Appendix A

Data set of Zuo and Oerlemans (1997a)

Table A.1 lists details of 100 glaciated regions adopted from Zuo and Oerlemans (1997a) and used in this thesis. In particular, latitude and longitude of the centred locations, the areas (in km^2), and the annual precipitation rates (in m w.e. $year^{-1}$) are given.

glaciated region		**lat**	**long**	**area**	**prec**
1	Ellesmere	80	-80	80,000	0.22
2	Axel Heiberg	79	-92	11,700	0.22
3	Devon Island	75	-82	16,200	0.225
4	N-Baffin Island	72	-78	18,500	0.312
5	S-Baffin Island	67	-66	18,500	0.5
6	Bylot Island	73	-78	5,000	0.22
7	Brooks Range	68	-150	722	0.375
8	Alaska Range	63	-151	13,900	0.875
9	Talkeetna Mts.	62	-149	800	0.875
10	Kilbuck Mts.	61	-160	230	0.75
11	Aleutian Island	54	-166	960	1.5
12	Alaska Peninsula	57	-157	1,250	1.25
13	Seward Peninsula	60	-149	100	3
14	Kenai Mts.	60	-150	4,600	1.25
15	Wrangell Mts.	62	-143	8,300	1.25
16	Chuhach Mts.	61	-145	21,600	1.75

glaciated region		lat	long	area	prec
17	St. Elias Mts.	61	-141	11,800	1.5
18	Coast Mts.	59	-134	10,500	2.5
19	Stikine River	57	-131	5,070	1.5
20	Yukon Territory	61	-140	10,000	1.5
21	Selwyn Mts.	62.5	-128	600	0.75
22	Rocky Mts.	58	-125	300	0.75
23	Coast Mts.	51	-125	13,500	2.5
24	Olympic Mts.	48	-123	46	4
25	N-Cascades	48.3	-121	266	2.5
26	Mt. Rainer / Adams	46	-122	63	4
27	Rocky Mts.	52	-118	3,000	1
28	Selkirk Mts.	51	-117	1,000	1.5
29	Rocky Mts.	44	-109	74	0.562
30	Sierra Nevada	37	-118	51	1
31	Mexico	19	-97	4	2.5
32	Mexico	19	-98.5	4	1.25
33	Mexico	19	-100	3	1.75
34	S.Nev de Merida	8.5	-71	3	1.5
35	Nev. del Huila	3	-76	19	1.5
36	Nev. del Ruzy / Tolima	4.7	-75.4	24	3
37	Nev. del Cocuy	6.5	-72.3	39	1.25
38	S. Nev de Santa Marta	10.8	-73.6	19	4
39	Ecuador	-0.8	-78.2	111	3.5
40	N. Cordilleras	-10	-77	873	1.5
41	N. Cordilleras	-12	-75.5	258	1
42	S. Cordilleras	-15	-73	649	0.813
43	Cordilleras Oriental	-15.6	-68	51	1.12
44	Andes, 30-16S	-23	-67.5	2,800	0.375
45	Chili	-34	-70	743	1.5
46	Mendoza / San Juan	-33	-70	1,170	1.5
47	Neuquen	-37	-70	156	3.5
48	Chili	-43	-72	3,570	3
49	N. Patagonia	-47	-73.5	5,720	2
50	S. Patagonia	-50	-73.5	16,900	2
51	Tierra del Fuego	-54.5	-70.5	2,700	2
52	S. Atlantic Islands	-57	-35	4,100	1

glaciated region		lat	long	area	prec
53	Vatnajokull	65.5	-17	8,300	4
54	Langjokull	65	-20	953	4
55	Hofsjokull	65.5	-19	925	2.5
56	Myrdalsjokull	63.5	-19	600	4
57	Drangajokull	66	-22	160	2.5
58	Svalbard	79	18	36,600	0.375
59	Franz Josef Land	81	57	13,700	0.312
60	Novaya Zemlya	75	57	23,600	0.5
61	Severnaya Zemlya	79	98	18,300	0.25
62	N. Scandinavia	67.5	17	1,080	2.5
63	S. Norway	61.7	7.4	1,630	4
64	Alps	46	7.5	2,910	2
65	Pyrenees	42.5	0	12	2
66	Bol'shoy Kavkaz	42.5	44	1,340	1.5
67	Turkey	38	43.5	24	1.25
68	Iran	38	46.5	20	0.75
69	Severnity Ural	66	61	800	1
70	Ili + Chu	43	77.5	2,300	1
71	Syrdar'ya / Amudar'ya	38	71	10,700	1
72	Tarim Ba	42	77.5	320	0.75
73	Pakistan/India	36	76	40,000	1.75
74	Nanga Parbat	35.3	74.6	301	1.25
75	Chitral	36.4	72.4	1,350	2
76	Himalaya / Nepal	28	87	12,700	0.75
77	Bhutan	28	90	1,340	0.75
78	Niangtingtanggula	30	89	7,540	1
79	Qilian Shan	39	99	2,380	0.75
80	Altai Shan	47	91	293	0.375
81	Kunlun Shan	36	87	11,600	0.25
82	Tyan Shan	42	80	9,550	1
83	Tanggula Shan	33	91	2,080	0.75
84	Hengduan Shan	28	99	1,460	1
85	Gangdisi Shan	31	82	2,190	0.625
86	Dzungarsky Alatau	45	80	910	1
87	Qiangtang Plateau	34	87	3,190	0.25
88	Orulgan	68	128	18	0.625

glaciated region		lat	long	area	prec
89	Cherskogo	65	145	372	0.875
90	Koryakskoye Khrebet	62.5	171	260	1.25
91	Suntar Khayata	62.5	141	202	1
92	Kodar	57.5	117	19	0.75
93	Kamtchatka	57.5	160	874	0.5
94	Mt. Kenya	-0.2	37.3	1	1.75
95	Mt. Kilimandjaro	-3.1	37.3	5	1.37
96	Ruwenzori	0.4	30	5	1.37
97	Irian Jaya	-4	137	7	3.75
98	New Zealand	-43.4	170	1,000	1.87
99	Kerguelen Island	-49	69	450	1.07
100	Heard Island	-53	73.5	450	1.72

Table A.1: Details on 100 glaciated regions adopted from Zuo and Oerlemans (1997a).

Appendix B

Supporting material for Chapter 2

Topographic maps of Alaska and Svalbard

Figures B.1 and B.2 show topographic maps of Alaska and Svalbard overlaid with the area-extents of glaciated regions of the digitised data set.

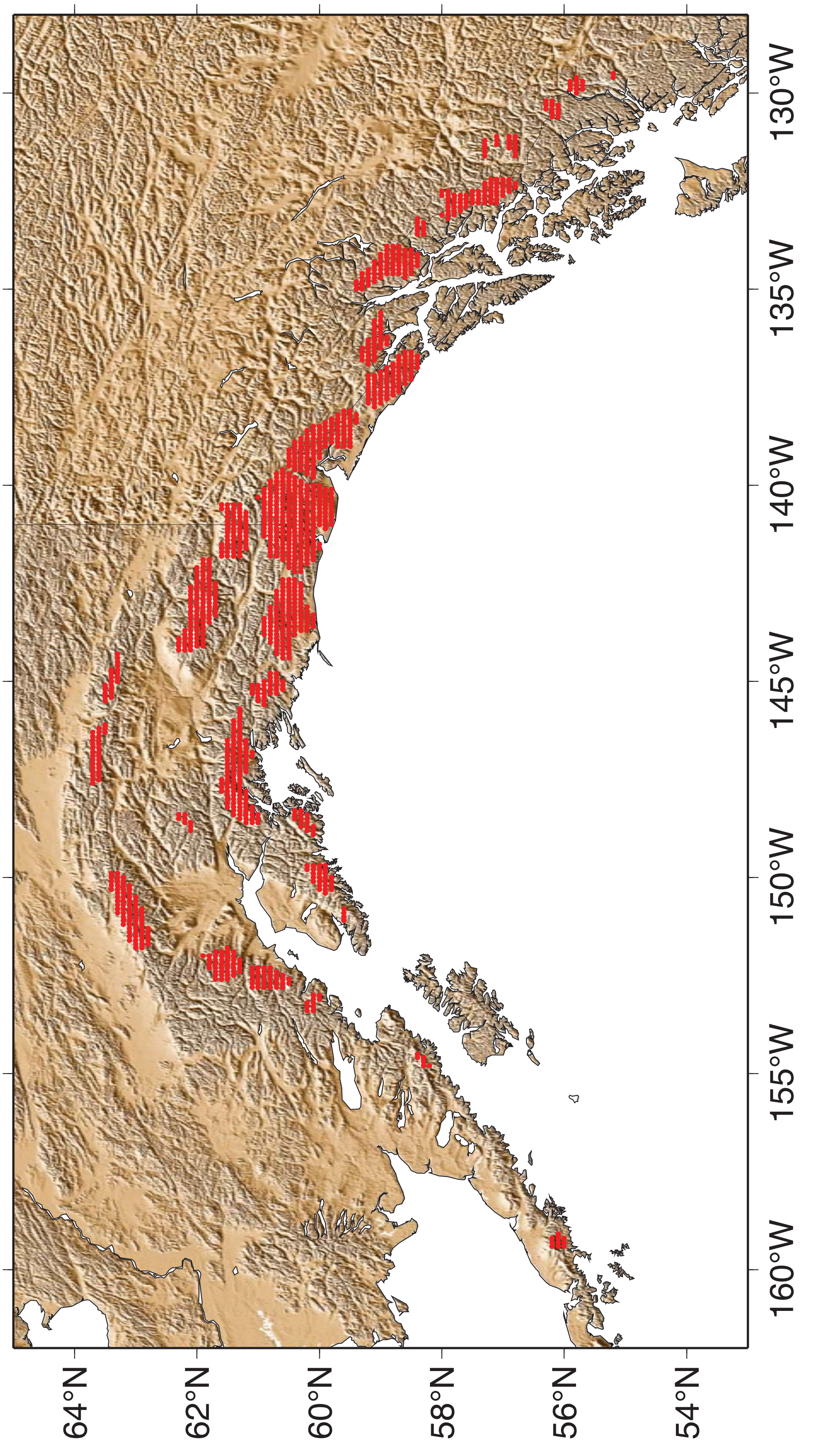


Figure B.1: Extent of glaciers in Alaska plotted on top of a topographic map.

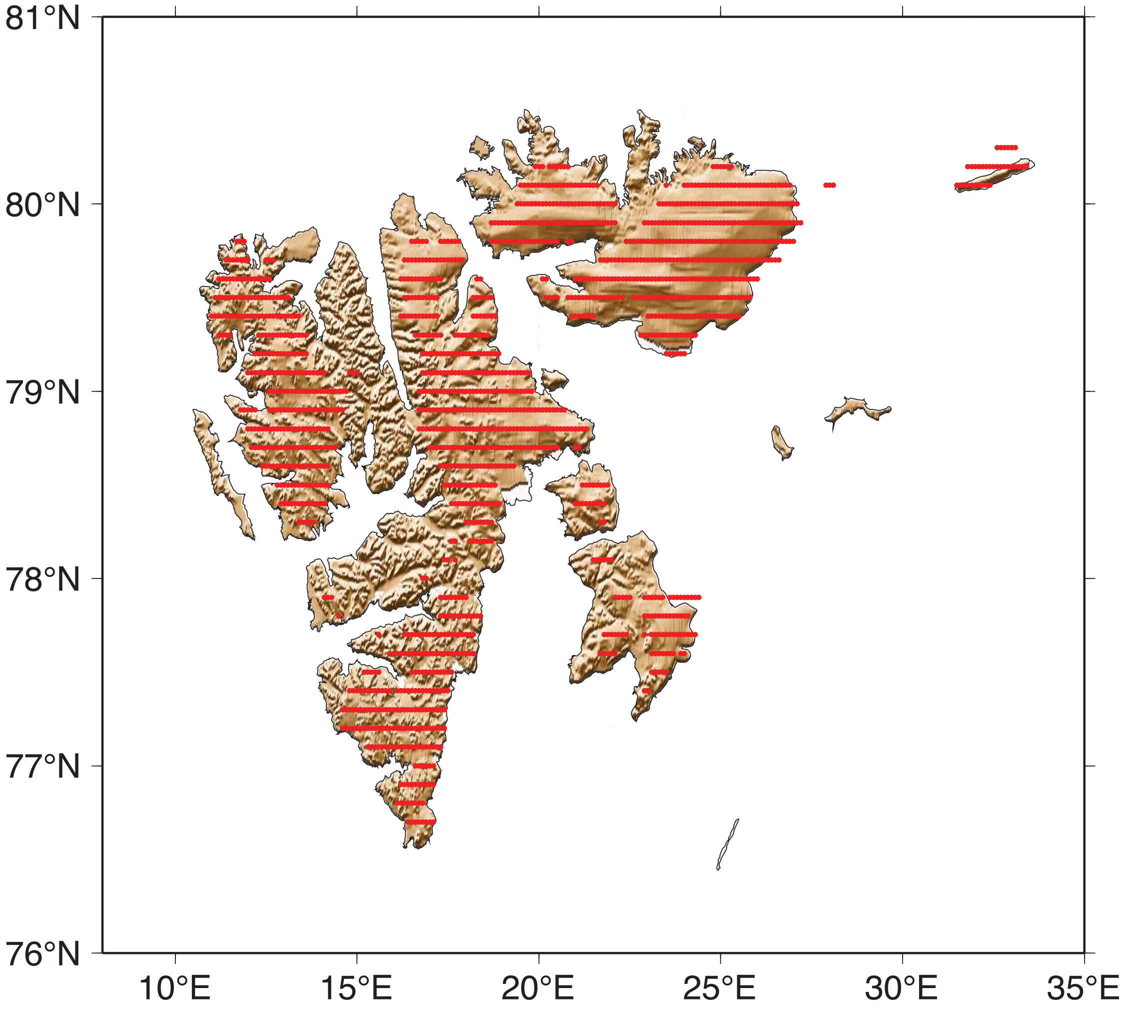


Figure B.2: Extent of glaciers on the Svalbard archipelago plotted on top of a topographic map.

Location of glaciated region and precipitation data

Table B.1 lists the centred location of 100 glaciated region and the nearest available precipitation grid point. The precipitation data set is taken from the Climate Research Unit (CRU) and is given on a 2.5° latitude by 3.75° longitude resolution.

	gl. region		**prec. grid**		**dist**
gl	**lat**	**long**	**lat**	**long**	**[km]**
1	80	-80	80	-86.25	121
2	79	-92	80	-86.25	161
3	75	-82	75	-93.75	338
4	72	-78	70	-82.5	276
5	67	-66	65	-67.5	233
6	73	-78	70	-82.5	369
7	68	-150	67.5	-150	56
8	63	-151	62.5	-150	75
9	62	-149	62.5	-150	76
10	61	-160	60	-161.25	131
11	54	-166	55	-161.25	326
12	57	-157	57.5	-157.5	63
13	60	-149	60	-150	56
14	60	-150	60	-150	0
15	62	-143	62.5	-142.5	61
16	61	-145	60	-146.25	131
17	61	-141	60	-138.75	166
18	59	-134	60	-135	125
19	57	-131	57.5	-131.25	58
20	61	-140	60	-138.75	131
21	62.5	-128	65	-127.5	279
22	58	-125	60	-123.75	234
23	51	-125	50	-123.75	142
24	48	-123	47.5	-123.75	79
25	48.3	-121	47.5	-120	116
26	46	-122	45	-123.75	176
27	52	-118	52.5	-116.25	132
28	51	-117	50	-116.25	123
29	44	-109	45	-108.75	113
30	37	-118	37.5	-116.25	165
31	19	-97	20	-97.5	123
32	19	-98.5	20	-97.5	153
33	19	-100	20	-101.25	172
34	8.5	-71	7.5	-71.25	115
35	3	-76	2.5	-75	124
36	4.7	-75.4	5	-75	55
37	6.5	-72.3	7.5	-71.25	161
38	10.8	-73.6	10	-71.25	272
39	-0.8	-78.2	0	-78.75	108
40	-10	-77	-10	-75	219
41	-12	-75.5	-12.5	-75	78
42	-15	-73	-15	-75	215
43	-15.6	-68	-15	-67.5	86
44	-23	-67.5	-20	-67.5	334
45	-34	-70	-35	-71.25	160
46	-33	-70	-32.5	-71.25	129
47	-37	-70	-37.5	-71.25	124
48	-43	-72	-42.5	-71.25	83
49	-47	-73.5	-47.5	-71.25	179
50	-50	-73.5	-50	-71.25	161
51	-54.5	-70.5	-55	-67.5	200
52	-57	-35	-60	-45	669
53	65.5	-17	65	-18.75	99
54	65	-20	65	-18.75	59
55	65.5	-19	65	-18.75	57
56	63.5	-19	62.5	-18.75	112
57	66	-22	65	-22.5	114
58	79	18	77.5	15	180
59	81	57	80	78.75	412
60	75	57	80	78.75	755
61	79	98	80	78.75	404
62	67.5	17	67.5	18.75	75
63	61.7	7.4	62.5	7.5	89
64	46	7.5	45	7.5	111
65	42.5	0	42.5	0	0
66	42.5	44	42.5	45	82
67	38	43.5	37.5	45	143
68	38	46.5	37.5	45	143
69	66	61	65	60	120
70	43	77.5	42.5	78.75	116
71	38	71	37.5	71.25	59.8
72	42	77.5	42.5	78.75	116.9
73	36	76	35	75	143.4
74	35.3	74.6	35	75	49.3
75	36.4	72.4	37.5	71.25	159.4
76	28	87	27.5	90	300.4
77	28	90	27.5	90	55.6
78	30	89	30	90	96.3
79	39	99	40	97.5	170.1
80	47	91	47.5	90	93.7
81	36	87	37.5	86.25	179.7
82	42	80	42.5	78.75	116.9
83	33	91	30	90	346.8
84	28	99	27.5	97.5	157.7
85	31	82	30	78.75	330.6
86	45	80	45	78.75	98.3
87	34	87	37.5	86.25	395.0
88	68	128	67.5	123.75	187.3
89	65	145	65	146.25	58.8
90	62.5	171	62.5	172.5	77.1
91	62.5	141	62.5	142.5	77.1
92	57.5	117	57.5	120	179.2
93	57.5	160	57.5	161.25	74.7
94	-0.2	37.3	0	37.5	31.4
95	-3.1	37.3	-2.5	37.5	70.3
96	0.4	30	0	30	44.5
97	-4	137	-7.5	138.75	434.7
98	-43.4	170	-45	168.75	203.9
99	-49	69	-50	71.25	196.9
100	-53	73.5	-50	71.25	368.1

Table B.1: Comparison of locations between glaciated regions and available precipitation data from the CRU. The last column lists the approximate distance in kilometre between the two locations.

Average annual mean precipitation of three sources

Table B.2 lists average annual precipitation rates of 100 glaciated regions from three sources:

$\mathbf{P}_{Z\&O}$	data from Zuo and Oerlemans (1997a)
$\mathbf{P}_{CRUaver}$	calculated from data of the Climate Research Unit (CRU)
$\mathbf{P}_{OFaver}$	calculated from the data sets provided by Siobhan O'Farrell

For the calculation of the average of the 100 glaciated regions (last row in Table B.2) using $P_{CRUaver}$ and P_{OFaver}, annual precipitation rates smaller than 0.22 m year^{-1} are set to that number (see page 36 for details on this parameter setting).

gl	$P_{Z\&O}$	$P_{CRUaver}$	P_{OFaver}
1	0.22	0.085±0.028<	0.259±0.045+
2	0.22	0.085±0.028<	0.251±0.042+
3	0.225	0.176±0.039<	0.226±0.0.35+
4	0.312	0.261±0.064	0.425±0.058+
5	0.5	0.514±0.119+	0.582±0.093+
6	0.22	0.261±0.064+	0.260±0.040+
7	0.375	0.426±0.103+	0.698±0.074+
8	0.875	0.691±0.117	1.652±0.185+
9	0.875	0.691±0.117	1.976±0.225+
10	0.75	0.541±0.165	1.076±0.113+
11	1.5	1.153±0.235	1.368±0.105
12	1.25	0.653±0.117	1.214±0.112
13	3	0.685±0.114	1.755±0.217
14	1.25	0.685±0.114	1.631±0.191+
15	1.25	0.306±0.056	1.791±0.176+
16	1.75	3.435±1.007+	2.024±0.247+
17	1.5	4.628±0.926+	2.368±0.261+
18	2.5	0.347±0.058	2.345±0.274
19	1.5	1.574±0.182+	2.580±0.313+
20	1.5	4.628±0.926+	2.368±0.261+
21	0.75	0.386±0.081	0.718±0.078
22	0.75	0.543±0.092	1.276±0.121+
23	2.5	1.423±0.198	2.478±0.345
24	4	2.284±0.334	1.798±0.253
25	2.5	0.833±0.133	1.826±0.270
26	4	2.016±0.331	1.530±0.242
27	1	0.540±0.069	1.294±0.121+
28	1.5	0.761±0.110	0.880±0.095
29	0.562	0.421±0.073	0.947±0.116+
30	1	0.173±0.053<	0.565±0.225
31	2.5	2.408±0.325	1.354±0.287
32	1.25	2.408±0.325+	1.996±0.270+
33	1.75	1.003±0.142	1.996±0.270+
34	1.5	1.818±0.260+	1.575±0.317+
35	1.5	2.025±0.338+	5.586±0.470+
36	3	1.020±0.173	4.520±0.596+
37	1.25	1.818±0.260+	2.216±0.289+
38	4	1.276±0.209	0.200±0.171<
39	3.5	1.529±0.373	6.851±0.369+
40	1.5	3.931±0.792+	2.713±0.403+
41	1	0.885±0.160	2.090±0.385+
42	0.813	0.006±0.006<	0.316±0.193
43	1.12	2.561±0.574+	2.467±0.241+
44	0.375	0.515±0.154+	0.457±0.259+
45	1.5	1.204±0.308	0.435±0.119
46	1.5	0.498±0.218	0.297±0.103
47	3.5	1.511±0.331	0.480±0.109
48	3	0.915±0.171	1.206±0.127
49	2	0.441±0.126	1.475±0.127
50	2	0.215±0.051<	1.248±0.108

gl	$P_{Z\&O}$	$P_{CRUaver}$	P_{OFaver}
51	2	0.693±0.146	1.662±0.131
52	1	0.593±0.259	1.147±0.070+
53	4	0.610±0.112	0.951±0.094
54	4	0.610±0.112	0.907±0.105
55	2.5	0.610±0.112	0.899±0.100
56	4	1.843±0.263	0.915±0.100
57	2.5	0.999±0.168	1.075±0.115
58	0.375	0.459±0.154+	0.461±0.066+
59	0.312	0.273±0.096	0.322±0.050+
60	0.5	0.273±0.096	0.376±0.070
61	0.25	0.273±0.096+	0.296±0.047+
62	2.5	0.638±0.082	0.756±0.093
63	4	1.442±0.257	0.964±0.114
64	2	1.222±0.214	1.639±0.202
65	2	0.788±0.149	0.646±0.135
66	1.5	0.983±0.118	1.114±0.170
67	1.25	0.486±0.076	0.628±0.145
68	0.75	0.486±0.076	0.437±0.117
69	1	0.623±0.117	0.816±0.096
70	1	0.478±0.086	0.688±0.123
71	1	0.369±0.097	0.786±0.165
72	0.75	0.478±0.086	0.816±0.121+
73	1.75	0.860±0.182	0.895±0.136
74	1.25	0.860±0.182	0.834±0.259
75	2	0.369±0.097	1.027±0.213
76	0.75	3.409±0.469+	1.806±0.207+
77	0.75	3.409±0.469+	1.322±0.140+
78	1	0.551±0.104	0.570±0.110
79	0.75	0.089±0.030<	0.728±0.074
80	0.375	0.155±0.039<	0.470±0.069+
81	0.25	0.027±0.017<	1.163±0.138+
82	1	0.478±0.086	0.577±0.151
83	0.75	0.551±0.104	0.145±0.059<
84	1	0.816±0.114	2.053±0.184+
85	0.625	1.646±0.358+	1.415±0.274+
86	1	0.391±0.082	0.350±0.077
87	0.25	0.027±0.017<	0.290±0.063+
88	0.625	0.356±0.061	0.557±0.077
89	0.875	0.312±0.075	0.697±0.075
90	1.25	0.404±0.093	0.891±0.124
91	1	0.259±0.066	0.794±0.125
92	0.75	0.429±0.076	0.970±0.110+
93	0.5	0.757±0.136+	0.763±0.110+
94	1.75	1.315±0.266	0.489±0.202
95	1.37	1.032±0.216	0.469±0.220
96	1.37	1.386±0.164+	2.447±0.252+
97	3.75	1.813±0.417	3.822±0.864+
98	1.87	1.091±0.187	1.261±0.138
99	1.07	0.992±0.319	1.649±0.095+
100	1.72	0.992±0.319	1.415±0.088
aver	**1.49**	**1.00**	**1.28**

Table B.2: Comparison of average annual mean precipitation and standard deviation (calculated from Equation 2.12) of 100 glaciated regions between the data sets of $P_{Z\&O}$, $P_{CRUaver}$, and P_{OFaver}. The unit is meters year^{-1} of water. Red numbers indicate calculated $P_{CRUaver}$ or P_{OFaver} that lie within 25% of the $P_{Z\&O}$ value. Calculated $P_{CRUaver}$ or P_{OFaver} that are greater than those of $P_{Z\&O}$ are indicated with a '+' symbol. The symbol '<' indicates that the calculated average annual precipitation is less than 0.22 m year^{-1} but has to be set to that number for any following calculations.

Trends of precipitation data sets

Table B.3 lists linear trends in precipitation of 100 glaciated regions calculated from the data set of the Climate Research Unit, **CRU**. The time periods vary for each region, not covering time before 1900 or after 1998 at all.

Trends in precipitation of 53 glaciated regions are **positive**. Of these:
35 trends are significant at a 1σ level
23 trends are significant at a 2σ level
4 trends are significant at a 3σ level

Trends in precipitation of 47 glaciated regions are **negative**. Of these:
23 trends are significant at a 1σ level
11 trends are significant at a 2σ level
5 trends are significant at a 3σ level

Table B.4 lists precipitation trends of 100 glaciated regions calculated from the data set of Siobhan **O'Farrell**. Data for the time period 1871-2000 is available and is given on a 1.875^o longitude by $\sim 1.86^o$ latitude grid.

Trends in precipitation of 66 glaciated regions are **positive**. Of these:
37 trends are significant at a 1σ level
15 trends are significant at a 2σ level
2 trends are significant at a 3σ level

Trends in precipitation of 34 glaciated regions are **negative**. Of these:
10 trends are significant at a 1σ level
4 trends are significant at a 2σ level
1 trend is significant at a 3σ level

gl	trend	gl	trend	gl	trend
1	0.649 ± 0.257	**35**	−1.149 ± 1.378	**69**	1.030 ± 0.406
2	0.649 ± 0.257	**36**	−0.254 ± 0.680	**70**	0.131 ± 0.308
3	0.697 ± 0.375	**37**	−0.832 ± 0.985	**71**	0.823 ± 0.337
4	−0.234 ± 0.701	**38**	−0.357 ± 0.794	**72**	0.131 ± 0.308
5	0.731 ± 1.166	**39**	−1.789 ± 1.563	**73**	0.477 ± 0.671
6	−0.234 ± 0.701	**40**	19.526 ± 8.232	**74**	0.477 ± 0.671
7	−0.139 ± 0.383	**41**	−0.065 ± 2.055	**75**	0.823 ± 0.337
8	−0.230 ± 0.425	**42**	−0.098 ± 0.082	**76**	−3.555 ± 1.672
9	−0.230 ± 0.425	**43**	−4.982 ± 2.031	**77**	−3.555 ± 1.672
10	−1.726 ± 0.822	**44**	−0.210 ± 0.545	**78**	−0.328 ± 0.378
11	1.970 ± 1.445	**45**	−2.516 ± 1.059	**79**	0.007 ± 0.218
12	−1.409 ± 0.497	**46**	−2.074 ± 0.743	**80**	0.050 ± 0.139
13	−0.019 ± 0.434	**47**	−2.611 ± 1.141	**81**	0.450 ± 0.183
14	−0.019 ± 0.434	**48**	−0.771 ± 0.600	**82**	0.131 ± 0.308
15	0.011 ± 0.210	**49**	1.298 ± 0.466	**83**	−0.328 ± 0.378
16	−11.788 ± 3.461	**50**	−0.346 ± 0.338	**84**	−0.490 ± 0.413
17	1.951 ± 3.269	**51**	−0.650 ± 0.560	**85**	−0.845 ± 1.282
18	−0.624 ± 0.195	**52**	3.720 ± 1.248	**86**	0.349 ± 0.288
19	−1.554 ± 0.622	**53**	0.420 ± 0.394	**87**	0.450 ± 0.183
20	1.951 ± 3.269	**54**	0.420 ± 0.394	**88**	0.233 ± 0.243
21	−0.066 ± 0.362	**55**	0.420 ± 0.394	**89**	0.568 ± 0.267
22	0.722 ± 0.316	**56**	3.740 ± 0.850	**90**	1.193 ± 0.441
23	1.125 ± 0.690	**57**	0.538 ± 0.590	**91**	0.670 ± 0.338
24	1.091 ± 1.213	**58**	4.036 ± 0.938	**92**	0.709 ± 0.259
25	0.803 ± 0.464	**59**	0.334 ± 1.346	**93**	0.992 ± 0.675
26	0.138 ± 1.173	**60**	0.334 ± 1.346	**94**	1.223 ± 0.960
27	0.558 ± 0.236	**61**	0.334 ± 1.346	**95**	−1.013 ± 0.782
28	1.223 ± 0.367	**62**	1.120 ± 0.268	**96**	1.260 ± 0.583
29	0.565 ± 0.252	**63**	2.025 ± 0.886	**97**	−1.986 ± 1.507
30	0.324 ± 0.185	**64**	−0.318 ± 0.757	**98**	−2.084 ± 0.674
31	−1.599 ± 1.262	**65**	−0.180 ± 0.528	**99**	−15.554 ± 4.119
32	−1.599 ± 1.262	**66**	−0.114 ± 0.416	**100**	−15.554 ± 4.119
33	0.442 ± 0.554	**67**	−0.088 ± 0.268		
34	−0.832 ± 0.985	**68**	−0.088 ± 0.268		

Table B.3: Trends and standard deviations (calculated from Equation 2.12) of precipitation at glaciated regions for the period 1900-1998 (or available years) in mm year^{-2}. The data is taken from the Climate Research Unit (CRU).

gl	trend	gl	trend	gl	trend
1	0.177 ± 0.103	**35**	−0.979 ± 1.100	**69**	0.471 ± 0.226
2	0.056 ± 0.099	**36**	0.563 ± 1.398	**70**	−0.213 ± 0.296
3	0.173 ± 0.083	**37**	0.199 ± 0.672	**71**	0.133 ± 0.428
4	0.287 ± 0.136	**38**	−0.323 ± 0.405	**72**	−0.404 ± 0.297
5	0.246 ± 0.214	**39**	−1.384 ± 0.864	**73**	0.282 ± 0.328
6	0.192 ± 0.095	**40**	0.337 ± 0.933	**74**	0.739 ± 0.600
7	0.261 ± 0.173	**41**	0.552 ± 0.909	**75**	0.406 ± 0.534
8	0.471 ± 0.443	**42**	−0.075 ± 0.449	**76**	−0.014 ± 0.485
9	0.612 ± 0.534	**43**	1.706 ± 0.559	**77**	−0.269 ± 0.335
10	0.182 ± 0.263	**44**	0.361 ± 0.609	**78**	−0.180 ± 0.255
11	0.653 ± 0.237	**45**	−0.678 ± 0.277	**79**	0.152 ± 0.173
12	0.563 ± 0.255	**46**	−0.437 ± 0.238	**80**	0.203 ± 0.162
13	0.853 ± 0.518	**47**	−0.781 ± 0.255	**81**	0.978 ± 0.339
14	0.637 ± 0.457	**48**	−0.722 ± 0.297	**82**	−0.083 ± 0.364
15	0.580 ± 0.416	**49**	−0.398 ± 0.293	**83**	0.121 ± 0.136
16	0.925 ± 0.590	**50**	−0.025 ± 0.251	**84**	0.555 ± 0.436
17	1.274 ± 0.616	**51**	0.255 ± 0.300	**85**	0.610 ± 0.629
18	1.928 ± 0.641	**52**	0.395 ± 0.160	**86**	−0.254 ± 0.179
19	1.344 ± 0.734	**53**	0.342 ± 0.216	**87**	0.216 ± 0.149
20	1.274 ± 0.616	**54**	0.644 ± 0.248	**88**	0.171 ± 0.183
21	0.143 ± 0.184	**55**	0.255 ± 0.233	**89**	0.192 ± 0.183
22	−0.252 ± 0.287	**56**	0.531 ± 0.237	**90**	−0.017 ± 0.287
23	0.665 ± 0.858	**57**	0.213 ± 0.265	**91**	−0.132 ± 0.290
24	0.504 ± 0.632	**58**	0.077 ± 0.157	**92**	−0.075 ± 0.267
25	0.466 ± 0.674	**59**	0.145 ± 0.115	**93**	0.607 ± 0.247
26	−0.067 ± 0.598	**60**	0.314 ± 0.163	**94**	−0.071 ± 0.466
27	0.043 ± 0.291	**61**	0.063 ± 0.107	**95**	−0.092 ± 0.509
28	−0.169 ± 0.222	**62**	0.388 ± 0.212	**96**	−0.451 ± 0.583
29	−0.099 ± 0.266	**63**	0.294 ± 0.268	**97**	0.626 ± 2.033
30	−0.035 ± 0.528	**64**	−0.053 ± 0.473	**98**	0.459 ± 0.319
31	−0.718 ± 0.667	**65**	0.124 ± 0.321	**99**	0.210 ± 0.228
32	0.394 ± 0.623	**66**	−0.884 ± 0.388	**100**	0.173 ± 0.202
33	0.394 ± 0.623	**67**	−0.170 ± 0.335		
34	−0.544 ± 0.737	**68**	−0.054 ± 0.272		

Table B.4: Trends and standard deviations (calculated from Equation 2.12) of modelled precipitation at glaciated regions for the period 1871-2000 in mm year^{-2}. The data is provided by Siobhan O'Farrell.

Correlation between observed and modelled temperature

Tables B.5 and B.6 show correlation coefficients between modelled (provided by Gregory or O'Farrell) and observed temperature series at a few glaciated regions. The observed temperature data set is taken from the NASA web page (http://www.giss.nasa.gov/data/update/gistemp/station_data). The temperature for each glaciated region is taken from the grid which is located closest to the centre of the glaciated region.

glaciated region			station - observed	corr. coeff	dist	yrs
Alaska	7	Brooks Range	1 Umiat	−0.28	177	10
			3 Allakaket	0.07	194	64
	12	Alaska Peninsula	1 King Salmon	0.04	190	71
			2 Iliamna FAA Airport	0.10	334	47
	15	Wrangell Mts.	1 Yakataga Airport	0.43	213	15
	17	St. Elias Mts.	1 Yakataga Airport	0.57	129	15
	18	Coast Mts.	1 Graham Inlet	−0.53	68	16
			4 Haines	0.09	83	63
			7 Gustavus	0.57	119	16
	20	Yukon Territory	1 Yakataga Airport	0.59	169	15
			2 Burwash, Yukon	0.08	86	23
NW USA	23	Coast Mts.	1 Mosley Creek	−0.52	67	10
			2 Tatlayoko Lake	0.05	88	61
	25	N. Cascades	1 Stehekin	0.03	25	82
			2 Winthrop	0.01	63	87
	29	Rocky Mts.	1 Buffalo Bill Dam	−0.05	25	89
			3 Red Lodge	0.11	134	97
Sth. Am.	49	N. Patagonia	1 Puerto Aysen	−0.02	188	27
			2 Balmaceda	0.22	184	26
	51	Tierra del Fuego	1 Punta Arenas	−0.15	168	109
			2 Rio Gallegos	0.31	332	60
Arctic	53	Vatnajokull	1 Akureyri	0.14	55	115
	55	Hofsjokull	1 Akureyri	0.14	47	115
	58	Svalbard	1 Svalbard	−0.19	105	19
	59	Franz Josef Land	1 Gmo Im	0.02	48	39
			2 Ostrov Vize	0.15	409	46
Europe	62	N. Scandinavia	2 Tromo	-0.18	237	76
	63	S. Norway	2 Dombas Norway	0.08	95	95
			5 Hellisoy Fyr	0.14	176	75
	64	Alps	1 Basel	−0.08	178	100
			6 Saentis	0.16	192	114
	65	Pyrenees	2 Pic Du Midi France	0.28	45	36
Asia	71	Syrdar'ya Amudar'ya	2 Dir	0.12	244	10
	76	Himalaya / Nepal	4 Darjeeling	0.10	163	97
	80	Altai Shan	1 Bulgan	0.52	110	21
			4 Hovd	0.00	120	46
	84	Hengduan Shan	1 Deqen	0.18	56	37
			2 Daocheng	0.24	176	34
NZ	98	New Zealand	1 Christchurch	0.20	202	92

Table B.5: Correlation coefficients between time series of T_G and observed temperature at a few glaciated regions. The column "dist" gives the approximate distance in kilometre between the location of the glaciated regions and the site with available temperature observations. The last column lists the number of years of temperature observation.

glaciated region			station - observed	corr. coeff	dist	yrs
Alaska	7	Brooks Range	1 Umiat	−0.46	177	10
			3 Allakaket	0.13	194	64
	12	Alaska Peninsula	1 King Salmon	0.01	190	71
			2 Iliamna FAA Airport	0.02	334	47
	15	Wrangell Mts.	1 Yakataga Airport	−0.01	213	15
	17	St. Elias Mts.	1 Yakataga Airport	0.02	129	15
	18	Coast Mts.	1 Graham Inlet	0.18	68	16
			4 Haines	0.14	83	63
			7 Gustavus	0.07	119	16
	20	Yukon Territory	1 Yakataga Airport	0.02	169	15
			2 Burwash, Yukon	0.14	86	23
NW USA	23	Coast Mts.	1 Mosley Creek	0.08	67	10
			2 Tatlayoko Lake	−0.19	88	61
	25	N. Cascades	1 Stehekin	0.15	25	82
			2 Winthrop	−0.05	63	87
	29	Rocky Mts.	1 Buffalo Bill Dam	0.06	25	89
			3 Red Lodge	0.09	134	97
Sth. Am.	49	N. Patagonia	1 Puerto Aysen	0.03	188	27
			2 Balmaceda	−0.14	184	26
	51	Tierra del Fuego	1 Punta Arenas	−0.22	168	109
			2 Rio Gallegos	0.06	332	60
Arctic	53	Vatnajokull	1 Akureyri	−0.17	55	115
	55	Hofsjokull	1 Akureyri	−0.24	47	115
	58	Svalbard	1 Svalbard	−0.42	105	19
	59	Franz Josef Land	1 Gmo Im	0.14	48	39
			2 Ostrov Vize	0.09	409	46
Europe	62	N. Scandinavia	2 Tromo	0.05	237	76
	63	S. Norway	2 Dombas Norway	0.04	95	95
			5 Hellisoy Fyr	0.04	176	75
	64	Alps	1 Basel	0.11	178	100
			6 Saentis	0.26	192	114
	65	Pyrenees	2 Pic Du Midi France	−0.17	45	36
Asia	71	Syrdar'ya Amudar'ya	2 Dir	−0.08	244	10
	76	Himalaya / Nepal	4 Darjeeling	−0.03	163	97
	80	Altai Shan	1 Bulgan	−0.01	110	21
			4 Hovd	0.14	120	46
	84	Hengduan Shan	1 Deqen	0.13	56	37
			2 Daocheng	0.26	176	34
NZ	98	New Zealand	1 Christchurch	0.15	202	92

Table B.6: Correlation coefficients between time series of T_{OF} and observed temperature at a few glaciated regions. The column "dist" gives the approximate distance in kilometre between the location of the glaciated regions and the site with available temperature observations. The last column lists the number of years of temperature observation.

Linear trends in temperature over the period 1871-1990

Table B.7 lists linear trends in temperature of 100 glaciated regions over the period 1871-1990 using T_G and T_{OF}.

Temperature trends based on the **Gregory** data set:

Trends in temperature of 97 glaciated regions are **positive**. Of those:
92 trends are significant at a 1σ level
58 trends are significant at a 2σ level
33 trends are significant at a 3σ level

Trends in temperature of 3 glaciated regions are **negative**: Of those:
1 trend is significant at a 1σ level.

Temperature trends based on the **O'Farrell** data set:

Trends in temperature of 99 glaciated regions are **positive**. Of those:
90 trends are significant at a 1σ level
83 trends are significant at a 2σ level
64 trends are significant at a 3σ level

The trend in temperature of 1 glaciated regions is **negative**.

gl	Gregory	O'Farrell	gl	Gregory	O'Farrell
1	0.0008 ± 0.0028	0.0088 ± 0.0025	**51**	0.0033 ± 0.0006	0.0044 ± 0.0006
2	0.0080 ± 0.0040	0.0091 ± 0.0022	**52**	0.0024 ± 0.0011	0.0021 ± 0.0009
3	0.0031 ± 0.0029	0.0097 ± 0.0027	**53**	0.0087 ± 0.0043	0.0041 ± 0.0036
4	0.0032 ± 0.0027	0.0100 ± 0.0027	**54**	0.0087 ± 0.0043	−0.0005 ± 0.0035
5	−0.0017 ± 0.0033	0.0064 ± 0.0033	**55**	0.0087 ± 0.0043	0.0028 ± 0.0039
6	0.0032 ± 0.0027	0.0088 ± 0.0032	**56**	−0.0003 ± 0.0014	0.0008 ± 0.0032
7	0.0105 ± 0.0025	0.0073 ± 0.0034	**57**	0.0002 ± 0.0021	0.0018 ± 0.0044
8	0.0041 ± 0.0023	0.0071 ± 0.0038	**58**	0.0316 ± 0.0087	0.0136 ± 0.0046
9	0.0041 ± 0.0023	0.0066 ± 0.0033	**59**	0.0196 ± 0.0045	0.0120 ± 0.0033
10	0.0103 ± 0.0048	0.0033 ± 0.0038	**60**	0.0144 ± 0.0034	0.0093 ± 0.0037
11	0.0063 ± 0.0026	0.0011 ± 0.0013	**61**	0.0050 ± 0.0027	0.0145 ± 0.0028
12	0.0051 ± 0.0031	0.0024 ± 0.0017	**62**	0.0076 ± 0.0028	0.0060 ± 0.0036
13	0.0044 ± 0.0041	0.0058 ± 0.0030	**63**	0.0046 ± 0.0037	0.0050 ± 0.0025
14	0.0044 ± 0.0041	0.0054 ± 0.0030	**64**	0.0045 ± 0.0027	0.0064 ± 0.0016
15	0.0043 ± 0.0022	0.0068 ± 0.0029	**65**	−0.0029 ± 0.0015	0.0073 ± 0.0016
16	0.0046 ± 0.0045	0.0067 ± 0.0030	**66**	0.0029 ± 0.0023	0.0057 ± 0.0020
17	0.0041 ± 0.0034	0.0066 ± 0.0028	**67**	0.0050 ± 0.0019	0.0047 ± 0.0016
18	0.0038 ± 0.0024	0.0068 ± 0.0027	**68**	0.0050 ± 0.0019	0.0036 ± 0.0017
19	0.0059 ± 0.0022	0.0059 ± 0.0023	**69**	0.0049 ± 0.0032	0.0072 ± 0.0036
20	0.0039 ± 0.0026	0.0066 ± 0.0028	**70**	0.0026 ± 0.0015	0.0084 ± 0.0018
21	0.0051 ± 0.0021	0.0077 ± 0.0024	**71**	0.0038 ± 0.0019	0.0099 ± 0.0019
22	0.0051 ± 0.0022	0.0070 ± 0.0022	**72**	0.0026 ± 0.0015	0.0096 ± 0.0016
23	0.0012 ± 0.0015	0.0061 ± 0.0019	**73**	0.0047 ± 0.0016	0.0091 ± 0.0015
24	0.0022 ± 0.0015	0.0054 ± 0.0015	**74**	0.0047 ± 0.0016	0.0076 ± 0.0020
25	0.0032 ± 0.0022	0.0061 ± 0.0016	**75**	0.0038 ± 0.0019	0.0100 ± 0.0023
26	0.0018 ± 0.0014	0.0060 ± 0.0015	**76**	0.0039 ± 0.0012	0.0098 ± 0.0025
27	0.0026 ± 0.0016	0.0083 ± 0.0017	**77**	0.0013 ± 0.0010	0.0112 ± 0.0024
28	0.0016 ± 0.0014	0.0081 ± 0.0016	**78**	0.0026 ± 0.0024	0.0099 ± 0.0027
29	0.0032 ± 0.0021	0.0087 ± 0.0015	**79**	0.0064 ± 0.0016	0.0067 ± 0.0012
30	0.0020 ± 0.0022	0.0076 ± 0.0018	**80**	0.0039 ± 0.0022	0.0063 ± 0.0019
31	0.0038 ± 0.0019	0.0092 ± 0.0017	**81**	0.0049 ± 0.0018	0.0083 ± 0.0012
32	0.0038 ± 0.0019	0.0085 ± 0.0015	**82**	0.0026 ± 0.0015	0.0083 ± 0.0017
33	0.0065 ± 0.0014	0.0085 ± 0.0015	**83**	0.0025 ± 0.0012	0.0089 ± 0.0016
34	0.0063 ± 0.0015	0.0098 ± 0.0021	**84**	0.0002 ± 0.0009	0.0057 ± 0.0012
35	0.0063 ± 0.0012	0.0068 ± 0.0016	**85**	0.0023 ± 0.0018	0.0077 ± 0.0021
36	0.0056 ± 0.0012	0.0075 ± 0.0016	**86**	0.0040 ± 0.0022	0.0070 ± 0.0019
37	0.0063 ± 0.0015	0.0089 ± 0.0019	**87**	0.0049 ± 0.0018	0.0076 ± 0.0018
38	0.0076 ± 0.0023	0.0084 ± 0.0018	**88**	0.0097 ± 0.0020	0.0019 ± 0.0020
39	0.0057 ± 0.0013	0.0067 ± 0.0014	**89**	0.0071 ± 0.0022	0.0005 ± 0.0019
40	0.0055 ± 0.0034	0.0083 ± 0.0021	**90**	0.0090 ± 0.0030	0.0028 ± 0.0023
41	0.0058 ± 0.0012	0.0069 ± 0.0018	**91**	0.0065 ± 0.0023	0.0003 ± 0.0020
42	0.0068 ± 0.0012	0.0087 ± 0.0021	**92**	0.0073 ± 0.0020	0.0037 ± 0.0018
43	0.0047 ± 0.0012	0.0070 ± 0.0018	**93**	0.0048 ± 0.0028	0.0018 ± 0.0024
44	0.0059 ± 0.0016	0.0087 ± 0.0021	**94**	0.0067 ± 0.0015	0.0081 ± 0.0014
45	0.0032 ± 0.0012	0.0079 ± 0.0011	**95**	0.0070 ± 0.0015	0.0079 ± 0.0013
46	0.0054 ± 0.0012	0.0083 ± 0.0011	**96**	0.0063 ± 0.0008	0.0086 ± 0.0012
47	0.0035 ± 0.0013	0.0085 ± 0.0011	**97**	0.0056 ± 0.0006	0.0069 ± 0.0007
48	0.0041 ± 0.0011	0.0065 ± 0.0012	**98**	0.0051 ± 0.0013	0.0031 ± 0.0009
49	0.0034 ± 0.0007	0.0054 ± 0.0009	**99**	0.0053 ± 0.0007	0.0072 ± 0.0007
50	0.0032 ± 0.0007	0.0057 ± 0.0009	**100**	0.0065 ± 0.0009	0.0079 ± 0.0008

Table B.7: Linear trends and standard deviations (from Equation 2.12) in annual temperature of 100 glaciated regions in K year^{-1} for the period 1871-1990 using T_G and T_{OF}.

Linear trends in temperature over the period 1871-1895

Table B.8 lists linear trends in temperature of 100 glaciated regions over the period 1871-1895 using T_G and T_{OF}.

Temperature trends based on the **Gregory** data set:

Trends in temperature of 41 glaciated regions are **positive**. Of those:
21 trends are significant at a 1σ level
5 trends are significant at a 2σ level
1 trend is significant at a 3σ level

Trends in temperature of 59 glaciated regions are **negative**. Of those:
30 trends are significant at a 1σ level
3 trends are significant at a 2σ level
0 trends are significant at a 3σ level

Temperature trends based on the **O'Farrell** data set:

Trends in temperature of 82 glaciated regions are **positive**. Of those:
31 trends are significant at a 1σ level
15 trends are significant at a 2σ level
5 trends are significant at a 3σ level

Trends in temperature of 18 glaciated regions are **negative**. Of those:
2 trends are significant at a 1σ level
0 trends are significant at a 2σ level
0 trends are significant at a 3σ level

gl	Gregory	O'Farrell	gl	Gregory	O'Farrell
1	−0.0158 ± 0.0348	−0.0051 ± 0.0294	**51**	0.0139 ± 0.0061	0.0022 ± 0.0055
2	−0.0316 ± 0.0447	0.0107 ± 0.0247	**52**	−0.0219 ± 0.0115	0.0053 ± 0.0084
3	−0.0250 ± 0.0389	0.0299 ± 0.0310	**53**	0.0585 ± 0.0568	0.1867 ± 0.0271
4	−0.0307 ± 0.0298	0.0276 ± 0.0330	**54**	0.0585 ± 0.0568	0.1747 ± 0.0259
5	−0.0755 ± 0.0382	0.0558 ± 0.0351	**55**	0.0585 ± 0.0568	0.2290 ± 0.0322
6	−0.0307 ± 0.0298	0.1088 ± 0.0345	**56**	−0.0119 ± 0.0153	0.1569 ± 0.0235
7	−0.0289 ± 0.0303	0.0166 ± 0.0338	**57**	−0.0106 ± 0.0251	0.2588 ± 0.0365
8	−0.0312 ± 0.0213	0.0169 ± 0.0334	**58**	0.1606 ± 0.0935	0.0763 ± 0.0507
9	−0.0312 ± 0.0213	0.0135 ± 0.0295	**59**	0.0704 ± 0.0472	0.0825 ± 0.0326
10	−0.0692 ± 0.0468	−0.0011 ± 0.0274	**60**	0.0827 ± 0.0394	0.0976 ± 0.0341
11	−0.0414 ± 0.0269	0.0046 ± 0.0111	**61**	−0.0157 ± 0.0277	0.0593 ± 0.0294
12	−0.0635 ± 0.0294	0.0033 ± 0.0133	**62**	0.1078 ± 0.0333	0.0789 ± 0.0395
13	−0.0592 ± 0.0365	0.0106 ± 0.0259	**63**	0.1166 ± 0.0458	0.0551 ± 0.0240
14	−0.0592 ± 0.0365	0.0086 ± 0.0254	**64**	−0.0113 ± 0.0269	0.0380 ± 0.0149
15	−0.0369 ± 0.0205	0.0118 ± 0.0268	**65**	−0.0097 ± 0.0145	0.0343 ± 0.0145
16	−0.0567 ± 0.0417	0.0128 ± 0.0268	**66**	−0.0325 ± 0.0289	−0.0194 ± 0.0263
17	−0.0428 ± 0.0292	0.0084 ± 0.0235	**67**	−0.0248 ± 0.0253	−0.0153 ± 0.0200
18	−0.0249 ± 0.0211	0.0165 ± 0.0236	**68**	−0.0248 ± 0.0253	0.0063 ± 0.0191
19	−0.0210 ± 0.0199	0.0238 ± 0.0194	**69**	0.0759 ± 0.0430	0.0522 ± 0.0326
20	−0.0300 ± 0.0226	0.0084 ± 0.0235	**70**	−0.0166 ± 0.0183	0.0274 ± 0.0180
21	−0.0405 ± 0.0208	0.0215 ± 0.0237	**71**	−0.0080 ± 0.0228	0.0132 ± 0.0224
22	−0.0257 ± 0.0207	0.0311 ± 0.0236	**72**	−0.0166 ± 0.0183	0.0318 ± 0.0165
23	−0.0191 ± 0.0141	0.0137 ± 0.0175	**73**	0.0100 ± 0.0180	0.0172 ± 0.0152
24	−0.0058 ± 0.0166	0.0025 ± 0.0156	**74**	0.0100 ± 0.0180	0.0039 ± 0.0214
25	−0.0138 ± 0.0236	0.0017 ± 0.0176	**75**	−0.0080 ± 0.0228	0.0200 ± 0.0373
26	−0.0025 ± 0.0180	0.0035 ± 0.0161	**76**	0.0126 ± 0.0102	0.0110 ± 0.0173
27	−0.0237 ± 0.0157	−0.0002 ± 0.0173	**77**	0.0079 ± 0.0086	0.0137 ± 0.0187
28	−0.0128 ± 0.0138	−0.0004 ± 0.0168	**78**	−0.0449 ± 0.0282	0.0150 ± 0.0191
29	−0.0091 ± 0.0243	−0.0013 ± 0.0153	**79**	0.0118 ± 0.0171	0.0137 ± 0.0129
30	−0.0364 ± 0.0302	−0.0168 ± 0.0142	**80**	−0.0500 ± 0.0258	0.0158 ± 0.0245
31	−0.0207 ± 0.0206	−0.0178 ± 0.0152	**81**	0.0036 ± 0.0194	0.0121 ± 0.0123
32	−0.0207 ± 0.0206	0.0060 ± 0.0130	**82**	−0.0166 ± 0.0183	0.0445 ± 0.0146
33	−0.0157 ± 0.0141	0.0060 ± 0.0130	**83**	−0.0117 ± 0.0154	0.0109 ± 0.0145
34	0.0029 ± 0.0164	0.0027 ± 0.0154	**84**	0.0000 ± 0.0099	0.0054 ± 0.0115
35	0.0072 ± 0.0154	0.0042 ± 0.0103	**85**	−0.0104 ± 0.0204	0.0017 ± 0.0222
36	0.0061 ± 0.0151	0.0118 ± 0.0108	**86**	−0.0224 ± 0.0256	0.0132 ± 0.0169
37	0.0029 ± 0.0164	0.0166 ± 0.0135	**87**	0.0036 ± 0.0194	0.0154 ± 0.0180
38	0.0169 ± 0.0247	−0.0030 ± 0.0099	**88**	0.0339 ± 0.0225	0.0050 ± 0.0221
39	0.0068 ± 0.0161	0.0063 ± 0.0092	**89**	0.0346 ± 0.0190	0.0025 ± 0.0215
40	0.0530 ± 0.0378	0.0121 ± 0.0147	**90**	0.0036 ± 0.0290	0.0364 ± 0.0256
41	0.0057 ± 0.0154	0.0187 ± 0.0134	**91**	0.0344 ± 0.0205	0.0152 ± 0.0242
42	0.0049 ± 0.0168	0.0105 ± 0.0161	**92**	0.0412 ± 0.0253	0.0300 ± 0.0224
43	0.0039 ± 0.0156	−0.0017 ± 0.0156	**93**	0.0169 ± 0.0260	0.0433 ± 0.0210
44	0.0147 ± 0.0172	0.0148 ± 0.0159	**94**	0.0286 ± 0.0177	−0.0093 ± 0.0116
45	−0.0031 ± 0.0122	−0.0003 ± 0.0116	**95**	0.0498 ± 0.0198	0.0013 ± 0.0111
46	0.0129 ± 0.0127	−0.0027 ± 0.0113	**96**	0.0029 ± 0.0110	0.0057 ± 0.0094
47	−0.0086 ± 0.0141	−0.0046 ± 0.0104	**97**	−0.0001 ± 0.0088	0.0043 ± 0.0053
48	−0.0035 ± 0.0119	−0.0134 ± 0.0140	**98**	−0.0386 ± 0.0140	−0.0025 ± 0.0073
49	0.0087 ± 0.0067	−0.0032 ± 0.0100	**99**	−0.0164 ± 0.0068	0.0136 ± 0.0056
50	0.0102 ± 0.0063	0.0017 ± 0.0096	**100**	−0.0084 ± 0.0098	0.0151 ± 0.0066

Table B.8: Linear trends and standard deviations (from Equation 2.12) in annual temperature of 100 glaciated regions in K year^{-1} for the reference period 1871-1895 using T_G and T_{OF}.

Appendix C

Supporting material for Chapter 3

Compiling mass balance observations into primary systems of Dyurgerov and Meier (2005)

Figures C.1 and C.2 show two examples of the method used by Dyurgerov and Meier (2005) to compile glacier observations into primary systems. The second last column shows the annual scaled ice-volume loss calculated in this thesis (scaling-method is illustrated with arrows in Figure C.1). The last column lists the numbers published by Dyurgerov and Meier (2005). Whereas Figure C.1 shows a successful reproduction, Figure C.2 shows an example where it was not possible to reconstruct the time series.

	primary system no. 6						sum	sum	scaled	D&M
	L. Aktru	M. Aktru	Pr. Aktru	No. 125	Stager	Sofiyskiy Gl	area	dV	1750	
1961										
1962		-0.00115					2.88	-0.00115	-0.70	-0.70
1963		-0.00098					2.88	-0.00098	-0.60	-0.60
1964		-0.00081					2.88	-0.00081	-0.49	-0.49
1965		-0.00161					2.88	-0.00161	-0.98	-0.98
1966		-0.00109					2.88	-0.00109	-0.67	-0.67
1967		0.00084					2.88	0.00084	0.51	0.51
1968		-0.00006					2.88	-0.00006	-0.04	-0.04
1969		0.00084					2.88	0.00084	0.51	0.51
1970		0.00035					2.88	0.00035	0.21	0.21
1971		0.00072					2.88	0.00072	0.44	0.44
1972		0.00020					2.88	0.00020	0.12	0.12
1973		0.00029					19.93	0.00029	0.03	0.03
1974		-0.00423					2.88	-0.00423	-2.57	-2.57
1975		0.00115					2.88	0.00115	0.70	0.70
1976		0.00196					2.878	0.00196	1.19	1.19
1977	0.00150	0.00141		0.00007	0.00018		10.296	0.00317	0.54	0.54
1978	-0.00231	-0.00118		-0.00017			10.044	-0.00367	-0.64	-0.64
1979	-0.00394	-0.00167		-0.00072			10.042	-0.00632	-1.10	-1.10
1980	-0.00013	0.00032	0.00097	-0.00011			13.91	0.00105	0.13	0.13
1981	-0.00200	-0.00089	-0.00128	-0.00001			13.889	-0.00418	-0.53	-0.53
1982	-0.00256	-0.00189	-0.00120	-0.00028			13.878	-0.00593	-0.75	-0.75
1983	0.00206	0.00043	0.00128	0.00014			13.867	0.00391	0.49	0.22
1984	0.00200	0.00089	0.00128	0.00025			13.856	0.00442	0.56	0.56
1985	0.00094	0.00069	0.00113	0.00018			13.845	0.00293	0.37	0.37
1986	0.00037	0.00011	0.00071	0.00010			14.714	0.00130	0.16	0.16
1987	0.00125	0.00049	0.00109	0.00015			14.693	0.00298	0.35	0.35
1988	0.00229	0.00135	0.00137	0.00013		0.00421	31.182	0.00935	0.52	0.52
1989	0.00016	0.00063	0.00074	0.00008		0.00084	30.621	0.00244	0.14	0.14
1990	0.00030	0.00035	0.00027	0.00011			13.33	0.00103	0.14	0.14
1991	-0.00249	0.00147		-0.00032			9.43	-0.00133	-0.25	-0.25
1992	-0.00100	0.00046		-0.00002			9.43	-0.00055	-0.10	-0.10
1993	0.00159	0.00093		0.00008			9.43	0.00260	0.48	0.48
1994	-0.00187	-0.00041		-0.00016			9.43	-0.00244	-0.45	-0.45
1995	0.00012	0.00049		0.00004			9.43	0.00065	0.12	0.12
1996	-0.00101	-0.00035		-0.00009			9.43	-0.00146	-0.27	-0.27
1997	-0.00089	-0.00014		-0.00013			9.43	-0.00116	-0.21	-0.21
1998	-0.00666	-0.00336		-0.00074		-0.01933	26.24	-0.03009	-2.01	-2.01
1999	-0.00083	-0.00030		-0.00007			9.43	-0.00120	-0.22	-0.22
2000	-0.00173	-0.00057		-0.00014			9.43	-0.00244	-0.45	-0.45
2001	-0.00143	-0.00052		-0.00011			9.43	-0.00205	-0.38	-0.38
2002	-0.00220	-0.00112		-0.00022			9.43	-0.00354	-0.66	-0.66
2003	-0.00238	-0.00101		-0.00024			9.43	-0.00363	-0.67	-0.67
aver									**-0.17**	**-0.17**

Figure C.1: Example of compiling observations on six glaciers into the primary system no. 6. Data for individual glaciers, the total and scaled values and the data of Dyurgerov and Meier (2005) are given in km^3 $year^{-1}$ w.e. and the area is given in km^2.

	primary system no. 35						scaled	D&M
	Tats	Lemon Creek	Taku	Menden-hall	sum area	sum dV	10500	
1961		-0.00281	0.32208		682.728	0.31927	4.91	3.49
1962		-0.00809	0.26169		682.728	0.25360	3.90	1.53
1963		0.00199	0.38247		682.728	0.38446	5.91	4.93
1964		0.01220	0.75823		682.728	0.77043	11.85	3.93
1965		0.00094	0.53009		682.728	0.53103	8.17	5.93
1966		-0.00575	0.05368		682.728	0.04793	0.74	11.85
1967		-0.00704	0.16775		682.728	0.16071	2.47	8.19
1968		-0.00258	0.30866		682.728	0.30608	4.71	0.76
1969		0.00246	0.78507		682.728	0.78753	12.11	2.50
1970		-0.00106	0.50996		682.728	0.50890	7.83	4.73
1971		-0.00469	0.42273		682.728	0.41804	6.43	12.14
1972		-0.00762	0.28182		682.728	0.27420	4.22	7.85
1973		-0.00610	0.34892		682.728	0.34282	5.27	6.46
1974		-0.00434	0.38918		682.728	0.38484	5.92	4.25
1975		0.00340	0.57035		682.728	0.57375	8.82	5.31
1976		-0.00293	0.44286		682.728	0.43993	6.77	5.95
1977		-0.00563	0.31537		682.728	0.30974	4.76	8.84
1978		-0.00938	0.20801		682.728	0.19863	3.05	6.80
1979		-0.00739	0.09394		682.728	0.08655	1.33	4.79
1980		-0.00317	0.36234		682.728	0.35917	5.52	3.09
1981		-0.00950	0.08052		682.728	0.07102	1.09	1.36
1982		-0.00504	0.10065		682.728	0.09561	1.47	5.55
1983		-0.01900	-0.28182		682.728	-0.30082	-4.63	1.12
1984		-0.00293	0.42944		682.728	0.42651	6.56	1.49
1985		0.00387	0.93940		682.728	0.94327	14.51	-4.59
1986		-0.00598	0.80520		682.728	0.79922	12.29	6.59
1987		-0.00985			11.728	-0.00985	-8.82	14.54
1988		0.00129			11.728	0.00129	1.16	12.35
1989	-0.00496	-0.01454			39.618	-0.01951	-5.17	1.62
1990		-0.01302			11.728	-0.01302	-11.66	9.76
1991		-0.00446			11.728	-0.00446	-3.99	-1.80
1992		-0.00774			11.728	-0.00774	-6.93	-0.69
1993		-0.01149			11.728	-0.01149	-10.29	5.56
1994		-0.00891			11.728	-0.00891	-7.98	3.17
1995		-0.01536			11.728	-0.01536	-13.76	0.43
1996		-0.01853			11.728	-0.01853	-16.59	2.31
1997		-0.02123			11.728	-0.02123	-19.01	-2.40
1998		-0.01712		-0.18240	131.728	-0.19952	-31.29	-4.71
1999				0.00000	120	0.00000	0.00	-6.68
2000				0.09840	120	0.09840	8.61	-5.17
2001								-1.09
2002								8.61
2003								-1.09
aver							**0.51**	**3.71**

Figure C.2: Example of compiling observations on four glaciers into the primary system no. 35. Data for individual glaciers, the total and scaled values and the data of Dyurgerov and Meier (2005) are given in km^3 $year^{-1}$ w.e. and the area is given in km^2.

Upscaling method from primary to regional systems of Dyurgerov and Meier (2005)

Figures C.3 and C.4 illustrate the method used by Dyurgerov and Meier (2005) to compile data of the primary systems to produce data for the regional systems. From the annual ice-volume changes of the primary systems, the change for the regional system is calculated by upscaling by the area difference between the available primary areas and the total area of the regional system (this is illustrated with the arrows in Figure C.3).

regional	1 Europe							scaled	D&M
	Alps	Scandi-navia	Iceland	Pyrenia	Cauca-sus				
primary	1	2	3	4	5	sum	sum		
area	2345	2942	11260	11	1432	area	dV	17286	
1961	-0.46	-2.14			0.55	6719	-2.05	-5.27	-4.78
1962	-1.04	4.35			-0.89	6719	2.42	6.23	5.20
1963	-0.42	-2.24			-1.20	6719	-3.86	-9.93	-9.43
1964	-2.92	1.24			0.63	6719	-1.05	-2.70	-4.20
1965	2.62	0.98			-0.03	6719	3.57	9.18	9.90
1966	1.45	-2.65			-0.75	6719	-1.95	-5.02	-3.85
1967	0.58	4.24			0.09	6719	4.91	12.63	11.91
1968	1.07	0.77			0.64	6719	2.48	6.38	6.45
1969	0.55	-4.24			-1.03	6719	-4.72	-12.14	-10.93
1970	-0.13	-1.93			-0.44	6719	-2.50	-6.43	-6.01
1971	-1.56	1.96			0.15	6719	0.55	1.41	0.39
1972	-0.16	-0.48			-1.34	6719	-1.98	-5.09	-4.79
1973	-1.50	4.33			-0.87	6719	1.96	5.04	3.80
1974	0.00	1.58			-0.97	6719	0.61	1.57	1.44
1975	1.06	2.67			-1.15	6719	2.58	6.64	6.92
1976	-1.70	3.14			0.47	6719	1.91	4.91	3.71
1977	2.99	-1.63			-0.06	6719	1.30	3.34	4.56
1978	3.42	-0.95			0.11	6719	2.58	6.64	7.83
1979	0.14	1.41			-0.04	6719	1.51	3.88	3.65
1980	2.63	-3.12			-0.60	6719	-1.09	-2.80	-0.80
1981	2.00	1.66			-0.90	6719	2.76	7.10	7.60
1982	0.03	-0.53			0.12	6719	-0.38	-0.98	-1.10
1983	-0.08	3.05			-1.45	6719	1.52	3.91	3.47
1984	1.41	1.27			0.39	6719	3.07	7.90	7.99
1985	0.10	-2.14			-0.33	6719	-2.37	-6.10	-5.56
1986	-0.77	-0.44			-0.86	6719	-2.07	-5.33	-5.29
1987	-0.31	2.36			1.23	6719	3.28	8.44	7.63
1988	-1.03	-3.56			0.44	6719	-4.15	-10.68	-10.36
1989	-0.74	6.59	9.14		0.02	17979	15.01	14.43	13.85
1990	-2.41	3.22	-1.78		0.25	17979	-0.72	-0.69	-1.14
1991	-1.87	0.44	-12.32		-0.24	17979	-13.99	-13.45	-13.41
1992	-1.83	4.17	14.17	0.00	0.02	17990	16.53	15.88	15.07
1993	-0.11	3.46	12.48	0.00	0.89	17990	16.72	16.07	15.54
1994	-1.43	0.69	2.63	0.00	-0.87	17990	1.02	0.98	0.69
1995	-1.76	2.52	-2.56	-0.01	0.00	17990	-1.81	-1.74	-1.99
1996	-1.17	-0.84	-4.50	0.00	-0.13	17990	-6.64	-6.38	-6.34
1997	-0.76	-0.11	-13.09	0.01	0.30	17990	-13.65	-13.12	-12.79
1998	-3.34	1.20	-8.64	-0.01	-1.83	17990	-12.62	-12.13	-12.19
1999	-1.24	-0.21	-5.27	-0.01	-1.02	17990	-7.75	-7.45	-7.49
2000	-1.72	3.32	-12.02	-0.01	-1.56	17990	-11.99	-11.52	-11.99
2001	0.15	-3.40	-4.78	0.00	-1.00	17990	-9.03	-8.68	-9.02
2002	-1.77	-3.22	-2.73	-0.01	0.47	17990	-7.26	-6.98	-7.25
2003	-6.57	-4.26	-8.54	-0.01	0.30	17990	-19.08	-18.33	-19.08
years	43	43	15	12	43			43	43
aver	**-0.43**	**0.52**	**-2.52**	**0.00**	**-0.29**			**-0.71**	**-0.75**

Figure C.3: Example of upscaling ice-volume changes of primary systems used by Dyurgerov and Meier (2005) to derive that of a regional system. Annual volume changes of the primary systems no. 1 to 5 are the basis for calculating annual ice-volume changes of the regional system no. 1. Data for primary systems, the total and scaled values and the data of Dyurgerov and Meier (2005) are given in km^3 year^{-1} w.e. and the area is given in km^2.

regional	2 W. USA + Canada								scaled	D&M
	Rockies +Coast	Labra-dor	Olym-pic	N. Cas-cade	M. & S. Rockies	Sierra Nevada				
primary	36	37	38	39	40	41	sum	sum		
area	38604	56	46	266	76	56	area	dV	39194	
1961	-13.81		0.02	-0.29	-0.13		38992	-14.21	-14.28	-14.32
1962	-2.28		0.01	0.05	-0.14		38992	-2.36	-2.37	-2.16
1963	-26.83		-0.03	-0.35	-0.20		38992	-27.41	-27.55	-27.54
1964	-2.91		0.03	0.32	-0.04		38992	-2.60	-2.61	-2.25
1965	-19.31		-0.03	-0.02	0.01		38992	-19.35	-19.45	-19.40
1966	-55.23		0.02	-0.23	-0.10		38992	-55.54	-55.83	-55.62
1967	-11.05		0.02	-0.25	-0.01	0.07	39048	-11.22	-11.26	-11.26
1968	-5.45		0.00	-0.28	-0.08	-0.04	39048	-5.85	-5.87	-5.87
1969	9.32		0.03	-0.05	0.01	0.04	39048	9.35	9.38	9.36
1970	11.99		-0.02	-0.23	0.03		38992	11.77	11.83	11.62
1971	-10.30		0.05	0.16	0.09		38992	-10.00	-10.05	-9.96
1972	31.76		0.02	0.39	-0.05		38992	32.12	32.29	32.36
1973	-20.46		-0.01	-0.28	0.02		38992	-20.73	-20.84	-20.88
1974	-24.59		0.09	0.23	0.02		38992	-24.25	-24.38	-23.99
1975	-30.87		0.03	-0.02	0.02		38992	-30.84	-31.00	-30.86
1976	-13.10		0.07	0.23	-0.01		38992	-12.81	-12.88	-12.53
1977	-15.14		-0.06	-0.35	-0.09		38992	-15.64	-15.72	-15.91
1978	-30.95		0.02	-0.10	-0.03		38992	-31.06	-31.22	-31.10
1979	-11.19		-0.05	-0.42	-0.13		38992	-11.79	-11.85	-12.08
1980	7.43		-0.07	-0.29	-0.07		38992	7.00	7.04	6.74
1981	-40.41		-0.06	-0.22	-0.02		38992	-40.71	-40.92	-40.95
1982	-27.15	0.00	0.03	0.02	-0.06		39048	-27.16	-27.26	-27.04
1983	-24.06	0.00	0.06	-0.21	-0.03		39048	-24.24	-24.33	-24.34
1984	-20.93	-0.01	0.02	0.08	0.02		39048	-20.82	-20.90	-20.73
1985	-33.60		0.02	-0.14	-0.02		38992	-33.74	-33.91	-33.83
1986	-32.79		-0.04	-0.08	0.01		38992	-32.90	-33.07	-33.01
1987	-47.92		-0.04	-0.31	-0.08		38992	-48.35	-48.60	-48.56
1988	-46.36		0.01	-0.11	-0.11		38992	-46.57	-46.81	-46.55
1989	-57.52		-0.03	-0.10	0.01		38992	-57.64	-57.94	-57.76
1990	-56.20		-0.05	-0.14	-0.09		38992	-56.48	-56.77	-56.56
1991	-31.51		-0.04	0.06	-0.11		38992	-31.60	-31.76	-31.46
1992	2.43		-0.05	-0.45	-0.01		38992	1.92	1.93	1.38
1993	-32.58		-0.06	-0.24	0.08		38992	-32.80	-32.97	-33.15
1994	-88.89		-0.08	-0.25	-0.07		38992	-89.29	-89.75	-89.51
1995	-0.57		0.00	-0.07	-0.06		38992	-0.70	-0.70	-0.70
1996	4.48		-0.04	0.05	-0.04		38992	4.45	4.47	4.87
1997	-27.92		-0.02	0.15	0.00		38992	-27.79	-27.93	-27.68
1998	31.08		-0.05	-0.43	-0.07		38992	30.53	30.69	30.17
1999	5.02		0.05	0.41	-0.06		38992	5.42	5.45	5.89
2000	24.11			0.07	-0.05		38946	24.13	24.28	24.28
2001	-33.49			-0.43	-0.17		38946	-34.09	-34.31	-34.30
2002	-20.69			0.06	-0.25		38946	-20.88	-21.01	-21.02
2003	-50.95			-0.40	-0.11		38946	-51.46	-51.79	-51.78
years	43	3	39	43	43	3			43	43
aver	**-19.52**	**0.00**	**-0.01**	**-0.10**	**-0.05**	**0.02**			**-19.78**	**-19.72**

Figure C.4: Example of upscaling ice-volume changes of primary systems used by Dyurgerov and Meier (2005) to derive that of a reg1ional system. Annual volume changes of the primary systems no. 36 to 41 are the basis for calculating annual ice-volume changes of the regional system no. 2. Data for primary systems, the total and scaled values and the data of Dyurgerov and Meier (2005) are given in km^3 $year^{-1}$ w.e. and the area is given in km^2.

Ice-volume changes of 100 glaciated regions

Table C.1 lists predicted ice-volume changes of 100 glaciated regions over the period 1871-1990, using various combinations of temperature and precipitation data sets, in particular $T_G P_{Z\&O}$, $T_G P_{CRU series}$, $T_{OF} P_{Z\&O}$, and $T_{OF} P_{OF series}$. The parameter Θ is set globally to 0.15 K except for one case where regionally variable Θs are used.

Table C.2 lists ice-volume changes adopted from Dyurgerov and Meier (2005) applied on 100 glaciated regions of Zuo and Oerlemans (1997a), denoted D&M compilation in this thesis.

gl	$\mathbf{T}_G$		$\mathbf{T}_{OF}$		
	$\mathbf{P}_{Z\&O}$	$\mathbf{P}_{CRUseries}$	$\mathbf{P}_{Z\&O}$	$\mathbf{P}_{OFseries}$	$\mathbf{P}_{OFseries}\ \Theta_{var}$
1	−1.634	−7.234	−1.536	−2.228	−5.080
2	−0.193	−0.310	−0.379	−0.465	−0.861
3	−0.649	−0.744	−0.387	−0.445	−0.957
4	−0.915	−0.849	−0.896	−1.287	−2.203
5	−0.107	−0.091	−0.884	−1.238	−2.372
6	−0.201	−0.229	−0.079	−0.120	−0.301
7	−0.068	−0.077	−0.014	−0.020	−0.022
8	−2.132	−1.837	0.277	0.317	0.242
9	−0.123	−0.106	0.001	−0.010	−0.015
10	−0.038	−0.029	0.010	0.014	0.014
11	−0.122	−0.101	−0.036	−0.034	−0.039
12	−0.143	−0.089	0.009	0.003	−0.002
13	−0.290	−0.132	−0.005	−0.020	−0.025
14	−0.834	−0.609	0.010	−0.022	−0.046
15	−1.540	−0.680	−0.343	−0.564	−0.612
16	−3.595	−5.277	−1.300	−1.675	−1.810
17	−2.253	−4.336	−0.795	−1.262	−1.344
18	−2.373	−0.771	−1.110	−1.061	−1.134
19	−1.226	−1.263	−0.478	−0.687	−0.724
20	−2.360	−4.341	−0.673	−1.070	−1.139
21	−0.067	−0.044	−0.034	−0.035	−0.037
22	−0.030	−0.024	−0.021	−0.034	−0.035
23	−1.759	−1.144	−4.725	−4.551	−2.613
24	−0.013	−0.009	−0.020	−0.013	−0.008
25	−0.107	−0.060	−0.109	−0.090	−0.059
26	−0.019	−0.013	−0.031	−0.018	−0.011
27	−0.359	−0.240	−0.785	−0.904	−0.627
28	−0.151	−0.101	−0.347	−0.251	−0.180
29	−0.001	−0.001	−0.013	−0.018	−0.012
30	−0.003	−0.001	−0.010	−0.006	−0.003
31	−0.001	−0.001	−0.002	−0.001	−0.001
32	−0.000	−0.001	−0.001	−0.001	−0.001
33	−0.001	−0.000	−0.001	−0.001	−0.001
34	−0.001	−0.001	−0.001	−0.001	−0.001
35	−0.005	−0.006	−0.004	−0.010	−0.010
36	−0.008	−0.004	−0.009	−0.011	−0.011
37	−0.008	−0.010	−0.008	−0.011	−0.011
38	−0.012	−0.006	−0.009	−0.001	0.000
39	−0.042	−0.023	−0.042	−0.067	−0.067
40	−0.261	−0.367	−0.191	−0.262	−0.262

gl	$\mathbf{T}_G$		$\mathbf{T}_{OF}$		
	$\mathbf{P}_{Z\&O}$	$\mathbf{P}_{CRUseries}$	$\mathbf{P}_{Z\&O}$	$\mathbf{P}_{OFseries}$	$\mathbf{P}_{OFseries}\ \Theta_{var}$
41	−0.052	−0.048	−0.038	−0.056	−0.056
42	−0.083	−0.036	−0.109	−0.037	−0.026
43	−0.051	−0.111	−0.090	−0.152	−0.152
44	−0.174	−0.225	−0.287	−0.202	−0.164
45	−0.538	−0.502	−0.219	−0.090	−0.059
46	−0.839	−0.569	−0.360	−0.118	−0.077
47	−0.137	−0.104	−0.088	−0.024	−0.017
48	−1.954	−1.239	−1.976	−1.113	−0.815
49	−1.945	−0.996	−1.674	−1.337	−0.789
50	−4.939	−2.038	−4.889	−3.462	−2.017
51	−0.764	−0.473	−0.665	−0.582	−0.302
52	−1.392	−1.129	−0.530	−0.589	−0.589
53	−4.251	−0.929	−5.594	−2.120	−4.290
54	−0.488	−0.107	−0.376	−0.141	−0.382
55	−0.329	−0.104	−0.404	−0.186	−0.419
56	−0.044	−0.022	−0.267	−0.103	−0.256
57	−0.015	−0.007	−0.063	−0.032	−0.078
58	−2.758	−3.449	−2.839	−4.148	−9.972
59	−0.636	−0.542	−0.631	−0.782	−2.489
60	−1.887	−1.012	−0.780	−0.845	−4.111
61	−0.359	−0.399	−0.713	−0.932	−3.084
62	−0.109	−0.017	−0.163	−0.062	−0.230
63	−0.191	−0.059	−0.593	−0.199	−0.500
64	−0.291	−0.211	−0.520	−0.438	−1.210
65	0.001	0.001	−0.004	−0.002	−0.003
66	−0.234	−0.186	−0.541	−0.419	−0.692
67	−0.006	−0.004	−0.006	−0.003	−0.006
68	−0.004	−0.003	−0.003	−0.002	−0.004
69	−0.099	−0.067	−0.052	−0.051	−0.183
70	−0.267	−0.141	−0.365	−0.262	−0.599
71	−0.748	−0.181	−2.801	−2.229	−2.858
72	−0.302	−0.203	−0.726	−0.731	−0.932
73	−8.563	−5.103	−11.529	−6.731	−9.307
74	−0.051	−0.038	−0.057	−0.034	−0.052
75	−0.196	−0.023	−0.606	−0.349	−0.444
76	−1.348	−4.143	−2.809	−4.819	−6.142
77	−0.123	−0.360	−0.263	−0.394	−0.507
78	−1.113	−0.646	−1.628	−1.073	−1.429
79	−0.320	−0.149	−0.351	−0.345	−0.478
80	−0.006	−0.003	−0.008	−0.008	−0.018

gl	$\mathbf{T}_G$		$\mathbf{T}_{OF}$		
	$\mathbf{P}_{Z\&O}$	$\mathbf{P}_{CRUseries}$	$\mathbf{P}_{Z\&O}$	$\mathbf{P}_{OFseries}$	$\mathbf{P}_{OFseries}\ \Theta_{var}$
81	−0.362	−0.405	−0.778	−2.485	−3.379
82	−1.110	−0.585	−2.235	−1.252	−1.706
83	−0.175	−0.137	−0.421	−0.188	−0.162
84	−0.167	−0.147	−0.223	−0.354	−0.520
85	−0.151	−0.397	−0.271	−0.499	−0.691
86	−0.155	−0.075	−0.083	−0.023	−0.054
87	−0.100	−0.111	−0.300	−0.299	−0.385
88	−0.002	−0.001	−0.001	−0.001	−0.001
89	−0.047	−0.026	−0.028	−0.022	−0.043
90	−0.047	−0.024	0.003	0.001	−0.016
91	−0.014	−0.004	−0.025	−0.021	−0.033
92	−0.000	0.000	−0.001	−0.001	−0.003
93	−0.026	−0.040	−0.055	−0.070	−0.120
94	−0.000	−0.000	0.000	0.000	0.000
95	−0.002	−0.001	−0.002	−0.001	−0.001
96	−0.001	−0.001	−0.001	−0.001	−0.001
97	−0.003	−0.002	−0.003	−0.003	−0.003
98	−0.510	−0.395	−0.203	−0.156	−0.156
99	−0.134	−0.130	−0.072	−0.095	−0.095
100	−0.190	−0.144	−0.093	−0.082	−0.082
total	**−64.45**	**−59.36**	**−65.38**	**−58.91**	**−85.57**
	(0.178)	(0.164)	(0.181)	(0.163)	(0.236)

Table C.1: Changes in ice-volume in km^3 year^{-1} w.e. of 100 glaciated regions over the period 1871-1990 using various combinations of temperature and precipitation data sets, i.e. $\mathrm{T}_G\mathrm{P}_{Z\&O}$, $\mathrm{T}_G\mathrm{P}_{CRUseries}$, $\mathrm{T}_{OF}\mathrm{P}_{Z\&O}$, and $\mathrm{T}_{OF}\mathrm{P}_{OFseries}$. The parameter Θ is set to 0.15 K except for the last column where regionally variable Θs are applied. Total ice-volume changes, listed in the last row, are given in km^3 year^{-1} w.e. and in mm year^{-1} of global sea-level change (in brackets).

gl	reg	area	dV	gl	reg	area	dV
1	3	80,000	−7.747	**41**	11	258	−0.027
2	3	11,700	−1.133	**42**	11	649	−0.068
3	3	16,200	−1.569	**43**	11	510	−0.053
4	3	18,500	−1.792	**44**	11	2,800	−0.293
5	3	18,500	−1.792	**45**	11	743	−0.078
6	3	5,000	−0.484	**46**	11	1,170	−0.122
7	7	722	−0.431	**47**	11	156	−0.016
8	7	13,900	−8.306	**48**	10	3,570	−3.032
9	7	800	−0.478	**49**	10	5,720	−4.858
10	7	230	−0.137	**50**	10	16,900	−14.352
11	7	960	−0.574	**51**	10	2,700	−2.293
12	7	1,250	−0.747	**52**	n/a	4,100	−0.802
13	7	1,000	−0.598	**53**	1	8,300	−0.360
14	7	4,600	−2.749	**54**	1	953	−0.041
15	7	8,300	−4.960	**55**	1	925	−0.040
16	7	21,600	−12.907	**56**	1	600	−0.026
17	7	11,800	−7.051	**57**	1	160	−0.007
18	7	10,500	−6.274	**58**	5	36,600	−6.050
19	7	5,070	−3.030	**59**	4	13,700	−0.608
20	7	10,000	−5.976	**60**	4	23,600	−1.047
21	2	600	−0.302	**61**	4	18,300	−0.812
22	2	300	−0.151	**62**	1	1,080	−0.047
23	2	13,500	−6.792	**63**	1	1,630	−0.071
24	2	46	−0.023	**64**	1	2,910	−0.126
25	2	266	−0.134	**65**	1	12	−0.001
26	2	63	−0.032	**66**	1	1,340	−0.058
27	2	3,000	−1.509	**67**	1	24	−0.001
28	2	1,000	−0.503	**68**	1	20	−0.001
29	2	74	−0.037	**69**	4	800	−0.036
30	2	51	−0.026	**70**	8	2,300	−0.609
31	n/a	4	−0.011	**71**	8	10,700	−2.831
32	n/a	4	−0.011	**72**	8	3,320	−0.878
33	n/a	3	−0.008	**73**	8	40,000	−10.584
34	2	3	−0.002	**74**	8	301	−0.080
35	2	19	−0.010	**75**	8	1,350	−0.357
36	2	24	−0.012	**76**	8	12,700	−3.360
37	2	39	−0.020	**77**	8	1,340	−0.355
38	2	19	−0.010	**78**	8	7,540	−1.995
39	2	111	−0.056	**79**	8	2,380	−0.630
40	11	873	−0.091	**80**	8	239	−0.063

gl	reg	area	dV
81	8	11,600	−3.069
82	8	9,550	−2.527
83	8	2,080	−0.550
84	8	1,460	−0.386
85	8	2,190	−0.579
86	8	910	−0.241
87	8	3,190	−0.844
88	9	18	−0.002
89	9	372	−0.046
90	9	260	−0.032
91	9	202	−0.025
92	9	19	−0.002
93	9	874	−0.108
94	n/a	1	−0.001
95	n/a	5	−0.003
96	n/a	5	−0.003
97	n/a	7	−0.003
98	n/a	1,000	−2.379
99	n/a	450	−0.088
100	n/a	450	−0.088
total		**527674**	**−146.5**
			(0.405)

Table C.2: Changes in ice volume dV in km^3 $year^{-1}$ w.e. of 100 glaciated regions (Zuo and Oerlemans, 1997a). The volume changes are based on those of the regional and primary (where first are not available) systems of Dyurgerov and Meier (2005). The column 'reg' gives the region of Dyurgerov and Meier (2005) used to derive the estimate for the region and where 'n/a' is listed no regional estimate value was available but instead the number of the primary system was used. Total ice-volume changes, listed in the last row, are given in km^3 $year^{-1}$ w.e. and in mm $year^{-1}$ of global sea-level change (in brackets).

Appendix D

Supporting material for Chapter 5

Tables D.1 and D.2 list locations of existing GPS and tide gauge stations which are referenced in Chapter 5.

site name	short	Latitude	Longitude
Fairbanks	fair	64.98	−147.50
Dunedin	ous2	−45.87	170.51
Ny Ålesund	nyal	78.93	11.87
Palmer	atw2	61.60	−149.13
Punta Arenas	parc	−53.13	−70.88
Resolute	reso	74.70	−94.89
Sheshan	shao	31.10	121.20
Sydney	sydn	−33.78	151.15
Tromsoe	tro1	69.66	18.94
Refrigerator Rock	frig	62.41	−143.01
Reykjavik	reyk	64.14	−21.96
Whitehorse	whit	60.75	−135.22

Table D.1: Latitudes and longitudes of GPS sites referenced in this thesis.

site name	Latitude	Longitude
Anchorage	61.23	−149.90
Barentsburg	78.07	14.25
Bartlett Cove	58.46	−135.88
Cordova	60.55	−145.77
Dunedin	−45.88	170.52
Juneau	58.30	−134.42
Kanmen	28.08	121.28
Ketchikan	55.33	−131.63
Langara Point	54.25	−133.03
Nikiski	60.68	−151.40
Ny Ålesund	78.93	11.93
Punta Arenas	−53.17	−70.90
Prince Rupert	54.32	−130.33
Queen Charlotte City	53.25	−132.07
Resolute	74.68	−94.88
Reykjavik	64.15	−21.93
Sand Point	55.33	−160.50
Seldovia	59.43	−151.72
Seward	60.12	−149.43
Sitka	57.05	−135.33
Skagway	59.45	−135.32
St. Pauls habor	57.75	−152.48
Sydney	−33.85	151.23
Tromso	69.65	18.97
Yakutat	59.55	−139.73
Valdez	61.13	−146.37
Womens Bay	57.72	−152.52

Table D.2: Latitudes and longitudes of tide gauge sites referenced in this thesis.

Appendix E

Supporting material for Chapter 6

Ocean bottom pressure changes and corresponding second order relative sea-level changes

Plots in Figure E.1 show the ocean bottom pressure changes over selected 10-year periods (data provided by Felix Landerer). Note the changes in scale in 2000, 2050, and 2100.

Plots in Figure E.2 show the corresponding relative sea-level changes due to ocean bottom pressure changes caused by thermal expansion. Note the change in scale in 2080.

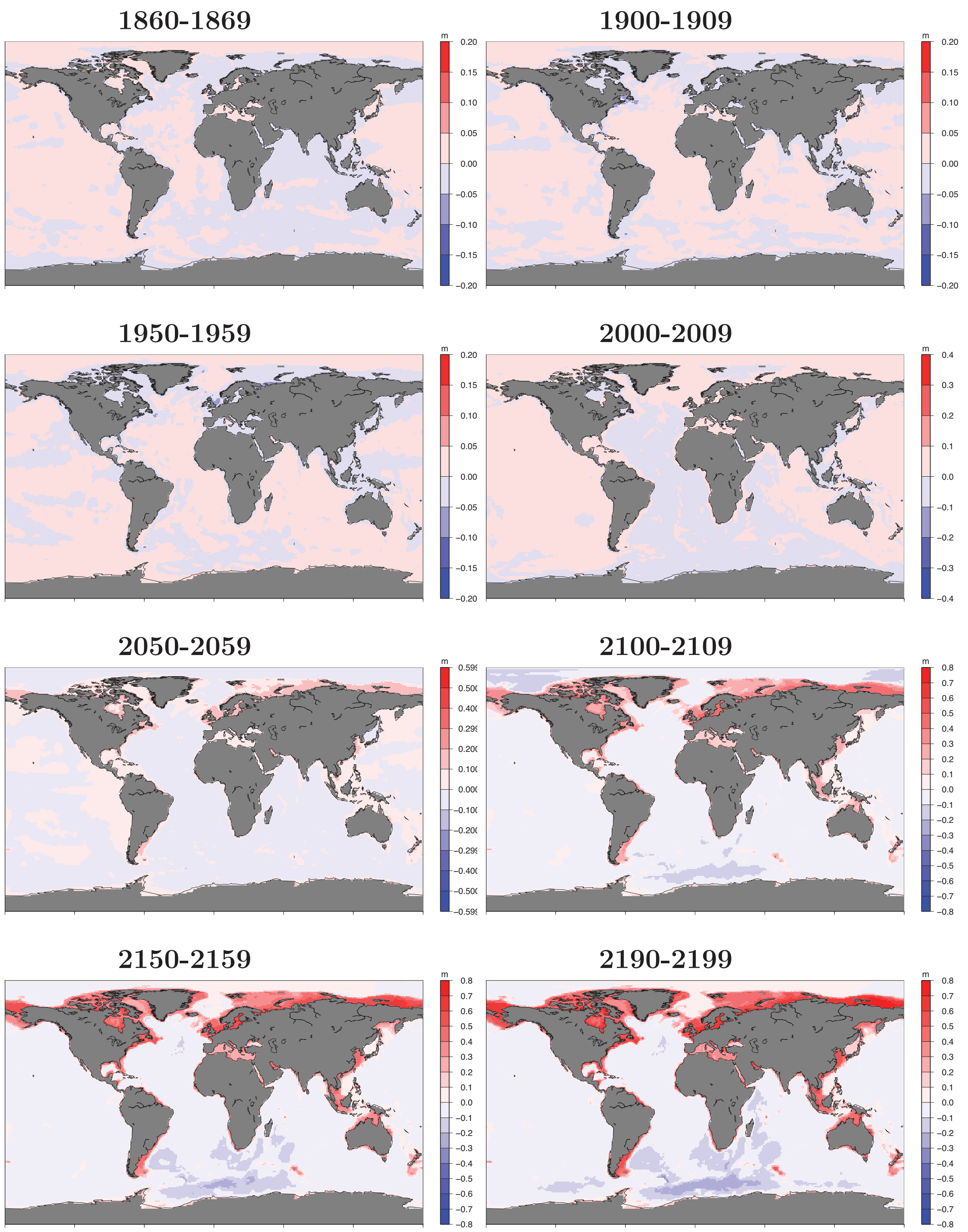
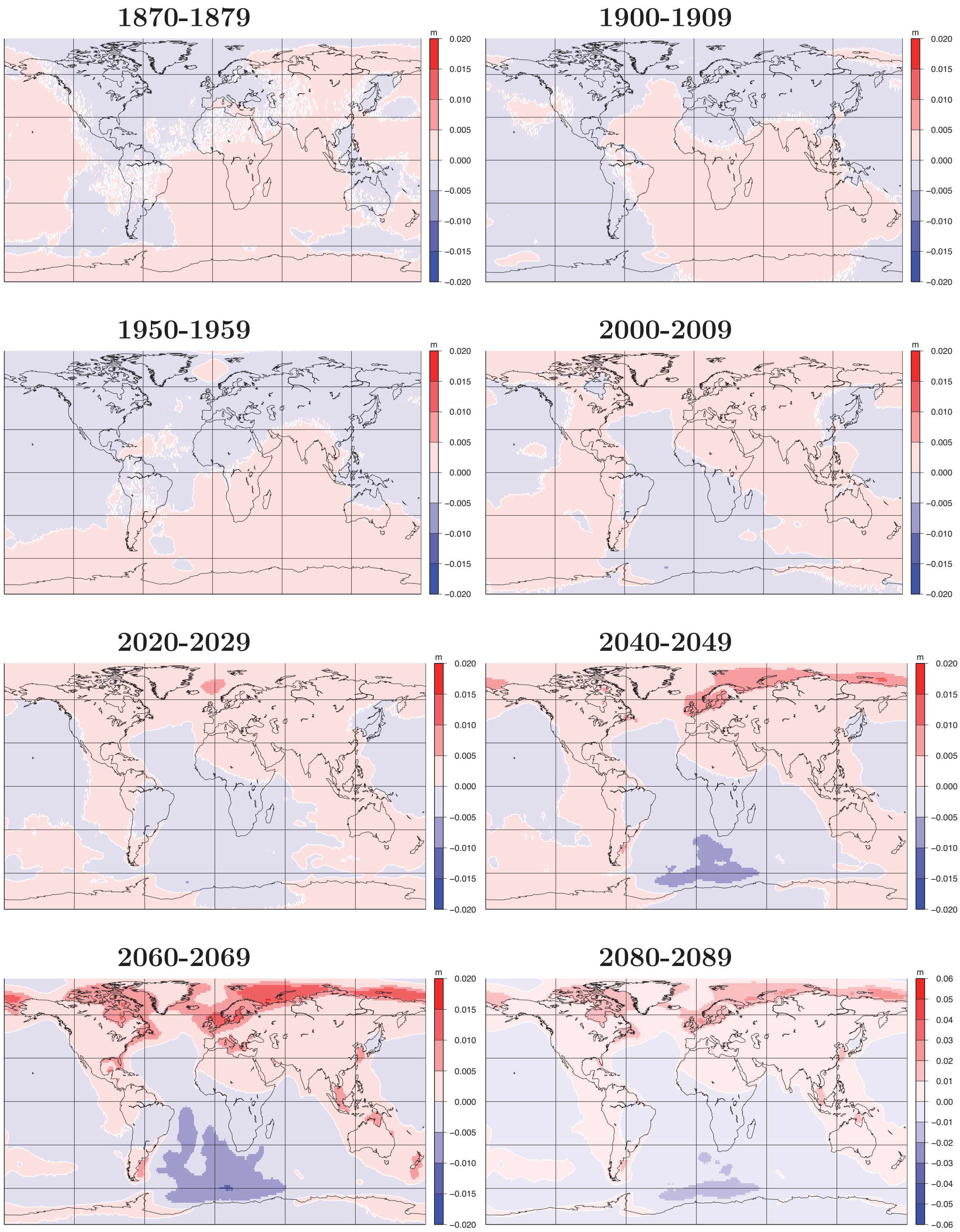


Figure E.1: Thermal expansion induced ocean bottom pressure changes of 10-year averages relative to an unperturbed ocean expressed in meters of mass load.


1870-1879
1900-1909
1950-1959
2000-2009
2020-2029
2040-2049
2060-2069
2080-2089
m
0.020
0.015
0.010
0.005
0.000
−0.005
−0.010
−0.015
−0.020
0.06
0.05
0.04
0.03
0.02
0.01
0.00
−0.01
−0.02
−0.03
−0.04
−0.05
−0.06

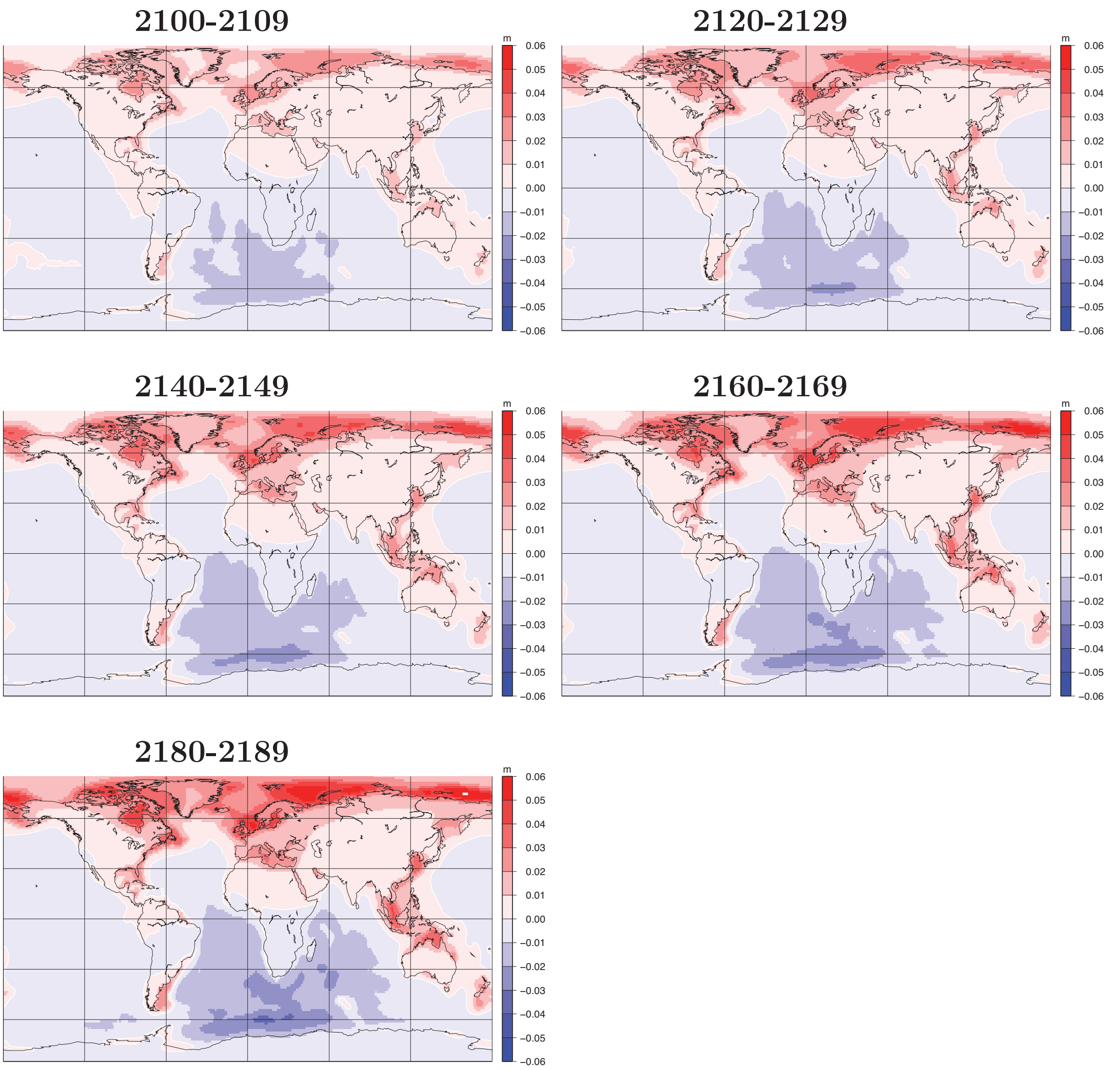


Figure E.2: Spatial distribution of relative sea-level changes relative to 1860-1869 in meter due to changes in ocean bottom pressure caused by thermal expansion of the A1B IPCC climate scenario.