Flanders FLOOD prevention

The development of an operational system to support Flanders flood prevention policy

VLM, division OC GIS-Vlaanderen
Jo Van Valckenborgh, joris De Man
Website: www.gisvlaanderen.be

Delft, 21 - 23 maart 2005

VLAANDEREN
ONDERSTEUNEND CENTRUM

OC GIS-Vlaanderen is a division of the Flemish Land Agency

GIS-Flanders

GIS-Flanders is defined as the legal framework for cooperation on the development of a structured communication and management system of spatially referenced data, with the ultimate aim to optimise the use of geographical information in Flanders (Belgium)

GIS-Flanders: Partners

Obligatory for:

- Agencies of the Flemish Government
- Flemish public service institutions
- municipalities
- provincial authorities

Through agreement open for:

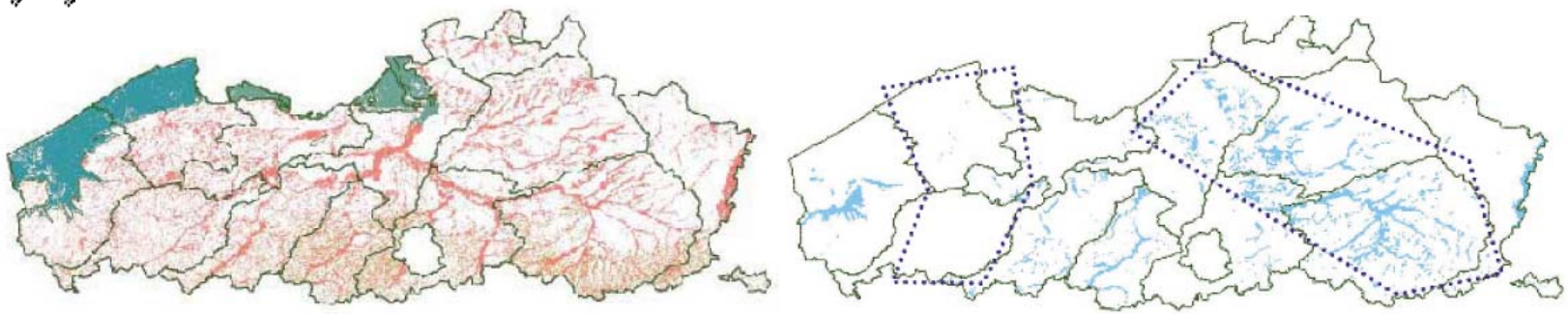
- federal institutions
- European institutions
- private sector

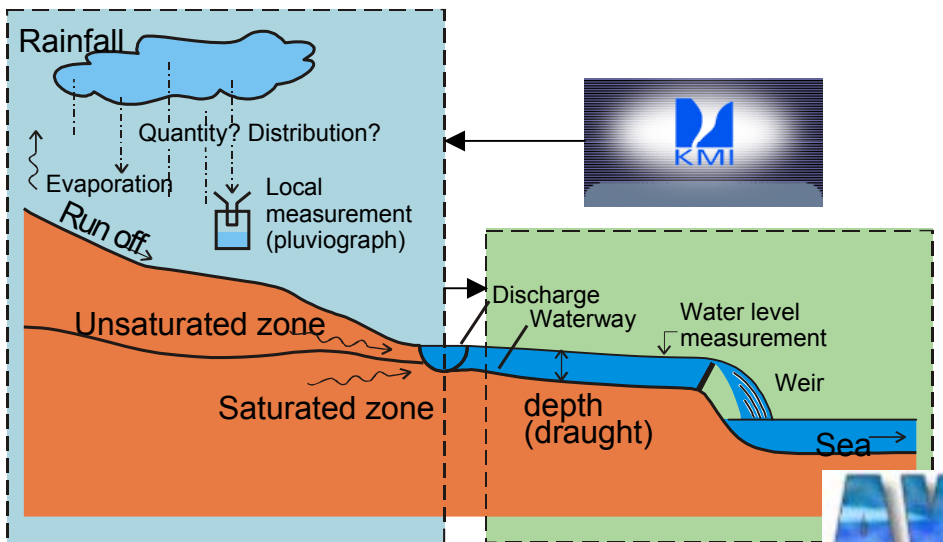
Provided online services

- Spatial Information Directory (SPIDI), meta database on-line at the Internet
- GIRAF: Geographical information retrieval application for Flanders
- GEO-Vlaanderen: Internet based consultation centre for information of public interest
- FLEPOS: Online RTK-GPS positioning system

Introducing the problem

NOG/ROG (1988-2000) --> Automatic flood detection





Validation of Models and actualisation database « fast and accurate »

Projects and initiatives

- Floodmap (Radar)
- DTM
- Large scale inundation mapping

Aim: Define operational scenario's to support Flanders flood prevention policy

Floodmap: Project situation

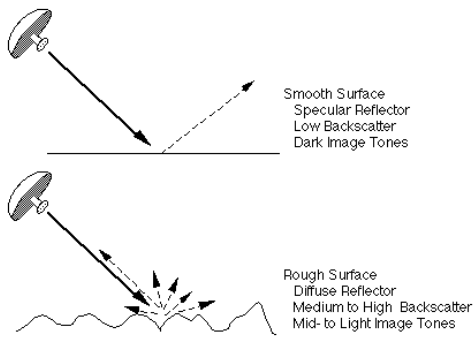
- STEREO-program DWTC

- Project partners
  - Royal Military Academy, Signal and Image Centre (RMA)
  - VLM, Support Center GIS-Flanders (SC)

Floodmap

- Project aiming at the detection and mapping (monitoring) of flooded areas using SAR satellite images

- Why RADAR-satellite images ?
  - Independent of weather (clouds)
  - Independent of sun light
  - Flooded regions are detectable (black objects)



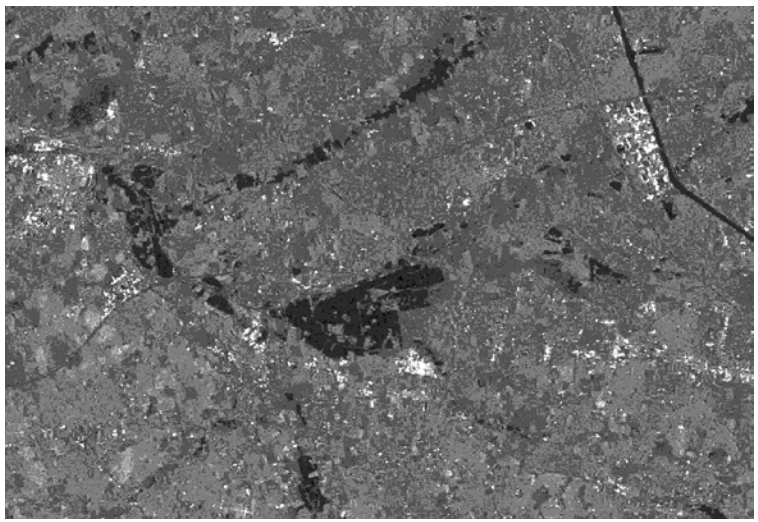
Project results

- Which RADAR-satellites suitable for mapping flooding?
  - ERS (fixed angle) -> not suitable: steep viewing angle, fixed = 23°, bad temporal frequency
  - ENVISAT (variable shallow incidence angle) -> suitable if angle > 30° acquisition frequency acceptable
  - RADARSAT (variable shallow incidence angle) -> suitable if angle > 30° acquisition frequency acceptable

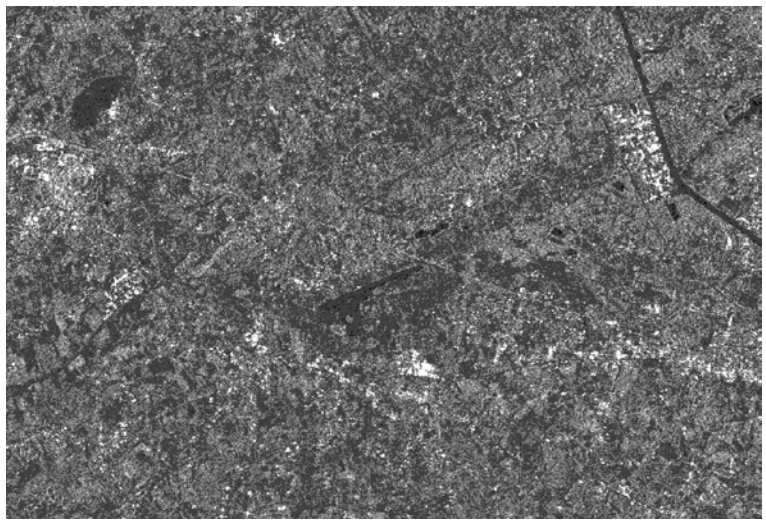
⇒ System is made operational for ENVISAT (ASAR) and RADARSAT-images

Reference image

- How flooded regions distinguish from existing water bodies (reference image) ?



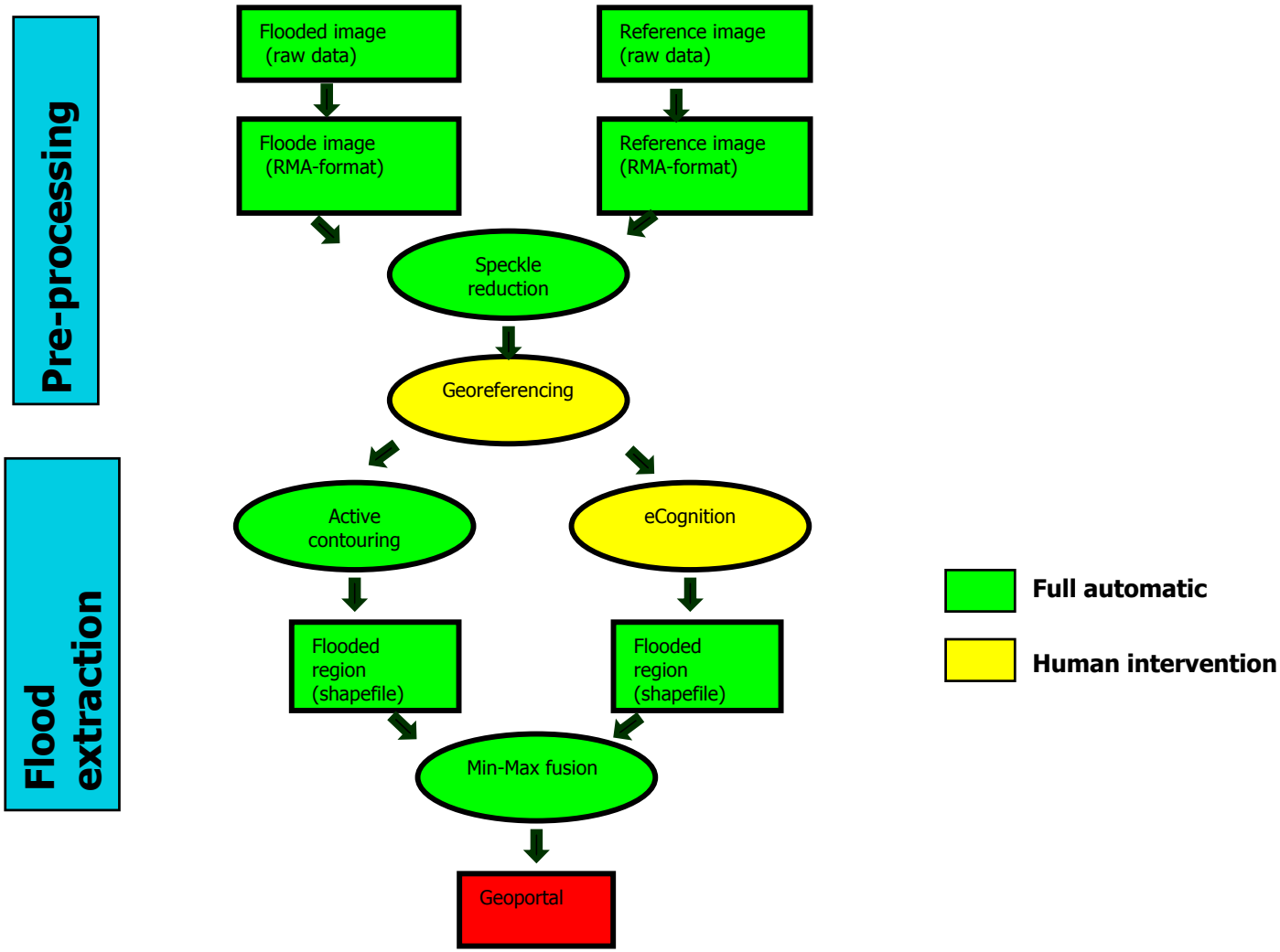
Flooded region



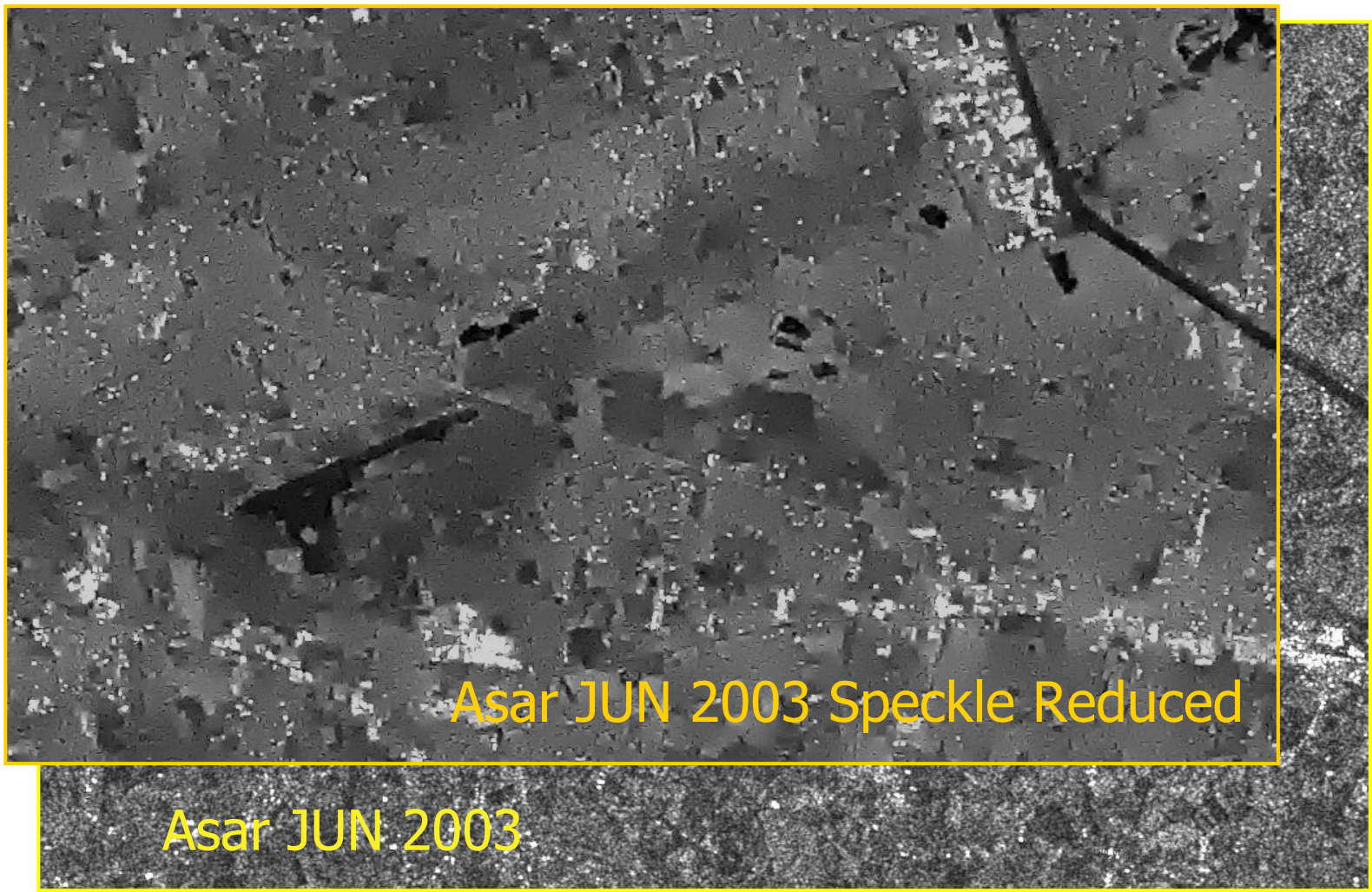
Reference image

=> System requires a flooded and a reference image

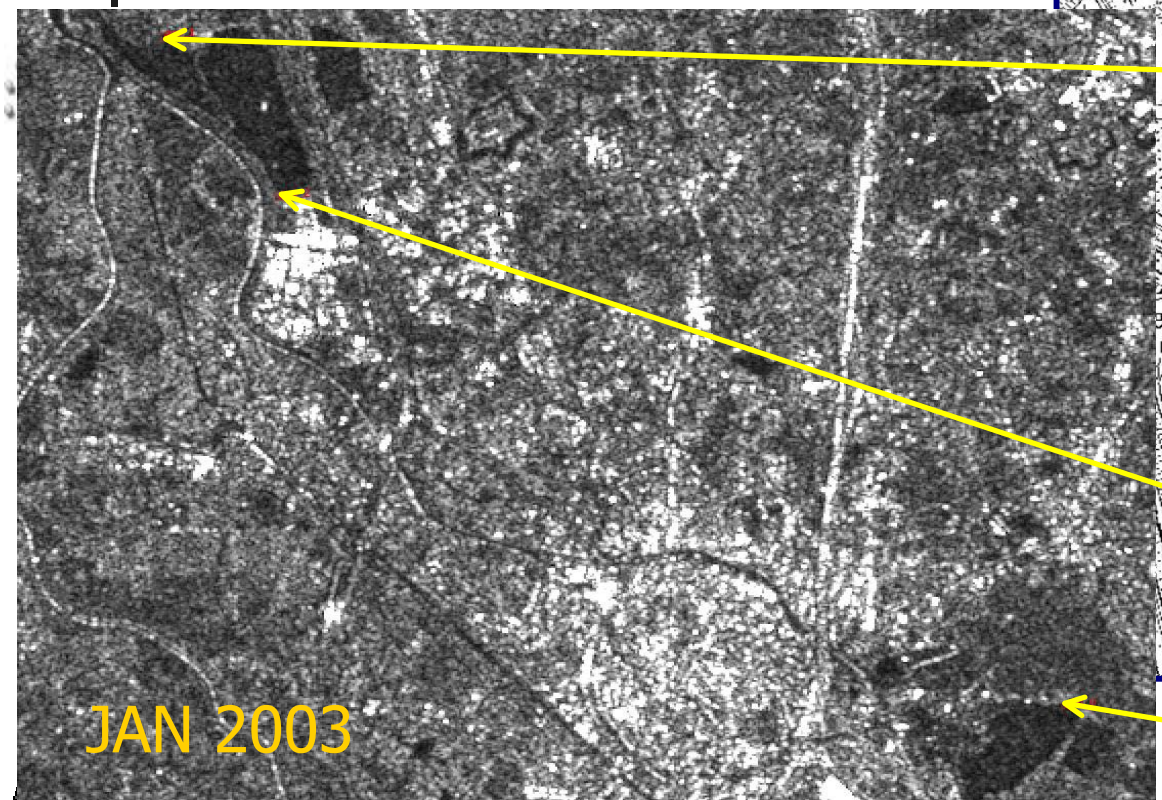
Flow chart of system

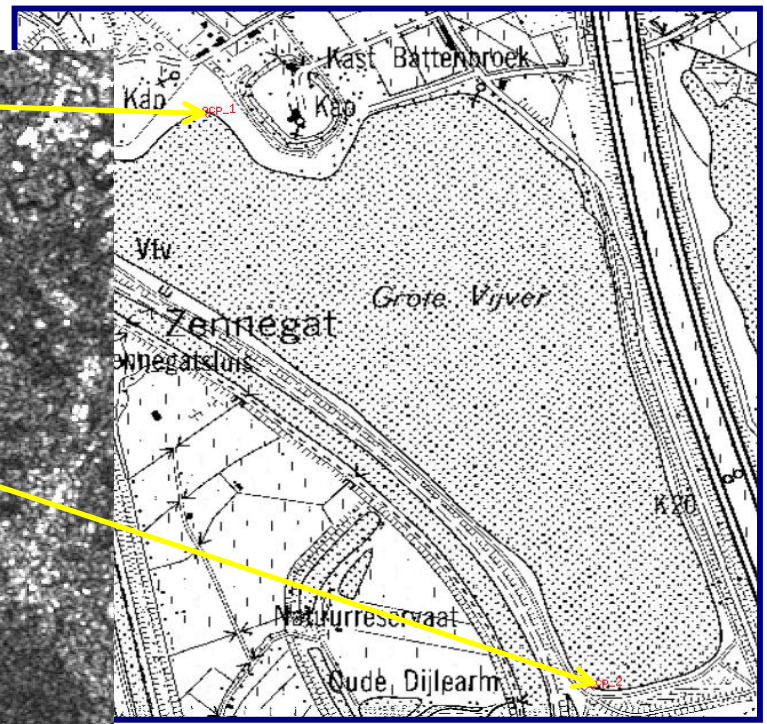


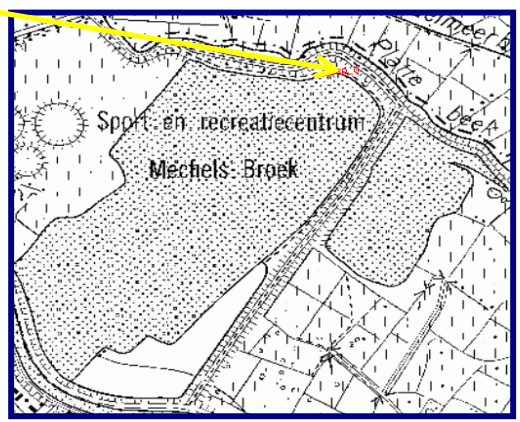
Speckle reduction



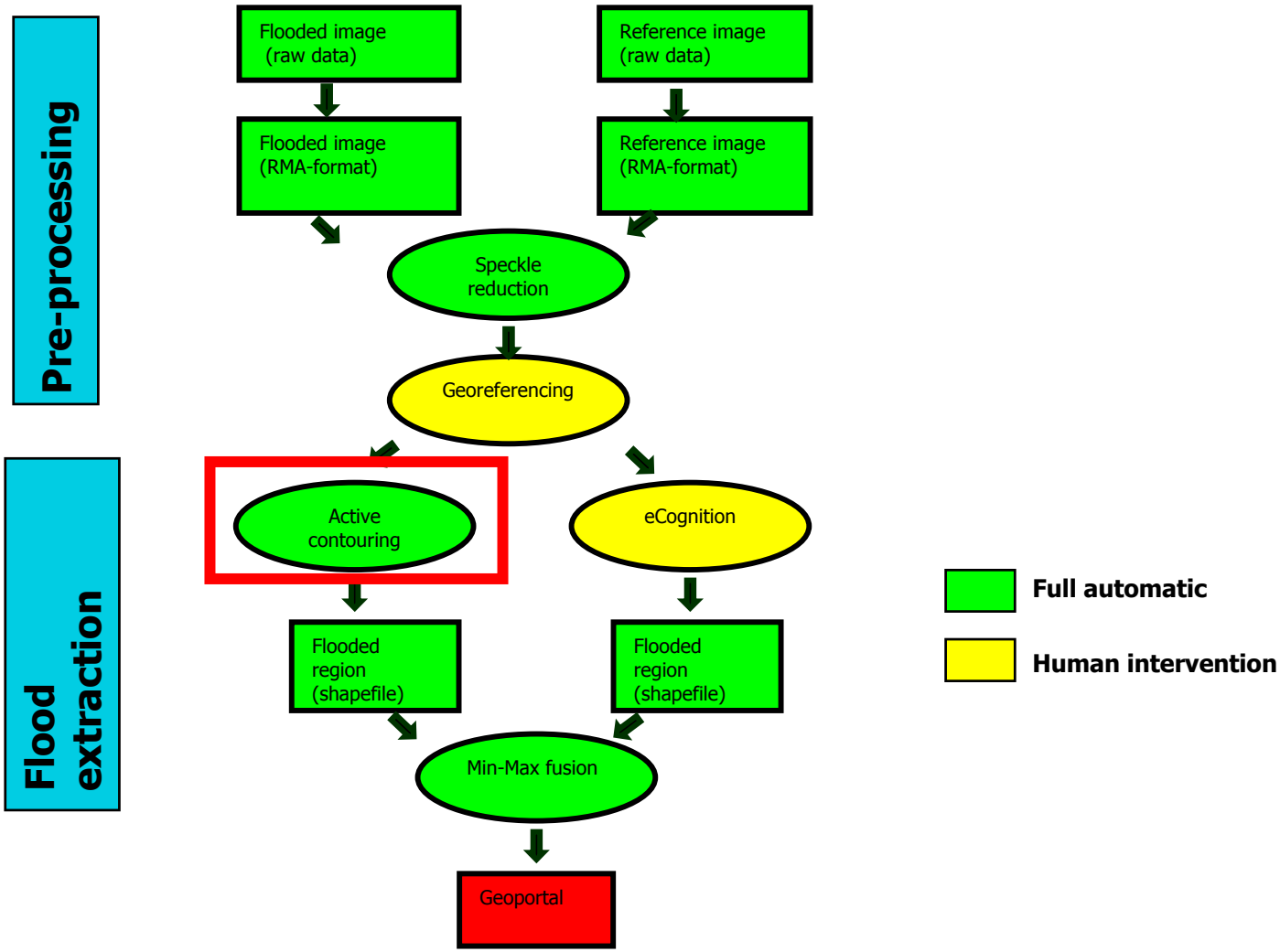
Georeferencing: GCP-matching (RADAR-TopoMap)







Flow chart of system



Active Contour (AC) method (RMA)

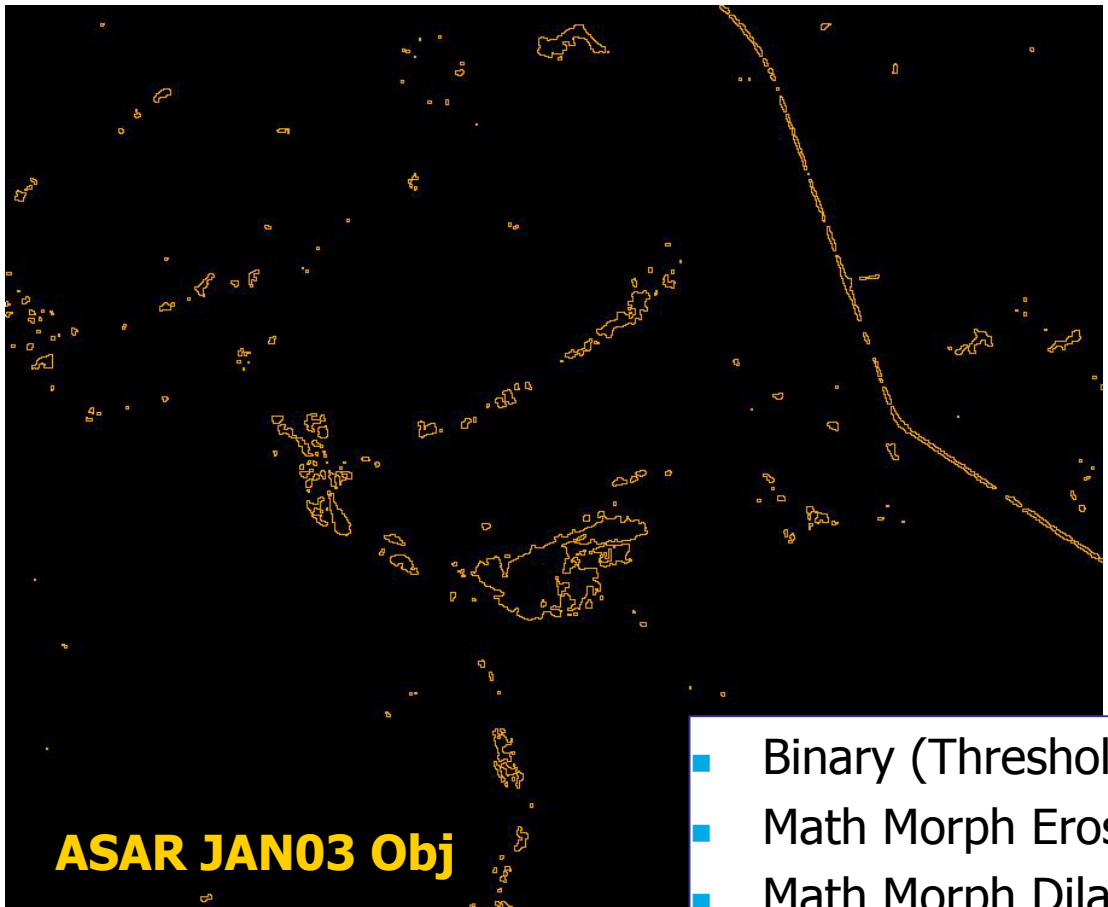
1. Initial AC Polygons

(Input)

- Binary (Threshold)
- Math Morph Erosion (st.el. square 5x5)
- Math Morph Dilatation (st. El. square 3x3)
- Region2Obj

2. Active Contour → 3. Difference between two images (Flooded–Reference image)

1. Initial Polygons



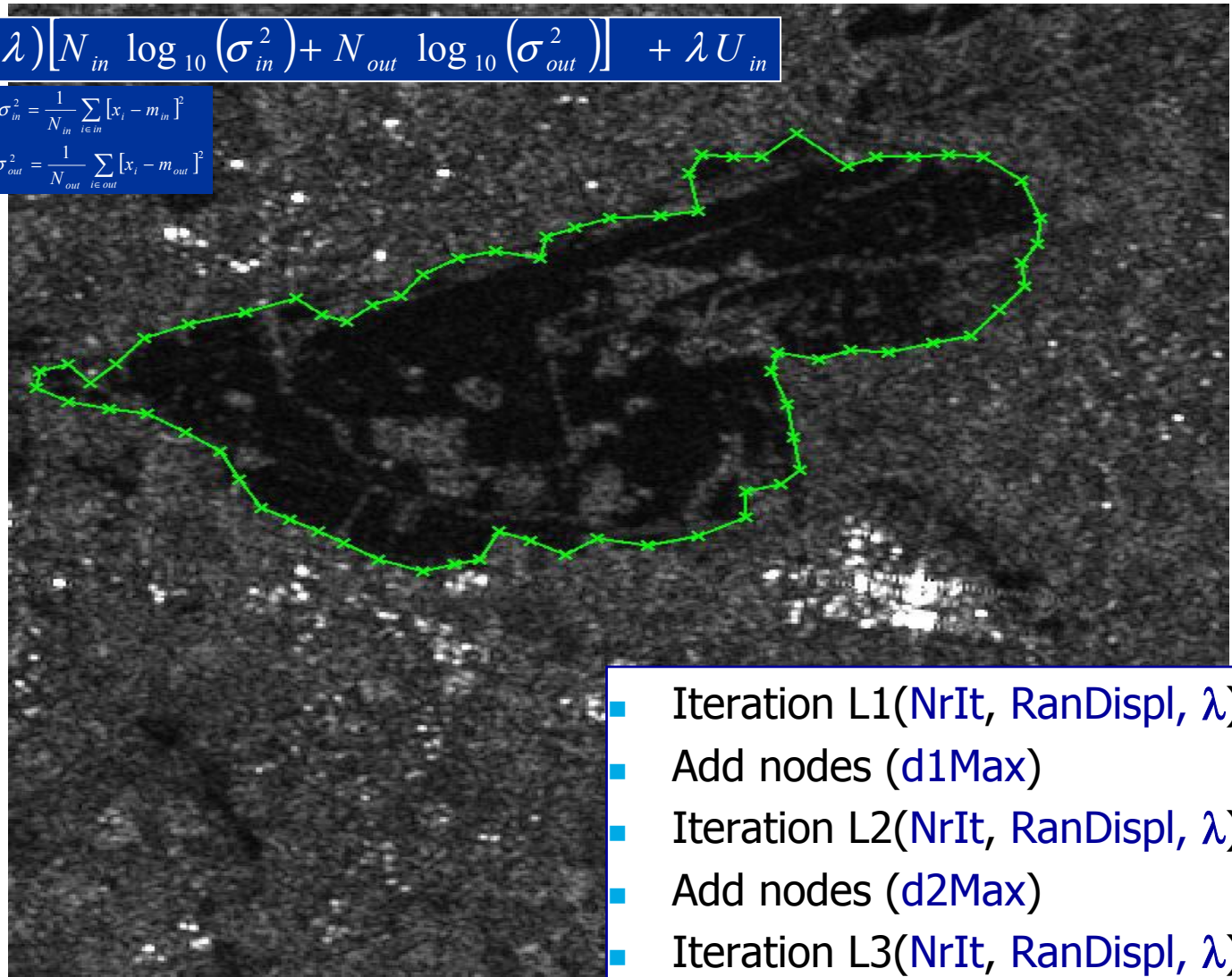
- Binary (Threshold)
- Math Morph Erosion (st.el. square 5x5)
- Math Morph Dilatation (st. El. square 3x3)
- Region2Obj

2. Active Contour mechanism

$$E(p,\lambda) = (1-\lambda)\left[N_{in}\ \log_{10}\left(\sigma_{in}^2\right) + N_{out}\ \log_{10}\left(\sigma_{out}^2\right)\right] + \lambda U_{in}$$

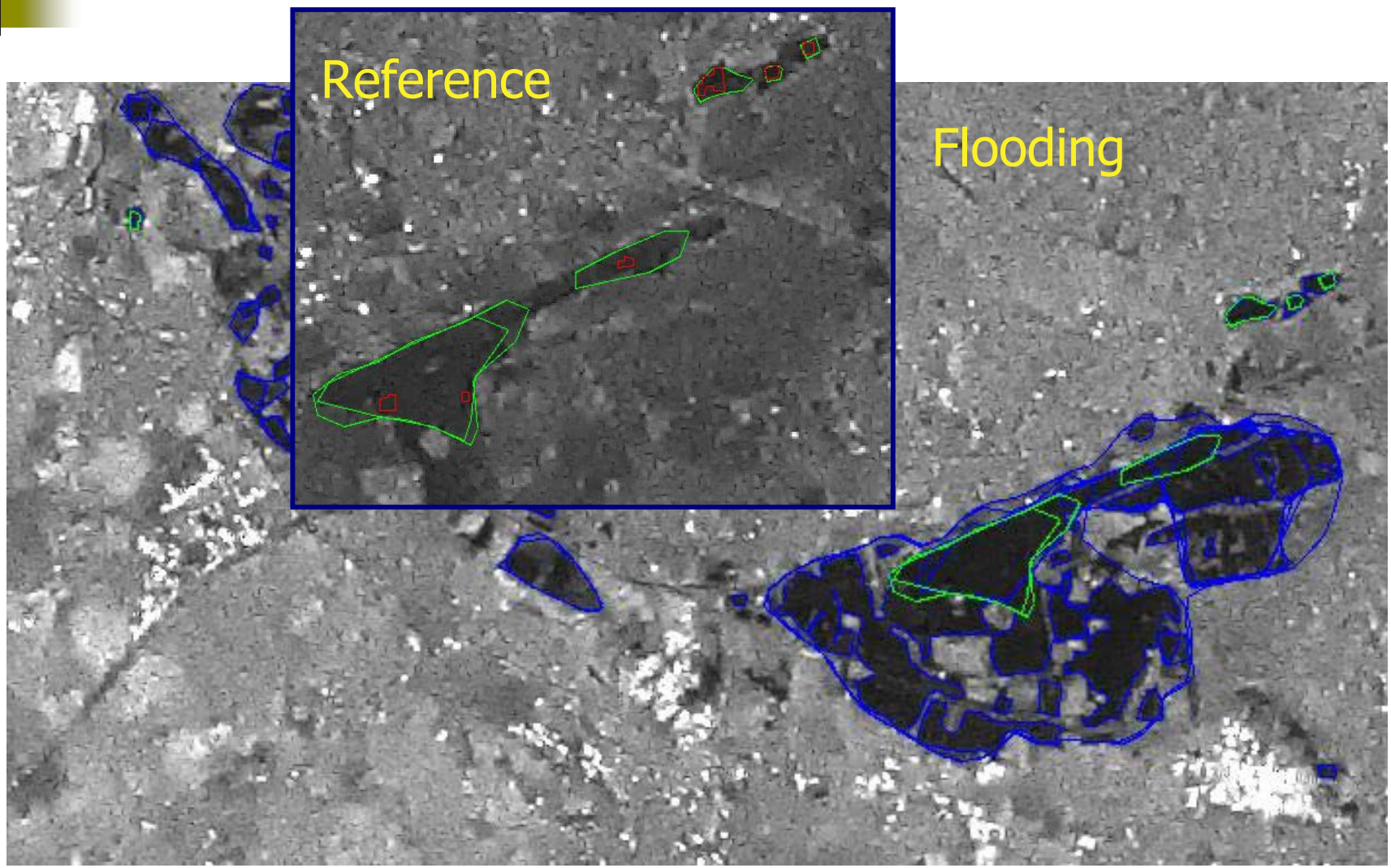
$$m_{in} = \frac{1}{N_{in}} \sum_{i \in in} x_i \qquad \sigma_{in}^2 = \frac{1}{N_{in}} \sum_{i \in in} [x_i - m_{in}]^2$$

$$m_{out} = \frac{1}{N_{out}} \sum_{i \in out} x_i \qquad \sigma_{out}^2 = \frac{1}{N_{out}} \sum_{i \in out} [x_i - m_{out}]^2$$

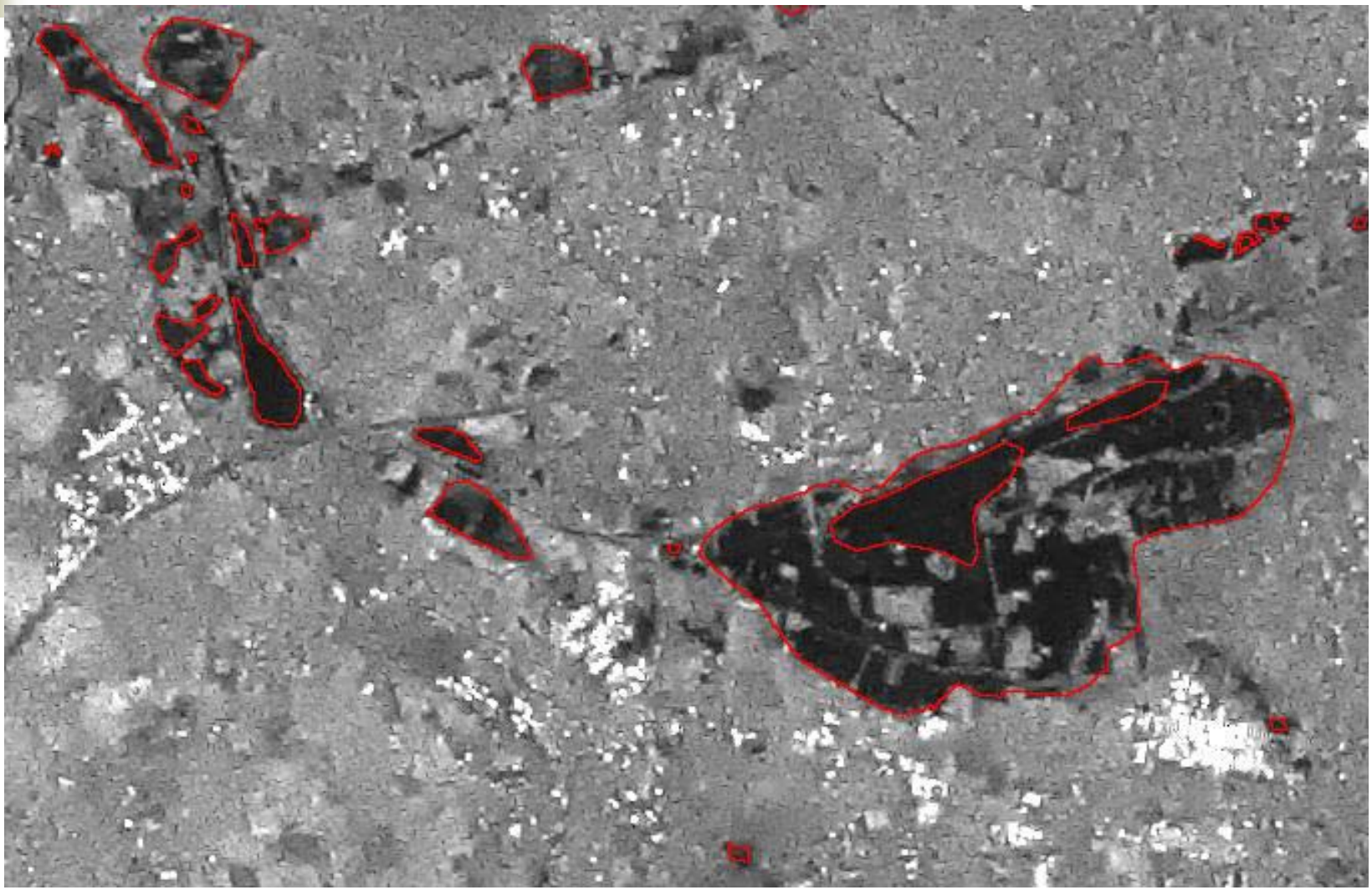


- Iteration L1(NrIt, RanDispl, λ)
- Add nodes (d1Max)
- Iteration L2(NrIt, RanDispl, λ)
- Add nodes (d2Max)
- Iteration L3(NrIt, RanDispl, λ)

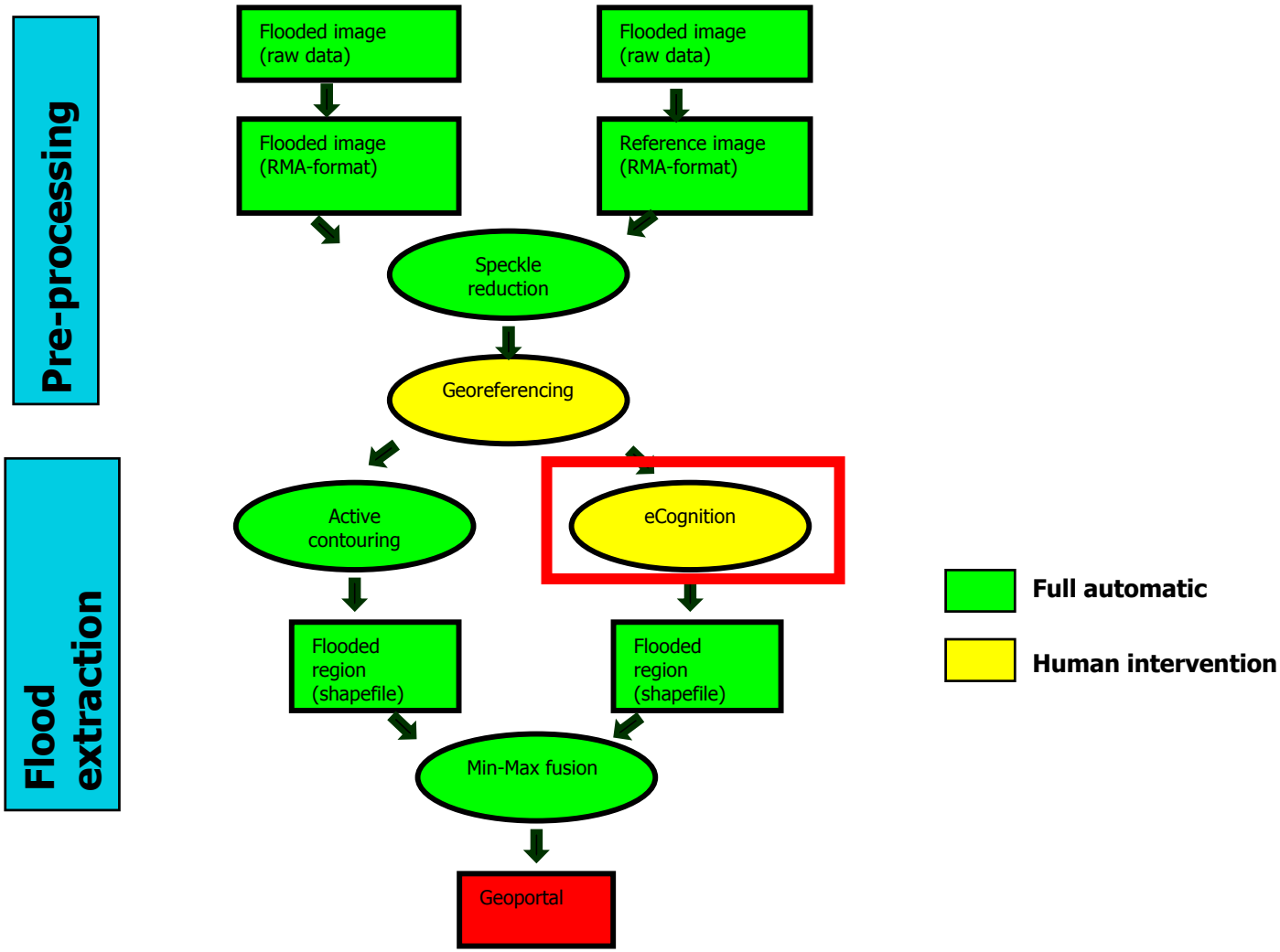
Active Contour result



3. Difference: Flooding – Reference



Flow chart of system



Object Oriented Classification
Ecognition method (SC GIS-Flanders)

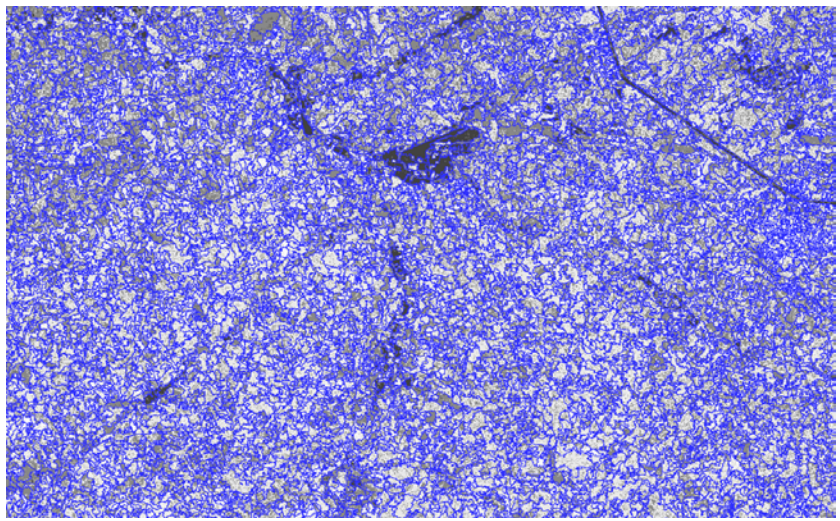
1. Segmentation

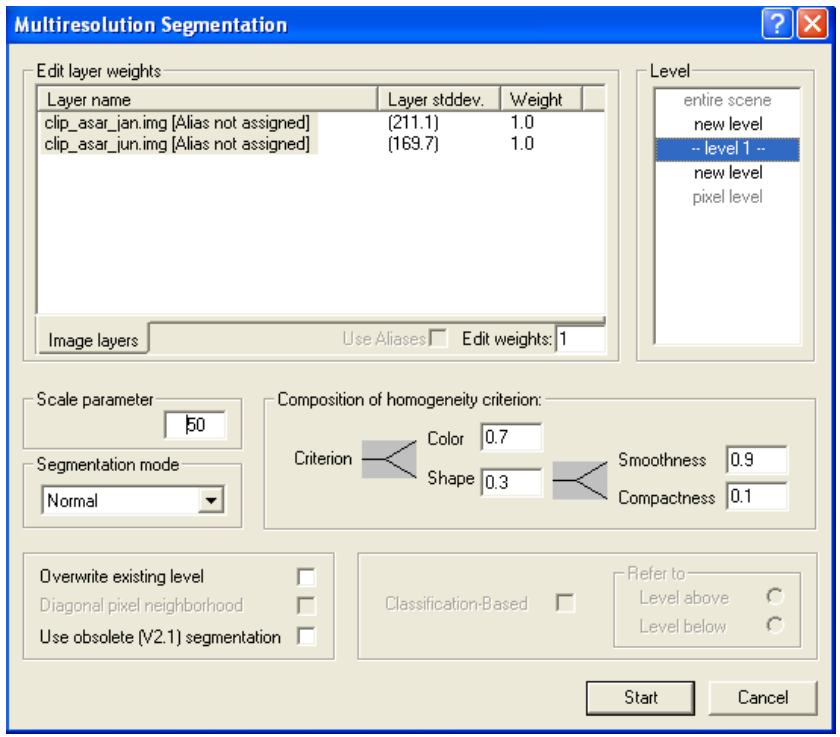
- Image segmentation : segments / objects

2. Classification

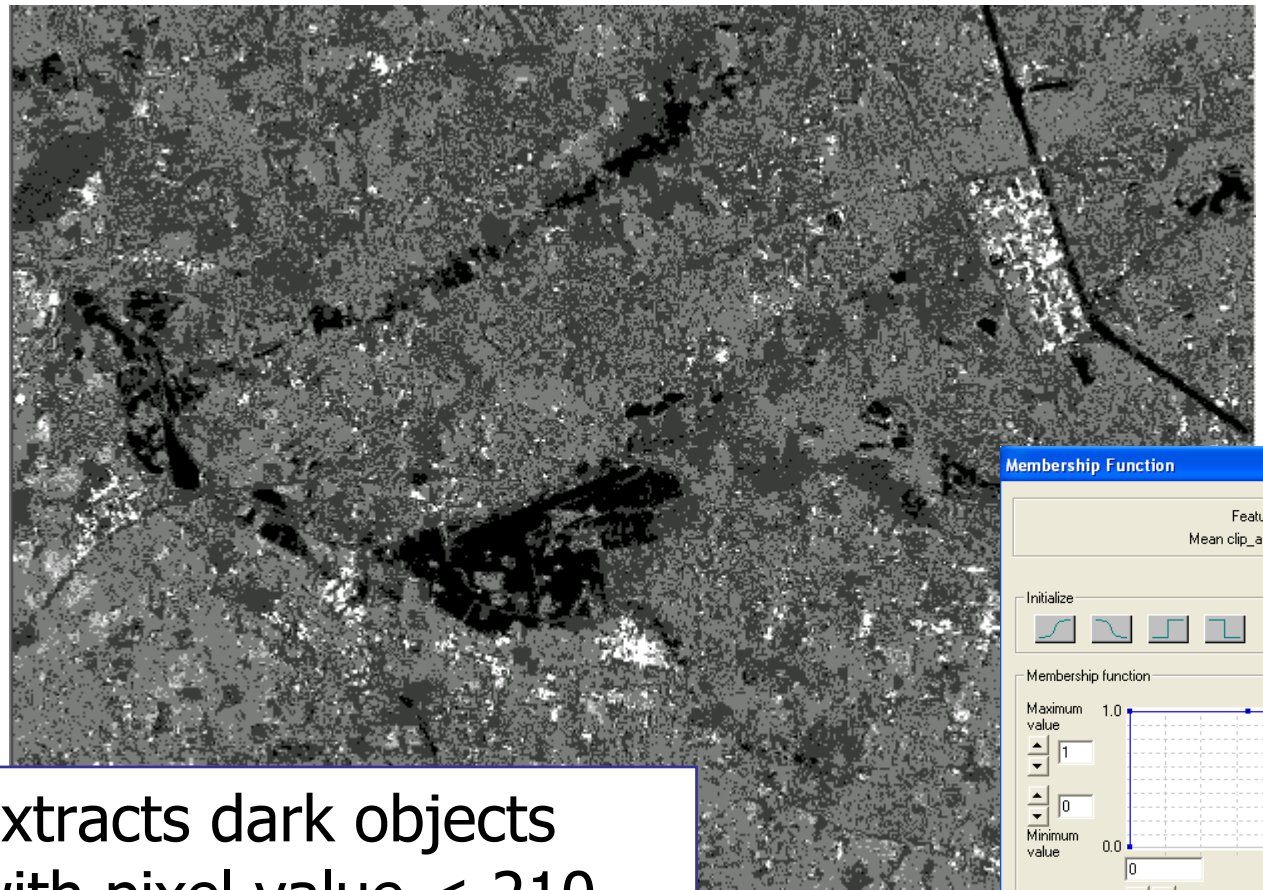
- Segments / objects classification

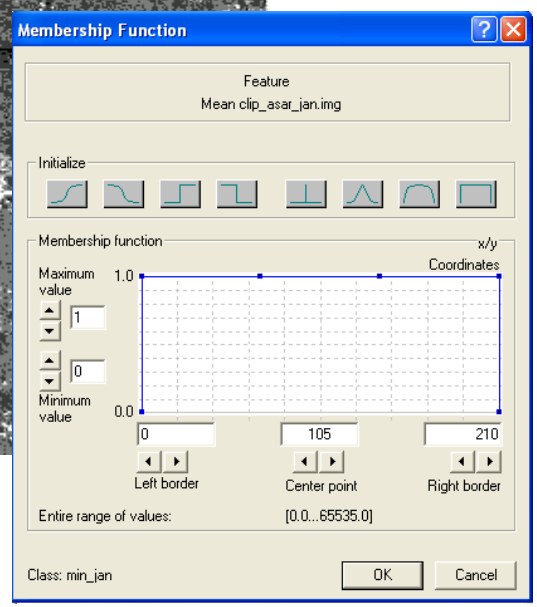
1. Segmentation





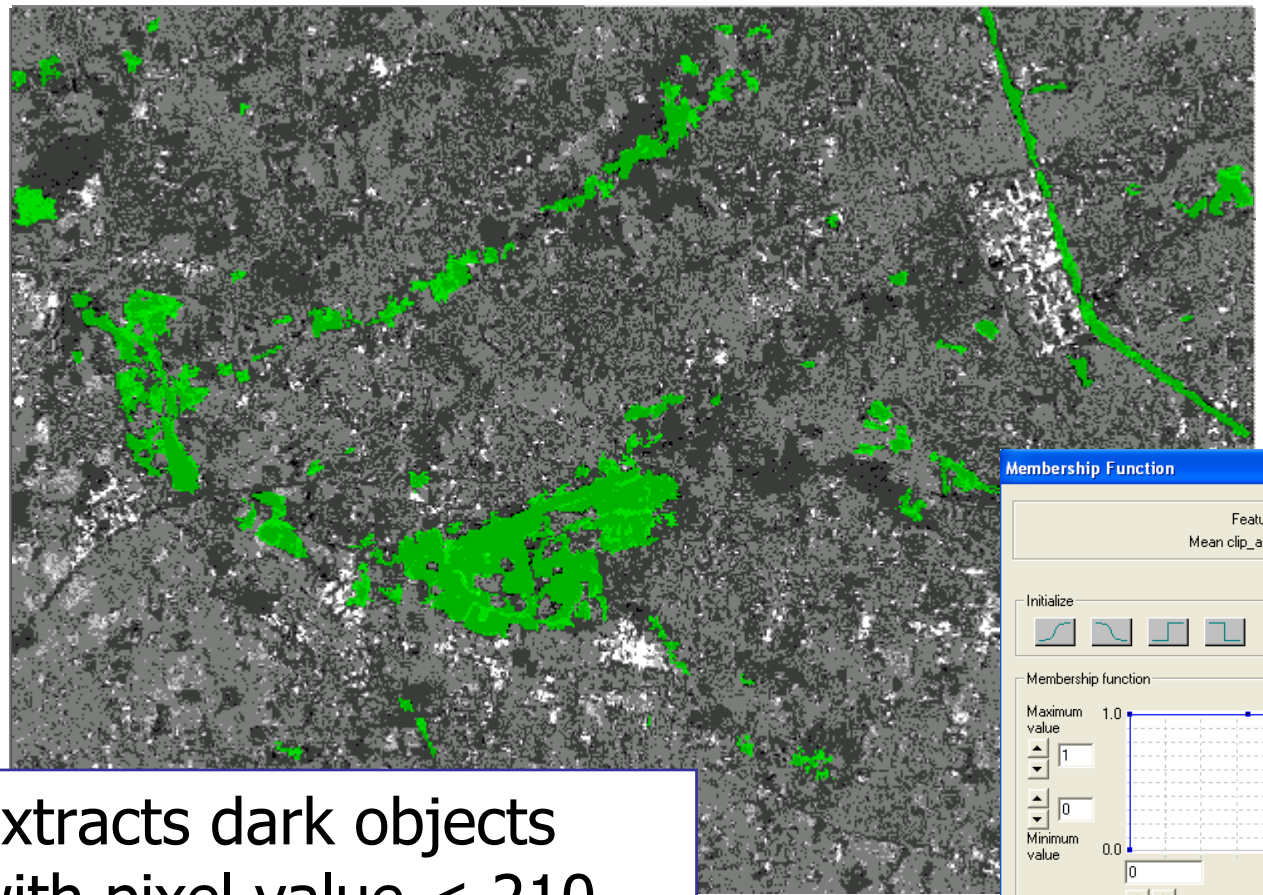
2. Classification : step 1

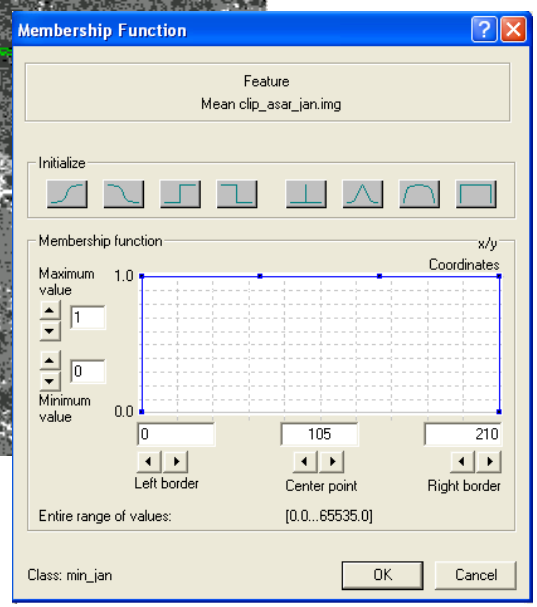




Extracts dark objects with pixel value < 210

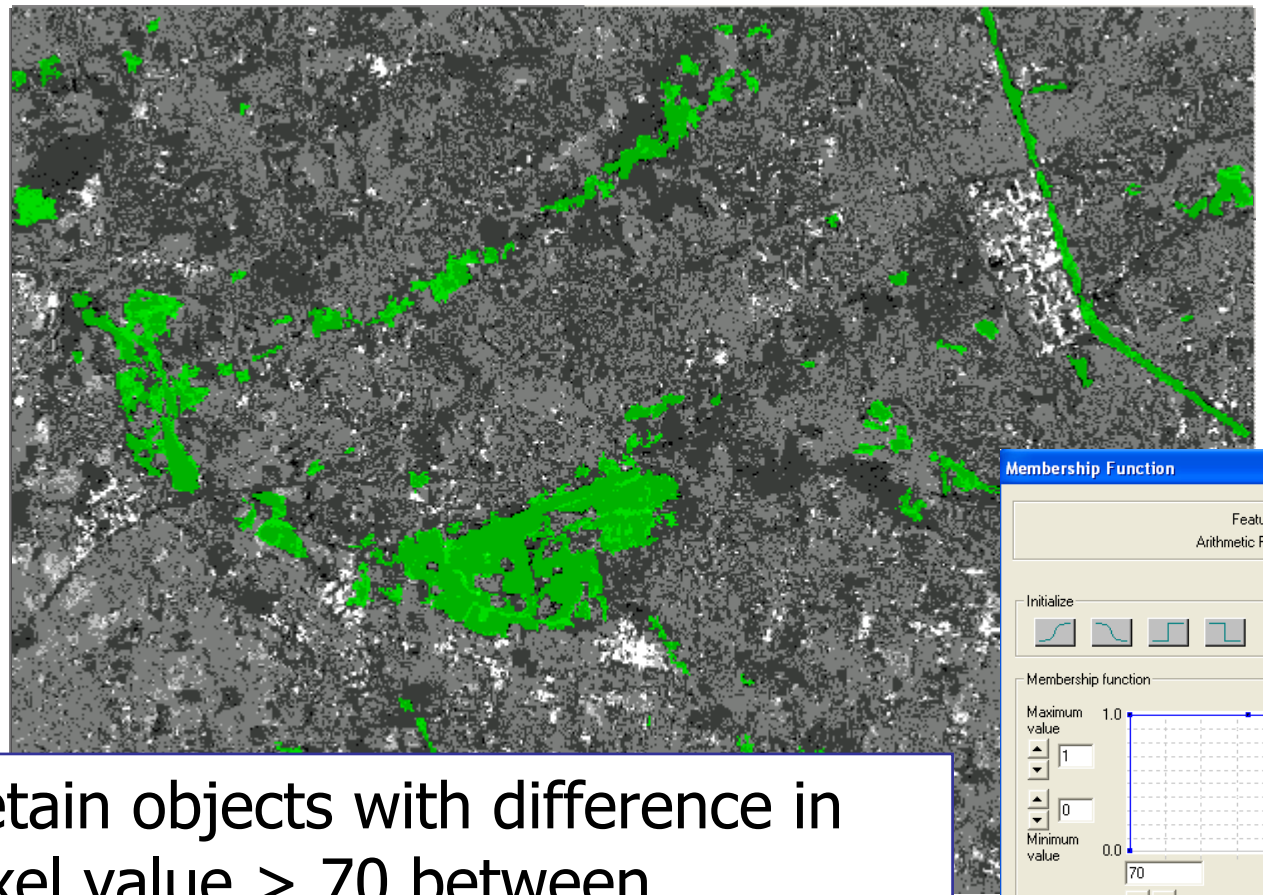
2. Classification : step 1

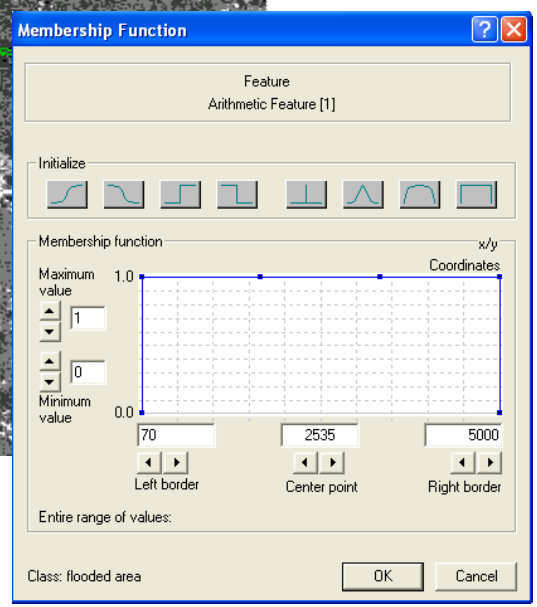




Extracts dark objects with pixel value < 210

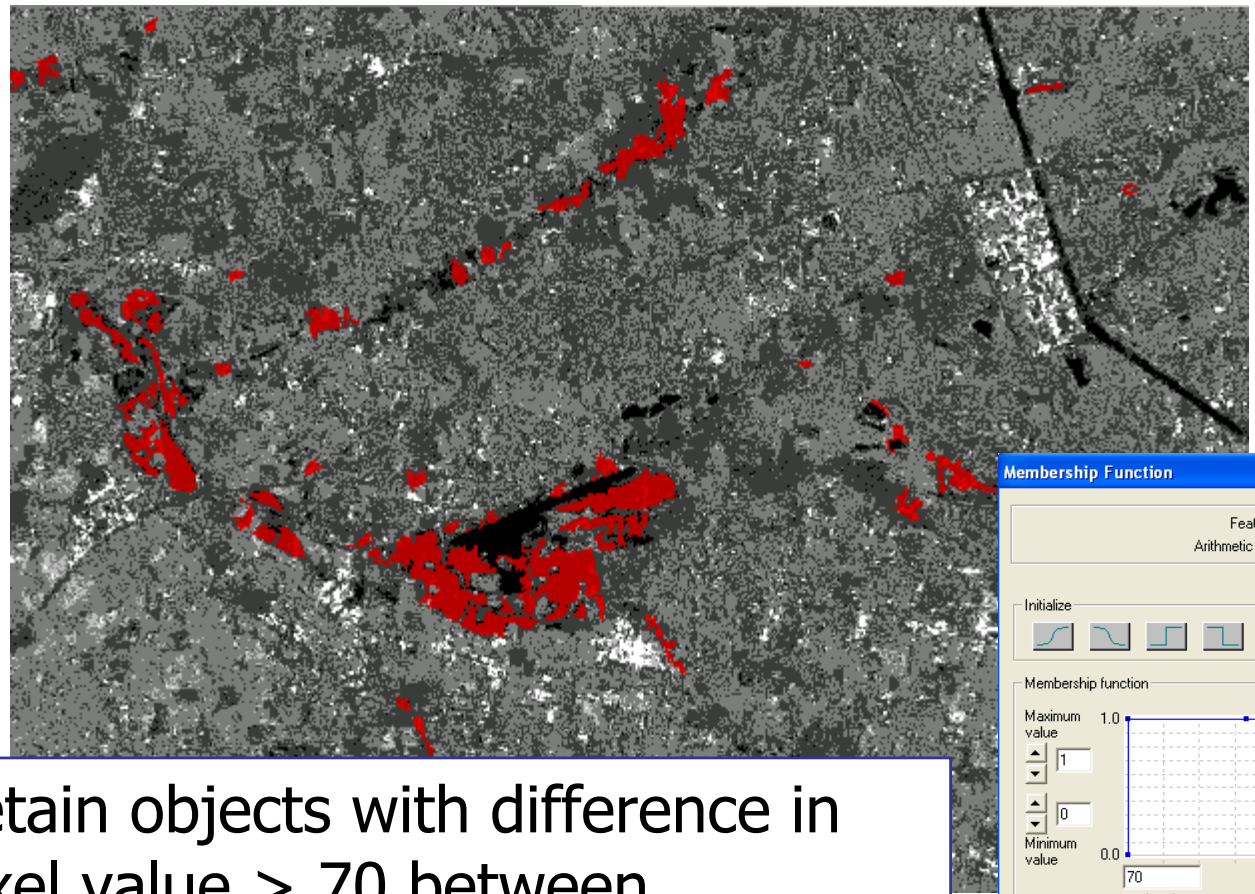
2. Classification : step 2

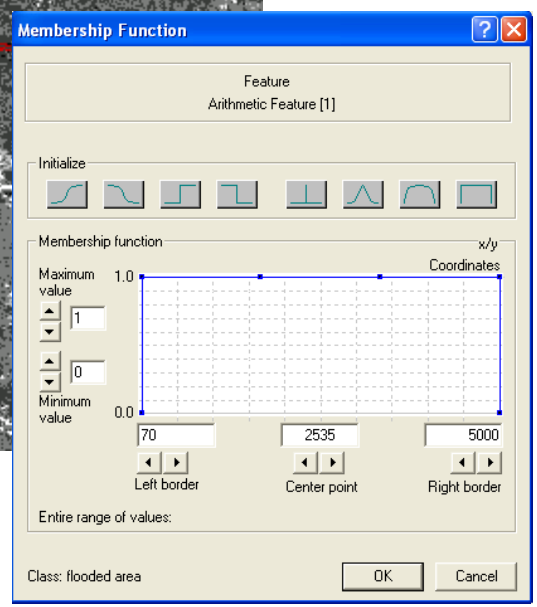




Retain objects with difference in pixel value > 70 between reference and flooded image

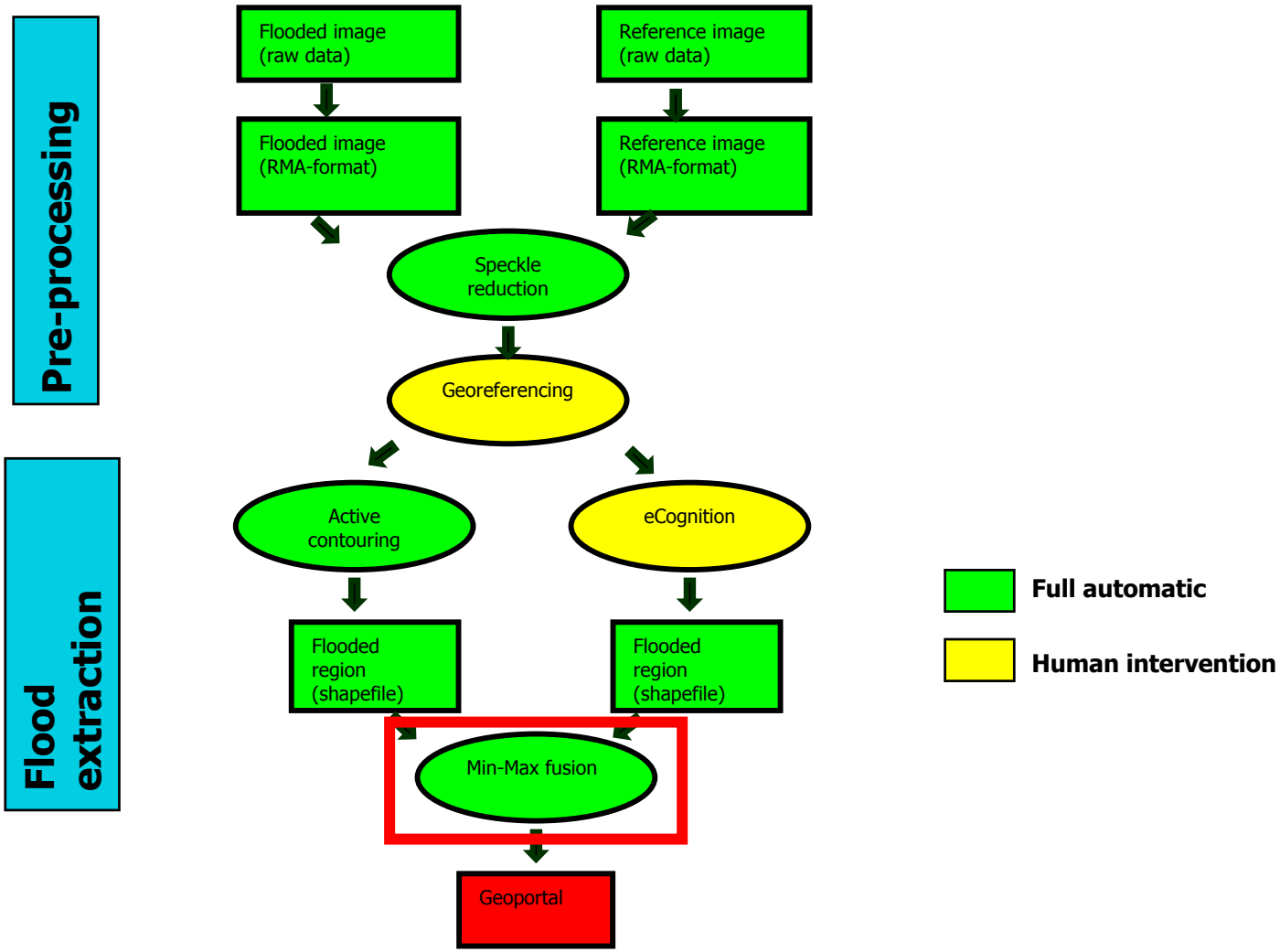
2. Classification : step 2



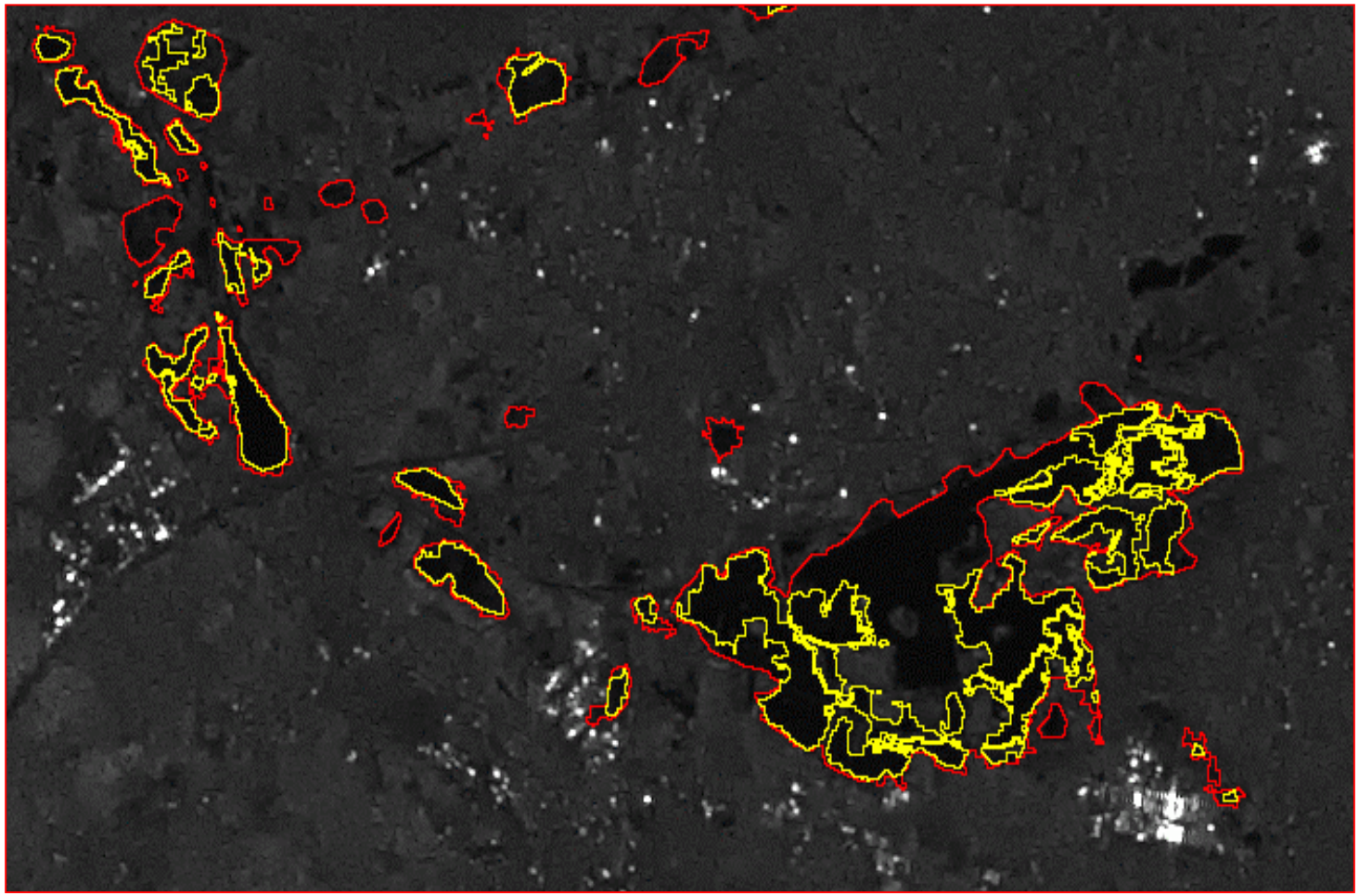


Retain objects with difference in pixel value > 70 between reference and flooded image

Flow chart of system



Fusion of results Act. Cont. & eCognition



Maximum **Minimum**

Comparison

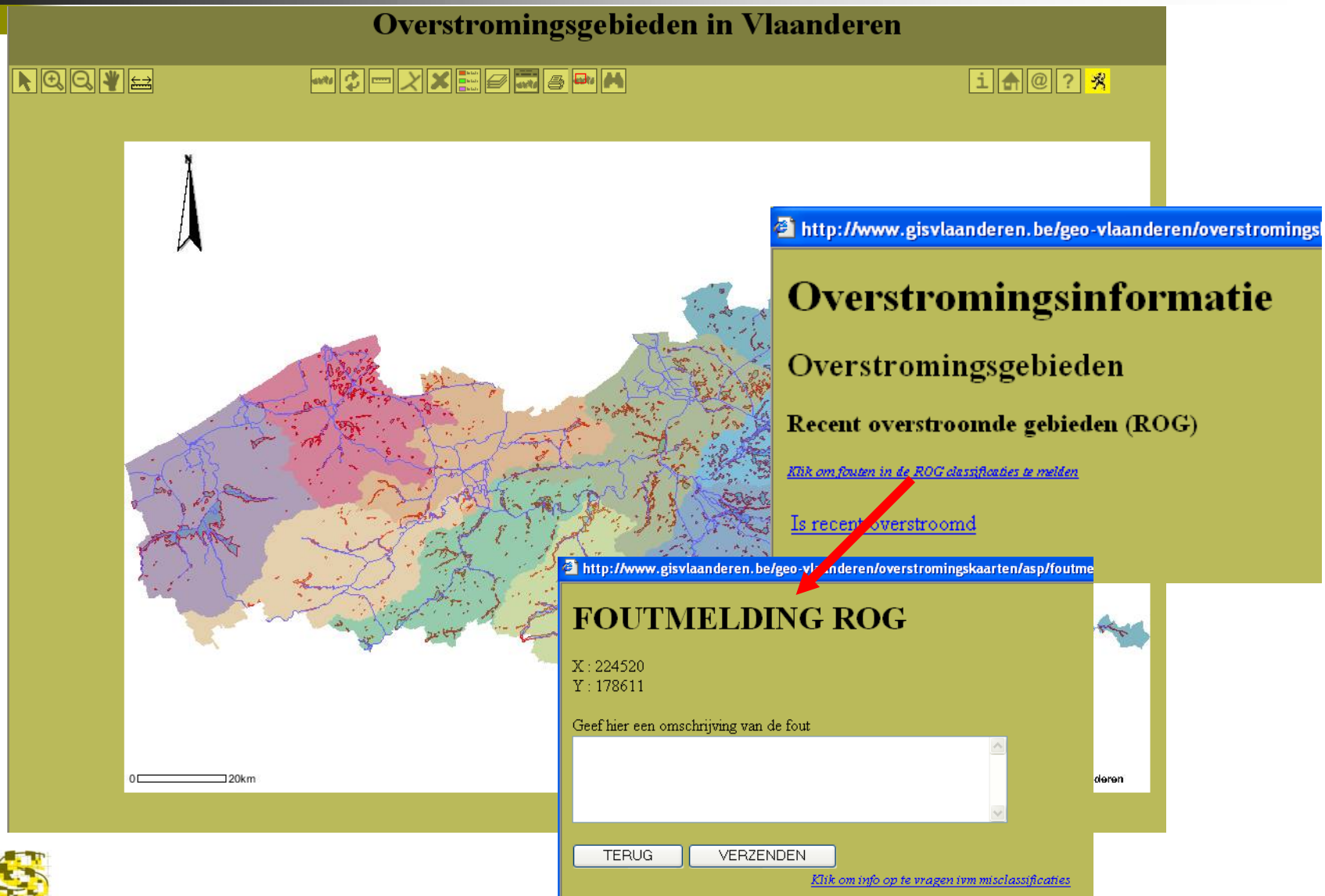
- The Object-Oriented algorithm
  delineates more precisely the black regions in the image
  -> the water areas

- The Active Contour algorithm
  finds the biggest region keeping the variance in colour low
  -> tolerates for instance water areas with some structure in it, like trees, bushes, etc...

- Both results are supplementary

Results on Geo-Portal

Results on Geo-Portal



DTM Flanders

- Aim:
  - Accurate, complete and multi-functional DEM for Flanders
  - Generate and distribute products on demands of customers
- Contracting authority:
  - AWZ, Hydrographic Information Centre
  - Aminal, Water department
- Technical coordination and quality control:
  - VLM - Supporting Centre GIS-Flanders (OC GIS – Vlaanderen)

DTM: Technical characteristics

- Two acquisition techniques:
  - Airborne laser scanning (95 %)
  - Photogrammetric techniques (5%, city core)
- Mean point density varies according to technique:
  - Airborne laser scanning:
    - acquisition Point density 1 point per 4 m²
    - Final point density 1 point per 20 m²
  - Photogrammetric techniques: 1 point per 100 m², with additional breaklines
- Acquisition period: 01 dec till 15 april
- Z-accuracy dependant on land cover
  - Short grass and hard surface 7 cm

DTM Flanders

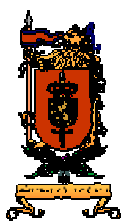
Used as input for hydrological modeling

Large scale inundation mapping

- Why
  - Precise knowledge of the size/location of the areas affected by flooding is basic information for the integral management of water systems.
- Aim
  - Define operational processes and scenario's to map actual inundations
- Requirements
  - Process time as short as possible
  - Maximum mapping possibilities
  - Good geometrical accuracy
  - Monitoring of time sequence situations
  - Acquisition during possible bad meteorological conditions

Conclusions

- Floodmap
  - System for mapping flooding operational for ENVISAT- en RADARSAT-images
  - Requires mapping flooding image and reference image to make a distinction water bodies and flooded regions
  - Full automatic for active contouring contour method (except. geo-referencing)
  - Suitable for mapping flooding “small and mid-scale”
- DTM available



- Research projects going on to define more scenario’s for flood prevention and managing

Future

- Floodmap
  - Automatic Geo-referencing
  - Building a database with existing water bodies -> reference map
  - Makes the system operational for:
    - New radar satellite systems with high resolution
    - Airborne radar-systems
- DTM allows precise simulations
- Scenario's for "rapid" inundation mapping

Ready to use Flood prevention and mapping system for Flanders to support flood prevention policy