# Hunter, Central and Lower North Coast Regional Climate Change Project 2007

REPORT 1

# Progress report 1 to HCCREMS on Stage 1 of the Regional Climate Change Study

An initiative of the Hunter & Central Coast Regional Environmental Management Strategy

The Hunter & Central Coast Regional Environmental Management Strategy – a program of the Environment Division of Hunter Councils

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# Executive Summary

This is the first report on a research project focused on the identification of key climate change variables and impacts for the Hunter, Lower North Coast and Central Coast regions. The project partners are Newcastle Innovation and the Tom Farrell Institute for the Environment (University of Newcastle) and the Hunter and Central Coast Regional Environmental Strategy (HCCREMS). The project comprises four stages: (1) Identification of the key synoptic patterns relevant to the study region; (2) analysis of how the synoptic patterns drive climate and climate-related variability in the region; (3) downscaling CSIRO global climate model (GCM) predictions for New South Wales (NSW) to the study region; and, (4) determination of the potential climate change impacts on the region based on the statistical downscaling.

**Stage 1 – Climate Data Analysis**

Stage 1 focuses on the identification and collation of regionally specific climate data that will subsequently be used in Stages 2 and 4 of the project. The study region encompasses 14 local government areas of the Hunter, Central and Lower North Coast region of NSW. For the purpose of data selection only, a buffer of 50 km was also placed around the study boundary. The study region and 50 km buffer zone used for data selection is shown in Figure 1. A detailed quality assurance procedure has been implemented to identify data sets that are of a suitable nature for use in the Regional Climate Change Project. The data includes: Australian daily precipitation; Australian daily maximum and minimum temperatures; Australian hourly temperature, humidity and pressure; Australian daily evaporation; Australian daily wind data; Australian hourly wind data; Daily cloudiness, visibility and sunshine hours data for Bureau of Meteorology (BOM) districts 60, 61 and 62; Six minute pluvial data for districts 60, 61 and 62, NSW monthly ocean wave height, period and direction data, and monthly ocean tide gauge data on sea-level. At this point hydrological data (e.g. streamflow) has not been purchased or assessed. New LIDAR data on coastal zone topography elevations has been measured by the NSW Department of Planning in conjunction with some of the HCC. We have made a request to Lake Macquarie City Council and John Hudson, NSW Department of Planning, for access to this data. We have not received a response at this stage.

Data have been analysed for daily precipitation, maximum and minimum temperatures, daily average temperature, 9am and 3pm relative humidity, daily average windspeed, daily maximum wind gust speed and daily pan evaporation. These particular climate variables were chosen as they have been highlighted as key climate indicators for climate change impact assessment in the Hunter and Central coast region (as per the CSIRO stakeholders workshop survey on climate change impacts in the Hunter Valley conducted in 1999). In addition, these variables will be suitable for future research carried out during Stage 4 of the project that may involve climate change impact assessments for climate related variables such as drought, evaporation, bushfire risk, heat stress, frost and streamflow etc.

***Synoptic Typing of Climate Patterns***

An important component of Stage 1 of the Regional Climate Change Study is to define the key synoptic patterns that drive the climate variability of the region (which will be used in the downscaling of the Global Climate Model (GCM) output to a regional scale). This report summarises progress made in developing a methodology to identify the key synoptic patterns for the region. The synoptic patterns were determined using self organized mapping (SOMS) techniques using two reanalysis global climate datasets: (1) ERA-40 Reanalysis data from the European Center for Medium Range Weather Forecasting (ECMWF); and (2) NCEP/NCAR Reanalysis (NNR) from the US National Oceanic & Atmospheric Administration (NOAA). These data sets contain gridded 6 hourly, daily and monthly data for the full range of climate parameters, from the surface through the atmosphere. At this stage of the project we have obtained the NNR daily and monthly sea-level pressure, and 500 hPa geopotential height data between 1948 and the present.

Synoptic climate typing (ST) has been performed on monthly sea-level pressure data (SLP) from January 1948 through to December 2007 for the region. Thirty-five synoptic types have been generated based on the SLP data covering a region that is considered to capture the major synoptic weather patterns influencing the region. These patterns define the clear seasonal trend in the location and intensity of the subtropical anticyclone, the monsoonal trough, the circumpolar trough, and the longwave features in the Pacific and Indian Ocean sectors. Further analysis will

reduce the number of synoptic types to the minimum number required to explain significant variability in the regional climate parameters and to serve as the baseline synoptic patterns for the impact assessment stage.

Each month from January 1948 through to December 2007 has been classified according to the 35 synoptic patterns, resulting in a monthly time series of synoptic types. This time series will be used during Stage 2 of the study to analyse the relationship between the regional synoptic patters and local changes in key climatic variables (i.e. the data sets analysed in this report). Further work being carried out with the synoptic typing involves the investigation of using daily pressure data and additional pressure levels to define the regional to hemispheric climate drivers of variability across the study site. Progress on this work will be reported in the second progress report due in September 2007.

The 35 synoptic patterns that have been generated using the SOM methodology and monthly SLP data are shown in Figure 2.

***Discussion and Recommendations for Stages 2-4***

The possibility of generating daily synoptic type (ST) patterns was investigated, particularly in regard to assessing the future likelihood of extreme weather events. The use of SOMS on daily and monthly data produces the same patterns. The patterns associated with extreme events is being examined using the upper and lower 10 decile climate data and linked to the monthly ST's. Hence, the ST's will be used in Stages 2-4 to examine mean climate change and the probability of a change in the frequency of extreme events based on the frequency of the monthly ST's. In addition, the reliability of GCM output on future climate patterns is currently best examined on monthly ST's. Paleoclimate or proxy climate data are also being examined to define the frequency or return periods of extreme weather events.

Whilst Stages 2 and 3 can be undertaken as stand alone scientific research exercises, Stage 4 will require detailed input from the key stakeholders and industries about the primary climate data that relate to the specific land uses, planning techniques or risk management. Hence, we need timely input from the proposed stakeholder workshops on which climate variables need to be defined in the examination of future climate variability and change, using the ST methodology and GCM downscaling techniques. We also need to discuss with the stakeholders the advantages and disadvantages of using monthly climate data, and further develop

the appropriate methodology to analyse the present and future changes in extreme weather events.


**Figure 1**. Study region and buffer zone used in climate data selection.

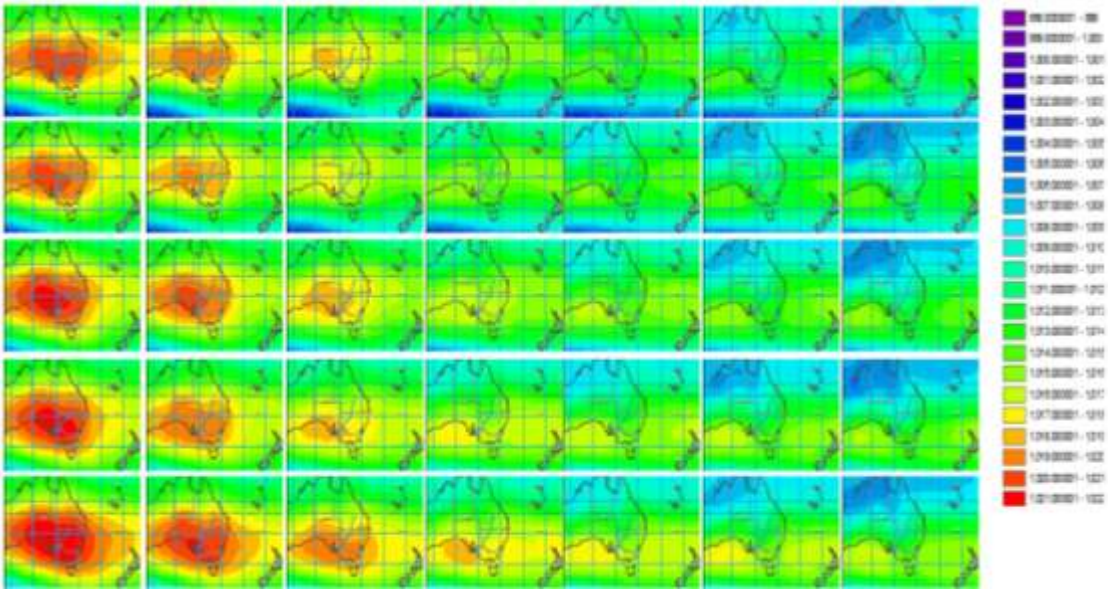

**Figure 2**. Diagram showing the 35 synoptic climate types of sea-level pressure defined in Stage 1.

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*SECTION 1*

# 1 Background of the project and outline of this report

The Hunter and Central Coast Regional Environmental Management Strategy (HCCREMS) is currently implementing a Regional Climate Change Project. This project aims to identify possible impacts of climate change in the Hunter, Central and Lower North Coast and raise awareness and understanding by local governments, industry and community in the region. In order to implement these goals, HCCREMS has commissioned the University of Newcastle (via The University of Newcastle Research Associates, TUNRA) to conduct the scientific research required for this study.

TUNRA's component of the Hunter and Central Coast Regional Climate Change project is being carried out over a number of stages (four in total). This report summarises the work undertaken for Stage 1 of the Hunter and Central Coast Regional Climate Change Project. During Stage 1 research has focused on two main objectives:

- Identification and analysis of climate and climate related data sources for the study region; and

- Development of a methodology to identify the key synoptic climate patterns that drive monthly climate variability in the region.

This report focuses primarily on the analysis carried out to identify and collate regionally specific climate data that will subsequently be used in Stages 2 and 4 of the project. A detailed quality assurance procedure has been implemented to identify data sets that are of a suitable nature for use in the Regional Climate Change Project. In addition, this report summarises progress made in developing a methodology to identify the key synoptic patterns for the region. Further research on the synoptic typing is currently being carried out (by refining the process to include daily data) which will be addressed in the second progress report for this study, which is due at the end of September 2007.

Progress to date on the two objectives of Stage 1 is outlined in the following sections. The study region is described in Section 2, while Section 3 discusses the climate and climate related data sources identified for the region. Section 4 outlines the methodology used to interrogate the climate data (to assess each record's

suitability for further use in the study) along with a description of the data sets that pass the selection criteria. Finally, Section 5 provides a brief discussion on the progress made on the synoptic typing for the study region and Section 6 summarises the findings of Stage 1 of the project.

# 2 The study region

The study region encompasses 14 local government areas of the Hunter, Central and Lower North Coast region of New South Wales. For the purpose of data selection only, a buffer of 50 km was also placed around the study boundary. It is considered that including a selection of quality data sets for stations within a suitable distance outside of the study region will aid in future research involving interpolation of point based climate data to grid a based format (by reducing boundary errors). The study region and 50 km buffer zone used for data selection is shown in Figure 1.


**Figure 1: Study region and buffer zone used in climate data selection.**

# 3 Climate and hydrological data sources

## 3.1 Bureau of Meteorology Station Climate data

Instrumental climate data sets have been obtained from the National Climate Centre of the Australian Bureau of Meteorology (BOM) for use in the project. These data sets will be the primary source of information used to study climate variability (Stage 2) and climate change impacts (Stage 4) for the region. To date the following data has been acquired:

- Australian daily precipitation;
- Australian daily maximum and minimum temperatures;
- Australian hourly temperature, humidity and pressure;
- Australian daily evaporation;
- Australian daily wind data;
- Australian hourly wind data;
- Daily cloudiness, visibility and sunshine hours data for BOM districts 60,61 and 62; and
- Six minute pluvial data for districts 60, 61 and 62.

## 3.2 Hydrological data

At this point hydrological data (e.g. streamflow) has not been purchased or assessed. This data may be purchased at a later stage if a hydrological impact assessment is conducted during Stage 4 of the study (pending the decision of the key sectors targeted for climate change impact assessment). If hydrological data is required, streamflow data may be purchased from DECC (PINEENA rainfall and streamflow CD for NSW -$200) or obtained from Hunter Water for a select number of sites.

## 3.3 Global reanalysis climate data

Two reanalyis global climate datasets are available. These are the ERA-40 Reanalysis data available from the European Center for Medium Range Weather Forecasting (ECMWF), and the NCEP/NCAR Reanalysis (NNR) available from the US National

Oceanic & Atmospheric Administration (NOAA). These data sets contain gridded 6 hourly, daily and monthly data for the full range of climate parameters, from the surface through the atmosphere. At this stage of the project we have obtained the NNR daily and monthly sea-level pressure, and 500 hPa geopotential height data between 1948 and the present.

# 4 Analysis of climate data for use in the Regional Climate Change Study

The following sections outline the climate data that is available for the study region (including the 50 km buffer zone) and the methodology used to interrogate this data to assess suitability for use in the Regional Climate Change Study. Data has been analysed for daily precipitation, maximum and minimum temperatures, daily average temperature, 9am and 3pm relative humidity, daily average windspeed, daily maximum wind gust speed and daily pan evaporation. These particular climate variables were chosen as they have been highlighted as key climate indicators for climate change impact assessment in the Hunter and Central coast region (as per the CSIRO stakeholders workshop survey on climate change impacts in the Hunter Valley conducted in 1999). In addition, these variables will be suitable for future research carried out during Stage 4 of the project that may involve climate change impact assessments for climate related variables such as drought, evaporation, bushfire risk, heat stress, frost and streamflow etc.

## 4.1 Daily Precipitation

Daily precipitation data is available for approximately 17300 sites across Australia. Of these, approximately 2000 are within the study region and 50 km buffer zone. The record length and continuity of the data varies from station to station, with some stations recording daily precipitation for more than 100 years, while others may have been operational for only a short period of time ( e.g. less than one year). The locations of all stations that have recorded daily precipitation for the study region ad buffer zone are shown in Figure 2 (following page).

It is important to insure that the data sets used in this study are of a sufficient length, cover a common time span and are reasonably complete. It is also important that the stations provide adequate spatial coverage of the study zone in order to conduct a regional analysis of climate change impacts. Therefore, the data sets shown in Figure 2 were interrogated in order to derive a high quality data set that will be used in the regional Climate Change Project.

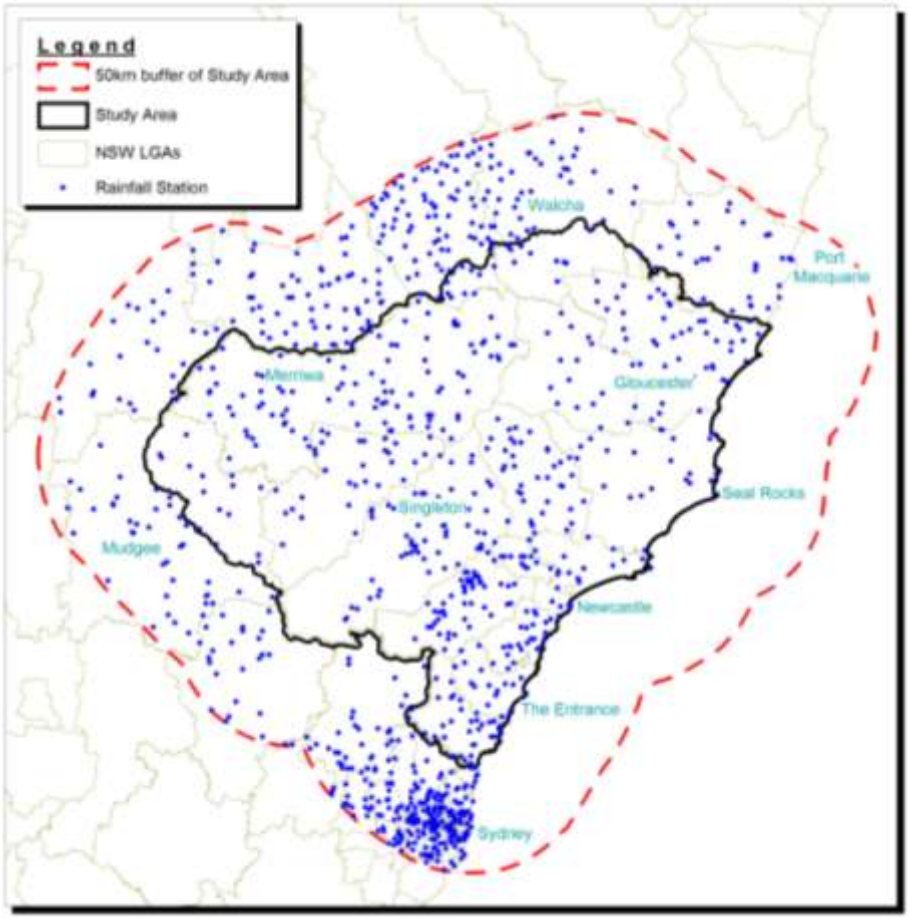



**Figure 2:** Location of stations that have recorded daily precipitation within the study region

The first stage of the data interrogation analysis was to filter the available data shown in Figure 2 to obtain a subset of data that included only those stations that have rainfall observations spanning the 1948 through to 2007 epoch (59 years). The year 1948 was chosen as the lower bound as this corresponds to the first year for which the atmospheric data is available in the NNR dataset (and therefore will also be the first year for which the synoptic typing will be carried out).

The second stage of the data interrogation process was to determine the completeness of each of the rainfall records. Each rainfall timeseries was checked for missing data between the years of interest (1948 and 2007) and this was converted to percentage completeness. It was determined that a good spatial coverage could still be maintained by restricting the final data set to stations with daily rainfall records that are at least 90% complete. A high number of stations are clustered around the Sydney region. As this area is outside the primary study boundary only a selection of key Sydney based stations were chosen for use in future analysis involving the interpolation of point source data to gridded data for the study region (i.e. during Stage 2 and 4).

A total of 80 stations were found to satisfy the selection criteria. The location of the rainfall stations that satisfied the selection criteria adopted is shown in Figure 3.

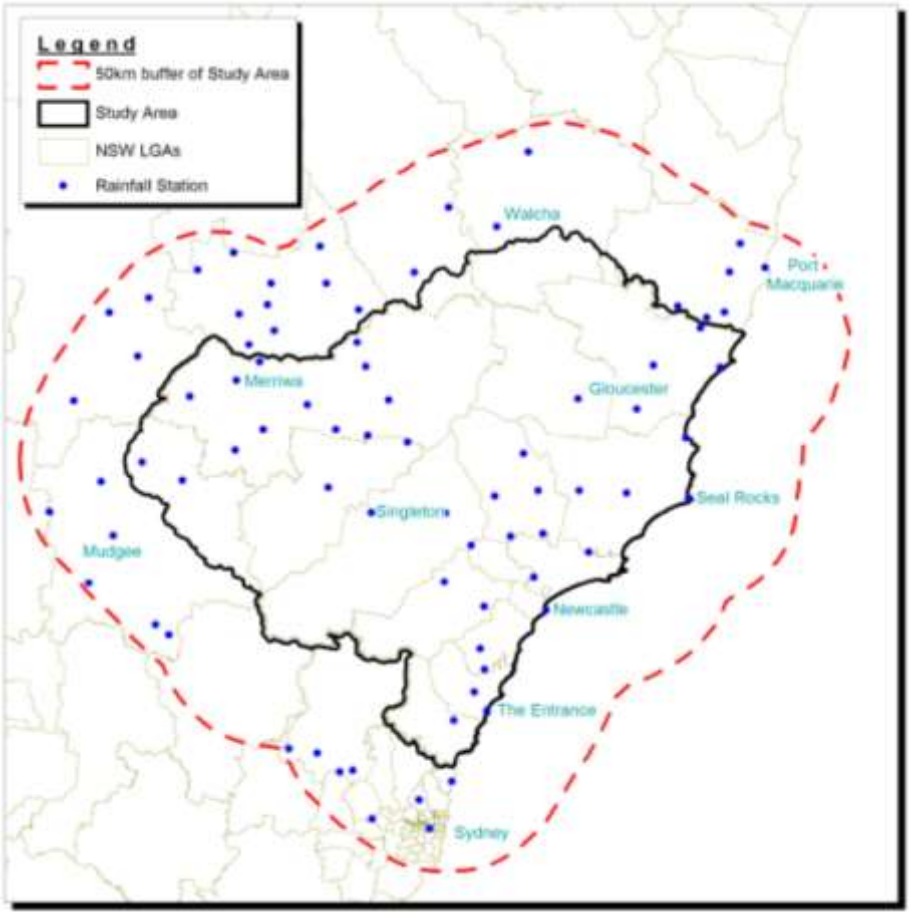



**Figure 3**: Location of rainfall stations suitable for use in the Regional Climate Change Study

Figure 3 demonstrates that the final stations chosen provide suitable spatial

coverage for a regional climate study with at least one gauge located in each LGA (and in many cases more than one). The coastal region is well represented, along with the in Upper Hunter. Stations recording rainfall in the Singleton, Dungog and Gloucester regions are not as dense; however it appears that sufficient data exist within the study boundary and buffer zone to interpolate climate impacts in these regions.

## 4.2 Daily maximum and minimum temperatures

Daily maximum and minimum temperature data is available for 1700 sites across Australia. Of these, 91 are located within the study region and buffer zone, as shown in Figure 4 (following page). Generally, temperature records are much shorter than those available for rainfall, with fewer stations measuring this element. The record length and continuity of the data also varies from station to station.

The data set shown in Figure 4 was filtered to include only those stations with measured maximum and minimum temperatures from at least 1970 through to 2007 (37 years). Many weather stations were opened just prior to 1970, therefore this date threshold was found to provide the longest data set with the greatest spatial coverage. In some instances weather stations have been decommissioned and relocated within a short distance from the original position (e.g. the monitoring station may have been moved from a post office to the new airport within the town) and in most cases the BOM assigns a new station number for this temperature gauge. Therefore, in order to maximise spatial coverage, temperature stations that have been discontinued and replaced by a secondary gauge at a nearby location were also considered for inclusion in the final data set. To maintain quality assurance, only those gauges with a period of overlap existing for the two data sets were considered. The daily temperature timeseries during the simultaneous time period were then compared to determine if the two gauges could suitably be merged to represent one continuous temperature record. Temperature records at four locations were found to satisfy this analysis, as shown in Appendix A.

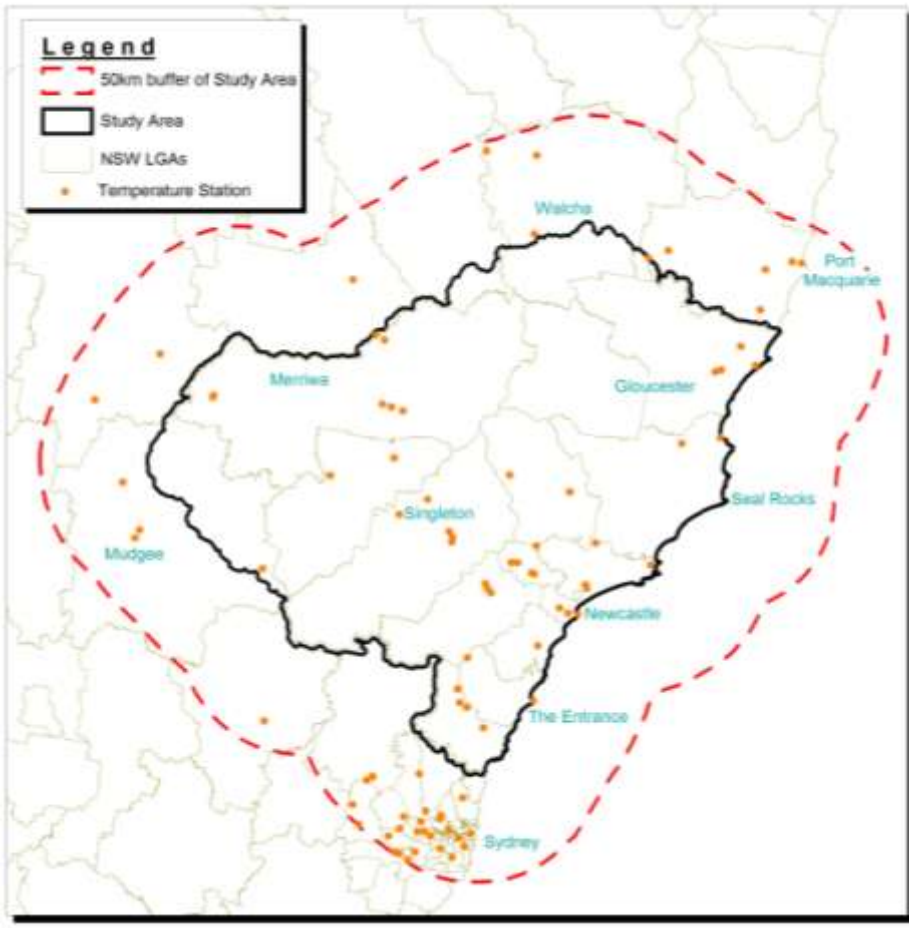



**Figure 4:** Location of maximum and minimum temperature stations within the study region

Each maximum and minimum temperature timeseries was checked for missing data between the years of interest (1970 and 2007) and this was converted to percentage completeness. It was determined that sufficient spatial coverage could still be maintained by restricting the final data set to include only those stations with daily maximum and minimum temperature data that is at least 90% complete. As for rainfall, a number of stations are clustered around the Sydney region. Two key Sydney stations were chosen for use in future analysis involving the interpolation of point source data to gridded data for the study region (i.e. during Stage 2 and 4). A total of 17 stations satisfy the selection criteria. The Sydney and Newcastle stations will be further analysed to discriminate the urban heat island effect from the climate variability study. The location of the temperature stations that that satisfied the criteria adopted for data selection is shown in Figure 5.

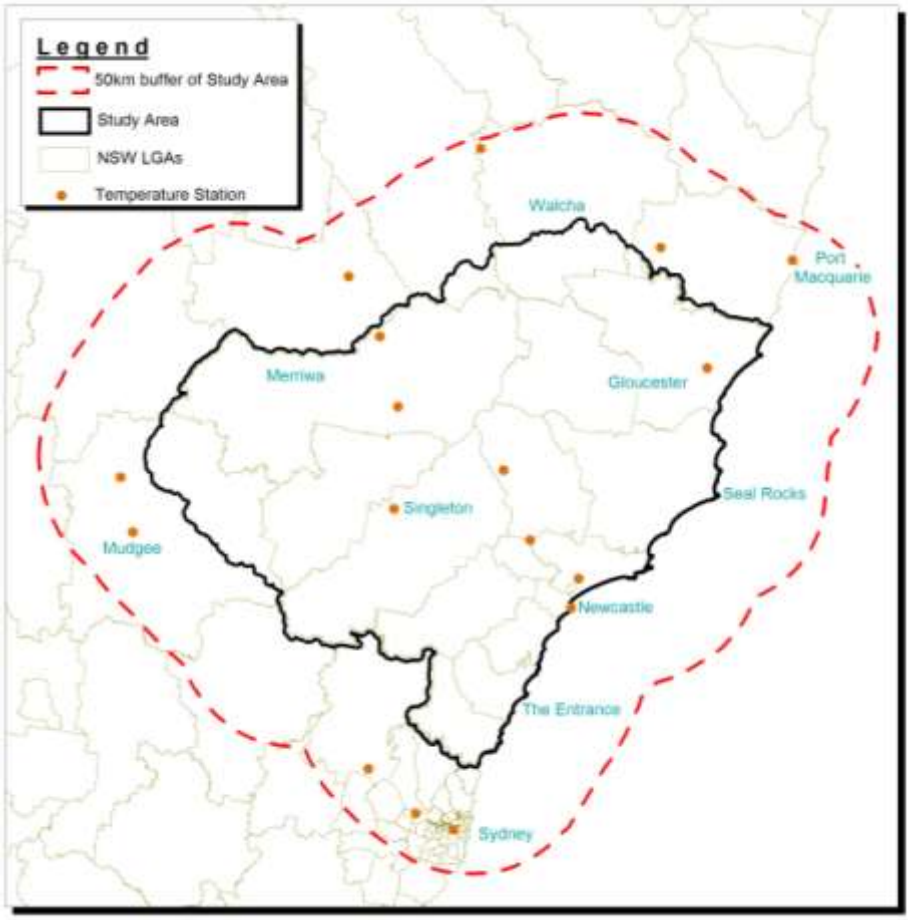



**Figure 5:** Location of temperature stations suitable for use in the Regional Climate Change Study

Figure 5 shows that, although a temperature record is not available for each of the 14 LGAs, the available stations provide reasonable spatial coverage for a regional study. It is also clear that utilising station data from just outside the study region is essential in order to gain maximum information on spatial variability of climate impacts.

## 4.3 Daily average temperature

Temperature data is available for 1730 sites across Australia at 3 hourly intervals which may be used to generate daily average temperatures (from the 9am and 3pm records). Of the 1730 sites, 91 are located within the study region and buffer zone, as shown in Figure 6. The record length and continuity of the data varies from station to station, with some of these stations recording temperature every three hours, while others have only recorded 9am and 3pm temperatures.

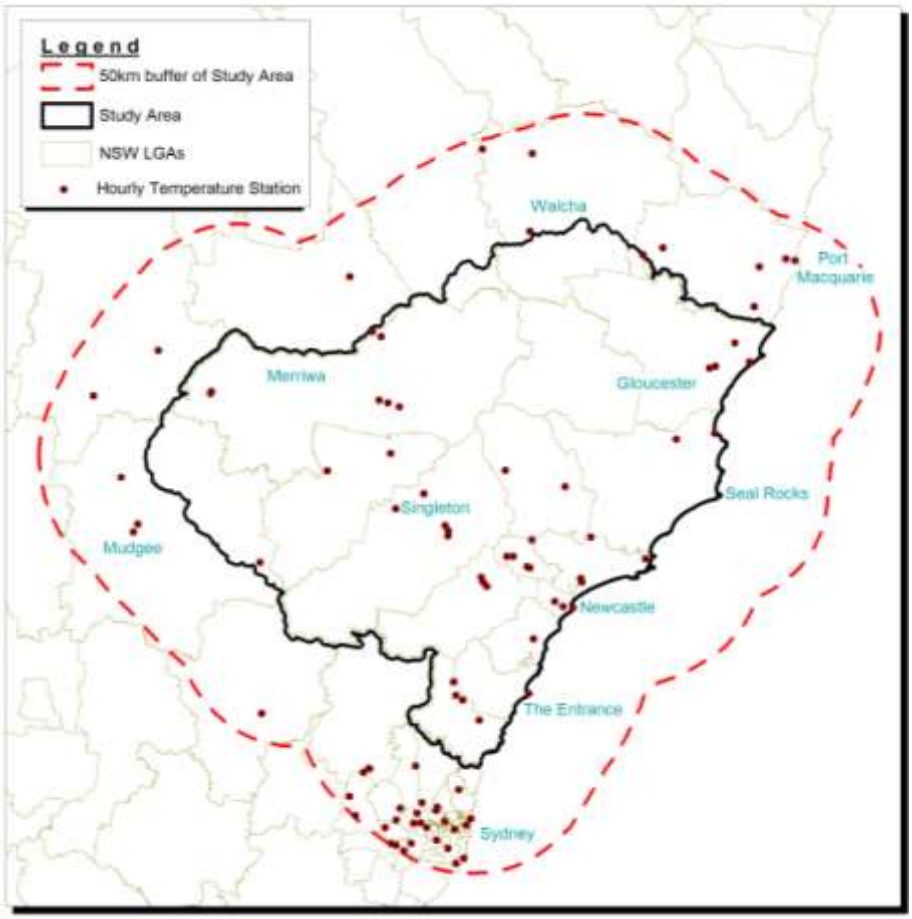



**Figure 6:** Location of hourly temperature stations within the study region

The data sets shown in Figure 6 were interrogated in order to derive a high quality data set that may then be used in Stages 2 and 4 of the Regional Climate Change Project. As for maximum and minimum temperature, data sets were chosen that span at least 1970 to 2007 (37 years) and are at least 90% complete (for 9am and 3pm temperature readings). Stations that have been discontinued and replaced by a secondary gauge at a nearby location were also considered for inclusion in the final data set using the quality assurance method outlined in Section 4.2 (see Appendix A). A total of 18 stations were found to satisfy the above selection criteria, as shown in Figure 7.

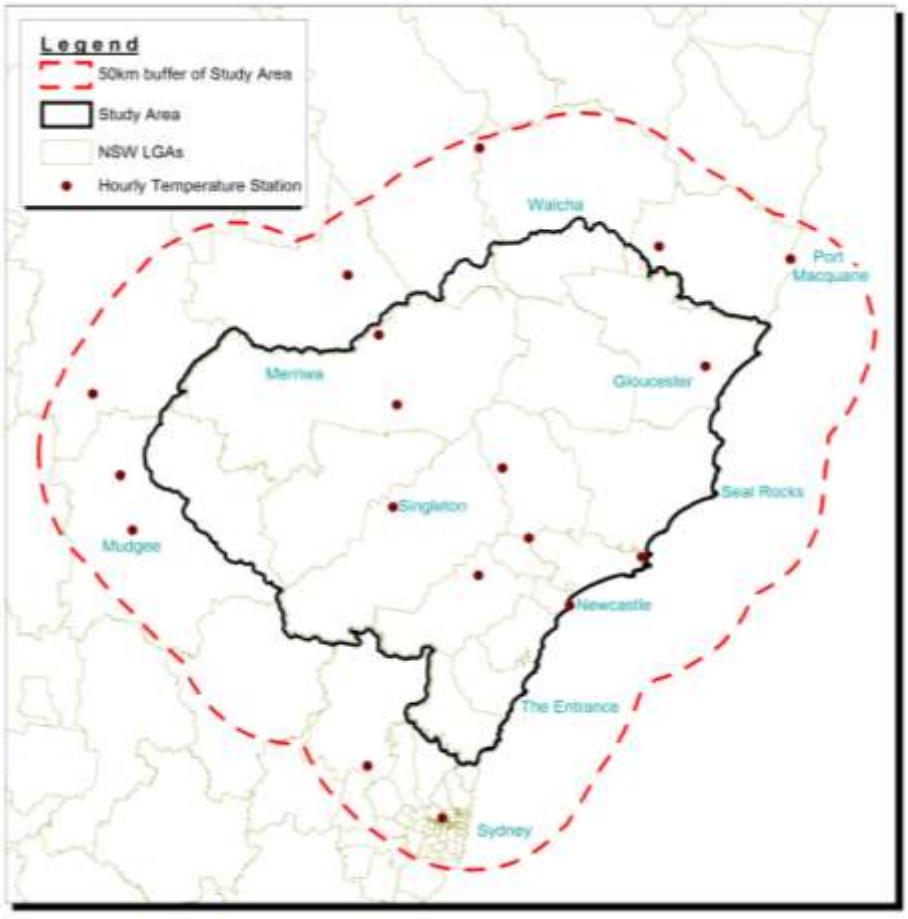



**Figure 7:** Location of hourly temperature stations suitable for use in the Regional Climate Change Study

Figure 7 demonstrates that, although an hourly temperature record is not available for each of the 14 LGAs, the available stations provide reasonable spatial coverage for a regional study. In particular, the data set provides information on both coastal regions and the Upper Hunter.

## 4.4 Relative humidity (9am and 3pm)

Relative humidity data is available for 1730 number of sites across Australia, measured at 9am ad 3pm. Of these, 91 are within the study region and buffer zone, as shown in Figure 8. As for all other climate records, the length and continuity of the data varies, with most records being less that 40 years long.

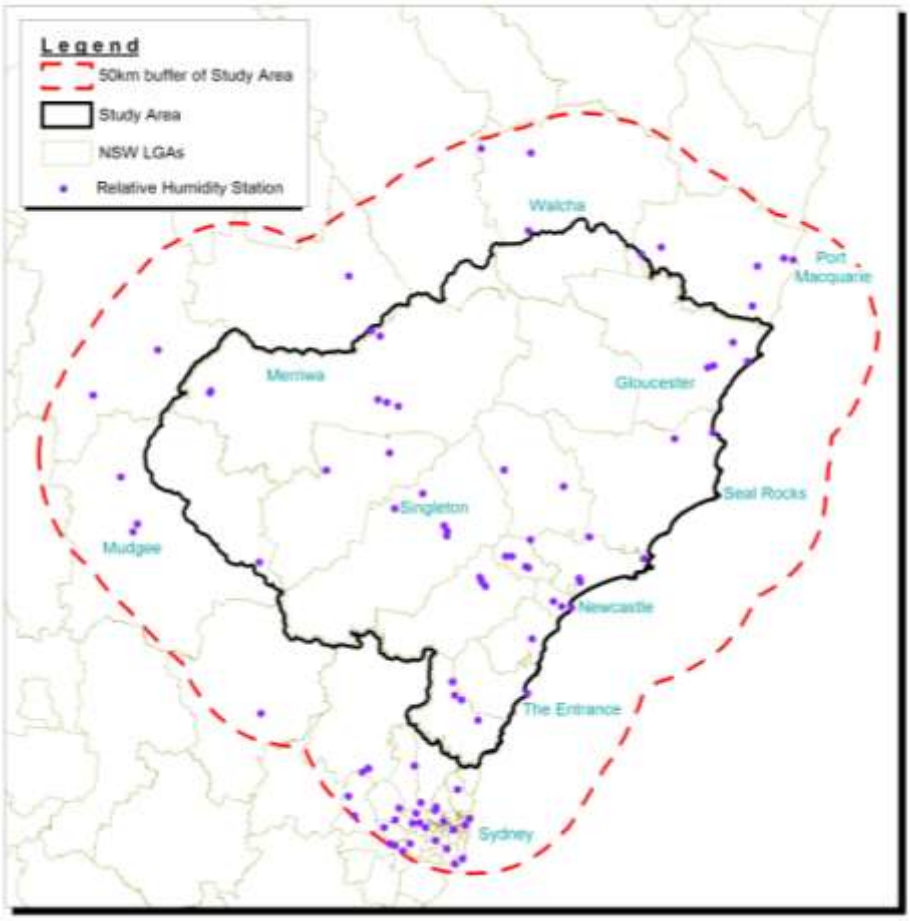



**Figure 8:** Location of relative humidity stations within the study region

The data sets shown in Figure 8 were interrogated in order to derive a high quality data set that may be used in the Regional Climate Change Project. As for temperature, data sets were chosen that span at least 1970 to 2007 (37 years) and are at least 90% complete. Stations that have been discontinued and replaced by a secondary gauge at a nearby location were also considered for inclusion in the final data set using the quality assurance method outlined in Section 4.2 (see Appendix A). A total of 11 stations were found to satisfy the selection criteria as shown in Figure 9.

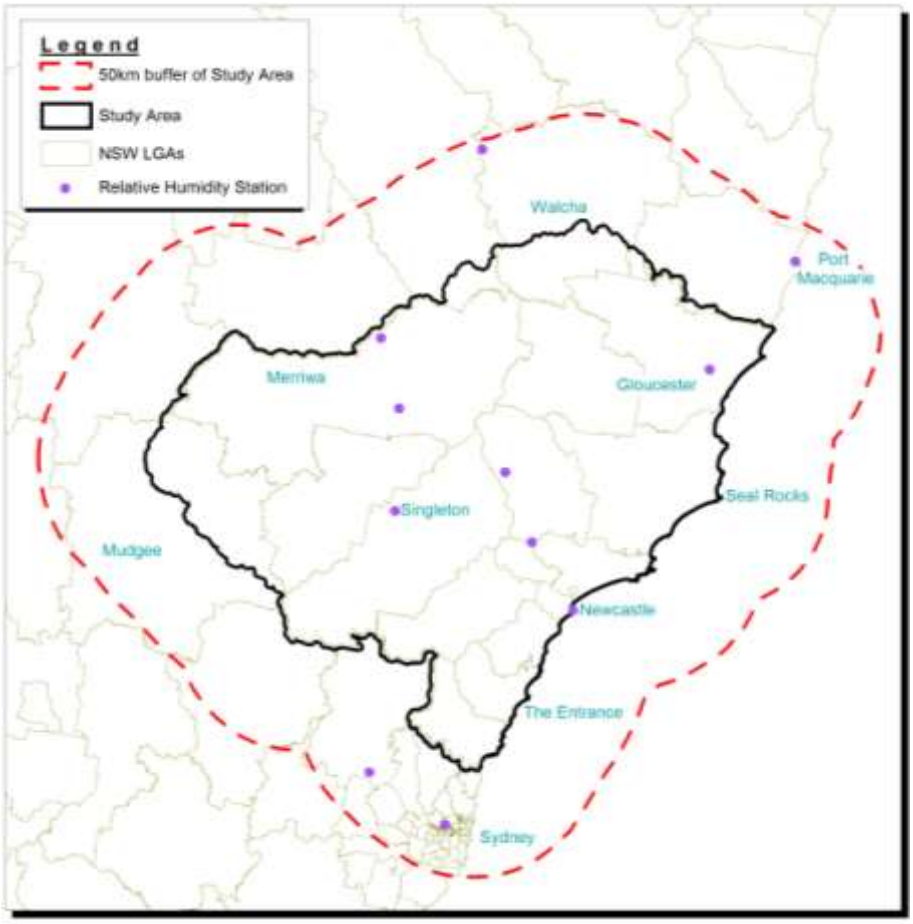



**Figure 9:** Location of relative humidity stations suitable for use in the Regional Climate Change Study

Figure 9 demonstrates that, although the data set for relative humidity is smaller than for temperature and rainfall, it should still be possible to gain some insight into the spatial variability of relative humidity for the Hunter and Central Coast region.

## 4.5 Daily average windspeed

Daily windspeed data is available for 1823 number of sites across Australia. Of these, 96 are within the study region and buffer zone, as shown in Figure 10. As for all other climate records, the length and continuity of the data varies from station to station, with most records being less that 40 years.

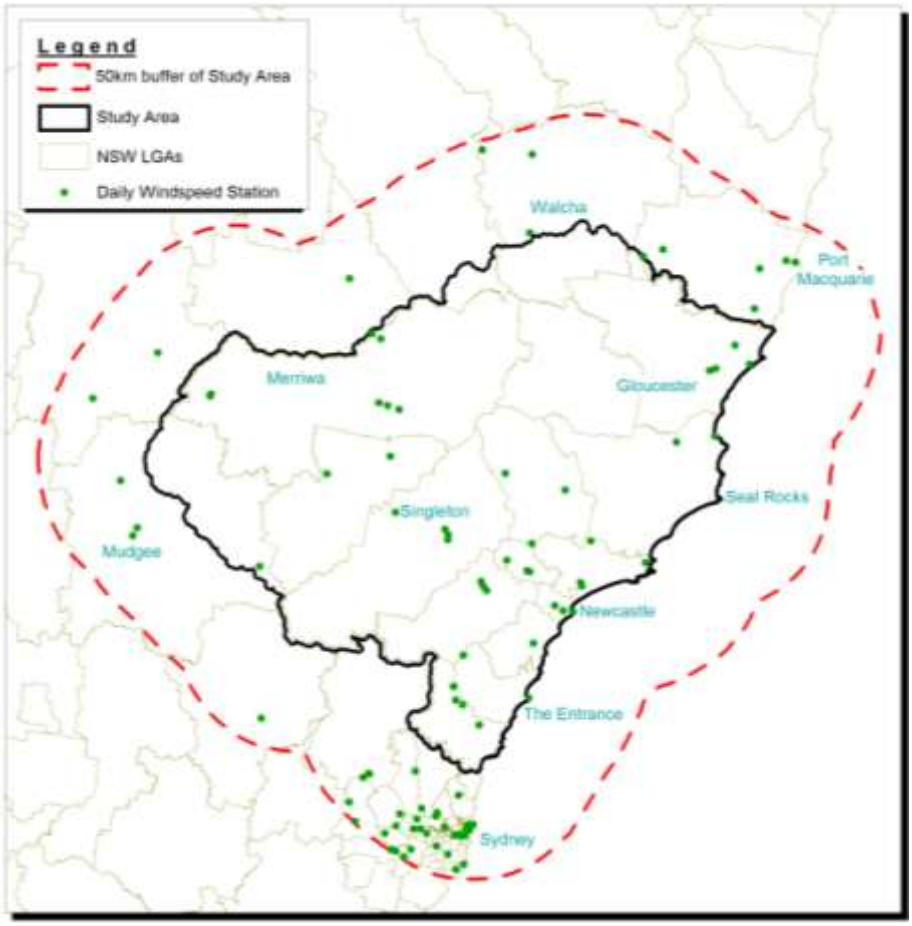



**Figure 10:** Location of daily windspeed stations within the study region

The data sets shown in Figure 10 were interrogated in order to derive a high quality data set that may then be used in the Regional Climate Change Project. As for temperature and humidity, data sets were chosen that span at least 1970 to 2007 (37 years) and are at least 90% complete. Stations that have been discontinued and replaced by a secondary gauge at a nearby location were also considered for inclusion in the final data set using the quality assurance method outlined in Section 4.2 (see Appendix A). A total of 14 stations were found to satisfy the selection criteria as shown in Figure 11.

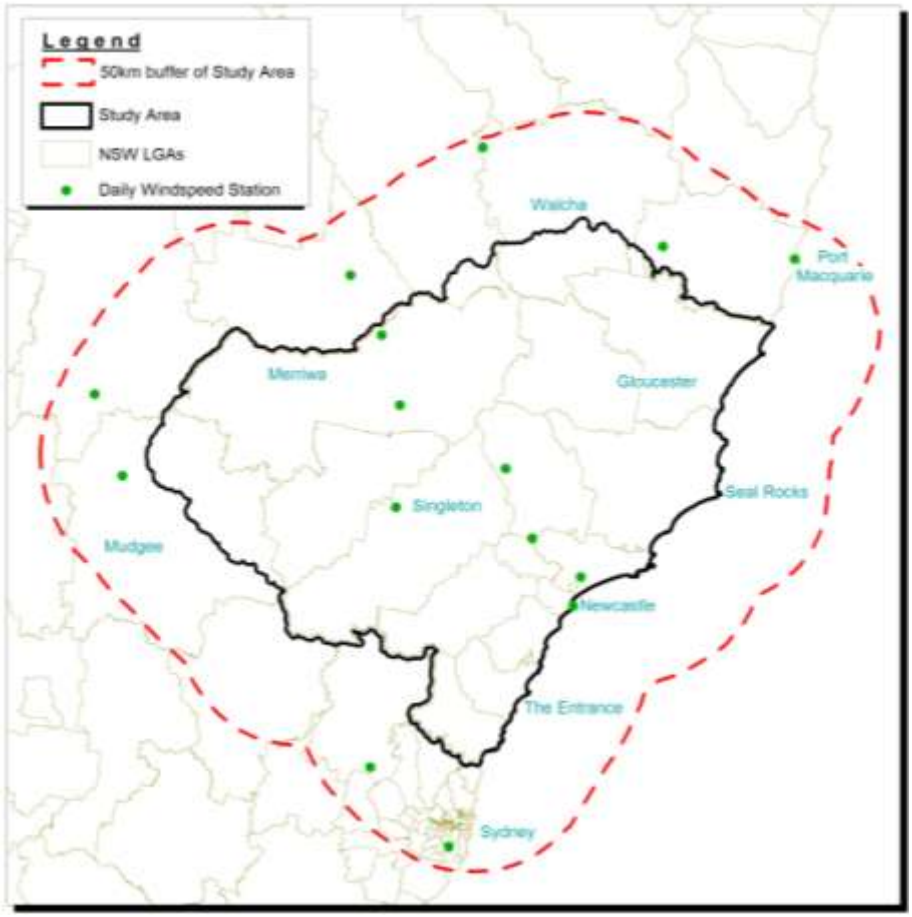



**Figure 11:** Location of daily windspeed stations suitable for use in the Regional Climate Change Study

Figure 11 shows that, although the windspeed data set is smaller than for temperature and rainfall, it may be possible to gain some insight into the spatial variability of windspeed for the regional study.

## 4.6 Maximum wind gust speed

Daily maximum wind gust data is available for 553 sites across Australia. Of these, only 26 are within the study region and buffer zone, as shown in Figure 12. As for all other climate records, the length and continuity of the data varies significantly from station to station.

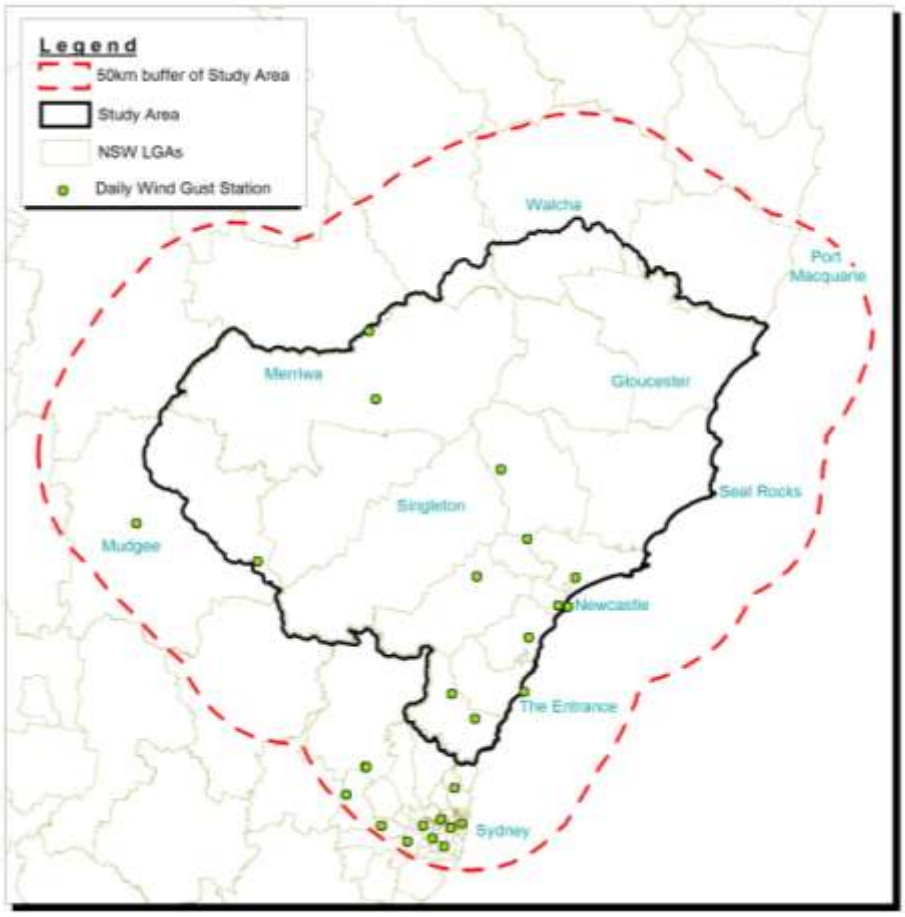



**Figure 12:** Location of maximum wind gust stations within the study region

The data sets shown in Figure 12 were interrogated in order to derive a high quality data set that may then be used in the Regional Climate Change Project. Data sets were chosen that span at least 1970 to 2007 (37 years) and are at least 90% complete. Maximum wind gust has not been monitored for a long period of time and the majority of stations do not have continuous data records for this variable. In fact, 14 of the 26 possible stations only began monitoring wind gust speed in 2003, while many other stations recorded this variable for a short period (less than 10 years). Only one station located within the study boundary (Williamtown) was found to satisfy the selection criteria as shown in Figure 13.

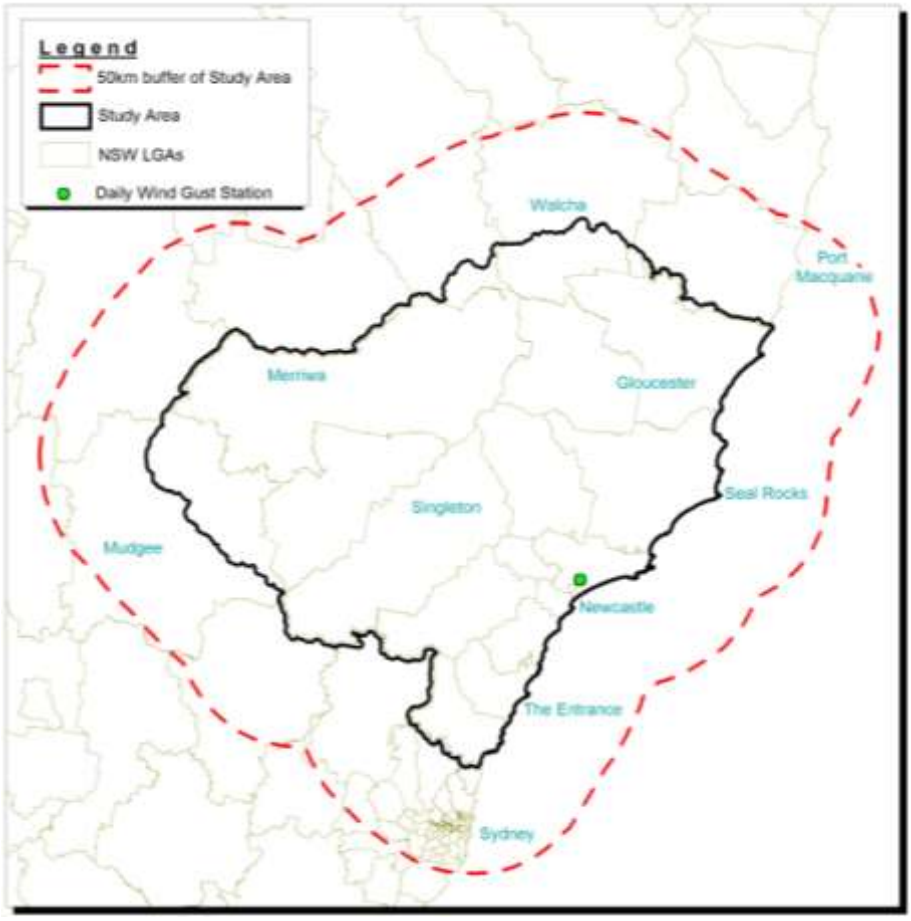



**Figure 13:** Location of maximum wind gust stations suitable for use in the Regional Climate Change Study

Due to the limited data available for maximum wind gust, regional variability in climate variability/climate change impacts will not be able to be addressed. However, this data may be useful to study local impacts on extremes for Newcastle.

## 4.7 Daily pan evaporation

Daily pan evaporation data is available for 630 sites across Australia. Of these, 30 are located within the study region and buffer zone, as shown in Figure 14. Pan evaporation has only been measured for a relatively short period of time in Australia, with the majority of records being less than 35 years in length.

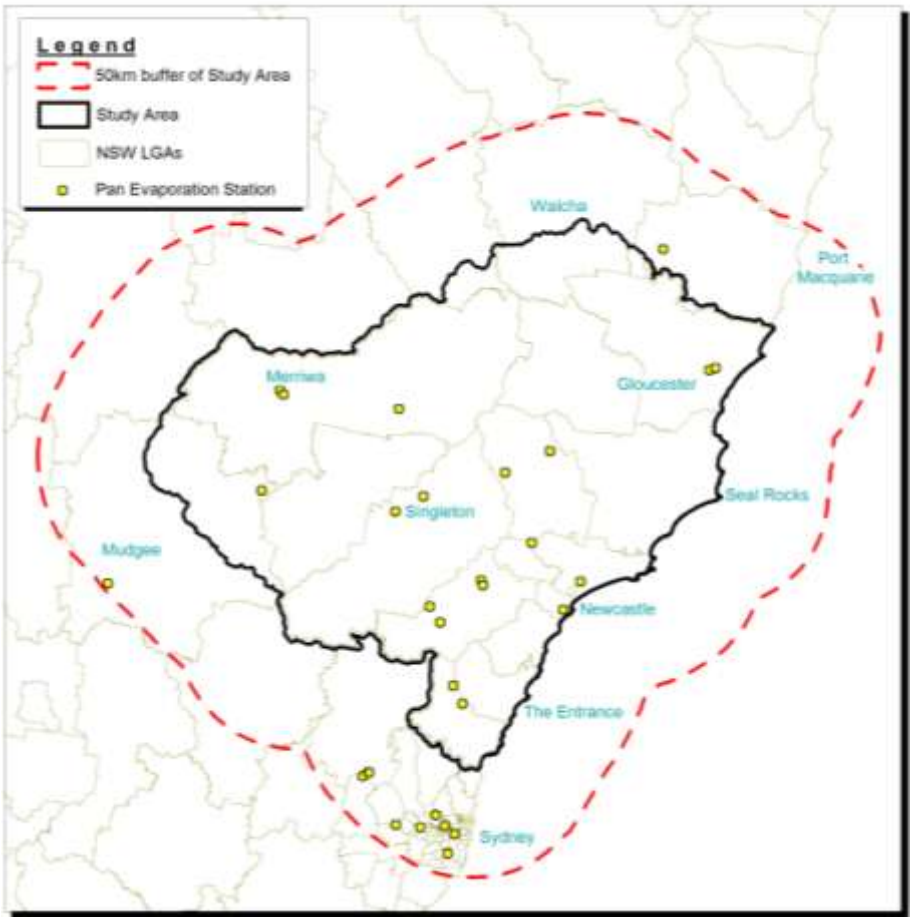



**Figure 14:** Location of pan evaporation stations within the study region

The data sets shown in Figure 14 were interrogated in order to derive a high quality data set that may then be used in the Regional Climate Change Project. Data sets were chosen that spanned at least 1974 to 2007 (33 years) and were at least 90% complete. A total of 7 stations were found to satisfy the selection criteria as shown in Figure 15.

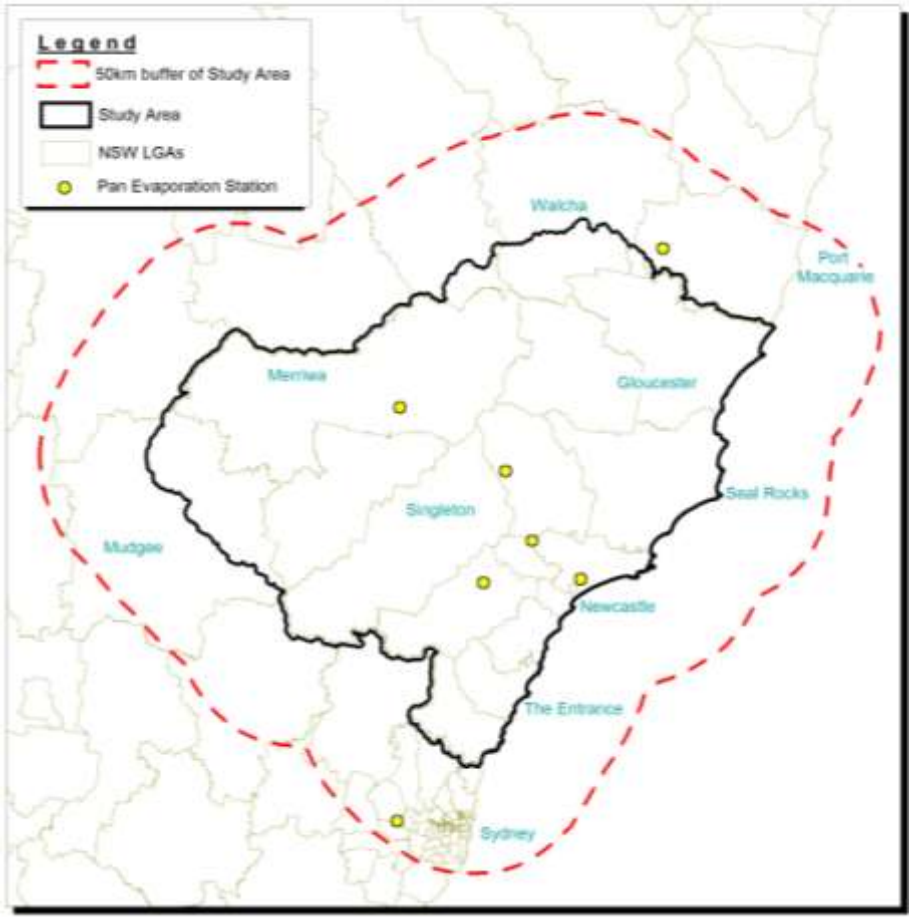



**Figure 15:** Location of pan evaporation stations suitable for use in the Regional Climate Change Study

Due to the limited data available for pan evaporation, regional variability of pan evaporation may not be able to be addressed in great detail. However, it appears that sufficient data exits to study the broad scale variability of pan evaporation across a number of LGAs located both along the coast and inland.

## 4.8 Ocean Wave Climate, Sea-Level and Extreme Sea-Level

Wave climate and sea-level data are essential for studies on beach erosion and shoreline fluctuations or trends. Daily and monthly wave climate data including, significant wave height, maximum wave height, peak period and mean wave direction, have been obtained from the Manly Hydraulics Laboratory, NSW Department of Commerce, and the NSW Department of Environment and Climate Change. The wave data have been obtained for two sites: Sydney, (1987 to present) and Crowdy Head (1985 to present) located near the northern limit of the study

area. Supplementary wave climate data are available for Newcastle from 1987 to present, through the Newcastle Port Corporation. The relationship between the Sydney monthly wave climate data and the South Pacific climate types was previously reported in Goodwin (2005). The new daily wave climate data timeseries will be analysed with the daily synoptic types output by the SOM to determine both the variability in the mean and extreme wave climates. This will be reported in the second Progress Report.

Monthly sea-level data from instrumental tide gauges are available for a number of sites within the study region. The 2 longest data sets are: Fort Denison, Sydney (1886 to present), and at Newcastle, from 1925 to present). We currently hold the Sydney data to 1999 and are obtaining the record from 1999 to present from the Manly Hydraulics Laboratory. We currently hold the Newcastle record to 1998 and are obtaining the remainder of the available record. Additional sea-level data administered by the Manly Hydraulics Laboratory are: Port Macquarie, Crowdy Head and Forster (1986 to present); Tomaree, Port Stephens (1985 to present); and Swansea, Lake Macquarie (1987-1991). Data on extreme sea-levels during storm surge are available for all sites by obtaining hourly data from the Manly Hydraulics Laboratory. However, this analysis will not be undertaken in the scope of this study. We will limit the study to identifying the variability in wave climate and mean sea-level, and the associated synoptic climate types.

New LIDAR data on coastal zone topography elevations has been measured by the NSW Department of Planning in conjunction with some of the HCC. We have made a request to Lake Macquarie City and Council and John Hudson, NSW Department of Planning for access to this data. We have not received a response at this stage.

# 5 Synoptic typing

An important component of Stage 1 of the Regional Climate Change Study is to define the key synoptic patterns that drive the climate variability of the region (which will be used in the downscaling of the Global Climate Model (GCM) output to a regional scale). A review of the literature revealed that synoptic patterns may be successfully identified from atmospheric pressure data using a methodology termed

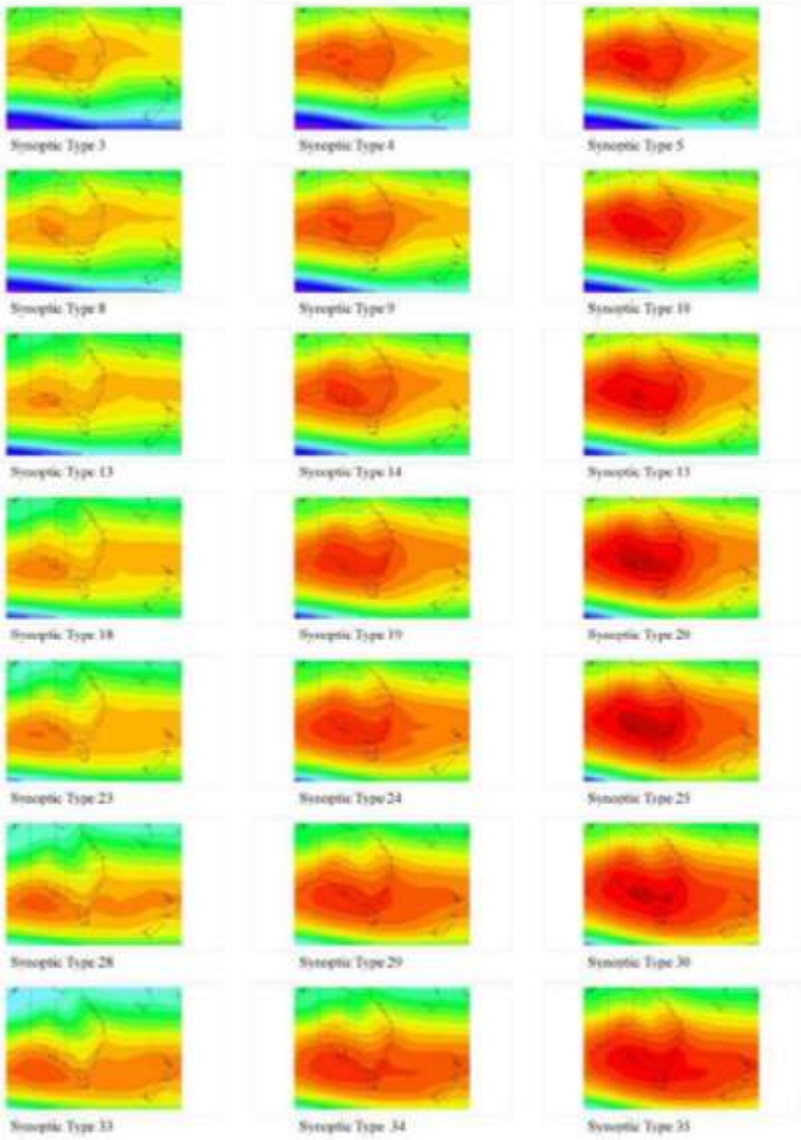
Self-Organising Mapping (SOM). The SOM methodology is particularly appropriate to synoptic climatology as there is no assumption of linearity (as with traditional Principle Component Analysis).

Synoptic climate typing (ST) has been performed on monthly sea-level pressure data (SLP) for the region using the SOM software ('SOM Toolbox for Matlab 5', produced by the SOM Toolbox Team, Helsinki University of technology, PO Box 5400, Finland).

Finland). The ST has been arbitrarily conducted to produce 35 types to allow the subtle discrimination of regional climate patterns on the key climate parameters, such as rainfall, evaporation and temperature. Thirty-five synoptic types have been generated based on SLP data (described in Section 3.3) covering a region that is considered to capture the major synoptic patterns influencing the region. The 35 synoptic types generated are shown to capture a range of significant synoptic features that are known to influence the weather of the region, including the clear seasonal trend in the location and intensity of the subtropical anticyclone, the monsoonal trough the circumpolar trough, and the longwave features in the Pacific and Indian Ocean sectors. Further analysis will reduce the number of synoptic types to the minimum number required to explain significant variability in the regional climate parameters, and to serve as the baseline synoptic patterns for the impact assessment stage.

Each month from January 1948 through to April 2007 has been classified according to the 35 synoptic patterns, resulting in a monthly timeseries of synoptic types. This timeseries will be used during Stage 2 of the study to analyse the relationship between the regional synoptic patters and local changes in key climatic variables (i.e. the data sets analysed in this report). Further work being carried out with the synoptic typing involves the investigation of using daily pressure data and additional pressure levels to define the regional to hemispheric climate drivers of variability across the study site. Progress on this work will be reported in the second progress report due in September 2007.

The 35 synoptic patterns that have been generated using the SOM methodology and monthly SLP data are shown in Figure 16.


Synoptic Type 3
Synoptic Type 4
Synoptic Type 5
Synoptic Type 8
Synoptic Type 9
Synoptic Type 10
Synoptic Type 13
Synoptic Type 14
Synoptic Type 15
Synoptic Type 18
Synoptic Type 19
Synoptic Type 20
Synoptic Type 23
Synoptic Type 24
Synoptic Type 25
Synoptic Type 28
Synoptic Type 29
Synoptic Type 30
Synoptic Type 33
Synoptic Type 34
Synoptic Type 35
Legend (hPa)

# 6 Summary of Stage 1 findings

This progress report has summarised the findings of Stage 1 of TUNRA's contribution to the Hunter, Lower North Coast and Central Coast Regional Climate Change Project. The focus of this stage of the project was to obtain and conduct a quality assurance check on regionally specific climate data that may then be used in Stages 2 and 4 of the Regional Climate Change Project. In addition, progress made to date on the synoptic typing component of this project has also been discussed. Further research is currently being conducted for the synoptic typing and this will be reported in the second progress report for this project (due in September).

In summary, instrumental climate data has been obtained from the BOM for precipitation (both daily and 6 minute pluvial), temperature (average, maximum and minimum), humidity (9am and 3pm), pressure, pan evaporation, windspeed (average and maximum wind gust), visibility and sunshine hours. In addition, global atmospheric pressure data (at various levels and timescales) has been obtained from the US National Oceanic & Atmospheric Administration. At this stage hydrological data for the study region has not been purchased. A detailed analysis of the BOM climate data has been carried out for a number of primary variables which have previously been highlighted as key climate indicators for climate change impact assessment in the Hunter, Lower North Coast and Central coast region. This analysis involved determining which data sets are suitable (in terms of length and quality of data) for use in Stages 2 and 4 of the Regional Climate Change Project. The quality assurance procedure carried out during Stage 1 resulted in the identification of 80 daily rainfall stations suitable for use in the project. The geographic spread of this data set is excellent, with at least one rainfall record in each of the 14 LGAs. A total of 17 daily temperature records and 18 hourly temperature records were found to be of a suitable length and quality for use in the study. The temperature records represent a board geographic zone, with spatial coverage appropriate for a regional climate change study. A total of 11 stations measuring relative humidity, 14 measuring windspeed and 7 measuring pan evaporation were also deemed to be of a quality sufficient for use in the study. While these data sets are smaller than for rainfall and temperature, it may be possible to gain some insight into the spatial variability for the Hunter and Central Coast region due to the fairly even

geographical spread of the stations. In addition, one record of maximum wind gust speed was found to be of a sufficient length to study local impacts on extremes for the Newcastle region.

# Appendix A – Discontinuous Station Data Analysis

As mentioned in Section 4 of this report, in some instances weather gauges have been decommissioned and relocated within a short distance from the original position and in most cases the BOM assigns a new station number for this temperature gauge. Therefore, in order to maximise spatial coverage, stations that have been discontinued and replaced by a secondary gauge at a nearby location were also considered for inclusion in the final data sets. This Appendix contains a comparison of meteorological data (during a 6 month period of overlap) for stations within the region that have been relocated. While a number of sites were considered, only those which were found to be suitable for this study (i.e. correlations greater than 0.7 and a similar timeseries during the period of overlap) are shown in the following sections.

## A1: Temperature

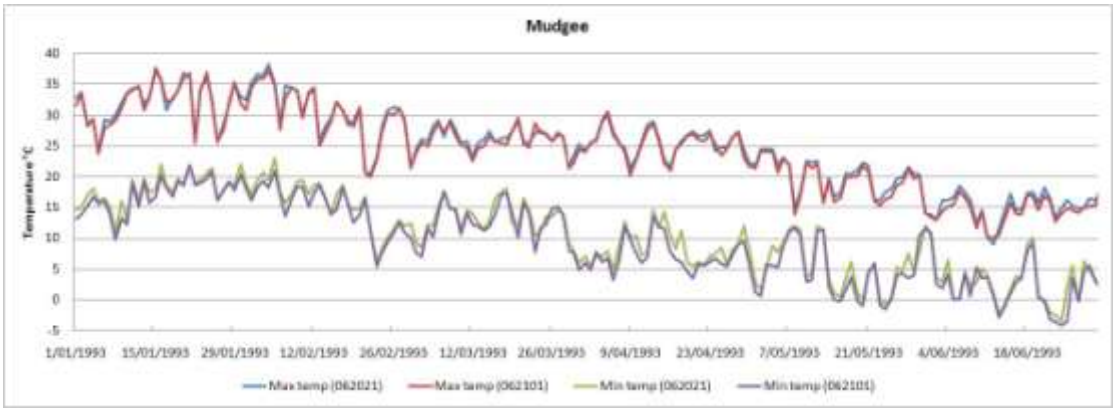



**Figure A1-1:** Comparison of temperature timeseries for Mudgee stations 062021 and 062101, exhibiting a correlation of 0.98 for max temp and 0.99 for min temp.

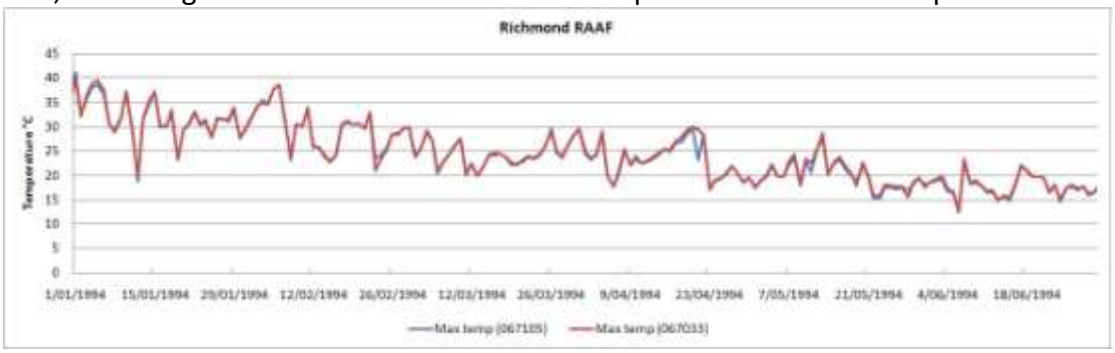



**Figure A1-2:** Comparison of temperature timeseries for Richmond RAAF stations 067105 and 067033, exhibiting a correlation of 0.99 for max temp (note that period of overlap unavailable for min temp).


**Figure A1-3:** Comparison of temperature timeseries for Taree stations 060030 and 060141, exhibiting a correlation of 0.98 for both max and min temperatures.

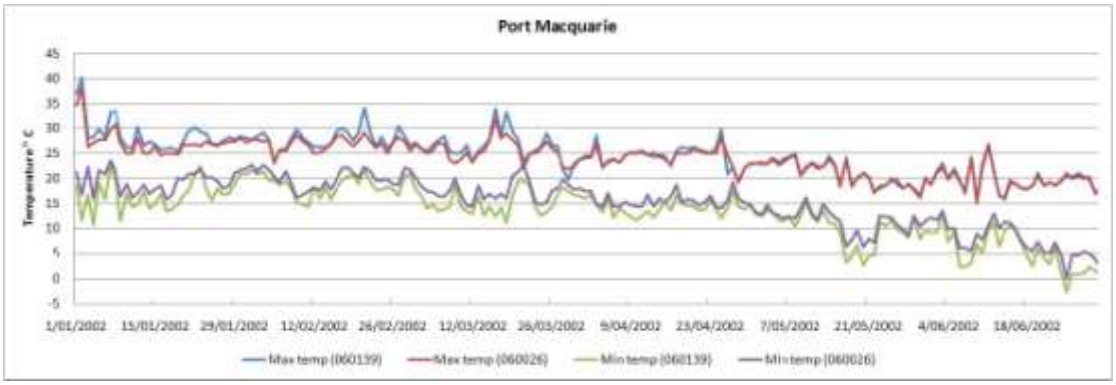



**Figure A1-4:** Comparison of temperature timeseries for Port Macquarie stations 060139 and 060026, exhibiting a correlation of 0.96 for max temp and 0.97 for min temp.

## A2: Relative Humidity

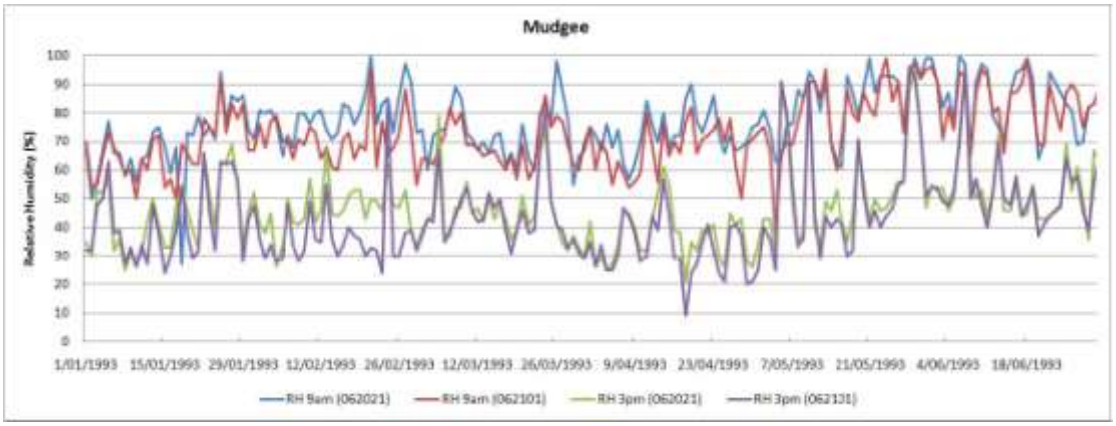



**Figure A2-1:** Comparison of relative humidity (RH) timeseries for Mudgee stations 062021 and 062101, exhibiting a correlation of 0.84 for 9am RH and 0.92 for 3pm RH.

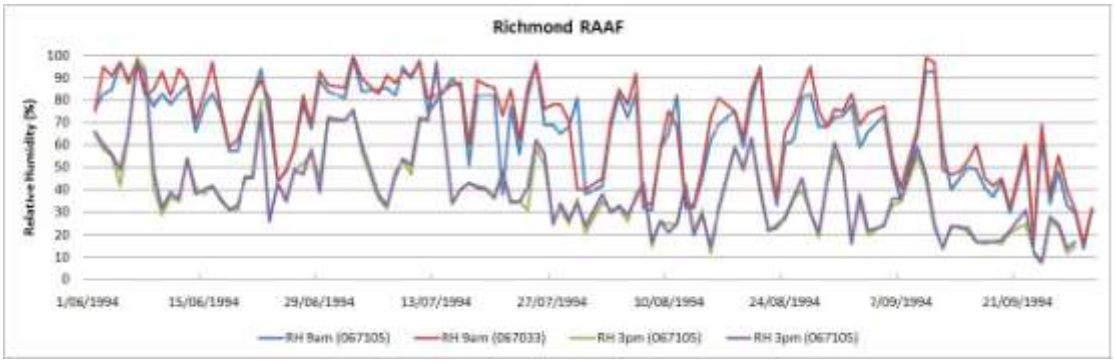



**Figure A2-2:** Comparison of relative humidity (RH) timeseries for Richmond RAAF stations 067105 and 067033, exhibiting a correlation of 0.95 for 9am RH and 0.99 for 3pm RH.

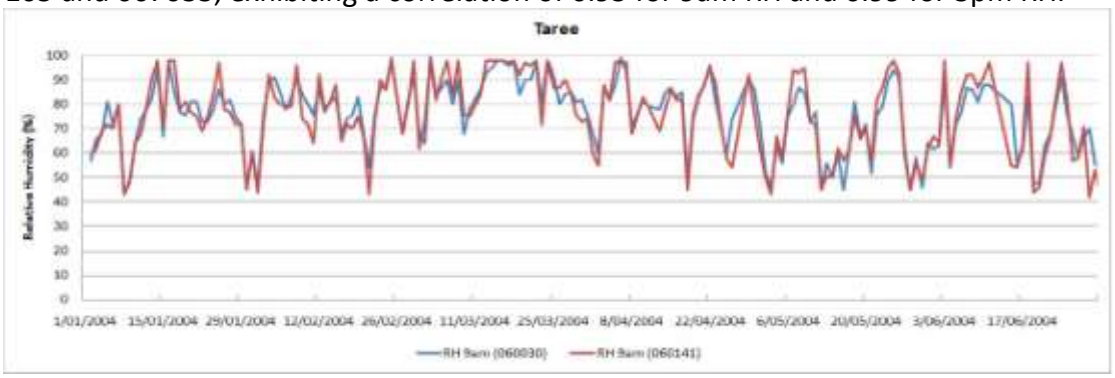



**Figure A2-3a:** Comparison of relative humidity (RH) timeseries for Taree stations 060030 and 060141, exhibiting a correlation of 0.88 for 9am RH.

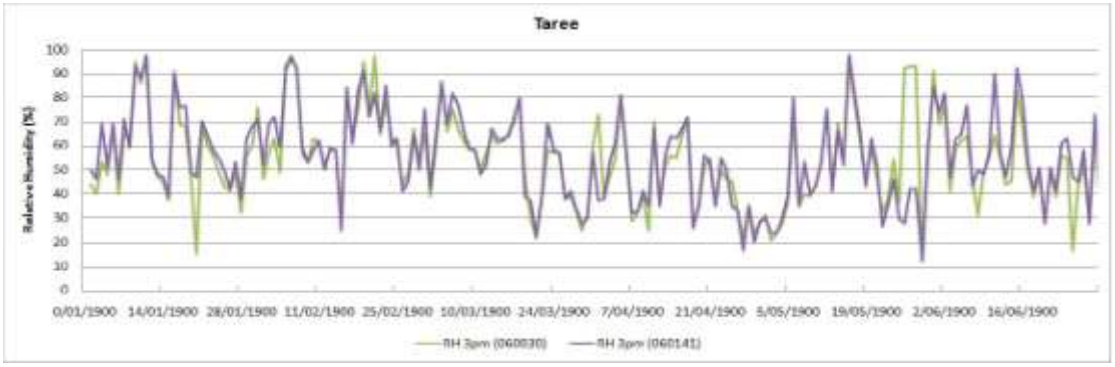



**Figure A2-3b:** Comparison of relative humidity (RH) timeseries for Taree stations 060030 and 060141, exhibiting a correlation of 0.88 for 3pm RH.

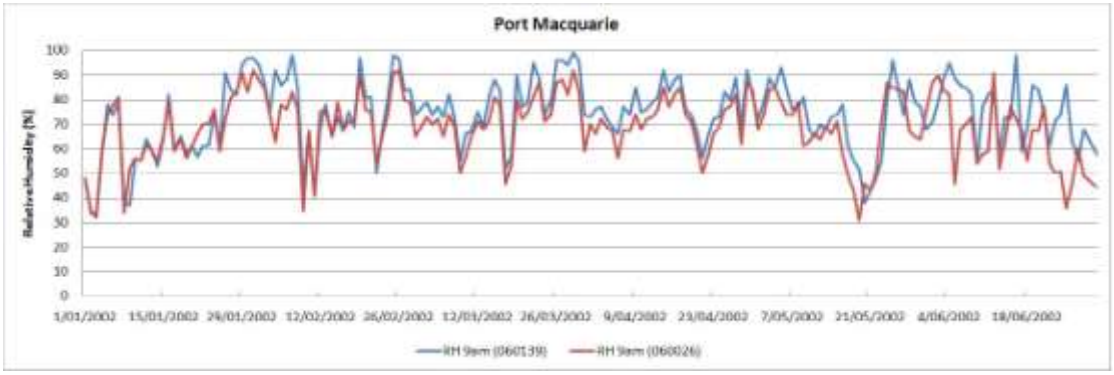



**Figure A2-4a:** Comparison of relative humidity (RH) timeseries for Port Macquarie stations 060139 and 060026, exhibiting a correlation of 0.84 for 9am RH.

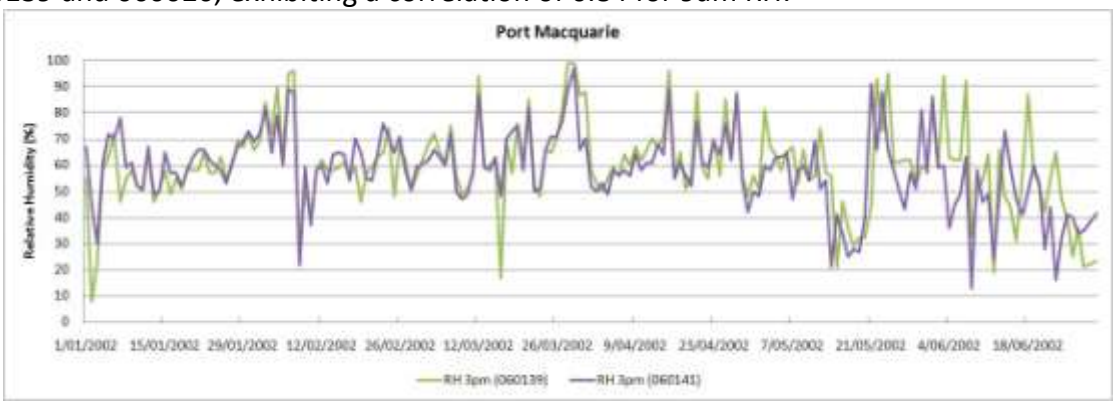



**Figure A2-4b:** Comparison of relative humidity (RH) timeseries for Port Macquarie stations 060139 and 060026, exhibiting a correlation of 0.73 for 3pm RH.

## A3: Windspeed

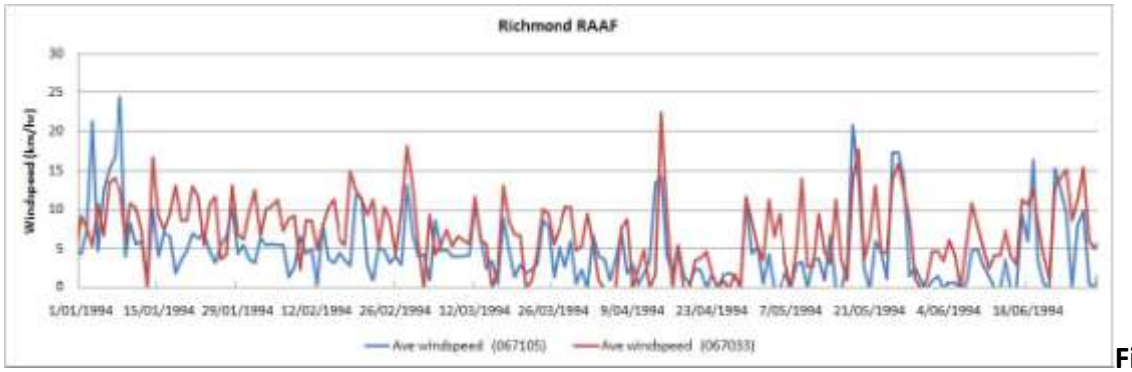



**Figure A3-1:** Comparison of windspeed timeseries for Richmond RAAF stations 067105 and 067033, exhibiting a correlation of 0.73.

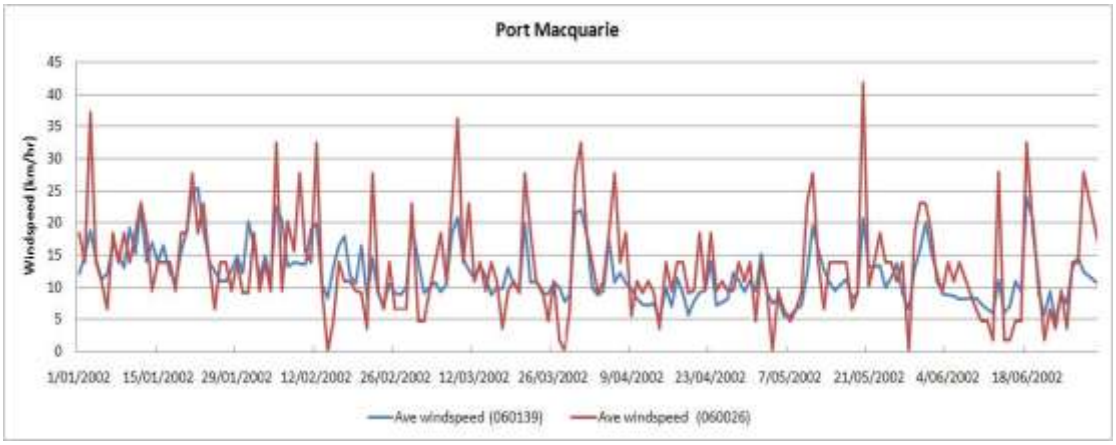



**Figure A3-2:** Comparison of windspeed timeseries for Port Macquarie stations 060139 and 060026, exhibiting a correlation of 0.74.

HCCREMS (the Hunter and Central Coast Regional Environmental Management Strategy) is a partnership initiative of the 14 local councils of the Hunter, Central and Mid North Coast regions of NSW.

Established in 1996, the HCCREMS team works with urban, rural and costal councils to facilitate a collaborative approach to sustainable planning, development and natural resource management. Our activities include:

- Facilitating local government input to a range of natural resource management and planning processes.
- Providing specialist support and services to member councils on environmental management and planning issues.
- Developing and maintaining a repository of the region's natural resource management data and maps.
- Designing and managing a range of regional environmental projects through the Hunter and Central Coast Regional Environmental Management Strategy (HCCREMS) framework.

At the time of publishing our project areas include:

- Biodiversity
- Aquatic and terrestrial weeds
- Roadside environmental management
- Climate change adaptation
- The urban water cycle
- Environmental compliance
- Sustainability
- Community education, including rural residential living
- Natural resource data management and mapping

For more information visit **www.huntercouncils.com.au/environment/hccrems**

With thanks to our partners:

and our member councils:

An initiative of the Hunter and Central Coast Regional Environmental Management Strategy.