THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Evaluation of the Atlant Technology for Rainfall Generation in Australia

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Table of Contents

1 Executive Summary

including
Conclusions and Recommendation

Evaluation of the Atlant Technology
for Rainfall Generation in Australia

Key Findings

This summary provides an overview of the findings of the evaluation team from The University of Queensland of the test of the Atlant rain enhancement technology conducted in SE Queensland during the period between 15 May to 30 June 2007. The target area was defined as the catchment area of the Wivenhoe, Somerset and North Pine dams, which are the main water supplies for the wider Brisbane area. The catchment area has been experiencing extreme drought conditions for over 6 years. The rainfall deficit in the catchment has been the worst on record and the combined dam levels were around 18% of capacity at the time of the test period.

Due to the short duration of the test and the difficulty in achieving scientifically conclusive results in meteorological studies, most of the observations reported are based on the professional assessment of the evaluation team using best available data and evaluation methods. The following key observations could be made during this test:

- Significant rainfall was measured in the catchment area within two weeks of the start of the Atlant operations on 15 May. This first rainfall event was not part of a widespread rain pattern in South-East Queensland and was unusual in that the easterly sourced rainfall passed and was even enhanced over the coastal ranges north of Brisbane and into the catchment area.
- There was unseasonably heavy and widespread rainfall in Queensland during June, restricting the ability to evaluate the direct impact of the Atlant system. However, direct rainfall measurements over the whole test period showed that the average rainfall in the catchment area was 28% (31 mm) higher than in the wider Southeast Queensland area outside the catchment. This is the highest positive difference observed over the same seasonal period in the last 50 years and contrasts the long-term average, which shows that the catchment area has typically around 12% less rainfall than the stations outside the catchment. Over the last 10 years (1997-2006) this difference was even much more pronounced (-25% or -20mm).
- A number of unusual meteorological patterns were observed whereby rainfall seemed to be enhanced in the vicinity of the Atlant system. These patterns included unusual intensification of rainfall areas after crossing the coastal ranges near the Atlant station and prolonged “anchoring” of intense rainfall areas downwind of the Atlant station. These observations are consistent with the expected influence of the processes believed to be initiated by the Atlant system.

The observations of this test, together with the existing information from previous tests, provide substantial evidence to indicate that the Atlant technology has an influence on the local and regional precipitation pattern. To make a conclusive assessment of the influence of the system, more detailed and scientifically validated evidence needs to be collected from a longer-term demonstration of the technology.

We strongly recommend the establishment of a carefully structured and scientifically evaluated demonstration project over at least one year and at several locations given the findings of this test and our understanding of the fundamentals of the technology. This view is further strengthened by the enormous potential that any such technology (based on harvesting atmospheric humidity) could have as part of the future water supply strategies in Australia. This effort could provide a major contribution to the scientific understanding of atmospheric and climatological processes and directly help in addressing the world’s current and future water supply issues.

Demonstration of Atlant Technology

The Atlant technology is utilising a ground-based ionisation system to influence the atmospheric conditions in the vicinity of the installation. The processes lead to the generation of an “ion wind”, which creates an updraft of low level, higher humidity air masses to the mid-level atmosphere where condensation lead to further enhanced convective airflows and the formation of clouds. These combined effects are believed to generate under suitable conditions large convective cumulus clouds (similar to thunderstorms), which can then initiate or increase precipitation in an area around the Atlant installation.

The technology has been developed over many years primarily in Russia where numerous projects have been conducted mostly on a contractual basis. Most recently tests have also been conducted in Switzerland, Germany and the United Arab Emirates. While there is extensive documentation of these events, the technology has not been fully scientifically documented.

To demonstrate and evaluate the potential of the Atlant technology in Australia, a demonstration test was conducted in southeast Queensland from 15 May to 30 June 2007 by the Australian Rain Corporation, which has the Australian licence to the Atlant technology owned by the Swiss company Meteo Systems AG.

The University of Queensland was contracted to evaluate the demonstration test, the findings of which are included in this report.

Assessment Methodology

The indicated target for the demonstration test was the catchment area of the Wivenhoe, Somerset and North Pine dams, which are the major water supply storages for Brisbane and surrounding areas. The Atlant installation was set up on the eastern edge of the Somerset catchment near Caboolture and was operated by Meteo Systems personnel.

The evaluation was undertaken on the basis of four main assessments, described in more detail in the following sections:

- Direct measurements of total rainfall through official Bureau of Meteorology (BoM) stations and an additional 50 University of Queensland measurement stations installed in the target area.
- Regional comparison of rainfall amounts over the test period inside and outside the target area.
- Assessment of the rainfall amounts in June compared to 50 year historic values for the same month.
- Evaluation of meteorological and climatological observations based on rain radar and satellite data during the test period.

It has to be acknowledged that, due to the short operating period of this test, the results can only be regarded as indications of the possible effects of the Atlant operation. The overall meteorological situation over northern and eastern Australia in June 2007 has been quite unusual, which has also impacted on the possible observations that could be made in relation to this test of the Atlant operation.

Direct Rainfall Measurements

Three major rain events were recorded during the operational period of the Atlant system (15 May to 30 June), which contributed an estimated total of 990 GL rainfall

(135 mm average) within the catchment area (Figure .). Most rainfall was registered in the north-eastern parts of the catchment decreasing towards the southern and western catchment boundaries. This is consistent with the higher precipitation expected on the coastal side of the catchment, which is also where the Atlant installation was placed in order to enhance the rainfall particularly in this part of the catchment.

The maximal amount of rainfall measured in the catchment was 242mm in the Woodford area, with many totals reaching 150-200 mm in the north-eastern catchment area. This was the most significant rainfall in the area for many months (see Chapter) .

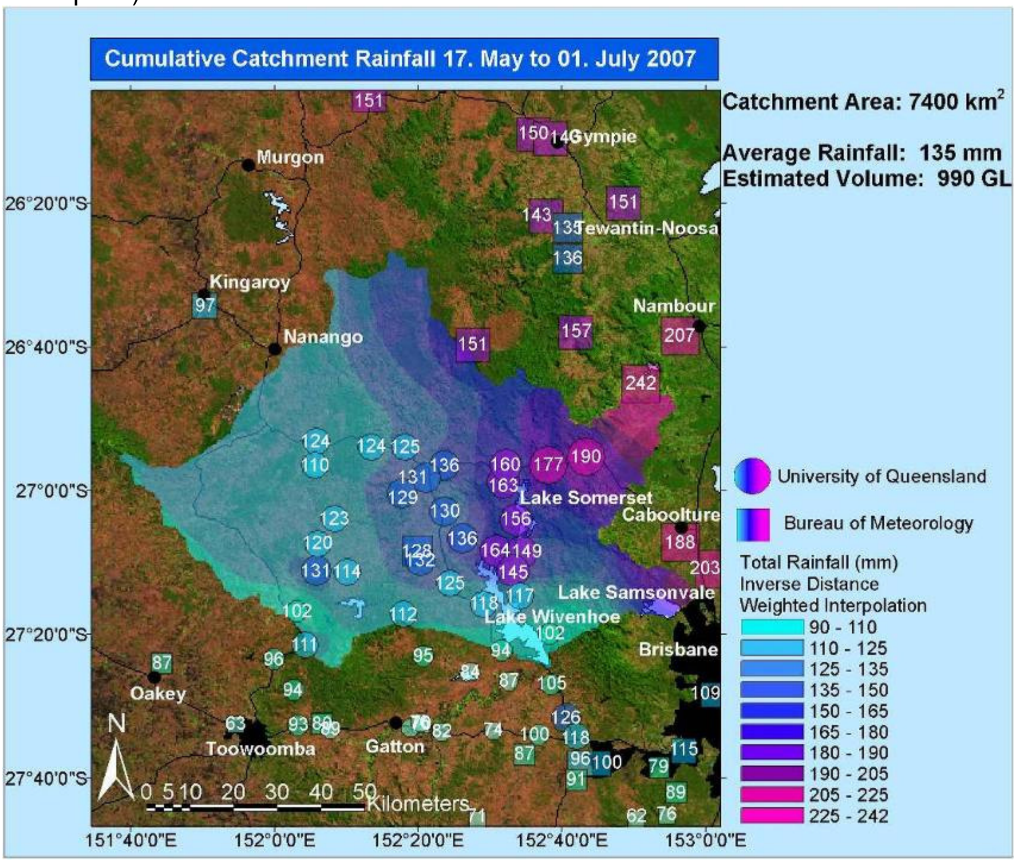

Figure .: Cumulative rainfall and interpolated values between 9am 17 May to 9am 1 July 2007. Numbers in circles and boxes denote rounded total rainfall measured by University of Queensland and Bureau of Meteorology rain gauges. Only stations with a complete record over the period are shown.

Regional Distribution of Rainfall

Using rainfall data from the BoM stations in and around the catchment area over the whole test period, the interpolated diagram shown in Figure . has been developed. Beside the expected trend of higher rainfall along the coast compared to inland areas, there is a distinct high rainfall area visible that extends into the catchment in the vicinity of the Atlant installation. This pattern is present to some degree in each of the major rainfall events observed during the test period. It was most pronounced in the event on 26/27 May, where there was only coastal rainfall in most areas, but a high rainfall area of 40-80mm was extended far into the north-eastern section of the catchment area, consistent with the meteorological observations reported below.

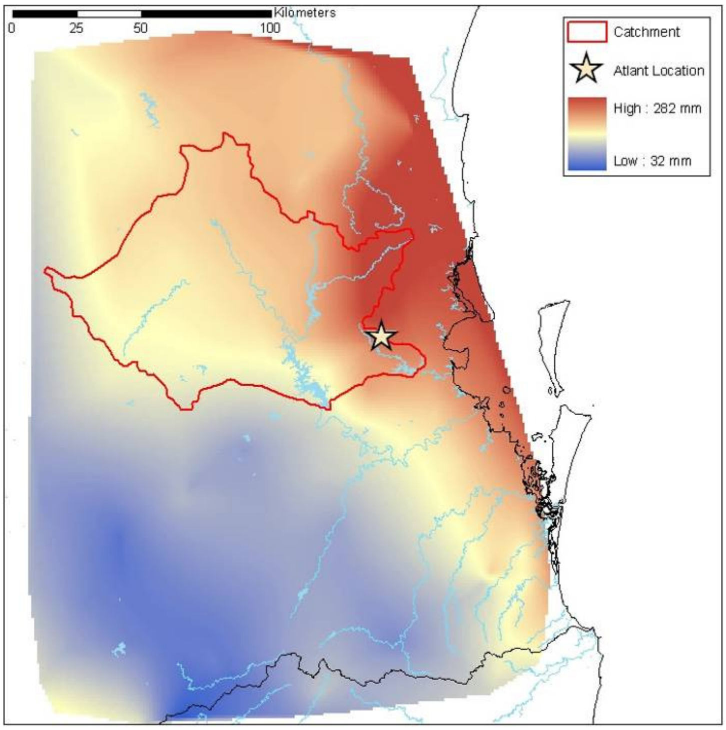

Figure .: Total rainfall from 15 May to 30 June 2007 (interpolation of data from 82 BOM stations). A band of high rainfall (red) reaches across the coastal plains and ranges into the eastern parts of the catchment.

These observations are also supported by the analysis of the rainfall data inside and outside the catchment. Between 15 May and 30 June 2007, stations in the catchment received an average of 142 mm, which is 31mm more than stations outside the catchment (111 mm) covering most of southeast Queensland (see Figure .). The stations in the catchment received 27% more rainfall in 2007 compared to all stations in the area. This is the highest absolute and relative difference recorded for the same seasonal period over the last 50 years, and is contrary to the long-term average of around 12% less rain in the catchment than outside. Over the last 10 years (1997-2006) this difference was even much more pronounced (-20 mm or -26%).

This observation is reflected in the mean percentiles over the period, which are considerably higher for the catchment area (87%-ile) compared to the outside areas (72%-ile compared to 50 year data).

The results of the rainfall distribution in and around the Wivenhoe/ Somerset/ North Pine catchment area show that there was a distinctively higher rainfall amount in the catchment, most particularly in the eastern part. While this does not prove a direct causal relationship with the Atlant operation, it is certainly remarkable and suggests a possible influence area around the Atlant station where rainfall is enhanced.

The range of influence of the Atlant system could be estimated to have a diameter of 50-100 km, depending on the meteorological situation in each case.

Statistical Comparison with Historic Data

The data considered was the average daily rainfall over all stations within the assessment region for the month June 2007. The historical data covering the period 1957 to 2007 was considered, including the subset of recent years 1992 to 2007.

Analysis of the natural logarithm of the rainfall data (shown to be approximately normally distributed) for the period 1957 to 2006 (June only) and then compared to the June 2007 data revealed:

- June 2007 (as well as the overall test period May/June 2007) was an unusually wet period compared to long-term averages for the same month, with the mean daily rainfall amount nearly double that of the long-term average and in the top 10%-ile of the 50-year data across the region.
- The recent 15 years (1992-2006) had a considerably lower rainfall amount than the long-term average, with the mean daily rainfall more than 30% lower in this time span compared to the 50-year average (1957-2006).
- This time-based statistical assessment leans some support to the general observations made in the previous section about the total rainfall in the area. Any possible effects of the Atlant system can not be discerned statistically in this small test study, a more extensive and longer-term study would be required to identify such effects using time-based statistical comparisons.

Meteorological and Climatological Observations

The Atlant trial took place during a period of unseasonable weather in conditions that are believed to be less than optimal for enhancement of precipitation through ionisation of the troposphere. The Atlant system aims to enhance the role that ions have in the troposphere in nucleation and cloud microphysics by triggering and/or enhancing the presence of condensation nuclei and condensation of water vapour onto cloud condensation nuclei. The subsequent release of latent heat of condensation causes a positive feedback with the potential to cause significant cumulus development and precipitation.

Accordingly, the Atlant system appears to have the advantage of potentially causing cloud development and precipitation under environmental conditions where clouds are not a prerequisite for operation, while also enhancing cloud development and potentially precipitation in existing unstable atmospheric conditions where clouds are present. Furthermore, the Atlant system has the potential to influence cloud microphysical processes over a large area > 50 km radius.

A review of the meteorological data including satellite and radar images, as well as aerological diagrams collected throughout the trial, identified possible enhancement of precipitation near the Atlant installation. These regions were associated with increased rainfall intensity and duration. In particular, the May rainfall event showed rain cells penetrating westwards and intensifying over the coastal ranges (and past the Atlant installation) into the catchment area. The June rainfalls exhibited an apparent shift in direction of rainfall patterns towards the Atlant installation and an unusual “anchoring” of intensive rainfall areas in the vicinity of the installation.

Possible significant enhancement of rain rate was observed in the region of the Atlant installation northeast of Brisbane on at least two occasions (Figure .), when moderate to heavy rainfall was recorded over a large area, consistent with the higher rainfall amounts measured in the same area. These areas of more intense rainfall occurred under two different synoptic scale circulation patterns, but exhibited similar spatial extent and form.

No evidence could be found during this trial indicating that the Atlant system did not enhance rainfall.

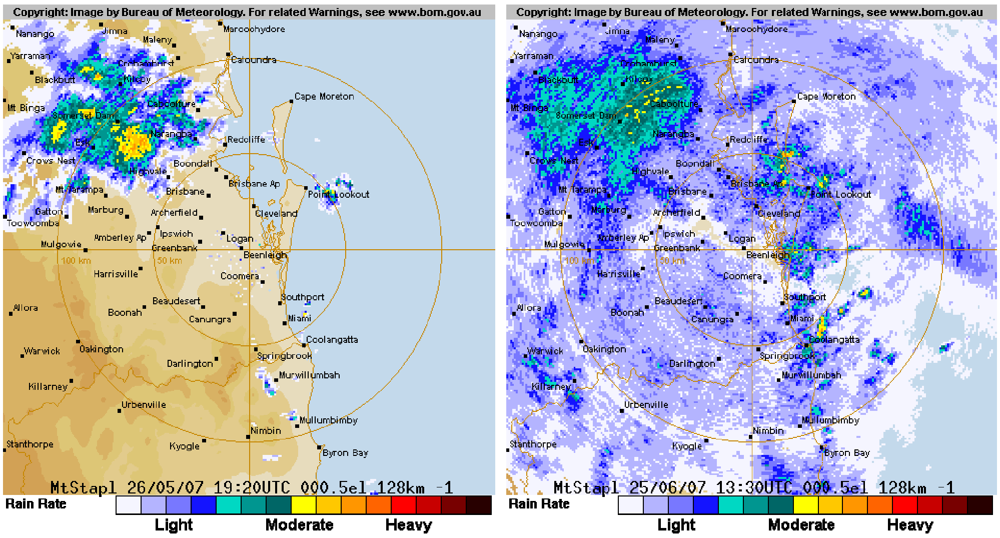

Figure .. Radar images showing higher rain rates (green/yellow shading) in the vicinity of the Atlant installation northeast of Brisbane on 27 May and 26 June 2007.

Conclusions

On the basis of the observations and measurements made during the test period in southeast Queensland, the following **conclusions** can be made:

1. During the test period there were several strong rain events, whereby the Atlant operation seems to have at least enhanced the rainfall amounts as observed in rain radar images and rainfall measurements in the area.
2. The statistical evaluation of the rainfall amounts and local distribution shows both a higher total rainfall intensity in the vicinity of the Atlant system, as well as a significantly higher rainfall amounts in the catchment area compared to the surrounding stations relative to long-term historic values.
3. The total amount of rainfall registered during the 47 day test period was estimated to be around 990 GL over the dam catchment area. Although only limited run-off was generated in this instance due to the severe drought conditions in the area prior to the test, this rainfall amount is equivalent to several years water supply from Wivenhoe, demonstrating the large potential benefits of enhancing rainfall (or harvesting atmospheric humidity) as part of the overall water supply strategy.
4. The major limitation of this trial is the short duration of the operating period and the fact that it coincided with a very unusual weather situation over most of northern and eastern Australia in June. For these reasons, the findings obtained in this trial are primarily based on the professional assessment of the evaluation team using all available data and observations, but should not be seen as conclusive scientific evidence. Nevertheless, the overall findings are considered to be highly promising and encouraging.
5. While the unseasonably heavy general rainfall in Queensland in June made it difficult to isolate the extent of Atlant's impact, the data and meteorological observations were consistent with the expected influence that this technology is believed to have on rainfall generation or enhancement. There was no evidence in the test period that the Atlant system did not generate or enhance rainfall events.

Recommendation

Considering:

- the direct observations and conclusions from the test period;
- the general view of expert scientists exposed to the technology during the test period that it the underlying principles of the technology appear to be sound and the claimed impact possible (together with a general agreement that more detailed observation of electrical and other atmospheric parameters around the Atlant operations is needed);
- the severity of Australia's and the world's water scarcity and the expected impact of climate change on the rainfall situation in many areas worldwide;
- the desirability of finding break-through solutions to the world's climatological and water supply problems; and
- the urgent need for long-term, scientific evaluation of the technology, including novel methods of measuring atmospheric and meteorological processes;

it is **strongly recommended** to conduct a carefully structured and scientifically assessed demonstration project of the Atlant technology across different climatic and orographic areas over at least a full 12-month seasonal cycle in Australia.

Such a demonstration project should be designed along the following principles:

- The Atlant operation and the scientific assessment should be conducted completely independently and funded separately. The minimum duration of an Australia-wide project should be 18 months (12 months operation, 6 months set-up and evaluation) to allow observations of the expected effects over at least one full seasonal cycle.
- At least three and ideally five independent Atlant systems should be established and assessed in different climatic and geographical locations in Australia. The operating periods (months) of each system should be randomly selected and the scientific assessment should be undertaken without knowledge of the operating status (blind test).
- In at least one location two identical (as far as possible) test and control areas should be established that allow the parallel assessment of the technology during the same time period.
- The scientific evaluation should be based on direct measurements of rainfall on the ground, but also from detailed scientific studies of the atmospheric conditions during the different operating periods of the Atlant system.
- The scientific evaluation should include interdisciplinary representation from the fields of water management, meteorology, climatology, atmospheric physics and aerosol science.
- The entire test plan and evaluation should be guided and monitored by an independent "expert council" with direct reporting to a Government authority, such as the National Water Commission.

Such a detailed demonstration project will provide a high level of statistical confidence and predictability of the effects of the Atlant technology and will also allow a good evaluation of the potential benefits and limitations of the application of such rain enhancement technologies in Australia in the future.

While such an extensive evaluation will require a major funding commitment, it could lead to major breakthroughs in scientific understanding of cloud formation and the precipitation processes, as well as demonstrate the efficacy of such a technology to significantly enhance rainfall and water supply. Assuming that the demonstration project will be operated in areas of major water shortages, the resulting rainfall could provide direct drought relief and generate highly valuable inflows to water supplies in areas where currently far greater expenditures for infrastructure developments are planned or already being invested.

There is historical evidence, backed by the results documented in this paper, that the Atlant system could provide a major contribution to Australia and the world's climate and water problems. In doing so Australia has the opportunity of making a major contribution to the science and well-being of our planet.

The evaluation team confirms the applicability of Atlant technology and supports a further demonstration project to investigate and determine the efficacy of such a water harvesting technology as a complementary tool to water saving, water recycling and desalination. The team is confident the Atlant technology could provide a valuable contribution to overcoming water scarcity problems associated with the currently observed drought and/or climate change effects.

For the Evaluation Team

Prof Jurg Keller, University of Queensland

2 Introduction and General Overview

Peter Wilderer

2.1 Climate change requires novel solutions

The planet Earth is warming up, glaciers and polar ice caps are melting, the sea level is rising and extreme weather events become more and more frequent. Such changes of the earth's system have been noticed for several years already, but with the release of the 4th report of the Intergovernmental Panel of Climate Change (IPCC) it is now clearly established that global warming and the resulting change of climate is not a natural phenomenon but caused by mankind.

Over the past two centuries, we have used fossil fuel at an exponentially increasing rate for a wide variety of purposes. Principally we have burned oil, gas and coal to generate energy required for heating and cooling, for cars and aircraft. We have emitted extraordinarily large amounts of the oxidation product CO_2 into the atmosphere. The consequences are threatening.

To avoid further deterioration of the habitability of the planet Earth the majority of political leaders have decided to take strict measures to cut down on CO_2 emissions. The energy issue has been elevated to a high level on the political agenda.

Without any question, cutting down on the emission of CO_2 and other green house gases is tremendously important. It should be understood, however, that reduced emission of green house gases will not show immediate effects. Until the measures proposed by political and scientific institutions become effective we have to expect a painful water stress situation in many parts of the world. Extreme weather conditions such as severe storms, flooding and droughts are likely to become more frequent. The consequences will pose severe impacts on the environment but also on the many fast growing urban areas where the demand for a safe, reliable and cost-efficient supply of water and food is especially high. It is very likely that the inability to cover the water demands - personal, industrial and agricultural - will lead to enormous social and economic pressures and possible instability. Not only will water supply to municipalities be in danger but also the ability to provide cooling water to power plants whether fuelled with oil, gas, bio-products or uranium. Decision makers must realize that without thoughtfully structured water management mankind runs the risk of getting into serious trouble. Thus, the water issue needs to be lifted to a level on the political agenda comparable to the energy issue.

Taking this into perspective, water supply and sanitation related research and development activities must be intensified with the aim of enhancing innovative technological and management potential applicable in areas where water scarcity is high. Usage of unconventional water sources such as sea water, brackish water and even wastewater is being actively developed. Loss of water in the water distribution and the wastewater collection systems must be minimized. The cascading use of water and water reuse should be considered as a viable solution to overcome water shortages wherever possible.

Many of these activities are well underway, however, one **additional water source - atmospheric vapour -** is still not considered adequately as part of the future mix of water supplies.

2.2 Water and vapour

Atmospheric humidity as a source of water has been receiving growing attention over the past years but is still not fully recognized despite its enormous potential. Approximately 50% of the total fresh water readily available for human consumption on earth is known to be in the form of atmospheric water vapour. In contrast to liquid water atmospheric humidity is much more equally distributed. Transport of atmospheric humidity over large distances does not require pipes and pumps but is achieved by wind, which has its origin in solar energy.

Atmospheric humidity converted into rainfall has sustained mankind from the very beginning. Natural rainfall is the result of a series of processes including evaporation (conversion of water in its liquid form into the vapour form), advective and convective transport (movement of vapour in horizontal and vertical directions driven by temperature gradients and by wind), condensation (conversion of vapour into liquid water or into ice), aggregation (merging of water particles to form larger particles) and the gravity driven descent of water droplets, hail or snow once the particles are heavy enough to overcome updraft.

Various methods are already in use to harvest atmospheric humidity. In ancient times, mankind had already learned to collect rainwater during rainfall events and store it in tanks or reservoirs. This approach is still practiced worldwide, and has recently experienced a renaissance (particularly in Australia).

Forced condensation of dew is a method which has been investigated during recent years on different scales. Technical solutions include coating of roof surfaces with plastic material which does not warm up much during day time, but cools down quickly below the dew point during the night. Operation of wind mills to drive a heat pump to cool collection surfaces down below the dew point is another option currently on trial.

“Milking” clouds by injecting silver iodide or other chemicals into existing clouds (cloud seeding) is an aggressive method to force rainfall to occur. Its efficiency appears to be closely related to the physical properties of the clouds moving into the area of concern, and on the prevailing meteorological and orographic conditions. Overall, the true contribution of the cloud seeding to the achieved rain/snowfall is still difficult to establish and currently very few scientific assessments of the actual enhancement efficiency are available, with some studies underway, most notably by Snowy Hydro in the Snowy Mountains area in NSW/VIC.

2.3 The Atlant technology

Beside the above mentioned methods of harvesting atmospheric humidity, an alternative concept has been proposed, investigated and applied in full scale by Meteo Systems scientists and engineers. It will be referred to in the following as “Atlant technology”. This method is based on an updraft of a high density stream of ions from a ground-based structure, the Atlant. The “ion wind” generated by the Atlant is assumed to drive a sequence of processes leading to rainfall (see more detailed descriptions in Chapter).

The technology has been applied at various locations in Russia, Korea, Switzerland and the United Arab Emirates (UAE), mostly on a contract basis. The settings, the meteorological and electrical charge conditions and the results were very carefully documented, but neither scientifically evaluated nor published. Nevertheless, the documentation confirms the success of the operation, as does the satisfaction expressed in reports given by the authorities who ordered the application of the method.

The chronicles and records of more than 40 tests conducted with the Atlant technology in the past have been extensively reviewed by members of the Evaluation Team and discussed with one of the originating scientists, Valeriy Uybo of Meteo Systems. This review clearly indicated that the technology has a strong potential to modify weather patterns on a local and regional scale. The technology is capable of increasing the probability for rainfall significantly, even under very dry conditions as demonstrated by the trails in the United Arab Emirates.

2.4 Test project in Queensland

The detailed information available from previous tests and the understanding of the underlying concepts have provided strong support for a test in Australia, which was conducted in South-East Queensland, in May/June 2007. An Atlant ion emitter was positioned at the north-easterly edge of the catchment area of the Wivenhoe dam and operated over a period of six weeks. The occurrence of rainfall events and the intensity of rainfall were monitored and scientifically evaluated by an evaluation team led by the University of Queensland. Details of the operation and the results of this study are presented in this report.

Certainly, the duration of the test was too short to generate a data set sufficient for robust statistical analysis. It also appears that the Atlant technology works best when the meteorological conditions are favourable. The question of which conditions are most suitable could not be answered over the short test period with a very limited range of climatic conditions. Nevertheless, the detailed rainfall measurements, the comparison with historical precipitation data, and the analysis of sequences of radar and satellite images obtained during the test period, all support the conclusion that the operation of the Atlant may indeed cause or enhance rainfall in the influence area.

In the scientific language this result reads: “There is no evidence that Atlant did not add to rainfall during the test period”. This statement leads to a strong recommendation for further application of the technology to help mitigate impacts of drought conditions and the resulting water stress in the Brisbane area as well as other parts of Australia.

2.5 Future demonstration project

Based on the overall positive and promising findings from the Queensland test, it is strongly recommended to invest in a well planned demonstration project over at least 12 months and at several different locations with diverse climatic and orographic conditions, including both inland and coastal areas. This research will determine under which conditions the method demonstrates its full potential and how much additional rainfall could be expected from the technology under varying conditions.

The brief for this demonstration project should also include details of the framework under which the Atlant technology is to be applied in the future. This includes the administrative conditions and regulations needed to handle legal responsibilities and conflicting interests. In this context, an in-depth risk/benefit assessment is to be conducted, and a solid risk management strategy needs to be developed for each individual case, bearing in mind the benefits and positive impact of the process. Commercial and operational considerations will also need to be addressed in conjunction with the scientific research work.

Additionally, investigations are required into the macro-economic impacts on various industrial sectors affected. Ecological impacts, positive and negative, are to be considered. Most importantly, the technology needs to be incorporated in an Integrated Water Resources Management concept to be applied to the whole water supply to ensure that long term, sustainable benefits can be achieved.

In conclusion, the evaluation team confirms the applicability and significant potential of the Atlant technology. We recommend a well planned and executed demonstration project to further investigate and develop the technology with the aim to develop this strategy as a complementary water supply option to the existing and newly developing water resources in Australia. The team is very confident that the method has the potential to contribute significantly to the solutions needed to overcome water scarcity problems in Australia and elsewhere likely caused by the currently ongoing climate change processes.

3 Description of Atlant Technology and Operation in Queensland

Information provided by Australian Rain Corporation

3.1 The Atlant technology and historical background

The main focus of Atlant operation (Figure .) is on the very detailed observation of natural occurrences; especially the events of precipitation, to assist Atlant to “mimic” them in an efficient and environmentally friendly manner (see next section). By addressing the underlying natural factors influencing the weather, natural occurrences could thus be systematically impacted upon to favourable effect.

Figure .: Atlant System during demonstration in Queensland May/June 2007

The ionization method (Figure .) is based on research in the early half of the 20th century in Russia and the USA (Prof. Bernard Vonnegut). By the 1960s, researchers in the USA had claimed significant results in attempts to influence the ionization of the atmosphere and induce rainfall.

Valeriy Uybo, the chief technologist of Meteo Systems, has been researching the earth‘s atmosphere and the possibilities of influencing it since the 1960s. He studied and worked to improve upon Vonnegut's methods, results and findings.

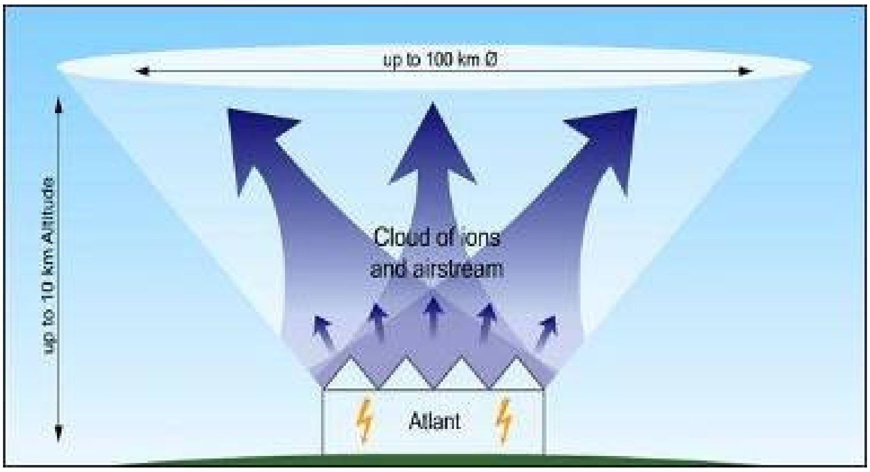

Figure .: Method of Atlant ionization process

Atlant mimics nature through supplementary ionization to trigger a cascading natural process. This process is best described in different phases. Each phase can be influenced by Atlant settings:

1. **Electrostatic Phase**
   A special high-voltage system produces a large amount of negative ions, by means of a corona discharge process, that form a negative electric space charge in the air mass above the Atlant system.

2. **Electrodynamic phase**
   The ions either attach themselves to an aerosol, thus charging the aerosol, or else grow by condensation and join into charged particles called ion clusters.
   Under the influence of the negative electric field of the earth and positive electric field of the ionosphere, this volume of electric charge is lifted up to higher and cooler layers of the atmosphere.

3. **Thermodynamic phase**
   The vertical effect of the enhanced electric current initiates an updraft that transfers more warm and humid air masses to levels in the atmosphere where condensation of water vapour takes place. Hydration occurs and charged droplets are formed, along with the release of latent heat of condensation. This initiates a dynamic convection process, which creates a positive feedback loop using energy available from the surrounding atmosphere in the form of heat of condensation. This process is enhanced by a number of circumstances like atmospheric convective flows, turbulences or thermals.

4. **Precipitation formation phase**
   The convection process is concluded by the formation of cumulonimbus clouds and the precipitation process. Cumulonimbus clouds can be distributed in a horizontal direction to a significant distance from the Atlant system by means of natural atmospheric transfer (wind).

In tandem with Uybo's research and application for patents, the Atlant technology has been successfully applied in more than 100 cases and experiments in Russia, Japan, Cyprus and Korea to achieve various weather modification effects (generating rainfall, fighting peat and forest fires, and preventing rainfall and dissipating fog).

The functionality and efficiency of this method was demonstrated in these trials. All cases were thoroughly documented. During the current assessment project the evaluation team scientists had access to the documentation which was partially translated and explained, being mainly in Russian.

Uybo focused more on entrepreneurial than scientific work as there was very little support for science in the post communist, Perestroika area. He financed his work principally through orders from agricultural and local government administrations. He lacked the funds and the opportunities to finally prove the causality between his trials and the results achieved.

In May 2005 the Swiss based technology company Meteo Systems AG purchased the Atlant technology. Successful experiments were conducted in Central Europe in autumn 2005 and February 2006.

In June 2006 the first test in an arid climate zone took place in the United Arab Emirates. Precipitation and the areas experiencing precipitation increased significantly. There were no similar events in preceding years nor since.

The Atlant System consists of a mains powered high voltage generator connected to a large network of thin wires of a special metal composition supported on a pyramidal framework. The system's dimensions are 12m x 4m x 5m and it weighs approximately 500 kg. It consumes about 500W of power and generates voltages of 80-85 kV.

3.2 Clearance from potential risk to human beings and the environment

During the different trials, various independent institutions have certified that the Atlant technology neither harms the environment nor influences air traffic control and communication systems.

The following further opinion was received from Professor Brian Lovell of The University of Queensland on 31 May 2007 (UniQuest Project No. 14959):

- "Similar, but much smaller, negative ion generators are sold in retail stores to help purify the air. There is no evidence of interference or health problems associated with these devices.
- All laser printers have similar negative ion generators to charge the printing drum. Once again, although widely deployed in office environments, there is no evidence of interference or health problems associated with these devices.
- The reported power consumption of the Atlant System is just 500W which is less than a microwave oven or floodlight and much less that a broadcast radio station which may be 10kW or greater. There is simply not enough energy consumption to cause significant interference over a wide area regardless of the signal modulation.
- As the electric field is static and not dynamic, there is no possibility of producing electromagnetic radiation from the field itself. Thus the effects of the electric field will most likely diminish as the inverse of distance squared. Given the low energy consumption, the risk of communication interference is minimal.
- It is my opinion that any electromagnetic radiation produced by the apparatus would be due to coronal discharge (sparking) due to electrical breakdown of the air. There is no need for sparking to occur to generate negative ions, so a well-designed system should not produce electromagnetic interference.
- Sources of negative ions in nature are waterfalls, fountains, and storms. While I cannot comment professionally on health issues, the general belief is that negative ions in the atmosphere do no harm and may promote a feeling of well-being.

In my professional opinion, based on the information provided, I do not believe that operation of the Atlant System presents any significant risk."

3.3 Preparation and execution of the demonstration

November 2006
Decision made to undertake a detailed demonstration of how the Atlant technology could be adopted to Australia in general. Contact with universities and institutions to receive specific data.

First contact with Queensland Government

January 2007
Detailed preparation of the test started in January 2007 with analysis of**:**

- **General data of weather and climate for Australia**
  - Climate peculiarities and reasons for these peculiarities
  - Seasonal diversities
  - Climate stability or presence of weather/climate anomalies for the last 10-15 years

- **Historical Precipitation Analysis**
  - Precipitation distribution maps

- **Standard Meteorological Data Analysis**
  - Historical and operational time standard meteorological data (temperature, pressure, wind speed, wind direction, evaporation data)

- **Satellite imagery archive**
  - General trend of cloud movement

- **Computer models**
  - 500 and 200 mbar
  - 850 and 700 mbar

March 2007
Participation at the Australian Water Association OzWater Conference 2007 in Sydney. Collecting newest information, meeting insiders and preparation of a proposal to hold the test in Queensland, focussing on rain generation by Atlant to generate additional water in the Wivenhoe/ Somerset dam catchment.

April 2007
Contact with The University of Queensland, Queensland Government and offices related to water. Initial selection of an appropriate location for the Atlant System, considering geographic and orographic specifics.

Foundation of Australian Rain Corporation with Australian investor The Handbury Group, which wished to see the technology developed in Australia to assist with water supply and drought issues and financed the proposed demonstration in SE Queensland. Implementation of a broad independent team of scientists – the Evaluation Team under the coordination of Prof Jurg Keller, Director of the Advanced Water Management Centre at The University of Queensland.

The Evaluation Team designed the details of its assessment:

- Selection of a proper location after a detailed survey of several potential locations for the Atlant System in the dedicated area
- Determination of the assessment area (8000 km^3) overlapping with the Wivenhoe/Somerset/North Pine catchment area (7400 km^3)
- Planning of additional 50 rain and weather measurement stations in the assessment area

May 2007
Start of Project: equipment was shipped in 11 air cargo containers from Europe to Brisbane. A team of technicians, logistics and Atlant technology experts arrived in Australia.

Several meetings with the Bureau of Meteorology and climate experts in South-East Queensland.

The infrastructure for analysis and monitoring, command and control and documentation were installed in Redcliffe, southeast Queensland. The IT structure of Meteo Systems was established for the office as well for connectivity and data exchange with the service people and experts remaining in the European headquarters.

The Atlant system was erected in Ocean View (near Mount Mee, SE Qld).

Parallel the installation of the measurement stations by the evaluation team took place.

15 May 2007
Start of demonstration time with calibration and programming of Atlant system. The following parameters were observed and/or modified once the calibration phase began:

- **Meteorological parameters**
  - Temperature
  - Humidity
  - Pressure
  - Wind velocity
  - Wind direction

- **Electrical parameters**
  - Ion concentration
  - Electrical field intensity etc.

- **Cloud**
  - Cloud cover density
  - Cloud mass thickness etc.

- **Dynamic parameters**
  - Horizontal wind shears on different levels
  - Vertical wind shears

The Atlant system operated during the whole demonstration period without any problems. More than 20 staff were involved in the operation, in two/three shifts for a 24/7 operation. Weekly meetings were held between the evaluation team (headed by Jurg Keller) and Australian Rain Corporation (headed by CEO Helmut Fluhrer).

30 June 2007
End of demonstration period

July 2007
Disassembly of Atlant system
Intensive analysis of measurement documentation, preparation of reports
Meetings with governmental institutions and high ranking scientists in Australia

3.4 General description of Atlant applications

In southeast Queensland coastal stream showers in south-easterly airflow are typically confined to the coastal plain and seldom travel far inland to cause rainfall west of the D'Aguilar Range. As a result, the Wivenhoe Dam under these conditions remains in a region of rain shadow (Figure .).

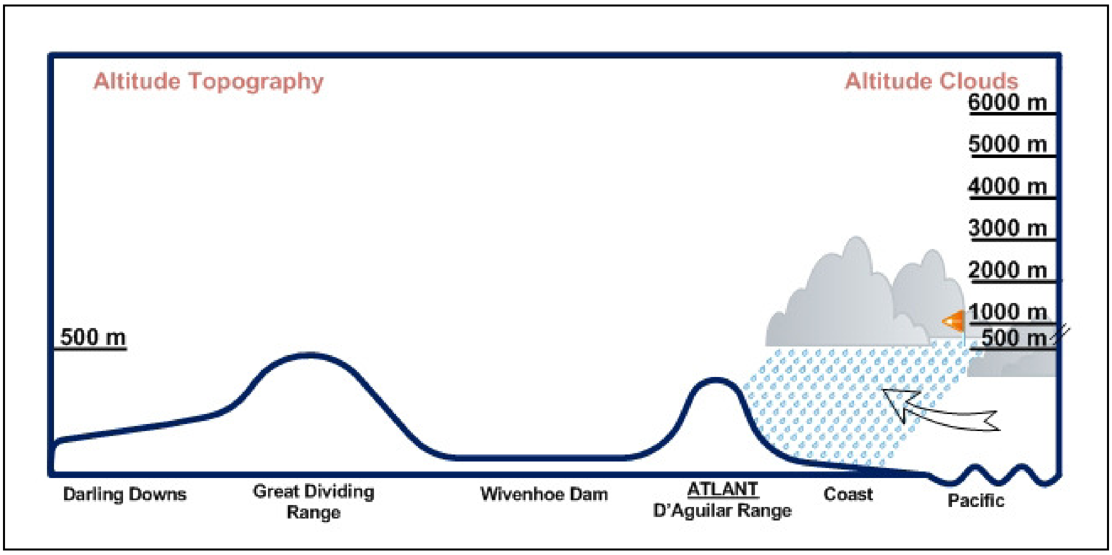

Figure .: A cross-section of southeast Queensland showing coastal stream showers in south-easterly airflow.

The potential enhancement of convective precipitation by the Atlant over the D'Aguilar Range is shown in Figure .. This situation would occur during weather patterns that produce warm and humid east to north-easterly airflow onto the southeast Queensland coast. In this situation positioning of the Atlant on a ridge above the coastal plain also ensures that dynamic lifting of the moist onshore airflow by the topography enhances the influence of the Atlant.

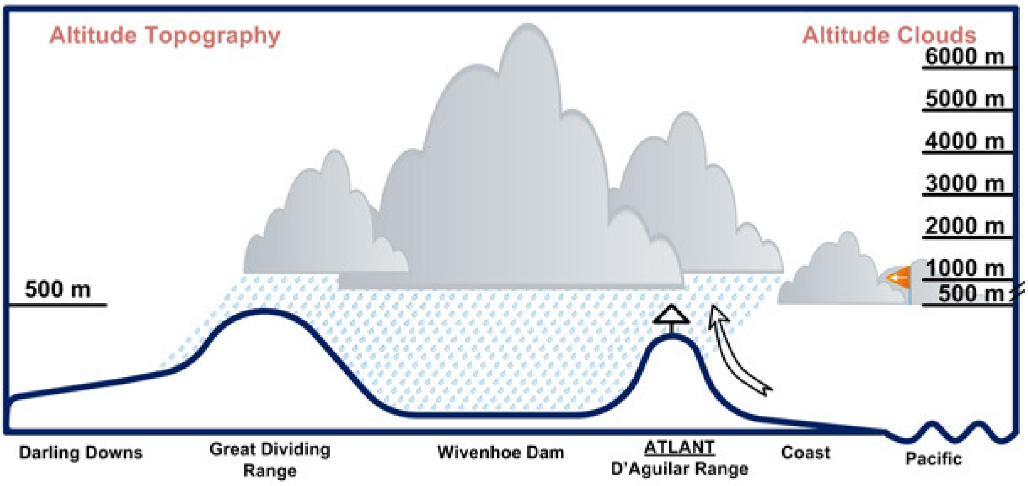

Figure .: Enhancement of convective precipitation by the Atlant over the D'Aguilar Range with rainfall generation downwind over the Wivenhoe Dam.

The Atlant potentially influences rainfall intensity during widespread precipitation events associated with stratus cloud (Figure .). In these situations, rainfall enhancement is considered likely to occur both upwind and downwind of the D'Aguilar range during light to moderate winds. At higher wind speeds, the area of rainfall enhancement would be shifted downwind of the Atlant.

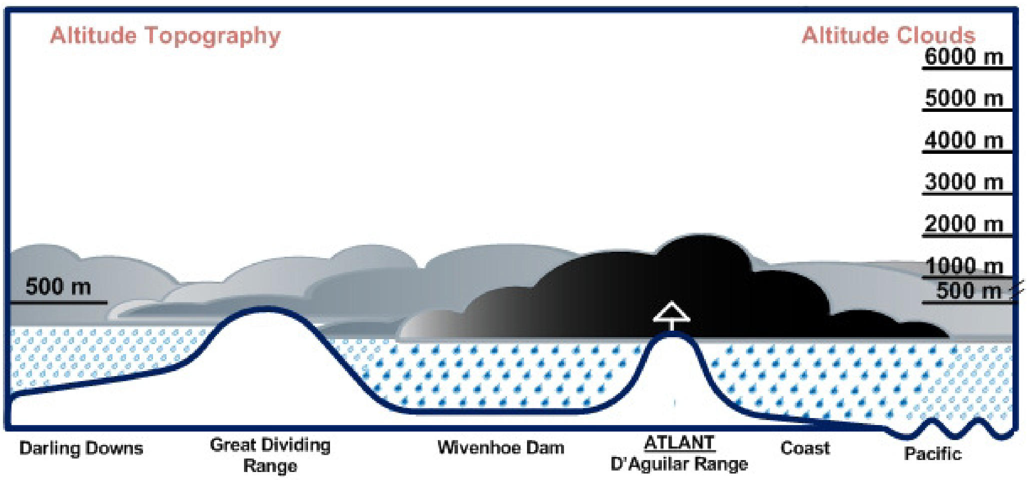

Figure .: Schematic representation of how the Atlant is believed to affect rainfall intensity during widespread precipitation events associated with stratus cloud over southeast Queensland.

4 Direct Rainfall Measurements

Markus Billerbeck
Jurg Keller

4.1 Methods

4.1.1 Study area

One part of the scientific evaluation of rain enhancement experiments by the Atlant technology involved the continuous recording and evaluation of weather data by the evaluation team using remote weather stations (described below).

A test area was defined prior to the rain enhancement experiments, covering 8000 km^2 and large parts of the Wivenhoe and Somerset catchment area (Figure .). Fifty weather stations were set up within the test area with approximately 10 km distance between neighbouring stations. Open and relatively easy accessible locations were preferably chosen for positioning of the stations.

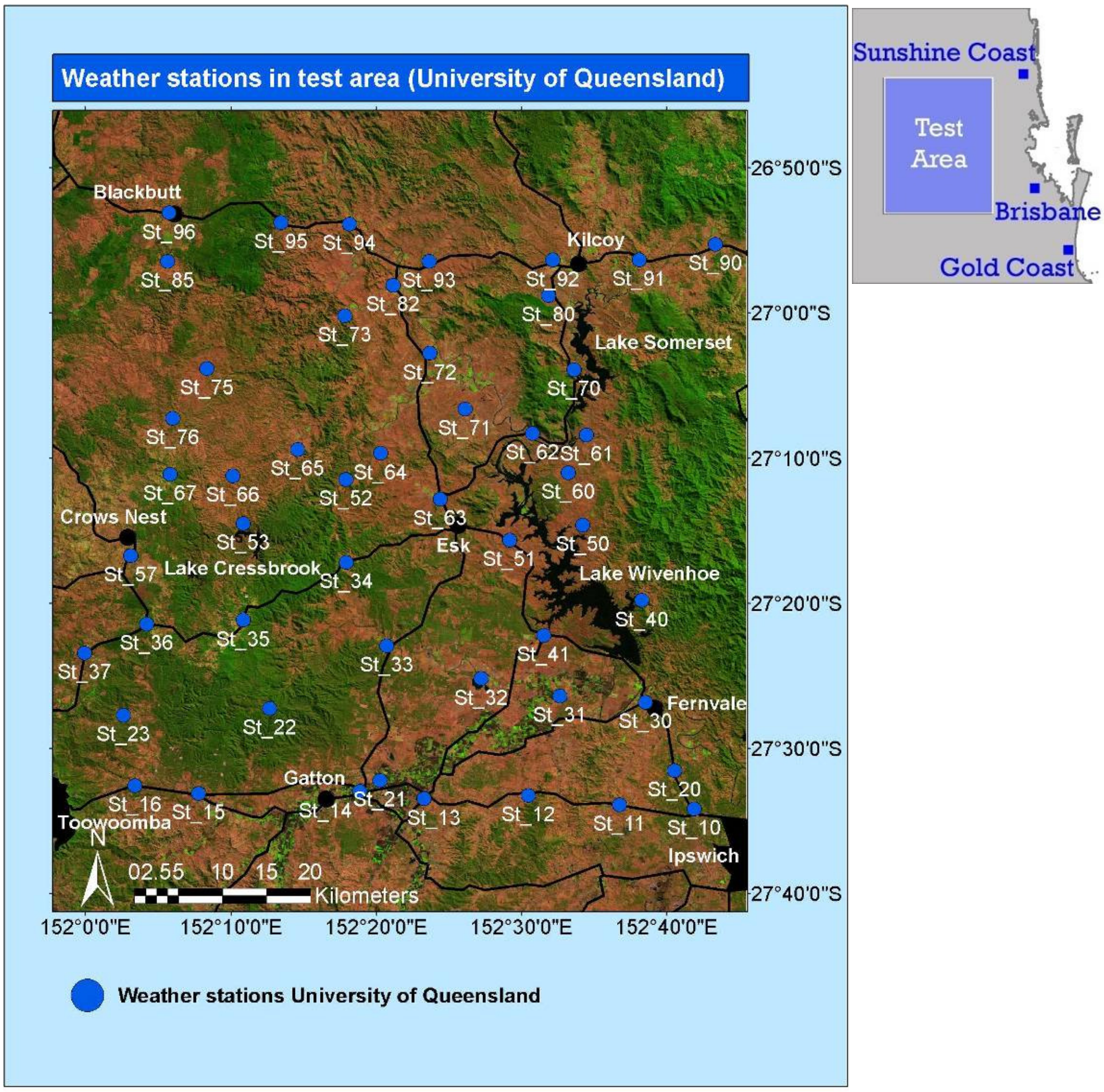

Figure .: Positions and identifiers of the 50 weather stations installed by the University of Queensland within the 8000 km^2 test area and location of the test area in southeast Queensland.

In order to estimate rainfall for the whole catchment area of the Wivenhoe, Somerset and North Pine dams (7400 km^2), daily rain data was extracted from the Bureau of

Meteorology Silo website (http://www.bom.gov.au/silo). The positions of the University of Queensland (UQ) and Bureau of Meteorology (BoM) rain gauges within and around the catchment area are shown in Figure .. The figure also shows the location of the Atlant system east of the catchment area. Three pairs of adjacent BoM and UQ stations with a complete data set were chosen for comparison of the rainfall measurements (red symbols in Figure .).

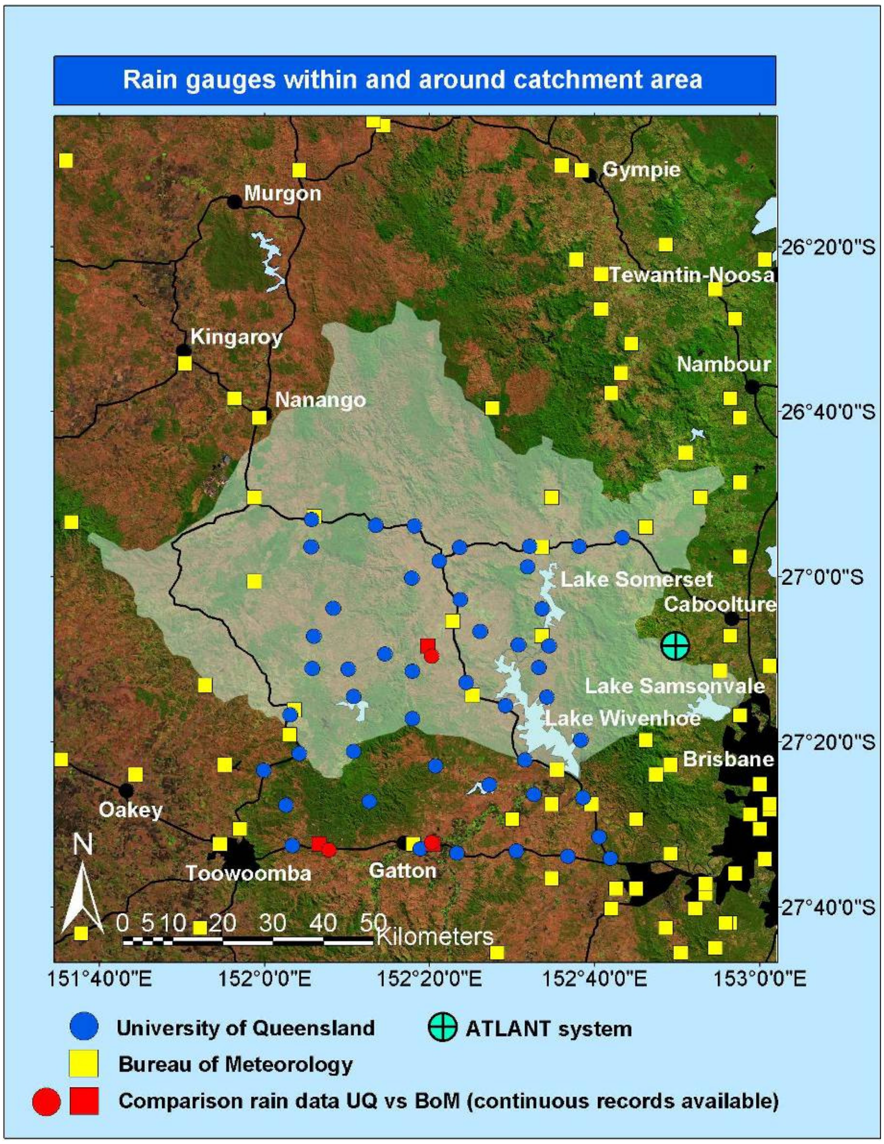

Figure .: Location of the Atlant system as well as positions of rain gauges of UQ and BoM within and around the catchment of the Wivenhoe, Somerset and North Pine dams (grey area: 7400 km^2). Red symbols denote adjacent stations of the UQ and BoM used for comparison of rain data.

4.1.2 Weather stations

Weather data of the 50 stations was recorded with WS2300 remote weather stations (www.heavyweather.info). The stations were mounted on a pole driven into the soil at the respective positions (Figure .). The base station and thermo-hygro sensor were protected from rain under a cover with ventilation slits.

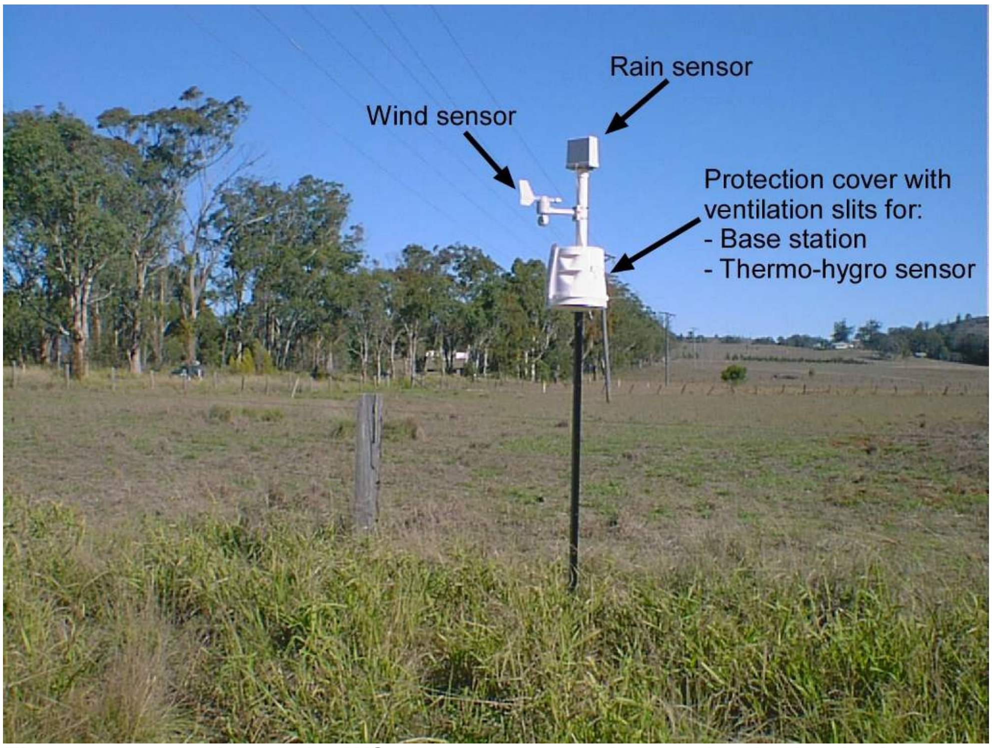

Figure .: Installation of the WS2300 remote weather station in the field.

The memory of the base station allowed storage of 175 consecutive records. Data were recorded in 20 minute to 1 hour intervals during the period of the experiment. Consequently, data were collected from the base stations in 2 to 7 day intervals.

Each record of the weather stations includes the time of recording and data for:

- Rainfall (mm)
- Air pressure (hPa)
- Temperature (℃)
- Humidity (%)
- Dew point (℃)
- Wind speed (km/h)
- Wind direction
- Wind chill (℃)

Only the rainfall data are discussed within the scope of this report.

4.1.3 Analysis

Since UQ weather stations recorded data from 17 May 9am to 01 July 9am, all data analysis was conducted with rainfall data from this period. Additionally, analysis was performed on rain data from the period 01 June 9am to 01 July 9am and for three individual rain events between 25 to 29 May, 5 to 7 June and 23 to 27 June 2007.

Database management of all weather data and plotting of spatial rain data was performed with ArcGIS 9.2 software.

The total rainfall volume was estimated for the 8000 km^2 test area and the 7400 km^2 catchments of the Wivenhoe, Somerset and North Pine dams. Inverse Distance Weighted Interpolation was used to infer rainfall volumes for areas where no point data was available. In this analysis the estimation of values between sample points is performed by averaging values of samples within a defined radius. The influence or weight of a sample point in the averaging process decreases with the distance to the point that is to be estimated. The geostatistical tools available in ArcGIS were used to optimize the analysis parameters of the interpolation.

The UQ weather station rain data was used to interpolate rainfall for the test area, whereas BoM as well as UQ data were taken for the estimation of rainfall within the catchment. The total rainfall volume over a specific period was calculated by multiplying the mean rainfall of the interpolation by the area. While calculations for the test area included values from the entire 8000 km^2 (see Figure .), only values from within the catchment boundaries (see Figure .) were used to calculate rainfall volumes for the catchment area.

The complete record of daily rainfall data from all UQ weather stations is included in the Appendix (Table . & Table .).

4.2 Results

4.2.1 Comparison of rain data between UQ and BoM stations

Daily rainfall data of 3 pairs of adjacent BoM and UQ stations were used to assess the reliability of the rainfall measurements conducted by the UQ (red symbols in Figure .).

UQ Stations 15, 21 and 64 were compared with BoM Stations Helidon TM (40829), University of Queensland Gatton (40082) and Rosentreters Bridge TM (40823). These stations had complete records over the test period. Other BoM rain gauges adjacent to UQ weather stations did not continuously record data and were therefore not used for this analysis. The distance between neighbouring UQ and BoM stations varied between 0.4 and 2.5 km for the three pairs.

The plot of daily rainfall before 9am (mm) recorded by the 3 UQ stations against the rainfall registered by the 3 adjacent BoM stations is shown in Figure .. Rainfall data of UQ and BoM stations were closely related during the study period, as demonstrated by the highly significant linear fit ($p<0.0001$), R^2 of 0.99. The close agreement of rainfall measurements of UQ and BoM is further underlined by correlation coefficients > 0.99 for the three pairs (see Appendix Figure .). However, UQ rainfall measurements were about 7 % higher than BoM recordings for the 3 pairs of stations (regression slope of 1.07).

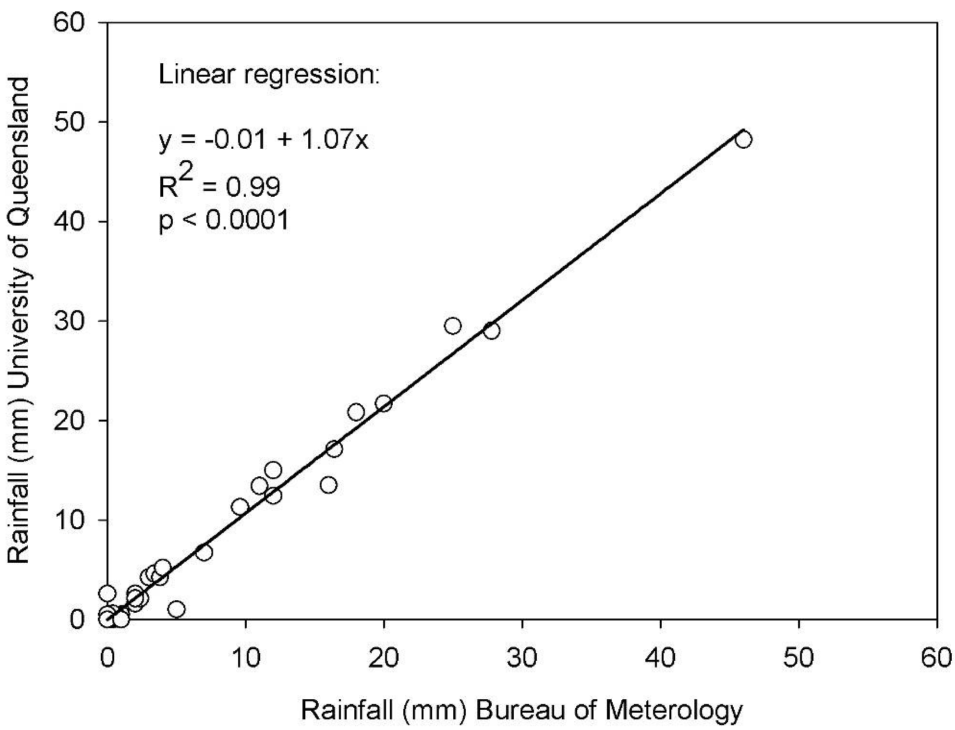

Figure .: Rainfall before 9am (mm) of UQ weather stations plotted against BoM rain gauge measurements during the experimental period. Linear regression is based on 3 pairs of adjacent BoM and UQ stations (see text).

4.2.2 Test area rainfall

During the period 17 May to 01 July 2007 an interpolated cumulative average of 118 mm rain was recorded in the 8000 km^2 test area (Figure .). This corresponds to an estimated cumulative rainfall of 930 GL over the study period.

Calculations for the month of June resulted in an interpolated average of 99 mm rain, corresponding to an estimated volume of 780 GL (Figure .).

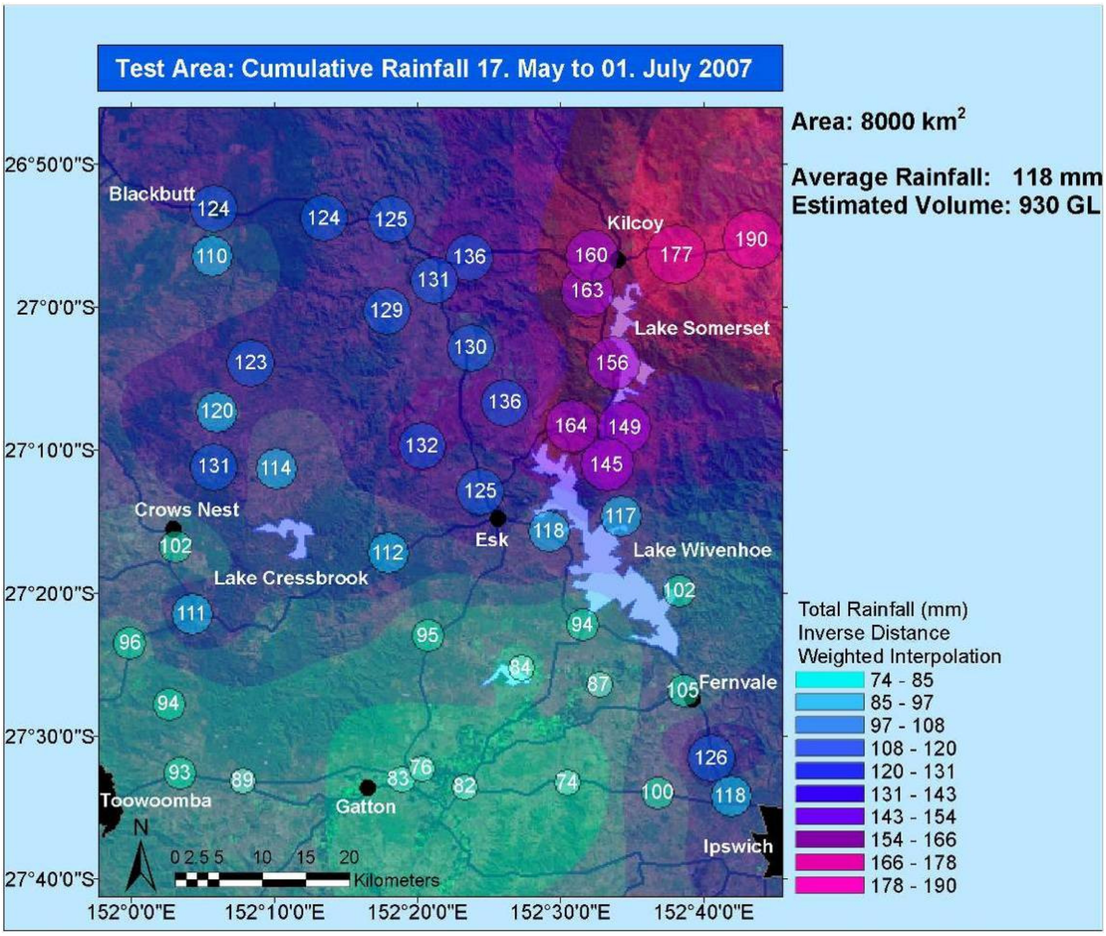

Figure .: Measured cumulative rainfall and interpolated values for 9am 17 May to 9am 01 July 2007 in test area. Numbers in circles denote rounded total rainfall measured by rain gauges. Only stations with a complete record over the period are shown.

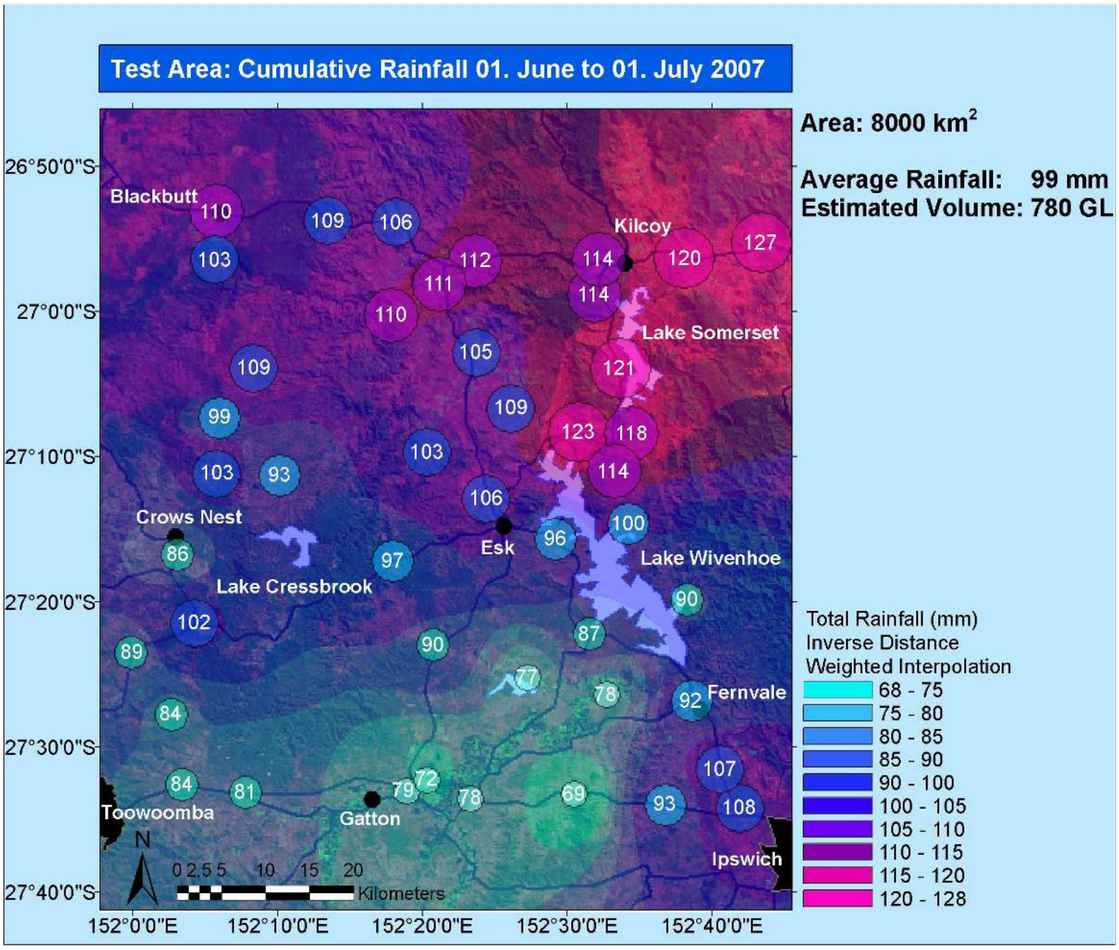

Figure .: Measured cumulative rainfall and interpolated values for 9am 01 June to 9am 01 July 2007 in test area. Numbers in circles denote rounded total rainfall measured by rain gauges. Only stations with a complete record over the period are shown.

The strongest cumulative rainfall was recorded in the northern part of the test area with highest values in the north-eastern part close to Lake Somerset and Lake Wivenhoe. The southern part of the test area received the least amount of cumulative rain.

Three major rain events during the study period contributed most to the cumulative rainfall:

Event 1: 25 to 29 May 2007
Event 2: 05 to 07 June 2007
Event 3: 23 to 27 June 2007

Figure . shows the measured and interpolated rainfall during the 3 major rain events.

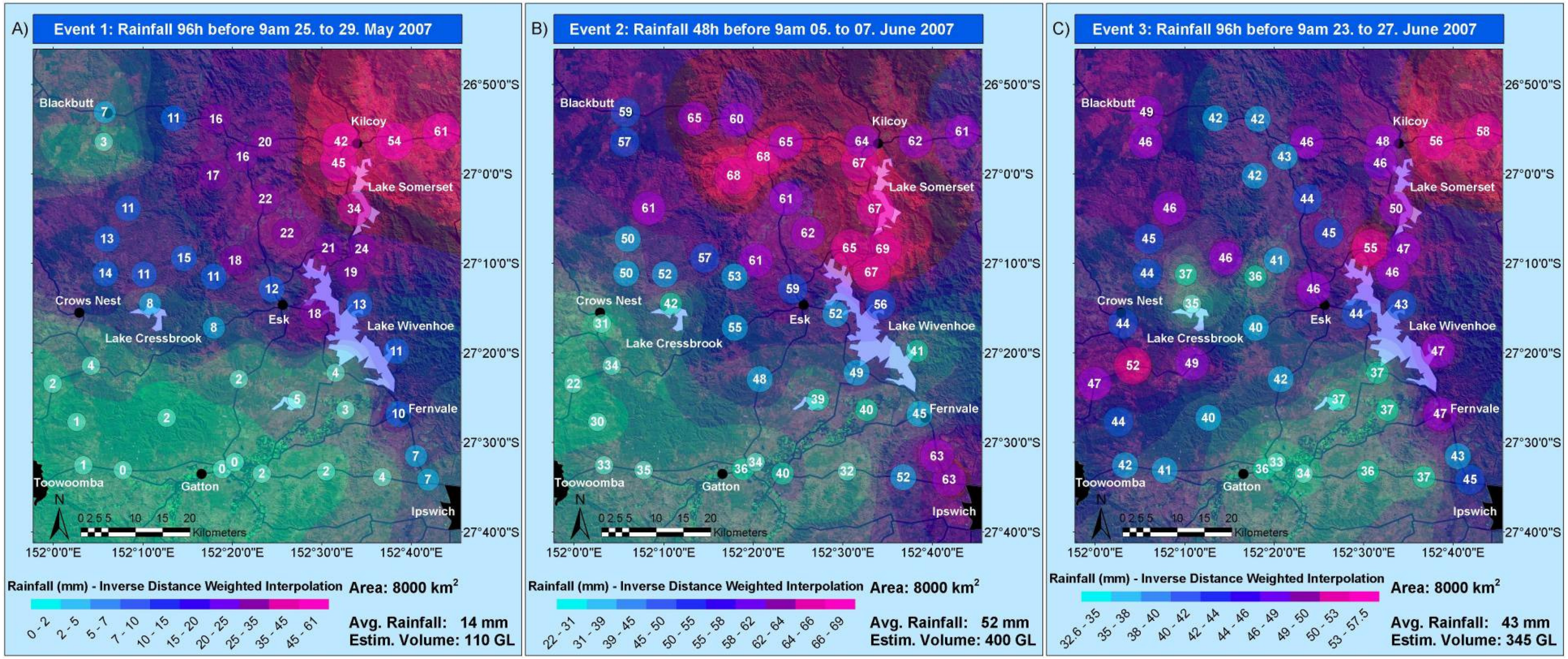

Figure .: Measured rainfall (mm) and interpolated values for (A) Rain Event 1, (B) Rain Event 2, (C) Rain Event 3 in the test area during the study period. Numbers in circles denote rounded total rainfall measured by UQ rain gauges. Only stations with a complete record over the respective period are shown.

Rainfall during of Event 1 (25 to 29 May) amounted to an estimated 110 GL with an average rainfall of 14 mm within 96 hours (Figure .A). Most of the rainfall during this event was recorded in the north-eastern section of the test area (20 to 61 mm). Almost no rain was recorded in the southern part of the test area.

The highest rainfall of the experimental period was recorded during Event 2 (Figure .B). An estimated 400 GL rain fell in 48h between 05 to 07 June 2007 with an average of 52 mm. Similar to the first event, strongest rainfall was recorded in the north-eastern part of the test area with values between 60 to 69 mm. Less rainfall between 22 and 40 mm was measured in the south-western parts of the test area.

During the last major rain event of the experimental period, approximately 345 GL rain fell within 96 hours between 23 and 27 June 2007 with 43 mm on average over the test area (Figure .C). Most rain was recorded in the eastern and western parts (40 to 58 mm) and less rain (33 to 46 mm) in the central parts of the test area.

4.2.3 Catchment area rainfall

An estimated cumulative 990 GL rain and average rainfall of 135 mm were recorded between 17 May and 01 July 2007 in the catchment area of the Wivenhoe, Somerset and North Pine dams (Figure .). During June 2007 the average rainfall of 104 mm in the catchment resulted in an estimated volume of 770 GL rain (Figure .).

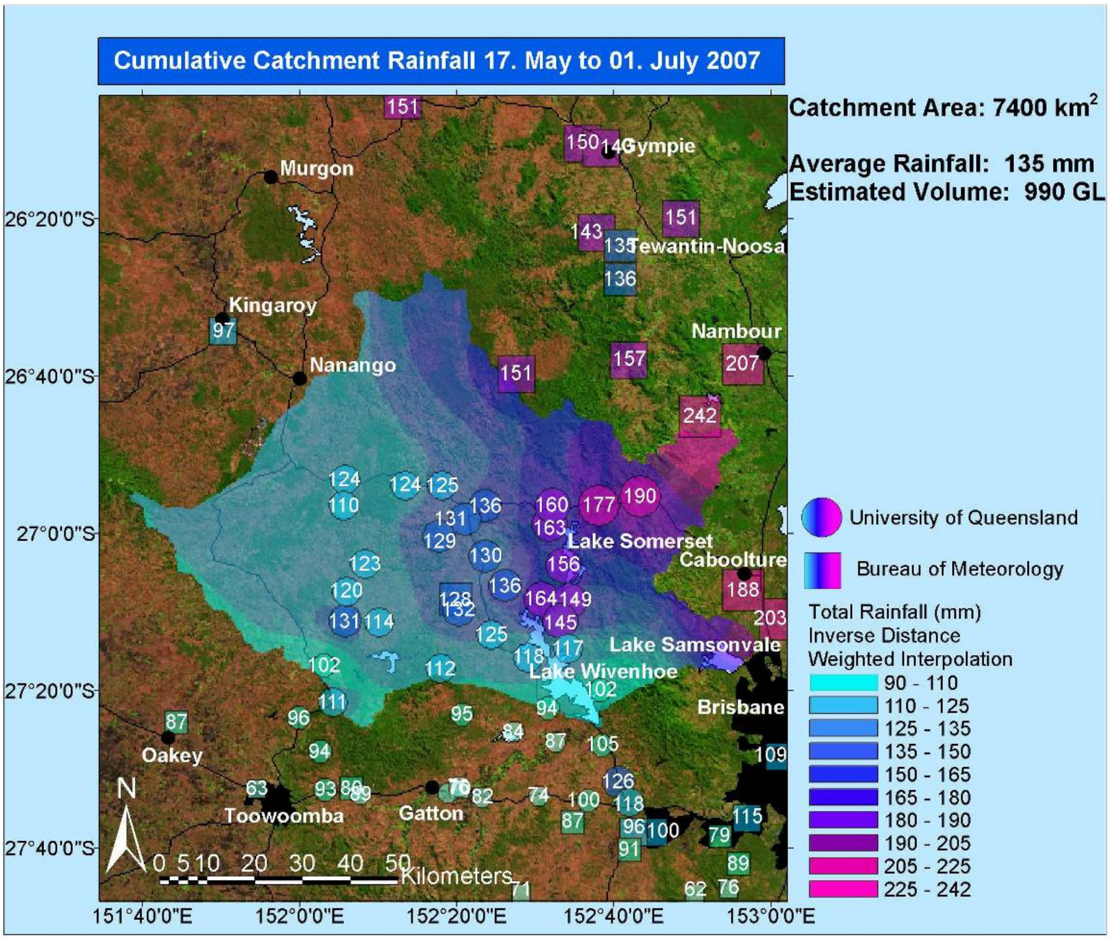

Figure .: Measured cumulative rainfall and interpolated values between 9am 17 May to 9am 01 July 2007 within the catchment. Only stations with a complete record over the period are shown.

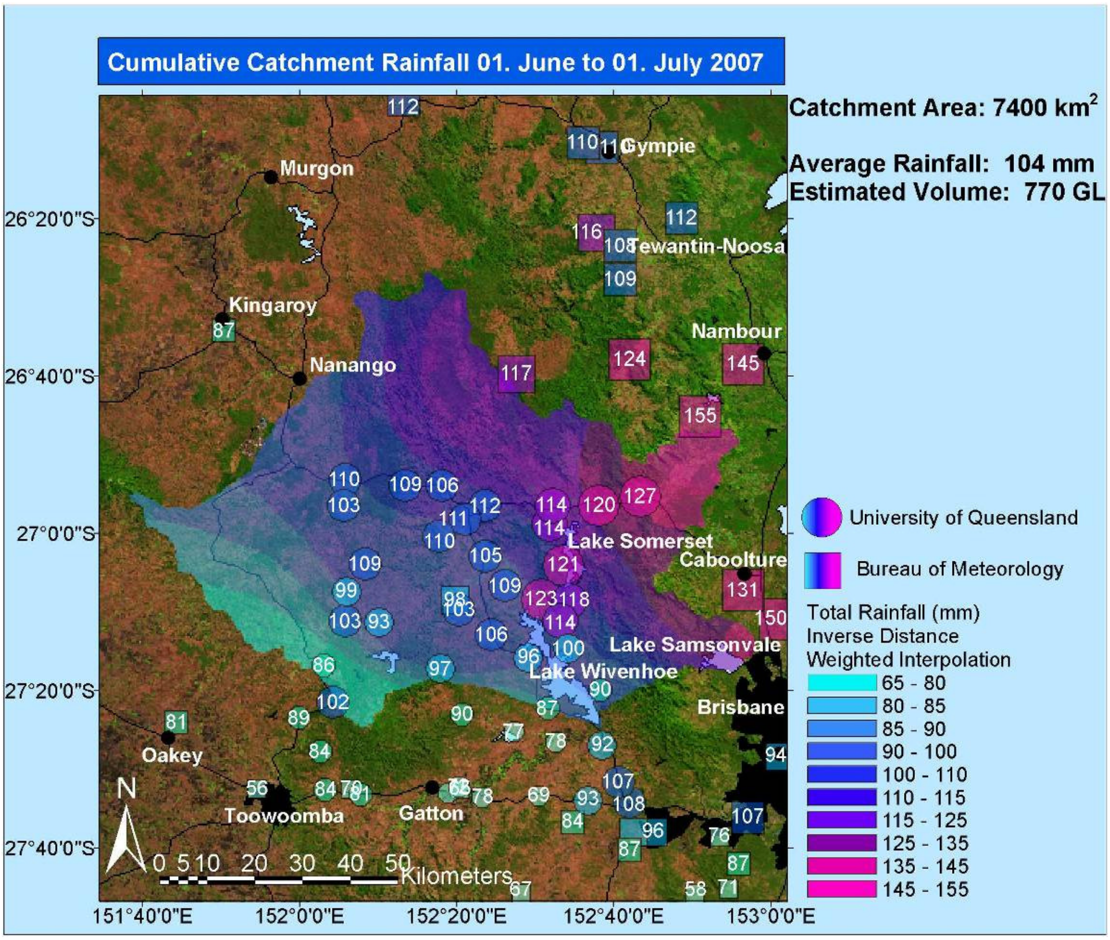

Figure .: Measured cumulative rainfall and interpolated values between 9am 01 June to 9am 01 July 2007 within the catchment. Only stations with a complete record over the period are shown.

These values are comparable to the rainfall measurements from the test area. Most of the rainfall occurred in the north-eastern parts of the catchment decreasing towards the southern and western catchment.

The measured and interpolated rainfall in the catchment during the 3 major rain events is shown in Figure ..

An estimated 145 GL rain and 20 mm average rainfall were recorded during the 96 hours of Event 1 (Figure .A). Relatively strong rainfall (40 – 80mm) was registered during 96 hours in the north-eastern parts of the catchment, whereas only 3 to 25 mm of rain was measured in the remaining parts of the catchment.

The strong rainfalls during the 48 hours of Event 2 amounted to 425 GL and 58 mm rain within the catchment area (Figure .B). The northern and eastern parts of the catchment received most of the rain (50 – 78 mm), while only 30 – 50 mm rain fell in the southern catchment.

During the 96 hours of Event 3, another estimated 340 GL rain fell in the catchment with 46 mm on average (Figure .C). Highest rainfall was measured in the north-eastern catchment (50 – 60 mm), whereas 35 – 45 mm rain was recorded in the southern and middle parts of the catchment.

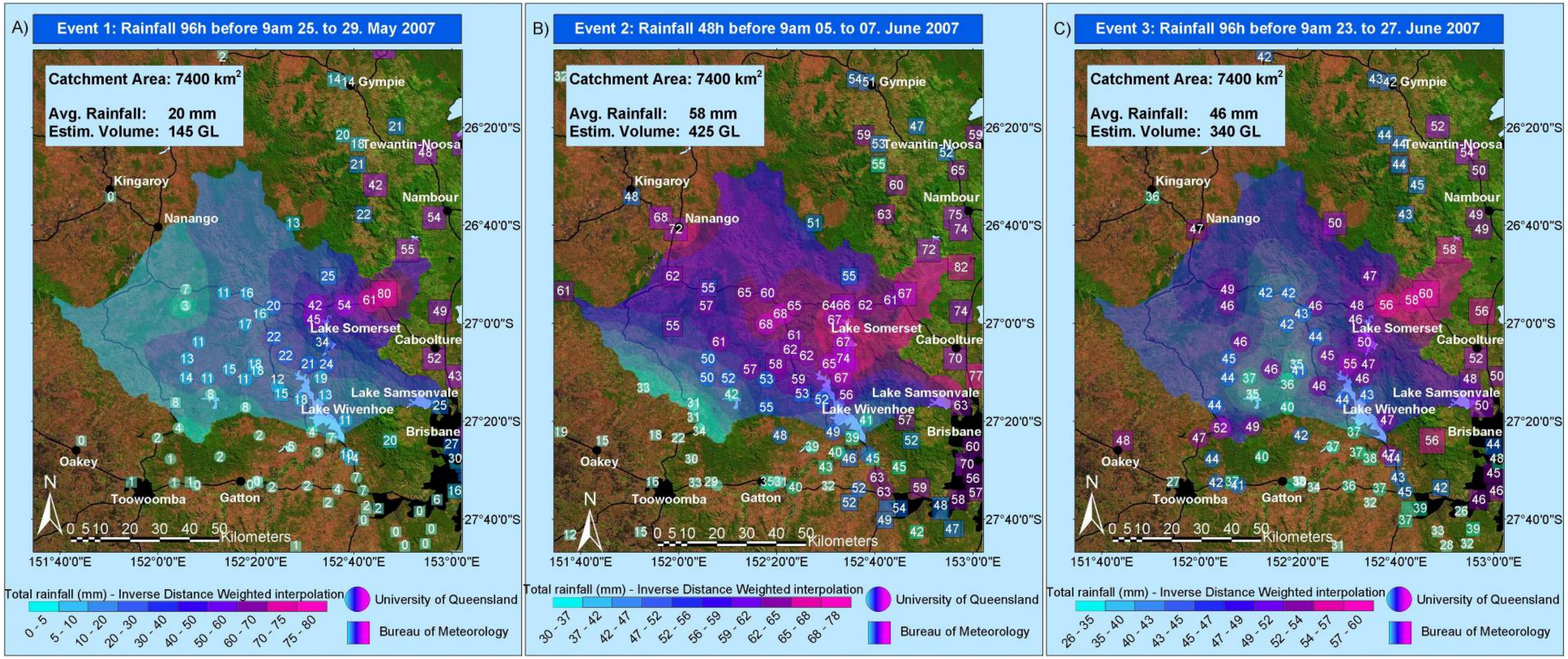

Figure .: Measured rainfall (mm) and interpolated values for (A) Rain Event 1, (B) Rain Event 2, (C) Rain Event 3 in the catchment area during the study period. Numbers in circles and boxes denote rounded total rainfall measured by UQ and BoM rain gauges, respectively. Only stations with a complete record over the respective period are shown.

5 Comparison with Historic and Regional Data

John A. Eccleston
Thomas Loetscher
Nick Denman
Jurg Keller

5.1 Methods

5.1.1 Historical rainfall data

Corresponding to the operational period of the Atlant system (15 May 2007 - 30 June 2007) rainfall events during this period were compared to the respective historical data (1957 to 2006). Daily rainfall data of 756 open stations (Figure .) within the area 151.5/-26.0, 154.0/-28.5 (longitude/latitude) was obtained from the Australian Bureau of Meteorology (BoM).

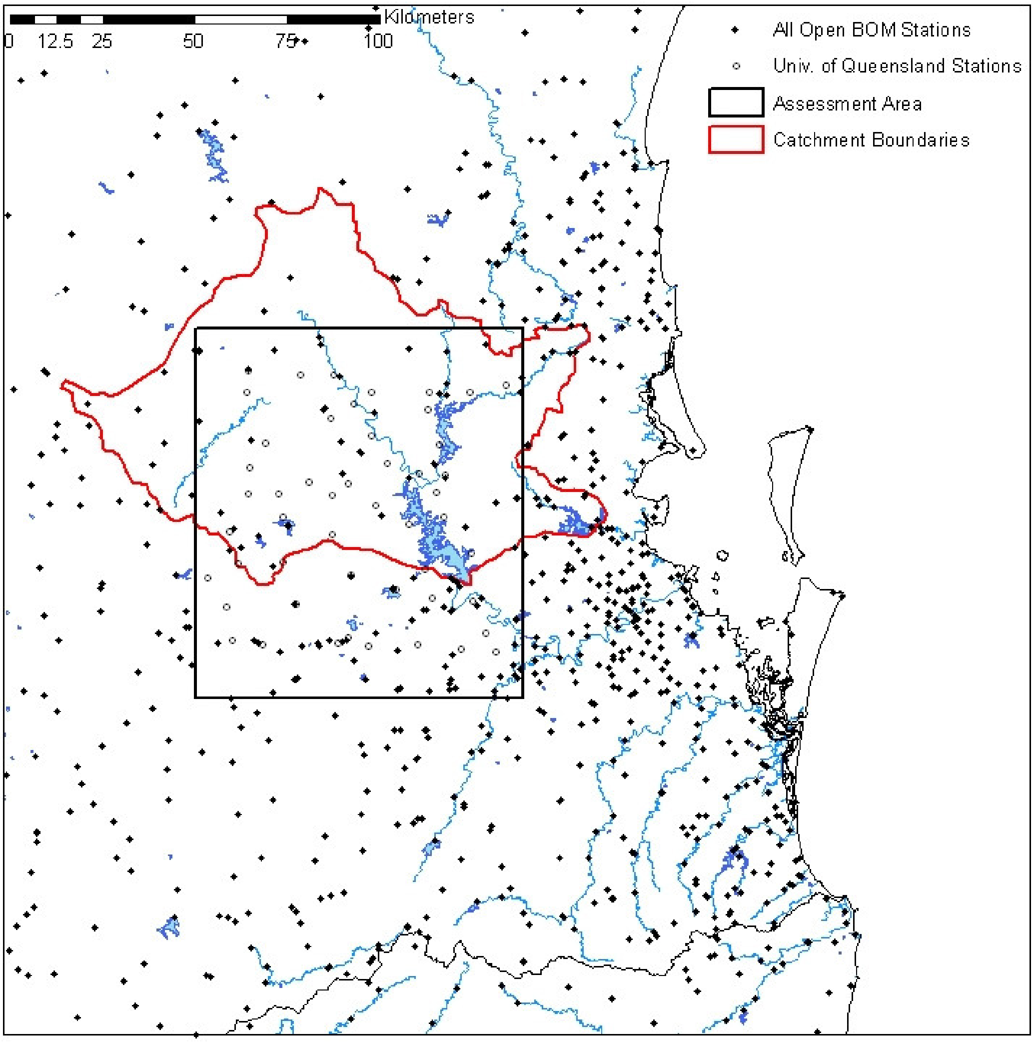

Figure .: Locations of weather stations in southeast Queensland. Red line denotes the catchment of the Wivenhoe- Somerset and North Pine dams (7400 km^2). Black box denotes the assessment area (8000 km^2) comprising 50 weather stations by the UQ.

The daily rainfall data (24 hours before 9am) was extracted from the original historical BoM data file using the PHP scripting language into a format suitable for statistical and data analysis.

Only 82 stations had a data completeness of more than 75% and were used for subsequent analysis. The analysis did not include measurements by UQ weather stations. The latter measurements are discussed in Chapter .

5.1.2 Percentiles for individual stations

The percentile rank of the 2007 total rainfall was calculated for each of the 82 stations with historical data completeness >75 %. Data for the 2007 period was complete. The percentile rank specifies the percentage of historical years (1957 to 2006) in which a given station has measured less rain than in 2007. The analysis was done for the period 15 May to 30 June.

For periods with less than 100 % but more than 75 % data completeness, total rainfall was normalized using Equation 1:

$$R = \frac{d_P}{d_M} A \qquad (\ )$$

Where R = normalized total rainfall (mm), A = actual measured total rainfall (mm), d_P = number of days in period, d_M = number of days with data. Stations with valid data for less than 75% of all years were excluded. Stations with data for less than 100% but more than 75% of all years had to have data starting from 1957, and years with no data had to be distributed more or less evenly over the period from 1957 to 2007.

5.1.3 Total rainfall measured by BoM stations

During the operational period of the Atlant (15 May to 30 June 2007) three major rainfall events occurred (see Chapter). Accordingly, total rainfall at the 82 stations was analysed for the whole period and for three sub-periods (15 to 31 May, 1 to 15 June, and 16 to 30 June), each of them containing one of these events.

Percentile and total rainfall data were interpolated using Natural Neighbours Interpolation in a 1 km grid, which is appropriate for unevenly distributed data points. ArcGIS was used to calculate and to visualize the results. The interpolated results are estimates and show tendencies. The further away they are from measured data points, the higher the probability is that they are inaccurate.

5.2 Results

5.2.1 Total rainfall measured by BoM stations in and around the catchment

Figure . shows the interpolated total rainfall from 15 May to 30 June 2007. The map shows increased rainfall north of the southern catchment boundary and along the coast.

The map shows evidence of increased rainfall in the test area and particularly in the vicinity of the Atlant location. It is noteworthy that the coastal range follows approximately parallel to the coast along the catchment area and would therefore not explain the increased rainfall in the catchment itself. There is no similar effect visible in the north and south of the catchment area. The higher rainfall totals near the Atlant support observational data from previous Atlant tests that the system may increase the topographic enhancement of precipitation under favourable conditions.

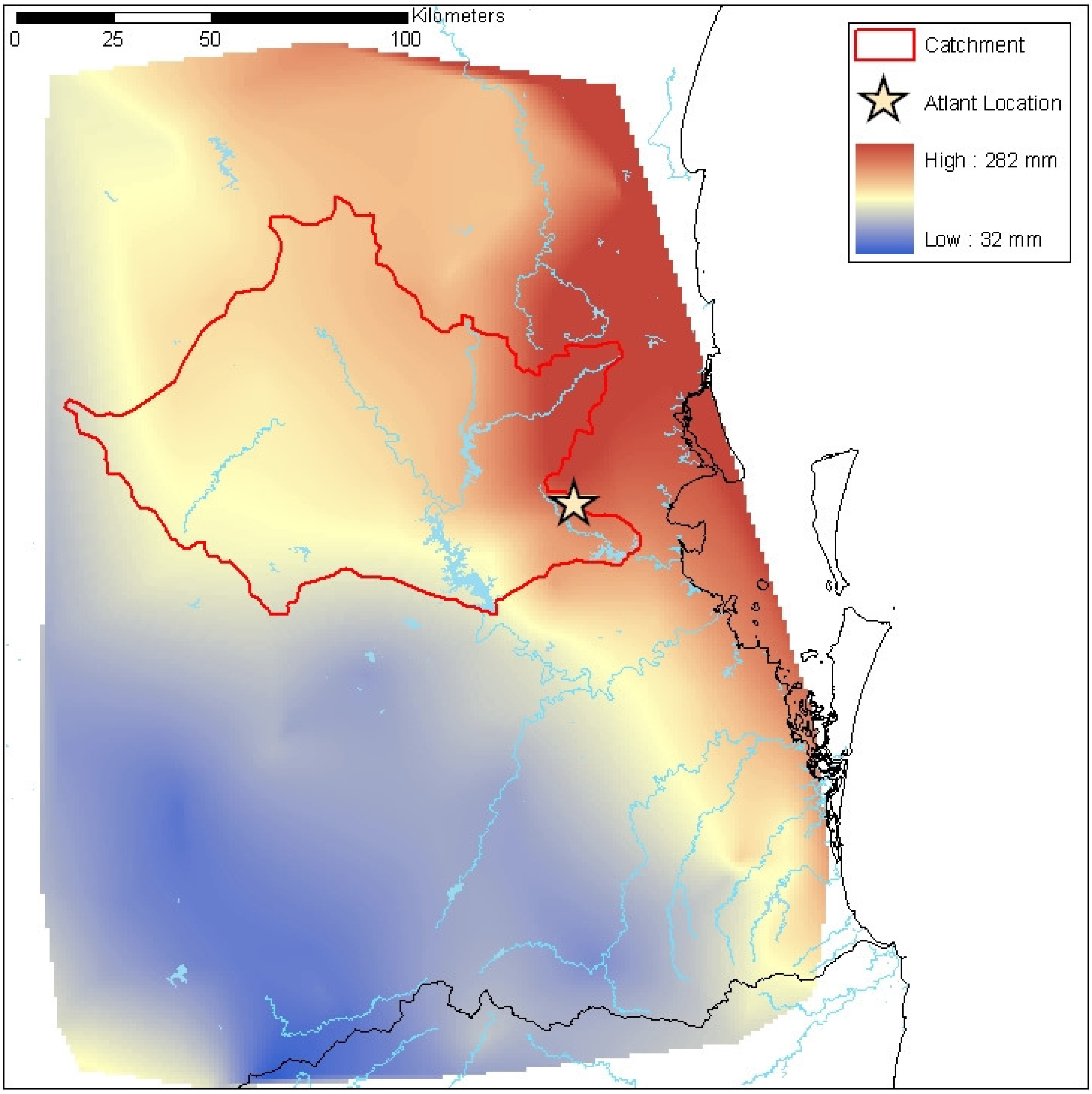

Figure .: Total rainfall from 15 May to 30 June 2007. Natural Neighbours interpolation of rainfall measured by 82 BOM weather stations. A substantially increased rainfall amount can be observed on the eastern side the catchment area to the north of the Atlant installation.

A similar picture presents itself when only looking at the period from 15 to 31 May, which contains the rainfall event of the 26 and 27 May (Figure .). The band of high rainfall crossing into the north-east corner of the catchment is even more pronounced. Convective conditions with a north-easterly wind direction were mainly responsible for this event (see details in Section), which are considered to be most suitable for the Atlant operation. Again, there is no similar effect discernible along the coast to the north or south of the catchment, and on this occasion there was no significant rainfall recorded in the western part of the catchment and also not to the south of the catchment.

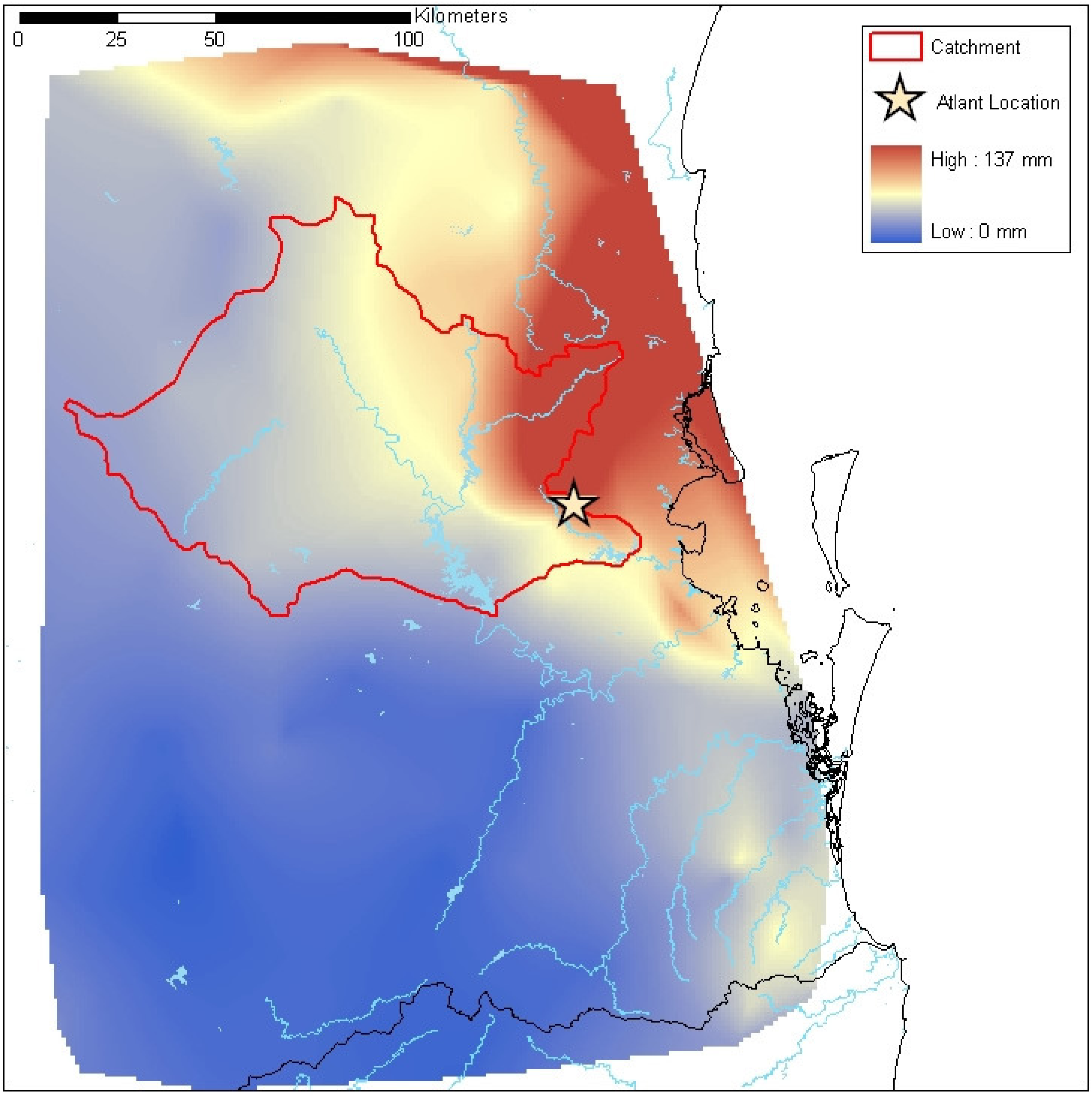

Figure .: Total rainfall from 15 to 31 May 2007. Natural Neighbours interpolation of rainfall measured by 82 BOM weather stations.

The second major rainfall event on 6 and 7 June was caused by a large cloud band approaching from a north-westerly direction. This was therefore a considerably different situation to that observed in the previously described event.

The resulting rainfall distribution for the period from 1 to 15 June is shown in Figure .. Although not as pronounced as previously, there is again an area of more intense precipitation visible further inland from the coast, which stretches along the eastern catchment boundary. The observed rainfall diminishes quite rapidly to the south of the catchment, but the rainfall to the north of the catchment is comparable to that within.

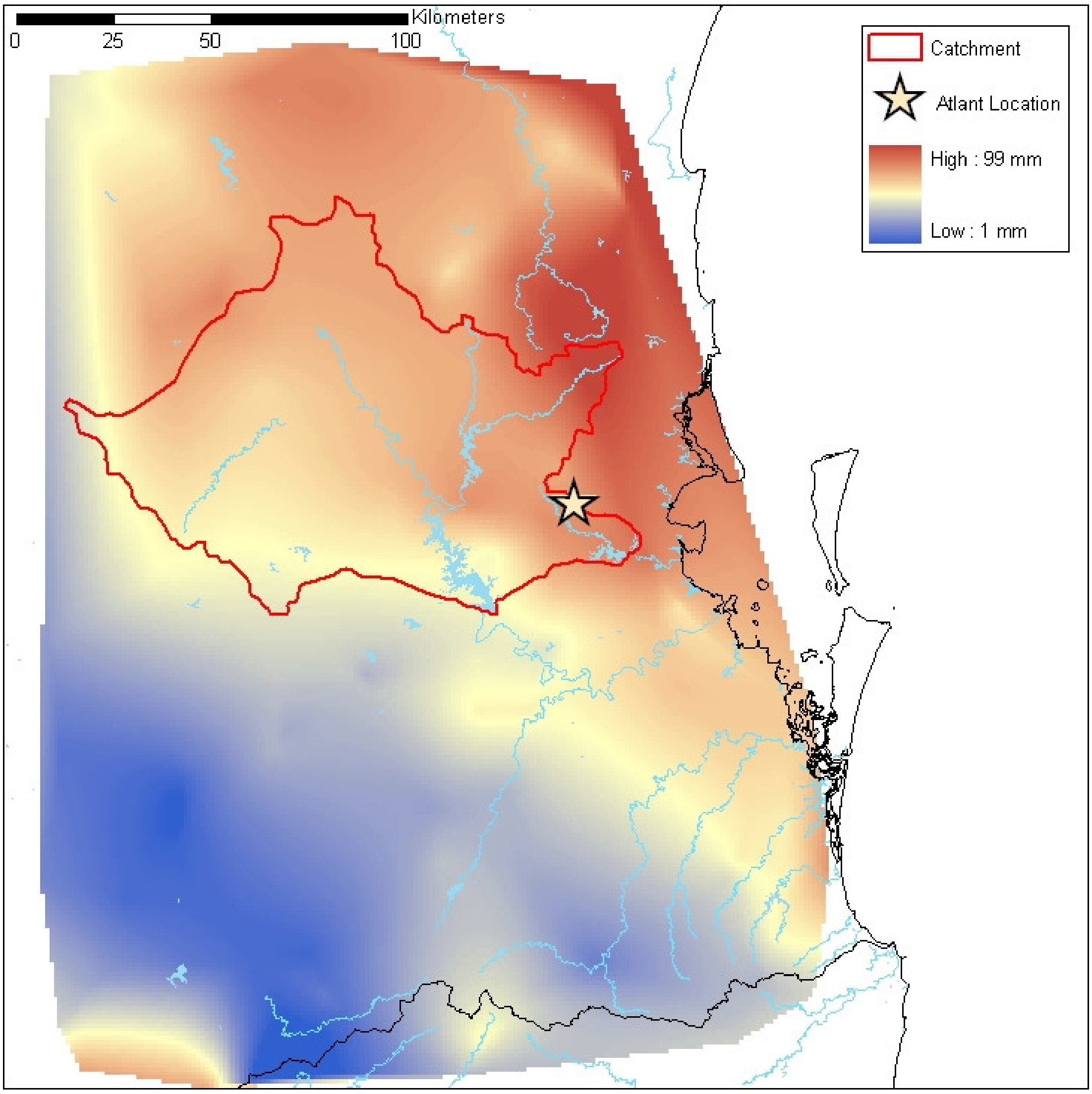

Figure .: Total rainfall from 1 to 15 June 2007. Natural Neighbours interpolation of rainfall measured by 82 BOM weather stations.

Weather conditions leading to the rain event on 25 and 26 June, which occurred during the third sub-period, were similar to those of the second event. A clear region of heavy rainfall detached from coastal precipitation can be observed again in the vicinity of the Atlant installation with significantly lower amounts to the west and south.(Figure .).

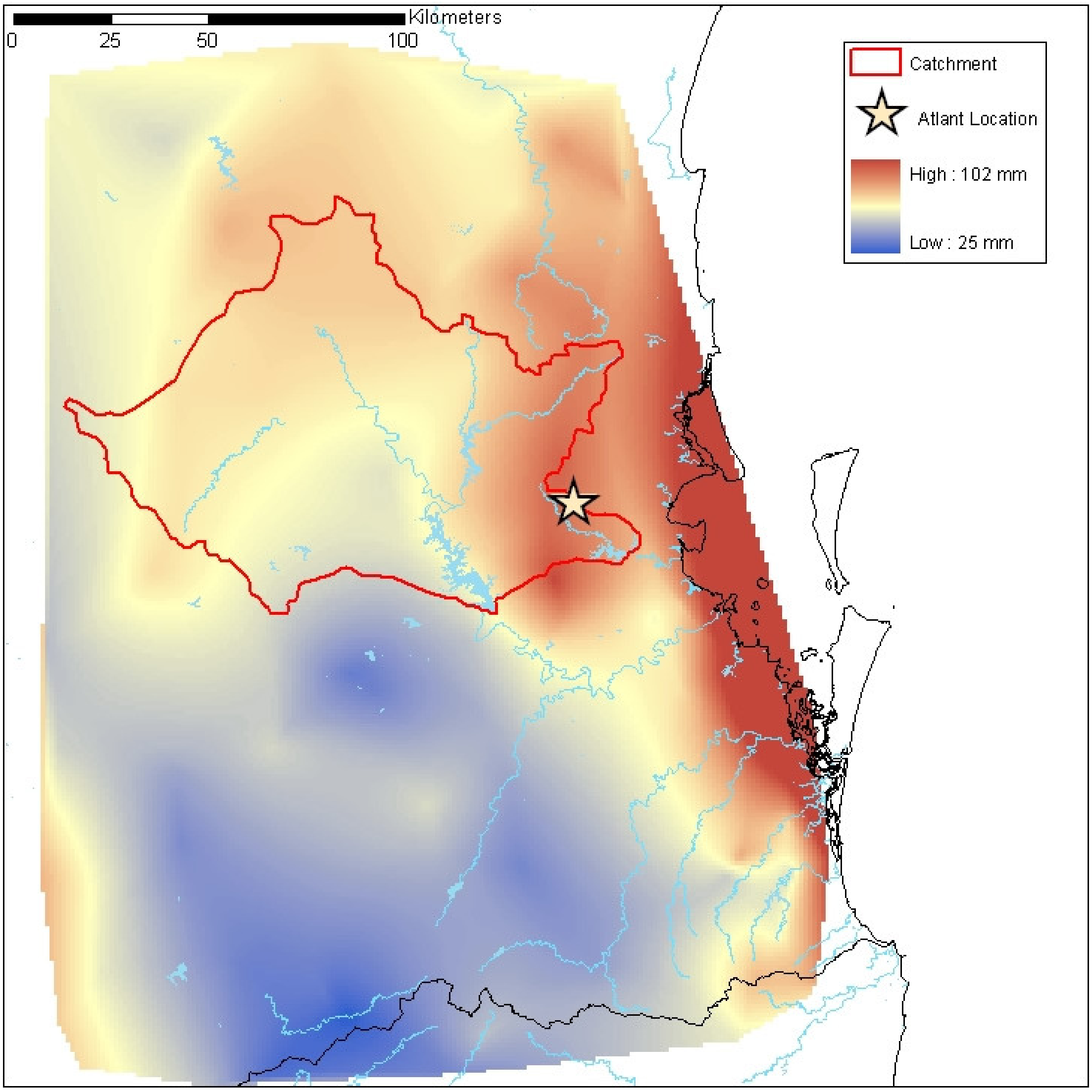

Figure .: Total rainfall from 16 to 30 June 2007. Natural Neighbours interpolation of rainfall measured by 82 BOM weather stations.

5.2.2 Percentiles of rainfall in 2007

Figure . shows the 2007 percentile rank of precipitation measured by each of the 82 BOM weather stations. The results confirm that the area north of the southern catchment boundary and, with a mean percentile of 87 (Table .), particularly the catchment itself received far more rain than usual. South of the southern catchment boundary, values drop rapidly from approximately 85% to between 50% and 70%.

There is a ridge of particularly high percentiles (90% and above) ranging from the north-west of the catchment through the centre of the catchment.

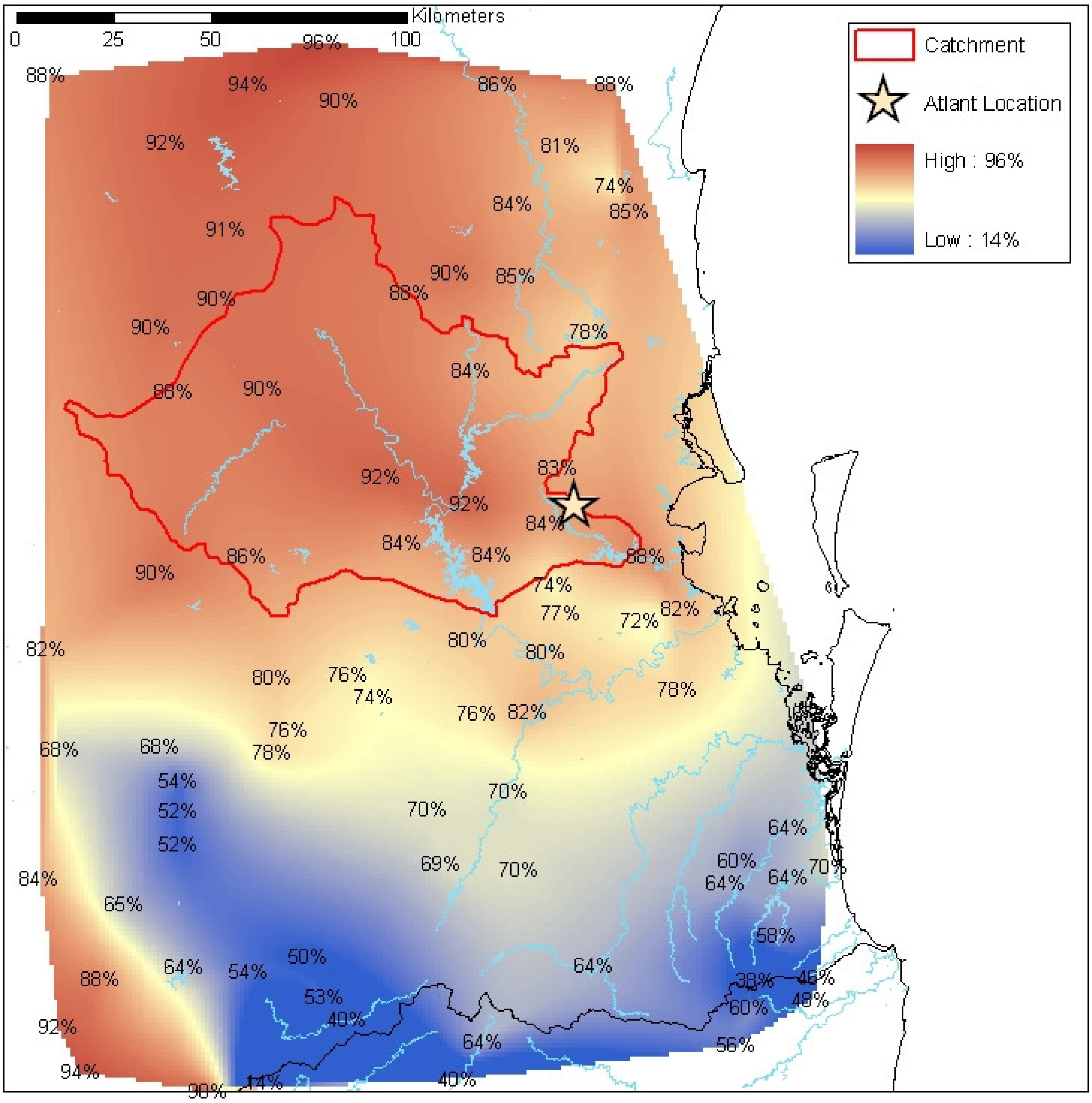

Figure .: Percentile rank of 2007compared to the years 1957 to 2006 with regards to total precipitation measured by 82 BOM weather stations (measured data and Natural Neighbours interpolation).

5.2.3 Regional comparison of rainfall amounts compared to historic values

Table . summarises the data for the three sub-periods and for the overall period from 15 May to 30 June.

In 2007, average precipitation measured by BOM stations in the catchment has been significantly higher than outside the catchment during all sub-periods. During 15 May to 30 June 2007, stations in the catchment received an average of 142 millimetres, 31mm more than stations outside. The stations in the catchment received 27% more rainfall in 2007 compared to all stations in the area. This is the highest absolute and relative difference recorded for the same seasonal period over the last 50 years, as shown in Figure . and Figure ..

Historically, over the previous 50 years (1957-2006), stations in the catchment received approximately 9mm less rain than stations outside, which means that the 2007 value is 39mm above the long-term average. Only two other years (1958 and 1983) had positive differences of more than 20mm. In the previous 10 years (1997-2006) the situation was even worse with an average difference of -20mm between inside and outside the catchment and only one year (2002) with a slightly positive balance. In relative terms compared to all stations in the area, the 50 year average before 2007 was -12% while the last 10 years (1997-2006) had a deficit of -26% for the stations inside the catchment area. This comparison shows that the rainfall amount within the catchment area was exceptionally higher than outside when compared to the previous 50 years and particularly the last 10 years (in the same assessment period).

This observation is also reflected in the mean values of the percentiles for each station, which are considerably higher for the catchment area (87%-ile) compared to the external areas (72%-ile compared to 50 year data).

Table .: Summary of rainfall inside and outside catchment area compared to data from last 50 years.

	15-31 May		1-15 June		16-30 June		15 May – 30 June		
Sample size: 82 stations	Mean 1957-2006 (mm)	Mean 2007 (mm)	Mean 1957-2006 (mm)	Mean 2007 (mm)	Mean 1957-2006 (mm)	Mean 2007 (mm)	Mean 1957-2006 (mm)	Mean 2007 (mm)	Mean percentile 2007
Total area	35	21	29	49	27	45	91	115	74
Inside catchment	33	31	27	61	24	50	84	142	87
Outside catchment	36	20	30	47	27	44	93	111	72

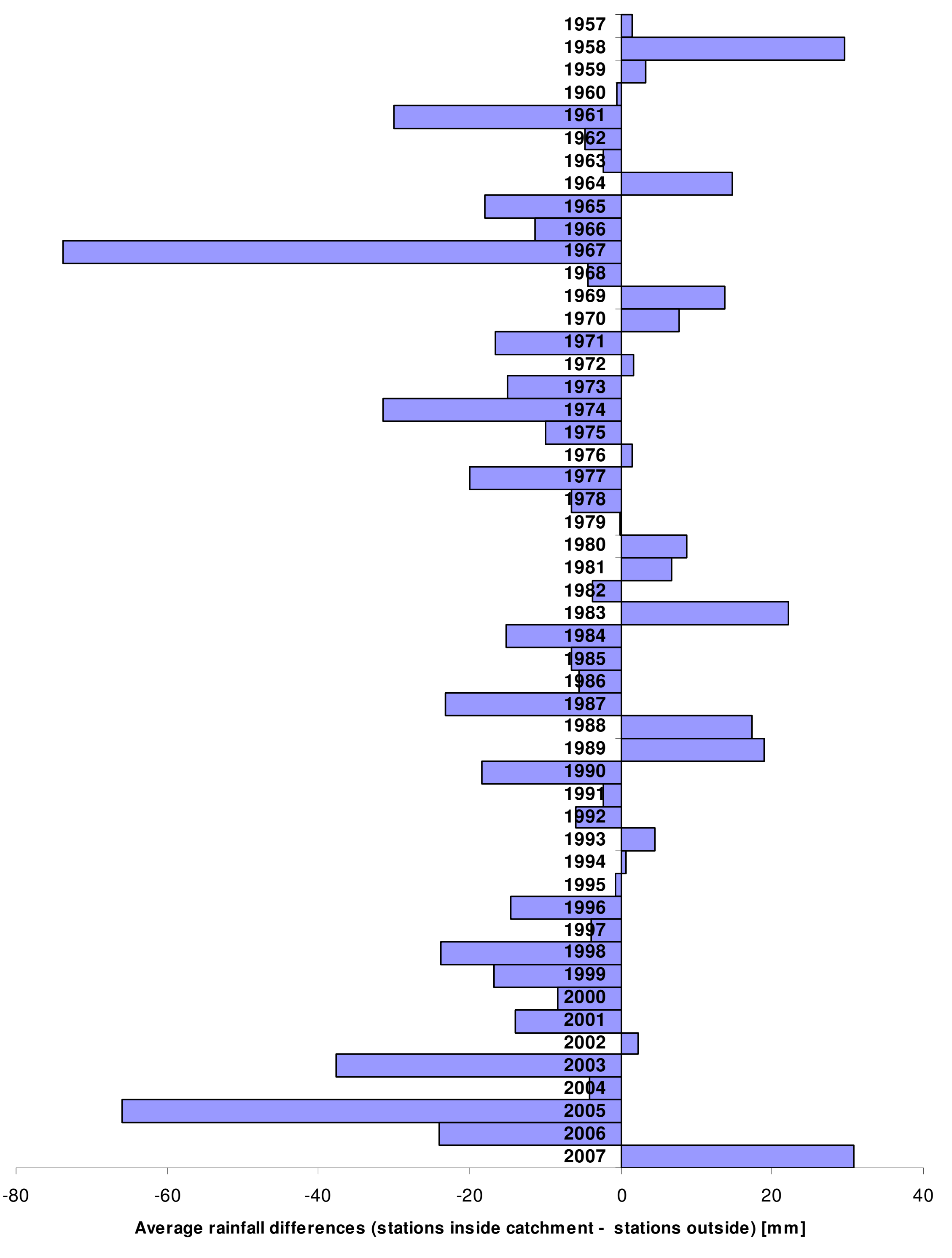

Figure . Average rainfall differences between stations inside catchment area and stations outside for 2007 and the previous 50 years (for period 15 May to 30 June).

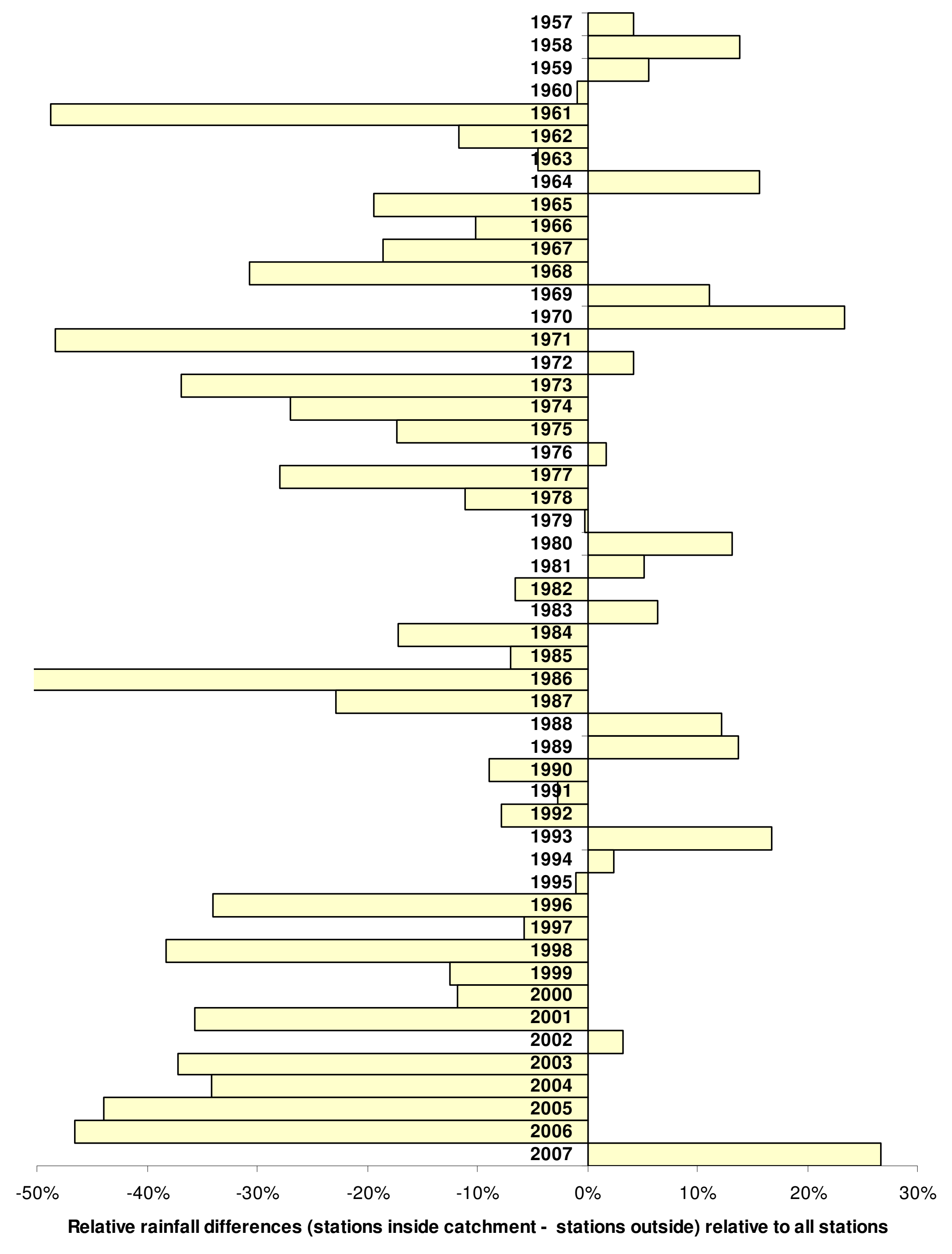

Figure . Relative rainfall differences between stations inside catchment area and all stations in SE Queensland (details see text) for 2007 and the previous 50 years (for period 15 May to 30 June).

The results of the rainfall distribution in and around the Wivenhoe/ Somerset/ North Pine catchment area show that there was a distinctively higher rainfall amount in the catchment, most particularly in the eastern part. This is also strongly reflected in the comparison of rainfall differences inside and outside the catchment area over the previous 50 years, which demonstrates that the rainfall difference in 2007 is the highest positive value (both absolute and relative to all stations) recorded during this whole period. While this does not prove a direct causal relationship with the Atlant operation, it is certainly remarkable and suggests that there is a possible influence area around the Atlant station where rainfall is enhanced. This is consistent with the meteorological observations described in Section below and seems to apply to all observed weather conditions during the test period.

The range of influence of the Atlant system could be estimated to have a diameter of 50-100 km, depending on the meteorological situation in each case. However, it has to be noted that these observations are based only on the data from the test period between 15 May and 30 June 2007 and longer-term observations would be necessary to generate more conclusive evidence of such an influence of the Atlant operation.

5.2.4 Statistical analysis of rainfall periods

Average daily rainfall (mm, calculated from total rainfall amount over period divided by number of days in period)) for the periods 1 June to 30 June and the complete assessment period 15 May to 30 June were used for the statistical analysis for each year from 1957 to 2007. Aside from the complete data set 1957-2007, subsets of recent years (1992-2007, 1997-2007 and 2000-2007) were considered.

Only the June data is presented and discussed in this report, the data for the 15 May to 30 June period is provided in Appendix B, together with the detailed yearly data for the June period.

Like most rainfall data the extracted data had many small values, a moderate number of modest values and a few very large values. Consequently the distribution of the data is highly skewed to the right as the histogram of the data from 1957 to 2006 illustrates (Figure .).

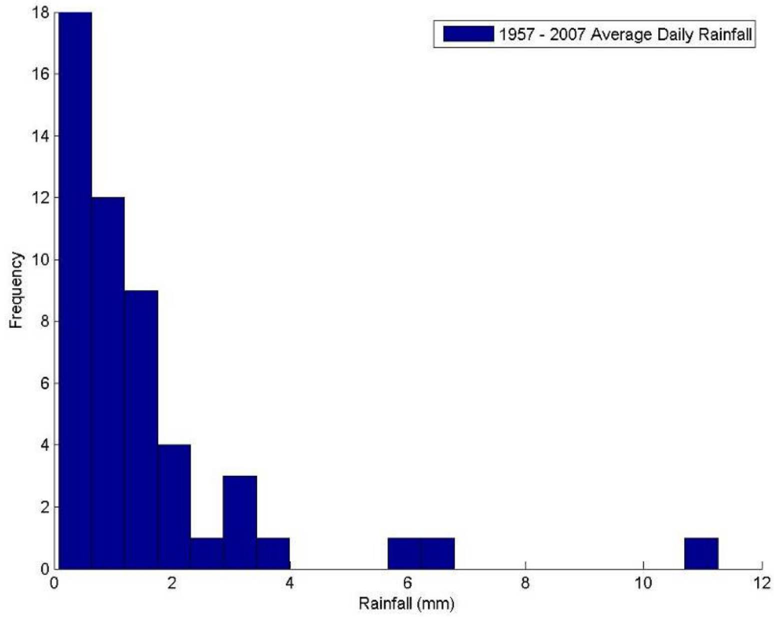

Figure .: Histogram of 1957 - 2007 Average Daily Rainfall for the period 1 June - 30 June

It is standard practice to transform such data by taking the logarithms and analysing the log data as though it were normally distributed. This was done here; indeed the transformed data was tested and found to be approximately normal (using the Anderson-Durbin test for normality).

In the work that follows the plots of the rainfall data are for the complete period (or relevant subsets) from 1957 to 2007. The analysis is in terms of the transformed log data and is performed on the historical data 1957-2006 and the 2007 results are then compared to these in terms of a confidence interval for the mean rainfall and percentile value. The confidence intervals are reported in terms of the transform units and the percentiles are calculated from the estimated normal distribution of the transform data. An interpretation of the results is given.

5.2.5 Statistical analysis of historic rainfall in the period of 1 June to 30 June

Figure . displays the daily rainfall for the period 1957 to 2007 for the BoM stations in and around the catchment. A summary of the statistical analysis of this data is provided in Table ..

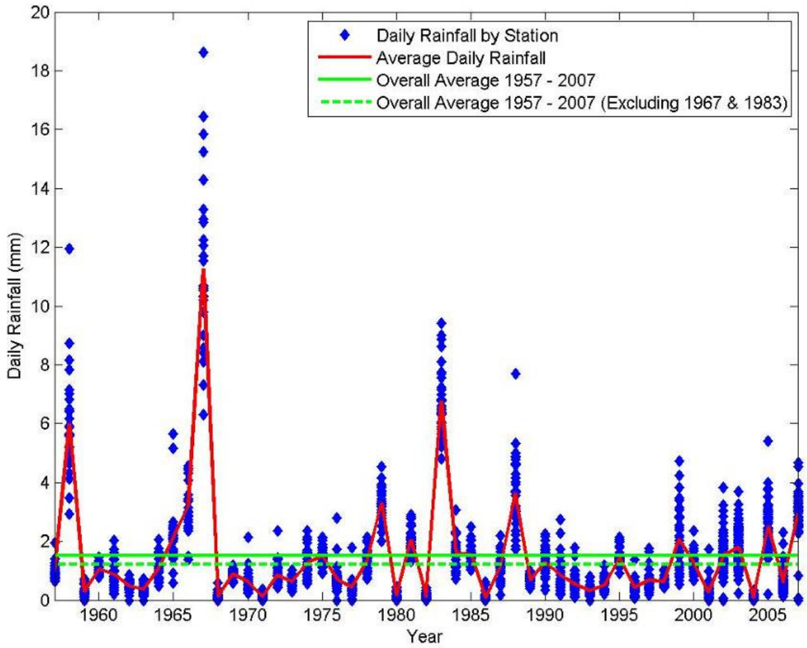

Figure . - Plot of 1957 – 2007 daily rainfall data for 1 June - 30 June.

Some observations from this plot are:

- There are two very high peaks in 1967 and 1983
- Since the early 1990's there has been low rainfall in a roughly oscillating pattern
- 2007 average rainfall is higher than in any year since 1988

Table .: Descriptive statistics of the average daily rainfall (mm)

Year	Mean	Median	St. dev.	Min	Max
1957 – 2006	1.48	0.88	1.95	0.08	11.25
1957 – 2006 excluding 1967, 1983	1.17	0.86	1.11	0.08	6.01

The daily average rainfall for June 2007 was 2.93 mm, which is nearly twice the mean value for the same month of all the 50 years prior to 2007.

The 95% confidence interval for the mean of the transformed average daily rainfall data does not contain the 2007 value of 2.93 (log(2.93) = 1.08), indicating that the June 2007 rainfall was significantly higher than the long-term average (Table .). The June 2007 log data value is at the 87th percentile (upper 15%) and 90th percentile (upper 10%) of the estimated normal distribution of the log data for 1957-2007 and 1957-2007 (excluding 1967,1983), respectively. This again supports the observation above that June 2007 was statistically an unusually wet period, with only 5-8 years of the last 50 years having similar of higher rainfall in June.

Table .: 95% confidence intervals for the log data (transformed data) and percentile for the estimated normal distribution.

Year	Confidence Interval (log data)	Percentile 2007
1957 – 2006	(-0.480, 0.132)	90%
1957 – 2006 excluding 1967, 1983	(-0.558, 0.015)	87%

To more specifically compare the June 2007 data with more recent years, the period 1992 – 2007 is plotted in Figure .. This graph also shows the daily rainfall averages over the last 51, 16, 11 and 8 years, respectively.

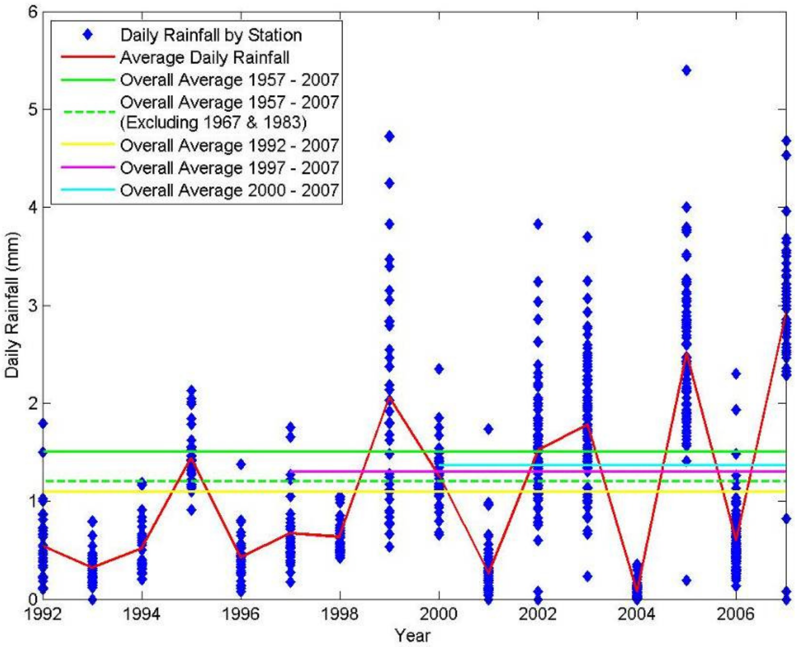

Figure .: Plot of 1992 – 2007 average daily rainfall for 1 June - 30 June.

From the plot for the recent subset of years the following observations can be made:

- The averages over the last 8 to 16 years (including 2007) are all below the long term average over the last 50 years.
- The June 2007 data point is the highest in this period, but only marginally higher than 2005.
- An oscillating pattern seems to have developed in recent years.

To compare the data until 2006 with the current June 2007 values, the following statistics can be calculated.

Table .: Descriptive statistics of the subsets and whole period 1957-2006 (in mm).

Year	Mean	Median	St. Dev.	Min.	Max.
1992 – 2006	0.98	0.64	0.74	0.08	2.51
1997 – 2006	1.14	0.96	0.81	0.08	2.51
2000 – 2006	1.14	1.26	0.88	0.08	2.51
1957 – 2006	1.48	0.88	1.95	0.08	11.25

Comments for 1992 – 2006, 1997 – 2006 and 2000 – 2006 results:

- Since the time spans overlap there is a fair degree of consistency across the data sets.
- The median is less than the mean for most data sets, indicative of a right skewed distribution.
- The maximum value for all subsets of years is 2.51 mm which is less than the 2007 value of 2.93 mm.
- The minimum value for the last 50 years was very recently (in 2004), and 9 of the last 15 years had values below the long-term median.

The same analysis as above has been undertaken for the whole test period of 15 May to 30 June (see Appendix B). There was very little change in the outcomes and none of the conclusions were affected in comparison to the June only data.

The overall analysis of this data shows that:

- June 2007 (as well as the overall test period May/June 2007) was an unusually wet period compared to long-term averages for the same month, with the mean daily rainfall amount nearly double that of the long-term average and in the top 10%-ile of the 50-year data across the region.
- The recent 15 years (1992-2006) had a considerably lower rainfall amount than the long-term average, with the mean daily rainfall more than 30% lower in this time span compared to the 50-year average (1957-2006).
- This time-based statistical assessment leans some support to the general observations made in the previous section about the total rainfall in the area. Any possible effects of the Atlant system can not be discerned statistically in this small test study, a more extensive and longer-term study would be required to identify such effects using time-based statistical comparisons.

6 Meteorological and Climatological Observations

Hamish McGowan
Jurg Keller

6.1 Background

6.1.1 Recent drought situation in Australia

Severe and prolonged drought has affected most of eastern Australia for the past 5 to 7 years with rainfall deficiencies in southeast Queensland exceeding those of the Federation drought between 1898 and 1903 (Figure .). This diagram (Day, 2007) shows that for the Wivenhoe dam catchment the cumulative rainfall deficit from April 2001 to May 2007 exceeded 1500 mm before recovering slightly in June to 1478mm. This situation is considerably worse than during the Federation drought, which broke in April 1903 (after 61 months) following a rainfall deficit of approximately 1250 mm.

Figure .: Comparison of the accumulated rainfall deficit in the catchment area to the west of Brisbane during the current drought (from April 2001 to June 2007) with the previous worst drought (from April 1898 to April 1903) (adopted from Day, 2007).

The ongoing severity of this drought, in spite of late autumn rains in some regions was highlighted in the National Climate Centre (NCC) Drought Statement, issued 3 May 2007 describing the drought for the 12-month period, that despite "... the demise of the 2006 El Niño event that brought in 2007 some general improvement in rainfall across Australia, there were serious to severe rainfall deficiencies over southern and eastern Australia in a broad arc extending across south-eastern South Australia, much of Victoria, much of south-eastern New South Wales west of the Great Divide, and a large part of southeast Queensland... The worst of the long-term deficiencies are likely to remain for some time. For them to be removed by the end of July, for example, falls over the next three months would need to be in the highest 10% of the historical record in many areas, especially in Victoria and southeast Queensland" (Figure .).

The deficiencies discussed in the May Drought Statement occurred against a backdrop of multi-year rainfall deficits as shown in Figure .. This situation has severely stressed water supplies in much of eastern Australia, and has led to continued water scarcity in southwest Western Australia.

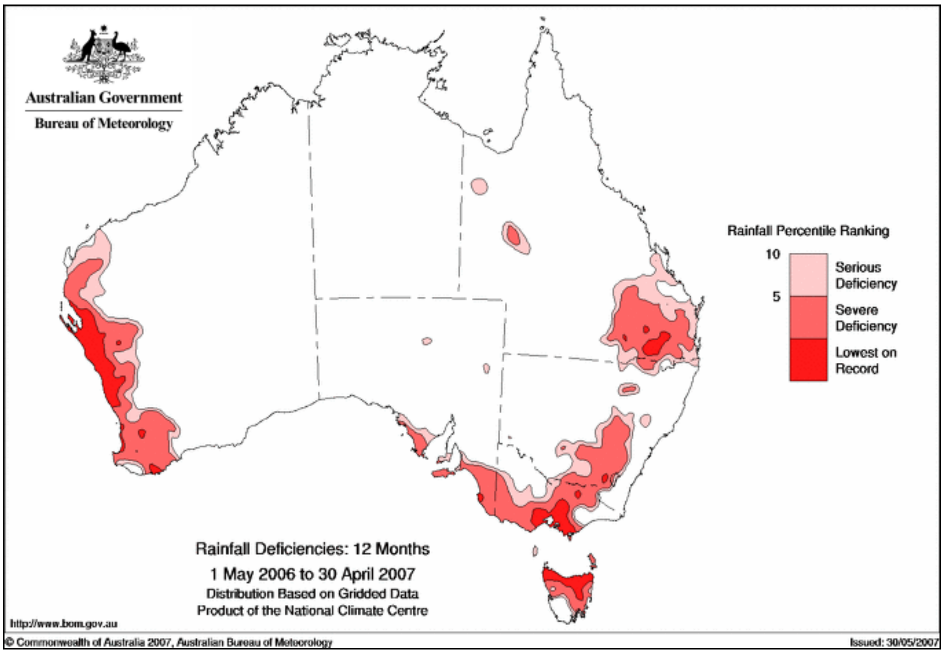

Figure .: Rainfall Deficiencies for 12 month: 1 May 2006 to 30 April 2007.

In the Drought Statement issued 4 June 2007 for the 12-month period ending 31 May 2007, the NCC declared: "Short term relief but long term drought persists. ….Autumn rainfall was average to above average over much of inland New South Wales, northern and western Victoria, Tasmania and southern South Australia, thereby providing some short-term relief to many agricultural systems and an easing of the severe drought caused in part by the 2006/07 El Niño event. However, some areas missed out [on rainfall], most notably eastern Queensland, southern Victoria and western West Australia...." (Figure .).

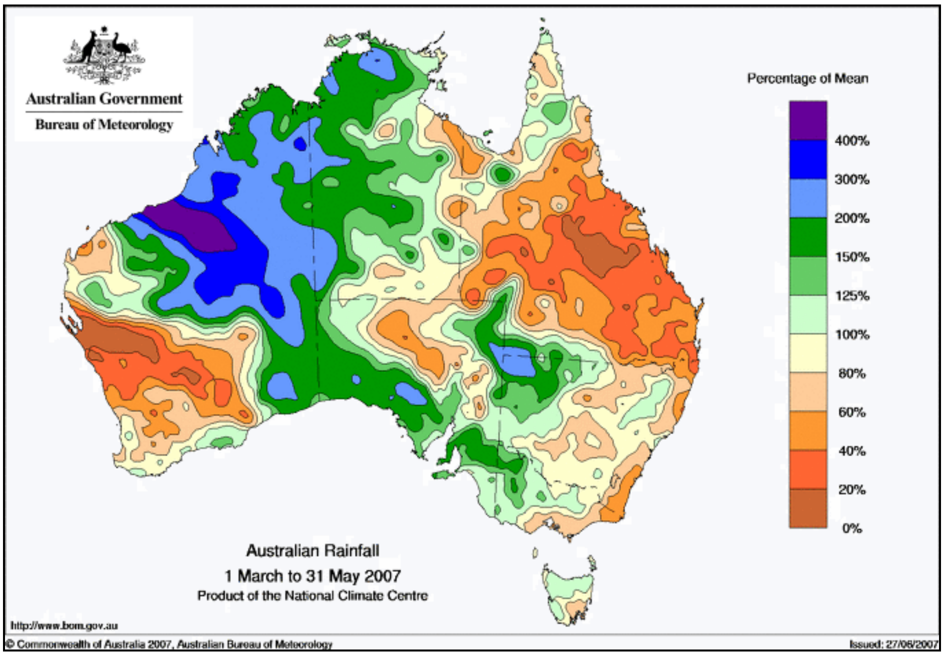

Figure .: Rainfall in Australia, 1 March 2007 to 31 May 2007.

6.1.2 Winter forecast for Australia

On 22 May 2007 the Australian Bureau of Meteorology (BoM) issued their National Seasonal Rainfall Outlook: probabilities for winter 2007, gave a 50:50 chance for above average winter rainfall. The seasonal outlook stated that: "...The national outlook for total winter rainfall (June to August), shows no strong swings in the odds towards either above normal or below-normal rainfall. Over Australia the chances of accumulating at least average rain for winter are relatively close to 50%. The pattern of seasonal rainfall odds across Australia is a result of recent higher than average temperatures (although with a cooling trend) in the tropical Pacific Ocean, and also in parts of the tropical and sub-tropical Indian Ocean. If, as computer models predict, the Pacific cools to such an extent that a La Niña forms during the next few months, subsequent issues of the seasonal rainfall outlook are likely to show increased chances of above average rainfall over eastern and northern Australia".

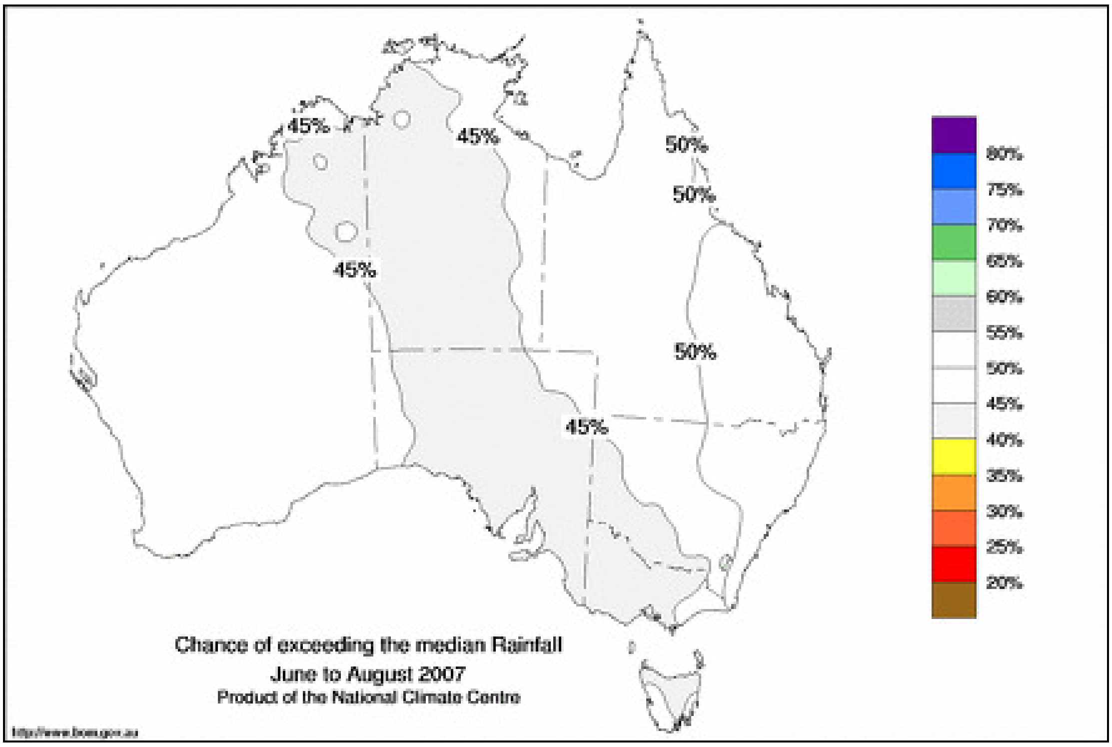

Figure .: Chance of exceeding the median rainfall for June - August 2007

The BoM statement went on to state that: "The chances of exceeding the median rainfall for the June to August period are between 40 and 45% in a band stretching from the Northern Territory across the centre and south of the continent to Tasmania (
Figure .). In other parts, the chances are between 45 and 55%. So in years with ocean patterns like the current, about five winters out of ten are wetter than average and five out of ten are drier".

6.1.3 Meteorological situation during the trial period

The trial of the Atlant system in southeast Queensland from the 17 May to 30 June 2007 was conducted under very warm conditions during May, but coincided in June with an unusually active transition from autumn to winter atmospheric circulation patterns. These included the formation of three significant East Coast Lows off the New South Wales Coast that resulted in flooding rains in regions such as Hunter Valley and Newcastle. The climatological average of these systems forming in June is less than 1. The impact of these systems on the June average mean sea level pressure field is shown in Figure ., while an extensive region of anomalously high air pressure affected most of central Australia extending south of the continent.

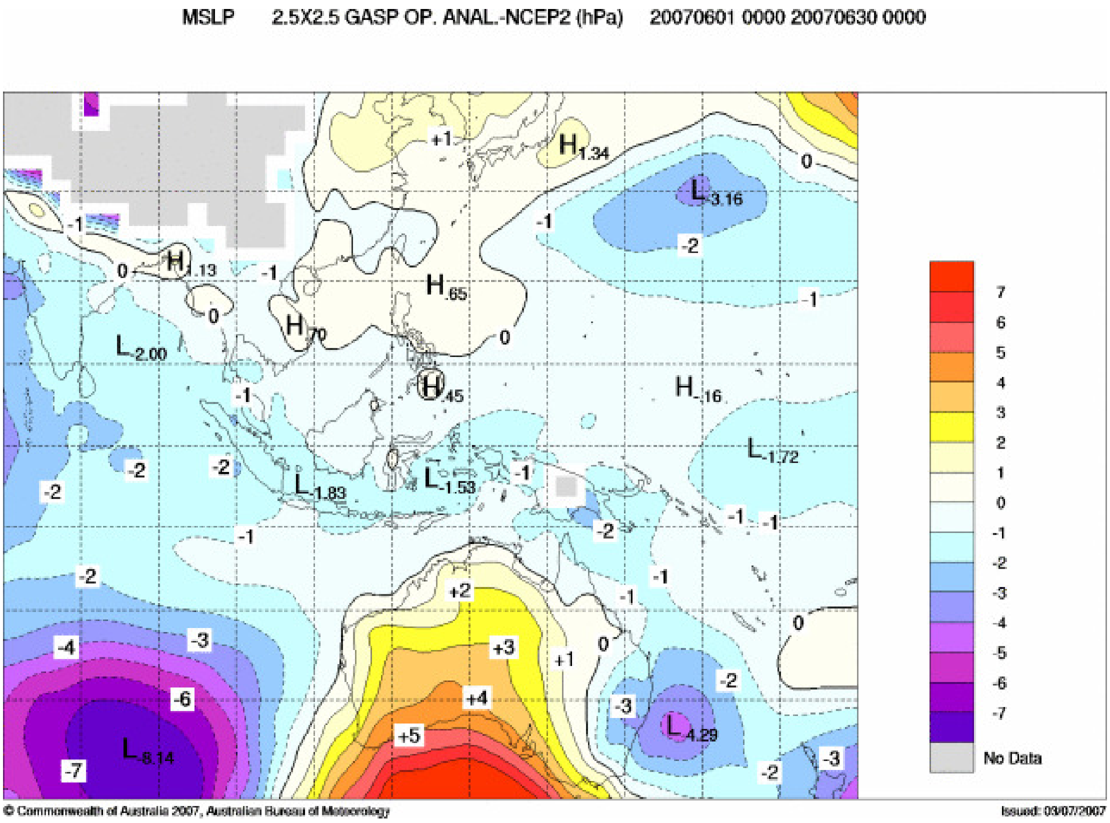

Figure .: Mean sea level pressure field anomalies 1 – 30 June 2007 showing the extensive region of uncharacteristically high surface level air pressures south of Australia and the region of lower pressure in the Tasman Sea east of the NSW coast.

6.1.4 Meteorological situation in Queensland during the trial period

The decision to conduct the trial of the Atlant system in southeast Queensland was made in response to the severe multi-year drought situation that had significantly stressed water reserves (Figure . and Figure .).

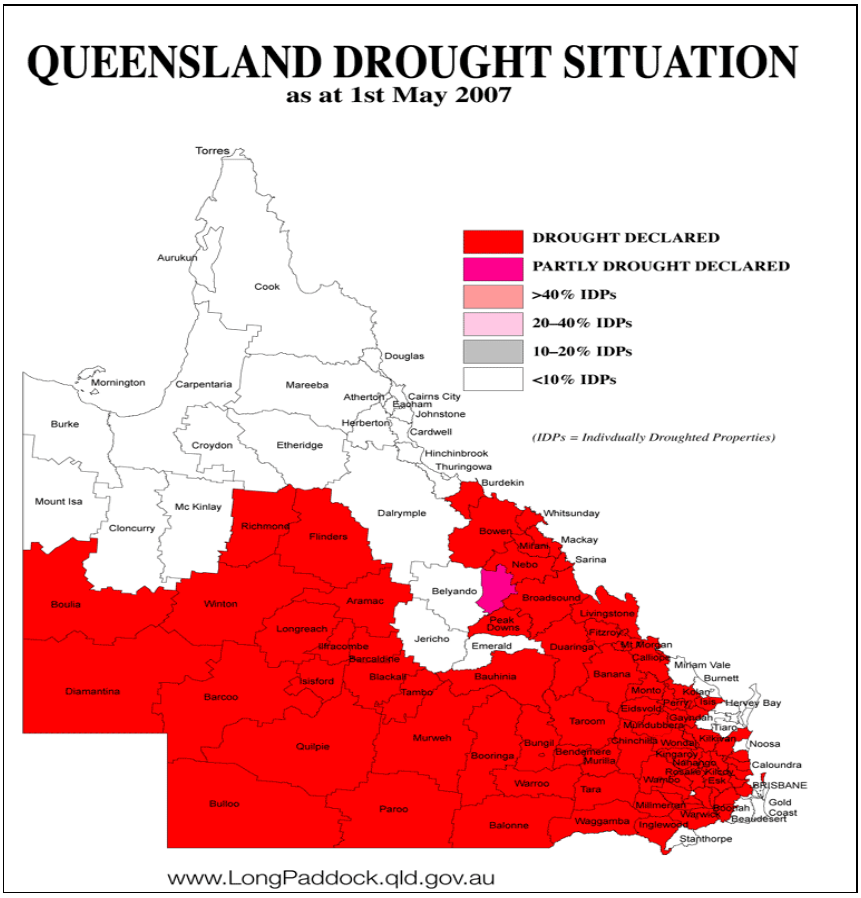

Figure .: Queensland's Drought Situation as at 1 May 2007.

According to the forecast briefings that the BoM made in early May and June, after the below average rainfall conditions in April, with a slight improvement during May - no major rainfalls in the southeast Queensland / Brisbane area were expected for the rest of May and June. However, starting in the second week of June, northern Australia experienced unseasonable rains with Queensland's area average rainfall 302% above normal.

This precipitation was associated with extensive cloud bands that formed over northern Australia in mid to upper levels of the troposphere. Enhanced westerly winds at these levels in the atmosphere along the pole ward limb of a long-wave trough contributed to the transport of this moisture in a south-easterly direction over central and southeastern Queensland.

It appears that this moisture was carried aloft by increased convection over the western equatorial Pacific (Indonesia) and northern Australia through late May and June (Figure .).

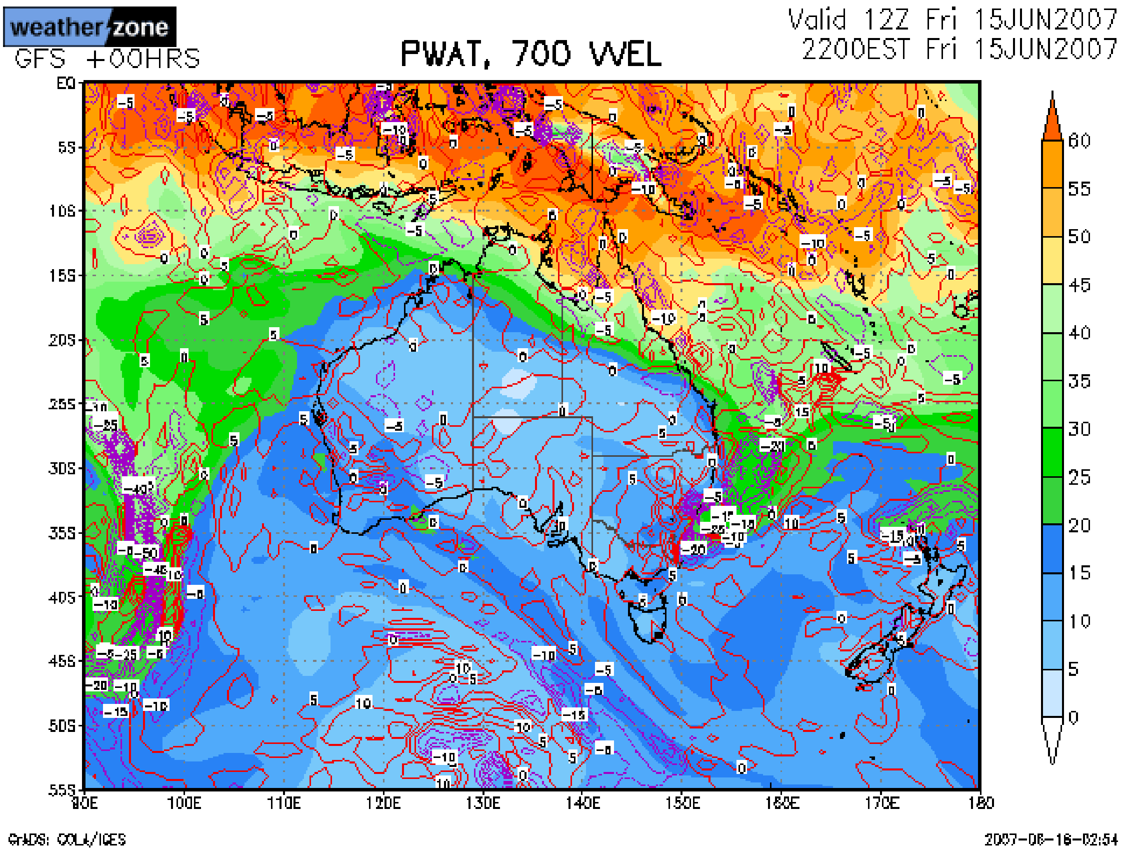

Figure .: Australia GFS Precipitable Water/700hpa for 15 June 2007 shows the vertical integral of the water content in a column of the atmosphere in mm. High values (above 40mm) indicate the potential for heavy rainfall.

This seems to have been linked to the transition from El Niño to La Niña and the associated re-organisation in ocean-atmosphere circulation across the tropical Pacific Ocean. During May and June El Niño – Southern Oscillation (ENSO) remained in a neutral phase with the mean June Southern Oscillation Index of 5.

6.2 Precipitation enhancement by atmospheric ionisation

The possible link between ions, cloud microphysical processes and weather and climate was originally addressed in the scientific literature almost 50 year ago by Ney (1959). More recently the role that cosmic rays may have in cloud formation has attracted considerable scientific interest due to the influence of clouds on the Earth's radiation budget and therefore temperature (see Carslaw et al. 2002). The basis of this research is that cosmic rays provide the only source of ions away from the Earth's surface. These ions are thought to trigger processes such as the "ion-aerosol clear air mechanism", where ion-catalysed nucleation leads to the formation of new ultrafine condensation nuclei that have the potential to grow into cloud condensation nuclei.

The Atlant system aims to enhance the role that ions are believed to have in the troposphere in nucleation and cloud microphysics by triggering and/or enhancing the presence of condensation nuclei and condensation of water vapour onto cloud condensation nuclei. The subsequent release of latent heat of condensation causes a positive feedback with the potential to cause significant cloud development and precipitation.

Therefore, a system based on these principles would seem to be best suited to operation in warm and humid environmental conditions, where the atmosphere may be conditionally unstable and require a trigger for cloud development (initialisation of convection) that may result in precipitation. Without such a trigger cloud development may not occur due to natural phenomenon such as capping inversions.

Accordingly, the Atlant system would appear to have the advantage of potentially causing cloud development and precipitation under environmental conditions where clouds are not a prerequisite for operation, while also enhancing cloud development and potentially precipitation in existing unstable atmospheric conditions where clouds are present. Furthermore, the Atlant system has the potential to influence cloud microphysical processes over a large area > 50 km radius.

6.3 Possible Atlant influence on precipitation events in SE Queensland

Throughout the Atlant trial several precipitation events occurred in southeast Queensland. While it is likely that these would have occurred irrespective of the operation of the Atlant system due to the prevailing synoptic scale circulation patterns, analysis of meteorological data, in particular the Bureau of Meteorology (BoM) Mt. Stapylton radar identified several interesting features during these events, which appeared to be consistent with the reported influence of the Atlant system on atmospheric thermodynamics.

6.3.1 Event 26-27 May 2007

The 26 May was characterised by deep east to north-easterly trade wind flow of 15 to 20 kts onto the southern Queensland coast. This was associated with an anticyclone centred in the Tasman Sea (Figure .). Embedded within this airflow were isolated stream showers. Aerological data from the Brisbane airport showed the atmosphere to be relatively dry (perceptible water content 20 mm) with a subsidence inversion at approximately 2100 m above the surface. Above this height the atmosphere became much drier.

The BoM forecast issued at 4:10PM 26 May predicted stream showers along the east coast overnight, more frequent about the northeast tropical coast with an upper level low moving over the southeast region generating enough instability for isolated thundery showers during the afternoon (27 May).

Stream shower activity along the southern Queensland coast, particularly north of Brisbane in the Noosa region has been common during the late summer/autumn 2007. However, these typically isolated showers have not produced any significant rainfall west of the coastal ranges in the Wivenhoe catchments.

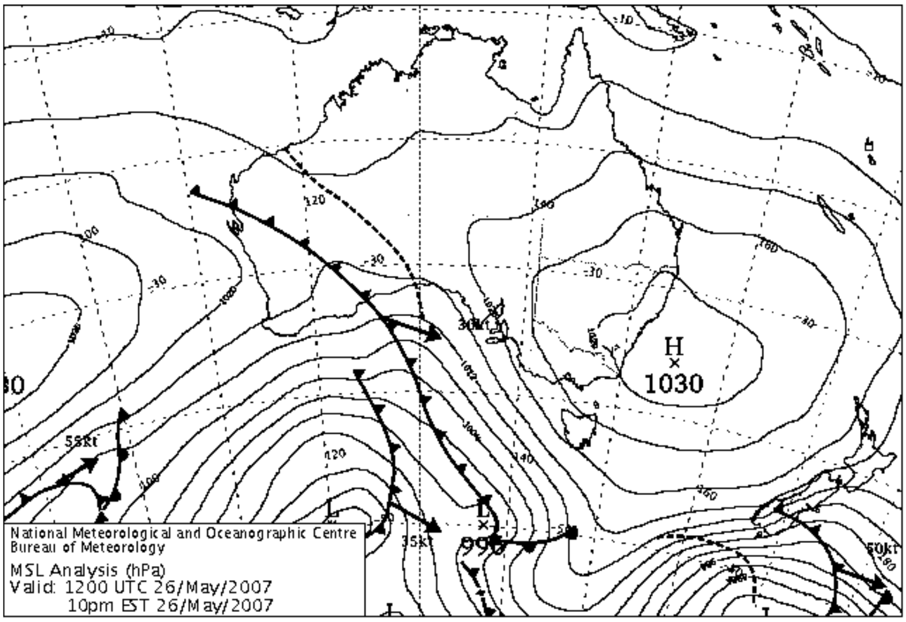

Figure .: Mean sea level analysis 10PM EST 26 May 2007.

The following four radar images show stream shower activity initially located offshore at 23:00EST (13:00UTC) 26 May (Figure .a), which then moved onshore in the prevailing north-easterly flow. As this occurred shower activity became more widespread, while showers to the south over North Stradbroke Island, Brisbane Airport etc dissipated as they moved onshore (Figure .b and Figure .c). At 5:20AM EST 27 May (19:20UTC 26 May) a more uniform region of precipitation developed with moderate to heavy rainfall (yellow) located over the Atlant installation (Figure .c). As this area of rain travelled further west-southwest away from the Atlant system it was observed to dissipate (Figure .d).

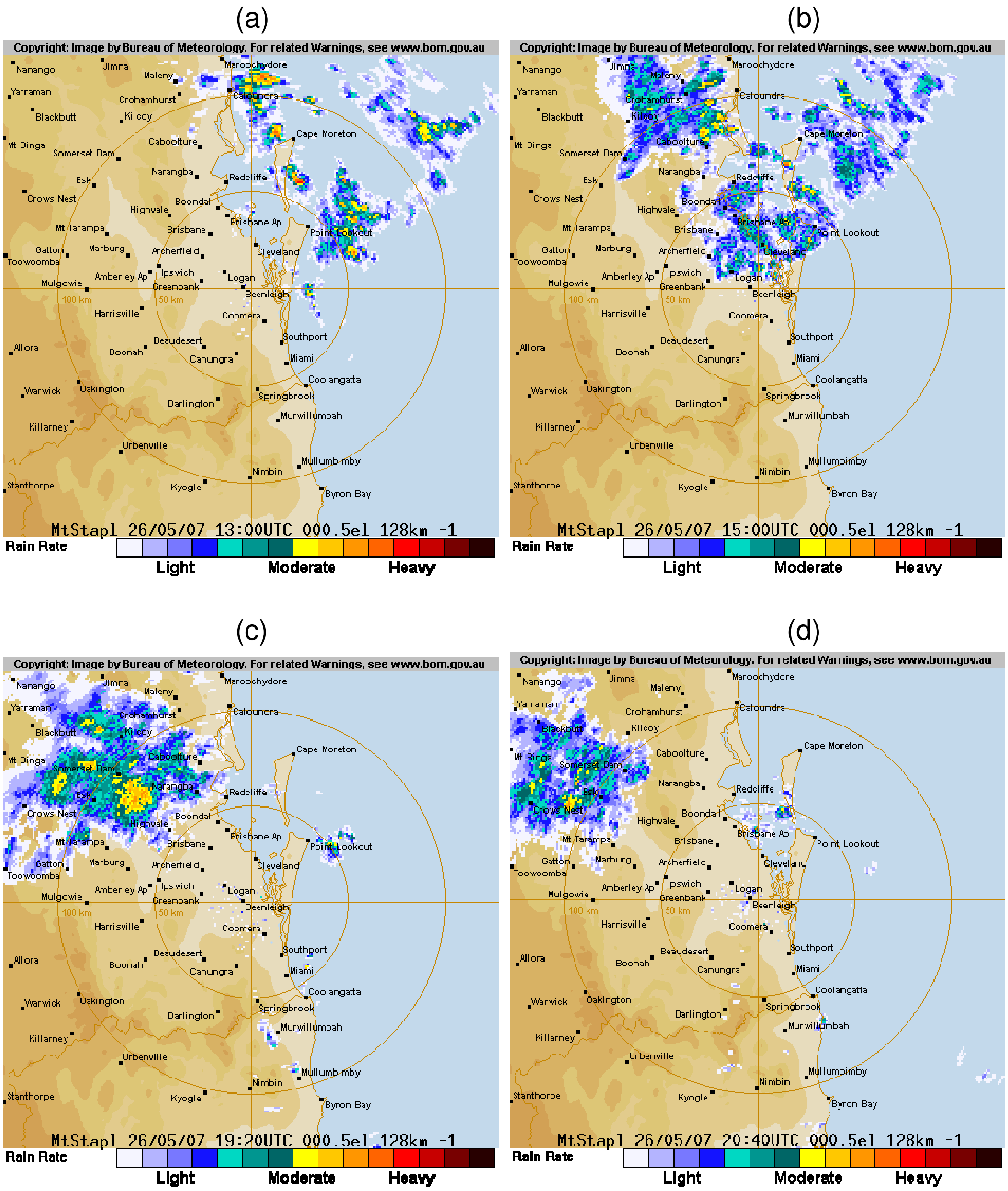

Figure .: A sequence of radar images showing isolated stream showers northeast of Brisbane (a), development of widespread showers over the coastline (b), moderate to heavy shower activity (yellow rain rate) over the Atlant system (c), decreasing rain rates as precipitation moves west of Atlant installation (d).

Similar shower activity was seen in radar imagery at approximately 23:00EST (13:00UTC) 27 May with initial isolated showers along the coast again coalescing to form a more uniform area of precipitation in the vicinity of Brisbane International Airport (southeast of the Atlant system). This area of rain travelled in a south-westerly direction over Brisbane's northern and western suburbs into the lower reaches of the Brisbane River catchment and then dissipated.

This event is notable for producing the first significant rainfall for many months in the Wivenhoe dam catchments under east to north-easterly conditions. Interestingly, stream shower activity as observed on the 26-27 May is typically confined to the coast and coastal plain in southeast Queensland. However, on this occasion it was able to penetrate inland to affect Somerset and Wivenhoe dams, which are located in the rain shadow of coastal ranges under east to north-easterly airflow.

Cumulative average rainfall in the catchment was 20 mm between 25 May 9am and 29 May 9am, but much higher localised totals of 40-80mm were recorded in the Somerset catchment area which is in proximity of the Atlant installation (see Chapter).

6.3.2 Event 6-7 June 2007

The event of the 6-7 June 2007 was associated with the development of a large cloud band over central and southeast Queensland (Figure .) associated with the passage of a mid-level trough. Mid to upper level winds over southeast Queensland were from the northwest with shower activity moving from the northwest to southeast.

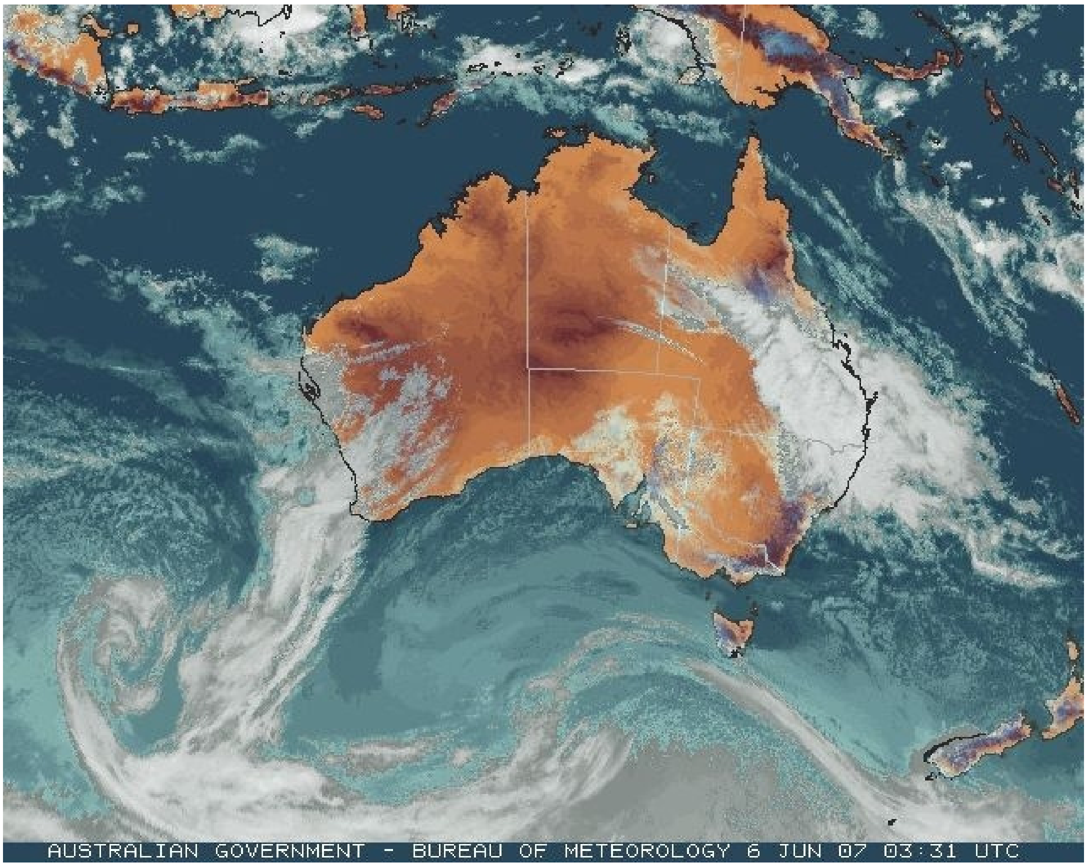

Figure .: Infrared satellite image taken at 13:31EST 6 June 2007 showing the extensive cloud cover over south-eastern Queensland.

Most computer models predicted moderate to heavy rainfalls, principally along the central Queensland coast, as a surface trough developed east of the central and southern Queensland coast on the 6 June (Figure .).

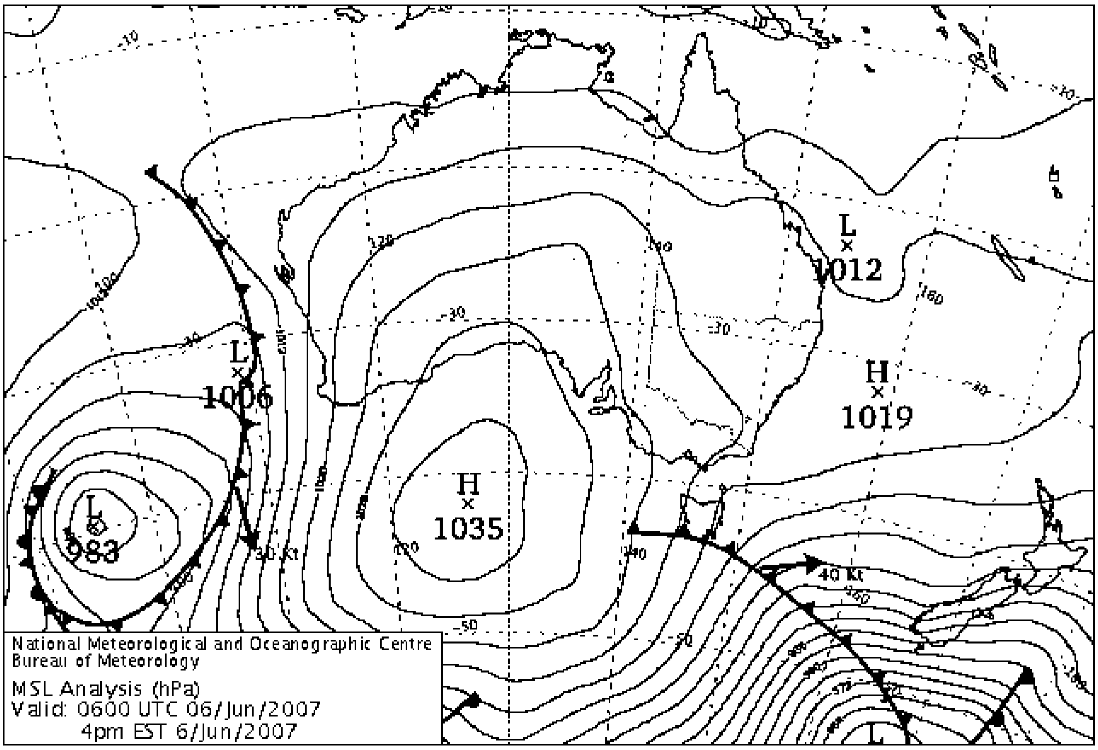

Figure .: Mean sea level analysis 4PM EST 6 June 2007 showing the developing trough located off the central Queensland coast.

The BoM forecast issued at 4:45AM 6 June stated, heavy falls over the Wide Bay District (Harvey Bay region), moderate falls over the SE (southeast Queensland including Brisbane).

A review of BoM radar images obtained for this event identified several rain bands downwind of the Atlant system travelling in a more southerly direction at approximately 25 to 30° to the prevailing north-westerly steering current.

Of particular interest was an area of more intense precipitation seen on the radar imagery (Figure .) embedded within the prevailing north-westerly shower activity. This remained almost stationary over the coastal plain northeast of Brisbane for approximately 4 hours before dissipating northeast of Moreton Island.

It did not appear to be linked to any obvious forcing mechanism such as topography or change in surface type downwind of the Atlant system. Cessation of this event occurred on the 7 June as the cloud and associated rain cleared the southern Queensland coast. Cumulative average rainfall in the catchment was 58 mm during this event (see Chapter).

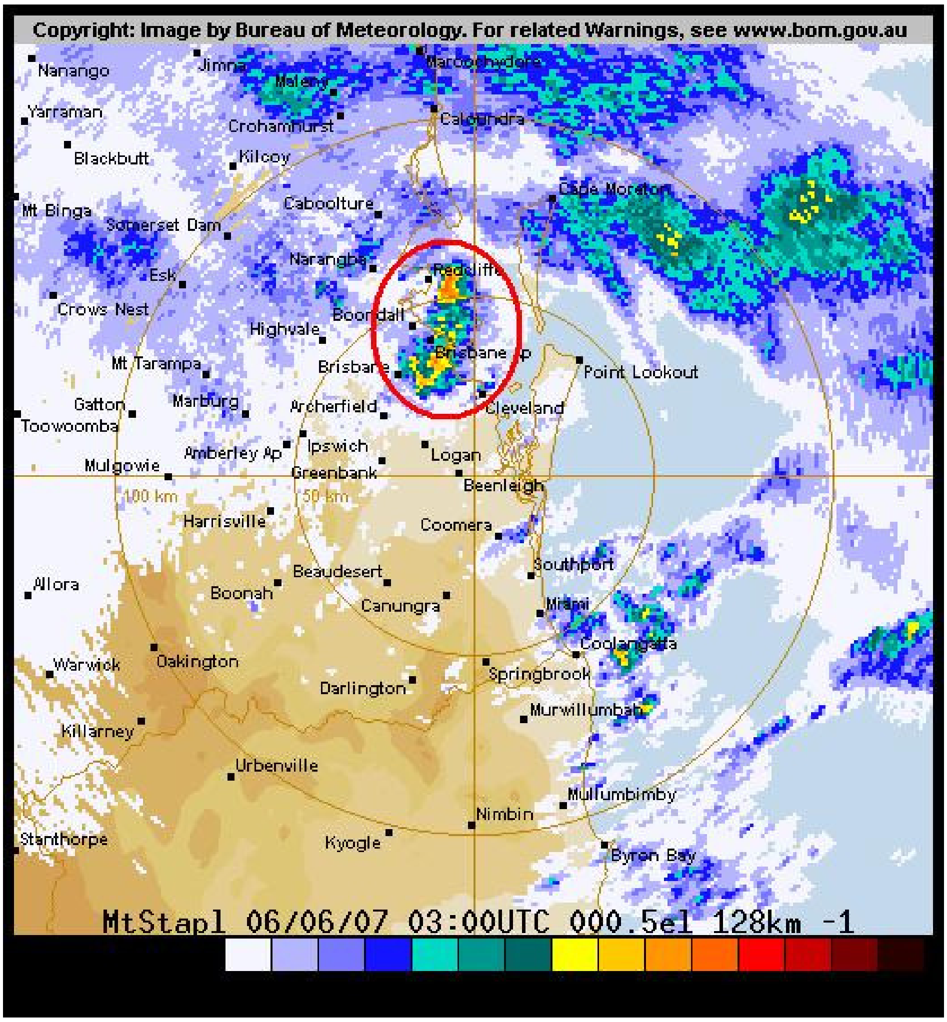

Figure .: Mt. Stapylton radar image taken at 13:00 EST 6 June 2007 with the area of higher intensity rainfall downwind of the Atlant system circled.

6.3.3 Event 25-26 June 2007

The event of the 25-26 June 2007 was similar to the 6-7 June 2007 as it was also associated with a large cloud band that developed over central and southeast Queensland (Figure .).

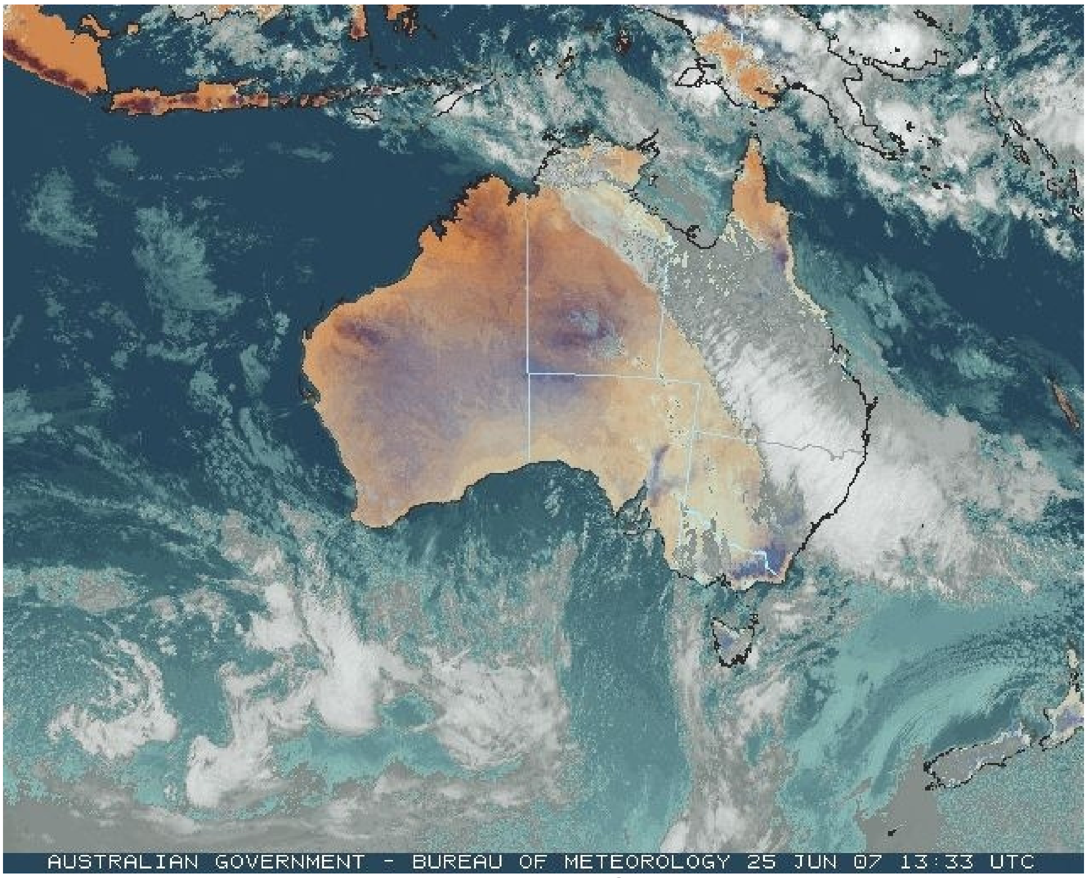

Figure .: Infrared satellite image taken at 23:33EST 25 June 2007 showing the extensive cloud cover over south-eastern Queensland.

The BoM forecast issued at 11:42AM on the 25 June stated, Scattered showers along the southeast coast will tend isolated along the remaining east coast.

Analysis of images from the BoM Mt. Stapylton radar showed the development of widespread light rain on the 25 June over coastal southeast Queensland.

An area of more intense precipitation became established in evening to the west of the Atlant installation. This contained isolated pockets of moderate to heavy rainfall (Figure .).

This feature prevailed for several hours resulting in a cumulative 46 mm of rain between 23 June 9am and 27 June 9am (see Chapter). Cessation of this event occurred on the 26 June as the cloud band and associated rain moved east of the southern Queensland coast.

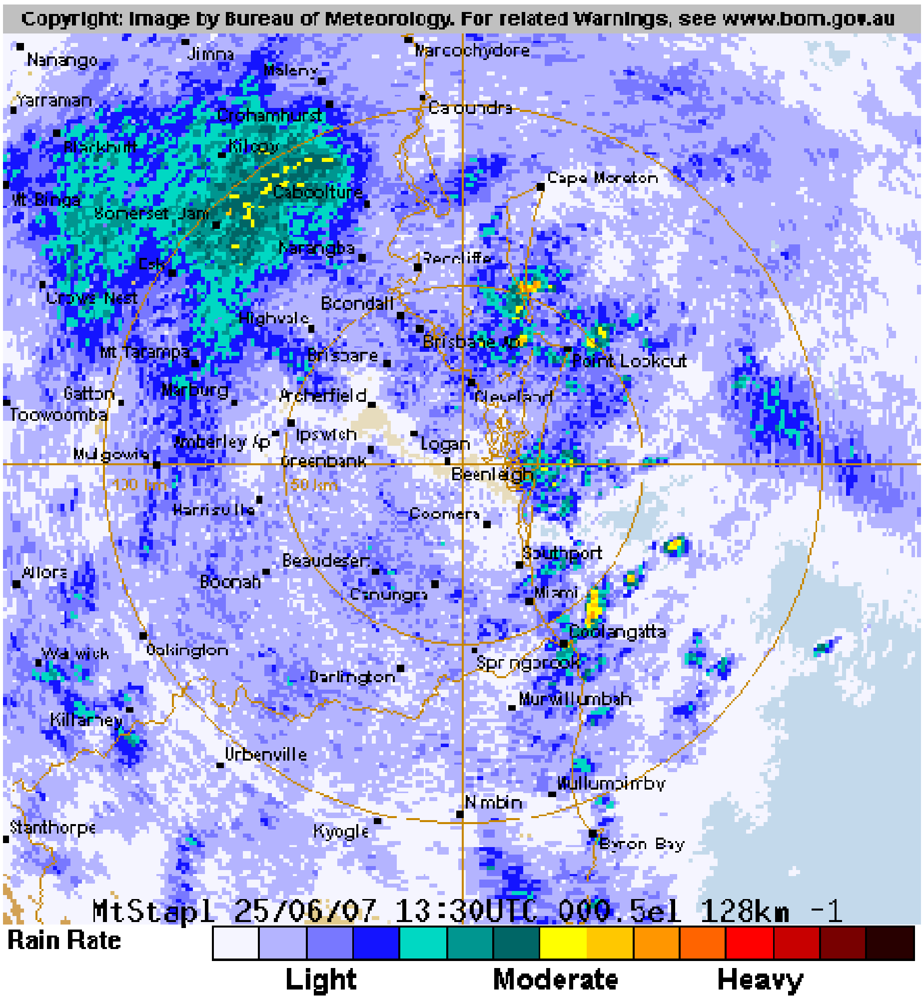

Figure .: Mt Stapylton radar image showing broad area of moderate rainfall over the Atlant system with isolated pockets of more intense rainfall (yellow), 23:30EST (13:30UTC) 25 May 2007.

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Day, K. 2007: Queensland Climate Change Centre of Excellence, *pers. comm.* and http://www.nrw.qld.gov.au/climatechange/pdf/SEQ_Drought_2007.pdf (accessed 7 Aug 2007)

Ney, E.P. 1959: Cosmic radiation and weather. *Nature*, vol. 183, pp 451-452.

7 Conclusions and Recommendation

(as included in Executive Summary)

7.1 Conclusions

Conclusions
On the basis of the observations and measurements made during the test period in southeast Queensland, the following **conclusions** can be made:

1. During the test period there were several strong rain events, whereby the Atlant operation seems to have at least enhanced the rainfall amounts as observed in rain radar images and rainfall measurements in the area.

2. The statistical evaluation of the rainfall amounts and local distribution shows both a higher total rainfall intensity in the vicinity of the Atlant system, as well as a significantly higher rainfall amounts in the catchment area compared to the surrounding stations relative to long-term historic values.

3. The total amount of rainfall registered during the 47 day test period was estimated to be around 990 GL over the dam catchment area. Although only limited run-off was generated in this instance due to the severe drought conditions in the area prior to the test, this rainfall amount is equivalent to several years water supply from Wivenhoe, demonstrating the large potential benefits of enhancing rainfall (or harvesting atmospheric humidity) as part of the overall water supply strategy.

4. The major limitation of this trial is the short duration of the operating period and the fact that it coincided with a very unusual weather situation over most of northern and eastern Australia in June. For these reasons, the findings obtained in this trial are primarily based on the professional assessment of the evaluation team using all available data and observations, but should not be seen as conclusive scientific evidence. Nevertheless, the overall findings are considered to be highly promising and encouraging.

5. While the unseasonably heavy general rainfall in Queensland in June made it difficult to isolate the extent of Atlant's impact, the data and meteorological observations were consistent with the expected influence that this technology is believed to have on rainfall generation or enhancement. There was no evidence in the test period that the Atlant system did not generate or enhance rainfall events.

7.2 Recommendation

Considering:

- the direct observations and conclusions from the test period;
- the general view of expert scientists exposed to the technology during the test period that it the underlying principles of the technology appear to be sound and the claimed impact possible (together with a general agreement that more detailed observation of electrical and other atmospheric parameters around the Atlant operations is needed);
- the severity of Australia's and the world's water scarcity and the expected impact of climate change on the rainfall situation in many areas worldwide;
- the desirability of finding break-through solutions to the world's climatological and water supply problems; and
- the urgent need for long-term, scientific evaluation of the technology, including novel methods of measuring atmospheric and meteorological processes;

it is **strongly recommended** to conduct a carefully structured and scientifically assessed demonstration project of the Atlant technology across different climatic and orographic areas over at least a full 12-month seasonal cycle in Australia.

Such a demonstration project should be designed along the following principles:

- The Atlant operation and the scientific assessment should be conducted completely independently and funded separately. The minimum duration of an Australia-wide project should be 18 months (12 months operation, 6 months set-up and evaluation) to allow observations of the expected effects over at least one full seasonal cycle.
- At least three and ideally five independent Atlant systems should be established and assessed in different climatic and geographical locations in Australia. The operating periods (months) of each system should be randomly selected and the scientific assessment should be undertaken without knowledge of the operating status (blind test).
- In at least one location two identical (as far as possible) test and control areas should be established that allow the parallel assessment of the technology during the same time period.
- The scientific evaluation should be based on direct measurements of rainfall on the ground, but also from detailed scientific studies of the atmospheric conditions during the different operating periods of the Atlant system.
- The scientific evaluation should include interdisciplinary representation from the fields of water management, meteorology, climatology, atmospheric physics and aerosol science.
- The entire test plan and evaluation should be guided and monitored by an independent "expert council" with direct reporting to a Government authority, such as the National Water Commission.

Such a detailed demonstration project will provide a high level of statistical confidence and predictability of the effects of the Atlant technology and will also allow a good evaluation of the potential benefits and limitations of the application of such rain enhancement technologies in Australia in the future.

While such an extensive evaluation will require a major funding commitment, it could lead to major breakthroughs in scientific understanding of cloud formation and the precipitation processes, as well as demonstrate the efficacy of such a technology to significantly enhance rainfall and water supply. Assuming that the demonstration project will be operated in areas of major water shortages, the resulting rainfall could provide direct drought relief and generate highly valuable inflows to water supplies in areas where currently far greater expenditures for infrastructure developments are planned or already being invested.

There is historical evidence, backed by the results documented in this paper, that the Atlant system could provide a major contribution to Australia and the world's climate and water problems. In doing so Australia has the opportunity of making a major contribution to the science and well-being of our planet.

The evaluation team confirms the applicability of Atlant technology and supports a further demonstration project to investigate and determine the efficacy of such a water harvesting technology as a complementary tool to water saving, water recycling and desalination. The team is confident the Atlant technology could provide a valuable contribution to overcoming water scarcity problems associated with the currently observed drought and/or climate change effects.

8 Appendices

8.1 Appendix A - Direct rainfall measurements

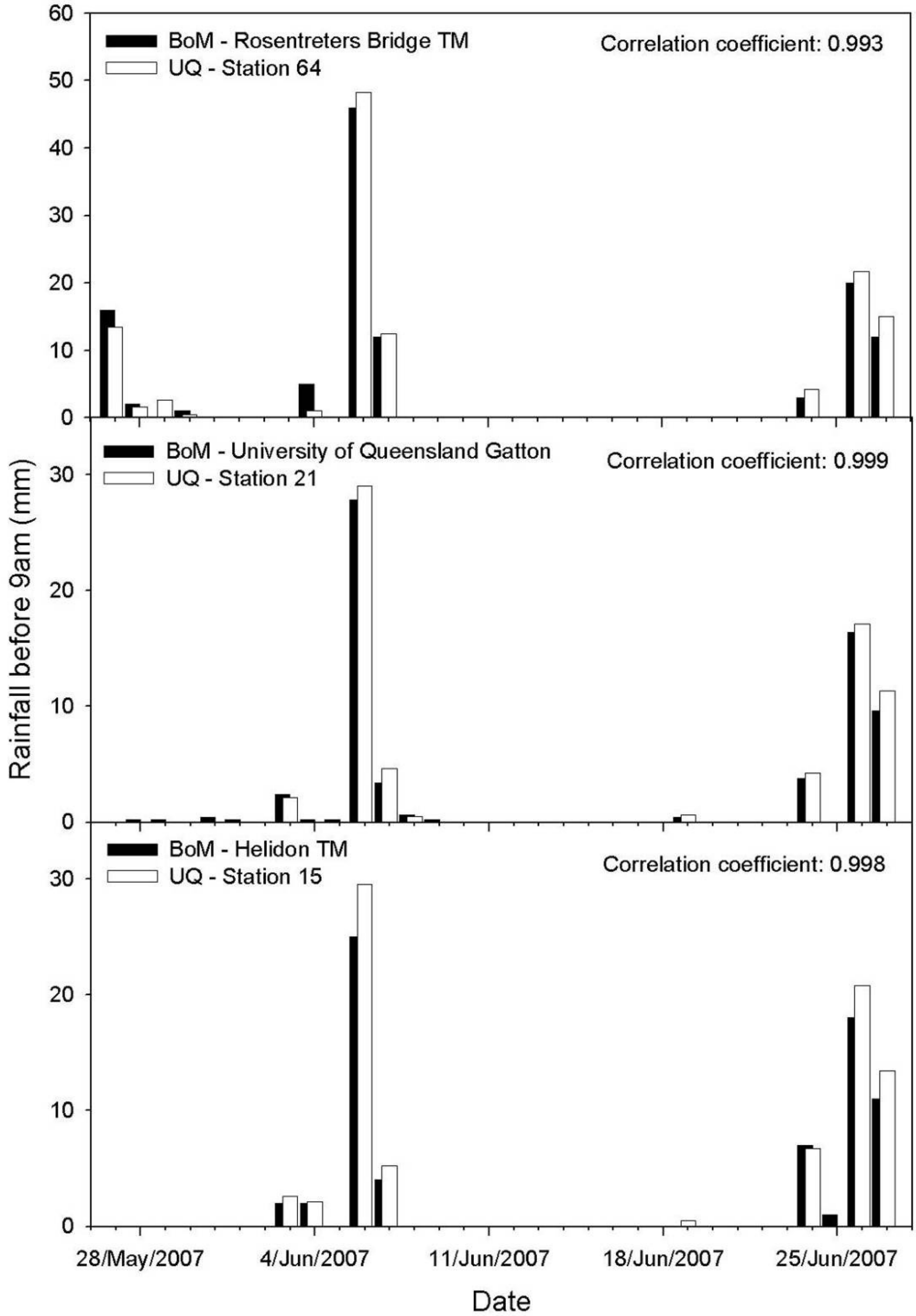

Figure .: Comparison of rainfall before 9am (mm) between adjacent UQ and BoM rain gauges and respective correlation coefficients.

Table .: Rainfall (mm) 24 hours before 9am of University of Queensland weather stations in test area (18 May – 09 June).

Station	18 May	19 May	20 May	21 May	22 May	23 May	24 May	25 May	26 May	27 May	28 May	29 May	30 May	31 May	01 Jun	02 Jun	03 Jun	04 Jun	05 Jun	06 Jun	07 Jun	08 Jun	09 Jun
St_10	0	0	0	0	1.5	0	0	0	0	1	5.7	0	0	1.5	0	0	0	0	0	53.4	6.7	0.5	0
St_11	0	0	0	0	1.5	0.5	0	0	0	0	3.6	0.5	0	1	0	0	0	0	0	45.6	5.2	3.1	0
St_12	0	0	0	0	3.6	0	0	0	0	0	1.6	0	0	0	0	0	0	0	0	27.5	4.7	0	0
St_13	0	0	0	0	2.6	0	0	0	0	0	1.1	0.5	0	0	0	0	1	0	0	36.3	3.6	1.1	1.5
St_14	0	0	0	0	4.7	0	0	0	0	0	0	0	0	0	0	0	4.1	0.6	0	32.1	3.6	2.1	0
St_15	0	0	0	2.6	5.2	0	0	0	0	0	0	0	0	0	0	0	2.6	2.1	0	29.5	5.2	0	0
St_16	0	0	0	1.6	6.7	0	0	0	0.5	0	0	0	0	0	0	0	3.7	5.1	0	27.5	5.2	0.5	0
St_20	0	0	0	0	9.8	0	0	0	0.5	0	6.8	0	0	2.1	0	0	0	0	0	55.9	6.7	0.6	0
St_21		0	0	0	4.2	0	0	0	0	0	0	0	0	0	0	0	2.1	0	0	29	4.6	0.5	0
St_22		0	0	1.1	6.2	0	0	0	1	0.5	0	0	0	0	0							0.6	0
St_23		0	0	1.6	7.2	0	0	0	0.5	0	0	0	0	0	0	0	1	8.3	0	24.9	4.6	1.6	0
St_30				0.6	1	0	0	0	0	1	6.8	2.6	0	1	0	0	0	0	0	36.8	8.3	0	0
St_31					2.1	0	0	0	0	0.5	2.6	0	0	3.1	0	0	0	0	0	33.7	6.7	0	0
St_32					2	0	0	0	1.6	2.6	0.5	0	0	0.5	0	0	0	0	0	33.7	5.7	0.5	0
St_33					2.1	0	0	0	0.5	1.5	0	0	0	0.5	0	0	0	0	0	40.5	7.2	0.5	0
St_34	0	0	0	0.5	6.2	0	0	0	1	6.2	0	0.5	0	0.5	0	0	0	2.1	0	47.7	7.2	0	0
St_35	0	0	0	1.6	4.6	0	0																0
St_36	0	0	0	1	4.7	0	0	0	0.5	2.6	0.5	0	0	0	0	0	0.6	7.7	0	27.5	6.7	2.6	0.5
St_37	0	0	0	1.5	4.7	0	0	0	1	0.6	0	0	0	0	0	0	0.5	11.9	0	18.1	4.1	4.1	0.6
St_40				1.1	0	0.5	0	0	4.6	4.2	2	0	0	0	0	0	0	0	0	28.6	12.4	0.5	0
St_41				1	0.6	0.5	0	0	0	2.6	1.5	0	0	0.5	0	0	0	0	0.5	38.4	10.3	0	0
St_50				1	3.2	0	0	0	4.6	7.3	1.5	0	0	0	0	0	0	0	0	40	15.5	0.5	0
St_51				1.1	3.1	0	0	0	10.3	6.2	1.1	0	0	0	0	0	0	0.5	0	38.8	13	0	0
St_52					11.4	0	0	0	1.5	9.3	0	0								41.9	10.9	0	0
St_53					12.9	0	0	0	1.6	6.2	0	0					0	0.6	0	33.7	8.3	0.5	0
St_57	0	0.6	0	3.6	6.7	0	0			4.2	0.5	0.5	0	0	0	0	0	8.3	0	24.3	6.3	1	1.1
St_60				1.5	9.9	0	0	0	3.6	11.9	2.1	1.5	0	0.6	0	0	0	0.5	0	49.2	17.7	0	0
St_61				1	3.7	0	0	0	1.5	18.1	2.1	2.6	0	1.6	0	0	1	0.5	0	53.9	15.5	0	0
St_62				1.5	6.3	6.2	0	0	1.5	17.1	1.6	0.5	0.5	6.2	0	0	0	0.5	0.6	50.2	15.1	1	0
St_63				1.5	5.7	0	0	0	2.6	8.8	0.5	0	0	0	0	0	0	0.6	0	47.1	11.4	0	0
St_64					8.3	0	0	0	0	13.5	1.6	2.6	0.5	0	0	0	0	1	0	48.2	12.4	0	0
St_65					6.3	0	0	0	1	13.5	0.5	0								45.1	11.4	0	0
St_66					9.3	0	0	0	1	9.9	0	0	0	0	0	0	0	3.1	0	42.4	9.9	0	0.5
St_67					13.9	0	0	0	2.6	10.9	0	0	0	0	0	0	0	6.7	0	39.4	10.4	1	0
St_70				0	1	0	0	0	0	27.5	5.2	1.5	0	0	0	1	0	0.6	0	48.1	19.2	1.6	0
St_71				2.1	2.5	0	0	0	0	20.3	2	0	0	0	0	0	0	1.6	0.5	47.7	14.5	0	0
St_72				1	1	0	0	0	0	20.2	1.6	0.5	0	0	0	0	0	0	0	46.1	14.5	0.5	0
St_73					2.1	0	0	0	0	13.9	2.6	0	0	0	0	0	0	0	0	51.3	17.1	0	0
St_75					3.7	0	0	0	0	8.8	2	0	0	0	0	0	0	1.1	0	47.1	13.5	0.5	0
St_76					5.7	0	0	0	1.5	11.4	0.5	0	0	0	0	0	0	2.6	0	39.9	10.4	0.5	0
St_80				0	3.7	0	0	0	1	33.2	9.8	1	0.6	0	0	0	0	0.5	0	46.6	20.2	0.6	0
St_82				0	3.7	0	0	0	0	10.3	3.1	2.6	0	0	0	0	0.5	0	0	49.8	18.1	0	0
St_85					3.7	0.5	0	0	0	2.6	0	0	0	0	0	0	0	0.5	0	42	14.5	0	0
St_90					1.6	0	0	0	0	44	10.9	5.7	0	0	0	0	0	3.1	0	37.8	22.8	4.1	0.5
St_91					2.6	0	0	0	0	36.7	12.5	4.6	0	0	0	0	0	2.1	0	34.7	27.5	0	0
St_92				0.5	3.6	0	0	0	0	28	9.8	4.2	0	0	0	0	0	1.5	0	41.5	22.8	0.5	0
St_93				0	4.2	0	0	0	1.5	12.5	5.1	1.1	0	0	0	0	0	0	0	43	21.7	0.5	0
St_94					2.6	0.5	0	0	1.1	12.9	2.1	0	0.5	0	0	1.5	1.6	0.5	0	42	18.1	0	0
St_95					3.6	0	0	0	0.5	9.3	1.1	0	0	0	0	0	1.5	0	0	46.6	18.1	1	0
St_96					6.7	0	0	0	0.5	6.2	0	0	0	0	0	0	0	1.6	0	40.9	18.2	0	0

Table .: Rainfall (mm) 24 hours before 9am of University of Queensland weather stations in test area (10 June – 01 July).

Station	10 Jun	11 Jun	12 Jun	13 Jun	14 Jun	15 Jun	16 Jun	17 Jun	18 Jun	19 Jun	20 Jun	21 Jun	22 Jun	23 Jun	24 Jun	25 Jun	26 Jun	27 Jun	28 Jun	29 Jun	30 Jun	01 Jul
St_10	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	9.3	0.5	18.1	16.6	0	0	0	0
St_11	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	6.2	1.1	16.5	13	1	0	0	0
St_12	0	0	0		0	0	0	0	0	0	0	0	0	0	5.7	0	19.2	11.4	0	0	0	0
St_13	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	4.1	0	18.2	11.9	0	0	0	0
St_14	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	4.6	0.5	19.2	11.4	0	0	0	0
St_15		0	0	0	0	0	0	0	0	0.5	0	0	0	0	6.7	0	20.8	13.4	0	0	0	0
St_16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10.9	0.5	20.7	9.9	0	0	0	0
St_20	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0.5	8.3	1	18.2	15	0	0	0	0
St_21	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	4.2	0	17.1	11.3	0	0	0	0
St_22	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	6.2	1.5	21.3	10.9	0	0	0	0
St_23	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	8.8	0.5	22.8	11.4	0	0	0	0
St_30	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	8.8	1.5	21.8	14.5	0	0	0	0
St_31			0	0	0	0	0	0	0	0.5	0	0	0	0	4.7	0.5	18.6	13.5	0	0	0	0
St_32	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	6.2	0.5	17.6	12.4	0	0	0	0
St_33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.2	0	21.8	13.5	0	0	0	0
St_34	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	3.6	1	21.8	13.5	0	0	0	0
St_35					0	0	0	0	0	0	0	0	0	0	7.8	3.1	24.3	14	0	0.5	0	0
St_36	0.6	0	0	0	0	0	0	0	0	0.5	0	0	0	0	9.8	0.5	26.5	15	0	2.1	1.5	0
St_37	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	9.3	0	22.3	15	0	1	1.1	0
St_40	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	9.9	2.1	20.2	15.1	0.5	0	0	0
St_41	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	6.7	0.5	17.1	12.4	0.6	0	0	0
St_50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.7	1	20.8	16.5	0.5	0	0	0
St_51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.8	0	19.2	15.5	0	0	0	0
St_52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6	0	20.2	13.5	0	0	0	0
St_53	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	2.1	0	21.2	11.4	0	0	0	0
St_57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.3	0	23.9	11.9	0	0.5	0.5	0
St_60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.7	0.5	21.8	17.1	0.5	0	0	0
St_61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.3	0.5	22.2	18.2	0	0	0	0
St_62	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	10.9	1	23.3	19.7		0	0	0
St_63	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	10.4	0	20.7	15	0	0	0	0
St_64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.2	0	21.7	15	0.6	0	0	0
St_65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.6	0.6	24.8	15.1	0	0	0	0
St_66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.1	0.5	23.3	11.4	0	0	0	0
St_67	0	0	0	0	0	0	0	0	0	0.5	0.6	0	0	0	6.7	0.5	22.8	13.5	0	0.5	0.5	0
St_70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.7	1.6	22.3	18.6	0	0	0	0
St_71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.2	0	22.3	15.6	0	0	0	0
St_72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.7	0.5	23.8	16.1	0	0	0	0
St_73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6	0	22.8	16.5	0	0	0	0
St_75	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	4.7	0.5	25.9	14.5	0	0	0	0
St_76	0	0	0	0	0	0	0	0	0	1	0	0	0	0	7.8	0	24.3	12.4	0	0	0	0
St_80	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	6.2	0.5	21.8	17.1	0	0	0	0
St_82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6	0.5	22.3	17.1	0	0	0	0
St_85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.6	0	27.5	14	0	0	0	0
St_90	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	13.4	1.1	23.8	19.2	1	0	0	0
St_91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14.5				0	0	0	0
St_92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.2	1	22.3	18.1	0	0	0	0
St_93	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	2.6	0	24.8	18.7	0	0	0	0
St_94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.1	0	22.8	17.1	0	0	0	0
St_95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.1	0.5	22.3	16	0	0	0	0
St_96	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	3.1	0	28.5	17.6	0	0	0	0

8.2 Appendix B– Comparison with historical data

Table .: Summary statistics for 1957 - 2007 daily rainfall for 1 June - 30 June

Year	Min	Q1	Median	Mean	Q3	Max	Std Dev	Std Error
1957	0.64	0.79	0.90	0.96	1.03	1.96	0.28	0.05
1958	2.94	4.95	5.64	6.01	6.73	11.96	1.80	0.35
1959	0.00	0.18	0.25	0.29	0.36	0.71	0.19	0.04
1960	0.79	0.87	1.04	1.05	1.17	1.46	0.19	0.04
1961	0.21	0.49	0.78	0.87	1.16	2.04	0.49	0.09
1962	0.00	0.37	0.54	0.49	0.64	0.86	0.21	0.04
1963	0.00	0.24	0.35	0.36	0.45	0.71	0.19	0.04
1964	0.48	0.73	0.99	1.07	1.30	2.05	0.41	0.08
1965	0.58	1.63	2.07	2.15	2.36	5.65	1.04	0.20
1966	1.38	2.67	3.09	3.22	4.07	4.58	0.89	0.18
1967	6.31	9.01	10.62	11.25	12.91	18.64	2.92	0.55
1968	0.00	0.04	0.09	0.12	0.17	0.57	0.13	0.02
1969	0.57	0.80	0.90	0.89	1.00	1.20	0.15	0.03
1970	0.24	0.35	0.53	0.61	0.70	2.14	0.39	0.07
1971	0.00	0.05	0.12	0.12	0.17	0.36	0.09	0.02
1972	0.42	0.59	0.73	0.85	1.01	2.35	0.39	0.07
1973	0.29	0.51	0.63	0.63	0.72	1.03	0.17	0.03
1974	0.57	0.93	1.11	1.27	1.61	2.35	0.47	0.08
1975	0.91	1.29	1.47	1.50	1.77	2.14	0.32	0.05
1976	0.00	0.50	0.62	0.71	0.78	2.80	0.47	0.08
1977	0.00	0.31	0.42	0.42	0.50	1.78	0.28	0.05
1978	0.73	1.01	1.29	1.31	1.53	2.14	0.35	0.06
1979	2.01	2.98	3.33	3.31	3.64	4.55	0.53	0.09
1980	0.00	0.07	0.12	0.16	0.28	0.46	0.13	0.02
1981	1.33	1.75	1.99	2.05	2.27	2.90	0.42	0.07
1982	0.00	0.00	0.07	0.10	0.17	0.43	0.12	0.02
1983	4.81	6.01	6.57	6.77	7.25	9.42	1.13	0.19
1984	0.73	1.12	1.58	1.59	1.95	3.06	0.54	0.09
1985	1.01	1.24	1.54	1.54	1.80	2.49	0.35	0.06
1986	0.00	0.00	0.01	0.08	0.09	0.61	0.15	0.03
1987	0.17	1.00	1.12	1.15	1.29	2.19	0.43	0.07
1988	1.72	2.86	3.61	3.65	4.59	7.69	1.21	0.21
1989	0.40	0.54	0.64	0.66	0.78	1.00	0.16	0.03
1990	0.35	0.90	1.22	1.29	1.62	2.26	0.50	0.09
1991	0.19	0.43	0.63	0.85	1.18	2.73	0.59	0.10
1992	0.10	0.26	0.45	0.54	0.72	1.79	0.38	0.06
1993	0.00	0.17	0.29	0.32	0.41	0.80	0.18	0.03
1994	0.20	0.33	0.41	0.52	0.66	1.19	0.26	0.04
1995	0.91	1.21	1.41	1.44	1.55	2.13	0.29	0.05
1996	0.08	0.29	0.38	0.42	0.53	1.38	0.25	0.04
1997	0.17	0.46	0.57	0.67	0.81	1.75	0.35	0.06
1998	0.42	0.50	0.63	0.64	0.71	1.05	0.17	0.03
1999	0.53	1.08	1.80	2.06	2.83	4.73	1.17	0.19
2000	0.66	1.10	1.21	1.26	1.40	2.35	0.31	0.05
2001	0.00	0.10	0.22	0.26	0.31	1.73	0.26	0.03
2002	0.00	1.17	1.41	1.52	1.77	3.83	0.60	0.06
2003	0.23	1.39	1.74	1.79	2.20	3.70	0.63	0.06
2004	0.00	0.03	0.07	0.08	0.11	0.35	0.07	0.01
2005	0.19	1.99	2.41	2.51	2.93	5.40	0.71	0.07
2006	0.13	0.38	0.53	0.60	0.73	2.30	0.34	0.03
2007	0.00	2.60	2.96	2.93	3.36	4.68	0.84	0.01

Graphic and statistical analysis over total test period of 15 May to 30 June

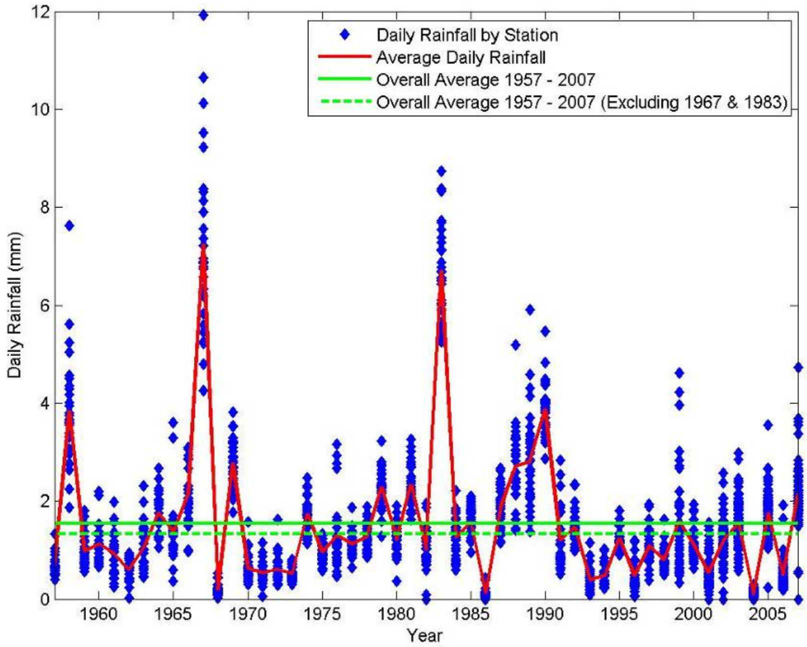

Figure .: Plot of 1957 – 2007. Daily rainfall data for 15 May - 30 June.

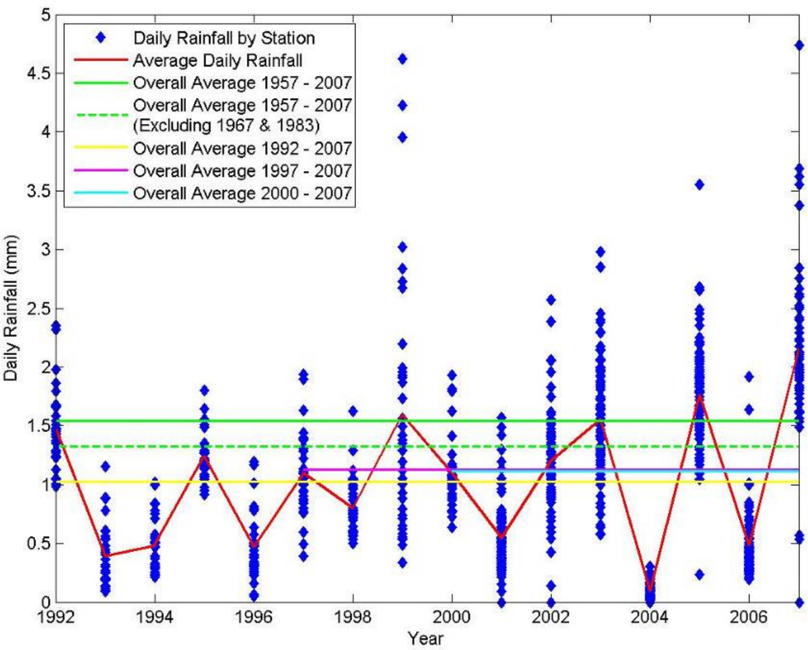

Figure .: Plot of 1992 – 2007. Daily rainfall with overall averages for 15 May - 30 June.

Table .: Descriptive statistics of the daily average raw rainfall (mm).

Year	Mean	Median	St. Dev.	Min.	Max.
1957 – 2006	1.53	1.20	1.41	0.09	7.25
1957 – 2006 excluding 1967, 1983	1.31	1.17	0.86	0.09	3.88
1992 – 2006	0.95	1.10	0.52	0.09	1.76
1997 – 2006	1.02	1.10	0.54	0.09	1.76
2000 – 2006	0.96	1.10	0.61	0.09	1.76

Table .: 95% confidence intervals for the log data (transformed data) and percentile for the estimated normal distribution.

Year	Confidence Interval (log data)	Percentile 2007
1957 – 2006	(-0.1372, 0.3384)	87%
1957 – 2006 (Excl. 1967, 1983)	(-0.1983,0.246)	90%
1992 – 2006	(-0.6927, 0.1713)	91%
1997 – 2006	(-0.8349, 0.4189)	87%
2000 – 2006	(-1.2876, 0.5984)	86%

None of the 95% confidence intervals in the above table contains the recorded 2007, log (rainfall value=2.1604), of 0.7703. Further the 2007 value has percentile values for the corresponding estimated normal distributions of between 85% (upper 15%) to 90% (upper 10%). Complete summary statistics for the period 15 May to 30 June are given in Appendix Table ..

Table .: Summary statistics for 1957 - 2007 daily rainfall for 15 May - 30 June

Year	Min	Q1	Median	Mean	Q3	Max	Std Dev	Std Error
1957	0.41	0.57	0.64	0.68	0.69	1.34	0.20	0.04
1958	1.88	3.13	3.67	3.85	4.33	7.63	1.16	0.22
1959	0.56	0.74	0.92	0.99	1.17	1.81	0.33	0.06
1960	0.66	0.85	1.10	1.13	1.34	2.20	0.39	0.07
1961	0.25	0.55	0.95	0.93	1.17	1.99	0.43	0.08
1962	0.03	0.43	0.62	0.60	0.79	0.94	0.23	0.04
1963	0.44	0.67	0.97	1.06	1.41	2.31	0.49	0.09
1964	1.05	1.32	1.76	1.76	2.04	2.68	0.43	0.08
1965	0.37	1.04	1.32	1.37	1.49	3.61	0.66	0.13
1966	0.97	1.86	2.03	2.13	2.67	3.10	0.58	0.11
1967	4.26	6.01	6.88	7.25	8.22	11.93	1.82	0.34
1968	0.02	0.11	0.16	0.19	0.24	0.53	0.12	0.02
1969	1.77	2.47	2.79	2.79	3.18	3.83	0.48	0.09
1970	0.30	0.46	0.57	0.63	0.69	1.58	0.27	0.05
1971	0.05	0.40	0.52	0.53	0.66	1.14	0.21	0.04
1972	0.28	0.44	0.52	0.61	0.77	1.63	0.27	0.05
1973	0.30	0.43	0.51	0.52	0.56	0.81	0.13	0.02
1974	1.13	1.48	1.76	1.74	1.93	2.47	0.35	0.06
1975	0.58	0.82	0.93	0.96	1.13	1.34	0.21	0.04
1976	0.47	0.86	1.10	1.30	1.47	3.17	0.73	0.13
1977	0.65	0.97	1.12	1.13	1.23	1.87	0.23	0.04
1978	0.85	1.02	1.27	1.27	1.46	1.90	0.27	0.05
1979	1.28	2.04	2.31	2.29	2.55	3.23	0.38	0.06
1980	0.36	1.02	1.21	1.21	1.39	1.90	0.31	0.05
1981	1.63	2.03	2.30	2.34	2.69	3.26	0.42	0.07
1982	0.00	0.79	0.90	1.01	1.25	1.96	0.41	0.07
1983	5.25	6.05	6.62	6.71	7.38	8.73	0.91	0.16
1984	0.60	0.88	1.26	1.25	1.47	2.22	0.40	0.07
1985	0.96	1.39	1.59	1.58	1.80	2.10	0.29	0.05
1986	0.00	0.04	0.09	0.11	0.13	0.44	0.11	0.02
1987	1.15	1.54	1.88	1.88	2.20	2.67	0.41	0.07
1988	1.41	2.27	2.71	2.71	3.26	5.20	0.75	0.13
1989	1.38	2.10	2.64	2.81	3.27	5.91	0.96	0.16
1990	2.88	3.55	3.89	3.88	4.07	5.47	0.51	0.09
1991	0.51	0.79	0.94	1.20	1.43	2.83	0.59	0.10
1992	0.99	1.27	1.45	1.48	1.66	2.35	0.32	0.05
1993	0.09	0.20	0.31	0.39	0.53	1.16	0.26	0.04
1994	0.21	0.29	0.47	0.48	0.58	1.02	0.23	0.04
1995	0.91	1.14	1.20	1.24	1.29	1.80	0.20	0.03
1996	0.05	0.31	0.40	0.47	0.56	1.20	0.27	0.05
1997	0.39	0.87	1.06	1.10	1.31	1.94	0.34	0.06
1998	0.50	0.60	0.75	0.80	0.93	1.62	0.23	0.04
1999	0.34	0.73	1.35	1.59	1.97	4.62	1.08	0.18
2000	0.63	0.94	1.06	1.10	1.15	1.93	0.29	0.05
2001	0.00	0.35	0.49	0.55	0.69	1.57	0.30	0.03
2002	0.00	0.96	1.15	1.20	1.41	2.57	0.41	0.04
2003	0.57	1.22	1.56	1.56	1.90	2.98	0.49	0.05
2004	0.00	0.04	0.09	0.09	0.13	0.30	0.07	0.01
2005	0.23	1.46	1.78	1.76	2.03	3.55	0.46	0.05
2006	0.19	0.32	0.42	0.48	0.57	1.91	0.26	0.03
2007	0.00	1.81	2.02	2.16	2.48	4.74	0.75	0.01

8.3 Appendix C - BoM data sample

The sample below is an excerpt of comma-delimited daily historical data as provided by the Australian Bureau of Meteorology (station 40004, years 2004 – 2005, first 5 days of each month):

```
dr,001,040004,2004, 1,0,0, 152.8,15,   0.0,  , ,   0.0,  , ,   0.0,  , ,   1.8, 1, 1,   3.6, 1, 1, ...
dr,001,040004,2004, 2,0,0, 138.0, 7,   0.0,  , ,   0.0,  , ,  68.0, 1, 1,   6.2, 1, 1,   0.2, 1, 1, ...
dr,001,040004,2004, 3,0,0, 110.0, 8,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , , ...
dr,001,040004,2004, 4,0,0,  40.0, 8,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.4, 1, 1, ...
dr,001,040004,2004, 5,0,0,  13.2, 3,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , , ...
dr,001,040004,2004, 6,0,0,   2.4, 3,   0.4, 1, 1,   0.6, 1, 1,   0.0,  , ,   0.0,  , ,   0.0,  , , ...
dr,001,040004,2004, 7,0,0,   3.8, 2,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , , ....
dr,001,040004,2004, 8,0,0,  15.6, 6,   0.0,  , ,   0.0,  , ,   1.4, 1, 1,   0.0,  , ,   0.0,  , , ....
dr,001,040004,2004, 9,0,0,  22.4, 7,   7.4, 1, 1,   5.6, 1, 1,   0.0,  , ,   0.0,  , ,      , , , ...
dr,001,040004,2004,10,0,0,  81.6, 7,   0.0,  , ,   0.6, 1, 1,   0.0,  , ,   0.0,  , ,   0.0,  , , ...
dr,001,040004,2004,11,0,0, 144.3,10,   0.0,  , ,   0.0,  , ,   0.0,  , ,   2.2, 1, 1,   0.0,  , , ...
dr,001,040004,2004,12,0,0, 118.7,14,   0.0,  , ,   0.0,  , ,   0.4, 1, 1,   0.0,  , ,   0.0,  , , ...
dr,001,040004,2005, 1,0,0,  74.4, 9,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , , ...
dr,001,040004,2005, 2,0,0,  17.1, 2,   0.0,  , ,   0.0,  , ,  15.6, 1, 1,   0.0,  , ,   0.0,  , , ...
dr,001,040004,2005, 3,0,0,  16.8, 7,   1.0, 1, 1,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , , ...
dr,001,040004,2005, 4,0,0,   9.0, 5,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , , ...
dr,001,040004,2005, 5,0,0,  35.7, 8,   0.0,  , ,   0.0,  , ,   1.0, 1, 1,   0.0,  , ,   0.0,  , , ...
dr,001,040004,2005, 6,0,0,  65.1, 8,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , , ...
dr,001,040004,2005, 7,0,0,   3.5, 5,   1.8, 1, 1,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , , ...
dr,001,040004,2005, 8,0,0,   7.7, 4,   0.0,  , ,   0.0,  , ,   0.0,  , ,   0.0,  , ,   1.2, 1, 1, ...
dr,001,040004,2005, 9,0,0,  23.5, 7,   0.0,  , ,   0.0,  , ,      , , ,      , , ,   4.3, 2, 1, ...
dr,001,040004,2005,10,0,0, 156.3,15,      , , ,   6.0, 2, 1,   0.0,  , ,   0.0,  , ,   0.0,  , , ...
dr,001,040004,2005,11,0,0,  64.9,14,   0.0,  , ,   0.2, 1, 1,   0.0,  , ,   3.9, 1, 1,      , , , ...
dr,001,040004,2005,12,0,0,  83.1, 8,   0.3, 1, 1,   1.0, 1, 1,   2.4, 1, 1,   0.0,  , ,   0.0,  , , ...
```

The file is formatted as follows:
Byte 1-2: Identifying code (dr)
Byte 4-6: Record code (001 means the record gives data details)
Byte 8-13: Bureau of Meteorology station number (000000-599999)
Byte 15-18: Year
Byte 20-21: Month (1-12)
Byte 23-23: Quality flag
Byte 25-25: Automatic weather station (0 = no, 1 = yes)
Byte 27-32: Monthly precipitation total (mm to 0.1, or null)
Byte 34-35: Monthly count of raindays (0-31, or null)
Byte 37-42: Precipitation for day 01 (mm to 0.1, or null)
Byte 44-45: Days of accumulation for day 01 (0-31, or null)
Byte 47-48: Precipitation type* for day 01 (1-6, or null)
: etc.

Byte 427-432: Precipitation for day 31 (mm to 0.1, or null)
Byte 434-435: Days of accumulation for day 31 (0-31, or null)
Byte 437-438: Precipitation type* for day 31 (1-6, or null)
Byte 439-439: Indicates the end of the record (#)

*) 1 rain, 2 fog 3 frost, 4 dew, 5 trace, 6 snow, 7 other

The Australian Bureau of Meteorology also provided longitude and latitude for each station.