

A PROBABILISTIC FRAMEWORK TO CHARACTERIZE UNCERTAINTIES IN SAR-BASED FLOOD MAPPING

L. Giustarini, R. Hostache, M. Chini, P. Matgen

G-POD

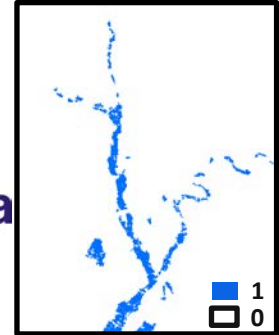
<http://gpod.eo.esa.int/>

The screenshot shows the G-POD website interface. At the top left is the ESA logo with the text "grid processing on demand" and "European Space Agency". A navigation menu includes "esa", "RSS portal", "Home", "Services", "Workspace", "Catalogue", "Products", "Schedulers", "Documentation", "My profile", and "Help". A search bar is present with the text "Showing the 5 results found...". A user profile section shows "Name: Patrick Matgen" and "Credits: 3" with a "Logout" button. Below the navigation is a "Services list" with five categories: "Land" (showing a landscape), "Marine" (showing a beach), "Atmosphere" (showing clouds), "Security" (showing people in a flooded area), and "Emergency Response" (showing a boat in rough seas). At the bottom left, there is a copyright notice: "© ESA 2010 powered by powered by Gridify - © 2006 - 2010 Terradue srl".

SAROTEC



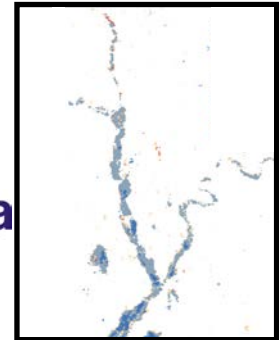
BINARY MAP



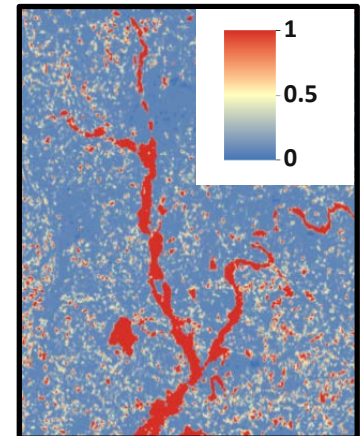
HASARD



HAZARD MAP



PROBABILISTIC MAP?



Applications:

Data Assimilation:

assimilation of uncertain flood extent into 2D hydraulic model

Additional Product:

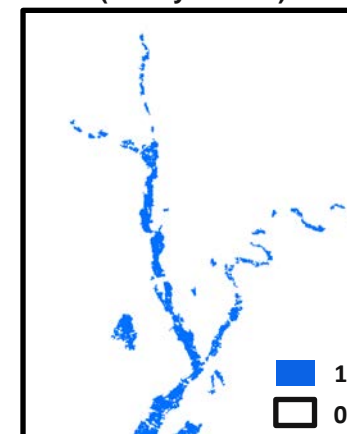
characterization of uncertainty in flood mapping delineation for decision-makers

Research Questions:

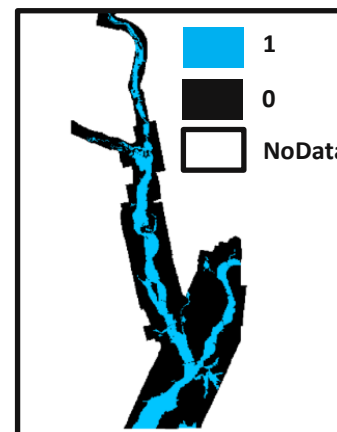
1) How to get a Probabilistic Map of flood?

2) How to evaluate its correctness?

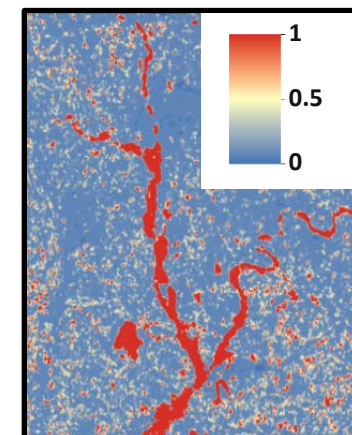
BINARY MAP
(binary values)



VALIDATION MAP
(binary values)

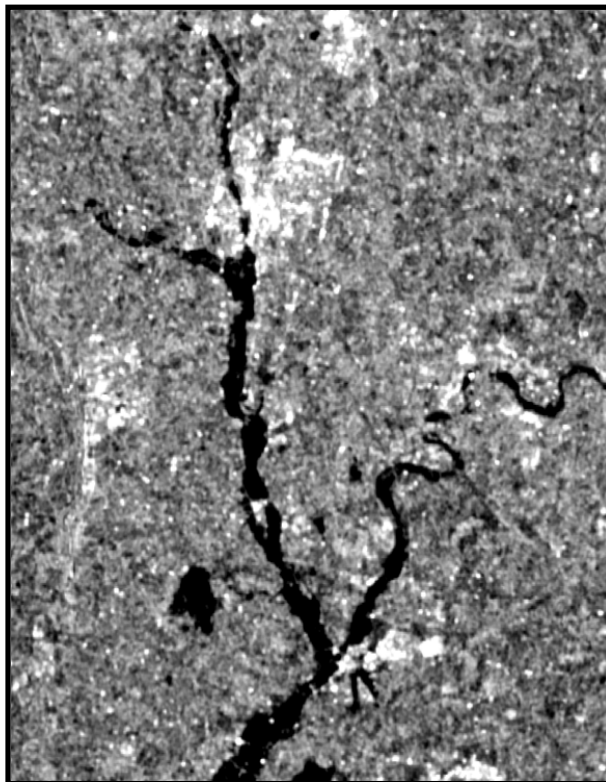
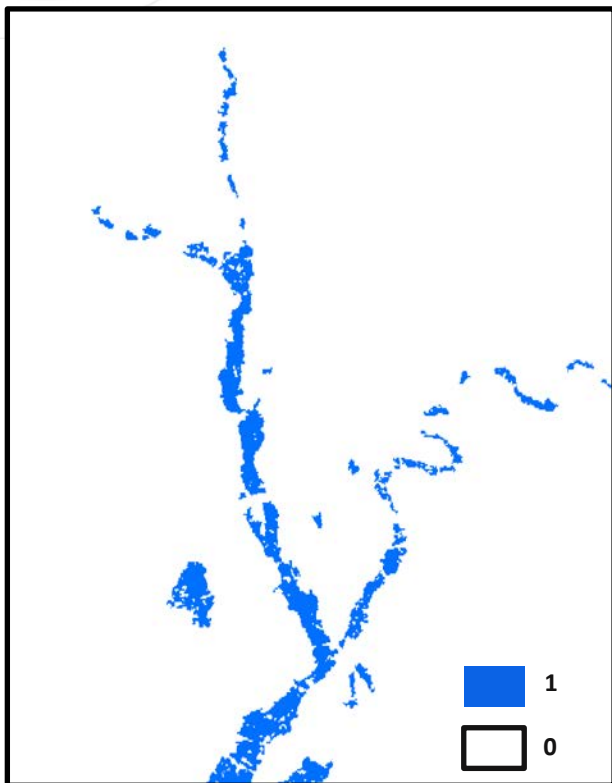


PROBABILISTIC MAP
(real values)

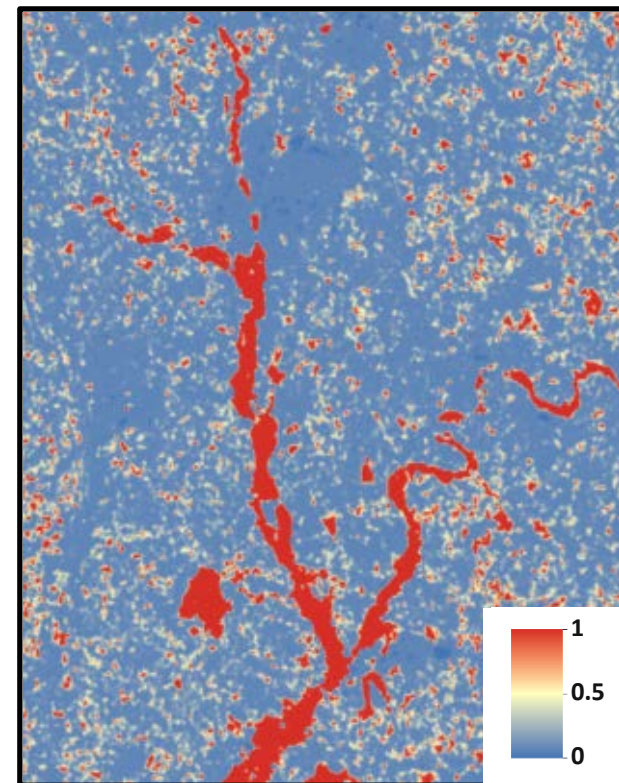


Satellite derived Inundation Map(s)

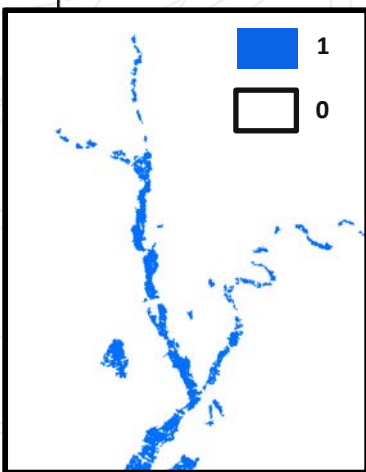
BINARY MAP



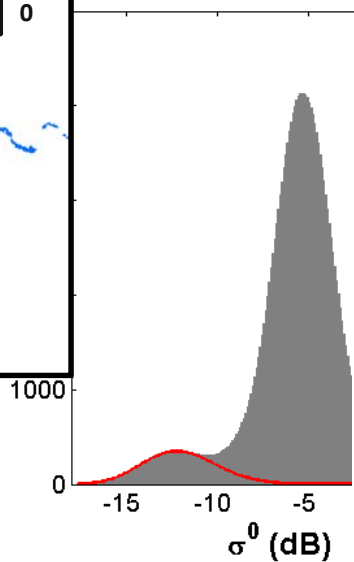
PROBABILISTIC MAP



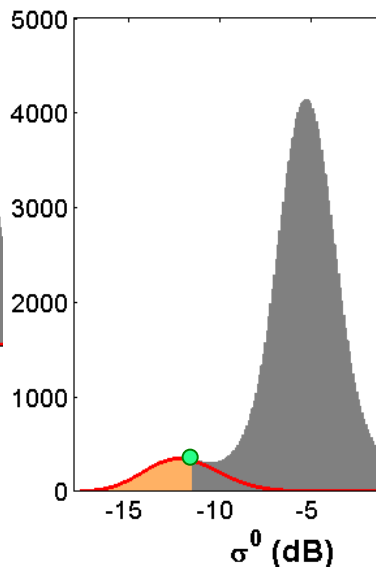
Binary Map



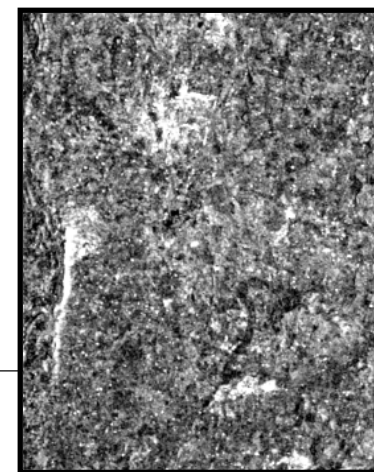
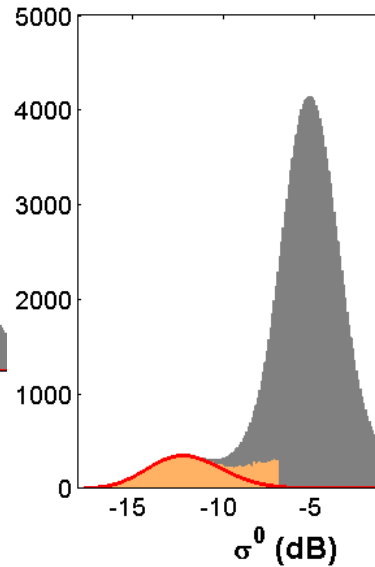
Gauss curve fitting



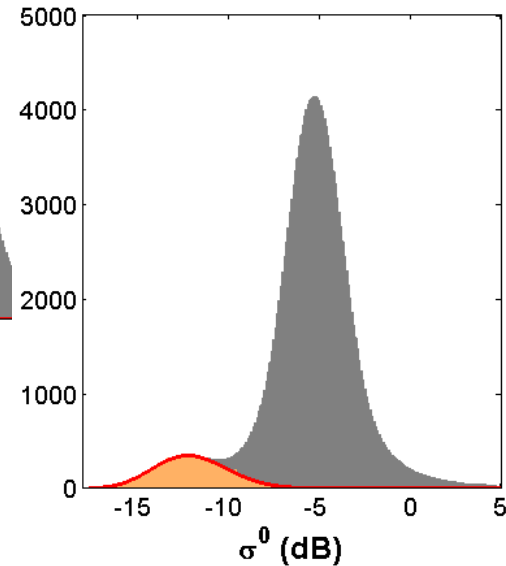
Threshold



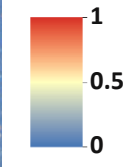
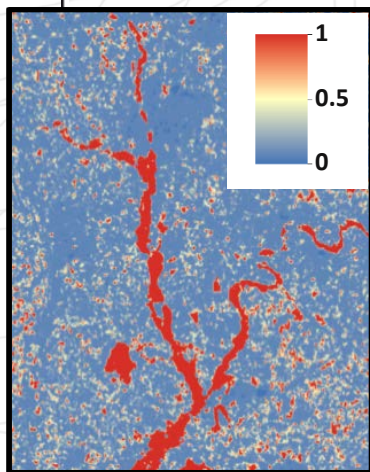
Region Growing



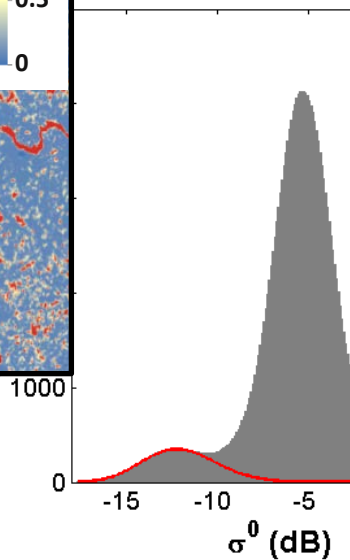
Change Detection



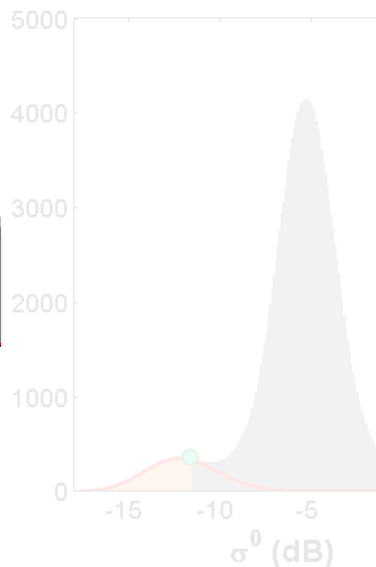
Probabilistic Map



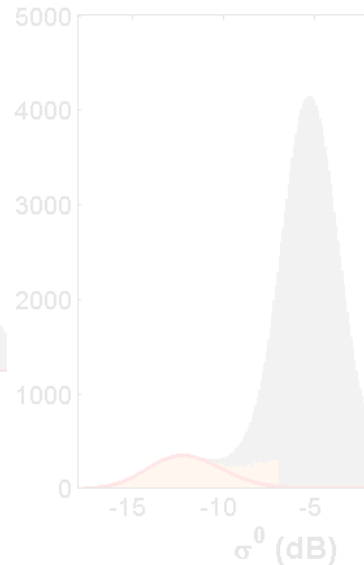
Gauss curve fitting



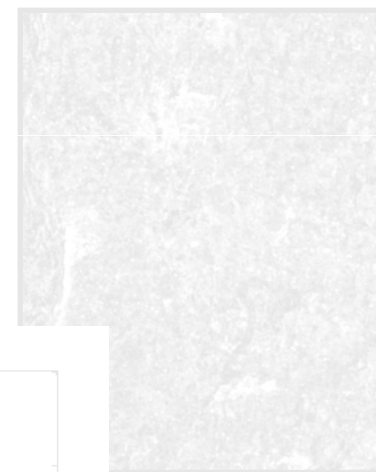
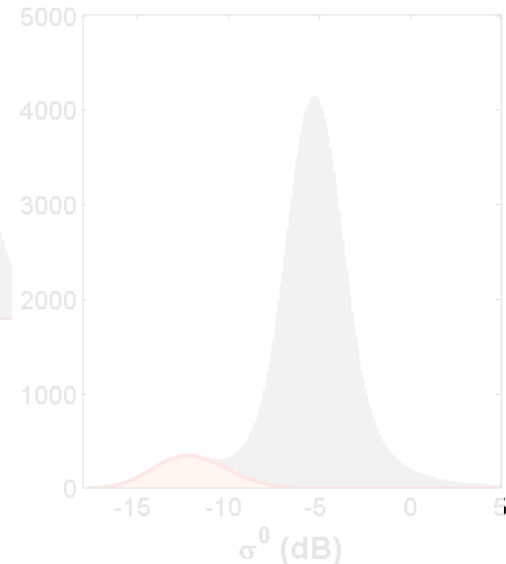
Threshold



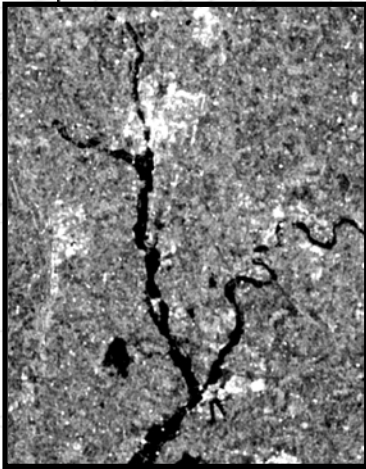
Region Growing



Change Detection



How to get a probabilistic map?



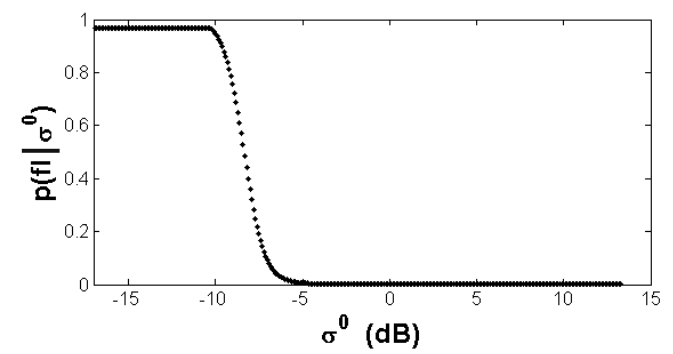
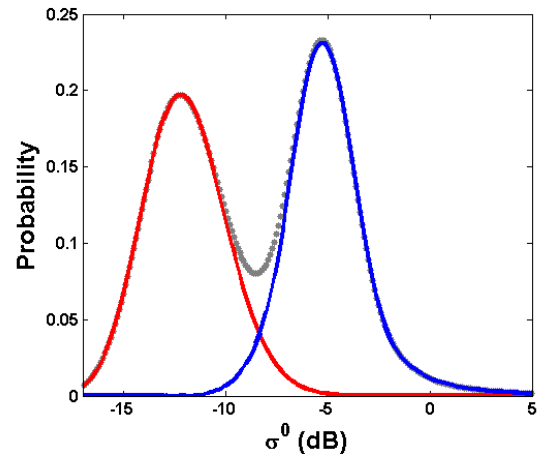
Conditional probability of a pixel being flooded given its backscatter value:

prior to the backscatter being measured

$$p(fl|\sigma^0) = \frac{p(\sigma^0|fl)p(fl)}{p(\sigma^0|fl)p(fl) + p(\sigma^0|nfl)p(nfl)} = \frac{p(\sigma^0|fl)p(fl)}{p(\sigma^0)}$$

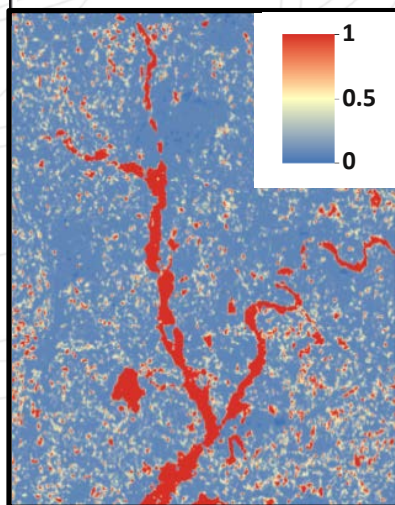
prob. pdf of σ^0 values for flooded pixels

prob. pdf of σ^0 values for non-flooded pixels

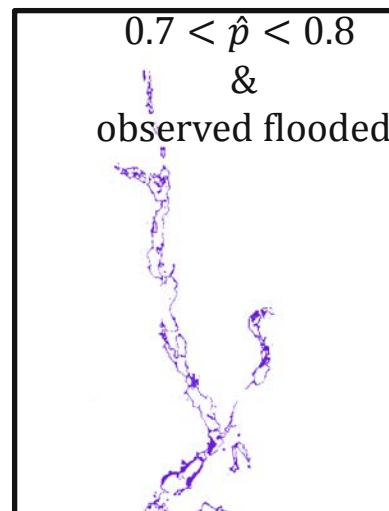
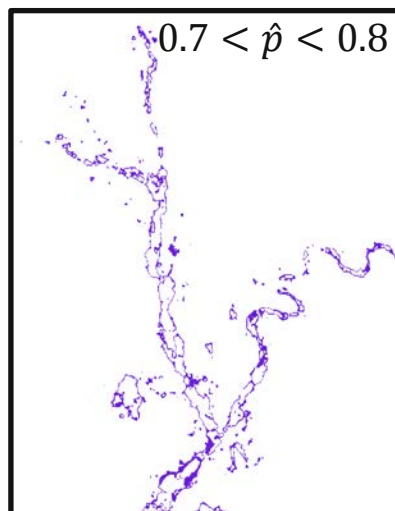


How to evaluate its correctness?

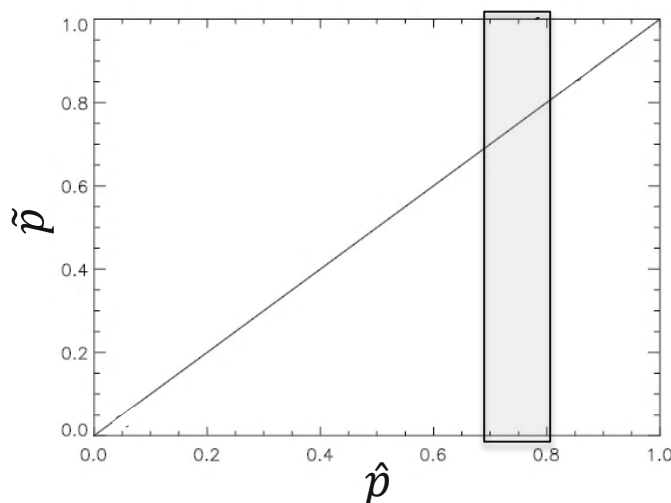
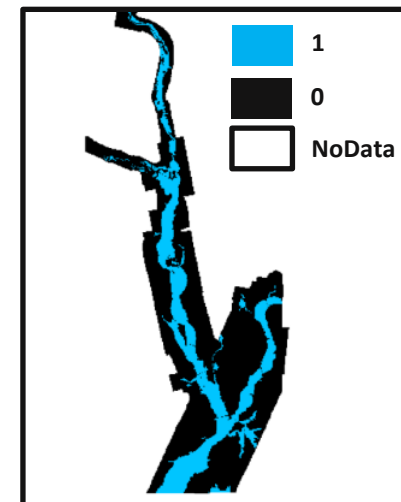
PROBABILISTIC MAP
(real values)



\hat{p}



VALIDATION MAP
(binary values)



$$\text{WRMS} = \sqrt{\frac{\sum_{i=1}^N ((\hat{p}_i(\text{fl}|\sigma^0) - \tilde{p}_i(\text{fl}|\sigma^0))^2 \cdot \text{np}x_i)}{\sum_{i=1}^N (\text{np}x_i)}}$$

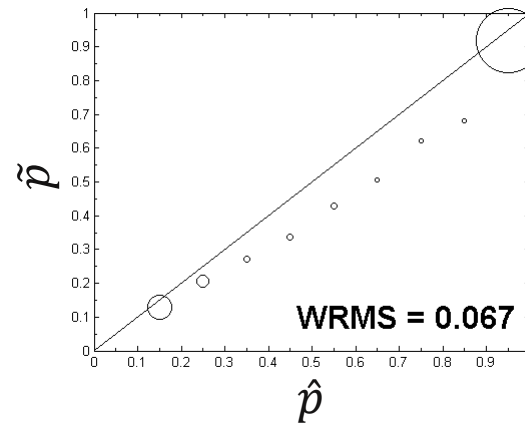
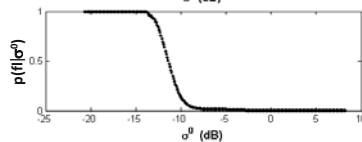
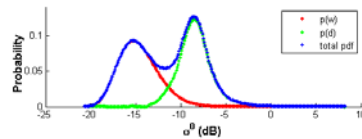
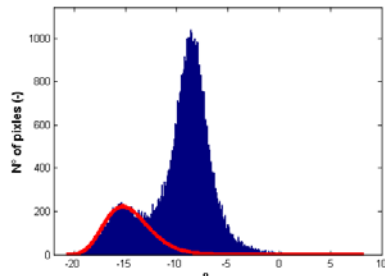
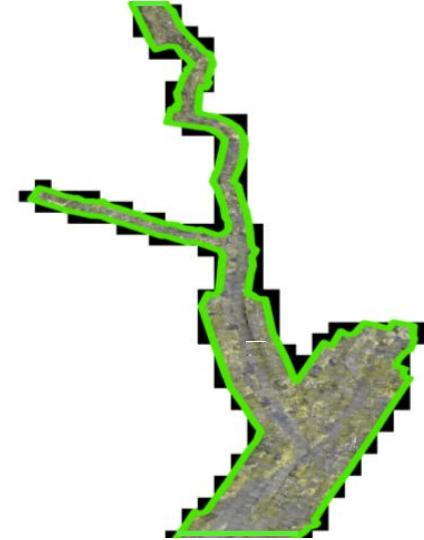
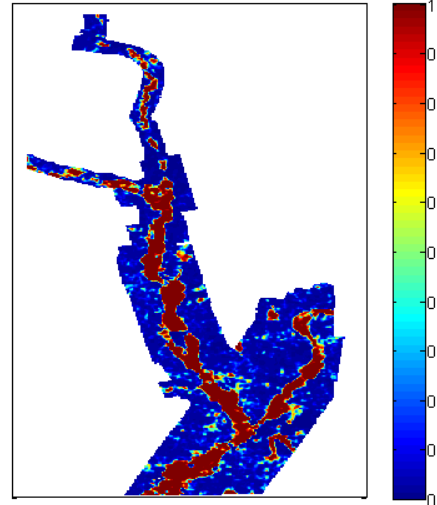
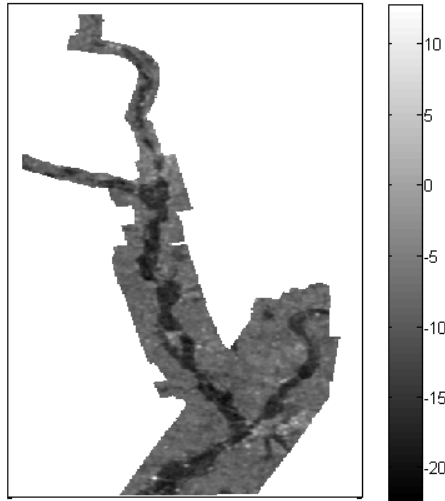
Horritt
A methodology for the validation
of uncertain flood inundation models.
JoH (2006)

CASE STUDIES

AOI	SAR			validation		
	type	time	Resolution [m]	type	time	% of water
Severn	ENVISAT	2007/07/23 10:27	150	aerial photos	2007/07/24	26
Severn	ENVISAT	2007/07/23 21:53	150	aerial photos	2007/07/24	26
Severn	TerraSAR-X	2007/07/25 06:34	3	aerial photos	2007/07/24	41
Red River	RADARSAT-1	1997/04/24 00:27	25	aerial photos	1997/04/24	74

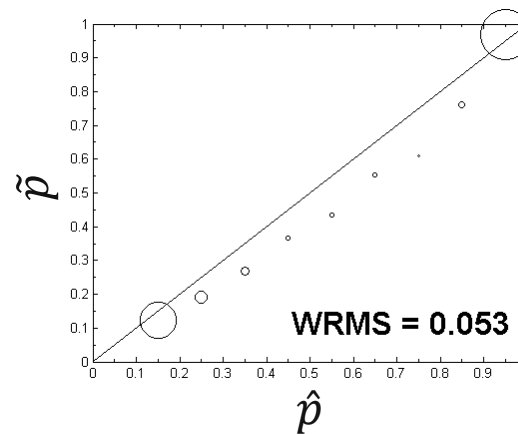
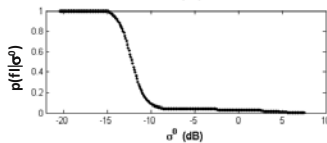
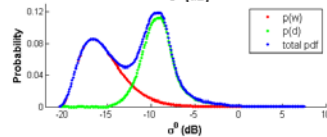
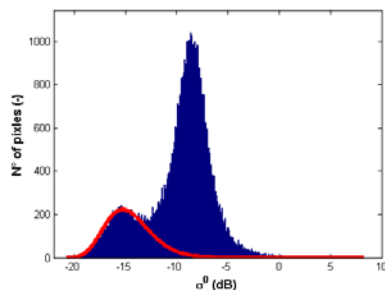
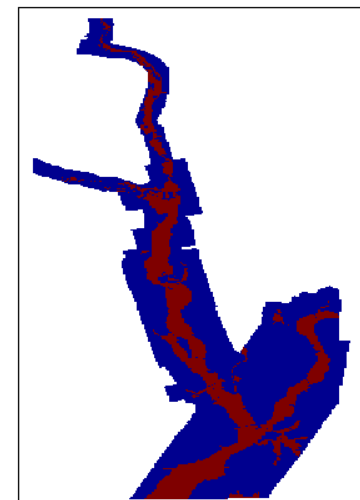
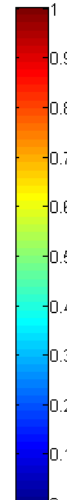
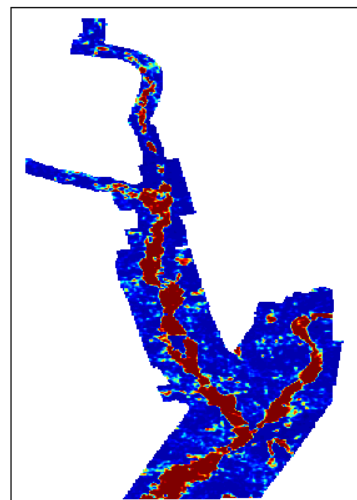
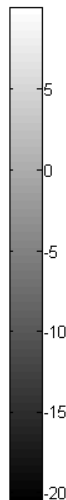
SEVERN

Envisat: 2007/07/23 10:27



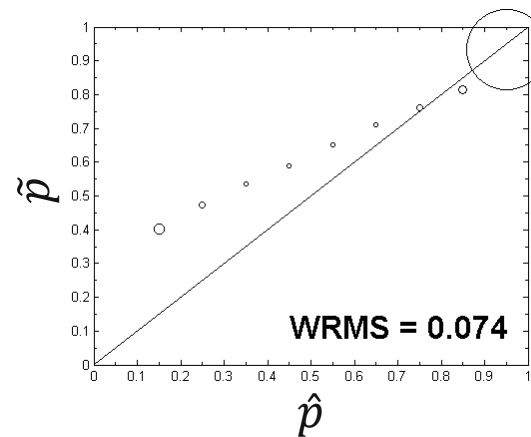
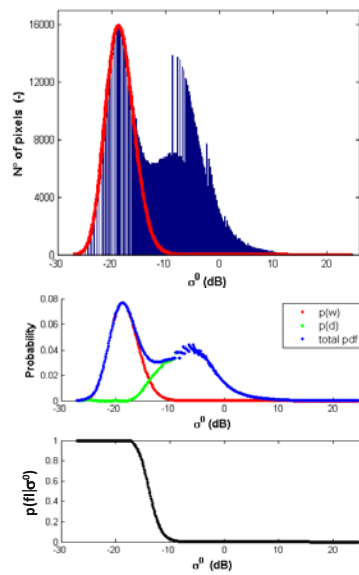
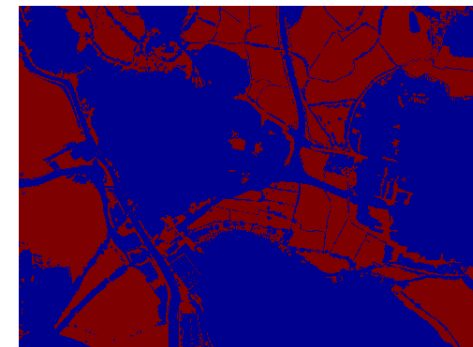
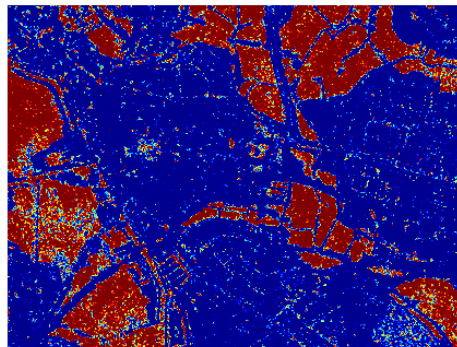
SEVERN

Envisat: 2007/07/23 21:53



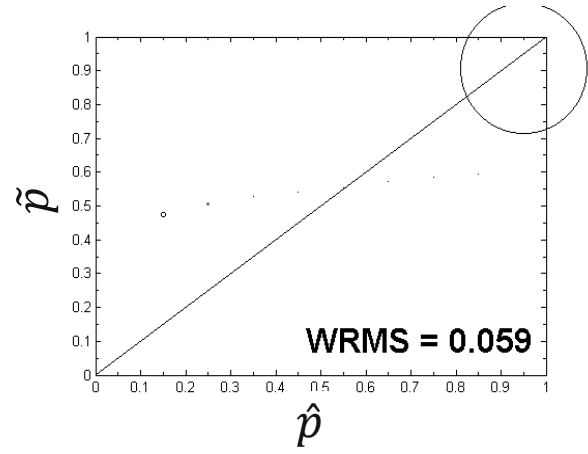
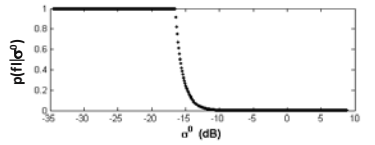
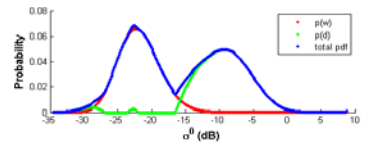
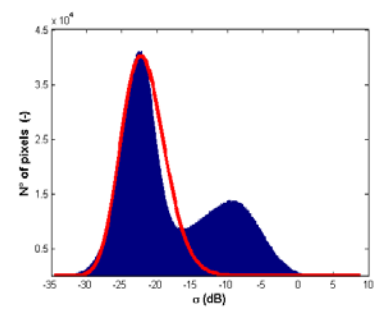
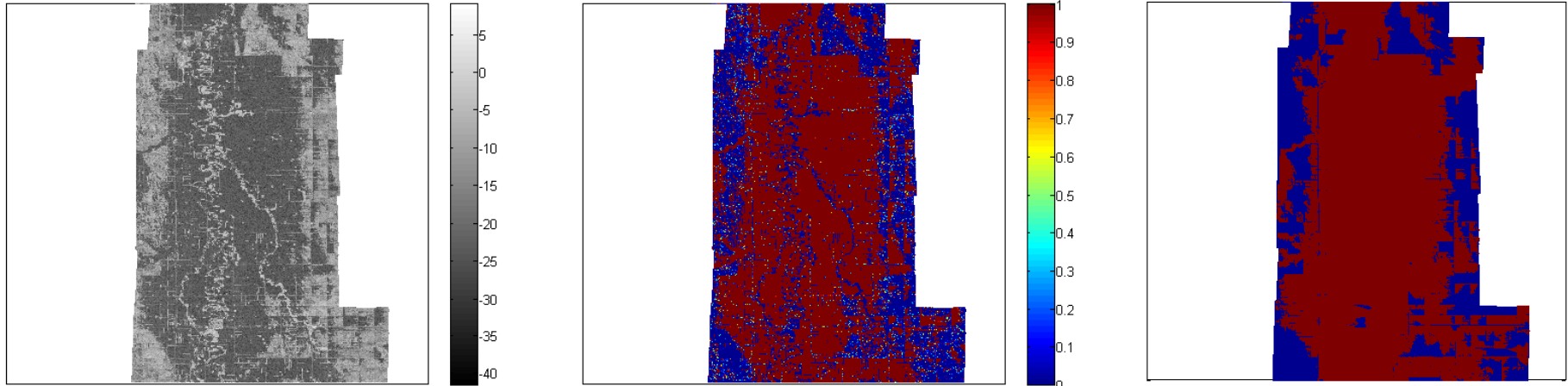
SEVERN

TerraSAR-X: 2007/07/25 06:34



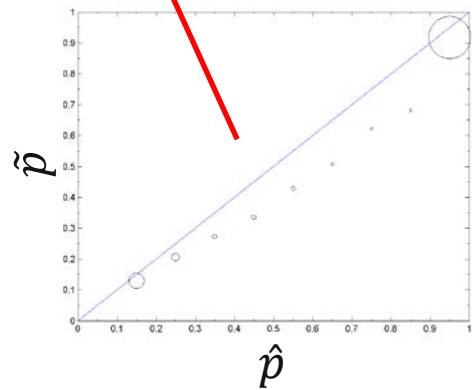
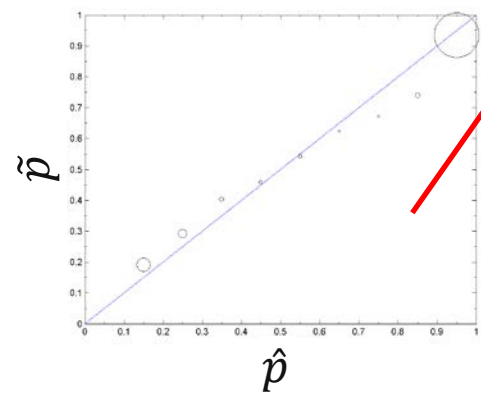
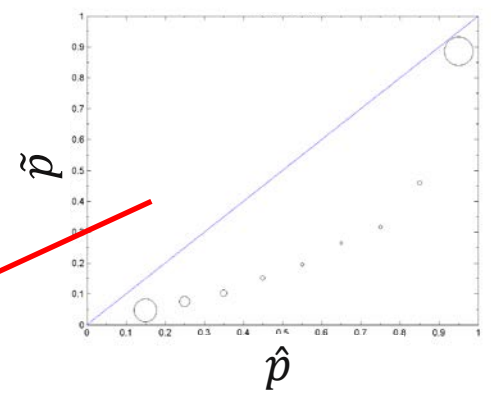
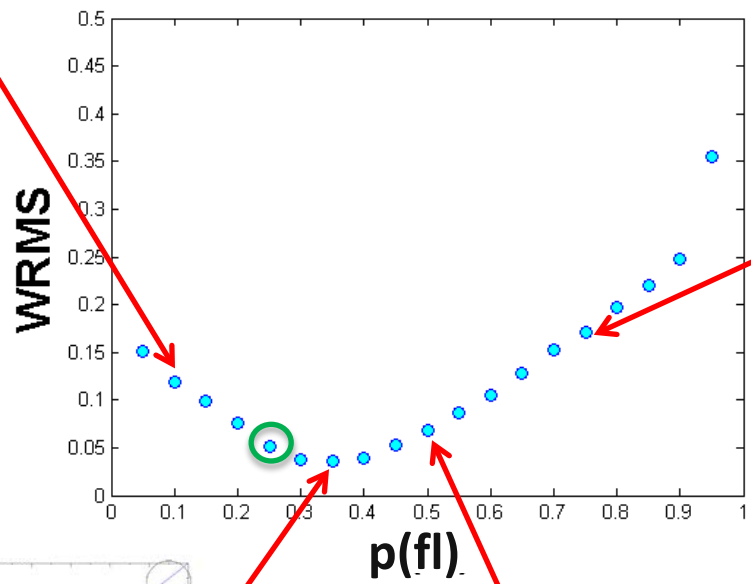
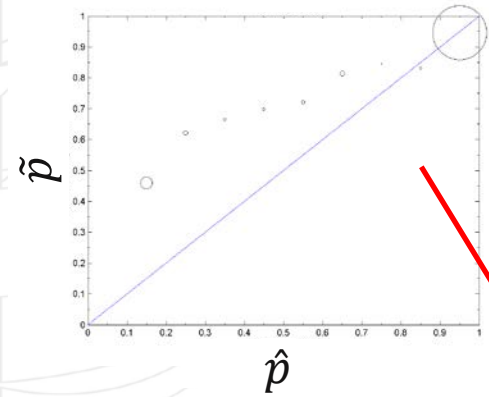
RED RIVER

RADARSAT-1: 1997/04/24 00:27



Analysis of prior pdf

SEVERN: Envisat 2007/07/23 10:27

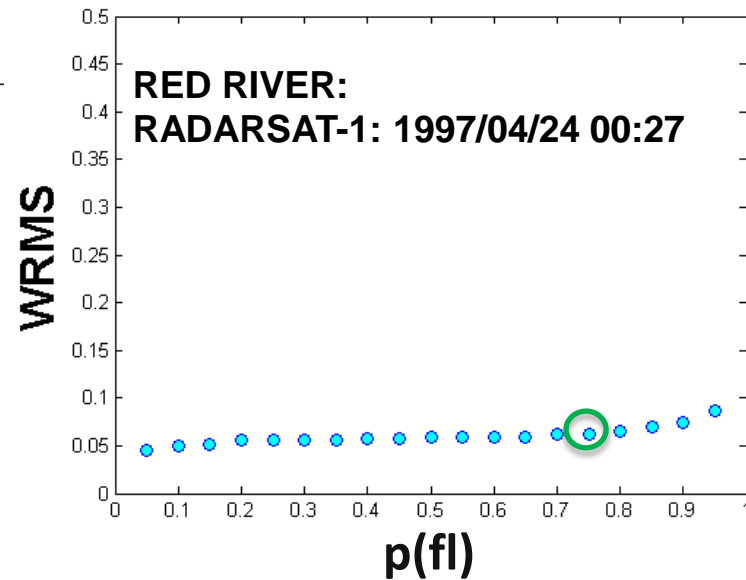
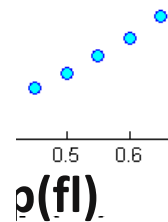
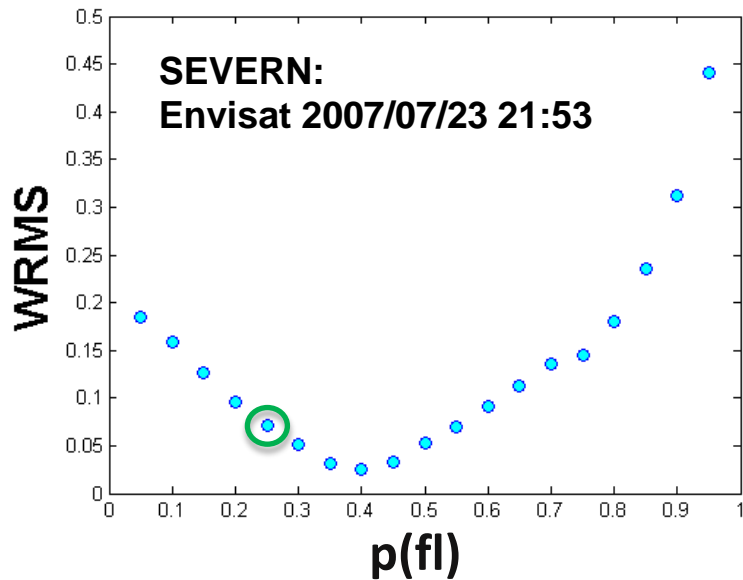
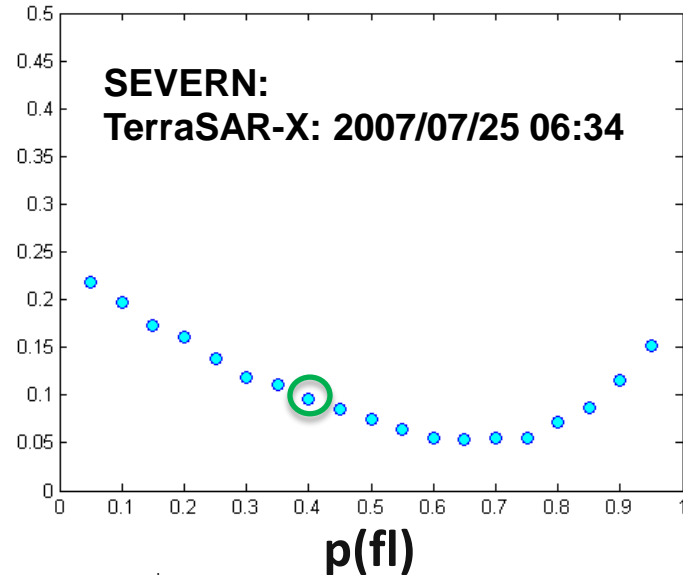
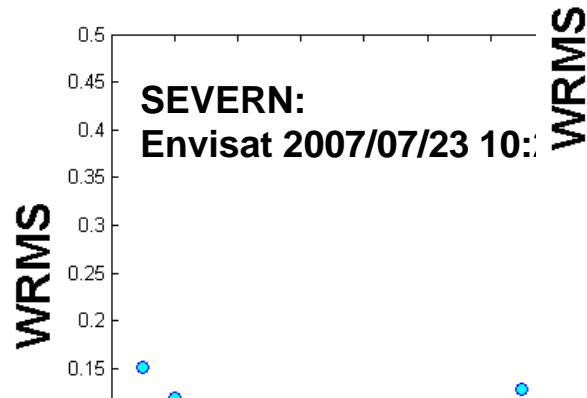


$$p(fl|\sigma^0) = \frac{p(\sigma^0|fl)p(fl) + p(\sigma^0|nfl)p(nfl)}{p(\sigma^0)} = \frac{p(\sigma^0|fl)p(fl)}{p(\sigma^0)}$$

prior to the backscatter value being measured
 prior pdf of flooded pixels (yellow)
 prior pdf of non-flooded pixels (blue)

prob. pdf of σ^0 values for flooded pixels (red)
 prob. pdf of σ^0 values for non-flooded pixels (blue)

Analysis of prior pdf



CONCLUSIONS

1) How to get a Probabilistic Map of flood?

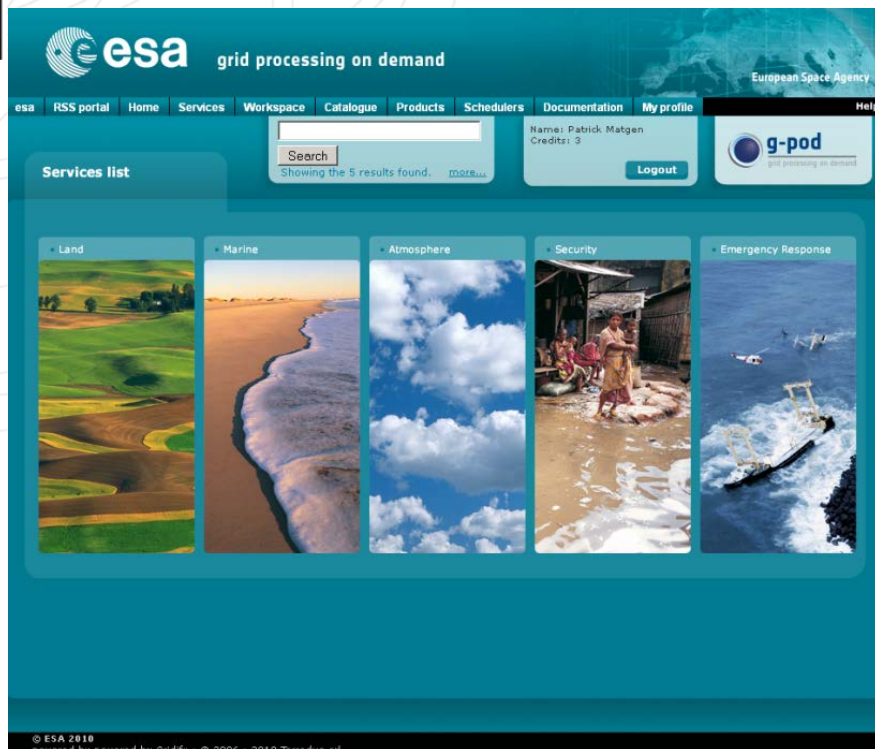
- Statistical framework on Bayes theorem;
- Uncertainty arising from a SAR image classification, based on backscatter values;
- Assumption on prior probabilities: 0.5

2) How to evaluate its correctness?

- Reliability plots, when ground truth is available: acceptable performance;
- Analysis of sensitivity on prior probabilities: 0.5 reasonable choice

AKNOWLEDGEMENTS

<http://gpod.eo.esa.int/>



Algorithm available upon request:

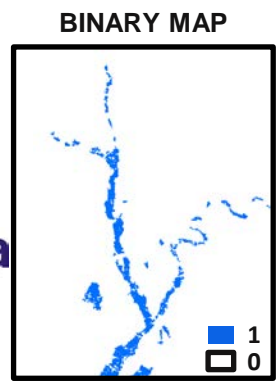
laura.giustarini@list.lu

renaud.hostache@list.lu

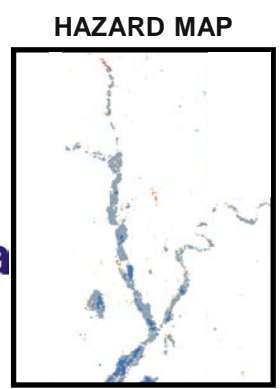
marco.chini@list.lu

patrick.matgen@list.lu

SAROTEC 



HASARD 



THANK YOU