Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2018-29-RC1, 2018

Geoscientific Model Development Discussions

Interactive comment on "Exploring coral reef responses to millennial scale climatic forcings: insights from a 1-D numerical tool pyReef-Core v1.0" *by* Tristan Salles et al.

Anonymous Referee #1

Received and published: 9 April 2018

This manuscript is well organized and clearly presented. I thought the introductory materials on carbonate systems and environmental controls of reef development (accommodation, hydrodynamic energy, and sediment input) were very concise and adequately thorough. I believe it is essentially ready for publication. My suggestions are for making it more practical and relevant for present and near future coral-reef responses to environmental changes. I also have a few minor editorial suggestions.

The models in this manuscript are for a special circumstance where "populations number. . .is a proxy for carbonate production with larger assemblage population corresponding to faster rate of vertical accretion" (Caption for Figure 6 and elsewhere in

the text). The first sentence of "3 Environmental controls on reef development" (bottom of page 3) states "Coral framework production is strongly linked to biological activity". Actually, there is a general "lack of congruence" between a reef's biological performance (rates of CaCO3 accretion, provision of topographic complexity for shelter and substrata for fish and invertebrates, abundance and diversity of corals) and geological performance (Kleypas et al. 2001). This is because of nearly ubiquitous bioerosion and export of carbonate materials. The authors do acknowledge that their ". . .model does not consider the destructional processes that occur on the reef due to physical, chemical and biological erosion but does account for erosional process during phases of subaerial exposure. . ." It is generally true, especially in the Pleistocene and Holocene, that population abundance or living surface cover of corals is associated with overall rate of carbonate production, but because of varying rates of erosion and other destructive forces, rate of carbonate production is only sometimes associated with net rate of vertical growth. I feel the paper does not need to be changed, but I feel the model is limited to particular circumstances.

In the Introduction (line 14), the pyReef-Core model incorportates "coral community dynamics into reef growth modeling at reef-scale resolution". A recent dynamic of reef growth is the combination of disturbances and stressors as the frequencies of disturbances and the duration of stressors both increase. When they both increase, they consistently do not allow the processes of recovery to materialize. Although there are still a number of local coral-reef communities that display remarkably rapid recovery, numerous surveys have indicated that average living coral cover is decreasing circumtropically. This is partly because disturbance is nearly always faster than recovery, damaged or stressed corals generally produce fewer larvae, reef community recovery times become longer when fast-growing branching corals are more vulnerable to stresses and disturbances and are replaced by more tolerant slow-growing corals, combinations of local and global disturbances and stresses result in positive feedbacks that accelerate reef degradation, and degraded reefs decrease the proportion of habitat acceptable to recruiting larvae. In the Holocene, many reefs had time to largely recover

before the next disturbance; otherwise the reefs at the sites would not have developed as well as they had. As more reefs are disturbed and become less favorable for survival of recruits, connectivity is reduced by fewer larvae produced, more areas become unattractive to larvae for settlement, distances between fewer favorable sites become longer, and larval pelagic duration sometimes becomes shorter with increasing temperature. As disturbances become more frequent and do not allow sufficient time for recovery, events become trends and feedback creates ratchets, perpetually inhibiting recovery. Without taking the frequency of disturbances and length of periods of stress, including their overlap, in relation to potential periods of successful recruitment, it does not serve an applied use for the present and near future. However, this is going beyond the scope of this manuscript. I realize that the model in this paper is to reproduce the details of stratigraphic sequences in the past, and it serves this purpose well, so the manuscript should be published.

Minor editorial matters:

Bottom line, page 4 — “acidity” is used to name an environmental factor in oceans. Although the ocean pH may have gotten as low as 7.4 – 7.6 during the Cretaceous and early Paleogene, I don’t think the oceans have ever been actually acidic. The term “acidification” is being used to refer to a lowering of pH towards acidity, but it will never actually reach acidity. Second line, page 6 — Change “have a negatively effect” to “have a negative effect”. Figure 2 caption — “GLVE equations” is redundant because the E in the initialization is for “equations” First line of text below Table 2 on page 15 – change “data implies” to “data imply” or “data suggest”. Top line, page 22 — change “data is scarce” to “data are scarces”. Figures 6 and 7 — I have a hard time distinguishing the shades of blue representing different depths. I suspect many readers will have the same problem. Please make the colors more distinct or use different colors for the different depths.

Citations Kleypas JA, Buddemeier RW, Gattuso J-P. 2001. The future of coral reefs in an age of global change. Int J Earth Sciences (Geol Rundsch) 90: 426-437

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