



## South Eastern Australian **Climate initiative**

Final report for Project 1.3.2

### **1.3.2 Station networks and data for statistical downscaling**

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## **Abstract:**

The statistical downscaling (SD) framework to be implemented across the south-east Murray Darling Basin (Projects 1.3.4 and 1.3.5) relates multi-site, daily precipitation data at the rain gauge scale to large-scale atmospheric variables ('predictors'). Optimum calibration of the SD model requires the highest quality daily rainfall records for the 1958-present period, this period being determined by the availability of high quality atmospheric data (NCEP/NCAR Reanalysis). This project identified and ranked the highest quality rain gauge records in terms of their completeness (minimal missing, infilled and deaccumulated data) and lack of untagged accumulations. From this ranked list, a comparison was made with station lists provided by client organisations (MDBC, DSE, Victoria and DNR, NSW). There was very little overlap between the clients' preferred gauges and those determined to be of sufficient quality for SD calibration.

## **Project Objectives:**

- Selection of a common set of daily rainfall stations to be used in all SEACI SD projects that encompass the south-eastern corner of the Murray-Darling Basin.

## **Summary of methods and modifications:**

- Consultation with the SEACI participants and researchers to select a set of candidate rainfall stations within the above study area. Early engagement will be made to determine the requirements of all parties and to obtain their proposed station sets. Similar exercises have been undertaken in previous downscaling studies involving the southwest of Western Australia (via the Indian Ocean Climate Initiative), the Mount Lofty Ranges in South Australia, the Murrumbidgee River basin, and the State of Queensland.
- Assessment of the data availability and quality for all candidate stations using standard methods and the technique devised by CSIRO Land and Water for the detection of untagged accumulations in rainfall series. This work will build on previous national assessments carried out by the Bureau of Meteorology since the early 1990s.
- Selection of final station network in consultation with the SEACI participants and researchers.
- Dissemination of station lists to all interested parties.

## **Statement of results, their interpretation, and practical significance against each objective:**

The region bounded by 143°E in the west to 149.75°E in the east and 37.75°S in the south to 33.5°S in the north, encompassing the MDB catchments that contribute to outflow from the Murrumbidgee River, was selected for this project. There are 673 Bureau of Meteorology (BoM) rain-gauges within this rectangular box, including many outside the catchment boundaries.

The Patched Point Dataset (<http://www.nrw.qld.gov.au/silo/ppd/>) was used as the source of daily rainfall records for these gauges. PPD has the advantage of a standardised and consistent methodology for data quality control and flagging of missing, infilled and deaccumulated data (Jeffrey *et al.* 2001).

Of the 673 gauges identified in the region, 210 gauges have less than 5% missing data for the 1986 to 2005 period. The 1986 to 2005 period will be used for SD model calibration. Of these 210 gauges, the 132 with the fewest 'untagged accumulations' were selected as candidates for further analysis (Table 1 and Figure 1). This analysis included examining the distributions of the daily amounts (as recommended by Lavery *et al.* 1992) to identify gauges with inconsistencies (e.g., problems with ignoring small rainfall catches; rounding rainfall to the nearest millimetre).

Normal BoM recording practice is for observers to note when a recorded rainfall value is actually an accumulation of several days' rainfall. Most commonly this occurs in situations where no readings are made over the weekend and so Monday's rainfall is an accumulation of the weekend's rainfall. Viney and Bates (2004) identified the further problem of 'untagged' accumulations, using statistical testing to determine periods in the record where multi-day accumulations are not noted, i.e. not 'tagged'. Such 'untagged accumulations' could potentially bias the calibration of the SD model by misrepresenting the rainfall pattern over the region on wet days that are recorded as dry days. Figure 2 summarises the results of untagged accumulations testing on the 210 gauges, as well as identifying periods of missing data. Table 2 lists data quality summaries for the 80 gauges with the fewest untagged accumulations.

In addition to assessing the frequency of untagged accumulations, these gauges can be ranked according to the length of missing data for the full 1958 to 2005 period, as good data is required to allow proper validation of the 1986-2005 calibrated SD models (Table 1). A sub-set of these, ensuring a reasonable geographical coverage of the region, will be selected for the initial SD calibration.

Following a workshop discussing MDBC and State Agency hydrological modelling needs, held in Canberra in September 2006, station lists and in some cases rain gauge data were provided by DNR, NSW and DSE, Victoria. Inclusion of these stations in SD calibration depends on the data quality of the stations. Figure 3 shows that many contain periods of missing data and untagged accumulations. Although they may not be suitable for use in SD calibration, their relationship with the rainfall statistics of good quality nearby stations, which are used in SD calibration, will be investigated.

The station selection undertaken has addressed the specific requirements of the subsequent SD calibration *Project 1.3.4* and it's focus on the southeast corner of the Murray-Darling Basin. This contrasts with *Project 1.1.1* which focussed on the full SEACI region and did not need to assess the presence of untagged accumulations to achieve its objectives. Thus the stations selected by *Project 1.1.1* would include stations not considered suitable for SD calibration due to probable contamination with untagged accumulations.

#### **List of publication titles:**

No publications have resulted from this project to date.

#### **References**

- Jeffrey SJ, Carter JO, Moodie KM, Beswick AR. 2001. Using spatial interpolation to construct a comprehensive archive of Australian climate data, *Environmental Modelling and Software*, 16(4), 309-330.
- Lavery B, Kariko A, Nicholls N. 1992. A historic rainfall data set for Australia, *Australian Meteorological Magazine*, 40, 33-39.
- Viney NR, Bates BC. 2004. It never rains on Sunday: the prevalence and implications of untagged multi-day rainfall accumulations in the Australian high quality data set, *International Journal of Climatology*, 24(9), 1171-1192.

## Project Milestone Reporting Table

To be completed prior to commencing the project				Completed at each Milestone date	
Milestone description <sup>1</sup> (brief) (up to 33% of project activity)	Performance indicators <sup>2</sup> (1- 3 dot points)	Completion date <sup>3</sup> xx/xx/xxxx	Budget <sup>4</sup> for Milestone (\$)	Progress <sup>5</sup> (1- 3 dot points)	Recommended changes to workplan <sup>6</sup> (1- 3 dot points)
1. Candidate station sets determined based on client needs.	Station lists and station data availability documented.	31/03/2006	6k	Completed	
2. Precipitation data quality assessed in detail.	Revised list of recommended stations documented.	30/05/2006	12k	Completed	
3. Feedback sought from clients and final stations lists compiled.	A document of 5 to 7 pages.	31/06/2006	2k	On-going	

**Table 1: Daily rainfall data quality summary for 132 candidate SD rain gauges.**

Order	BoM ID	Name	Lat	Lon	Miss86-05	Miss58-85	TotMiss
1	49046	BALDWIN (TILLARA)	-34.64	143.05	89	100	189
2	50045	YALGOGRIN NORTH (ROLOMA)	-33.85	146.83	249	616	865
3	70009	BUKALONG STATION	-36.8	149.2	2	8	10
4	70013	BOMBALA (CAMBALONG)	-36.89	149.11	66	15	81
5	70014	CANBERRA AIRPORT	-35.3	149.2	3	0	3
6	70021	COLLECTOR (BROOKDALE)	-34.91	149.43	314	435	749
7	70027	DELEGATE (WEEWALLA)	-37.05	148.99	130	133	263
8	70028	YASS (DERINGLLEN)	-34.74	148.89	44	7	51
9	70032	FAIRLIGHT STATION	-35.23	148.91	67	8	75
10	70035	BUNGENDORE (GIDLEIGH)	-35.31	149.47	42	20	62
11	70045	HALL (LOCHLEIGH)	-35.15	149.06	40	13	53
12	70054	COOMA (KAORA)	-36.2	149.06	31	12	43
13	70064	MICHELLEGO (SOSLUI)	-35.68	149.16	34	41	75
14	70071	GOULBURN (POMEROY)	-34.85	149.5	101	300	401
15	70091	YASS (LINTON HOSTEL)	-34.83	148.91	117	149	266
16	70098	BREDBO (BREDBO STATION)	-35.97	149.16	174	1626	1800
17	70105	MOUNT FAIRY (MERIGAN)	-35.17	149.59	142	1200	1342
18	70106	CATHCART (OLD POST OFFICE)	-36.84	149.39	20	56	76
19	70131	WOODHOUSELEE (LEESTON)	-34.54	149.62	128	102	230
20	72019	HOLMBROOK (GLENFALLOCH)	-35.86	147.56	249	3	252
21	72023	HUME RESERVOIR	-36.1	147.03	4	0	4
22	72044	TUMUT (WATTLE CRES)	-35.32	148.23	249	9	258
23	72150	WAGGA WAGGA AMO	-35.16	147.46	0	1	1
24	73007	BURRINJUCK DAM	-35	148.6	8	0	8
25	73014	GREENFELL (QUONDONG RD)	-33.9	148.17	292	221	513
26	73025	OLD JUNE (MILLSBANK)	-34.79	147.56	2	7	9
27	73032	QUANDIALLA POST OFFICE	-34.01	147.79	0	289	289
28	73038	TEMORA A.R.S.	-34.41	147.52	132	31	163
29	73044	WANTABADGERY EAST	-35.06	147.75	319	81	400
30	73051	MURRINGO (WINDERMERE)	-34.21	148.55	44	28	72
31	73054	WYALONG POST OFFICE	-33.93	147.24	0	152	152
32	73100	BUMBALDRY (WEEWANA)	-33.91	148.44	78	9	87
33	74008	GRONG GRONG (BEREMBED)	-34.86	146.82	170	50	220
34	74017	TOOTLOOL (BRYNTIRION)	-35.29	146.97	33	13	46
35	74025	BURRUMBUPTOCK (HOLYROOD)	-35.85	146.78	244	23	267
36	74026	URANA (BUTHERWAH)	-35.35	146.31	4	32	36
37	74026	LEETON CARAVAN PARK	-34.57	146.41	222	65	287
38	74087	URANA (NOWRANIE)	-35.33	146.03	3	13	16
39	74128	DENILQUIN (WILKINSON ST)	-35.53	144.95	38	0	38
40	74236	BUNGOWANNA(ROSELEIGH)	-36.02	146.76	45	46	91
41	75012	WAKOOL (CALIMO)	-35.42	144.6	4	17	21
42	75020	MALLAN (NIEMUR VALLEY)	-35.16	143.87	99	49	148
43	75031	HAY (MILLER STREET)	-34.52	144.85	20	2	22
44	75049	MAUDE (NAP NAPI)	-34.45	144.17	151	0	151
45	75050	NARAHAN (URALBA)	-33.61	146.32	142	125	267
46	75054	CONARGO (PUCKAWIDGEE)	-35.28	145.21	2	30	32
47	75056	BOOROOBAN (RAMSAY)	-34.94	144.74	24	4	28
48	75062	MOULAMEIN (TOHELERY)	-34.81	144.17	154	221	375
49	75064	GROONGAL (TOGANMAIN)	-34.47	145.61	126	14	140
50	75067	CARRATHOOL (JARDRY)	-34.47	145.3	140	1530	1670
51	75075	CONGO (WILLIBRAH)	-35	145.09	12	3	15
52	75080	WANGANELLA (ZARA)	-35.17	144.7	107	734	841
53	76012	MANANGATANG (EUREKA EAST)	-35.17	143	70	152	222
54	76044	NYAH	-35.18	143.37	84	30	114
55	76046	NYAH (YARRABY TANK)	-35.17	143.28	126	4	130
56	76050	PIRA WILD HORSE PLAINS	-35.26	143.37	81	28	109
57	77001	QUARRATOOK (BARRAPORT NORTH)	-35.98	143.65	35	9	44
58	77014	CULGOA (POST OFFICE)	-35.72	143.1	249	36	285
59	77016	BOORT (GREDGWIN)	-35.98	143.61	69	11	80
60	77021	LAKE BOGA (KUNAT)	-35.49	143.57	113	20	133
61	77025	LAKE BOGA	-35.46	143.63	68	1869	1937
62	77027	LEAGHUR	-35.97	143.78	10	42	52
63	77034	QUARRATOOK SOUTH	-35.93	143.5	2	171	173
64	78041	WOOROOOOK	-36.25	143.18	175	50	225
65	79014	EVERSLEY	-37.19	143.17	37	20	57
66	79031	MOONAMBEL	-36.99	143.27	323	171	494
67	79039	REDBANK	-36.91	143.34	45	9	54
68	79079	ST ARNAUD (TOTTINGTON)	-36.79	143.12	6	45	51
69	80004	CANARY ISLAND	-35.98	143.85	149	45	194
70	80009	ST ARNAUD (CONOOPER BRIDGE)	-36.48	143.35	137	39	176
71	80015	ECHUCA AERODROME	-36.17	144.76	8	0	8
72	80017	GLADFIELD HOPEFIELD ESTATE	-36.04	143.94	38	20	58
73	80019	GLENLOTH SHINGLE HUT HMSD	-36.16	143.33	192	149	341
74	80020	GUNBOWER GEE TEE STUD	-35.97	144.37	51	1461	1512
75	80023	KERANG	-35.72	143.92	0	96	96
76	80023	KERANG (MERAN DOWNS)	-35.87	143.8	219	17	236
77	80029	LAKE MARMAL	-36.15	143.52	16	16	32
78	80036	MINCHA	-36	144.09	34	20	54
79	80039	YARRAWALLA SOUTH	-36.19	144.05	146	48	194
80	80044	PATHO WEST	-36	144.42	97	6	103
81	80048	ROCHESTER	-36.36	144.71	180	48	228
82	80053	TANGRAM	-36.43	144.25	36	17	53
83	81006	BURKES FLAT	-36.67	143.55	28	18	46
84	81007	CANIAMBO	-36.46	145.66	55	17	72
85	81008	COLBINABBIN	-36.53	144.77	0	10	10
86	81019	NAGAMBIE (GOULBURN WEIR)	-36.72	145.17	72	579	651
87	81032	MIEPOLL (AVONDALE)	-36.66	145.5	74	599	673
88	81033	MOLKA (LOWRAN)	-36.64	145.42	38	428	466
89	81048	TATURA INST SUSTAINABLE AG	-36.44	145.27	208	11	219
90	81058	BRIDGEWATER (POST OFFICE)	-36.6	143.94	129	221	350
91	82002	BENALLA (SHADFORTH STREET)	-36.55	145.97	0	4	4
92	82006	BOORHAMAN	-36.22	146.28	10	44	54
93	82008	CALLAGHAN CREEK STATION	-36.46	147.43	218	135	353
94	82009	CARDBORO	-36.61	146.54	33	31	64
95	82018	UPLANDS (GIBBO RIVER PARK)	-36.77	147.69	73	141	214
96	82021	INDIGO	-36.1	146.6	75	108	183
97	82029	MILAWA BROWN BROS	-36.46	146.43	113	142	255
98	82032	MOYHU	-36.58	146.38	272	368	640
99	82035	NARIEL CREEK (SIMPSON)	-36.33	147.8	139	469	608
100	82039	RUTHERGLEN RESEARCH	-36.1	146.51	32	14	46
101	82049	STRATHBOGIE NORTH	-36.79	145.82	47	402	449
102	82047	TALLANGATTA (BULLIOH)	-36.19	147.35	221	25	246
103	82057	WOORAGEE	-36.3	146.73	2	65	67
104	82127	PEECHELBA EAST	-36.14	146.25	116	4	120
105	83010	EUROBIN	-36.64	146.86	39	22	61
106	83028	OMEO COMPARISON	-37.1	147.6	34	83	117
107	83031	WHITFIELD	-36.75	146.41	20	55	75
108	83032	WHITLANDS (BURDER'S LANE)	-36.85	146.32	37	528	565
109	83038	TAWONGA	-36.66	147.13	22	224	246
110	84014	DELLICKNORA (TELLICURA)	-37.11	148.68	284	45	329
111	84044	BLACK MOUNTAIN	-37.01	148.27	33	70	103
112	86035	ELTHAM	-37.7	145.15	52	555	607
113	86073	MICKLEHAM	-37.55	144.88	70	22	92
114	86090	WARBURTON (O'SHANNASSY RESERVOIR)	-37.71	145.79	344	2	346
115	86117	TOOROURRONG RESERVOIR (TOOROURRONG)	-37.48	145.15	326	4	330
116	86219	CORANDERRK BADGER WEIR	-37.69	145.56	64	12	76
117	87007	MORRISONS (BALLARK)	-37.74	144.14	70	16	86
118	87011	BEALES RESERVOIR	-37.54	144.03	0	5	5
119	87014	BUNGAREE (KIRKS RESERVOIR)	-37.55	143.93	0	4	4
120	87045	MOORABOOL RESERVOIR	-37.51	144.08	2	4	6
121	87046	SCOTSBURN (MOUNT BUNINYONG)	-37.67	143.94	11	33	44
122	87067	WILSONS RESERVOIR	-37.52	144.02	0	45	45
123	88007	BONNIE DOON GARAGE	-37.03	145.85	348	99	447
124	88011	CAMPBELLTOWN	-37.22	143.96	0	44	44
125	88023	LAKE EILDON	-37.23	145.91	0	33	33
126	88042	MALSBURY RESERVOIR	-37.2	144.37	33	8	41
127	88048	NEWSTEAD	-37.11	144.06	147	210	357
128	88050	PYALONG WEST (CAVAN PARK)	-37.11	144.83	219	423	642
129	88060	KINGLAKE WEST (WALLABY CREEK)	-37.45	145.21	226	41	267
130	88061	WOODEND (CARLISLE STREET) (WOODEND)	-37.35	144.54	77	14	91
131	88131	NARBETHONG	-37.5	145.68	199	193	392
132	89002	BALLARAT AERODROME	-37.51	143.79	10	6	16

**Table 2: Data quality of the 80 gauges with the least untagged accumulations.**

Station	A	B	C	D	E	D+E
49048	0	0	-25	62	38	100
63029	0	0	-6	1926	33	1959
63064	0	0	-20	93	23	116
63271	0	0	-18	0	6	6
70013	0	0	-35	62	19	81
70014	0	0	-5	0	3	3
70032	0	0	-33	61	14	75
70035	0	0	-27	31	31	62
70054	0	0	-29	31	12	43
70071	0	0	-33	271	130	401
70131	0	0	-13	124	106	230
70278	0	0	-46	5754	95	5849
71021	0	0	-44	456	17	473
72019	0	0	-35	216	36	252
72023	0	0	-6	0	4	4
72049	0	0	-1	945	178	1123
72146	0	0	-12	9314	2	9316
72150	0	0	-13	1	0	1
73022	0	0	-21	1066	52	1118
73041	0	0	-15	517	46	563
73044	0	0	-5	306	94	400
73100	0	0	-14	1	86	87
74008	0	0	-18	183	37	220
74017	0	0	-12	28	18	46
74025	0	0	-10	215	52	267
74087	0	0	-18	0	13	13
74108	0	0	-9	3211	130	3341
74195	0	0	-10	3226	24	3250
74221	0	0	0	4352	23	4375
75004	0	0	-28	2619	24	2643
75012	0	0	-20	0	21	21
75020	0	0	-9	122	26	148
75029	0	0	-2	1614	19	1633
75054	0	0	-20	30	2	32
75080	0	0	-11	824	17	841
75134	0	0	0	3349	19	3368
76044	0	0	-21	61	53	114
76046	0	0	-15	122	8	130
76050	0	0	-24	62	47	109
77001	0	0	-24	31	13	44
77016	0	0	-35	61	19	80
77021	0	0	-3	93	40	133
77025	0	0	-23	1796	141	1937
78041	0	0	-19	91	134	225
79079	0	0	-18	37	14	51
80009	0	0	-10	155	21	176
80017	0	0	-24	40	18	58
80020	0	0	-1	1492	20	1512
80024	0	0	-10	215	21	236
80029	0	0	-13	0	32	32
80039	0	0	-9	153	41	194
80044	0	0	-20	92	11	103
80053	0	0	-45	0	53	53
80098	0	0	-5	3896	11	3907
81115	0	0	-12	6088	39	6127
81118	0	0	-51	9587	28	9615
82018	0	0	-6	0	214	214
82021	0	0	-17	90	93	183
82022	0	0	-32	3874	73	3947
82047	0	0	-10	153	93	246
82057	0	0	-4	33	34	67
82076	0	0	-14	5876	107	5983
82127	0	0	-1	63	57	120
82137	0	0	-20	10531	58	10589
83010	0	0	-22	39	22	61
83038	0	0	-35	31	215	246
84044	0	0	-39	0	103	103
84107	0	0	-19	4383	169	4552
86090	0	0	-12	342	4	346
87011	0	0	-45	0	5	5
87014	0	0	-29	0	4	4
87045	0	0	-52	0	6	6
87046	0	0	-38	1	43	44
87067	0	0	-31	39	6	45
88011	0	0	-49	31	13	44
88042	0	0	-15	31	10	41
88050	0	0	-9	577	65	642
88060	0	0	-21	253	14	267
88118	0	0	-22	4018	41	4059
88131	0	0	-40	89	303	392

- A: Number of years with suspected untagged accumulations
- B: Estimated total number of untagged accumulations within the years in A
- C: Estimated total number of untagged accumulations in all years
- D: Total number of missing days (excluding tagged accumulations)
- E: Total number of days in tagged accumulations

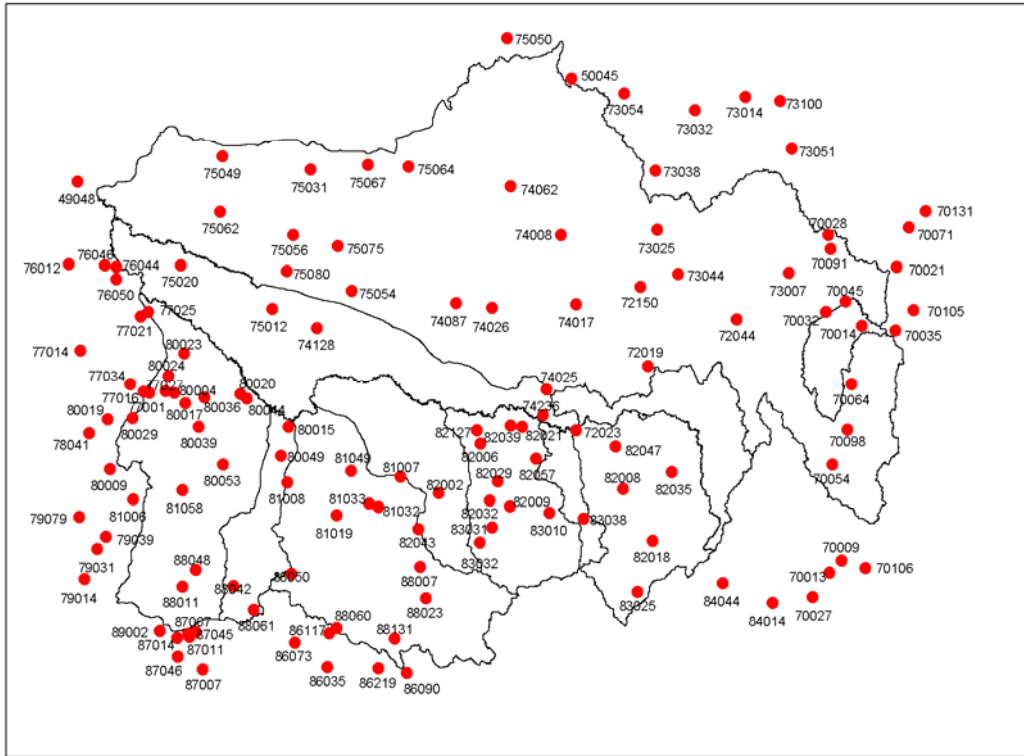


Figure. 1. SD study region showing location of 132 high quality stations

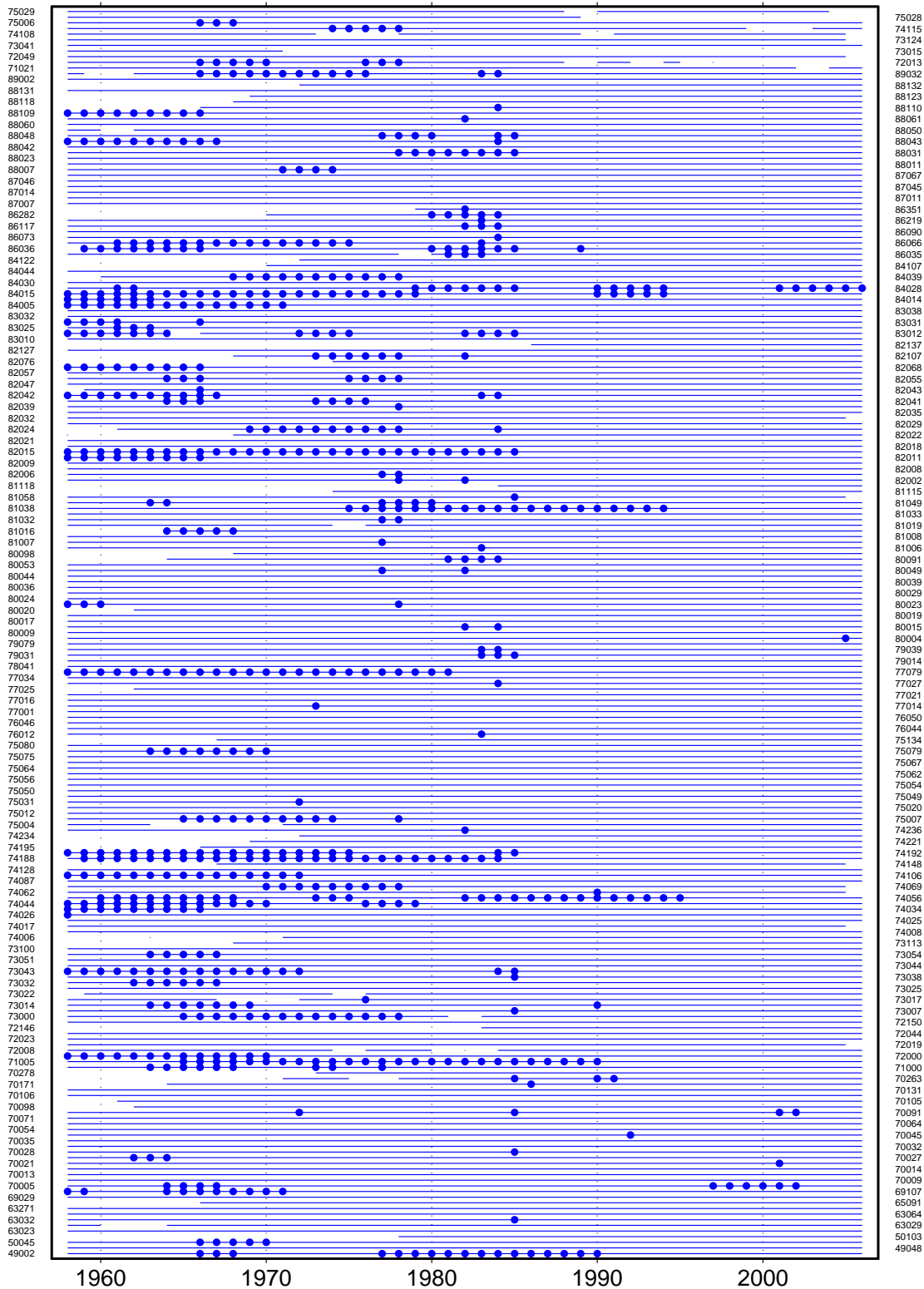


Figure 2: Schematic of missing records and untagged accumulations for rain gauges in the south-east Murray-Darling Basin. 221 gauges: 210 with <5% missing records 1986-2005 and 11 used in a previous Murrumbidgee study. Unbroken lines are periods with recorded data. Dots are periods with untagged accumulations.



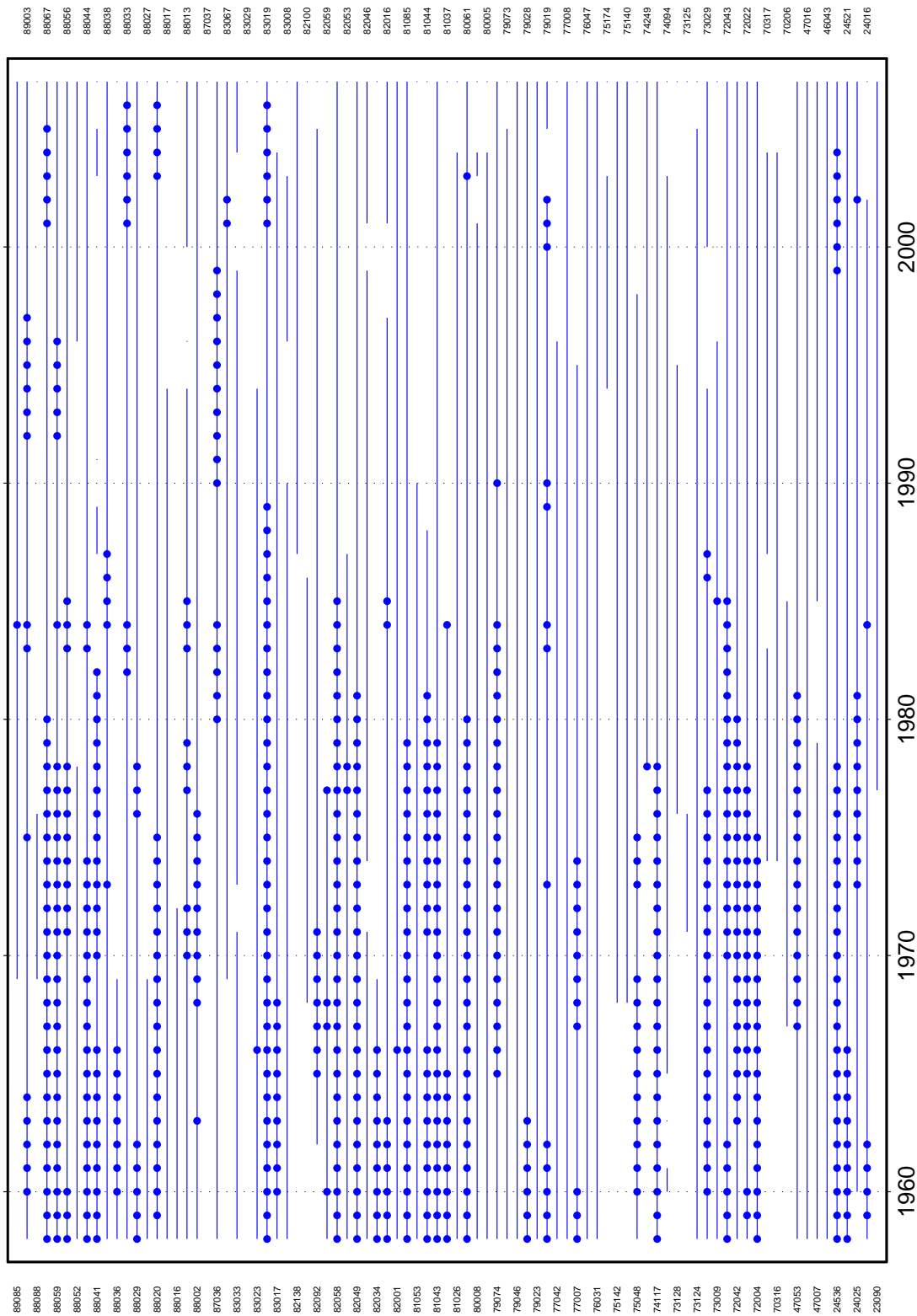


Figure 3: Schematic of missing records and untagged accumulations for rain gauges in the south-east Murray-Darling Basin identified by DNR, NSW and DSE, VIC. Unbroken lines are periods with recorded data. Dots are periods with untagged accumulations.