CEOS-WGCV39 Terrain Mapping Sub-group: Current Status and Future Uncertainty

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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 specifications for the generation of '*standardised terrain surface products with known accuracy'* from similar sensing systems in the context of data continuity,
  - to specify evaluation methods and statistics which give transparent information about the *quality and heritage of terrain models*.
  - To update the current dossier of test sites 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 up to date record of the current status of sensors which produce data for terrain mapping and of the DEMs available.
  - To produce a DEM requirements document with a science rationale, taking into account the output from current space assets.

TMSG Modus Operandi

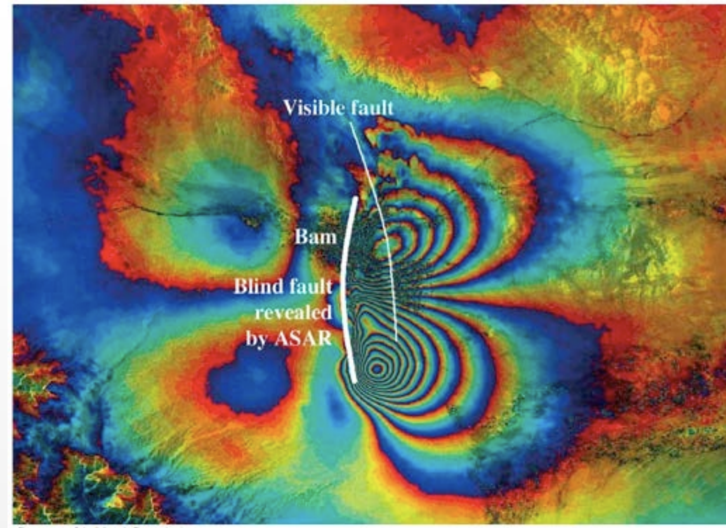
- Terrain mapping SG linked to ISPRS IV/3 on “Global DEM interoperability” and GEO task IN-02-C2.1 on “Global DEM”
- Annual technical workshops as part of an international conference
  - ISPRS Commission IV Symposium, Orlando, FL, 16-18 November 2010
  - 2011 symposium had to be abandoned due to Japanese tsunami
  - Special session at ISPRS Congress, Melbourne, 26 August – 2 September 2012
  - Invited talk & sessions at ISPRS Comm.IV Symposium, Suzhou, 18-20 May 2014
  - Planned sessions at ISPRS 2016 in Prague, Czech Republic, 12-19 July 2016
- News announcements as and when there is relevant news (included news on the release of the SRTM v3 aka SRTM-Plus)
- Emails to collect inputs for WGCV #39 (59 on email list, 4 responses in total)
- Everything done on a “best efforts” basis with minimal funding so limited ambitions to meet specific objectives
- Key goals are the generation of higher spatial resolution spaceborne DEMs (and bathymetric DEMs) and derived DTMs for next generation sensors
- Keen to move forward with studying impacts of DEM uncertainties on derived LPV, IVOS and SAR products

Overview

- Why does GEO need global topography/bathymmetry?
- Current State-of-the-art in DEM production & quality assessment
  - Status of 30m NASADEM (provided by Bob Crippen, JPL)
  - Assessment of UK TanDEM-X (Lang Feng & JPM)
  - Euro-Maps3D (provided by Andreas Uttenthaler, GAF AG)
  - Data fusion using Cosmo-Skymed (provided by M. Liao, Wuhan)
  - Assessment of TanDEM-X i-DEM over CEOS-WGCV test site in Tasmania (provided by Medhavy Thankappan, Geoscience Australia)
- Status of tasks in IN-02-C2.1 Global DEM
- TMSG Future Uncertainty

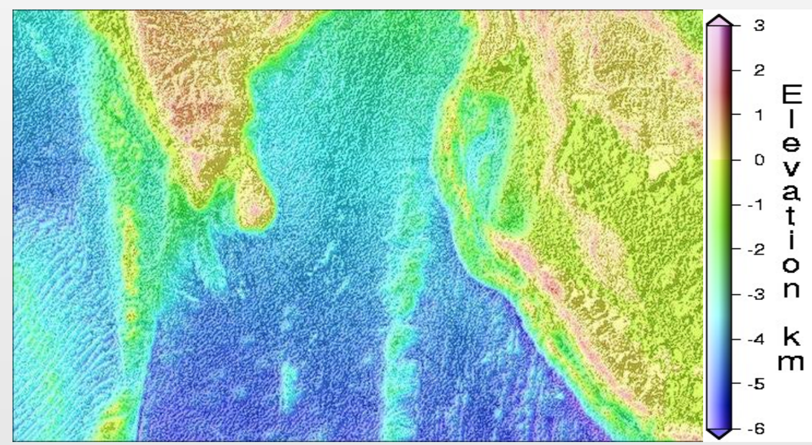
Why does GEO need global topography/bathymmetry?

- *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*
- *Ts* … *entation*



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

NASADEM

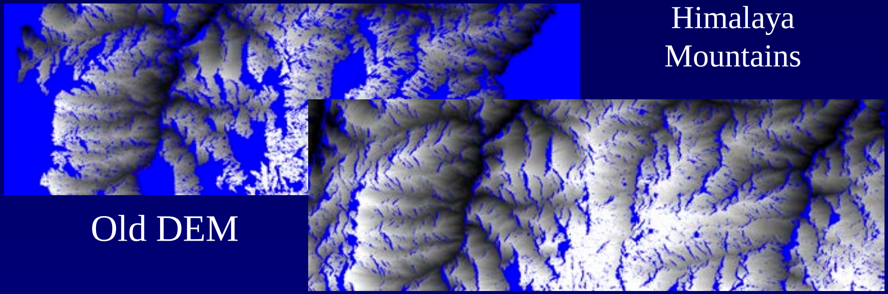
Jet Propulsion Laboratory

"NASADEM" MEaSUREs Primary Tasks

Making Earth Science Data Records for Use in Research Environments

1. Reprocess the SRTM DEM

Use advanced software to reprocess raw SRTM data primarily to reduce the occurrence of DEM voids.



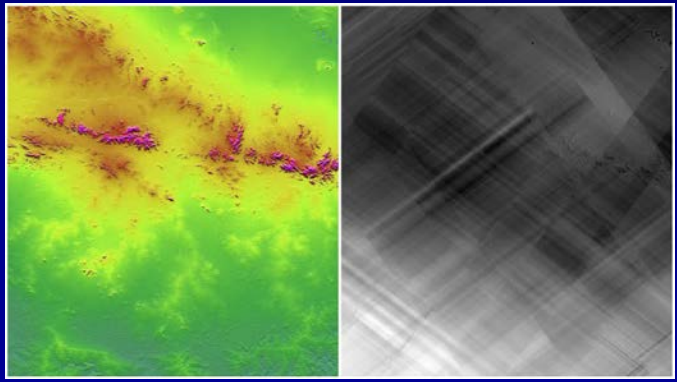
Himalaya Mountains

Old DEM

New DEM

2. SRTM-ICESat Synergism

Use precise ICESat elevation profiles to correctly match overlapping SRTM swaths for seamless DEM mosaics.



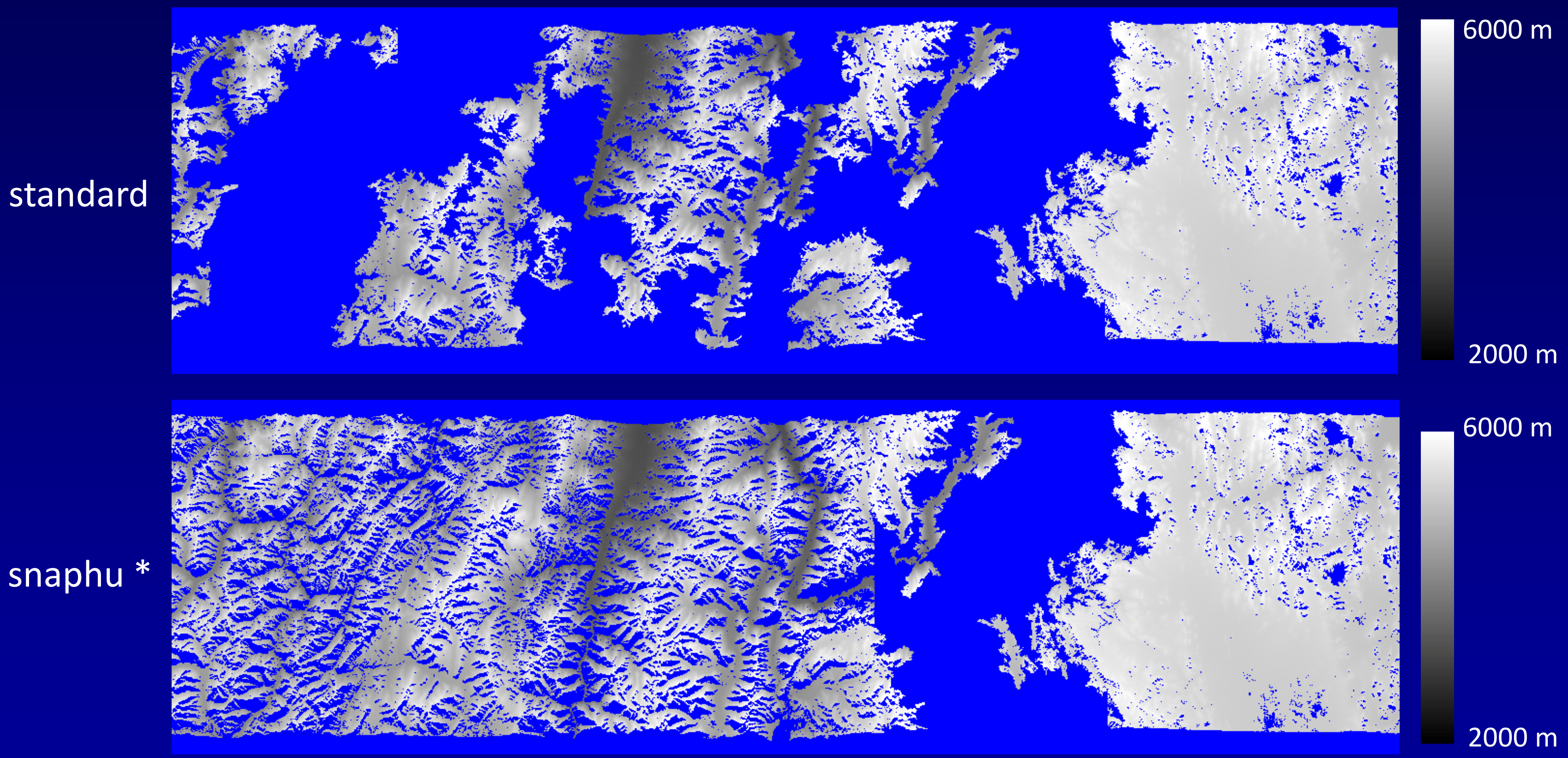
Ayer's Rock area DEM

New-minus-Old DEM (seams in Old)

…and then again fill remaining voids with ASTER GDEM and other best-available alternative DEMs, but with improved methods.

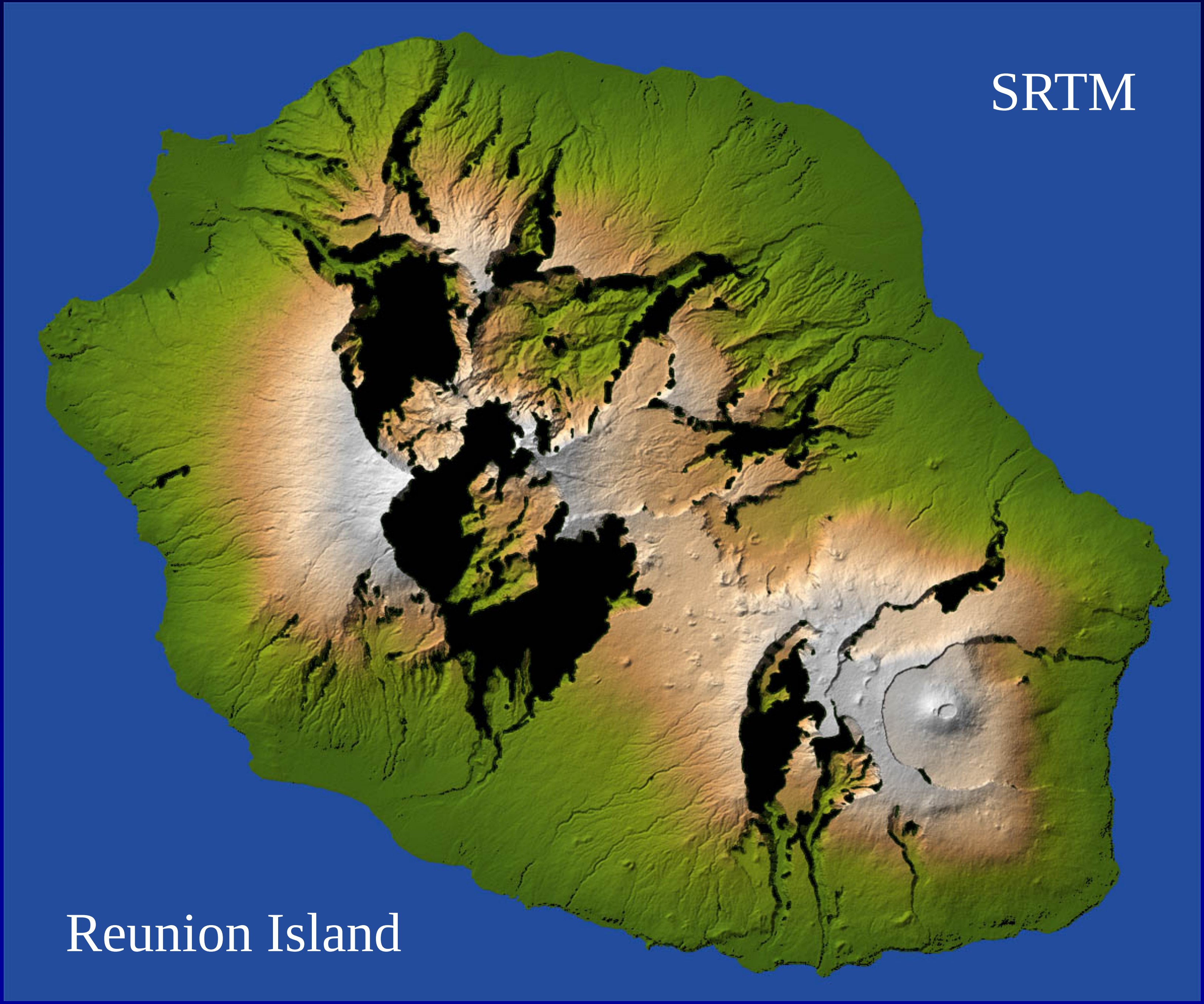
Results on a single data take – Himalaya Mountains

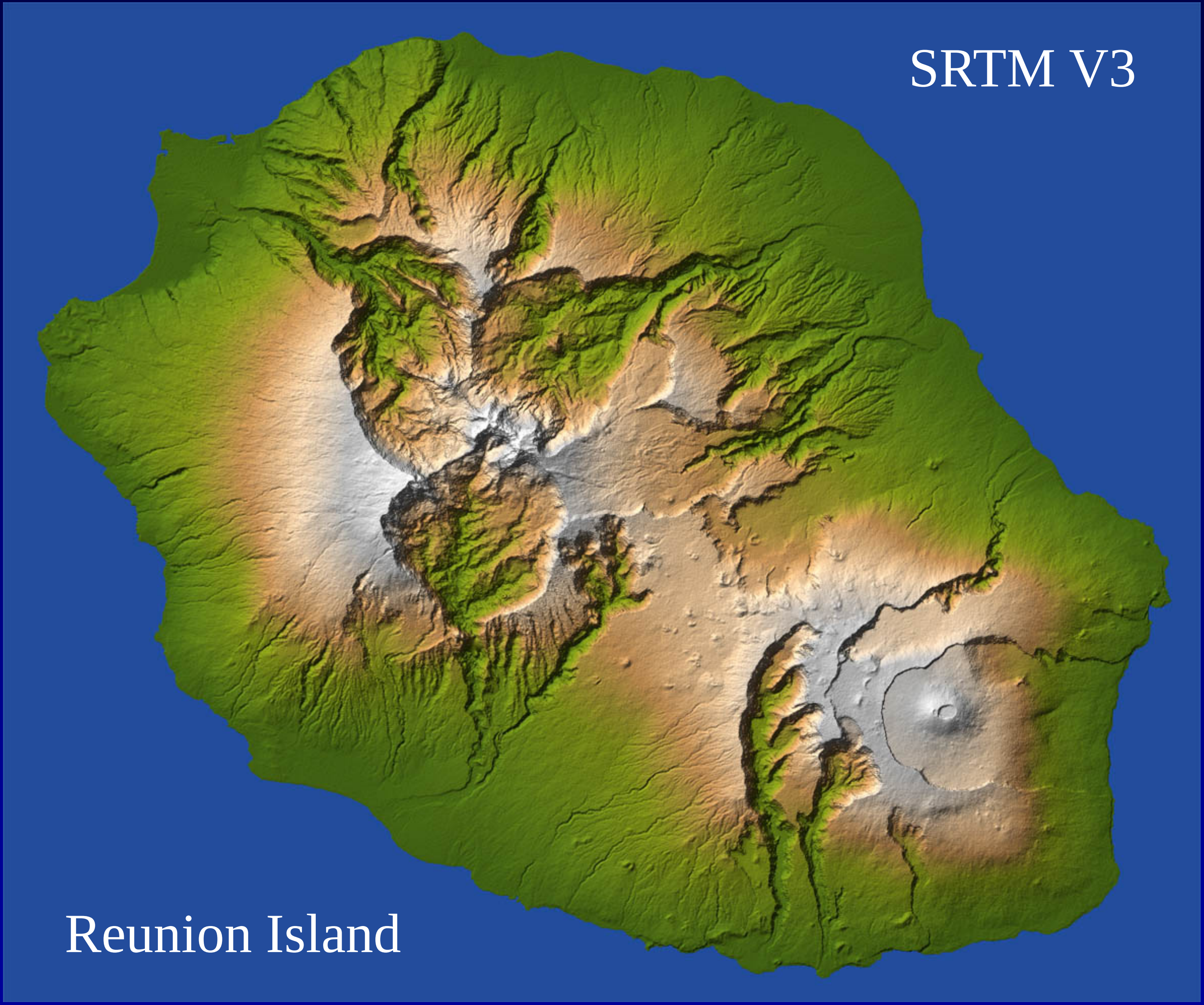
SRTM reprocessing for void reduction



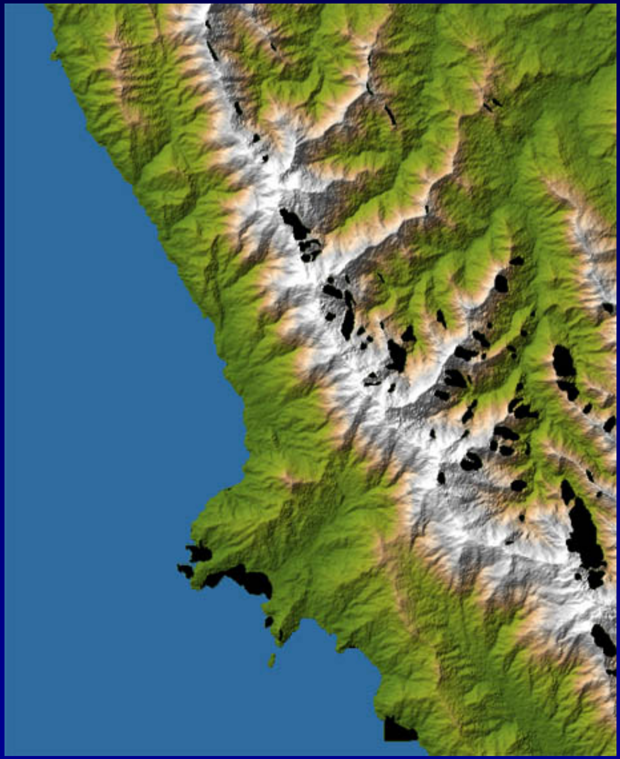
Marco LaValle, 2014

*** SNAPHU: Statistical-Cost, Network-Flow Algorithm for Phase Unwrapping (Chen and Zebker, Stanford Radar Interferometry Research Group)**


SRTM
Reunion Island

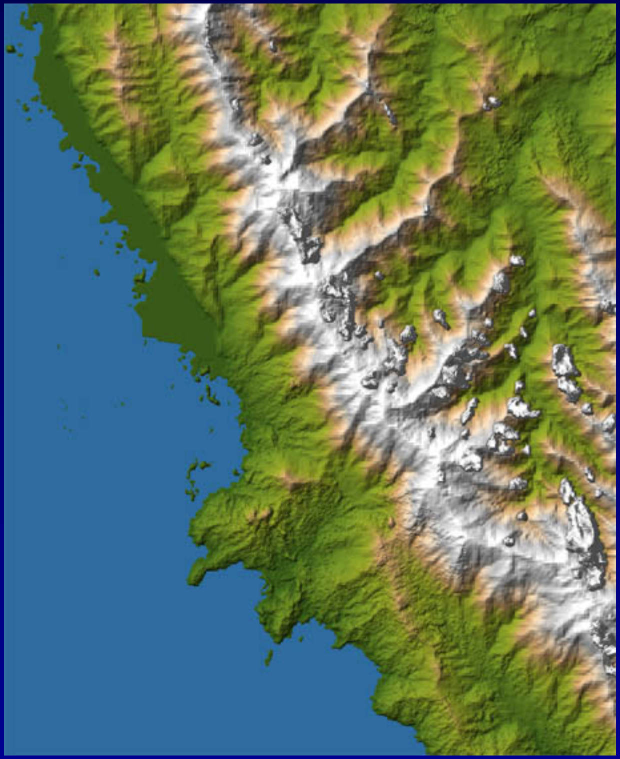

SRTM V3
Reunion Island

Southeast Panama: Shorelines and Clouds



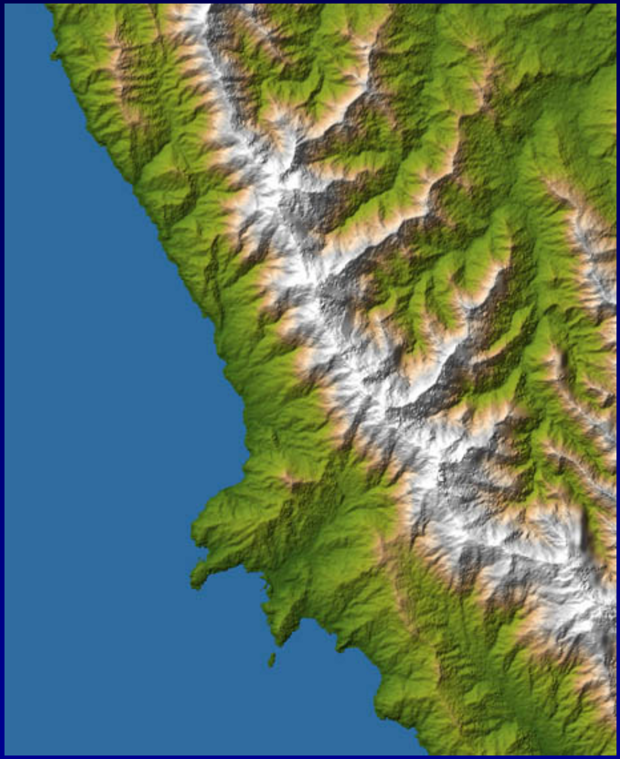
SRTM

Voids &
Water Mask Errors



GDEM

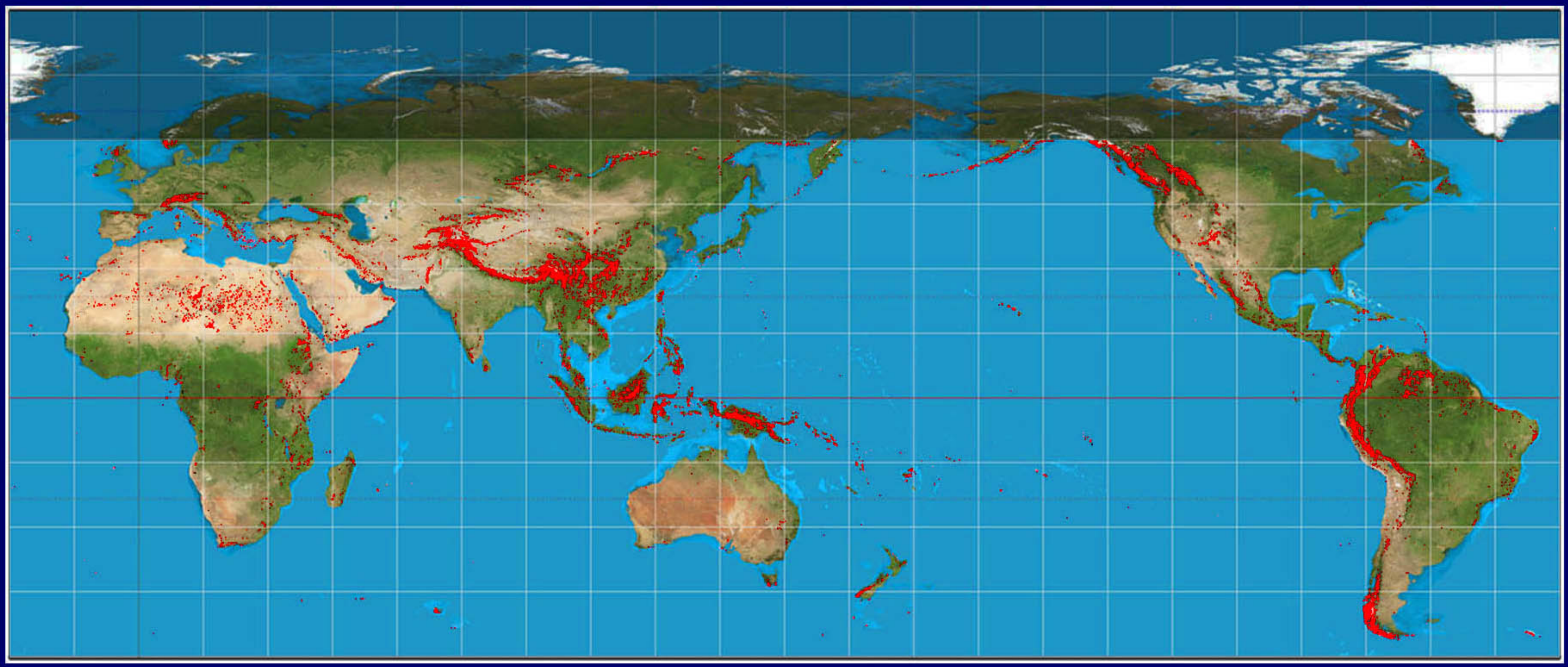
Clouds &
Shoreline Errors



SRTM Plus (v3)

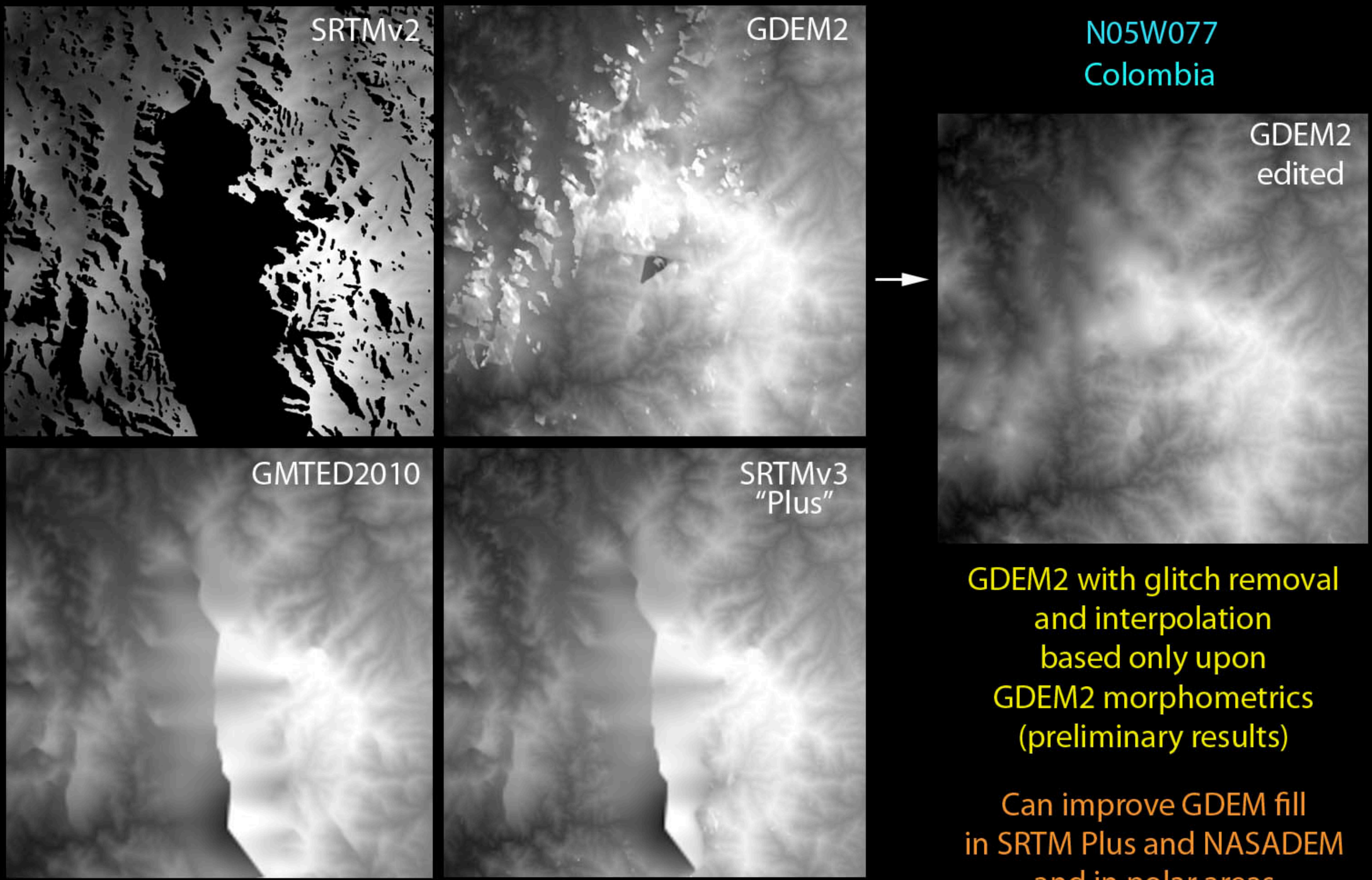
Generally good at
replacing bad GDEM
with GMTED2010

Use of GMTED2010 in SRTM Plus (NASA v3)



Relates to:
* Voids in SRTM (always)
* Clouds in GDEM (some places)
* Misc Elevation Errors in SRTM / GDEM
  (e.g. SRTM interferometric unwrapping errors)

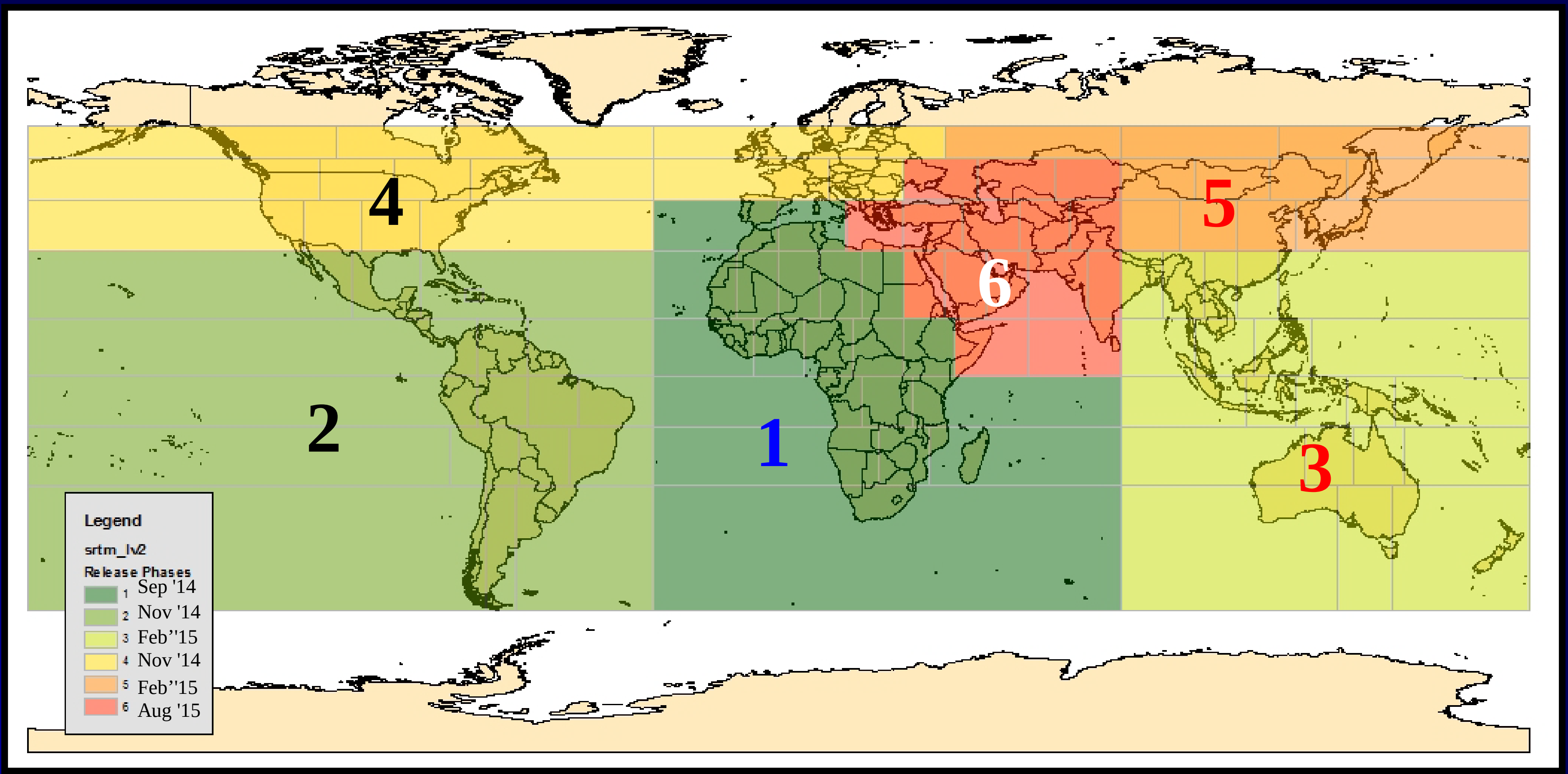
SRTM Void Fill Improvements



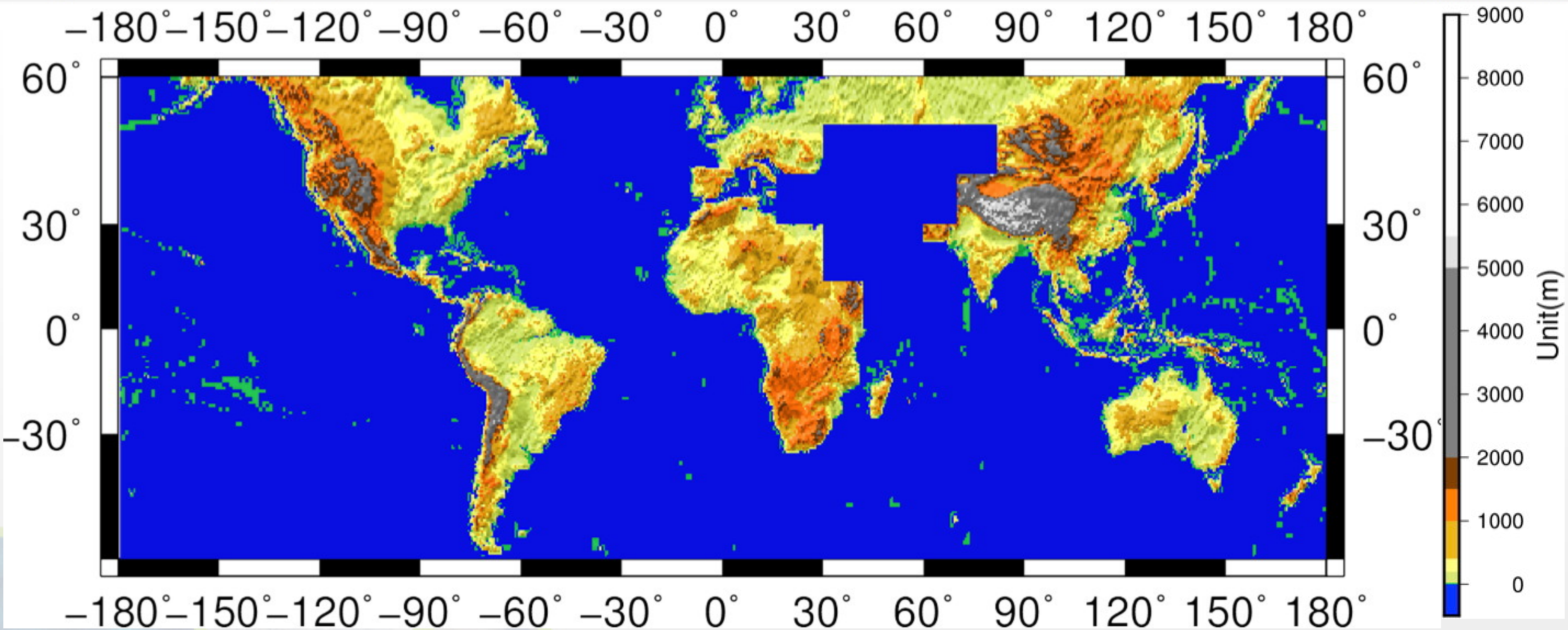
GDEM2 with glitch removal
and interpolation
based only upon
GDEM2 morphometrics
(preliminary results)

Can improve GDEM fill
in SRTM Plus and NASADEM
and in polar areas

SRTM2 Release Phases 1 - 6



SRTM1 v2 released to date at 1” (30m)



Mosaic created by L. Feng (UCL-MSSL). Gap due to be filled in August 2015

TanDEM-X: Science Activities

Irena Hajnsek[1/2], Manfred Zink[1] 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 DEM 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**

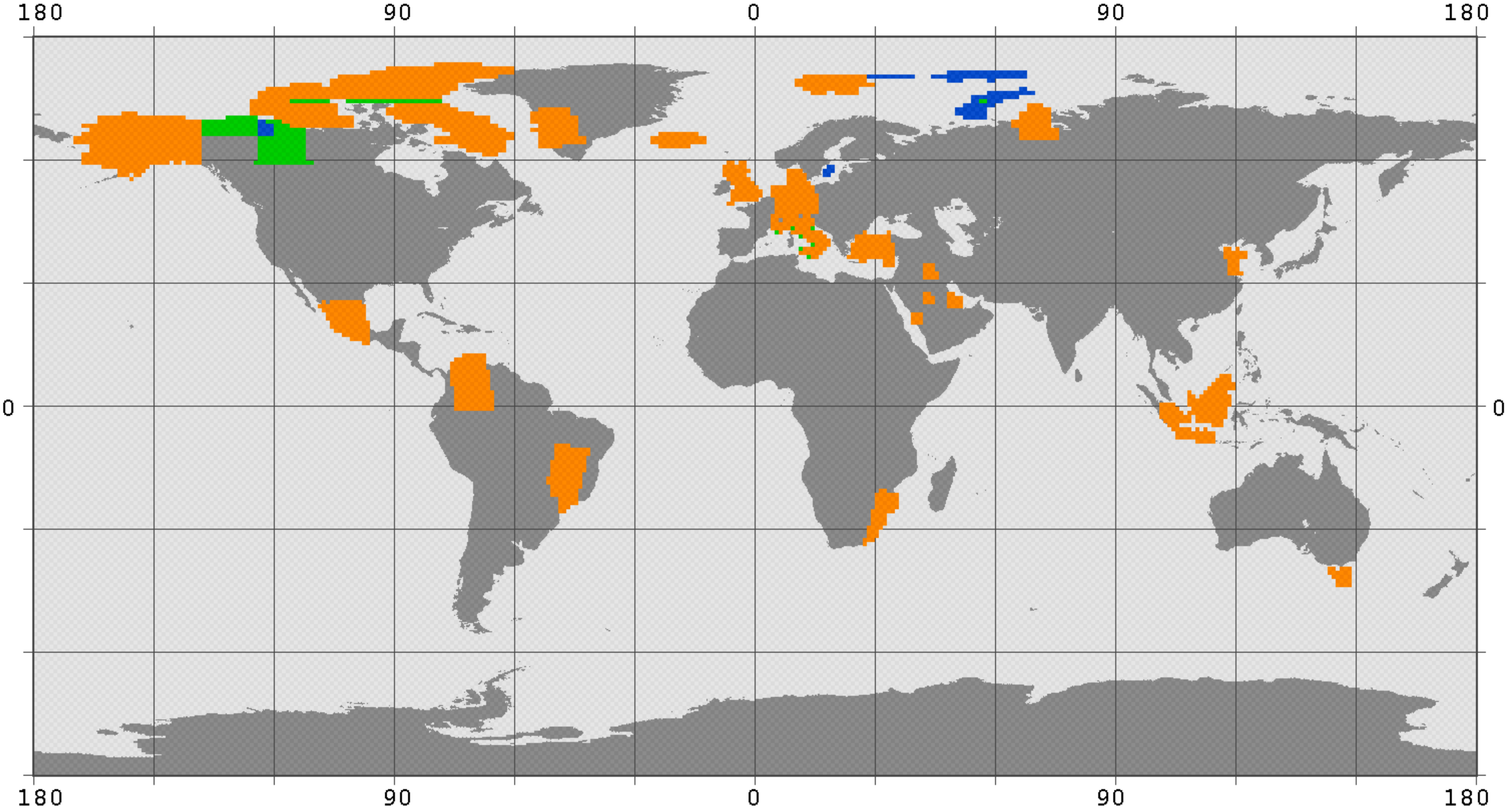
- **TanDEM-X DEM** **Autumn 2016??**

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

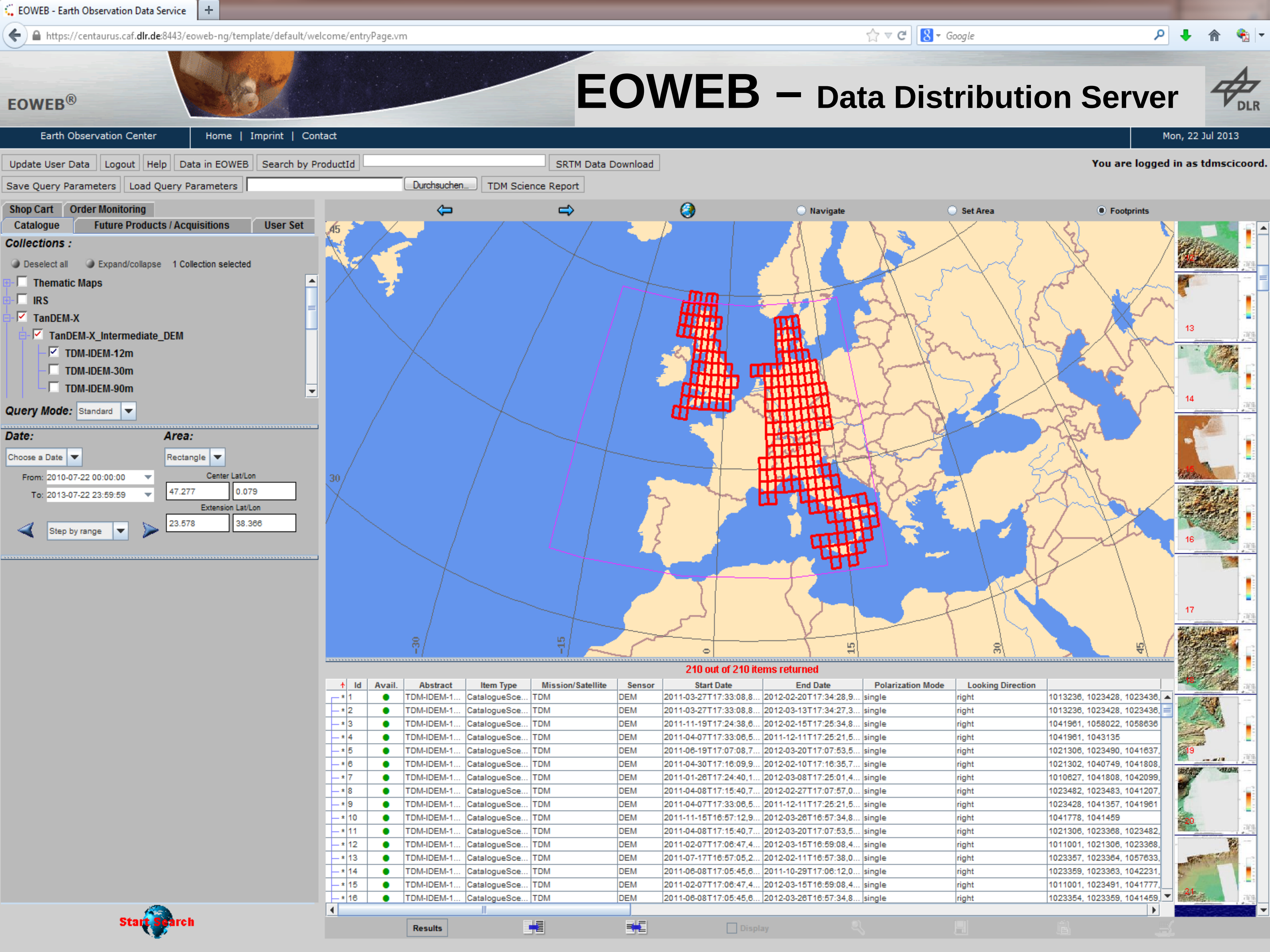
Mon Jul 8 05:51:11 2013

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:
Area:
Choose a Date
Rectangle
From: 2010-07-22 00:00:00
To: 2013-07-22 23:59:59
Center Lat/Lon
47.277
0.079
Extension Lat/Lon
23.578
38.366
Step by range
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
Results
Display

Preliminary assessment of TanDEM-X i-DEM over the UK

Jan-Peter Muller, Lang Feng

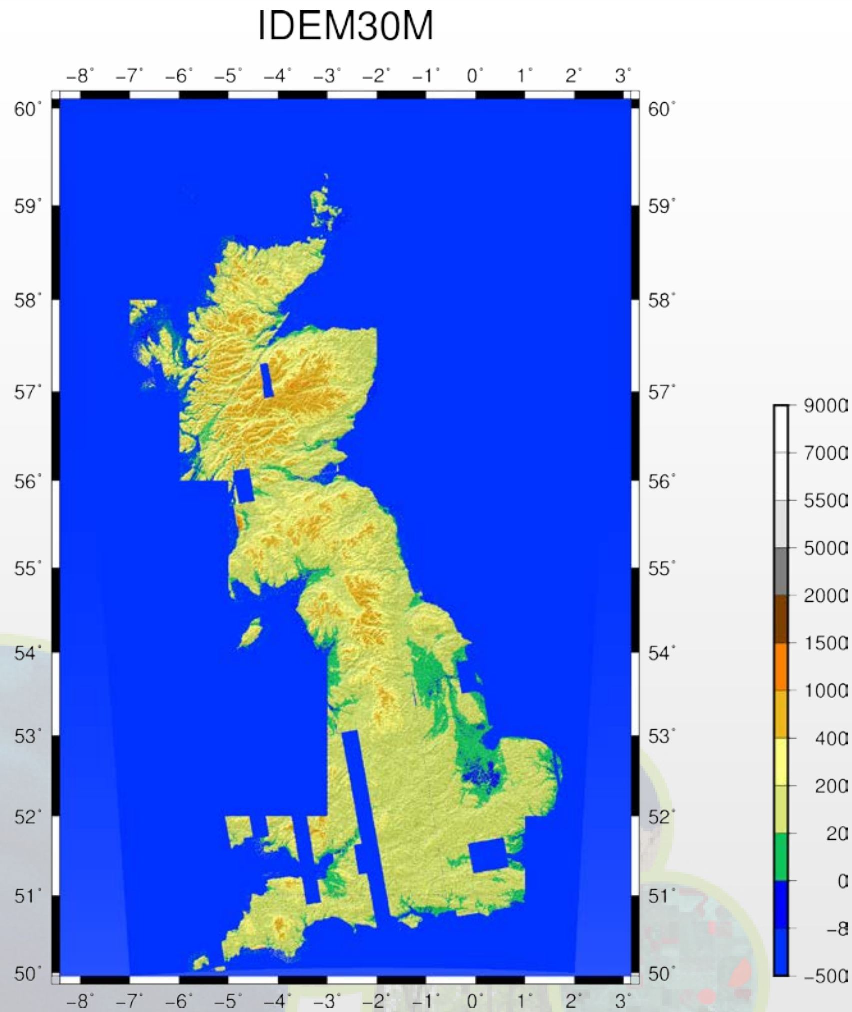
May 2015

Experiment DEM Input datasets

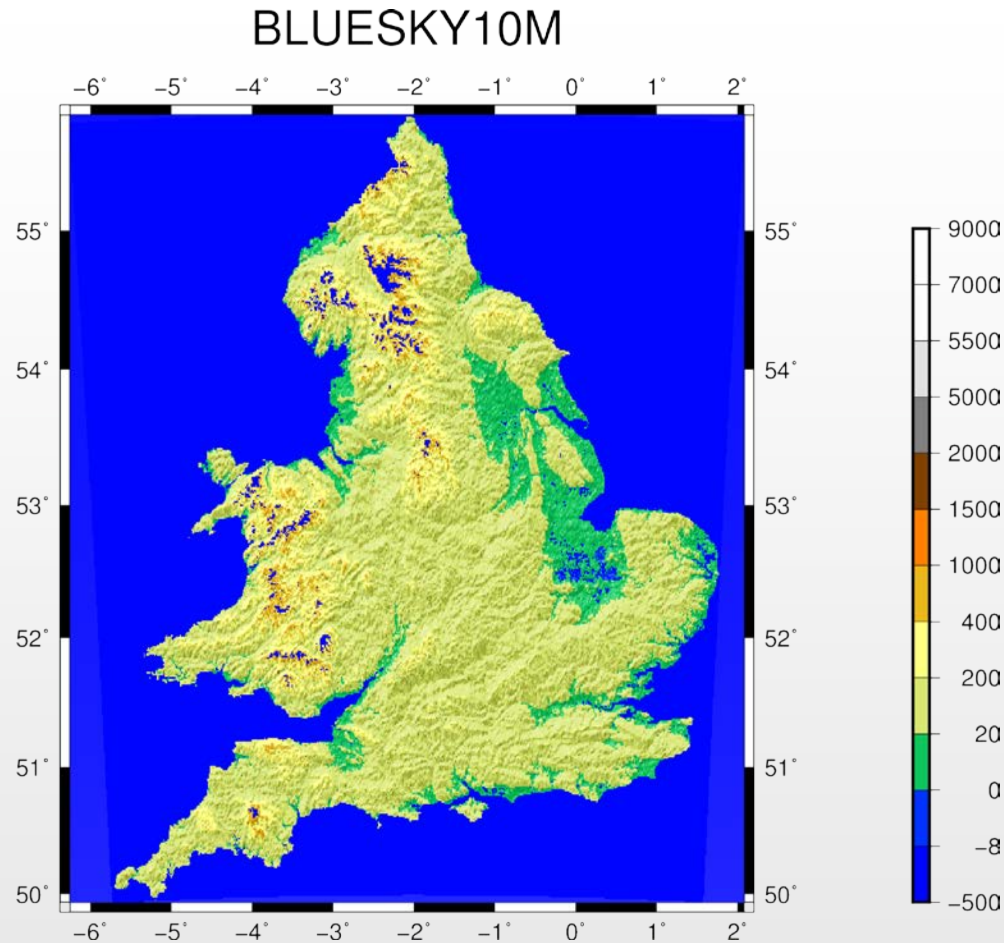
Quality assessment

Input Data Set:	SRTM	Aster GDEM	i DEM	Blue Sky
Coverage:	GLOBAL	GLOBAL	UK & worldwide (3”)	UK, N. Ireland
Source:	NASA JPL/USGS	USGS	DLR-TerraSAR-X	-
Resolution:	1 arc-second	1 arc-seconds	0.4” (≈12m) 1” (≈30m) 3” (≈90m)	10m or 5m
ellipsoid:	WGS84	WGS84	WGS84-G1150	OSGB36
Vertical Datum:	EGM96	EGM96	WGS84-G1150	ODN
Projection:	Geographic Lat/Lon	Geographic	Geographic	TM projection
Acquisition Date:	February 2000	February 2000	2011-13 (?)	-

UK DEMs' coverage

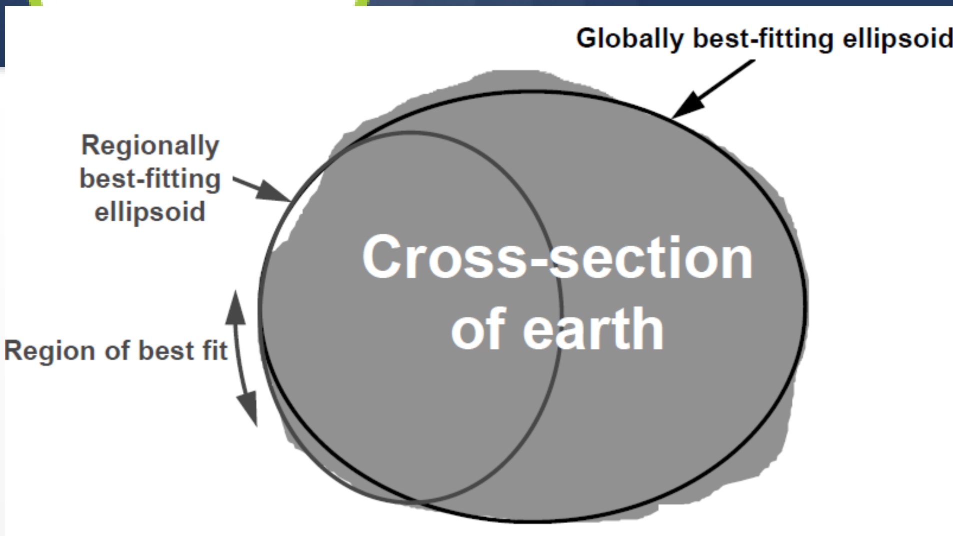


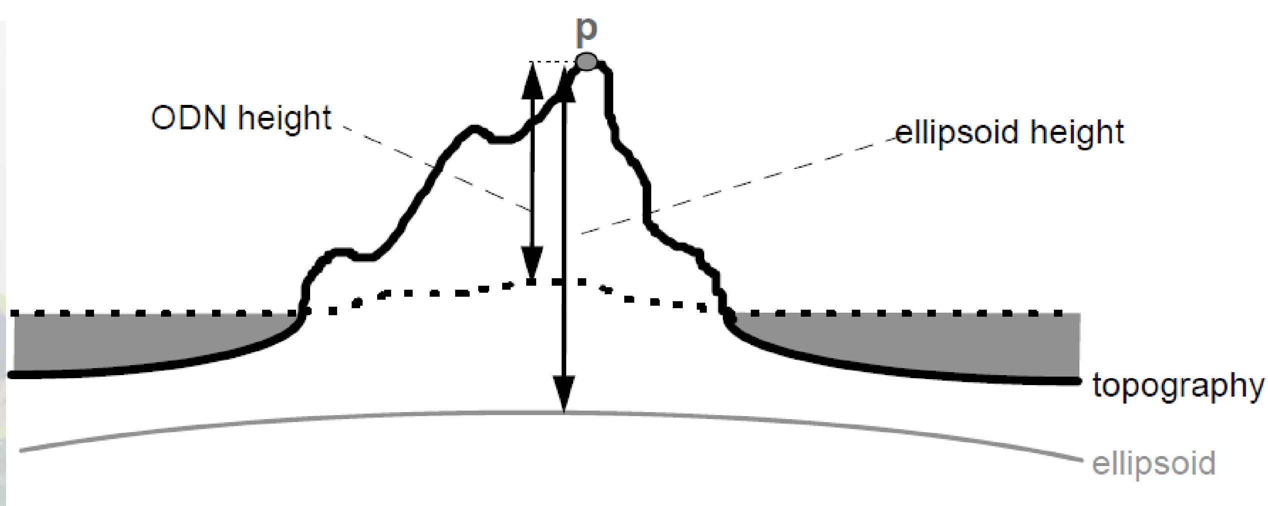
TerraSAR-X+TanDEM-X



Aerial stereo-photogrammetry

Coordinate systems





- How to convert EO-DEMs to OSGB36?

Methods of WGS84 to OSGB 1936 --- OSTN02_OSGM02

6.6 Approximate WGS84 to OSGB36/ODN transformation

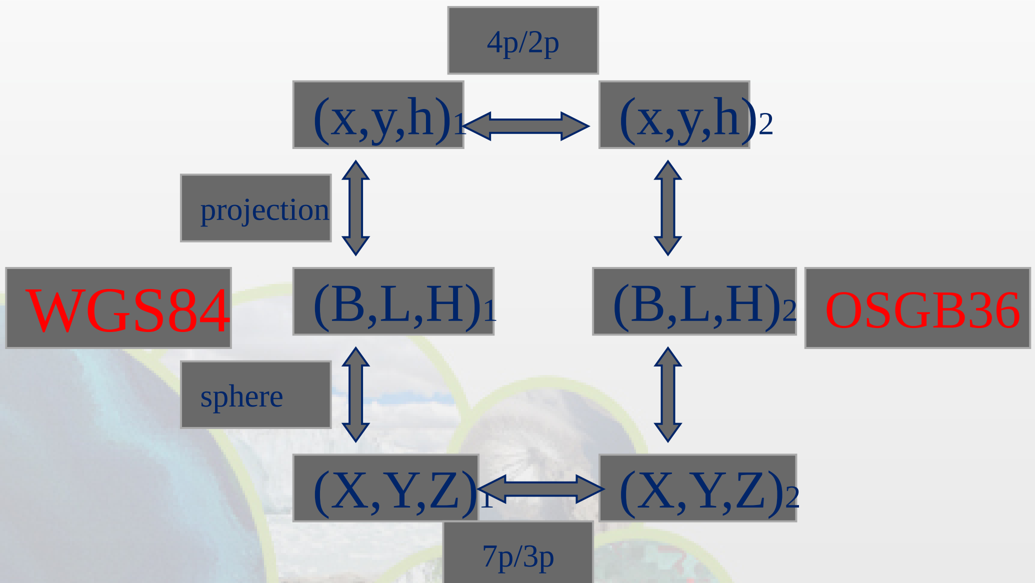
The following Helmert transformation converts WGS84 (or ETRS89 or ITRS, the differences are negligible here) coordinates to 'something like' OSGB36 and 'something like' ODN heights. The error is up to five metres both horizontally and vertically. This is good enough for certain applications. This transformation is for use with equation (3). Note the remarks made about Helmert transformations in section 6.2.

ETRS89 (WGS84) to OSGB36/ODN Helmert transformation

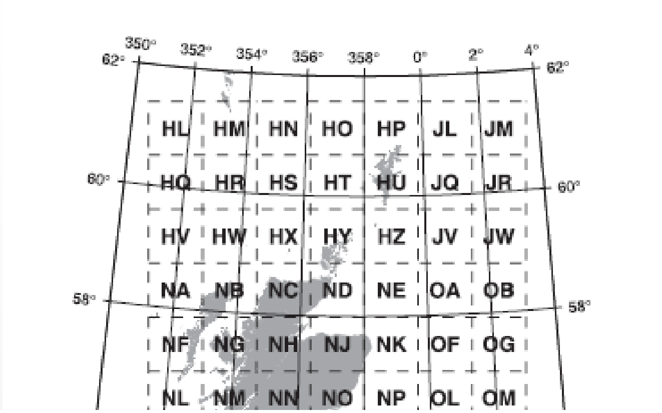
t_X (m)	t_Y (m)	t_Z (m)	s (ppm)	r_X (sec)	r_Y (sec)	r_Z (sec)
- 446.448	+ 125.157	- 542.060	+ 20.4894	- 0.1502	- 0.2470	- 0.8421

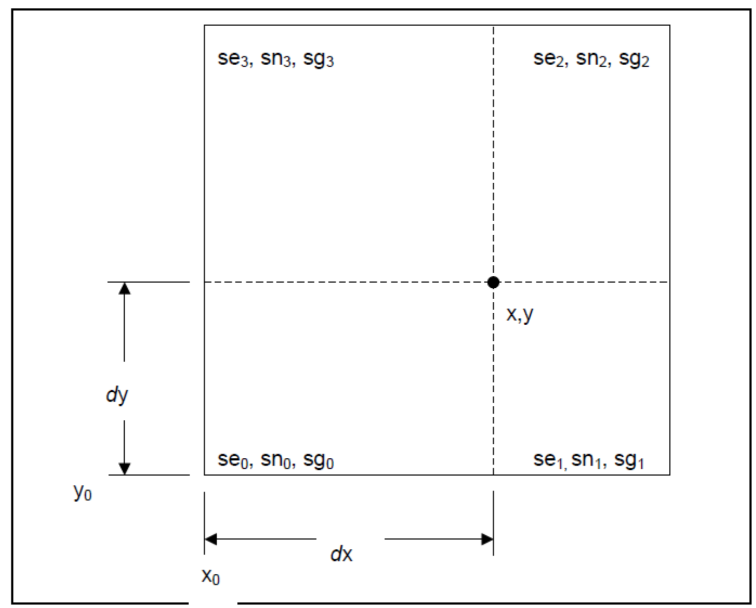
NOTE 1: OSGB36 is an inhomogeneous TRF by modern standards. Do not use this transformation for applications requiring better than 5 metre accuracy in the transformation step, either vertically or horizontally. Do not use it for points outside Britain.

NOTE 2: OSGB36 does not exist offshore.

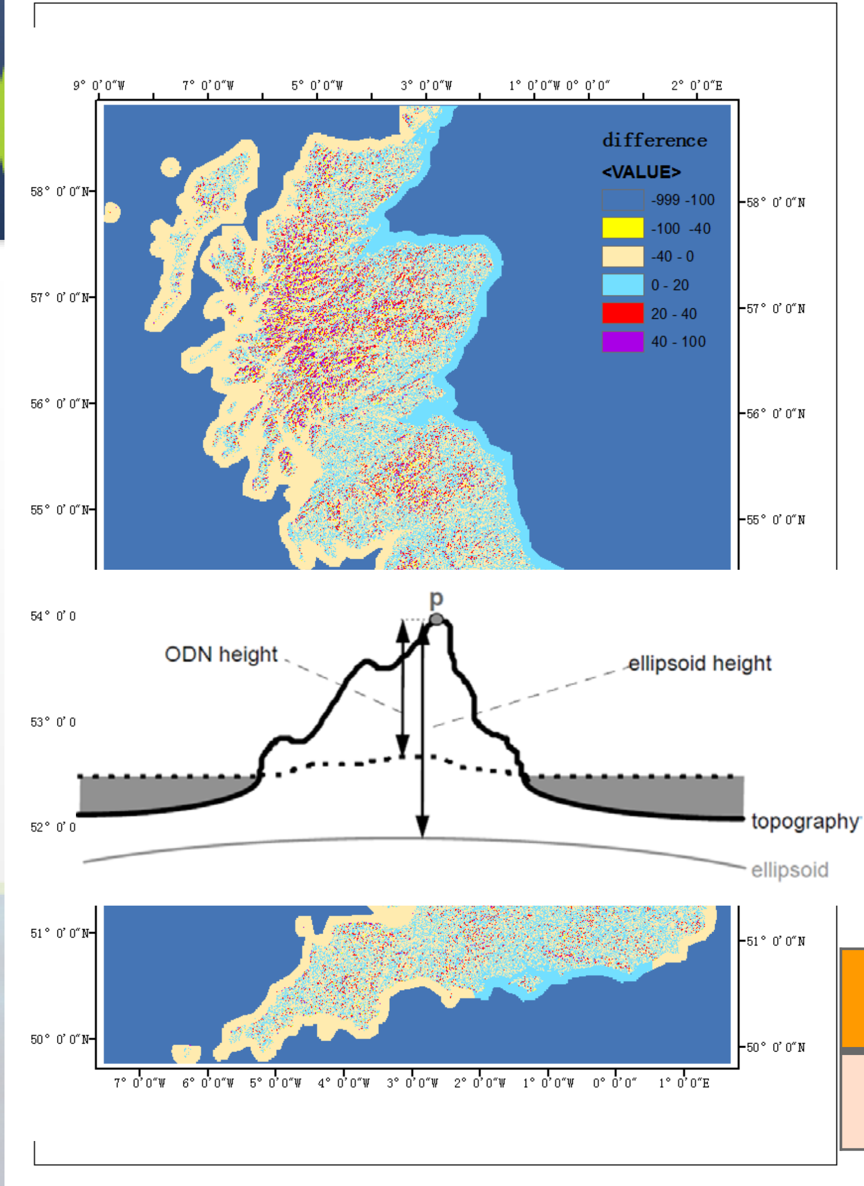


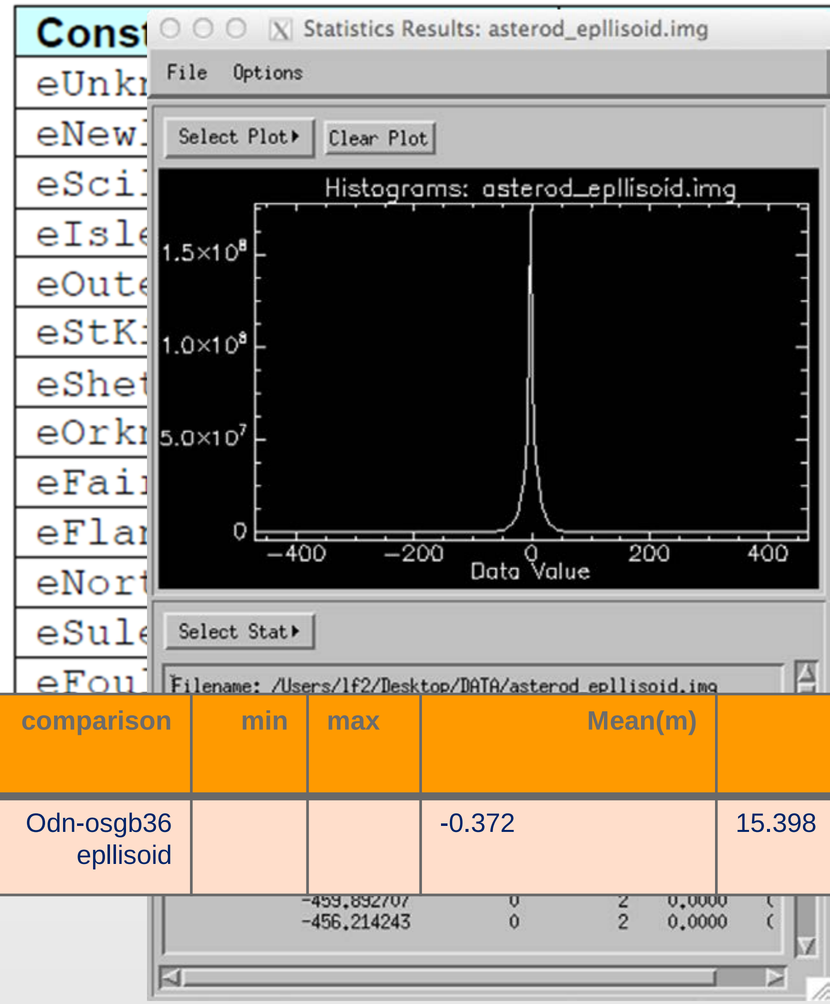
7 parameters





Coding and comparison results of two methods





comparison	min	max	Mean(m)	Stdev(m)
Odn-osgb36 epllisoid			-0.372	15.398

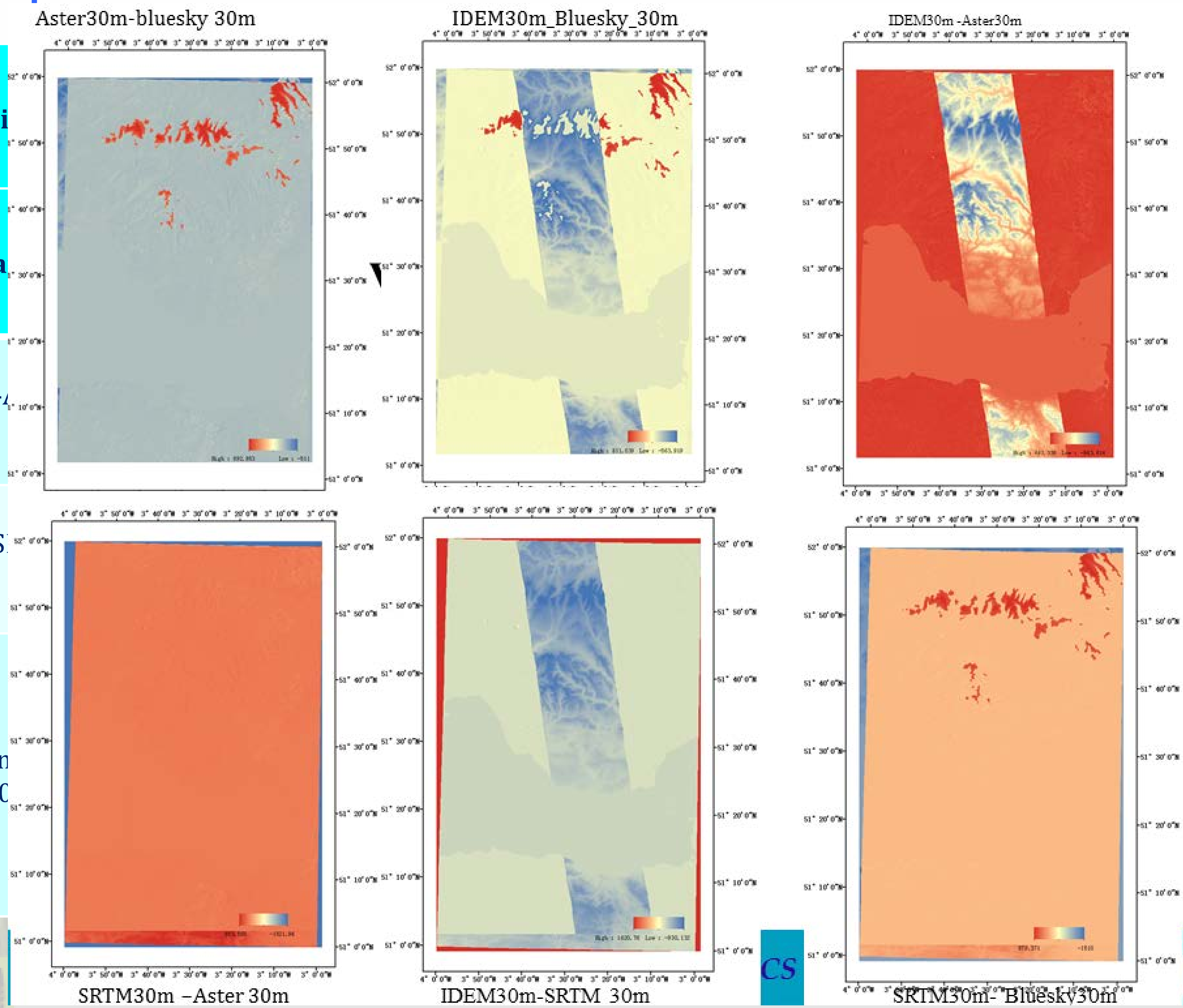
The datum varies in OSGB36 national grid

Wales results

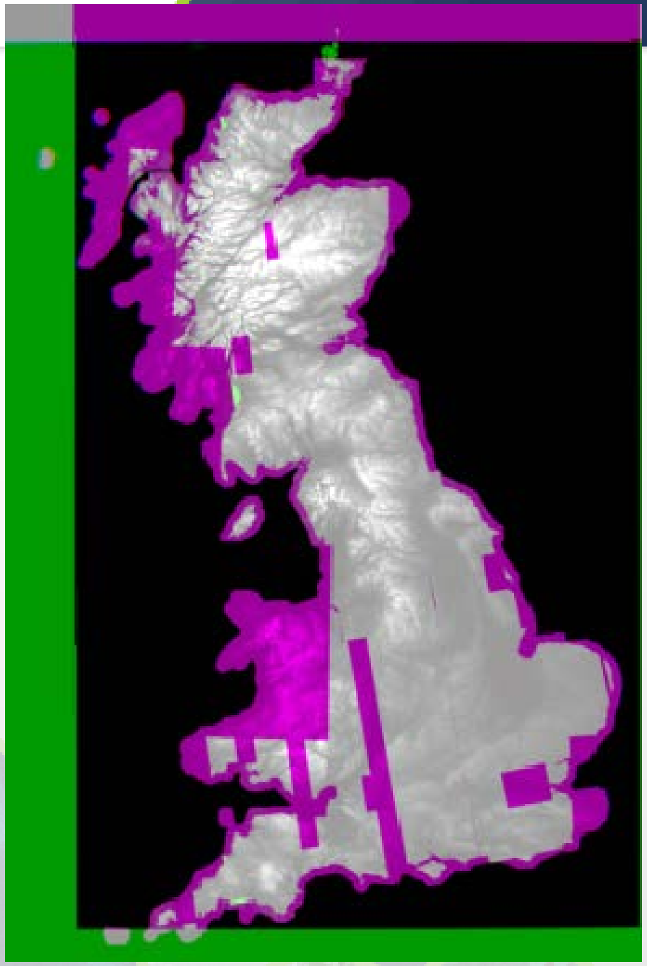
CEOS test site in Wales, W4-W3 and N51-N52 (UpperLeft:(-4º,52º), LowerRight(-3º,51º)

Basic Stats	Mi
Aster30m-bluesk 30m	
IDEM30m-bluesk 30m	
IDEM30m - Aster30m	

Basic Sta
SRTM30m –A 30m
IDEM30m-S 30m
SRTM30n Bluesky30



UK DEM 30m after registration



b1(r):Aster b2 (g):IDEM
b3(b):SRTM b4:BLUESKY

mask

Ps:b is band

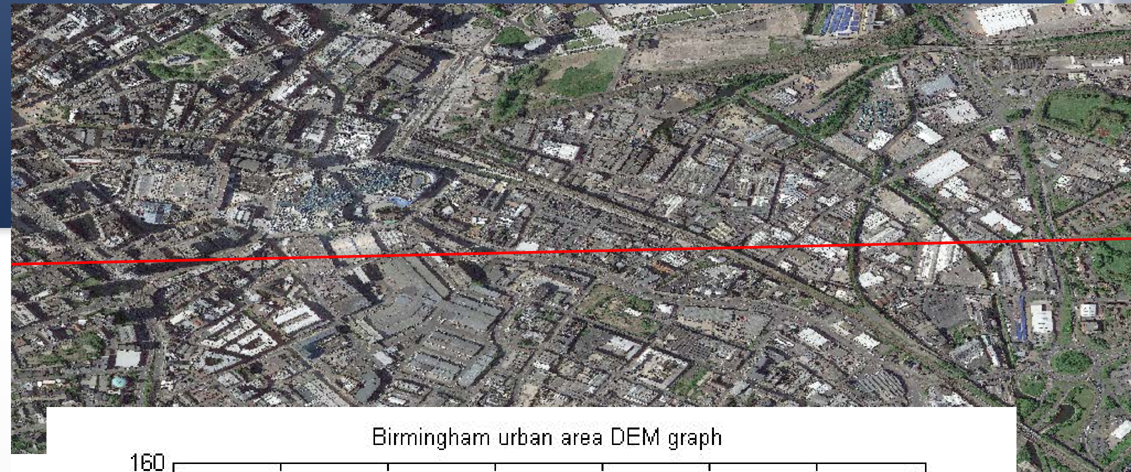
UK area results-England

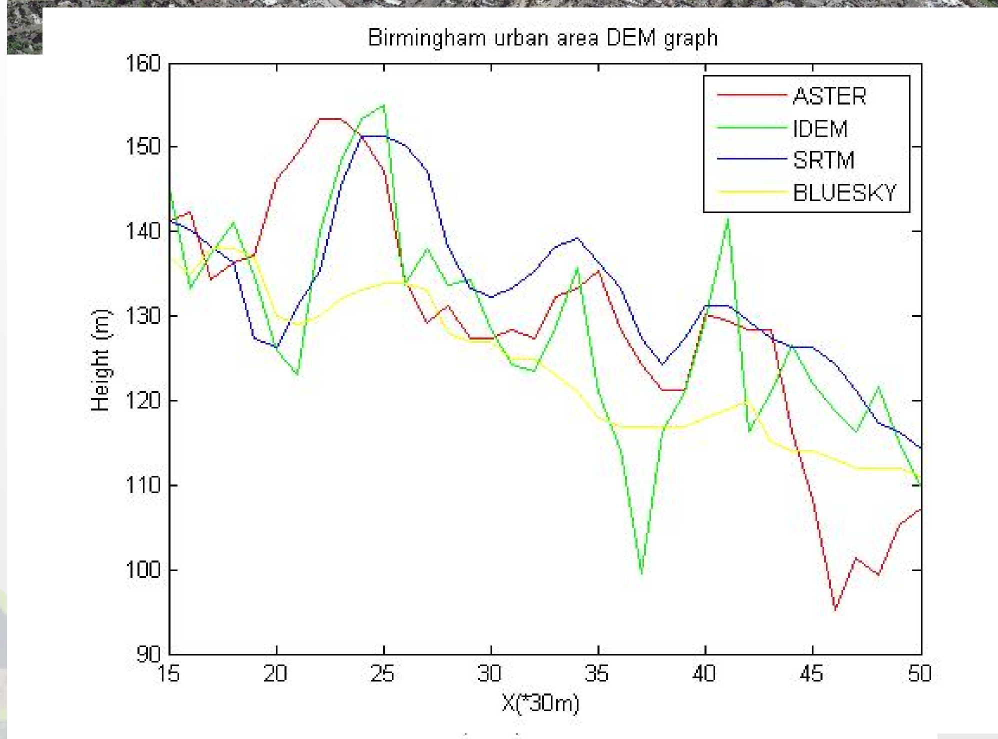
Basic Stats	Min	Max	Mean(m)	Stdev
SRTM30m-Bluesky30m	-13.751	41.582		
Aster30m-bluesky 30m				
SRTM30m –Aster 30m				

Basic Stats	Min	Max	Mean(m)	Stdev
IDEM30m-SRTM 30m	-15.992	25.4.832	-0.603	5.829
IDEM30m-bluesky 30m	-15.911	41.819	1.136	7.274
IDEM30m - Aster30m	-41.598	26.683	0.729	10.865

Analysis areas in UK

- Birmingham
- MSSL, Surrey
- Wales
- Swanage, Dorset

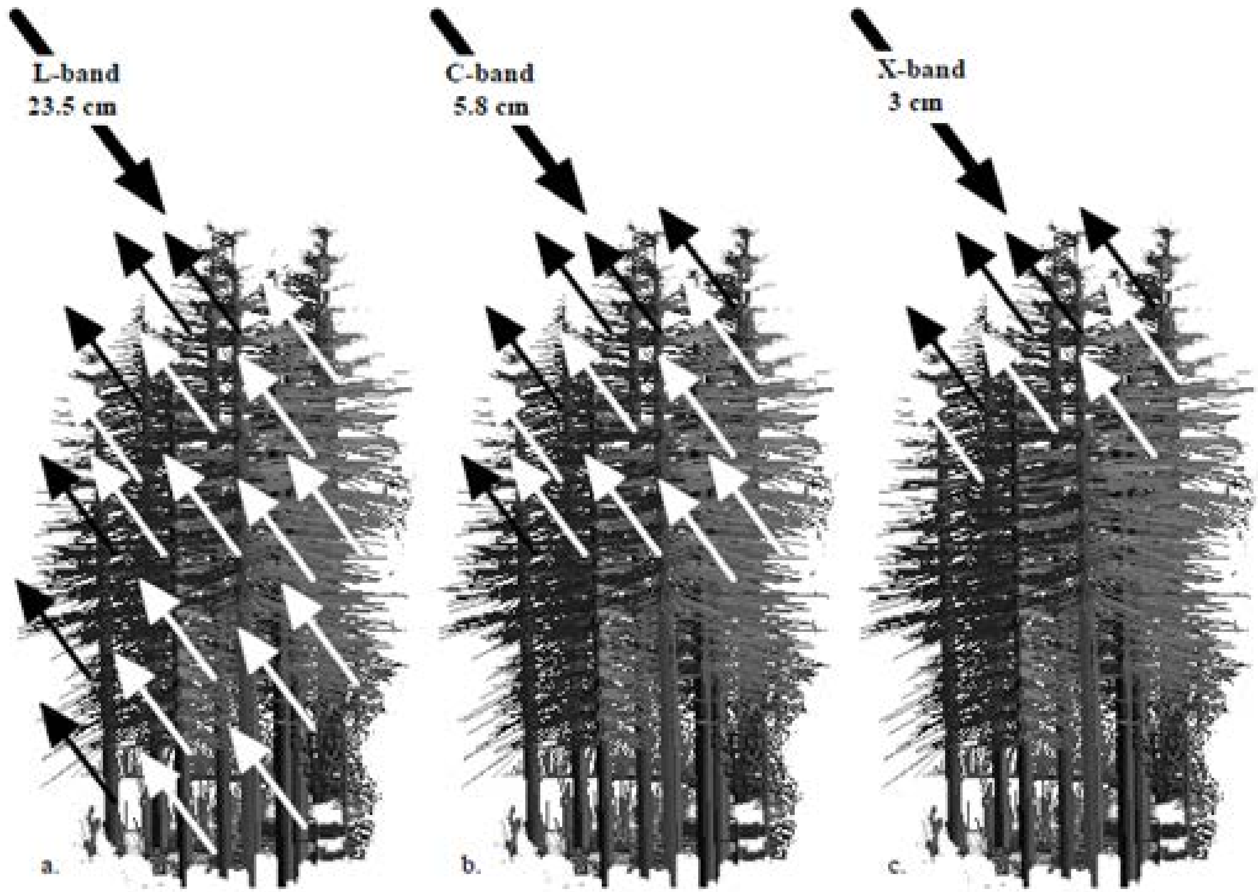




- **Urban building area in Birmingham**

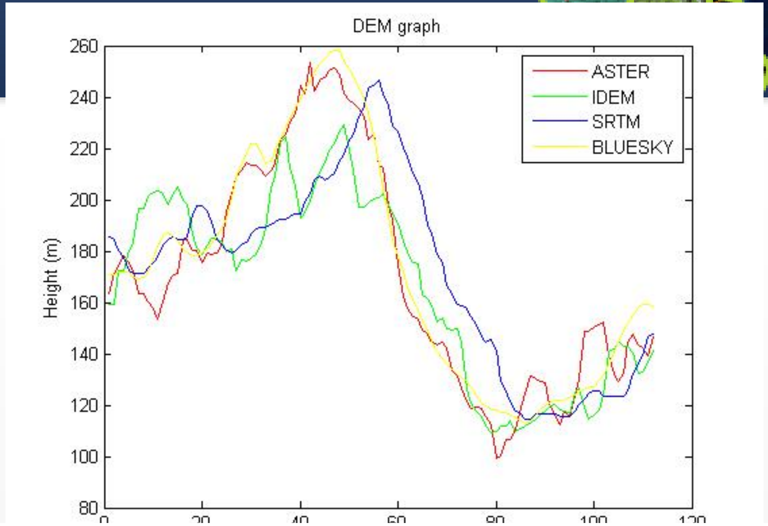
Conclusion: in urban area,Bluesky is DTM . IDEM,SRTM,ASTER are higher than Bluesky

SAR backscattering is controlled by **Radar Wavelength**

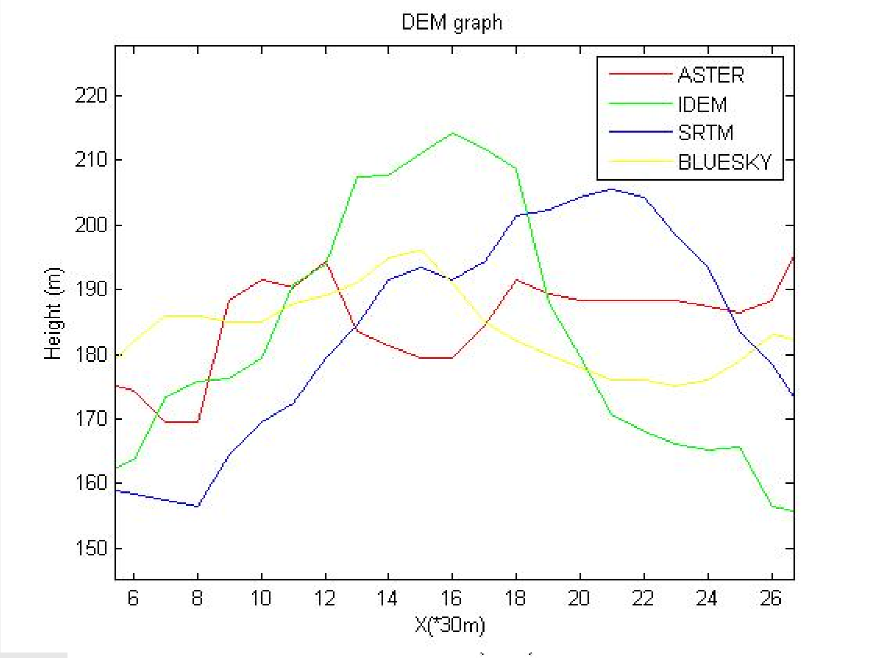


Penetration ability to forest

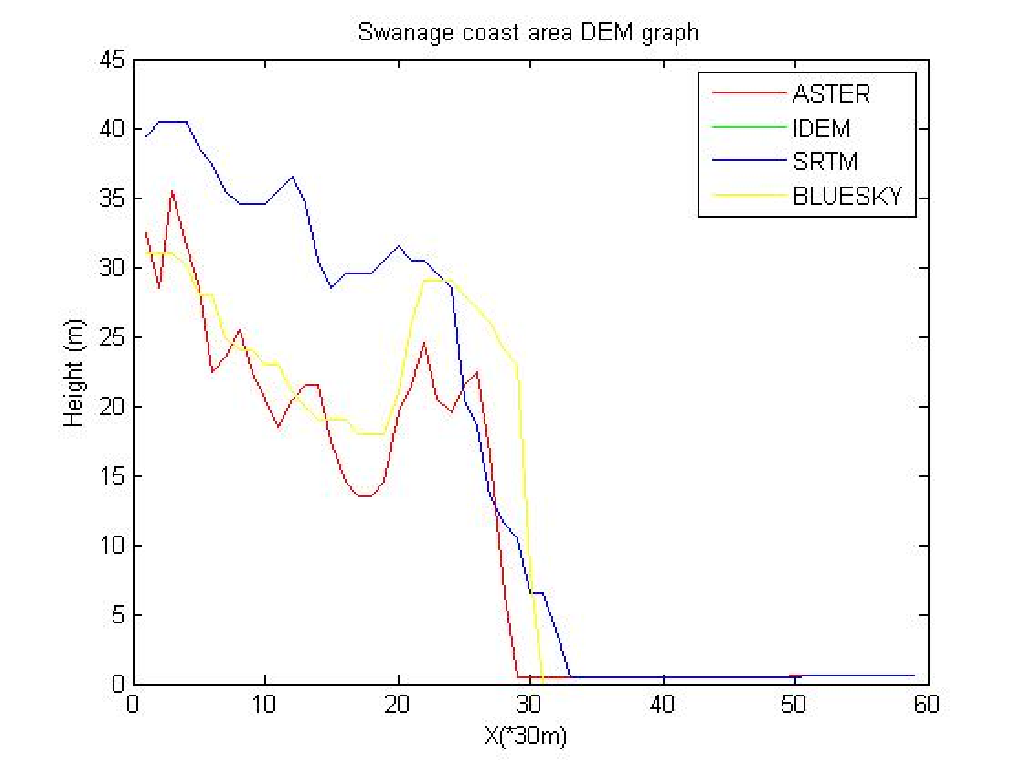
Test area –MSSL –forest



Zoom in



Forest Canopy



- Swanage coast area
- Coast area : IDEM has Null values
- Visible optical wavelength can penetrate coastline water

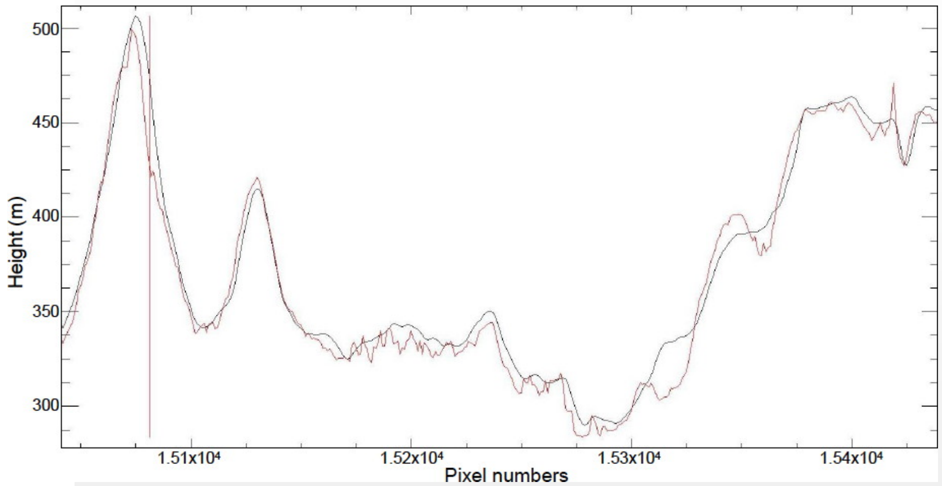
Evaluation of the TanDEM-X Intermediate DEM for Terrain Illumination Correction in Landsat Data

Li, F.[1], Jupp, D.L.B. [2], Thankappan, M. [1], Wang, L.W. [1], Lewis, A.[1] and Held, A. [2]

Objectives

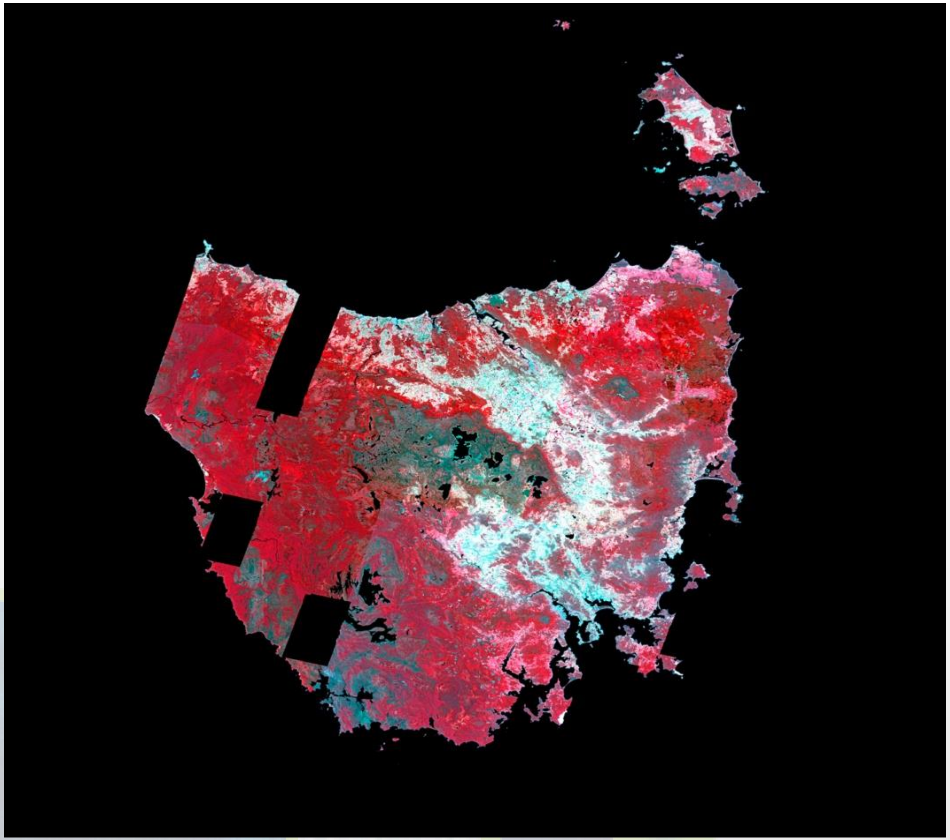
- Assess the impact of different sources of spaceborne DEMs on the georadiometric correction of surface spectral BRF (Bi-directional Reflectance Factors)
- Perform qualitative assessments from the "look-and-feel" of the output results as well as explore the correlation between cos (solar_elevation) and BRF
- Assessed the impact of using (a) SRTM at 30m; (b) iDEM at 12m; (c) iDEM at 30m as part of the topographic correction model which includes water vapour (NCEP), aerosols (AATSR) and BRDF (MODIS)

Geographical context & DEM profiles assessment

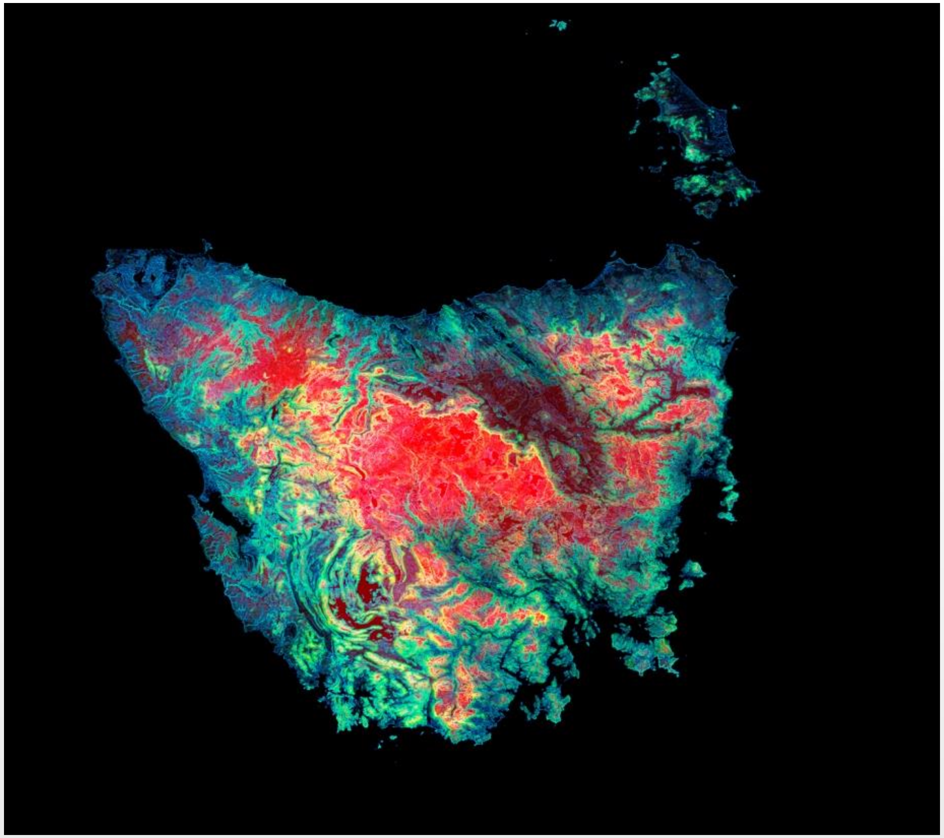


SRTM (black), iDEM (red)

Landsat mosaics

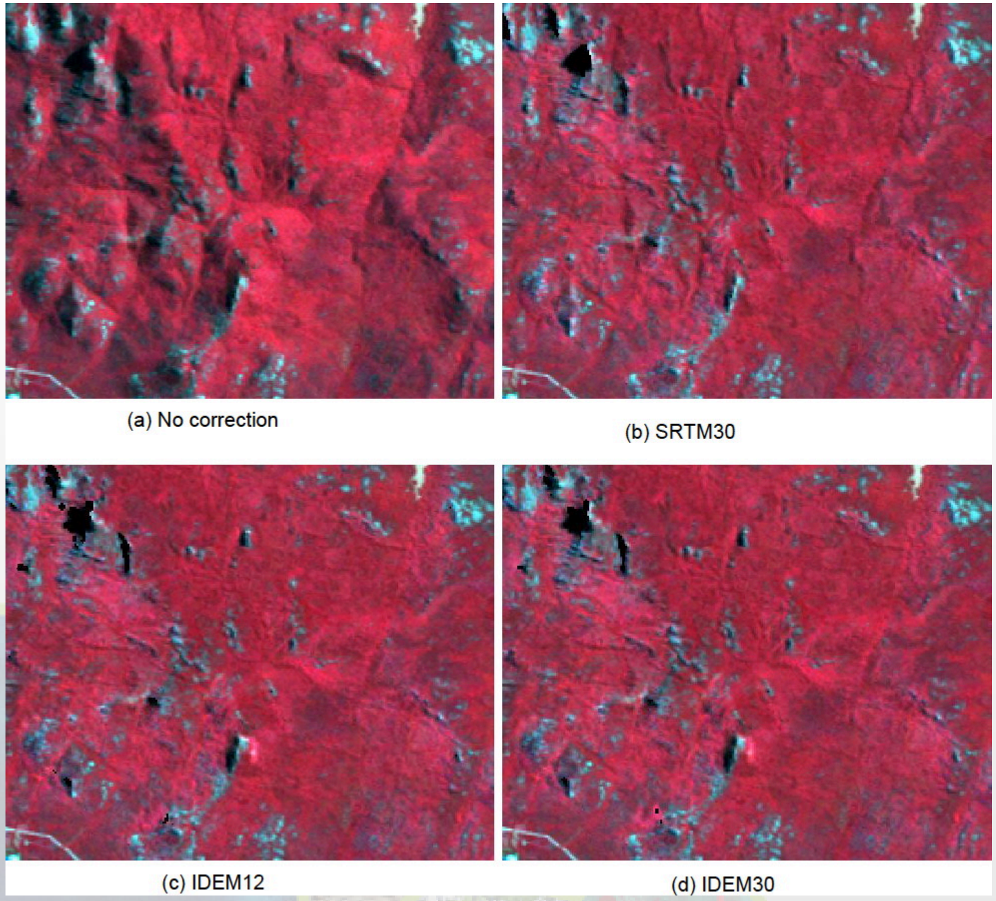


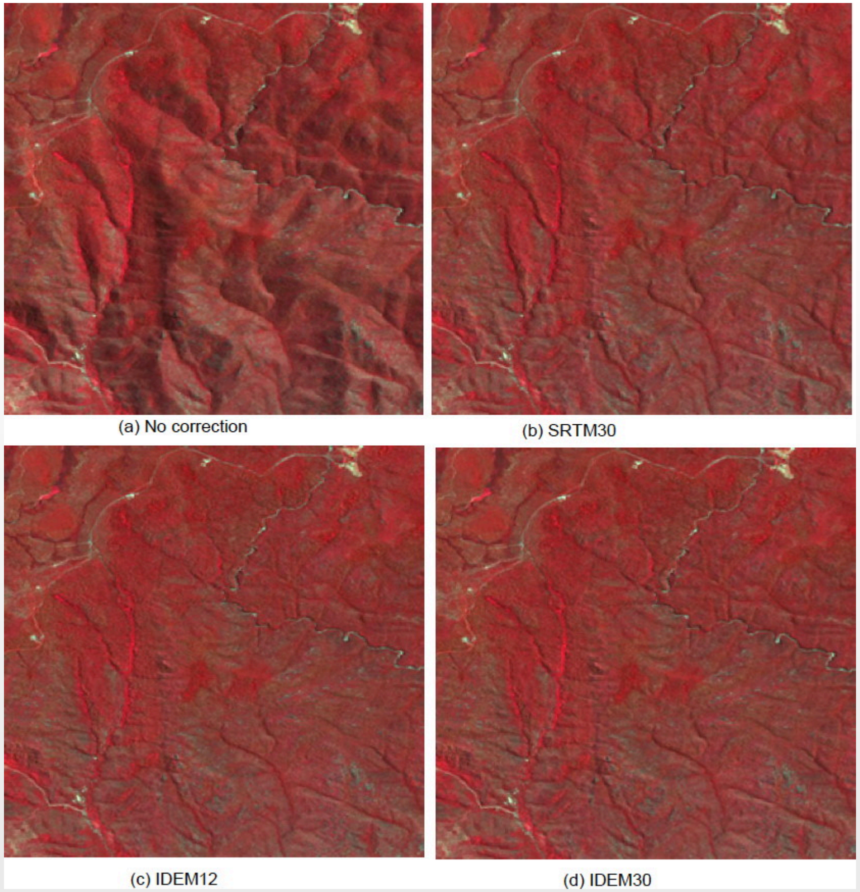
Mosaic of terrain corrected Landsat false colour images (bands 4, 3, 2 for Landsat 7 and 5, 4, 3 for Landsat 8) using IDEM 12 m



False colour Composite of height, slope and curvature

Examples of terrain illumination correction





iDEM12 and iDEM30m show better georadiometric correction

GAF AG

an e-GEOS (ASI / Telespazio) Company

Euro Maps 3D

A Transnational High-Resolution Digital Surface Model

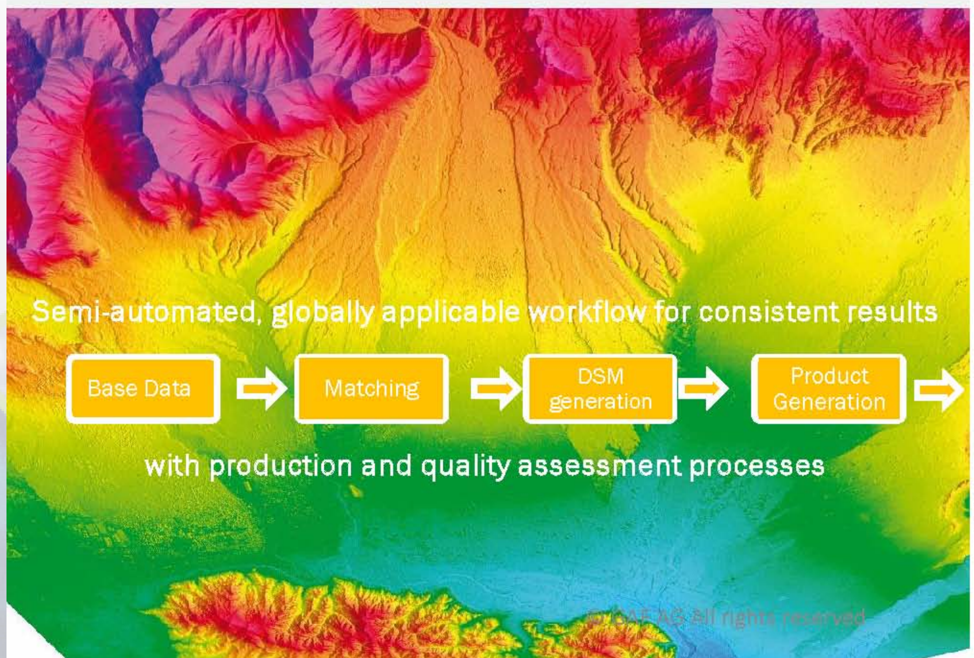
Euro Maps 3D

GAF AG

an e-GEOS (ASI / Telespazio) Company

Euro-Maps 3D is realized in a long-standing cooperation

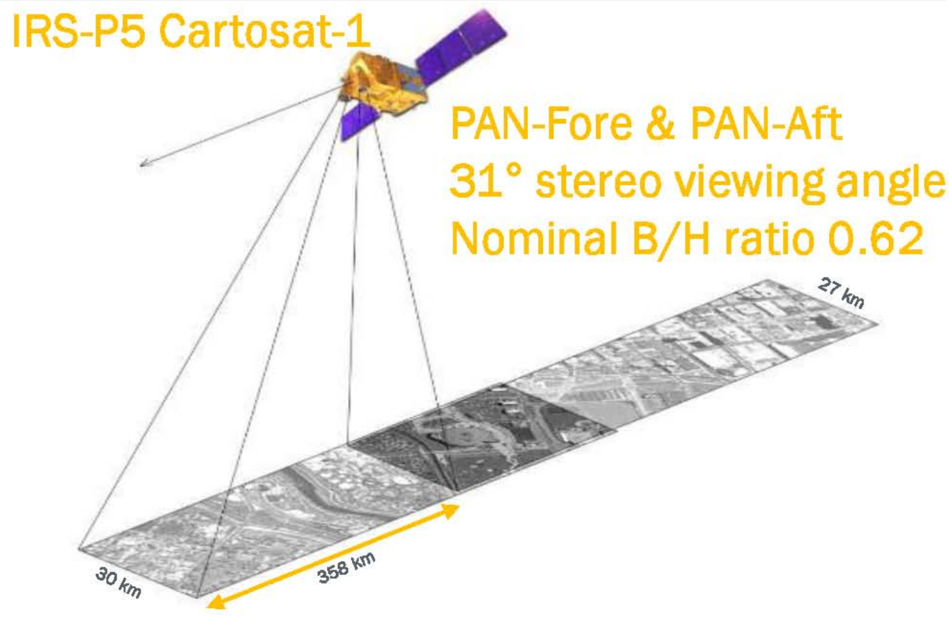
- Data: ANTRIX
- Software: DLR
- Production: GAF AG
- Distribution: GAF AG



Alluvial fans south of Turin/ Italy
© 2015, GAF AG, includes Antrix material

Euro Maps 3D

GAF AG
an e-GEOS (ASI / Telespazio) Company



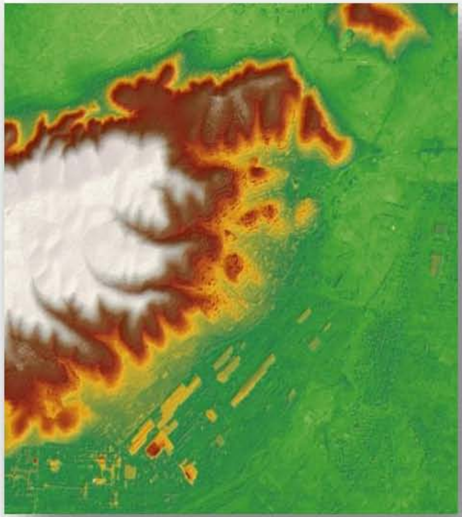
- Stereo optimized satellite
- Since 2005 continuous collection of stereo data

CEOS

Euro Maps 3D

GAF AG
an e-GEOS (ASI / Telespazio) Company

- Highly reliable photogrammetric optical stereo approach
  - Pixel based Semi-Global Matching
  - Leading to a very sharp representation of the surface



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Base Data → **Stereo Matching** → DSM Generation → Product Generation → Final QC

CEOS

Euro Maps 3D

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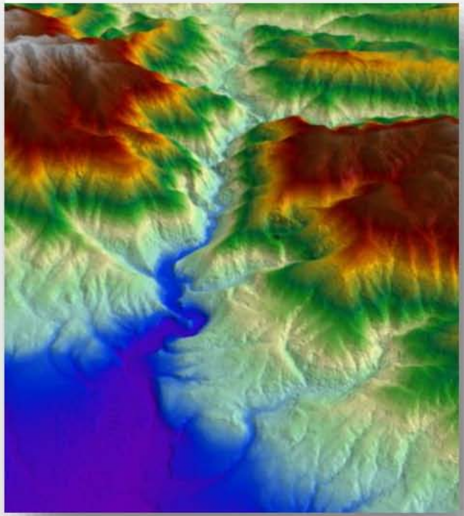
- Highly standardized and automated workflow benefiting from high data redundancy, leading to very reliable height information



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Base Data → Matching → **DSM Generation** → Product Generation → Final QC

Euro Maps 3D

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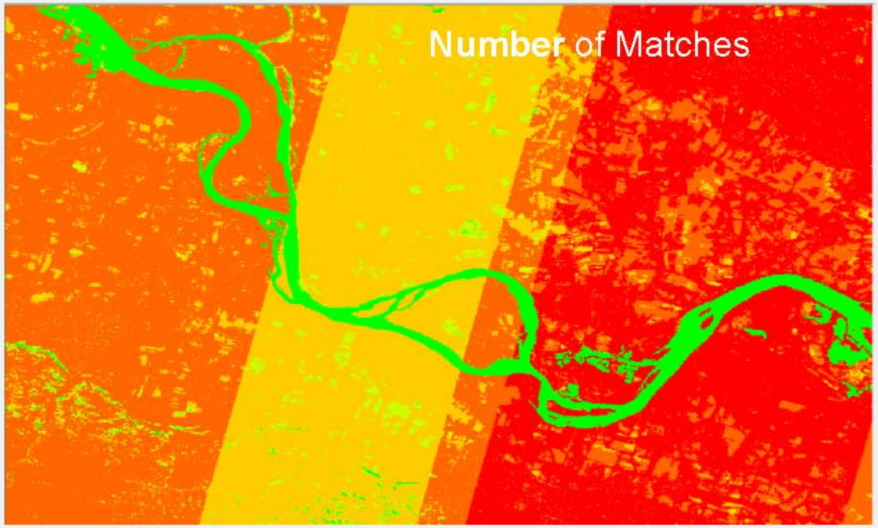

Full transparency of:

- source data,
- production and
- quality through several quality- and traceability layers

Base Data → Matching → DSM Generation → **Product Generation** → Final QC

Euro 3D Maps

Test site	Land cover/relief	LE90	CE90
Ankara	Urban, hilly	3.9	4.2
Kastamonu	Urban, hilly	3.4	2.2
Uzunköprü	Agriculture, flat	8.3	4.0
Aydin	Agriculture, forest, mountainous	5.5	5.9
Arles	Wetlands, agriculture, flat	2.6	9.4
Nebelhorn-north	Mountainous	3.9	4.6
Nebelhorn-south	Mountainous	4.1	5.8
Munich	Urban, agriculture, flat	6.3	4.3
Heidelberg	Forest, urban, agriculture, hilly	5.2	5.8
Koblenz	Forest, urban, open cast mining, hilly	7.1	5.6
Tunis	Urban, hilly	4.4	6.0
Le Kef 1	Dry, flat	3.9	5.7
Le Kef 2	Dry, flat	4.0	7.8
Sfax	Dry, very flat, salt lake	4.0	7.9
Gafsa	Dry, flat	3.6	7.4
Mlawa	Forest, agriculture, flat	8.4	5.1
Nowy Targ	Agriculture, forest, mountainous	6.4	7.4
Mostar	Agriculture, hilly	4.5	7.0
Trebinje	Agriculture, hilly	5.6	4.1
Relizane	Dry, flat	5.9	6.9
Gospic	Forest, hilly	8.4	3.1
Friedrichshafen	Agriculture, forest, flat	5.3	8.9

Base Data → Matching → DSM Generation → Product Generation → **Final QC**

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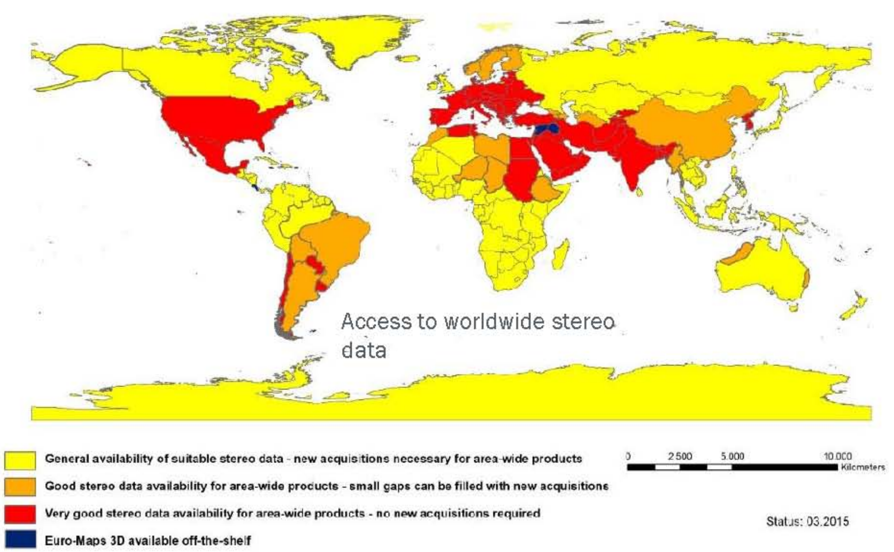
Tested and verified against GPS transects in 22 test sites
▶ different landscapes and types of relief:

CE90 6.7 m

and

LE90 5.1 m

Euro Maps 3D



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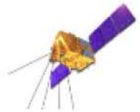

IRS-P5 Cartosat-1

Stereo Coverage

Euro Maps 3D

Post spacing	5 m
Spatial reference system	DD or UTM / WGS84
Height reference system	EGM96
Relative vertical accuracy	LE90 <2.5 m
Absolute vertical accuracy	LE90 5-10 m
Absolute horizontal accuracy	CE90 5-10 m
File format	GeoTIFF (16-bit)
Tile-based DSM	0.5° x 0.5° tiles
Base data	IRS-P5
Ortho layer pixel size	2.5 m

HRE80 and HREGP accuracy requirements are fulfilled

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Euro-Maps 3D Standard

Product Specifications

Euro Maps 3D

Digital Surface Model (incl. ortho image layer, quality and traceability layers)	Price per km²
Product < 50,000 km²	€ 7.50
Product > 50,000 km²	€ 4.50

1) Minimum AOI size is 700 km^2
2) Minimum width of the AOI is 14 km

See also: http://www.euromap.de/products/prod_001.html

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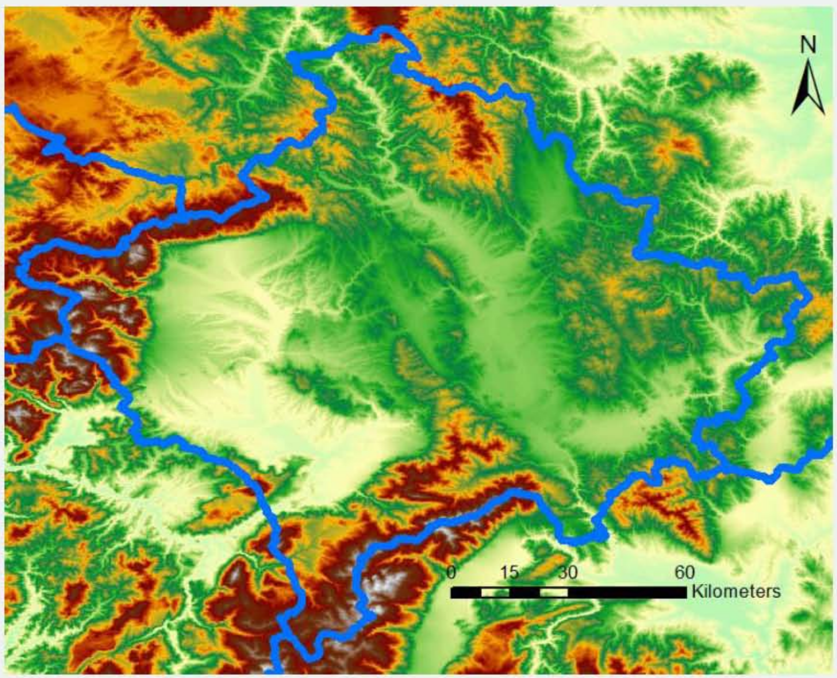
Euro-Maps 3D

Prices

CEOS

Euro Maps 3D



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Euro-Maps 3D Kosovo

- Seamless mosaic
- ~ 130 Stereo pairs
- Multiple coverage of up to 8 stereo pairs

Euro Maps 3D Area-wide coverages: Example: Syria-Northern Iraq

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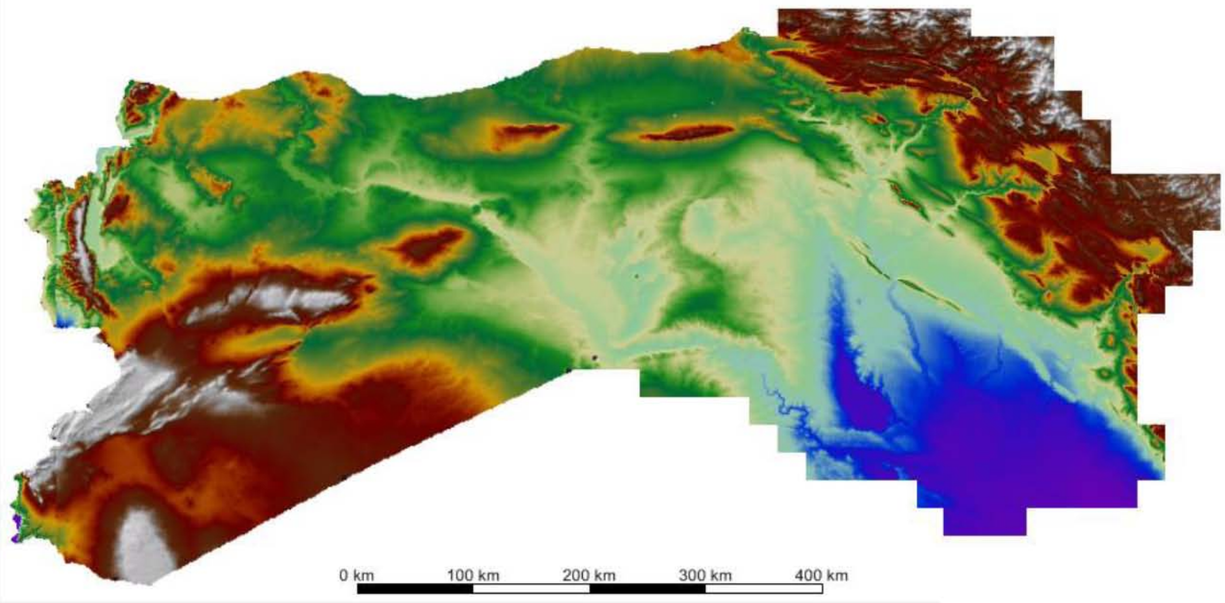
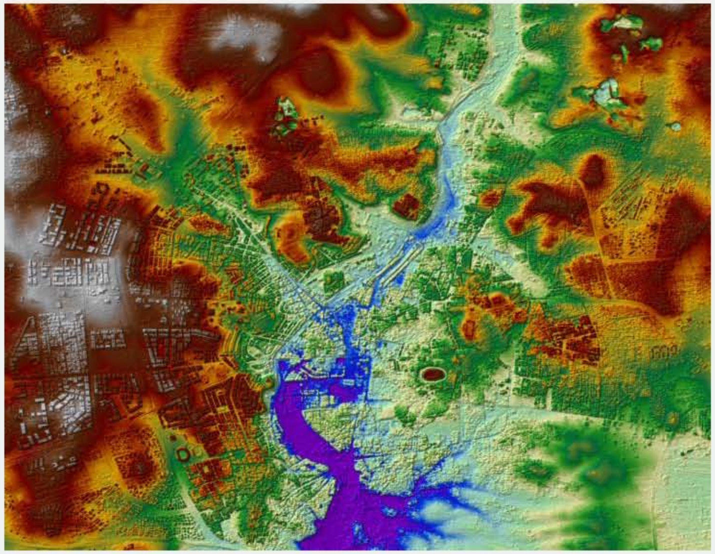


Syria + Northern Iraq (Euro-Maps 3D)

Examples: Urban Structures



City of Aleppo, Syria
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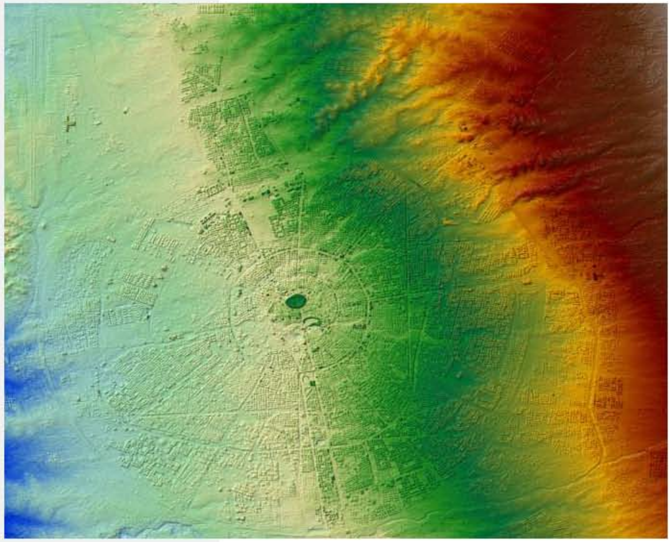

City of Arbil, Iraq
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Euro Maps 3D

Examples: Forest structures

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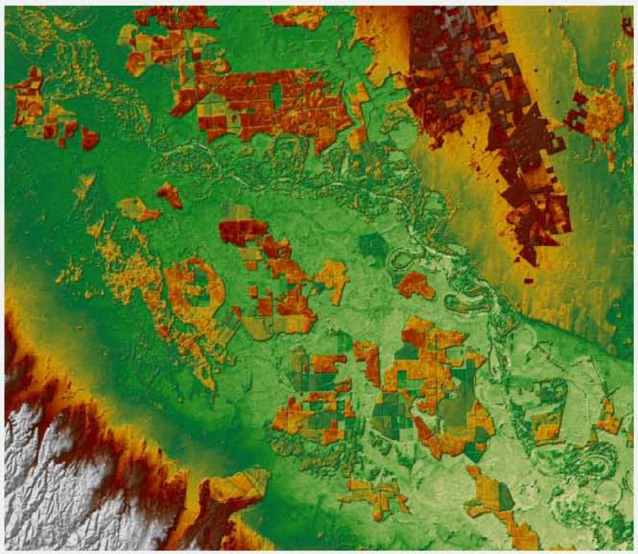

Ferdinandovac, Croatia-Hungarian border
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Friedrichshafen, Germany
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Euro 3D Maps

Examples: Geological Structures

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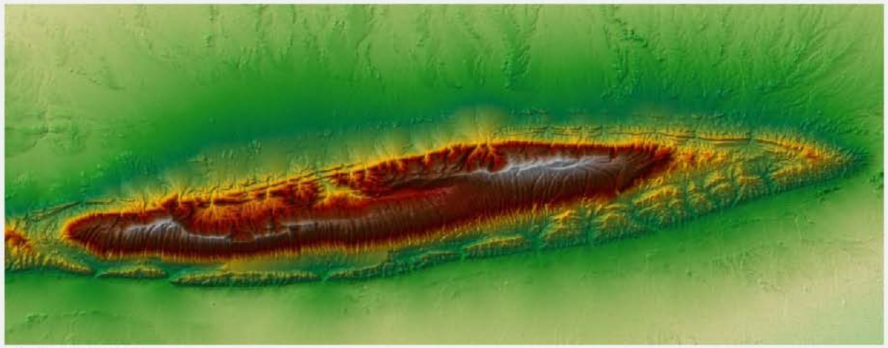
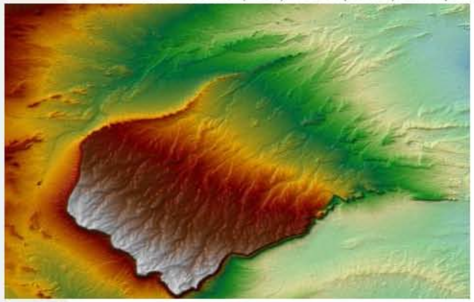
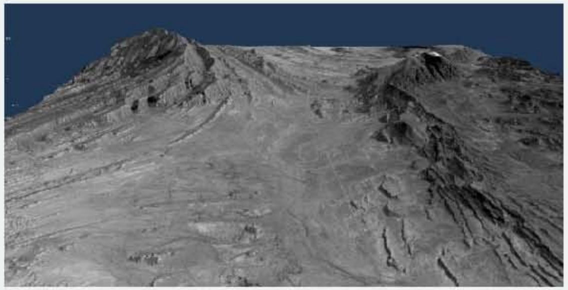


Sinjar Mountains, Iraq



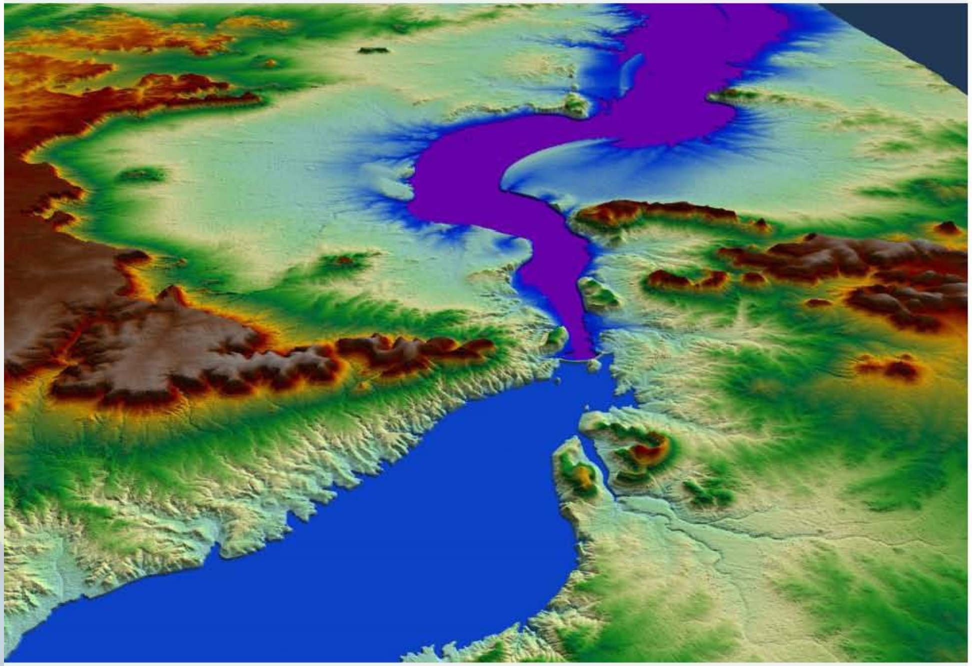
Al Sukhnah, Syria



Bandar Abbas, Iran

Aeolian Islands, Italy

Water body editing



River Euphrat Lake Assad
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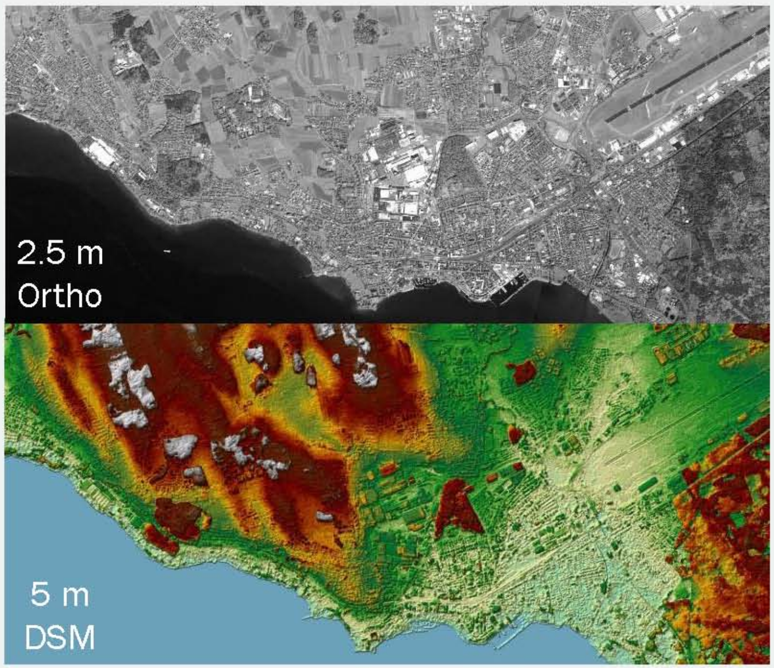

Friedrichshafen, Germany
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Ortho image & DSM

Validation of height values

Euro Maps 3D

- **Infrastructure planning (cross border)**
  - Modelling (hydrological, geological, wind,…)
  - Urban planning
  - Oil & Gas exploration / monitoring
  - Telecommunication network planning
  - Radio propagation
  - Site location assistance (wind turbines,…)
  - Calculation of volumina (e.g. open cast mining,..)
  - Optimization of fuel consumption (best route assessment,…)

- **Hazard analysis**
  - Slope and exposure
  - Flood and flow regime

- **Visualization**
  - 2D (terrain impressions)
  - 3D (fly through; low level flight planning; touristic applications)

- **Derivation of new data products**
  - Orthorectification of satellite data
  - Digital terrain model creation
  - Topographic mapping, e.g. contour lines
  - Elevation input for 3D vector data, urban block models….

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Application examples

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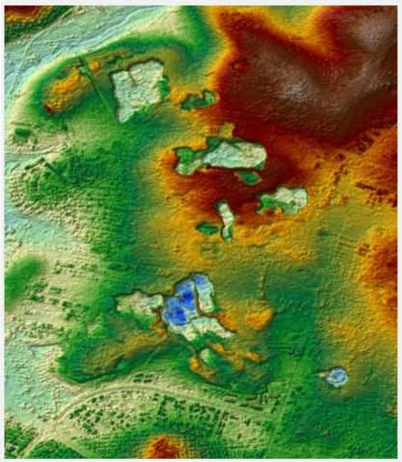
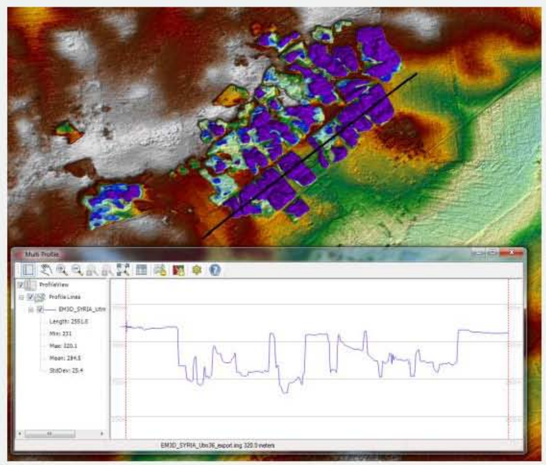
Mining





Mining area, Hamah, Syria
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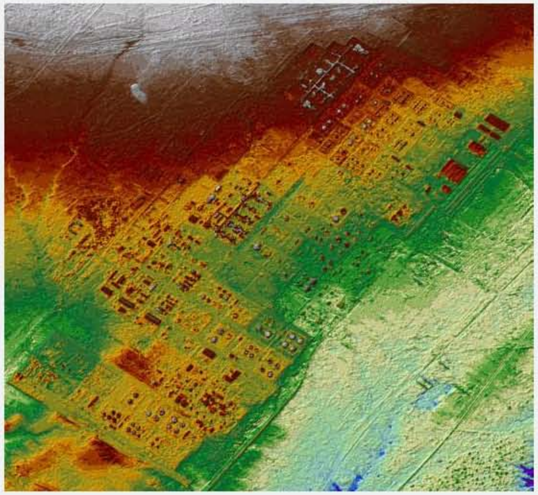

Baji Oil Refinery, Iraq
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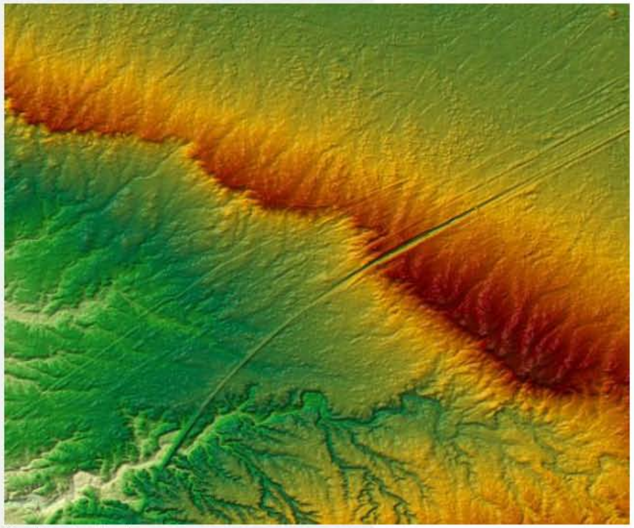
Oil & Gas exploration

Infrastructure Planning



Road construction, Iraq
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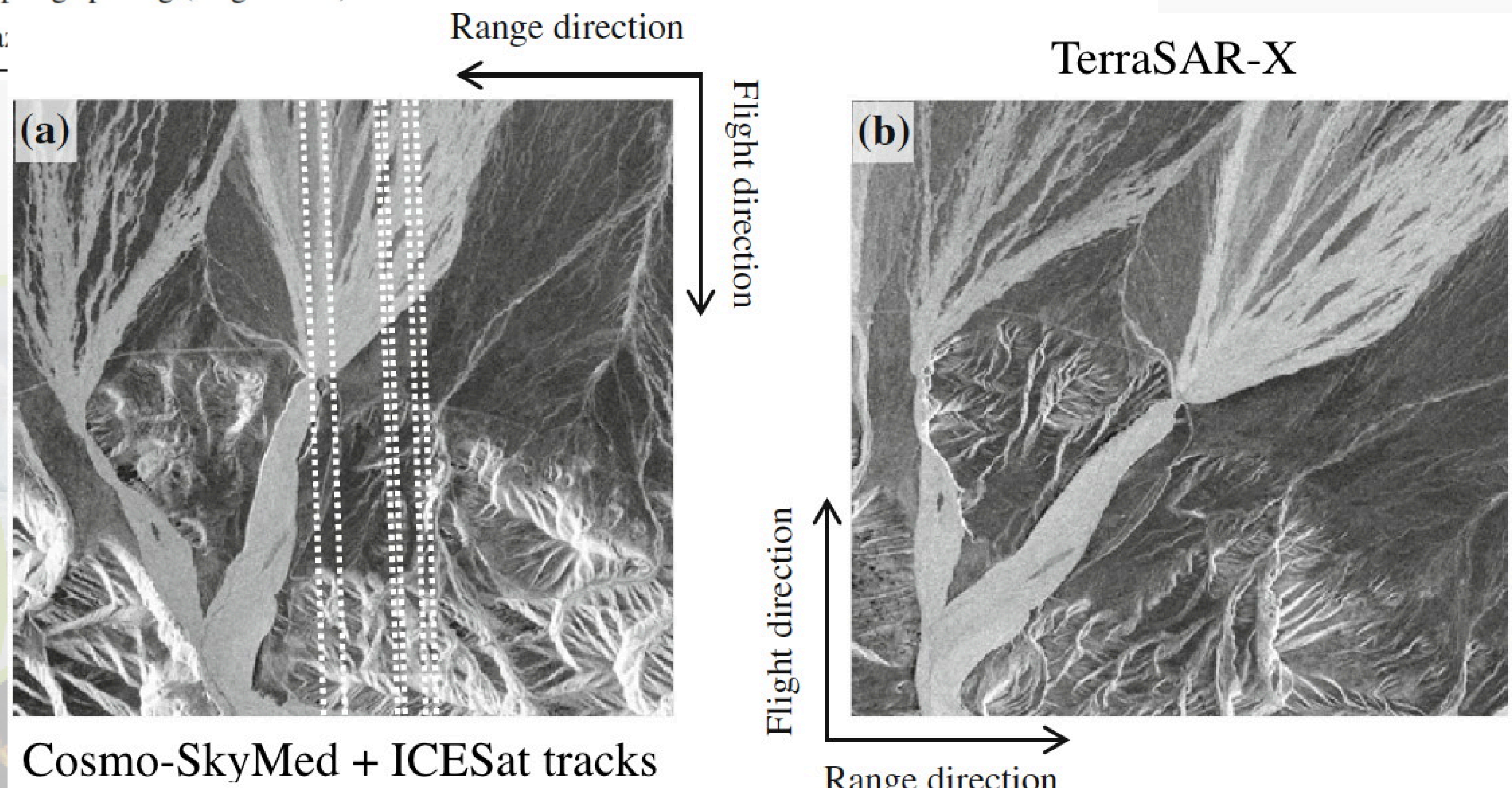
Fusion of high-resolution DEMs derived from COSMO-SkyMed and TerraSAR-X InSAR datasets

Mingsheng Liao
Wuhan University

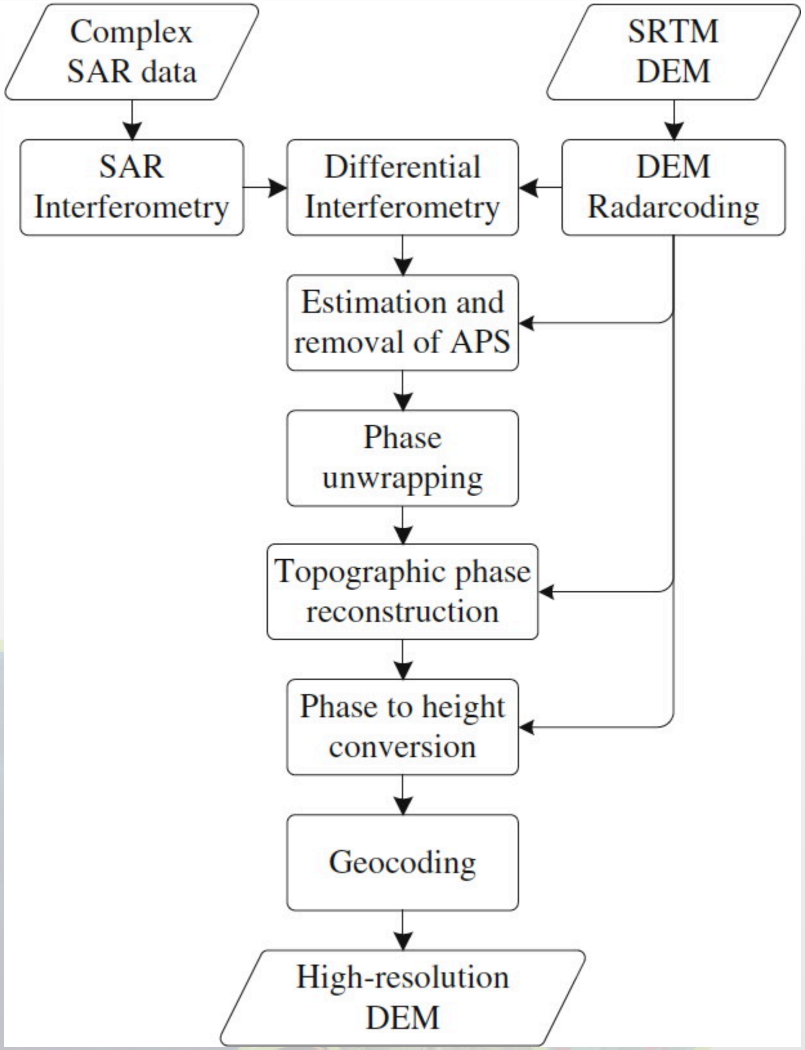
Task description

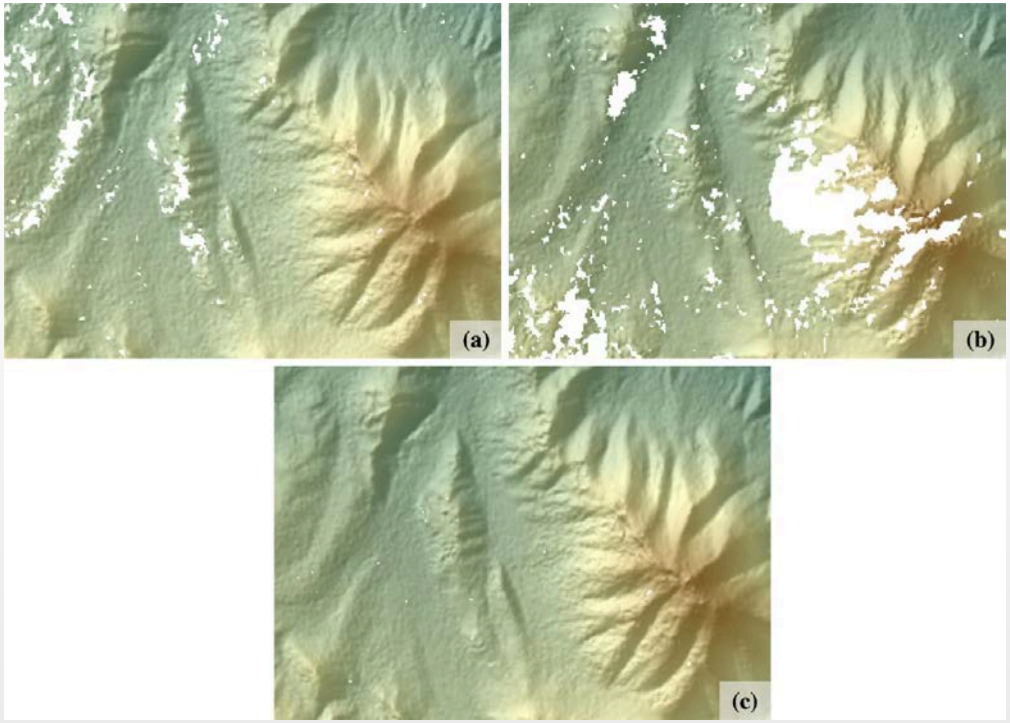
- Fuse 10m InSAR DEMs generated from TerraSAR-X and Cosmo-Skymed
- Voids present in both DEMs (6.9% & 5.7% respectively). After fusion ≤0.13% have voids
- Test site of 10 x 10km, located in NW China
- ICESat and national DEMs from 1:50,000 maps used for validation

Basic information of the two InSAR data pairs used	COSMO-SkyMed	TerraSAR-X
Acquisition date	3 and 4 June 2009	18 and 29 Apr 2008
Orbit direction (heading angle)	Descending (−171.22°)	Ascending (−13.40°)
Temporal baseline (days)	1	11
Nominal incidence angle (°)	48	28
Normal baseline (m)	63	71
Height of ambiguity (m)	164	59
Doppler centroid frequency (master/slave at scene center)	555 Hz/−243 Hz	−2 Hz/−13 Hz
Azimuth/range bandwidth	3106.9 Hz/73.5 MHz	2765 Hz/150 MHz
Azimuth/range sampling spacing (single-look)	2.21 m/1.63 m	1.89 m/0.91 m
Ground coverage (a		

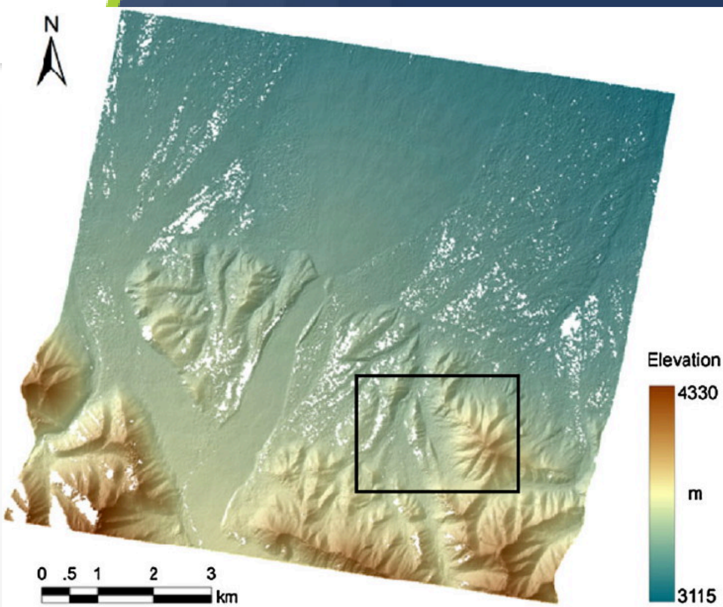


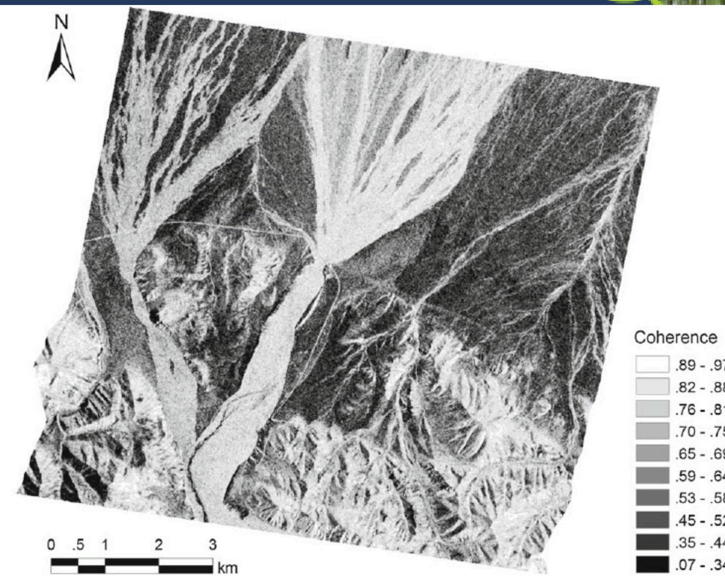
Method applied



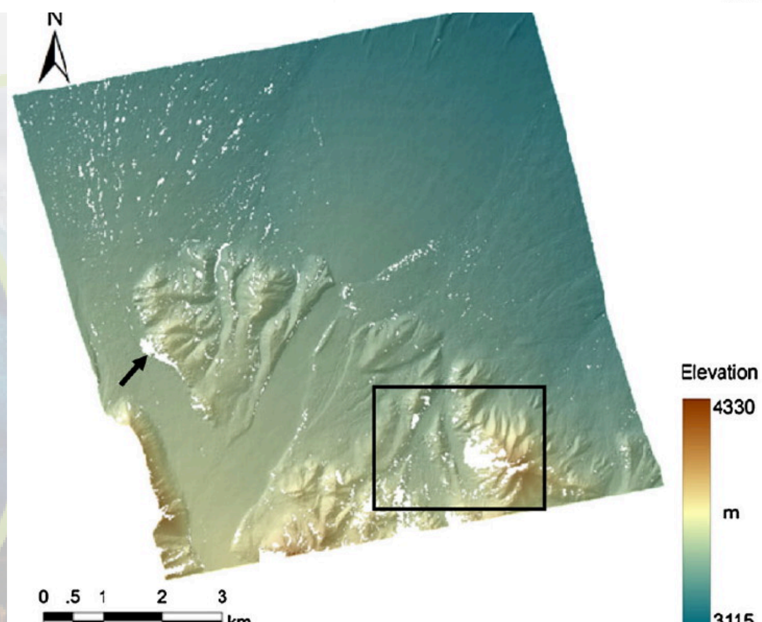


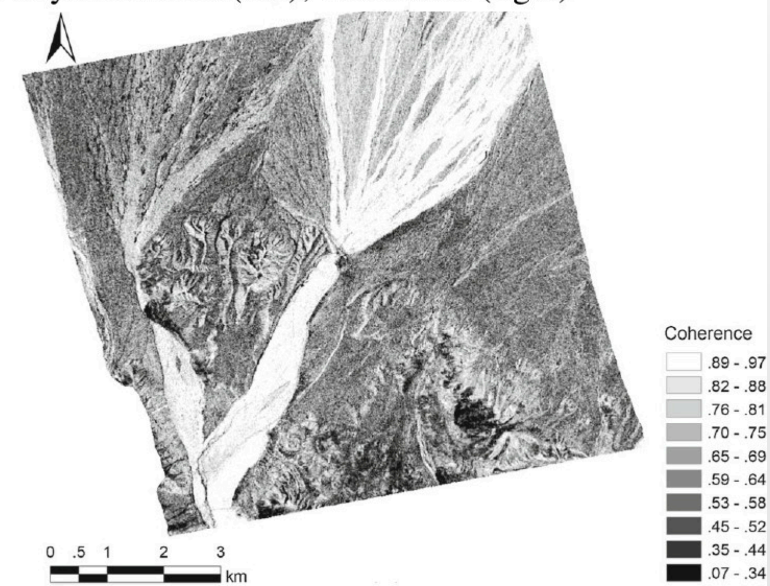
DEMs + Phase Coherence products





Cosmo-SkyMed DEM (left), Coherence (right)



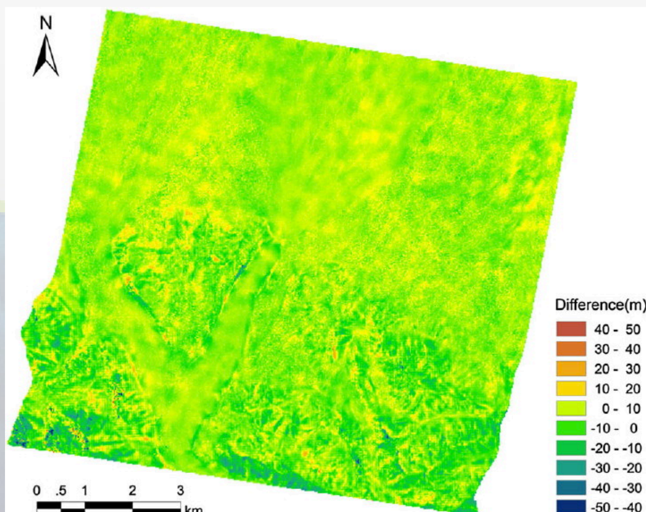


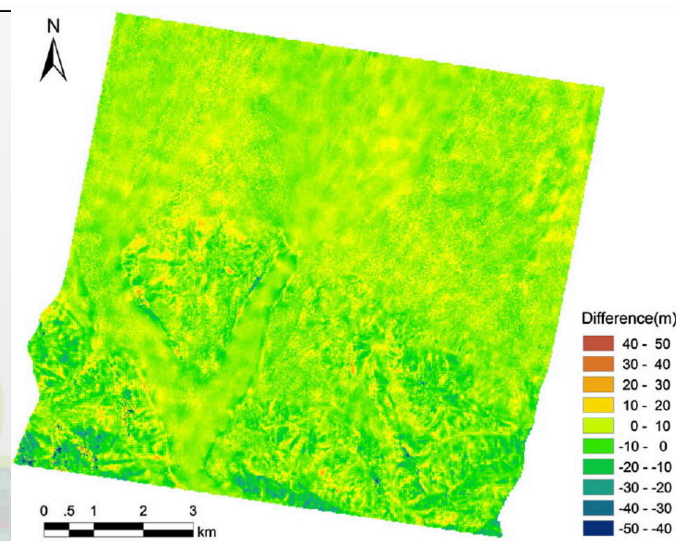
TerraSAR-X DEM (left), Coherence (right)

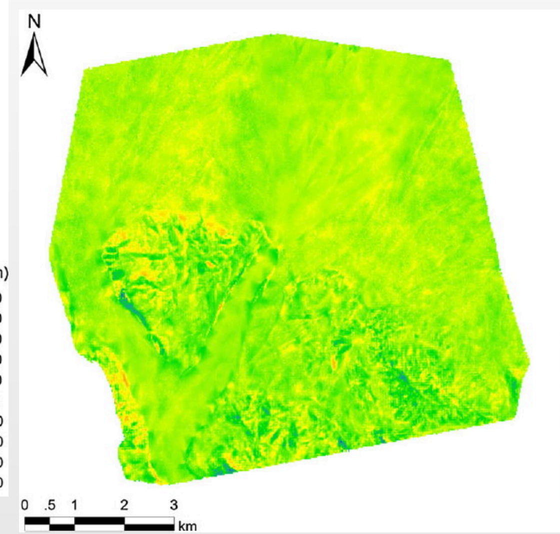
Validation using ICESat & National DEM

Table 2 Statistical error indicators of the result DEMs with respect to the GLAS data

Elevation differences	COSMO-SkyMed DEM			TerraSAR-X DEM			Fused DEM		
	Mean (m)	Median (m)	SD (m)	Mean (m)	Median (m)	SD (m)	Mean (m)	Median (m)	SD (m)
$Diff_1$ (GLAS elevation value—elevation value at the center of the 3 × 3 window)	−6.41	−5.56	6.81	−6.33	−5.47	6.48	−6.36	−5.50	6.24
$Diff_2$ (GLAS elevation value—min. elevation value within the 3 × 3 window)	−4.43	−4.34	6.14	−4.22	−4.15	5.86	−4.29	−4.17	5.75
$Diff_3$ (GLAS elevation value—median elevation value within the 3 × 3 window)	−6.41	−5.45	6.42	−6.29	−5.38	6.19	−6.33	−5.44	6.15
$Diff_4$ (GLAS elevation value—max. elevation value within the 3 × 3 window)	−9.52	−7.83	6.95	−7.90	−6.63	6.87	−8.29	−6.75	6.86







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
  - 2014/15 release of SRTM V2 at 1 arc-second (≈30m)
  - 2016/17 release of TanDEM-X DEM at 3 arc-seconds (≈90m)
  - 2015/16 release of ALOS-PRISM DEM at 1 arc-seconds (≈30m)
  - 2017 release of re-processed NASADEM at 1 arc-seconds (≈30m)
  - Unknown dates for creation of bathymetry of continental shelves using SAR & high resolution EO, once support is released
- What is the status of this recommendation?

TMSG Uncertain Future

- UK Space Agency recently performed review of CEOS commitments (report not yet available) for EOAC
- Decided to re-focus on WG Climate and withdraw support from TMSG
- JPM will have to step down at the end of WGCV39 if no space agency support can be found as without any support it will be impossible to continue
- UKSA not interested in supporting any TMSG-promoted activities
- CEOS-WGCV should review whether it wishes to continue with TMSG and if it does, seek a new chair for the future