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Towards an efficient storm surge and inundation forecasting system over the Bengal delta: chasing the Supercyclone Amphan

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1 Bathymetry

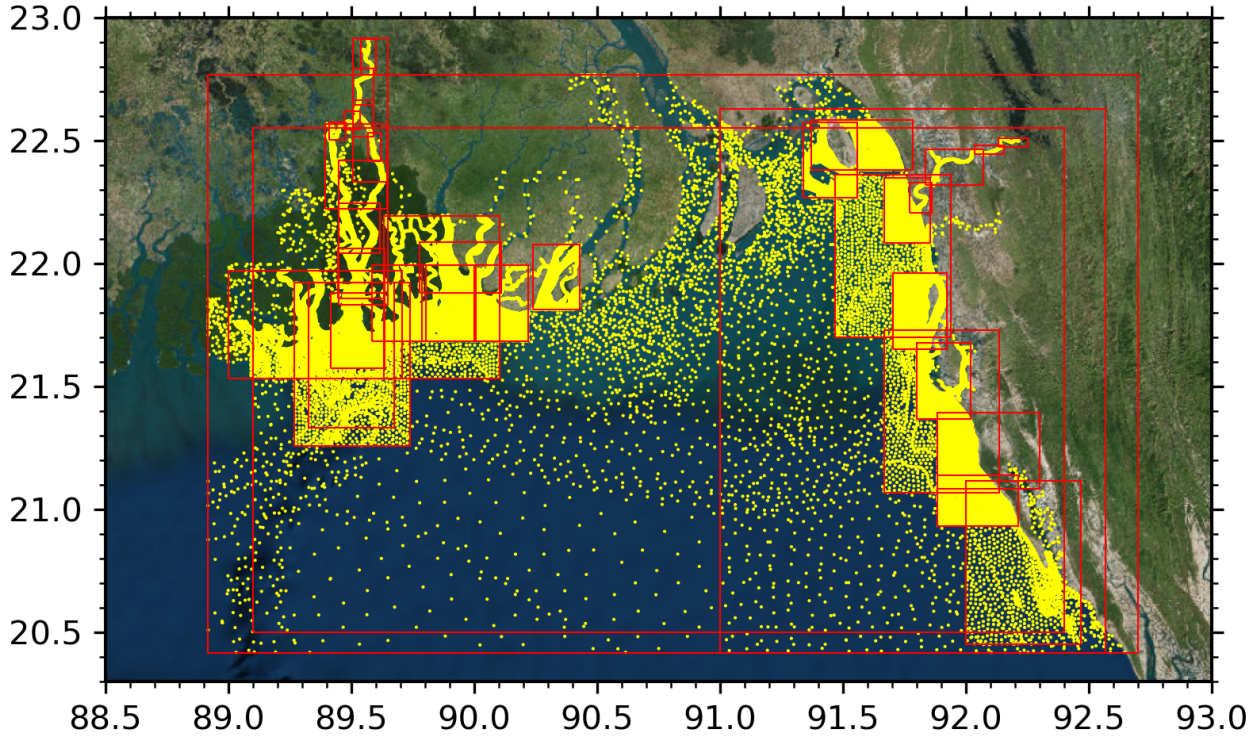

Figure S1. Newly digitized sounding points from Bangladesh Navy charts (in yellow) (Khan et al., 2019). The red boxes show the individual chart outlines. The background is a RGB image composite derived from B2, B3, and B4 channels of Sentinel-2.

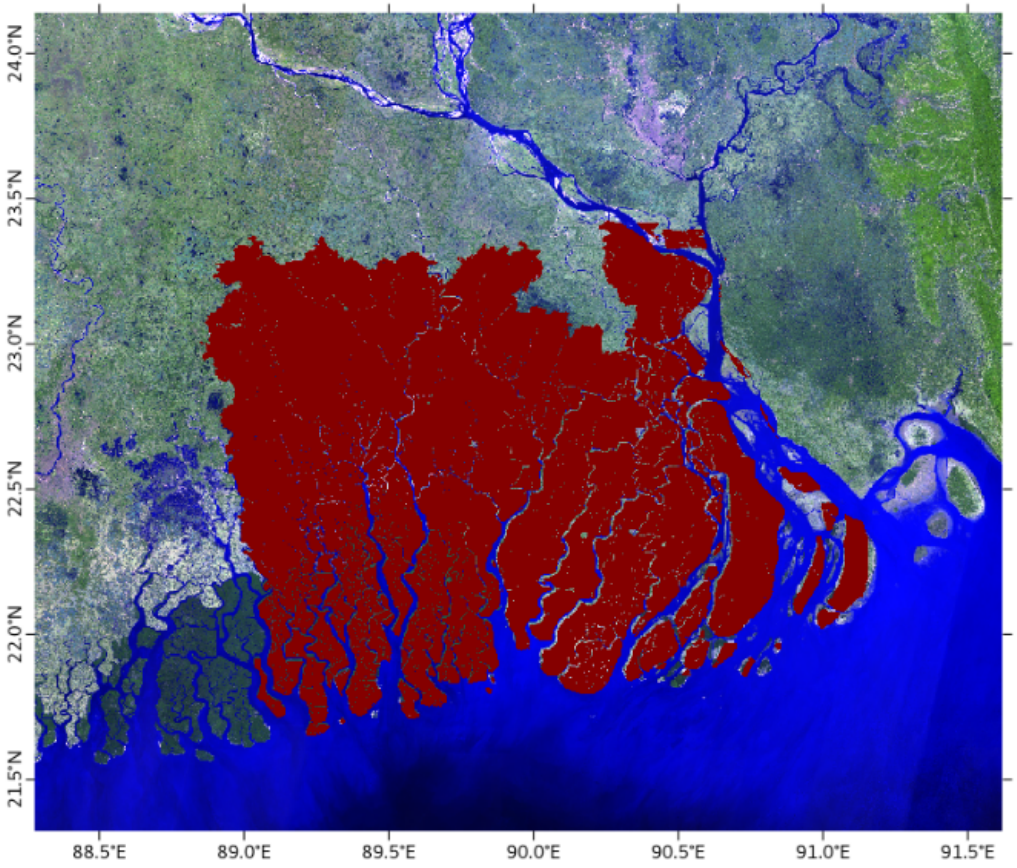

Figure S2. Extent of the 50 m resolution inland topography dataset (in red). The background is a false-colour image composite derived from B12, B11, and B4 channels of Sentinel-2.

2 Tide model validation

Our tidal model is validated at 7 tide gauge locations, around the Bengal delta (See Table S1). We have used complex error as the performance indicator (Mayet et al., 2013). The harmonic analysis is done using the Tidal toolbox developed at LEGOS (Allain, 2016). The modulus of the complex difference defines the complex error for a tidal constituent.

$$|\Delta z| = |A_m e^{i\phi_m} - A_o e^{i\phi_o}| \tag{S1}$$

Where A and ϕ are the amplitude and phase (in radians) respectively, of the tidal harmonics. The subscript denotes the model (m) and observation (o). The total error of all the constituent at one location is calculated as the squared root of half of the squared sum.

$$\sigma_s = \sqrt{\frac{1}{2}\sum_N |\Delta z|^2} \tag{S2}$$

Along the coast of Bengal delta, only four of the constituents - M2, S2, K1, and O1 are found to contribute significantly to the tidal energy (Sindhu and Unnikrishnan, 2013). As in many cases, information for other tidal harmonics is not available, only these four constituents are considered for calculating the total complex error at a location.

A comparison of the complex error between the global models and the model presented here is shown in Table S1. Amplitudes (A) and errors are in centimeter, phase (ϕ) is in degrees. Hooghly River, Diamond Harbour, Garden Reach and Chandpur are not represented in global tidal models (FES, GOT, and TPXO) due to their location in far upstream.

Table S1. Performance of tidal model at tide-gauge locations.

Station		Observation		FES2012-Hydro			FES2012			GOT4.8			TPXO7.2			Krien et al. (2016)			This Model		
		A_0	ϕ_0	A_m	ϕ_m	Error	A_m	ϕ_m	Error	A_m	ϕ_m	Error	A_m	ϕ_m	Error	A_m	ϕ_m	Error	A_m	ϕ_m	Error
Sagar Roads (88.0300°E, 21.6500°N)	M2	140	116	142	99	42	137	104	29	113	113	27	132	104	28	143	116	3	144.5	114.9	5.3
	S2	66	150	73	141	13	62	141	11	40	145	40	48	126	29	62	155	7	62.4	153.3	5.2
	K1	15	262	17	256	2	16	253	3	14	277	14	14	258	1	17	265	2	15.6	265.4	1.1
	O1	5	250	6	251	1	6	243	1	5	270	2	5	252	0.4	6	248	1	5.7	251.6	0.8
	σ_s					**31**			**22**			**27**			**29**			**6**			**5.3**
Diamond Harbour (88.1733°E, 22.1928°N)	M2	157	168													166	161	21	142.3	165.6	15.9
	S2	68	210													68	207	4	57.6	208.6	10.4
	K1	15	285													16	284	1	13.2	286.3	1.8
	O1	7	258													5	253	2	5.4	257.7	1.6
	σ_s																	**15**			**13.6**
Hiron Point (89.4780°E, 21.8169°N)	M2	81	127	86	88	56	87	91	52	80	88	53	104	110	35	81	115	17	99.9	115.0	26.7
	S2	34	159	45	121	28	40	122	24	37	118	25	37	136	14	35	148	7	41.6	150.5	9.3
	K1	13	268	15	250	5	16	252	5	14	248	5	14	261	2	15	265	2	15.0	265.7	1.7
	O1	5	258	6	244	2	6	238	2	5	244	1	5	256	0.3	6	245	1	5.7	255.0	0.7
	σ_s					**44**			**40**			**42**			**27**			**13**			**20.0**
Dhulasar (90.2700°E, 21.8500°N)	M2	73	158	58	114	52	80	117	53	79	117	54	86	121	51	51	156	22	67.6	143.3	18.8
	S2	35	193	39	141	33	39	142	32	39	146	29	35	135	34	20	194	15	28.5	179.6	9.8
	K1	13	286	15	262	6	16	256	8	15	260	6	15	255	8	12	297	3	13.3	287.8	0.5
	O1	4	278	6	256	3	6	243	3	6	256	3	6	250	3	5	280	1	5.6	273.8	1.6
	σ_s					**44**			**44**			**44**			**44**			**19**			**15.0**
Charchanga (91.0500°E, 22.2188°N)	M2	96	234	110	202	57	115	208	50	97	204	49	84	154	103	67	208	46	95.8	216.9	28.5
	S2	37.5	265	38	238	18	30	243	15	34	234	19	36	186	47	27	241	17	36.6	250.3	9.5
	K1	13	304	17	298	4	16	300	4	7	314	6	16	272	8	14	309	2	16.8	308.7	4.0
	O1	8	285	7	289	1	6	284	2	4	303	4	6	267	3	8	289	0	8.1	293.1	1.1
	σ_s					**43**			**37**			**37**			**80**			**35**			**21.5**
Chittagong (91.8274 °E, 22.2434°N)	M2	173	196	118	193	56	126	200	49	120	192	54	89	153	123	156	198	18	149.2	194.8	24.1
	S2	64	229	41	230	23	33	236	31	43	227	21	40	160	62	58	235	9	55.0	225.8	9.6
	K1	19	278	17	294	6	17	295	6	9	300	11	16	258	7	20	289	4	19.1	284.9	2.3
	O1	8	263	7	285	3	6	280	3	4	289	5	6	252	2	8	269	1	7.9	267.3	0.6
	σ_s					**43**			**41**			**42**			**98**			**14**			**18.4**
Chandpur (90.6385°E, 23.2344°N)	M2	29.7	31.4																33.6	333.7	30.7
	S2	10.5	62.3																11.2	6.3	10.2
	K1	5.6	18.6																5.4	21.9	0.7
	O1	3.4	12.9																3.6	357.4	1
	σ_s																				**22.9**

3 Inundation

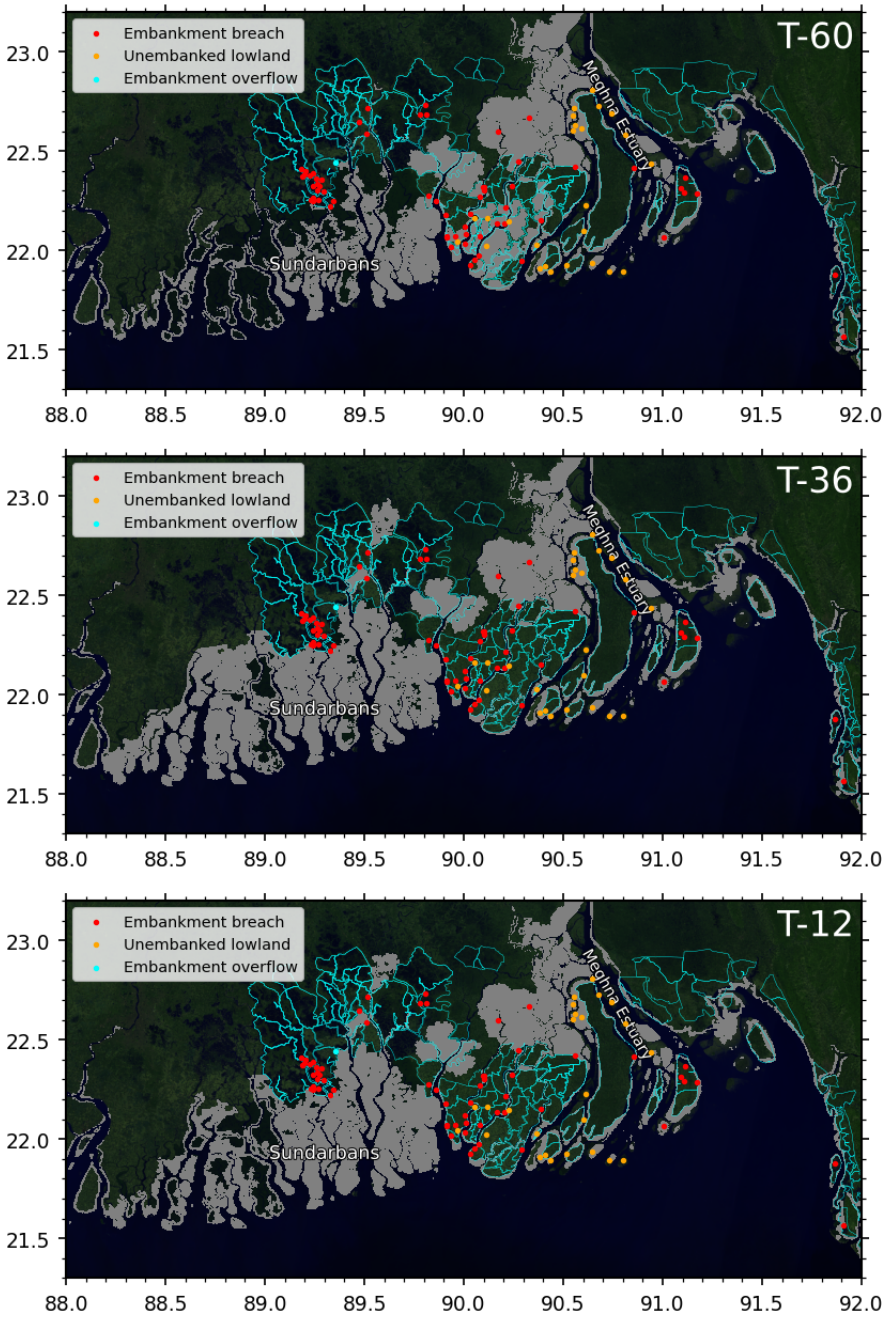

Figure S3. Same as Figure 9 for forecasts at T-60, T-36, and T-12 hours.

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