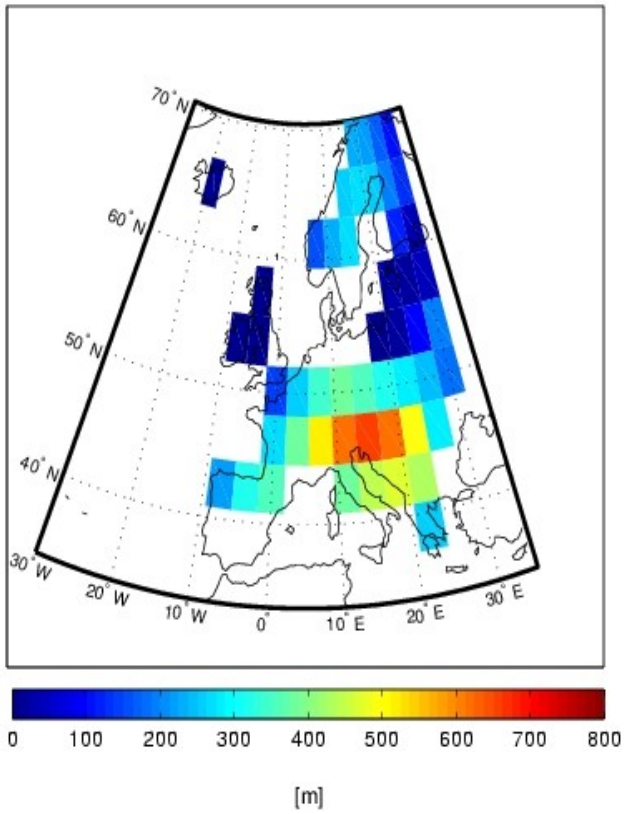
Horizontal Resolution 2,81° x 2,81°
20 vertical layers
increased tropical resolution

...eine Klimarekonstrukion

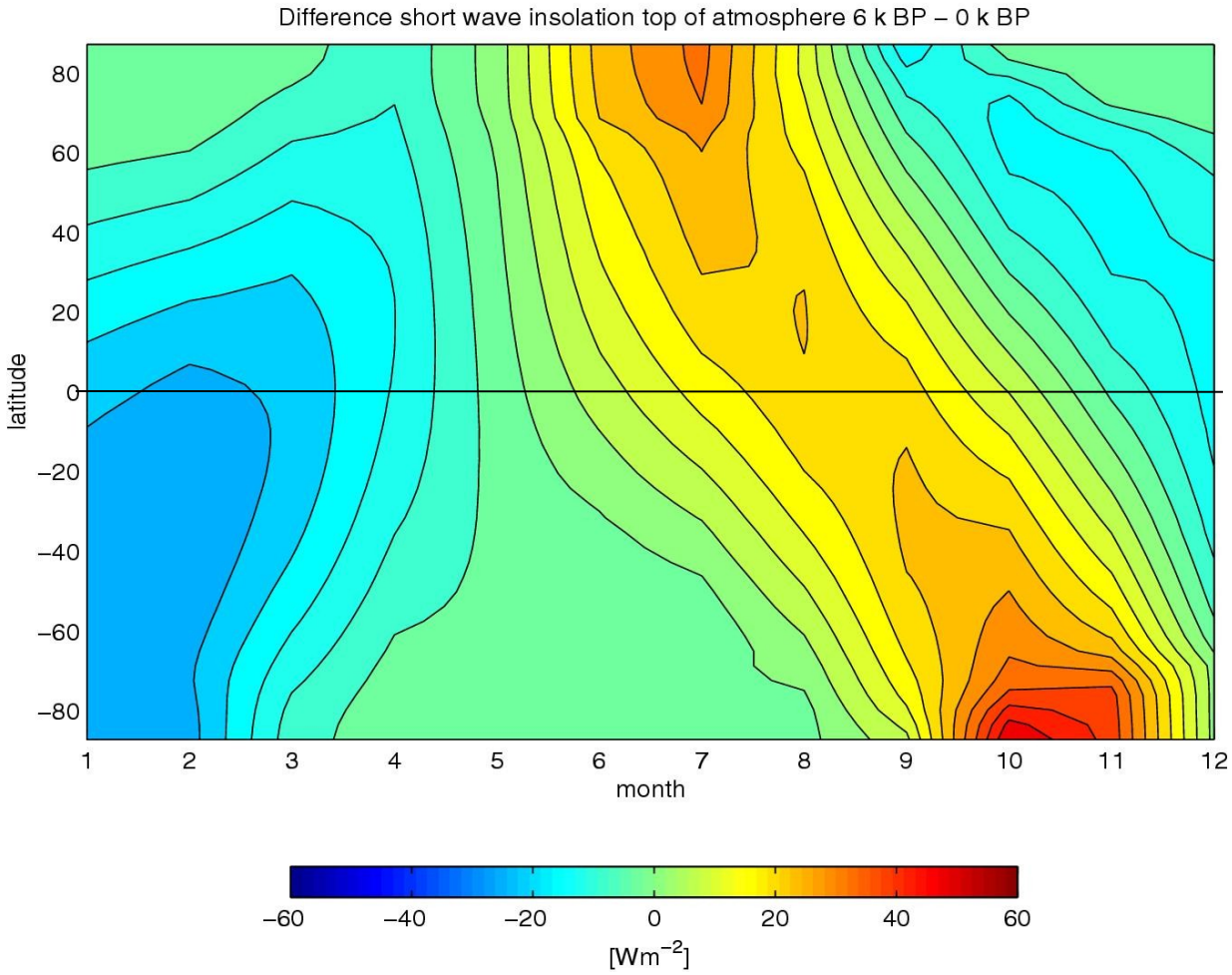
Simulation with the model ECHO-G



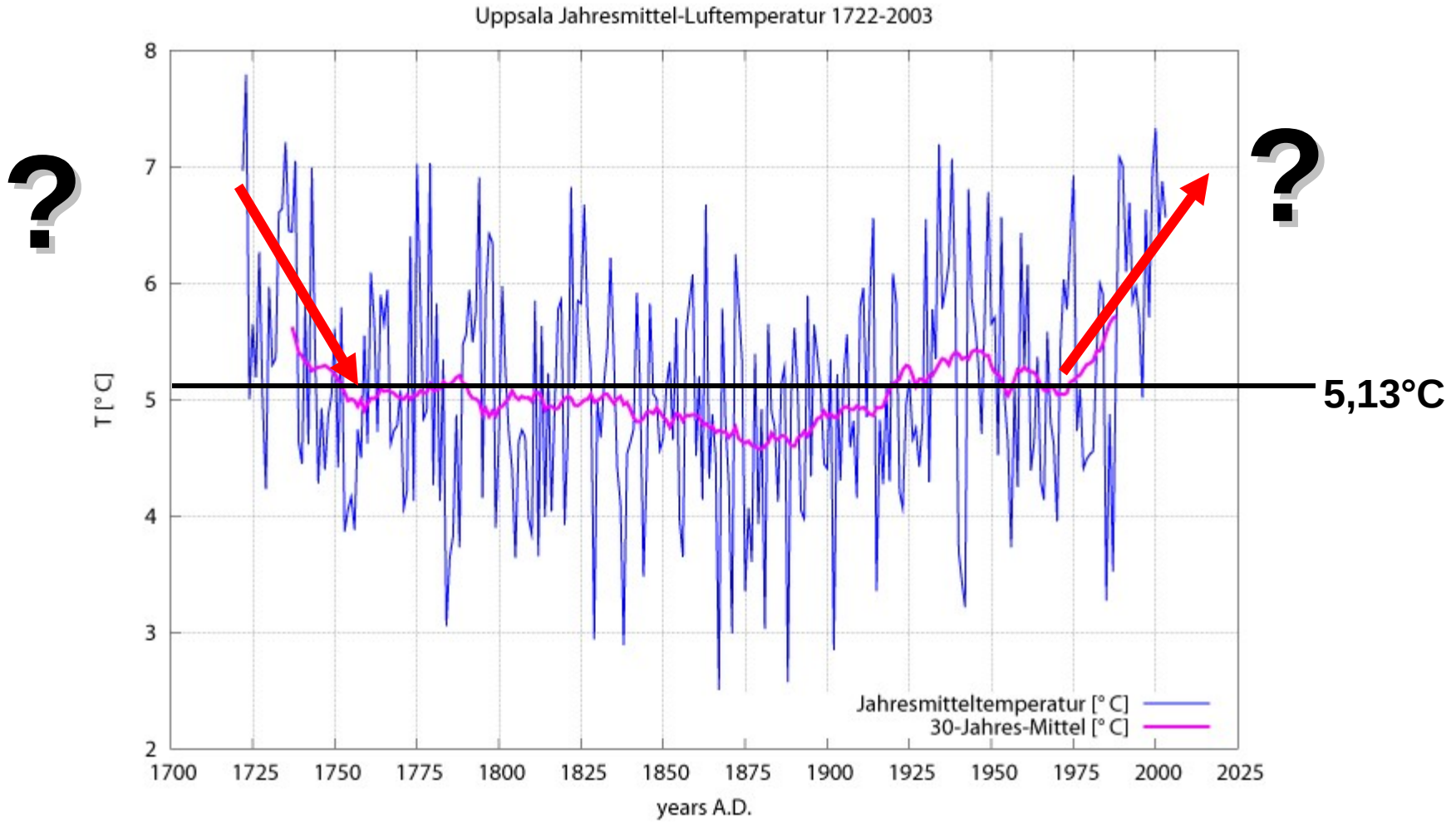
T-30 Orographie Europa ECHAM



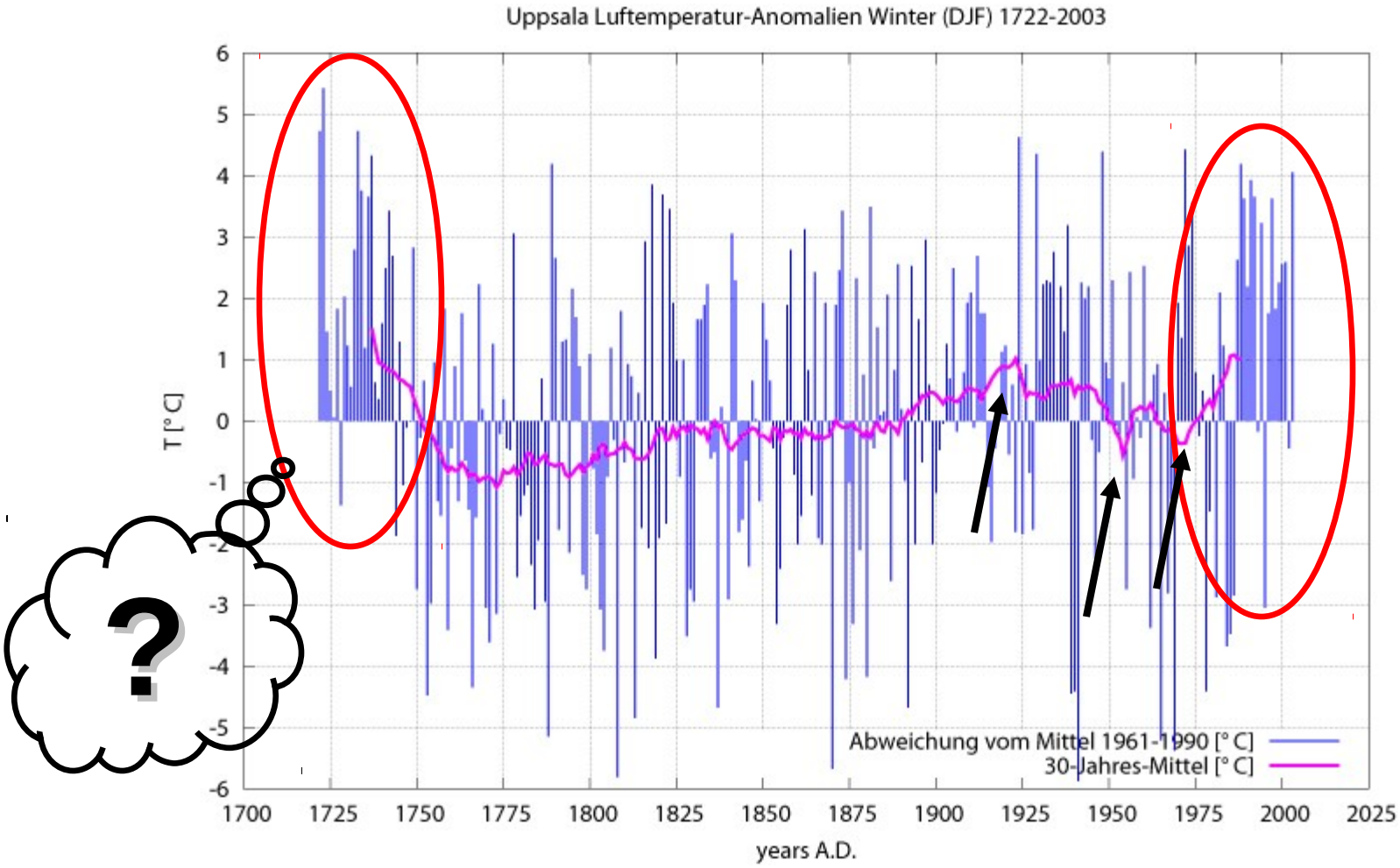
OETZI-Simulations

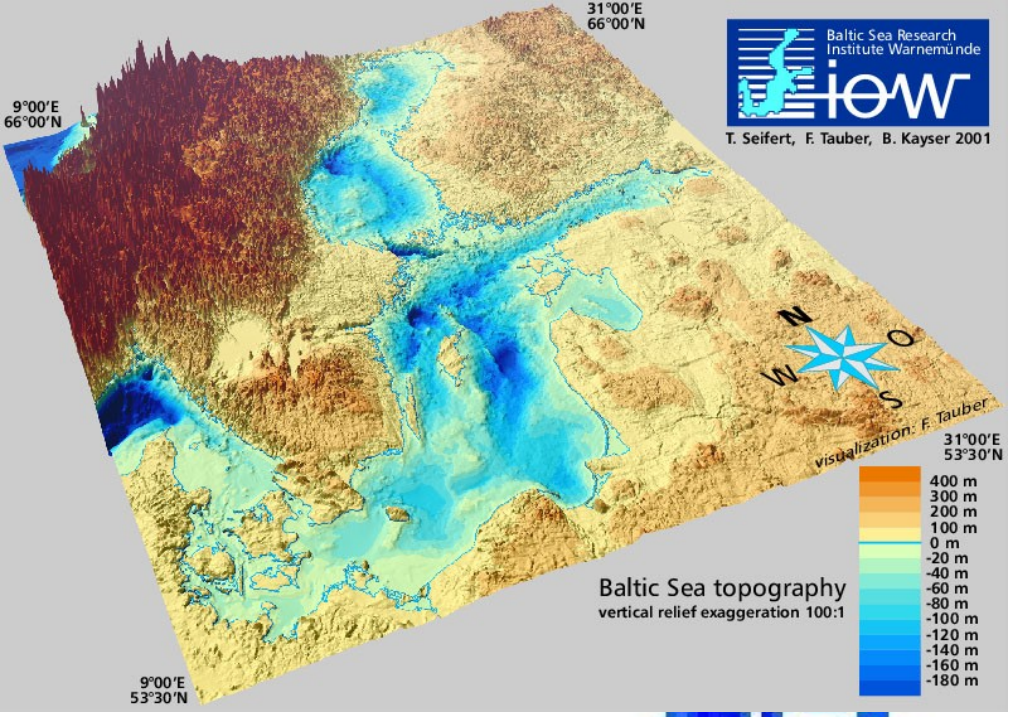


Uppsala Temperatur



Uppsala T2M-Anomalies





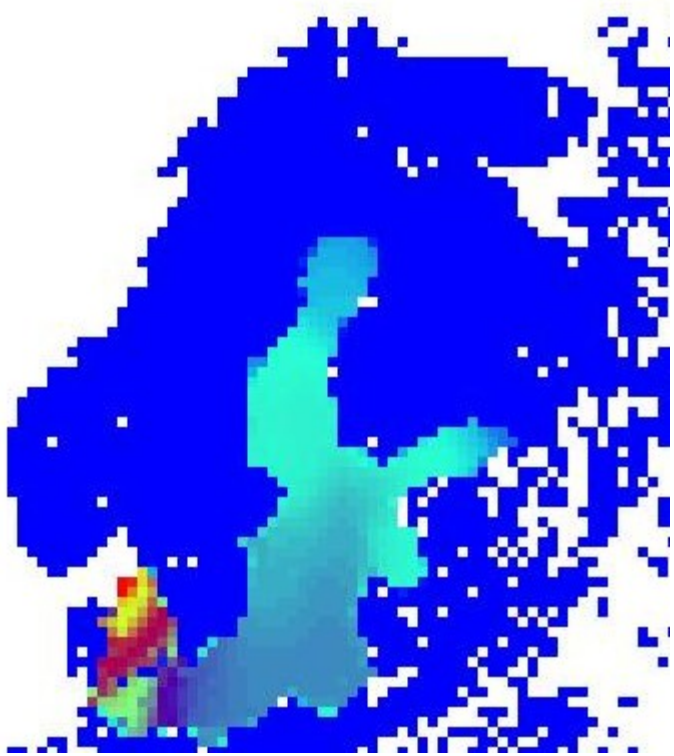
DEPTH_LK

Bathymetry: ~0.02° (2 km)
added to updated lake data base by E. Kourzeneva

FLake: limit 50 m

T. Seifert, F. Tauber, B. Kayser: 2001: "A high resolution spherical grid topography of the Baltic Sea – 2nd edition", Baltic Sea Science Congress, Stockholm 25-29. November 2001, Poster #147

Sea-Surface-Salinity



MERSEA Baltic Sea - North Sea S/T climatology[1]

Salinity in PSU [g/kg], *5 m as interfacial salinity*

horizontal resolution: 0.2° x 0.1°

[vertical resolution: z_min: 5.0, z_max: 750.0

vertical levels: 18, monthly climatology]

***Ocean Database 2001* (WOD01), NOAA**

global SSS with 1° x 1°, [24 vertical levels, mons.]

SSS [kg/kg]

[1] ***Janssen et al. (1999): A climatological data set for temperature and salinity for the Baltic Sea and the North Sea. Deutsche Hydrographische Zeitschrift, Supplement 9.***

New 2D-Fields

Freezing point (Gill 1982):

$$T_f(S) = -A + B \cdot S^{3/2} - C \cdot S^2$$

T of max. density (Neumann & Pierson 1966):

$$T_{\rho_{\max}}(S) = 273.09 - A \cdot S - B \cdot S^2$$

New 2D-Fields

The One Atmosphere International Equation of State for Seawater, UNESCO 1980

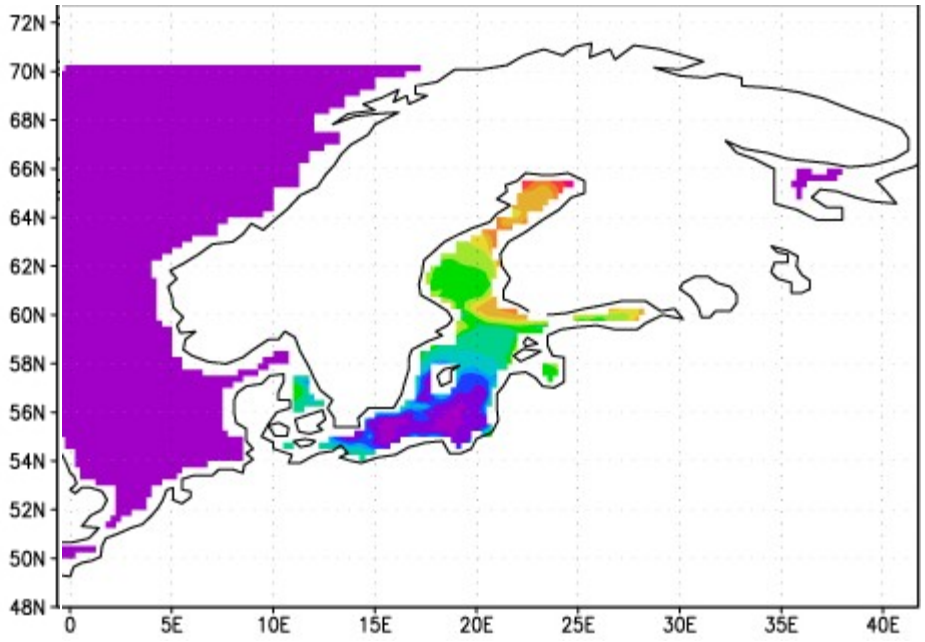
Max. density:

$$\rho(S, T_{\rho_{\max}}, 0) = \rho_w - A(T_{\rho_{\max}}) \cdot S + B(T_{\rho_{\max}}) \cdot S^{3/2} + C \cdot S^2$$

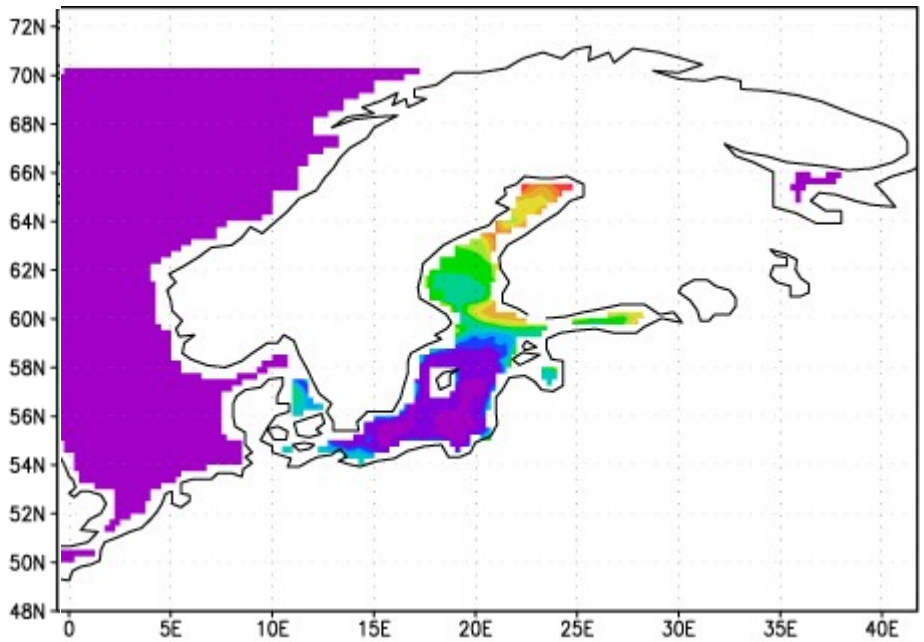
Density of Standard Mean Ocean Water (SMOW):

$$\rho_w(T_{\rho_{\max}}) = 999.842 + POLYN5(T_{\rho_{\max}})$$

Spatial ice-cover (max.)



Bflake (fresh water)



bs7psu (salt water)

Severe ice winter 1985/86 (max. 1986-03-10)

Ice winters from SMHI OBS