

# Supplement

**Table S1 Out-of-fold (OOF) blocked cross-validation skill metrics for the monthly statistical reconstructions over the calibration period 1930-1994 in the SA9 domain. Model performance is reported for LASSO and Random Forest models using root mean square error (RMSE), Pearson's correlation coefficient (R), Spearman's rank correlation coefficient ( $\rho$ ), mean absolute error (MAE) and percent bias (PBIAS). Ensemble predictions are derived from a weighted combination of the two models, with weights computed from inverse-squared RMSE values and normalised within each month.**

1930-1994 Month/Season	Lasso						Random Forest						Ensemble				
	RMSE	Pearson's R	Spearman's $\rho$	MAE	PBIAS	Weight	RMSE	Pearson's R	Spearman's $\rho$	MAE	PBIAS	Weight	RMSE	Pearson's R	Spearman's $\rho$	MAE	PBIAS
<b>Jan</b>	19.92	0.82	0.80	15.14	0.22	0.57	23.04	0.74	0.74	17.86	0.38	0.43	20.51	0.80	0.79	15.80	0.29
<b>Feb</b>	17.38	0.85	0.87	13.37	0.57	0.58	20.61	0.79	0.82	16.38	0.00	0.42	18.04	0.84	0.86	13.99	0.33
<b>Mar</b>	19.36	0.77	0.71	15.78	-0.88	0.56	21.86	0.70	0.68	17.39	-0.19	0.44	20.16	0.75	0.71	16.29	-0.58
<b>Apr</b>	14.90	0.78	0.80	11.03	1.04	0.57	17.05	0.71	0.72	13.21	2.78	0.43	15.42	0.77	0.78	11.71	1.79
<b>May</b>	21.84	0.76	0.79	16.56	-0.40	0.59	26.18	0.63	0.66	19.27	0.36	0.41	22.91	0.74	0.76	16.58	-0.09
<b>Jun</b>	22.38	0.72	0.72	17.83	-0.38	0.54	24.02	0.67	0.67	18.33	2.64	0.46	22.74	0.71	0.72	17.77	1.03
<b>Jul</b>	21.74	0.73	0.75	17.30	-0.78	0.53	22.89	0.69	0.73	18.85	-0.43	0.47	22.10	0.72	0.73	17.98	-0.61
<b>Aug</b>	22.69	0.76	0.77	18.31	0.14	0.53	24.03	0.74	0.74	19.79	1.26	0.47	22.85	0.76	0.77	18.66	0.66
<b>Sep</b>	25.99	0.72	0.75	20.76	-0.28	0.53	27.37	0.68	0.67	22.37	-1.14	0.47	26.11	0.71	0.72	20.98	-0.69
<b>Oct</b>	24.80	0.78	0.79	18.83	1.10	0.54	26.66	0.73	0.73	20.74	0.65	0.46	25.15	0.77	0.78	19.08	0.89
<b>Nov</b>	25.37	0.73	0.75	19.09	0.47	0.52	26.29	0.70	0.71	20.06	-0.46	0.48	25.39	0.73	0.76	18.93	0.02
<b>Dec</b>	24.45	0.73	0.70	19.17	-1.12	0.54	26.55	0.67	0.67	19.88	-0.46	0.46	24.38	0.73	0.71	18.13	-0.82
<b>Annual</b>	81.55	0.70	0.70	65.63	-0.03	-	85.62	0.66	0.67	67.39	0.36	-	81.30	0.69	0.70	64.98	0.14
<b>Winter</b>	39.50	0.80	0.79	30.96	-0.24	-	44.97	0.73	0.73	34.52	-0.13	-	40.78	0.78	0.77	31.42	-0.18
<b>Spring</b>	33.92	0.76	0.75	25.39	-0.12	-	36.69	0.72	0.72	27.49	0.91	-	34.23	0.76	0.75	25.24	0.32
<b>Summer</b>	41.23	0.74	0.76	31.23	-0.32	-	42.62	0.71	0.75	31.73	1.13	-	41.15	0.74	0.76	31.00	0.36
<b>Autumn</b>	45.33	0.72	0.72	36.26	0.43	-	50.72	0.64	0.63	39.80	-0.31	-	46.99	0.69	0.68	37.18	0.08
<b>MJJA</b>	45.29	0.77	0.74	35.73	-0.34	-	48.80	0.73	0.73	37.73	0.94	-	45.62	0.77	0.77	36.03	0.25

**Table S2 Out-of-fold (OOF) blocked cross-validation skill metrics for the monthly statistical reconstructions over the calibration period 1930-1994 in the SA-upland domain. Model performance is reported for LASSO and Random Forest models using root mean square error (RMSE), Pearson's correlation coefficient (R), Spearman's rank correlation coefficient ( $\rho$ ), mean absolute error (MAE) and percent bias (PBIAS). Ensemble predictions are derived from a weighted combination of the two models, with weights computed from inverse-squared RMSE values and normalised within each month.**

1930-1994 Month	Lasso						Random Forest						Ensemble				
	RMSE	Pearson's R	Spearman's $\rho$	MAE	PBIAS	Weight	RMSE	Pearson's R	Spearman's $\rho$	MAE	PBIAS	Weight	RMSE	Pearson's R	Spearman's $\rho$	MAE	PBIAS
Jan	33.65	0.80	0.79	26.67	-0.75	0.57	38.97	0.72	0.71	31.43	0.31	0.43	35.11	0.78	0.76	28.09	-0.30
Feb	26.74	0.85	0.87	20.72	0.26	0.59	31.95	0.77	0.80	25.00	-0.06	0.41	27.71	0.83	0.85	22.10	0.13
Mar	31.00	0.77	0.71	25.15	-0.24	0.56	34.75	0.70	0.67	28.69	-0.35	0.44	32.28	0.75	0.71	26.64	-0.29
Apr	22.81	0.78	0.77	17.52	0.96	0.55	25.20	0.72	0.71	19.78	-0.52	0.45	23.25	0.77	0.75	18.23	0.29
May	30.25	0.79	0.82	22.56	-0.08	0.57	34.76	0.72	0.73	25.07	0.26	0.43	31.06	0.78	0.80	22.21	0.07
Jun	25.59	0.77	0.76	20.65	-0.40	0.56	28.73	0.70	0.69	22.55	1.95	0.44	26.22	0.76	0.75	21.16	0.64
Jul	24.89	0.82	0.84	19.63	-1.99	0.55	27.74	0.76	0.78	22.31	0.04	0.45	24.96	0.81	0.84	19.64	-1.09
Aug	32.68	0.77	0.82	25.43	0.27	0.50	32.79	0.77	0.82	25.22	1.25	0.50	31.82	0.79	0.83	24.62	0.76
Sep	32.70	0.78	0.79	26.84	-0.18	0.56	36.92	0.71	0.68	31.21	-0.87	0.44	33.56	0.77	0.76	28.11	-0.48
Oct	36.62	0.75	0.78	27.78	0.10	0.53	38.64	0.71	0.72	30.14	0.56	0.47	35.47	0.77	0.79	27.20	0.31
Nov	38.41	0.73	0.75	29.17	0.04	0.53	40.47	0.69	0.67	32.15	-0.64	0.47	38.58	0.72	0.73	29.84	-0.28
Dec	35.67	0.77	0.76	29.25	-0.13	0.57	41.46	0.67	0.65	34.35	-0.55	0.43	37.13	0.75	0.72	30.22	-0.31
Annual	128.11	0.67	0.66	102.93	-0.18	-	134.55	0.63	0.63	107.92	0.05	-	127.48	0.67	0.66	102.24	-0.08
Winter	60.45	0.82	0.83	49.58	-0.59	-	72.23	0.73	0.73	58.77	-0.44	-	64.36	0.79	0.81	53.20	-0.52
Spring	52.68	0.77	0.76	39.54	0.17	-	54.18	0.76	0.75	39.65	-0.21	-	52.15	0.78	0.78	38.52	0.00
Summer	51.04	0.78	0.79	38.98	-0.68	-	50.85	0.77	0.80	37.36	1.05	-	49.08	0.79	0.80	36.68	0.11
Autumn	69.29	0.70	0.70	55.42	-0.01	-	77.45	0.61	0.58	61.80	-0.31	-	70.90	0.68	0.68	56.17	-0.15
MJJA	56.42	0.80	0.77	43.94	-0.53	-	59.97	0.77	0.77	45.56	0.85	-	55.26	0.81	0.81	43.69	0.10

**Table S3 Robustness estimates for the calibration period for the SA9 (top) and SA-upland (bottom) rainfall reconstruction using a true split-period approach, based on the tree-ring  $\delta^{18}\text{O}$ -based reconstruction. Two configurations are shown: calibration over 1930-1965 with verification over 1966-2000, and its reverse arrangement. Model performance is evaluated using root mean square error (RMSE), Pearson's correlation coefficient (R), mean absolute error (MAE) and percent bias (PBIAS), computed from paired observed and reconstructed values within each verification period.**

Domain	Model	Cal/Val	Period	RMSE	Pearson's R	MAE	PBIAS
SA9	Early calibration - Late validation	calibration	1930-1965	68.71	0.54	54.62	>0.01
		validation	1966-2000	62.71	0.55	48.57	4.65
	Late calibration - Early validation	calibration	1966-2000	62.66	0.55	47.70	>0.01
		validation	1930-1965	70.94	0.54	55.65	-3.87
SA-upland	Early calibration - Late validation	calibration	1930-1965	90.13	0.52	73.19	>0.01
		validation	1966-2000	85.64	0.54	68.59	5.06
	Late calibration - Early validation	calibration	1966-2000	88.45	0.54	70.64	>0.01
		validation	1930-1965	97.45	0.52	80.34	-3.61

**Table S4 Top 20 wettest and driest years (1865-1977) for observations and reconstructions. Years highlighted by bold are extreme years present in both the Jenkinson and statistical reconstructions' top 20.**

	SA9						SAupland						
	Ensemble		Jenkinson		Observed		Ensemble		Jenkinson		Observed		
	Rank	Year	Annual totals	Year	Annual totals	Year	Annual totals	Year	Annual totals	Year	Annual totals	Year	Annual totals
Wettest	1	<b>1872</b>	1153.27	<b>1872</b>	1154.17	1960	1208.93	<b>1872</b>	1660.34	<b>1872</b>	1638.94	1960	1768.61
	2	<b>1903</b>	1122.18	<b>1960</b>	1133.33	1958	1159.96	1924	1632.35	<b>1960</b>	1609.35	1872	1687.71
	3	<b>1924</b>	1096.77	1928	1128.8	1872	1158.39	<b>1903</b>	1630.54	<b>1928</b>	1602.92	1882	1685.83
	4	1927	1096.4	<b>1903</b>	1110.68	1916	1137.06	<b>1960</b>	1586.84	<b>1903</b>	1577.19	1966	1680.39
	5	<b>1960</b>	1090.16	<b>1958</b>	1106.15	1882	1132.84	<b>1930</b>	1586.51	<b>1958</b>	1570.76	1958	1626.59
	6	<b>1877</b>	1080.06	<b>1877</b>	1105.25	1900	1128.88	1927	1577.51	<b>1877</b>	1569.47	1877	1624.63
	7	<b>1930</b>	1077.94	<b>1924</b>	1092.57	1966	1126.04	1951	1543.36	1924	1551.46	1946	1619.84
	8	<b>1958</b>	1063.09	<b>1954</b>	1074.45	1930	1109.67	1912	1538.36	<b>1954</b>	1525.73	1930	1586.8
	9	1951	1060.72	<b>1966</b>	1055.42	1877	1105.93	<b>1958</b>	1528.91	<b>1966</b>	1498.72	1947	1568.63
	10	<b>1910</b>	1043.5	<b>1882</b>	1052.7	1946	1100.82	1866	1518.27	<b>1882</b>	1494.86	1876	1554
	11	<b>1916</b>	1042.48	1938	1048.17	1947	1089.29	<b>1966</b>	1516.16	1938	1488.43	1965	1553.6
	12	1912	1038.91	<b>1948</b>	1043.64	1910	1075.85	<b>1877</b>	1508.8	<b>1948</b>	1481.99	1928	1550.84
	13	1866	1038.05	<b>1930</b>	1039.12	1924	1068.04	<b>1928</b>	1492.29	<b>1930</b>	1475.56	1900	1532.24
	14	<b>1966</b>	1031.56	<b>1965</b>	1030.96	1876	1066.89	<b>1882</b>	1491.58	<b>1965</b>	1463.98	1897	1512.36
	15	<b>1882</b>	1029.09	<b>1900</b>	1030.06	1954	1055.99	<b>1910</b>	1487.87	<b>1900</b>	1462.7	1954	1490.82
	16	1928	1028.06	<b>1947</b>	1023.71	1897	1052.97	1950	1486.69	<b>1947</b>	1453.69	1875	1480.57
	17	<b>1965</b>	1027.51	<b>1916</b>	1021	1965	1050.03	<b>1965</b>	1477.8	1916	1449.83	1910	1480.54
	18	<b>1954</b>	1025.44	<b>1946</b>	1016.47	1948	1037.74	<b>1954</b>	1469.54	<b>1946</b>	1443.4	1977	1474.65
	19	1891	1020.18	<b>1897</b>	1015.56	1931	1036.82	<b>1946</b>	1464.8	<b>1897</b>	1442.11	1948	1472.72
	20	1950	1017.93	1950	1011.94	1903	1030.08	1916	1460.58	1950	1436.97	1903	1468.65
Driest	1	<b>1921</b>	673.58	<b>1887</b>	647.75	1887	559.75	<b>1921</b>	988.08	<b>1887</b>	919.81	1887	718.29
	2	1973	739.42	<b>1933</b>	689.42	1971	682.73	<b>1887</b>	1023.07	<b>1933</b>	978.99	1971	898.75
	3	<b>1887</b>	741.07	<b>1893</b>	695.76	1893	685.13	1973	1035.45	<b>1893</b>	988	1884	945.18
	4	<b>1949</b>	757.23	<b>1971</b>	719.32	1933	688.9	<b>1975</b>	1078.82	<b>1971</b>	1021.44	1873	946.06
	5	<b>1975</b>	758.89	<b>1953</b>	770.05	1884	720.54	<b>1949</b>	1093.41	<b>1953</b>	1093.48	1870	994.85
	6	<b>1971</b>	761.56	<b>1975</b>	775.49	1922	724.34	<b>1933</b>	1099.82	<b>1975</b>	1101.2	1921	1002.36
	7	<b>1870</b>	766.43	<b>1952</b>	779.11	1949	726.2	<b>1971</b>	1102.76	<b>1952</b>	1106.35	1922	1009.13
	8	<b>1933</b>	766.51	<b>1870</b>	781.83	1953	726.69	<b>1870</b>	1115.83	<b>1870</b>	1110.21	1933	1021.02
	9	<b>1953</b>	785.08	1941	783.64	1975	733.45	<b>1953</b>	1129.92	1941	1112.78	1949	1023.62
	10	1976	788.3	<b>1921</b>	788.17	1873	743.12	<b>1905</b>	1151.42	<b>1921</b>	1119.21	1917	1038.97
	11	1956	800.48	<b>1969</b>	794.51	1870	748.28	1955	1157.18	<b>1969</b>	1128.22	1893	1040.76
	12	1955	804.95	<b>1905</b>	797.23	1921	754.79	1976	1161.66	<b>1905</b>	1132.08	1975	1050.12
	13	<b>1905</b>	817.73	1955	808.1	1945	760.96	1956	1166.54	1955	1147.52	1953	1050.17
	14	1962	829.42	1919	815.35	1952	765.73	1896	1172.64	<b>1919</b>	1157.81	1905	1055.14
	15	1896	832.88	<b>1885</b>	819.88	1905	768.38	1874	1199.22	<b>1885</b>	1164.24	1885	1072.53
	16	<b>1945</b>	834.85	1889	820.78	1906	776.63	1944	1200.97	1889	1165.53	1869	1077.32
	17	1944	841.14	<b>1922</b>	823.5	1961	787.72	1964	1202.97	<b>1922</b>	1169.39	1919	1087.57
	18	1964	847.33	1902	823.5	1904	793.12	<b>1969</b>	1211.33	1902	1169.39	1969	1092.94
	19	1959	850.66	1909	832.56	1969	794.41	1962	1212.76	1906	1182.25	1935	1098.78
	20	1899	851.32	<b>1906</b>	832.56	1885	800.38	<b>1952</b>	1219.92	1909	1182.25	1952	1105.85

**Table S5 Jaccard Index (JI) scores for the agreement between reconstructed and observed rainfall in identifying the top 20 wettest and driest years in SA9 across annual and seasonal aggregations. Results are shown for the Jenkinson reconstruction, statistical ensemble (ENS), and  $\delta^{18}\text{O}$  based reconstruction (MJJA only), all compared against observations over the period 1865-1977. The numerator represents the number of years common to both the reconstruction and observed top-20 lists (intersection), while the denominator represents the total number of unique years across both lists (union). JI values range from 0 (no overlap) to 1 (complete agreement), with higher values indicating greater consistency in the identification of extreme years.**

Series	Model vs Obs.	Type	Numerator	Denominator	JI
ANN	Jenk vs Obs.	Wettest	16	23	0.67
ANN	Jenk vs Obs.	Driest	14	26	0.54
ANN	Ens vs Obs.	Wettest	13	27	0.48
ANN	Ens vs Obs.	Driest	10	30	0.33
DJF	Jenk vs Obs.	Wettest	15	25	0.60
DJF	Jenk vs Obs.	Driest	14	26	0.54
DJF	Ens vs Obs.	Wettest	14	26	0.54
DJF	Ens vs Obs.	Driest	13	27	0.48
MAM	Jenk vs Obs.	Wettest	14	26	0.54
MAM	Jenk vs Obs.	Driest	13	27	0.48
MAM	Ens vs Obs.	Wettest	10	30	0.33
MAM	Ens vs Obs.	Driest	12	28	0.43
JJA	Jenk vs Obs.	Wettest	15	25	0.60
JJA	Jenk vs Obs.	Driest	15	25	0.60
JJA	Ens vs Obs.	Wettest	12	28	0.43
JJA	Ens vs Obs.	Driest	12	28	0.43
SON	Jenk vs Obs.	Wettest	11	29	0.38
SON	Jenk vs Obs.	Driest	16	24	0.67
SON	Ens vs Obs.	Wettest	10	30	0.33
SON	Ens vs Obs.	Driest	14	26	0.54
MJJA	Jenk vs Obs.	Wettest	15	25	0.60
MJJA	Jenk vs Obs.	Driest	16	24	0.67
MJJA	Ens vs Obs.	Wettest	12	28	0.43
MJJA	Ens vs Obs.	Driest	12	28	0.43
MJJA	Trees vs Obs.	Wettest	11	29	0.38
MJJA	Trees vs Obs.	Driest	9	31	0.29

**Table S6 Jaccard Index (JI) scores for the agreement between reconstructed and observed rainfall in identifying the top 20 wettest and driest years in SA-upland across annual and seasonal aggregations. Results are shown for the Jenkinson reconstruction, statistical ensemble (ENS), and  $\delta^{18}\text{O}$  based reconstruction (MJJA only), all compared against observations over the period 1865-1977. The numerator represents the number of years common to both the reconstruction and observed top-20 lists (intersection), while the denominator represents the total number of unique years across both lists (union). JI values range from 0 (no overlap) to 1 (complete agreement), with higher values indicating greater consistency in the identification of extreme years.**

Series	Model vs Obs.	Type	Numerator	Denominator	JI
ANN	Jenk vs Obs.	Wettest	16	24	0.67
ANN	Jenk vs Obs.	Driest	14	26	0.54
ANN	Ens vs Obs.	Wettest	13	27	0.48
ANN	Ens vs Obs.	Driest	11	29	0.38
DJF	Jenk vs Obs.	Wettest	13	27	0.48
DJF	Jenk vs Obs.	Driest	14	26	0.54
DJF	Ens vs Obs.	Wettest	13	27	0.48
DJF	Ens vs Obs.	Driest	13	27	0.48
MAM	Jenk vs Obs.	Wettest	14	26	0.54
MAM	Jenk vs Obs.	Driest	13	27	0.48
MAM	Ens vs Obs.	Wettest	13	27	0.48
MAM	Ens vs Obs.	Driest	13	27	0.48
JJA	Jenk vs Obs.	Wettest	16	24	0.67
JJA	Jenk vs Obs.	Driest	15	25	0.60
JJA	Ens vs Obs.	Wettest	14	26	0.54
JJA	Ens vs Obs.	Driest	13	27	0.48
SON	Jenk vs Obs.	Wettest	12	28	0.43
SON	Jenk vs Obs.	Driest	14	26	0.54
SON	Ens vs Obs.	Wettest	12	28	0.43
SON	Ens vs Obs.	Driest	10	30	0.33
MJJA	Jenk vs Obs.	Wettest	13	27	0.48
MJJA	Jenk vs Obs.	Driest	16	24	0.67
MJJA	Ens vs Obs.	Wettest	13	27	0.48
MJJA	Ens vs Obs.	Driest	16	24	0.67
MJJA	Trees vs Obs.	Wettest	9	31	0.29
MJJA	Trees vs Obs.	Driest	10	30	0.33

Figure S1 Extended Dublin Snow and Sleet (DSS) series (1748-1974). Annual number of days with observed snow and/or sleet (black), with 10-year running mean (blue).

### Extended Dublin Snow/Sleet Series

