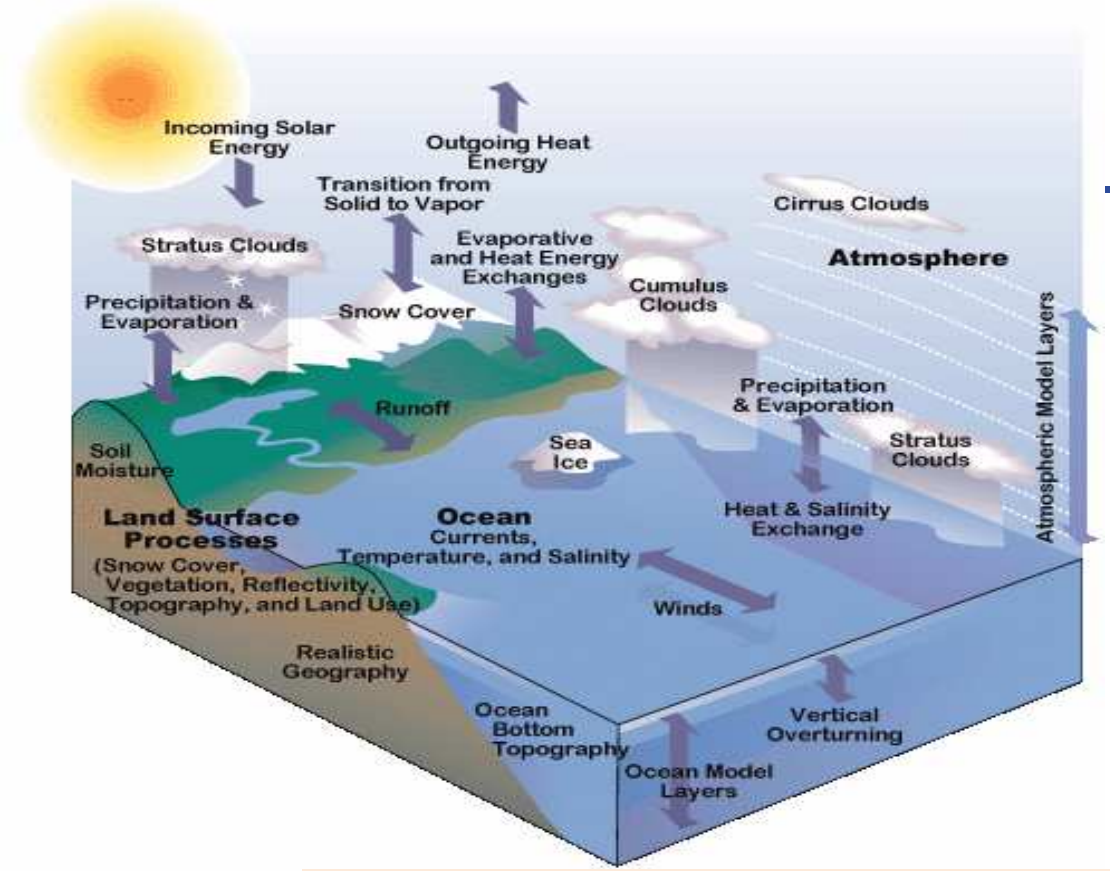

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Regional decadal prediction: adding value by coupling a regional ocean with a regional climate model?

Trang Van Pham[1]
Jennifer Brauch[1], Barbara Früh[1], Bodo Ahrens[2]
(1) Deutscher Wetterdienst
(2) Goethe University Frankfurt

COSMO User Seminar 08.03.2017

Content

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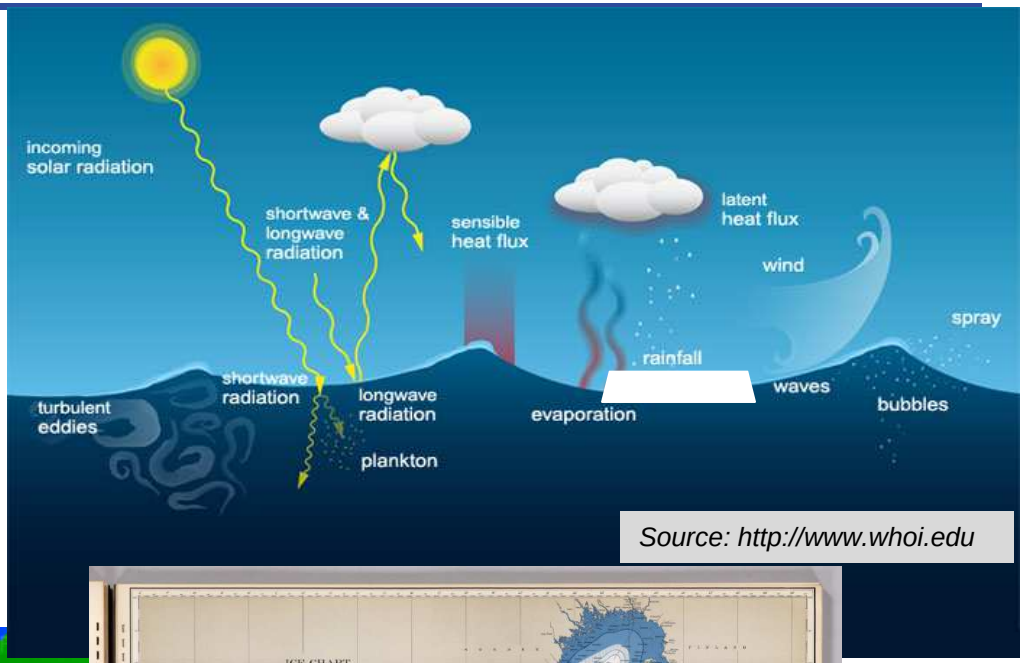
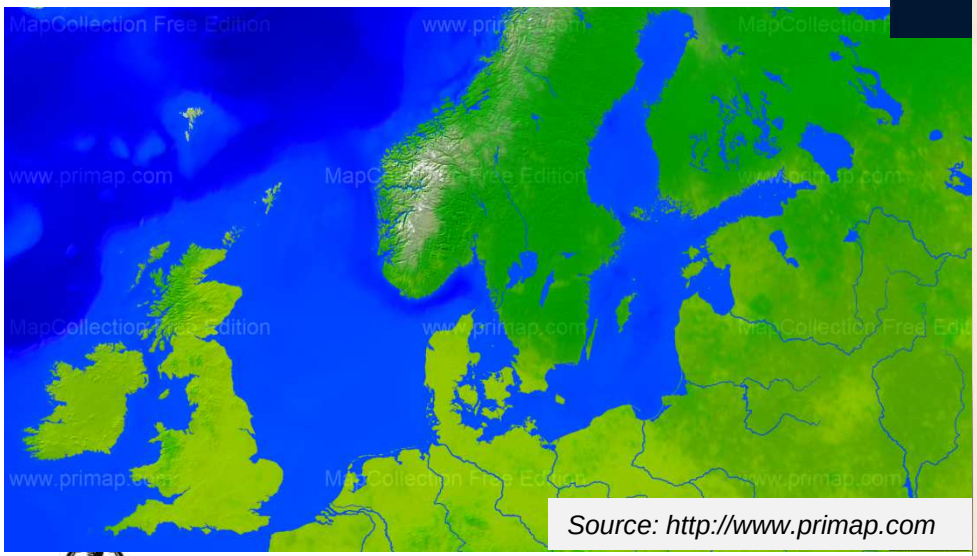
Motivation

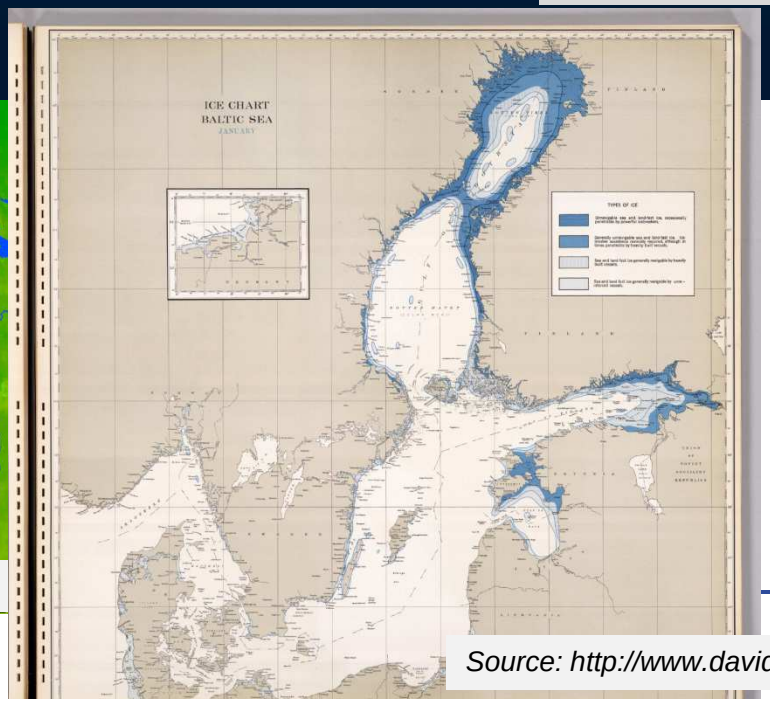
- Better understand the interaction of the climate components (atmosphere, ocean, ice)
- Baltic Sea with complex topography: not resolved by global model
- Ice in Baltic Sea: not well simulated by stand-alone atmospheric model COSMO-CLM



Source: http://www.whoi.edu



Source: http://www.primap.com



Source: http://www.davidrumsey.com

Motivation

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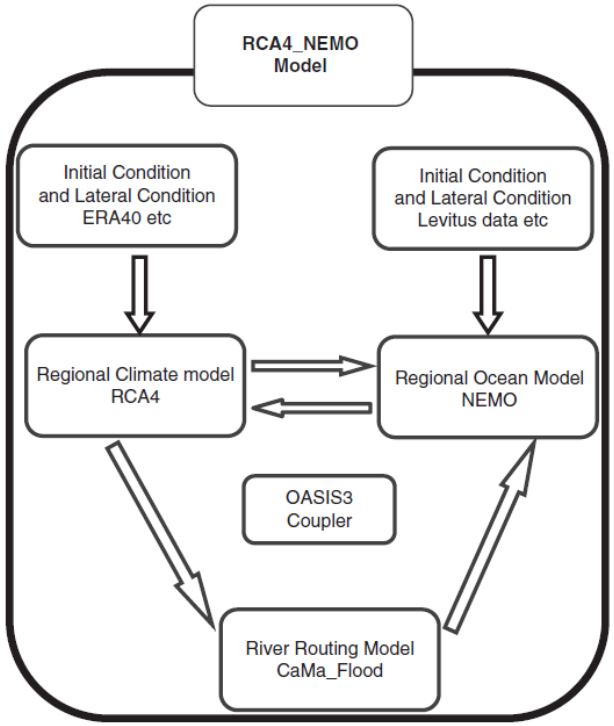
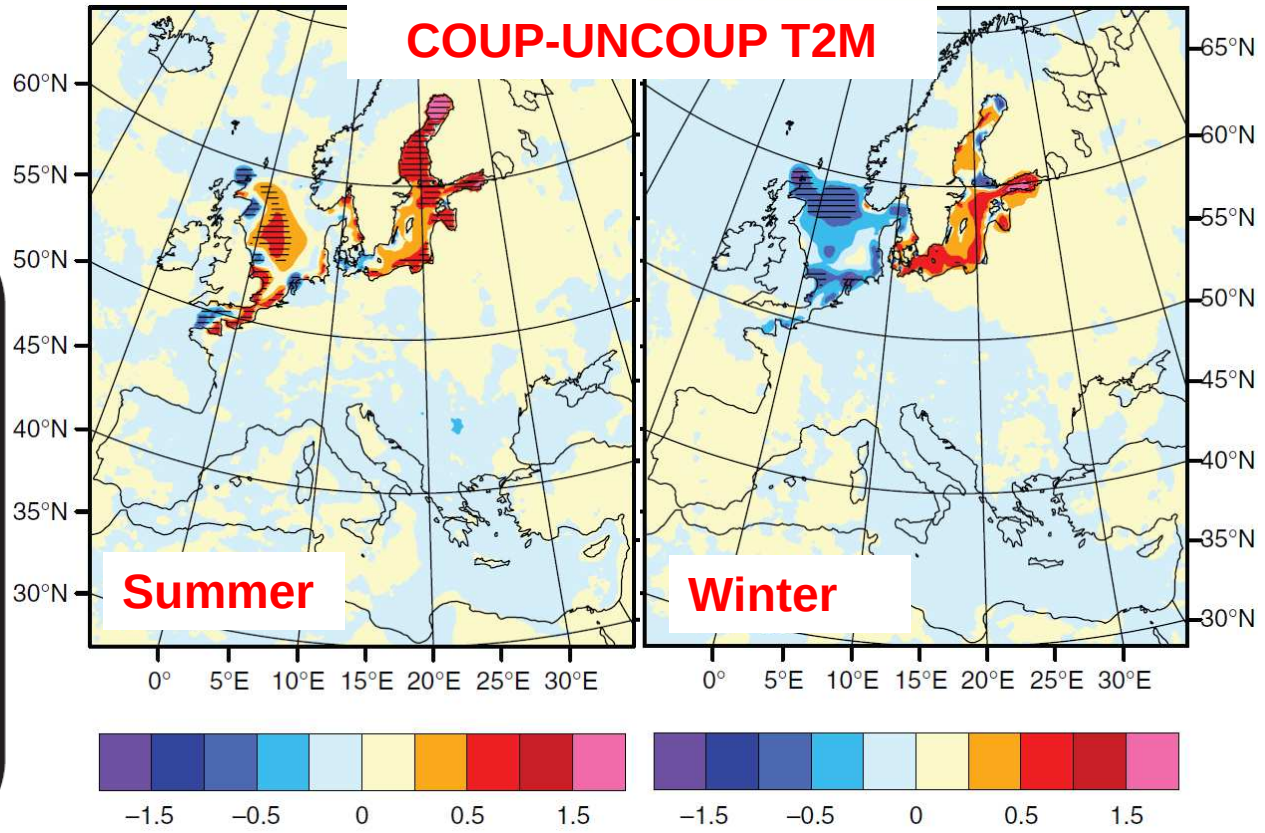
RCA4/NEMO/CaMa_Flood



COUP-UNCOUP T2M

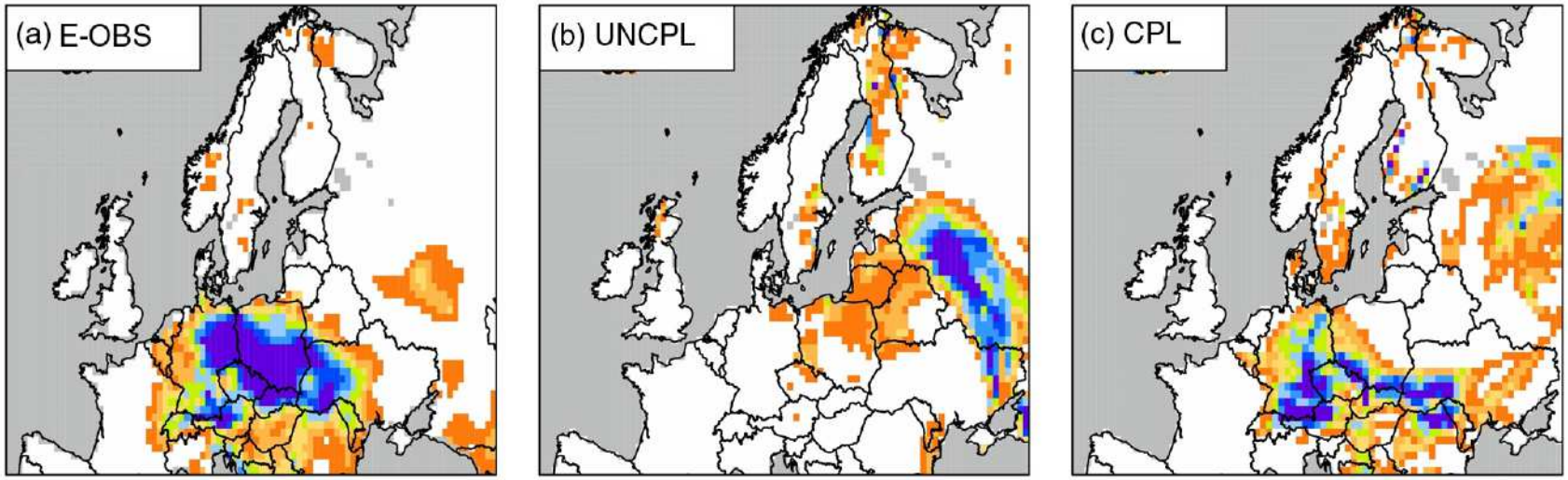


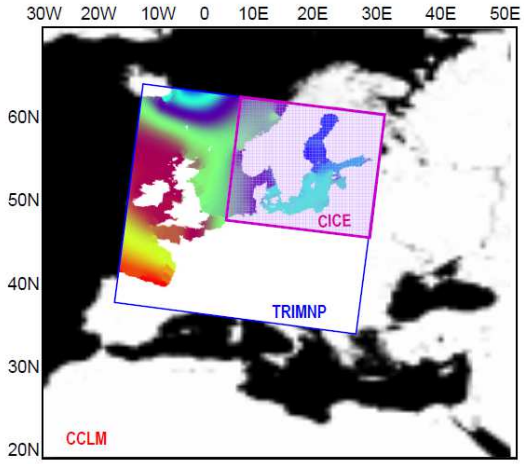
- ERA-Interim reanalysis data simulations
- Differences mainly over coupled area
- Over land: not significant

Quelle: Wang, S., Dieterich, C., Döscher, R., Höglund, A., Hordoir, R., Meier, H.M., Samuelsson, P. and Schimanke, S., 2015. Development and evaluation of a new regional coupled atmosphere-ocean model in the North Sea and Baltic Sea. Tellus A, 67.

Motivation

Oder Flood 1997 with COSTRICE (COSMO-CLM/TRIMP/CICE)





Averaged precipitation (mm/day) 18-20 July 1997

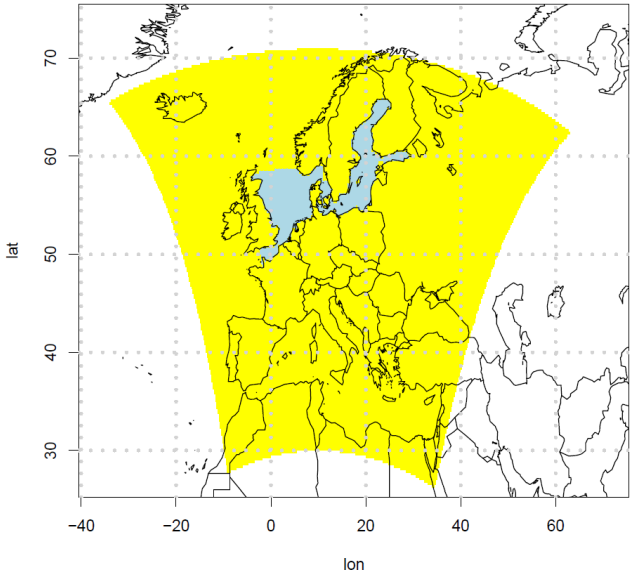
- Uncoupled model: precipitation maximum in wrong location
- Coupled model:
  - better precipitation pattern
  - Maximum in right location
  - Underestimation of rainfall amount

Quelle: Ho-Hagemann, H.T.M., Hagemann, S. and Rockel, B., 2015. On the role of soil moisture in the generation of heavy rainfall during the Oder flood event in July 1997. Tellus A, 67.

Coupled system COSMO-CLM/NEMO

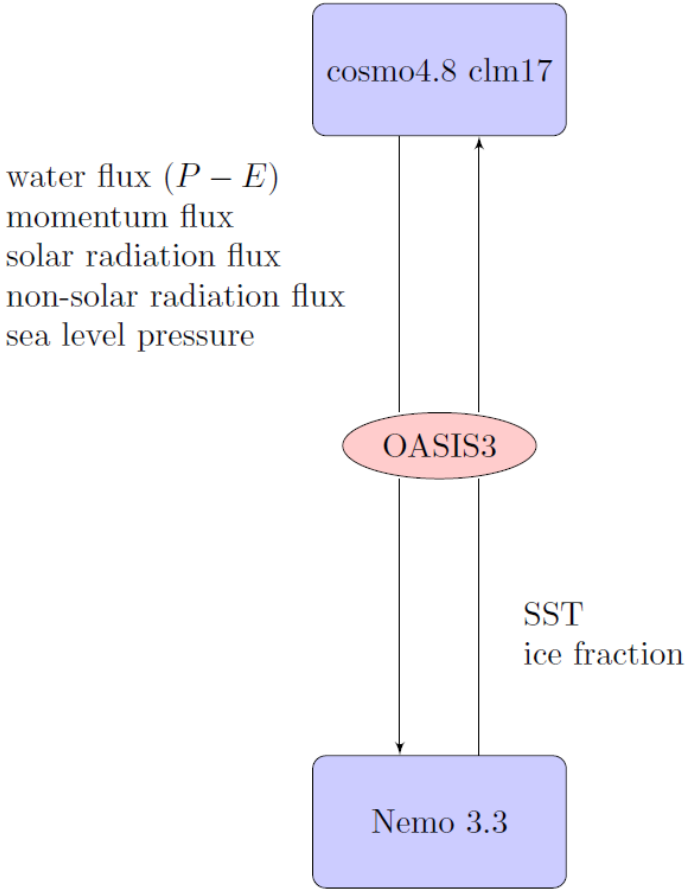
COSMO-CLM

- Domains: Euro-CORDEX or COSMO-EU
- Resolutions: 25km or 50km
- Lower boundary condition: reanalysis or global model

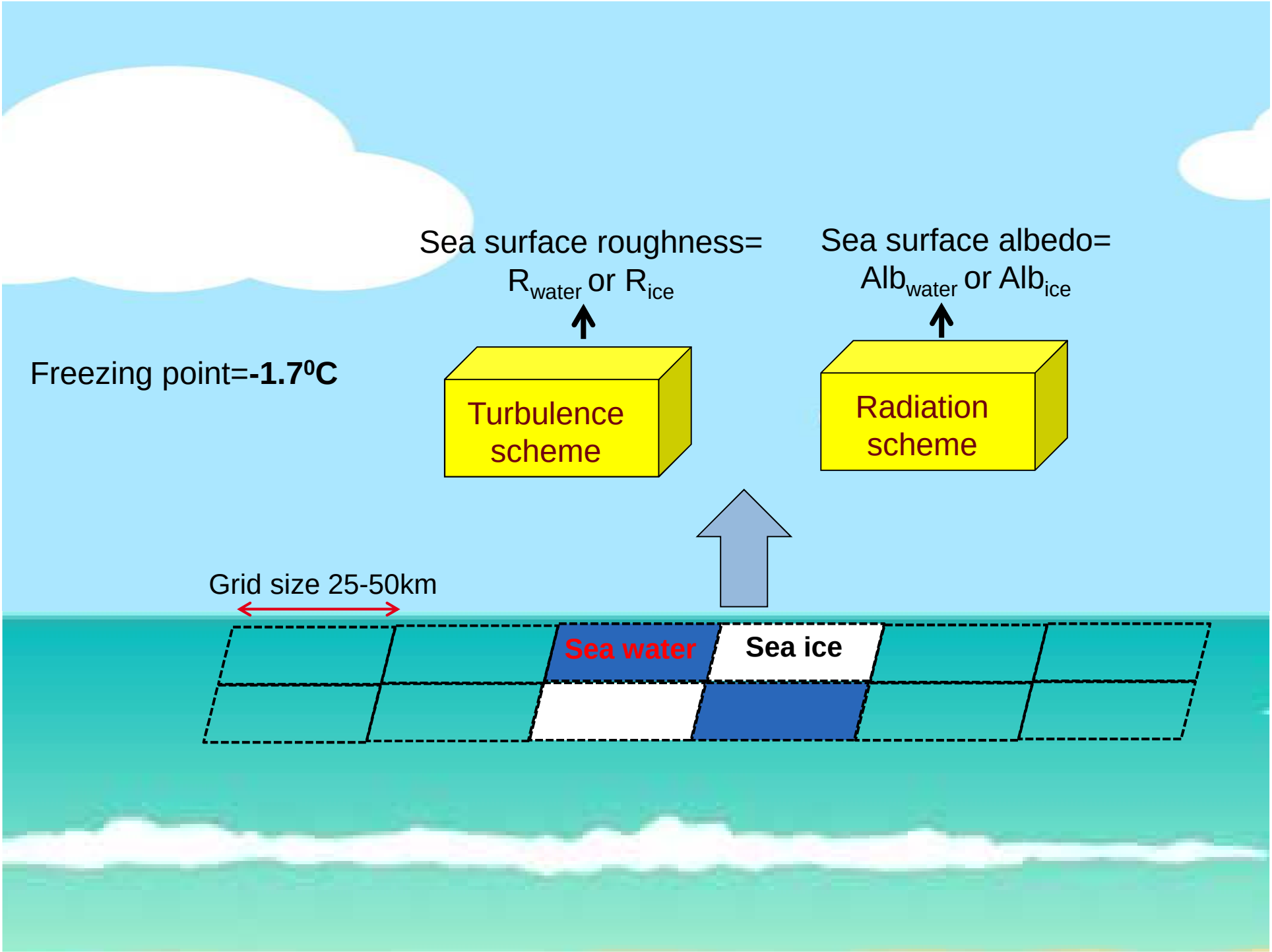


NEMO-NORDIC

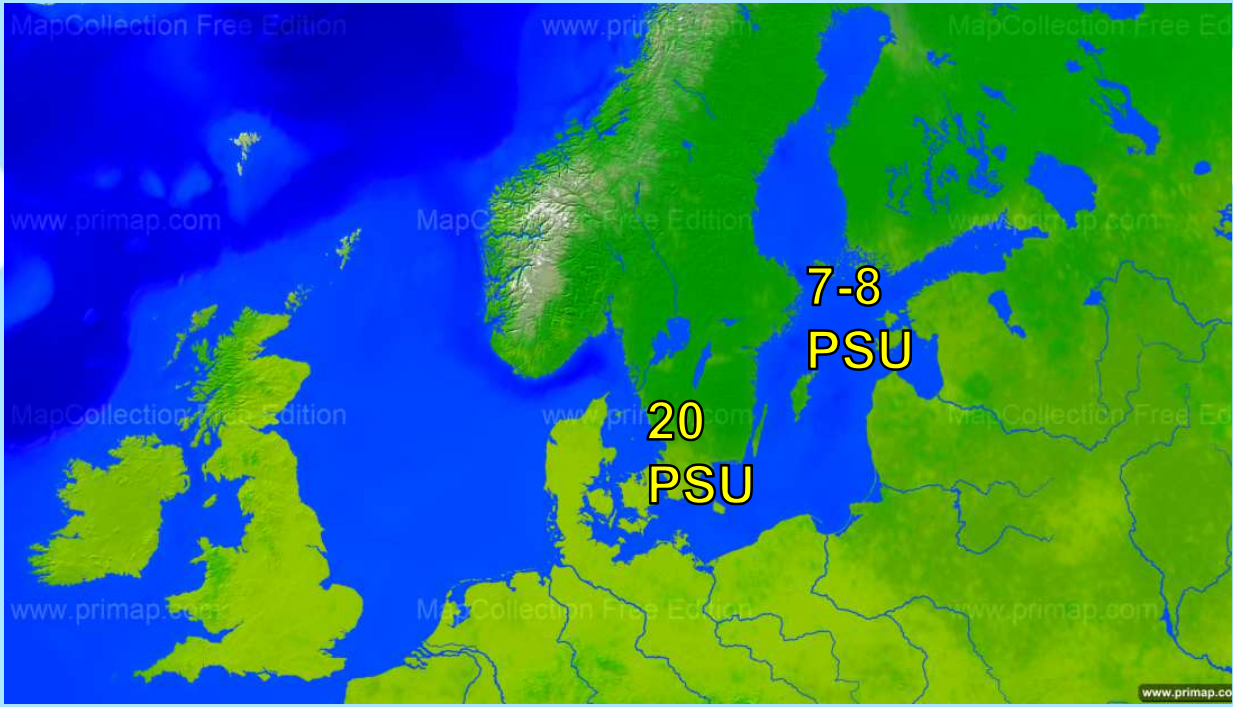
- Adapted from SMHI setups
- Ice model LIM3



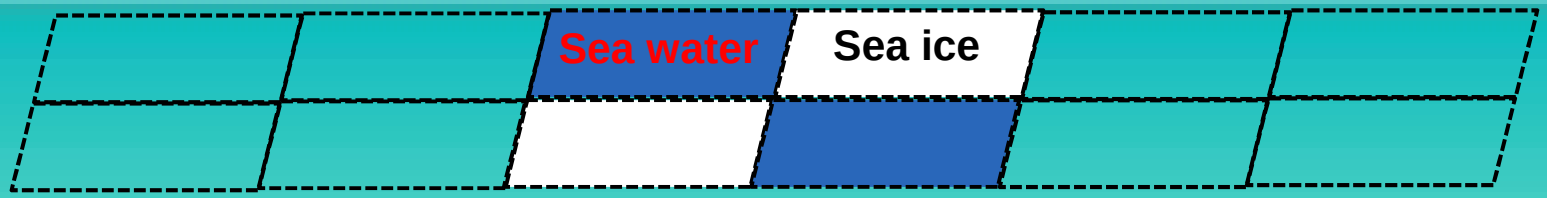
COSMO/CLM-NEMO System

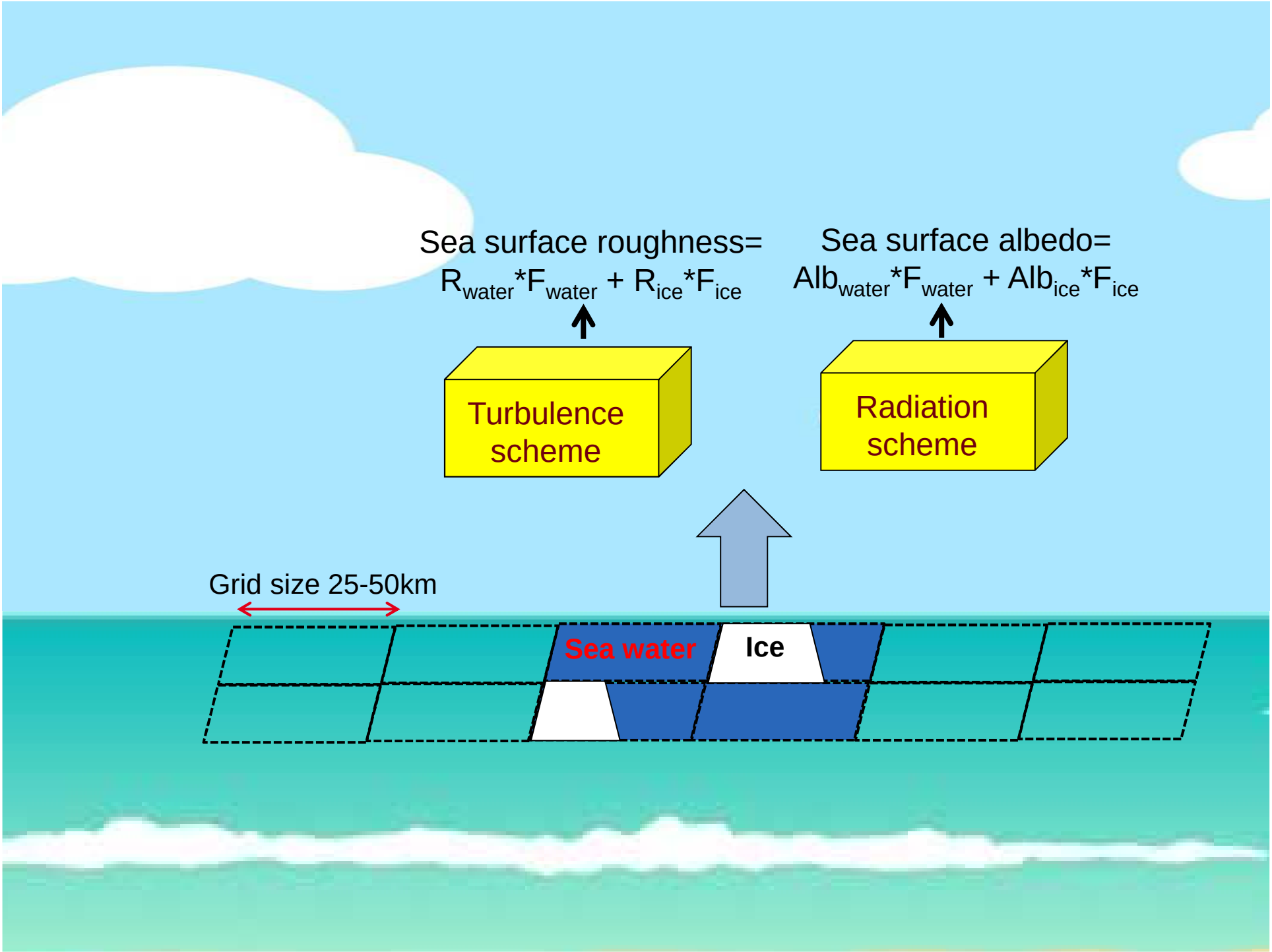

Sea surface roughness=
R_{water} or R_{ice}
Sea surface albedo=
Alb_{water} or Alb_{ice}
Freezing point=**-1.7⁰C**
Turbulence scheme
Radiation scheme
Grid size 25-50km
Sea water
Sea ice

Freezing point =**-1.7^{0}C**
However:
Baltic Sea: brackish water



Grid size 25-50km

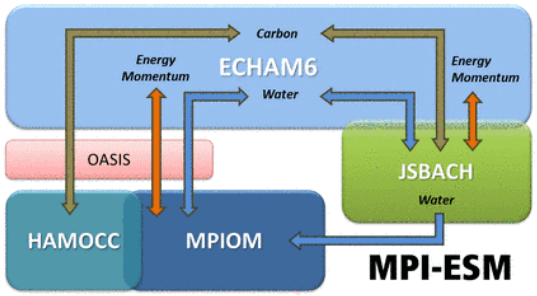



Sea surface roughness=
$R_{water}*F_{water} + R_{ice}*F_{ice}$
Sea surface albedo=
$Alb_{water}*F_{water} + Alb_{ice}*F_{ice}$
Turbulence scheme
Radiation scheme
Grid size 25-50km
Sea water
Ice

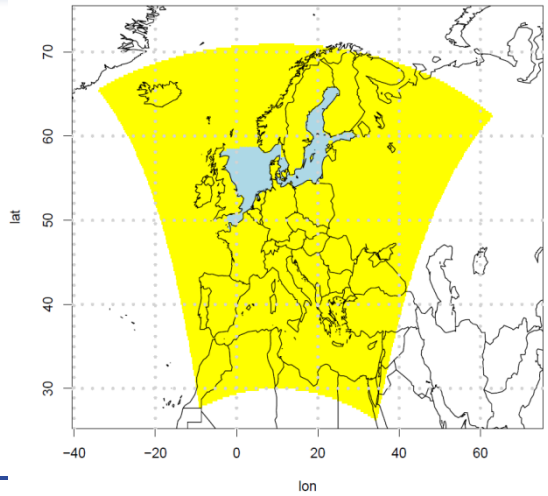
Experiment setups

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Time	Experiments	Lateral and lower boundary conditions	Lower boundary conditions over North and Baltic Seas
1960s-2000s	COSMO-CLM	MPI-ESM-LR baseline 1 Realisation 1	MPI-ESM-LR
1960s-2000s	COSMO-CLM/NEMO	MPI-ESM-LR baseline 1 Realisation 1	NEMO-Nordic

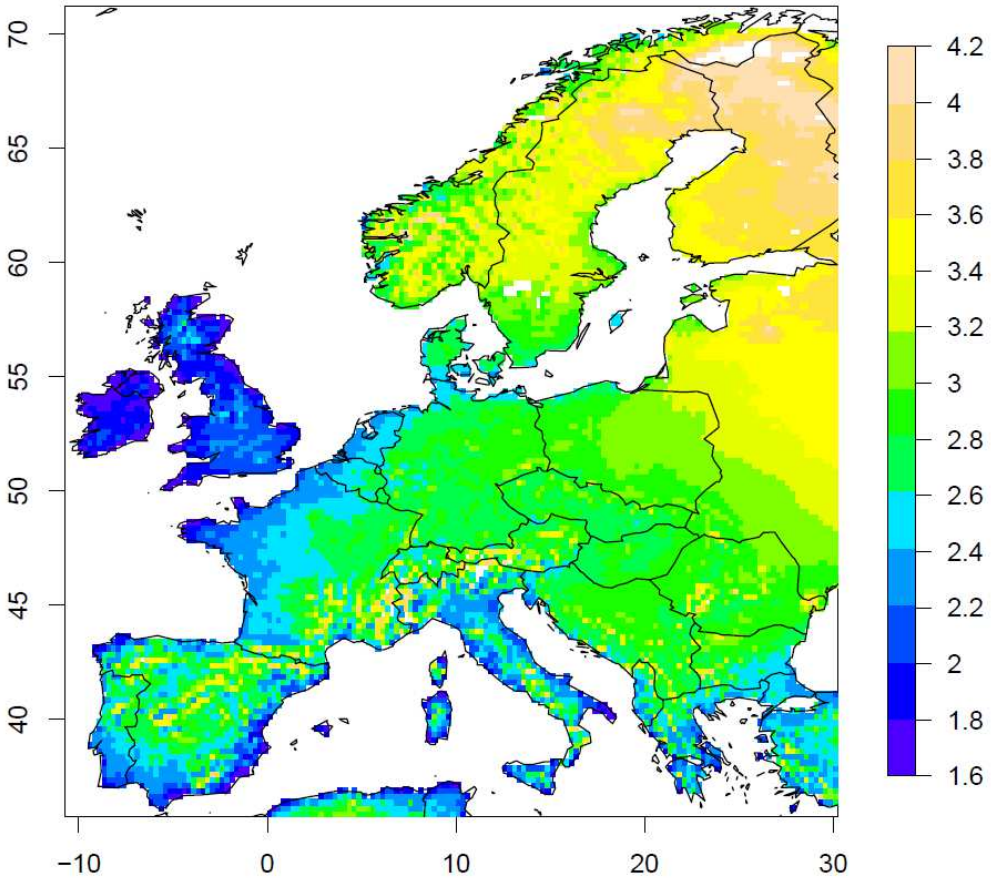


- ➔ Domain: COSMO-EU
- ➔ Resolution: 25 km
- ➔ NEMO boundary conditions: climatology



CCLM/NEMO vs. E-OBS

CCLM/NEMO vs. E-OBS
RMSE 2mT
1961-2010



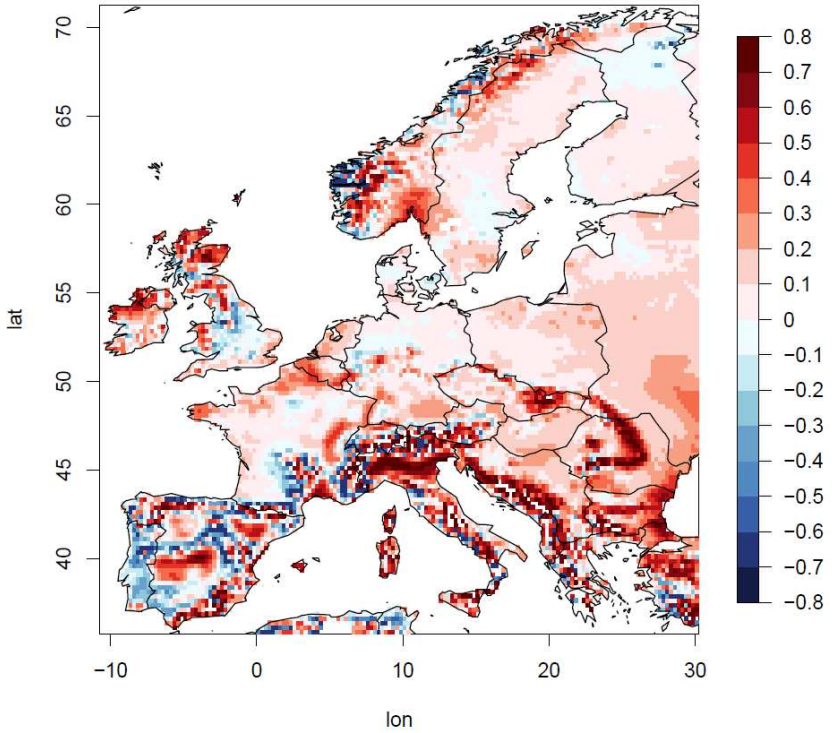
- Biases are generally lower than 3K over Europe
- Biases get larger towards the north-east of the domain
- CCLM has similar patterns and magnitude of biases

CCLM/NEMO vs. MPI-ESM-LR

$$MSESS = 1 - \frac{MSE_I}{MSE_R}$$

- positive scores: coupled model has better predictive skill
- central EU: ca. 20% added skill
- Higher scores over mountainous area (higher resolution -> better topography presentation)
- Questions:

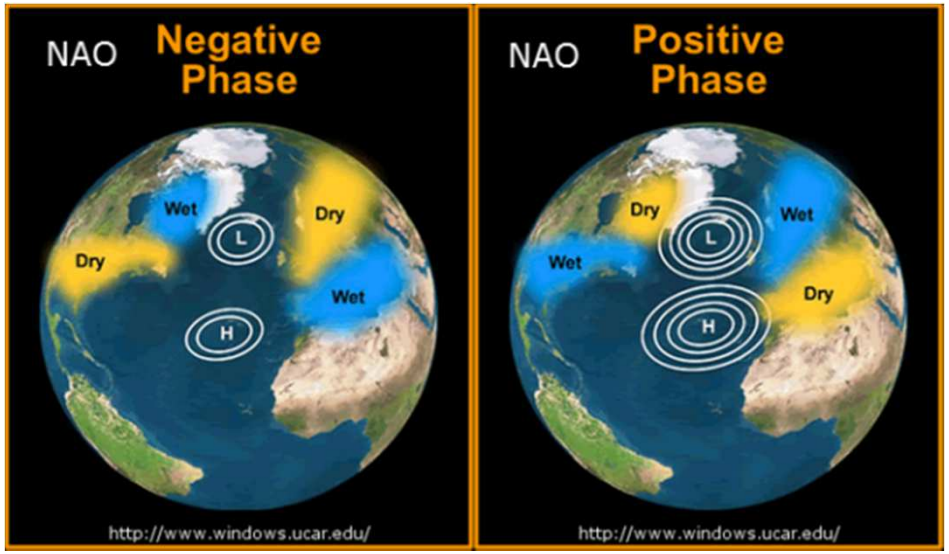
  When the coupled model give added values compared with uncoupled?



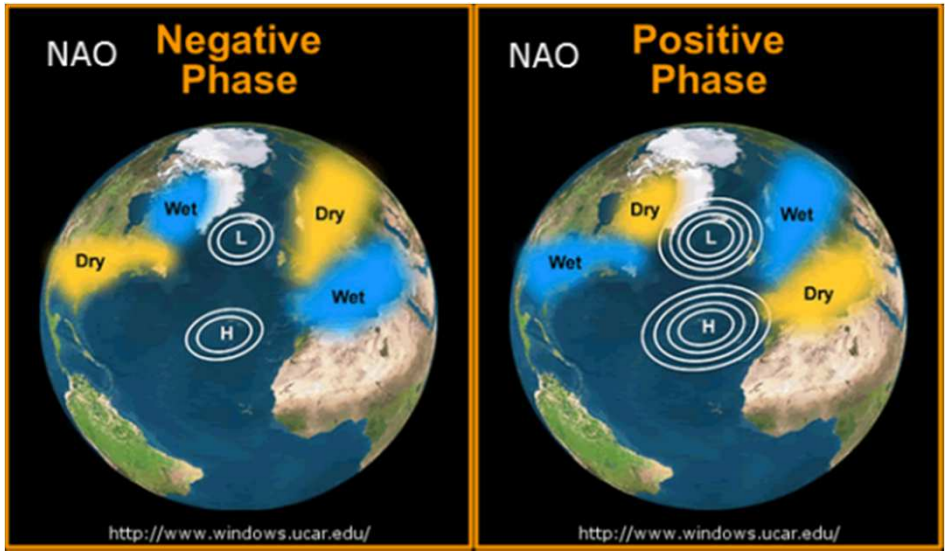
MSESS monthly 2mT
CCLM/NEMO vs. MPI-ESM-LR
relative to E-OBS
1961-2010

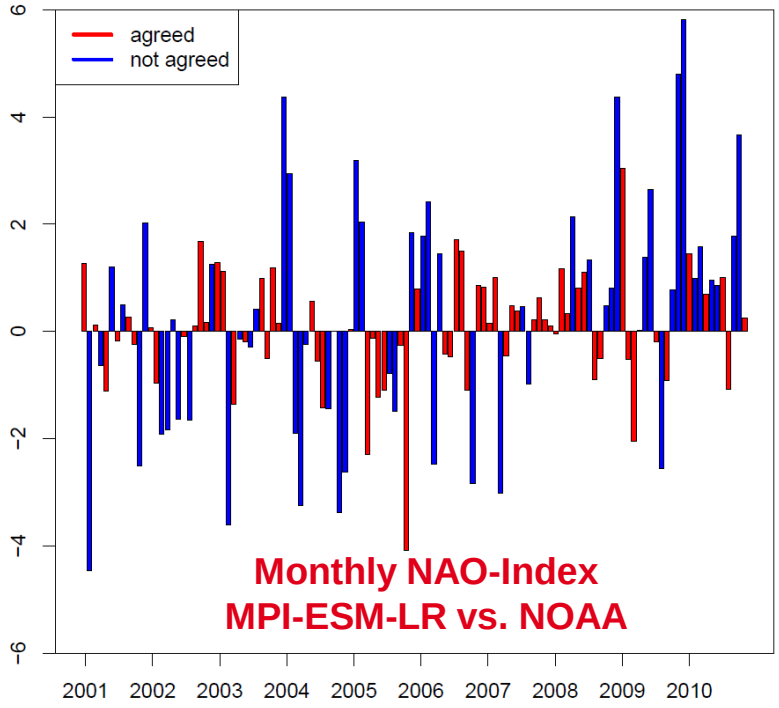
North Atlantic Oscillation (NAO)

- Positive phase: strong influence of NAO over Europe
- Negative phase: weaker influence from NAO -> stronger local impact of North and Baltic Seas

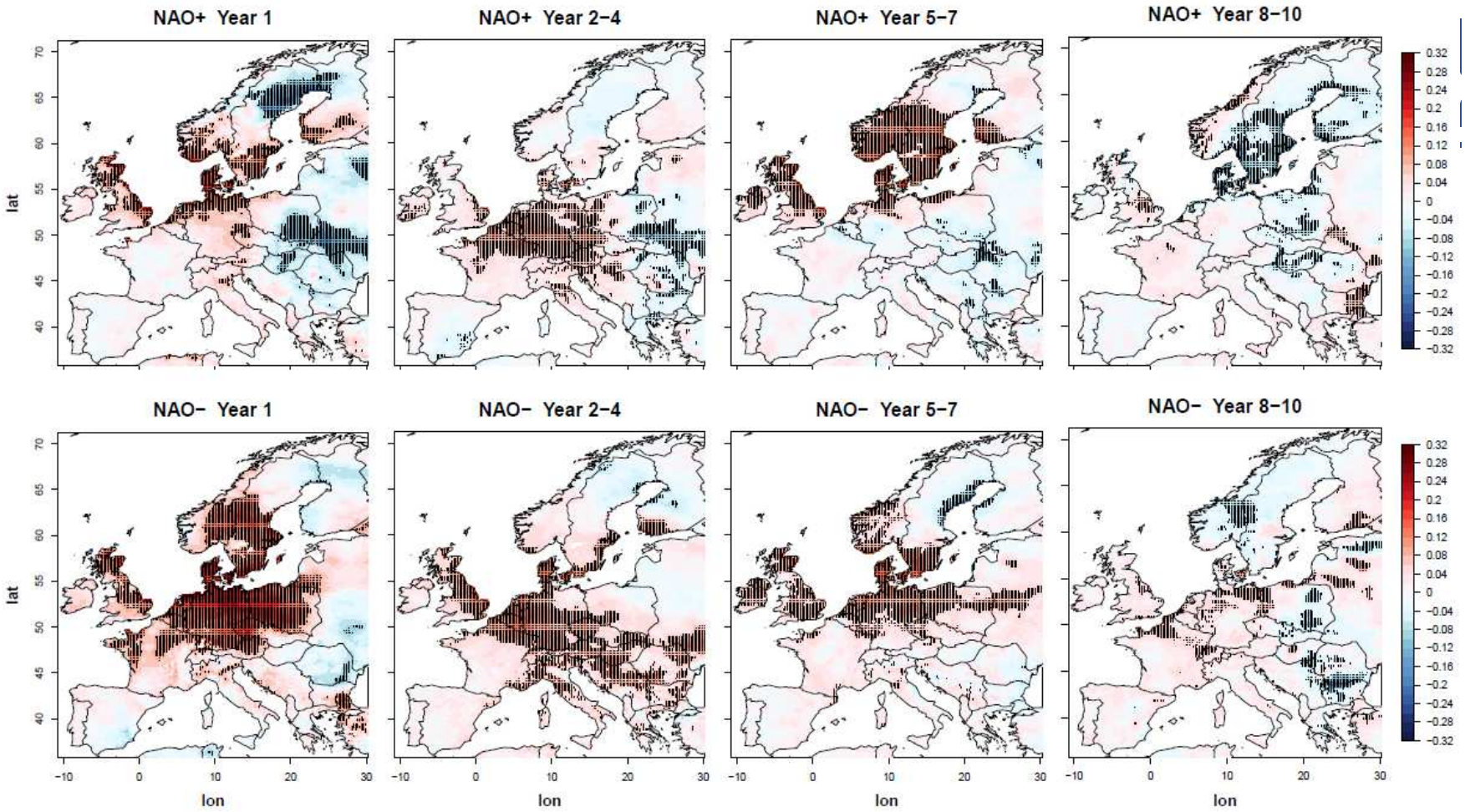


North Atlantic Oscillation (NAO)





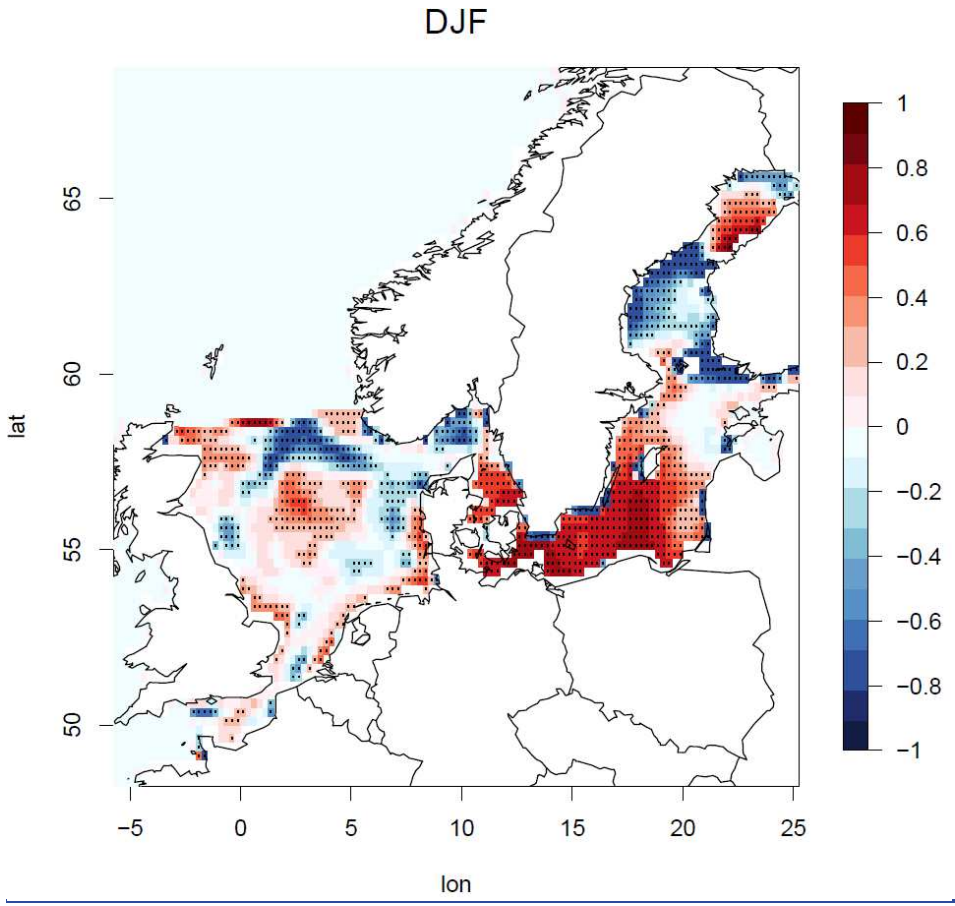
- NAO index calculation: from MPI-ESM SLP
- Compared with NOAA data
- Only when same phase (red): the monthly data were taken into account



MSESS monthly 2mT
CCLM/NEMO vs. CCLM relative to E-OBS (1961-2010)

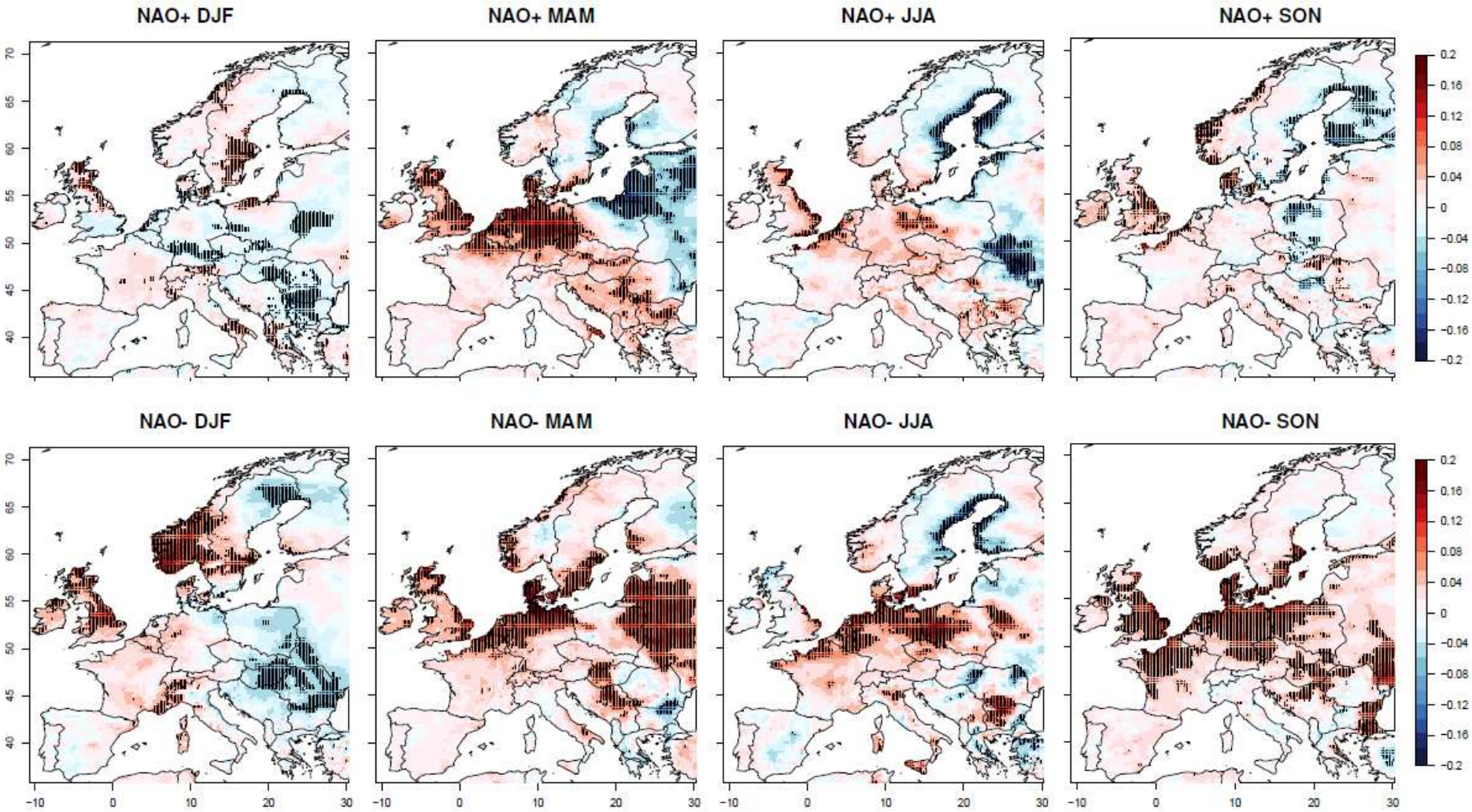
- NAO-: MSESS is higher -> better forecast quality from coupled model
- Coupled model: more than 30% added skills to lead year 7
- MSESS reduces with time -> one possible source of added skills: initialization of ocean model

MSESS SST Winter 1981-2010 CCLM/NEMO vs. CCLM relative to OISST



- Short evaluation period due to data availability
- Winter: highest skillscores of SSTs
- Largest correlation between winter SSTs and spring 2mT

	Correlation coefficient
Winter SST - Winter T_2M	0,37
Winter SST – Spring T_2M	0,63
Winter SST – Summer T_2M	0,17



- Winter: strong activity of NAO -> MSESS smaller
- MSESS high in spring: delay in response of the atmosphere to the changes in the sea.

MSESS monthly 2mT
In four seasons
CCLM/NEMO vs. CCLM relative to E-OBS (1961-2010)

Conclusion

- CCLM/NEMO simulated good climatology of 2mT compared with EOBS
- CCLM/NEMO had added forecast skills compared with CCLM and MPI-ESM-LR
- When NAO is weak, the added values are higher
- When NAO is strong, the coupling effect is less obvious
- Two possible sources of added skills:
  - Better SST simulation from ocean model
  - Better initialization
- ***In preparation:*** ***Pham, T. V., Brauch, J., Früh, B. and Ahrens, B., 2017.*** Added values of using coupled model COSMO-CLM/NEMO in decadal hindcasts.

Job opening at DWD

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Offenbach, begins 01.07.2017, 2 years
- Evaluating the ocean simulation with the regional ocean model operated by DWD, NEMO_NORDIC for the North and Baltic Seas
- Evaluating the regional coupled model COSMO-CLM/NEMO-NORDIC operated by DWD for climatological period
- Supporting the BSH (Bundesamts für Seeschifffahrt und Hydrographie: Federal Maritime and Hydrographic Agency) in the coupling of the regional ocean model via OASIS coupler
- https://www.bav.bund.de/SharedDocs/Stellenangebote/DE/DWD/20170314_0002_DWD.html

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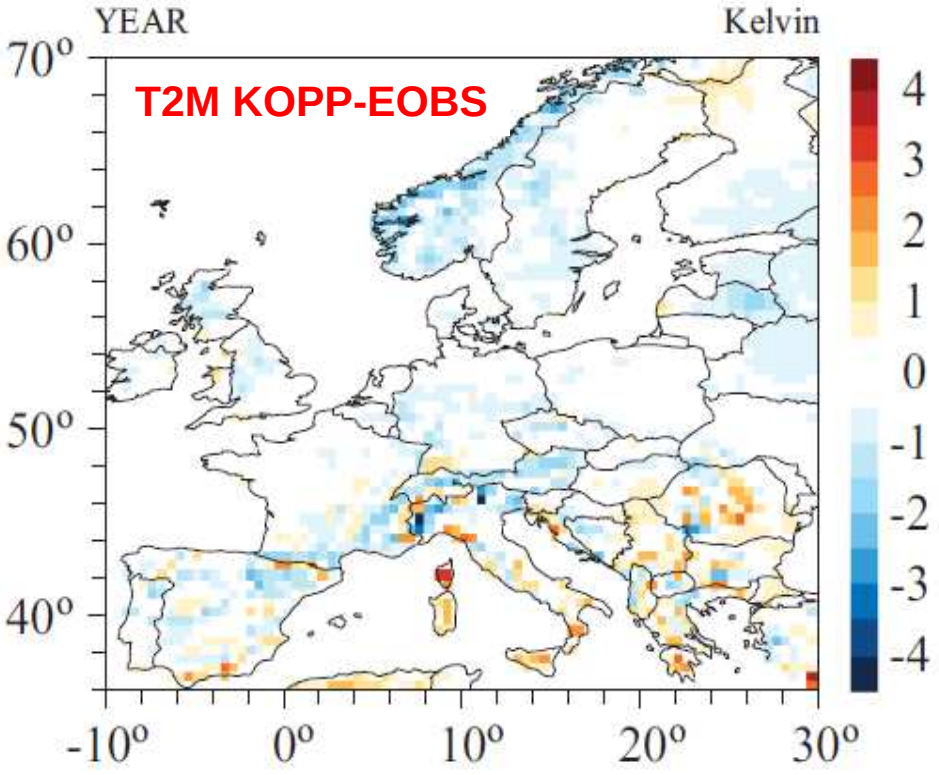
Thanks for your attention!



COSMO-CLM/NEMO angetrieben von ERA-Interim

Jahresmittelwert verglichen mit E-OBS 1985-1994:

- kleine Abweichungen (<+/-1 K)
- kleinere Abweichungen nah von dem gekoppelten Gebiet
- größere Abweichungen im Süd-Europa

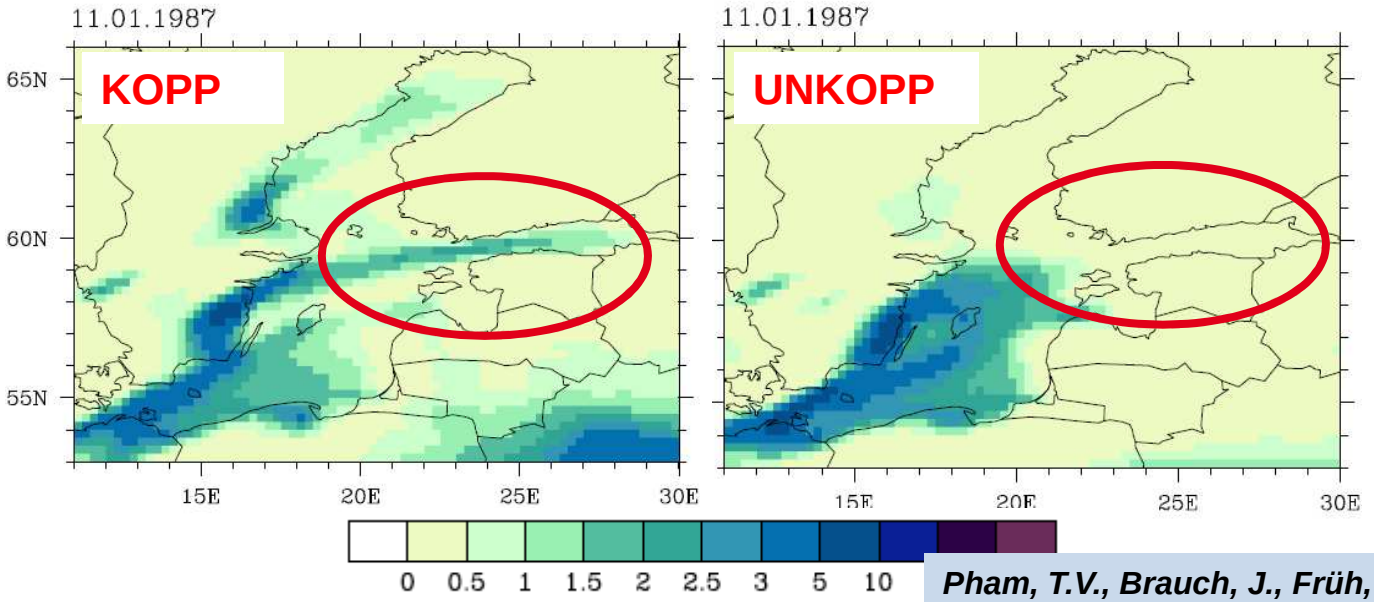
Pham, T. V., Brauch, J., Dieterich, C., Frueh, B. and Ahrens, B., 2014. New coupled atmosphere-ocean-ice system COSMO-CLM/NEMO: assessing air temperature sensitivity over the North and Baltic Seas. Oceanologia, 56(2), pp.167-189.

Extreme Schneebandreignisse

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Dates	Location	Reference	Start time for coupled model spin-up
03–07.01.1985	Gulf of Finland to Kalmar, Sweden	Andersson and Nilsson (1990)	01.01.1984
23.12.1986	Gulf of Finland	Andersson and Nilsson (1990)	01.01.1986
11.01.1987	Gulf of Finland	Andersson and Gustafsson (1994); Gustafsson et al. (1998)	01.01.1986
04–07.12.1998	Gulf of Bothnia to Gävle, Sweden	Vihma and Brümmer (2002); Savijärvi (2012)	01.01.1998
17–18.01.2006	Gulf of Finland	Savijärvi (2012)	01.01.2005
30.11.2010	Coast of Germany	Witterungsreport Express, Deutscher Wetterdienst (11.2010)	01.01.2010

Extremereignis Schneeband über Ostsee



ungekoppeltes Modell: kein Schneeband über dem Finnischen Meerbusen

Pham, T.V., Brauch, J., Früh, B. and Ahrens, B., 2016. Simulation of snowbands in the Baltic Sea area with the coupled atmosphere-ocean-ice model COSMO-CLM/NEMO. Meteorologische Zeitschrift.