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Operational SAR Data Processing in GIS Environments for Rapid Disaster Mapping

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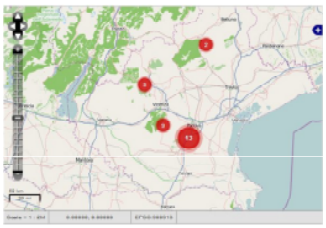

Figure 1 Map of the Veneto region, Italy.
The four red symbols indicate where the major flooding event happened. The dimension is proportional to the entity of the disaster. Region 13 indicates the community of Bovolenta.
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http://alluvioneveneto.pbworks.com/w/page/32321522/Alluvione%20Veneto%202010

Figure 2 The community of Bovolenta was covered by several meters of water, many people had no access to their houses.
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http://www.ilmanifesto.it/archivi/fuoripagina/anno/2010/mese/11/articolo/3708/

Introduction

Having access to SAR data can be highly important and critical especially for disaster mapping. Updating a GIS with contemporary information from SAR data allows to deliver a reliable set of geospatial information to advance civilian operations.

The operational processing of SAR data within a GIS environment for rapid disaster mapping is exemplified by the November 2010 flash flood in the Veneto region, Italy. A series of COSMO-SkyMed acquisitions was processed in ArcGIS® using a single-sensor, multi-mode, multi-temporal approach. The relevant processing steps were combined using the ArcGIS ModelBuilder to create a new model for rapid disaster mapping in ArcGIS, which can be accessed both via a desktop and a server environment.

Case Study: Flood Detection with High-Resolution COSMO-SkyMed Data

The Bacchiglione River burst its banks on Nov. 2nd 2010 after two days of heavy rainfall throughout the northern Italian region (see Figure 1). The community of Bovolenta, 22 km SSE of Padova, was covered by several meters of water (see Figure 2).

The extent of this flooding is documented by a series of COSMO-SkyMed acquisitions. For the present case study we focused on a COSMO-SkyMed-3 image acquired at Nov. 5th 2010, i.e. 3 days after the flash flood. As a reference we used a COSMO-SkyMed-2 image, acquired at May 9th 2011. Both images were acquired in StripMap mode and ordered as Detected Ground Multi-look (DGM) product (Level 1B) with a GSD of 2.5 m and HH polarization (see Figure 6).

The SAR Data Processing Workflow

- **Step 1**: The single COSMO-SkyMed images are filtered with a Gamma Distribution-Entropy Maximum a Posteriori (DE-MAP) filter to reduce the speckle effect (see Figure 7).
- **Step 2**: The filtered images are geocoded using a reference DEM (SRTM3v4). Geocoding is performed by rigorously applying the Range and Doppler equations. This step includes the radiometric calibration, which is carried out by following the radar equation law (see Figure 7).
- **Step 3**: A subsequent change detection analysis generates the final map showing the extent of the flood (see Figure 8). This customized process combines band arithmetic, segmentation, morphology filtering, and raster-to-vector conversion.

Implementation of the Workflow in ArcGIS

These 3 processing steps are combined using the ArcGIS ModelBuilder to create a new model for rapid disaster mapping.

Filtering (**Step 1**) and geocoding (**Step 2**) of a single COSMO-SkyMed image are integrated in a sub-model (see Figure 3), which is called twice in the main model, both for the "before" and the "after" image (see Figure 4). The two process sequences converge in the final change detection analysis (**Step 3**).

The underlying algorithms are provided by three different sources:

- Geocoding & radiometric calibration (**Step 2**) is a standard functionality from the ENVI SARscape Toolbox for ArcGIS.
- This toolbox is extended by the filter tool (**Step 1**), which is called from the ENVI SARscape.
- The change detection analysis (**Step 3**) is based on ENVI processing routines and scripted with IDL (Interactive Data Language).

The three tools are implemented in ArcGIS using a Python script file. This script file retrieves the parameters from the ArcGIS user interface and invokes the ENVI/IDL-based entry point procedure stored in an IDL .sav file, consisting of the precompiled IDL code (see Figure 5).

Conclusions

We developed an operational workflow for change detection analysis with SAR data, provided as an additional ArcGIS toolbox. Thus disaster zones, e.g. after severe flooding, can be automatically identified and mapped to support local task forces.

The benefits of the resulting processing chain include:

- Execution by the responsible operators without SAR expert knowledge in a familiar GIS environment.
- The open architecture platform IDL allows to customize single processing steps, or to create additional tools from the full complement of ENVI functionality. These image analysis processes can be integrated into any other ArcGIS models to update a GIS with contemporary information from remotely sensed data.
- The ArcGIS model presented here can be dissolved from its desktop environment and published to users across the ArcGIS Server enterprise.

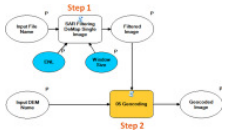


Figure 3 ArcGIS model for filtering (**Step 1**) and geocoding (**Step 2**) of a single COSMO-SkyMed image.

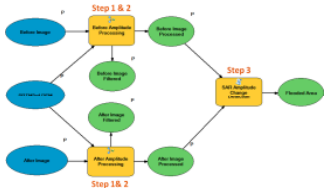
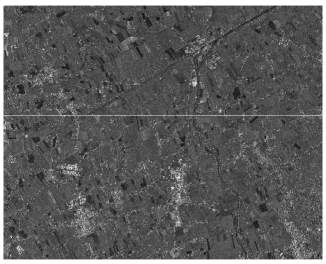


Figure 4 ArcGIS model for the complete SAR processing workflow including the final change detection analysis (**Step 3**).
"Before Image": May 9th 2011.
"After Image": Nov. 5th 2010.

Figure 5 Filtering (**Step 1**) with the ENVI SARscape Gamma Distribution-Entropy Maximum A Posteriori filter.
The filter is called via an IDL batch routine (below).
This routine is linked to a customized ArcGIS Toolbox via a Python script (above).



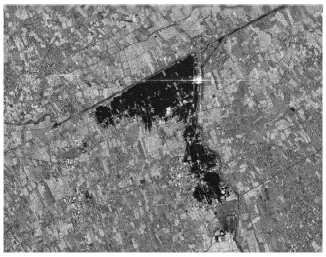


Figure 6 "Before Image" (above) and "After Image" (below).
COSMO SkyMed 2, StripMap DGM, May 9th 2011 (above).
COSMO SkyMed 3, StripMap DGM, Nov. 5th 2010 (below).
Unfiltered, not geocoded & calibrated.

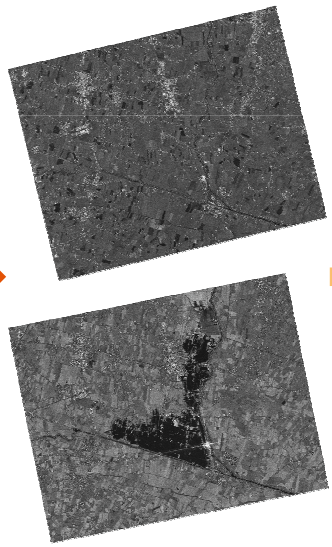


Figure 7 "Before Image" (above) and "After Image" (below).
COSMO SkyMed 2, StripMap DGM, May 9th 2011 (above).
COSMO SkyMed 3, StripMap DGM, Nov. 5th 2010 (below).
"Gaussian DE MAP" filtered , DEM-geocoded & calibrated.

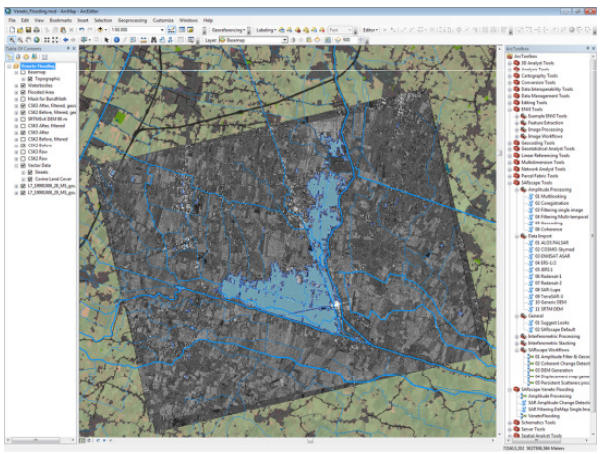


Figure 8 Flooded areas overlaid from the resulting change detection analysis.
COSMO SkyMed 3, StripMap DGM, Nov. 5th 2010.
"Gaussian DE MAP" filtered, DEM-geocoded & calibrated.

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