EOSIEM

European Gravity Service for Improved Emergency Management

Flood volume estimation based on EO data

- Ganges-Brahmaputra test case -

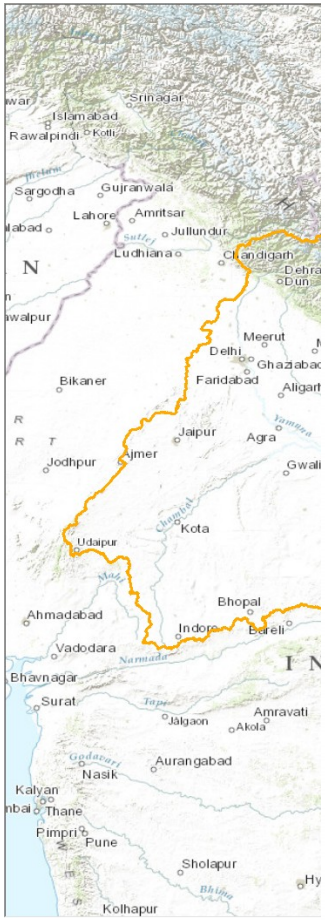
WP6 – T6.1

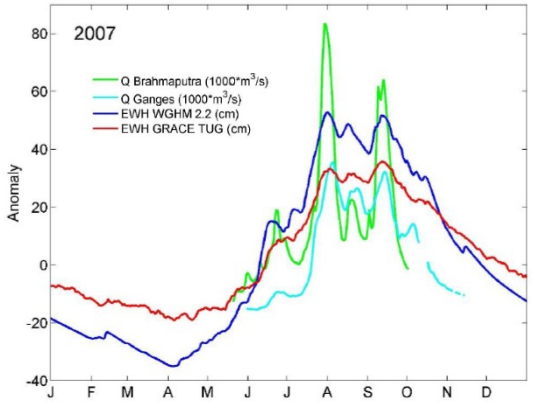
Hendrik Zwenzner - DLR

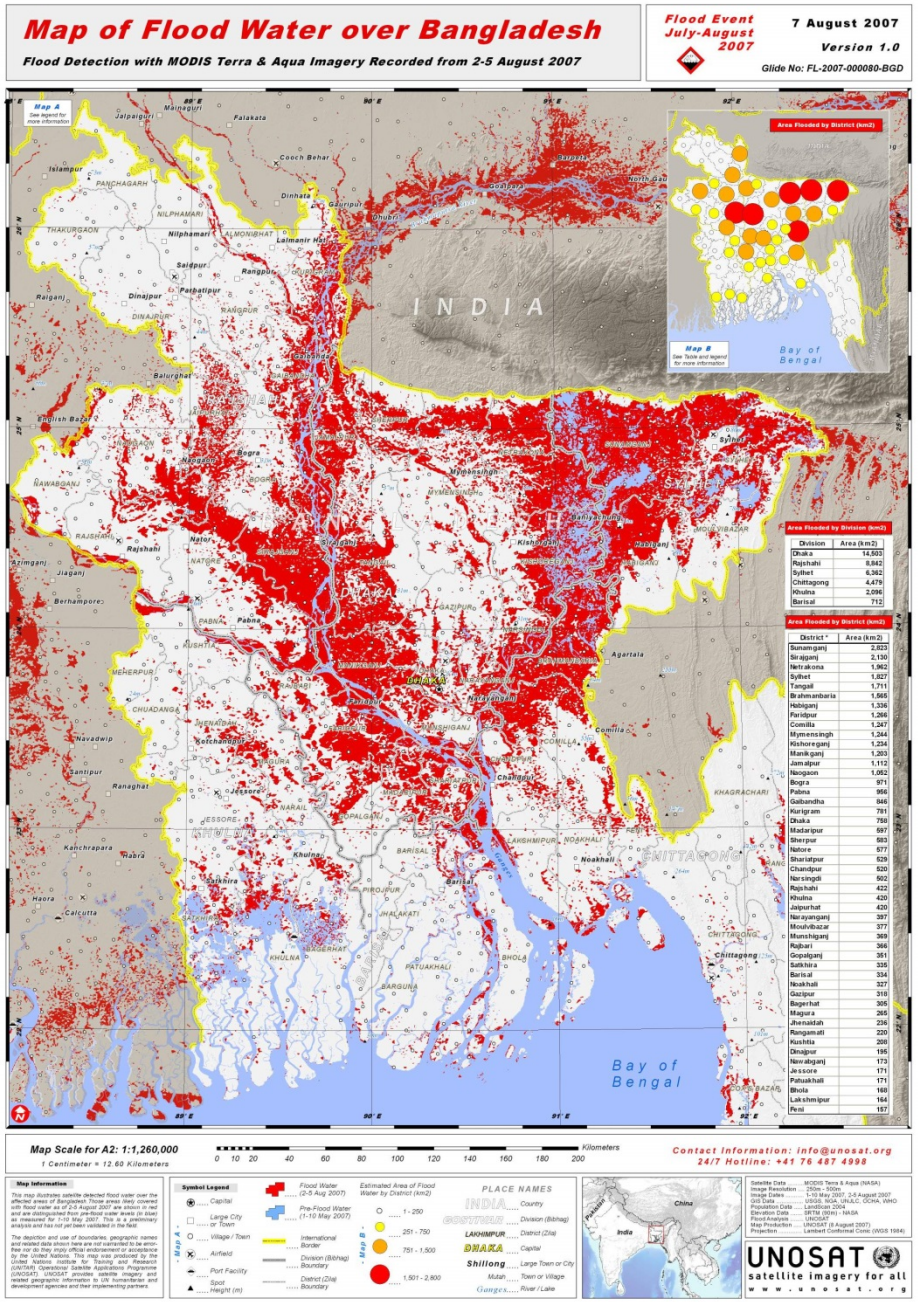
HORIZON 2020

Ganges/Brahmaputra

- Extreme flood event during 2007
- Size: ca. 220.000 km²







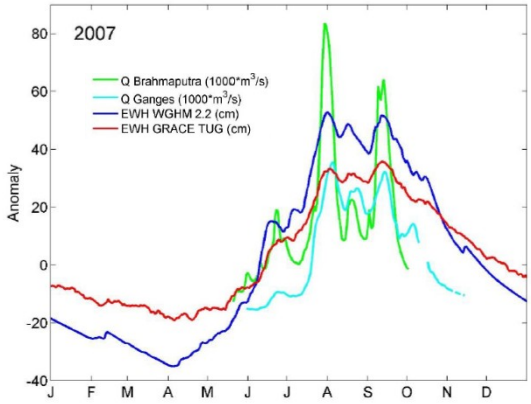
HORIZON 2020

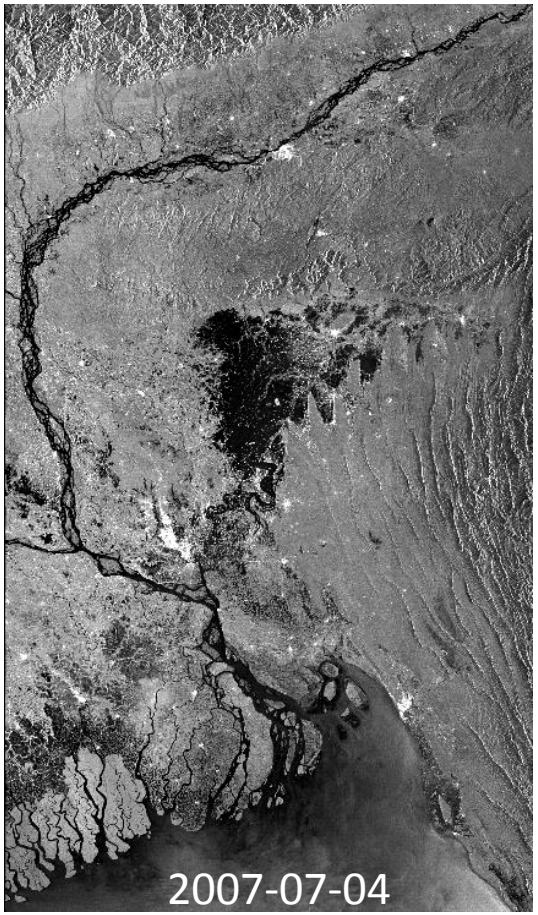
Ganges/Brahmaputra

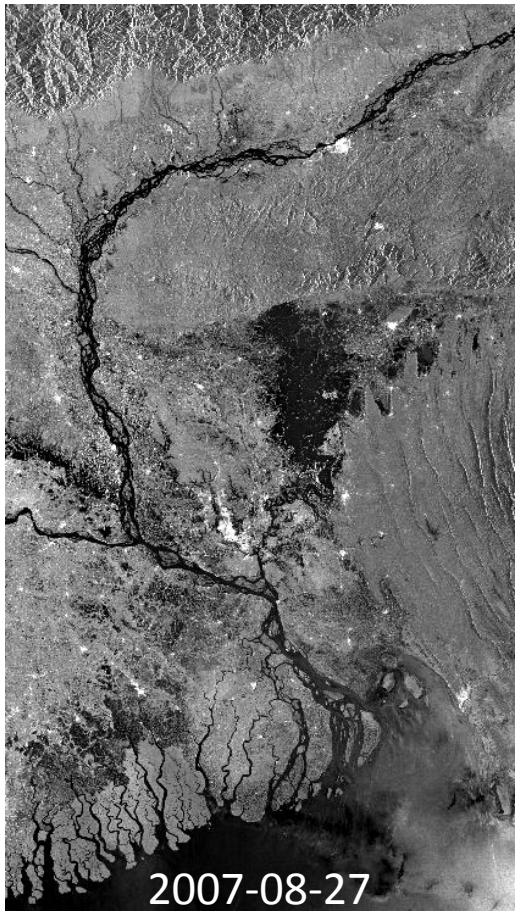
EOSIEM
European Gravity Service for Improved Emergency Management

ENVISAT-ASAR wideswath (150m)

Id	Mission	Sensor	date	track	pass
1	ENVISAT-1	ASAR/WS	2007-07-04	319	D
2	ENVISAT-1	ASAR/WS	2007-07-23	90	D
3	ENVISAT-1	ASAR/WS	2007-08-11	362	D
4	ENVISAT-1	ASAR/WS	2007-08-27	90	D
5	ENVISAT-1	ASAR/WS	2007-09-04	212	A
6	ENVISAT-1	ASAR/WS	2007-09-07	255	A
7	ENVISAT-1	ASAR/WS	2007-09-23	484	A
8	ENVISAT-1	ASAR/WS	2007-10-09	212	A







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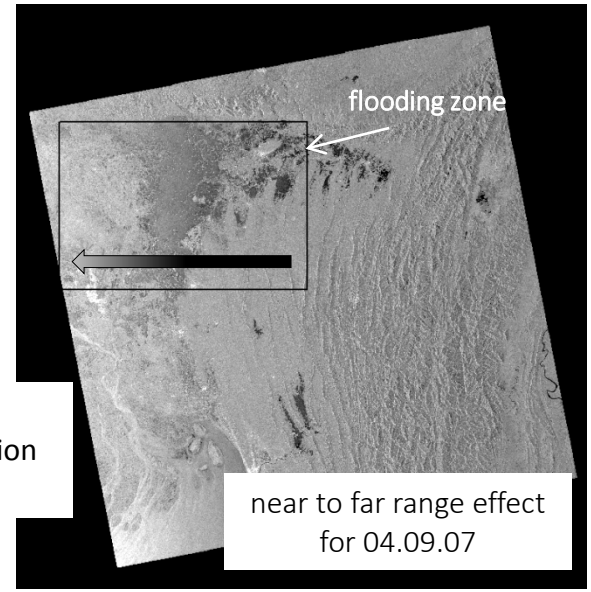
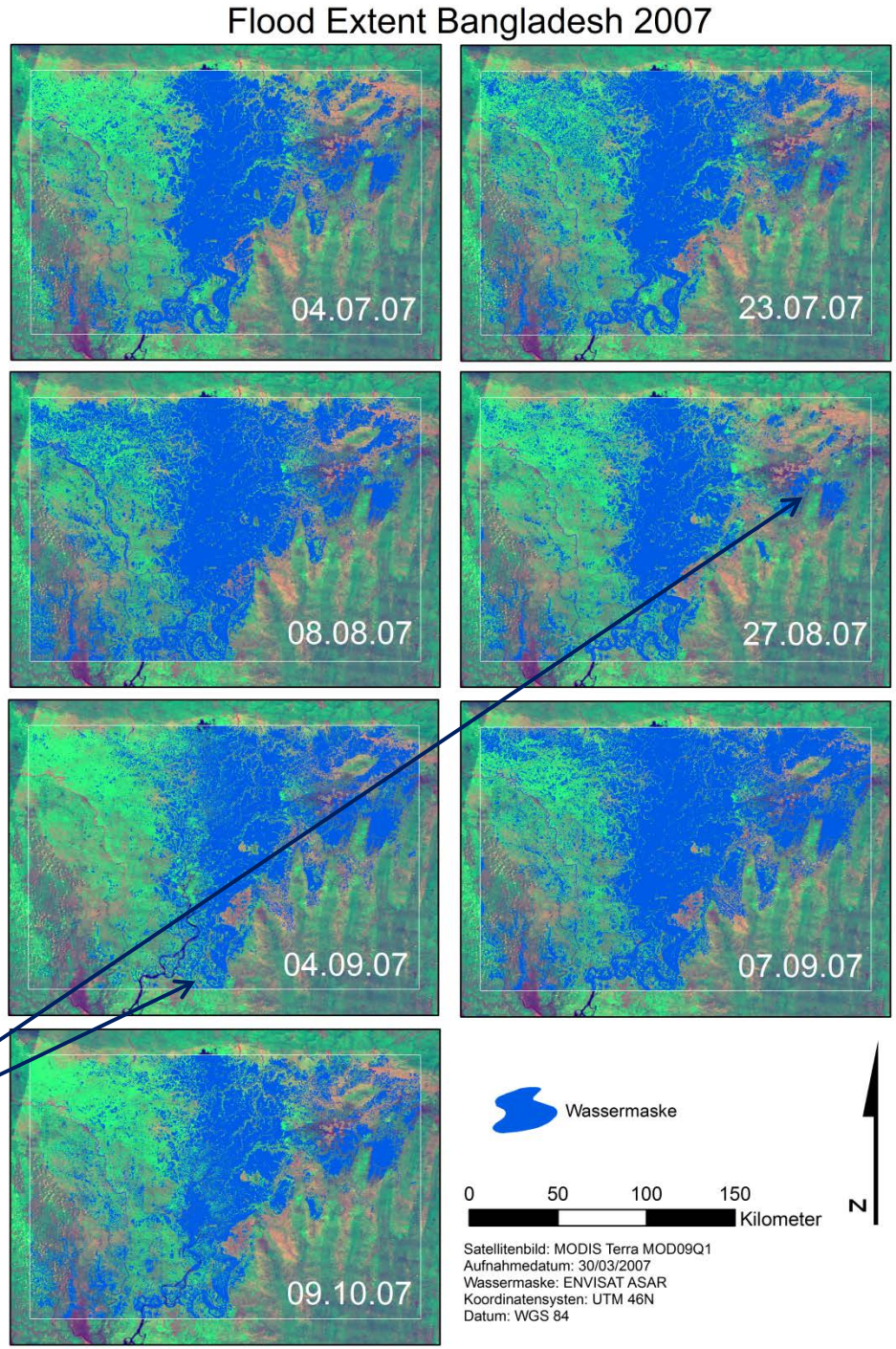
HORIZON 2020

Water Extent: Floodingzone



attempts of brightness correction weren't satisfying

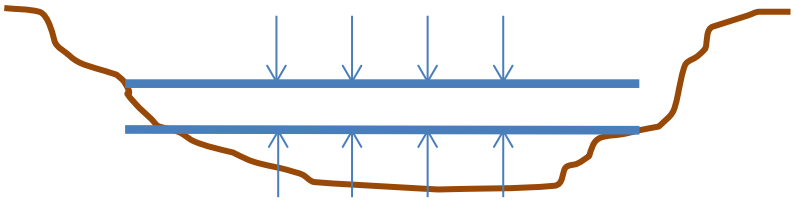
The difference in brightness due to the near & far range effect leads to an inaccurate water mask in the western flooding zone for the 4th of September and eastern for 27th August. Water pixel are not recognized, the water extent is underestimated and thus the volume.



Data integration

European Gravity Service for Improved Emergency Management

- Combination of flood mask and DEM (both datasets resampled to 30m)



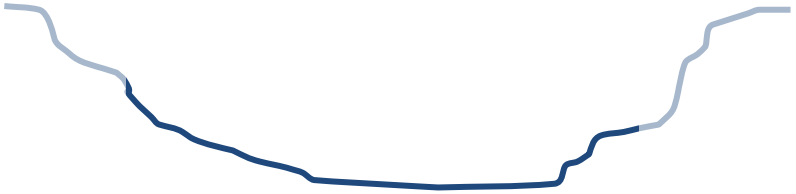
Plain water surface is assumed (no slope)

- Coarse resolution and inconsistencies between both datasets do not allow for accurate determination of vertical water profile

Data integration

European Gravity Service for Improved Emergency Management

- Combination of flood mask and DEM (both datasets resampled to 100m)

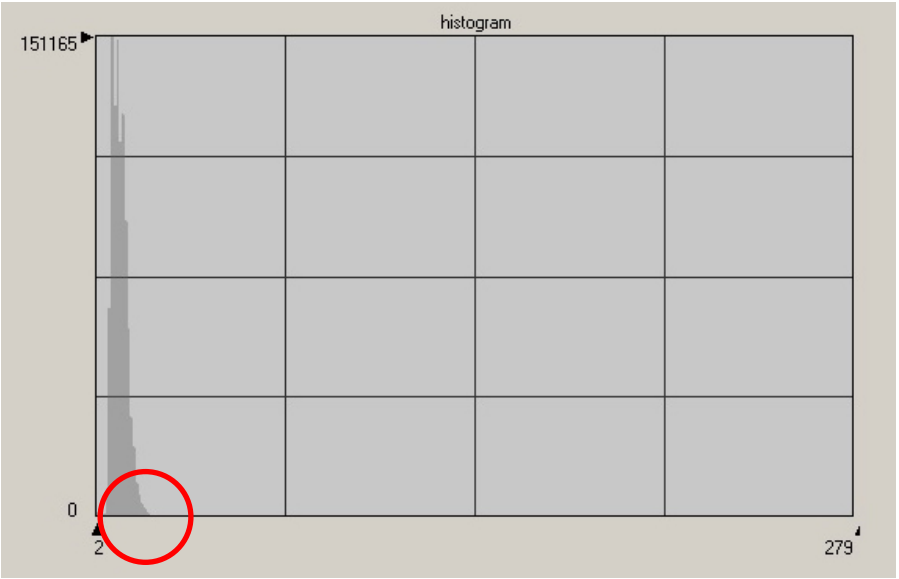


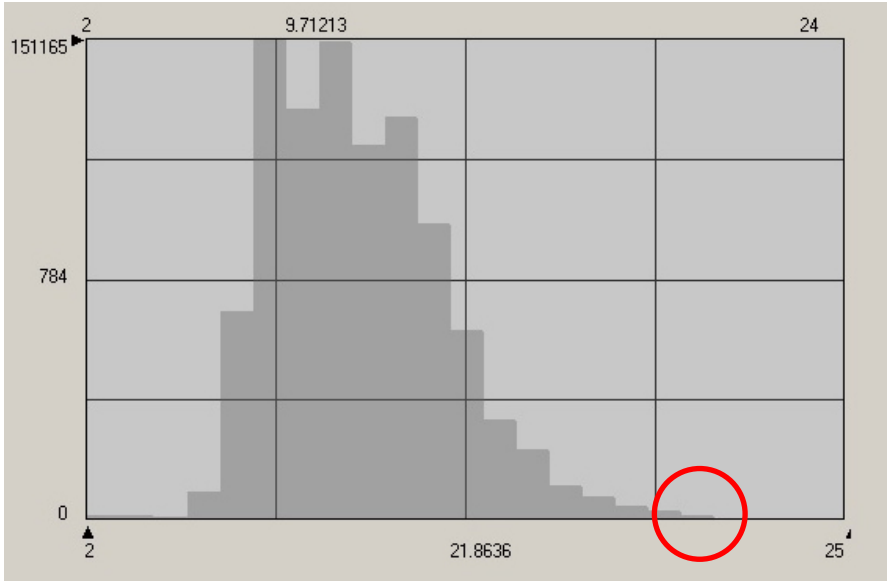
Plain water surface is assumed (no slope)

- Coarse resolution and inconsistencies between both datasets do not allow for accurate determination of vertical water profile

Histogram

European Gravity Service for Improved Emergency Management

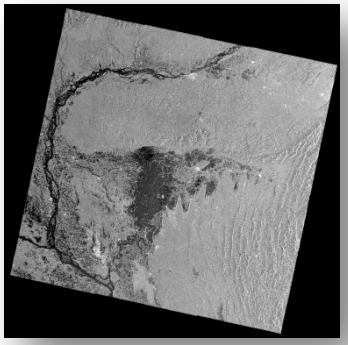




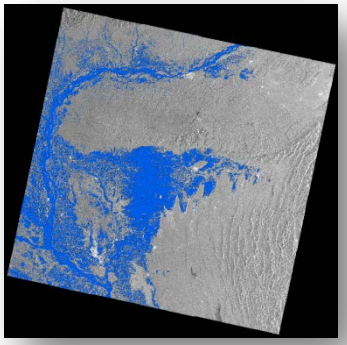
- Histogram shows distribution of elevation of flood pixels
- Flood water level is defined by land-water-boundary
- optimal threshold to be found (due to classification errors, etc.)

Workflow

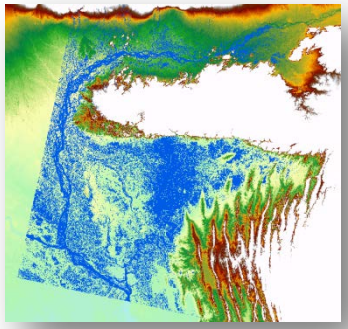
SAR-Scene



Water classification



Clip SRTM 30 m for water mask

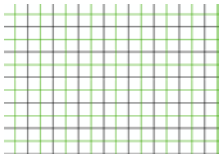


clipped DEM
(height only for flood pixels)

ArcGIS Model
(Toolbox: Fishnet & Zonal Histogram)

Input

Grid Cell Size
(adjustable)



Output

Grid Cell ID

LABEL	OID_2377	OID_2378	OID_2379	OID_2380
2	0	8781	0	0
3	0	695	1367	4333
4	0	955	976	1615
5	0	3604	789	4733
6	2490	30522	18417	27717
7	10756	30773	30672	21427
8	29417	8546	17577	13513
9	8050	1592	6295	6375
10	3778	230	2139	2340
11	986	47	798	720
12	296	6	310	284
13	112	0	144	92
14	19	2	74	49
15	9	2	28	19
16	5	0	17	8
17	1	0	10	7
18	0	0	5	2
19	0	0	5	2
20	0	0	2	1

DEM Value

Histogram for one
grid cell

Volume calculation with R

R-Script

```
for(a in 1:length(filename)){       #iterates every .dbf file in the folder

  #file <- read.dbf(filename[a])
  file <- read.table(filename[a], sep=",", header=T)  # use for txt file
  TOTAL <- matrix(nrow=1,ncol= 0)
  rownames(file)<- file$LABLE # rownames are now the terrain elevation value
```

calculates threshold and sums
up the volume for each grid cell

Volume

12,518 Gt

Thresholding (I)

A **threshold of 15%** leads to promising results. However, water levels do not fit to gauge/altimetry data due to:

- Time difference between altimetry measurement and satellite data acquisition
- Point measurement vs. Extensive coverage of satellite image

Each OID represents a certain grid cell

07.09.2007	Ganges_P	Ganges_R	Ganges_Q	Ganges_S	Ganges_D	Ganges_BWDB	Brah_BWDB
DEM elevation	OID_5009	OID_4912	OID_4719	OID_4428	OID_3528	OID_3909	OID_5568
1					7130	0	
2	0	0	0	0	6729	0	
3	0	0	0	0	207	2000	
4	0	0	0	0	340	3111	
5	0	0	0	0	428	3046	
6	0	0	0	0	434	198	
7	0	19095	0	0	713	139	
8	2944	20394	5239	0	715	439	
9	36870	10184	9012	34396	789	285	
10	7938	3607	18474	8049	592	371	
11	2615	1245	6957	3639	4353	673	0
12	1000	448	3557	1077	2807	320	0
13	366	167	1817	338	930	354	0
14	143	67	898	91	438	355	0
15	68	24	422	21	283	377	7453
16	26	12	190	10	143	341	4817
17	9	7	82	3	84	184	326
18	3	4	25	0	36	279	247
19	2	6	10	0	7	63	293
20	2	2	4	0	2	27	331
21	1	0	0	0	0	28	1546
22	1	0	0	0	0	15	11532
23	0	0	0	0	1	10	8098
24	0	0	0	0	1	7	3497
25	0	0			1	5	1436
26	0	0			1	8	456
27	0	0			0	0	141
28	0	0			0	1	34
29	0	0			1	3	16
30	0				0	2	9
31	0				1	3	9
32	0				0	0	6
33					0	8	6
34					1	2	1
Date	**15.09.2007**	**15.09.2007**	**15.09.2007**	**15.09.2007**	**02.09.2007**		**08.08.2007**
Gauge Data/ Altimeter	7.44	7.28	6.65	6.53	11.03	13.25	20.46
Korrigiert für WGS84	10.574	10.445	9.506	8.947	8.424	NO	NO
Summe	51988	55262	46687	47624	27168	12665	40264
5%	2599.4	2763.1	2334.35	2381.2	1358.4	633.25	2013.2
10%	5199	5526	4669	4762	2717	1267	4026
15%	7798	8289	7003	7144	4075	1900	6040
20%	10398	11052	9337	9525	5434	2533	8053
	12174	15773	7005	5179	999	125	5618
Ergebnis 5%	11	10	12	11	12	11	24
Ergebnis 10%	10	9	11	10	12	5	23
Ergebnis 15%	9	9	10	10	11	5	23
Ergebnis 20%	9	8	10	9	2	5	23

Number of pixels with a water level of 12 m

Thresholding (II)

Results depend on grid cell size. Which size of the grid cells and which threshold fits best?

Resulting threshold equals(± 0.5 m) the gauge measurement

Resulting threshold deviates from the gauge measurement > 4 m

Threshold fits best here

Gauge	Ganges_P	Ganges_R	Ganges_Q	Ganges_S	Gan_337	Ganges_D	Gan_524	Gan_982low	Ganges_BWDB	Brah_BWDB	Gan_438		
Water Mask: 07.09.07	OID_5009	OID_4912	OID_4719	OID_4428	OID_3528	OID_3528	OID_3909	OID_3529	OID_3908	OID_5568	OID_2956		
Date of measurement	15.09.2007	15.09.2007	15.09.2007	15.09.2007	28.07.2007	02.09.2007	08.09.2007	24.09.2007	07.09.2007	07.09.2007	05.09.2007		
height in meters	7.44	7.28	6.729	6.53	10.728	11.03	14.14	9.915	13.25	20.46	6.14		
corrected for EGM96	10.574	10.445	9.506	8.947	11.243	8.424	14.364	10.457	NO	NO	6.859		
50km 5%	10	10	12	10	12	12	18	12	12	24	10	2	0
50km 10%	10	9	11	10	11	11	4	11	4	23	9	2	2
50km 15%	9	8	10	9	11	11	4	10	3	23	8	4	2
50km 20%	9	8	10	9	2	2	4	1	3	22	8	2	5
75km 5%	11	10	12	11	12	12	15	12	15	24	9	3	
75km 10%	10	9	11	10	12	12	5	12	5	23	9	1	2
75km 15%	9	9	10	10	11	11	5	11	5	15	8	2	2
75km 20%	9	8	10	10	11	11	5	11	5	15	8	2	2
100km 5%	11	10	12	11	12	12	11	13	11	24	9	2	0
100km 10%	10	9	11	10	12	12	5	12	5	23	8	2	2
100km 15%	9	9	10	10	11	11	5	12	5	23	8	2	2
100km 20 %	9	8	10	9	2	2	5	11	5	23	8	2	4

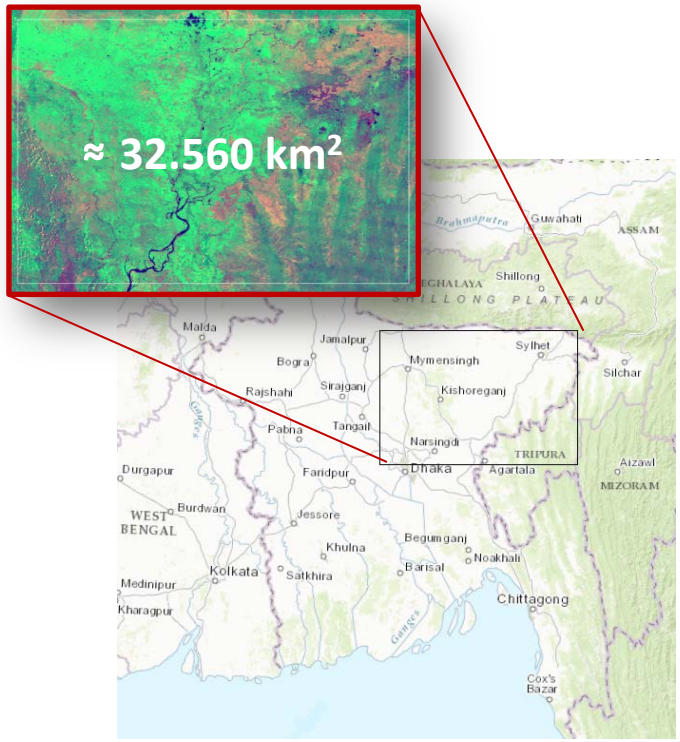
➔Threshold of 15% and Grid Cell Size of 50 km fits best to the reference data.

Volume: Flooding zone

Date	Volume in Gt Grid Cell 30 x 30 km	Volume in Gt Grid Cell 75 x 75 km	Volume in Gt Grid Cell 100 x 100 km
04.07.07	13,809	15,340	15,784
23.07.07	15,364	17,152	17,520
08.08.07	19,027	20,883	21,262
27.08.07	12,518	14,158	14,034
04.09.07	13,426	14,394	14,293
07.09.07	19,679	21,511	21,545
09.10.07	13,024	14,563	14,488

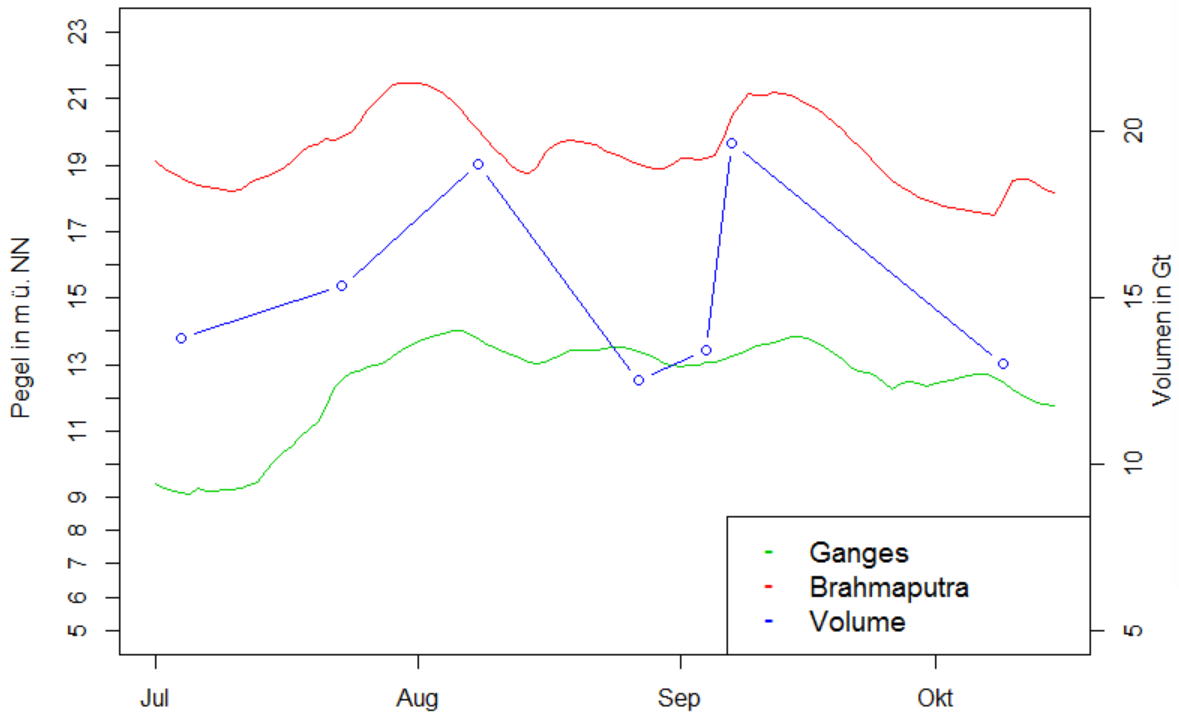
Size of the grid cell determines flood volume.
Flood peak: ~ 7 Sep. 2007
Threshold: 15 %
For comparison: ca. 160 Gt for the whole of Bangladesch (ca. 100 Gt ground water) → 60 Gt surface water
(STECKLER et al. 2010)

Flooding Zone
(covered by every scene)



Volume: Flooding zone

Daily water gauge measurements from BWDB (Bangladesh Water Development Board) for Ganges & Brahmaputra (1st July to 15th Oktober) as well as calculated flood volumes for 7 Envisat ASAR szenes



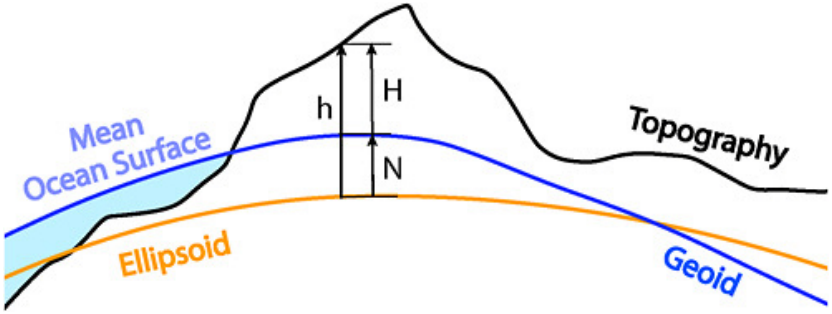
Location of water gauges (google earth)

The temporal resolution of the volume data is much lower than the one of the gauges. Still it is possible to see higher amounts of volume for the two peaks in the gauge data (begin of August & mid of September)

Next Steps

- The threshold must be more accurate
  - Integrate more reference measurements
  - Different method for threshold calculation
- Processing and flood volume calculation for entire ENVISAT ASAR scene for better comparison with GRACE daily solutions

Appendix: Geoid-Reference



nap.edu

- SRTM 30 m: WGS84 EGM96
- ENVISAT: Ganges & Brahmaputra
  - Grace Ellipsoid GGM02C
- ENVISAT: Ganges: EGM2008

→There are several online tools for conversion of EGM96 into EGM2008, Basis WGS84 Ellipsoid

→GGM02C and many others: http://icgem.gfz-potsdam.de/ICGEM/