Increasing confidence in flood model outputs with uncertain SAR imagery

or

How fuzziness increases information content

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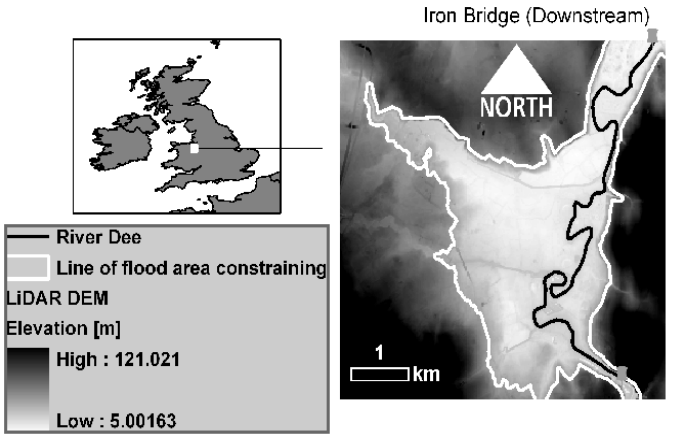
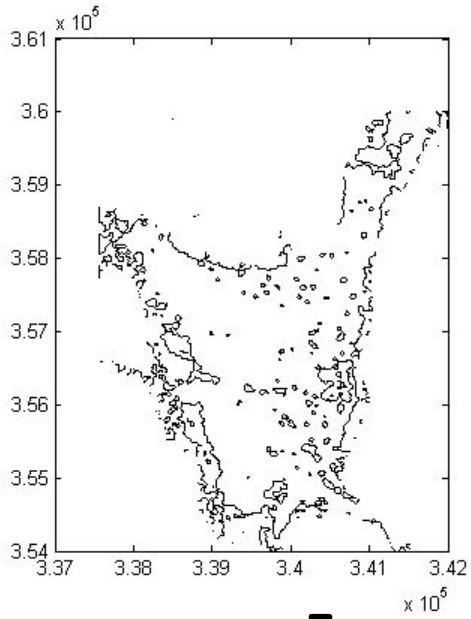
Flood mapping within an uncertainty framework

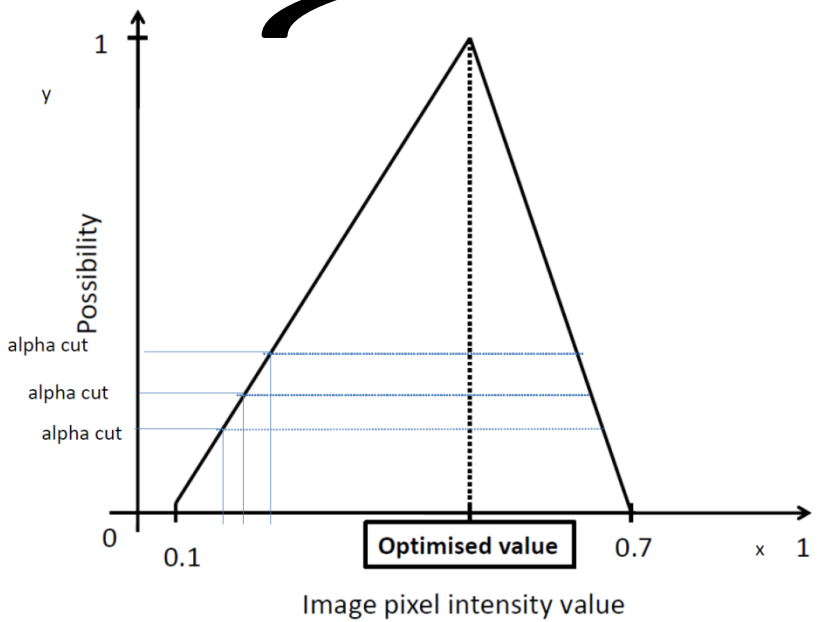
- It is widely recognized that flood parameters (mostly flood edge/area) from satellite imagery, particularly from SAR, are invaluable for model cal/val research
- However, to date there is still great concern about adequate image processing and, more importantly, about appropriate model performance measures that account for the large amount of spatial information
- This research looks at the value of accounting for uncertainty in flood mapping to propose a possible solution to the current problems
- Test case: December 2006 event on the River Dee, NE England

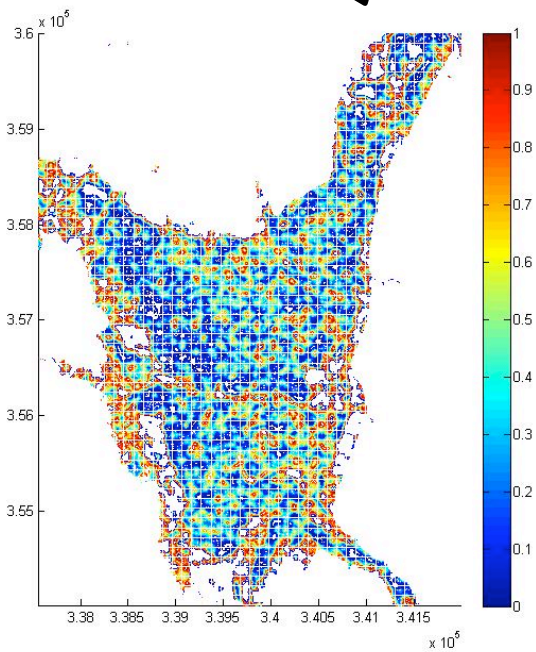


Flood edge uncertainty map

- Most widely used simple histogram threshold method for grayscale imagery (Otsu, 1979) => use perimeter function to retrieve flood edge pixels
- One parameter (keep it simple), the threshold level, which can be optimized or preset by user
- However: great deal of uncertainty associated with this parameter, especially when operating on SAR imagery



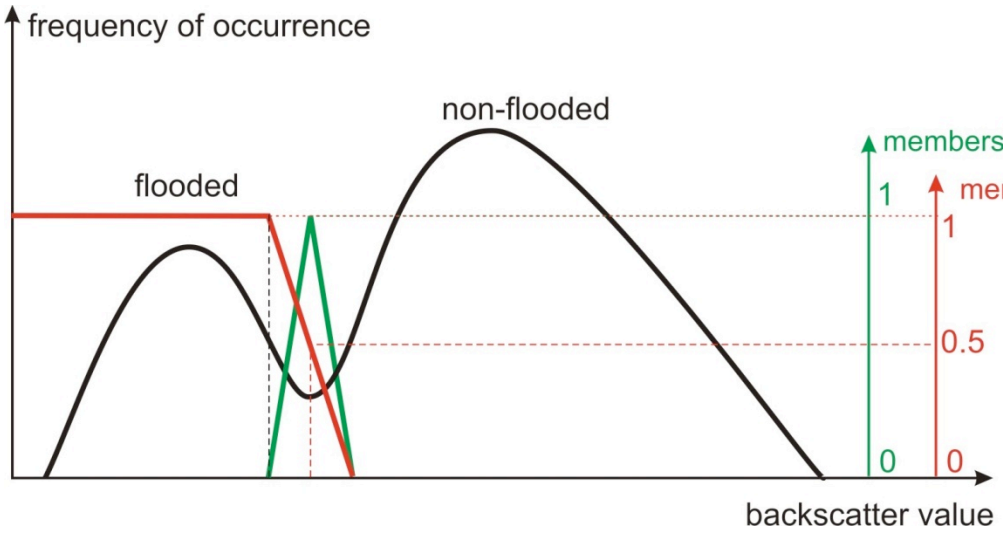


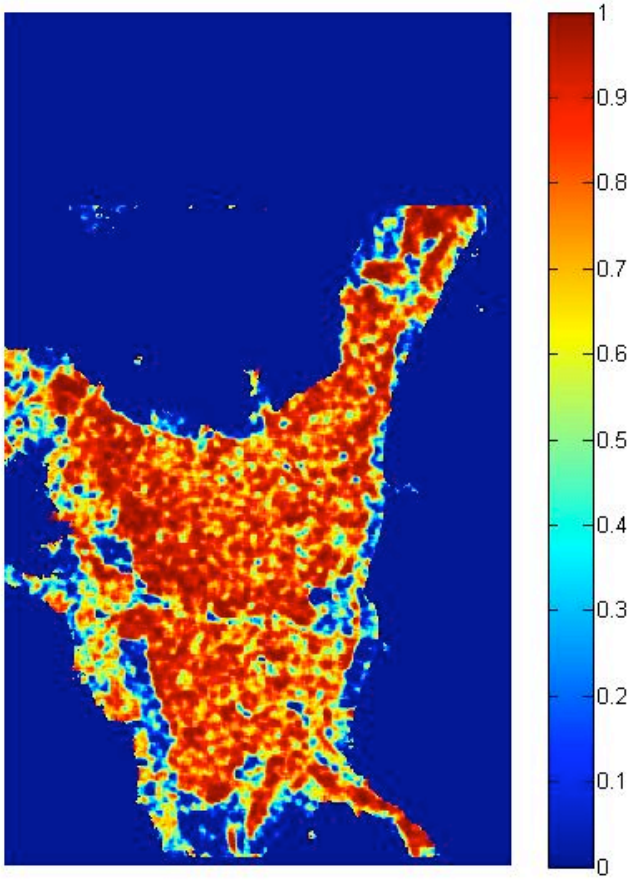


Area vs. edge

- Instead of flood edge we might prefer flood area (areas inside the flooded zone are ignored when using flood edges and these might include areas where the model may be underpredicting – dry)
- A lot of the debates in recent literature about model performance and measures of skill revolve around flooded area
- There is a need to develop an ‘unambiguous’/unbiased measure that expresses model skill using an observed fuzzy flooded area
- We use the same image processing approach as with edge but keep the area information

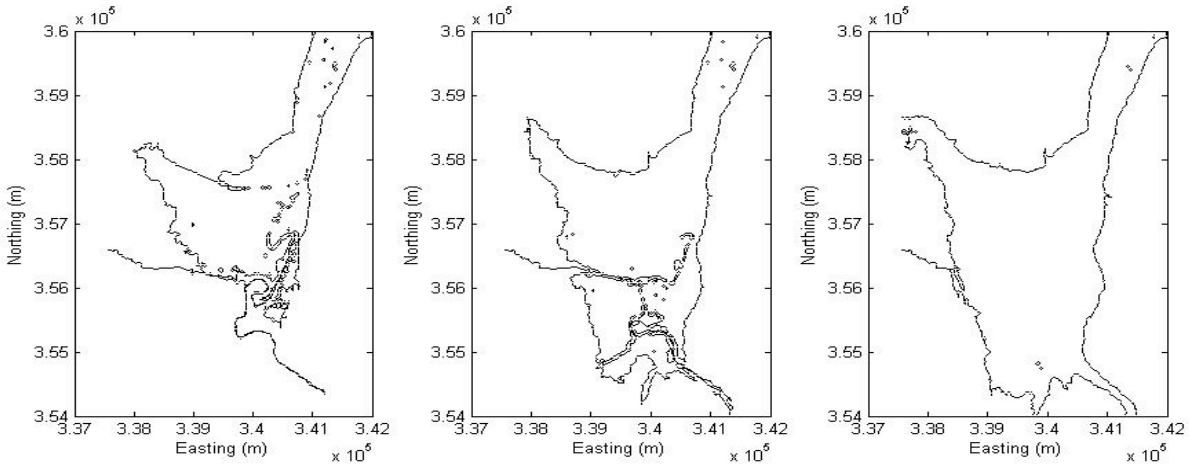
Flood area uncertainty map





Model calibration

- Run a range of model simulations (simplified 2D LISFLOOD-FP)
- Retrieve flood edge and area for each model run

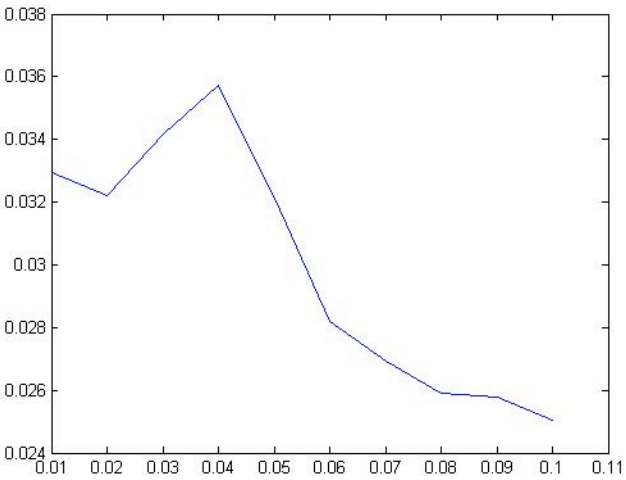


- Jaccard similarity index
- Divides the sum of the minimum possibility (sum{min(SAR_i,$Model_i$)}) by the sum of the maximum possibility (sum{max(SAR_i,$Model_i$)})
- Needs to be maximised for model calibration

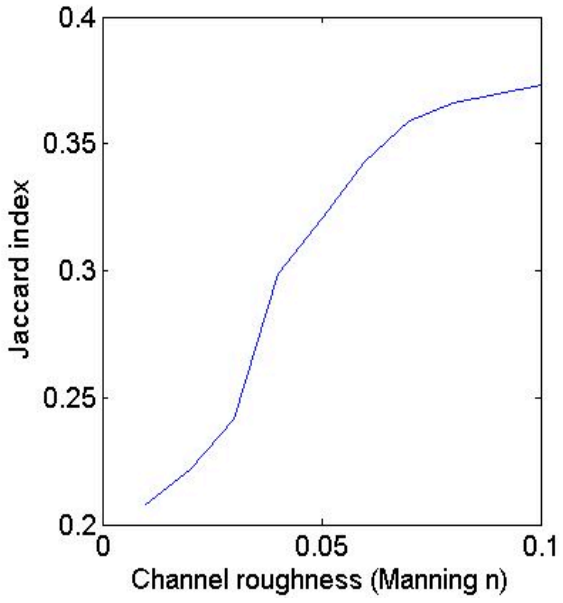
Jaccard similarity index?

- Advantage: it is not a global measure of skill based on averaging but rather a similarity measure
- Works for edge but not really for area (yet?)! Model exhibits greatest sensitivity at edges…

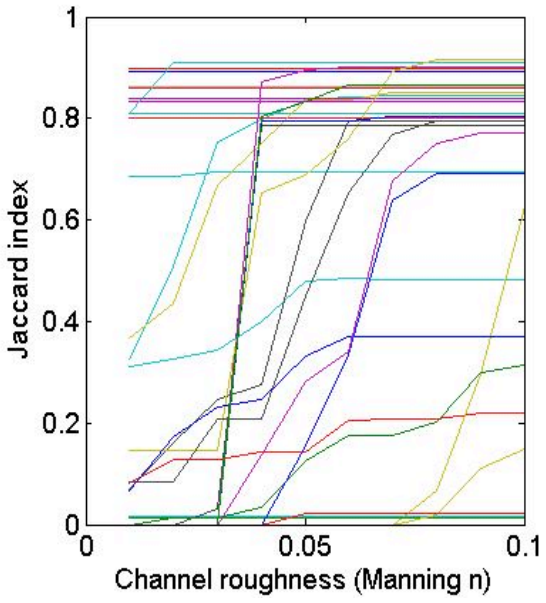
Fuzzy edge: global



Fuzzy area: global



Fuzzy area: local



JoH/IEEE calibration comparison

- Ensure the robustness of estimating fuzziness….?!?

A

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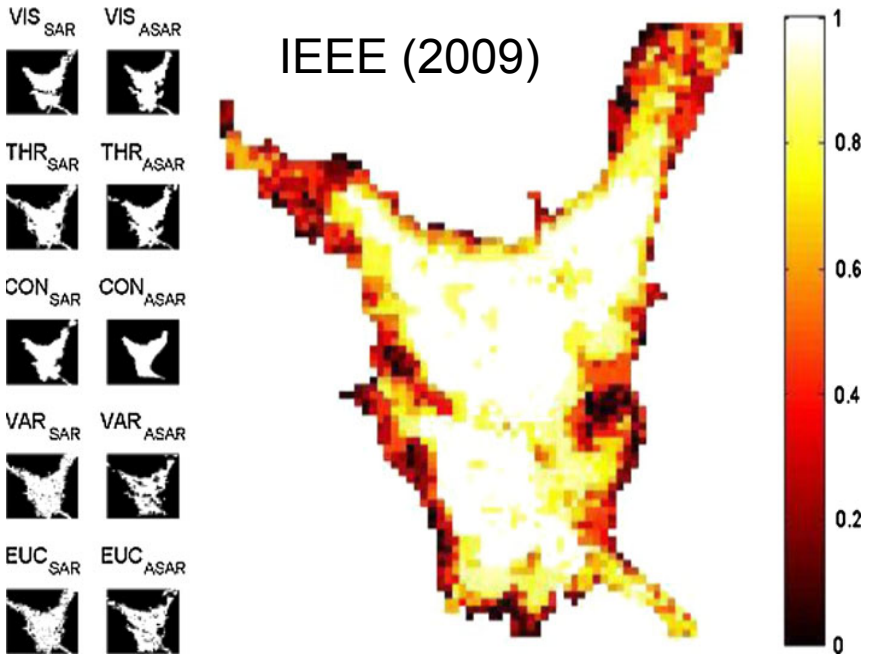
The Utility of Spaceborne Radar to Render Flood Inundation Maps Based on Multialgorithm Ensembles

Guy Schumann, *Associate Member, IEEE*, Giuliano Di Baldassarre, and Paul D. Bates



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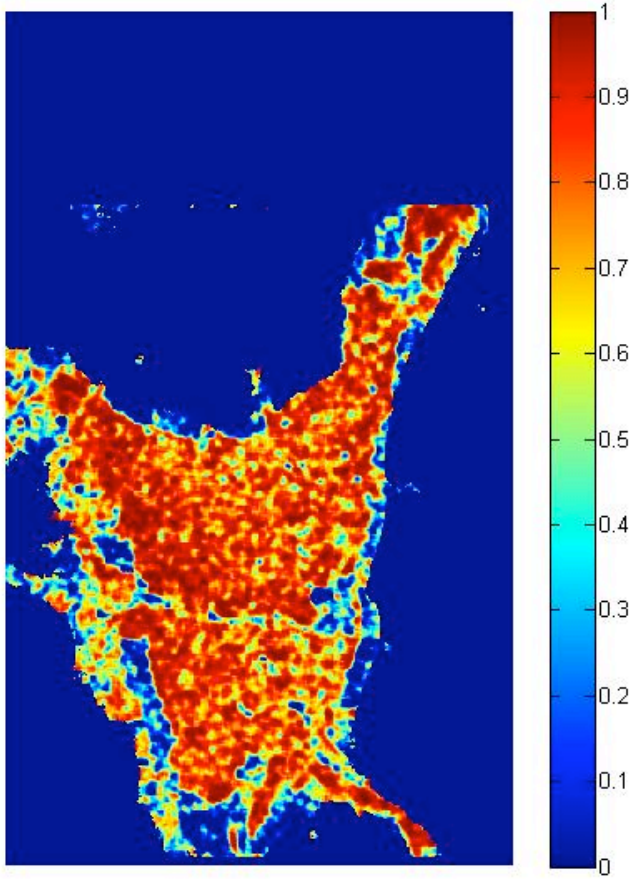

It does not seem to matter that much…

- … according to calibration results of the same LISFLOOD-FP model

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A technique for the calibration of hydraulic models using uncertain satellite observations of flood extent

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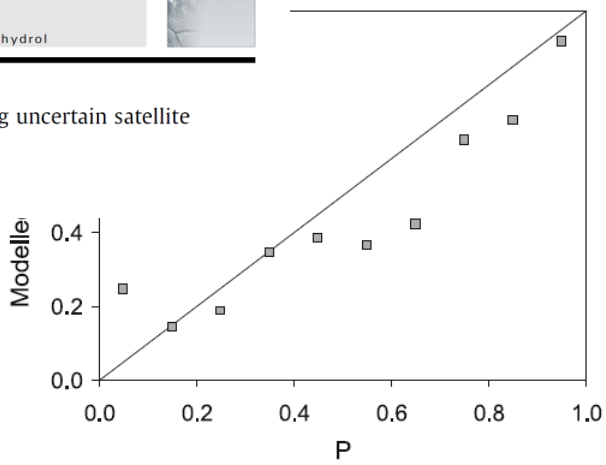
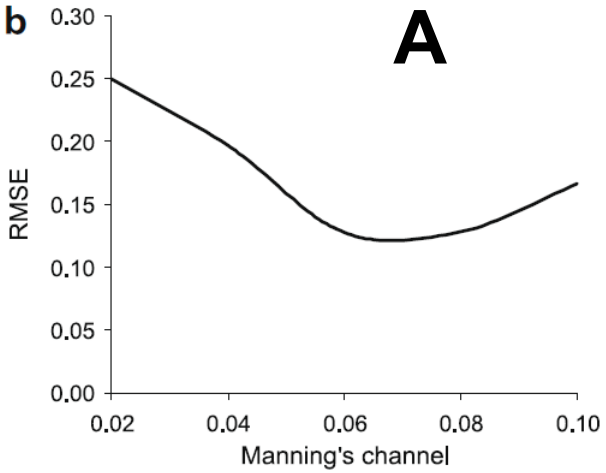
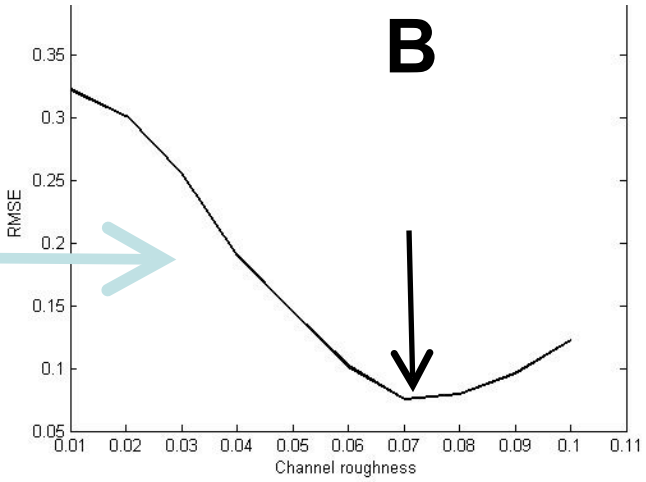




Statistical (possibilistic) framework approach presented here is more discriminative



Summary

- Flood mapping within an uncertainty framework can be straightforward
- In our case, flood model parameter identifiability can definitely be increased using a ‘fuzzy’ map rather than an ‘optimised’ map
- It was illustrated that the way fuzziness is derived does not really affect model calibration results
- We might move away from ambiguous spatial performance measures (such as the ‘F’ measure)
- In our case, the best possible model(s) for the global scale calibration (~ n_{ch} = 0.04) using fuzzy flood edges but no model could be selected when using fuzzy flooded area (this result applies to the Jaccard index we used)
- Questions still need to be addressed:
  - Are we handling possibilities the right way when calibrating the model (is it statistically sound?)?
  - Are our chosen PMs really unbiased (i.e. is there no preference for over- or under-estimation of flooded area?)?
  - How important are the particular flood event characteristics?
  - …

What next…

- We still need to figure out how to calibrate/which skill measure to use with fuzzy flooded area
- Jaccard similarity index seems promising and works for fuzzy flood edges
- Maybe other coefficients are more appropriate for area similarity (Tanimoto coefficient aka extended Jaccard index; Dice coefficient???)
- Can we set regional performance scores which means models can be calibrated on a regional or even local scale => the best model would perform equally satisfactory everywhere?
- i.e. Targeted model calibration (where flood risk is highest for instance)

Thanks! Any questions/suggestions?

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