



Supplement of

Characteristics of precipitation extremes over the Nordic region: added value of convection-permitting modeling

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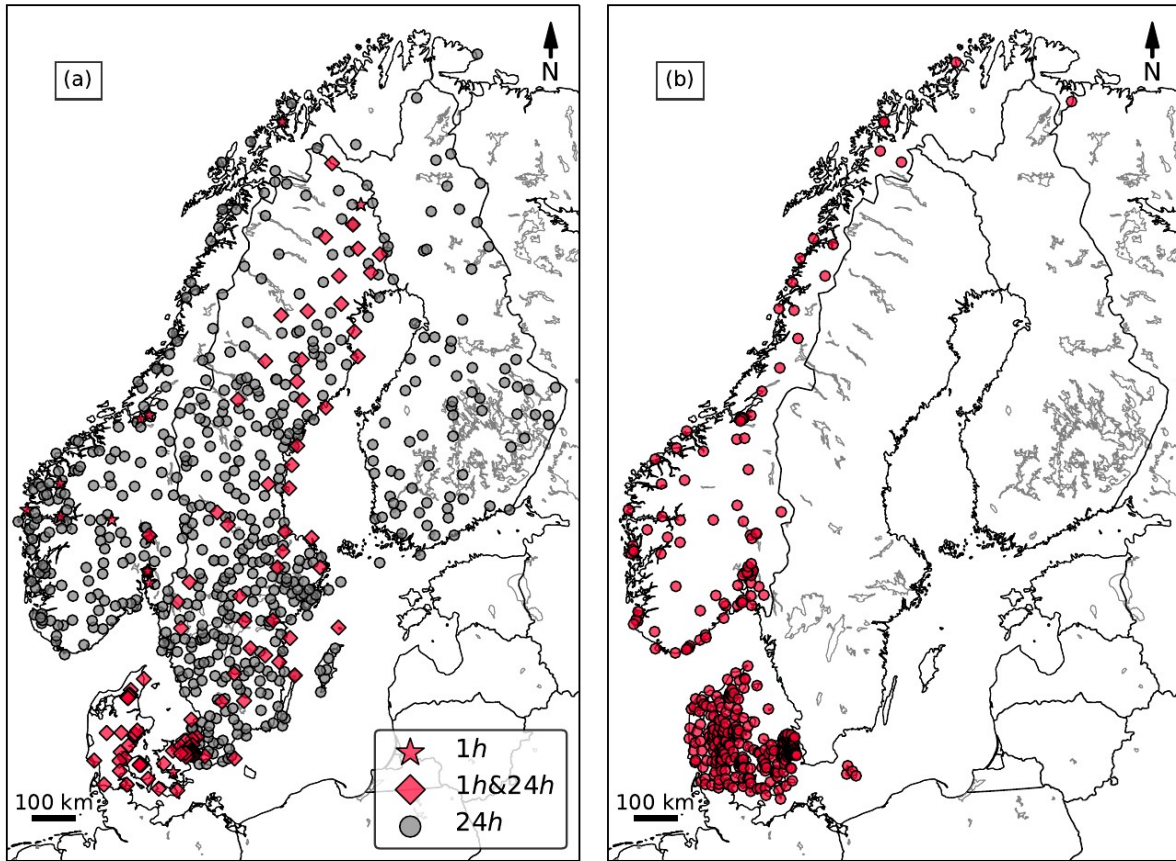


Figure S1. (a) Locations of stations used in the AM dataset at daily (24 h) and hourly (1 h) time scales for 1998–2018. (b) Locations of stations that are used for geographic sampling and that have been operational during the entire period of 2010–2018 (seNorge, Norway) and 2011–2018 (Klimagrid, Denmark).

Table S1. Relative biases in the medians of average precipitation over the 95th and 99th percentiles ($p_{95-99.9_{avg}}$), the frequency of heavy (R10mm) and very heavy (R20mm) precipitation days, as well as daily return level estimates for return periods (T) of 5, 10, and 20 years ($x_{1d.T}$) in HCLIM12 and HCLIM3 compared to NGCD (E-OBS in Denmark). Comparisons to national high-resolution (in situ stations for GEV) datasets are in brackets. All units are in percentages. The bolded value highlights which model setup, HCLIM12 or HCLIM3, has smaller absolute relative biases for the metric in question over each country.

	Finland		Sweden		Norway		Denmark	
	HCLIM12	HCLIM3	HCLIM12	HCLIM3	HCLIM12	HCLIM3	HCLIM12	HCLIM3
p₉₅_{avg}	-3.5	3.0	-2.6 (-6.6)	3.5 (0.3)	5.5 (10.6)	11 (14.9)	22.3 (-5.2)	32.4 (-1.6)
p_{99.9}_{avg}	-9.0	13.4	-1.2 (-7.3)	8.3 (-0.4)	0.0 (10.2)	7.4 (20.1)	55.3 (2.7)	84.4 (7.5)
R10mm	4.4	-2.0	2.6 (-5.2)	3.5 (-2.6)	24.9 (26.6)	23.6 (22.6)	26.6 (3.0)	21.5 (-9.0)
R20mm	-14	7.0	-14.8 (-20.7)	9.2 (0.0)	15.1 (29.6)	33.3 (48.2)	135 (-15.4)	205.9 (1.5)
x_{1d.5}	0.9 (-3.3)	18.8 (13.9)	1.5 (-1.2)	12.1 (9.1)	3.1 (7.5)	5.0 (9.5)	30.0 (-13.0)	52.1 (1.8)
x_{1d.10}	3.0 (-2.4)	21.1 (14.8)	2.5 (0.2)	12.8 (10.4)	4.5 (6.5)	8.7 (10.8)	31.3 (-13.6)	53.7 (1.1)
x_{1d.20}	0.3 (-4.5)	19.4 (13.7)	2.8 (0.2)	12.4 (9.6)	2.8 (3.7)	8.1 (9.1)	29.8 (-15.3)	53.7 (0.2)

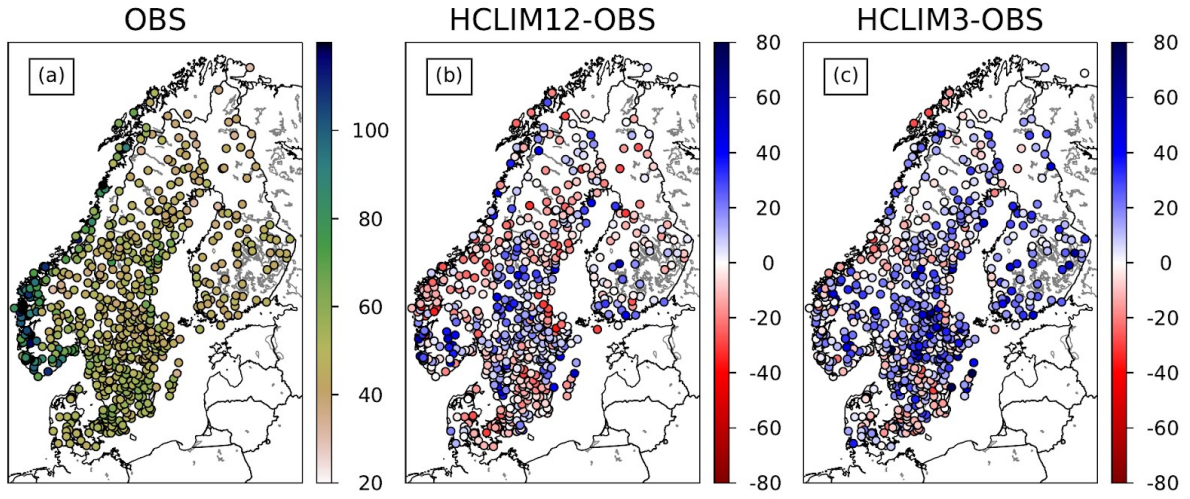


Figure S2. The daily return levels of the 10-year return period in (a) in situ observations and the relative biases in (b) HCLIM12 and (c) HCLIM3 compared to in situ observations. The results are shown in their native grids. The units are mm/day in the sub-figure (a) and percentage in sub-figures (b) and (c).

Table S2. Relative biases in the medians of average hourly precipitation over the 95th and 99th percentiles ($p_{95-99.9_{avg}}$), the frequency of heavy (R5mm) precipitation hours, as well as hourly return level estimates for return periods (T) of 5, 10, and 20 years ($x_{1h.T}$) in HCLIM12 and HCLIM3 compared to national high-resolution datasets (in situ stations for GEV). The mean biases are reported for the diurnal cycle of the 99.9th percentiles. The values in brackets show the results with geographical sampling (Norway, Denmark). All units are in percentages. The bolded value highlights which model setup, HCLIM12 or HCLIM3, has smaller absolute relative biases for the metric in question over each country.

	Sweden		Norway		Denmark	
	HCLIM12	HCLIM3	HCLIM12	HCLIM3	HCLIM12	HCLIM3
p95_{avg}	-14.7	-5.8	-5.2 (-14.9)	18.0 (-4.3)	0.5 (-5.9)	2.6 (-7.5)
p99.9_{avg}	-36.8	17.5	-25.6 (-36.3)	27.0 (13.6)	-20.0 (-37.3)	44.1 (15.1)
R5mm	-69.1	5.4	-53.5 (-70.8)	62.8 (10.5)	-42.9 (-60.8)	59.0 (10.4)
Diurnal cycle	-2.1	0.4	-0.9 (-1.8)	0.8 (0.5)	-1.0 (-2.0)	1.5 (0.5)
x1h.5	-50.5	5.2	-48.3	2.6	-58.8	-6.6
x1h.10	-52.3	3.0	-49.2	8.2	-60.1	-10.2
x1h.20	-54.2	0.1	-51.0	11.9	-62.1	-13.6

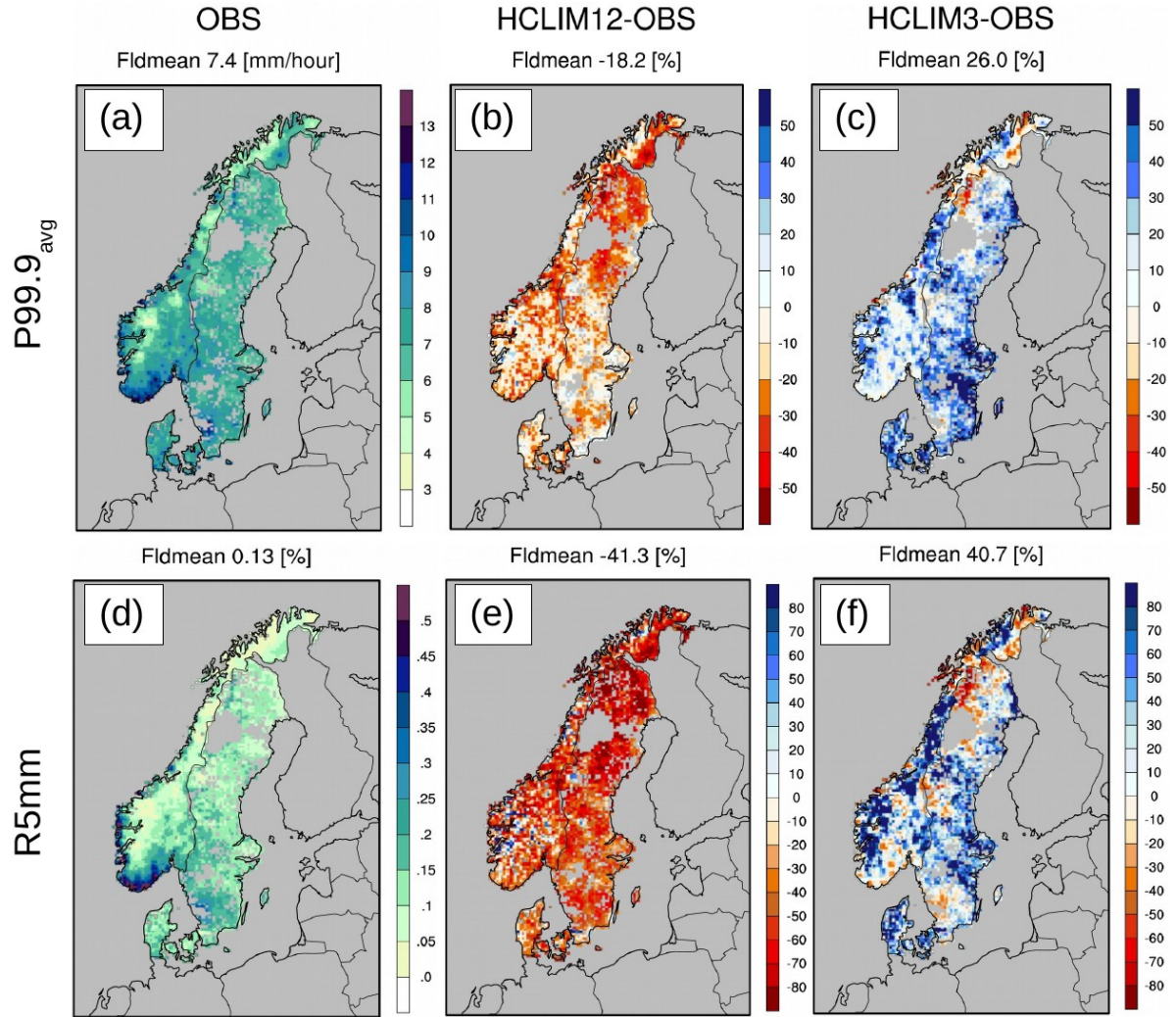


Figure S3. Top panel: Average hourly precipitation over the 99.9th percentile ($p99.9_{avg}$) in (a) national high-resolution observations and the relative biases of $p99.9_{avg}$ in (b) HCLIM12 and (c) HCLIM3 with a reference to the national high-resolution observations. Bottom panel: R5mm values in (d) national high-resolution observations and the relative biases of R5mm in (e) HCLIM12 and (f) HCLIM3 with a reference to the national high-resolution observations. Observations and HCLIM3 data were remapped onto HCLIM12's grid prior to computations. Fldmean represents the average bias over the domain. All units are in percentage except in sub-figure (a) for which the unit is in mm/hour.

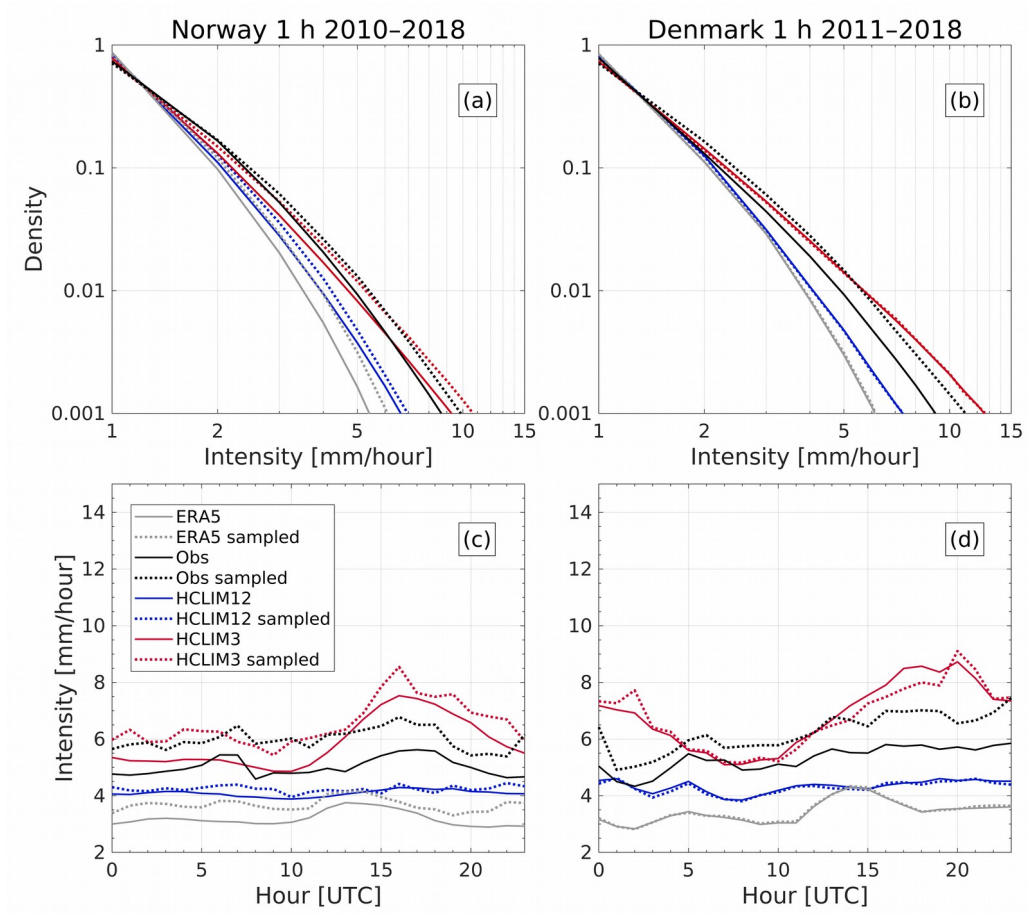


Figure S4. Top panel: The mean probability density functions for (a) Norway and (b) Denmark. A threshold of 0.1 mm/hour was used prior to analysis. Bottom panel: The mean diurnal cycles of the 99.9th percentile events for (c) Norway and (d) Denmark. ‘Obs’ refers to the national high-resolution gridded datasets and ‘sampled’ refers to the results with geographic sampling. All data are presented on their native grids.

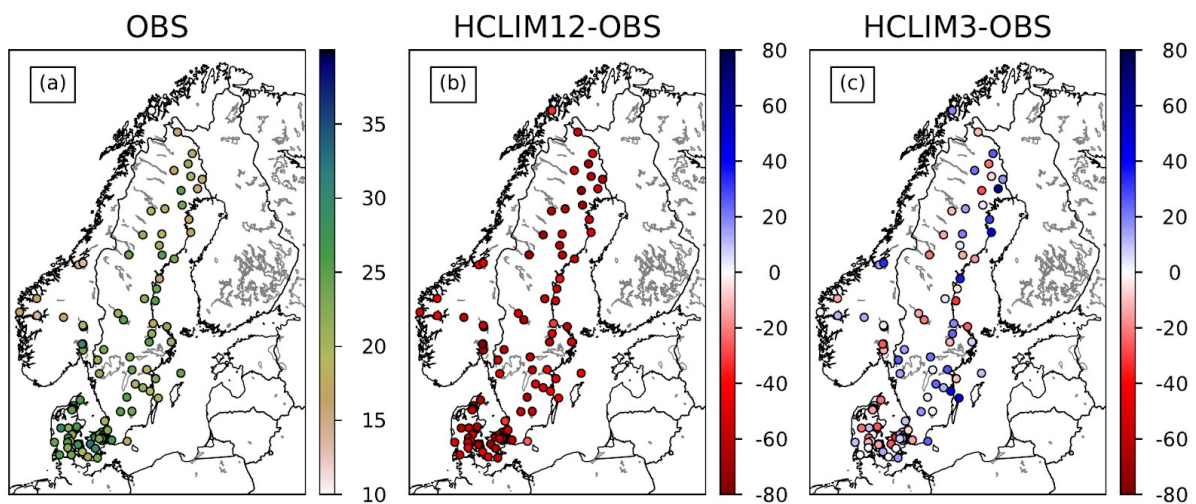


Figure S5. The hourly return levels of the 10-year return period in (a) in situ observations and the relative biases in (b) HCLIM12 and (c) HCLIM3 compared to in situ observations. The results are shown in their native grids. The units are mm/hour in the sub-figure (a) and percentage in sub-figures (b) and (c).