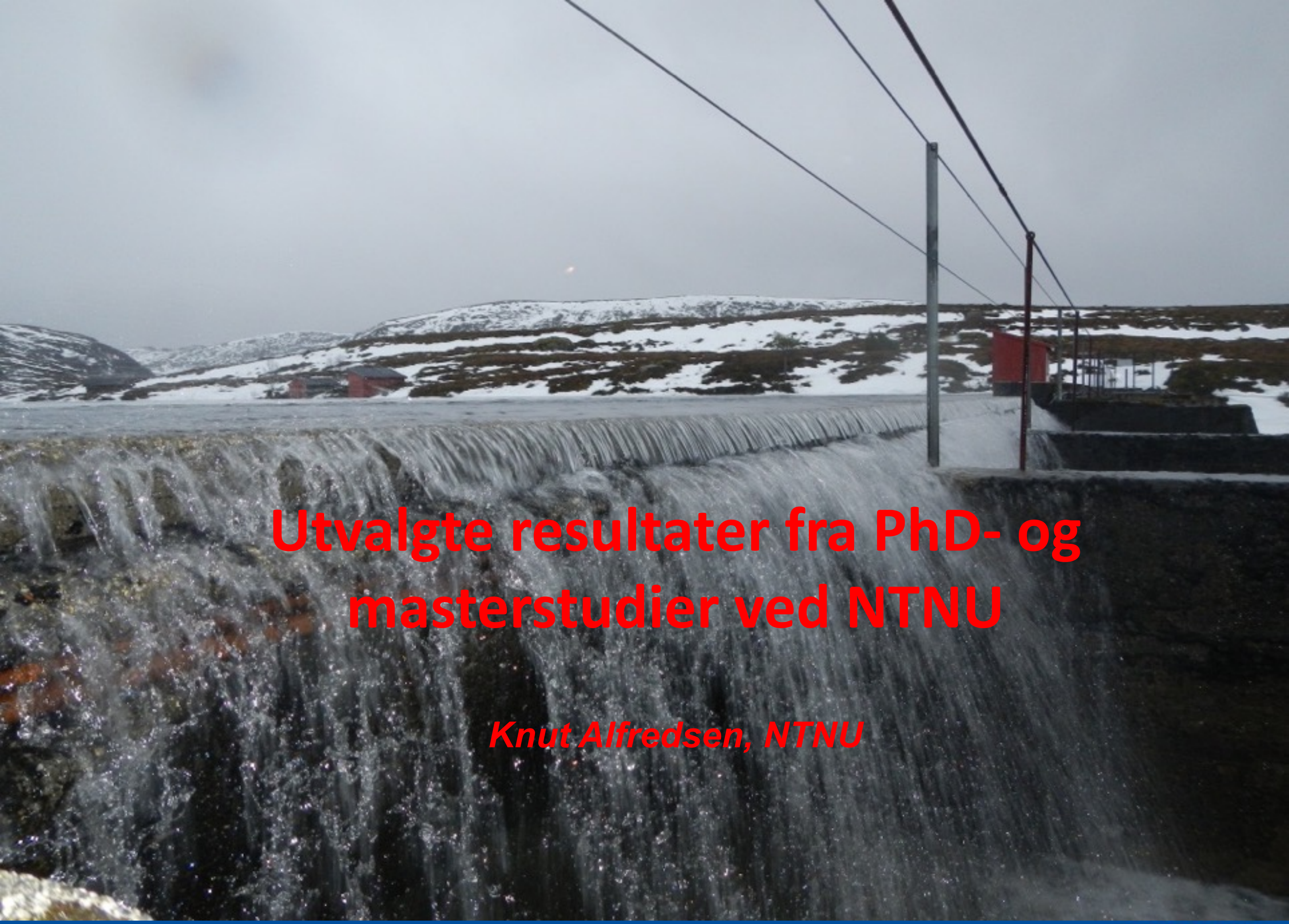
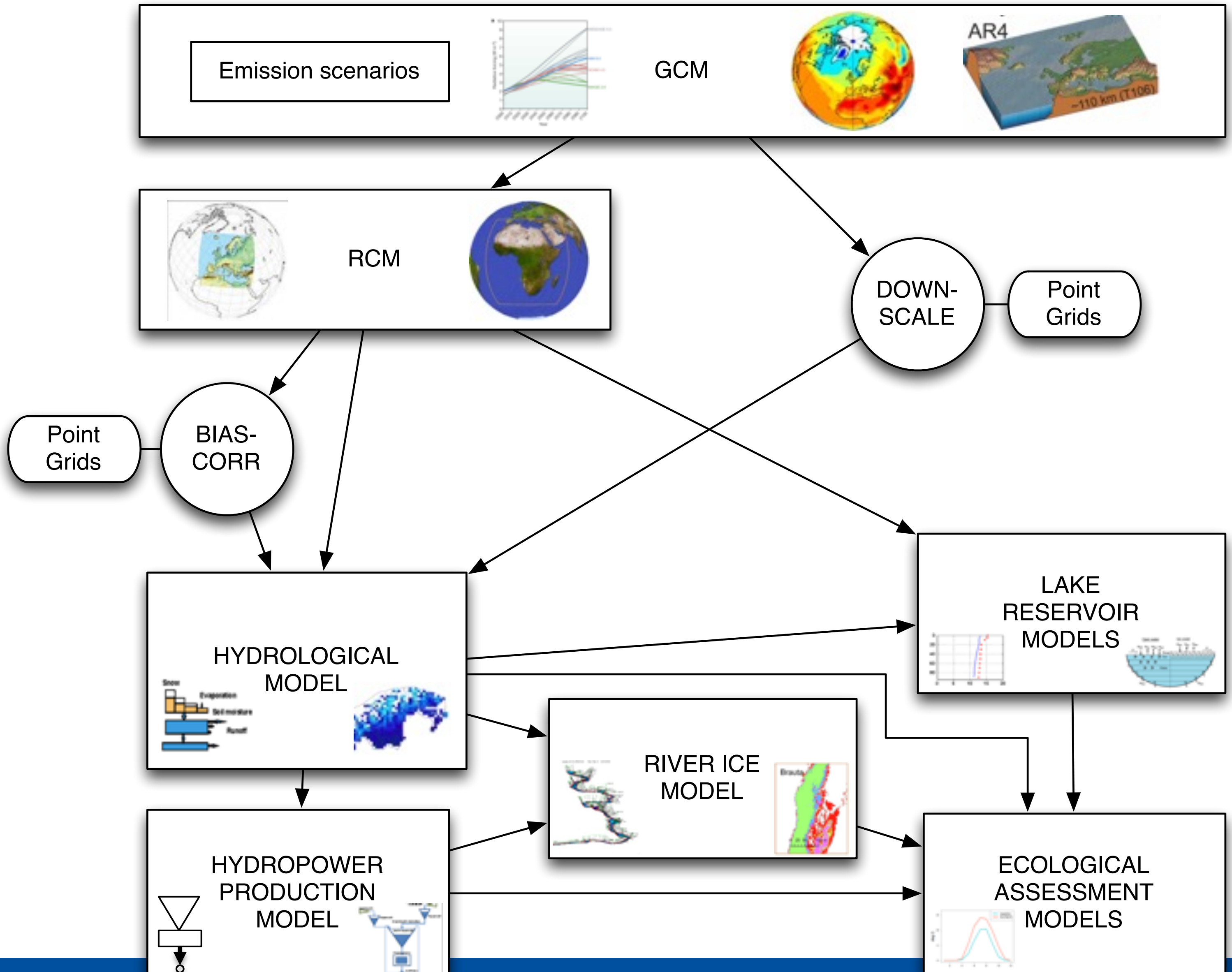


Utvalgte resultater fra PhD- og masterstudier ved NTNU

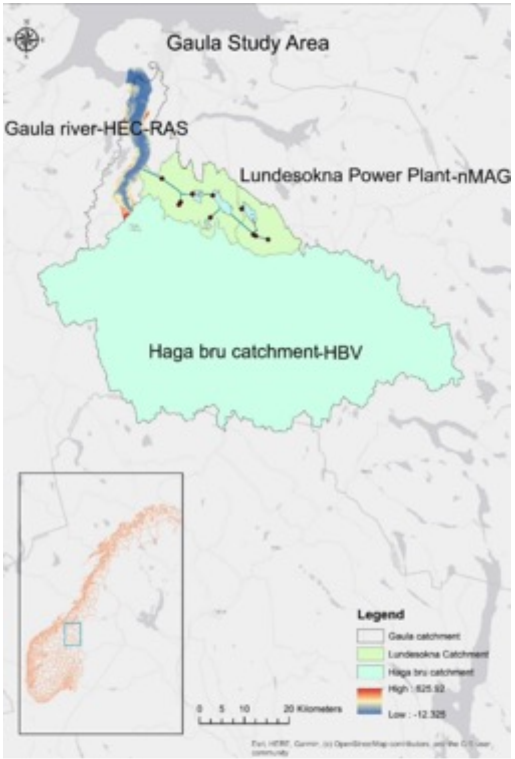
Knut Alfredsen, NTNU

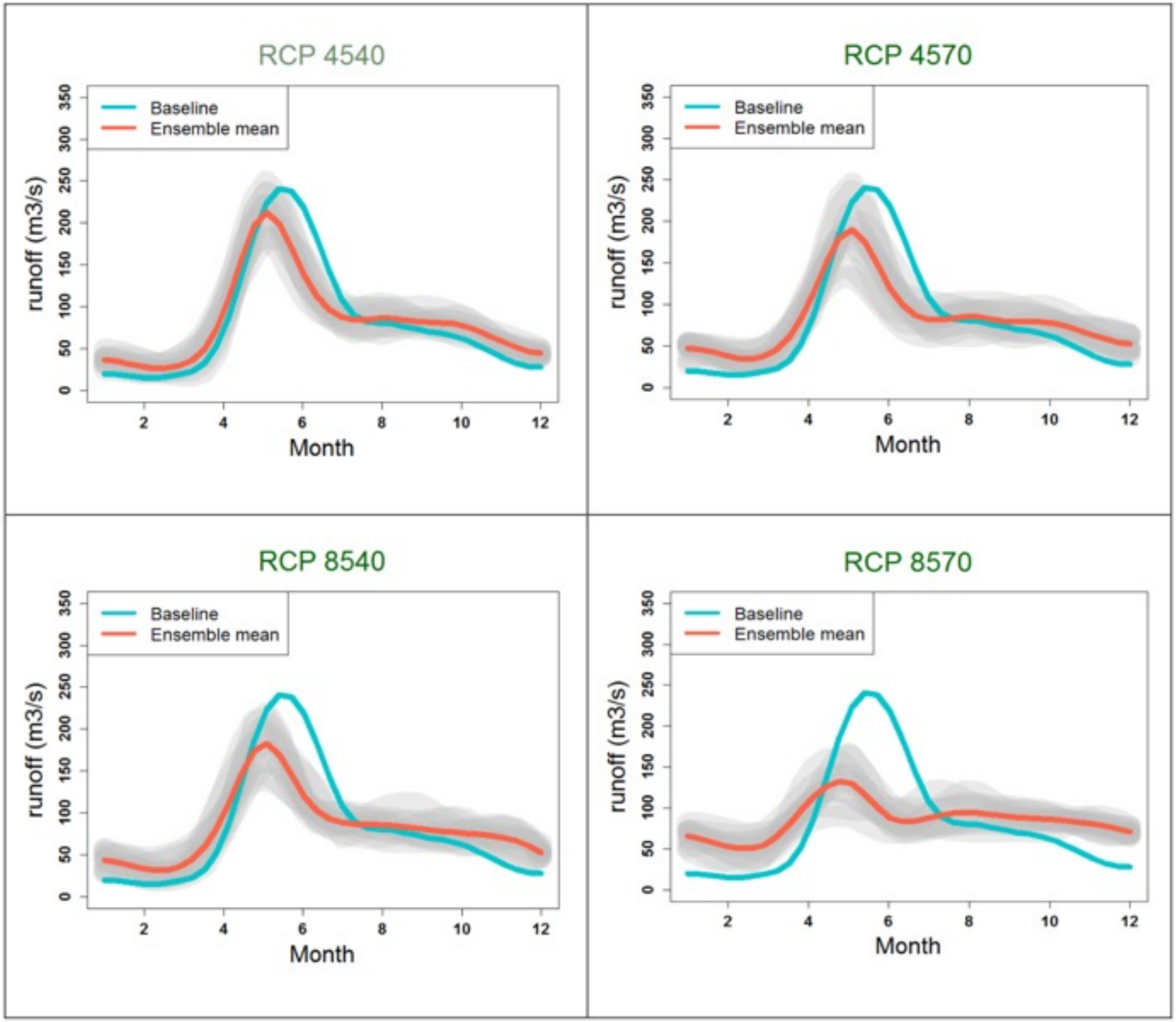
NTNU

Metodeoppsummering



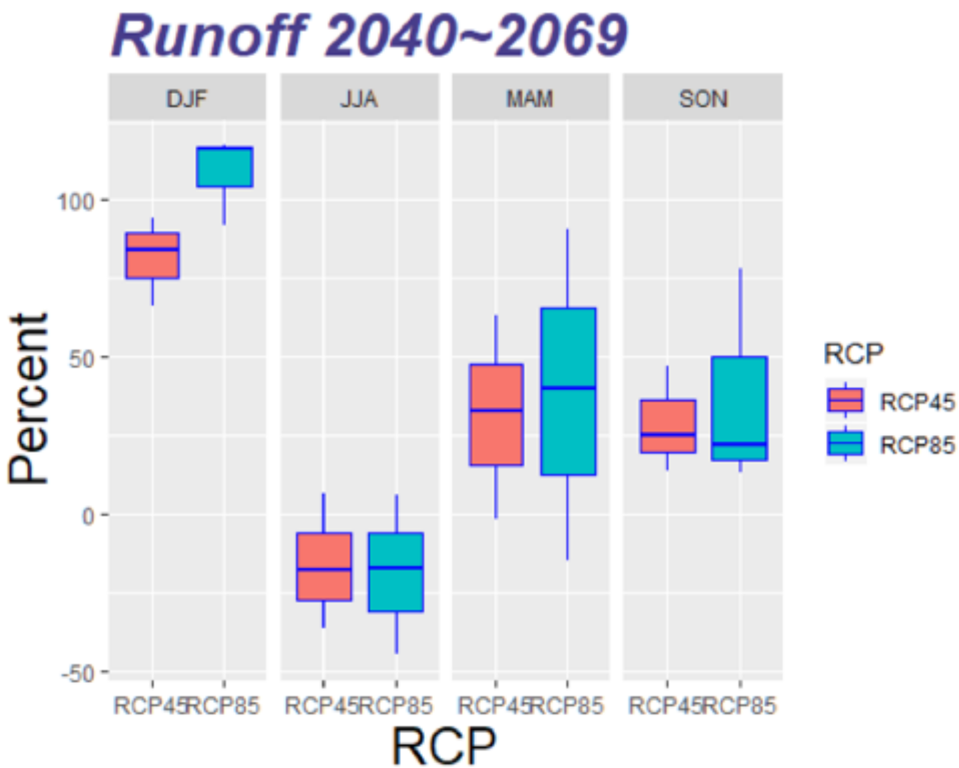
Tilsig Gaula

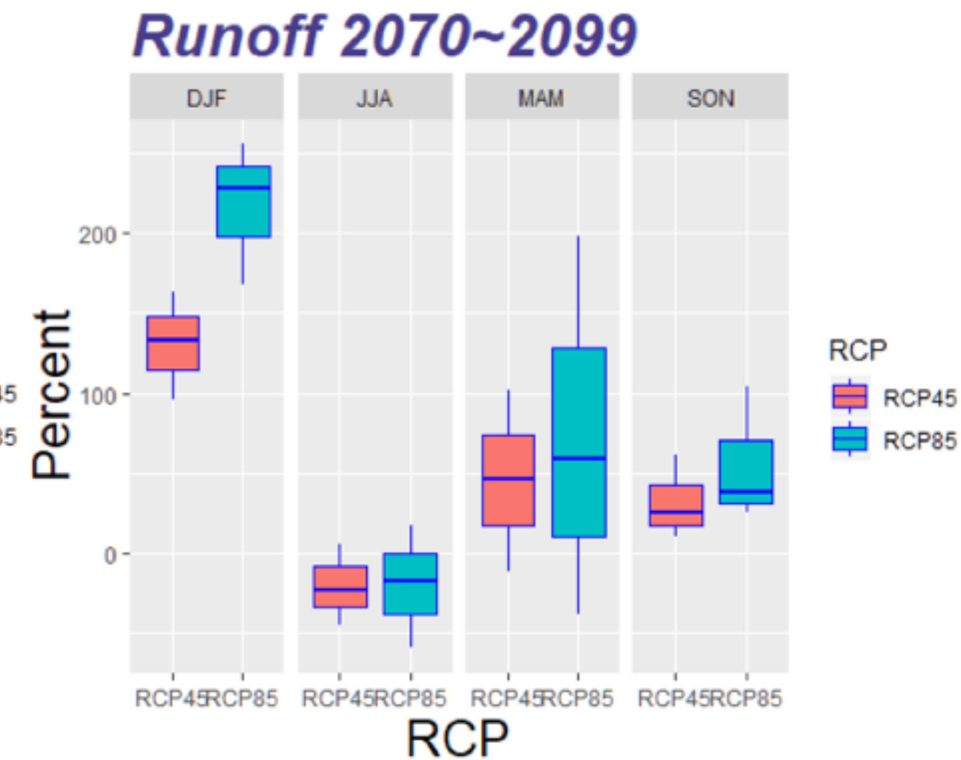




Kamrun Naher (2019) «Climate Change Assessments for the Gaula River» Masteroppgåve, NTNU

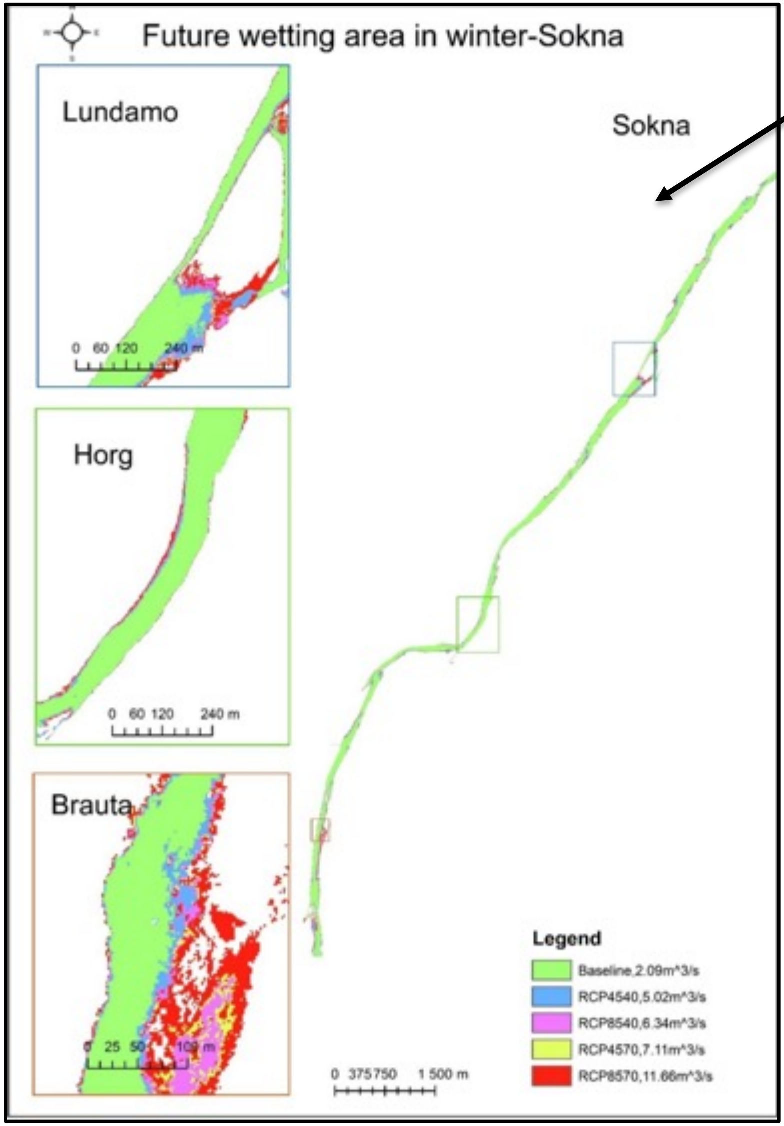
Sesongvariasjon



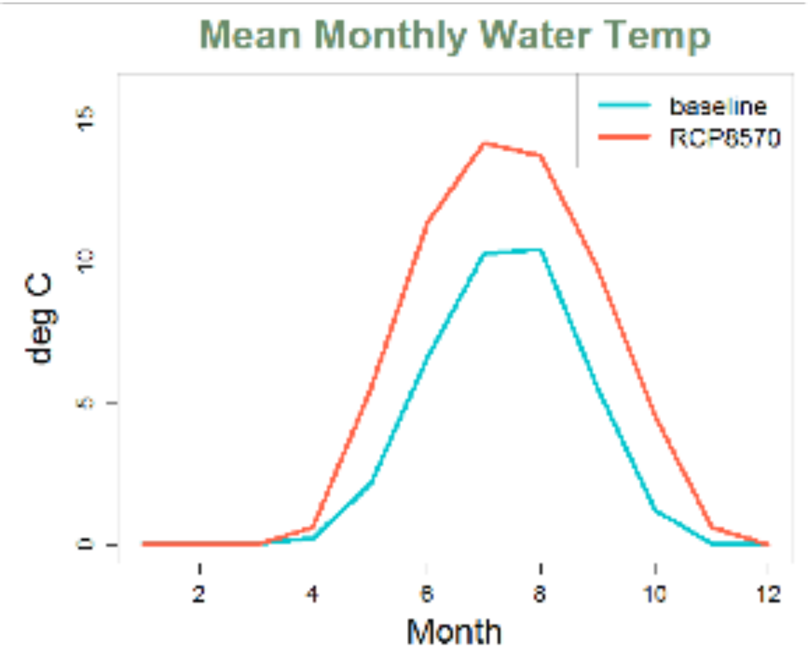


Kamrun Naher (2019) «Climate Change Assessments for the Gaula River» Masteroppgåve, NTNU

Effekt av endringar



Vassdekt areal, 25-percentil vassføring vinter



Vasstemperatur, Eggafoss

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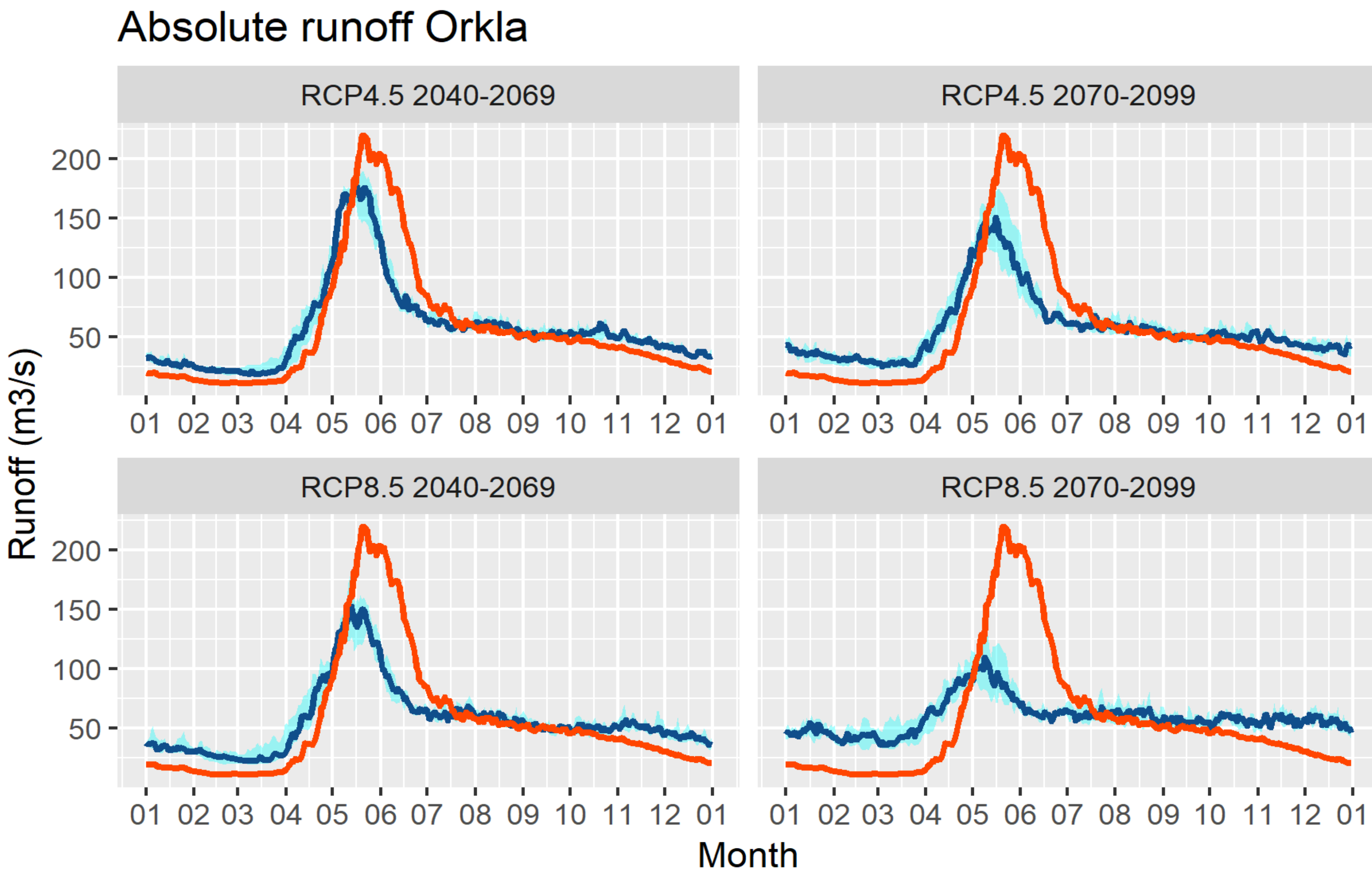
Tilsig Orkla



Red-control period, blue – future scenarios

 Lars deGraaff (2019) MSc, NTNU/Univ. Wageningen

Mean monthly discharge changes Orkla (Grana)

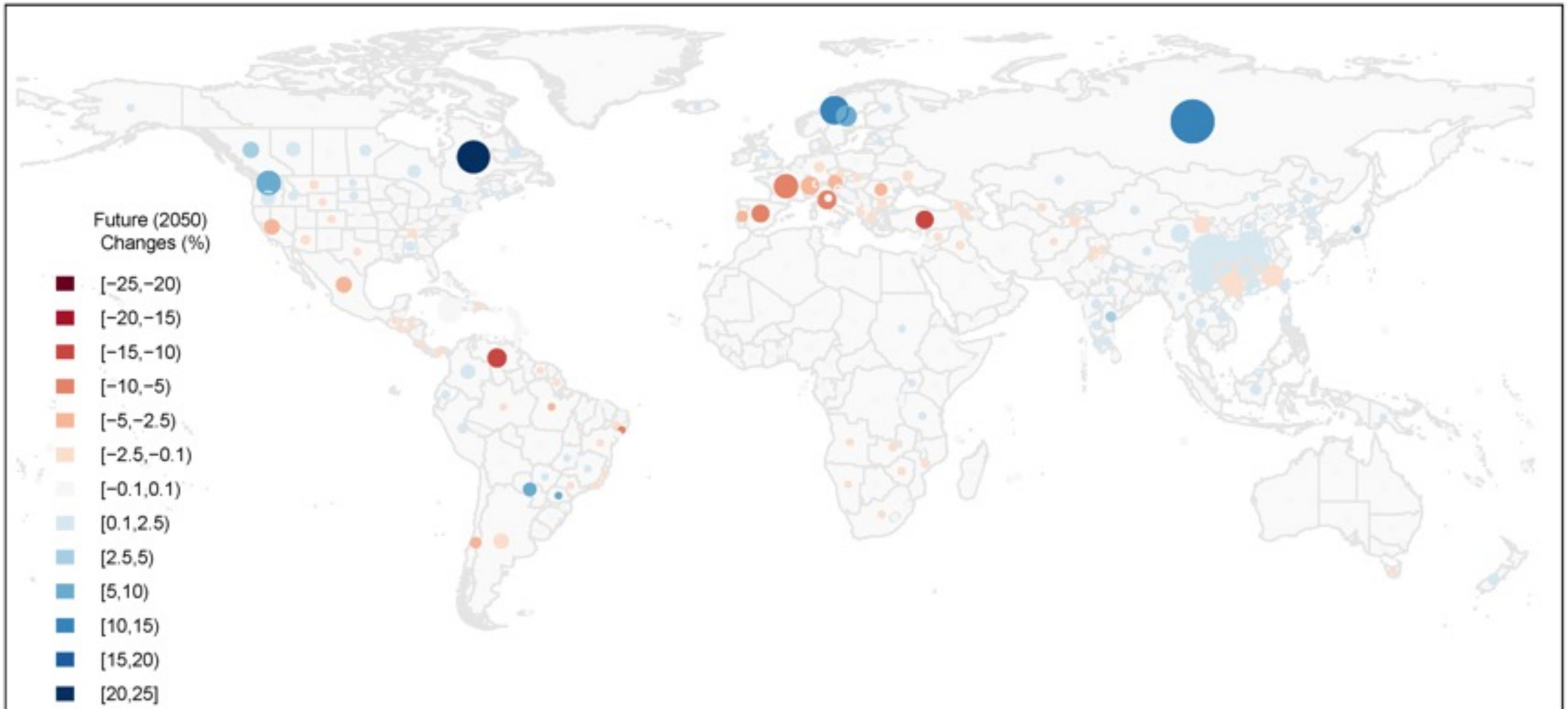
Mean monthly discharge changes Orkla (Bjørset)

Orkla - Grana	Control 1971-2000	Rcp4.5 2040-2069	Rcp4.5 2070-2099	Rcp8.5 2040-2069	Rcp8.5 2070-2099
Mean value January	42.13	51.40	59.76	56.09	66.92
Mean value February	38.83	47.30	54.56	51.02	63.52
Mean value March	38.51	45.79	51.95	50.10	60.44
Mean value April	53.97	69.31	66.45	71.92	71.99
Mean value May	70.21	68.49	56.45	61.12	43.33
Mean value June	77.84	41.65	45.10	37.56	29.45
Mean value July	42.08	29.57	27.97	30.03	27.02
Mean value August	30.99	30.62	28.59	28.67	29.63
Mean value September	31.17	29.67	29.12	28.24	28.96
Mean value October	48.33	51.03	47.67	46.35	46.52
Mean value November	45.29	51.40	51.67	53.55	57.63
Mean value December	37.15	46.90	50.18	51.81	61.52
Mean value winter (m3/s)	40.08	48.71	55.29	55.23	64.39
Mean value spring (m3/s)	56.05	62.84	58.14	59.90	58.90
Mean value summer (m3/s)	50.29	34.65	32.85	32.51	29.37
Mean value autumn (m3/s)	41.72	45.26	43.21	43.35	43.99
Average runoff (m3/s)	46.89	47.62	47.56	47.65	49.74
Annual 1 day max (m3/s)	209.30	195.56	200.65	198.31	214.78
Annual 1 day min (m3/s)	10.33	14.18	13.56	14.13	15.07
Annual 3 day max (m3/s)	194.26	177.77	178.59	175.49	186.44
Annual 3 day min (m3/s)	12.42	15.74	14.71	15.85	15.48
Annual 7 day max (m3/s)	167.14	148.30	142.97	143.61	147.59
Annual 7 day min (m3/s)	14.07	16.66	15.43	16.66	16.00
Date of 1 day max (day)	147.52	164.78	161.15	171.50	198.27
Date of 1 day min (day)	220.30	233.38	212.67	230.93	225.23
Winter/spring 1 day max (m3/s)	206.26	182.32	176.19	169.57	160.85
Date of winter/spring 1 day max (day)	137.17	121.03	106.55	106.53	84.05
Summer/autumn 1 day max (m3/s)	125.86	148.49	136.36	150.91	175.59
Date of summer/autumn 1 day max (day)	246.05	273.55	270.82	281.80	293.02
Winter/spring 1 day min (m3/s)	14.40	19.45	17.72	19.15	18.97
Date of winter/spring 1 day min (day)	121.74	135.37	142.85	142.52	155.35
Summer/autumn 1 day min (m3/s)	13.60	15.71	15.30	15.35	15.78
Date of summer/autumn 1 day min (day)	308.60	268.32	258.35	264.17	240.98
Winter 1 day max (m3/s)	56.87	81.19	101.75	97.35	125.86
Beginning of snowmelt (day)	122.22	116.60	110.89	108.52	109.13
Low flow (m3/s)	18.64	19.59	18.35	19.22	18.21
No. of high pulses (-)	8.50	9.05	8.78	8.67	8.75
No. of low pulses (-)	7.07	6.63	6.65	6.67	6.92
No. of winter high pulses (-)	0.92	1.65	1.97	1.72	2.38
No. of winter low pulses (-)	2.07	1.40	1.47	1.53	1.55
No. of summer low pulses (-)	3.98	4.85	4.72	4.63	5.07
Mean duration of high pulses (day)	12.00	11.05	11.58	11.51	11.75
Mean duration of low pulses (day)	15.10	16.00	15.95	15.99	15.95
Mean duration of winter/spring low pulses (day)	9.83	7.15	8.32	7.43	8.56
Mean duration of summer/autumn low pulses (day)	22.79	20.76	19.71	20.91	19.67

 Lars deGraaff (2019) MSc, NTNU/Univ. Wageningen

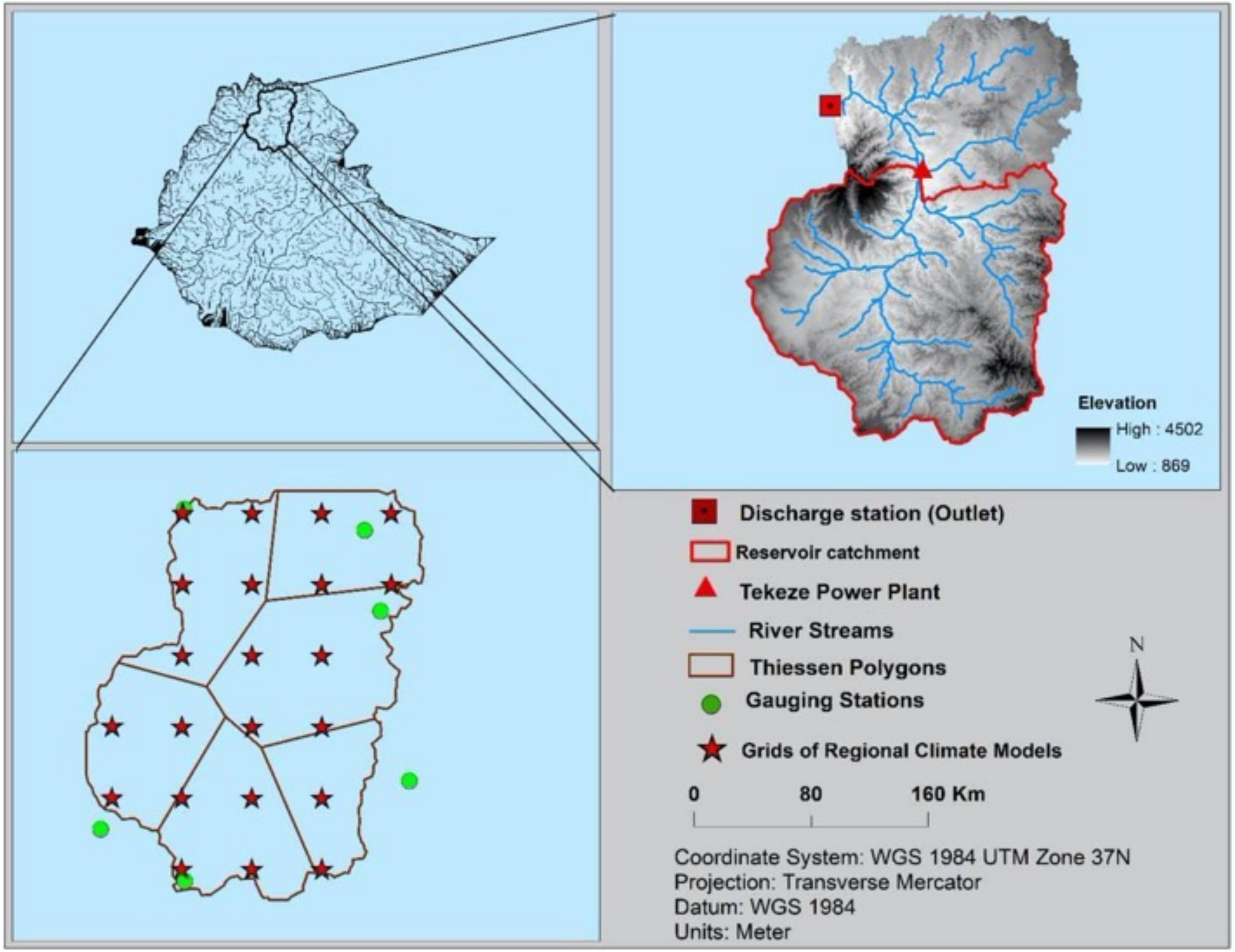
Kraftproduksjon

- Global oversikt
- Vurderingar av regionar og enkeltsystem



Hamududu og Killingtveit (2012) Energies

Tekeze power plant, Ethiopia



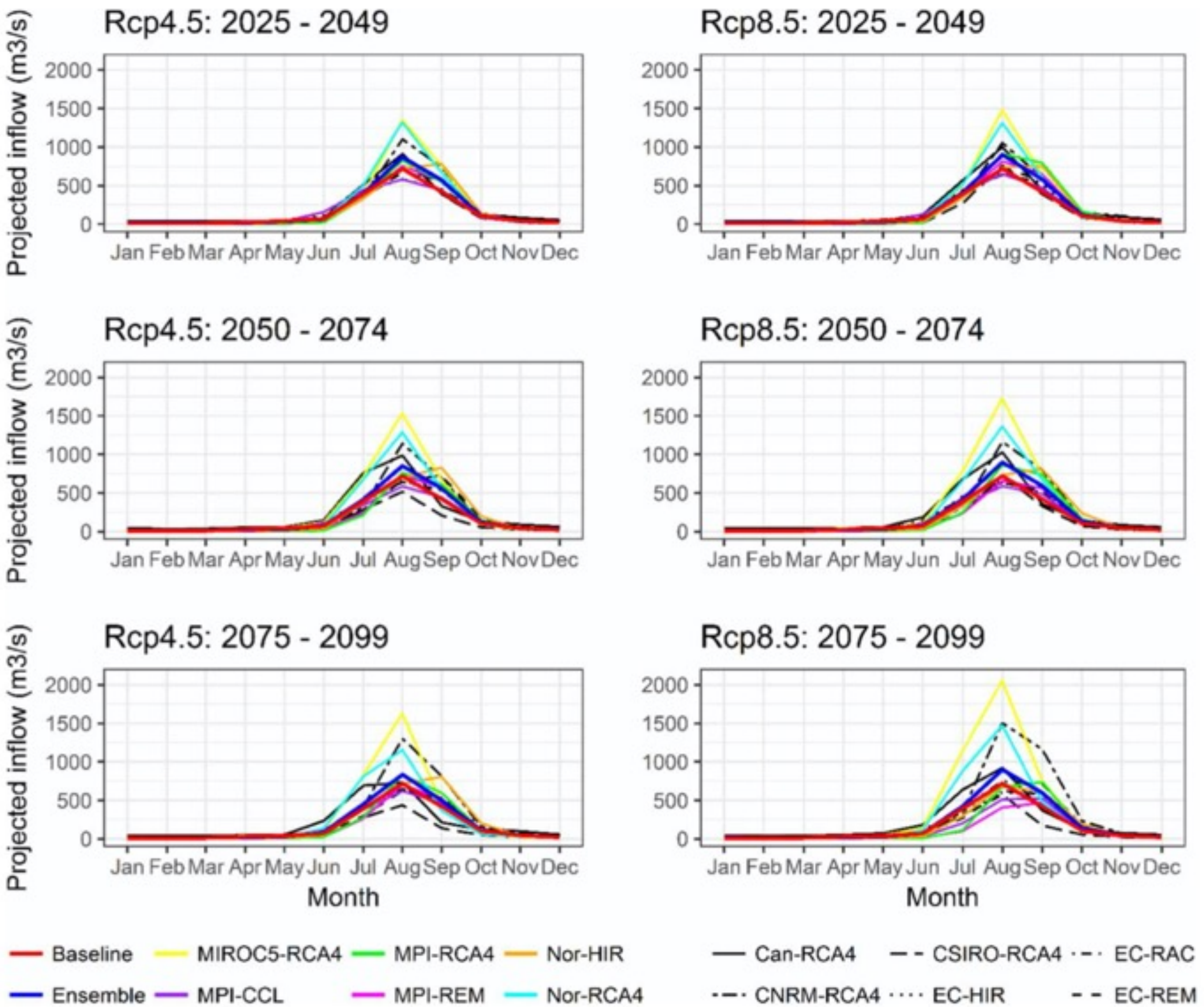
Adera & Alfredsen (2019) Journal of Water and Climate Change

Klimadata – CORDEX Africa

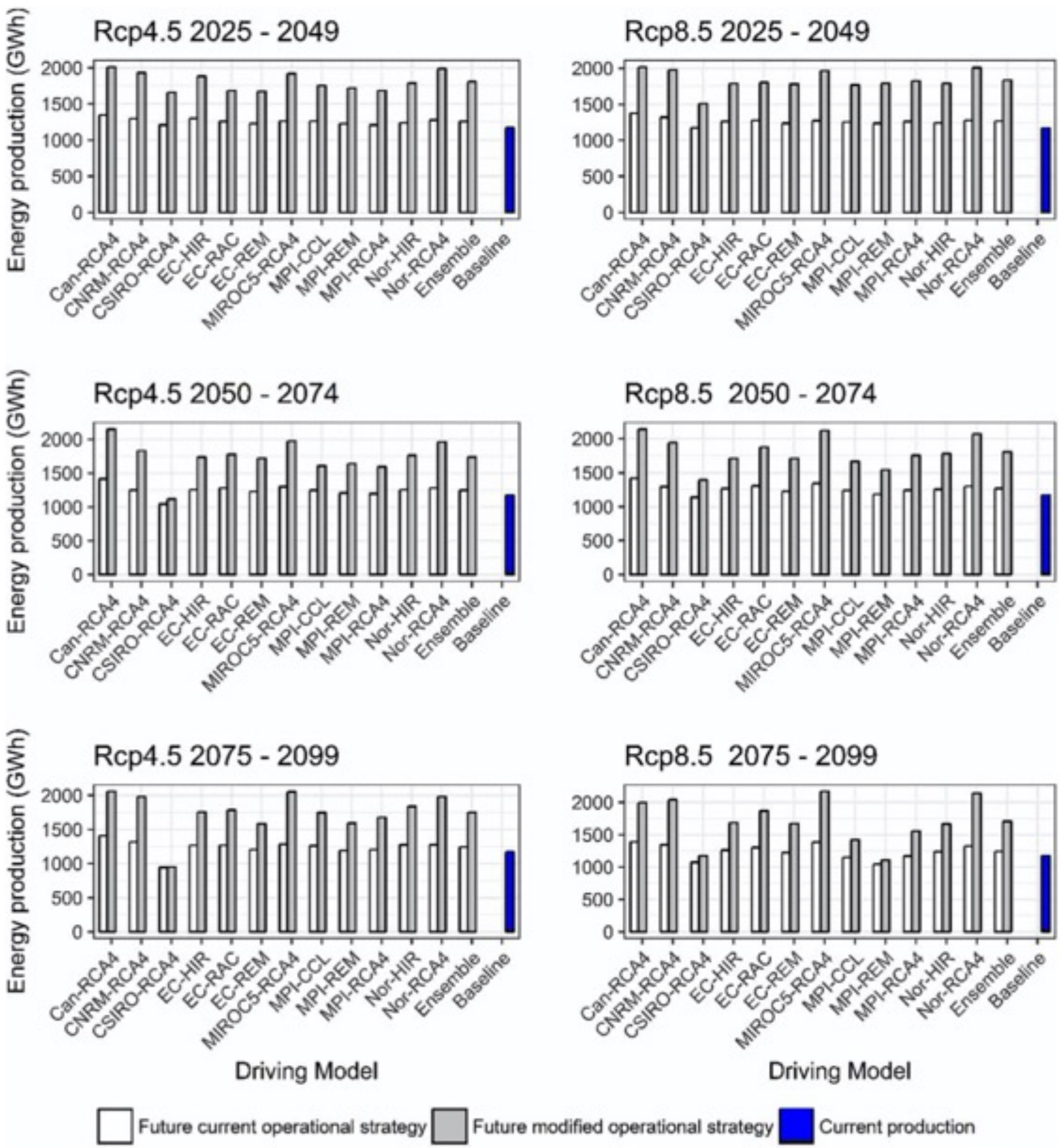
No.	GCM model	RCM model	Abbreviated as	Origin of GCM	Origin of RCM
1	CanESM2	RCA4	Can-RCA4	CCCma, Canada	SMHI, Sweden
2	CNRM-CM5	RCA4	CNRM-RCA4	CNRM, France	SMHI, Sweden
3	CSIRO-Mk3	RCA4	CSIRO-RCA4	CSIRO-QCCCE, Australia	SMHI, Sweden
4	EC-EARTH	HIRHAM5	EC-HIR	ICHEC, Europe	DMI, Denmark
5	EC-EARTH	RACMO22T	EC-RAC	ICHEC, Europe	KNMI, Netherlands
6	EC-EARTH	REMO2009	EC-REM	ICHEC, Europe	MPI-CSC, Germany
7	MIROC5	RCA4	MIROC5-RCA4	JAMSTEC, Japan	SMHI, Sweden
8	MPI-ESM-LR	CCLM4-8-17	MPI-CCL	MPI, Germany	CLMcom, Switzerland
9	MPI-ESM-LR	REMO2009	MPI-REM	MPI, Germany	MPI-CSC, Germany
10	MPI-ESM-LR	RCA4	MPI-RCA4	MPI, Germany	SMHI, Sweden
11	NorESM1-M	HIRHAM5	Nor-HIR	NCC, Norway	DMI, Denmark
12	NorESM1-M	RCA4	Nor-RCA4	NCC, Norway	SMHI, Sweden

Data er justerte med kvantilkorreksjon
Middelfeil mellom observert og justert er 2.2 – 5.1% for seks ulike stasjonar

Simulert tilsig

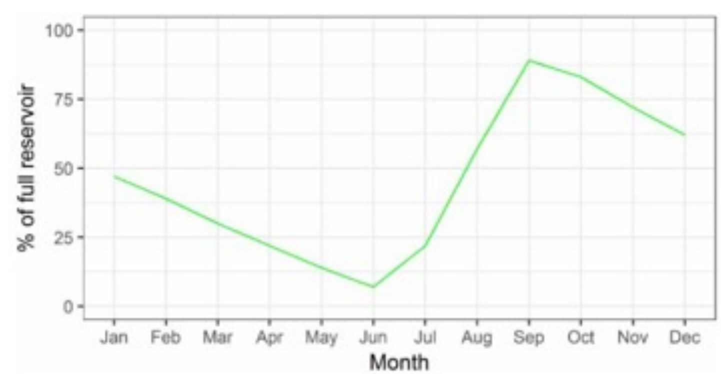


Produksjon

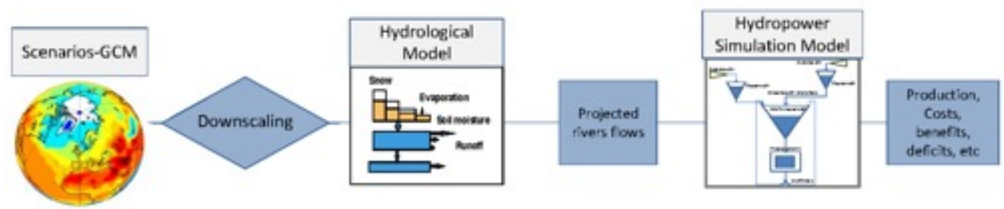


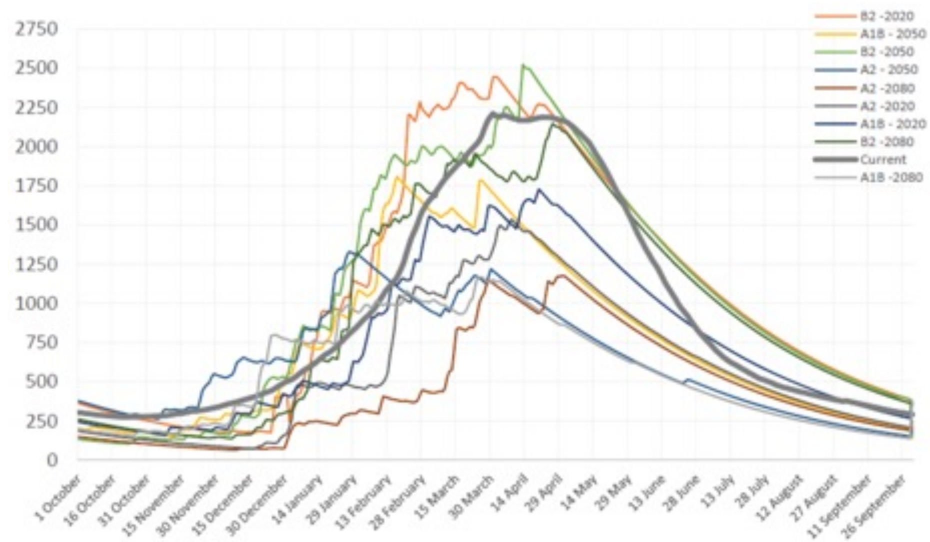
Konklusjon:

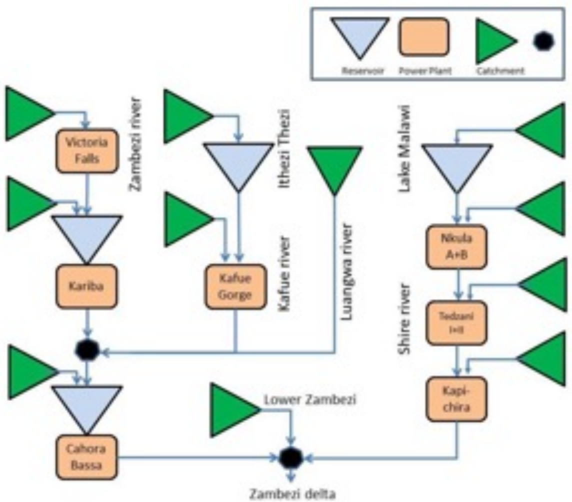
- Variasjon mellom modellar
- Noko auke i tilsig
- Betre driftsstrategi mogleg
- Mindre flomtap
- Større produksjon

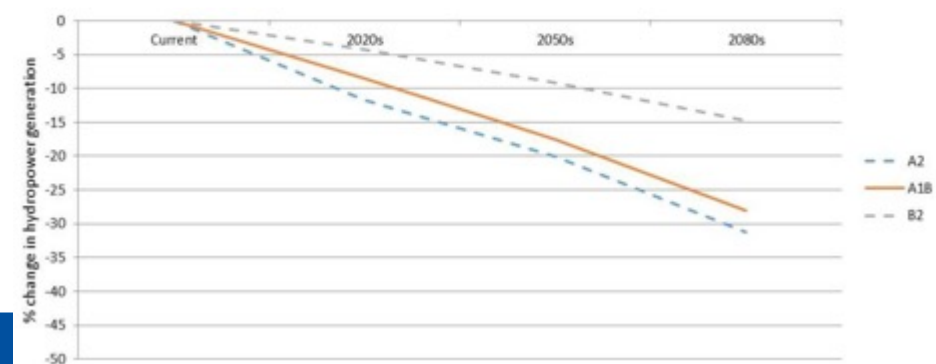


Zambezi



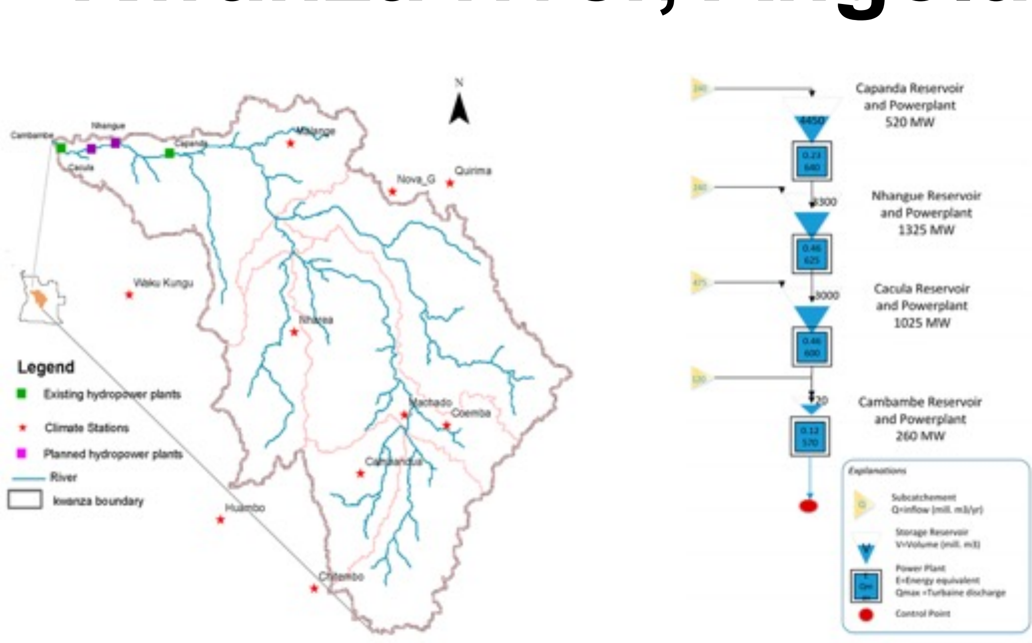




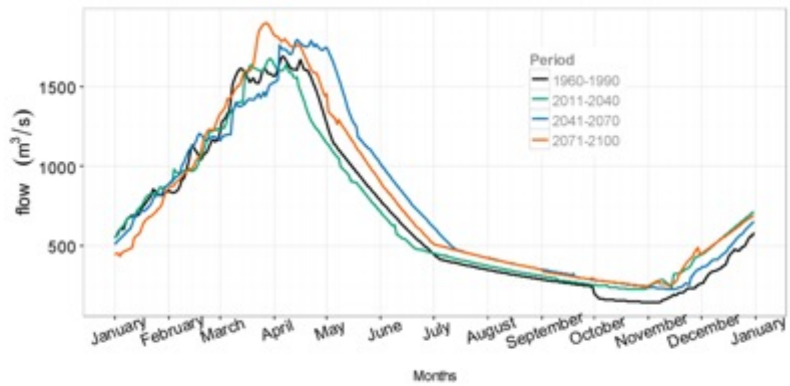


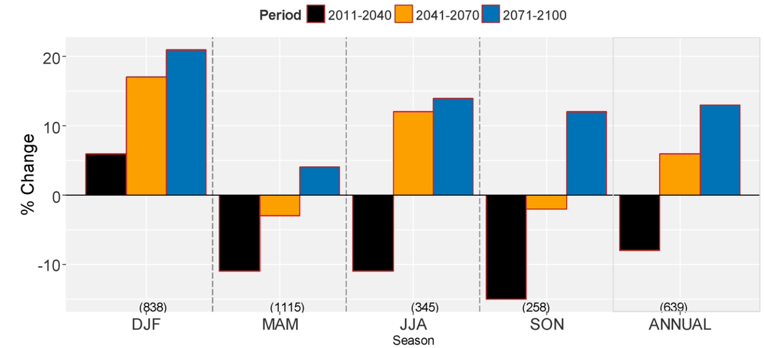
 Hamududu & Killingtveit (2016a), Energies

Kwanza river, Angola



(a) (b)



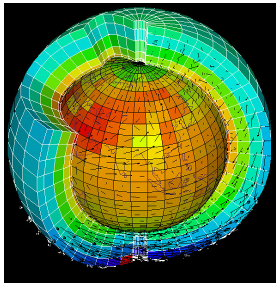


Period	Inflow Million m³	Reservoir Evaporation	Inflow Change %	Energy Production GWh/Year	Change %
Current	19,700	220		15,492	
2020s	19,306	231	−2	15,222	−3
2050s	21,079	243	7	15,899	4
2080s	22,064	255	12	16,975	10

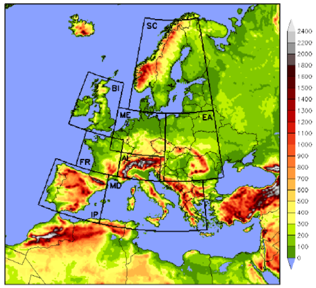
Hamududu & Killingtveit (2016b), Energies

Drikkevatn i Trondheim i framtida

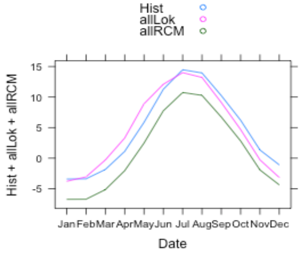
GCM



RCM



Kvantil-korreksjon



△

T +4.5

P * 25%

Klimamodell	CORDEX simulering	Regionalmodell	Ensemblenummer
CRNM	SMHI	RCA4	r1i1p1
IPSL-CM5A-MR	SMHI	RCA4	r1i1p1
MPI-ESM-LR	SMHI	RCA4	r1i1p1
MOHC-HadGEM2-ES	SMHI	RCA4	r1i1p1
ICEHEC-EC-EARTH	Dansk Met Institutt	HIRHAM5	r3i1pi

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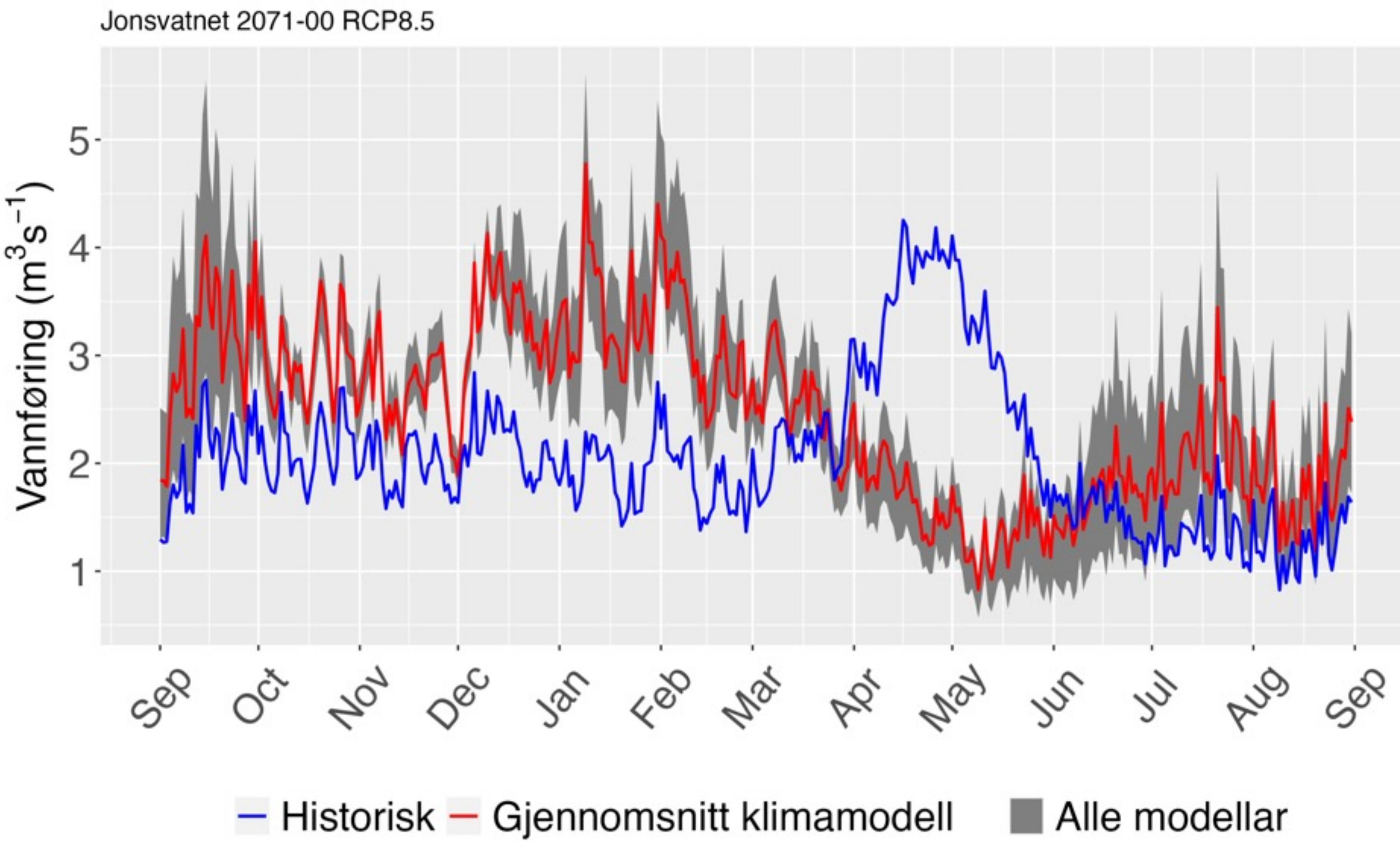
Tilsig Jonsvatnet



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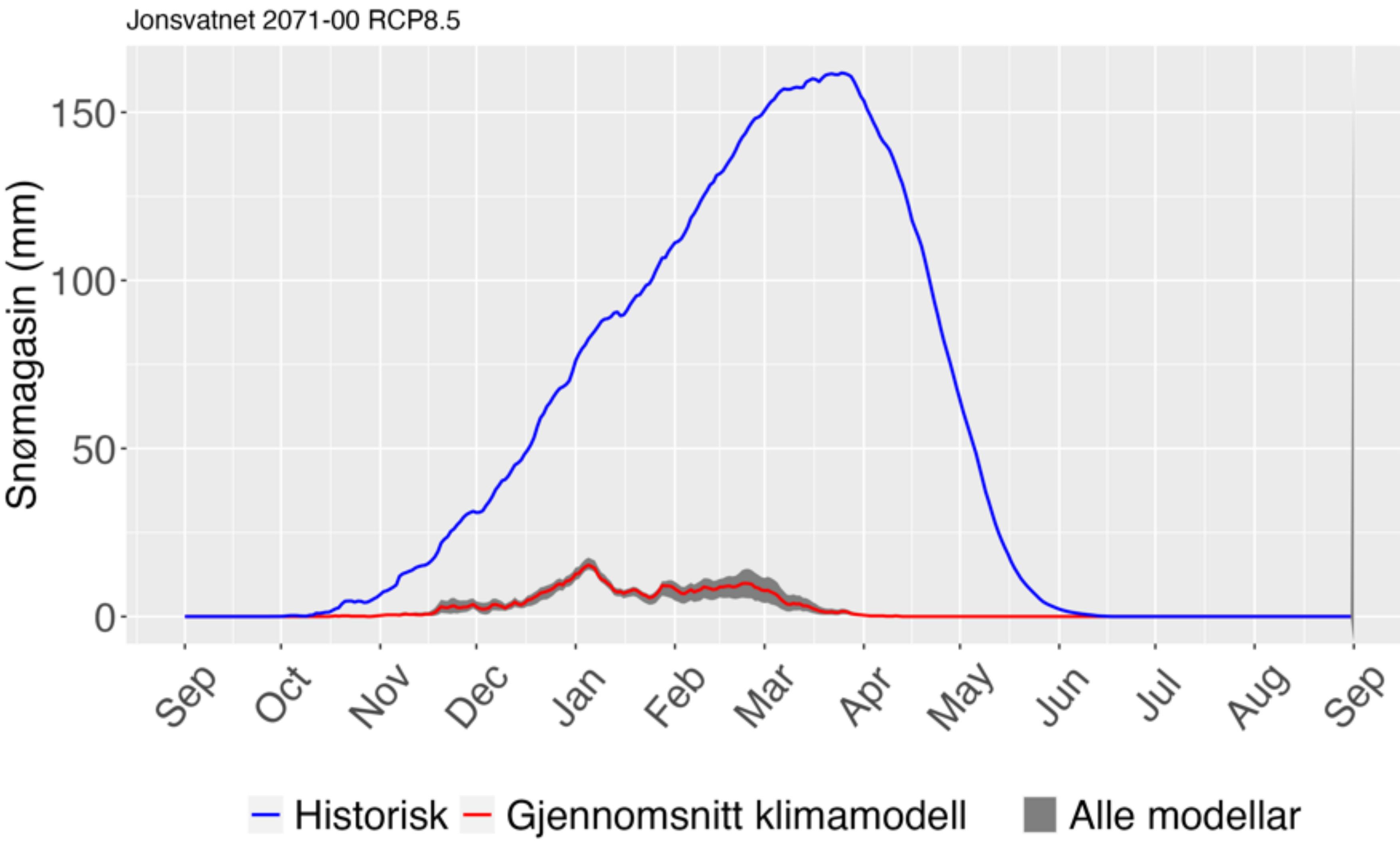
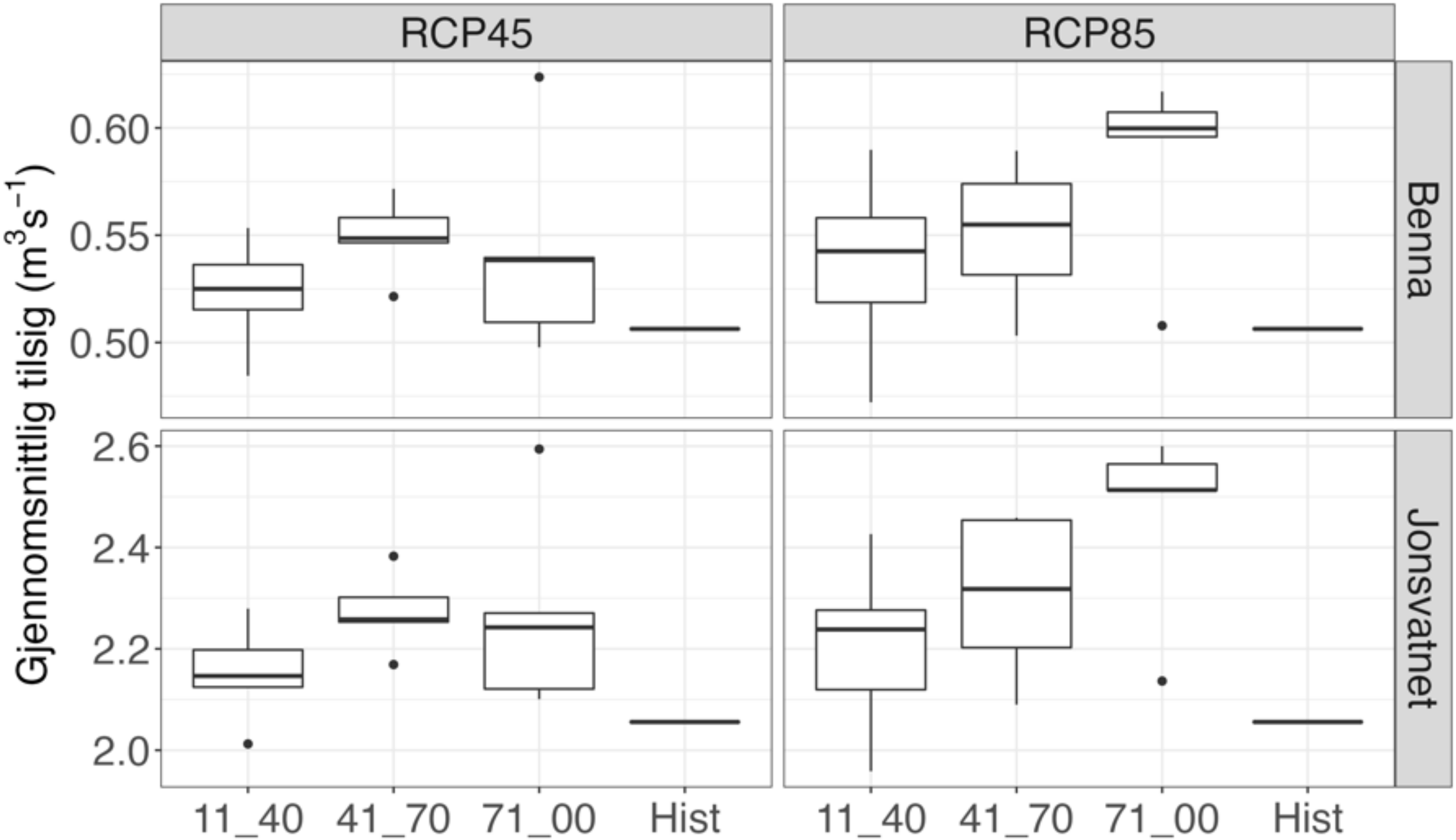
Snømagasin Jonsvatnet



Tilsig oppsummert



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Jonsvatnet - capacity

Jonsvatnet	Beregnet leveringskapasitet (m^3/s) for 31 alternativ							
	JHIST		RCP45				RCP85	
	1985	2025	2055	2085		2025	2055	2085
JHIST	1.228							
CNRM		1.324	1.315	1.276		1.378	1.286	1.409
HAD		1.151	1.321	1.262		1.307	1.373	1.406
ICEHEC		1.291	1.327	1.286		1.257	1.237	1.196
MPI		1.248	1.342	1.459		1.366	1.423	1.380
IPSL		1.304	1.228	1.143		1.124	1.332	1.441
Min		1.151	1.228	1.143		1.124	1.237	1.196
Mid		1.264	1.307	1.285		1.286	1.330	1.366
Max		1.324	1.342	1.459		1.378	1.423	1.441

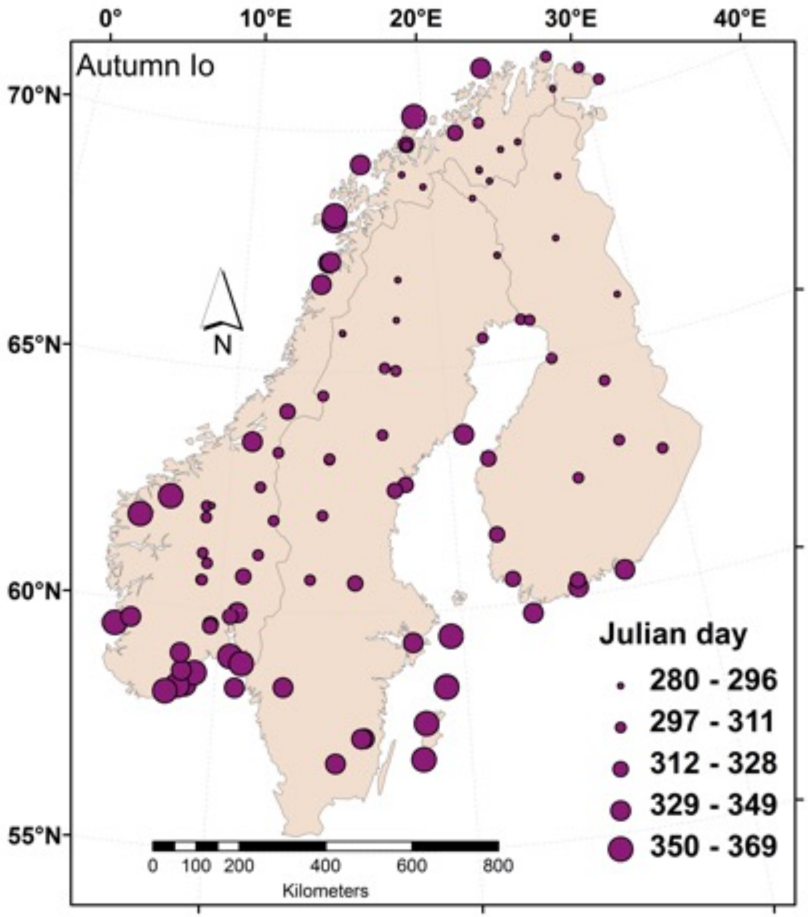
Is og temperatur

- Få observasjonar om islegging i Norge

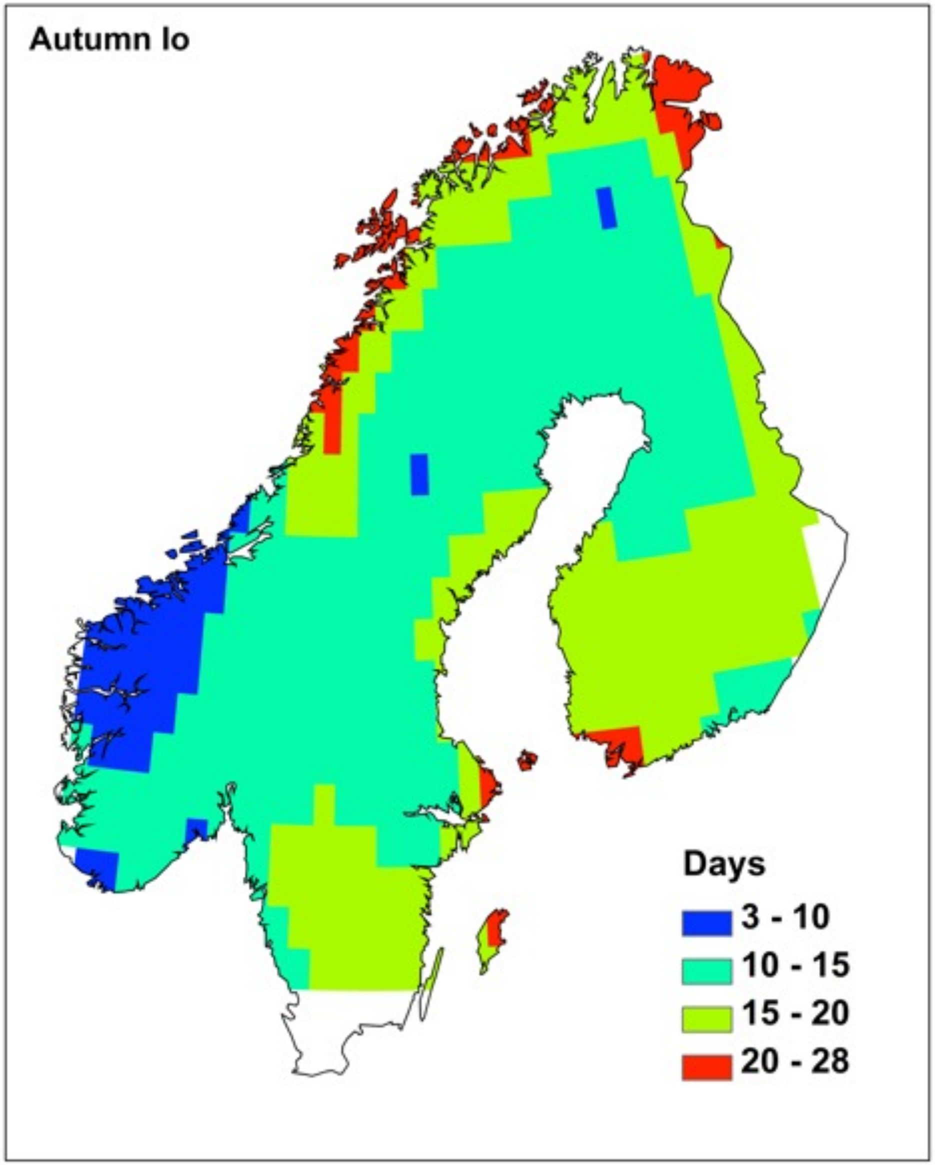
- Kople islegging til klimatologiske indeksar– bruke desse til å seie noko om framtida
  - 0°-isotherm (autumn, spring)
  - Accumulated freezing degree days
  - Mid winter thaws

- Bruk av modellar for å rekne på is lokalt og regional
  - Regional modell for Norden (CRAICC)
  - Modell av kraftverksmagasin

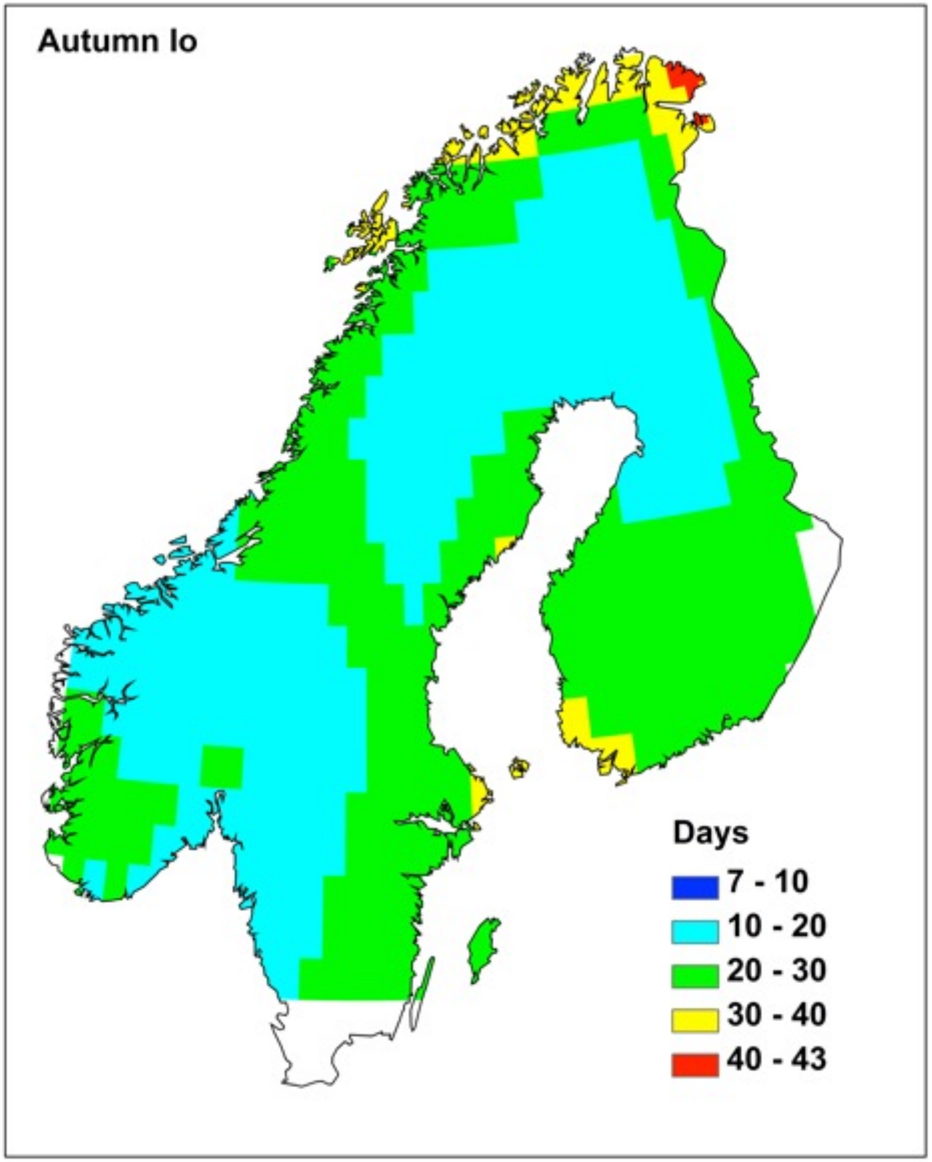
Winter indicies (1961-2010)



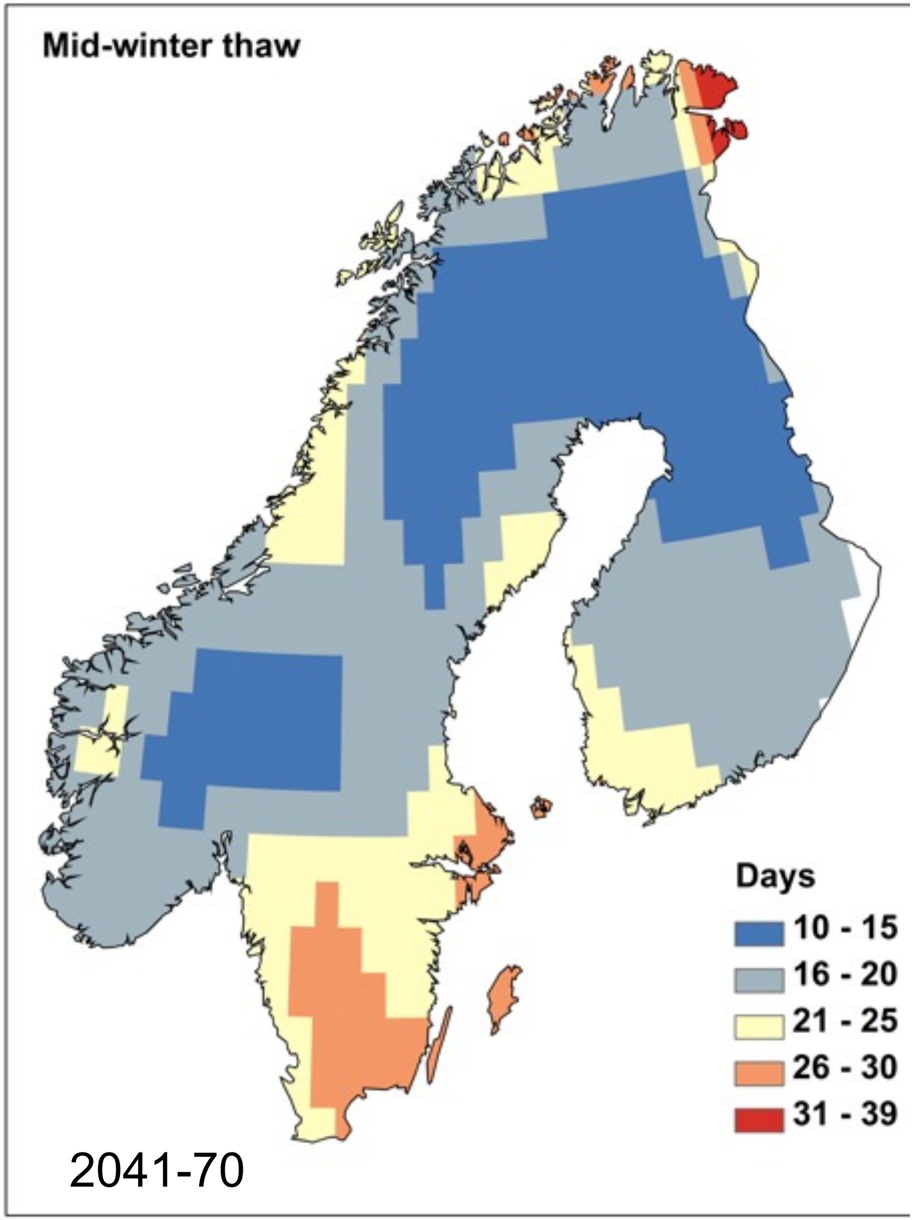
- Autumn isotherm dates : (0.35± .06)
- Spring isotherms dates : (-2.9± 1.1)
- Winter duration (-5.2 ± 2.9)
- Max. Ann. AFDD (-57.4 ± 35.4)
- MWT frequency (2.5 ± 1.5)

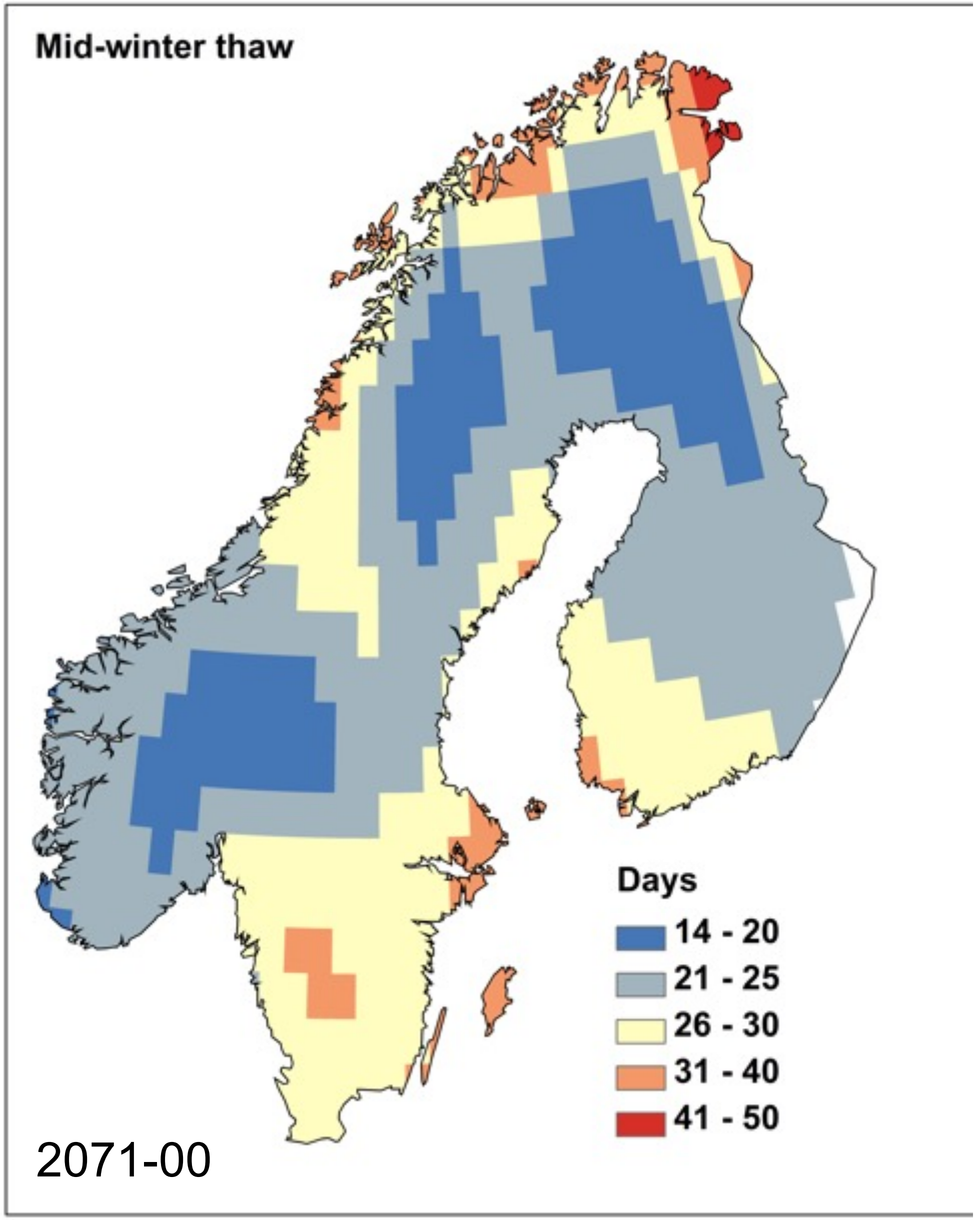


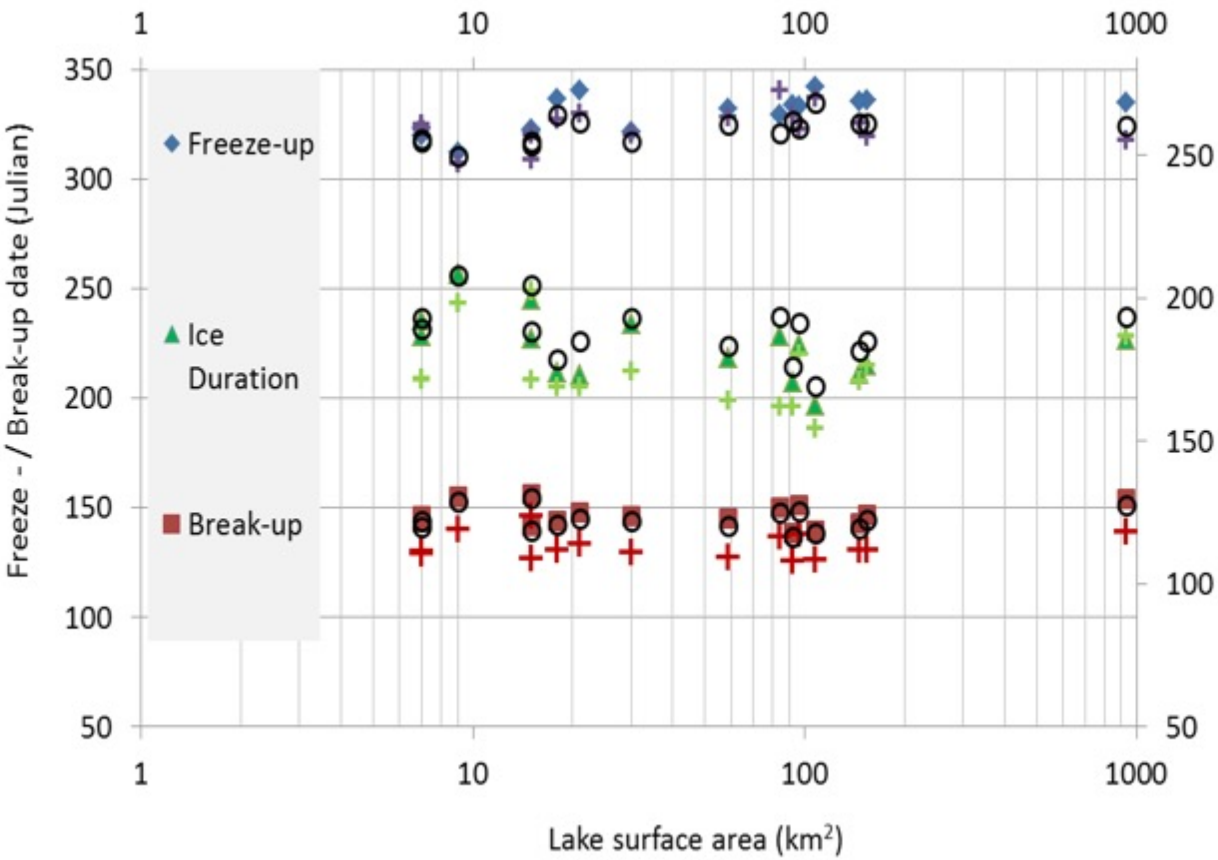
2041-70

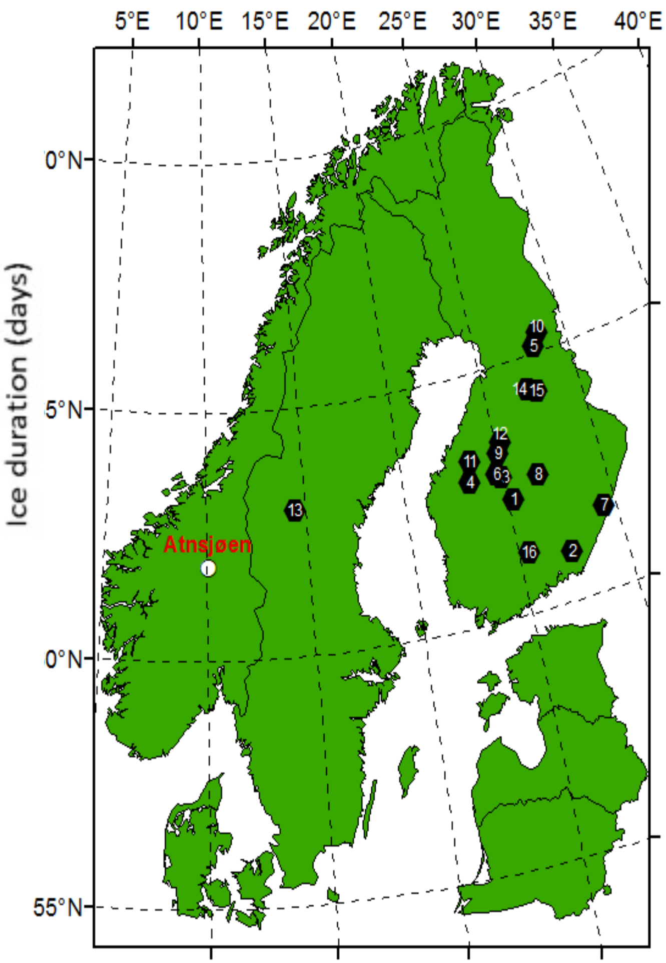


2071-00


Mid-winter thaw
Days
10 - 15
16 - 20
21 - 25
26 - 30
31 - 39
2041-70

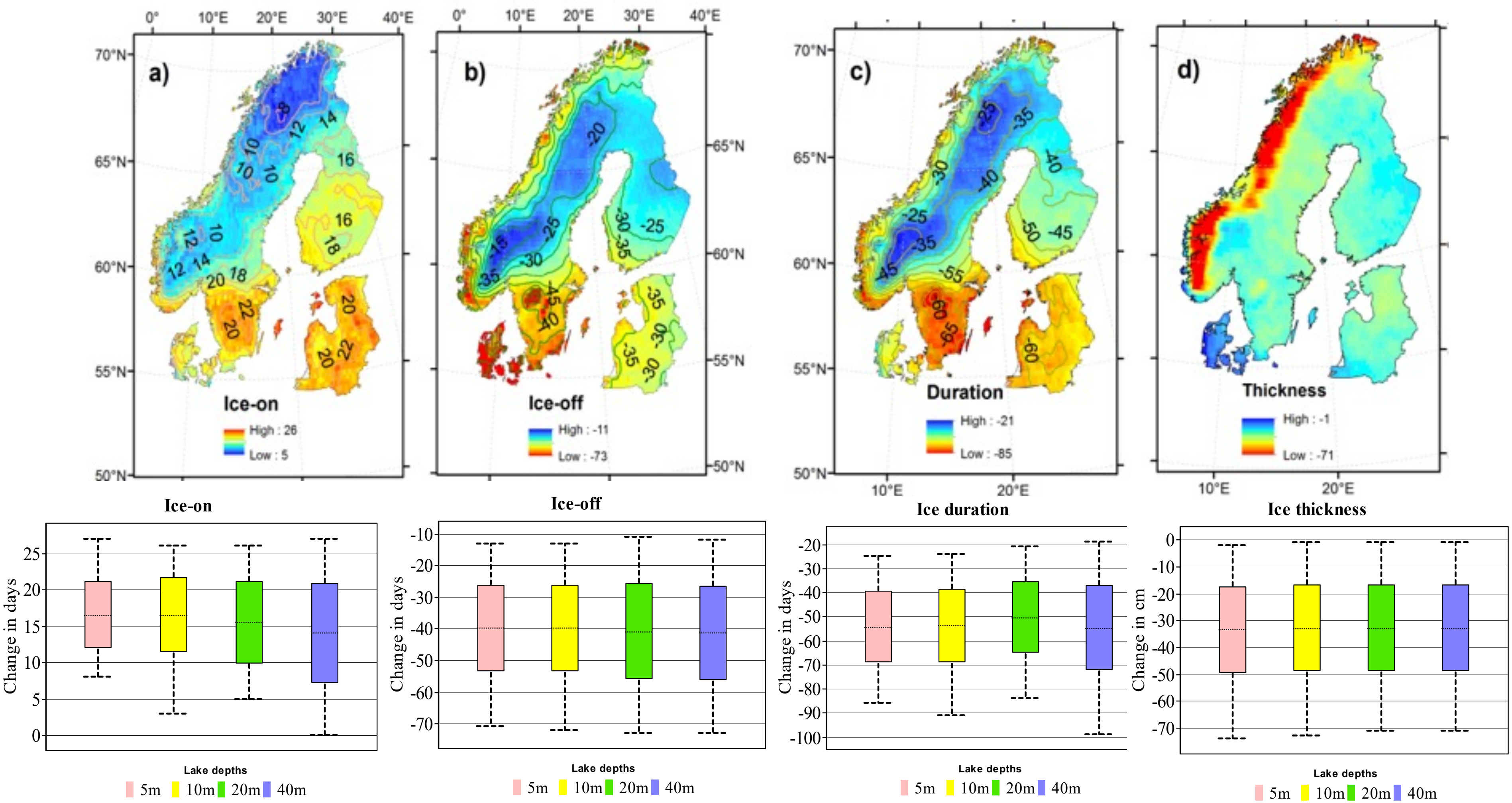

Mid-winter thaw
Days
14 - 20
21 - 25
26 - 30
31 - 40
41 - 50
2071-00





- Triangle – Simulated with actual area
- Circle – Simulated with model lake
- Cross – Observed

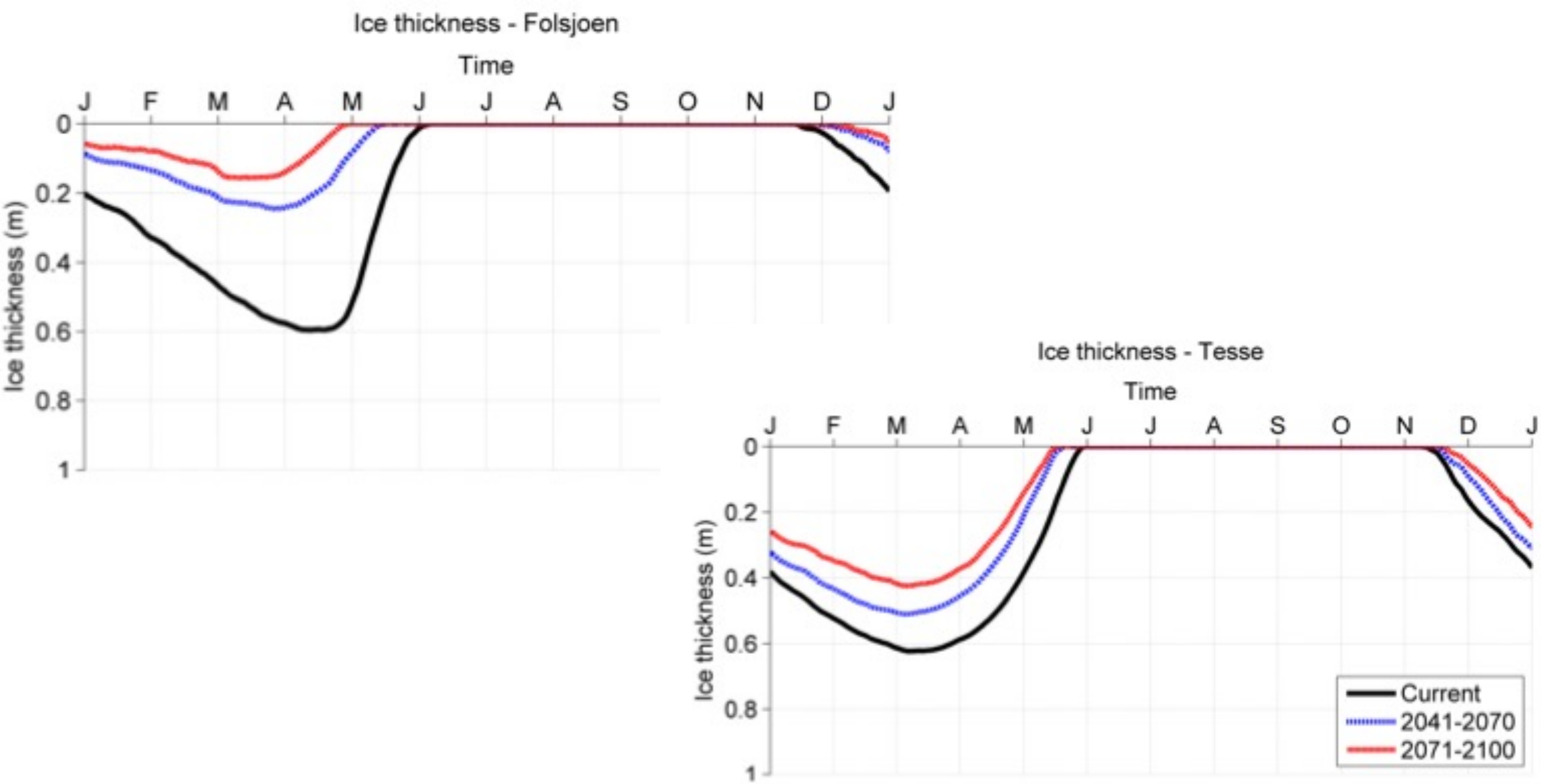
Future lake ice



Gebre et al. The Cryosphere (2014)

NTNU

Reservoir ice



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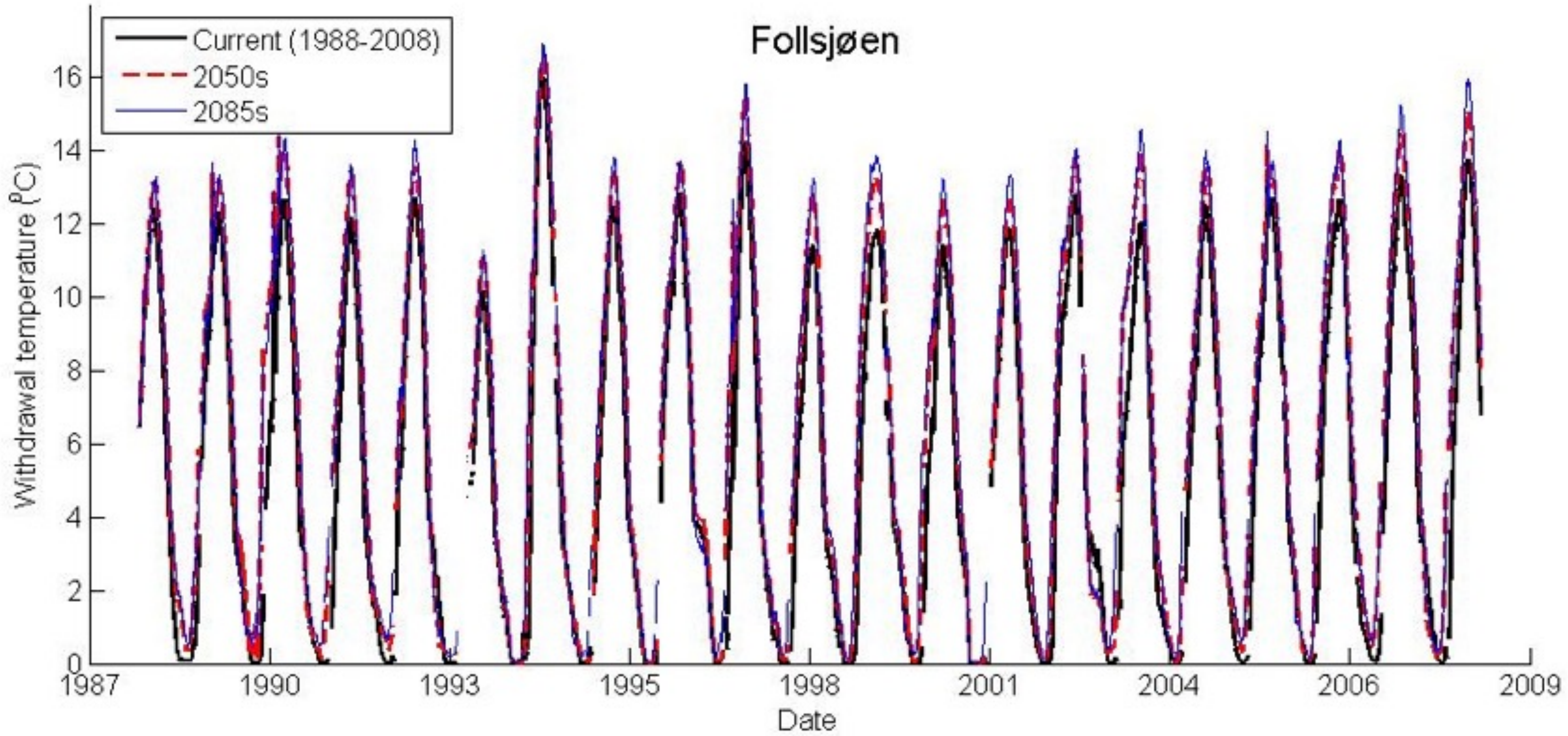
Gebre et al. J.Hydrology (2014)

NTNU

Temperature of released water



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 Gebre et al. J.Hydrology (2014)