Performance analysis of the TanDEM-X DEM generated with DIAPASON

XTI_LAND1554

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Agenda

- BIO_SOS - FP7-SPACE-2010-1 project

- DIAPASON adaptation to TanDEM-X data

- TanDEM–X for HR DEM generation

  - Veluwe (The Netherlands) HR DSM generation

  - Fors Cohno (Wales) HR DSM generation

- Conclusion

BIO_SOS GA 263435, FP7-SPACE-2010-1 Project

BIOdiversity Multi-**SO**urce Monitoring **S**ystem: From Space To Species

www.biosos.eu

- BIO_SOS aims to monitor the induced human effects on Biodiversity within and around **Natura 2000** sites by detecting VHR Land Cover/Use (LCLU) changes.

- The main objective is the development of a pre-operational multimodular ecological modeling system (EODHaM) based on the integration of EO and *in-situ* data. Outputs:

  ✓ **VHR LCLU and habitat maps.**

  ✓ **Biodiversity Indicators**

- **Vegetation height is used for habitat classification and habitat management monitoring.**

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Contribution of TanDEM-X data to the Project

- Evaluation of capacity of TanDEM-X to measure **vegetation height**: Digital Surface Model (DSM) over Canopy.

- Evaluation of the TanDEM-X **coherence for supporting Landcover** classification procedures.

- **Adapt** DIAPASON InSAR **processor** to the particularities of TanDEM-X:
  - Bi-static acquisition
  - CoSSCs products

- On going project by now.

Cors Fochno (Wales)
DEM Generation

Veluwe (The Netherlands)
DEM Generation

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DIAPASON adaptation to TanDEM-X data
Bi-static InSAR processing adaptation

CoSSC images

ML interf.
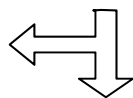
Data Extraction

RAW Interferogram

Reference Interferogram

ML | GCP | Proj.
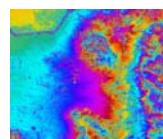
Phase Unwrapping

Height Conversion

Output DEM

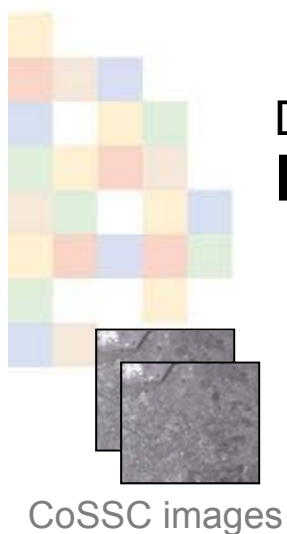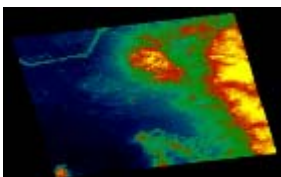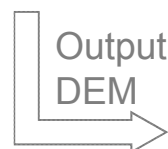- Data extraction: Annotation QCs check, orbit state vectors, image timing annotation, Id Master scene

- RAW interferogram generation: Hermitian product master-slave

- Reference interferogram generation (with SRTM at 3" if available, if not WGS84)

- Phase Multilooking, definition of GCPs & definition of ground projected geometry

- Phase unwrapping

- Phase to Height conversion with geocoding

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Image timing annotation QCs

- Simulation of the SAR synthetic amplitude image due to the ground topography (SRTM at 3") and comparison with the product amplitude (ml55)
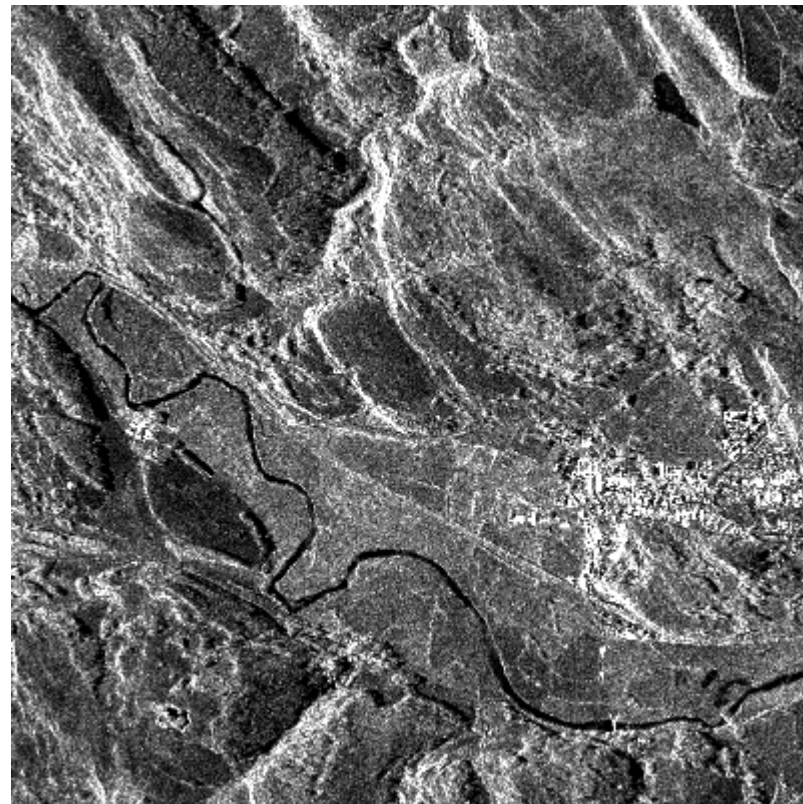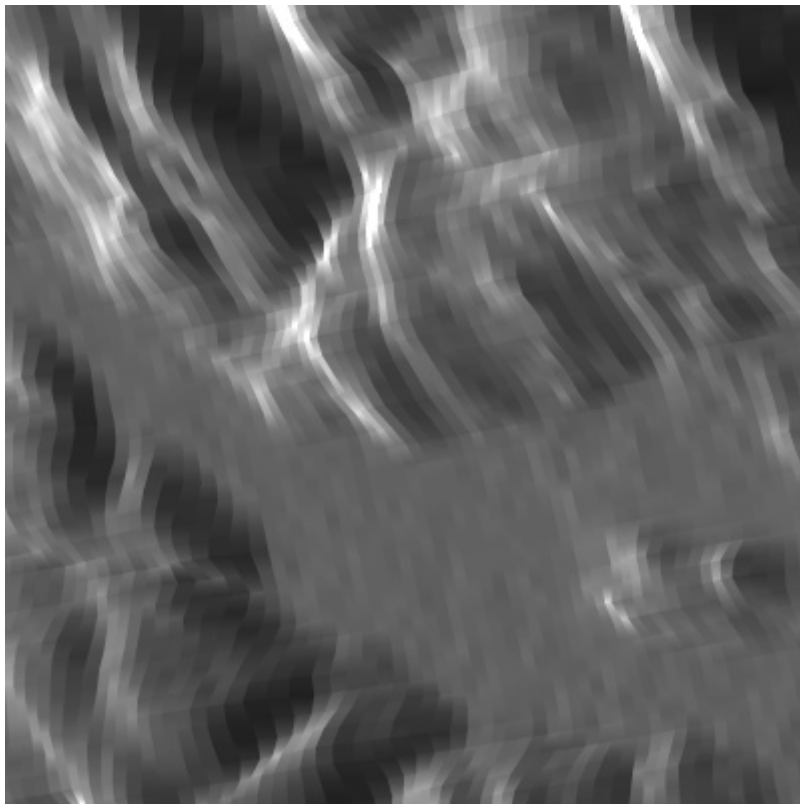
Image timing annotation QCs

- Simulation of the SAR synthetic amplitude image due to the ground topography (SRTM at 3") and comparison with the product amplitude (ml55)

  ➢ Offsets of 7 samples and 15 samples in range and azimuth
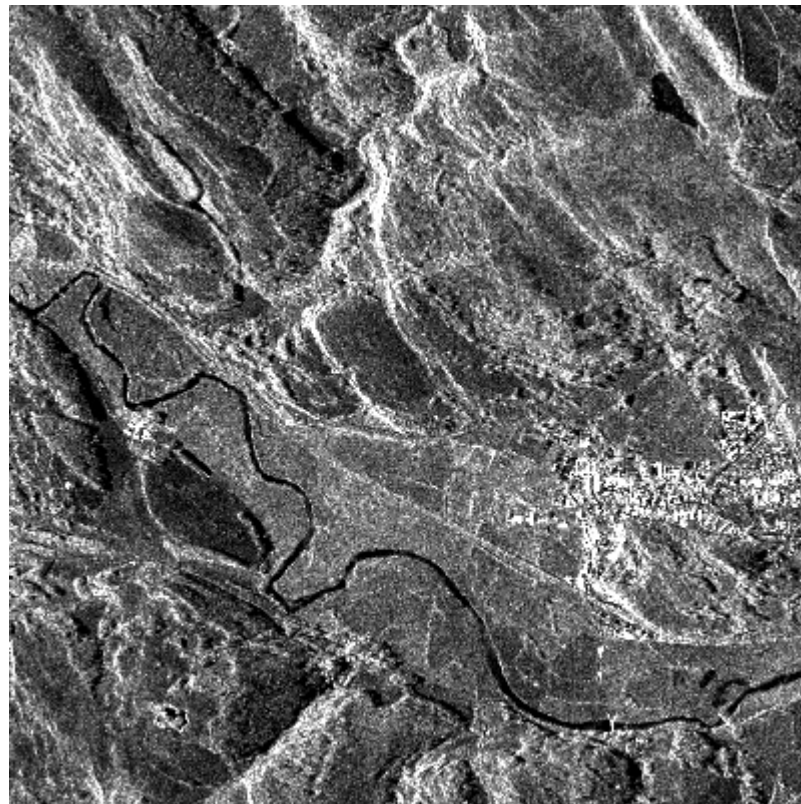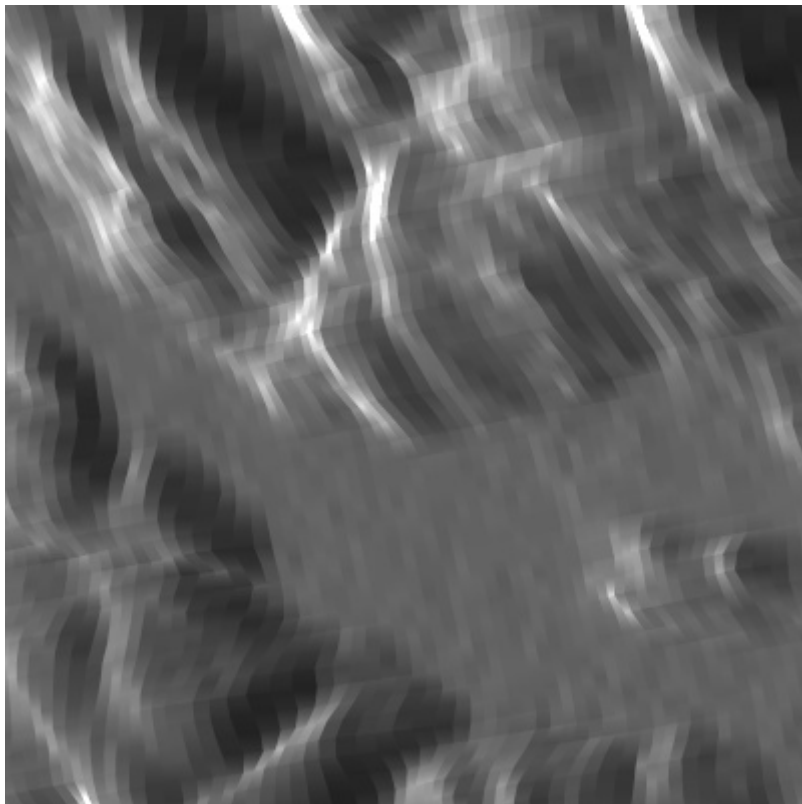
DIAPASON adaptation to TanDEM-X data
Image timing annotation Correction

- After the timing correction the differential interferogram present less residual fringes

Before Correction

After Correction

Before Correction

DIAPASON adaptation to TanDEM-X data
Image timing annotation Correction

- After the timing correction the differential interferogram present less residual fringes

After Correcton
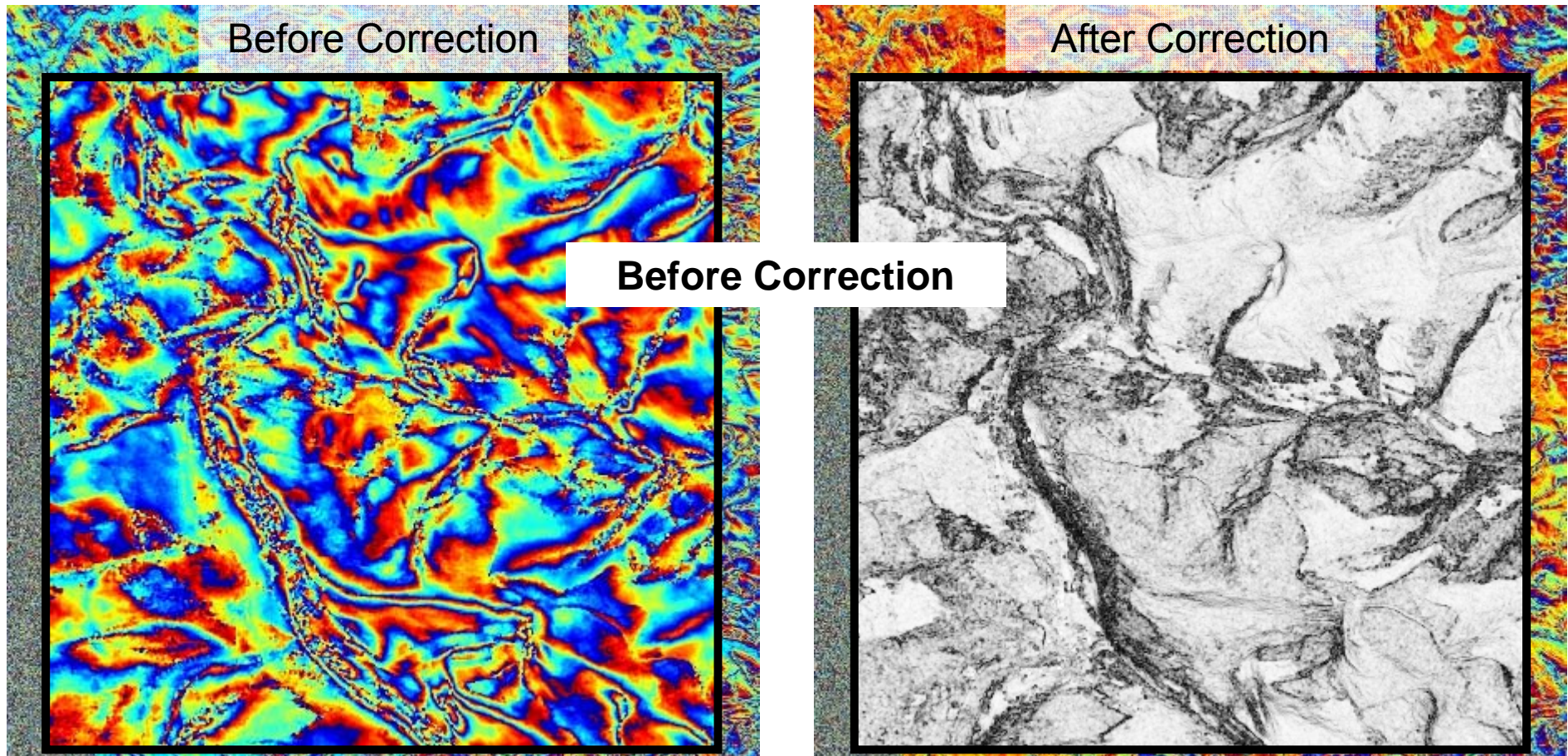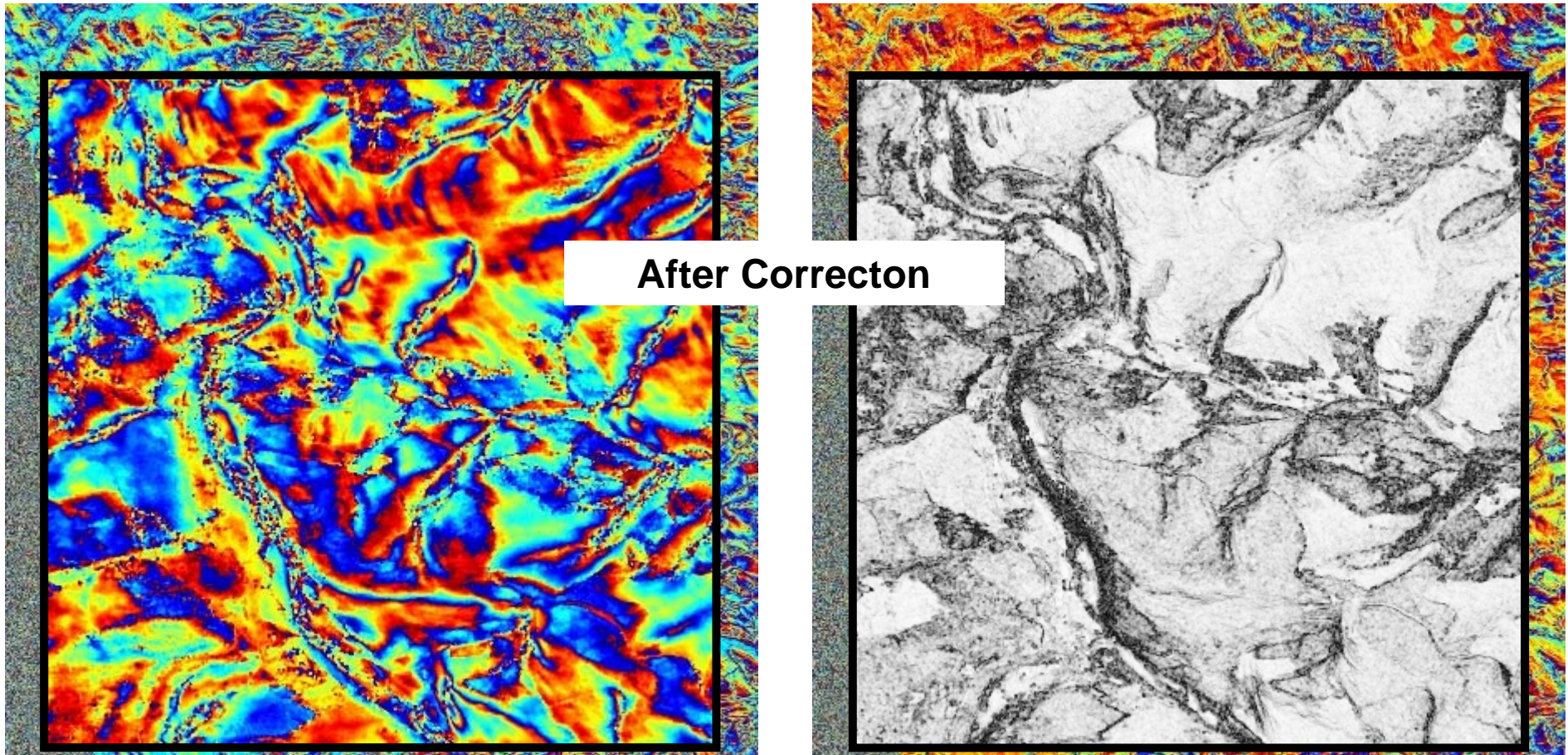
Phase to Height conversion with geocoding

- Solving an equitation system with 3 unknowns
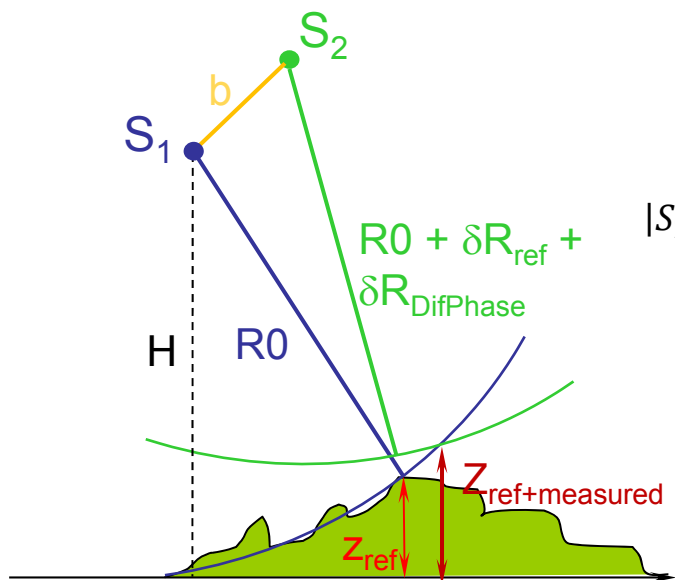
$$|S_1 - P|^2 = (S_{x1} - P_x)^2 + (S_{y1} - P_y)^2 + (S_{z1} - P_z)^2 = R0^2$$

$$|S_2 - P|^2 = (S_{x2} - P_x)^2 + (S_{y2} - P_y)^2 + (S_{z2} - P_z)^2 = \left(R0 + Rref + \frac{\lambda\theta}{2\pi}\right)^2$$

$$f_D = \frac{2}{\lambda} \cdot \frac{(v_s - v_p)(P - S_1)}{|P - S_1|}$$

➤ **Calibration of the slant-range InSAR phase based on mean offset retrieval (GCPs)**

➤ Direct transformation of the unwrapped interferometric phase to geocoded heights for each SAR pixel

➤ Initial guess P_0 provided based on SRTM to speed up the solution

➤ Output geometry is set according to the product needs (& ML of the processing)

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Global comparison TDX with LiDAR DSM

LiDAR DSM 15m. res.

TDX DSM 15m. res.
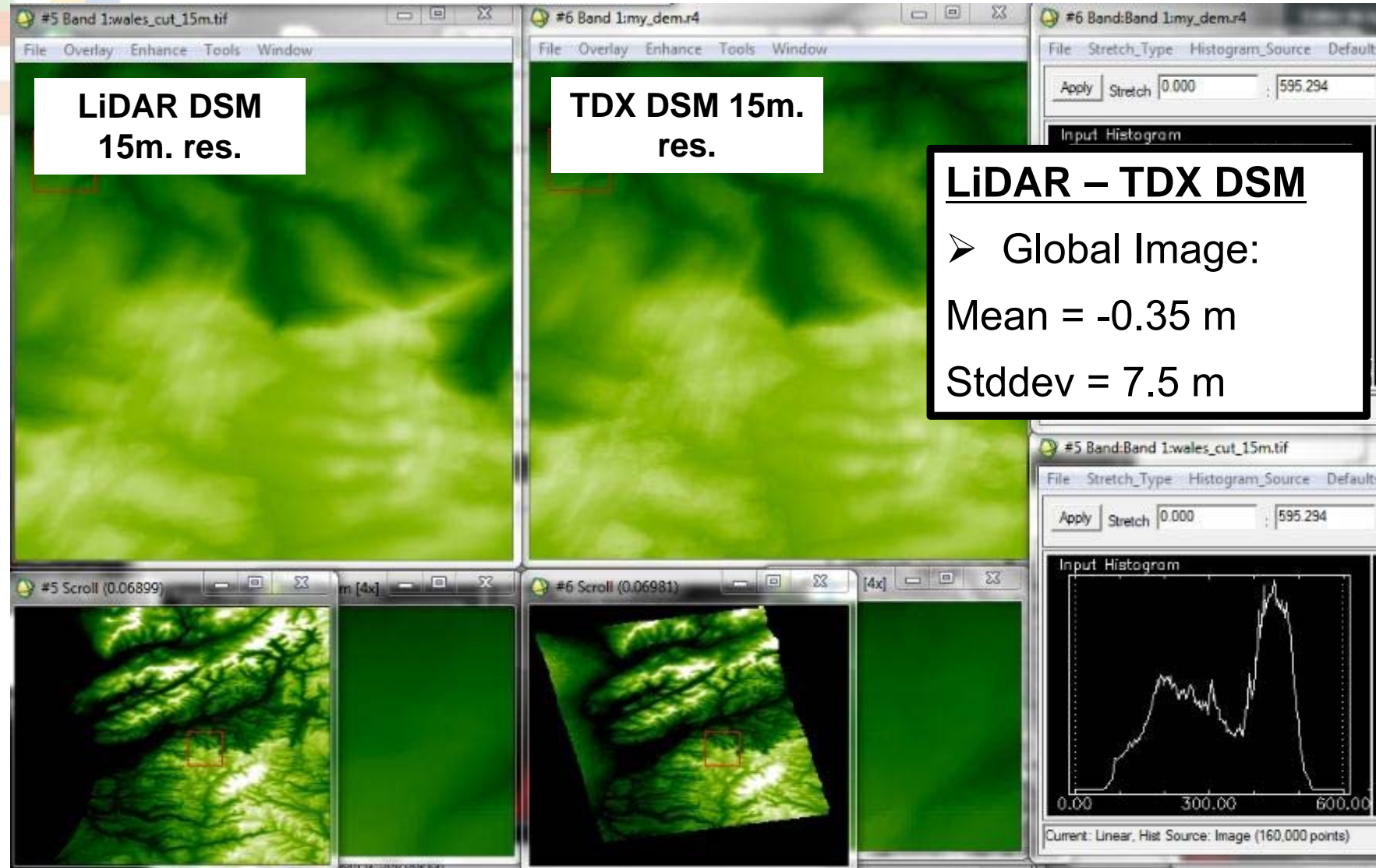
LiDAR – TDX DSM

➢ Global Image:

Mean = -0.35 m

Stddev = 7.5 m

DIAPASON adaptation to TanDEM-X data
LiDAR and TDX DSMs over fat areas

LiDAR and TDX DSMs over fat areas

LiDAR DSM 15m. res.

TDX DSM 15m. res.

LiDAR – TDX DSM

- Flat areas:

  Mean = -0.66 m

  Stddev = 0.96 m

- TDX provides more details of the ground topography

TanDEM-X for HR DEM generation
Status of the work

- Dates (November/December 2012) with normally low to moderate vegetation (**post-flush**).

- On-going processing of those datasets
  - Preliminary DEMs have been generated for Veluwe.
  - Comparison with ground truth data (GCPs, orthophoto, LiDAR DEM for Cors Fochno site) + comparison with SRTM and ASTER DEMs

- New acquisitions have been obtained in beginning of June 2013 (**peak flush**).

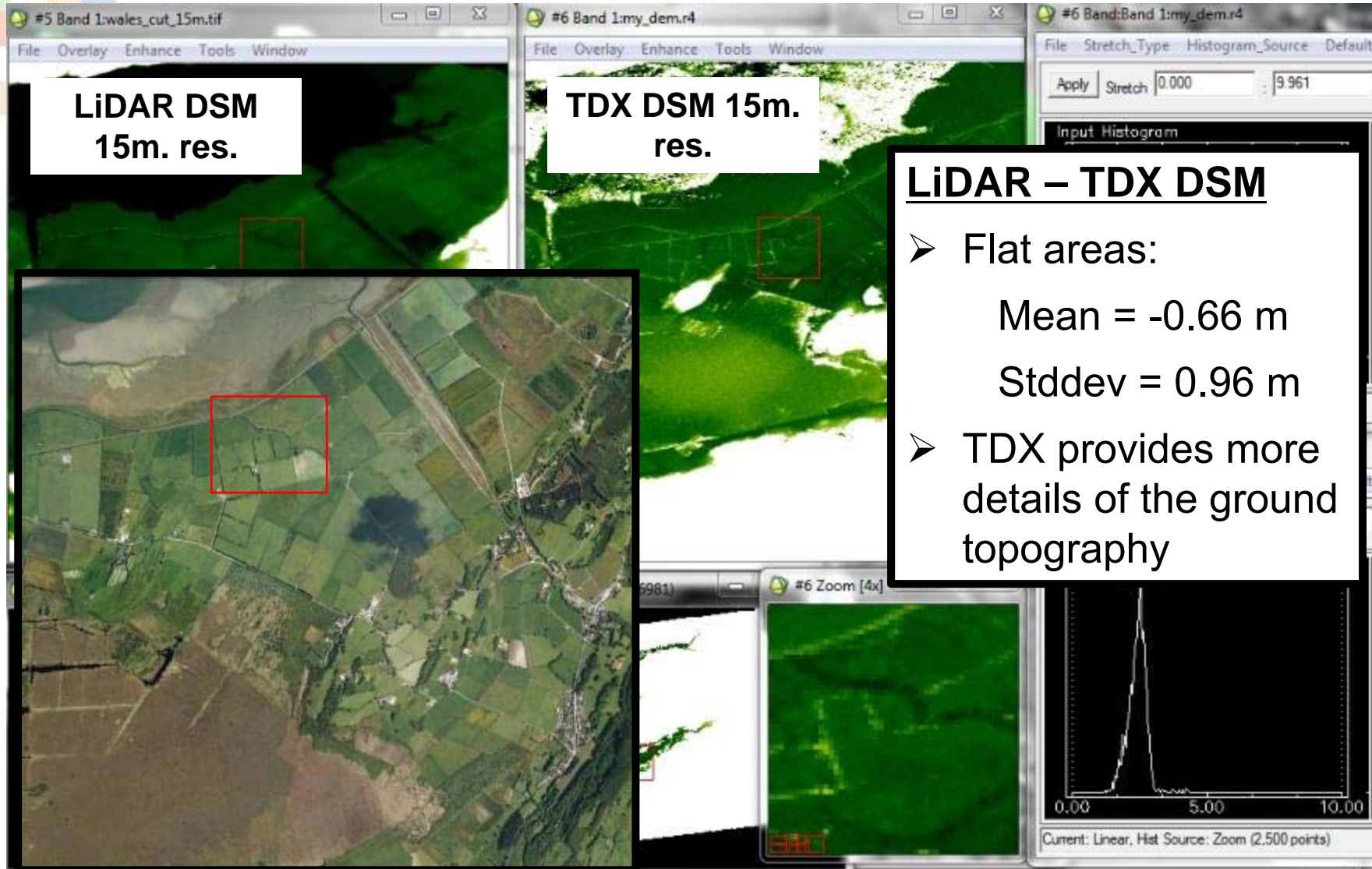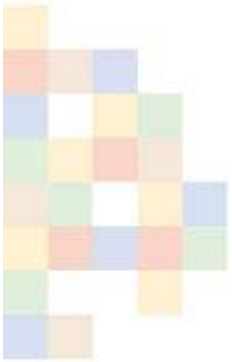| Order Name:	Cors Fochno	
1 Acquisition Item Id:		
Tap Take Id:	SCG_0203.072_S_EU_GBR_tanDEM_a2_005R_085.14_180_20121005T092933	
Acquisition Window		**Start UTC**
Time Window (ref)		
Preferred Time (ref)		2012-11-09T17:52:42.267480Z
Scheduled Time		
Imaging Mode	**Interferometric Mode**	**Beam Id**
SM	bistatic	tanDEM_a2_005
Looking Direction	**Pass Direction**	**Cycle**
right	ascending	180
Estimated Mean Perpendicular Cross Track Baseline [m]		
297.3720226		

| Order Name:	Veluwe_Post_Flush	
2 Acquisition Item Id:		
Tap Take Id:	SCG_0203.072_S_EU_NLD_tanDEM_a2_025R_115.14_184_20121005T093259	
Acquisition Window		**Start UTC**
Time Window (ref)		
Preferred Time (ref)		2012-12-25T17:18:04.032919Z
Scheduled Time		
Imaging Mode	**Interferometric Mode**	**Beam Id**
SM	bistatic	tanDEM_a2_025
Looking Direction	**Pass Direction**	**Cycle**
right	ascending	184
Estimated Mean Perpendicular Cross Track Baseline [m]		
261.8742374		

Fors Cohno (Wales) area & data

- Clear forested zones in mountain area

- River and water reservoir

- LiDAR DSM at 15m
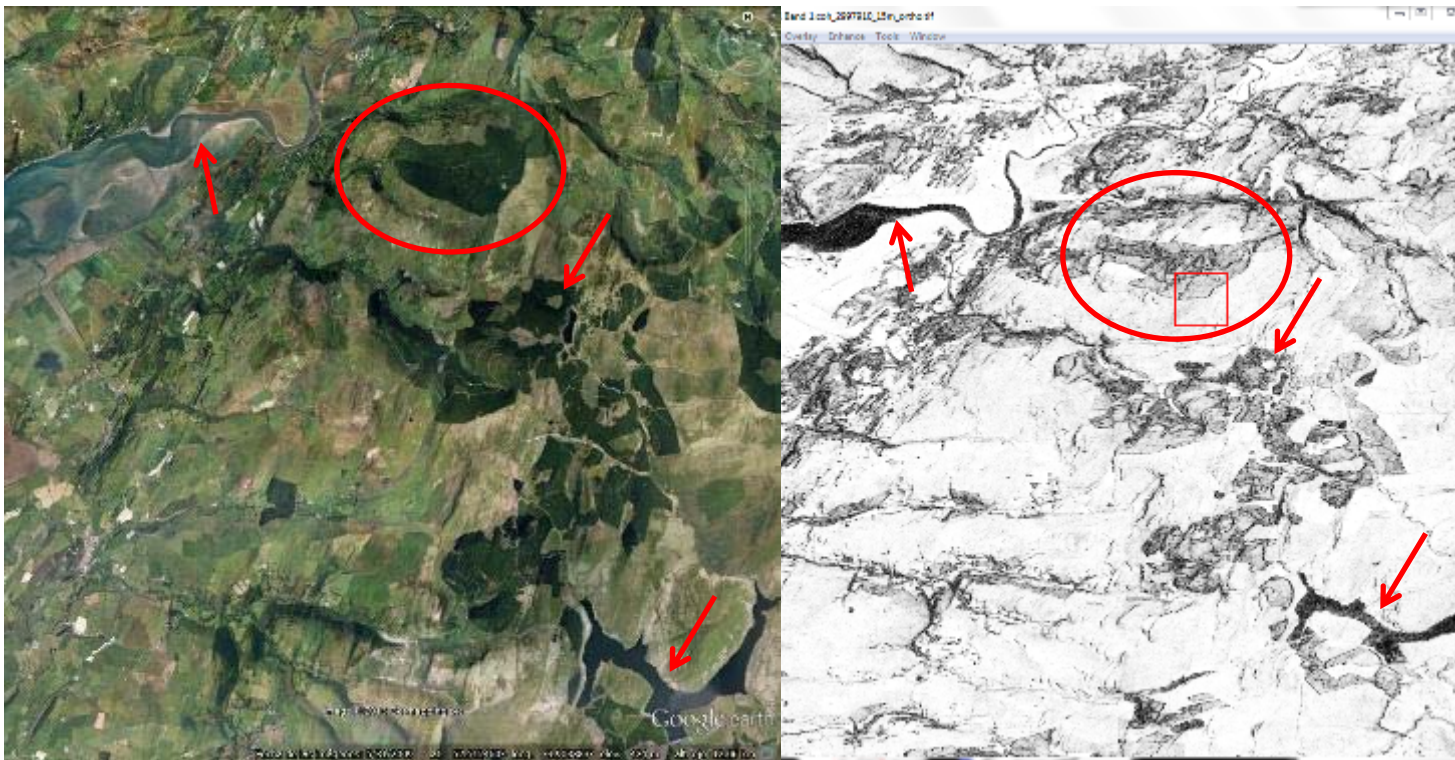
- Stack Worldview-2 for classification
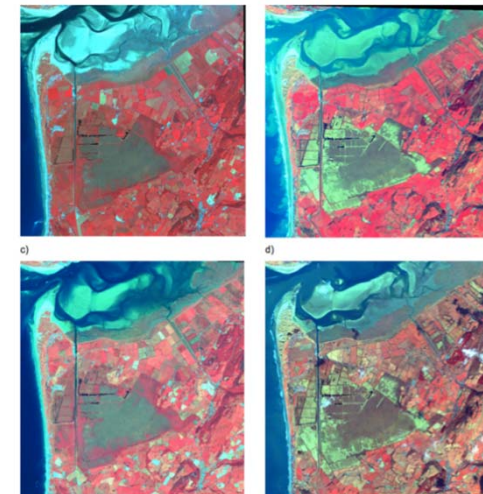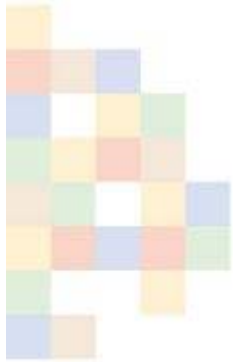
Fors Cohno (Wales) TDX data

- Preliminary Analysis of the bi-static InSAR with landcover
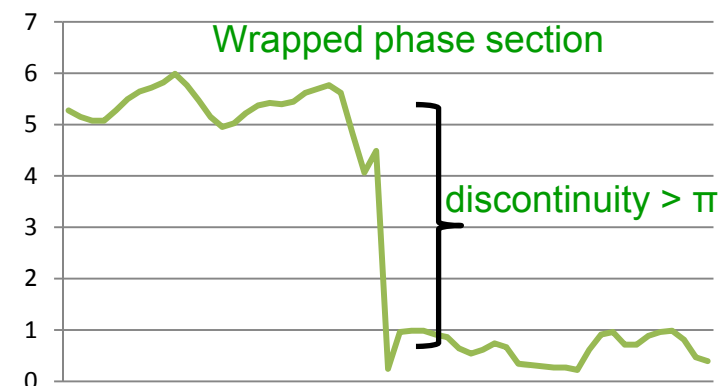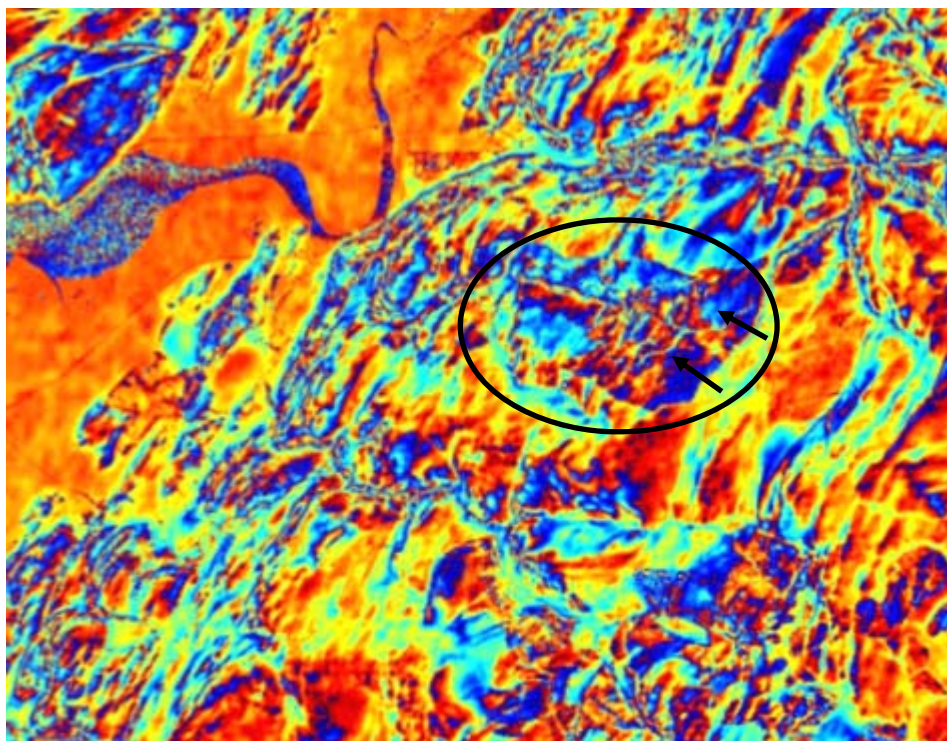
  Acq date: 2012/12/25 h_{amb}=37.2m

Low coherence areas are tied with forested areas and water surfaces
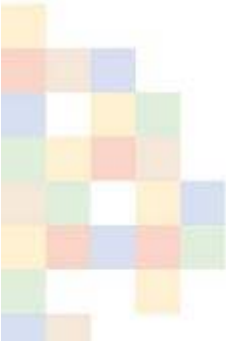
Fors Cohno (Wales) InSAR phase over trees

- Exploitation of the phase for trees height measurement

Wrapped phase section

discontinuity > π

- Phase profiles captured crossing the trees induced discontinuity

- Relative phase measurements in the discontinuity used to retrieve possible trees heights from (7 to 14 m this case)

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Fors Cohno (Wales) HR DSM generation

- Exploitation of the TDX DSM for trees height measurement

Fors Cohno (Wales) HR DSM generation

- Exploitation of the TDX DSM for trees height measurement

-18m

+18m

LiDAR –TDX DSM differences

Input Histogram

-20.00   0.00   20.00

> Phase unwrapping cannot resolve the phase ambiguity in forest areas since there is no transition

Image © 2013 Getmapping plc
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
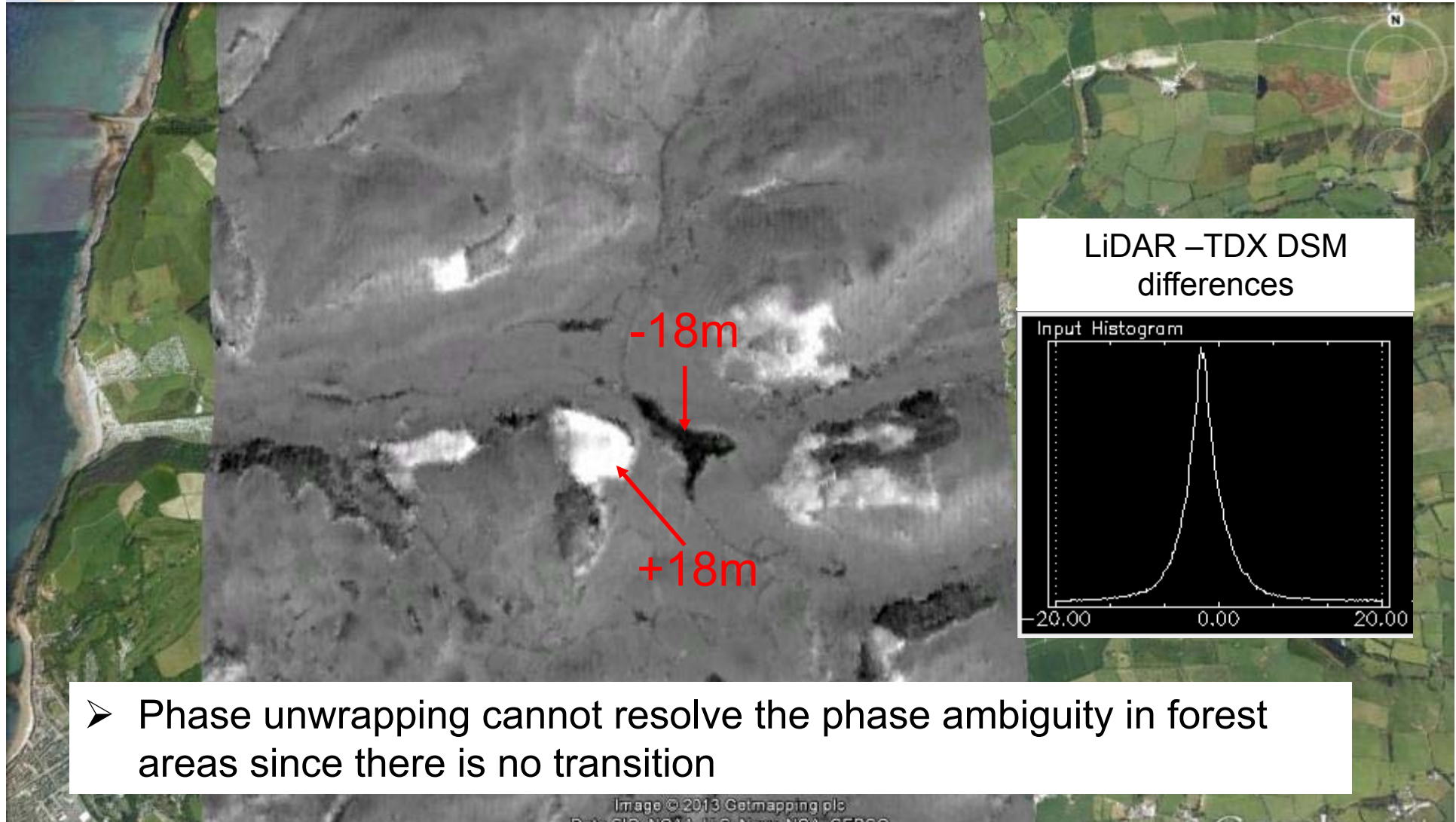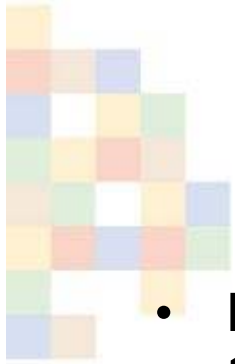
Preliminary Analysis and Key Facts
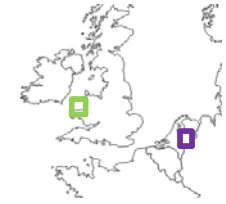
- Produced **TSX DSM have a very high level of details** of the ground topographic surface

- **Trees volumetric backscattering** seems to reduce scene interferometric coherence

- **Coherence** might be used combined with height information as **land cover classifier** given its sensitivity to forested and water areas

- **Phase unwrapping** present **difficulties** to retrieve trees height → Trees height sensitivity is constrained by height of ambiguity

- Interferometric **phase** might be used to retrieve **trees height** with DInSAR interferograms at **different seasons of the year**

- **Future** and sustainability of **BIO_SOS project**: Evaluate the costs and feasibility of the elaboration of a TD-X HR DSM vs. LIDAR DSM

Thank you for your attention

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