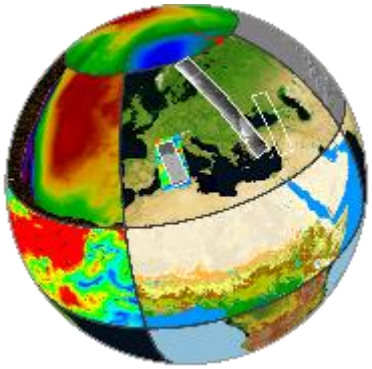

VH-RODA 2019

Assessment of DEM quality and applications

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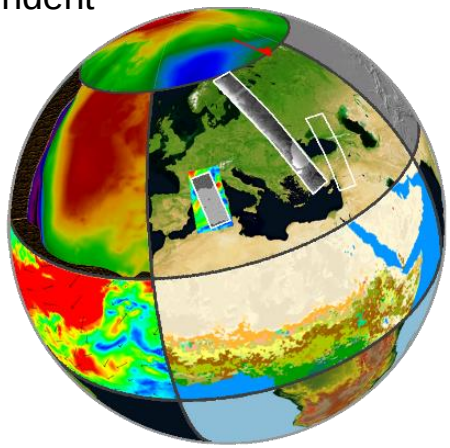
- **Statistical assessment**
  - Intercomparison of DEMs – On-the-fly reprojection / difference / 8-bits rendering
  - Elevation control – ICESat LiDAR reference data
  - Analysis of errors – global / regional / altitude-dependent / roughness-dependent
- **Use-base assessment**
  - Sentinel-1 level 1B (10m) products
  - Envisat MERIS level 1B (300m) products
  - Extraction of watersheds, ridges and drainage network
- **Towards a DEM intercalibration platform**
  - Access to open data references - LiDAR, geodetic points, altimeter data…
  - Access to open data vertical grids - DEMs, geoids
  - Display tools – On-the-fly parameters (resampling methods), hypsometric LUTs, shadowing coeff…
  - Interactive control tools – Differences, sharing of residual maps, dynamic control reports…
  - Geomorphological analysis tools – Density of local extrema / saddle points, extraction of characteristic lines (ridges, talwegs), watershed trees, dynamic comparisons (differences, linear regression…)



Technical note *"Assessment of DEM quality and applications"* – SOW requirements

This task is dedicated to specific studies related to multi-mission data quality assessment.

This task will be useful for setting up rapidly studies that can benefit to the CEOS environment, facilitating future applications and allowing interoperability across missions to foster synergies.

For example, following the success of the ACIX exercise (Atmospheric Correction inter-Comparison eXercise) [R - 29] CEOS WGCV is currently discussing inter-comparison exercises on various domains: cloud masking, DEM. Specific support will be trigger to support these activities. It can consist in reviewing the literature on the subject, putting in place reference data and procedures, applying the various methodologies and comparing the results. In some cases, publications will be asked.

2.6.1 Task Description

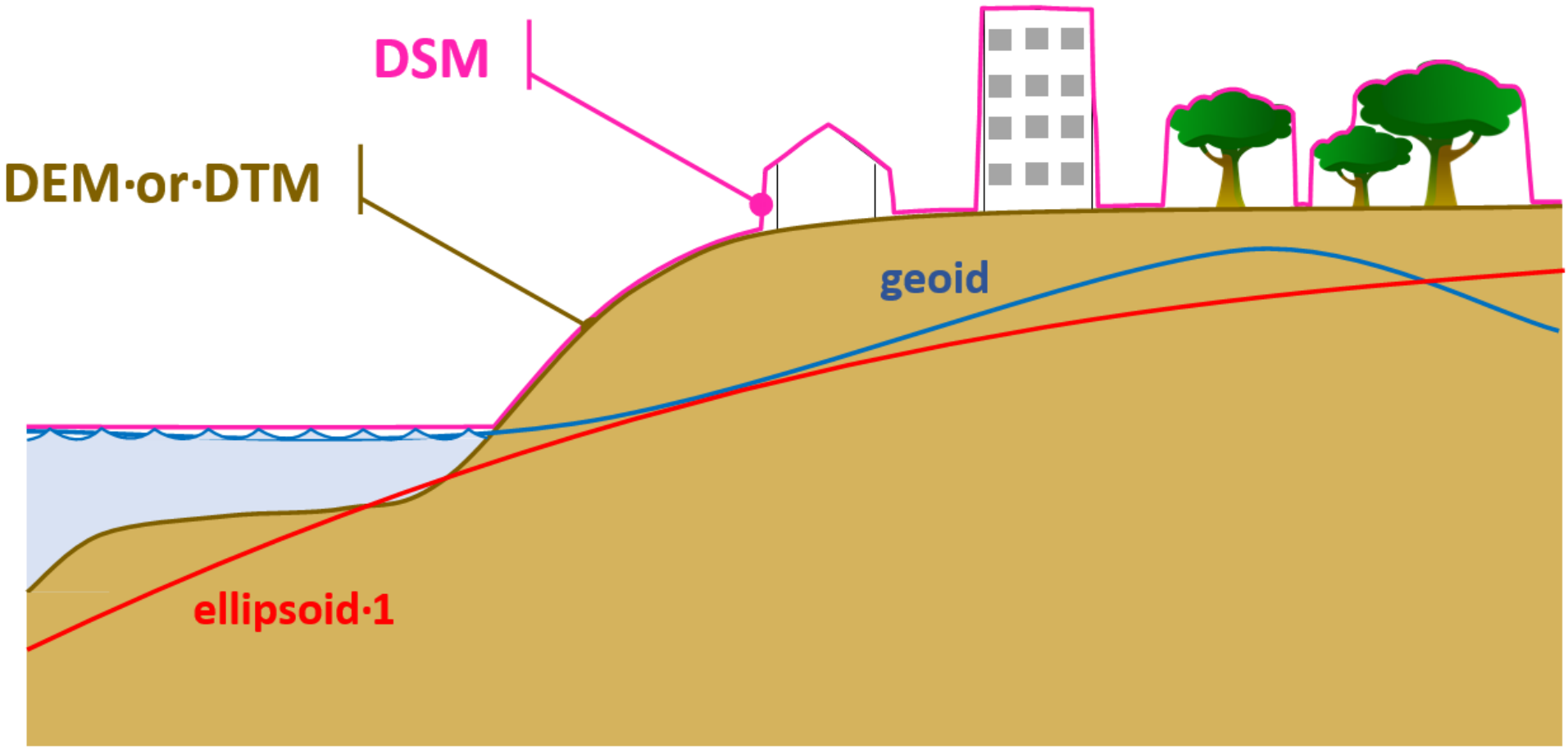
Studies will be necessary for assessing the quality of Digital Elevation Models in difficult areas (high mountains, cities, etc.) and suitability for different data resolutions during orthorectification processes, checking also the difference between Digital Surface Model and Digital Terrain Model. Interpolation techniques will have to be assessed with respect to the various spatial resolution missions characteristics (VHR, HR, MR). Finally, the completeness of DEMs at various spatial resolutions will be assessed. Other studies may be added at a later stage.

2.6.2 ***Output***

- D - 10: Technical note for activities related to DEM.

DEM, DSM or DTM

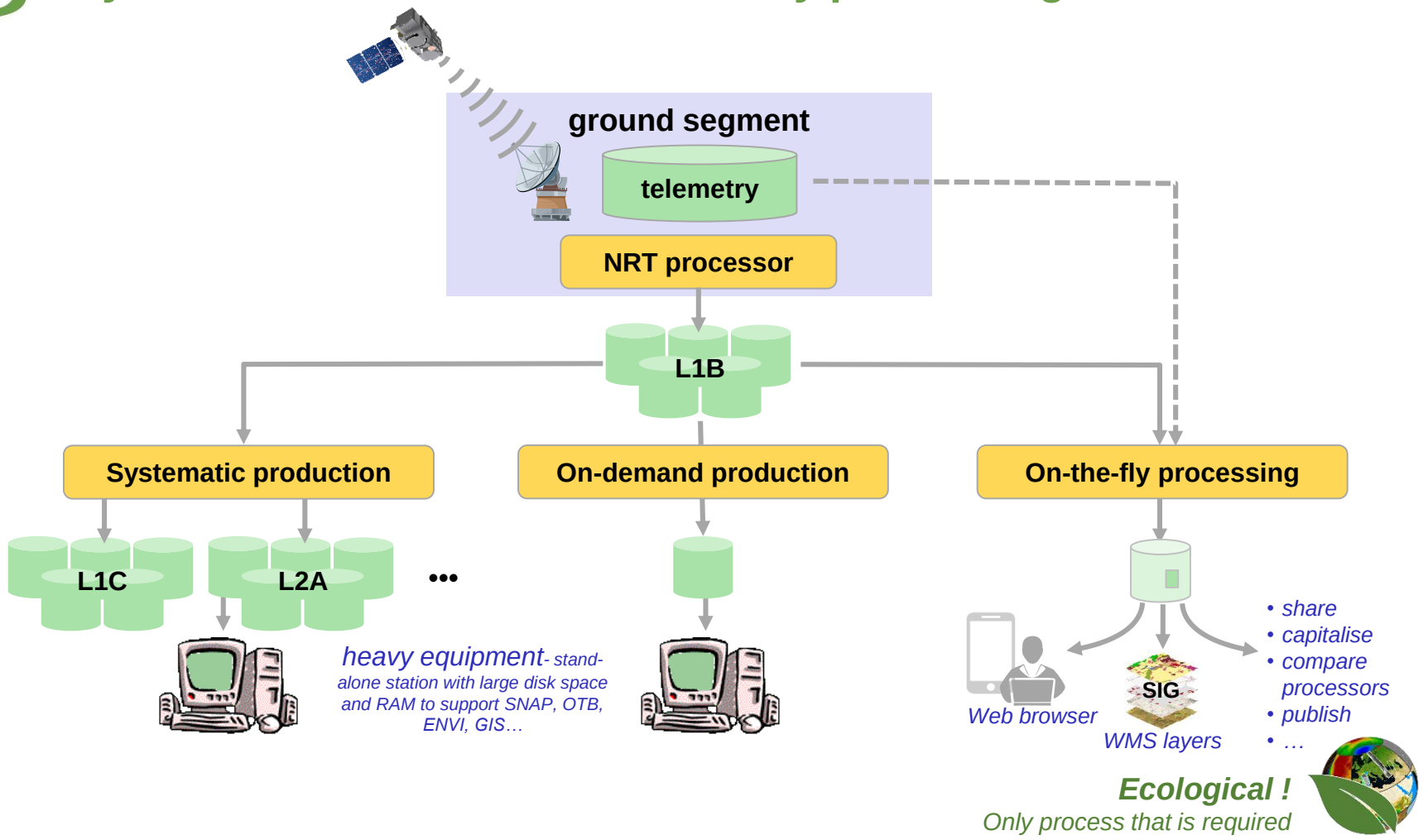
Vertical reference system



DEMs to be controlled

DEM	version	mode	observation range	GSD	extents	CRS	VRS
SRTM GL1	3.0 (2015)	IF	11 Feb.2000 22 Feb.2000	1''	56°S – 60°N	Geo.	EGM96
ASTER GDEM	2.0 (2011)	PG	Dec.1999- Feb.2011	1''	Global	Geo.	EGM96
ALOS World 3D	2.2 (Apr.2019)	PG	2006 2011	1''	Global	Geo.	EGM96
Copernicus DEM EEA 10	draft	IF	Dec.2010 Mid-2014	0.3'' var.	Europa 39 countries	Geo.	EGM 2008
Copernicus DEM GLO-30	draft	IF	Dec.2010 Mid-2014	1''	Global	Geo.	EGM 2008
Copernicus DEM GLO-90	draft	IF	Dec.2010 Mid-2014	3''	Global	Geo.	EGM 2008

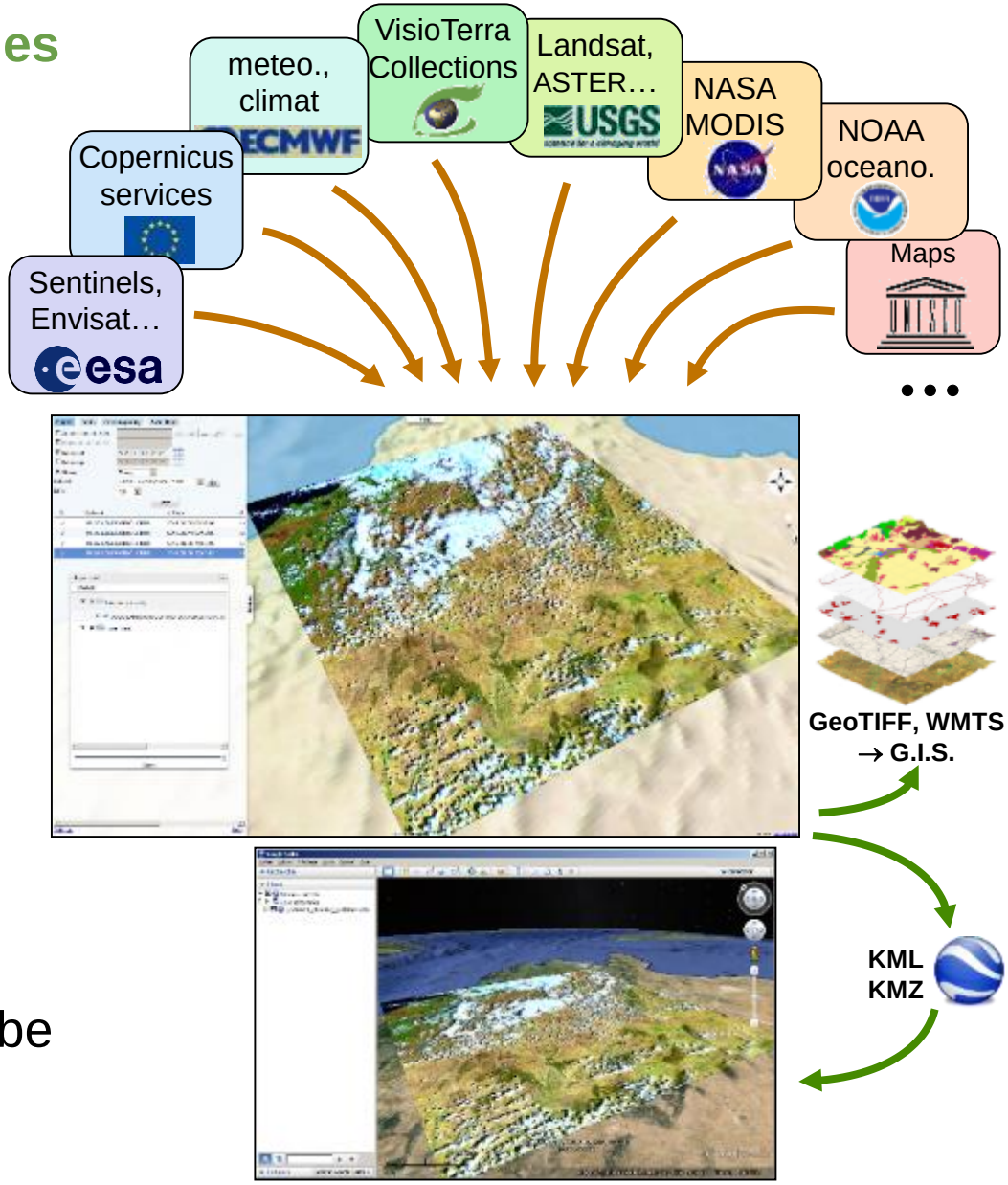
Systematic / on-demand / on-the-fly processing



heavy production (peta-bytes)	light (one whole product)	very light (area at scale of interest)
new version of the processor ⇒ reprocess the whole archive	*no impact*	*no impact*
download with high bandwidth	download high large bandwidth	*very low bandwidth*

VtWeb – Design principles

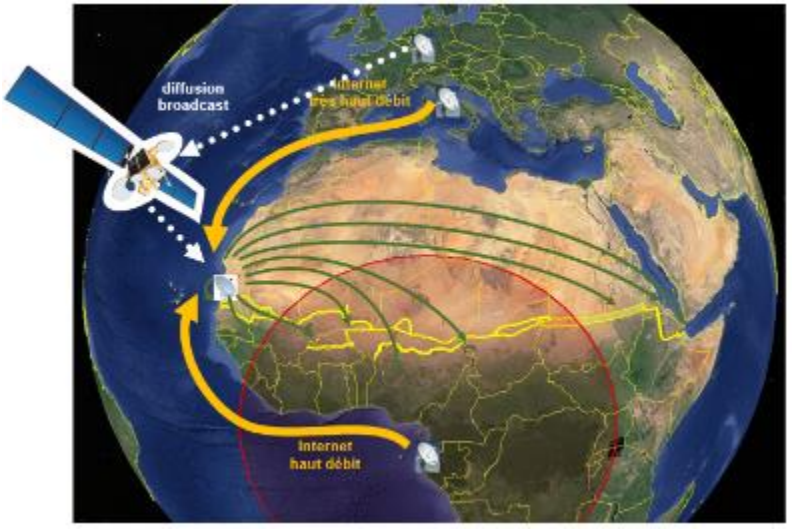
- www.visioterra.fr/?VtWeb
- global / free data
- data retrieval / data mining
- satellites / meteo / ECV / altimetry models / maps…
- Near Real-Time access
- automated processing
  - ❑ for citizen
    - default style
    - predefined styles
  - ❑ for scientists
    - parameter tuning
    - toward a P.O.F. toolbox
- collaborative infrastructure(s)
- 2D webmapping / 3D virtual globe
- on your area of interest
- archives to analyse changes
- value-added services, recurring monitoring, alarms…

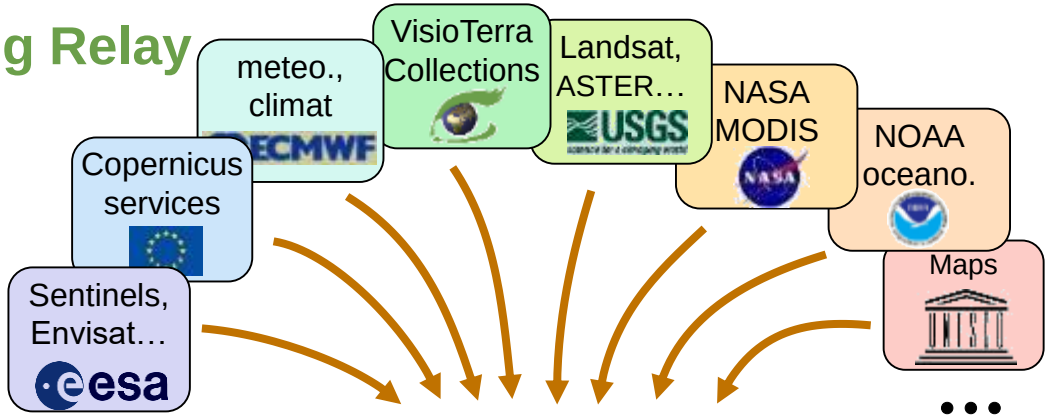


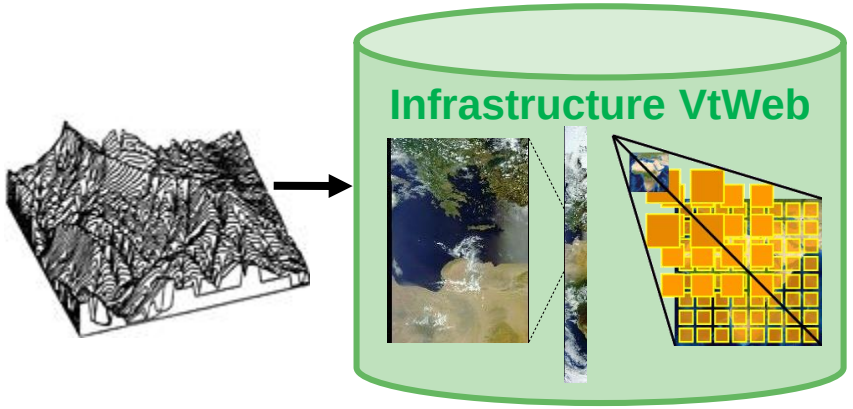
VtWeb – Data Processing Relay

- VtWeb infrastructure
  - 1 PB (1000 TB) available
    - 50 TB ASAR and ERS
    - 150 TB MERIS
  - 1 Gb/s symmetric fibre
  - 4 powerful servers

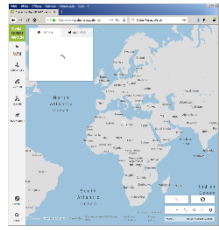
- DPR as a solution for Africa



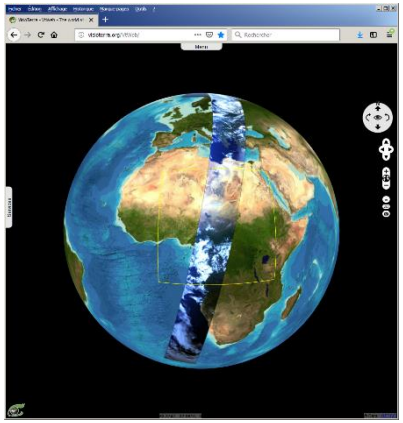




Other infrastructures

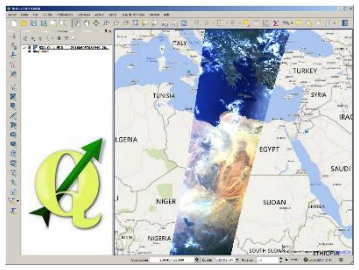


VtWeb client



Google Earth

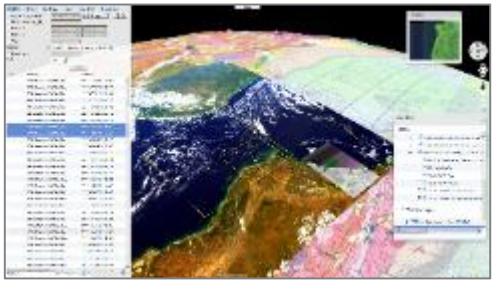
G.I.S.



VtWeb – Generic platform for customized platforms

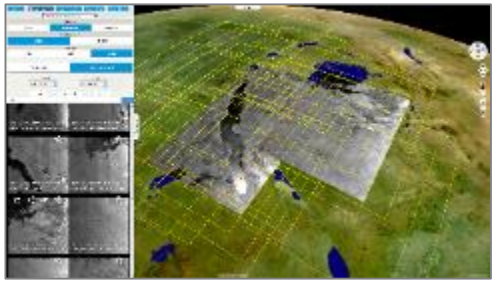
visioterra.org/**VtWeb**

An advanced one-stop-shop model

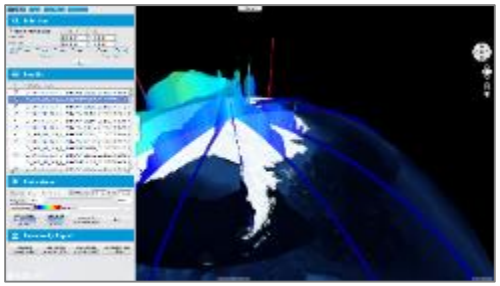


A showcase capitalising VisioTerra know-how

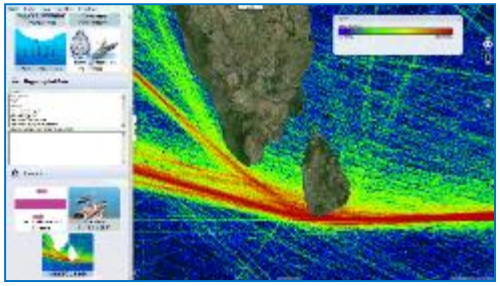
hedavi.esa.int



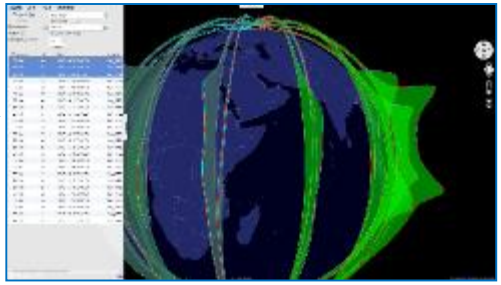
visioterra.net/**VtCryoSat**



visioterra.net/**VtPace**

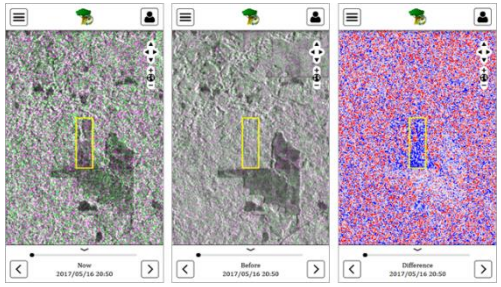


visioterra.net/**VtGsep**



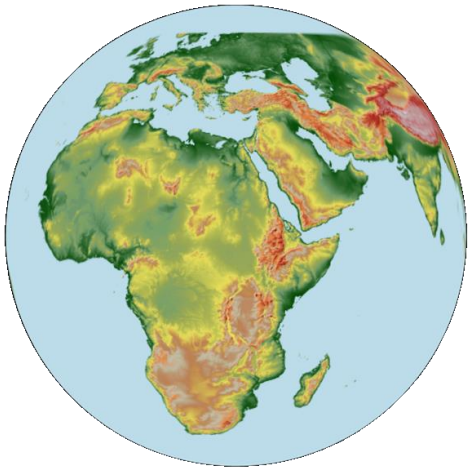
www.**sentinelvision**.eu

visioterra.org/**FlegtWatch**

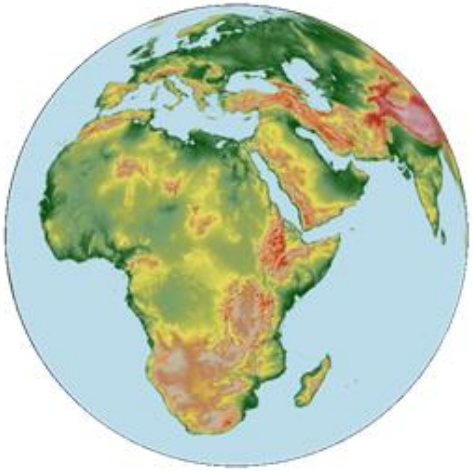


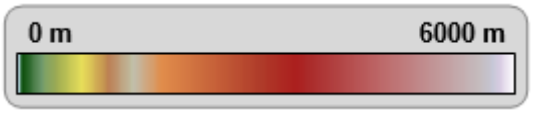
Qualitative assessment – Intercomparison of DEMs

SRTM

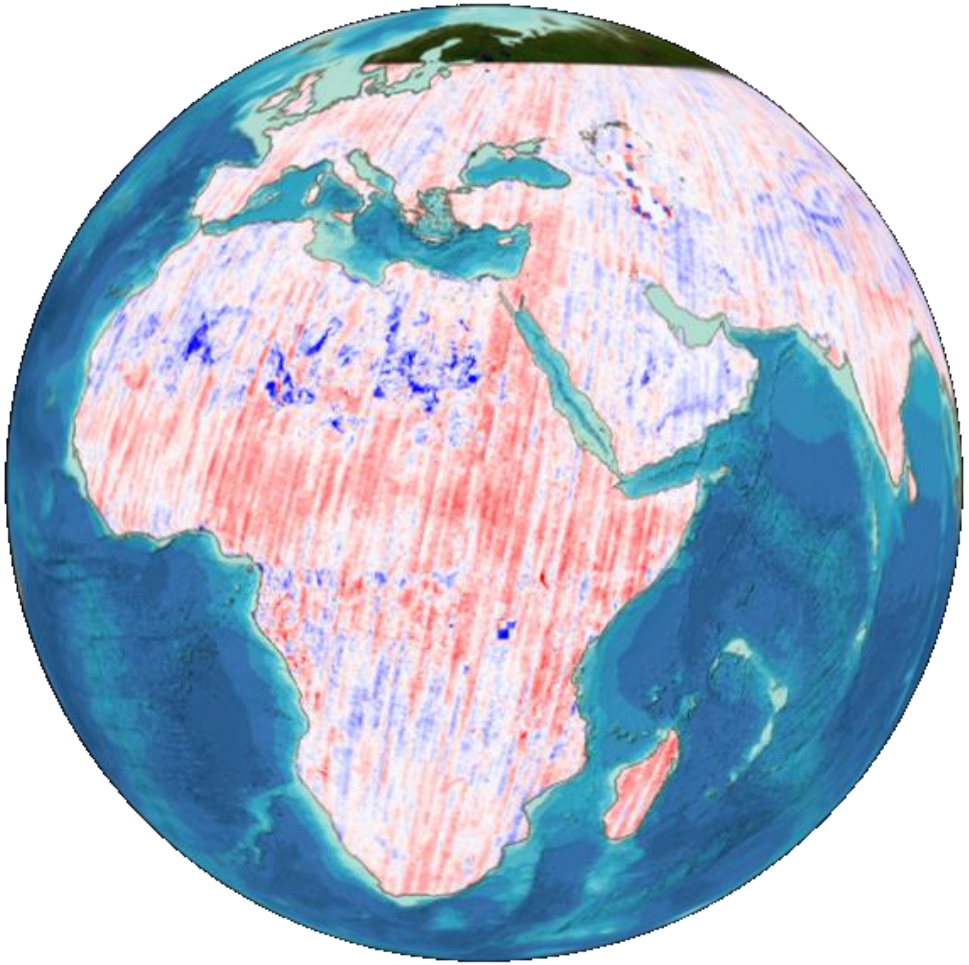


ASTER GDEM



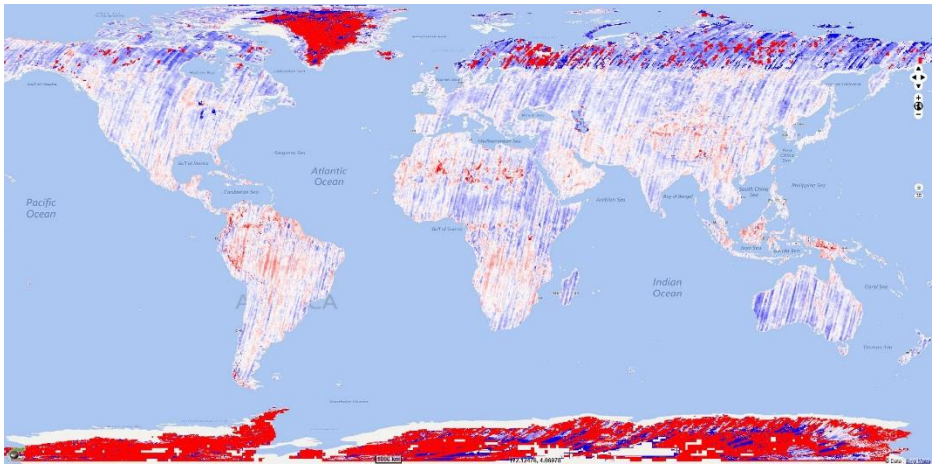


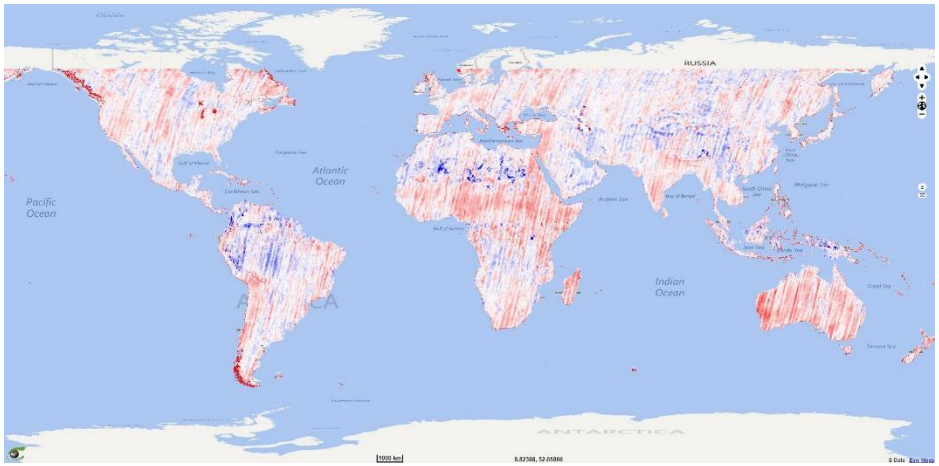
SRTM - ASTER GDEM

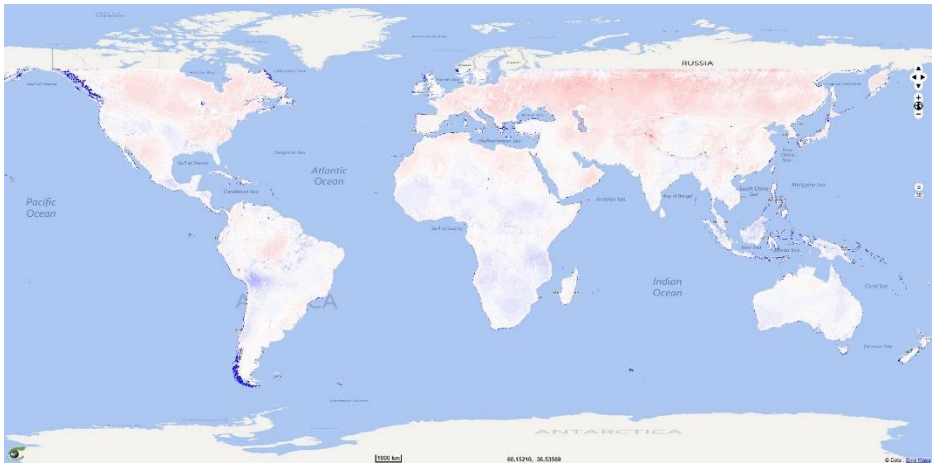


Qualitative Intercomparison

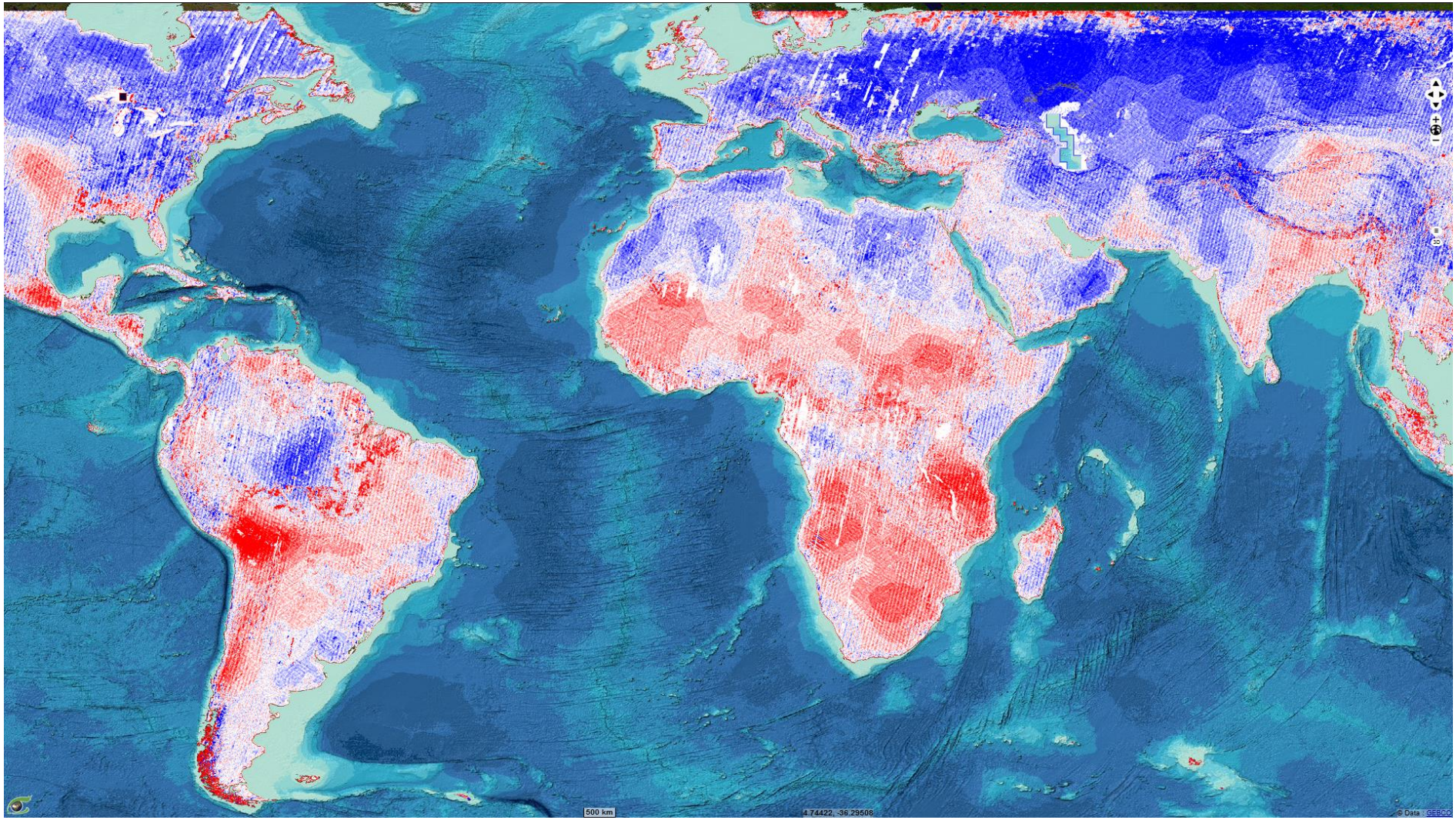
- On-the-fly preprocessing and difference in VtWeb
- Hyperlooks
  - SRTM – ASTER GDEM
  - ASTER GDEM – ALOS World 3D
  - ALOS World 3D - SRTM







(SRTM – ALOS World 3D) enigma ?

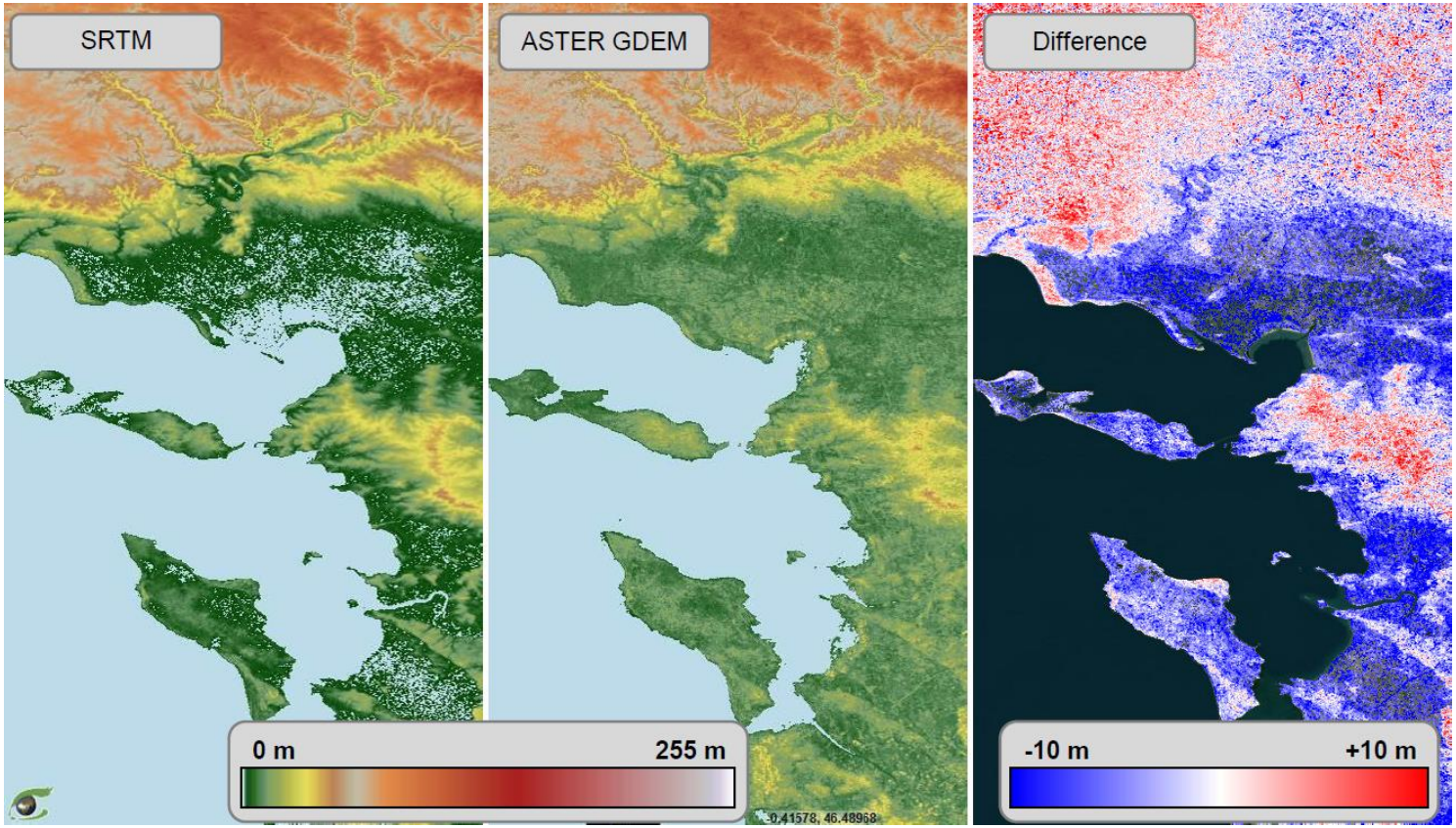


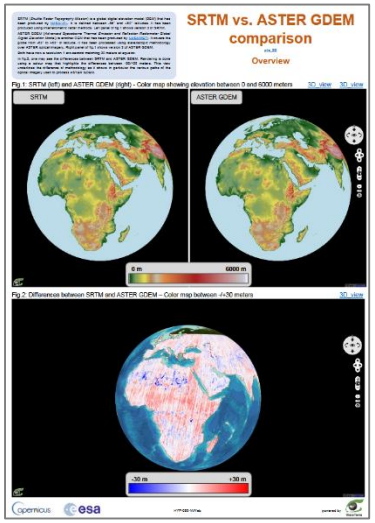
Hyperlook

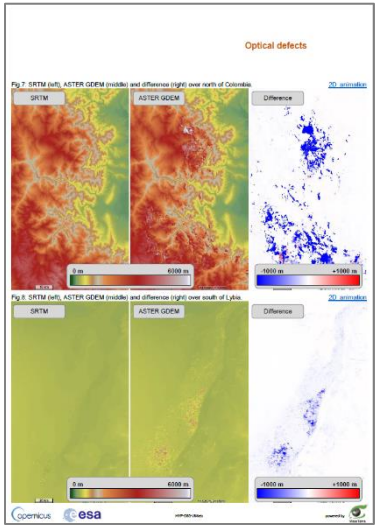
Height anomalies

- Hyperlook document
  HYP-080-VtWeb-v2

- SRTM (left), ASTER GDEM (middle) and difference (right) over La Rochelle. 2D_animation



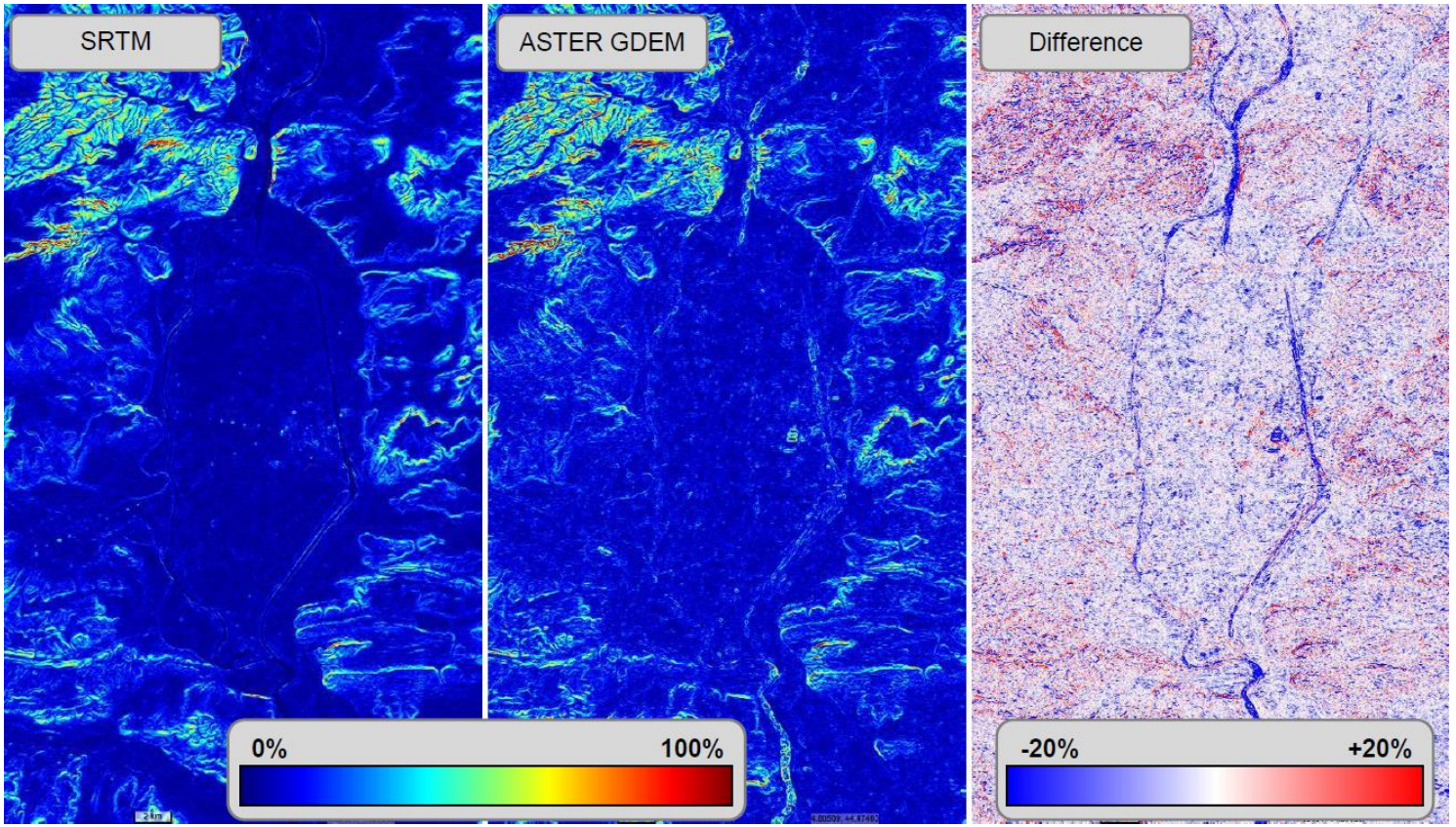


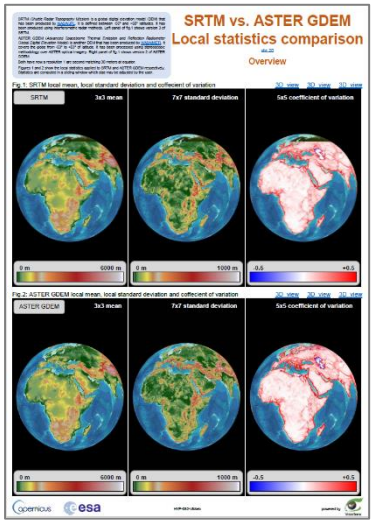


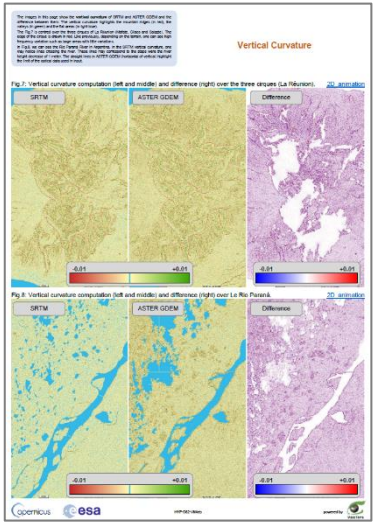
Local statistics anomalies

- Hyperlook document – **Slope / Azimuth / Curvatures**
  HYP-082-VtWeb

- Slope computation (left and middle) and difference (right) over Vallée du Rhône (France). 2D_animation

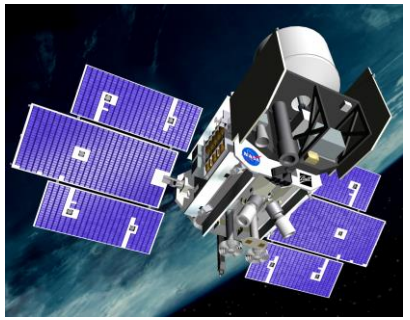




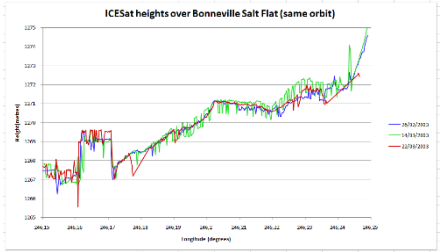


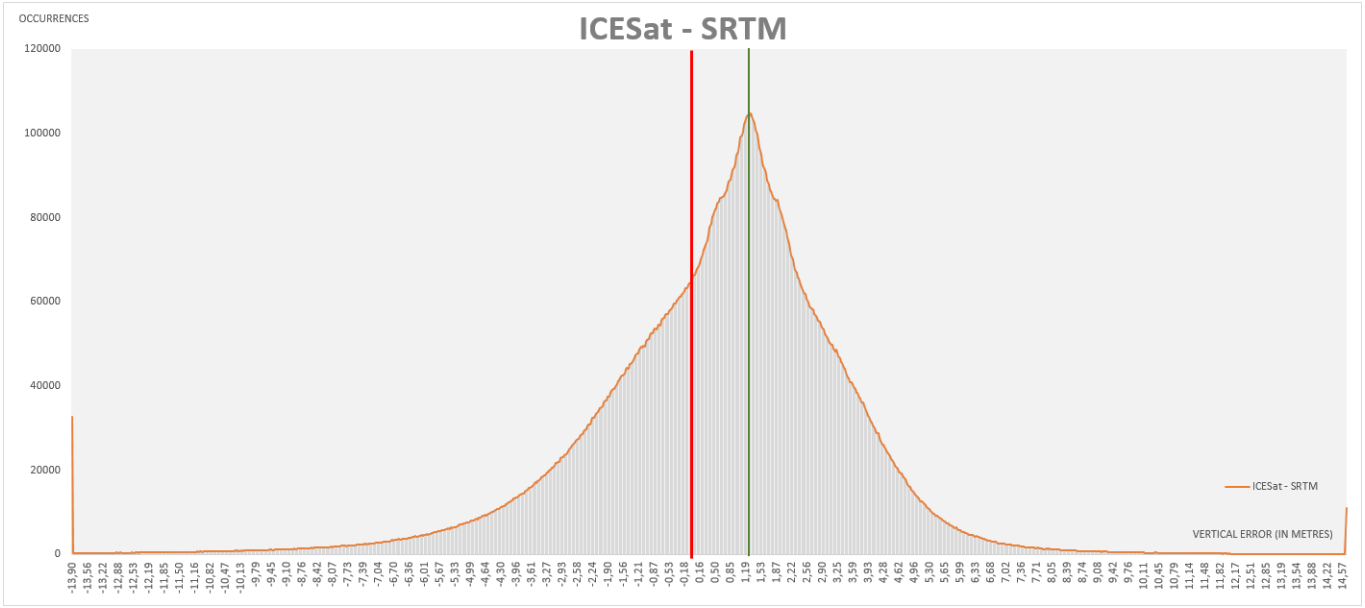
Quantitative assessment

Reference values of **ICESat-1 / GLAS LiDAR** instrument 2003-2010, phase 1 (8 days) and 2 (91 days), central wavelength 532 nm (green) and 1064 nm (near infrared), footprint 70m x 70m, GSD 170m, sampling rate 40 Hz



Assessment of ICESat-1 / GLAS from homologous tracks (phase 1) on flat areas Bonneville Salt Flats





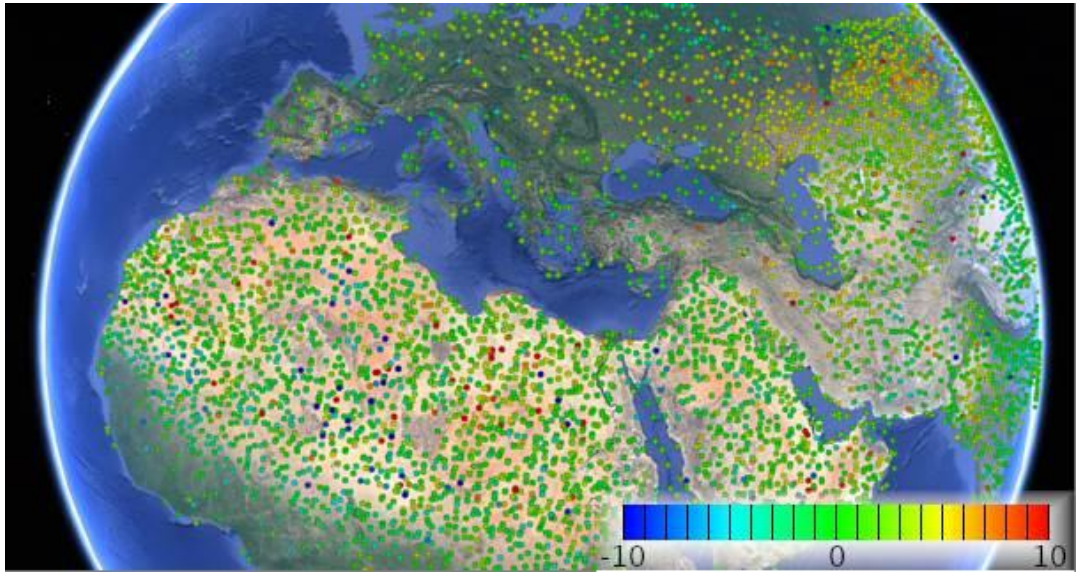
ICESat – SRTM

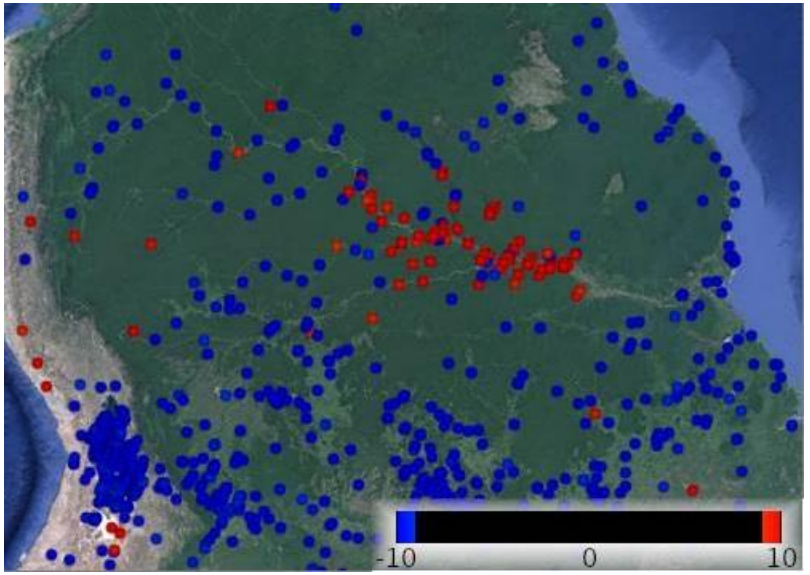
642 GLAH14 products

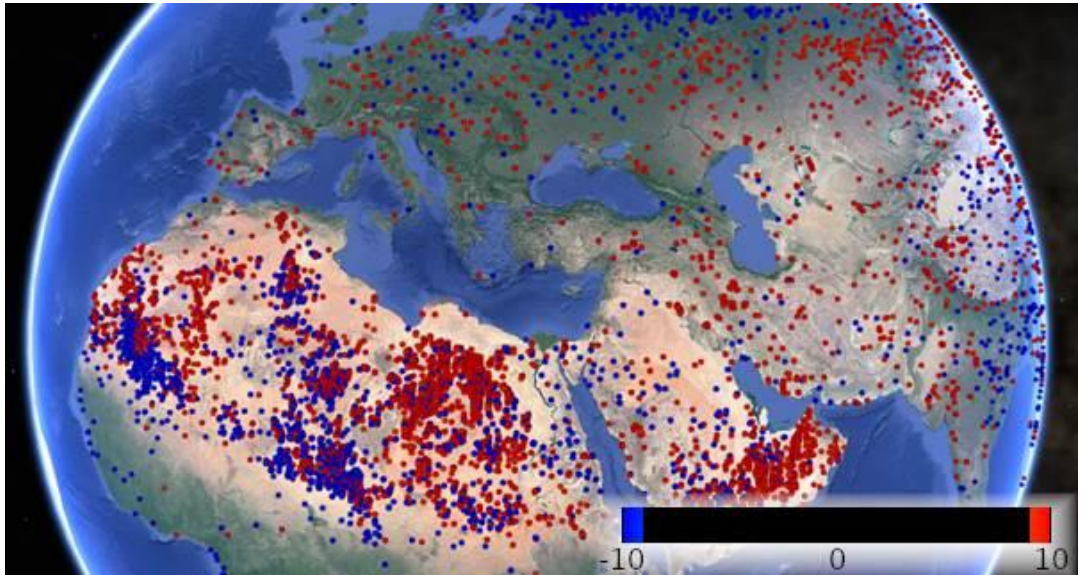
71 090 228 points

Algebraic mean	***0.766 m***
RMSE	***5.042 m***
Standard deviation	***4.984m***

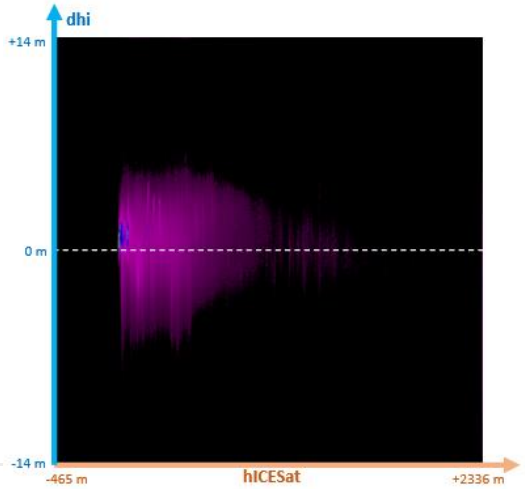
Error location

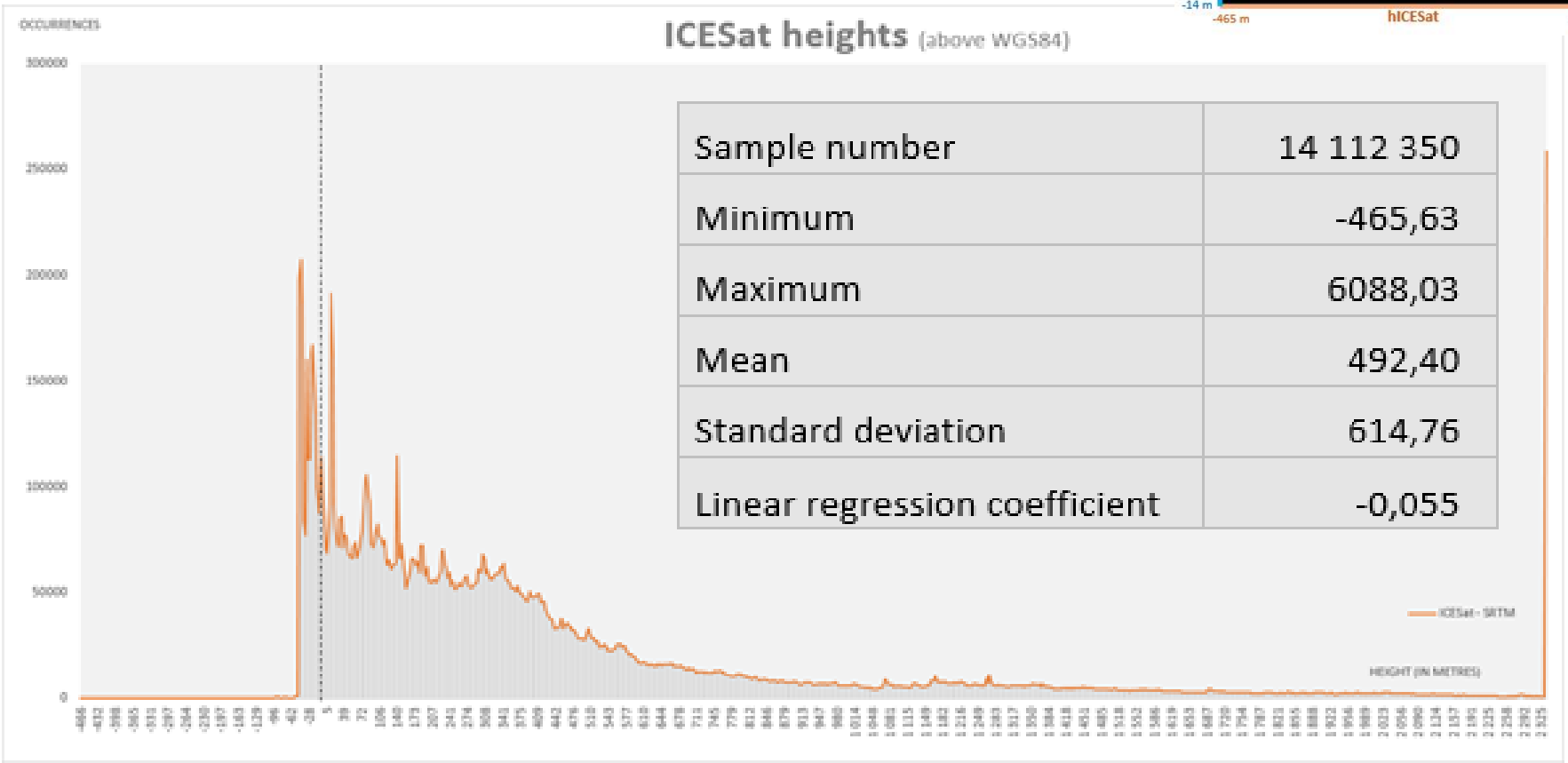






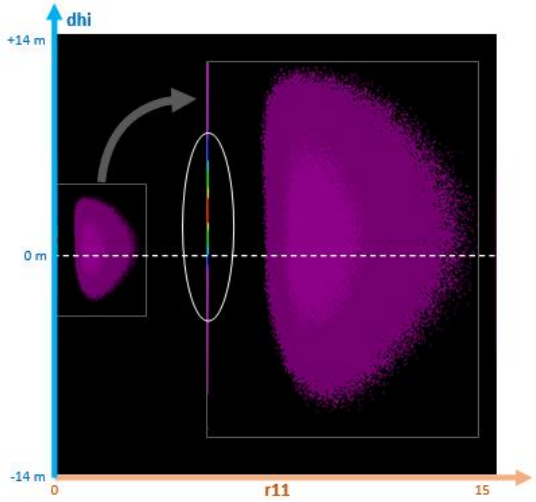
Correlation of errors with ICESat height





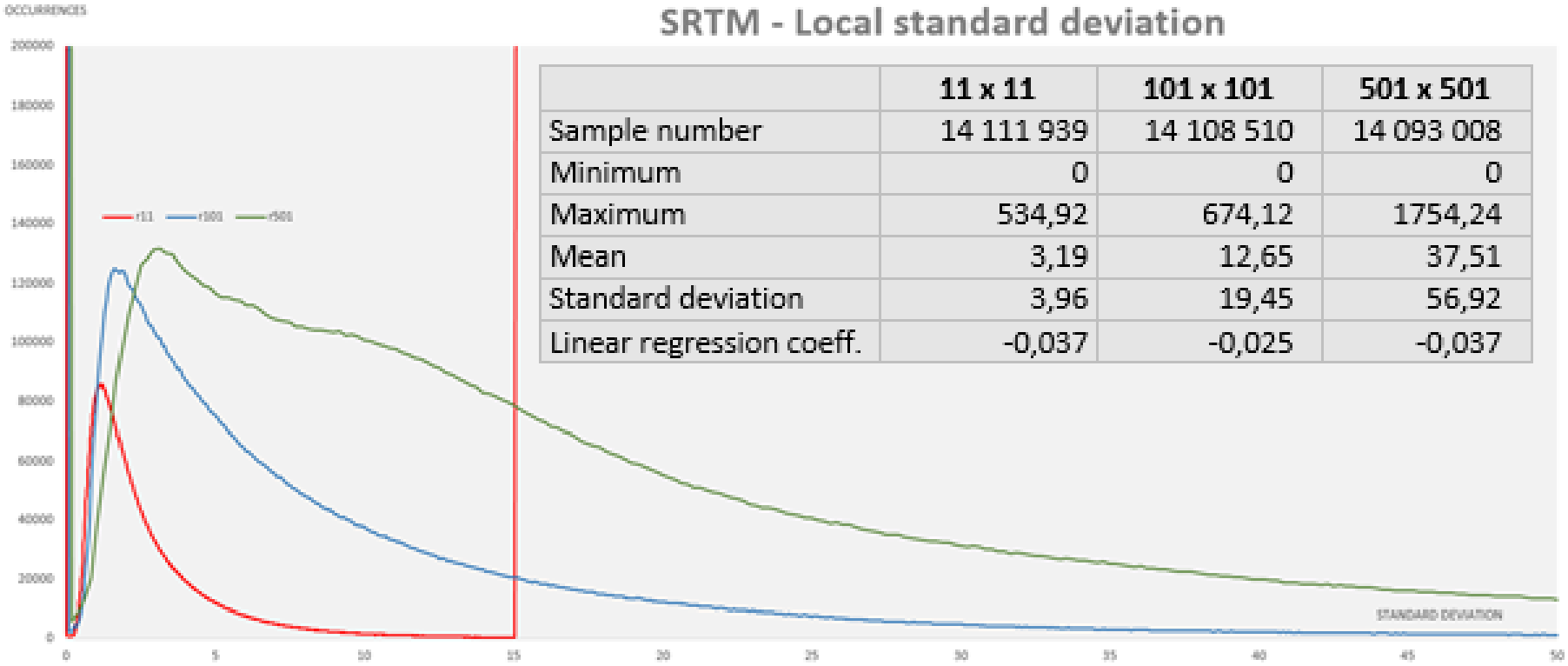
Sample number	14 112 350
Minimum	-465,63
Maximum	6088,03
Mean	492,40
Standard deviation	614,76
Linear regression coefficient	-0,055

Correlation of errors with terrain roughness

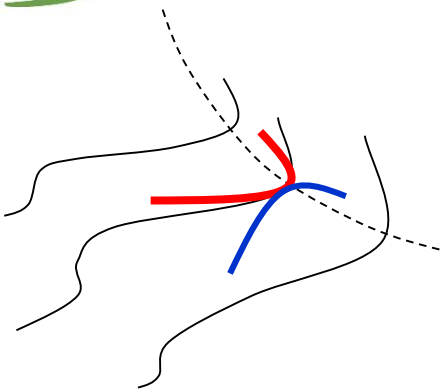


SRTM - Local standard deviation

	11 x 11	101 x 101	501 x 501
Sample number	14 111 939	14 108 510	14 093 008
Minimum	0	0	0
Maximum	534,92	674,12	1754,24
Mean	3,19	12,65	37,51
Standard deviation	3,96	19,45	56,92
Linear regression coeff.	-0,037	-0,025	-0,037



Correlation of errors with curvatures



$$K_h = \frac{dXX \times dY^2 - 2 \times dXY \times dX \times dY + dYY \times dX^2}{p \times \sqrt{p}}$$

$$K_v = \frac{dXX \times dX^2 - 2 \times dXY \times dX \times dY + dYY \times dY^2}{p \times q \times \sqrt{q}}$$

$$K_t = \frac{dXX \times dY^2 - 2 \times dXY \times dX \times dY + dYY \times dX^2}{p \times \sqrt{q}}$$

$$dX = \frac{-\left[h_{i+1,j} - h_{i-1,j}\right]}{2 \times GSD_X}$$

$$dY = \frac{-\left[h_{i,j+1} - h_{i,j-1}\right]}{2 \times GSD_Y}$$

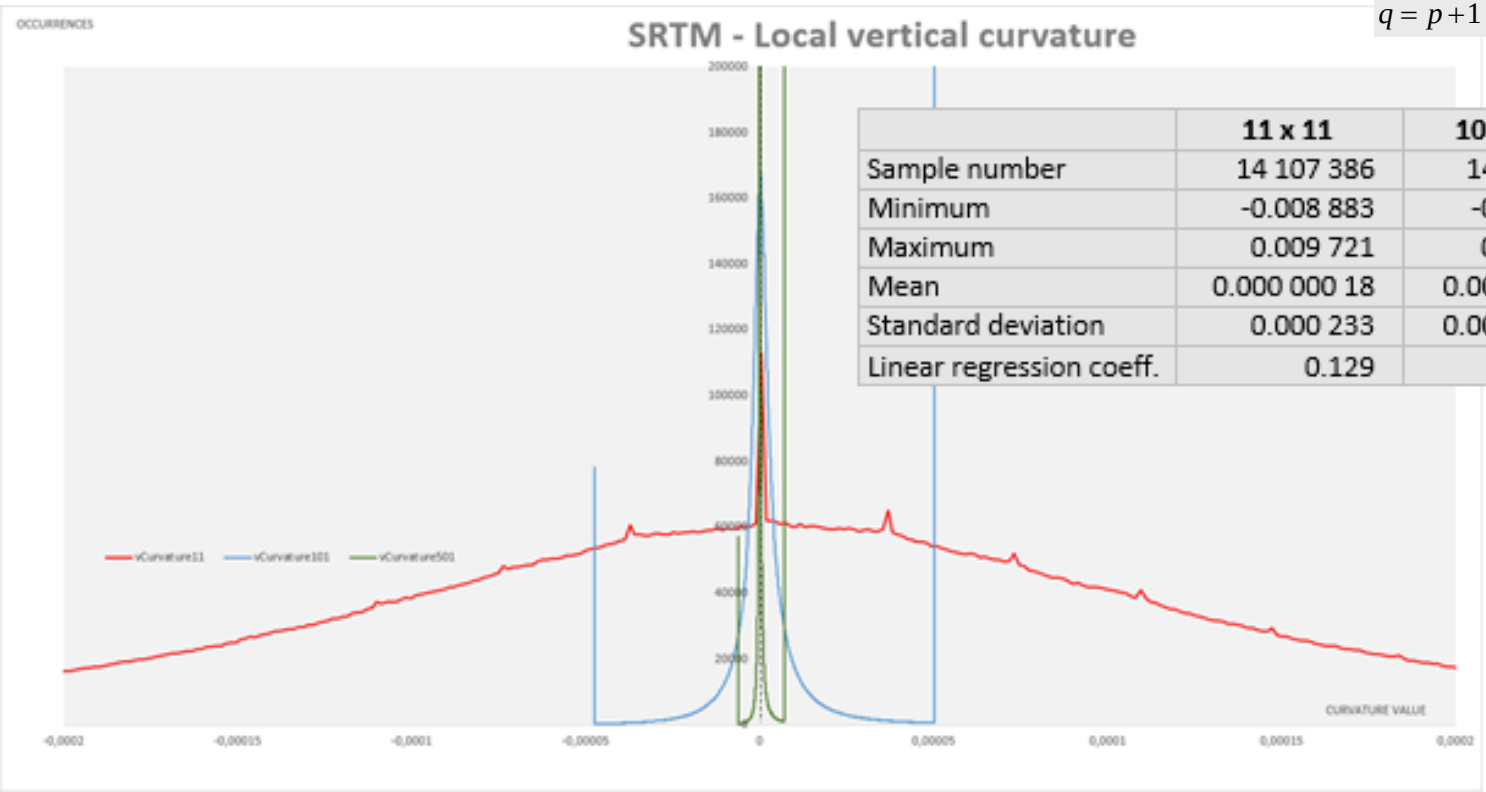
$$dXX = \frac{h_{i+1,j} - 2 \times h_{i,j} + h_{i-1,j}}{GSD_X^2}$$

$$dYY = \frac{h_{i,j+1} - 2 \times h_{i,j} + h_{i,j-1}}{GSD_Y^2}$$

$$dXY = \frac{\left[h_{i+1,j+1} - h_{i+1,j-1}\right] - \left[h_{i-1,j+1} - h_{i-1,j-1}\right]}{4 \times GSD_X \times GSD_Y}$$

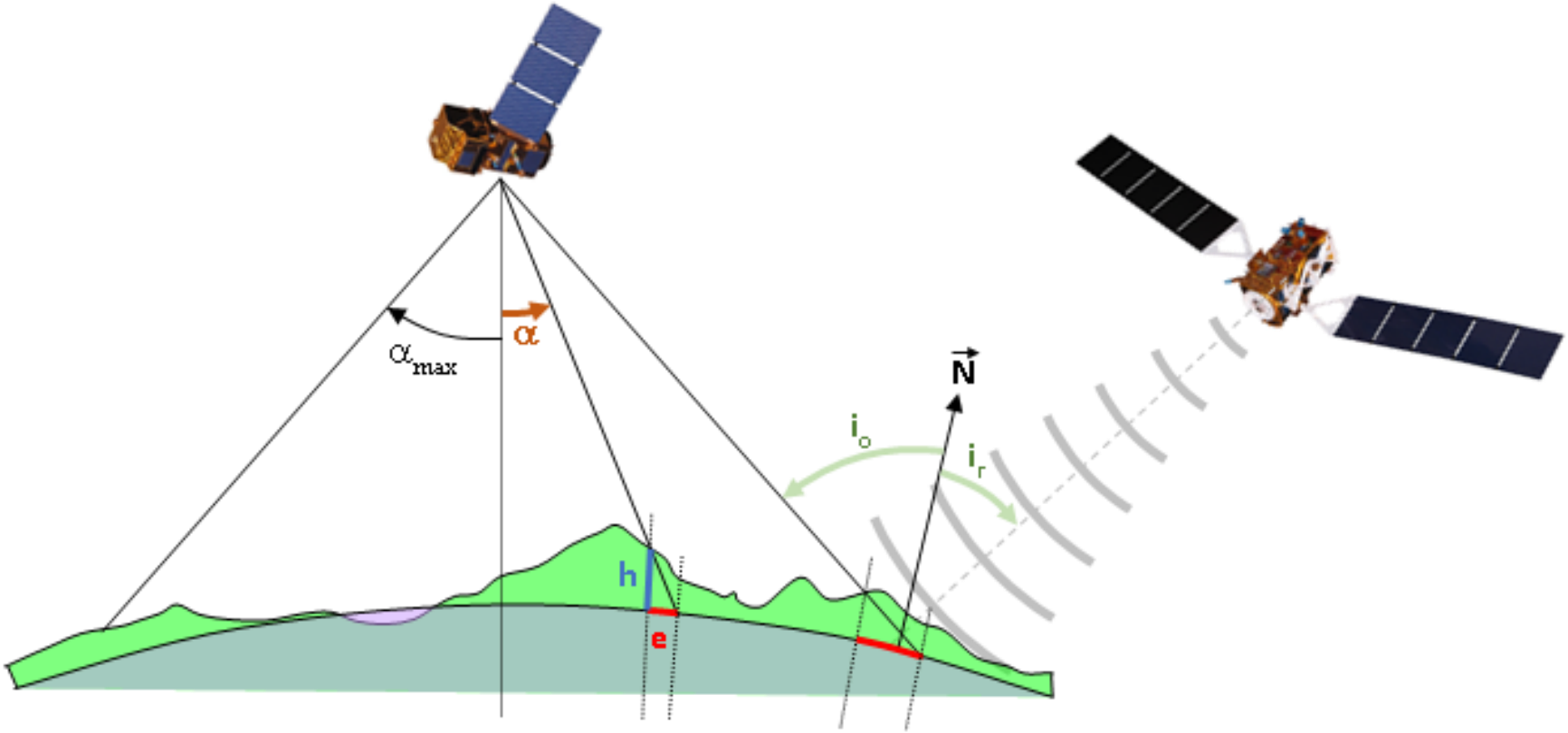
$$p = dX^2 + dY^2$$

$$q = p + 1$$



	11 x 11	101 x 101	501 x 501
Sample number	14 107 386	14 100 067	14 081 352
Minimum	-0.008 883	-0.000 809	-0.000 006
Maximum	0.009 721	0.000 799	0.000 006
Mean	0.000 000 18	0.000 000 13	0.000 000 03
Standard deviation	0.000 233	0.000 001 63	0.000 000 21
Linear regression coeff.	0.129	0.007	-0,025

Orthorectification for optical and radar instruments



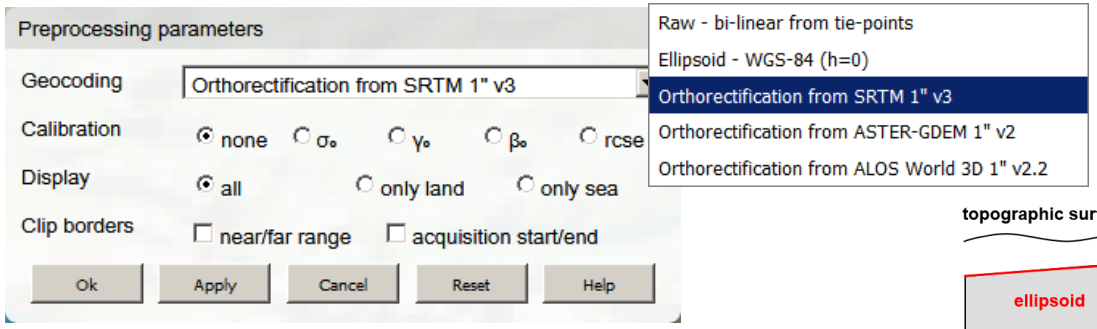
parallax: $e = h \times \tan(i_0) = h \times \tan(\pi/2 - i_r)$

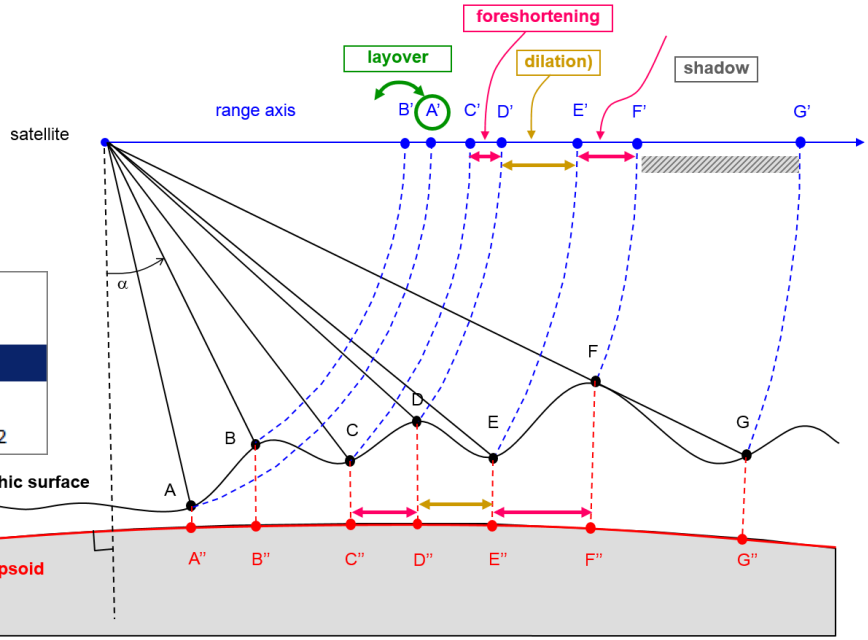
$e \approx h \times \tan(\alpha)$

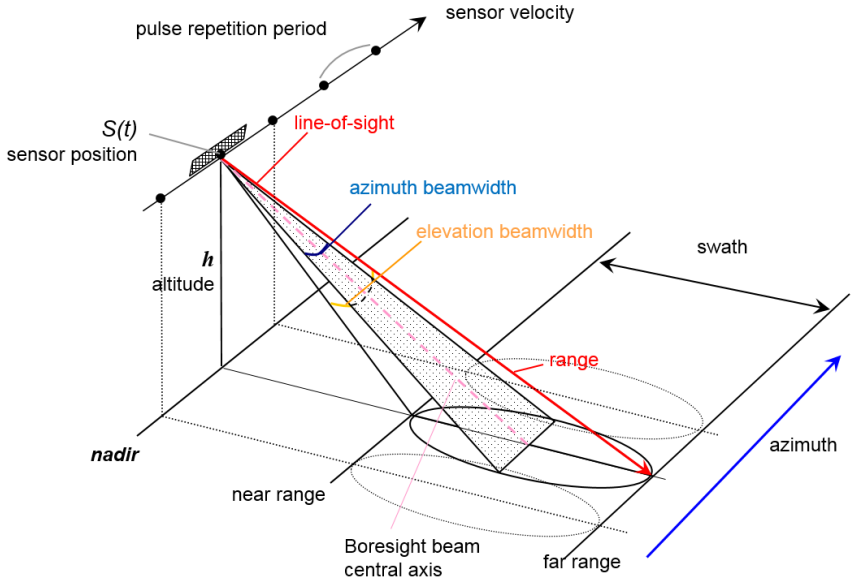
Radar orthorectification

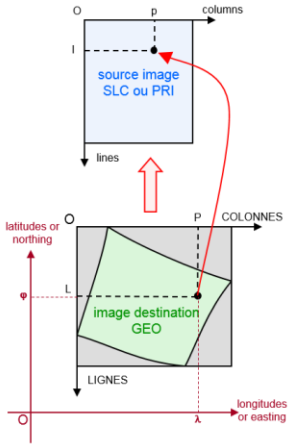
Orthorectification on-the-fly choosing:

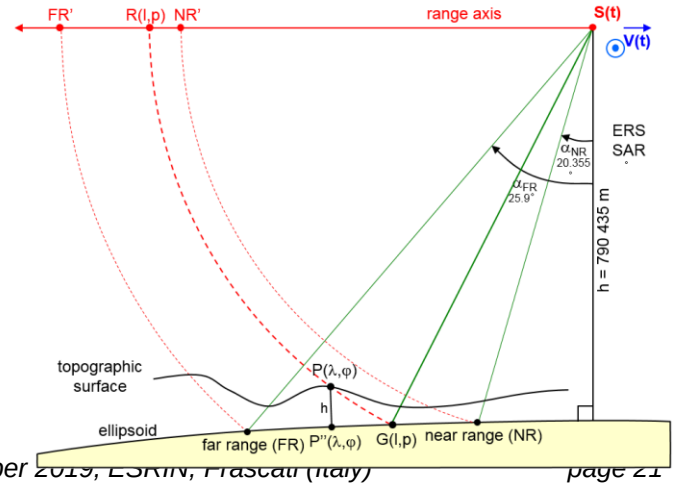
- DEM (SRTM, ASTER-GDEM, AW3D)
- Geoid model (EGM96, EGM2008)





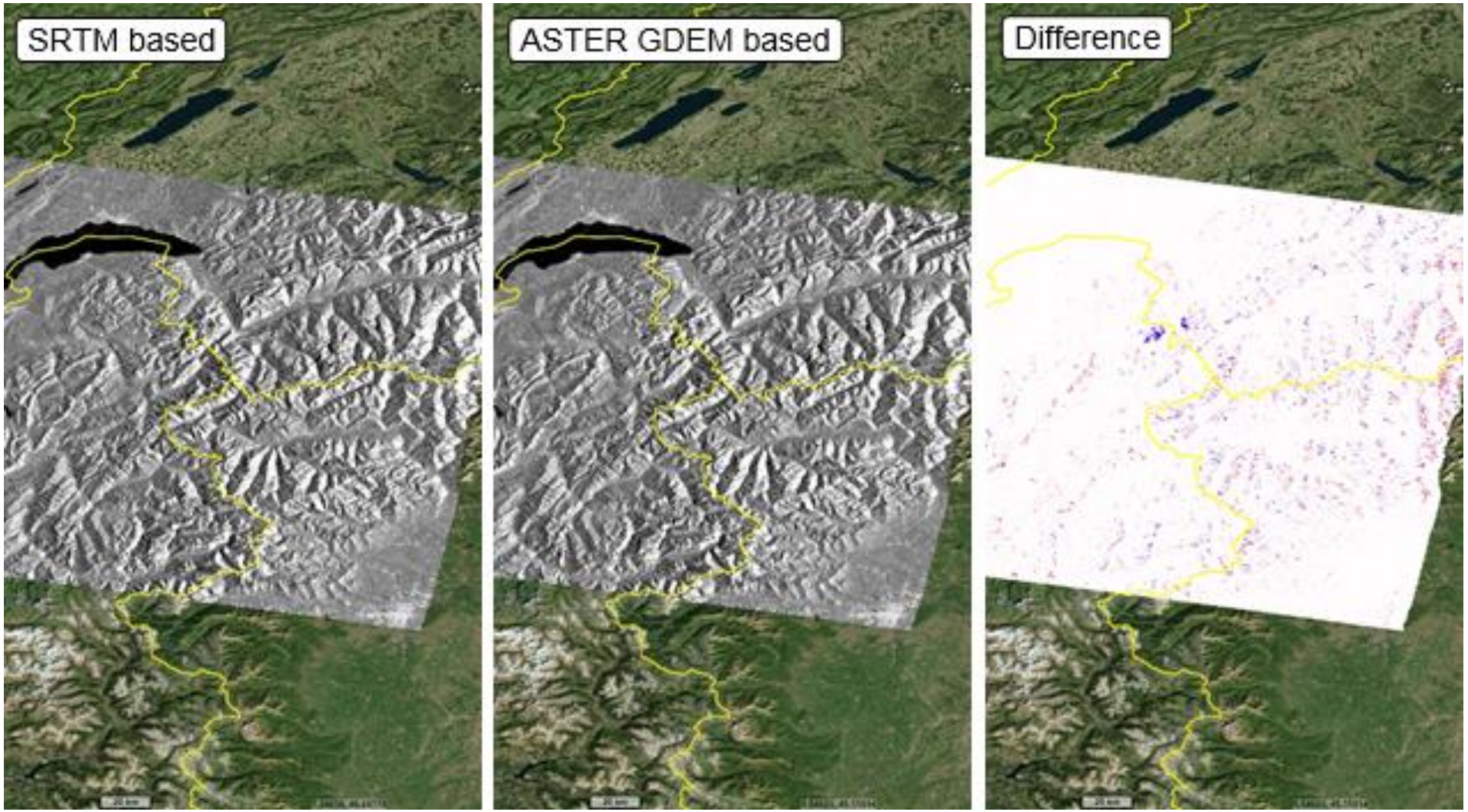






Radar result 1

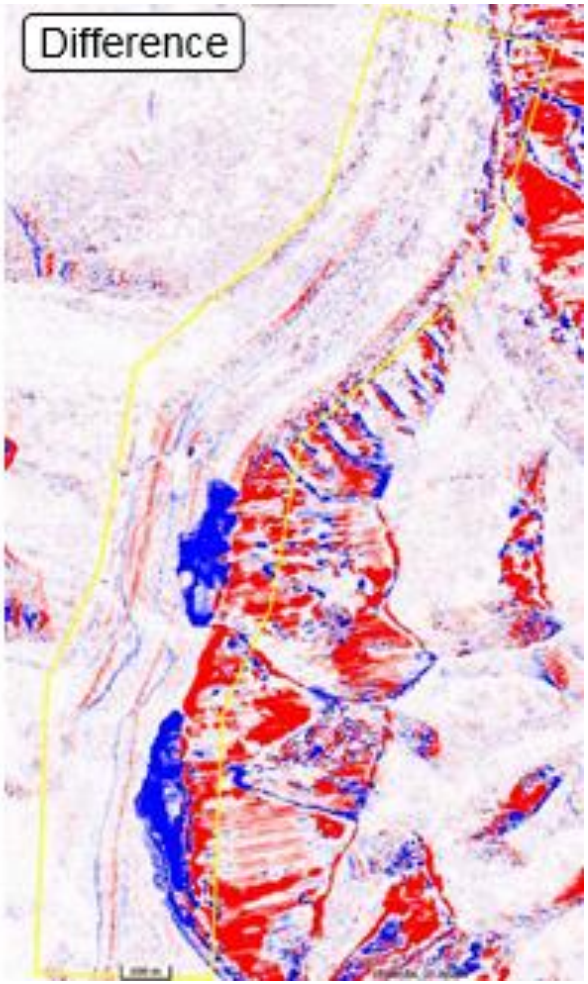
- Alps (S1B 2019-09-13 05:42:58) - hyperlook 2D_view



Radar result 2

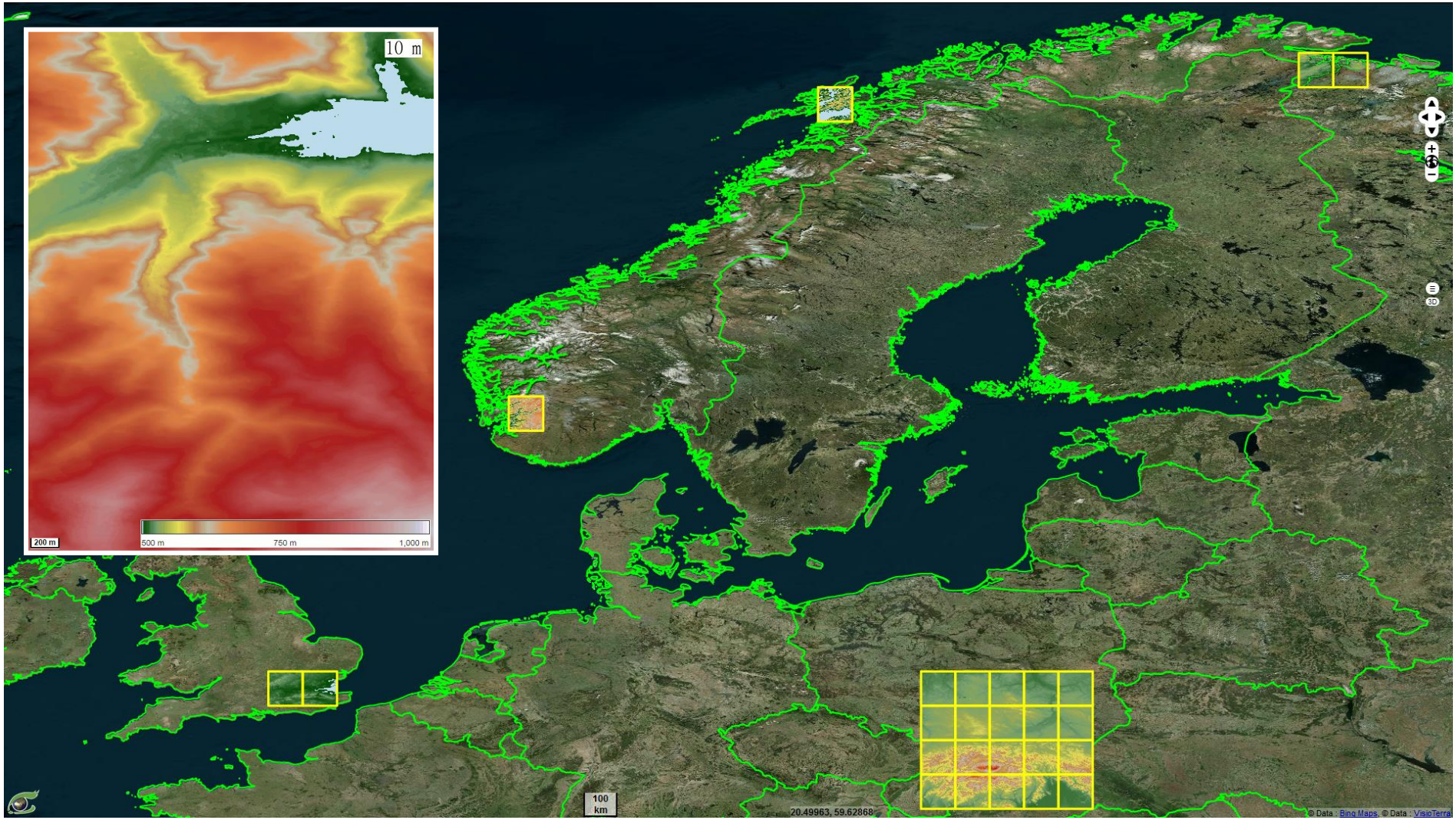
Document **Impacts of DEM on orthorectification** HYP-086-VtWeb

Himalaya (S1A 2019-09-13 12:39:36) - hyperlook 2D_animation



Copernicus DEMs

6+2+20 tiles – hyperlook 2D_view animation_10-20-30m



Merci de votre attention

Thank you for your attention

Questions ?

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www.visioterra.fr