Automatic Water Mapping algorithm using Sentinel-1 data within the ESA Hydrology TEP

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Layout

- ESA’s Hydro Thematic Exploitation Platform. TRE-Altamira Services.
  - Flood Monitoring
  - Small Water Bodies Monitoring

- Methodology Block Diagram
  - Sentinel-1 and Sentinel-2 Combination
  - Multi-frame approach

- Case studies

- Conclusions and Future Work
Hydrology Thematic Exploitation Platform

Online processing platform for the generation of hydrological services and products:
- Flood monitoring
- Hydrological modelling
- WOIS Software tools
- Small water body mapping
- Rivers and lakes water levels
- Rivers and water quality
The **Flood Monitoring Service** developed, enables the detection and extent analysis of large extent floods.

**Service inputs:**
- DEM
- SAR Sentinel-1 / ASAR images
- Sentinel-2 images

**Service outputs:**
- Water masks
- Flood maps
- Reference water extent map
- Water Frequency map (occurrence)
- Flood Frequency Map
- Maximum Floodable area
- Time Series
The **Small Water Body Mapping Service** provides the extent and temporal evolution of permanent and non-permanent water bodies providing them into detailed mapping.

**Service inputs:**
- DEM
- SAR Sentinel-1 / ASAR images
- Sentinel-2 images

**Service outputs:**
- Water mask raster in geotiff
- Water Body Surface raster
- Water Body ID raster
- Water Frequency Map
Challenging objectives

- **Cloud EO Processing Services**
  Automatic query to ESA SCI-HUB Sentinel Catalogue to access and process data. Remote access.

- **Large Capability: Large Scale EO processing**
  The Flood & SWBM services are designed to handle more than a single Sentinel-1 frame.

- **Services simplified to ease the access to non-EO experts**
  Hydrological and Water Management experts to run services with low-medium EO background.

- **Unsupervised automatic process on-demand (not systematic)**
  Constrains were imposed by the full automation of the service with minimum open parameters.

- **Multiregional project with very different land covers (deserted, forest, jungle)**
  Two Pilot project areas (Niger River and Red River) + Myanmar community.

- **Integration and interaction between services**
  SWBM outputs are inputs for Water Level (Altimetry) and Hydrological Models.
Workflow of the services in the platform

End User (EO-SSO account) → Job request → ESA Catalogue (SCI_HUB) → query

ESA Catalogue (SCI_HUB) → download

Download data → HEP platform → visualization

HEP platform → processing

processing → store

store → End User (EO-SSO account)
Methodology: Block Diagram

- S1 GRD Images
- SNAP pre-processing (Platform Compatibility)
- Gamma MAP speckle filter
- VH polarization

- Hartigan’s Unimodality Tests
- Mean (outlayers removal) for Global Threshold
- Extended K-means
- Closing and SWB removal

**Inputs - Outputs**

- N SAR Images
- DEM

**Process**

- Registration
- Calibration
- Despeckle
- Geom. Masks
- N Images
- LFA Rate Prob. Filt.

**Classification**

- Bands & Spectral Indexes Analysis
- High Prob. Non Water Mask
- High Prob. Water Mask

**Pre-process**

- N Images
- DEM

**Water Mask Thresholding**

- Blocks division
- Contrast Evaluation
- Bi-Modal Blocks Sel.
- Threshold
- N Rough Water Masks

**Water Mask Refinement**

- N Refined WM
- N WM
- Decision Threshold
- Possible Water Segments
- Image Class. + Segm.

**Flood Mapping**

- Freq. Map
- Max. Flood Area
- TS

- Flood Map Stats
- N-1 Flood Maps
- TS Freq. Map
- WM Stats

**Optical Proc.**

- M L1C TOA Images
- High Prob. Non Water Mask
- High Prob. Water Mask
Methodology: S1 and S2 Combination

Classification Map based on S2 spectral indexes

High Probability Water Mask

High Probability Non-Water Mask

Setting the SAR image as the reference and checking the temporal baseline for allowing combination, S2 Masks are integrated in different parts of the block diagram to reduce false alarm rate in the Water Mask generation step.
Methodology: Multi-frame Approach
Case Studies: Thanh Hóa, Vietnam
Case Studies: Irrawaddy river, Myanmar
Water Frequency / Water Occurrence map (5th Sep - 23rd Oct 2017)
Case Studies: Irrawaddy river, Myanmar
Water Frequency / Water Occurrence map (5th Sep - 23rd Oct 2017)
Flood Event in Costa Rica caused by **Hurricane Otto (24th-26th November 2016)** monitored with SNT-1 images with HEP Flood Monitoring methodology and compared with International Disaster Charter (left). 1st SNT-1 image is on Nov 28th.
Case Studies: Haiti
Flood map qualitative validation (with International Disaster Charter)

Flood Event in Haiti caused by **Hurricane Matthew (20-24th April 2016)** monitored with SNT-1 images with HEP Flood Monitoring methodology and compared with International Disaster Charter (left). 1st SNT-1 image is on April 26th.
Conclusion and Future Work

- **HEP platform** has passed the Acceptance Report and **has started Pre-Operations** in March focusing on Pilot Areas (Niger River and Red River Basins).
- **User Community showed a lot of interest** in the Flood Monitoring Service in the conducted Workshops (Niger 2016 (Niamey), Vietnam and Myanmar 2017).
- **Constrains were imposed by the full automation on the Platform.** Balance between expert and non-expert user and multi-regional areas to set the automatic processing parameters configuration.
- **Sentinel-1 and Sentinel-2 combination improves the quality** of the water masks, therefore of the service outputs.
- **In house-processing** allows based on an **adaptive configuration.** Improvements focused in the **standardization** of results and **systematization** of the process.
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