Biogeosciences Discussions

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Reply on RC1

Federica Maggioni et al.

Author comment on "The Bouraké semi-enclosed lagoon (New Caledonia) – a natural laboratory to study the lifelong adaptation of a coral reef ecosystem to extreme environmental conditions" by Federica Maggioni et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-90-AC2, 2021

This work is very detailed chemically, physically and biologically. It provides very accurate temporal measurements and data that characterize the Bouraké semi-enclosed lagoon of New Caledonia quite well. Consequently, although quite extensive, it is seem a good paper that address relevant scientific question for this journal. However, based on their results, I do not agree with the authors' assertion that this area is a natural analogue to the future affected by climate change.

Response: We really thank Rev. #1 for her/his appreciation of our study and for considering our manuscript suitable for publication in Biogeosciences. We also thank Rev. #1 for the constructive comments.

We agree that it is difficult or even impossible to find what can be correctly called "a natural analogue for future conditions". Indeed, the definition of "natural analogues" has always been an issue, since the first time (Hall-Spencer et al., 2008, Nature) we proposed CO2 vents for this role (comments by R. Rodolfo-Metalpa). A real "natural analogues" does not exist and honestly it is pure speculation as we do not know what the future will be, especially for a coastal reef where not only the most classic environmental drivers will fluctuate (one of the parameters that modern models do not take in account), but the environment will be affected by a combination of factor which has never been considered in our bench experiments. Among them, increasing turbidity, increasing organic and nutrient inputs, etc. We agree with you. Natural analogue is incorrect, and we will change it throughout the ms and in the title. However, it would be inexact to say that mangrove systems, particularly the mangrove system of Bouraké, cannot be used to study the future effect of CC on organisms *in situ*. Once we admit that conditions are even worse than expected in the future, once we show their variability, once we drastically smooth our predictions based on evidences from our natural lab, we firmly believe that the mangrove area we are using is much better than other largely accepted "natural analogues" because it offers a realistic combination of drivers that will (more or less) characterise future reefs.

Specific comments

The methods used here are well development and valid. The results support most of the conclusions (see comment below). The authors describe in great detail the measurements taken and the calculations performed, sufficiently for reproduction, and generate interesting results that are well represented by the corresponding figures and tables.

Response: We would like to thank Rev #1 to highlight the validity of our methods, the large amount of data collected and analyzed and the well representation of the results.

As the authors have pointed out, this work describes a "natural laboratory" of great scientific interest. However, the authors have described the mangrove of New Caledonia as a place with the characteristics "analogous to future climate change" and in my opinion this term is incorrect.

Response: We corrected it through the ms (see below).

Although the CO2 seeps are considered to be analogous to future conditions, due to the extra input of CO2-rich volcanic gases. This does not apply to the mangrove described in this paper. The results presented in this paper affirm that in addition to the chemical parameters typical of climate change (CC) studies, there are numerous external elements that are affecting the living things that live in the mangrove. When we talk about a natural laboratory to study the effect of climate change, we are talking about a place where we can study the future effect of CC on organisms in situ and in my opinion it is not possible to do this in mangrove areas.

Response: In our understanding, the Rev. #1 affirms that mangrove areas do not mimic future CC conditions while CO2 seeps do. The phrase: "input of CO2-rich volcanic gases" suggests us that the reason is the lack of CO2 injection in the mangrove: i.e., the increase in CO2 in the mangrove is chemical (likely due to a combination of mechanisms in the sediment; we did not discuss the mechanisms, just reported the data) and not directly due to a CO2 input such as in the seeps. We agree, but the result is very similar even better than CO2 seeps. For instance, at our site we showed that carbonate chemistry is variable according to the tide but largely predictable, and it does not radically and suddenly change as at seeps due to the effect of wind and current. In addition, the averaged total alkalinity measured, although significantly different between stations, only varied from 2256 to 2393 µmol Kg-1 (see Table 2), so the chemical change does not affect it, which is important when mimicking future conditions.

That said, it is still a very interesting place as a natural laboratory. I agree that it is a special place to see the adaptation of corals and other living organisms to extreme environments. Therefore, I suggest that the authors change the comments related to being "analogous to future climate change", both in the title (see below), abstract (e.g. lines 17-19), introduction (e. g. lines 50-51), discussion (e.g. 562, 788) and conclusions (lines 804-805).

Response: We changed the term "natural analogue" with "natural laboratory" as:

Abstract.

L 19: "Although they do not perfectly mimic future conditions, these natural laboratories provide unique opportunities to explore how reef species could keep pace with climate change".

L 36: "We describe the natural dynamics of the Bouraké ecosystem and its relevance as a natural laboratory to investigate the benthic organism's adaptive responses to multiple extreme environmental conditions".

Introduction.

L50: "These sites may be used as natural laboratories of future climatic conditions when at least one or more environmental parameters naturally mimic climate change-like conditions over a large area of the ecosystem".

L 89: "The semi-enclosed lagoon of Bouraké (New Caledonia, SW Pacific Ocean) has been put forward to be as one of the most suitable natural laboratory to study the effects of future extreme environmental conditions (Camp et al., 2019)".

Discussion.

L 562: "Coral reefs, that are exposed to seawater pH and temperature values close to or even worse than those expected for the future, have likely developed physiological trade-offs and expressed molecular changes that allow them to survive sub-optimal and extreme conditions".

L804-805: "We used a multi-scale approach to characterize the physical and chemical environmental parameters of one of the most suitable natural laboratory for extreme environmental conditions, the semi-enclosed lagoon of Bouraké (New Caledonia), and accurately map its benthic community for the first time".

Again, I want to emphasis the idea that these mangroves can be considered as tools for species conservation in the future that we will face due to climate change and human activity, and this can be commented on in the discussion perfectly well (which the authors have already done).

Response: We really thank Rev. #1. We intentionally avoided in the discussion all statements that could be considered too speculative.

Ergo, after reading the content of the article and knowing its results, I recommend to the authors a change of title: "The Bouraké semi- enclosed lagoon (New Caledonia). A natural laboratory to study the life-long adaptation of a coral reef ecosystem to extreme ambient conditions" or something like that.

Response: We changed the title with: "The Bouraké semi- enclosed lagoon (New Caledonia). A natural laboratory to study the life-long adaptation of a coral reef ecosystem to extreme environmental conditions".

On the other hand, I have noticed some lack of bibliography in the discussion, as in the lines 562, 564, 610, 623, 653 comments that would be better if they were supported by the corresponding literature. I would also like to add my recommendation in line 657, I could replace the citation from Teixidó (paper on species diversity in the Mediterranean) by any other work related to corals or sponges in tropical seas, for examples, Enochs et al., 2015 nature climate change letters.

Response: We have added the requested bibliography at each suggested point. We also agree to add the citation (e.g., Enochs et al., 2015), which is more specific to tropical coral reef.

Technical corrections:

Although Figure 10 is added at the end with which the map was made and the source of the photographs, this information is missing in Figure 1. It is recommended to add the following information to Figure 1.

Response: We have added the required information.

Lines 236 and 237, in situ and in vitro should be in italic.

Response: Done.

Line 589 remove additional "(".

Response: Done.