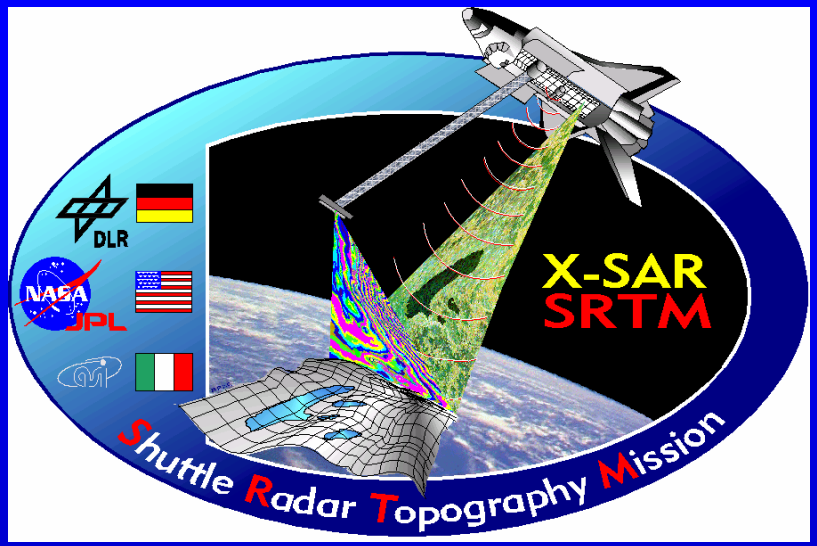

Workshop:
"The Shuttle Radar Topography Mission – Data Validation and Applications"
June 14-16, 2005 , Reston, Virginia, USA

Comparison of DEMs derived from SRTM / X- and C-Band

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2 DLR, German Remote Sensing Data Center (DFD)
3 DLR, Remote Sensing Technology Institute (IMF)

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Tel. 08153 28 2397, Fax: 08153 28 1135
e-mail: Marian.Werner@dlr.de

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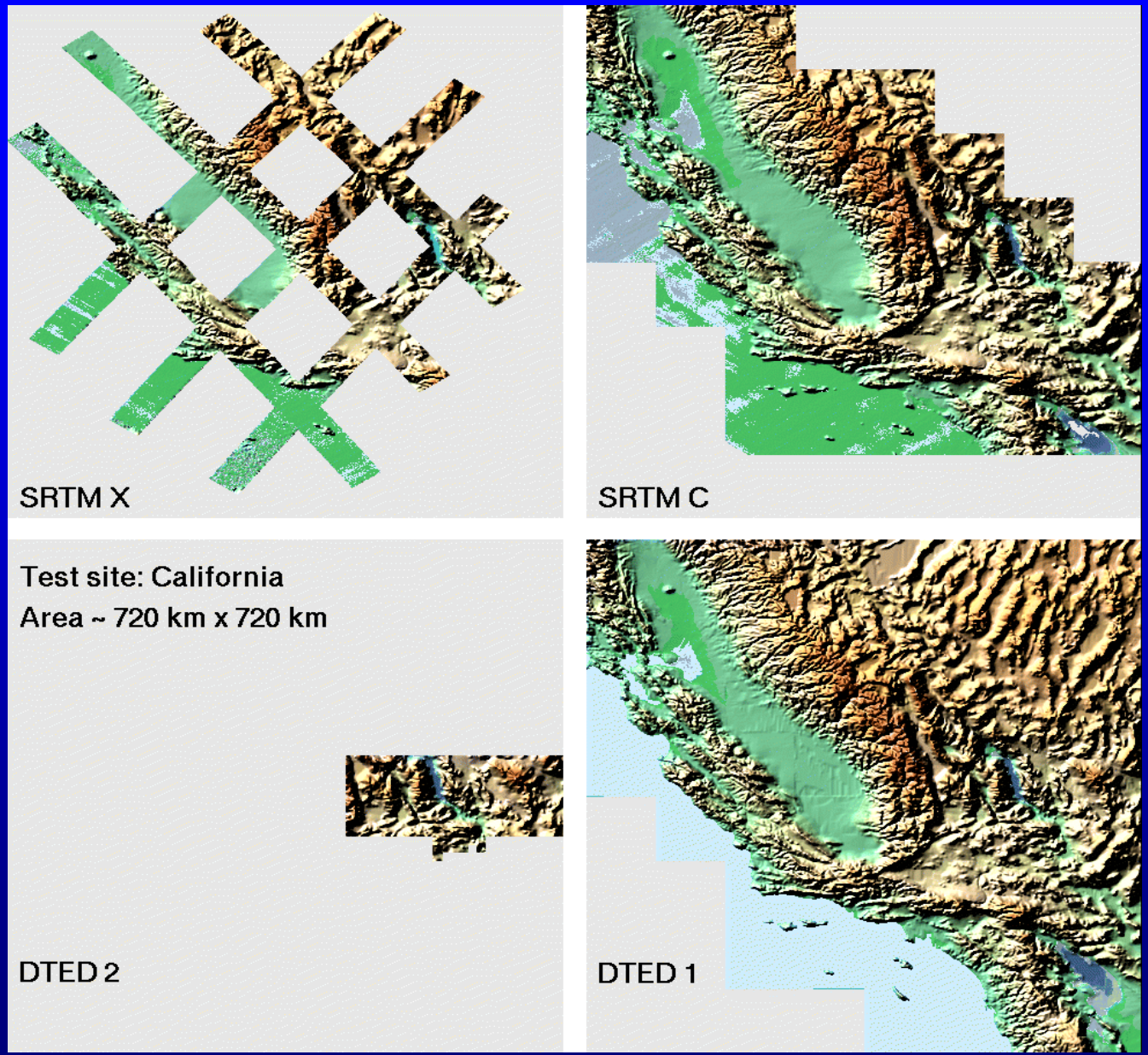
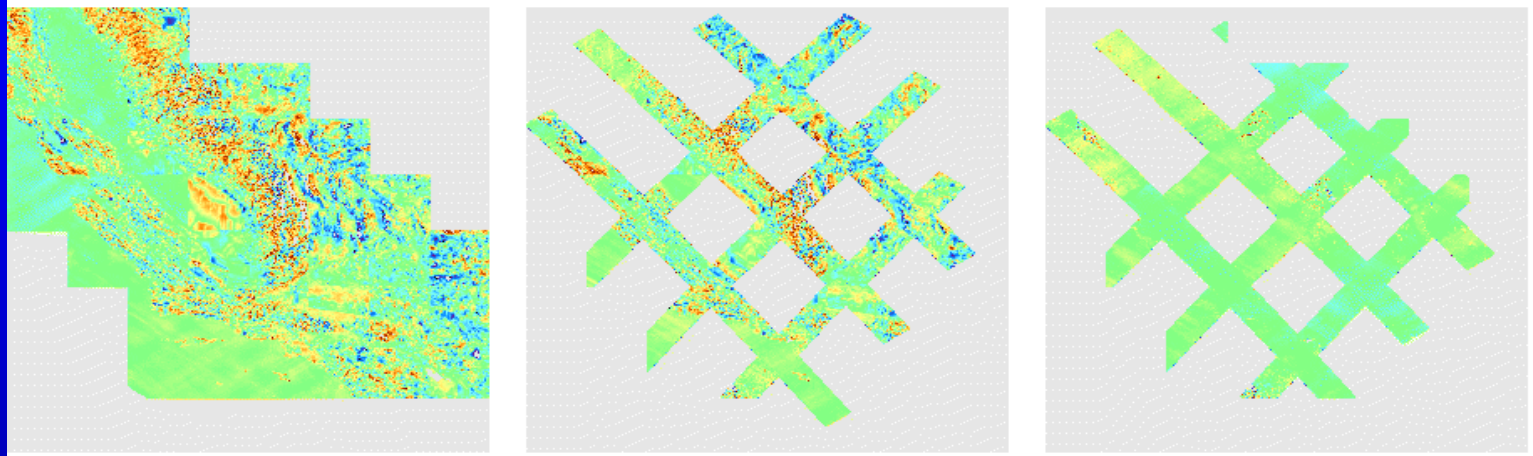
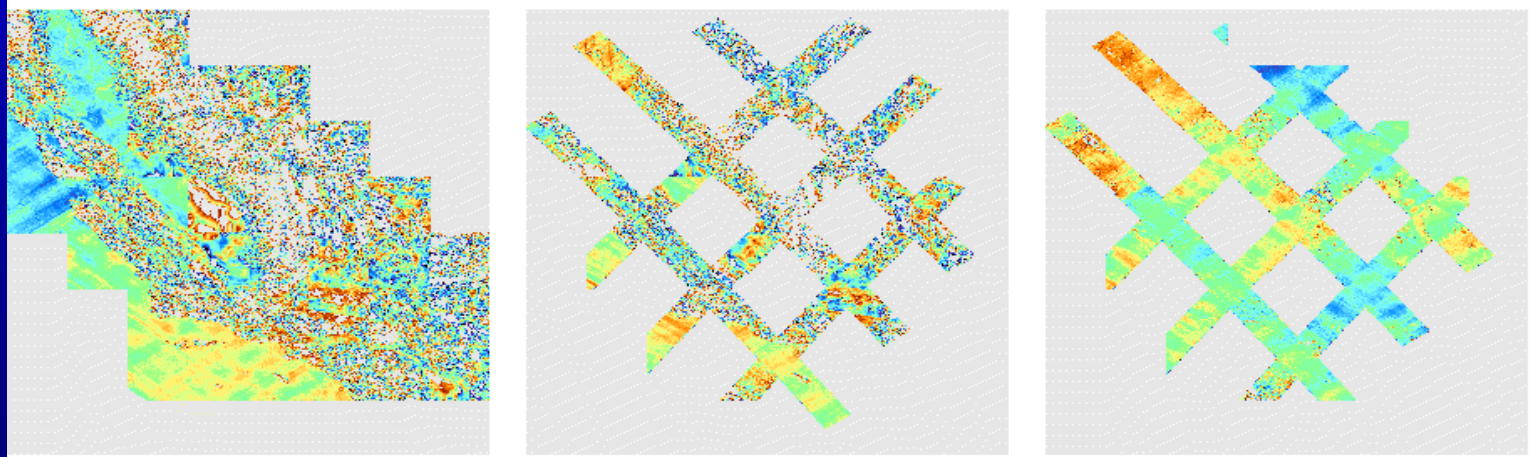
Cross-Comparison SRTM-C & SRTM-X

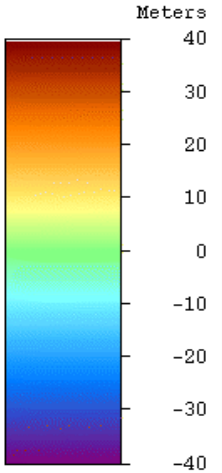


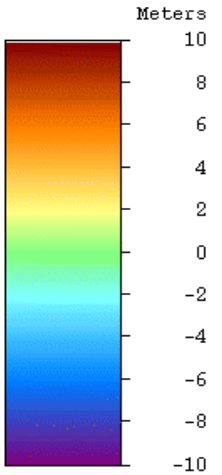
Height Difference Statistics

	SRTM C – DTED1	SRTM X – DTED1	SRTM X – SRTM C
Mean	1.42 m	1.38 m	0.56 m
Std	23.18 m	26.71 m	11.10 m
RMS	23.22 m	26.75 m	11.12 m



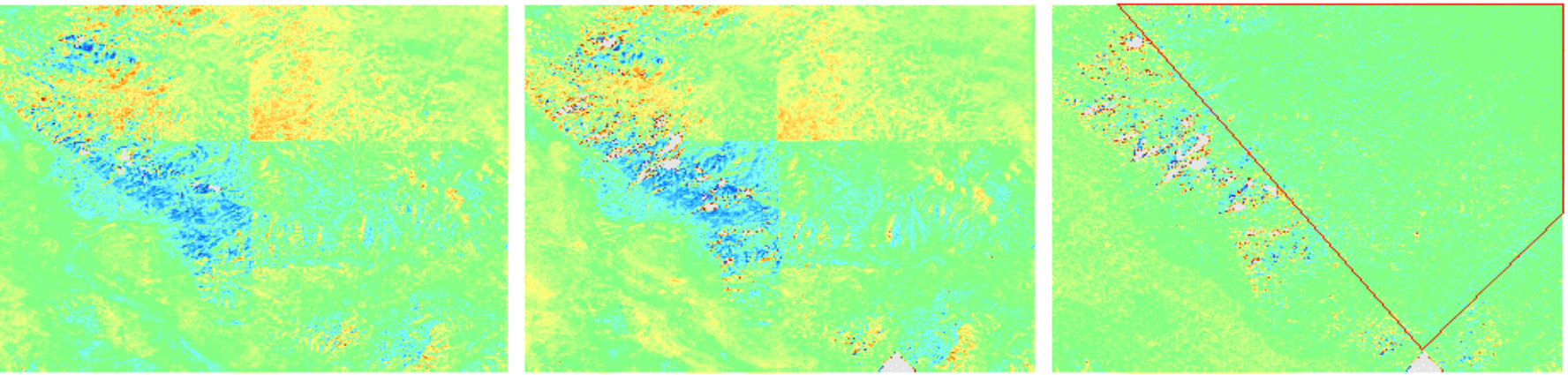


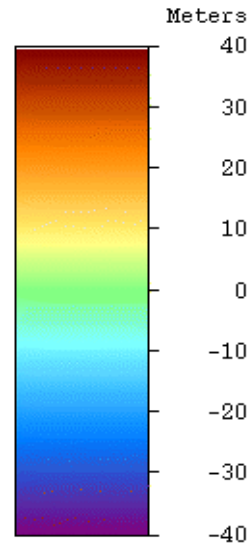


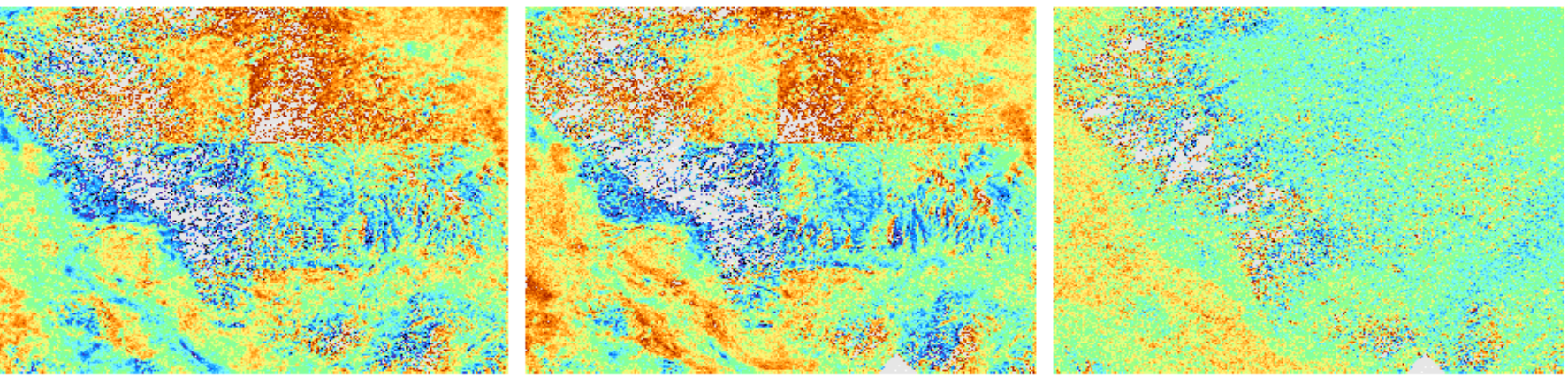


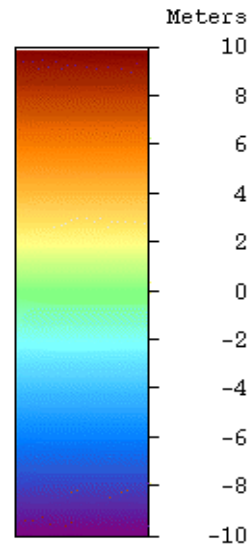
Height Difference Statistics

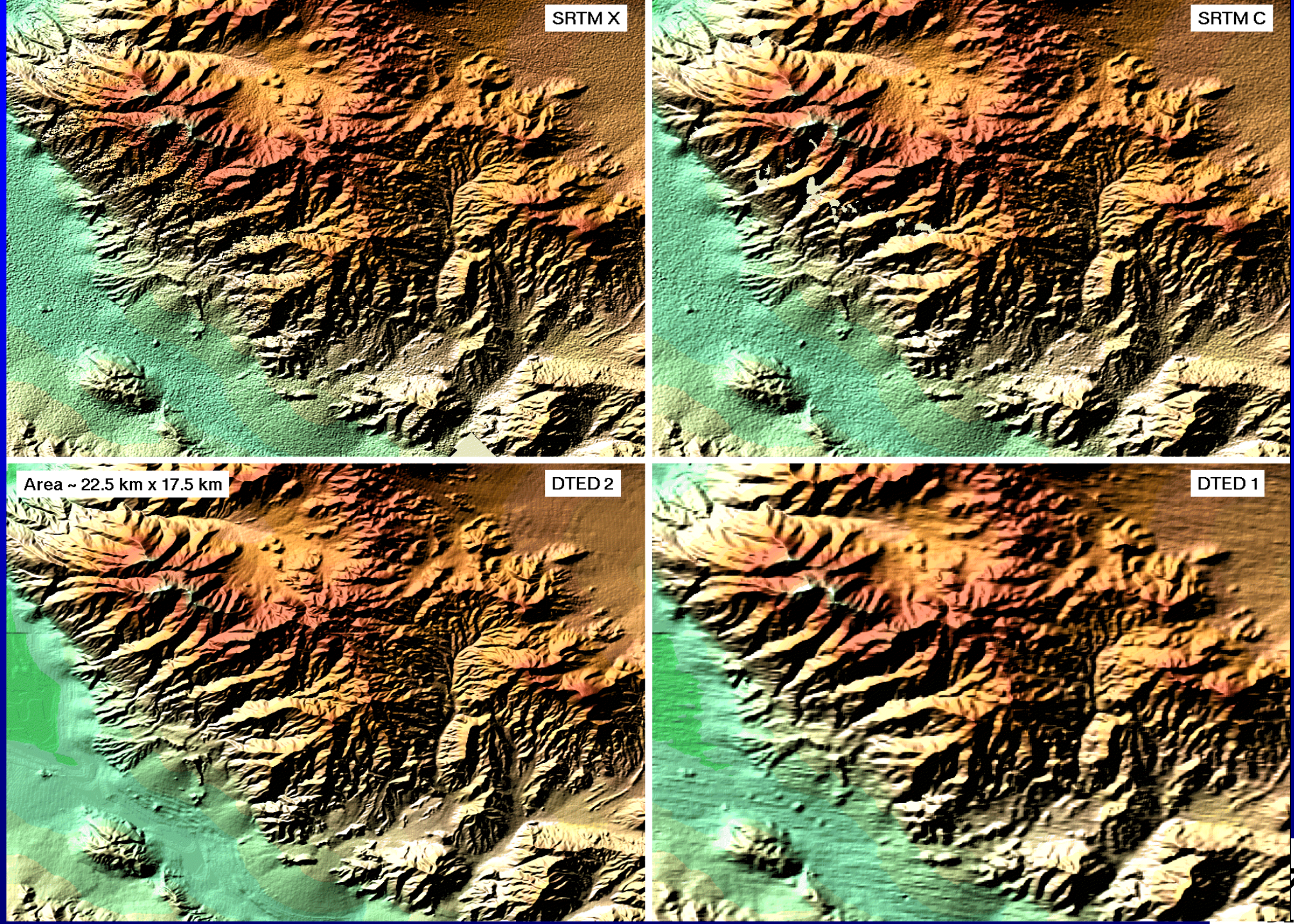
	SRTM C – DTED2		SRTM X – DTED2		SRTM X – SRTM C	
Mean	1.94 m	3.15 m	1.16 m	2.45 m	0.73 m	−0.69 m
Std	7.03 m	5.82 m	13.26 m	5.55 m	11.72 m	3.77 m
RMS	7.13 m	6.62 m	13.40 m	6.07 m	11.74 m	3.84 m

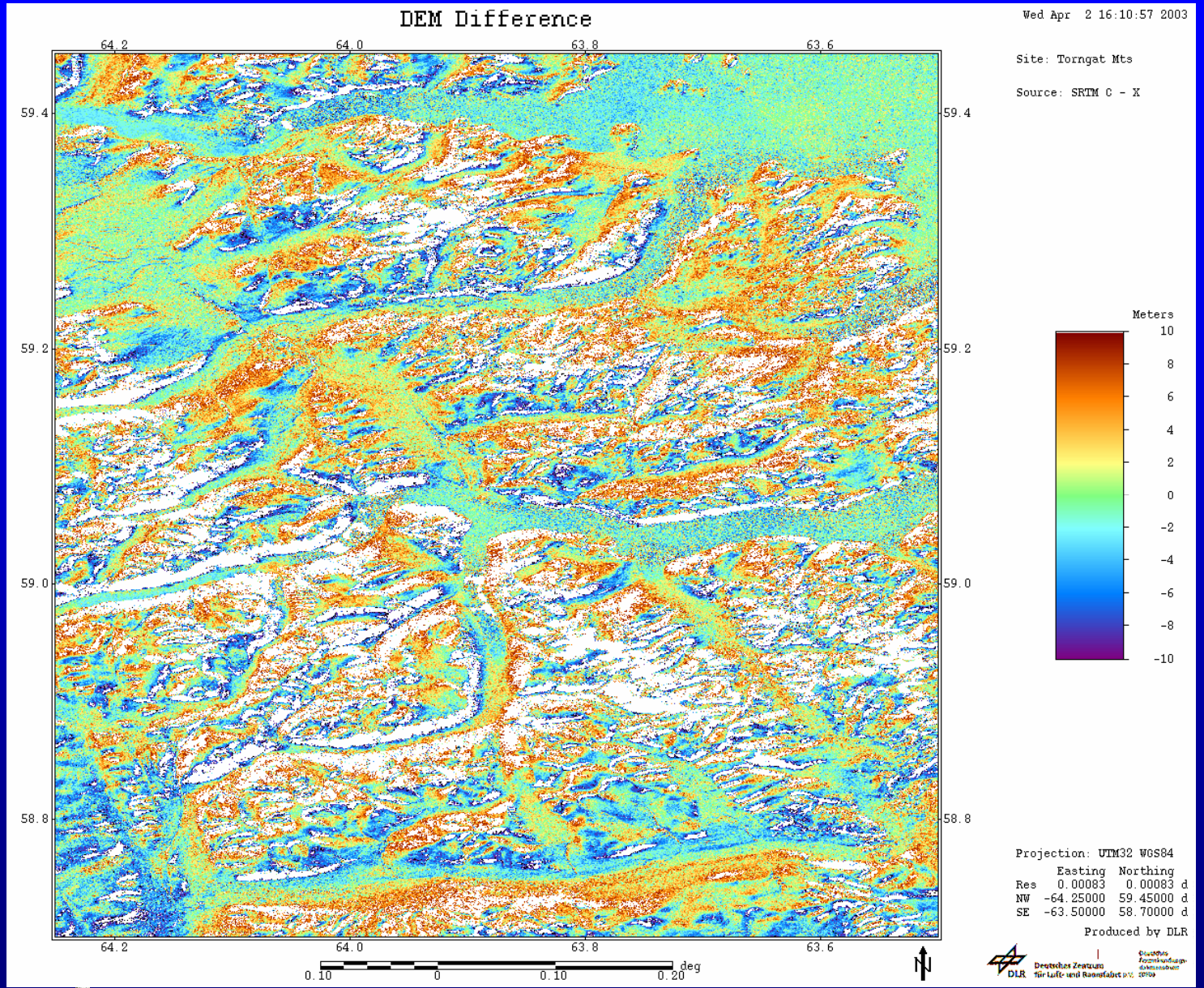








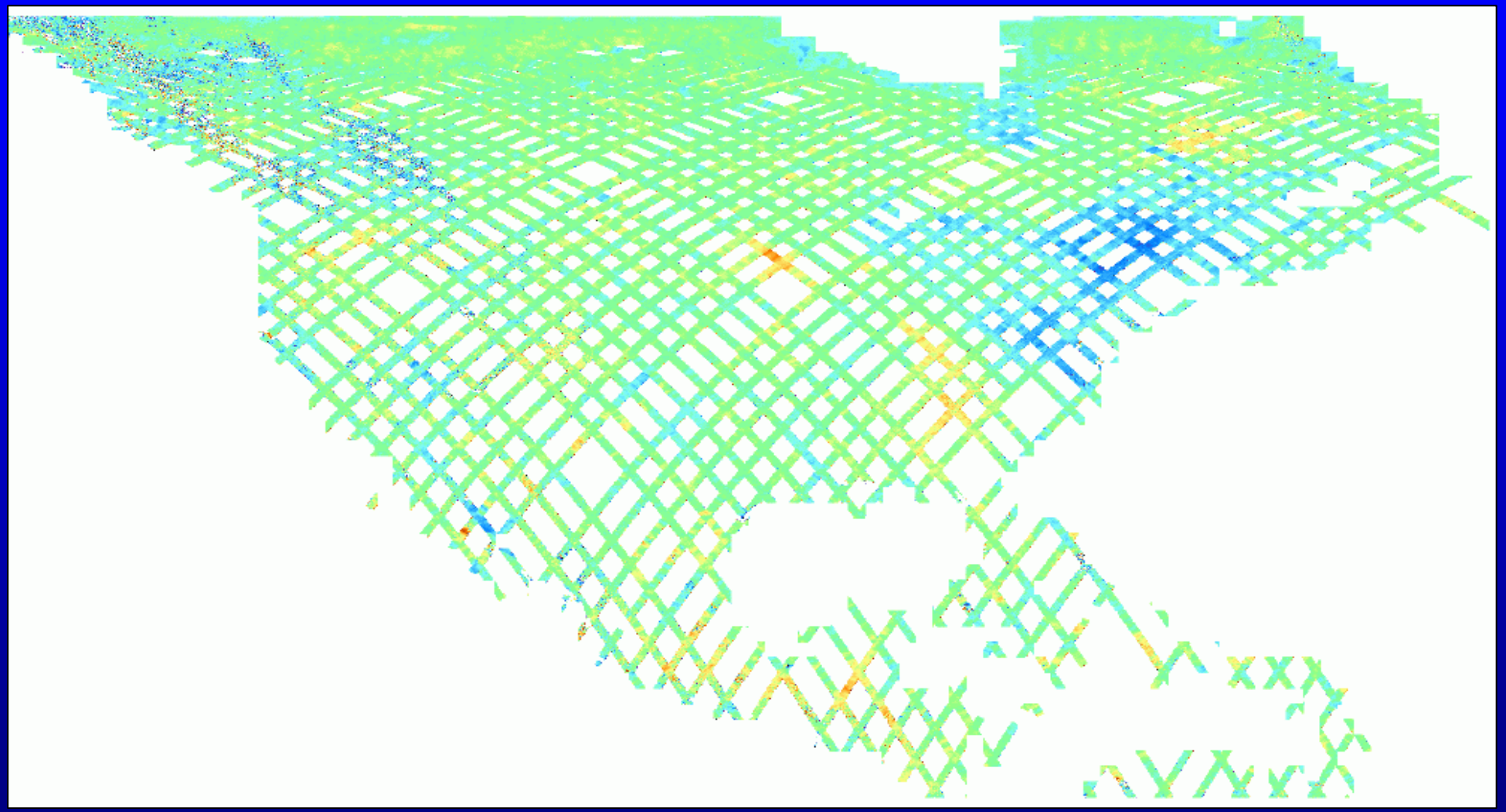

SRTM X
SRTM C
Area ~ 22.5 km x 17.5 km
DTED 2
DTED 1



C-X DEM Difference Torgat Mountains

Comparison of C-band and X-band SRTM results Torngat Mountains

Differenz SRTM C-band -X- band



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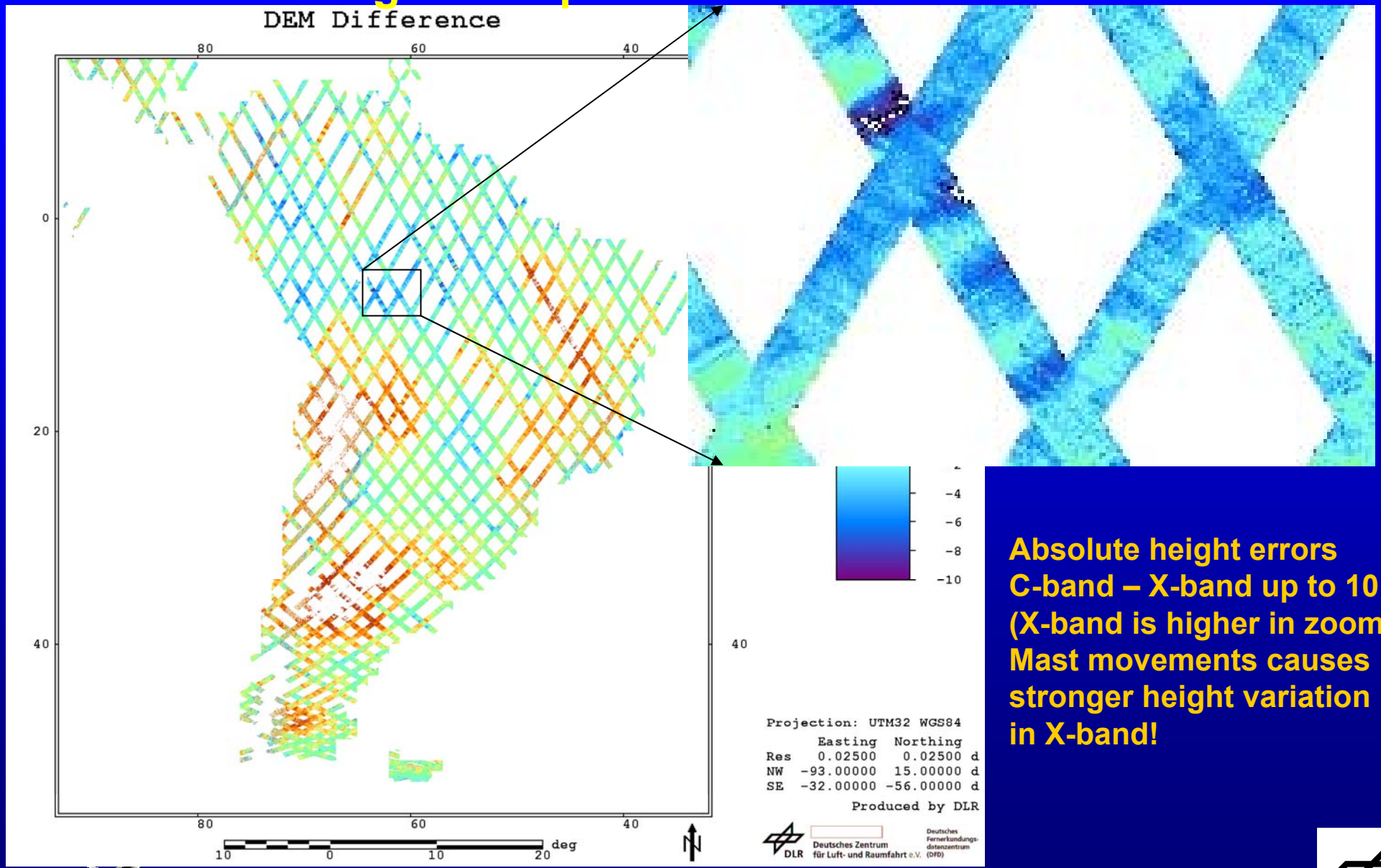
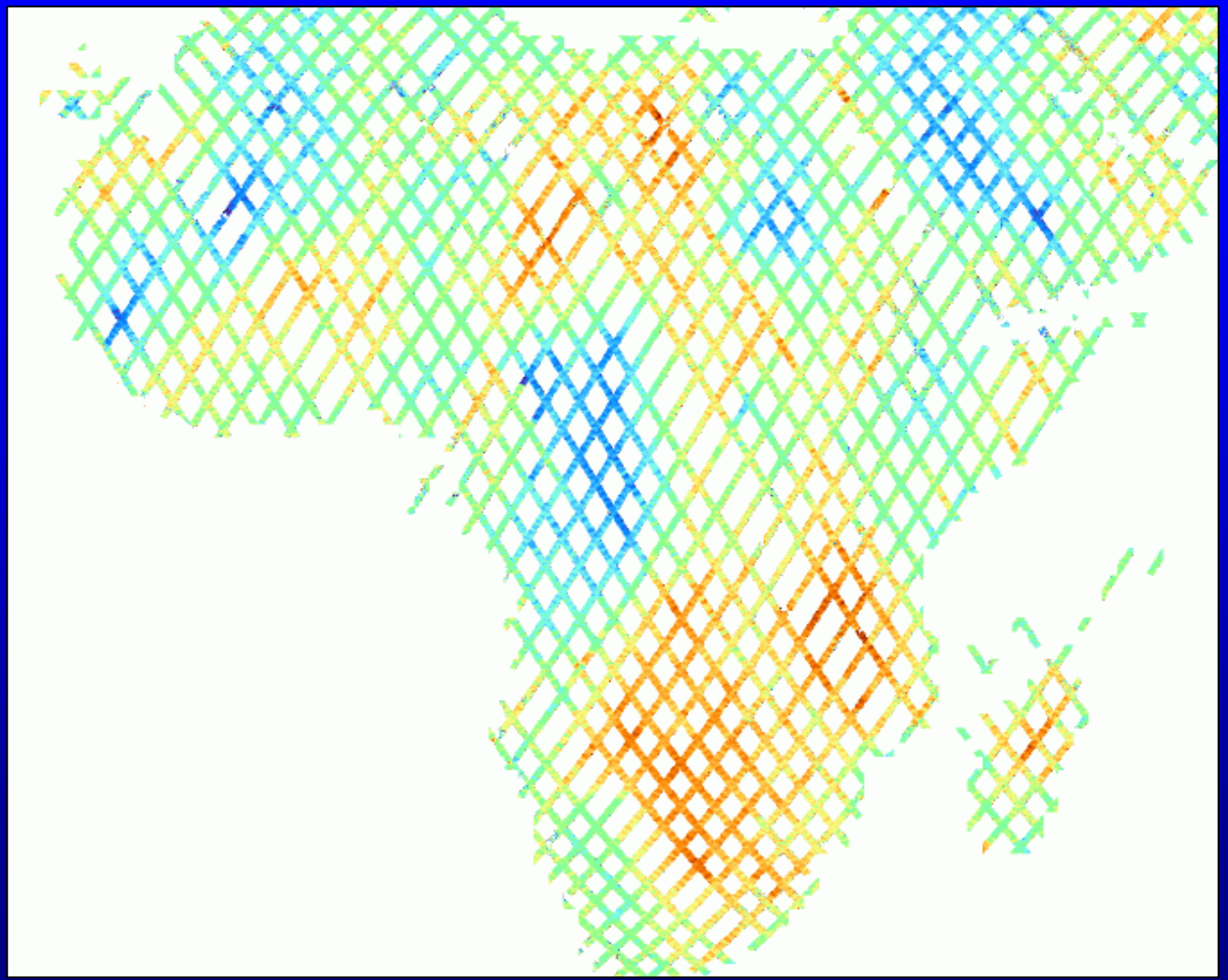
SRTM X-C Height Comparison over the Amazon Rainforest



Absolute height errors C-band – X-band up to 10 m (X-band is higher in zoom) Mast movements causes stronger height variation in X-band!

Difference SRTM C-band -X- band



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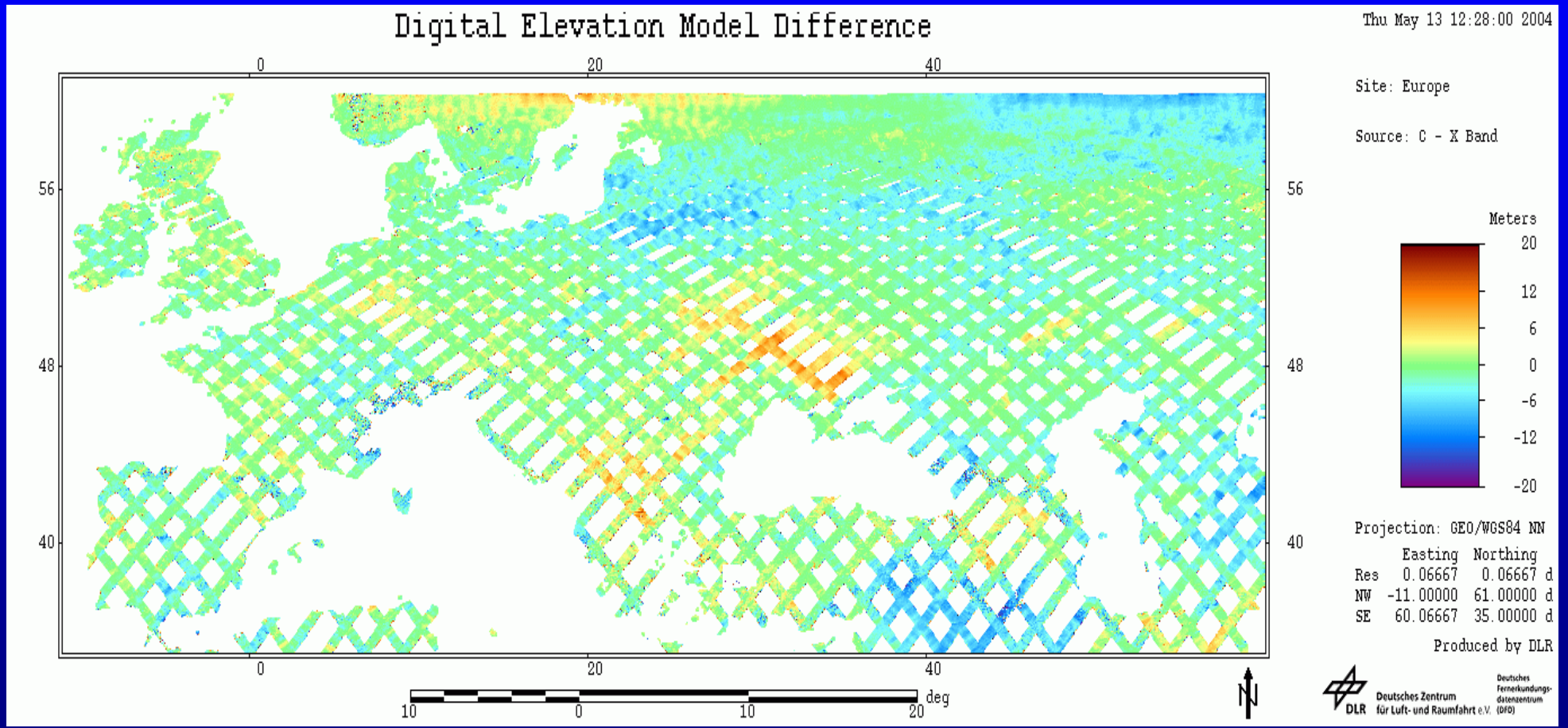
Difference SRTM C-band - X-band



Europa

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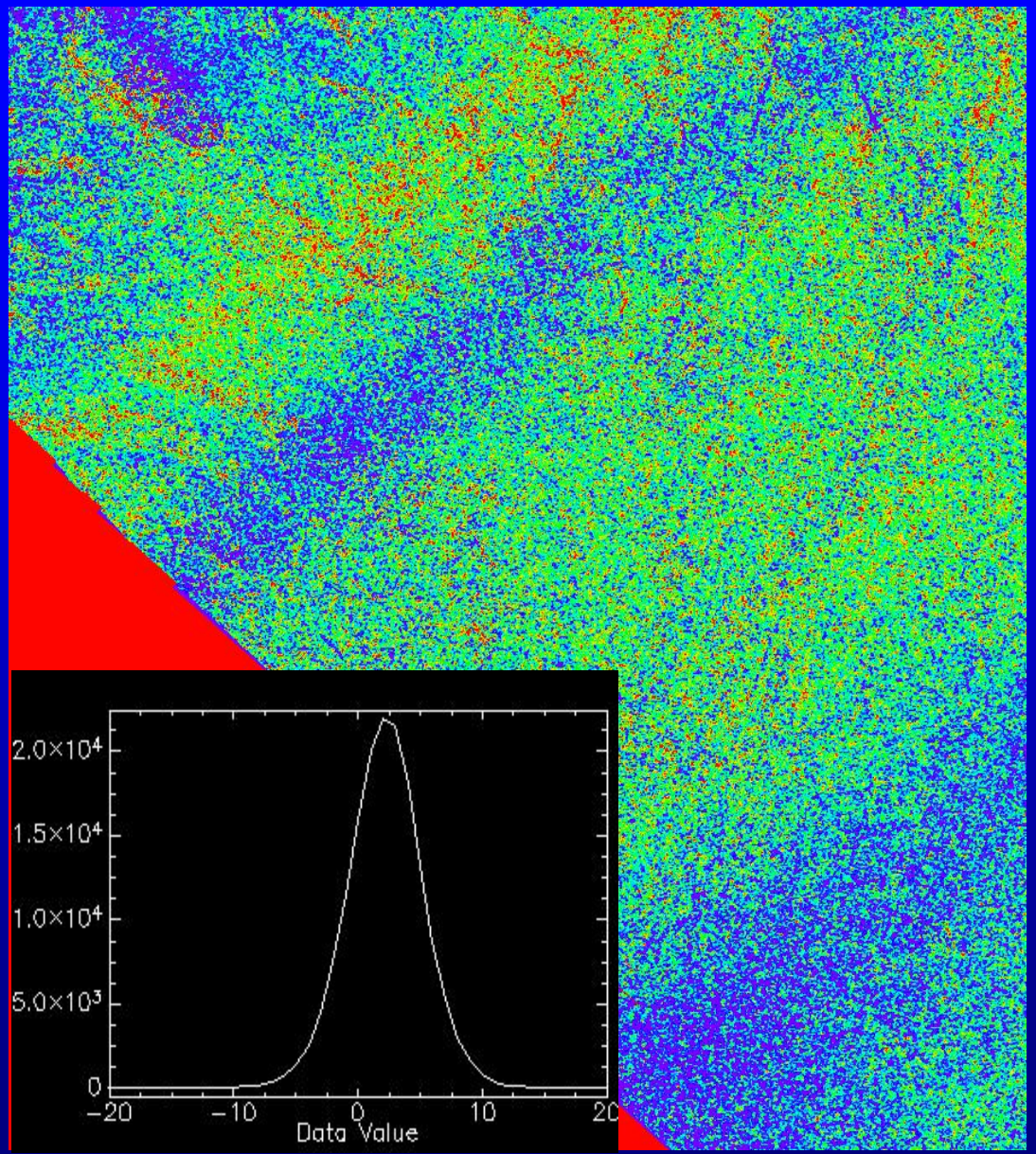
Comparison of SRTM/C- & X-Band DEMs



Height difference, X-band minus C-band,
shows systematic error along track due to uncompensated mast motion.
The statistics show a min of -50m, a max of 40m, a mean of 2.14 m and a standard deviation of 3.12m.
There is no difference observable which is correlated with forest coverage.

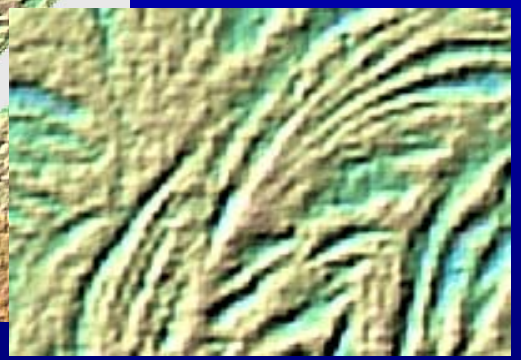
Details SRTM X- and C-Band

Detail SRTM X-Band, Schweiz

Detail SRTM C-Band, Schweiz

Detail SRTM X-Band, Brasilien 1 arcsec

Detail SRTM C-Band, Brasilien 3 arcsec



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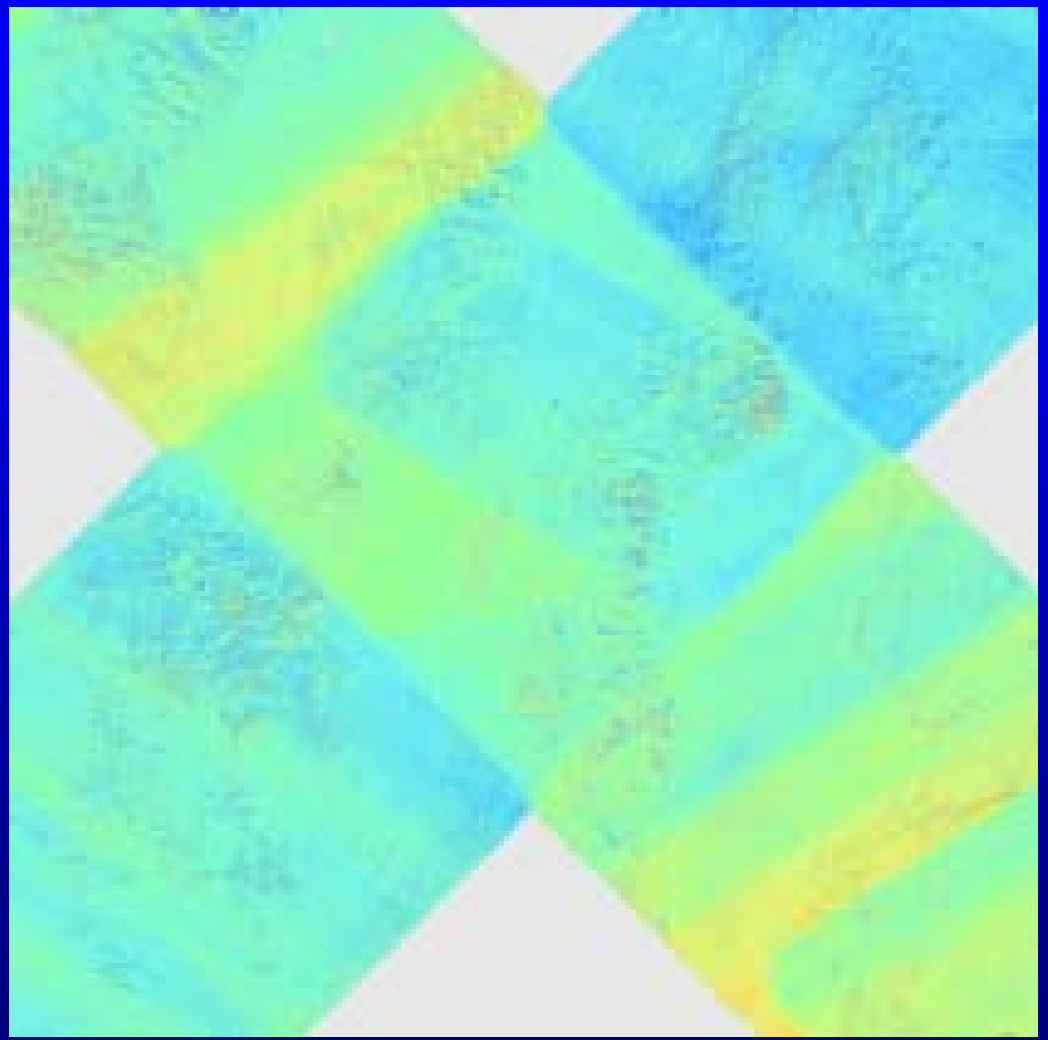
Comparison of SRTM C-band and X-band location errors



Height Difference map shows no shifts between SRTM C-band (1 arc sec) and X-band (yellow = 6m; blue = -6m)

	Northing [m]	Easting [m]
CR1	-15.46	-2.96
CR2	-5.78	-8.65
CR3	-18.96	7.25
CR4	-9.23	-6.04
CR5	-2.27	-6.61
CR6	-10.39	3.07
CR7	-10.48	-0.07
Mean	-10.37	-2.00
Standard Dev.	5.60	5.74

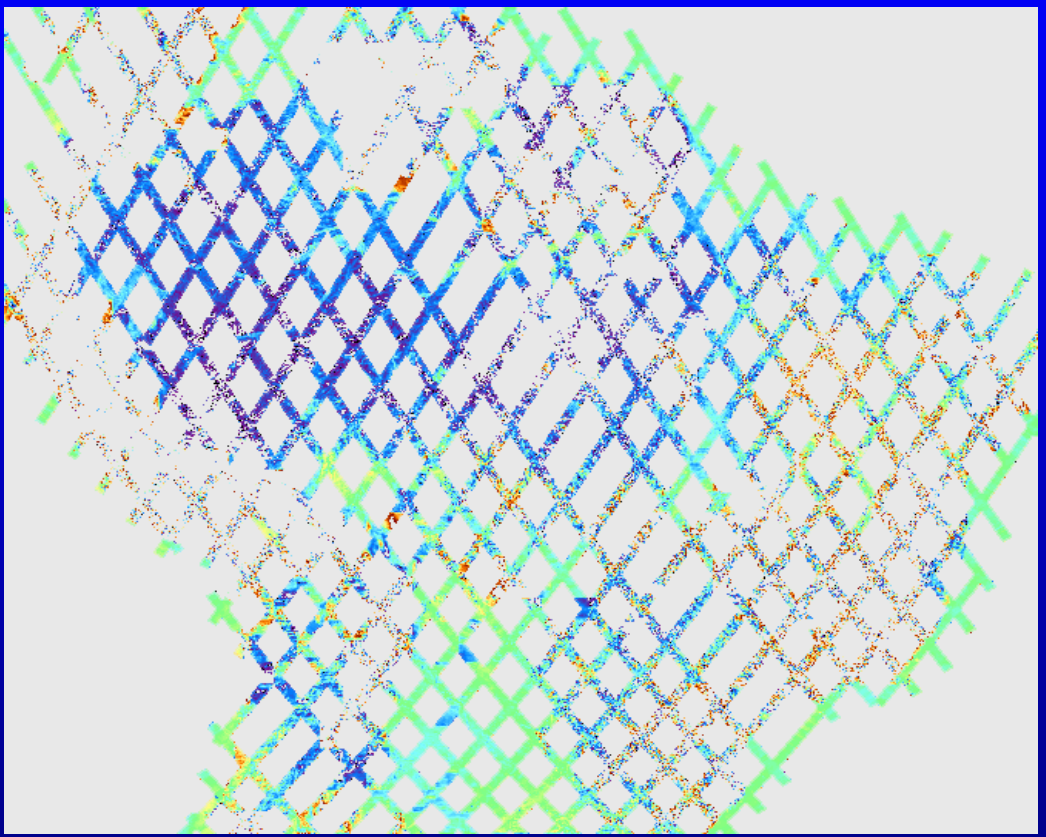
Horizontal location error of corner reflectors

Global Differences between DEMs from SRTM X- und C-Band

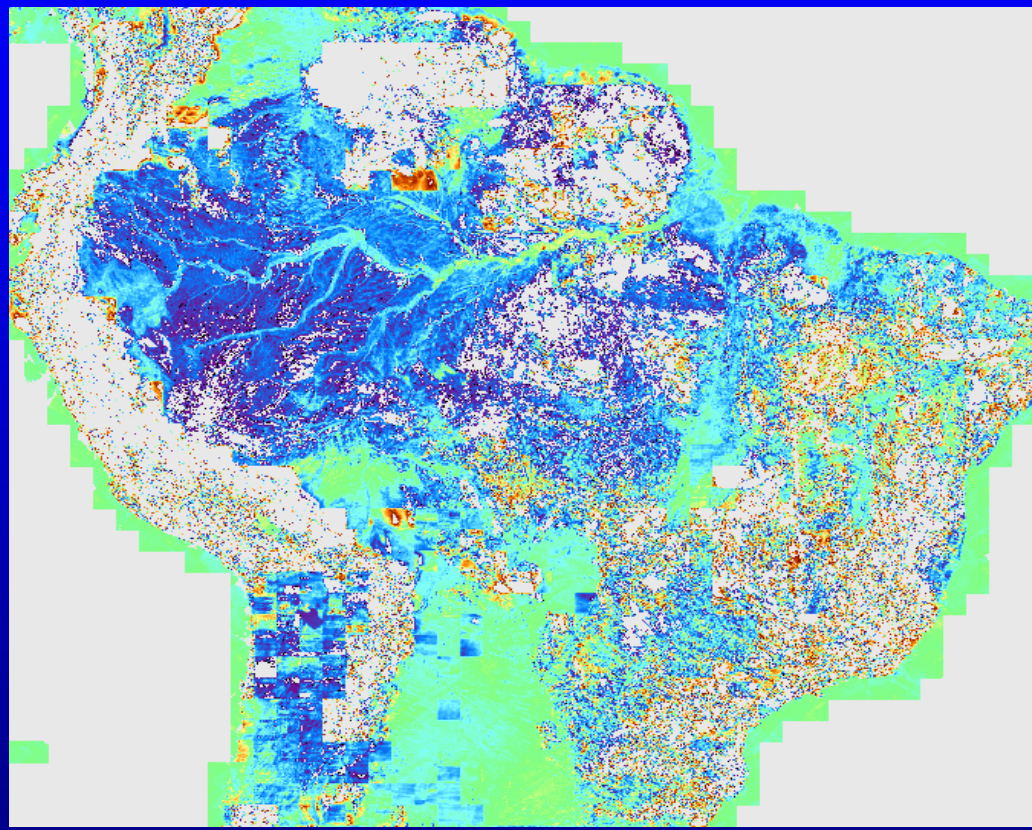
Continent	Average	Standard-deviation
Europe	- 0.89 m	18.25 m
Africa	1.04 m	48.74 m
North America	- 1.02 m	12.36 m
South America	1.66 m	16.01 m
Asia	0.24 m	20.15 m
Australia	1.45 m	12.85 m

Comparison with other global DEMs

Difference between Global Altimeter DEM (ACE) and SRTM



ACE - SRTM X-Band, Brasilien



ACE - SRTM C-Band, Brasilien

X-SAR/SRTM Shuttle Radar Topography Mission

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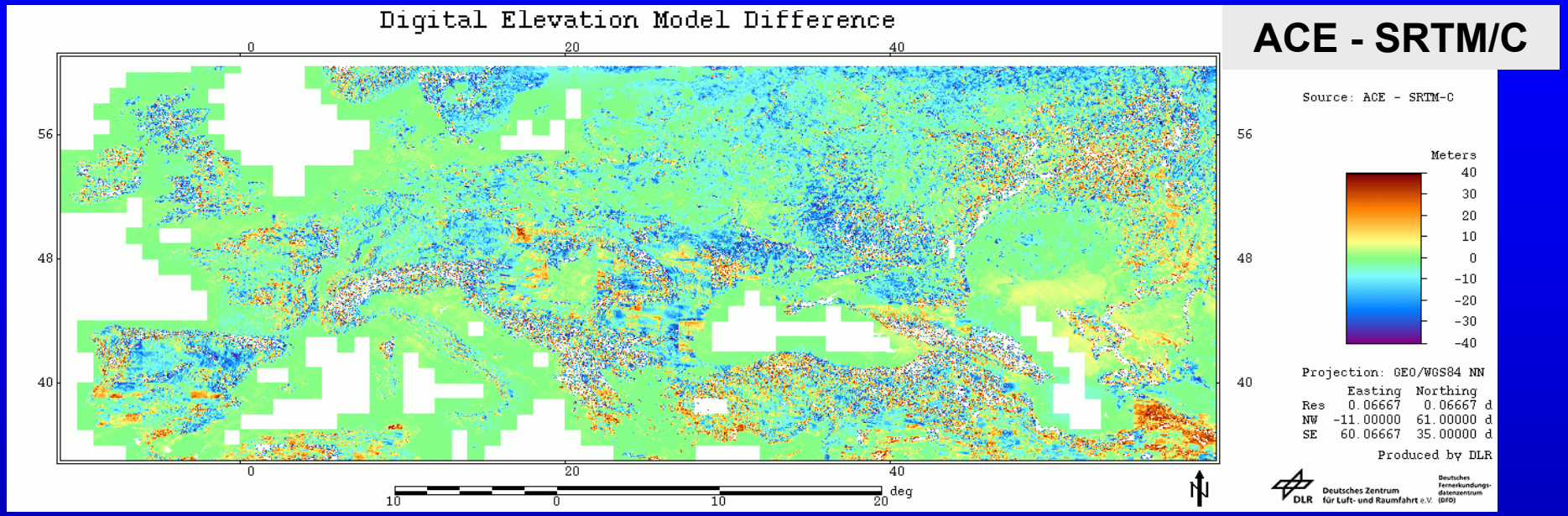
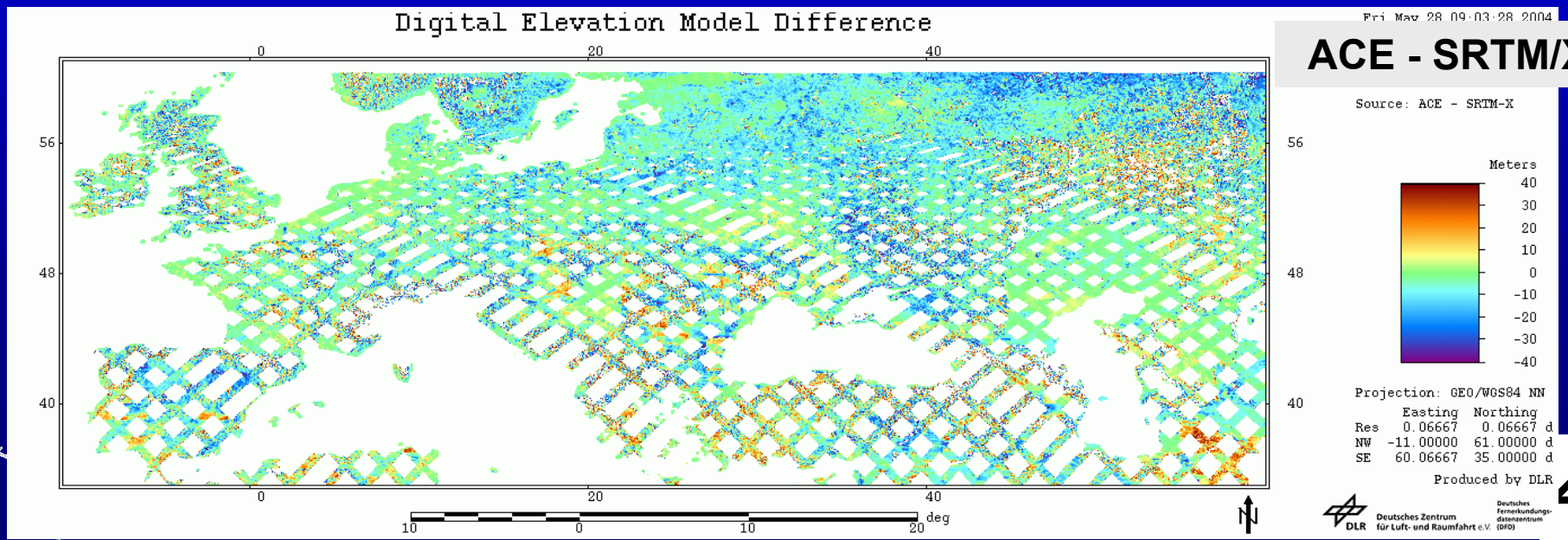
Comparison of SRTM/C- & X-Band DEMs





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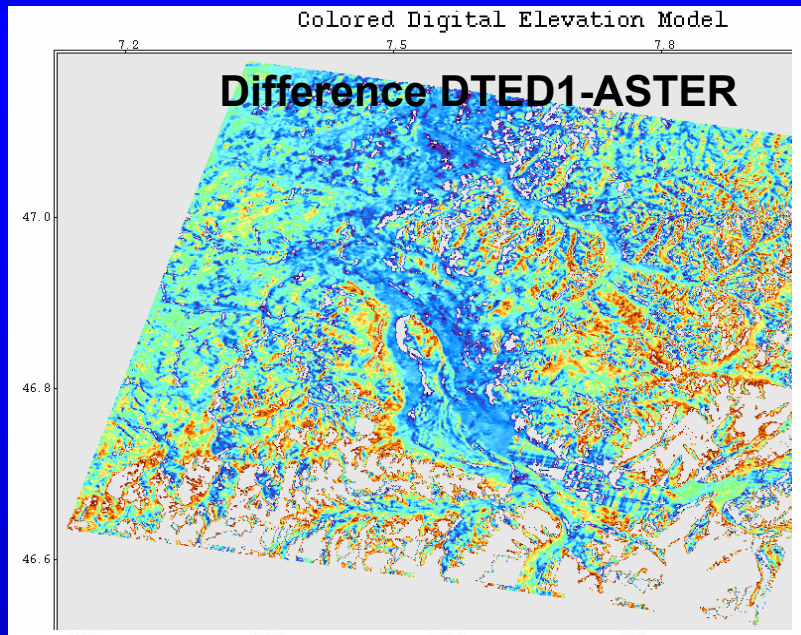
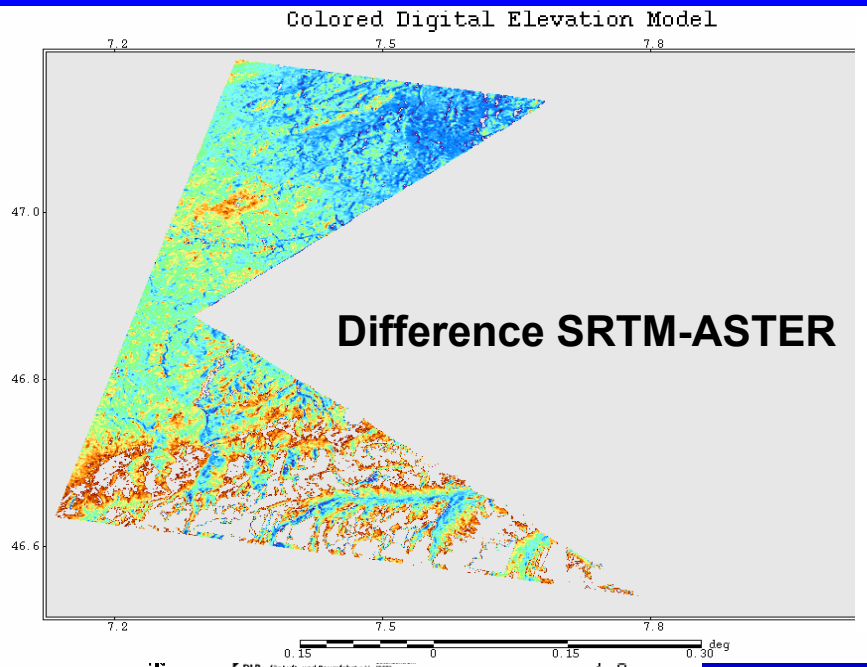
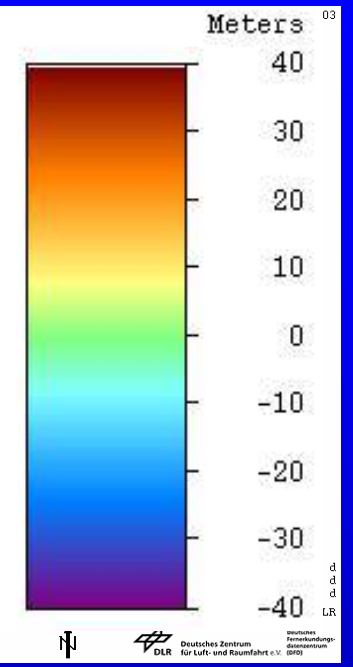
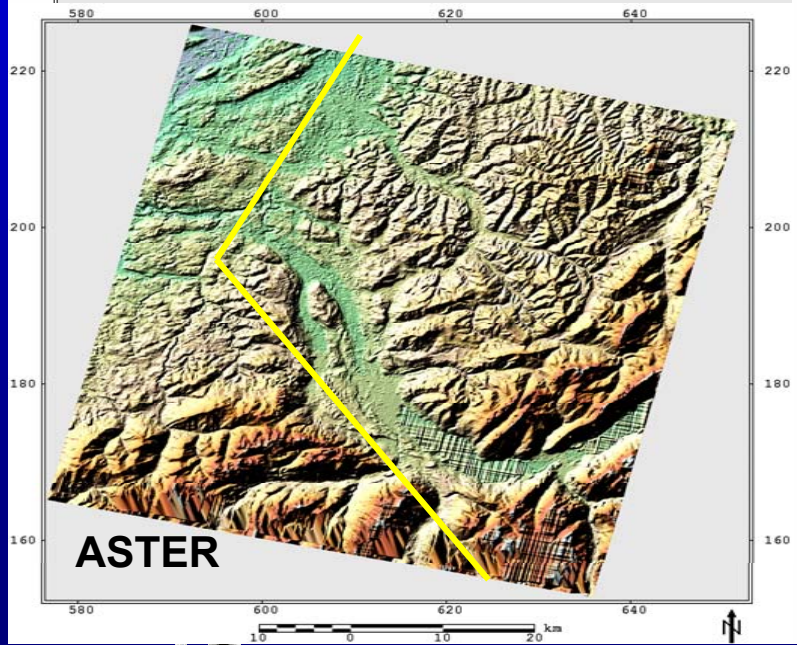
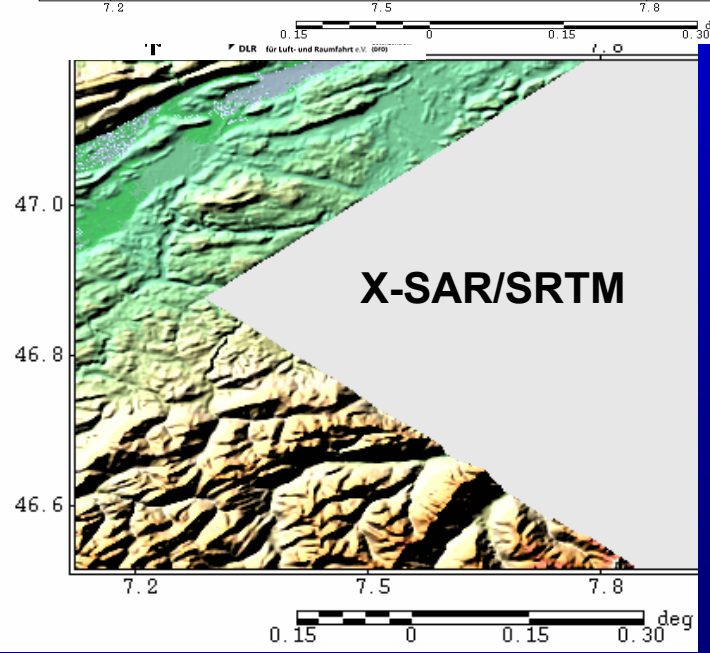






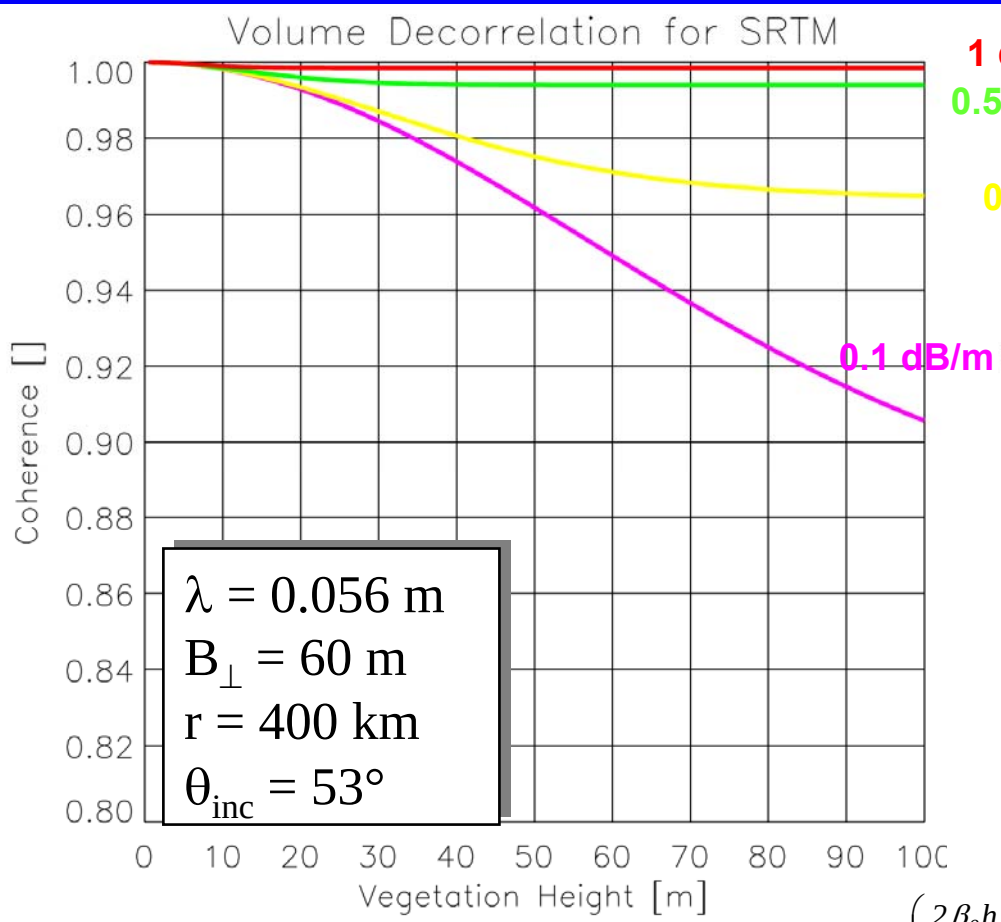


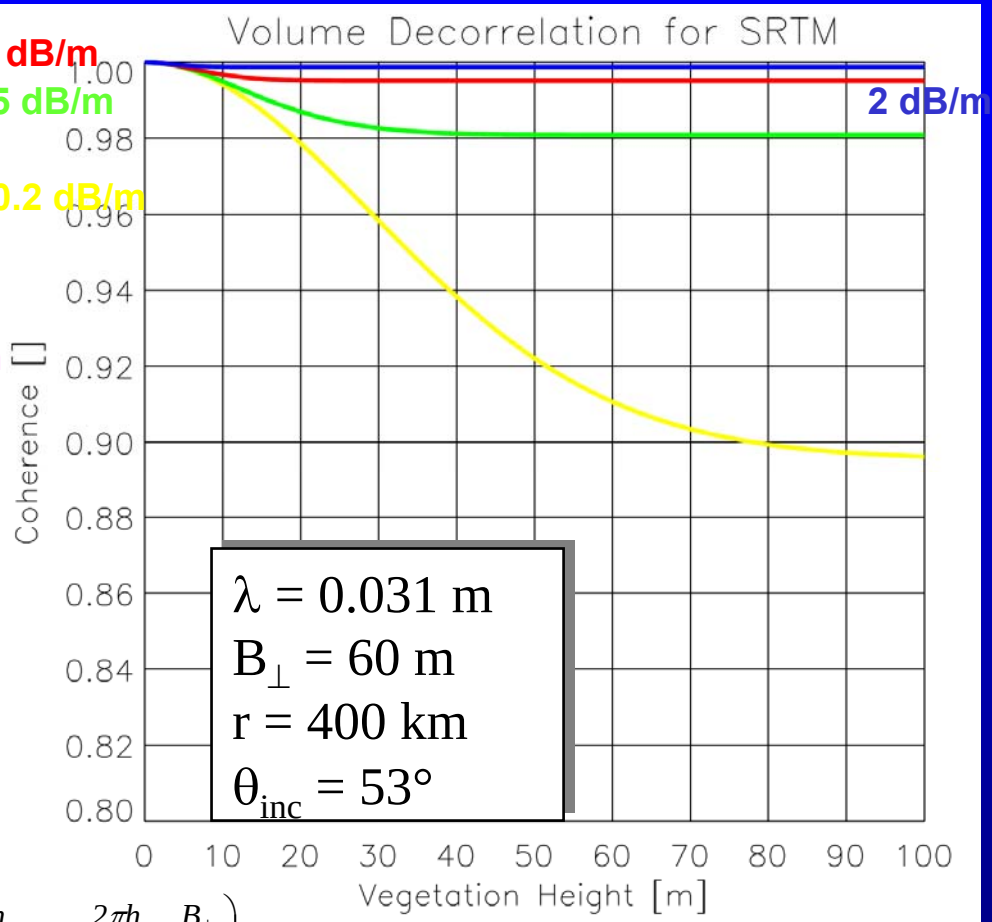


Comparison between X-Band SRTM and Optical system ASTER

X-SAR/SRTM Shuttle Radar Topography Mission

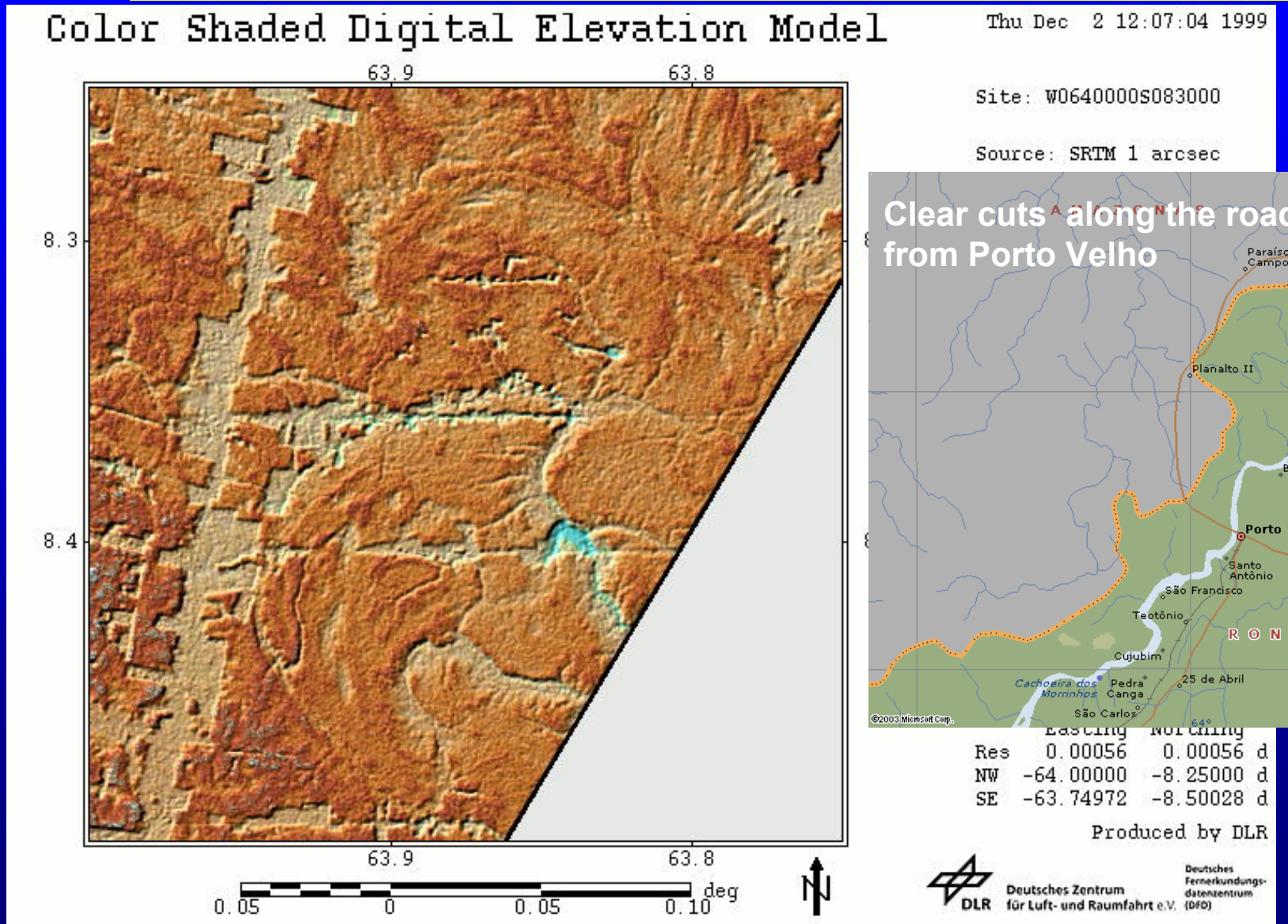
Volume Decorrelation for SRTM? No!

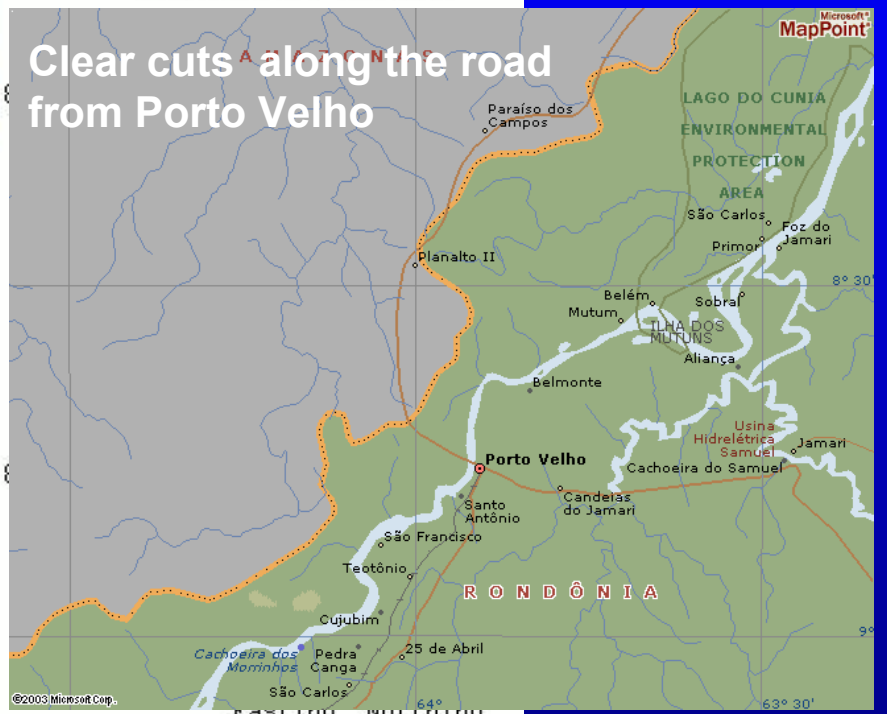




$$\gamma_{vol} = \frac{\exp\left(\frac{2\beta_0 h_v}{\cos\theta_i} - j\frac{2\pi h_v}{\lambda \sin\theta_i}\frac{B_\perp}{r}\right) - 1}{\left(\exp\left(\frac{2\beta_0 h_v}{\cos\theta_i}\right) - 1\right)\cdot\left(1 - j\frac{\pi}{\beta_0 \lambda \tan\theta_i}\frac{B_\perp}{r}\right)}$$

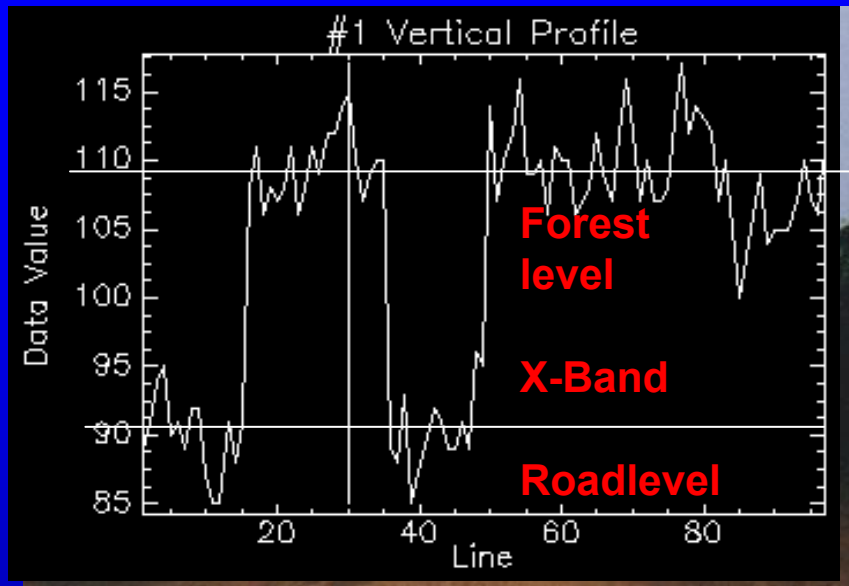
SRTM X-C Height Comparison over the Amazon Rainforest

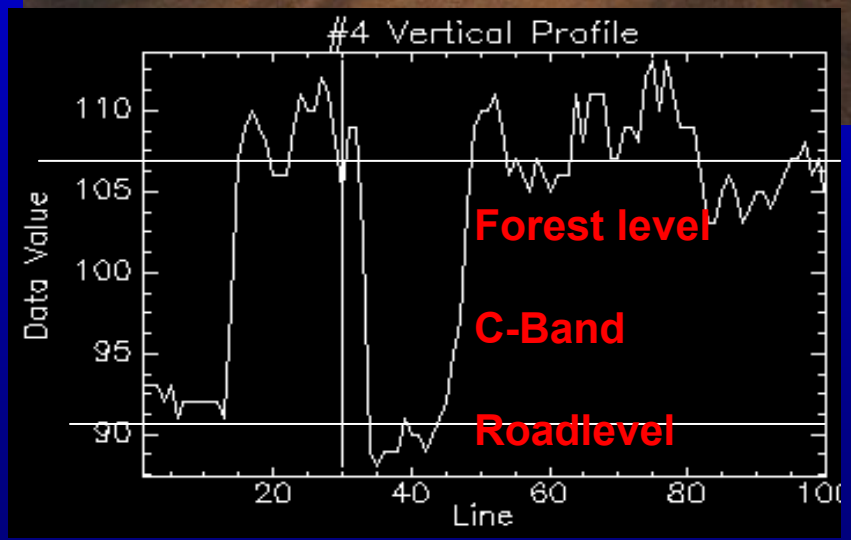




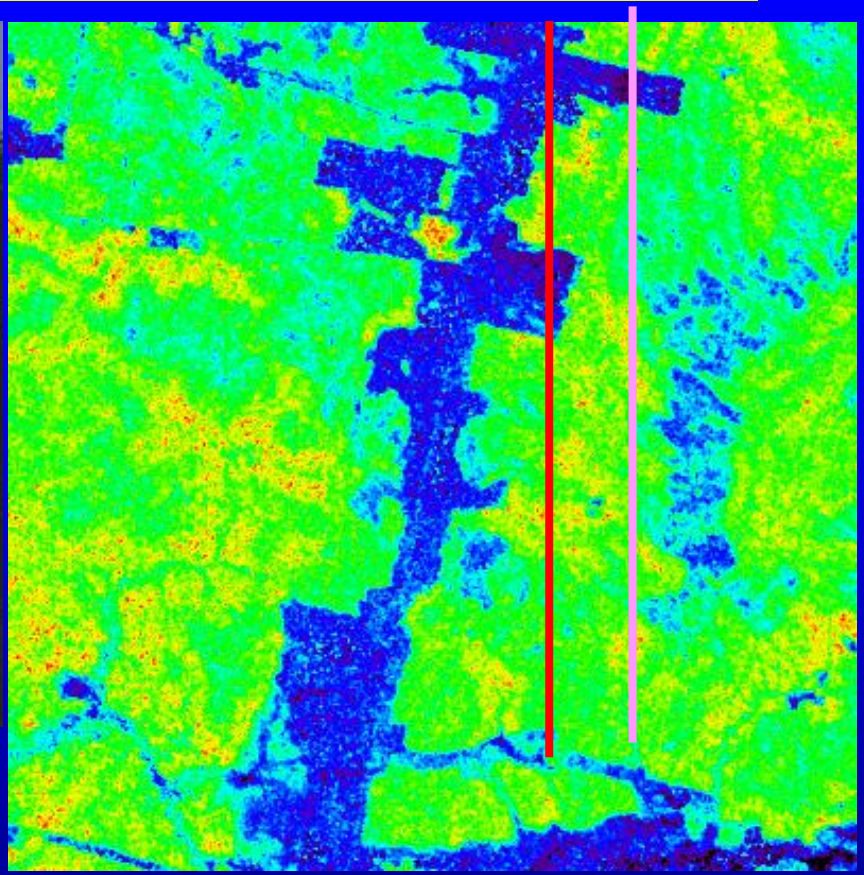
X-SAR/SRTM Shuttle Radar Topography Mission

SRTM X-C Height Comparison over Amazon Rainforest



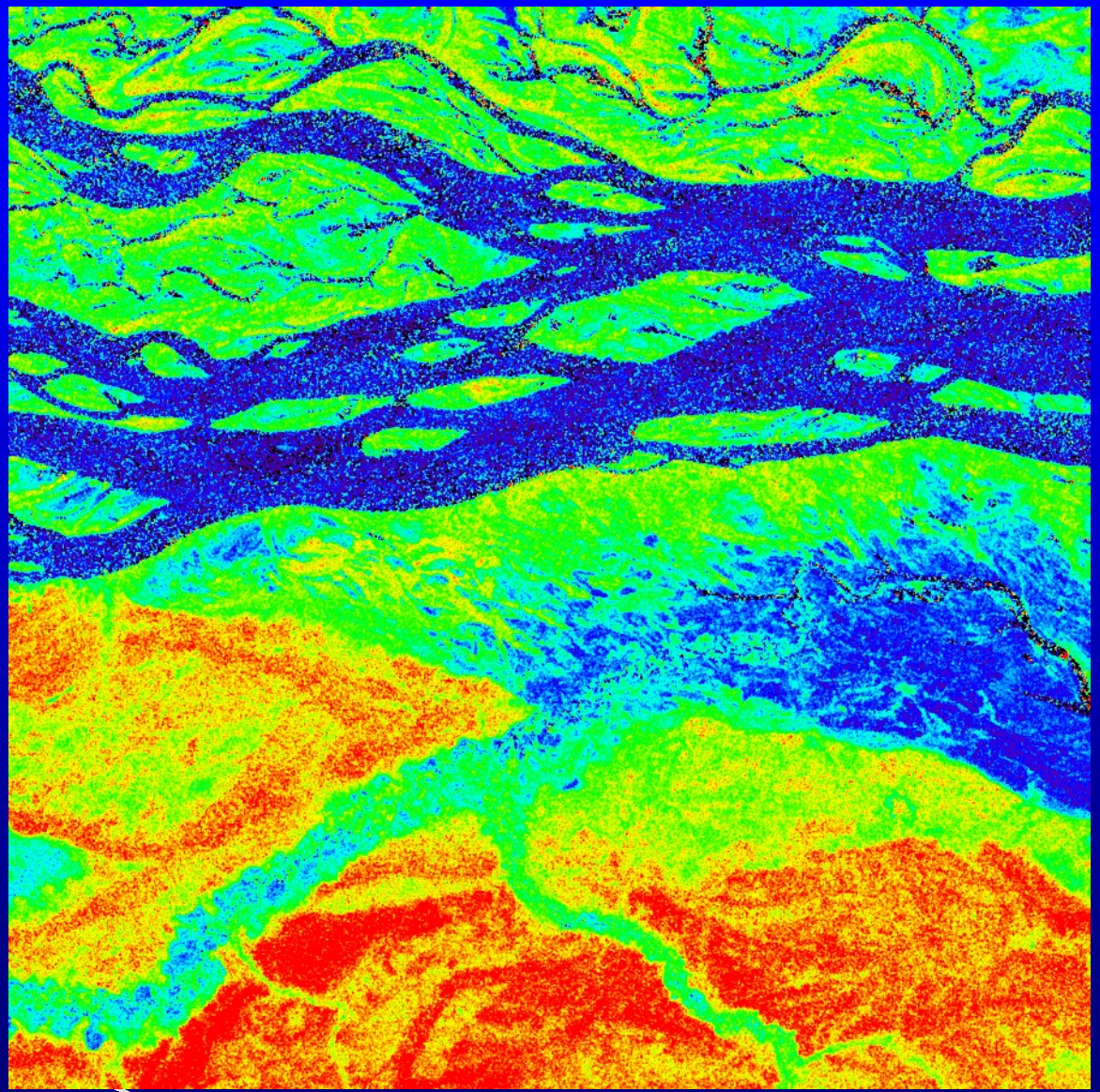


Example



Mean Difference Forest-Clear-cut C-band, Mean=13,95m
Mean Difference Forest-Clear-cut X-band, Mean =14,91m
Standard deviation < 4,7m

SRTM X-C Height Comparison over the Amazon Rainforest



X-Band

Min	Max	Mean	Stdev	Diff.
-15	57	18.896562	4.496045	14,89 m
-34	71	33.784949	5.436442	14,83 m
36	64	48.622653	3.582792	

C-Band

Min	Max	Mean	Stdev	Diff
7	51	25.551797	4.875591	14,71 m
13	50	40.262077	4.126496	13,13 m
42	64	53.401326	3.004250	

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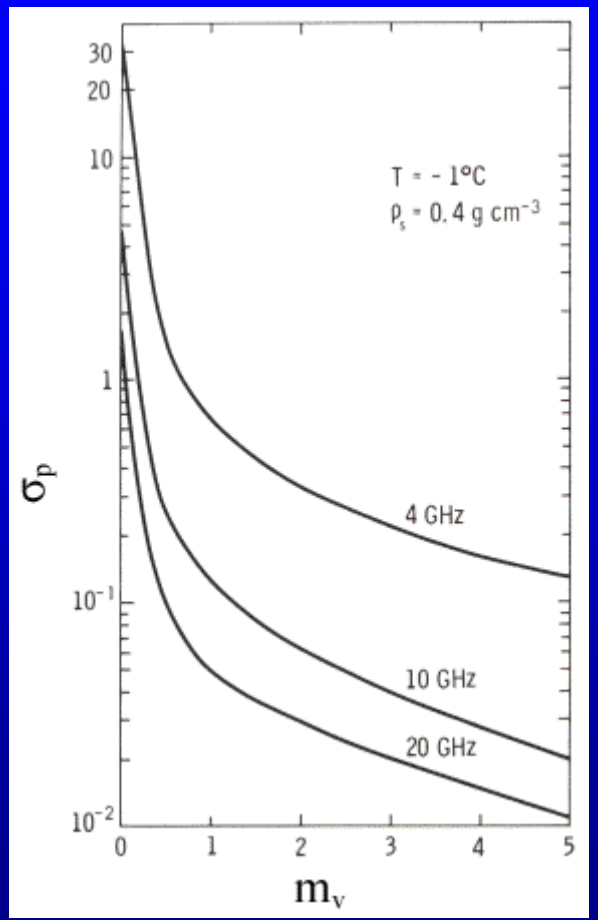
SRTM X-C Height Comparison over snow



The penetration depth dp at the wavelength in free space λ_0 can be estimated from the real ε' and imaginary ε" parts of the complex permittivity according to:

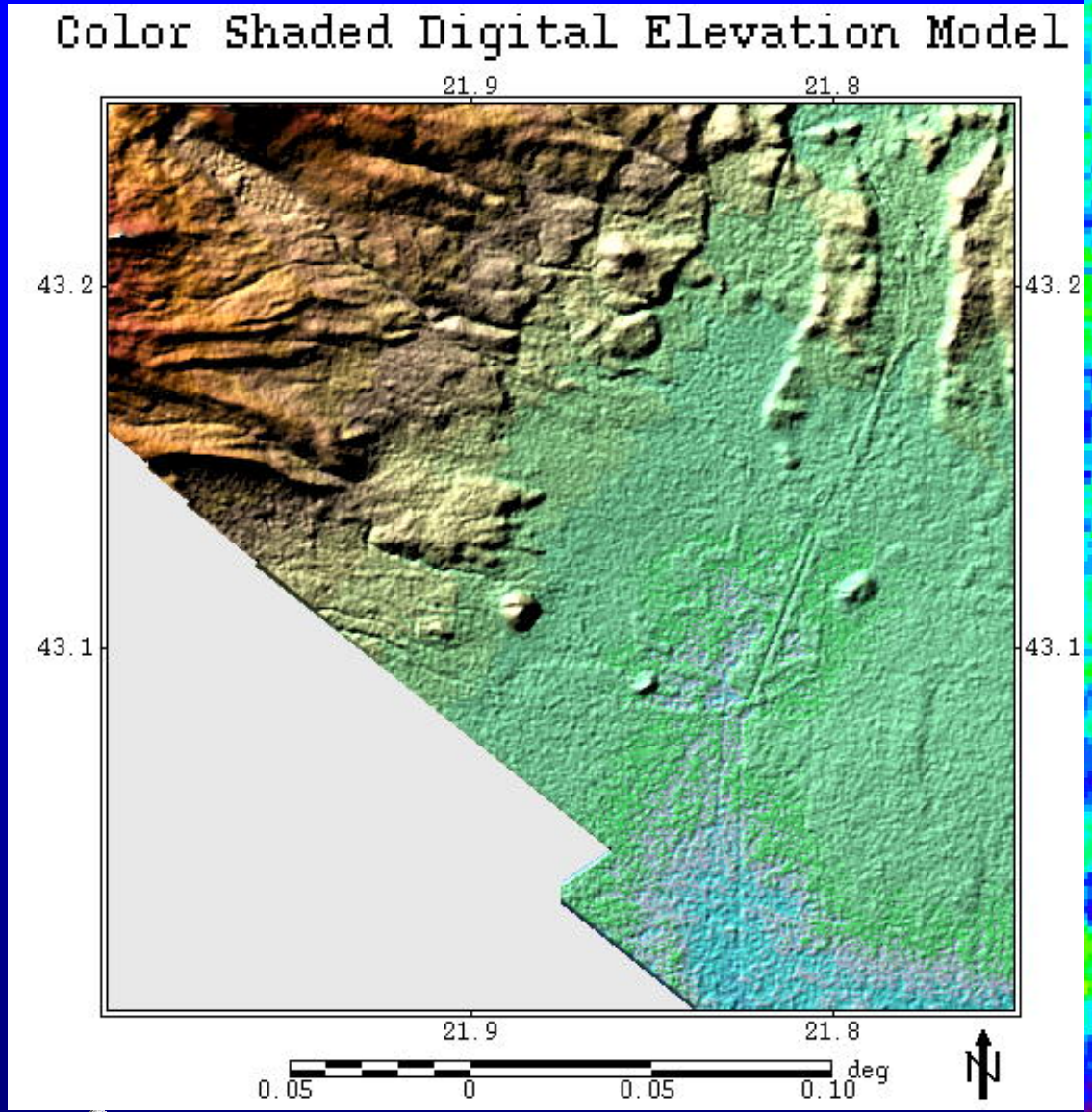
$$d_p = \frac{\lambda_0 \sqrt{\varepsilon'}}{2\pi \varepsilon''}$$

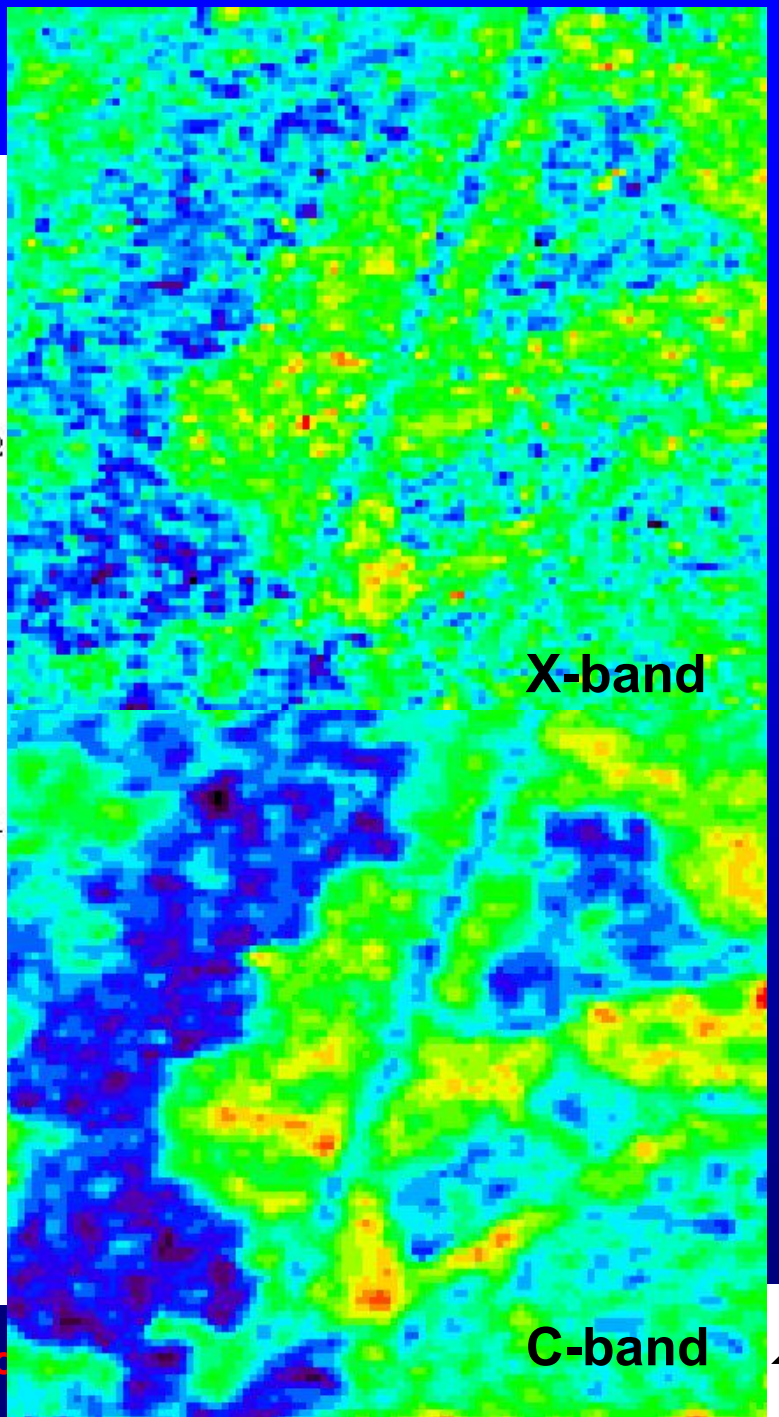
$$\varepsilon'_s = 1 + 1.60\rho_s + 1.86\rho_s^3$$

where p is specified in [g/cm3].

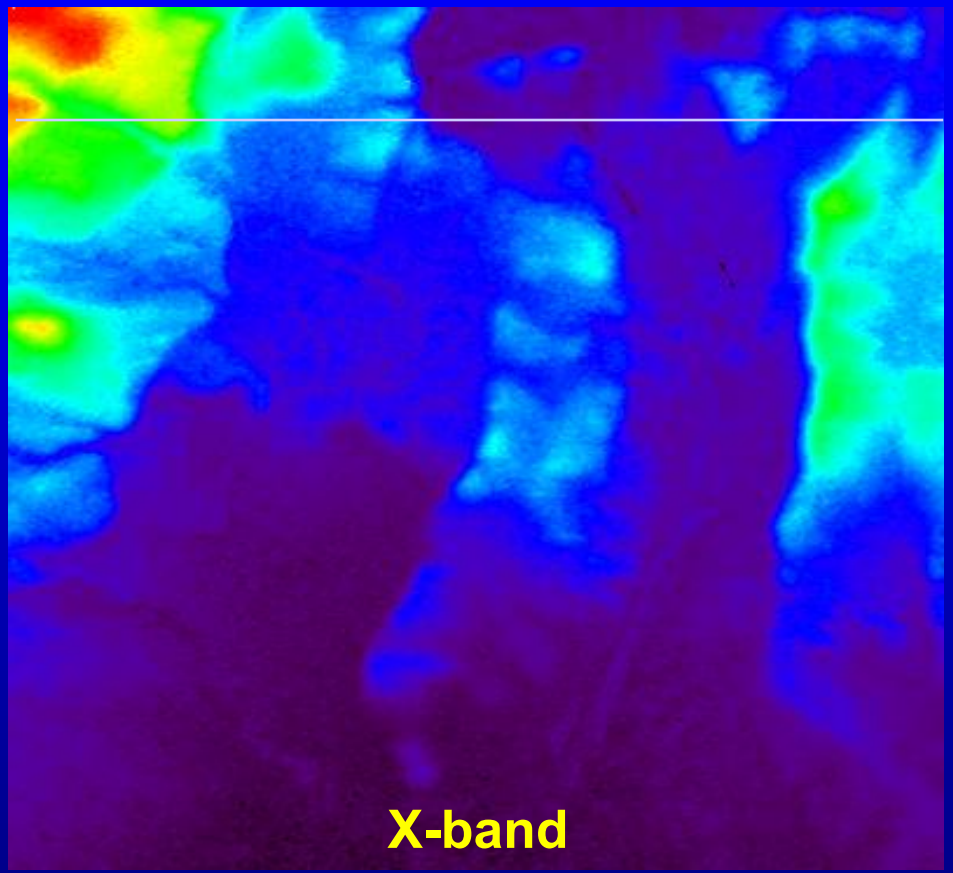
This results in a typical penetration depth of dry winter snow 0,3g/cm^3 of
$d_p \approx 20$ m at C-band and
$d_p \approx 6$ m at X-Band

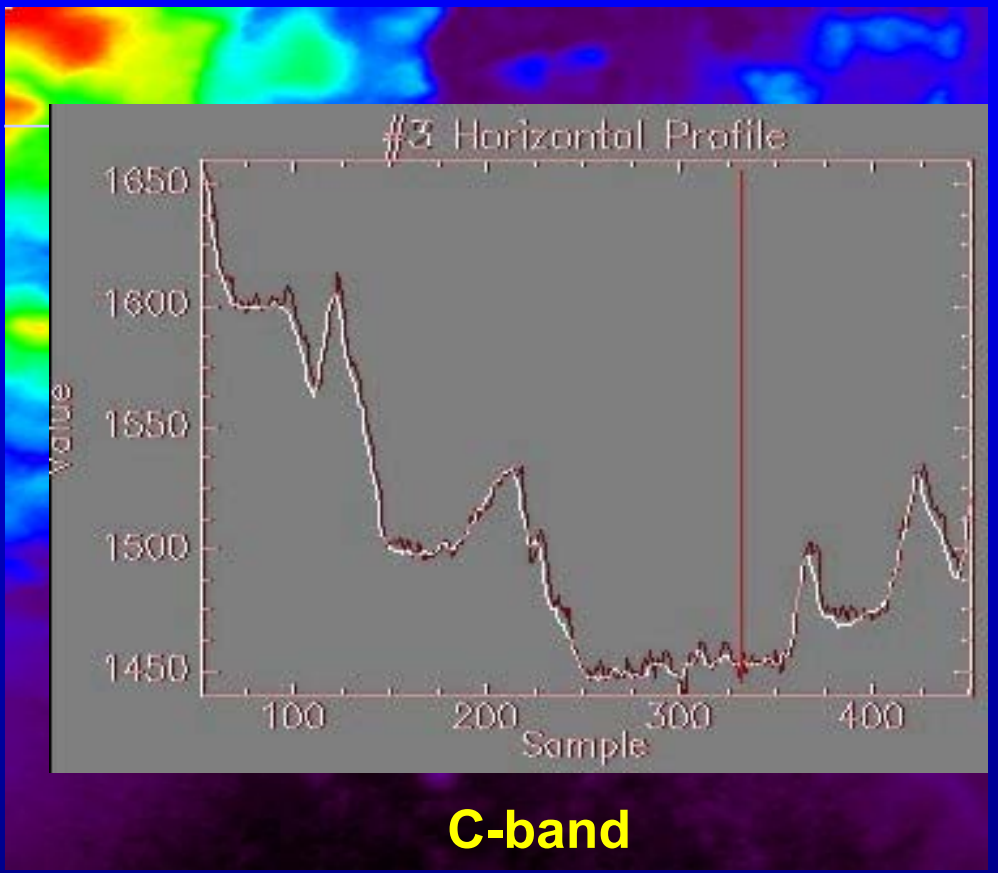
SRTM X-C Height Comparison

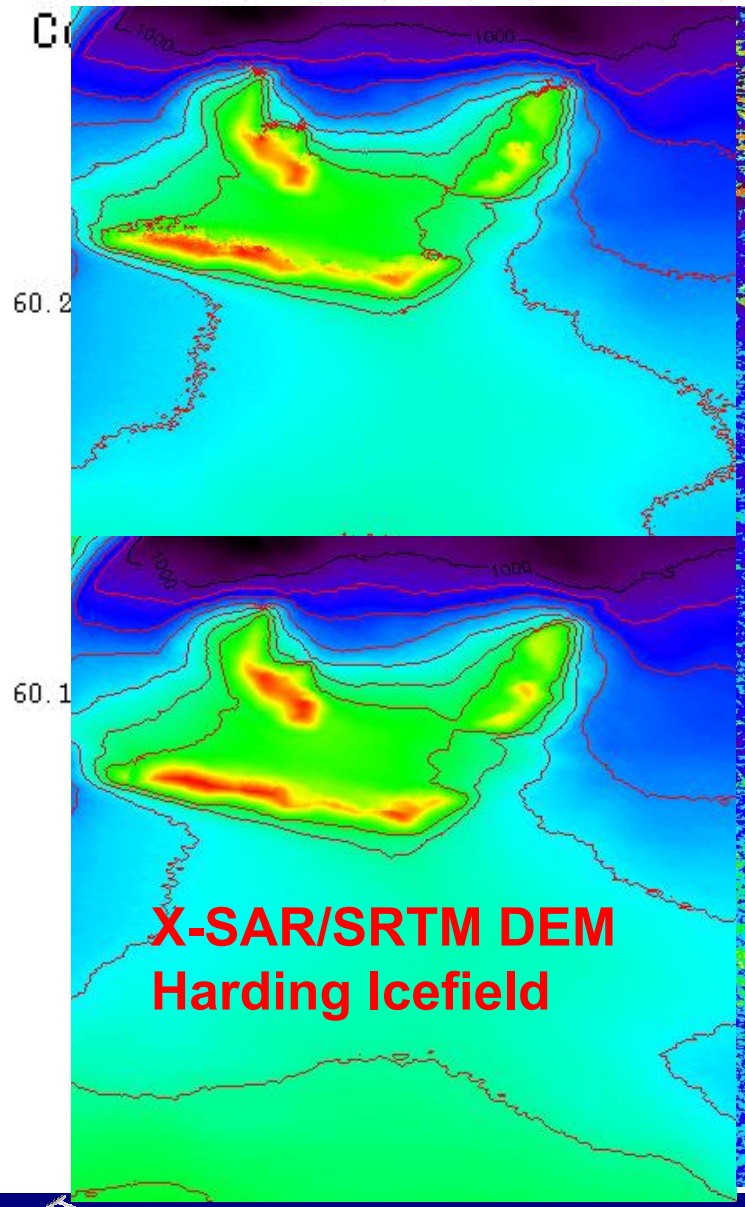


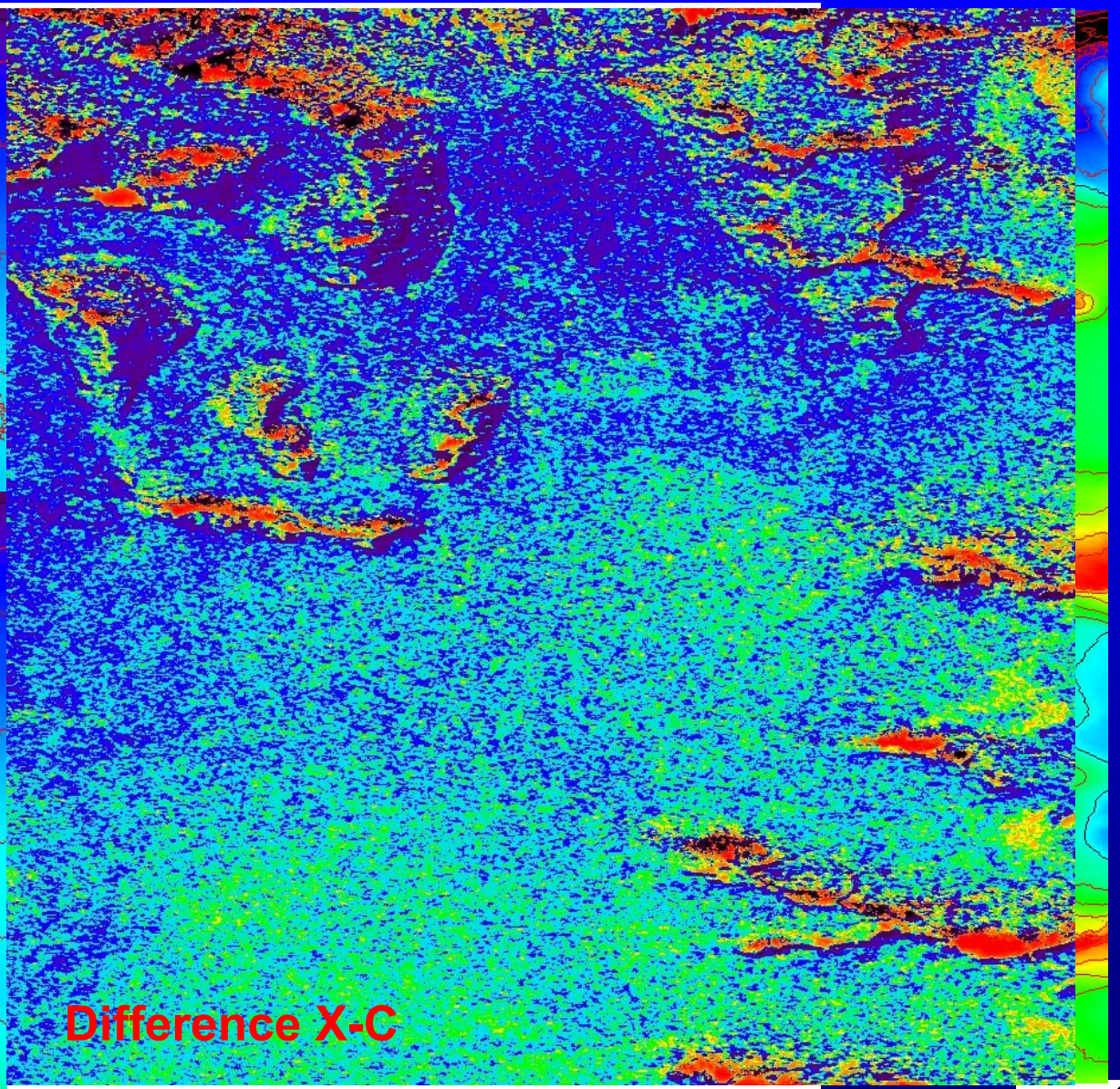


SRTM X-C Height Comparison over forest

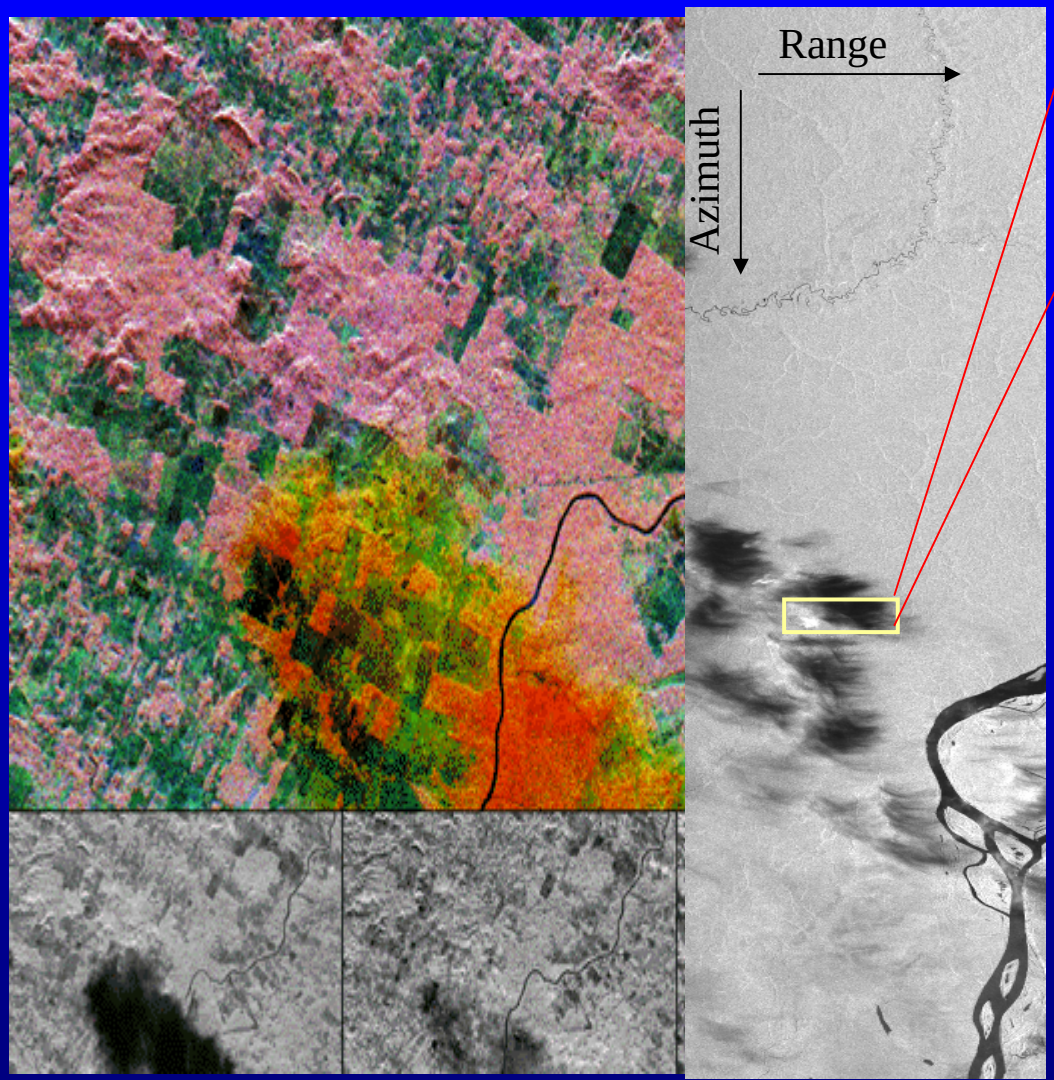


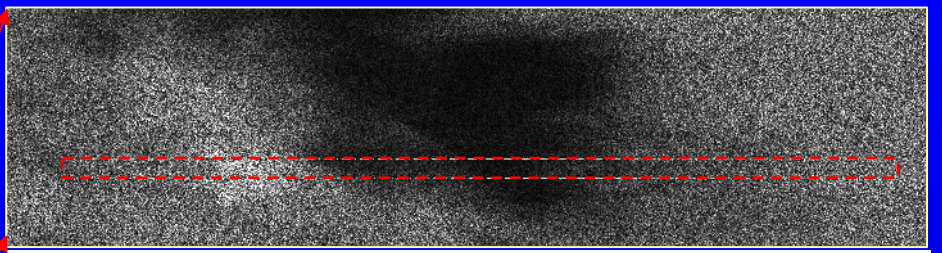


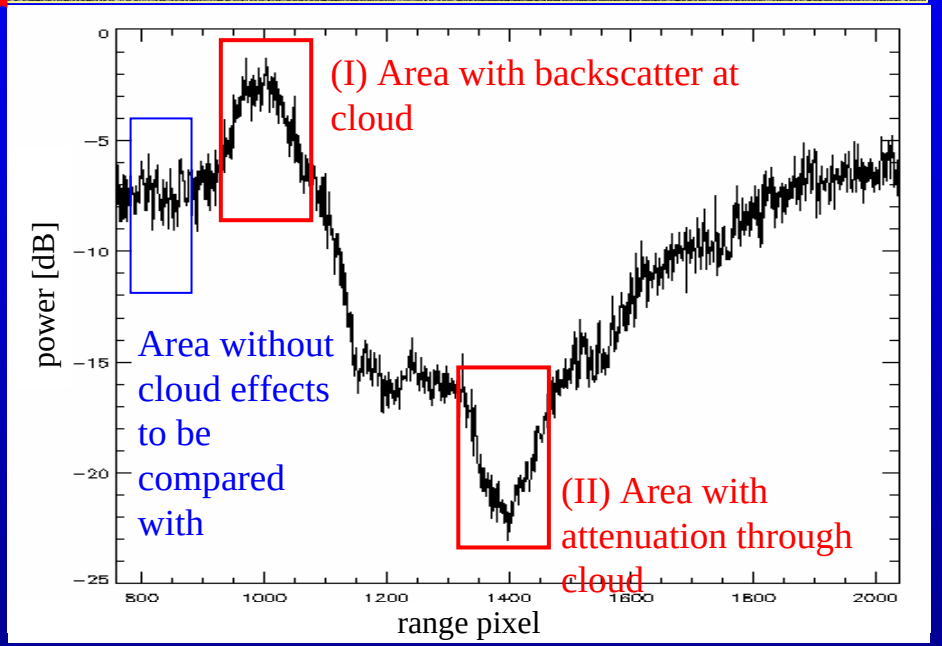

60.2
60.1
X-SAR/SRTM DEM
Harding Icefield


Difference X-C

Rain Cloud effects in SRTM X- und C-Band DEMs?







Rain cells did not cause remarkable systematic errors in the interferomertic phase of SRTM

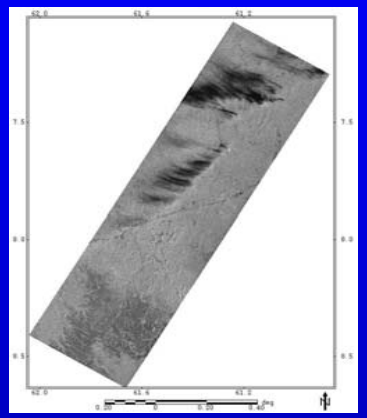
X-SAR SIR-C X-SAR/SRTM

X-SAR/SRTM Shuttle Radar Topography Mission

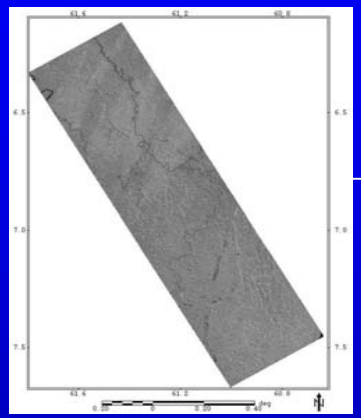
DLR

Analysis of Rain Cell Influence on Interferometric Phase for SRTM

Pair of crossing interferometric data sets in X-band



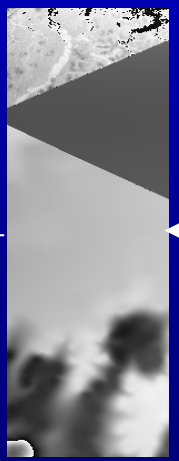
With Clouds



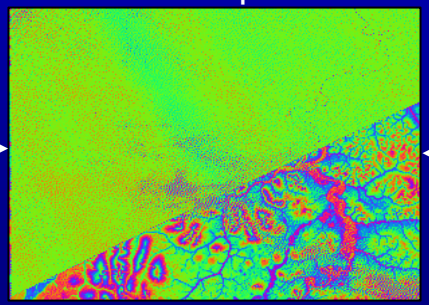
Without Clouds

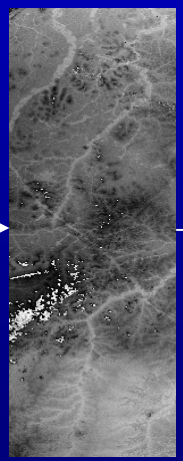
Calculate DEM of cloudless scene

Simulate interferogram of cloud scene from DEM of crossing scene



Differential interferogram of overlap area





Interferogram of cloud scene

M.Werner 2003

DLR