Simulation of present and future climate variability over the Baltic Sea area with new SMHI atmosphere-ocean-ice model RCA4_NEMO

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Outline

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- Motivation
- Coupled model system descriptions
- Model evaluation
- Results from two climate change scenarios
- Summary

Motivation

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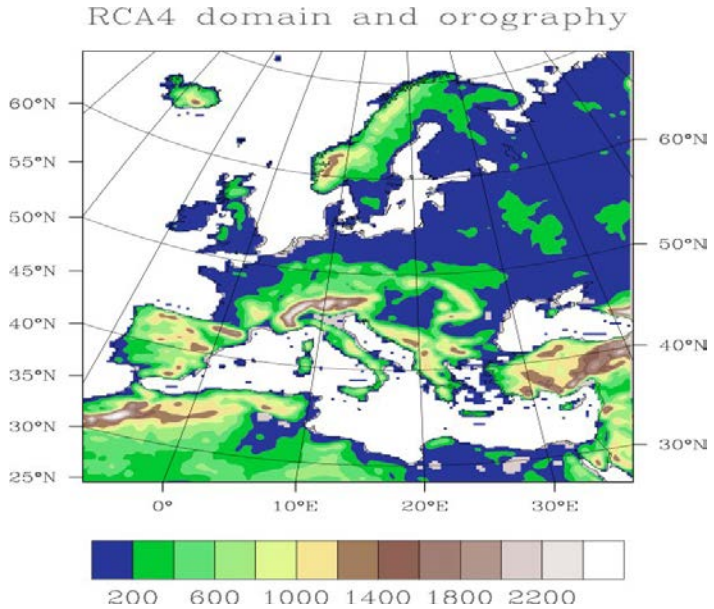
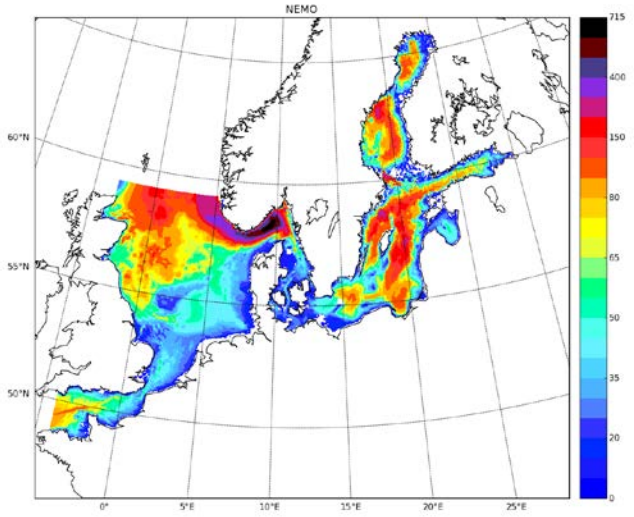
- North Sea provide salted water and oxygen for Baltic Sea, the exchange between North Sea and Baltic Sea cannot be neglected for long term climate change study

- The earth model system include different components, but it is still quite expensive to run global earth model system at high resolution (<50km), it is necessary to develop a regional earth model system for this purpose and to investigate the interaction between different components, particularly the air-sea interaction, as we know there is robust fresh water and heat fluxes between ocean and atmosphere.

Atmosphere Model RCA4 and Ocean model NEMO



- Rossby Centre regional climate model RCA4
- Europe domain
- Rotated grid
- 0.22 with 40 vertical levels



- North Sea-Baltic Sea model (4°W-30°E,48°N-59.5°N)
- NEMO 3.3.1 with LIM3
- $\Delta\lambda=\Delta\varphi=2'$, 56 levels
- Open boundaries in the English Channel and along 59.5°N
- Tides from tidal model from OSU (M2,S2,N2,K2,K1,O1,P1,Q1,M4,MS4,MN4)

CaMa Flood model

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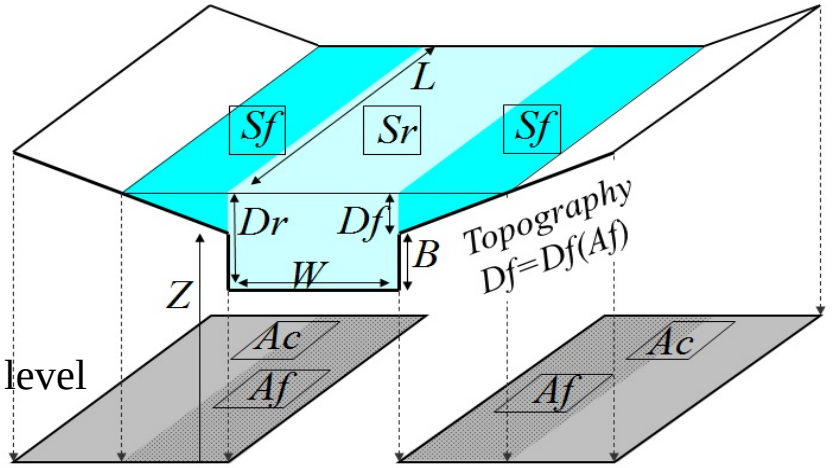
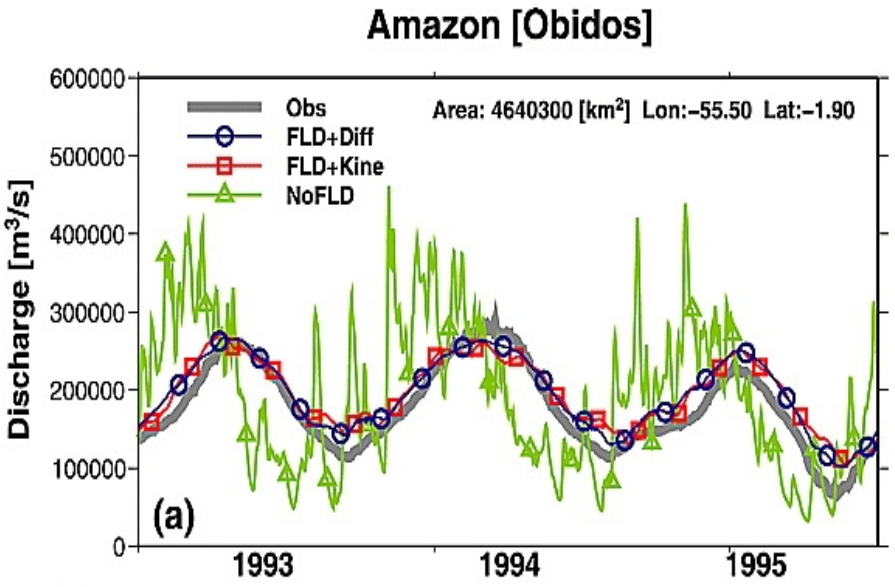
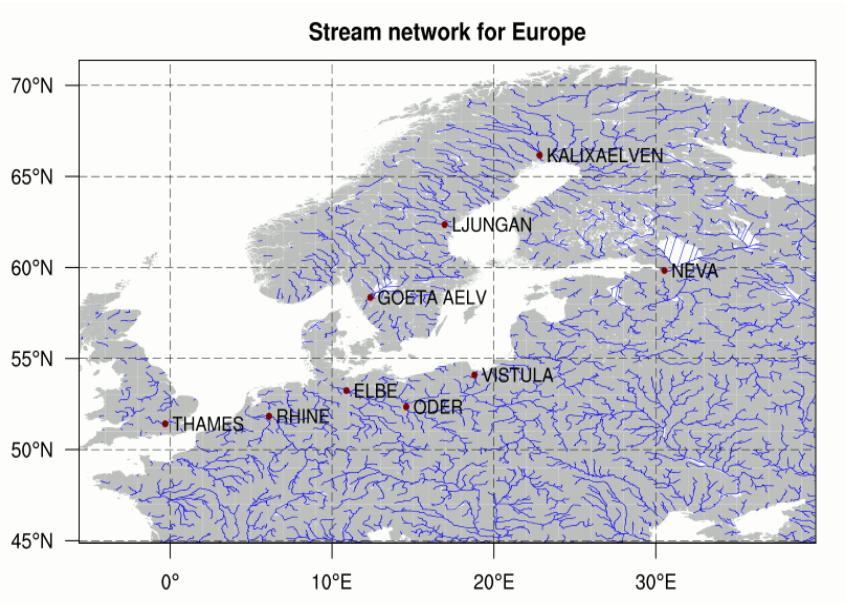


- Catchment based Macro-scale Floodplain model (**CaMa Flood**)
- Developed by Dai Yamazaki from University Tokyo
- Physically based description of floodplain inundation dynamics
- Realistically describe a relationship between water storage, water level and inundated area
- Resolution is flexible
- Channel width and bank height are based climatology



(Yamazaki, 2011)



Schematic Description of RCA4_NEMO Model

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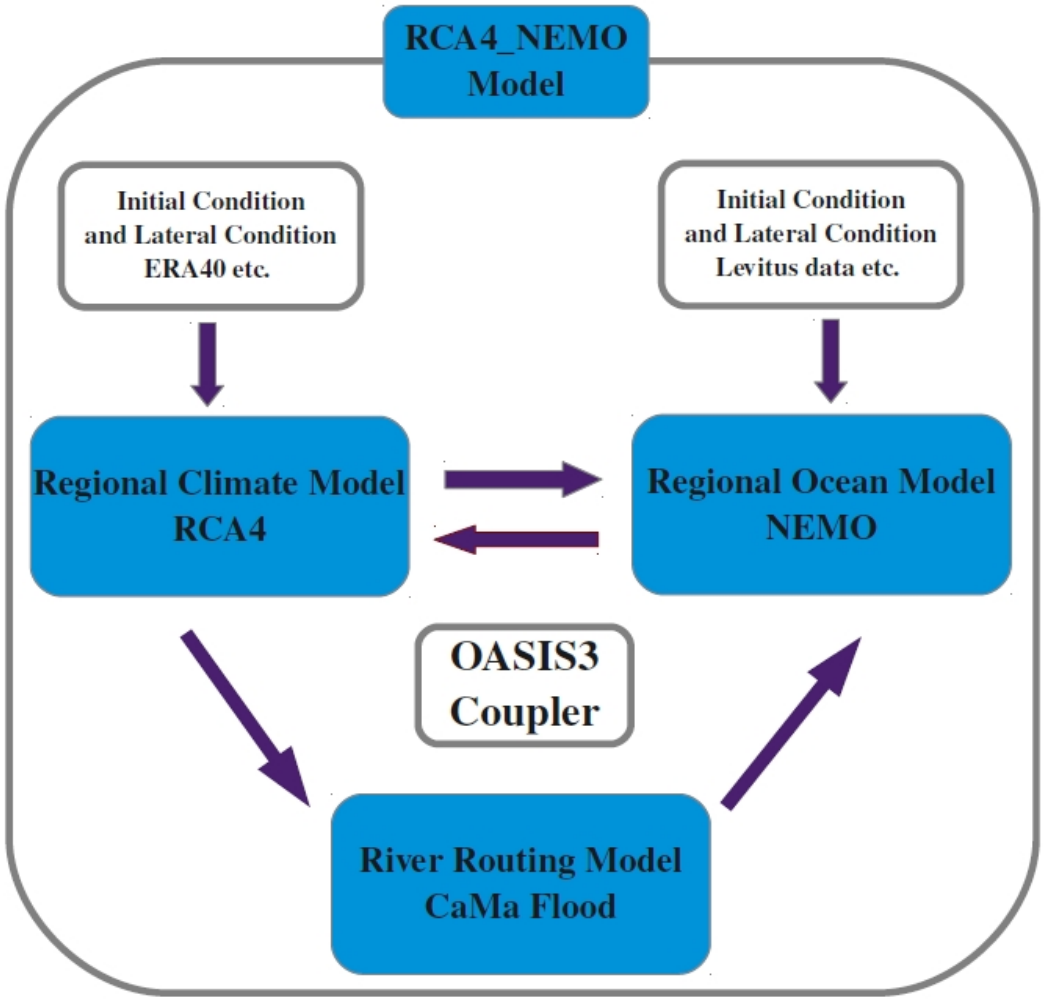

RCA4 ==> NEMO

Heat fluxes
Fresh water fluxes (E-P)
Momentum fluxes
No-solar heat flux derivative
Sea level pressure

RCA4 <== NEMO

SST
Sea ice temperature
Sea ice concentration
Albedo

Coupling Frequency:3h

RCA4 ==> CaMa Flood

Runoff

CaMa Flood ==> NEMO

River Discharge

Model Domain and Couple Region

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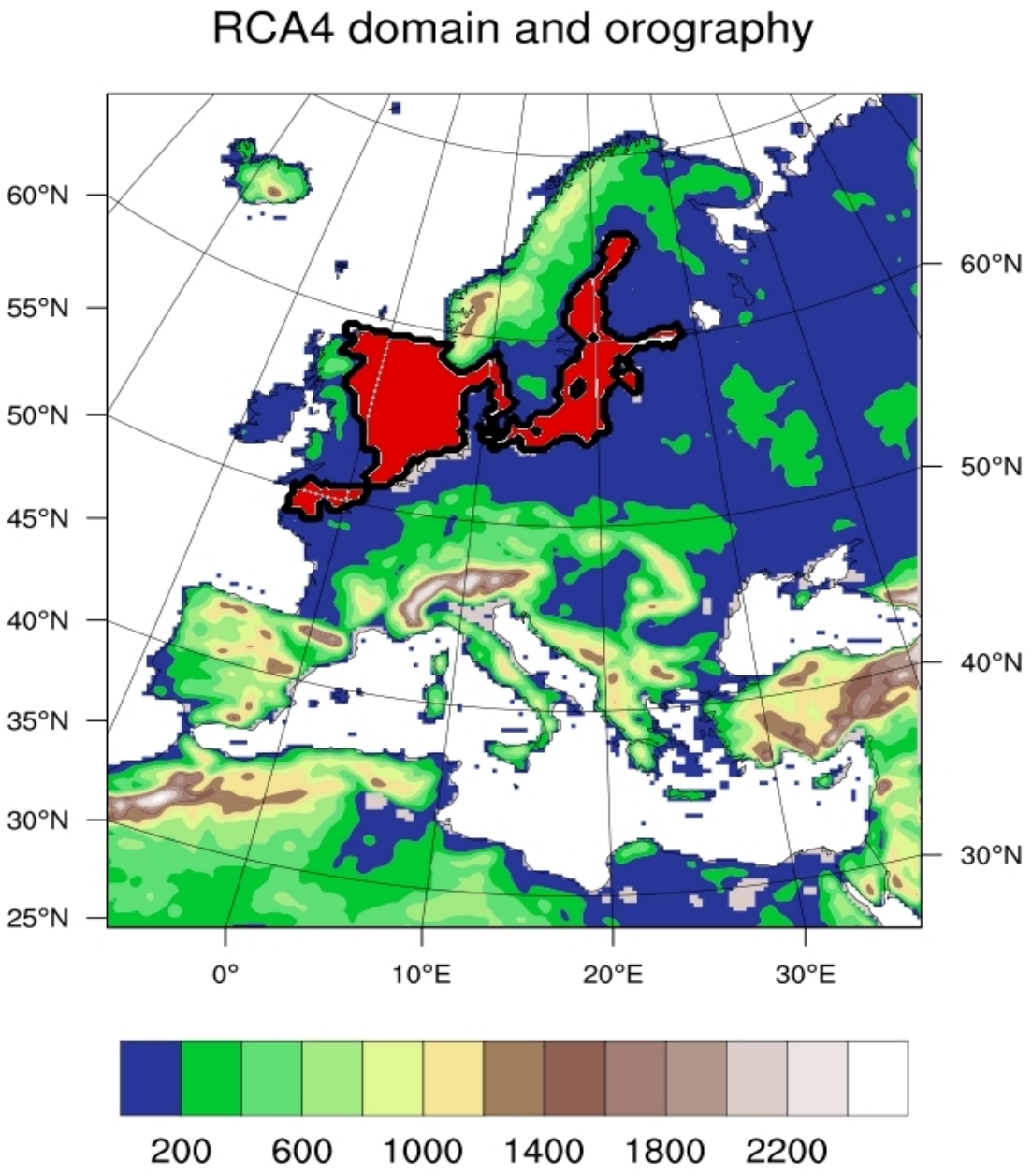

RCA4

Initial fields

Initialized with ERA_interim data

Lateral boundary

ERA_interim (1979-2008)

NEMO

Initial fields

Initialized with restart file from NEMO standalone run

Lateral boundary

Levitus Climatology

CaMa Flood

Initialized with restart file from one year offline run driven ERA40 data

T2m JJA

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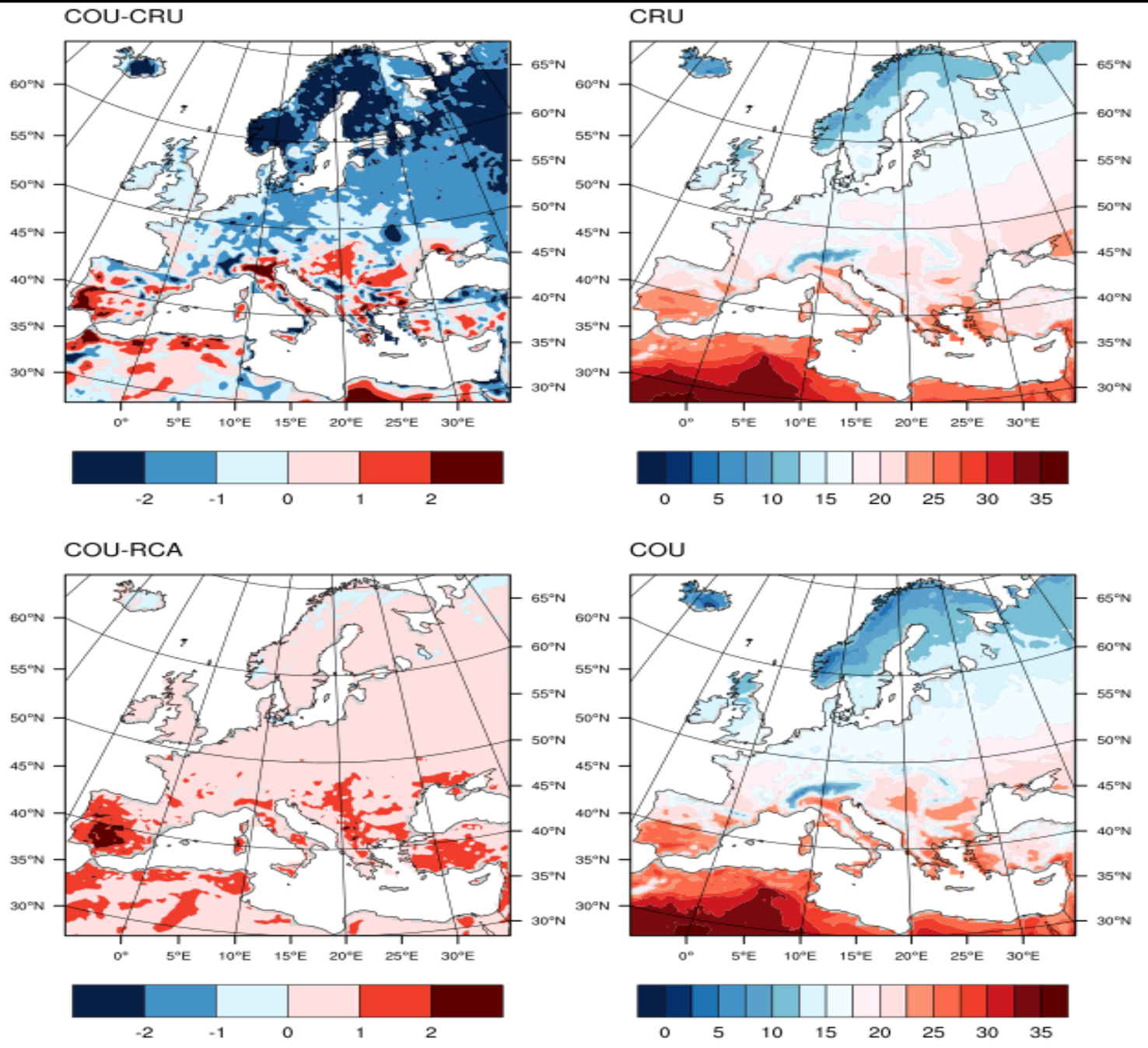
COU-CRU
CRU
COU-RCA
COU
60°N
55°N
50°N
45°N
40°N
35°N
30°N
65°N
0°
5°E
10°E
15°E
20°E
25°E
30°E
-2
-1
0
1
2
0
5
10
15
20
25
30
35

Evaluation

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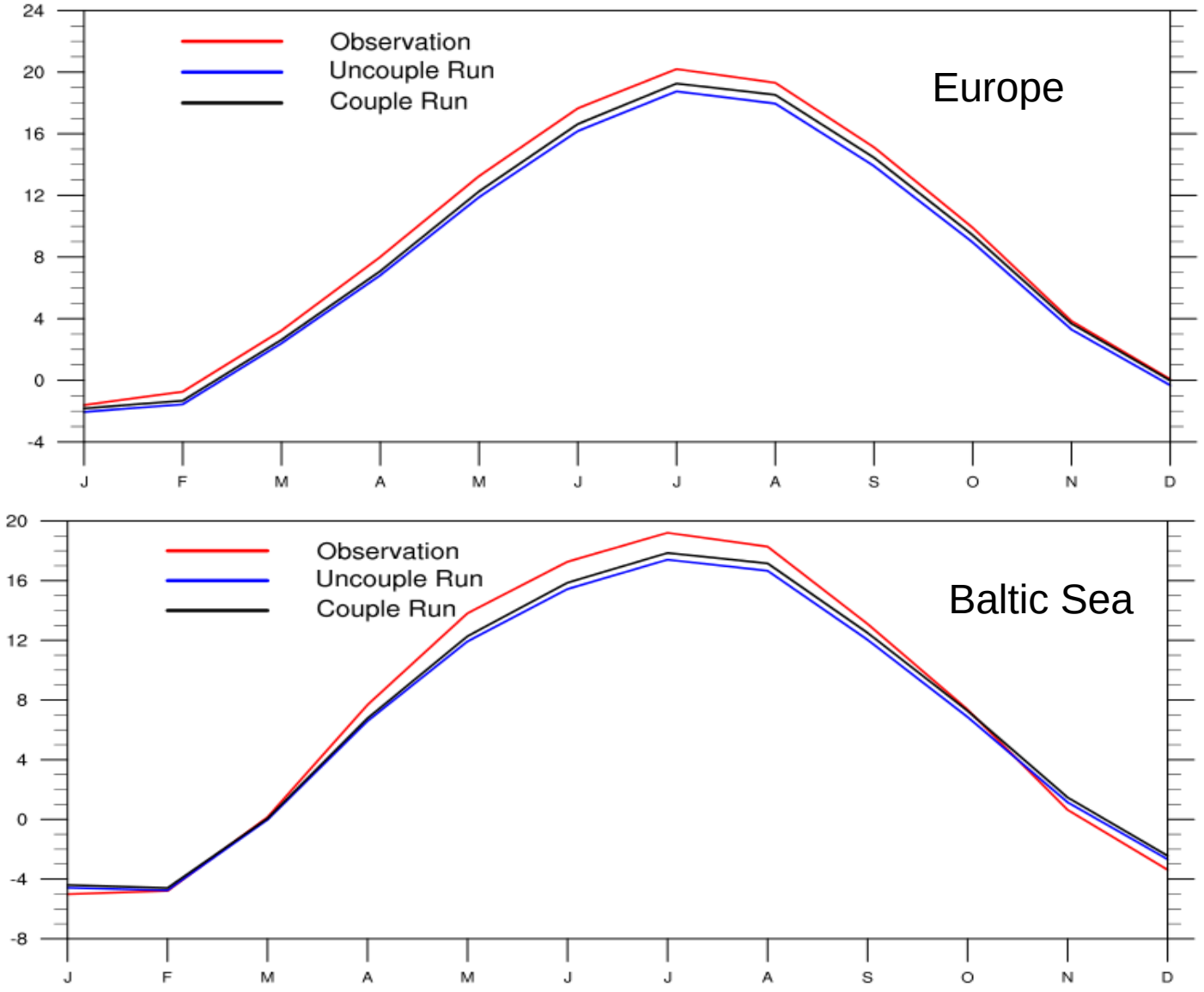
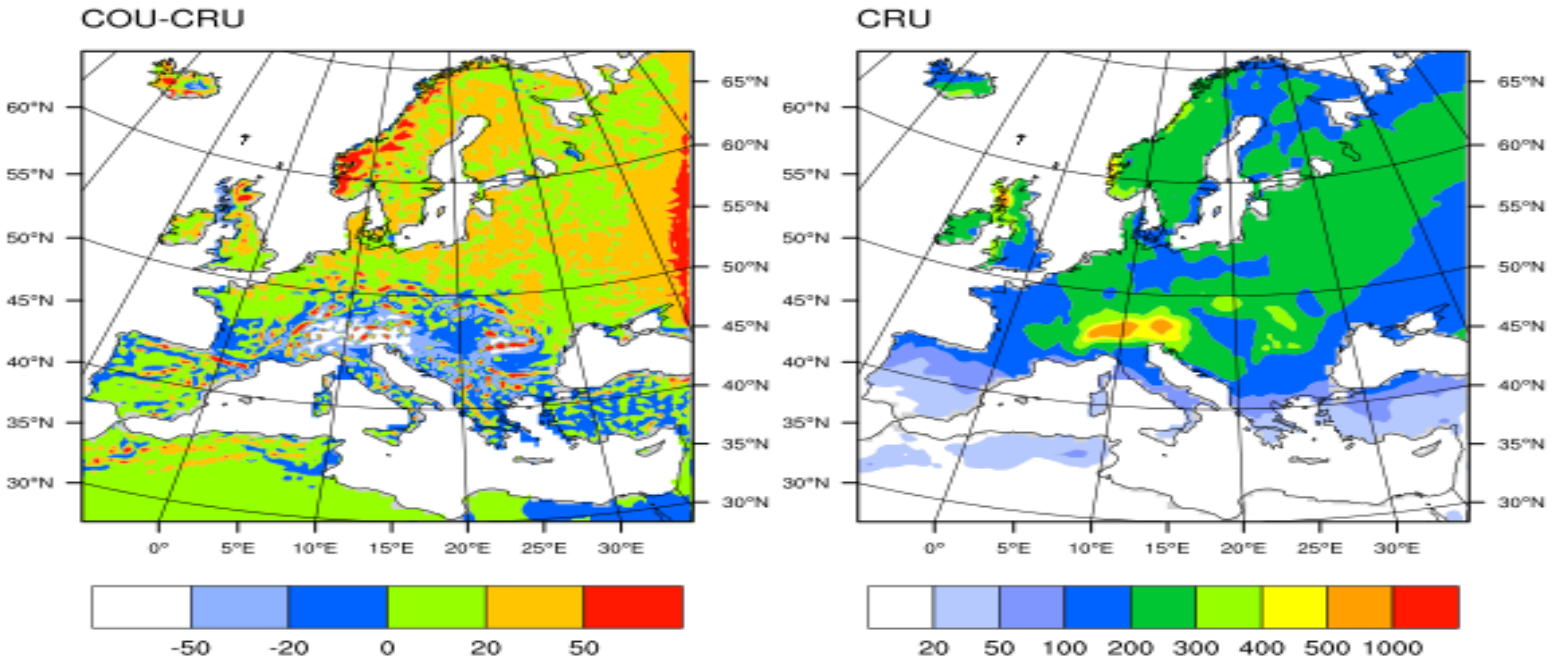
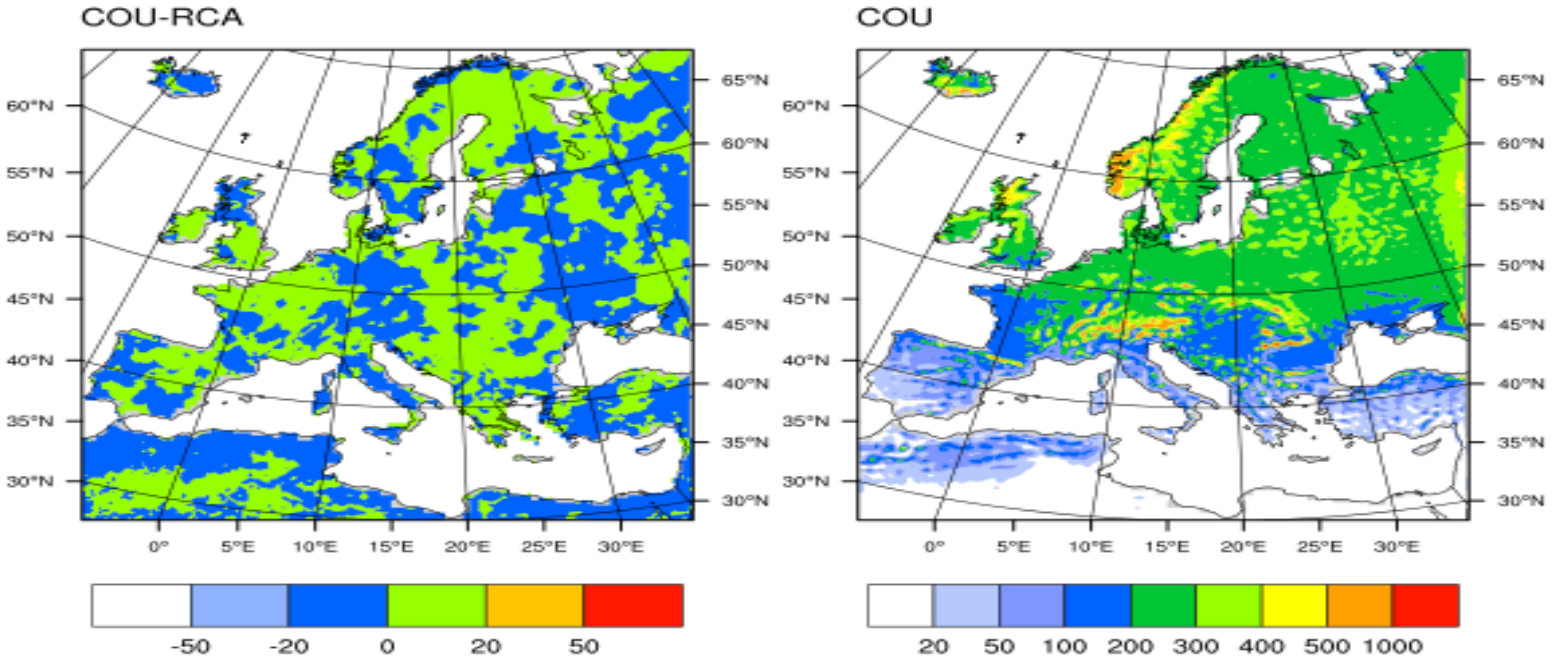
2m Temperature averaged over land area
Monthly mean value between 1979-2008



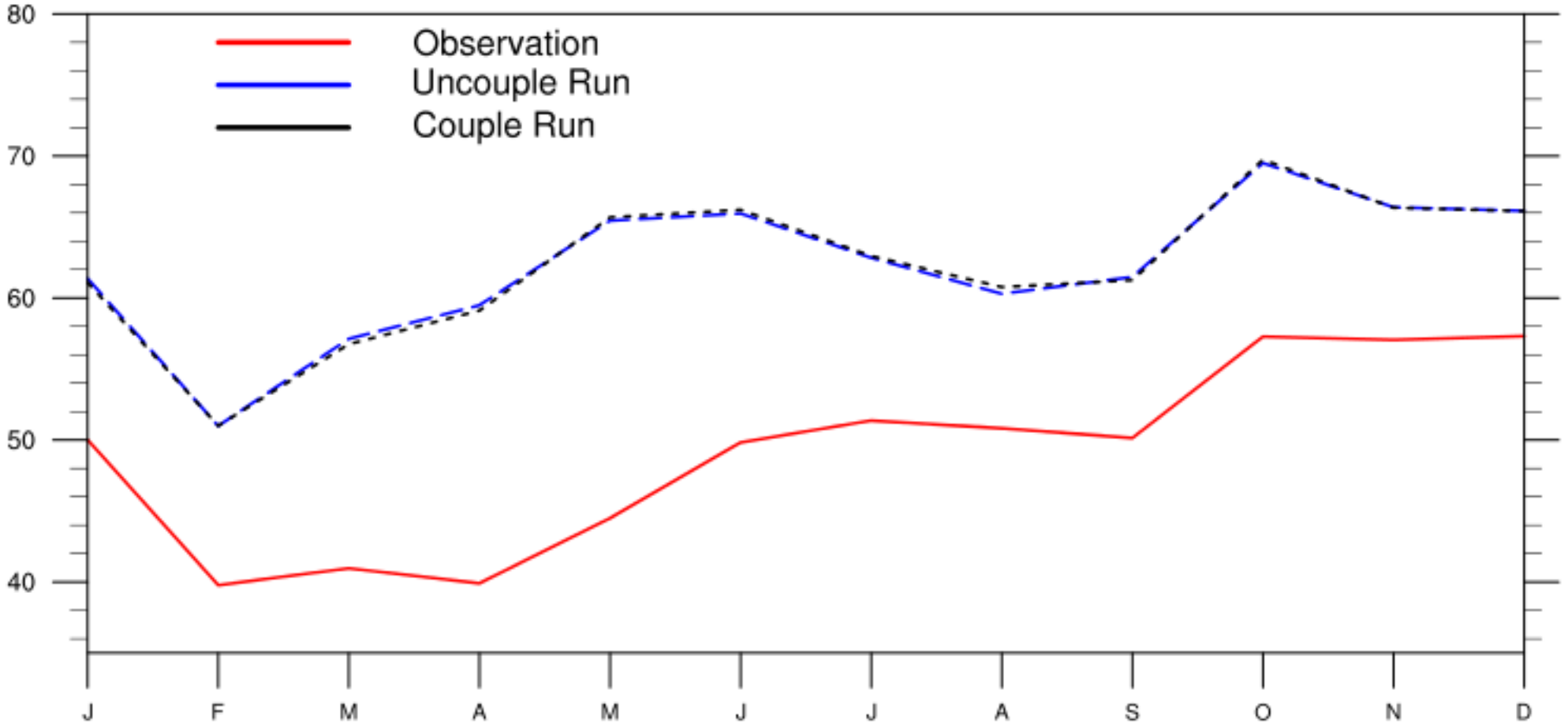
Precipitation JJA





SMHI

Total Precipitation averaged over land area
Monthly mean value between 1979-2008



Taylor Diagram: Comparison between the simulation and observation

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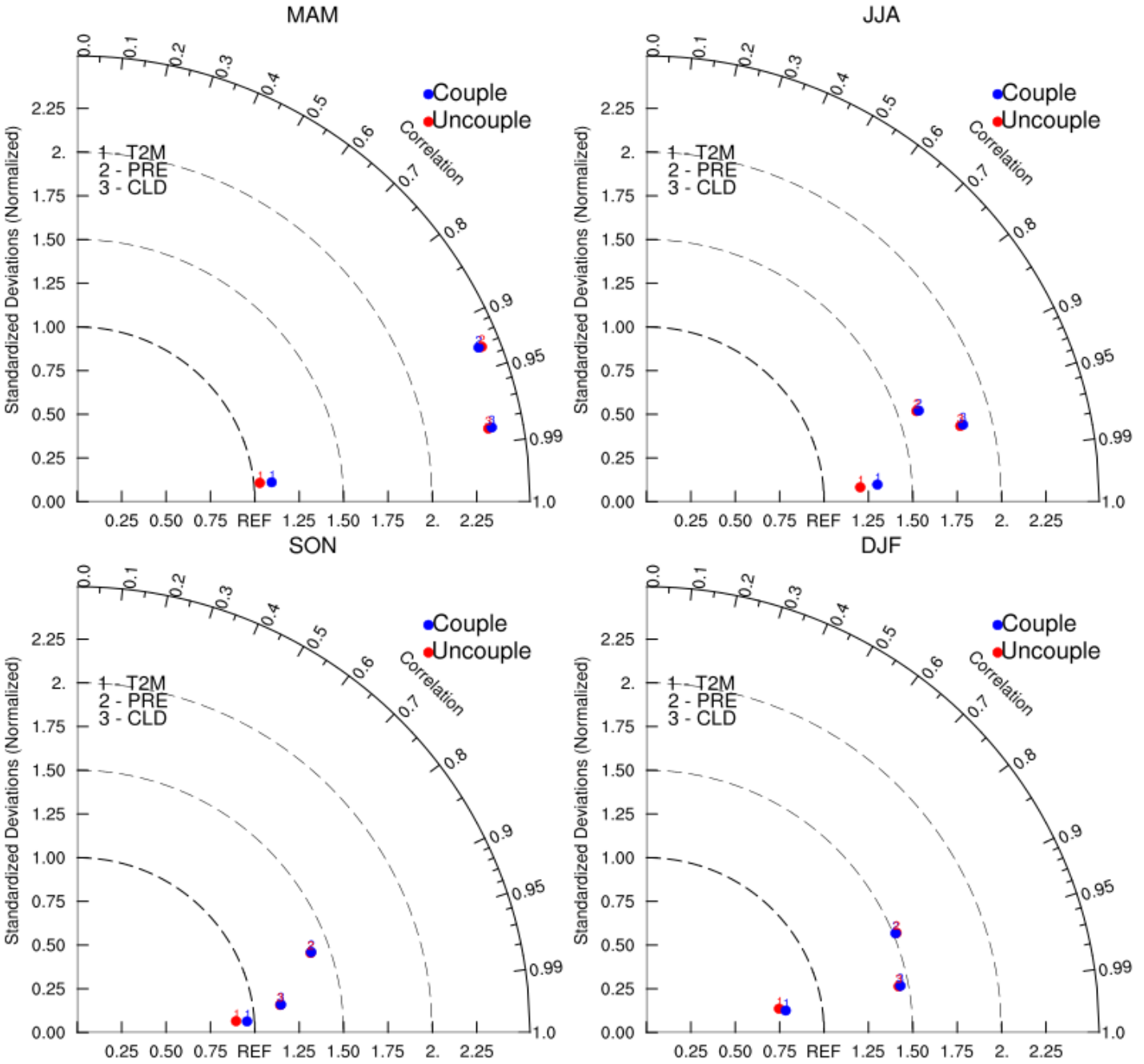
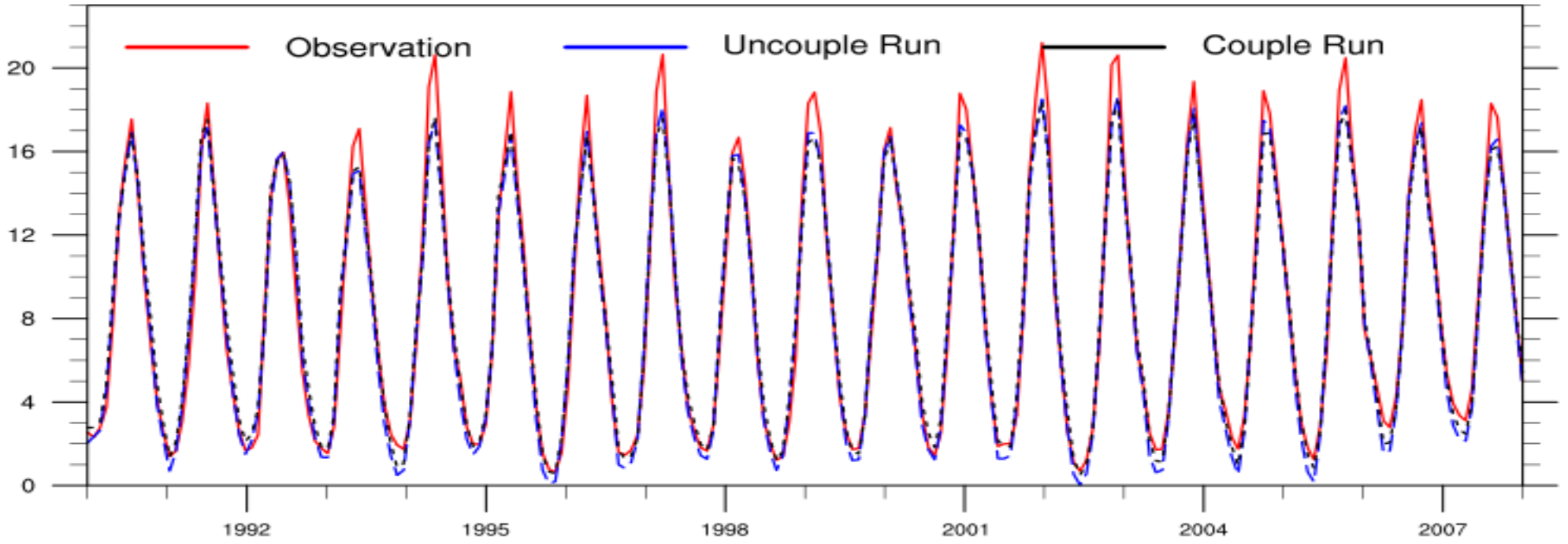
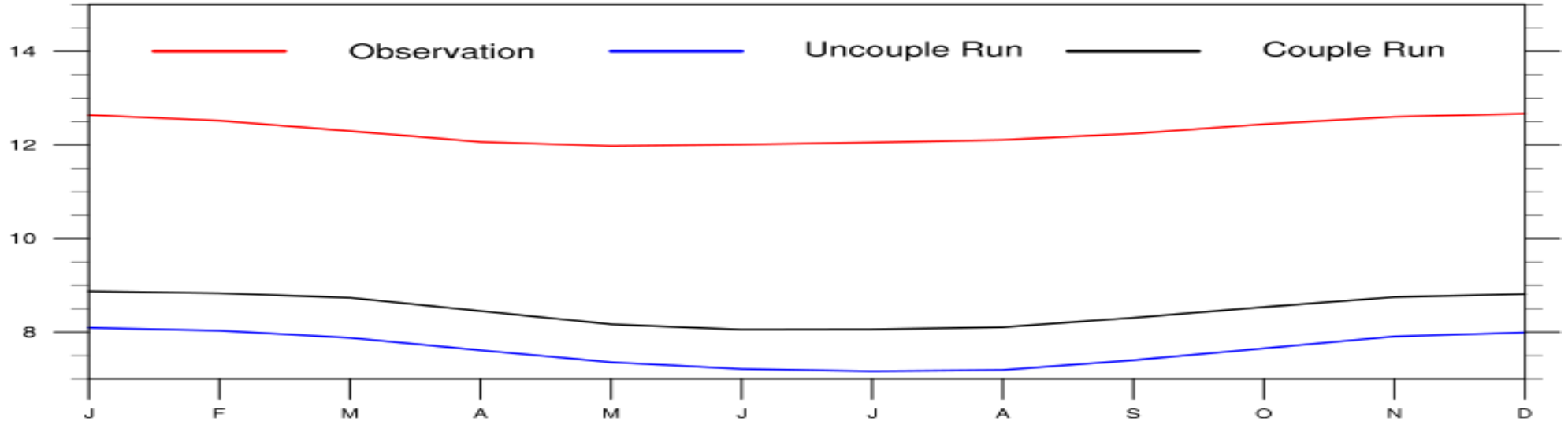


1 T2M
2 Preci
3 Cloud Cover

SST averaged over Baltic Sea



SSS averaged over Baltic Sea



Baltic Sea SST January

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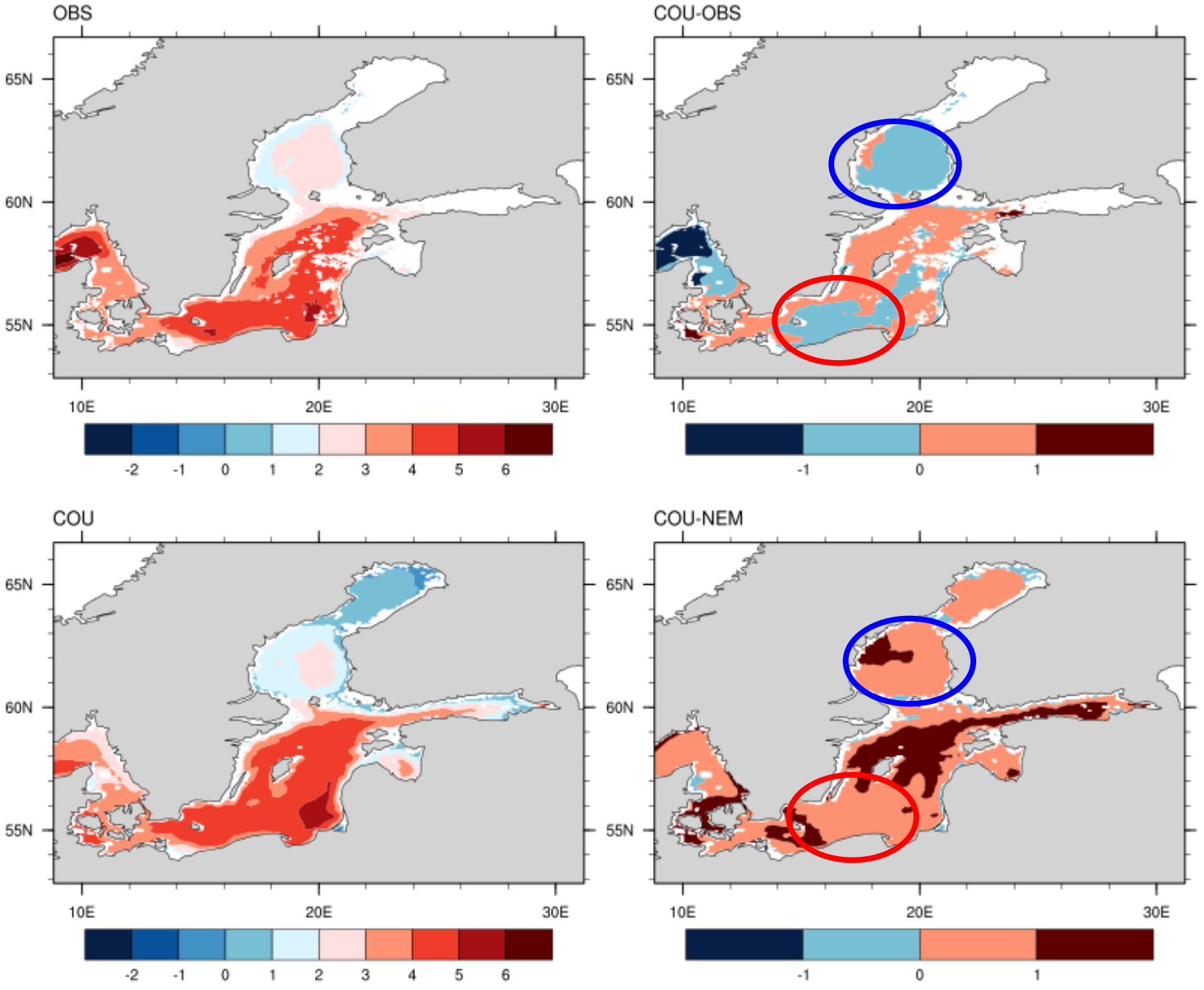

Climate change simulation

Future projection with boundary data from EC-EARTH model, which include two rcp scenarios:rcp4.5 and rcp8.5

Two set of experiments are analyzed:
50km : RCA4 standalone run from CORDEX-EUROPE
25km : RCA4-NEMO coupled run

Changes in T2m | CTL:1980-1999 |SCN1:2030-2049 | SCN2: 2080-2099

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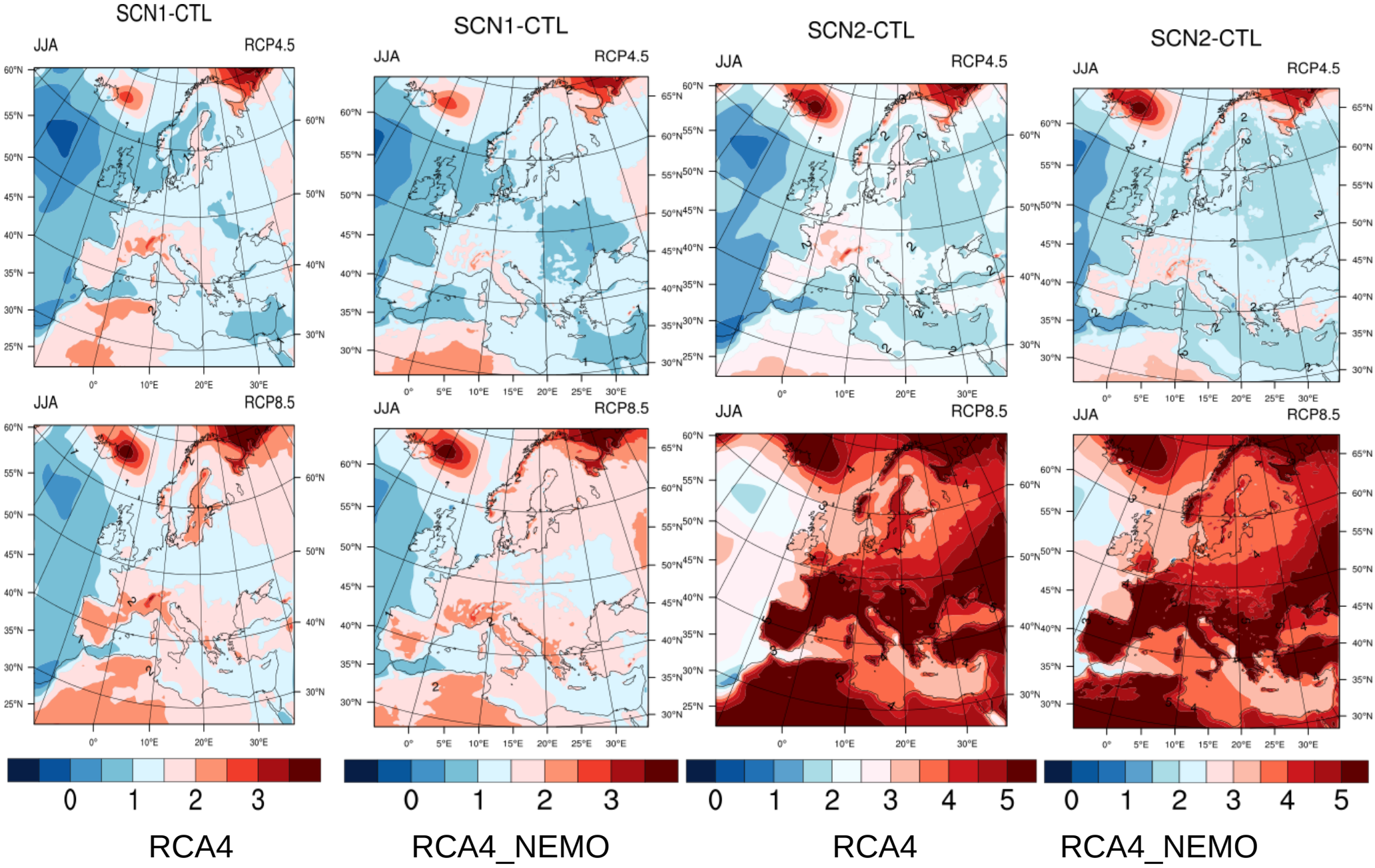

Changes in T2m | CTL:1980-1999 |SCN1:2030-2049 | SCN2: 2080-2099

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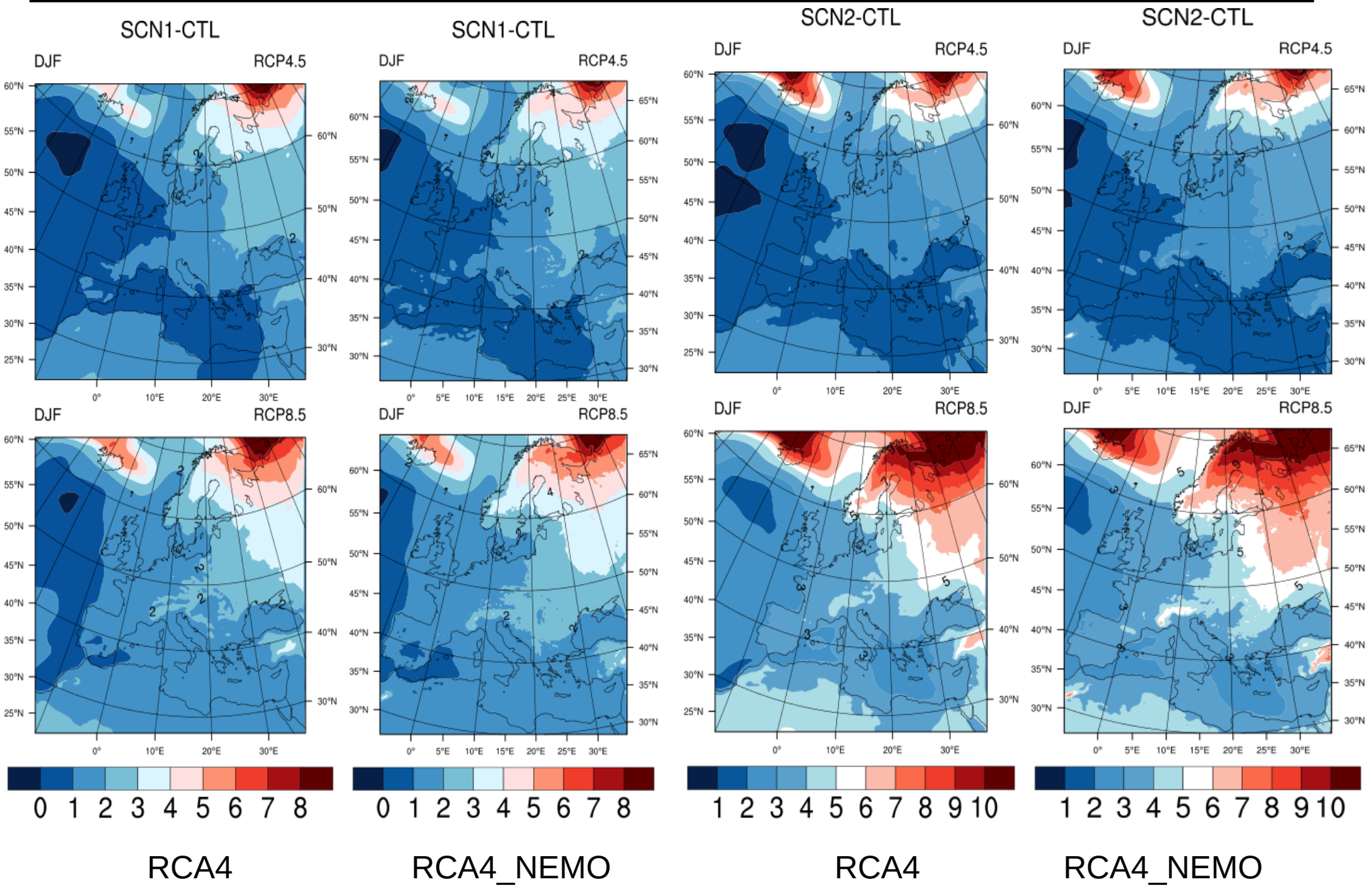
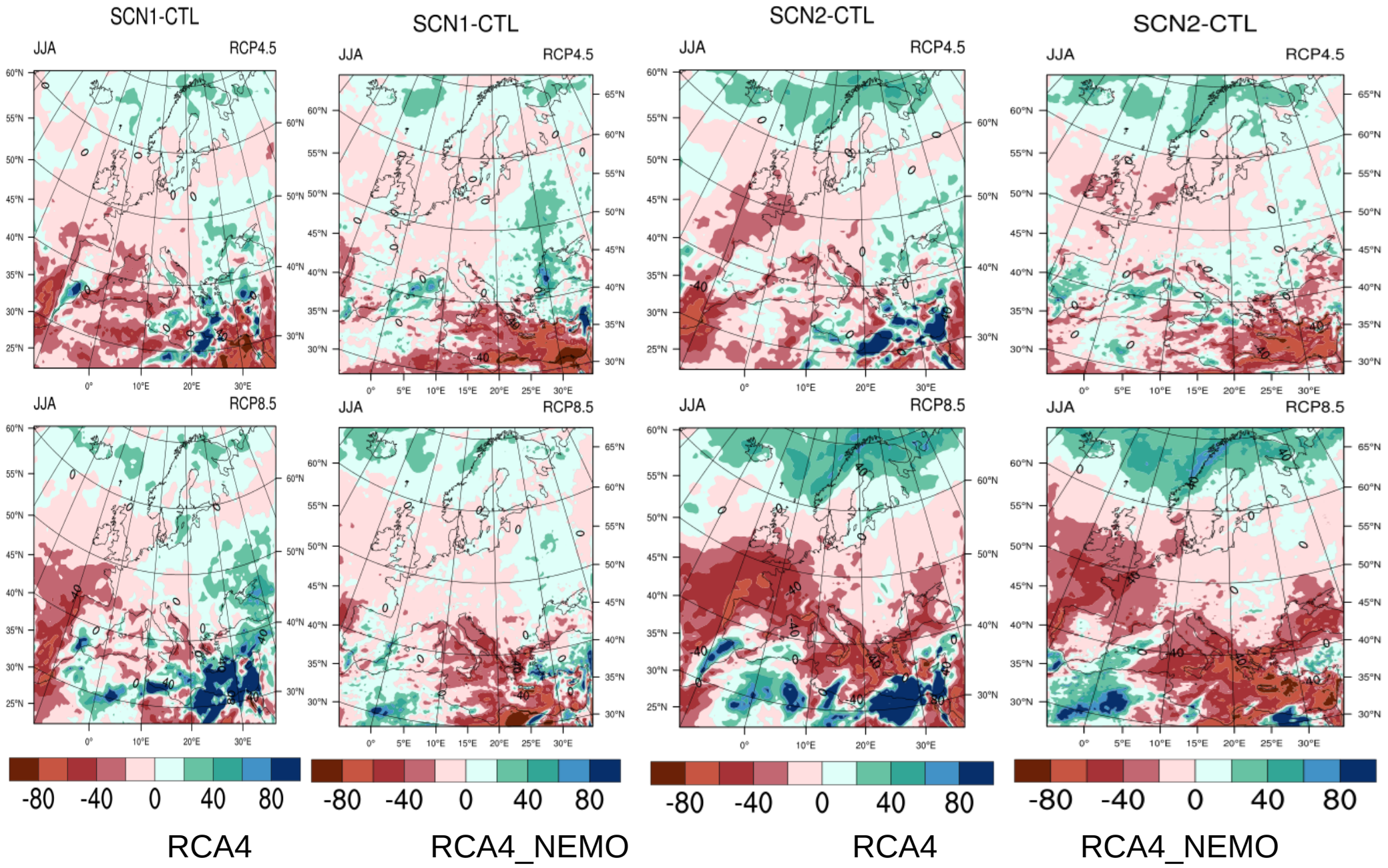


Changes in Precipitation (%) | CTL:1980-1999 | SCN1:2030-2049 | SCN2: 2080-2099

SMHI



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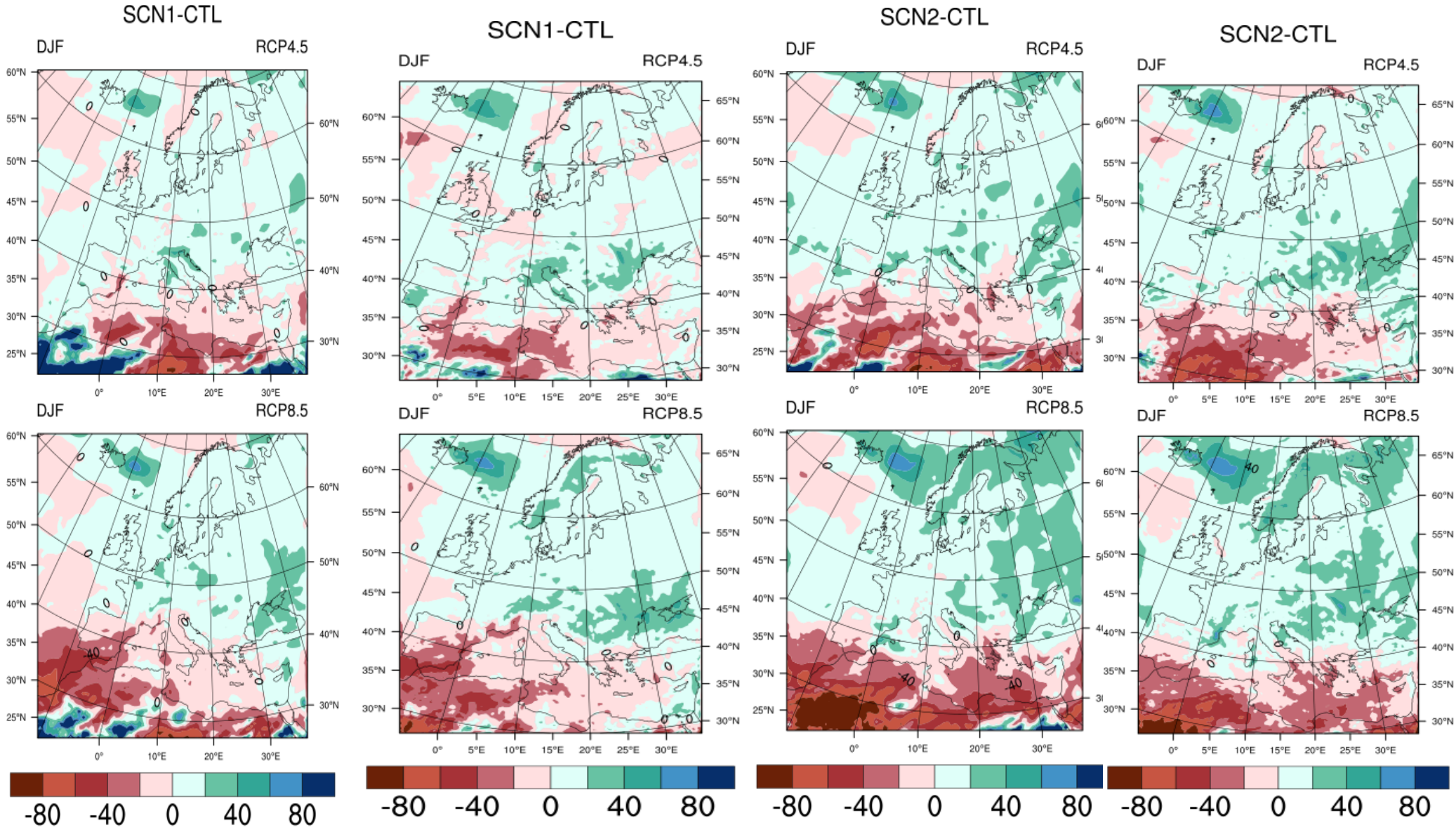
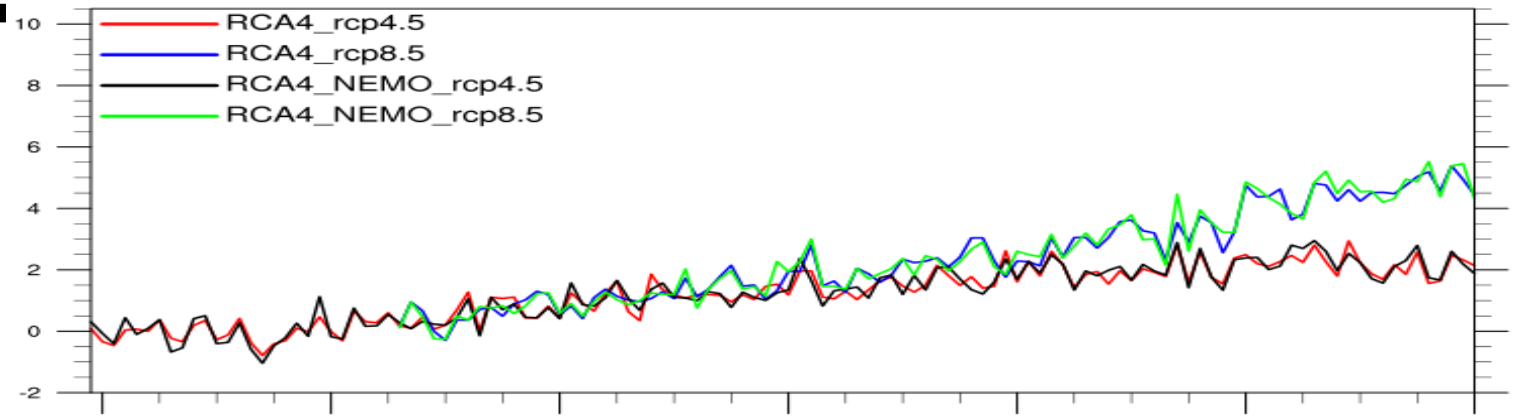


RCA4 RCA4_NEMO RCA4 RCA4_NEMO

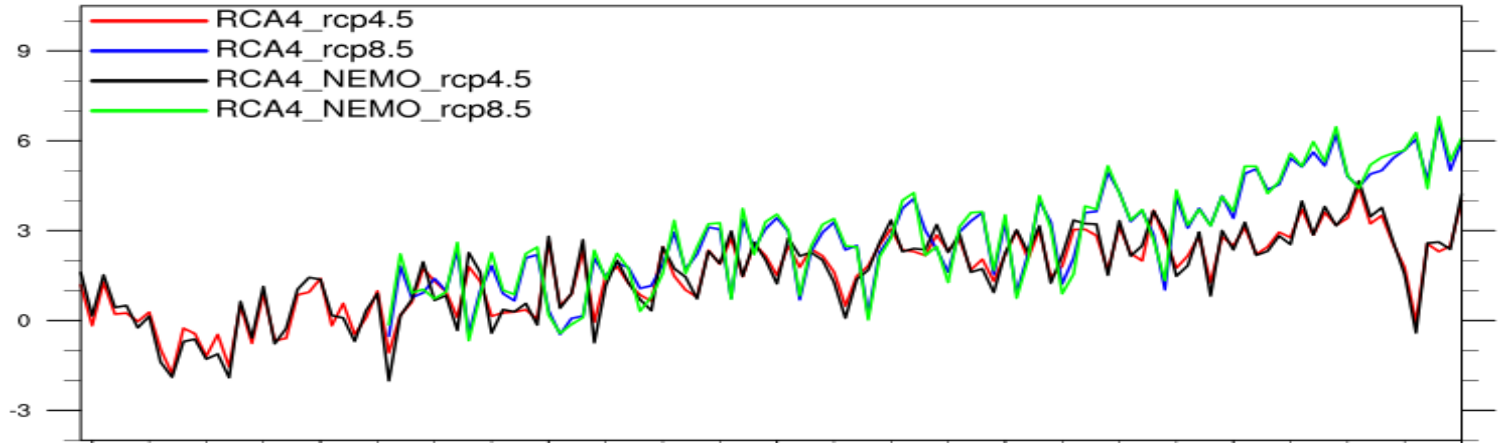
RCA4 and RCA4_NEMO climate scenarios T2M

SMHI

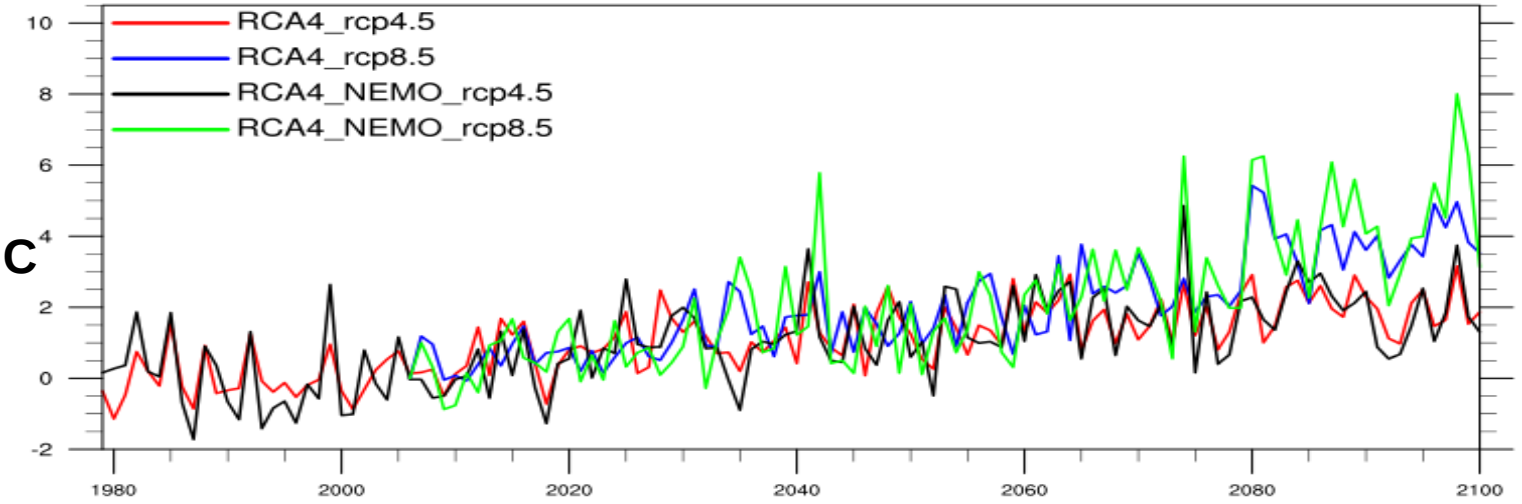
JJA



DJF



JJA BALTIC



Anomalized T2m over whole land area based on 1979-2005 average

Summary

From evaluation:
(1) This coupled model system can realistically simulate the present climate. The effect on the atmosphere is small, but there is still some improvement for certain parameters, e.g. T2m.

(2) The improvement for the ocean model is more pronounced, particularly for SST and salinity.

From climate change scenarios
(1) These two Ec-EARTH scenarios show that large warming and drying in summer over major of Europe and more wetting in winter in Europe continental region.

(2) the impact of coupling on climate change depend on region and season. The difference caused by air-sea interaction should be considered when interpreting climate change signal.

Thank you for your attention !