PROJECT 1.4: REGIONALLY SPECIFIC CLIMATE DATA AND MONITORING FOR THE NORTH-WEST AND SOUTH-WEST TO SUPPORT THE UNDERSTANDING OF PAST, PRESENT AND FUTURE CLIMATE

Principal Investigator:

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Objectives

- To apply rigorous scientific methods to the development and extension of climate change datasets for WA.
- To enhance the range of datasets used within IOCI 3.
- To increase the accessibility and usability of the datasets.

Milestone 1.4.1 *High-quality and scientifically documented daily rainfall dataset extended back to 1900.*

Principal Investigators

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This milestone is complete. The new high-quality network for rainfall has been prepared and is available from the author. A science paper is being finalised (a draft is available from the author) and will be submitted for publication by December 31, 2010.

Key Research Findings and Highlights

Introduction

High-quality daily rainfall observations are essential for properly characterising climate change at fine space and time scales. Such observations are also an important input of downscaling techniques (that have been developed as part of IOCI) aimed at projecting future rainfall changes.

For Western Australia (WA), and particularly in the north-west region, the observational network is sparse with large distances between stations. Additionally, stations across the state have varied periods of operation, resulting in a non stationary network over time. Errors in recorded data may relate to observing practices, instrumentation error, instrumentation exposure changes, site moves or a range of other possible factors. All of these issues contribute to the exclusion of observational records from high-quality data sets that have been previously defined by researchers.

The work by Lavery *et al.,* (1991) identified 191 high-quality long-term rainfall records in Australia. This was later increased to 379 stations (Lavery *et al.,* 1997). The rainfall data from each of these stations was considered high-quality, with a subset of these stations also having high-quality daily data available. In WA, most of the Lavery data come from the far south of the state (see Figure 1).

The aim of this sub-project is to add to the existing high-quality networks to improve the spatial coverage, especially in the north of the state and test the quality of existing high-quality rainfall data. Enhancing the high-quality rainfall network has been done in two steps. Firstly the completeness of the rainfall data for stations was assessed to compile a list of candidate rainfall stations with long and largely complete records. The second step was to identify those stations of the highest quality through the application of a range of statistical test on data quality. The new high-quality rainfall dataset covers those stations with long and complete records and recordings assessed as being reliable.

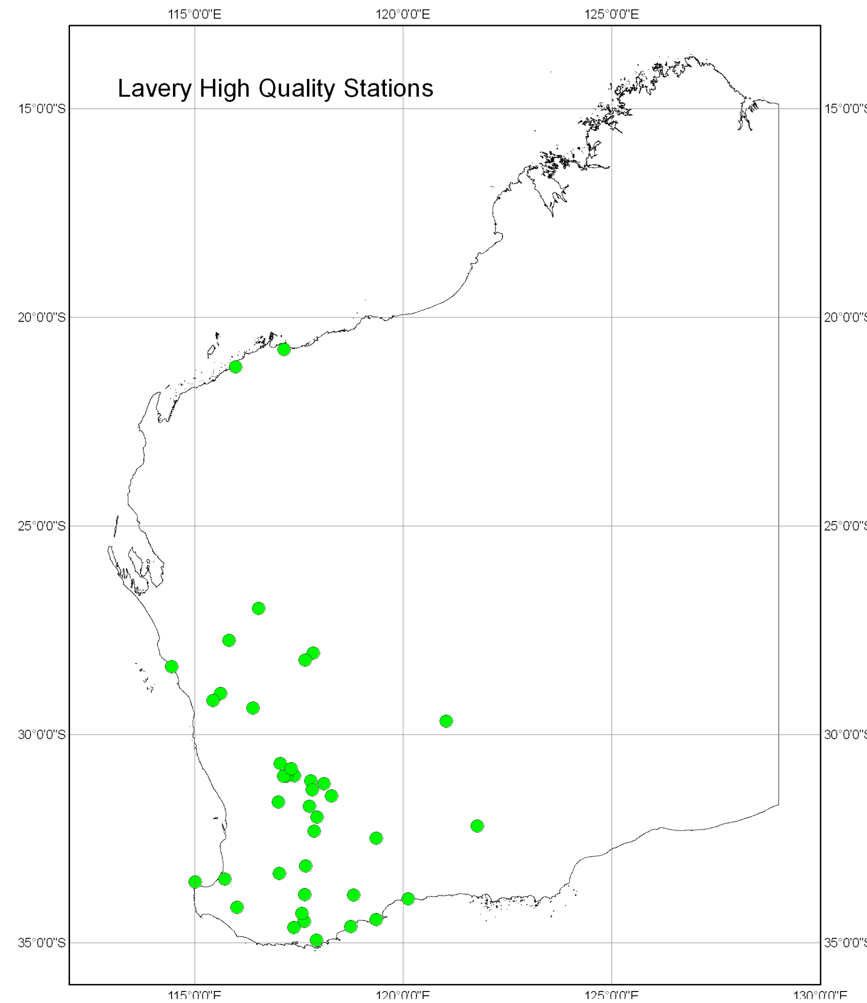

Figure 1: The Lavery *et al.,* 1997 daily high-quality stations.

Analysis of Data Completeness

For IOCI 3, enhancing the high-quality rainfall network has been done in two steps. Firstly the completeness of the rainfall data for Western Australian stations was assessed to compile a list of candidate high-quality rainfall stations with long and largely complete records. The second step was to identify which of these stations is of the highest quality through the application of a range of statistical tests.

The data completeness tests for possible new high-quality rainfall candidate stations were carried out for two periods, 1950-2008 and 1900-2008.

In the first case, stations must have been open in 1950, still be open at the end of 2008, and the daily rainfall dataset be at least 95% complete in the 1950-2008 period. An exception was made for the Bureau of Meteorology station of Giles (near the WA/NT/SA border intersection), which was opened in 1957, due to its location in a large data gap, expected high-quality (due to it being a Bureau of Meteorology staffed station), and completeness.

In the second case, candidate stations covering the period pre 1950 to 2008 were determined. By default, all of the stations in the 1950-2008 >95% group were included for further analysis in the decades before 1950. If a station was >95% complete for the period 1920-1930 to 2008, it was listed as single station candidate.

If this completeness occurred only post ~1940, then stations within 30 Km of it were analysed to see if they could be used to make a composite station (to extend the time period). Finally, in data sparse regions, all other stations were analysed for use in composites. These did not need to be opened pre-1950, but did need to be >95% complete in data and have a 3 year overlap with the nearby stations (within 30km) that also have a high data completeness in the preceding decades. The number of stations in a composite was limited to a maximum of three. The overlapping rainfall measurements in these composite candidates were statistically (correlation and regression) tested to see how closely their measurements, and rainfall trends, agreed. The earliest date of the rainfall in the composite stations is in the first decades of the 20th century. The methods used to determine the candidate single or composite is graphical shown in Figure 2.

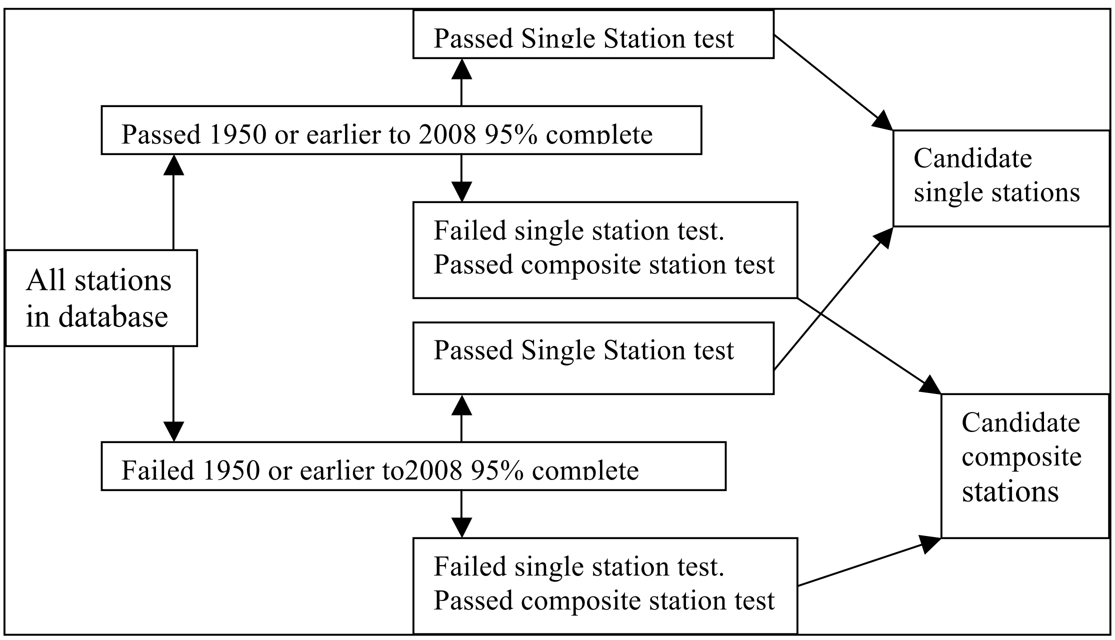

Figure 2: Data completeness analysis steps.

Composite stations

Of the 214 high-quality candidate stations, there are 196 single stations and 18 composite stations. The stations that passed the 95% completeness criteria test for the 1950-2008 period are shown in Figure 3(a). Figure 3(b) shows the "other" single and composite stations i.e. those that did not pass the 1950-2008 > 95% selection test. While these occur throughout the state, the significant number in the north is important as it may help to fill the lack of high-quality stations in the northern half of the state, especially the Kimberley.

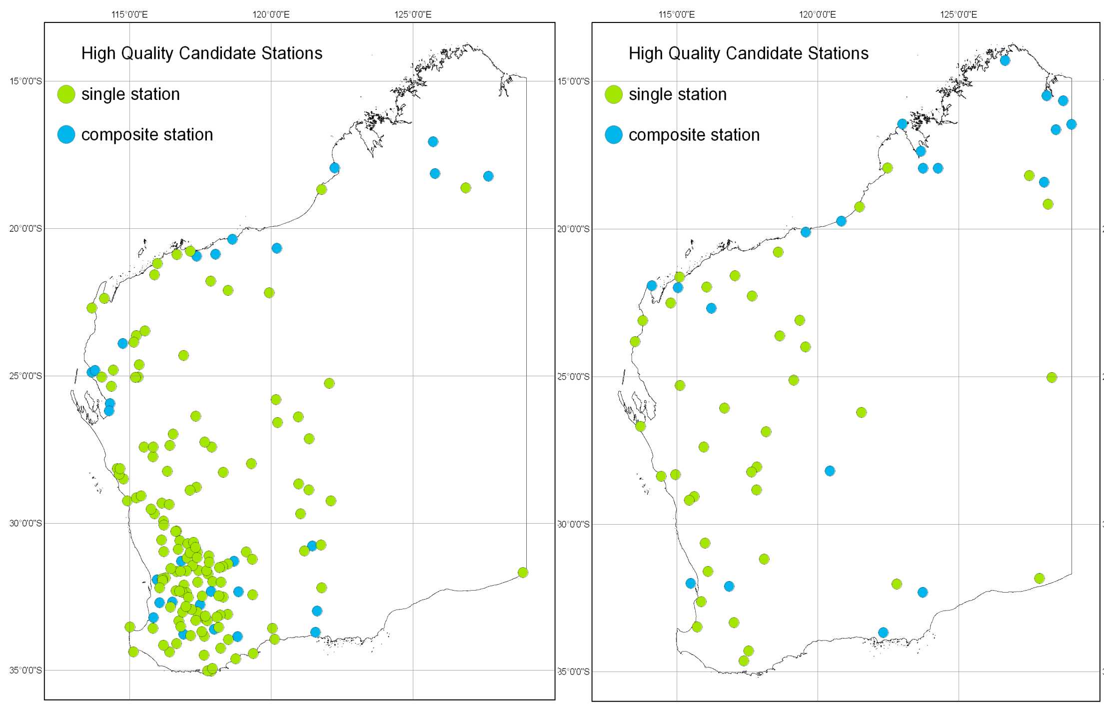

Figure 3: HQ candidate stations at (a) stations which passed the 1950-2008 > 95% test and (b) "Other" stations with long records.

Further Analysis Using Statistical Tests.

The stations with sufficient data completeness were statistically compared with nearby stations in similar climates to identify measurement and/or observation errors. The initial test visually compared the temporal trends in yearly rainfall (year verses yearly total) with high resolution gridded data to identify clear outliers. There was a good agreement between the candidate stations and the spatial trends in most cases.

Further analysis steps compared the candidate station annual and seasonal total rainfall measurements with nearby stations, as well as regional stations that are considered of high-quality (because of their documentation and location). In general, it is expected that nearby stations should have higher correlations, especially in the winter period in the southwest of the state. The stations in the north of the state are expected to be less in agreement in their summer (wettest) period because of the patchiness of monsoonal rainfall patterns.

The tests had four basic steps and is highlighted in the schematic in Figure 4. The steps are:

1. Further analysing of the completeness of data in the candidate stations which excluded insufficiently complete years from inter-station comparison;
2. Plotting the candidate stations for visual inspection (year verses yearly total rainfall). Comparison of associated regressions;
3. Statistical comparison of candidate stations, using covariance and correlation metrics; and

4. Analysis for other anomalies (rounding of measurements, clear biases).

If nearby stations are found not to be well correlated, then this suggests that the measurements of one of the stations may contain errors or be affected by other factors. Comparison with other neighbouring stations, if they exist, can further refine this filtering process.

Visual Precipitation Comparison

For each station, year verses annual total rainfall was plotted and visually inspected and compared with neighbouring stations for anomalies such as unexpectedly high or low yearly totals and clear discontinuities in trends.

The regression of the time verses yearly totals and time verses moving 20 year mean yearly totals was also calculated. These results reflected the long term temporal trend in the rainfall. They were used with caution as (a) they were not found to add to the conclusions in any significant way and (b) are more prone to error due to their sensitivity to missing years.

Statistical Analysis

All candidate HQ stations yearly rainfall totals were statistically compared. The statistical tests were correlation, covariance, regression: for each 2 station comparison. The distance, and their approximate direction, of the closest stations from the reference station, was also recorded. The annual and seasonal results were recorded.

Lavery and Trewin Anomalies Tests.

These tests look for errors in the measurement caused by the rounding of measurements, ignoring low values or clear biases. The Lavery test created 2 measurement frequency histograms for each potential station. The first was for all measurements up to and including 1973 (point measurements) and post 1973 (metric 0.2mM minimum measurements). In unbiased measurements, the histograms should have the highest frequency at the lowest possible measurement (1 point or 0.2 ml). The Trewin test calculated the % number of measurements above 1 and 2mm, and the ratio of these results relative to one another. These, could then be compared to nearby station.

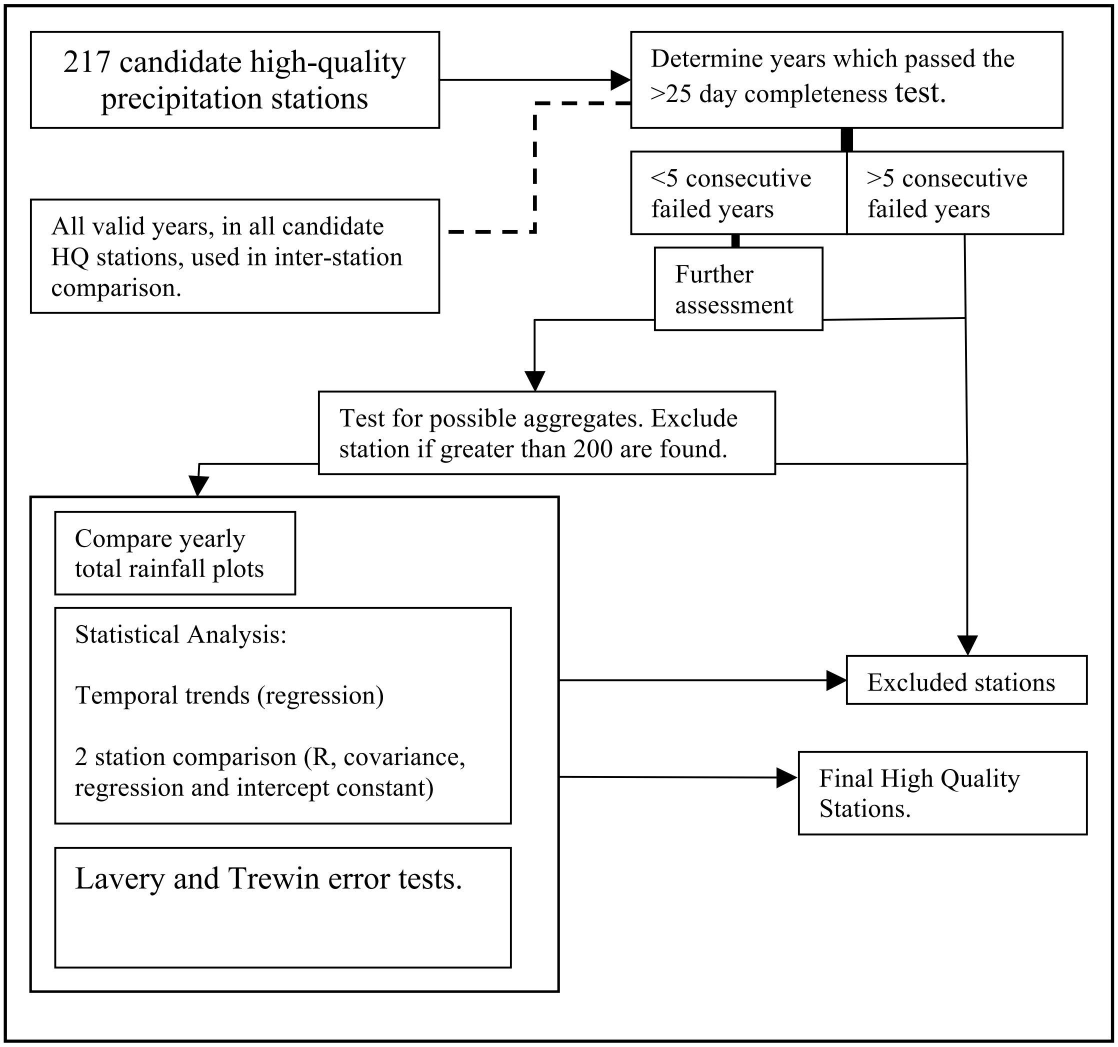

Figure 4: Data quality analysis steps.

Improvements arising from the new dataset

The most obvious benefit of the new dataset, compared to the previous version, is its much greater spatial extent, especially in the north of WA. The distribution of the stations in the new high-quality rainfall dataset and the average rainfall at these stations is shown in Figure 5. The new dataset covers most climate zone, with substantially improved coverage in the northern parts. Analysis of the new data is at an early stage with results to be published in the next year.

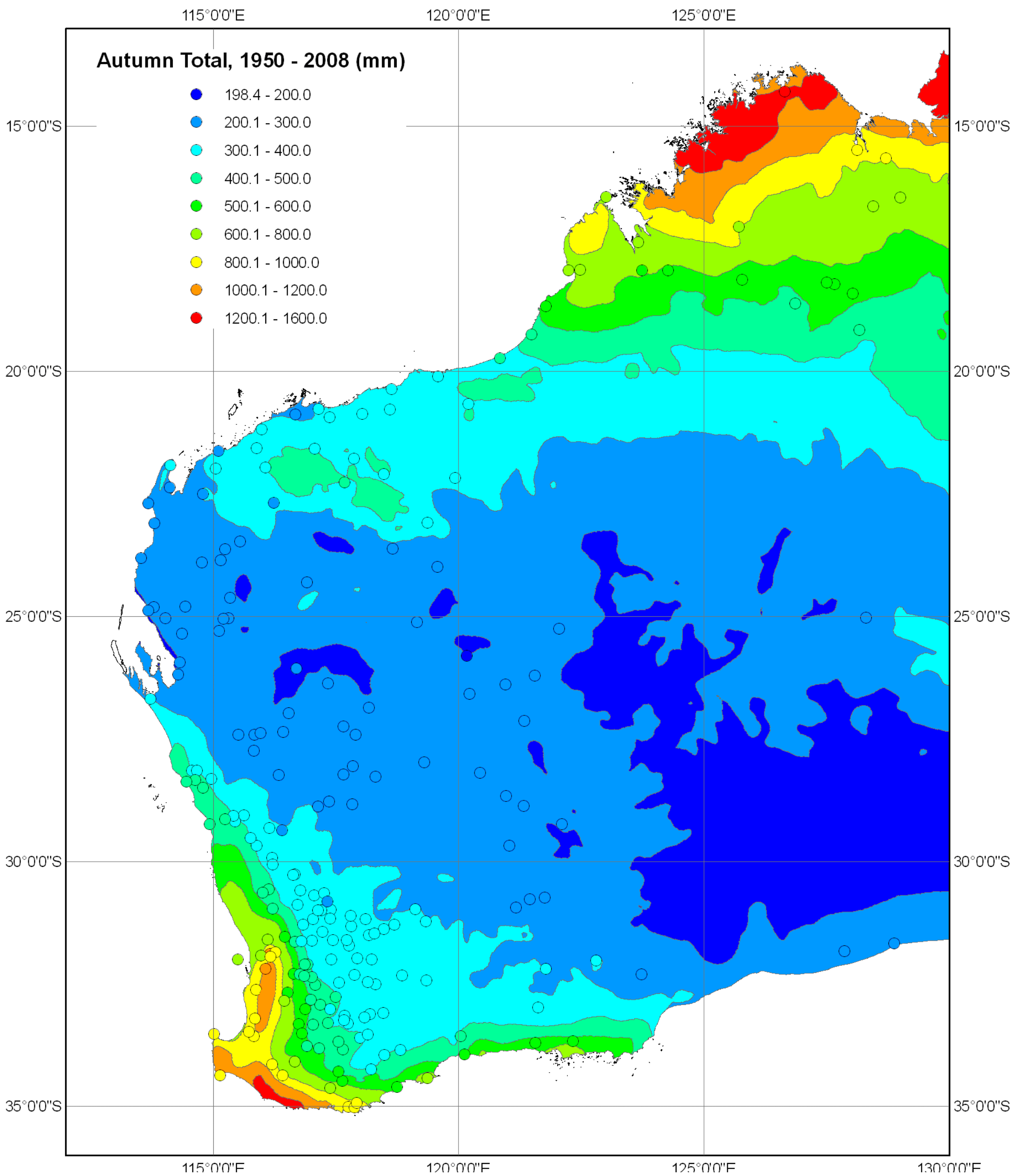

Figure 5: Annual average rainfall for WA together with station totals for the final high-quality station network overlaid (circles).

References

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Summary of new linkages to other IOCI 3 Projects

Data from this milestone will be used across a range of IOCI projects.

Summary of any new research opportunities that have arisen (if any; dot points)

The new data will make possible the analysis of rainfall and extreme rainfall changes in northwest Australia and improved representation of rainfall changes in the southwest.

List of publications accepted and submitted.

Nil

List of IOCI-related presentations at national and international conferences, symposia and workshops.

M. Marinelli, K. Braganza, D. Collins, D. Jones, D. Maquire, C. Ganter, P. Hope and G. Cook. 2010. Improved Climate Data and Monitoring for Western Australia to Support the Understanding of Past, Present and Future Climate. Presentation to the 17th AMOS National Conference, Canberra, 27-29 January 2010.

C. J. Ganter, K. Braganza, D. Collins, S. Maguire and D. Jones. 2010. A Comparison of Tipping Bucket Rain Gauges with Manually Read Rain Gauges in Australia. Presentation to the 17th AMOS National Conference, Canberra, 27-29 January 2010

Milestone 1.4.2: Extended high-quality and scientifically documented daily station temperature dataset extended back to 1910

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This milestone was due for completion in December 2009 but requires a 12-month extension to December 2010 for the following reasons: The Project has faced some delays owing to unexpected problems with data in Western Australia. In addition, recent enhanced climate sceptic scrutiny of data has meant that the decision has been made to expose the new dataset to an additional level of peer review to ensure its robustness. In combination, these factors mean that the new high-quality data will not be available for release until late 2010.

Key Research Findings and Highlights

Background

The previously existing Australian high-quality daily station temperature dataset included 103 stations over Australia, with just 19 in WA, and generally extended from 1957 to 1996 (Torok and Nicholls 1996, Trewin, 2001) . The new dataset extends these records in many places back to 1910, including a large quantity of recently digitised data which were not available for use in previous studies, as well as fully including recent year. The new set has also been extended to 112 stations, with six new stations in WA, making a total of 25 (as shown in Figure 1). This will improve the spatial resolution of long-term temperature analyses, particularly in the south-west of WA.

Introduction

Long-term temperature datasets are subject to numerous influences which can affect data for reasons not associated with changes in the climate. These include site relocations, changes in instruments, changes in observing practices (such as the time at which observations are made) and changes in the local site environment, including, but not limited to, urban development. A detailed review of such influences and their impact on temperature observations may be found in Trewin (2010).

In order to develop long-term data sets suitable for climate change monitoring, it is necessary to identify these external influences, and either remove stations subject to them, or make adjustments to data ("homogenisation") where necessary to remove their effect on observations. There are numerous data sets, both at the national (e.g. Torok and Nicholls, 1996; Menne *et al.,* 2009) and global (e.g. Jones and Moberg, 2003; Smith *et al.,* 2008) scale, where such adjustments have been used in developing long-term temperature data sets at the annual and/or monthly timescale.

A further issue in dealing with daily data is that an external influence can have varying impacts on temperature data depending on the weather situation; for example, urban influences on temperature tend to be strongest on calm, clear nights, which are also likely to be cool nights. Two case studies from the inland NSW locations of Inverell (Trewin and Trevitt, 1996) and Coonabarabran (Trewin, 2005) found minimum temperature differences between sites within a few kilometres of each other which ranged from 5-10°C on the coldest winter nights but were near zero on the warmest nights. Such variable influences, if not corrected for, can lead to time series of temperature extremes remaining inhomogeneous even if the means have been successfully homogenised.

A number of methods have been proposed to address this problem (e.g. Trewin, 2001; Della-Marta and Wanner, 2006; Brandsma and Können, 2006). The original version of the high-quality Australian daily temperature dataset (Trewin, 2001) employed methods based on the matching of percentile points in frequency distributions, a broadly similar method to that used for the updated dataset and described more fully below. While the field is currently an active area of research (see http://www.homogenisation.org), to our knowledge this remains the only national-level dataset homogenised at the daily timescale, although a similar dataset is currently under development in Canada.

Methodology

The updated dataset contains a total of 112 stations, including 25 in WA (Figure 2). Compared with the original version of the dataset, six in WA (10 for Australia as a whole) have been added.

At the time the original dataset was developed, had digitised daily data from 1957 onwards. Since then a major digitisation project has made a much larger quantity of data available back to 1910. Some pre-1910 data also exist but were not considered for use in this study because of the widespread use of instrument shelters which were not compatible with post-1910 standards (Torok and Nicholls, 1996).

The first stage in the process was to subject the data to detailed quality control procedures, involving checks for internal consistency between maximum and minimum temperatures and between those and hourly or three-hourly data (where available), as well as spatial consistency with surrounding stations. The purpose of this was to subject all of the historical data, as far as possible, to a level of quality control comparable with that carried out as part of the National Climate Centre's present-day routine quality control procedures.

The second stage was to identify potential inhomogeneities in the data at each station. A detailed search of metadata, in particular the hard-copy files of station correspondence and inspection reports maintained by the Bureau of Meteorology, was carried out to identify potential inhomogeneities such as site moves. As metadata are often incomplete or open to interpretation, inhomogeneities in monthly data were also identified by statistical methods (e.g. Easterling and Peterson, 1995), using comparisons with data from nearby sites.

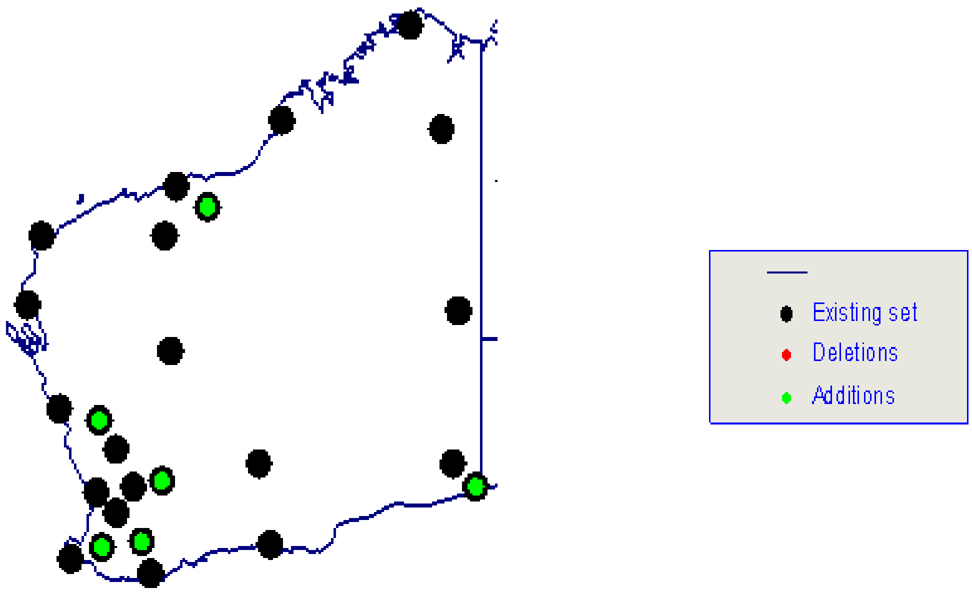

Figure 1: Stations in the updated daily temperature dataset, including additions and deletions (nil for WA) from the previous version.

Once all known inhomogeneities were identified at the monthly timescale, adjustments were then carried out on the daily maximum and minimum temperature data. Where overlapping data existed, these were done by defining a transfer function based on the differences between the 5th, 10th,…, 95th percentile points of the frequency distributions during the period of overlap. Where no overlap existed a two-stage process was carried out using up to four neighbouring sites.

Improvements arising from the new dataset

The most obvious benefit of the new dataset, compared to the previous version, is its much greater length, extending from 1910 to 2009. This will allow century-scale analyses of changes in temperature extremes, both in WA and elsewhere, and will also allow monthly data from the 1910-1949 period to be included in the Bureau's real-time monitoring products. Whilst the 1957-1996 data set has been progressively updated using real-time data, no further homogenisation had taken place, resulting in some anomalous results in analyses where there have been significant inhomogeneities in the post-1996. The new analysis makes adjustments for such recent inhomogeneities.

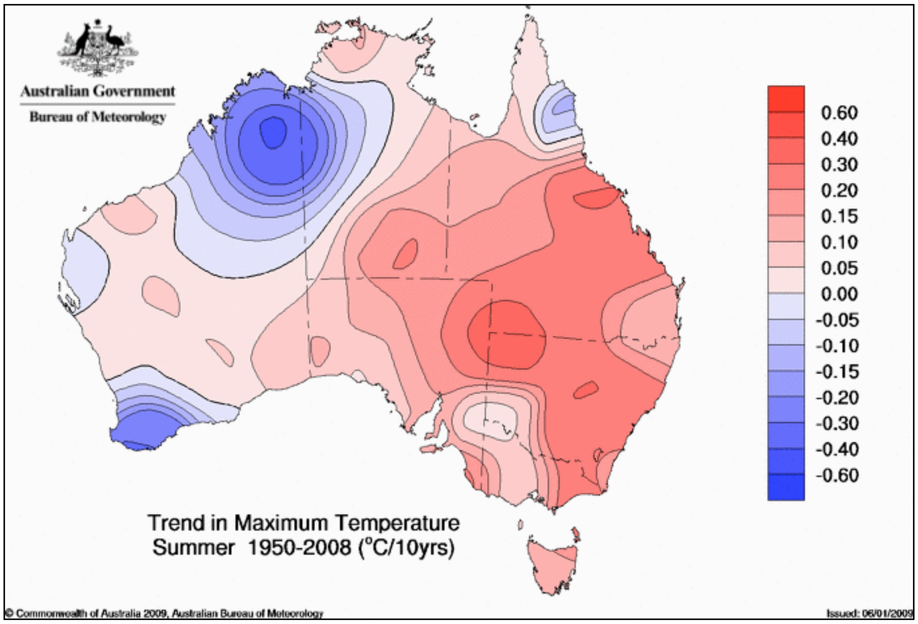

Figure 2: Summer maximum temperature trends over the 1950-2008 period, derived using the previous dataset.

A particular benefit to WA of the new data set is increased data density and quality in the southwest of the state. Four new stations have been added in this area (Morawa, Merredin, Bridgetown and Katanning). In addition, records from Albany were severely affected by a 1965 move, with no overlap period, from the town centre to the airport 10 km inland, but the re-opening in 2002 of a site near the pre-1965 location has greatly improved the confidence with which adjustments for that area can be made. A specific goal which the updated dataset will fulfil is to allow the apparent summer cooling since 1950 (Figure 2) to be resolved more precisely; in the previous, relatively coarse, network, analyses "projected" anomalies at Albany a substantial distance inland, an effect which will be reduced by the new network.

New research opportunities

A new international project, led by the UK Meteorological Office, is under way to develop a new global temperature data set at the daily timescale. It is expected that the new dataset will be a substantial contribution to this, and that the methods used will provide a basis for similar work in other parts of the world. It is also planned that this project will include a detailed evaluation of different data homogenisation methods in use in various parts of the world.

References

Brandsma, T. and Können, G.P. 2006. Application of nearest-neighbour resampling for homogenizing temperature records on a daily to sub-daily level. *Int. J. Climatol.*, 26, 75-89.

Della-Marta, P.M. and Wanner, H. 2006. A method of homogenizing the extremes and mean of daily temperature measurements. *J. Clim.*, 19, 4179-4197.

Easterling, D.R. and Peterson, T.C. 1995. A new method for detecting and adjusting for undocumented discontinuities in climatological time series. *Int. J. Climatol.*, 15, 369-377.

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Menne, M.J., Williams, C.N. and Vose, R.S. 2009. The U.S. Historical Climatology Network monthly temperature data, version 2. *Bull. Amer. Met. Soc.*, 90, 993-1007.

Smith, T.M., Reynolds, R.W., Peterson, T.C. and Lawrimore, J. 2008. Improvements to NOAA's historical merged land-ocean surface temperature analysis (1880-2006). *J. Clim.*, 21, 2283-2286.

Torok, S.J. and Nicholls, N. 1996. A historical annual temperature dataset for Australia. *Aust. Met. Mag.*, 45, 251-260.

Trewin, B.C. and Trevitt, A.C.F. 1996. The development of composite temperature records. *Int. J. Climatol.*, 16, 1227-1242.

Trewin, B.C. 2001. *Extreme temperature events in Australia*. Ph.D thesis, School of Earth Sciences, University of Melbourne.

Trewin, B.C. 2005. A notable frost hollow at Coonabarabran, New South Wales. *Aust. Met. Mag.*, 54, 15-21.

Trewin, B.C. 2010. Exposure, instrumentation and observing practice effects on land temperature measurements. *Wiley Interdisciplinary Reviews: Climate Change*, 1, 490-506.

List of Publications Accepted and Submitted

Trewin, B. and Vermont, H. 2010. Changes in the frequency of record temperatures in Australia, 1957-2009. *Aust. Met. Oceanogr. J.*, 60, 113-119.

Conference papers on this work

B. Trewin and H. Vermont 2010. Temporal Distribution of Record Temperatures in Australia through the 1957-2007 Period. 17th AMOS National Conference, Canberra, 27-29 January 2010.

B.Trewin. 2010. New indices for monitoring changes in heatwaves and extended cold spells. 11th International Meeting on Statistical Climatology, Edinburgh, 12-16 July 2010.

***Milestone 1.4.3**: Dedicated website providing access to relevant climate datasets for WA in support of IOCI 3 projects*

Principal Investigator:

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This milestone is complete. Additional improvements to the website in terms of data quantity, quality and site navigation will be made incrementally over the lifetime of IOCI3.

Key Research Findings and Highlights

Milestone 1.4.3 delivers high-quality datasets produced through, and for, the IOCI project to IOCI partners, the public and other interested parties through a dedicated web-portal < http://www.bom.gov.au/climate/change/hqsites/ >. The high-quality datasets include rainfall, temperature (maximum, minimum, mean and diurnal range), cloud cover and evaporation with other variables added as they become available to the project. In addition, the web-portal supports simple statistical data analysis, such as calculation of trends and running averages. The principle purpose of this milestone is to maximise the availability of climate datasets for IOCI to facilitate ongoing and future scientific analysis of climate variations and changes across WA.

The web portal has been built and will be improved over the remainder of the IOCI phase 3 period in response to feedback from partners and users. The website has received substantial use with an average of more than 1000 discrete site visits per calendar month in 2010. Data from the portal have been used to support a wide number of climate analysis and research projects with use expected to grow into the future as researchers make use of the free and easy access to data that the website provides.

Summary of new linkages to other IOCI 3 Projects

Data from this milestone have been used across a range of IOCI projects including projects 1.1 and 1.2.

Summary of any new research opportunities that have arisen (if any; dot points).

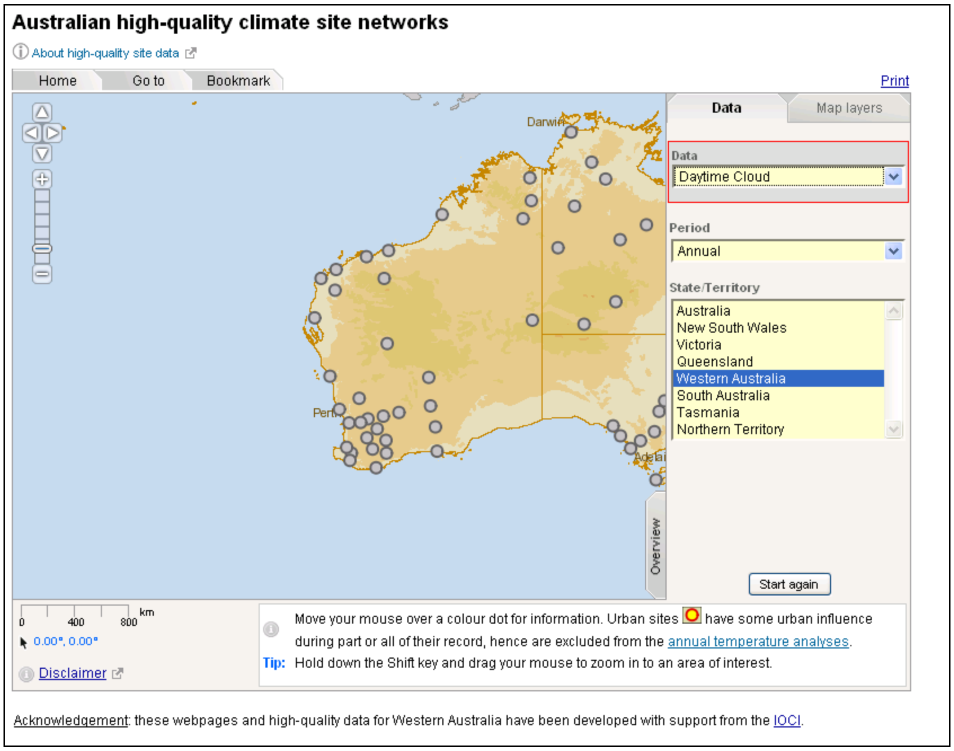
Not applicable.

List of publications accepted and submitted.

Nil.

List of IOCI-related presentations at national and international conferences, symposia and workshops.

Nil.



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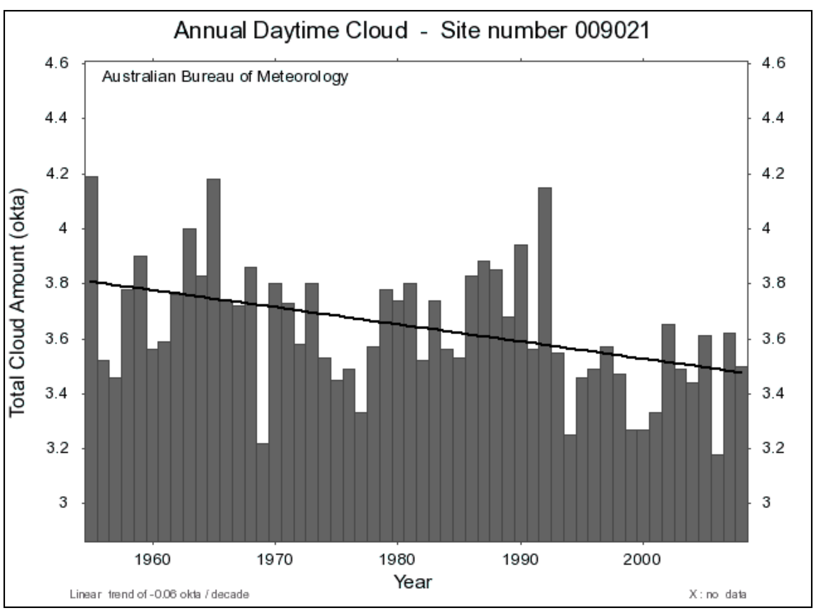

(b)

Figure 1: Screen shot showing the location of high-quality cloud cover sites on the climate data portal (a), and mean annual cloud cover for the Perth region demonstrating a large local decline since the mid 1950s (b).

Milestone 1.4.4: Enhanced local capacity in climate analysis and monitoring, including an enhanced presence in the Western Australian Regional Office.

Principal Investigator:

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This milestone is ongoing with the continued employment of Marco Marinelli and enhanced climate science and services being provided to the people of Western Australia.

Key Research Findings and Highlights

Marco Marinelli was recruited as a climate scientist based in the WA Climate Services Centre to work on IOCI Stage 3 project 1.4. Marco's main focus during the past year has been on Milestone 1.4.1 (see above) with additional support provided to the other Milestones and real-time climate analysis activities.

Marco has enhanced the skills in climate analysis in WA, particularly in the area of Geographic Information Systems, statistical analysis, and climate data manipulation. He has also provided a focal point for interaction with IOCI partners, whilst also liaising with the partners to understand their climate data needs. This interaction has developed over the past year with attendance at IOCI forums, WA Climate Change Policy Interdepartmental Steering Group (CCPISG) – Science sub-committee meetings, and at WAMSI, Australian Meteorological and Oceanographic Society (AMOS), and CSIRO symposiums.

The availability of other Bureau of Meteorology datasets such as the new high resolution gridded analyses will provide further scope for a generally expanded level of service to IOCI partners and the public.

Preliminary work on Milestone 1.4.7 (see below) has led to Marco developing closer links to Western Australian Regional Office (WARO) meteorologists and severe weather experts, whilst also enhancing his programming skills by undertaking a Python programming course. This language is commonly used in the WARO and will be used to process data for Milestone 1.4.7 projects.

The first half of 2010 has seen abnormally dry conditions affect the southwest of WA which has brought into focus the background long-term drying trend for the region. In addition, the last 12 months have been the hottest on record for the state of WA. A brief climate report was written in response to these conditions and provided to IOCI partners in early August. Further updates are anticipated over the remainder of 2010 if conditions do not improve.

Summary of new linkages to other IOCI 3 Projects

Not applicable.

Summary of any new research opportunities that have arisen (if any; dot points).

Not applicable.

List of publications accepted and submitted.

A very dry year so far in southwest Western Australia, Special Climate Statement 21, Bureau of Meteorology 2010, 3pp. Available from http://www.bom.gov.au/climate/current/special-statements.shtml .

List of IOCI-related presentations at national and international conferences, symposia and workshops.

M. Marinelli, K. Braganza, D. Collins, D. Jones, D. Maquire, C. Ganter, P. Hope and G. Cook. 2010. Improved Climate Data and Monitoring for Western Australia to Support the Understanding of Past, Present and Future Climate. Presentation to the 17th AMOS National Conference, Canberra, 27-29 January 2010.

M. Marinelli, K. Braganza, D. Collins, D. Jones, D. Maquire, C. Ganter, P. Hope and G. Cook. 2010. Improved Climate Data and Monitoring for Western Australia to Support the Understanding of Past, Present and Future Climate. Poster presentation to the 11th International Meeting on Statistical Climatology, Edinburgh, Scotland, 12-16 July 2010.

C. J. Ganter, K. Braganza, D. Collins, S. Maguire and D. Jones. 2010. A Comparison of Tipping Bucket Rain Gauges with Manually Read Rain Gauges in Australia. Presentation to the 17th AMOS National Conference, Canberra, 27-29 January 2010.

Milestone 1.4.5: *A very high-resolution (e.g., 0.025º) regional historical analysis of rainfall, temperature and vapour pressure for the South-West of Western Australia, covering the key runoff and agricultural regions.*

Principal Investigators

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Phone: 03 9669 4085; Email: d.jones@bom.gov.au .

Improved climate analyse have been developed and made available to the IOCI project meaning that the milestone is complete. Over the remainder of IOCI3 incremental improvement and analysis will be undertaken, as new data become available and opportunities for improvement arise.

Key Research Findings and Highlights

The last year has seen the delivery of very high-resolution spatial analyses for rainfall, maximum and minimum temperature and vapour pressure at a spatial resolution of 0.05º (approximately 5km). These analyses have led to a very substantial improvement in the accuracy of climate analyses for WA and improved the representation of rainfall trends in the southwest and northwest corners of the state in particular (see below).

The new analyses are detailed enough to resolve finer-scale topographical influences such as the Darling Escarpment and will provide the base data for many IOCI observational analyses going forwards. Already they have been used as the basis for a Special Climate Statement on southwest Australian rainfall during 2010, for developing the new high-quality rainfall station datasets and in the development of the high-quality cloud dataset.

Among the highlights of this analysis is evidence that the southwest rainfall decline has been particularly severe at higher elevations. Early results from analysing the rainfall decline in the southwest suggest total declines in mean rainfall approaching 400mm over the last 110 years or around 25% at higher elevations (Figure 1). The declines with elevation supports earlier research from IOCI that the decline in rainfall is due to a weakening of westerly rainfall events and a strengthening of the subtropical high-pressure belt. It also suggest that the higher elevations have seen the largest net rainfall reduction.

The new high-resolution rainfall data have been applied to the Perth region and reveal that a statistically significant step change to a new drier climate occurred in the late 1960s. The physical interpretation is that the weather systems delivering rainfall to Perth have changed to the extent that the region is now experiencing a fundamentally different climate.

Summary of new linkages to other IOCI 3 Projects

The new high-resolution data have been made available to IOCI partners and will be used by projects 1.1, 1.2 and 1.3. They have also been used for other subprojects in 1.4.

Summary of any new research opportunities that have arisen (if any; dot points).

The new data have opened the opportunity to use gridded data to support very detailed downscaling for rainfall and temperature, the analysis in real-time of extreme weather events and an analysis of the robustness of high-quality data for analysing historical climate changes over Australia.

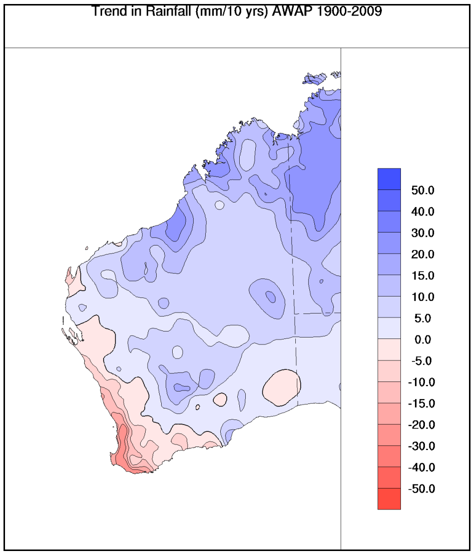
List of publications accepted and submitted.

A very dry year so far in southwest Western Australia, Special Climate Statement, 21, Bureau of Meteorology 2010, 3pp. Available from http://www.bom.gov.au/climate/current/special-statements.shtml .

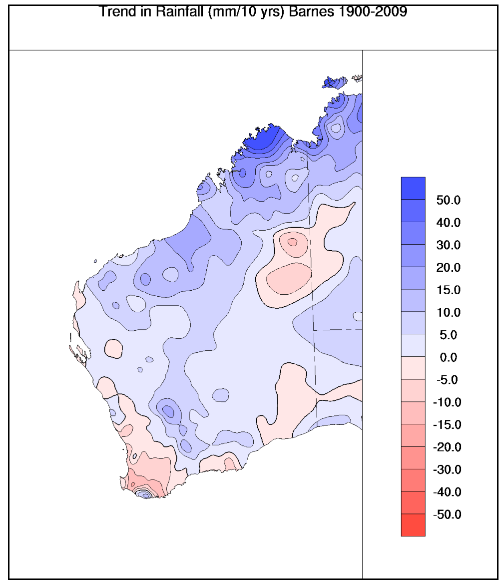
R. Fawcett, Trewin B. and Jones D. 2010. On Emerging Droughts. *Bull. of the Aust. Meteor. and Ocean. Soc*., 23, 28-36.

List of IOCI-related presentations at national and international conferences, symposia and workshops.

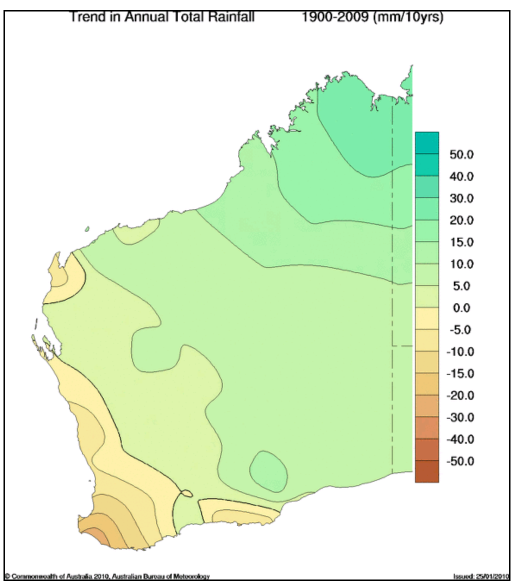
D. Jones, W. Wang, R. Fawcett, S. Maguire, 2010. The Development and Application of High Resolution Spatial Analyses for Australia. Presentation to the 17th AMOS National Conference, Canberra, 27-29 January 2010.



(a)



(b)



(c)

Figure 1: Analyses of the 110 year trend in rainfall for WA from the new high-resolution analyses at 0.05° resolution (a), earlier gridded analyses at a resolution of 0.25° (b) and based on the high-quality gauge network (c). The new data resolve the enhanced rainfall reductions at higher elevation and revealed that the far south coast increase in (b) is likely to be a result of network changes rather than a real observed change.

Milestone 1.4.6: *High-quality surface solar radiation data set for WA based on the newly developed Australian high-quality cloud dataset.*

Principal Investigators

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The new cloud-dataset has been completed and is available from the author. These data are being added to the web-site (Milestone 1.4.3) with this expected to be completed by December 31, 2010.

Key Research Findings and Highlights

The last year has seen the development of a high-quality cloud dataset with 33 stations in WA. This dataset has been made available through the new climate data portal and has been the basis of a recently accepted science paper in the journal Climatic Change. Analysis of this data has revealed a decline in winter cloudiness since the 1950s which has become particularly marked since the early 1980s. Summer cloud cover has tended to increase about the north coast and in inland parts where rainfall has also shown an increase.

The cloudiness declines in the southwest of WA will have exacerbated the large rainfall reductions through an increase in evaporative demand. Jovanovic *et al.* (2008) found increases in pan evaporation in the southwest of WA during autumn, winter and spring which coincide with the reductions in cloudiness. This combination of decreasing rainfall and decreasing cloudiness partly explains the severity of the runoff decline in the southwest.

The summer increase in cloudiness in northern and central parts of WA is consistent with rainfall changes though the greatest cloud cover increases have tended to be further south (near Giles) than the greatest rainfall increases (about the Kimberly region).

Satellite based estimates of surface solar radiation are now being provided in real time and at daily resolution on a 0.05° grid dating back to 1990 by the Bureau of Meteorology. These data are freely available and have complete coverage for WA. The availability of these new data means that proxy estimates of solar radiation from cloud cover are no longer seen as useful.

Jovanovic B, Jones DA and Collins D 2008. A high-quality monthly pan evaporation dataset for Australia. Climatic Change, 87, 517-535.

Summary of new linkages to other IOCI 3 Projects

The new data have only recently become available so links and use is at an early stage.

Summary of any new research opportunities that have arisen (if any; dot points).

The new data have opened the opportunity for future analyses of past changes in the hydrological cycle beyond rainfall. They also provide for a better mechanistic understanding of the rainfall decline in the southwest and increases in the northwest. At a later stage these data may provide base observational sets for the calibration of downscaled future climate change projections.

List of publications accepted and submitted.

Jovanovic B, Collins D, Braganza K, Collins D and DA Jones, 2010. A high-quality monthly total cloud amount dataset for Australia. Climatic Change, in press.

List of IOCI-related presentations at national and international conferences, symposia and workshops.

Nil.

Milestone 1.4.7: *Sector-relevant climatologies, baselines data and trend analyses for WA covering such measures as thermal heat-stress and fire indices.*

Principal Investigators

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This milestone is in progress and on track for completion as scheduled in December 2011.

Key Research Findings and Highlights

Preliminary work on sector-relevant climatologies commenced in 2010, with scoping of possible projects.

Fire weather climatology work for WA has been discussed with Bureau of Meteorology WA Severe Weather Section staff and a draft project plan has been developed to address the needs of both weather forecasters and sectoral users such as the Fire and Emergency Services Authority (FESA) and the WA Department of Environment and Conservation (DEC). Work continues to complete a literature survey, assessment of the proposed techniques to meet requirements within the Bureau of Meteorology, as well as the requirements of the relevant sectors, before commencing a fire weather climatology for WA.

Preliminary discussions have been held with FESA and the WA Department of Health in relation to a heatwave warning service for the Bureau of Meteorology, and it is envisaged that climatological studies as part of Milestone 1.4.7 could be undertaken to provide background to such a service. Future work will involve broad consultation with key sectors to determine their needs, followed by the development of a project plan before heat wave climatologies for WA will be prepared.

Summary of new linkages to other IOCI 3 Projects

Nil

Summary of any new research opportunities that have arisen (if any; dot points).

Nil.

List of publications accepted and submitted.

Nil.

List of IOCI-related presentations at national and international conferences, symposia and workshops.

Nil.

Milestone 1.4.8: *Enhanced homogenised tropical cyclone database for WA providing base data for Project 2.2.*

This milestone is in progress and on track for completion as scheduled in December 2011. The historical tropical cyclone track data have been assembled and access has been gained to supplementary tropical cyclone information from international and domestic collaborators. A science paper has been commenced, and will be finalised in the next year.

Principal Investigators

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Key Research Findings and Highlights

This project is in its first year and results remain limited. The main effort so far has been to reconcile all known existing sources of tropical cyclone data and undertake some homogenisations of datasets.

The main emphasis has been:

- As far as possible, develop a data set from existing data sources to which a consistent set of definitions has been applied, with respect to regional boundaries, reaching of cyclone intensity, and tropical/extratropical status;
- Remove gross errors from the tropical cyclone data set; and
- Completely document the underlying procedures used, and the uncertainties and biases which arise, over time in observing tropical cyclones.

The main impact of the homogenisation which has been applied has been to reduce the observed frequency of cyclones between approximately 1955 and 1970. Whilst there is still a downward trend in observed cyclone occurrence since the 1970s which is linked to changes in the El Niño-Southern Oscillation, it is weaker than previously suggested.

Summary of new linkages to other IOCI 3 Projects

As these data and associated analyses develop they will support Project 2.2 in particular.

Summary of any new research opportunities that have arisen (if any; dot points).

Nil.

List of publications accepted and submitted.

A paper is in the early stages of writing. It is expected to be submitted in early 2011.

List of IOCI-related presentations at national and international conferences, symposia and workshops.

Nil