Use of SAR data at EUSC

ESARDA/INMM Conference
Aix en Provence 16-21 Oct 2011

The European Union Security Strategy and the European External Action Service

The European Union Satellite Centre

Synthetic Aperture Radar Principles

SAR Techniques for Proliferation Monitoring
The European Security Strategy

Key Threats
- Terrorism
- Proliferation of WMD
- Regional Conflicts
  - Failed states
  - Organised crime

European Union actively support the strengthening of global non-proliferation regimes and in particular the multilateral treaty-based systems.

Common Foreign & Security Policy (CFSP)

The European External Action Services

Crisis Management Structure
- Chair EUMC
- EUSI
- CMPD
- CPCC
- FRONTEX
- EUMS
- CB Secretariat
- Political Affairs
- Strategic Planning
- CB Secretariat
- EP & National Parliaments
- Legal Affairs
- SPCEN
- Non-Proliferation
  - Disarmament

The European Union
- External Action
- HR/VP
- Chief Operating Officer
- Executive Secretary General
- Corporate Board
- Policy Coordination
- Strategic Planning
- EP & National Parliaments
- Legal Affairs
- MD Asia
- MD Africa
- MD Europe & Central Asia
- MD North Africa, Middle East, Asian Peninsulas, Iran & Iraq
- MD Americas
- MD Global & Multilateral Issues
- Non-Proliferation & Disarmament
EUSC Missions

- The EUSC supports the decision-making of the European Union in the field of Common Foreign and Security Policy (CFSP) and in particular the European Security and Defence Policy (ESDP).

- The EUSC support its users in the prevention and management of the following key threats, in coherence with the European Security Strategy:
  - Terrorism,
  - Proliferation of weapons of mass destruction,
    - Verification of arms control and non-proliferation agreements
    - General security surveillance over areas of interest
  - Regional conflicts,
  - Failed States,
  - Organised crime.

Non-Proliferation Issues

- The Non-Proliferation Cell consists of 5 staff and 2 SNEs.
- It uses 180 satellite images on September 2011.
- The Nuclear Fuel Cycle includes mining, conversion, enrichment, fabrication, and reprocessing.
- Means of delivery include space rocket programs and space launch vehicles.
### SAR Principles

**SAR** - Synthetic Aperture Radar

**RADAR** - Radio Detection And Ranging

- **Side Looking**
- **Active & Coherent**

### SAR Complex Data

**Amplitude** (Intensity)

**Surface Properties**

**Dielectric Properties**

**Phase**

**Complex Data**

- **Terrain Relief**
- **Surface**
- **Subsidence**
- **Land Motion**

**Specular reflection**

**Diffused reflection**

**High reflection**

**Uncoherent Phase**

**Coherent Phase**

**Dielic Properties**

- **Moisture**

The higher or brighter the backscatter on the image, the rougher the surface being imaged.
Single Amplitude SAR Data: Analysis

- The analysis of single SAR data required a very good experience and a good understanding of the specific SAR geometry.

![Diagram showing the analysis of infrastructure and activity.](image1)

- During the national celebration (from 1 to 11 February), ballistic missiles will be launched.

![Diagram showing loading vehicle.](image2)

Single Amplitude SAR Data: Weather Conditions

- The analysis of single SAR data required a very good experience and a good understanding of the specific SAR geometry.

- During the national celebration (from 1 to 11 February), ballistic missiles will be launched.

![Diagram showing bad weather conditions (clouds, snow, and rain).](image3)
Single Amplitude SAR Data: Nocturnal Activities

- The analysis of single SAR data required a very good experience and a good understanding of the specific SAR geometry.

- Proliferation countries prepare operation mainly during night period.

Local time of acquisition → 05:30:27

Nocturnal Activity

Single Amplitude SAR Data: Daylight

- The analysis of single SAR data required a very good experience and a good understanding of the specific SAR geometry.

- Due to the geographical location of the area (high latitude), it usually remains unobservable in the winter due to cloud cover and/or limited daylight.

Poor daylight during winter season
Single Amplitude SAR Data: Visualisation

- The visualisation (display) of full range of SAR dynamic data is one of the main challenges.

![Visualisation Diagram](image)

Amplitude Change Detection

- The Amplitude Change Detection (ACD) technique consists of a combination of two or more SAR amplitude data acquired with similar orbit and frequency parameters on different dates.

![ACD Diagram](image)

**Orbit:** Ascending  
**Viewing side:** Right  
**Polarization:** VV  
**Mode:** Spotlight
Amplitude Change Detection

Amplitude image data are co-registered if necessary and then each one is assigned respectively to one of the colour channel (Red, Green and Blue).

Ships moored

Changes appear in colour according to the colour synthesis model defined

Vehicle activity

Building construction

Tide height
- 1 m
- 2.5 m

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One of the particularities of the SAR systems is to be coherent. The phase of a single image is not exploitable. Thus when two or more SAR data have been acquired with identical orbit and frequency parameters, the phases shift are indicators of changes such as structural changes, terrain subsidence or motion.

Phase Analysis: Coherence Map

The information provided by the coherence map proceed from two SAR data is different and complementary to that one provided by the technique of ACD.
Phase Analysis: Multi-Temporal Coherence Analysis

- The Multi-Temporal Coherence product merged the Amplitude Change Detection and coherence analysis. It consists of the combination of two amplitude images and the corresponding coherence computed image.

Each image is assigned to one of the colour channel (Red, Green and Blue). The MTC image may highlights changes between two states of a target which on the ACD analysis appeared unchanged.

Phase Analysis: Multi-Temporal Inverse Coherence

SAR Data
- Synthetic Aperture Radar (SAR) data is used.

Coherence Maps
- Inverse Coherence maps are used to analyze changes.

Synthetic Aperture Radar (Multi-Temporal Inverse Coherence Map)
- The map shows changes over time in a specific area.
Phase Analysis (DnInSAR): DEM generation

- The use of interferometric techniques for DEM generation is well known. However, the EUSC use the difference interferometry techniques (DnInSAR) in order to estimate volumes which have changed between two acquisition dates.

Detailed 3D view
- Analysis complement
- Volume calculation

3D model / Draped processed DEM

Example of Analysis using Volume Extraction

- Volume of earth and rocks extracted from underground or below ground level may be estimated by the difference of two DEM processed from SAR data.

Volume estimation

- The estimated volume of dumped spoil: 187,000 m³
- Volume estimation of underground excavation: 125,000 m³

Difference of two DEM processed from SAR data
Subsidence and Motion Detection

- In order to detect and survey ground-surface deformation phenomena induced by underground development of non-declared installation, Synthetic Aperture Radar interferometry (InSAR) subsidence map is a particularly interesting and appropriate tool.

- Interferograms, formed from patterns of interference between the phase components of two SAR data acquired from the same orbit (viewing angle) but at different times, provides high-density spatial mapping of ground-surface displacements. Under ideal conditions, it is possible to resolve changes in elevation on the order of few millimetres.

Use of SAR data - Recap

- Weather conditions (clouds and rain)
- Nocturnal activity or poor day light
- Change detection
- Terrain analysis and FOLPEN
- DEM generation
- Landslide and subsidence
The EUSC has Memorandum of Understanding with German and Italian MoD.

Use of Governmental SAR Imagery

The slide contains a diagram showing the timeline and usage of various SAR data from different years and technologies. The diagram includes labels for different bands (X-band, C-band, L-band), and categories such as Military, Dual, and Commercial. It also highlights the use of SAR data with examples like COSMO-SkyMed and SARLupe. The text on the slide mentions the use of governmental SAR imagery for various purposes, as indicated by the timeline and the specific years mentioned.