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3D numerical modelling of the Holocene evolution of One Tree Reef, Southern Great Barrier Reef: Implications for understanding the growth and architecture of coral reefs

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The Holocene reefs in the outer Great Barrier Reef (GBR) represent a thin veneer (10-30 m) built upon an older basement substrate reef surface. The morphology, stratigraphy and maturity (i.e. degree of sediment infilling - Hopley, 1982) of the modern reefs is thought to result from the interplay between the shape of the basement substrate, Holocene reef processes such as coralgal accretion, sediment erosion and transport in response to sea level rise. We use the 3D forward stratigraphic model CARBONATE-3D (CARB3D) to quantitatively simulate the Holocene evolution of One Tree Reef. Specifically, we test the influence of different basement substrate surfaces, sea level curves, reef accretion rates, sediment erosion and transport parameters to assess their relative importance in controlling reef evolution - particularly reef growth histories, 3D internal structure and stratigraphy and reef maturity. The range of parameters tested produced the full spectrum of reef maturities from unfilled "juvenile" buckets to planar "senile" reefs with sediment filled lagoons. We find that the shape and depth of the basement substrate and the sea level curve have the strongest influence - significantly impacting reef evolution and final maturity including the shape of the "bucket", size of the reef margins and internal reef structure. In contrast, variations in sediment production, erosion and transport mainly controlled the degree of lagoonal sediment filling. This study has implications for better understanding the past evolution of the GBR but also constraining the possible trajectories of the reef in the face of future environmental changes.