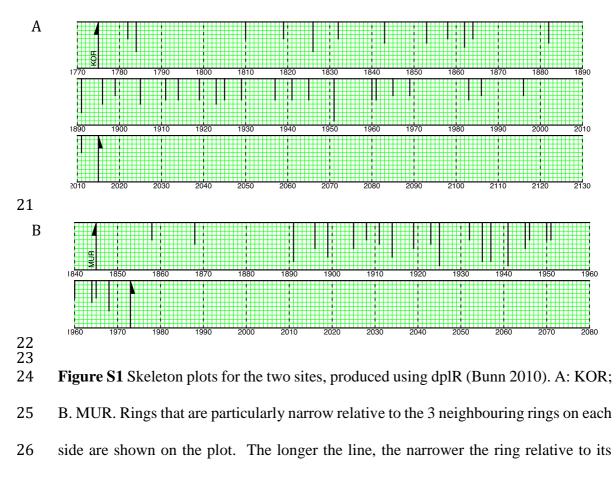
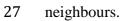
1 Supplementary Information

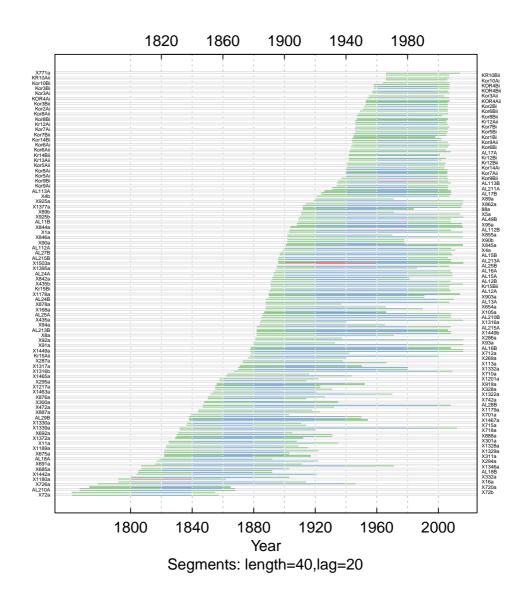
- 2
- 3

Appendix S1. Is there a missing ring in the MUR chronology at 1951?

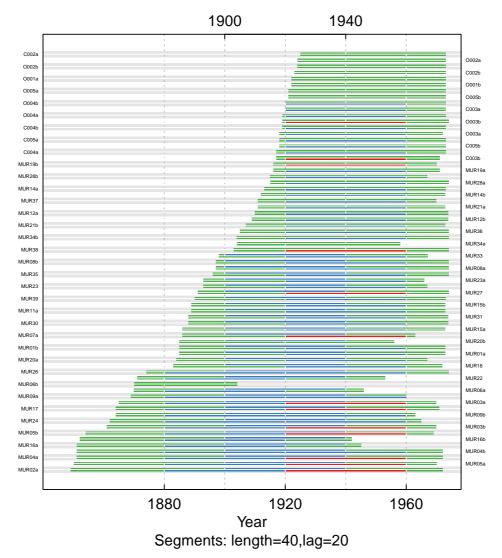
4 A possible missing ring in the MUR chronology at 1951, the point at which the 5 visual relationship between the series appears to break down (Figure 3), may be 6 responsible for slightly greater variability in correlations with climate at MUR (Figures 7 4,S3-6). Drew et al. (2011) have noted that missing rings are more likely to occur in 8 grove trees that isolated trees, and the MUR trees were sampled from groves (Hammer 9 et al. 1981), whereas – at least at the time of sampling - KOR trees mostly grew as 10 isolated individuals. However, not only is a missing ring in all (~50) series at MUR 11 (Figure S2) that include this period site highly unlikely, but inserting one in all series from MUR at this point did not noticeably improve the relationship between the two 12 13 chronologies (data not shown). Additionally, a comparison of the skeleton plots for the 14 two sites shows no strong evidence either for or against a missing ring at MUR in 1951 15 (Figure S1). For example, signature rings noted in the skeleton plot for KOR include 16 1960, 1961 and 1965 while for MUR, 1960, 1964 and 1965 are identified as signature 17 rings (Figure S1), making it difficult to assess the likelihood of a missing ring. Without 18 concrete evidence of a missing ring in a well-replicated chronology, there is no reason 19 to insert one.







А



30 31 32 Figure S2 Plots of 40-year segments, overlapping by 20 years of all series in each site 33 chronology. Each segment has been correlated (Spearman Rank) with a master series 34 for the site that excludes the series in question. Blue indicates correlations significant 35 at the p = 0.1 level, red indicates correlations not significant at this level and green 36 represents segments for which no correlations have been calculated due to incomplete 37 temporal overlap with the master series. A is KOR and B, MUR. Non-significant 38 correlations, indicating potentially problematic segments, are most likely due to 39 microsite factors, rather than dating errors. Package dplR (Bunn 2008; 2010) was 40 used to generate these plots.

41 Appendix S2. Relationship of chronologies with climate

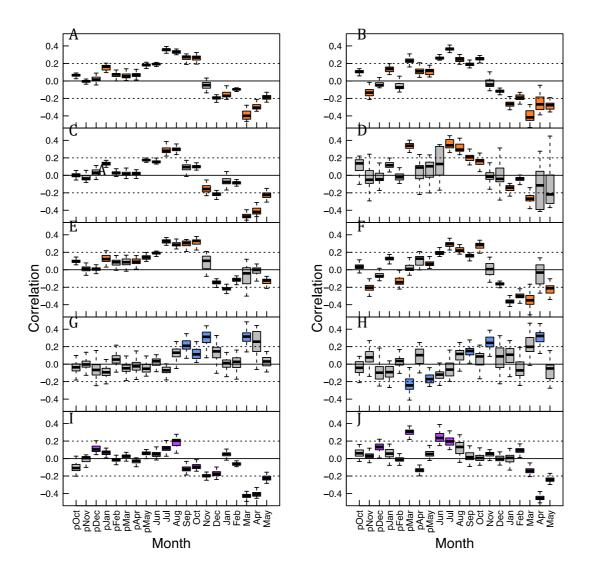
42 S2.1 Monthly climate correlations: temperature, precipitation, evapotranspiration

Our results indicate consistent monthly patterns in mean temperature-ring width relationships across the region for both KOR and MUR (Figure S3). Strongest positive and significant ($p \le 0.05$) monthly grid-point correlations between both chronologies and mean temperature occur from July to October. Strongest negative (and generally significant, $p \le 0.05$) monthly correlations occur from March to May. Overall, there is slightly more spread in correlations for MUR relative to KOR.

49 While the general pattern of correlation with monthly maximum temperature is 50 broadly similar for the two sites, variability across the gridded data is greater for most 51 months at MUR. There are statistically significant positive correlations between both 52 chronologies and maximum July-August temperature for all gird points. Statistically 53 significant negative relationships with maximum temperature during March-May exist 54 for most grid points at KOR only. Positive relationships between minimum temperature 55 and the chronologies (significant at KOR; p < 0.05) occur over the July-October period. 56 Negative correlations over the January-March period are appreciably stronger for MUR 57 than KOR, displaying mostly significant ($p \le 0.05$) correlations. A comparison with 58 monthly temperatures at the Darwin ACORN-SAT station, is consistent with those for 59 the gridded data (Figure S4).

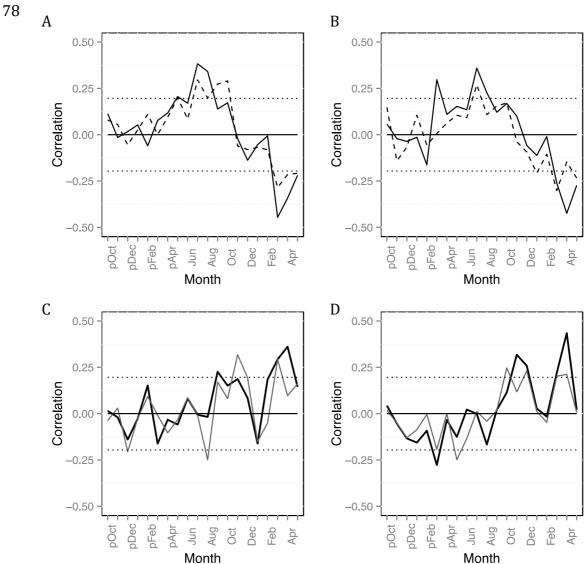
The pattern of correlations between the chronologies and gridded monthly precipitation is more difficult to discern than for temperature due to substantial variability in monthly correlations at both sites (Figure S3). There is a general tendency for both sites to have positive relationships with precipitation from July – October and from March to April. As for the temperature data, relationships with single point monthly data at the two closest long-term high quality stations (Oenpelli 1910-2013 and Warruwi 1916-2017) is consistent with correlations shown for the griddedprecipitation data (Figure S4).

Gridded potential evapotranspiration across the study area is strongly (and
mostly significantly) negatively correlated with ring width at KOR from March to May
and with MUR from April-May.



71

Figure S3 Boxplots of regional monthly correlations of the two chronologies with A B mean temperature; C-D maximum temperature; E-F minimum temperature; G-H
precipitation; I-J potential evapotranspiration. The left column shows monthly
correlations for KOR and the right, MUR respectively. Coloured boxes are those for



77 significance limits. A 'p' in front of the x-axis label denotes the year prior to growth.

79 80

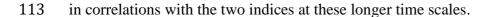
Figure S4 Correlations between the two chronologies and site temperature and 81 precipitation. Left: KOR, Right: MUR. A and B Relationships with maximum (solid 82 line) and minimum (dashed) temperatures at Darwin. C and D Relationships with 83 Oenpelli (thick black line) and Warruwi (grey line) precipitation. Dotted lines represent 84 the 95% significance level.

86 S2.2 Correlations with the drought indices

87 The pattern of correlations with the gridded SPEI scaled at 1, 3, 6 and 12 months 88 (SPEI-1, SPEI-3, SPEI-6, SPEI-12) is shown in Figure S5. While the Figure in the main 89 text simply shows the SPEI-3 correlations for the seasons as defined in the main text, 90 here we show the values for each month; i.e. the 3-month SPEI value for October 91 reflects the August-October period and that for February reflects December-February. 92 The pattern in correlations is similar for the two chronologies (Figure S5) with greater 93 spread evident for MUR. In broad terms, relationships with SPEI-1 and SPEI-3 tend to 94 be positive from September-May although there is an hiatus in January – February 95 (more obvious at KOR). SPEI correlations for KOR are positive and mostly significant 96 (p < 0.05) from March - May at all timescales (Figure S5). MUR exhibits relatively 97 strong negative correlations with the SPEI-6 from the previous March through to 98 August while correlations for this same period at KOR are negligible. The relationship 99 between both chronologies and the SPEI-12 is nominally negative until about March 100 when it becomes positive.

101 Correlations with the sc-PDSI for 1 and 3 months are weak from the previous 102 October until August for KOR (Figure S6), and from the previous October until the 103 previous March-May at MUR when they become nominally negative. This pattern is 104 very similar to that for SPEI1 and 3. The relationship steadily becomes positive over 105 the next 3 (KOR) -6 (MUR) months. There are strong positive (significant for KOR) 106 correlations with the 12-month sc-PDSI over the June-November period at which point, 107 the strength of correlations drops and then steadily increases until May. These positive 108 correlations are not observed for the 12-month SPEI, and neither are the high positive 109 correlation values for single months for the 6-month sc-PDSI (Figures S5 & S6). These 110 differences in responses to the two drought indices at longer time-scales, particularly at 111 the 12-month scale demonstrates it may be unwise to attempt to model drought at these

112 longer scales without better understanding the reasons for the considerable differences



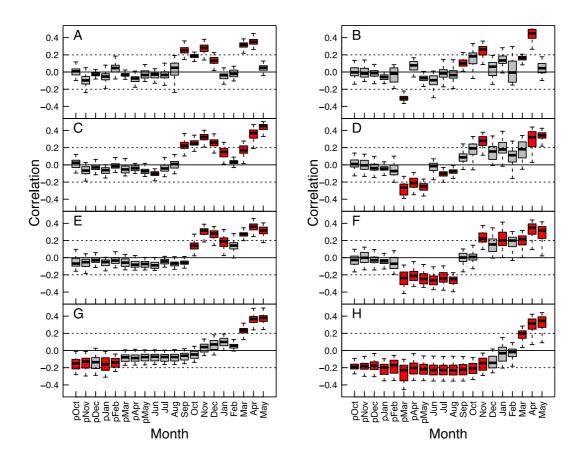


Figure S5. Boxplots of Pearson correlations of KOR (A, C, E, G) and MUR (B, D, F,
H) with variously scaled SPEI indices. A box plot for December 3-month SPEI relates
to the SPEI scaled over Oct – Dec. A and B monthly: SPEI-1; C and D SPEI-3; E and
F SPEI-6; G and H SPEI-12. A 'p' in front of the x-axis label denotes the year prior to
growth.

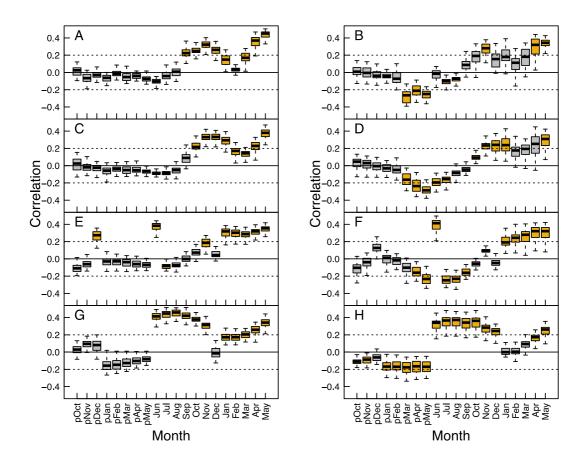


Figure S6. As for Figure S3, but for scPDSI-1 and scPDSI averaged over 3,6,12 monthperiods.

125 S2.3 Site differences in climate relationships at the monthly scale

As previously identified by Baker et al. (2008), there can be important differences between climate sensitivity at different sites. With lower variability in correlations with most climate variables (Figures S3, S5-6), the slightly inland site, KOR appears to better represent climate across the region than does the more coastal MUR. There are, however, several important factors that must be considered in relation to this lower variability.

132 The first is the slightly different period over which correlations were calculated 133 for the two sites, and the second is simply related to geographic distance from each site 134 to the centroid of each grid point for the gridded data. However, based on the drought 135 indices for the period September - May (chosen to account for, on average, 99% of 136 annual moisture input; Figure 2A), neither of these two factors appears to be important 137 for months when relationships are relatively strong (Figures S7 & S8). The most 138 obvious differences associated with these two factors are: a change from a weakly 139 negative to weakly positive correlation between KOR and the January-February SPEI-140 1 for the 1903 – 1973 period; a stronger correlation between ring width at KOR and the 141 November - May period sc-PDSI for the 1903 - 1973 period; and some small 142 geographical differences in correlations, again for months with relatively variable and 143 weak correlations (Figures S7 and S8).

144 The broader area from which the MUR trees were sampled may also have 145 resulted in greater variability in responses. Finally, the competitive environment of the 146 trees sampled may matter. Differential sensitivity of isolated and grove trees can lead 147 to important differences in growth and its timing in C. intratropica (Drew et al., 2011). 148 Trees in more densely populated groves are more sensitive to water availability and 149 develop greater water deficits more rapidly than isolated trees. In contrast, isolated trees 150 experience a more rapid recovery from severe water deficits at the start of the following 151 wet season (Drew et al., 2011). The slightly earlier positive relationship between the 152 KOR chronology (relative to MUR) and the drought indices at the start of the wet 153 season may be consistent with the results of this detailed physiological work. However, 154 our descriptions of the two sites relate only to what was observed at a point in time, and 155 may not reflect growing conditions prior to this. Therefore, our comments here are very 156 tentative. Drew et al. (2014) concluded that, where possible (and obviously subject to 157 the constraint that prior growing conditions are not necessarily known) hydroclimate 158 reconstructions based on C. intratropica should use sites that incorporate both isolated trees and trees from groves. 159

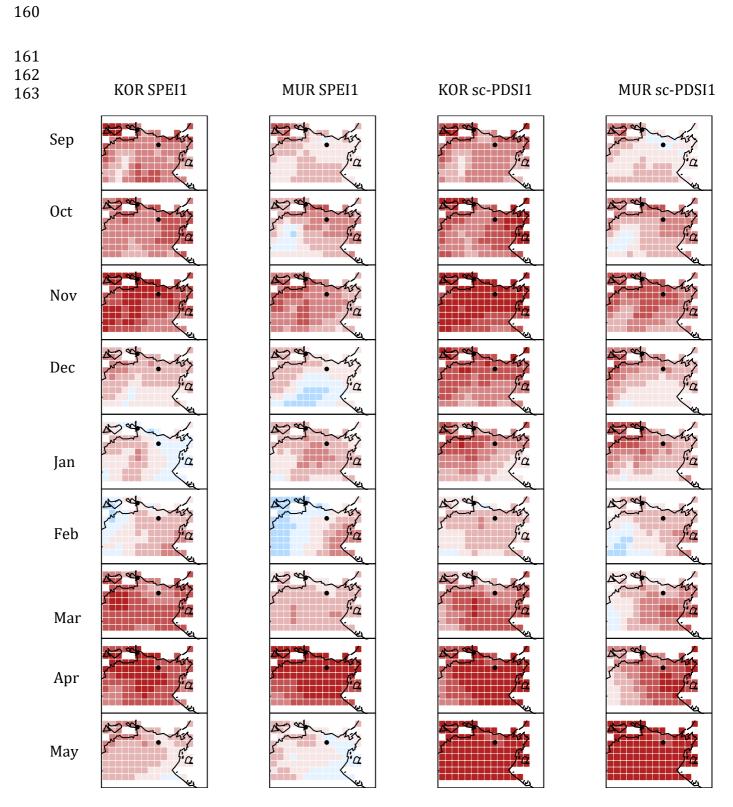


Figure S7. Correlations across space, KOR and MUR with SPEI1 and sc-PDSI1 (1903

165 – 1973), period in common between chronologies

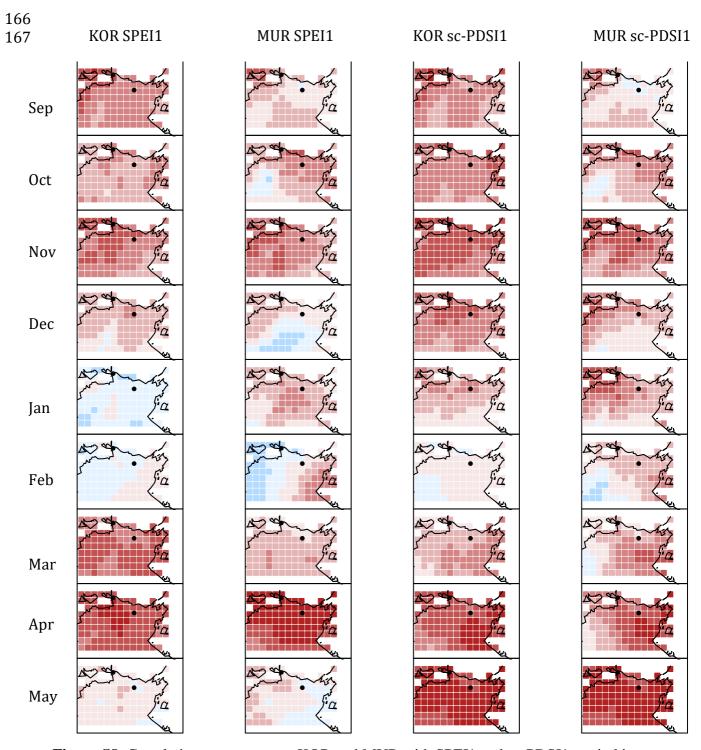


Figure S8. Correlations across space, KOR and MUR with SPEI1 and sc-PDSI1, period in common between climate data and each chronology respectively (KOR 1903 – 2015; MUR 1903 – 1973)

171 S2.3 Spatial correlations amongst gridded data

Overall, spatial correlations amongst gridded data are highest for temperature
(~0.88) data and lowest for precipitation (0.59) and then the drought indices (0.69;
Table S1). The lower correlation in precipitation across the region is consistent with the
greater variability in relationships with the chronologies (Figure 4, Figure S3).

176

Variable	Average correlation	Standard deviation
Mean temperature	0.91	0.04
Maximum temperature	0.89	0.03
Minimum temperature	0.86	0.07
Precipitation	0.59	0.07
Potential	0.89	0.03
evapotranspiration		
SPEI	0.69	0.06
Sc_PSDI	0.69	0.06

177 **Table S1**: Average intercorrelations amongst all gridded climate data for each

178 variable. Values calculated are based on monthly data and then averaged for the year.

Year	KOR	MUR	Oenpelli total annual rainfall	Warruwi total annual rainfall	Oenpelli days of rain	Warruwi days of rain
1911	*	*	rannan	rannan	Tani	ram
1911						
1912						
1913 1914 E	*		-1.97		-1.78	
1914 E 1915			-1.97		-1.78	
1916 L 1917 L						
1917 L 1918					-2.33	
1918 1919 E	*		-1.06	-1.07	-2.55	
1919 E 1920			-1.00	-1.07	-1.95	
1920 1921						
1921						-1.84
1922	*			-1.21		-1.04
1923 1924 L				1.21		
1924 E 1925 E	*	*	-2.02		-1.38	-1.84
1926			2.02		1.50	-1.66
1927						2.00
1928 L				-1.66		
1929	*					-2.28
1930				-1.06		-2.03
1931				-1.27	-1.02	
1932						
1933						
1934			-1.10			
1935		*	-1.21	-1.63	-2.63	-1.66
1936						
1937		*				-1.53
1938 L						
1939						
1940 E						
1941 E	*	*	-2.34	-1.31	-2.58	-1.10
1942 L						
1943					-1.78	
1944					-1.18	
1945	*	*	-1.03			
1946 E			-1.22	-1.03	-1.28	
1947						
1948						
1949 L						
1950 L						
1951 E	*		-2.17	-1.38	-1.78	-1.35

1952 -1.47 1954 L -1.47 1955 L -1.47 1955 L -1.95 1957 E -1.43 1959 C -1.44 1961 * -1.44 1962 P -1.44 1963 E -1.44 1964 P -1.44 1965 E -1.96 1966 P -1.35 -1.63 -1.04 1970 P -1.35 -1.63 -1.04 1970 P -1.35 -1.62 -1.04 1971 P -1.62 -1.04 -1.04 1970 P -1.62 -1.02 -1.04 1977 E -1.62 -1.62 -1.62 1977 E -1.62 -1.62 -1.62 1977 E -1.02 -1.02 -1.02 -1.02 -1.02 1980 F -1.02 <t< th=""><th></th><th></th><th></th><th></th><th></th></t<>					
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1994 E 1995 1996 *	1992				
1995 1996 *	1993 E		-1.12		
1996 *	1994 E				
1990	1995				
1997 E	1996	*			
	1997 E				

1998 L					
1999					
2000					
2001			-1.98		
2002 E			-1.71		-1.22
2003					
2004				-1.23	-2.28
2005					
2006 E			-1.25		
2007 L		-1.05	-1.04	-1.18	
2008 L					
2009 E					
2010 L					
2011 L					
2012					
2013					
2014					
2015 E			-1.43		

182 Table S2: Narrow rings (identified after filtering series with a 32-year spline to remove 183 low frequency variability) and years in which precipitation, and days on which 184 precipitation fell, were well below average (more than one standard deviation below 185 average). One (two) * indicates a ring at least one (two) standard deviations below the 186 mean are listed for individual chronologies. Also shown are years in which El Niño or 187 Niña obtained La events began (data from 188 http://www.bom.gov.au/climate/enso/lnlist/). Shaded areas show the periods covered 189 by the different records. Both precipitation values apply to the August – July period. 190 Warruwi rainfall data extends from 1916 - 2018 and Oenpelli from 1910 - 2013. 191 Individual station data has been used here rather than the gridded product because it is 192 this information is not available for individual grid points in the monthly GPCC data 193 set. 194 195

197 **References**

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