Memo

Date	14/05/2019
To	Lyn Carmichael
CC	Melissa Robson-Williams
From	Dan Clark

Setting trigger levels and evaluating a flow regime for the Opihi River

Background

The Orari-Temuka-Opihi-Pareora (OTOP) Zone Committee released their Zone Implementation Programme Addendum (ZIPA) in December 2018. The ZIPA included recommendations for water management in the OTOP Zone. The ZIPA recommendations for the flow regime in the mainstem of the Opihi River were in the form of a set of principles, rather than prescribed minimum flows as recommended by the committee for the sub-catchments which feed in to the Opihi River. The flow regimes in this paper apply to AA and BA consents in the Opihi catchment, regardless of whether they abstract from the Opihi River or one of its tributaries. These minimum flows do not apply to either AN or BN consents as they have minimum flows at State Highway 1 on the Opihi River.

An adaptive management working group (AMWG) formed and funded by Opuha Water Limited provided a proposal that they wanted the Zone Committee to consider in their recommendations. This proposal was provided in four iterations and was not complete until the final version in October 2018, which was too late for evaluation prior to the recommendations being finalised by the committee. In response to the late proposal, the Zone Committee recommended that an adaptive flow regime be developed for the mainstem to the Opihi at Saleyards Bridge to align with a set of principles for the regime outlined in the ZIPA. Following the release of the ZIPA, the AMWG proposal was evaluated and found that it did not align with a number of the principles set by the Zone Committee and provided so much discretion to Opuha Water Limited and the Opuha Environmental Flow Release Advisory Group (OEFRAG) that it would be very difficult for Environment Canterbury to ensure that the regime was being complied with. Some components of the AMWG proposal would mean that Environment Canterbury would be unable to do any real time compliance checking on Opuha Water and their shareholders.

An evaluation of the AMWG proposal was completed following the ZIPA release and is reported in Clark (2019). The AMWG proposed regime could result in lower flows in the Opihi River than the current regime for much of the year and the frequency of reduced flows is dependent on OEFRAG's judgment.

As the AMWG proposal did not align with the Zone Committee's recommendations, Environment Canterbury is tasked with developing a flow regime that does align with these recommendations. Environment Canterbury Planning staff have requested that a regime is

developed that aligns with the principles of the Zone Committee and integrates as much of the AMWG proposal as possible, while still being implementable and able to be monitored for compliance. This regime is intended to retain the triggers of snow storage, inflows to the lake, and lake level (stored water). By retaining these triggers for entering lower flow regimes, the plan regime will respond to periods of climatic dry conditions and climate change by reducing the minimum flow requirement that must be met in the Opihi River.

In a media interview, Vice Chair of the Opuha Water Limited board of directors, Nicky Hyslop indicated that Opuha Dam was always expected to be insufficient in 1 in 20 years (Benny, 2015), this agrees with the recent current state reporting (Dodson and Steel 2018). This frequency is consistent with the original AMWG proposal for Level 2 reduction in flow to occur in 1 in 20 years. This frequency is also considered to be outside of the normal year-to-year climate variation and would likely be considered a drought event.

The proposed plan regime

The proposed flow regime is a simplification of the AMWG that retains the concept of Full availability, Level 1, and Level 2 minimum flow requirements at Saleyards Bridge. Triggers are calculated monthly and changes between each level of minimum flow can only occur at the change of the month.

The triggers for entering the Level 1 and Level 2 minimum flow regimes are as follows:

Level 1- When any two of the following occur:

- Snow storage for the month (during July to December) is below the 20th percentile (1 in 5 year) for that month
- Inflow to the lake is below the 20th percentile (1 in 5 year) for that month
- Lake level is below 385 masl (approx. 50% storage)

Level 2- When any two of the following occur:

- Snow storage for the month (during July to December) is below the 5th percentile (1 in 20 year) for that month
- Inflow to the lake is below the 5th percentile (1 in 20 year) for that month
- Lake level is below 380 masl (approx. 25% storage)

Calculation of the thresholds for each of the triggers has been completed by Environment Canterbury technical staff. Data for snow storage, inflows, and lake level were obtained from OWL and are the same dataset used in their proposal and the evaluation of the AMWG proposal. These data were used to complete a frequency analysis to calculate the non-exceedance probabilities for each month. The thresholds in Table 1 were calculated as the 20% and 5% non-exceedance probability in each month; these correspond to 1 in 5 year and 1 in 20 year respectively. As these thresholds have been set per month, the chance of the threshold being breached in any given month is 1 in 5 or 1 in 20 chance and so the probability of the threshold being breached in any given year is greater than 1 in 5 or 1 in 20 years.

Table 1 Thresholds calculated from historic snow storage and lake inflows frequency analysis.

Adaptive Management Regime Triggers												
Inflows (l/s)												
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Level 1	2522	2094	2481	1955	4995	2792	3454	3376	3574	5662	6212	6483
Level 2	2430	1497	2473	1889	4995	2686	3433	3358	3421	4956	6111	6483
Snow Storage (Mm^3)												
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Level 1	0	0	0	0	4	11	17	22	20	15	7	1
Level 2	0	0	0	0	3	11	17	21	18	14	6	1

The frequency analysis has been completed for each month, but the AMWG recommended that the snow storage trigger is only valid from July to December, the months outside of this should be excluded for snow storage. The distributions for each of the thresholds have been shown in the appendix of this memo.

Other components of the flow regime are as follows:

The minimum flow at Saleyards Bridge remains an instantaneous minimum flow, to ensure that sufficient water is in the river at all times. This will protect the instream values and ensure that the quantum of water being abstracted by shareholders is available in the river at the time it is being abstracted from the catchment.

Restrictions in the flow regime are also calculated daily to be consistent with the restrictions that apply on the tributaries. Shareholders on the tributaries will be restricted by the most restrictive of either their tributary specific minimum flow, or the Opihi main stem minimum flow.

The volume of water released for artificial flushing flows can be recouped via a reduction in minimum flow requirement following the flush. The volume recouped should only be that which comes from storage from the dam. Freshes from the Upper Opihi River or Te Ana Wai River cannot be credited into additional storage for OWL.

The minimum flows in the plan flow regime are those that were proposed by OEFRAG in 2008. These flows have been presented by the AMWG as having the same volumetric requirements at Saleyards Bridge as the current ORRP minimum flows and also the full availability under the AMWG proposal.

The ZIPA recommends that the gains in flow made in the tributaries is retained in the main stem flow. To do this, the monthly full availability flows are increased by the sum of the

increase in minimum flow from the Upper Opihi and Te Ana Wai Rivers. If the minimum flows are not increased by this amount, then the gains in the tributary flows are retained in the lake and would not provide the gain for the catchment as a whole. As the Opihi Catchment is managed as a whole system, where shareholders' abstractions on the tributaries are 'offset' by water released down the mainstem, then any gain in flow in the tributary must therefore result in a gain in the flow at Saleyards Bridge. If this gain does not occur, then the concept of 'offsetting' abstraction in the tributaries presents a conflict in the water balance.

Evaluation of the plan regime

This evaluation is focussed on the triggers within the flow regime and frequency at which the different minimum flow requirements will be in place. This evaluation does not address the ecological merit of the minimum flow values set in each step of the flow regime.

Using the same data set as was used to calculate the thresholds, an evaluation was done to estimate how frequently the triggers would be met to enter Level 1 or Level 2 minimum flow reductions. Figure 1 shows that conditions are met to enter Level 1 and Level 2 minimum flow restrictions in many years. The most significant periods are in the 2014-2015 years and 2000-2001, which correspond to the years when climatic conditions resulted in low inflows to the lake and reduced storage. This indicates that this flow regime allows reductions in minimum flows at times when there is a risk that flows may not be able to be maintained later in the season due to climatic conditions.

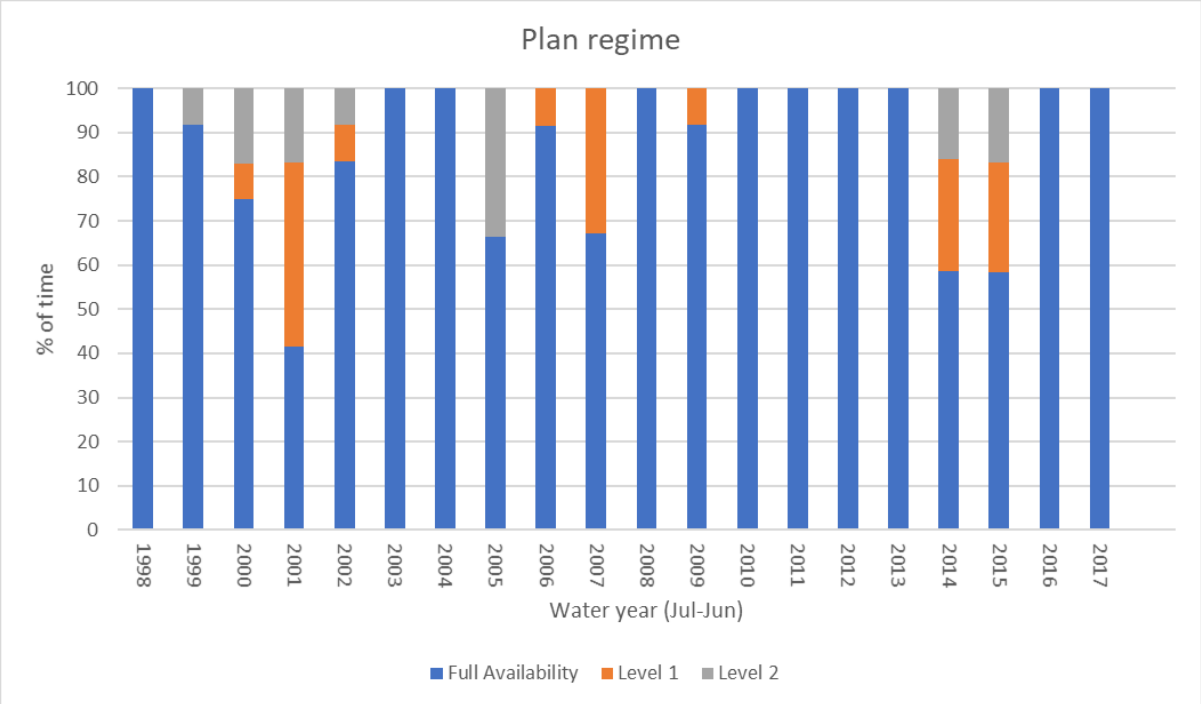


Figure 1 Percent of time in each year that could be spent in each of the minimum flow regimes

The flow regime in the plan provides a compromise between the flexibility requested by the AMWG and a practicable solution that Environment Canterbury can be confident in the likely consequences of, and also monitor for compliance, while still meeting the principles set out by the Zone Committee. Under the plan flow regime there is greater certainty that flows will be

improved when compared to the AMWG proposal and it also allows greater transparency at times when flows are reduced.

This flow regime relies on the inflow and snow storage estimates used in the AMWG proposal, and these datasets will need to be maintained to determine if the triggers are met to allow a reduction in flow at Saleyards Bridge.

This evaluation looked at how frequently triggers would be hit to allow a change in the flow regime; it does not take into account irrigation demand or how OWL operates storage within the dam. As the proposed minimum flow requirement under the full availability flow regime is the same volume of water as the current regime plus the flow increase from the increased flows in the tributaries, the volume of water leaving the dam should be similar to that which is required under the ORRP.

Acknowledgements

This memo includes flow frequency analysis which was completed with the assistance of Wilco Terink (Environment Canterbury), who developed and ran the required python scripts This memo has been reviewed by Jen Dodson prior to release.

References

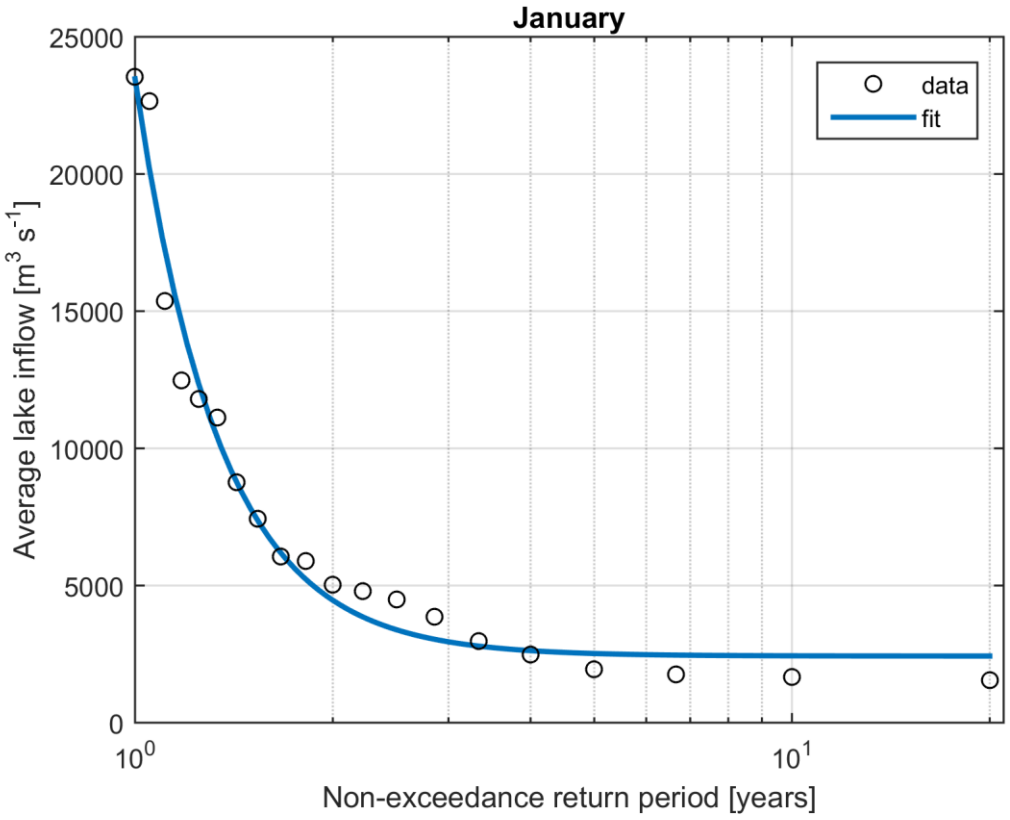
Benny, T. (2015). Opuha Water Scheme delivers in time of need | Stuff.co.nz. Retrieved April 2, 2019, from Stuff website: https://www.stuff.co.nz/business/farming/agribusiness/67488153/null

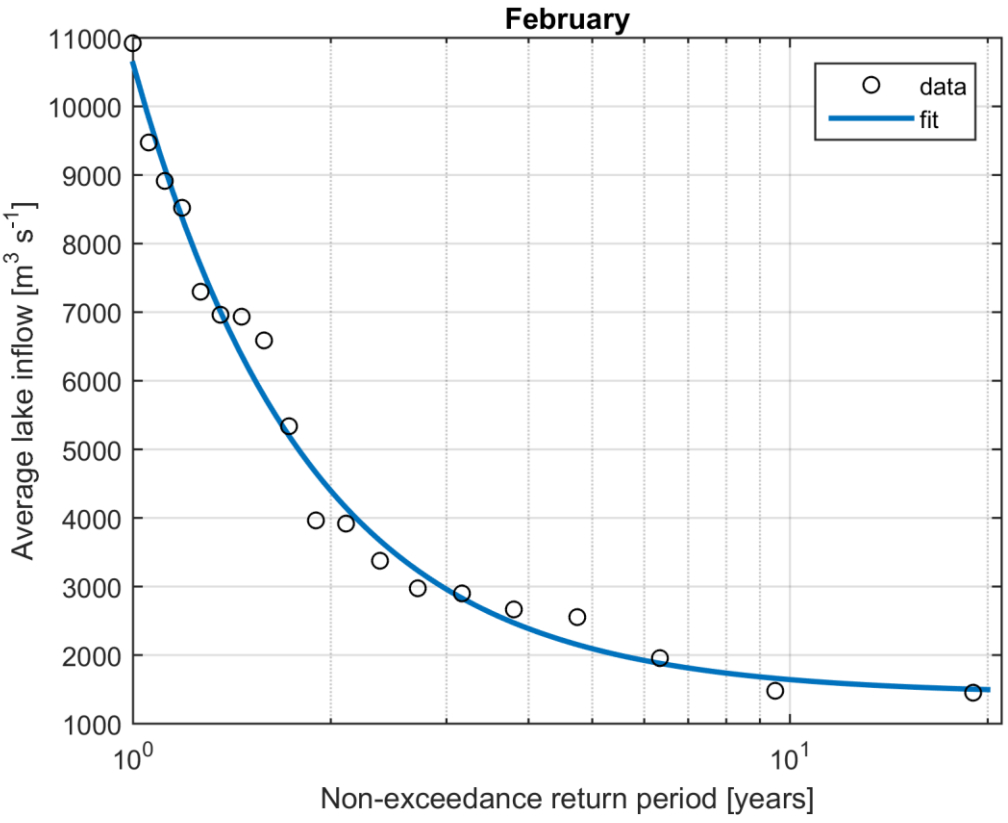
Clark, D. (2019). Hydrology technical summary report to support the Orari, Temuka, Opihi and Pareora limit-setting process, *In press*

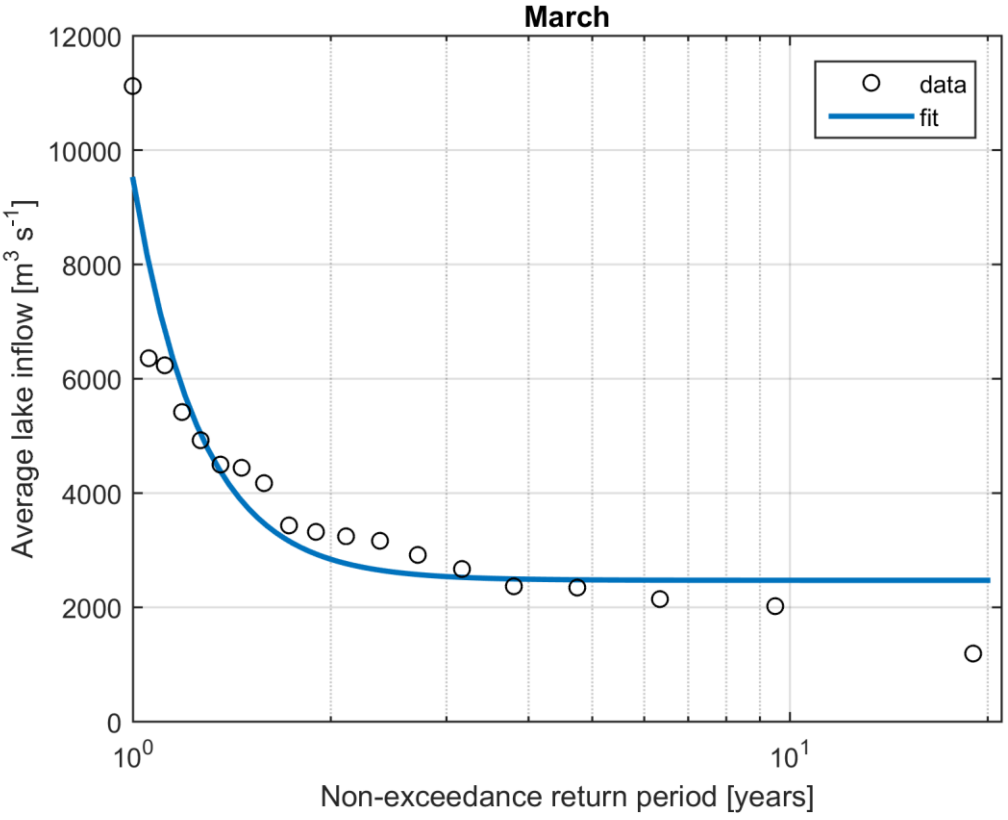
Dodson, J., Steel, K., (2018) Current state of surface water hydrology in the greater Opihi catchment. Environment Canterbury technical report R 18/80

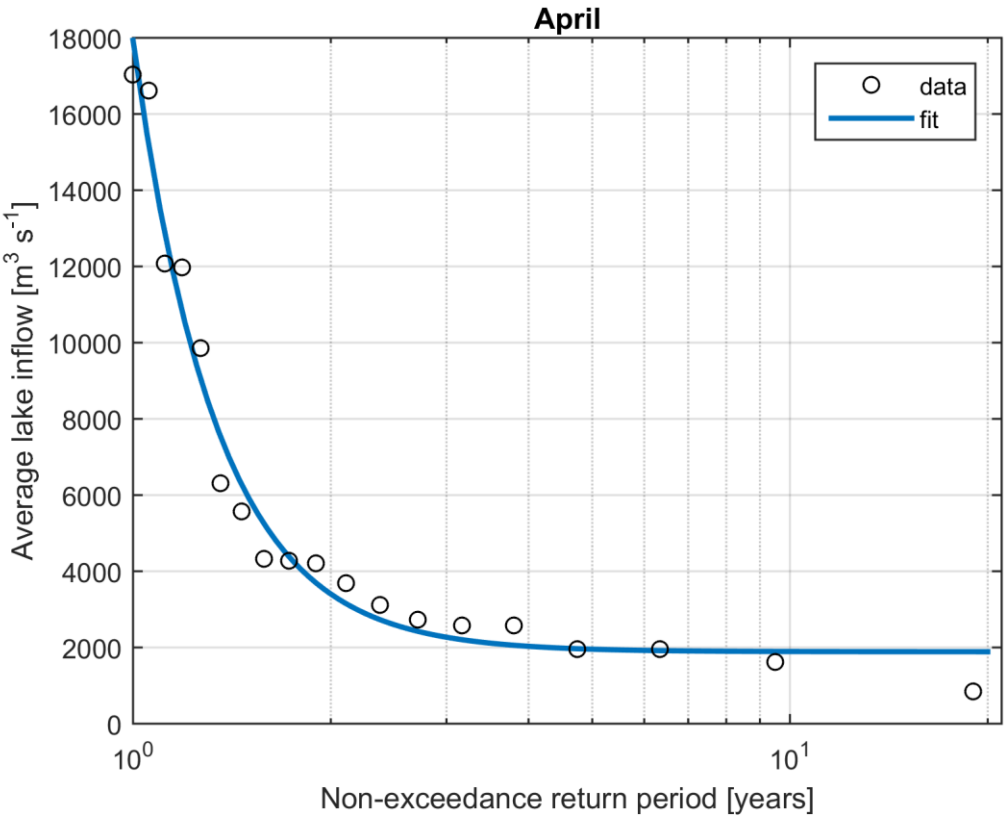
Appendix.

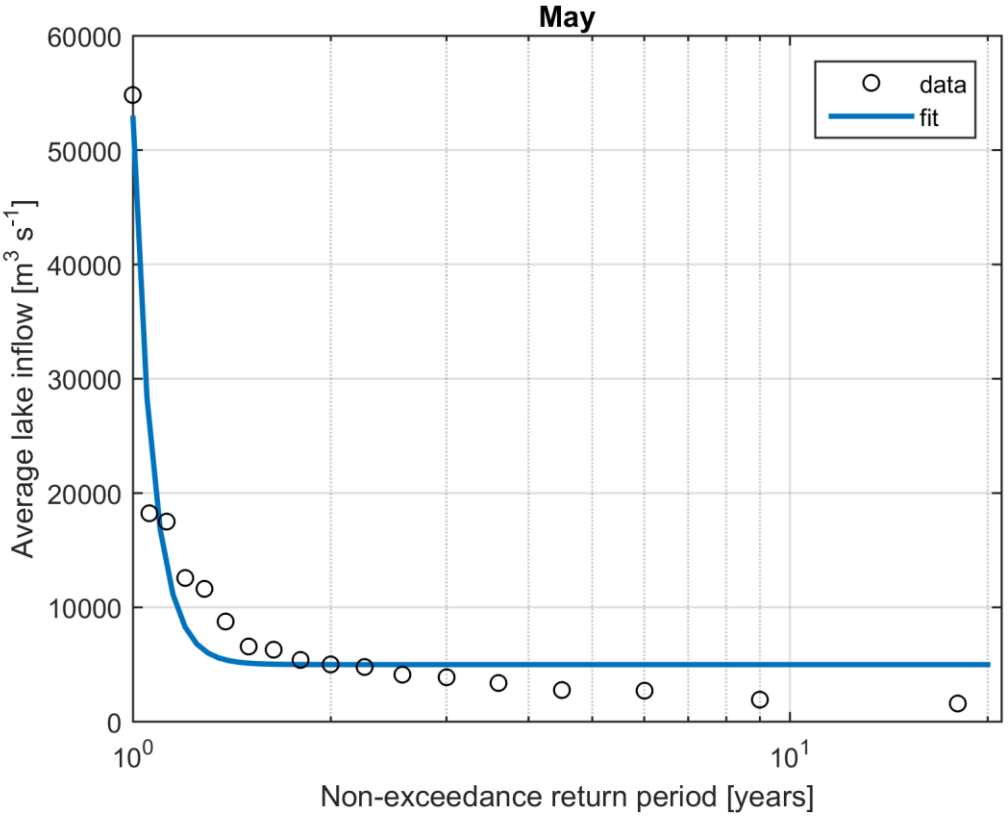
Lake Opuha inflow monthly frequency analysis

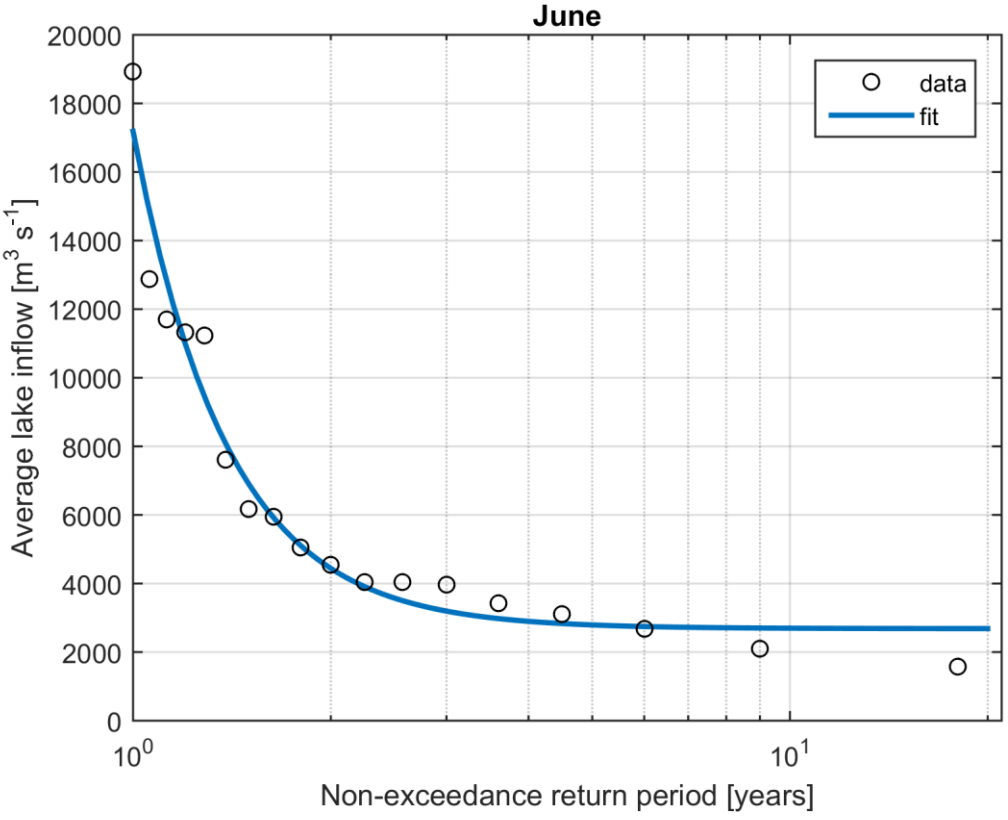


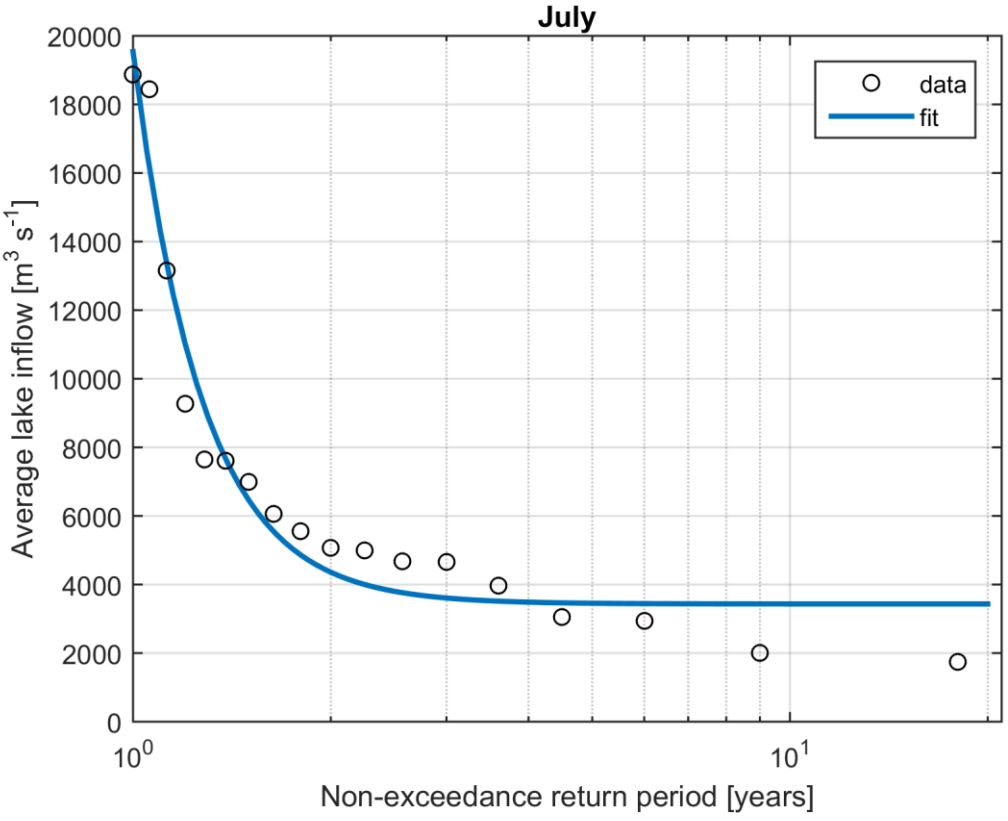

February
data
fit
Average lake inflow [m3 s-1]
Non-exceedance return period [years]
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
10^0
10^1

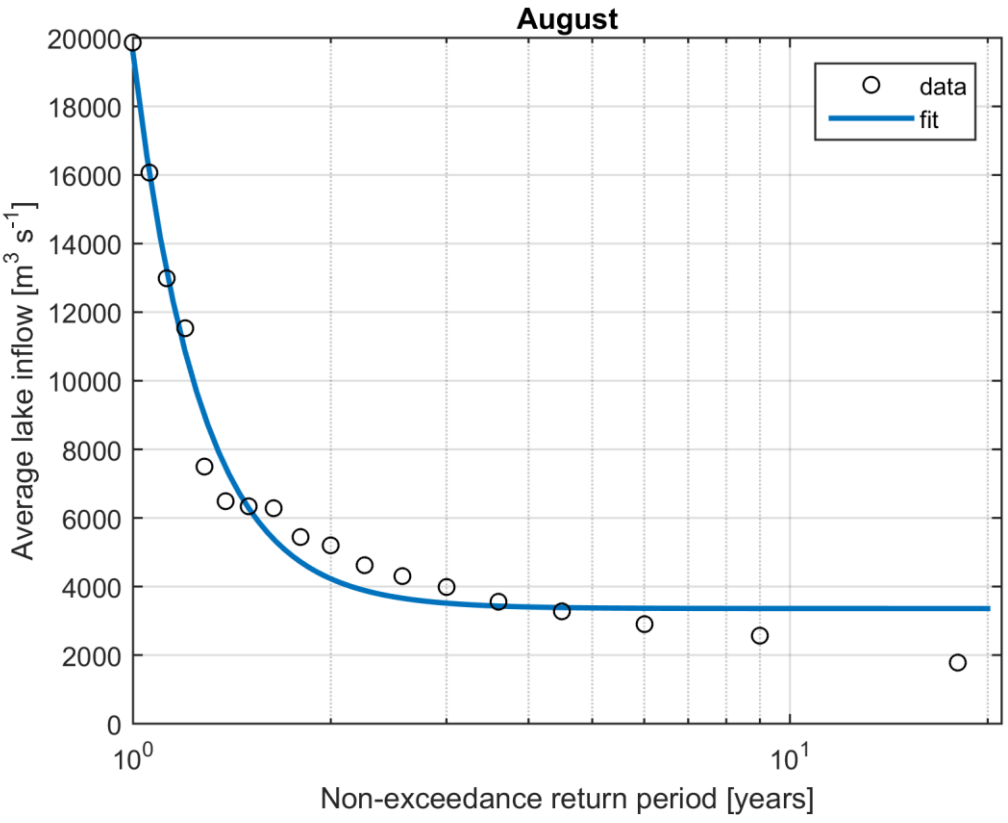

March
data
fit
Average lake inflow [m3 s-1]
Non-exceedance return period [years]
12000
10000
8000
6000
4000
2000
0
10^0
10^1

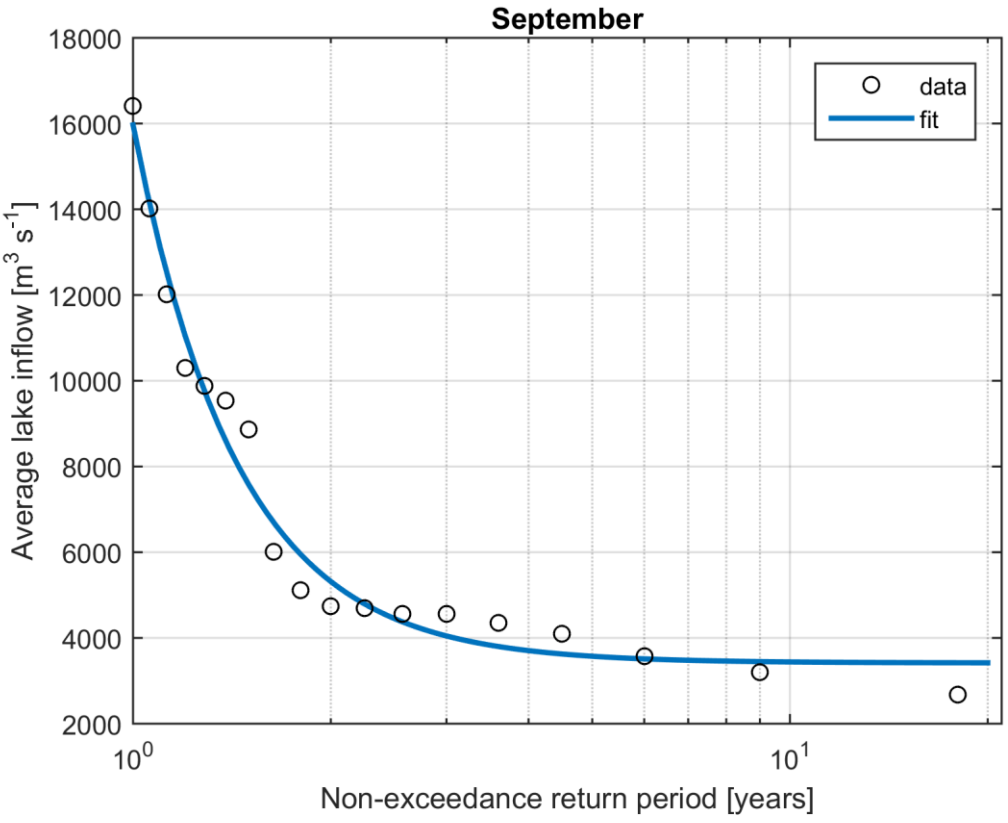

April
data
fit
Average lake inflow [m3 s-1]
Non-exceedance return period [years]
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
10^0
10^1

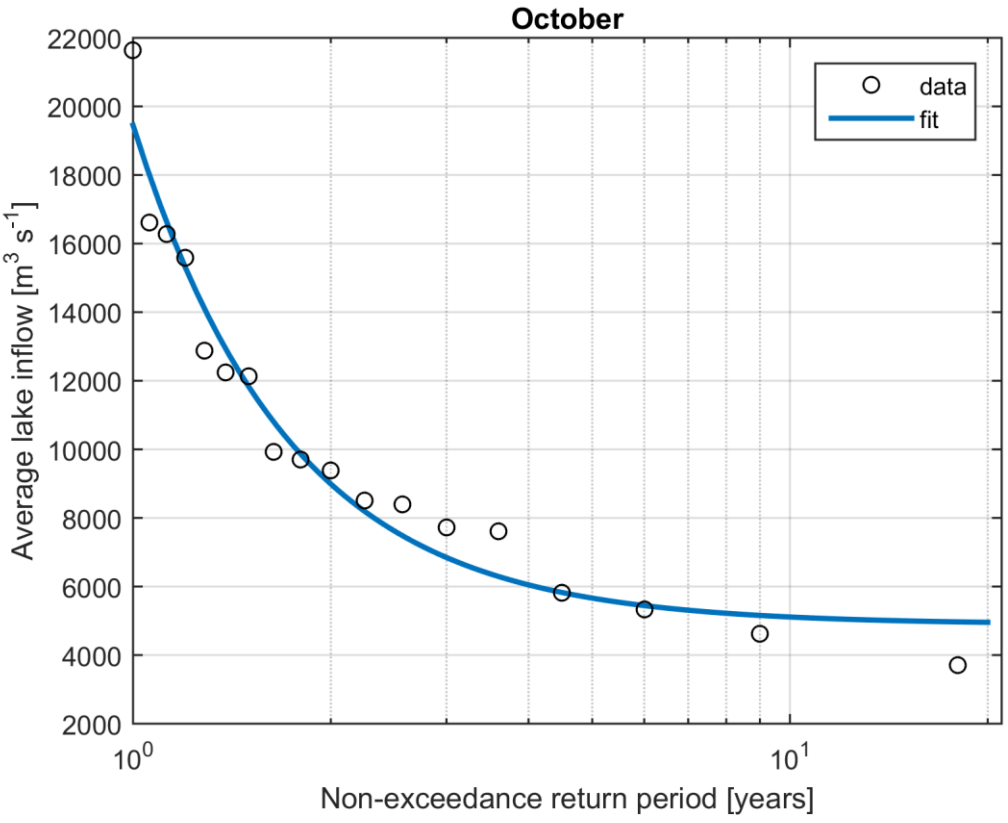

May
data
fit
Average lake inflow [m3 s-1]
Non-exceedance return period [years]
60000
50000
40000
30000
20000
10000
0
10^0
10^1

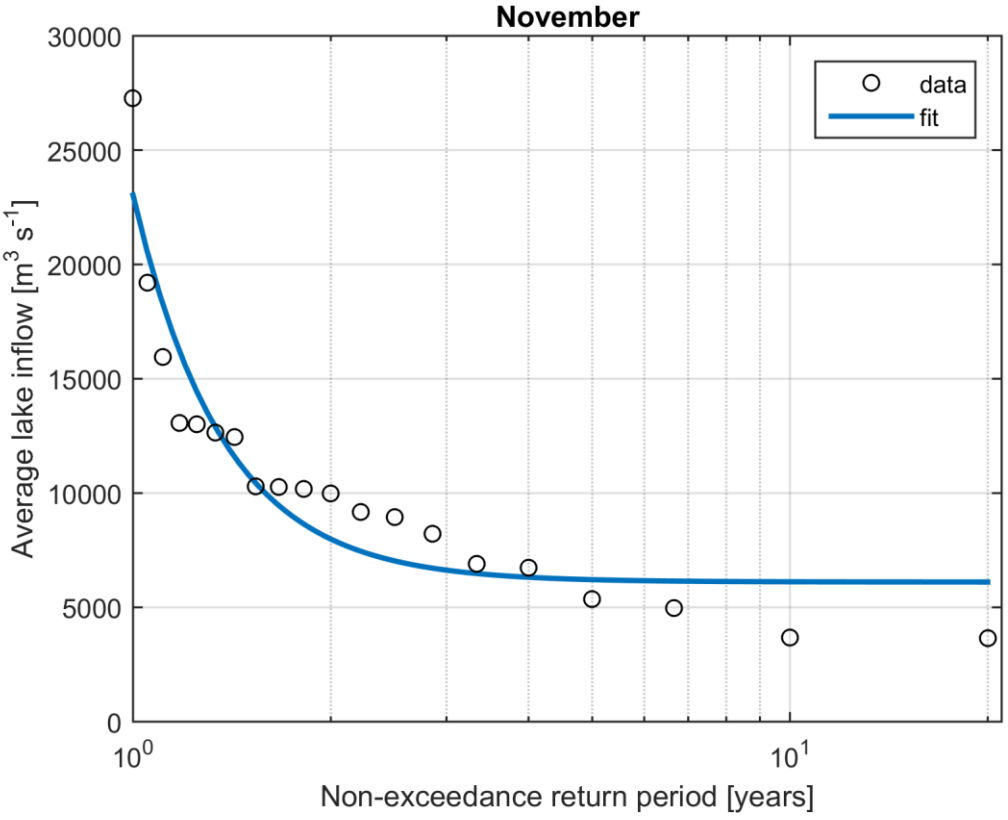

June
data
fit
Average lake inflow [m3 s-1]
Non-exceedance return period [years]
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
10^0
10^1

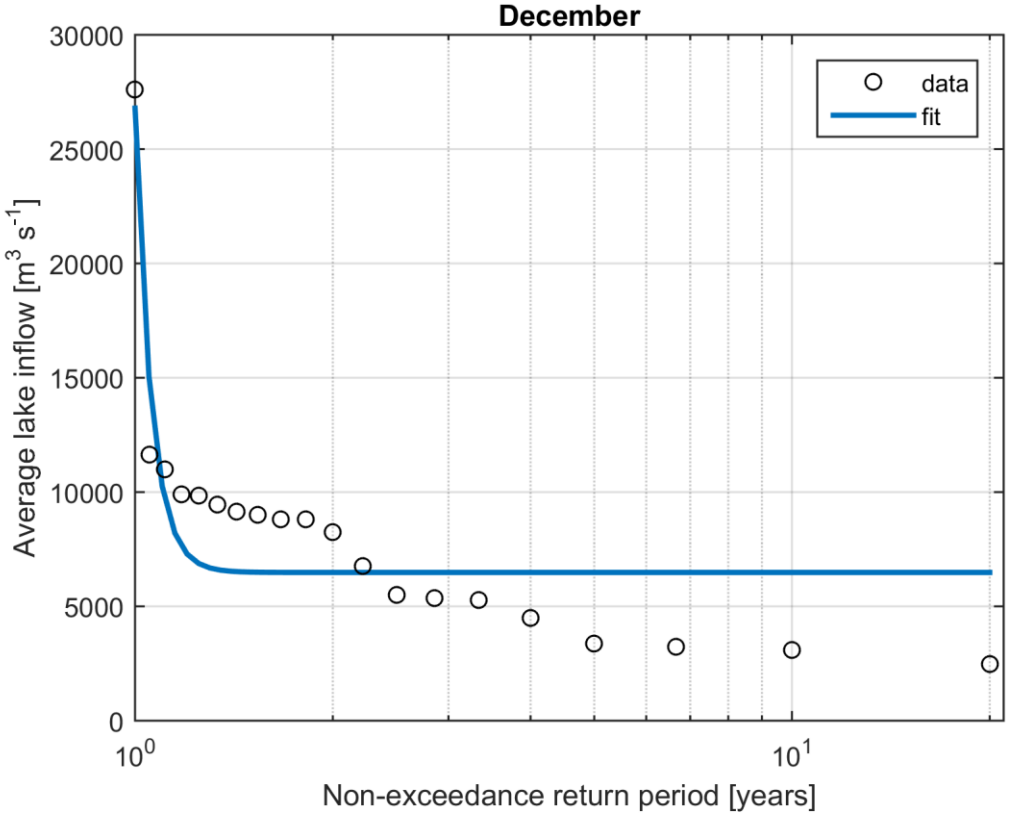

July
data
fit
Average lake inflow [m3 s-1]
Non-exceedance return period [years]
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
10^0
10^1

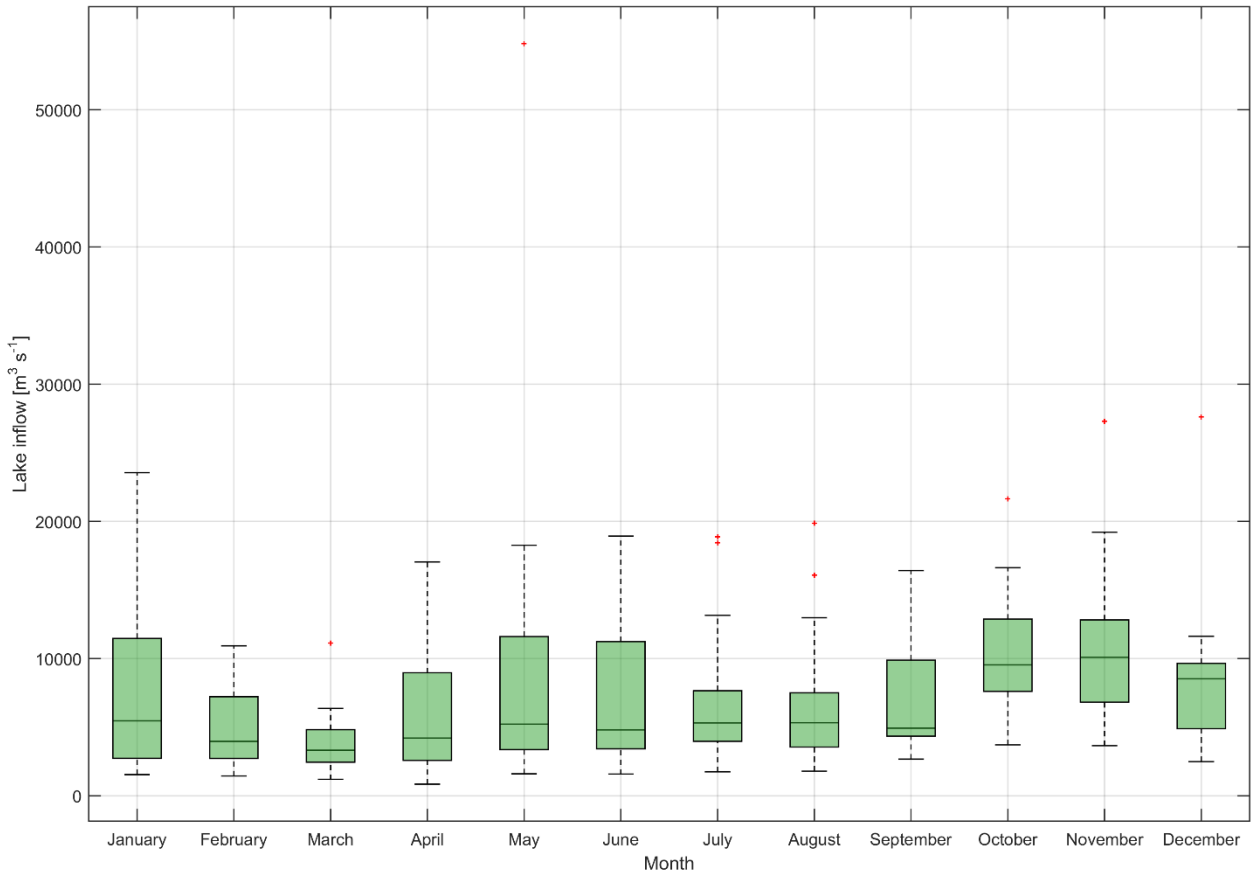

August
data
fit
Average lake inflow [m3 s-1]
Non-exceedance return period [years]
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
10^0
10^1


September
data
fit
Average lake inflow [m3 s-1]
Non-exceedance return period [years]
18000
16000
14000
12000
10000
8000
6000
4000
2000
10^0
10^1

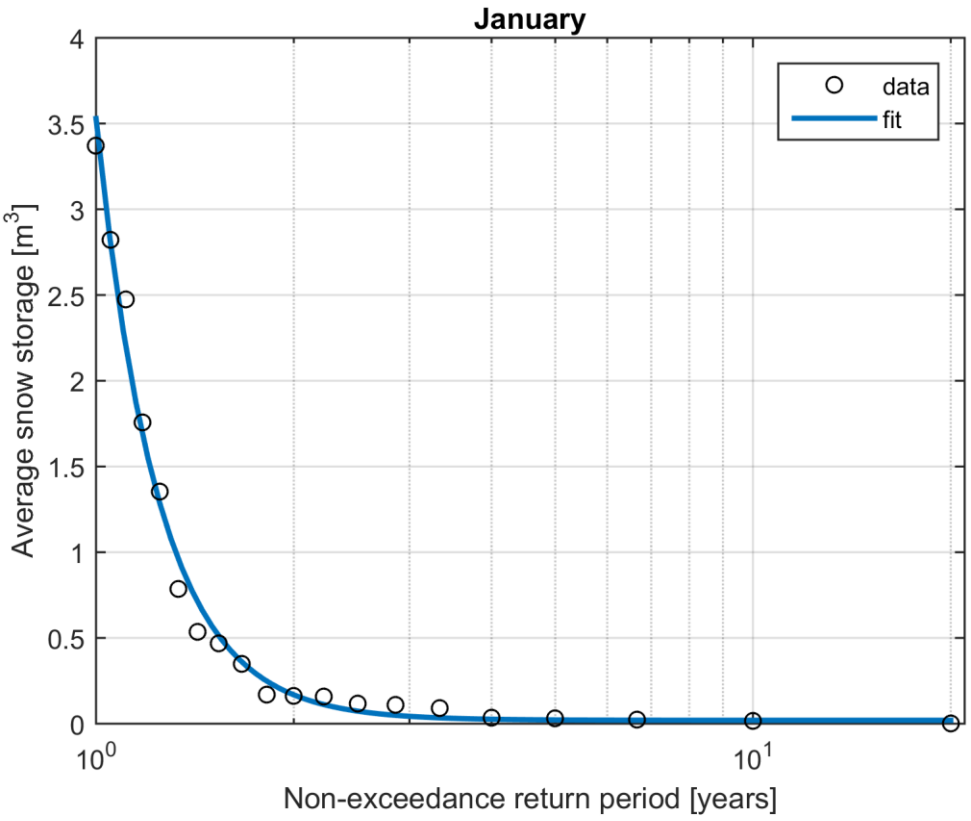

October
data
fit
Average lake inflow [m3 s-1]
Non-exceedance return period [years]
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
10^0
10^1

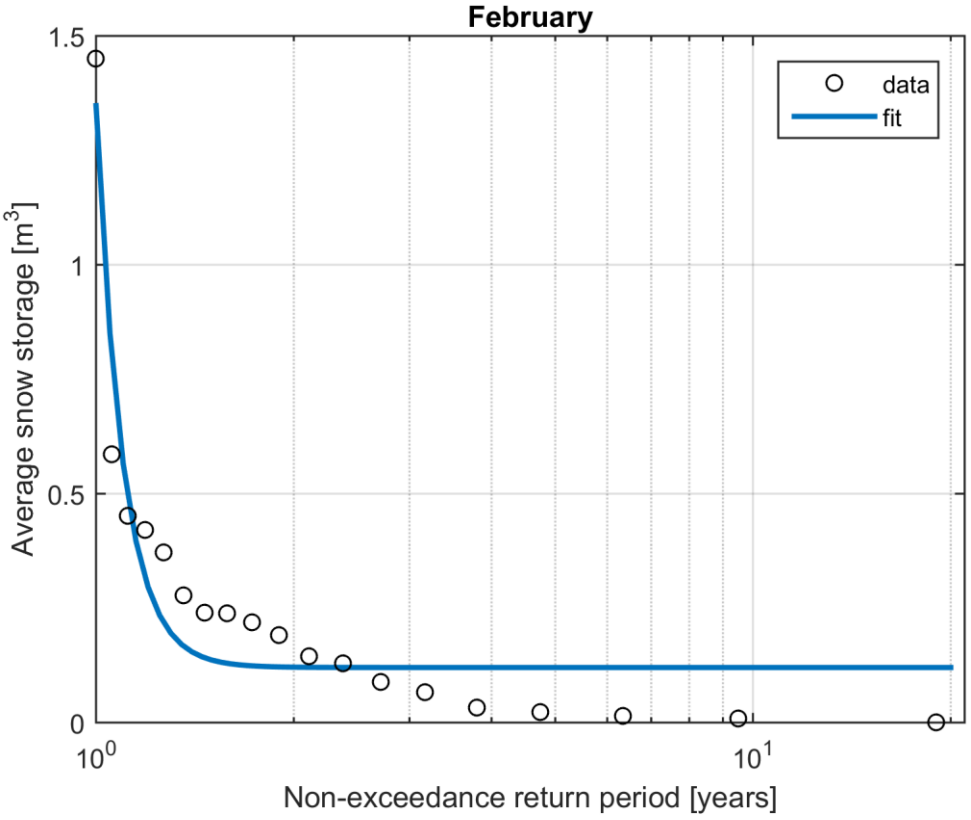

November
data
fit
Average lake inflow [m3 s-1]
Non-exceedance return period [years]
30000
25000
20000
15000
10000
5000
0
10^0
10^1

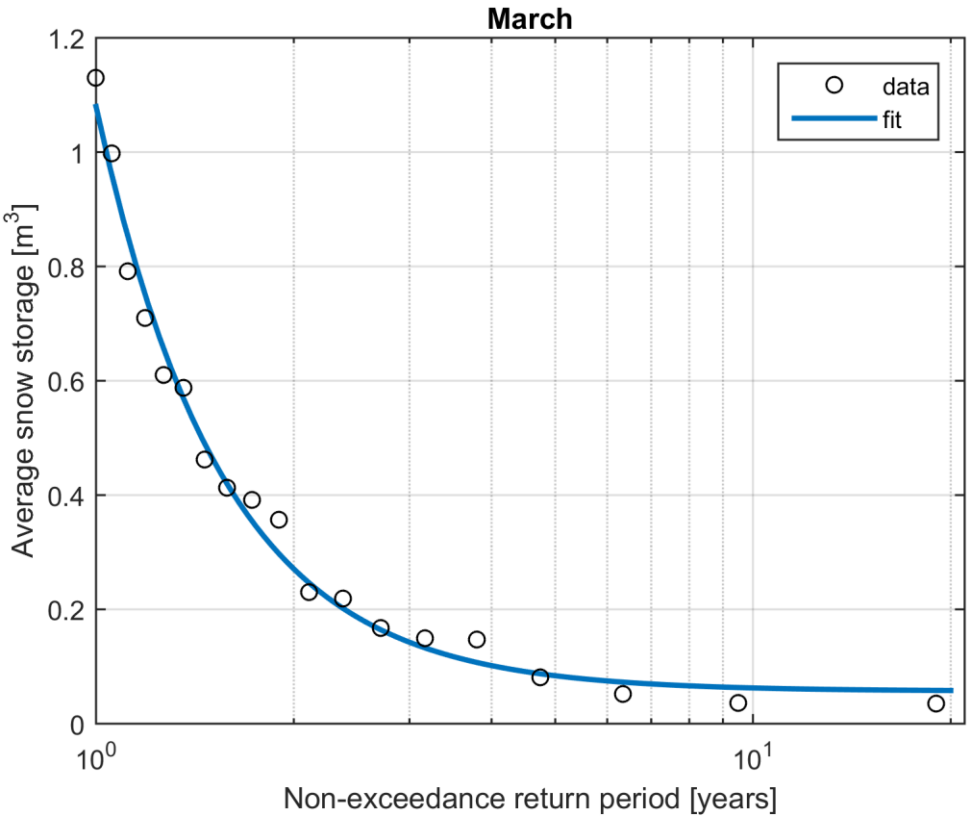

December
data
fit
Average lake inflow [m3 s-1]
Non-exceedance return period [years]
30000
25000
20000
15000
10000
5000
0
10^0
10^1

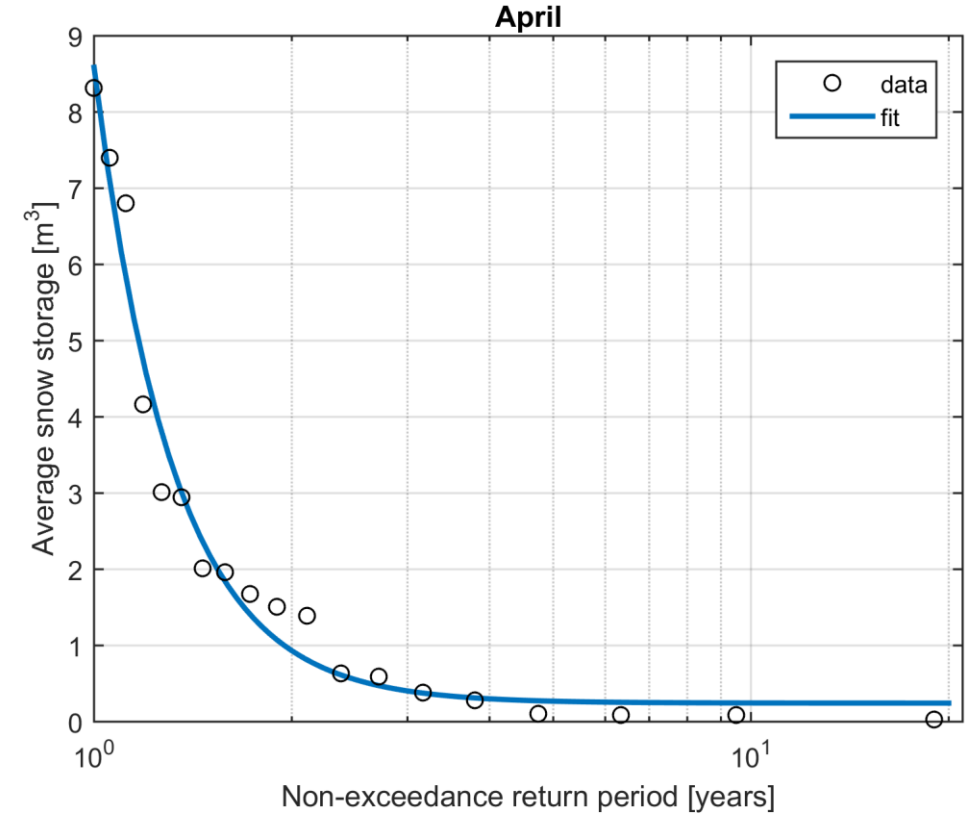

Lake inflow [m3 s-1]
Month
50000
40000
30000
20000
10000
0
January
February
March
April
May
June
July
August
September
October
November
December

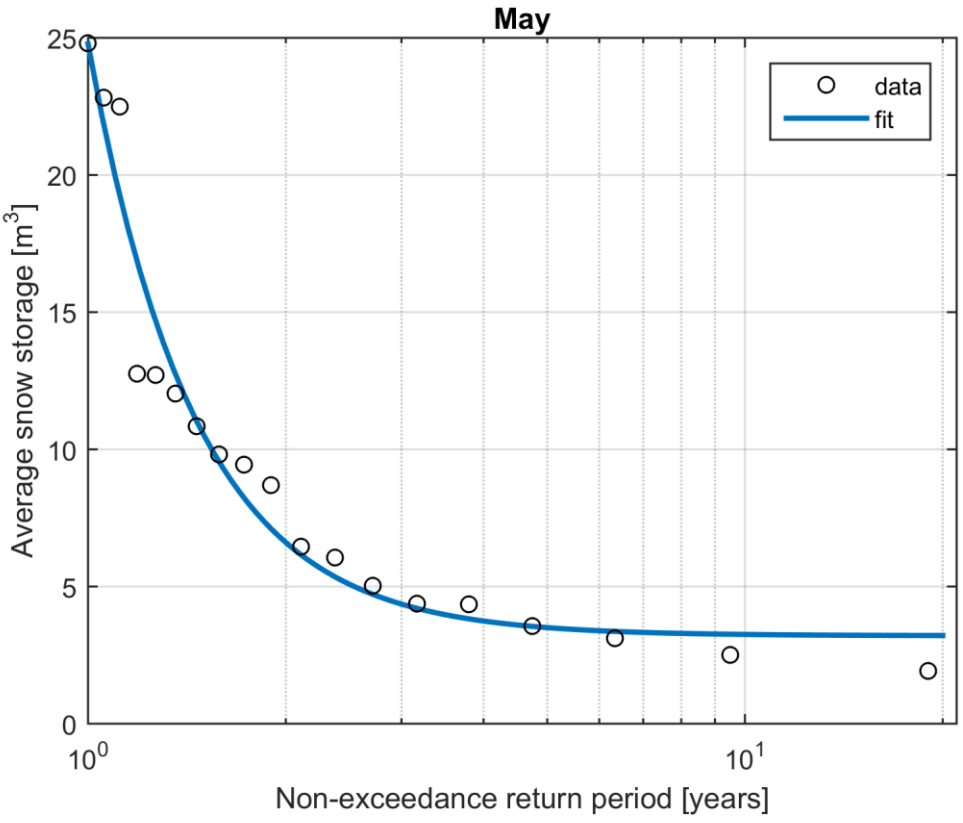
Snow storage monthly frequency analysis

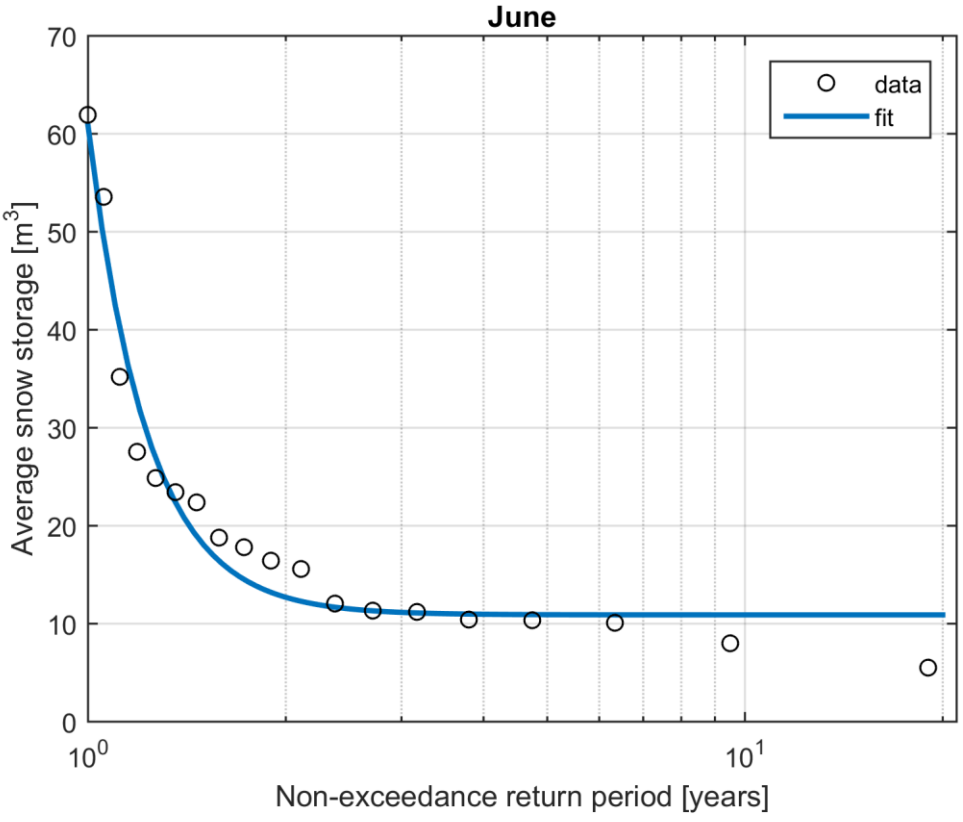


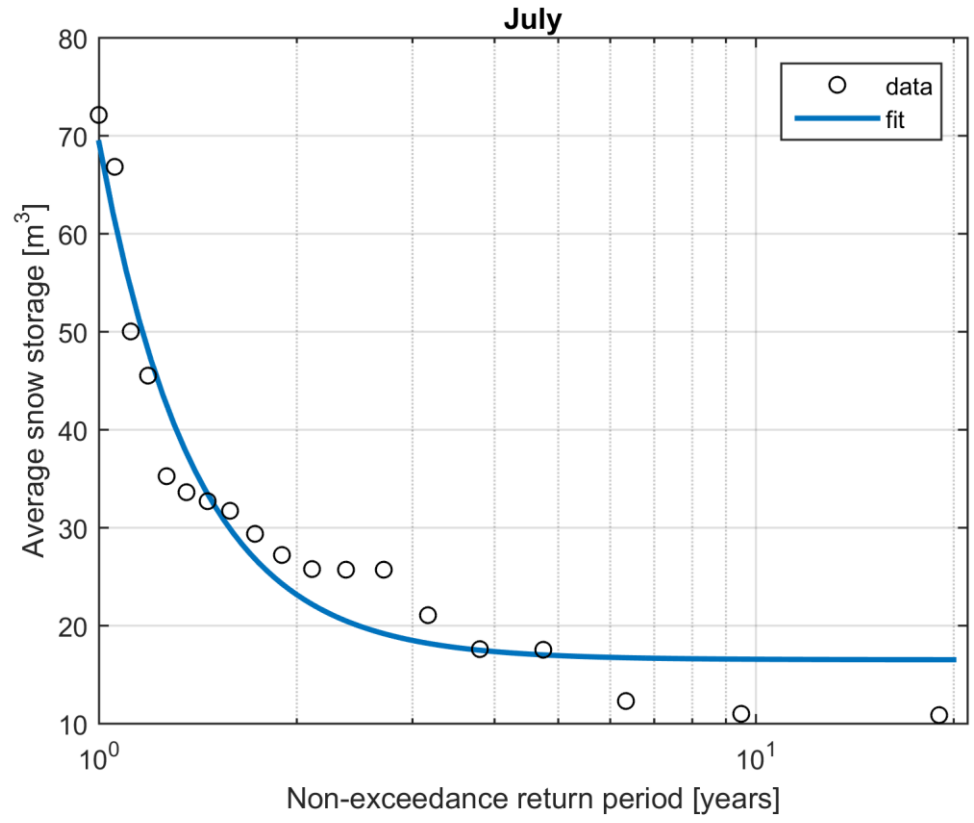


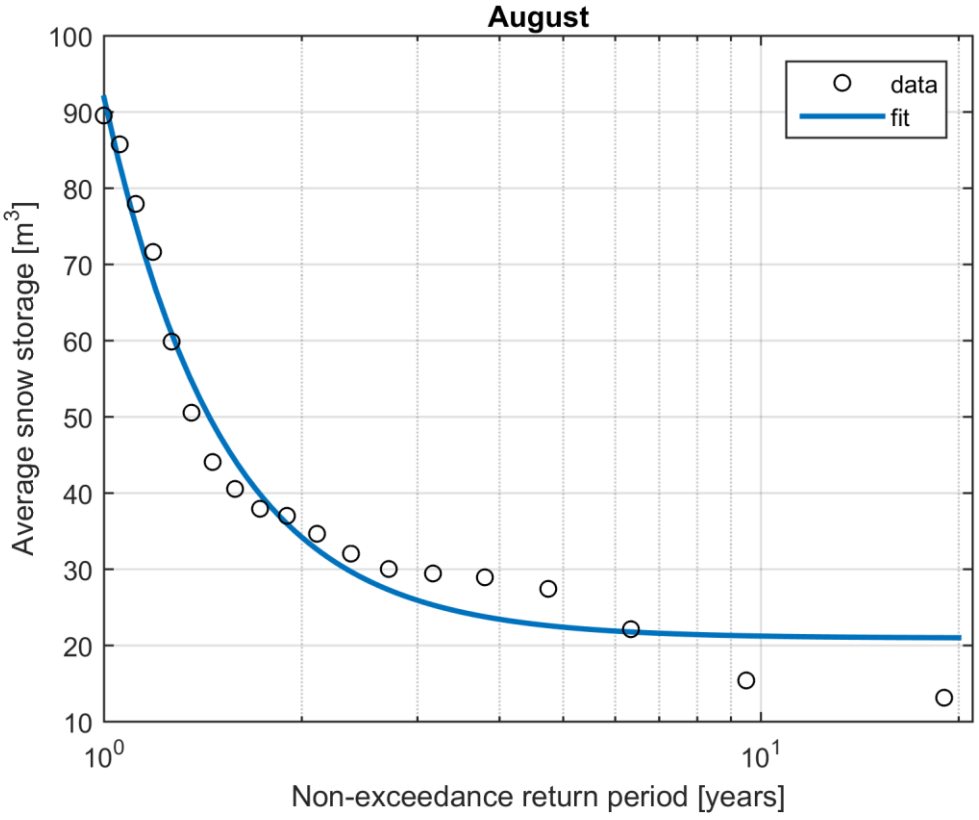

March
data
fit
Average snow storage [m3]
Non-exceedance return period [years]
0
0.2
0.4
0.6
0.8
1
1.2
10^0
10^1

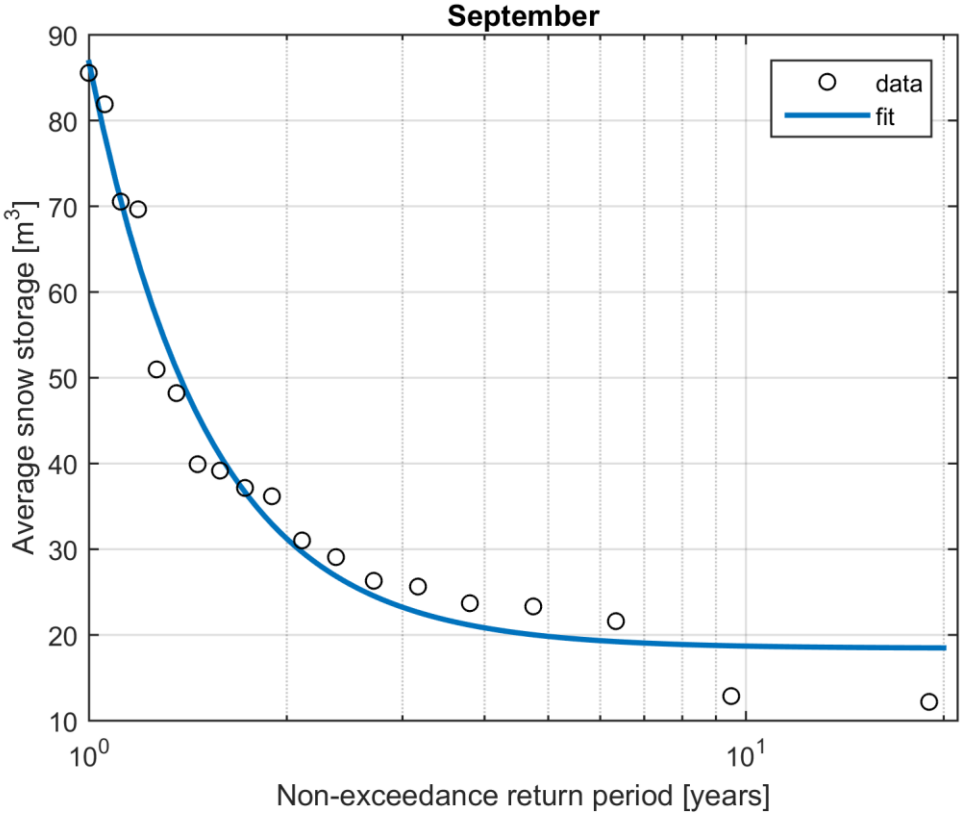

April
data
fit
Average snow storage [m3]
Non-exceedance return period [years]
0
1
2
3
4
5
6
7
8
9
10^0
10^1

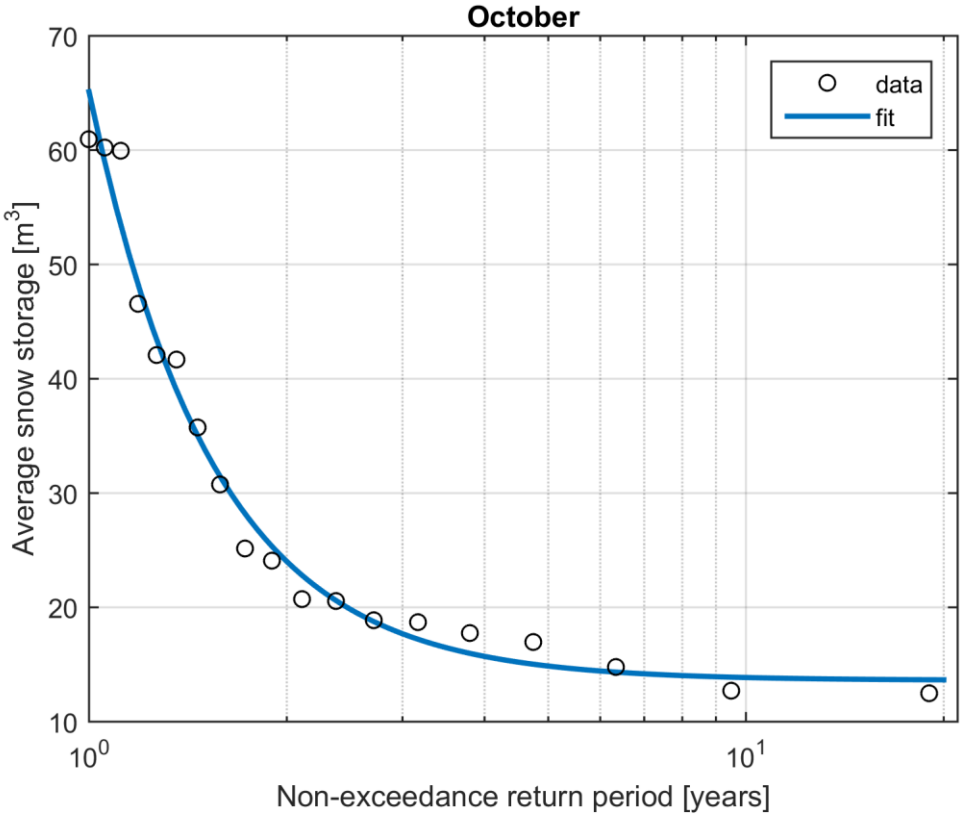

May
data
fit
Average snow storage [m3]
Non-exceedance return period [years]
0
5
10
15
20
25
10^0
10^1

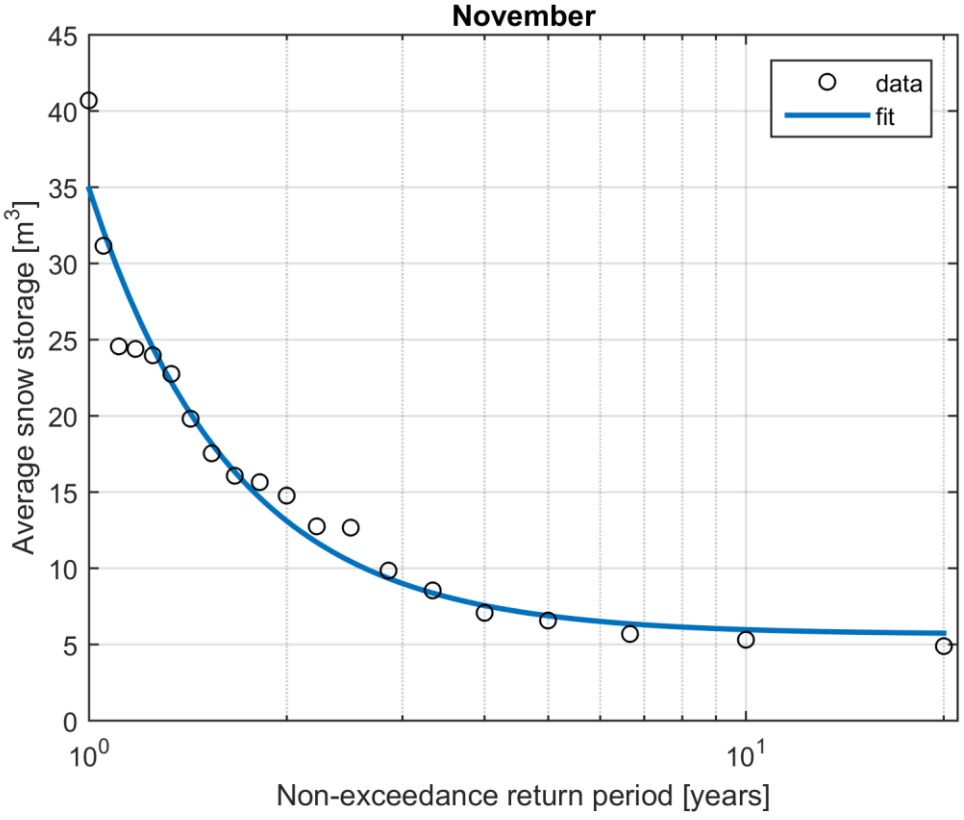

June
data
fit
Average snow storage [m3]
Non-exceedance return period [years]
0
10
20
30
40
50
60
70
10^0
10^1

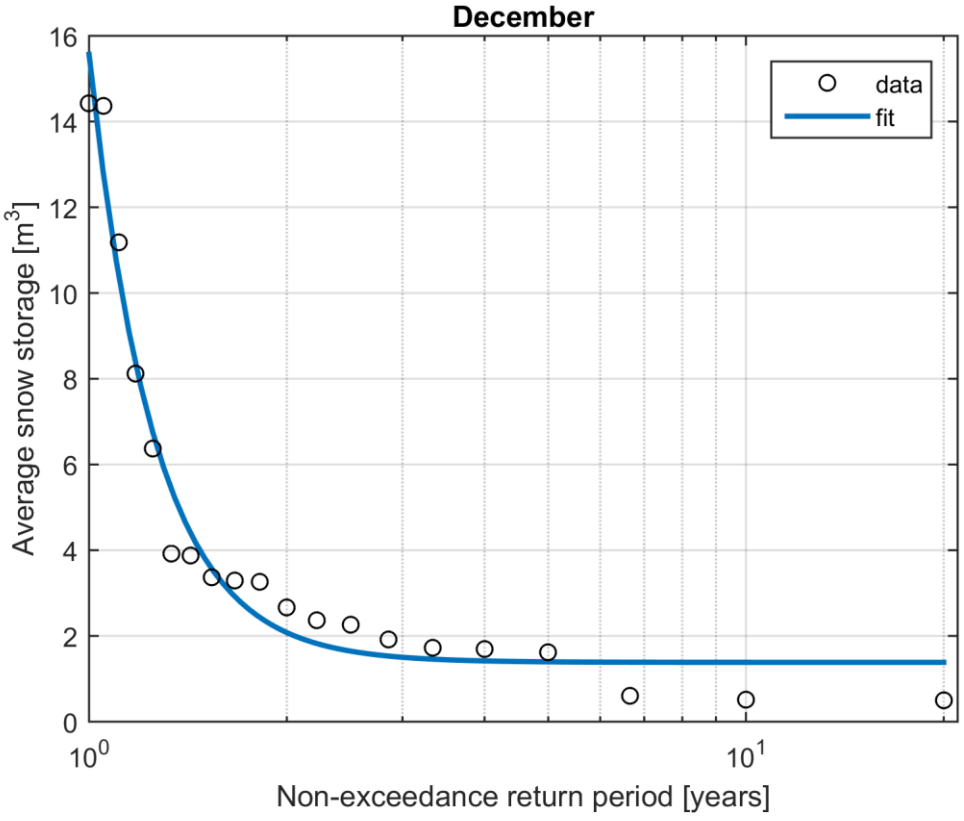

July
data
fit
Average snow storage [m3]
Non-exceedance return period [years]
80
70
60
50
40
30
20
10
10^0
10^1

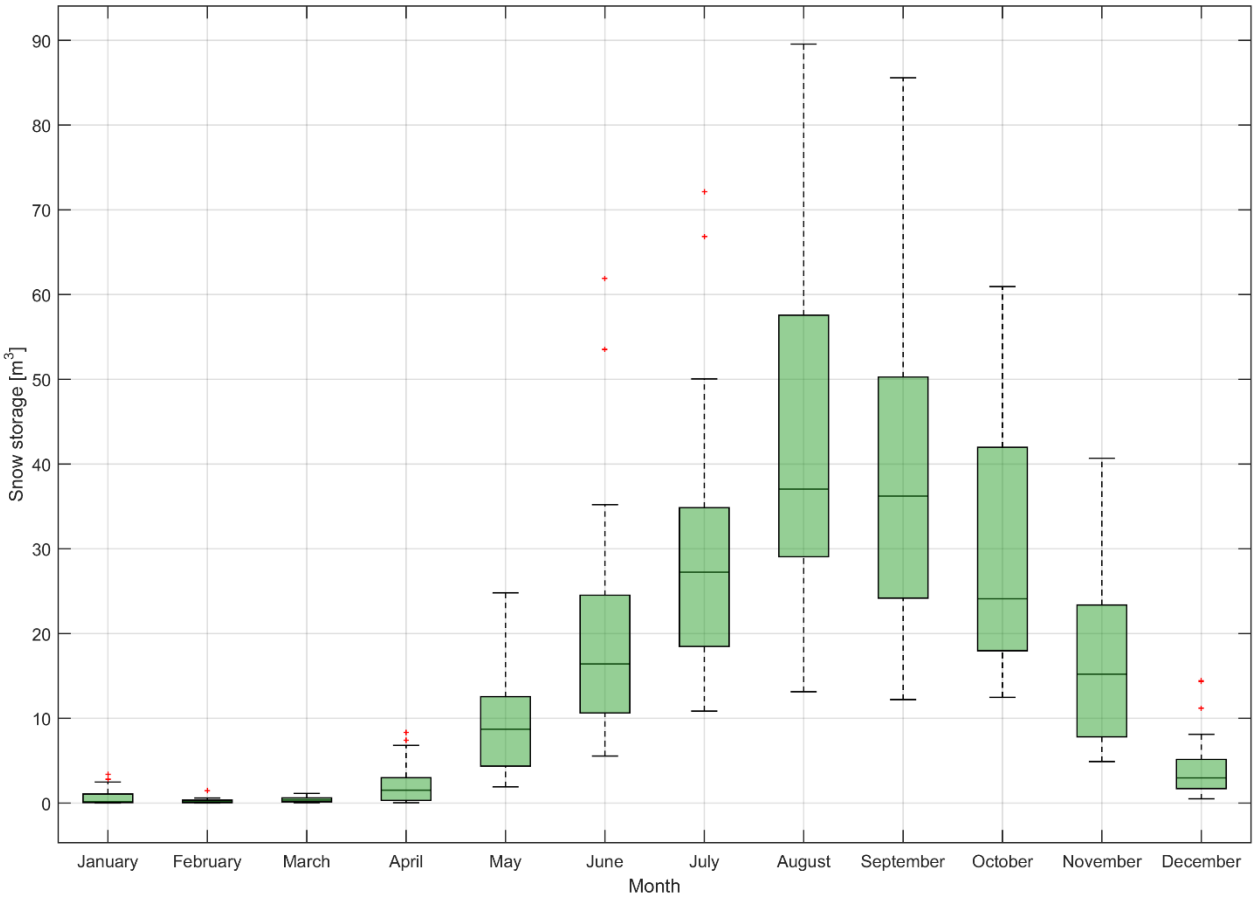

August
data
fit
Average snow storage [m3]
Non-exceedance return period [years]
100
90
80
70
60
50
40
30
20
10
10^0
10^1


September
data
fit
Average snow storage [m3]
Non-exceedance return period [years]
90
80
70
60
50
40
30
20
10
10^0
10^1


October
data
fit
Average snow storage [m3]
Non-exceedance return period [years]
70
60
50
40
30
20
10
10^0
10^1


November
data
fit
Average snow storage [m3]
Non-exceedance return period [years]
0
5
10
15
20
25
30
35
40
45
10^0
10^1


December
data
fit
Average snow storage [m3]
Non-exceedance return period [years]
0
2
4
6
8
10
12
14
16
10^0
10^1


Snow storage [m3]
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
Month