

Heavy rainfall in Norway in present and future climate:

Design values, mapping, trends, climate factors

Eirik J. Førland, MET Norway, Riga 19.05.2016

NCCS is a cooperation between:



Recent Heavy Rainfall Events in Norway



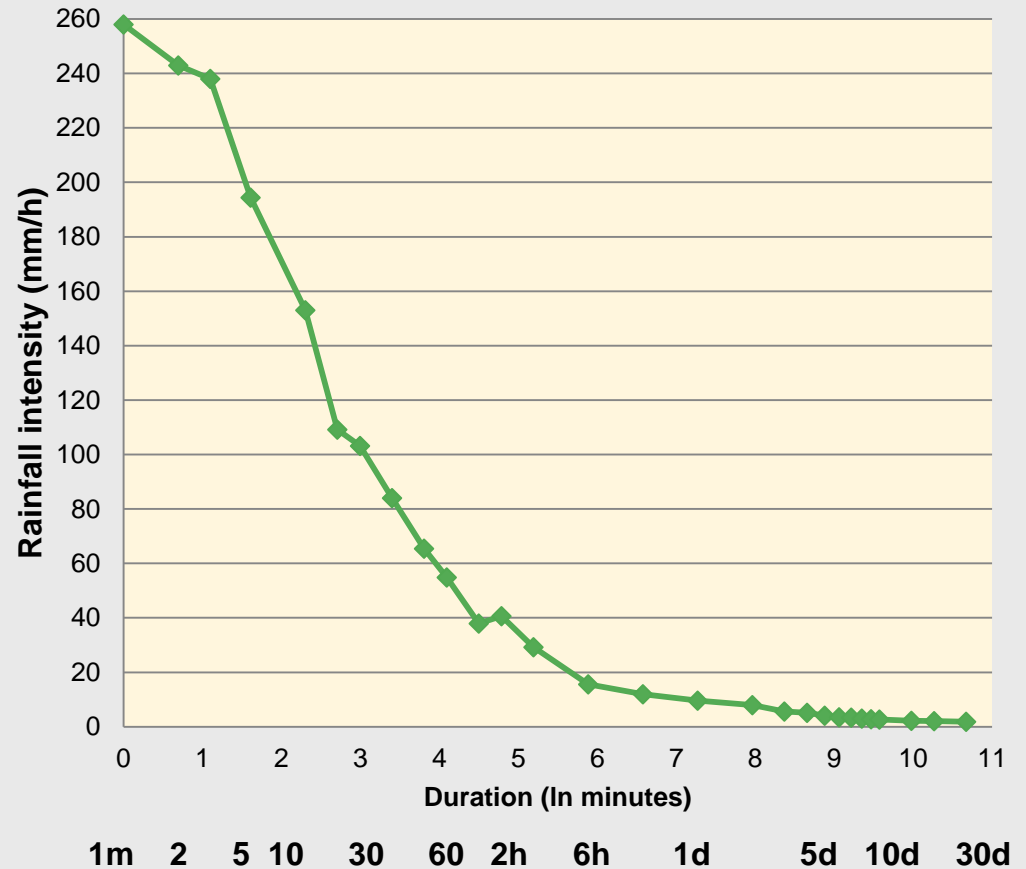
We're not even adapted to present climate....!



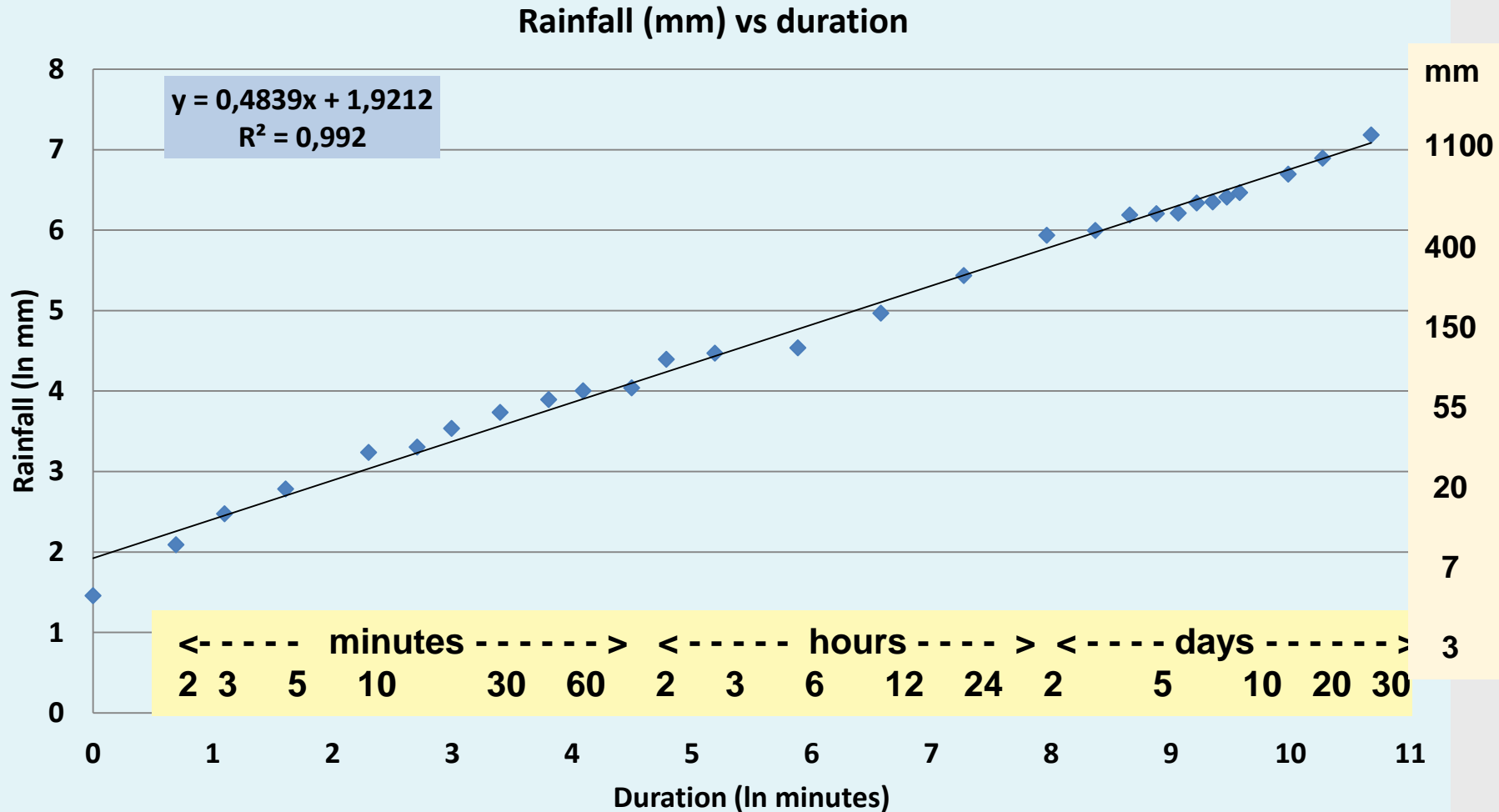
Max. obs. rainfall at MET Norway's stations

Duration	Rainfall (mm)
1 minute	4,3
5 minutes	16,2
10 minutes	25,5
30 minutes	42,0
45 minutes	49,1
1 hour	54,9
2 hours	81,2
6 hours	93,6
12 hours	144,0
1 day	229,6
2 days	378,9

Rainfall intensity (mm/h) vs. duration



Max. obs. rainfall at MET Norway's stations



Norwegian guidelines for preparing for «Flood and land-slides»

(Norwegian Water Resources and Energy Directorate (NVE) Report no. 2/2011)

Areas with residential and commercial buildings:

→ Return period $T = 200$ years

Areas where flooding may cause severe damages (human life, pollution, etc.):

→ Return period 500 – 1000 years

New NVE-maps will show areas flooded by 1000-year floods

Large dams and reservoirs for hydropower production:

→ Probable Maximum Precipitation, PMP → Probable Maximum Flooding, PMF

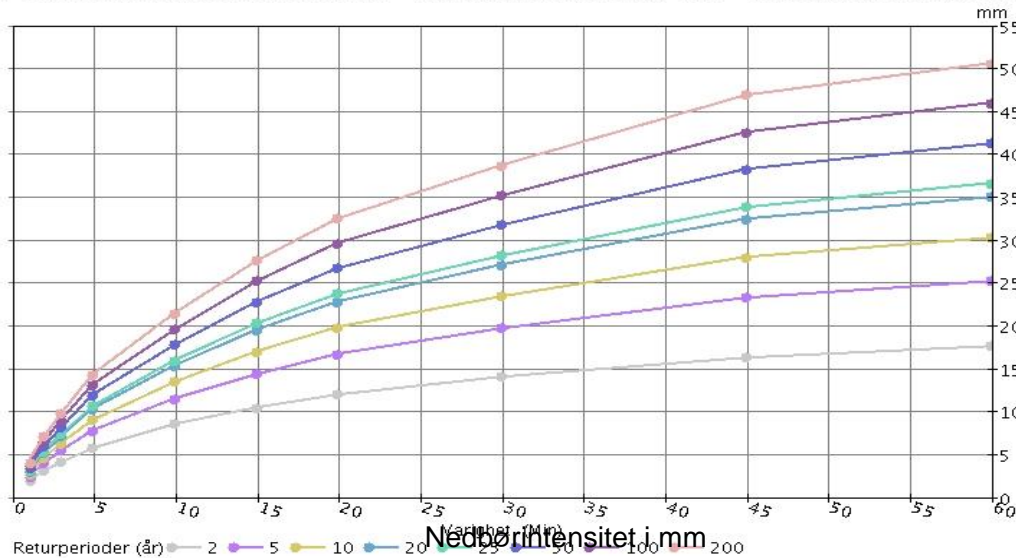
→ Challenge: Sparse network, few long series, trends

Rainfall <24hrs: Longest series ~50 years (Most series < 25 yrs)

Rainfall ≥ 1 day: Several series >120 years

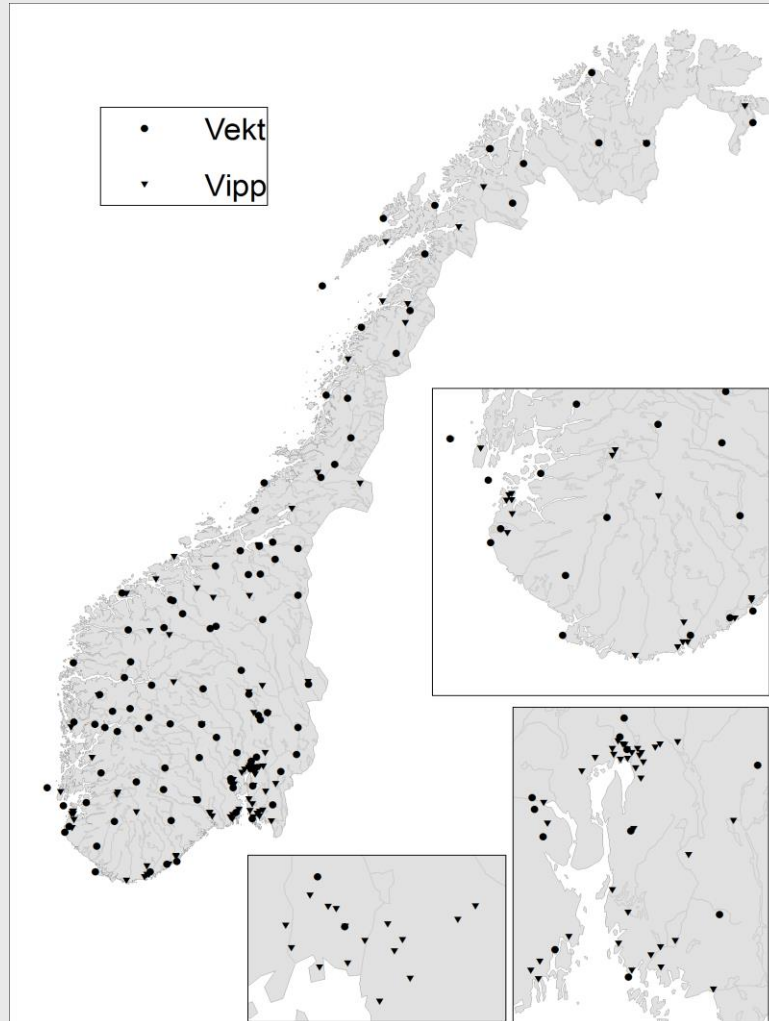
Example: IDF-values for Oslo-Blindern (1968 – 2014)

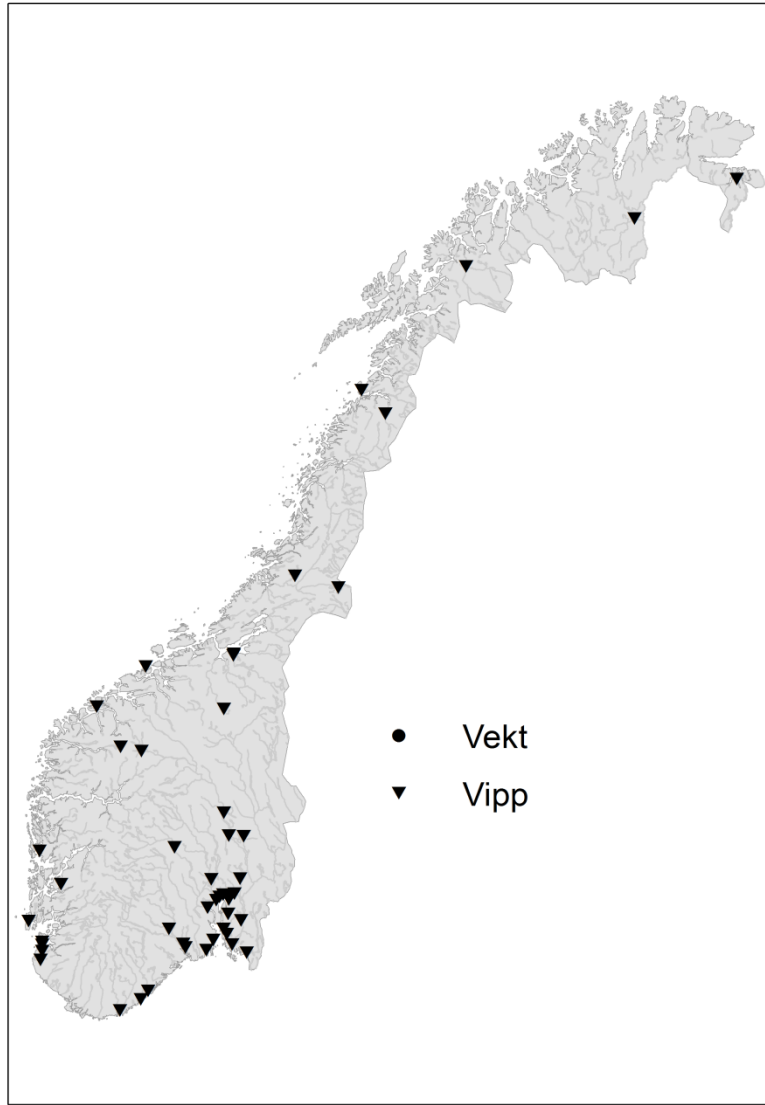
IVF-kurve i millimeter for 18701 OSLO - BLINDERN PLU. (Periode: 1968 - 2014. Antall sesonger: 46)



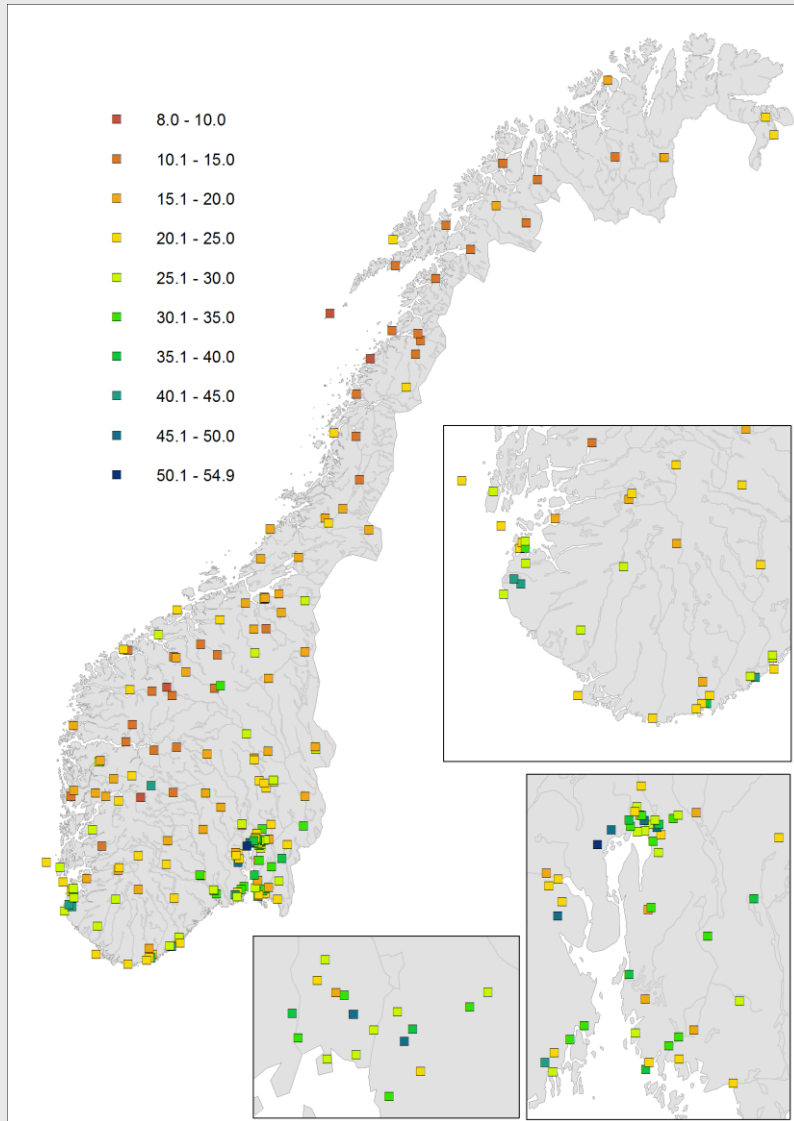
År	Varighet (minutter)										
	1	5	10	15	30	45	60	180	360	720	1440
2	1,7	5,7	8,4	10,3	14,0	16,2	17,6	22,8	25,9	35,0	42,3
5	2,2	7,6	11,4	14,3	19,6	23,2	25,1	30,2	34,1	44,1	51,0
10	2,6	8,9	13,3	16,9	23,4	27,9	30,1	35,2	39,5	49,7	57,0
20	2,9	10,2	15,2	19,4	27,0	32,3	35,0	40,0	44,7	55,3	63,1
25	3,0	10,6	15,8	20,2	28,1	33,8	36,5	41,5	46,4	57,0	64,8
50	3,3	11,8	17,7	22,6	31,6	38,1	41,1	46,1	51,4	62,6	70,0
100	3,6	13,0	19,5	25,1	35,1	42,4	45,8	50,8	56,4	67,8	76,0
200	3,9	14,2	21,3	27,5	38,6	46,8	50,5	55,4	61,3	73,4	81,2

Pluviometerstations, Norway 2015



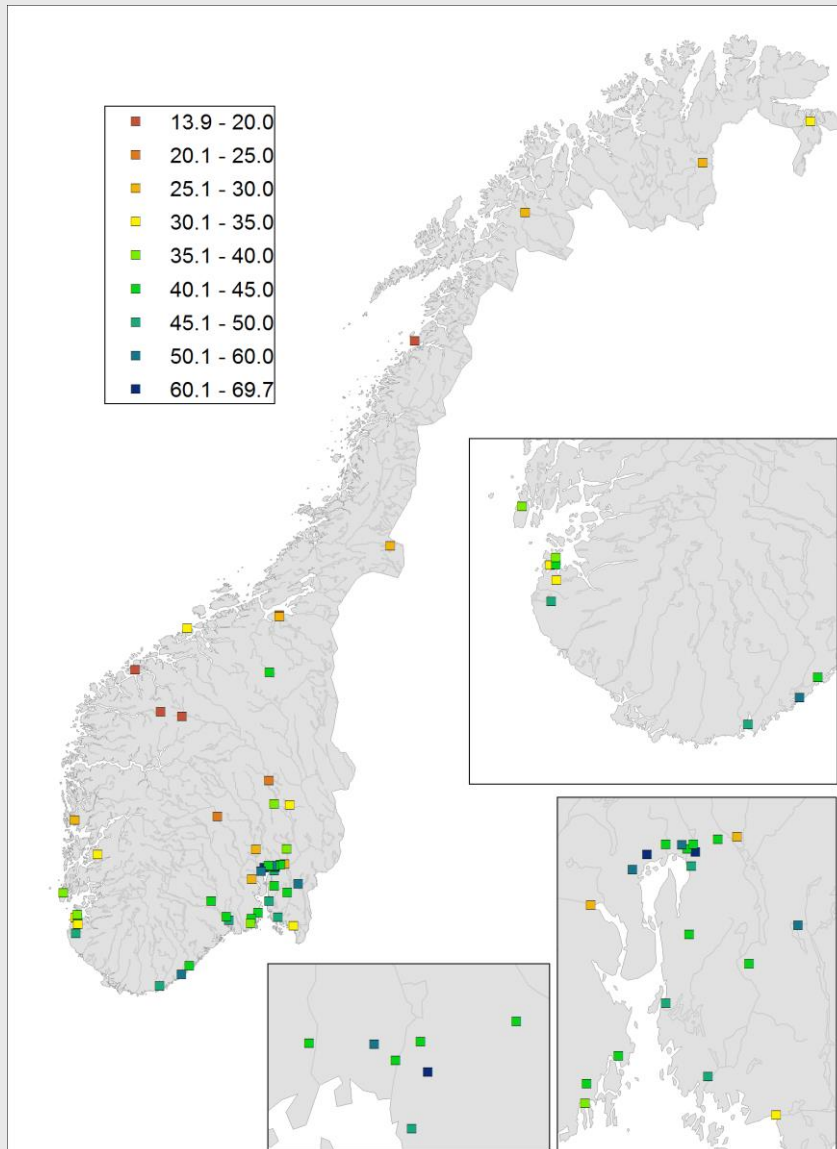


Stations with IDF-statistics (ajour May-2016)

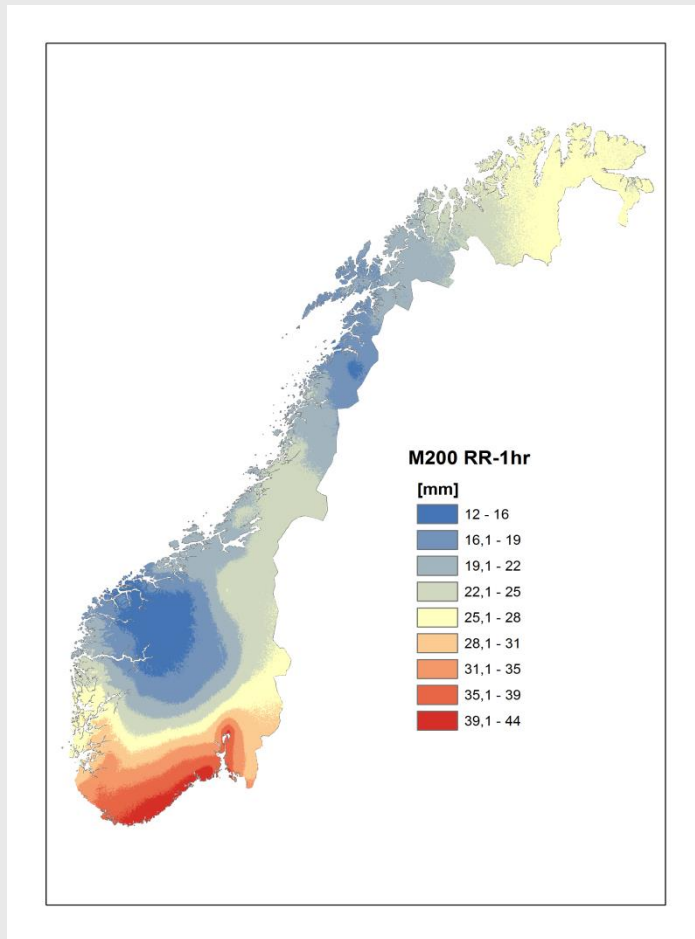


Observed maximum 1-hour rainfall 1968-2015

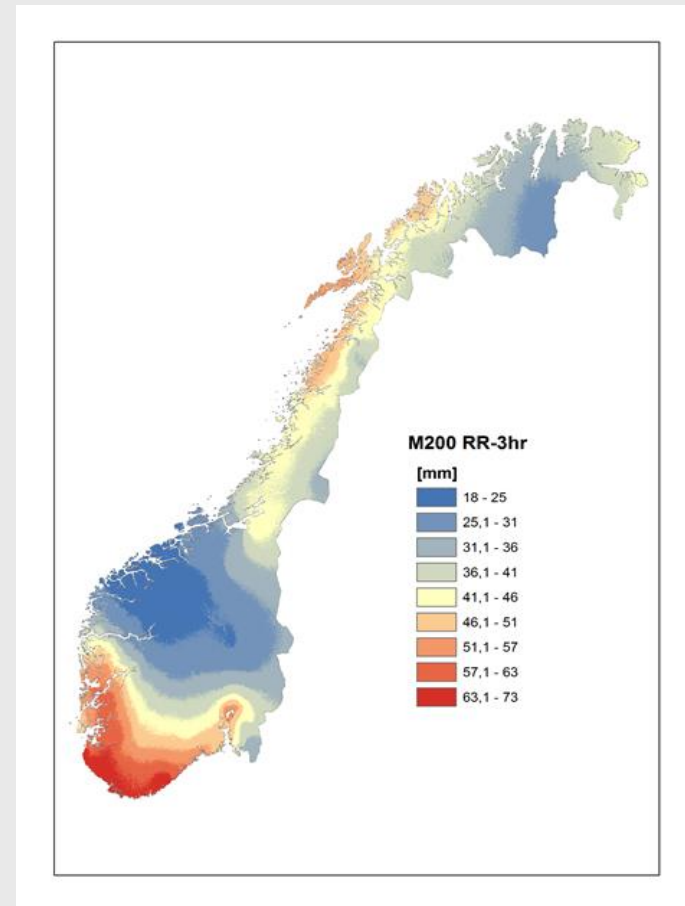
1 hour rainfall (mm), Return period 200 years



1h and 3h rainfall (mm), T = 200 years



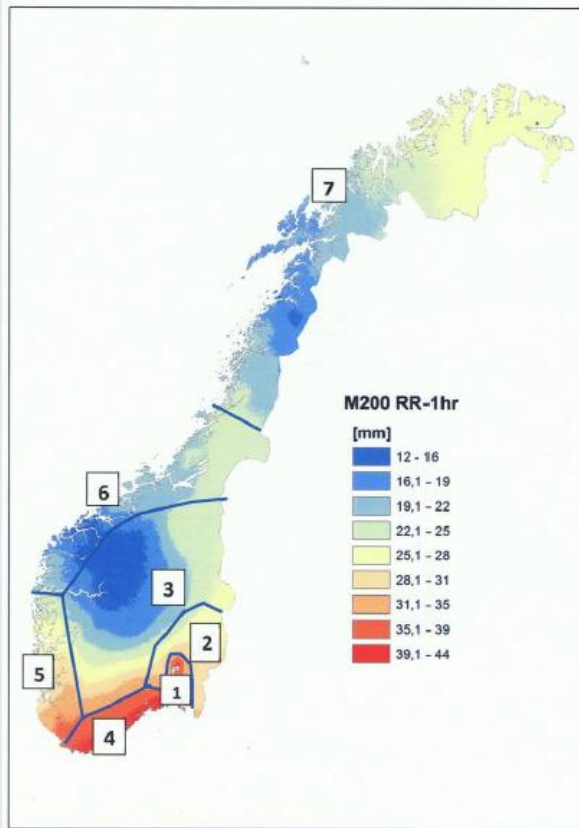
1 hour



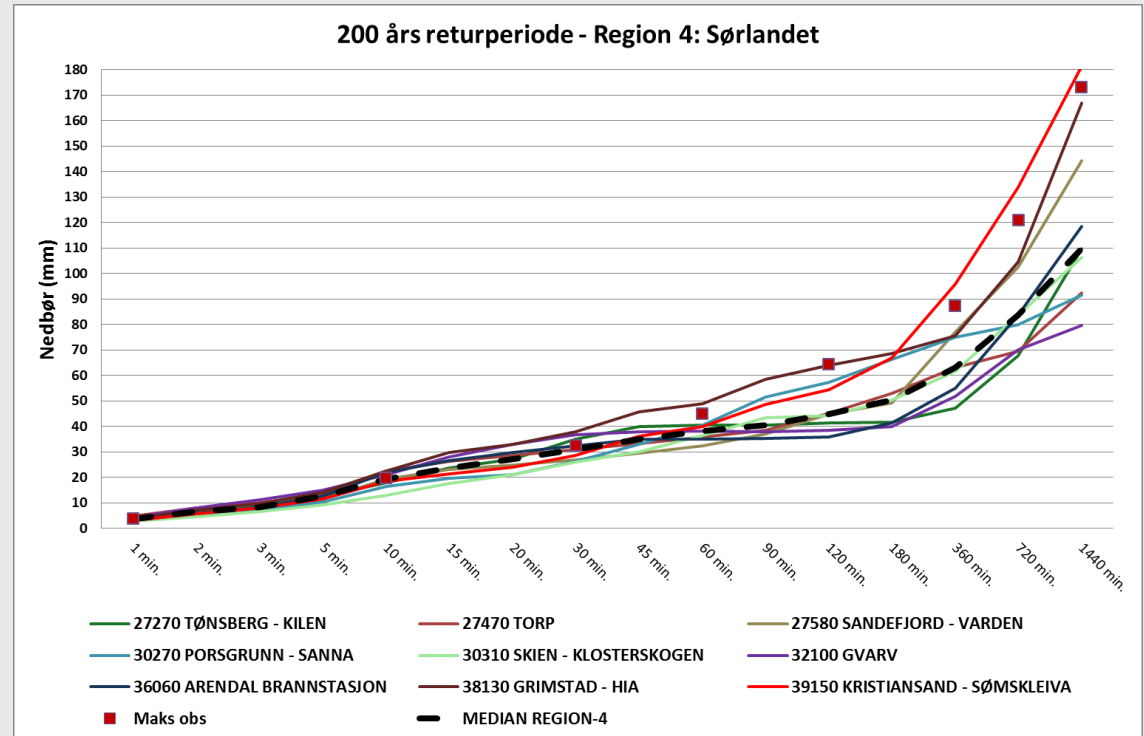
3 hours

Design values for heavy rainfall

(IDF = Intensity – Duration - Frequency)



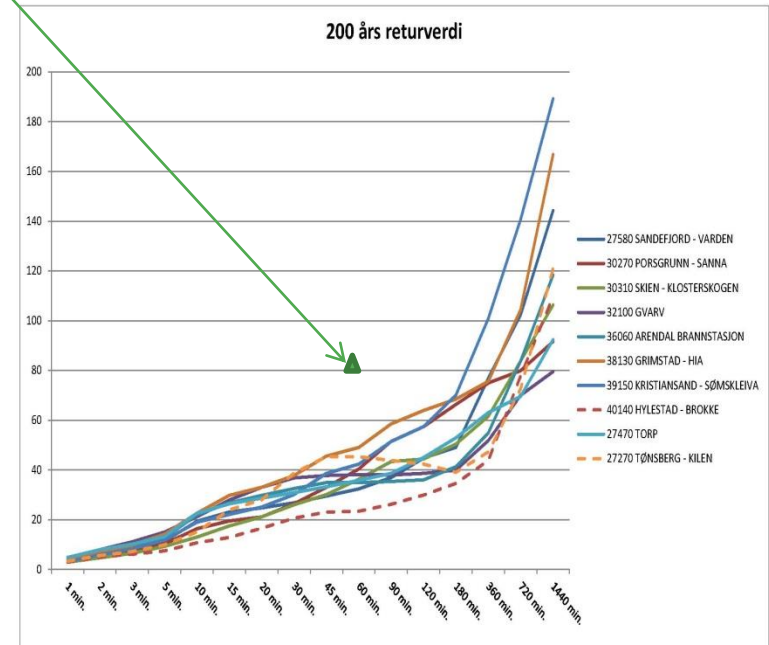
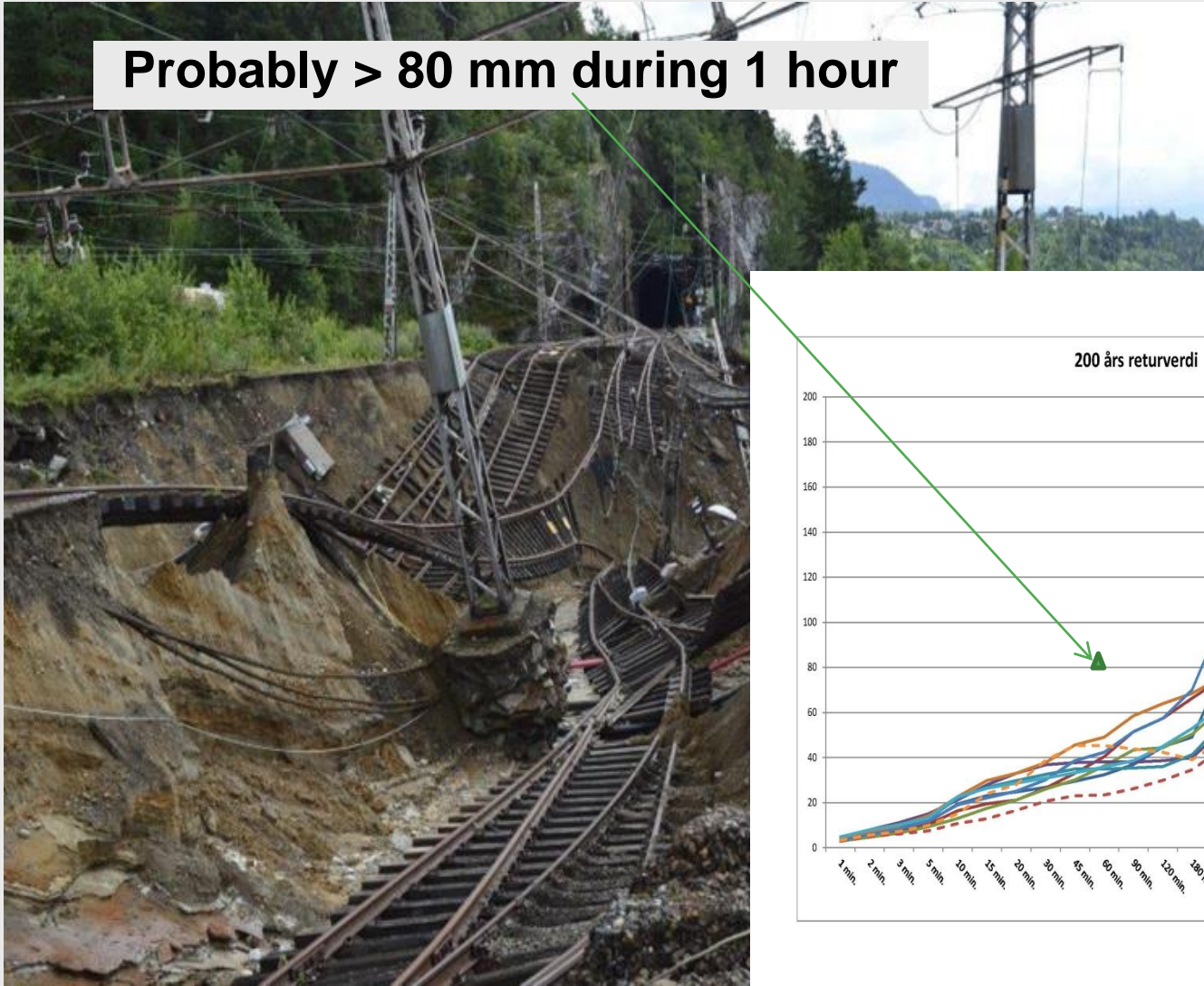
IDF-Regions



IDF-values for return period T=200 years for region 4 «Sørlandet»

Heavy rainfall: Notodden 24.July-2011

Probably > 80 mm during 1 hour



Nedre Eiker 6 - 7. August 2012 («Frida»)

Private measurements:

5 min: 21,8 mm

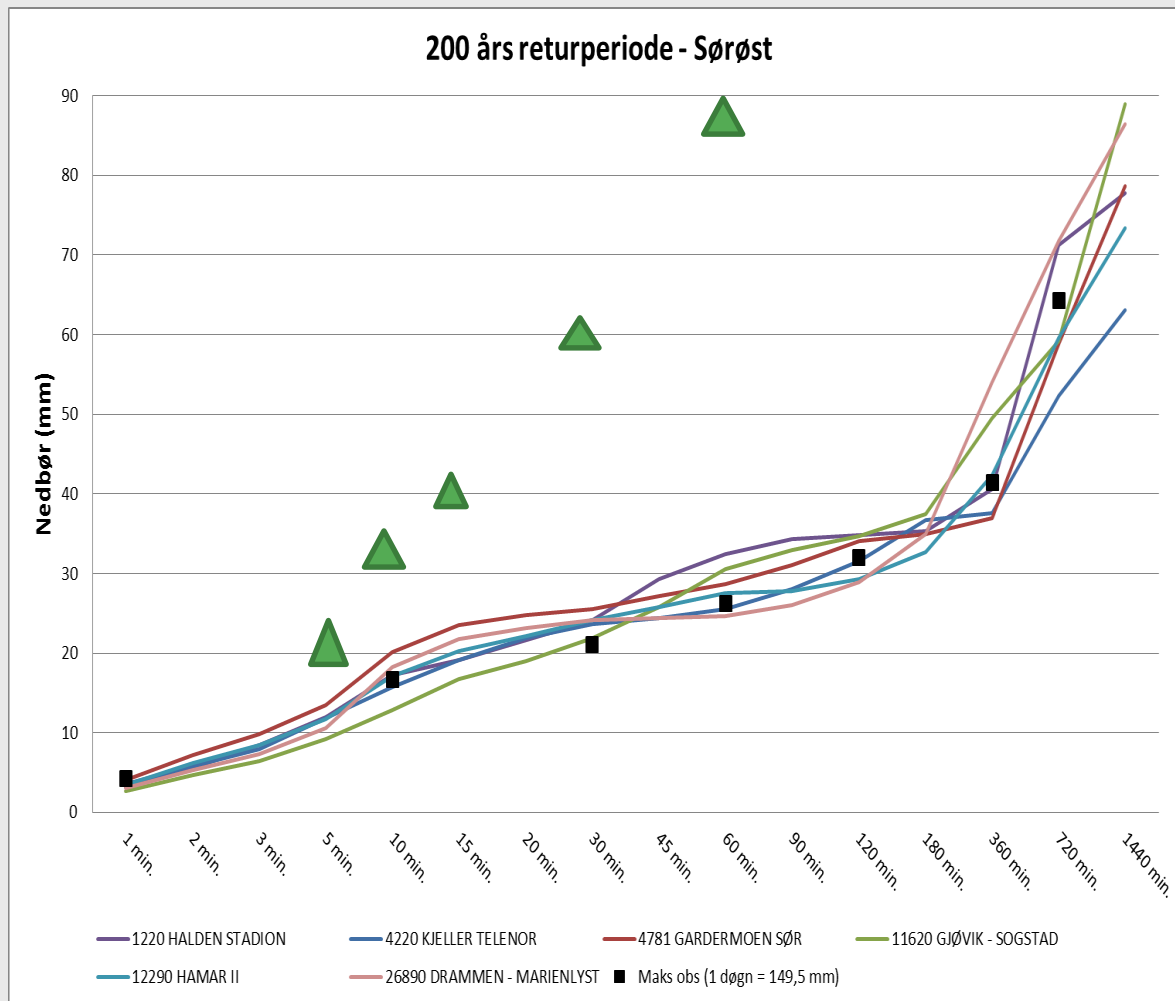
10 min: 32,0 mm

15 min: 38,7 mm

30 min: 59,4 mm

1 hour: 88,2 mm

2 hrs: 114,2 mm



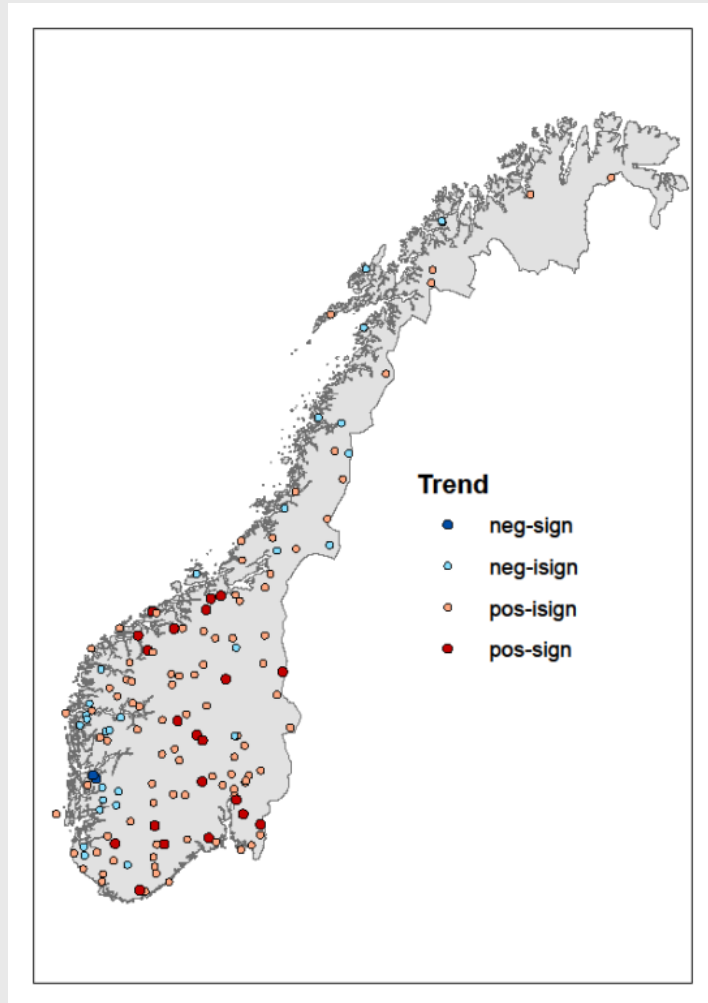
Probability of exceedance of return period values for different time periods

$$P = 1 - \left\{1 - \frac{1}{T}\right\}^L$$

where T is Return period, and P is Probability for higher values during L years

Return period T	Period Length (years)					
Years	10	50	100	200	500	1000
10	65	99	100	100	100	100
50	18	64	87	98	100	100
100	10	40	63	87	99	100
200	5	22	39	63	92	99
500	2	10	18	33	63	86
1000	1	5	10	18	39	63

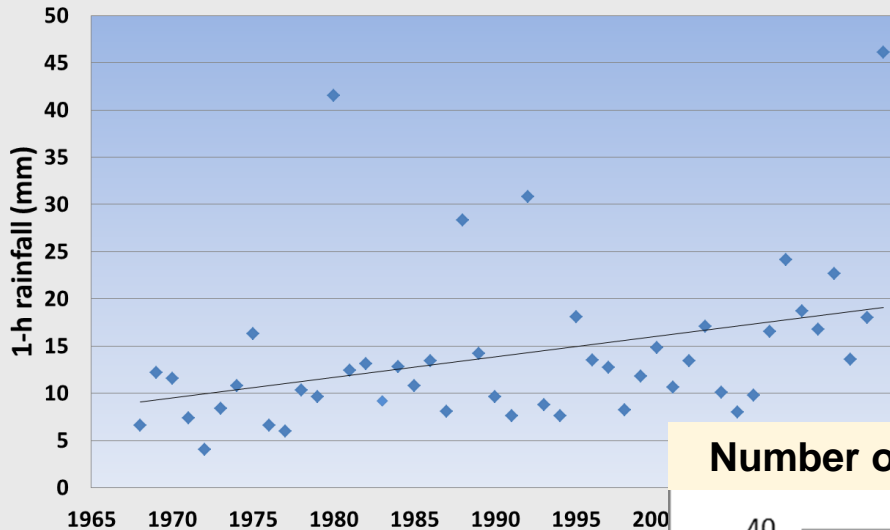
Trends for highest 1-day rainfall during summer season 1968-2014



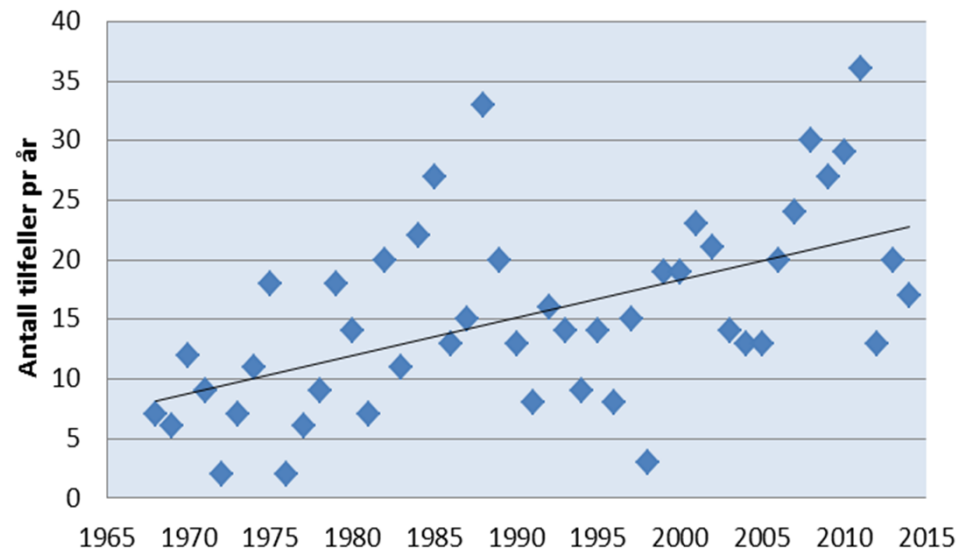
Red = positive
Blue = negative
(dark colors: Stat. sign. 95 % level)

1-hour rainfall Oslo-Blindern 1968-2014

Maximum 1-h rainfall, Oslo (mm)



Number of cases/year with hourly rainfall > 5 mm



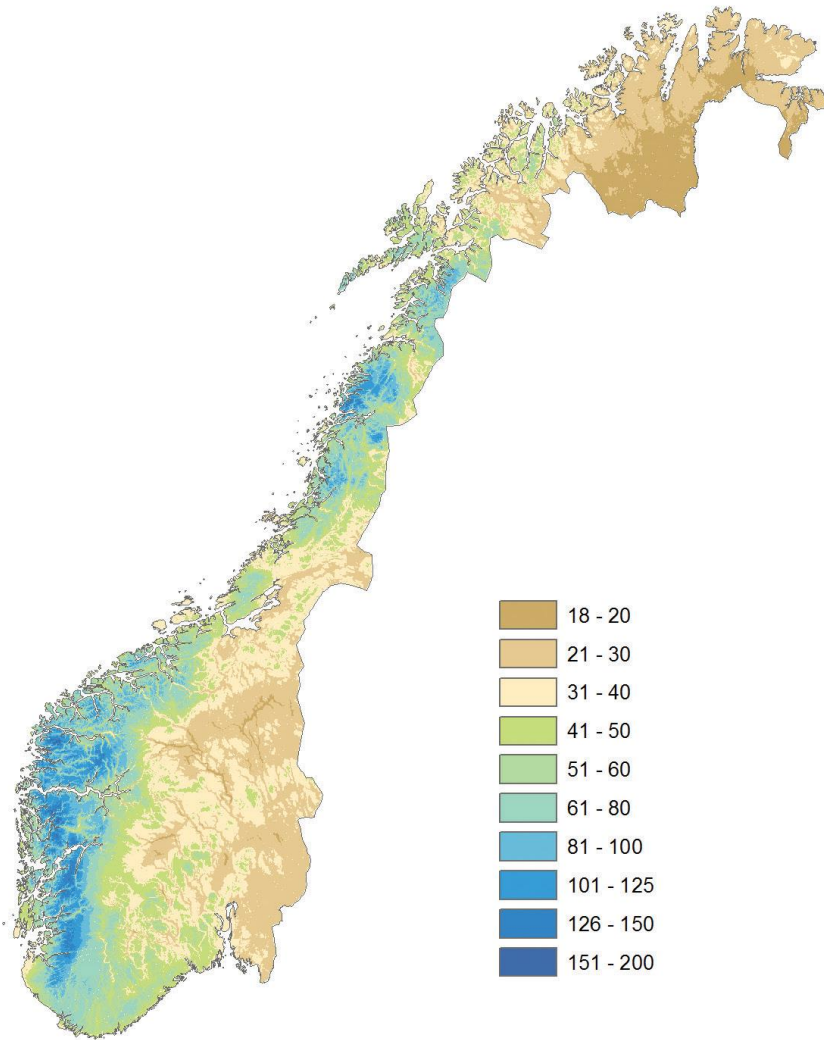
Trends in short-term rainfall 1968-2014*

Red: Positive trend, Blue: Negative trend

Dark: Statistically significant trend (95%), light: non-significant

* Some stations have shorter series

Duration (minutes)	Highest annual value				Peak Over Threshold		
	10	30	60		10	30	60
4781 Gardermoen							
12290 Hamar							
17870 Ås							
18020 Oslo-Lambertseter							
18320 Oslo-Hausmannsgt							
18701 Oslo-Blindern							
19710 Asker							
39150 Kristiansand							
64300 Kristiansund-Karih.							
68230 Trondheim-Risv.							



**Extreme daily rainfall:
Rainfall (mm/day)
exceeded in
0,5 % of days
during 1971–2000**

Climate factor

$$Cf (GI, T, D, Z, S) = I(GI, T, D, Z, S) / I(GI, t, D, Z)$$

Cf = Climate factor

*I = Design value for rainfall intensity [l/s*ha or mm]*

GI = Return period (years)

D = Rainfall duration

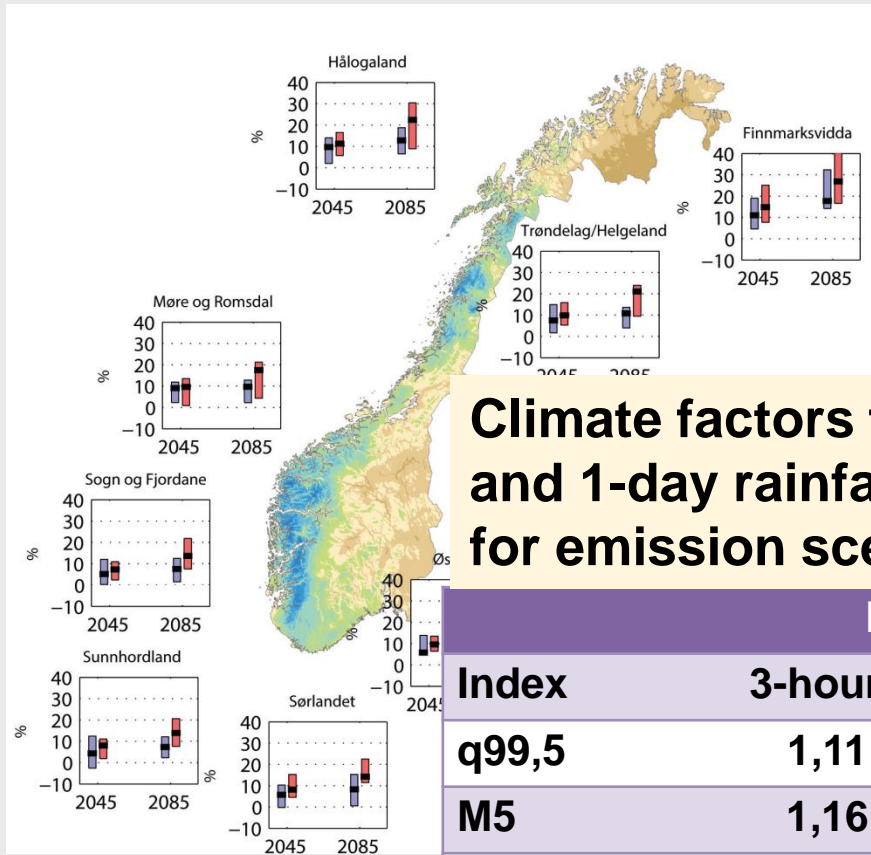
Z = Geographic position (lat, lon, elevation)

t = reference period (e.g. 1980-2010)

T = Projection period (e.g. 2071-2100)

S = Climate emission scenario (e.g. RCP8.5)

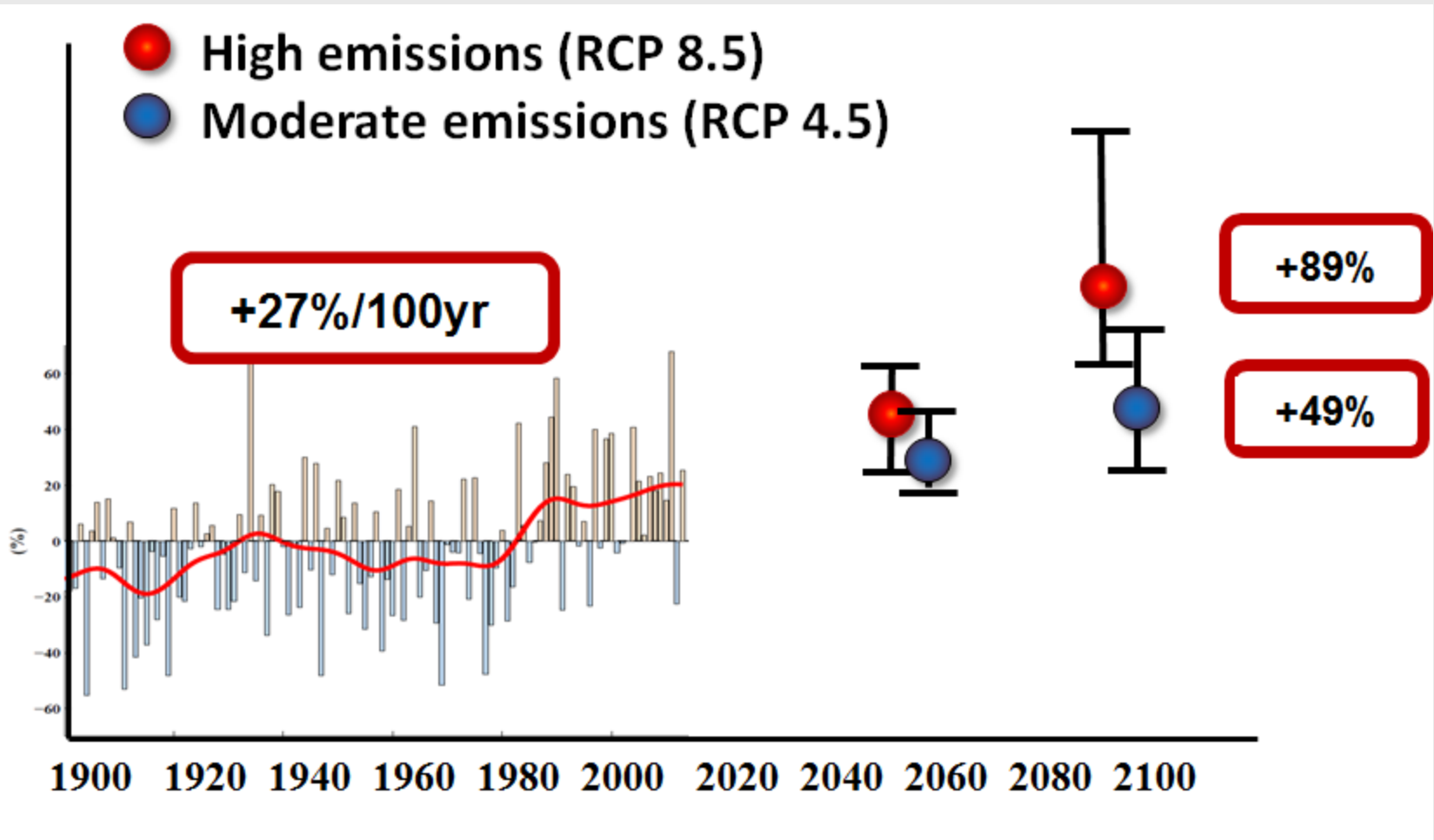
Change (%) in precipitation amount for days with heavy rainfall



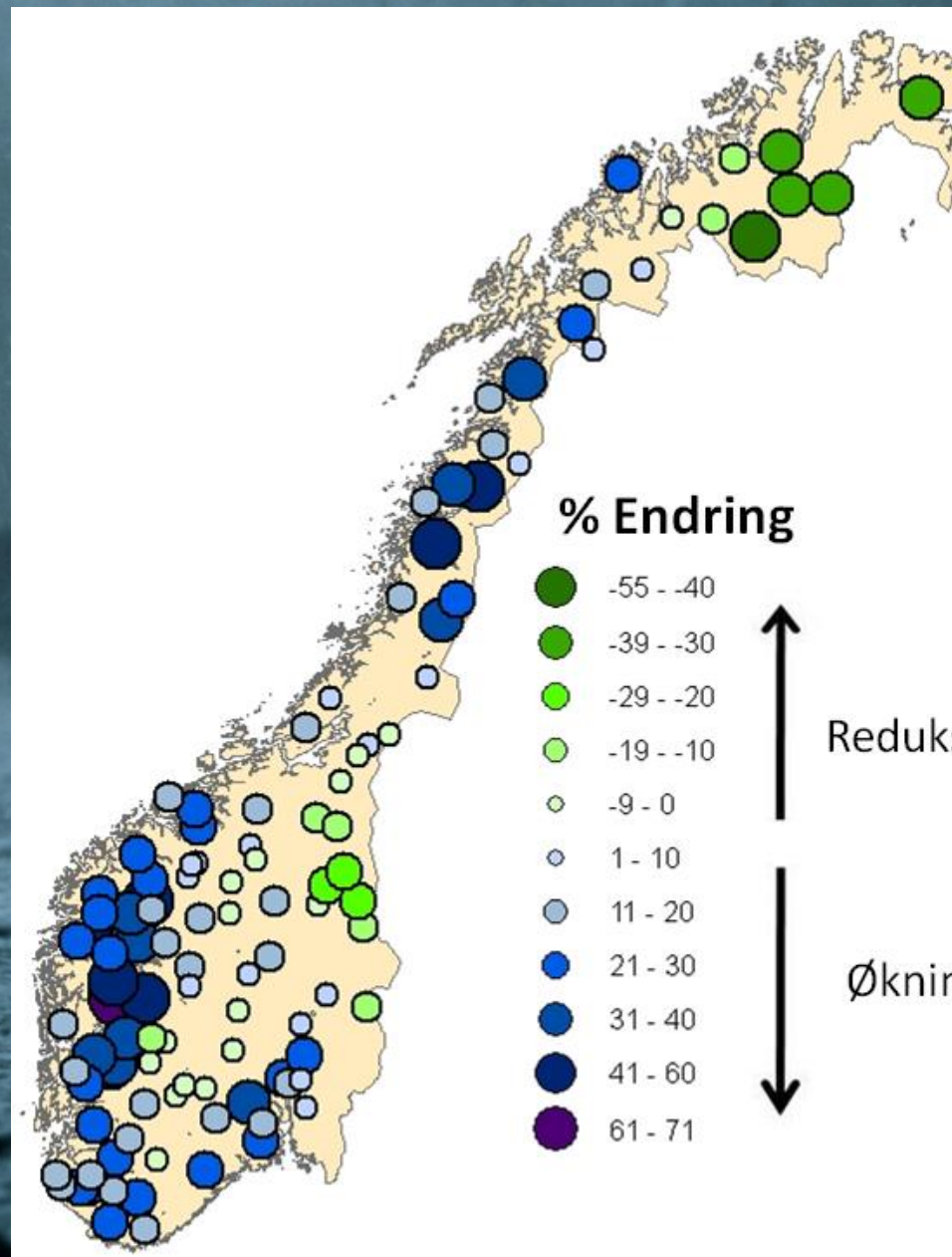
Climate factors for Norway for change in 3 hourly and 1-day rainfall from 1976-2005 to 2071-2100 for emission scenarios RCP4.5 and RCP8.5.

Index	RCP4.5		RCP8.5	
	3-hours	1-day	3-hours	1-day
q99,5	1,11	1,11	1,20	1,20
M5	1,16	1,13	1,28	1,22
M200	1,19	1,14	1,38	1,26

Number of extreme events

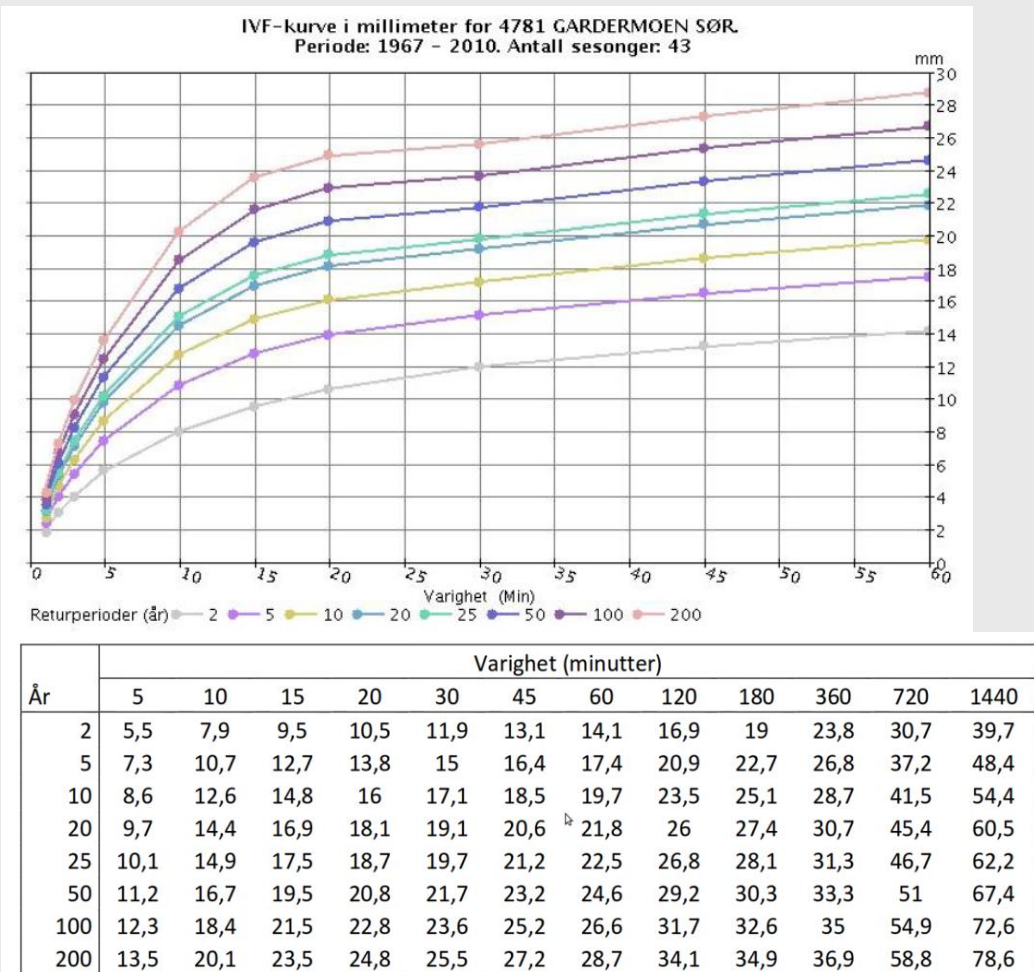
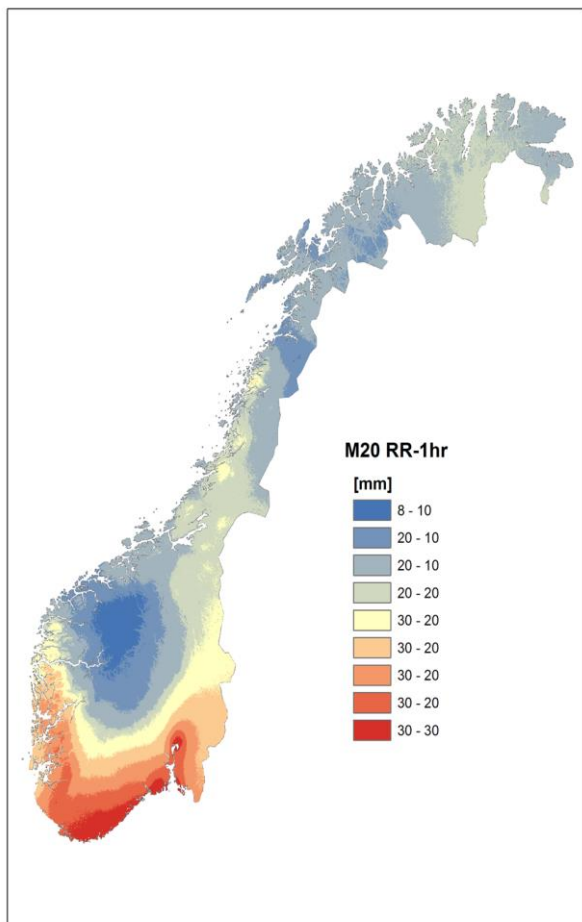


Projected change in «200-year flood» up to year 2100



Ongoing development at NCCS and ExPrecFlood-project

→ Interactive IDF-statistics for various durations and return periods for present and future climate (incl. uncertainty estimates)



Uncertainty

End users want a measure of uncertainty!

- Limited observational network
- Short time series
- Estimation method

- Climate models
- Emission scenario

