GHG emissions and regional warming in the Baltic Sea region

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What will happen with climate in the future?

Temperature change North Europe December-February





CMIP5 RCP4.5 scenarios at the end of the century: Change in DJF temperature

25%

50%

75%





RCM simulations

24 EURO-CORDEX simulations with 7 RCMs under RCP8.5 (available at ESGF in October 2018) at 12.5 km grid spacing (GCMs from CMIP5)



No	Institute	RCM	GCM	
1	SMHI	RCA4	EC-EARTH-r12	
2			HadGEM2-ES	
3			MPI-ESM-LR-r1	
4			NorESM1-M	
5			IPSL-CM5A-MR	
6	BTU Cottbus	CCLM4-8-17	EC-EARTH_r12	
7			MPI-ESM-LR-r1	
8	DWD	CCLM4-8-17	CanESM2	
9			MIROC5	
10	ETH	CCLM4-8-17	HadGEM2-ES	
11	HZG- GERICS	REMO2009 REMO2015	MPI-ESM-LR-r1	
12			MPI-ESM-LR-r2	
13			EC-EARTH_r12	
14			HadGEM2-ES	
15			CanESM2	
16			MIROC5	
17	KNMI	RACMO2.2	EC-EARTH-r1	
18			EC-EARTH-r12	
19			HadGEM2-ES	
20		HIRHAM5	EC-EARTH-r3	
21	DMI		HadGEM2-ES	
22			NORESM1-M	
23	IPSI	WRF3.3.1	IPSL-CM5A-MR	
24	IFJL	WRF3.6.1	HadGEM2-ES	

Changes at different warming levels

Global annual mean 2m-temperature

30-year running mean anomaly w.r.t. 1861-1890 in one simulation by one global climate model



Ensemble mean temperature change (DJF)



Annual mean temperatures 1971-2000 in the Nordic and Baltic countries are about 0.7-0.9°C above those in the second half of the 19th century

Responses differ between simulations

SCN-CTL (ENS)

Why is this the case?



Sea Level Pressure (psl) | EUR-11 CTL • 1971-2000 | SCN • 2°C | DJE | rcp85

MSLP (DJF)

Strong dependency on forcing GCM and ensemble members

	CTL (ENS)	SCN-CTL (ENS)		Гісроз	
026 024 022 020 018 016 016 014 012 012 010 008					
006 004 002 002 998 998 hPa		RACMO (EC-E-r1)	RACMO (EC-E-r12)	RACMO (HadGEM)	REMO (MPI-ESM-r2)
	REMO2015 (MIROC)	REMO2015 (CanESM2	REMO2015 (EC-E-112)	REMO2015 (HadGEM)	REMO (MPI-ESM-r1)
	CCLM (MIROC)	CCLM (CanESM2)	CCLM (EC-E-r12)	CCLM (HadGEM)	CCLM (MPI-ESM-r1)
	RCA (IPSL)	RCA (NorESM)	RCA (EC-E-r12)	RCA (HadGEM)	RCA (MPI-ESM-r1)
		HIRHAM (NorESM)	HIRHAM (EC-E-r3)	HIRHAM (HadGEM)	
		-4 -3 -2	-1 0 1 SCN - CTL hPa	2 3 4	

Precipitation (pr) | EUR-11 CTL: 1971-2000 | SCN: 2°C | DJF | rcp85

Precipitation (DJF)

Strong dependency on forcing GCM and ensemble members

		CIL: 19/1-2000	J SCN: 2°C DJ		
	CTL (ENS)	SCN-CTL (ENS)	WRF361H (HadGEM)		
300 200 150 120 105 90 75 60 45 30 15 0 mm/mon					
		RACMO (EC-E-r1)	RACMO (EC-E-r12)	RACMO (HadGEM)	REMO (MPI-ESM-r2)
	REMO2015 (MIROC)	REMOZUIS (CARESM2)	REMO2015 (EC-E-r12	REMO2015 (HadGEM)	REMO (MPI-ESM-r1)
	CCLM (MIROC)	CCLM (CanESM2)	CCLM (EC-E-r12)	CCLM (HadGEM)	CCLM (MPI-ESM-r1)
		RCA (NorESM)	RCA (EC-E-r12)	RCA (HadGEM)	RCA (MPI-ESM-r1)
	WRF331F (IPSL)	HIRHAM (NorESM)	HIRHAM (EC-E-r3)	HIRHAM (HadGEM)	
		-40 -20 -20	-10 0 10	20 20 40	
		-40 -30 -20	(SCN - CTL)/CTL %	20 30 40	

MSLP (DJF)

Large differences between members of the same GCM – indicative of large influence of natural internal variability



Precipitation (DJF)

Large differences between members of the same GCM – indicative of large influence of natural internal variability



Sea Level Pressure (psl) | EUR-11

MSLP (DJF)

RCMs does not seem to influence the large-scale **MSLP** signal



Daily Temperature range (dtr) | EUR-11 CTL: 1971-2000 | SCN: 2°C | DJF | rcp85

Diurnal Temperature Range (DJF)

Strong dependency on RCMs that modulate the largescale signal



RCMs can improve the simulated climate w.r.t. the GCM also on larger scales



Sørland et al., 2018

RCMs may change the spread in results compared to the underlying GCMs



Sørland et al., 2018

Summary

- Already at SWL1.5 many changes are significant while at SWL2 stronger and more robust changes are found
- Undertainties related to choice of GCM, RCM and ensemble members varies with variable
- There is a strong impact of changes in the large-scale circulation
- Generally, there is a large impact of natural variability
- RCMs can improve also large-scale features in a GCM
- RCMs can significantly change the regional response in a GCM

Kjellström et al., 2018. European climate change at global mean temperature increases of 1.5 and 2 °C above pre-industrial conditions as simulated by the EURO-CORDEX regional climate models, *Earth Syst. Dynam.*, 9, 459-478, https://doi.org/10.5194/esd-9-459-2018.

Sørland, S., Lüthi, D., Schär, C. and **Kjellström, E.**, 2018. Bias patterns and climate change signals in GCM-RCM model chains. *Environ. Res. Lett.*, 13, 074017, https://doi.org/10.1088/1748-9326/aacc77.