ARRCC - Regional sea level projections for South Asia

Summary of preliminary findings

Coastal sites included in initial set of sea level projections, selected from tide gauge stations available on the Permanent Service for Mean Sea Level (PSMSL).

Ben Harrison – benjamin.harrison@metoffice.gov.uk

Reviewed by Matt Palmer and Joe Daron

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Asia Regional Resilience to a Changing Climate

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Summary

Sea level rise presents an acute threat to vulnerable coastal communities in the South Asia region. Until recently, coastal risk assessments in the region have been restricted to using global sea level projections and trends from short-duration tide gauge records. A new set of sea level projections for locations across South Asia has been produced using state-of-art science from the Met Office Hadley Centre and recent observation studies by regional partners.

Through the Climate Analysis for Risk Information and Services in South Asia (CARISSA) project, under the Asia Regional Resilience to a Changing Climate (ARRCC) programme, the Met Office is working in partnership with organisations in South Asia to enhance the use of regional climate information to inform adaptation planning. As part of CARISSA, the Met Office have produced new sea level projections for selected tide-gauge locations in the South Asia region. The work has been conducted to understand differences between projected regional and global sea level changes in South Asia, and to provide more relevant information for applications that inform adaptation policy and decision-making.

The Met Office recently produced new sea level projections for tide-gauge locations around the United Kingdom for the UK Climate Projections 2018 (UKCP18) project. The methods developed have since been used to generate sea level projections for tide-gauge locations around the world. This document presents sample outputs from the sea level projections generated through adapting the UKCP18 methods for application to selected locations in the South Asia region for the 21st century.

Tide-gauge locations were selected from the Arabian Sea, Bay of Bengal and Northern Equatorial Indian Ocean regions. Under all future climate scenarios, there are clear geographical differences in projected sea level change across the region. For Bangladesh and Pakistan, which are focal countries for the ARRCC programme, spatial variations in sea level projections arise primarily from differences in the contributions from the Glacial Isostatic Adjustment and differences in land water storage changes (net changes from reservoir impoundment and ground water extraction). For India, additional spatial variations between the northern and southern

areas of both coastlines are due to differences in the patterns of sea level change that arise from the loss of land-based ice stored in the Greenland and Antarctica ice sheets.

In the Arabian Sea and Bay of Bengal, the regional projected sea level changes are slightly smaller than projected global average sea level changes but the differences become smaller for warmer climate scenarios. There are north-south gradients in projected sea level change for both the Arabian Sea and the Bay of Bengal, with larger changes at locations in the south of these regions. In the far south of the Arabian Sea (Cochin, India) and Bay of Bengal (Port Blair, India Andaman Islands), projected sea level changes are larger than projections for global sea level change. Projected changes for locations in the east of the Bay of Bengal (Chennai, India) are slightly larger than for locations at similar latitudes in the west (Port Blair, India Andaman Islands). For all locations in the Northern Equatorial Indian ocean (e.g. Male, Maldives), the projected changes are larger than global average sea level changes.

Key findings

- 21st century projections of time-mean sea level change at tide-gauge locations around the Bay of Bengal and Arabian sea vary substantially by magnitude and geographic location. The projected ranges for sea-level rise at selected tide gauge locations are summarised for each greenhouse gas Representative Concentration Pathway (RCP) scenario in the main report; Table 1 shows the values of projected changes for three selected cities spanning the region, Chittagong, Karachi and Chennai, and figures 1 and 2 show temporal changes for six locations for the RCP2.6 and RCP8.5 scenarios respectively.
- Greater sea level rise is projected for southern sections of the Arabian Sea and Bay of Bengal coastlines, where projected values are similar or slightly less than the global mean sea level projections.
- In the north of the Arabian Sea and Bay of Bengal, sea level rise projections are slightly lower than global mean projections, with the lowest projected changes found along the Pakistan coast.
- Tide gauge records show substantial year-to-year and seasonal changes in coastal water level, related to natural variability in the South Asian Monsoon. In using future climate projections in coastal management applications, practitioners

and decision-makers must account for this variability in risk assessments, particularly for short-term planning horizons.

- The risk of coastal flood events is expected to rise as a result of increases in time-mean sea level, not taking into account any significant changes to tropical cyclone frequency, intensity and trajectories in Arabian Sea and Bay of Bengal. Future changes to tropical cyclones in South Asia are beyond the scope of the present study.

YEAR	Chittagong			Karachi			Chennai		
	RCP2.6	RCP4.5	RCP8.5	RCP2.6	RCP4.5	RCP8.5	RCP2.6	RCP4.5	RCP8.5
2020	0.05 to 0.10	0.05 to 0.10	0.05 to 0.10	0.04 to 0.10	0.05 to 0.10	0.05 to 0.10	0.05 to 0.10	0.05 to 0.10	0.06 to 0.11
2040	0.10 to 0.21	0.10 to 0.21	0.11 to 0.22	0.08 to 0.20	0.09 to 0.20	0.10 to 0.22	0.11 to 0.22	0.11 to 0.22	0.12 to 0.24
2060	0.14 to 0.33	0.17 to 0.36	0.21 to 0.42	0.11 to 0.31	0.14 to 0.34	0.19 to 0.41	0.15 to 0.34	0.17 to 0.38	0.22 to 0.44
2080	0.18 to 0.45	0.24 to 0.53	0.33 to 0.69	0.13 to 0.43	0.19 to 0.51	0.30 to 0.68	0.19 to 0.48	0.24 to 0.56	0.31 to 0.73
2100	0.22 to 0.59	0.31 to 0.72	0.48 to 1.05	0.13 to 0.55	0.23 to 0.68	0.42 to 1.03	0.22 to 0.62	0.31 to 0.75	0.49 to 1.09

Table 1: Projected ranges of sea level rise (metres) for South Asia cities under RCP2.6, RCP4.5 and RCP8.5 relative to a baseline period of 1986-2005.

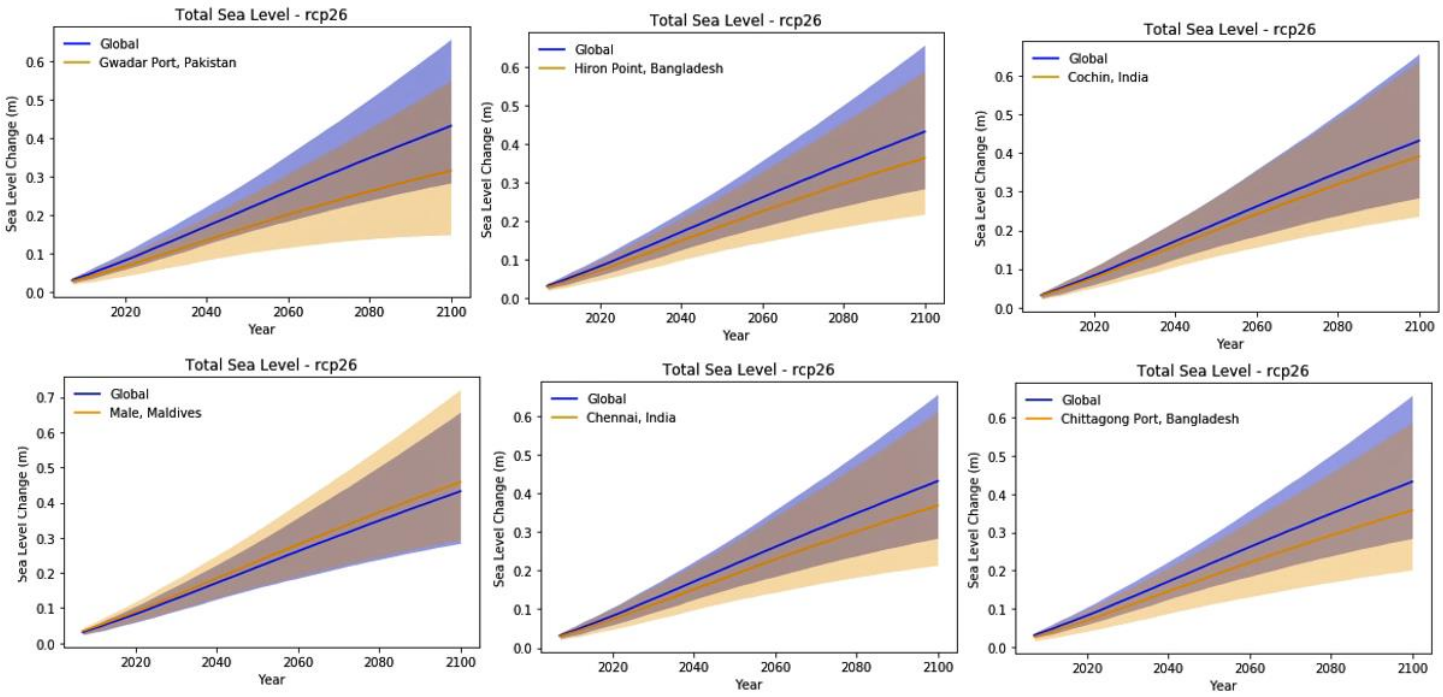

Figure 1: Mean sea-level projections for tide gauge locations under climate scenario RCP2.6. Shaded areas show the 5th to 95th percentile range and solid lines the central estimate for the location (yellow) and global average (blue).

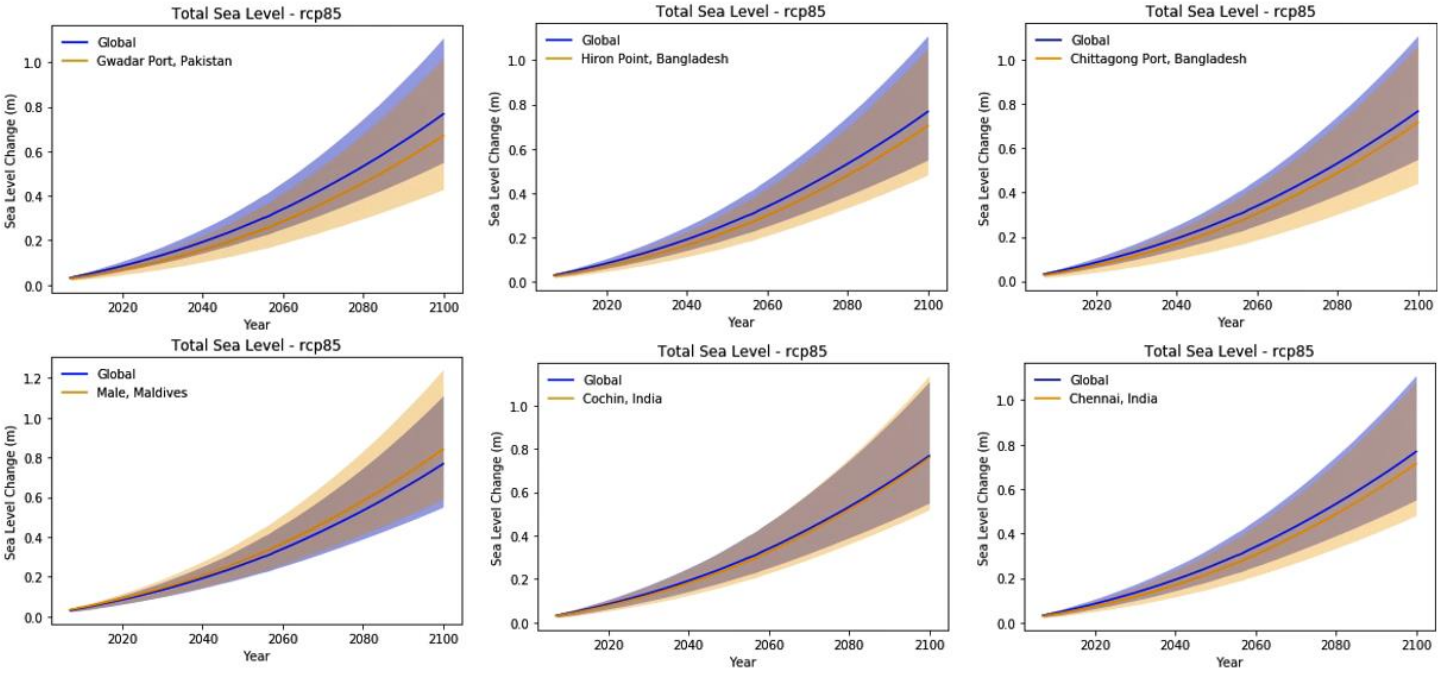

Figure 2: Mean sea-level projections for tide gauge locations under climate scenario RCP8.5. Shaded areas show the 5th to 95th percentile range and solid lines the central estimate for the location (yellow) and global average (blue).

Caveats and limitations

- The range of sea-level projections shown are based on the 5th to 95th percentiles of the underlying model distributions. There may be a greater than 10% chance that the real-world response lies outside the 5th to 95th percentile range and this likelihood cannot be accurately quantified. We cannot rule out substantial additional sea level rise associated primarily with dynamic ice discharge from the West Antarctic Ice Sheet.
- The sea level projections do not include estimates for non-climate processes such as vertical land movement due to subsidence or tectonic uplift.
- The land water storage estimates used in this study assume that 100% of the abstracted groundwater ends up in the oceans but more recent estimates show the fraction reaching the oceans is approximately 80%.
- The 21st century projections presented in this report are predicated on climate models from the fifth Climate Model Intercomparison Project (CMIP5) and the RCP climate change scenarios. The results are therefore subject to any inherent limitations of the underlying model ensembles and assumed climate change scenarios.
- Coastal decision makers should make use of multiple strands of evidence, when assessing vulnerabilities to future extreme water levels. The full report contains comparisons with projections from the IPCC Special Report on Cryosphere and Oceans.

Further Work

A full report describing the methods and findings of these projections is currently being finalised. The CARISSA team are working with regional partners, including the Institute for Water Modelling (IWM) in Bangladesh, to integrate the projections with local vulnerability and exposure datasets for coastal decision-makers. In parallel, training materials and guidance on the use of sea level rise projections are being produced.

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