Monitoring rivers and lakes with a Ka-band Interferometric Radar Altimeter: an assessment of the performances

Vivien ENJOLRAS
Thales Alenia Space

Ernesto RODRIGUEZ
NASA Jet Propulsion Laboratory

Agenda

Recall of the WatER (Water Elevation Recovery) / Hydrosphere Mapper / SWOT (Surface Water Topography) mission

- Scientific objectives over inland waters
- Main instrument and mission parameters

Implementation of a Virtual Mission to validate the instrument performances

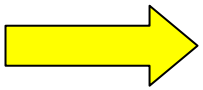
- Data simulator
- First Ground Processing
- Three case studies

Main results of the Virtual Mission

Conclusions and perspectives

A Need for Global, Satellite-based Observations of Terrestrial Surface Waters

- River discharge, lake and wetland storage of water are critical terms in the surface water balance, but are poorly observed
- Two ways of observation, not appropriate:
  - Gauges
  - Profiling altimetry

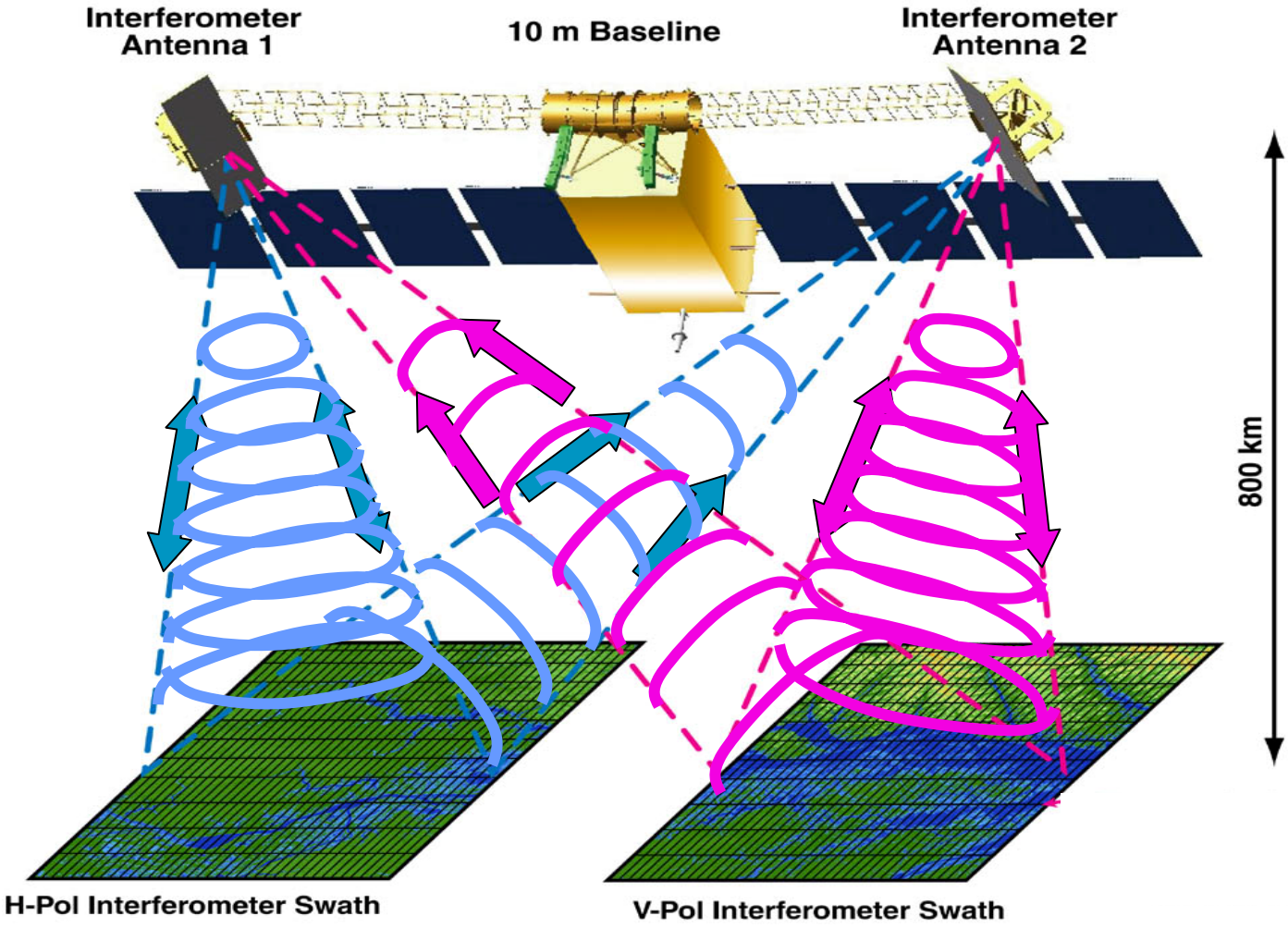


Need for a global dataset of discharge and storage changes, concomitant with other missions (Precipitation: TRMM; Land: Landsat, Modis; Soil Moisture: SMOS)

- Proposition of the WatER mission, wide-swath interferometric imaging radar altimeter
  - Heritage from SRTM, WSOA
  - More complex instrument to access more complex area

Objectives: 10 cm, 10 µrad

Large Swath Concept

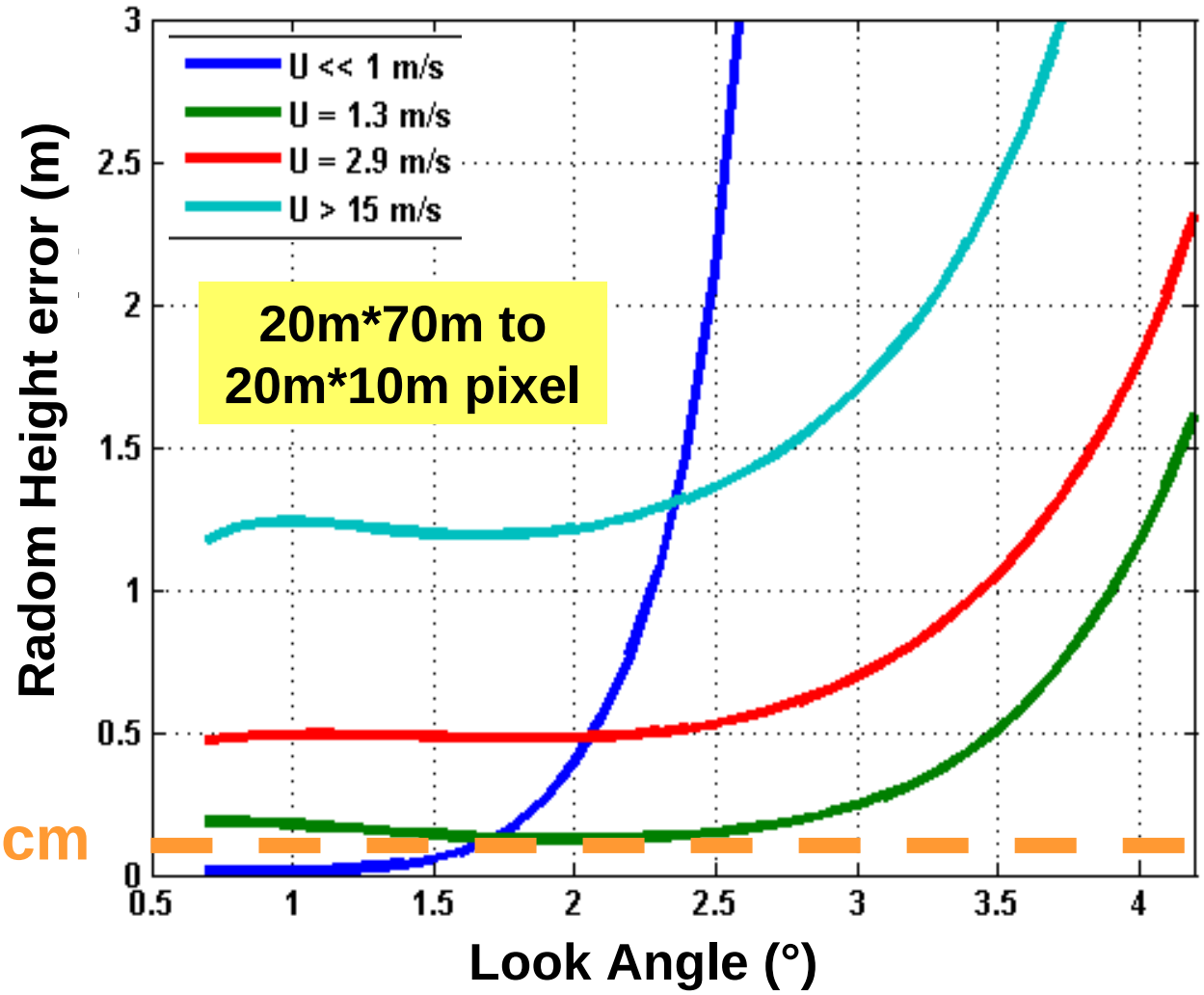


Going to High Resolution

	Ocean Wide Swath	HR Wide Swath
Altitude (km)	815/950	824/950
Inclination (°)	98.67/80	98.70/80
Frequency (GHz)	13,5	36,5
Bandwidth (MHz)	20	200
Peak Power (W)	120	1500
PRF per antenna (Hz)	1000	4400
Antenna Length (m)	2.2	3.8
Mast length (m)	10	10
Range resolution (cm)	750	75
Ground resolution (m)	700-100	70-10
Azimuth single-look resolution (m)	13000	5
Swath Width (km)	85	50
Datarate (Mbit/s)	0.01-0.1	310

WatER instrumental (random) error budget

4 Looks Processing



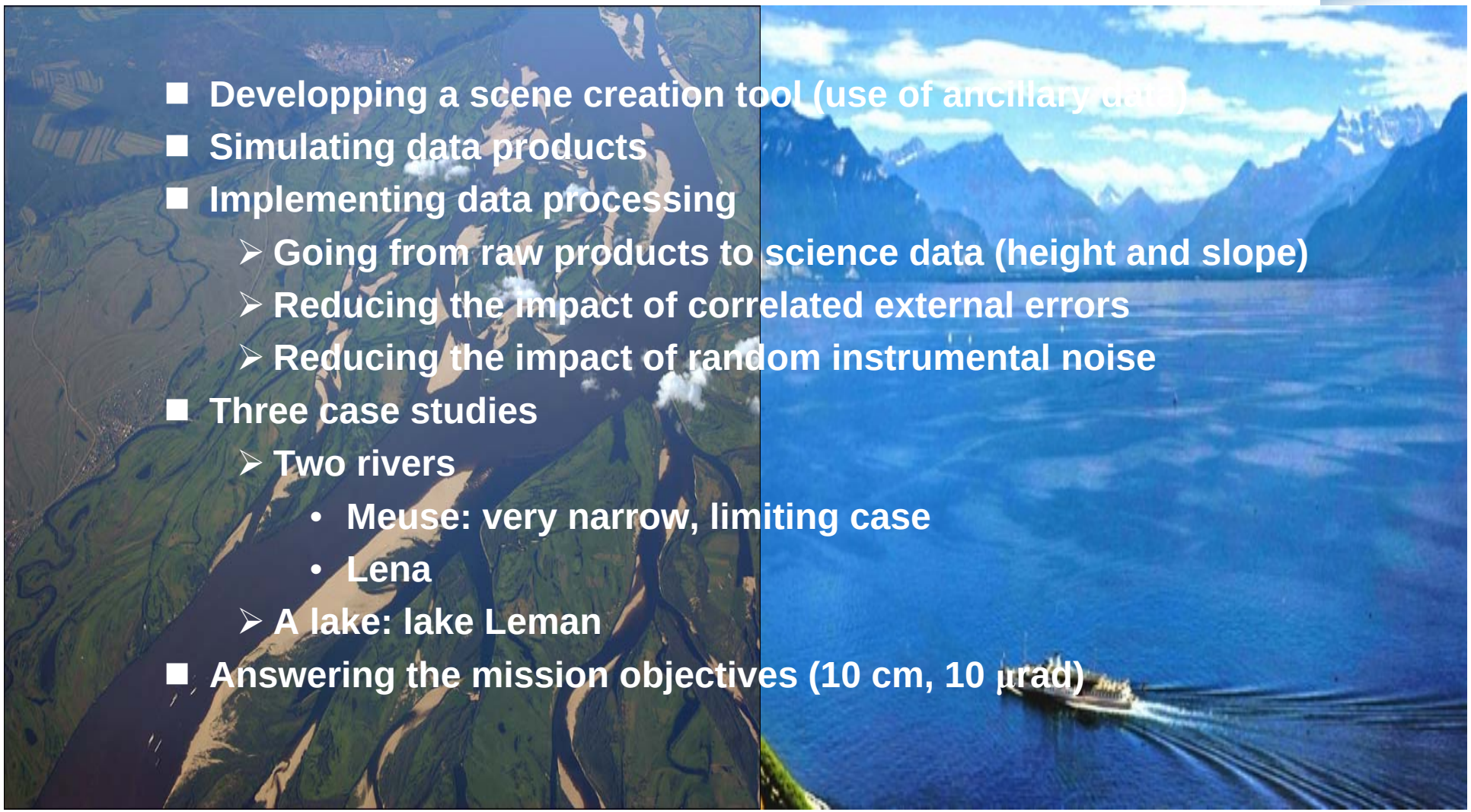
10 cm

Correlated errors (a few meters…)

ROLL

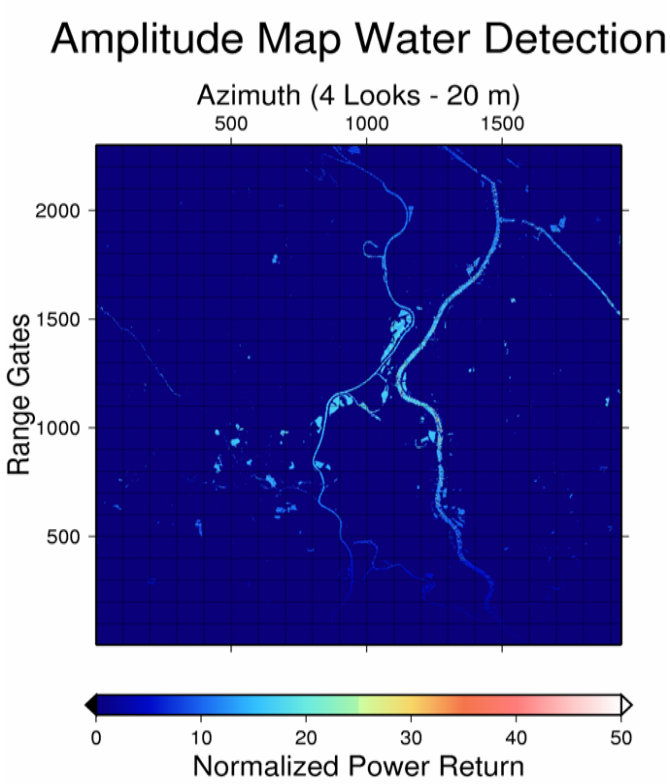
BASELINE

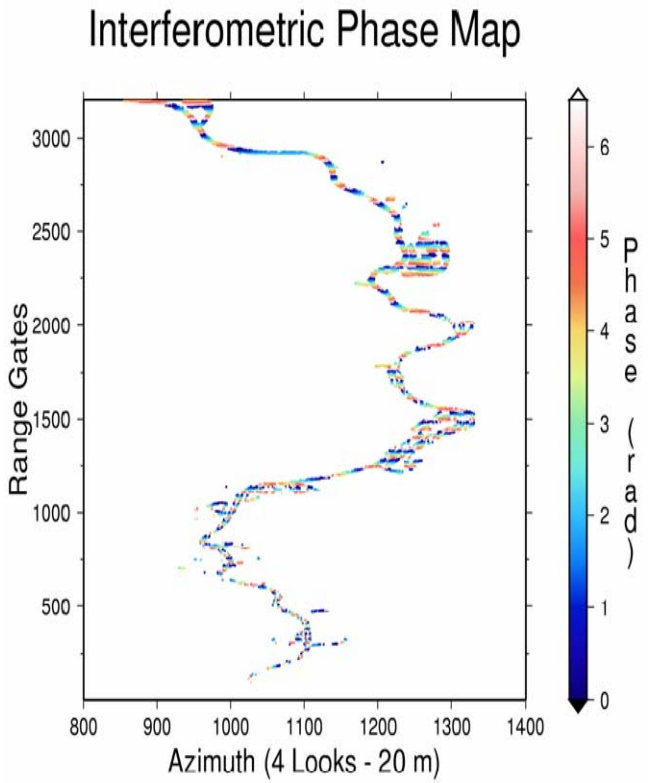
TROPOSPHERE

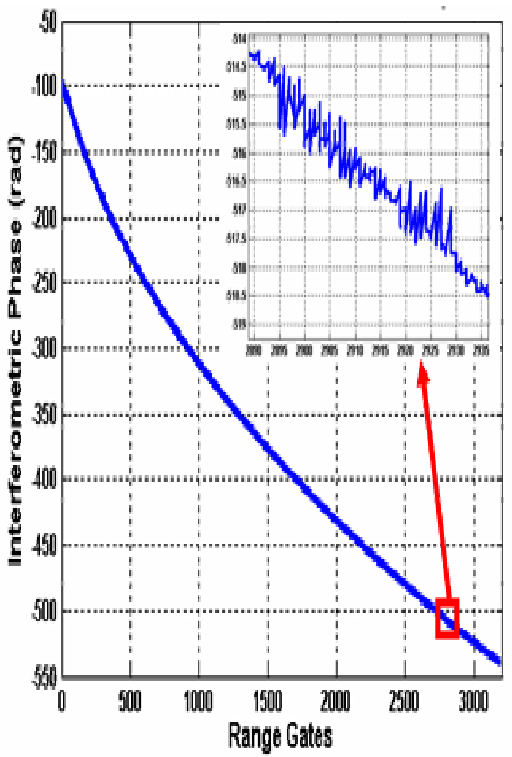


- Developping a scene creation tool (use of ancillary data)
- Simulating data products
- Implementing data processing
  - Going from raw products to science data (height and slope)
  - Reducing the impact of correlated external errors
  - Reducing the impact of random instrumental noise
- Three case studies
  - Two rivers
    - Meuse: very narrow, limiting case
    - Lena
  - A lake: lake Leman
- Answering the mission objectives (10 cm, 10 µrad)

Going from raw data to science data







Amplitude threshold

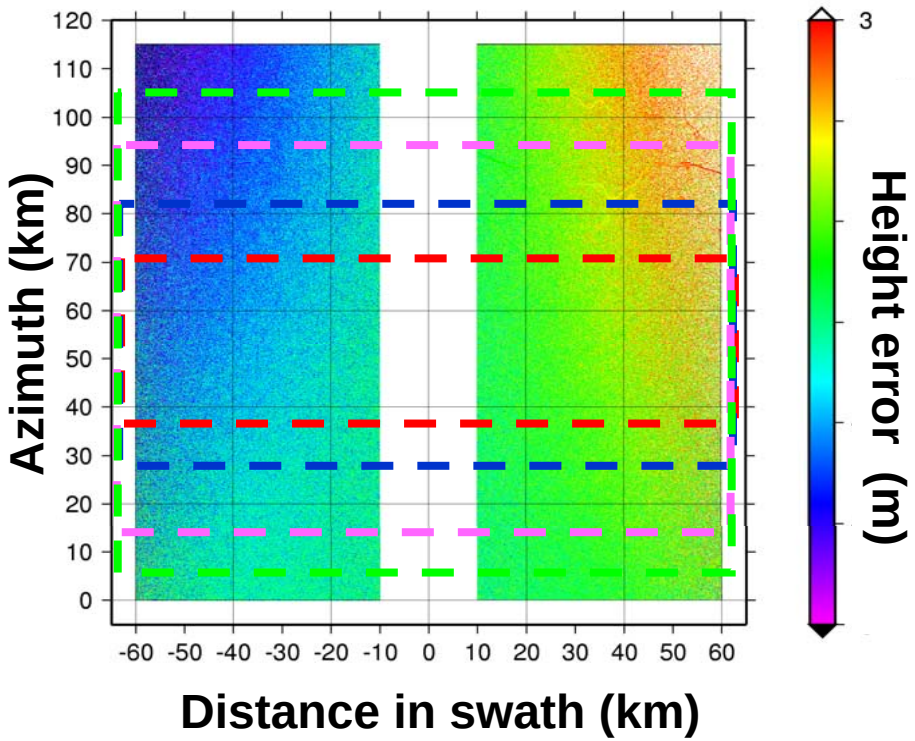
Localization of water extent

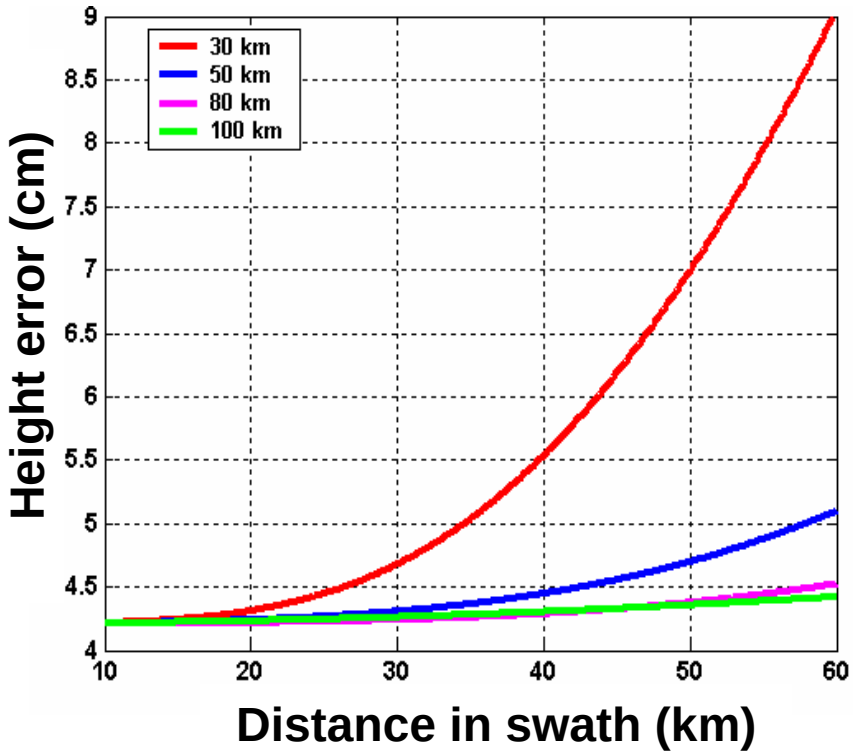
Interferometric phase selection

From interferometric phase to topography (phase unwrapping)

Correlated errors extraction

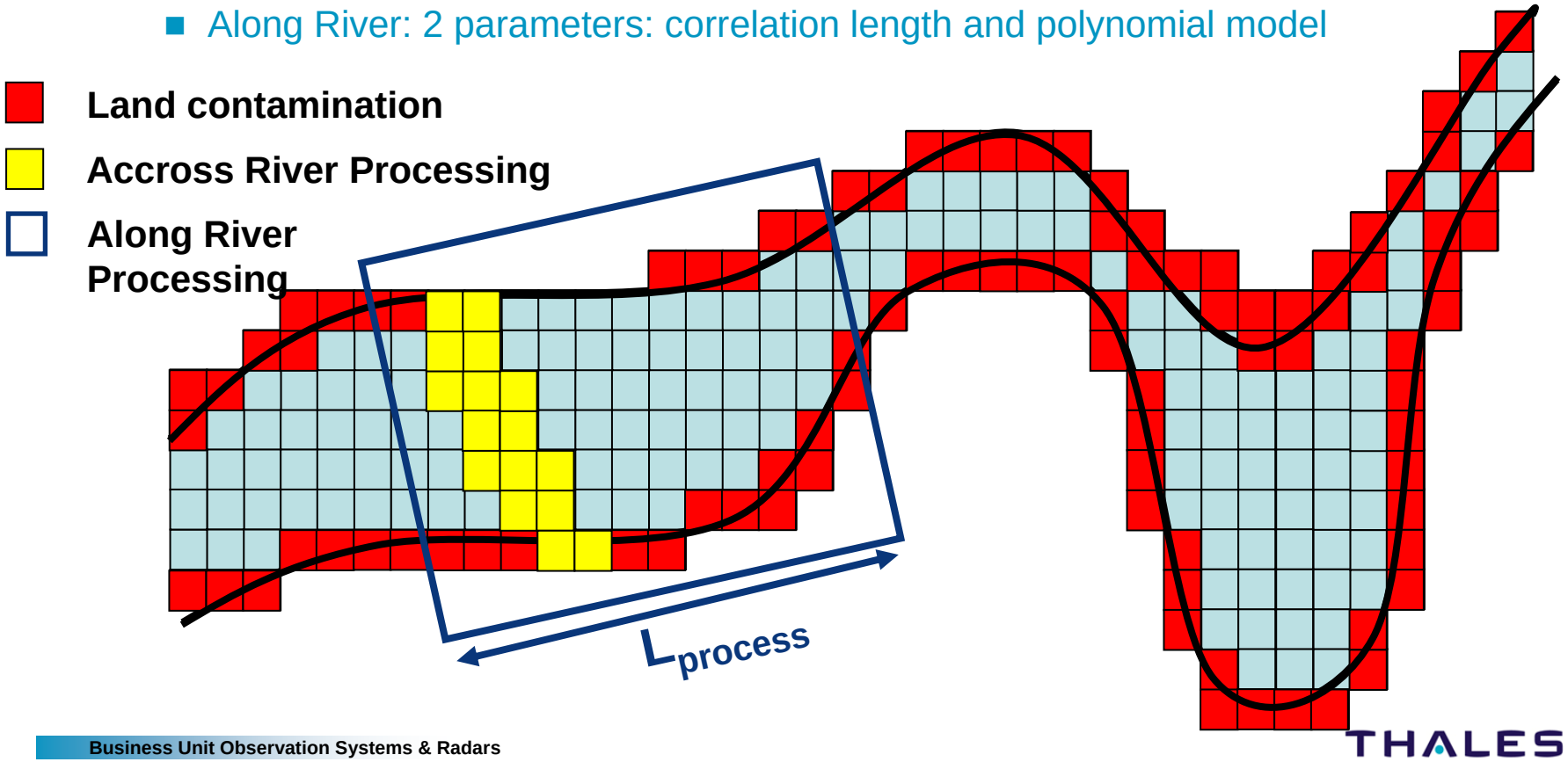
- Low frequency signatures are major contributors
- Objective : extract them from the products
- Idea : Use a stable topographic reference as a way of comparison (SRTM)
- Interferometric phase maps difference and smoothing over 1 by 1 km (random errors from instrument and DEM erased through the process)



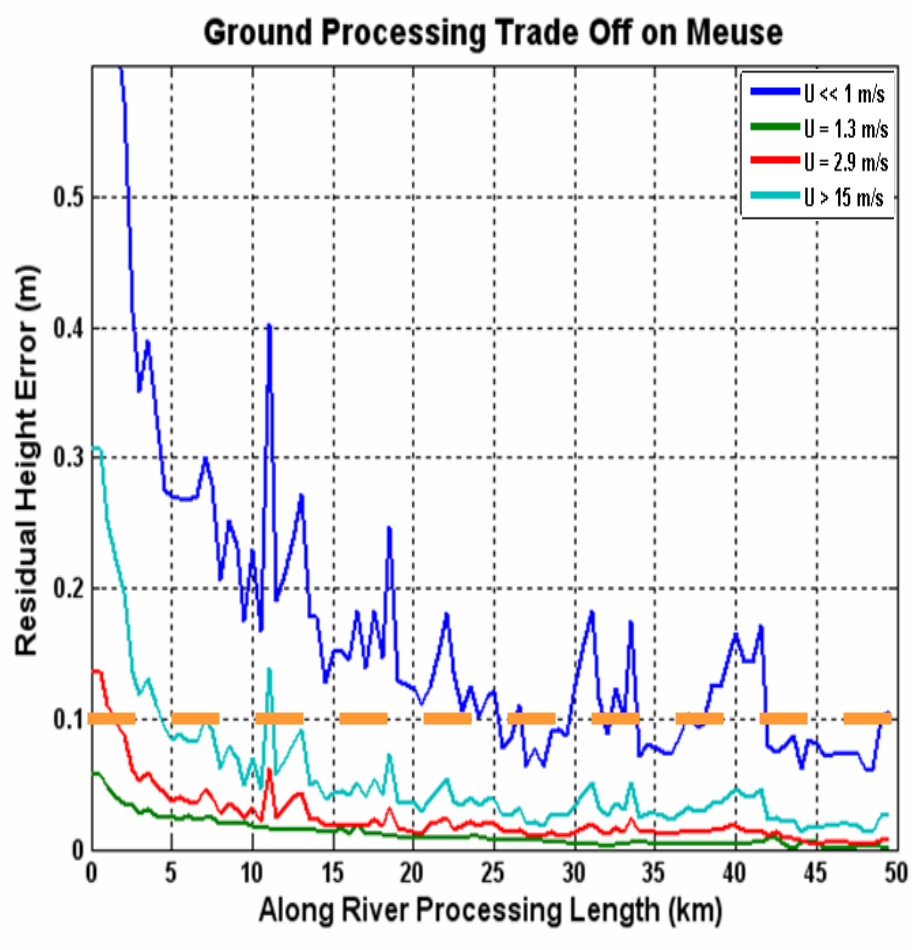


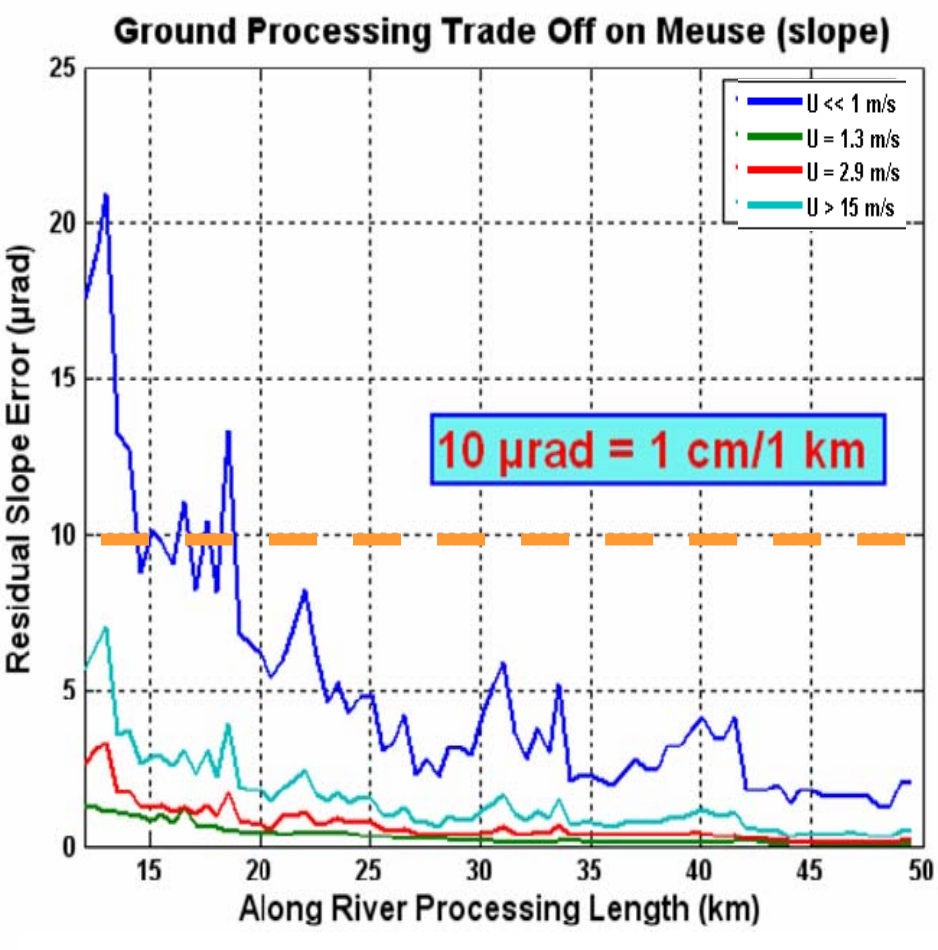
Random instrumental error reduction

- A priori known pixels contaminated by land not used in the selection step
- Two independent processes applied over height profiles
  - Accross River: same curvilinear abscissa = same elevation
  - Along River: 2 parameters: correlation length and polynomial model

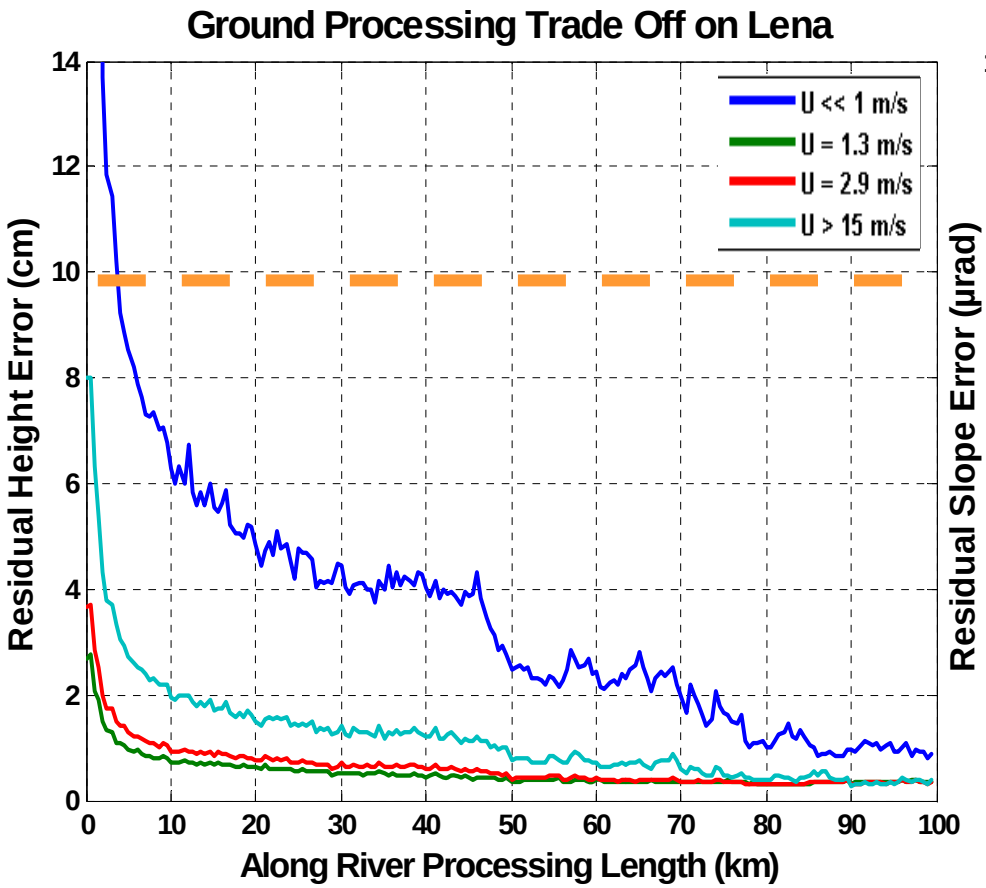


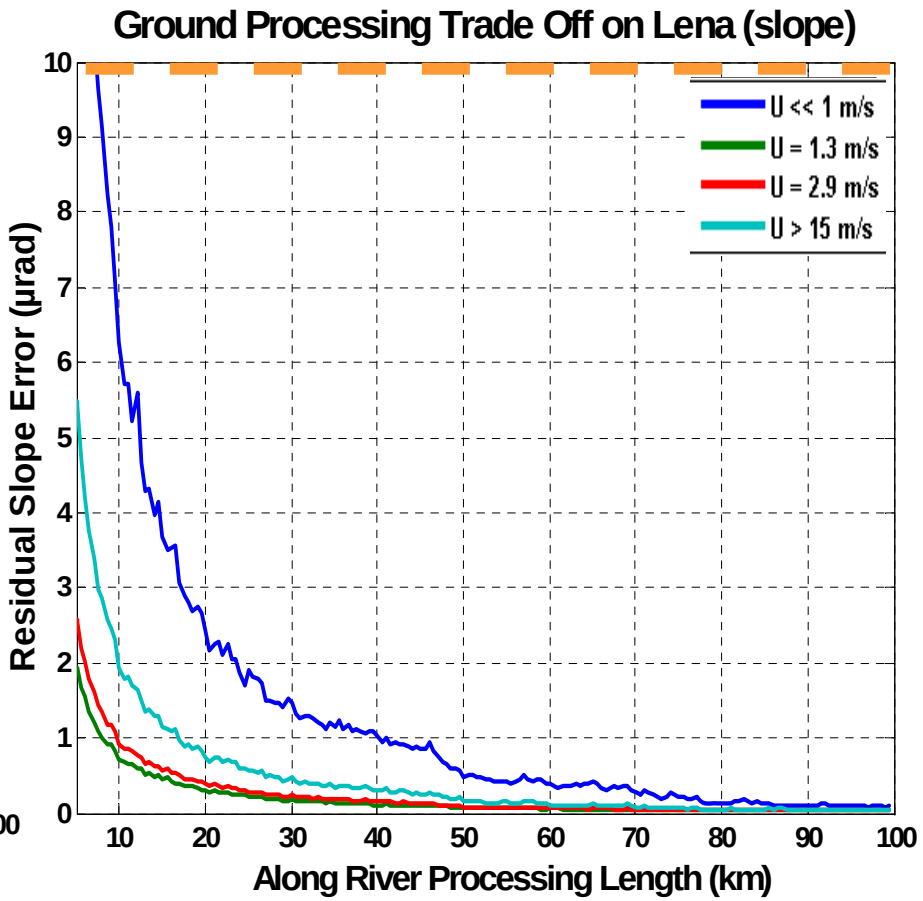
Results on Meuse



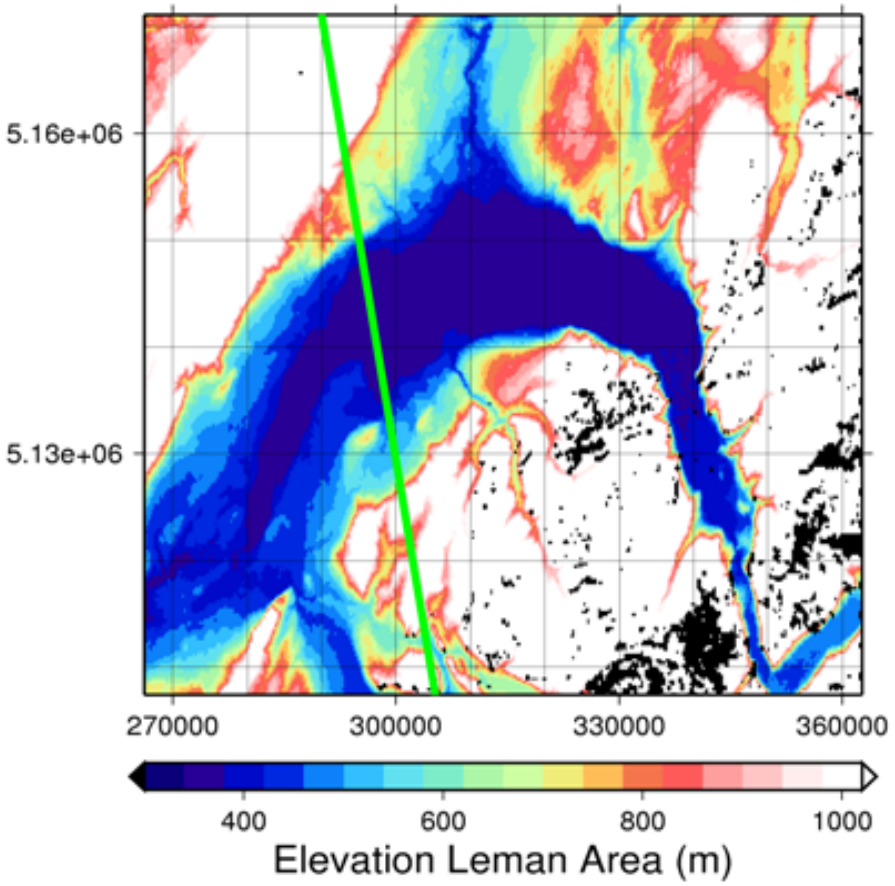


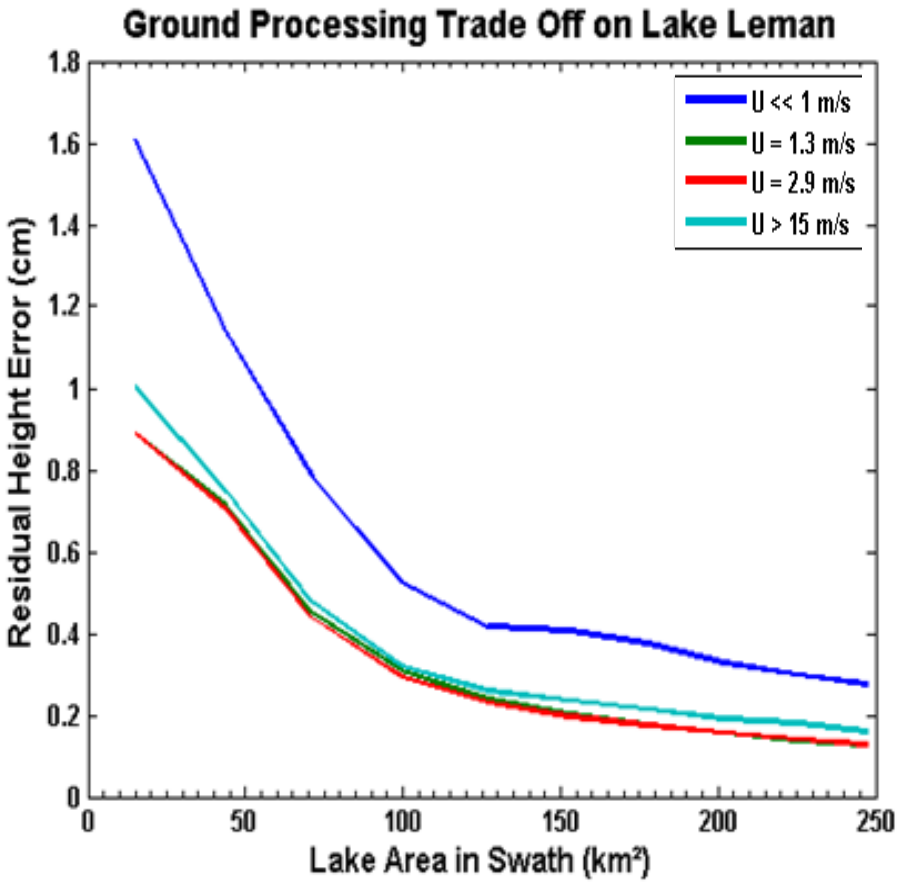
Results on Lena





Results on lake Leman





Conclusions

A Virtual Mission has been developed

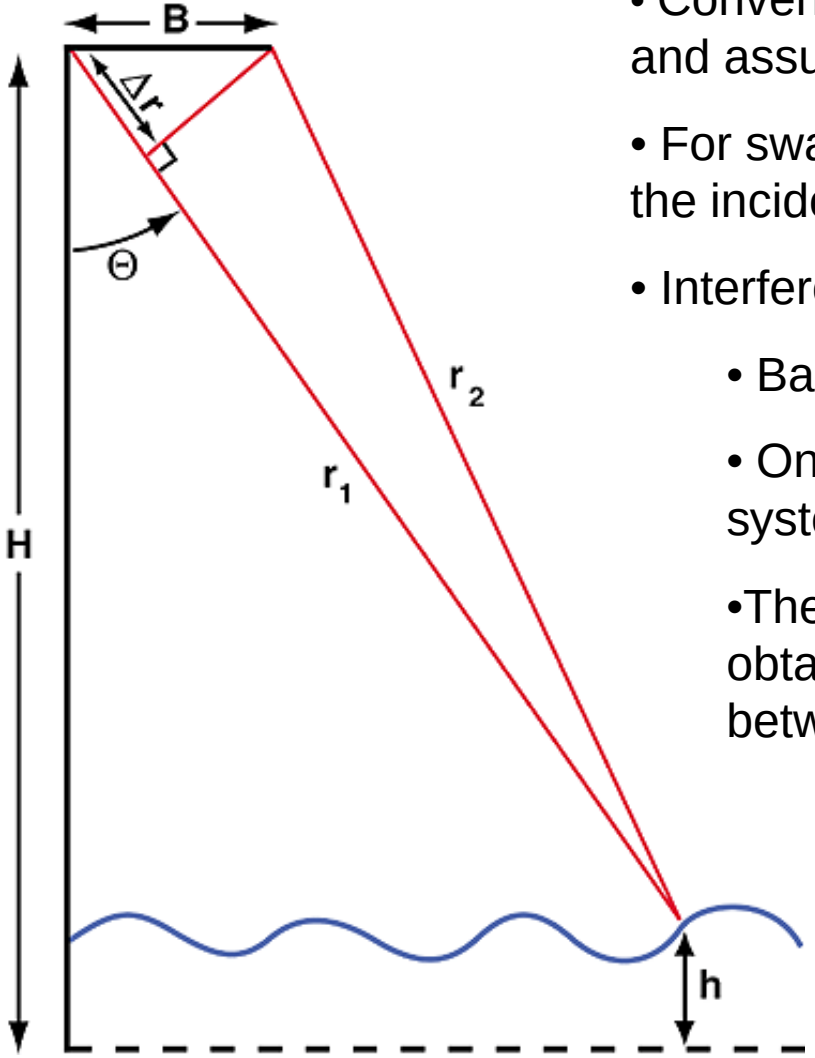
- River Meuse especially is very constraining!
- Scientific objectives are met

A publication is currently reviewed in IEEE TGRS:

- Enjolras, V. ; Rodriguez, E. An Assesment of the WatER Mission Accuracy over Eurasian Rivers. IEEE Transaction on Geoscience and Remote Sensing, 2007.

A perspective is the determination of the quality of the end products from that of the height and slope profiles obtained

Interferometric Measurement Concept



- Conventional altimetry measures a single range and assumes the return is from the nadir point
- For swath coverage, additional information about the incidence angle is required to geolocate
- Interferometry is basically triangulation
  - Baseline B forms base (mechanically stable)
  - One side, the range, is determined by the system timing accuracy
  - The difference between two sides (Δr) is obtained from the phase difference (Φ) between the two radar channels.

$$\Phi = 2\pi \Delta r/\lambda = 2\pi B \sin \Theta/\lambda$$

$$h = H - r \cos \Theta$$

No waveform fitting is required for interferometry. The phase is unique for each resolved pixel

Instrumental Error Budget over oceans