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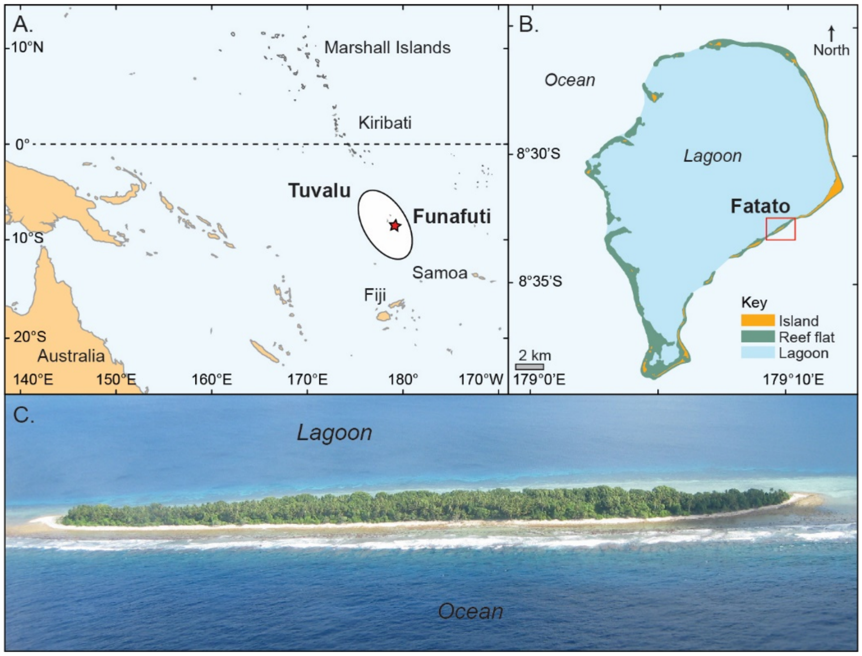
DRI Appendix 1 Island Setting

Fatato island, located on the windward south-eastern rim of Funafuti atoll (8°30.6'S, 179°6.0'E), Tuvalu, in the southwest Pacific Ocean (DRI Figure 1) was chosen as the prototype island to construct the scale model for laboratory flume experiments. Fatato was selected as the prototype island as: 1) it is uninhabited and free of any significant anthropogenic alterations that may have compromised its morphology or nearshore process regime; 2) the island is a predominantly gravel '*motu'* typical of islands on exposed atoll reef rims (McLean and Hosking, 1992); and, 3) extensive morphological and extended hydrodynamic datasets have been generated from the location with which to constrain and validate the physical model experiments (Baines and McLean, 1976; Ryan, 2012; Beetham et al., 2015; Kench et al., 2017).

The morphology of Fatato is typical of islands on the eastern rim of Funafuti and other windward reef islands throughout the Pacific Ocean (Woodroffe 2008). Approximately 90m wide at the largest point and 860m long, Fatato is an elongate island aligned in a roughly NE/SW direction. The Island is characterised by a steep and narrow ocean fronting beach-face with an elevated berm, a vegetated central basin and a lower elevation lagoon side berm (DRI Figure 1). Comprised of carbonate sediment derived from the surrounding reef, and consistent with *motu*, the ocean shoreline of Fatato is composed of coarse coral gravel (-4.2 to -6.4 phi, 18.4 mm to 84.4 mm, Ryan, 2012; Kench et al., 2017) with some sand sized sediment (1.15 to 0.32 phi, 0.45 mm to 0.8 mm, Ryan, 2012; Kench et al., 2017). The beach-face has a ~12° gradient with no marked step at the base or other significant features apart from a berm that is elevated 3-4 m above mean sea-level (MSL) and extends 20-30 m landward, composed of coarse cobble to boulder size material. The central depression is 1.5-2 m above MSL and is covered in thick tropical vegetation. Finer pebble to sand size sediments are present on the lagoon beach face (Ryan, 2012). Boulder size deposits on the reef flat, beach face and central depression indicate evidence of historic high energy and wave overtopping events, suggesting storms or swell exposure have played an important role in the formation and maintenance of the island's geomorphology.

The ocean reef flat at Fatato is ~100 m wide and exhibits a range of morphological features with the landward section characterised by a semi-continuous area of cemented rubble, while central and outer sections of the reef flat are comprised of smooth reef pavement covered in crustose coralline algae with encrusting corals present on the seaward reef crest. The ocean facing fore-reef at Fatato has a slope of 27° and is characterised by a distinct spur and groove system. The leeward (lagoon) reef flat is ~130 m wide.

Funafuti Atoll has a semi-diurnal microtidal regime with marked differences between spring and neap conditions (Fig. 2a). Spring tide range is 2.0 m, with spring high tide water level up to 1.1 m above MSL. Situated in the trade wind zone, the atoll experiences prevailing easterly winds, while winds from the north and west are more common during December through March (Bosserelle et al., 2015). Located on the south-eastern atoll rim, the island shoreline faces southeast (149°) and is exposed to ocean waves approaching from angles between 65° and 214° (or between -65° and 84° with respect to shore normal = 0°) with offshore mean significant wave height (H_s) of 1.85 m (99th percentile H_s = 2.8 m, maximum H_s = 3.7 m) (30 year WaveWatch 3 hindcast data). The largest waves that impact Funafuti are generated by tropical cyclone activity that produce significant wave heights between 3 – 4+ m with moderate periods (10 - 14 s) and typically occur every 3–5 years between December and April (Bosserelle et al., 2015).



DRI Figure 1: Location of Tuvalu within the Pacific. B) Location of Fatato Island, Funafuti atoll, Tuvalu. C) Aerial photograph of Fatato Island taken by Paul Kench, February 2013.

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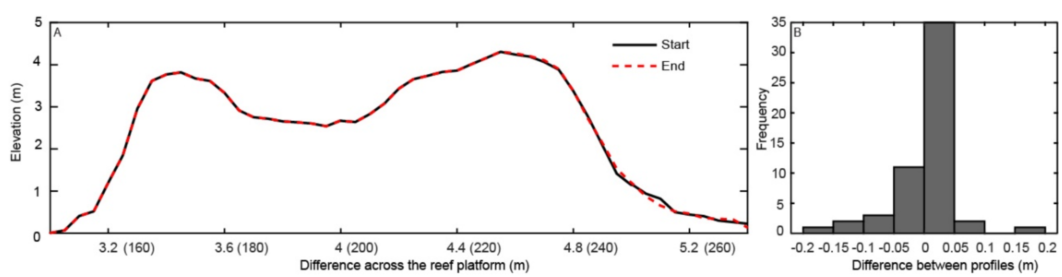
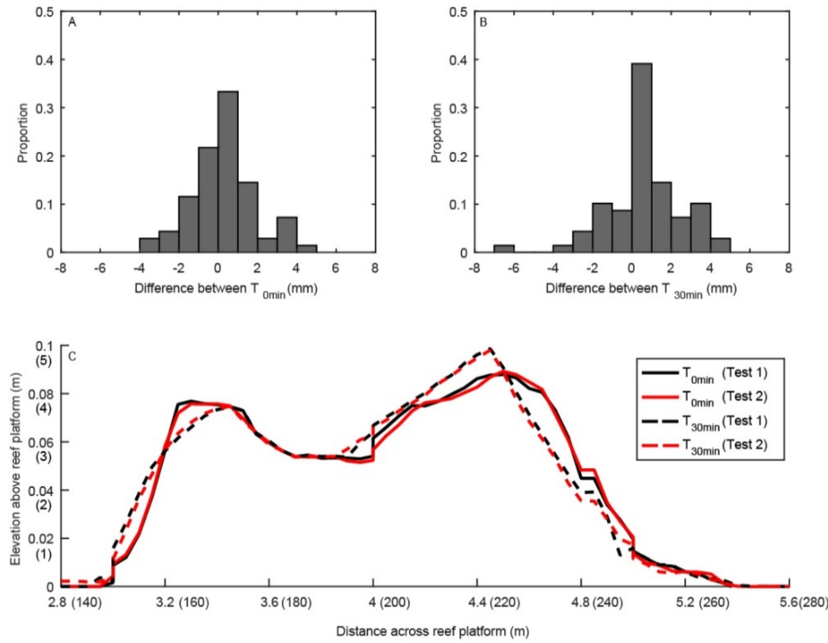
DRI Appendix 2 Model Validity

Experiments were undertaken to test the repeatability and validity of model simulations. To test the validity of the geomorphic outcomes observed during the modelling experiments island morphodynamics in response to mean wave conditions were tested (DRI Figure 2). The island was exposed to 0.02 m water level, representing mid tide (1.0 m above reef flat level) at prototype and 0.026 m wave conditions, representing *Hs* of 1.3 m at prototype, which closely match mean wave conditions offshore of Fatato Island. When exposed to the mean wave conditions experienced by Fatato Island, the model island should remain in equilibrium and exhibit minimal morphodynamic change. The morphodynamic test results show negligible island change in response to mean wave conditions at mid tide (DRI Figure 2). Although slight adjustment of the beach face is observed, this is expected as *motu* shorelines are known to be highly dynamic even under mean energy conditions (Kench et al., 2017).



DRI Figure 2: Results of morphodynamics verification analysis. A) Difference between start and end profiles, B) the start and end profiles plotted together, C) difference histogram of the start and end profiles.

To test model repeatability Test E1.2 was repeated where the island was subject to the same hydrodynamic parameters (DRI Table 1) for two 30 minute experiments. The model yielded consistent results between the two experiments with an average difference of 1.1 mm and 1.4 mm between the two start (T_0) and two end (T_{30}) profiles (DRI Figure 3).



DRI Figure 3: Results of reproducibility analysis of Test E1.2. A) Difference histogram of the E1.2 start profiles at model scale. B) Difference histogram of the E1.2 end profiles. C) The start profiles plotted with the end profiles of Test E1.2. Prototype values are given in parentheses.

References

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DRI Table 1: Hydrodynamic parameters used within physical flume experiments.
Exp. = experimental run. H_s = significant wave height, h_{reef} = water level on reef, T_p = wave period, T_{test} = test time. Prototype values are given in parentheses.

Test	(H_s) (m)	(h_{reef}) (m)	T_p (seconds)	T_{test} (mins)
Exp 1.1	0.06 (3)	0.04(2; HT)	1.4 (9.9)	30
Exp 1.2	0.06 (3)	0.05(2.5;	1.4 (9.9)	90
Exp 1.3	0.06 (3)	0.06(3; HT+1m)	1.4 (9.9)	90
Exp 2.1	0.08 (4)	0.04(2; HT)	1.4 (9.9)	90
Exp 2.2	0.08 (4)	0.05(2.5;	1.4 (9.9)	90
Exp 2.3	0.08 (4)	0.06(3; HT+1m)	1.4 (9.9)	420