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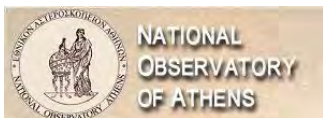
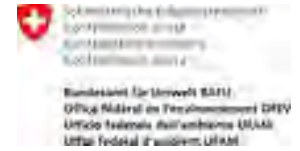
Terrafirma Project Leader



Agenda

- **Introduction to Terrafirma**
- **Validation Project**
- **Service Coverage**
- **Products Suite**

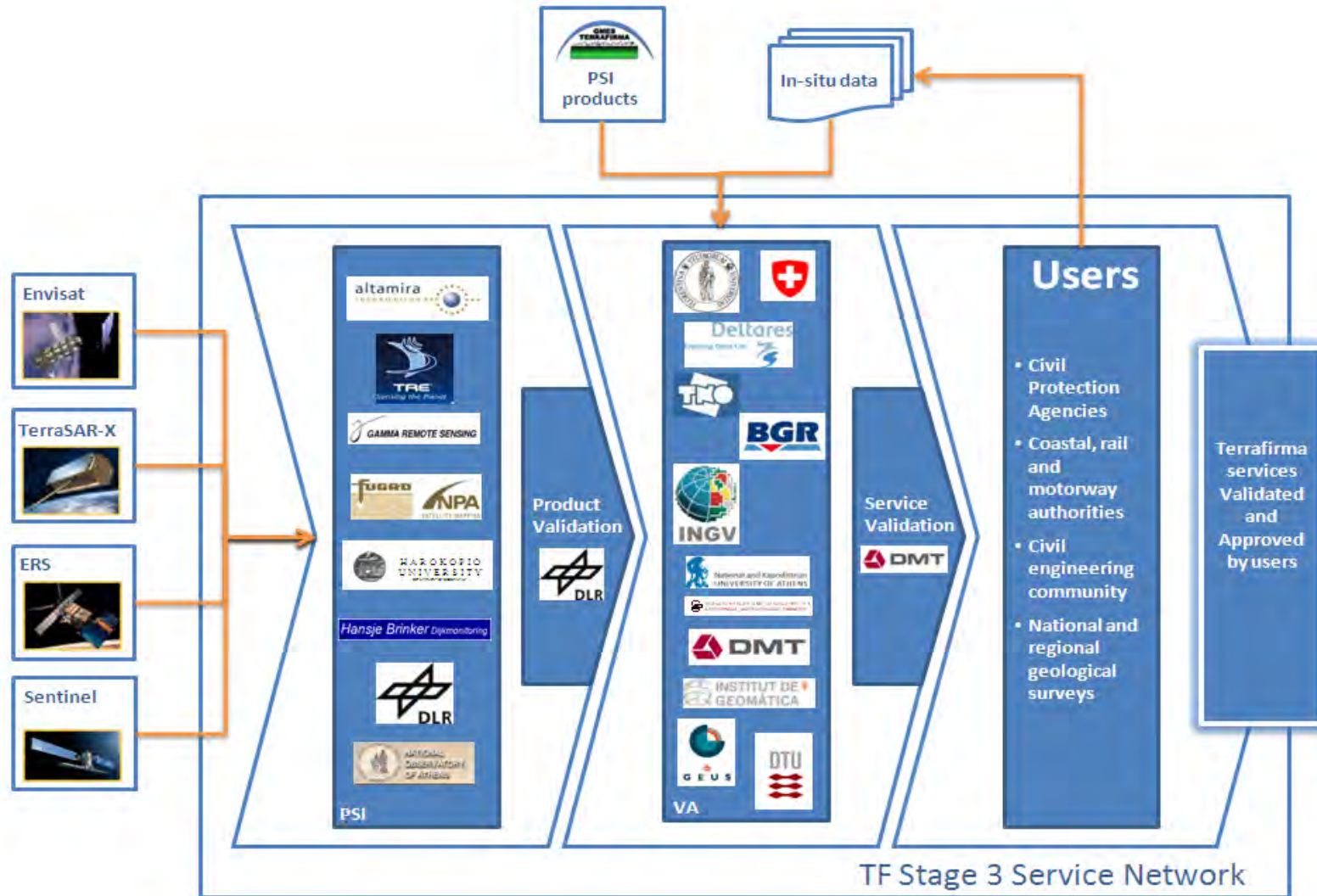
Terrafirma Team



A team of experts around Europe providing services and working together for a common objective since 2003



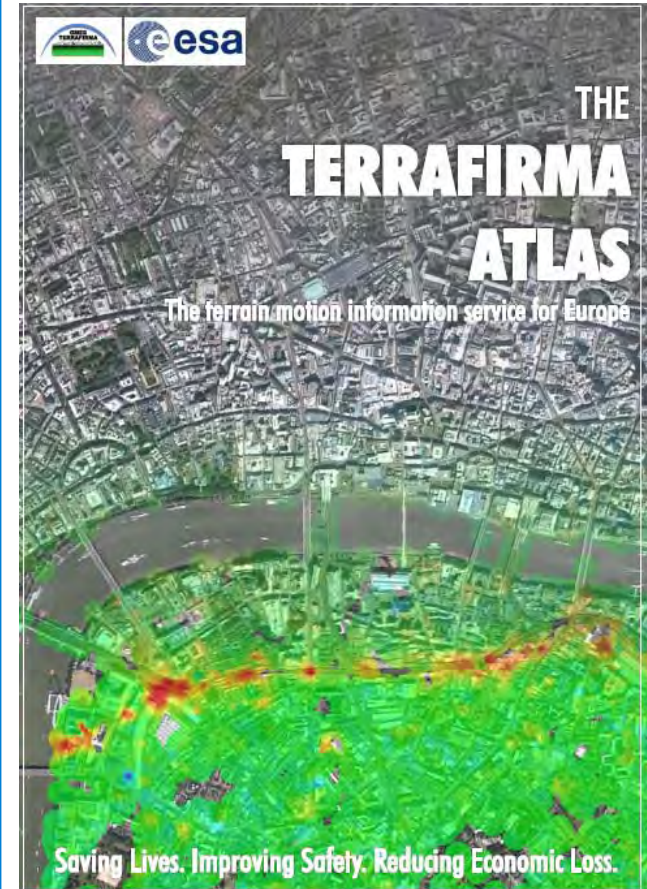
Terrafirma Service Network



Introduction to Terrafirma 1/2

Terrafirma is a pan-European terrain motion hazard information service

- Terrafirma is a GMES project to deliver public services to public users concerned with geo-hazard risk assessment
- It is supported by the European Space Agency under the GMES Service Element Program.
- Terrafirma started in 2003 and ESA funding will continue until 2012. Its continuation beyond 2012 depends on users.
- The current (Third Stage) of the project is lead by Altamira Information it has a budget of 3M€ over 3 years
- Terrafirma is an open service partnership where competitor providers work together to produce a standardised and validated service.



Terrafirma services help to identify and mitigate risk.

Introduction to Terrafirma 2/2

Terrafirma is a pan-European terrain motion hazard information service

- Terrafirma services combine qualified InSAR service products with expert interpretation and ground data to provide a series of services for specific themes.
- Terrafirma has a network of users that have expressed interest and have in many cases gained exposure and experience in using InSAR-derived motion services.
- Terrafirma services have been delivered to over 50 users via a Service Level Agreement, which includes User Feedback and Utility reports.
- The Terrafirma service offering includes the development of a wide-area map designed to enable the delivery of seamless motion maps over wide areas utilising the Sentinel-1 satellites



Terrafirma services help to identify and mitigate risk.



Terrafirma within GMES

- Terrafirma 2003-2012
- SubCoast (lead by TNO) (2010-2013)
- DORIS (lead CNR with many TF partners) recently Kicked Off (2010-2013)
- The three projects have a combined budget of 10M€ and will have strong collaboration e.g.:
 - Collaborative plan for sustainability
 - Back-to-back/joint workshops
 - In many cases shared user groups
- Future project: PanGeo (currently in negotiation)

Other collaborative projects include

- EPOS (2010 – 2048) European Plate Observing System (lead by INGV)

Research Infrastructure and e-science for Data and Observatories on Earthquakes, Volcanoes, Surface Dynamics and Tectonics

Timeline

Stage 1 (2003-2006): Consolidation of service provision

Stage 2 (2006-2009): Scaling-up consolidated services

- PSI validation project

Stage 3 (2009-2012): Achieve Sustainable service provision

- Focus on thematic lines (flooding, tectonics and hydrogeology) to deliver service to meet specific user needs
- Facilitate introduction into users operations -> achieve sustainability
- Deliver wide area synoptic product (designed to use Sentinel-1 data) to serve regional/Europe-wide users



Terrafirma services help to identify and mitigate risk.

Validation Project (2006-2008)

Designed to validate the PSI processing of the four Terrafirma PSI Providers.

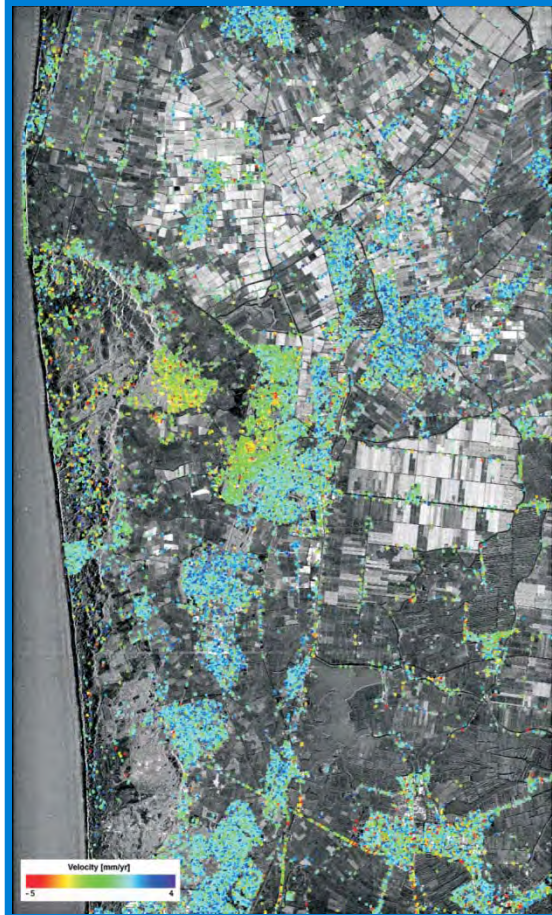
1. **Process validation**: inter-comparison of the PSI Suppliers processed slant-range outputs the analysis of their intermediate results (a precision and consistency check)
2. **Product validation**: the geocoded PSI products were validated against ground truth (an accuracy check)
 - For the first time, this work has determined an accuracy on PSI processing over typical PSI test-sites.

Outcome:

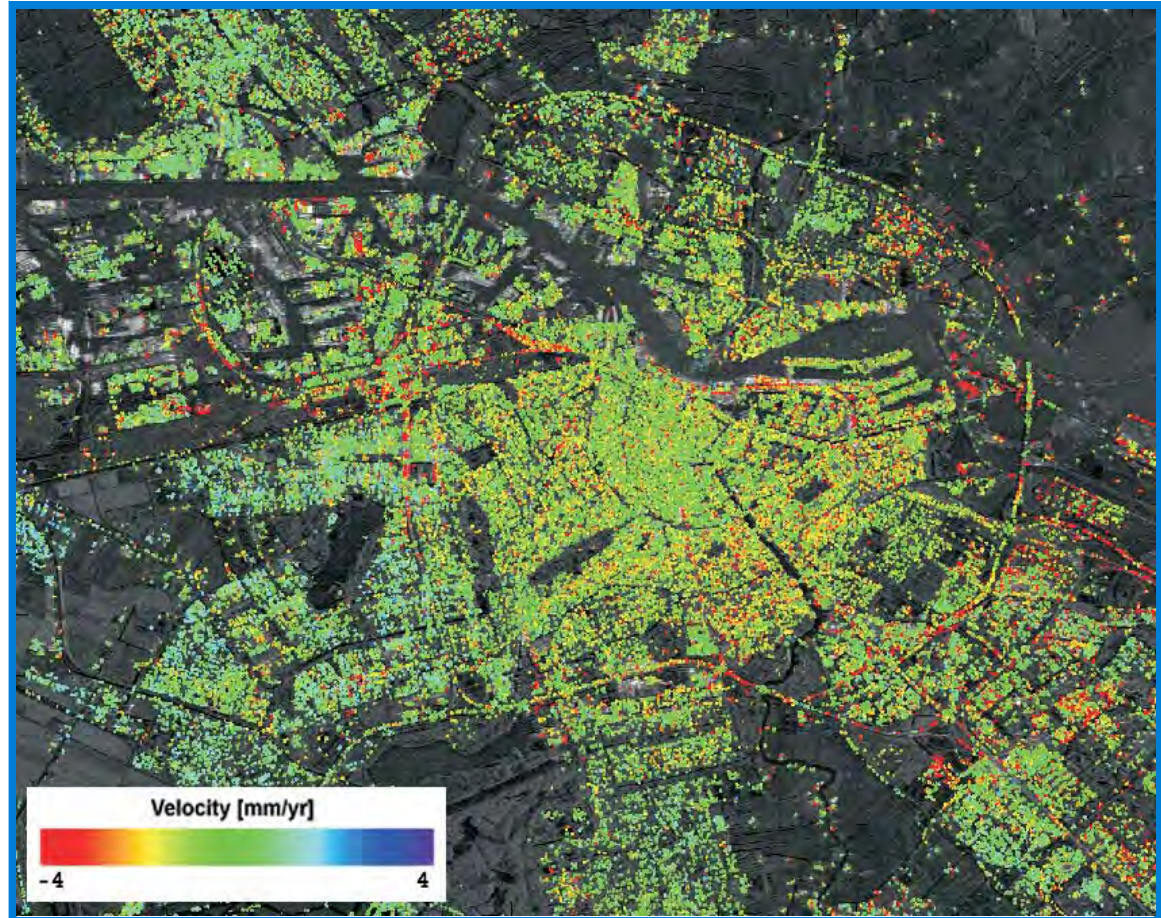
- Tightened quality control in the processing chains
- Qualification for the Terrafirma Suppliers
- A way for additional PSI Suppliers to qualify

Validation Project (2006-2008)

Alkmaar : rural area of forest, dunes, beaches and villages.



Amsterdam : urban area including autonomous and spatially uncorrelated terrain-motion over the 9.5km route of the new N-S metro line.



Validation Project (2006-2008)

Outcome: Process and product validation confirmed quality of Terrafirma products

Process comparison:

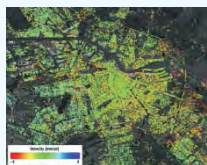
Estimated standard deviations for each OSP were 0.40 – 0.53mm/year for velocities, 1.1 – 4.0mm for time series, and 2.14 – 4.71m for topographic corrections.

Comparison with groundtruth



Alkmaar:

Direct velocity validation against the leveling shows RMS error ranges from **1.0 – 1.5mm/year** for ERS, and **1.3 – 1.8mm/year for Envisat**. Direct time-series validation shows RMS error ranges from 6.2 – 8.7 mm for ERS and 3.6 – 4.8 mm for Envisat.



Amsterdam:

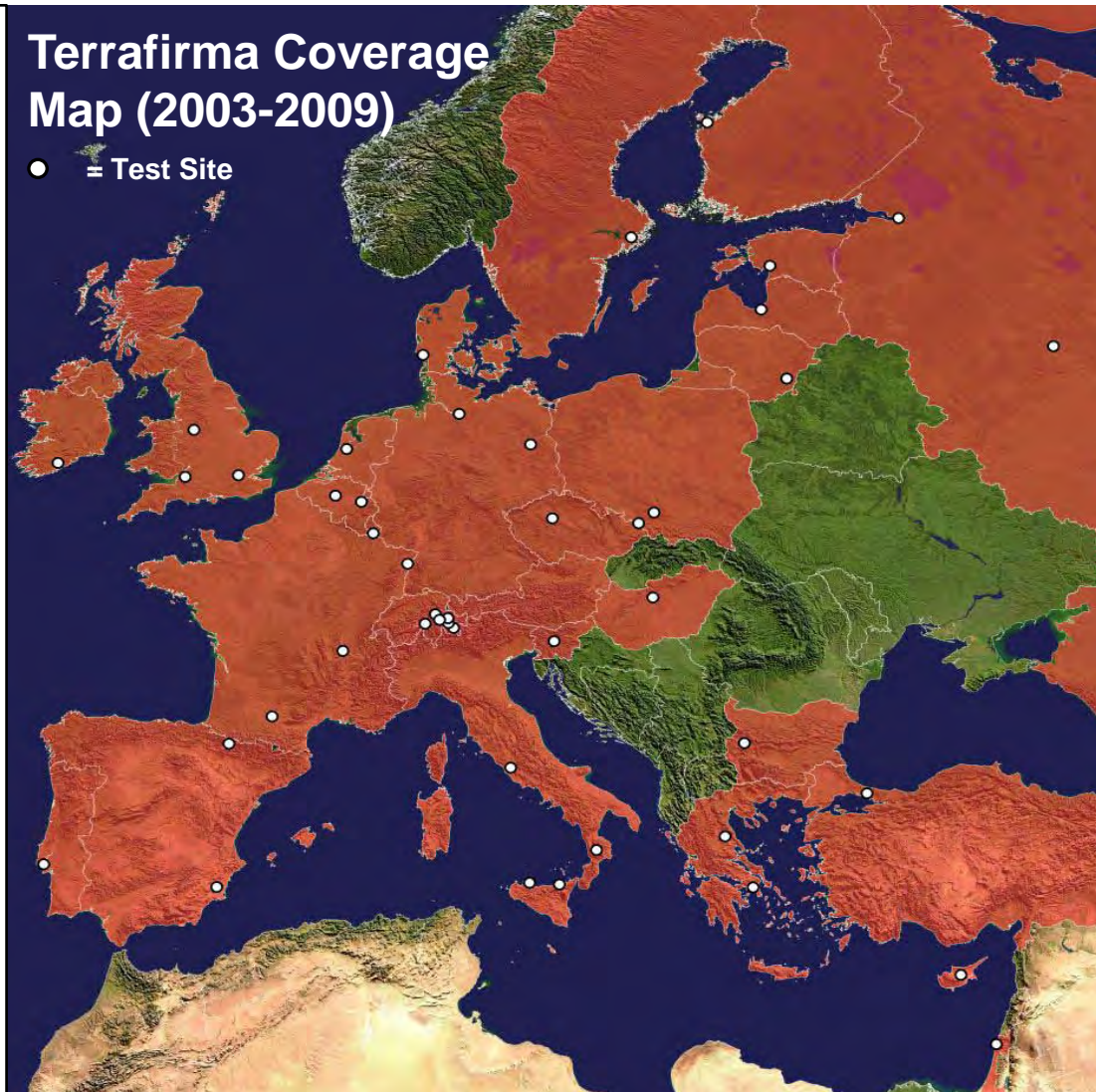
The absolute standard deviation of the double difference in velocity ranges from **1.0 to 1.2mm/year**. The average RMS errors of single deformation measurements in the time series range from 4.2 to 5.5mm.

Stages 1 & 2: Pan-European User Network

- Pan-European network of users enrolled via SLA: 88 SLAs signed with 51 different users Stage 1 & 2 (2003-2009)
- 51 users includes EU-27 members + Israel, Turkey, Russia and Switzerland.

Terrafirma Coverage Map (2003-2009)




● = Test Site



Terrafirma Service Coverage 2009-2011

Expert interpreted service delivery Stage 3, Years 1 & 2 (SLA defined sites)

Hydrogeology

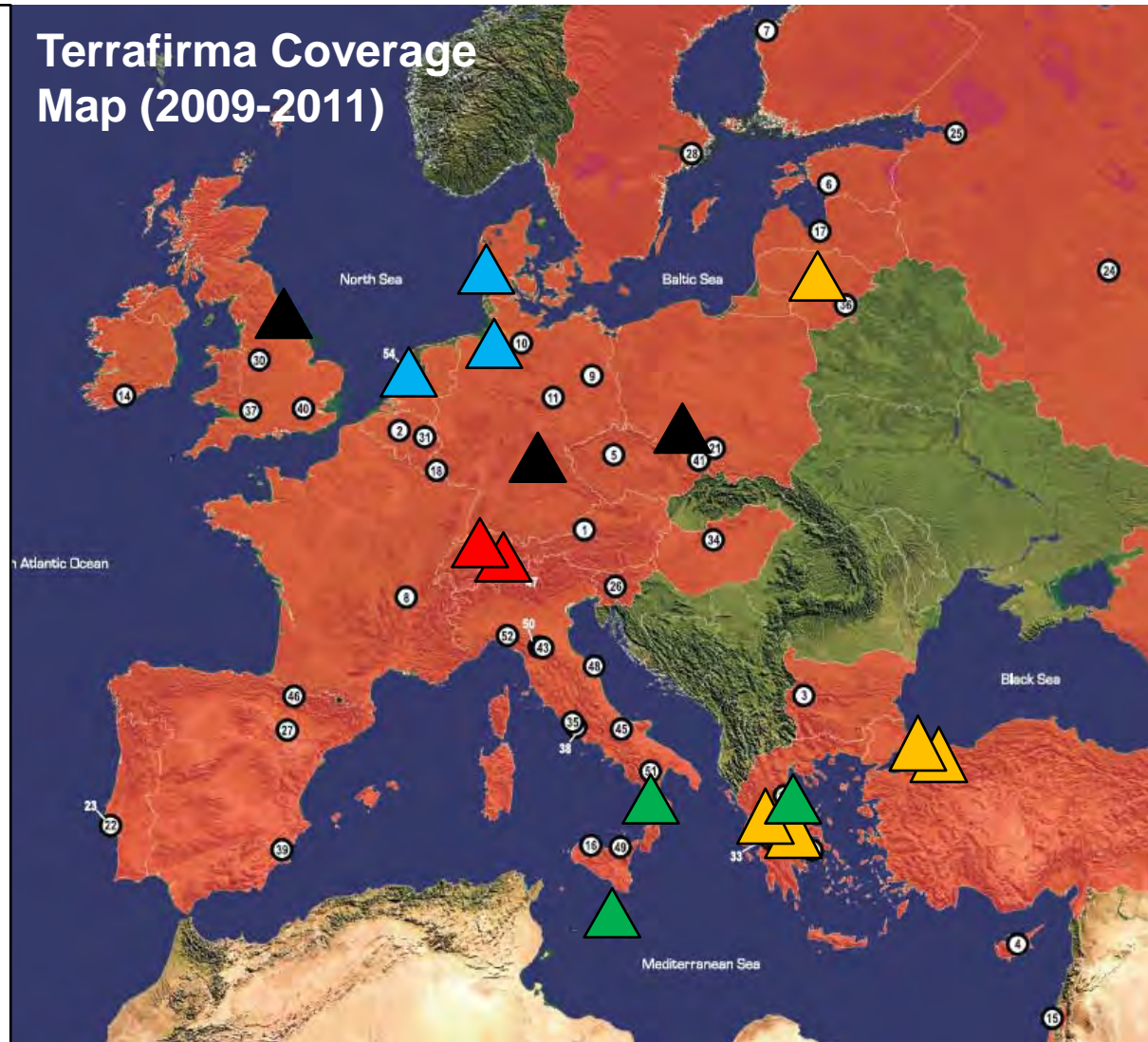
-  •Groundwater
-  •Landslide
-  •Abandoned Mines

Flood

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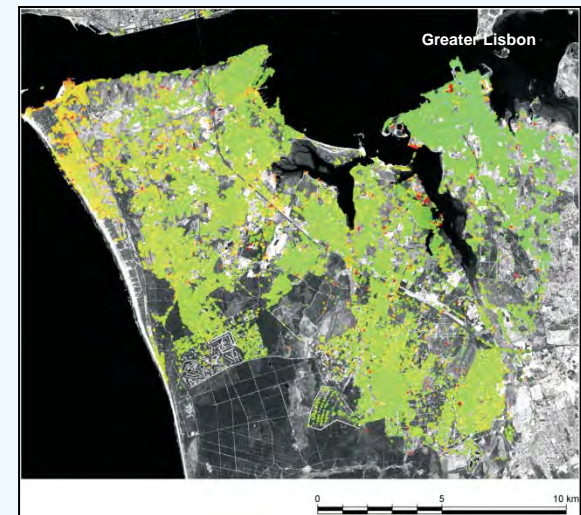
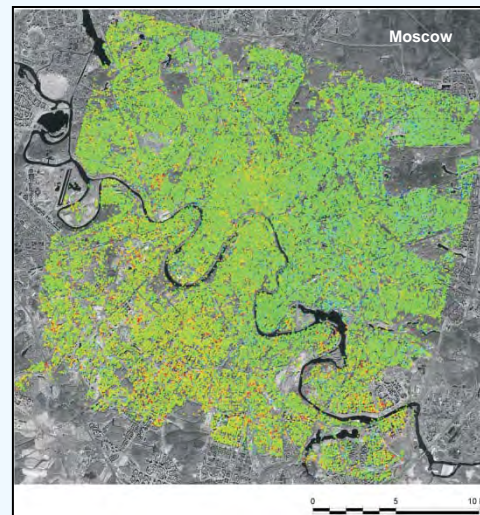
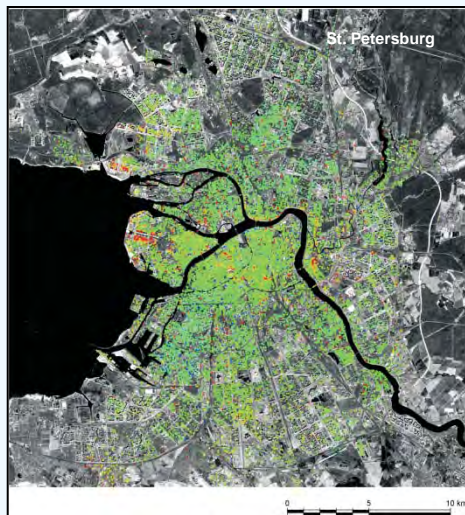
Tectonics

Terrafirma Coverage Map (2009-2011)



Terrafirma products open to users

- Over 50 Products available from Stages 1 & 2
- 17 new products during Stage 3
- Past and potential Terrafirma Users are invited to participate even though there would be no new production on their particular sites of interest
 - Opportunity to receive any already existing PSI datasets via a light Service Level Agreement (i.e. an SLA placing fewer requirements on feedback): <http://www.terrafirma.eu.com/>



Terrafirma Products Suite (Stage 3)

1) Advanced Terrain Motion Mapping (ATM-Mapping)

ascending + descending pass data

2) Advanced Terrain Motion Modelling (ATM-Modelling)

Tectonic Products



INGV

Fault creep mapping

Soil vulnerability mapping

Hydrogeology Products



Università degli Studi di Firenze
DEPARTMENT OF EARTH SCIENCES

Groundwater management

Mountainous Area (landslides)

Inactive/abandoned mines

Flood Products



Lowland flood risk mapping

Flood defence structure monitoring

A Wide-area PSI product is being developed which could input into any of the themes and is designed to use Sentinel-1 data as input and provide PSI motion data for large areas (e.g. European scale)

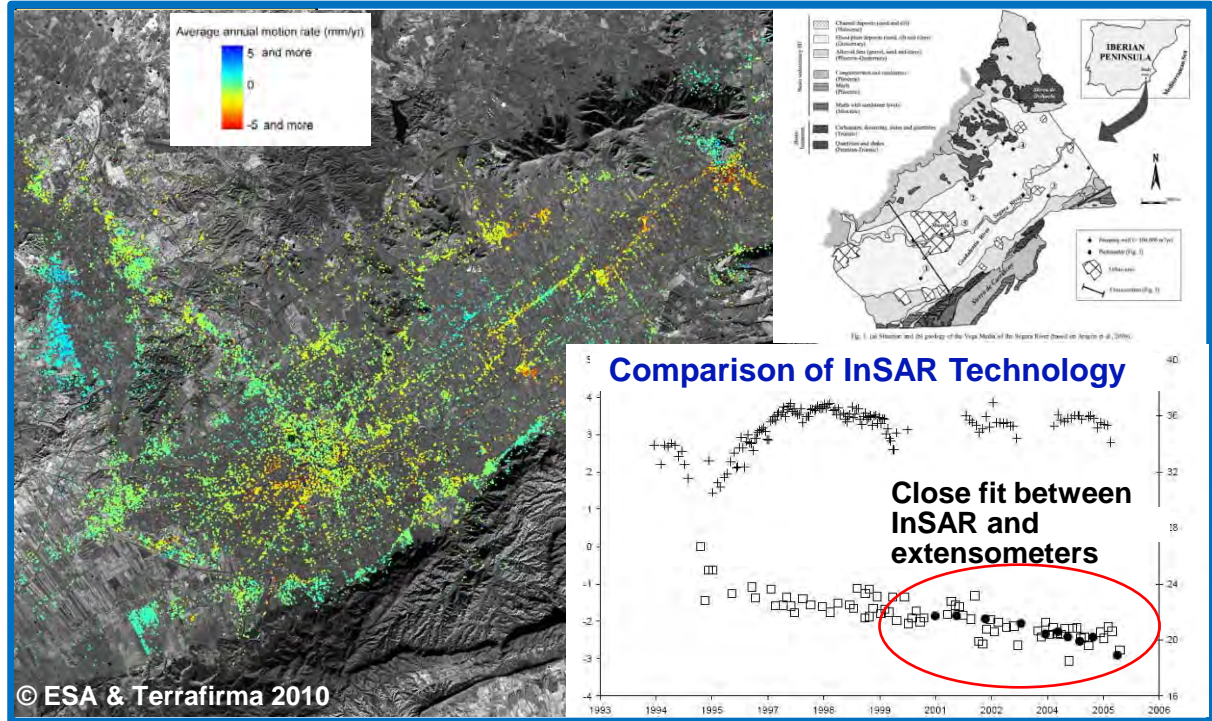
Case Study: Murcia, Spain: Vega Media del Segura– Exploitation of aquifers

Objective of the project

- Detection and mapping of areas affected by uplift and subsidence movements due to exploitation of aquifers in Murcia City (Spain) and surroundings.
- Locate and measure subsidence accurately in the study area and find the main cause of such movement.

Analysis and results

- Period of study: 1995-2008
- Subsidence measurements up to 3cm in Murcia City and up to 11cm in the whole Vega Media del Segura
- Validation of InSAR measurements: Match of measurements with extensometers
- Correlation between deformation measurements InSAR/ extensometers and piezometric levels



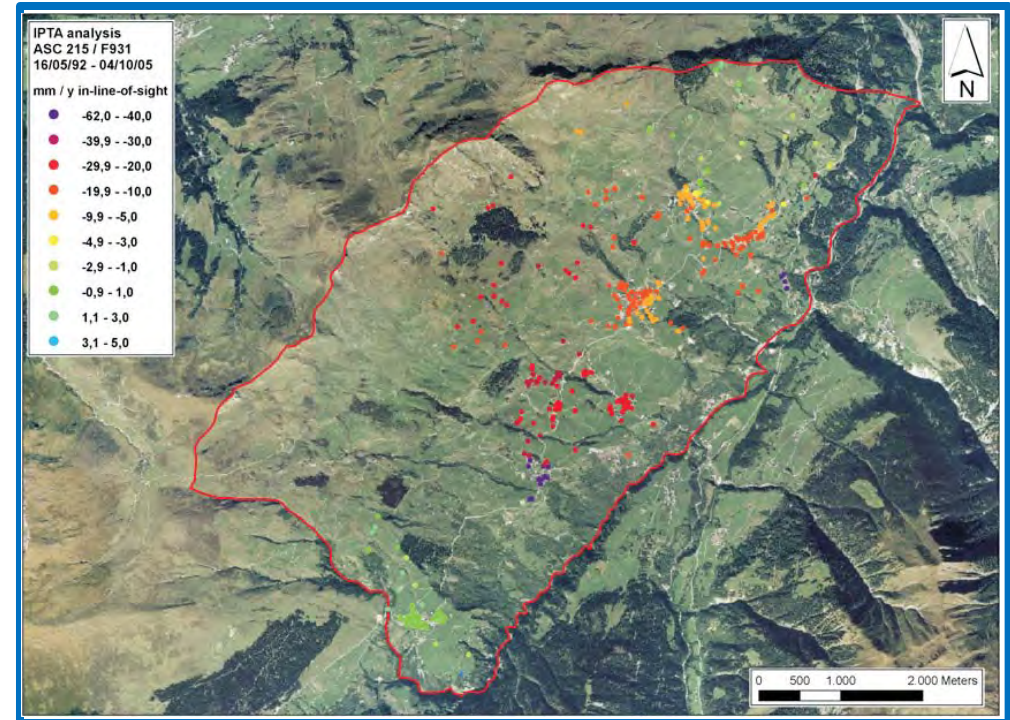
InSAR results show up to 11cm of subsidence in the area of aquifer exploitation. These measurements coincide with the results of deformation measured on the extensometers.

Objective

- Val Lumnez is one of the most active landslide regions in the urbanised areas of Switzerland.
- Within the 18km unstable area, seven villages are affected by the displacements and open cracks in houses and walls are frequent.

Analysis and results

- **Period of study: 1992-2005**
- The north-east part of the slope, where the villages of Cumbel, Morrissen and Vella are located, is the slower moving zone with slope-parallel
- Towards the toe of this part of the landslide, displacement rates increase which has caused extensive damage in the village of Peiden as witnessed in field surveys.



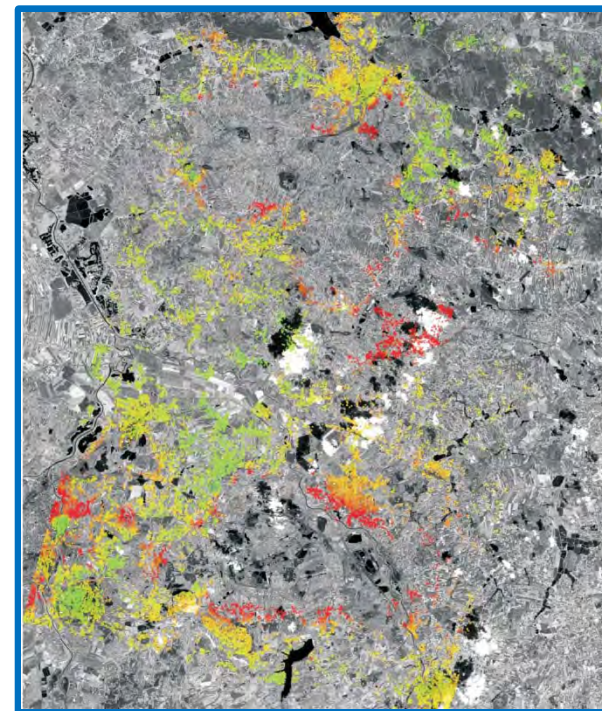
“Following participation in the Terrafirma project, FOEN have now recommended the inclusion of InSAR measurements as part of the Swiss guidelines for monitoring mountainous / alpine regions.” - FOEN

Objective

- Terrain-motion in the Rybnik-Ostrava region is related to coal mining and geological structures including faults, folds, and lithological boundaries.
- The site covers the Czech Republic regions of Ostrava and the Karvina coal basin which gave an opportunity for cross-border collaboration with Czech (IRSM) partners.

Analysis and results

- Period of study: 1992-2008
- The Terrafirma product confirmed the known active processes in the area while the use of ALOS PALSAR data in the Monitoring update product allowed areas of greater rates of motion to be analysed.
- There is a clear correspondence with mining-associated deformation and motion indirectly connected to tectonic structures.
- A direct correlation as found between the interferometric fringes and the mining exploitation zones.



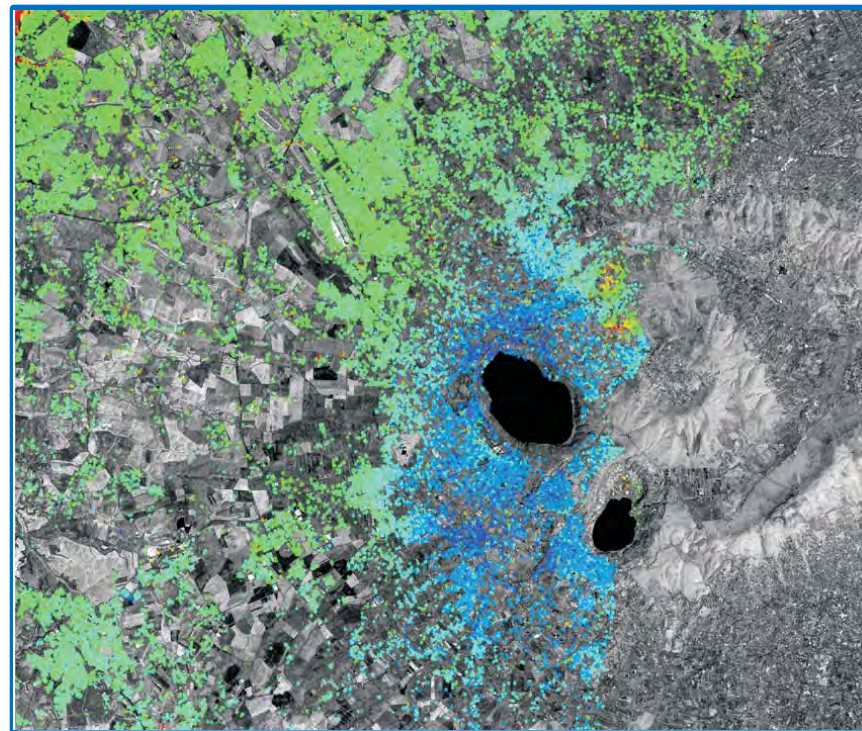
“The investigation area shows that satellite interferometry should be considered as a standard monitoring tool for hazardous mining areas.” – Polish Geological Institute

Objective

The aim is to define a model explaining the displacement field, in particular to locate and model the inflation source.

Analysis and results

- Period of study: 1992-2005
- Volcanic inflation was confirmed as the cause of the uplift zones.
- Local subsidence areas are also visible which have been attributed to water pumping zones.
- Two subsidence phenomena are detected, both very local. One 1km x 3km is present to the north east of Albano lake and can be attributed to sediment compaction due to strong water pumping causing a lowering of the water table.

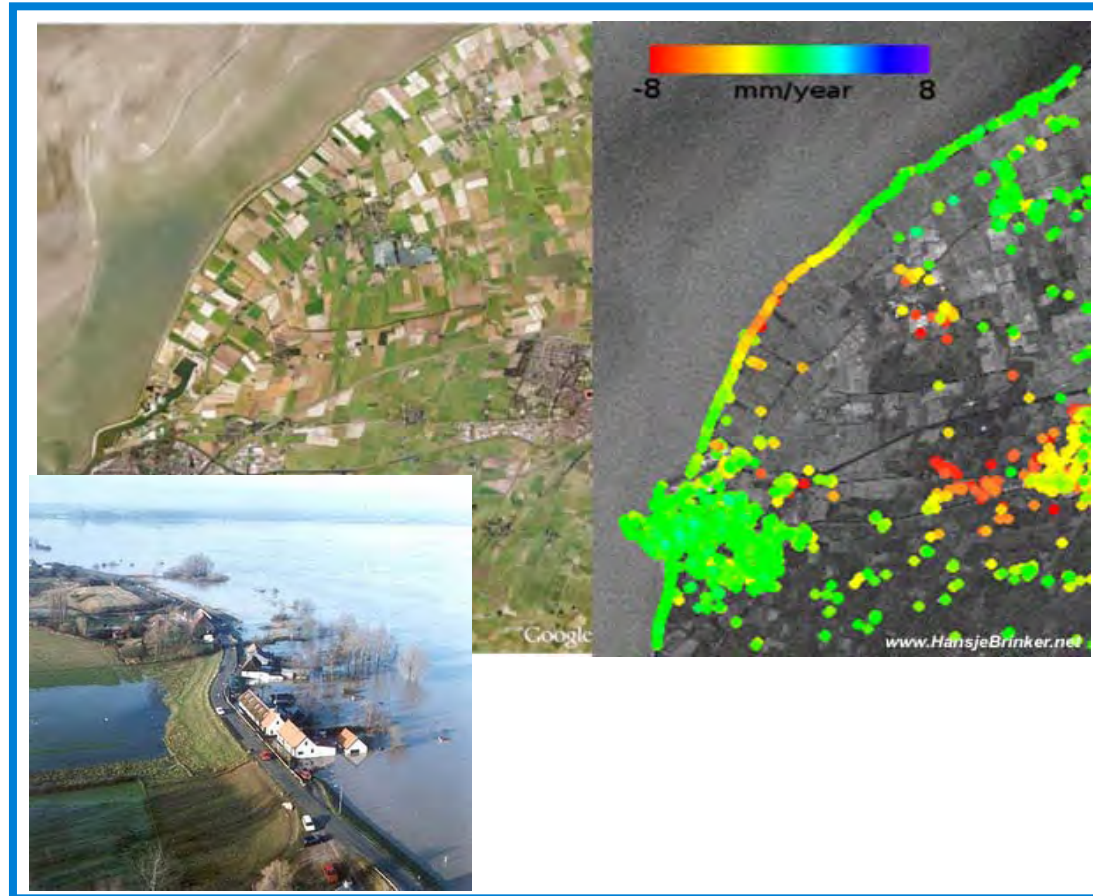


“The great amount of terrain-motion data made available by Terrafirma on the extended urban area of Rome cannot be acquired at similar costs and in comparable time with any other alternative source.” - APAT

Objective

Monitoring data (Envisat & TerraSAR-X) for assessment of dike behaviour

- PSI-derived monitoring of flood defense stability and integrity
- Shows creeping movements along flood defense structures
- Services to be delivered in Netherlands and Germany
- Utilises TerraSAR-X data for high resolution, high measurement point density



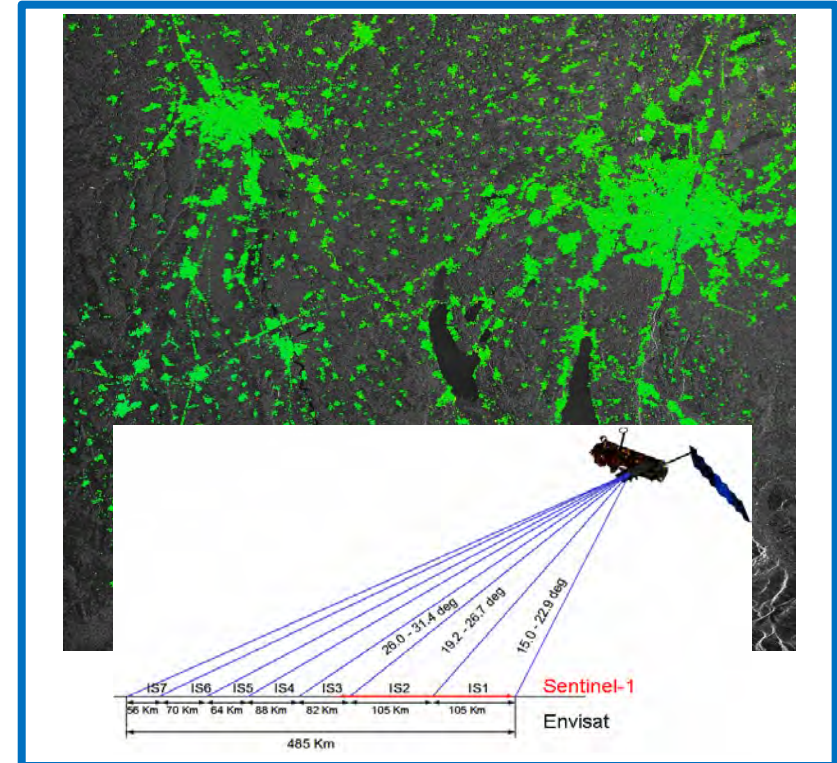
Wide area map

This service aims to provide coverage of wide areas using Envisat and future Sentinel-1 data



Description of Services

- Method for integrating multiple track datasets into a single motion map
- Example map (covering several tracks) will be produced during TF
- Methodology will be applicable to Sentinel-1 data to allow rapid wide area motion maps to be produced
- Resulting datasets can be used for TF services (value adding interpretation & integration) or as stand-alone synoptic terrain motion maps



The Wide Area Service will exploit wide area coverage of Sentinel-1 data to enable the future generation of European-wide motion data

- **Opportunity to receive any already existing PSI datasets via a light Service Level Agreement (i.e. an SLA placing fewer requirements on feedback):**
<http://www.terrafirma.eu.com/>

Thank you for your attention

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