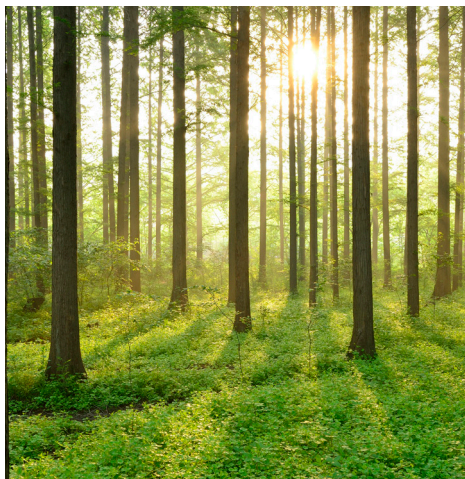


KLIMATFÖRÄNDRINGARNAS INVERKAN PÅ VATTENKRAFTENS PRODUKTIONS- OCH REGLERFÖRMÅGA

RAPPORT 2023:924 **BILAGA A**





KLIVA-rapport bilaga A Dalälven

Richard Scharff, Chalmers, 2023-02-01

Kommentarer

- Bilagan innehåller ett axplock av diagram för att illustrera indata till vattenkraftmodellen samt dess resultat
- Resultaten skiljer sig mellan älvsystem, år och uppvärmningsnivå
- Insikter, slutsatser och detaljer beskrivs i rapporten

→ Rapporten finns på: <https://energiforsk.se/program/klimatforandringarnas-inverkan-pa-vattenkraften/rapporter/klimatforandringarnas-inverkan-pa-vattenkraftens-produktions-och-reglerformaga/>



 Energiforsk

KLIVA-projektet har analyserat **klimatförändringarnas påverkan** på vattenkraftens produktions- och balanseringsförmåga

Innehåll diagrammsamling

- Systembeskrivning
 - Älvsystem
 - Energi per Mm³ lokaltillrinning
 - Vattendommar
- Klimatpåverkan lokaltillrinning
 - Klimatfaktorer
 - Total tillrinning



- Optimering
 - Lokaltillrinning
 - Elpriser
 - Älvens elproduktion
 - Produktion per station
 - Stationsvattenföring
 - Spill per magasin
 - Vattenytor per magasin
- Aggregerade resultat
 - Produktionsförmåga
 - Balanseringsförmåga

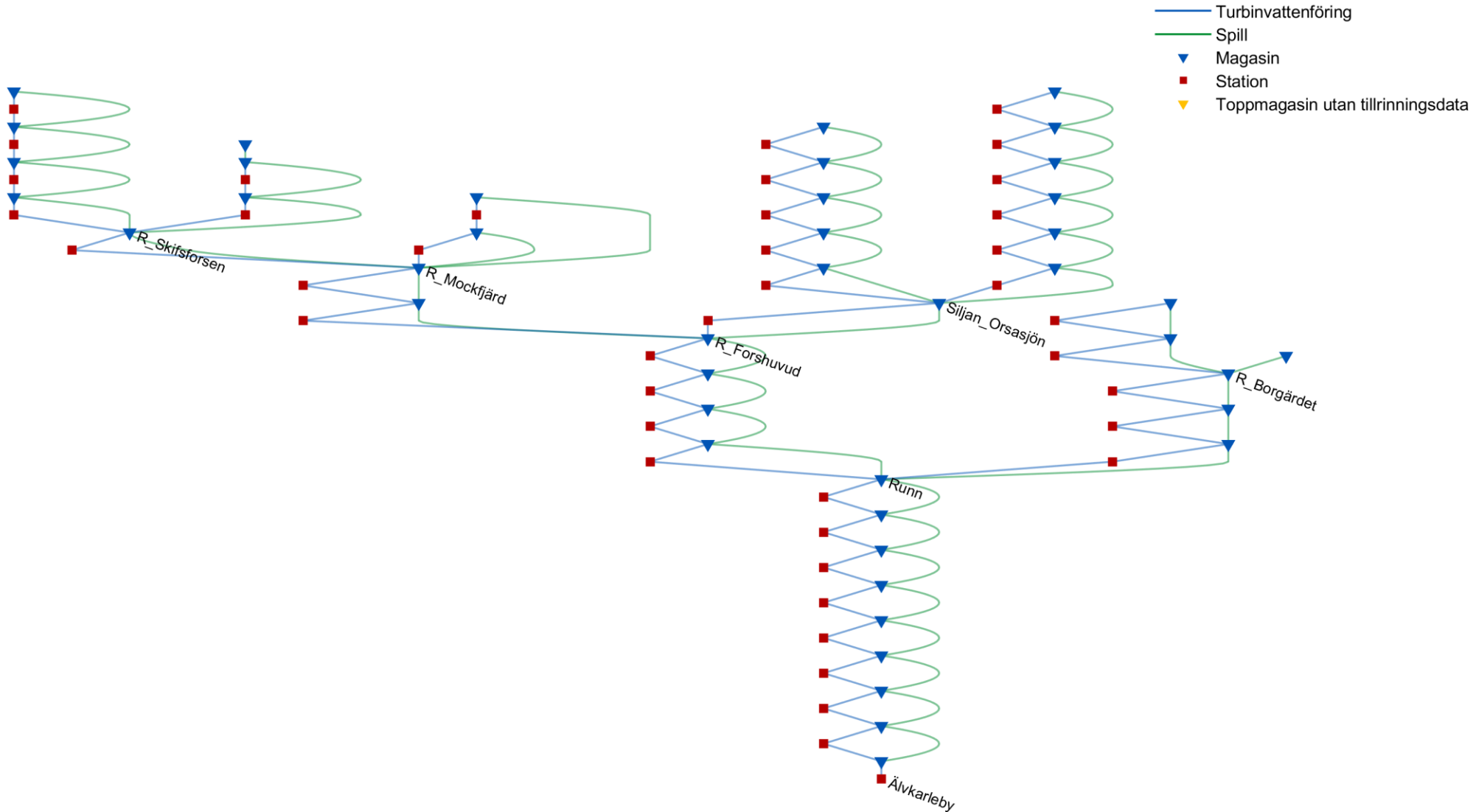
Optimeringen görs för **19 år**, alltid ett kalenderår i taget. I den här bilagan presenteras indata och resultat för **ett utvalt år** med uppvärmningsnivån **GWL2,0°C**.



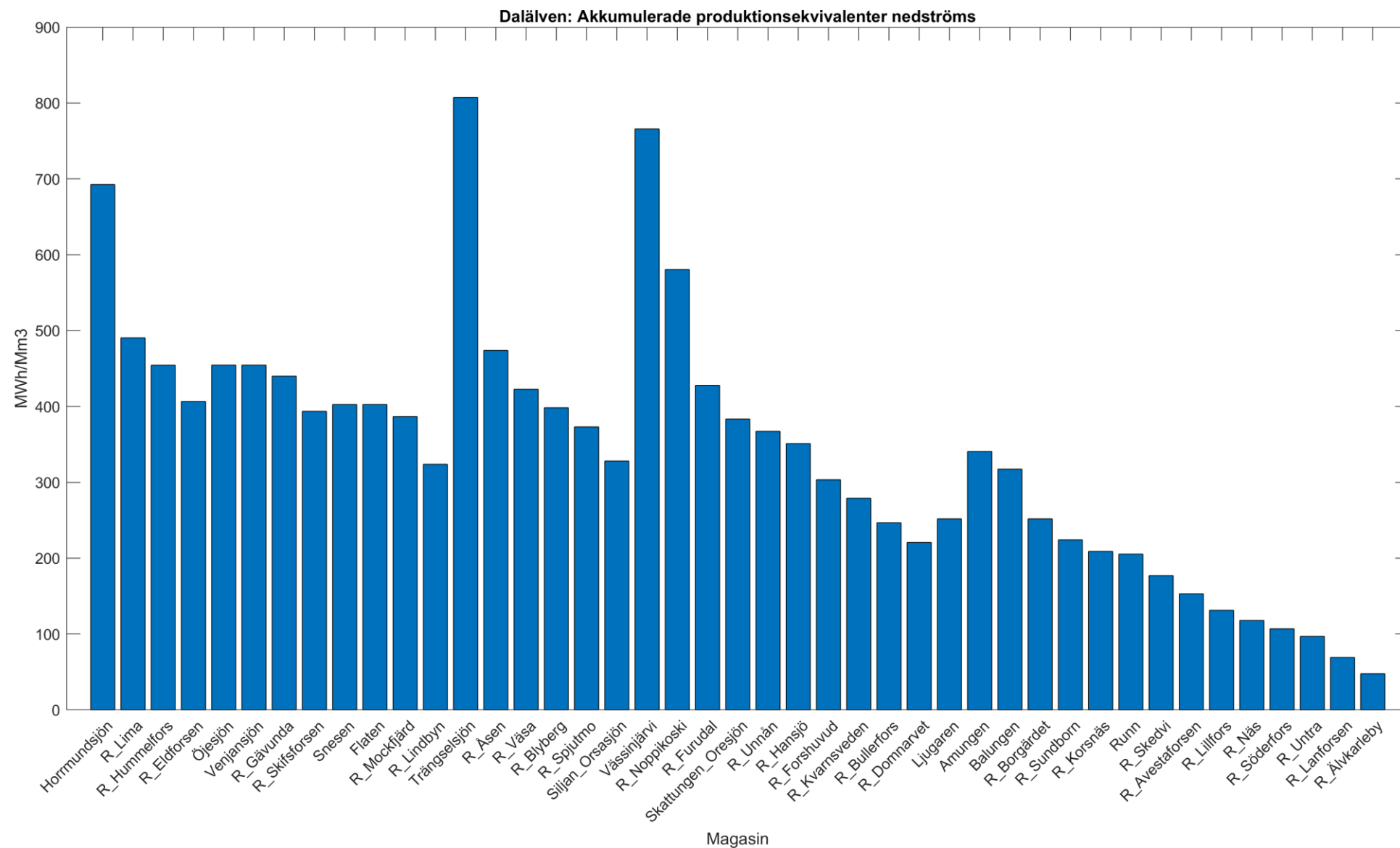
Systembeskrivning

Älvsystem

Dalälven

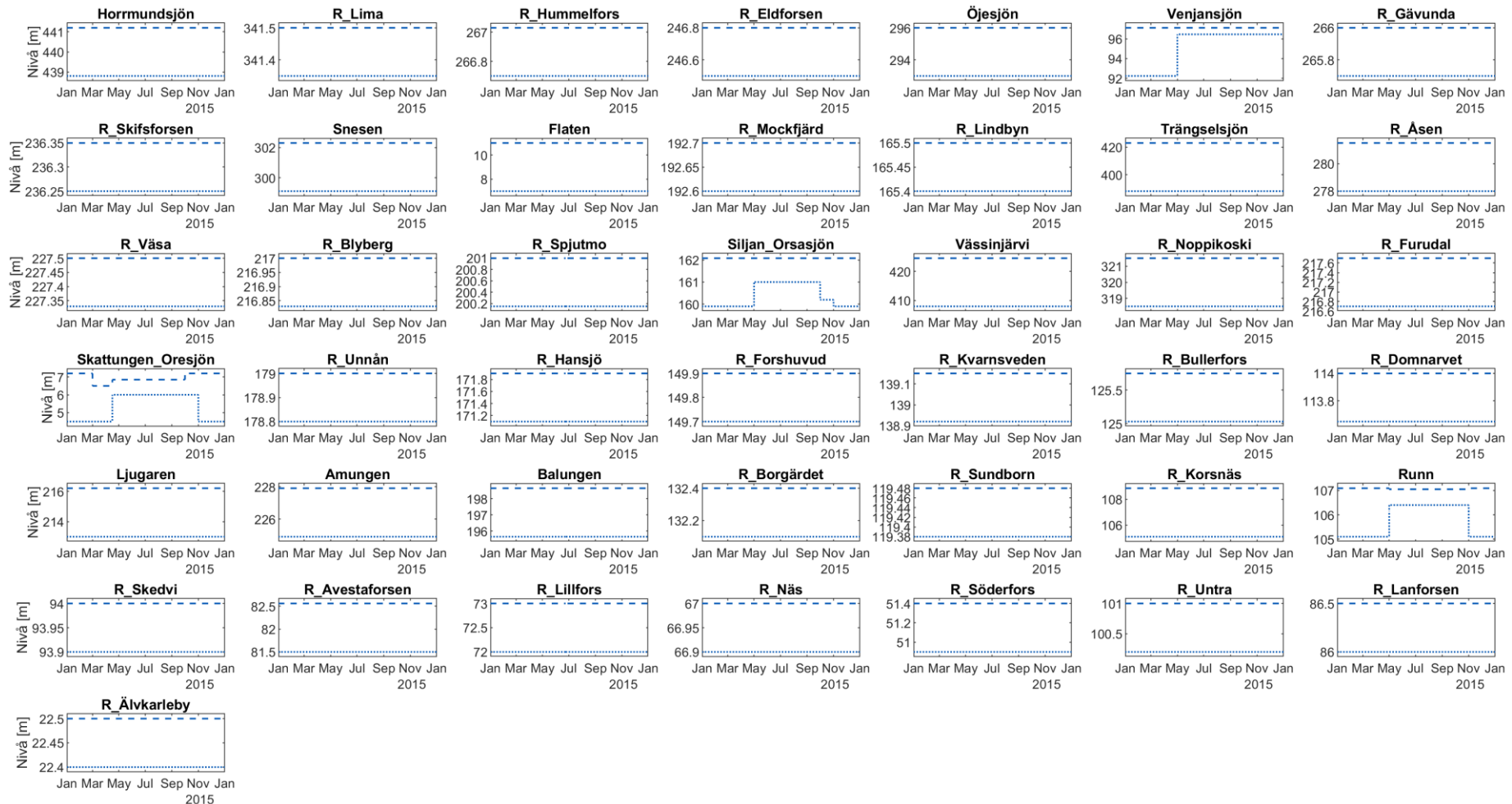


Energi per Mm³ lokaltillrinning



Vattendomar "WaterLevel"

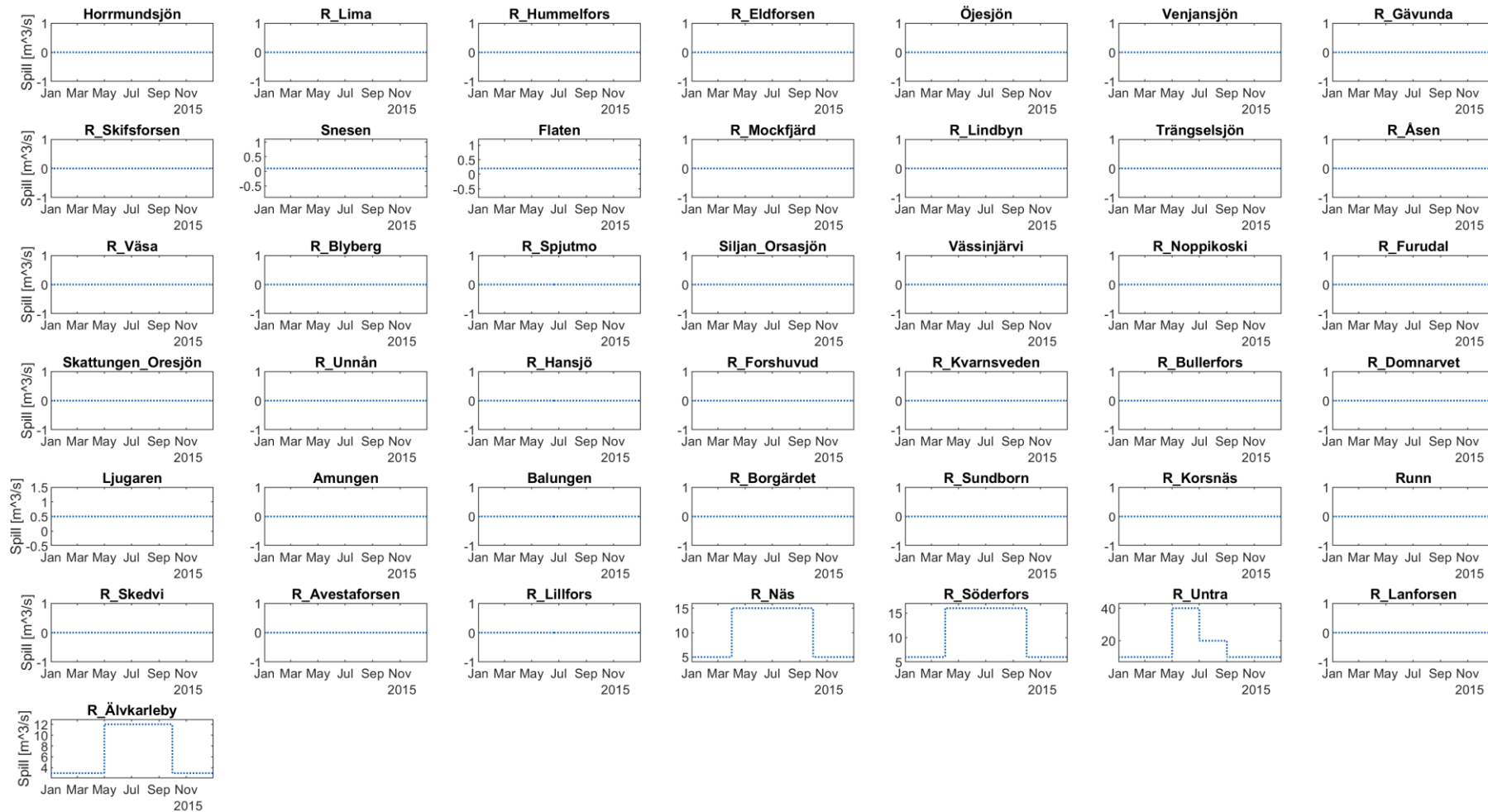
Dalälven



..... min - - - max

Vattendomar "MinSpill"

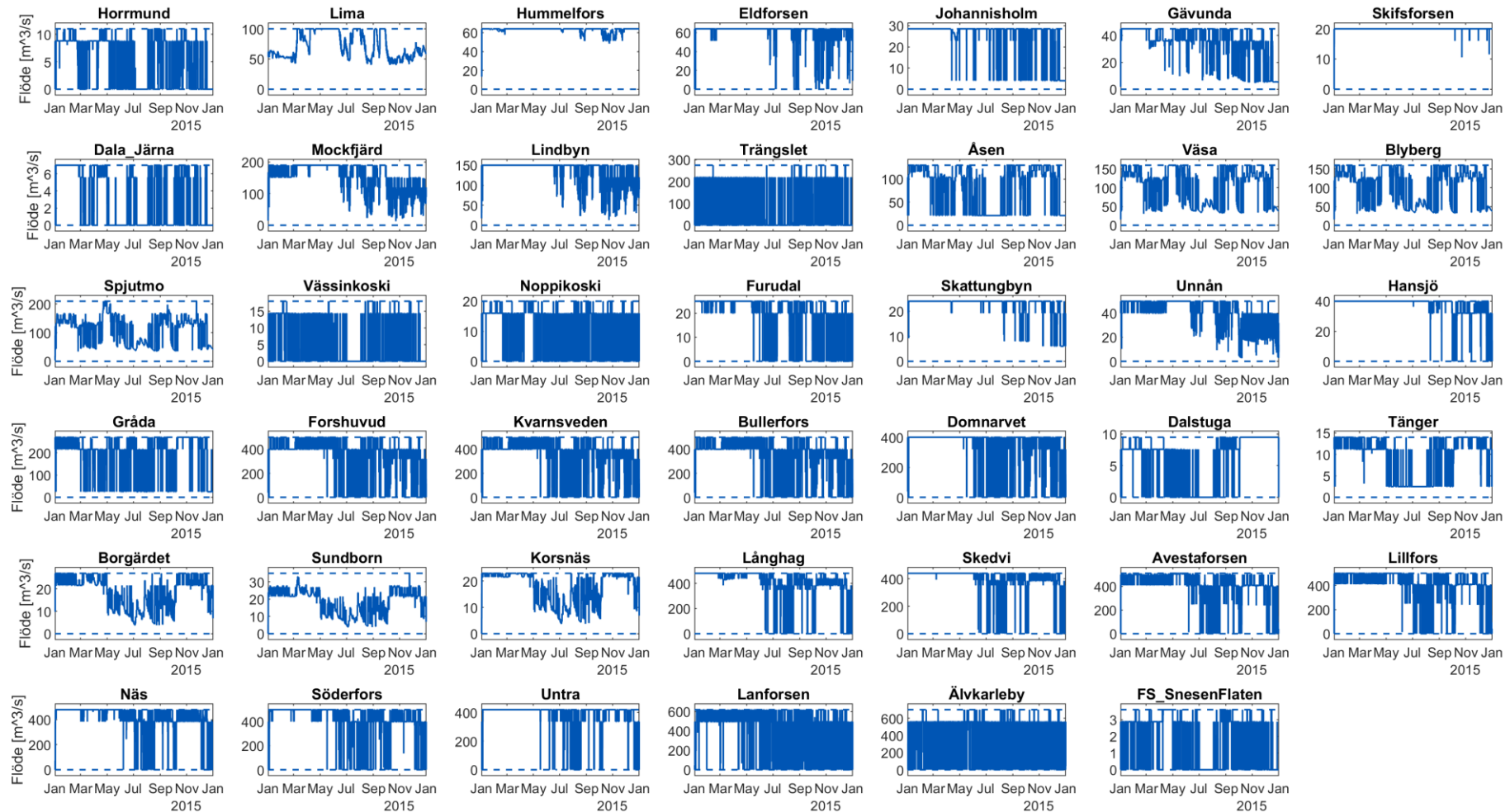
Dalälven



min

Vattendomar "MinFlow"

Turbinvattenföring för Dalälven

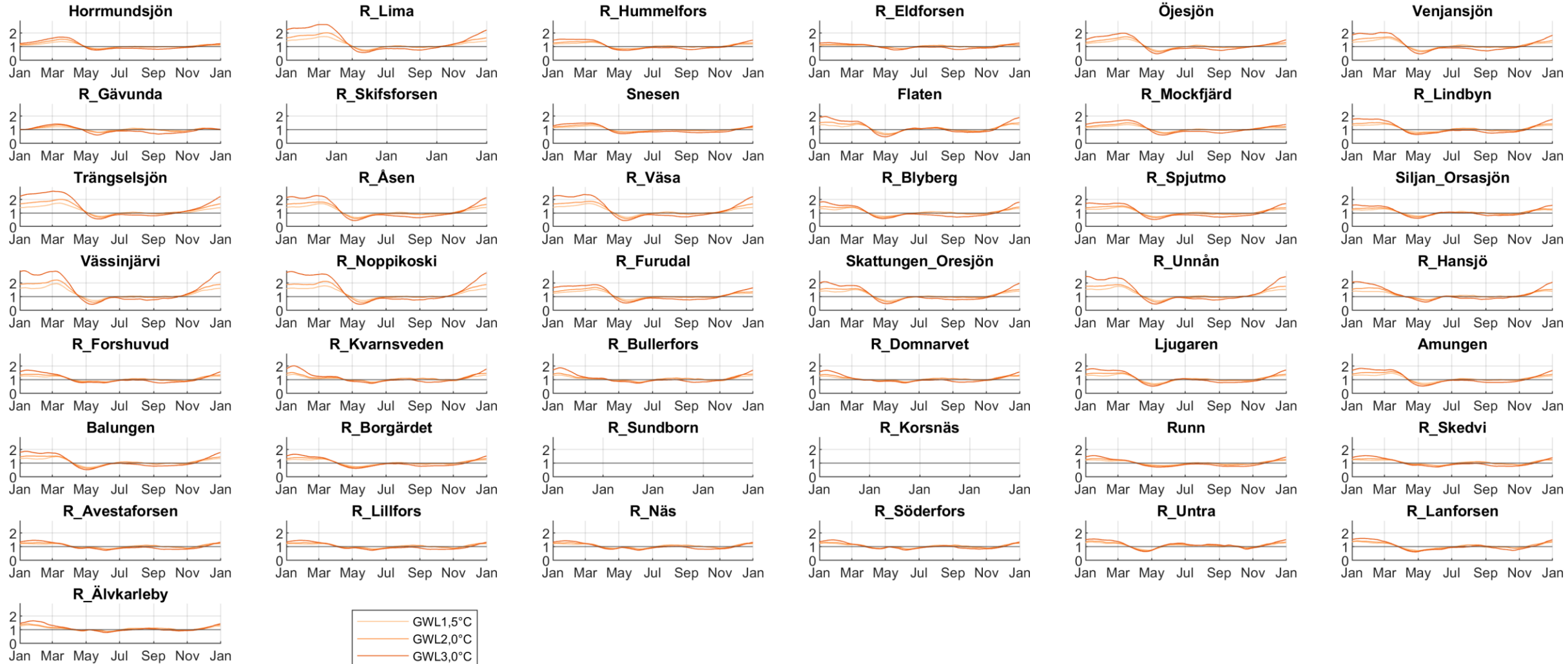


— KLIVA

Klimatpåverkan på lokaltillrinningar

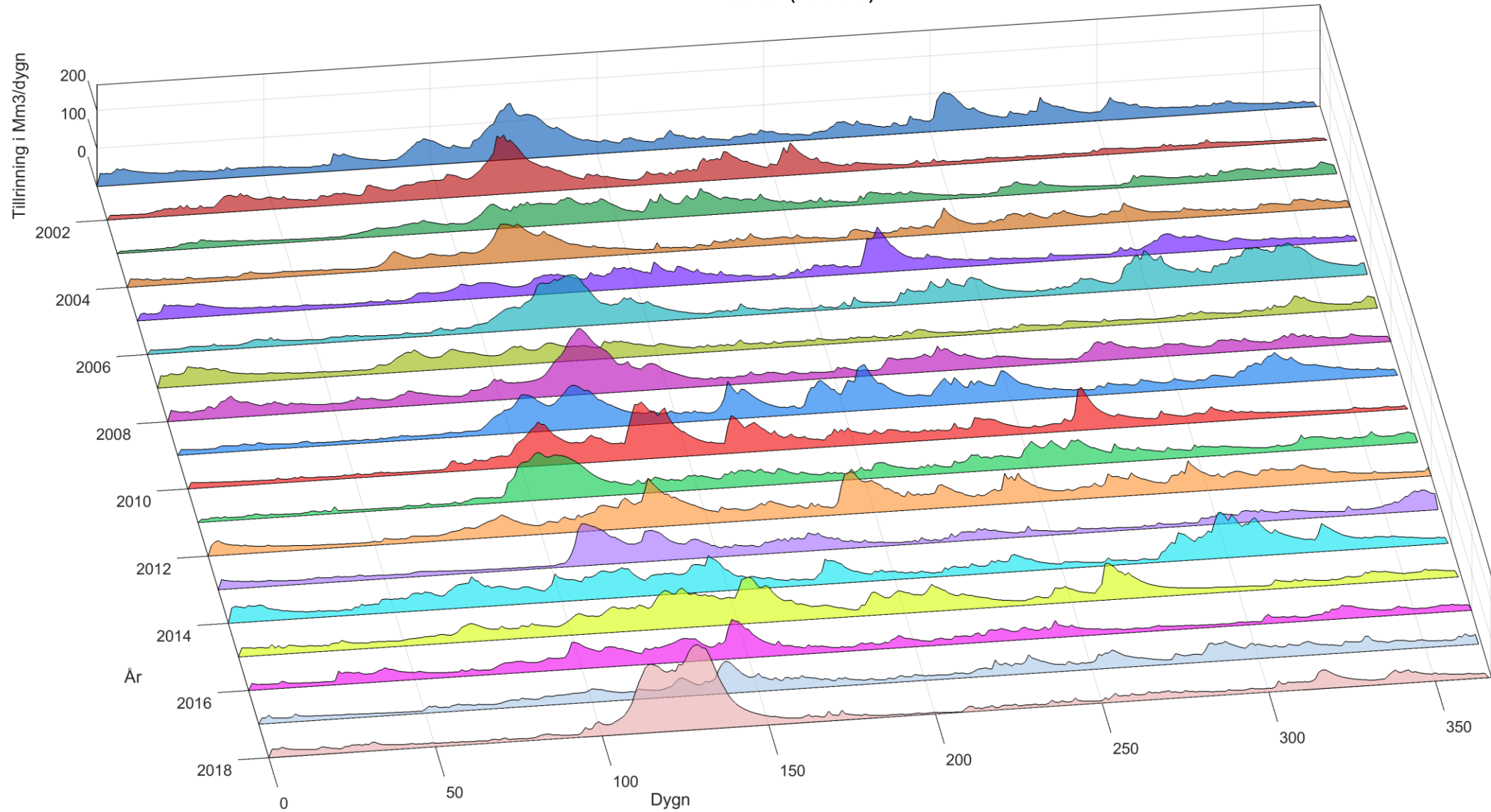
Klimatfaktorer

Klimatfaktorer Dalälven



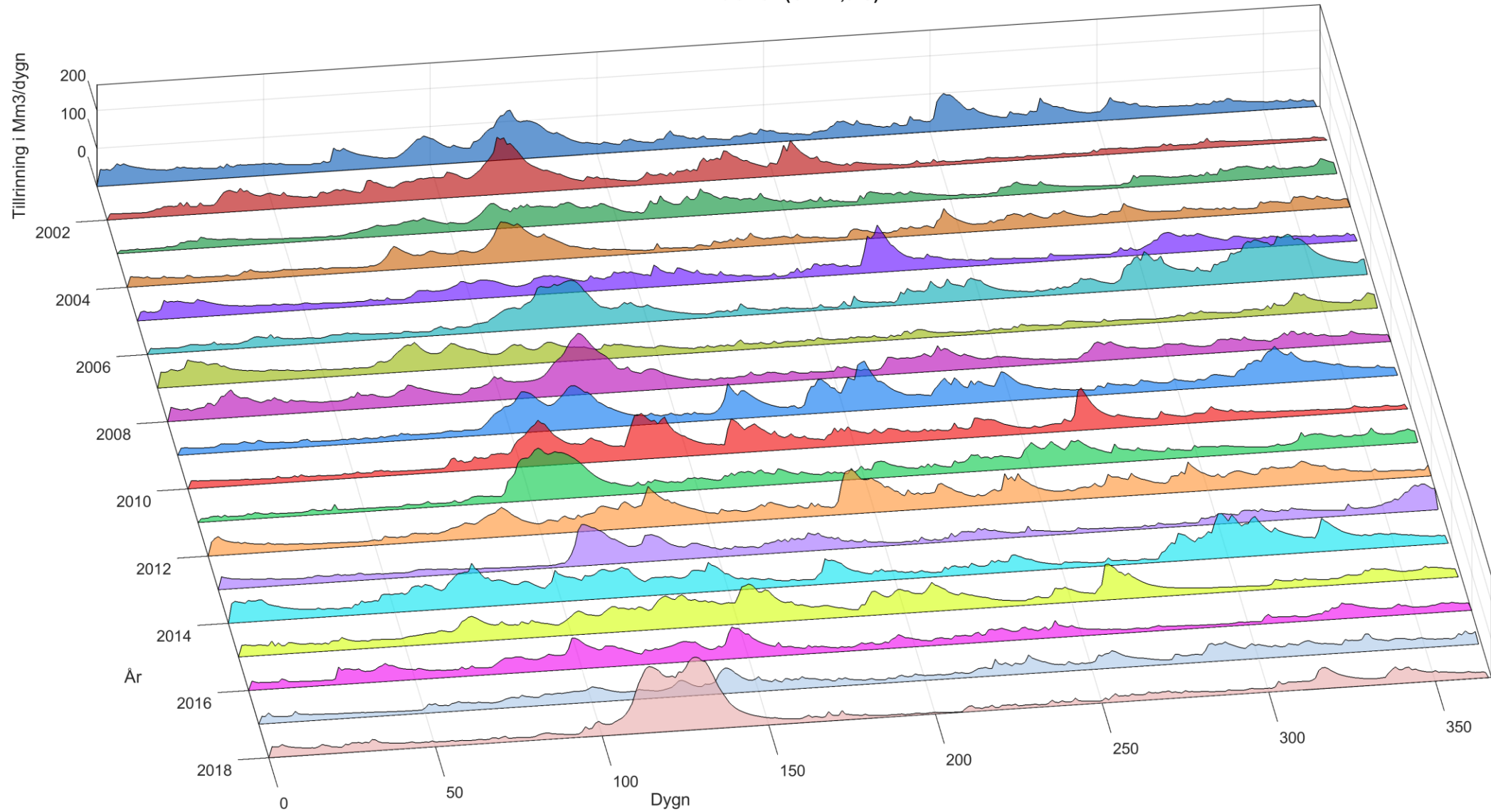
Total tillrinning (Referens)

Dalälven (Referens)



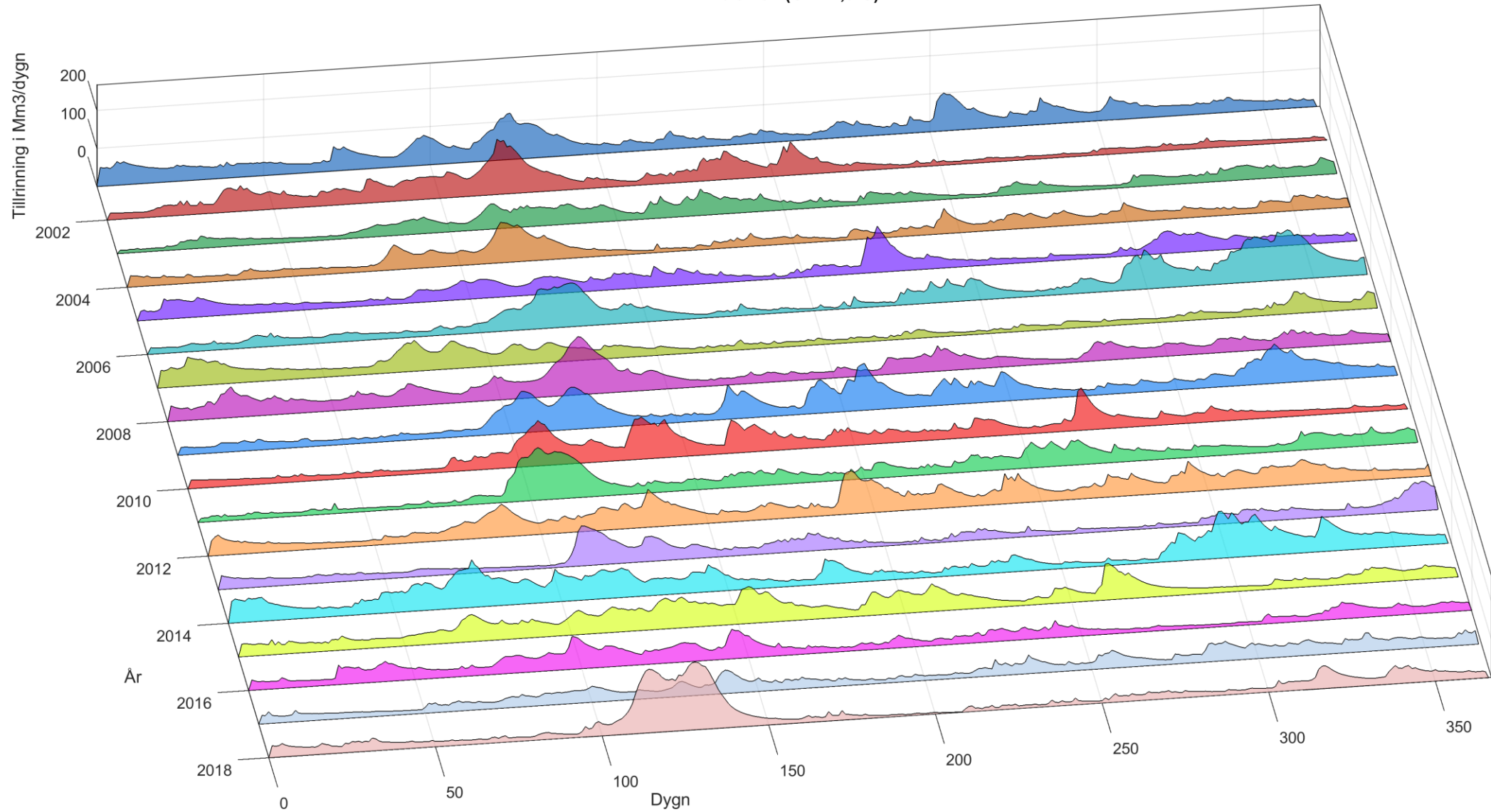
Total tillrinning (GWL1,5°C)

Dalälven (GWL1,5°C)



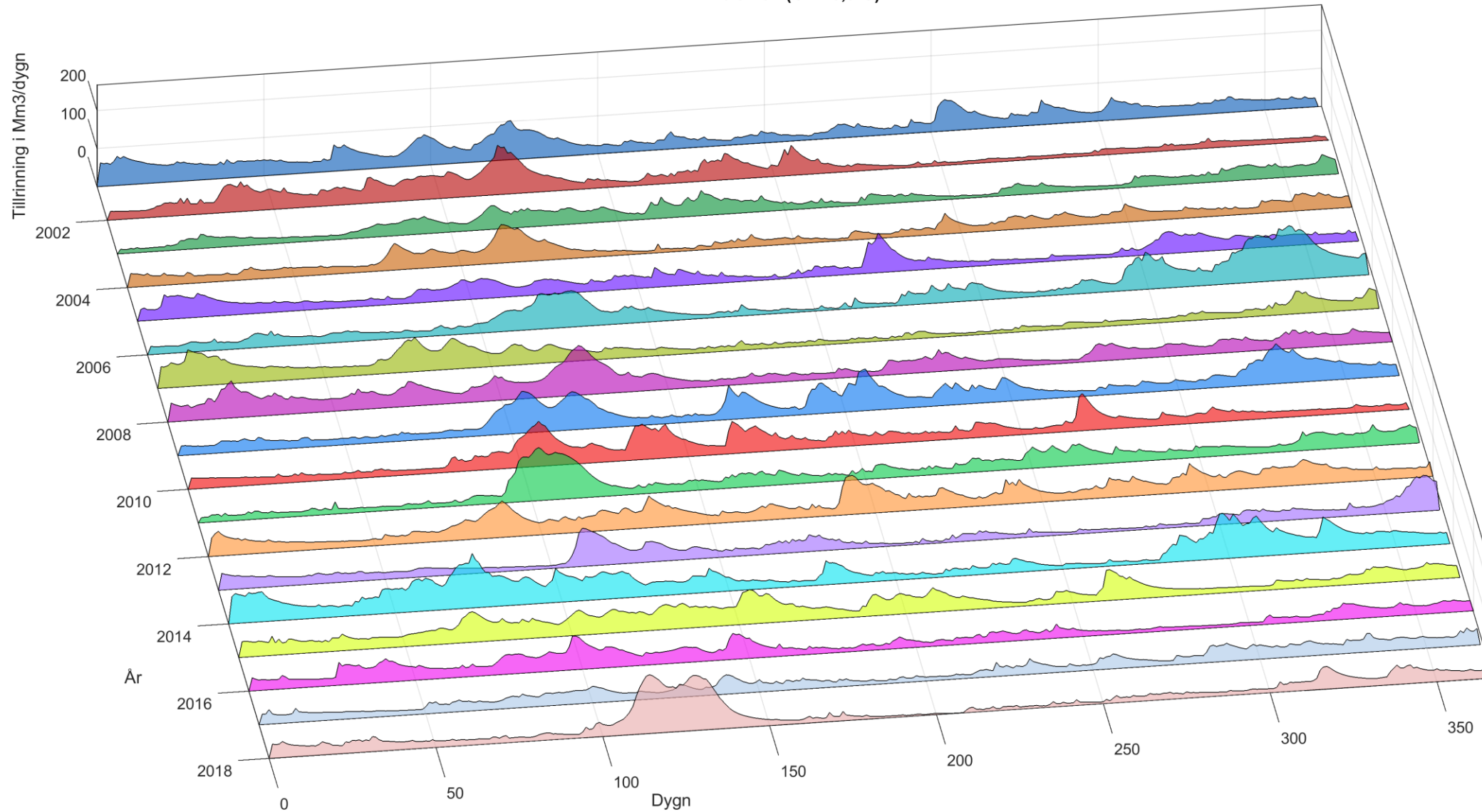
Total tillrinning (GWL2,0°C)

Dalälven (GWL2,0°C)



Total tillrinning (GWL3,0°C)

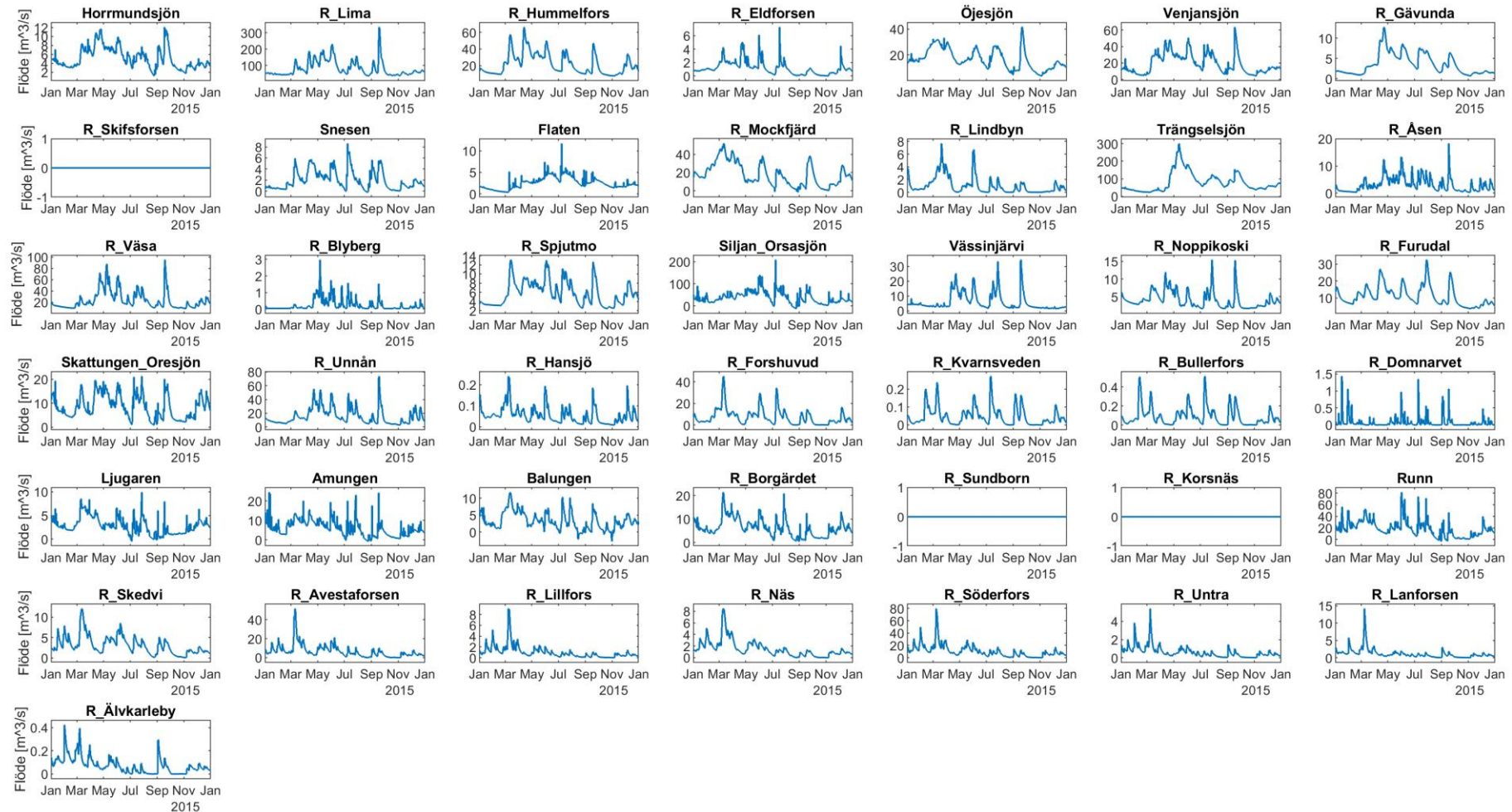
Dalälven (GWL3,0°C)



Resultat (exempel GWL2,0°C för 2015)

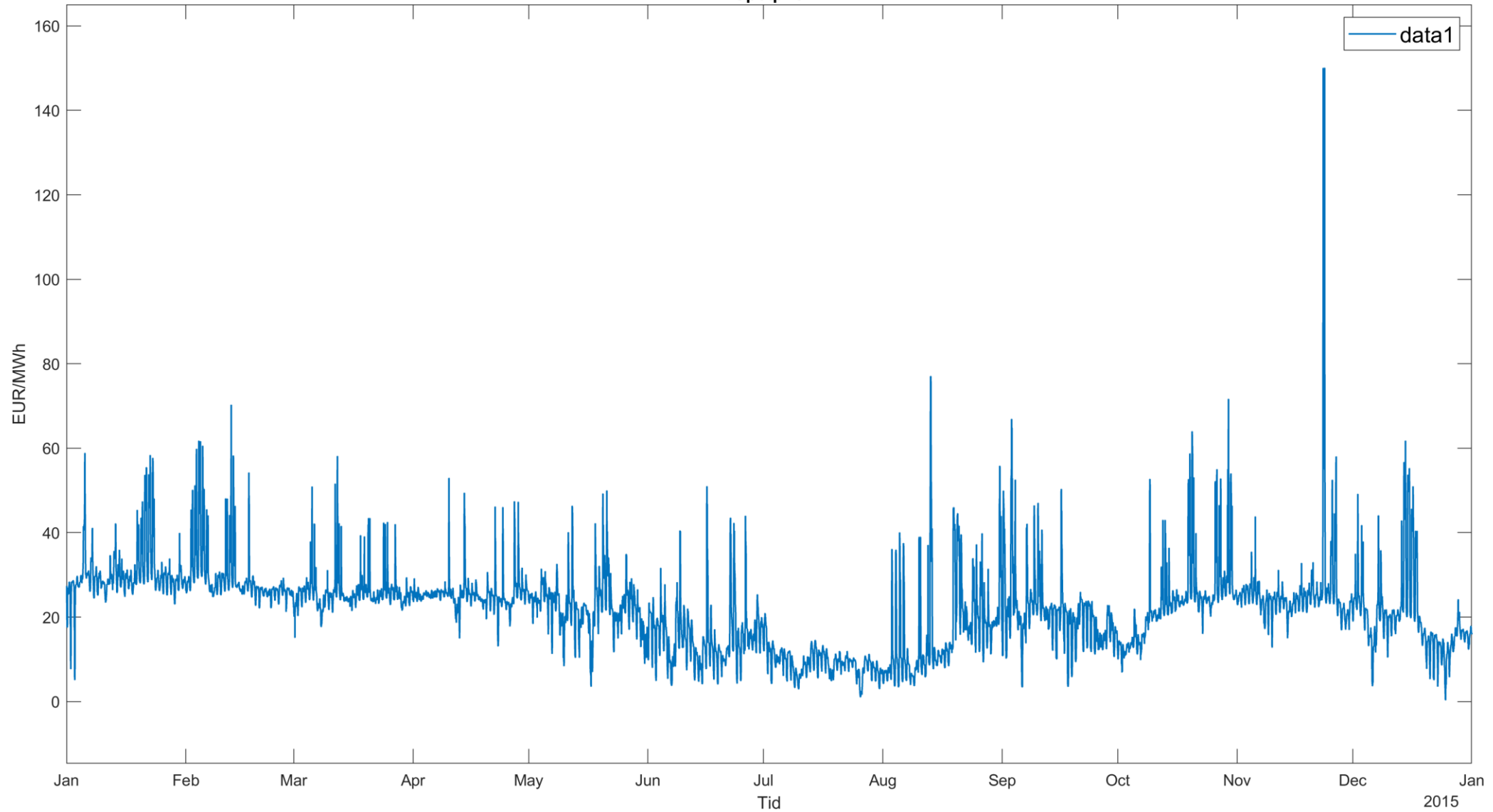
Lokaltillrinning

Lokal tillrinning för Dalälven

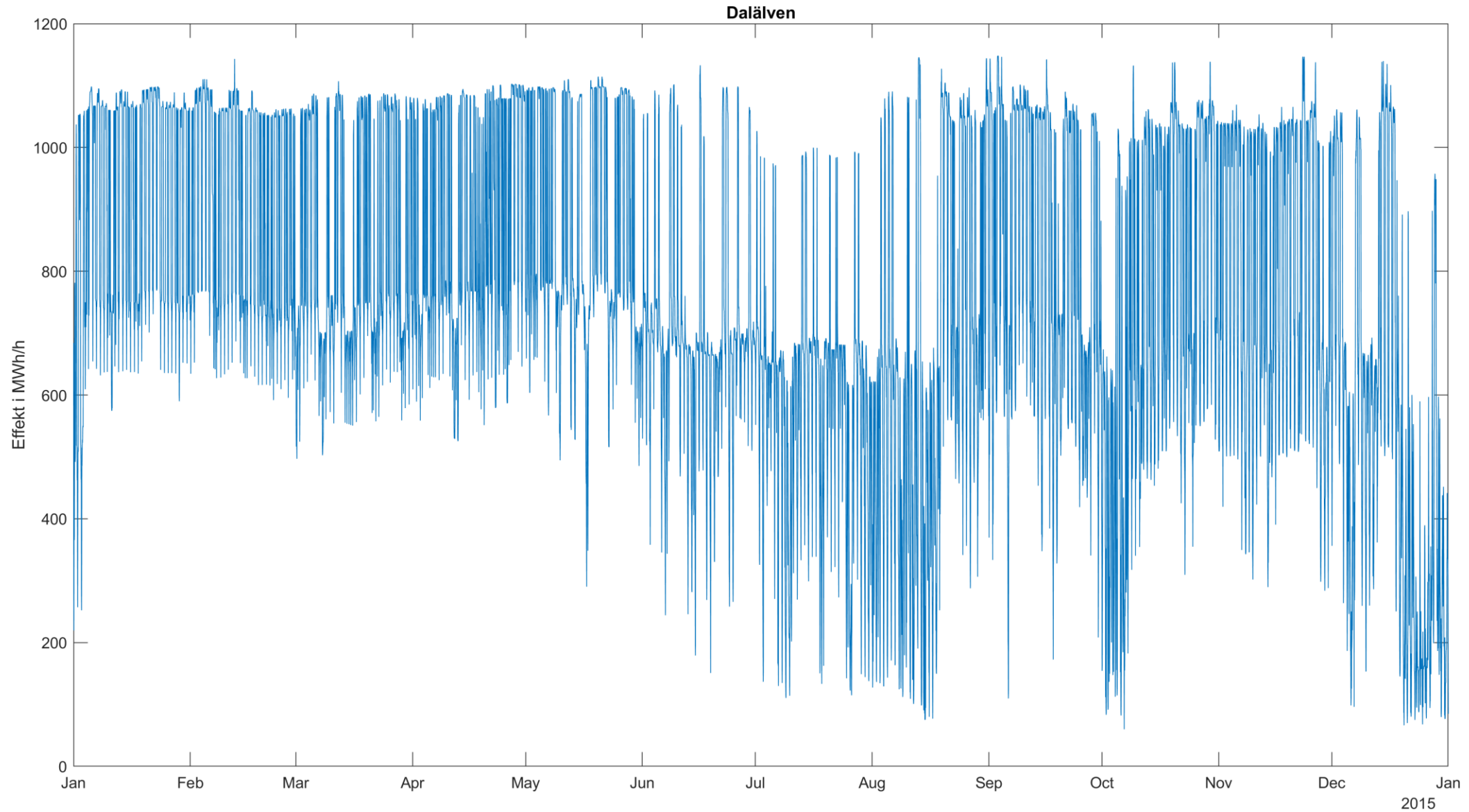


Elpriser

Spotpris

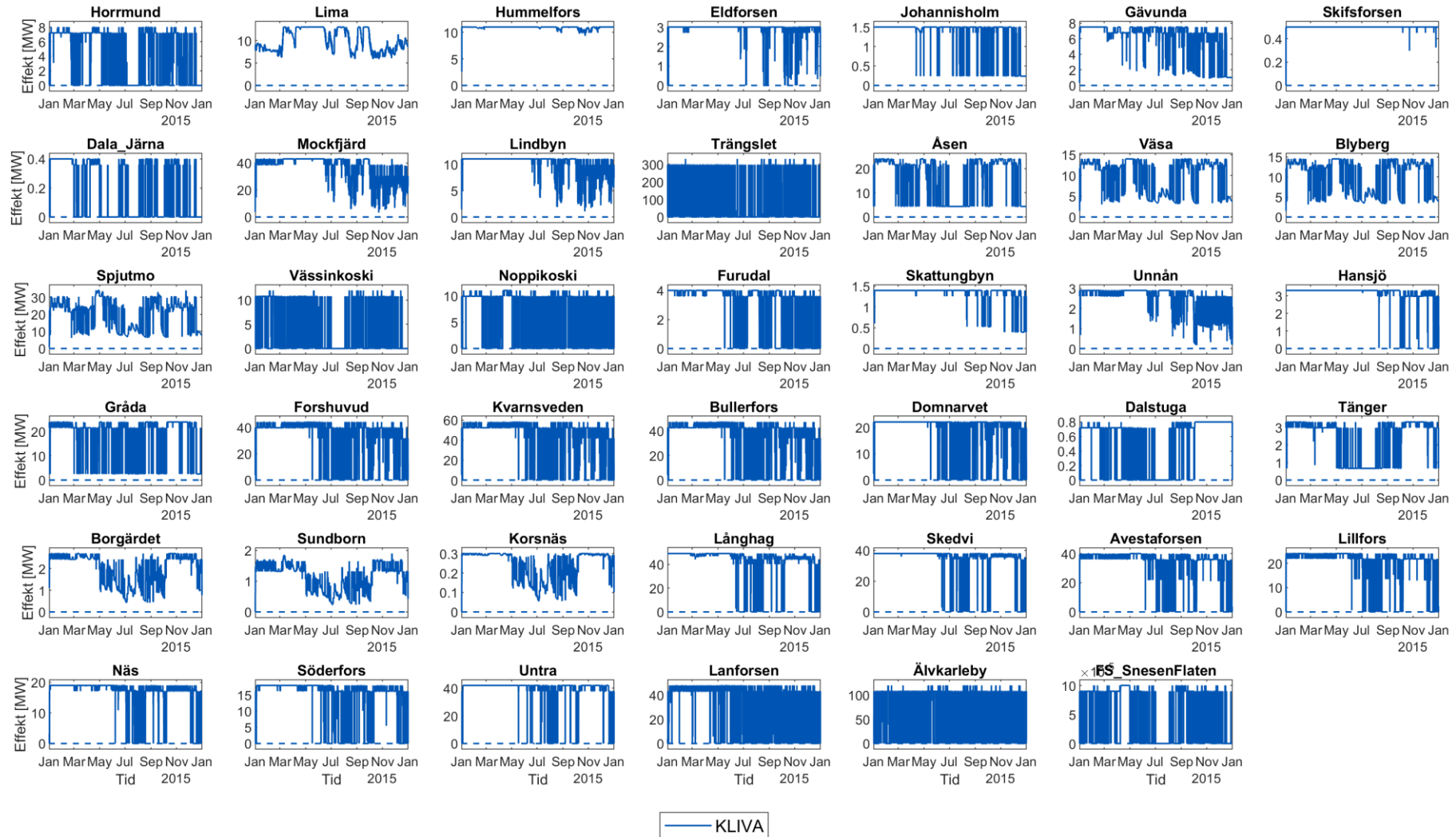


Produktion älvsystem



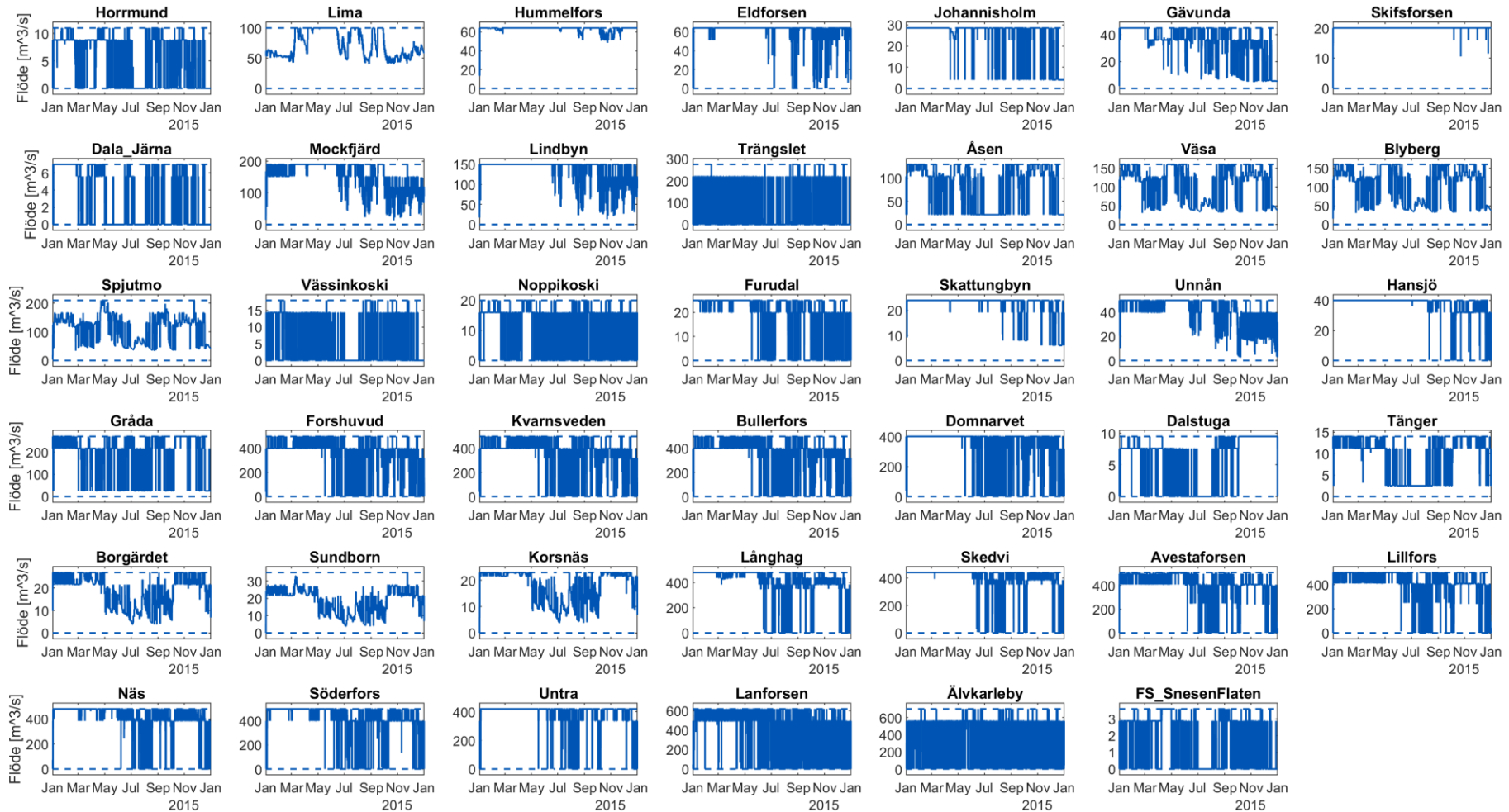
Produktion

Produktion per station för Dalälven



Stationsvattenföring

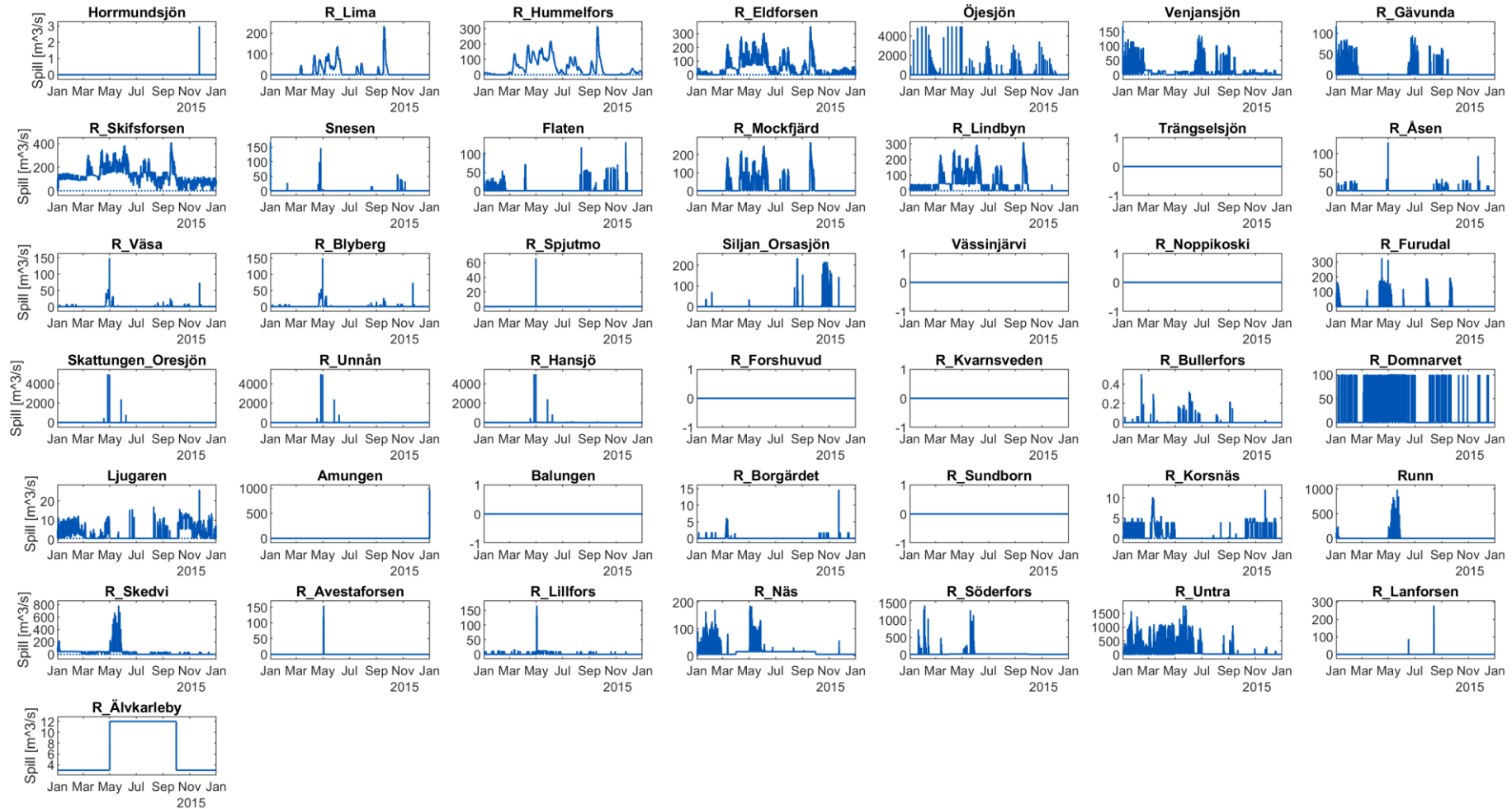
Turbinvattenföring för Dalälven



— KLIVA

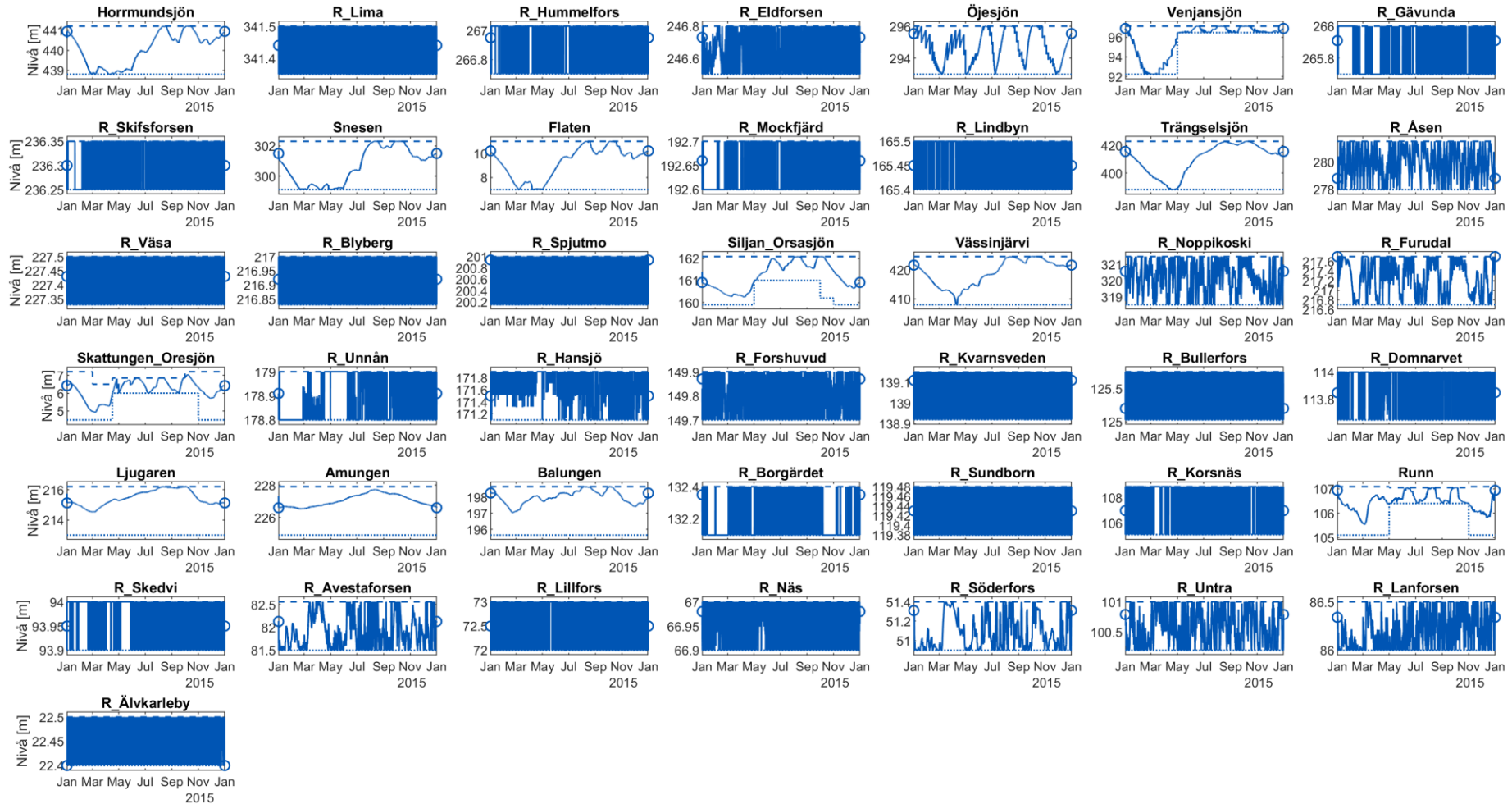
Spill

Dalälven



Vattenstånd

Dalälven

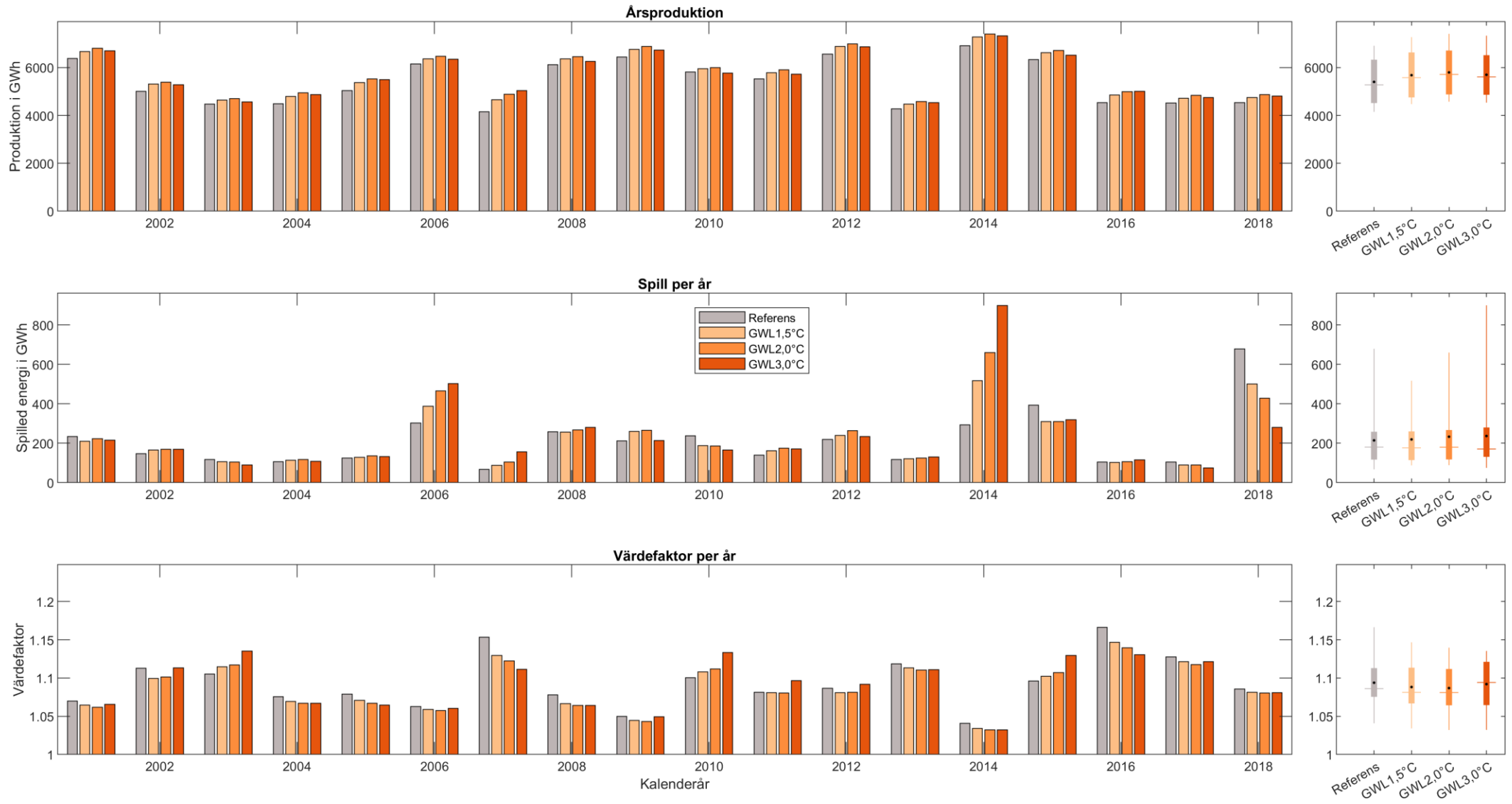


— KLIVA min - - - max ○ Randvillkor

Aggregerade resultat

Årsvärden produktion, spill, värdefaktor

Dalälven



Statistik produktion, spill, värdefaktor

Produktion i GWh

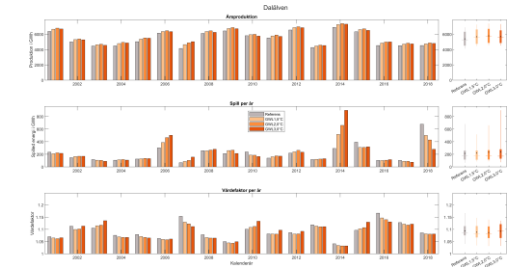
GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	5402	(Ref)	(Ref)	4518	6328	1810	4150	6910
GWL1, 5°C	5682	+280	+5 %	4753	6631	1878	4474	7272
GWL2, 0°C	5798	+396	+7 %	4878	6711	1833	4575	7408
GWL3, 0°C	5699	+297	+5 %	4864	6516	1652	4536	7332

Spill i GWh

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	215	(Ref)	(Ref)	117	258	141	68	679
GWL1, 5°C	219	+4	+2 %	115	260	145	88	517
GWL2, 0°C	233	+18	+8 %	118	267	149	89	660
GWL3, 0°C	237	+22	+10 %	131	280	149	75	900

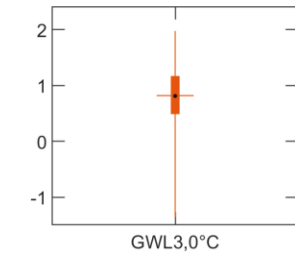
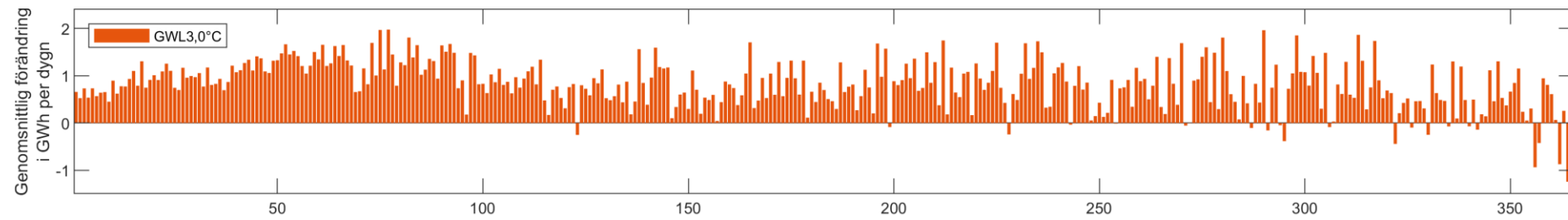
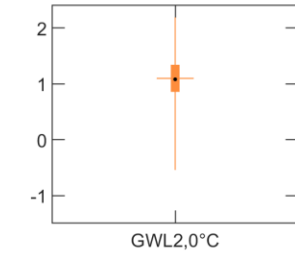
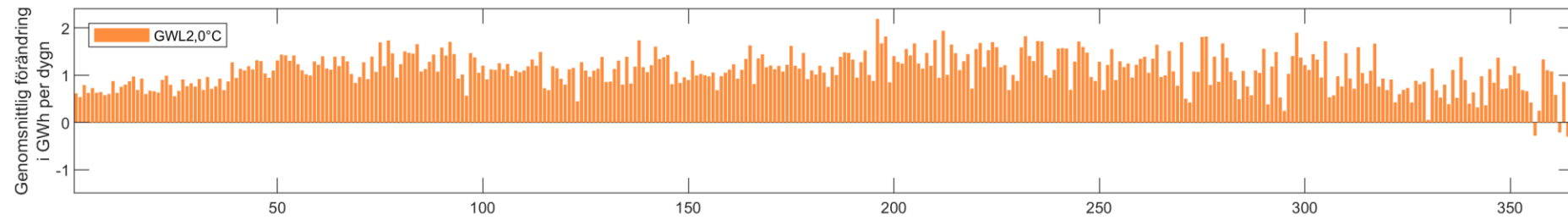
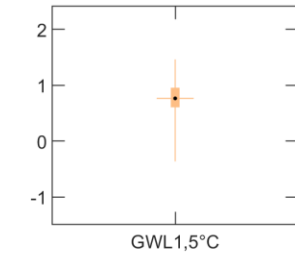
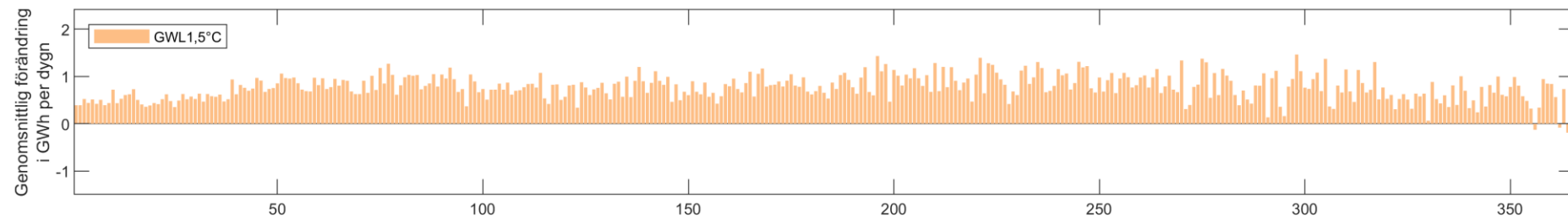
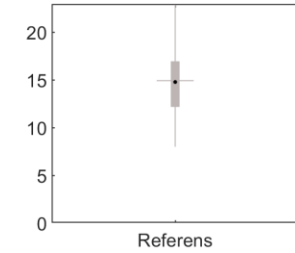
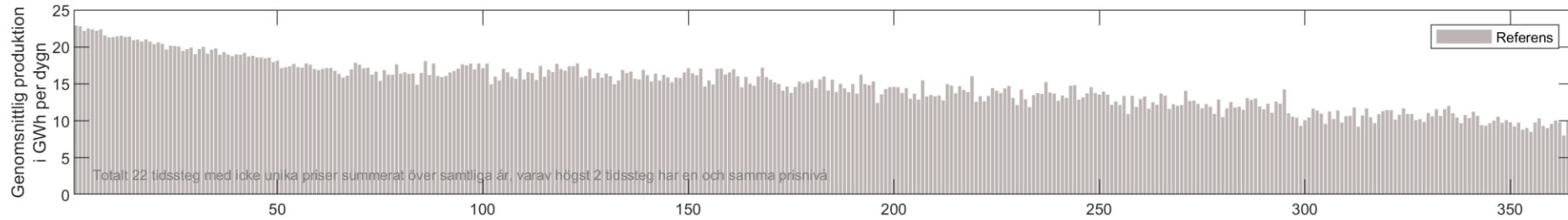
Värdefaktor

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	1.094	(Ref)	(Ref)	1.075	1.113	0.038	1.041	1.166
GWL1, 5°C	1.088	-0.006	-1 %	1.067	1.114	0.047	1.034	1.147
GWL2, 0°C	1.087	-0.007	-1 %	1.064	1.112	0.048	1.032	1.140
GWL3, 0°C	1.092	-0.002	+0 %	1.065	1.121	0.056	1.032	1.135



Förändring i balanseringsförmågan

Flerårs prissorterad produktion Dalälven (24 h)



Dygn



Kontakt AP2

richard.scharff@vattenfall.com



KLIVA-rapport bilaga A Indalsälven

Richard Scharff, Chalmers, 2023-02-01

Kommentarer

- Bilagan innehåller ett axplock av diagram för att illustrera indata till vattenkraftmodellen samt dess resultat
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Energiforsk

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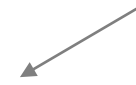
Innehåll diagrammsamling

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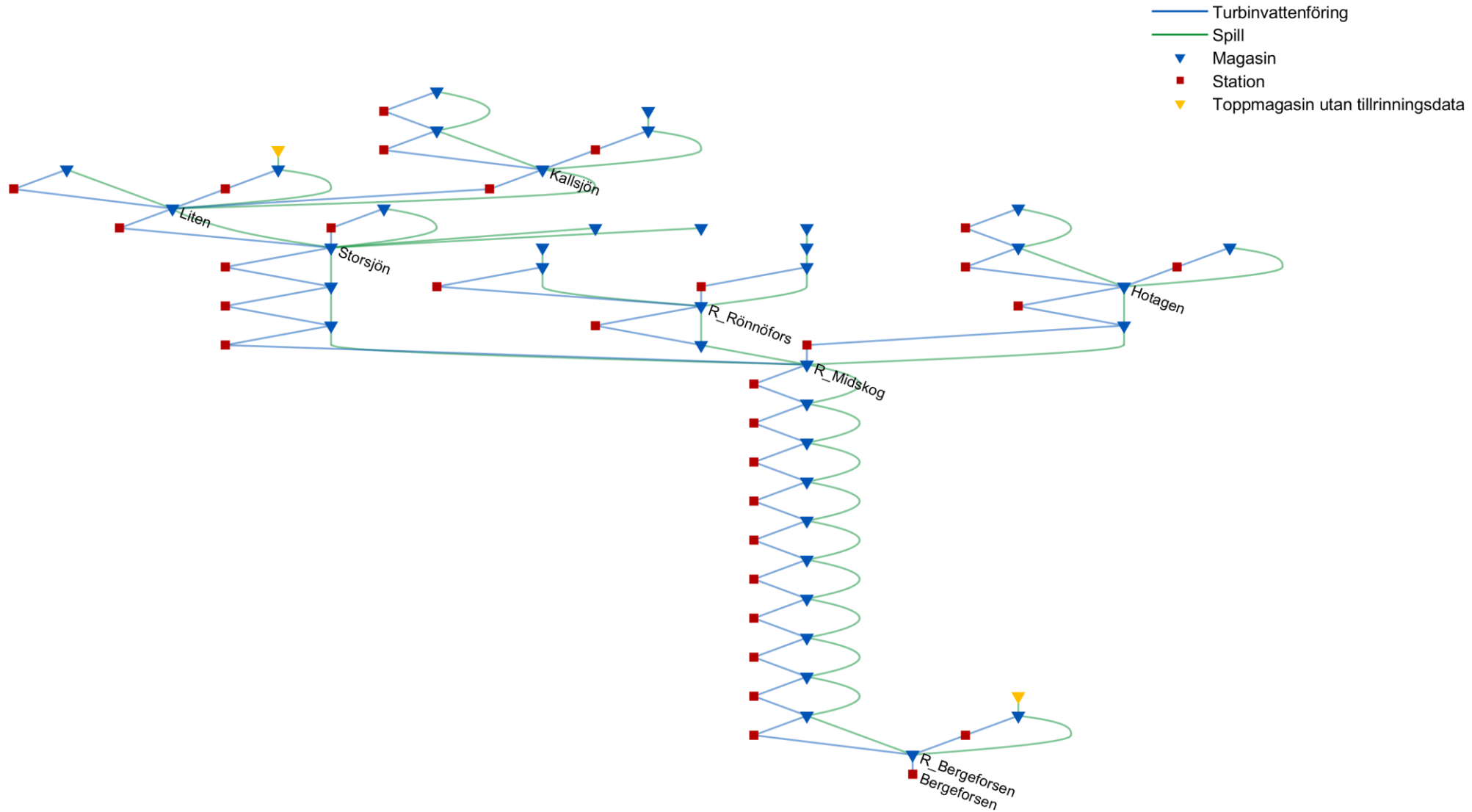
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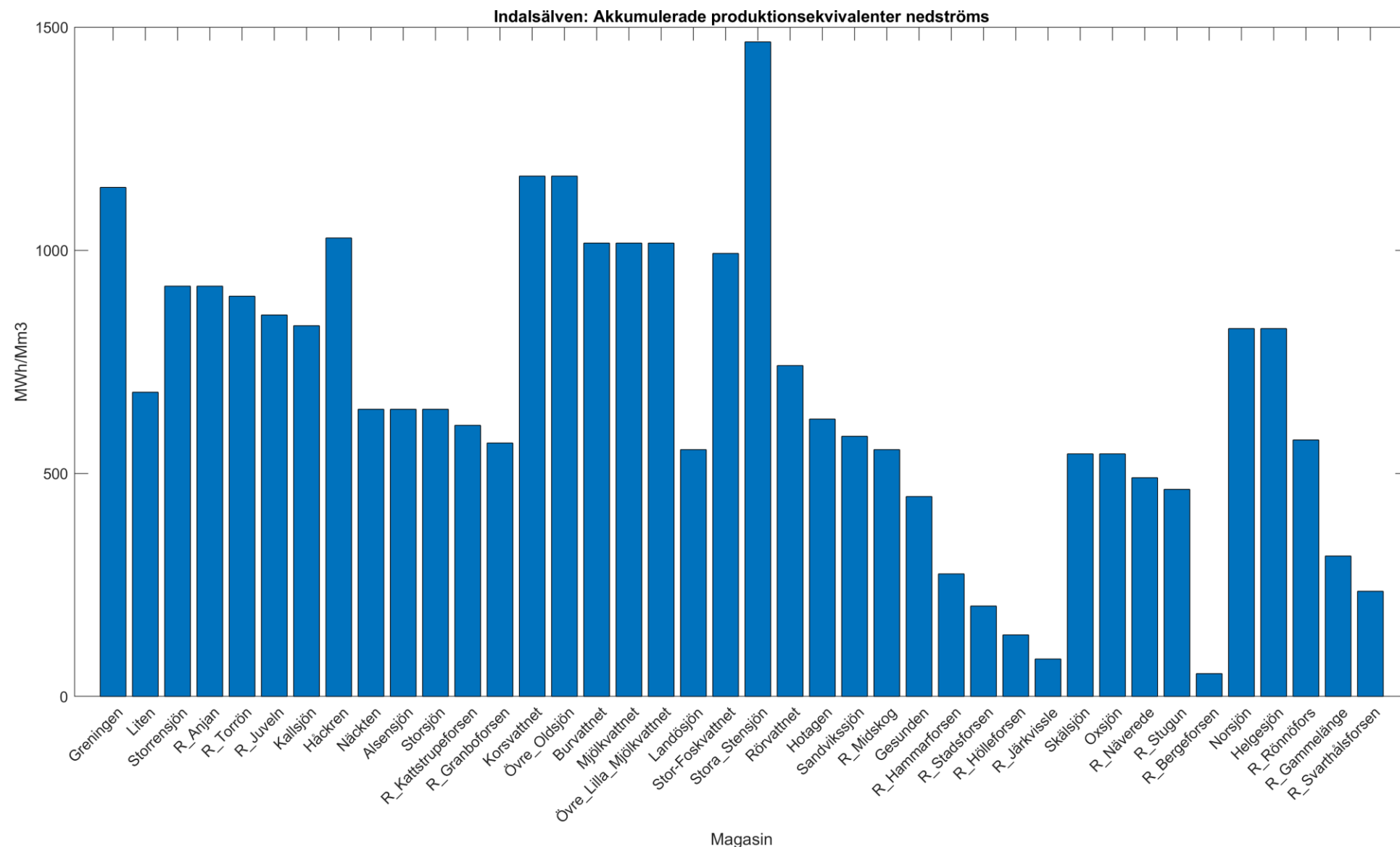
Systembeskrivning

Älvsystem

Indalsälven

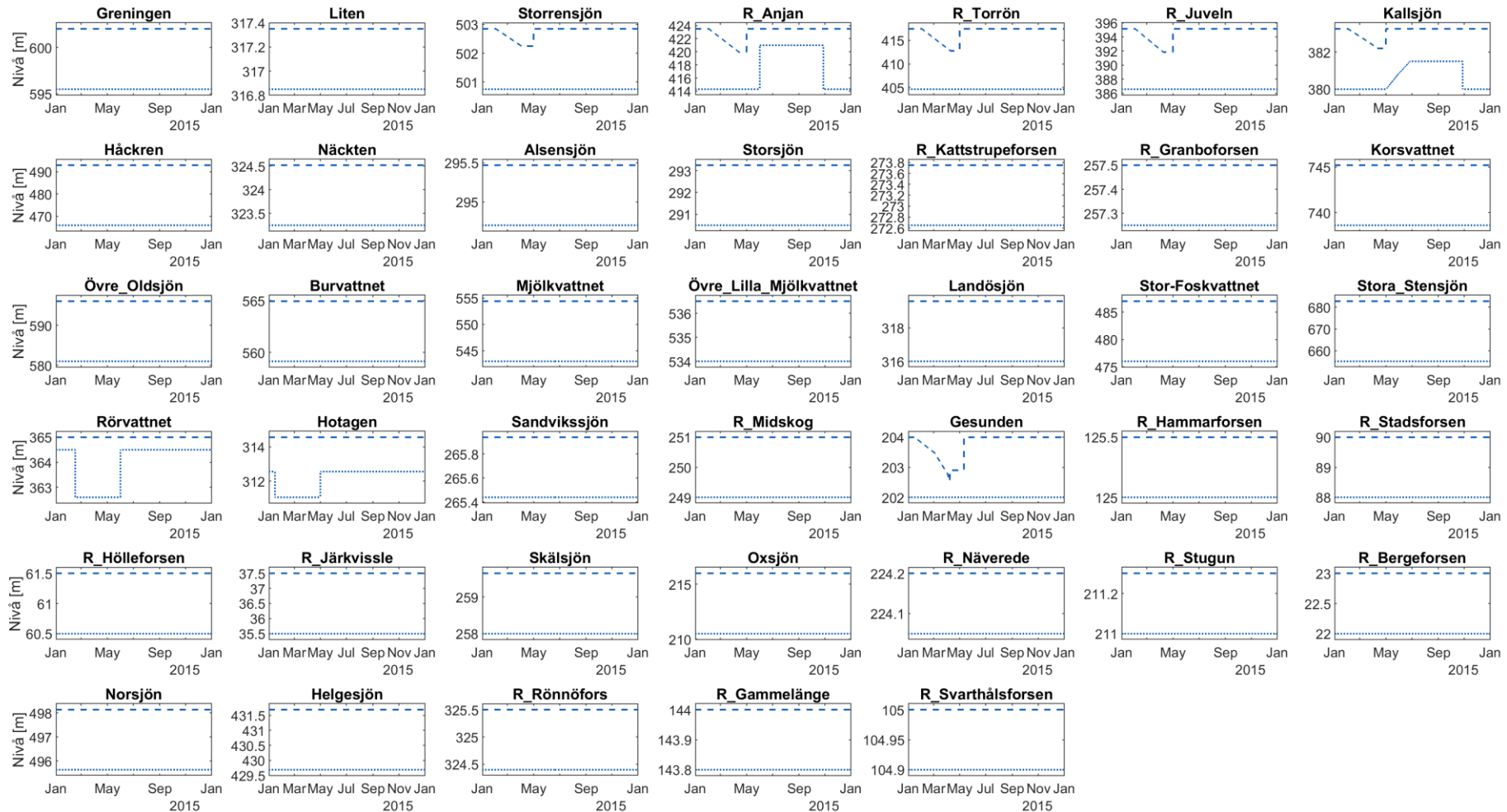


Energi per Mm³ lokaltillrinning



Vattendomar "WaterLevel"

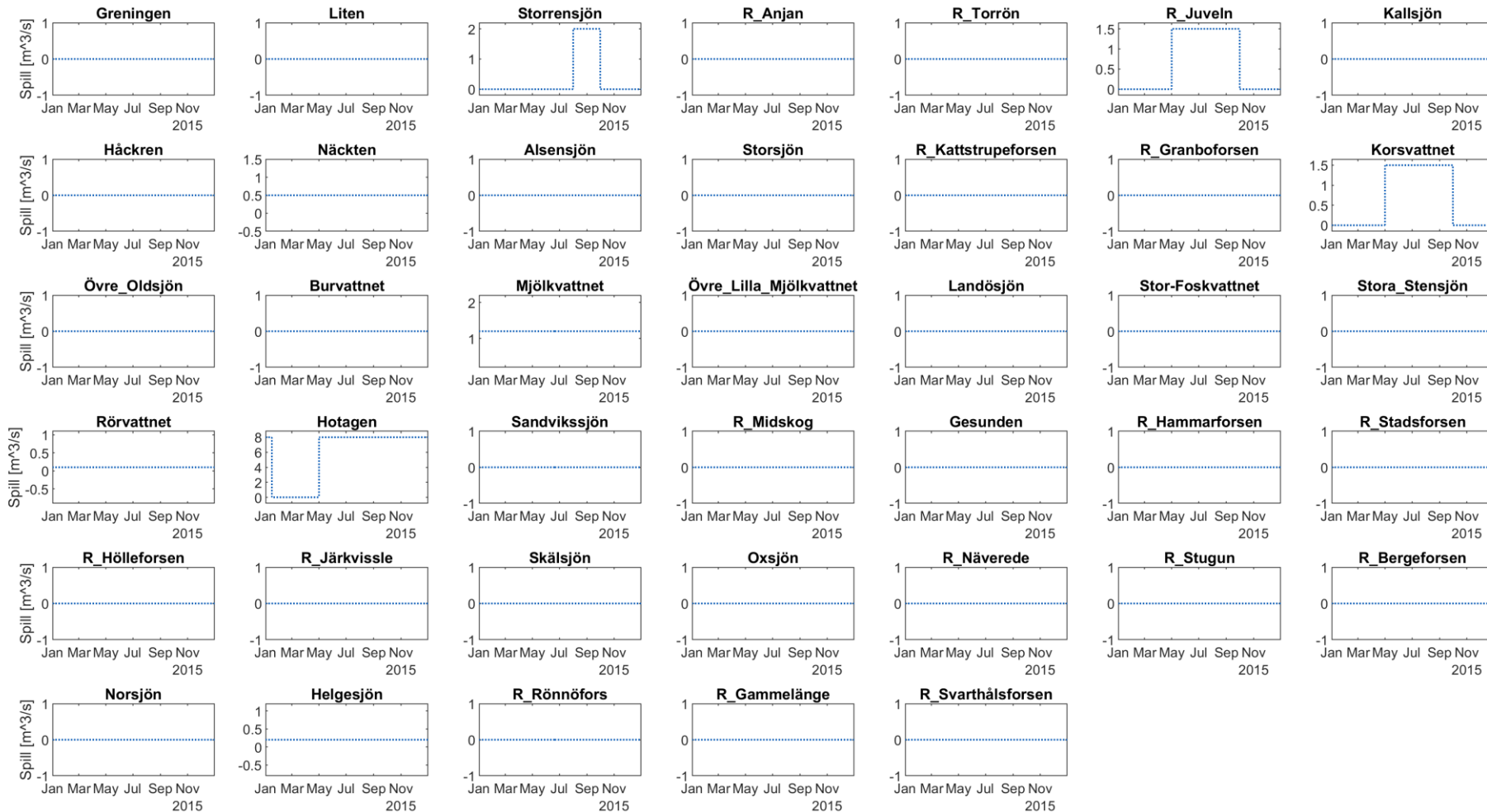
Indalsälven



..... min - - - max

Vattendomar "MinSpill"

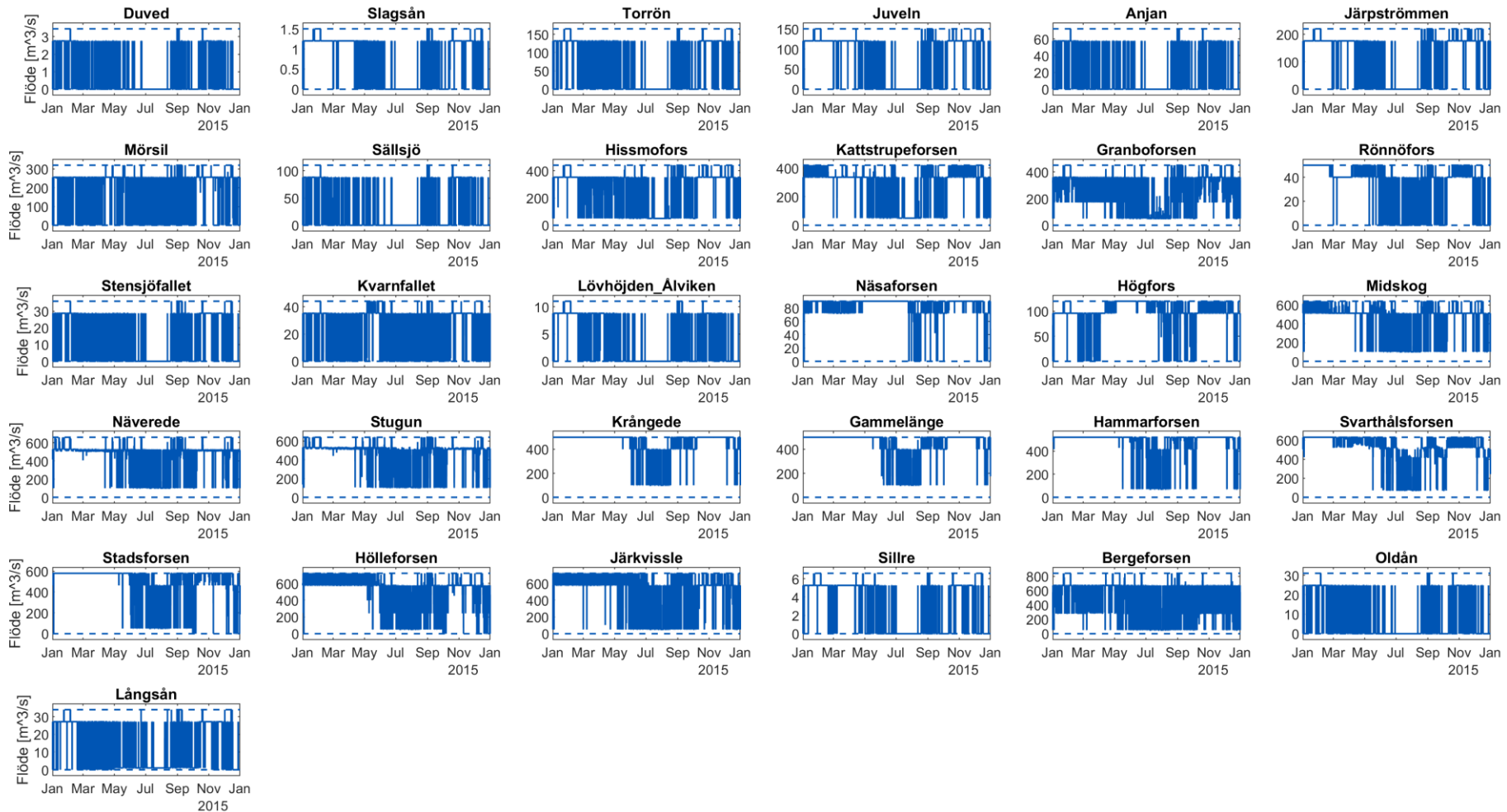
Indalsälven



..... min

Vattendomar "MinFlow"

Turbinvattenföring för Indalsälven

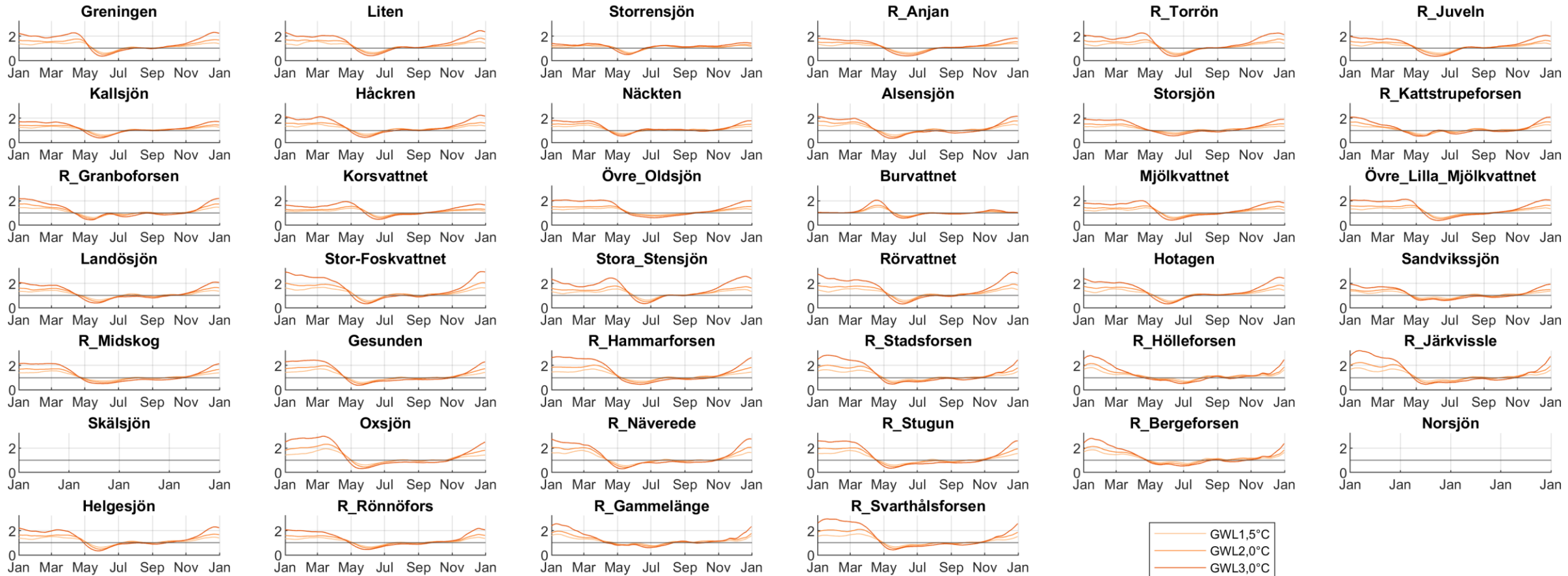


— KLIVA

Klimatpåverkan på lokaltillrinningar

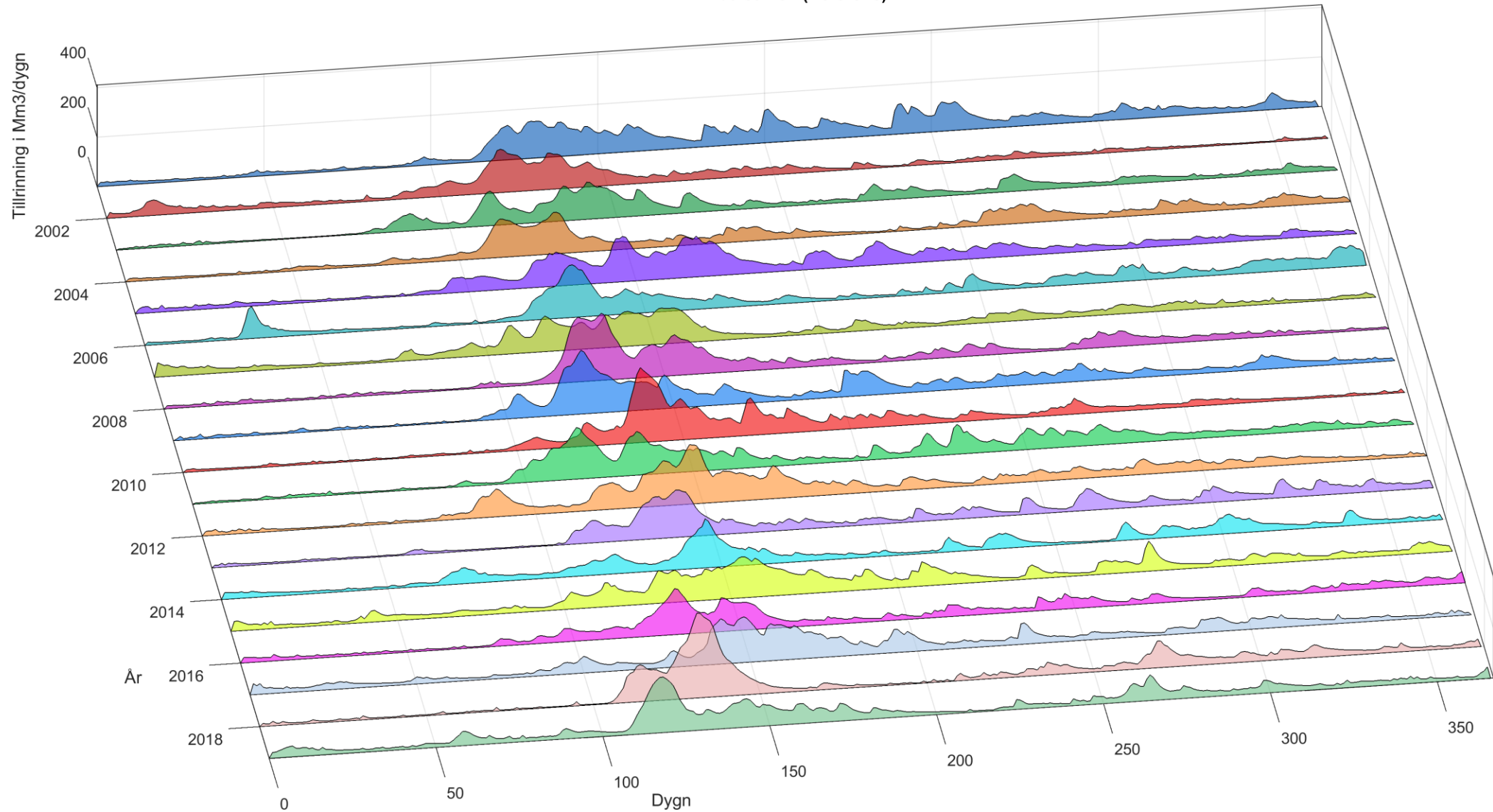
Klimatfaktorer

Klimatfaktorer Indalsälven



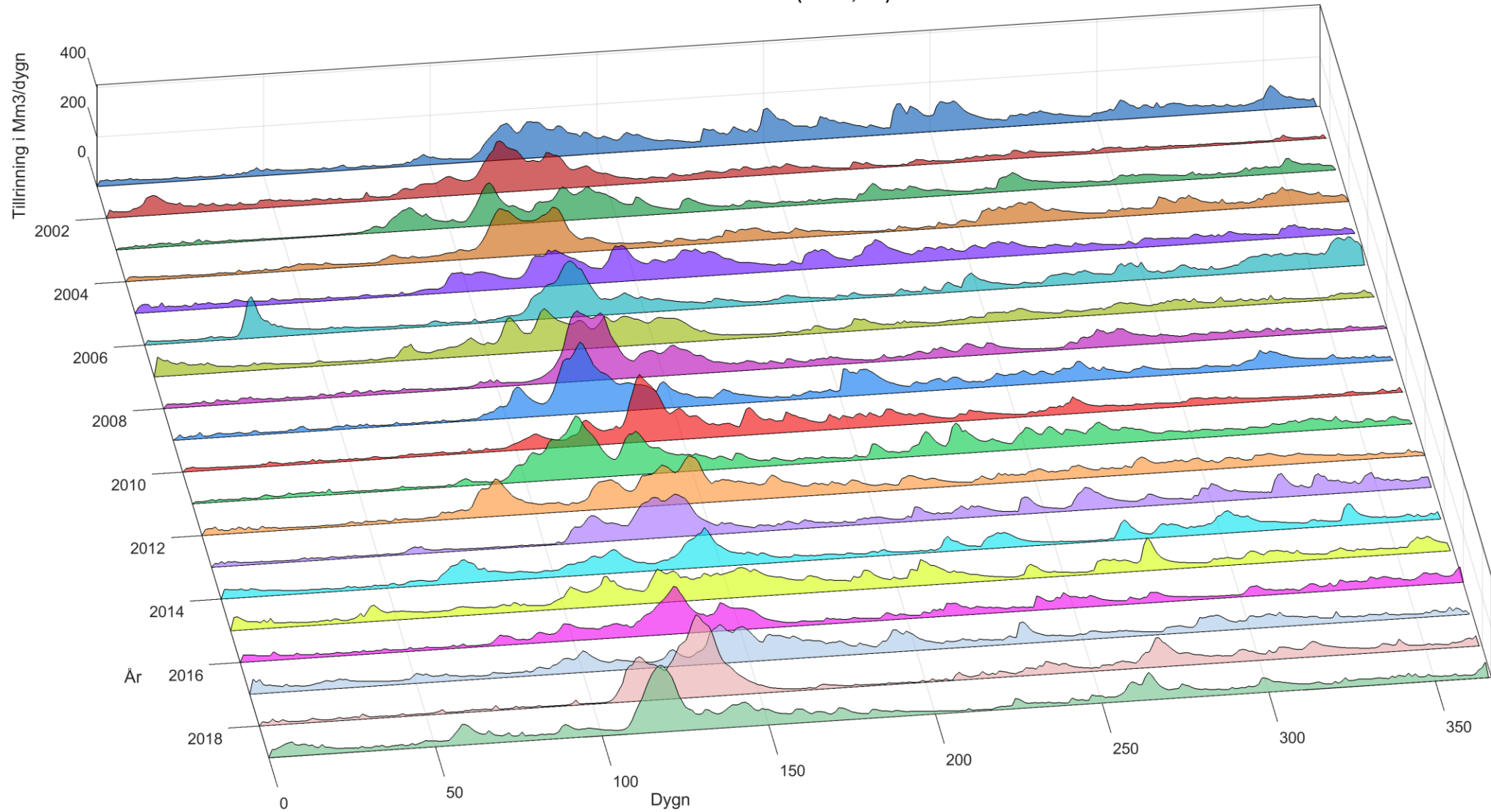
Total tillrinning (Referens)

Indalsälven (Referens)



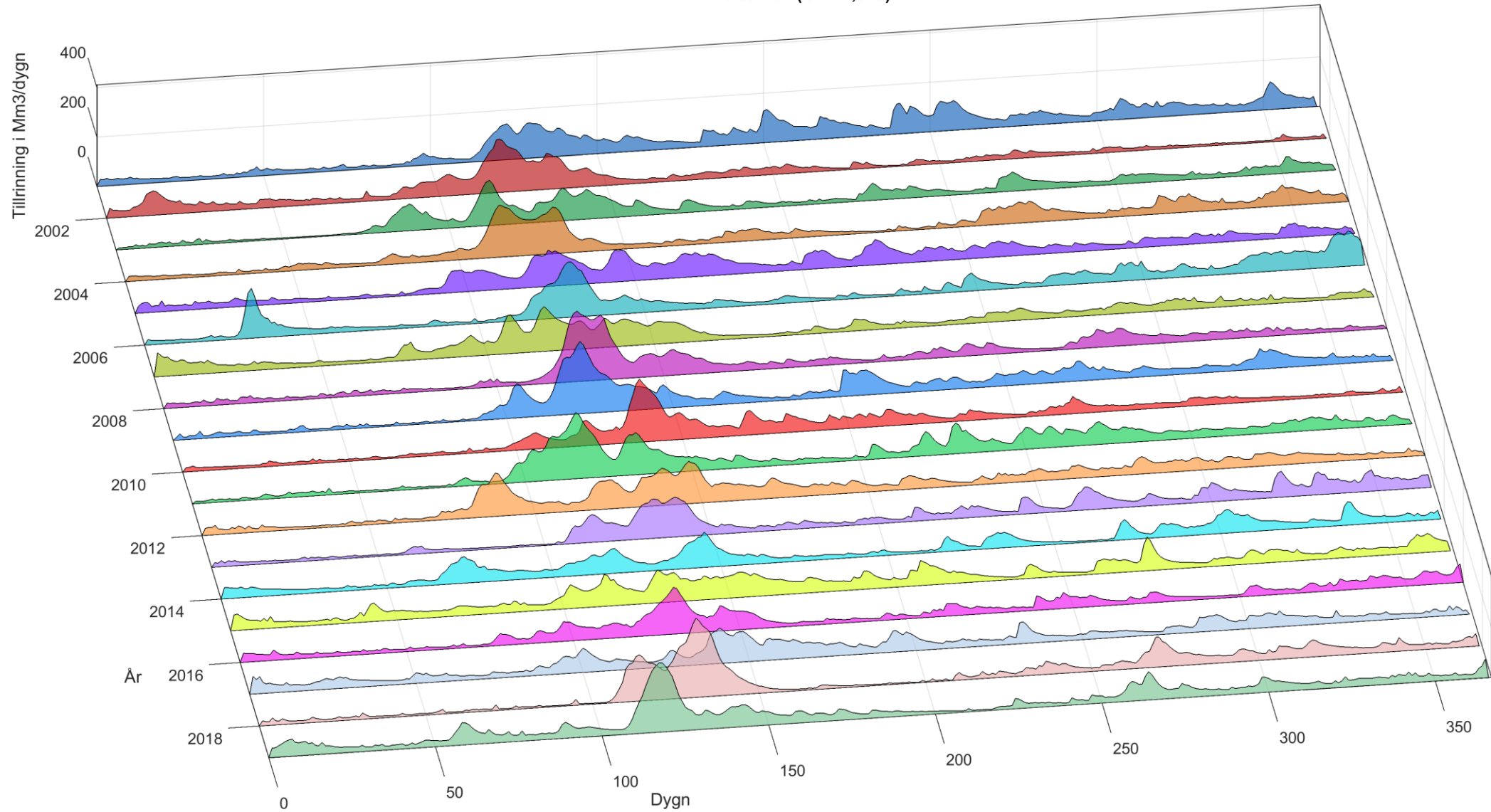
Total tillrinning (GWL1,5°C)

Indalsälven (GWL1,5°C)



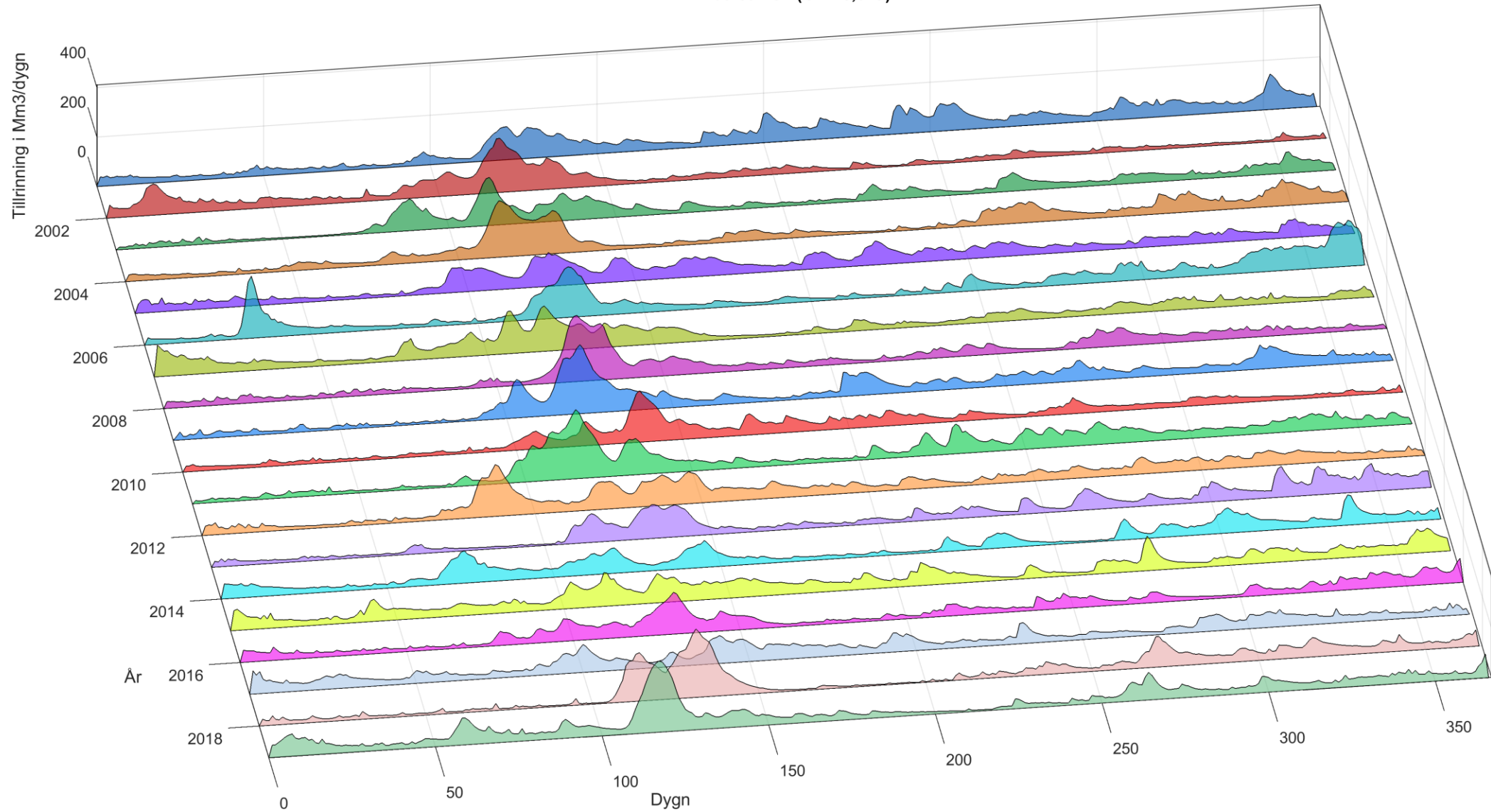
Total tillrinning (GWL2,0°C)

Indalsälven (GWL2,0°C)



Total tillrinning (GWL3,0°C)

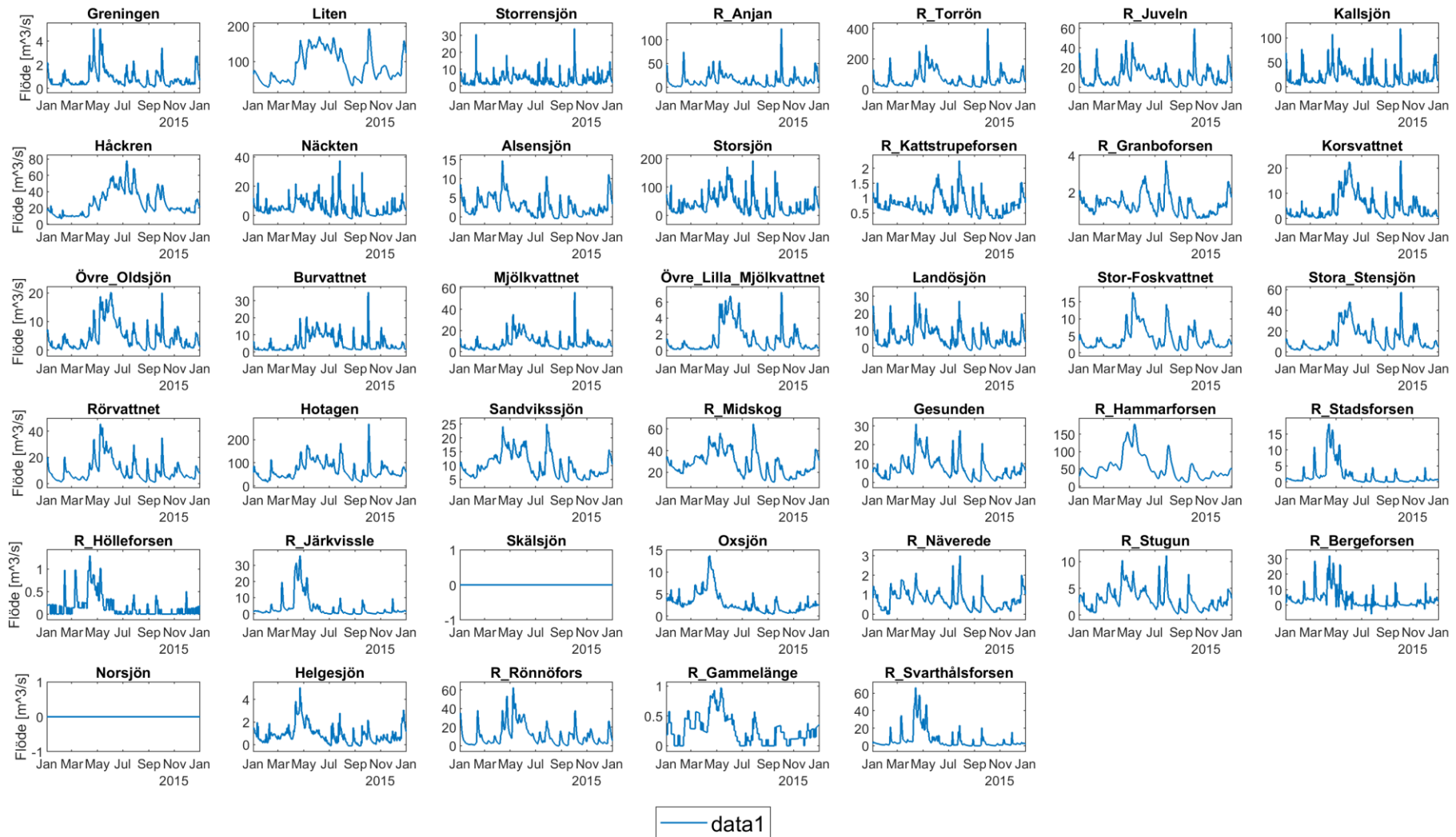
Indalsälven (GWL3,0°C)



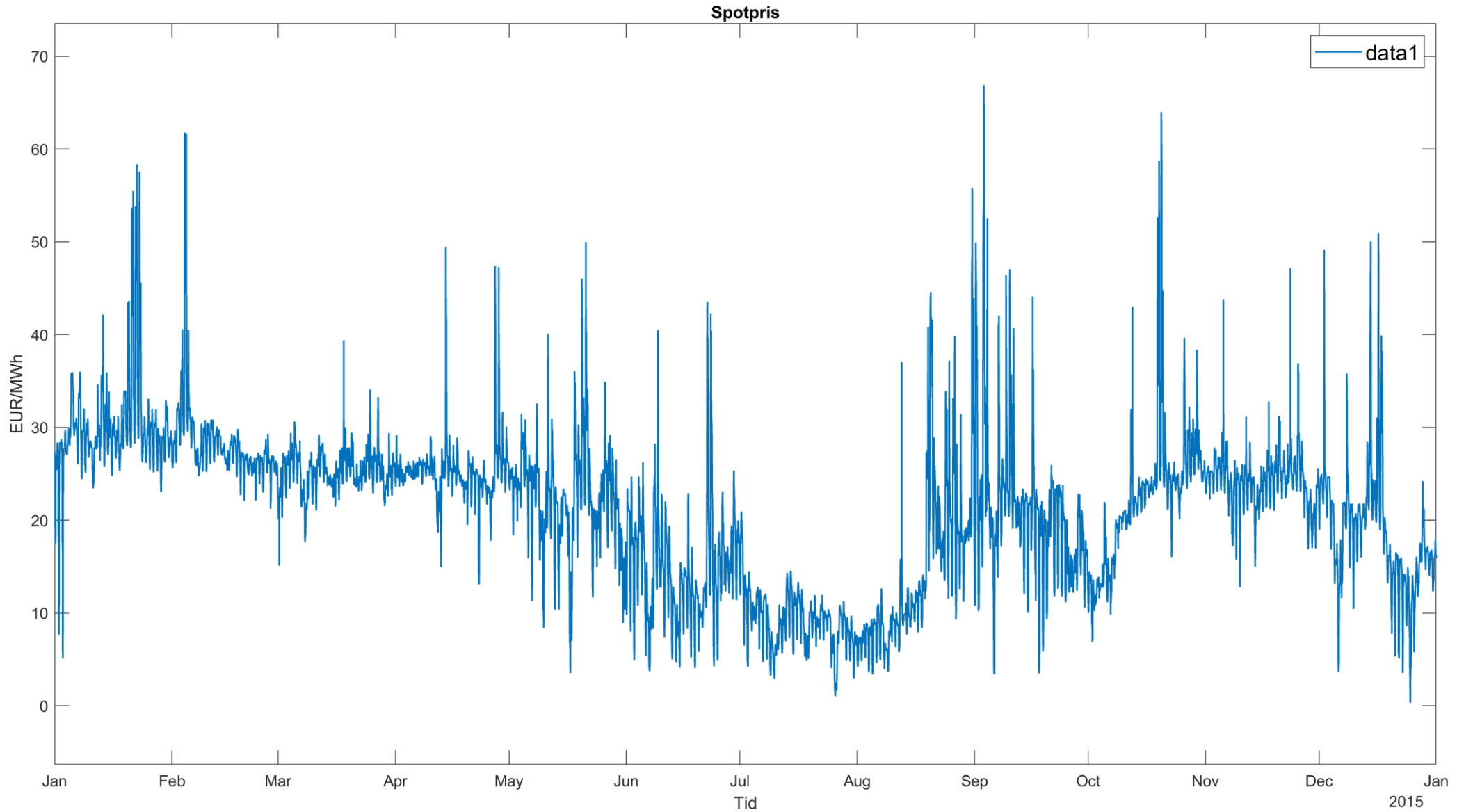
Resultat (exempel GWL2,0°C för 2015)

Lokaltillrinning

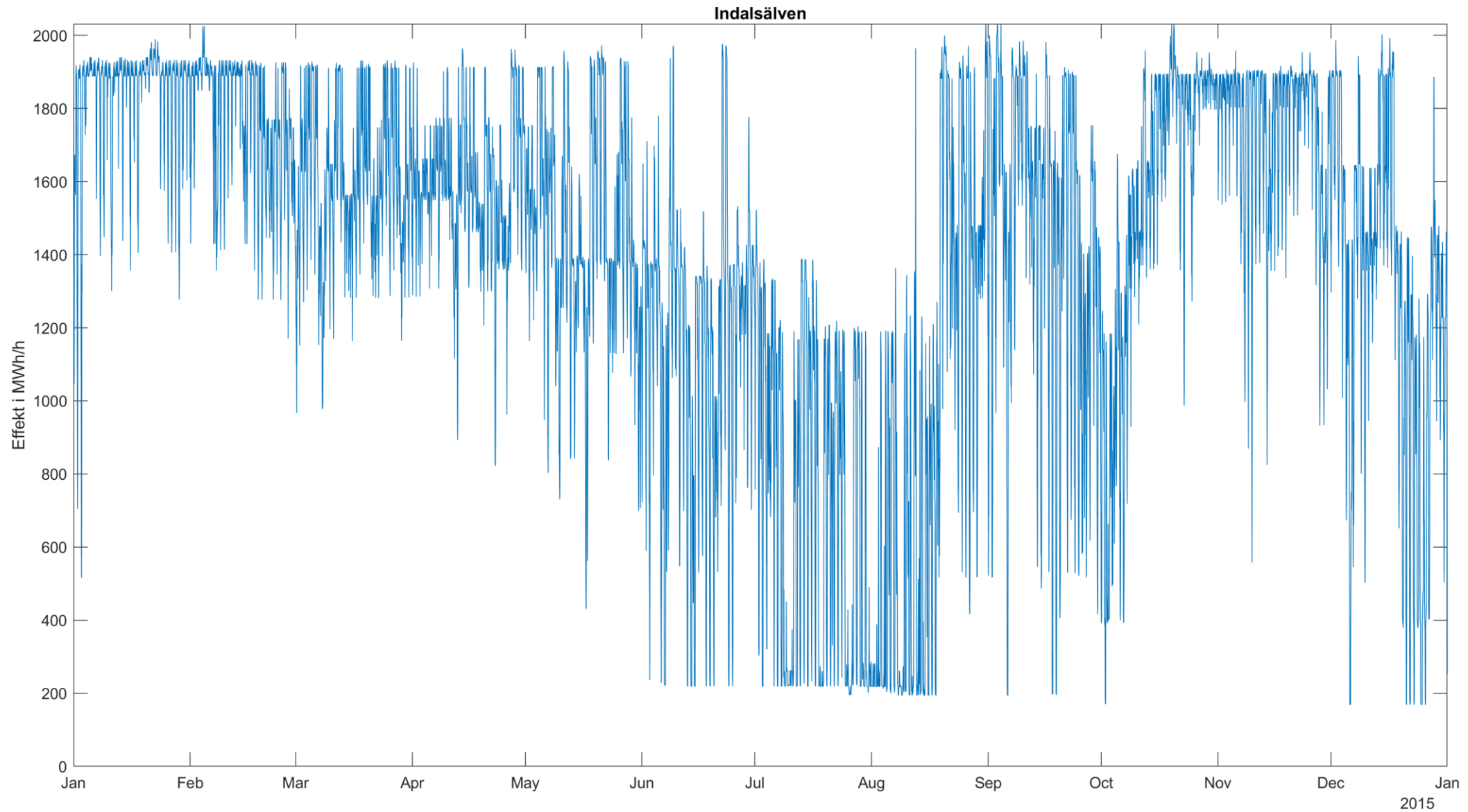
Lokal tillrinning för Indalsälven



Elpriser

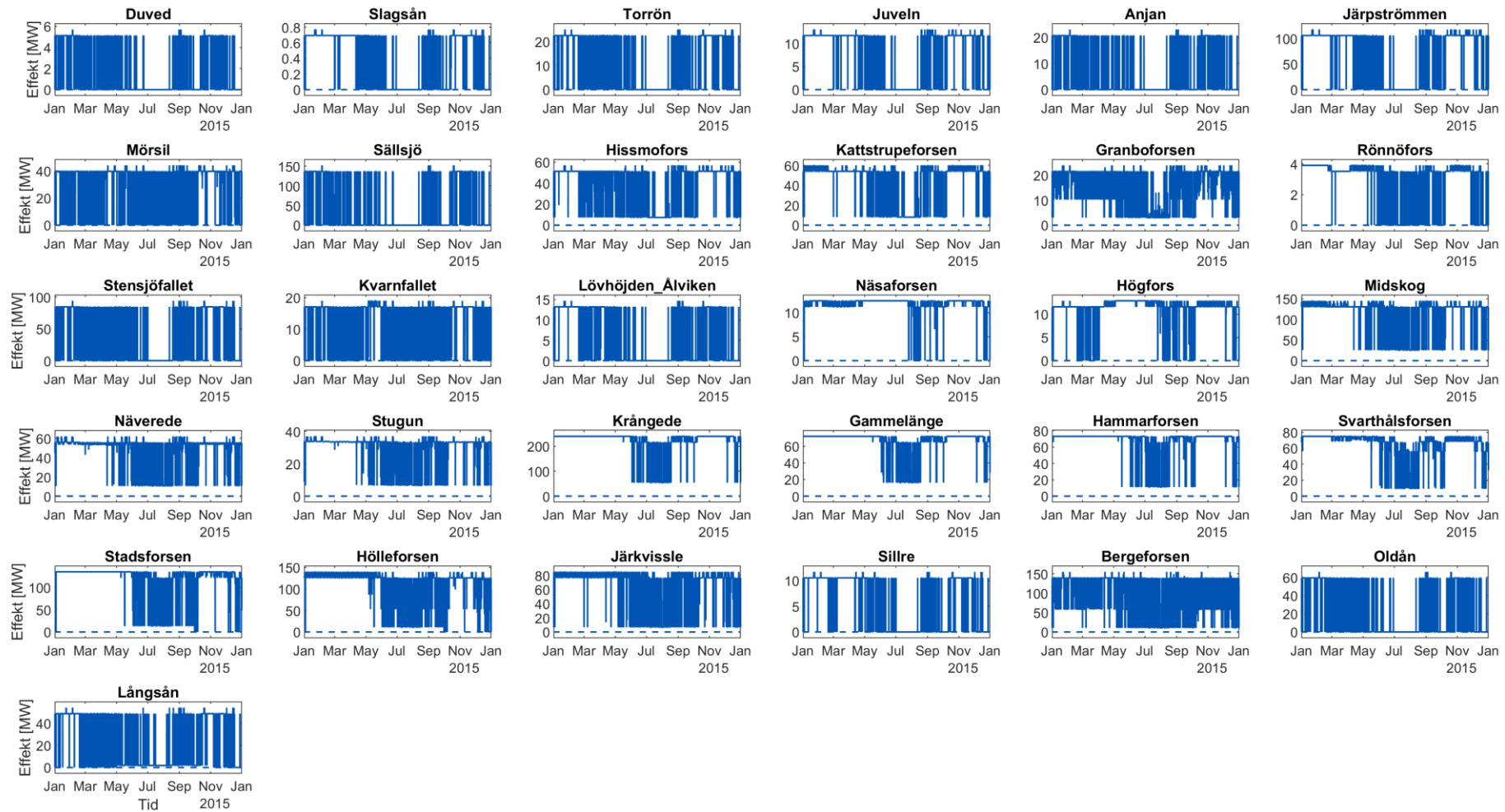


Produktion älvsystem



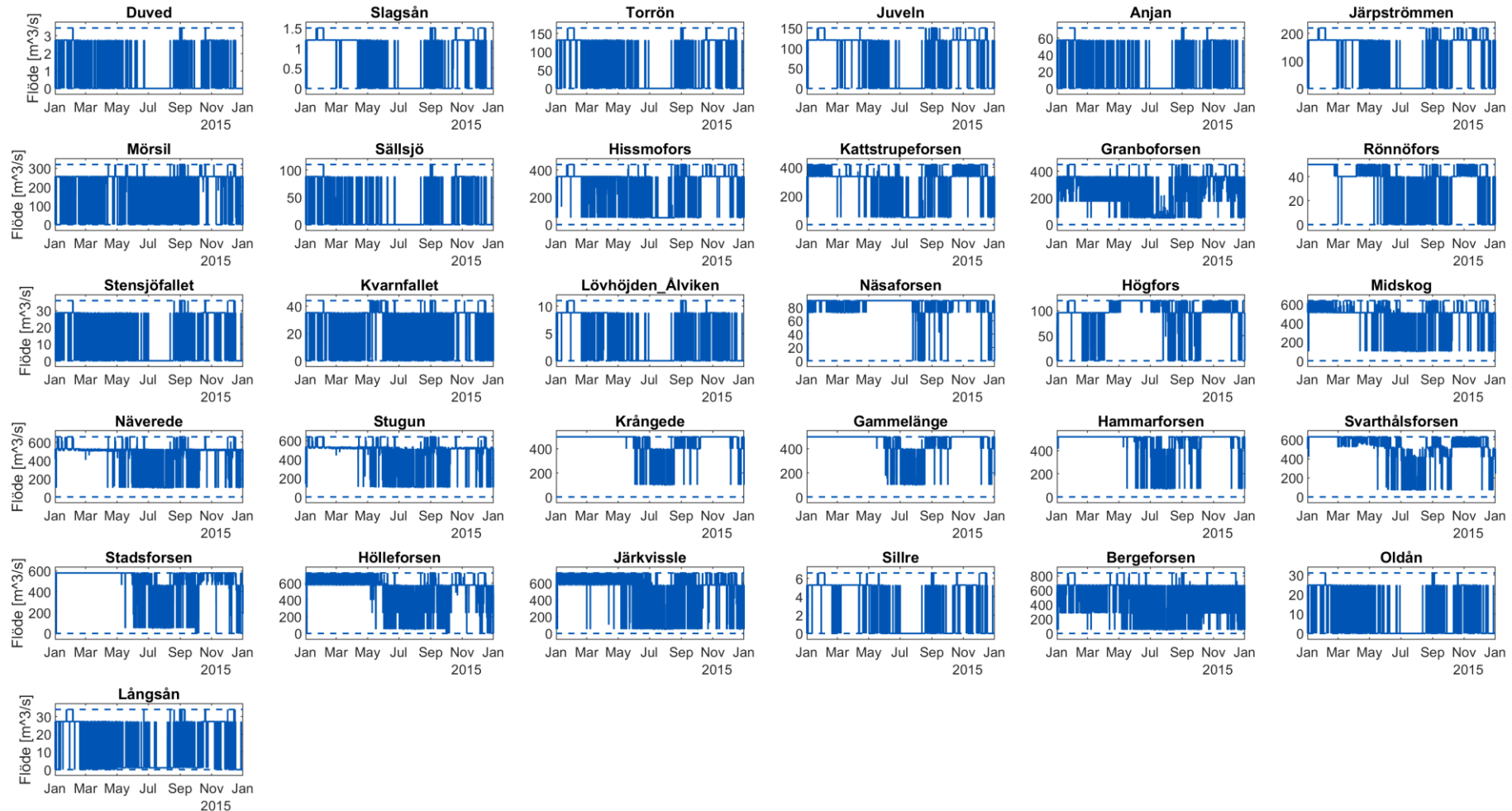
Produktion

Produktion per station för Indalsälven



Stationsvattenföring

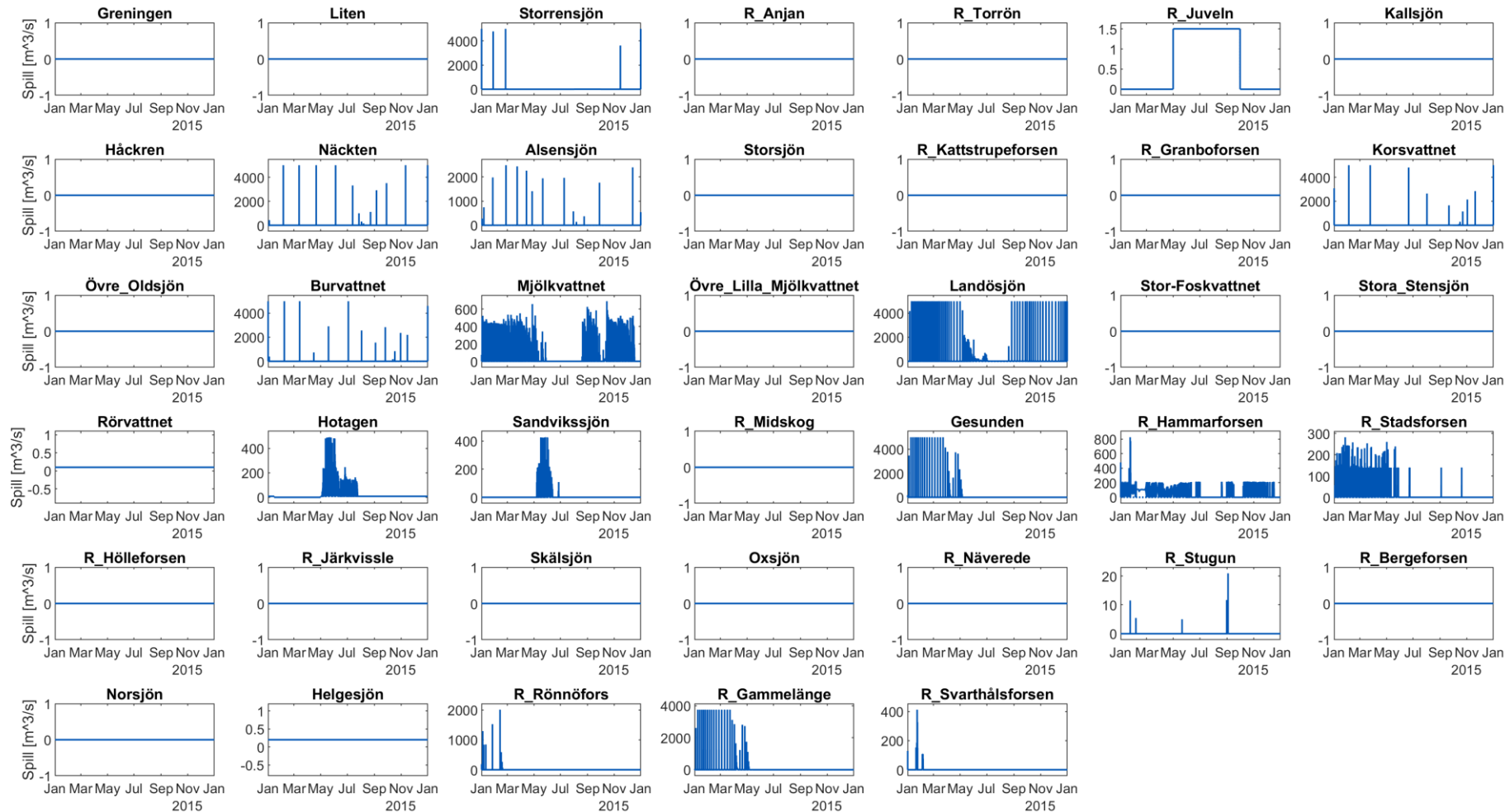
Turbinvattenföring för Indalsälven



— KLIVA

Spill

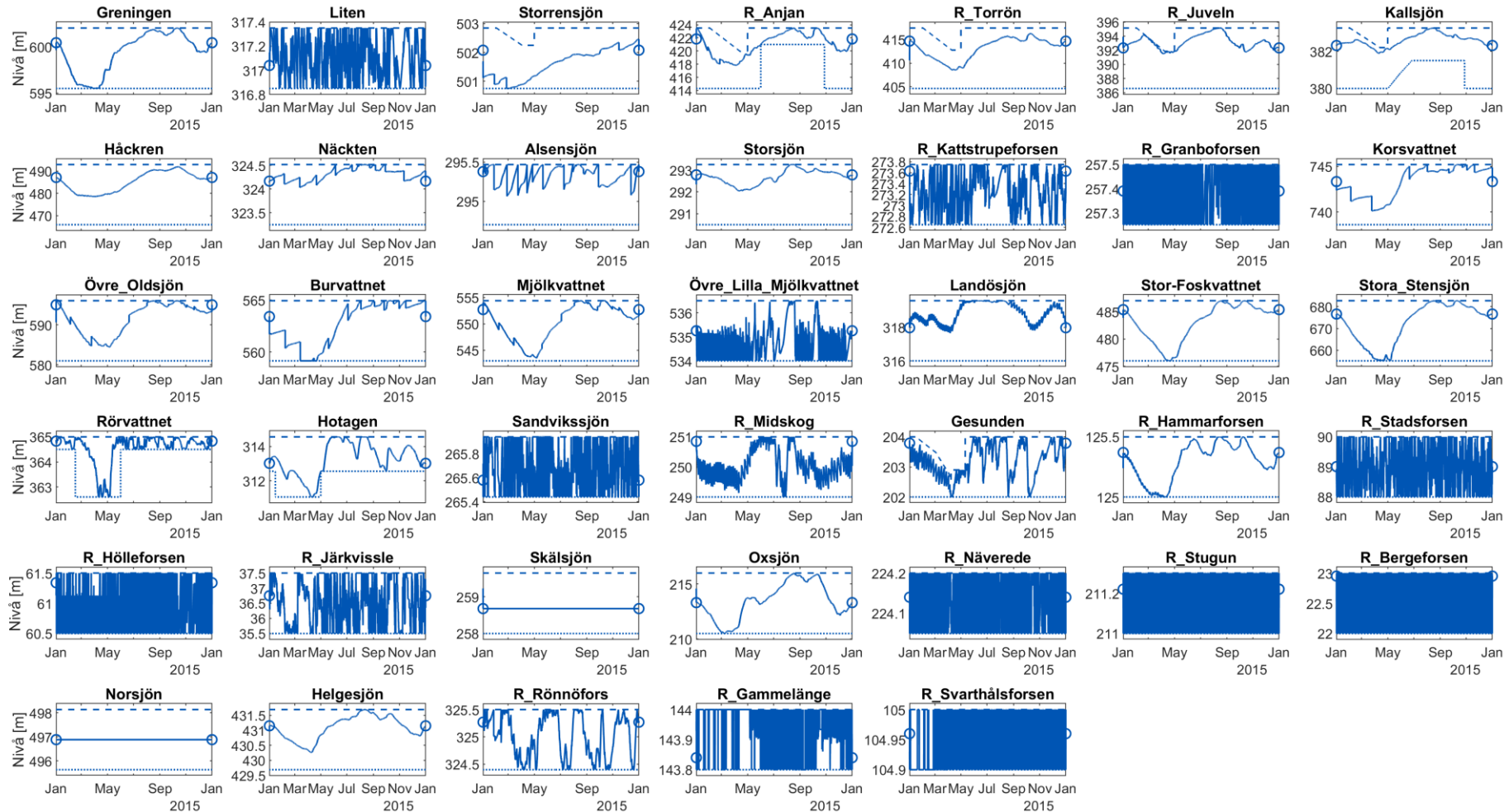
Indalsälven



— KLIVA min

Vattenstånd

Indalsälven

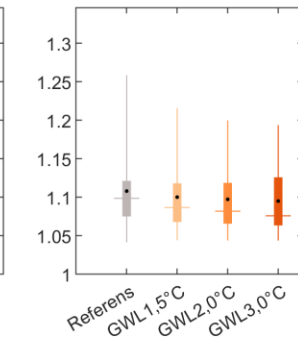
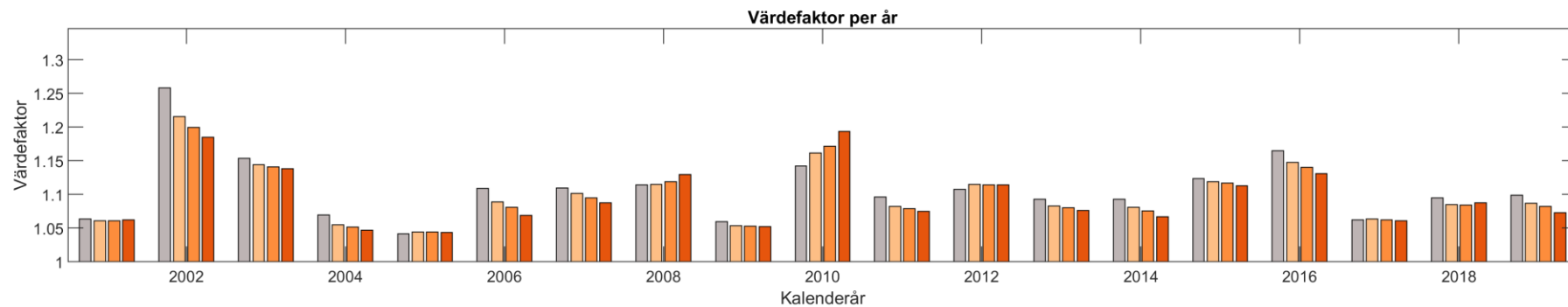
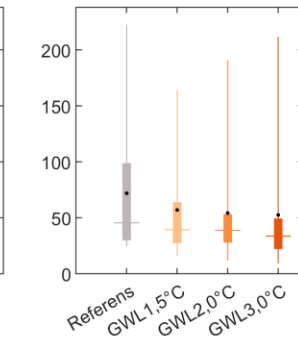
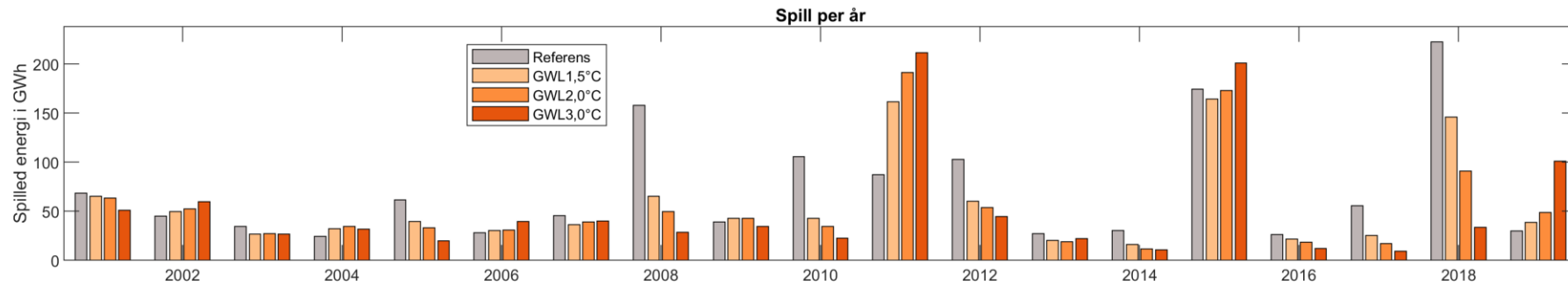
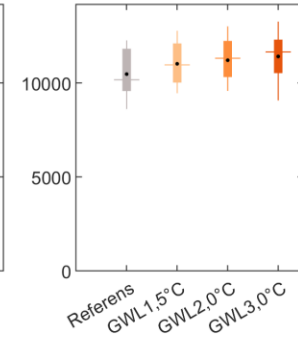
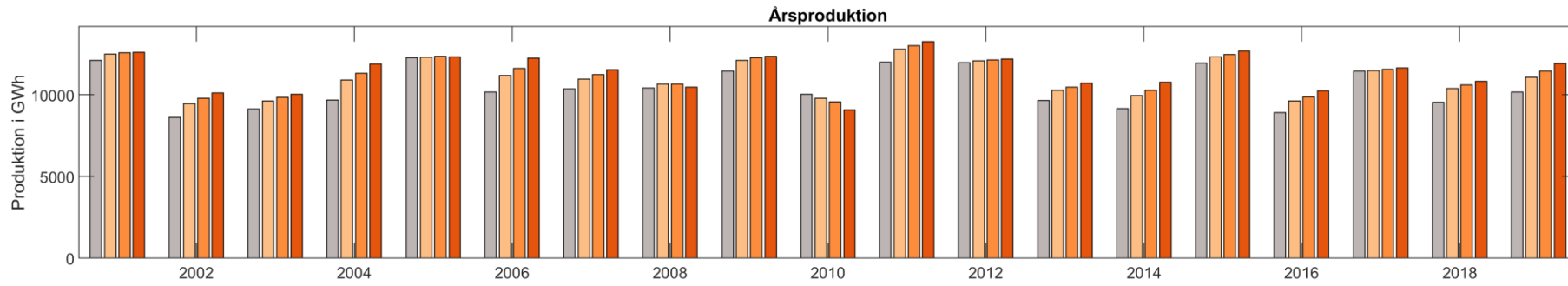


— KLIVA min - - - max ○ Randvillkor

Aggregerade resultat

Årsvärden produktion, spill, värdefaktor

Indalsälven



Statistik produktion, spill, värdefaktor

Produktion i GWh

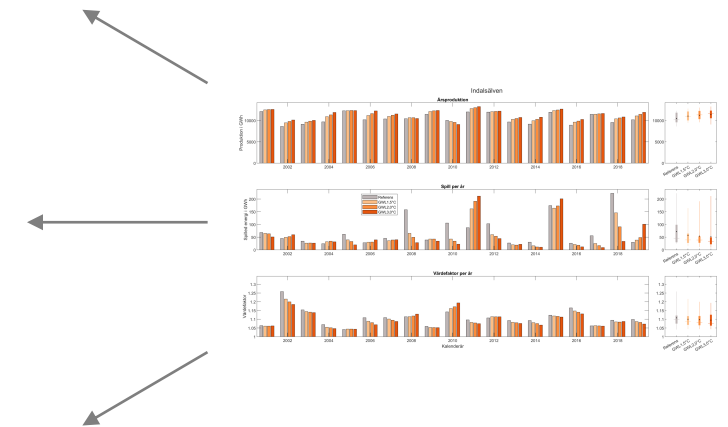
GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	10480	(Ref)	(Ref)	9577	11828	2251	8619	12271
GWL1, 5°C	11027	+547	+5 %	10029	12112	2083	9462	12783
GWL2, 0°C	11216	+736	+7 %	10324	12244	1920	9584	13014
GWL3, 0°C	11417	+937	+9 %	10530	12313	1783	9082	13271

Spill i GWh

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	72	(Ref)	(Ref)	30	99	69	25	223
GWL1, 5°C	57	-15	-21 %	28	64	36	16	164
GWL2, 0°C	54	-18	-25 %	28	53	25	12	191
GWL3, 0°C	53	-19	-26 %	22	50	28	10	212

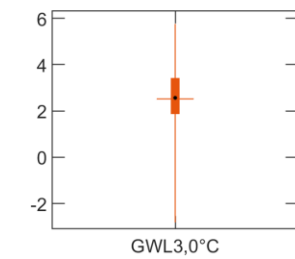
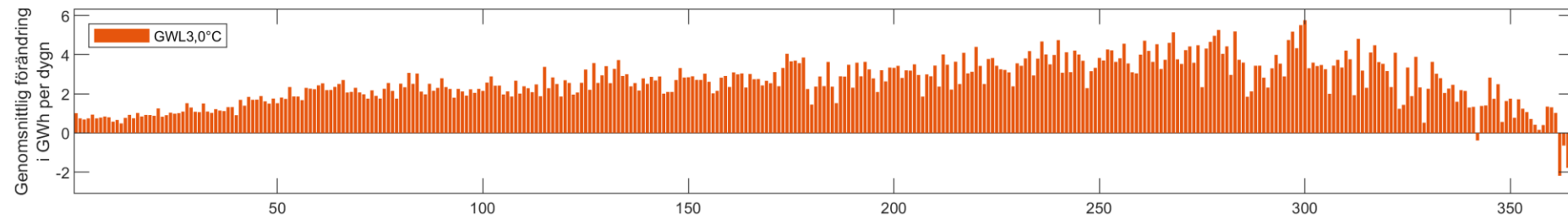
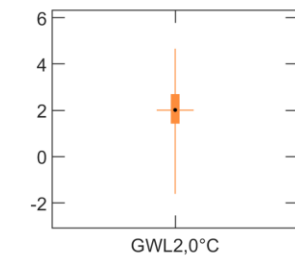
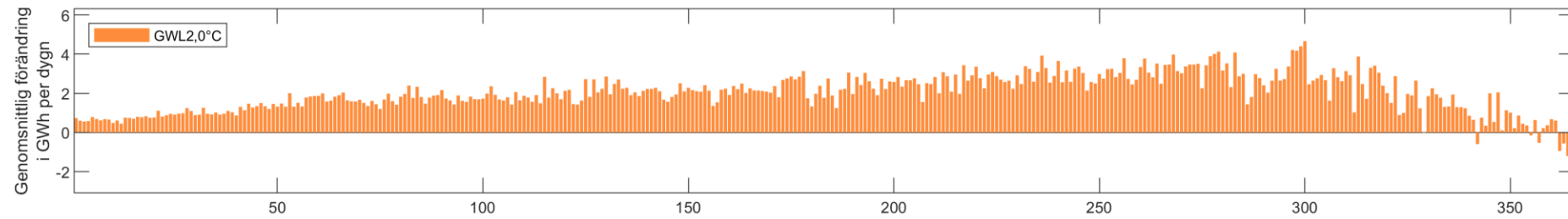
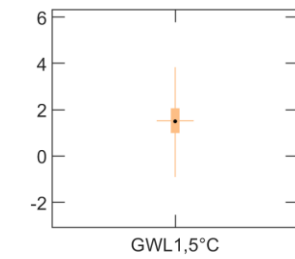
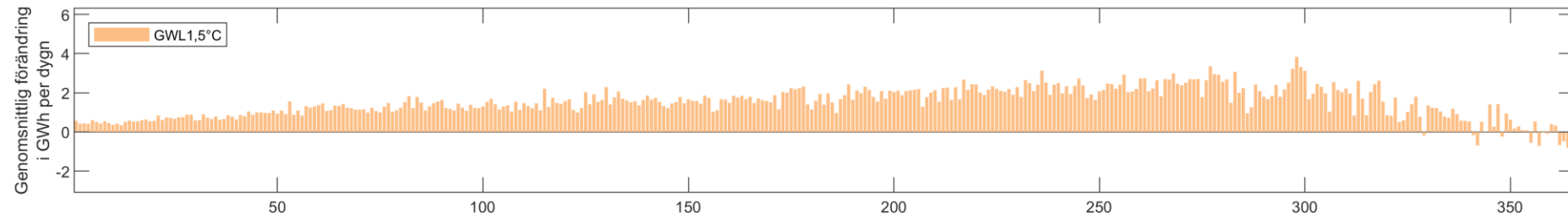
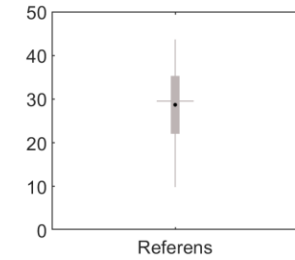
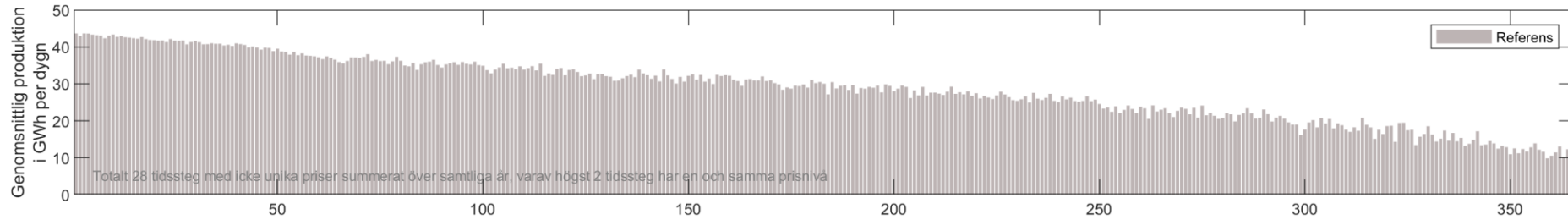
Värdefaktor

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	1.108	(Ref)	(Ref)	1.075	1.121	0.046	1.042	1.258
GWL1, 5°C	1.100	-0.008	-1 %	1.068	1.118	0.050	1.044	1.216
GWL2, 0°C	1.097	-0.011	-1 %	1.066	1.119	0.053	1.044	1.200
GWL3, 0°C	1.095	-0.013	-1 %	1.064	1.126	0.062	1.044	1.194



Förändring i balanseringsförmågan

Flerårs prissorterad produktion Indalsälven (24 h)



Dygn



Kontakt AP2

richard.scharff@vattenfall.com



KLIVA-rapport bilaga A Lagan

Richard Scharff, Chalmers, 2023-02-01

Kommentarer

- Bilagan innehåller ett axplock av diagram för att illustrera indata till vattenkraftmodellen samt dess resultat
- Resultaten skiljer sig mellan älvsystem, år och uppvärmningsnivå
- Insikter, slutsatser och detaljer beskrivs i rapporten

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KLIVA-projektet har analyserat **klimatförändringarnas påverkan** på vattenkraftens produktions- och balanseringsförmåga

Innehåll diagrammsamling

- Systembeskrivning
 - Älvsystem
 - Energi per Mm³ lokaltillrinning
 - Vattendommar
- Klimatpåverkan lokaltillrinning
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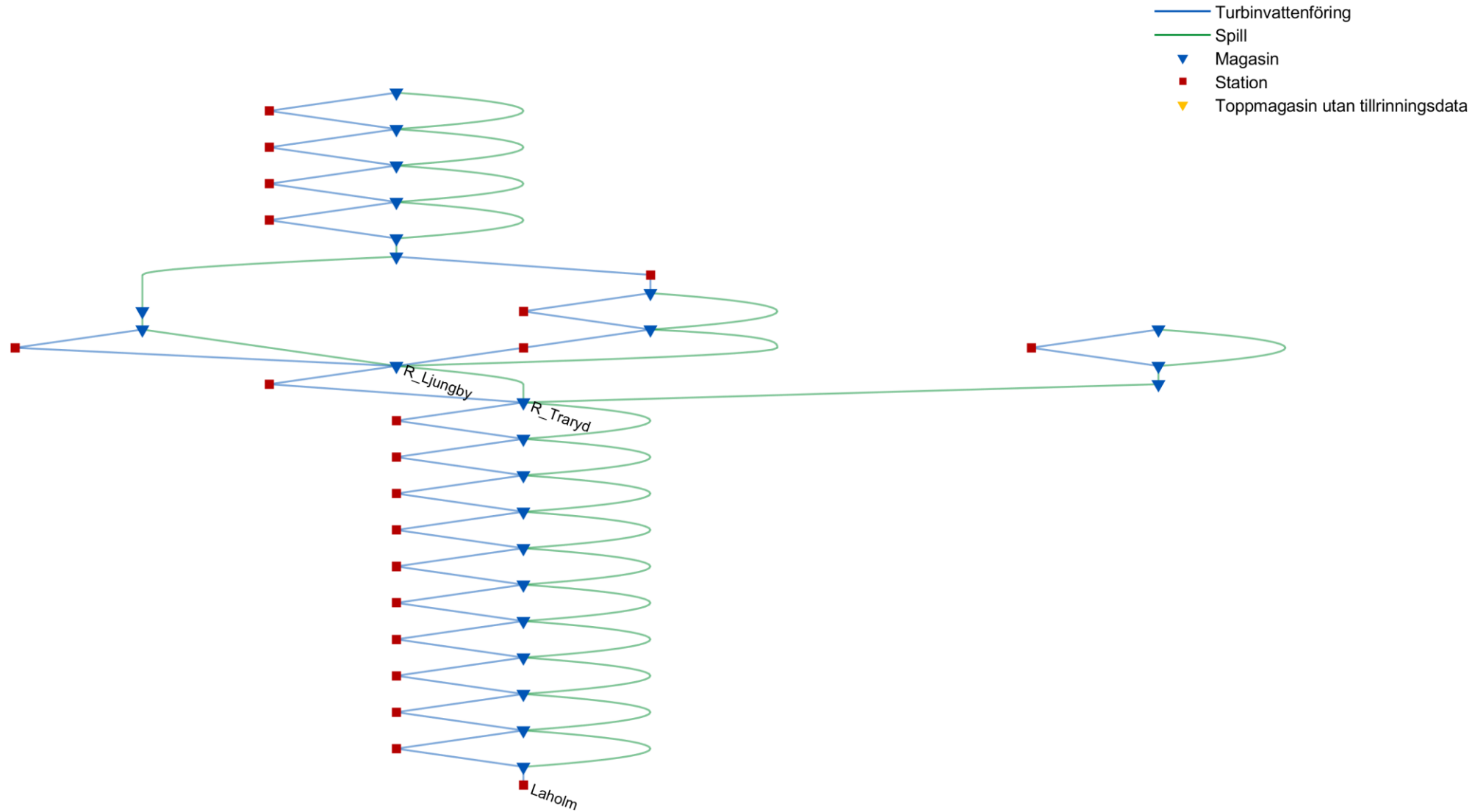
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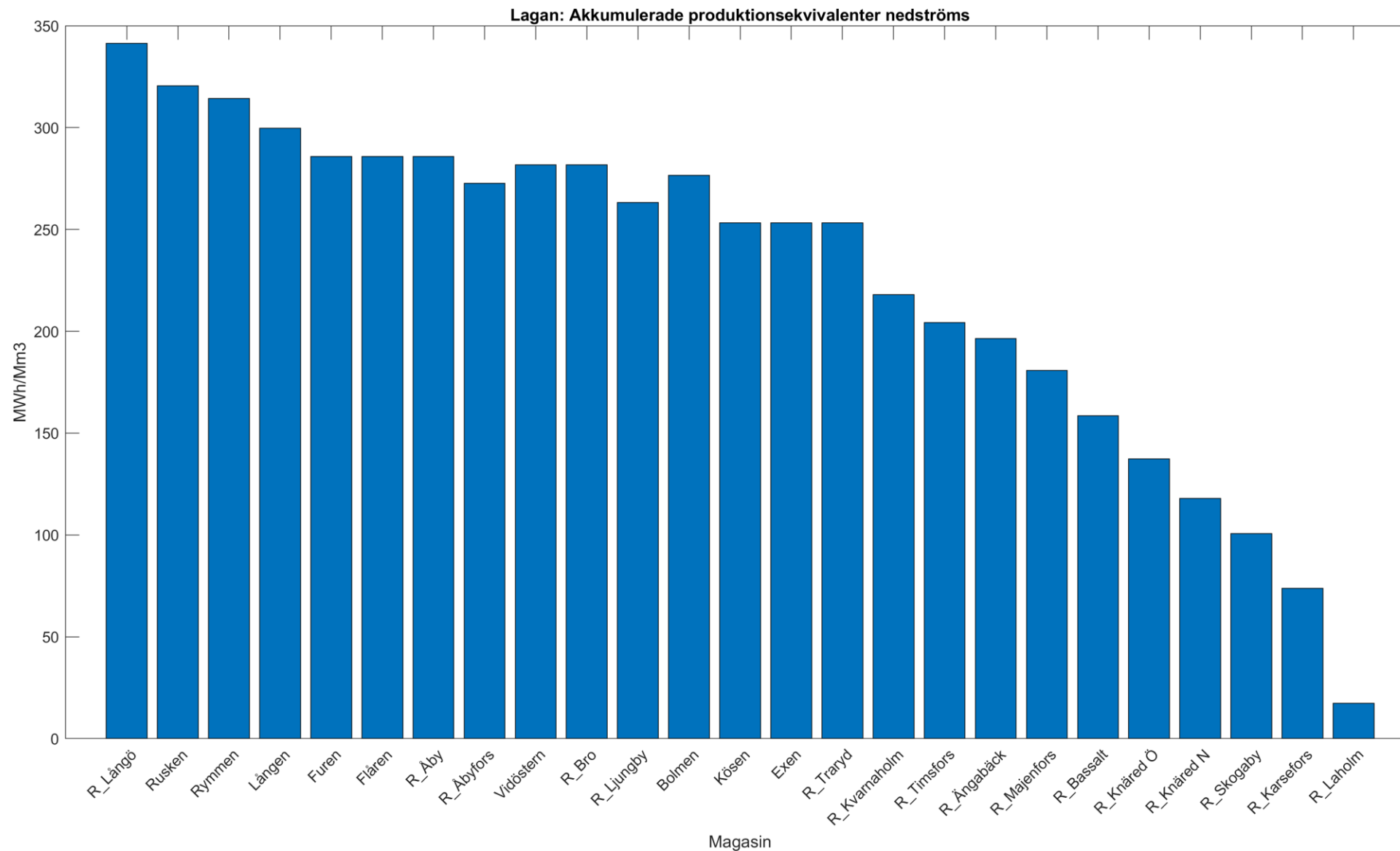
Systembeskrivning

Älvsystem

Lagan

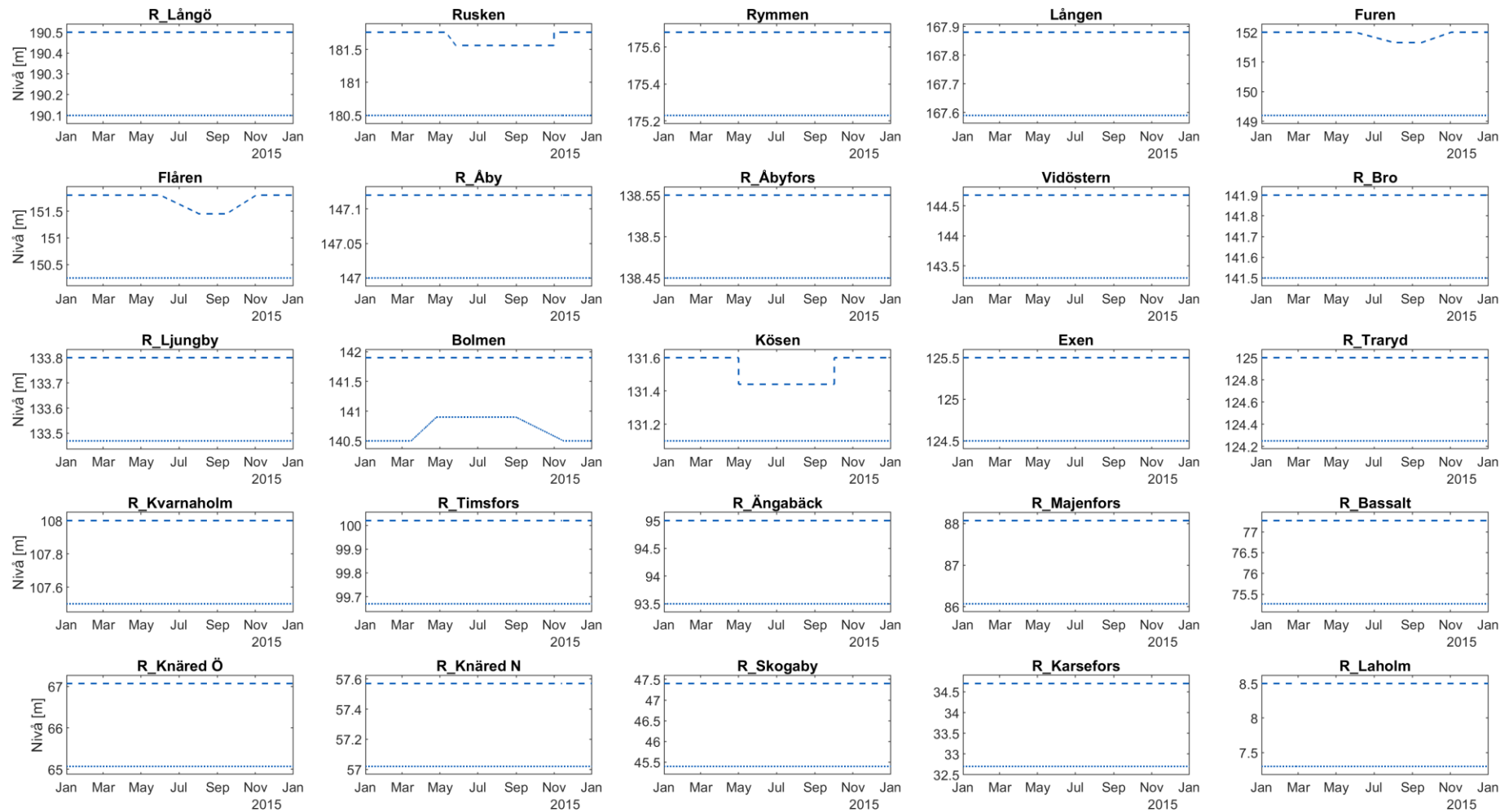


Energi per Mm³ lokaltillrinning



Vattendomar "WaterLevel"

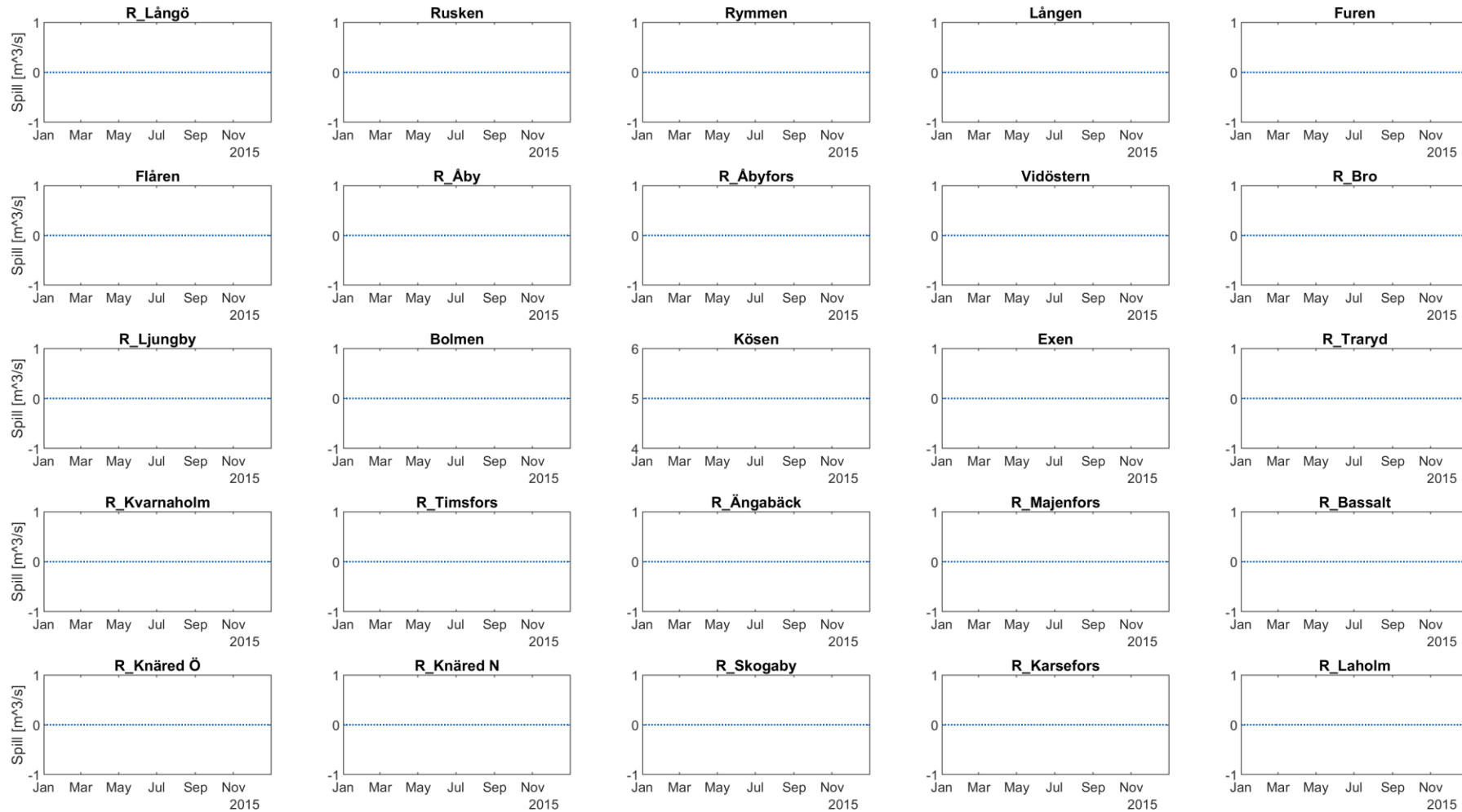
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min - - - max

Vattendomar "MinSpill"

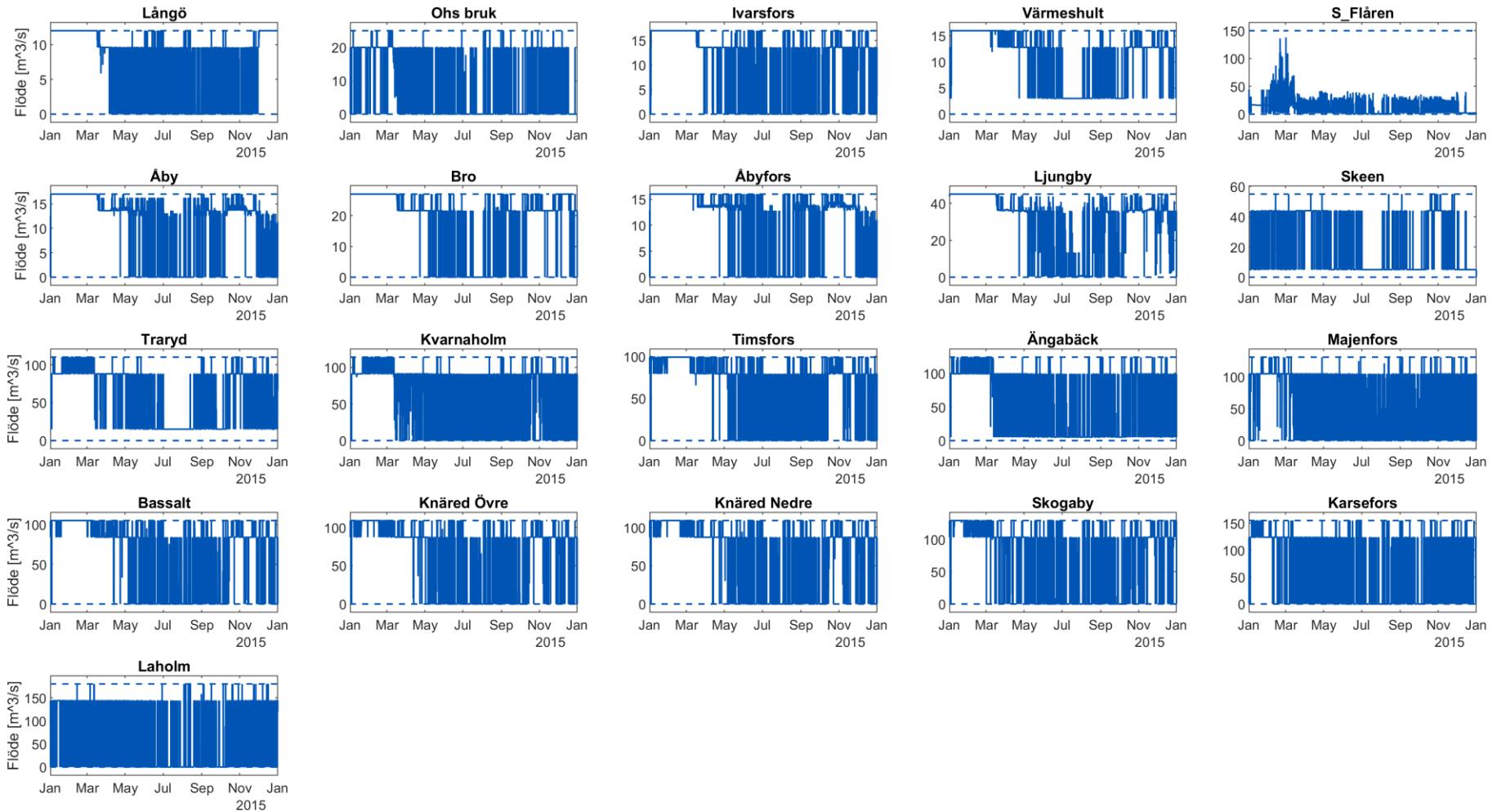
Lagan



..... min

Vattendomar "MinFlow"

Turbinvattenföring för Lagan

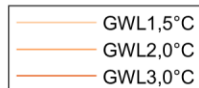
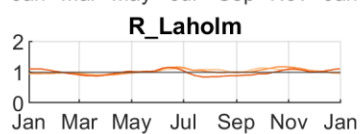
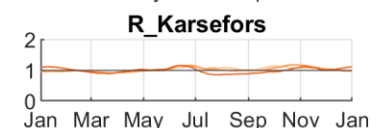
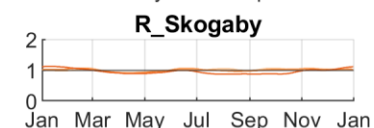
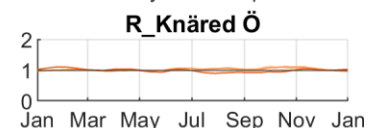
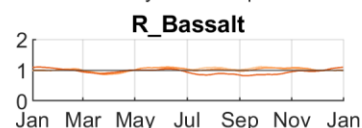
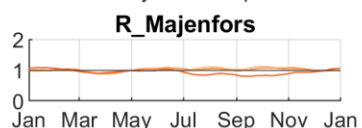
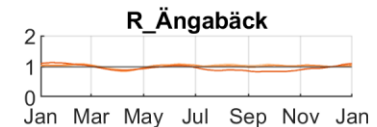
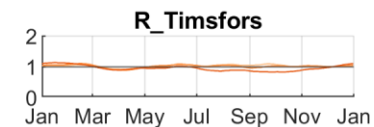
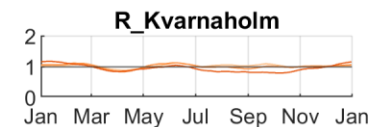
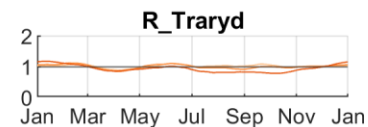
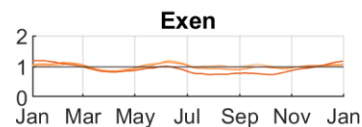
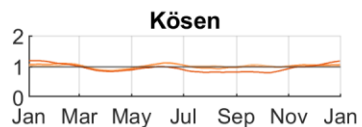
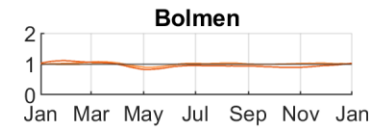
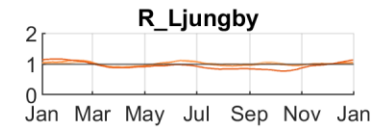
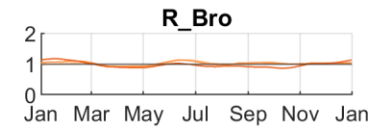
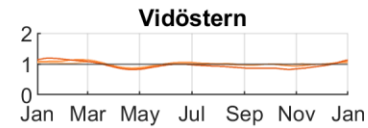
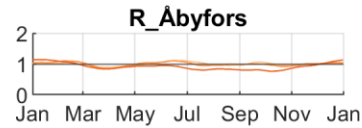
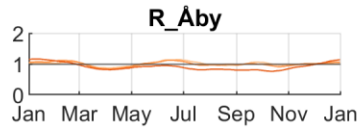
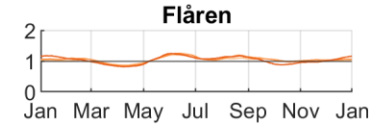
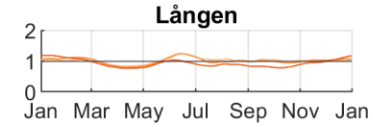
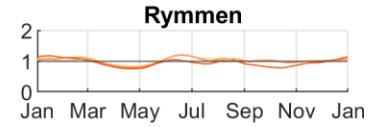
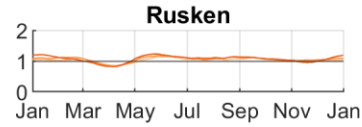
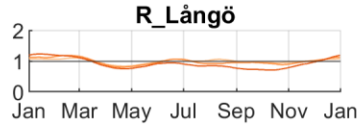


— KLIVA

Klimatpåverkan på lokaltillrinningar

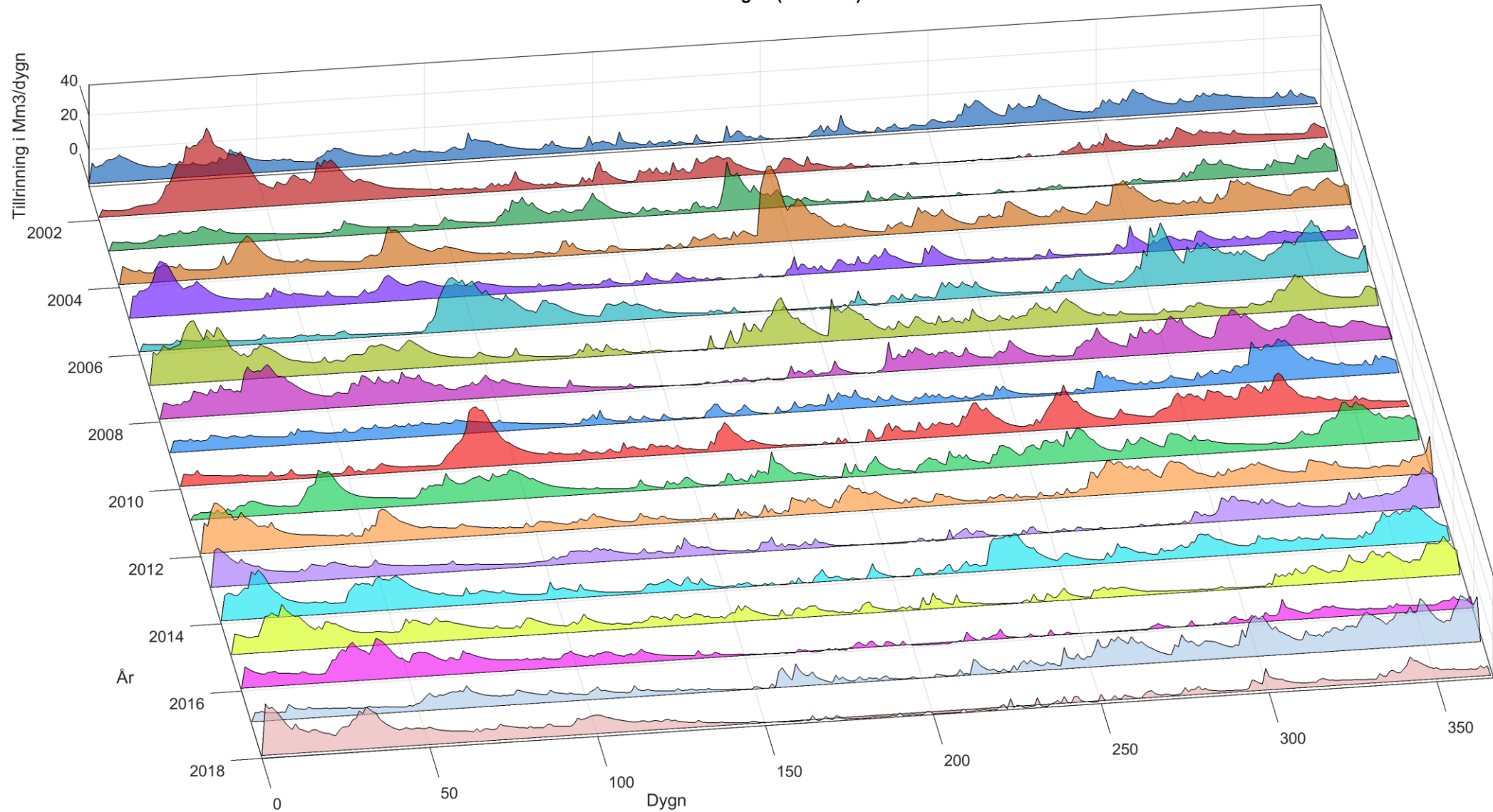
Klimatfaktorer

Klimatfaktorer Lagan



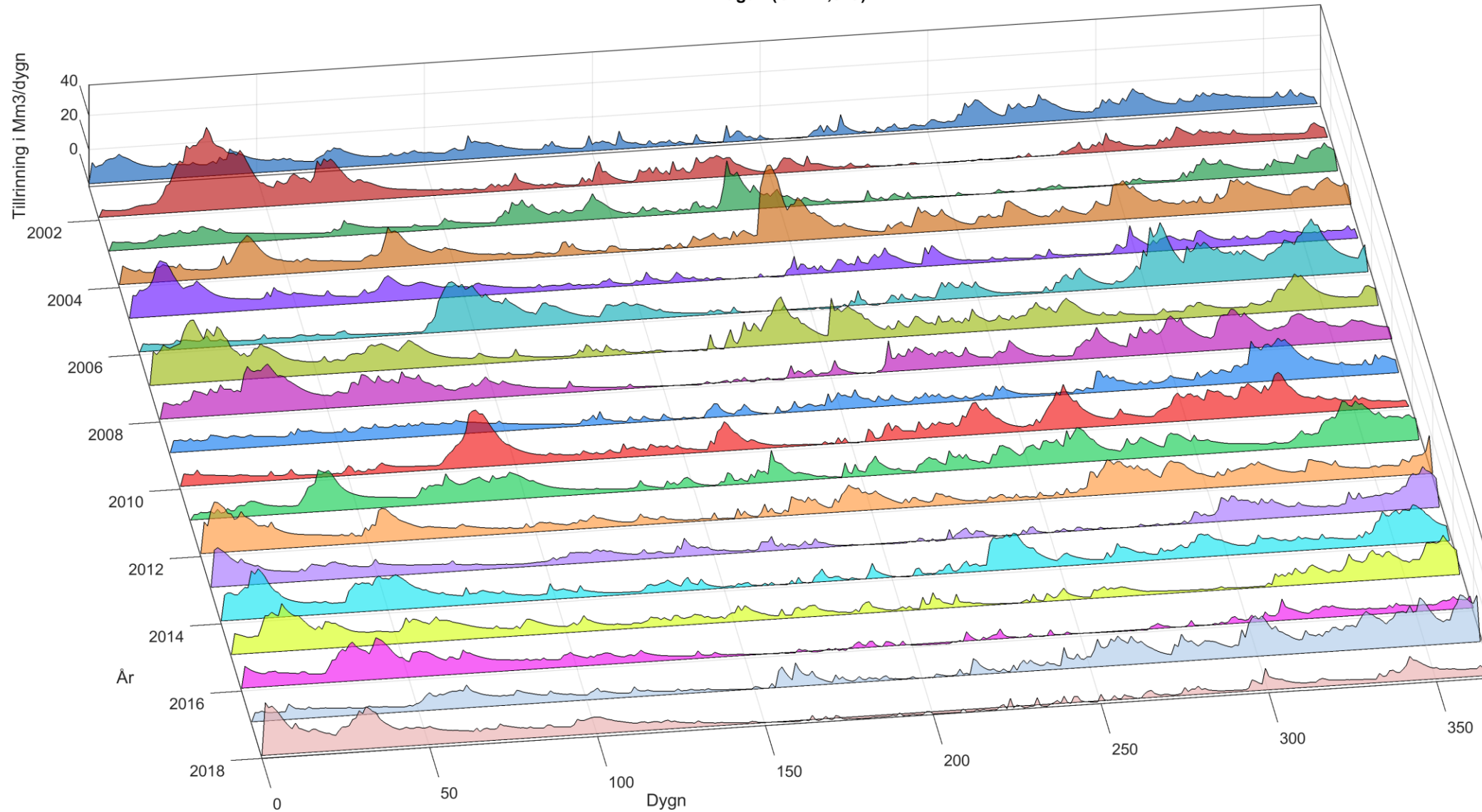
Total tillrinning (Referens)

Lagan (Referens)



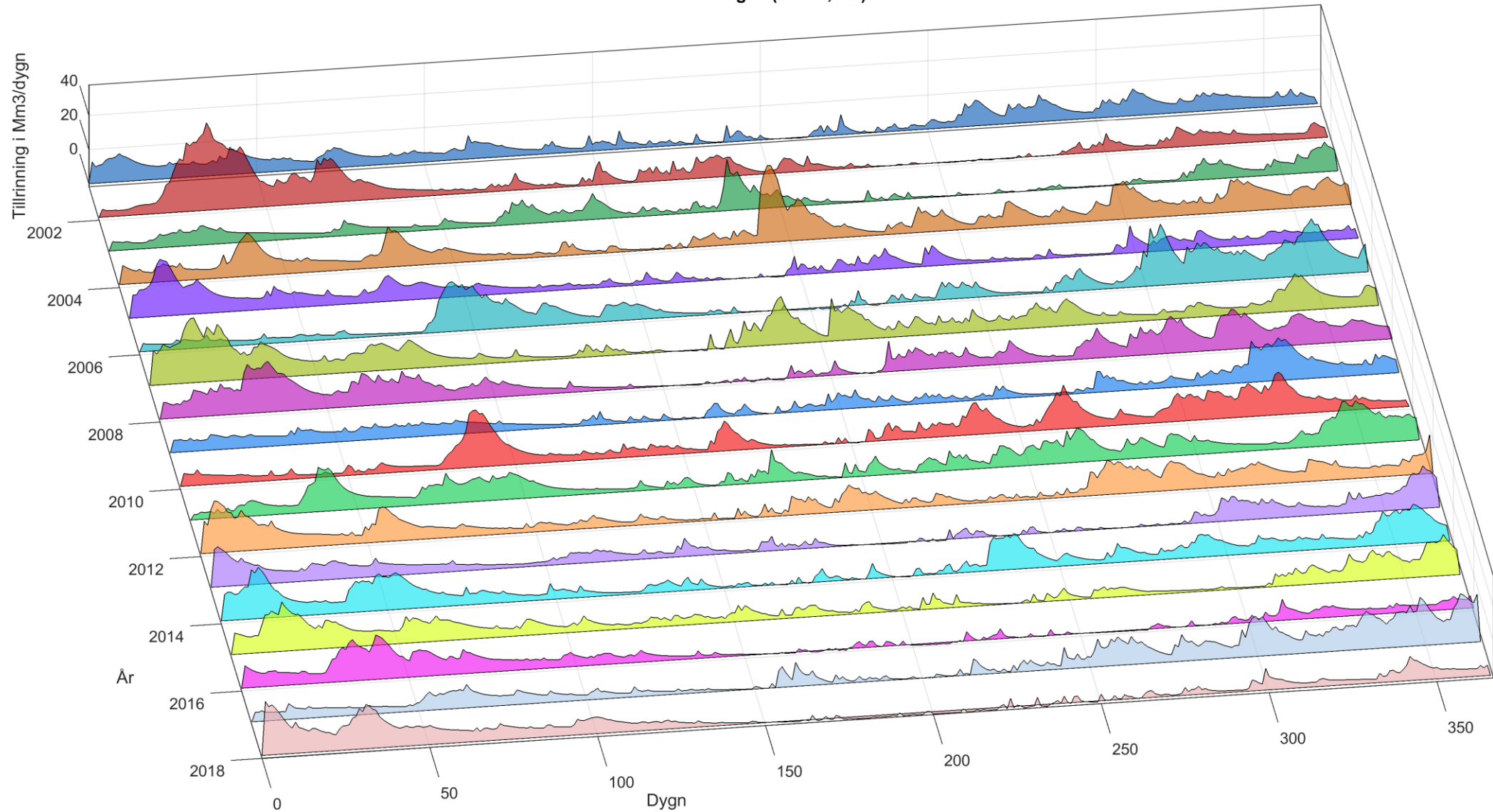
Total tillrinning (GWL1,5°C)

Lagan (GWL1,5°C)



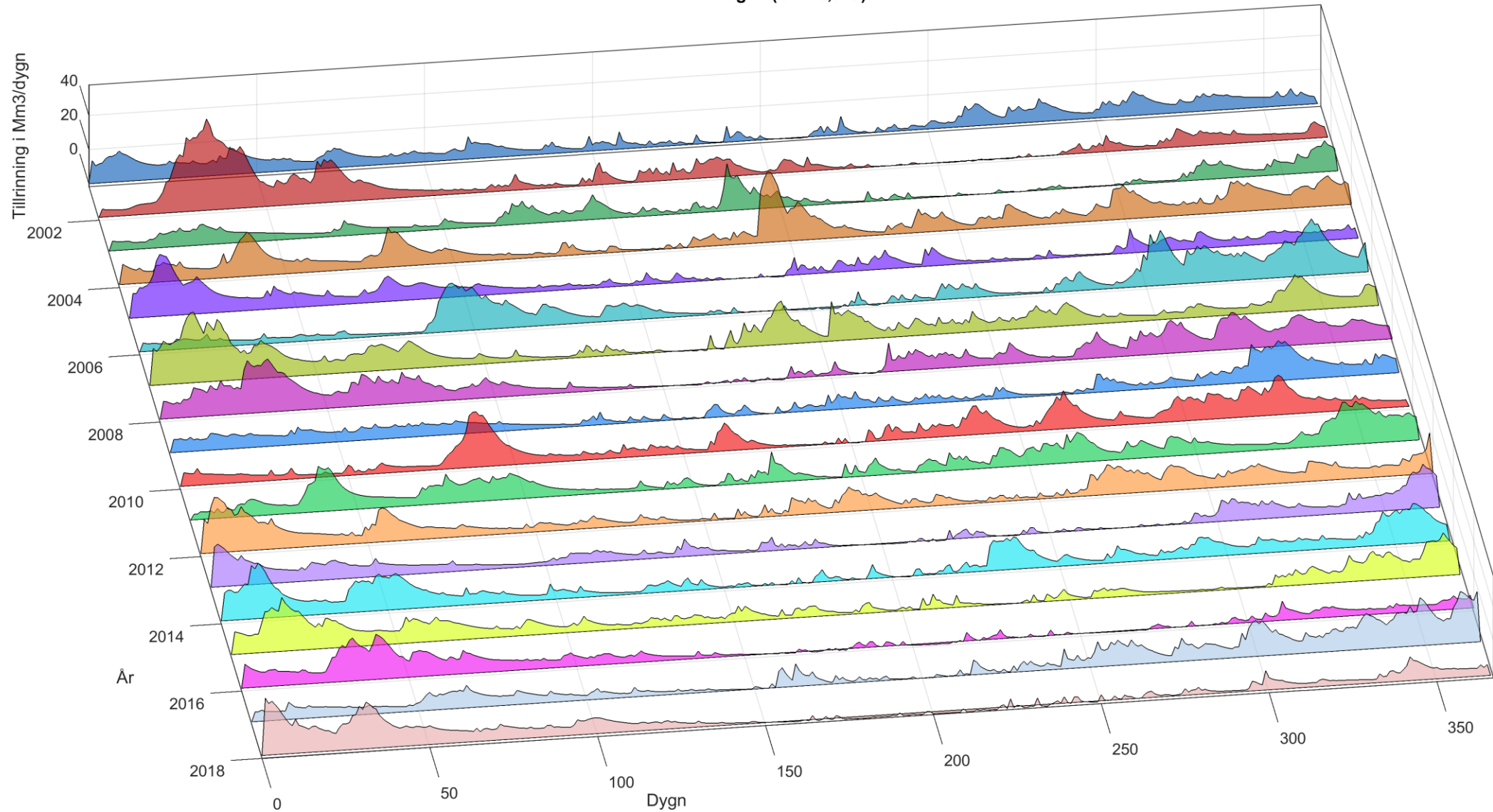
Total tillrinning (GWL2,0°C)

Lagan (GWL2,0°C)



Total tillrinning (GWL3,0°C)

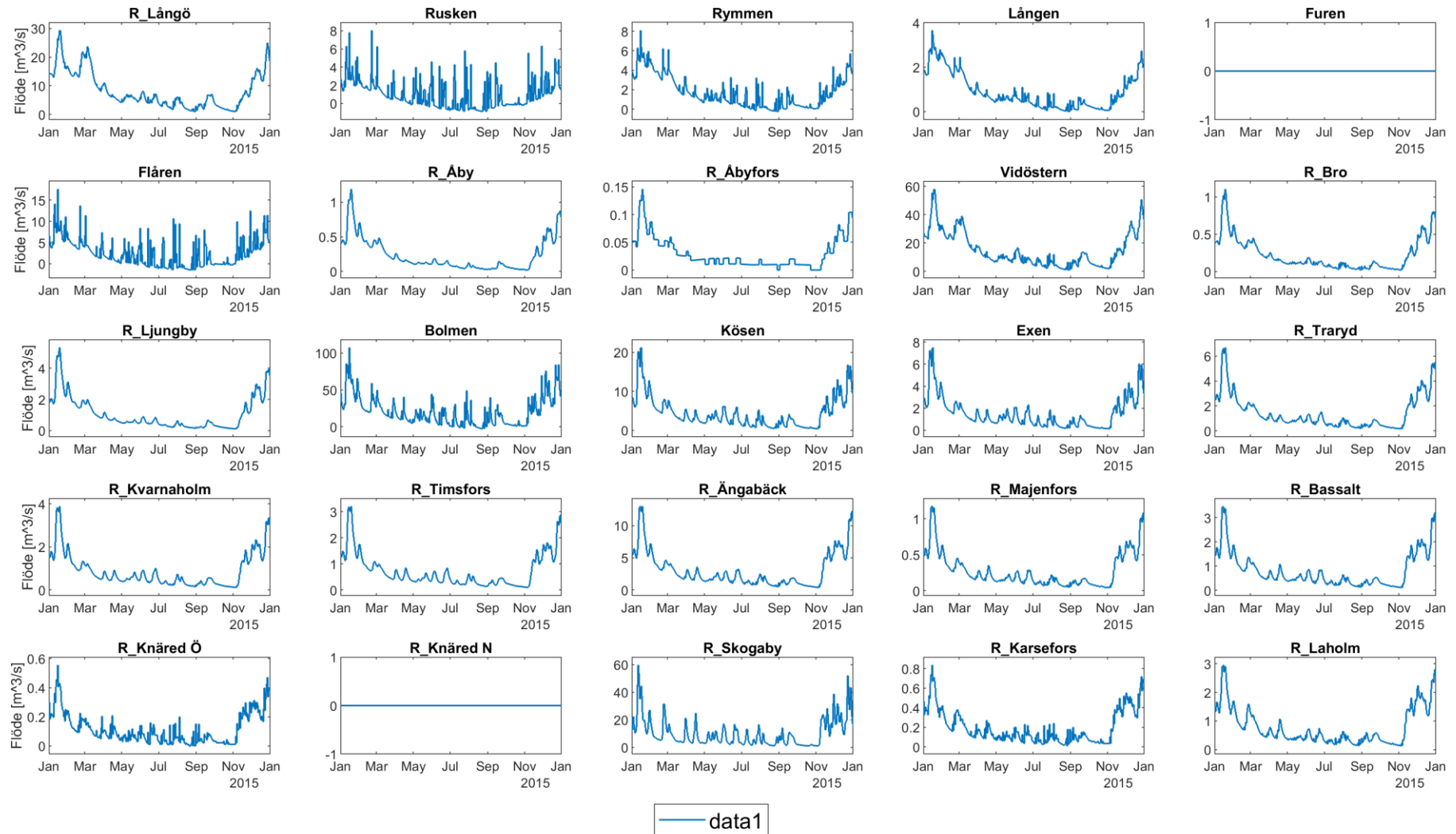
Lagan (GWL3,0°C)



Resultat (exempel GWL2,0°C för 2015)

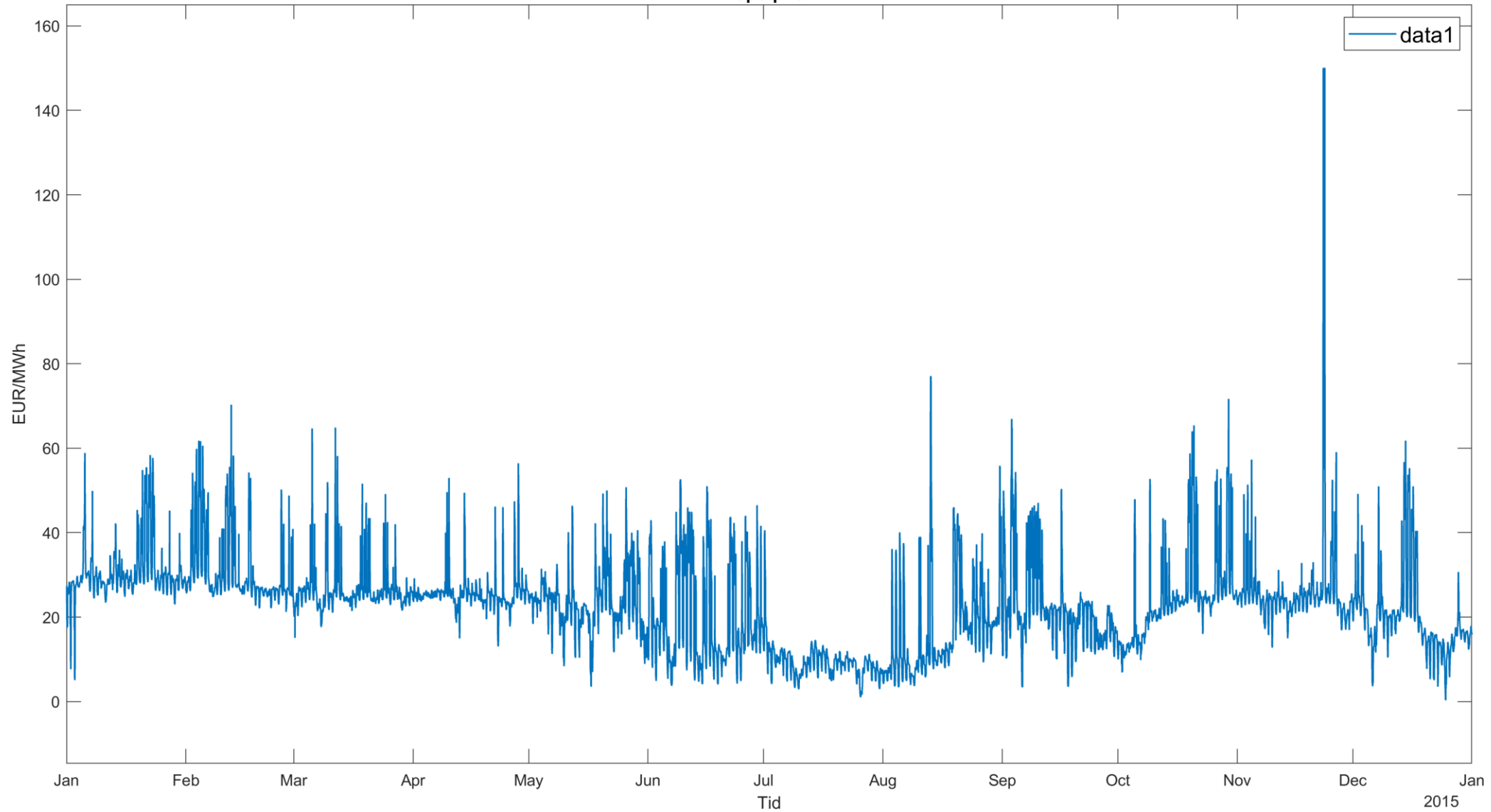
Lokaltillrinning

Lokal tillrinning för Lagan

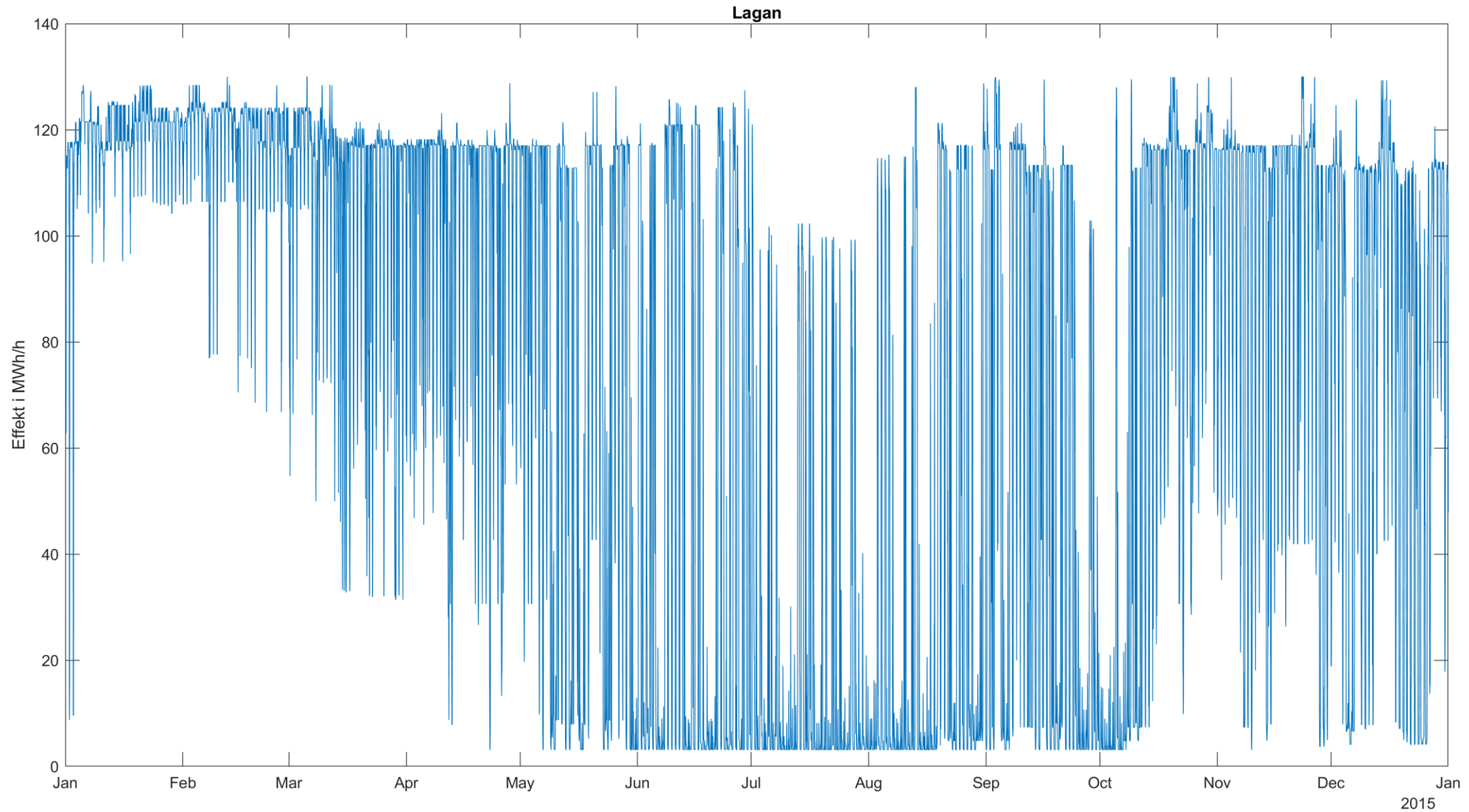


Elpriser

Spotpris

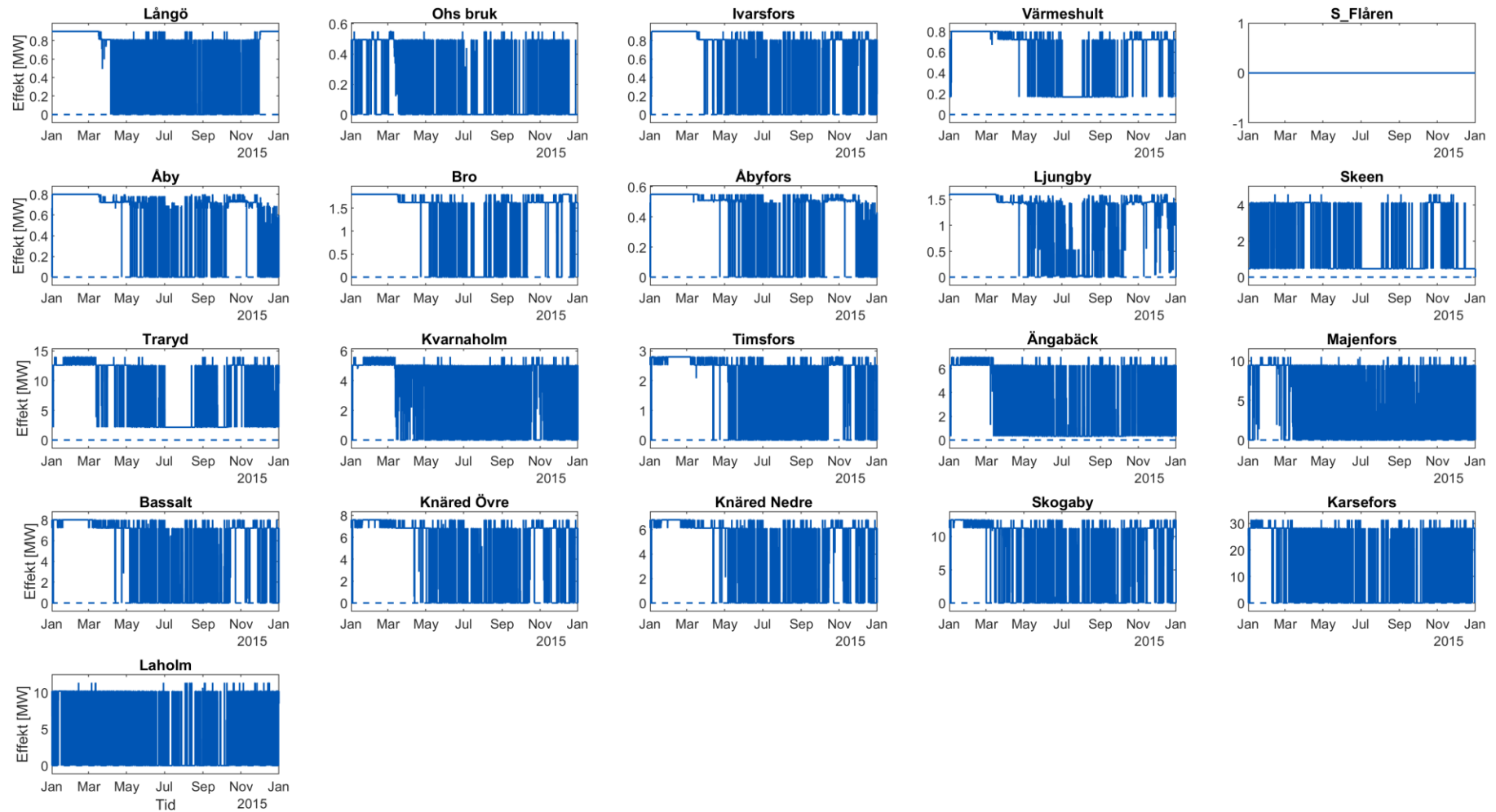


Produktion älvsystem



Produktion

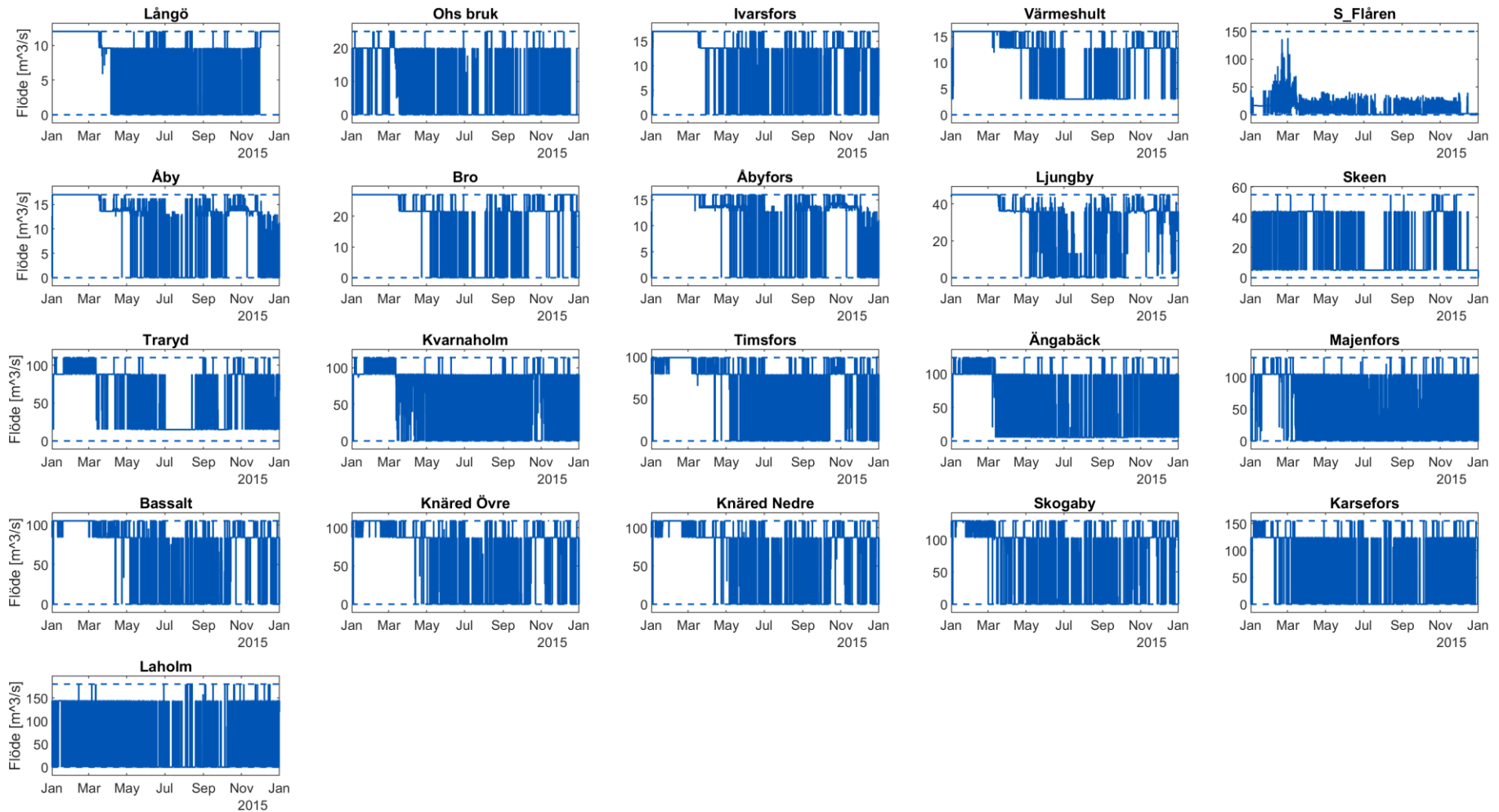
Produktion per station för Lagan



— KLIVA

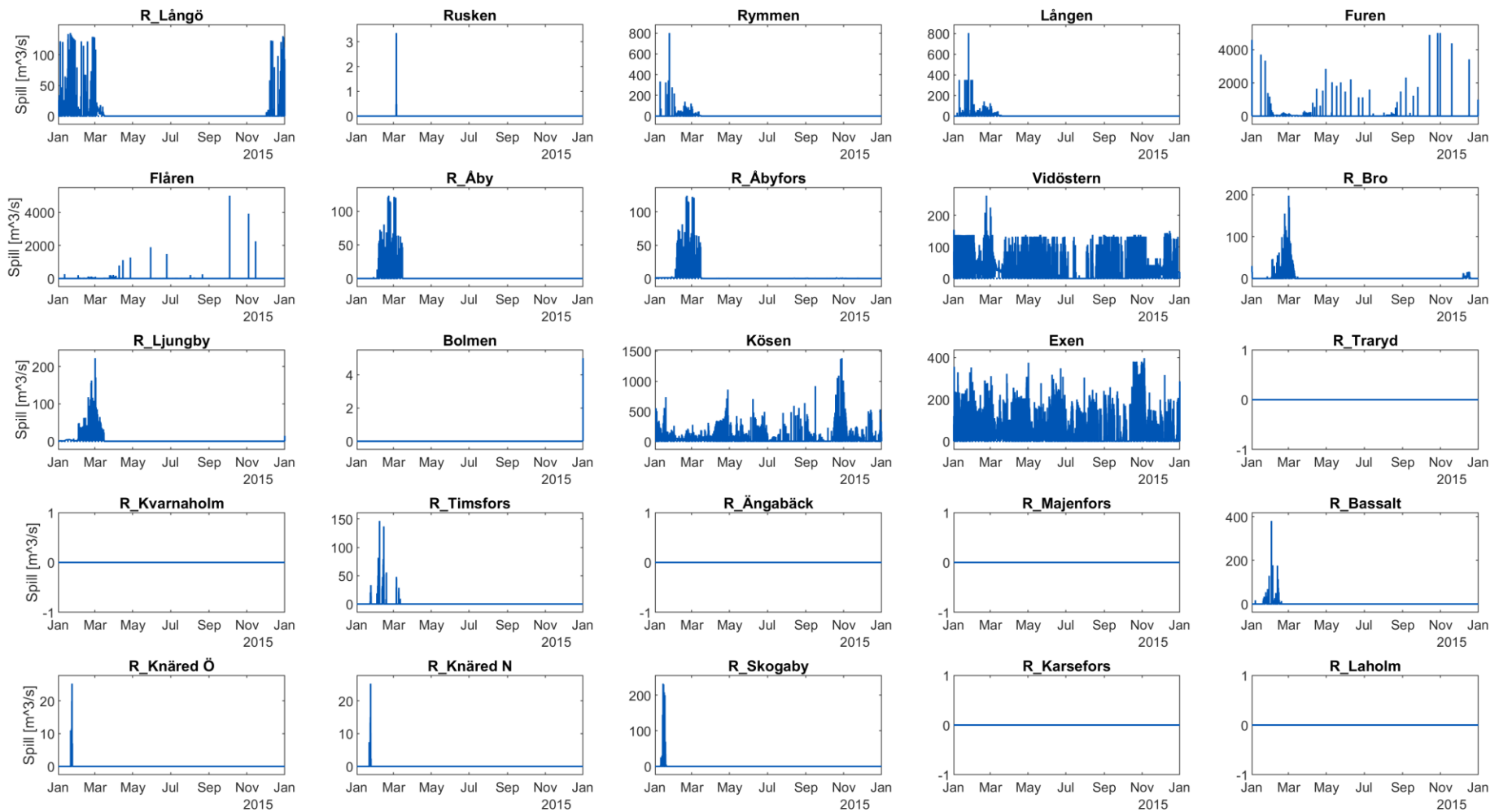
Stationsvattenföring

Turbinvattenföring för Lagan



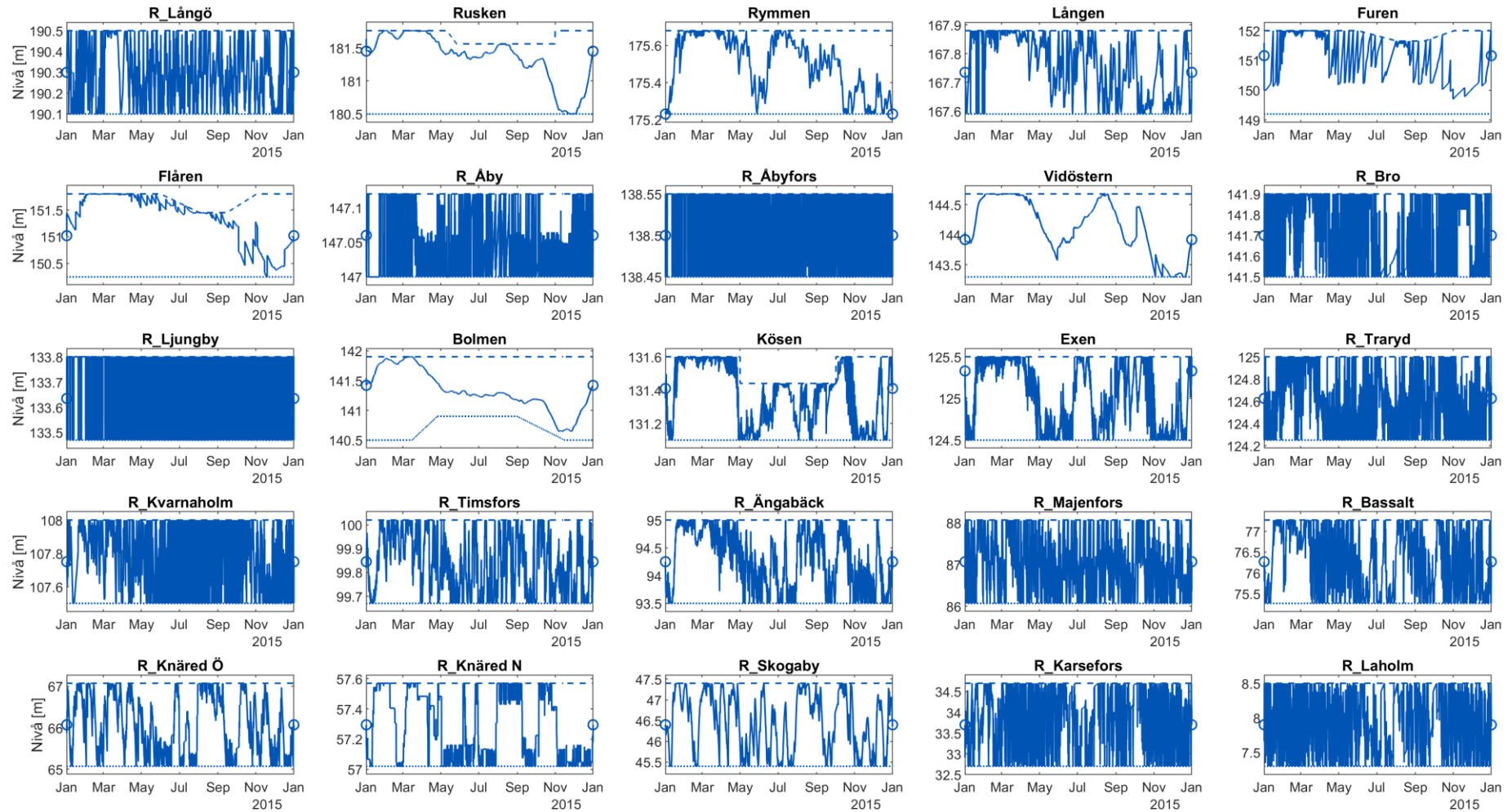
Spill

Lagan



Vattenstånd

Lagan

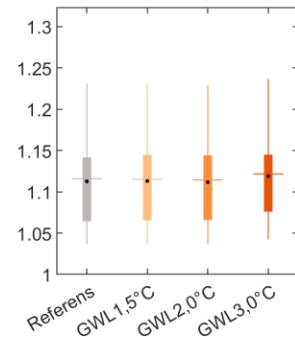
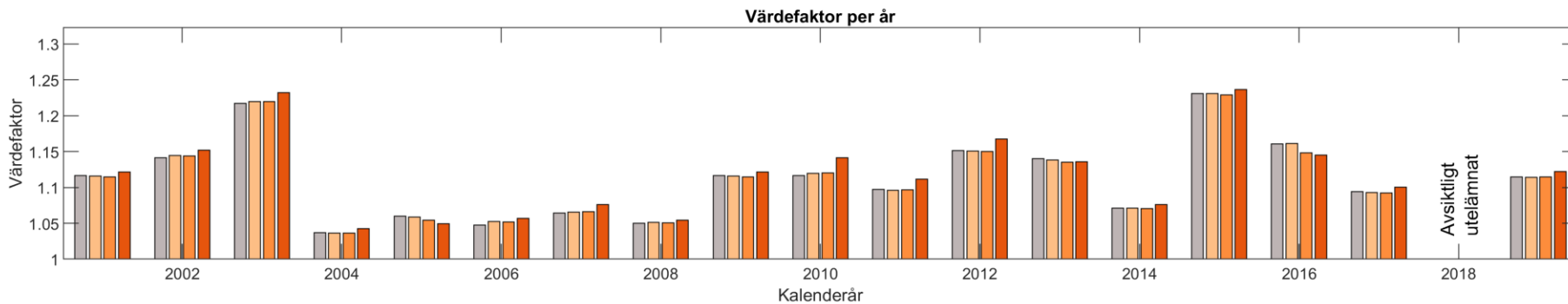
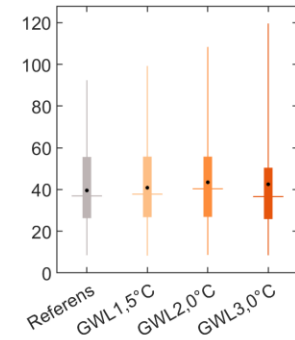
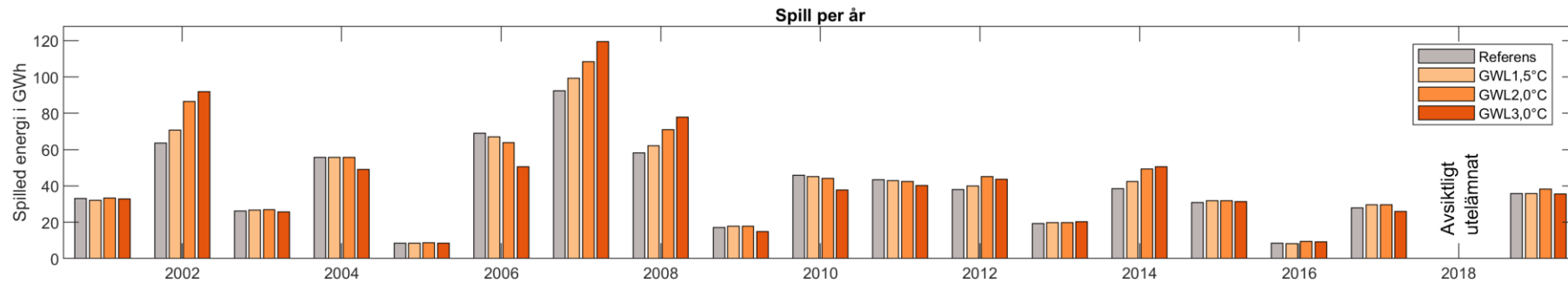
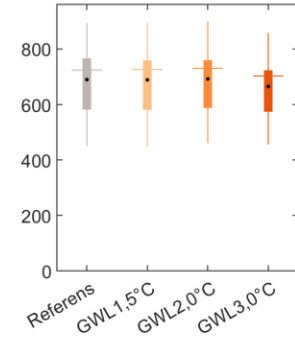
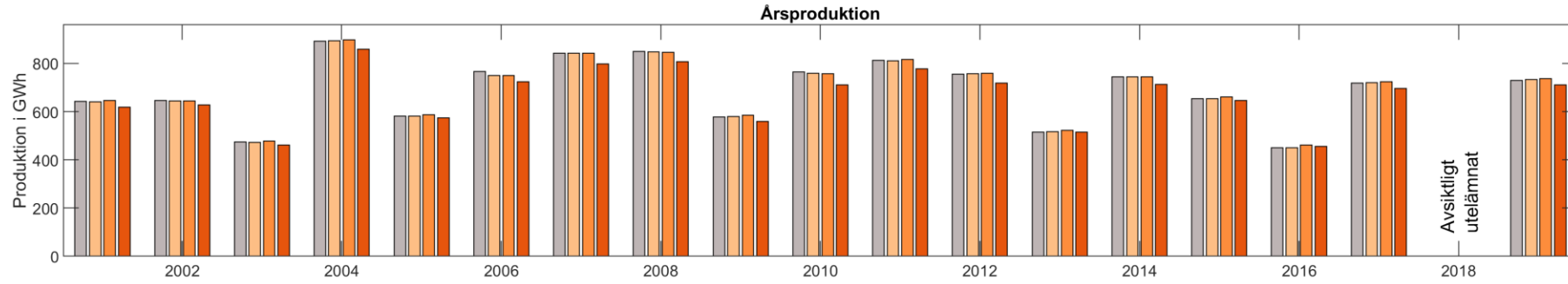


— KLIVA min - - - max ○ Randvillkor

Aggregerade resultat

Årsvärden produktion, spill, värdefaktor

Lagan



Statistik produktion, spill, värdefaktor

Produktion i GWh

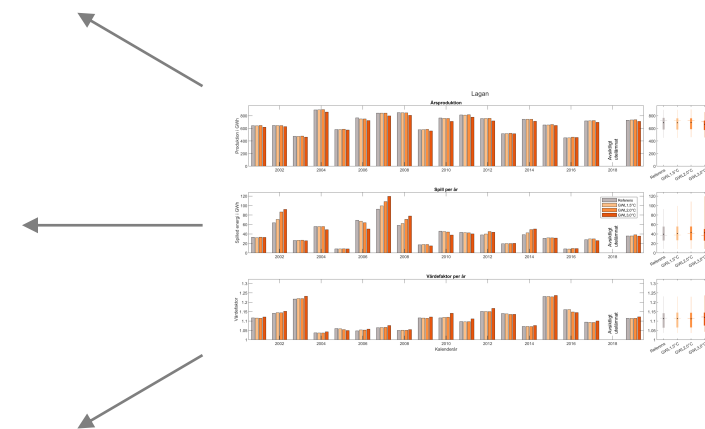
GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	688	(Ref)	(Ref)	581	778	197	450	893
GWL1, 5°C	686	-2	+0 %	581	772	191	450	895
GWL2, 0°C	690	+2	+0 %	587	774	187	461	899
GWL3, 0°C	663	-25	-4 %	570	737	167	456	859

Spill i GWh

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	40	(Ref)	(Ref)	25	56	31	9	92
GWL1, 5°C	41	+1	+3 %	25	57	32	8	99
GWL2, 0°C	44	+4	+10 %	25	58	33	9	108
GWL3, 0°C	43	+3	+8 %	24	50	26	8	120

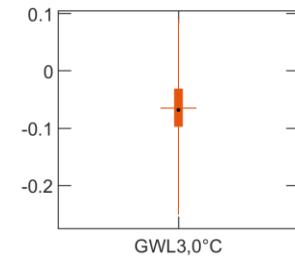
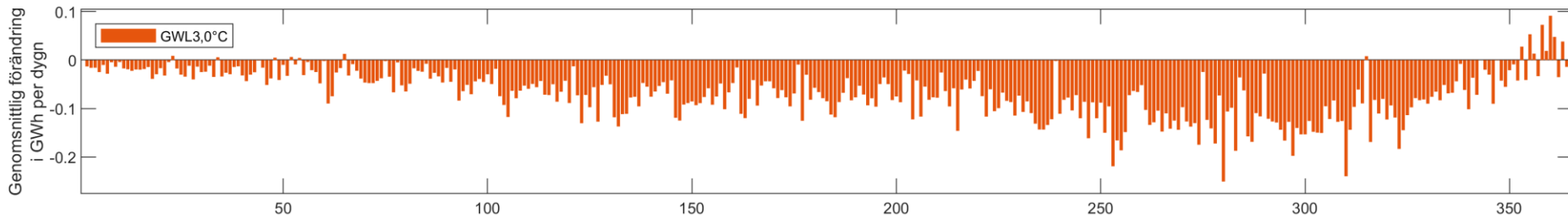
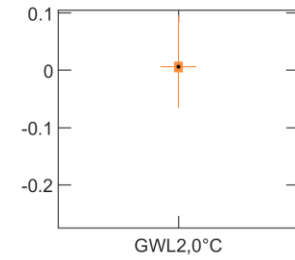
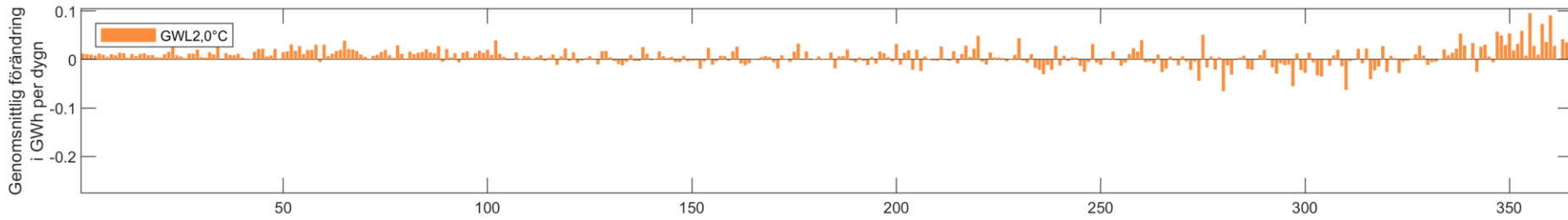
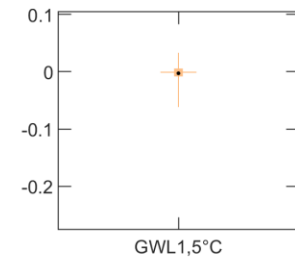
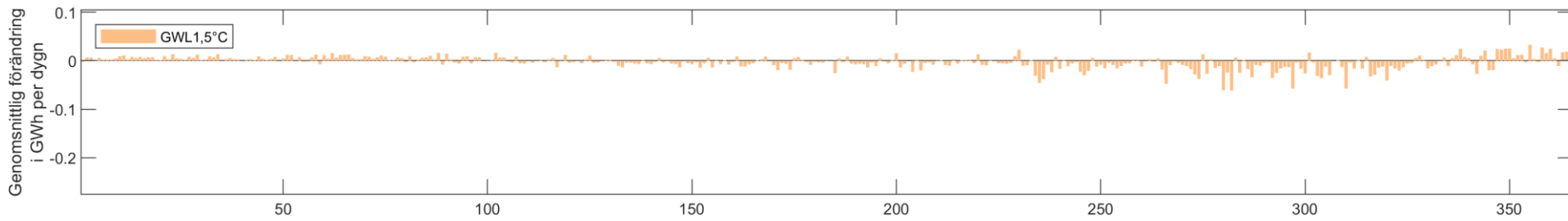
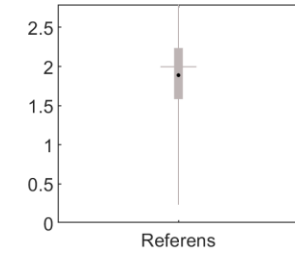
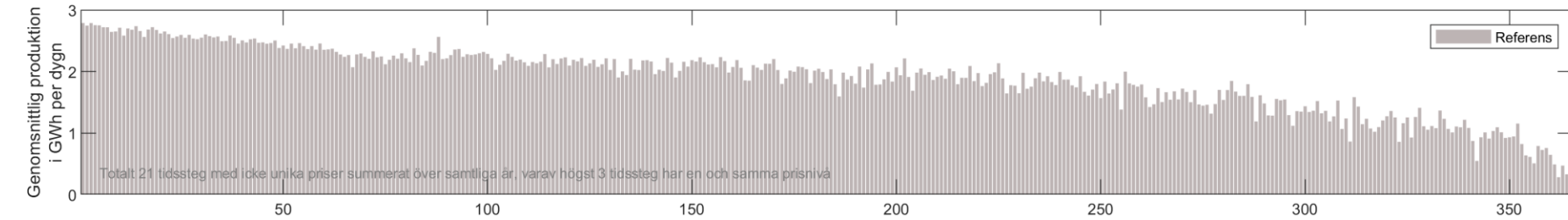
Värdefaktor

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	1.113	(Ref)	(Ref)	1.063	1.144	0.081	1.037	1.231
GWL1, 5°C	1.113	+0.000	+0 %	1.064	1.146	0.082	1.037	1.231
GWL2, 0°C	1.112	-0.001	+0 %	1.063	1.145	0.082	1.036	1.229
GWL3, 0°C	1.119	+0.006	+1 %	1.071	1.147	0.076	1.043	1.237



Förändring i balanseringsförmågan

Flerårs prissorterad produktion Lagan (24 h)



Dygn



Kontakt AP2

richard.scharff@vattenfall.com



KLIVA-rapport bilaga A Ljungan

Richard Scharff, Chalmers, 2023-02-01

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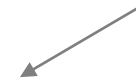
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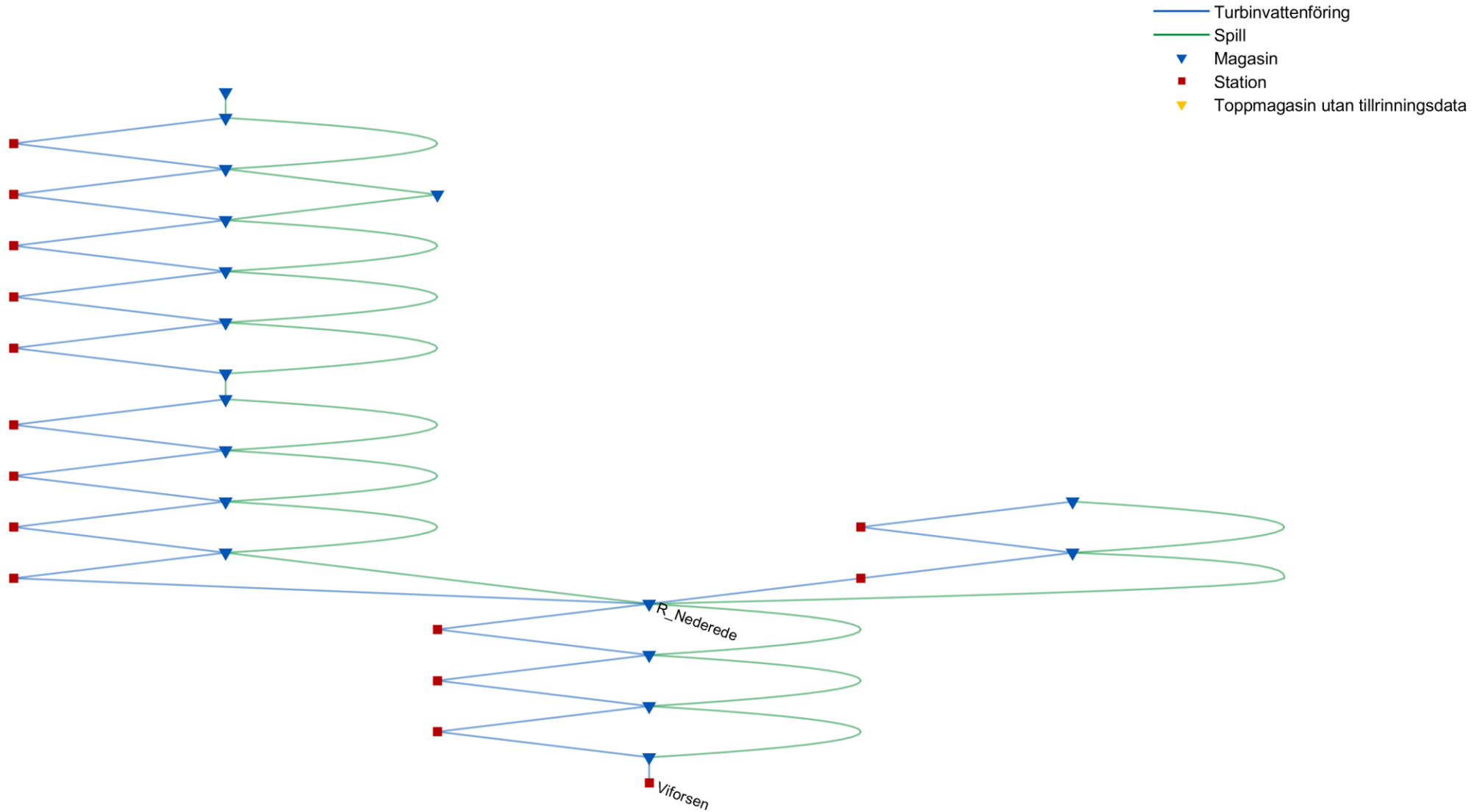
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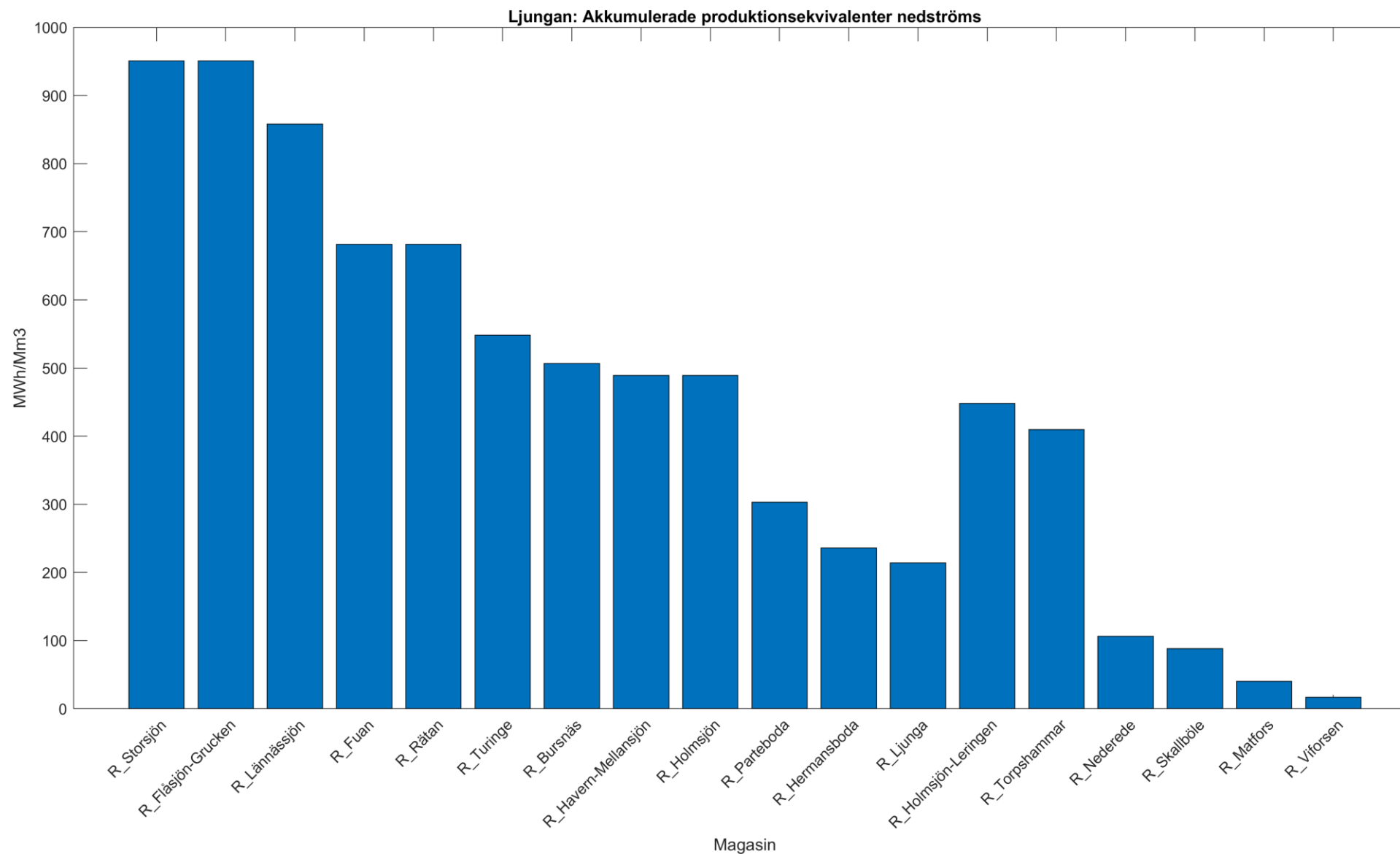
Systembeskrivning

Älvsystem

Ljungan

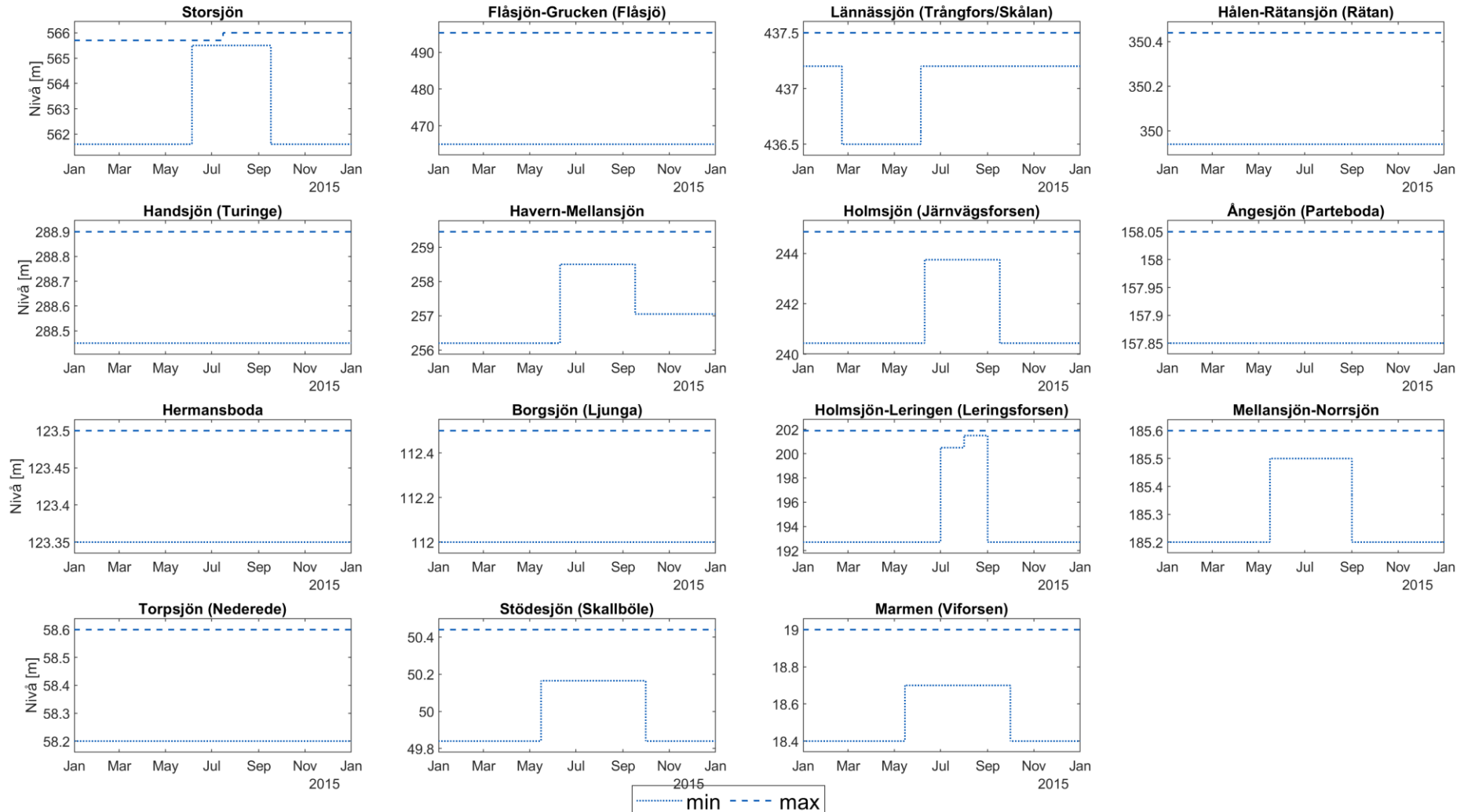


Energi per Mm³ lokaltillrinning



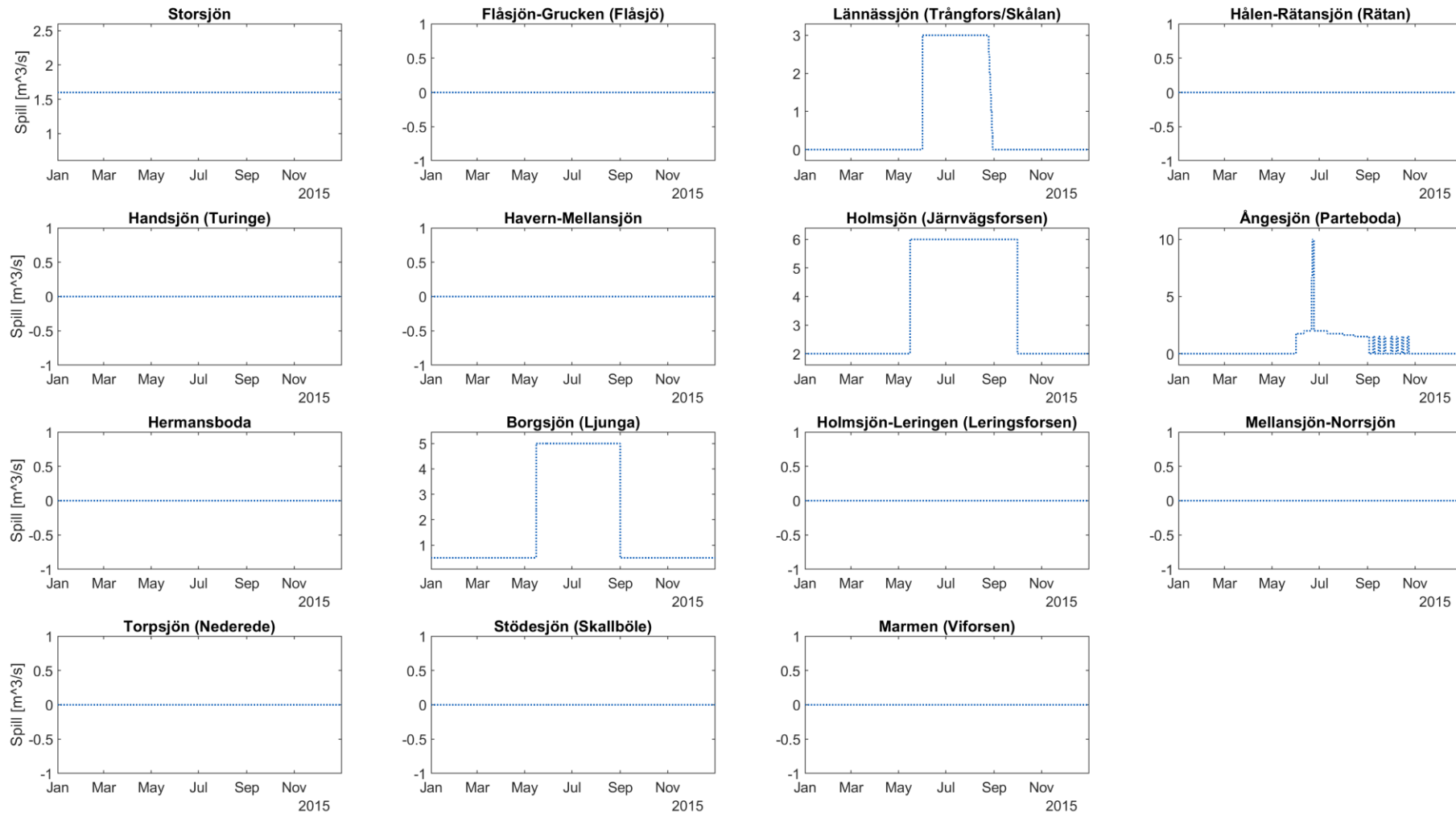
Vattendomar "WaterLevel"

Ljungan



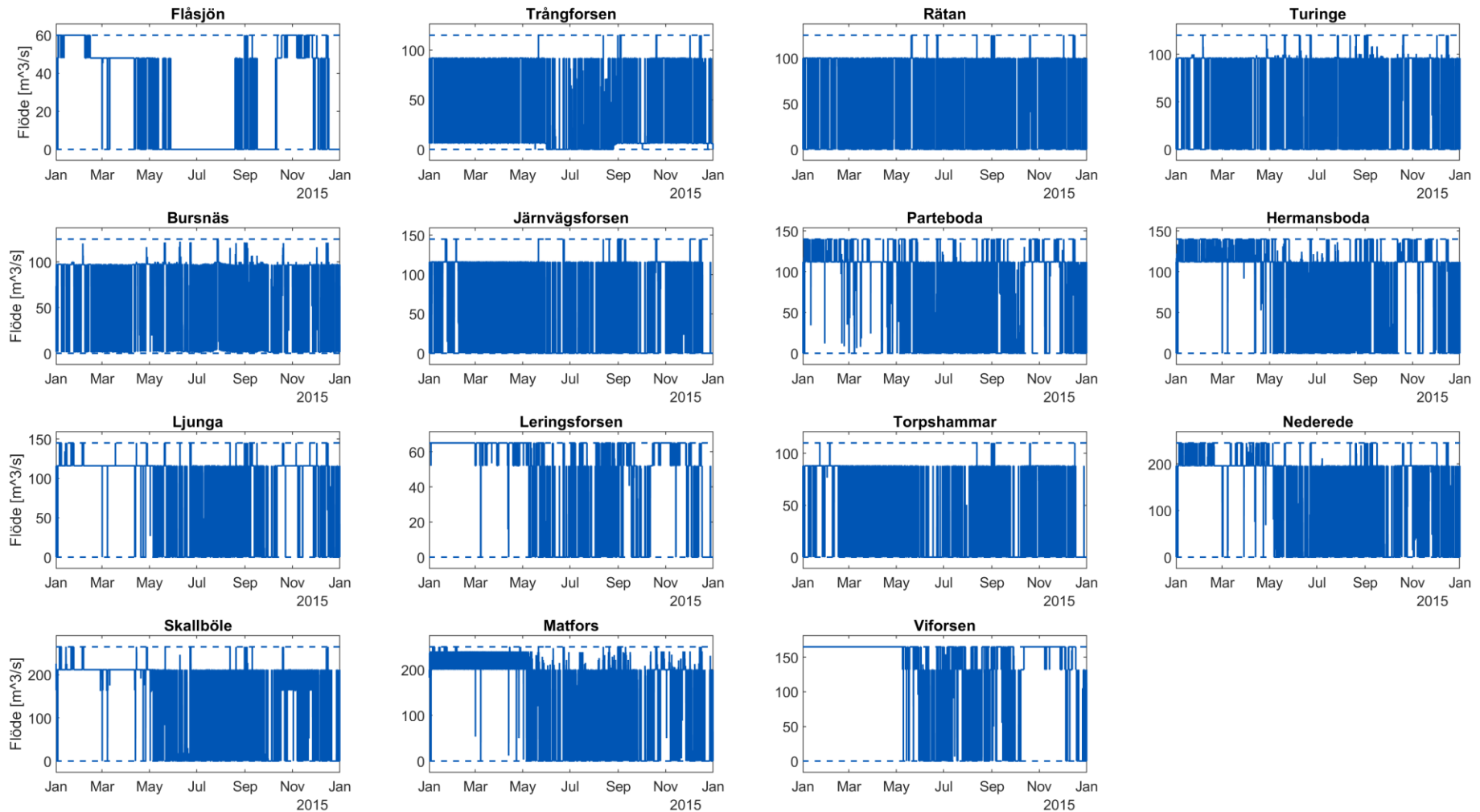
Vattendomar "MinSpill"

Ljungan



Vattendomar "MinFlow"

Turbinvattenföring för Ljungan

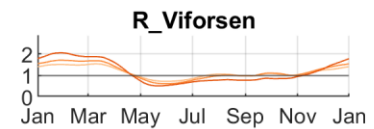
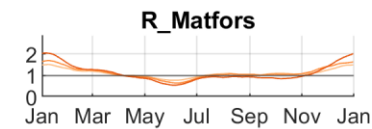
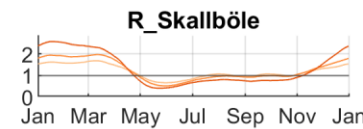
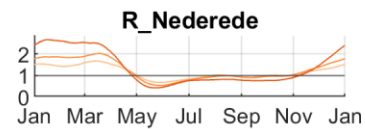
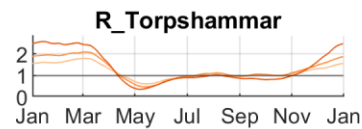
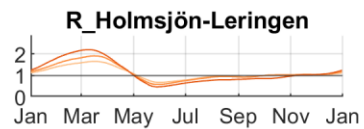
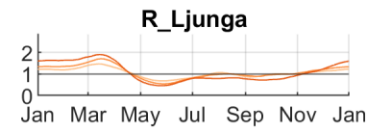
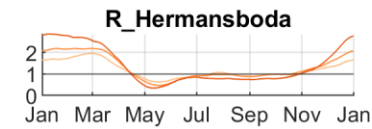
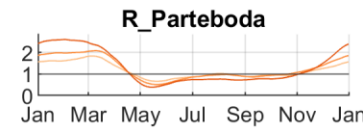
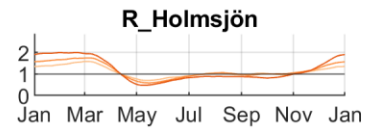
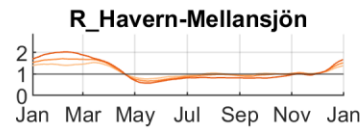
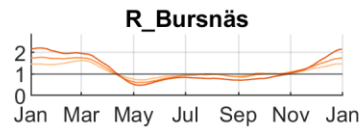
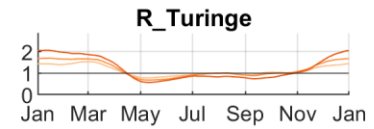
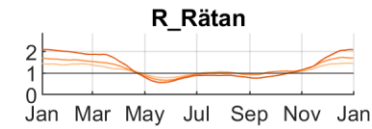
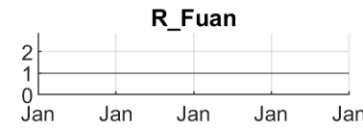
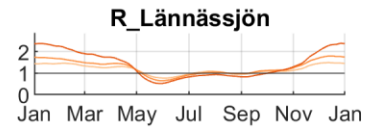
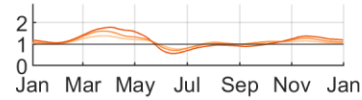
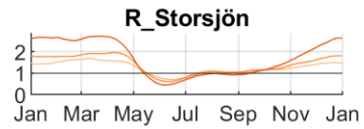


— KLIVA

Klimatpåverkan på lokaltillrinningar

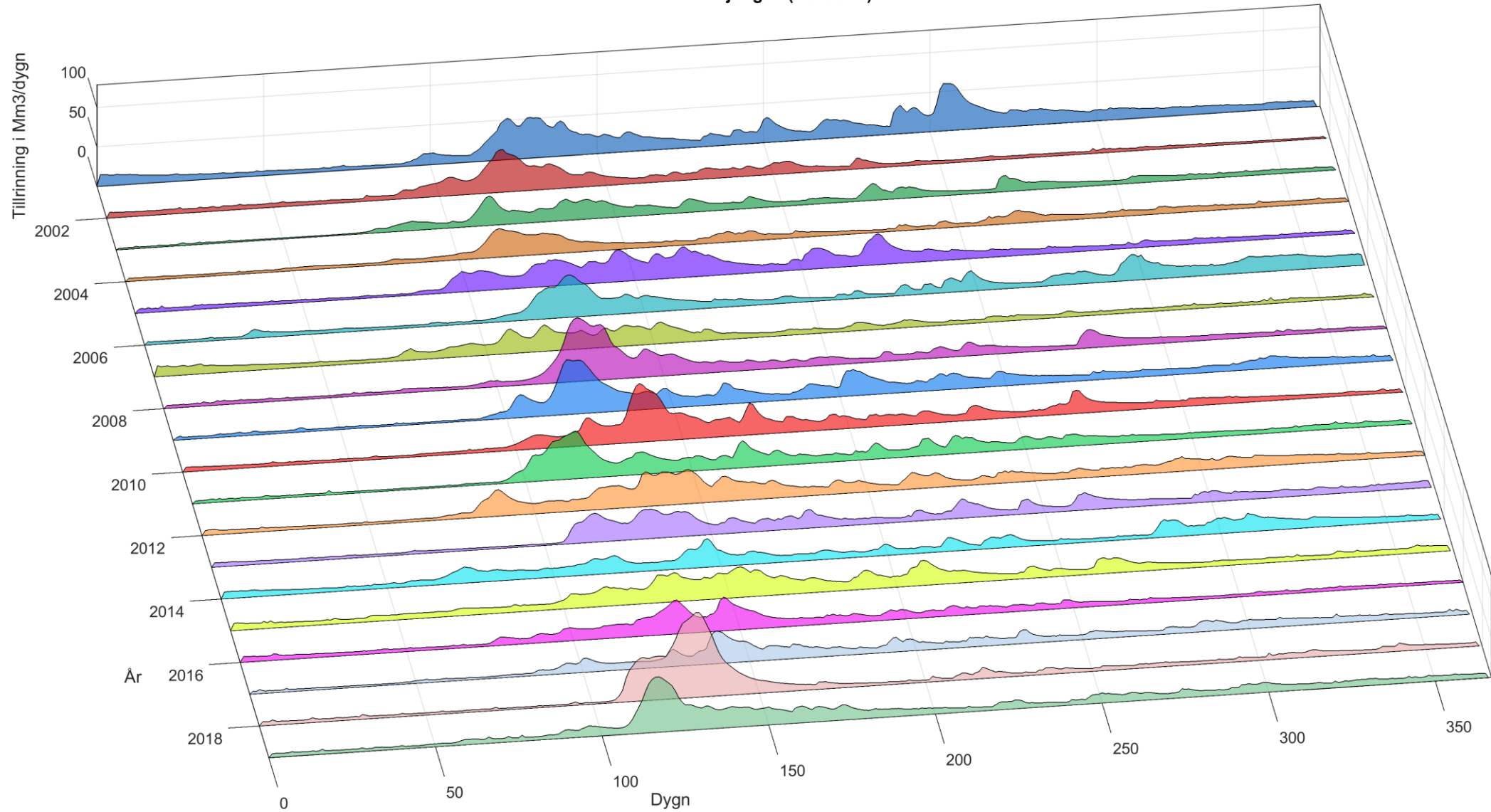
Klimatfaktorer

Klimatfaktorer Ljungan



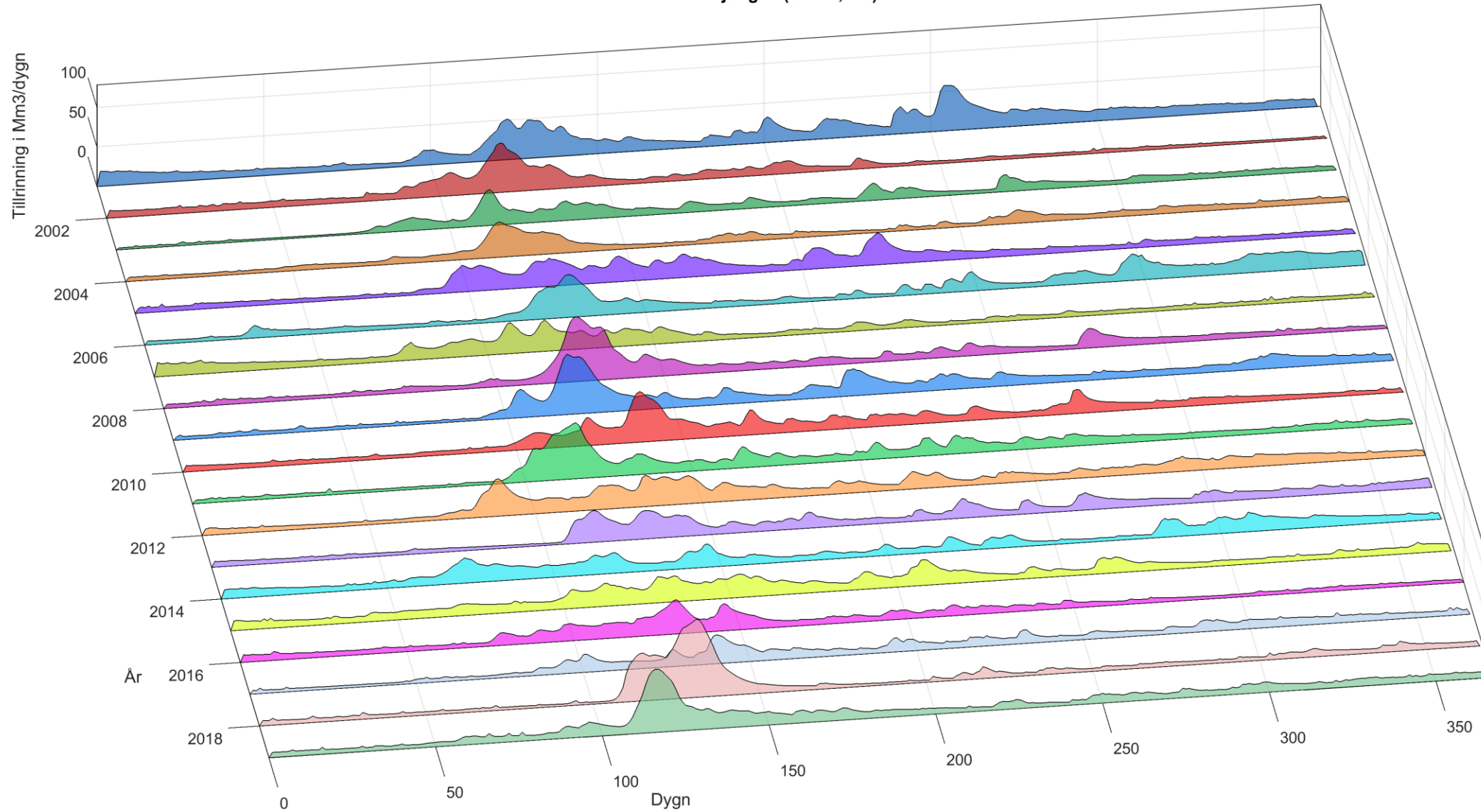
Total tillrinning (Referens)

Ljungan (Referens)



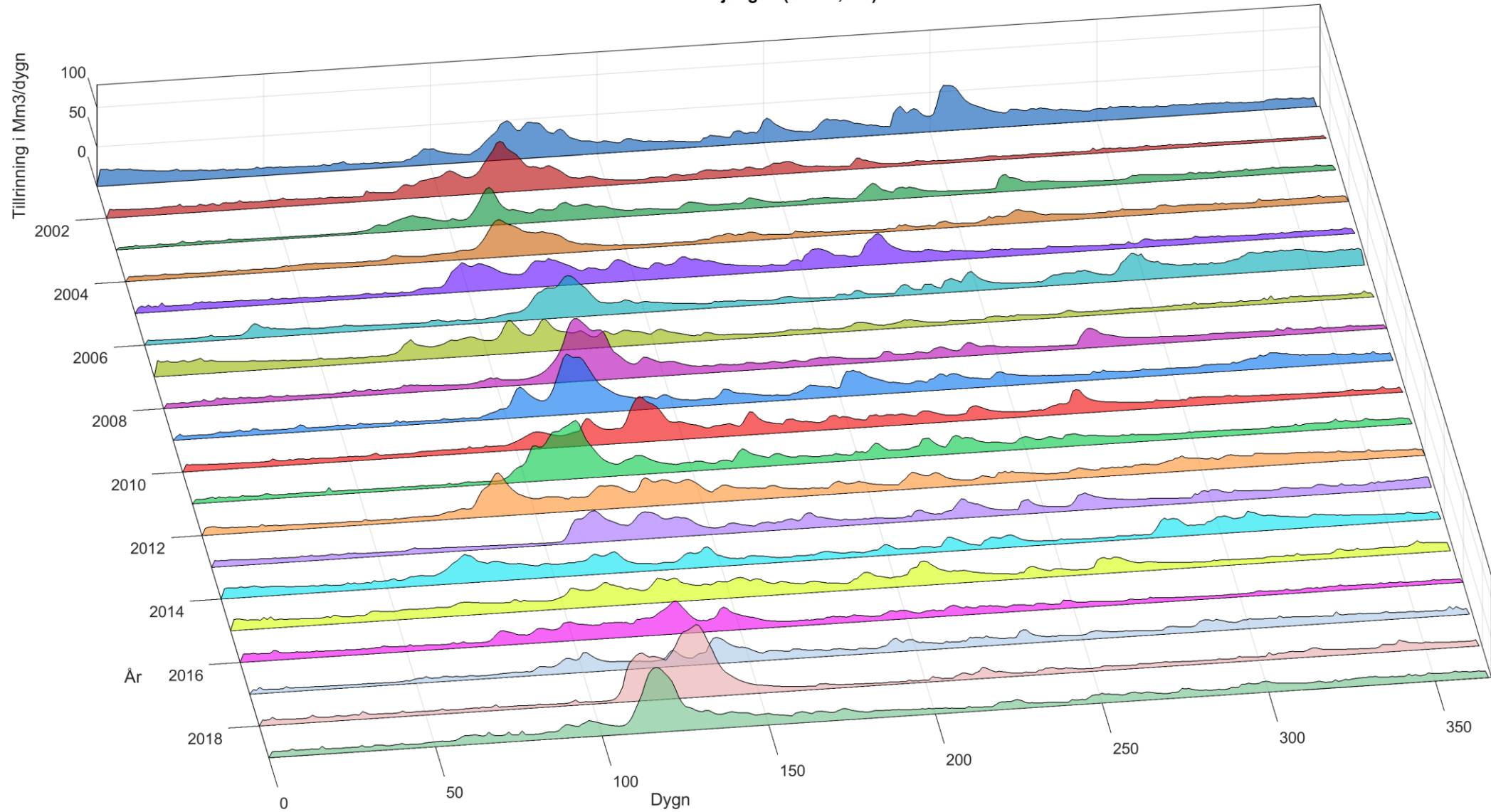
Total tillrinning (GWL1,5°C)

Ljungan (GWL1,5°C)



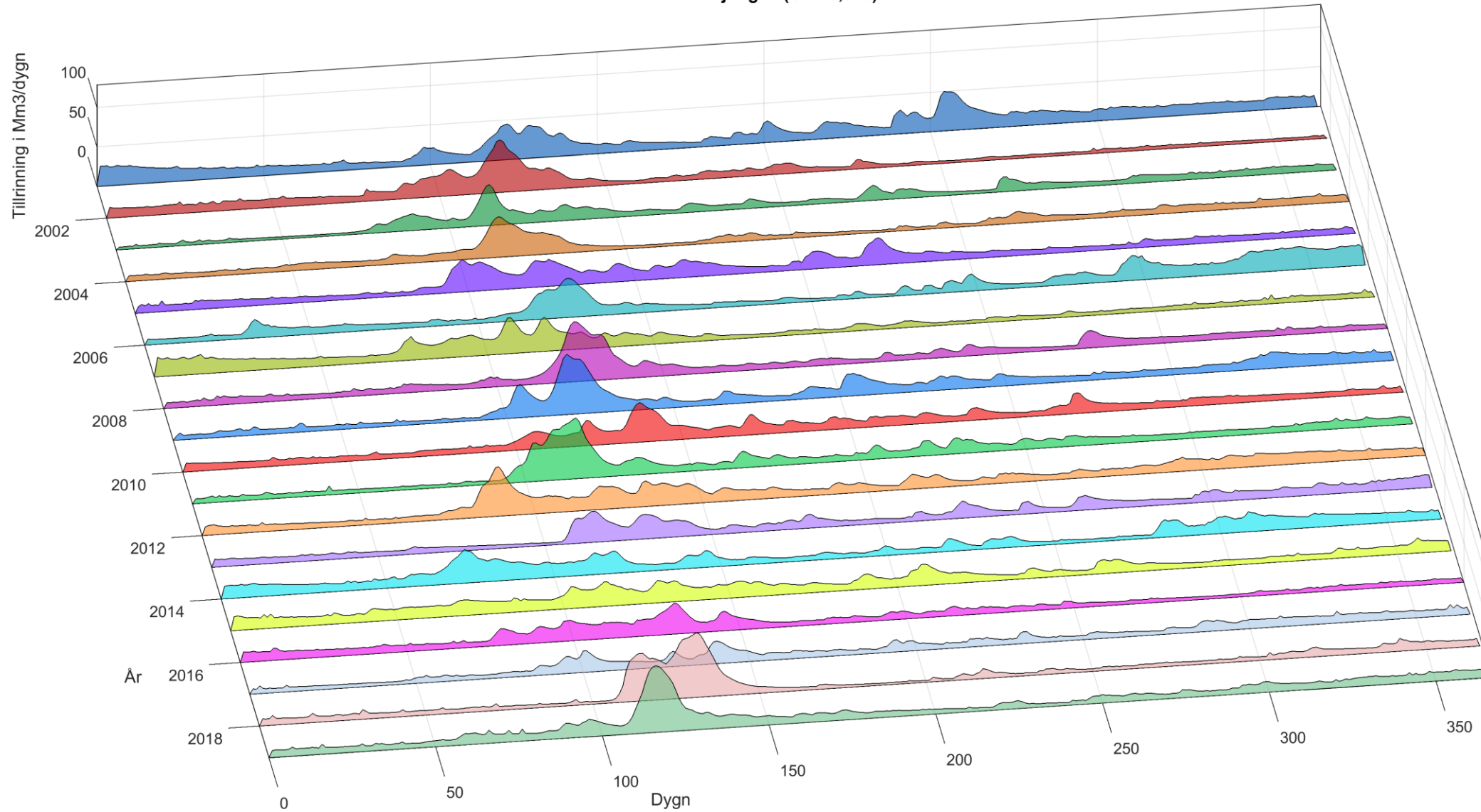
Total tillrinning (GWL2,0°C)

Ljungan (GWL2,0°C)



Total tillrinning (GWL3,0°C)

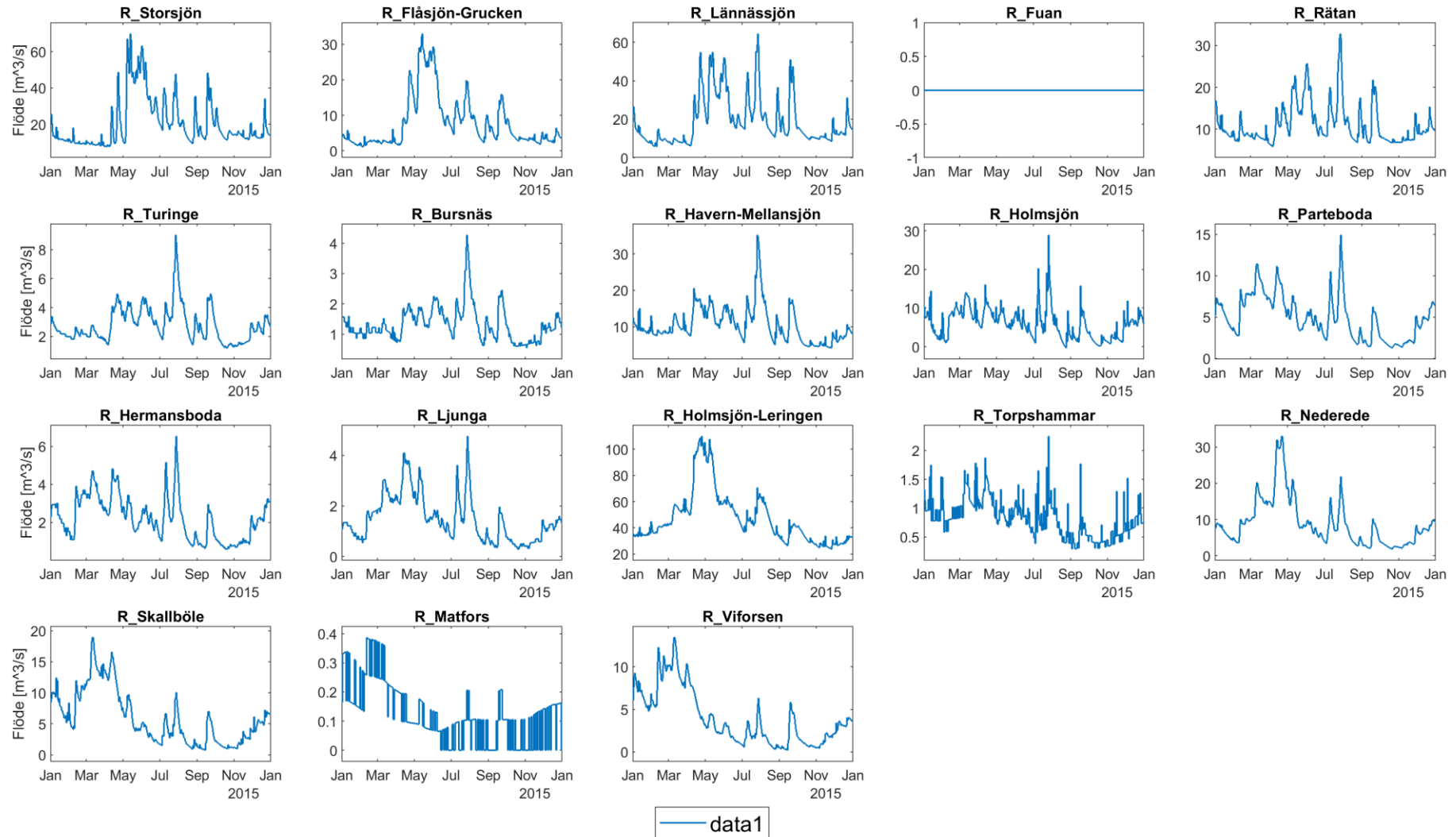
Ljungan (GWL3,0°C)



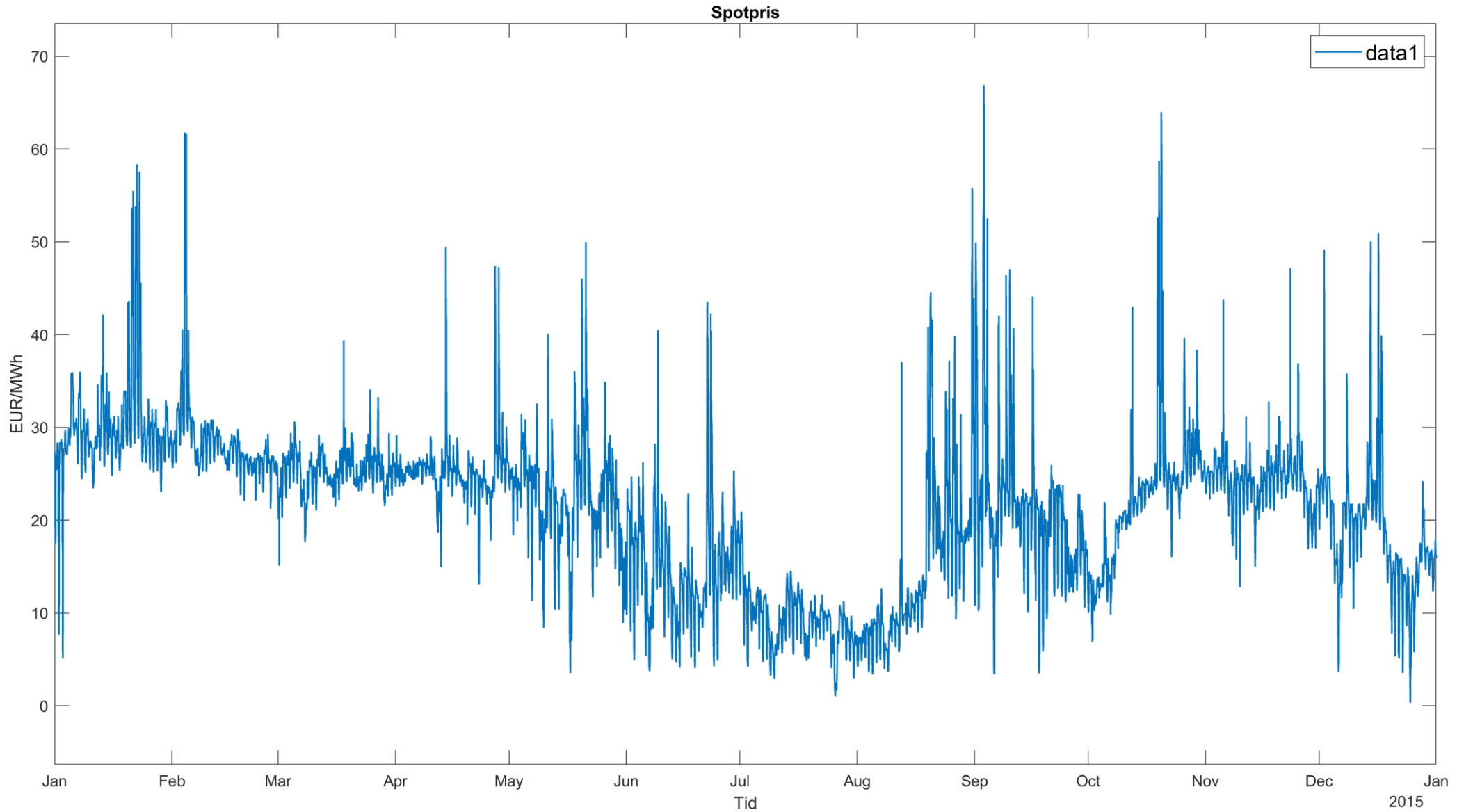
Resultat (exempel GWL2,0°C för 2015)

Lokaltillrinning

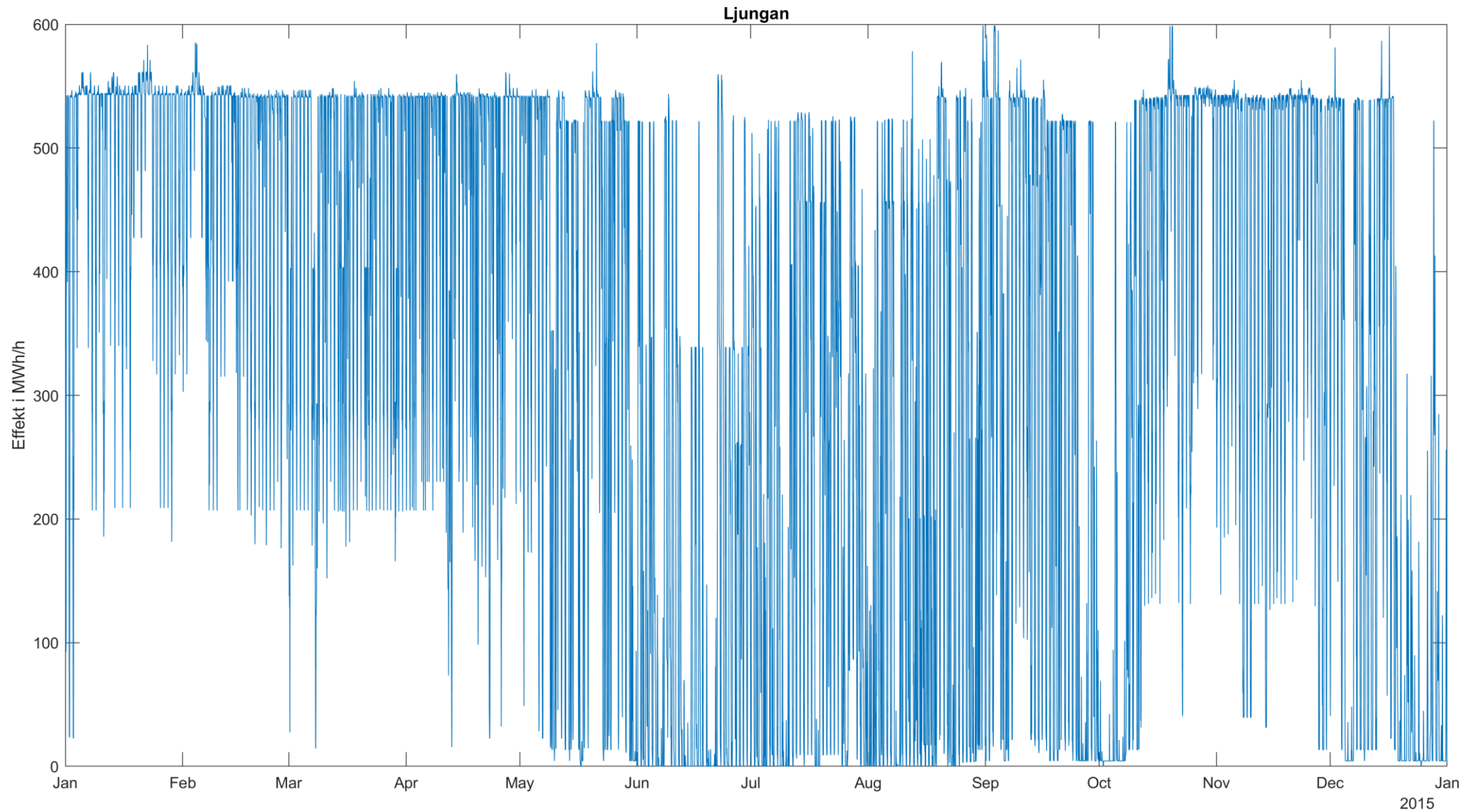
Lokal tillrinning för Ljungan



Elpriser

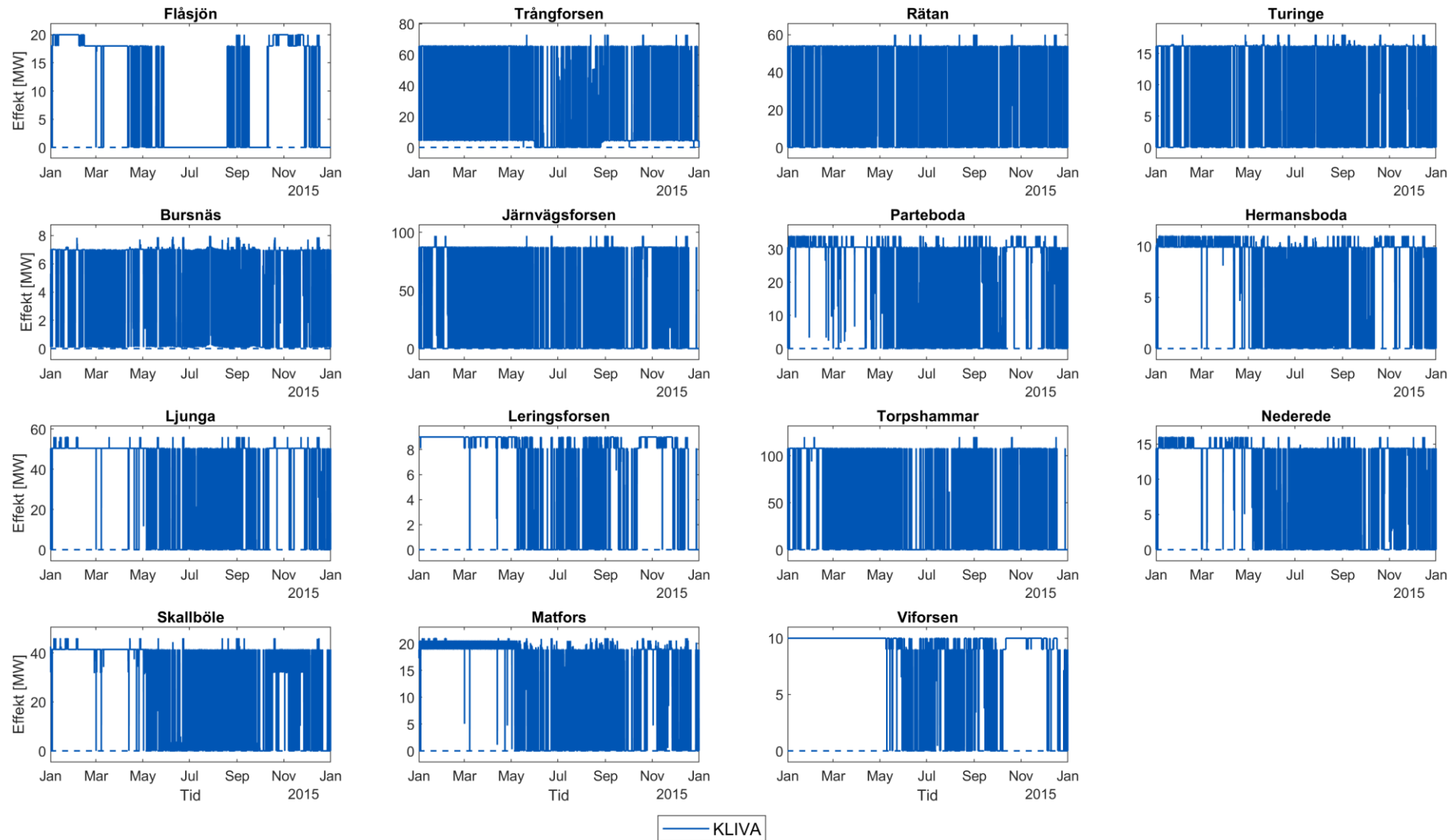


Produktion älvsystem



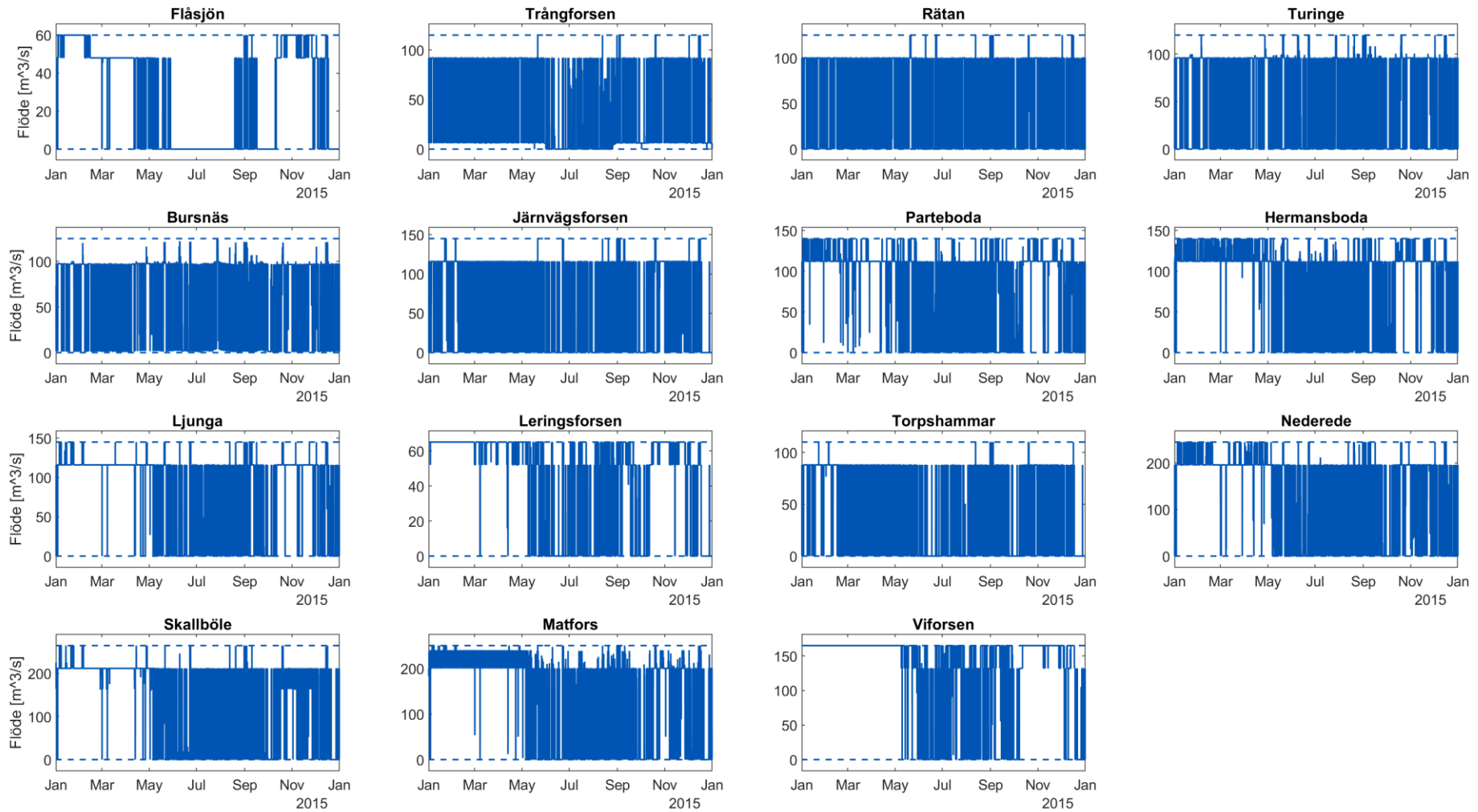
Produktion

Produktion per station för Ljungan



Stationsvattenföring

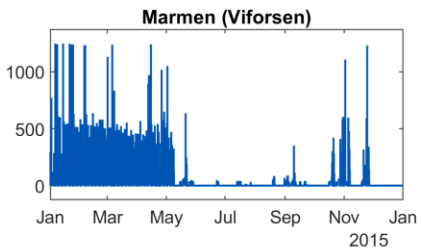
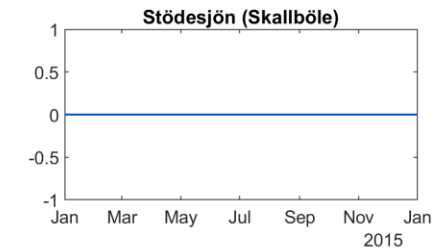
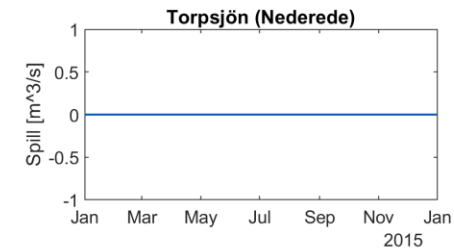
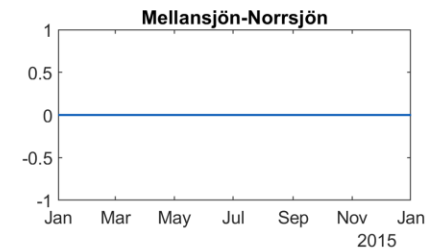
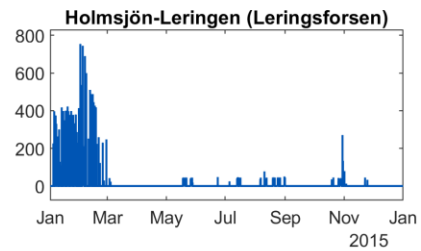
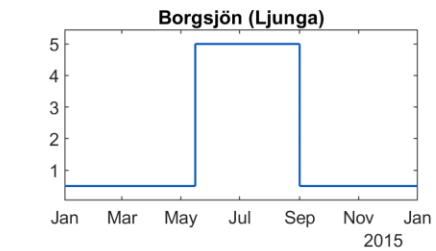
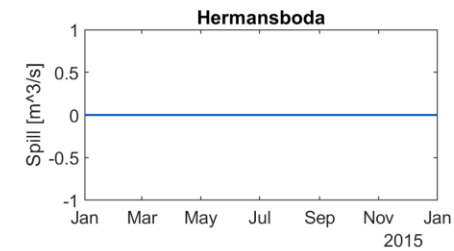
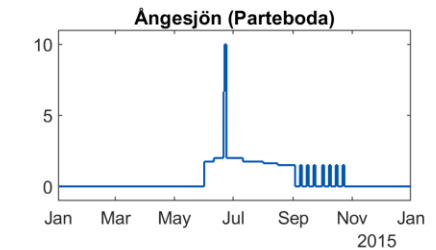
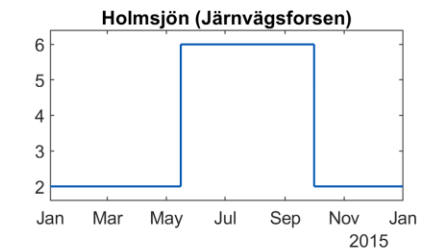
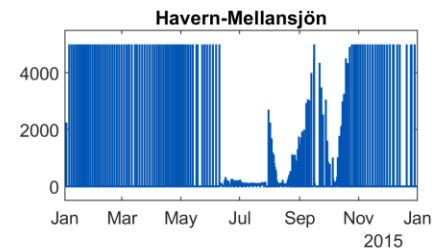
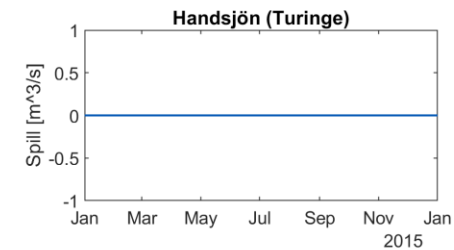
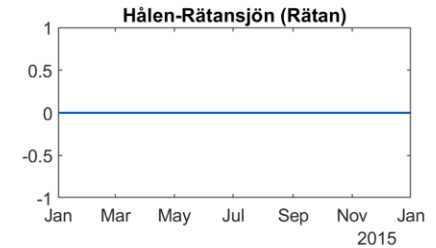
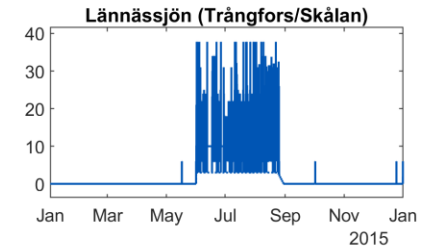
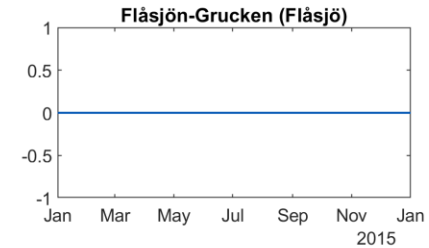
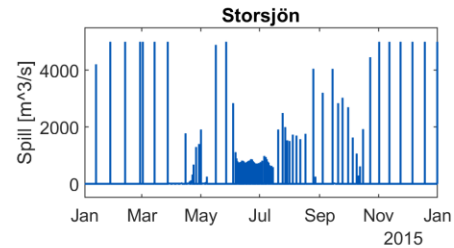
Turbinvattenföring för Ljungan



— KLIVA

Spill

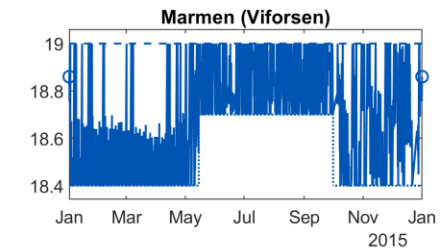
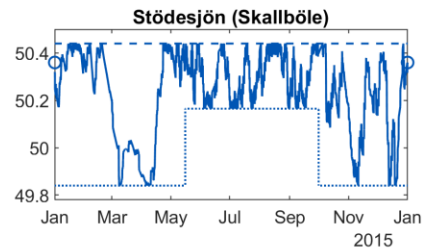
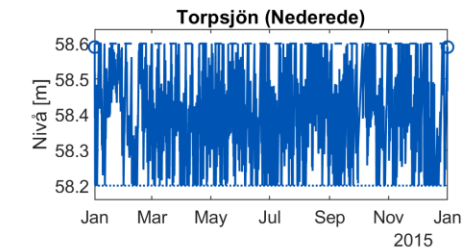
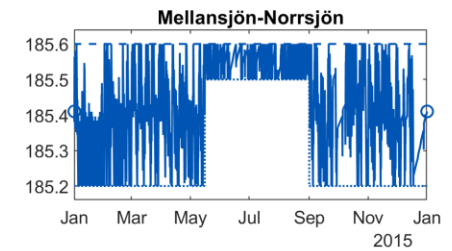
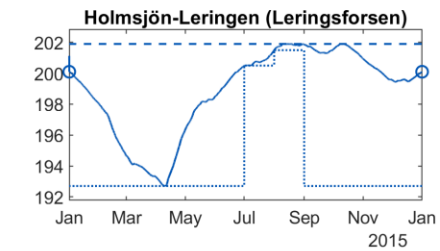
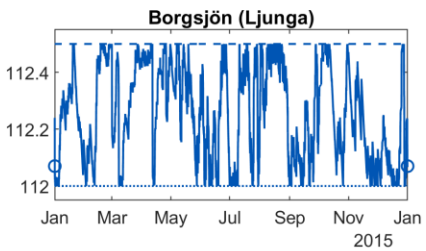
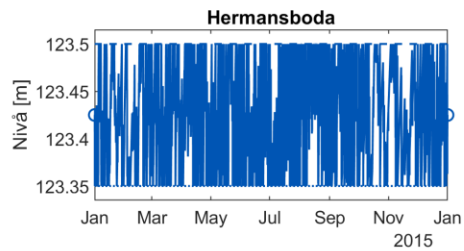
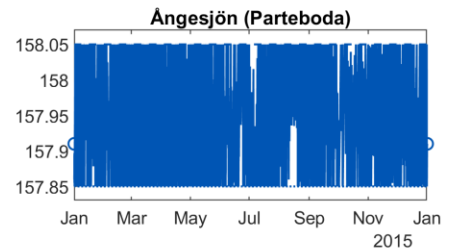
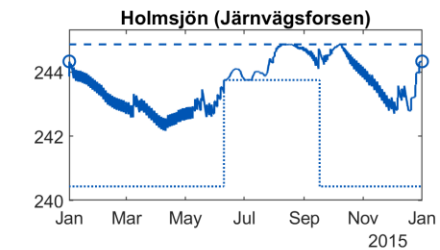
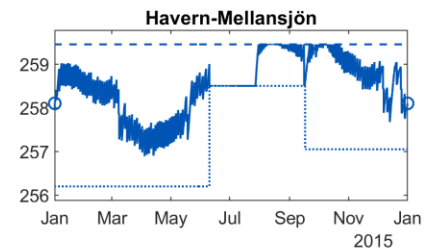
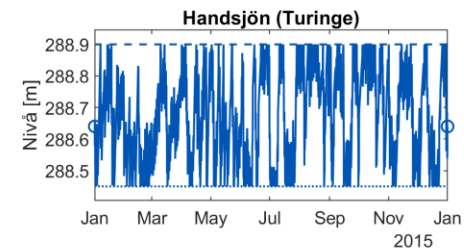
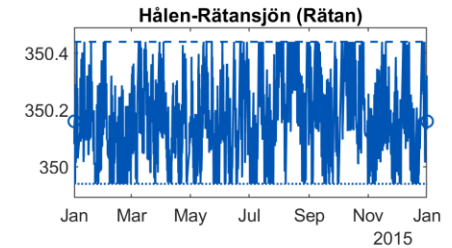
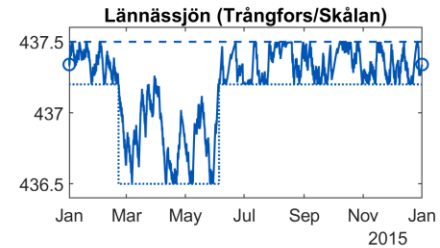
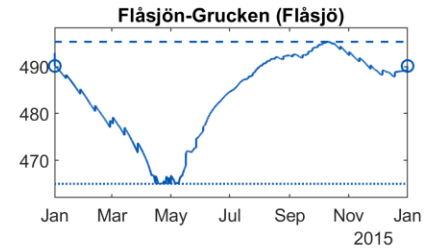
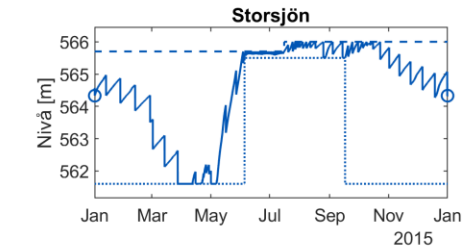
Ljungan



— KLIVA min

Vattenstånd

Ljungan

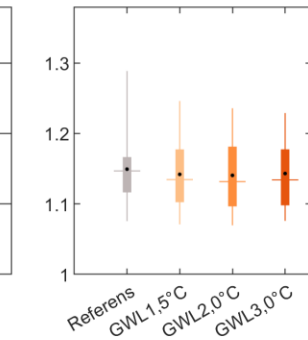
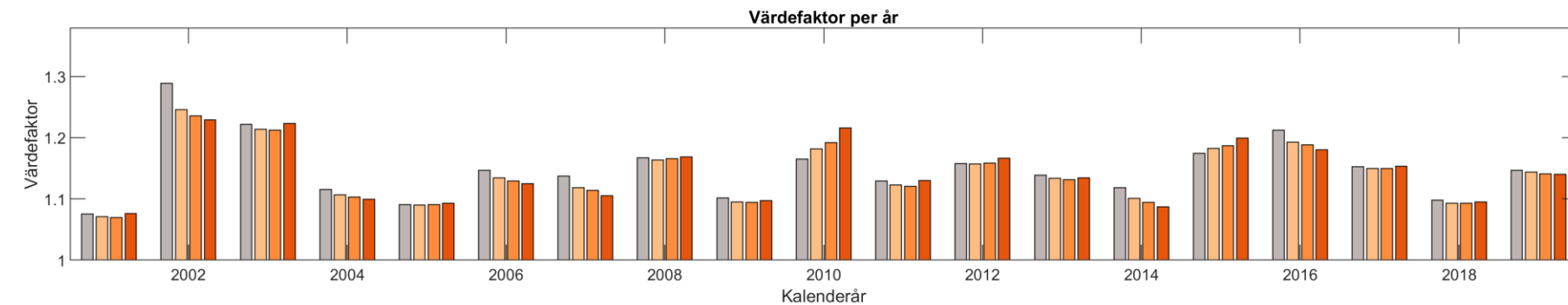
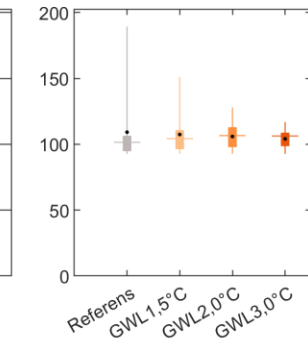
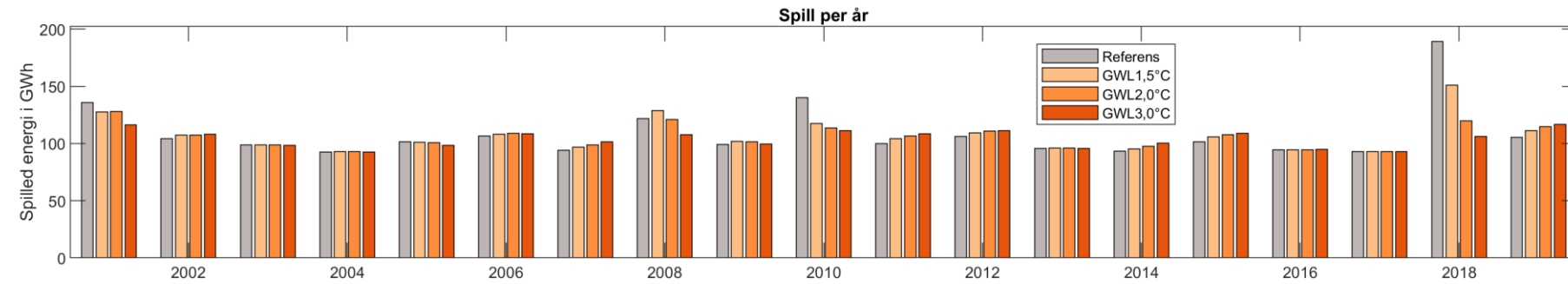
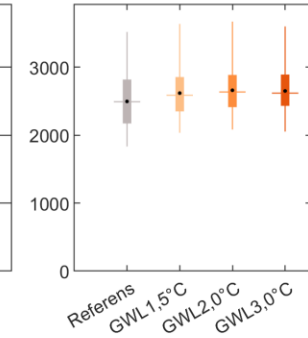
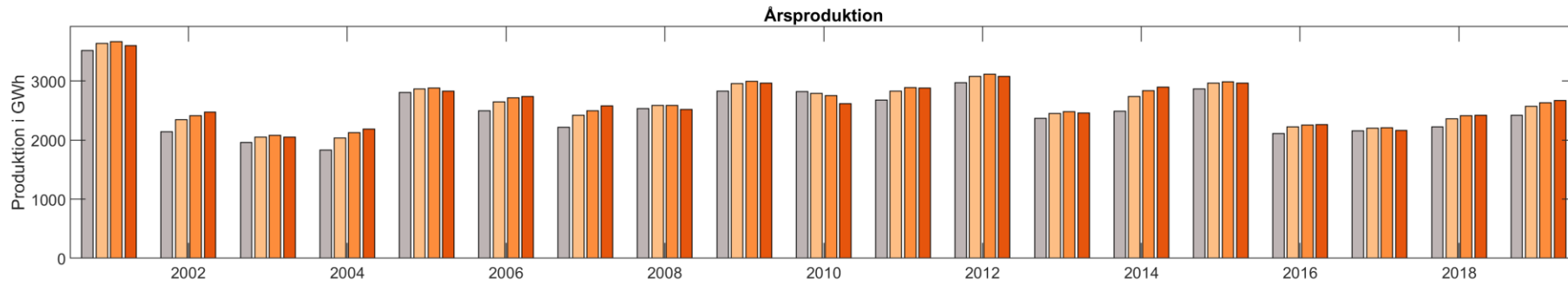


— KLIVA min - - - max ○ Randvillkor

Aggregerade resultat

Årsvärden produktion, spill, värdefaktor

Ljungan



Statistik produktion, spill, värdefaktor

Produktion i GWh

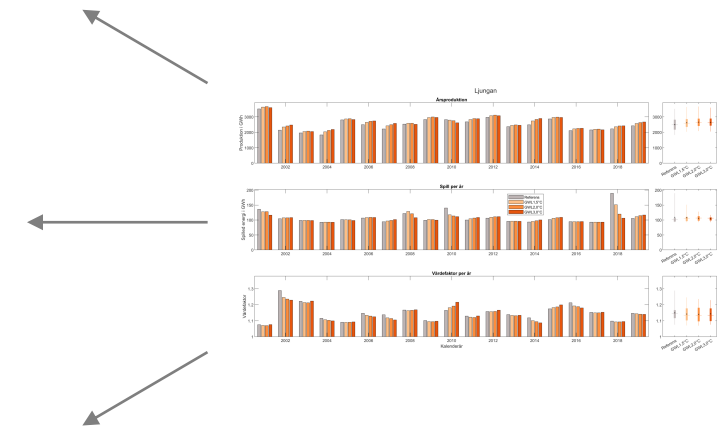
GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	2495	(Ref)	(Ref)	2171	2816	645	1832	3515
GWL1, 5°C	2617	+122	+5 %	2349	2853	504	2034	3634
GWL2, 0°C	2659	+164	+7 %	2410	2884	474	2081	3668
GWL3, 0°C	2648	+153	+6 %	2430	2890	460	2051	3596

Spill i GWh

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	109	(Ref)	(Ref)	95	106	11	93	189
GWL1, 5°C	107	-2	-2 %	96	111	15	93	151
GWL2, 0°C	106	-3	-3 %	98	113	15	93	128
GWL3, 0°C	104	-5	-5 %	99	109	10	93	117

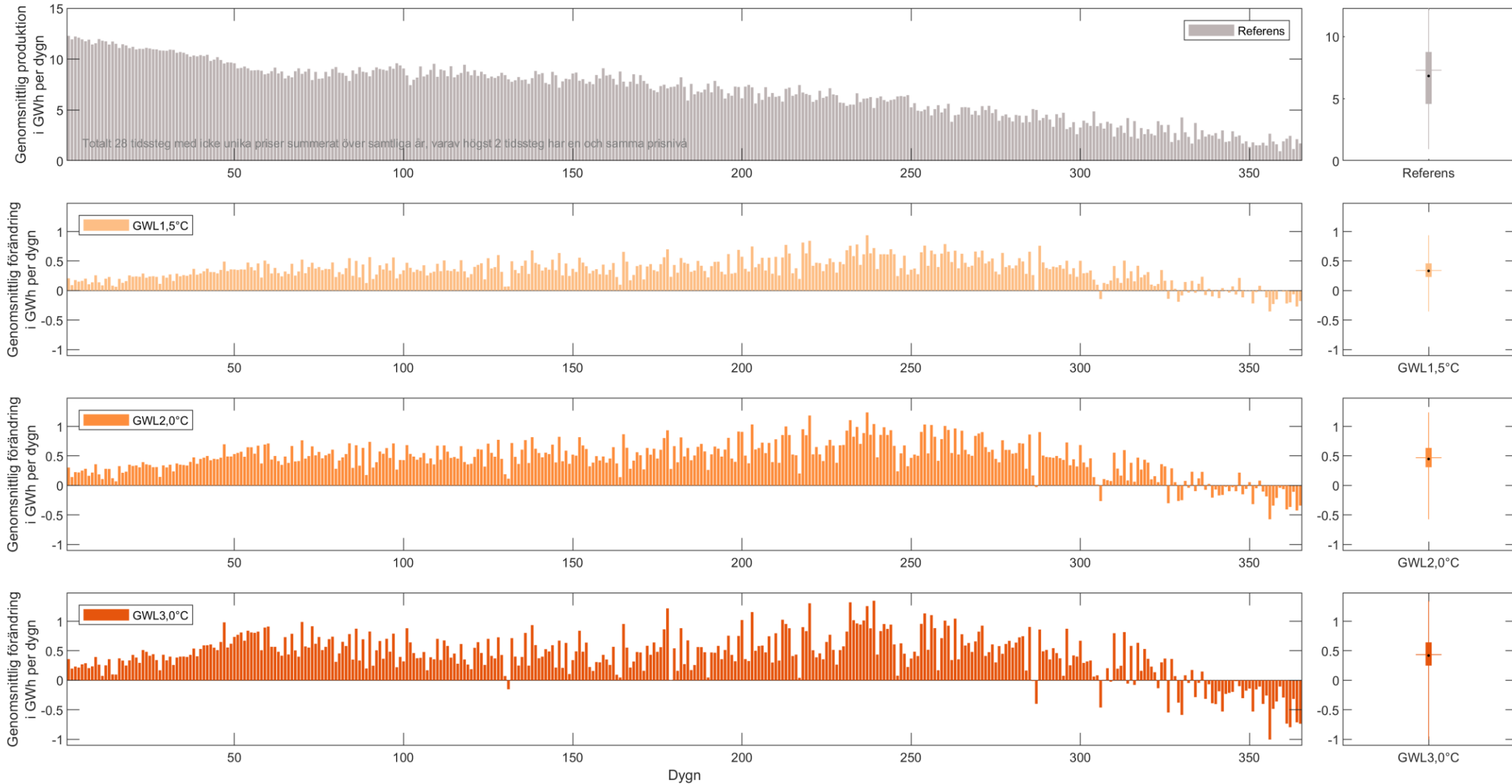
Värdefaktor

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	1.149	(Ref)	(Ref)	1.116	1.166	0.050	1.076	1.289
GWL1, 5°C	1.142	-0.007	-1 %	1.102	1.177	0.075	1.071	1.246
GWL2, 0°C	1.140	-0.009	-1 %	1.096	1.181	0.085	1.070	1.236
GWL3, 0°C	1.143	-0.006	-1 %	1.098	1.177	0.079	1.076	1.229



Förändring i balanseringsförmågan

Flerårs prissorterad produktion Ljungan (24 h)





Kontakt AP2

richard.scharff@vattenfall.com



KLIVA-rapport bilaga A Ljusnan

Richard Scharff, Chalmers, 2023-02-01

Kommentarer

- Bilagan innehåller ett axplock av diagram för att illustrera indata till vattenkraftmodellen samt dess resultat
- Resultaten skiljer sig mellan älvsystem, år och uppvärmningsnivå
- Insikter, slutsatser och detaljer beskrivs i rapporten

→ Rapporten finns på: <https://energiforsk.se/program/klimatforandringarnas-inverkan-pa-vattenkraften/rapporter/klimatforandringarnas-inverkan-pa-vattenkraftens-produktions-och-reglerformaga/>



Energiforsk

KLIVA-projektet har analyserat **klimatförändringarnas påverkan** på vattenkraftens produktions- och balanseringsförmåga

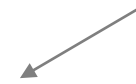
Innehåll diagrammsamling

- Systembeskrivning
 - Älvsystem
 - Energi per Mm³ lokaltillrinning
 - Vattendomar
- Klimatpåverkan lokaltillrinning
 - Klimatfaktorer
 - Total tillrinning



- Optimering
 - Lokaltillrinning
 - Elpriser
 - Älvens elproduktion
 - Produktion per station
 - Stationsvattenföring
 - Spill per magasin
 - Vattenytor per magasin
- Aggregerade resultat
 - Produktionsförmåga
 - Balanseringsförmåga

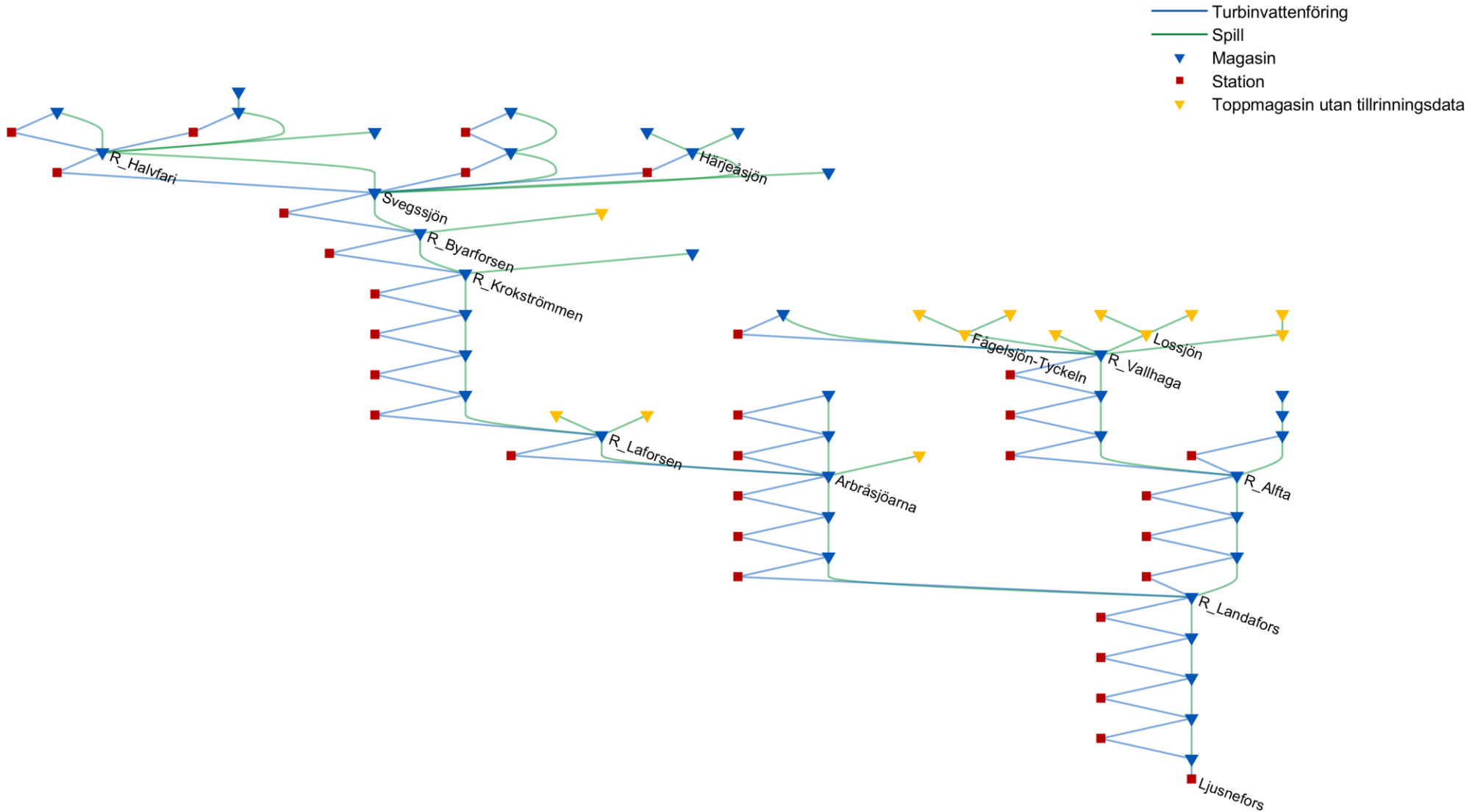
Optimeringen görs för **19 år**, alltid ett kalenderår i taget. I den här bilagan presenteras indata och resultat för **ett utvalt år** med uppvärmningsnivån **GWL2,0°C**.



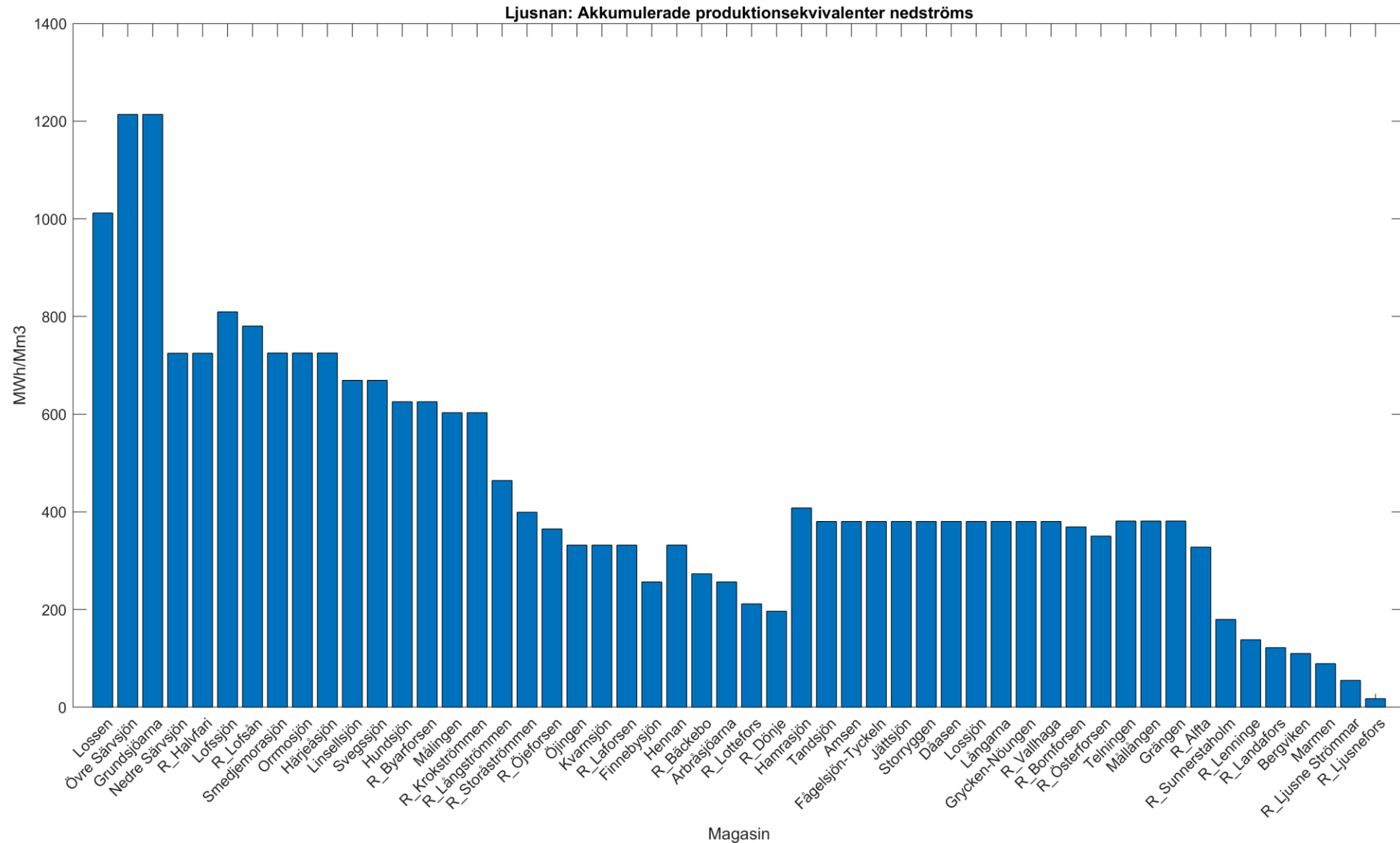
Systembeskrivning

Älvsystem

Ljusnan

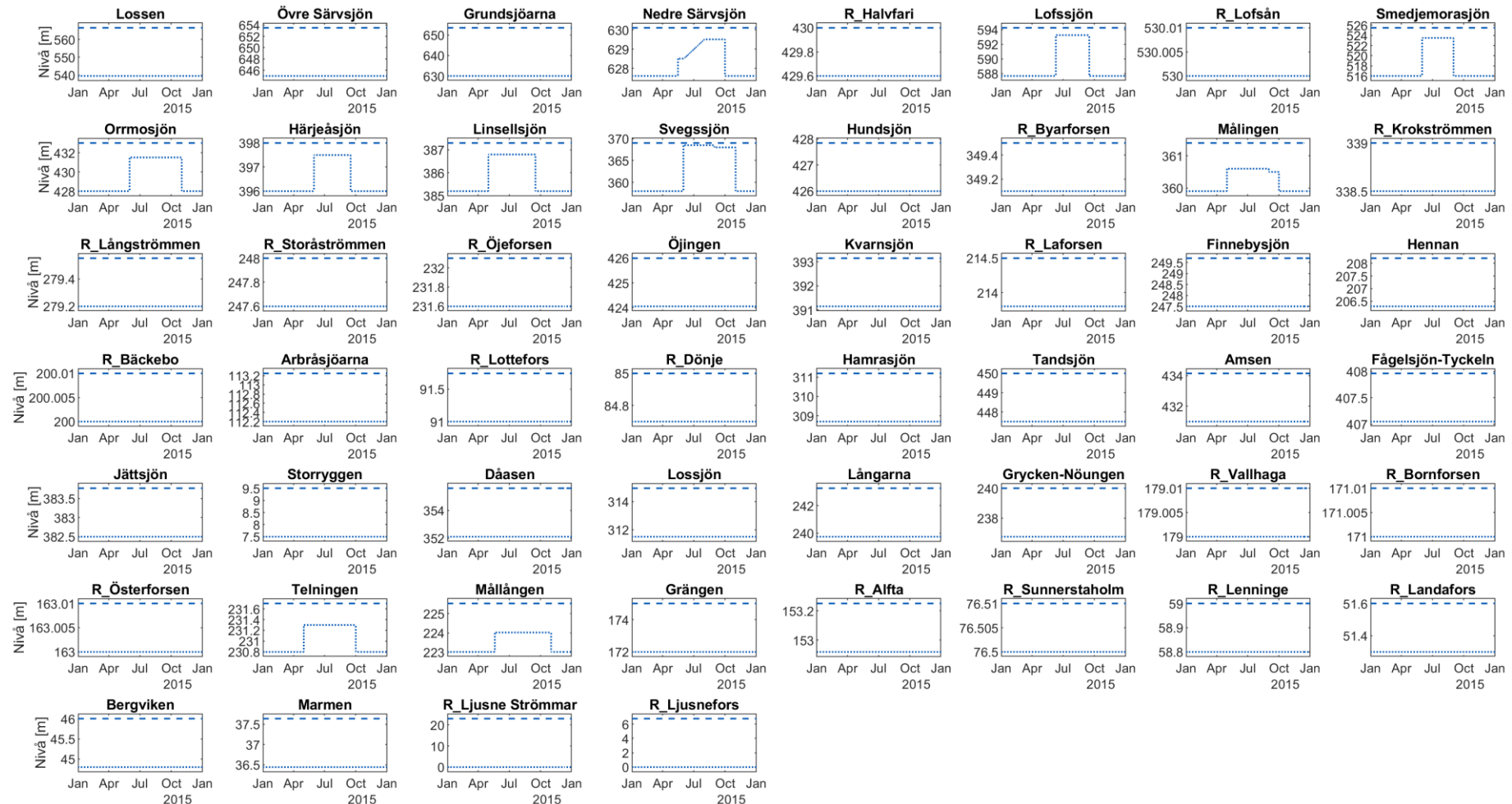


Energi per Mm³ lokaltillrinning



Vattendomar "WaterLevel"

Ljusnan



..... min - - - max

Vattendomar "MinSpill"

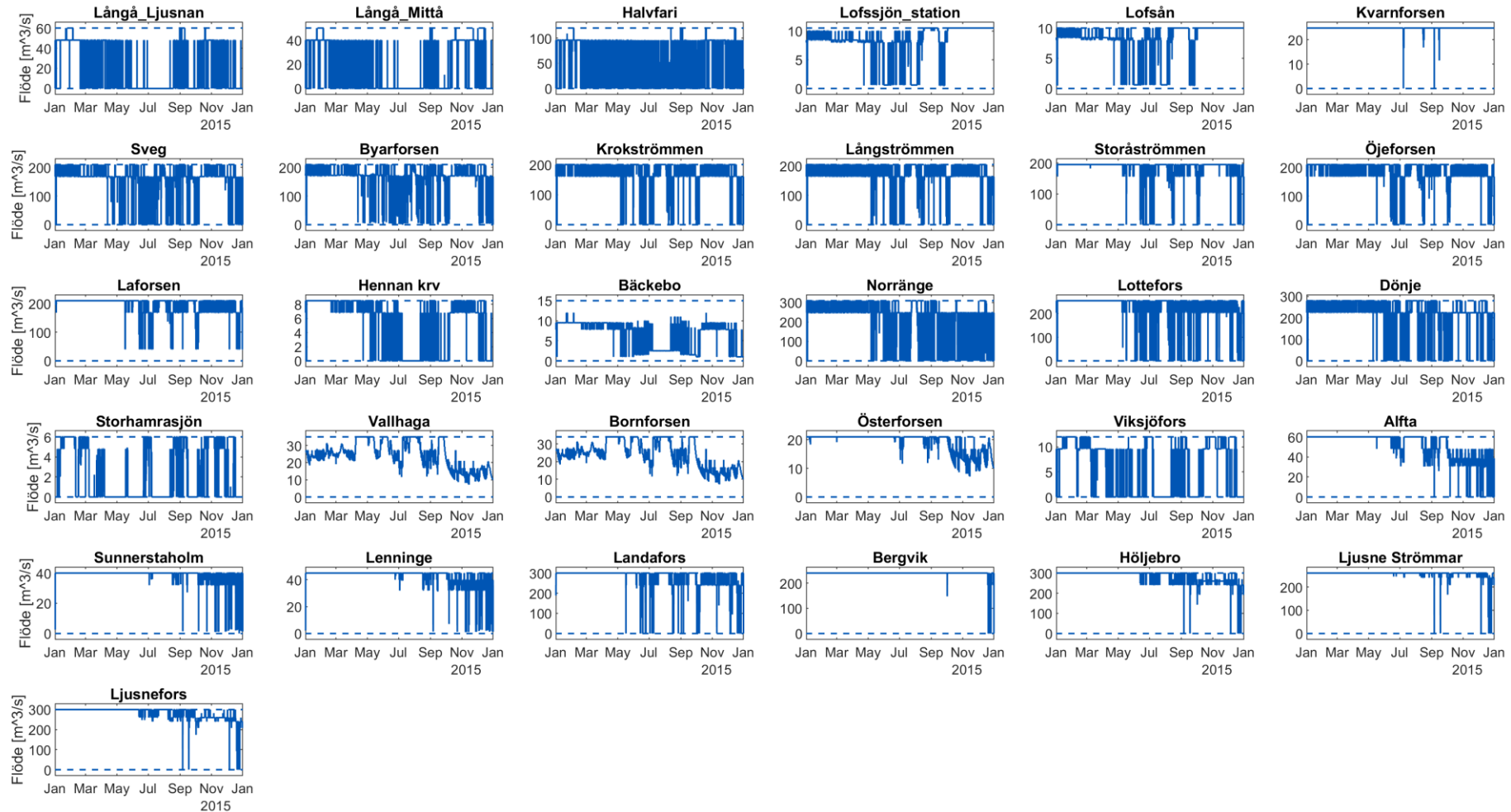
Ljusnan



min

Vattendomar ”MinFlow”

Turbinvattenföring för Ljusnan



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Klimatpåverkan på lokaltillrinningar

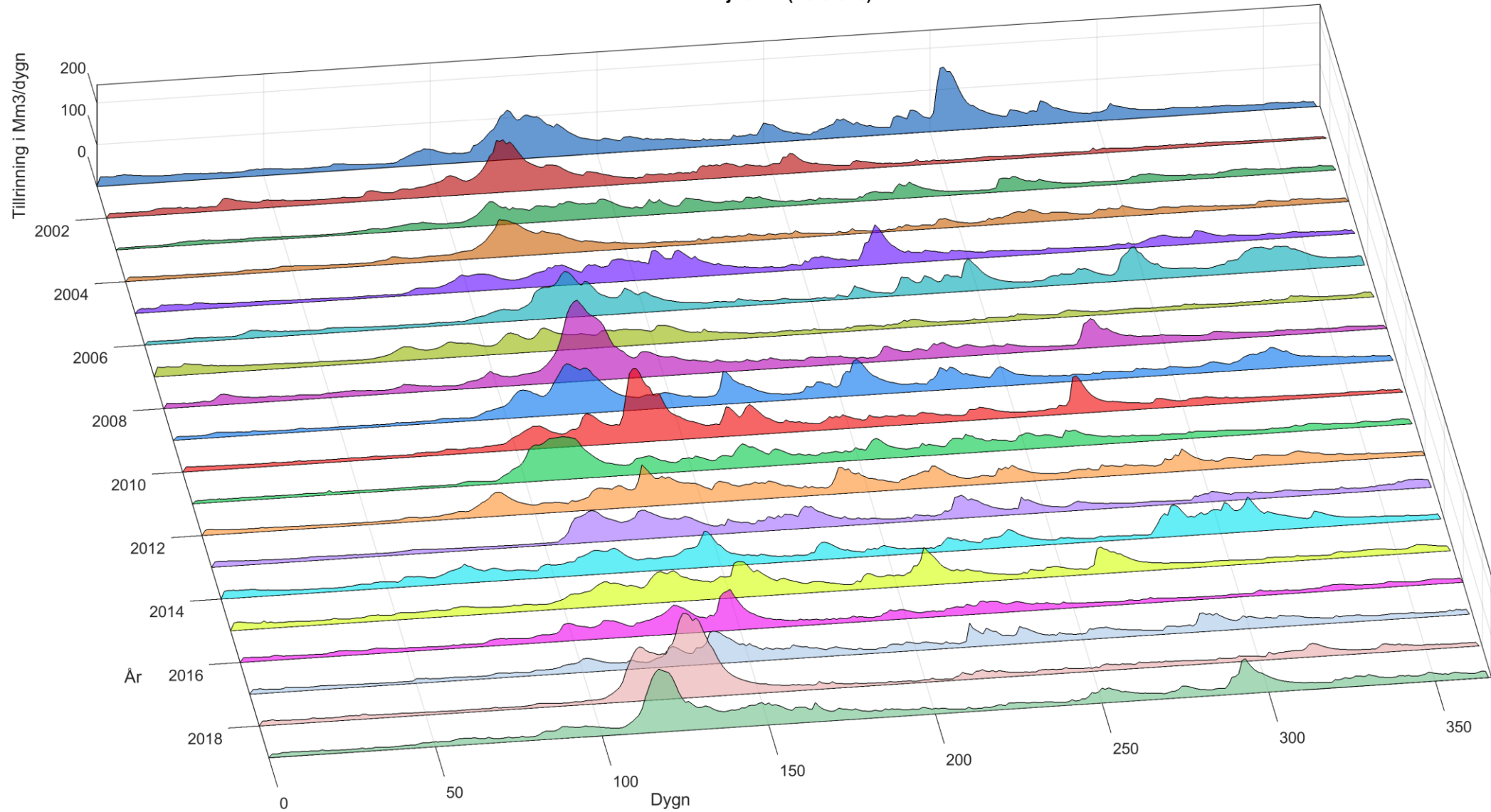
Klimatfaktorer

Klimatfaktorer Ljusnan



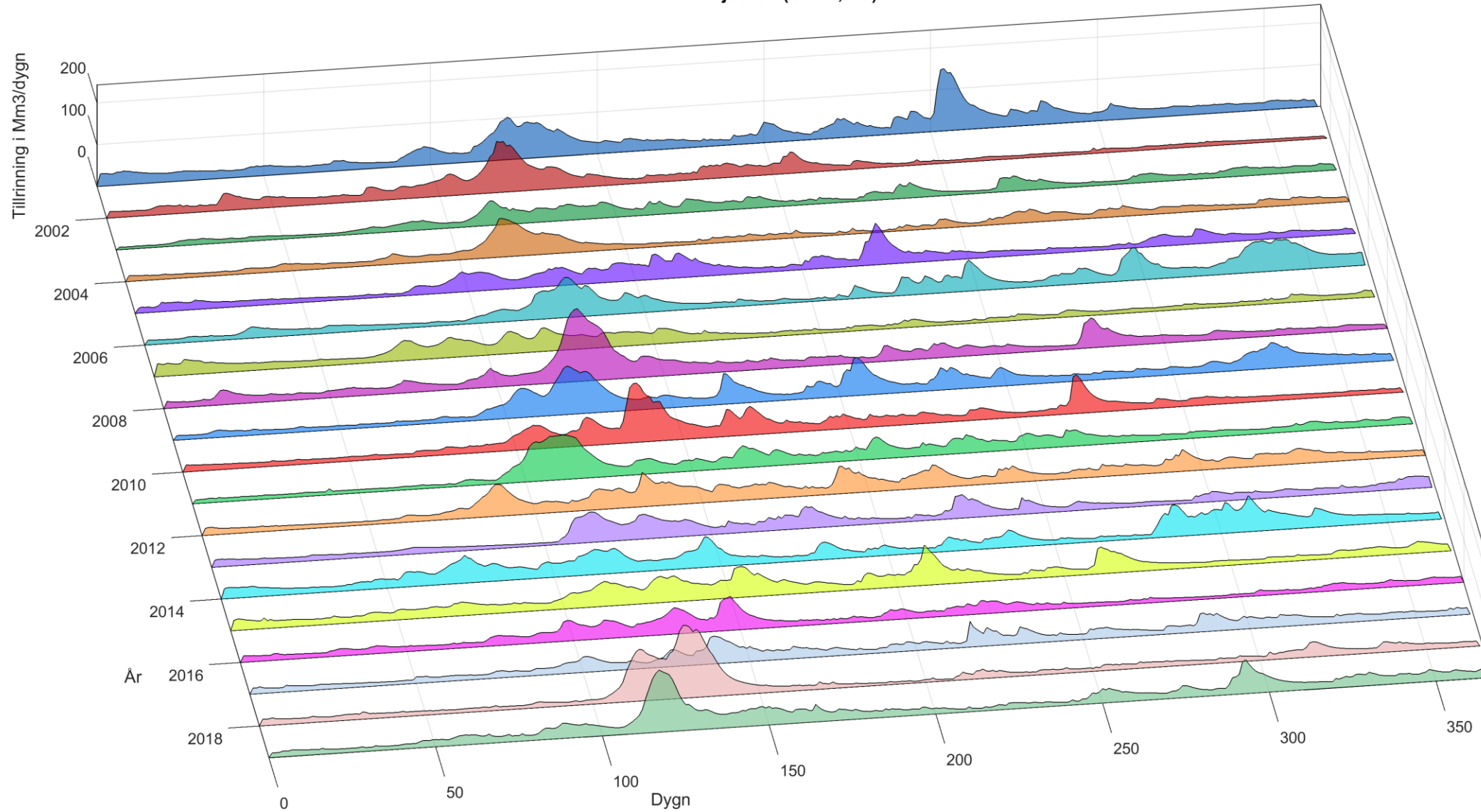
Total tillrinning (Referens)

Ljusnan (Referens)



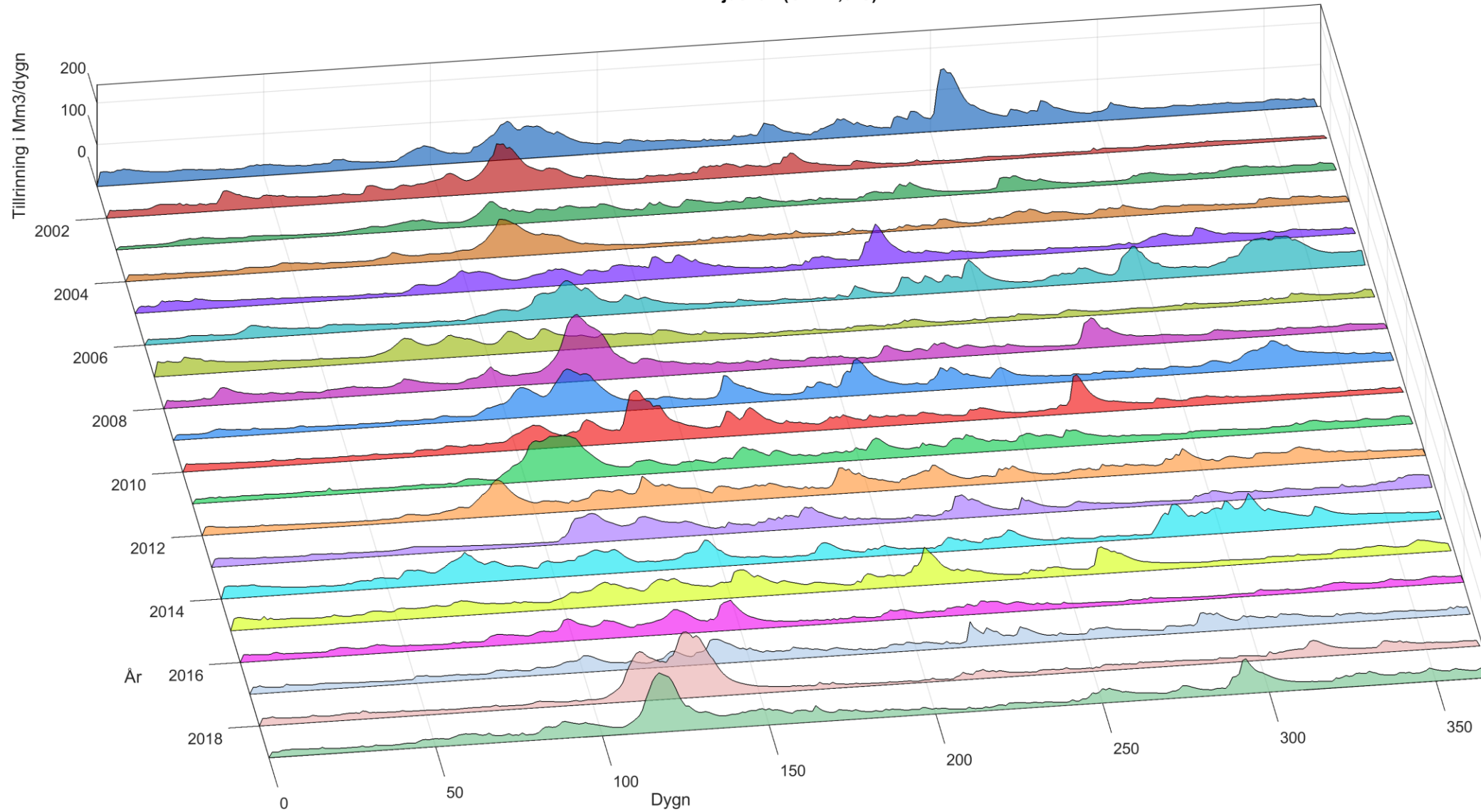
Total tillrinning (GWL1,5°C)

Ljusnan (GWL1,5°C)



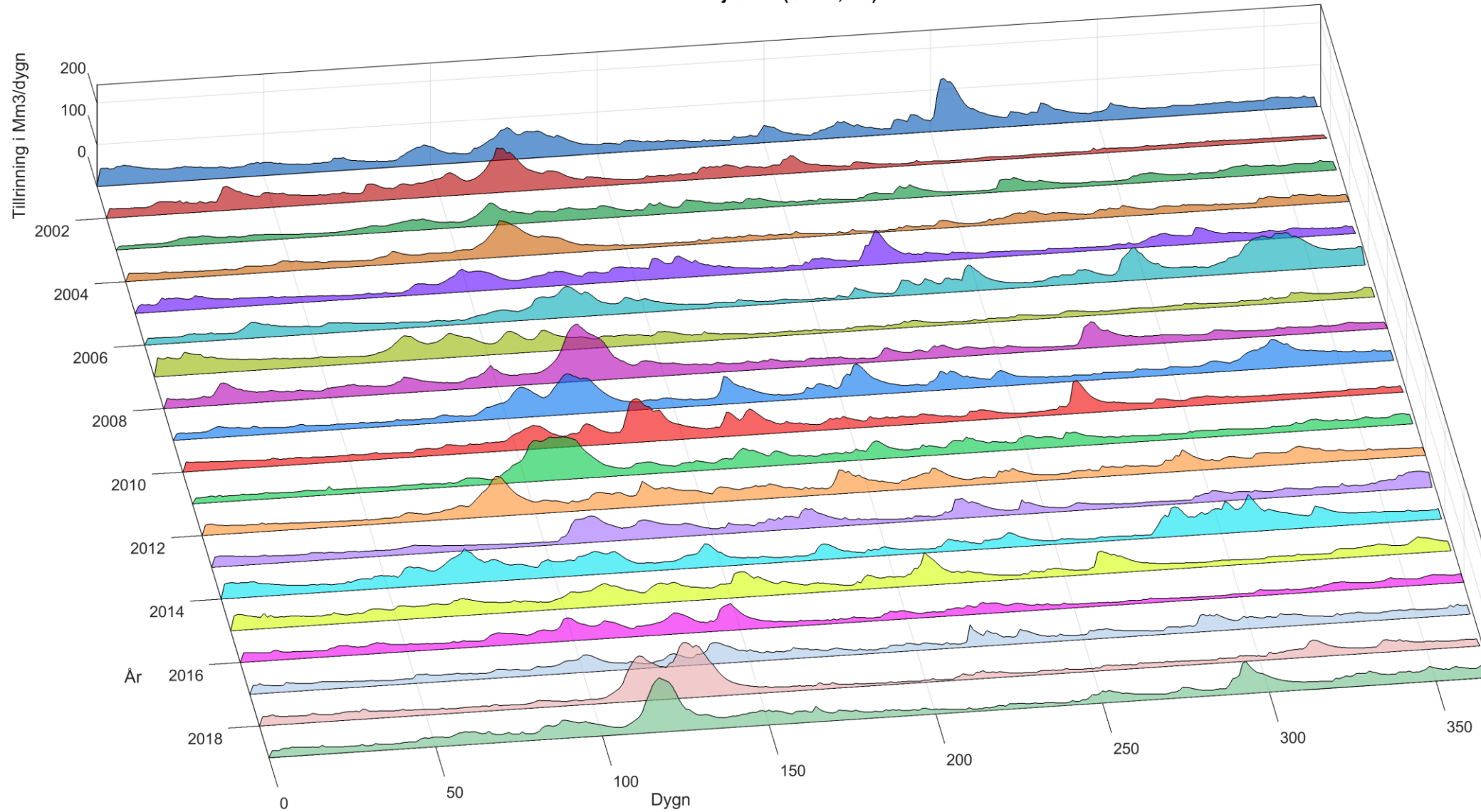
Total tillrinning (GWL2,0°C)

Ljusnan (GWL2,0°C)



Total tillrinning (GWL3,0°C)

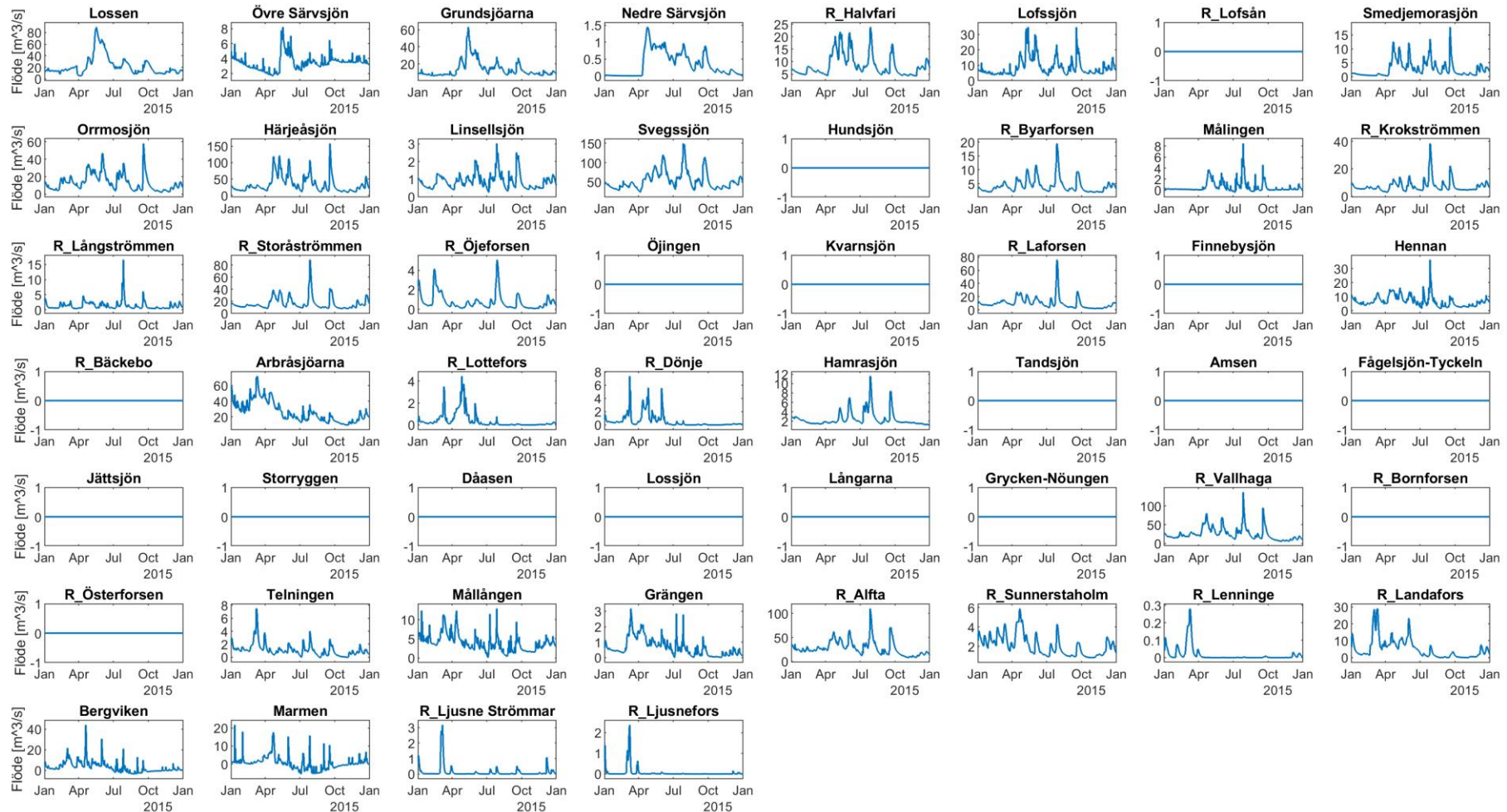
Ljusnan (GWL3,0°C)



Resultat (exempel GWL2,0°C för 2015)

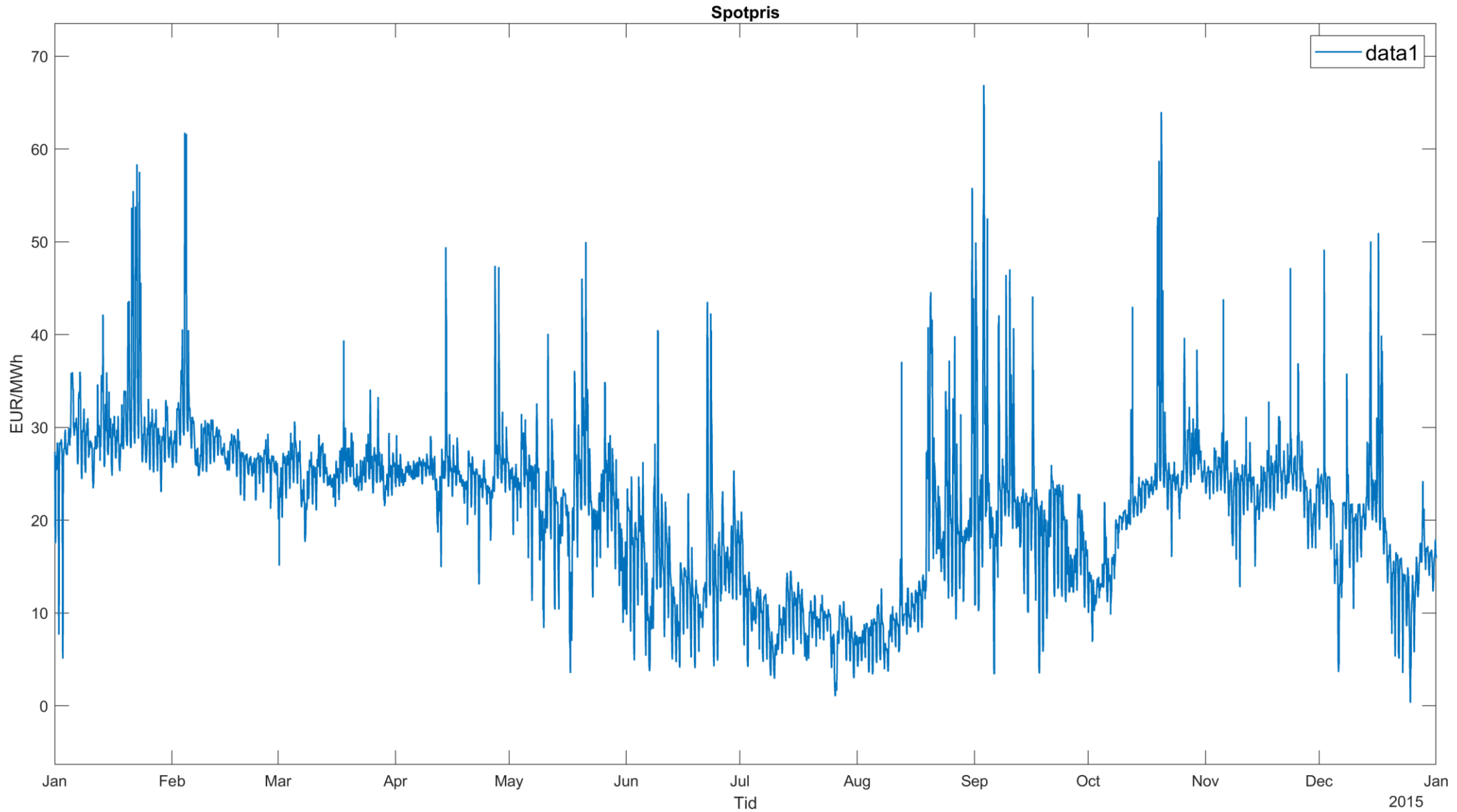
Lokaltillrinning

Lokal tillrinning för Ljusnan

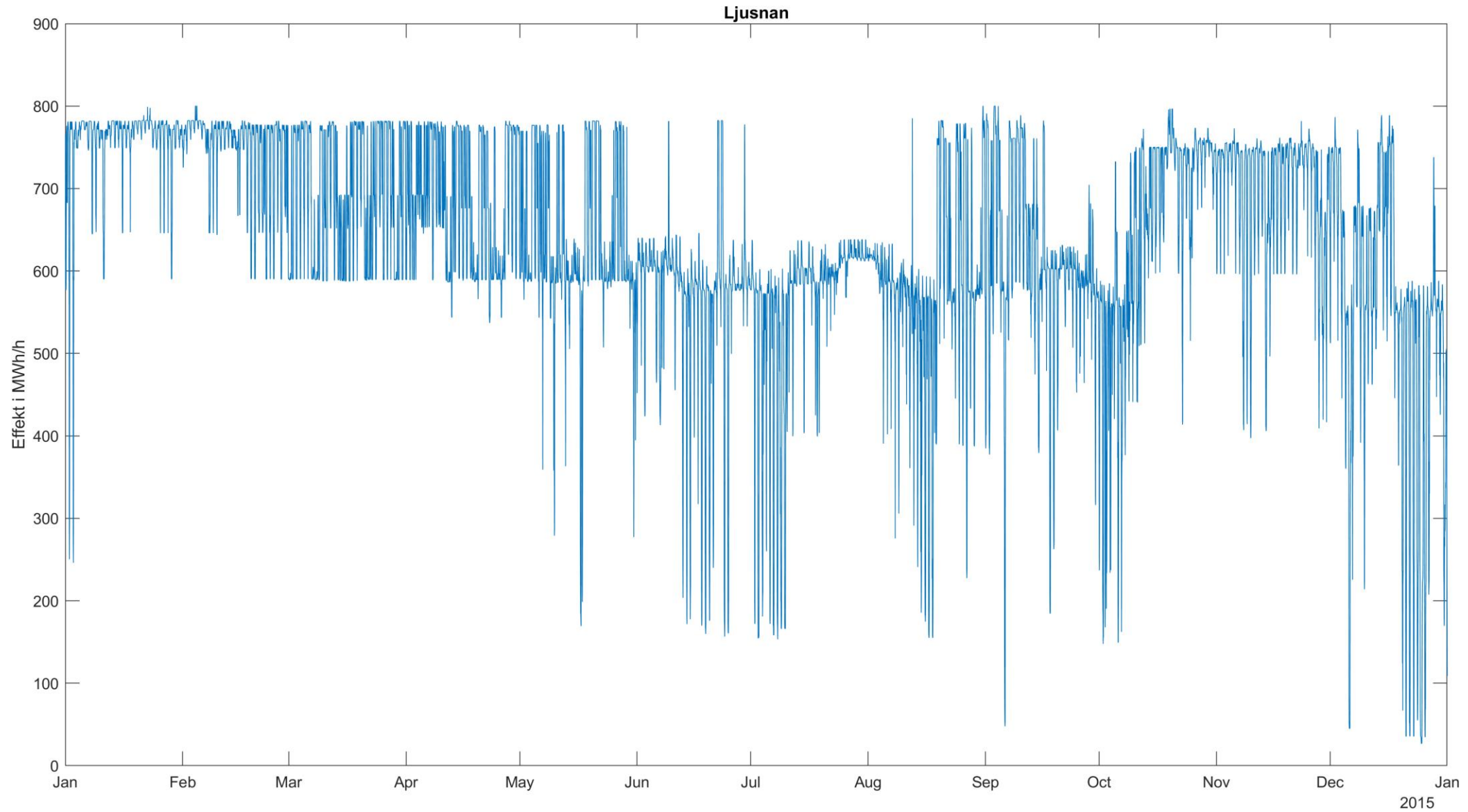


— data1

Elpriser

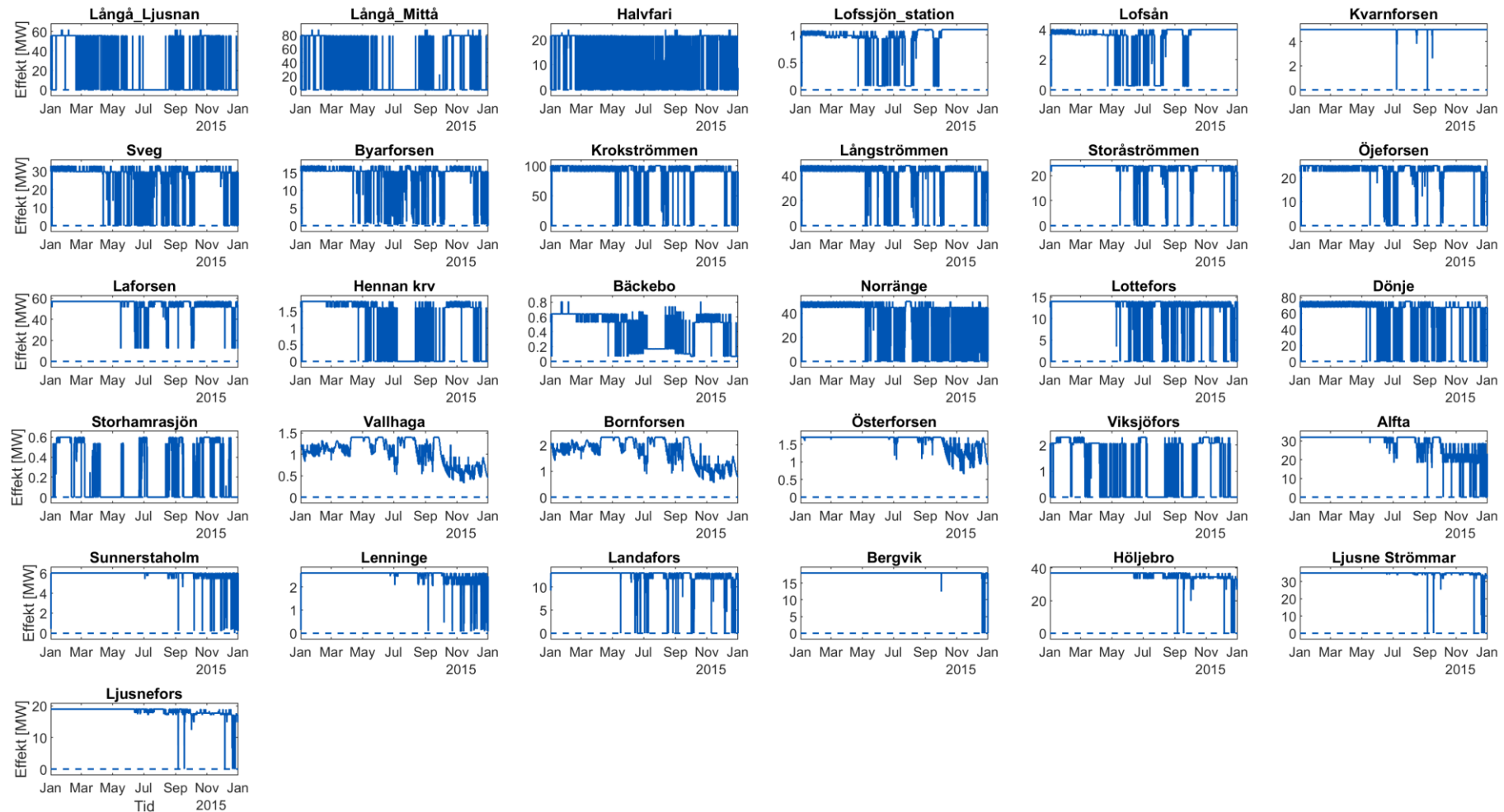


Produktion älvsystem



Produktion

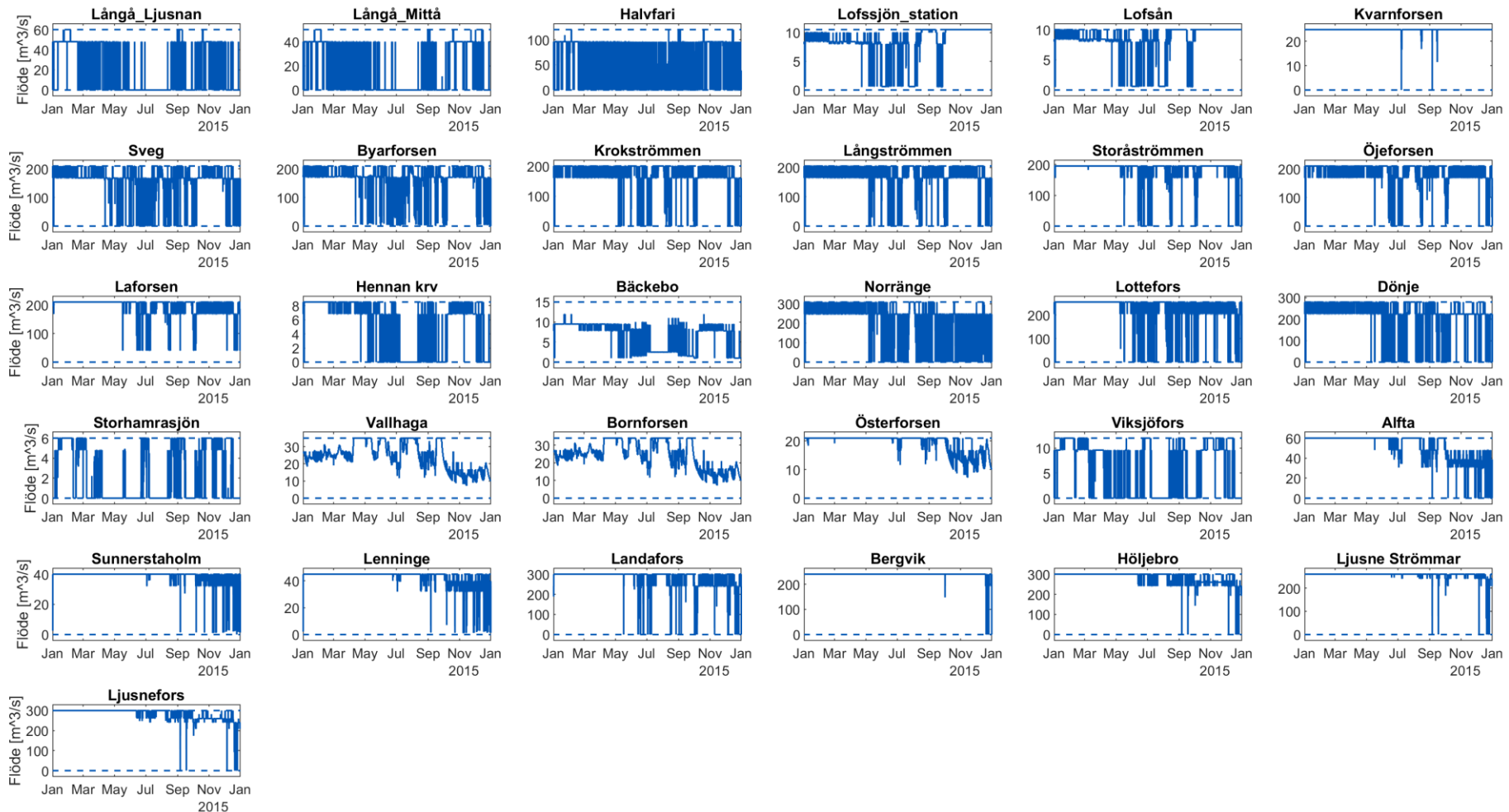
Produktion per station för Ljusnan



— KLIVA

Stationsvattenföring

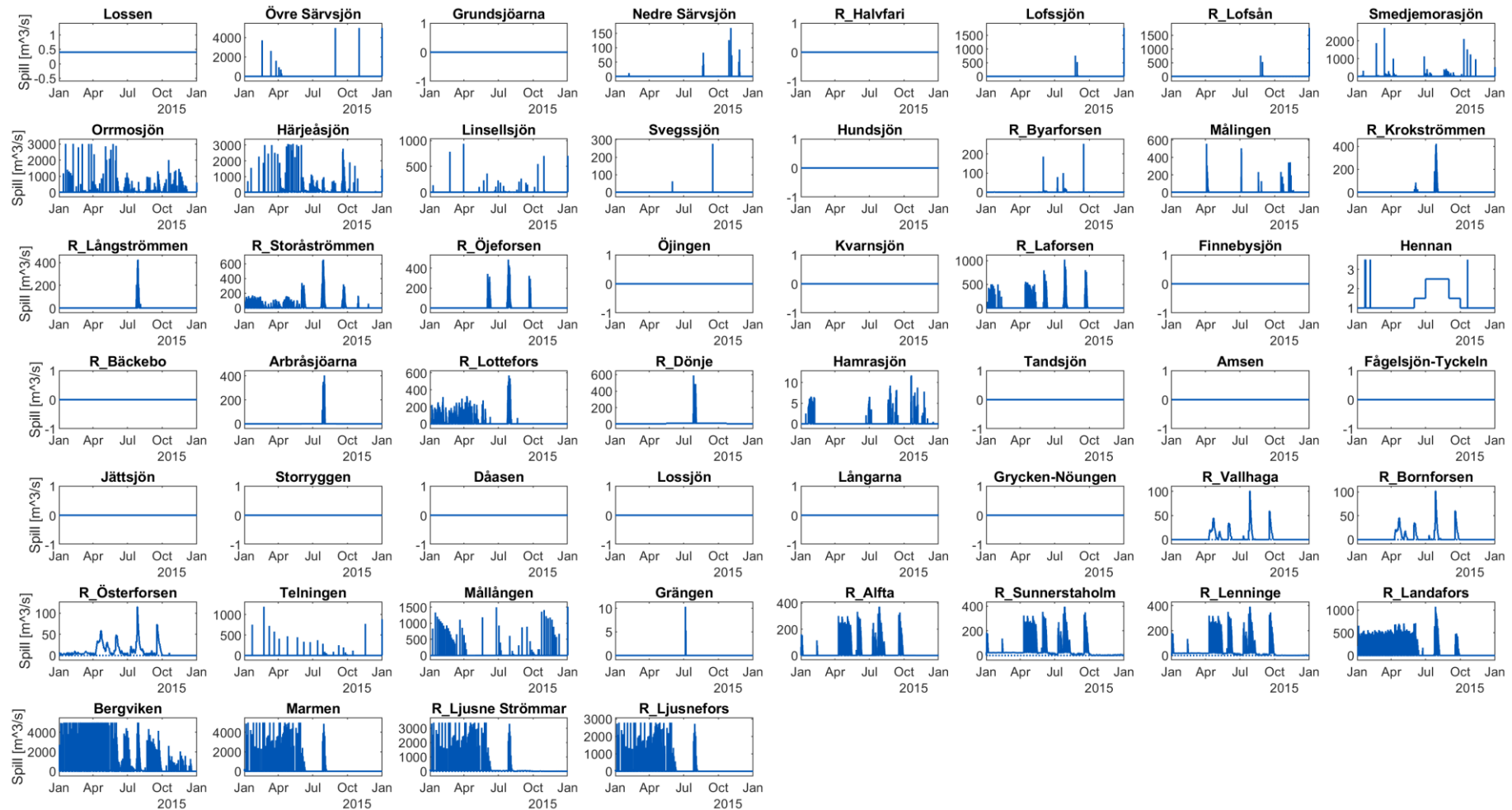
Turbinvattenföring för Ljusnan



— KLIVA

Spill

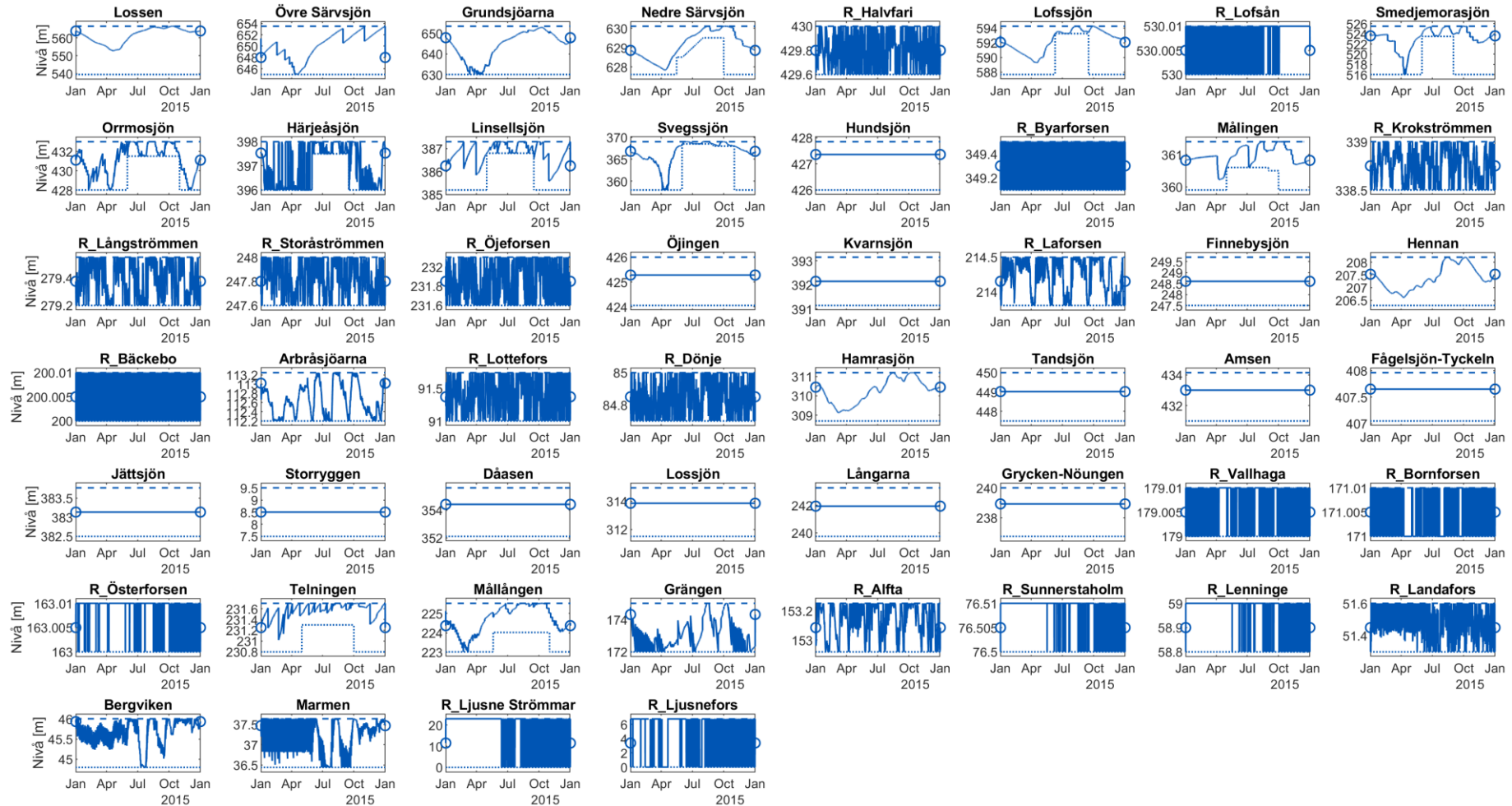
Ljusnan



— KLIVA min

Vattenstånd

Ljusnan

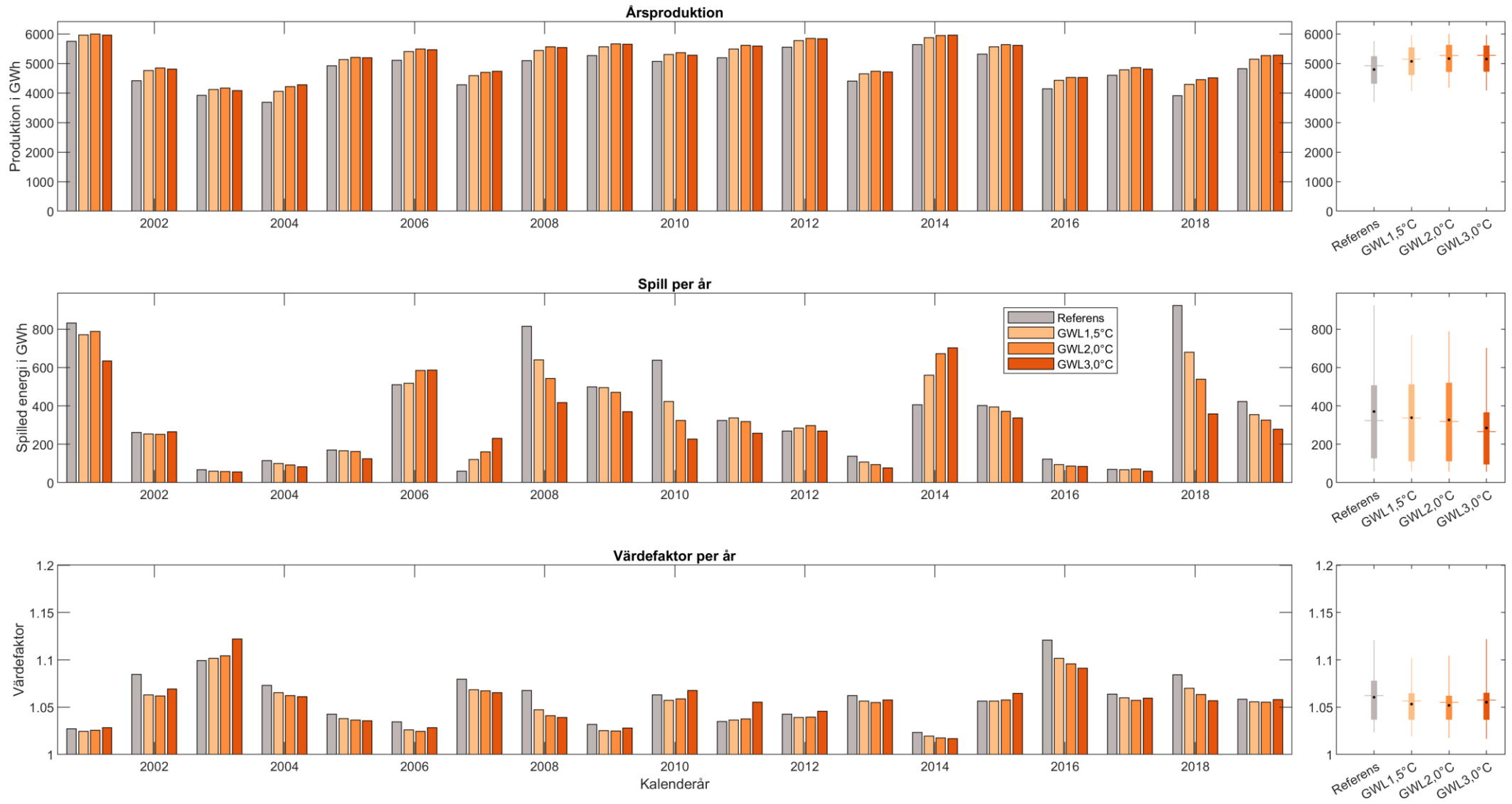


— KLIVA min - - - max ○ Randvillkor

Aggregerade resultat

Årsvärden produktion, spill, värdefaktor

Ljusnan



Statistik produktion, spill, värdefaktor

Produktion i GWh

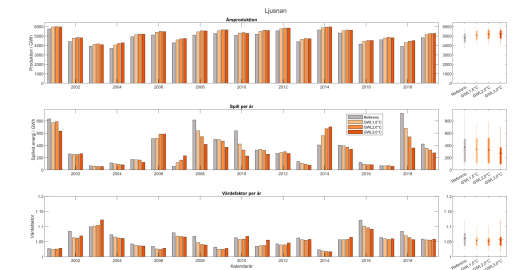
GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	4794	(Ref)	(Ref)	4314	5245	931	3686	5752
GWL1, 5°C	5069	+275	+6 %	4605	5545	940	4062	5957
GWL2, 0°C	5163	+369	+8 %	4711	5628	917	4174	6001
GWL3, 0°C	5149	+355	+7 %	4721	5607	886	4085	5964

Spill i GWh

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	370	(Ref)	(Ref)	126	507	381	59	924
GWL1, 5°C	338	-32	-9 %	111	512	401	60	770
GWL2, 0°C	327	-43	-12 %	111	521	410	58	788
GWL3, 0°C	285	-85	-23 %	95	367	272	56	702

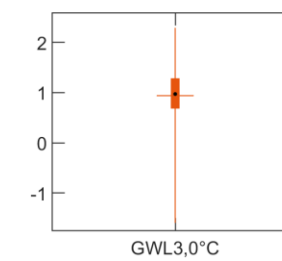
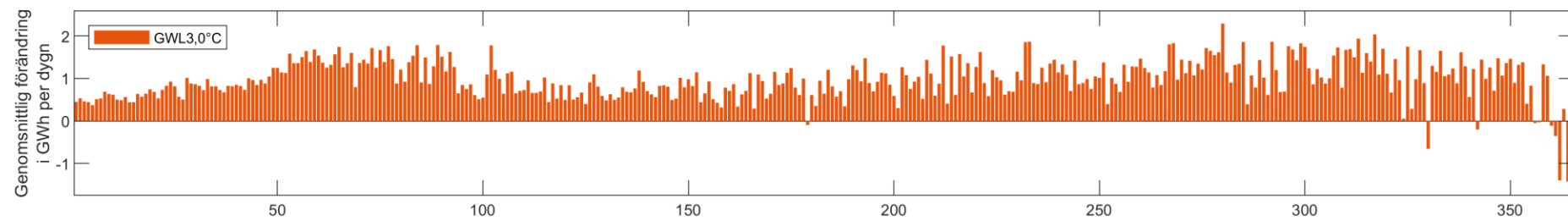
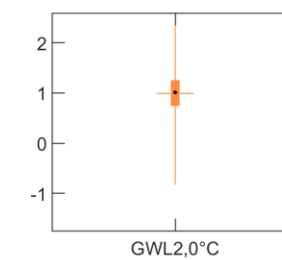
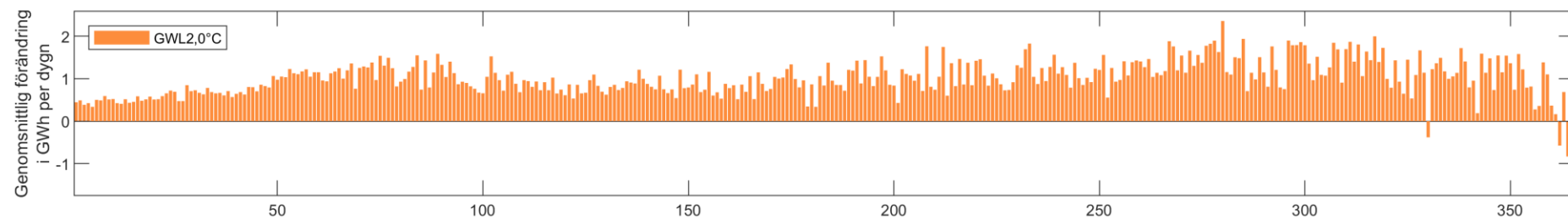
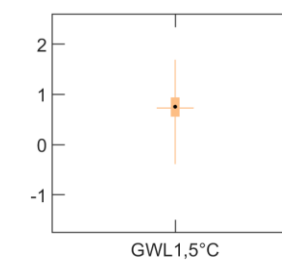
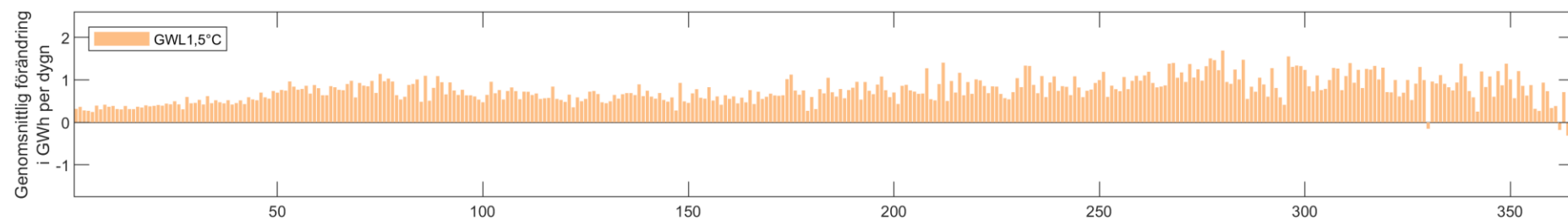
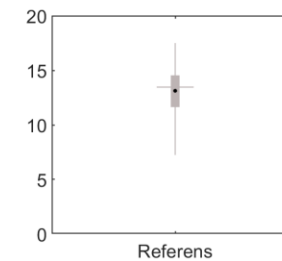
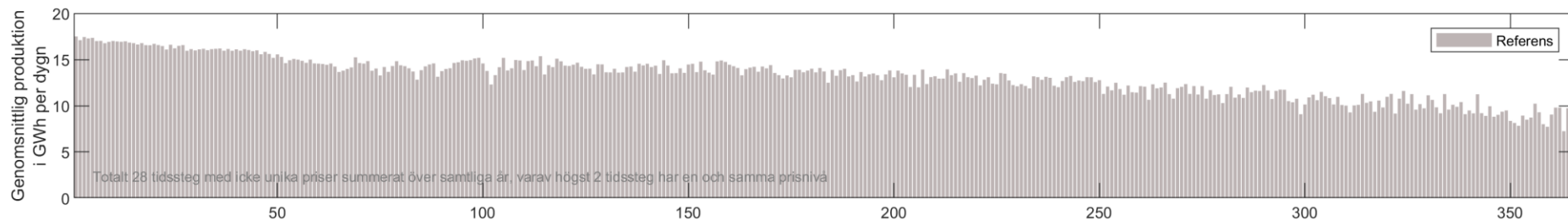
Värdefaktor

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	1.061	(Ref)	(Ref)	1.037	1.078	0.041	1.023	1.121
GWL1, 5°C	1.053	-0.008	-1 %	1.037	1.065	0.028	1.019	1.102
GWL2, 0°C	1.052	-0.009	-1 %	1.037	1.062	0.025	1.018	1.104
GWL3, 0°C	1.055	-0.006	-1 %	1.037	1.065	0.028	1.017	1.122



Förändring i balanseringsförmågan

Flerårs prissorterad produktion Ljusnan (24 h)





Kontakt AP2

richard.scharff@vattenfall.com



KLIVA-rapport bilaga A Luleälven

Richard Scharff, Chalmers, 2023-02-01

Kommentarer

- Bilagan innehåller ett axplock av diagram för att illustrera indata till vattenkraftmodellen samt dess resultat
- Resultaten skiljer sig mellan älvsystem, år och uppvärmningsnivå
- Insikter, slutsatser och detaljer beskrivs i rapporten

→ Rapporten finns på: <https://energiforsk.se/program/klimatforandringarnas-inverkan-pa-vattenkraften/rapporter/klimatforandringarnas-inverkan-pa-vattenkraftens-produktions-och-reglerformaga/>



Energiforsk

KLIVA-projektet har analyserat **klimatförändringarnas påverkan** på vattenkraftens produktions- och balanseringsförmåga

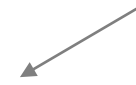
Innehåll diagrammsamling

- Systembeskrivning
 - Älvsystem
 - Energi per Mm³ lokaltillrinning
 - Vattendommar
- Klimatpåverkan lokaltillrinning
 - Klimatfaktorer
 - Total tillrinning



- Optimering
 - Lokaltillrinning
 - Elpriser
 - Älvens elproduktion
 - Produktion per station
 - Stationsvattenföring
 - Spill per magasin
 - Vattenytor per magasin
- Aggregerade resultat
 - Produktionsförmåga
 - Balanseringsförmåga

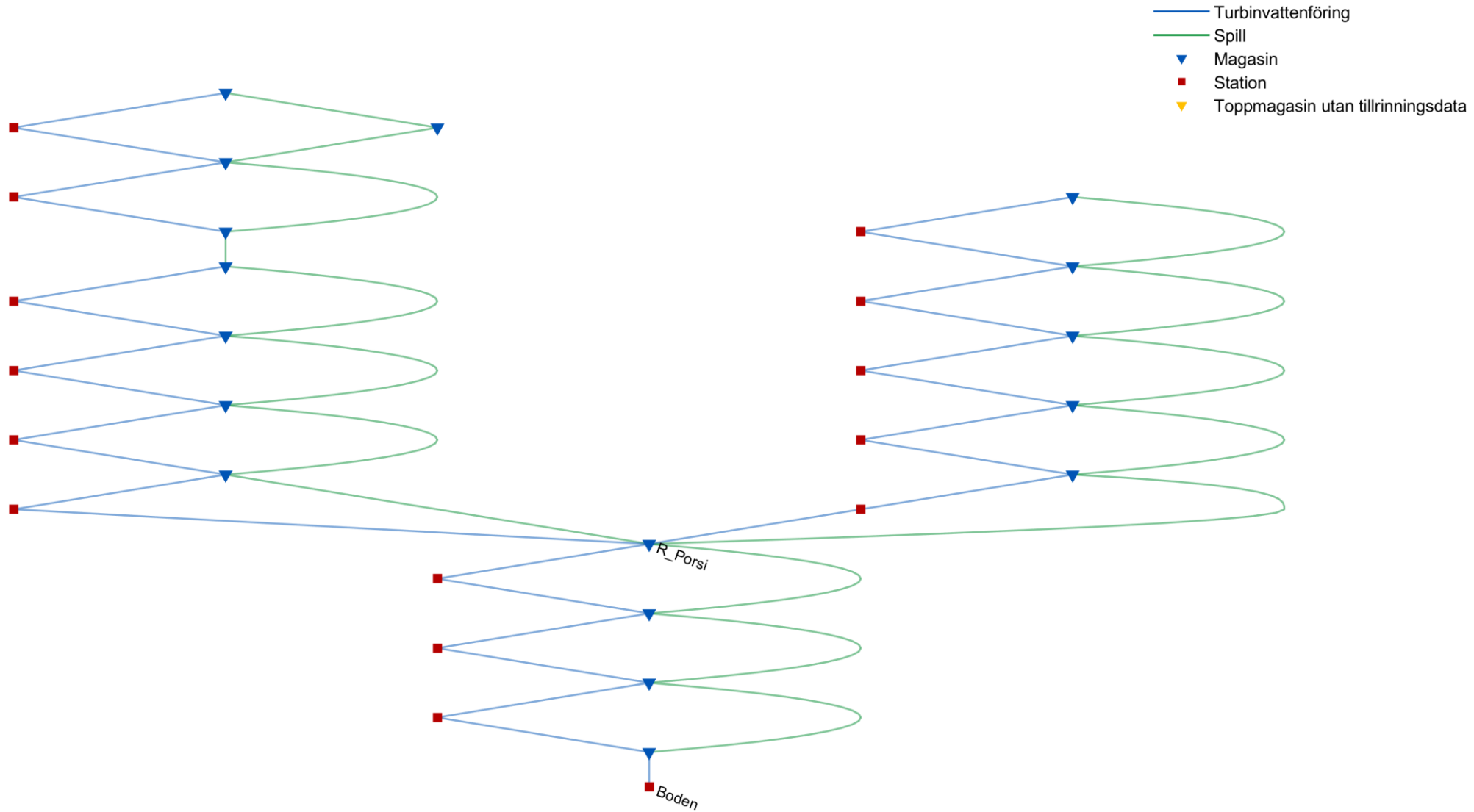
Optimeringen görs för **19 år**, alltid ett kalenderår i taget. I den här bilagan presenteras indata och resultat för **ett utvalt år** med uppvärmningsnivån **GWL2,0°C**.



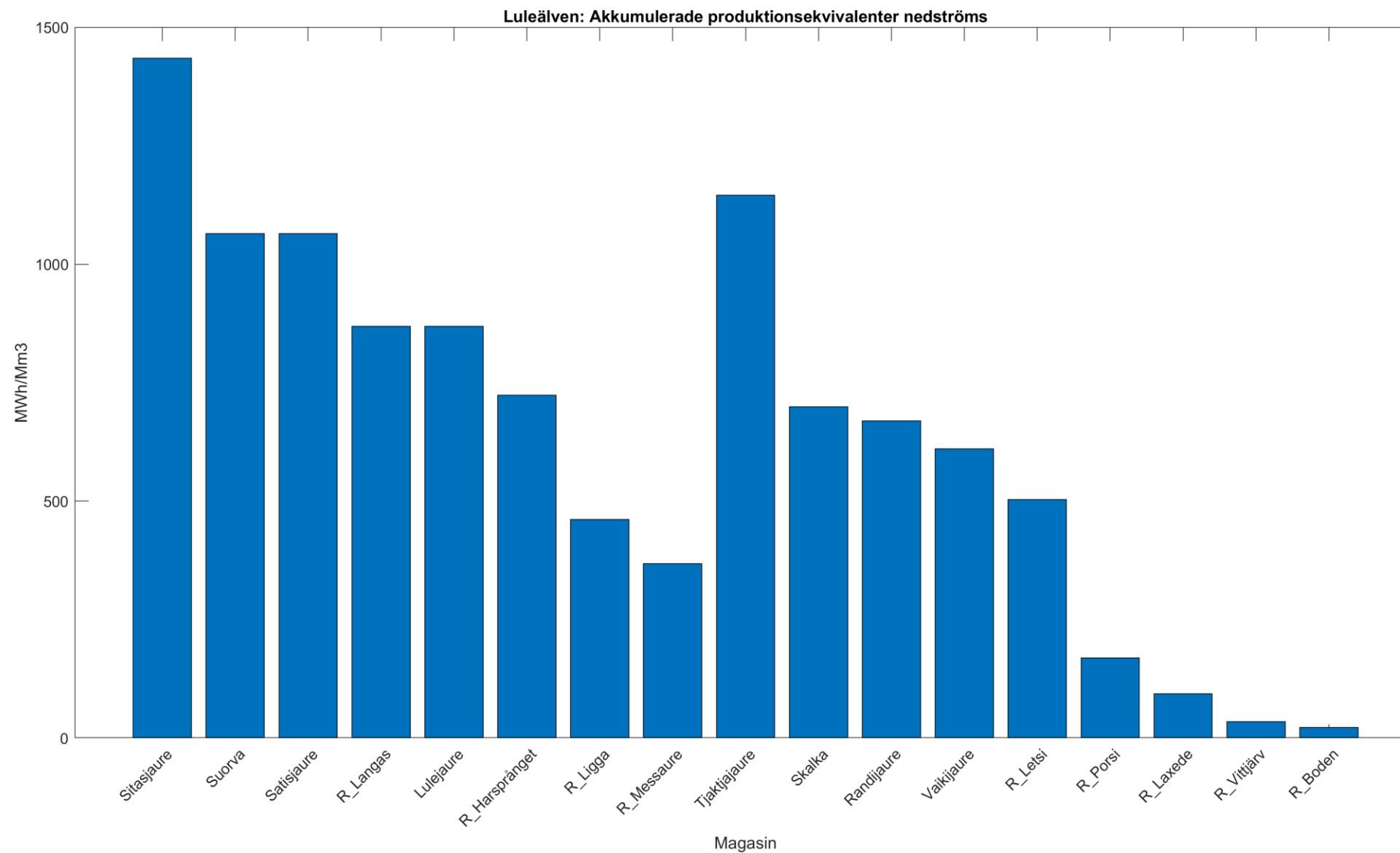
Systembeskrivning

Älvsystem

Luleälven

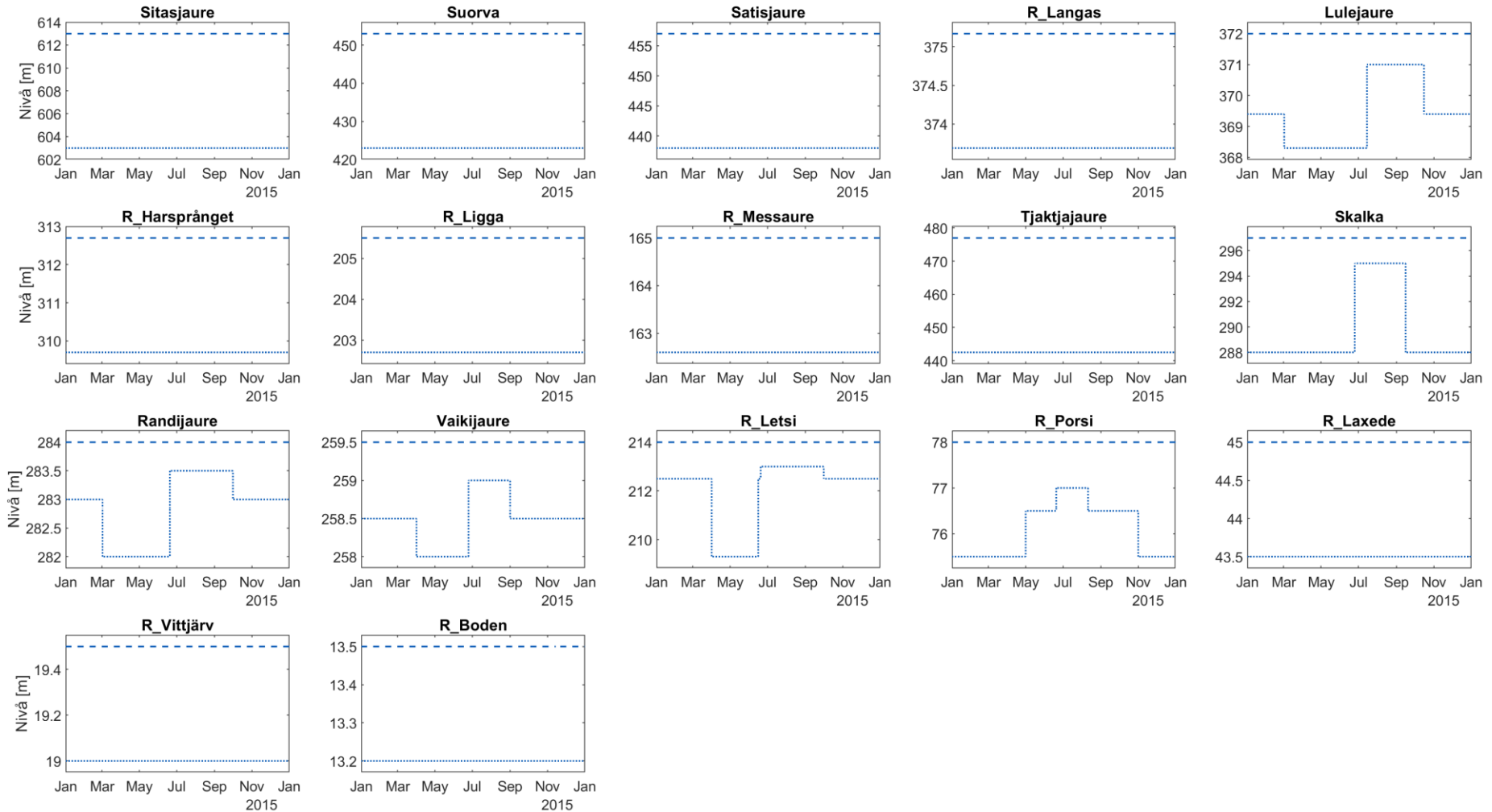


Energi per Mm³ lokaltillrinning



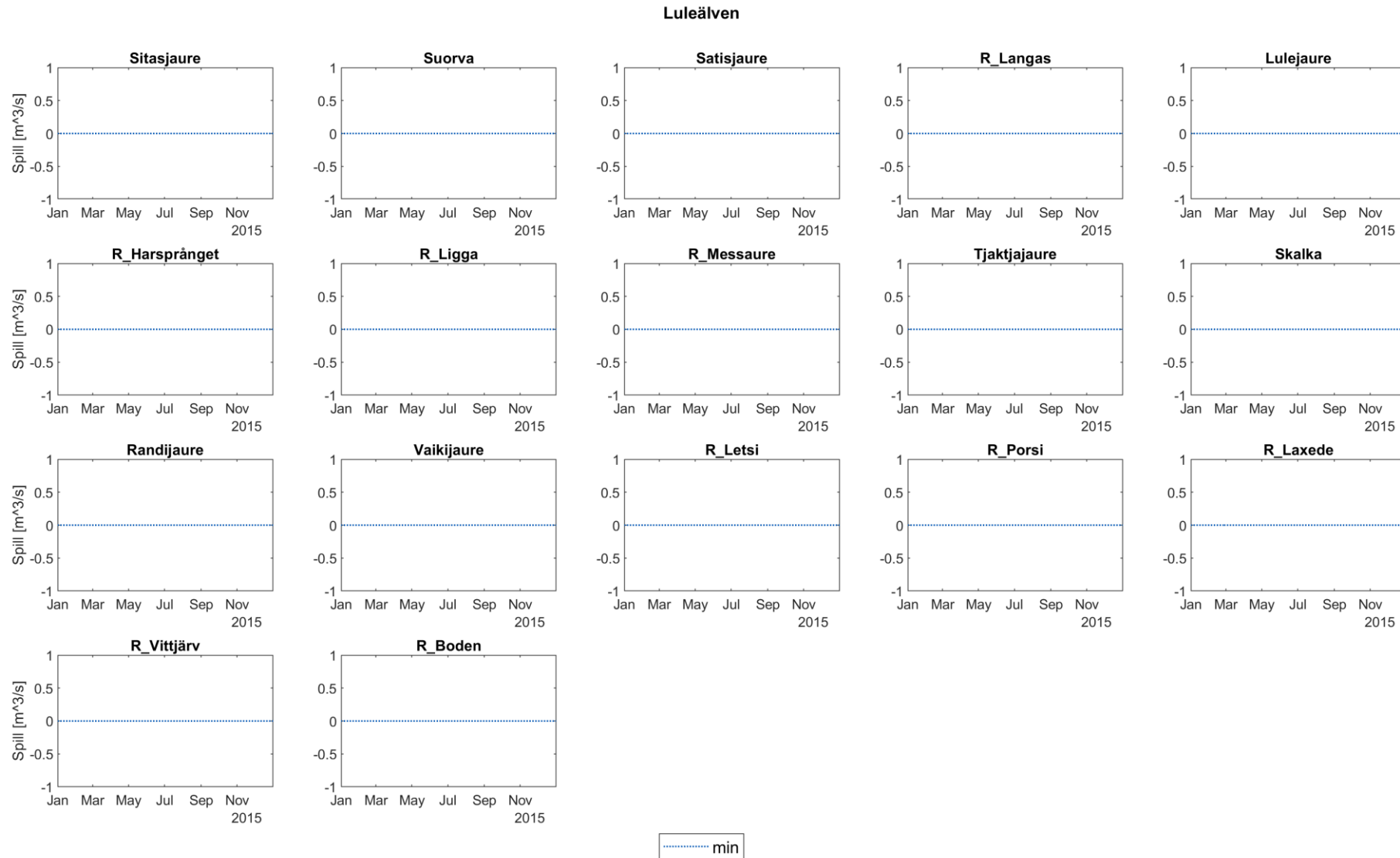
Vattendomar "WaterLevel"

Luleälven



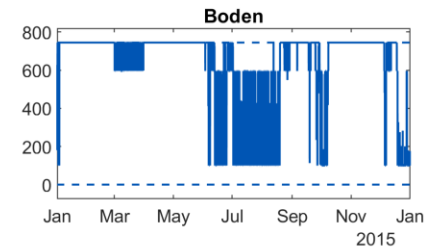
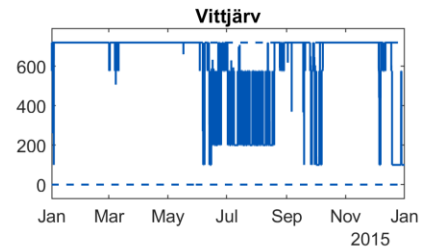
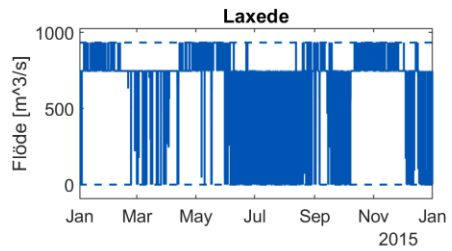
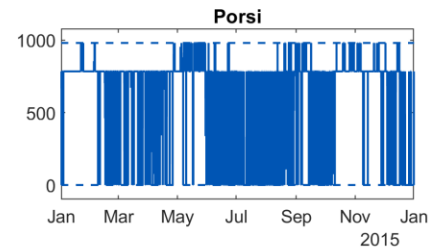
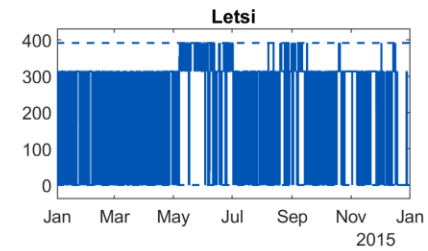
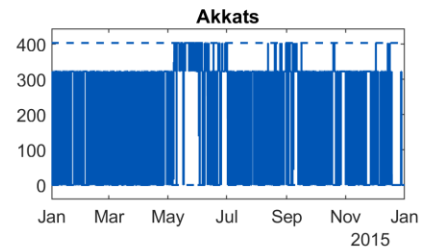
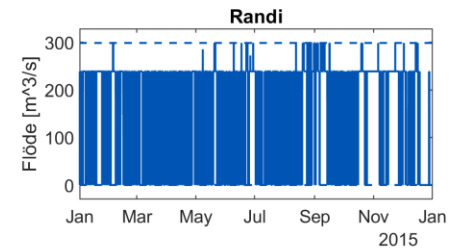
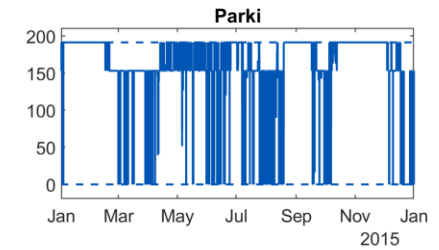
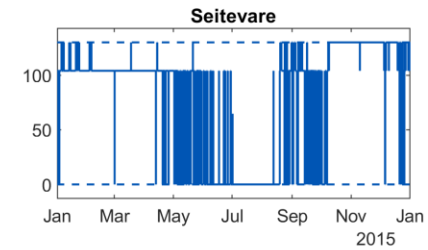
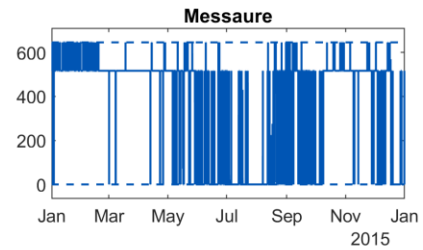
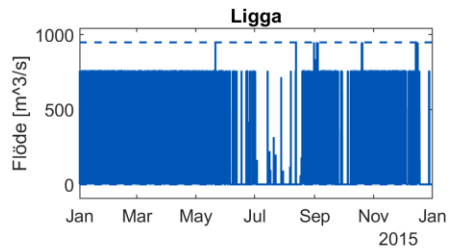
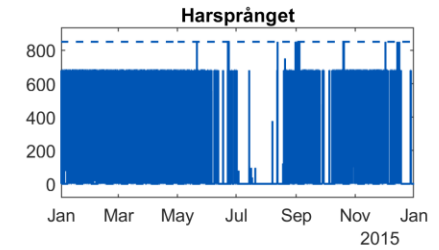
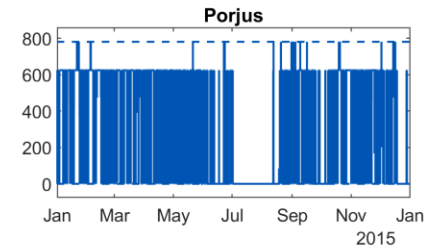
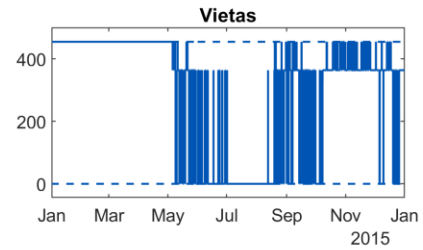
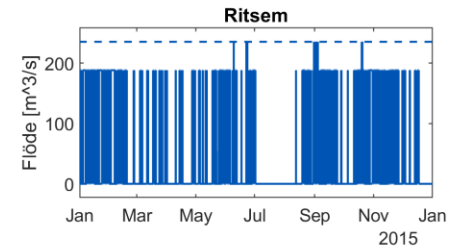
..... min - - - max

Vattendomar "MinSpill"



Vattendomar "MinFlow"

Turbinvattenföring för Luleälven

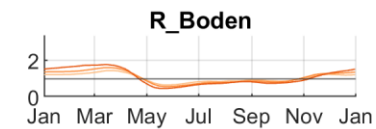
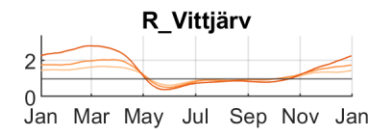
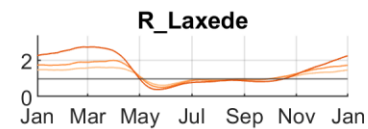
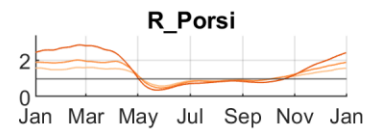
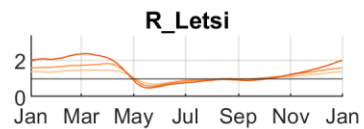
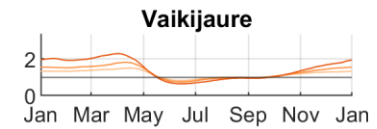
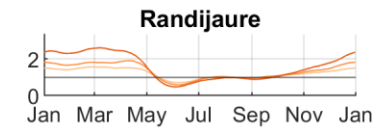
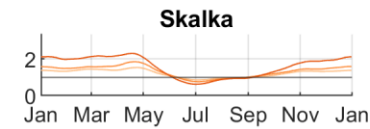
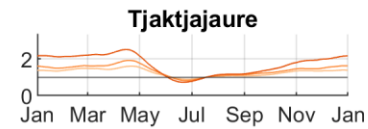
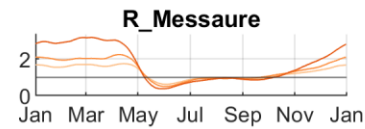
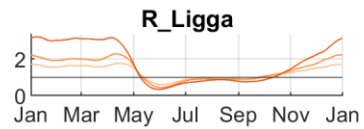
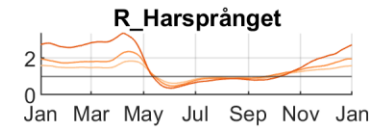
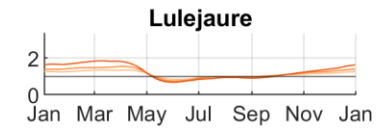
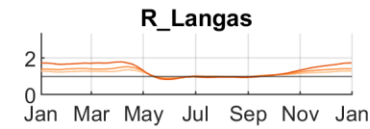
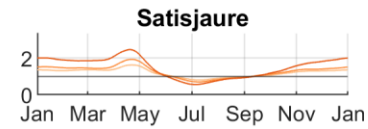
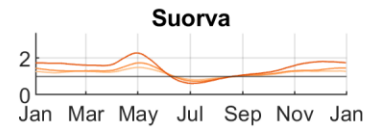
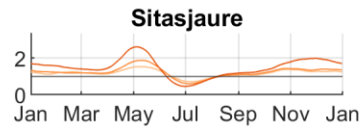


— KLIVA

Klimatpåverkan på lokaltillrinningar

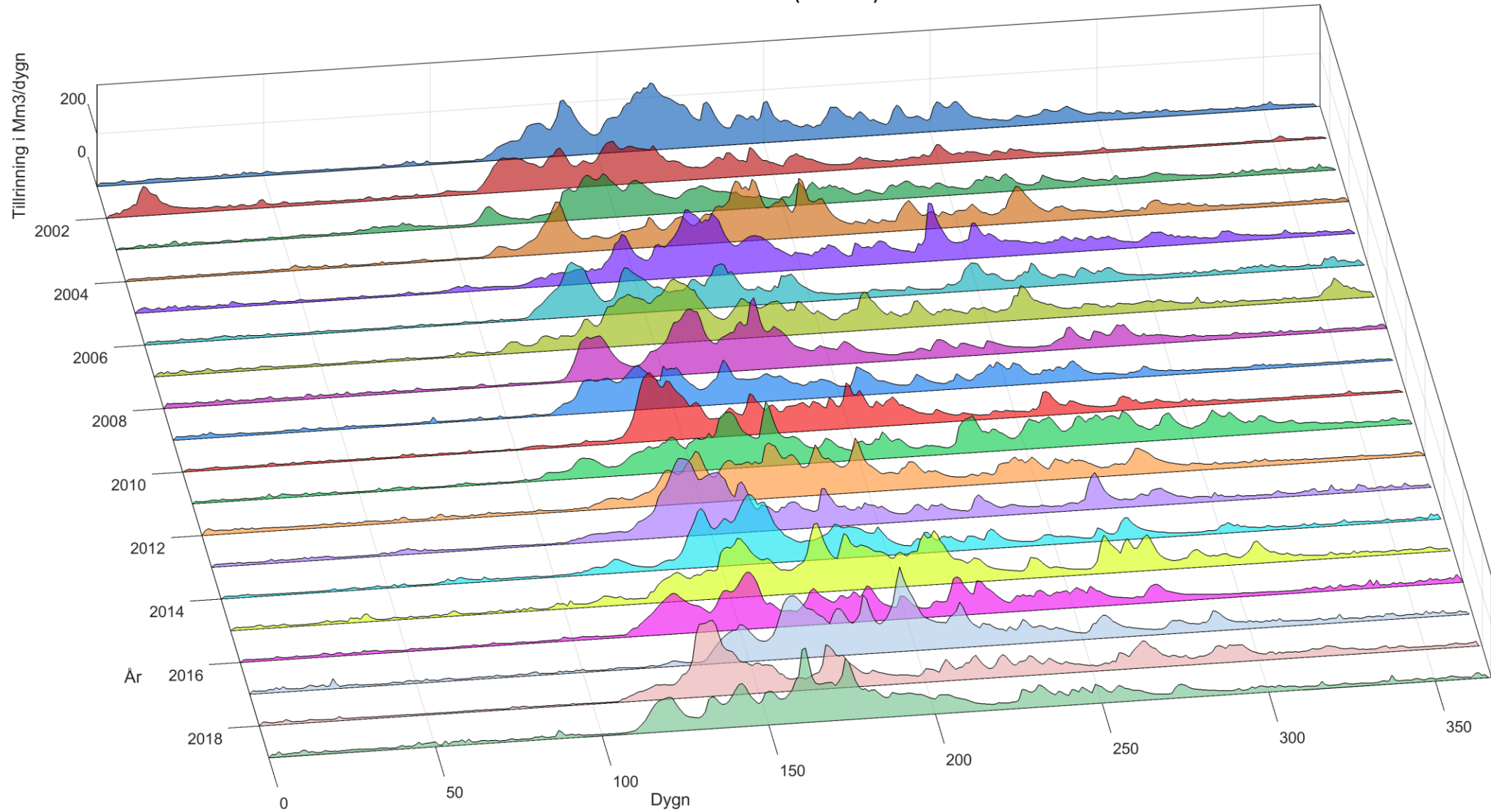
Klimatfaktorer

Klimatfaktorer Luleälven



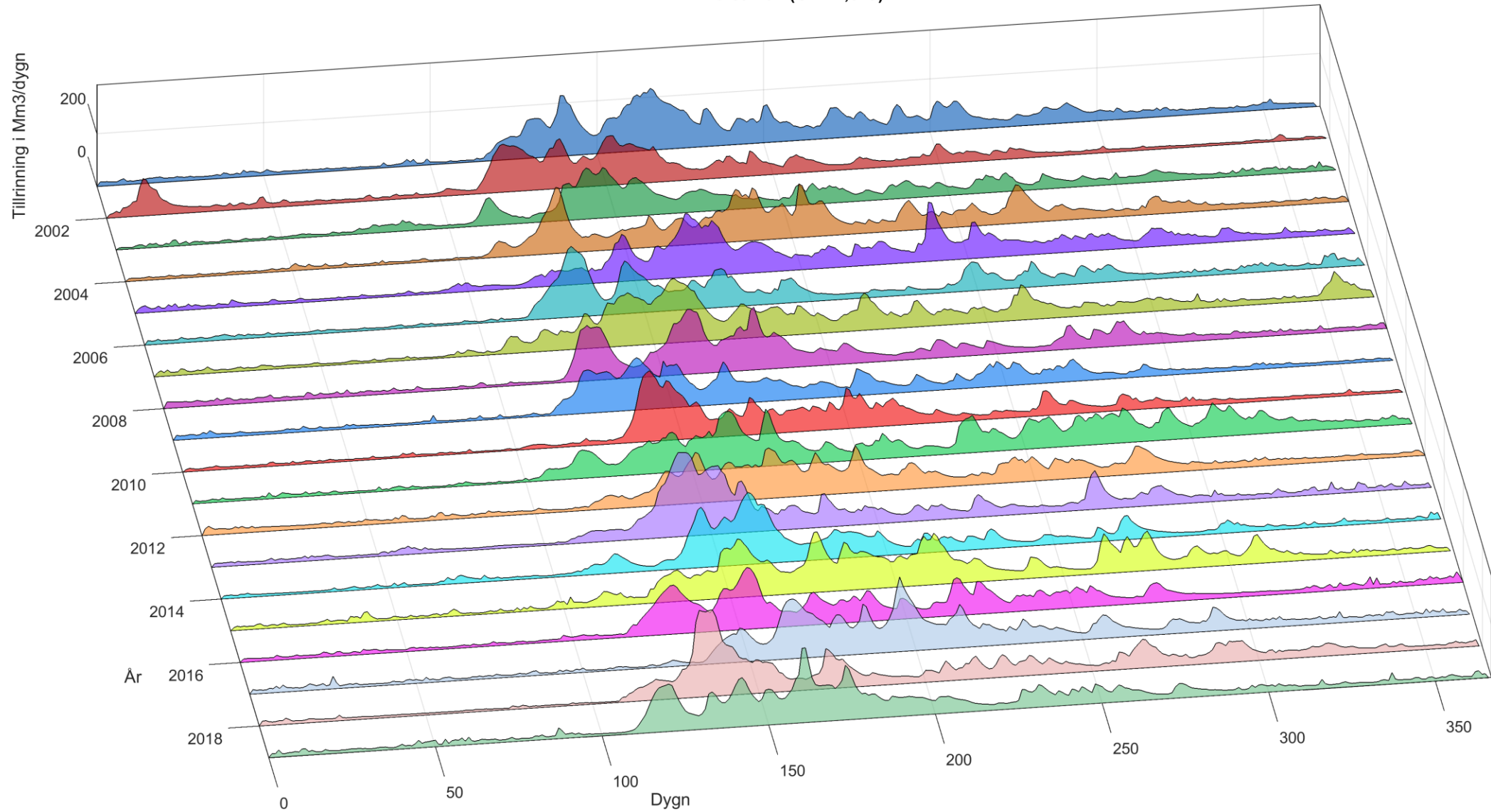
Total tillrinning (Referens)

Luleälven (Referens)



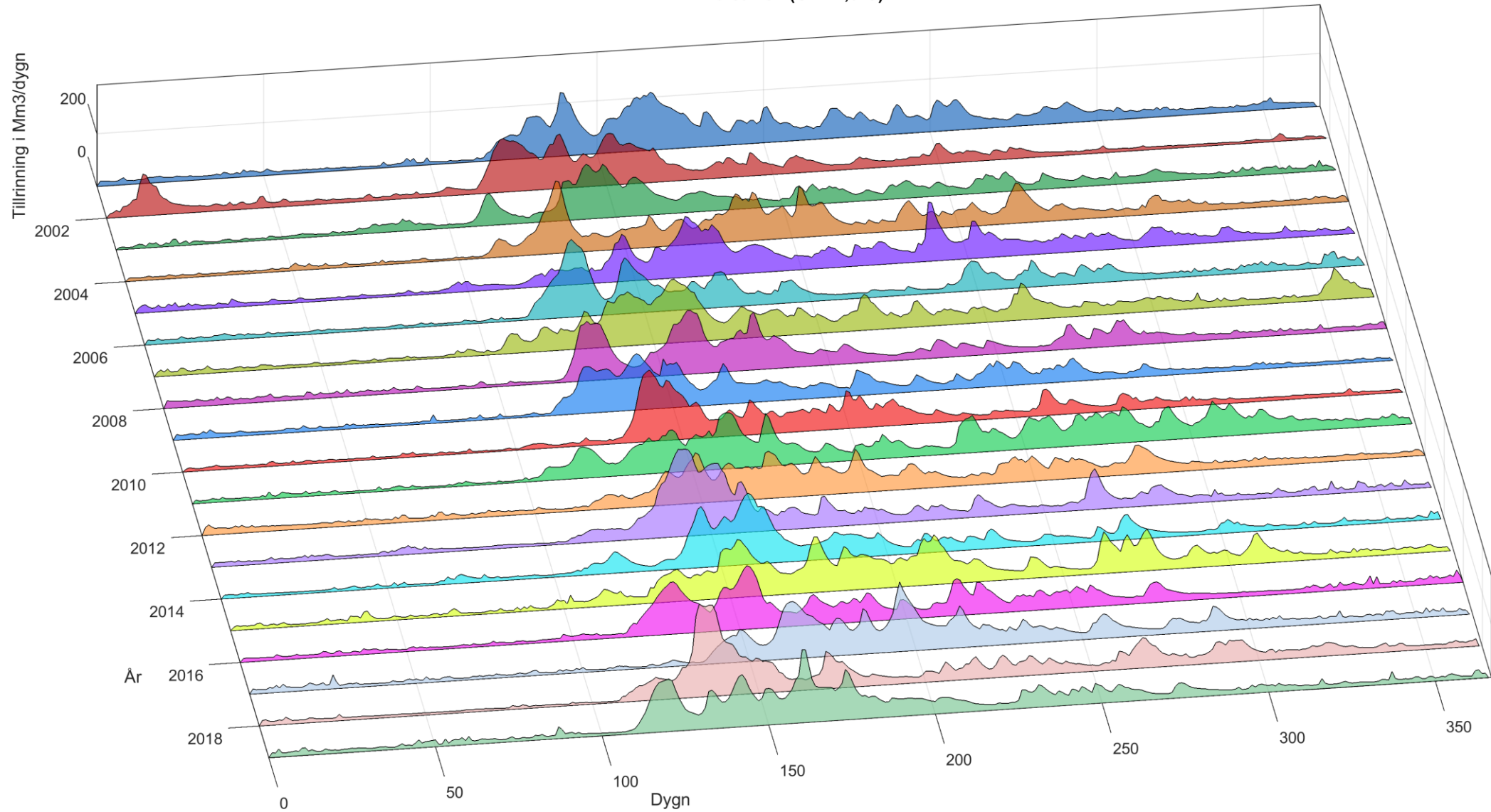
Total tillrinning (GWL1,5°C)

Luleälven (GWL1,5°C)



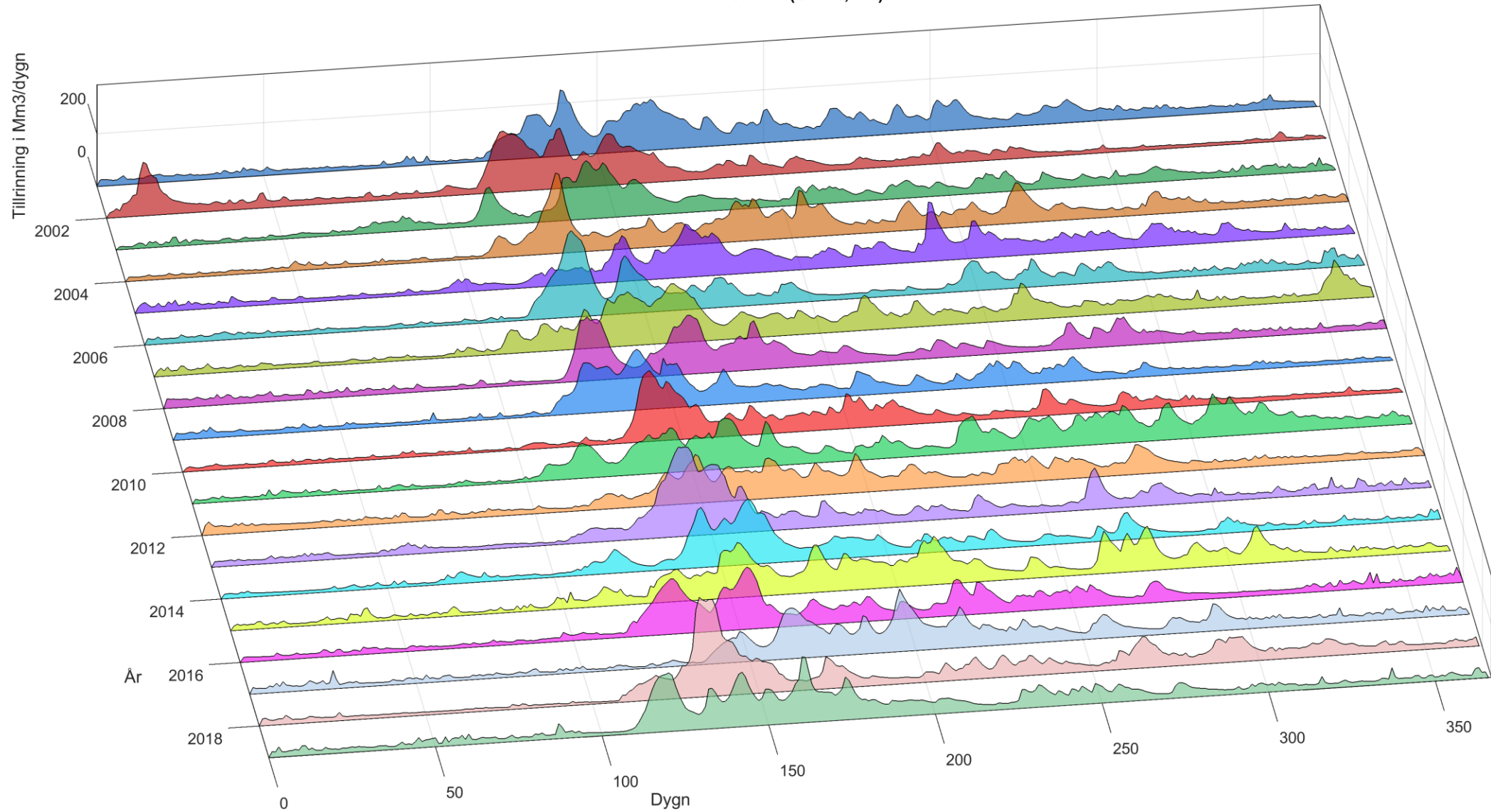
Total tillrinning (GWL2,0°C)

Luleälven (GWL2,0°C)



Total tillrinning (GWL3,0°C)

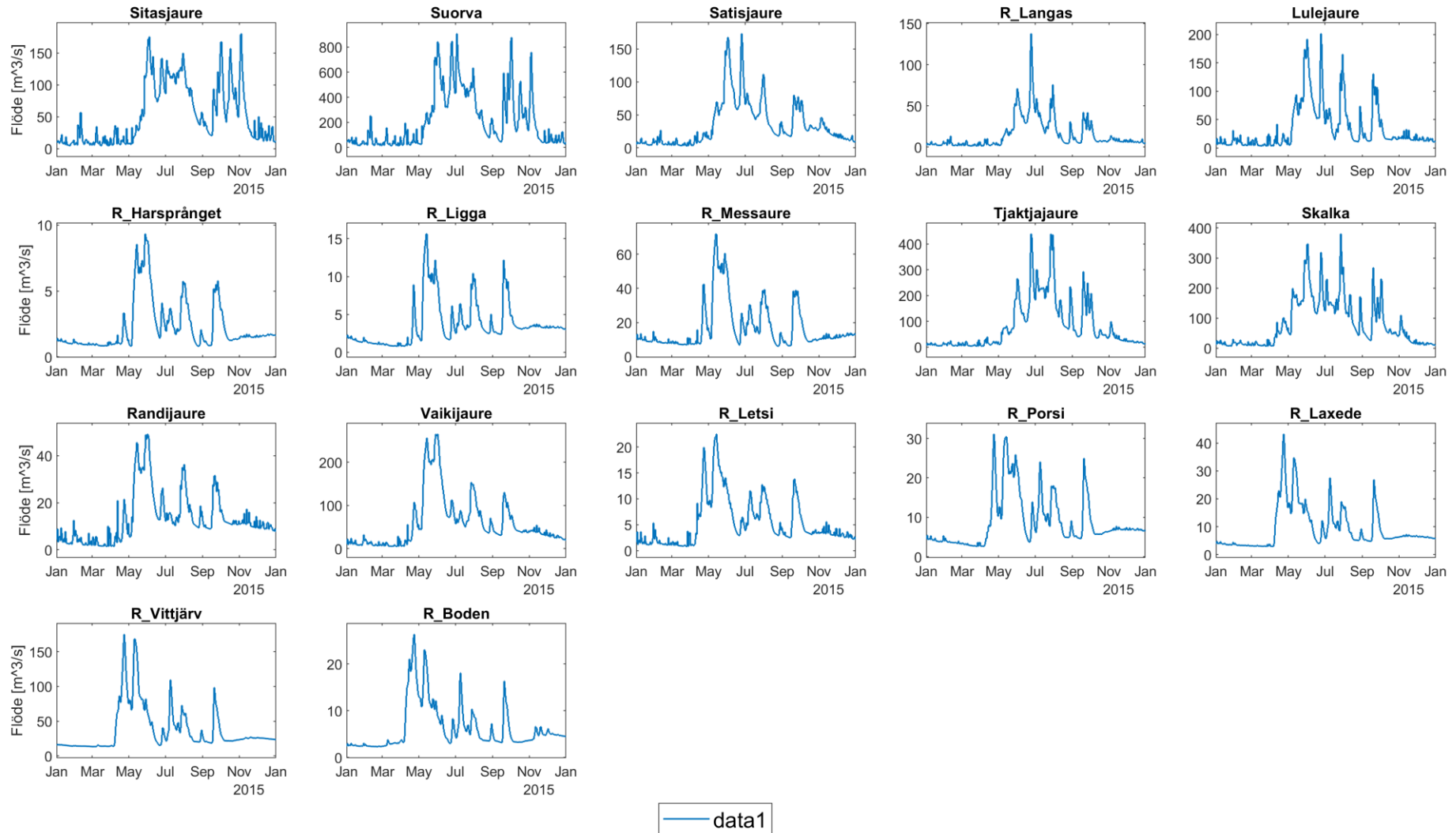
Luleälven (GWL3,0°C)



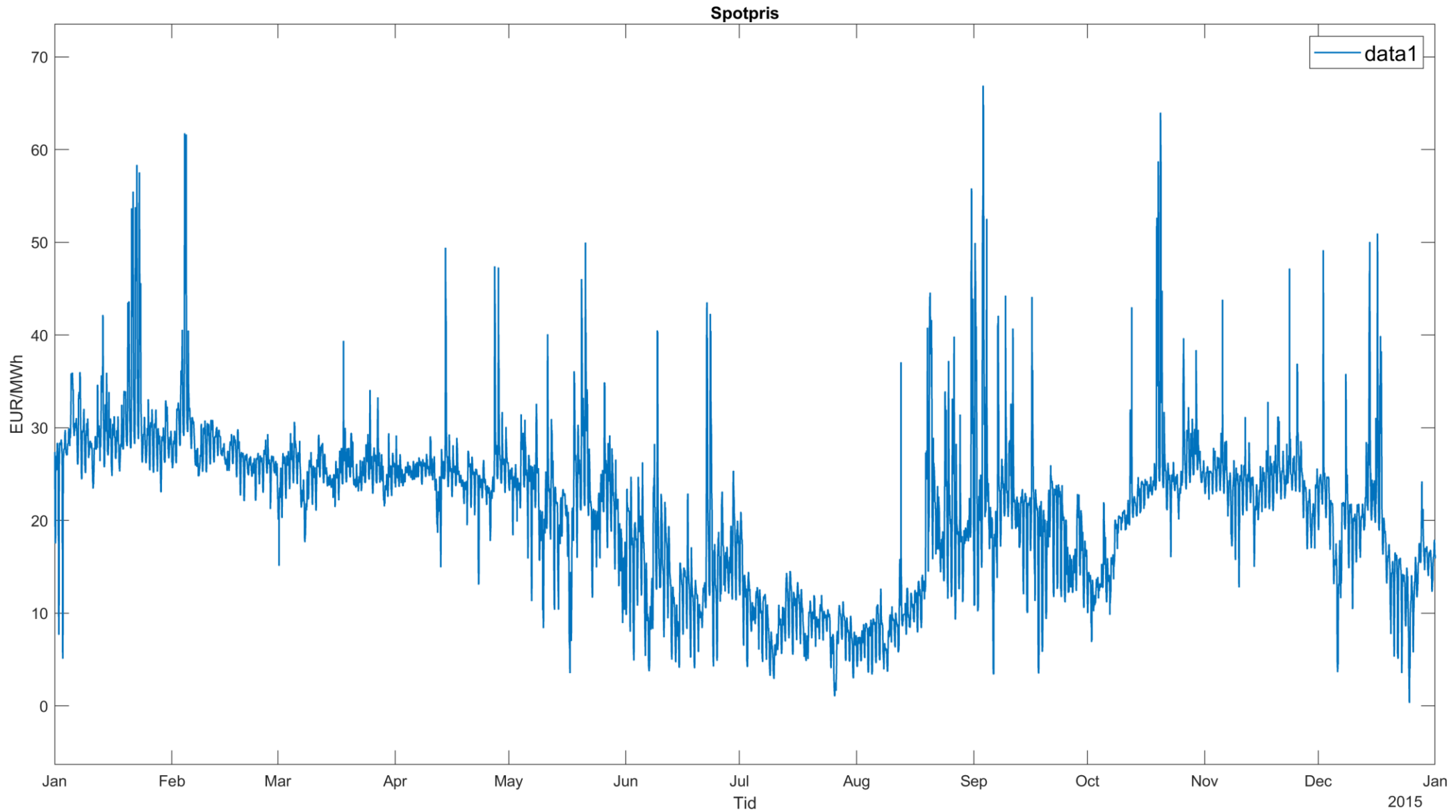
Resultat (exempel GWL2,0°C för 2015)

Lokaltillrinning

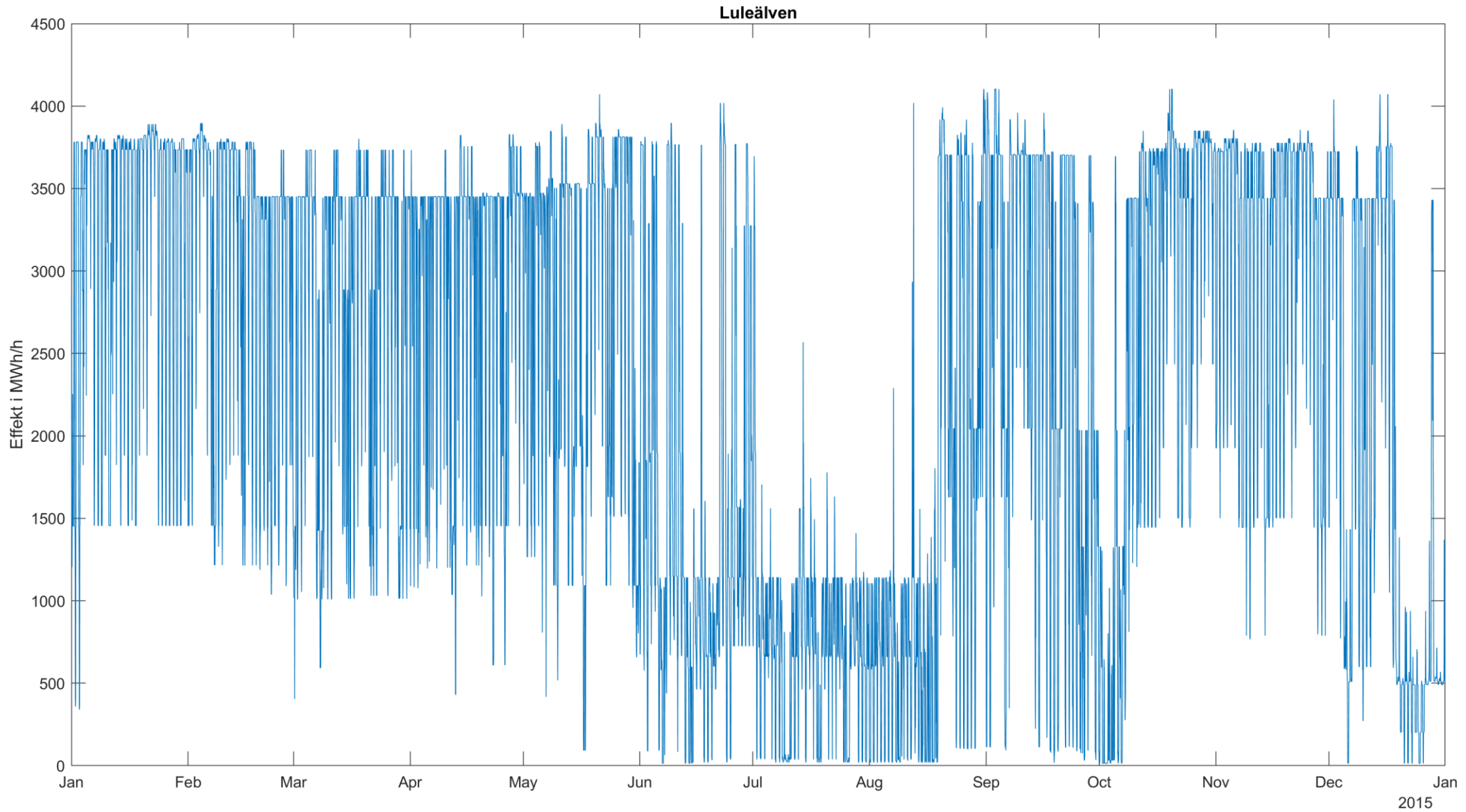
Lokal tillrinning för Luleälven



Elpriser

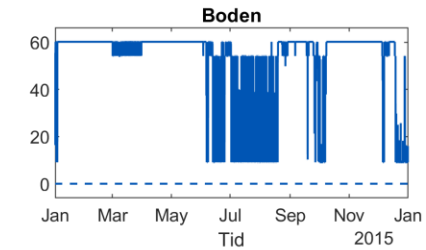
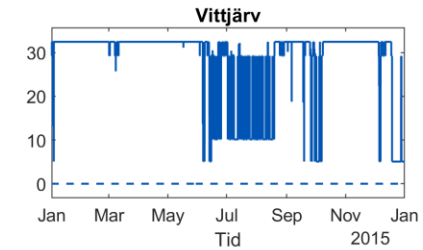
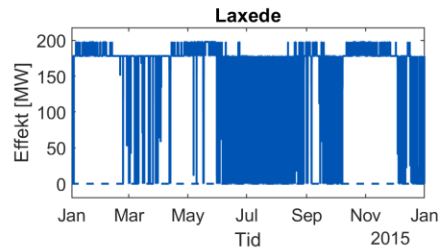
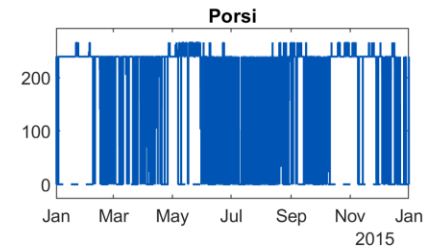
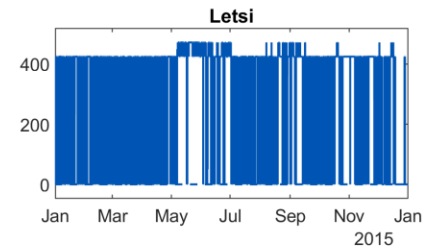
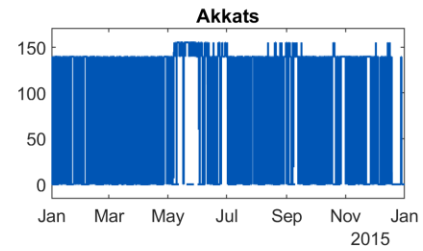
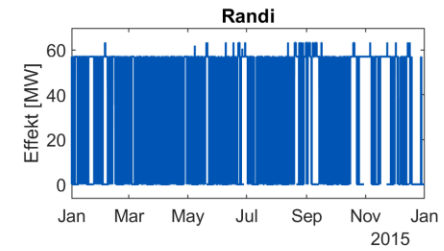
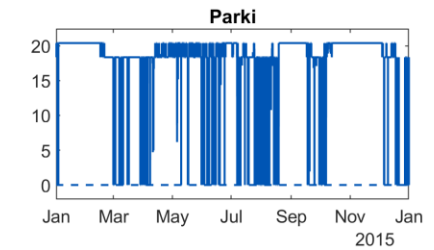
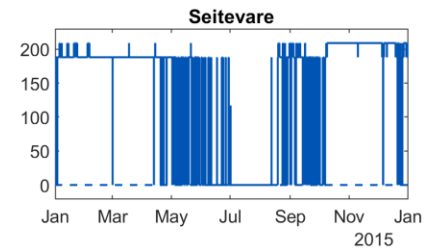
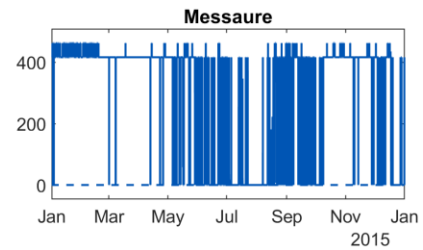
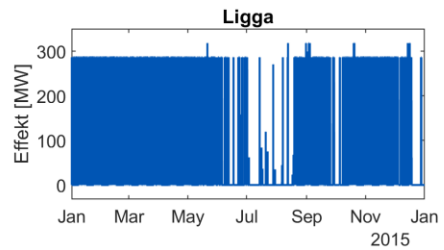
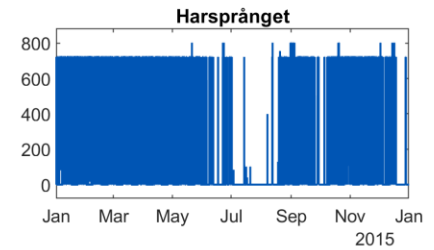
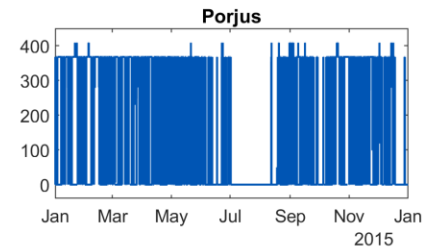
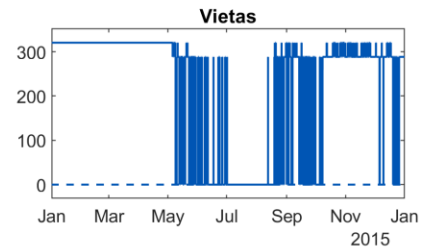
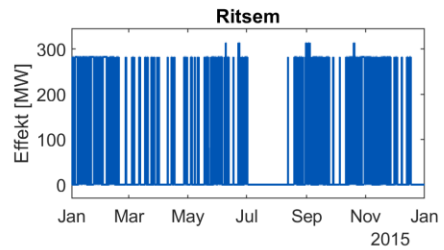


Produktion älvsystem



Produktion

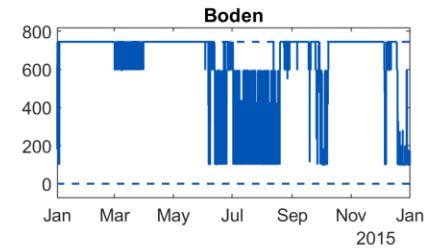
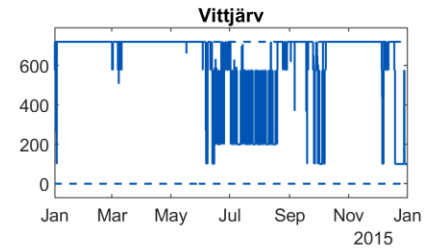
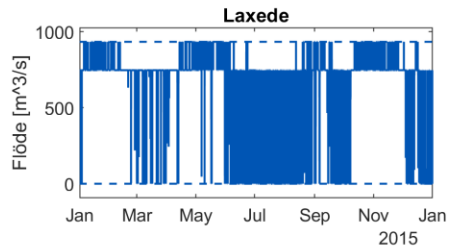
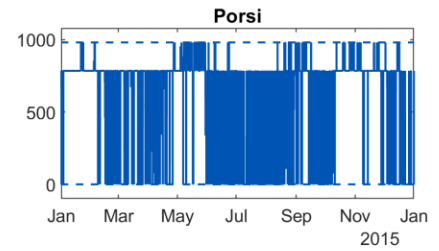
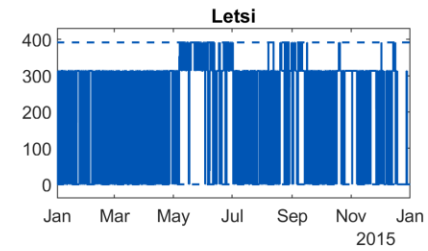
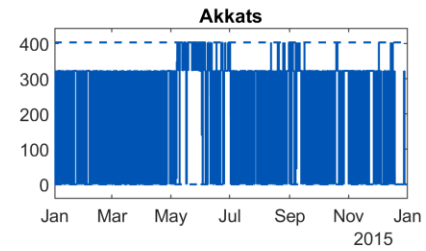
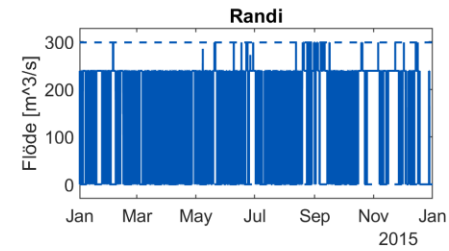
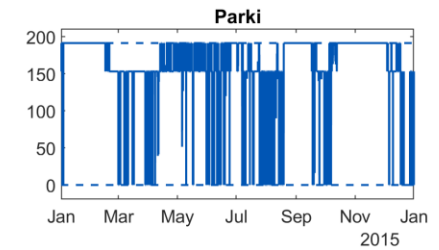
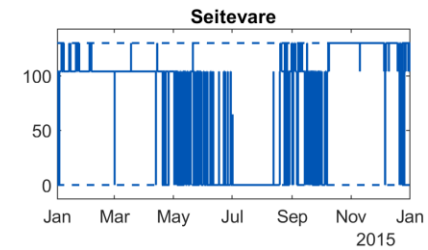
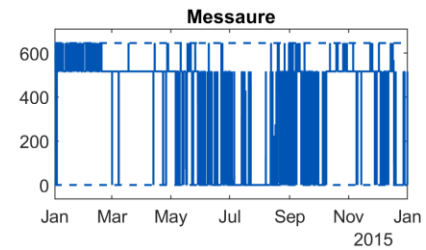
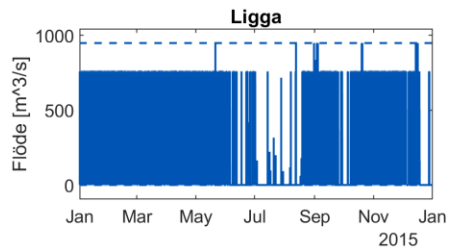
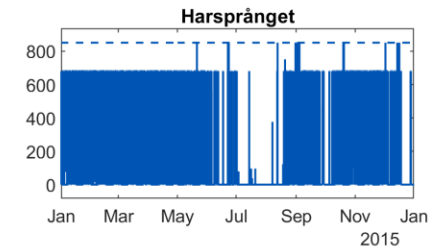
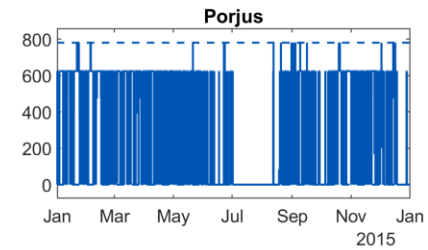
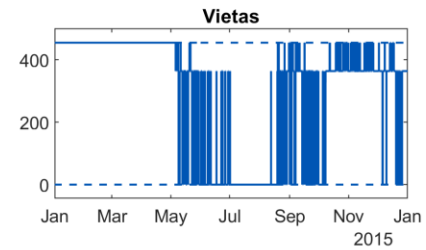
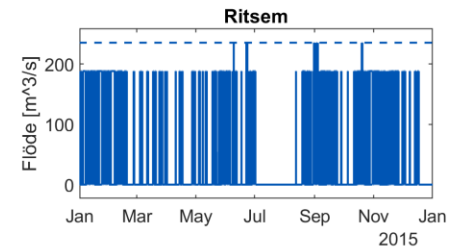
Produktion per station för Luleälven



— KLIVA

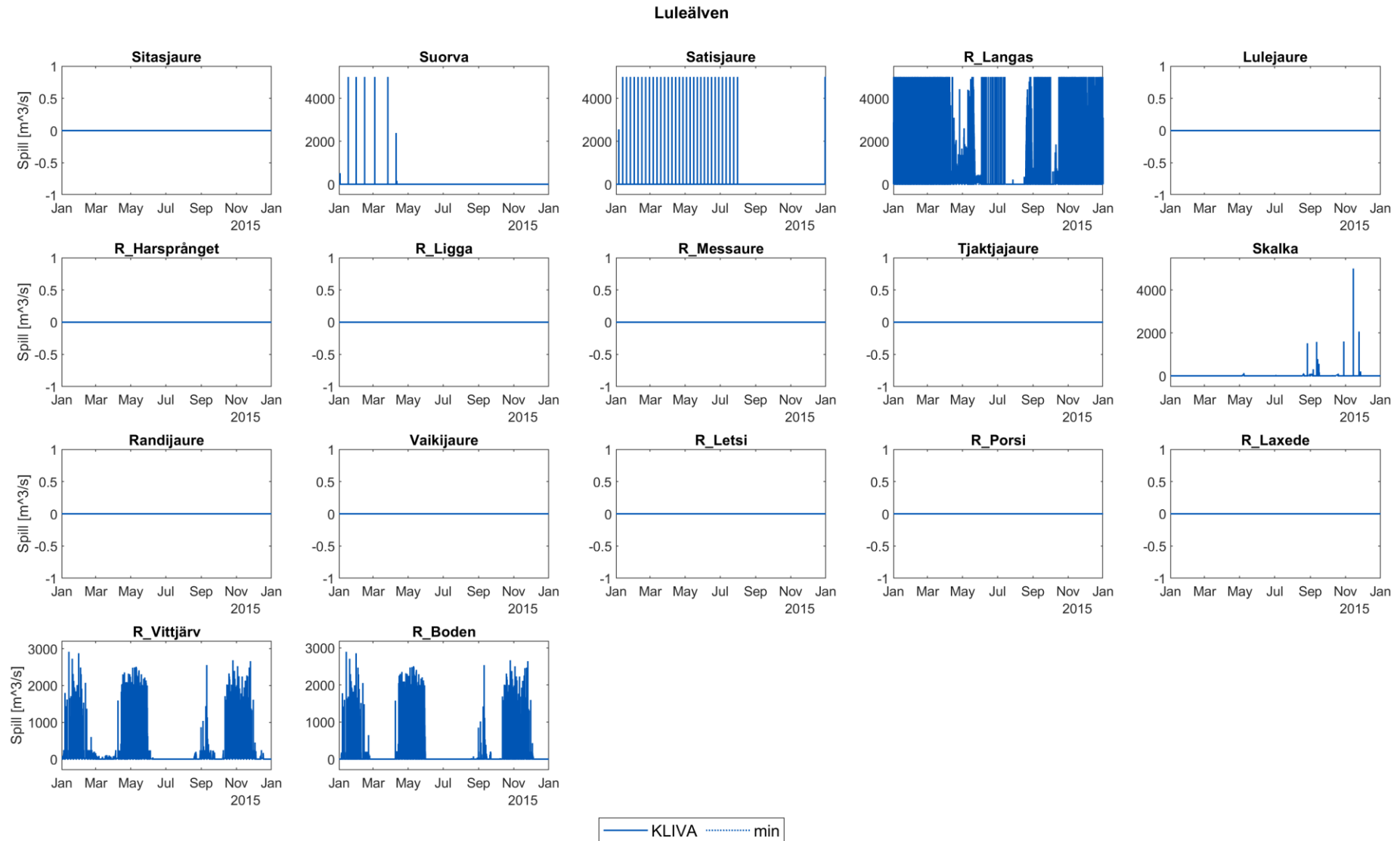
Stationsvattenföring

Turbinvattenföring för Luleälven

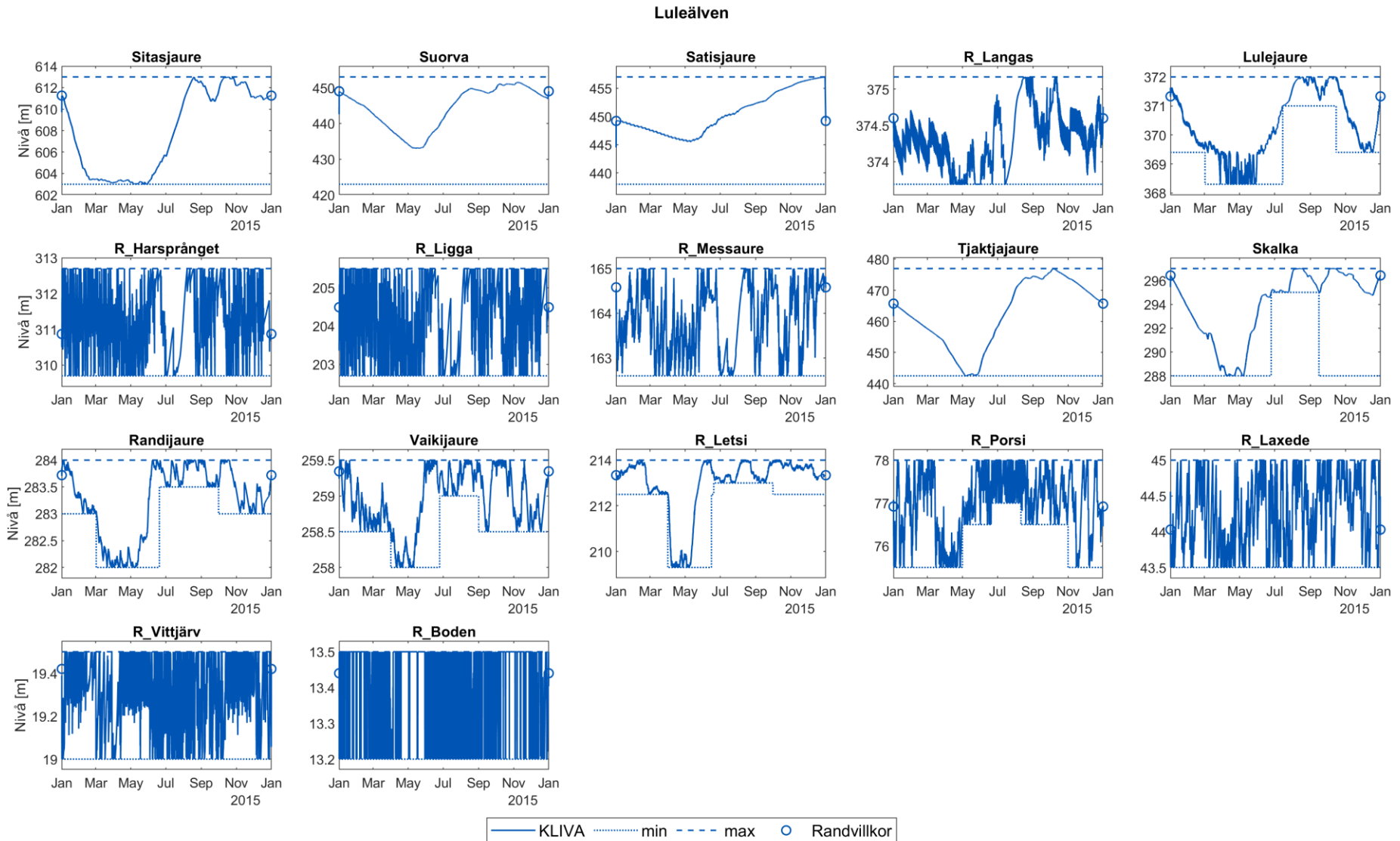


— KLIVA

Spill



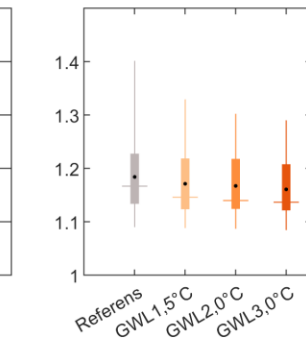
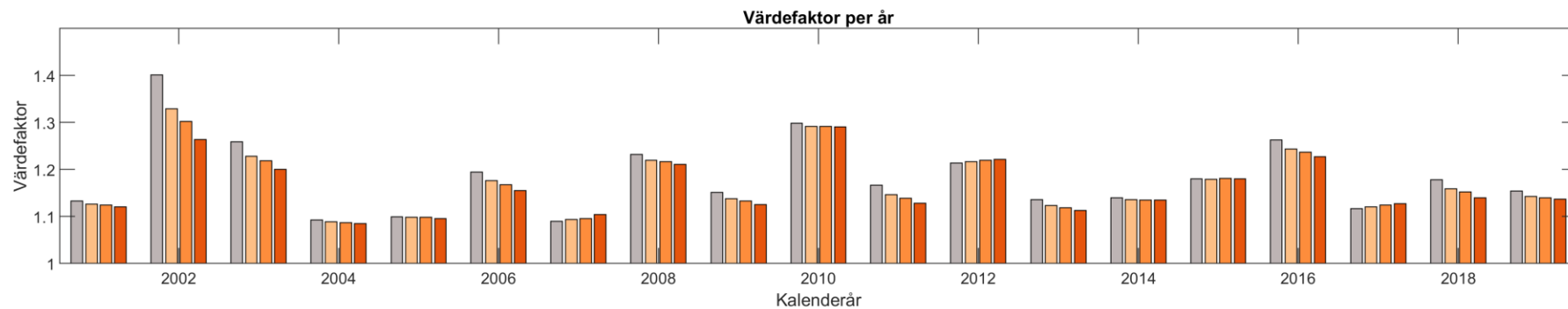
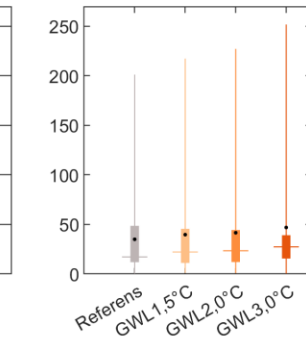
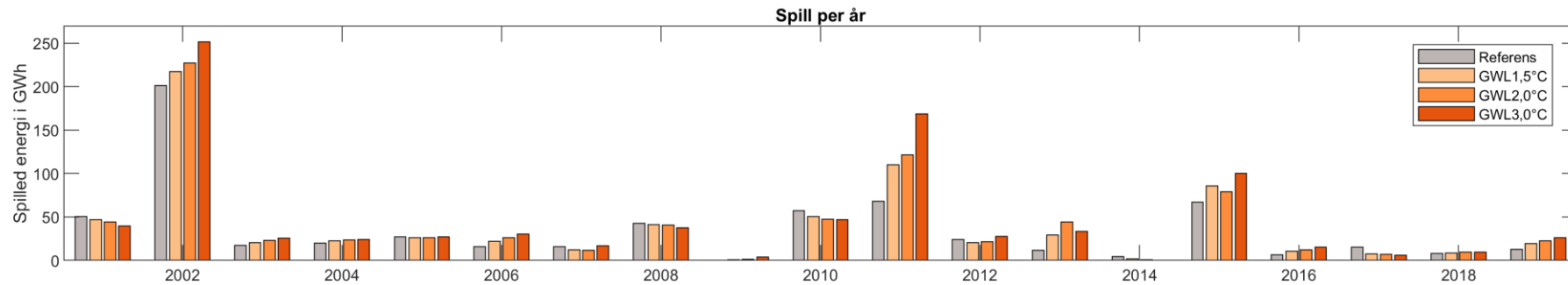
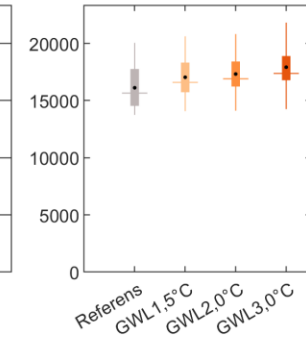
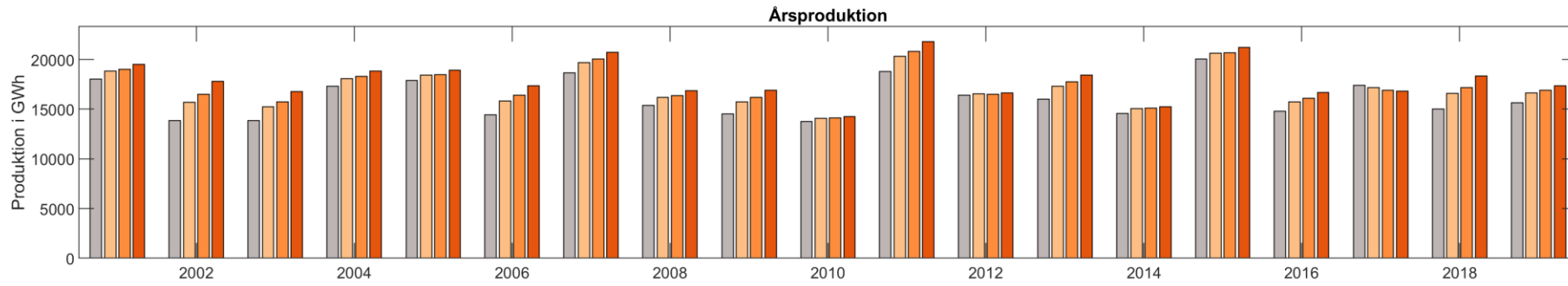
Vattenstånd



Aggregerade resultat

Årsvärden produktion, spill, värdefaktor

Luleälven



Statistik produktion, spill, värdefaktor

Produktion i GWh

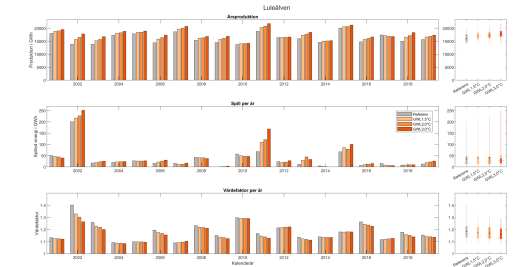
GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	16123	(Ref)	(Ref)	14541	17769	3228	13755	20055
GWL1, 5°C	17044	+921	+6 %	15735	18328	2593	14078	20623
GWL2, 0°C	17327	+1204	+7 %	16235	18425	2190	14117	20822
GWL3, 0°C	17926	+1803	+11 %	16786	18904	2118	14258	21825

Spill i GWh

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	35	(Ref)	(Ref)	12	49	37	0	201
GWL1, 5°C	40	+5	+14 %	11	46	35	1	217
GWL2, 0°C	42	+7	+20 %	12	44	32	1	227
GWL3, 0°C	47	+12	+34 %	16	39	23	0	252

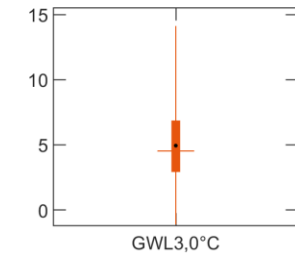
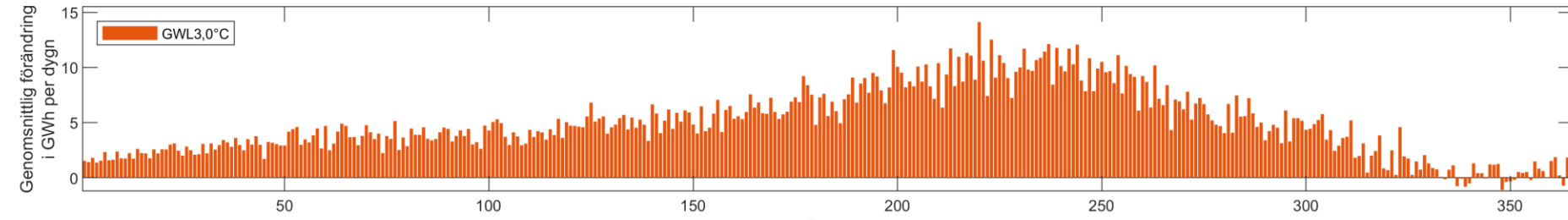
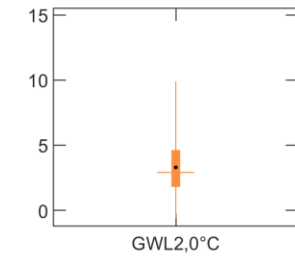
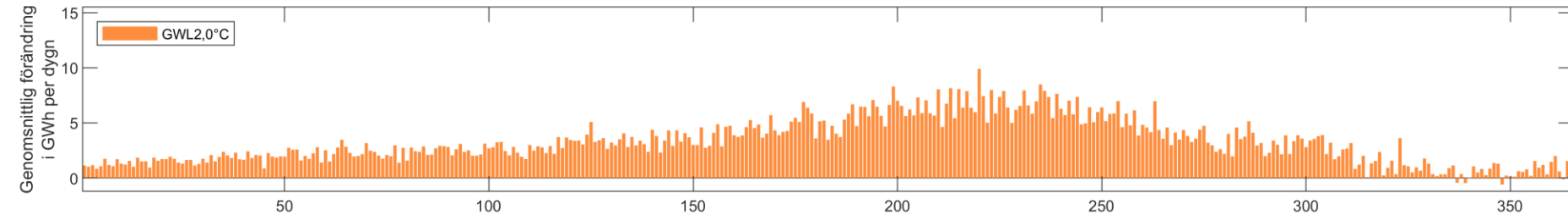
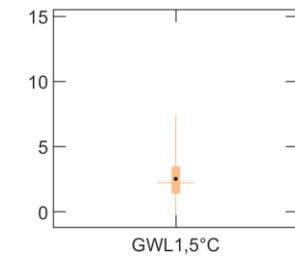
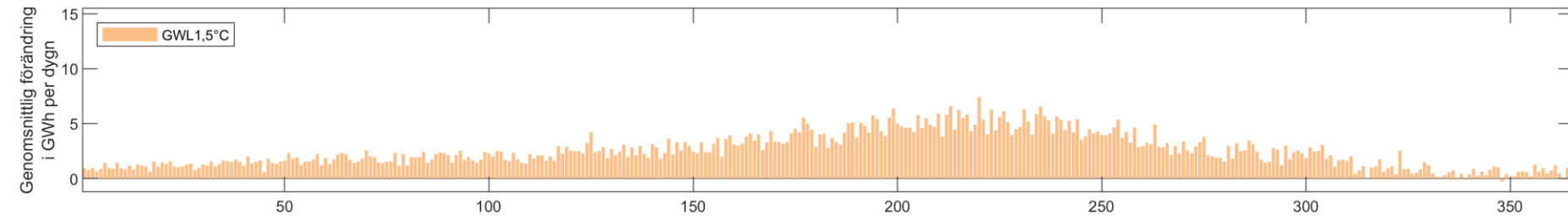
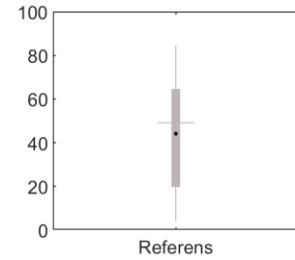
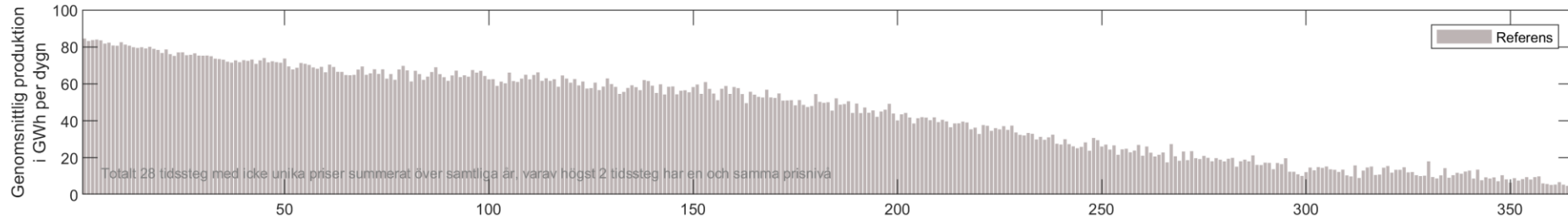
Värdefaktor

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	1.184	(Ref)	(Ref)	1.134	1.228	0.094	1.090	1.401
GWL1, 5°C	1.171	-0.013	-1 %	1.124	1.219	0.095	1.089	1.329
GWL2, 0°C	1.167	-0.017	-1 %	1.124	1.218	0.094	1.087	1.302
GWL3, 0°C	1.161	-0.023	-2 %	1.122	1.208	0.086	1.085	1.290



Förändring i balanseringsförmågan

Flerårs prissorterad produktion Luleälven (24 h)





Kontakt AP2

richard.scharff@vattenfall.com



KLIVA-rapport bilaga A Luleälven

Richard Scharff, Chalmers, 2023-02-01

Kommentarer

- Bilagan innehåller ett axplock av diagram för att illustrera indata till vattenkraftmodellen samt dess resultat
- Resultaten skiljer sig mellan älvsystem, år och uppvärmningsnivå
- Insikter, slutsatser och detaljer beskrivs i rapporten

→ Rapporten finns på: <https://energiforsk.se/program/klimatforandringarnas-inverkan-pa-vattenkraften/rapporter/klimatforandringarnas-inverkan-pa-vattenkraftens-produktions-och-reglerformaga/>



KLIVA-projektet har analyserat **klimatförändringarnas påverkan** på vattenkraftens produktions- och balanseringsförmåga

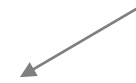
Innehåll diagrammsamling

- Systembeskrivning
 - Älvsystem
 - Energi per Mm³ lokaltillrinning
 - Vattendommar
- Klimatpåverkan lokaltillrinning
 - Klimatfaktorer
 - Total tillrinning



- Optimering
 - Lokaltillrinning
 - Elpriser
 - Älvens elproduktion
 - Produktion per station
 - Stationsvattenföring
 - Spill per magasin
 - Vattenytor per magasin
- Aggregerade resultat
 - Produktionsförmåga
 - Balanseringsförmåga

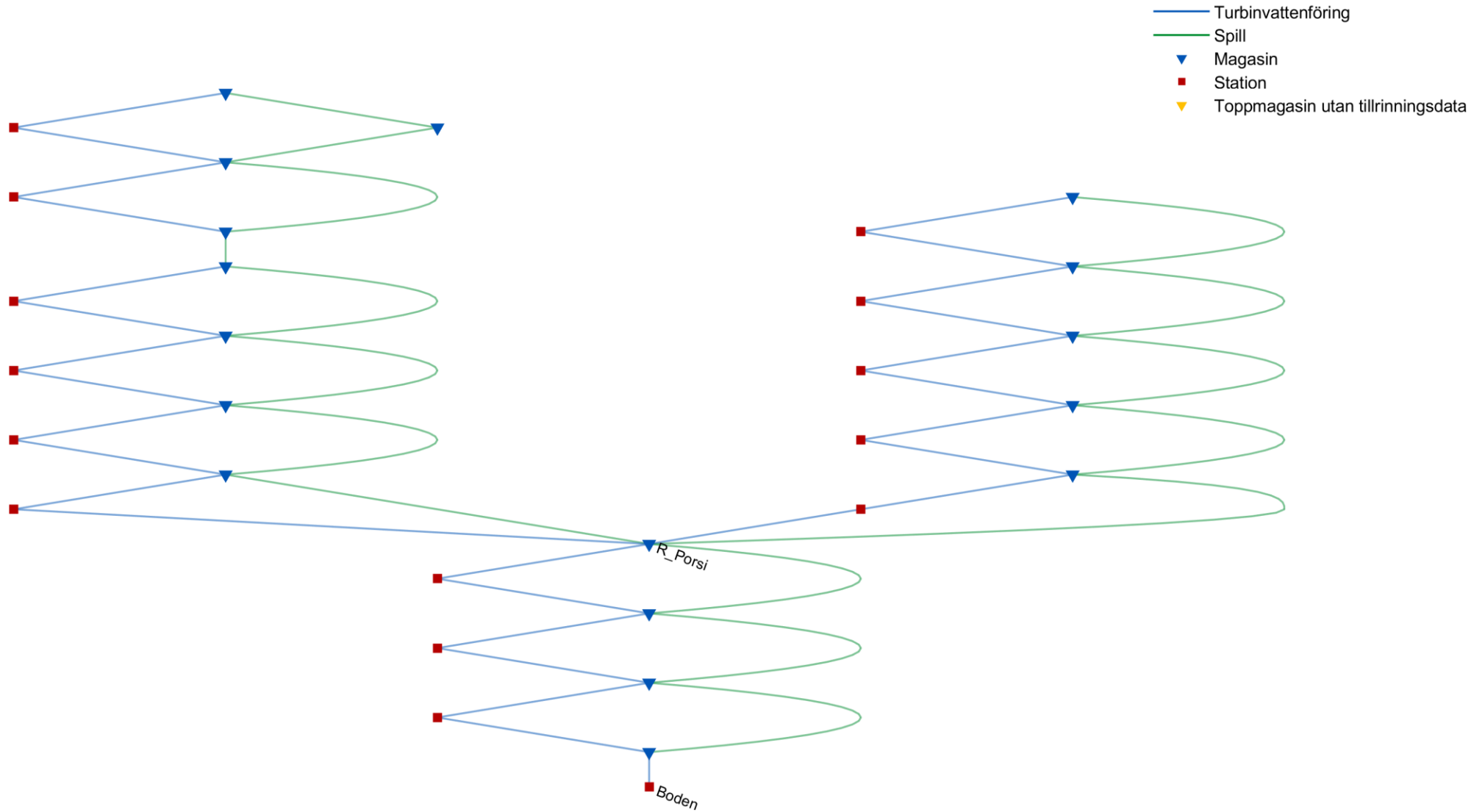
Optimeringen görs för **19 år**, alltid ett kalenderår i taget. I den här bilagan presenteras indata och resultat för **ett utvalt år** med uppvärmningsnivån **GWL2,0°C**.



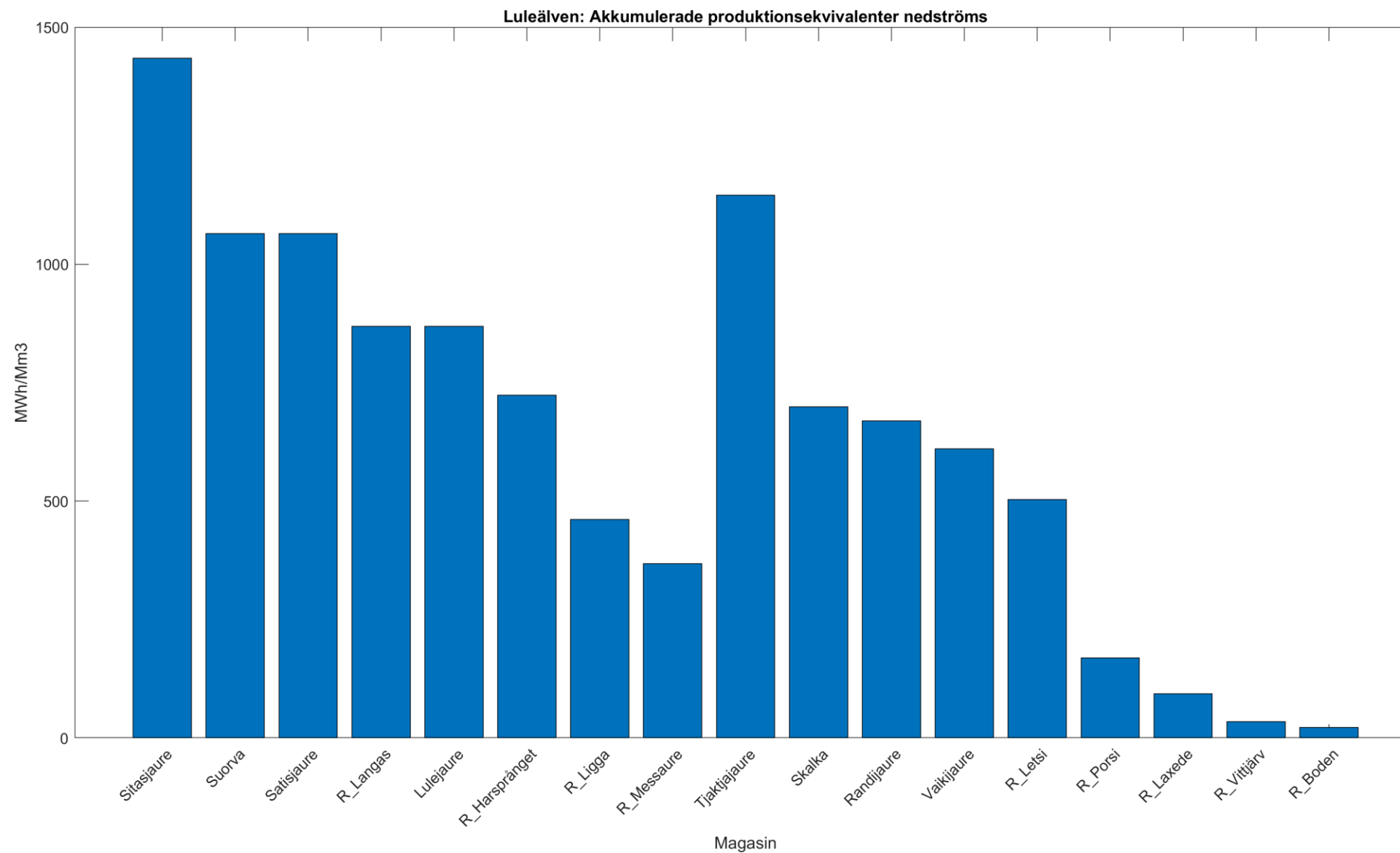
Systembeskrivning

Älvsystem

Luleälven

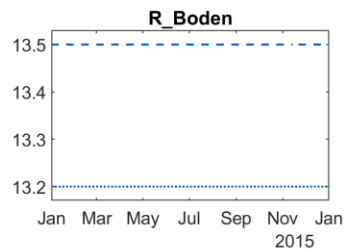
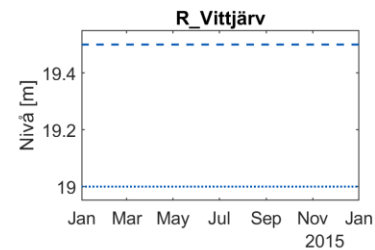
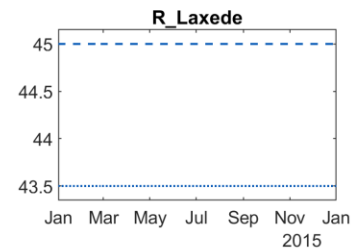
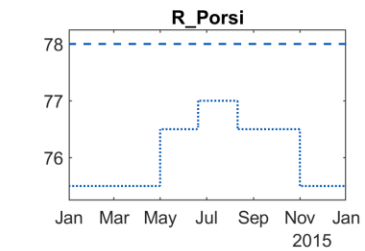
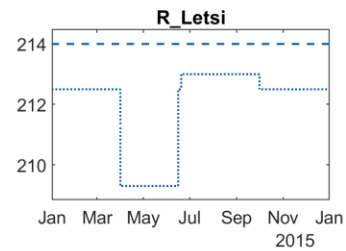
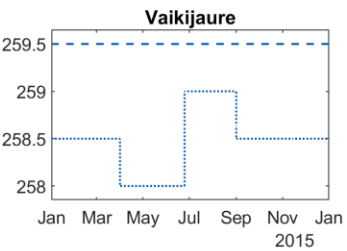
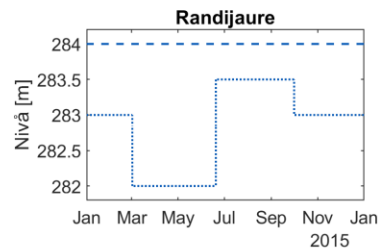
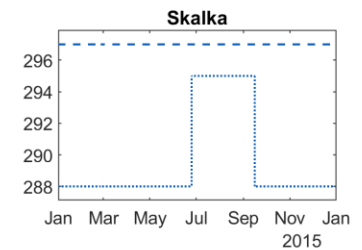
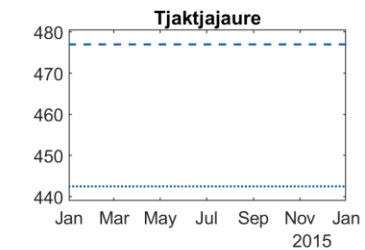
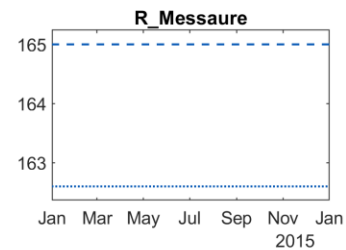
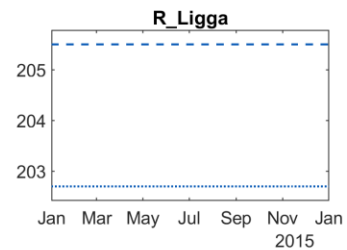
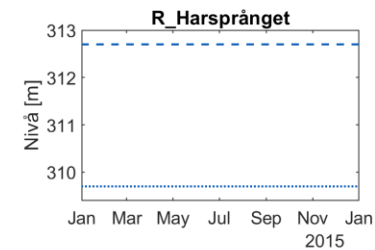
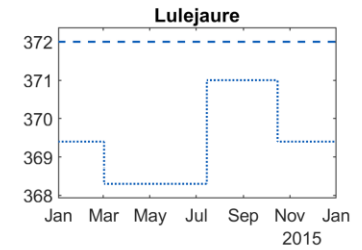
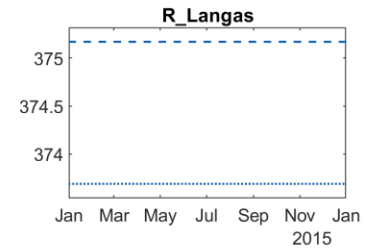
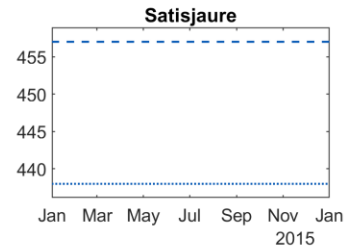
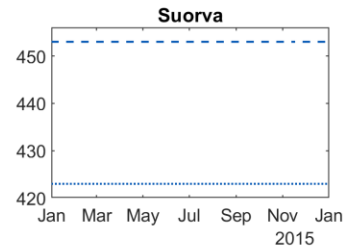
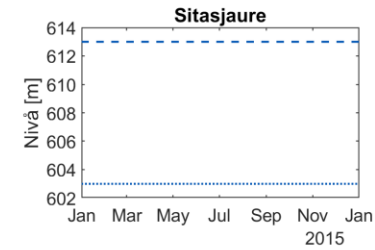


Energi per Mm³ lokaltillrinning



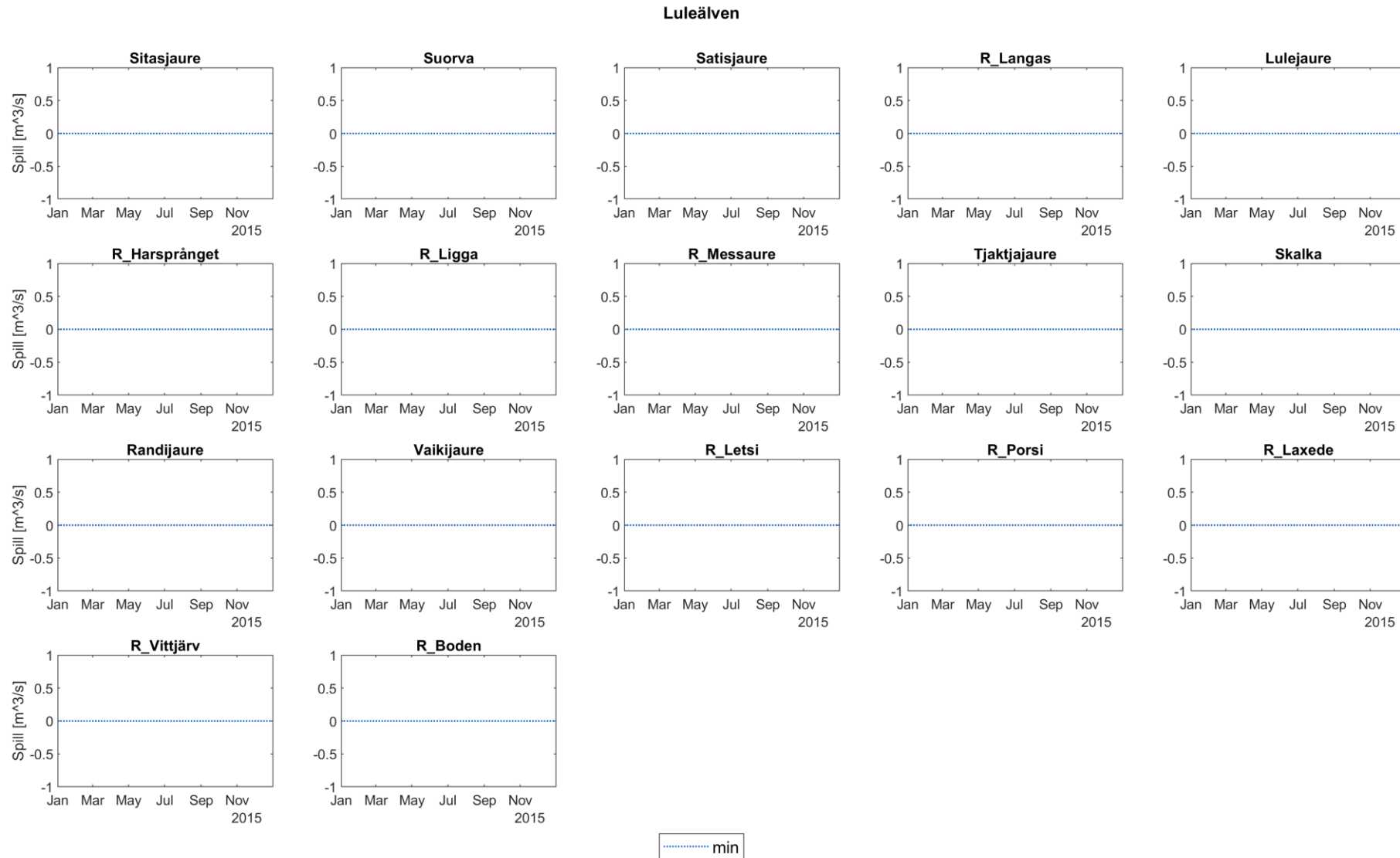
Vattendomar "WaterLevel"

Luleälven



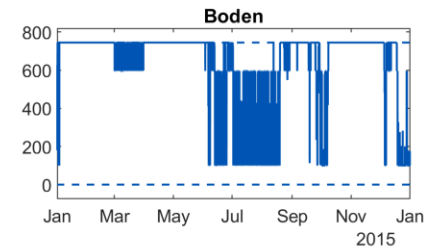
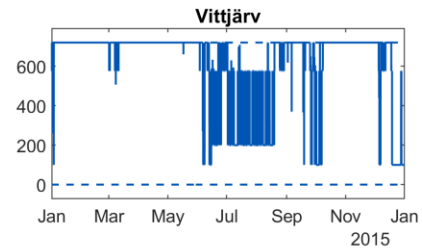
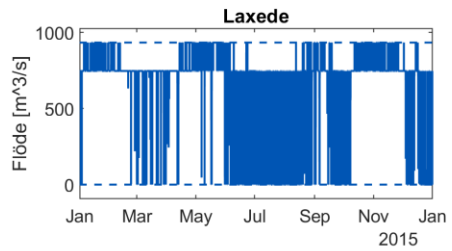
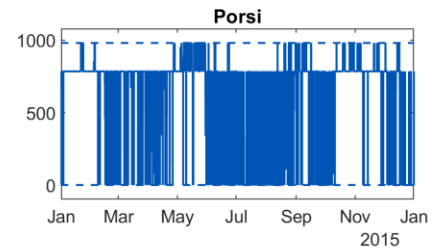
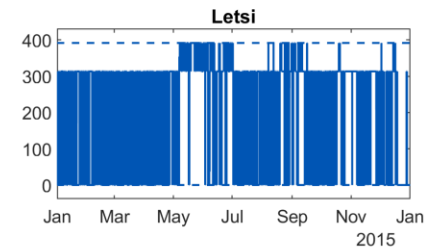
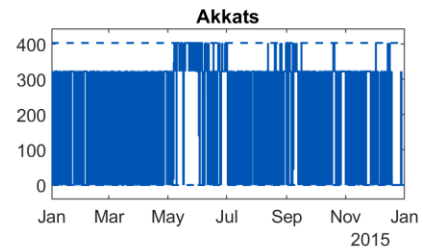
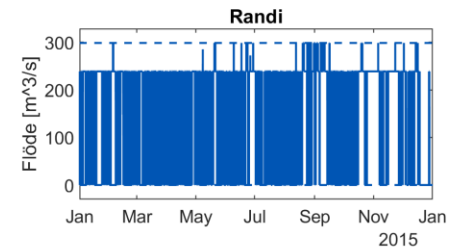
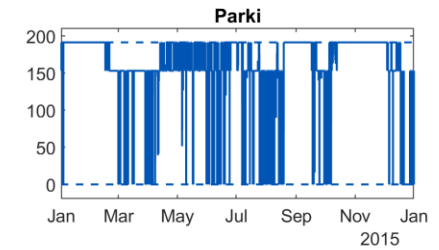
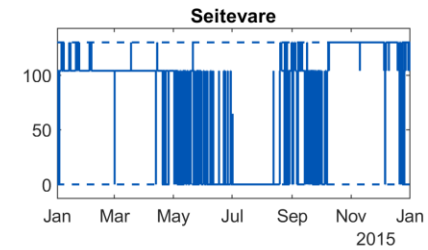
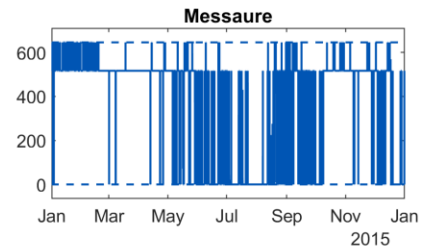
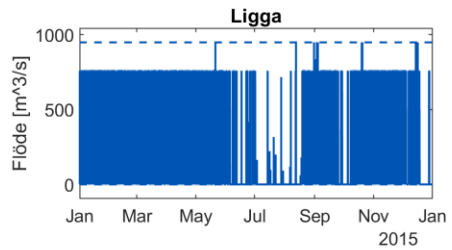
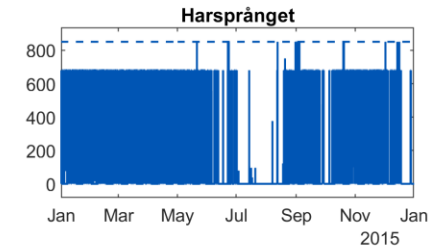
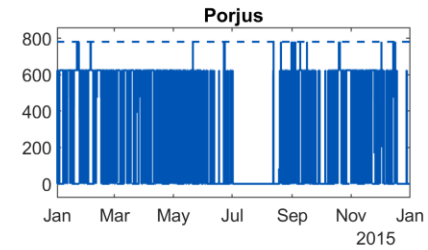
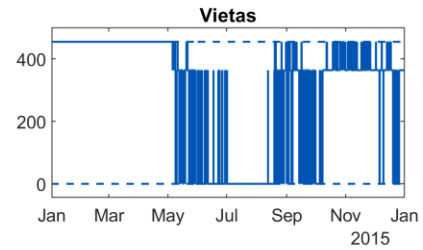
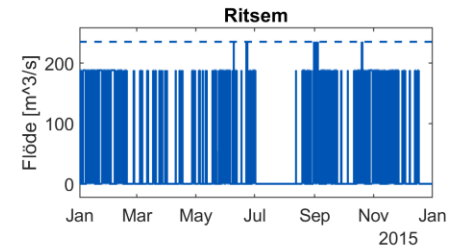
..... min - - - max

Vattendomar "MinSpill"



Vattendomar "MinFlow"

Turbinvattenföring för Luleälven

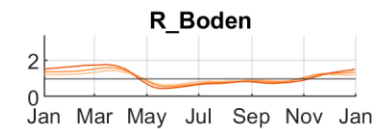
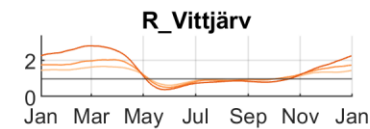
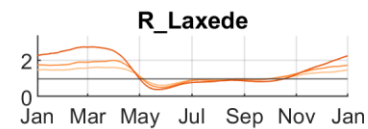
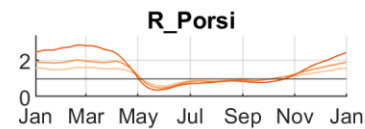
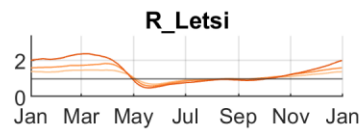
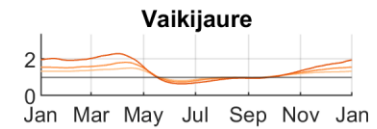
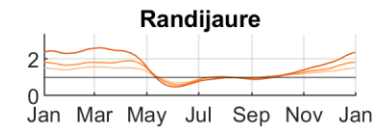
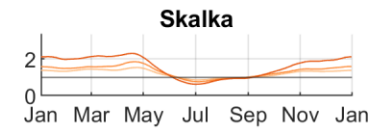
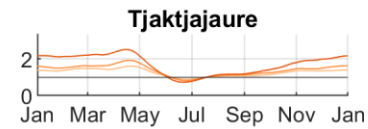
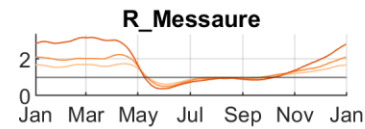
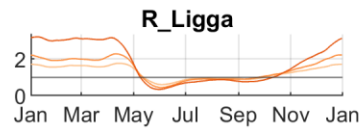
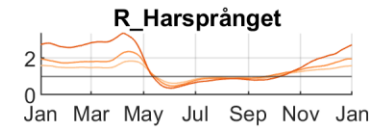
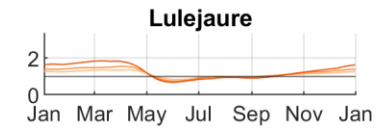
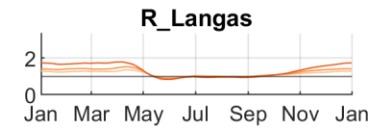
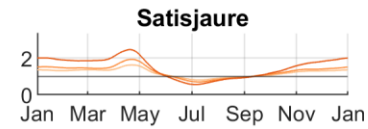
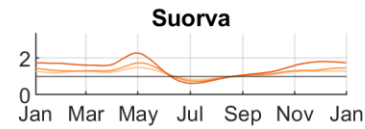
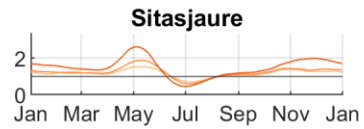


— KLIVA

Klimatpåverkan på lokaltillrinningar

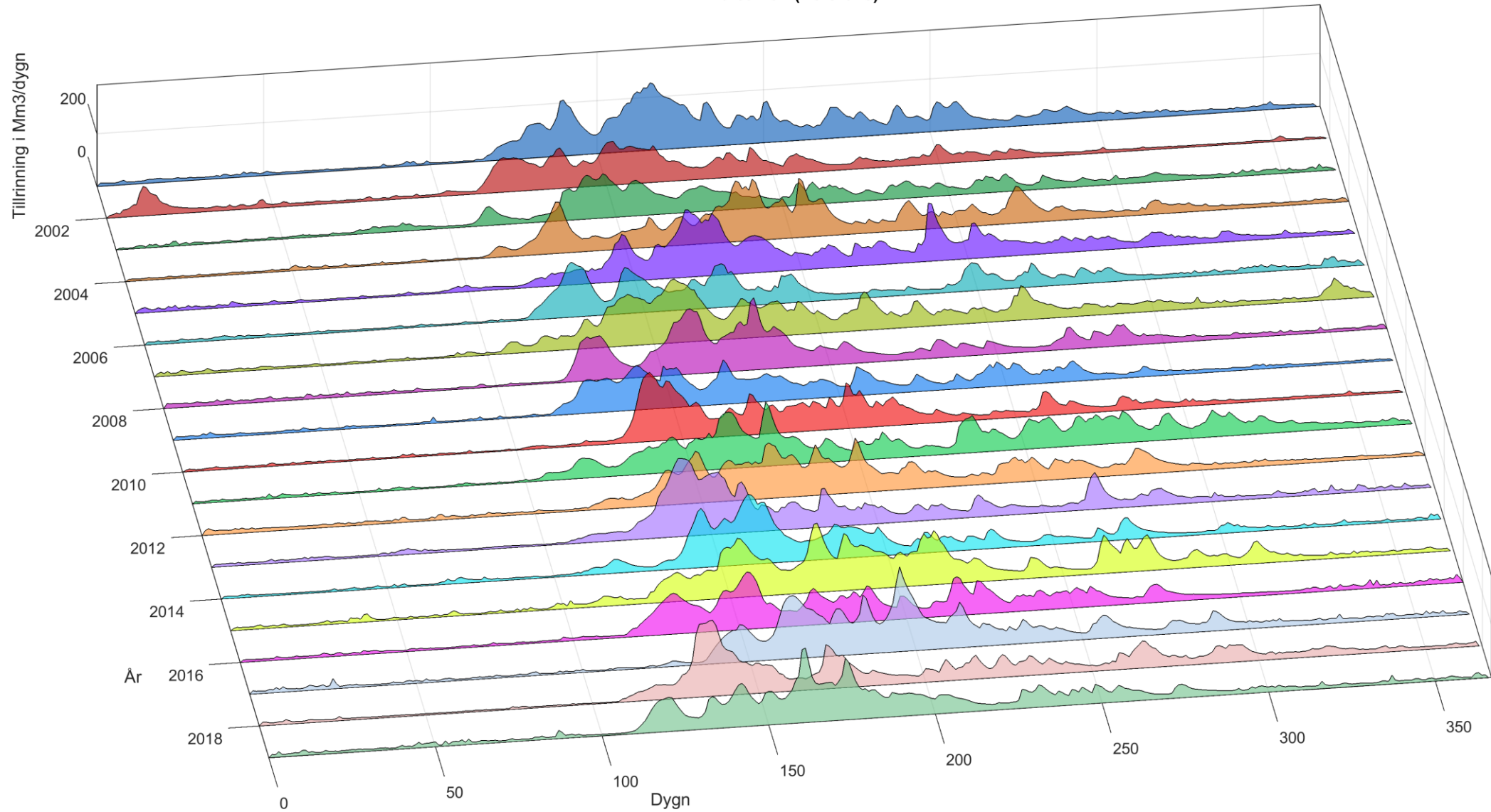
Klimatfaktorer

Klimatfaktorer Luleälven



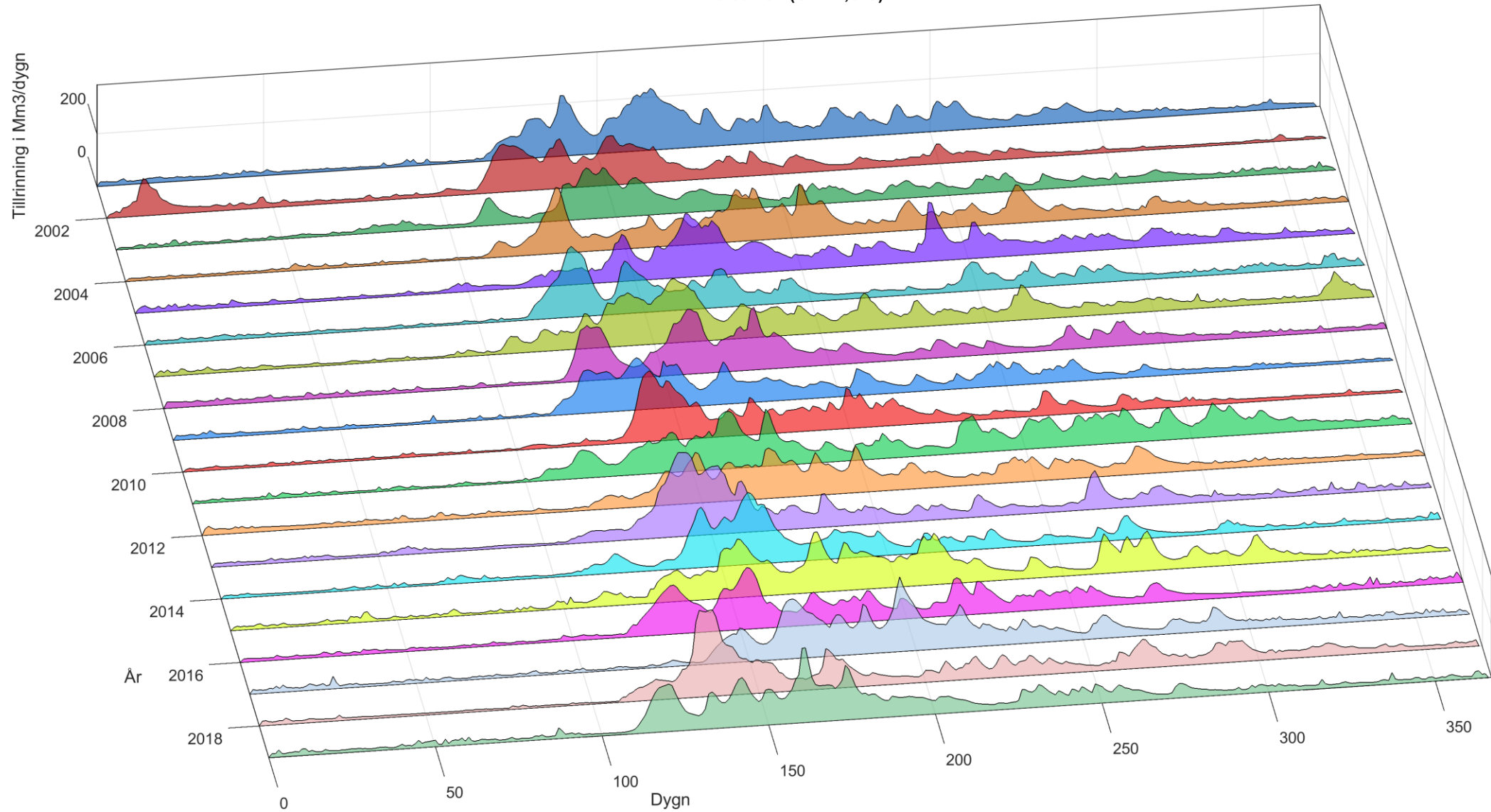
Total tillrinning (Referens)

Luleälven (Referens)



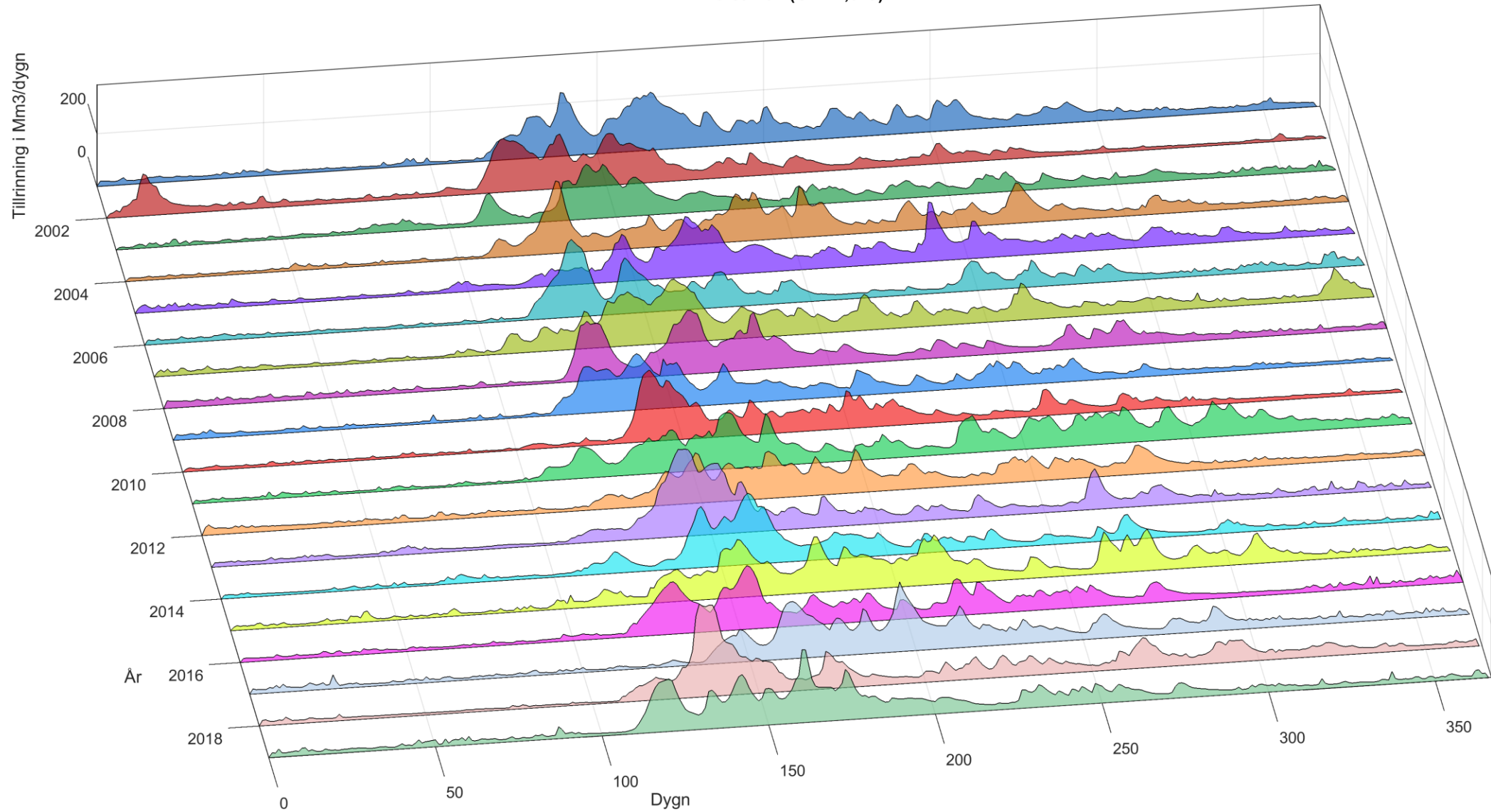
Total tillrinning (GWL1,5°C)

Luleälven (GWL1,5°C)



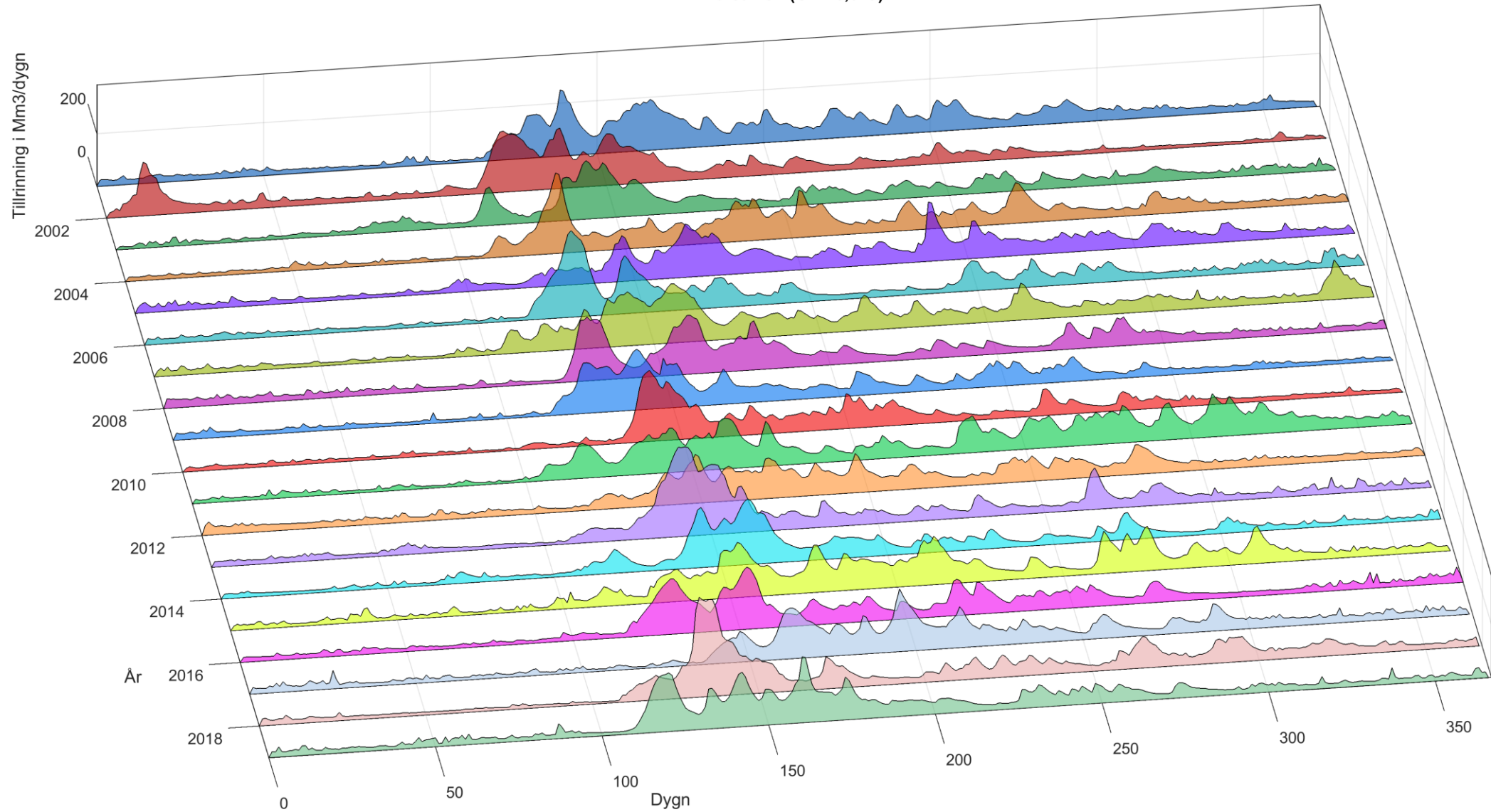
Total tillrinning (GWL2,0°C)

Luleälven (GWL2,0°C)



Total tillrinning (GWL3,0°C)

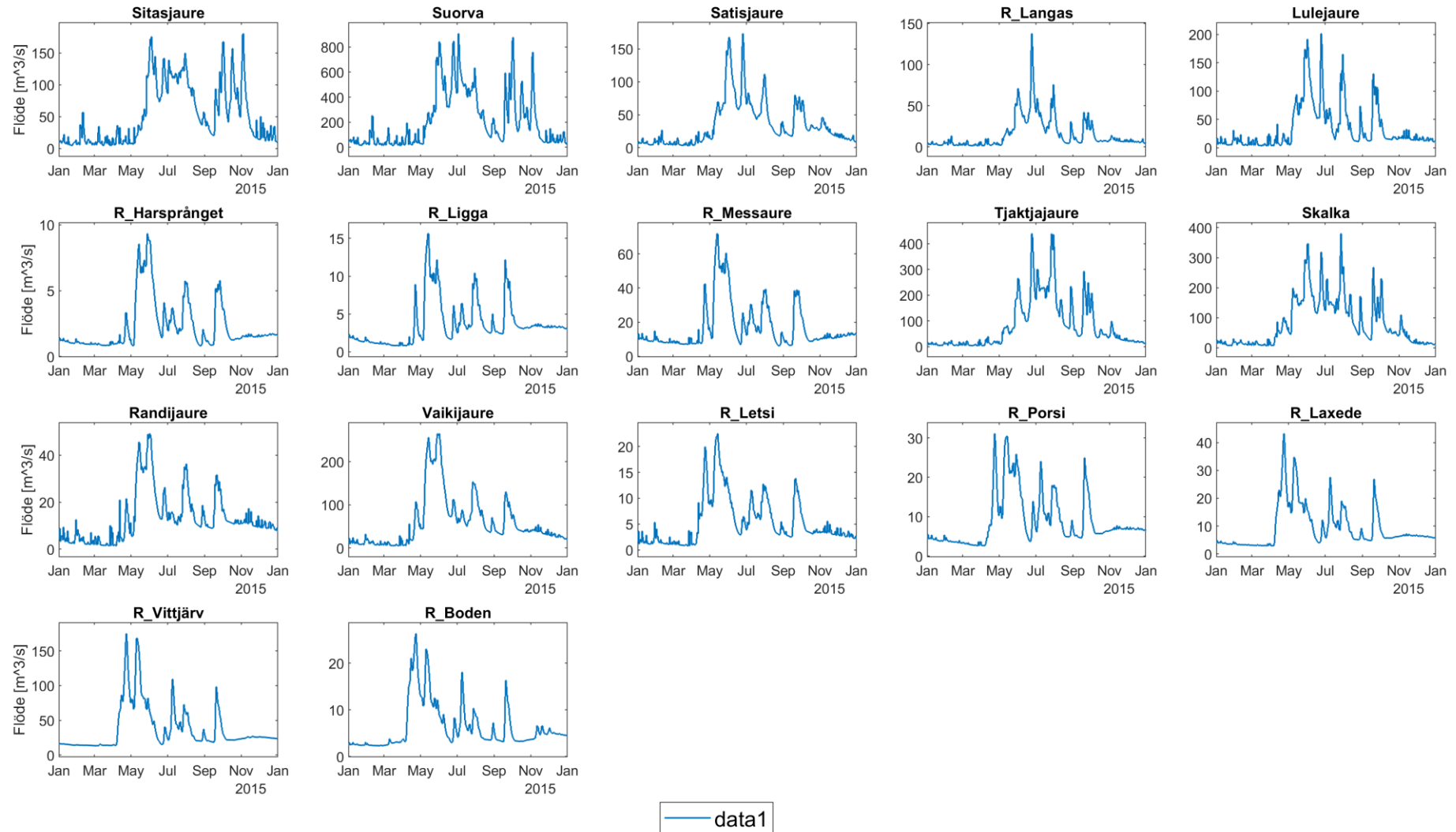
Luleälven (GWL3,0°C)



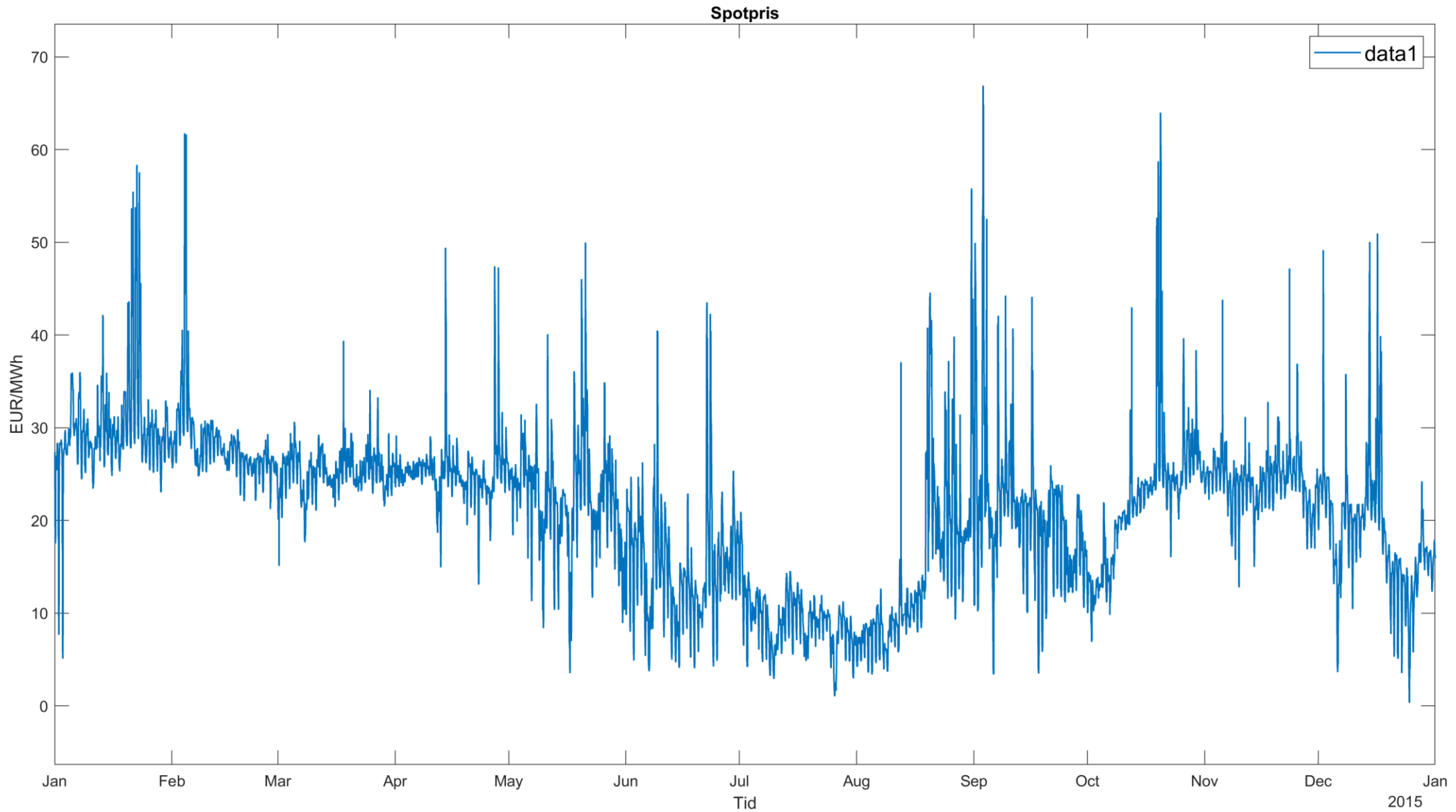
Resultat (exempel GWL2,0°C för 2015)

Lokaltillrinning

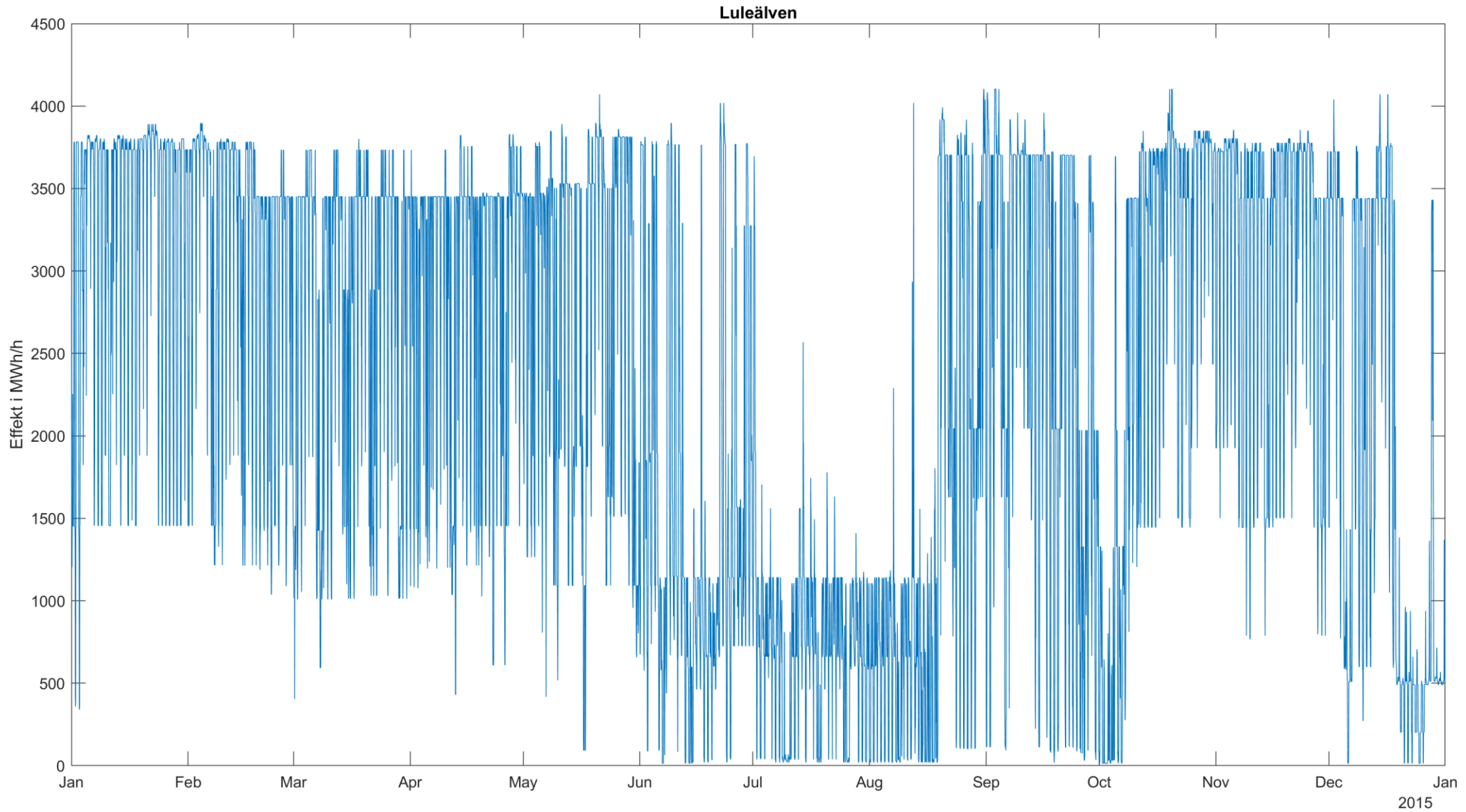
Lokal tillrinning för Luleälven



Elpriser

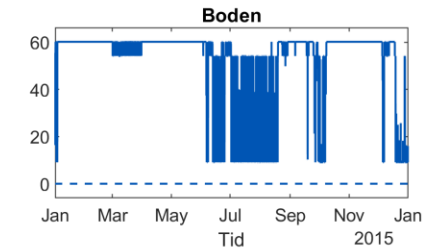
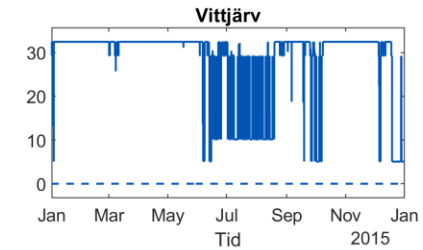
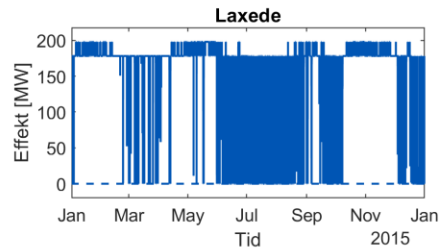
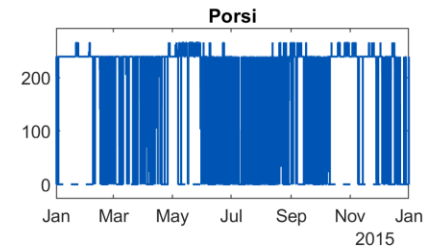
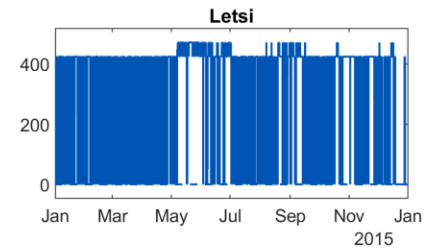
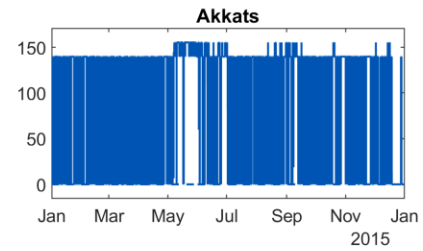
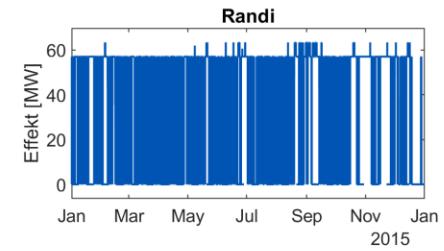
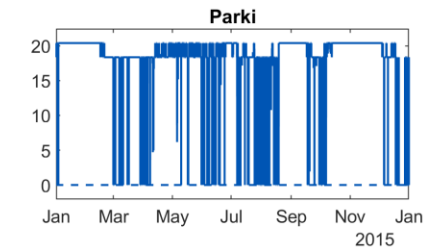
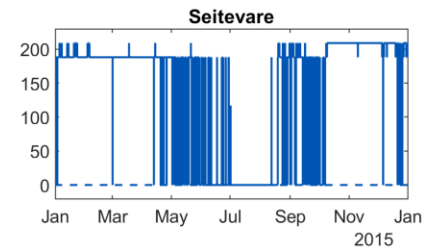
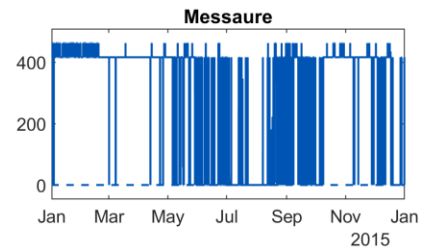
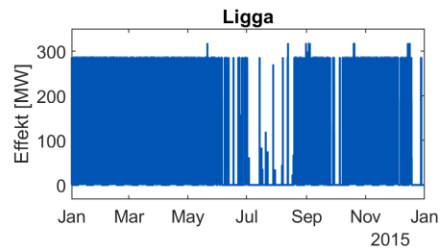
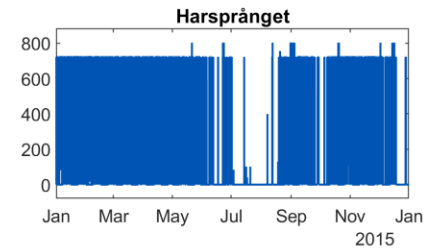
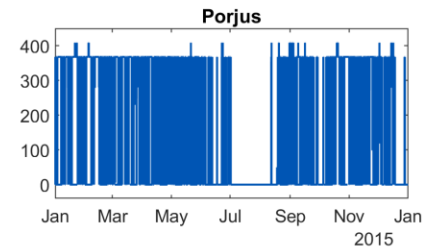
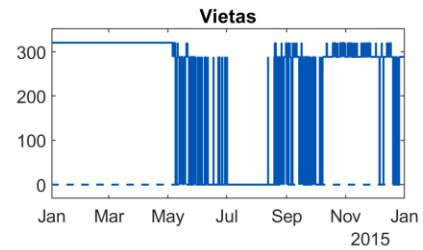
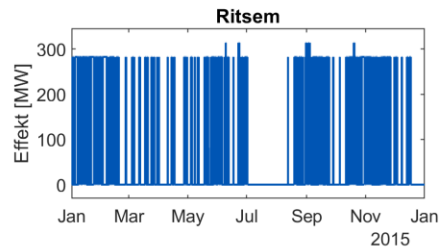


Produktion älvsystem



Produktion

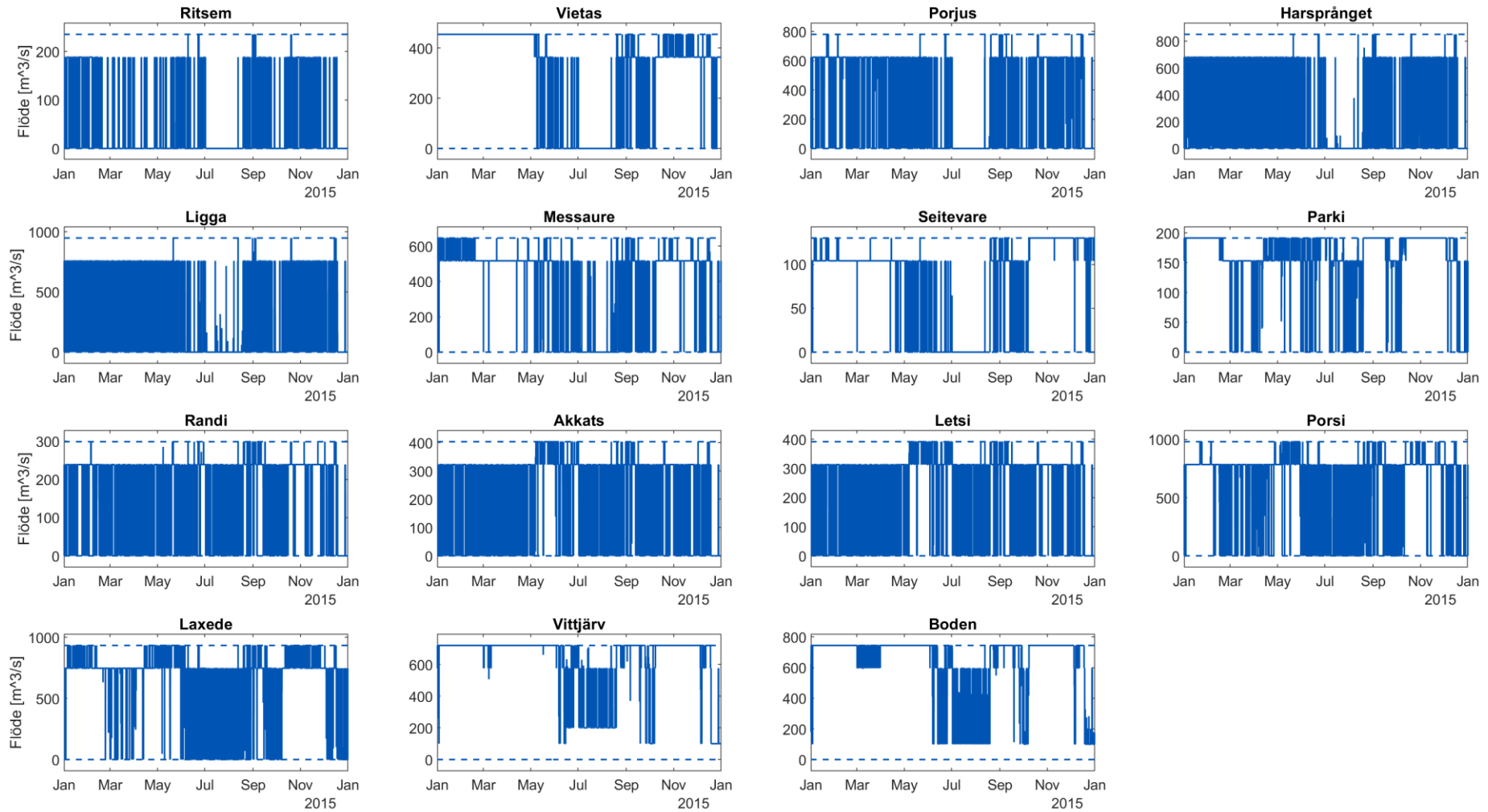
Produktion per station för Luleälven



— KLIVA

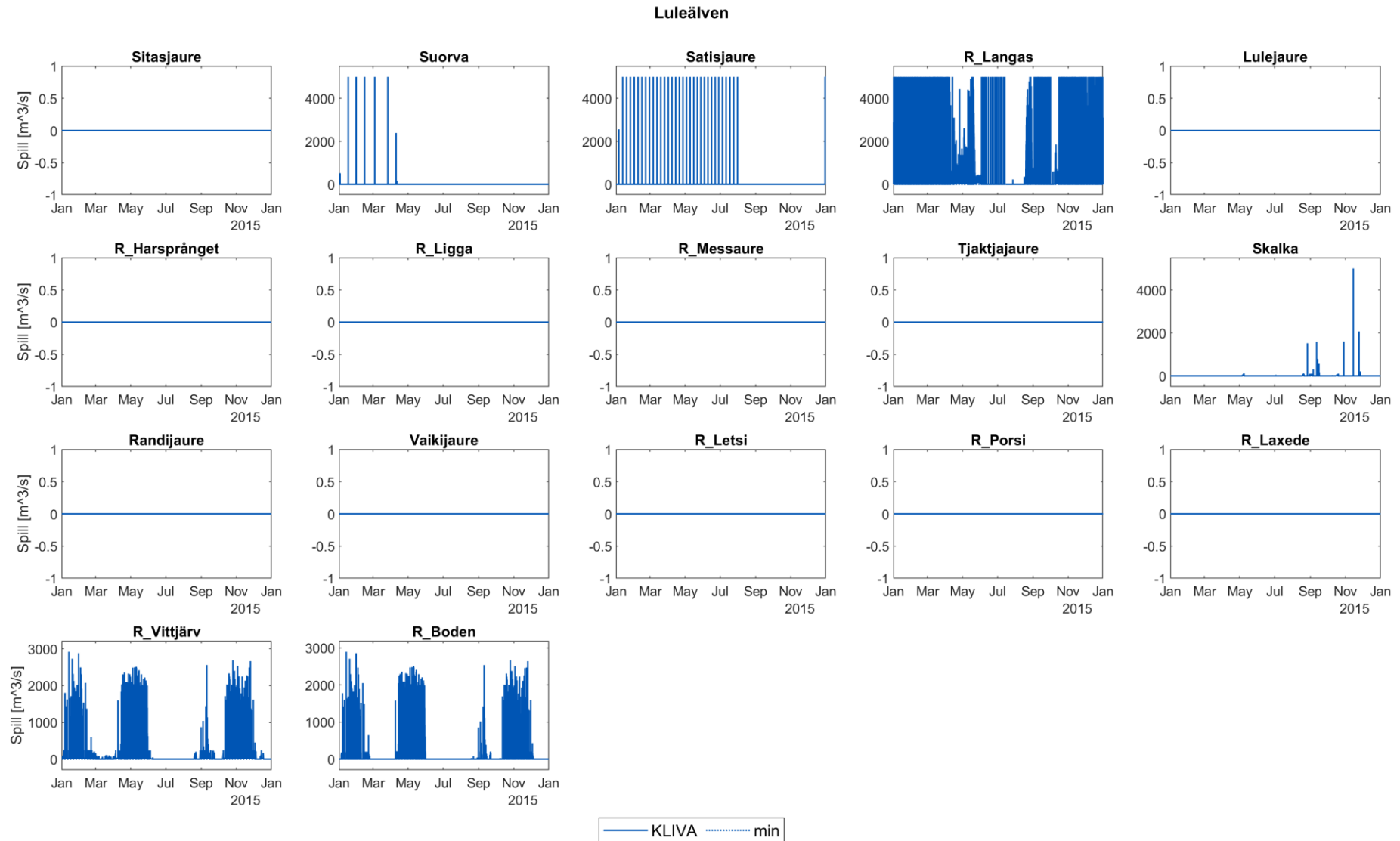
Stationsvattenföring

Turbinvattenföring för Luleälven



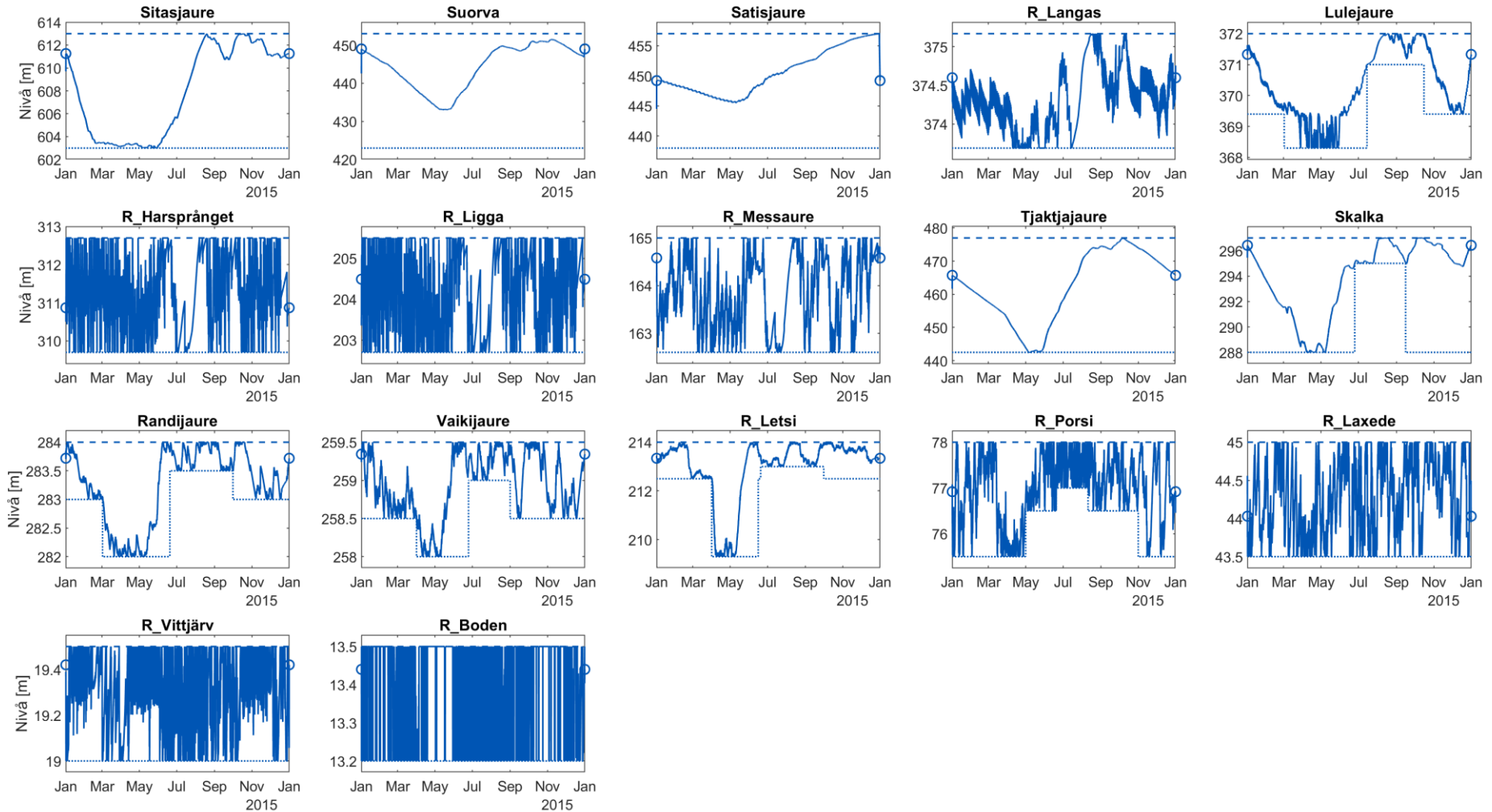
— KLIVA

Spill



Vattenstånd

Luleälven

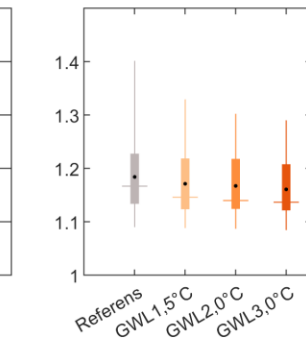
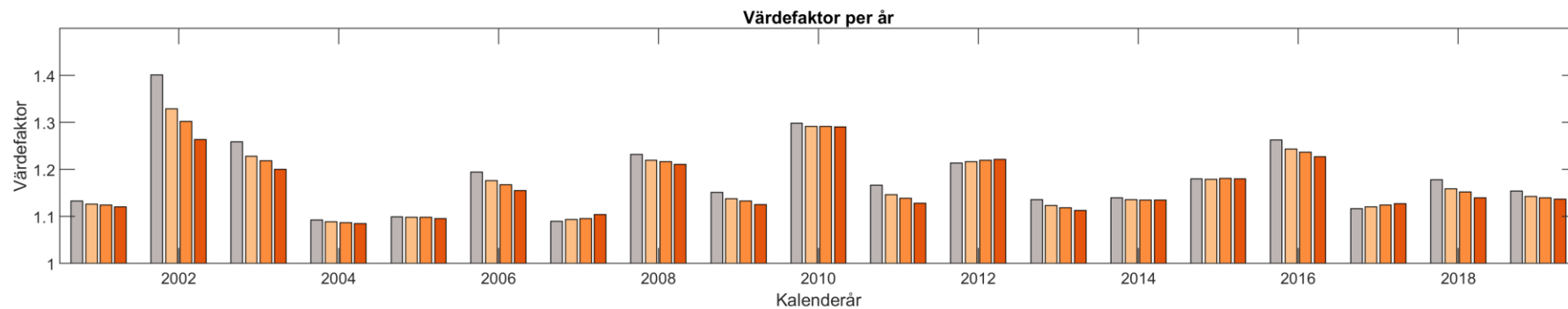
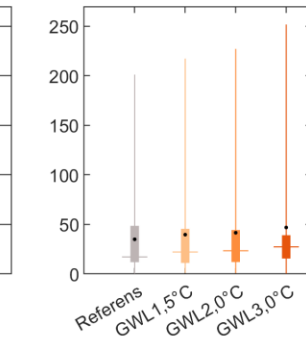
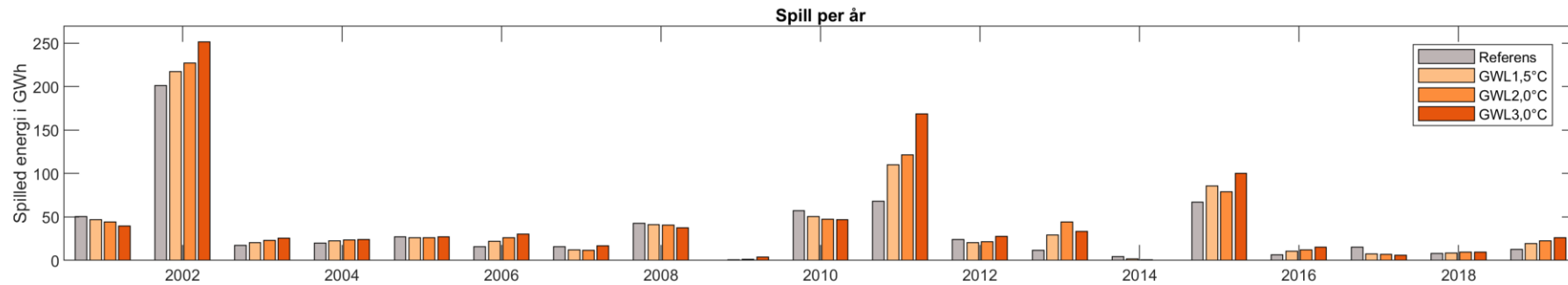
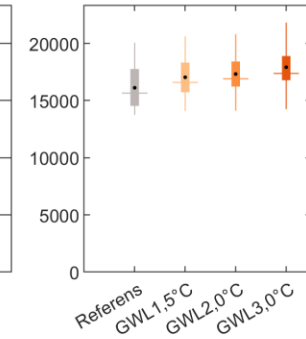
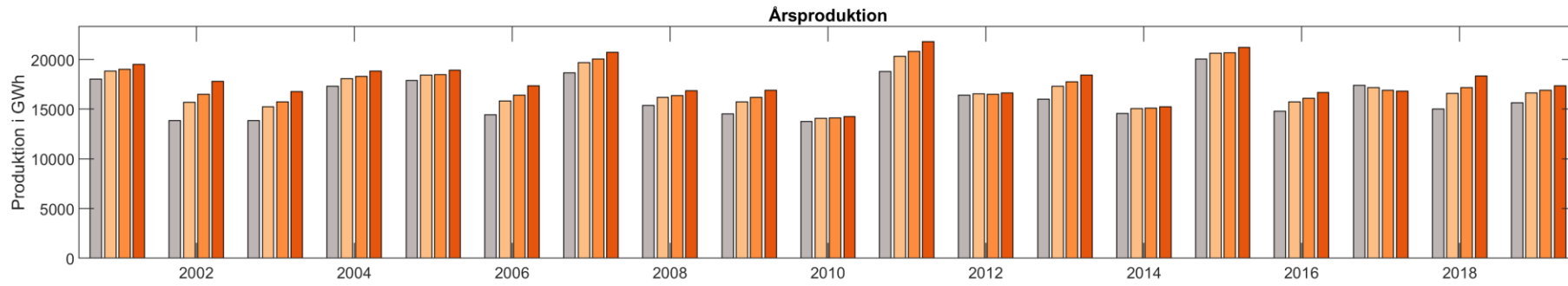


— KLIVA min - - - max ○ Randvillkor

Aggregerade resultat

Årsvärden produktion, spill, värdefaktor

Luleälven



Statistik produktion, spill, värdefaktor

Produktion i GWh

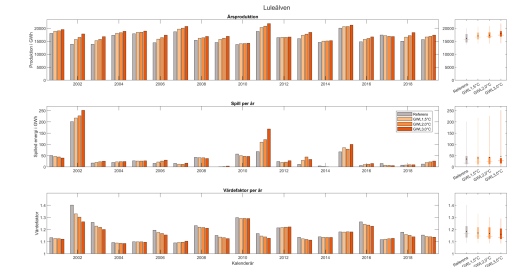
GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	16123	(Ref)	(Ref)	14541	17769	3228	13755	20055
GWL1, 5°C	17044	+921	+6 %	15735	18328	2593	14078	20623
GWL2, 0°C	17327	+1204	+7 %	16235	18425	2190	14117	20822
GWL3, 0°C	17926	+1803	+11 %	16786	18904	2118	14258	21825

Spill i GWh

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	35	(Ref)	(Ref)	12	49	37	0	201
GWL1, 5°C	40	+5	+14 %	11	46	35	1	217
GWL2, 0°C	42	+7	+20 %	12	44	32	1	227
GWL3, 0°C	47	+12	+34 %	16	39	23	0	252

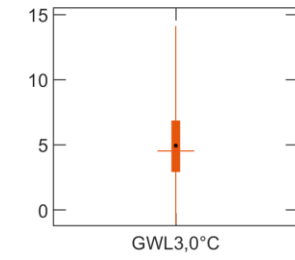
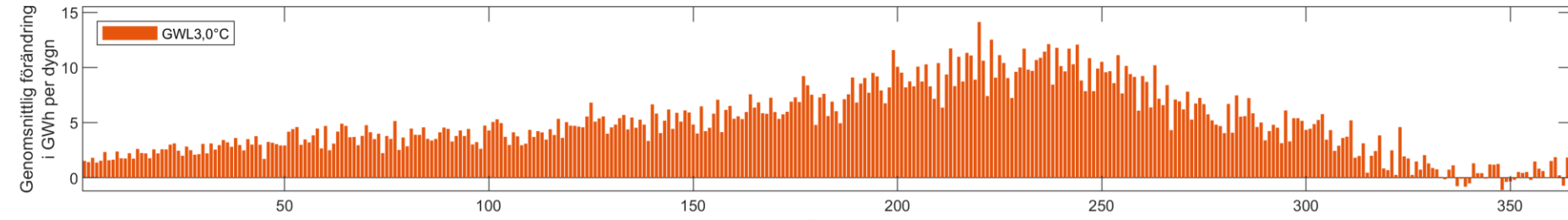
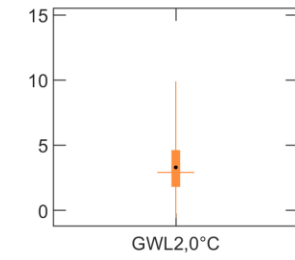
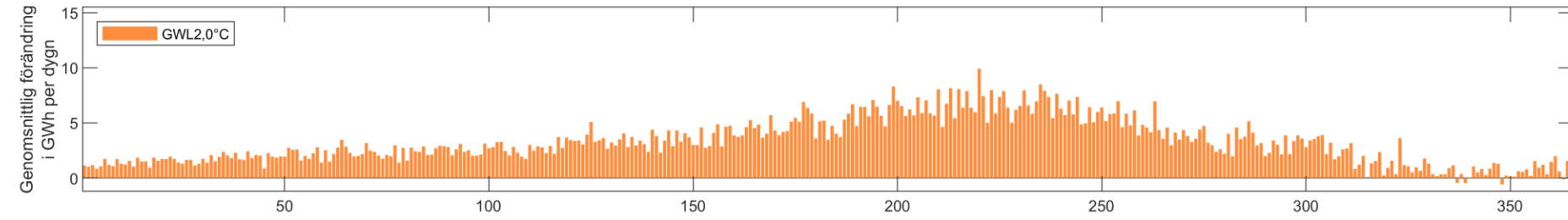
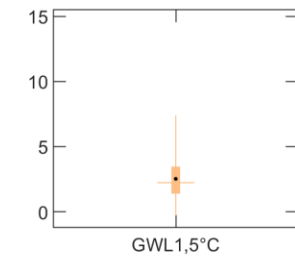
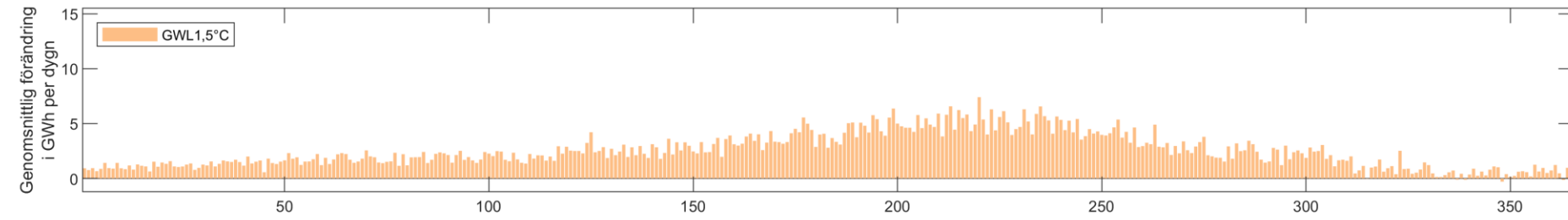
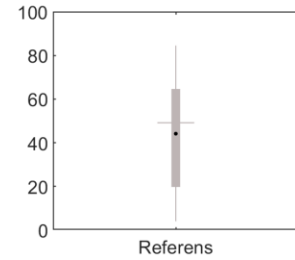
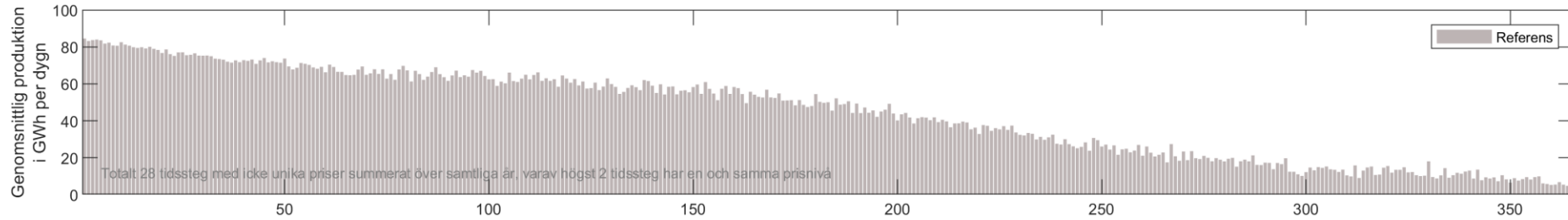
Värdefaktor

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	1.184	(Ref)	(Ref)	1.134	1.228	0.094	1.090	1.401
GWL1, 5°C	1.171	-0.013	-1 %	1.124	1.219	0.095	1.089	1.329
GWL2, 0°C	1.167	-0.017	-1 %	1.124	1.218	0.094	1.087	1.302
GWL3, 0°C	1.161	-0.023	-2 %	1.122	1.208	0.086	1.085	1.290



Förändring i balanseringsförmågan

Flerårs prissorterad produktion Luleälven (24 h)





Kontakt AP2

richard.scharff@vattenfall.com



KLIVA-rapport bilaga A Skellefteälven

Richard Scharff, Chalmers, 2023-02-01

Kommentarer

- Bilagan innehåller ett axplock av diagram för att illustrera indata till vattenkraftmodellen samt dess resultat
- Resultaten skiljer sig mellan älvsystem, år och uppvärmningsnivå
- Insikter, slutsatser och detaljer beskrivs i rapporten

→ Rapporten finns på: <https://energiforsk.se/program/klimatforandringarnas-inverkan-pa-vattenkraften/rapporter/klimatforandringarnas-inverkan-pa-vattenkraftens-produktions-och-reglerformaga/>



Energiforsk

KLIVA-projektet har analyserat **klimatförändringarnas påverkan** på vattenkraftens produktions- och balanseringsförmåga

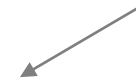
Innehåll diagrammsamling

- Systembeskrivning
 - Älvsystem
 - Energi per Mm³ lokaltillrinning
 - Vattendommar
- Klimatpåverkan lokaltillrinning
 - Klimatfaktorer
 - Total tillrinning



- Optimering
 - Lokaltillrinning
 - Elpriser
 - Älvens elproduktion
 - Produktion per station
 - Stationsvattenföring
 - Spill per magasin
 - Vattenytor per magasin
- Aggregerade resultat
 - Produktionsförmåga
 - Balanseringsförmåga

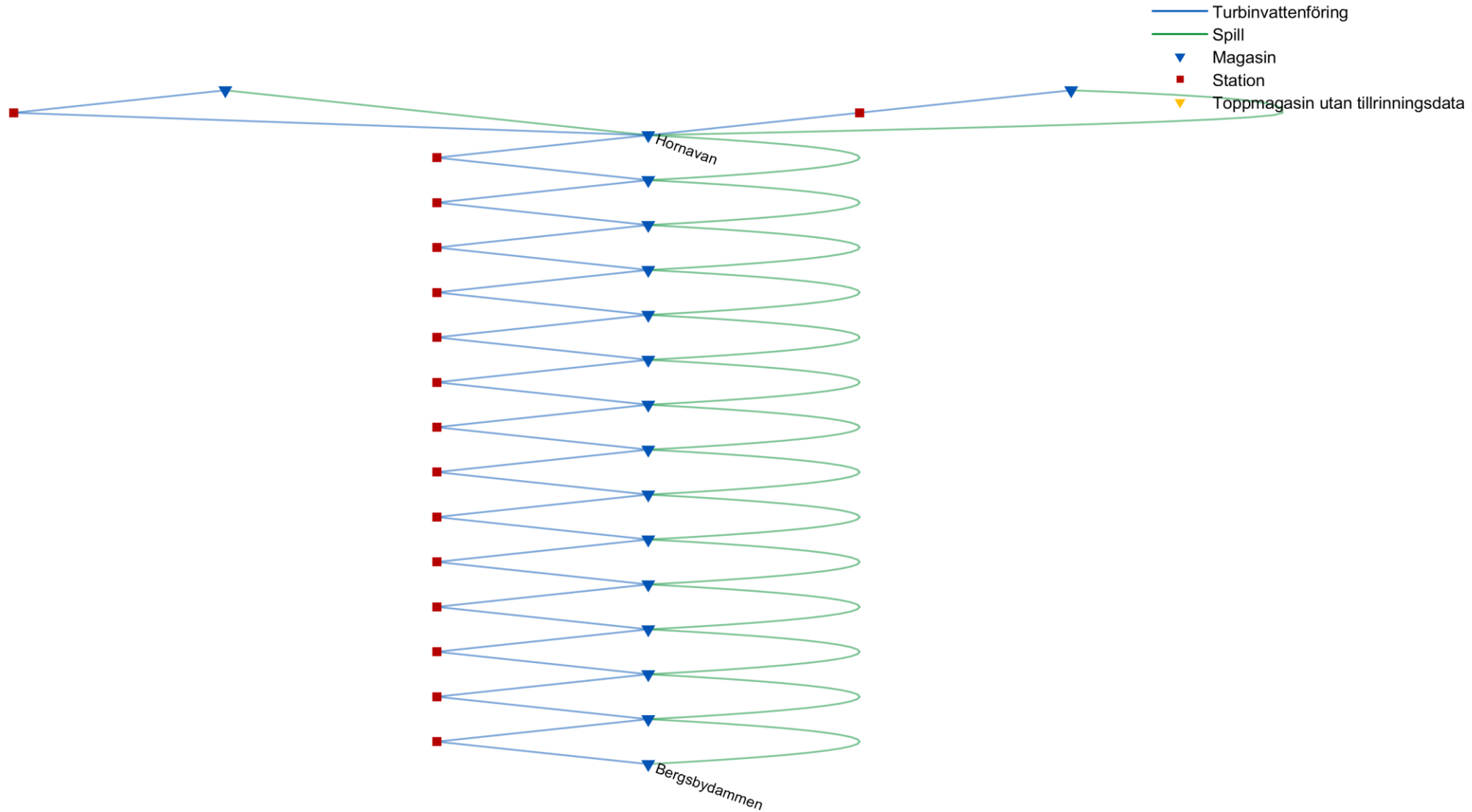
Optimeringen görs för **19 år**, alltid ett kalenderår i taget. I den här bilagan presenteras indata och resultat för **ett utvalt år** med uppvärmningsnivån **GWL2,0°C**.



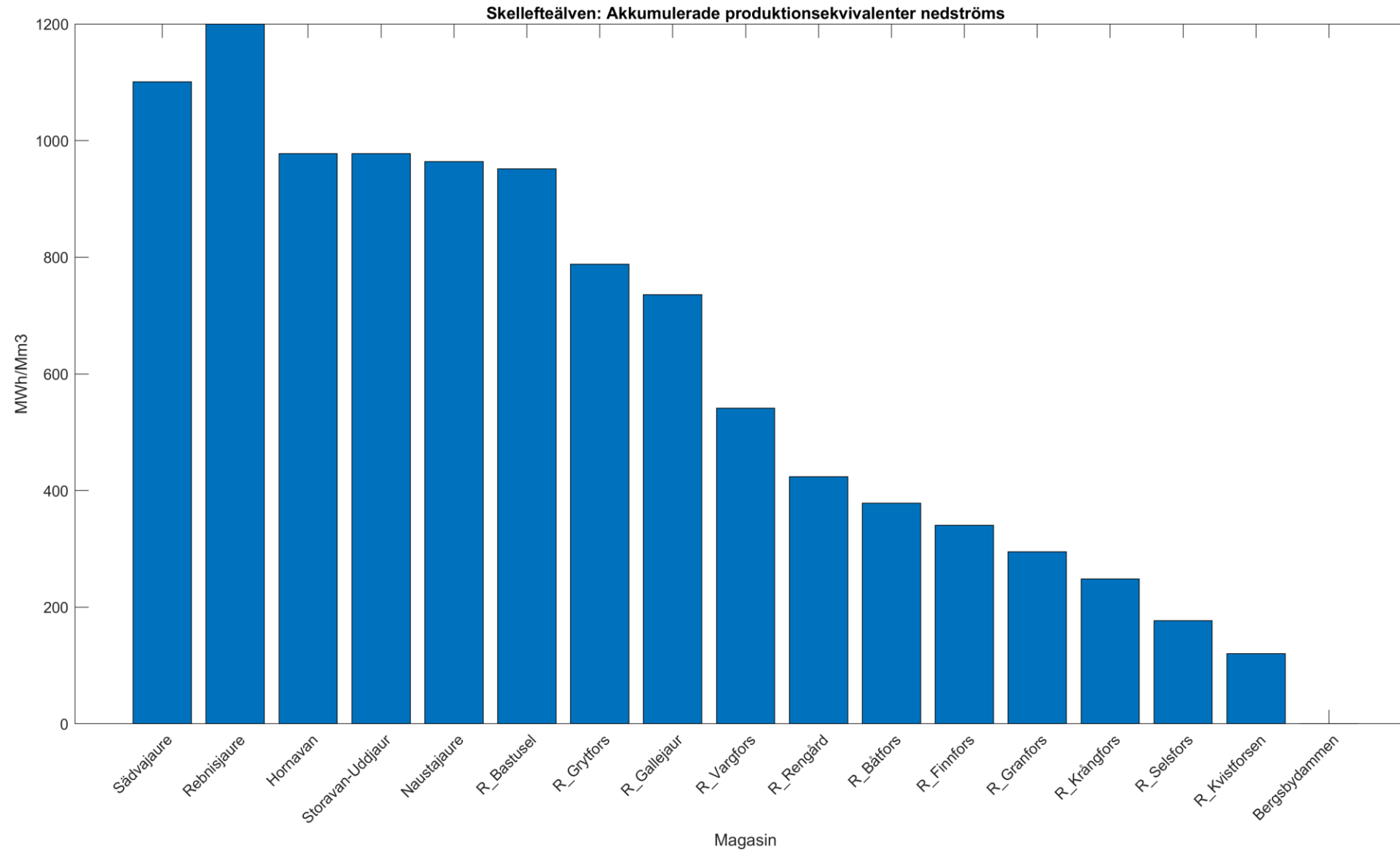
Systembeskrivning

Älvsystem

Skellefteälv

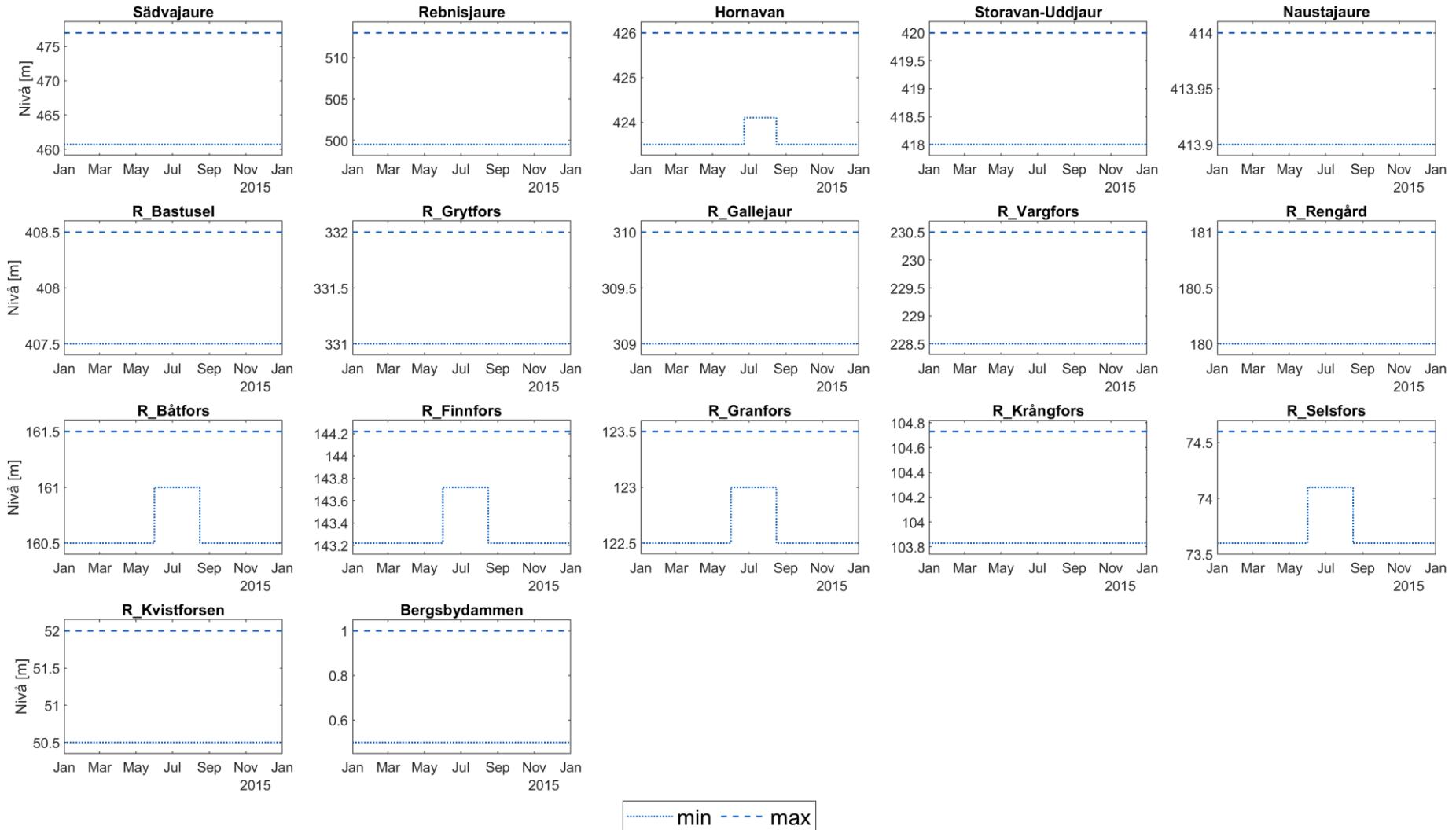


Energi per Mm³ lokaltillrinning

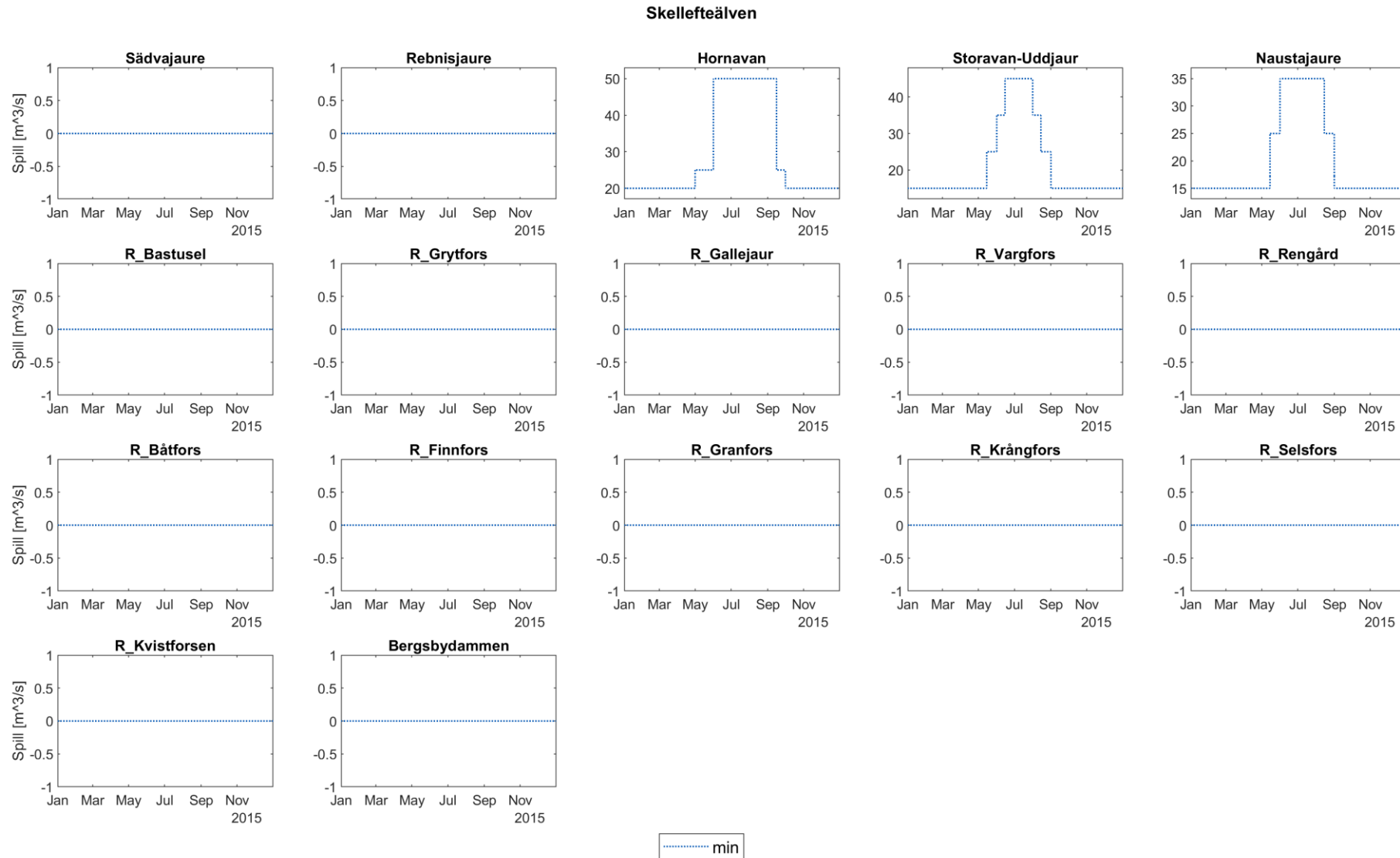


Vattendomar "WaterLevel"

Skellefteälven

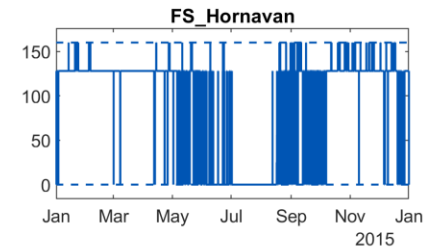
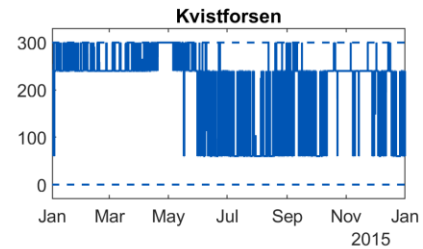
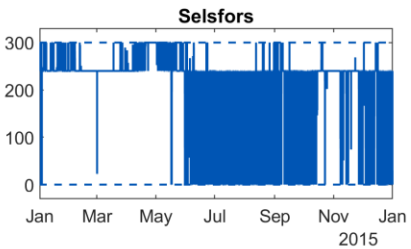
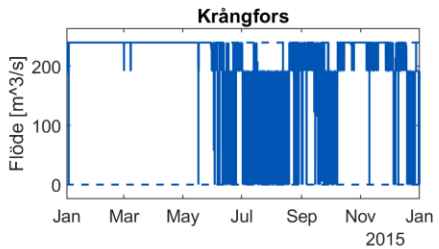
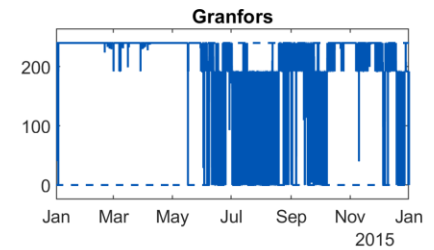
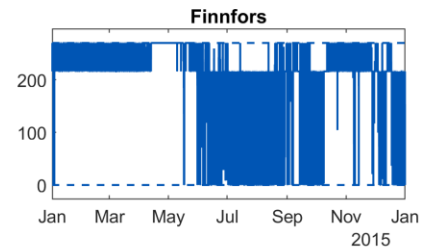
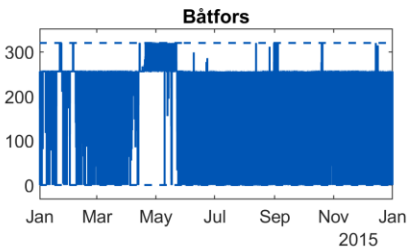
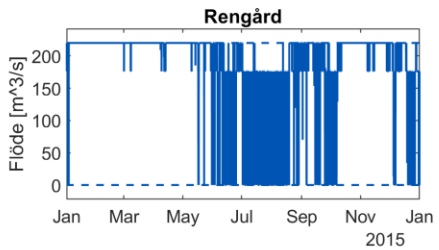
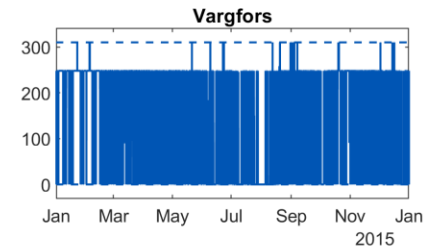
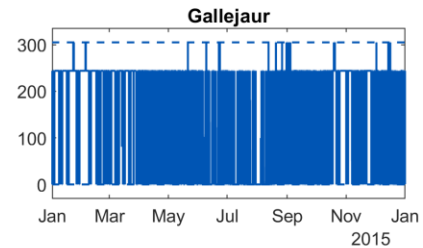
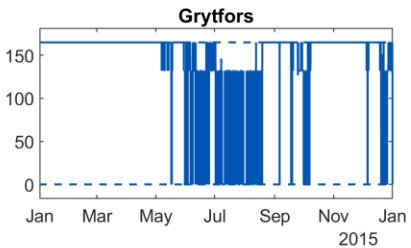
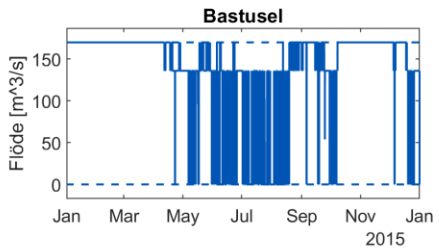
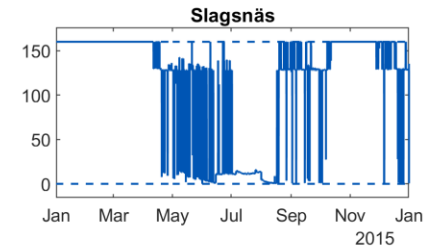
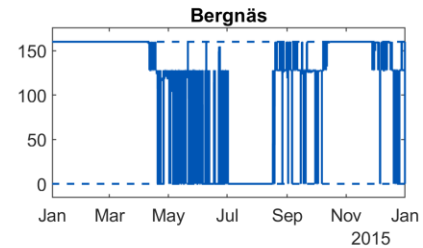
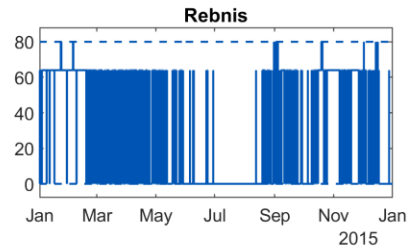
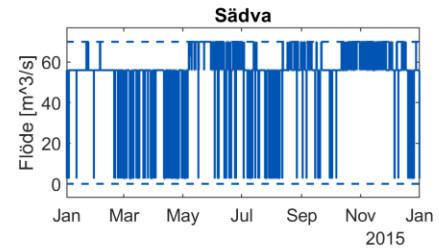


Vattendomar "MinSpill"



Vattendomar "MinFlow"

Turbinvattenförling för Skellefteälven

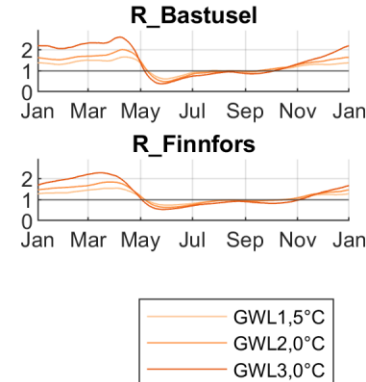
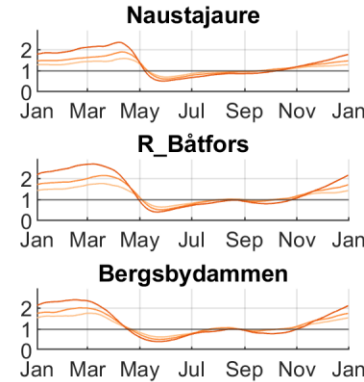
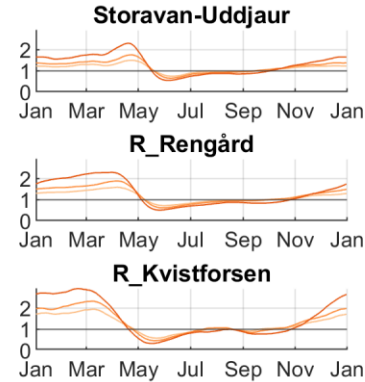
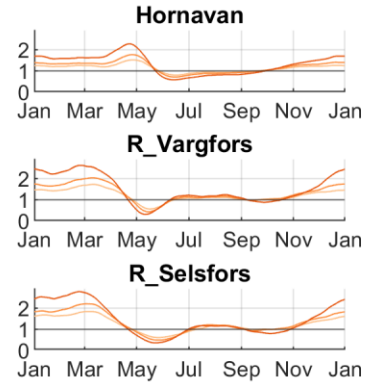
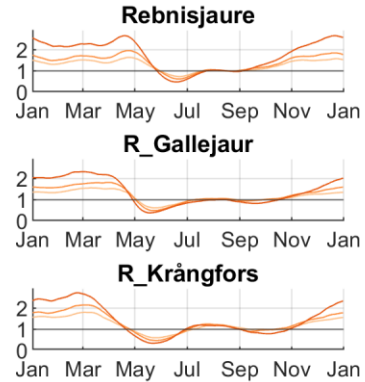
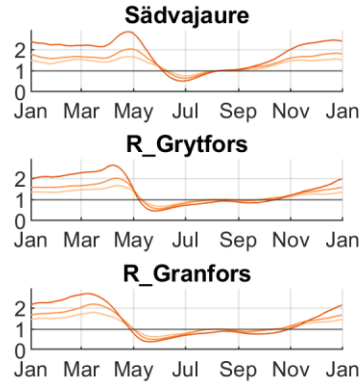


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Klimatpåverkan på lokaltillrinningar

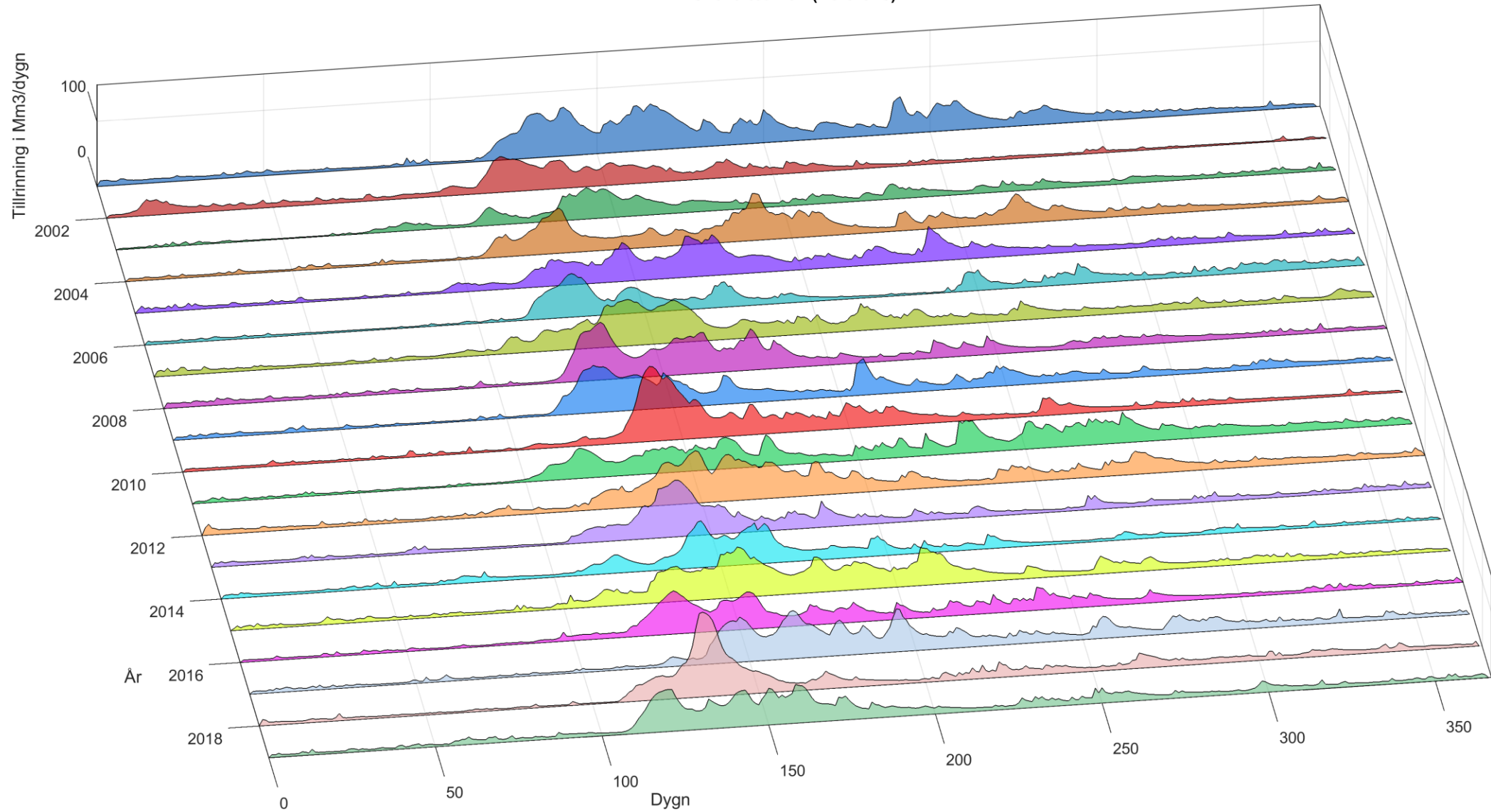
Klimatfaktorer

Klimatfaktorer Skellefteälven



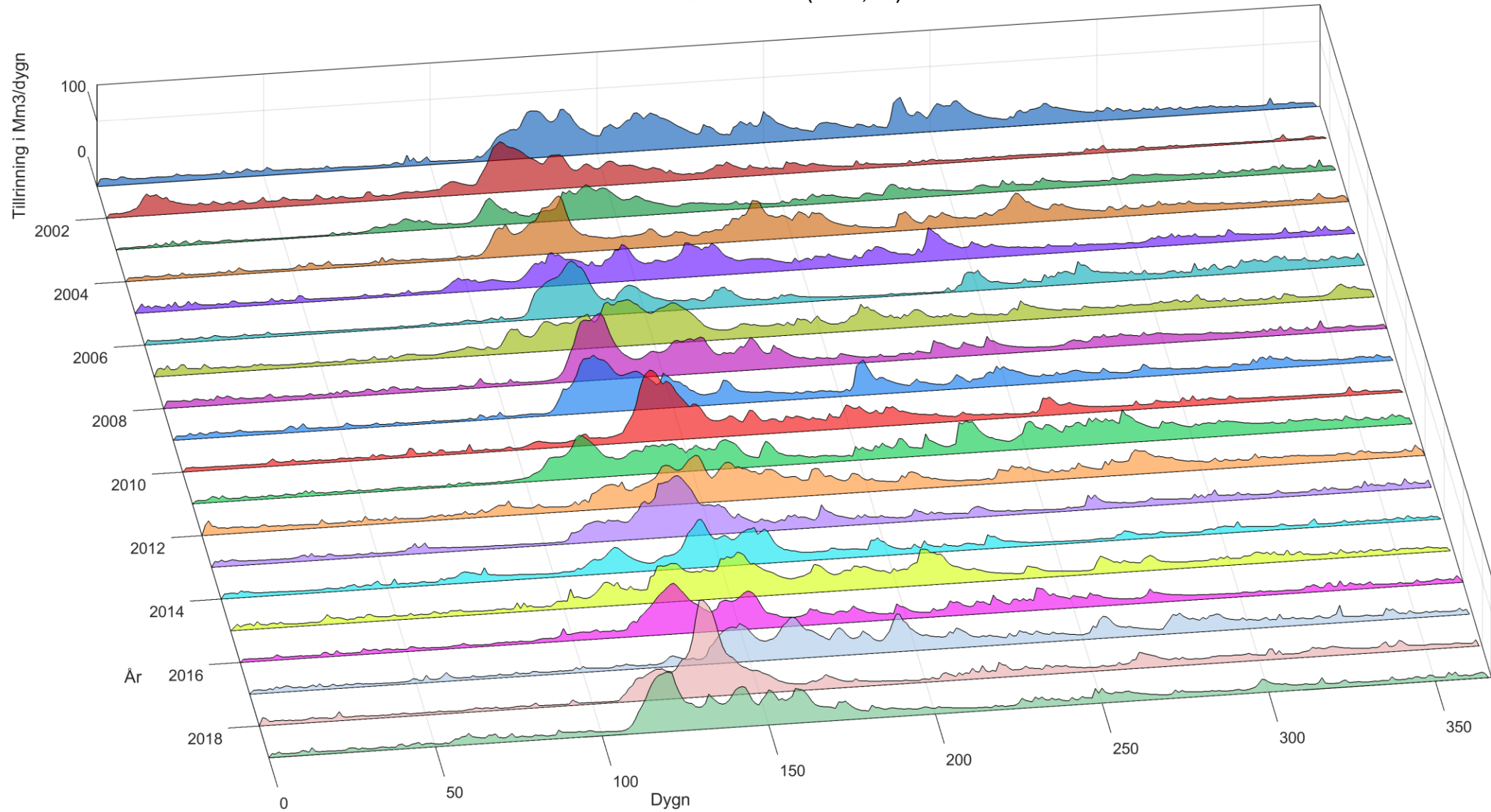
Total tillrinning (Referens)

Skellefteälven (Referens)



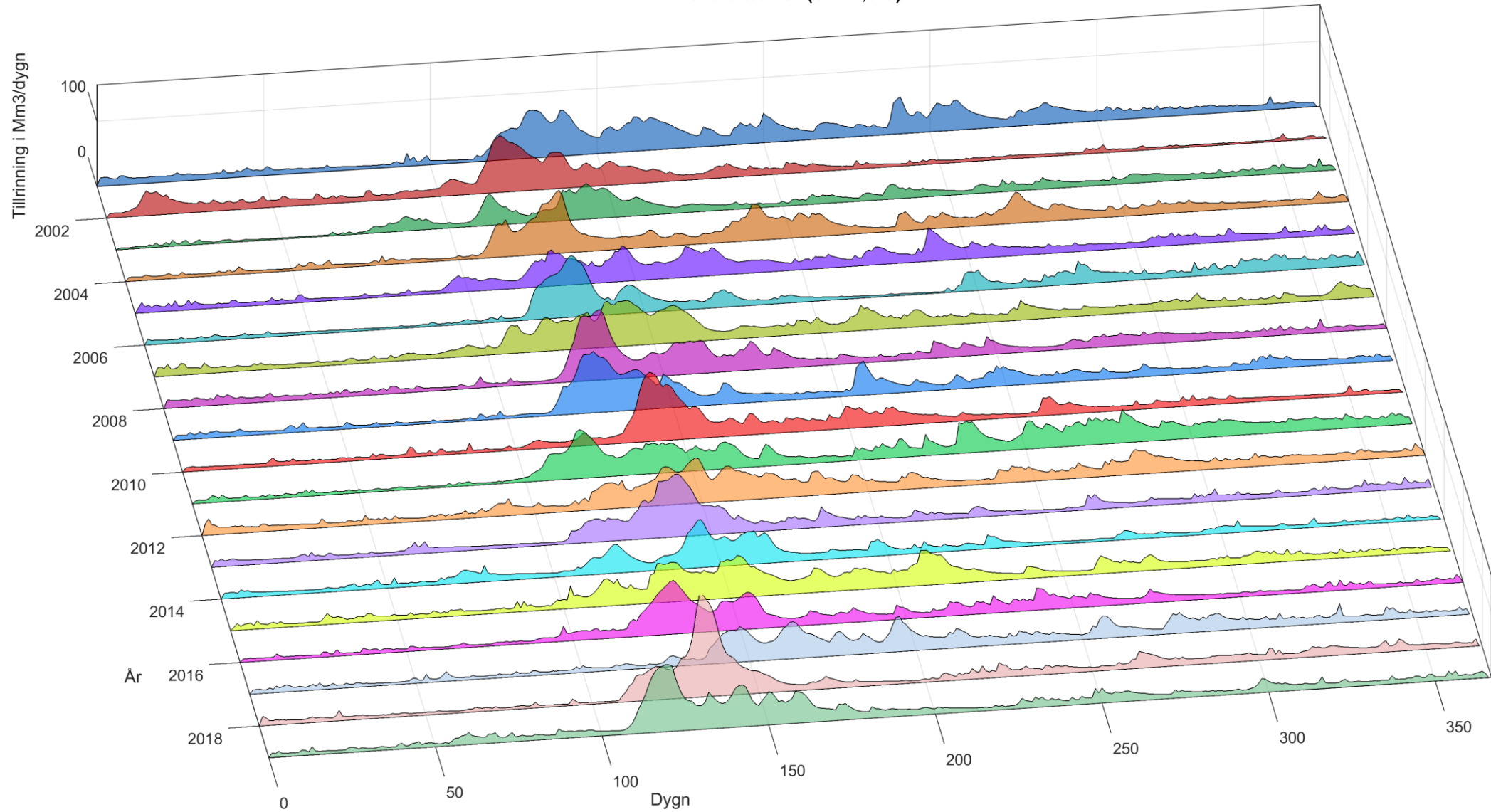
Total tillrinning (GWL1,5°C)

Skellefteälven (GWL1,5°C)



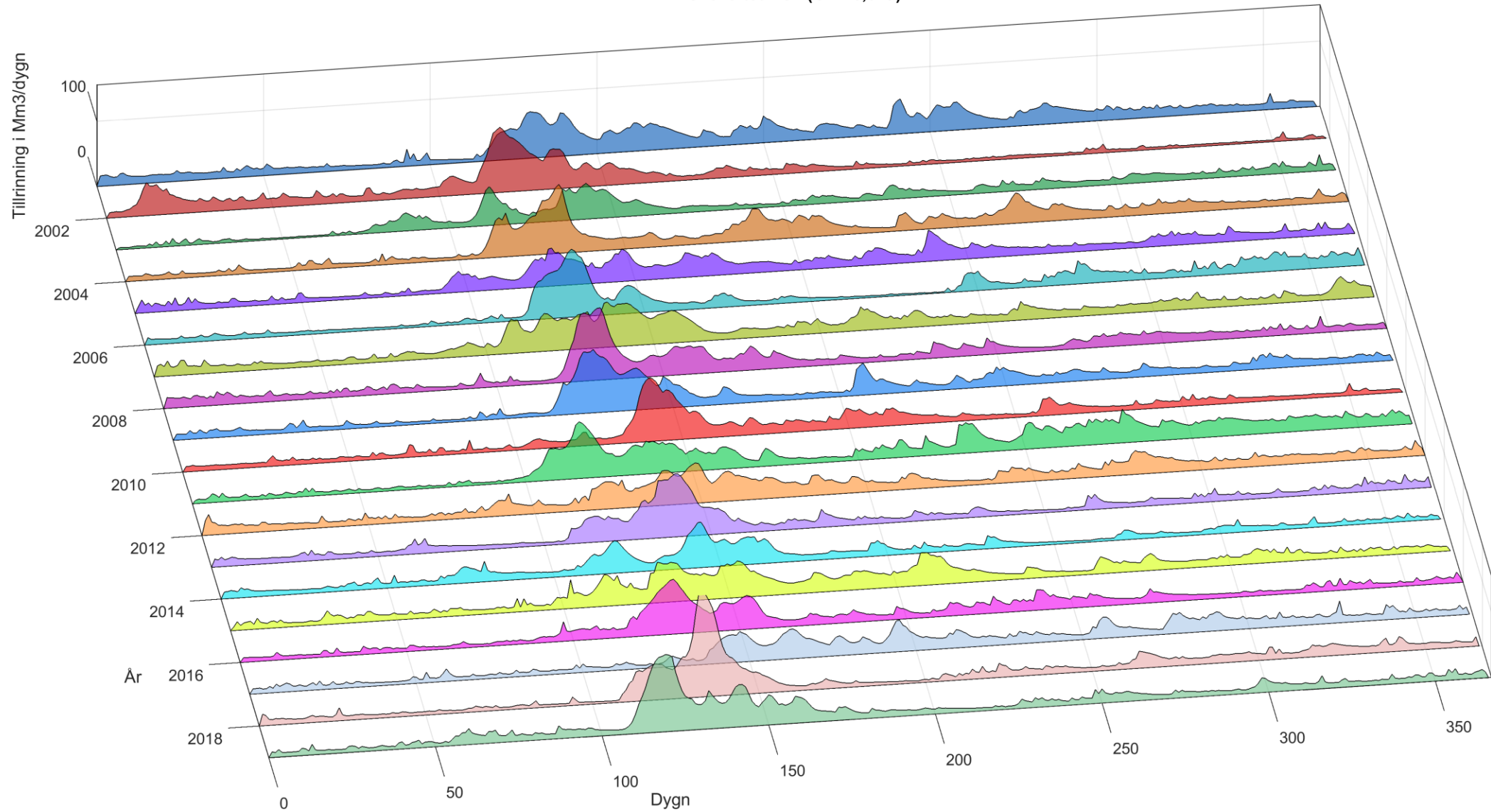
Total tillrinning (GWL2,0°C)

Skellefteälven (GWL2,0°C)



Total tillrinning (GWL3,0°C)

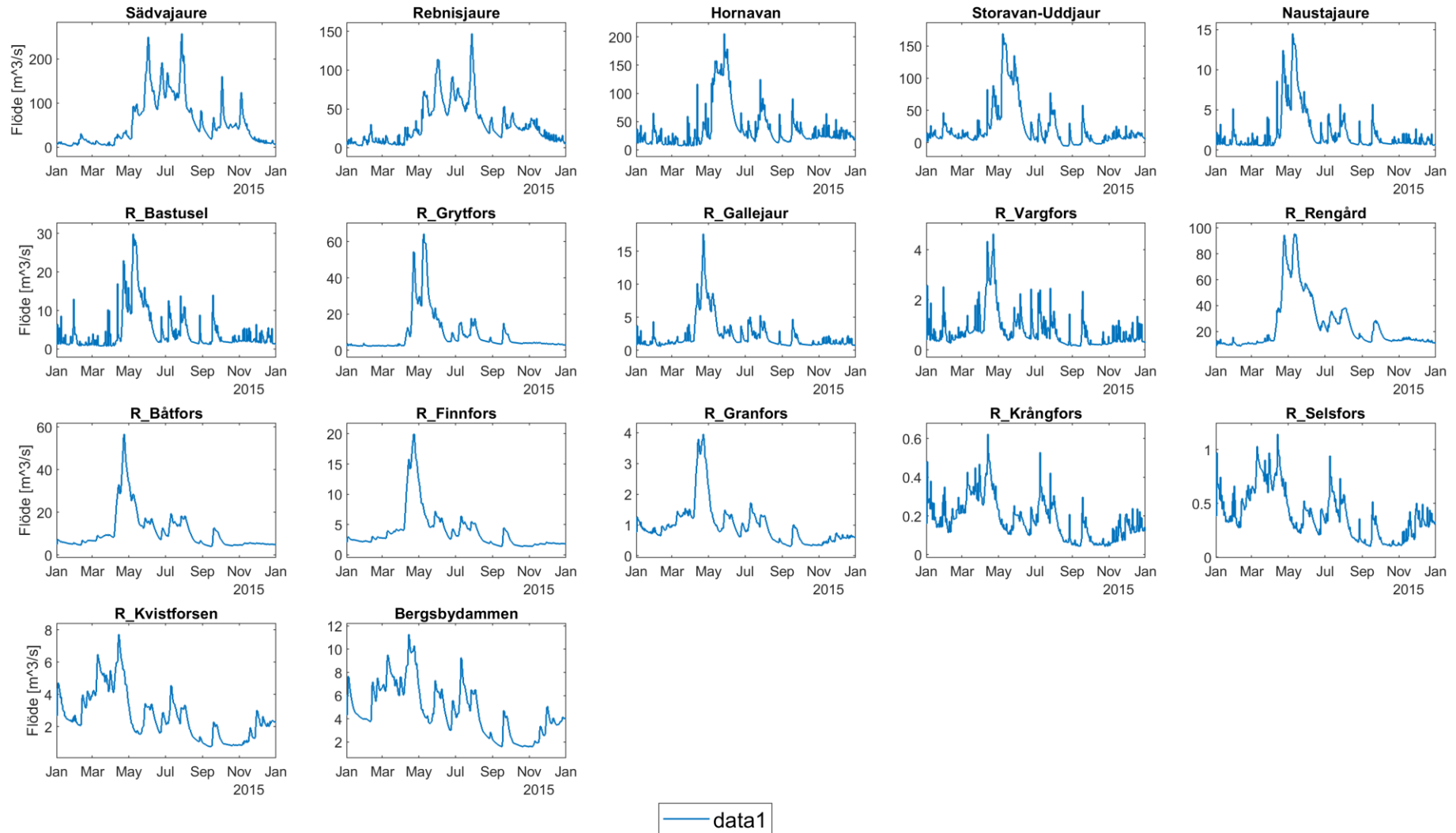
Skellefteälven (GWL3,0°C)



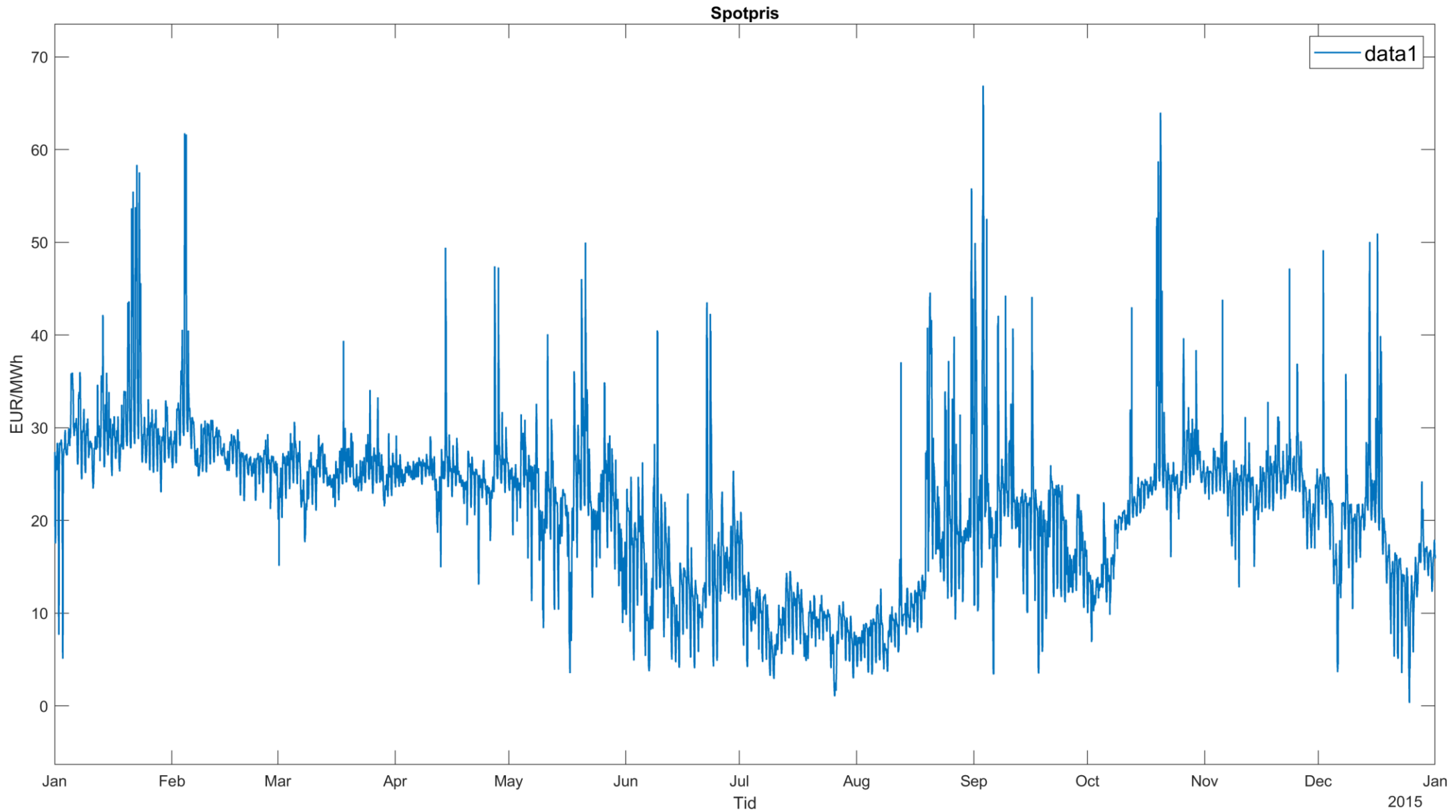
Resultat (exempel GWL2,0°C för 2015)

Lokaltillrinning

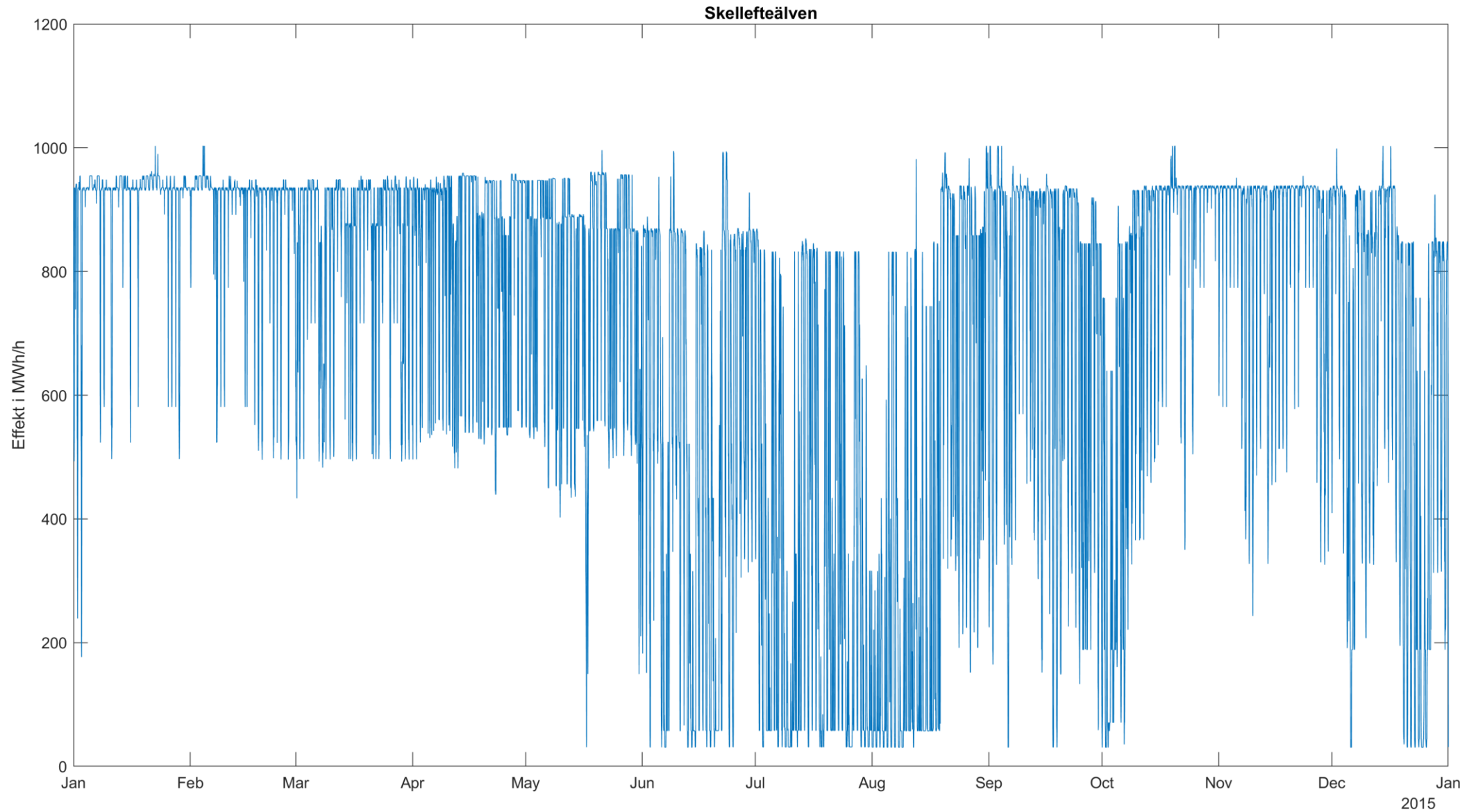
Lokal tillrinning för Skellefteälven



Elpriser

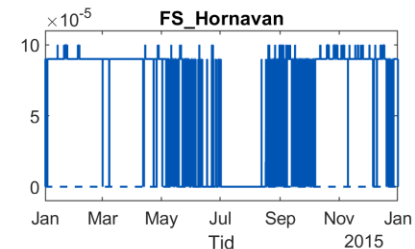
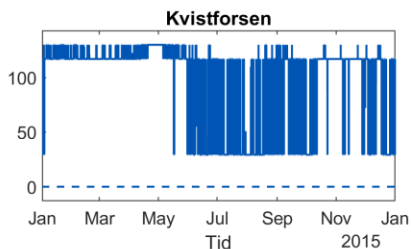
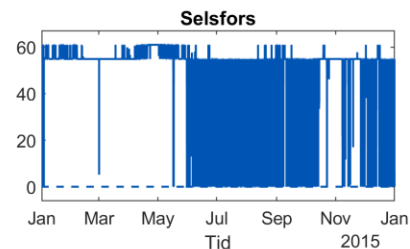
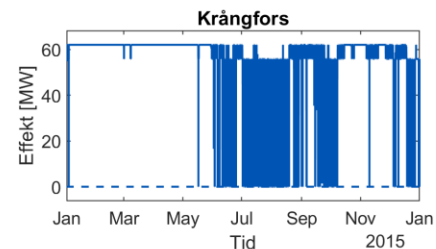
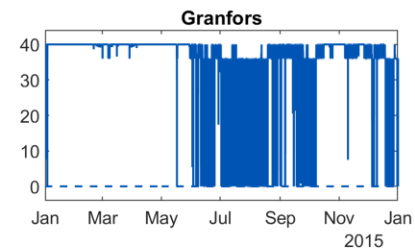
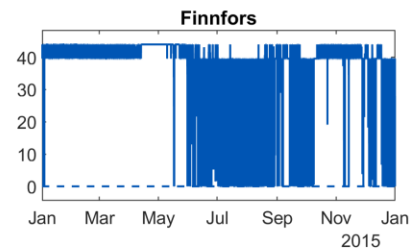
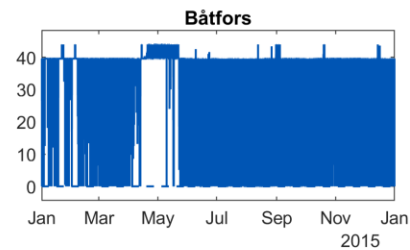
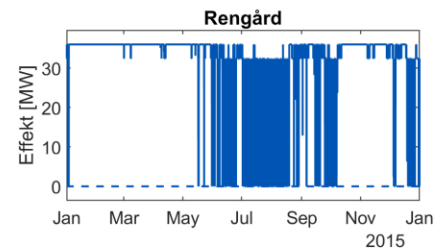
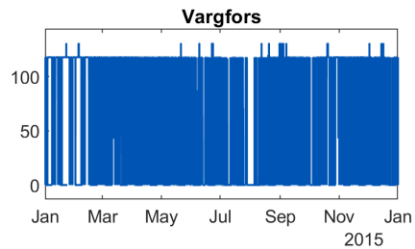
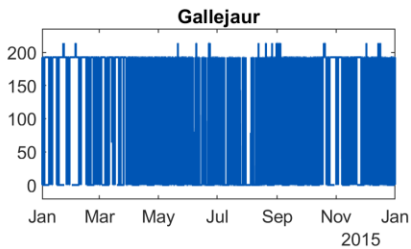
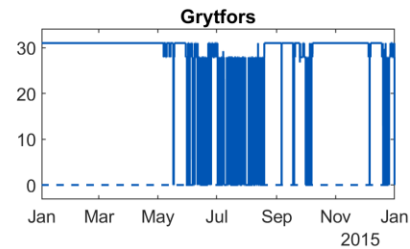
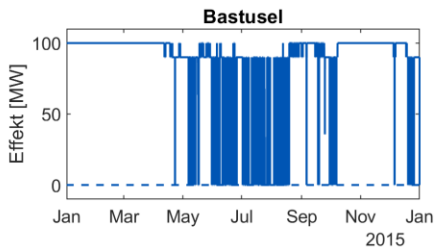
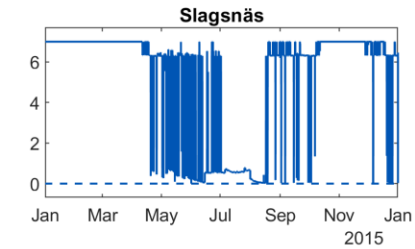
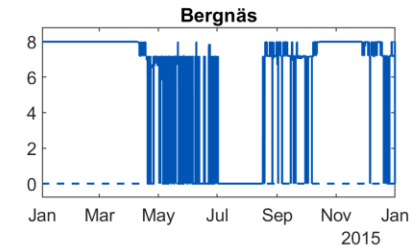
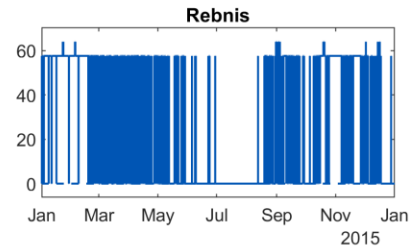
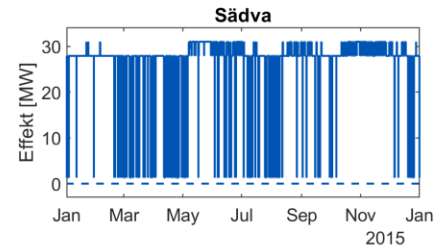


Produktion älvsystem



Produktion

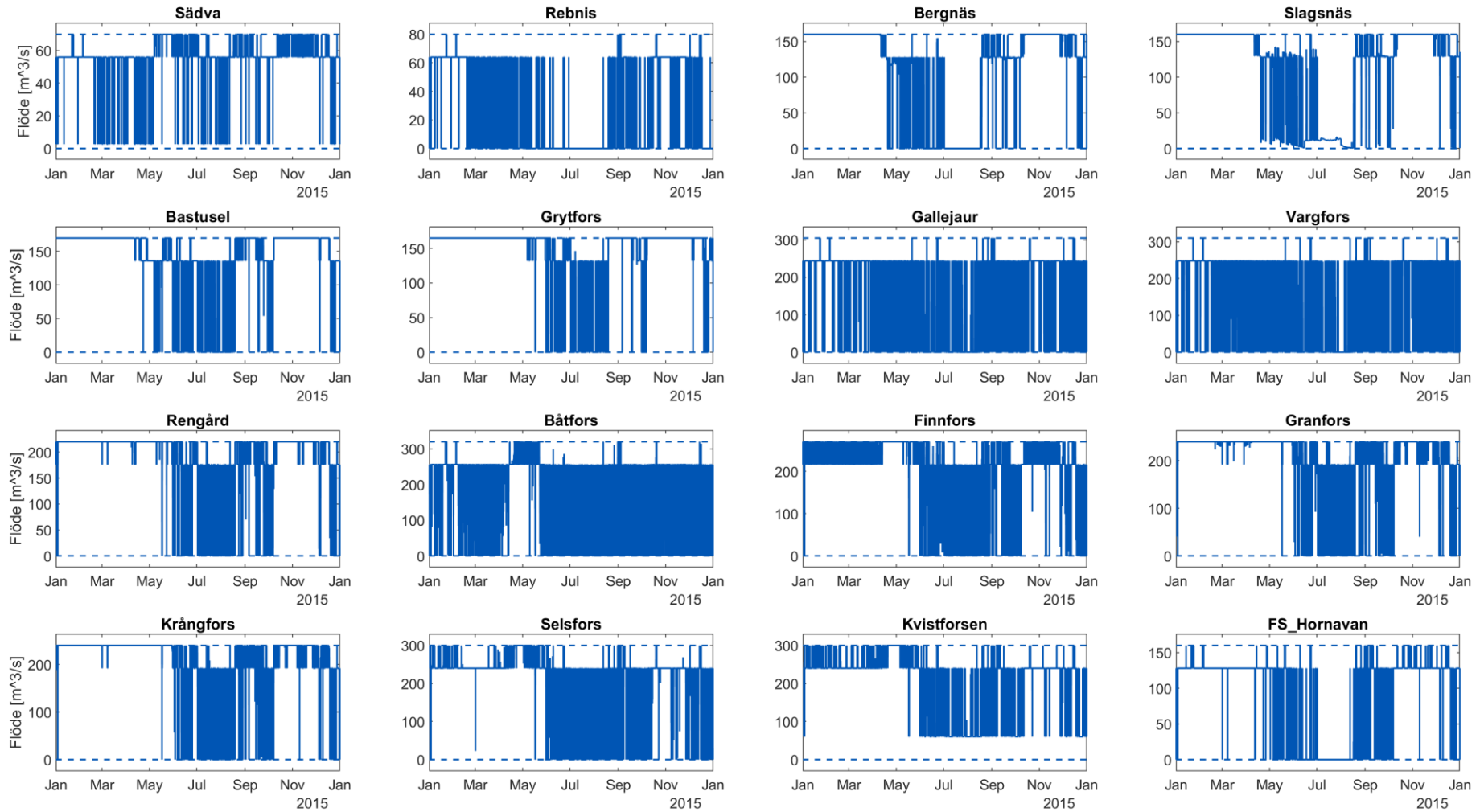
Produktion per station för Skellefteälven



— KLIVA

Stationsvattenföring

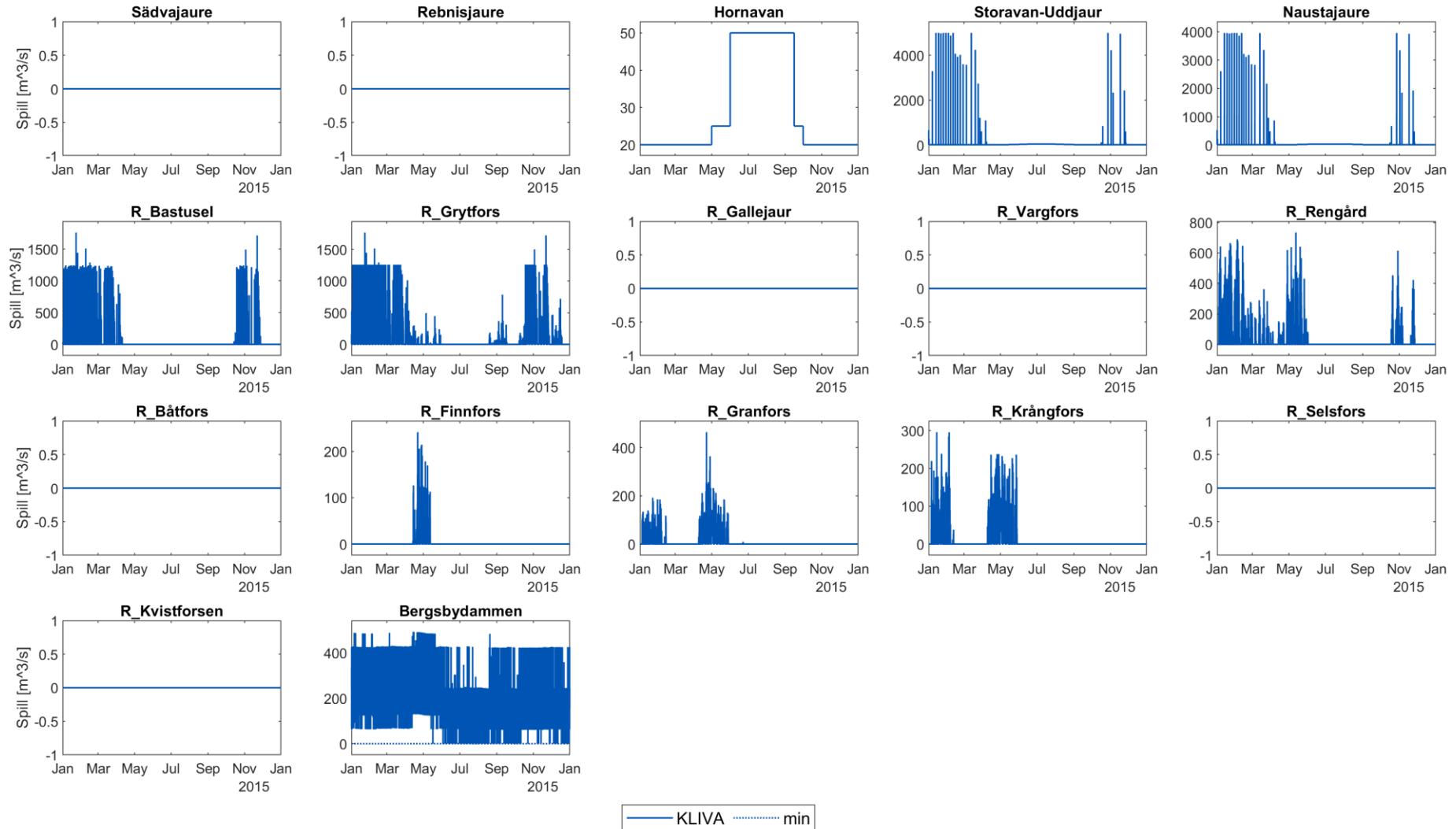
Turbinvattenföring för Skellefteälven



— KLIVA

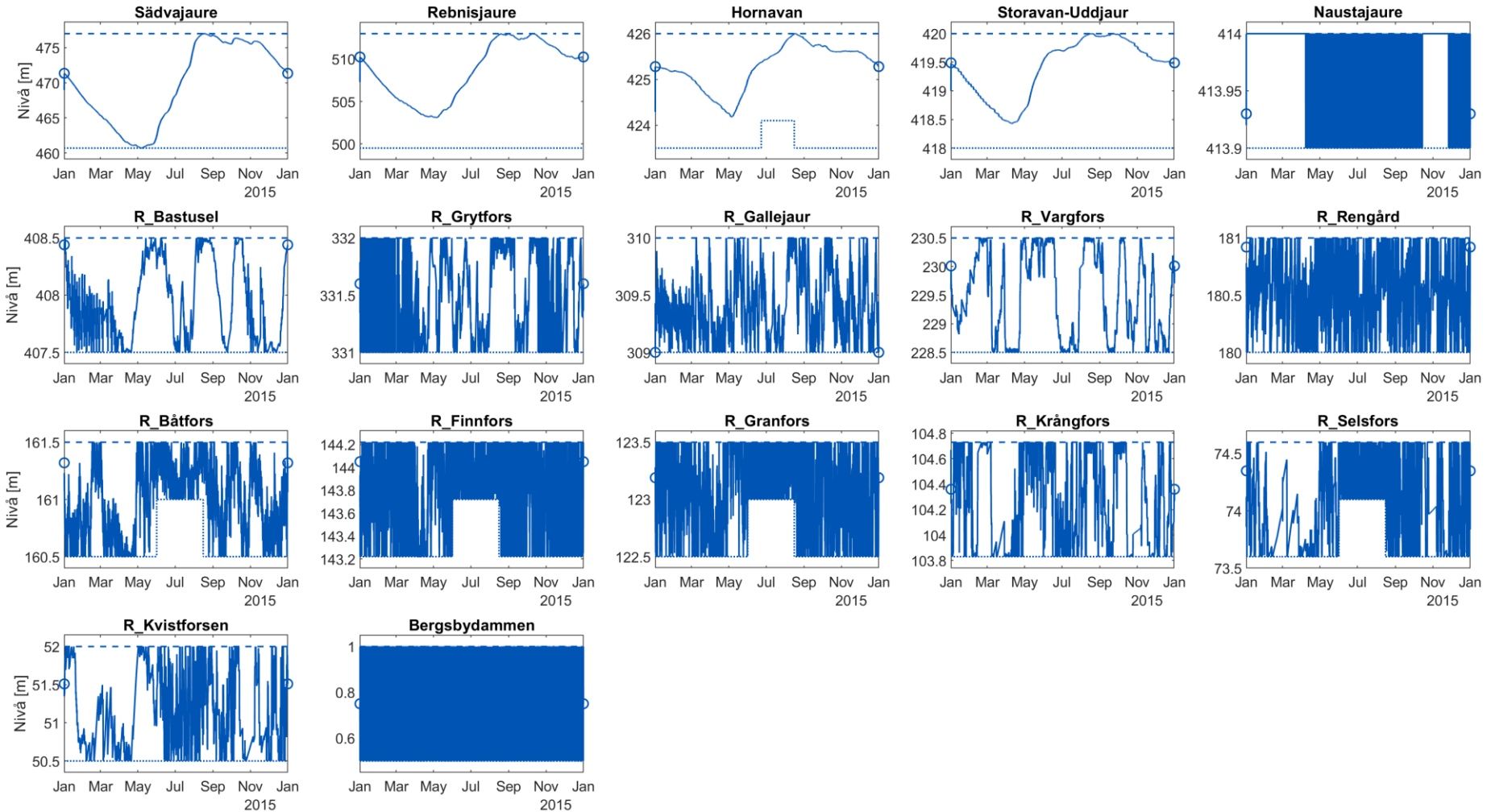
Spill

Skellefteälven



Vattenstånd

Skellefteälven

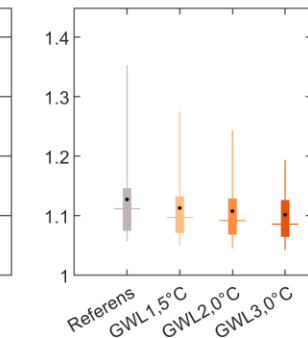
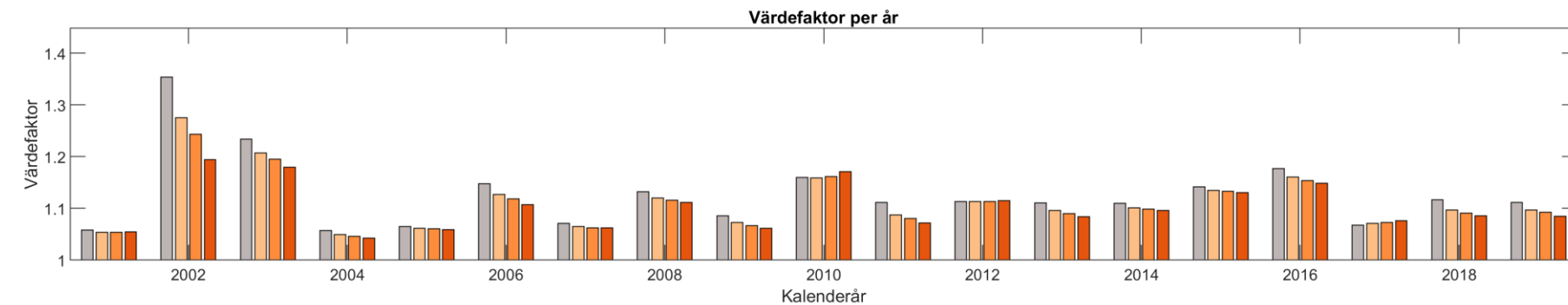
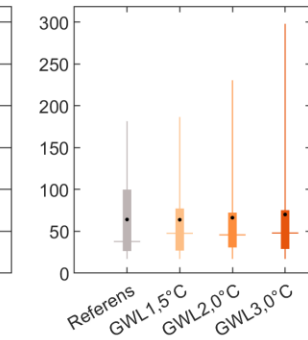
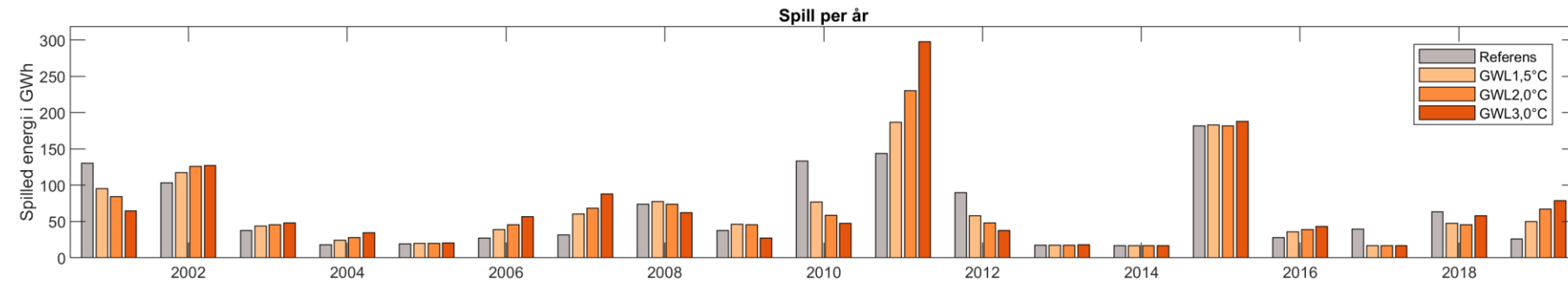
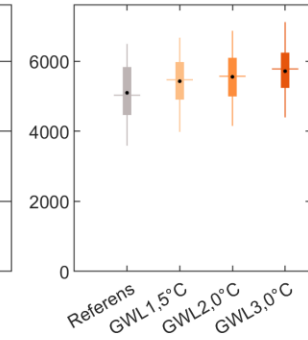
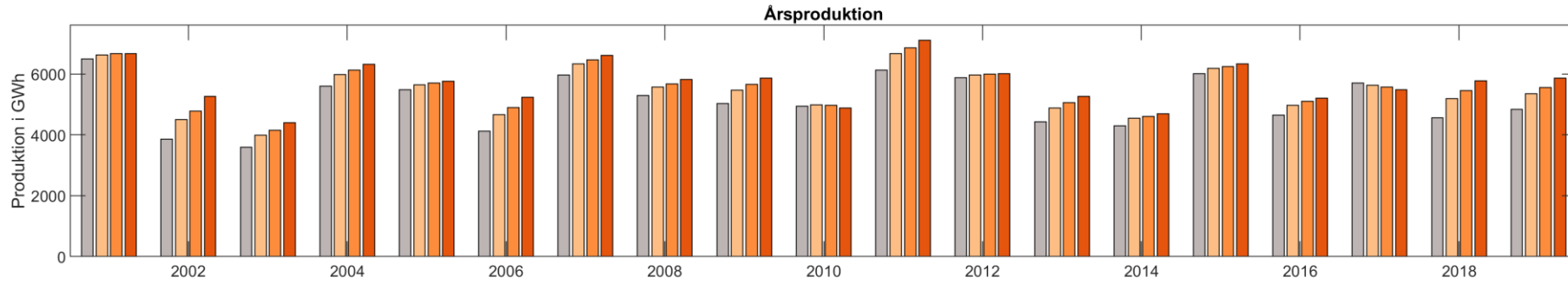


— KLIVA min - - - max ○ Randvillkor

Aggregerade resultat

Årsvärden produktion, spill, värdefaktor

Skellefteälven



Statistik produktion, spill, värdefaktor

Produktion i GWh

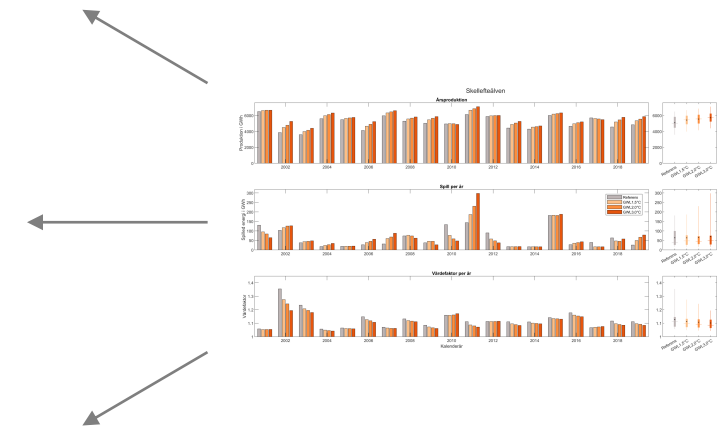
GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	5100	(Ref)	(Ref)	4466	5837	1371	3592	6495
GWL1, 5°C	5432	+332	+7 %	4906	5979	1073	3985	6675
GWL2, 0°C	5557	+457	+9 %	4997	6101	1104	4156	6870
GWL3, 0°C	5718	+618	+12 %	5241	6246	1005	4399	7120

Spill i GWh

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	64	(Ref)	(Ref)	26	100	74	17	182
GWL1, 5°C	64	+0	+0 %	27	77	50	17	187
GWL2, 0°C	66	+2	+3 %	31	72	41	17	231
GWL3, 0°C	70	+6	+9 %	29	75	46	17	298

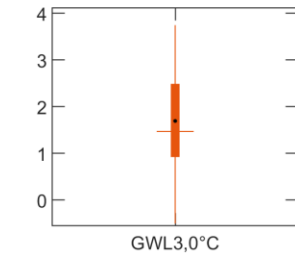
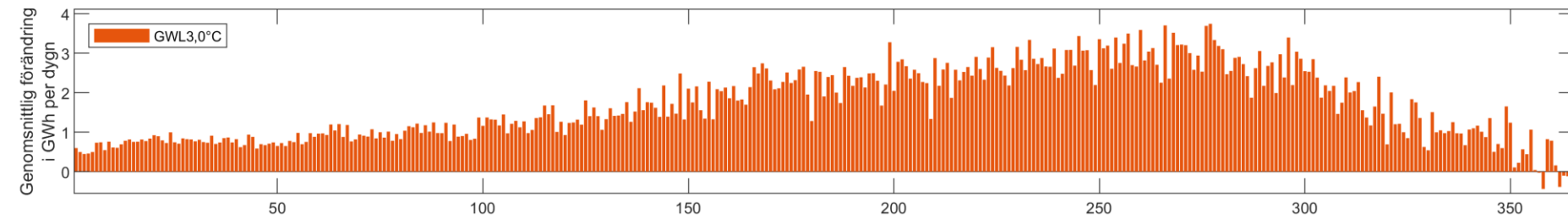
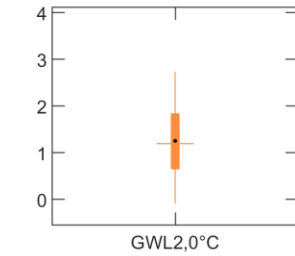
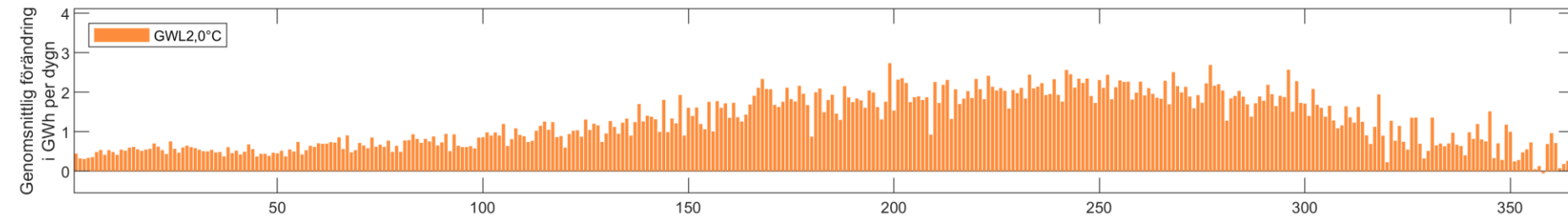
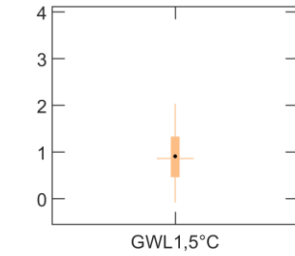
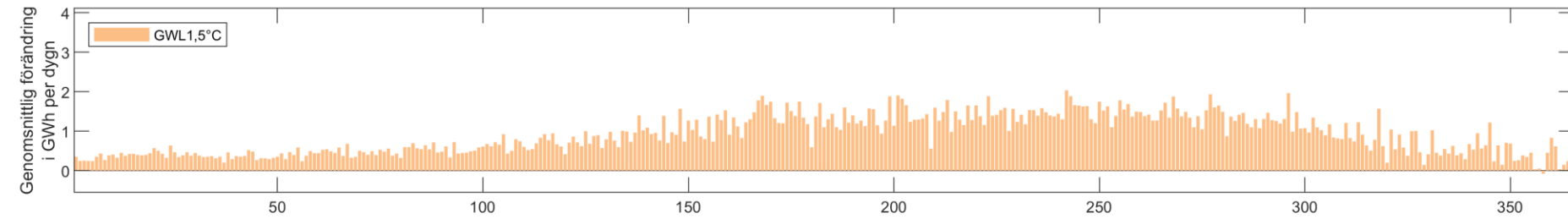
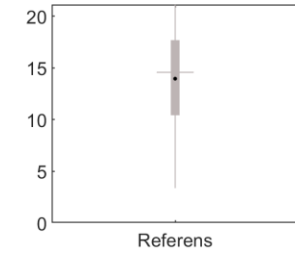
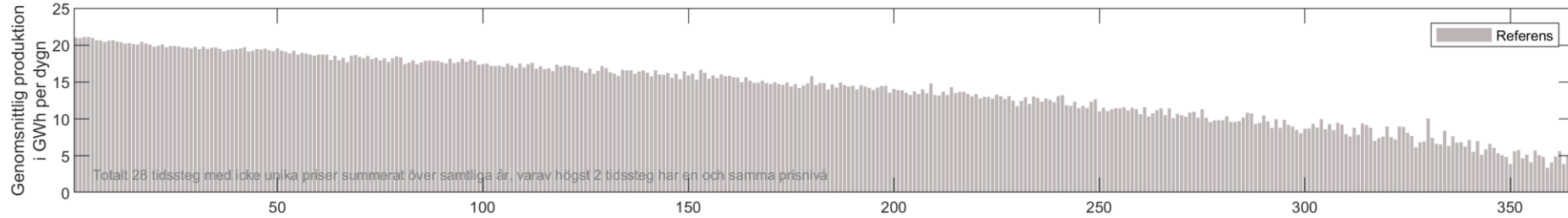
Värdefaktor

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	1.128	(Ref)	(Ref)	1.075	1.146	0.071	1.057	1.353
GWL1, 5°C	1.113	-0.015	-1 %	1.071	1.133	0.062	1.049	1.275
GWL2, 0°C	1.108	-0.020	-2 %	1.069	1.129	0.060	1.046	1.244
GWL3, 0°C	1.102	-0.026	-2 %	1.065	1.127	0.062	1.043	1.194



Förändring i balanseringsförmågan

Flerårs prissorterad produktion Skellefteälven (24 h)



Dygn



Kontakt AP2

richard.scharff@vattenfall.com



KLIVA-rapport bilaga A Skellefteälven

Richard Scharff, Chalmers, 2023-02-01

Kommentarer

- Bilagan innehåller ett axplock av diagram för att illustrera indata till vattenkraftmodellen samt dess resultat
- Resultaten skiljer sig mellan älvsystem, år och uppvärmningsnivå
- Insikter, slutsatser och detaljer beskrivs i rapporten

→ Rapporten finns på: <https://energiforsk.se/program/klimatforandringarnas-inverkan-pa-vattenkraften/rapporter/klimatforandringarnas-inverkan-pa-vattenkraftens-produktions-och-reglerformaga/>



Energiforsk

KLIVA-projektet har analyserat **klimatförändringarnas påverkan** på vattenkraftens produktions- och balanseringsförmåga

Innehåll diagrammsamling

- Systembeskrivning
 - Älvsystem
 - Energi per Mm³ lokaltillrinning
 - Vattendomar
- Klimatpåverkan lokaltillrinning
 - Klimatfaktorer
 - Total tillrinning

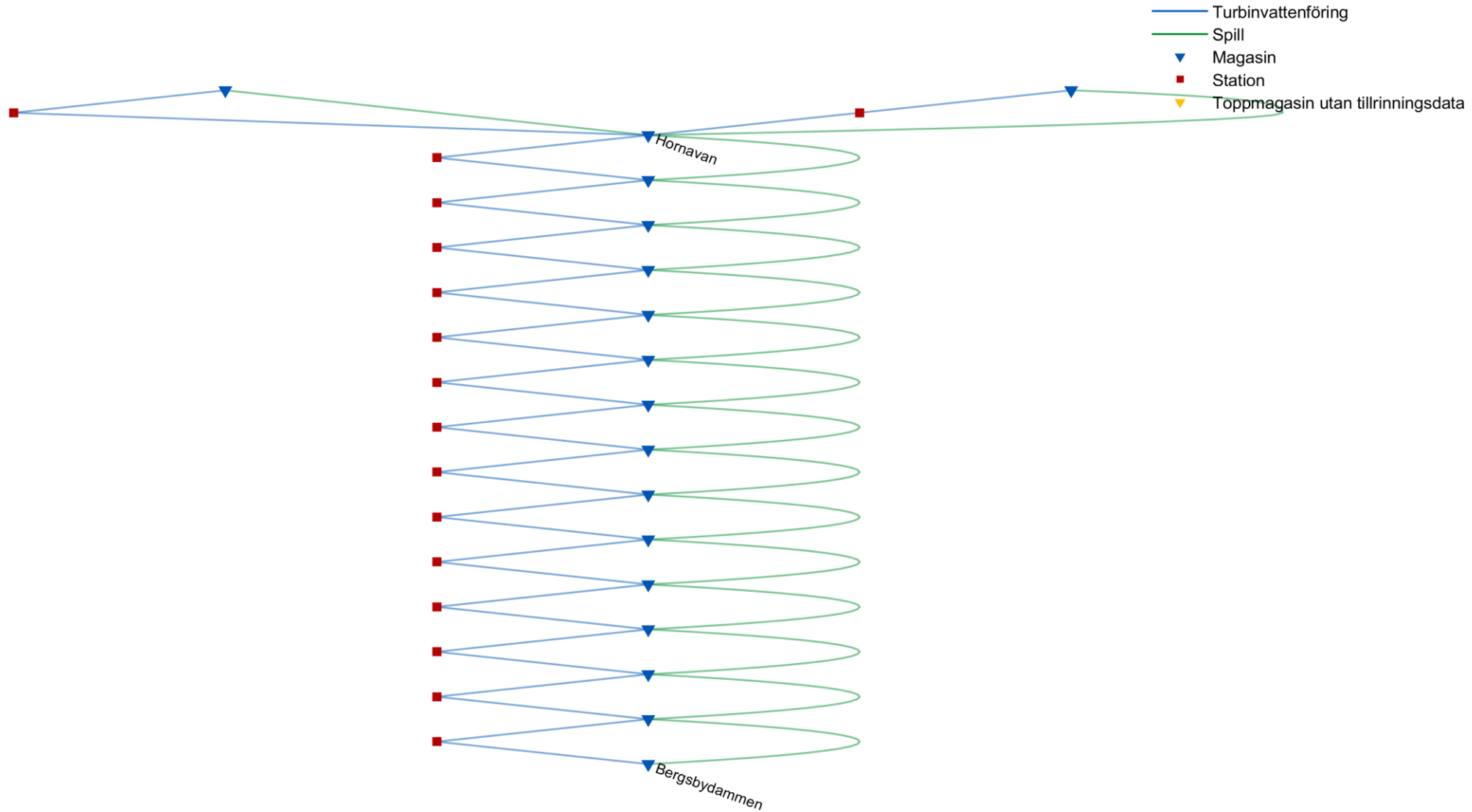
- Optimering
 - Lokaltillrinning
 - Elpriser
 - Älvens elproduktion
 - Produktion per station
 - Stationsvattenföring
 - Spill per magasin
 - Vattenytor per magasin
- Aggregerade resultat
 - Produktionsförmåga
 - Balanseringsförmåga

Optimeringen görs för **19 år**, alltid ett kalenderår i taget. I den här bilagan presenteras indata och resultat för **ett utvalt år** med uppvärmningsnivån **GWL2,0°C**.

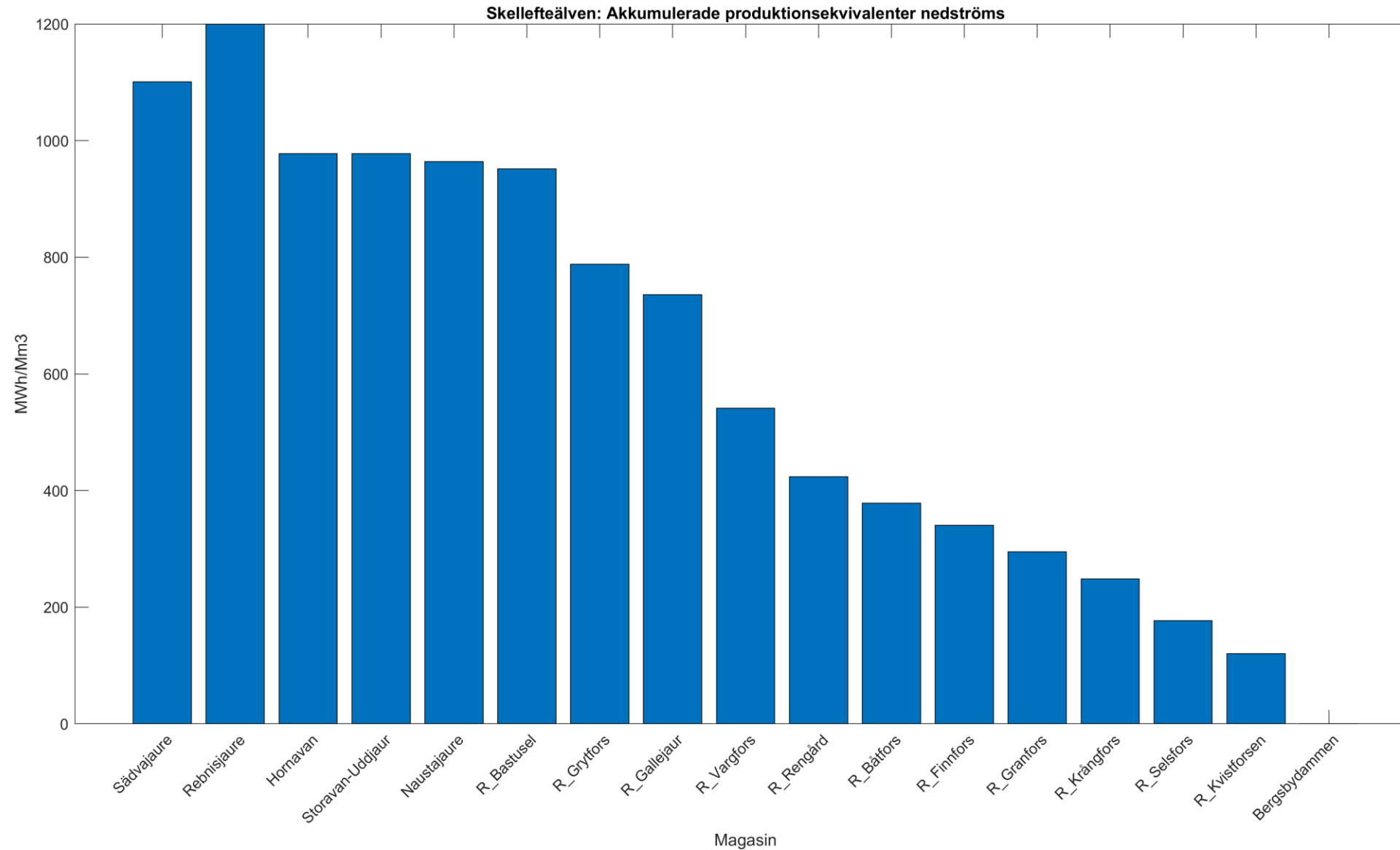
Systembeskrivning

Älvsystem

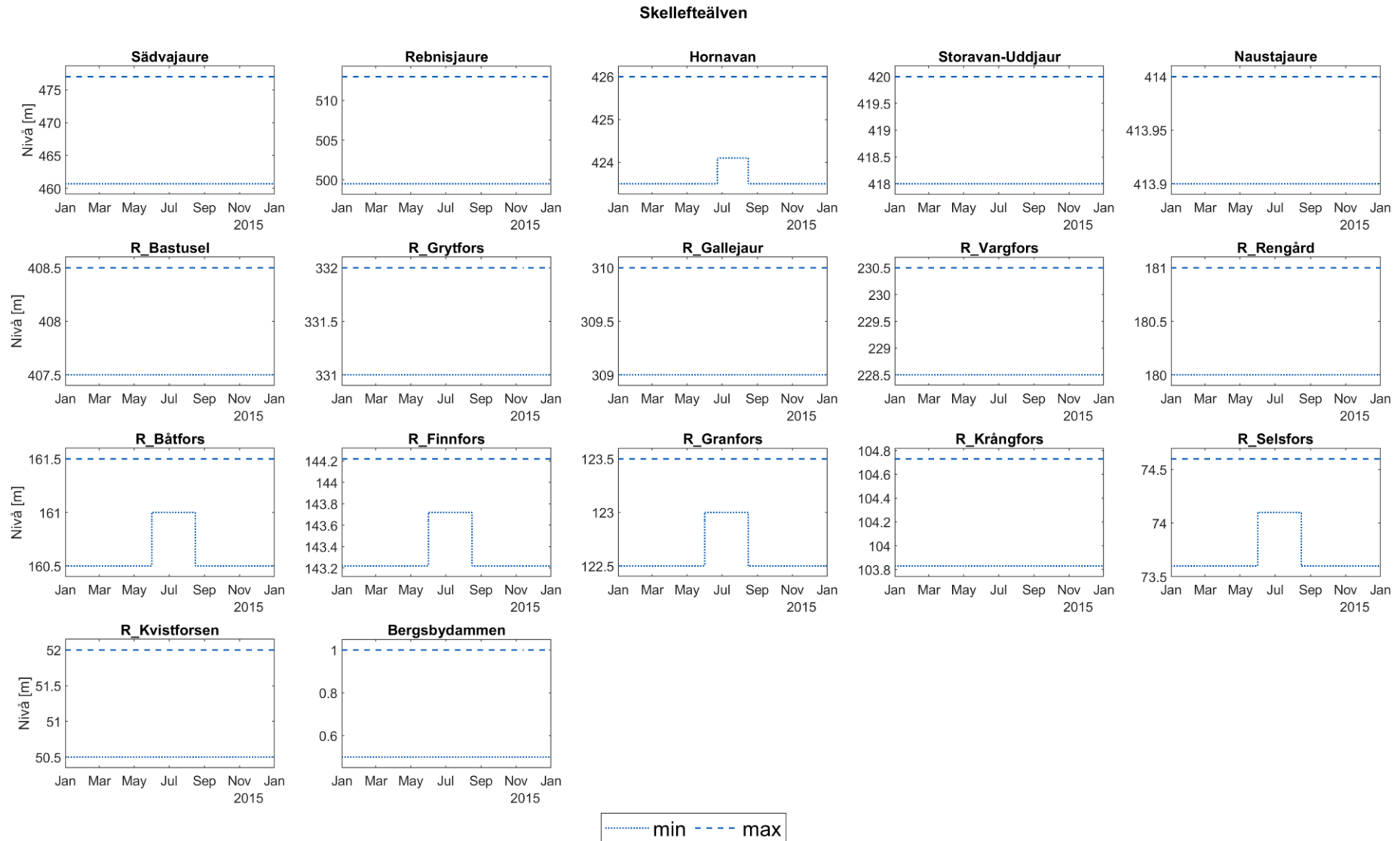
Skellefteälv



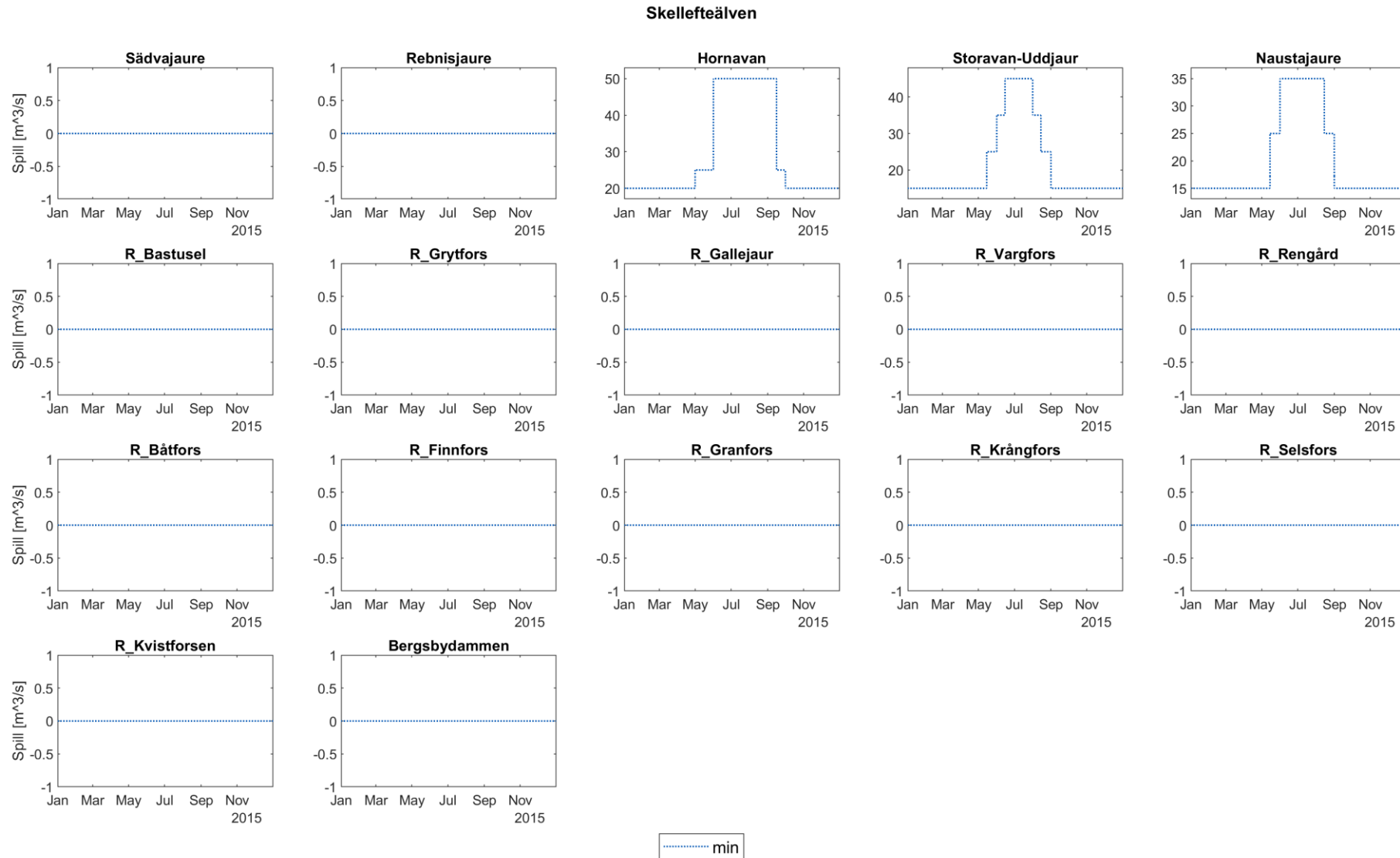
Energi per Mm³ lokaltillrinning



Vattendomar "WaterLevel"

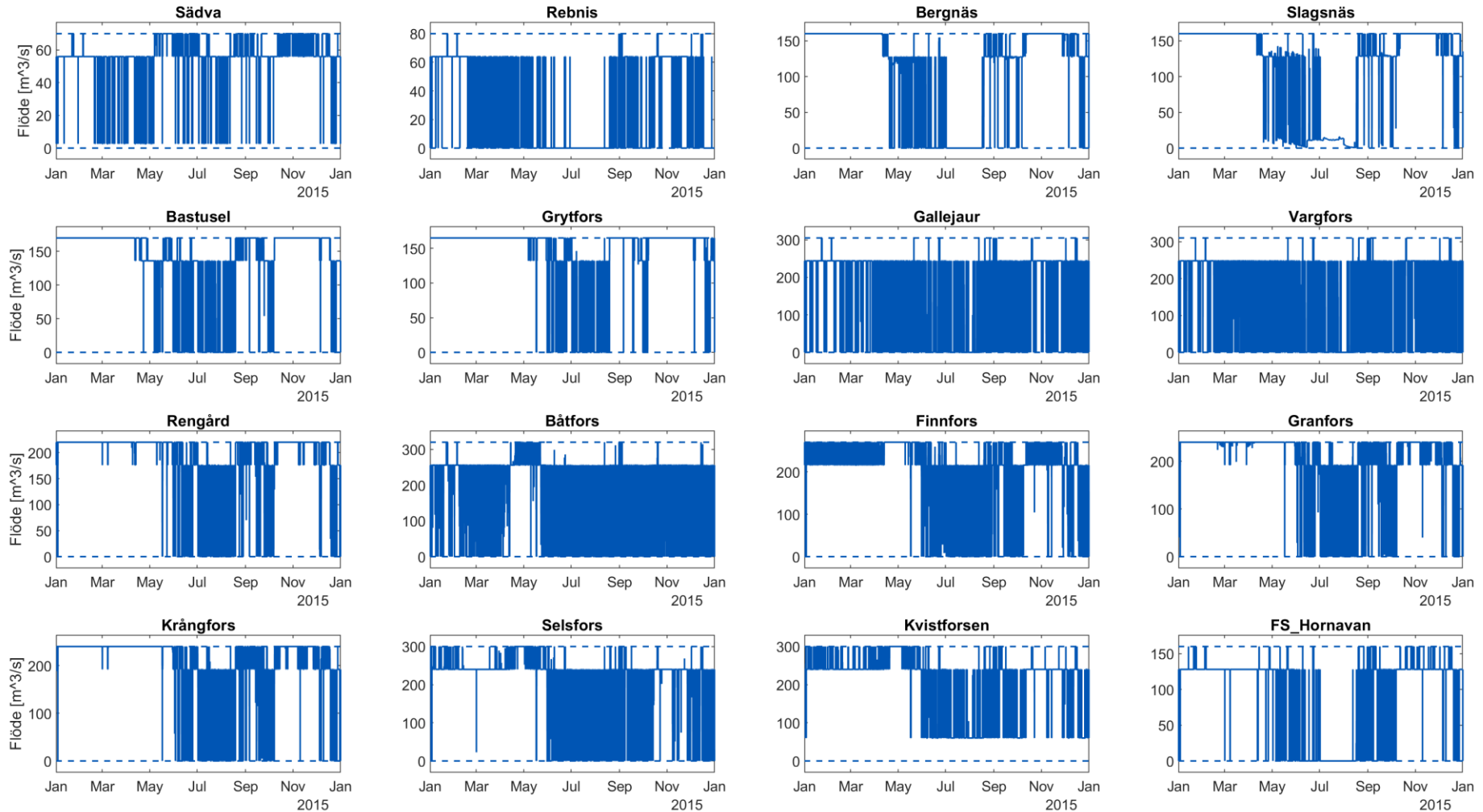


Vattendomar "MinSpill"



Vattendomar "MinFlow"

Turbinvattenföring för Skellefteälven

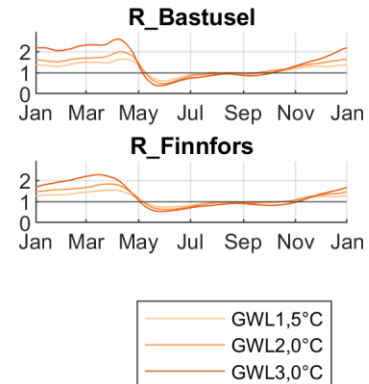
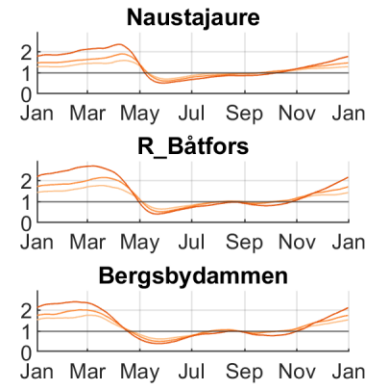
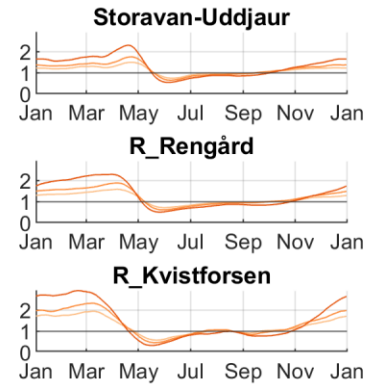
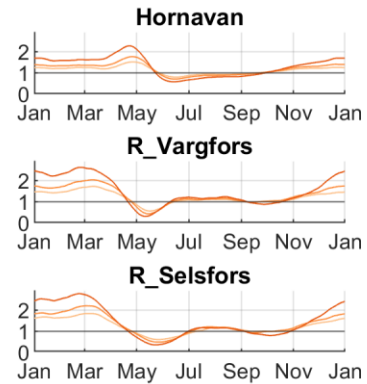
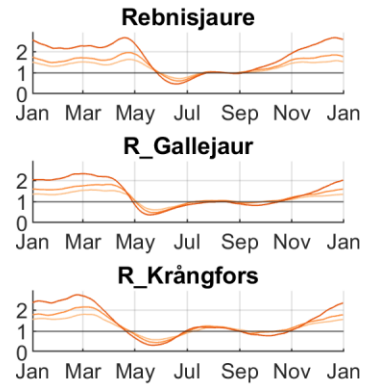
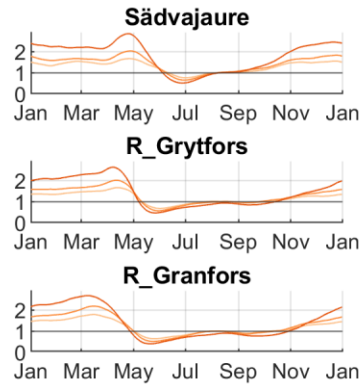


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Klimatpåverkan på lokaltillrinningar

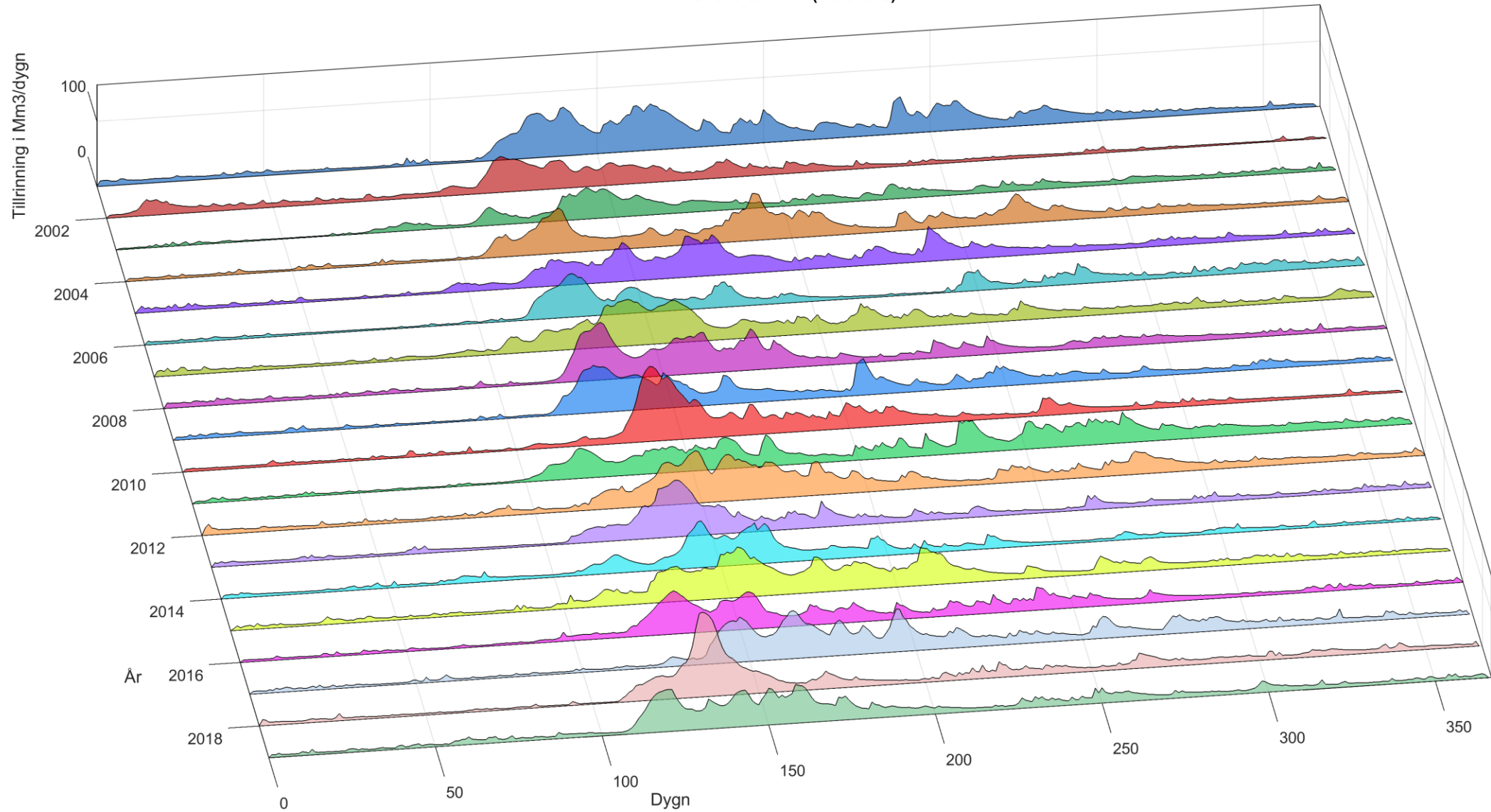
Klimatfaktorer

Klimatfaktorer Skellefteälven



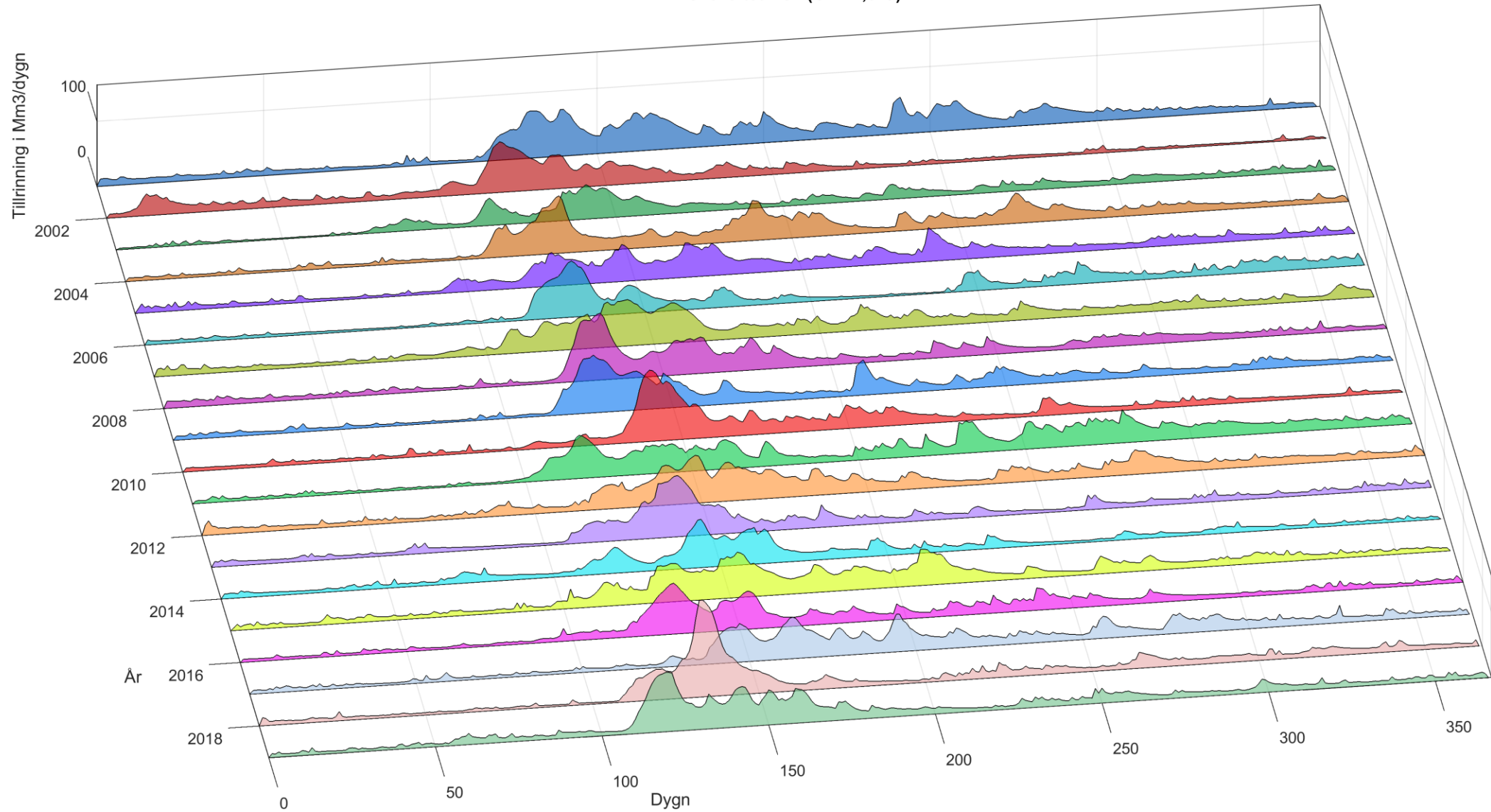
Total tillrinning (Referens)

Skellefteälven (Referens)



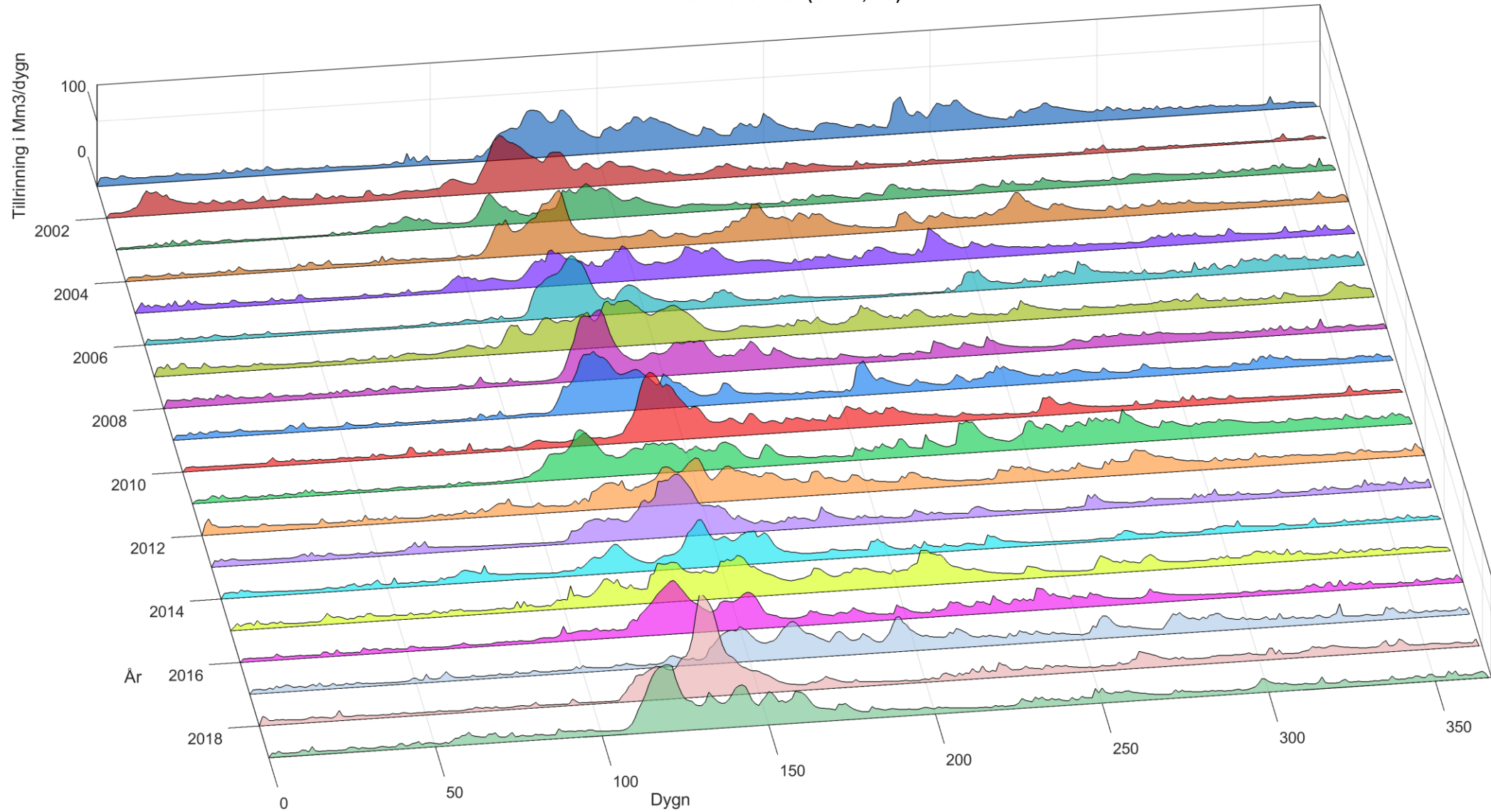
Total tillrinning (GWL1,5°C)

Skellefteälven (GWL1,5°C)



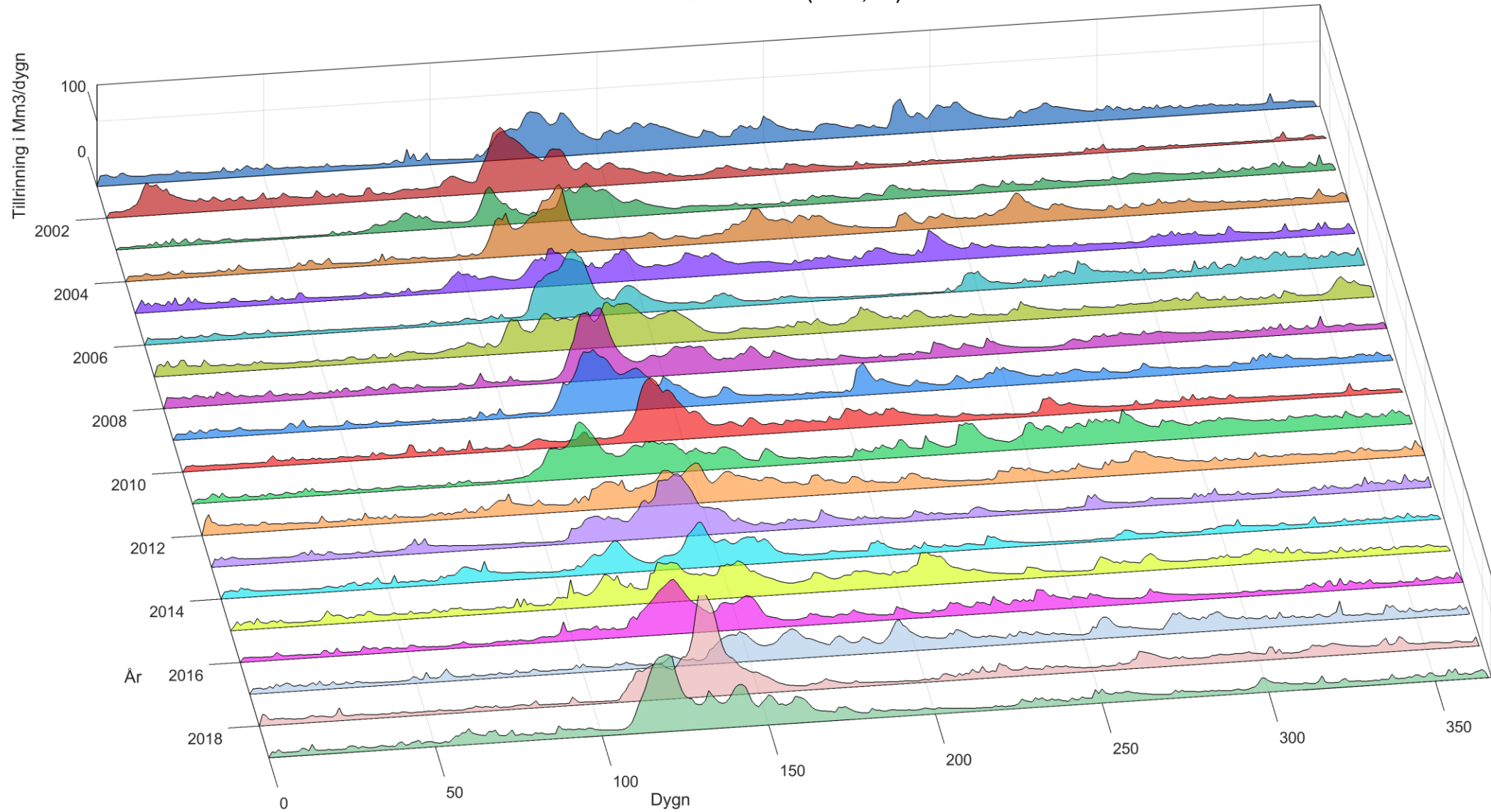
Total tillrinning (GWL2,0°C)

Skellefteälven (GWL2,0°C)



Total tillrinning (GWL3,0°C)

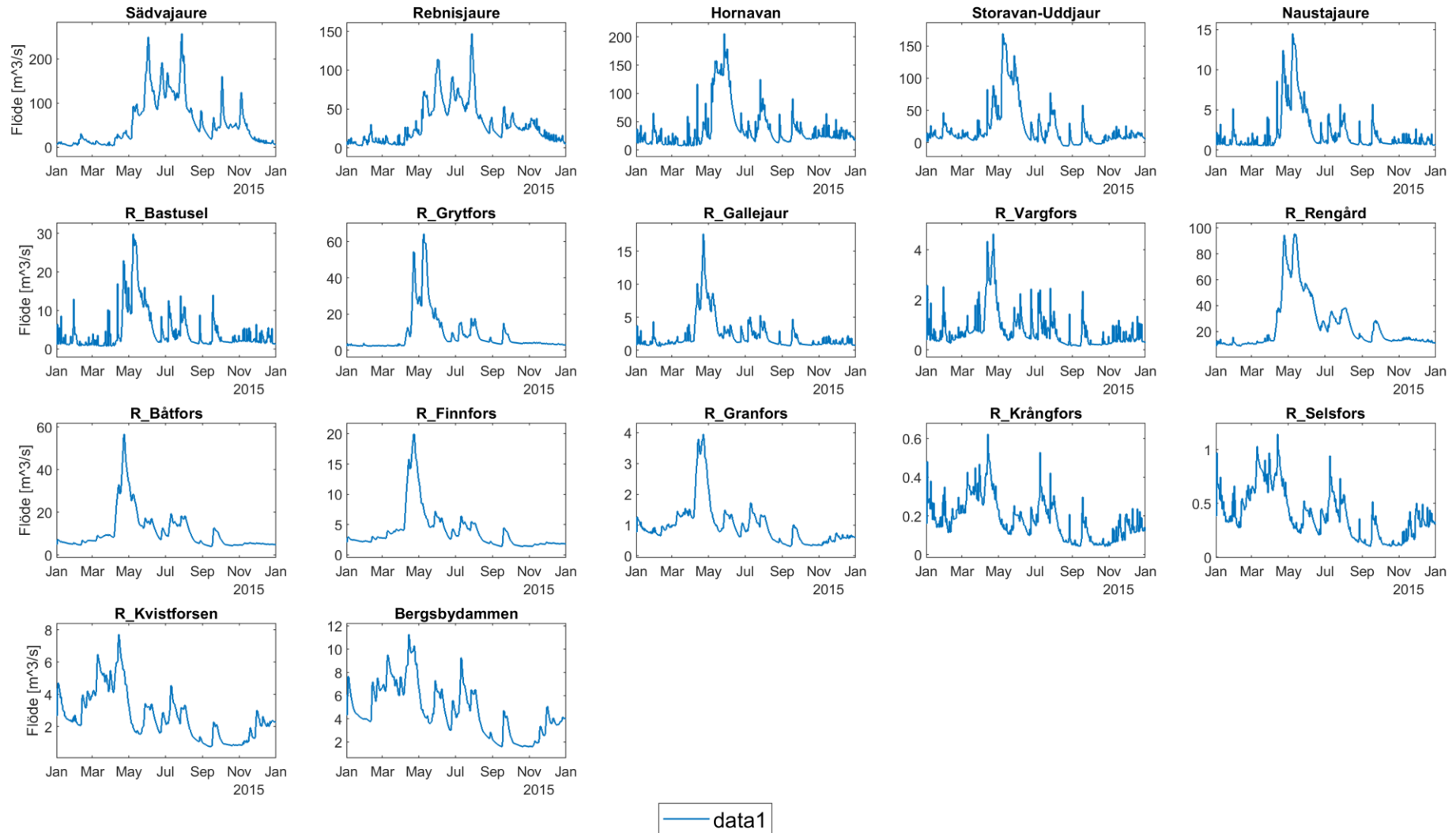
Skellefteälven (GWL3,0°C)



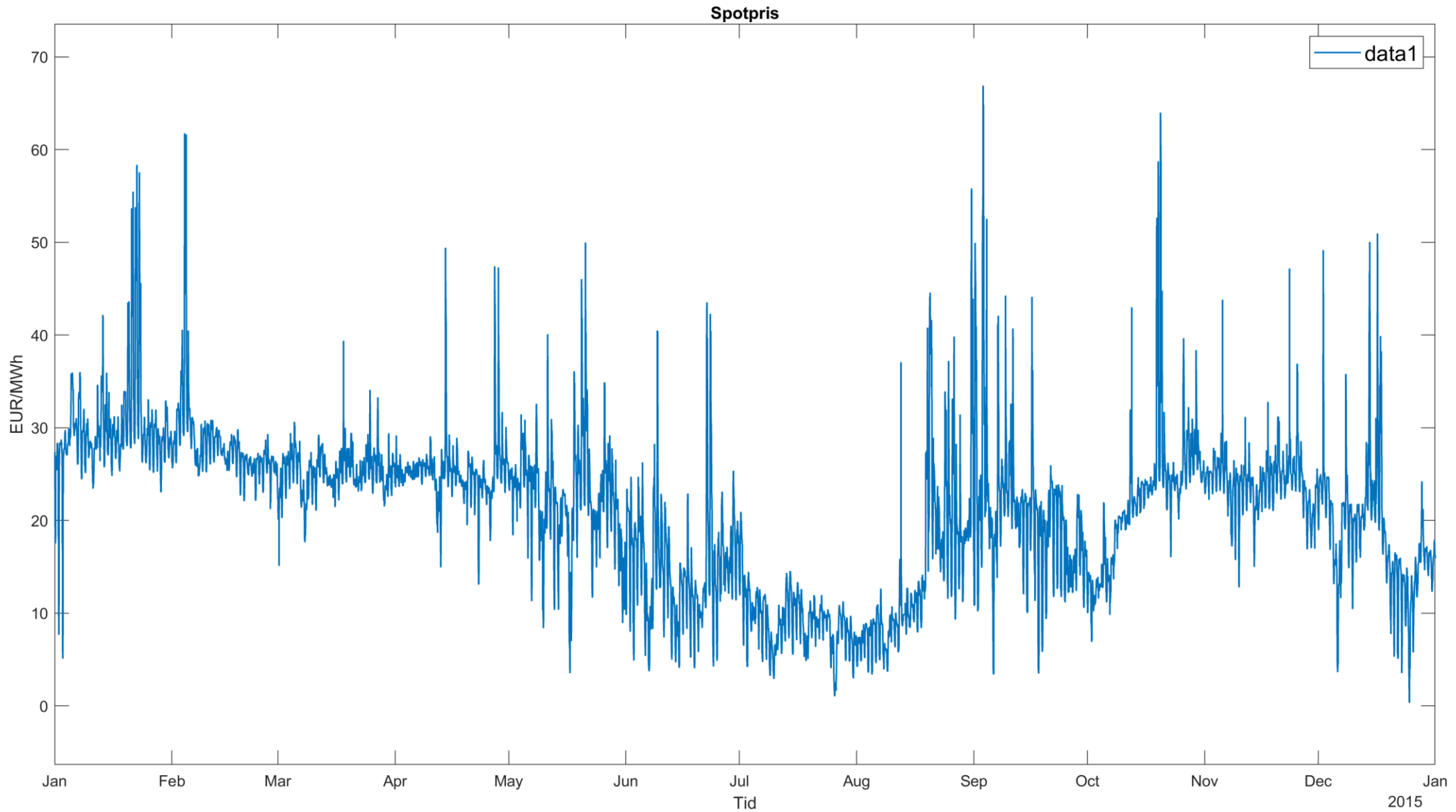
Resultat (exempel GWL2,0°C för 2015)

Lokaltillrinning

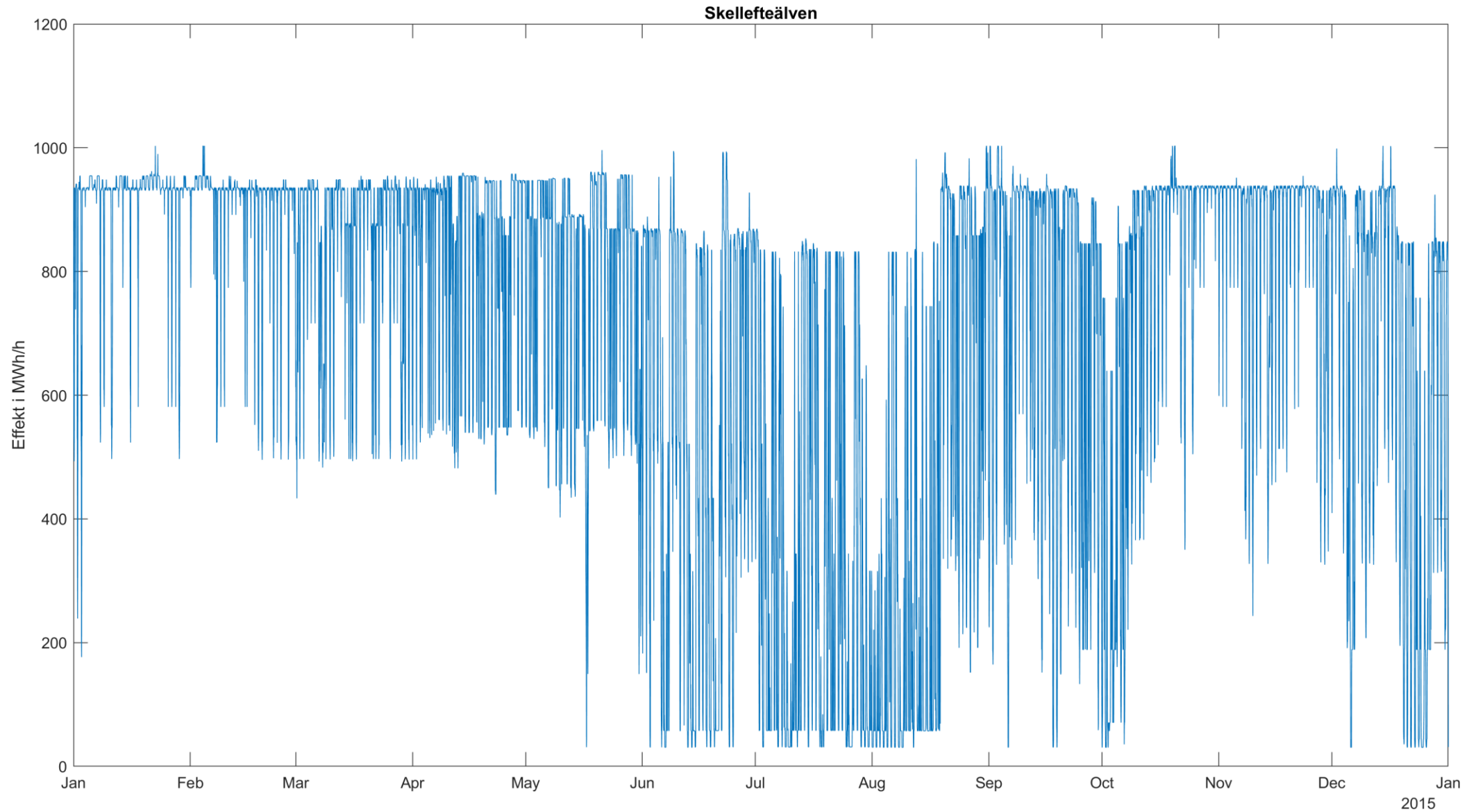
Lokal tillrinning för Skellefteälven



Elpriser

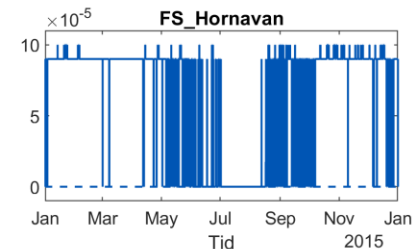
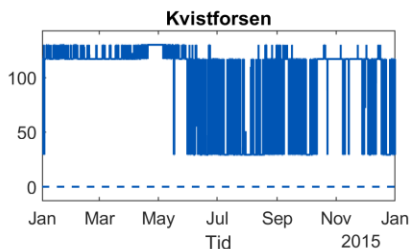
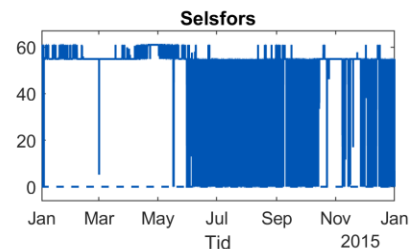
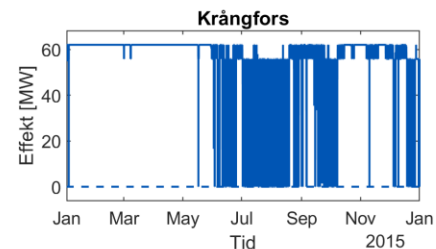
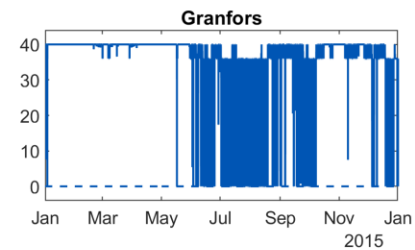
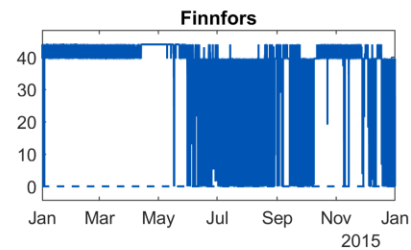
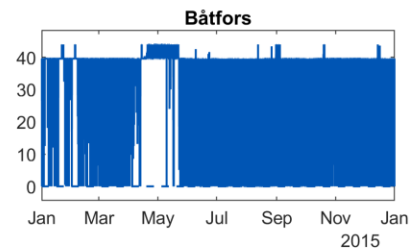
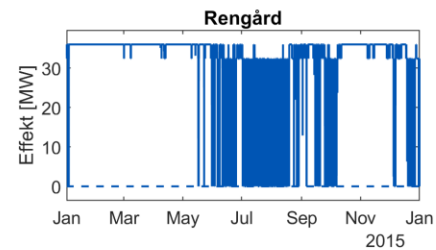
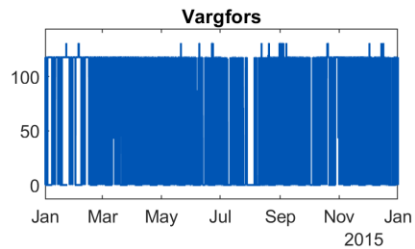
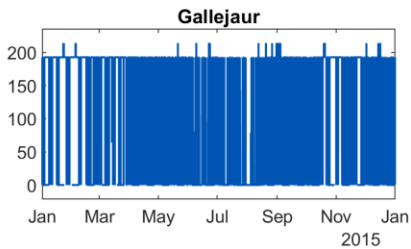
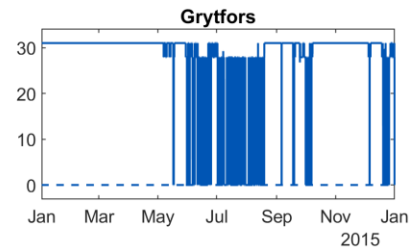
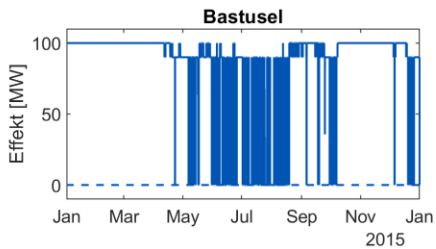
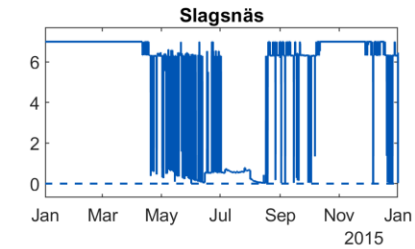
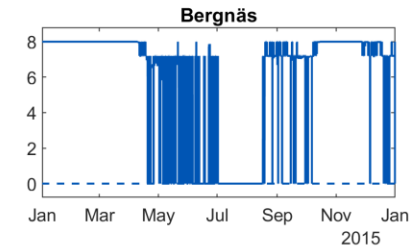
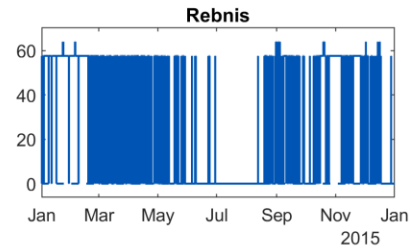
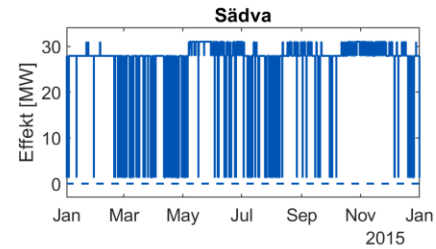


Produktion älvsystem



Produktion

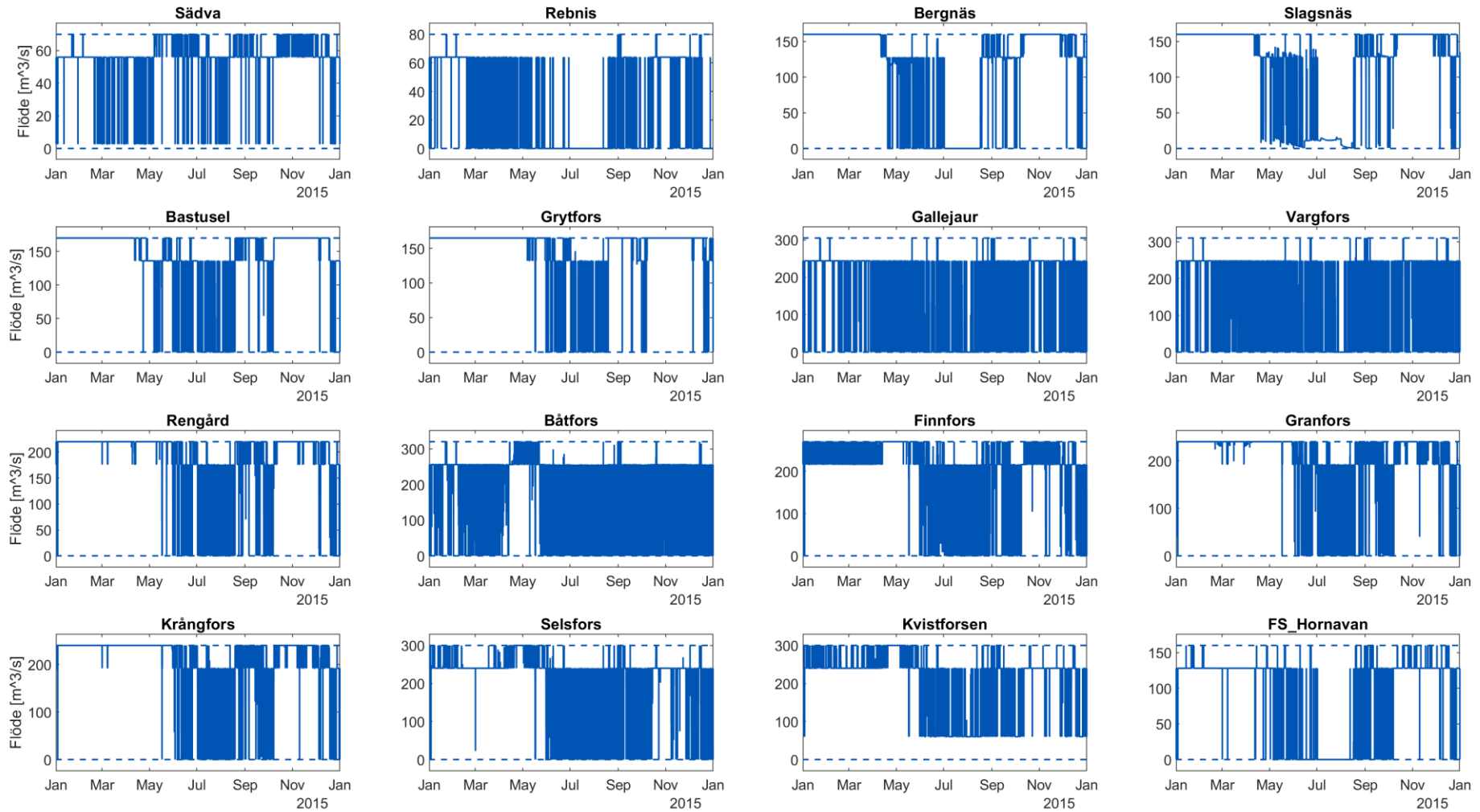
Produktion per station för Skellefteälven



— KLIVA

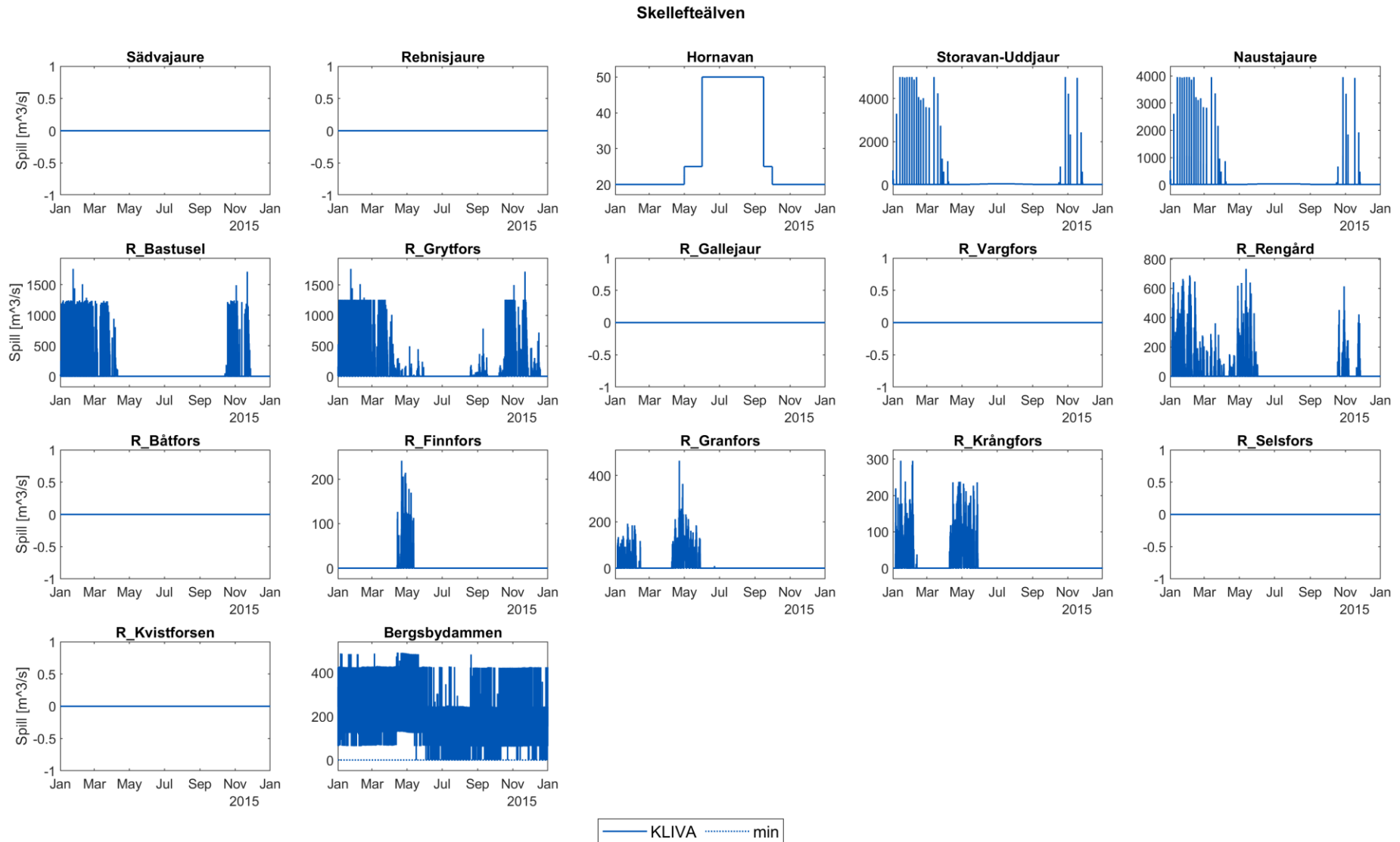
Stationsvattenföring

Turbinvattenföring för Skellefteälven



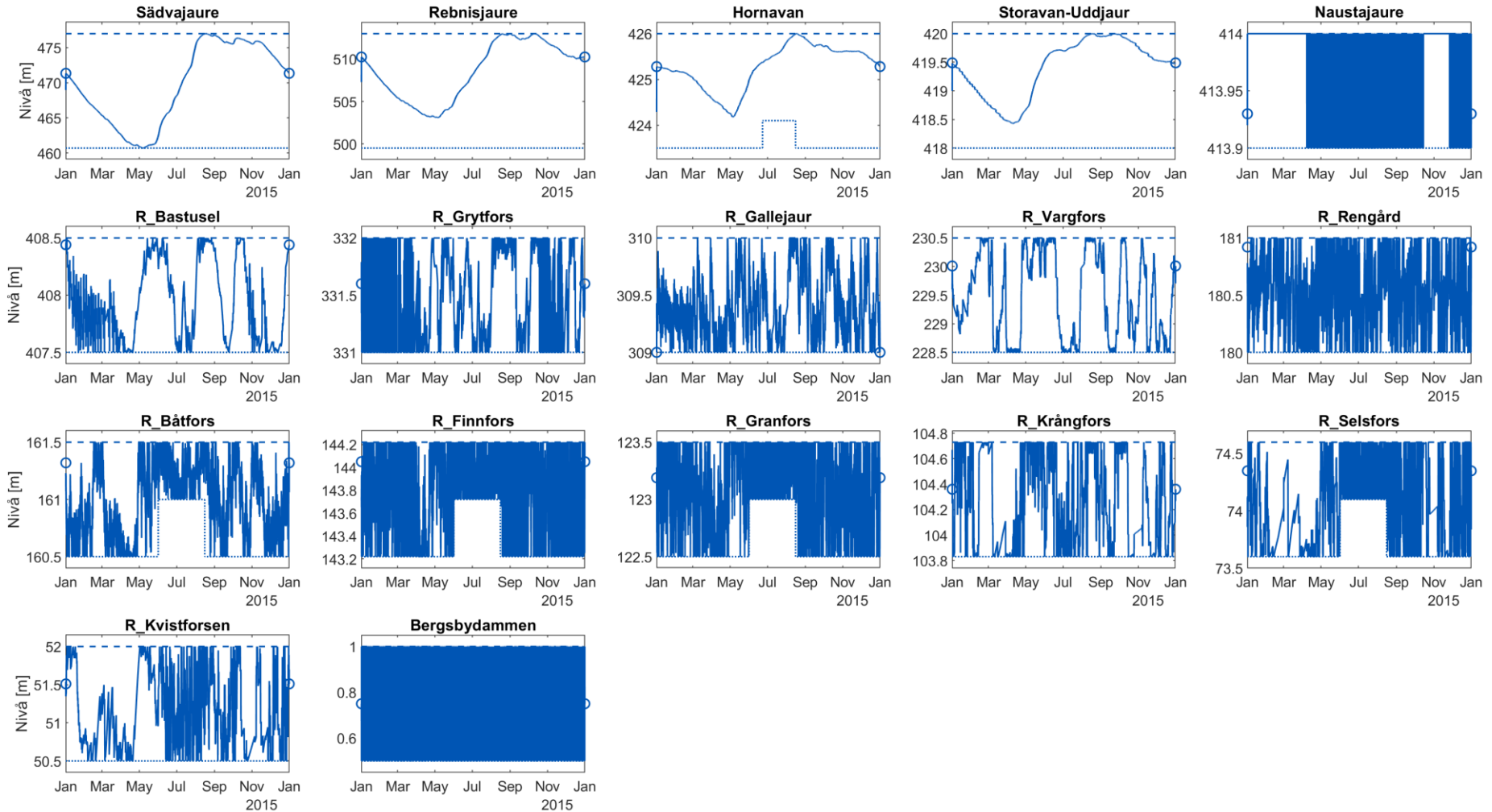
— KLIVA

Spill



Vattenstånd

Skellefteälven

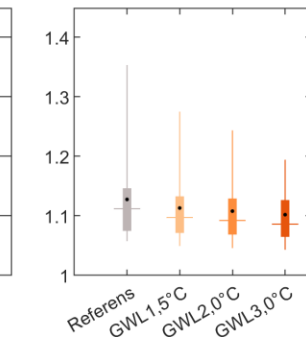
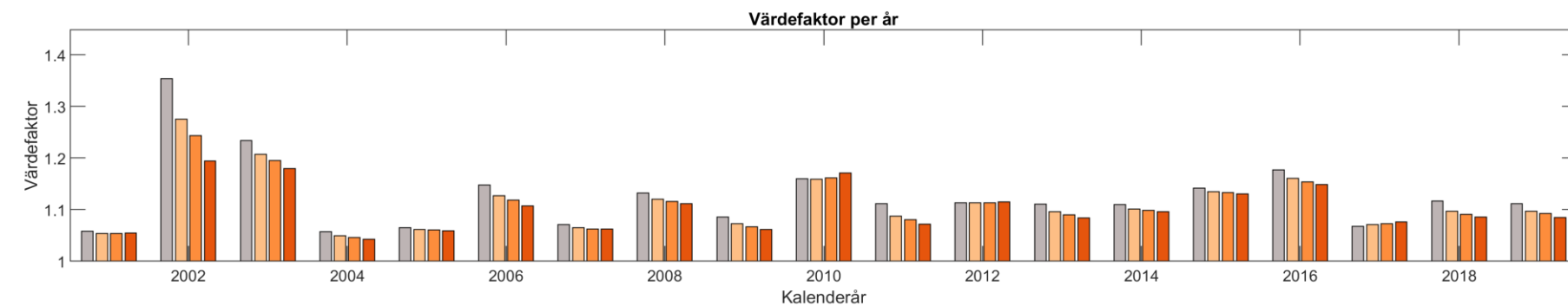
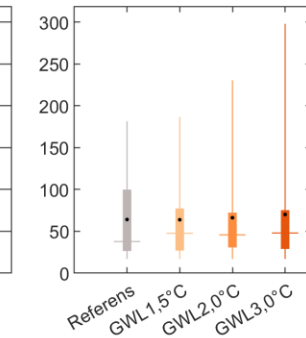
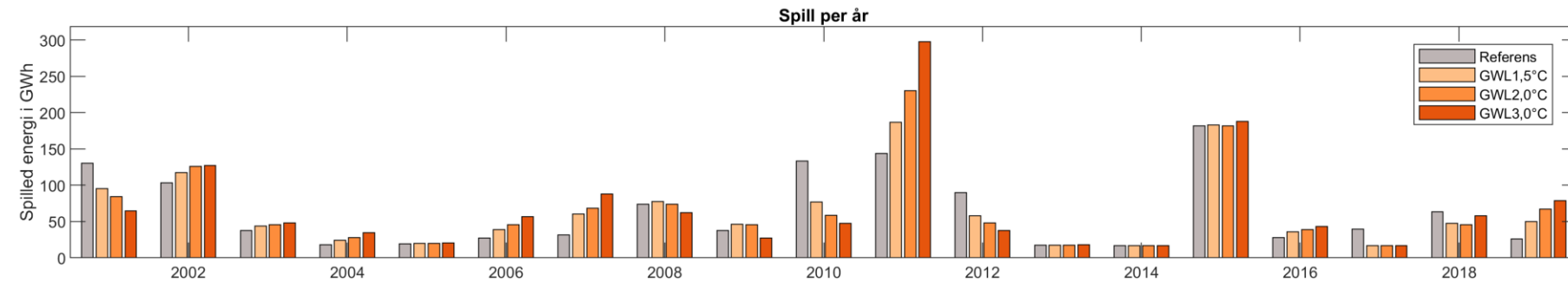
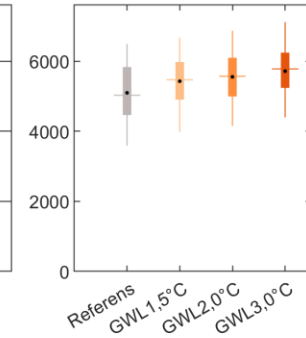
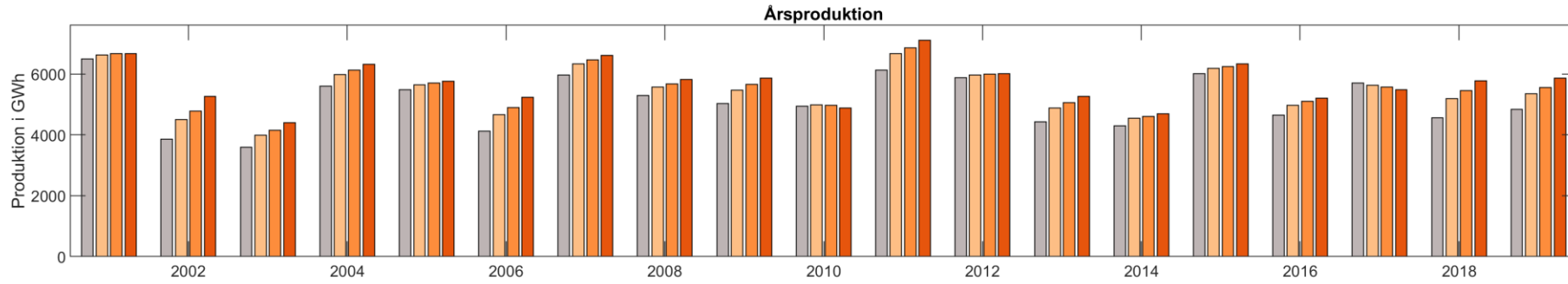


— KLIVA min - - - max ○ Randvillkor

Aggregerade resultat

Årsvärden produktion, spill, värdefaktor

Skellefteälven



Statistik produktion, spill, värdefaktor

Produktion i GWh

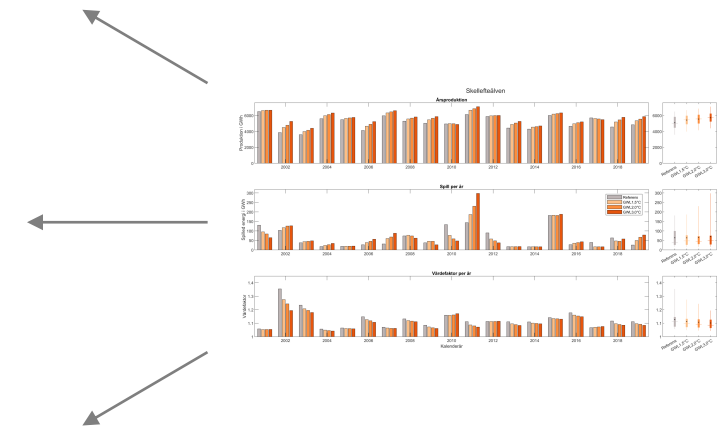
GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	5100	(Ref)	(Ref)	4466	5837	1371	3592	6495
GWL1, 5°C	5432	+332	+7 %	4906	5979	1073	3985	6675
GWL2, 0°C	5557	+457	+9 %	4997	6101	1104	4156	6870
GWL3, 0°C	5718	+618	+12 %	5241	6246	1005	4399	7120

Spill i GWh

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	64	(Ref)	(Ref)	26	100	74	17	182
GWL1, 5°C	64	+0	+0 %	27	77	50	17	187
GWL2, 0°C	66	+2	+3 %	31	72	41	17	231
GWL3, 0°C	70	+6	+9 %	29	75	46	17	298

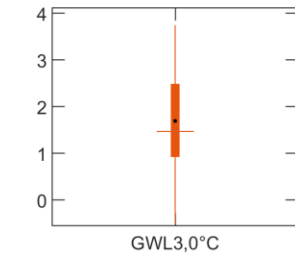
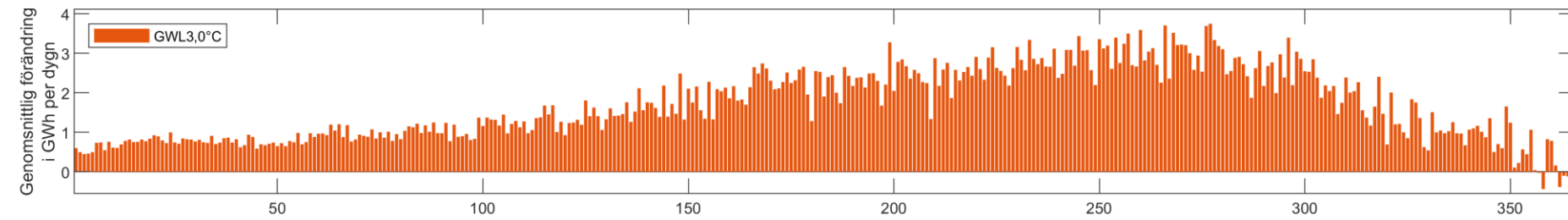
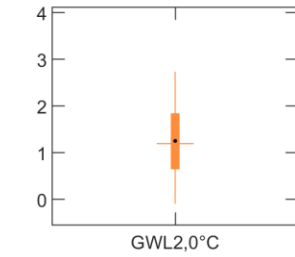
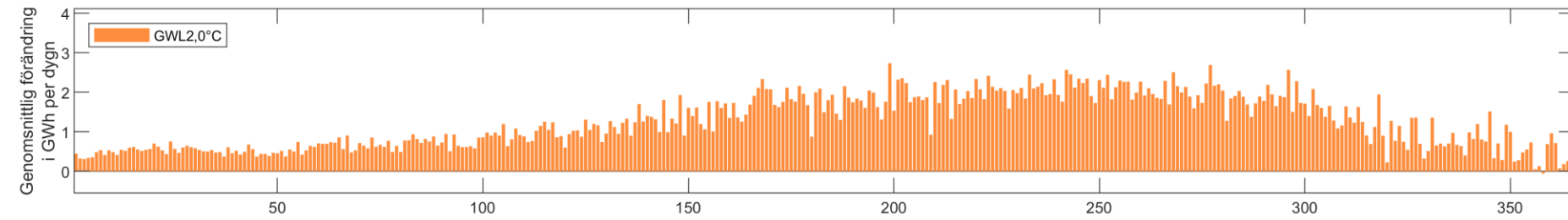
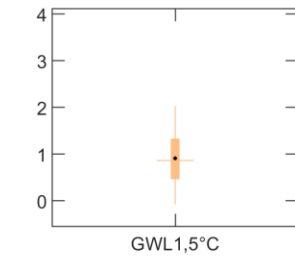
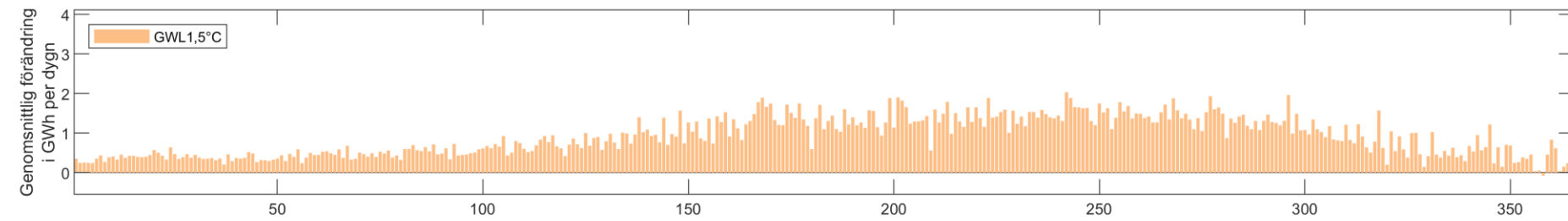
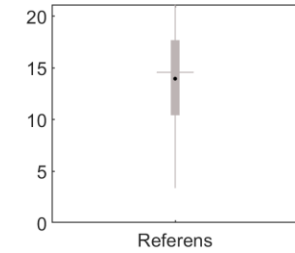
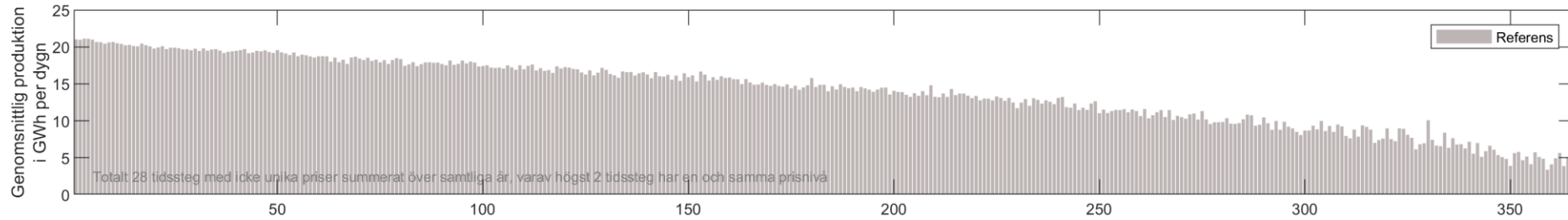
Värdefaktor

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	1.128	(Ref)	(Ref)	1.075	1.146	0.071	1.057	1.353
GWL1, 5°C	1.113	-0.015	-1 %	1.071	1.133	0.062	1.049	1.275
GWL2, 0°C	1.108	-0.020	-2 %	1.069	1.129	0.060	1.046	1.244
GWL3, 0°C	1.102	-0.026	-2 %	1.065	1.127	0.062	1.043	1.194



Förändring i balanseringsförmågan

Flerårs prissorterad produktion Skellefteälven (24 h)



Dygn



Kontakt AP2

richard.scharff@vattenfall.com



KLIVA-rapport bilaga A Umeälven

Richard Scharff, Chalmers, 2023-02-01

Kommentarer

- Bilagan innehåller ett axplock av diagram för att illustrera indata till vattenkraftmodellen samt dess resultat
- Resultaten skiljer sig mellan älvsystem, år och uppvärmningsnivå
- Insikter, slutsatser och detaljer beskrivs i rapporten

→ Rapporten finns på: <https://energiforsk.se/program/klimatforandringarnas-inverkan-pa-vattenkraften/rapporter/klimatforandringarnas-inverkan-pa-vattenkraftens-produktions-och-reglerformaga/>



 Energiforsk

KLIVA-projektet har analyserat **klimatförändringarnas påverkan** på vattenkraftens produktions- och balanseringsförmåga

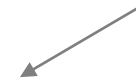
Innehåll diagrammsamling

- Systembeskrivning
 - Älvsystem
 - Energi per Mm³ lokaltillrinning
 - Vattendomar
- Klimatpåverkan lokaltillrinning
 - Klimatfaktorer
 - Total tillrinning



- Optimering
 - Lokaltillrinning
 - Elpriser
 - Älvens elproduktion
 - Produktion per station
 - Stationsvattenföring
 - Spill per magasin
 - Vattenytor per magasin
- Aggregerade resultat
 - Produktionsförmåga
 - Balanseringsförmåga

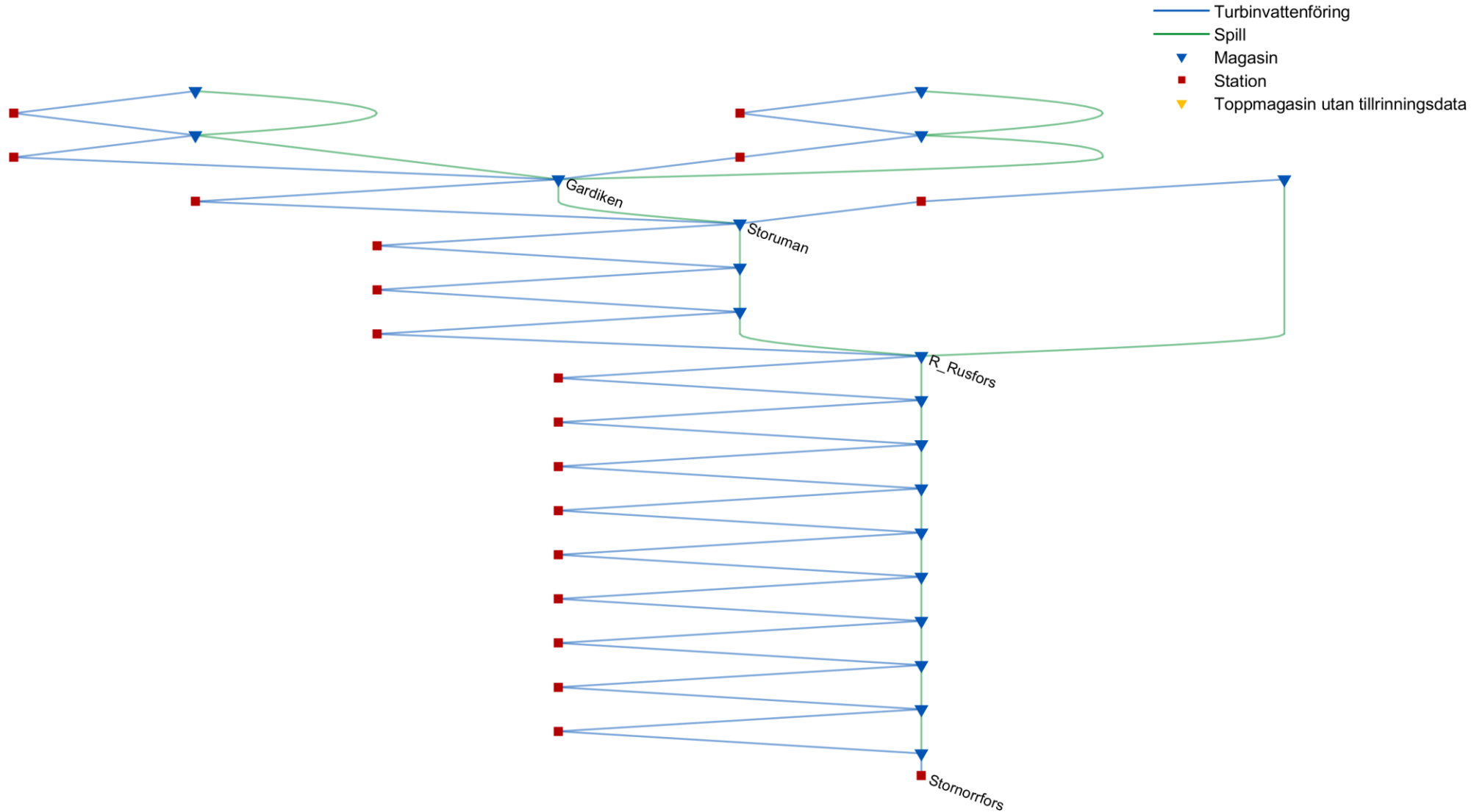
Optimeringen görs för **19 år**, alltid ett kalenderår i taget. I den här bilagan presenteras indata och resultat för **ett utvalt år** med uppvärmningsnivån **GWL2,0°C**.



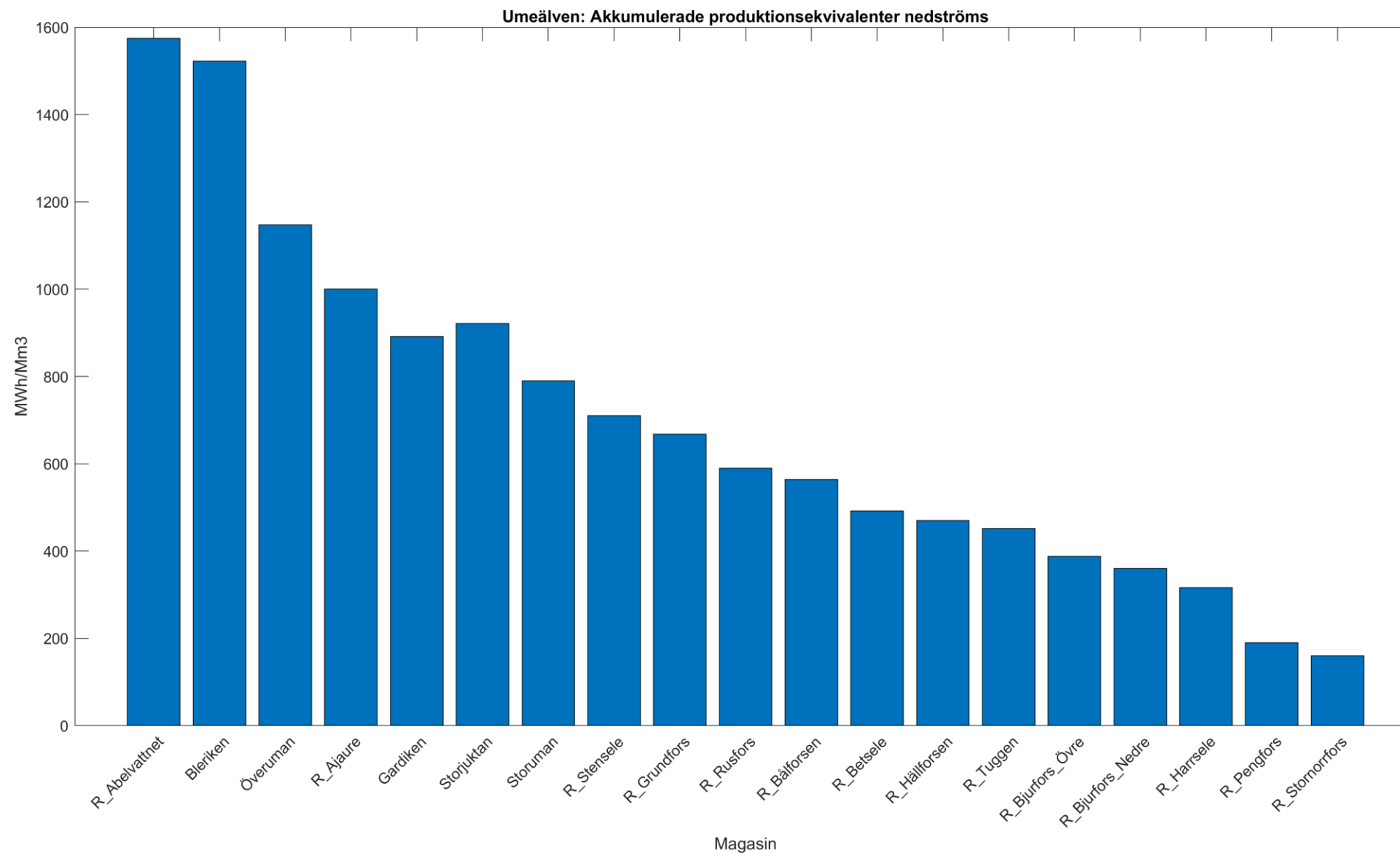
Systembeskrivning

Älvsystem

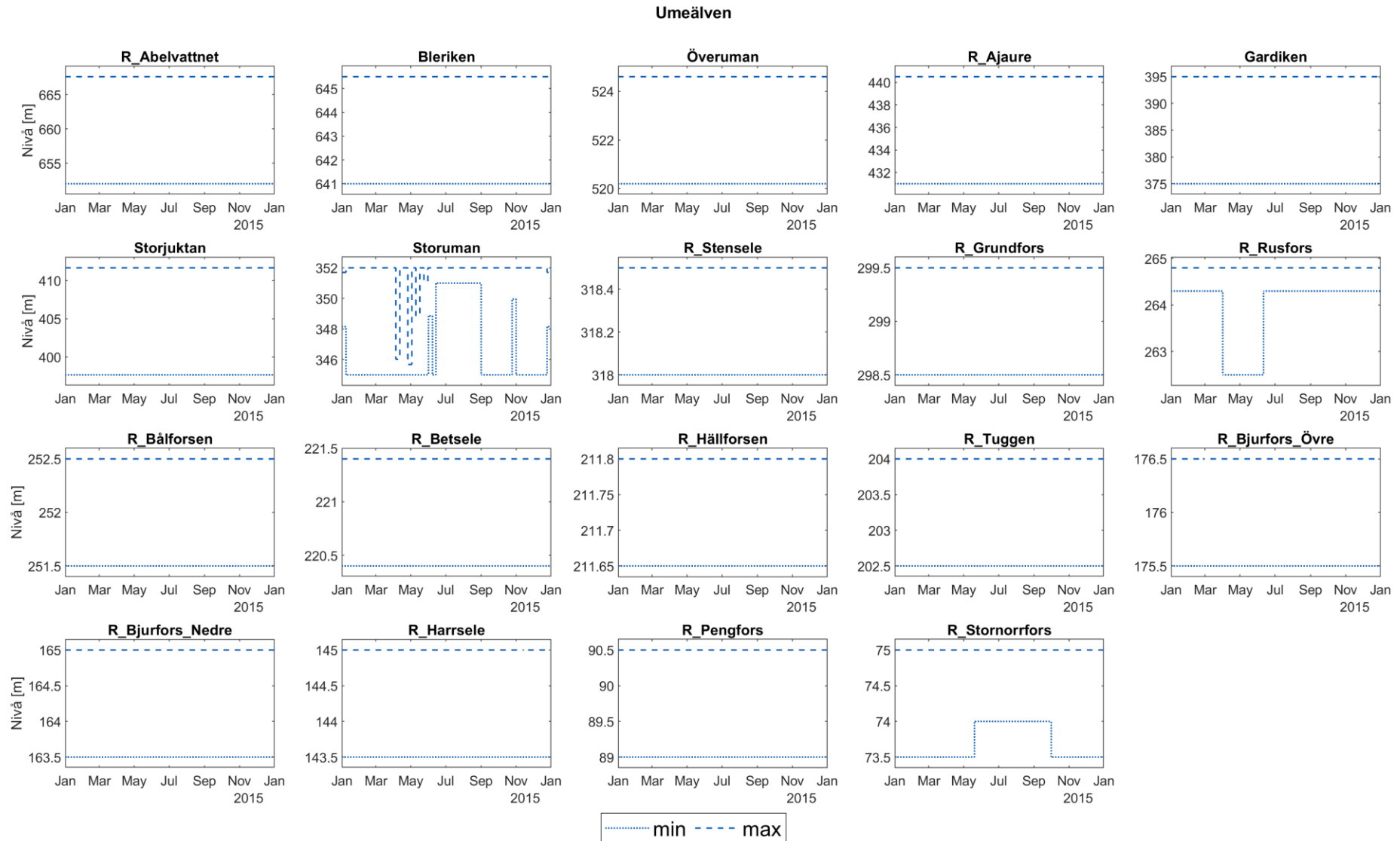
Umeälven



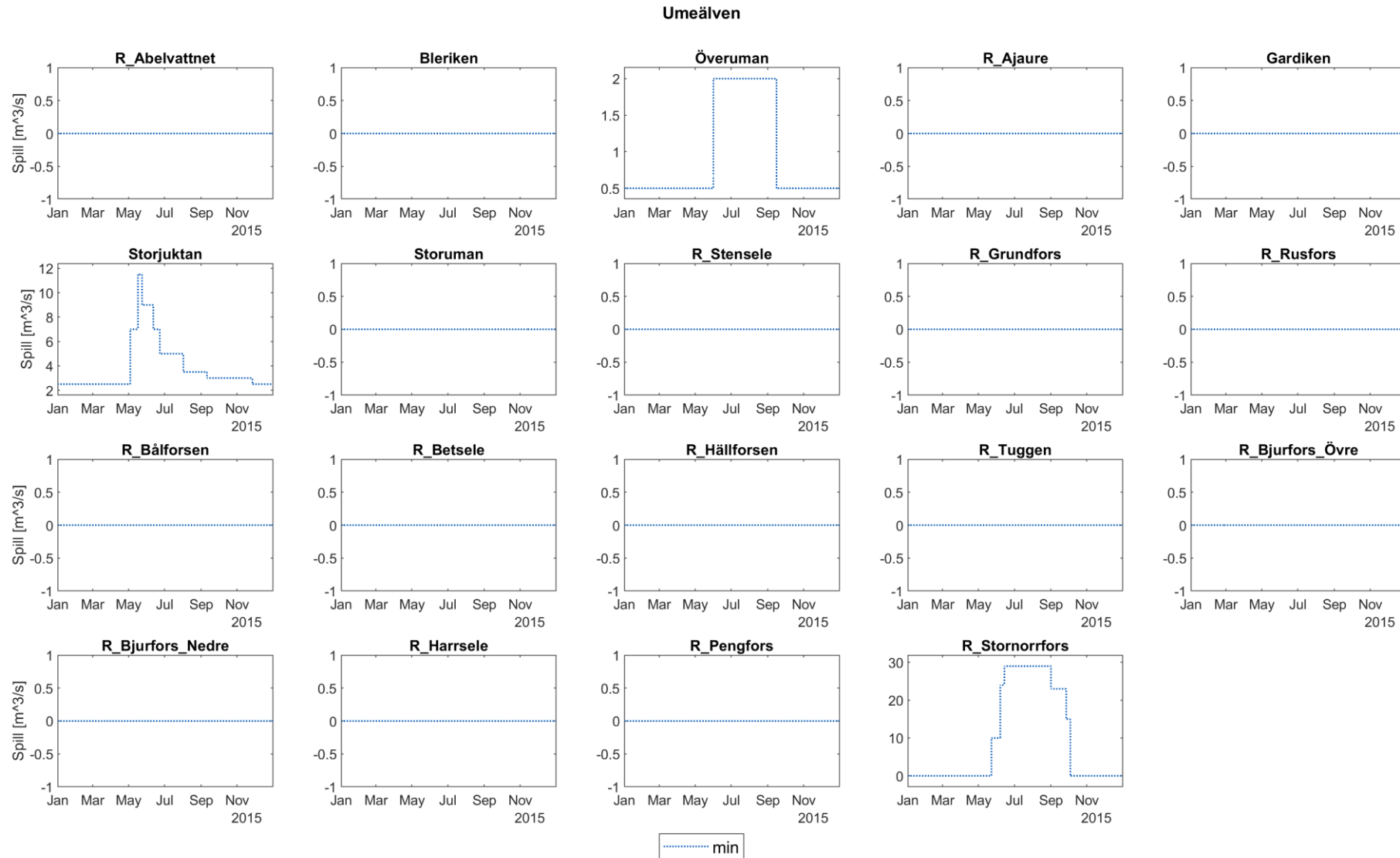
Energi per Mm³ lokaltillrinning



Vattendomar "WaterLevel"

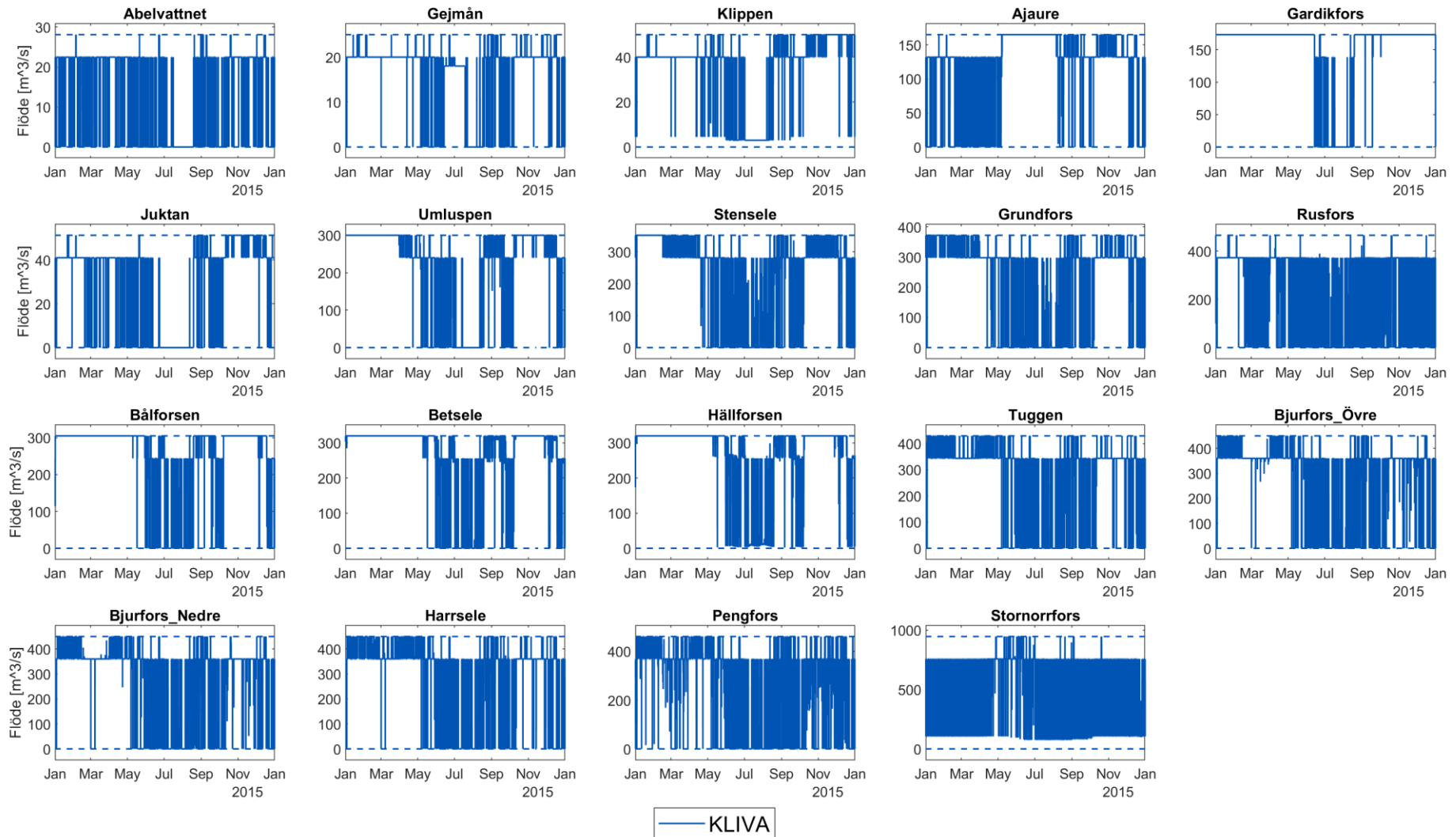


Vattendomar "MinSpill"



Vattendomar "MinFlow"

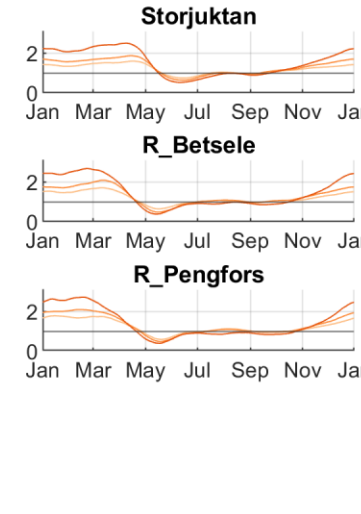
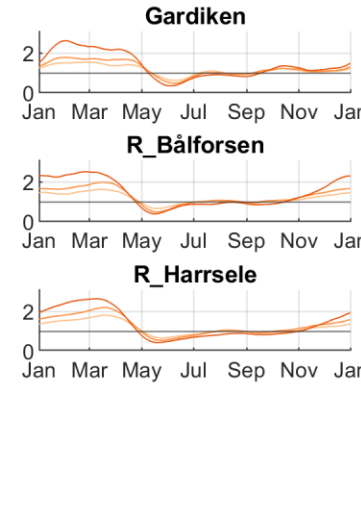
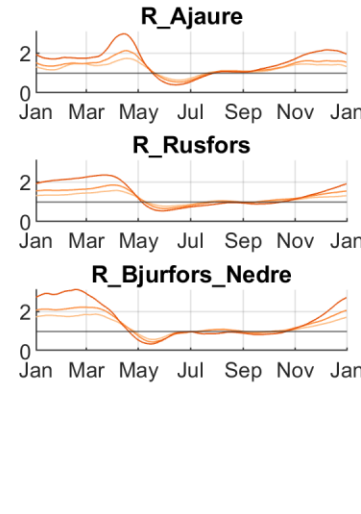
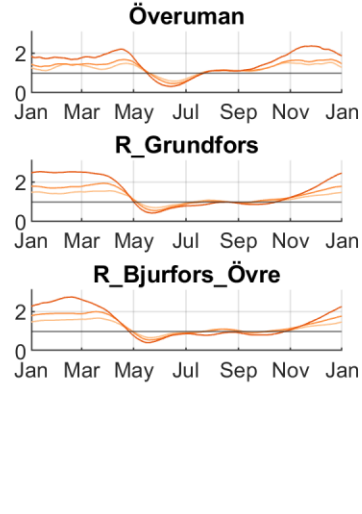
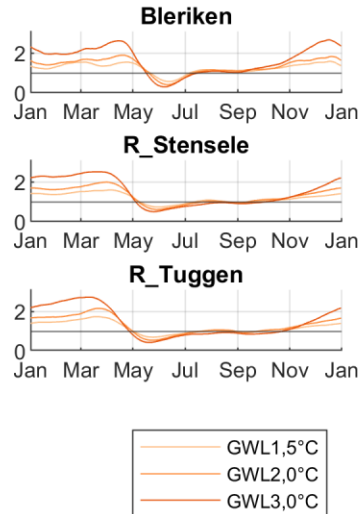
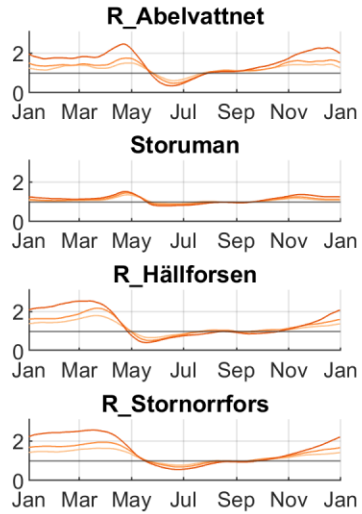
Turbinvattenföring för Umeälven



Klimatpåverkan på lokaltillrinningar

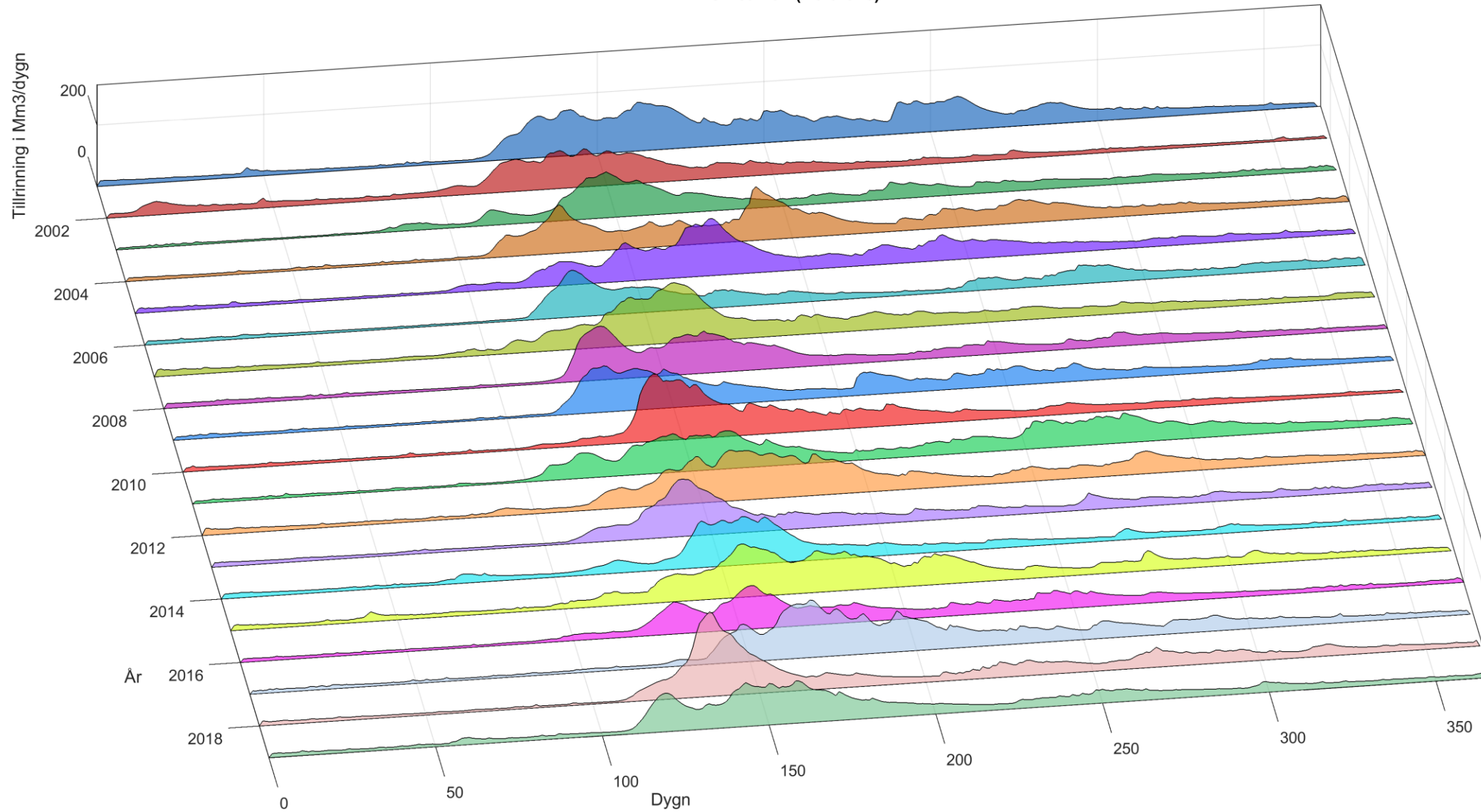
Klimatfaktorer

Klimatfaktorer Umeälven



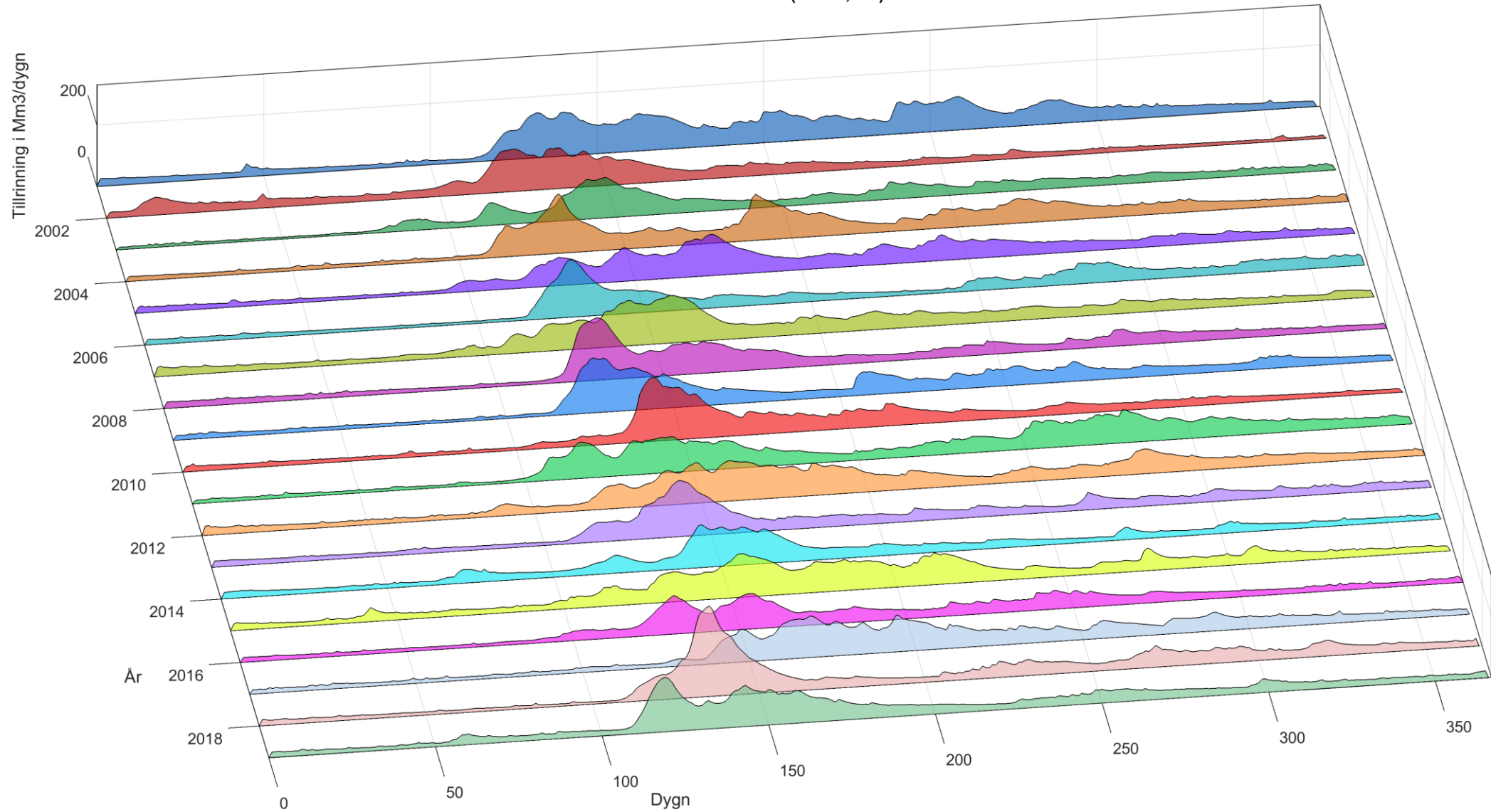
Total tillrinning (Referens)

Umeälven (Referens)



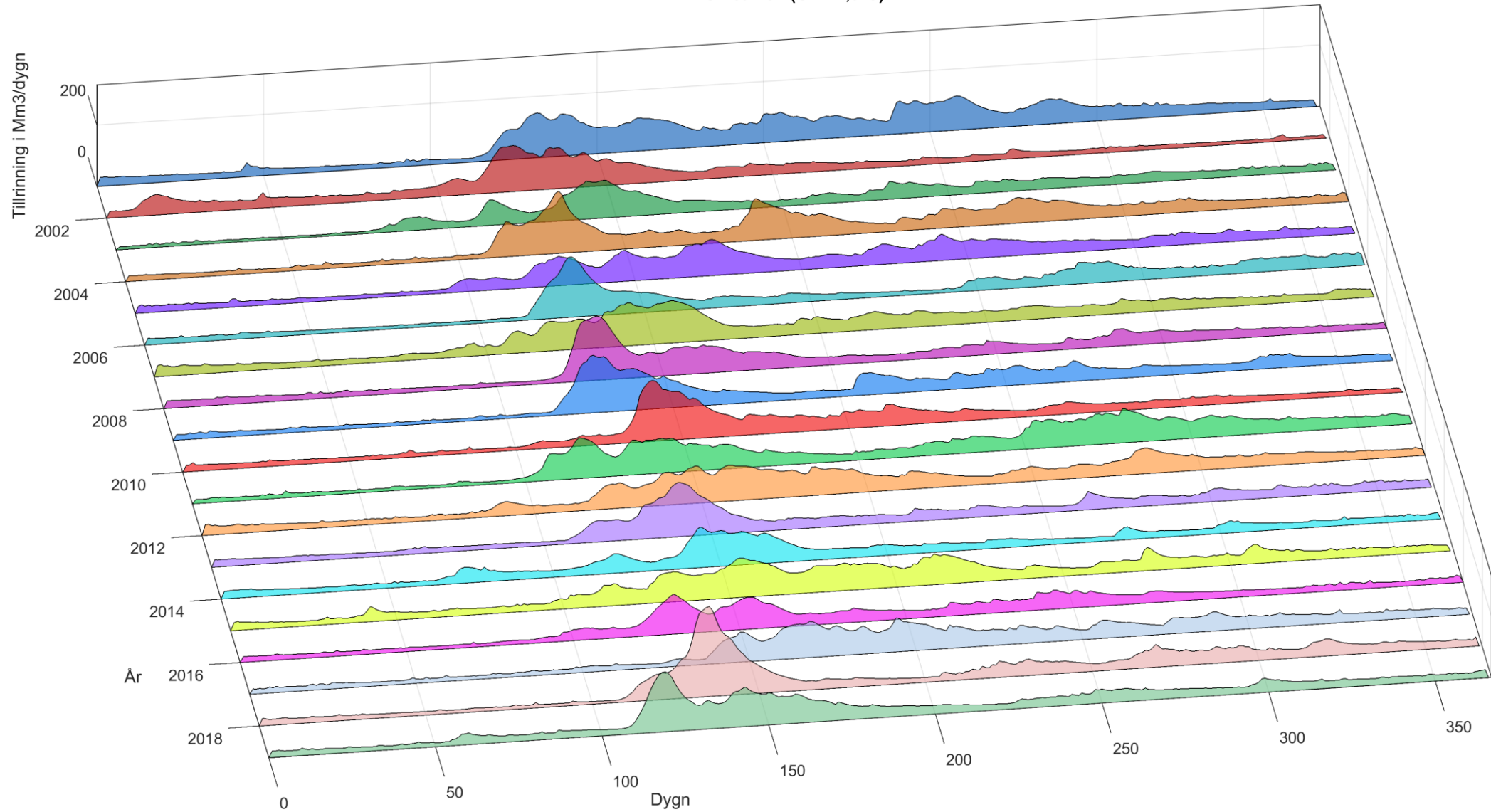
Total tillrinning (GWL1,5°C)

Umeälven (GWL1,5°C)



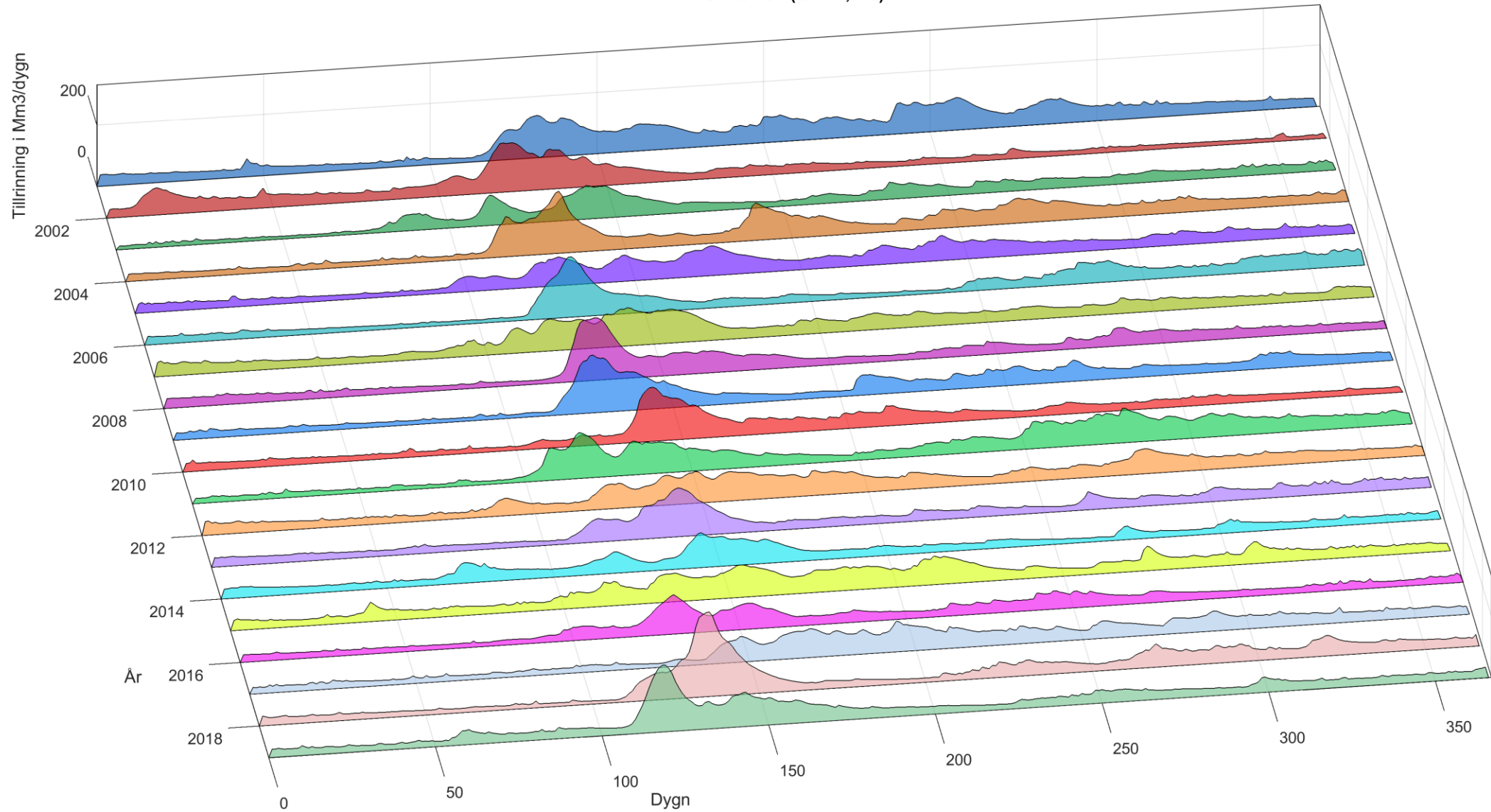
Total tillrinning (GWL2,0°C)

Umeälven (GWL2,0°C)



Total tillrinning (GWL3,0°C)

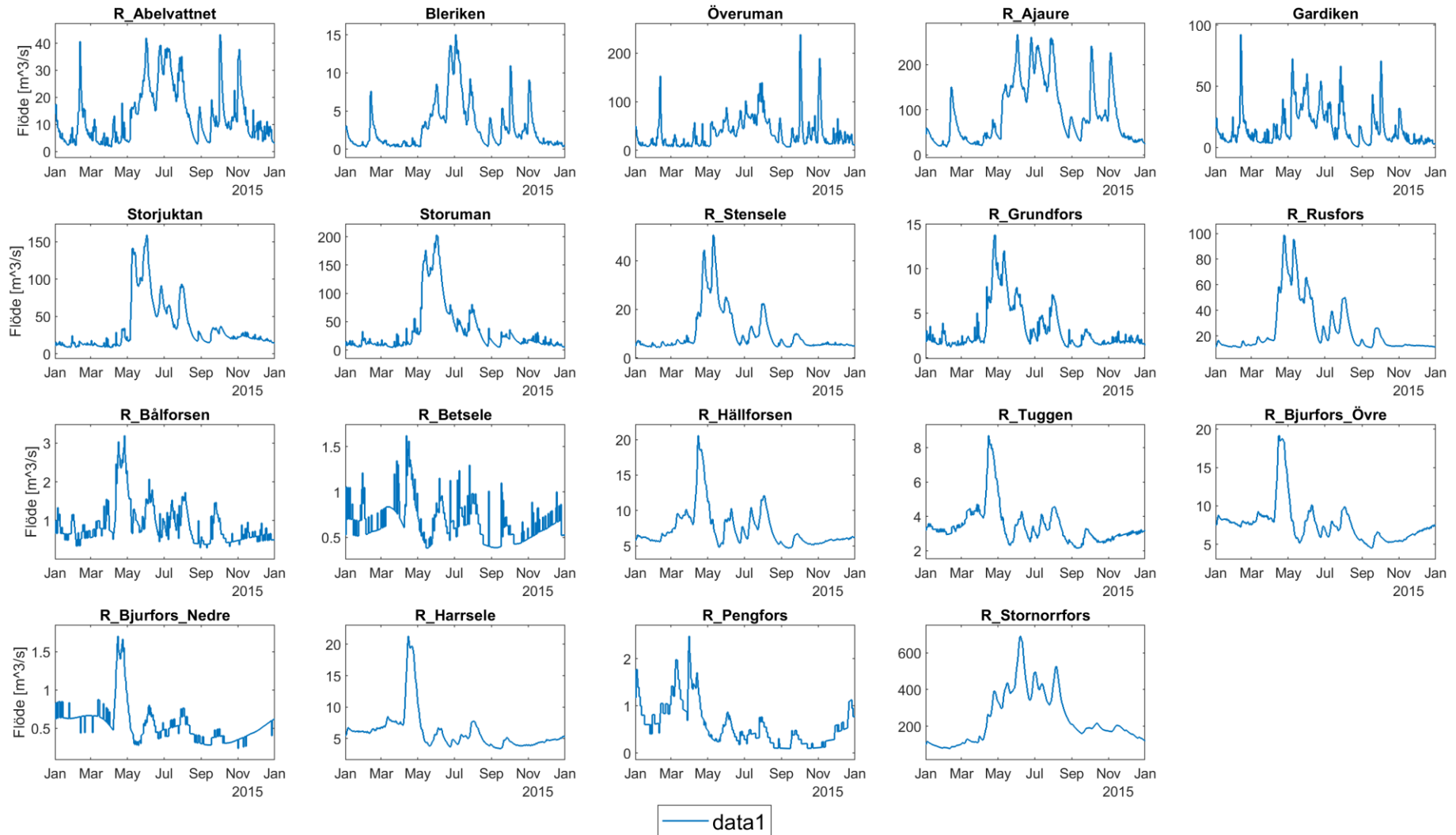
Umeälven (GWL3,0°C)



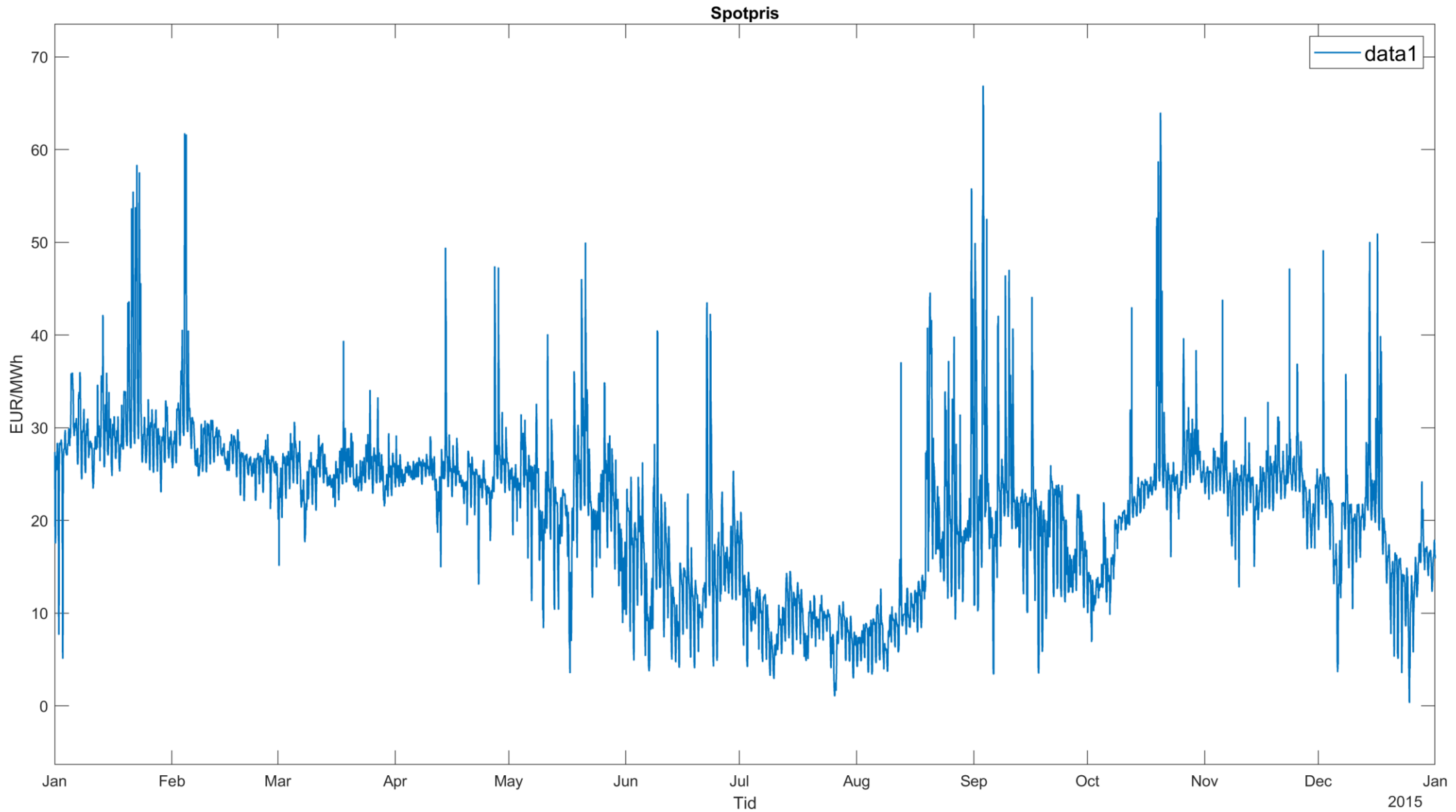
Resultat (exempel GWL2,0°C för 2015)

Lokaltillrinning

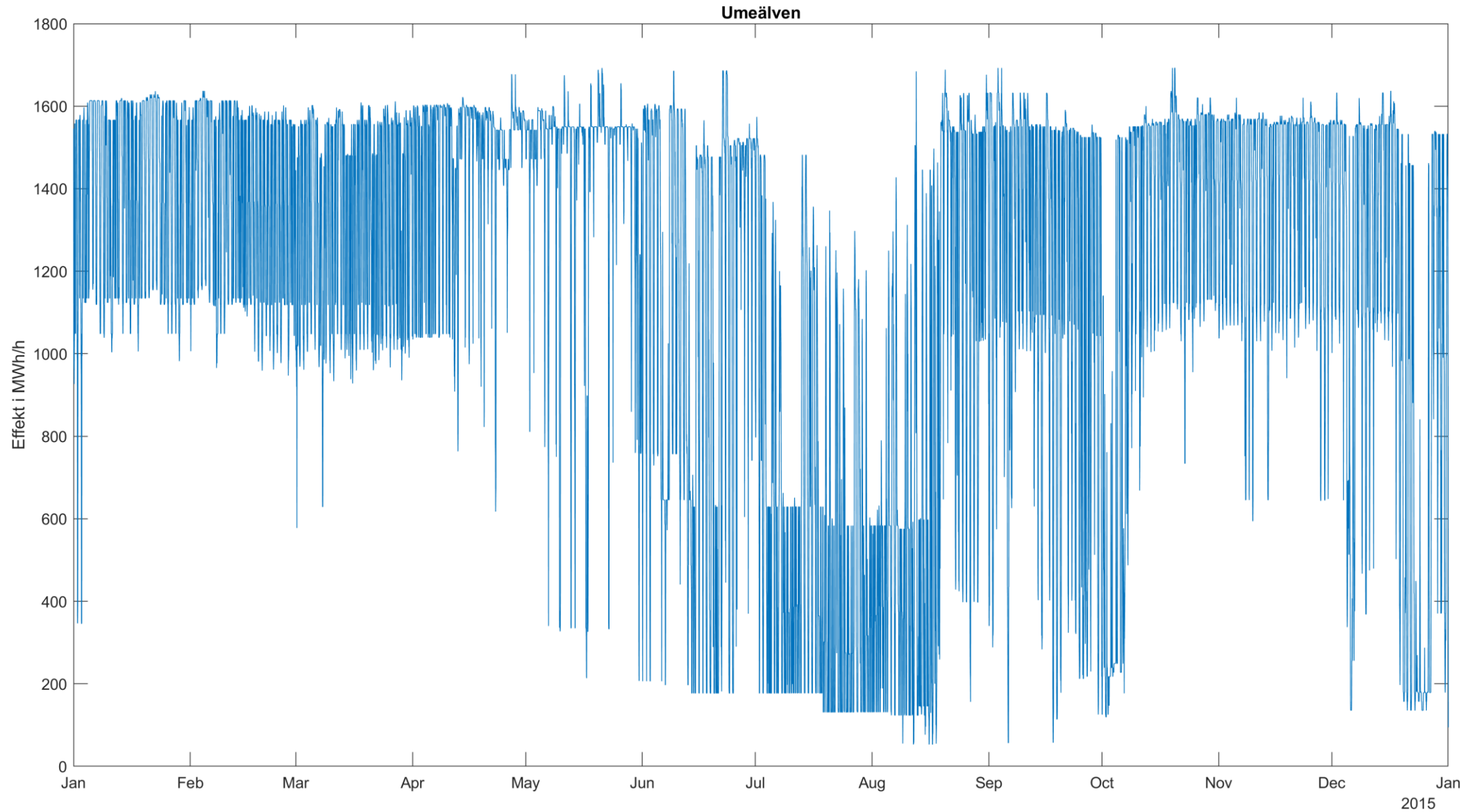
Lokal tillrinning för Umeälven



Elpriser

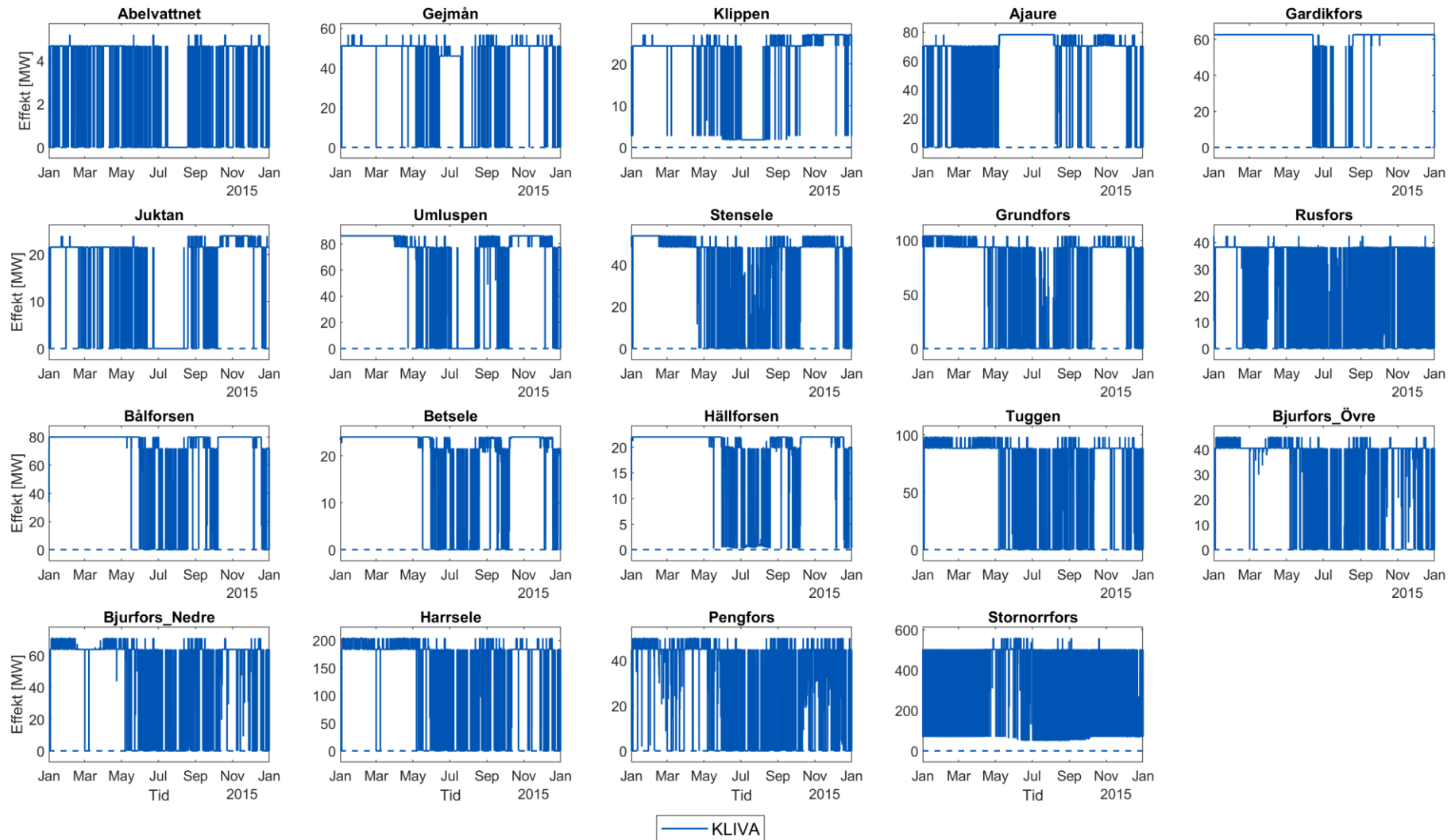


Produktion älvsystem



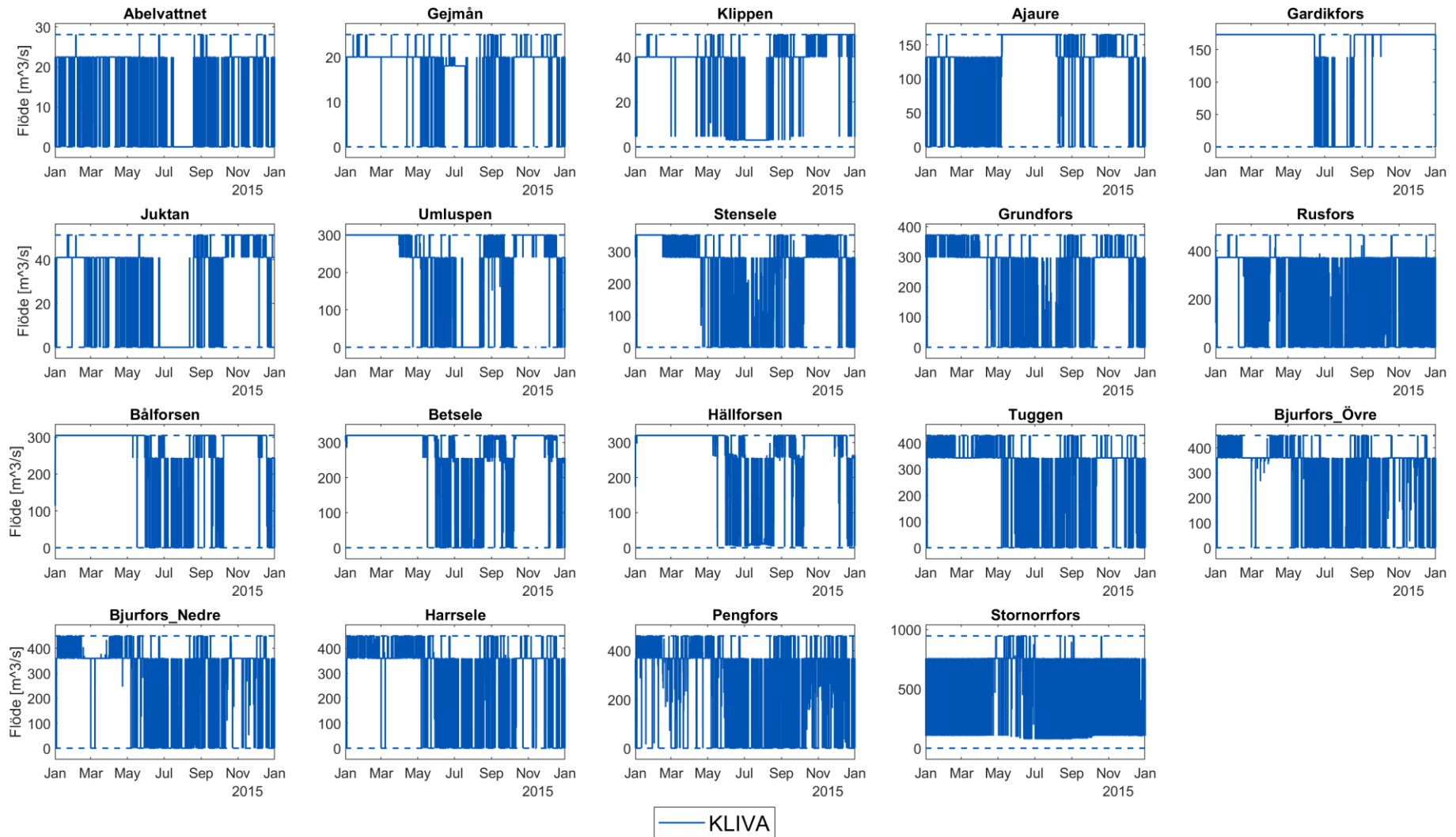
Produktion

Produktion per station för Umeälven



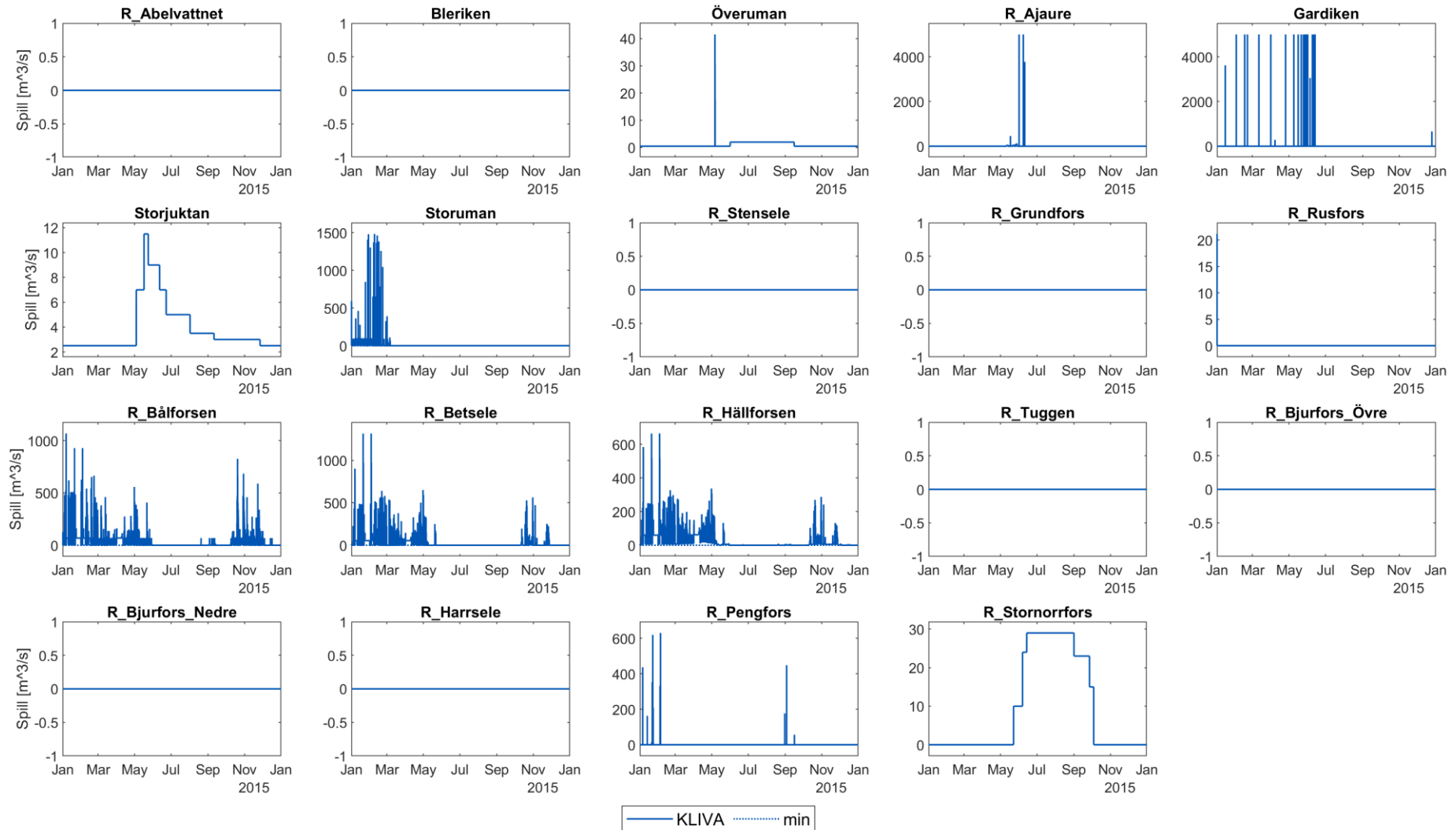
Stationsvattenföring

Turbinvattenföring för Umeälven



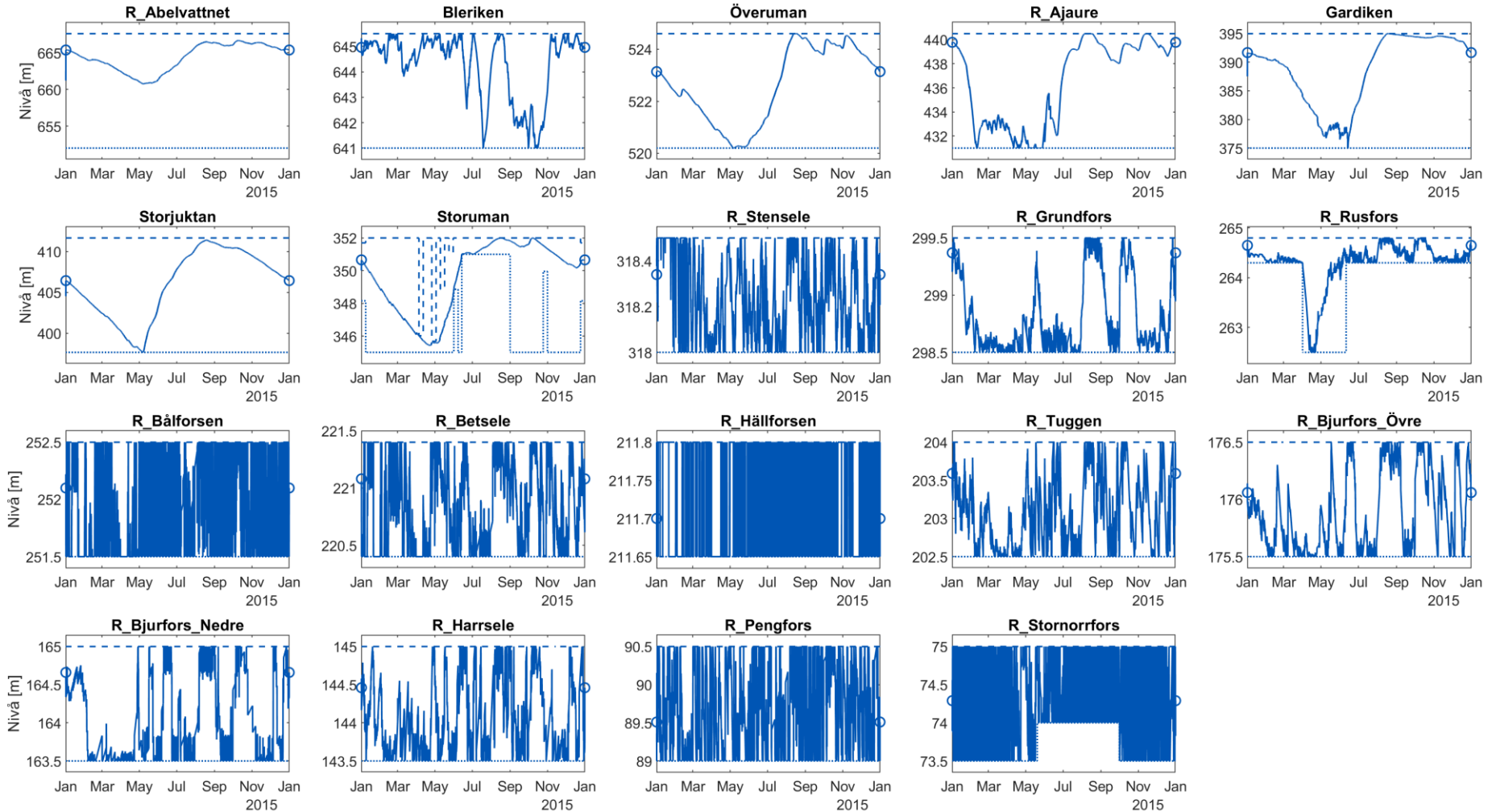
Spill

Umeälven



Vattenstånd

Umeälven

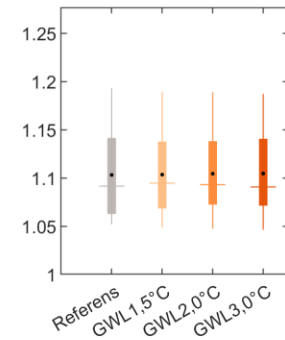
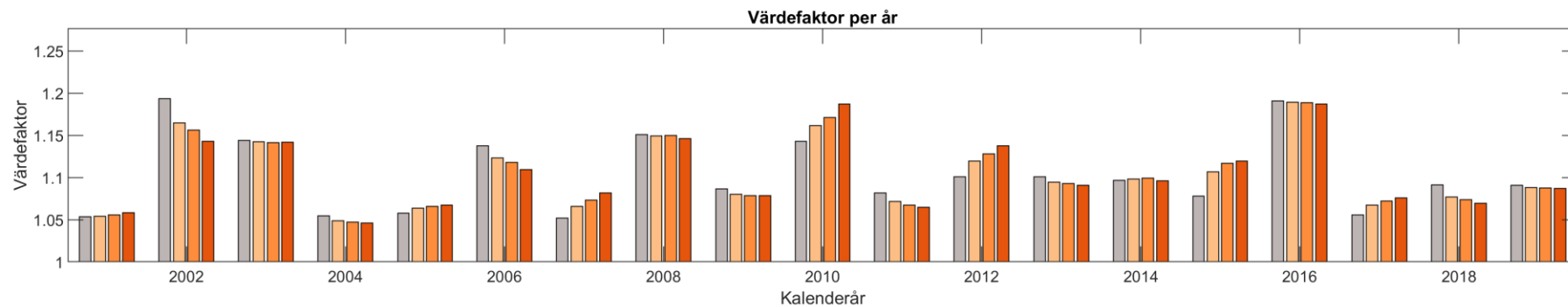
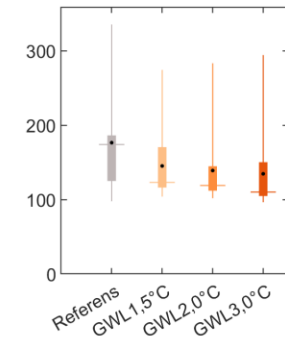
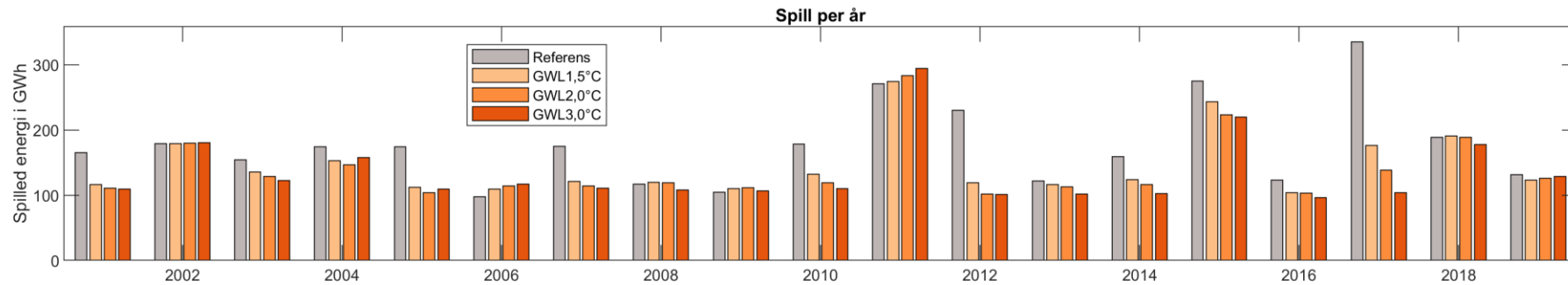
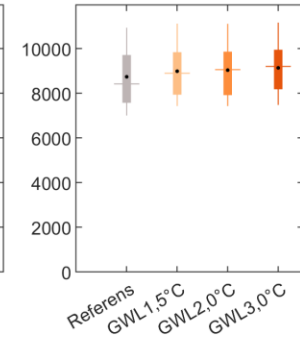
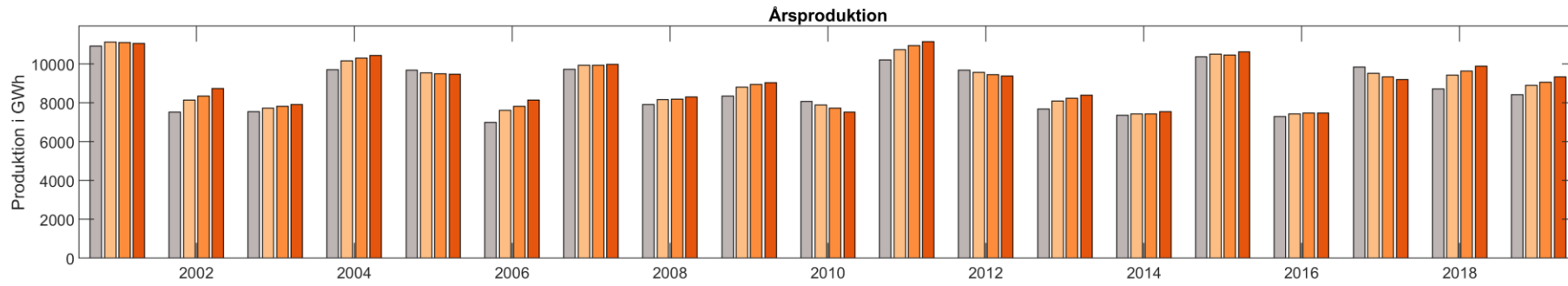


— KLIVA min - - - max ○ Randvillkor

Aggregerade resultat

Årsvärden produktion, spill, värdefaktor

Umeälven



Statistik produktion, spill, värdefaktor

Produktion i GWh

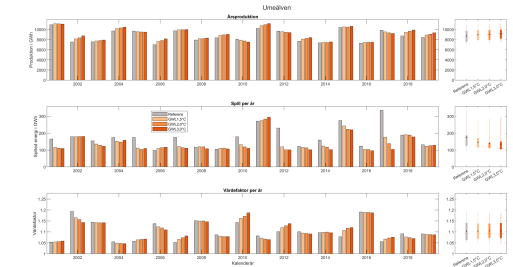
GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	8740	(Ref)	(Ref)	7573	9714	2141	7005	10934
GWL1, 5°C	8989	+249	+3 %	7939	9842	1903	7432	11119
GWL2, 0°C	9037	+297	+3 %	7918	9864	1946	7428	11108
GWL3, 0°C	9137	+397	+5 %	8180	9949	1769	7480	11164

Spill i GWh

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	177	(Ref)	(Ref)	125	186	61	98	336
GWL1, 5°C	145	-32	-18 %	116	171	55	104	274
GWL2, 0°C	139	-38	-21 %	112	145	33	102	283
GWL3, 0°C	135	-42	-24 %	105	150	45	96	294

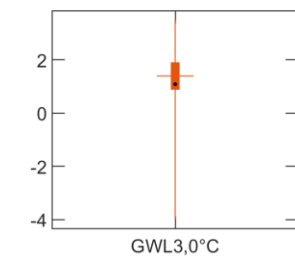
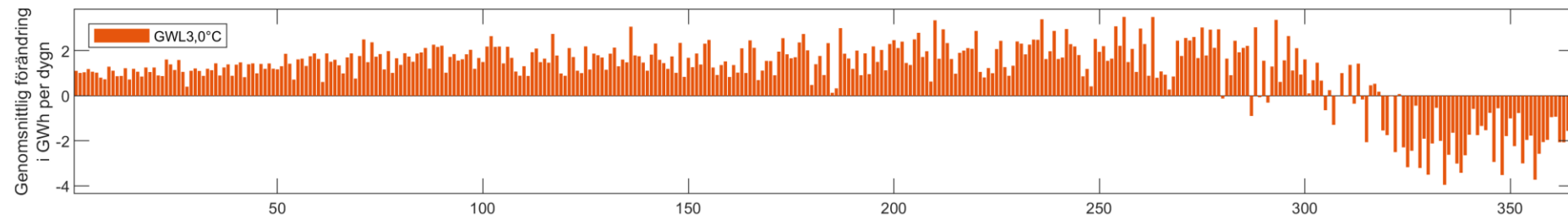
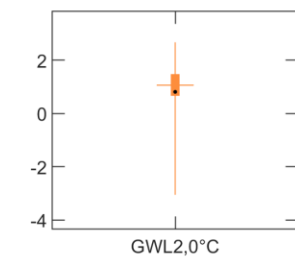
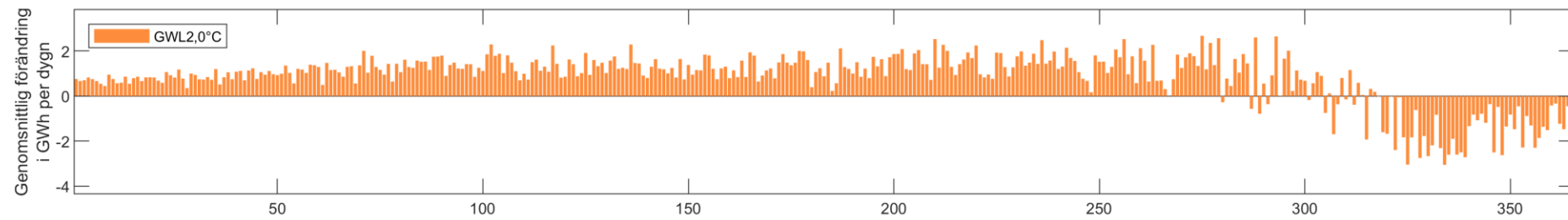
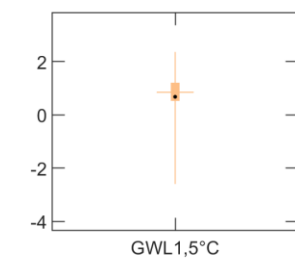
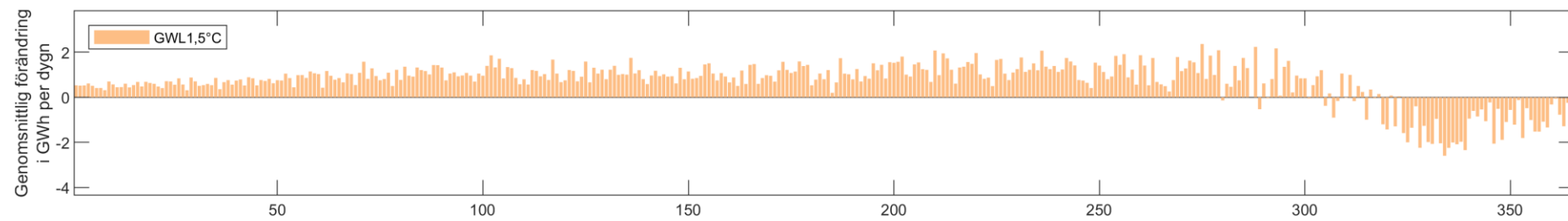
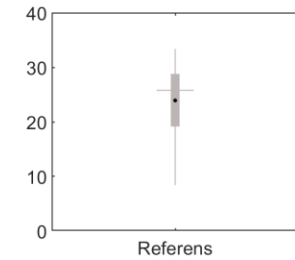
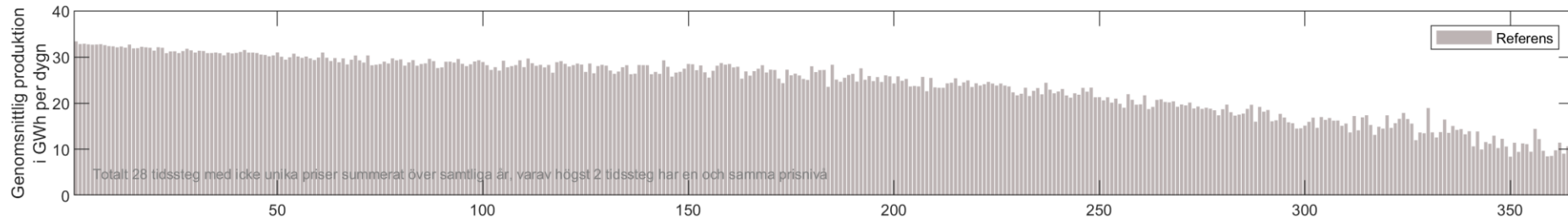
Värdefaktor

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	1.103	(Ref)	(Ref)	1.063	1.141	0.078	1.052	1.193
GWL1, 5°C	1.103	+0.000	+0 %	1.068	1.138	0.070	1.049	1.189
GWL2, 0°C	1.104	+0.001	+0 %	1.072	1.138	0.066	1.047	1.189
GWL3, 0°C	1.105	+0.002	+0 %	1.071	1.141	0.070	1.046	1.187



Förändring i balanseringsförmågan

Flerårs prissorterad produktion Umeälven (24 h)



Dygn



Kontakt AP2

richard.scharff@vattenfall.com



KLIVA-rapport bilaga A Ångermanälven

Richard Scharff, Chalmers, 2023-02-01

Kommentarer

- Bilagan innehåller ett axplock av diagram för att illustrera indata till vattenkraftmodellen samt dess resultat
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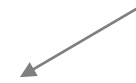
Innehåll diagrammsamling

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 - Energi per Mm³ lokaltillrinning
 - Vattendomar
- Klimatpåverkan lokaltillrinning
 - Klimatfaktorer
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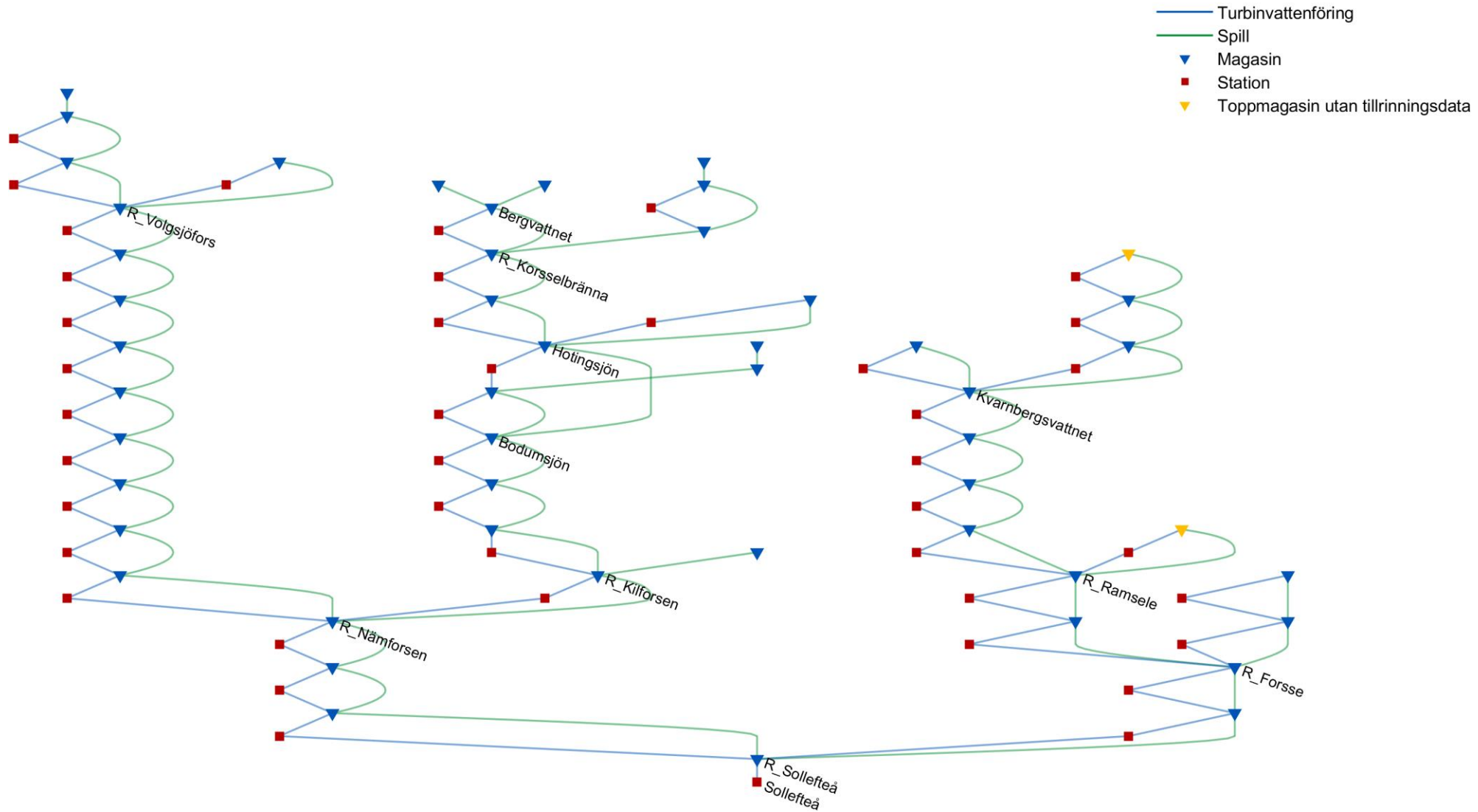
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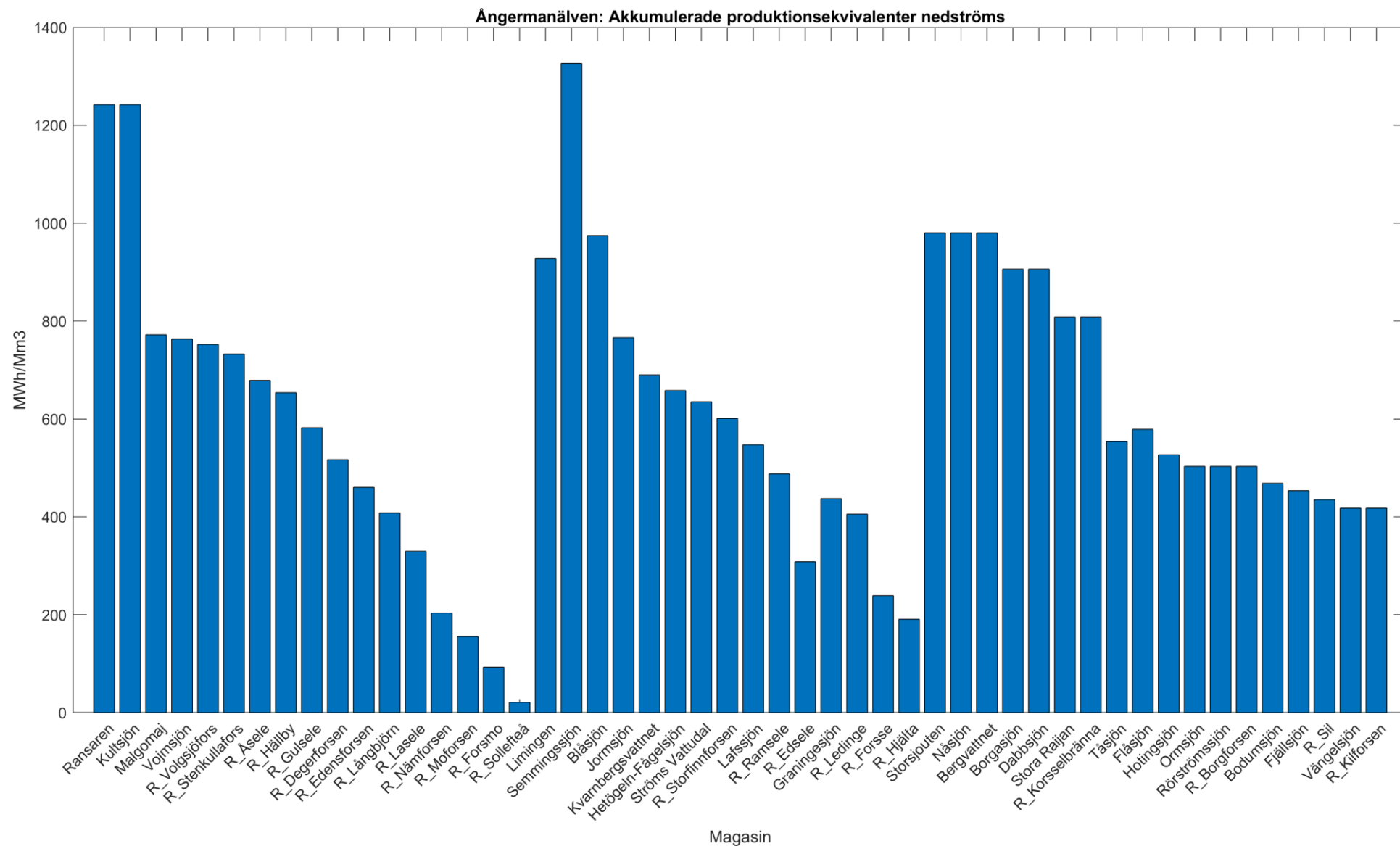
Systembeskrivning

Älvsystem

Angermanälven

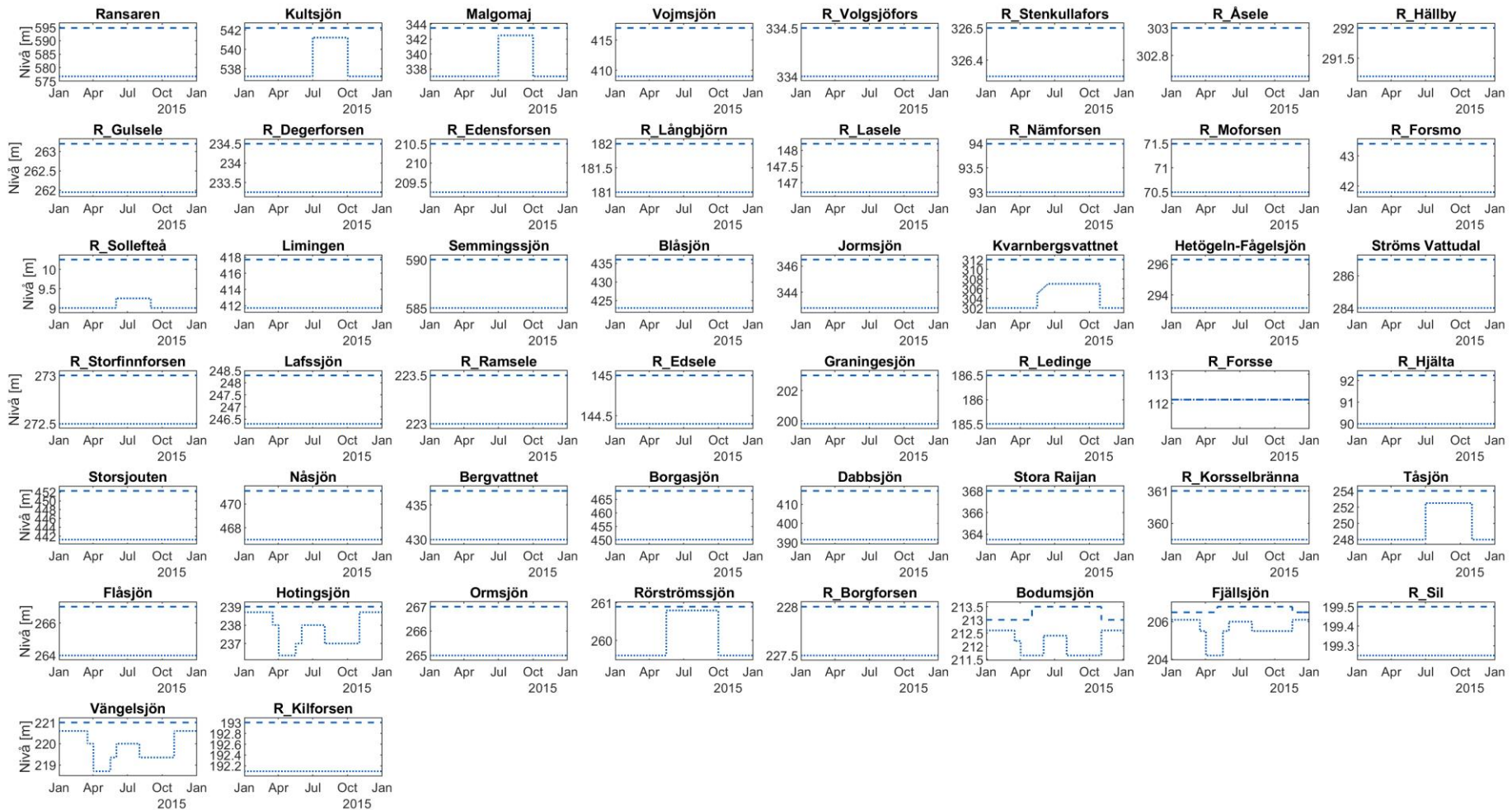


Energi per Mm³ lokaltillrinning



Vattendomar "WaterLevel"

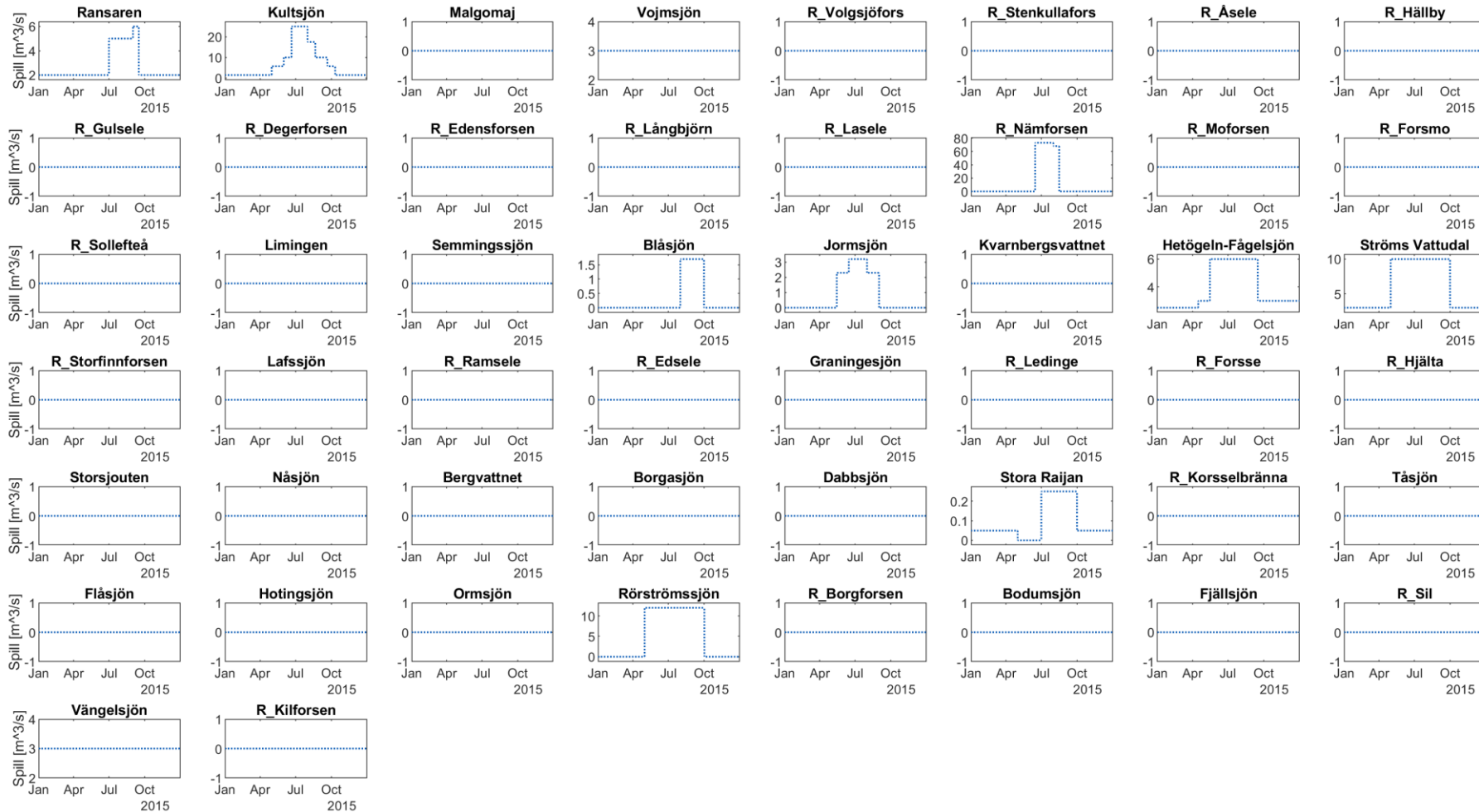
Angermanälven



..... min - - - max

Vattendomar "MinSpill"

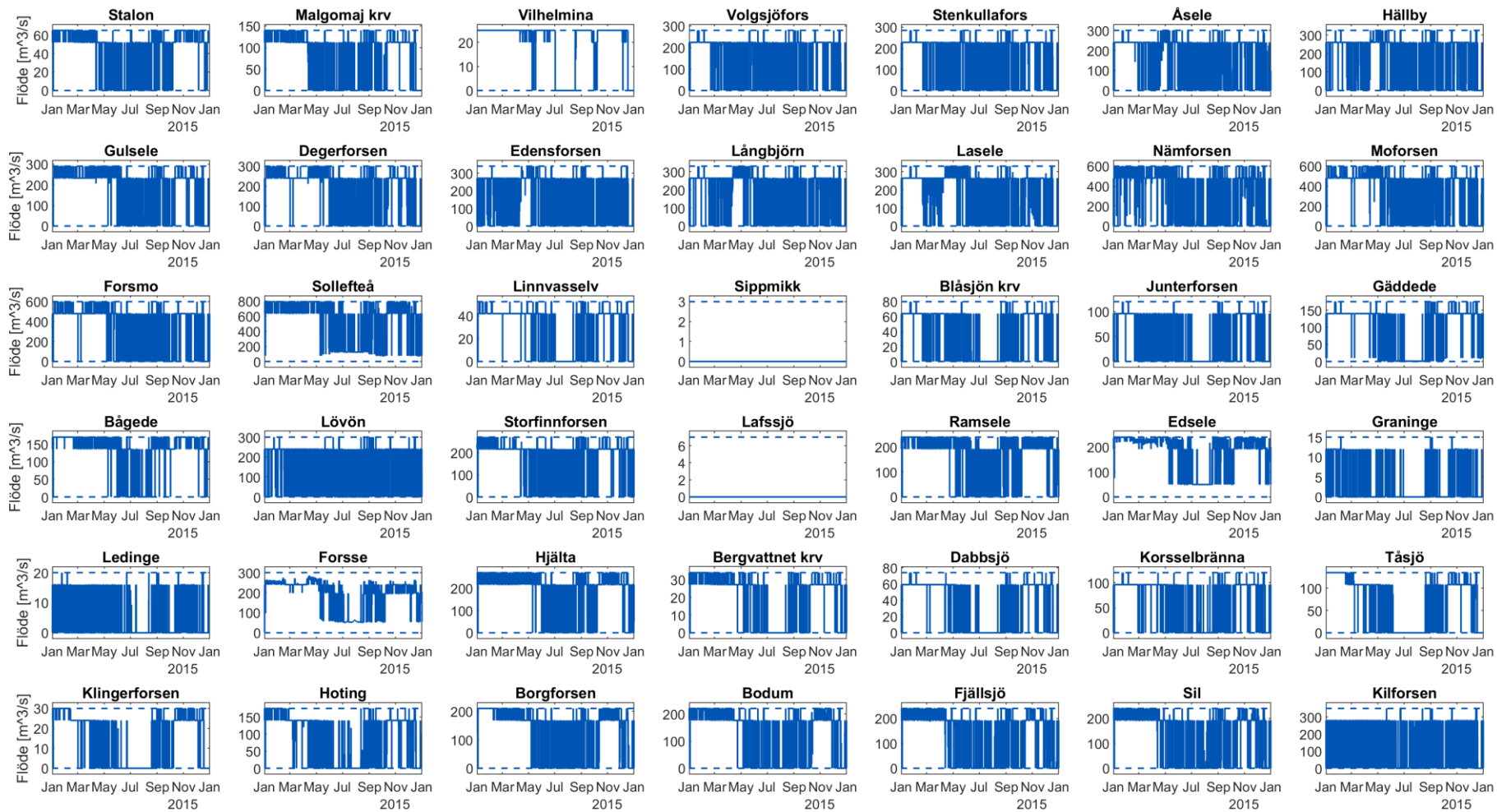
Angermanälven



..... min

Vattendomar "MinFlow"

Turbinvattenföring för Ängermanälven

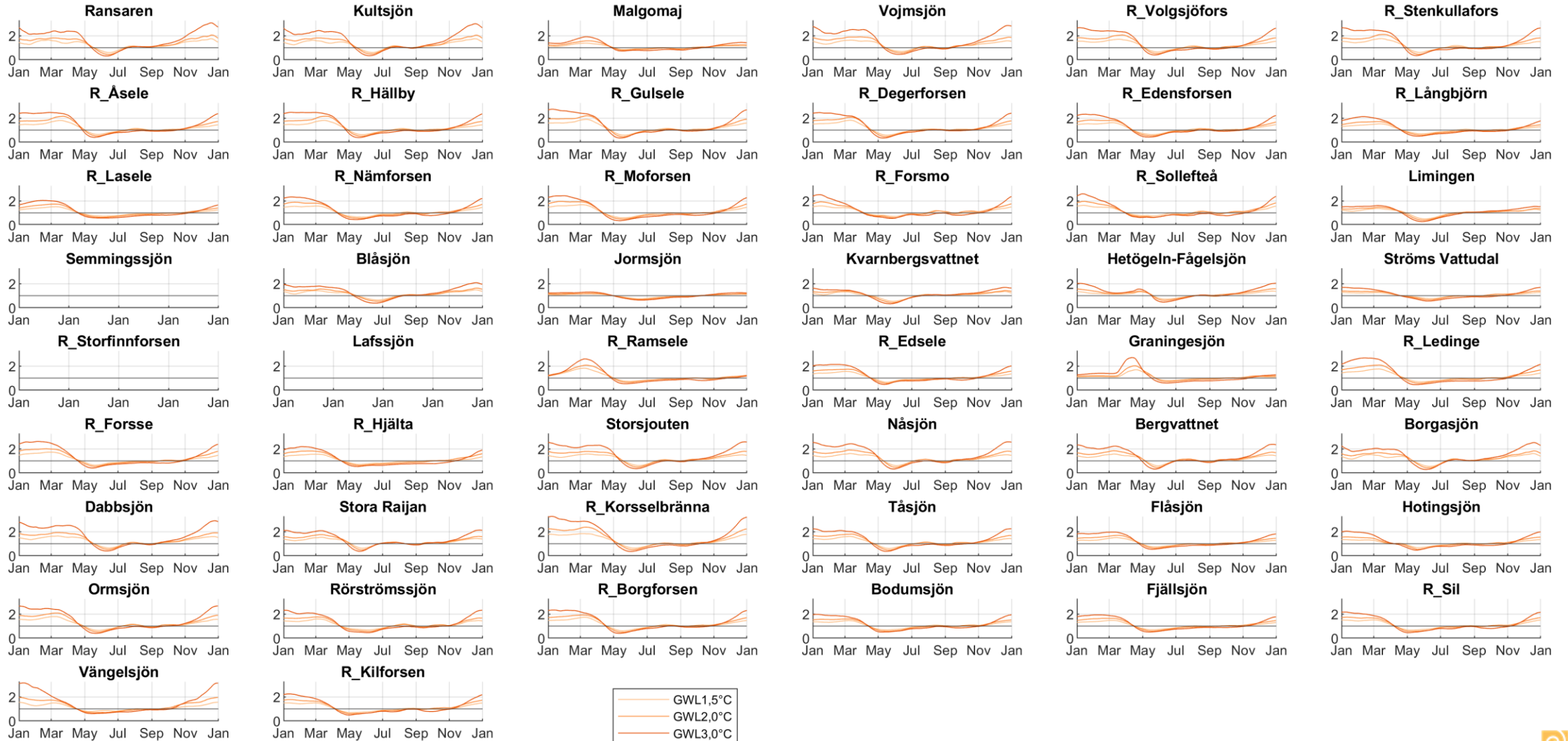


— KLIVA

Klimatpåverkan på lokaltillrinningar

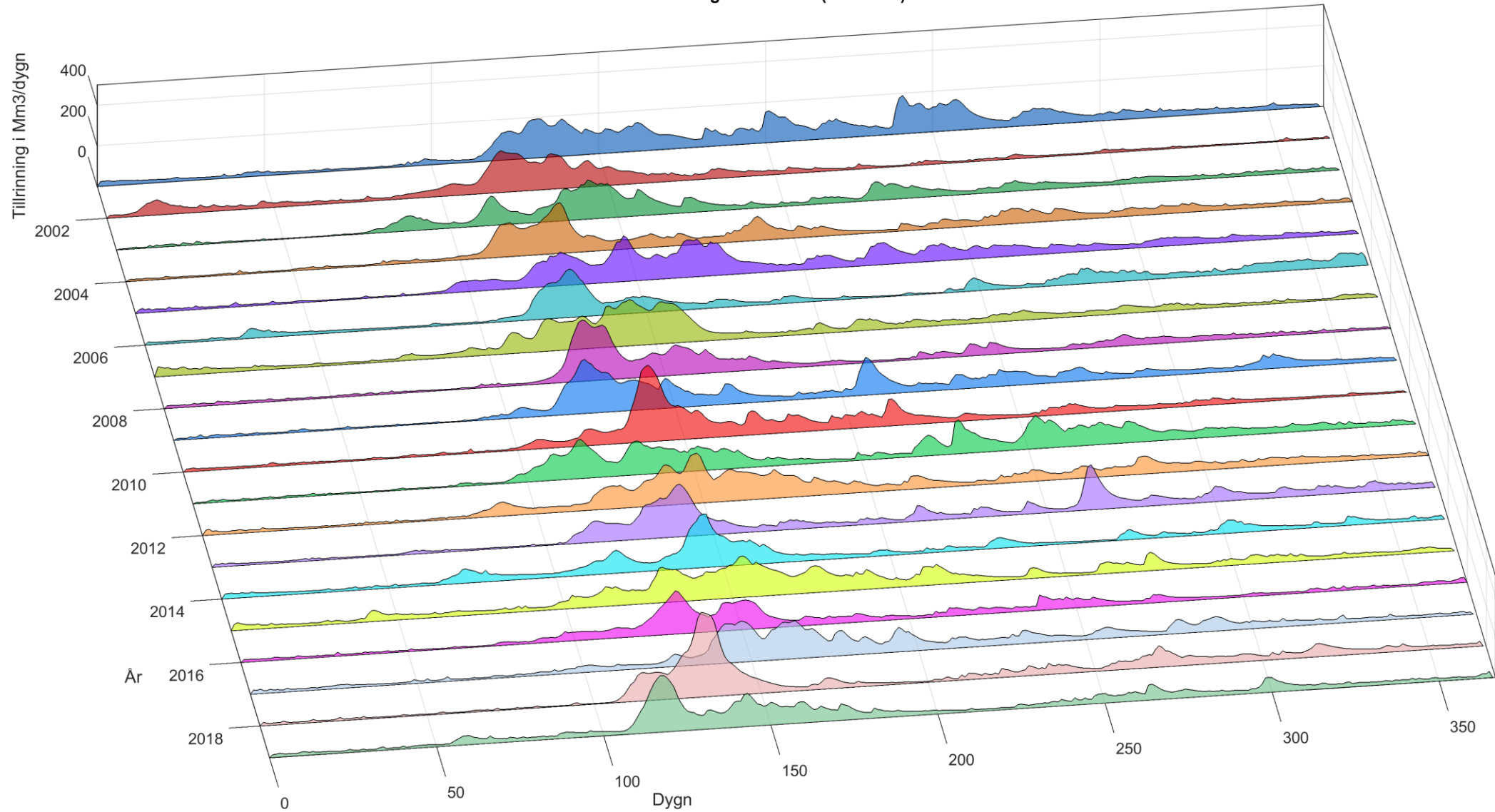
Klimatfaktorer

Klimatfaktorer Ångermanälven



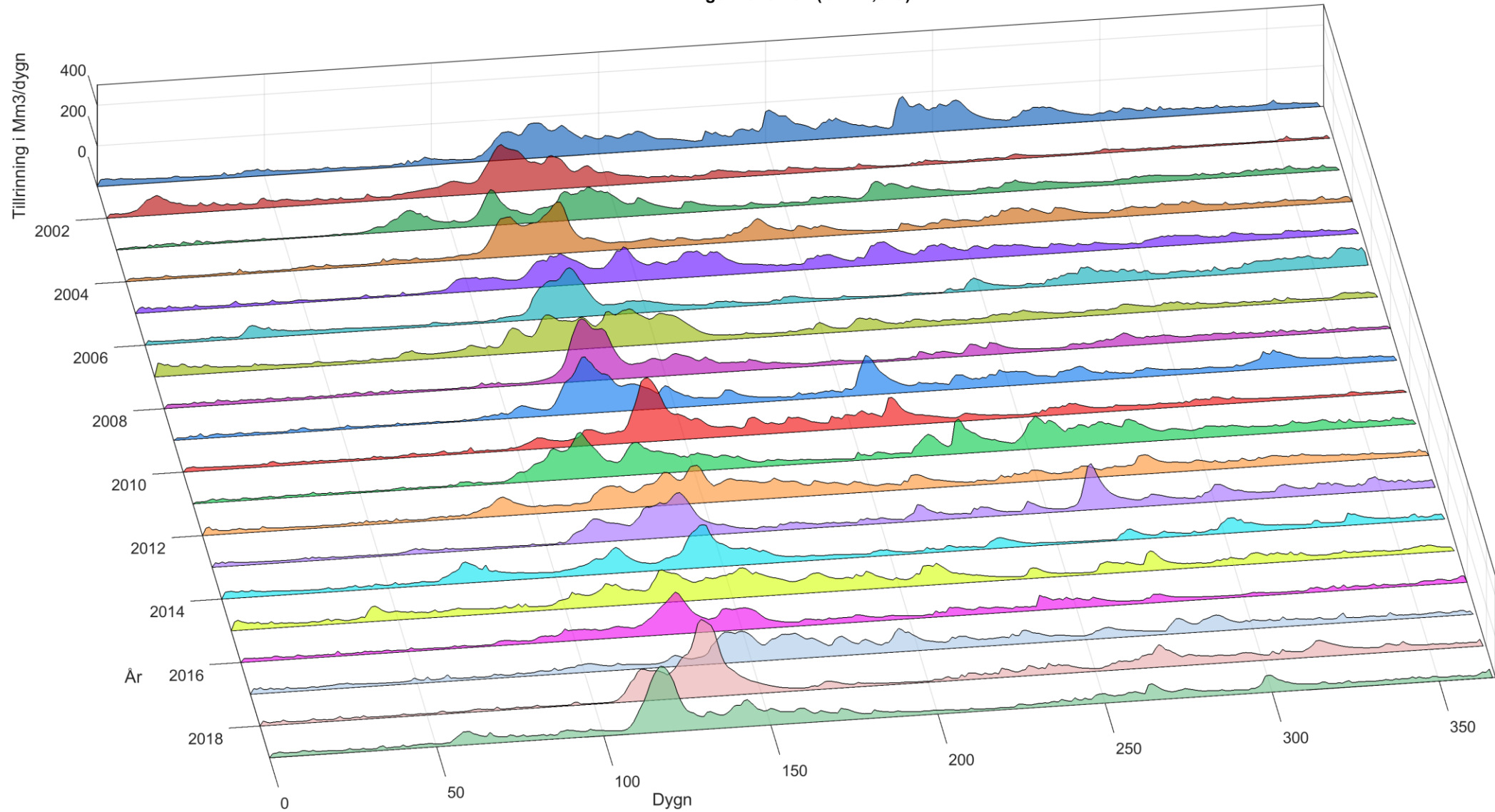
Total tillrinning (Referens)

Ångermanälven (Referens)



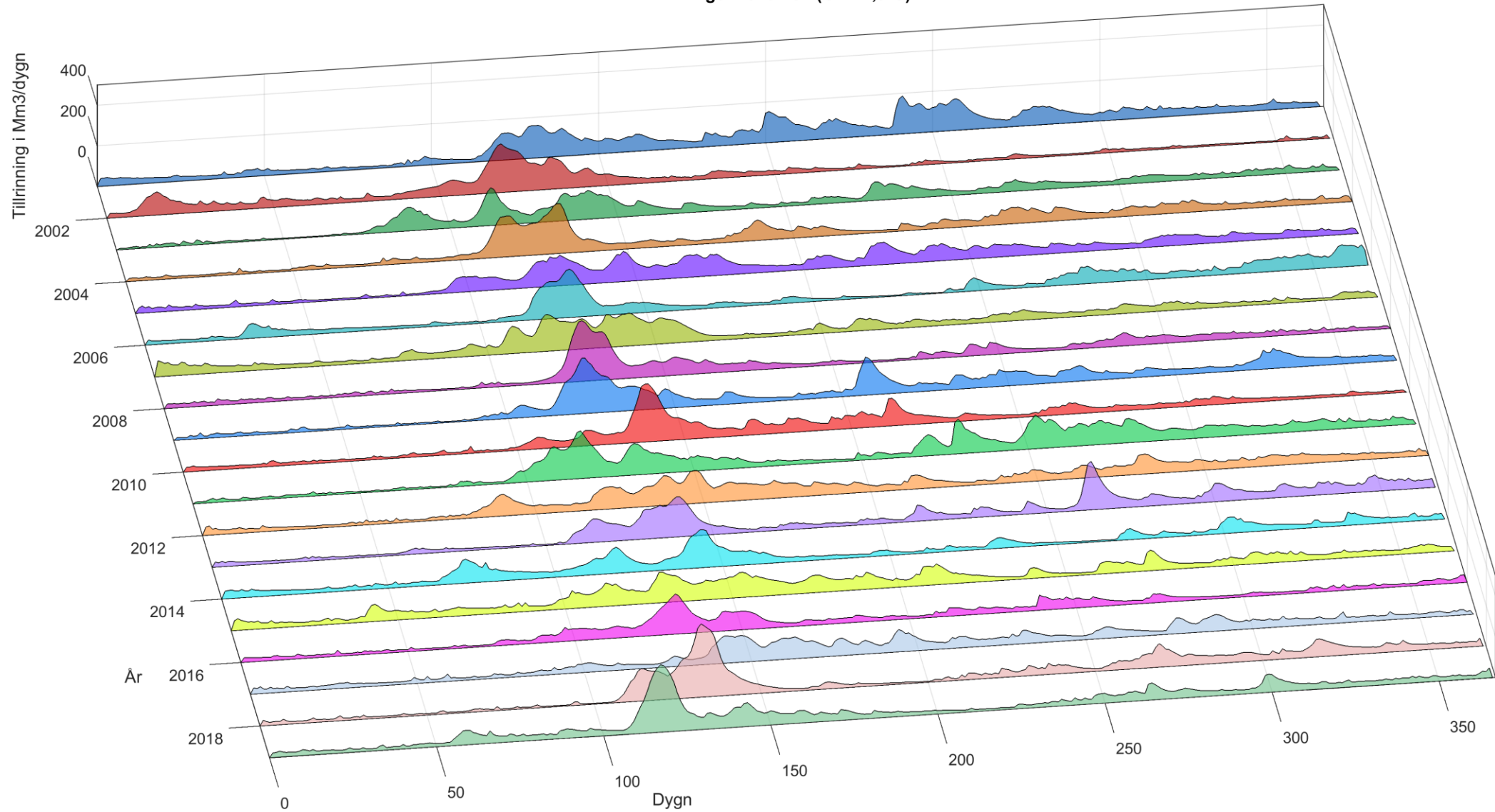
Total tillrinning (GWL1,5°C)

Ångermanälven (GWL1,5°C)



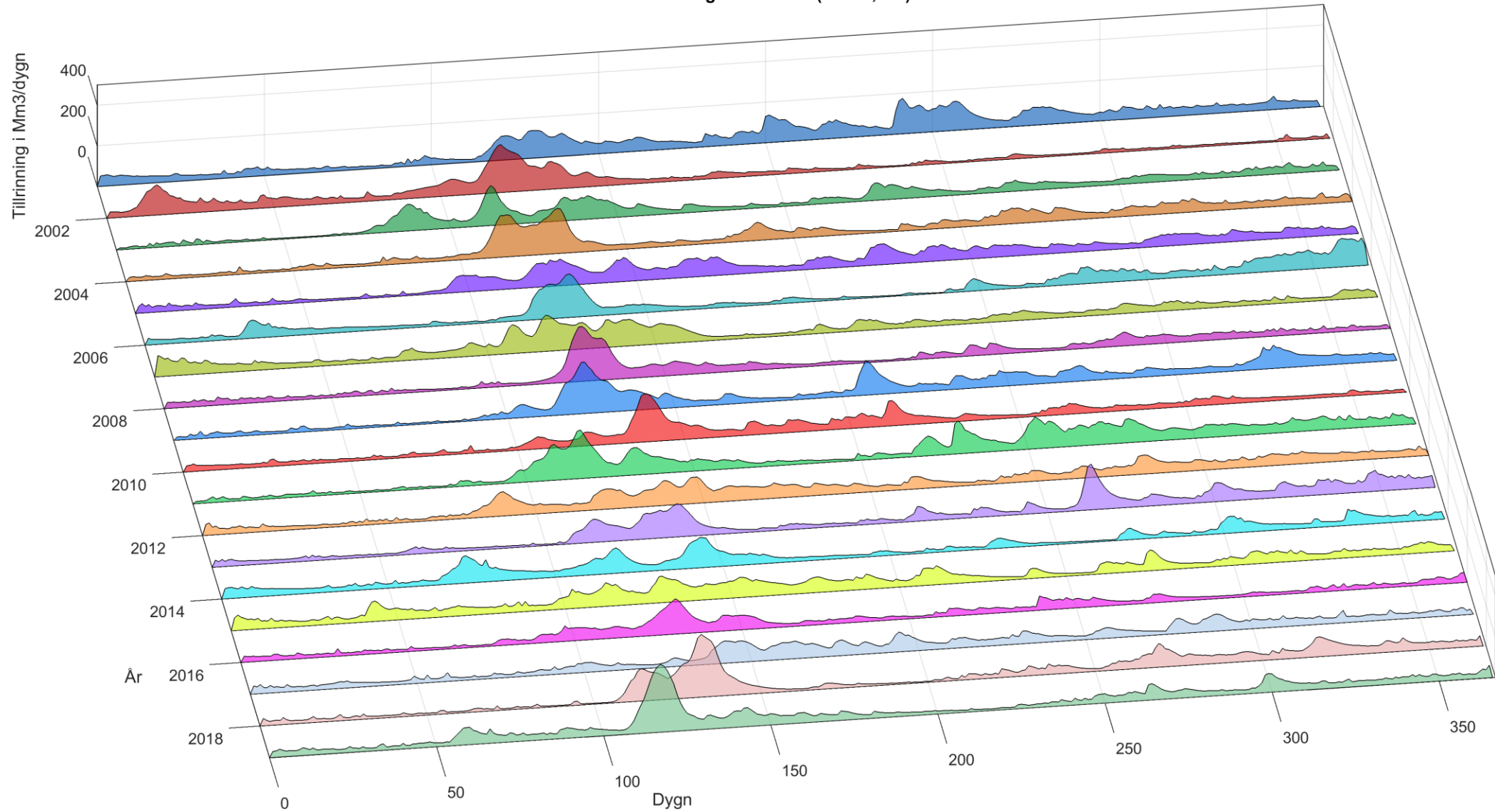
Total tillrinning (GWL2,0°C)

Ångermanälven (GWL2,0°C)



Total tillrinning (GWL3,0°C)

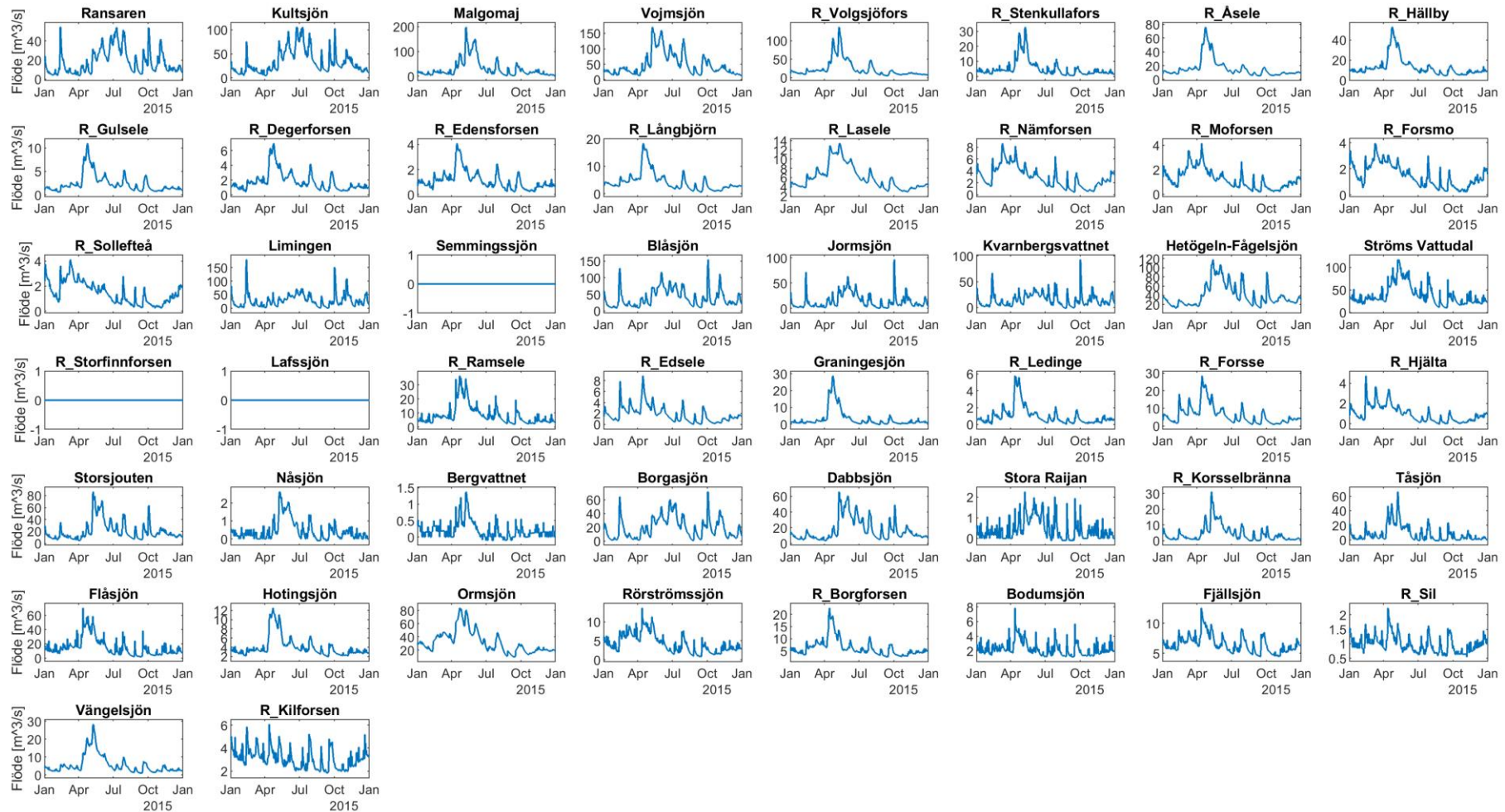
Ångermanälven (GWL3,0°C)



Resultat (exempel GWL2,0°C för 2015)

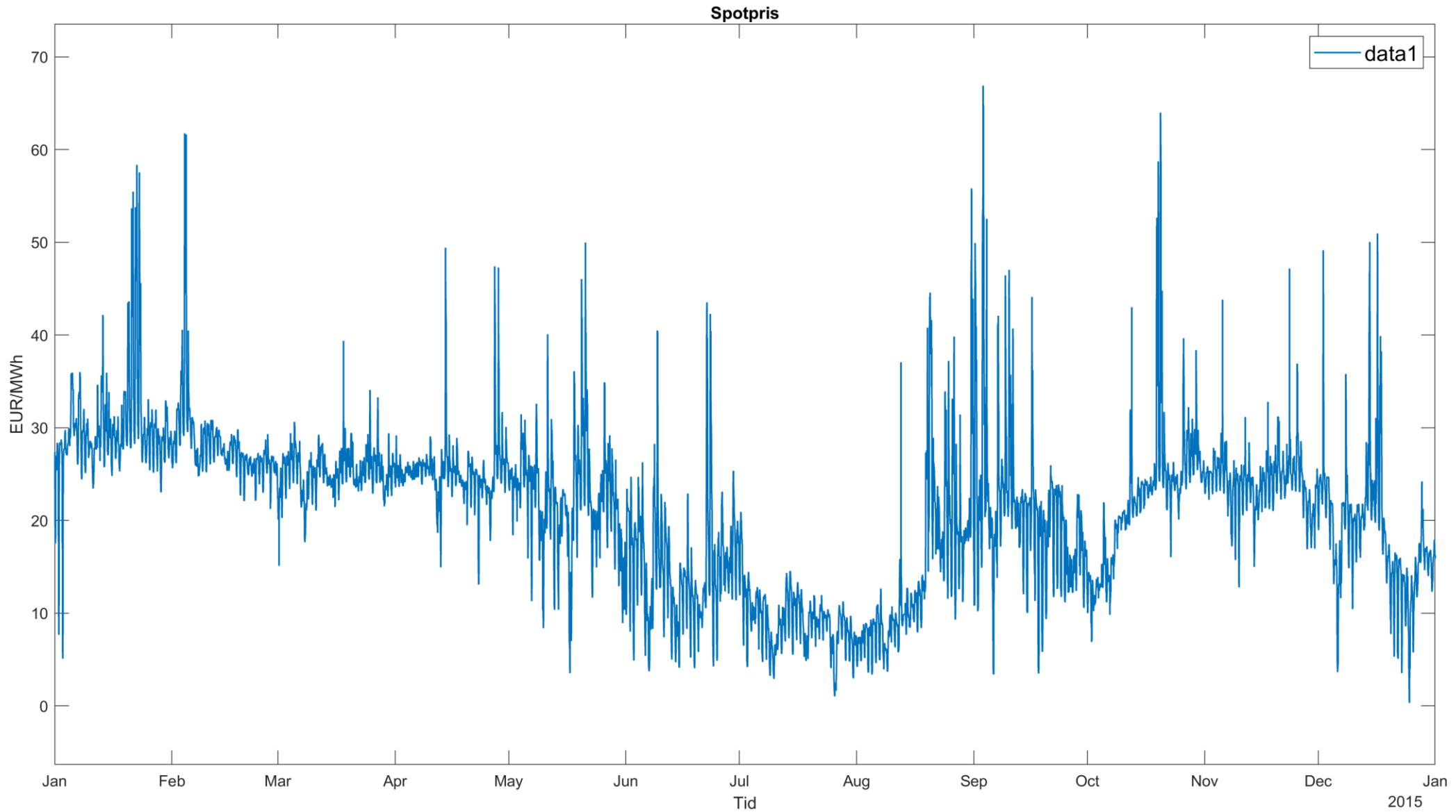
Lokaltillrinning

Lokal tillrinning för Ångermanälven



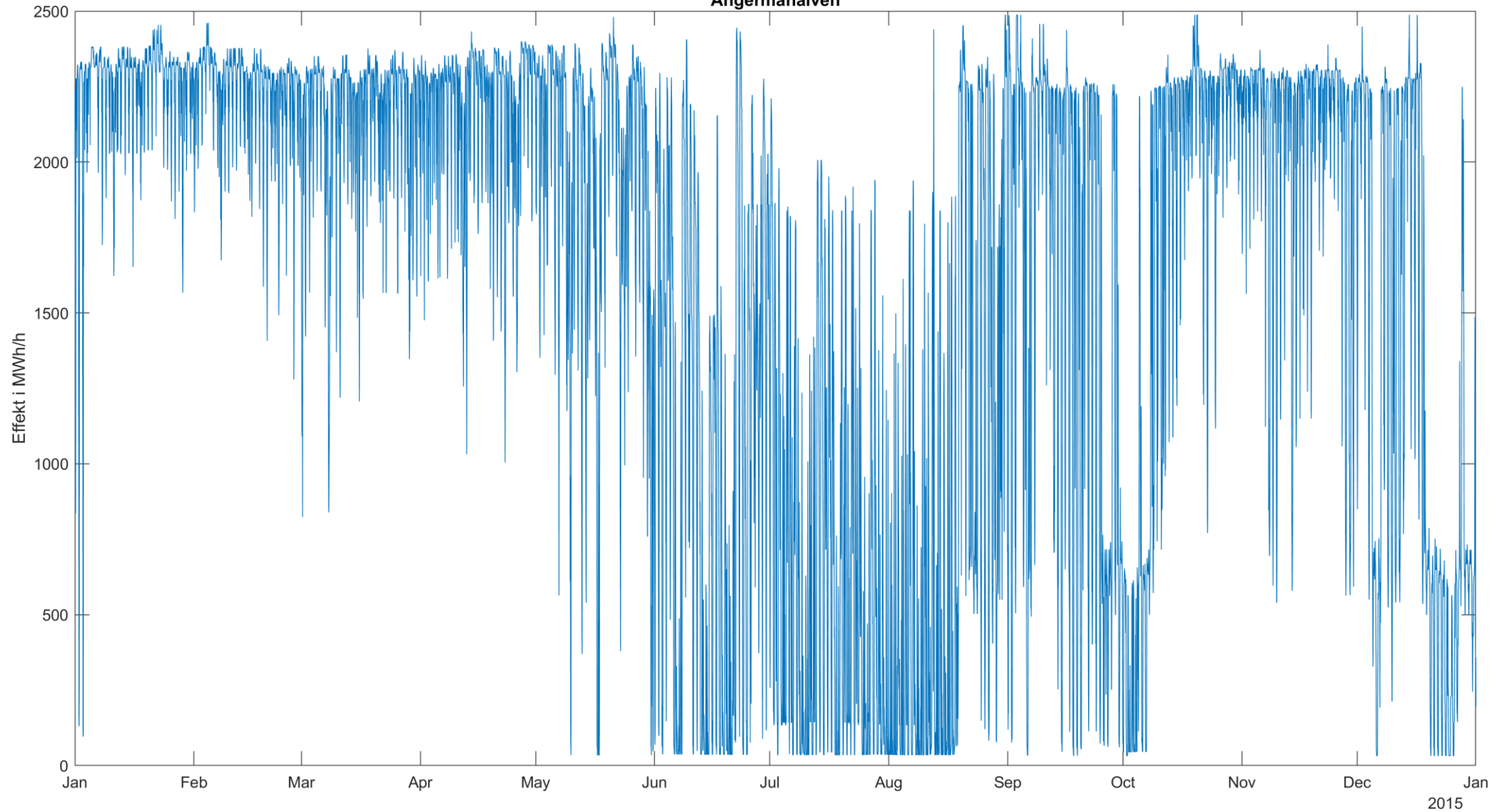
— data1

Elpriser



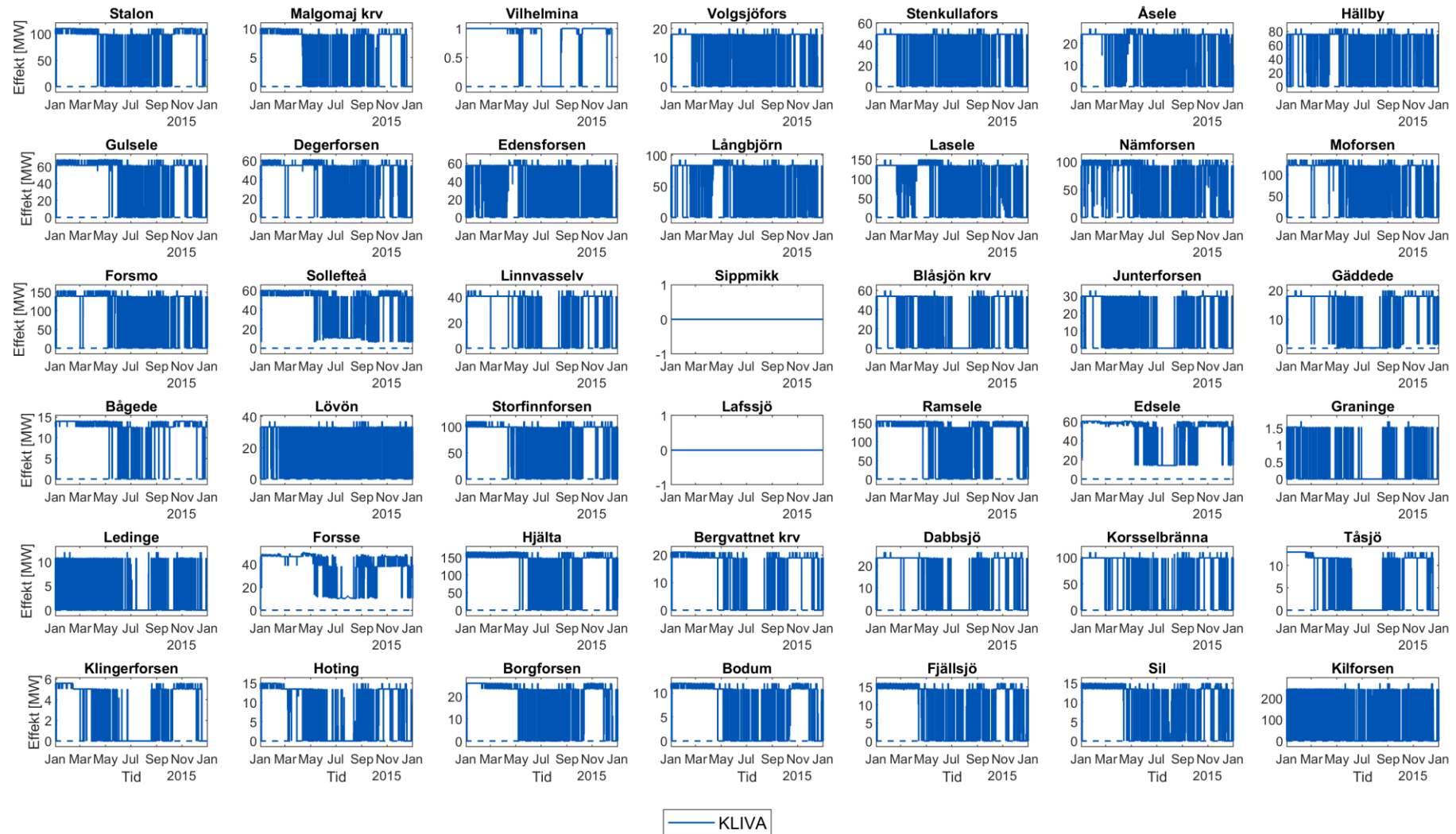
Produktion älvsystem

Ångermanälven



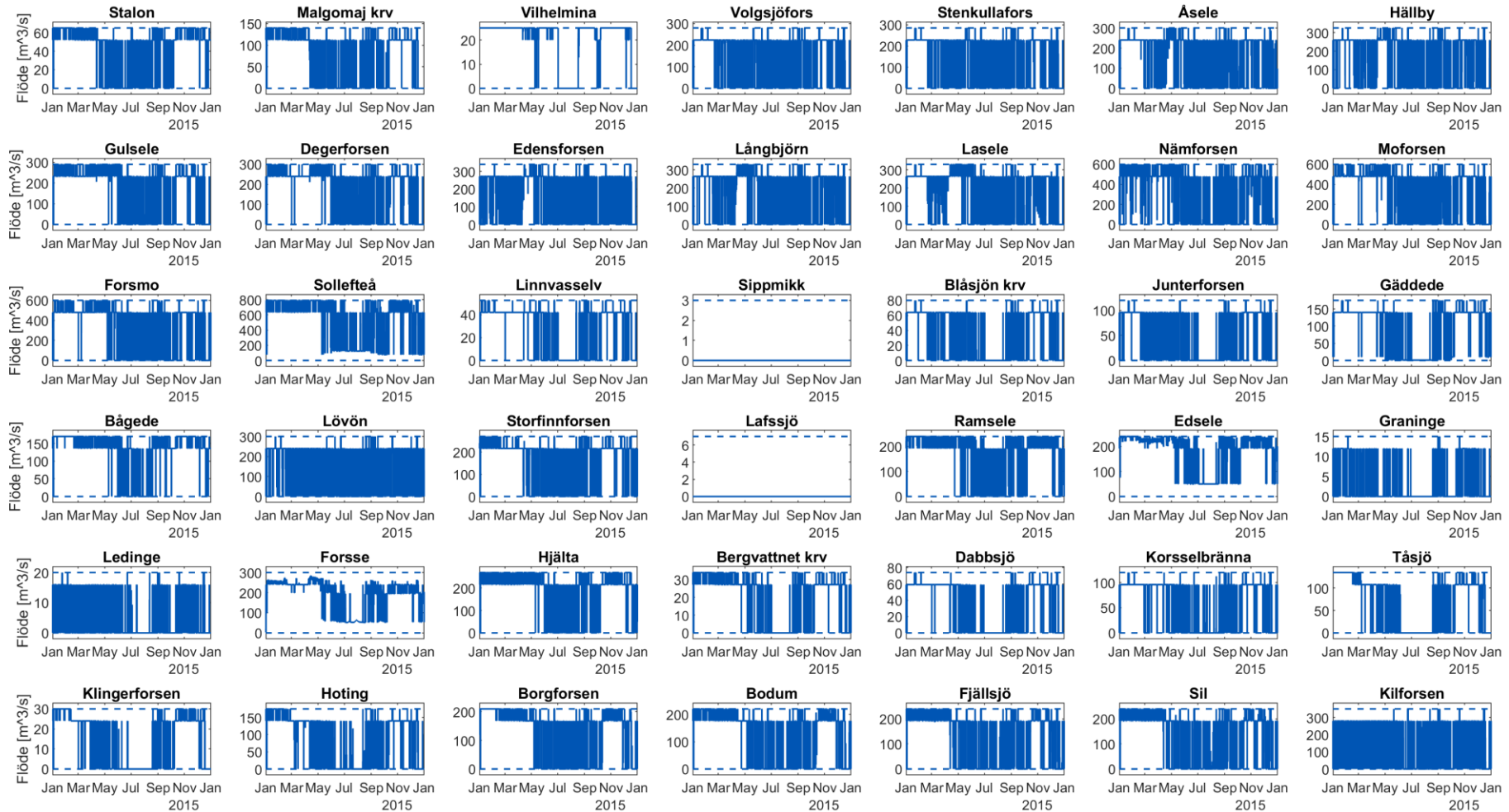
Produktion

Produktion per station för Ångermanälven



Stationsvattenföring

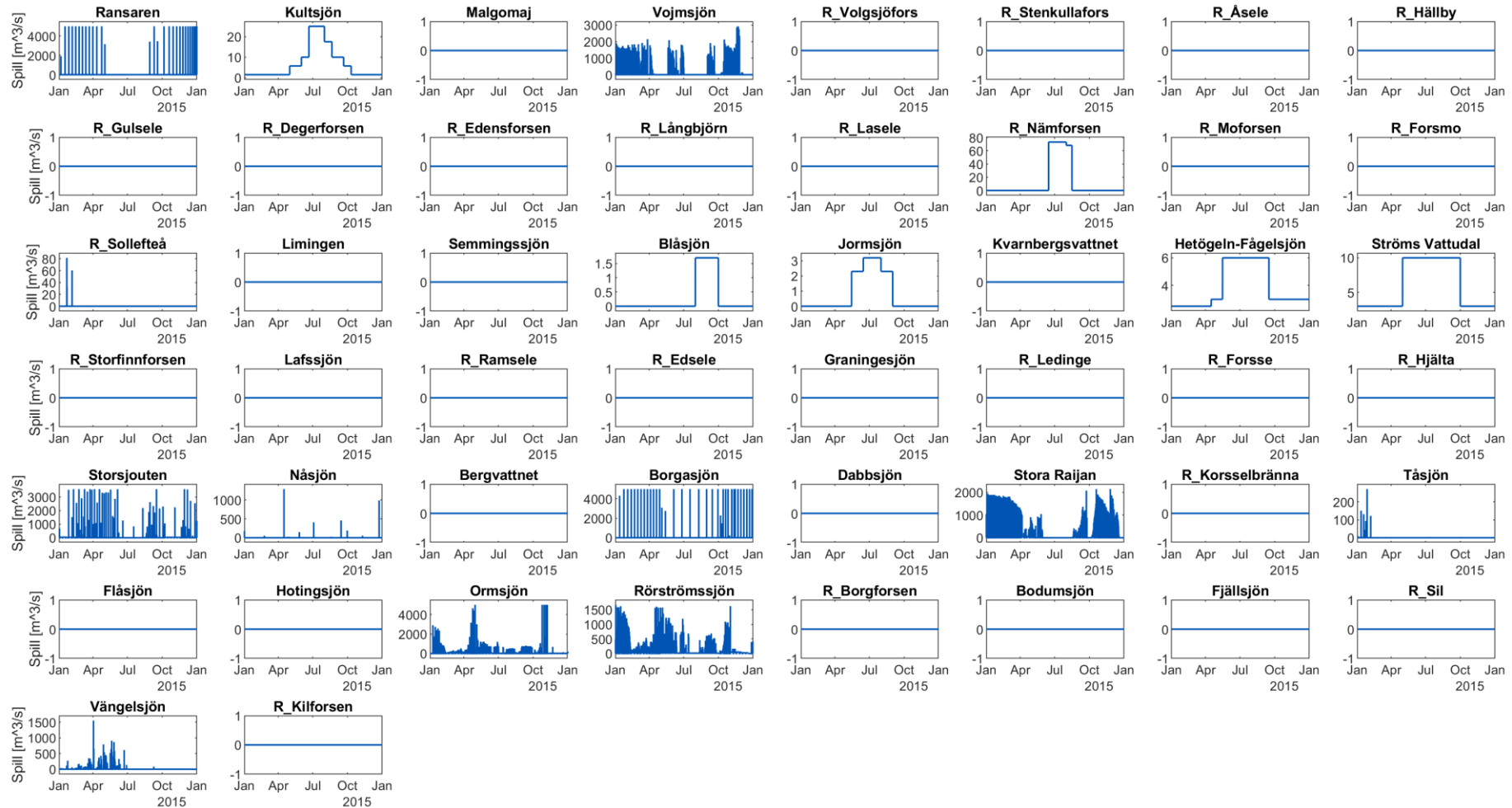
Turbinvattenföring för Ångermanälven



— KLIVA

Spill

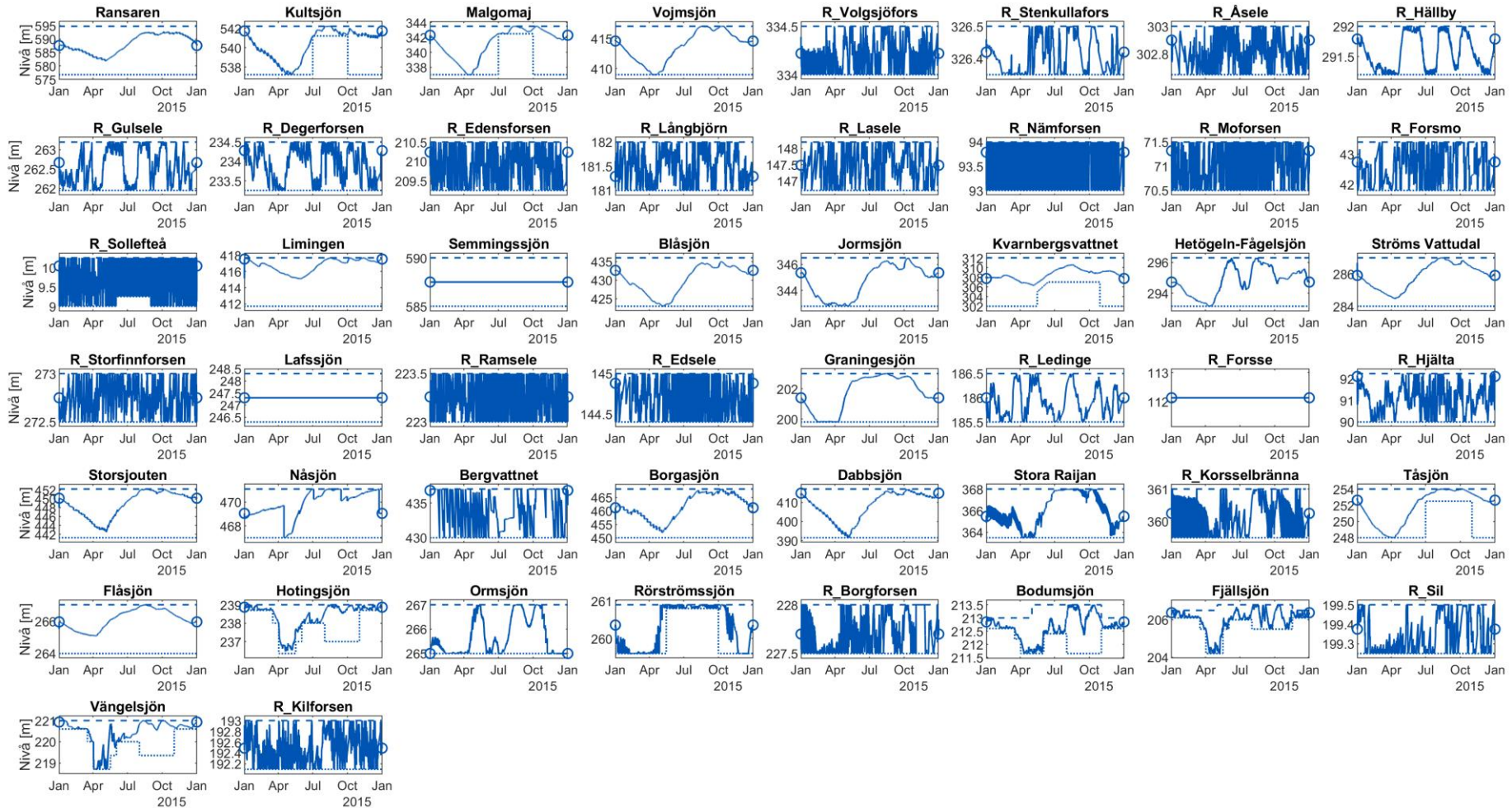
Angermanälven



— KLIVA min

Vattenstånd

Angermanälven

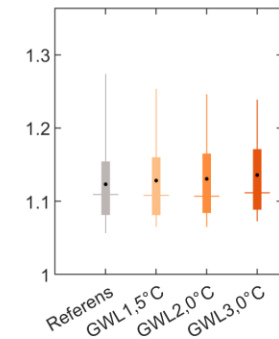
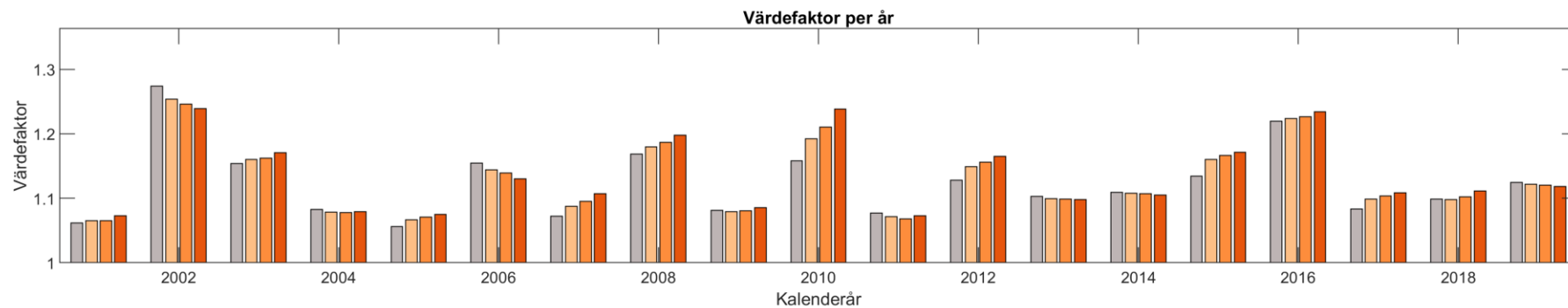
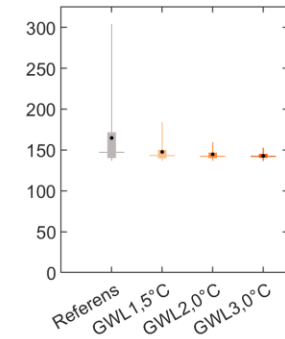
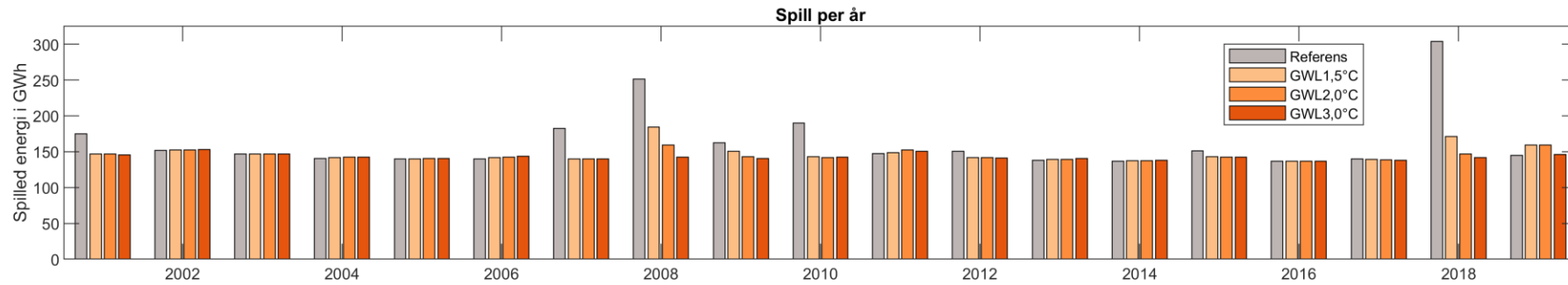
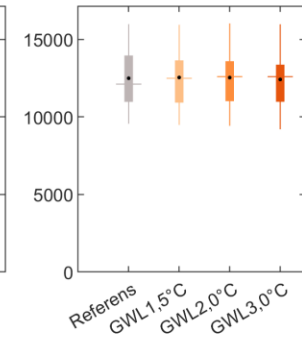
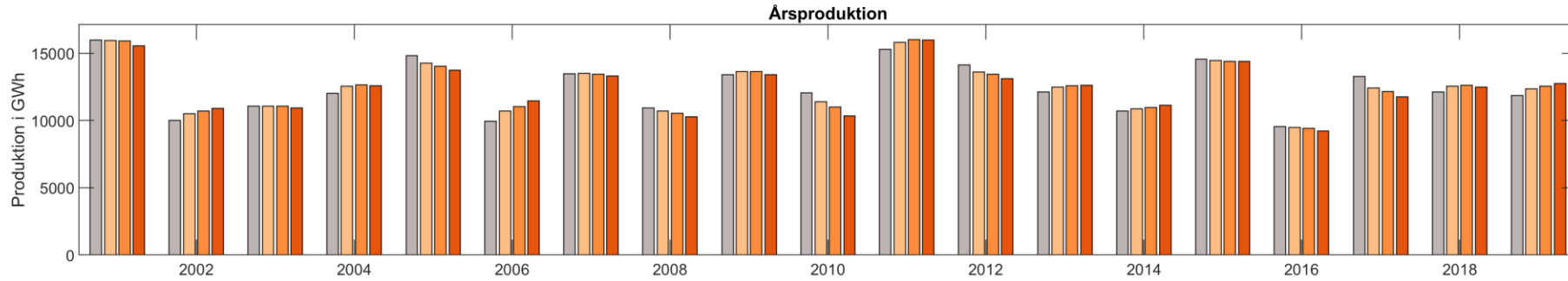


— KLIVA min - - - max ○ Randvillkor

Aggregerade resultat

Årsvärden produktion, spill, värdefaktor

Ångermanälven



Statistik produktion, spill, värdefaktor

Produktion i GWh

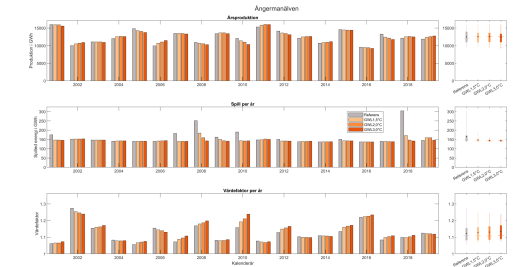
GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	12492	(Ref)	(Ref)	10969	13958	2989	9559	15977
GWL1, 5°C	12541	+49	+0 %	10919	13643	2724	9480	15937
GWL2, 0°C	12533	+41	+0 %	11012	13591	2579	9423	16025
GWL3, 0°C	12413	-79	-1 %	10971	13366	2395	9201	15971

Spill i GWh

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	165	(Ref)	(Ref)	140	172	32	137	304
GWL1, 5°C	148	-17	-10 %	140	150	10	137	184
GWL2, 0°C	145	-20	-12 %	140	147	7	137	160
GWL3, 0°C	143	-22	-13 %	140	145	5	137	153

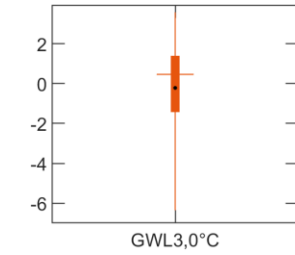
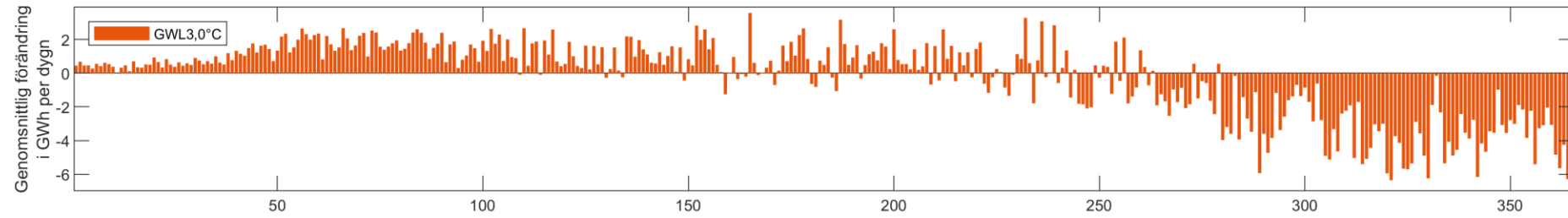
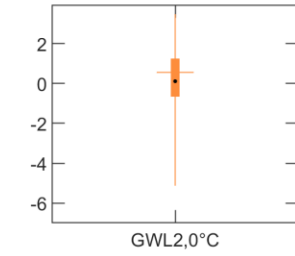
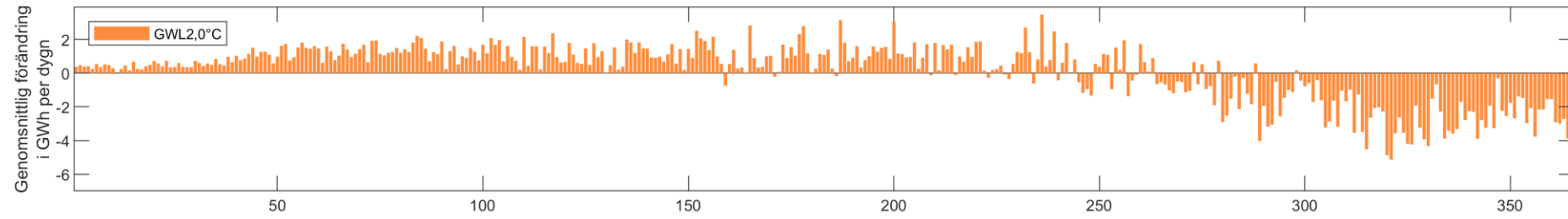
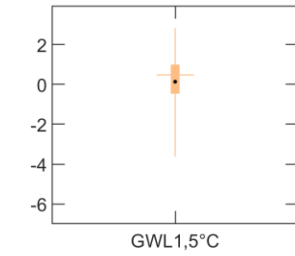
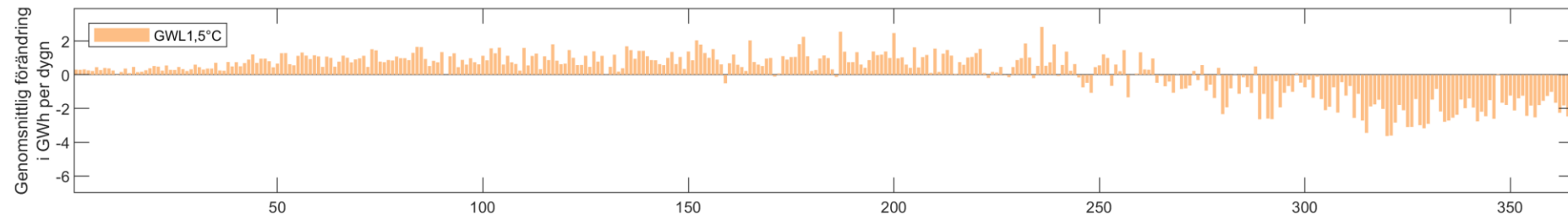
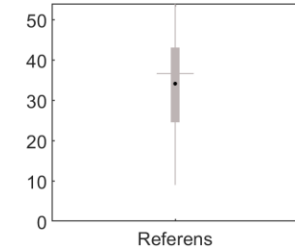
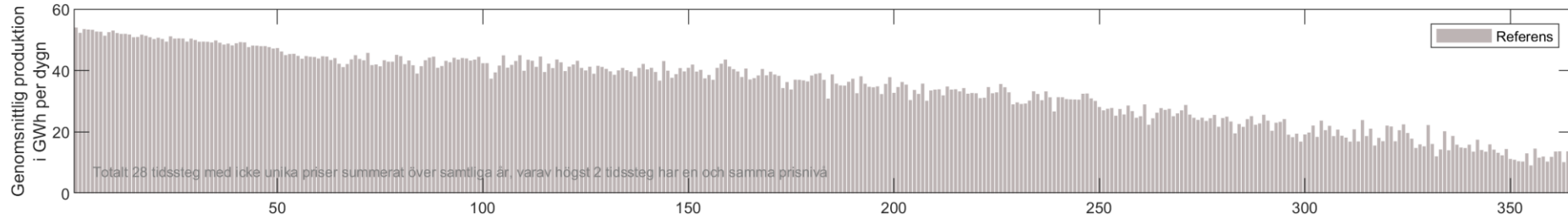
Värdefaktor

GWL	Medel	Förändring (abs)	Förändring (rel)	p25	p75	IQR	Min	Max
Referens	1.123	(Ref)	(Ref)	1.081	1.154	0.073	1.057	1.274
GWL1, 5°C	1.128	+0.005	+0 %	1.081	1.160	0.079	1.065	1.254
GWL2, 0°C	1.131	+0.008	+1 %	1.084	1.165	0.081	1.065	1.246
GWL3, 0°C	1.136	+0.013	+1 %	1.089	1.171	0.082	1.073	1.239



Förändring i balanseringsförmågan

Flerårs prissorterad produktion Ångermanälven (24 h)



Dygn



Kontakt AP2

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