CEOS WGCV#26 Report: Terrain mapping sub-group (TMSG)

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Chair, CEOS-WGCV-TMSG

MODIS & MISR science team member (NASA EOS)

TerraSAR-X and TANDEM-X CoI

HRSC CoI (ESA Mars Express)

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 SRTM.**

CEOS WGCV Terrain Mapping and GEO Activities

- **What is the relevance of TMSG to GEOSS 10-year Implementation Plan?**
  - **Six out of the Nine Societal Benefit areas state an urgent need for global topographic information of the highest possible quality, reliability and in some cases resolution (particularly disasters).**
  - **It could be argued that the other 3 areas (weather, biodiversity, ecosystems) have not yet thought through about the role of topography**
  - **Most of the mapping requirements were NOT discussed but are appear to be starting to be addressed**
- **What are the GEO tasks that include DEM components?**
  - **AR-06-06 DEM interoperability**
  - **DA-06-04 Data Management**
  - **DA-06-05 GIS data**
  - **DA-06-07 Web portal**
- **What is (are) the GEO task(s) which TMSG could make a significant contribution in the future?**
  - **DA-06-07 DEM**

Overview

- **Programmatic status**
  - **2006 activities**
  - **Future activities**
- **Scientific status of DEM production & validation activities**
  - **SPOT5**
  - **ASTER**
  - **C-band and X-band SRTM issues**
  - **Data fusion to create seamless DEM - example over Three Gorges**
  - **ALOS-PRISM test site**
  - **TANDEM-X**
- **Programmatic status and plans**
  - **Global Topography (GLOBETOP) 2.0**
  - **WGISS/ICEDS prototype**
  - **Replacement chair**
- **Status of Recommendation from CEOS Plenary #18 (London, 11/05)**

Programmatic Status - 2006 activities

- **Special Issue of *Photogrammetric Engineering and Remote Sensing* on "The Shuttle Radar Topography Mission – Data Validation and Applications". Edited by Dean Gesch (EDC), JPM (UCL), Tom Farr (JPL) and published in March 2006.**
- **Discussions started with Chinese Academy of Sciences Surveying and Mapping Institute, Beijing and Wuhan University about collaboration on DEM QA for DEMs created by 3rd parties over P.R. China. Hit a brick wall with authorities relating to difficulties in releasing any information whatsoever on larger-scale (<1:1M) DEM information. Unsure how to proceed.**
- **Resulting from discussions which took place at the joint WGISS-WGCV#25 in Budapest, a strawman proposal was made for the creation of a new global topography project between WGISS-"Task Team on Global datasets" joint with WGCV-TMSG (see later)**
- **No progress on obtaining 30m SRTM-DEMs for all non-US TMSG test-sites for WTF**
- **No progress on obtaining resourcing for web reporting on "Known Issues - Errors in SRTM DEM" on a public web-site**
- **Limited progress on EO Data Portal - CEOS-WGISS ICEDS (see later)**

Special Issue on SRTM Validation

PE&RS March 2006

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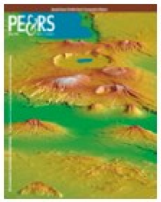


The Shuttle Radar Topography Mission (SRTM), flown aboard Space Shuttle, Endeavour in February 2000, acquired elevation measurements for nearly all of Earth's landmass between 60°N and 56°S latitudes. SRTM data were used to generate this view of the Crater Highlands along the East African Rift in Tanzania. Landforms are depicted with colored height and shaded relief, using a vertical exaggeration of 2X and a southwestwardly look direction.

Lake Eyasi is depicted in blue at the top of the image, and a smaller lake occurs in Ngorongoro Crater. Near the image center, elevations peak at 3648 meters at Mount Loolmalasin, about 2800 meters above the adjacent rift valley. The view continues forward to Mount Longido and the Meto Hills.

Tectonics, volcanism, landslides, erosion and deposition - and their interactions - are all very evident in this view. For many areas of the world SRTM data provide the fi rst detailed three-dimensional observation of landforms at regional scales.

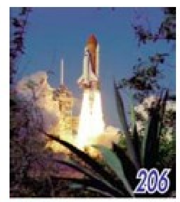
SRTM data are available from the United States Geological Survey at http://edc.usgs.gov/products/elevation.html.

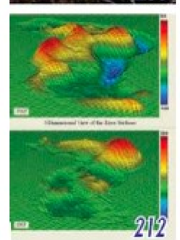
Additional information about the SRTM project is available at http://www.jpl.nasa.gov/srtm/.

This image and an extended caption are available at http://photojournal.jpl.nasa.gov/catalog/PIA06669.
Image by Robert Crippen, NASA/JPL.

Foreword

Highlight Article





Columns & Updates

Announcements

Departments

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Programmatic Status - future activities

- **CEOS-WGISS EO Data Portal project currently working towards**
  - **Addition of edited 3” SRTM DEMs (both WMS and WCS)**
  - **Addition of NASA-GSFC-cascaded ICESAT-GLAS profiles**
  - **Addition of Landsat 5 mosaics for Europe and North America (Dr Nevin Bryant, JPL)**
  - **Extraction of GCP WFS-WCS database (subject to funding) for GRID-enabled automated geocoding and orthocorrection**
- **Working on Global Topography 2.0 proposal and seeking suitable funding sources (see later)**
- **In concert with the relevant national and international bodies, planning to make a push on the creation of an OGC-compliant global Ground Control Points from global mosaiced Landsat and SPOT5 datasets**
- **Current Chair actively seeking replacement after 5 years at the helm. Individual identified but awaiting Employer and Space Agency approval.**

TMSG ACTION Update

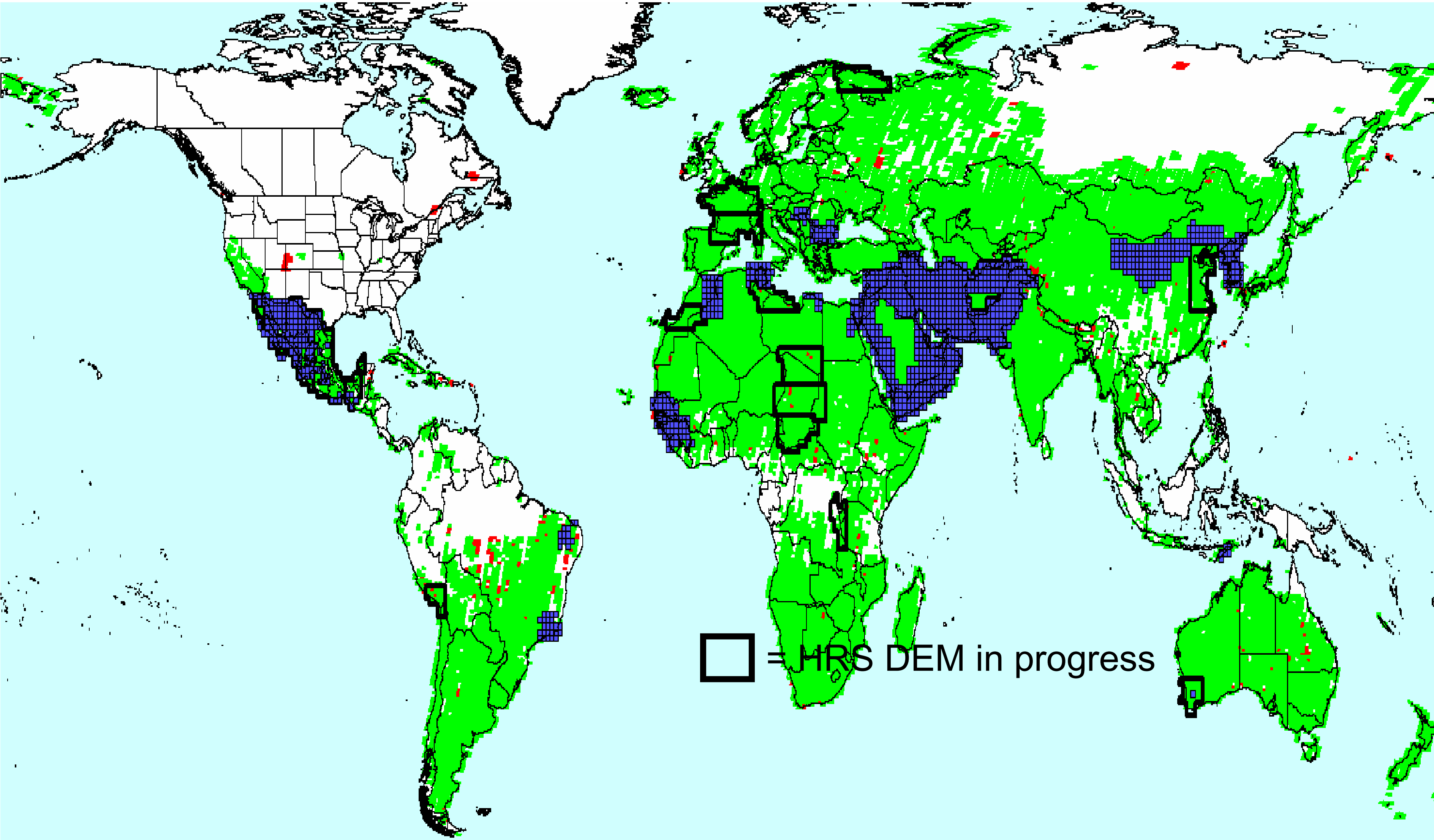
- No progress on obtaining funding for assessment of global coarse elevation datasets (especially SRTM30 and GETASSE30), see discussion in WGCV#25
- Studies underway at USGS-NGA to investigate different options for filling in gaps of >16 grid-points in SRTM as well as completing polar coverage from activities such as RADARSAT stereo
- Plan to hold a meeting on the Global Topography 2.0 project in mid 2007. JPM has invited USGS to host this meeting jointly with NGDC. No progress since invitation in the middle of September
- Inputs received from ALOS on PRISM from recent ESA-sponsored workshop including the final list of Japanese DEM validation test sites
- No interaction with GEO tasks (yet)

Why do we need global topography?

- Six out of the 9 societal areas in the 10-year Implementation Plan for GEOSS require the highest possible resolution VALIDATED DEM (Digital Elevation Model)
- Most urgent, short-term need comes from Disasters
- Georadiometric processing of any land products require global DEM (e.g. global land cover)
- CEOS Plenary and WGCV have previously agreed that this DEM should be sourced from spaceborne sources and be fully VALIDATED
- Need to consider the development of global base maps in this context also as ALL 9 areas require this

> 97 Mkm² of HRS cloud-free stereopairs (red = recent)

SPOT 5 HRS DTED2 DEM + orthoimage (>13M km²)



Independent accuracy assessments

- ISPRS (International Society for Photogrammetry and Remote Sensing) **launched a "Study Team" in Nov 2002 to assess HRS accuracy. Final results were presented at the Istanbul ISPRS congress in July 2004.**

- DGIA (UK MoD) **found Reference3D fully compatible with DTED level 2 standard**

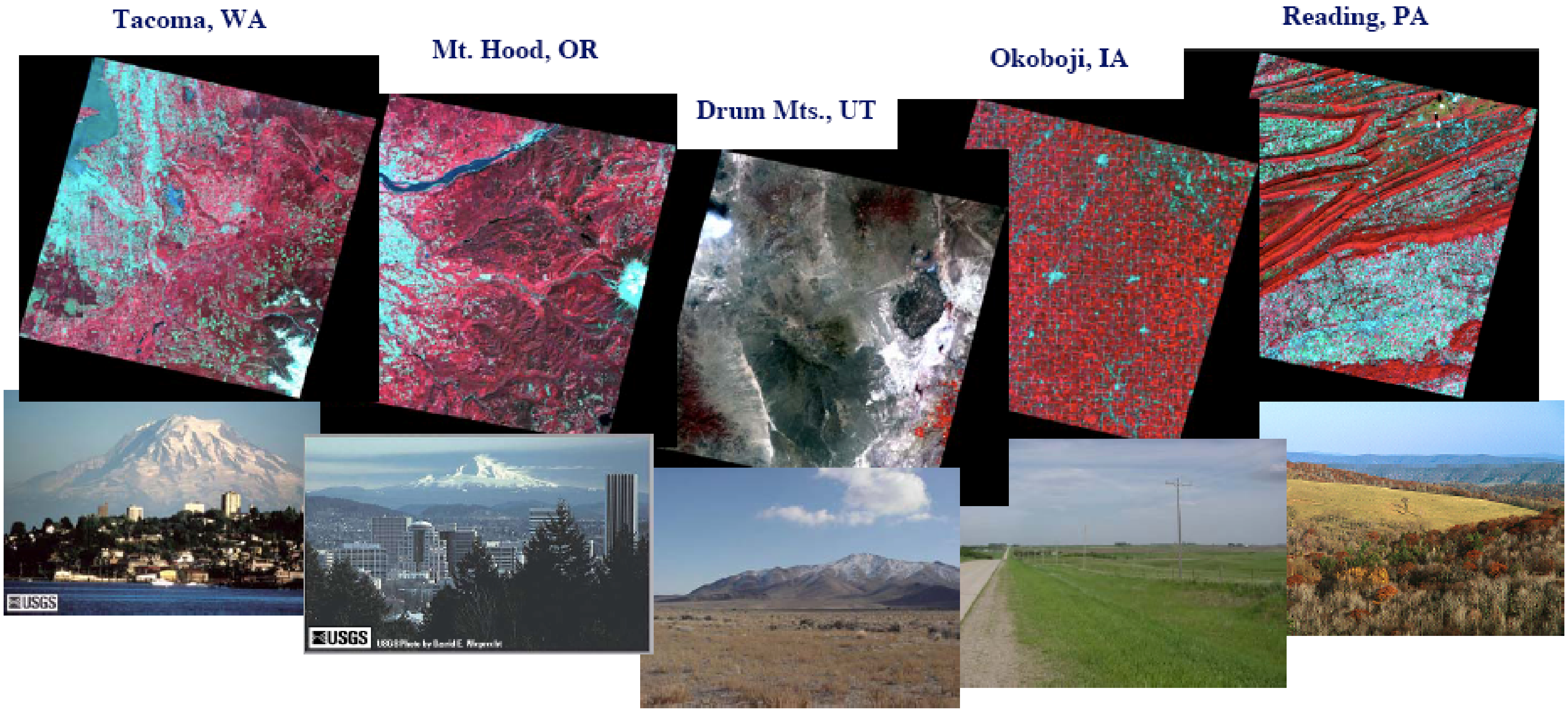
- SRTM - Reference3D **cross evaluation with** NGA **: full compatibility**

- JRC Ispra (European Commission) and FÖMI (Hungarian Mapping) **performed an in-depth assessement of Reference3D over Hungary, using "official" Hungarian data : RMSEz = 3.4m RMSExy = 5.75m**

ASTER DEM status and issues

Thanks to Bryan Bailey (USGS-EDC)

Study Site Selection and Characteristics



- Five sites selected
- Variable terrain
- Two ASTER scenes per site
- Early & recent dates
- Multiple pointing angles

General Methodology

- Generate DEM's from ASTER L1A data (30 m postings).
  - GDS and LP DAAC produced DEM's per our request.
  - We produced DEM's using SILCAST and AsterDTM software.
- Assess horizontal accuracies.
  - Used USGS orthophoto quads and topo maps to determine x-y offsets.
  - Calculate statistics to determine RMSEx and RMSEy values.
- Assess vertical accuracies.
  - Used USGS National Elevation Data (NED) as primary reference data.
  - Produced NED - ASTER DEM "difference" images.
  - Calculated means and standard deviations on all difference images.
  - Calculated RMSEz values from 25 randomly selected and evenly distributed points within each difference image.

Typical Ground Control Point Distribution

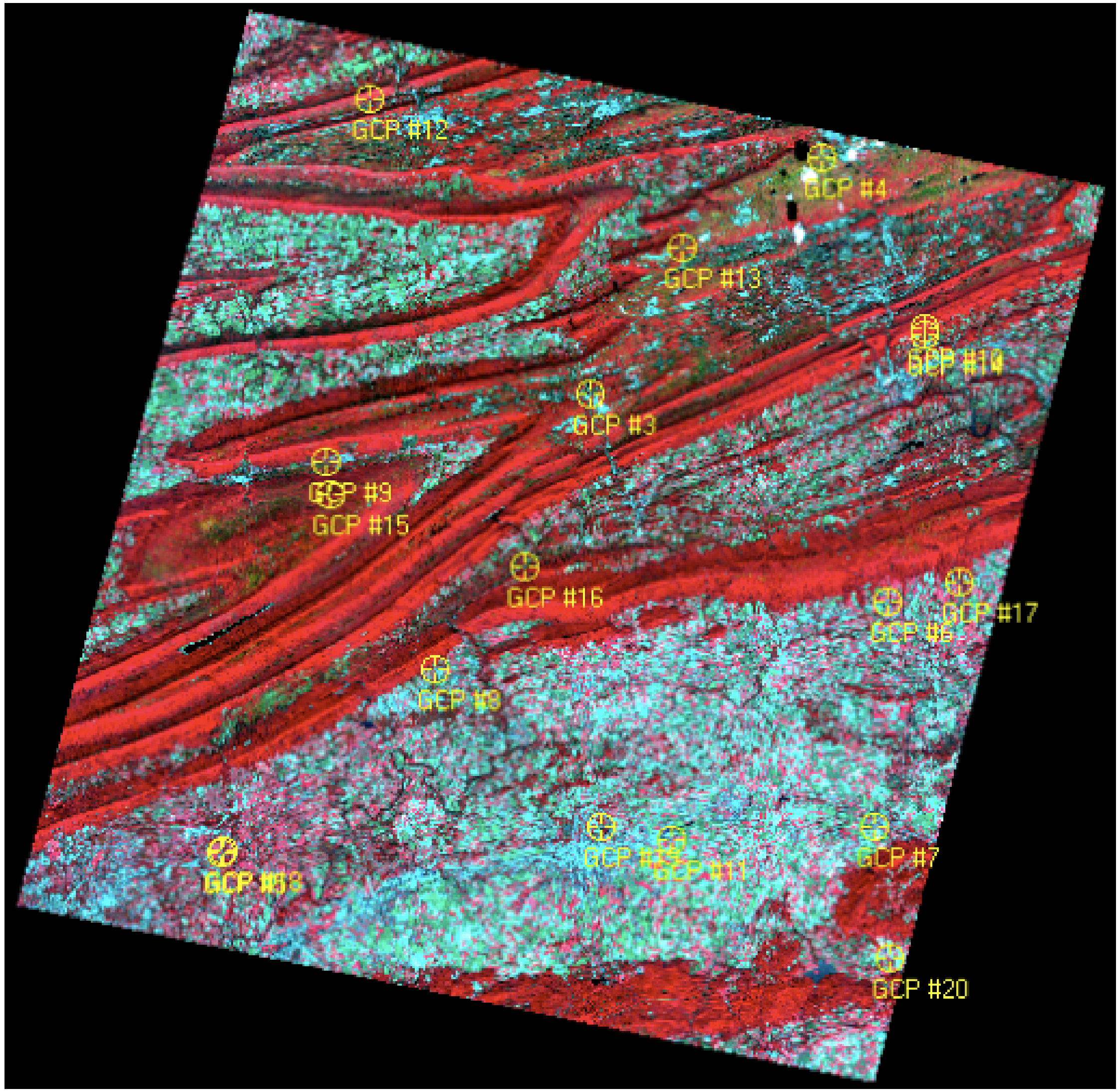
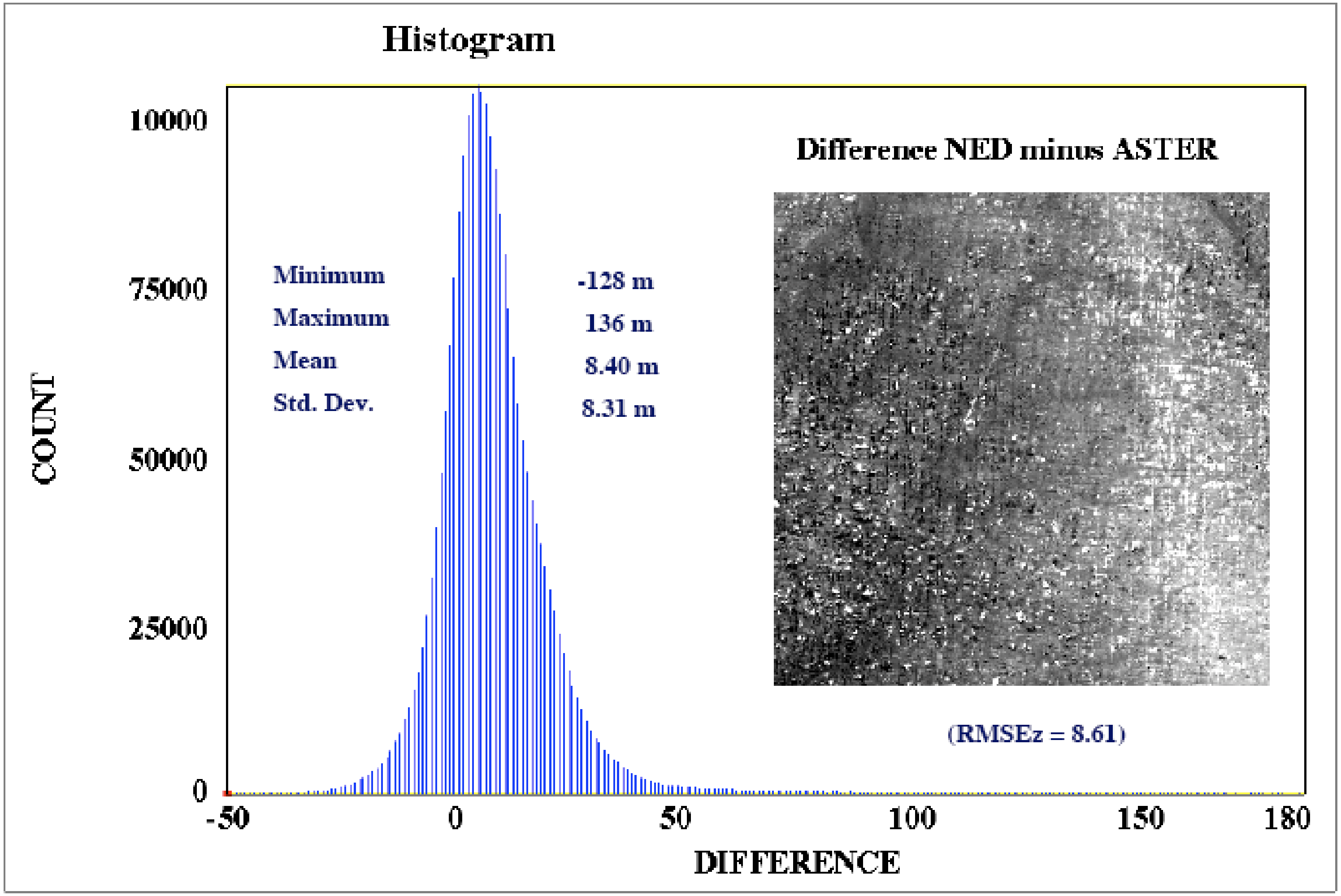


Image Statistics Derived from Difference Image



Vertical Accuracies by DEM Generation System

Software System		X	Y	Z				Z		
		RMSEx	RMSEy	Mean	Std Dev	RMSEz		Mean	Std Dev	RMSEz
SILC Early		16.98	14.08	**10.46**	**15.40**	**14.36**		**7.04**	**13.89**	**11.64**
SILC Recent		22.76	15.53	**3.63**	**12.38**	**8.92**				
GDS Early		50.71	10.60	**9.68**	**14.23**	**14.00**		**10.13**	**15.87**	**15.68**
GDS Recent		95.55	17.39	**10.58**	**17.51**	**17.36**				
SulSoft Early		20.66	21.99	**24.47**	**18.69**	**18.97**		**22.70**	**20.33**	**18.99**
SulSoft Recent		65.46	23.85	**20.92**	**21.97**	**19.00**				
DAAC Early		68.03	23.13	**17.71**	**21.66**	**26.77**		**20.73**	**25.22**	**31.18**
DAAC Recent		104.36	28.16	**23.76**	**28.78**	**35.58**				

* Recent S/W enhancements implemented by GDS, SulSoft, and LP DAAC since completion of this study may improve some results shown in this table.

Vertical Accuracies Compared: SRTM vs. ASTER DEM's

ASTER (SilCast)				
		Z		
Test Site	Acquisition Date	Mean	Std Dev	RMSEz
Drum Mountains, UT	31-Jul-00	-8.83	11.17	11.29
Mt Hood, OR	24-Sep-02	-21.79	15.91	20.02
Okoboji, IA	31-Aug-01	11.49	18.85	15.02
Reading, PA	05-Oct-01	-8.14	15.93	15.27
Tacoma, WA	28-Jun-00	2.03	15.15	10.22
	Average (Abs)	10.46	15.40	14.36
Drum Mountains, UT	20-Mar-04	0.15	8.78	8.78
Mt Hood, OR	27-Jul-04	-3.97	18.84	9.73
Okoboji, IA	22-Oct-03	-3.93	9.68	9.23
Reading, PA	06-May-04	4.61	11.67	8.50
Tacoma, WA	05-Jun-03	5.49	12.94	8.35
	Average (Abs)	3.63	12.38	8.92

SRTM				
		Z		
Test Site	Acquisition Date	Mean	Std Dev	RMSEz
Drum Mountains, UT	N/A	-2.20	2.95	2.78
Mt Hood, OR	"	-13.80	14.23	16.83
Okoboji, IA	"	4.71	1.78	4.83
Reading, PA	"	-5.63	6.25	8.02
Tacoma, WA	"	-1.99	10.75	7.91
	Average (Abs)	5.67	7.19	8.07

Future ASTER research

- Understand source of mean difference bias and relate this to land surface cover and orbital errors
- Investigate how accurately relative ASTER-DEMs can be corrected using SRTM-90m data
- Study error characteristics of ASTER vs SRTM to understand whether ASTER-DEMs can be used to fill in gaps in SRTM-DEM coverage
- Add ASTER-DEMs to CEOS-ICEDS EO Data Portal coverages (completed)

C- and X-band SRTM issues

Thanks to Paul Salamonowicz (NGA) and Marian Werner (DLR)

SRTM Accuracy Goals

- **SRTM Accuracy Design Goals at 90% Probability Level:**
  - Absolute Horizontal (AH) = 20 m
  - Absolute Vertical (AV) = 16 m
  - Random Vertical = 8m → Relative Vertical (RV) = 11 m

- **The accuracies associated with SRTM are defined as follows:**
  - **Absolute Horizontal (AH)** - 2-D horizontal error value such that if any point in the DTED cell or sub-cell is selected at random there is a 90% probability that its true horizontal position is within the AH value of a given position
  - **Absolute Vertical (AV) –** 1-D vertical error value such that if any point in the DTED cell or sub-cell is selected at random there is a 90% probability that the true elevation is within the AV value of the given elevation
  - **Relative Vertical (RV)** - 1-D vertical error such that if any two points in the DTED cell or sub-cell are selected at random there is a 90% probability that the true difference in elevation between them is within the RV value of the computed difference in elevation.
  - NOTE: Relative Horizontal (RH) error estimates are not provided for SRTM DTED® because it is difficult to measure with the coarse resolution data

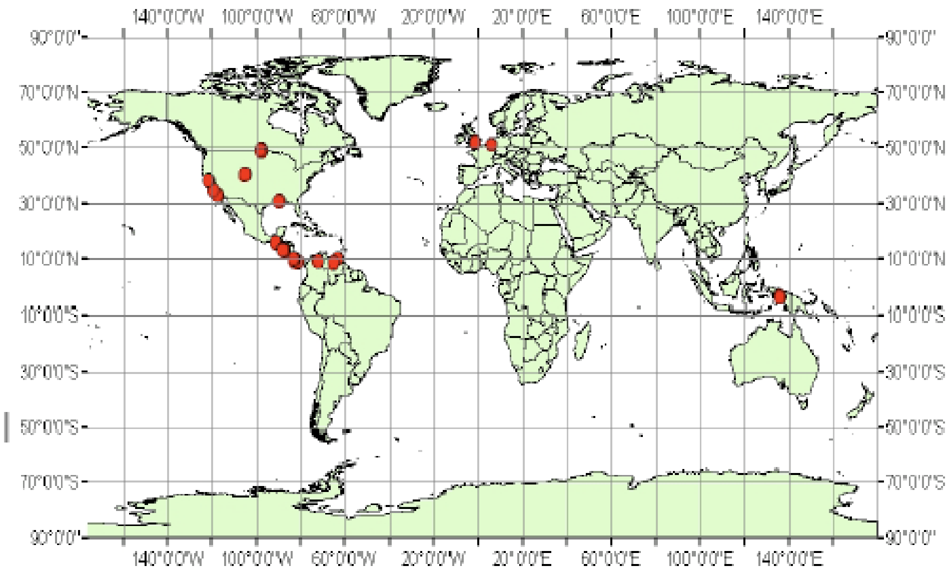
Overview of SRTM Products

- **Digital Terrain Elevation Data - Level 2® (DTED-2®)**
  - Consists of cells covering a 1° x 1° geographical area
  - Post spacing: 1" x 1" between equator and 50° latitude, 1" x 2" above 50° latitude
  - Vertical Reference: Mean Sea Level (MSL)
  - Provides cell wide error predictions at the 90% confidence level for: AH, AV, RH

- **Terrain Height Error Data (THED)**
  - Attempt to provide error estimates at a finer resolution than those provided with the DTED®
  - Provides an estimate of the elevation random error per post
  - Includes metadata known as Vertical Systematic Error Model (VSEM)
    - VSEM divides a cell into 64 sub-cells (8 x 8)
      - Each sub-cell covers 7.5' x 7.5' and contains 450 x 450 posts
    - VSEM Provides (at the 90% confidence level):
      - A representative random error per sub-cell
      - An estimate of the distance over which the error is correlated
      - An estimate of the long-wavelength (systematic) error
    - Based on the estimated errors above, the VSEM also provides an estimate of the absolute vertical (AV) and relative vertical (RV) errors on both a cell and sub-cell basis.

Ground Truth Data

- **Elevation Ground Truth**
  - Star-3i X-band IFSAR
    - 10 meter or 5 meter post spacing
    - Vertical Accuracy =1,2,3 m (1σ)
    - Horizontal Accuracy = 2.5 m (1σ)
  - 152 samples
  - Each sample covers approx. 1 sub-cell
  - Cover 21 unique geographic areas



Star-3i Data Samples

- **Land Classification Data**
  - The Global Land Cover 2000 (GLC2000)
    - The GLC 2000 was created as part of a project by the European Commission titled Global Environment Information System (GEIS)
    - Land cover classification was generated from SPOT-4 VEGETATION sensor
      - Contains Blue, Red, NIR, and SWIR channels
    - Worldwide data collected in 14 months from 1 November 1999 – 31 December 2000
    - The USGS/EROS Data Center participated in the classification of the data over North America.
    - More information on the dataset can be found at http://www.gvm.jrc.it/glc2000

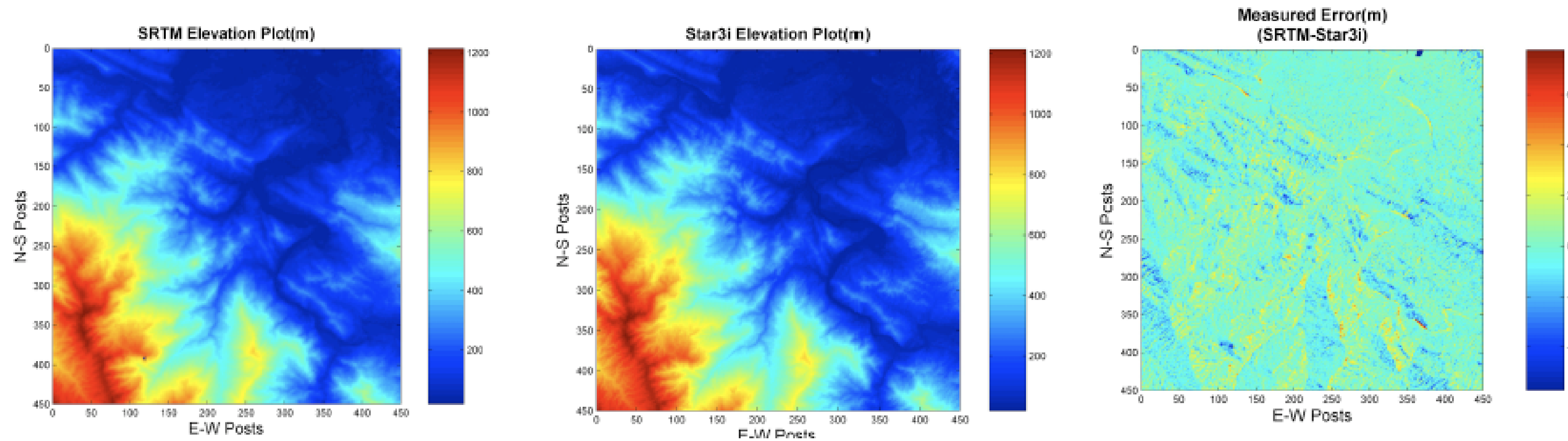
Reference: "Global Land Cover 2000 database. European Commission, Joint Research Centre, 003. http://www.gvm.jrc.it/glc2000."

▶ DTED-2® Analysis

Error estimates at 90% Probability Level

Sample of a Poor Sub-Cell: Panama – GT3N09W082C5V1

	Pre Horizontal Adjustment				Post Horizontal Adjustment Shift X:-21m Shift Y: -6m			
	LW /Bias (m)	RRE (m)	AV (m)	RV (m)	LW /Bias (m)	RRE (m)	AV (m)	RV (m)
Predicted	4.9	6.9	8.5	9.7	4.9	6.9	8.5	9.7
Measured	3.0	15.1	15.6	21.1	2.1	12.2	12.2	16.9

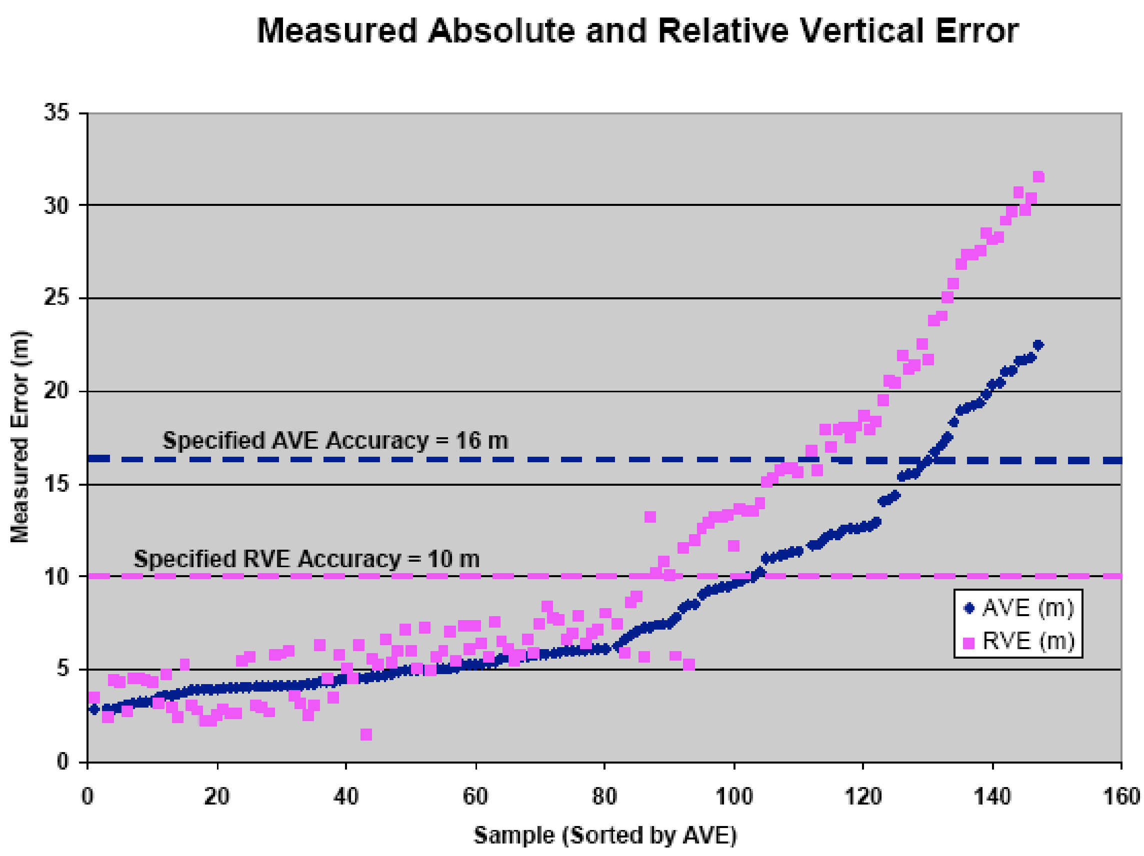


DTED-2® Vertical Accuracy Results

- The measured AV for the various samples show that most of them (88%) meet the SRTM specification

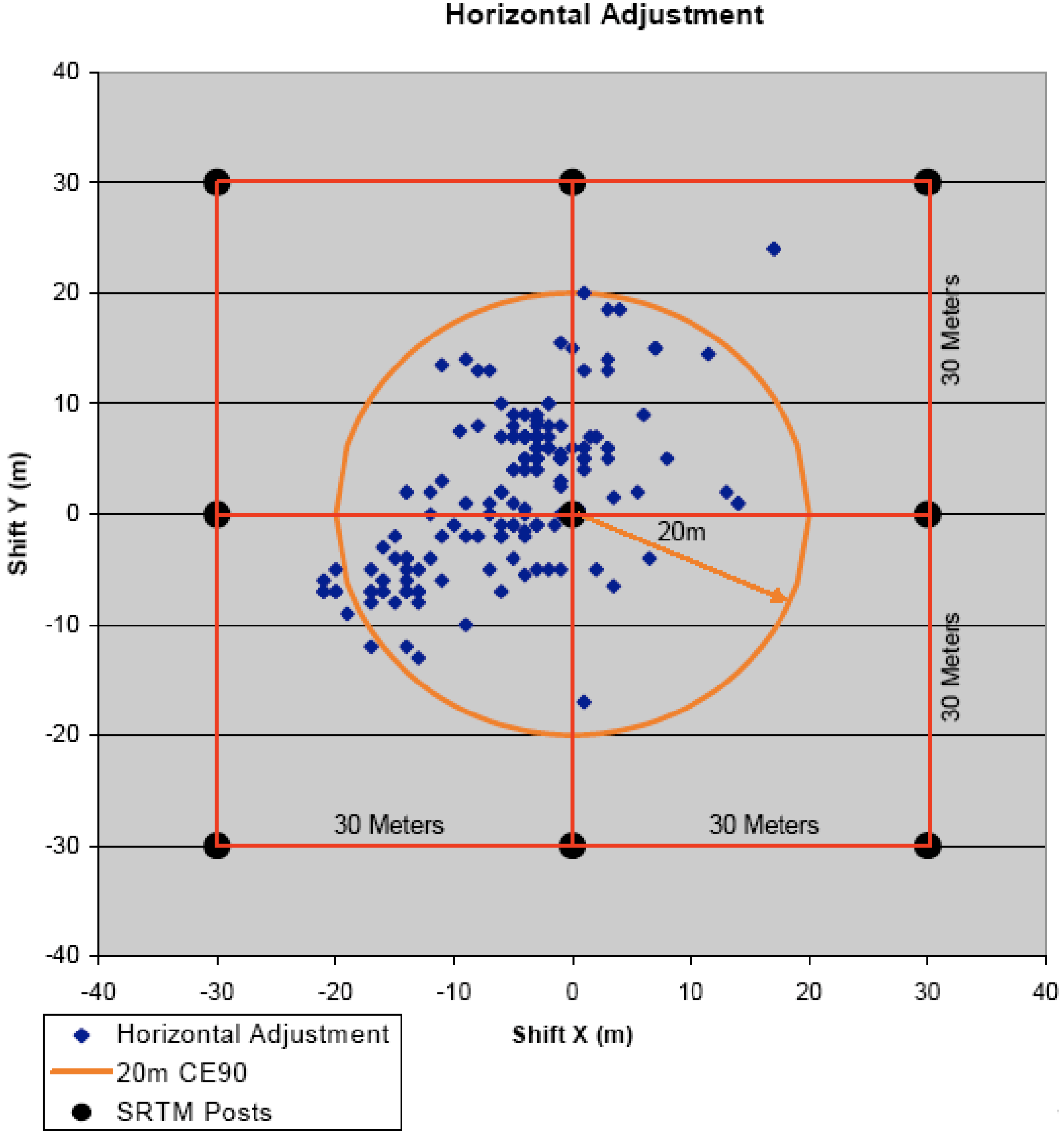
- Only 60% of the RV meet the specification

Note: Many of the samples used in this study are from regions that make IFSAR collection difficult



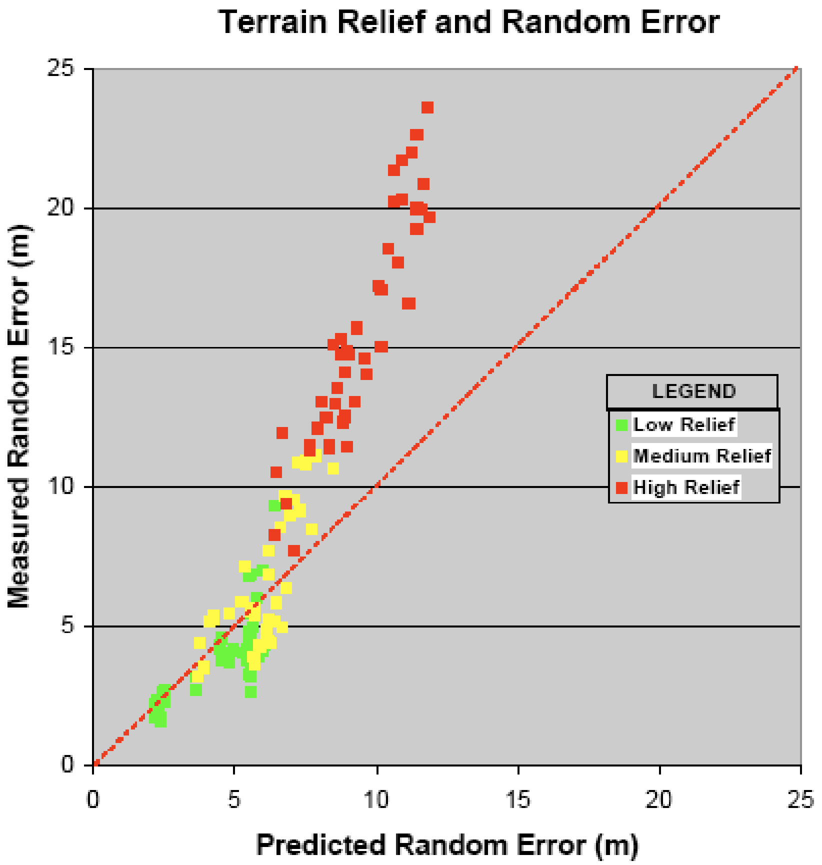
DTED-2® Horizontal Accuracy Results

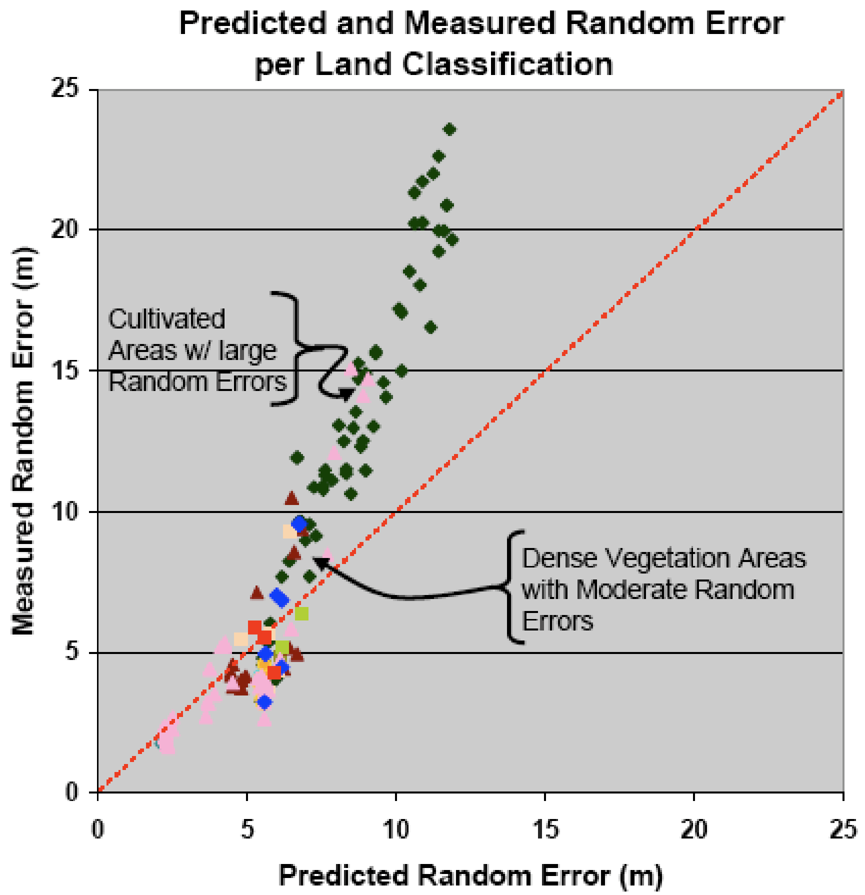
- Quality of the horizontal positioning of the SRTM data is very good
- Design spec for absolute horizontal accuracy was 20 meters at the 90% confidence interval
- The measured horizontal shifts are well within this value



SRTM / THED Error Analysis

Comparison of the random error plot based on terrain and based on land classification





Representative Sample

Average accuracy results for our sample at the 90% probability level

	Random	AV (m)	RV (m)	Global Percentage
Overall	8.11	8.38	10.90	100.00
Low Relief	3.69	4.79	5.04	67.03
Mid Relief	6.36	6.64	8.76	25.69
High Relief	15.46	15.18	21.36	7.28

- Using global percentages for relief to normalize SRTM accuracies based on the results of this study yields the following global accuracy estimate:

  AV = 6.0 m   RV = 7.2 m   Random = 5.2 m

- These compare well to the JPL results averaged across continents:

  AV = 6.8 m   RV = 6.9 m

Validation: SRTM / X-SAR DEM over Germany

(Navigation Point Height) – (SRTM Height)

flat terrain				
	number	μ	σ	RMS
forested areas	2329	-6.20	6.74	9.16
urban areas	1683	-2.63	4.10	4.87
open landscape	**20786**	**-0.94**	4.31	**4.41**
Σ	24798	-1.55	4.84	5.08
moderate relief				
	number	μ	σ	RMS
forested areas	1970	-1.98	7.60	7.86
urban areas	725	-1.14	4.86	5.00
open landscape	**8000**	**+0.15**	4.54	**4.54**
Σ	10695	-0.33	5.33	5.34
highlands				
	number	μ	σ	RMS
forested areas	2272	-4.43	8.62	9.69
urban areas	766	-1.04	5.29	5.39
open landscape	**7693**	**-0.74**	5.36	**5.41**
Σ	10731	-1.54	6.37	6.55

Tab. 1: SRTM DEM validation against navigation points in the western part of Germany

Reference Data:

- 46231 Navigation Points (NPs), provided by AMilGeo Euskirchen, Germany
- Test area: western part of Germany 1000 km x 300 km
- The mean of the SRTM heights is in good accordance to the NPs for open landscape
- Urban and forested areas show the expected bias (= mean difference between surface and terrain height)
- Standard deviations correspond to the height errors induced by the uncompensated boom oscillations
- PDF of tree heights => higher RMS values for forested areas

X- and C-SRTM DEM: Future Issues

- **JPL have completed editing the SRTM 3" (≈90m) DEM and USGS now distribute this using anonymous ftp**
- **JPL have completed the orthorectification of the SRTM SAR amplitude subsetted by orbit and by a 1º x 1º tile**
- **At the workshop, NASA and USGS requested that NGA release the SRTM 1" (≈30m) DEM as well as the THED. NGA responded by stating that the US had various bi-lateral agreements with countries around the globe which prevented this. The debate continues but it should be noted that Scott Hensley (JPL) showed that the true resolution of SRTM-1" was some 45-60m cf. 30m. Perhaps a compromise could be reached with data release at 2 arc-seconds?**
- **User's priority (e.g. UN, GEOSS) is to fill gaps in SRTM coverage including above 60ºN and below 56ºS**
- **NASA has prioritised the re-processing of SRTM including X- and C- as well as ICESAT-GLAS rather than a new mission for these areas**
- **DLR have received the results of a national review and the proposed TANDEM-X (dual TerraSAR-X) will be funded**

Fusion of ASTER and SRTM

Thanks to Nick Austin (UCL,
ESA DRAGON Prizewinner 2006)

DEM fusion

- **Sources of Data:**
  - **Shuttle Radar Topographic Mission (SRTM) DEM**

    FREE from the Global Land Cover Facility's (GLCF) ftp site (ftp://ftp.glcf.umiacs.umd.edu/glcf/SRTM/), USGS EROS data server, and ICEDS.

    90m resolution, good vertical accuracy, almost complete coverage (voids exist)
  - **Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)**

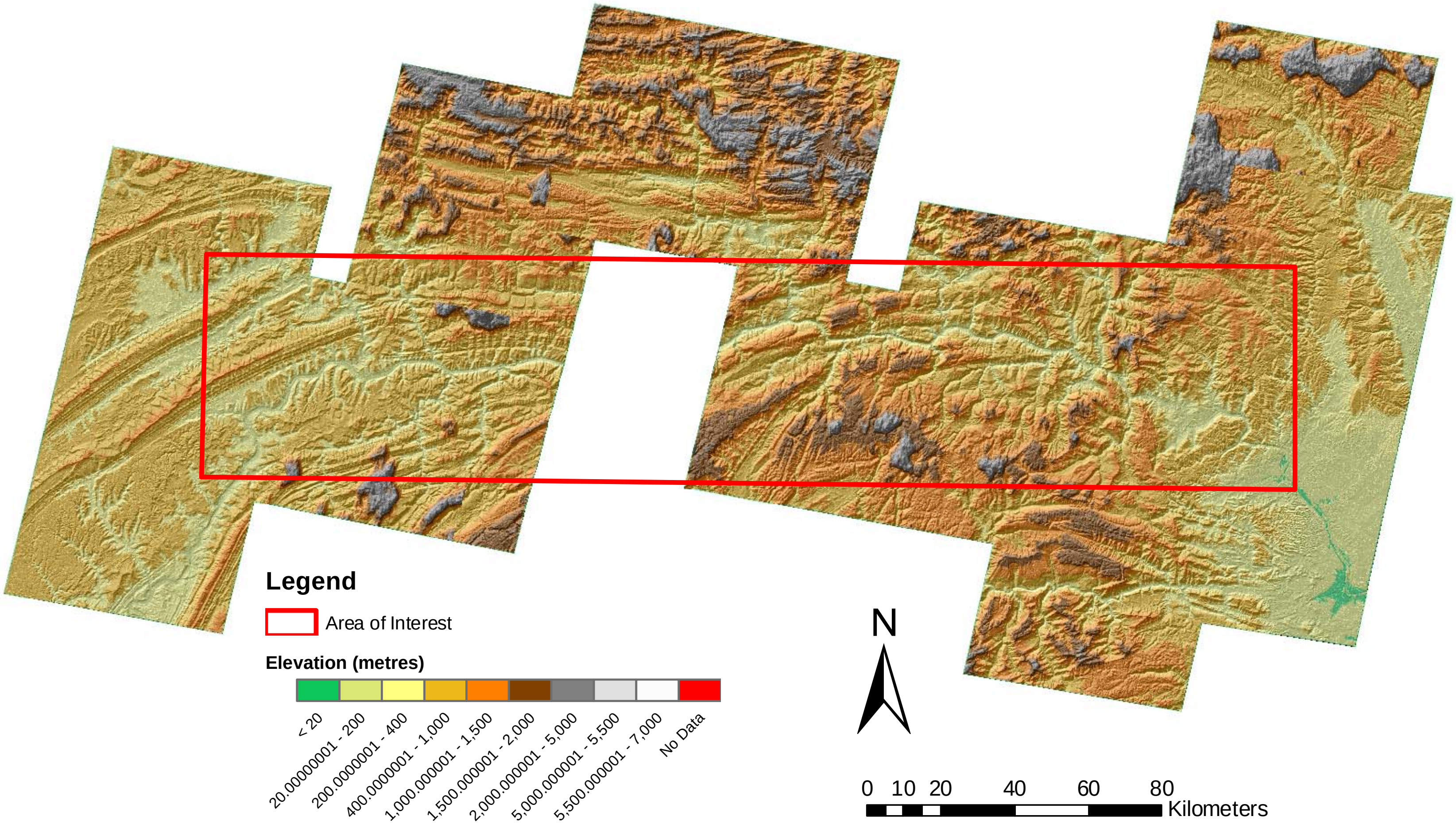
    Obtained from NASA's Earth Observing System (EOS) Data Gateway (available at http://edcimswww.cr.usgs.gov/pub/imswelcome/)

    NASA HQ kindly supported FREE access to ASTER DEM and ASTER level 1A products (as no official orthoimage products were available at the time)

    30m resolution, poor vertical accuracy in high altitude areas,

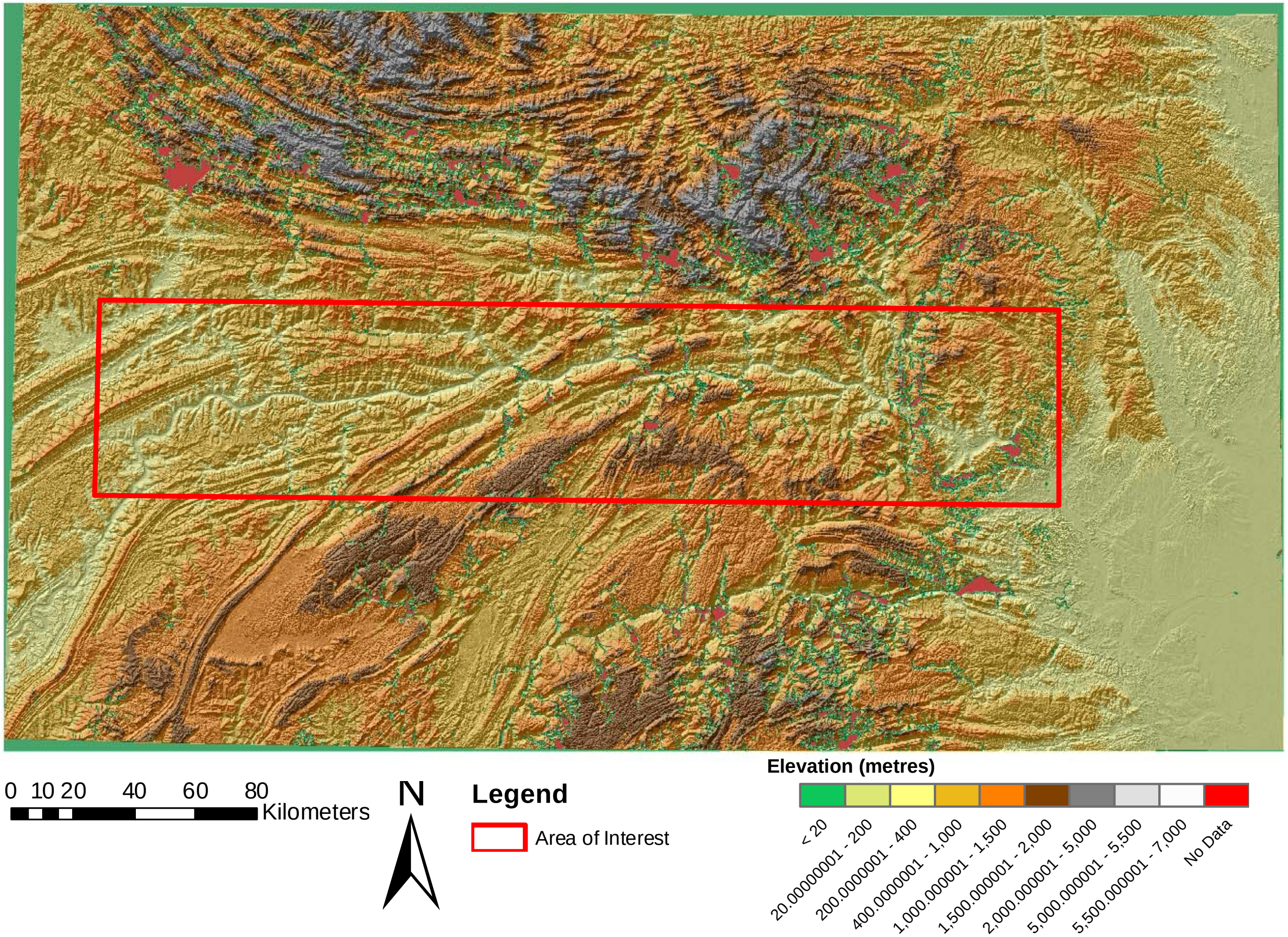
    artefacts caused by cloud cover
- **Aim is to explore different methods of how to fuse DEMs together to get advantages of both (coverage vs reliability vs resolution)**

ASTER DEM Mosaic created in ER Mapper of the Three Gorges Reservoir Region



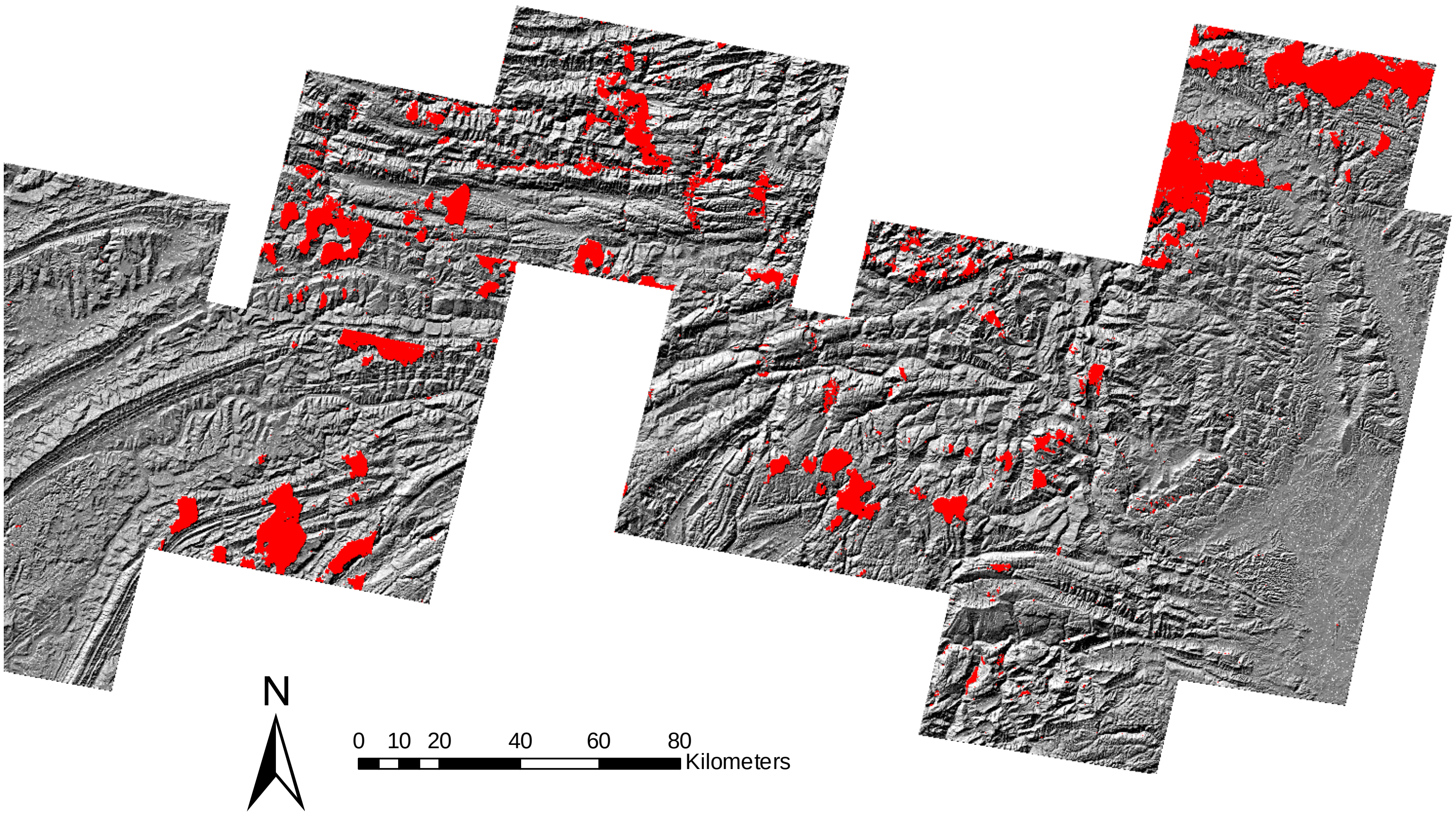
ASTER DEM mosaic hill-shaded in ArcMap with 30° altitude and 330° azimuth for the light direction, using ICEDS custom hill-shading colour scheme

SRTM DEM Mosaic of the Three Gorges Reservoir Region



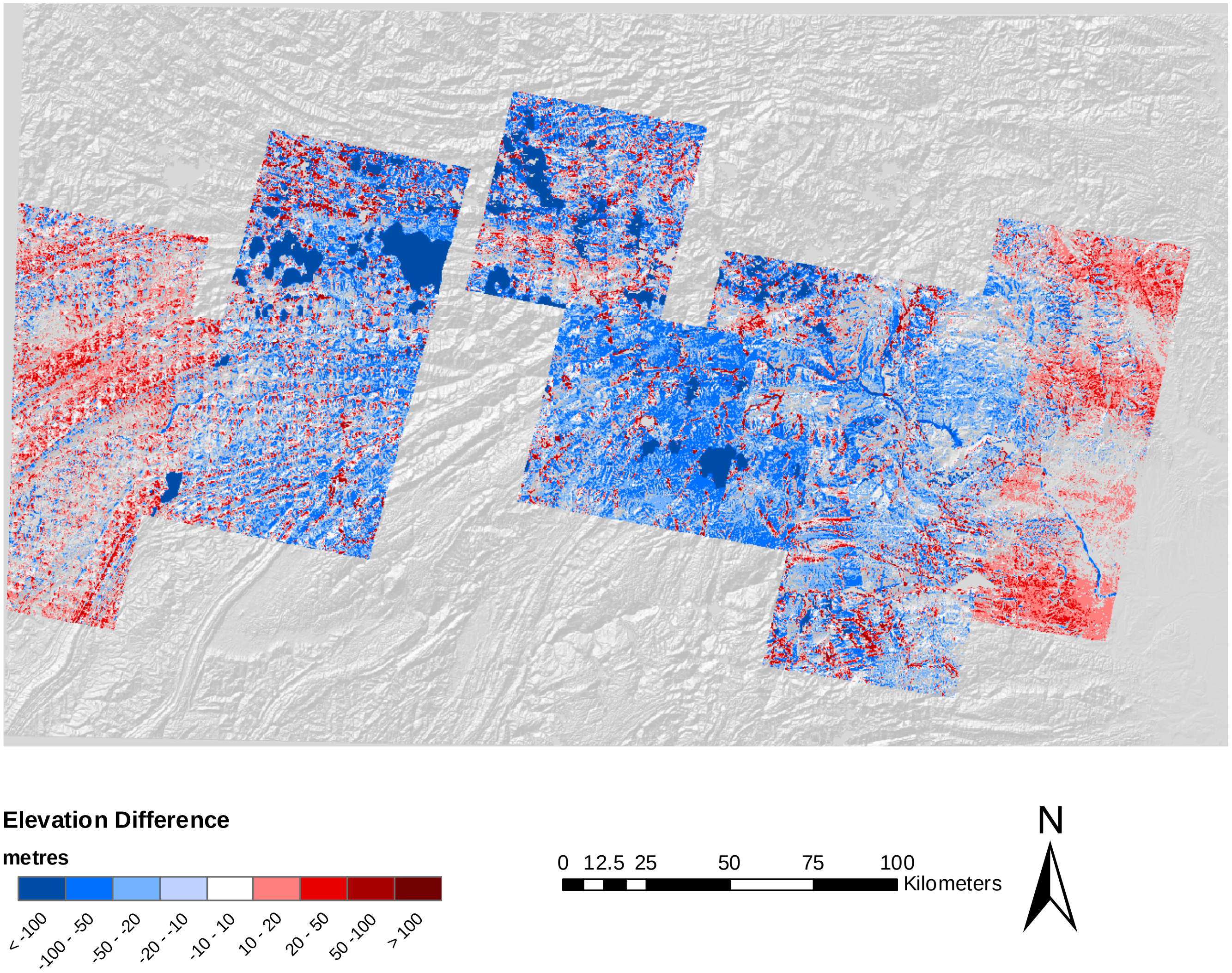
SRTM DEM mosaic hill-shaded in ArcMap with 30° altitude and 330° azimuth for the light direction and using ICEDS custom hill-shading colour scheme. Notice the red areas of missing data.

ASTER DEM Mosaic contains a number of artefacts (clouds in the original data)

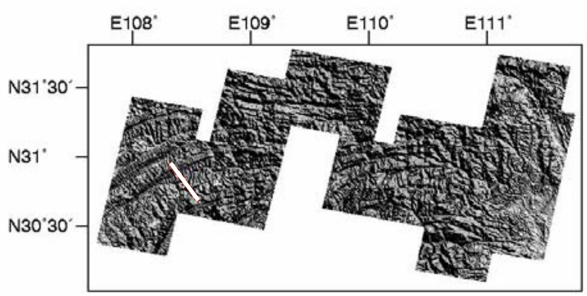


Elevation difference map created in ArcMap showing cloud cover artefacts in the ASTER DEMs. The map was obtained by subtracting the SRTM DEM mosaic from the ASTER DEM mosaic, removing subtle differences between the DEMs and applying a mask. The red areas represent height differences caused by clouds in the original ASTER L1a stereo images

Elevation difference image: SRTM DEM – ASTER DEM Mosaic

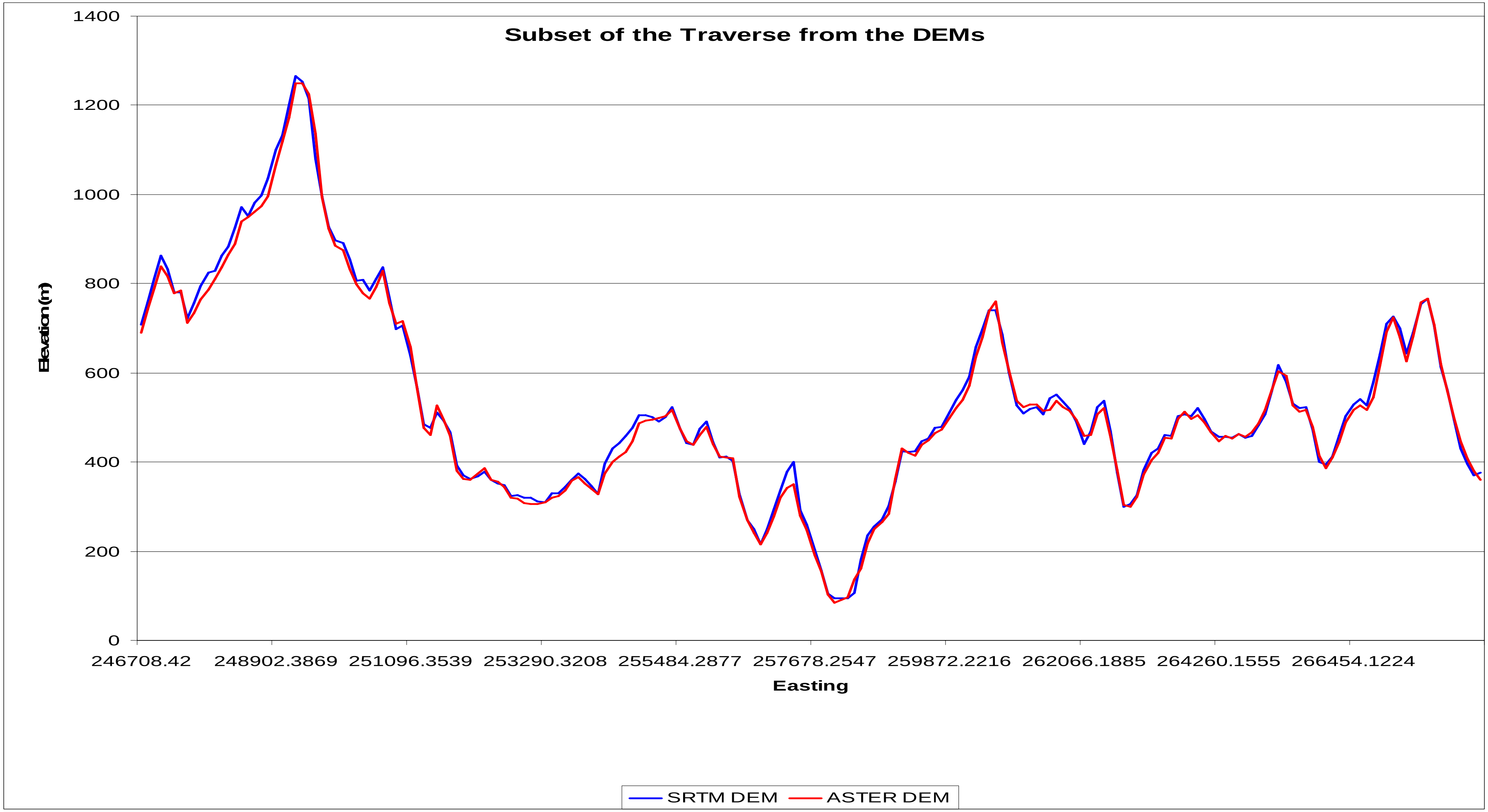


Elevation Difference Map created in ArcMap displayed on top of the hill shaded SRTM DEM. SRTM DEM used as the ‘correct’ DEM and the ASTER DEM mosaic subtracted from it. Notice clouds shown as areas of dark blue.
(mean = -29.79m, min = -3178m, max = 545m, std. deviation = 176.45m)



Good comparison between two DEMs

Mean difference = 7.59m
Standard deviation = 13.42m

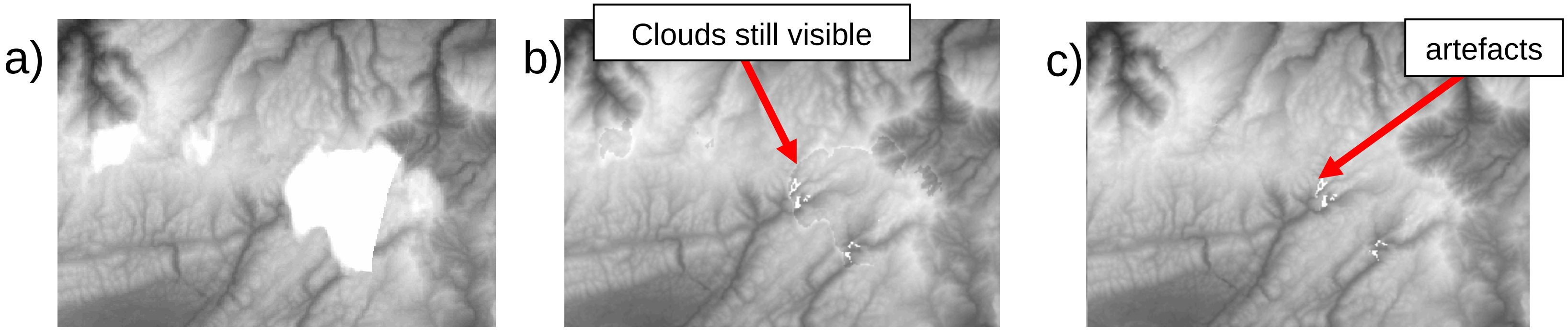


Formula applied in ER Mapper® to fuse DEMs together, remove cloud and improve vertical accuracy of ASTER DEM mosaic

The formula used is as follows:

If i1 = 0 then i2 else if abs(i1 – i2) > 100 then i2 else (i1+i2)/2

Where i1 = ASTER DEM
Where i2 = Improved SRTM DEM
Where 0 is the no data value in the ASTER DEM mosaic



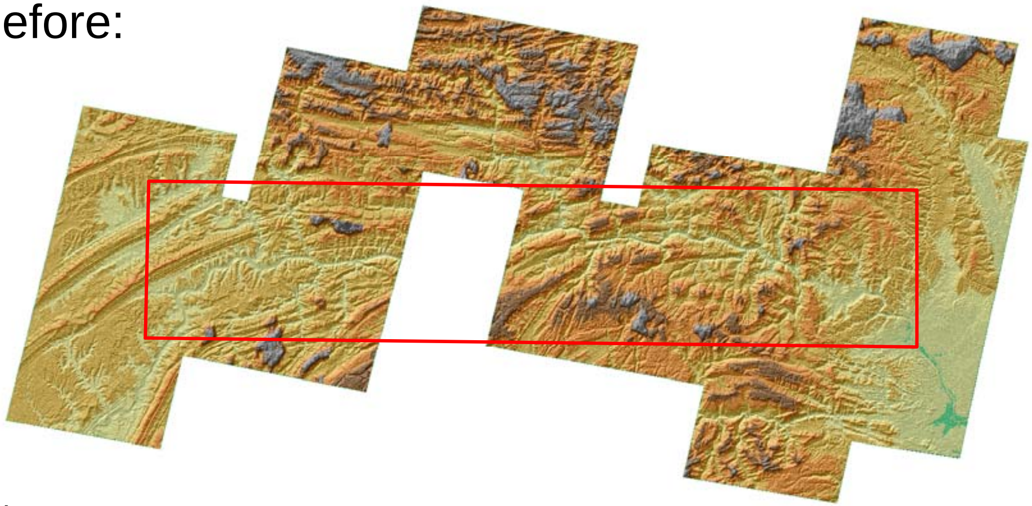
ASTER DEM Prior to cloud removal

DEM with 500m threshold applied filled with SRTM data

DEM with 100m threshold applied filled with SRTM data

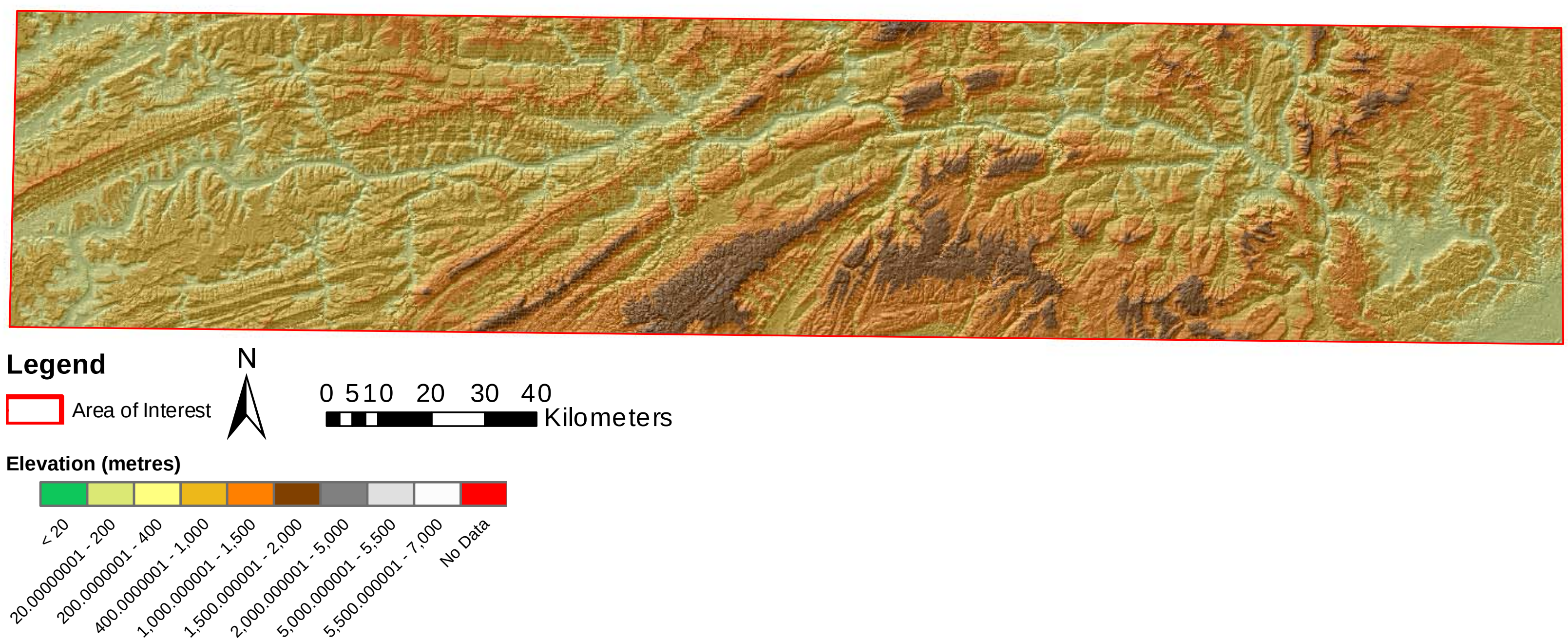
The artefacts in the final DEM, shown in (c) were the result of limited data availability. They are areas of the DEM where cloud existed in the original ASTER DEM mosaic and data missing from the original SRTM DEM

Before:

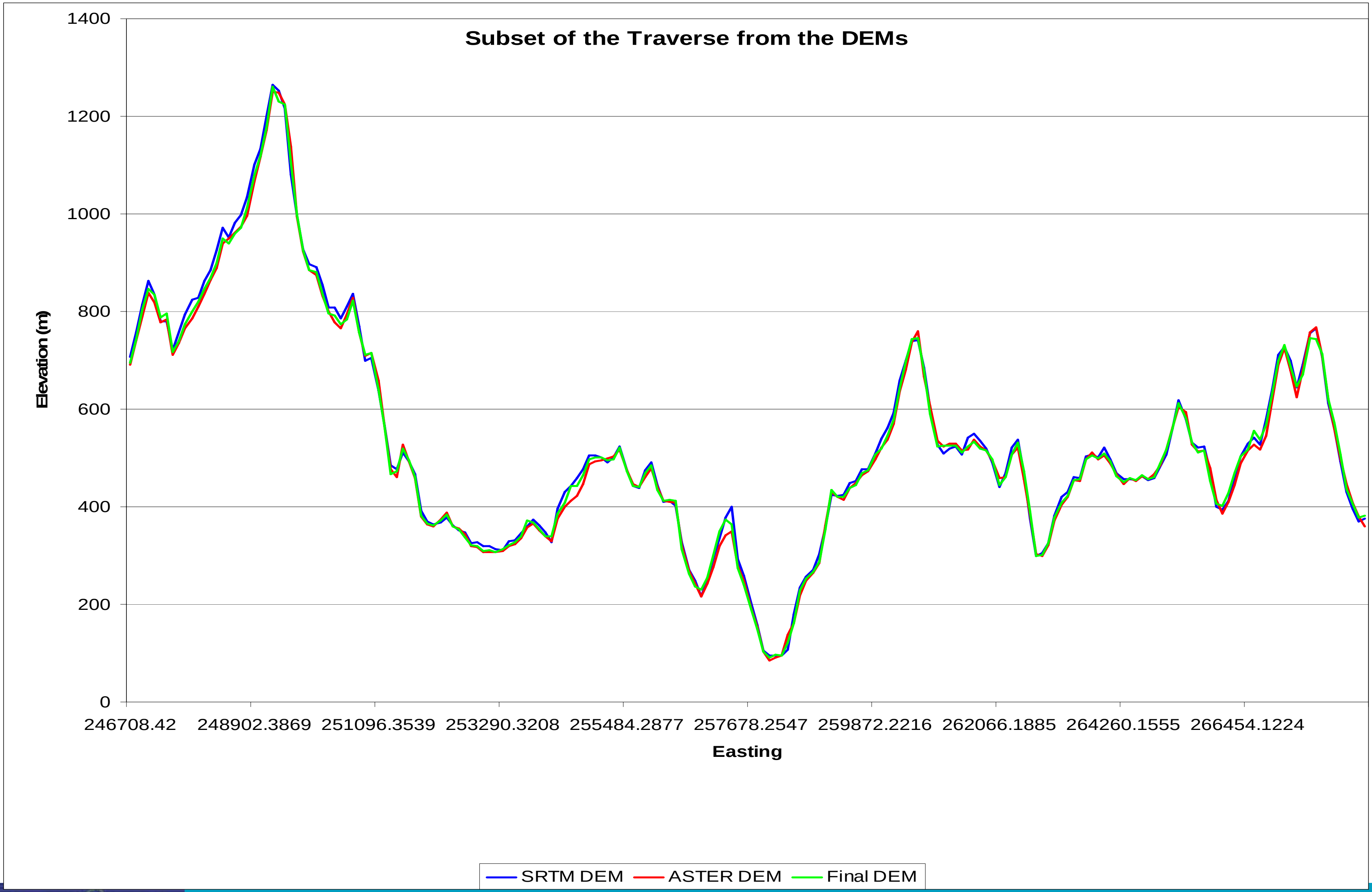


Final 30m resolution fused DEM for area of interest

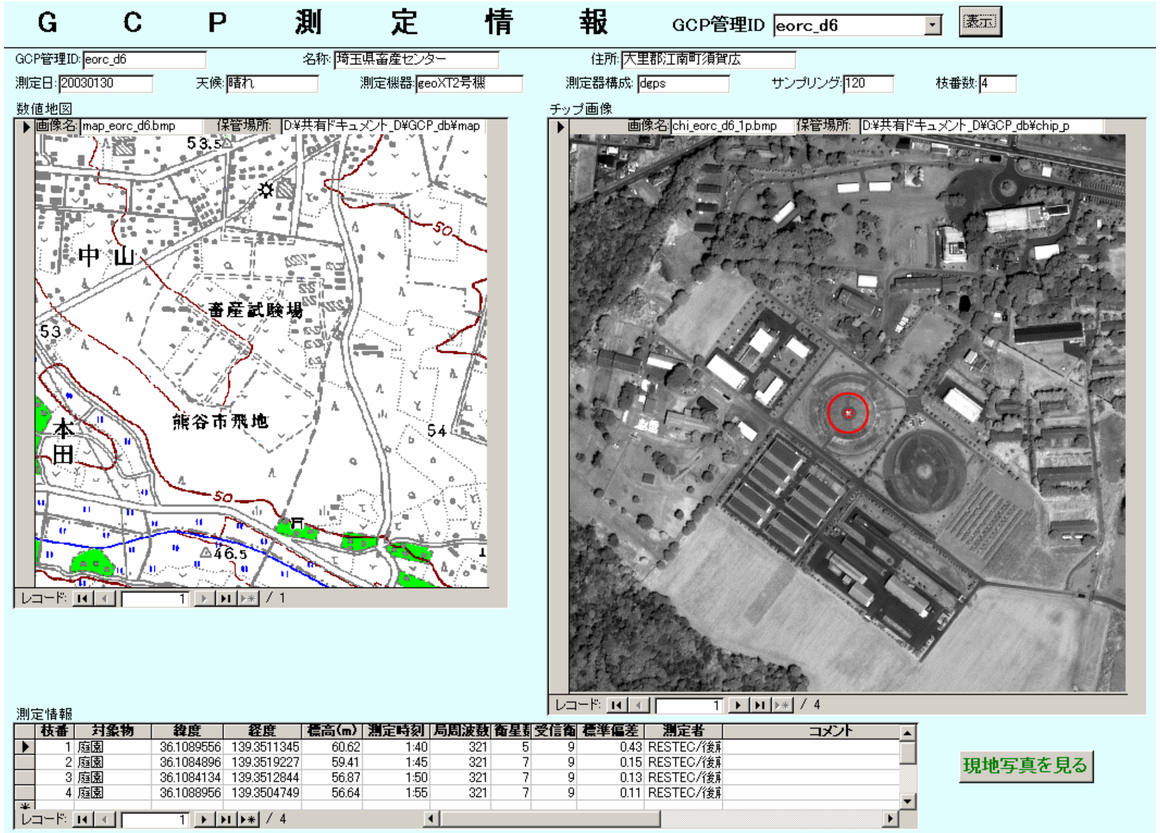
After:



Graph showing comparison of the original DEMs with the final DEM with changes in Easting for the same profile location as previous slide.
(Mean difference = 4.62m, Standard Deviation = 10.3)



ALOS-PRISM GCP Database (Shimada)



a) Top image.

b) Site picture.

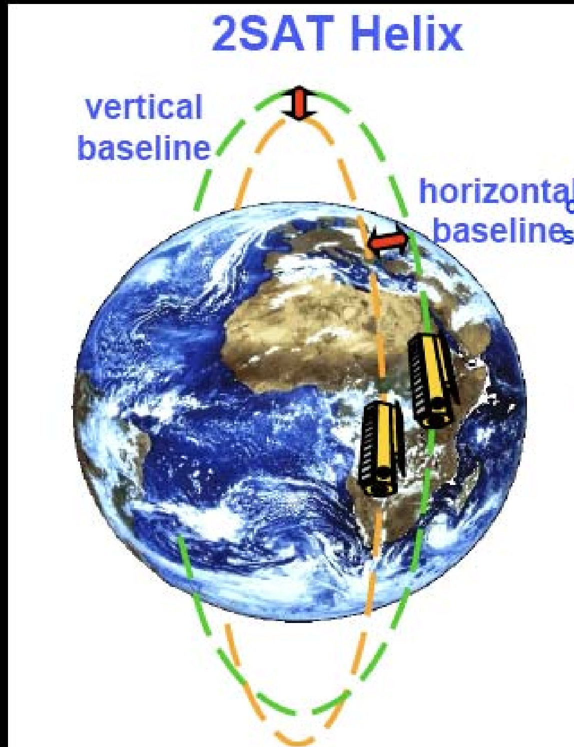
* Aerial photo : 42cm/pixel, 1024x1024pixel
  IKONOS : 1m/pixel, 512x512pixel

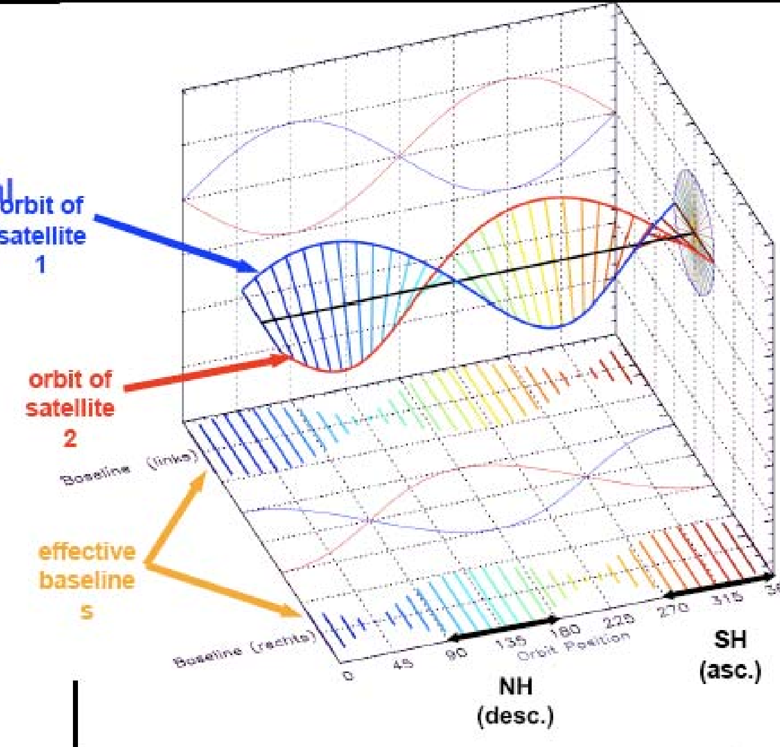
- **Contents of GCP database**
- ✓ **Latitude, Longitude : ITRF 97**
- ✓ **Altitude : GRS 80 ellipsoid height**
- ✓ **Chip image : Aerial photograph or IKONOS**
- ✓ **Geographical map image**
- ✓ **Site location picture *etc.***

Awaiting inputs from ALOS on the location of PRISM DEM test sites so that harmonisation can take place between TMSG and ALOS

Interferometry with TanDEM-X

Digital Elevation Model (DEM) from SRTM Mission





Single-Pass Cross-Track Interferometry with TerraSAR-X Tandem:

- ***no temporal surface decorrelation (as opposed to repeat-pass interferometry)***
- ***almost no atmospheric distortions (as opposed to repeat-pass interferometry)***
- ***large selectable interferometric baselines***

Way forward : GLOBETOP 2.0

- **Requirements (updated after discussions with NOAA-NGDC):**
  - **DEM available by 2010 at the very latest**
  - **DEM must be free of ©, cost and 3rd party issues**
  - **DEM should be at least 3 arc-seconds (≈90m) without any gaps**
  - **DEM should preferably be 1 arc-seconds (≈30m)**
  - **DEM should include improved coastline (≈30m)**
  - **DEM should include bathymmetry of continental shelves**
- **Where are we now?**
  - **C-SRTM provides ≈80% coverage of region from 60ºN-56ºS**
  - **X-SRTM could be employed to fill in many gaps (© and cost issues)**
  - **ERS-tandem could be employed to fill in remaining gaps but need remains to correct for atmospheric effects**
  - **ASTER stereo can be employed to fill in many gaps but cloud coverage is still an issue although planimetric offsets have now been resolved with SRTM**
  - **Unknown status of ALOS-PRISM global topography project described at ISPRS 1996. Unknown status of ©, cost and 3rd party IPR issues. No plans to produce global DEM**
  - **TANDEM-X has been approved but DEM at 10m will be ©, very high cost and many 3rd party issues**

Moving forward : GLOBETOP 2.0

- GDTT to find a champion who will provide co-ordination of GLOBETOP 2.0 including promotion of the fusion of these different input data sources, develop documentation, provide final fused DEM, develop OGC-compliant distribution
  - USGS approached but no status as of this time
- GDTT to produce a requirements (or "gap") document in association with GEO Secretariat
  - no progress on this yet, awaiting feedback from USGS as to whether they will become the champion for this project
- GDTT to issue a call for proposals for participation in GLOBETOP 2.0 with participants bringing their own funding and providing products freely without © restrictions or any 3rd party issues
- TMSG propose a joint workshop on GLOBETOP 2.0 in mid 2007 at USGS Reston
  - USGS approached but no status as of this time
- TMSG to provide validation, with suitable resourcing of individual input and fused products

WGISS EO Data Portal - Update on ICEDS wrt TMSG

- Drill-down to anywhere on the planet to scales of 1:25 000 (30m) for colourised hill-shaded SRTM-DEMs (unedited at present)
- Find out what archived DEM data is available for anywhere (e.g. NASA ASTER, courtesy of EDC) to fill gaps in SRTM DEMs
- Explore change (e.g. Landsat 5 to 7) using transparency and flicker and context (e.g. rivers, transportation networks) including SRTM-derived water features
- Interactive exploration of geographical relationships at the continental and global scale (e.g. sea-level rise impact of global population)
- http://iceds.ge.ucl.ac.uk

Recommendations Agreed at Nov05 CEOS Plenary: TMSG

- Background: It has previously been agreed that spaceborne DEMs will be used preferentially for georadiometric processing of other EO data products. The existence of ACE and SRTM global DEM products is acknowledged. Current georadiometric processing at NASA uses non-EO data sources of dubious quality containing many artifacts. Current georadiometric processing at ESA uses an unvalidated DEM (GETASSE30)
- WGCV Requirement: Spaceborne DEMs should only be used for georadiometric processing if and only if their errors and artifacts have been fully characterised.
- Recommendation: CEOS recommends member space agencies evaluate the impact of using different sources, especially space-based DEMs for georadiometric processing of EO data products. CEOS further recommends that quantitative evaluation of spaceborne DEM products be performed and published as part of any future web infrastructure for validation.
- WGCV Follow-up Activities: TMSG offer to provide, with suitable resourcing, the error characterisation required of these spaceborne DEMs as well as examples of "Known Issues" with downstream products caused by errors in the DEMs used for georadiometric processing. No progress since 12/05 especially with regard to resourcing and finding champion.

Summary of ACTION items

- Become more pro-active in GEO tasks and try to link across WGISS-WGCV Terrain mapping (and other cartographically) related activities
- Find a replacement chair including job description, needs for support and preliminary programme and find space agency sponsor to ensure that this programme is properly supported
- Advance the GOBETOP 2.0 project and merge these with GEO requirements as far as practicable
- Co-ordinate a GLOBETOP 2.0 workshop in mid 2007 for both dataset creation and their validation
- Question: how do we add further test sites to the one at Puget Sound to WTF and promote their use in the terrain mapping community in terms of
  - setting QA/QC standards
  - developing new techniques in QA/QC
  - inter-comparison of different research and commercial DEM production systems
  - Developing the "Known Issues" web-site at the WTF site (or elsewhere)
  - How do we link to CEOS-WGCV "web portal"