CEOS-WGCV37 Terrain Mapping Sub-group: Current Status and GEO IN-02-C2.1 report

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Point-of-Contact, GEOSS Task IN-02
Chairperson, CEOS-WGCV Sub-group on Terrain mapping from satellites
Chairperson, ISPRS Commission IV WG on "Global DEM Interoperability"
Head, Imaging Group
Professor of Image Understanding and Remote Sensing
HRSC Science Team Member (ESA Mars Express 2003)
Stereo Panoramic Camera Science Team Member (ESA EXOMARS)
MODIS & MISR Science Team Member (NASA EOS Project)
TerraSAR-X and TANDEM-X science team member (DLR-Astrium)

**partially supported by UK Space Agency*

CEOS WGCV Terrain Mapping

- **What is the mission of the Terrain Mapping Sub-Group (TMSG)?**
  - **To ensure that characteristics of digital terrain models produced from Earth Observation sensors at global and regional scale are well understood and that products are validated and used for appropriate applications.**
- **What are the specific objectives of this group?**
  - **To develop <u>specifications</u> for the generation of '*standardised terrain surface products with known accuracy*' from similar sensing systems in the context of data continuity,**
  - **to specify <u>evaluation methods and statistics</u> which give transparent information about the *quality and heritage of terrain models*.**
  - **To update the current <u>dossier of test sites</u> and identify new sites, particularly to satisfy the cal/val requirements of future missions and generally improve access to validation data sets.**
  - **To keep an <u>up to date record</u> of the current status of sensors which produce data for terrain mapping and of the DEMs available.**
  - **To produce a <u>DEM requirements document</u> with a science rationale, taking into account the output from SRTM.**

TMSG Modus Operandi

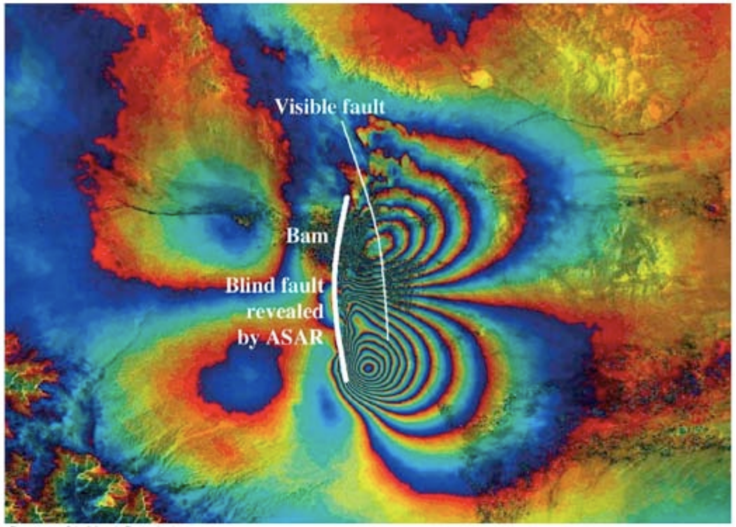
- **Terrain mapping SG linked to ISPRS IV/3 on "Global DEM interoperability" and GEO task IN-02-C2.1 on "Global DEM"**
- **Annual technical workshops as part of an international conference**
  - **IGARSS09, Cape Town , South Africa, July 2009**
  - **ISPRS Commission IV Symposium, Orlando, FL, 16-18 November 2010**
  - **2011 symposium had to be abandoned due to Japanese tsunami**
  - **Special session at ISPRS Congress, Melbourne, 26 August – 2 September 2012**
  - **Sessions at ISPRS Comm.IV Symposium, Suzhou, 18-20 May 2014**
- **News announcements as and when there is relevant news (recently included news on the release of the SRTM v3, TanDEM-X AO)**
- **Emails to collect inputs for WGCV #37 (59 on email list, 6 responses in total)**
- **Everything done on a "best efforts" basis with minimal funding so limited ambitions at present to meet specific objectives**
- **JPM planned to step down in 12/2013 after more than 13 years in the post. Hannes Reuter (ISRIC World Soil Information) agreed to become Vice-Chair and received support by ISIC. HR moved to EUROSTAT in 9/13. EC are not supporting his travel. JPM to continue until he finds replacement**
- **UK Space Agency able to provide partial support for JPM travel. Unable to sort out contracts currently. Hope situation will improve in 2014/15.**

Overview

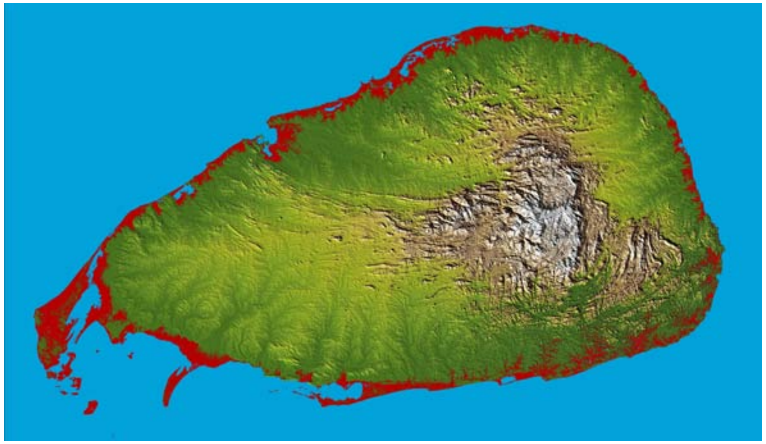
- Why does GEO need global topography/bathymmetry?
- Current State-of-the-art in DEM production & quality assessment
  - Assessment of SRTM v3 by National Aerospace Institute of Spain (INTA) (provided by Enrique Nicolás Gesé & Pablo Sánchez Gámez, INTA, Spain)
  - TanDEM-X DEM AO (provided by Irena Hajnsek, DLR)
  - Status of NASADEM (provided by Marc Simard, JPL)
  - Example of multi-DEM fusion for alpine region of Italy/Switzerland (provided by Laura Carcano, POLIMI)
- Status of tasks in IN-02-C2.1 Global DEM
- Next steps and recommendations for CEOS Plenary for global bathymetry

Why does GEO need global topography/bathymmetry?

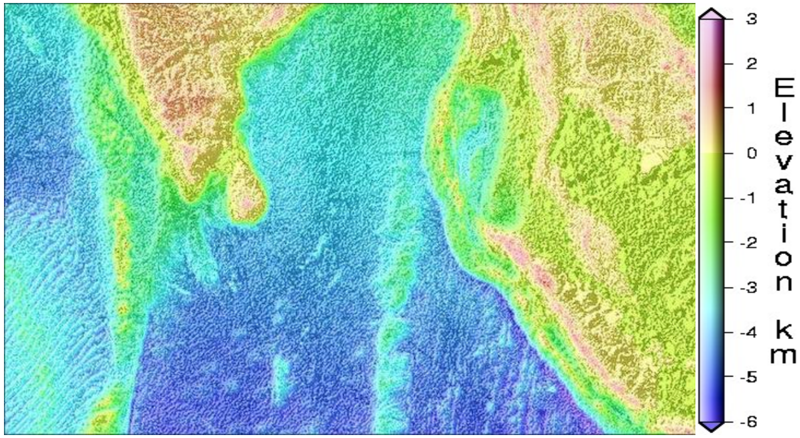
- Global DEM required for 6 of the 9 societal benefit areas identified by the Implementation Plan of GEOSS 2005-2015, and for 2015-2025
- Natural disasters all require detailed knowledge of topography
  - either directly for volcanic dome monitoring, flood inundation areal predictions, landslides
  - or for downstream EO processing, e.g. InSAR for earthquake monitoring and possible prediction
- Poor bathymetric and topography knowledge hinders tsunami forecasts
- Tsunami a main spur for GEO implementation



Courtesy of A. Monti-Guarnieri



30m height “flood-fill” based on SRTM-DTED1® 3” (≈90m)



2’ (≈4km) Smith, Walter H.F., and David T. Sandwell, 1997 "Global Sea Floor Topography from Satellite Altimetry and Ship Depth Soundings", Science, 277, 1956-1962, 1997

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Instituto Nacional de Técnica Aeroespacial

VALIDATION STUDIES OF SRTM V3 DEM

Enrique Nicolás Gesé
National Aerospace Institute of Spain (INTA).
Earth Observation, Remote Sensing and Atmosphere Department.
Observation Systems Area / Image Processing Laboratory.
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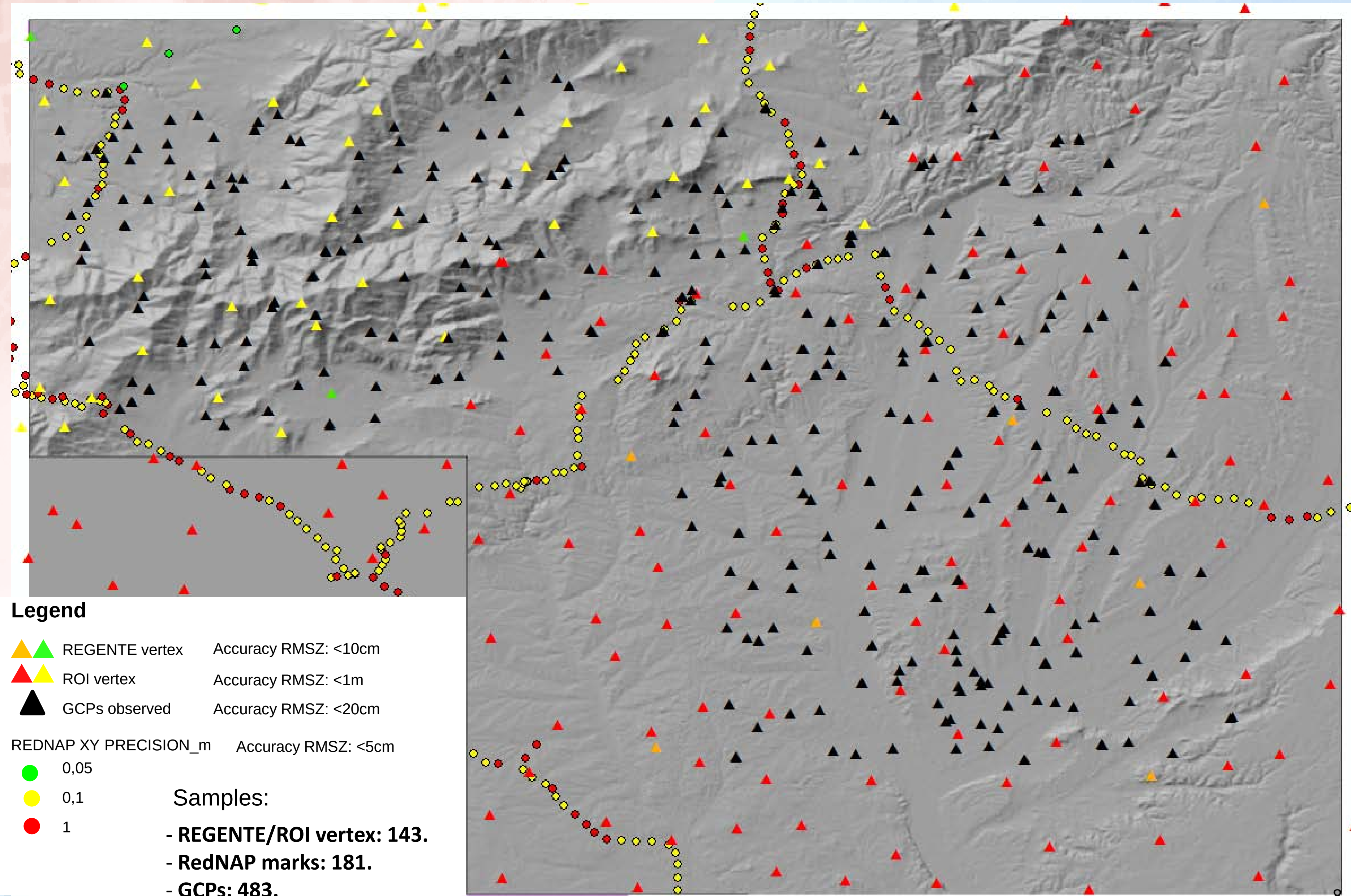
Objectives:

- Analyse the accuracy of the newly released SRTM DEM (V3) in relation to previous versions for the AOI of Madrid.

Methodology:

- Height harmonisation to the Spanish official height frame (from EGM96 to EGM08-RedNAP).
- Discrete accuracy analysis: extraction of Z values from the DEM in correspondence with values from different Ground truth datasets. (from 550m to 2430m ASL)
- Continuous accuracy analysis: difference between SRTM V3 and the most accurate DEM (DSM) freely available of the AOI (MDT5_LiDAR).

Discrete ground truth data used



Samples:

- **REGENTE/ROI vertex: 143.**
- **RedNAP marks: 181.**
- **GCPs: 483.**

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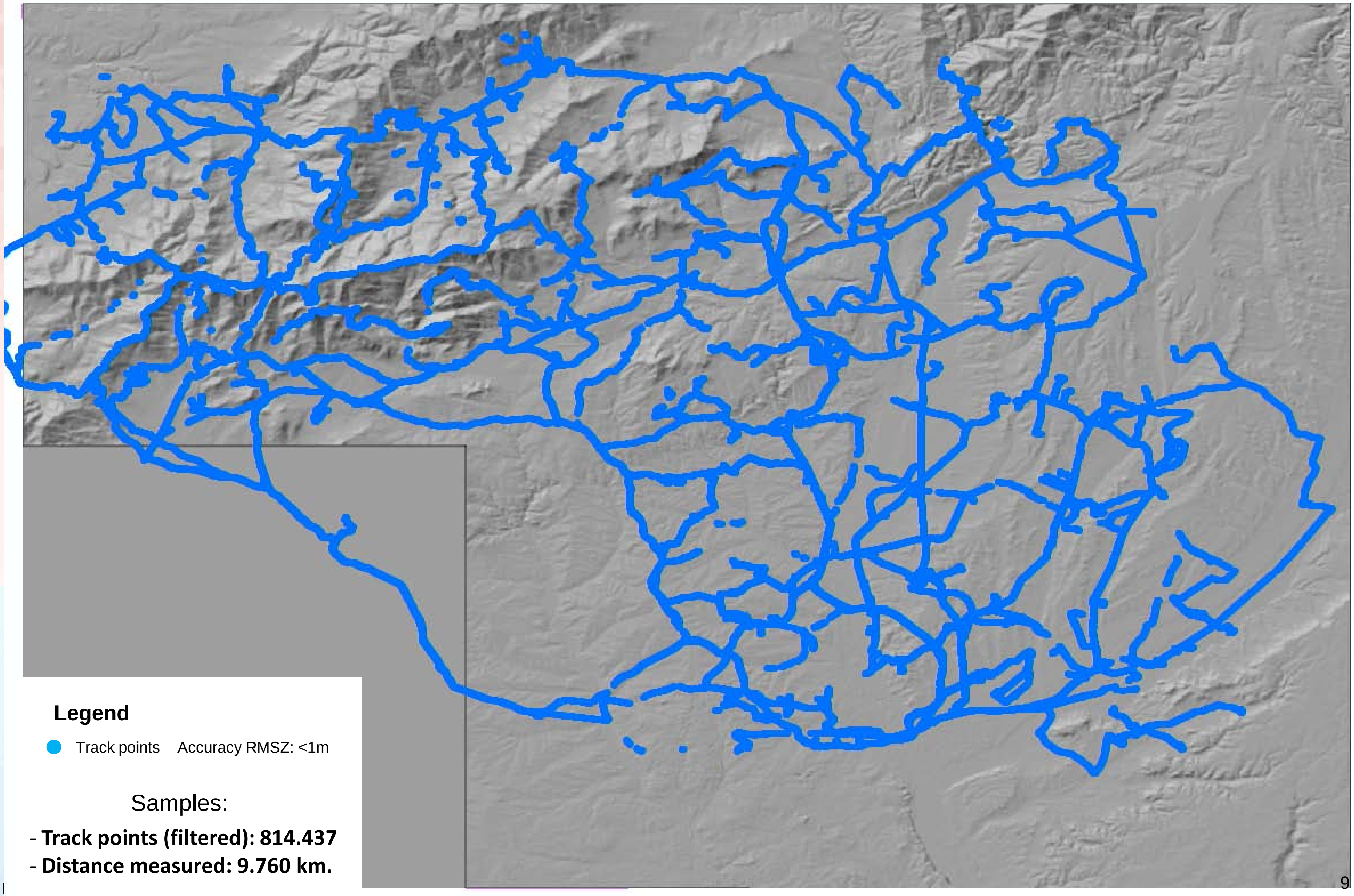
Discrete ground truth data used – GPS Z-Tracks
(Madrid region, Spain)



Legend

Track points   Accuracy RMSZ: <1m

Samples:

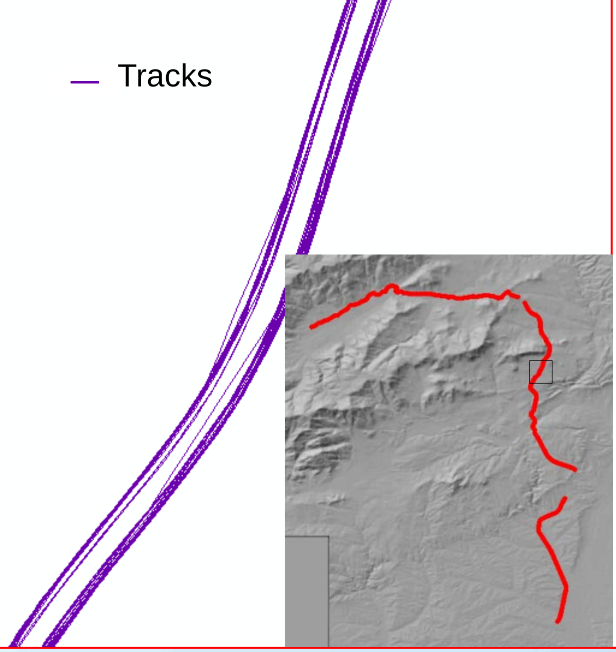
- **Track points (filtered): 814.437**
- **Distance measured: 9.760 km.**

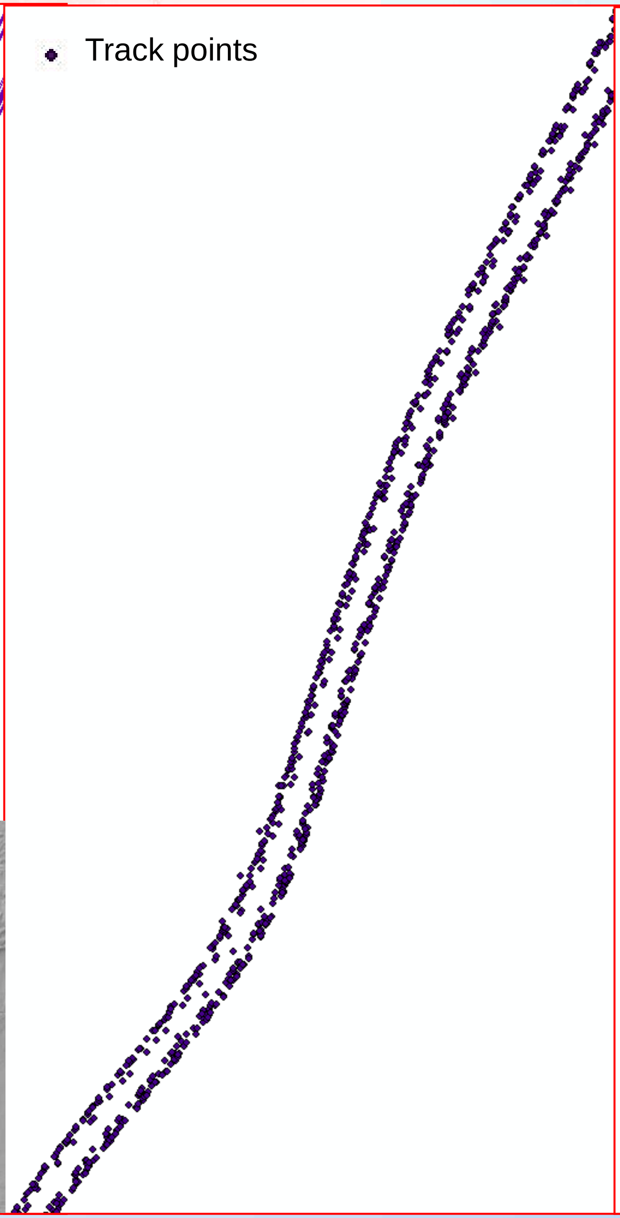
Discrete ground truth data used – Synthetic Z-Track over a highway

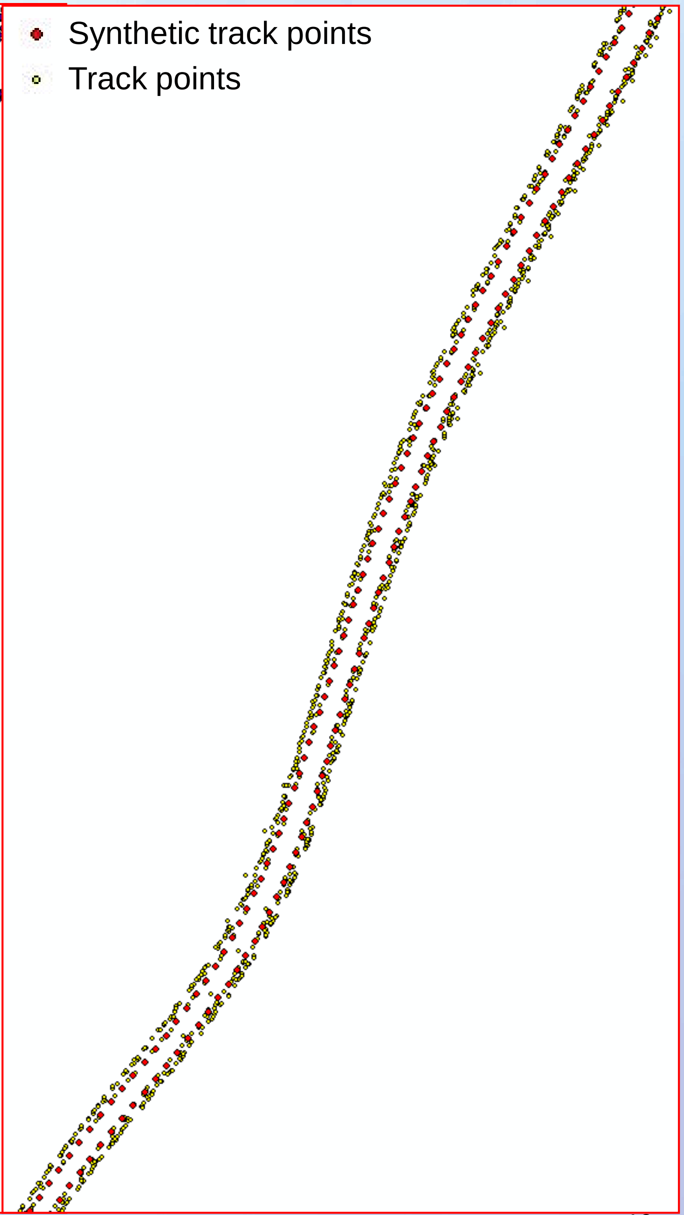
-More than 30 concurrent tracks (64,208 points).

-Extracted 1 synthetic point every 10m of road taking into account the nearest points (search radius = 10m, Z weighted mean in terms of distance).

-Total of 10.749 points (107 km).







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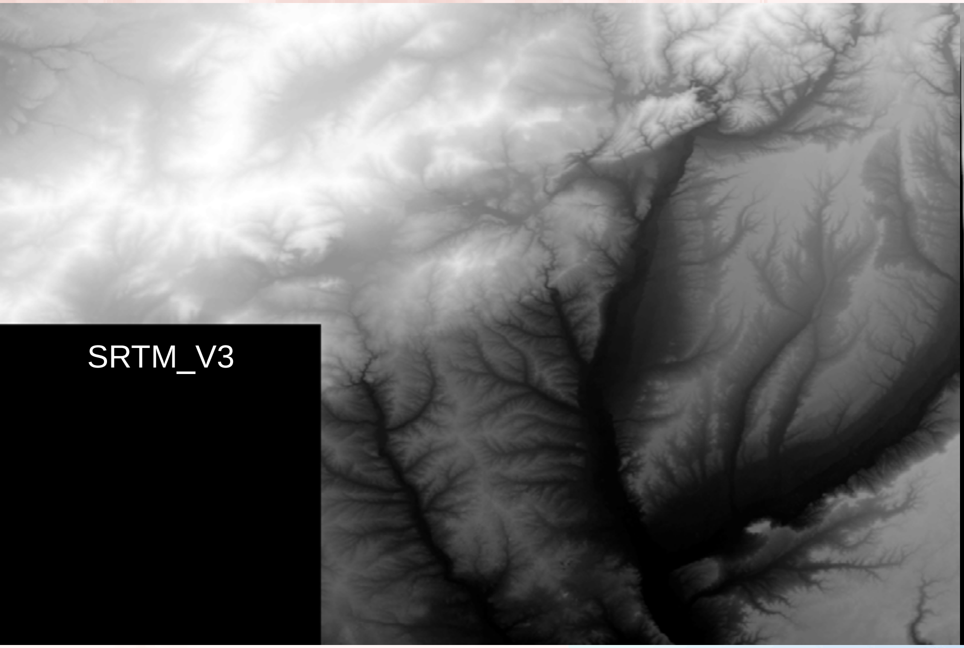
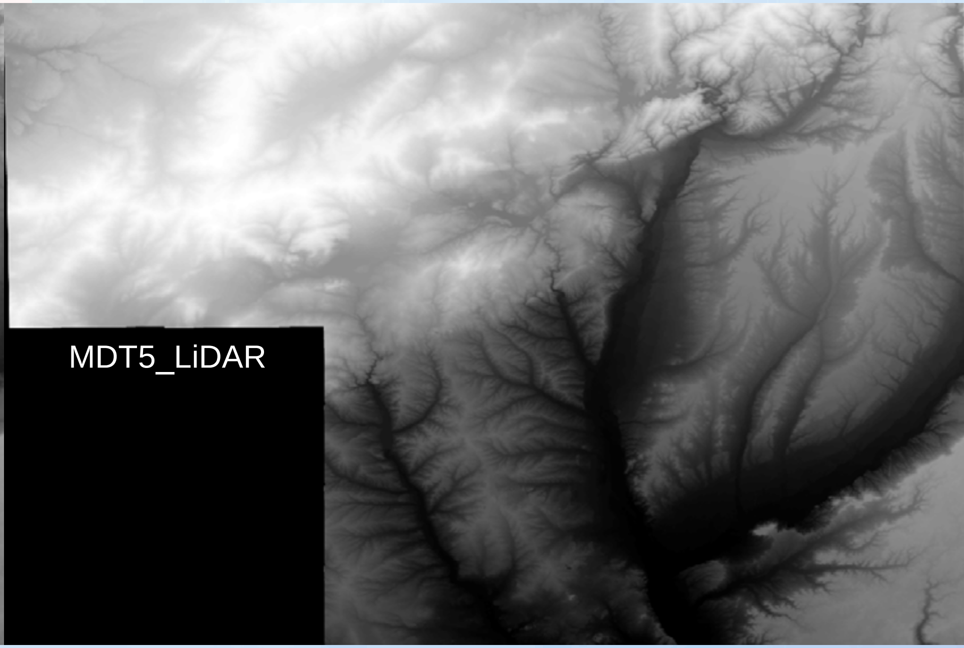
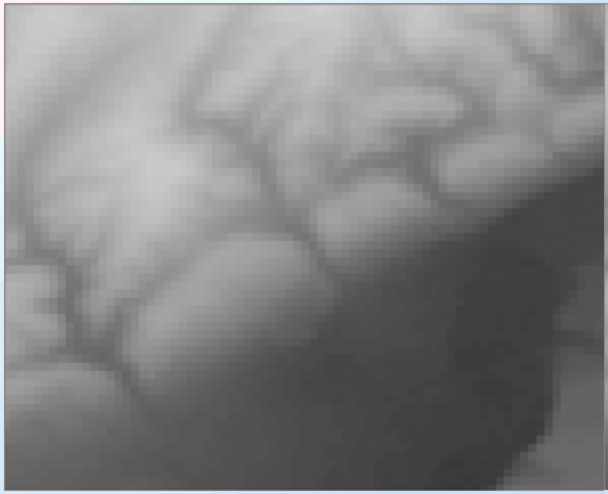
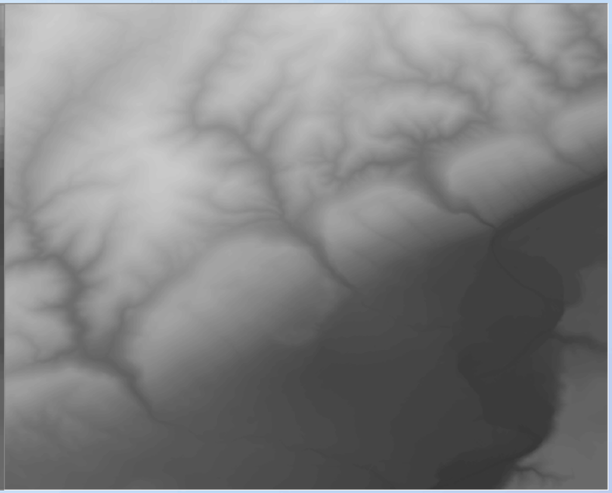
Continuous ground truth data used – MDT5_LiDAR (DSM)





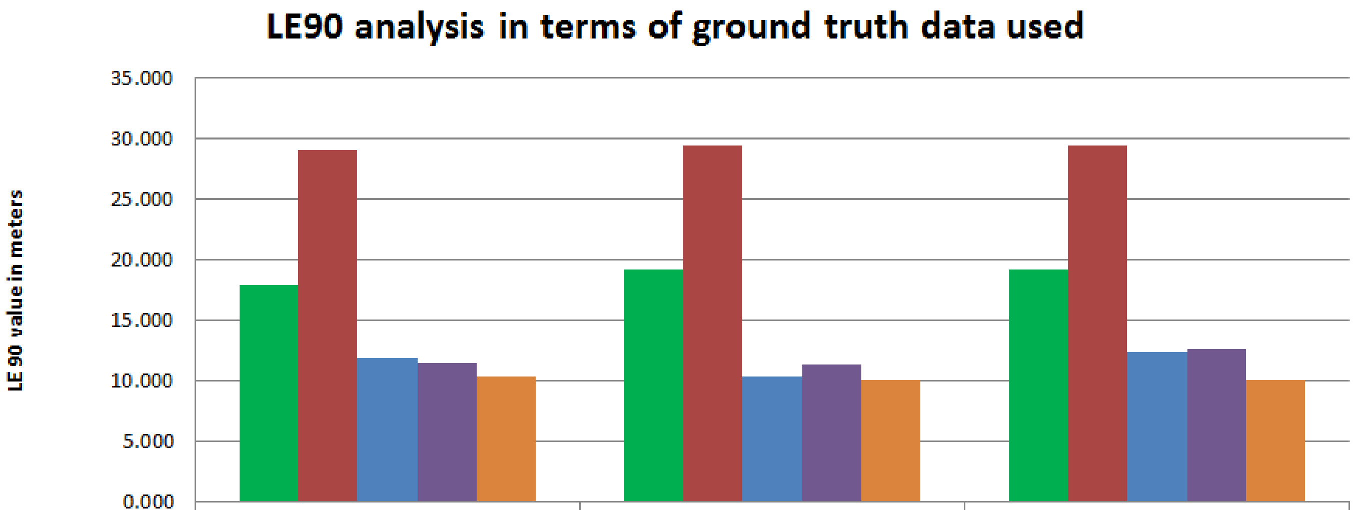
-Geographic WGS84.
-Geoid: EGM96.
-GSD: 90m.
-Interferometry derived.
-Vertical absolute accuracy: 6.2m (Rodriguez et al, 2005)





-UTM h-30 ETRS89 .
-Geoid: EGM08-RedNAP
-GSD: 5m.
-Airborne LiDAR derived: 0.5points/m2.
-Vertical absolute accuracy: 1m

Discrete analysis – Results
(Comparison with previous versions of SRTM)

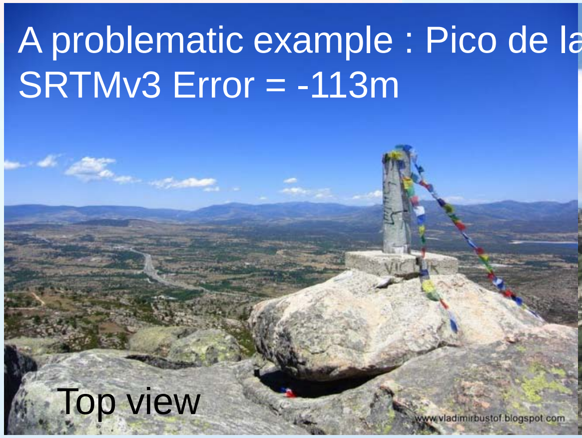


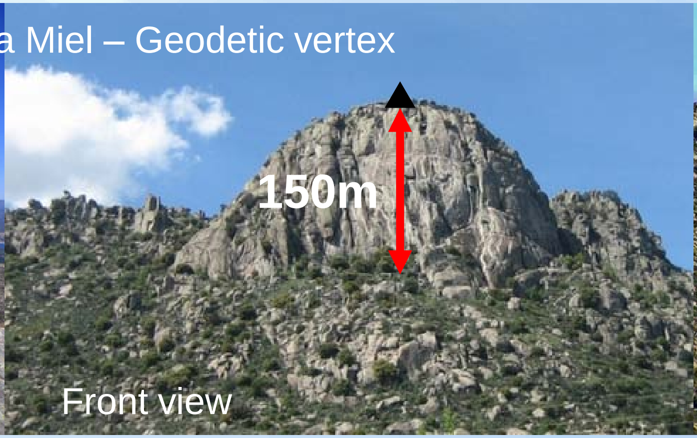
	SRTM CGIAR v4	SRTM V3	SRTM V2_1
Z-Tracks	17.945	19.161	19.161
Geodetic vertex	29.111	29.428	29.447
RedNAP marks	11.902	10.362	12.340
GPS GCPs	11.501	11.377	12.606
Sinthetic Z-Track	10.264	10.072	10.073

-An explanation for the differences in the case of a Geodetic Vertex is the position of this marks in the terrain, usually on the top of hills, mountains or ridges where there are good visibility between them, but this creates problems to the DEMs with high GSD.

-In the case of Z-tracks, some of them have been acquired walking through the mountainous ridges and or in trails along mountain side with high slopes, this also creates problems for DEMs with high GSD.

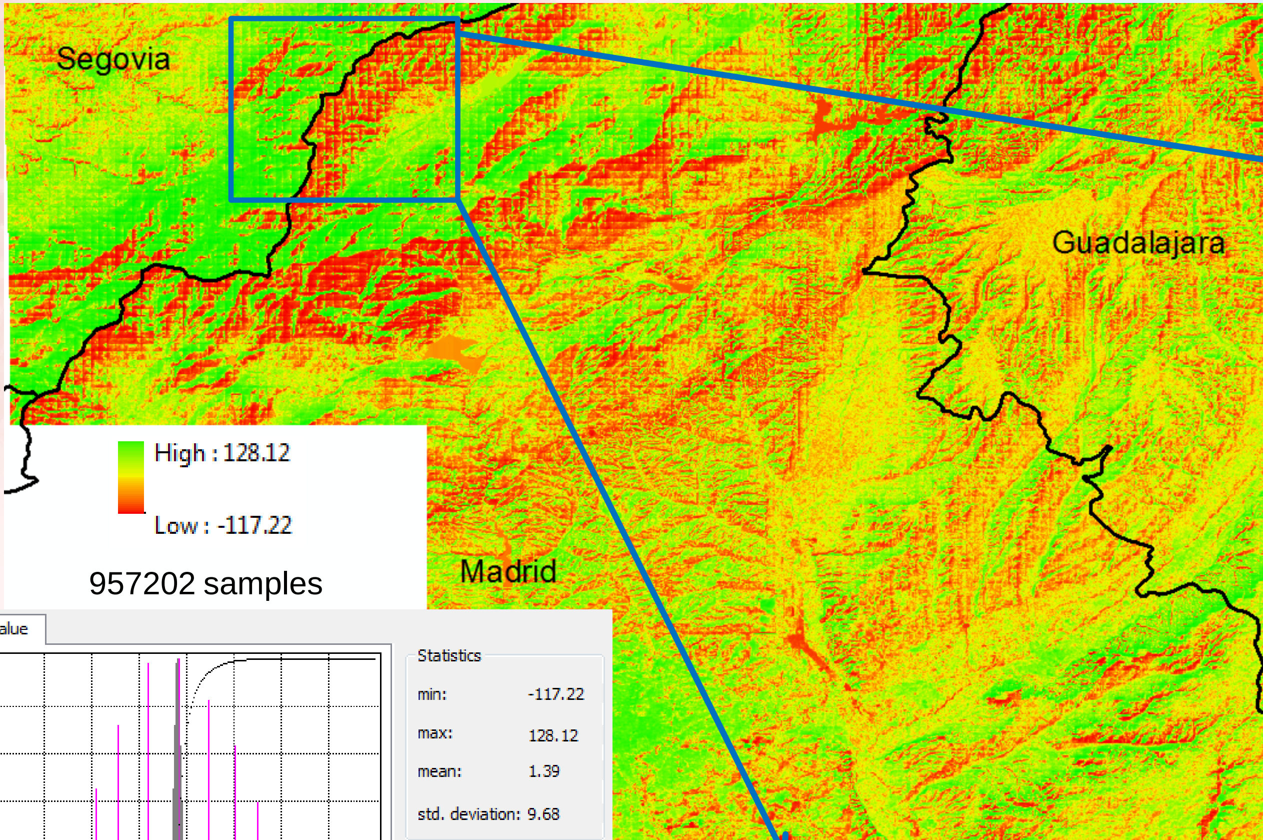
A problematic example : Pico de la Miel – Geodetic vertex
SRTMv3 Error = -113m

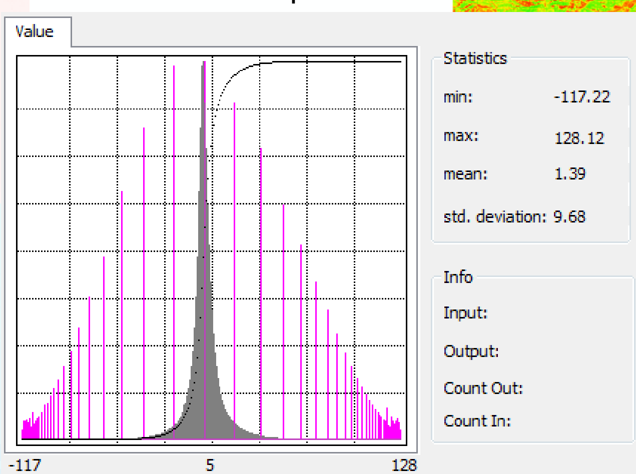


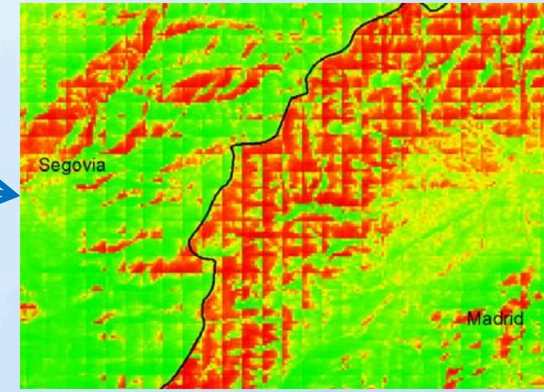


Continuous analysis – Results

(Comparison between SRTMv3 and MDT5_LiDAR DSM)

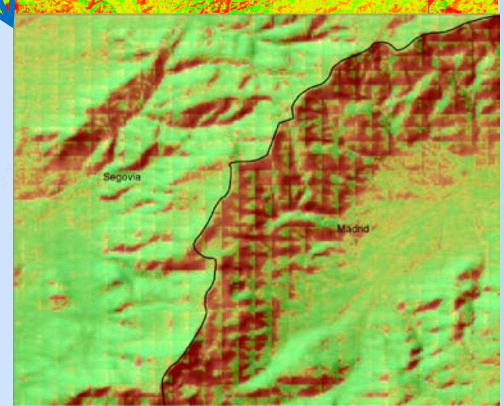






-The pattern that appears in the difference image is related to the construction of the LiDAR DEM, based on small patches of ASCII data over the territory. For full resolution differences (5m GSD) the pattern disappears, but in down-sampled resolution differences (90m GSD) produce sensitive altimetric jumps more visual in areas with high relief.

-Is also remarkable that the co-registration between the mountain ridges and the change in the direction of the error (NW/SE). In this case probably is related to the origin of the SRTM DEM. Radar geometry may cause errors depending on the viewing angle (Layover/foreshortening/Shadow) or ascending/descending orbit. These errors may cause holes that must be filled mainly in shadow areas.



Fusion of shaded relief and difference map allowing to check the correlation between the direction of the error and the orientation of the mountains

CONCLUSIONS

-The use of different sources of ground truth allows us to approximate to the real accuracy of the DEMs.

-Each particular ground truth has their own restrictions in relation to the actual relief and the GSD of the DEM. A more in depth study must be carried out to evaluate the real accuracy of the DEMs in very complex areas and in relation to its building origin.

-Traditionally, ground truth sources avoid the use of measurements in high relief areas (difficult access). A complete validation must take into account all the natural scenarios available in a validation area in terms of make realistic validation of DEMs.

-SRTM v3 in the AOI of Madrid doesn´t show remarkable improvements with respect to its predecessor SRTM V2_1. Mainly because there are few holes interpolated in the area with the source GDEMv2 and other sources.

-The accuracy over high relief areas can be degraded up to 3 times the accuracy over flat areas in the case of SRTMv3. (see Synthetic Z-track vs Geodetic vertex ground truth sources).

TanDEM-X: Science Activities

Irena Hajnsek[1/2] and Thomas Busche[1]

1 Microwaves and Radar Institute, DLR
2 Institute of Environmental Engineering, ETH

Oberpfaffenhofen, Feb 2014

DLR

Announcements of Opportunity

Science Opportunities for the following products:

Announcements (release date, closing date)

- **Intermediate DEM** (from first global coverage, difficult terrain excluded, for selected regions only) **5.12.13, 14.3.14**
- **CoSSC** from the global DEM acquisition **5.12.13, 14.3.14**

- **TanDEM-X DEM** **Summer 2014**

DEM Products for Scientific Use

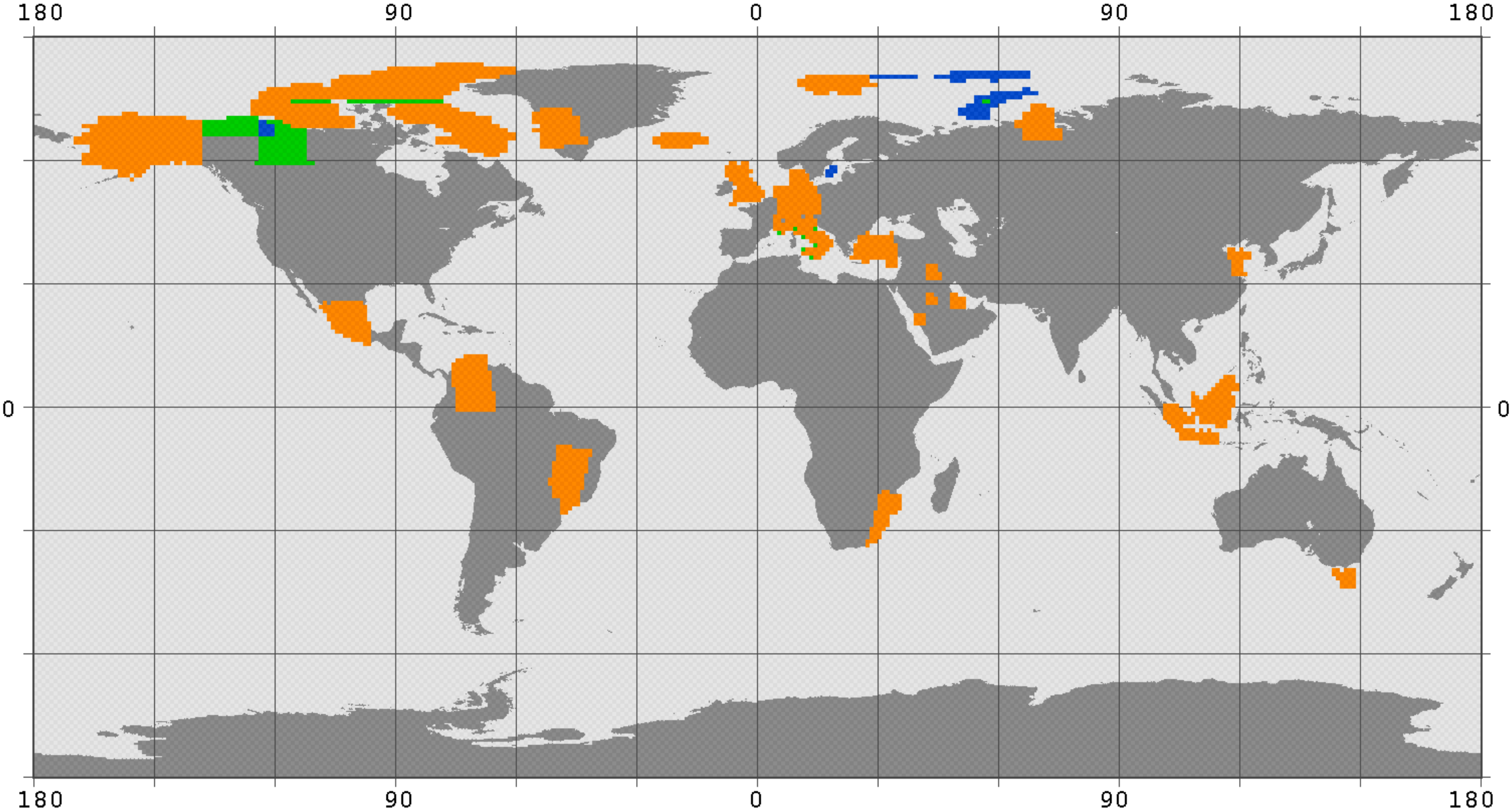
Intermediate DEM (no global coverage)

DEM Product	Spatial Resolution Absolute	Horizontal Accuracy CE90	Absolute Vertical Accuracy LE90	Relative Vertical Accuracy
IDEM (intermediate DEM)	~12m (0.4 arcsec @ equator	<10m	<10m	Not specified
IDEM (1 arcsec)	~30 m (1 arcsec @ equator)	<10m	<10m	Not specified
IDEM (3 arcsec)	~90 m (3 arcsec @ equator)	<10m	<10m	Not specified

DLR

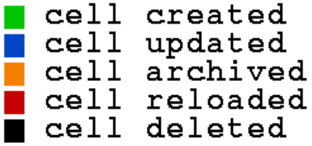
Mon Jul 8 05:51:11 2013

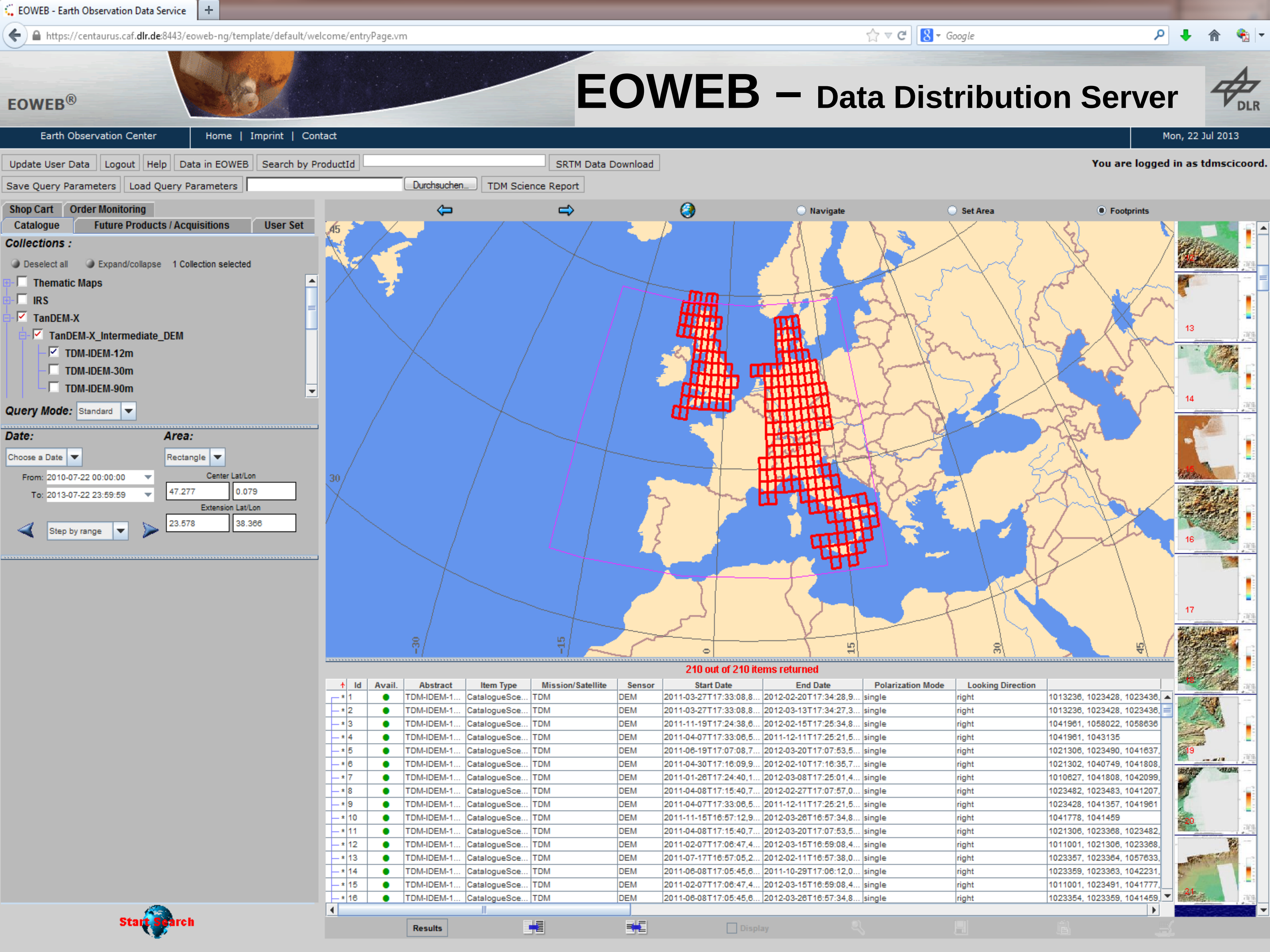
Intermediate DEM (IDEM): Distribution



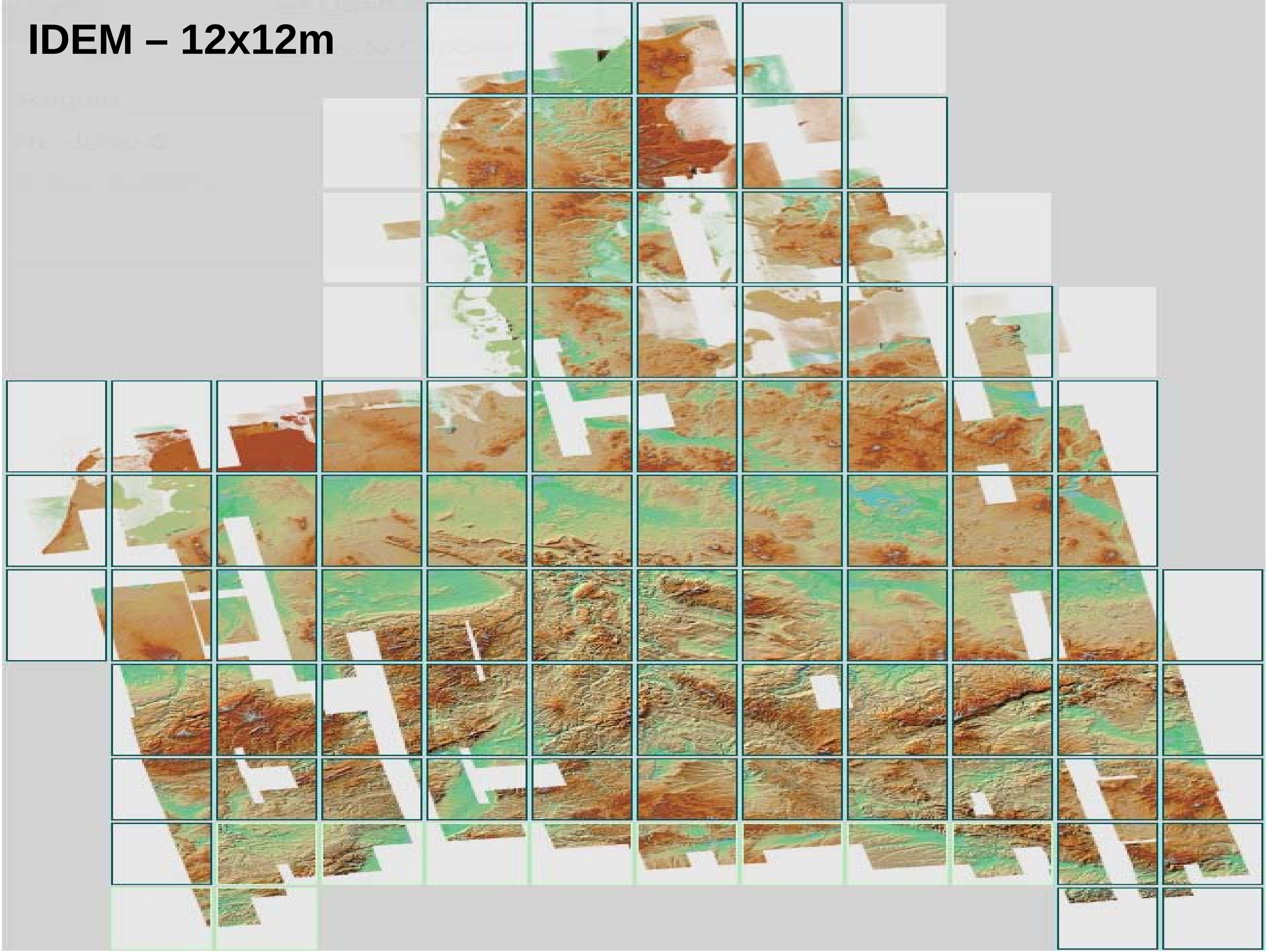
Investigated area: ul-lr lon/lat -180 90 - 180 -90

Found cells: 2697
Total kbytes: 1517837008
Covered skm: 12656286.0




EOWEB - Earth Observation Data Service
https://centaurus.caf.dlr.de:8443/eoweb-ng/template/default/welcome/entryPage.vm
EOWEB®
EOWEB – Data Distribution Server
DLR
Earth Observation Center
Home | Imprint | Contact
Mon, 22 Jul 2013
Update User Data
Logout
Help
Data in EOWEB
Search by ProductId
SRTM Data Download
You are logged in as tdmscicoord.
Save Query Parameters
Load Query Parameters
Durchsuchen...
TDM Science Report
Shop Cart
Order Monitoring
Catalogue
Future Products / Acquisitions
User Set
Collections :
Deselect all
Expand/collapse
1 Collection selected
Thematic Maps
IRS
TanDEM-X
TanDEM-X_Intermediate_DEM
TDM-IDEM-12m
TDM-IDEM-30m
TDM-IDEM-90m
Query Mode: Standard
Date:
Choose a Date
From: 2010-07-22 00:00:00
To: 2013-07-22 23:59:59
Step by range
Area:
Rectangle
Center Lat/Lon
47.277
0.079
Extension Lat/Lon
23.578
38.366
Start Search
Navigate
Set Area
Footprints
210 out of 210 items returned
Id | Avail. | Abstract | Item Type | Mission/Satellite | Sensor | Start Date | End Date | Polarization Mode | Looking Direction
1 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-03-27T17:33:08,8... | 2012-02-20T17:34:28,9... | single | right | 1013236, 1023428, 1023436,
2 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-03-27T17:33:08,8... | 2012-03-13T17:34:27,3... | single | right | 1013236, 1023428, 1023436,
3 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-11-19T17:24:38,6... | 2012-02-15T17:25:34,8... | single | right | 1041961, 1058022, 1058636
4 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-04-07T17:33:06,5... | 2011-12-11T17:25:21,5... | single | right | 1041961, 1043135
5 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-06-19T17:07:08,7... | 2012-03-20T17:07:53,5... | single | right | 1021306, 1023490, 1041637,
6 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-04-30T17:16:09,9... | 2012-02-10T17:16:35,7... | single | right | 1021302, 1040749, 1041808,
7 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-01-26T17:24:40,1... | 2012-03-08T17:25:01,4... | single | right | 1010627, 1041808, 1042099,
8 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-04-08T17:15:40,7... | 2012-02-27T17:07:57,0... | single | right | 1023482, 1023483, 1041207,
9 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-04-07T17:33:06,5... | 2011-12-11T17:25:21,5... | single | right | 1023428, 1041357, 1041961
10 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-11-15T16:57:12,9... | 2012-03-26T16:57:34,8... | single | right | 1041778, 1041459
11 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-04-08T17:15:40,7... | 2012-03-20T17:07:53,5... | single | right | 1021306, 1023368, 1023482,
12 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-02-07T17:06:47,4... | 2012-03-15T16:59:08,4... | single | right | 1011001, 1021306, 1023368,
13 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-07-17T16:57:05,2... | 2012-02-11T16:57:38,0... | single | right | 1023357, 1023364, 1057633,
14 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-06-08T17:05:45,6... | 2011-10-29T17:06:12,0... | single | right | 1023359, 1023363, 1042231,
15 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-02-07T17:06:47,4... | 2012-03-15T16:59:08,4... | single | right | 1011001, 1023491, 1041777,
16 | TDM-IDEM-1... | CatalogueSce... | TDM | DEM | 2011-06-08T17:05:45,6... | 2012-03-26T16:57:34,8... | single | right | 1023354, 1023359, 1041459,
Results
Display

IDEM – 12x12m



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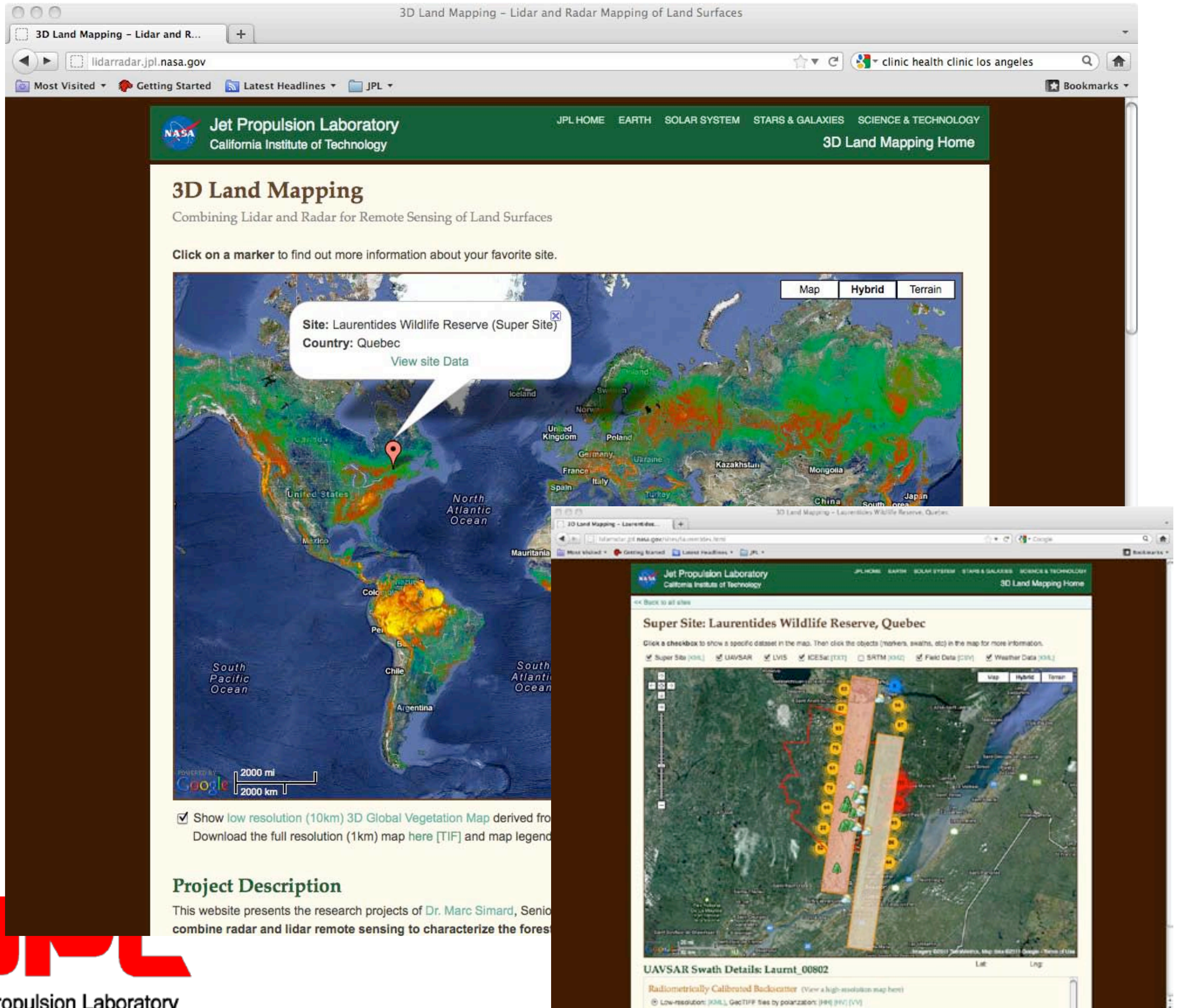
The Laurentides cal/val Super Site http://lidarradar.jpl.nasa.gov



- Goal is to provide public data for cal/val of DEM and canopy structure RS products
- Easy data download
- Website will be upgraded in March
- New data sets being added
- New cal/val sites planned

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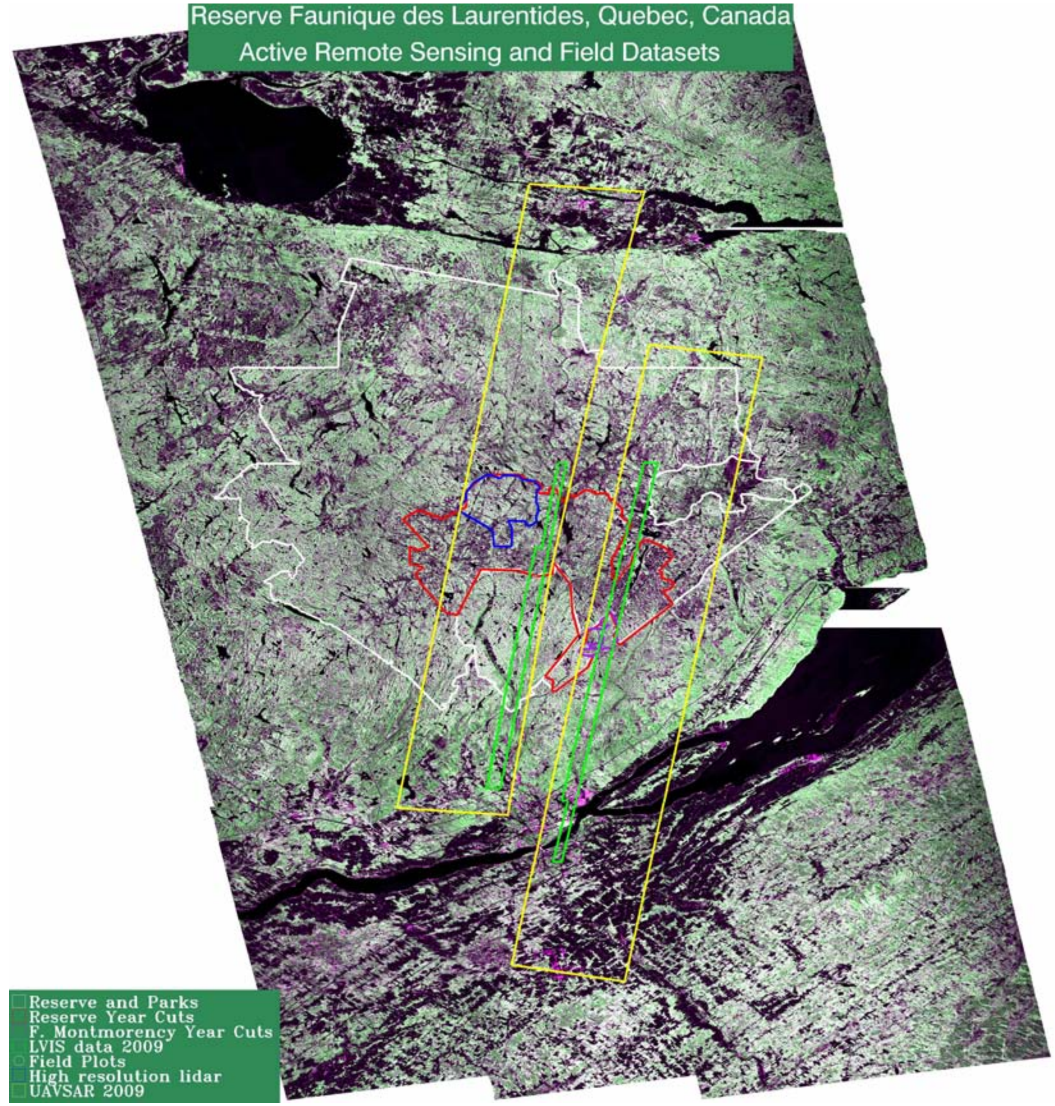
A Cal/Val Super Site for Active Remote Sensing Platforms

Réserve Faunique des Laurentides (Québec, Canada) proposed at CEOS 2010

- Laurentides
  - 1000m elevational gradient
  - Temperate tp boreal forests
  - National Parks
  - Experimental forests
  - Large scale lumber management
  - Public access to all sites
- Available Data
  - Airborne radasr:
    - repeat-pass UAVSAR (Multi-temporal)
    - DBSAR (GSFC)
  - Airborne Lidars :
    - LVIS,
    - SIMPL (being processed)
    - high resoltion commercial optech.
  - Airborne hyperspectral:
    - CAR (GSFC)
  - Spaceborne:
    - ICESat/GLAS,
    - ALOS/PALSAR
    - MODIS, LANDSAT
    - SRTM
    - **TanDEM-X (co-Is)**
  - Field
    - Canopy structure
    - GPS/GCP field elevation data
    - Weather data
    - Government/industry participation
    - Stand age
  - Real Time Weather data



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NASADEM Objectives

Buckley, Simard, Crippen, Hensley, Kobrick, Rosen, +

1. Reprocess SRTM data from raw sensor measurements with several enhancements to the original processing algorithms and including an integrated ICESat control to produce an SRTM DEM with improved spatial resolution, vertical accuracy and geographic coverage
2. Fill voids and merge the new SRTM DEM with ASTER/GDEM2 and ICESat control to create a spatially continuous global one-arcsecond DEM product
3. Create new SRTM- and DEM-related products such as pixel-based **elevation error** propagated from SRTM system parameters; **estimated vegetation bias maps**; radar backscatter imagery; interferometric coherence; and DEM slope, aspect and curvature

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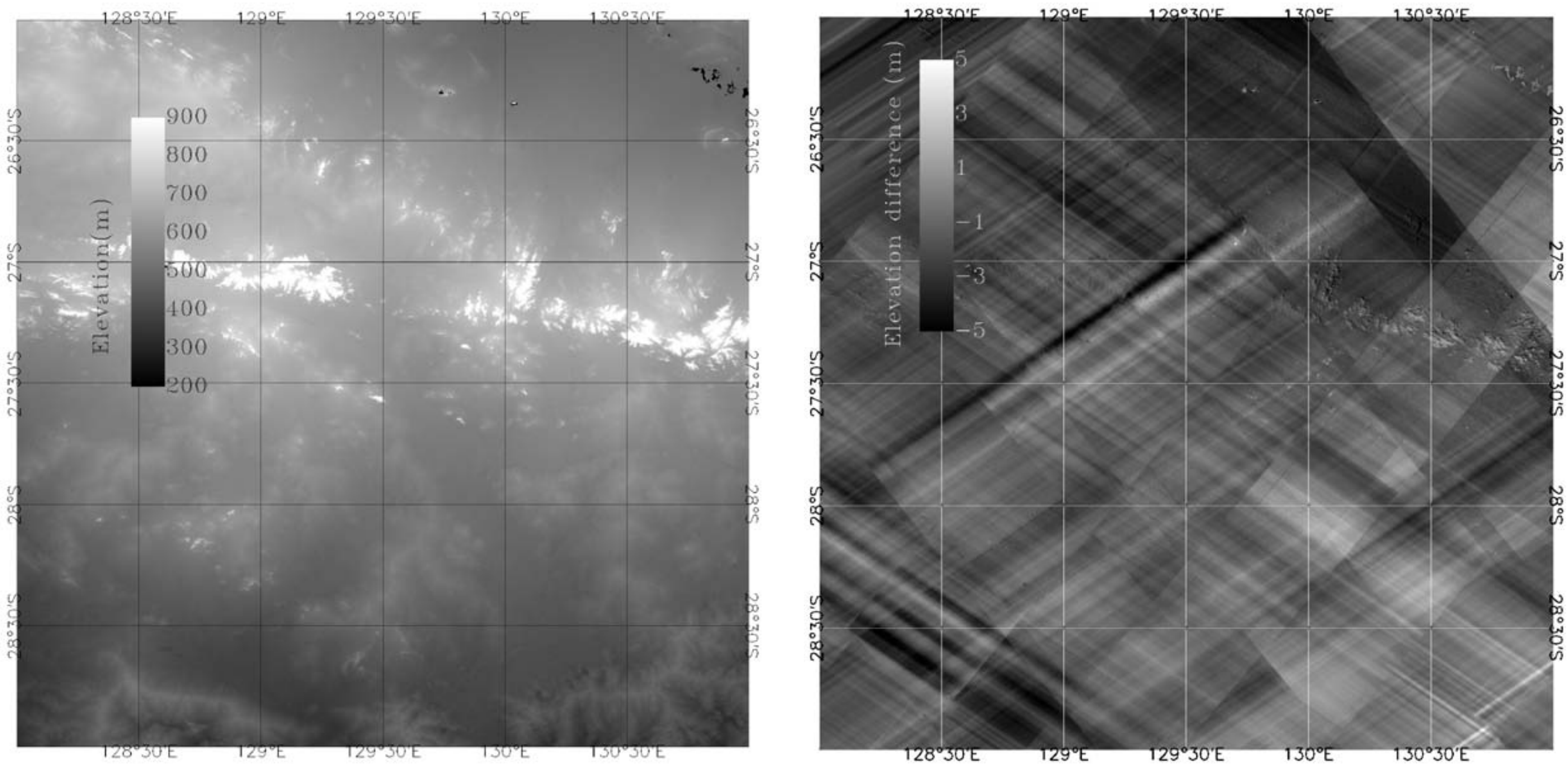
Example of SRTM re-processing
Elevation Ripple Removal



Left: New SRTM DEM over central Australia. Right: Correction (difference) between the new and original SRTM DEM. The crisscross pattern results from merging several SRTM ascending and descending passes containing artifacts. The ripples along each radar strip are removed with our new approach incorporating ICESat/GLAS data.

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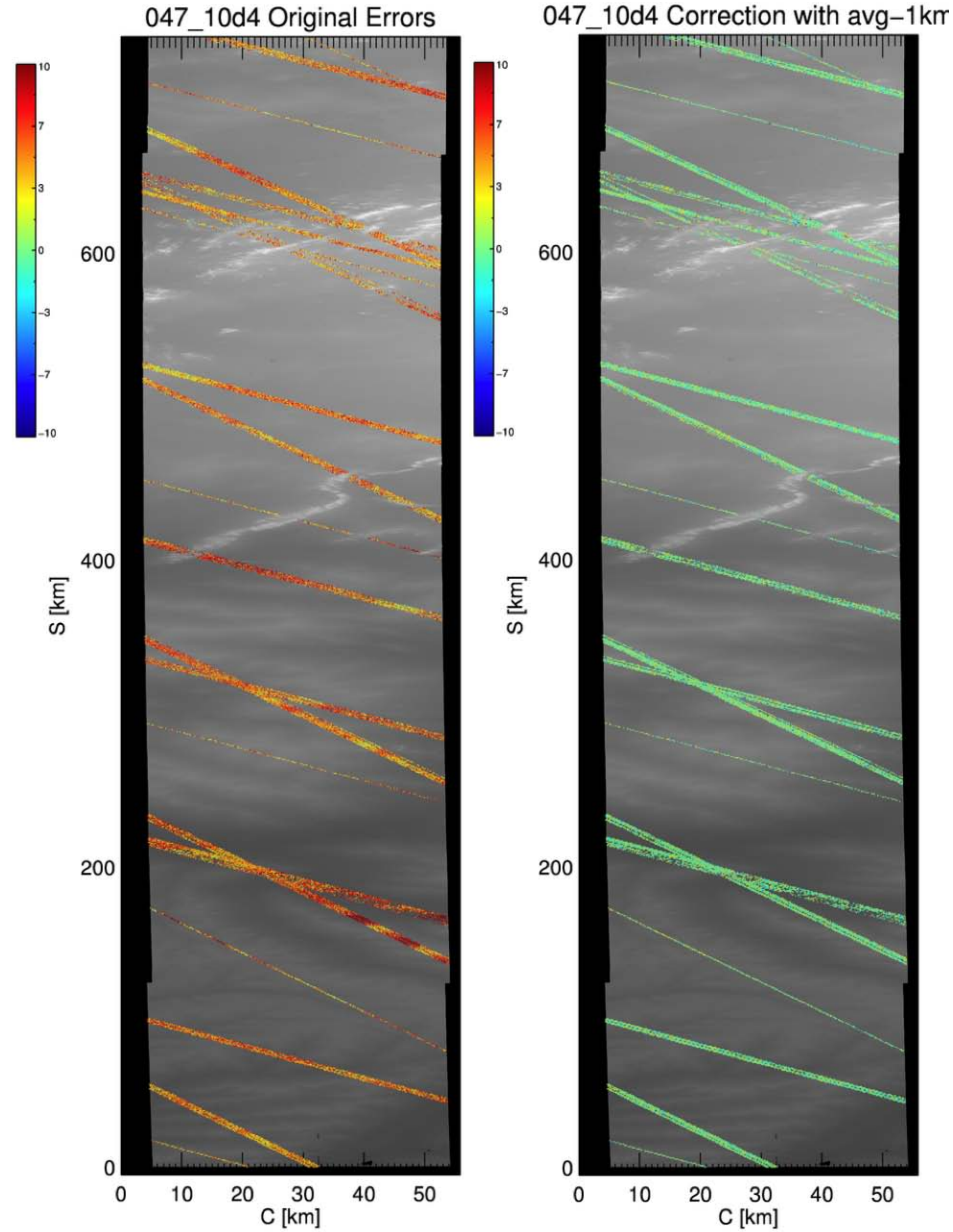
Overplotting estimated errors (left) and residual errors after correction (right) on the strip DEM map.



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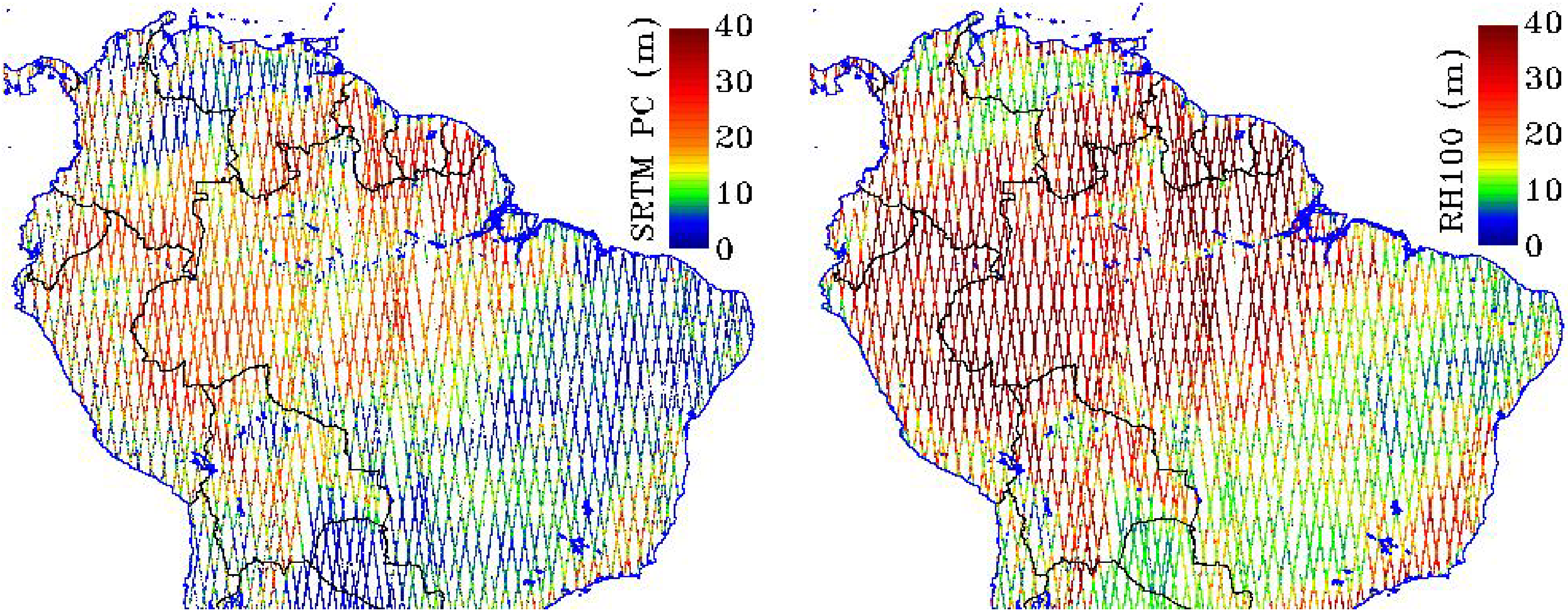
Canopy Height Bias from ICESAT and SRTM



- a) SRTM phase center (PC) bias due to forest canopy above ground elevation below canopy (i.e. GLAS RH0). b) Top canopy height from GLAS RH100

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POLITECNICO DI MILANO
DICA,
Laboratorio di Geomatica
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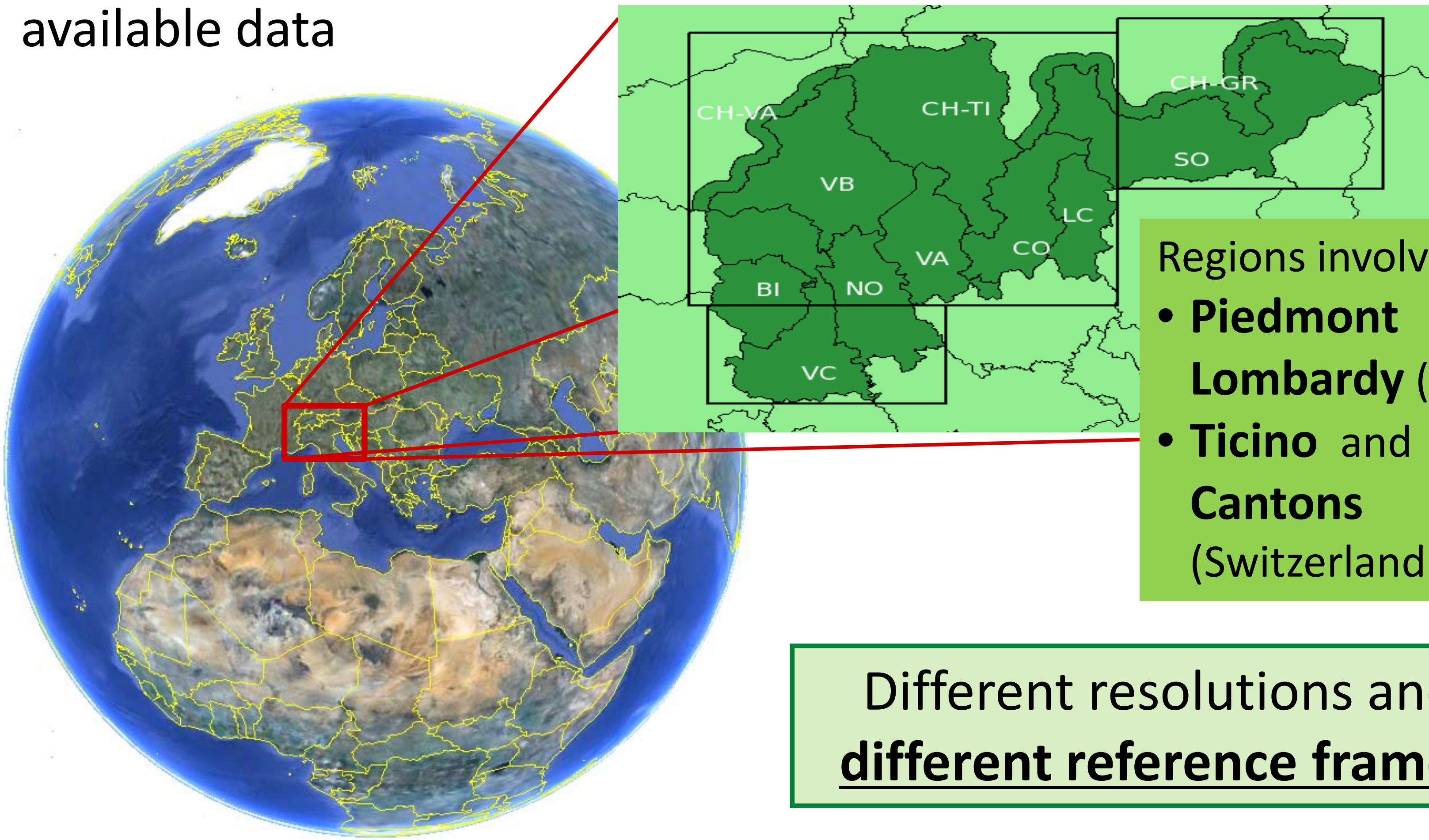
Merging of regional DTMs:
the HELI-DEM project, problems and solutions

Ph.D supervisor: **Ludovico Biagi**
Ph.D tutor: **Sansò Fernando**

Ph.D student: **Laura Carcano**

Aim: development of a multiresolution DTM for the alpine area between Italy and Switzerland, produced by integrating all of the available data



Regions involved:

- **Piedmont** and **Lombardy** (Italy),
- **Ticino** and **Grigioni Cantons** (Switzerland)

Different resolutions and **different reference frames**

Steps:

To achieve the goal of the project

Alignment of the DTMs to the same reference frame

Comparison between cross-border Low Resolution DTMs (similar resolutions)

Analysis of bias, variances and spatial correlations

LR DTMs validation using High Resolution DTMs

External validation using GNSS (RTK surveys)

Re-gridding of the DTMs on a unique base - creation of the final unified DTM

Web publication of the final DTM

Additional analyses after the conclusion of the project

Study and implementation of a different method to merge

different DTMs on a unified grid

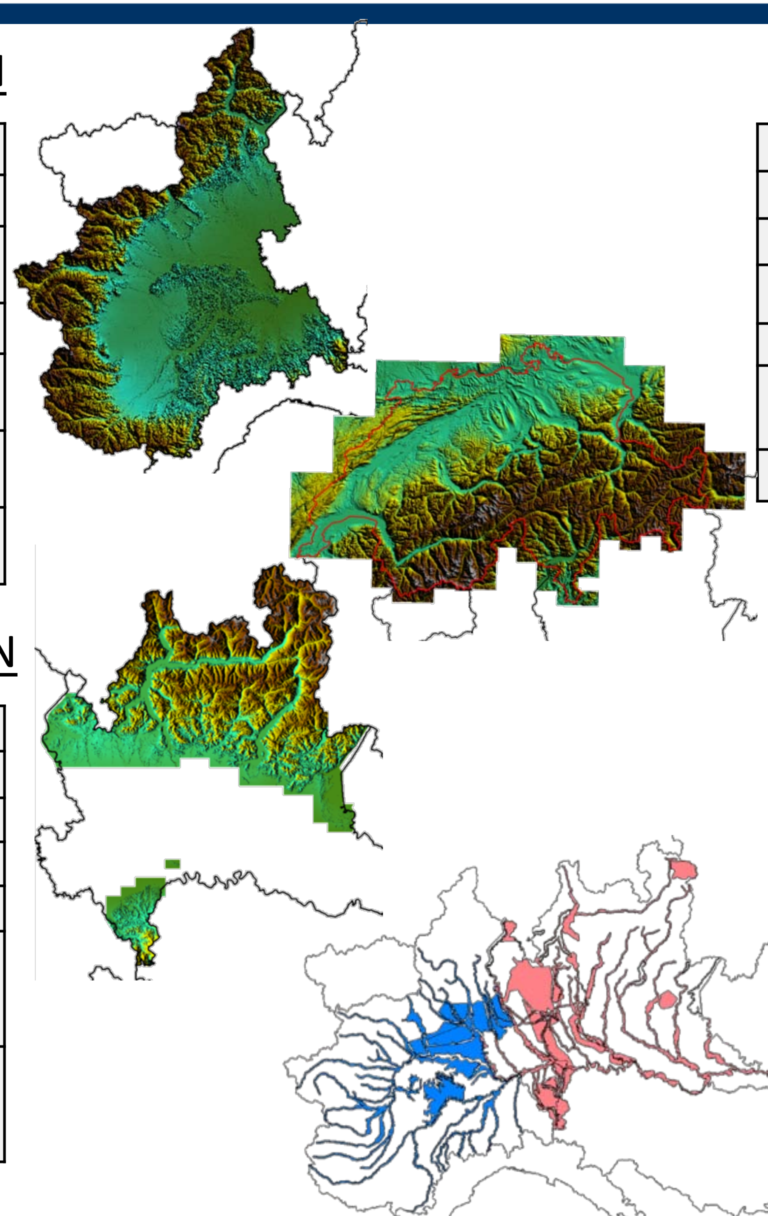
Available data

DTM Piedmont region

Resolution: 50 metres / 5 metres
Extension: Piedmont region
Year of creation: ’90s (re-organised in 2003)
Data source: photogrammetry
Reference system: WGS84 - IGM95 (ETRF89)
Coordinate system: UTM fuse 32, orthometric heights
Accuracy: 2.5 m (in height), 4 m (in planimetry)

DTM Lombardia region

Resolution: 20 metres
Extension: Lombardy region
Year of creation: 2002
Data source: cartography
Reference system: Roma40
Coordinate system: Gauss-Boaga fuse Ovest, orthometric heights
Accuracy: 5-10 m (in height), 2 m (in planimetry)



DTM SwissTopo

Resolution: 25 metres (1” sexagesimal)
Extension: Switzerland
Year of creation: 2001
Data source: cartography and contour maps
Reference System: ETRS89
Coordinate system: geographic, orthometric heights LN02
Accuracy: 1.5 - 3 m (in height)

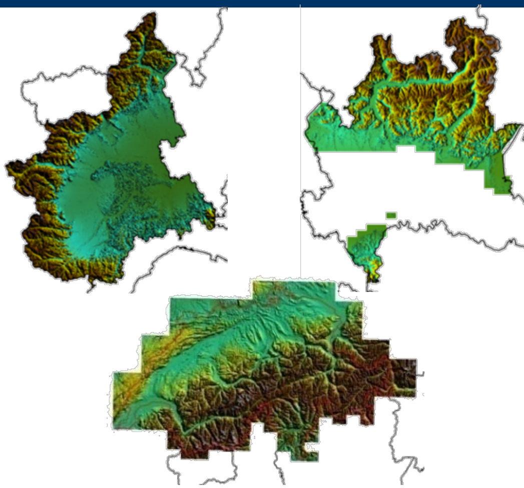
DTM LIDAR

Hydrographic basins

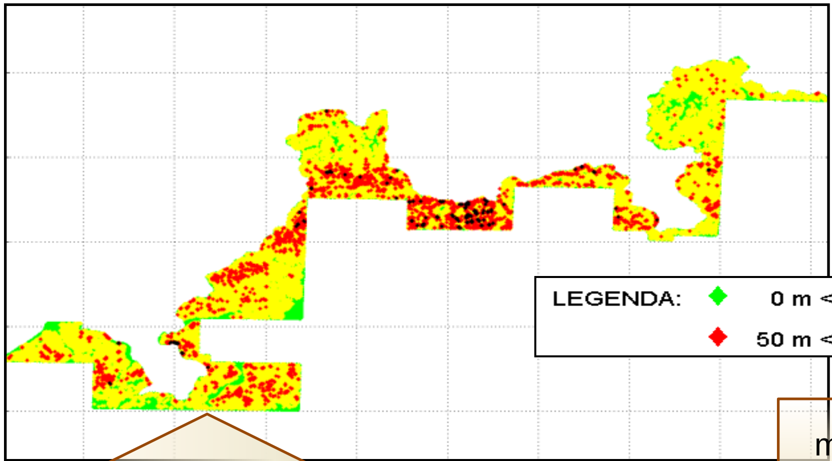
Resolution: 1 metre (0.00001 sexadecimal degrees)
Extension: Piedmont and Lombardy – main idrographic basins
Year of creation: currently in realization
Data source: LiDAR
Reference system: WGS84-IGM95 (ETRF89)
Coordinate system: geographic, orthometric heights
Accuracy: ~ 1 m (in height)

Comparison between cross-border LR DTMs

1) DTM Switzerland 25 m VS. DTM Lombardy 20 m
2) DTM Switzerland 25 m VS. DTM Piedmont 50 m
3) DTM Piedmont 50 m VS. DTM Lombardy 20 m



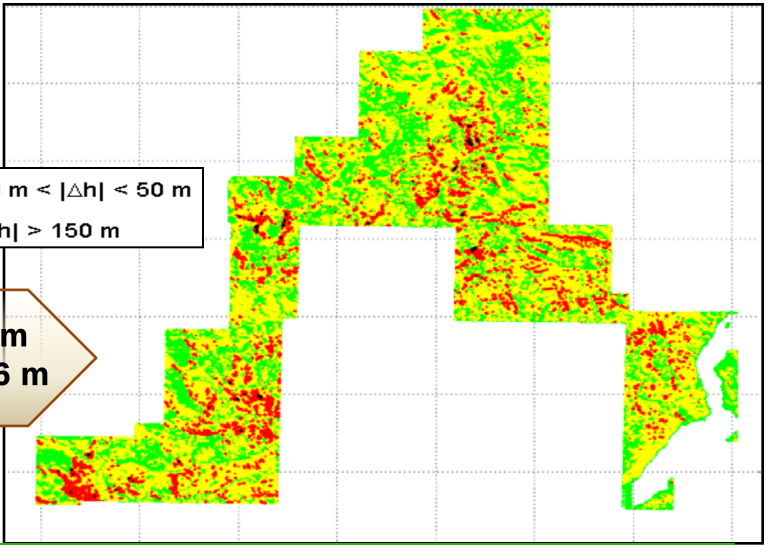
SWITZERLAND 25m – LOMBARDY 20m



mean = **-0.1 m**
std = **±19 m**

LEGENDA: 0 m < |Δh| < 10 m; 10 m < |Δh| < 50 m; 50 m < |Δh| < 150 m; |Δh| > 150 m

SWITZERLAND 25m – PIEDMONT 50m



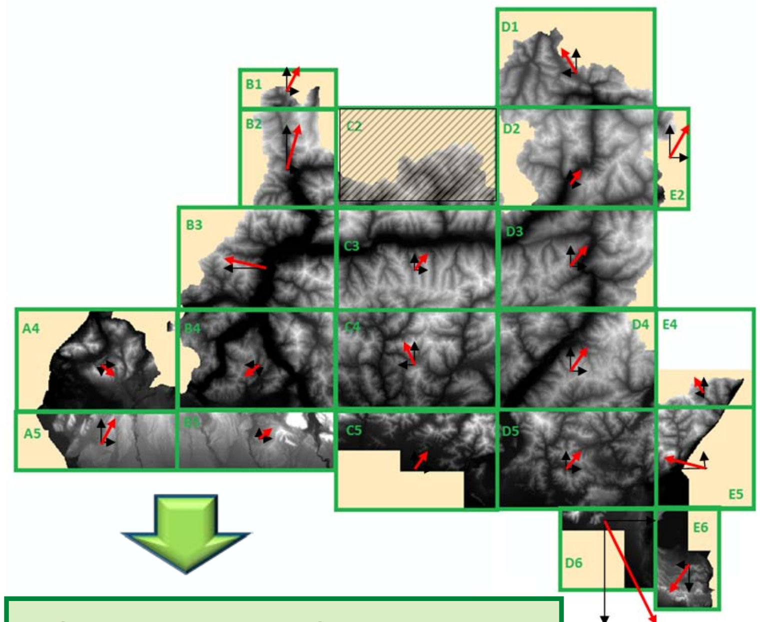
mean = **1.3 m**
std = **± 26 m**

No correlation between differences and elevations/slopes

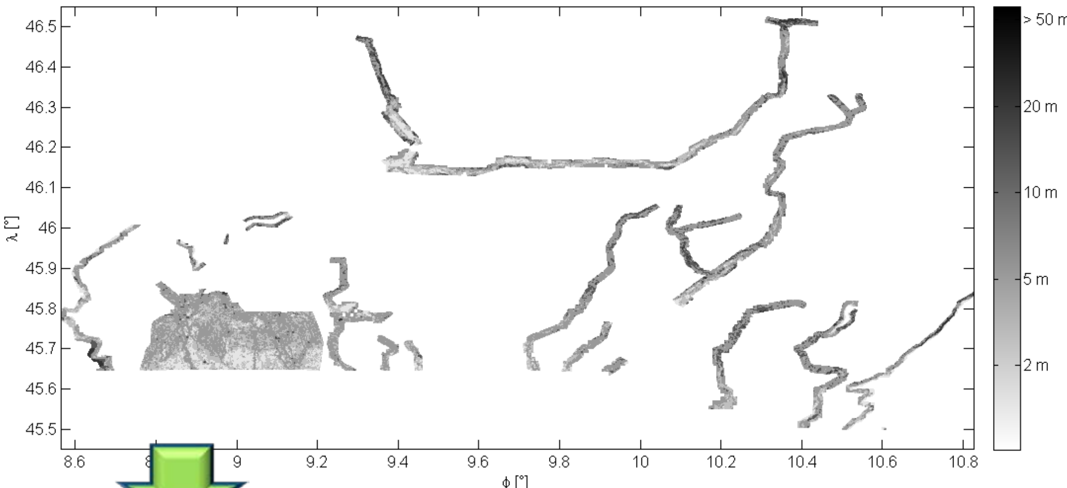
LR DTMs validation using HR DTMs

LOMBARDY DTM 20 M RESOLUTION - LIDAR DTM 1 M RESOLUTION

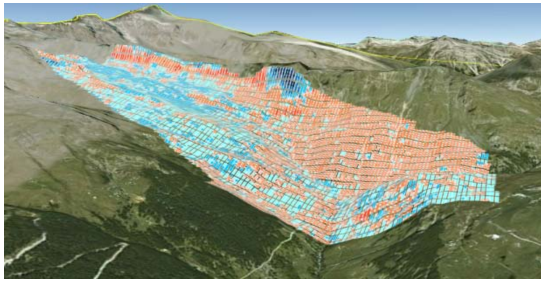
- Prediction of the LiDAR DTM on the Lombardy DTM nodes
- Comparison between the two elevations
- Least squares estimation of the planimetric translation between the Lombardy DTM and the LiDAR DTM



There is no planimetric translation or height bias.



Differences have zero mean, but local, spatially correlated biases exist

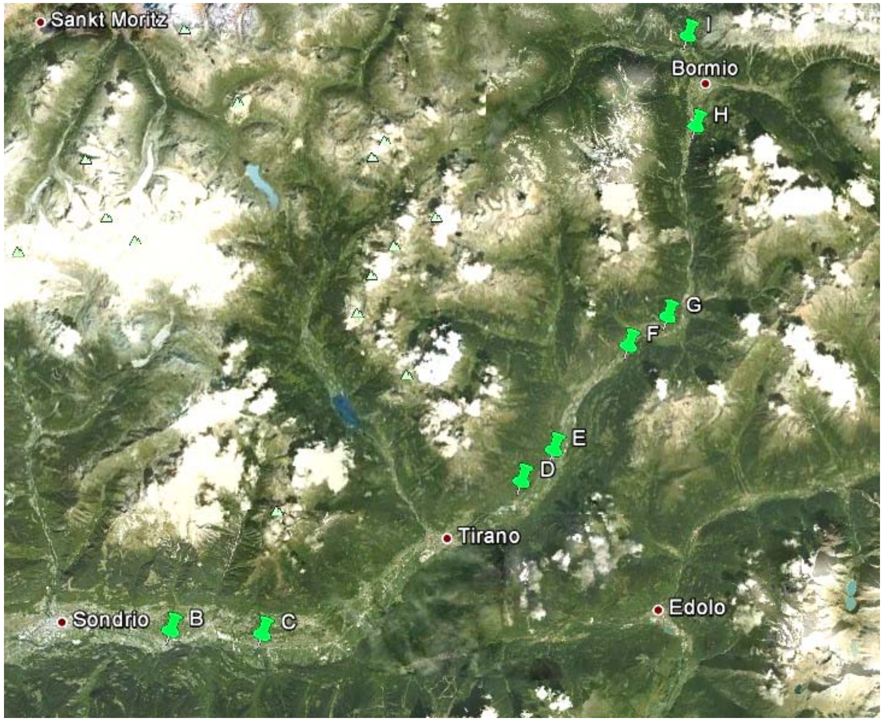


External validation of LiDAR DTM using GNSS (RTK surveys)

- Selection of 8 areas in Valtellina (Lombardy) with differences between LiDAR and Lombardy DTMs **higher than 10 m**
- RTK surveys on **predefined trajectories** (country roads, river banks)
- Fast static (**5 seconds**) points every 30 metres in flat areas, denser on slopes
- RTK surveys connected to a permanent network positioned ad-hoc for the project

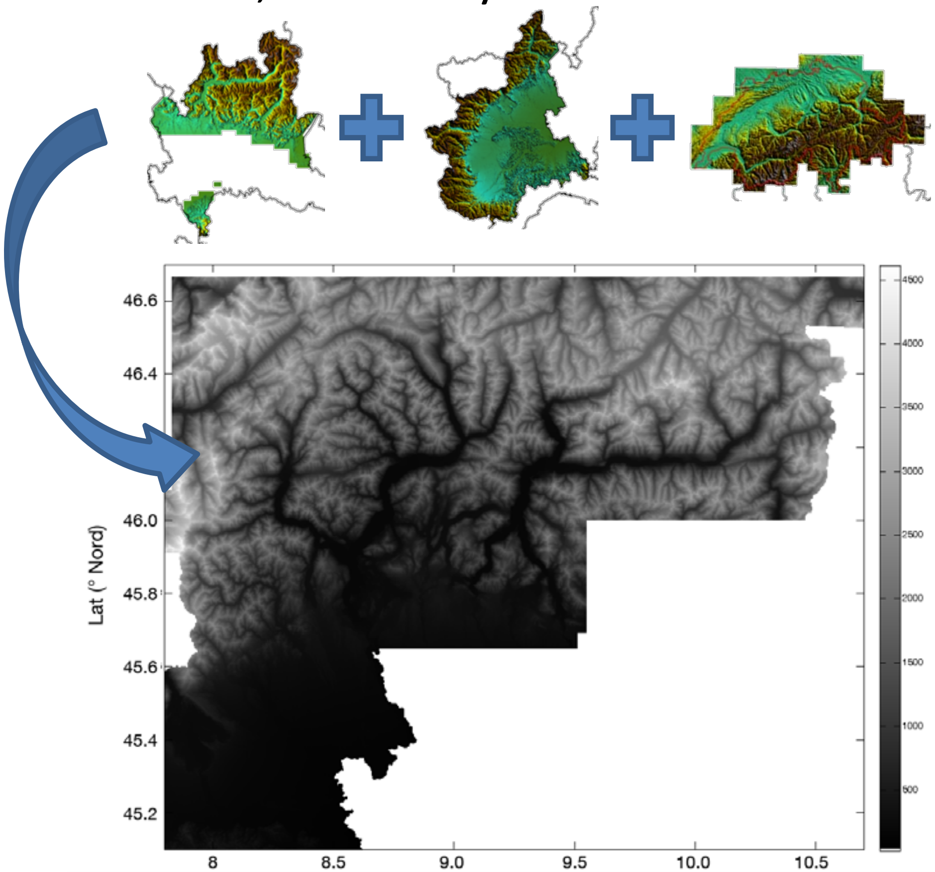
Several outliers (|Δh|>100cm) probably due to non optimal GNSS survey conditions

Despite the presence of several pointwise outliers, the LiDAR DTM is consistent with the RTK results



Creation of the final unified DTM

Interpolation onto the final grid of the three low/medium resolution DTMs of Piedmont, Lombardy and Switzerland



600,000,000 input nodes

116,000,000 nodes of the final output grid

IMPLEMENTED PROCEDURE:

- Transformation of the three DTMs to the final reference frame
- Independent interpolation of the three DTMs onto the nodes of the output unified grid (**BICUBIC** interpolation surface)
- Average of the elevations inside the overlapping areas

CHARACTERISTICS:

REFERENCE FRAME: **ETRF2000**

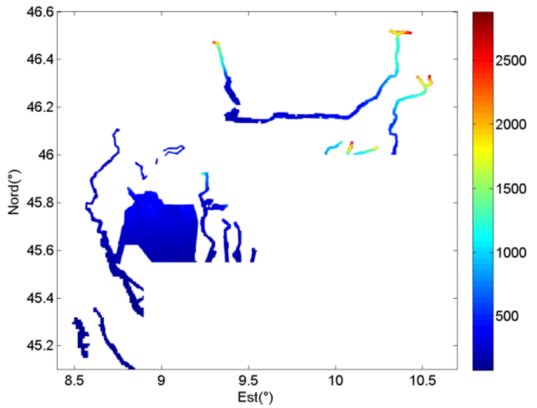
COORDINATE SYSTEM: **geographic**

PLANIMETRIC RESOLUTION: **ϕ= 2*10^{-4} ° (~22 m)**

λ = 2*10^{-4} ° (~15 m)

Correction of the final unified HELI-DEM DTM with HR data

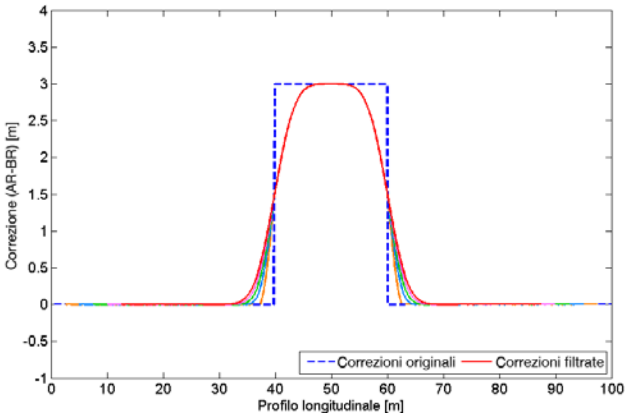
Use of the LiDAR HR data to correct the unified LR HELI-DEM DTM in area where LiDAR DTMs exists



Computation of the differences between HR and LR DTMs

The simple addition of the differences to the LR DTM can introduce jumps

The problem can be solved by filtering appropriately the differences before their application → filter that allows to maintain LiDAR data unchanged as much as possible and that acts mainly at the borders (numeric implementation by Fast Fourier Transform)



After the application of the filter, the elevations of the corrected DTM are more consistent with the LiDAR DTM

Conclusions and future analyses

- ✓ The unified DTM produced by the merging of the regional DTMs is free and downloadable through a geoservice ad hoc created (www.helidemdataserver.como.polimi.it)

- ✓ During the production of the final DTM, advantages and problems of different literature approaches have been studied

- ✓ In parallel, a different method for the merging of DTMs to create a unified grid have been implemented. This method, which should be optimal, have been implemented in MATLAB and will be implemented in the next months also in the GIS FOSS environment.

GEO Task IN-02: Global Datasets Role for Global DEM

- **IN-02 Earth datasets consist of 2 sub-tasks:**
  - **C1: Advances in Life-cycle Data Management**
  - **C2: Development of Regional/Global Information and Cross-cutting Datasets**
- **IN-02 Point of Contact: Mike Abrams (JPL, ASTER PI)**
- **Proposed on 1-Feb-14 to CEOS Executive Officer, Kerry Sawyer, that activity continue into the next 3 year implementation period under CEOS wing to cover**
  - **2014 release of TanDEM-X DEM at 3 arc-seconds (≈90m)**
  - **2017 release of re-processed SRTM DEM at 1 arc-seconds (≈30m)**
  - **Unknown dates for creation of bathymetry of continental shelves using SAR & high resolution EO, once support is released**

GEO Task IN-02: Global Datasets Activities for Global DEM

- **Global DEM fusion methods**
- **Temporal aspects of DEMs (as the DEMs become higher spatial resolution they become dynamic), e.g. time-tagging metadata**
  - **Vegetation**
  - **Mining**
  - **Ice-sheets**
  - **Urban**
  - **Landslides**
  - **Fracking**
- **Bare-earth DTM extraction methods? Link between land cover and bare earth DTMs**
- **Low contrast methods due to surface low surface roughness and desert (surface penetration)**

GEO Task IN-02: Global Datasets Proposed activities for Global DEM

- Establishment of a global set of 3D GCPs and CCPs (Canopy Control Points)
  - ICESat from NASA-GSFC (waveform processed for retrieval of ToC (Top of Canopy) and Bare Earth (DTM))
  - Global Elevation testing facility (runways)
  - SRTM control data from Marc Simard (JPL)
- Creation of coastal zone 3D models including
  - (a) bathymetry of continental shelves;
  - (b) coastline;
  - (c) uniform co-ordinate reference system for merging land topography (France & US have exemplary projects in this area)
- Biomass retrieval from X, C & L as well as ICESat-II
- Polar areas with specific requirements
- Possibility of joining with Global land cover at 30m?

Global DEM for continental shelves and coastal zones: a new GEO sub-task

- **EO visible/near-IR data can be employed to derive bathymetry for shallow water with low turbidity for depths up to 30m**
- **Turbidity is mapped from ocean colour sensors such as the ESA MERIS and could be used to decide when higher resolution systems such as Landsat-8 or Sentinel-2 could be employed to map water depth**
- **EO SAR high resolution (1-3m) data can be employed to map how swell-wave patterns are transformed and these SAR amplitude images can then be inverted to provide bathymetry as demonstrated by Susanne Lehner and colleagues at DLR/OP**
- **Coastal zones, particularly those with wetlands are extremely difficult to map. Work needs to focus on use of higher resolution VIS/NIR and SAR**

Recommendation to CEOS Plenary: Bathymetry from Space

- **CEOS should encourage its constituent space agencies to provide EO data for TMSG to establish Global test sites for assessing the accuracy and reliability of retrieving continental-shelf bathymetry on 30m grids from EO sensors over sites which are (a) clearwater; (b) turbid water**
- **Existing bathymetry is either non-existent or copyright-bound. Bathymetry is required for retrieval of water-leaving radiance and derived products in Case II waters. Bathymetry also required for modelling tsunami landfall**
- **Endorsement is required to enable TMSG to move forward with a plan to set-up and populate these test sites**
- **Request that CEOS space agencies supply data (e.g. high resolution multispectral visible/NIR, very high resolution SAR (TSX, Cosmo-SkyMEd, Radarsat-2, NASA-NOAA SHOALS) that could be employed to evaluate different approaches for mapping continental shelves**