

Supplementary information for

Elevated Southern Hemisphere moisture availability during glacial periods

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Supplementary Tables 1 and 4

Other Supplementary Materials for this manuscript include the following:

- Supplementary Table 2. Naracoorte and Leeuwin-Naturaliste speleothem U-Th data (an Excel spreadsheet)
- Supplementary Table 3. Naracoorte pollen data (an Excel spreadsheet)

Supplementary Table 1 | Antarctic temperature anomalies corresponding to the peak value of each additive quantile regression model (qGAM). qGAMs model the 0.9 quantile of each Antarctic temperature³² versus Southern Hemisphere subtropical hydroclimate proxy relationship.

Antarctic temperature anomaly	0.9 qgam maximum	Region	Latitude	Proxy
-4.2	2.1	SE Australia	-37.0	Naracoorte KDE (this study)
-9.5	3.4	SW Australia	-34.0	Leeuwin Naturaliste KDE (this study)
-3.8	2.9	SE Africa	-26.2	MD96-2048 log(Fe/Ca) ²⁵
-3.8	4.2	SE Africa	-26.2	MD96-2048 % <i>Podocarpus</i> ³⁰
-9.5	3.1	SW Africa	-23.3	MD08-3167 δD ²⁷
-3.3	3.6	SW Africa	-25.6	MD96 -2098 charcoal ²⁸
-4.7	3.6	SW Africa	-35.1	U1479 % <i>Podocarpus</i> ³¹
-9.5	1.9	SE S. America	-27.2	Botuverá Mg/Ca ²⁶
-6	2.8	SW S. America	-27.5	GeoB-3375/15016 log(Fe/Ca) ²⁶
-3	2.4	Central Australia	-28.4	Megalake Kati Thanda/Lake Eyre, KDE of dated bedload units ³³
-5	0.5	SE Africa.	-25.4	Tswaing Crater total inorganic C) ³⁵
-9.5	2.6	SW S. America	-20.1	Salar de Uyuni gamma ³⁴
4.5	1.7	SE Australia	-44.3	FR1-94 GC3 log(Fe/Ca) ⁴²
-3.1	1.6	NW Australia	-27.4	U1460 Ti/Ca ⁴³
2.2	0.7	NW Australia	-22.1	MD00-2361 log(Fe/Ca) ⁴⁴
1.4	2.3	NW Australia	-15.1	SO257-18548 log(terrigen/Ca) ⁴⁵
-3.7	2.3	SE Africa	-21.6	GeoB-9311 log(Fe/Ca) ⁴⁶
-0.6	3.3	SE Africa	-11.3	Lake Malawi % <i>Podocarpus</i> ⁴⁷
-6.5	2.9	SE Africa	-11.3	Lake Malawi lake level ⁴⁸
4.5	3.6	SE Africa	-6.7	Tanganyika δD ⁴⁹

Supplementary Table 2 | Naracoorte and Leeuwin-Naturaliste speleothem U-Th data.
(An Excel spreadsheet file)

Supplementary Table 3 | Naracoorte pollen data. (An Excel spreadsheet file)

Supplementary Table 4 | Fossil pollen types used in the climatic reconstructions, and their plausible source species.

Pollen type	Higher or inclusive clade	Geographically plausible source species used in the palaeoclimatic reconstruction	Atlas of Living Australia download citation
<i>Banksia ornata</i>	<i>Banksia</i> (Proteaceae), clade Cryptostomata ^{73,106}	<i>B. ornata</i>	10.26197/ala.ca80c518-52d7-4e78-b40d-fc74528823cb
<i>Banksia marginata</i>	<i>Banksia</i> (Proteaceae), clade Phanerostomata ^{73,106}	<i>B. marginata</i>	10.26197/ala.62b2ad11-18f0-4666-b810-df98806a574a
<i>Leucopogon</i> -type ^a	Styphelioideae:Eriaceae ¹⁰⁷	<i>L. affinis</i> , <i>L. australis</i> , <i>L. clelandii</i> , <i>L. collinus</i> , <i>L. concurvus</i> , <i>L. costatus</i> , <i>L. ericoides</i> , <i>L. gelidus</i> , <i>L. glacialis</i> , <i>L. hirsutus</i> , <i>L. microphyllus</i> , <i>L. neurophyllus</i> , <i>L. parviflorus</i> , <i>L. pilifer</i> , <i>L. thymifolius</i> , <i>L. virgatus</i>	10.26197/ala.463f0fe2-8878-493d-82e2-67ea3cf1bf89; and 10.26197/ala.d1b64741-b2a7-4e70-9a70-dd39571f6f6a
Restionaceae ^b	Restionaceae	<i>Apodasmia brownii</i> , <i>A. similis</i> , <i>Baloskion australe</i> , <i>B. tetraphyllum</i> , <i>Calorophus elongatus</i> , <i>Desmocladus diacolpicus</i> , <i>D. fasciculatus</i> , <i>Empodisma minus</i> , <i>Eurychorda complanata</i> , <i>Hypolaena fastigiata</i> , <i>Lepidobolus drapetocoleus</i> , <i>Leptocarpus tenax</i> , <i>Lepyrodia anarthria</i> , <i>L. flexuosa</i> , <i>L. muelleri</i> , <i>L. valliculae</i> , <i>Sporadanthus interruptus</i> , <i>S. strictus</i> , <i>S. tasmanicus</i>	10.26197/ala.bf821b71-88c9-4395-9720-ed167c28afd610.26197/ala.bf821b71-88c9-4395-9720-ed167c28afd6
<i>Opercularia</i> -type ^c	Anthospermeae:Rubiaceae	<i>Opercularia aspera</i> , <i>O. ovata</i> , <i>O. scabrida</i> , <i>O. varia</i> , <i>Coprosma quadrifida</i> , <i>C. hirtella</i> , <i>Leptostigma reptans</i>	10.26197/ala.f9f89b54-8d11-4516-b909-5e49485e2482; and 10.26197/ala.d18358ca-36e9-460e-adaa-1ba1f464df8c; and 10.26197/ala.d5684434-da5a-48eb-ae62-a48ed835f39a
<i>Monotoca</i> -type ^d	Styphelioideae:Eriaceae ¹⁰⁷	<i>Monotoca scoparia</i> , <i>M. glauca</i> , <i>M. elliptica</i> , <i>M. billawinica</i> , <i>M. rotundifolia</i> , <i>M. oreophila</i>	10.26197/ala.9c4527fb-bde6-4bdd-a17f-dc9f490d7060
<i>Amperea</i> ^e	Acalyphoideae:Euphorbiaceae	<i>Amperea xiphoclada</i>	10.26197/ala.2c021203-5def-45db-a799-70d9454f7f9d
<i>Nertera</i> ^f	Anthospermeae:Rubiaceae	<i>Nertera granadensis</i>	10.26197/ala.b3987737-d178-40f2-a351-c751a359ce83
<i>Acaena</i> ^g	Sanguisorbeae:Rosaceae	<i>Acaena novae-zelandiae</i> , <i>A. echinata</i> , <i>A. ovina</i> , and the natural hybrid, <i>A. anserovina</i>	10.26197/ala.f8174bc8-6717-4264-901d-ef7825d4cd56
<i>Pteris</i>	Pteridaceae ¹⁰⁸	<i>P. tremula</i>	10.26197/ala.e33e52a6-79f9-4700-a569-55750c6cdcd2

- The 'S-type' or 'M-type' epacrid pollen type¹⁰⁹, in which three microspores abort early in the development of the pollen tetrad, or a tetrad with 'three rudimentary aborted cells'¹¹⁰. This morphology occurs frequently within *Leucopogon*. The genus is polyphyletic¹¹¹, but in the absence of a comprehensive species-level phylogeny and a corresponding palynological reference collection, we interpret this fossil type in terms of South Australian and Victorian *Leucopogon* spp.
- All Victorian and South Australian Restionaceae spp included in the climatic reconstruction.
- Western Victorian and South Australian *Opercularia turpis* was excluded from the climate reconstruction because its distinctly regulate exine is inconsistent with Naracoorte fossil pollen. Today herbaceous *Opercularia* is the only genus within the Anthospermeae that is widespread within South Australia. Creeping herbaceous *Leptostigma* extends into coastal, far southeastern South Australia, and two species of shrubby *Coprosma* extend westward in Victoria, to within ca. 100 km east (*C. hirtella*) and southeast (*C. quadrifida*) of Naracoorte. Because of the possibility that the latter three species may have extended to Naracoorte during the Pleistocene, their occurrences are included in the climate reconstruction.
- Epacrid tetrad characterised by three aborted microspores separated from the functional microspore by "a dividing wall"¹¹⁰. Victorian and South Australian *Monotoca* spp.
- Pollen of *Amperea*, part of an endemic Australian Acalyphoideae radiation ('core Acalyphoids A4', of Wurdack et al.¹¹²), can be distinguished from its sister genus *Monotaxis* by the former's unusually high and prominent columellae¹¹³. Only one species, *A. xiphoclada*, is present in eastern Australia.
- Inaperturate with supratectal elements (baculae/clavae)¹¹⁴; one species in eastern Australia.
- All Victoria and South Australian *Acaena* spp. used in the climatic reconstruction.