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Temporal and spatial variability of ice cover occurrence on Carpathian rivers: a regional perspective

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The document includes:

- classification of water gauges taking into account their division into those that are significantly influenced by human activity and those that remain largely independent of it: **Tab. S1.**,

- a table showing trends in the first and last days with ice cover in the period 1950–2020 (IC): **Tab. S2.**,

- MARTA charts showing the moving averages and trends in the average days of the first and last days with ice cover (IC): **Fig. S1.**,

- MARTA charts for the time series of the number of days with border ice (BI), total ice cover (TIC) and the sum of these phenomena (IC), made using data from each water gauge cross-section (P1–P25).

Tab. S1. Classification of water gauges taking into account their division into those that are significantly influenced by human activity and those that remain largely independent of it.

Group of water gauges	**Water gauge codes**
Without the strong influence of human activity	P3, P4, P5, P7, P8, P9, P11, P14, P15, P16, P17, P18, P21, P23, P24
Influenced by the operation of reservoirs	P1, P12, P13, P19
Other water gauges influenced by human activity	P2, P22, P25

Tab. S2. Trends in dates of ice cover formation and disappearance at individual stations over the period 1950–2020.

Station code	Trend in date of first day with ice cover [days/decade].		Trend in the date of the last day with ice cover [days/decade].	
	Sen slope	Linear reg.	Sen slope	Linear reg.
P1	1.8	2.6	-2.2	
P2	-1.6		-0.2	
P3	-0.3		-0.8	
P4	-1.3	-1.6	-0.9	
P5	1.5		0	
P6	0.6		-0.7	
P7	**-2.5**	-2.4	-0.8	
P8	1.5	1.3	**-2.7**	
P9	-0.5	-1	0.5	
P10	-0.5		-2	
P11	-1	-1.3	-0.8	
P12	2.2	1.5	**-3.3**	**-3.7**
P13	**3**		**-3**	
P14	0.5		**-2.2**	
P15	0.9	0.6	-1.3	
P16	-1.1		0.3	
P17	0	-0.7	-2.5	
P18	-1.4	-1.7	0.7	
P19	1.4	1.1	-2	
P20	2.2	1.6	-2	
P21	-1.8	**-2.5**	-0.4	
P22	0	-0.4	0.3	0.2
P23	1.8		-1.5	
P24	-0.4		-0.6	

P25	2.1	1.7	**-3.8**	
Mean	0.28	-0.08	-1.28	-1.75

The trends determined using the Theil-Sen estimator (Sen.) and the linear regression equation (Lin.) are presented. The results for linear regression were included only if the regression residuals had a normal distribution. Statistically significant trends at the $p<0.05$ level are indicated in bold, based on the Mann-Kendall test for the Theil-Sen estimator and the Student's t-test for linear regression.

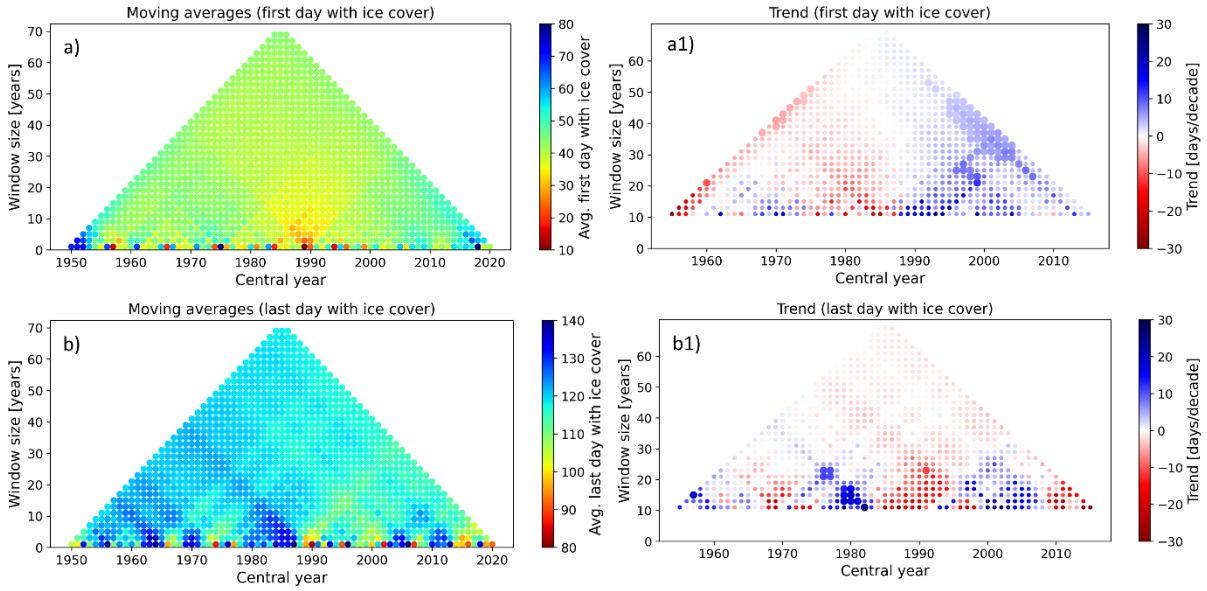
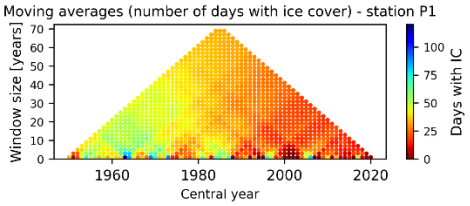
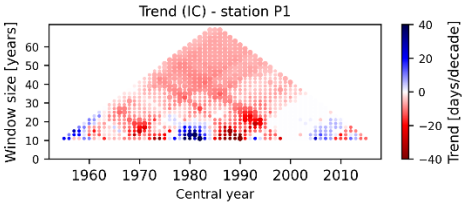
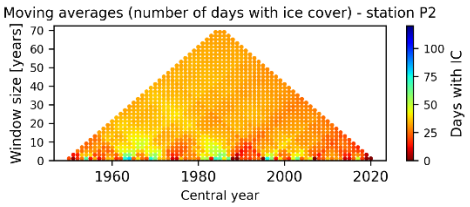


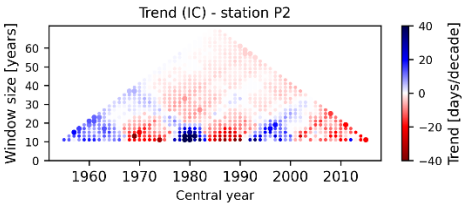
Fig. S1. MARTA graphs showing moving average (a and b) and trend (a1 and b1) in average annual dates of appearance (a and a1) and disappearance (b and b1) of ice cover (average values from all P1–P25 stations). In the a1 and b1 graphs, statistically significant values at the $p<0.05$ level are marked with larger markers.

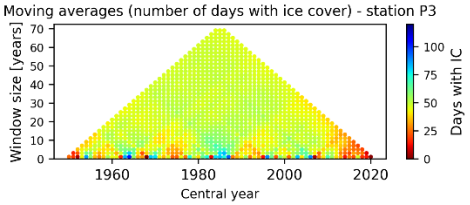
MARTA charts for ice cover (sum of border ice and total ice cover):

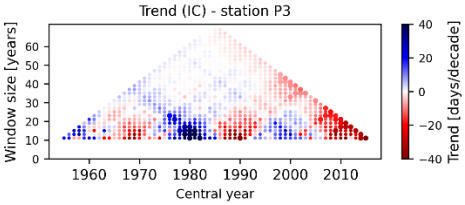


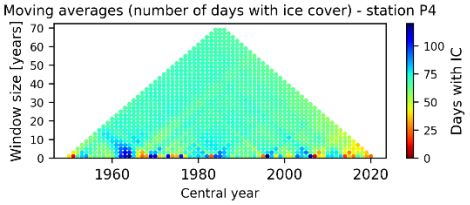


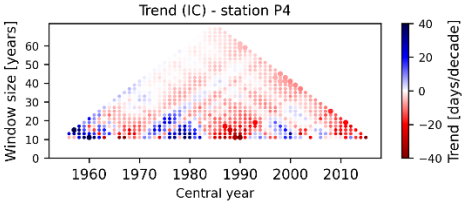


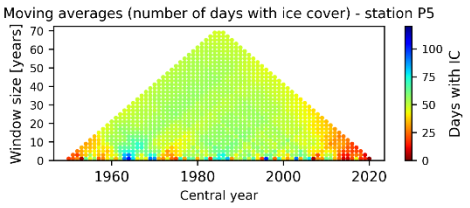


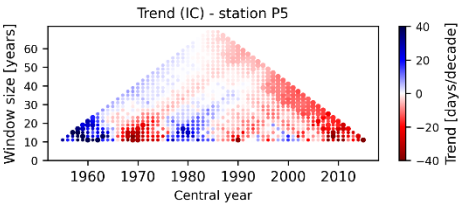


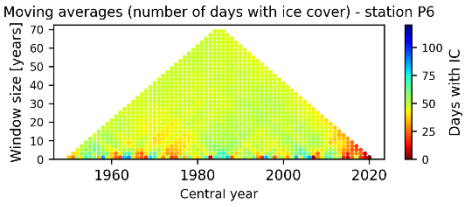


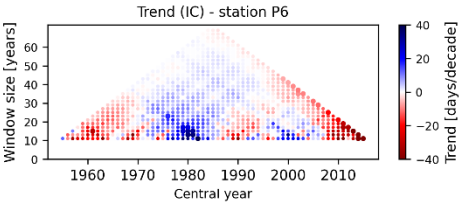


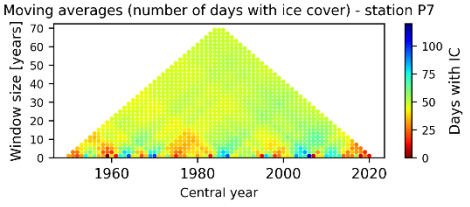


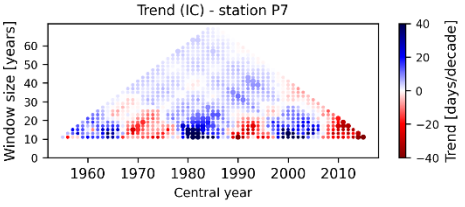


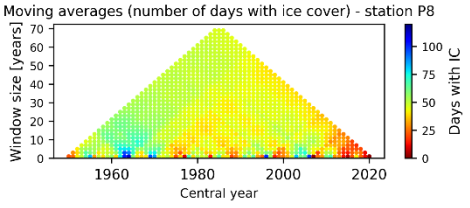


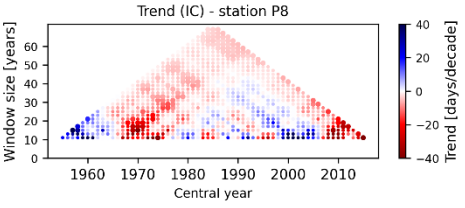


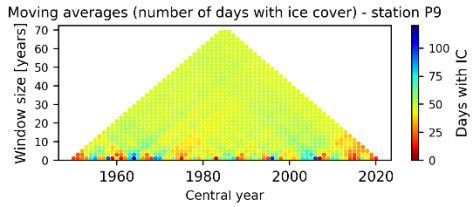


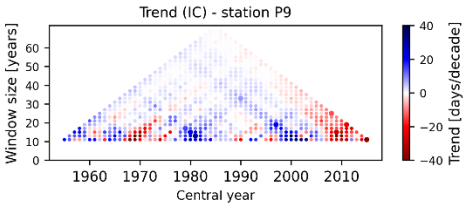


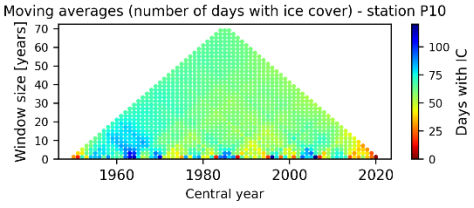


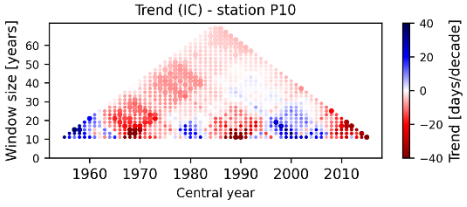


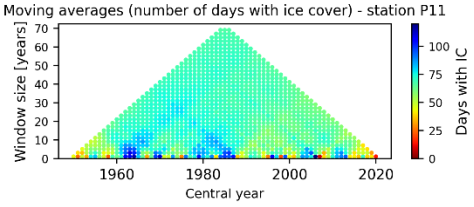


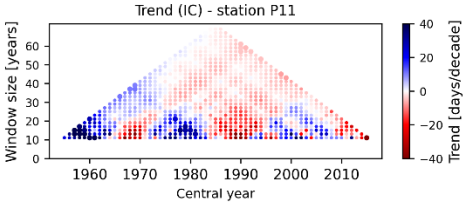

Moving averages (number of days with ice cover) - station P9
Window size [years]
Central year
Days with IC

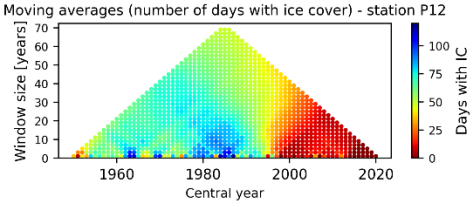

Trend (IC) - station P9
Window size [years]
Central year
Trend [days/decade]

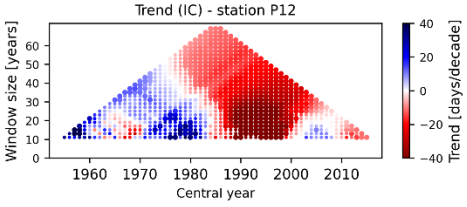

Moving averages (number of days with ice cover) - station P10
Window size [years]
Central year
Days with IC

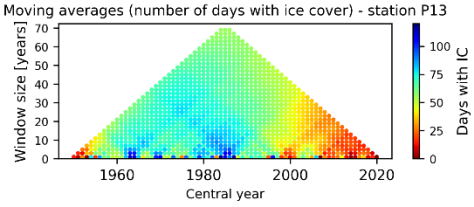

Trend (IC) - station P10
Window size [years]
Central year
Trend [days/decade]

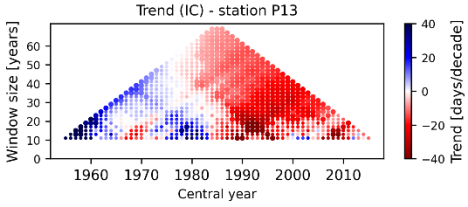

Moving averages (number of days with ice cover) - station P11
Window size [years]
Central year
Days with IC

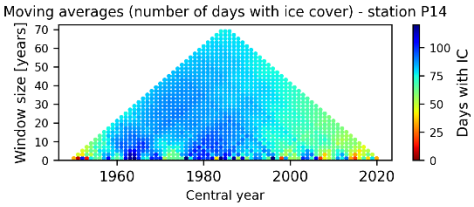

Trend (IC) - station P11
Window size [years]
Central year
Trend [days/decade]

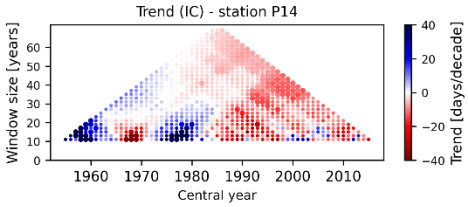

Moving averages (number of days with ice cover) - station P12
Window size [years]
Central year
Days with IC

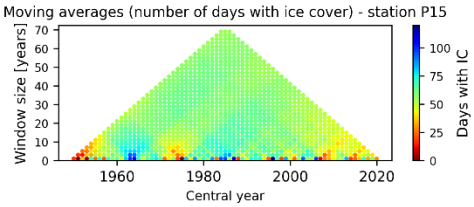

Trend (IC) - station P12
Window size [years]
Central year
Trend [days/decade]

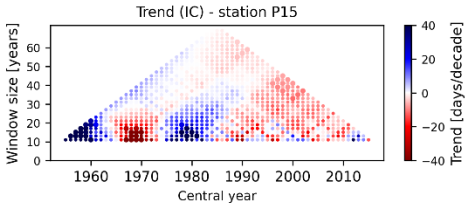

Moving averages (number of days with ice cover) - station P13
Window size [years]
Central year
Days with IC

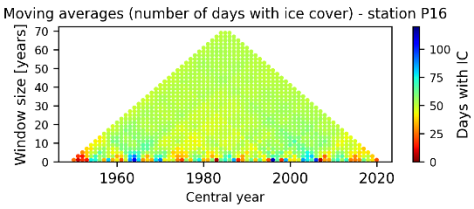

Trend (IC) - station P13
Window size [years]
Central year
Trend [days/decade]

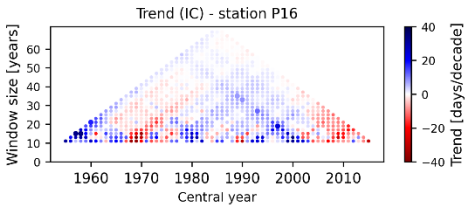

Moving averages (number of days with ice cover) - station P14
Window size [years]
Central year
Days with IC

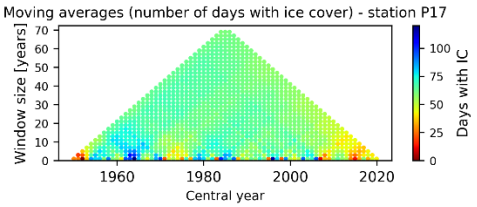

Trend (IC) - station P14
Window size [years]
Central year
Trend [days/decade]

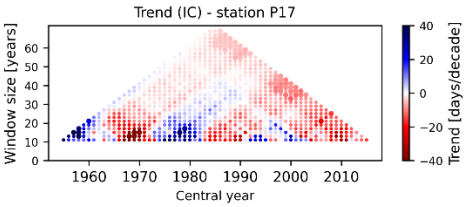

Moving averages (number of days with ice cover) - station P15
Window size [years]
Central year
Days with IC

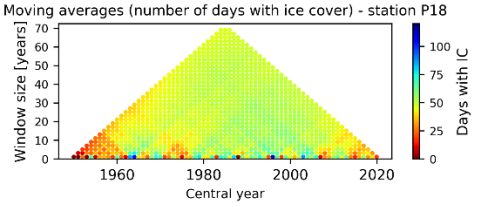

Trend (IC) - station P15
Window size [years]
Central year
Trend [days/decade]

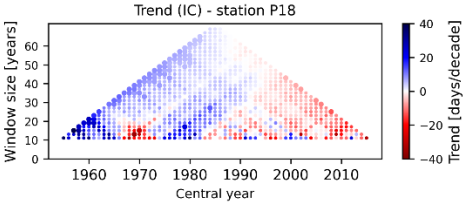

Moving averages (number of days with ice cover) - station P16
Window size [years]
Central year
Days with IC

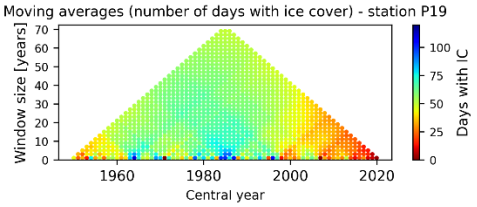

Trend (IC) - station P16
Window size [years]
Central year
Trend [days/decade]

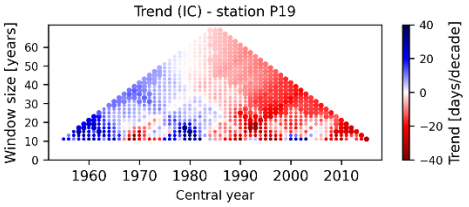

Moving averages (number of days with ice cover) - station P17
Window size [years]
Central year
Days with IC

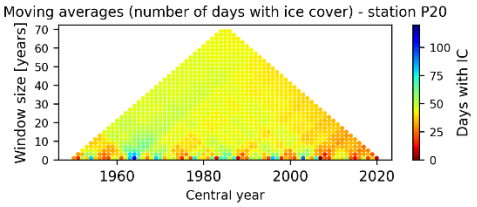

Trend (IC) - station P17
Window size [years]
Central year
Trend [days/decade]

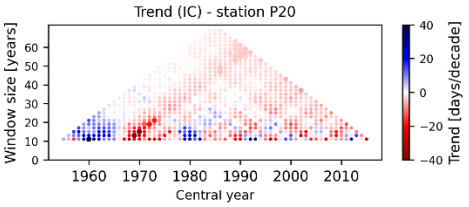

Moving averages (number of days with ice cover) - station P18
Window size [years]
Central year
Days with IC

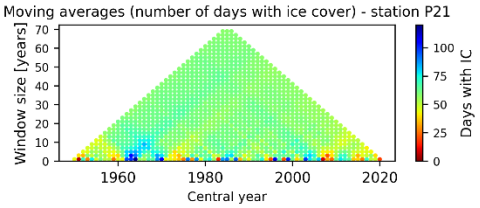

Trend (IC) - station P18
Window size [years]
Central year
Trend [days/decade]

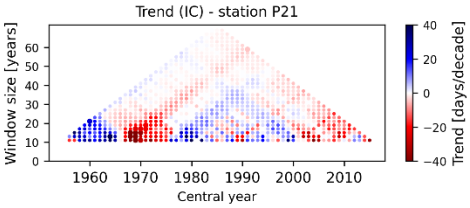

Moving averages (number of days with ice cover) - station P19
Window size [years]
Central year
Days with IC

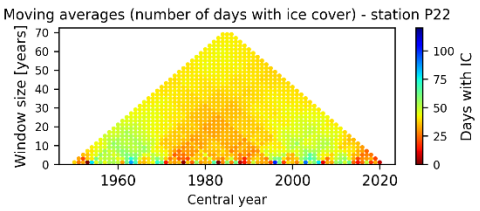

Trend (IC) - station P19
Window size [years]
Central year
Trend [days/decade]

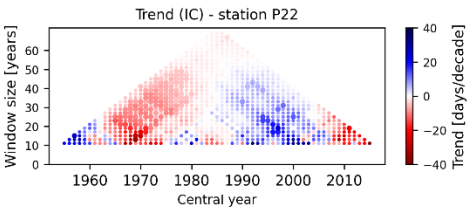

Moving averages (number of days with ice cover) - station P20
Window size [years]
Central year
Days with IC

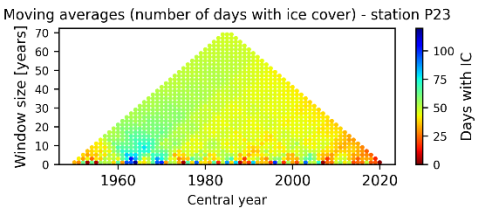

Trend (IC) - station P20
Window size [years]
Central year
Trend [days/decade]

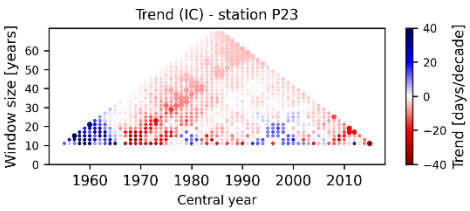

Moving averages (number of days with ice cover) - station P21
Window size [years]
Central year
Days with IC

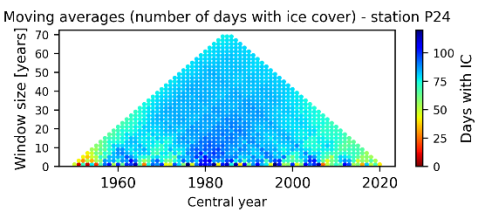

Trend (IC) - station P21
Window size [years]
Central year
Trend [days/decade]

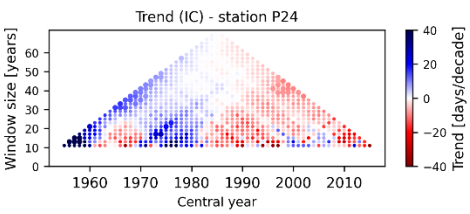

Moving averages (number of days with ice cover) - station P22
Window size [years]
Central year
Days with IC

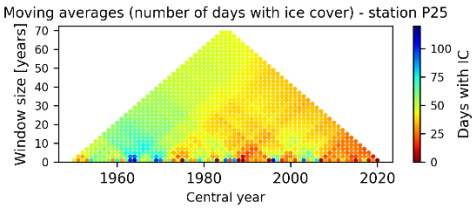

Trend (IC) - station P22
Window size [years]
Central year
Trend [days/decade]

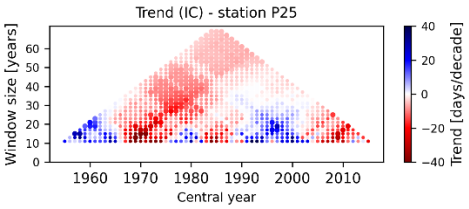

Moving averages (number of days with ice cover) - station P23
Window size [years]
Central year
Days with IC


Trend (IC) - station P23
Window size [years]
Central year
Trend [days/decade]

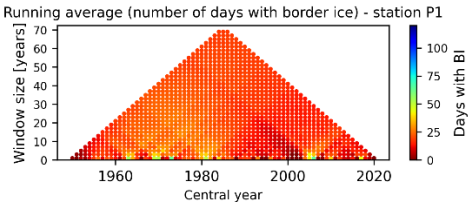

Moving averages (number of days with ice cover) - station P24
Window size [years]
Central year
Days with IC

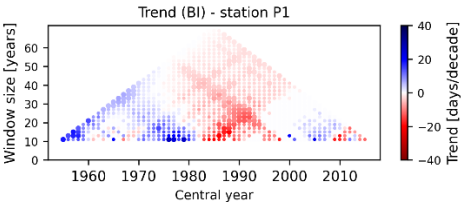

Trend (IC) - station P24
Window size [years]
Central year
Trend [days/decade]

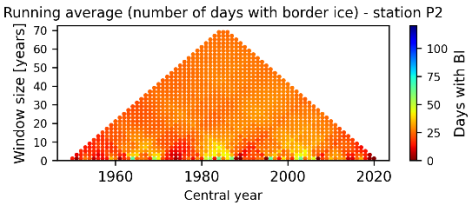


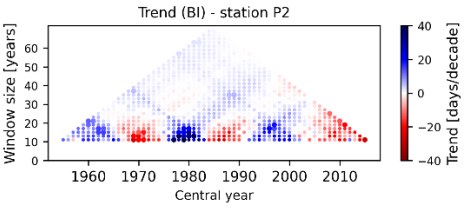


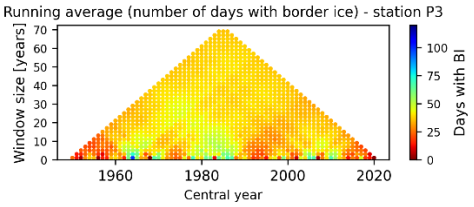
MARTA charts for border ice:

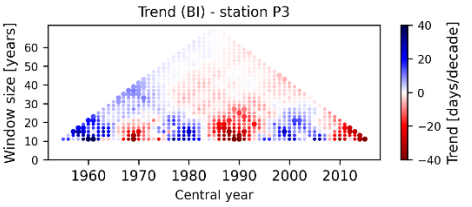


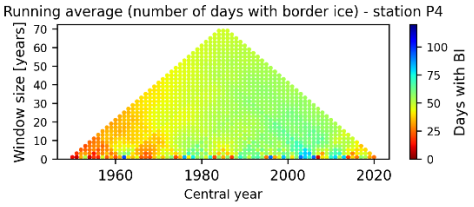


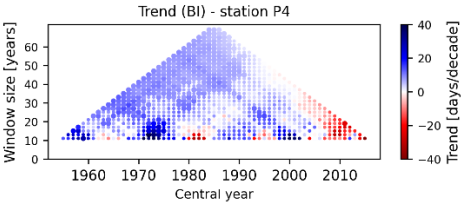


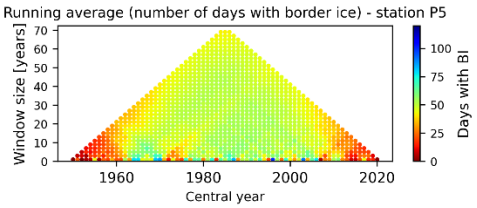


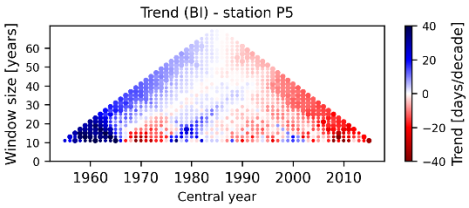


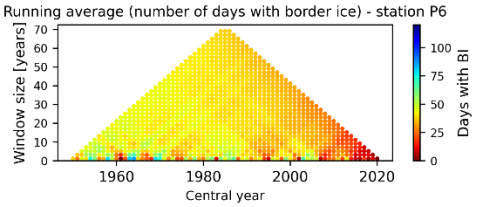


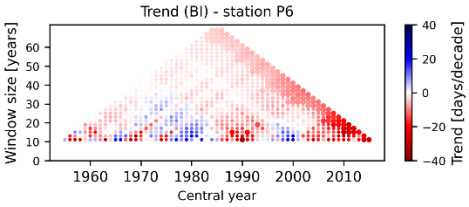


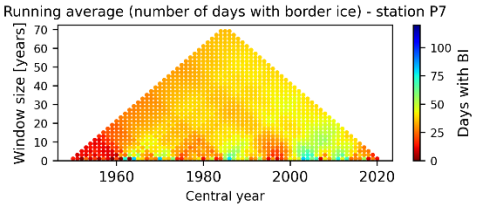


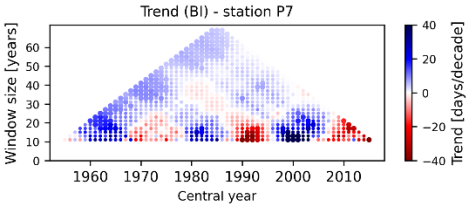

Running average (number of days with border ice) - station P5
Window size [years]
Central year
Days with BI

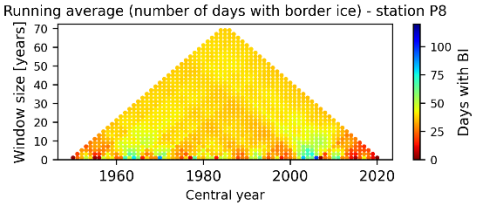

Trend (BI) - station P5
Window size [years]
Central year
Trend [days/decade]

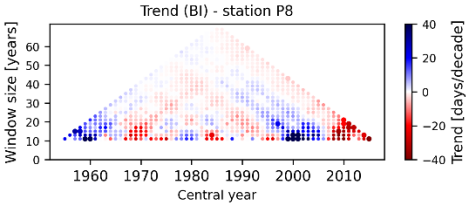

Running average (number of days with border ice) - station P6
Window size [years]
Central year
Days with BI

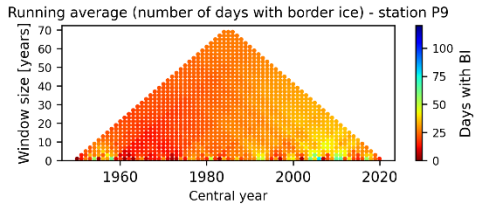

Trend (BI) - station P6
Window size [years]
Central year
Trend [days/decade]

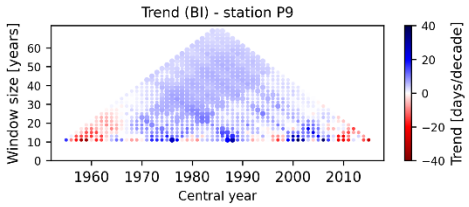

Running average (number of days with border ice) - station P7
Window size [years]
Central year
Days with BI

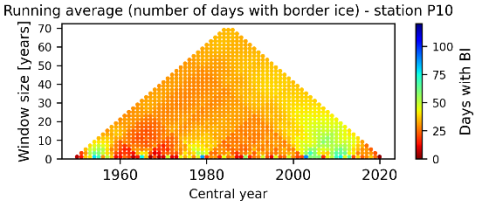

Trend (BI) - station P7
Window size [years]
Central year
Trend [days/decade]

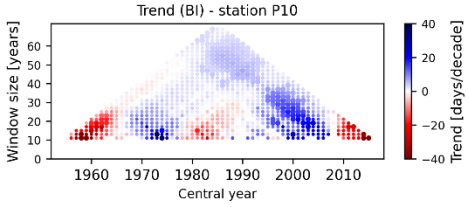

Running average (number of days with border ice) - station P8
Window size [years]
Central year
Days with BI

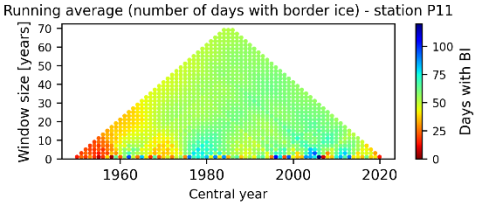

Trend (BI) - station P8
Window size [years]
Central year
Trend [days/decade]

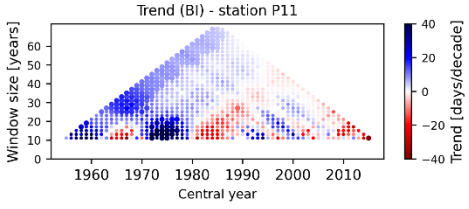

Running average (number of days with border ice) - station P9
Window size [years]
Central year
Days with BI

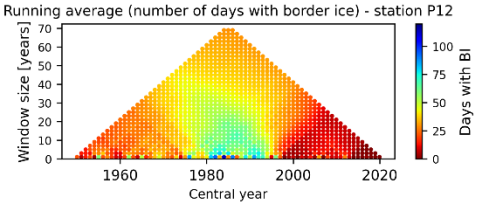

Trend (BI) - station P9
Window size [years]
Central year
Trend [days/decade]

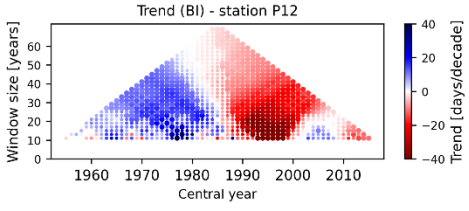

Running average (number of days with border ice) - station P10
Window size [years]
Central year
Days with BI

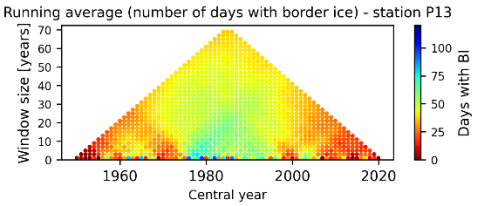

Trend (BI) - station P10
Window size [years]
Central year
Trend [days/decade]

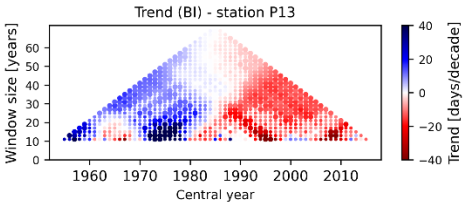

Running average (number of days with border ice) - station P11
Window size [years]
Central year
Days with BI

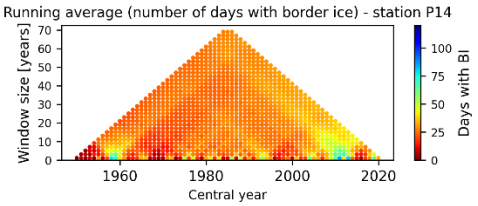

Trend (BI) - station P11
Window size [years]
Central year
Trend [days/decade]

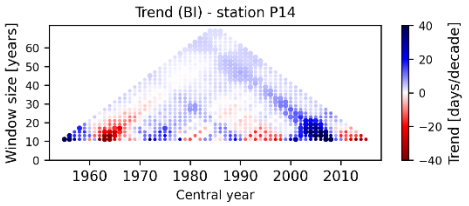

Running average (number of days with border ice) - station P12
Window size [years]
Central year
Days with BI

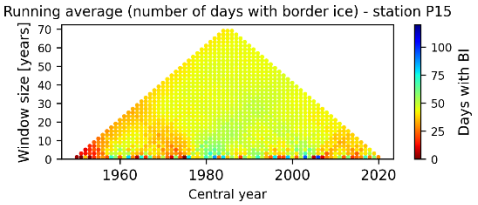

Trend (BI) - station P12
Window size [years]
Central year
Trend [days/decade]

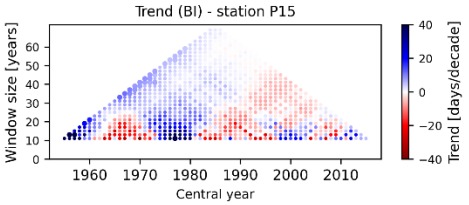

Running average (number of days with border ice) - station P13
Window size [years]
Central year
Days with BI

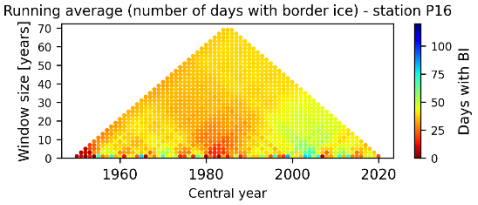

Trend (BI) - station P13
Window size [years]
Central year
Trend [days/decade]

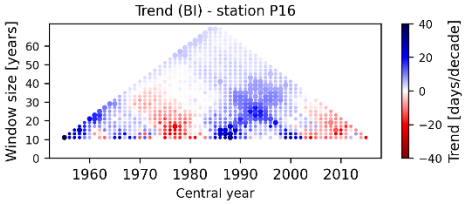

Running average (number of days with border ice) - station P14
Window size [years]
Central year
Days with BI

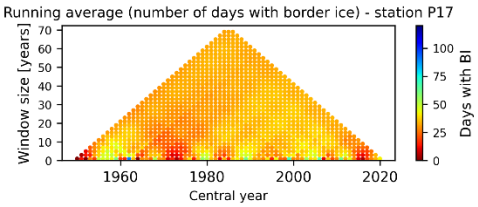

Trend (BI) - station P14
Window size [years]
Central year
Trend [days/decade]

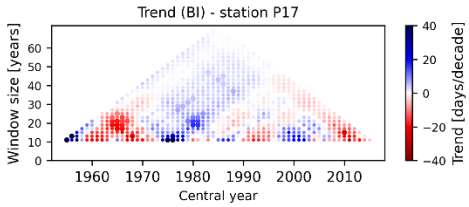

Running average (number of days with border ice) - station P15
Window size [years]
Central year
Days with BI

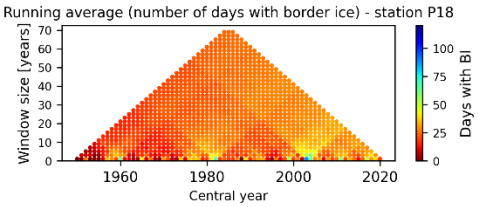

Trend (BI) - station P15
Window size [years]
Central year
Trend [days/decade]

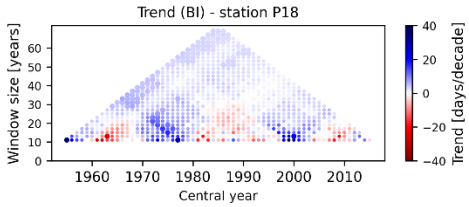

Running average (number of days with border ice) - station P16
Window size [years]
Central year
Days with BI

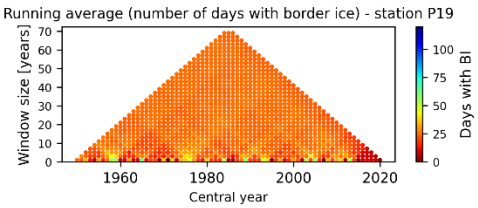

Trend (BI) - station P16
Window size [years]
Central year
Trend [days/decade]

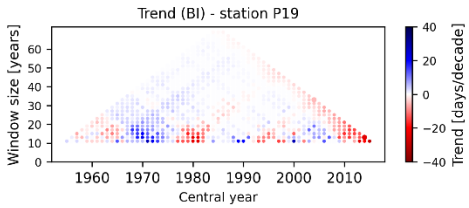

Running average (number of days with border ice) - station P17
Window size [years]
Central year
Days with BI

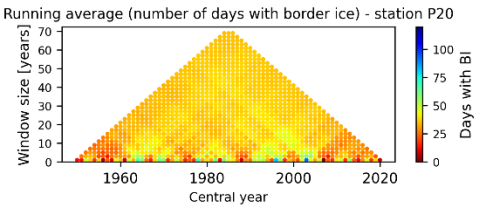

Trend (BI) - station P17
Window size [years]
Central year
Trend [days/decade]

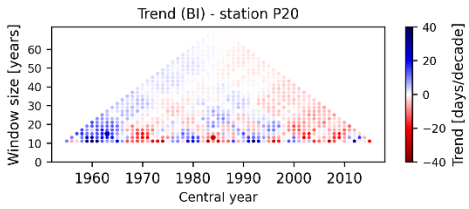

Running average (number of days with border ice) - station P18
Window size [years]
Central year
Days with BI

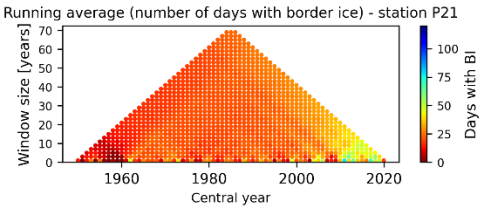

Trend (BI) - station P18
Window size [years]
Central year
Trend [days/decade]

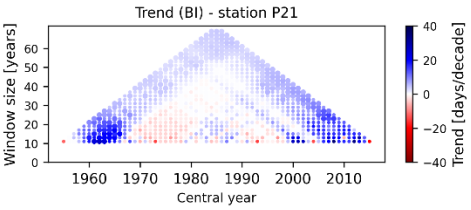

Running average (number of days with border ice) - station P19
Window size [years]
Central year
Days with BI

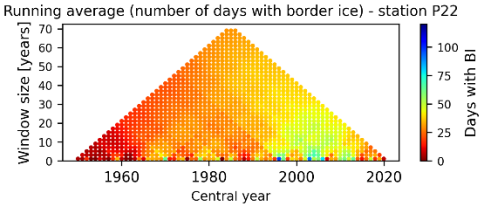

Trend (BI) - station P19
Window size [years]
Central year
Trend [days/decade]

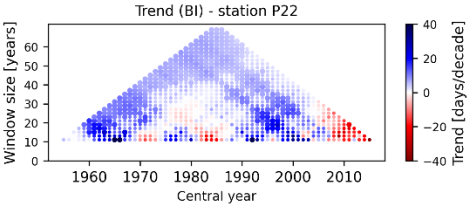

Running average (number of days with border ice) - station P20
Window size [years]
Central year
Days with BI

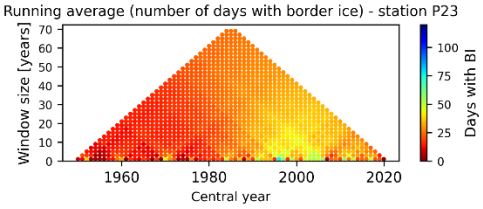

Trend (BI) - station P20
Window size [years]
Central year
Trend [days/decade]

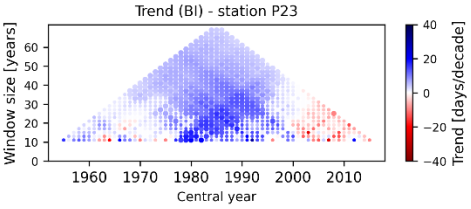

Running average (number of days with border ice) - station P21
Window size [years]
Central year
Days with BI

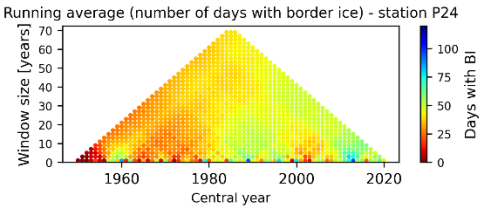

Trend (BI) - station P21
Window size [years]
Central year
Trend [days/decade]

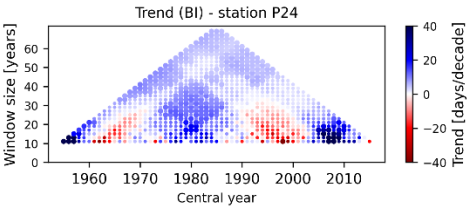

Running average (number of days with border ice) - station P22
Window size [years]
Central year
Days with BI

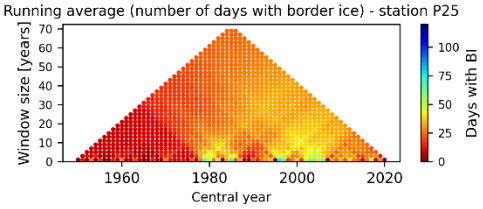

Trend (BI) - station P22
Window size [years]
Central year
Trend [days/decade]

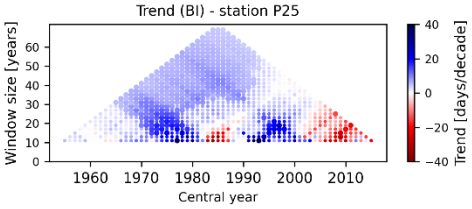

Running average (number of days with border ice) - station P23
Window size [years]
Central year
Days with BI


Trend (BI) - station P23
Window size [years]
Central year
Trend [days/decade]

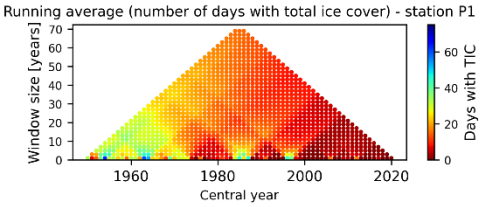

Running average (number of days with border ice) - station P24
Window size [years]
Central year
Days with BI

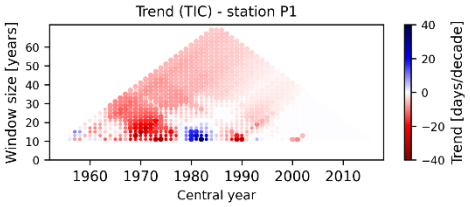

Trend (BI) - station P24
Window size [years]
Central year
Trend [days/decade]

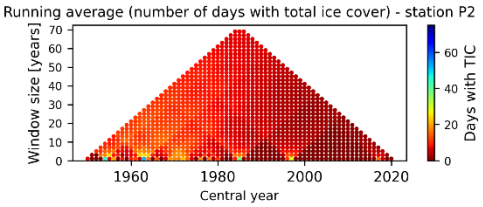

Running average (number of days with border ice) - station P25
Window size [years]
Central year
Days with BI

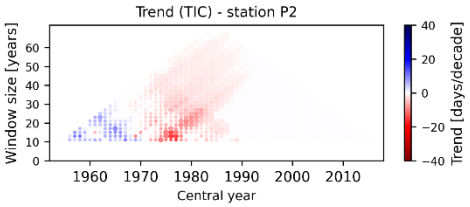

Trend (BI) - station P25
Window size [years]
Central year
Trend [days/decade]

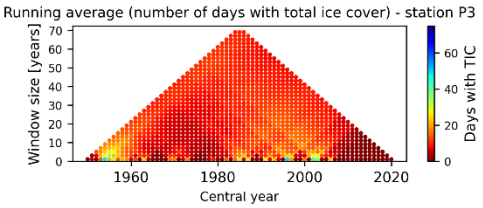
MARTA charts for total ice cover:

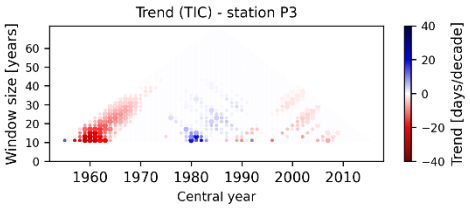


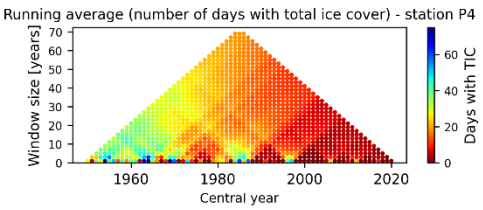


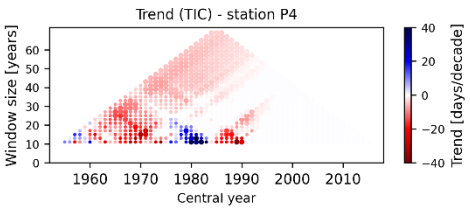


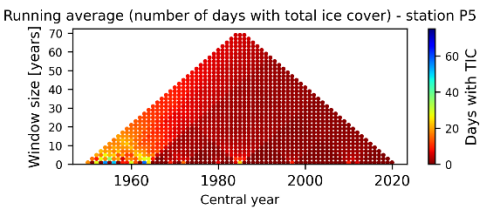


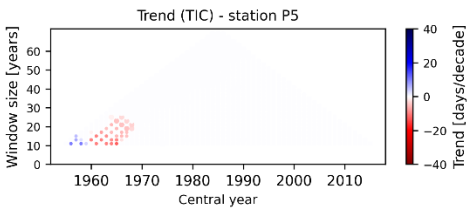


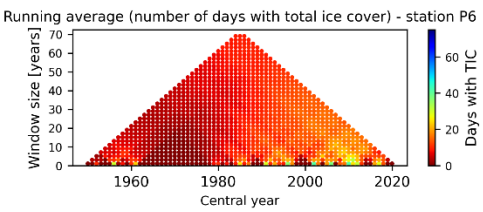


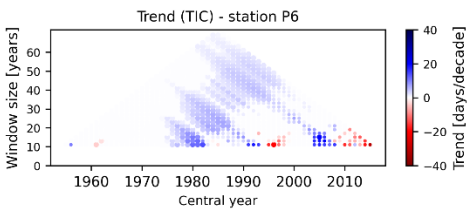


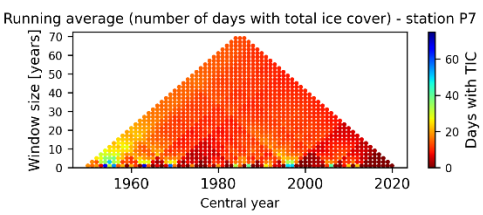


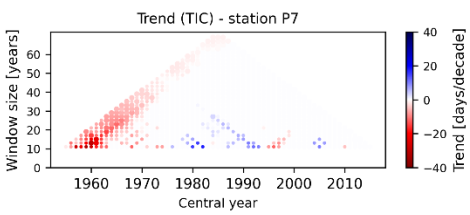


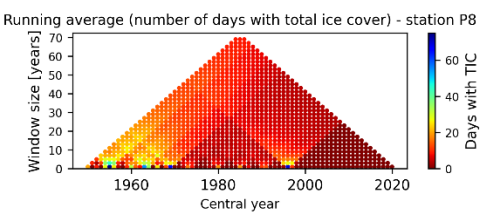


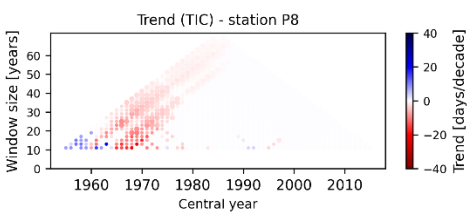


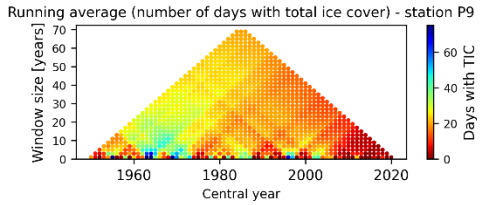


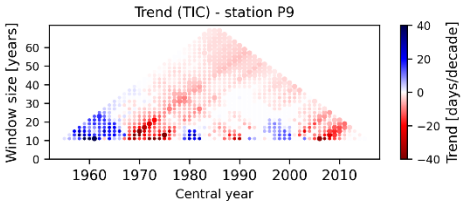


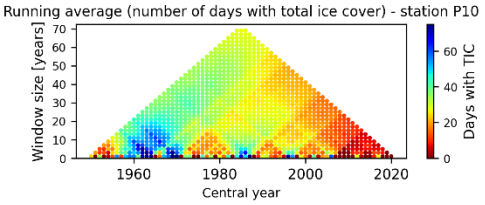


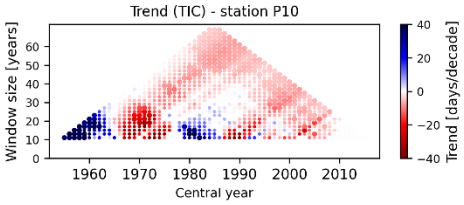


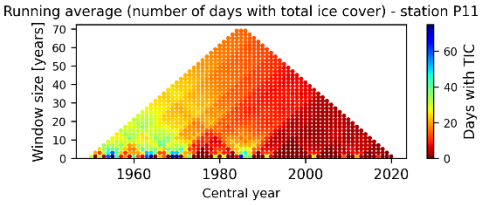


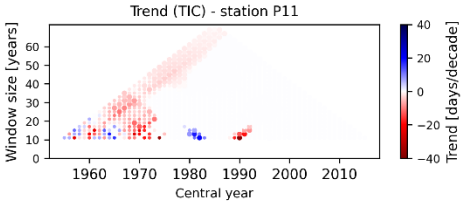

Running average (number of days with total ice cover) - station P9
Window size [years]
Central year
Days with TIC

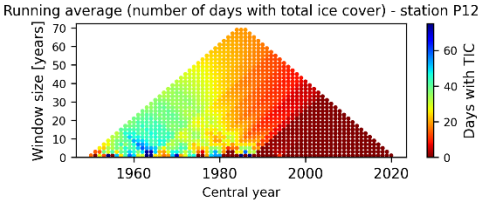

Trend (TIC) - station P9
Window size [years]
Central year
Trend [days/decade]

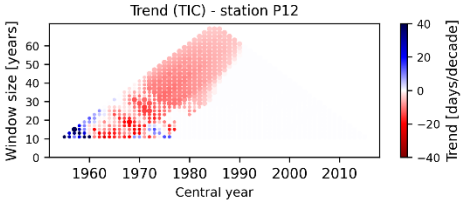

Running average (number of days with total ice cover) - station P10
Window size [years]
Central year
Days with TIC

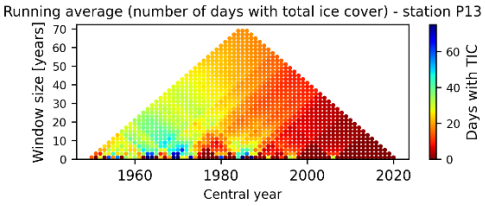

Trend (TIC) - station P10
Window size [years]
Central year
Trend [days/decade]

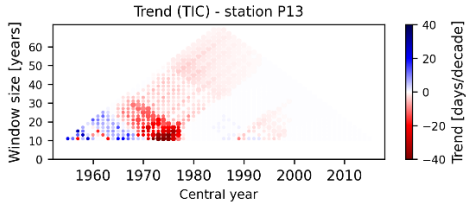

Running average (number of days with total ice cover) - station P11
Window size [years]
Central year
Days with TIC

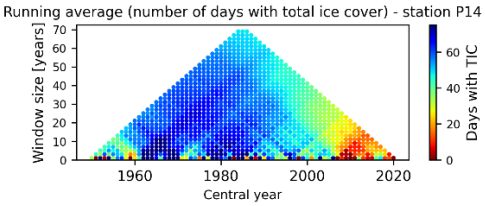

Trend (TIC) - station P11
Window size [years]
Central year
Trend [days/decade]

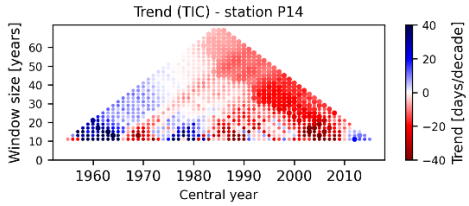

Running average (number of days with total ice cover) - station P12
Window size [years]
Central year
Days with TIC

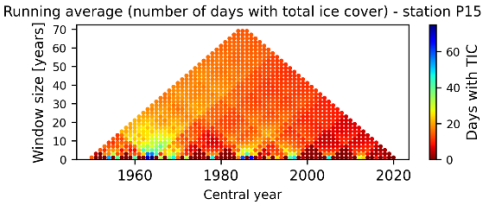

Trend (TIC) - station P12
Window size [years]
Central year
Trend [days/decade]

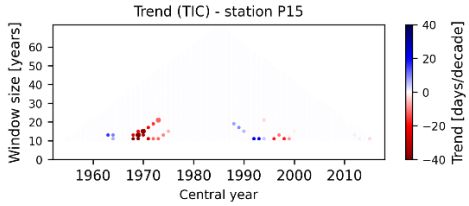

Running average (number of days with total ice cover) - station P13
Window size [years]
Central year
Days with TIC

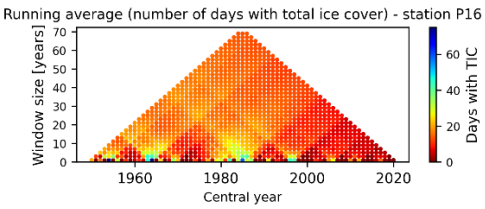

Trend (TIC) - station P13
Window size [years]
Central year
Trend [days/decade]

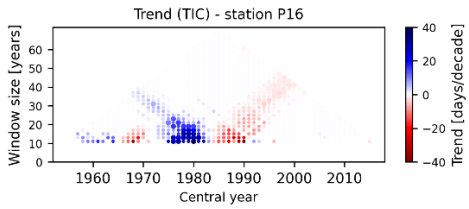

Running average (number of days with total ice cover) - station P14
Window size [years]
Central year
Days with TIC

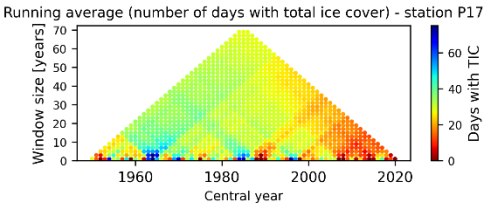

Trend (TIC) - station P14
Window size [years]
Central year
Trend [days/decade]

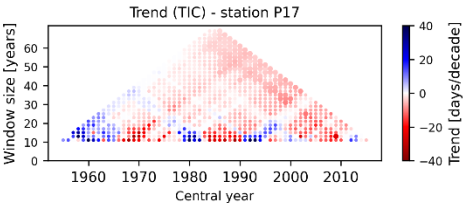

Running average (number of days with total ice cover) - station P15
Window size [years]
Central year
Days with TIC

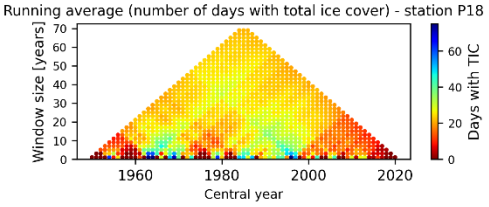

Trend (TIC) - station P15
Window size [years]
Central year
Trend [days/decade]

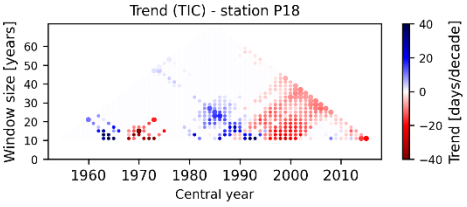

Running average (number of days with total ice cover) - station P16
Window size [years]
Central year
Days with TIC

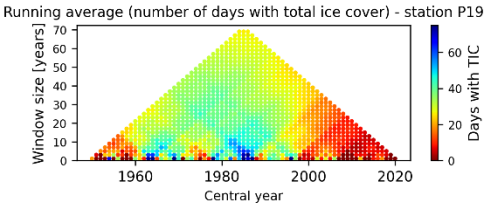

Trend (TIC) - station P16
Window size [years]
Central year
Trend [days/decade]

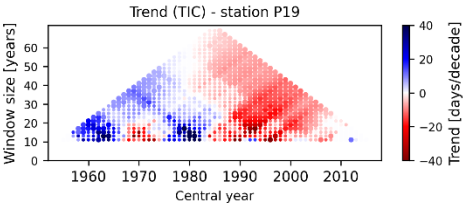

Running average (number of days with total ice cover) - station P17
Window size [years]
Central year
Days with TIC

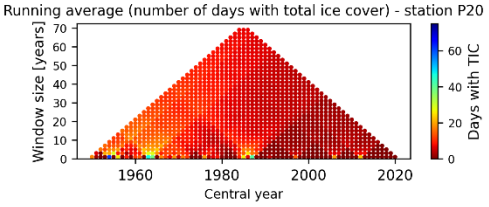

Trend (TIC) - station P17
Window size [years]
Central year
Trend [days/decade]

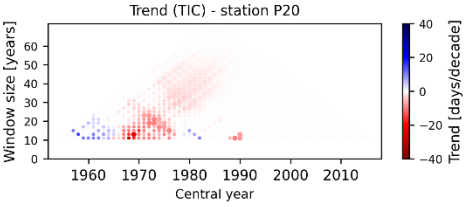

Running average (number of days with total ice cover) - station P18
Window size [years]
Central year
Days with TIC

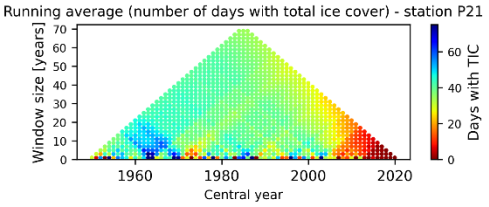

Trend (TIC) - station P18
Window size [years]
Central year
Trend [days/decade]

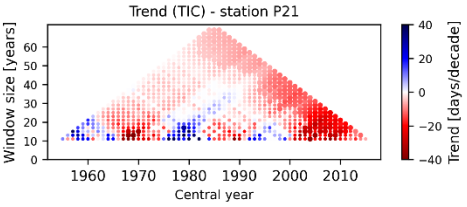

Running average (number of days with total ice cover) - station P19
Window size [years]
Central year
Days with TIC

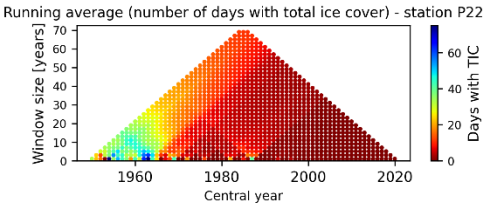

Trend (TIC) - station P19
Window size [years]
Central year
Trend [days/decade]

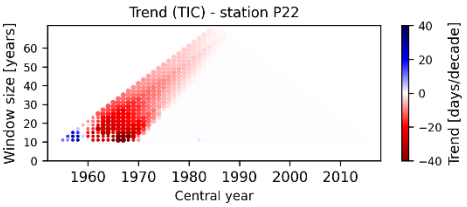

Running average (number of days with total ice cover) - station P20
Window size [years]
Central year
Days with TIC

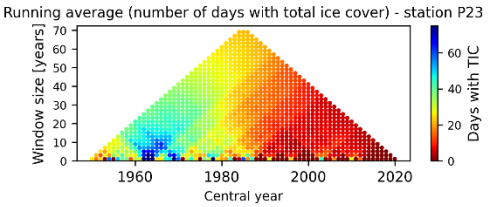

Trend (TIC) - station P20
Window size [years]
Central year
Trend [days/decade]

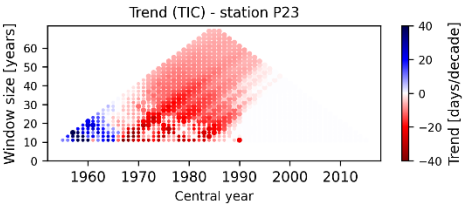

Running average (number of days with total ice cover) - station P21
Window size [years]
Central year
Days with TIC

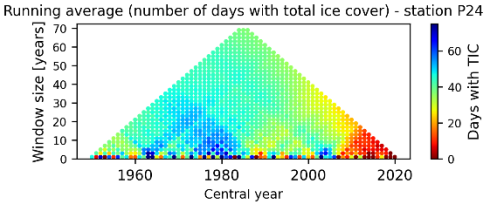

Trend (TIC) - station P21
Window size [years]
Central year
Trend [days/decade]

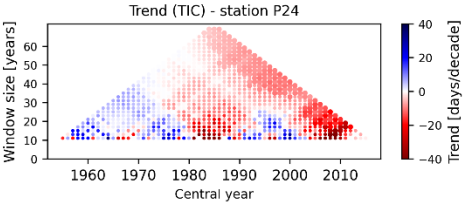

Running average (number of days with total ice cover) - station P22
Window size [years]
Central year
Days with TIC

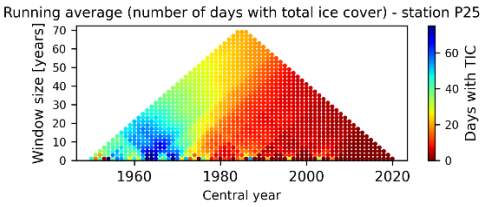

Trend (TIC) - station P22
Window size [years]
Central year
Trend [days/decade]

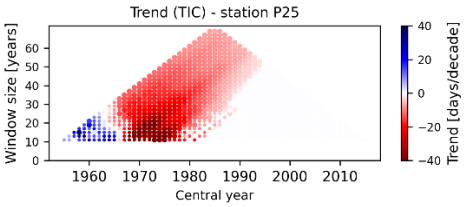

Running average (number of days with total ice cover) - station P23
Window size [years]
Central year
Days with TIC


Trend (TIC) - station P23
Window size [years]
Central year
Trend [days/decade]


Running average (number of days with total ice cover) - station P24
Window size [years]
Central year
Days with TIC


Trend (TIC) - station P24
Window size [years]
Central year
Trend [days/decade]


Running average (number of days with total ice cover) - station P25
Window size [years]
Central year
Days with TIC
0
10
20
30
40
50
60
70
1960
1980
2000
2020
0
20
40
60


Trend (TIC) - station P25
Window size [years]
Central year
Trend [days/decade]
0
10
20
30
40
50
60
1960
1970
1980
1990
2000
2010
40
20
0
−20
−40