APPLICATION OF WIRELESS SENSOR NETWORKS TO COASTAL OBSERVING SYSTEMS, AN EXAMPLE FROM THE GREAT BARRIER REEF

Scott Bainbridge[(1)] **and Damien Eggeling**[(1)]

[(1)]*Australian Institute of Marine Science, PMB 3 MC, Townsville Qld 4810 Australia, s.bainbridge@aims.gov.au*

1. INTRODUCTION

The Great Barrier Reef Ocean Observing System (GBROOS) is an observation system that seeks to understand the impact of the Coral Sea, in particular cool and warm water intrusions, on the Great Barrier Reef (GBR) of north eastern Australia. GBROOS is a regional node of the Australian Integrated Marine Observing System (IMOS) [1]. One component of GBROOS is the deployment of wireless sensor networks at seven reefs along the GBR.

Sensor networks have the potential to provide large amounts of cost effective real-time data from a range of sensors but most existing applications have focused on small scale terrestrial deployments. GBROOS looks to apply these new technologies to remote marine systems to better understand the thermal events that lead to coral bleaching and how the exchange of water from outside the reef impacts local conditions within the reef.

2. MATERIALS AND METHODS

Seven reefs along the GBR will be instrumented; current deployments include Heron and One Tree Islands in the southern GBR and Davies Reef in the central GBR. Rib and Myrmidon Reefs, also in the central GBR, and Lizard Island in the northern GBR, will be completed by mid 2010.

At each site a base station is installed using existing towers or platforms. A high speed IP based data link is installed back to the mainland using 3G phone networks, line of sight microwave or surface ducted microwave [2]. Around the reef lagoon six metre steel relay-poles are placed to create the wireless network with one of the poles also housing a Vaisala WXT520 weather station [3]. Into the wireless network are deployed moored buoys onto which the main sensors are attached using a mix of inductive modem technology and simple cables.

An example deployment from One Tree Island is shown in Fig. One. The main lagoon has a number of small circular coral micro-atolls. A relay pole is installed in the centre of the micro-atoll and a sensor string run from the pole across to the edge of the atoll, up and over the rim and down into the main lagoon. This gives a vertical profile down the atoll wall as well as measurements within the atoll and the lagoon. This design is repeated in each of the three main sub-lagoons within the reef.

The design uses a cheaper thermistor string coupled with more expensive oceanographic grade instruments with a SeaBird SBE39 [4] located within the atoll and a SeaBird SBE37 [4] deeper in the lagoon (Fig. One). The SeaBird instruments act as a reference for the cheaper thermistors. The instruments are monitored by an intelligent controller that controls the sampling rates, coordinates the collection of data and monitors the battery life. Data are collected every ten minutes and sent, via the base station, back to the main data centre.

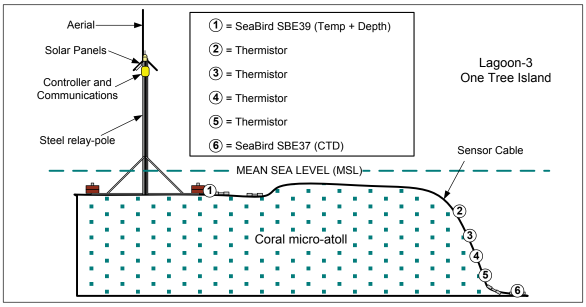

Figure One. Example deployment from One Tree Island.

Automated quality control is done to identify bad data using the International Oceanographic Data and Information Exchange (IODE) quality control flags [5]. This produces a 'Level-1' product that is available in near-real time. Every month the data is manually reviewed and corrected to produce a Level-2 product, higher level summary products are also produced. The quality control system is also used to detect events such as anomalous temperature changes and sensor failures.

3. RESULTS

The data shows the dynamics of these lagoonal reefs such as how the lagoons are mixed, under what circumstances thermal stratification occurs, the daily range of temperatures that corals get exposed to and the influence of the atmosphere on water conditions.

A good example is tropical cyclone *Hamish* which went past One Tree Island on the 9th of March 2009. The real-time data (Fig. Two) shows a drop in pressure as the cyclone moves by with a corresponding increase in wind speed. There was a marked mixing of the lagoon, the temperature profile shown in the bottom of Fig. Two shows a stratified pattern before the cyclone (black line is surface temperature, dark-grey is 3m depth while the light-grey line is 6m depth) and a well mixed one after.

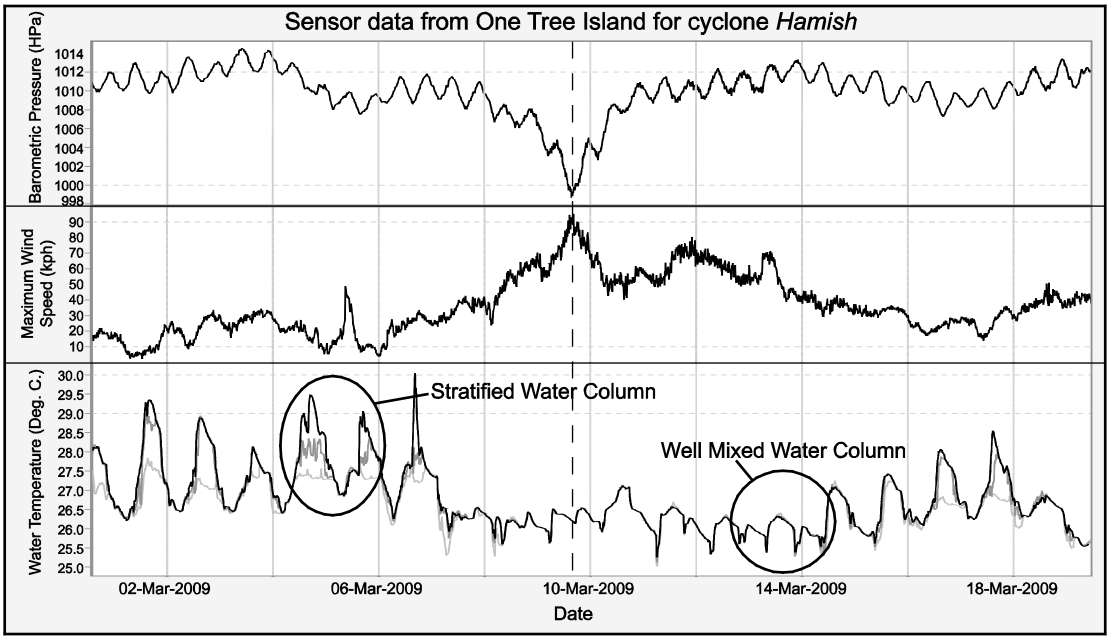

Figure Two. Real time data from One Tree Island showing the impact of cyclone 'Hamish'.

4. DISCUSSION

Sensor networks offer a new set of capabilities for observing systems including real-time data, the ability to monitor and manage sensors and instruments remotely and the ability to adaptively sample to better capture events of interest.

Most sensor network deployments have been in terrestrial environments using 'cheap and cheerful' sensors; the GBROOS project is one of the first to mix smart controllers with real-time communications and oceanographic grade instruments. This design returns scientifically robust data along with the many benefits of the new smart sensors such as rules based and adaptive sampling, central control and monitoring.

The need to make data available in near-real time makes quality control problematic as only limited automated checks can be applied. The idea of data 'levels' has been developed with the lowest level as raw data with more processing and correction applied for higher levels [6]. Another issue is the lack of standards for data access and discovery. The Open GIS Consortium (OGC) Sensor Web Enablement (SWE) protocols [7] promise, when fully developed, to provide standards for data access, discovery, alerting and integration.

The GBROOS project shows a practical demonstration of the value of sensor networks, when combined with oceanographic grade instruments and smart adaptive sampling systems, to provide real time scientifically robust data of a range of ocean phenomena and the processes that drive them.

5. REFERENCES

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