

## Supplementary Files for Climate and Disease in Australian Imperial Force (AIF) in World War 1 (WW1)

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Table S2 Mean winter (Dec-Feb) temperatures for Oxford, Southampton, Paris and Brussels 1915-1919, compared to the 30-year baseline averages (Dec-Feb) 1887-1916.

<b>Oxford (av 4.2 Deg C)</b>	<b>Dec</b>	<b>Jan</b>	<b>Feb</b>	<b>Winter</b>	<b>change from av</b>
30 yr av to 1916 (Deg C)	4.5	3.9	4.2	4.2	
1915 (Deg C)	5.3	4.4	4.9	4.9	0.7
1916 (Deg C)	4.2	7.7	2.6	4.8	0.6
1917 (Deg C)	1.8	1.7	1.5	1.6	-2.6
1918 (Deg C)	2.0	3.9	6.6	4.1	-0.1
1919 (Deg C)	7.5	2.9	1.7	4.0	-0.2
<b>Southampton (av 5.1 Deg C)</b>					
30 yr av to 1916 (Deg C)	5.5	4.7	5.1	5.1	
1915 (Deg C)	6.0	4.9	5.3	5.4	0.3
1916 (Deg C)	7.1	8.0	4.6	6.6	1.5
1917 (Deg C)	3.0	1.9	2.2	2.3	-2.8
1918 (Deg C)	2.7	4.8	6.6	4.7	-0.4
1919 (Deg C)	8.0	3.8	3.2	5.0	-0.1
<b>Paris (av 3.3 Deg C)</b>					
30 yr av to 1916 (Deg C)	3.4	2.5	3.8	3.3	
1915 (Deg C)	6	3.8	4.2	4.7	1.4
1916 (Deg C)	7.5	6.8	4.1	6.1	2.8
1917 (Deg C)	3.5	0.2	-1.1	0.9	-2.4
1918 (Deg C)	-0.1	2.5	4.8	2.4	-0.9
1919 (Deg C)	7.1	2.6	2.2	4	0.7
<b>Brussels (av 2.1 Deg C)</b>					
30 yr av to 1916 (Deg C)	2.6	1.5	2.4	2.1	
1915 (Deg C)	4.9	2.5	3.4	3.6	1.5
1916 (Deg C)	5.8	5.8	2.8	4.8	2.7
1917 (Deg C)	2.4	-1	-2.4	-0.3	-2.4
1918 (Deg C)	-0.6	2.9	4.6	2.3	0.2
1919 (Deg C)	5.8	1.6	0.9	2.8	0.7

Table S3: Temperature differences from the 1887-1916 average (in brackets) for the coldest previous winters (Dec-Feb) over United Kingdom and Western Front regions between 1881 and 1917 (°C)

Year	Difference from Average (Deg C) (1887-1916)				
	Oxford (4.2)	S'Hampton (5.1)	Paris (3.3)	Brussels (2.1)	Average
1891	-3.0	-3.0	-3.8	-3.5	-3.3
1895	-2.9	-2.7	-0.6	-3.1	-2.3
1917	-2.6	-2.8	-2.4	-2.4	-2.5

Table S4: Comparison of the extremes of the winter of 1917 across Europe (based on data from NASA)

City	Previous record	No. years	City	Previous record	No. years
Paris	1891	26	Berlin	1909	8
Brussels	1895	22	Basel	1909	8
Oxford	1895	22	Geneve (Fr)	1909	8
Southampton	1891	26	Randers (Den)	1900	17
Stockholm	1893	24	Torungen Fr	1900	17
Nantes	1895	22	Emden (W Ger)	1897	20
Hannover	1895	22	Breslau (Poland)	1909	8

Table S5: Comparison of categories of AIF deaths between the Official War History (OWH) and Australian War Memorial Roll of Honour (ROH) for specified time periods and location.

Locations are United Kingdom (UK), Western Front (WF), Middle East (ME), Australia (Aus), Died at Sea (DAS), German New Guinea (AN&MEF) and Other.

Categories of death are Killed in Action (KIA), Died of Wounds (DOW), Died of Disease (DD), Accident and other and Prisoners of War (POW). (Data excludes Died after Discharge)

		KIA	DOW	DD	Accident & other	POW	Total	ROH- OWH
UK (1915-1919)	ROH	9	642	1368	170		2189	936
	OWH	3	1	1072	177		1253	
WF (Apr 1916-Mar 1919)	ROH	34079	10146	1186	394	220	46025	-942
	OWH	33402	11356	1473	399	337	46967	
Gallipoli (Apr- Dec 1915)	ROH	5815	2025	347	14		8201	-217
	OWH	5833	1985	569	31		8418	
ME (Dec 14-Dec 1919)	ROH	660	328	751	130	60	1929	306
	OWH	636	337	454	136	60	1623	
Aus (1914-1919)	ROH		0	1317	218		1535	70
	OWH		34	1231	200		1465	
DAS* (1914-1919)	ROH			408	47		455	43
	OWH				412		412	
Other# (1914-1919)	ROH	8	3	67	42		120	11
	OWH	1		103	5		109	
AN&MEF (1914-1920)	ROH	2	3	20	23		48	
	OWH	2	3	21	22		48	0
								207
Total ROH	60,502							
Total OWH	60,295							
Difference from OWH	207	0.3%						
* Enroute and RTA only								
# Includes other DAS								

Table S6: Summary of total deaths in the Australian Military Forces during the First World War by location 1914-1921, including Prisoners of War (POW) as specified

Locations are United Kingdom including Ireland (UK), France and Belgium (including Denmark) (Western Front (WF), Died at sea (either returning to Australia (RTA) from Western Front (WF) or Middle East (ME), or En Route from Australia or other), German New Guinea with the Australian Naval and Military Expeditionary Force (AN&MEF) and other areas of conflict. Data Sources: Australian War Memorial Roll of Honour (ROH) and Australian National Archives records (NAA).

WW1 ROH		Deaths	
Germany/Switzerland (POW)		220	
UK/Ireland (in AIF)		2194	
UK (Died after Discharge)		13	
Belgium/Denmark		12684	
France		33150	
Died RTA from WF		124	
	S/T WF +UK		48385
Gallipoli/Greece/Malta/Gibraltar		8201	
ME ex Gallipoli		1871	
Turkey (POW)		60	
Died RTA from ME		34	
	S/T ME		10166
Australia (Still in AIF)		1681	
Australia (Died after discharge)		905	
Died at sea (Enroute from A)		297	
Died at Sea (other)		21	
German NG/Rabaul		49	
Other		52	
Other (Died after discharge)		4	
	S/T Other		3009
<b>Total</b>			<b>61560</b>
<b>Died after Discharge</b>			<b>922</b>
<b>Total deaths during WW1 on active service</b>			<b>60638</b>

Table S7: Australian War Memorial Roll of Honour (ROH) deaths for First World War 1914-1921. Categories of death are Killed in Action (KIA), Died of Wounds (DOW), Died of Disease (DD), Accident etc, Suicide, Drowned, Died after Discharge (DAD) and other). Locations are United Kingdom (UK), France, Belgium, Middle East and Gallipoli (ME), Germany and Turkey Prisoners of War (POW), Australia, German New Guinea (G NG), Died at Sea (returned to Australia (RTA), en route to the war from Australia (en route) and other)

All deaths 1914-1921	Accident					Died after			Total
	KIA	DOW	DD	etc	Suicide	Drowned	discharge	Other	
UK	9	642	1373	128	18	16	13	8	<b>2207</b>
France	23514	8178	1102	301	20	29		6	<b>33150</b>
Belgium	10566	1976	98	43		1			<b>12684</b>
Germany POW								220	<b>220</b>
ME	6475	2353	1098	90	18	28		10	<b>10072</b>
Turkey POW								60	<b>60</b>
Australia		0	1407	137	50	35	905	52	<b>2586</b>
G NG	2	3	21	5	2	16			<b>49</b>
Other	3		37	0	1	6	4	5	<b>56</b>
Died at Sea (RTA)			131	2	12	12		1	<b>158</b>
Died at Sea (en route)			277	7	3	8		2	<b>297</b>
Died at sea (other)	3		8	2		8			<b>21</b>
	<b>40572</b>	<b>13152</b>	<b>5552</b>	<b>715</b>	<b>124</b>	<b>159</b>	<b>922</b>	<b>364</b>	<b>61560</b>
									<b>61560</b>

Table S8: AIF disease deaths (DD) as percentages of total disease deaths and location disease deaths by specified time periods.

Locations are United Kingdom/Western Front (WF/UK), Middle East and Gallipoli (ME), Australia and Died at Sea (DAS)

Location	Period of analysis	DD	% location	% total (5552)
WF/UK	Apr 1916-Mar 1919	2469		44%
	(Apr-Sep)	568	23%	10%
	(Oct-Mar)	1901	77%	34%
	Dec 1916-Feb 1917	441	18%	8%
	Oct 1918-Mar 1919	1075	44%	19%
	Apr 1916-Sep 1918	1392		25%
	(Apr-Sep)	568	41%	10%
	(Oct-Mar)	824	59%	15%
	Dec 1916-Feb 1917	441	32%	8%
	ME	Dec 1914-Jan 1920	1098	
(May-Dec 1915) Gallipoli		347	32%	6%
(May-Dec 1915) ME ex Gallipoli		181	16%	3%
Combined May-Dec 1915		528	48%	10%
(Jan 1916-Jun 1916)		190	17%	3%
(Oct 1918-Dec 1918)		223	20%	4%
Australia	Sep 1914-Mar 1921	1407		25%
	1915	418	30%	8%
	1916	404	29%	7%
	1917	126	9%	2%
	1918	165	12%	3%
	1919	179	13%	3%
	1920	79	6%	1%
DAS	1914-1919	416		7%
	En Route	277	67%	5%
	RTA	131	31%	2%
	Other	8	2%	0%

Table S9: AIF disease deaths through hospitalization by reason of admission for specified location and time period compared to total disease deaths.

Locations are United Kingdom (UK) and France and Belgium (WF)

	UK	%	WF	%	Total	%
All Died of Disease	1373		1200		2573	
Already hospitalized	74	5%	22	2%	96	4%
Ill/Accident	24		12		36	37.5%
Wounded	50		10		60	62.5%
Dec 1916-Mar 1917	310		226		536	
Already hospitalized	7	2%	5	2%	12	2%
Ill/Accident	6		4		10	83.3%
Wounded	1		1		2	16.7%
Dec 1917-Mar 1918	83		68		151	
Already hospitalized	5	6%	2	3%	7	5%
Ill/Accident	3		2		5	71.4%
Wounded	2		0		2	28.6%
Dec 1918-Mar 1919	215		269		484	
Already hospitalized	7	3%	1	0%	8	2%
Ill/Accident	3		1		4	50.0%
Wounded	4		0		4	50.0%
Dec-Mar totals					27	2%
Ill/Accident					19	70%
Wounded					8	30%



Table S10: Monthly disease death(DD) as a proportion of average strength for Western Front (WF) and United Kingdom (UK) Apr 1916-Mar 1919. (monthly av. strength calculated as constant change between the months Jan, Apr, Jul and Oct)

Year	Month	WF	UK	Total	WF	UK	Combined	WF DD/av	UK DD/av	Combined	UK/WF DD ratio	
		DD	DD	WF+UK	Av strength	Av strength	Av strength	Ratio per 1000	Ratio per 1000	DD ratio per 1000		
1916	APR	13	4	17	40801	6863	47664	0.32	0.58	0.36	1.83	
	MAY	15	0	15	57750	34651	92401	0.26	0.00	0.16	0.00	
	JUN	21	6	27	74700	62439	137139	0.28	0.10	0.20	0.34	
	JUL	24	15	39	91649	90227	181876	0.26	0.17	0.21	0.63	
	AUG	11	18	29	90514	90319	180833	0.12	0.20	0.16	1.64	
	SEP	8	15	23	89379	90412	179791	0.09	0.17	0.13	1.85	
	OCT	7	27	34	88244	90504	178748	0.08	0.30	0.19	3.76	
	NOV	15	25	40	97902	82674	180576	0.15	0.30	0.22	1.97	
	DEC	88	63	151	107561	74843	182404	0.82	0.84	0.83	1.03	
	1917	JAN	48	82	130	117219	67013	184232	0.41	1.22	0.71	2.99
		FEB	55	105	160	118043	71601	189644	0.47	1.47	0.84	3.15
		MAR	35	60	95	118866	76190	195056	0.29	0.79	0.49	2.67
APR		34	46	80	119690	80778	200468	0.28	0.57	0.40	2.00	
MAY		8	24	32	120213	76144	196357	0.07	0.32	0.16	4.74	
JUN		8	22	30	120736	71509	192245	0.07	0.31	0.16	4.64	
JUL		7	22	29	121259	66875	188134	0.06	0.33	0.15	5.70	
AUG		14	17	31	119589	63391	182980	0.12	0.27	0.17	2.29	
SEP		6	16	22	117919	59906	177825	0.05	0.27	0.12	5.25	
OCT		10	22	32	116249	56422	172671	0.09	0.39	0.19	4.53	
NOV		10	22	32	116489	57411	173900	0.09	0.38	0.18	4.46	
DEC		15	14	29	116729	58401	175130	0.13	0.24	0.17	1.87	
1918	JAN	18	26	44	116969	59390	176359	0.15	0.44	0.25	2.84	
	FEB	16	13	29	118604	56376	174980	0.13	0.23	0.17	1.71	
	MAR	18	30	48	120240	53361	173601	0.15	0.56	0.28	3.76	
	APR	13	17	30	121875	50347	172222	0.11	0.34	0.17	3.17	
	MAY	17	20	37	119565	51804	171369	0.14	0.39	0.22	2.72	
	JUN	11	26	37	117255	53260	170515	0.09	0.49	0.22	5.20	
	JUL	16	19	35	114945	54717	169662	0.14	0.35	0.21	2.49	
	AUG	9	15	24	107296	56529	163825	0.08	0.27	0.15	3.16	
	SEP	13	18	31	99647	58340	157987	0.13	0.31	0.20	2.36	
	OCT	123	123	246	91998	60152	152150	1.34	2.04	1.62	1.53	
	NOV	216	127	343	89862	56426	146288	2.40	2.25	2.34	0.94	
	DEC	63	31	94	87726	52701	140427	0.72	0.59	0.67	0.82	
1919	JAN	28	33	61	85590	48975	134565	0.33	0.67	0.45	2.06	
	FEB	143	122	265	69323	53888	123211	2.06	2.26	2.15	1.10	
	MAR	37	31	68	53056	58800	111856	0.70	0.53	0.61	0.76	
Post Mar 1919		13	69	82	36789	63713	100502					
Av Apr 1916-Mar 1919					102096	62601	164697	0.37	0.58	0.44	2.55	

Table S11: AIF Disease Death (DD) and Morbidity (M) as proportions of average monthly strength and monthly Paris temperature for the Western Front. Data Sources: WF morbidity Mar 16-Dec 18 ( Butler, 1940 Vol II Appendix 1 P 865). WF Average strength (Butler, 1943 Vol III Ch XVII Table 27 p 897) No monthly morbidity data available for Jan-Mar 1919.

		DD	Av strength	Ratio	Ratio per 1000	M	DD/M	M/av strength	Paris T
Pre Mar 1916		0							
1916	MAR	1				40			
1916	AP	13	40801	0.0003	0.3	1720	0.8%	4.22E-02	9.7
	MAY	14	57750	0.0002	0.2	1667	0.8%	2.89E-02	14.4
	JUN	21	74700	0.0003	0.3	2148	1.0%	2.88E-02	13.4
	JUL	23	91649	0.0003	0.3	3603	0.6%	3.93E-02	16.7
	AU	11	90514	0.0001	0.1	3471	0.3%	3.83E-02	17.7
	S	8	89379	0.0001	0.1	3732	0.2%	4.18E-02	13.9
	O	7	88244	0.0001	0.1	4847	0.1%	5.49E-02	10.7
	N	15	97902	0.0002	0.2	12161	0.1%	1.24E-01	6.1
	D	88	107561	0.0008	0.8	12268	0.7%	1.14E-01	3.5
1917	JAN	48	117219	0.0004	0.4	10407	0.5%	8.88E-02	0.2
	F	55	118043	0.0005	0.5	9716	0.6%	8.23E-02	-1.1
	MAR	35	118866	0.0003	0.3	8197	0.4%	6.90E-02	3.8
	AP	34	119690	0.0003	0.3	7583	0.4%	6.34E-02	6.1
	MAY	8	120213	0.0001	0.1	6427	0.1%	5.35E-02	16.3
	JUN	8	120736	0.0001	0.1	6433	0.1%	5.33E-02	18.5
	JUL	7	121259	0.0001	0.1	7206	0.1%	5.94E-02	18
	AU	13	119589	0.0001	0.1	6096	0.2%	5.10E-02	16.4
	S	6	117919	0.0001	0.1	5965	0.1%	5.06E-02	15.4
	O	9	116249	0.0001	0.1	8376	0.1%	7.21E-02	8.5
	N	10	116489	0.0001	0.1	6193	0.2%	5.32E-02	7.5
	D	14	116729	0.0001	0.1	6485	0.2%	5.56E-02	-0.1
1918	JAN	18	116969	0.0002	0.2	7597	0.2%	6.49E-02	2.5
	F	16	118604	0.0001	0.1	6538	0.2%	5.51E-02	4.8
	MAR	18	120240	0.0001	0.1	7822	0.2%	6.51E-02	6.1
	AP	13	121875	0.0001	0.1	5968	0.2%	4.90E-02	8.3
	MAY	17	119565	0.0001	0.1	7751	0.2%	6.48E-02	15.2
	JUN	11	117255	0.0001	0.1	7943	0.1%	6.77E-02	15.1
	JUL	16	114945	0.0001	0.1	6191	0.3%	5.39E-02	18
	AU	9	107296	0.0001	0.1	6140	0.1%	5.72E-02	18
	S	13	99647	0.0001	0.1	4526	0.3%	4.54E-02	14.4
	O	123	91998	0.0013	1.3	4715	2.6%	5.13E-02	8.8
	N	216	89862	0.0024	2.4	4862	4.4%	5.41E-02	5.3
	D	62	87726	0.0007	0.7	3184	1.9%	3.63E-02	7.1
1919	JAN	27	85590	0.0003	0.3				
	F	143	69323	0.0021	2.1				
	MAR	37	53056	0.0007	0.7				

Post Mar 1919	13		
Total	1200	36789	207978
Apr16-Mar 19	1186		

Table S12: Disease Death (DD) and Morbidity (M) data for the United Kingdom compared to average strength and average monthly UK temperature between Oxford and Southampton

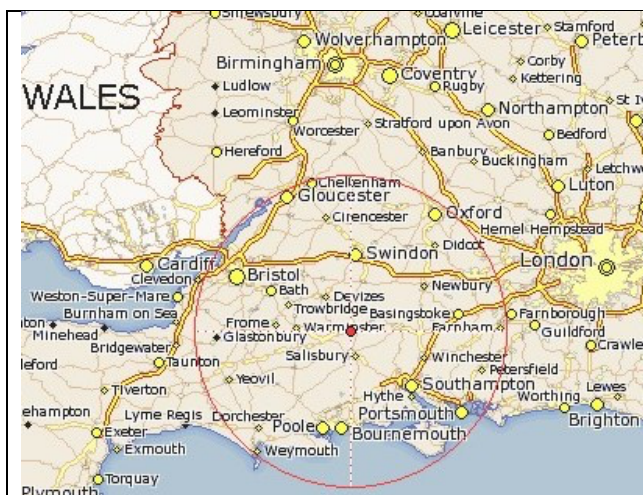
		DD UK	Av strength	Ratio/1000	Av UK T	Calculated M	DD/M	M/av strength
Pre Mar 1916		23						
1916	MAR	5						
	APR	4	6863	0.6	9.3	89	529	289
	MAY*	0	34651		12.8	276	0	1000
	JUN	6	62439	0.1	12.4	513	614	1795
	JUL	15	90227	0.2	16.3	2217	2252	3547
	AUG	18	90319	0.2	17.6	5668	5680	3464
	SEP	15	90412	0.2	13.8	7078	6998	3775
	OCT	27	90504	0.3	11.9	19174	18696	4971
	NOV	25	82674	0.3	7.0	17116	20268	10269
	DEC	63	74843	0.8	2.4	6111	8783	8536
1917	JAN	82	67013	1.2	1.8	10164	17779	5950
	FEB	105	71601	1.5	1.8	11251	18549	5893
	MAR	60	76190	0.8	3.8	9007	14052	5254
	APR	46	80778	0.6	6.4	6924	10259	5118
	MAY	24	76144	0.3	14.0	12213	19281	4071
	JUN	22	71509	0.3	16.3	10478	17691	3810
	JUL	22	66875	0.3	16.8	12490	22647	3974
	AUG	17	63391	0.3	16.0	3924	7402	3231
	SEP	16	59906	0.3	14.8	8081	15907	3030
	OCT	22	56422	0.4	8.5	8944	18427	4065
	NOV	22	57411	0.4	8.3	6715	13625	3052
	DEC	14	58401	0.2	2.4	3028	6053	3245
1918	JAN	26	59390	0.4	4.3	5572	10973	3857
	FEB	13	56376	0.2	6.7	2525	5312	3108
	MAR	30	53361	0.6	6.7	5786	13037	3471
	APR	17	50347	0.3	7.5	3224	7804	2465
	MAY	20	51804	0.4	13.9	3951	9119	3358
	JUN	26	53260	0.5	14.1	8528	18774	3608
	JUL	19	54717	0.3	16.5	3500	7352	2947
	AUG	15	56529	0.3	16.7	5391	10233	3235
	SEP	18	58340	0.3	13.0	3669	6267	2650
	OCT	123	60152	2.0	9.9	3083	4715	3083
	NOV	127	56426	2.3	6.4	1795	2859	3053
	DEC	31	52701	0.6	7.7	941	1567	1913
1919	JAN	33	48975	0.7				
	FEB	122	53888	2.3				
	MAR	31	58800	0.5				
	APR	22	63713					
Post Mar 1919		47						
Total		1373				209424	343502	125090
Apr16-Mar 19		1276						
OWH						77773		

Table S13: Correlation and p-value statistics

	Pearson correlation	n	t-stat	p-value
Monthly av SH/Ox T 1914-1919	0.998	72	134.75	<0.001*
Monthly av Paris/Brussels T 1914-1919	0.995	72	83.35	<0.001*
UK/WF av T 1914-1919	0.985	72	47.76	<0.001*
UK/WF av T Apr 1916-Dec 1918	0.988	33	35.62	<0.001*
UK/Paris av T Apr 1916-Dec 1918	0.988	33	35.62	<0.001*
Paris/Brussels winter T 1881-1919	0.915	38	13.61	<0.001*
S/Hampton/Oxford winter T 1881-1919	0.978	38	28.13	<0.001*
Av UK/WF winter T 1881-1919	0.901	38	12.46	<0.001*
SQRT Monthly UK/WF DD Apr 1916-Mar 1919	0.800	30		<0.001*
SQRT Monthly UK/WF DD Apr 1916-Mar 1917	0.569	12	2.47	0.019***
SQRT Monthly UK/WF DD Apr 1917-Mar 1918	0.571	12	-1.19	0.244
SQRT Monthly UK/WF DD Apr 1918-Mar 1919	0.943	12	0.553	0.584
SQRT WF DD morbidity Apr 1916-Mar 1918	0.469	20		0.005**
SQRT WF DD/morbidity Apr 1916-Mar 1917	0.670	12	3.94	<0.001*
SQRT WF DD/morbidity Apr 1917-Mar 1918	0.417	12	2.07	0.052

\*Significant at  $p < 0.001$ \*\* Significant at  $p < 0.01$ \*\*\* Significant at  $p < 0.05$

Figure S1: Maps of Southern UK and the Western Front



<http://www.itraveluk.co.uk/maps/england/all/1191/lark-hill.html>

Location of Lark Hill in relation to Oxford and Southampton



<https://anzacday.org.au/maps-of-world-war-1>  
courtesy of Department of Public Information – Army

Location of AIF engagement on Western Front

Figure S2: Maps of Gallipoli, Turkey and Middle East campaigns



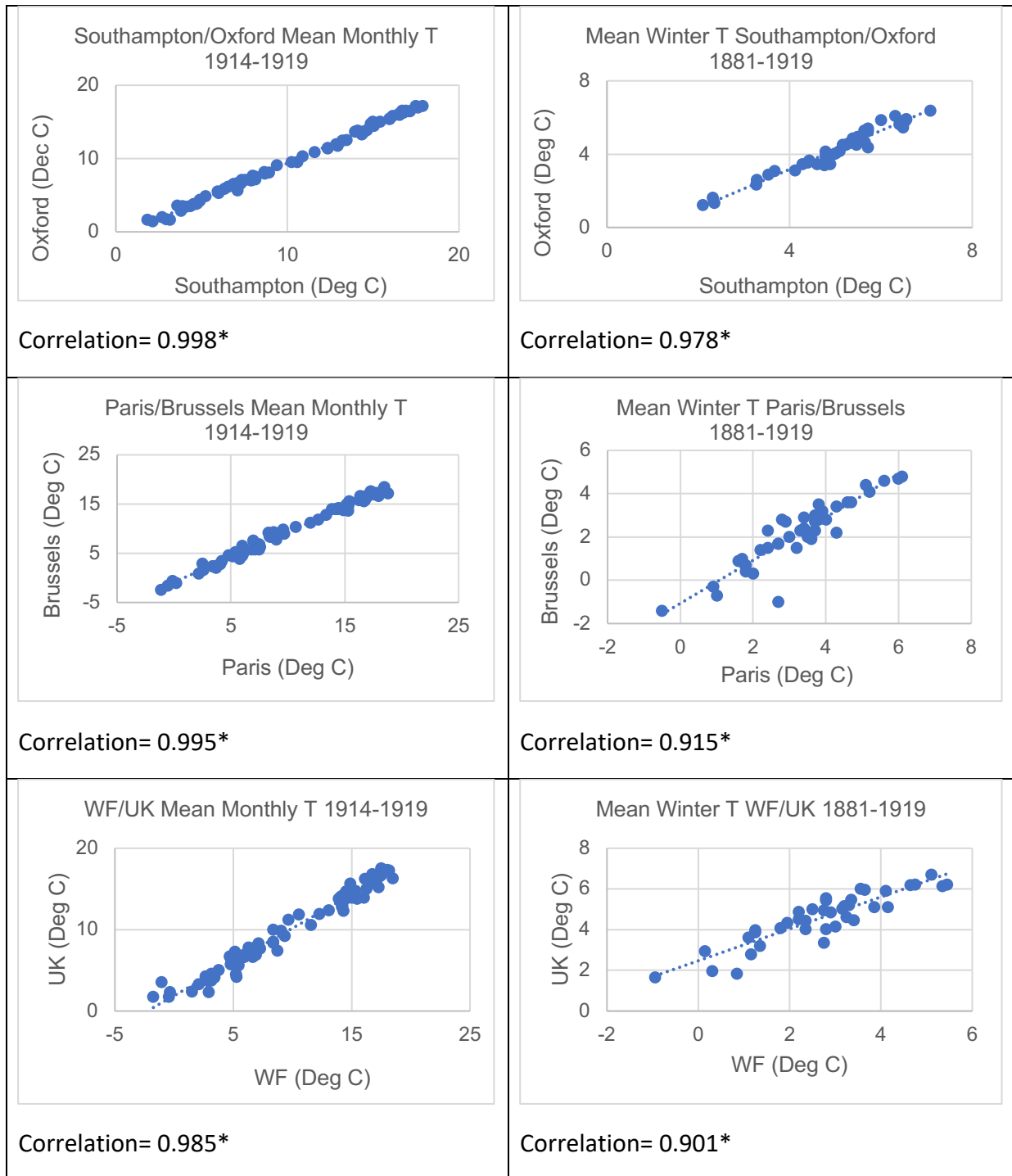
<https://anzacday.org.au/maps-of-world-war-1>  
courtesy of Department of Public Information – Army

Green colours indicate terrain heights.



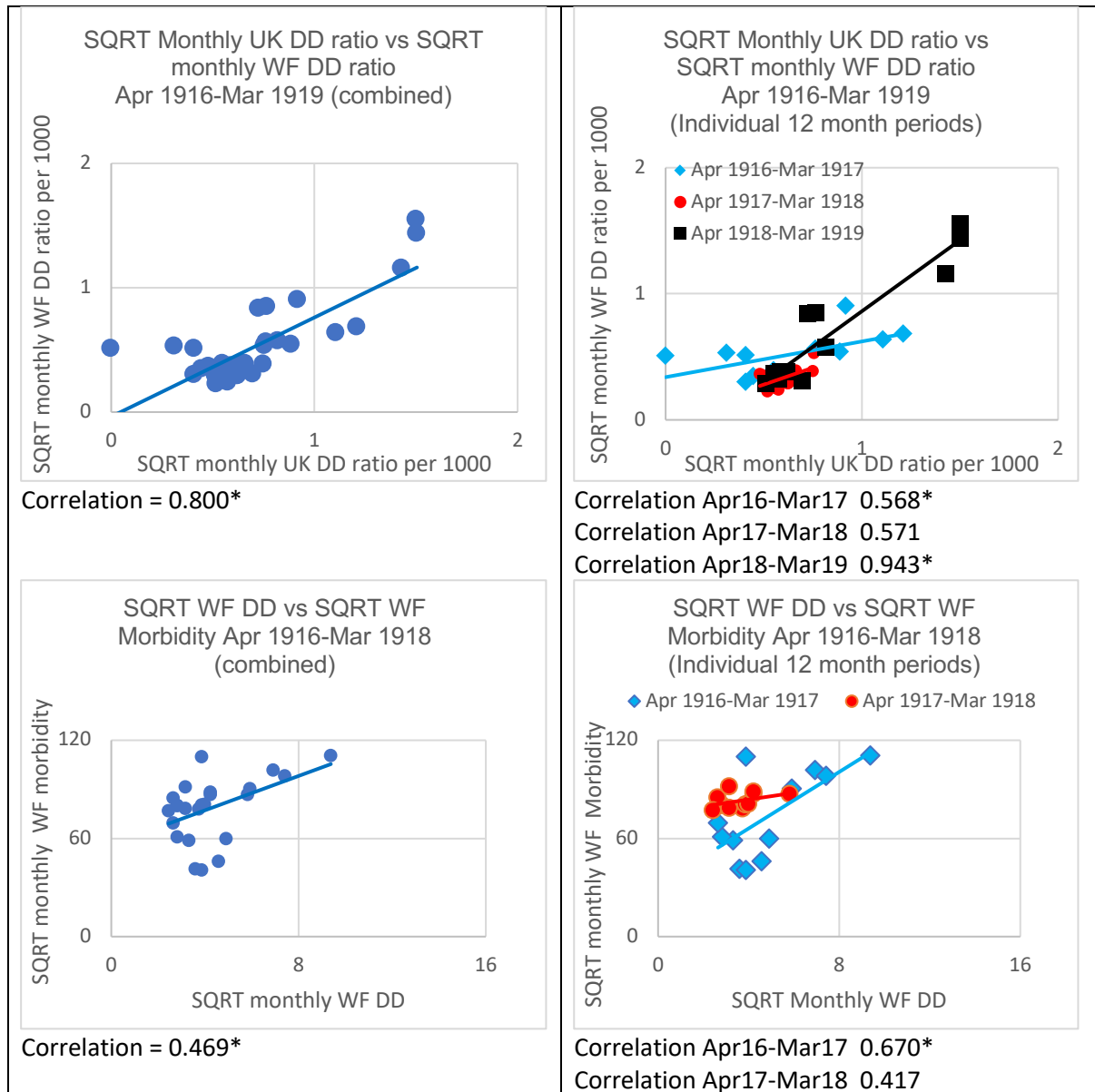
<https://anzacday.org.au/maps-of-world-war-1>  
courtesy of Department of Public Information - Army

Figure S3: Correlations between mean monthly and winter temperatures in southern United Kingdom (Oxford and Southampton) and Western Front (Paris and Brussels)



\*significant at p-value<0.001

Figure S4: Comparisons of Square Root monthly United Kingdom (UK)/Western Front (WF) disease death (DD)ratios per 1000 Apr 1916-Mar 1919 and Square root WF monthly disease death/morbidity data Apr 1916-Mar 1918 (total and individual 12-month periods)



\*significant at p value<0.05



Figure S5: Statistical plots associated with Residual Analysis (rsplot, qqnorm and Cooksd)

