Dear Editor and Reviewers,

We thank the reviewers for their time and expertise in reviewing our submitted manuscript "Late Holocene temperature variability in Tasmania inferred from borehole temperature data". We appreciate the constructive comments provided by the reviewers, and have taken the opportunity to use these suggestions to improve our revised manuscript.

In summary:

- Manuscript is revised thoroughly as per reviewers' comments with suggested references and updated figures.
- Used comments and suggestions to clarify the text, and make our submission more readable and less open to misinterpretation.
- Where we disagree with the reviewers comments, provided justifications and detailed explanations for our reasoning.
- Necessary references and arguments are added to support spatial variation of paleotemperature and East Australian Current (EAC) considered being one of the major drivers for the spatial variation.

This document includes a detailed list of how we have interpret each comment, and where appropriate, how we have altered the manuscript to improve its readability or the ability of the reader to interpret our study. Note that our comments are displayed in red to distinguish between review and comment.

Regards,

Asadusjjaman Suman, Fiona Dyer, and Duanne White

Reviewer 1

Review of Suman et al, Late Holocene temperature variability in Tasmania inferred from borehole temperature data

General comments

This article starts well, with a good explanation of using boreholes for palaeotemperature research and explaining the method of extracting a temperature profile from the holes.

However, the conclusions are not supported by the results given. There is not enough evidence to support the claim that the EAC is responsible for the increased warming closer to the coast, nor any reference to other studies using models or observational data to that cover the same topic.

The comparison between the borehole data and instrumental data is superficial, and would benefit from some additional statistics. You could apply a high-pass filter to the instrumental data to give is a temporal variability similar to the borehole data, or access some modern ground surface temperature data to support your findings.

Authors: Thanks for all of your comments. Manuscript is revised with additional references to support the concept of EAC is one of the major drivers for warmer NE coast of Tasmania. Beside this, necessary statistical analysis also incorporated into the revised version.

I am not a borehole expert, but it's also unclear what is new about this study. Is this the first time these boreholes have been used? What new information does this bring to the story of climate change in Tasmania or the Southern Hemisphere? Highlighting why these results are interesting would improve the paper.

Authors: Borehole studies are not new in global concept. However, it has had limited application in Australian paleoclimate studies. Borehole data is a direct measurement of paleotemperature, and is not as strongly affected by the environmental factors like rainfall, temperature or human intervention most proxy data. Therefore, borehole technique can be an important aid to other proxy in paleoclimate study in Australia, particularly teasing out the relative importance of temperature and rainfall changes during climatic shifts.

In this paper, we show Tasmanian paleotemperature, the geographic distribution of paleotemperature changes on land, as driven by a change in the EAC during the past few hundred years. This was not clearly understood before by either the meteorological record, or by other proxies.

Further, this study addresses issues around the number of borehole required to reconstruct plausible paleotemperature from a region.

Specific comments

Line 55: I'd update this sentence to say "High-quality instrumental data records", as there are temperature observations in Hobart that date back to the 1840s (Ashcroft *et al.*, 2014).

Authors: Thanks, text changed as per suggestion. For comparison with meteorological record we have used high quality ACORN-SAT station data and network (Bureau of Meteorology, 2016) and records are available since 1910 in some stations in Tasmania. The Ashcroft et al., 2014 data are a useful general resource for short-term fluctuations, but the lack of absolute temperatures with respect to the modern instrumental data makes it difficult to contrast to the borehole record.

Line 113: You should present figures in the order they are mentioned. Can you provide a little map of the borehole locations as a Figure 1? I think it would be helpful for the rest of the paper too.

Authors: Following Figure added as per suggestion.

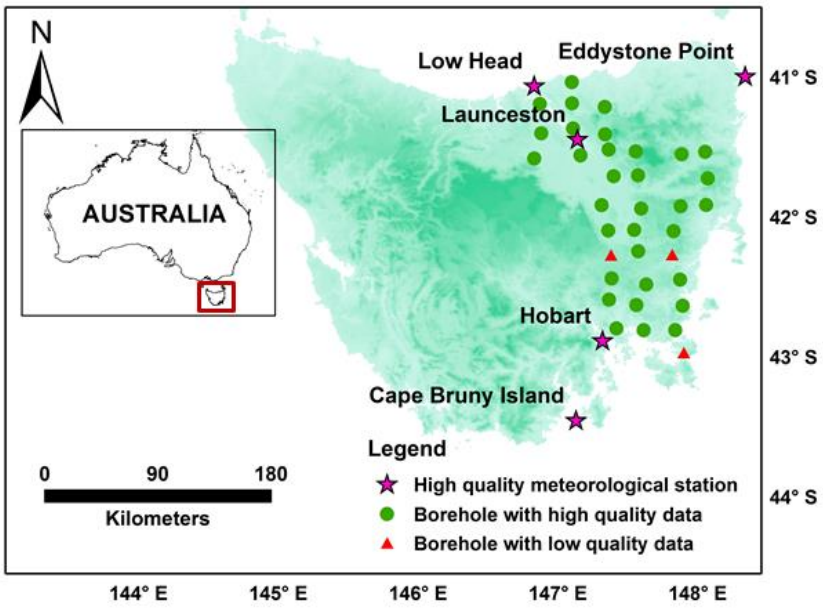

Fig. 1 Location of 36 boreholes sites in Tasmania. High quality ACORN-SAT (Bureau of Meteorology, 2016) meteorological stations are shown in stras.

Line 200 and elsewhere: What is the complete reference to the Suman and White paper in review?

Authors: (Suman and White, 2017) was recently published in Geothermics and added in the text and reference

Line 204 and section 5.1: What SST area-average are you using? The Tasmanian region or the whole Southern Hemisphere?

Authors: SST from HadSTT for Southern Hemisphere were used and added in the text

Figure 4: What does the red circle mean? The five best boreholes? I can only see one blue line, does this represent the average of the five stations? And over which

period are the temperature changes from the meteorological stations calculated? Surely not the last 500 years? Please provide more information.
Authors: More information provided in the text to clarify the issue and blue line removed to avoid confusion.

Figure 4 and elsewhere: Does maximum temperature change mean the greatest temperature change found in each borehole, or changes in maximum temperature?
Authors: "Maximum temperature change" as written in the submitted manuscript represents the greatest temperature change observed in each borehole, rather than maximum daily (or monthly, etc) temperatures. This has been changed to Greatest Temperature Change (GTC) in the entire manuscript to make this distinction clearer.

Page 15, Ln 319–320: "Thus, the data should be considered to provide stable centennial-average temperature trends prior to the 20th Century." What does this mean for the 20th century results? Are they unreliable or unstable?
Authors: No – it means there was no change in centennial-mean temperatures in the borehole reconstruction between the 15th and 19th centuries, and then a sharp increase in the 20th century. Text has been reworded to clarify this meaning.

Figure 7: This figure is very complicated. I think it would be greatly improved by plotting each individual borehole as a continuous grey line, or the range of individual boreholes as shading behind the average, with the average over the top in a red line. You can then plot the meteorological data on top of that in a thick black line, without offsetting it. That would make it much easier to compare. You should also note in the figure caption that the individual borehole profiles are pictured. You could also have a Figure 7b just showing the five boreholes with have mid-20th C cooling, as it's hard to see here.
Authors: Figure modified as suggested with an inset reconstruction from seven boreholes that shown a cooling period in mid-20th Century before rapid warming in late 20th Century.

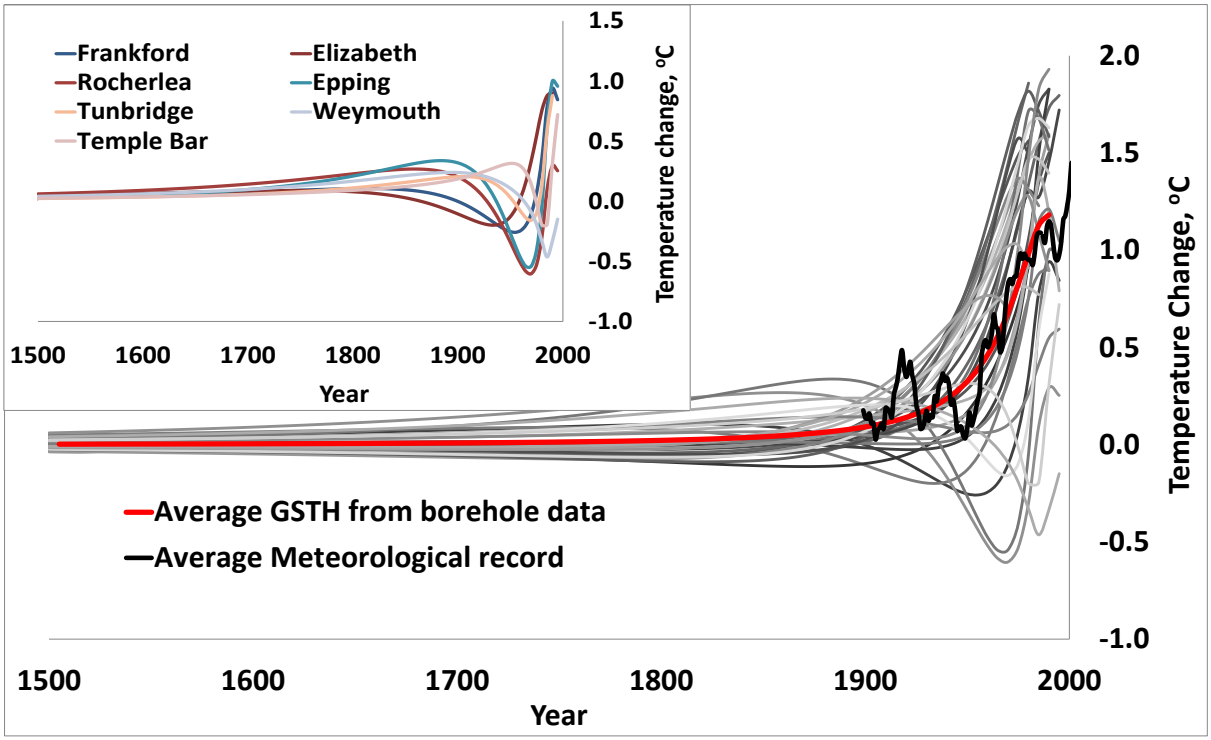

Fig. 2: Reconstructed GSTH from Tasmanian high quality data set, red line shows average reconstruction from 33 boreholes and temperature anomalies based on long term average (1500 to 1700 AD) Black line represent average temperatures from meteorological data compiled from surrounding five (Low Head #091293, Launceston #091311, Hobart #094029, Cape Bruny Island #094010 and Eddystone Point #092045) meteorological stations. Temperature change was calculated from mean of 1961 to 1990. In inset reconstruction from seven boreholes shows early to mid-20th Century cooling before rapid warming in the end of the 20th Century.

Section 4.2. Why don't the other boreholes show the mid-20th Century cooling? What does the literature say about this cooling pattern for Australia? (e.g. Power *et al.*, 1999; Nicholls and Collins, 2006) You say that the warming from the GSTH agrees well with the meteorological data, but can you provide some statistical evidence to support this claim?

Authors: Following text added to make the issue clear

"Theoretically, low resolution reconstruction from borehole temperature data are not capable to display any decadal variability in past temperature history. We consider these patterns probably either due to site specific truncation error or random variability in the borehole temperature data. Although, meteorological record at national scale in Australia also shows a cooling event during mid-20th Century (Karoly and Braganza, 2005; Nicholls, 2003; Nicholls and Collins, 2006). But, it is very unlikely to correlate this mid-20th Century cooling event with above mentioned seven borehole cooling event during early to mid-20th Century"

Following text with statistical evidence inserted "Average borehole reconstruction correlates significantly (r=0.9 and p-value: 0.00) at the 0.05 level with surrounding average meteorological record"

Figure 8: This figure is also a bit confusing. So the smaller circles mean larger misfit? It might be better to use black and grey instead: black is high quality, grey is low quality. You could then use size differences to illustrate the temperature changes instead.
Authors: Figure modified as suggested

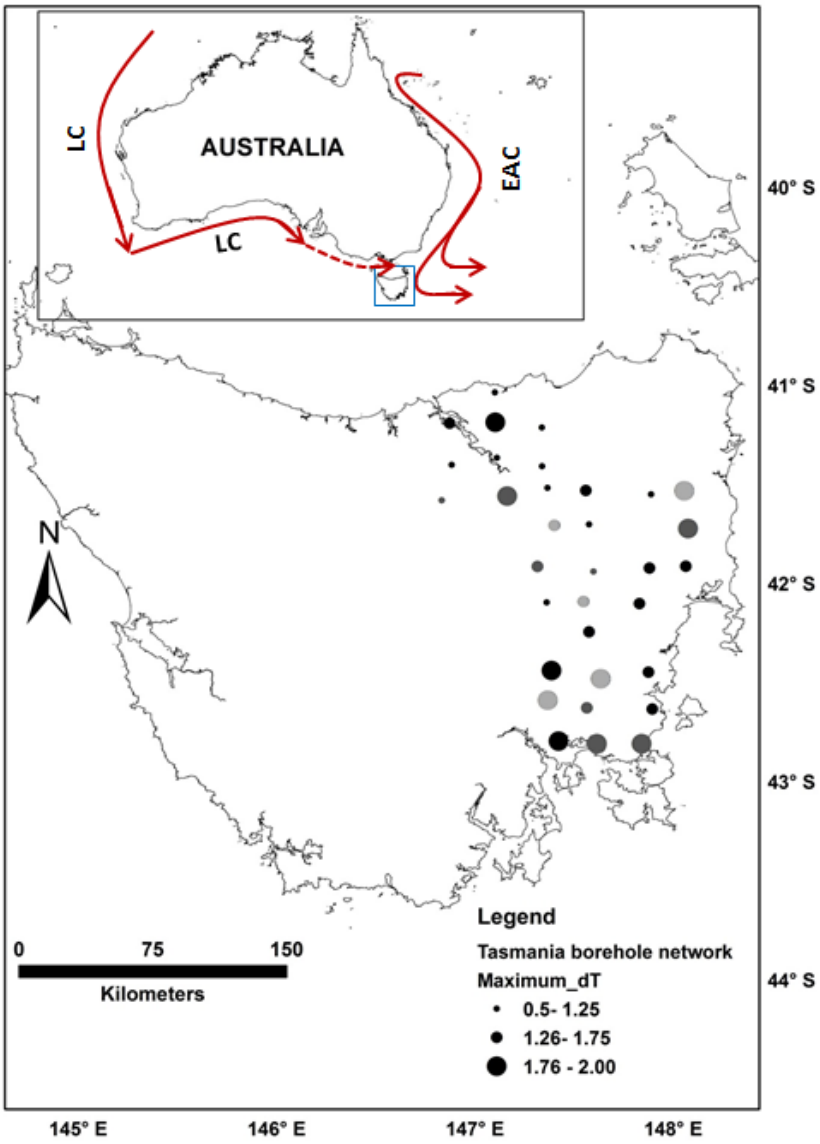

Fig. 3: Spatial variation of regional GTC in Tasmania during the past 500 years. The shading represent area misfit between measured and modelled downhole temperature data: dark grey <0.04, mid-grey -0.04 – 0.06 and light grey >0.06 (to 0.08) m^2/m. Symmetric representation and flow directions of two major current systems around Australia are presented in the inset.

EAC=East Australian Current, LC=Leeuwin Current (dashed line represent the extent of Leeuwin current during La Nina phase)

Figure 9: The R^2 value on the figure (0.1398) does not agree with the correlation coefficient given in the text (–0.4). The finding of this section are also quite weak.
Authors: Following text added in the manuscript
"The distance of the borehole from the coast is moderately correlated (negatively) with the GTC. The relation is statistically significant at the 0.05 level (p-value 0.03)." SPSS output added to support the inference.

Table 1: Correlation between distance from coast, km and the GTC.

Correlations

		Dist_from_coast_km	Maximum_dT
Dist_from_coast_km	Pearson Correlation	1	-.374*
	Sig. (2-tailed)		.032
	N	33	33
Maximum_dT	Pearson Correlation	-.374*	1
	Sig. (2-tailed)	.032	
	N	33	33

*. Correlation is significant at the 0.05 level (2-tailed).

Section 5.2, line 429: Data from two boreholes is not really enough to support the claim that the EAC is responsible for greater temperature changes in the north-east coast of Tasmania. Have you looked into any other research or Tasmanian climatology studies to support your findings, or changes in the EAC over time (e.g. Ridgway, 2007)? I think the language around these results needs to be softened, or your findings put in better context.
Authors: Following text added to clarify the issue
"Boreholes records were not available at west coast of Tasmania. Therefore, it was difficult to show any trend of temperature change from the far west to east of Tasmania from borehole data alone. However, comparing 20 years low pass filtered tree ring reconstruction from Mount Read, Western Tasmania (Cook et al., 2000) with boreholes from North-Eastern Tasmania shows mean borehole reconstruction was significantly (independent sample t-test p-value=0.02) higher during 20th Century.

Observation record from Maria Island, located on East coast of Tasmania shows that the region become both saltier and warmer with mean trends of 0.34 psu/century and 2.28 ^{o}C/century over the 1944 to 2002 period (Ridgway and Hill, 2009). Same study also shows EAC has strengthened and extended further southward during this period. The enhanced

warming in the region is also pointed out by the result from SST using Comprehensive Ocean-Atmosphere Data Set (Smith and Reynolds, 2003). Beside these, model studies also estimate the extending of EAC towards south and strengthening around NE of Tasmania (Cai et al., 2005; Cai, 2006). In addition, warming of Tasman Sea around NE Tasmania is also indicated by movement of some temperature sensitive marine species (*Centrostephanus rodgersii*, *Carcinus maenas*) from north tropics towards south in the last century (Ling et al., 2008; Pittock, 2003; Thresher et al., 2003)

Our GSTH provide evidence that this offshore warming produced by an enhanced EAC increased temperatures on land. Borehole temperature increases during the 20th Century were higher near the coast when compared to the overall borehole dataset (Fig. 3). Therefore, it is more likely that strengthening of the warm EAC has influenced the pattern of temperature changes in NE Tasmania during the 20th Century. The high quality meteorological network also shows higher temperature change at north eastern Tasmanian coast during 20th Century (data available period, Fig. 12, in the manuscript)(Bureau of Meteorology, 2016) in compared to the other midland stations. Our data refine the geographic extent of this enhanced warming, and suggest that it has been most important within ~ 50 km of the north-east coast"

Figure 11: Why have you used a topographical map here? If there is a reason, could you add a scale to it?
Authors: To show the location of meteorological stations that are considered for comparing average borehole record with meteorological record. Scale added in the Fig.

Line 442: "Overall, between 3 and 5 high quality borehole temperature depth profiles are enough to reconstruct robust paleotemperature from any area." I'm not sure where this conclusion came from. Didn't you find a difference in palaeotemperatures across the area of study, and that some boreholes showed a cooling in the mid-20th C while others didn't? If this is a finding of your study, it needs to be explained in the results section, alternatively it needs to be explained better here.
Authors: To clarify the issue following text added in the manuscript

"Availability of borehole data is limited in many areas and drilling boreholes is costly. So, understanding the quality of borehole data and number of borehole required to reconstruct plausible past temperature history is useful for interpretation of the existing records. Theoretically, boreholes with lowest area misfits are free from non-climatic perturbation that can provide plausible past temperature history and less variable with the average high quality borehole reconstruction.

Standard deviation can be used to measure variability of GTC in different group. Standard deviation of GTC from boreholes with low (<0.01 m^2/m), moderate (0.01-0.1 m^2/m) and high (>0.1 m^2/m) area misfits increase from 0.2 to 0.4 and 2.0^oC respectively. Therefore, five

boreholes with area misfit <0.01 m^2/m shows lowest variation in their GTC and variation increase significantly within boreholes with increasing area misfit.

Beside this, strength of the correlation among time series decreases with the increase of area misfit of boreholes. Correlation matrix shows the highest correlation among the best 3 to 5 boreholes with area misfit <0.01 m^2/m. Moreover, these 3 to 5 borehole's average temperature record correlates highly with the surrounding average meteorological record (r=0.95, p-value=0.00) during their period of overlap and other proxy results. Therefore, we concluded 3 to 5 boreholes with area misfit <0.01 m^2/m can be used for plausible past temperature reconstruction from any other area. Boreholes with moderate area misfits may also provide reliable GSTH, but would require twice this number of boreholes to provide a similarly precise GSTH measurement."

Regarding cooling in the early to mid 20th Century text added in the result section to put the issue in better context and mentioned above under comment for section 4.2.

Technical corrections

Please see annotated PDF for suggested typographical corrections.

Authors: Sincerely thanks. Entire manuscript is corrected as per suggestion and corrections are reflected in the track change version.

Reviewer 2

Interactive comment on "Late Holocene temperature variability in Tasmania inferred from borehole temperature data" by Asadusjjaman Suman et al.

General comments

This paper presents: (i) inversions for temperature-depth profiles from 36 boreholes in eastern Tasmania, (ii) comparison of the resultant individual temperature histories against observational data, and (iii) spatial correlation analyses to explain the potential drivers of temperature variability seen in the borehole data. The manuscript structure is sound and the introduction, study setting and methodology are clearly written. However, I have concerns about the data interpretation and therefore the conclusions drawn by this study (see specific comments below). It would also be easier to review this paper if the companion paper cited throughout (Suman and White, in review) was published. The figures are generally clear, although I have made some recommendations below to improve clarity in some cases. The text would benefit from a thorough grammatical check.

Authors: Many thanks for constructive comments. All issues raised by reviewers are addressed thoroughly in the revised manuscript. Suman and White, 2017 was recently published in the Geothermics and added in the text and reference.

Specific comments

It is difficult to determine how the primary data presented in the present manuscript (Suman et al.) may differ from the unpublished Suman and White (in review) manuscript mentioned in the text. From the present citations this separate manuscript also presents the borehole data (line 219), borehole temperature inversions with comparison to observational data (line 263), and exploratory spatial correlation analyses (line 377).

Authors: The primary data are indeed the same. The interpretation and discussion in the Geothermics paper is largely focussed on influence of paleotemperature changes on geothermal exploration. Here, we focus attention on how to identify boreholes that provide reliable paleotemperature measurements, and the climate record that these boreholes provide.

I presume that the unique aspect of the present Suman et al. manuscript is the consideration of the climatic mechanisms responsible for the observed temperature variability. However I am unconvinced that the authors' interpretations are sufficiently supported by the data. I question the authors' conclusion that there are significantly different maximum amplitudes of ground surface temperature between the bores situated in northern/eastern coastal sites, compared to southern/non-coastal sites. For example the data presented in Fig. 9 displays a very weak negative correlation, which appears to be mis-quoted in the text (line 359). The summary of temperature change presented on the map in Fig. 8 also does not provide a convincing argument for any spatial gradients. This weak conclusion thus undermines the connection made to the changing ocean currents made in the underdeveloped paragraphs of section 5.2. Are there any borehole data from the west coast? If the authors could clearly show an east-west gradient in the temperature variability then this would make for a more compelling connection to the EAC.

Authors: All the issues are addressed thoroughly in the revised manuscript with updated Figures. To support the spatial variation of paleotemperature especially higher temperature change across NE coast following text added in the manuscript.

"Boreholes records were not available at west coast of Tasmania. Therefore, it was difficult to show any trend of temperature change from the far west to east of Tasmania from borehole data alone. However, comparing 20 years low pass filtered tree ring reconstruction from Mount Read, Western Tasmania (Cook et al., 2000) with boreholes from North-Eastern Tasmania shows mean borehole reconstruction was significantly (independent sample t-test p-value=0.02) higher during 20th Century.

Observation record from Maria Island, located on East coast of Tasmania shows that the region become both saltier and warmer with mean trends of 0.34 psu/century and 2.28 ^{o}C/century over the 1944 to 2002 period (Ridgway and Hill, 2009). Same study also shows EAC has strengthened and extended further southward during this period. The enhanced warming in this region is also pointed out by the result from SST using Comprehensive Ocean-Atmosphere Data Set (Smith and Reynolds, 2003). Beside these, model studies also estimate the extending of EAC towards south and strengthening around NE of Tasmania (Cai et al., 2005; Cai, 2006). In addition, warming of Tasman Sea around NE Tasmania is also indicated by movement of some temperature sensitive marine species (*Centrostephanus rodgersii*, *Carcinus maenas*) from north tropics towards south in the last century (Ling et al., 2008; Pittock, 2003; Thresher et al., 2003).

Our GSTH provide evidence that this offshore warming produced by an enhanced EAC increased temperatures on land. Borehole temperature increases during the 20th Century were higher near the coast when compared to the overall borehole dataset (Fig. 3). Therefore, it is more likely that strengthening of the warm EAC has influenced the pattern of temperature changes in NE Tasmania during the 20th Century. The high quality meteorological network also shows higher temperature change at north eastern Tasmanian coast during 20th Century (data available period, Fig. 12, in the manuscript)(Bureau of Meteorology, 2016) in compared to the other midland stations. Our data refine the geographic extent of this enhanced warming, and suggest that it has been most important within ~ 50 km of the north-east coast"

Even if the present interpretation of spatial temperature variability in the suite of east coast boreholes is robust, the paucity of data concerning land use changes prior to 1980 precludes rejection of an alternative hypothesis that temperature variability between boreholes is the principally the product of changing vegetation cover. To that end, the most robust finding of this study is the c. 1 K warming during the 20th Century, which is common to all borehole records. The significance of this finding is

weak given that there appears to be reasonable observational data that covers this time window.

Authors: We disagree with this comment. There is little evidence of influence of land cover in our data. Reconstructed GTC were slightly higher in the grassland/farming borehole compared to forested borehole, but this changes are statistically insignificant (independent sample t-test, p-value=0.21) at the 0.05 level. This inference is produced using 33 boreholes with high quality data and available land use data since 1980 (SPSS output included for reference, p value red circled). Therefore, we concluded land use change has secondary implication on spatial pattern of GTC. Further, given the increased prevalence of grassland (and thus forest-grassland conversion, which may result in an anomalous warming in recent GSTH) in the interior of the study region, this factor would only serve to mute the trend that we observe.

Group Statistics

	Ground_Cover2	N	Mean	Std. Deviation	Std. Error Mean
Maximum_dT	1.00 (forest)	19	1.3632	.38134	.08749
	2.00 (grass)	14	1.5471	.42030	.11233

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Maximum_dT	Equal variances assumed	.040	.843	-1.312	31	.199	-.18398	.14024	-.47000	.10203
	Equal variances not assumed			-1.292	26.510	.207	-.18398	.14238	-.47638	.10841

Pollen records from Western Tasmania (Colhoun et al., 1999; Colhoun, 2000), Central Plateau (Hopf et al., 2000) and Eastern Tasmania (Mackenzie and Moss, 2014) shows Tasmanian vegetation did not change greatly during mid to late Holocene. In addition, historical analysis also shown, despite changes in species composition (Fensham, 1989), the overall landscape vegetation structure of midland Tasmania has not change sufficiently in last few hundred years to affect the observed trends in GSTH. Where land cover change has occurred near our boreholes, this is largely been from sparse forest to grassland. Therefore, it is less likely vegetation change prior 1980s is the driver of the spatial variation of paleo temperature in Tasmania.

Manuscript section: Variation due to land use reworded to avoid any confusion and make it clear to the reader.

Observational data are available only for past 100 years. Borehole reconstruction for last 500 years added spatial density in paleoclimate study in Tasmania. Study reveals some important issues i.e. number of boreholes required to reconstruct plausible past temperature history, less variability of past temperature between 15th and 19th Century at Centennial scale in Tasmania, and regional spatial variation of paleotemperature. Study also confirms the concept of southward movement of EAC and strengthening around NE of Tasmania as higher temperature changes found in the boreholes are mostly located proximity of NE coast (Fig. 3).

Technical corrections

Line 331: The substrate lithology does not make these records 'highly reliable' in an absolute sense. Rather, these records may relatively more reliable than mixed lithology bores

Authors: Agreed and text changed as per suggestion

Line 359: the reported correlation statistics do not much those in Fig. 9. The data shown in Fig. 9 appears to exhibit a very weak correlation between temperature change and distance from the coast.

Authors: The correlation is moderate. However, the relation is statistically significant at the 0.05 level (p-value 0.03).

Correlations

		Dist_from_coast_km	Maximum_dT
Dist_from_coast_km	Pearson Correlation	1	-.374*
	Sig. (2-tailed)		.032
	N	33	33
Maximum_dT	Pearson Correlation	-.374*	1
	Sig. (2-tailed)	.032	
	N	33	33

*. Correlation is significant at the 0.05 level (2-tailed).

Fig. 1: Needs a small legend to easily discriminate dashed/full lines. Also redefine T0 in the legend

Authors: Corrected as per suggestion.

Fig. 5 remove arrowhead lines – these interfere with the data on the left hand plot

Authors: Corrected as per suggestion.

Fig 7. I suggest splitting this figure into two panels. First have the figure as currently presented, but in the second panel I suggest presenting just the 20th Century portion of the data on a higher resolution x-axis, so that the finer details of individual records

are more clearly visible.
Also, I am confused about the y-axis. What is the reference datum from which temperature has changed? Is it the AD1500? If so, to what datum is the observational data referenced? Please define this in the axis label or figure caption

Authors: Separate Figure added and necessary information provided in the text as suggested.

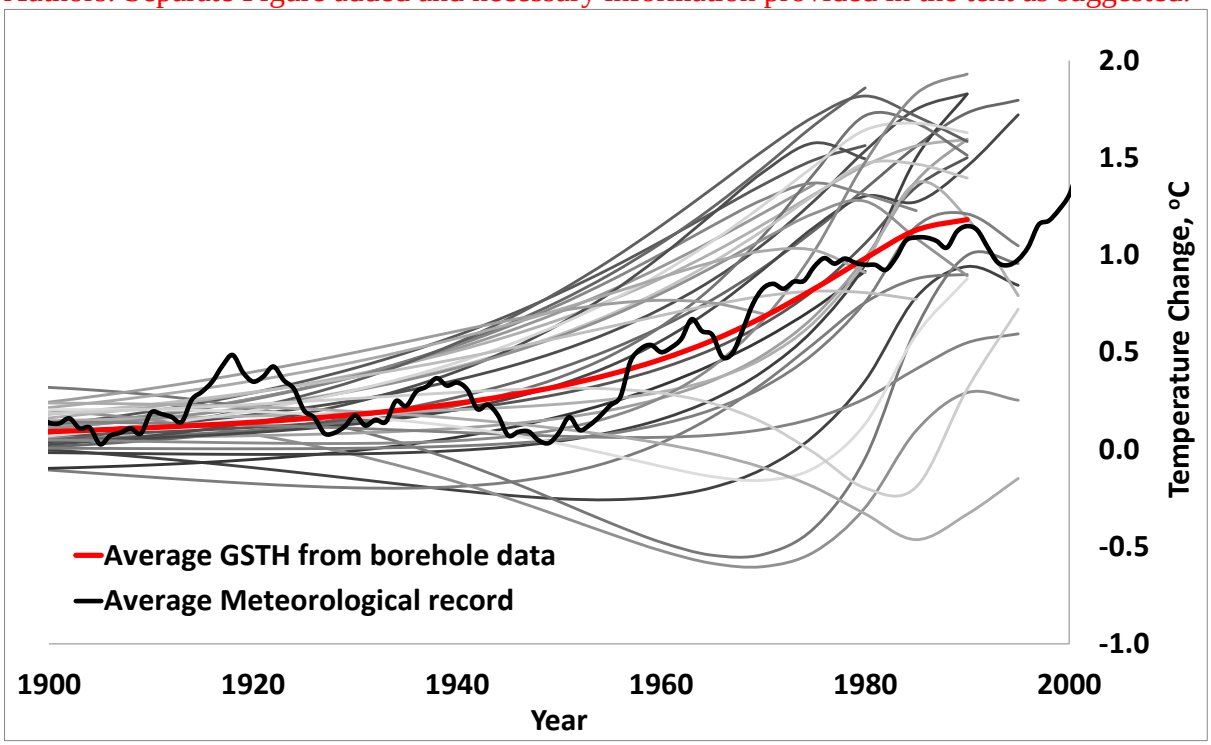

Fig. 4 Individual and average borehole reconstruction with average meteorological record during 20th Century for visibility.

Fig. 8. It is somewhat counterintuitive to have sites with low misfits represented by bigger symbols, and vice-versa. More importantly, the classification of these categories appears arbitrary, yet is used to support arguments of significant spatial variability in the dataset. What, if any, is the significance of the <2.0> area misfit division?

Authors: We have more confidence on the reconstruction of boreholes with less area misfit. Figure modified (Fig. 3) to make it clear.

References

Bureau of Meteorology. 2016. ACORN-SAT station data and network: Long-term temperature record, Australian Climate Observations Reference Network – Surface Air Temperature. http://www.bom.gov.au/climate/change/acorn-sat/#tabs=Data-and-networks.

Cai W. 2006. Antarctic ozone depletion causes an intensification of the Southern Ocean super-gyre circulation. *Geophys. Res. Lett.* **33**:1–4.

Cai W, Shi G, Cowan T, Bi D, Ribbe J. 2005. The response of the Southern Annular Mode, the East Australian Current, and the southern mid-latitude ocean circulation to global warming. *Geophys. Res. Lett.* **32**:1–4.

Colhoun EA. 2000. Vegetation and climate change during the Last Interglacial-Glacial cycle in western Tasmania, Australia. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **155**:195–209.

Colhoun EA, Pola JS, Barton CE, Heijnis H. 1999. Late Pleistocene vegetation and climate history of Lake Selina, western Tasmania. *Quat. Int.* **57**–**58**:5–23.

Cook ER, Buckley BM, D'Arrigo RD, Peterson MJ. 2000. Warm-season temperatures since 1600 BC reconstructed from Tasmanian tree rings and their relationship to large-scale sea surface temperature anomalies. *Clim. Dyn.* **16**:79–91.

Fensham RJ. 1989. The pre-European vegetation of the Midlands, Tasmania: a floristic and historical analysis of vegetation patterns. *J. Biogeogr.* **16**:29–45.

Hopf FVL, Colhoun EA, Barton CE. 2000. Late-glacial and Holocene record of vegetation and climate from Cynthia Bay, Lake St Clair, Tasmania. *J. Quat. Sci.* **15**:725–732.

Karoly DJ, Braganza K. 2005. Attribution of recent temperature changes in the Australian region. *J. Clim.* **18**:457–464.

Ling SD, Johnson CR, Ridgway KR, Hobday AJ, Haddon M. 2008. Climate change drives range extension of a marine ecosystem engineer: Informing future patterns from correlations of the recent past. *Glob. Chang. Biol.* **14**.

Mackenzie L, Moss P. 2014. A late Quaternary record of vegetation and climate change from Hazards Lagoon, eastern Tasmania. *Quat. Int.*

Nicholls N. 2003. Continued anomalous warming in Australia. *Geophys. Res. Lett.* **30**:23–1.

Nicholls N, Collins D. 2006. Observed climate change in Australia over the past century. *Energy Environ.* **17**:1–12.

Pittock AB. 2003. Climate Change: An Australian Guide to the Science and Potential Impacts. In: . Canberra, ACT: Australian Greenhouse Office.

Ridgway K, Hill K. 2009. The East Australian Current. In A Marine Climate Change Impacts and Adaptation Report Card for Australia 2009 (Eds. E.S. Poloczanska, A.J. Hobday and A.J. Richardson), NCCARF Publication 05/09, ISBN 978-1-921609-03-9:1–16.

Smith TM, Reynolds RW. 2003. Extended reconstruction of global sea surface temperatures based on COADS data (1854-1997). *J. Clim.* **16**:1495–1510.

Suman A, White D. 2017. Quantifying the variability of paleotemperature fluctuations on heat flow measurements. *Geothermics* **67**:102–113.

Thresher RE, Proctor C, Ruiz GM, Gurney R, MacKinnon C, Walton W, Rodriguez L, Bax N. 2003. Invasion dynamics of the European shore crab, Carcinus maenas, in Australia. *Mar. Biol.* **142**:867–876.