An automated approach to estimate large-scale flood volumes based on SAR satellite imagery and different DEMs

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EGSIEM – European Gravity Service for Improved Emergency Management

DLR Deutsches Zentrum für Luft- und Raumfahrt

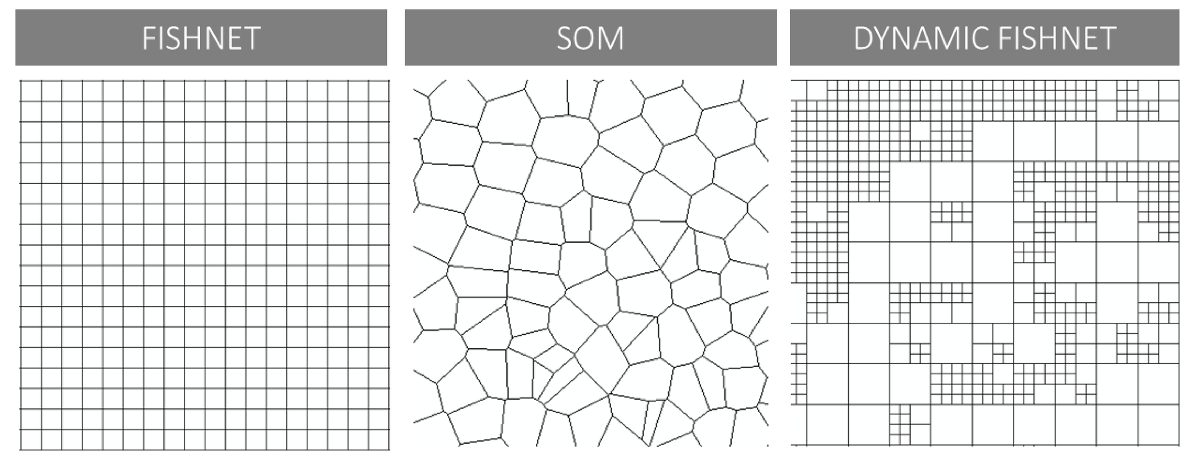
INTRODUCTION

Flood depth and **flood volume** are usually outputs of hydraulic models which are difficult to parameterize. In this study a new approach is presented which is based on the combination of **Sentinel-1 flood masks** and the **SRTM DEM** as well as additional information from altimetry and in-situ sensors for a flood in Bangladesh. This work has been carried out in the framework of the H2020 **EGSIEM** (European Gravity Service for Improved Emergency Management) project, in which we want to investigate the correlation of gravity measurements from space with flood information derived from earth observation satellites. For this task **3-d flood information**, i.e. flood volume or water mass, is needed instead of 2-d flood masks.

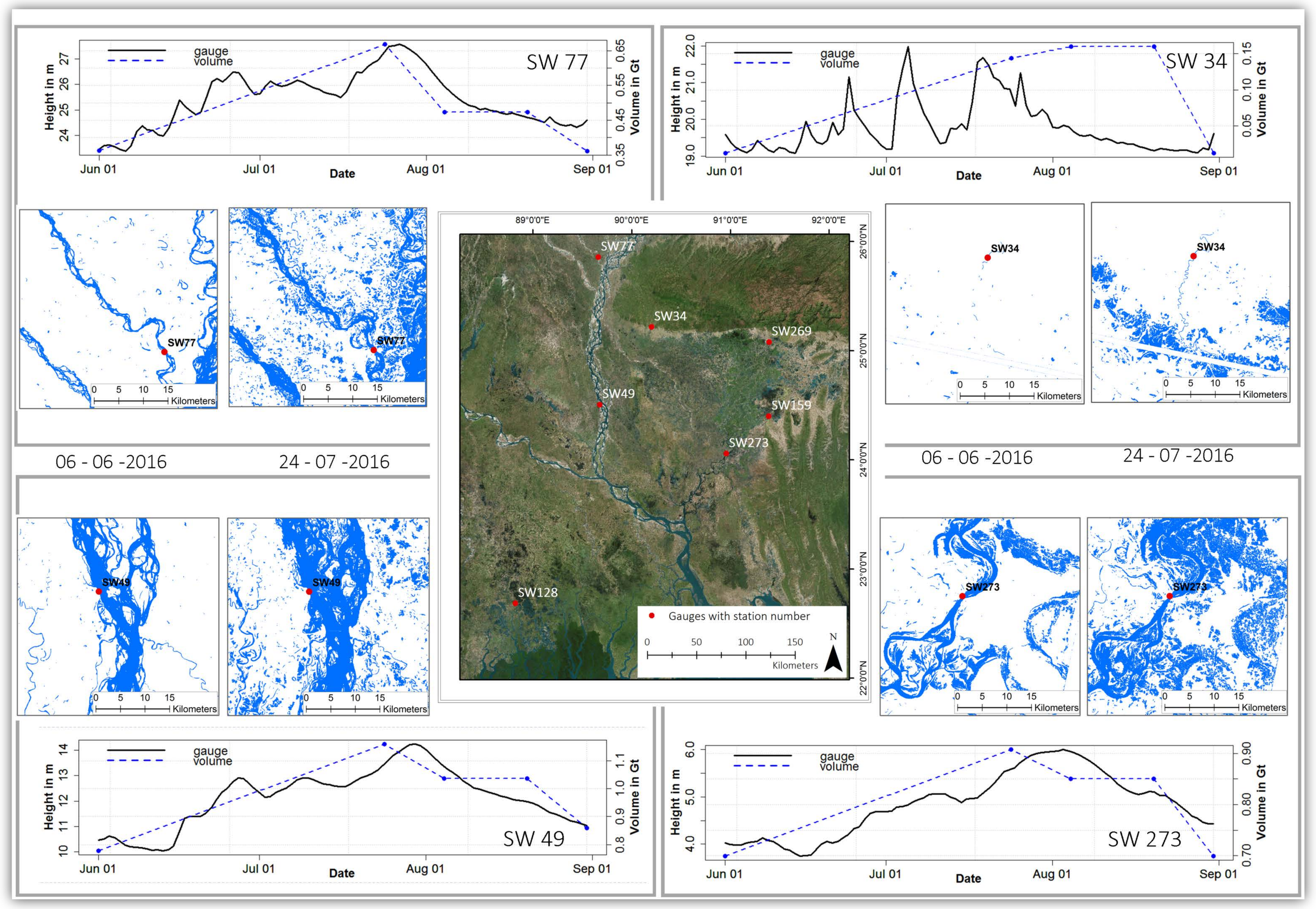
GRIDDING

Several approaches were tested to find the **optimal tiling algorithm** for defining **river sections** with a **horizontal water surface**

- **Static fishnet** with different grid cell sizes (5- 50 km)
- **Self-Organizing Maps** (SOM): a dynamic approach of a net gridded on the basis of similar height values
- **Dynamic fishnet** forming grid cells based on further tiling (5-20 km) according to the slope of the water surface



VOLUME ESTIMATES

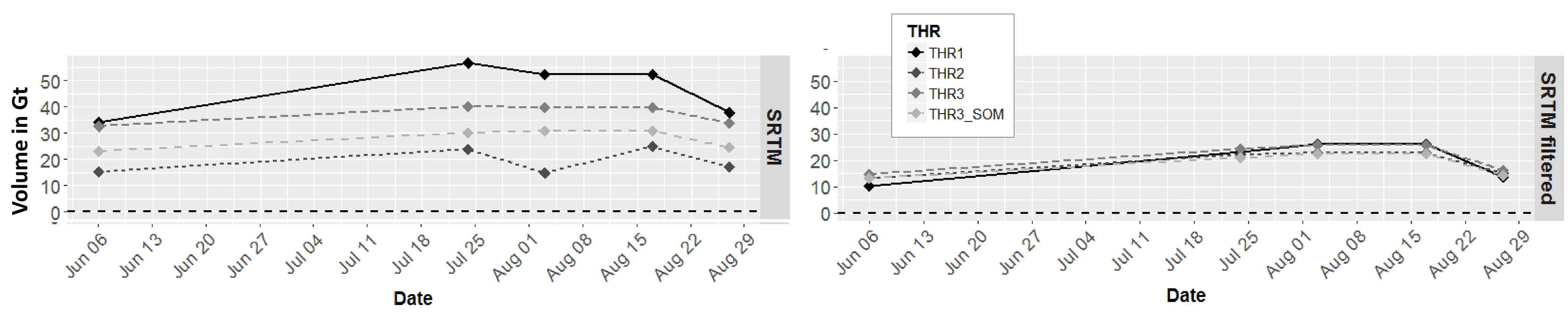


Local Volumes

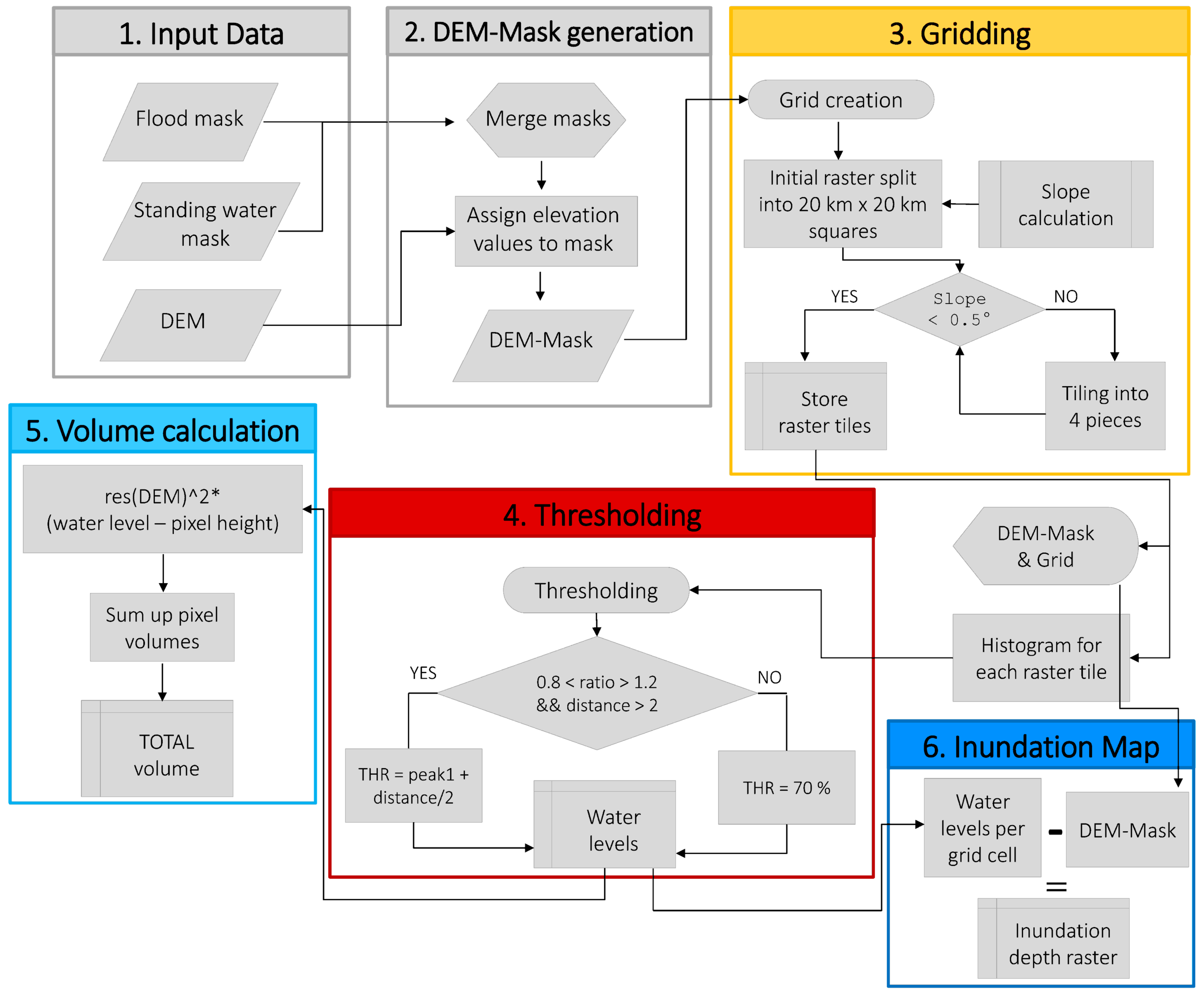
- Rise of the **flood volume** (calculated per tile) corresponds to the rise in **water levels** (gauge measurement) of the respective river section
- Regions with **retention areas** show a much lower decrease of the flood volume compared to the decrease of water levels measures on the main river

Flood Volume and the optimal combination of different GRIDS and THRESHOLDS

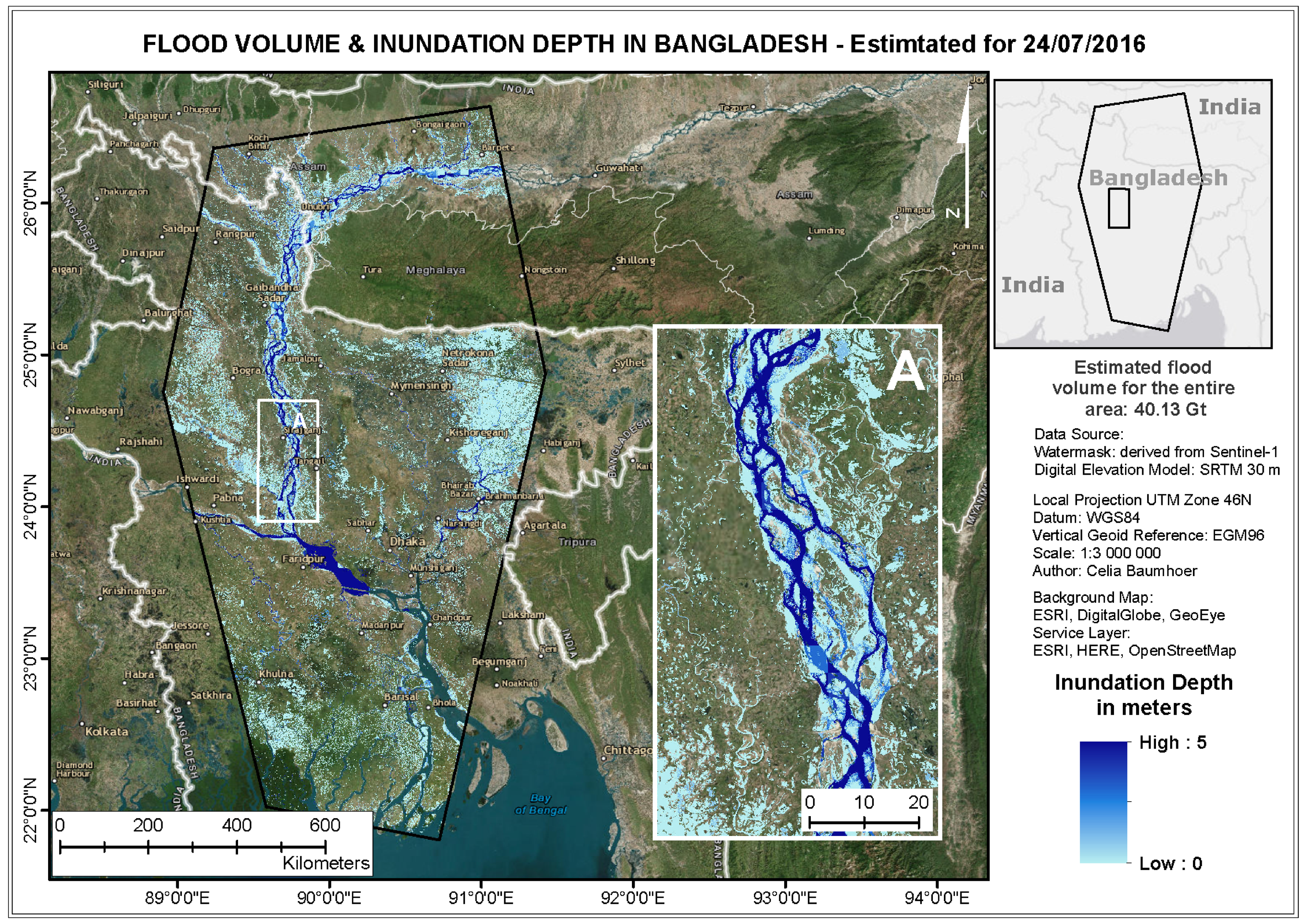
- Best combinations were chosen for each threshold and grid (according to the correlation with in situ water level measurements)
- Uncertainties are lowest for **THR3** and **dynamic fishnet grid** (RMSE = 1.73 m)
- **SRTM DEM** was filtered to reduce the influence of 1-meter steps in the initial SRTM:



WORKFLOW



INUNDATION DEPTH MAP



THRESHOLDING

Thresholding is applied on each histogram per grid cell. Best results could be achieved with applying thresholds by distinguishing between:

- **uni-modal distribution**: an empirical threshold of 70 % of the cumulative pixel sum is set
- **bi-modal distribution**: arises out of two or more water bodies in one tile (less than 1% of the tiles)

Optimal water level calculation can be performed for uni-modal distributions. A compromise had to be found for bi-modal distributions as shown in the workflow above.

CONCLUSIONS

It is possible to estimate flood volumes for large scale areas ⇨ see FLOOD VOLUME & INUNDATION DEPTH MAP for the Ganges-Brahmaputra basin in Bangladesh

- For volume estimates areas with horizontal water surface have to be defined (**TILING/GRIDDING**). Dynamic tiling which accounts for **local topography and slope of the water surface** yielded best results. Static grids did not work because too small sizes do not cover the river banks of the braided river, whereas too big cell sizes overestimate water levels for smaller mountain tributaries.
- Applying a **THRESHOLD** works well for **uni-modal distributions**. In case of bi-modal distributions a compromise had to be found to prevent unrealistic estimates of water levels.
- The **vertical resolution of a DEM** is important. Higher accuracy yields much better results. Hence, the acquisition date of the DEM as well as the editing for water surfaces has a high influence on the results