



Australian Government

Bureau of Meteorology

Australian Climate Observations Reference Network – Surface Air Temperature (ACORN-SAT)

Bureau of Meteorology Response to the Recommendations of the
Technical Advisory Forum

July 2015



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The Bureau of Meteorology welcomes the release of the first annual report of the Technical Advisory Forum established to advise the Bureau on the development and operation of the Australian Climate Observations Reference Network – Surface Air Temperature (ACORN-SAT) dataset.

The Forum was established in response to one of the recommendations of an independent peer-review of the dataset undertaken in 2011, which expressed overall confidence in the Bureau's practices and found its data and analysis methods to be among the best in the world.

The Forum members were appointed by the Parliamentary Secretary to the Minister for the Environment for a three-year period to meet annually and provide recommendations on further development of ACORN-SAT. The Forum's first report, delivered on 12 June 2015, provides the Bureau with valuable advice on the future management of the dataset.

We are pleased to note that the Forum was satisfied with the Bureau's commitment to continuous improvement and approach to the methodological development and operation of the ACORN-SAT dataset. In particular, the Forum noted the progress made by the Bureau in implementing the recommendations of the 2011 peer review and its commitment to transparency and information provision.

The Bureau welcomes the Forum's conclusion that data homogenisation plays an essential role in eliminating artificial non-climate systematic errors in temperature observations, so that a meaningful and consistent set of records can be maintained over time. The Bureau notes that the Forum considers that the analyses conducted by the Bureau reflect good practice in addressing the problem of how to adjust the raw temperature series for systematic errors.

The Bureau also notes the view expressed by the Forum that the unsolicited submissions it considered do not provide evidence or offer justification for contesting the overall need for homogenisation and the scientific integrity of the Bureau's climate records. The Bureau is committed to improving public understanding of the ACORN-SAT dataset and methods and will soon release a discussion paper addressing some of the key questions raised in those submissions. Various recommendations in the Forum report, when implemented, will further aid the objective of enhancing public understanding.

The Forum made five key recommendations to guide the Bureau's approach to continuously improve the ACORN-SAT dataset. The Bureau has given careful regard to each of the recommendations and is committed to making several practical improvements over the duration of the Forum's three year term. The five key recommendations include:

- improve communication concerning the importance and value of the ACORN-SAT dataset;
- continue to improve the accessibility of the ACORN-SAT data and information;
- continue to develop and improve the statistical methods employed in developing the dataset;
- continue to improve access and handling of the metadata information; and
- continue to expand the ACORN-SAT dataset and supporting analysis.

These recommendations align well with the Bureau's own plans and priorities in ACORN-SAT development.

The Forum concluded there is scope for improvements that can boost the transparency of the dataset and increase its usefulness as a decision-making tool, particularly in the area of developing uncertainty measures. Uncertainty estimation remains a field of active research, and there are a range of new and novel approaches that can be brought to this problem. Ongoing dialogue with Forum members and the 2016 Forum will provide further guidance and support for achieving these improvements.

Communication is a key aspect of ensuring data are applied with confidence and in an appropriate way, and we support the recommendations on how this can be improved.

The Bureau notes the Forum's support for continued improvement to ACORN-SAT through activities such as further data digitisation, addition of new data sources (e.g., more stations), and the extension of ACORN methodologies to other data types such as rainfall. While there remain both technical and resource challenges in implementing these recommendations, the Bureau will do its best to progress them.

We note that the Forum assigned a priority, indicated by one or two asterisks, to each recommendation. The Forum stated those with two asterisks are the most important. The Bureau has taken this into account in setting a timeframe for delivering each recommendation.

The Bureau wishes to record its sincere appreciation of the Forum members. The Forum was conducted with a high degree of professionalism, with members applying themselves constructively and practically to the task. The Bureau is committed to a process of continuous improvement, ensuring that we provide Australians with the best intelligence to inform their decision making across all time scales.

The Bureau looks forward to working closely with the Forum for the duration of its three-year term to further enhance the quality and value of the ACORN-SAT dataset. The Bureau's detailed response to the recommendations of the Forum is provided in the following Table.

Recommendation 1

1. The Forum recommends that the Bureau continue to improve its communications related to the ACORN-SAT dataset by:

Forum recommendation	Bureau response	Bureau comments
<p>1a **</p>	<p>Expediting the Bureau’s current work on developing uncertainty measures in closer consultation with the statistical community. The Forum recommends the Bureau seek to better understand the sources of uncertainty and to include estimates of statistical variation such as standard errors in reporting estimated and predicted outcomes, including:</p> <ul style="list-style-type: none"> quantifying the uncertainty for both raw and adjusted data; prioritising the provision of explicit standard errors or confidence intervals, which should further inform the Bureau’s understanding and reporting of trends in all temperature series maintained by the Bureau; examining the robustness of analyses to spatial variation; and articulating the effect of correcting for systematic errors on the standard error of resulting estimates. 	<p>Agreed</p> <p>This will be an on-going area of work over the next three years and will be reported on at the next Forum meeting in 2016</p> <p>As the Forum report indicates, this is work that is already in progress within the Bureau. The Bureau will endeavour to provide explicit confidence intervals for as many ACORN-SAT measures as possible.</p> <p>Given the specialist statistical expertise required for this task, the Bureau will seek active collaboration with the Technical Advisory Forum.</p>
<p>1b **</p>	<p>Developing a clearer articulation of the purpose for the ACORN-SAT exercise to enhance public understanding of the program, and communicating processes for developing and using ACORN-SAT in a way that is appropriately clear, broad and supported by graphics and data summaries. In particular, the central focus on the Australian annual mean temperature anomaly as the primary end point of the ACORN-SAT exercise should be reconsidered and a broader narrative around including regional effects should be developed.</p>	<p>Agreed</p> <p>To be completed by the next Forum meeting in 2016</p> <p>The Bureau agrees that the utility value of ACORN-SAT is far broader than the estimation of mean annual temperature anomaly.</p> <p>The Bureau will prepare a plain-language guide to articulate the purpose of the ACORN-SAT dataset and relevant supporting information. Particular focus will be given to how the dataset can be used to describe changes in regional temperature and changes in temperature extremes.</p>

Forum recommendation	Bureau response	Bureau comments
<p>1c *</p> <p>Avoiding jargon in explaining statistical uncertainty that could mean different things in scientific language versus common usage. The Bureau should carefully define or use alternative words without common connotations that are different to the scientific use.</p>	<p>Agreed</p> <p>To be completed by the next Forum meeting in 2016</p>	<p>The Bureau will prepare specialised communication products for the general public to assist with their understanding of climate data homogenisation and why it is necessary.</p> <p>These products will aim to avoid scientific language that has different meaning in the broader community, and will contain definitions where helpful to assist public understanding.</p> <p>As most of the terminology used in ACORN-SAT is in general use in the climate science community the Bureau will retain that when contributing to the technical literature.</p>
<p>1d</p> <p>Maintaining on its website links to journals databases where the public can access peer-reviewed, published research relating to climate science and the ACORN-SAT dataset, and providing example case studies or evidence of other climate analyses by the Bureau and independent bodies that use the ACORN-SAT data. Where such literature can only be accessed by payment of a fee, this should be indicated next to the relevant web link.</p>	<p>Agreed</p> <p>To be completed by the next Forum meeting in 2016</p>	<p>A detailed list of relevant literature will be provided on the ACORN-SAT website.</p>
<p>1e **</p> <p>Reducing the potential for confusion between temperature series that measure fundamentally different physical quantities (e.g. satellite temperatures are different to air temperatures near the ground) by clarifying the differences between different types of measurements in public statements regarding other datasets.</p>	<p>Agreed</p> <p>To be completed by the next Forum meeting in 2016</p>	<p>The Bureau has written articles on the difference between the various temperature datasets and will look to give this material more prominence. The Bureau will prepare an FAQ on this topic and will post it on the ACORN-SAT website.</p> <p>The Bureau will also refer to this information in our communication products for the general public (see response to Recommendation 1c).</p>

Recommendation 2

2. The Forum recommends that the Bureau continue to improve the accessibility of ACORN-SAT data and information by adopting the following:

Forum recommendation	Bureau response	Bureau comments	
2a	Utilising a universal text-based format such as CSV for providing both raw and adjusted data.	Agreed To be completed by the end of 2016	
2b *	Providing the CSV files for the 112 ACORN-SAT stations that contain time series of maximum and minimum temperature records together with the relative contribution (such as a relative weighting or similar) to the Australian average temperature record. This provision should be accompanied by advice consistent with the reconsideration of the Australian annual mean temperature anomaly as a central output of analyses supported by the ACORN-SAT dataset.	Agreed in principle This will be an on-going area of work over the next three years and will be reported on at the next Forum meeting in 2016	The Bureau will endeavour to provide information that gives guidance on the effective 'footprint' of individual locations. The Australian temperature anomalies published by the Bureau are based on daily and monthly gridded data with more than one station contributing towards values at each grid point. Unlike simpler methods such as Thiessen polygons, there is no specified set of weights attached to these. The effective contributions change on a daily or monthly basis, depending on which stations did or did not report on any given day or month.
2c *	Consolidating all downloads of raw and adjusted data using links on a single web page.	Agreed To be completed by the end of 2016	
2d *	Improving the usability of the website for downloading data (both raw and adjusted) to allow downloads of bundled data by year rather than by site, and if possible, the option to download all data with appropriate warnings about file size and potential download costs.	Agreed To be completed by the end of 2016	
2e *	Releasing the Python computer code for ACORN-SAT as a downloadable link along with all supporting documentation and listing of the technical requirements for the software. The Bureau should also monitor and gather download statistics to gauge demand for this software.	Agreed To be completed by August 2015	Python computer code for ACORN-SAT has been available on request. The Bureau will provide a downloadable link on the ACORN-SAT website and monitor the level of access to the code.

Forum recommendation	Bureau response	Bureau comments
2f *	Publishing a brief, plain-language (as far as possible) description of the criteria for adjustment and the basis for adjustment itself.	<p>Agreed</p> <p>To be completed by the next Forum meeting in 2016</p> <p>The Bureau will produce a plain-language fact sheet on the adjustment criteria and methods used.</p>
2g *	<p>Adopting an at-cost fee-for-service approach for the provision of custom data, noting that the provision of custom data may impose a substantial resource burden on the Bureau. The Bureau should include a statement on the ACORN-SAT website that while reasonable assistance may be provided by the Bureau, extensive assistance may not be provided without an appropriate cost-recovery charge to be determined by the Bureau's management. Access to the complete data (i.e., without user-requested customisations) should remain free, consistent with the Australian Government's Open Government Initiative.</p>	<p>Agreed</p> <p>This recommendation is consistent with the Bureau's current practice for cost recovery.</p> <p>The Bureau will include a statement on the ACORN-SAT website as recommended.</p> <p>Access to the basic datasets will remain free as recommended.</p>
2h *	Providing advice on its website about the necessary level of end-user expertise and resources necessary for reproducing the ACORN-SAT analysis.	<p>Agreed</p> <p>To be completed by the next Forum meeting in 2016</p> <p>The Bureau will prepare advice on this topic and publish it on the ACORN-SAT web site.</p>
2i	Examining the provision of a robust code that supports a level of automation that allows sensitivity analyses to be reasonably undertaken by independent parties.	<p>Agreed</p> <p>The Bureau will report back at the next Forum meeting in 2016</p> <p>The Bureau will undertake a short study to examine what might be useful and affordable in this area.</p>

Recommendation 3

3. The Forum recommends the Bureau should continue to develop and improve the statistical methods employed in developing the ACORN-SAT dataset by adopting the following:

Forum recommendation	Bureau response	Bureau comments
3a *	<p>Developing a work program for engagement with the statistical community on an on-going basis to ensure that its data analysis methods are leading practice.</p>	<p>Agreed</p> <p>This will be an on-going area of work over the next three years and will be reported on at the next Forum meeting in 2016</p> <p>The Bureau will work with the statistical community with a particular focus on quantifying uncertainty in the ACORN-SAT dataset. In planning the future work program, the Bureau will seek guidance from the Technical Advisory Forum.</p>
3b **	<p>Refining the choice of data fitting functions and identification of temporal changes in the data used within the statistical methods for the ACORN-SAT dataset.</p> <p>i. While it is acknowledged that the quadratic function is one valid fit to the available data, the Forum recommends that the Bureau revisit the use of piecewise linear fits or nonparametric smoothers such as LOWESS for the purposes of data description. The Forum strongly recommends that these fitting methods be investigated for public communication about temperature changes over time. The Forum recommends that the Bureau clearly communicate that all such fitted curves should be interpreted as descriptions of available data and cautions against the use of these forms for forecasting or predicting specific future temperature behaviour.</p> <p>ii. Where breakpoints are identified by statistical means, the Bureau should seek to apply them at the time value at which they were detected (as opposed to applying them from the beginning of the calendar year), so that, for example, breakpoints in annual series are attributed to the year, while for daily series, breakpoints would be attributed to a specific day.</p>	<p>i. The Bureau has trialed a number of data fitting procedures to estimate observed changes in Australian mean temperature. These include polynomial and LOWESS models, as well as piecewise linear models. The Bureau does not use these fitting procedures to forecast future temperatures and agrees it would be invalid to do so. As per Recommendation 1b the Bureau will communicate this more clearly in the relevant documentation.</p> <p>ii. The Bureau seeks further discussion with the Forum on this issue. The statistical detection method is primarily deployed on annual data (with some support from seasonal data) and hence breakpoints are not generally detected with a time resolution finer than one year, unless supported by specific metadata. The Bureau has been guided by the experience of the US dataset (which used a very similar detection algorithm, but using monthly data), in which an uncertainty assessment was carried out that found that the uncertainty of timing of statistically detected breakpoints was typically in the order of plus or minus several months. Some breakpoints (e.g., those arising through an encroachment of vegetation) will also be gradual and cannot reliably be tied to a specific date.</p>

Forum recommendation	Bureau response	Bureau comments
<p>3c * Undertaking appropriate sensitivity analyses to demonstrate the extent to which the process of adjustment has a material effect on indicative temperature patterns.</p>	<p>Agreed</p> <p>This will be an on-going area of work over the next three years and will be reported on at the next Forum meeting in March 2016</p>	<p>The Bureau has undertaken such an analysis for indicators such as the national-mean temperature, as well as spatially for mapped surface temperatures.</p> <p>The Bureau believes that the intent of this recommendation is best served by generation of the uncertainty estimates per Recommendation 1a and will advise the Forum in 2016 of the resourcing and timeframes for the extension of national sensitivity analysis to specific locations.</p> <p>The Bureau will work with the Technical Advisory Forum over the next three years to address this recommendation.</p>
<p>3d * Incorporating weights within the data-fitting process that reflect the differential uncertainty associated with the measurements from pre-1910 and attempting to undertake regional analyses (e.g. for south-eastern Australia).</p>	<p>Agreed</p> <p>This will be an on-going area of work over the next three years and will be reported on at the next Forum meeting in March 2016</p>	<p>The Bureau will investigate uncertainties arising from spatial interpolation of sparse colonial era networks in eastern Australia.</p> <p>The question of the potential use of pre-1910 southeastern Australian data is discussed further under Recommendation 5c.</p>

Recommendation 4

4. The Forum recommends that the Bureau continue to improve the access and handling of metadata information by:

Forum recommendation	Bureau response	Bureau comments	
4a	<p>Providing links to access metadata information for each station via clickable maps.</p>	<p>Agreed in principle</p> <p>To be completed by March 2017</p>	<p>As a first step, the Bureau will release an expanded station catalogue including information similar to that already made available for six stations through factsheets on the ACORN-SAT website (www.bom.gov.au/climate/change/acorn-sat/) for all 112 locations.</p> <p>The resourcing of an interactive map user interface will be considered when the catalogue of all 112 sites has been published (refer to response to 2f).</p>
4b	<p>Developing a framework for standardising metadata information so that adjustments made on the basis of metadata are seen as both transparent and objective. This development should result in a set of agreed guidelines that support digitisation of metadata.</p>	<p>Agreed in principle</p> <p>This will be an on-going area of work over the next three years and will be reported on at the next Forum meeting in March 2016</p>	<p>As a first step, we propose to focus on the referencing of metadata in the ACORN-SAT fact sheets and catalogue. This will enhance the transparency of the homogenisation process, which is the underlying intent of this recommendation.</p> <p>Our experience is that some of the metadata is in forms that cannot easily be codified in a standardised manner.</p>
4c	<p>Examining the feasibility of developing a robust, uniform digital format for metadata.</p>	<p>Agreed</p> <p>The Bureau will report back at the next Forum meeting in 2016</p>	<p>As described in 4b above, the Bureau considers it unlikely that it will be possible to develop a uniform digital classification for relevant items of metadata that is completely comprehensive. However, where feasible, existing material will be placed into a uniform format.</p> <p>Work is currently taking place in this field under the auspices of the WMO (Commission for Basic Systems Inter-Programme Expert Team on Metadata Implementation), which met in Melbourne in June 2015.</p> <p>The Bureau will monitor international developments in metadata digitisation.</p>
4d	<p>Examining crowd-sourcing as an option for improving data-gathering processes, with appropriate safeguards for ensuring data integrity.</p>	<p>Agreed</p> <p>The Bureau will report back at the next Forum meeting in 2016</p>	<p>The Bureau will examine the potential of crowd-sourcing for improving data gathering processes and advise the Forum what might be achievable with current resources.</p>

Recommendation 5

5. The Forum recommends that the Bureau continue to expand the ACORN-SAT dataset and supporting analyses.

Forum recommendation	Bureau response	Bureau comments	
5a	<p>The Bureau should augment the ACORN-SAT dataset with other data such as ACORN-RAIN to build a more complete understanding of climate trends in Australia and broaden the public discourse on climate change.</p>	<p>Agreed</p> <p>To be completed by March 2018</p>	<p>The Bureau currently has operational homogeneous datasets for temperature, cloud amount and pan evaporation. Homogeneous datasets for rainfall and upper-air temperatures are currently under development. We will endeavour to progress this work as quickly as resources allow.</p>
5b	<p>Regional sub-analyses should be undertaken as a means for assessing the sensitivity of ACORN-SAT analyses to regional differences.</p>	<p>Agreed</p> <p>This will be an on-going area of work over the next three years and will be reported on at the next Forum meeting in March 2016</p>	<p>The Bureau sees merit in comparing ACORN-SAT and other datasets (e.g., AWAP) at the regional scale, and in quantifying uncertainties in regional statistics. The Bureau has started work toward this end in some areas of southeastern Australia.</p> <p>Work on uncertainty and sensitivity will be discussed with the Technical Advisory Forum as it progresses.</p>
5c	<p>Further, the possible availability of pre-1910 data at south-eastern sites may allow for a comparative analysis to be performed for south-eastern Australia to assess whether the inclusion of pre-1910 data is worthwhile in attempting to understand current temperature patterns.</p>	<p>Agreed in principle</p> <p>The Bureau will report back at the next Forum meeting in 2016</p>	<p>The Bureau has worked closely with university scientists to develop pre-1910 data sets and this work is published.</p> <p>The Bureau sees merit in examining the pre-1910 data more closely with a view to enriching our interpretation of historical variability and change in southeastern Australia's climate. It will continue to work closely with university scientists leading this work.</p> <p>This will include an assessment of the existing University of Melbourne dataset for southeastern Australia, to determine the extent to which information from it can be incorporated into the Bureau's various climate publications.</p>