Flood Inundation Modelling Under Uncertainty Using Globally and Freely Available Remote Sensing Data

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1. Objective

Investigate the usefulness of SRTM topography to support flood inundation modelling in view of the other sources of error that are unavoidably associated to the hydraulic modelling of floods, such as the inaccurate estimation of the design flood and parameter uncertainty.

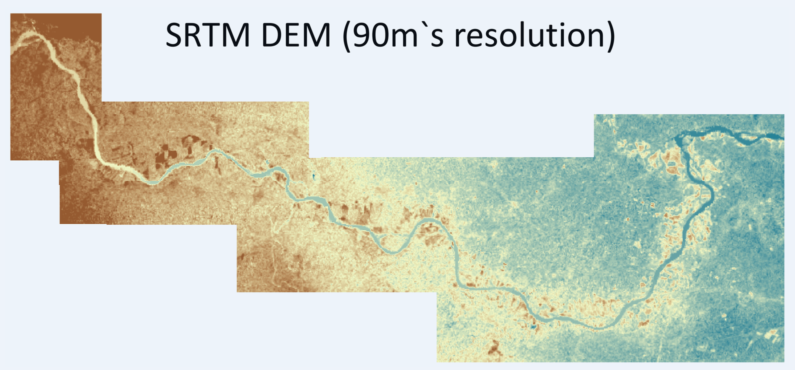
2. Case studies and Modelling tools

- River Po, Italy. 98 km reach of River Po from Cremona to Borgoforte. HEC-RAS (US Army Corps of Engineers, Hydrologic Engineering Center, 2001) is used to compute flood profiles.
- River Dee, UK. 10-km reach between the two EA maintained gauging stations at Farndon and Iron Bridge. A simple raster-based inundation model (LISFLOOD-FP, Bates and De Roo, 2000) is used to simulate the inundation extent.

3. Case study: River Po

LiDAR DEM (2m`s resolution)

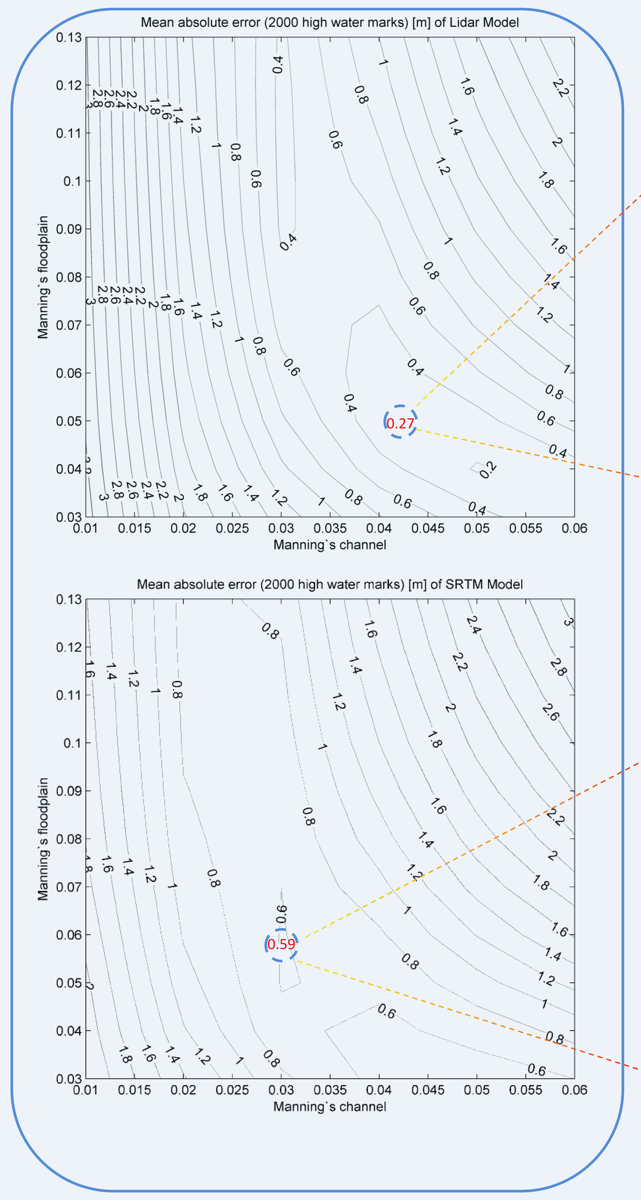
SRTM DEM (90m`s resolution)



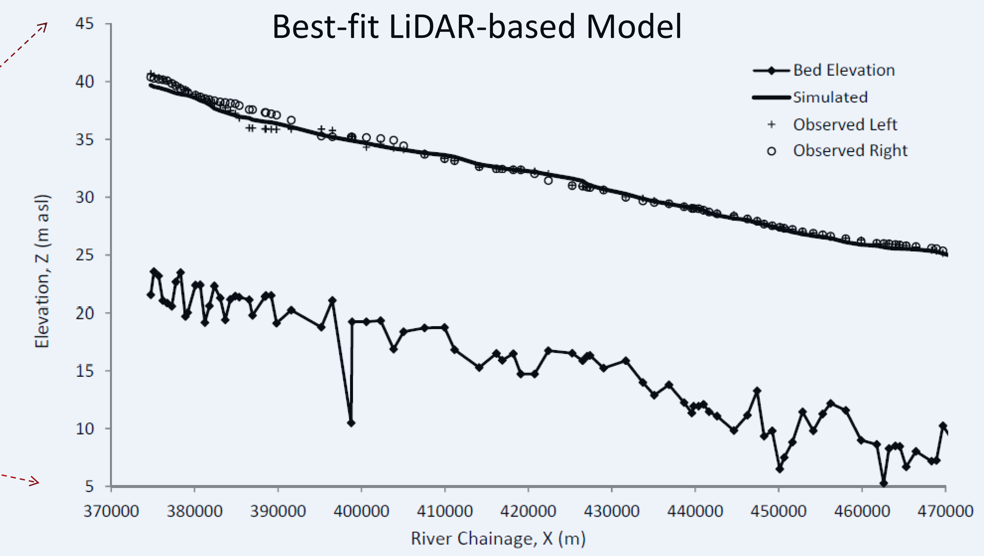
Two models are built based on LiDAR and SRTM topography data.

Calibration data: High water marks

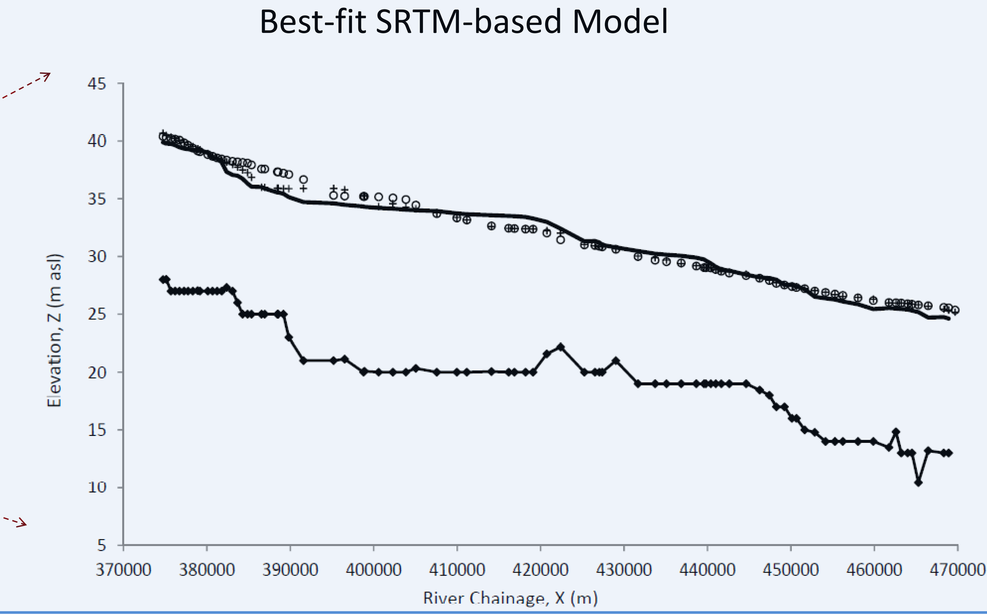
Calibration event: October, 2000 flood event



Best-fit LiDAR-based Model



Best-fit SRTM-based Model



Parameter Uncertainty:

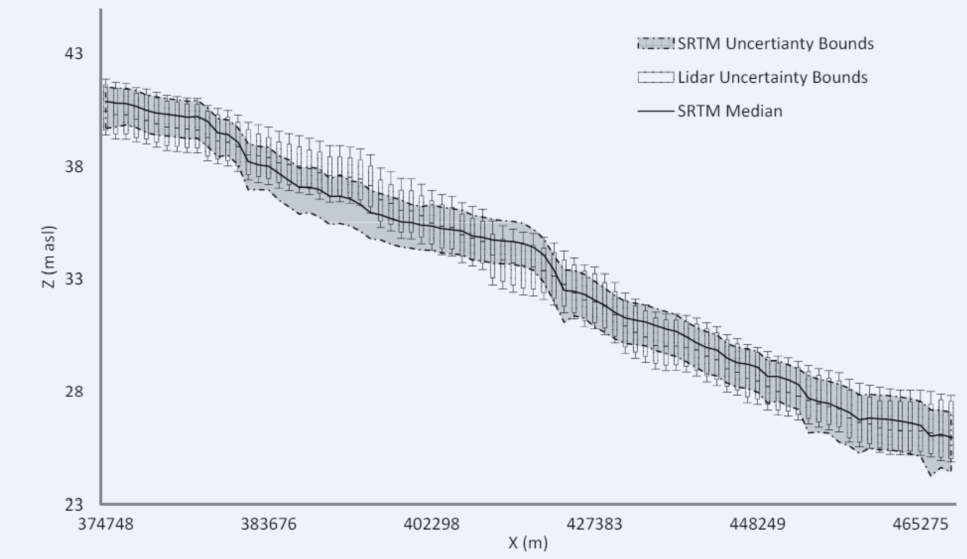
- Select behavioural model
- Calculate likelihood weights:

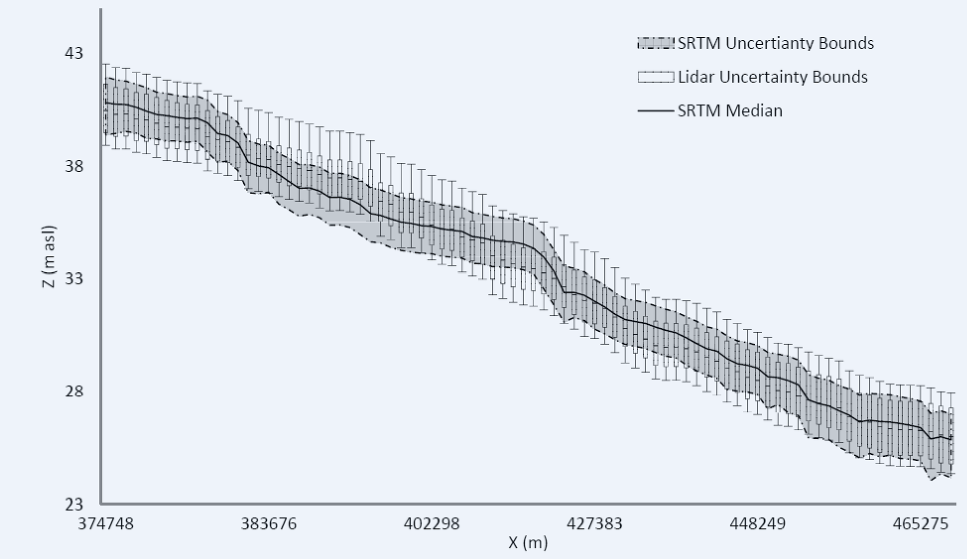
$$W_i = \frac{\max(\varepsilon_i) - \varepsilon_i}{\max(\varepsilon_i) - \min(\varepsilon_i)}$$

- Plot weighted percentile design flood profiles

Parameter + Inflow Uncertainty:

- Feeding all behavioural models using the 5 design flood values

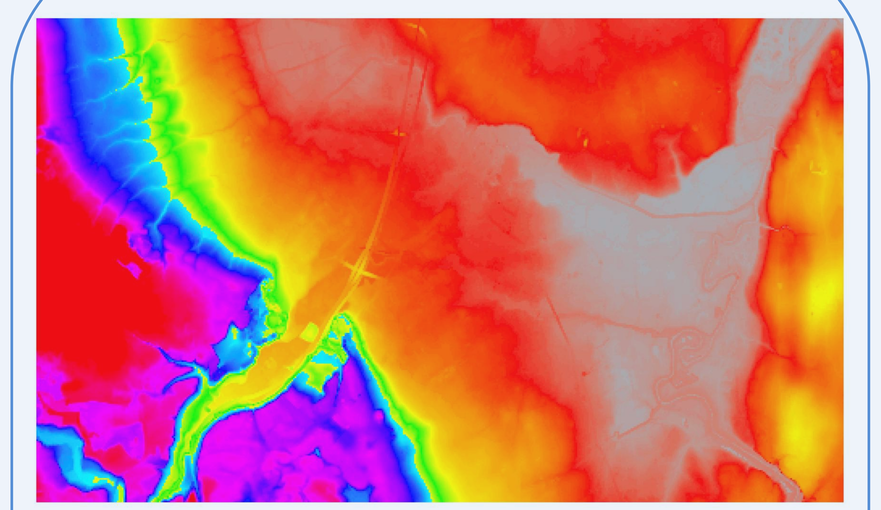




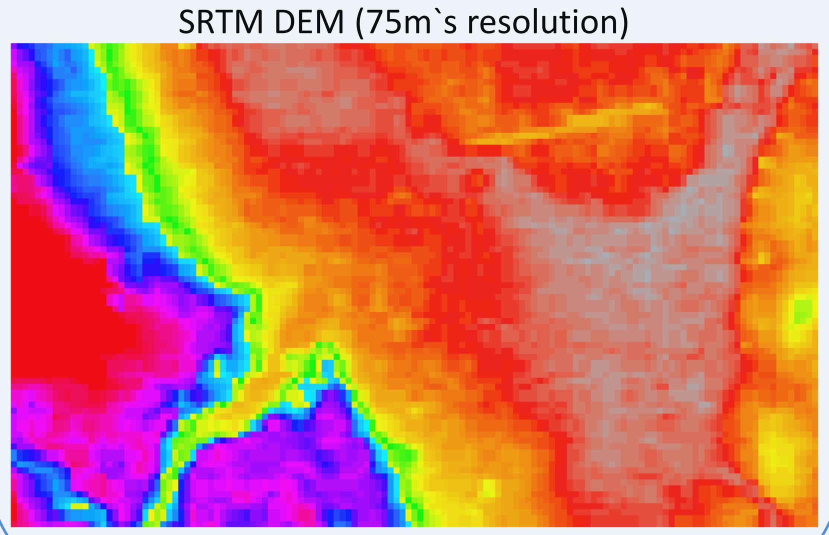
1-in-200 design flood profile prediction by considering : parameter uncertainty (upper panel), parameter + inflow uncertainty (lower panel) ; LiDAR-based Model uncertainty bounds are shown in boxplot (lower and upper quantile are 5th and 95th percentile), SRTM-based Model uncertainty bounds are shown in grey area (dash lines show 5th and 95th percentile)

4. Case study: River Dee

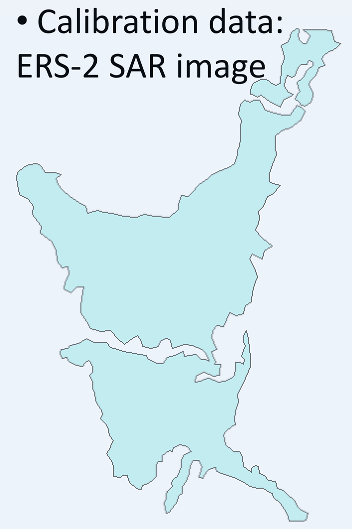
LiDAR DEM (20m`s resolution)



SRTM DEM (75m`s resolution)



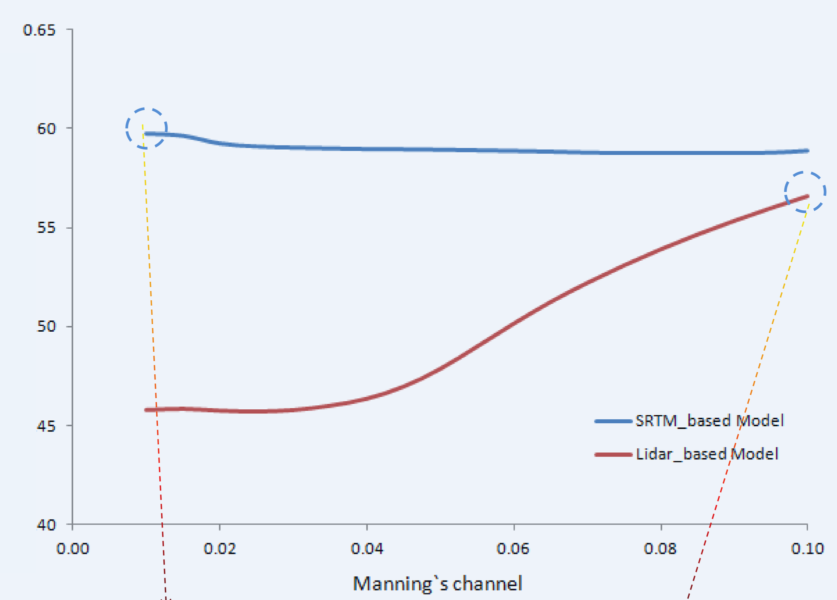
- Calibration data: ERS-2 SAR image

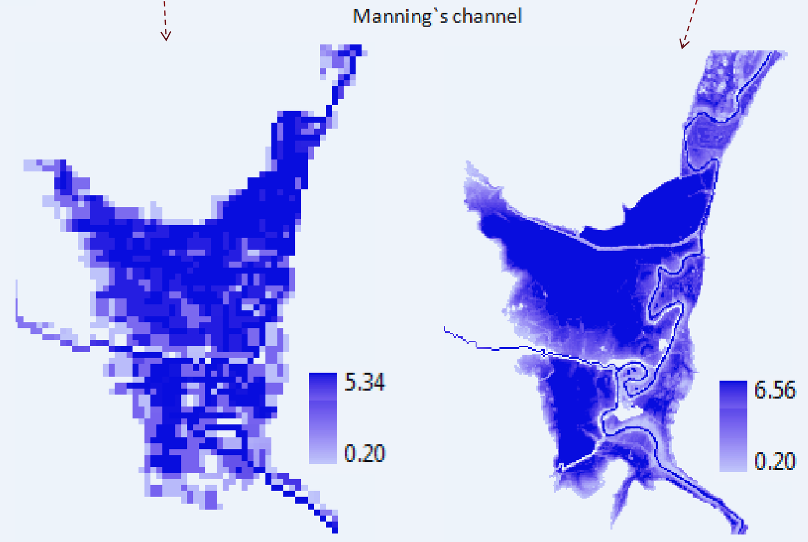


- Calibration event: December 2006 flood
- Performance measure:

$$F = \frac{A - B}{A + B + C}$$

A: Correct prediction
B: Over prediction
C: Under prediction





Best-fit Inundation map conditioned on 2006 event: SRTM-based (left panel), LiDAR-based (right panel)

Parameter Uncertainty

- Select behavioural model
- Likelihood weight calculation:

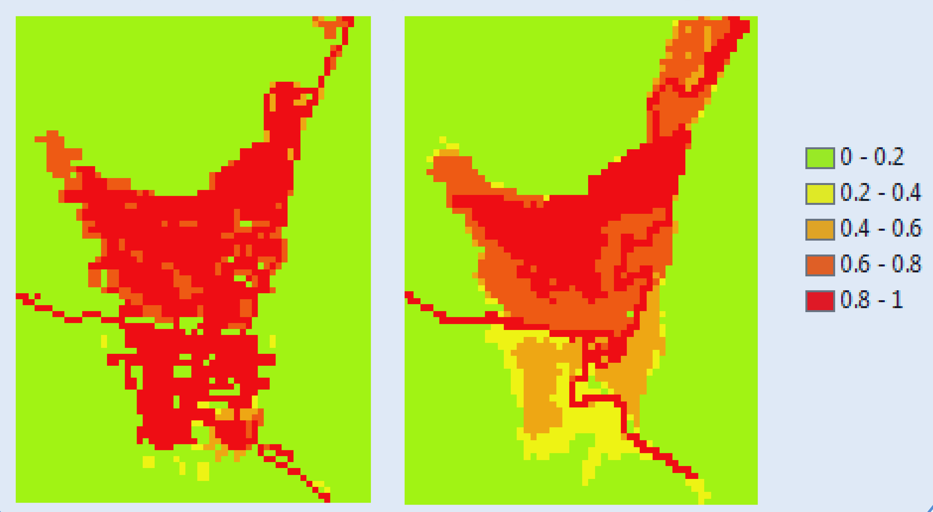
$$L_i = \frac{F_i - \min(F_i)}{\max(F_i) - \min(F_i)}$$

- Weighted average flood state calculation:

$$C_j = \frac{\sum_i L_i w_{ij}}{\sum_i L_i}$$

- Classify inundation probability from 0 to 1

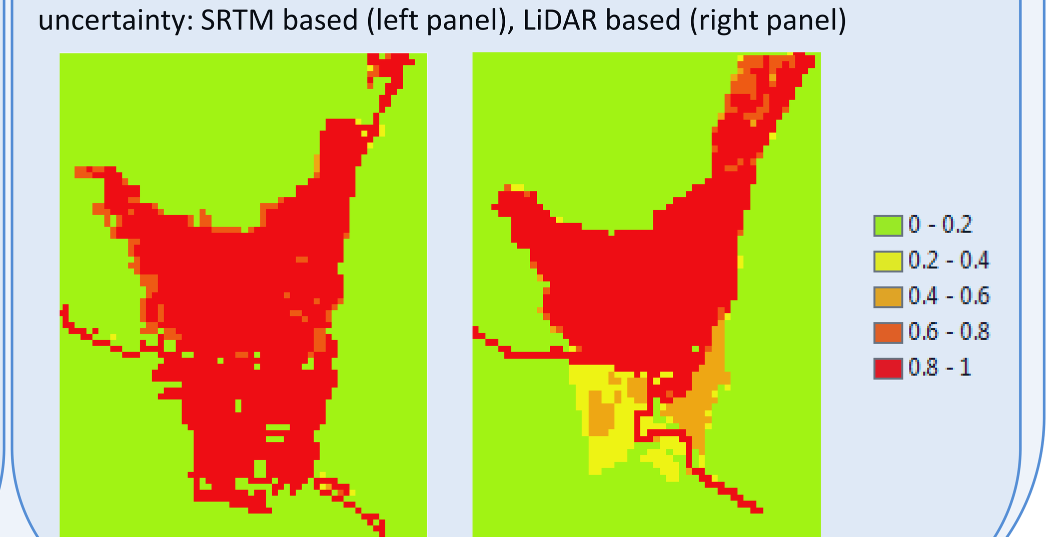
Probabilistic 1-in 100 year flood inundation map considering parameter uncertainty: SRTM based (left panel), LiDAR based (right panel)



Inflow Uncertainty

100 random values equally distributed in the range [1-in-100 year discharge] ±20% were used as the boundary condition for the ensemble simulation. The Manning`s coefficients with the best performance conditioned on 2006 flood event were selected as the model parameters.

Probabilistic 1-in 100 year flood inundation map considering inflow uncertainty: SRTM based (left panel), LiDAR based (right panel)



5. Conclusions

This study is a first attempt to quantitatively evaluate the value of the SRTM topography to support hydraulic modelling with the purpose of predicting design flood profiles and inundation extent in view of the main sources of uncertainty associated to the modelling exercise.

The results indicate that SRTM topography has some value in supporting the prediction of design flood profiles in medium-to-large scale rivers.

Regarding to inundation extent prediction, the results show the value of SRTM topography is not that clear due to the ignorance of embankments.

6. References

Bates, P.D. and De Roo, A.P.J. (2000). A simple raster-based model for flood inundation simulation. *Journal of Hydrology* **236**(1-2): 54-77.

Hydrologic Engineering Center (2001). Hydraulic Reference Manual. US Army Corps of Engineers. Davis, California, USA.