THE UNSW AIRBORNE LI DAR: CAPABILITIES AND RECENT BEACH OBSERVATIONS

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Abstract

Coastal communities and governments are increasingly concerned about coastal erosion worldwide. Coastal damage from the June 5th East Coast Low ranged from Coffs Harbour to Eden. The UNSW School of Aviation airborne research platform (a Piper PA44 fitted with airborne LiDAR and positioning equipment) was deployed immediately pre- and post-storm. The data set is unique and covers topography of a wide range of beaches. The system can survey up to 30 hot spots (critical beaches and estuary entrances) in a single flight covering over 500 km of coastline. Surveying a number of beaches in a single flight provides significant cost-benefit advantages, especially when a quick mobilization is important and a large-scale physical scale is envisaged.

In this paper we describe the system, its capabilities, and provide a description of samples of data collected from the wide range of beaches surveyed both pre- and post-storm. Included are a number of beach erosion hot spots defined by the Office of Environment and Heritage, including Lake Cathie, Old Bar, Hargraves Beach and Narrabeen/Collaroy beach, each of which was heavily exposed to the ENE storm wave direction. With an exceptional high tide of 2.05 m at 20:30 on June 5th, and again at 2.04 m at 21:20 on June 6th, the loss of volume, and inland extent of erosion provides wake-up call on the impacts of coastal storms and importance of coastal management. With the future coastal storms potentially being more severe, the need for ongoing monitoring of critical areas is likely to become more important.

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Introduction

In 2011, the School of Aviation began a collaboration with the Water Research Laboratory with the objective of using Aviation's airborne LiDAR capability to observe beach topography over a number of beaches. For several years the School's Piper PA 44 undertook "speculative" missions monitoring some key beaches in the Sydney area (Dee-Why, Narrabeen-Collaroy, Monavale, Bilgola and Wamberal-Terrigal, and Avoca) with the plan of being able to capture a significant erosion event. A minor event was captured in 2011 and the capability reported by Middleton et al. (2012).

Following this, funding was obtained from the ARC by a team led by Ian Turner, and from OEH to continue the work. Regular surveys were undertaken over intervalsof 3 to 4 months, and later included surveys to Coffs Harbour. At this stage, it was clearly uncertain as to what beaches might be affected by the next major erosion event and not clear when that might happen.

The storm of June 5th 2016 provided a substantial impetus to capture pre-storm data, and this was obtained for a number of beaches. Post storm a large number of beach surveys were flown again, from border to border, with support of the ARC funding and additional support from OEH.

The UNSW Airborne LiDAR system

The LiDAR is a Riegl VQ480i with geo-positioning acquired through Novatel OEM5 SPAN AG62 GPS/IMU. In effect the return LiDAR signal provides an accurate estimate of the distance of the LiDAR from the topography, and the GPS/IMU system logs position and attitude of the aeroplane at all times. Postion and attitude data is post-processed with Novatel Waypoint software to provide an accurate flight trajectory. Riegl software then calculates a point cloud field of topographic heights which may be converted to .LAS format (the LiDAR standard). Absolute accuracy is around 0.01m, while relative height accuracy can be < 0.005m (Middleton, et al, 2013).

Importantly the system can acquire data effectively over a period of 3+ hours, with a nominal 300m wide swath (at 1000 ft flying height) and a sampling rate of 300Hz. This set-up is ideal for beach surveys as it gives around 10 points of topographic elevation per square metre. The lidar is eye safe, and at 1000 ft altitude allows legal flight operations over built-up areas or crowds. A survey over 26 beaches generates around 12G Bytes of raw data.

The aeroplane is a twin-engined Piper PA 44 Seminole, with an approved observation port cut into the floor of the baggage compartment. It is owned and operated by the School of Aviation at UNSW. The twin-engined configuration gives some stability in mild turbulence and allows extensive over-water flight with peace of mind. Surveys are typically flown at 110 knots (200km/hr) and track guidance is provided by a small oblique camera which is allows the pilot to see where the aeroplane is heading. The aeroplane can be flown at night or in poor weather for repositioning flights.

Figure 1. Flying North during a typical survey at 1000 ft.

Survey Periods and Areas

The pre-storm surveys closest in date to June 2016 are as follows:

- Sydney northern beaches (5/4/16)
- Central Coast beaches (5/4/16)
- Newcastle to Coffs Harbour (31/5/16)

Post storm beach surveys now include:

- Sydney northern beaches (7/6/16) (5/7/16) (13/9/16) (19/9/16)
- Central Coast beaches (7/6/16) (5/7/16) (13/9/16)
- Newcastle to Coffs Harbour (8/6/16) (2/8/16) (16/9/16)
- Coffs Harbour to Tweed Heads (1/8/16) (2/8/16) (15/9/16)
- Sydney south to Wollongong (9/6/16) (5/7/16) (19/9/16)
- Wollongong to Eden (15/6/16)

The beach segments of the coast which for which data has been acquired are shown in Figure 2.

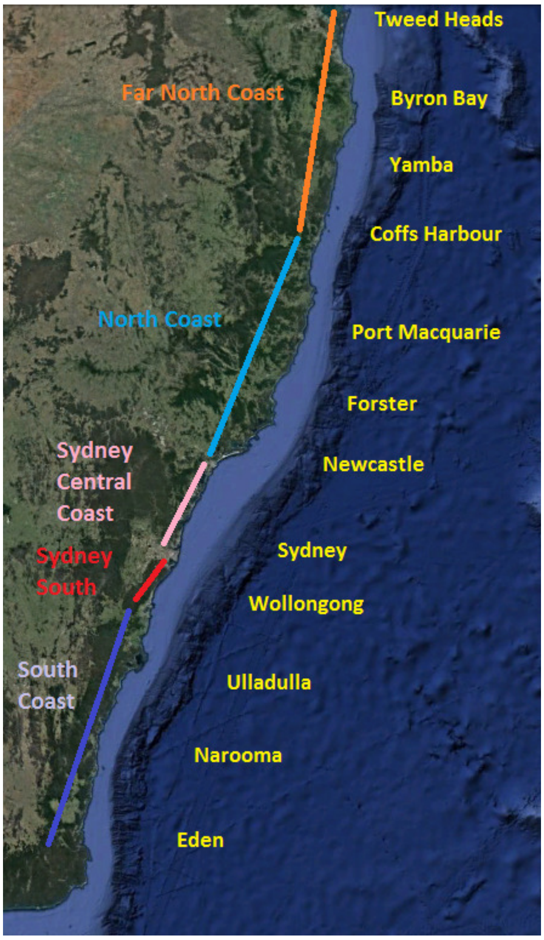

Figure 2. Areas of coastal survey operations, NSW

Results

To explain the nature of the data in pictorial form, Figure 3 shows an image of the topography of Ocean View Beach (north of Woolgoolga at 30.04S), with hypsometric colouring to indicate different heights. Clearly evident is the beach, vegetation, roads and houses. This image was produced from a single survey pass (which would have taken less than 30 s), and shows the effective swath width at 1000 ft height. Detail can be enhanced by multiple passes if required.

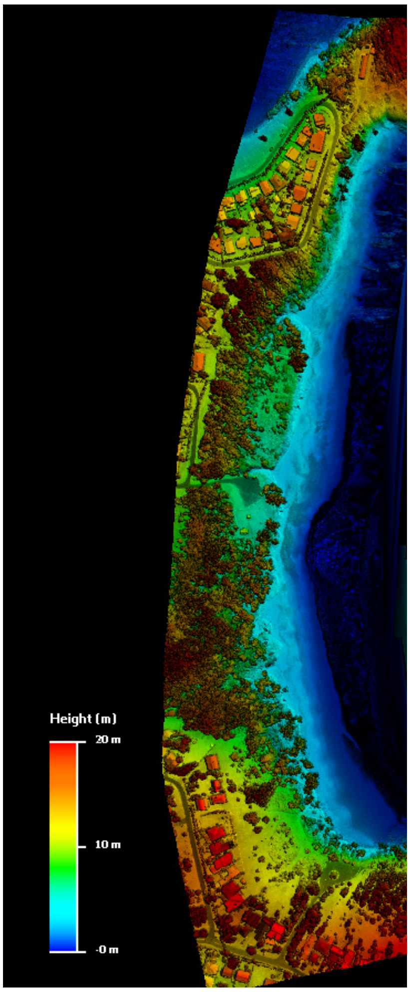

Figure 3. Ocean View Beach; 1/8/2016

For many beaches there is both pre and post storm data, and also we have now acquired some further follow up post storm beach recovery data.

There is a vast quantity of data at high resolution for beaches between Sydney and Coffs Harbor covering the June ECL event. Analysis of these data sets can reveal many attributes of the effect of storms on beaches. A visual approach is to generate coloured plots showing height change after the ECL. The results from processing data from several beaches are presented; North Narrabeen, Hargraves and Wamberal Beaches. Changes in the sand height using the (05/04/2016) data set as a reference have been generated for immediately after the ECL (to show sand loss) and after recovery periods (to show sand gain).

Storm tides and wave heights

At the height of the storm on June 5th, the tide was predicted to be 2.05m at 2030 at Fort Denison in Sydney, an extremely high value even for Spring Tides. It is most likely that storm surge effects enhanced the local sea levels. Previous high tides and those seen soon after were also extremely high. The wind blew significantly for around 3 days producing maximum wave heights of over 8 m (some over 10 m) and significant wave heights of over 6 m. This combination provided ideal circumstances for coast erosion around each high tide, with wave and wind data presented in Figure 4 measured by the OEH waverider buoy.

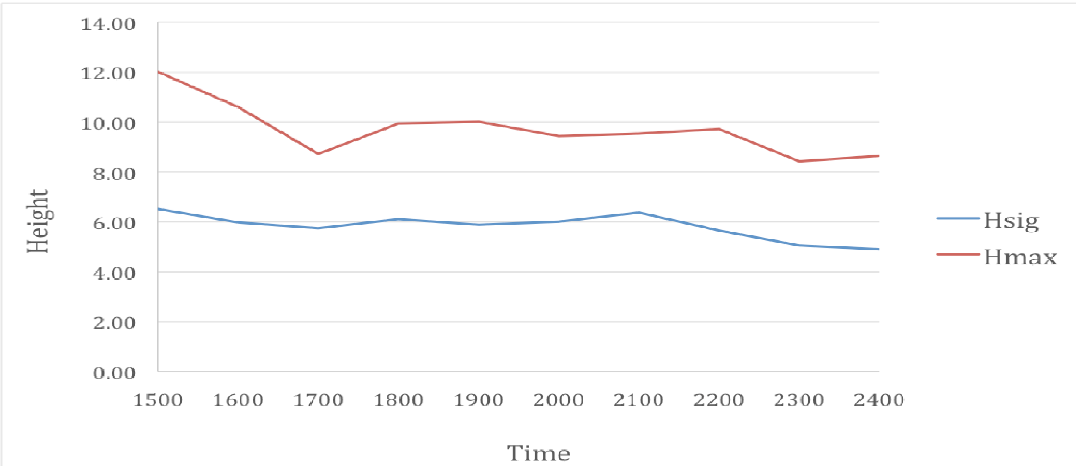

Figure 4. Data from the Sydney waverider buoy for the period of interest

The following subsections detail the changes which occurred over the period for some selected beaches, as examples of data coverage and quality. Detailed analyses of the events will be described elsewhere.

North Narrabeen

North Narrabeen data were acquired on; 7/4/2014, 7/6/2016 and 13/9/2016. The first data set is from before the June ECL, the second data set is immediately after the June ECL and the third data set is 3 months later. The differences between data sets provide a visual guide to the changes that have occurred and are provided in Figures that follow.

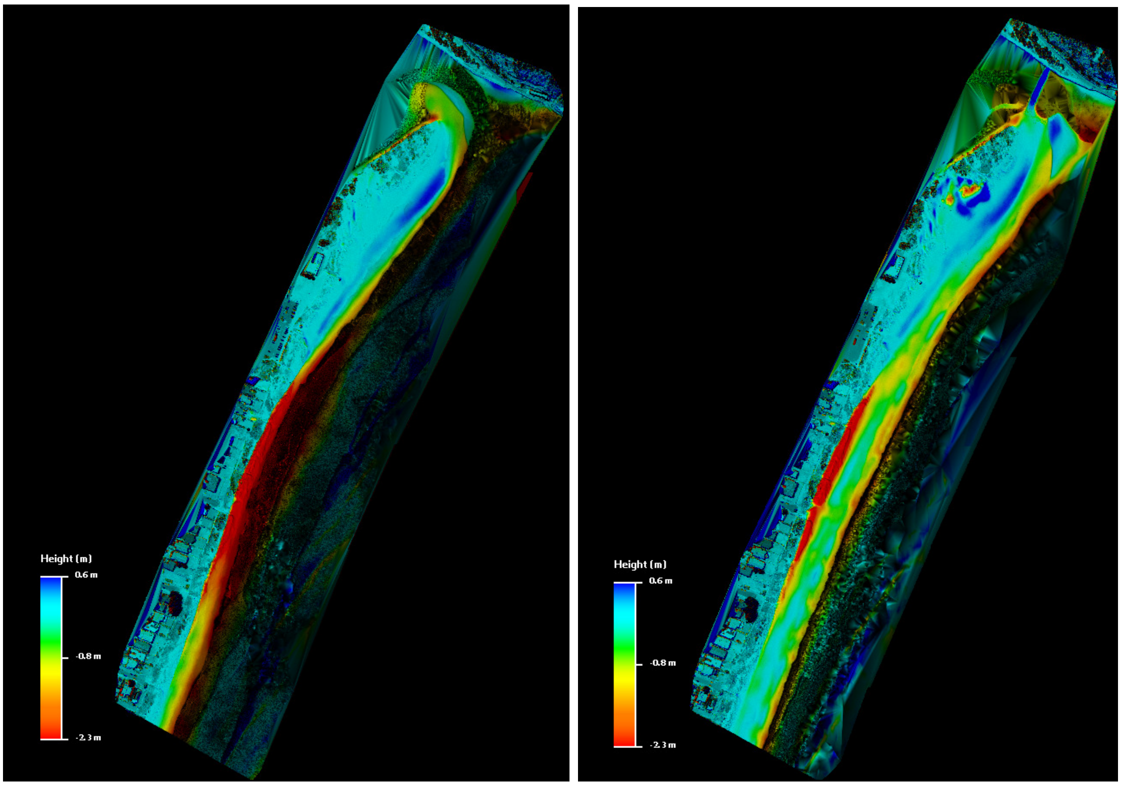

Figure 5. North Narrabeen; sand eroision due to ECL, three month recovery

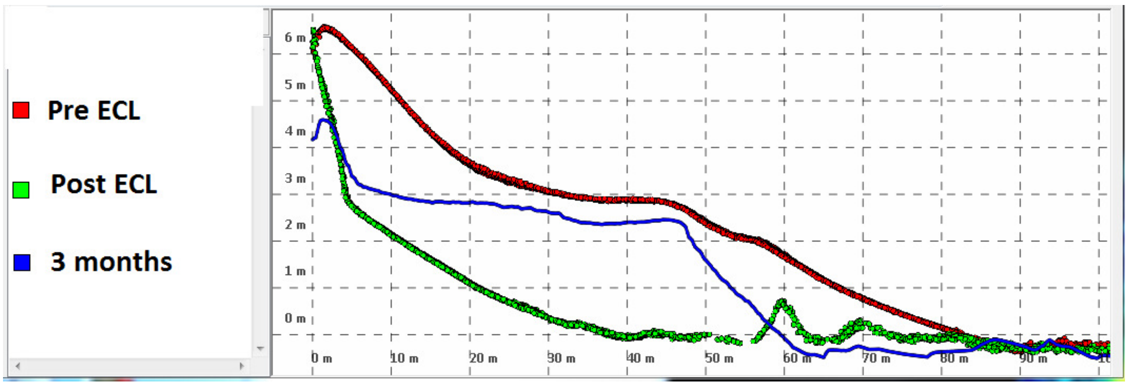

Figure 6. North Narrabeen; profiles

Figure 5 shows the sand removal immediately after the ECL. It can be seen there is a concentrated area where erosion is most severe. Figure 5 also shows how the beach has recovered in the 3 months since the ECL. It is clear that the middle beach has gained a lot of sand, while the upper beach has not gained much at all. Transects across the beach in the most effected area are provided in Figure 6, showing that up to 3 m depth of sand was removed during the ECL in this area.

Hargraves Beach

Hargraves Beach data was collected on; 5/4/2016, 7/6/2016 and 5/7/2016. The first two data sets are before and after the June ECL, and the third set is 1 month later. Figure 7 shows the height change of the beach immediately after the ECL, and one month later on. Figure 8 provides a transect across the beach. It is interesting to note that only after one month the sand surface in middle beach area is higher than before the ECL.

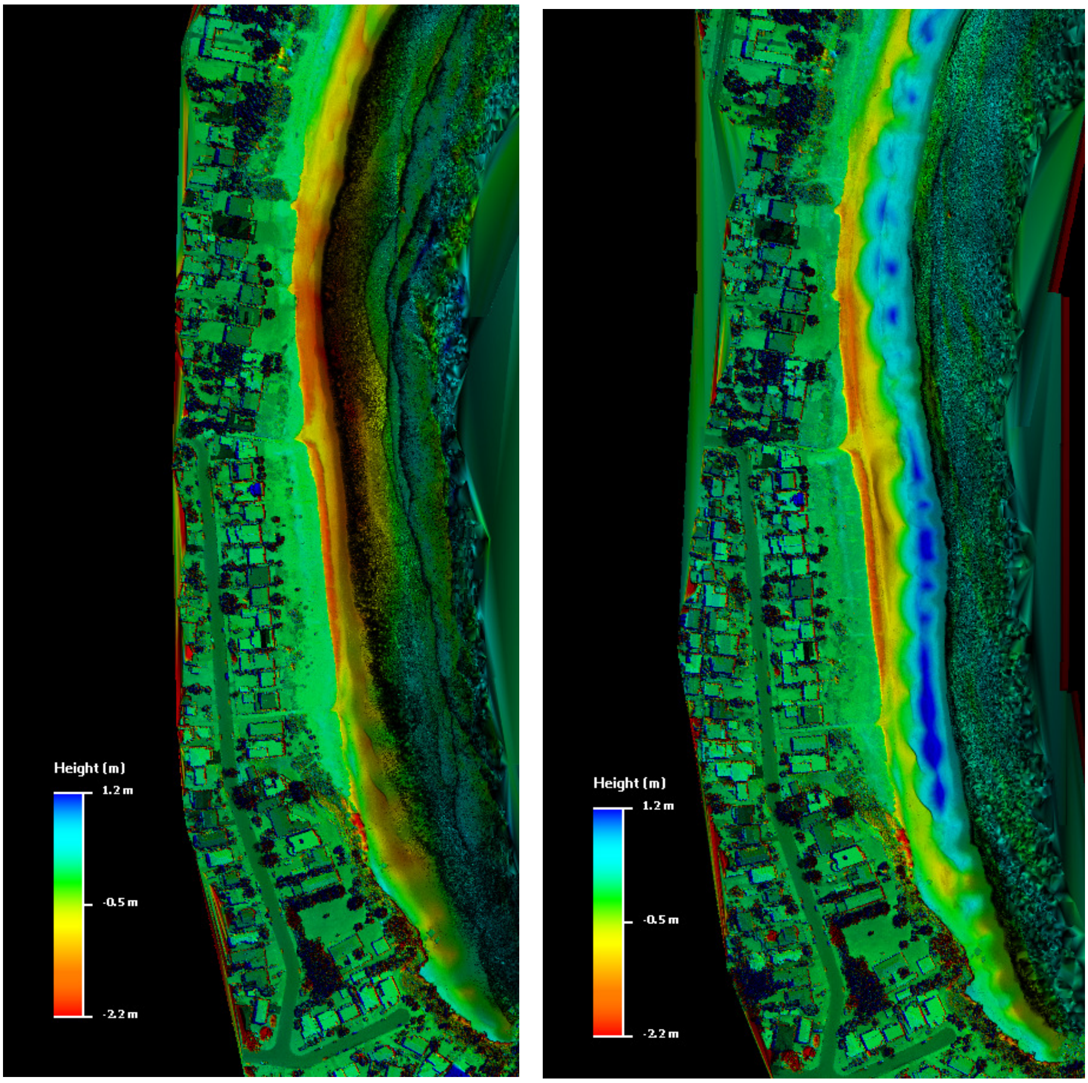

Figure 7. Hargraves Beach; sand erosion due to ECL, one month recovery

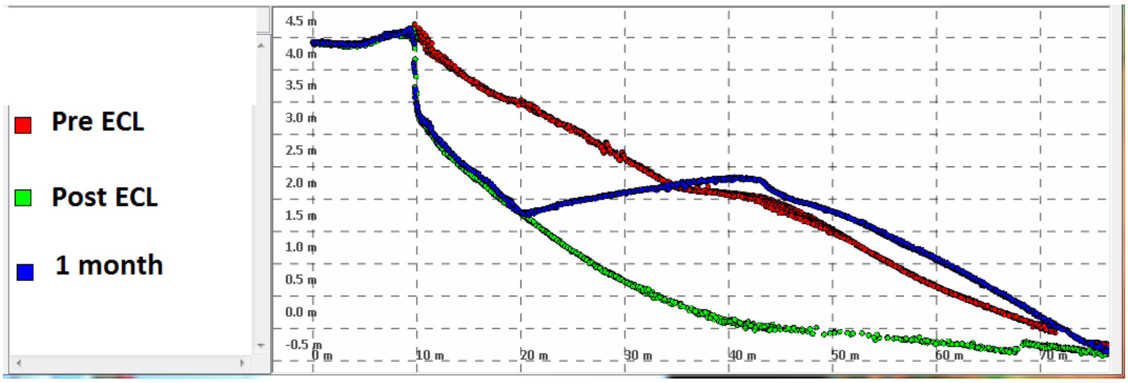

Figure 8. Hargraves Beach; profiles

Wamberal Beach

Wamberal Beach data was collected on; 5/4/2016, 7/6/2016, 5/7/2016 and 13/9/2016. Figure 9 shows the difference of sand height immediately after the ECL. Figure 10 shows the difference of sand height 1 month and 3 months after. It can be seen that recovery has slowed down between 1 and 3 months post ECL. The transect in Figure 11 is located approximately 1/3 along the beach, heading North. In this area the sand height profile has not changed much since the first month post ECL recovery period.

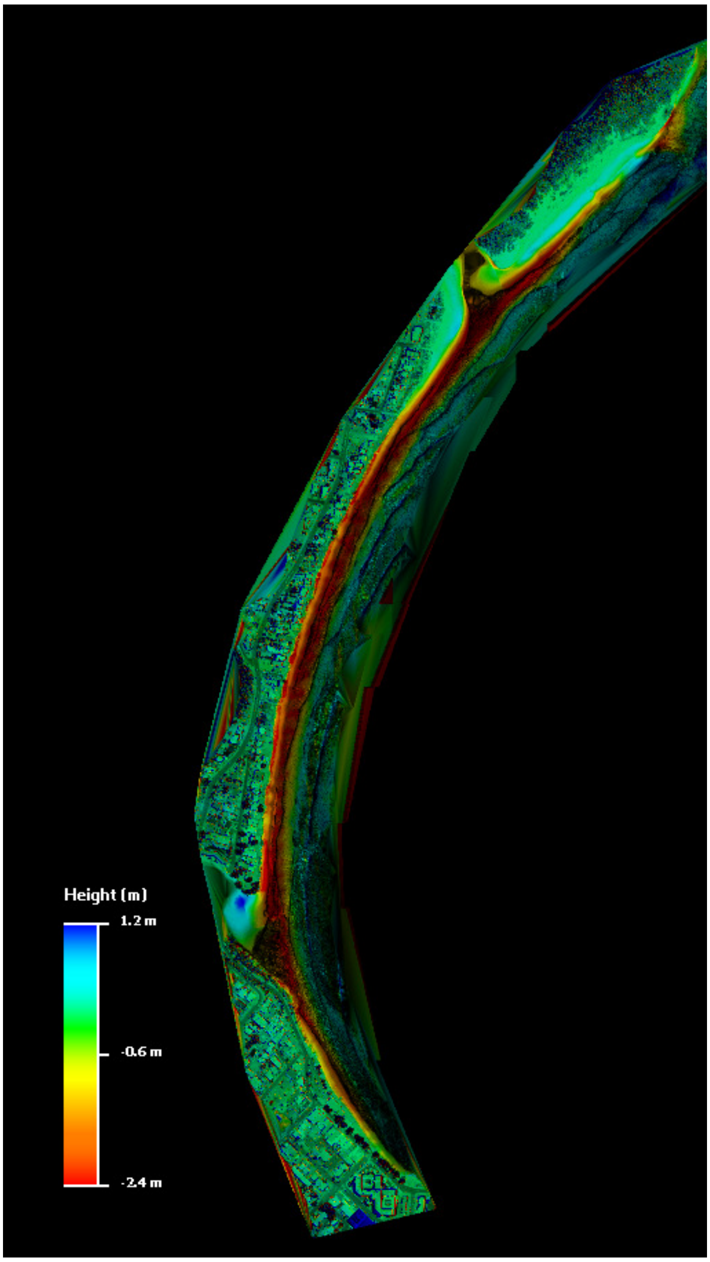

Figure 9. Wamberal Beach; sand loss after June ECL

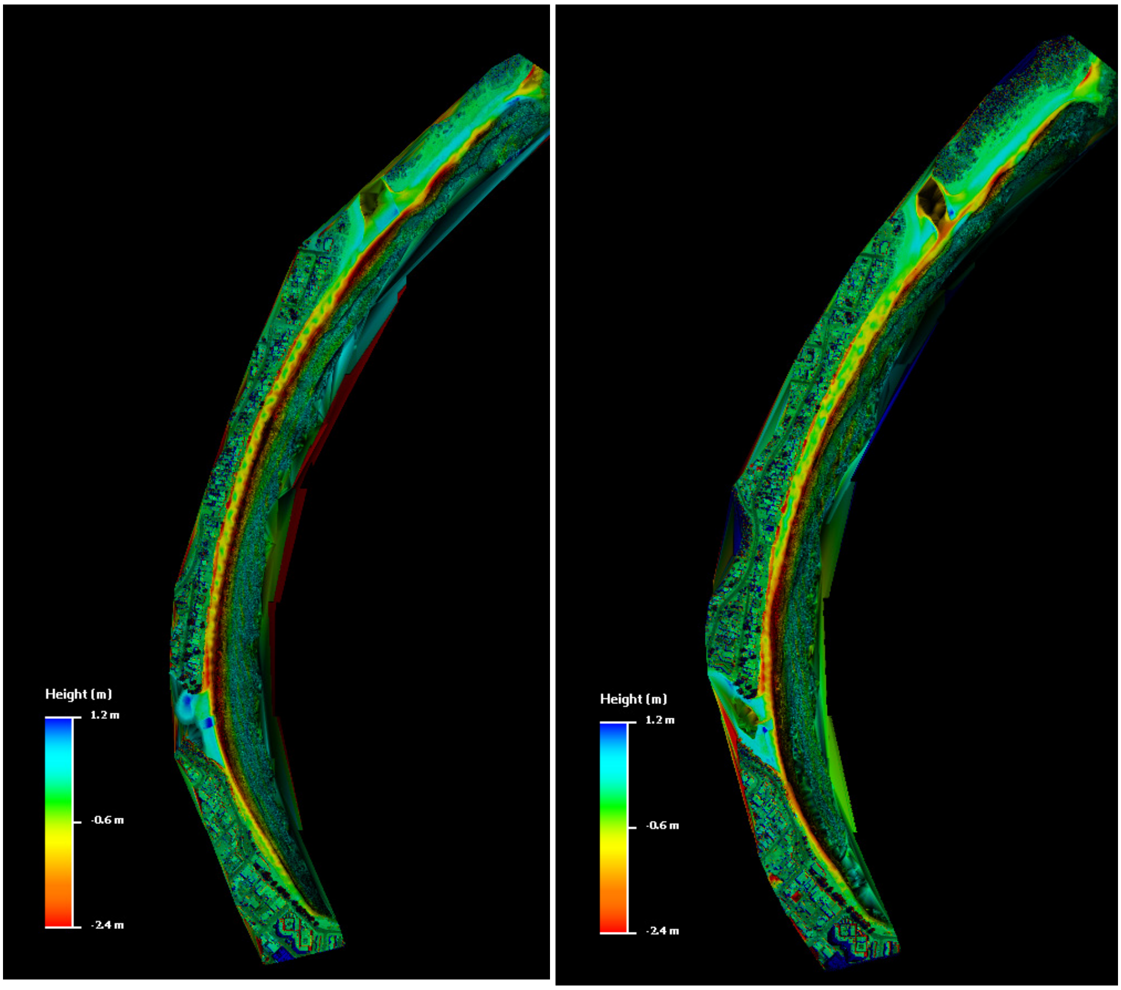

Figure 10. Wamberal Beach; recovery: 1 month, 3 months

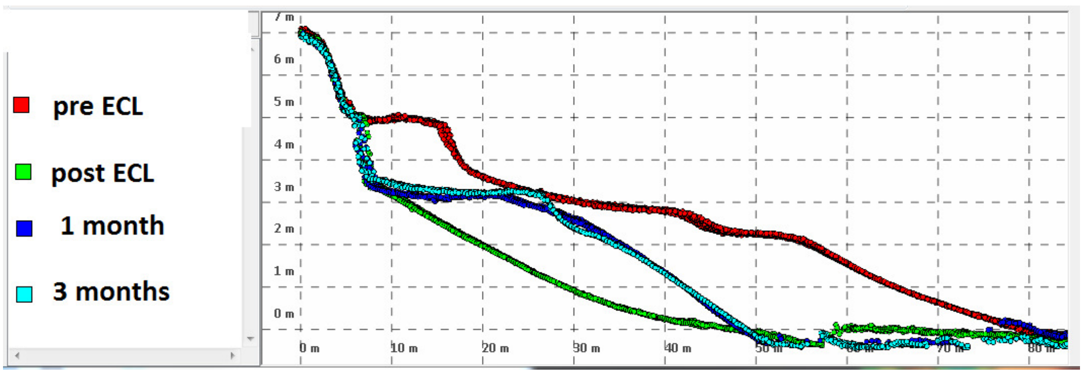

Figure 11. Wamberal Beach; profiles

Seawall at Forster / Tuncurry

Analysis of the data around the river mouth at Forster / Tuncurry revealed structural damage to the end of the northern seawall. Figure 12 shows the height change immediately after the June ECL. Circled in red is an area where material has been removed from the head of the seawall. There was also significant sand loss from the beach immediately south of that seawall.

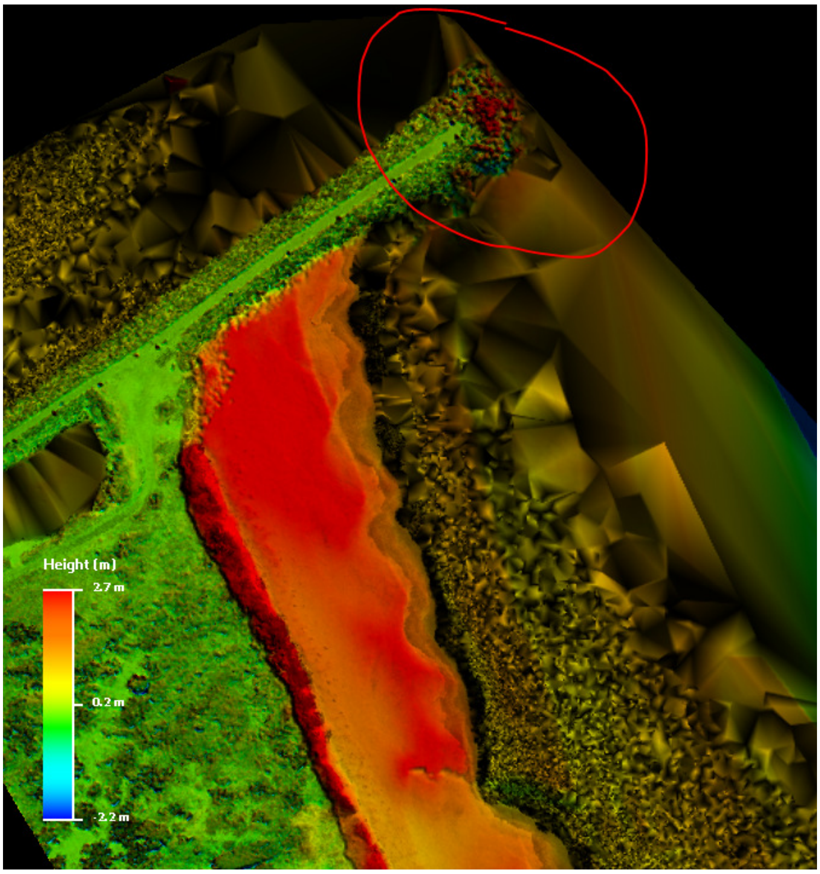

Figure 12. Seawall damage at Tuncurry

Future Plans

There is clearly a large number of experts now working to analyse and interpret this data, and other complementary data sets acquired before and after the storm, as described elsewhere in these proceedings.

From the perspective of the airborne lidar surveys, ongoing funding exists from ARC into 2017, and additional funding is being sought to continue the program of data acquisition. As those who do environmental research know only too well, it is not possible to go back in time and undertake a survey which should have been done. Insight, luck and future planning will all play a role in the continued effectiveness of coastal research in New South Wales.

Acknowledgements

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References

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