

1 **Supplementary Materials to**
2 **How do extreme ENSO events affect Antarctic surface mass**
3 **balance?**

4 *The Cryosphere*

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24 **Introduction**

25 This supporting information provides supplementary figures, tables and text to the main
26 manuscript of *How do extreme ENSO events affect Antarctic surface mass balance?*

27

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41 **Section 1.1: Classifying Central Pacific and Eastern Pacific El Niño indices**

42 **Text S1.**

43 Central Pacific (CP) El Niño events and Eastern Pacific (EP) El Niño events are classified in
44 the same way as Macha et al. (2024) according to the Ren and Jin (2011) N_{CP} and N_{EP}
45 indices respectively:

46

47 $N_{EP} = N_3 - \alpha N_4$ (S1)

48 $N_{CP} = N_4 - \alpha N_3$ (S2)

49 Where:

50
$$\alpha = \begin{cases} \frac{2}{5} N_3 N_4 > 0, \\ 0, otherwise \end{cases}$$

51

52 Here, N_3 is the Niño-3 index, which is the SST anomaly averaged over the regions 5°N--5°S
53 and 150°-90°W, and N_4 is the Niño-4 index, which is the SST anomaly averaged over the
54 regions 5°N--5°S and 160°E--150°W (Ren and Jin, 2011). Niño-3 and Niño-4 indices are
55 sourced from NOAA (Rayner et al. 2003), based on the HadISST dataset. We use 3-month
56 seasonal averages from 1979--2018 CP and EP El Niño indices (Equations 1; 2).

57

58 **Section 2.1: Calculating Outliers**

59 **Text S2.**

60 We identify outliers in each regional cumulative SON SMB anomaly dataset using Equations
61 S1-S3 (Mudelsee, 2010) for Figure 5.

62 $IQR = Q3 - Q1$ (S3)

63 $Upper\ Outlier\ Bound = Q3 + 1.5\ IQR$ (S4)

64 $Lower\ Outlier\ Bound = Q1 - 1.5\ IQR$ (S5)

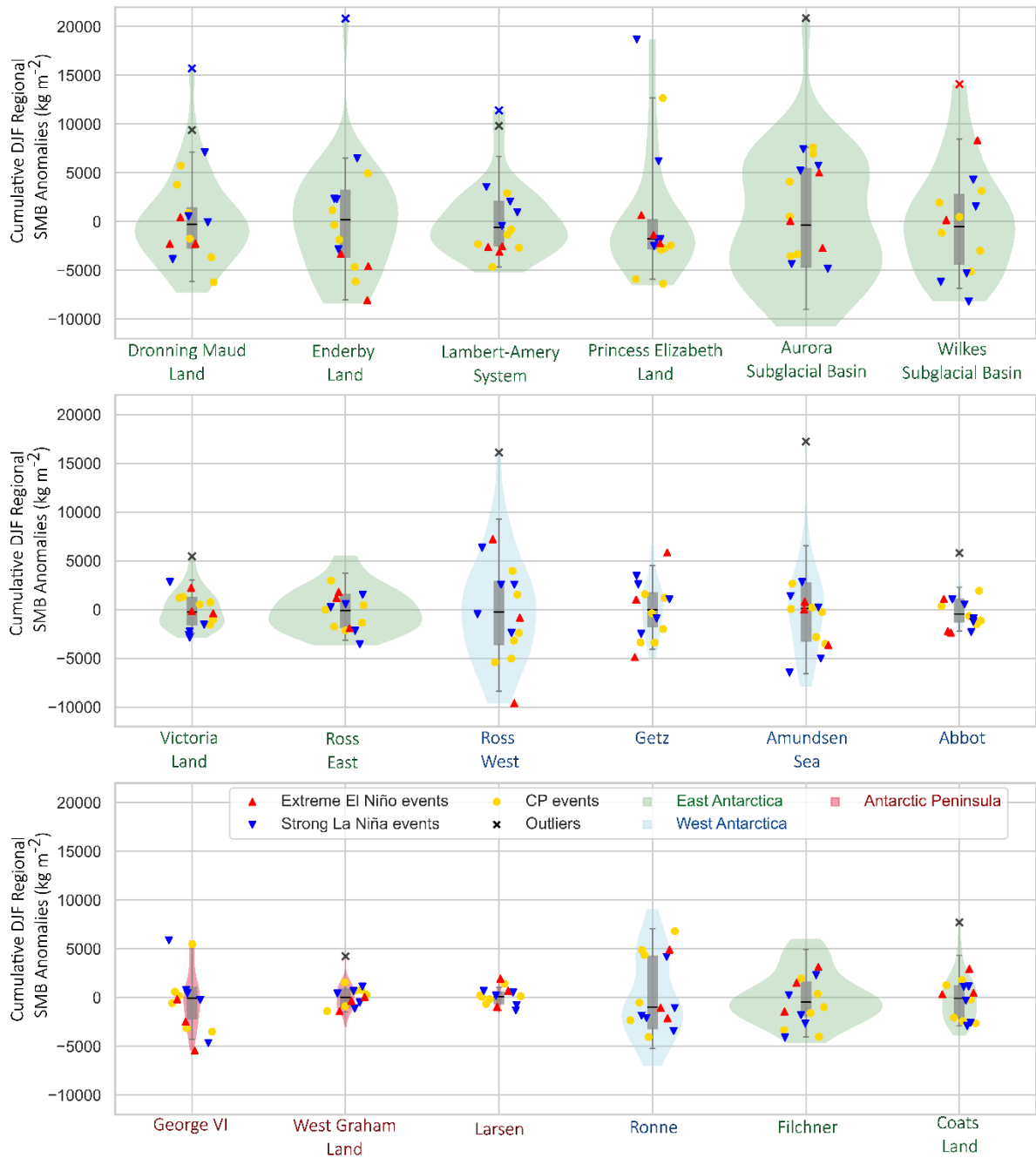
65 where:

66 $Q1 = lower\ quartile\ (25th\ percentile)$

67 $Q3 = upper\ quartile\ (75th\ percentile)$

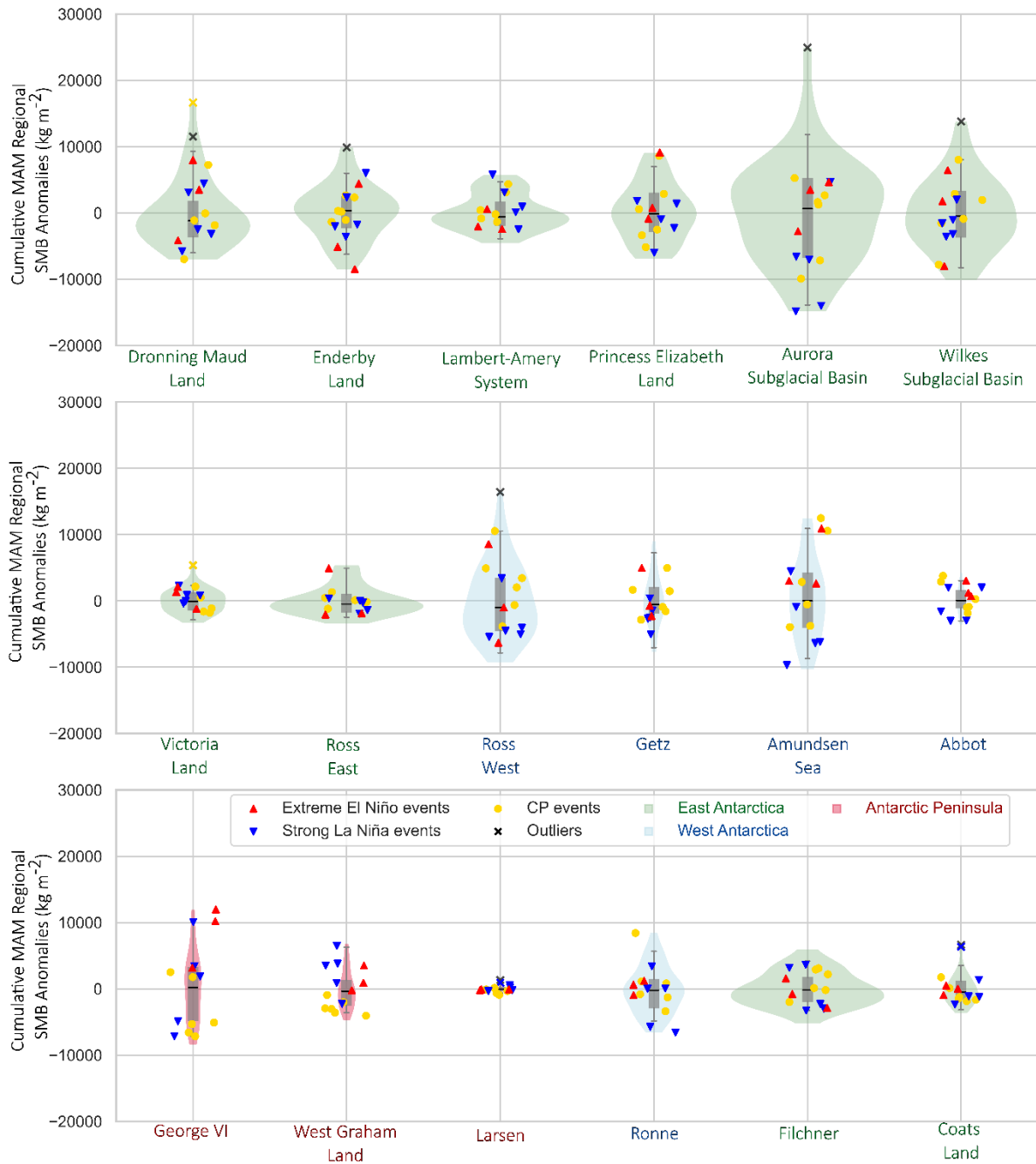
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69 **Section 3.1: Violin plots of SMB**



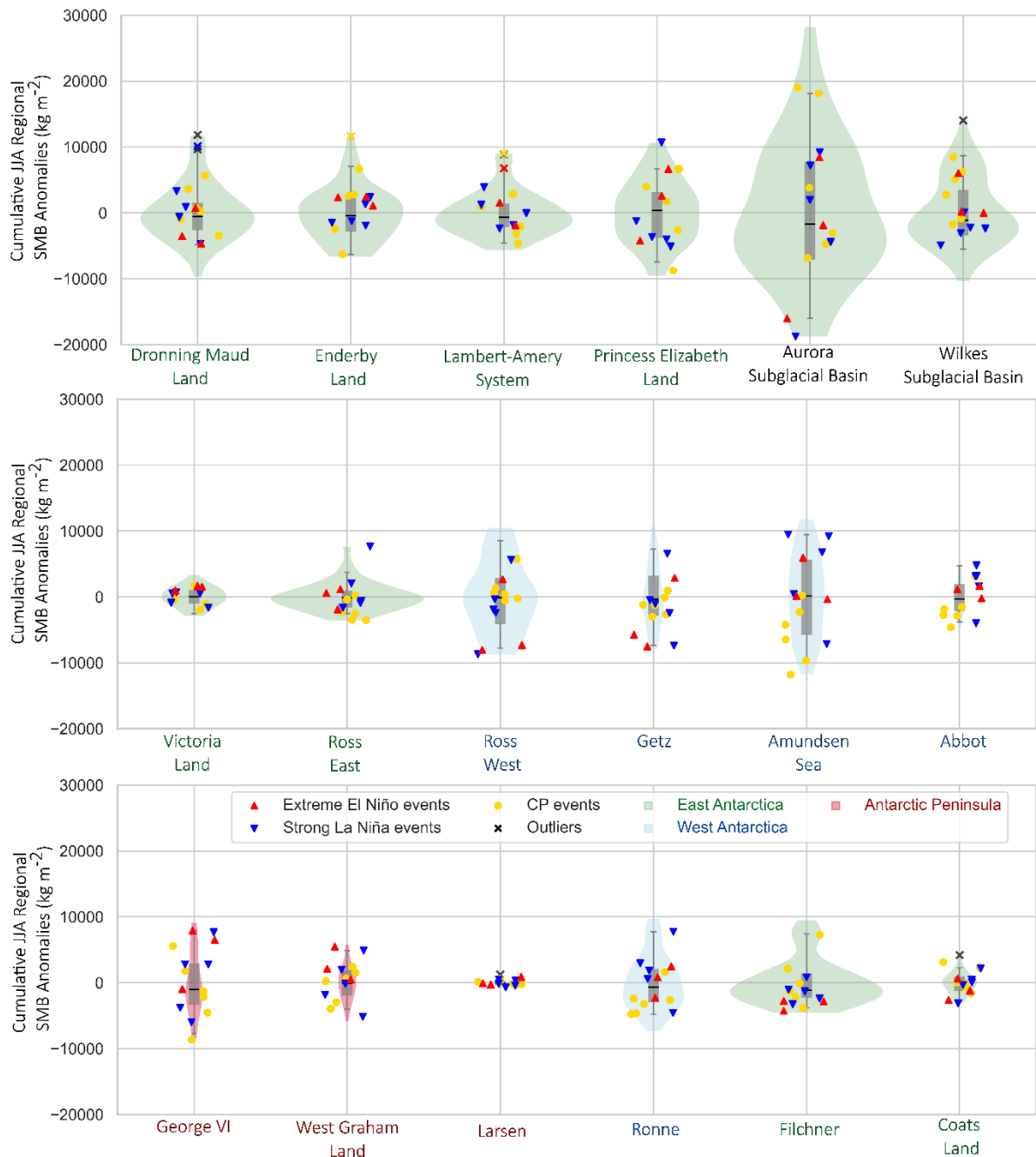
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71 **Supplementary Figure S1. Relationship between extreme ENSO events and regional**
 72 **Antarctic surface mass balance anomalies during DJF.** Density curves of regional
 73 cumulative DJF SMB anomalies for each Antarctic Ice Sheet regional catchment (a-j), scaled
 74 by the regional catchment size. Box plots show the interquartile range (IQR), with medians
 75 (black line) and whiskers (5th and 95th percentiles). East Antarctic (light green), West
 76 Antarctic (light blue) and Antarctic Peninsula (pink) catchments, outliers (crosses; see
 77 supplement), extreme El Niño events (red), strong La Niña events (blue) and Central Pacific
 78 El Niño events (yellow) are highlighted.



79

80 **Supplementary Figure S2. Relationship between extreme ENSO events and regional**
 81 **Antarctic surface mass balance anomalies during MAM.** Density curves of regional
 82 cumulative MAM SMB anomalies for each Antarctic Ice Sheet regional catchment (a-j),
 83 scaled by the regional catchment size. Box plots show the interquartile range (IQR), with
 84 medians (black line) and whiskers (5th and 95th percentiles). East Antarctic (light green),
 85 West Antarctic (light blue) and Antarctic Peninsula (pink) catchments, outliers (crosses; see
 86 supplement), extreme El Niño events (red), strong La Niña events (blue) and Central Pacific
 87 El Niño events (yellow) are highlighted.

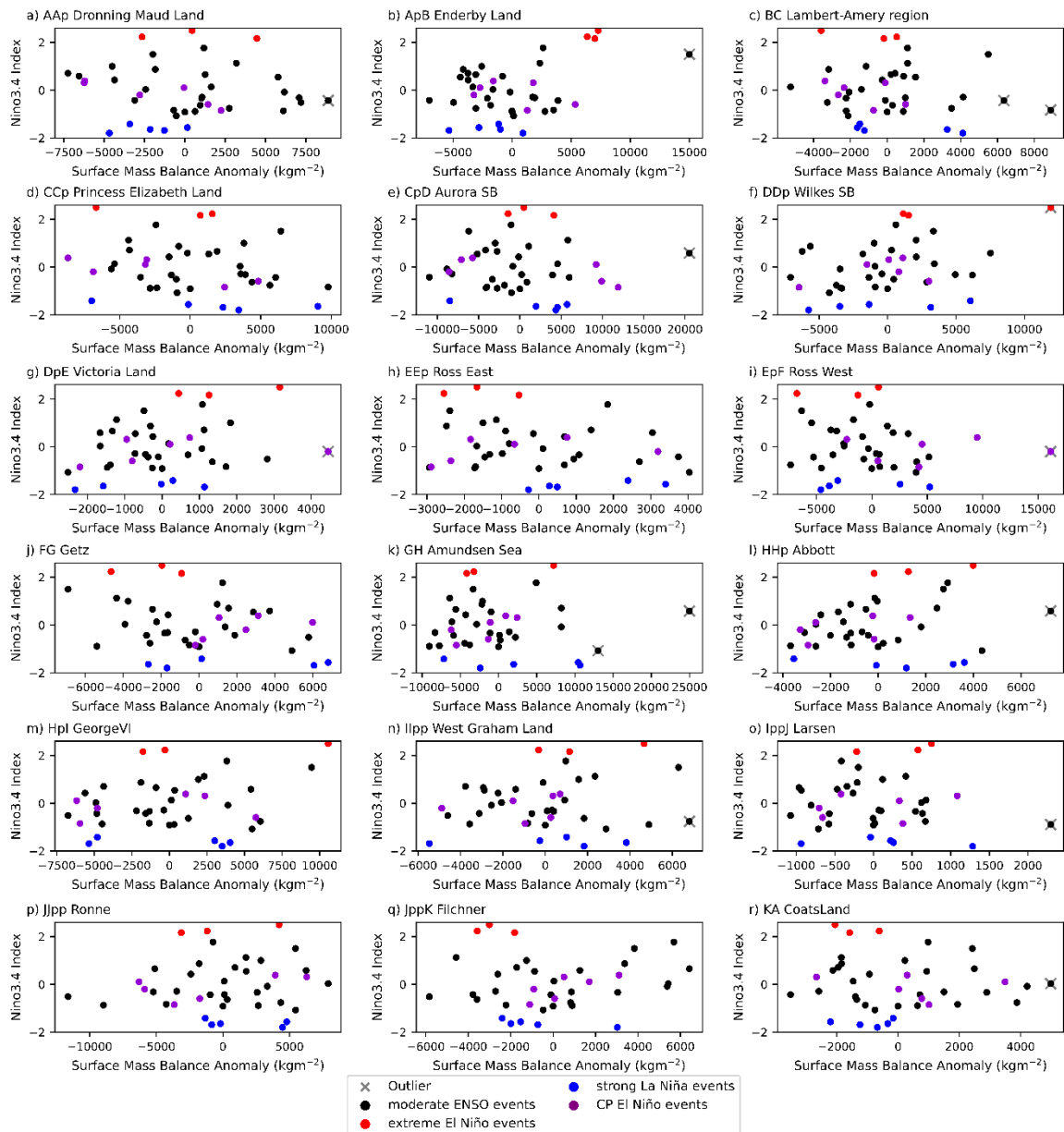


88

89 **Supplementary Figure S3. Relationship between extreme ENSO events and regional**
 90 **Antarctic surface mass balance anomalies during JJA.** Density curves of regional
 91 cumulative JJA SMB anomalies for each Antarctic Ice Sheet regional catchment (a-j), scaled
 92 by the regional catchment size. Box plots show the interquartile range (IQR), with medians
 93 (black line) and whiskers (5th and 95th percentiles). East Antarctic (light green), West
 94 Antarctic (light blue) and Antarctic Peninsula (pink) catchments, outliers (crosses; see
 95 supplement), extreme El Niño events (red), strong La Niña events (blue) and Central Pacific
 96 El Niño events (yellow) are highlighted.

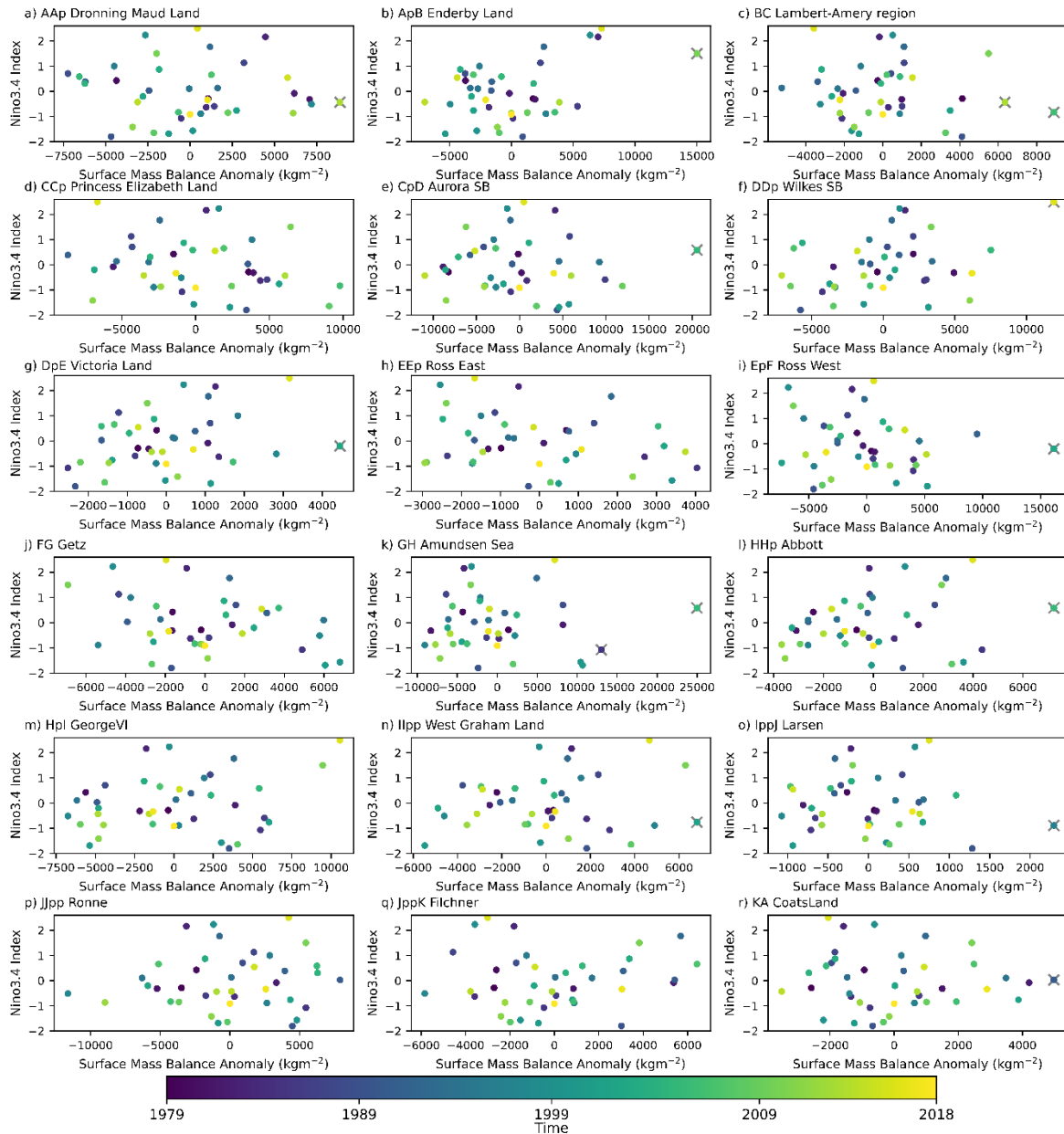
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98 **Section 3.2: Scatter plots of SMB**



99

100 **Supplementary Figure S4.** Scatter plots of regional cumulative SON surface mass balance
 101 anomaly from 1979-2018 against the Niño3.4 Index across all Antarctic Ice Sheet regional
 102 basins (a-r). No trendlines are included as no trendline is statistically significant at the 5%
 103 confidence level using a two-tailed Students' *t* test. Outliers (grey cross), moderate ENSO
 104 events (black), extreme El Niño events (red), strong La Niña events (blue) and Central
 105 Pacific El Niño events (purple).



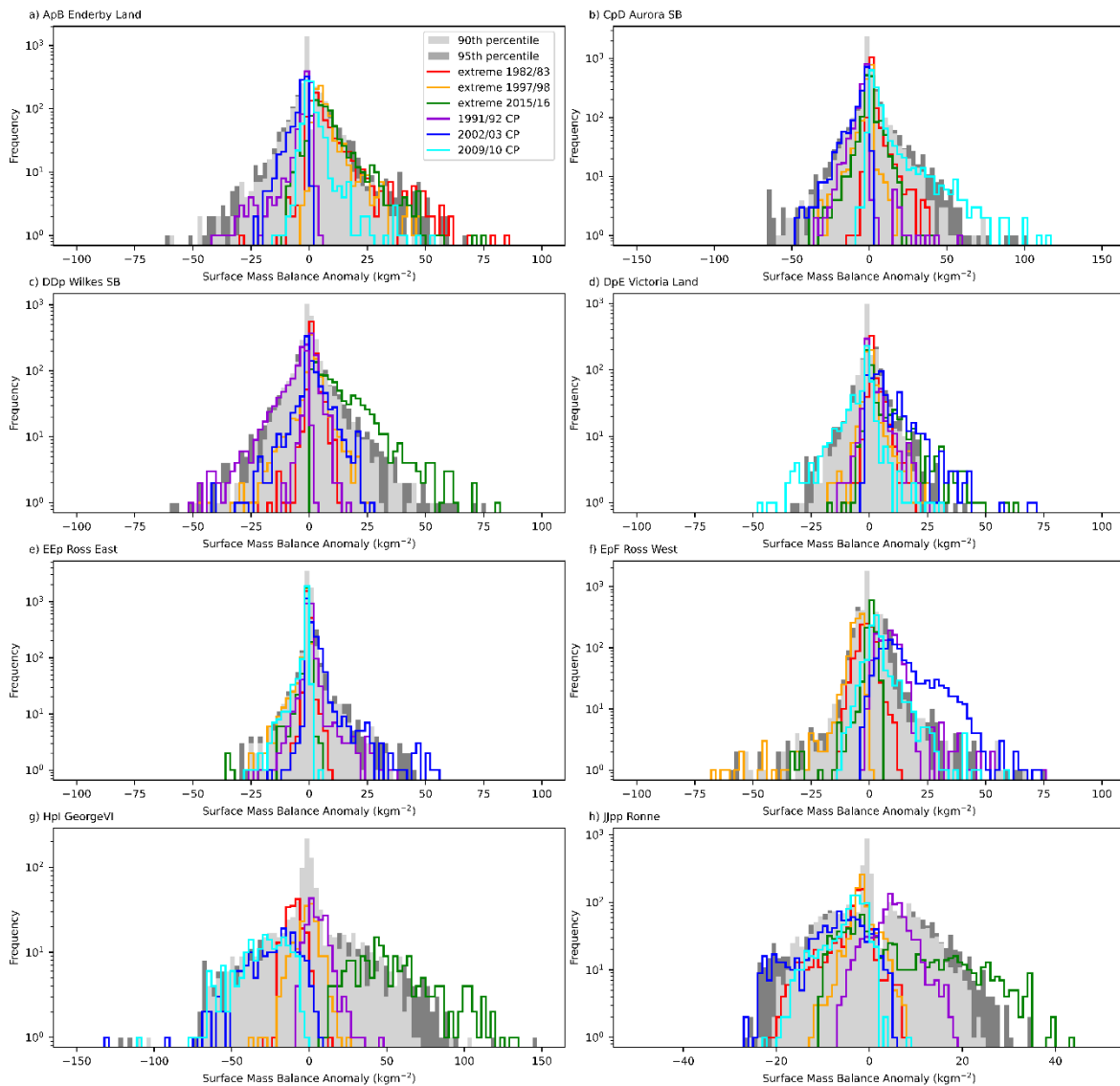
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107 **Supplementary Figure S5.** Scatter plots of regional cumulative SON surface mass balance
 108 anomaly from 1979-2018 against the Niño3.4 Index across Antarctic Ice Sheet regional
 109 basins (a-r), coloured according to year (colour bar).

110

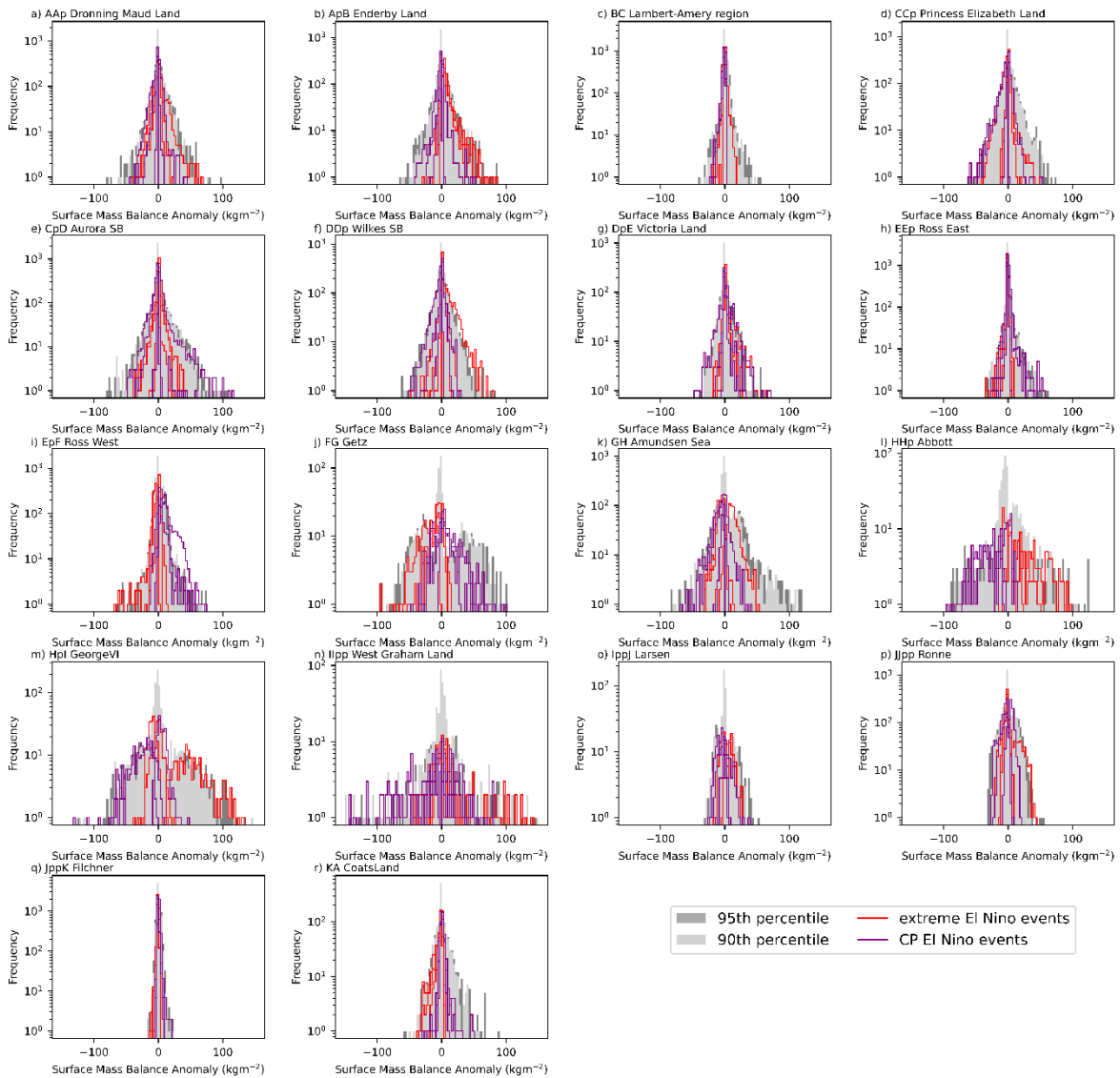
111 **Section 4.1: Regional SMB histograms during extreme El Niño events**

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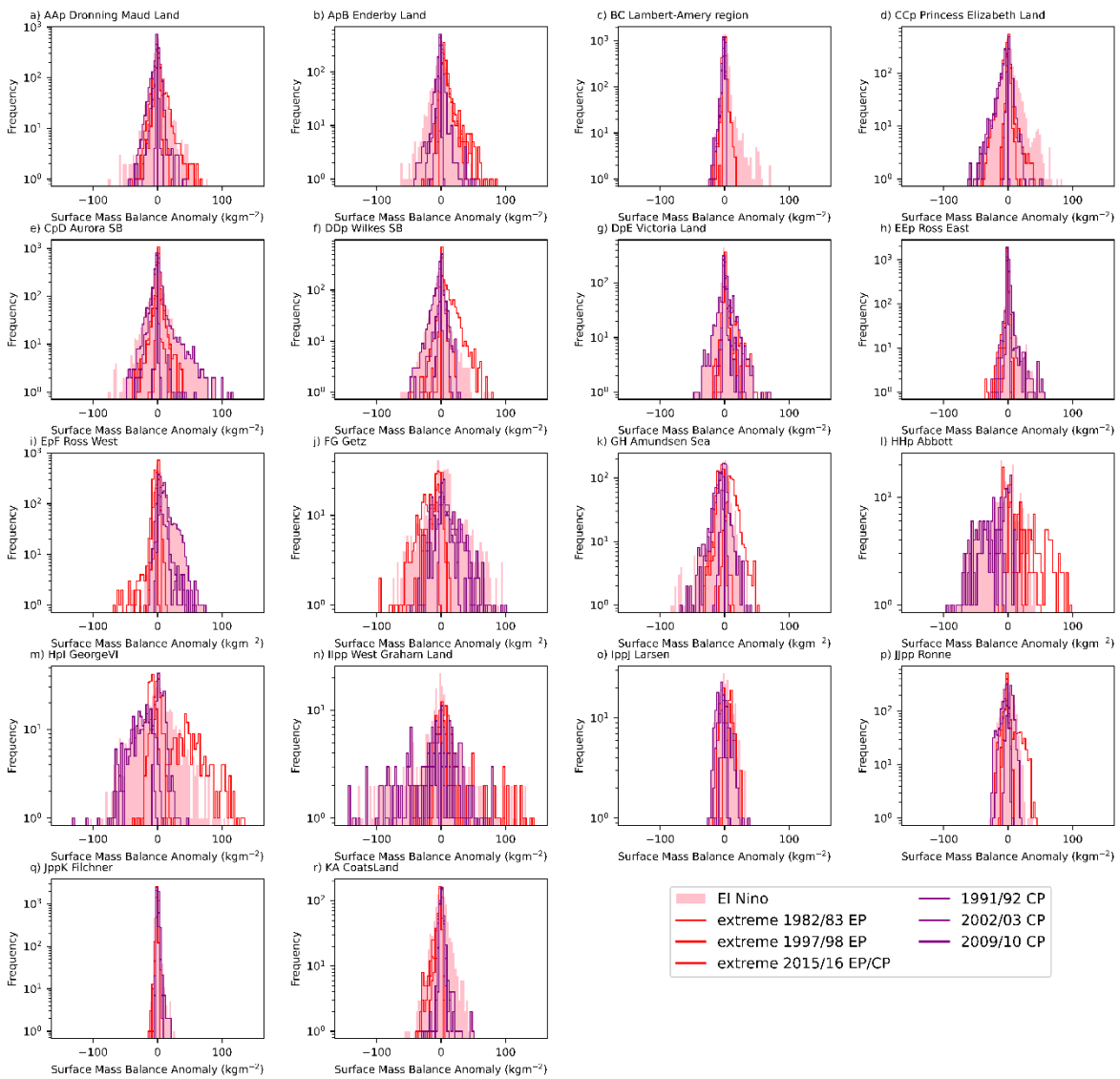


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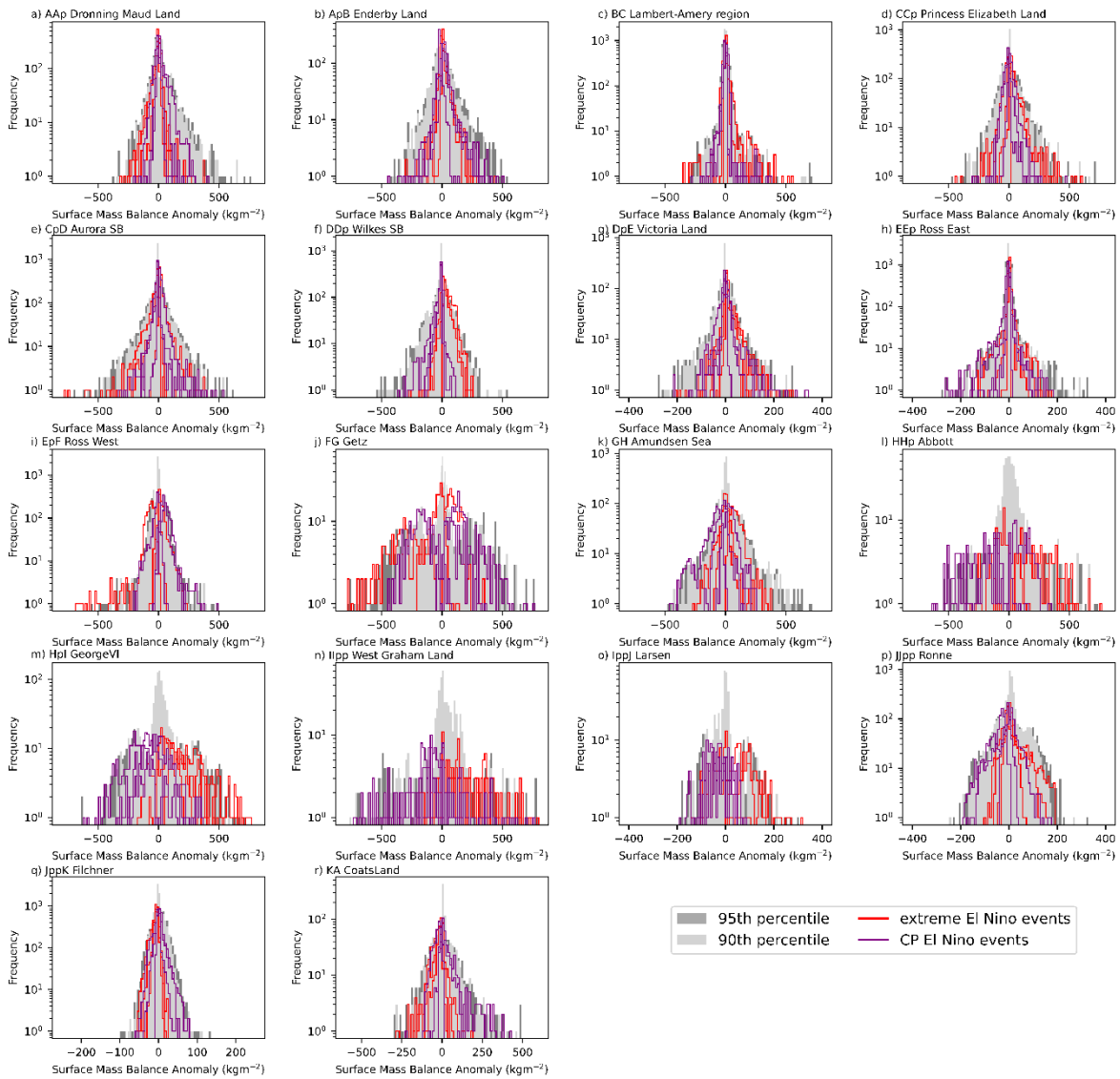
114 **Supplementary Figure S6. Probability distributions of regional Antarctic surface mass**
 115 **balance anomalies during extreme El Niño events and CP El Niño events.** Regional
 116 SMB probability distributions of SMB anomalies in SON for extreme El Niño events: 1982/83
 117 (red), 1997/98 (orange) and 2015/16 (green); and CP El Niño events: 1991/92 (purple),
 118 2002/03 (blue) and 2009/10 (cyan). Regional 90th (light grey shading) and 95th percentile
 119 (dark grey shading) SMB anomalies for SON for 1979-2018 period.



122 **Supplementary Figure S7. Probability distributions of regional Antarctic surface mass**
 123 **balance anomalies during extreme El Niño events and CP El Niño events in**
 124 **SON.** Regional SMB probability distributions of SMB changes in SON for extreme El Niño
 125 events (red lines) and CP events (purple lines), and regional 90th (light grey shading) and
 126 95th percentile (dark grey shading) SMB anomalies for SON for 1979-2018 period.



128 **Supplementary Figure S8.** Regional SMB probability distributions of SMB changes in SON
 129 for El Niño events excluding extreme events (pink shading), during extreme El Niño events
 130 (red lines) and CP events (purple lines)



132

133 **Supplementary Figure S9.** Regional SMB probability distributions of cumulative annual
 134 SMB anomalies (relative to 1979-2018 average) for extreme El Niño events (red lines) and
 135 CP events (purple lines), and regional 90th (light grey shading) and 95th percentile (dark
 136 grey shading) SMB anomalies for 1979-2018 period.

137

138 **Section 4.2: Statistical significance testing of regional SMB anomalies distributions**
 139 **during extreme El Niño events.**

	Kolmogorov-Smirnov (K-S) test											
	1982/83		1997/98		2015/16		1991/92		2002/03		2009/10	
	statistic	<i>p-value</i>	statistic	<i>p-value</i>	statistic	<i>p-value</i>	statistic	<i>p-value</i>	statistic	<i>p-value</i>	statistic	<i>p-value</i>
AAp	0.330	<0.001	0.187	<0.001	0.152	<0.001	0.546	<0.001	0.467	<0.001	0.308	<0.001
ApB	0.539	<0.001	0.680	<0.001	0.562	<0.001	0.250	<0.001	0.511	<0.001	0.261	<0.001
BC	0.263	<0.001	0.110	<0.001	0.396	<0.001	0.370	<0.001	0.330	<0.001	0.175	<0.001
CCp	0.331	<0.001	0.354	<0.001	0.579	<0.001	0.615	<0.001	0.534	<0.001	0.422	<0.001
CpD	0.481	<0.001	0.162	<0.001	0.087	<0.001	0.569	<0.001	0.574	<0.001	0.521	<0.001
DDp	0.452	<0.001	0.281	<0.001	0.628	<0.001	0.336	<0.001	0.186	<0.001	0.540	<0.001
DpE	0.492	<0.001	0.184	<0.001	0.258	<0.001	0.141	<0.001	0.531	<0.001	0.251	<0.001
EEp	0.201	<0.001	0.465	<0.001	0.371	<0.001	0.155	<0.001	0.201	<0.001	0.488	<0.001
EpF	0.104	<0.001	0.651	<0.001	0.367	<0.001	0.680	<0.001	0.744	<0.001	0.447	<0.001
FG	0.266	<0.001	0.563	<0.001	0.326	<0.001	0.468	<0.001	0.326	<0.001	0.085	0.144
GH	0.393	<0.001	0.347	<0.001	0.638	<0.001	0.326	<0.001	0.509	<0.001	0.376	<0.001
HHp	0.303	<0.001	0.490	<0.001	0.753	0.241	0.264	<0.001	0.609	<0.001	0.543	<0.001
Hpl	0.422	<0.001	0.231	<0.001	0.751	<0.001	0.390	<0.001	0.485	<0.001	0.611	<0.001
IIpp	0.221	0.002	0.172	0.005	0.356	<0.001	0.164	0.014	0.402	<0.001	0.184	0.002
IppJ	0.239	<0.001	0.408	<0.001	0.512	<0.001	0.342	<0.001	0.408	<0.001	0.316	<0.001
JJpp	0.361	<0.001	0.259	<0.001	0.220	<0.001	0.450	<0.001	0.403	<0.001	0.402	<0.001
JppK	0.209	<0.001	0.469	<0.001	0.450	<0.001	0.395	<0.001	0.203	<0.001	0.329	<0.001
K	0.369	<0.001	0.312	<0.001	0.288	<0.001	0.292	<0.001	0.163	0.208	0.378	<0.001

140
 141 **Supplementary Table S1.** Kolmogorov-Smirnov test statistics and *p-value* results showing
 142 statistically significant difference in SMB SON distributions for extreme El Niño events
 143 (1982/83, 1997/98, 2015/16) and CP El Niño events (1991/92, 2002/03, 2009/10) for each
 144 Antarctic region compared to the SMB SON distribution for the region for the full 1979-2018
 145 time period with Monte-Carlo Sampling and 1000 simulations. Results in **bold** are
 146 statistically significant at the 5% significance level.

		Kolmogorov-Smirnov (K-S) test									
		1997/98		2015/16		1991/92		2002/03		2009/10	
		statistic	p-value	statistic	p-value	statistic	p-value	statistic	p-value	statistic	p-value
AAp	1982/83	0.4212	<0.001	0.25597	<0.001	0.75072	<0.001	0.68577	<0.001	0.20248	<0.001
	1997/98	0.000	1.000	0.33047	<0.001	0.38109	<0.001	0.3171	<0.001	0.47851	<0.001
	2015/16			0.000	1.000	0.69628	<0.001	0.61032	<0.001	0.16523	<0.001
	1991/92					0.000	1.000	0.30946	<0.001	0.85005	<0.001
	2002/03							0.000	1.000	0.76504	<0.001
ApB	1982/83	0.20629	<0.001	0.14219	<0.001	0.75758	<0.001	0.89977	<0.001	0.50583	<0.001
	1997/98	0.000	1.000	0.12238	<0.001	0.92424	<0.001	0.98718	<0.001	0.669	<0.001
	2015/16			0.000	1.000	0.80769	<0.001	0.89277	<0.001	0.55245	<0.001
	1991/92					0.000	1.000	0.59557	<0.001	0.26923	<0.001
	2002/03							0.000	1.000	0.77156	<0.001
BC	1982/83	0.33525	<0.001	0.60046	<0.001	0.6194	<0.001	0.58611	<0.001	0.17394	<0.001
	1997/98	0.000	1.000	0.45867	<0.001	0.38576	<0.001	0.2744	<0.001	0.26693	<0.001
	2015/16			0.000	1.000	0.09357	<0.001	0.27669	<0.001	0.54363	<0.001
	1991/92					0.000	1.000	0.19805	<0.001	0.52928	<0.001
	2002/03							0.000	1.000	0.50459	<0.001
CCp	1982/83	0.16945	<0.001	0.89075	<0.001	0.90301	<0.001	0.85842	<0.001	0.23523	<0.001
	1997/98	0.000	1.000	0.9175	0.016	0.92642	<0.001	0.88852	0.106	0.3311	<0.001
	2015/16			0.000	1.000	0.10814	<0.001	0.05128	<0.001	0.92419	<0.001
	1991/92					0.000	1.000	0.12152	<0.001	0.93088	<0.001
	2002/03							0.000	1.000	0.90635	<0.001
CpD	1982/83	0.43324	<0.001	0.46996	<0.001	0.94726	<0.001	0.92857	<0.001	0.31976	<0.001
	1997/98	0.000	1.000	0.18158	<0.001	0.68892	<0.001	0.68892	<0.001	0.5988	<0.001
	2015/16			0.000	1.000	0.64486	<0.001	0.65421	<0.001	0.50868	<0.001
	1991/92					0.000	1.000	0.11081	<0.001	0.97597	<0.001
	2002/03							0.000	1.000	0.96061	<0.001
DDp	1982/83	0.20348	<0.001	0.64635	<0.001	0.31665	<0.001	0.44831	<0.001	0.90098	<0.001
	1997/98	0.000	1.000	0.54516	<0.001	0.16104	<0.001	0.28509	<0.001	0.76061	<0.001
	2015/16			0.000	1.000	0.66268	<0.001	0.57345	<0.001	0.98803	<0.001
	1991/92					0.000	1.000	0.24157	0.023	0.86289	<0.001
	2002/03							0.000	1.000	0.72035	<0.001
DpE	1982/83	0.37961	<0.001	0.32337	<0.001	0.52197	<0.001	0.4007	<0.001	0.72408	<0.001
	1997/98	0.000	1.000	0.2478	<0.001	0.2355	<0.001	0.52373	<0.001	0.41476	<0.001
	2015/16			0.000	1.000	0.27768	<0.001	0.32865	<0.001	0.46924	<0.001
	1991/92					0.000	1.000	0.48155	<0.001	0.33743	<0.001
	2002/03							0.000	1.000	0.69596	0.047
EEp	1982/83	0.34936	<0.001	0.22254	<0.001	0.28571	<0.001	0.27676	<0.001	0.4743	<0.001
	1997/98	0.000	1.000	0.25365	<0.001	0.48986	<0.001	0.43517	<0.001	0.21641	<0.001
	2015/16			0.000	1.000	0.43517	<0.001	0.36822	<0.001	0.34559	<0.001
	1991/92					0.000	1.000	0.17067	<0.001	0.54125	<0.001
	2002/03							0.000	1.000	0.46157	<0.001
EpF	1982/83	0.62098	<0.001	0.44986	<0.001	0.77921	<0.001	0.84085	<0.001	0.53818	<0.001
	1997/98	0.000	1.000	0.93008	<0.001	0.99264	<0.001	0.98896	<0.001	0.89052	<0.001
	2015/16			0.000	1.000	0.77921	0.107	0.86569	<0.001	0.45538	<0.001
	1991/92					0.000	1.000	0.29255	<0.001	0.49402	<0.001
	2002/03							0.000	1.000	0.62466	<0.001

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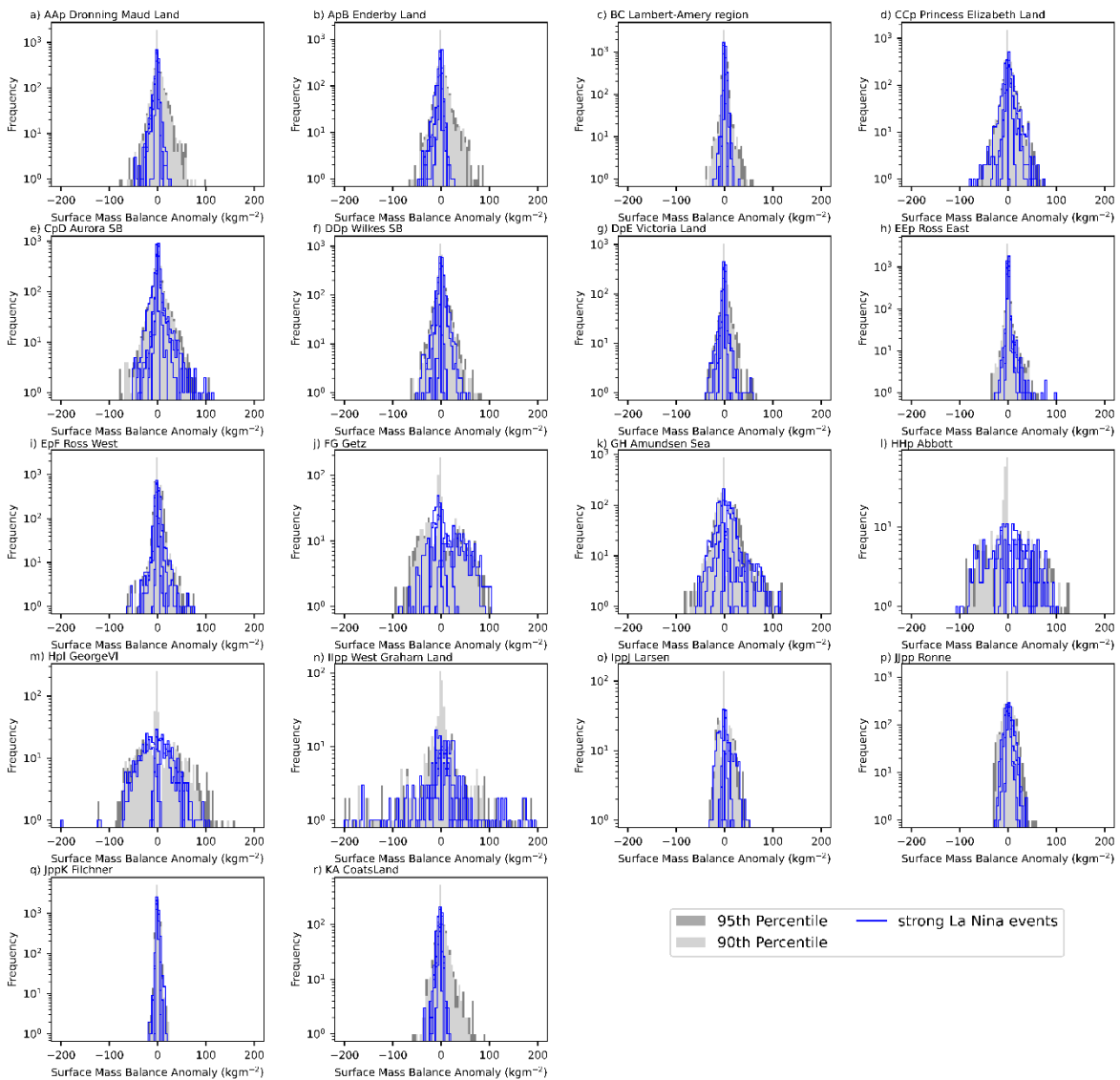
148 **Supplementary Table S2.** (continued on next page) Kolmogorov-Smirnov test statistics and
149 *p-value* results showing statistically significant difference between SMB SON distributions
150 between each extreme El Niño event (1982/83, 1997/98, 2015/16) and each CP El Niño
151 event (1991/92, 2002/03, 2009/10) for each Antarctic region, with Monte-Carlo Sampling and
152 1000 simulations. Results in **bold** are statistically significant at the 5% significance level.

		Kolmogorov-Smirnov (K-S) test									
		1997/98		2015/16		1991/92		2002/03		2009/10	
		statistic	p-value	statistic	p-value	statistic	p-value	statistic	p-value	statistic	p-value
FG	1982/83	0.625	<0.001	0.21591	<0.001	0.65909	<0.001	0.54545	<0.001	0.26136	<0.001
	1997/98	0.000	1.000	0.44318	<0.001	0.98864	<0.001	0.8125	<0.001	0.56818	<0.001
	2015/16			0.000	1.000	0.73864	<0.001	0.61932	<0.001	0.35227	<0.001
	1991/92					0.000	1.000	0.1875	<0.001	0.4375	<0.001
	2002/03							0.000	1.000	0.30114	<0.001
GH	1982/83	0.22442	<0.001	0.90305	<0.001	0.68402	<0.001	0.2316	<0.001	0.1526	<0.001
	1997/98	0.000	1.000	0.92819	<0.001	0.59246	<0.001	0.37702	<0.001	0.19569	<0.001
	2015/16			0.000	1.000	0.7289	<0.001	0.96409	<0.001	0.92998	<0.001
	1991/92					0.000	1.000	0.81329	<0.001	0.63375	<0.001
	2002/03							0.000	1.000	0.21903	<0.001
Hhp	1982/83	0.59524	<0.001	0.95238	0.064	0.14286	<0.001	0.89286	<0.001	0.79762	<0.001
	1997/98	0.000	1.000	0.63095	<0.001	0.52381	<0.001	0.9881	<0.001	0.97619	<0.001
	2015/16			0.000	1.000	0.878	0.281	0.810	<0.001	0.91526	0.084
	1991/92					0.000	1.000	0.83333	0.362	0.71429	<0.001
	2002/03							0.000	1.000	0.15476	0.072
Hpl	1982/83	0.52941	<0.001	0.9893	<0.001	0.78075	<0.001	0.51872	<0.001	0.68984	<0.001
	1997/98	0.000	1.000	0.96257	<0.001	0.37968	<0.001	0.65241	<0.001	0.80214	<0.001
	2015/16			0.000	1.000	0.89305	<0.001	0.784	0.069	0.617	0.181
	1991/92					0.000	1.000	0.86096	<0.001	0.97326	<0.001
	2002/03							0.000	1.000	0.20321	<0.001
lpp	1982/83	0.21875	<0.001	0.34375	<0.001	0.16667	<0.001	0.59375	<0.001	0.38542	<0.001
	1997/98	0.000	1.000	0.48958	<0.001	0.21875	<0.001	0.45833	<0.001	0.26042	<0.001
	2015/16			0.000	1.000	0.38542	<0.001	0.64583	<0.001	0.41667	<0.001
	1991/92					0.000	1.000	0.55208	<0.001	0.33333	<0.001
	2002/03							0.000	1.000	0.35417	<0.001
lppJ	1982/83	0.5679	<0.001	0.71605	0.011	0.22222	<0.001	0.48148	<0.001	0.4321	<0.001
	1997/98	0.000	1.000	0.22222	<0.001	0.7037	0.252	0.80247	<0.001	0.20988	<0.001
	2015/16			0.000	1.000	0.83951	<0.001	0.83951	<0.001	0.39506	<0.001
	1991/92					0.000	1.000	0.34568	<0.001	0.60494	<0.001
	2002/03							0.000	1.000	0.7037	<0.001
Jpp	1982/83	0.2503	<0.001	0.44164	<0.001	0.77617	<0.001	0.35981	<0.001	0.14801	<0.001
	1997/98	0.000	1.000	0.38628	<0.001	0.68592	<0.001	0.55836	<0.001	0.38267	<0.001
	2015/16			0.000	1.000	0.35018	<0.001	0.44525	<0.001	0.47774	<0.001
	1991/92					0.000	1.000	0.75572	<0.001	0.80987	<0.001
	2002/03							0.000	1.000	0.29723	<0.001
JppK	1982/83	0.47135	<0.001	0.4627	<0.001	0.41477	<0.001	0.2	<0.001	0.32937	<0.001
	1997/98	0.000	1.000	0.1236	<0.001	0.84108	<0.001	0.36685	<0.001	0.52865	<0.001
	2015/16			0.000	1.000	0.83748	<0.001	0.29441	<0.001	0.47568	<0.001
	1991/92					0.000	1.000	0.58919	<0.001	0.72288	<0.001
	2002/03							0.000	1.000	0.18883	<0.001
K	1982/83	0.35613	<0.001	0.1396	<0.001	0.65527	<0.001	0.50427	<0.001	0.70085	<0.001
	1997/98	0.000	1.000	0.32479	<0.001	0.34473	0.106	0.39886	<0.001	0.48718	<0.001
	2015/16			0.000	1.000	0.54416	<0.001	0.4188	<0.001	0.63533	<0.001
	1991/92					0.000	1.000	0.1567	<0.001	0.19658	<0.001
	2002/03							0.000	1.000	0.22792	<0.001

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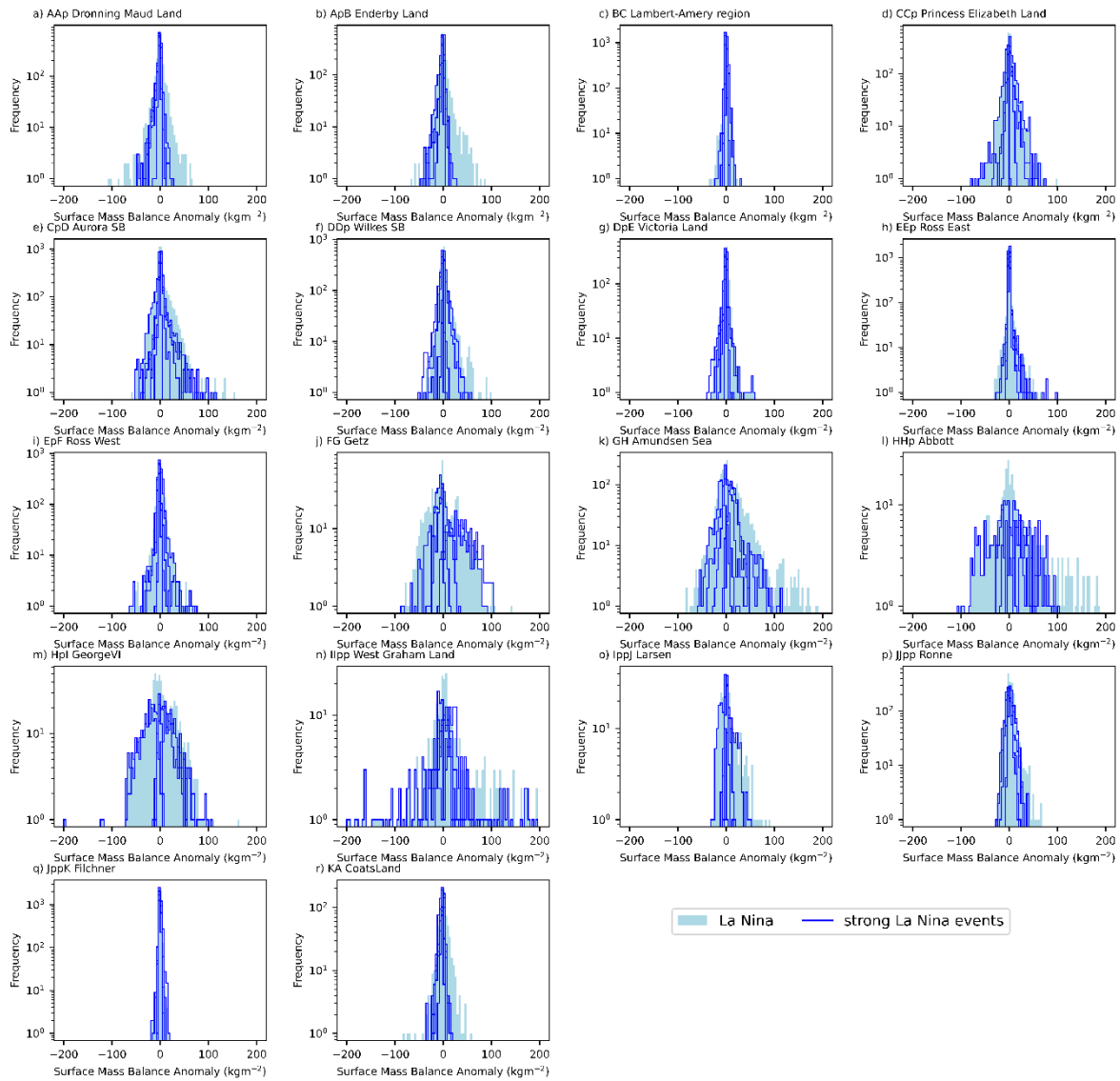
155 **Section 5.1: Regional SMB histograms during strong La Niña events**



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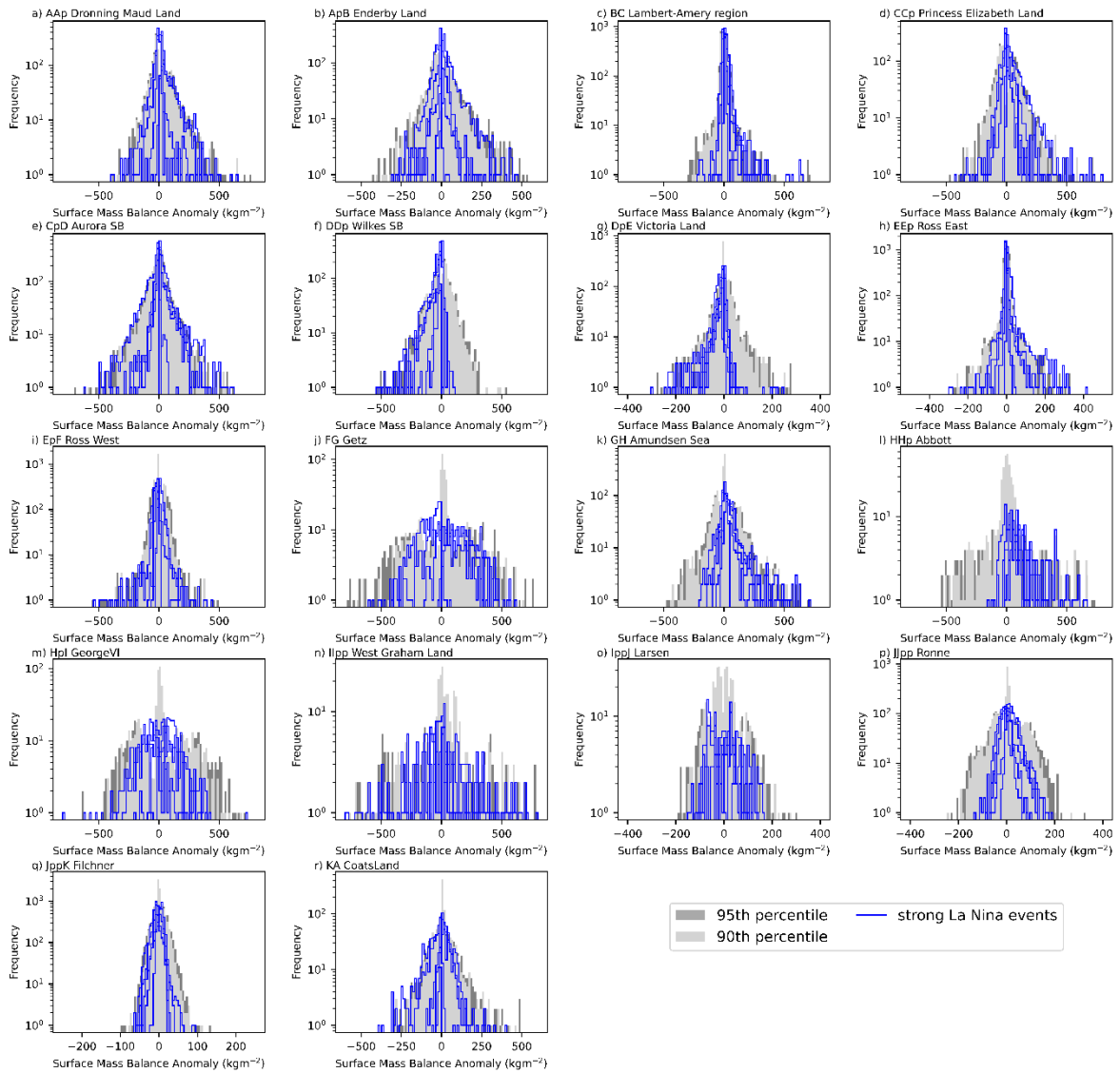
157 **Supplementary Figure S10.** Regional SMB probability distributions of SMB changes in
 158 SON for strong La Niña events (blue lines), and regional 90th (light grey shading) and 95th
 159 percentile (dark grey shading) SMB anomalies for SON for 1979-2018 period.

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Supplementary Figure S11. Regional SMB probability distributions of SMB changes in SON for La Niña events excluding strong events (light blue shading), during strong La Niña events (blue lines).



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166 **Supplementary Figure S12.** Regional SMB probability distributions of cumulative annual
 167 SMB anomalies (relative to 1979-2018 average) for strong La Niña events (blue lines) and
 168 regional 90th (light grey shading) and 95th percentile (dark grey shading) SMB anomalies for
 169 1979-2018 period.

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171 **Section 5.2: Statistical significance testing of regional SMB anomalies distributions**
 172 **during strong La Niña events.**
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	Kolmogorov-Smirnov (K-S) test									
	1988/89		1998/99		1999/00		2007/08		2010/11	
	statistic	p-value	statistic	p-value	statistic	p-value	statistic	p-value	statistic	p-value
AAp	0.266	<0.001	0.231	<0.001	0.181	<0.001	0.227	<0.001	0.257	<0.001
ApB	0.413	<0.001	0.233	<0.001	0.629	<0.001	0.495	<0.001	0.531	<0.001
BC	0.218	<0.001	0.320	<0.001	0.390	<0.001	0.226	<0.001	0.598	<0.001
CCp	0.527	<0.001	0.208	<0.001	0.544	<0.001	0.300	<0.001	0.346	<0.001
CpD	0.236	<0.001	0.290	<0.001	0.563	<0.001	0.292	<0.001	0.208	<0.001
DDp	0.409	<0.001	0.485	<0.001	0.352	<0.001	0.538	<0.001	0.176	<0.001
DpE	0.566	<0.001	0.511	<0.001	0.388	<0.001	0.172	<0.001	0.498	<0.001
EEp	0.434	<0.001	0.505	<0.001	0.454	<0.001	0.276	<0.001	0.171	<0.001
EpF	0.364	<0.001	0.346	<0.001	0.221	<0.001	0.399	<0.001	0.203	<0.001
FG	0.342	<0.001	0.625	<0.001	0.234	<0.001	0.601	<0.001	0.510	<0.001
GH	0.368	<0.001	0.767	<0.001	0.056	0.085	0.580	<0.001	0.101	<0.001
HHp	0.508	<0.001	0.714	<0.001	0.212	<0.001	0.552	<0.001	0.281	<0.001
Hpl	0.404	<0.001	0.595	<0.001	0.624	<0.001	0.224	<0.001	0.482	<0.001
Ilpp	0.478	<0.001	0.272	<0.001	0.192	<0.001	0.484	<0.001	0.411	<0.001
IppJ	0.341	<0.001	0.478	<0.001	0.449	<0.001	0.749	<0.001	0.651	<0.001
JJpp	0.200	<0.001	0.535	<0.001	0.314	<0.001	0.191	<0.001	0.643	<0.001
JppK	0.423	<0.001	0.042	<0.001	0.174	<0.001	0.280	<0.001	0.454	<0.001
K	0.176	<0.001	0.209	<0.001	0.360	<0.001	0.197	<0.001	0.313	<0.001

174 **Supplementary Table S3.** Kolmogorov-Smirnov test statistics and *p-value* results showing
 175 statistically significant difference in SMB SON distributions for strong La Niña events
 176 (1988/89, 1998/99, 1999/00, 2007/08, 2010/11) for each Antarctic region compared to the
 177 SMB SON distribution for the region for the full 1979-2018 time period with Monte Carlo
 178 Sampling and 1000 simulations. Results in **bold** are statistically significant at the 5%
 179 significance level.
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		Kolmogorov-Smirnov (K-S) test							
		1998/99		1999/00		2007/08		2010/11	
		statistic	p-value	statistic	p-value	statistic	p-value	statistic	p-value
AAp	1988/89	0.191	<0.001	0.233	<0.001	0.238	<0.001	0.320	<0.001
	1998/99	0.000	1.000	0.388	<0.001	0.245	<0.001	0.452	<0.001
	1999/00			0.000	1.000	0.195	<0.001	0.166	<0.001
	2007/08					0.000	1.000	0.288	<0.001
ApB	1988/89	0.645	<0.001	0.900	<0.001	0.893	<0.001	0.473	<0.001
	1998/99	0.000	1.000	0.593	<0.001	0.347	<0.001	0.728	<0.001
	1999/00			0.000	1.000	0.477	<0.001	0.928	<0.001
	2007/08					0.000	1.000	0.960	<0.001
BC	1988/89	0.528	<0.001	0.334	<0.001	0.108	<0.001	0.797	<0.001
	1998/99	0.000	1.000	0.661	0.103	0.525	<0.001	0.389	<0.001
	1999/00			0.000	1.000	0.286	<0.001	0.883	<0.001
	2007/08					0.000	1.000	0.823	<0.001
CCp	1988/89	0.727	<0.001	0.182	<0.001	0.713	<0.001	0.870	<0.001
	1998/99	0.000	1.000	0.749	<0.001	0.236	<0.001	0.202	<0.001
	1999/00			0.000	1.000	0.829	<0.001	0.880	<0.001
	2007/08					0.000	1.000	0.219	<0.001
CpD	1988/89	0.404	<0.001	0.633	<0.001	0.328	<0.001	0.361	<0.001
	1998/99	0.000	1.000	0.812	<0.001	0.132	<0.001	0.175	<0.001
	1999/00			0.000	1.000	0.853	<0.001	0.700	<0.001
	2007/08					0.000	1.000	0.163	<0.001
DDp	1988/89	0.868	<0.001	0.178	<0.001	0.923	<0.001	0.277	<0.001
	1998/99	0.000	1.000	0.834	<0.001	0.138	<0.001	0.603	<0.001
	1999/00			0.000	1.000	0.873	<0.001	0.245	<0.001
	2007/08					0.000	1.000	0.664	<0.001
DpE	1988/89	0.953	<0.001	0.821	<0.001	0.703	<0.001	0.445	<0.001
	1998/99	0.000	1.000	0.399	<0.001	0.678	<0.001	0.794	<0.001
	1999/00			0.000	1.000	0.548	<0.001	0.659	<0.001
	2007/08					0.000	1.000	0.617	<0.001
EEp	1988/89	0.289	<0.001	0.842	<0.001	0.700	<0.001	0.488	<0.001
	1998/99	0.000	1.000	0.854	<0.001	0.728	<0.001	0.488	<0.001
	1999/00			0.000	1.000	0.423	<0.001	0.388	<0.001
	2007/08					0.000	1.000	0.290	<0.001
EpF	1988/89	0.176	<0.001	0.329	<0.001	0.759	<0.001	0.555	<0.001
	1998/99	0.000	1.000	0.330	<0.001	0.696	<0.001	0.454	<0.001
	1999/00			0.000	1.000	0.568	<0.001	0.298	<0.001
	2007/08					0.000	1.000	0.419	<0.001

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Supplementary Table S4. (continued on next page). Kolmogorov-Smirnov test statistics and p-value results showing statistically significant difference between SMB SON distributions between each strong La Niña events (1988/89, 1998/99, 1999/00, 2007/08, 2010/11) for each Antarctic region, with Monte Carlo Sampling and 1000 simulations. Results in **bold** are statistically significant at the 5% significance level.

		Kolmogorov-Smirnov (K-S) test							
		1998/99		1999/00		2007/08		2010/11	
		statistic	<i>p-value</i>	statistic	<i>p-value</i>	statistic	<i>p-value</i>	statistic	<i>p-value</i>
FG	1988/89	0.943	<0.001	0.494	<0.001	0.813	<0.001	0.841	<0.001
	1998/99	0.000	1.000	0.761	<0.001	0.972	<0.001	0.159	<0.001
	1999/00			0.000	1.000	0.778	<0.001	0.665	<0.001
	2007/08					0.000	1.000	0.949	<0.001
GH	1988/89	0.937	<0.001	0.339	<0.001	0.930	<0.001	0.355	<0.001
	1998/99	0.000	1.000	0.792	<0.001	0.820	<0.001	0.741	<0.001
	1999/00			0.000	1.000	0.594	<0.001	0.115	<0.001
	2007/08					0.000	1.000	0.600	<0.001
HHp	1988/89	0.798	<0.001	0.488	<0.001	0.964	<0.001	0.774	<0.001
	1998/99	0.000	1.000	0.917	<0.001	0.832	<0.001	0.940	<0.001
	1999/00			0.000	1.000	0.726	<0.001	0.369	<0.001
	2007/08					0.000	1.000	0.417	<0.001
Hpl	1988/89	0.556	<0.001	0.631	<0.001	0.299	<0.001	0.856	<0.001
	1998/99	0.000	1.000	0.096	<0.001	0.679	<0.001	0.963	<0.001
	1999/00			0.000	1.000	0.733	<0.001	0.947	<0.001
	2007/08					0.000	1.000	0.695	<0.001
Ilpp	1988/89	0.323	<0.001	0.583	<0.001	0.271	<0.001	0.792	<0.001
	1998/99	0.000	1.000	0.333	0.061	0.323	0.052	0.594	0.084
	1999/00			0.000	1.000	0.583	<0.001	0.344	<0.001
	2007/08					0.000	1.000	0.781	<0.001
lppJ	1988/89	0.778	<0.001	0.741	0.709	0.988	<0.001	0.951	<0.001
	1998/99	0.000	1.000	0.074	<0.001	0.975	0.744	0.296	<0.001
	1999/00			0.000	1.000	0.951	<0.001	0.346	<0.001
	2007/08					0.000	1.000	0.988	<0.001
JJpp	1988/89	0.685	<0.001	0.502	<0.001	0.153	<0.001	0.838	<0.001
	1998/99	0.000	1.000	0.750	<0.001	0.579	<0.001	0.929	<0.001
	1999/00			0.000	1.000	0.454	<0.001	0.721	<0.001
	2007/08					0.000	1.000	0.833	<0.001
JppK	1988/89	0.397	<0.001	0.591	<0.001	0.685	<0.001	0.178	<0.001
	1998/99	0.000	1.000	0.199	<0.001	0.304	<0.001	0.434	<0.001
	1999/00			0.000	1.000	0.140	<0.001	0.595	<0.001
	2007/08					0.000	1.000	0.721	<0.001
K	1988/89	0.228	<0.001	0.513	<0.001	0.356	<0.001	0.185	<0.001
	1998/99	0.000	1.000	0.379	<0.001	0.236	0.106	0.379	<0.001
	1999/00			0.000	1.000	0.202	<0.001	0.598	<0.001
	2007/08					0.000	1.000	0.459	<0.001

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