DSCIM-Coastal v1.1: An Open-Source Modeling Platform for Global Impacts of Sea Level Rise

The discussion below represents our response to the second round of reviewer comments, as facilitated by the topical editor following our revised and resubmitted manuscript after the initial round of feedback from Reviewers 1 and 2. Given the extent of our revisions, updates to input data and modifications to the original manuscript text, the editor deemed it necessary to solicit a final iteration of review by Reviewer 1. We agree and appreciate the careful review this publication has received. We hope the responses we provide here offer the clarity and detail sought by these most recent inquiries. We have not revised our manuscript further as we do not believe any of the reviewer's comments, nor our responses, suggest that changes are needed.

1. In the result section, the high costs in regions whose coasts are not densely populated such as Yakutia (Sakha republic) in North-east Russia are a bit surprising and may be worth double checking.

   This is a good observation and brings up an important characteristic of losses projected by pyCIAM. Not all cost types scale directly with population or capital density. The end-of-century annual costs incurred in the large region of Yakutia for the SSP2-4.5 (medium confidence), IIASA AR6 scenario shown in Fig. 5, totaling roughly $1.1 billion, are primarily driven by wetland loss and associated ecosystem services loss (valued at ~$900 million). This is due to the large extent of land area and abundance of low-lying, coastal wetland-classified lands within it. The next most significant cost type in this region is the value of (dry) land permanently lost to inundation ($80 million). Given that neither of these costs are dictated by the presence of capital assets or human population, it is logical that they are driving the cost signal seen here and in other sparsely-populated regions. The absence of capital and population in regions like Yakutia is reflected in the following figure, Fig. 6, which shows the benefits of optimal adaptation. Here, the values are near-zero for Yakutia and most high-latitude regions given the low amount of protection construction or proactive retreat occurring in these areas due to their low populations.

   Globally speaking, the sum of human-associated annual costs from storm damage, mortality, cost of building protection and cost of relocating are significantly larger than the combined wetland loss or land inundation costs. Here is the breakdown of global cost shares by cost type for annual costs in 2100 for that same scenario, assuming optimal adaptation:

   Total Costs (2100): $362 billion
   Wetland: 7.95 %

Inundation: 16.48 %
Relocation: 17.93 %
Protection: 32.67 %
Storm damage: 4.62 %
Storm mortality: 20.35 %

2. It would be good to know the levels of protection selected by the model in places such as the Netherlands, in order to compare with existing standards (which can indeed not be strictly followed on the ground).

   In all scenarios, including in the no-climate-change scenarios, all 31 segments in the Netherlands adapt by building protection to at least the 1000-year surge height, with 21 of 31 segments adapting to the 10000-year height. This appears to reasonably approximate current protection in the country given the fact that the design heights of current protective infrastructure for all Dutch coastlines reported in the FLOPROS dataset (Scussolini et al., 2016) are listed as being between 4000-year and 10000-year surge heights.

3. It would be good to investigate the implementation of a GIS approach to limit the maximum extent of flooding in extremely low lying areas and avoid the overestimation of losses due to the bathtub approach.

   We agree that improving upon the current implementation of our "locally bathtub" flood modeling approach is a good candidate for future improvements. We do currently employ an extensive amount of geospatial (i.e. GIS) processing to the CoastalDEM tiles in all regions in order to ensure that we are only considering areas below 20m that are hydraulically-connected to the ocean and therefore likely vulnerable to SLR. However, given the computational intensity and lack of relevant datasets (e.g. surface roughness, soil porosity etc.) that would be necessary for a more sophisticated hydrodynamic flood modeling approach at a similar (10m) resolution to our DEM, we opted to stick with the bathtub method for this v1 model release.

4. I noticed the 50km resolution and so does the other reviewer - I think that investigating ways to improve the resolution would be very relevant.

   We agree and hope to improve upon this resolution in future iterations of this modeling platform. However, we are currently limited by the spatial granularity of the necessary input datasets available to us for this estimation. Given the 50-km resolution of the CoDEC extreme sea level dataset, the gains from using smaller coastal segments would be limited because each of smaller segments within a 50km segment would be assigned identical flood heights. Furthermore, we are not aware of substantial evidence indicating the granularity at which protection or retreat decisions are made. Assigning too fine resolution for the segments would enable overly flexible decision making beyond what is practical. Investigating methods to improve upon this resolution and the coastal segmentation algorithm in general is a consideration for us moving forward.

References:

Scussolini, P., Aerts, J.C.J.H., Jongman, B., Bouwer, L.M., Winsemius, H.C., De Moel, H. and Ward, P.J., 2015. FLOPROS: an evolving global database of flood protection standards. Nat. Hazards Earth Syst. Sci. Discuss, 3, pp.7275-309.