Reply to Anonymous Referee #3

The paper uses numerical modelling to analyze the effects of sea level rise (SLR) on the storm surge generated by tropical cyclones (TC) in the Bangladesh coast and the associated inundation on that area. Model results are validated using observations of two previous TC and a number of additional simulations are made to study future scenarios. The manuscript is pretty well written, although it can be improved following the suggestions detailed below. Besides the assumptions made to simplify the high level of uncertainty, the obtained results show how SLR would increase the inundation associated to TC in this area and can help coastal managers to design adaptation measures to deal with these problems. Therefore, the manuscript fits the scope of NHESS and may be published provided the authors address the following comments.

We would like to thank the referee for the evaluation and for providing feedback which helped to improve the manuscript. Please find our responses below for general and minor comments.

General comments –

The authors should justify why they use the SLR projections from AR4 (IPCC, 2007) (line 60) instead of those from AR5 (IPCC, 2013), although they are based on the worst AR4 scenario (A1F1, line 72). Taking into account that regional SLR rates are much higher than the global rate (lines 64-66) and that global SLR projections from AR5 are worse than AR4, the scenarios considered by the authors could be too optimistic.

The SLR projections used in this research is from Caesar et al. (2017; under review) which is based on IPCC AR5. We've modified the manuscript text to clarify and added the information about AR5.

In this proposed work, we will use the SLR projections from Caesar et al. (2017; under review), which **is based on IPCC AR5 and** suggests a projection of SLR of 26 cm for the mid-21st century (2040 -2060) and 54 cm for the end-21st century (2079 -2099).

- A number of geographical sites are cited in the text (e.g. Bay of Bengal and Andaman Sea (line 37); Ganges, Brahmaputra, Meghna rivers (line 92); Baguna (lines 97 and 100); Patuakhali (lines 99 and 106); Khulna (lines 100 and 106); Jhalokati (line 100); Chandpur (line (106), Sundarban (lines 238, 239, 240)) that should be placed in a map to facilitate the reading of the text. In the same way, a figure showing the topography of the area would be very useful. In addition, the shorelines should be clearer in figures 1, 4, 5 and 8, to better understand the magnitude of the flooded areas.

Thank you for the suggestion. We've updated Figure 1 and added another one with that to represent the topography and bathymetry of the study area as Figure 1b. We've made the shorelines more clear in the updated figures (Figure1, 4, 5, 8). The location of the Ganges, Brahmaputra and Meghna river was also marked on the map. Green colored area is showing Sundarban forest and its under Khulna division. In addition, the landfall locations of the storms were marked on the map. Since Patuakhali, Barguna and Jhalokathi are under the Barisal division, we've marked the Barisal division on the map. And Chandpur is under the Chittagong division and it was also marked on the map.

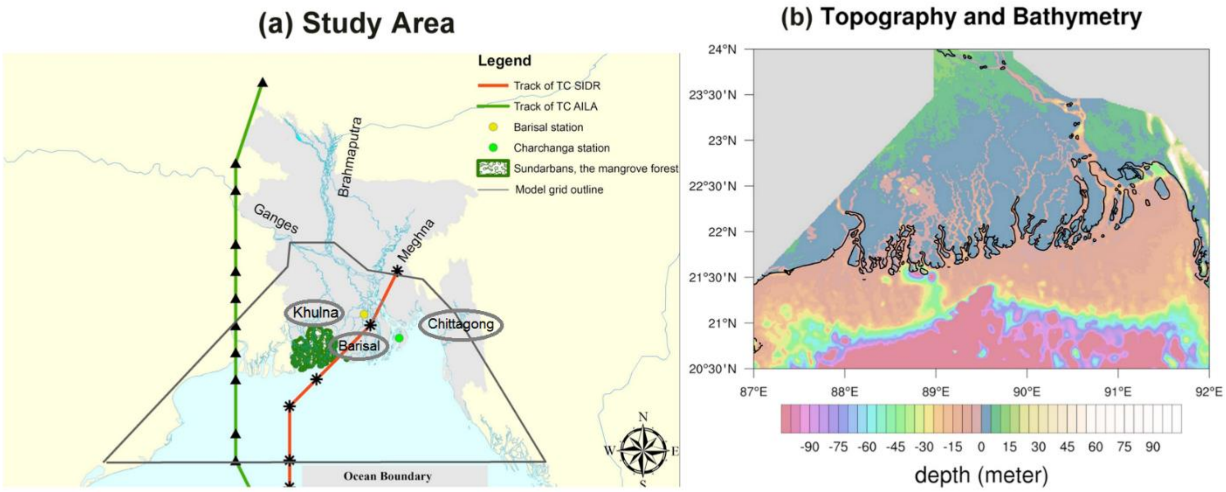

Figure 1. (a) Map of the study area for this work. The red and green lines represent the tracks of TC Sidr and TC Aila respectively. Area marked with green color indicates the Sundarban mangrove forest region. Location of the Ganges, Brahmaputra and Meghna rivers are shown on the map. Khulna, Barisal and Chittagong which are landfall locations for the historical TCs used for ensemble projection, shown inside a circular box on the map. Two circles over the study area are the observation stations of Bangladesh Inland Water Transport Authority (BIWTA). The black colored outline shows the extent of model grid over the region. (b) Topography and bathymetry of the model domain. Negative depth values represent water bodies (ocean and rivers) and positive depth values areas represent land.

- In lines 201-206 the authors discuss the potential influence of the tide level on the inundation and indicate that different simulations have been performed considering diverse tide conditions, which are summarized in Table 2. However, nowhere is the magnitude of the tides shown. A description of tide features is necessary to understand the influence of this factor in the inundation.

In line 200, we've added this:

For example, the tides shown in Figures 3 and 7 as the water level oscillations have amplitudes as high as 3 m, which could significantly affect the extension of flooded area, depending on whether the storm's landfall coincides with a high tide or a low tide.

And in line 203, we've added the following:

The change of timing in these tide-related experiments was implemented by modifiying the tracks of the storms so that their landfalls coincide with a high tide, a tide, or a zero-tide condition, in addition to their actual tidal phases.

- The writing of sections 3.2, 3.3, 3.4 and 4 is a little bit confusing with the mixing of percentages, inundation areas and water levels. Perhaps the results could be summarized in a table to ease the understanding of the changes associated to each scenario.

Thank you for the suggestion. We've added three new tables for section 3.3 and 3.4. in addition to that, we've added a new Table 2 for the TC tracks that were used in the ensemble projections.

Table 5. Comparison of inundated area between present day & future SLR scenarios and calculated change in percentage with respect to present day scenario.

Scenario	TC Sidr		TC Aila	
	Inundated Area	(%) change	Inundated Area	(%) change
Present Day	1860		1208	
Mid-century	2436.6	+31	1550	+28.3
End-century	2845.8	+53	1770	+46.5

Table 6. Comparison of storm surge level between present day and future SLR scenarios for the case of TC Sidr

Scenario	Barisal		Charchanga	
	Storm surge level (m)	% increase	Storm surge level (m)	% increase
Present Day	1.873		1.641	
Mid-century (0.26m)	2.13	13.72	1.870	13.95
End-century (0.54m)	2.41	28.67	2.19	33.45

Table 7. Comparison of storm surge level between present day and future SLR scenarios for the case of TC Aila

Scenario	Barisal		Charchanga	
	Storm surge level (m)	% increase	Storm surge level (m)	% increase
Present Day	1.299		2.5	
Mid-century (0.26m)	1.584	21.93	3.075	23
End-century (0.54m)	1.961	50.96	3.875	55

Table 2 List of 12 historical TC events used for ensemble projection of storm surge inundation

Name	**Date**	**Landfall**
Tropical storm 13	14-18 November, 1973	Noakhali
Cyclone 12	23-28 November, 1974	Bhola
Tropical storm 19	07-12 November, 1975	Chittagong
Tropical storm 1	22-25 May, 1985	Noakhali
Cyclone 4	21-30 November, 1988	Khulna
Cyclone 2	22-30 April, 1991	Chittagong
Cyclone 2	26 April – 30 May, 1994	Cox's Bazar
Cyclone 4	18-25 November, 1995	Cox's Bazar
Cyclone 1	13-20 May, 1997	Noakhali
Tropical storm 4	24-27 October, 2008	Barguna
Tropical storm Mahasen	10-16 May, 2013	Patuakhali
Tropical storm Roanu	18-21 May, 2016	Chittagong

- *Lines 321-324: In the discussion about the used methods, the authors say that they "included the increased sea level in open ocean boundary instead of adding it into the whole ocean depth". In my opinion this makes no sense because it introduces a discontinuity in the water level that physically is not possible. As the authors say, this produces an additional pressure gradient force acting towards the coast. Therefore, the obtained results are spurious. I suggest removing any reference to this method, including figure 8.*

This method was actually not used in this study to simulate future storm surge inundation. This method was used by some previous studies (Pickering et al. 2012) which we included in the revised text [Revised line 322]:

Rather, we included this as part of sensitivity experiments to show how the inundation could be different based on the consideration of SLR in the model. In the later part, we also clarified by mentioning this [Revised line 327-329]:

To make the future SLR simulation realistic, we considered the increased sea level in ocean bathymetry and increased the depth by 0.26 and 0.54 m, respectively, by considering land submergence near the coast. In that case, the result looked much more realistic than the previous one and this is the method we followed in this paper.

Some of the presented results seem inconsistent:

o In Figure 5 the comparison of inundated areas between present day and future climate scenarios is shown. In this figure, there are several small areas of yellow color indicating zones flooded under present conditions but not flooded during future SLR conditions. The authors should explain why these low lying coasts are flooded with present SLR and not with higher SLR, contrary to what would be expected.

We've added the following explanations regarding this in the manuscript [Revised line 258 – 261]

However in Figure 5, there are several small areas of yellow color indicating zones flooded under present conditions but not flooded during future SLR conditions. This is because Figure 5 showed snapshots of the inundation conditions at one particular time. Some areas may experience alternating wetting and drying conditions, which may explain why some areas are flooded with present SLR and not with higher SLR: this is so only at that particular time. The authors expect that those areas are flooded at other times.

o In lines 226-227 the authors say: "the measured water level variation displayed larger amplitudes than did the model output". Observing Figure 3b, the trend seems the opposite (for positive values) and the red line (modeled) is located above the black one (observed). On the contrary, negative values and total oscillations are greater in the case of observed data. I suggest clarifying this point

Thank you for pointing this out. We've updated the text [Revised line 222-224]

….the measured water level variation displayed smaller amplitudes than did the model output for positive tides and larger amplitudes than the modeled water level for negative tides, perhaps due to the coarse resolution of bathymetry.

o When comparing water levels of Figure 7 and Figure 3, the observed and modelled values are different in panels (a) and (b) of both figures. It looks like in one of both figures, these panels are exchanged.

We've made correction for calculated values of storm surge level in section 3.4 and relevant Figure 7.

Line 295 [Revised line 287]: 2.13 meters instead of 2.3 meters.

Line 296 [Revised line 288]: 13.7% instead of 21%.

Line 297 [Revised line 289]: 28.67% instead of 37%.

Line 298 [Revised line 290]: 2.41 m instead of 2.6 m.

Line 300 [Revised line 292]: 13.95% instead of 14% …. 1.87 meters instead of 2.24 meters……33.45% instead of 31%

Line 301 [Revised line 293]: 2.19 m instead of 2.59 m.

Line 302 [Revised line 296]: 21.93% instead of 22%..........1.299 meters instead of 1.61 meters.

Line 304 [Revised line 298]: 50.96% instead of 51%

Line 307 [Revised line 301]: 3.075 meters instead of 3.01 meters…….23% instead of 50%

Line 308 [Revised line 302]: 55% instead of 68%.

Based on the corrected calculations, we've also updated figure 7. In the initial submission, Figure 7a was mentioned as "TC Sidr at Barisal" and Figure 7b was mentioned as "TC Sidr at Charchanga". Actually, Figure 7a was representing TC Sidr at Charchanga and Figure 7b was representing TC Sidr at Barisal. We've corrected this mistake in the updated manuscript too.

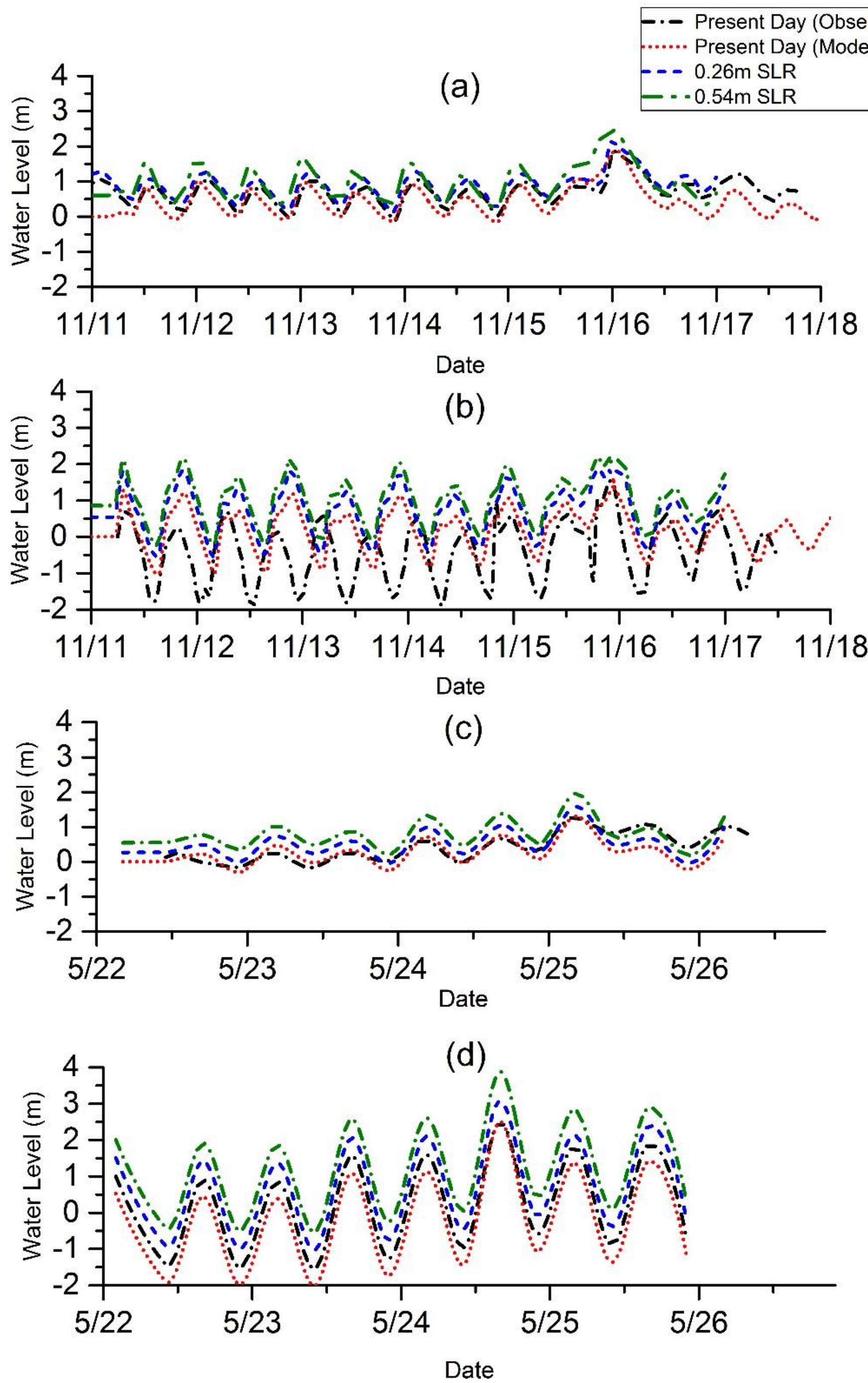

Figure 7. Comparison of storm surge water level between present day and future SLR scenarios. (a) TC Sidr at Barisal (b) TC Sidr at Charchanga (c) TC Aila at Barisal (d) TC Aila at Charchanga. The observed, modeled present-day, mid-of-21st century and end-of-21st century storm surge levels are denoted by the black dash-dotted, red dotted, blue dashed, and green dash-dottted lines, respectively.

Specific comments –

Lines 55-56: "the deaths of hundreds of thousands of lives". Better "the loss of hundreds of thousands of lives". This sentence is very similar to the following one: "This type of coastal flooding. . .", so probably both sentences could be combined into one.

Thank you. We've updated the text and merged these lines [Revised line 54-56].

The geomorphological characteristics of the region have made the locale locales prone to major TC events, events which have occurred multiple times in the past, directly causing loss of hundreds of thousands of lives, property, livelihoods and the economy of the country (Haque, 1997).

- Line 83: "The impact of climate change. . ... are still debatable" should be "The impact of climate change. . ... is still debatable" or "The impacts of climate change. . ... are still debatable".

Thank you. It's corrected.

- Line 88: "will be method of this study", better "will be the method of this study".

Corrected.

- The name of a district is written differently: Patuakhali (line 99), Patukhali (line 106), Pataukhali (line 106). Please be consistent and use only one name.

Sorry about the mistakes. We've corrected these in the updated manuscript.

- Lines 110-114: This paragraph seems a repetition of a previous one.

Removed.

- Lines 129-130: P0 and f are not defined in equations (2) and (3).

It's now corrected. Thank you.

- Line 156: The reference Heming et al. (1980) is missing or there is a mistake and should be Heming et al. (1995).

It should be Heming et al. (1995). Thank you.

- Line 167: The meaning of e is not defined in equation (6).

It's the base of the natural logarithm (=2.71828182846) (Delft Hydraulics, 2011). We've included this information in the revised version.

- Line 178: "methods described in Zhang et al. (2012) was followed" should be "methods described in Zhang et al. (2012) were followed".

Corrected.

- Line 184: "boundary was shown in Figure 1", better "boundary is shown in Figure 1". - Line 206: ". . .in making ensemble projections shown in Table 2" should be ". . .in making ensemble projections are shown in Table 2"

Corrected.

- Line 212: "(-ve)" looks a typo.

It's now corrected.

- Line 215: Equation (8) is wrong. The MAE is obtained by comparing observations with model results

Corrected.

- Line 234: "the two TCs considered were shown in Figure 4.", better : "the two TCs considered are shown in Figure 4."

Thank you. We've corrected it.

- Lines 262-263: Please substitute "square kilometers" by "km2".

Corrected.

- Lines 269-272: This paragraph is a repetition of the previous one.

Thanks for pointing this out. We've removed those lines.

- Lines 310-313 are redundant with the previous paragraphs and although they coincide with Figure 7 caption (which is wrong), they do not describe Figure 7.

Sorry about the mistake. We've removed that paragraph and corrected the caption of Figure 7

- Line 351: "SLR conditions; which is. . .", better "SLR conditions, which is. . .".

Thank you. We've corrected this.

- References: Alam (1996), Mohal et al. (2006) and Vatvani et al. (2002) are listed in References but are not cited in the text.

Alam (1996) and Mohal et al. (2006) were removed from the updated manuscripts. Vatvani et al. (2002) should be in line 168. In addition to that, references regarding WES (Delft Hydraulics, 2011) was added in line 156 and was listed in references list.

- *The reference corresponding to Delft3D model is cited in the text as Delft Hydraulics (2006) but is listed as Hydraulics, D. (2006). Please be consistent.*

Sorry about that. We've updated that.

- *Figure 7 caption is wrong and it does not describe this figure, since the results of both future scenarios are included in each figure.*

Caption is now updated as follows [Revised line 538 - 540]

Figure 7. Comparison of storm surge water level between present day and future SLR scenarios. (a) TC Sidr at Barisal (b) TC Sidr at Charchanga (c) TC Aila at Barisal (d) TC Aila at Charchanga. The observed, modeled present-day, mid-of-21st century and end-of-21st century storm surge levels are denoted by the black dash-dotted, red dotted, blue dashed, and green dash-dottted lines, respectively.