



Australian Climate Observations Reference Network

Surface Air Temperature
(ACORN-SAT)

**Report of the Technical Advisory Forum
September 2016**

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11 August 2016

The Hon Josh Frydenberg MP
Minister for the Environment and Energy
Parliament House
CANBERRA ACT 2600

Dear Minister

It is with great pleasure that I attach the second annual report on the Australian Climate Observations Reference Network Surface Air Temperature (ACORN-SAT) dataset on behalf of the Technical Advisory Forum. I am providing you with this report following the appointment of the Forum by the previous Parliamentary Secretary to the Minister for the Environment in 2015. The Forum has been established for a three year period to annually review the development and operation of the ACORN-SAT dataset and to provide advice and recommendations on further developments. This report follows the Forum's first annual report which was released in June 2015.

The Forum commends the Bureau of Meteorology for their progress in addressing the five recommendations made in the first annual report. In the 2016 report, the Forum members considered three aspects of the ACORN-SAT dataset as required by our Terms of Reference:

- the extent of the public availability of the ACORN-SAT information;
- developments since the 2011 Independent Peer Review of the Bureau's data and analysis methods;
- the scientific integrity and robustness of the Australian climate record and the homogenisation process.

This report further supports the Forum's 2015 conclusion that ACORN-SAT is a complex and well-maintained dataset. The Forum reiterates its comments from 2015 that the dataset represents an important source of information on the climate trends affecting Australia. The Forum has made three new recommendations in this report that we feel will contribute to continuous improvement of the ACORN-SAT dataset.

The Forum members would like to thank the Department of the Environment for continuing to support and manage the Forum's membership. We also record our appreciation of staff from the Bureau in providing information and answering questions on the dataset.

I have provided a copy of the report to Dr Andrew Johnson, Director of the Bureau of Meteorology, and look forward to the Bureau's response. I would be very pleased to discuss the Forum's report with you, if you would like further details about our deliberations or conclusions.

Yours sincerely



Dr Ron Sandland AM FTSE
Chair, ACORN-SAT Technical Advisory Forum
On behalf of: Emeritus Professor Bob Vincent (Vice Chair), Dr Phillip Gould, Dr John Henstridge,
Ms Susan Linacre, Professor Michael Martin, Professor Patty Solomon, Professor Terry Speed

11 August 2016

Dr Andrew Johnson
Director of Meteorology and Chief Executive Officer
Bureau of Meteorology
GPO Box 1289
Melbourne VIC 3001

Dear Dr Johnson

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I am providing you with this report following the appointment of the Forum by the previous Parliamentary Secretary to the Minister for the Environment in 2015. The Forum has been established for a three year period to annually review the development and operation of the ACORN-SAT dataset and to provide advice and recommendations on further developments. This report follows the Forum's first annual report which was released in June 2015. I have also provided a copy of the report to the Minister for the Environment and Energy, the Hon Josh Frydenberg MP.

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I congratulate the Bureau for their ongoing work on the ACORN-SAT dataset, and extend the Forum's thanks and appreciation to the Bureau staff for their detailed and energetic presentations and responses to the Forum's questions.

Yours sincerely



Dr Ron Sandland AM FTSE
Chair, ACORN-SAT Technical Advisory Forum
On behalf of: Emeritus Professor Bob Vincent (Vice Chair), Dr Phillip Gould, Dr John Henstridge,
Ms Susan Linacre, Professor Michael Martin, Professor Patty Solomon, Professor Terry Speed

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Acronyms

ACORN-SAT	Australian Climate Observations Reference Network—Surface Air Temperature
ACORN-RAIN	Australian Climate Observations Reference Network—Rainfall
AWAP	Australian Water Availability Project
CAWCR	Collaboration for Australian Weather and Climate Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FAQ	Frequently Asked Question
GCM	Global Climate Models
HDR	Higher degree by research
WMO	World Meteorological Organization

Executive summary

This is the second annual report of the Technical Advisory Forum established by the Australian Government in January 2015. The Forum was established to review the development and operation of the Bureau of Meteorology’s Australian Climate Observation Research Network—Surface Air Temperature (ACORN-SAT) dataset and to review, provide advice and make recommendations on the present situation and further developments in the maintenance, reporting and use of that dataset.

The ACORN-SAT is the Bureau’s long-term homogenised dataset of Australian daily temperatures covering the period from 1910 to the present. In light of the importance of the integrity of this dataset in understanding long term climate trends affecting Australia, the Bureau initiated an independent peer review of the ACORN-SAT dataset in 2011. The peer review expressed overall confidence in the Bureau’s practices and considered its practices as among the best in the world. One of the recommendations of the peer review was for the Bureau to establish a Technical Advisory Forum to review and provide advice on the ongoing development and operation of the dataset.

The Forum’s Terms of Reference require it to consider:

- the extent of the public availability of the ACORN-SAT information;
- developments since the 2011 Independent Peer Review of the Bureau’s data and analysis methods; and
- the scientific integrity and robustness of the Australian climate record and the homogenisation process.

This report outlines the Bureau’s progress against the recommendations made by the Forum in its first report in 2015 and contains three new recommendations. This report should be read alongside the contextual information provided in the first annual report which is available on the Bureau’s website.

2015 report

The Forum first met in March 2015 and released its first annual report in June the same year. The Forum concluded that the ACORN-SAT dataset is complex and well-maintained. The Forum was generally satisfied with the Bureau’s commitment to continuous improvement and their approach to the methodological development and operation of the ACORN-SAT dataset. In particular, the Forum noted the approach adopted by the Bureau in implementing the recommendations of the 2011 peer review and its commitment to transparency and information provision. The Forum noted that the Bureau is recognised internationally for its expertise in methodological approaches to homogenisation.

The Forum also recognised that homogenisation plays an essential role in eliminating artificial non-climatic systematic errors in temperature observations so that a meaningful and consistent set of records can be maintained over time. There is a need to adjust the historical temperature record to account for site changes, changes in measurement practices, and identifiable errors in measurement. In 2015, the Forum considered 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. To this end, the Forum supported the need for the Bureau’s homogenisation process to incorporate both metadata-based adjustments and adjustments based on the statistical detection of atypical observations.

The Forum compared the Bureau’s activities in detail against each of the three key considerations in the Terms of Reference and made five recommendations in their first annual report to support and inform the Bureau’s continuous improvement of the ACORN-SAT dataset.

2016 report

The Forum met for a second time in June 2016 to consider the Bureau’s progress to date against the five recommendations. The Forum commends the Bureau on its progress against the recommendations and thanks the Bureau’s staff for demonstrating a strong commitment to improving the dataset and responding to the Forum’s questions. The Forum’s summary of the Bureau’s progress is documented in Appendix A. The agenda, meeting minutes and the Chair’s communiqué are in Appendices B and C.

In particular, the Forum welcomes the Bureau’s progress in improving the communication and accessibility of the dataset to the public; improving the access and handling of metadata; and expanding the ACORN-SAT data and supporting analyses. The Forum notes that the Bureau intends to release an update to the ACORN-SAT dataset in late 2016, thereby implementing more of the recommendations related to the communication and accessibility of the dataset.

The Forum continues to support the need for the Bureau’s homogenisation process to incorporate both metadata-based adjustments and adjustments based on the statistical detection of atypical observations. It reiterates the importance of homogenisation in supporting the maintenance of a meaningful and consistent set of temperature records over time.

The Forum continues to be generally satisfied with the Bureau’s commitment to continuous improvement of the ACORN-SAT dataset. The Forum notes again that the Bureau is recognised internationally for its expertise in methodological approaches to homogenisation. This

reputation is evident through the Bureau’s involvement with various international steering committees and working groups—for example, its work with the World Meteorological Organization to develop guidance on data homogenisation and its coordination with the International Surface Temperatures Initiative to establish teams to consider parallel observations and their impacts on observed climate variables.

The Forum has also identified areas where the Bureau’s progress against the recommendations could be strengthened or where it considers that further guidance would be beneficial, particularly in the Bureau’s engagement with the statistical and research community and in the Bureau’s efforts at characterising and estimating uncertainty within ACORN-SAT. The Forum has made three new recommendations to guide future work in these areas. Acknowledging that most of the 2015 recommendations have been met, the 2016 recommendations are designed to replace them.

The three new recommendations can be grouped thematically and address two key aspects of ACORN-SAT, namely: a) continuing efforts to improve the communication and accessibility of the dataset; and b) increasing engagement with the statistical and research community.

The recommendations have been designed with disciplinary differences in data management and analytical practices between meteorologists, climatologists and statisticians in mind, and to encourage best practice improvements to the ways that the ACORN-SAT dataset is constructed, developed and promoted. Importantly, addressing these recommendations is expected to assist with reassuring the public of the already acknowledged robust and rigorous management of Australia’s temperature record and climate data in general. Improving the communication, accessibility and expert management of the ACORN-SAT dataset will help to maintain public confidence in the Bureau’s activities.

The Forum highlighted priorities amongst its 2015 recommendations by marking them with one or two asterisks, with those with two asterisks being the most important. The Forum was pleased that the Bureau’s responses to the 2015 recommendations were made consistent with these priorities. The further recommendations made in this report reflect longer-term goals or are contingent upon the timing of the update to the ACORN-SAT data expected later in 2016. The Forum thus decided not to assign priorities to its 2016 recommendations, and acknowledges that the Bureau’s ability to address these recommendations will be subject to resource availability and that full implementation of the 2016 recommendations may take longer than the term of the Forum.

The Forum considers that its recommendations to the Bureau will help to deliver further improvements to the management and communication of the ACORN-SAT dataset. However,

these recommendations do not pre-suppose any particular narratives concerning Australia's temperature trend, and it is not currently possible to determine whether implementation of the Forum's 2015 and 2016 recommendations will result in an articulated increased or decreased warming trend as estimated using the ACORN-SAT dataset.

The Forum expresses its confidence in the Bureau's efforts to explore deeper connections with the broader statistical community in developing its understanding, analyses and communications relating to the ACORN-SAT dataset. The Forum expects that the progress made towards implementing its 2016 recommendations, as well as discussion of the need for final recommendations, will be matters for consideration at the Forum meeting in 2017.

2016 recommendations

Acknowledging the substantial progress that the Bureau has made against the 2015 recommendations, the Forum proposes the following 2016 recommendations for continued development and improvement of the ACORN-SAT dataset.

RECOMMENDATION 1:

To support continued progress on improving the communication and accessibility of the ACORN-SAT dataset, the Forum recommends that the Bureau:

- a) Continues to implement its communication and accessibility work plan for the release of the updated ACORN-SAT dataset, and advise the Forum when this work has been completed so it can be reviewed against the relevant 2015 recommendations;
- b) Develops case studies that illustrate how the ACORN-SAT dataset and similar data can be used to support climate analyses and decision-making, and make them available on the Bureau website;
- c) Refines its articulation of the ACORN-SAT dataset’s value and purpose both in its context of providing an accurate description of Australia’s historical temperature record and also in relation to its potential use in testing or evaluating climate models. Clarity in this regard could be enhanced by expanding the details provided in response to ACORN-SAT Frequently Asked Question 19 to more explicitly state the way that ACORN-SAT is used in validation and testing of climate models. The Bureau could also identify other appropriate areas on the website and in public communication material to clarify the dataset’s purposes;
- d) Publishes, as part of the ACORN-SAT dataset, effective weights for every ACORN-SAT station at each time point as well as an explanation of how each station influences the national average temperature anomaly, to further improve the transparency and robustness of the ACORN-SAT dataset. The Bureau should seek further guidance and advice from the Forum as needed within the process of developing and communicating such effective weights;
- e) Continues to expand its practice of making source code available for the ACORN-SAT dataset, despite low demand for the source code from users to date. This will improve the transparency of the Bureau’s data adjustment procedures and further align their practices to trends of open access and reproducibility. In making this recommendation, the Forum acknowledges that this is a longer-term project that will be subject to resourcing considerations.

RECOMMENDATION 2:

To build on existing domestic and international engagement with the statistical research community on the ACORN-SAT dataset, the Forum recommends that the Bureau:

- a) Undertakes targeted and active consultation with expert statisticians about the Bureau’s work plan on understanding and communicating uncertainty. This work should recognise the disciplinary differences between meteorologists, climatologists and statisticians in describing and estimating uncertainty, with a view to optimising the Bureau’s approach by adopting appropriate methods from each of these disciplines;
- b) Continues with its preparations to hold a one-day homogenisation workshop prior to the 2017 ACORN-SAT Forum meeting. The Forum is available to assist the Bureau to identify relevant literature and participants for the workshop if required;
- c) Seeks opportunities to present their work on understanding and analysing climate data, for example by presenting at relevant conferences or by publishing in appropriate peer-reviewed journals;
- d) Considers options to undertake a comparative analysis of pre-1910 data at south-eastern sites (for example, by supporting an honours student) to assess whether the inclusion of pre-1910 data is worthwhile in attempting to understand current temperature patterns. Within this recommendation, the Forum acknowledges the Bureau’s current efforts to engage with the research community on this question.

RECOMMENDATION 3:

To support continued progress in the handling of ACORN-SAT metadata and homogenisation, the Forum recommends the Bureau:

- a) Continues to develop high-level metadata factsheets for each station following the release of the next ACORN-SAT dataset. The factsheets should specify the timing of and reasons for adjustments and the reference stations used in making those adjustments;
- b) Further considers the need for and feasibility of transition to an automated homogenisation process, acknowledging that this would require a longer term program of work and be subject to resourcing considerations.

1. Introduction

This is the second annual report containing the findings and recommendations of the Technical Advisory Forum on the Australian Climate Observations Reference Network—Surface Air Temperature (ACORN-SAT) dataset created and maintained by the Bureau of Meteorology. This report should be read as a companion to the Forum’s first annual report published on the Bureau’s website in June 2015.

Australian Climate Observations Reference Network— Surface Air Temperature

The Australian Climate Observations Reference Network—Surface Air Temperature (ACORN-SAT) is a dataset of national temperature records maintained by the Bureau of Meteorology which contains long-term, adjusted surface air temperature data from 112 stations across Australia for the last 106 years.

Homogenisation, as it is commonly known, is the standard approach in meteorology and climate science that enables weather monitoring institutions to maintain a consistent set of temperature records over time, while eliminating non-climate factors that affect temperature readings. Non-climate related factors can include:

- the replacement of thermometers;
- changes in observing practices;
- expansion of the network into remote locations;
- changes in infrastructure surrounding a weather station;
- relocation of weather stations.

The homogenisation adjustment process helps to eliminate artificial systematic errors or artefacts induced by such changes and is a key requirement for compiling and then analysing long-term records of daily maximum and minimum temperatures for any given location. While similar adjusted datasets are maintained by meteorological institutions around the world, ACORN-SAT is the world’s first continental-scale homogenised dataset of daily temperatures.

In 2011, the Bureau initiated an independent and detailed peer review of ACORN-SAT to investigate the robustness of its observing practices, station selection, data homogenisation, calculation of trends and overall public confidence in ACORN-SAT.

The independent peer review expressed overall confidence in the Bureau’s practices and noted that its practices are among the best in the world. The peer review made 31 recommendations to

further increase confidence levels and ensure the highest levels of transparency are maintained. Of these recommendations, 20 have been implemented fully, 10 are in progress and one is no longer applicable. One of the recommendations was to establish a Technical Advisory Forum to review and advise the Bureau on the ongoing development and operation of ACORN-SAT.

Technical Advisory Forum

The Technical Advisory Forum was established by the former Parliamentary Secretary to the Minister of the Environment on 19 January 2015 to review the development and operation of ACORN-SAT annually and to comment on further developments over the years 2015–2017.

Forum members were chosen for their expertise in disciplines such as atmospheric physics and statistics to provide independent advice on the Bureau’s statistical and data analysis methods. Nominations for Forum Members were made by Australia’s Chief Scientist, the Acting Australian Statistician, the Australian Academy of Science and the Australian Academy of Technological Sciences and Engineering. The members of the Forum¹ are:

Dr Ron Sandland AM FTSE	Forum Chair
Emeritus Professor Bob Vincent FAA	Forum Vice Chair
Dr Phillip Gould	Forum Member
Dr John Henstridge CStat, AStat, AFAIM, QPMR, FSS	Forum Member
Ms Susan Linacre	Forum Member
Professor Michael Martin PFHEA	Forum Member
Professor Patty Solomon	Forum Member
Professor Terry Speed FRS, FAA	Forum Member

¹ Biographies for the Forum members are available at Appendix D.

Terms of Reference

The Technical Advisory Forum is to examine and provide comment on:

1. The extent of the public availability of the ACORN-SAT information including:
 - Raw and adjusted data;
 - Documentation of data methods;
 - Computer code;
 - Adjustments;
 - Metadata;
 - Inputs and outputs of peer review; and
 - Ability to reproduce findings.

2. Developments since the 2011 Independent Peer Review (IPR) of ACORN-SAT data and methods including:
 - ACORN-SAT network, in the context of the Bureau’s Observation strategy;
 - Addition of new temperature data, including from individual stations and data post-2010, and whether there is merit in inclusion of pre-1910 data;
 - Progress with metadata to allow independent replication of homogeneity analyses;
 - Progress against the IPR recommendations; and
 - Extent of scientific adoption of data and analyses.

3. The scientific integrity and robustness of the Australian climate record and the homogenisation process including:
 - Compared to raw (unadjusted) data, how does homogenisation affect the overall climate trend for Australia?
 - Compared to other available datasets how do the trends indicated by ACORN-SAT compare?
 - How does the Bureau’s curation methods compare to other international curation methods?
 - What steps should be taken to document or improve the consistency of decision making for the selection of data periods or stations and of the adjustment methods and decisions?
 - How has the ABS assessed ACORN-SAT as part of the Essential Statistical Assets for Australia?

First annual report

The Forum held its first meeting on 26 March 2015. In line with its Terms of Reference, the Forum considered three aspects of ACORN-SAT: the extent of the public availability of the ACORN-SAT information; developments since the 2011 Independent Peer Review of the Bureau’s data and analysis methods; and the scientific integrity and robustness of the Australian climate record and the homogenisation process. At the first annual meeting, the Forum considered a broad range of information and data concerning the management and development of the ACORN-SAT dataset provided by the Bureau as well as unsolicited submissions by some members of the public. It released its first annual report in June 2015 which is available on the [Bureau’s website](#).

The Forum held its second annual meeting on 16 and 17 June 2016. The meeting reviewed the Bureau’s progress against the recommendations made in the first annual report and allowed Forum members to participate in conversations within the Forum and with Bureau staff with a view to making further recommendations for the ongoing development of and communication about ACORN-SAT. This report contains the Forum’s 2016 recommendations following that meeting.

Submissions

Members of the Forum were appointed to provide advice on the basis of their formal expertise, and the Terms of Reference do not require the Forum to receive or respond to unsolicited submissions. Before the first annual meeting in 2015, the Forum received around 20 unsolicited submissions from some members of the public about the dataset and the nature of these are outlined in the Forum’s first annual report. In the opinion of the Forum members, those unsolicited submissions did not provide evidence or offer a justification for contesting the overall need for homogenisation and the scientific integrity of the Bureau’s temperature records. No unsolicited submissions were received prior to the Forum’s 2016 meeting.

2. Public availability of the ACORN-SAT information

In its first annual report, the Forum outlined in detail the public availability of the ACORN-SAT dataset and information. It contained a baseline description of the then current availability of raw and adjusted data; documentation on data methods; access to computer code; details on adjustments; individual metadata details; provision of peer reviewed papers; and the ability to reproduce adjustment and homogenisation processes.

Following the analysis of these components, the Forum made recommendations in its first report to improve the public availability of the ACORN-SAT dataset. The following discussion outlines where progress has been made and where gaps remain in the context of the recommendations and information presented in the first report. The information below should be read in conjunction with the contextual information provided in the first report. See also Appendix A, which sets out the Forum's 2015 recommendations alongside an evaluation of the Bureau's progress.

Progress against 2015 recommendations

The Forum commends the Bureau for its progress in improving the public availability of the ACORN-SAT dataset, and acknowledges the substantial work undertaken by the Bureau to improve communication and availability of the data.

In particular, the Forum welcomes:

- the improvements made to the content and usability of the ACORN-SAT pages of the Bureau website, which now provide a well-organised and readily accessible point of entry and source of information for the dataset, including
 - links to the raw and adjusted data
 - new factsheets
 - new information on station metadata and streamlined station summary sheets
 - links to peer-reviewed literature and reports
 - a comprehensive set of Frequently Asked Questions (FAQ) and responses to clarify public understanding of the purposes and use of ACORN-SAT;
- new information to articulate adjustment methods and the relationship between the ACORN-SAT dataset and temperature data within the Australian Water Availability Project (AWAP);
- improvements in the availability of both the raw and adjusted data in formats that are convenient and accessible;

- the availability of the Python source code for implementing the percentile-matching method used for homogenisation and described in CAWCR Technical Report 049² (on request from the website), noting that there have been only a very small number of requests for the code from the public to date;
- the provision of information on the website about the skill, experience and resources required to reproduce the ACORN-SAT data analysis, and the level of support that the Bureau can provide in assisting others to reproduce ACORN-SAT analyses; and
- details of the Bureau’s collaboration with the World Meteorological Organization to develop guidance on the management and recording of metadata, including the development of a uniform format for such recording.

The Bureau has informed the Forum that a new update to the ACORN-SAT dataset will be released later in 2016. To avoid duplication of effort, the Forum agrees that the Bureau should align the timing of its implementation of some of the Forum’s 2015 recommendations concerning communication and accessibility of the dataset with that of the upcoming data release. The Forum looks forward to being informed of the Bureau’s progress once the new version of ACORN-SAT has been released.

Recommended next steps

The Bureau has made substantial progress in improving the public availability and communication of ACORN-SAT information since the first annual report of the Forum. The Forum has, however, identified some areas for further work.

While the current ACORN-SAT web page provides simplified access to materials related to the ACORN-SAT data set, the Forum felt that public communication about ACORN-SAT would be further improved if the value and purpose of ACORN-SAT was more clearly articulated, both in its context as providing an accurate description of Australia’s long-term historical temperature record, but also in relation to its potential use in testing or evaluating climate models. A clear articulation of the various purposes for which ACORN-SAT data could be used would support greater public awareness of the dataset’s intention and importance as a critical data asset for Australia. Along these lines, the Forum also recommends that the Bureau continues with its plan to develop and make available on the website case studies that illustrate how the ACORN-SAT dataset and similar data, including for example, how satellite temperature data and other data sets such as ACORN-RAIN can be used to support climate analyses and decision-making for public users of Bureau climate data.

² Trewin, B., “Techniques involved in developing the Australian Climate Observations Reference Network—Surface Air Temperature (ACORN-SAT) dataset”, CAWCR Technical Report 049, March 2012. Centre for Australian Weather and Climate Research.

The Forum encourages the Bureau to expand the practice of making source code related to adjustments within ACORN-SAT data available to the public. The code made available to date facilitates an important part of the homogenisation process, but additional code being made available that implements other critical parts of the data adjustment algorithm—for example, the identification of break points in the raw data and estimation of the respective adjustments—would be a welcome initiative. Notwithstanding that few requests for the existing code have been made to date, the Forum notes the trend in modern scientific discourse in favour of open access and reproducibility, and thus feels that the availability of source code improves the transparency of procedures related to ACORN-SAT data. In endorsing such practices, the Forum recognises that they have material resource implications for the Bureau, and thus makes this statement cognisant that all such activities must fit within resource constraints.

To support greater understanding of estimates of the national annual temperature anomaly, the Forum investigated with the Bureau the question of how stations were weighted in the calculation of these averages. While the Forum understood that the national average calculation is more complex than a simple weighted average of site values, the provision of approximate weights that reflect the relative contributions of different sites to the final reported average would assist the public in forming a basic understanding of how such national averages may be interpreted. The Forum considers that providing effective weights for every ACORN-SAT station at each time point and an explanation of how each station influences the national average temperature anomaly would further improve the transparency and robustness of the ACORN-SAT dataset. These weights should be provided as a part of the published ACORN-SAT dataset.

The Forum is keen to see successful implementation of the outstanding 2015 recommendations related to communications and accessibility fully implemented in the new release of the ACORN-SAT dataset. The Forum requests that the Bureau provides an update on this work at the 2017 Forum meeting.

3. Developments since the 2011 Independent Peer Review of ACORN-SAT data and methods

At its first meeting, the Forum was presented with detailed information by the Bureau on developments since the 2011 Independent Peer Review of the ACORN-SAT data and methods. The Forum acknowledged and commended the work of the Bureau in implementing the recommendations of the 2011 review, and provided a detailed overview of these developments in its first annual report. The Forum made two broad recommendations to the Bureau to assist them with improving the use of Australian temperature records which were outlined in the Forum's first report. The discussion below outlines how the Bureau has addressed these two recommendations, and should be read in conjunction with the contextual information provided in the Forum's first annual report. See also Appendix A, which sets out the Forum's 2015 recommendations alongside an evaluation of the Bureau's progress.

Progress against 2015 recommendations

The Forum reiterates its comments from the first report and acknowledges the Bureau's continuing efforts and commitment to improve the ACORN-SAT dataset since the 2011 Independent Peer Review. In particular, the Forum welcomes:

- the Bureau's articulation of the use of the ACORN-SAT dataset as providing more than only an estimate of the Australian annual-mean temperature anomaly. Information on such uses is now available on the Bureau's ACORN-SAT dataset web pages within the Frequently Asked Questions (FAQ) section; and
- the extensive work done since the first Forum meeting related to quantifying uncertainty in estimates derived from the ACORN-SAT dataset, particularly consideration of the relevant sources of uncertainty within ACORN-SAT data.

The Forum also notes with interest the developments in crowd-sourcing the digitisation of data from physical records, as well as the work currently underway in the Bureau's Adelaide office to digitise the Adelaide Glaisher screen temperature data as a means of obtaining weights for pre-1910 instrumentation. This digitisation work will allow for a more complete understanding of the larger differences that exist between modern screens and historical practices.

Recommended next steps

The Forum welcomes the Bureau's efforts in articulating the purposes of ACORN-SAT, but feels there remains some ambiguity and confusion, particularly about the extent to which the data can be used in the context of climate modelling, for example for testing or evaluating. Although the Forum understood the Bureau's advice that climate projections are based largely on global climate models (GCMs) that incorporate physics-based computer modelling involving a broad suite of climate variables, it was felt that historical, observational data such as that provided within ACORN-SAT remained a valuable tool for testing or evaluating large-scale, physical climate models. The Forum recommends that this potential use for ACORN-SAT data be explicitly addressed within the ACORN-SAT web pages, perhaps by expanding the response to ACORN-SAT FAQ 19 on the web page. The Bureau should also identify other appropriate areas on the website and in public communication material about ACORN-SAT to articulate the dataset's purposes.

The Forum notes the Bureau's progress on developing uncertainty measures related to estimates produced from ACORN-SAT data and acknowledges that developing an appropriate framework for describing such uncertainty is a longer term project that could not have been realistically completed in the time since the first Forum meeting. The Forum noted, in particular, the Bureau's efforts in identifying potential sources of uncertainty within ACORN-SAT data/methods and on developing techniques to quantify uncertainty, and the Forum acknowledges the Bureau for undertaking these initial steps to address the Forum's views that uncertainty measures are an important feature for understanding ACORN-SAT data. Reflecting on the progress to date, the Forum recommends the Bureau undertakes more targeted and active consultation with statistical professionals as the Bureau pursues its work programme on understanding and communicating uncertainty. The Forum has provided preliminary advice to the Bureau on identifying suitable experts. The Forum appreciates that this ongoing work needs to recognise the disciplinary differences between meteorologists, climatologists and statisticians in describing and estimating uncertainty, and so should seek to optimise the Bureau's approach by adopting appropriate methods from each of these disciplines.

The Forum also recognises the importance to the Bureau of maintaining its position and reputation within the meteorology and climate research communities. The Forum thus encourages the Bureau to continue to seek opportunities to present their work on understanding and analysing climate data, including on uncertainty measures in the context of ACORN-SAT, by presenting at relevant conferences and/or by publishing in appropriate peer-reviewed journals.

4. The scientific integrity and robustness of the Australian climate record and the homogenisation process

In its first annual report, the Forum provided detail of its findings regarding the scientific integrity and robustness of the Australian climate record and the homogenisation process. It outlined and discussed: a rationale for the need for adjustment; the effect of homogenisation; analysis of raw and adjusted data; a regional sensitivity sub-analysis and the availability of pre-1910 data; a comparison of ACORN-SAT data trends compared to other datasets; curation of both raw and adjusted data; the dataset's capacity to improve the consistency of decision making; and noted the Australian Bureau of Statistics' assessment of the ACORN-SAT dataset as an essential statistical asset. Following consideration of these components in the first report, the Forum made several recommendations aimed at further improving the scientific integrity and robustness of the dataset and related analyses. The following discussion outlines the Forum's assessment as to where progress has been made and where gaps remain in the Bureau's addressing of the recommendations and information presented in the first report. The information below should be read in conjunction with the contextual information provided in the first annual report. See also Appendix A, which sets out the Forum's 2015 recommendations alongside an evaluation of the Bureau's progress.

Progress against 2015 recommendations

The Forum commends the Bureau on its progress in improving the ACORN-SAT dataset and analyses aligned with the recommendations made in the first annual report. The Forum reiterates its view from the first meeting that there is a need to adjust the historical temperature record to account for site changes, changes in measurement practices, and identifiable errors in measurements. The Forum strongly supports the Bureau's homogenisation process, which incorporates both metadata-based adjustments and adjustments based on the statistical detection of atypical observations.

In assessing progress against the 2015 recommendations, the Forum welcomes:

- the Bureau's analysis and considerations regarding breakpoints and whether they can be reliably attributed to specific days and months;
- the research and analysis of the use of piecewise linear fits or nonparametric smoothing approaches for the purposes of data description; and
- advances in the development of the ACORN-RAIN dataset, with the view to having a first version of the homogenised rainfall data available for preliminary assessment in the second half of 2017.

Recommended next steps

The Forum acknowledges the Bureau’s international reputation as a leader in research concerning homogenisation of climate data, and notes its consistent record of publishing research of this nature in international peer-reviewed journals. The Forum recommends that the Bureau continue to identify opportunities to present their work on climate data, for example at conferences and/or by publishing in appropriate peer-reviewed journals.

The Forum noted the collaboration that the Bureau is undertaking within the international meteorological community to support the development of a uniform format for recording metadata related to the homogenisation process. The Forum awaits with interest the outcomes of the further development and dissemination of this format, both with a view to the improvements it may allow in automating homogenisation processes and with regard to further enhancing the Bureau’s reputation as a research leader in this area.

The Forum was pleased to learn of the Bureau’s plans to hold a one-day homogenisation workshop prior to the 2017 ACORN-SAT Forum meeting, and supports this initiative which leverages the Bureau’s considerable international reputation as leaders in research in this area of climate science. The Forum is available to assist the Bureau to identify relevant literature and participants for the workshop if required.

One recommendation of the first Forum meeting on which progress remains to be made is that of the Bureau examining the practical implications and feasibility of transitioning to full automation of homogenisation processes. The Forum noted that current homogenisation processes remained somewhat manual, the code used for homogenisation having certain legacy features linking it to internal Bureau systems as well as requiring multiple user choices to be made in order to fully reproduce the Bureau’s analyses. While the Forum feels that automating the homogenisation process would be desirable to enhance reproducibility, it does acknowledge that such a program of work remains a long-term project and must be subject to resourcing considerations.

Notwithstanding the clear scientific rationale for homogenisation, there remains a need to carefully communicate this rationale in public communications about the ACORN-SAT dataset, and the Forum notes the central role that the development of station fact sheets plays in guiding the public discourse about necessary data adjustments. In this vein, the Forum notes the Bureau’s initiatives in developing high-level metadata factsheets for each station within the ACORN-SAT network. The Forum recommends that the Bureau continues this development for each station following the release of the next ACORN-SAT dataset. These factsheets should specify the timing of and reasons for adjustments and the reference stations used in making those adjustments.

The availability of such fact sheets represent an important component in improving public understanding of circumstances that require data adjustment.

The Forum also recommends that the Bureau considers options to undertake a comparative analysis of pre-1910 data at south-eastern sites to assess whether the inclusion of pre-1910 data is worthwhile in attempting to understand current temperature patterns. Within this recommendation, the Forum acknowledges the Bureau's current efforts to engage with the research community and notes the potential for higher degree by research (HDR) students to engage in research projects on such a topic.

Appendix A

Forum’s summary of the Bureau’s progress against the 2015 recommendations

Progress against 2015 recommendations

The Forum acknowledges the substantial progress towards meeting the 2015 recommendations, noting that not all recommendations were expected to be completed before the Forum’s 2016 meeting. The Forum appreciates the Bureau’s genuine efforts to consider and implement the recommendations despite resourcing constraints and competing priorities. The below table outlines the Forum’s views on the Bureau’s progress against the 2015 recommendations.

Forum’s 2015 recommendations [†]	The Bureau’s progress against the Forum’s 2015 recommendations
<p>1. The Forum recommends that the Bureau continue to improve its communications related to the ACORN-SAT dataset by:</p> <p>a. Expediting the Bureau’s current work on developing uncertainty measures³ 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>The Forum acknowledges the substantial work undertaken by the Bureau to improve communications related to the ACORN-SAT dataset. In particular, the Forum notes the new factsheets and the Frequently Asked Questions (FAQ) designed in consultation with cognitive scientists in the UK which are now available within the ACORN-SAT web pages. The Forum also welcomes the overall re-design of the ACORN-SAT web pages within the Bureau web site. The new design facilitates intuitive and straightforward access to data and explanatory materials and improves public communication about ACORN-SAT.</p> <p>Recognising that a new update to the ACORN-SAT dataset will be released in 2016 and to avoid duplication of effort, the Forum supports the Bureau’s suggestion to align the timing of the implementation of some of the Forum’s 2015 recommendations concerning public communication with that of the release of the updated ACORN-SAT dataset.</p>

3. Such measures could include standard deviations for recorded temperature measurements or standard errors for derived measures such as homogenised temperatures. The development of such measures could allow the development of confidence bands for both raw and homogenised temperature series to properly represent the statistical properties of these measurements.

† The recommendations from 2015 that were to be given highest priority are marked with one or two asterisks.

Forum’s 2015 recommendations [†]	The Bureau’s progress against the Forum’s 2015 recommendations
<p>b. 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 anomaly⁴ 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>c. 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>d. 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>e. 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>The Forum looks forward to being informed of the Bureau’s further progress once the new version of ACORN-SAT has been released. In particular, the Forum looks forward to seeing the case studies that the Bureau intends to publish online to illustrate how to apply ACORN-SAT and similar data for decision-making.</p> <p>The Forum identified that there remains a need to strengthen the articulation of the value and purposes of the ACORN-SAT dataset, particularly in relation to its potential to test or evaluate climate models.</p> <p>The Forum also welcomes the Bureau’s work on assembling station metadata within the homogenisation process including the development of a uniform format for metadata, however recommends the Bureau further considers moving towards the automation of homogenisation in the future, noting that this is potentially a long-term project and is necessarily subject to resource considerations.</p> <p>In addition, the Forum welcomes the Bureau’s progress on developing uncertainty measures and acknowledges this is also a longer term project. The Forum recognises that this area remains a priority for the Bureau, and recommends they more actively engage with the statistical research community to continue to progress this work. The Forum also notes the challenge associated with the disciplinary differences between meteorologists, climatologists and statisticians in describing and estimating uncertainty.</p>

⁴– A temperature anomaly is the deviation of a specific temperature value from a long-term (usually 30-year) climatological mean reference value.

Forum’s 2015 recommendations [†]	The Bureau’s progress against the Forum’s 2015 recommendations
<p>2. The Forum recommends that the Bureau continue to improve the accessibility of ACORN-SAT data and information by adopting the following:</p> <ul style="list-style-type: none"> a. Utilising a universal text-based format such as CSV for providing both raw and adjusted data.* b. 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.* c. Consolidating all downloads of raw and adjusted data using links on a single web page.* d. 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.* e. 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.* f. Publishing a brief, plain-language (as far as possible) description of the criteria for adjustment and the basis for adjustment itself.* 	<p>The Forum acknowledges the Bureau’s progress in meeting the recommendations to improve the accessibility of ACORN-SAT data and information.</p> <p>In particular, the Forum welcomes the development of a central website location for all ACORN-SAT related reports and references, factsheets and Frequently Asked Questions (FAQs). The Forum also acknowledges that the adjustment code is now available-on-request from the website but that there have been only a very small number of requests for the code from the public since the last Forum meeting.</p> <p>The Forum acknowledges that the implementation of many of the accessibility recommendations will be finalised following the release of the update to the ACORN-SAT temperature dataset later in 2016. The Forum looks forward to being updated on progress once the new version has been released.</p> <p>The Forum recommends the Bureau strengthens the accessibility of ACORN-SAT data through the provision of effective weights for every ACORN-SAT station at each time point to communicate more effectively to the public the way in which individual station data contribute to calculation of the national annual mean temperature anomaly.</p>

Forum’s 2015 recommendations†	The Bureau’s progress against the Forum’s 2015 recommendations
<ul style="list-style-type: none"> <li data-bbox="320 555 922 992">g. 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)* <li data-bbox="320 1014 898 1122">h. Providing advice on its website about the necessary level of end-user expertise and resources necessary for reproducing the ACORN-SAT analysis.* <li data-bbox="320 1144 922 1276">i. Examining the provision of a robust code that supports a level of automation that allows sensitivity analyses to be reasonably undertaken by independent parties. 	

Forum’s 2015 recommendations [†]	The Bureau’s progress against the Forum’s 2015 recommendations
<p>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:</p> <ul style="list-style-type: none"> a. 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. * b. 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. ** <ul style="list-style-type: none"> 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. 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>The Forum acknowledges the Bureau’s efforts to develop and improve the statistical methods used with the ACORN-SAT dataset. In particular, the Forum welcomes the Bureau’s work in exploring the use of piecewise linear fits or nonparametric smoothing approaches to improve data description and communication; undertaking breakpoint detection analysis; applying sensitivity analyses to quantify uncertainties associated with the homogenisation process; and considering the incorporation of weights within data-fitting processes. The Forum notes that a number of improvements will be made to the updated ACORN-SAT dataset as a result of this work.</p> <p>The Forum notes the international engagement the Bureau has had, including with the World Meteorological Organization, the International Surface Temperatures Initiative and the Parallel Observation Science Teams and notes that the Bureau is a member of various international steering committees and taskforces related to homogenisation.</p> <p>The Forum recommends the Bureau undertakes more targeted and active consultation with statistical professionals as the Bureau pursues its work programme on understanding and communicating uncertainty. The Forum has provided preliminary advice to the Bureau on identifying suitable experts. The Forum appreciates that this ongoing work needs to recognise the disciplinary differences between meteorologists, climatologists and statisticians in describing and estimating uncertainty.</p>

Forum’s 2015 recommendations†	The Bureau’s progress against the Forum’s 2015 recommendations
<p>c. Undertaking appropriate sensitivity analyses to demonstrate the extent to which the process of adjustment has a material effect on indicative temperature patterns. *</p> <p>d. 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>	

Forum’s 2015 recommendations†	The Bureau’s progress against the Forum’s 2015 recommendations
<p>4. The Forum recommends that the Bureau continue to improve the access and handling of metadata information by:</p> <ul style="list-style-type: none"> a. Providing links to access metadata information for each station via clickable maps. b. 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. c. Examining the feasibility of developing a robust, uniform digital format for metadata. d. Examining crowd-sourcing as an option for improving data-gathering processes, with appropriate safeguards for ensuring data integrity. 	<p>The Forum notes the Bureau’s effort in developing streamlined metadata factsheets for 6 of the 112 ACORN-SAT stations, and acknowledges the time and resourcing implications of developing metadata factsheets for the remaining 106 stations. The Forum is supportive of the Bureau’s alternative approach to develop streamlined material for each station that at a minimum covers the timing and cause of data adjustments as well as the reference stations used within the homogenisation process. The Forum understands that the continued production of further station fact sheets will follow the release of the ACORN-SAT dataset update in late 2016.</p> <p>The Forum acknowledges the Bureau’s work with the World Meteorological Organization to develop a uniform format for recording metadata, and supports the Bureau’s approach to await the results of this coordinated international collaboration rather than pursuing an independent development of another format.</p> <p>The Forum also notes with interest the crowd-sourcing project underway to assist with the digitisation of ACORN-SAT data (and climate data more broadly), noting that it has a different objective to that of this recommendation (4d) but that the lessons learned from these initiatives will be relevant to future actions in respect of the recommendation.</p>

Forum’s 2015 recommendations†	The Bureau’s progress against the Forum’s 2015 recommendations
<p>5. The Forum recommends that the Bureau continue to expand the ACORN-SAT dataset and supporting analyses.</p> <ul style="list-style-type: none"> a. 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. b. Regional sub-analyses should be undertaken as a means for assessing the sensitivity of ACORN-SAT analyses to regional differences. c. 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>The Forum acknowledges the progress in improving the ACORN-SAT dataset and analyses, and notes the work underway to develop a similar rainfall dataset, ACORN-RAIN.</p> <p>The Forum looks forward to an update on the regional sub-analyses at the 2017 TAF meeting, and sees value in the Bureau connecting with a university or research institution to progress the comparative analysis of pre-1910 data at south-eastern sites, perhaps within HDR student research projects or other research collaborations with universities.</p>

At the 2016 meeting, the Bureau also informed the Forum about the proposed future of the ACORN-SAT dataset. The Forum appreciates the presentation and notes the information but has no specific comments or recommendations related to this material.

Appendix B

Technical Advisory Forum communiqué and meeting outcomes

Meeting communiqué issued on 16 June 2016

The Technical Advisory Forum held its second annual meeting today to advise on part of Australia’s official climate record—the Australian Climate Observations Reference Network—Surface Air Temperature (ACORN-SAT) data set. The ACORN-SAT data set is the record of daily temperatures from locations around Australia over the last 100 years. It is maintained by the Bureau of Meteorology.

The Forum first met in March 2015 and found that the data set is complex and well maintained. We released our first annual report in June 2015 with five key recommendations to increase the transparency of the ACORN-SAT data set and its usefulness as a decision-making tool. The report is available on the Bureau of Meteorology’s website.

Today’s meeting reviewed the Bureau’s progress against these recommendations. The discussions were productive and the Forum would like to thank the Department of the Environment for managing the Forum’s membership and assisting the Chair. The Forum would also like to thank the Bureau for the detailed report demonstrating sound progress to date on the Forum’s five recommendations. The Forum also thanked the Bureau for their generosity with time and expertise in answering the panel’s questions.

I would also like to thank the experts who make up the Forum panel for their excellent engagement in this process. Their contributions will help to inform the Bureau’s ongoing dataset management and analyses practices.

In line with its Terms of Reference, the Forum discussed three aspects of ACORN-SAT: the extent of the public availability of the ACORN-SAT information; developments since the 2011 Independent Peer Review of the Bureau’s data and analysis methods; and the scientific integrity and robustness of the Australian climate record and the homogenisation process. The Forum considered a broad range of information and data concerning the management and development of the ACORN-SAT data set provided by the Bureau.

The Australian Government appointed the Technical Advisory Forum as an independent advisory body to provide greater transparency and an impartial framework for quality assurance tests and analysis of the Bureau’s data sets.

The Forum will deliver its second annual report by August 2016.

16 June 2016

Meeting Minutes

Thursday 16 June 2016

Bureau of Meteorology Head Office, 700 Collins Street, Melbourne, VIC

Attendees: **Technical Advisory Forum**—Dr Ron Sandland (Chair), Professor Bob Vincent (Vice Chair), Dr Phillip Gould, Dr John Henstridge, Ms Susan Linacre, Professor Michael Martin, Professor Patty Solomon and Professor Terry Speed

Bureau of Meteorology—Graham Hawke (Deputy Director, Environment and Research Division), Neil Plummer (Assistant Director, Climate), David Jones (Manager, Climate Analysis Section), Karl Braganza (Manager, Climate Monitoring), Blair Trewin (Senior Climatologist), Simon Grainger (Senior Climatologist), Robert Fawcett (Senior Climatologist), Karl Monnik (Senior Climatologist), Joel Lisonbee (Secretariat; Climate Liaison Officer)

Department of the Environment—Dr Rhondda Dickson (Deputy Secretary, Office of Climate Change and Renewables Innovation), Katie Eberle (Secretariat; Director, Adaptation and Climate Science Policy), and Ebony Holland (Secretariat; Senior Policy Officer, Adaptation and Climate Science Policy)

1. Welcome, introductions and purpose of meeting

The Forum Chair, Dr Ron Sandland, introduced members of the Technical Advisory Forum (TAF) and welcomed everyone to the meeting.

Dr Rhondda Dickson, on behalf of the Department of the Environment, thanked the Forum members for their participation and thanked the Bureau for their work in producing the ACORN-SAT dataset and responding to the Forum’s recommendations from 2015. Dr Dickson noted the importance of the Forum’s advice for the management of the ACORN-SAT dataset, acknowledging there has been a resurgence of interest in climate information. She also highlighted the importance of communicating uncertainty effectively.

Mr Graham Hawke, on behalf of the Bureau of Meteorology, welcomed Forum members, and noted the critical importance of the Forum to the Bureau. Thanks to the efforts of the Forum, the general public can continue to have high confidence in the Bureau as a public agency. Mr Hawke noted some of the work the Bureau has done to improve our work due to last year’s recommendations of the Forum. The expectation of today is that the Technical Advisory Forum can provide the technical advice needed and that the Bureau can then rise to the challenge.

2. Developments since last TAF

Several Bureau staff made presentations to the TAF.

Dr David Jones showed that since implementing the recommendations of the TAF from last year, the number of visits to the ACORN-SAT web page have increased by about 30 per cent.

Dr Blair Trewin went over the international developments since the last TAF including: The World Meteorological Organization (WMO) Task Team on Homogenisation, parallel measurements studies, benchmarking studies, and continuous improvements to global datasets.

3. Report on recommendations from last TAF

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

Dr Karl Braganza demonstrated changes that were made to the Bureau of Meteorology's web site in response to the recommendation. These changes include: a short-cut link to the ACORN-SAT data from the climate main-page; an exhaustive list of frequently asked questions; a link to www.climatechangeinaustralia.gov.au; and link to send a request for the raw Python code.

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

In addition to the improvements demonstrated with recommendation 1, Dr Karl Braganza further reported on the various data formats that are part of planned improvements to the new release of the ACORN-SAT dataset. The group discussed approaches to further improve the accessibility of ACORN-SAT data and information.

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

Dr Simon Grainger reported on the Bureau of Meteorology's engagement with the statistical community, including attendance at international conferences. He also described some of the statistical developments used to distinguish inhomogeneous breakpoints from the natural ups and downs of the weather. Dr Grainger's presentation was followed by a discussion on, and invitations to, statistical conferences, and other events. Further discussion was had about the details of the statistical methods used to develop the ACORN-SAT dataset.

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

Dr Blair Trewin led a discussion on different methodologies used to describe different land surface types and other information about the weather observation sites. He also demonstrated the Bureau’s Sites Data Base (known as SitesDB) with some of its strengths and weaknesses. He spoke of the value of historical metadata such as photographs and site diagrams. Dr Trewin reported on the Bureau’s plans in the area of ACORN-SAT metadata and data digitisation, and on progress in the development of a WMO metadata standard. There was a discussion about the accessibility of such data and the cost of digitising data still stored (in some cases) as paper copies in archives.

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

Dr Karl Braganza led a discussion about pre-1910 data, improvements to the Australian Water Availability Project (AWAP) dataset, proxy climate data, plans for ACORN-RAIN, a separate high-quality upper-air data base.

4. Understanding and communicating data uncertainty

Dr Simon Grainger led a discussion about calculating the uncertainty of national annual temperature estimates. The four main sources of uncertainty considered come from the uncertainty that is inherent in the temperature measurement, the uncertainty that comes from applying the measurement at a point location to a representative area, the uncertainty from the adjustment in the homogenisation process and the uncertainty in the network sampling of the Australian continent. The forum members contributed their expertise on the topic, which led to a discussion about innovations that could be applied.

5. Looking beyond ACORN-SAT

Dr David Jones led a discussion about the overall purpose of ACORN-SAT to monitor climate variability and change in Australia. Dr Jones pointed to other means that are becoming available to support that purpose such as satellite data, physical model data assimilation and reanalysis, improvements to the AWAP dataset, etc. The Bureau will not stop taking surface observations, but want to ensure that measurements taken are a true representation of the weather and climate.

6. In-Camera session for forum members only: Outstanding matters or further discussion

Discussion topics were all at the discretion of the chair.

7. Next steps

The Forum Chair thanked presenters for their preparation, along with the Secretariat and the Department of the Environment for providing support to the Forum.

Meeting closed at 5:00pm.

Forum members met again the next day to develop new recommendations and commence drafting the second annual report, in line with the Forum's Terms of Reference.

Minutes prepared by the ACORN-SAT Technical Advisory Forum Secretariat, Bureau of Meteorology.

Appendix C

ACORN-SAT Technical Advisory Forum— Meeting agenda

ACORN-SAT TECHNICAL ADVISORY FORUM

SECOND ANNUAL MEETING

AGENDA

16 and 17 June 2016

Location: Level 6 meeting room, 700 Collins Street, Melbourne

Attendees: **Technical Advisory Forum (TAF)**—Dr Ron Sandland (Chair), Professor Bob Vincent (Vice Chair), Dr Phillip Gould, Dr John Henstridge, Ms Susan Linacre, Professor Michael Martin, Professor Patty Solomon and Professor Terry Speed

Bureau of Meteorology—Joel Lisonbee (Secretariat), Perry Wiles (Secretariat), Graham Hawke, David Jones, Karl Braganza, Blair Trewin, Simon Grainger, Robert Fawcett

Department of the Environment—Rhonda Dickson, Katie Eberle and Ebony Holland

AGENDA—Day 1, Thursday 16 June				
Time	No.	Description	Lead	Timing
8:30		<i>Arrival, tea and coffee</i>		
9:00	1.	Introduction 1. Welcome, introductions and purpose of meeting a. Review agenda and TAF Terms of Reference	Chair	30 minutes
		2. Opening from the Department— Briefing from DoE on Government related matters	Rhondda Dickson	
		3. Greetings and remarks from the Bureau	Graham Hawke	
9:30	2.	Developments since last TAF: Briefing from BoM on (a) demand for ACORN-SAT data and metadata since the first TAF, and (b) international developments	BoM	20 minutes
9:50	3.	Progress since first annual TAF meeting: Response and progress against recommendations 1. <i>The Forum recommends that the Bureau continue to improve its communications related to the ACORN-SAT dataset</i> 2. <i>The Forum recommends that the Bureau continue to improve the accessibility of ACORN-SAT data and information</i>	BoM	10 minutes + 15 minutes for discussion/clarification for each item 50 minutes total
10:40		<i>Morning Tea</i>		20 minutes
11:00		Progress since first annual TAF meeting: Response and progress against recommendations (continued) 3. <i>The Forum recommends the Bureau should continue to develop and improve the statistical methods employed in developing the ACORN-SAT dataset.</i> 4. <i>The Forum recommends that the Bureau continue to improve the access and handling of metadata information</i> 5. <i>The Forum recommends that the Bureau continue to expand the ACORN-SAT dataset and supporting analyses.</i>	BoM	Approx. 10 minutes to raise item + 20 minutes for clarification/discussion for each item. [further time allowed later in the program if required] 90 minutes total
12:30		<i>Lunch</i>		60 minutes

AGENDA—Day 1, Thursday 16 June				
Time	No.	Description	Lead	Timing
13:30	4.	A short introductory presentation followed by discussion among BoM and forum members Topic: Understanding and communicating data uncertainty.	BoM	30 minutes + 60 minutes for discussion
15:00	<i>Afternoon tea</i>			30 minutes
15:30	5.	Bureau’s vision: looking beyond ACORN-SAT (AWAP, reanalysis and other developments)	BoM	15 minutes
15:45	6.	Outstanding matters or further discussion. Discussion timing, topics and external attendees (non-forum members) are all at the discretion of the chair.	Chair	45 minutes
16:30	7.	Next steps and media handling	Chair	30 minutes
17:00	8.	Close	Chair	10 minutes
18:30	<i>Forum dinner</i>			

AGENDA—Day 2, Friday 17 June				
(BoM staff will be available throughout the day for further discussion)				
Time	No.	Description	Lead	Timing
9:00	1.	Primarily devoted to drafting the report with DoE.	Chair	90 minutes
10:30	<i>Morning Tea (provided)</i>			30 minutes
11:00	2.	Drafting report continued	Chair	90 minutes
12:30	<i>Lunch (provided)</i>			60 minutes
13:30	3.	Drafting report continued	Chair	90 minutes
15:00	4.	Close	Chair	

Appendix D

ACORN-SAT Technical Advisory Forum

Member Biographies

Dr Ron Sandland AM FTSE (Chair)

Dr Sandland holds a PhD in statistics from the University of New South Wales. His research interests concerned applying statistics to solve challenging real problems in areas as diverse as growth of organisms, analysis of mark-recapture experiments, ore-reserve estimation and quality improvement.

He was appointed the Deputy Chief Executive for CSIRO in 1999 and led the Flagship Initiative. This involved six major cross-disciplinary research programs and was aimed at addressing problems of a national priority.

He is an Honorary Life Member of the Statistical society of Australia and is a Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE), and was made a member of the Order of Australia in 2007.

Emeritus Professor Bob Vincent FAA (Vice Chair)

Robert Vincent is Emeritus Professor in the School of Physical Sciences at the University of Adelaide. His major expertise is in the area of the atmospheric sciences with a background in experimental studies of atmospheric processes including the development of radar hardware, software and data analysis techniques.

He has served on international and national panels covering Antarctic research and solar-terrestrial physics. His professional standing is recognised by election to the Australian Academy of Science, election as a Fellow of the American Geophysical Union, and as President of the International Council for Science/Scientific Committee for Solar-Terrestrial Physics from 2007–2011.

Dr Phillip Gould

Dr Gould holds a PhD from Monash University specialising in time series econometrics.

He is currently managing the Education and Data Integration Branch within the Australian Bureau of Statistics and has also worked there as a methodologist, managing a team which delivers high quality analytical work for the ABS and external clients. Prior to joining the ABS Dr Gould worked in banking and finance with a focus on econometric modelling of time series data.

Dr John Henstridge CStat, AStat, AFAIM, QPMR, FSS

Dr Henstridge holds a PhD from the Australian National University and is adjunct professor at the University of Western Australia. In 1988 he founded Data Analysis Australia which is now the largest private statistical organisation in Australia.

He is a Fellow and Chartered Statistician of the Royal Statistical Society and an Accredited Statistician of the Statistical Society of Australia. He has served as President of both the Statistical Society of Australia’s Western Australian branch and of the Geostatistical Association of Australasia and is currently National President of the Statistical Society of Australia.

Ms Susan Linacre

Ms Linacre holds a first class honours degree in Statistics and an Economics degree, both from the Australian National University.

She has spent most of her career at the Australian Bureau of Statistics where she held a number of senior roles including Deputy Australian Statistician (Social Statistics Group) and First Assistant Statistician (Methodology Division). Ms Linacre has also worked in the UK as head of the Directorate of Methodology and IT in the Office for National Statistics. She is a member of the International Statistical Institute and past President of the International Association of Survey Statisticians.

Professor Michael Martin PFHEA

Professor Martin holds a PhD from the Australian National University where he is currently Professor of Statistics in the Research School of Finance, Actuarial Studies and Statistics and the Centre for Higher Education, Learning & Teaching.

His research interests are applied statistics, statistical theory and statistical education. He also has been deeply involved in the teaching of statistics and has won a number of awards for teaching excellence. He is a Fellow of the American Statistical Association, an elected member of the International Statistical Institute and a Principal Fellow of the Higher Education Academy.

Professor Patty Solomon

Professor Solomon is Professor of Statistical Bioinformatics at the University of Adelaide.

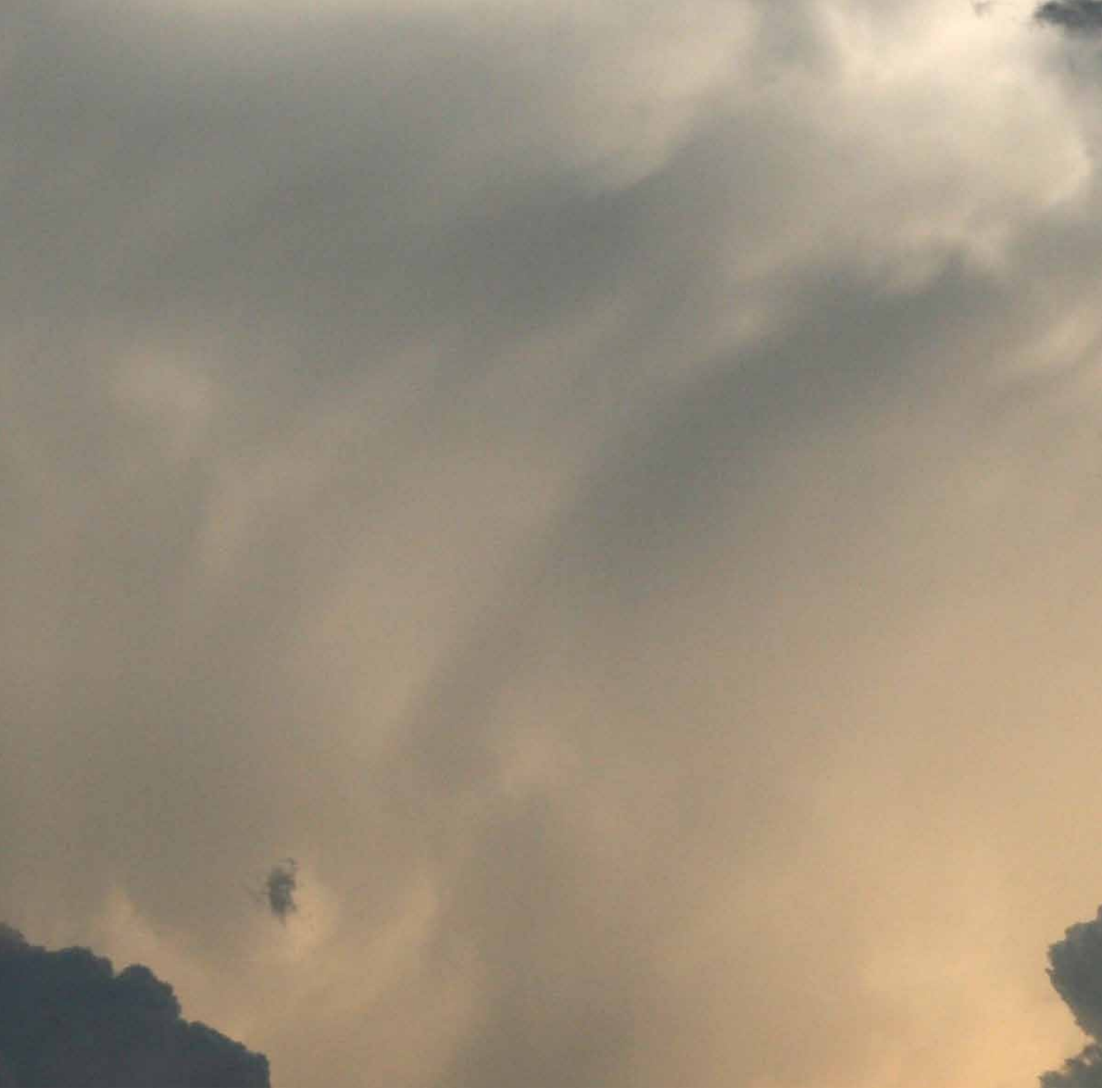
Her research interests include Biostatistics, Bioinformatics, Statistical data mining, Clinical trials and Epidemiology. She has over 100 publications and has been funded by the Australian Research Council and the National Health and Medical Research Council.

Professor Solomon is an elected Member of the International Statistical Institute and is a member of the American Statistical Association, International Society for Clinical Biostatistics, Statistical Society of Australia and the Australian Mathematical Society.

Professor Terry Speed FRS, FAA

Professor Terry Speed FAA holds a PhD from Monash University and is a lab head in the Bioinformatics division at the Walter and Eliza Hall Institute of Medical Research. His research interests include the statistical and bioinformatic analysis of microarray, DNA sequence and mass spectrometry data from genetics, genomics, proteomics and metabolomics.

He has served as President of the Institute of Mathematical Statistics and has been awarded a number of prizes including the Pitman medal in 2002 and the Prime Minister's Prize for Science in 2013.



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