Reply to
Sandy beaches can survive sea-level rise

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Reply to: Sandy beaches can survive sea-level rise

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REPLYING TO J. A. G. Cooper et al. *Nature Climate Change* https://doi.org/10.1038/s41558-020-00934-2 (2020)

In our global analysis of sandy shoreline dynamics during the twenty-first century[1] we show that many sandy coastlines worldwide are under threat of erosion due to sea-level rise (SLR) and ambient shoreline changes. We base our findings on a probabilistic global modelling effort that improves the state of the art on global sandy beach erosion modelling and integrates new global datasets. Cooper et al.[2] contest our findings and claim that "provided that accommodation space is available, beaches migrate landwards as sea level rises and shorelines recede"; a point also made in our paper. In our analysis, we do not address the challenging topic of morphological evolution of retreating sandy coastlines, which Cooper et al. discuss. Most of their discussion focuses on beach width maintenance, whereas the focus of our work is shoreline retreat under SLR. There is a subtle, but important, difference between the two. In the absence of a global dataset on sandy beach width and accommodation space, we produced estimates of shoreline change assuming that there are no physical limits on potential shoreline retreat. In the final section of our paper, we then discuss results in a regional/global perspective, with a clearly stated assumption that "we consider beaches that are projected to experience a shoreline retreat >100 m as seriously threatened by coastal erosion". The aim of such a discussion was to give a socio-economic dimension to our findings, given that many popular sandy beaches worldwide have even less than 100 m of available accommodation space at their backshore. Some of these thoughts are common with other recent studies[3].

The support for the claims of Cooper et al. that sandy beaches will survive SLR refers to landward sandy beach migration observed during the postglacial SLR[4–6]. During the 8,000 years that have passed since then, the sparsely populated postglacial world has been transformed and many coastal zones around the globe have become heavily populated and developed[7], a trend that is projected to continue in the future[8,9]. Human encroachment in coastal zones and backshore developments have limited the space for shorelines to retreat into, and recent global studies on shoreline change highlight that many of the major transitions are due to human interventions[10,11]. This is also supported by the study Cooper et al. mention as an example of natural beach survival between 1950 and 2014 (ref. [12]). The studied 280-km-long coastal stretch in southwest France is one where a dune management programme has been in place since the 1980s and it is clearly stated in the study that such human interventions are largely responsible for the stable shoreline position.

Cooper et al. strongly object to the use of the Bruun rule, which predicts a landward and upward displacement of the cross-shore beach profile in response to SLR. Despite its known shortcomings, which we also discuss in our manuscript[1], the Bruun rule is the most widely used method for determining shoreline response to SLR, especially for large-scale applications where data scarcity is the norm (several examples are cited in our paper and there are many more in the literature). Several comprehensive and objective reviews[13–15] of the many attempts to verify Bruun rule predictions against field and laboratory data have confirmed the qualitative validity of the basic concept of the Bruun rule; that is, landward and upward displacement of the cross-shore profile in response to SLR in the absence of any other sediment sources/sinks. The quantitative accuracy of straightforward applications of the Bruun rule, especially for local-scale decision-making, is what has been questioned for decades[16]. In this context, we agree with the observations of Cooper et al. on the shortcomings of the Bruun rule and discussed these issues at length in the Limitations section of our paper. It should also be re-iterated that we used the Bruun rule within the constraints of its main assumptions (that is, longshore averaged beach response to SLR only), while the term AC (ambient change) in our governing equation is applicable worldwide, is independent of the type of coastline and captures the other aspects raised by Cooper et al. (such as sediment budget, source and sinks, large-scale, long-term longshore processes). Furthermore, we introduced a correction factor E to account for local-scale variability and uncertainty in the shoreline response predicted by the Bruun rule. The values used for E are based on previous studies that compared estimates of straightforward applications of the Bruun rule with those of more physics-based probabilistic models[17–20]. We believe that these improvements make our approach vary from a "straightforward application of the Bruun rule". Cooper et al. mention that alternatives to the Bruun rule are being sought; however, with the exception of the Wolinsky and Murray model[21], all their examples are simple extensions of the Bruun rule to which certain source/sink terms have been added.

We feel that statements made by Cooper et al. such as "beaches ... will survive" lack the evidence needed to substantiate them. There is the risk that coastal communities and managers are lulled into a false sense of security (in contrast to recent examples of devastating beach erosion, such as in the beaches of Narrabeen, Collaroy and Wamberal in New South Wales, Australia, in 2020). Although we do not dispute that better models would be useful for more accurate long-term predictions of coastal change, we also note that there is at present no better way to compute future shoreline change at the global scale and none of the methods

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proposed by Cooper et al. can be applied at such a scale due to lack of site-specific data. Global-scale assessments require certain generalizations and the use of global datasets that cannot fully capture local-scale dynamics and variability[22–24]. This is common to most disciplines[25,26], yet global models are considered the best available tools for projecting future climate at the global scale and provide the basis for all climate change impact research, including IPCC reports.

Our work should be seen in view of this, and considered as a first-pass global-scale assessment that could be complemented by more detailed local-scale assessments at high-risk locations. We share the concern of Cooper et al. about the existence of beaches worldwide, but disagree that "shoreline retreat must, and will, happen" everywhere. Cooper et al. conclude that the biggest threat to the continued existence of beaches is coastal defence structures that limit their ability to migrate. We could not agree more on that despite our reference to the Dutch coastal engineering, which was merely used as an example of a coastline that has been mildly accreting over the past few decades primarily due to coastal management practices. As societies are taking measures against the anticipated effects of SLR, our results[1] call for global (GHG emission mitigation) and local (coastal planning and management) action to safeguard sandy beaches worldwide. Rather than conflicting, global assessments such as ours and local detailed studies should go hand in hand to steer both processes.

Online content

Any methods, additional references, Nature Research reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at https://doi.org/10.1038/s41558-020-00935-1.

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Author contributions
All authors conceived, wrote and commented on the manuscript at all stages.

Competing interests
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