



Reply to: Terry, J. and Goff, J. comment on “Late Cenozoic sea level and the rise of modern rimmed atolls” by Toomey et al. (2016), *Palaeogeography, Palaeoclimatology, Palaeoecology* 4 51: 73–83.



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We appreciate Terry and Goff's thoughtful comment in response to our proposed atoll development model. Flank collapse of reef-built slopes likely does affect plan-form atoll morphology in some locations and potentially poses a tsunami hazard to low-lying Pacific islands (Terry and Goff, 2013). However, given the often rapid rates of lagoon infill (> 1 mm/yr; Montaggioni, 2005), such failure events would likely need to be frequent and widespread in order to leave a morphologic imprint on modern western Pacific atoll lagoon depths. Few atoll flank collapse features have been dated but many of the arcuate bight-like structures (ABLS) identified could be inherited from scars incised into the initial volcanic edifice (e.g. Terry and Goff, 2013 and refs. therein) – submarine mass wasting has been extensively documented on young hotspot islands (e.g. Hawaiian Islands: Moore et al., 1989; Reunion: Oehler et al., 2008). Atolls in the Marshall Islands, where our main study site Enewetak Atoll is located, are likely ~50–100 million years old (Larson et al., 1995) and dating of adjacent deep-water turbidite aprons in the Nauru Basin (DSDP Site 462; Schlanger and Silva, 1986) suggests that large atoll flank collapse events have been relatively infrequent there since the mid-Miocene (< 11 Ma). In our simple, 1D atoll development model (Toomey et al., 2016a), we included the minimum set of processes (vertical accretion, dissolution, and lagoonal infilling) required to accurately simulate Enewetak's 'recent' depositional history (8.5–0 Ma) and explain basic differences in lagoon depth among western Pacific atolls.

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We agree future development of a model incorporating the wider range of processes impacting connectivity between reef-bound lagoons and the ocean (e.g. Ouillon et al., 2004; Toomey et al., 2016b), including stochastic mass wasting events, will be essential for exploring the plan-form and 3D shapes of atolls. To our knowledge, no quantitative model of long-term atoll development has explicitly linked lagoon restriction/sedimentation to episodic flank collapse events (e.g. Montaggioni et al., 2015; Paterson et al., 2006; Quinn, 1991; Warrlich et al., 2002). Testing Terry and Goff's proposed conceptual model for how rim failure processes affect atoll morphology in a numerical context will require deep drilling along arcuate bight-like structures, as well as adjacent, unaffected, rim and lagoon areas, in order to quantify how often failures occur and how quickly the rim/lagoon is rebuilt afterwards. The model we present here provides a general framework capable of integrating atoll flank collapse processes once they are sufficiently constrained by such observational datasets.

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