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

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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

(Completed 31/12/2009)

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Final Report

Key Research Findings

This work has defined a new high quality daily precipitation network. Stations were included in the network if they passed a series of tests which determined that they have high data completeness and have no clear errors in the precipitation measurement entries. This combination of empirical and analytical methods resulted in the definition of a new high quality network of 157 stations for Western Australia (Figure 1). These stations have a very high completeness of precipitation entries and have a small level of gross error (determined by statistical and empirical tests). In addition to *single stations*, 12 composites were created where (a) a single station with a sufficiently complete record was not found or (b) a station passed all other tests but was recently closed. The record studied included all entries in years up to and including 2008. The high quality of the chosen stations makes them ideal candidates for further analysis such as (a) correcting clear discontinuities using changepoint detection tests and (b) disaggregation tests.

Summary of steps in analysis of data completeness and composite station creation.

Firstly, an initial analysis of the completeness of the precipitation data, for all stations in Western Australian, was performed with the aim of determining which stations are very complete (at least 95% data completeness) from pre 1950 until the end of 2008. These are the single stations described in the previous section.

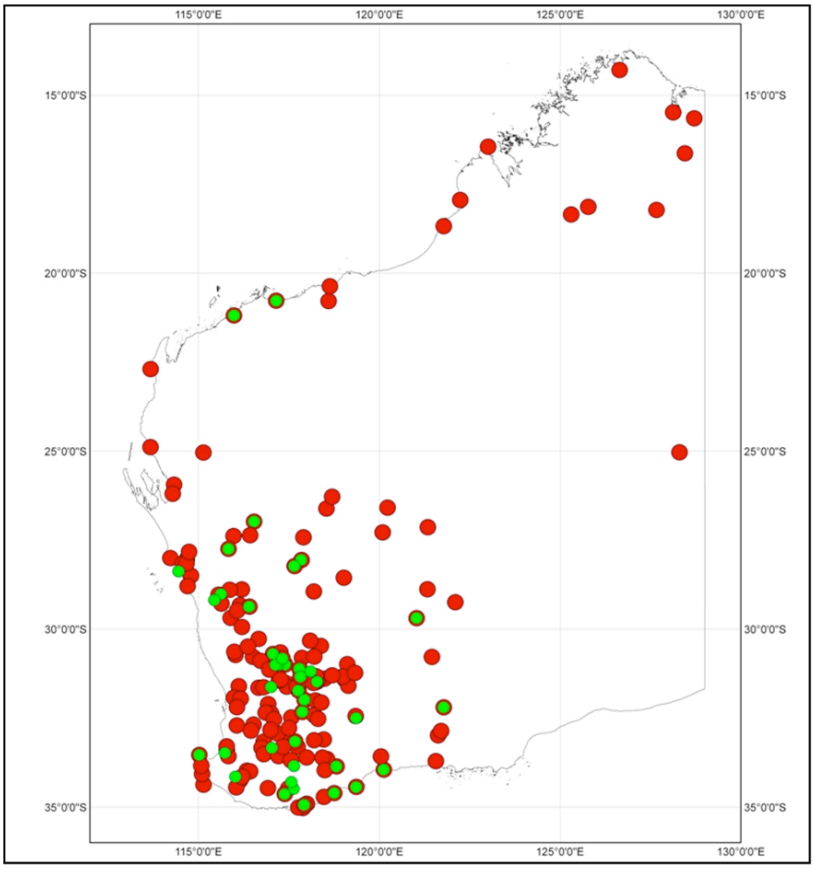

Figure 1: New network of high-quality daily stations (red) and sites from the daily Lavery network (green).

Secondly, the stations that did not pass this test were further analysed to see if they were suitable to make a composite station comprising of a maximum of 2 or 3 stations. These stations must,

1. Have long periods with very complete records (ideally >30 years), except when the join date of the composite's stations is recent, as occurs when an old station was recently closed and its replacement recently opened.
2. The monthly and yearly total precipitation of the stations in a composite, on overlapping dates, were visually and statistically compared as they must have a very high agreement (correlation >0.95; therefore, no adjustment of the data was considered necessary).
3. The stations in a composite must be within a 30 km radius of each other. The composite station details are given in Table 1.

Almost none of the composites have a join date earlier than 1930. This is because if a station has a high completeness from for that period, it was considered adequately long (~70-80 years). Therefore, it was classified and further tested as a single station.

Summary of Statistical analysis of the 306 candidate stations

The second step comprises of 4 subsequent steps; (1) temporal trend analysis and comparison nearest station (2) correlation, regression and covariance with nearest stations (3) test for the frequency of small number of days of missing data and (4) final analysis of errors possibly caused during data entry. These 4 tests are further detailed in the following sections and their sequence illustrated in Appendix 1.

For steps 1 and 2, the yearly and seasonal total rainfall measurements were compared. This minimises the effect caused by the naturally high variability present in rainfall measurements. These totals were only calculated for years where every month of the year had more than 25 days of data (the '25 day test'). This reduced the biasing of results that would be caused by large intra annual periods of missing data.

(1) The Temporal Trend Analysis.

Regression coefficients were calculated for annual (all months in a year) and seasonal (all months in a season in a year) totals. They closely agree with the temporal change grids available from the Bureau of Meteorology (http://www.bom.gov.au/cgi-bin/climate/change/trendmaps.cgi). Regression coefficients for candidate stations were also compared to the nearest candidate station. In these comparisons, the candidate stations did not exhibit significantly different regression coefficients which indicated no significant errors in the measurements i.e. change over time was as expected for each station, in the region where the station was located (negative in the south, positive in the north).

(2) The Two Station Statistical Comparison

Statistical characteristics of all 306 candidate stations were compared to nearest stations, for both annual and seasonal totals. The results were mapped to allow an easy comparison with nearest stations as well as visual assessment of statistical patterns reflecting the climatology of a region. This latter point considered important due to the difference in rainfall patterns. For example, there should be a high correlation between stations which receive most of their rainfall from the winter front crossing from the Indian Ocean (such as Cape Leeuwin and Cape Naturaliste). At

these, most of the rainfall comes from southwest to northwest depending on the northerly extent of the front. However, for stations east of Albany such as Cape Ritchie, most of the rainfall comes from the south east (from the onshore flow in the wake of the cold front).

(3) The Removal of stations with frequent multi-day periods of missing data.

This step determined and catalogued the frequency of occurrence of small data gaps in the remaining candidate stations (missing entries of less than 6 days, as the 25 day filter has already filtered larger data gaps). These small gaps might be due to many days of rainfall that has been entered as one entry (an aggregation). This occurs to varying degrees at almost all stations. But, this still does not significantly influence the quality of these stations if long term changes are studied using monthly means or totals. However, they are important when a high completeness of daily measurements is required.

(4). The Lavery and Trewin Anomalies tests

These tests are used to identify errors which may not have affected the statistical comparison to a large degree but should not be present in a high quality precipitation dataset.

The first method, as discussed in Lavery (1992), identifies biases in entries (such as rounded measurements) by generating frequency histograms of the daily rainfall measurements. As expected, the majority of measurements should be low and not rounded to less than 0.2 mm or 1 point (the current decimal and pre 1973 imperial minimum scales in the Bureau of Meteorology rain gauges). If there is a bias toward a certain measurement, this should be clear in the histogram.

The final test applied in this analysis calculated the ratio of measurements above 1mm versus the measurements above 2mm (Trewin, pers. comm..). This, for the station of interest, was compared to the same ratio at a near trusted station (such as at an airport or town). It was found that this test did not result in the removal of any further stations from the final high quality list.

References

B. Lavery, A. Kariko and N. Nicholls. 1992. A historical rainfall dataset for Australia. Aust. Met. Mag. 40, 33-39.

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, S. Maguire, 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, S. Maguire, 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 11th International Meeting on Statistical Climatology, 12-16 July 2010.

M. Marinelli, K. Braganza, D. Collins, D. Jones, S. Maguire, 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*. Australia New Zealand Climate Forum. Hobart, 12 October 2010.

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

(Completed 31/12/2010)

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A beta version of the homogenised data set was completed in December 2010 and updated in June 2011. As a result of the intense public scrutiny of temperature data in Australia and elsewhere (including a court case involving the equivalent data set in New Zealand), it was decided to undertake an additional external review of the data set prior to its public release. This review was undertaken by a panel of experts convened by the Bureau of Meteorology, consisting of four independent peer reviewers from Australia, the US, Canada and New Zealand. This review took place in August 2011 and its findings have been received by the Bureau of Meteorology, although they have not yet been publicly released at the time of writing.

A series of six reports were prepared for the external review by the international panel in August 2011. The temperature data set is documented under the *ACORN-SAT analysis and results document: Report 3a for the Independent Peer Review of the ACORN-SAT data-set*. This report went through a number of expert science reviews within the Bureau of Meteorology in preparation for the international review in August 2011.

The newly developed high-quality temperature data set constitutes a major advance on existing Australian datasets and the need to provide more publicly accessible information around the data, methods and metadata have meant more work has been required than initially expected. Recent changes in the FOI laws and experiences with such datasets in other countries support the need for this extra work. Preparation of the dataset for rigorous review has meant further work is

necessary but this is also added insurance for the solidity and robustness of the techniques applied. It is expected that this will considerably value add to the work made possible from the IOCI investment. In a similar vein, a very detailed technical report has been prepared but due to the aforementioned this report has had to undergo a very strict and lengthy internal review process prior to submission for publication. This will also be true of a condensed version which will be submitted as a journal paper before the end of 2011.

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.

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

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

(Completed 31/12/2010)

This milestone was completed and extensively reported in Milestone Report 2. Ongoing revision and enhancement will be made based on user feedback.

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

(Ongoing milestone which ends on 31/12/2011)

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Key Research Findings and Highlights

This milestone is on-going, and the report in the Milestone Report 2 is still relevant.

Summary of new linkages to other IOCI 3 Projects

The outputs of project 1.4.7 will enhance the local analysis and prediction of extreme heat events.

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

Not applicable.

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

(Completed 31/12/2010)

This project has been completed and had been extensively reported on in the Milestone Report 2.

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

(Completed 31/12/2010)

This project has been completed. High-quality cloud data are now available online http://www.bom.gov.au/climate/change/hqsites/

In particular, data are available for both the morning and afternoon observations (09:00 and 15:00) as well as daytime clouds (average of the two) for a range of periods (annual, seasonal, monthly). Time series of averages and anomalies can be selected from a point-and-click map and nearest alternate sites can easily be identified. A scientific paper has now been published.

Satellite based estimates of surface solar radiation are now being provided in real time and at daily resolution on a 0.05° grid. These estimates of global solar exposure can be extracted free of charge from the Solar Exposure Archive (daily grids, http://www.bom.gov.au/jsp/awap/solar/archive.jsp?colour=colour&map=solarave&period=daily&area=nat) and through Climate Data Online (CDO) http://www.bom.gov.au/climate/data/

A map interface allows selecting locations to extract both daily and monthly solar exposure, either for just one year or for all available years of record (back to 1 January 1990). Figure 2 gives an indication of the spatial coverage provided for Western Australia.

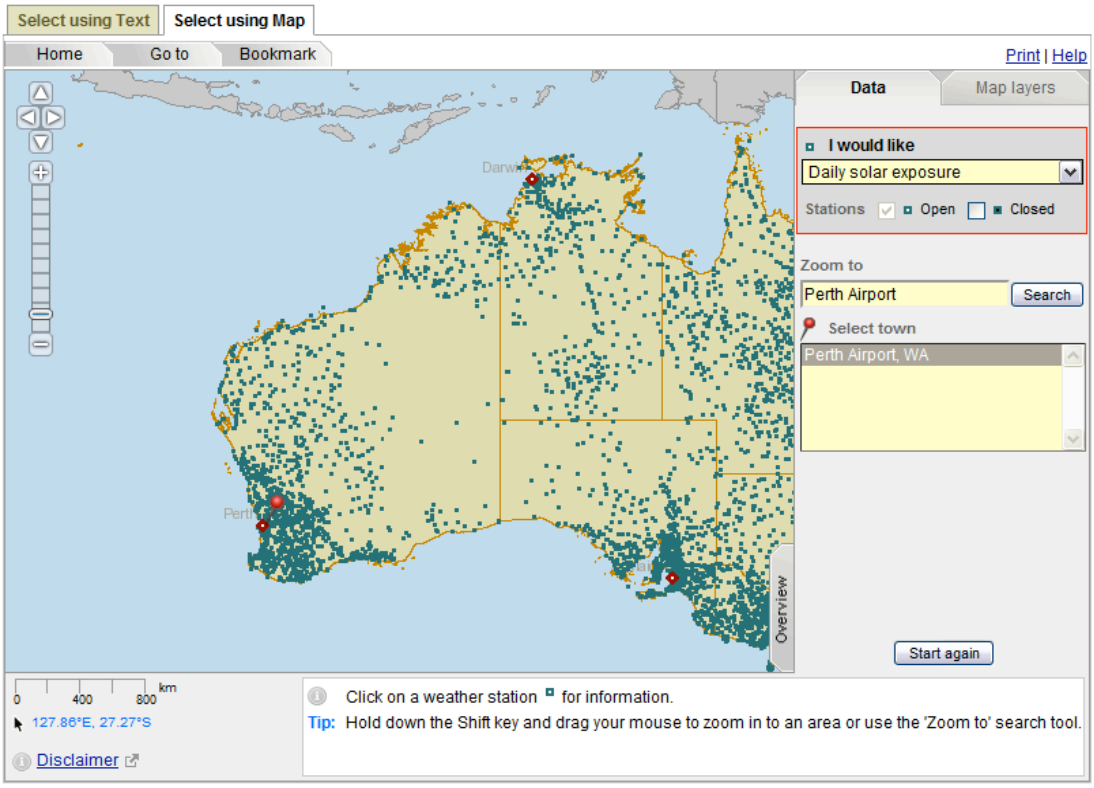

Figure 2: Map interface for selection of stations with daily solar exposure estimates

Data can be downloaded as Excel spreadsheet (.csv) or in PDF format for printing. Alternatively, data can be displayed as shown in the three figures below.

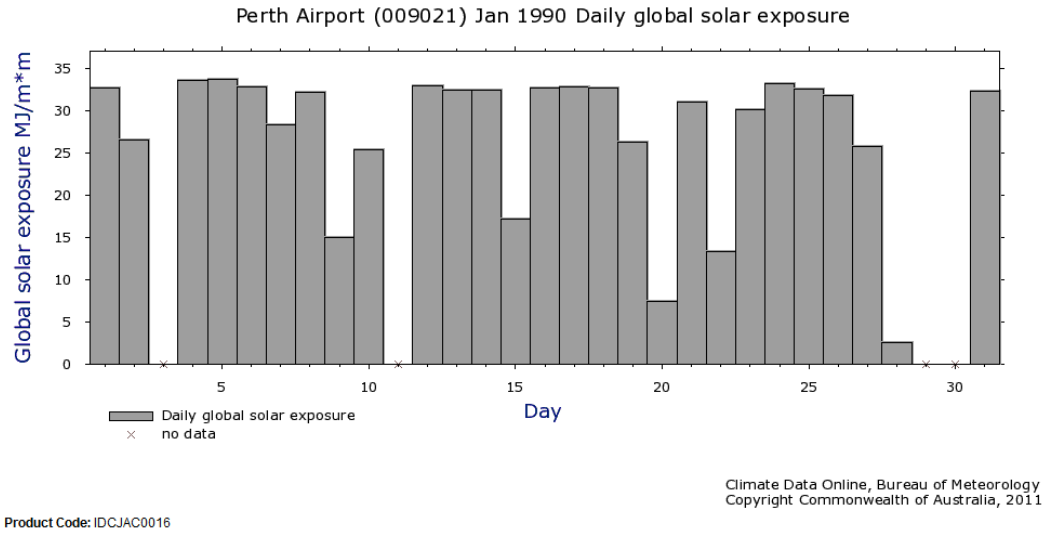

Figure 3: Daily global solar exposure at Perth Airport for January 1990

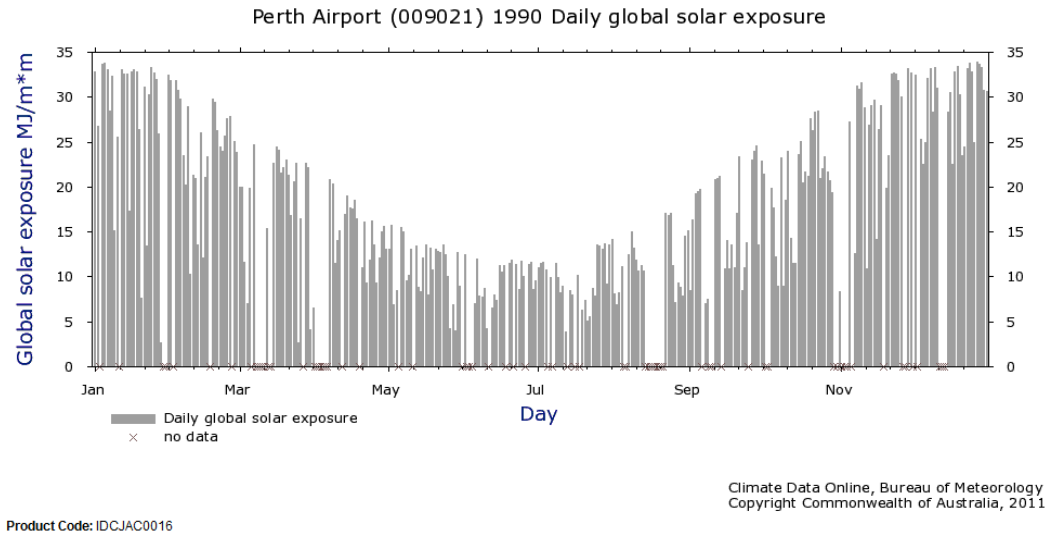

Figure 4: Daily global exposure at Perth Airport for 1990

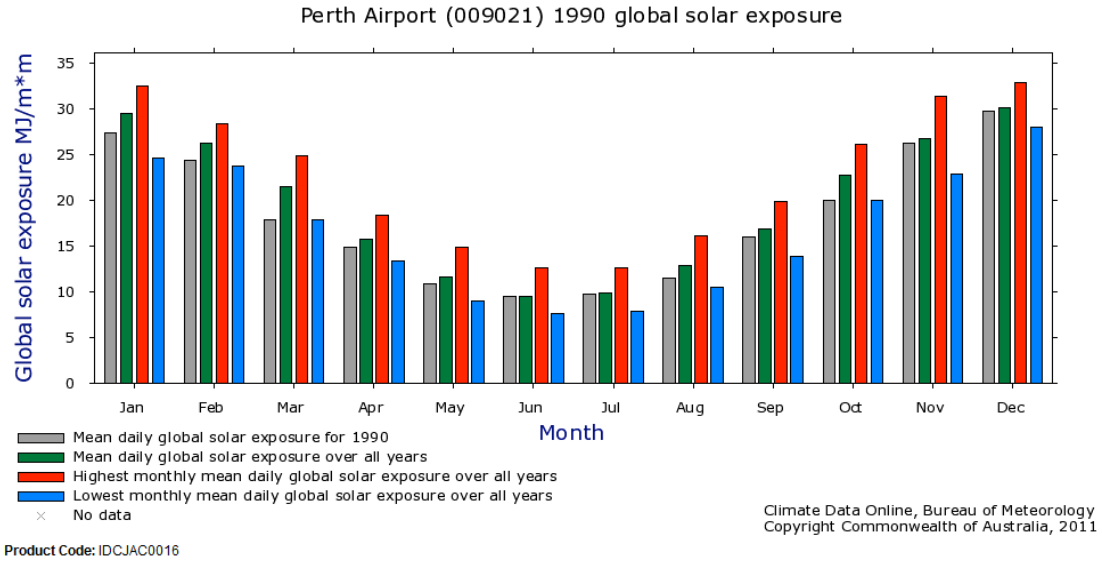

Figure 5: Comparison of mean daily global solar exposure at Perth Airport for 1990 with climatology based on all years

Satellite-derived global solar exposure estimates are based on images from the Geostationary Meteorological Satellite GMS-5, Geostationary Operational Environmental Satellite (GOES-9) and MTSAT-1R and MTSAT-2 satellites, which are provided with permission of the Japan Meteorological Agency (JMA) and the United States National Oceanic & Atmospheric Administration (NOAA).

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, published online.

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

(Progress report – to be completed 31/12/2011)

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Background

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). The objective of this work is to develop a fire weather climatology for WA. Initially these analyses will be based on reanalysis data (ERA40). Analysis will then be repeated on the basis of station data to allow comparison and developing an adjustment procedure which may require introducing meteorological considerations (especially near the coast to account for sea breeze effects).

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. As part of this work, the WA Department of Health has been contacted for relevant data (hospital admission, mortality rates). Initially, an approach based on station data will be implemented with the aim to compare results to those from an approach based on gridded data and develop adjustments.

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

(Progress report – to be completed 31/12/2011)

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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 mid 2011.

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

Nil.