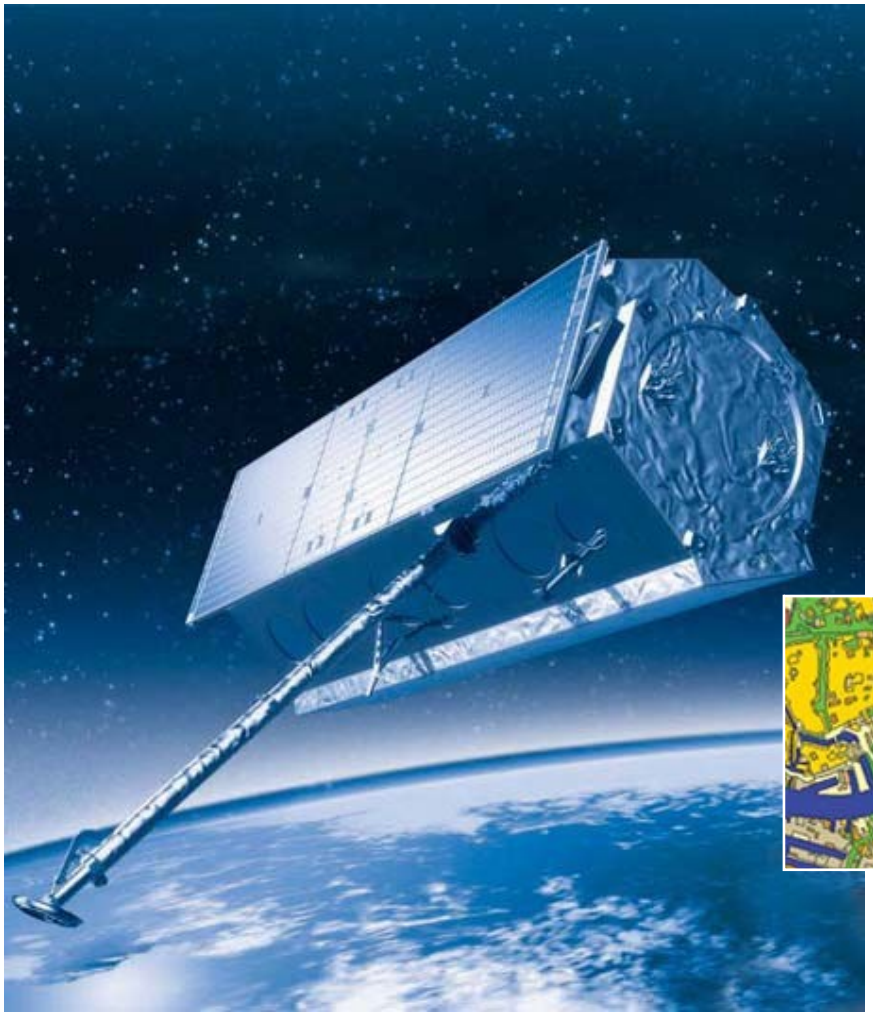


# TerraSAR-X for CwRS / CAPI

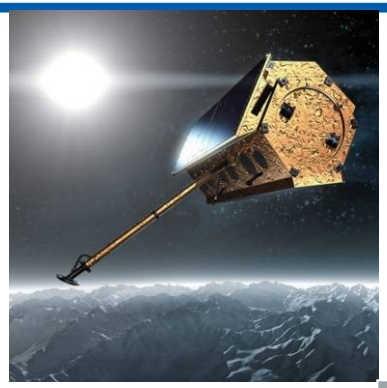
## High geometric quality by automated image processing

Presented by:

4th December 2008, Ljubljana

# TerraSAR-X

## First commercial 1m resolution radar satellite



- Launched June, 15th 2007
- Weather independent acquisition, worldwide
- High acquisition flexibility
- Quick site access of 2.5 days maximum (2 days at 95% probability)
- Unique agility: rapid switches between imaging modes and polarisations
- Unrivalled geometric pixel location accuracy
- 2009: highly accurate DEM generation from twin satellite constellation with TanDEM-X





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# Contents

- **Infoterra – some introduction**
- **TerraSAR-X - Basics**
  - Imaging modes
  - TerraSAR-X products and services
- **TerraSAR-X orthorectification**
  - ORI$^{SAR}$
  - Accuracies
  - Activities for 2008s' campaign
- **TerraSAR-X based applications**
  - Land Cover / Topographic mapping
  - Change Mapping
  - Mapping agriculture





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# TerraSAR-X imaging modes

# SpotLight (1m res) Acquisition of Ottawa, Canada





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# StripMap (3m res) Acquisition of Ottawa, Canada





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# ScanSAR (16m res) Acquisition of Ottawa, Canada





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# TerraSAR-X products & services

# TerraSAR-X Products and Services

## Basic Image Products

- Single Look Slant Range Complex (SSC)
- Multilook Ground Range Detected (MGD)
- Geocoded Ellipsoid Corrected (GEC)
- Enhanced Ellipsoid Corrected (EEC)

## Enhanced Image Products

- Radiometric Calibrated Image ($RAN^{SAR}$)
- Orthorectified image ($ORI^{SAR}$)
- Mosaic ($MC^{SAR}$)
- Ascending / Descending Merge ($ADM^{SAR}$)

## Customization Services

- Oriented Image ($OI^{SAR}$)
- Customized Projection
- Customized Image Format
- Rescaling





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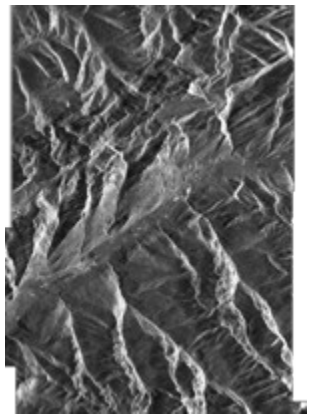
# TerraSAR-X orthorectification

# TerraSAR-X Basic Image Products



## Single Look Slant Range Complex (SSC)

- Polarimetry
- Interferometry
- Interpretation of sensitive small features that would be destroyed by resampling

## Multilook Ground Range Detected (MGD)

- Few artefacts due to minimized resampling
- No geocoding
- Own geocoding or orthorectification may be applied

## Geocoded Ellypsoid Corrected (GEC)

- Coarse geocoding (UTM /UPS)
- No processing artefacts due to correction to terrain on slopes
- Fast orientation with reference data

## Enhanced Ellypsoid Corrected (EEC)

- Precise geocoding especially in mountainous terrain (UTM / UPS)
- Geocoded local incidence angle information, layover and shadow areas available Æ radiometric calibration
- Fast orientation with reference data
- High spatial accuracy for all mapping purposes

**Towards map geometry**





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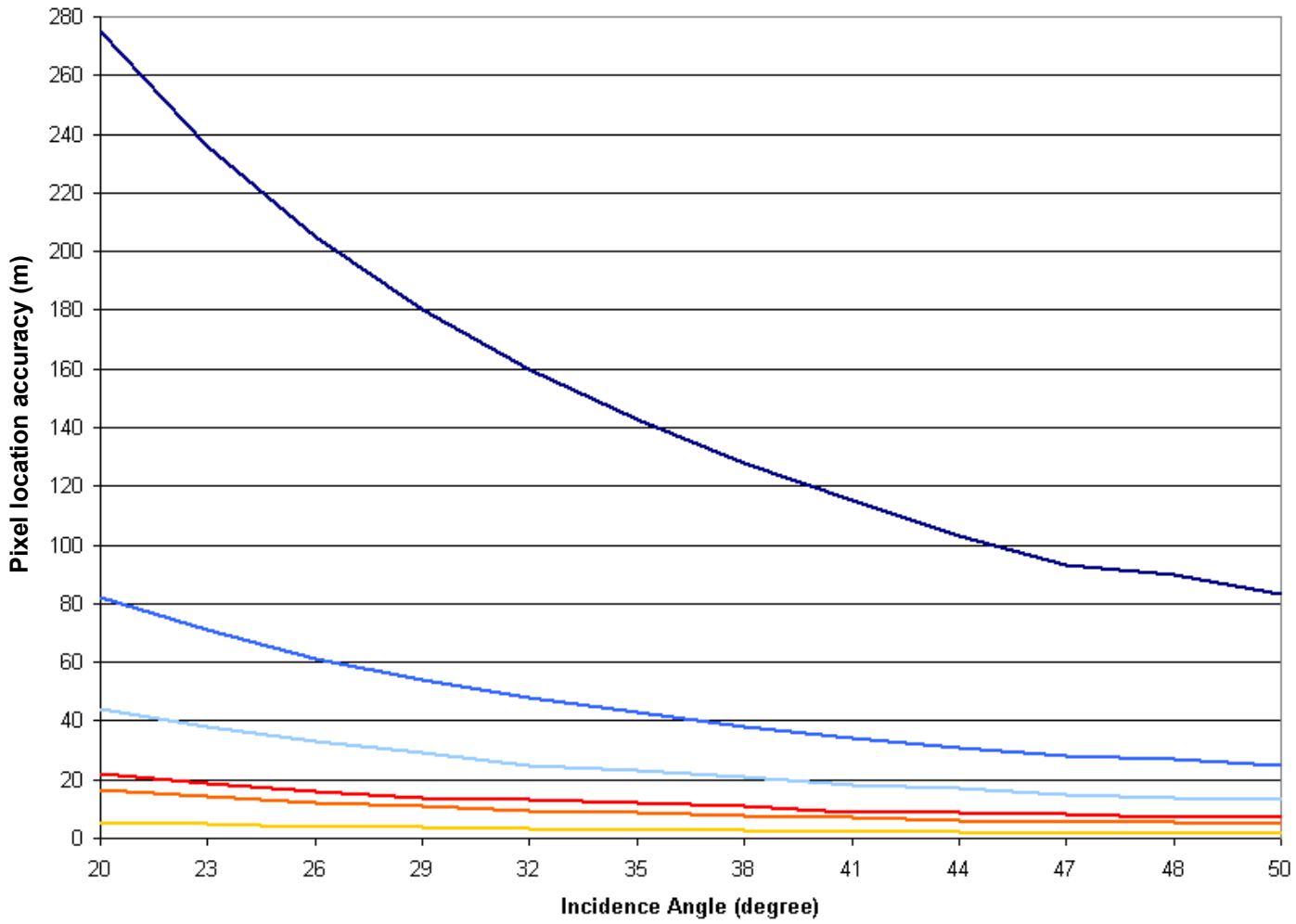
# DEM used for Level 1 b EEC

| | Vertical accuracy [m] | | Grid size | Limitations |
|---|---|---|---|---|
| DEM product | relative | absolute | | |
| **SRTM/X-SAR** | **6** | **16** | **1”** | **+- 60º with gaps** |
| **SRTM/C-band** | **8** | **16** | **3”** | **+- 60º** |
| **ERS-tandem** | **20** | **30** | **1”** | **Limited availability** |
| **DTED-1** | **20** | **30** | **3”** | **Limited availability** |
| **GLOBE** | **Varying 10 to 100s meters** | | **30”** | **No restrictions, poor quality** |

# Pixel location accuracies using different DEMs




DEM elevation error (m)

DEM quality for ORI processing
- 2 m
- 6 m
- 8 m

- 16 m (SRTM-X/C)
- 30 m (DTED-1)
- 100 m (GLOBE)

Global available DEMs





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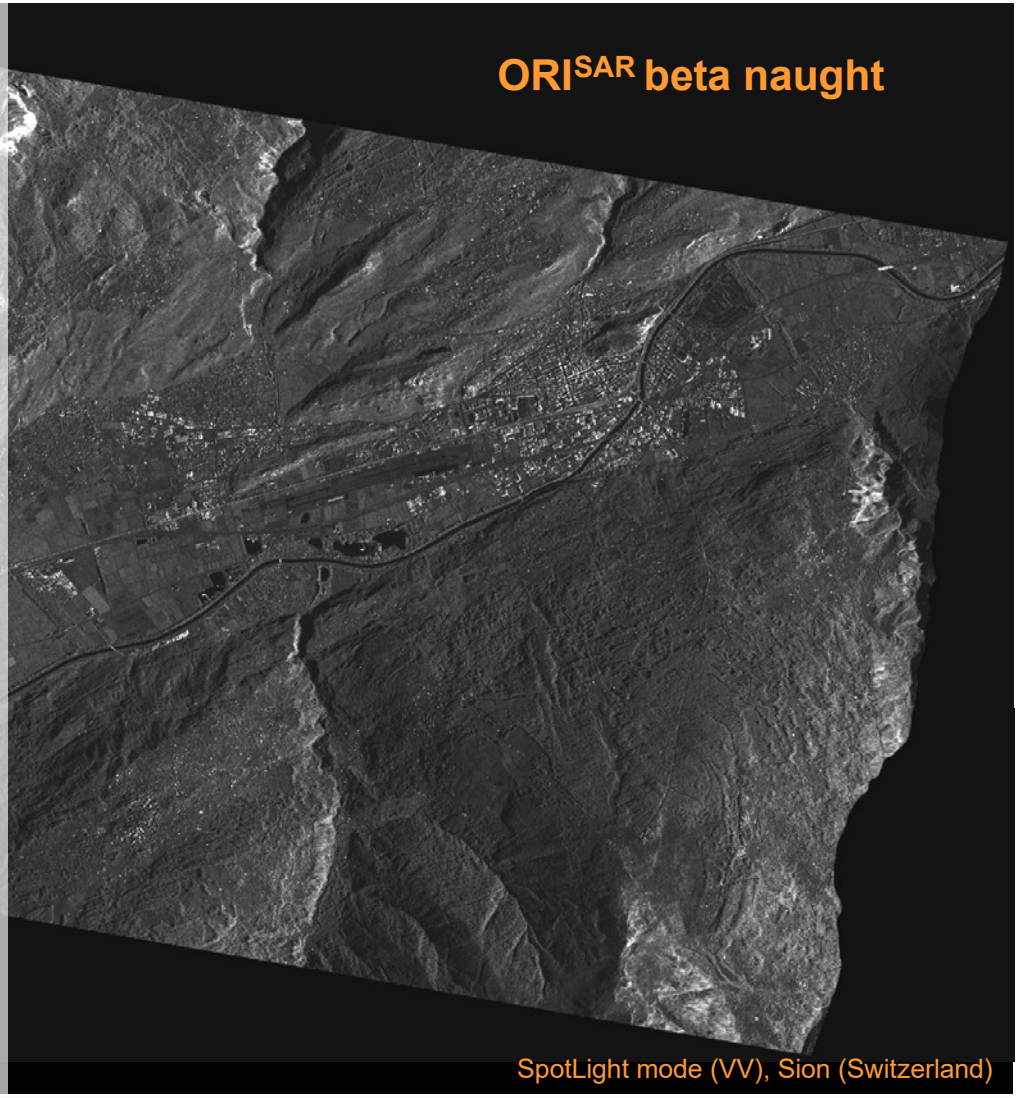
# TS-X Enhanced Image Products - ORI$^{SAR}$

- **Product characteristics:**
  - Multilook detected
  - Re-sampling to WGS84 reference ellipsoid with standard projections UTM or UPS
  - Choice of radiometric representation:
    - Radar brightness (beta naught)
    - Radiometric calibration (σ0)
    - Radiometric normalisation (γ0)
  - Information on local incidence angle, layover and shadow areas provided
  - Different SAR Filters can be applied to the data (GAMMA MAP, Lee, etc)

DEM derived from airborne DoSAR (1m)





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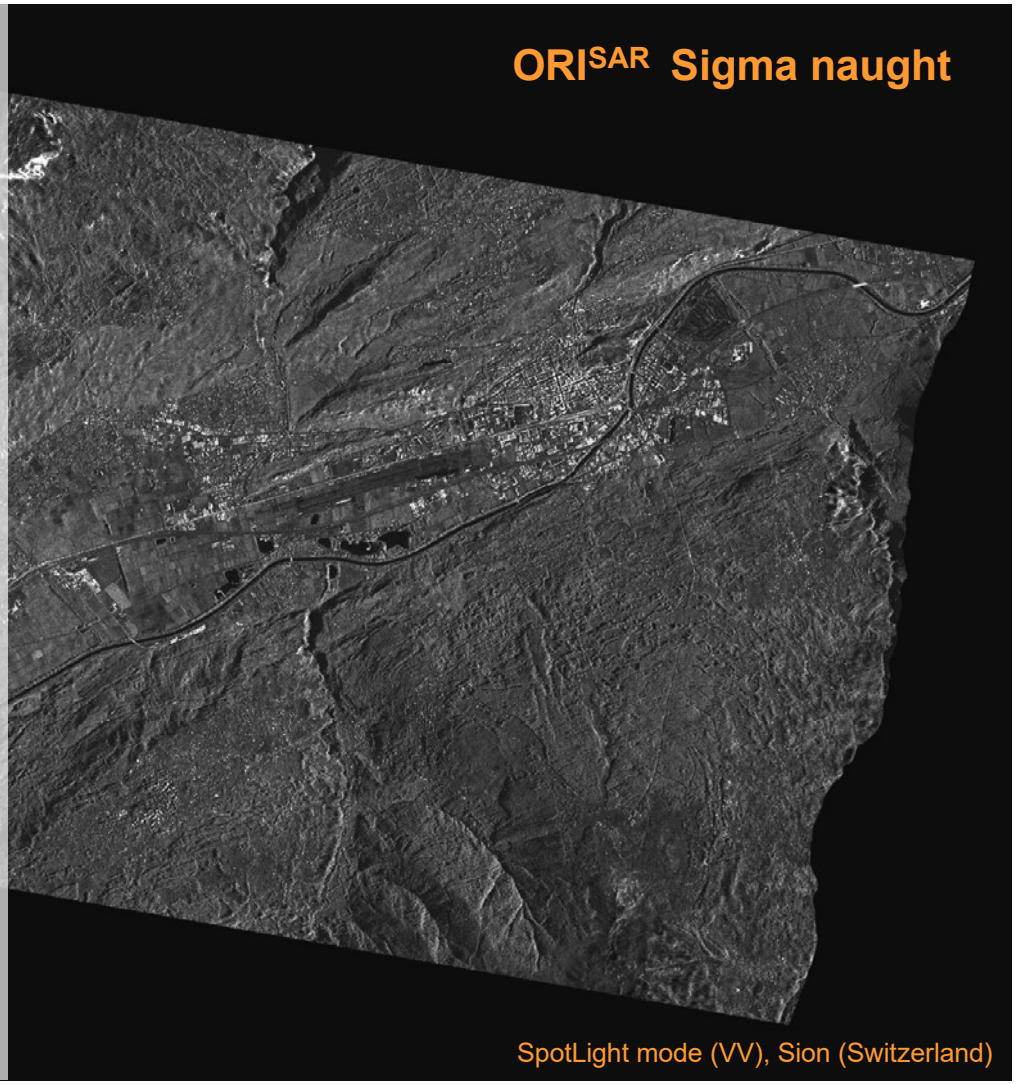
# TS-X Enhanced Image Products - ORI$^{SAR}$

- **Processing techniques:**
  - Support of two geocoding approaches:
    - Rigorous approach based on a pixel-by-pixel backward geocoding
    - Interpolative approach, where a rigorous backward geocoding is performed for coarse grid.
  - Different resampling methods are possible (NN, cubic convolution, bilinear)
  - Processing without Ground Control Point (GCP) selection using the most accurate orbit accuracy
  - Enhancement of pixel location accuracy with help of GCP selection
  - Re-usage of available GCPs with help of chip matching technique





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# Activities for 2008s‘ campaign

**Area Assessment:**

- **France: Maussane** – 9 High Resolution Spot Light, 8 Spot Light, 7 StripMap

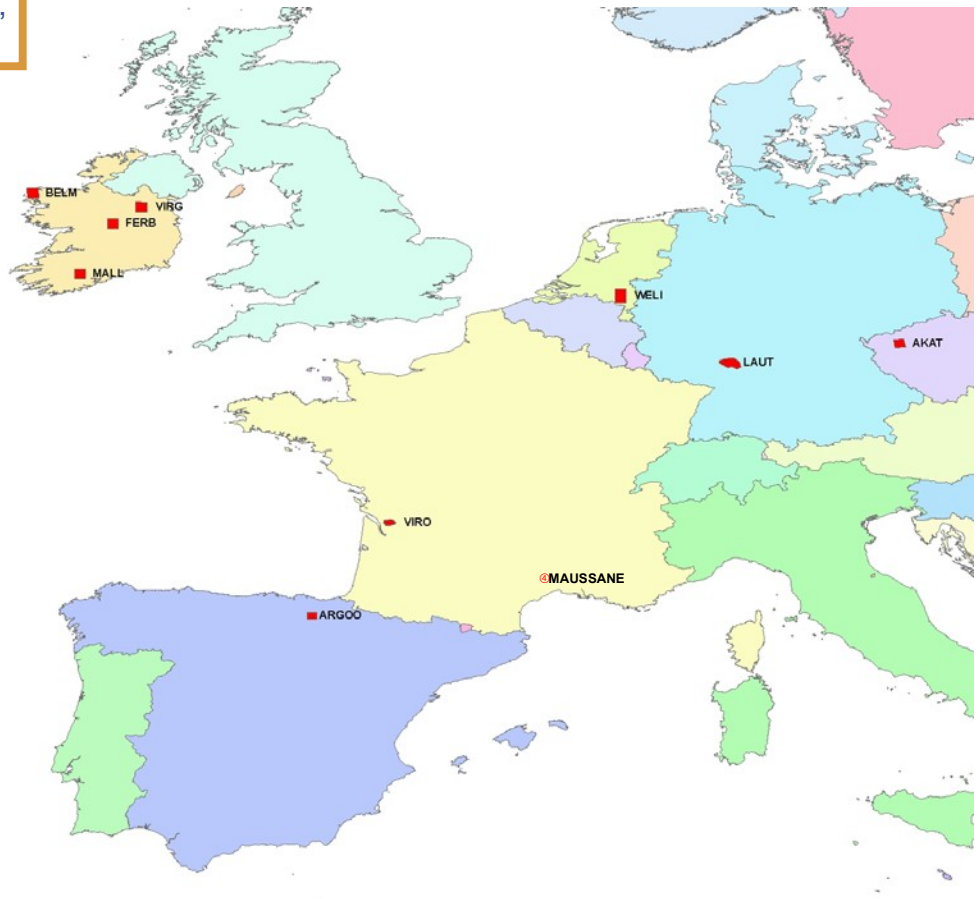
**Cooperation Agreement JRC/Infoterra:**

- **France: VIRO**
  - 6 Spot Light scenes, contractor SIRS
- **Germany: LAUT**
  - 5 scenes SpotLight, 1 StripMap
  - contractor: EFTAS
- **Czech Republic: AKAT / HLOH**
  - 7 SpotLight scenes (Akat)
  - 5 StripMap scenes (Hloh)
  - contractor GISAT
- **Spain: ARGOO**
  - 6 SpotLight scenes
  - contractor Tragsatec
- **The Netherlands: WELI**
  - 15 SpotLight scenes
  - contractor GEORAS

Î **in total 45 scenes for 6 control zones in 5 countries**

**Under Framework Contract:**

- **Ireland**
  - VIRG, BELM: 1 StripMap scene each
  - MALM, FERB: 8 SpotLight scenes each
  - contractor ICON





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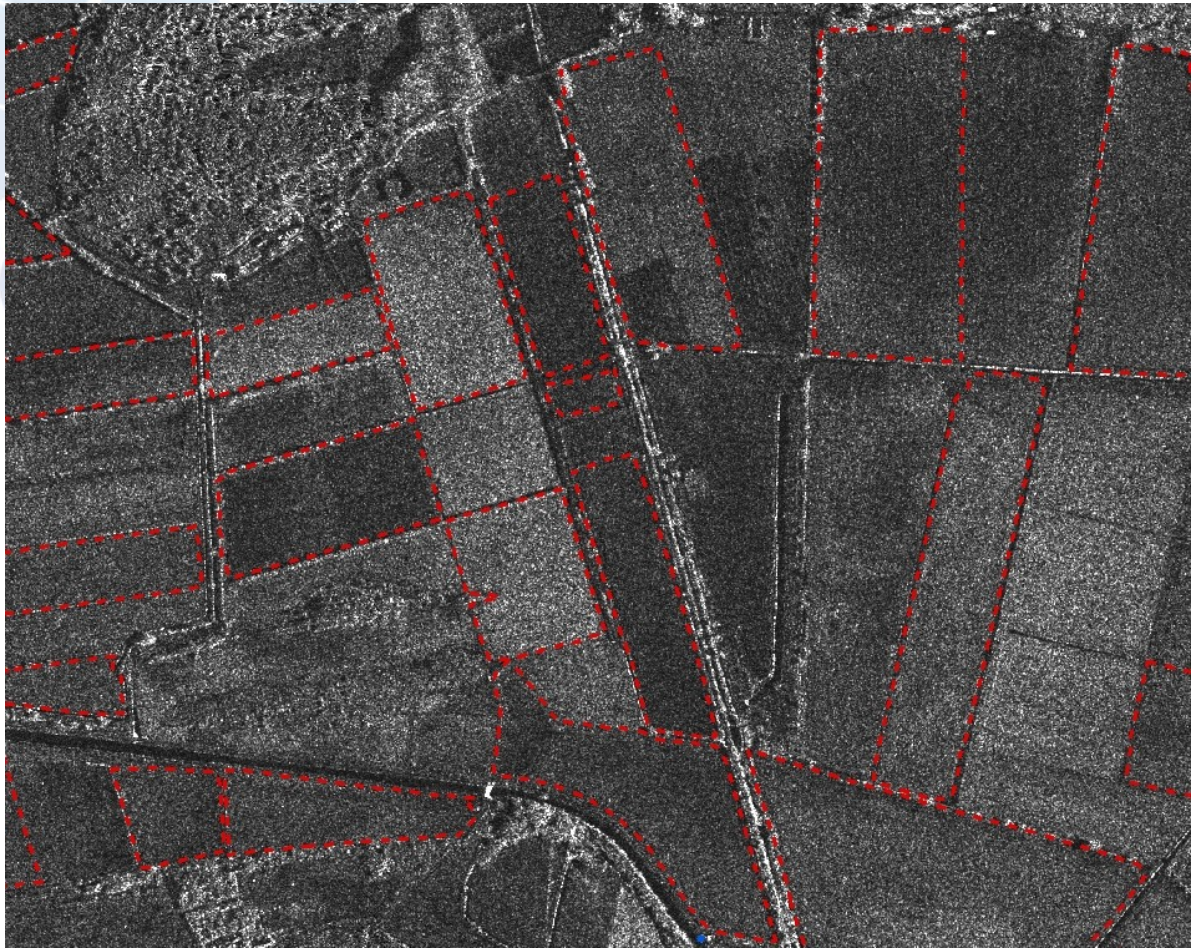
# France – Maussane



- TerraSAR-X SpotLight image
- Overlay with reference parcel boundaries provided by JRC
- very good matching of reference parcels with SAR detectable field boundaries





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# Orthorectification results (RMSE) for Maussane TerraSAR-X SpotLight ORI$^{SAR}$ product

| Scenario | Product | Orbit | Acquisition date | Optimization | RMSE X | RMSE Y | RMSE Total |
|---|---|---|---|---|---|---|---|
| 1 | MGD-SE | science | 2008-05-31 | none | 0,96 | 0,93 | **1,38** |
| 2 | MGD-SE | predicted | 2008-05-31 | GCP | 1,14 | 0,87 | **1,44** |
| 3 | EEC-SE | science | 2008-05-31 | none | 1,97 | 1,72 | **2,74** |

- **~pixel accuracies could be achieved for ORI$^{SAR}$ by**
  - automated process using science orbit
  - manual interaction (GCPs) using predicted orbit (for fast image delivery)
- **~2 pixel accuracy for basic product (EEC)**

# Irland – Mall control zone

*VHR optical subset with LPIS overlay*

*TerraSAR-X SpotLight with LPIS overlay*





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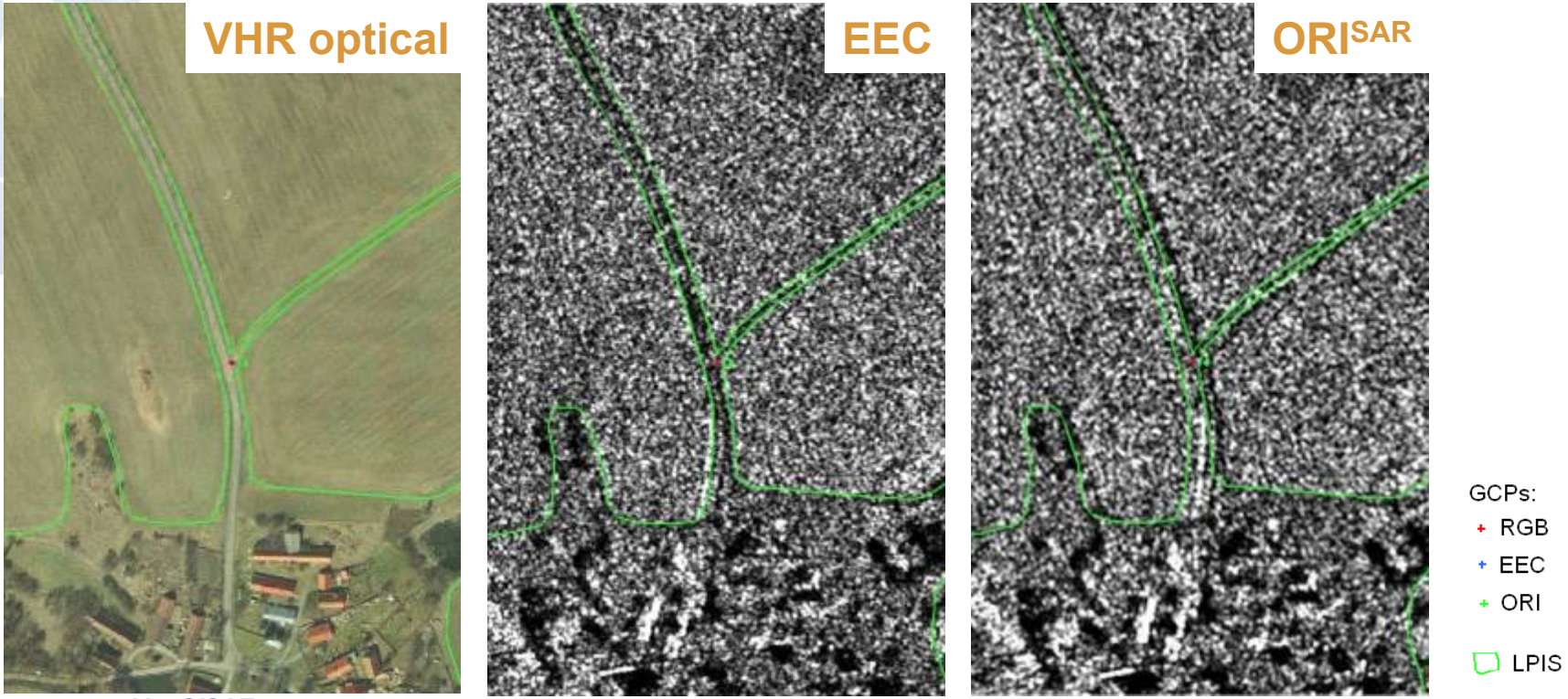
# Czech Republic – AKAT control zone

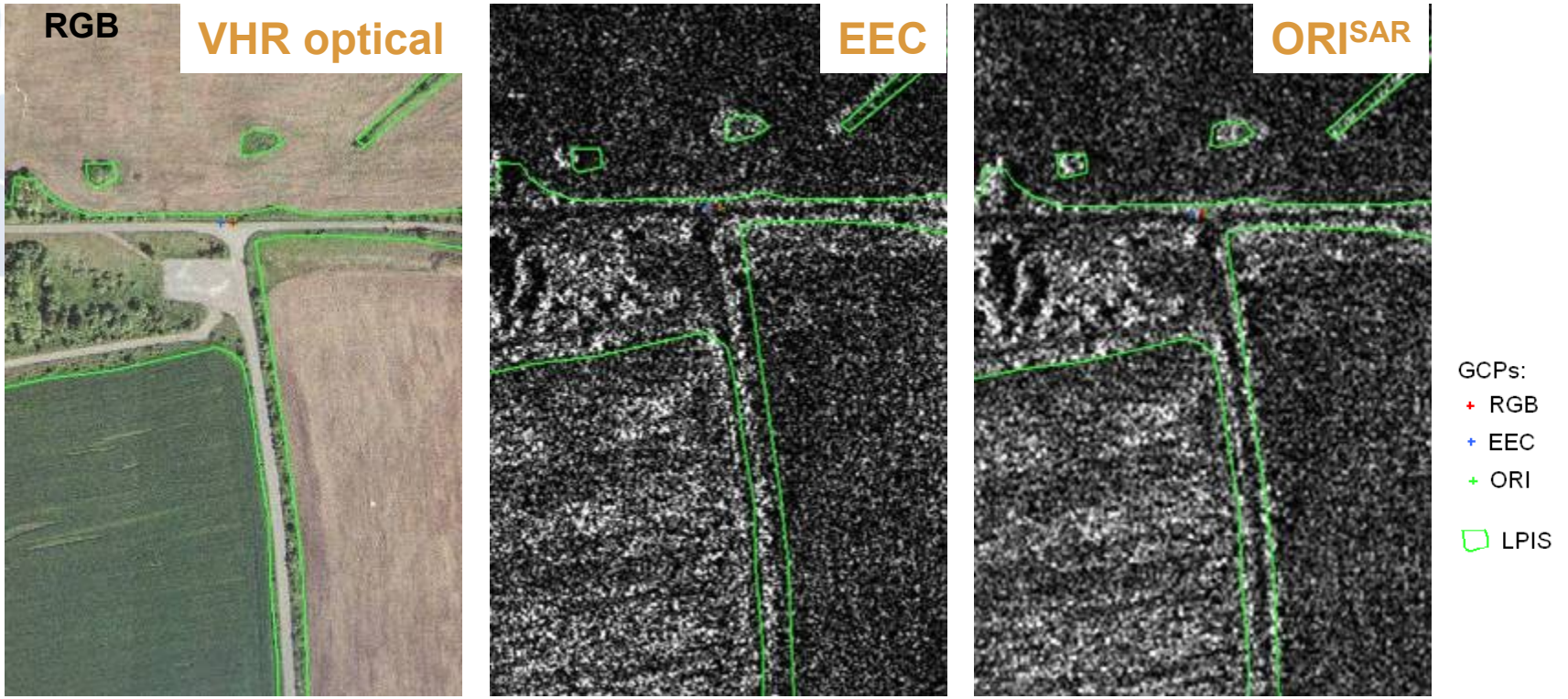
*Example of GCP with residual EEC < residual ORI*




*prepared by GISAT*

# Czech Republic – AKAT control zone

*Example of GCP with residual EEC < residual ORI*




*prepared by GISAT*

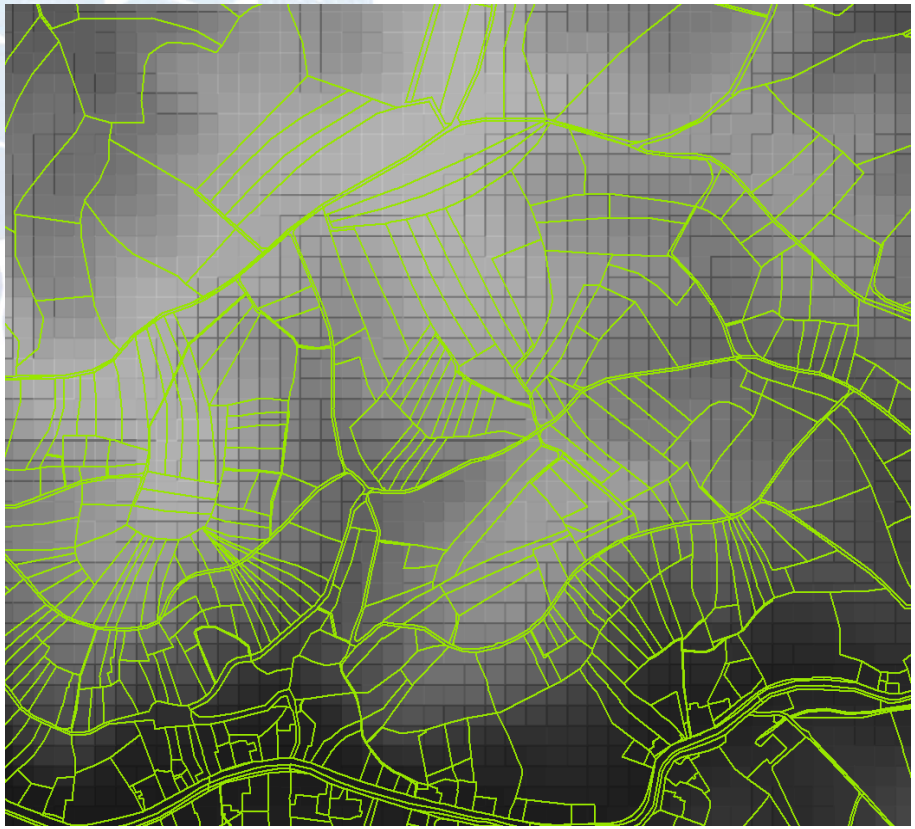
# Within image shifts of geometry

- **possible reasons:**
  - no exact information on projection and datum parameters
  - any resampling done on DEM could cause height shifts in DEM

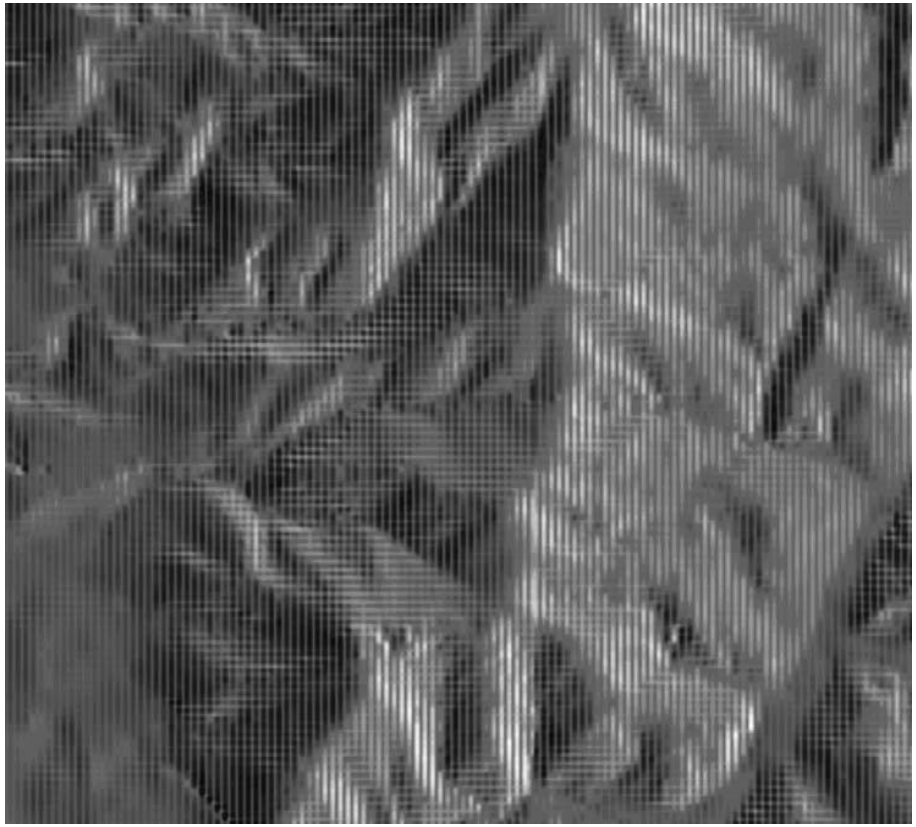
- **This specific issues will be further evaluated jointly by GISAT & Infoterra GmbH**

# Another test site...

*DEM subset with LPIS overlay*



*DEM subset of hilly terrain*



- **Strong disturbances in customer provided DEM**





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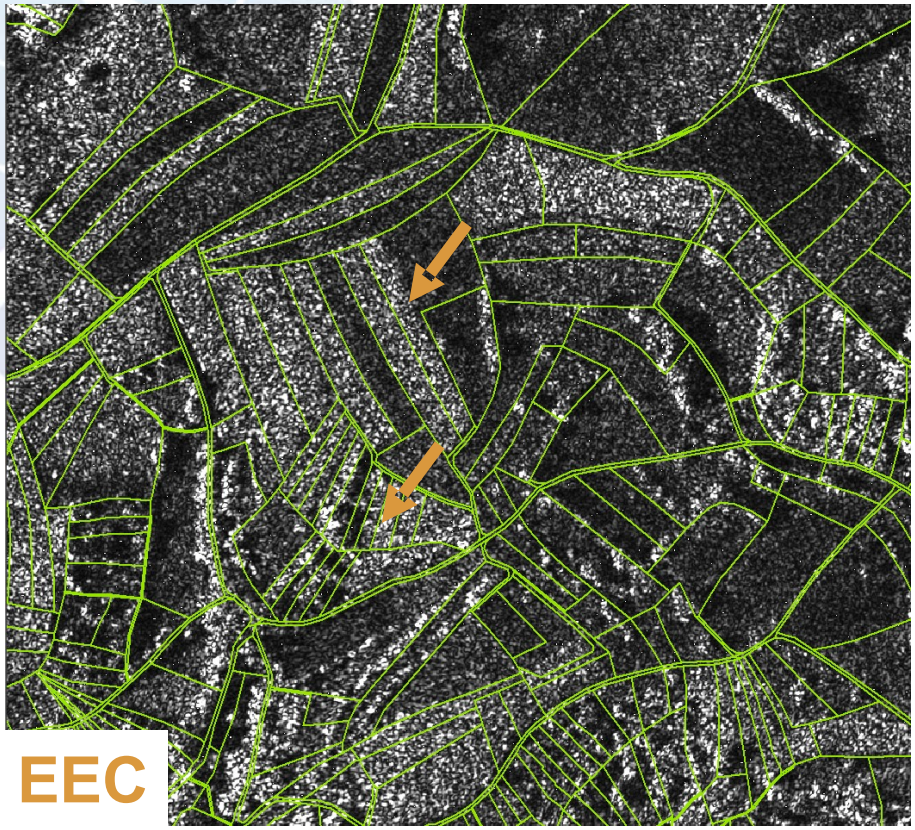
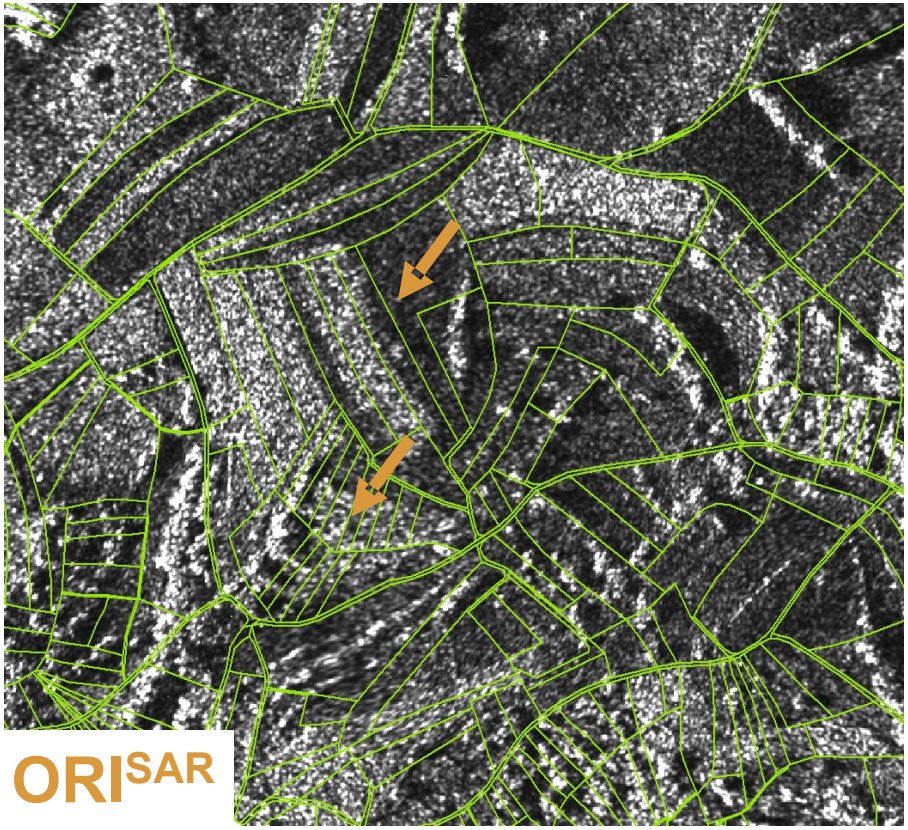
# Another test site...



EEC



ORI$^{SAR}$

- Artefacts in customer provided DEM does not allow for accurate orthorectification
- EEC shows very good results Æ EEC has been delivered





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# Resumee – ORI$^{SAR}$ production

- **Fully automated process by using**
  - high precision of orbit parameters (<10cm)
  - DSMs / DTMs
  - optional manual editing: GCPs, if sufficient reference material is available
- **very much dependent on the quality of DSMs / DTMs**
  - very accurate definition of projection and datum definition required
  - DEMs should not be merged, resampled, manually edited to a certain degree
- **Absolute geometric accuracies achieve theoretical RMSE**

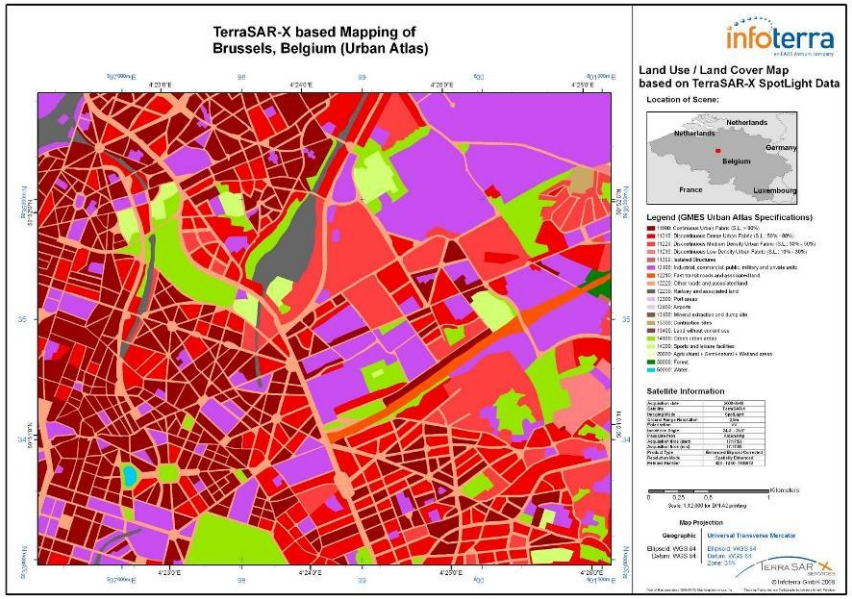
# TerraSAR-X EEC/ORI$^{SAR}$ products for CwRS process

- Flat terrain: EEC products already sufficient geometric quality
- Hilly terrain: using high resolution DSM/DTM of great advantage for geometric accuracy (ORI$^{SAR}$)

- ¾ Standard products, delivered from data provider directly into the system
- ¾ No or less interaction needed by contractors
- ¾ Direct integration of data into CwRS databases

# TerraSAR-X based applications

# Land Use / Land Cover Mapping in Urban Areas




**up-to-date - reliable - cross-border - cost-efficient**

- **Up to 26 classes**
- **Scale: up to 1:10,000**

## Basis for a variety of geo-information applications:

- Monitoring of land take trends & soil sealing
- Protection of natural habitats of endangered flora & fauna
- Regional & urban planning
- Identification of in-eligible land use





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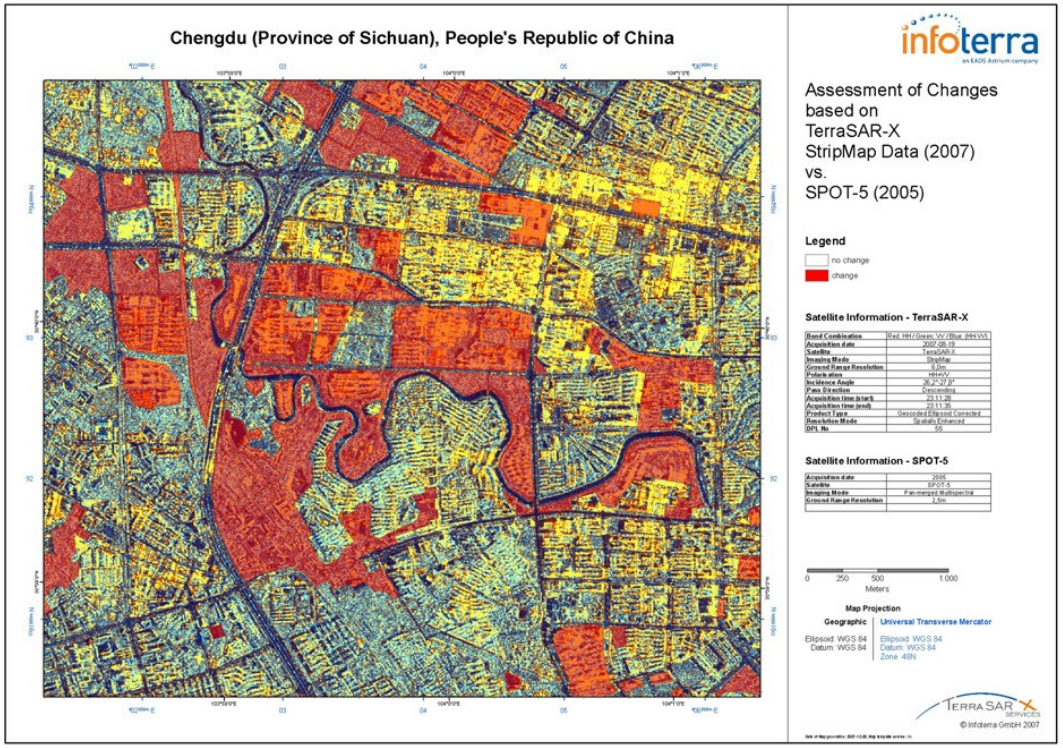
# Change Detection

## Reliable change detection based upon multi-temporal satellite data




### Essential basis for:

- Map updates
- Urban monitoring and planning
- Assessment of changes in environmentally sensitive areas





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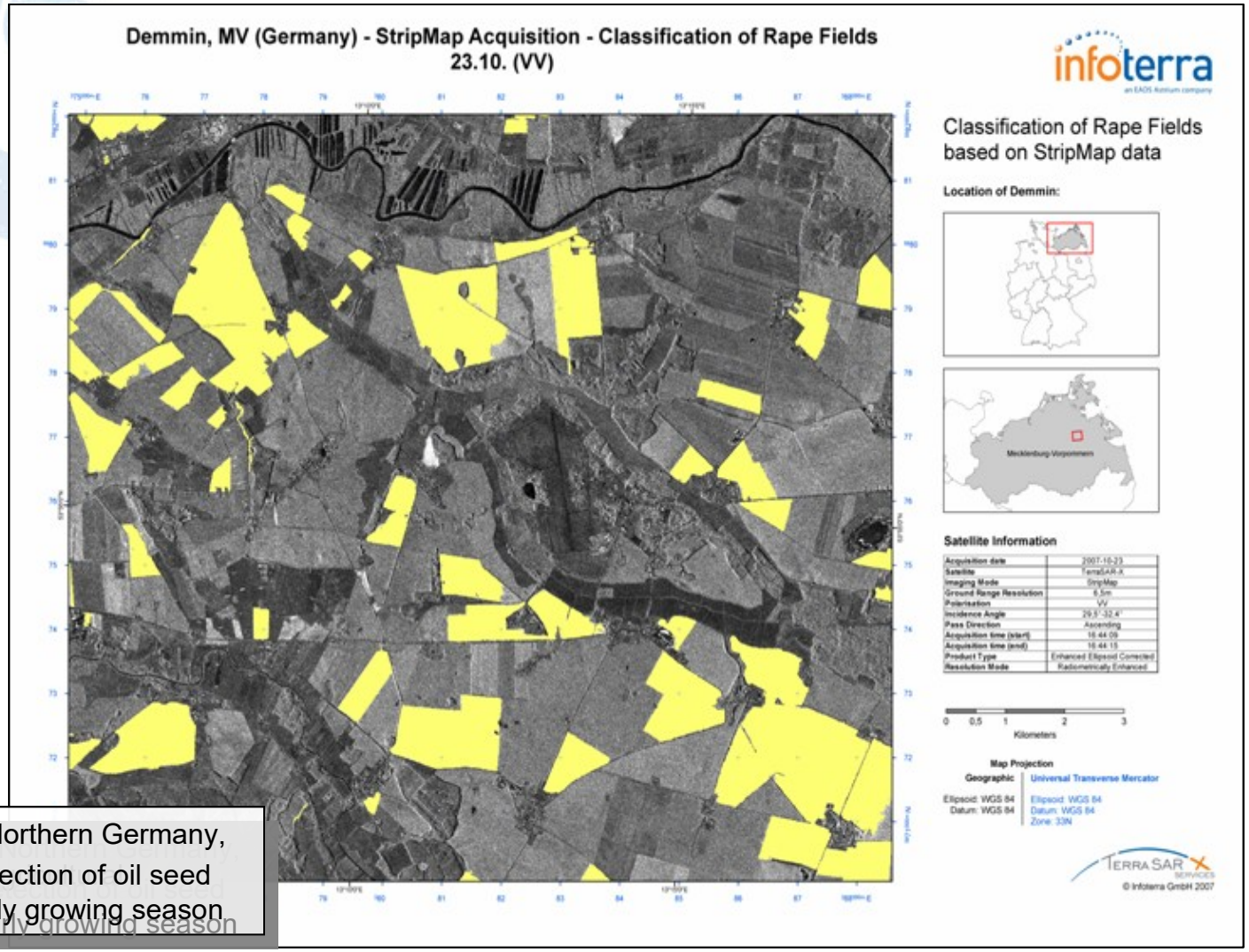
# Additional possibilities with TerraSAR-X data




Rural area in Northern Germany,
Automated detection of oil seed rape in the early growing season





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# Thank you!

**Toulouse:**
31, avenue des Cosmonautes
31402 Toulouse Cedex 4
France

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Claude-Dornier-Strasse
88090 Immenstaad
Germany

**Leicester:**
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41 Wembley Road
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United Kingdom

**Barcelona:**
Parc de Montjuïc
08038 Barcelona
España

Booth No. 2P-09

## All the geo-information you need

www.infoterra-global.com





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