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A Commentary on

Holocene relative sea-level histories of far-field islands in the mid-Pacific

by F. Tan, N. S. Khan, T. Li, A. J. Meltzner, J. Majewski, N. Chan, P. M. Chutcharavan, N. Cahill, M. Vacchi, D. Peng, B. P. Horton, *Quaternary Science Reviews* 310: 107995; <https://doi.org/10.1016/j.quascirev.2023.107995>

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Mid-ocean islands from the South-Central Pacific are of pivotal importance for the reconstruction of Holocene sea-level changes and constraining the melt history of ice sheets. Far-field islands, i.e., far away from former ice sheets, represent ideal locations for such reconstructions, as the effect of the glacial isostatic adjustment (GIA) is minimized. We agree with Tan et al. (2023) that it is essential to critically evaluate the relative sea-level (RSL) data that are used to validate GIA models. This implies a careful quality check that must be conducted during field studies, as the quality control of field data cannot be properly performed solely on photographs.

Our comment focuses on the Tuamotus Islands (French Polynesia) that have been considered by Tan et al. in their database. French Polynesia is an ideal region for palaeo sea-level studies as the islands can be considered as tectonically stable during mid-late Holocene times and because their microtidal regime allows the reconstruction of low-amplitude sea-level changes. We have conducted extensive field studies in 15 islands from four different archipelagos in French Polynesia to reconstruct in unprecedented detail an accurate record of sea-level change and reef development over the last 6,000 years (Hallmann et al., 2018, 2020; Fig. 1a).

The Tuamotus database compiled by Tan et al. relies mostly on results obtained by Pirazzoli and Montaggioni (1988) and related studies. We have investigated several of these outcrops during our studies in French Polynesia. Of the 20 sea-level index points (SLIPs) that have been used for statistical modelling by Tan et al., 16 are based on beachrocks and conglomerates that contain coral colonies and fragments. Only two SLIPs concern microatolls. We notice that these two microatolls do not fulfill the fundamental criteria stated by the authors, i.e., the availability of photographs, sketches and/or cross-sections of microatolls where concentric growth rings are visible. This demonstrates an inconsistent approach in the data treatment and quality control by Tan et al. In addition, we notice that these two data points are characterized by large uncertainties regarding their elevations, which were not measured by GPS, and radiocarbon ages. We conclude that these two data points should not have been considered as SLIPs.

The other data points considered by Tan et al. as SLIPs in the Tuamotus concern coral colonies or fragments embedded in conglomerates, hence reworked deposits, which correspond to storm deposits (Hallmann et al. 2018, 2020). Thus, these data points do not meet the fundamental criteria stated by Tan et al. for SLIPs. Some data points correspond to coral colonies that have been described as being in growth position in the original papers and considered by Tan et al. to be *in situ*. However, this assumption cannot be confirmed by the authors. Our statistical analysis of reworked deposits has demonstrated that many reworked coral colonies may appear in growth position as a consequence of sedimentary processes (Hallmann et al., 2018, 2020).

Our sea-level curve from French Polynesia is based on *in situ* coral microatolls - 91 samples from 78 microatolls collected on six islands - that have been accurately controlled, documented, measured and dated (Hallmann et al., 2018, 2020; Fig. 1a). An additional 156 samples from various mid-late Holocene features have been dated to better understand the dynamics of the reef system. The development of reef flat units follows the reconstructed sea-level curve based on microatolls but lies generally 0.3 to 0.4 m below it on average (Hallmann et al., 2020). In our study, vertical elevations with maximum errors of ± 2 cm and accurate ages with uncertainties of about 20 to 30 years were measured. Elevations of fossil coral microatolls have

been directly compared to those of their modern counterparts living in open-water settings, i.e., not being ponded, and in similar environmental settings, thus providing the most precise reconstruction of relative sea-level changes. Thus, coral microatolls considered in our study fulfill the fundamental criteria that the authors set in their manuscript and which are based on decades of microatoll studies. We are therefore in disagreement with the authors who state that microatolls described in our study are deeper-water corals that provide a minimum bound on RSL. We disagree with their reinterpretation of our Tuamotu data as ‘marine limiting datapoints’ based on the assumption that our microatolls have been heavily eroded and that they lack the concentric rings (obviously without having seen the outcrops nor any photographs). All reported coral microatolls exhibit clear concentric growth and lack any erosion features (see Fig. 1b-d; Fig. 2 in Hallmann et al., 2018 and Fig. 1 in Hallmann et al., 2020, among others). Consequently, Tan et al.’s statement that ice-equivalent sea-level change for the mid-late Holocene could be potentially smaller than defined by Hallmann et al. (2018) is not justified. Moreover, microatolls of the same age are at the same elevation, have the same surface morphology and can be mapped over tens of metres (see Fig. 2 in Hallmann et al., 2018 and Fig. 4 in Hallmann et al., 2020).

The timing of the mid-late Holocene highstand in French Polynesia does not remain ‘obscure’ as stated by Tan et al. Our sea-level curve differs markedly from previous reconstructions by Pirazzoli and Montaggioni (1988) and related studies, which were not based on *in situ* coral microatolls and which lacked the accuracy and precision of the methods used in our study. We wonder why Tan et al. did not consider records from the Society Islands, like Bora Bora and Maupiti, which are characterized by very slow and regular subsidence and a tidal range of 0.15 m, implying that these islands are ideal locations for sea-level reconstructions. Many Society Islands exhibit extensive fields of mid-late Holocene coral microatolls, which are crucial to reconstruct low-amplitude sea-level changes. In addition, recent reef drilling operations in Bora Bora have provided an accurate record of early Holocene sea-level change (Gischler et al., 2019) that could be directly compared to the one obtained in Tahiti (Bard et al., 2016; Montaggioni et al., 2017; Cabioch et al., 1999; Camoin et al., 1999). We therefore consider that the Bora Bora record should have been included in the database compiled by Tan et al. to better constrain early Holocene sea-level change.

In summary, we think that the quality control that Tan et al. applied to establish the database concerning the Tuamotu islands, which is mostly based on data from Pirazzoli and Montaggioni (1988) and related studies, is not consistent with the criteria defined in their Section 3. We wonder to what extent this has impacted the modeling results presented by Tan et al., especially

if a similar quality control has been applied for data from other groups of islands considered in their study. More accurate field studies will be needed in other regions that have been considered in this paper to obtain reliable RSL data that are used to validate GIA models. Any geophysical modelling crucially must be based on high-quality SLIPs.

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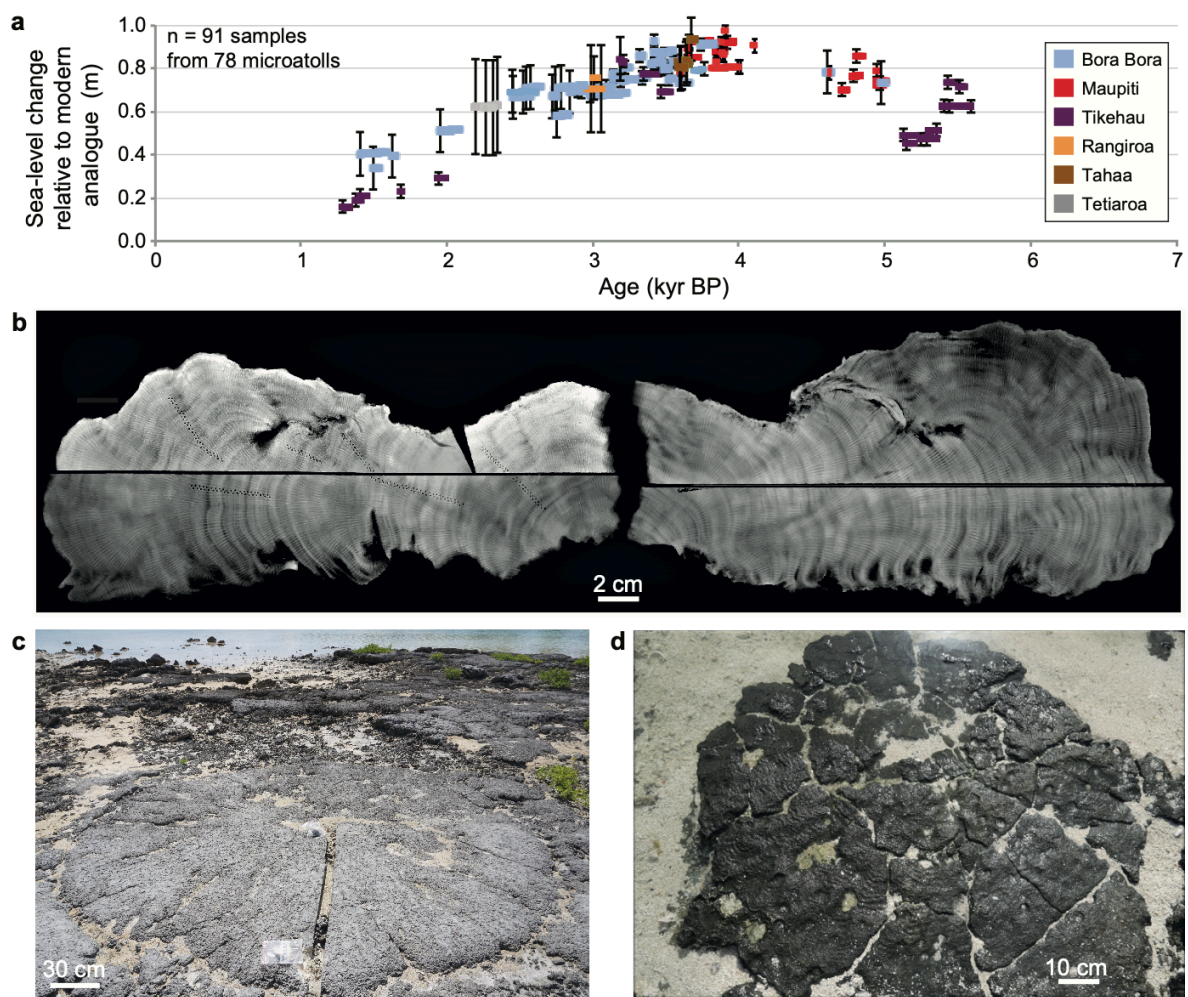


Fig. 1. Reconstruction of mid-late Holocene RSL changes in French Polynesia based on coral microatolls. a) Age vs elevation plot of dated microatolls as published in Hallmann et al. (2018). Calculated elevations are based on the height difference between living microatolls and their fossil counterparts. b) X-ray image of a *Porites* microatoll from Maupiti lacking erosion, showing annual growth bands and a predominantly lateral growth direction. c) *Porites* microatoll from Tikehau (TIK-74), which has been slabbed for paleoclimate analyses. d) *Porites* microatoll from Maupiti displaying clear concentric growth bands on its upper surface.