CENTRE NATIONAL D'ÉTUDES SPATIALES

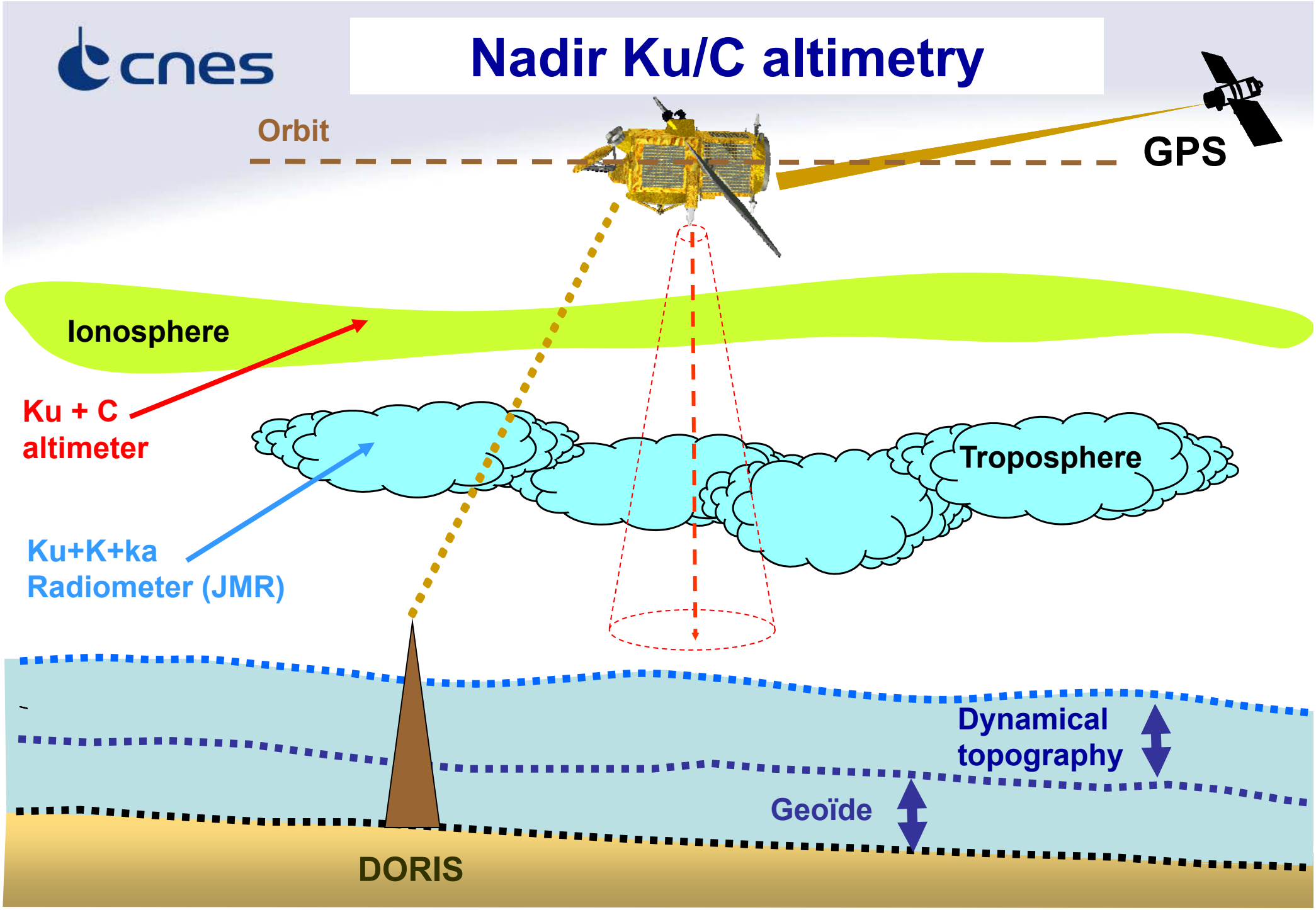
Upcoming altimeter measurements : explaining Ka-band, SAR mode, interferometric SAR

Jean-Claude Souyris CNES, Service Altimétrie & Radar

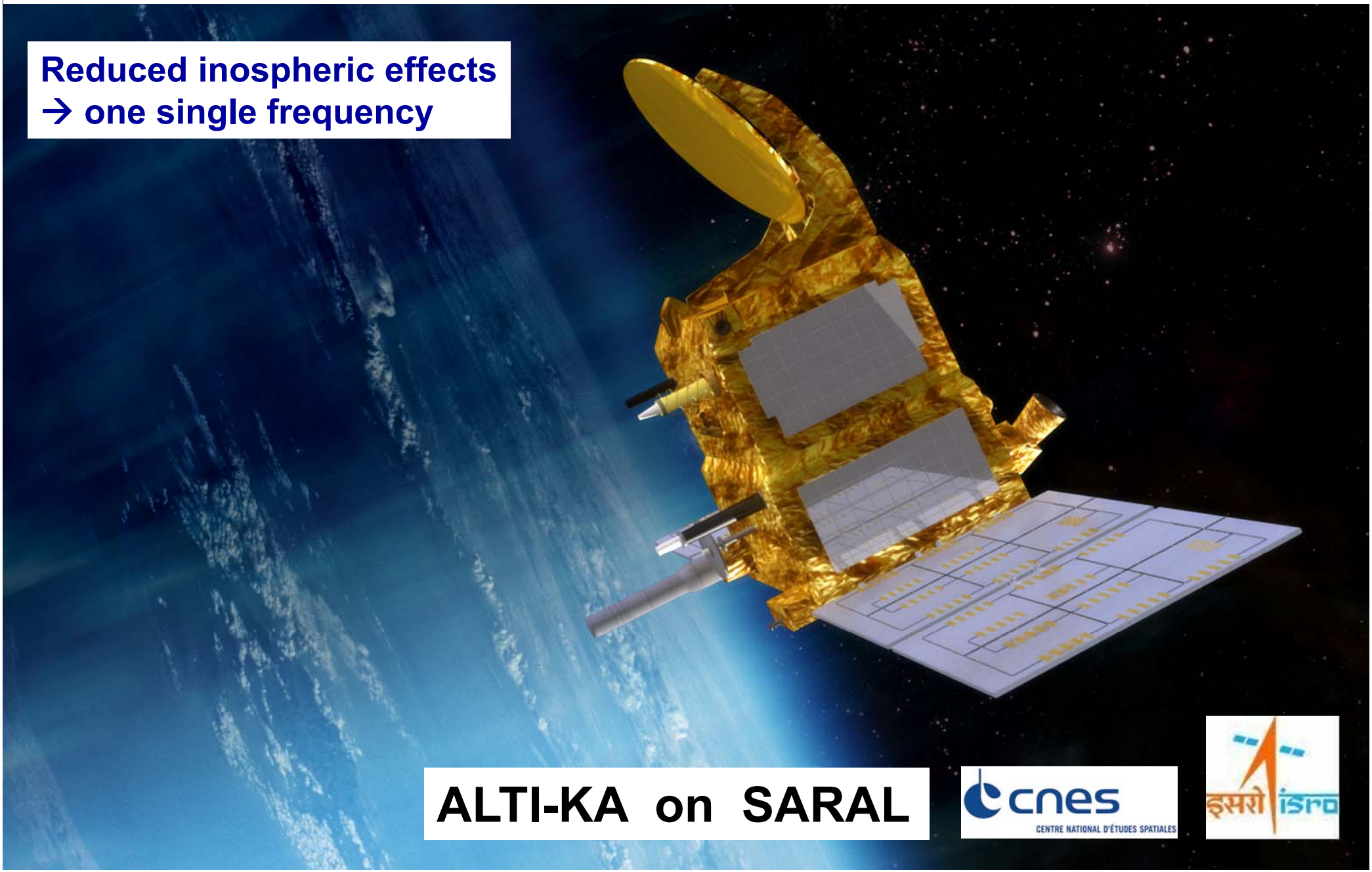
Acknowledgments : Nathalie Steunou, Roger Fjortoft, Alain Mallet

- Nadir Ku/C Altimetry
- From Nadir Ku/C to Ka : AltiKa
- Wide Swath altimetry : SAR mode
- Wide Swath altimetry : Interferometry
- About SWOT
- Summary

Nadir Ku/C altimetry

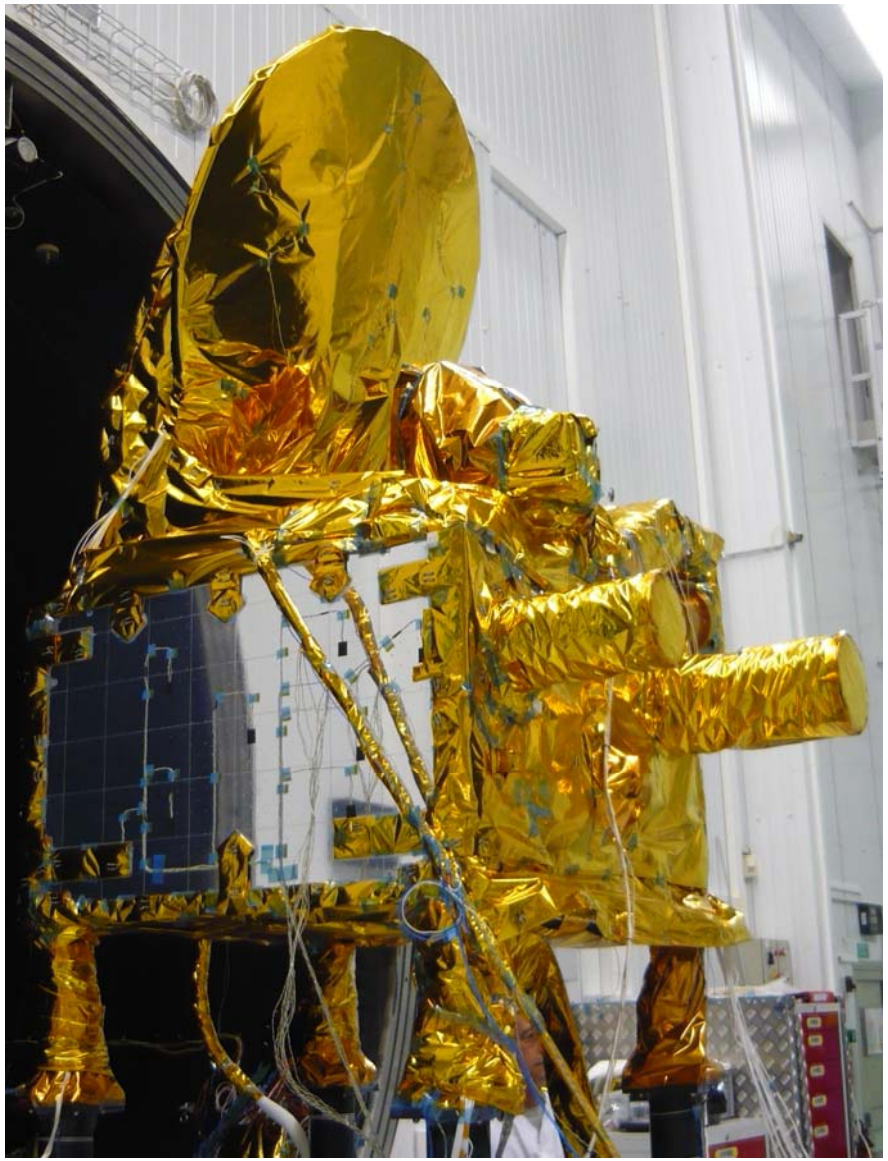


From Nadir Ku/C to Ka (35 GHZ) : AltiKa



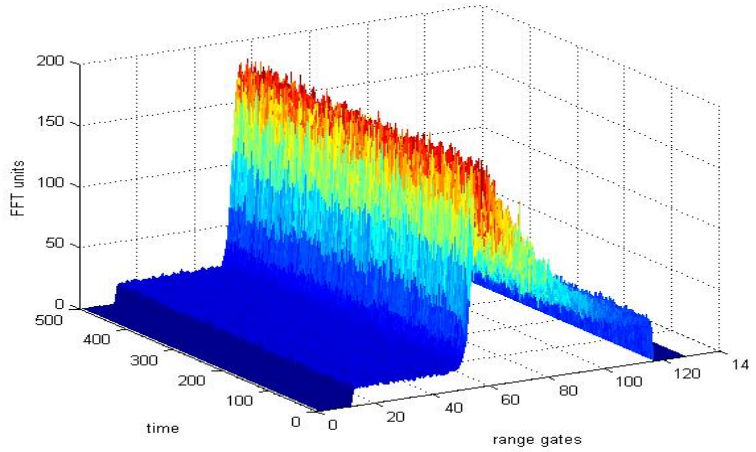
Ka band altimetry : AltiKa

- **Ka-band altimeter**
  - Developed by Thales Alenia Space- FRANCE (delivery and full validation : 12/09)
  - Improved spatial resolution (30 km → 8 km)
  - Limitations : atmospheric water content (Data loss between 3% and 10%)
- **Dual-frequency radiometer** (23.8 GHz, 37 GHz)
  - Shares the altimeter Digital Processing Unit and antenna *(compact)*



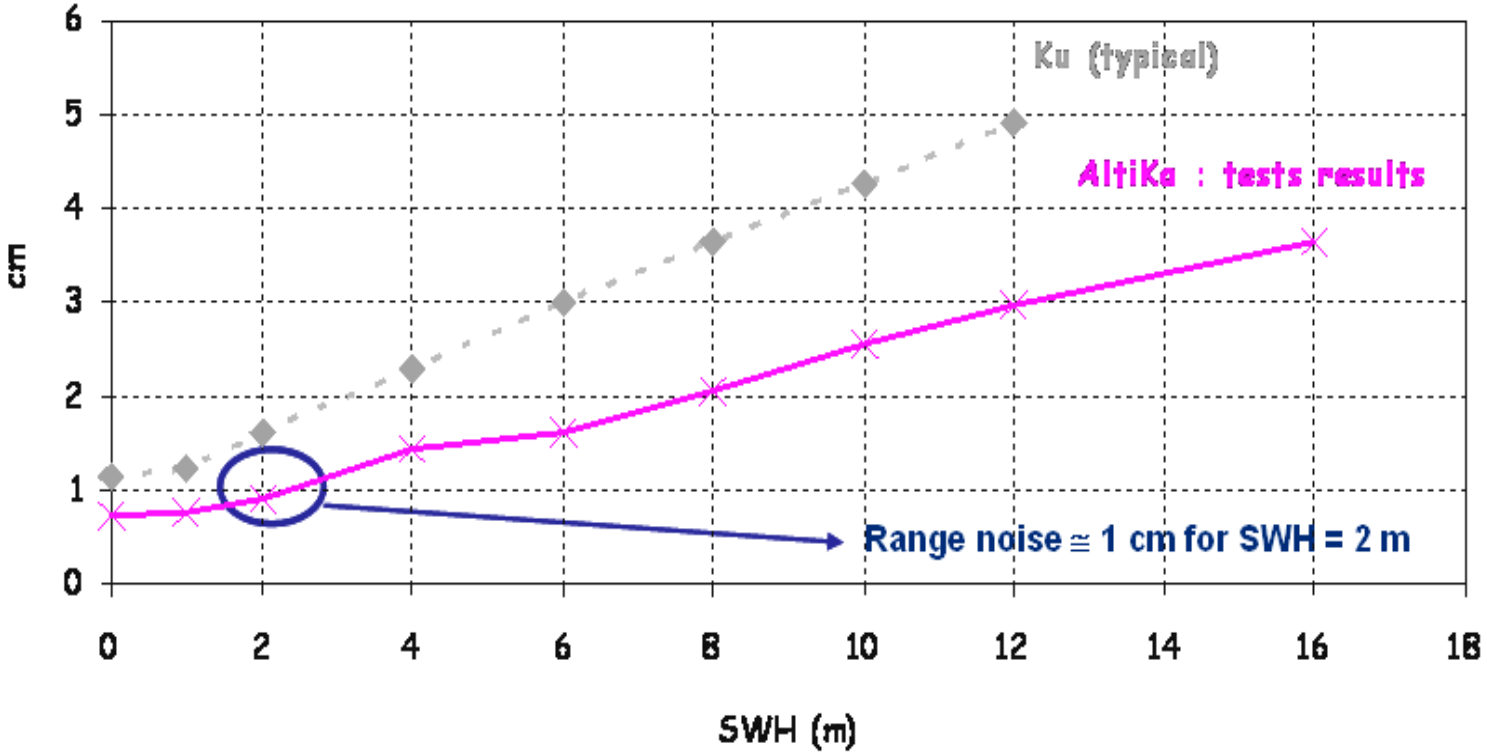
Ka band altimetry : AltiKa

→ Altimeter performances



AltiKa waveforms

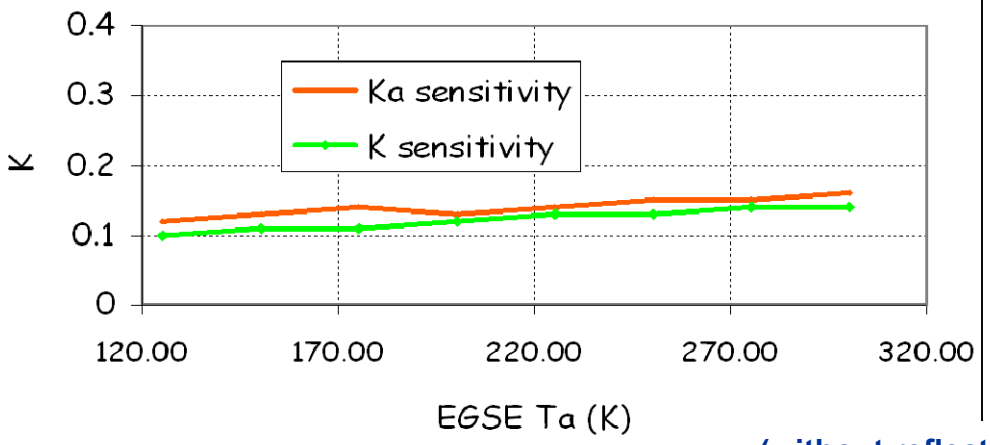
Range noise (1 s) : 1cm for SWH=2m



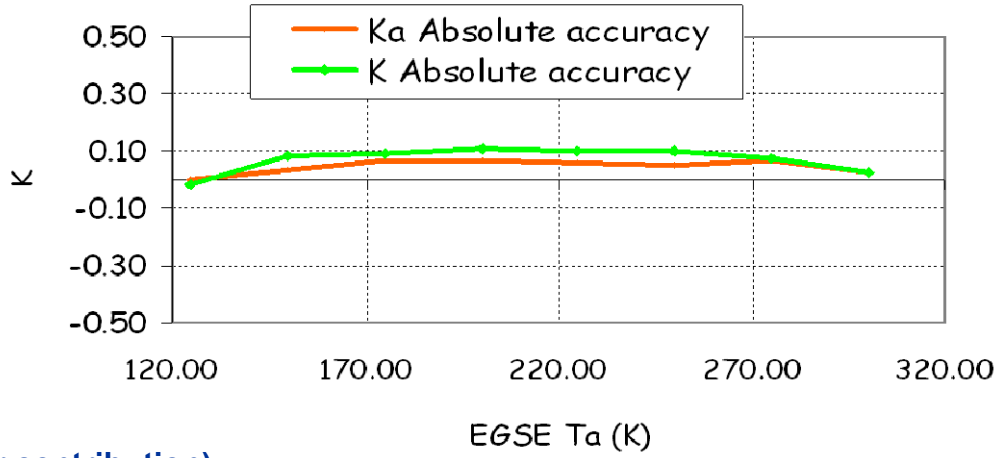
Ka band altimetry : AltiKa

→ Radiometer performances

Sensitivity (20°) 0.12 K



Absolute accuracy (20°)0.1 K



(without reflector contribution)

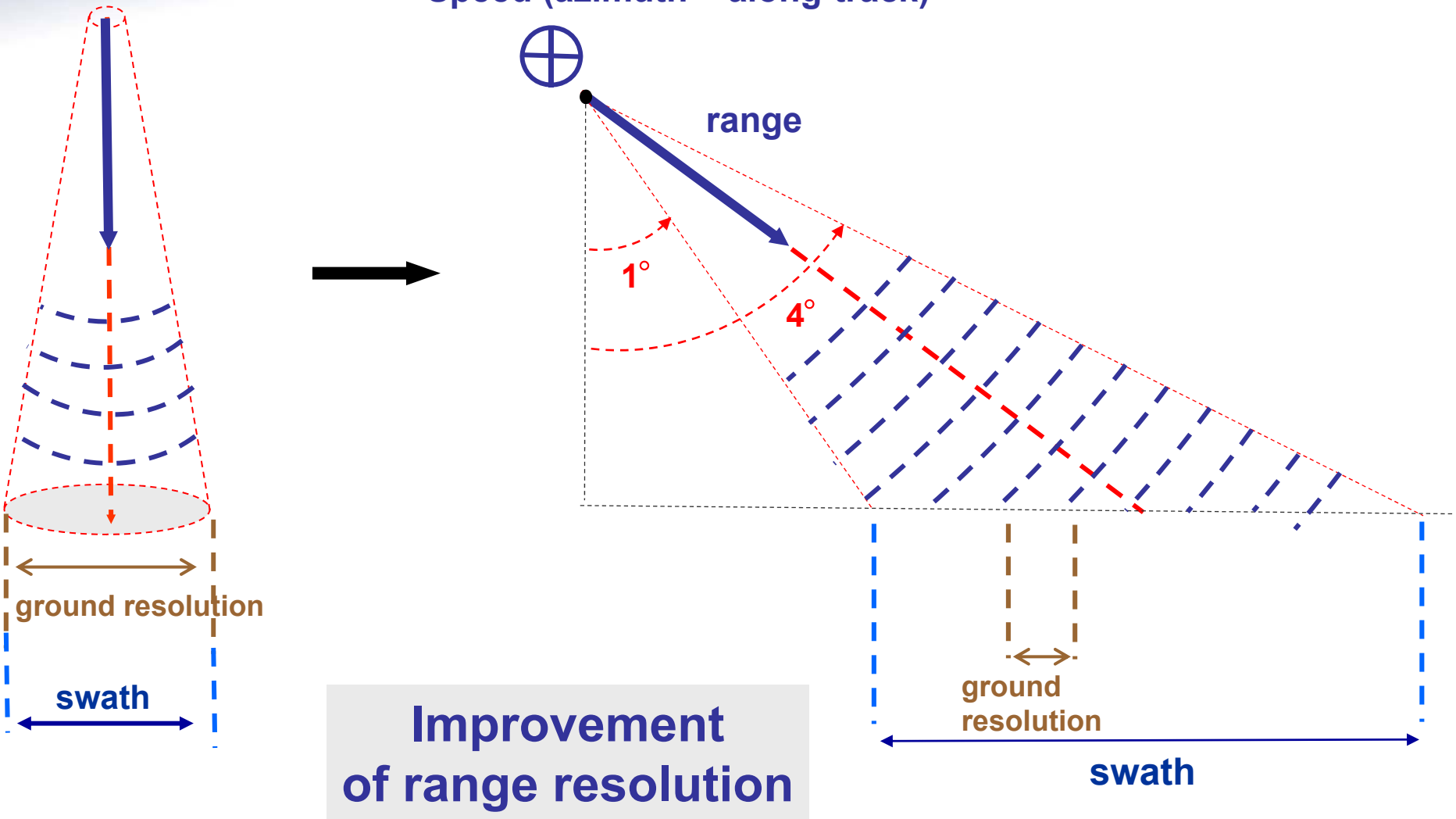
* Worst case sensitivity : **0.2 K** (spec 0.4 K in Ka , 0.3 K in K) (0° C, 20° C and 40° C)

* Worst case absolute accuracy : **< 1.3 K** (spec. 3 K)

• Cf. Poster « **Altika, a new concept of Altimeter … » from N. Steunou et al.,**

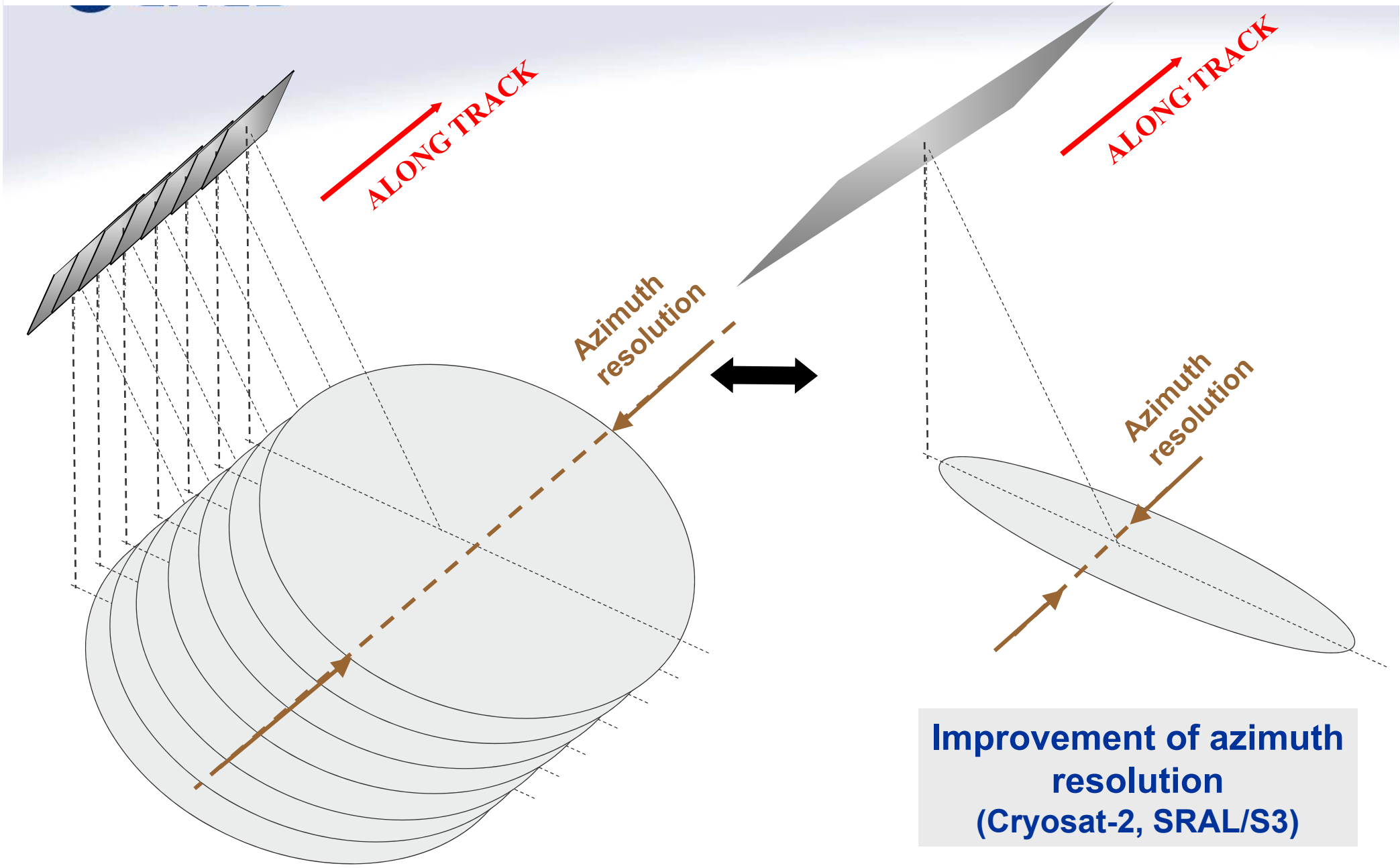
From nadir to wide swath altimetry

→ Off-Nadir illumination



Improvement of range resolution

Wide swath altimetry : SAR mode



Improvement of azimuth resolution
(Cryosat-2, SRAL/S3)

SAR mode in action

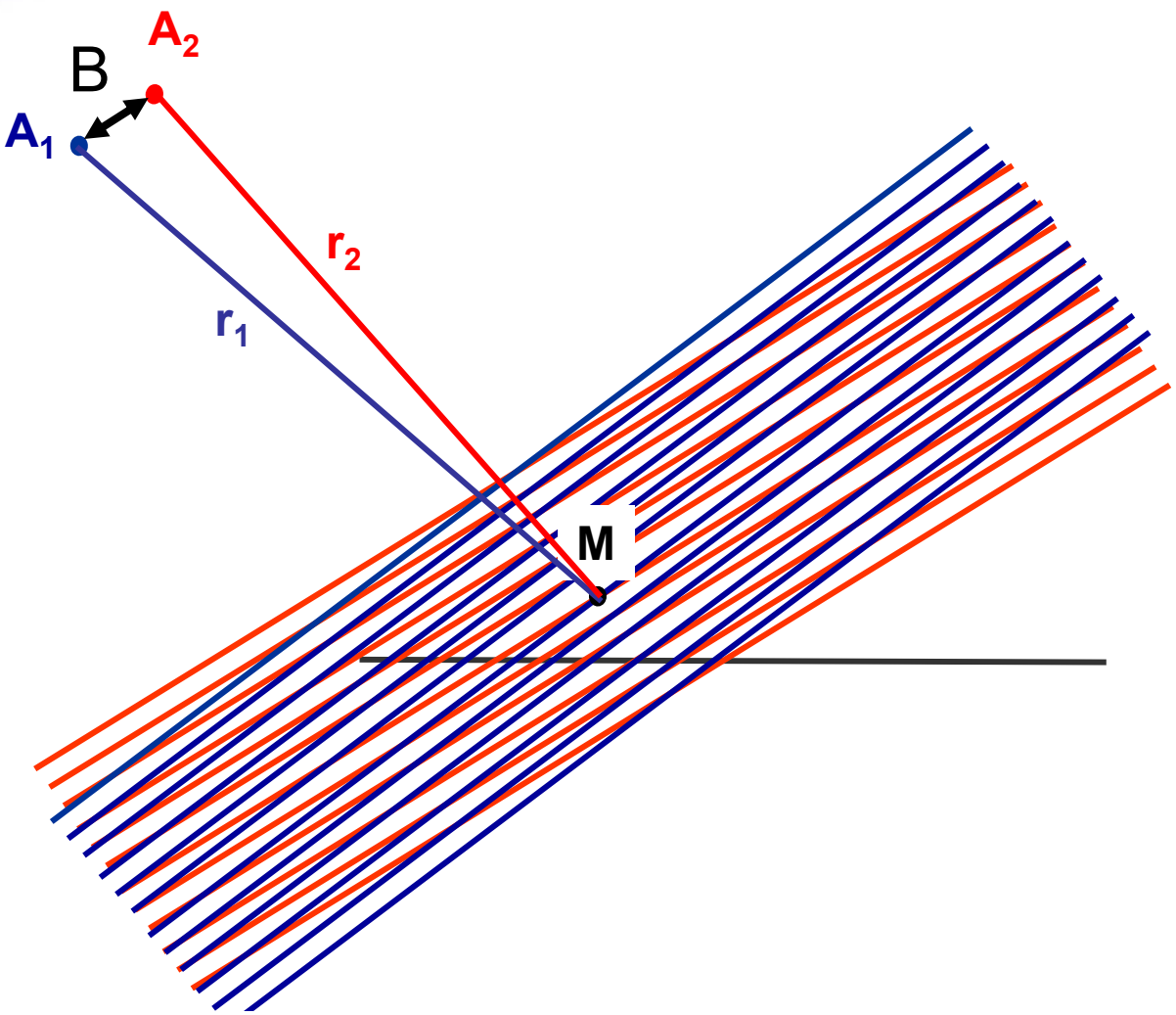
RADAR IMAGES

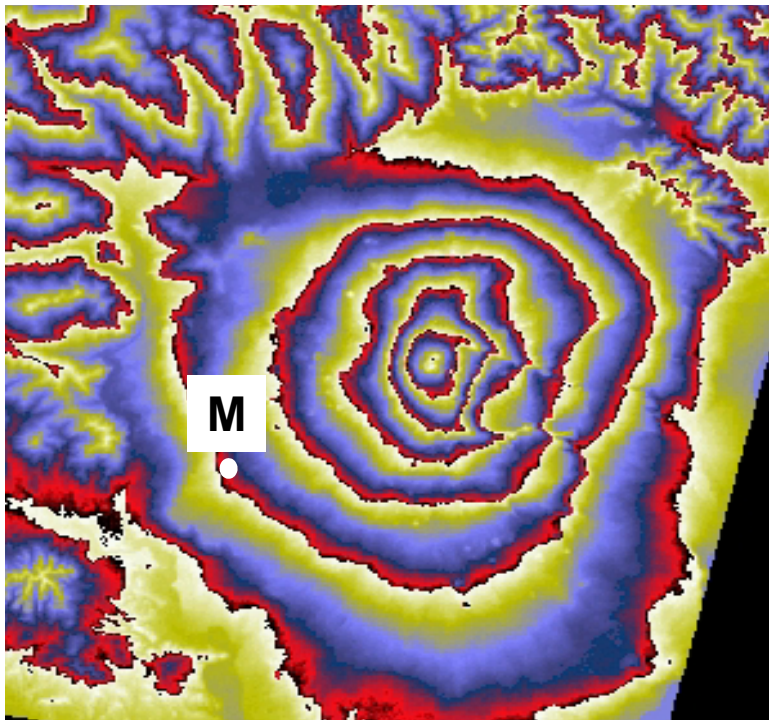
Radar echoes

Azimuth synthesis

Wide swath altimetry : interferometry for height extraction

Baseline : B (10 m)



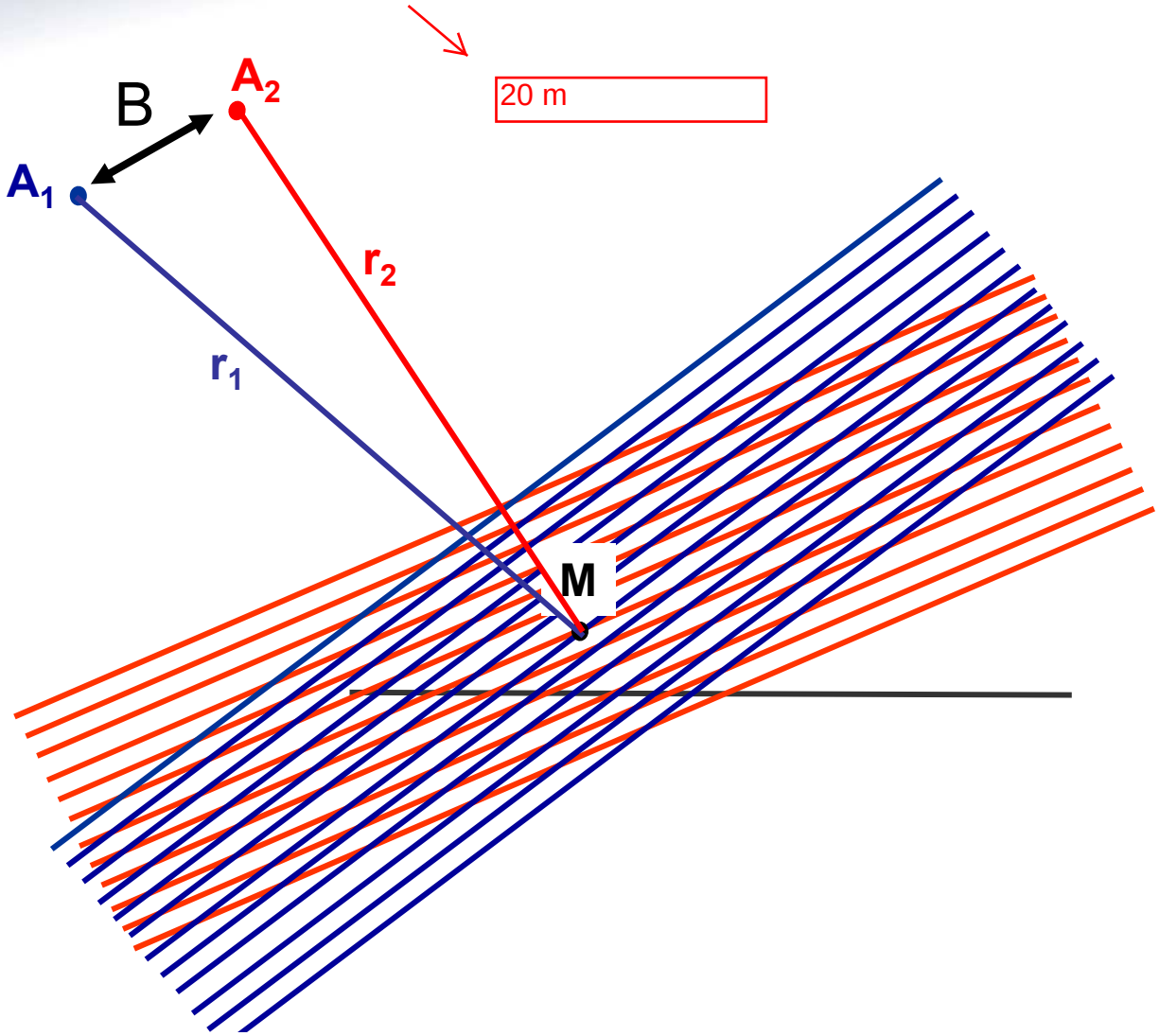


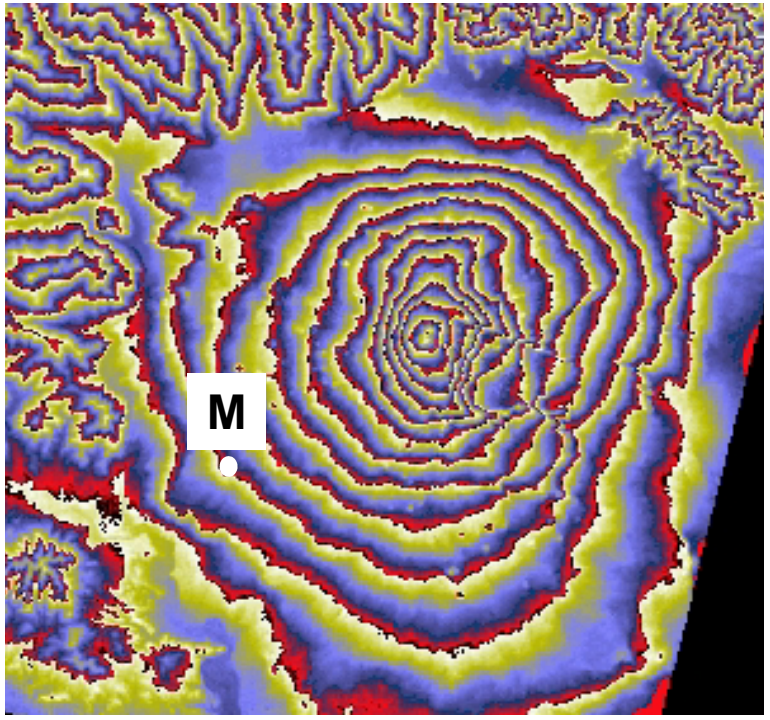
Iso-altitude line (r_1-r_2)

→ Height measurement

Wide swath altimetry : interferometry for height extraction

Baseline : B ~~(10 m)~~





Iso-altitude line (r_1-r_2)

→ Height measurement

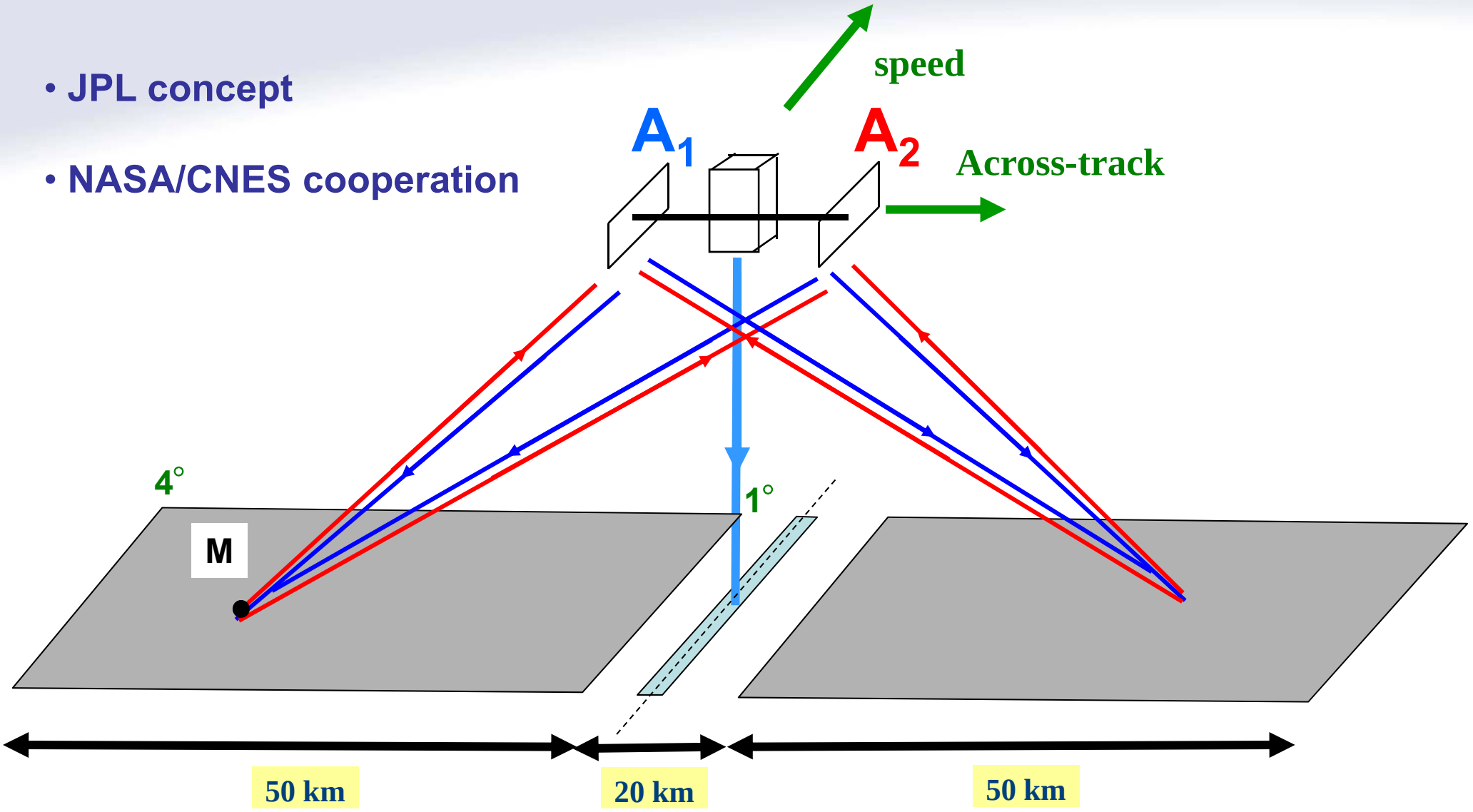
Wide swath altimetry : interferometry for height extraction

- Interferometry = Height measurement
- Topographic sensitivity ↗ when B/λ ↗
- B/λ ↗ when λ ↘ (easiest than ↗ B ! - mast length-)

→ Transition from Ku to Ka (Gain in height sensitivity : 2.6)

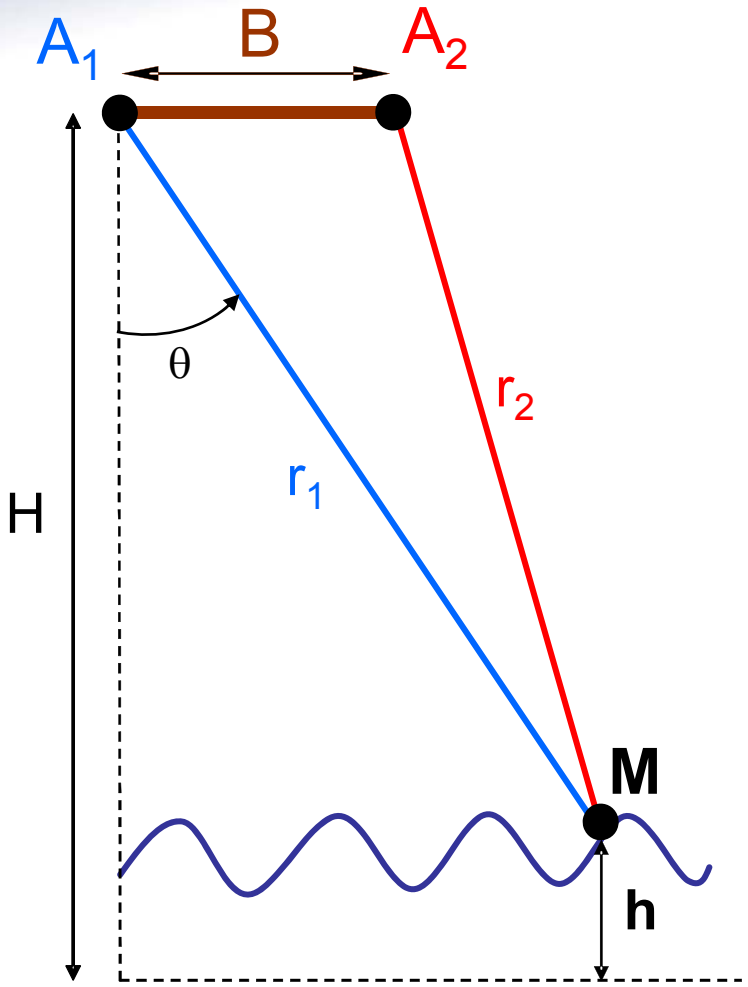
SWOT

- JPL concept
- NASA/CNES cooperation



Cf. "KARIN/SWOT performance analysis tool - application to near nadir swath extension", A. MALLET

SWOT : geometry



Interferometric Phase (r_1-r_2)

Baseline

$$h = f(H, B, r_1, \Phi)$$

Orbit
(DORIS, GPS)

Range (on-board clock)

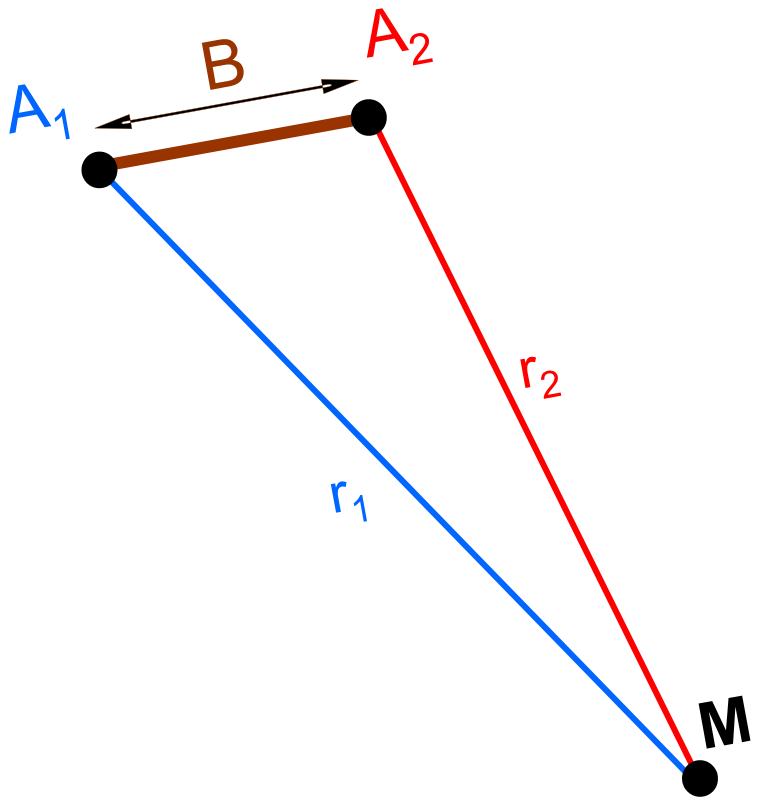
Height knowledge : absolute or relative ?

B → baseline

r_1 → range

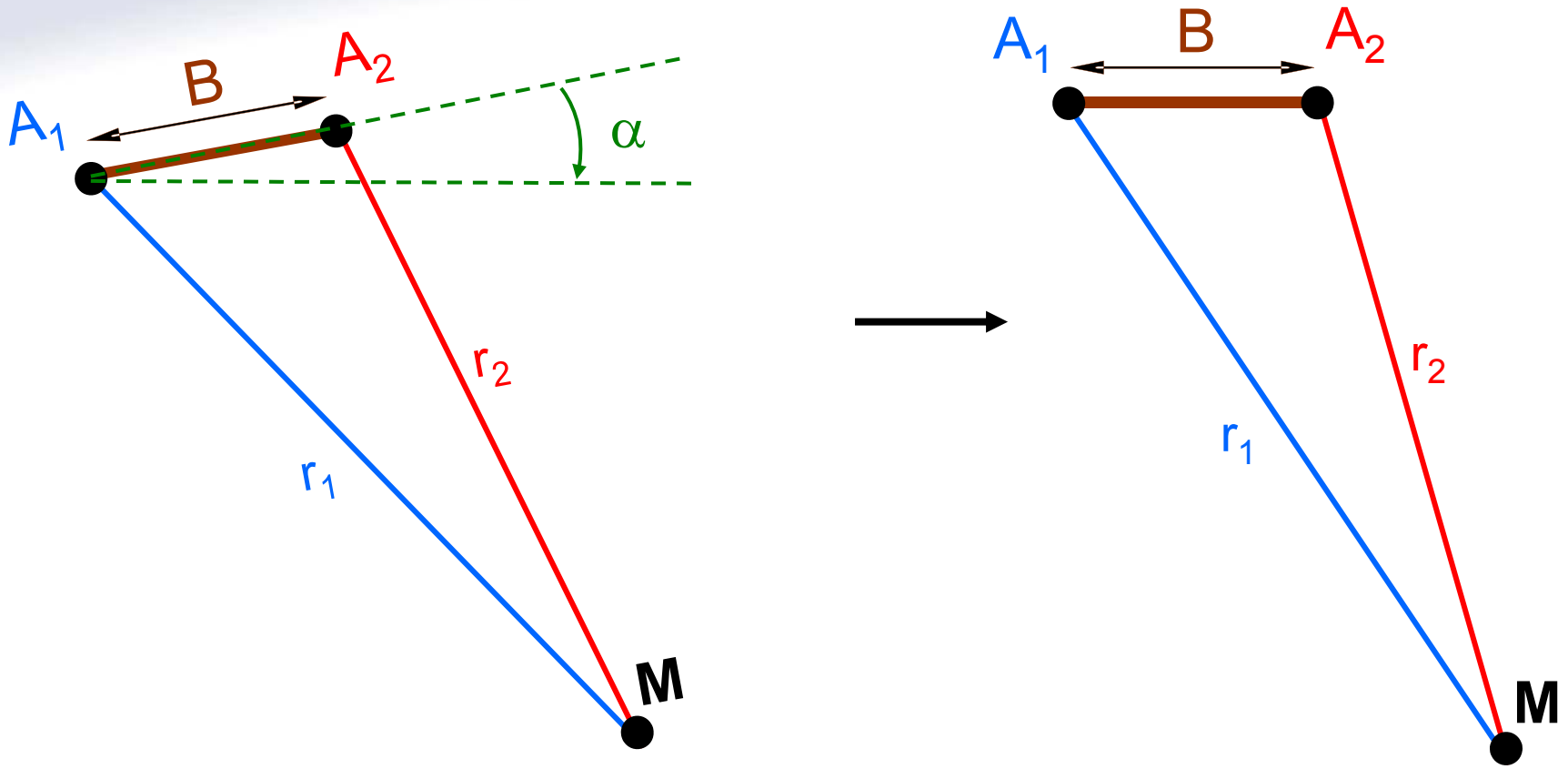
Φ → phase

Radar measurement …



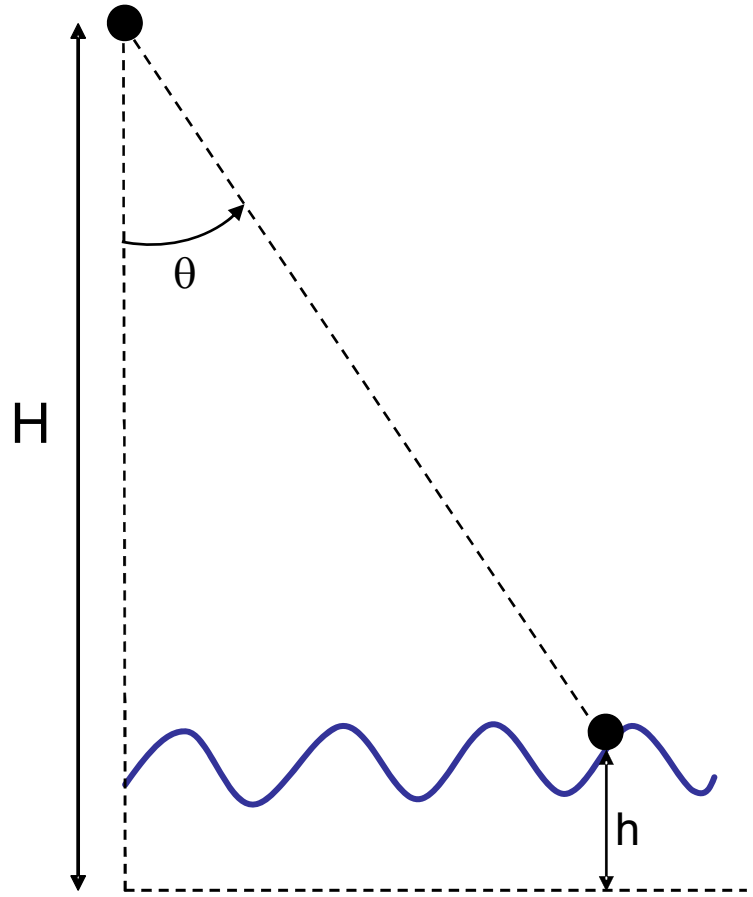
… only gives the relative knowledge of the triangle (A_1, A_2, M)

From relative to absolute height : roll correction

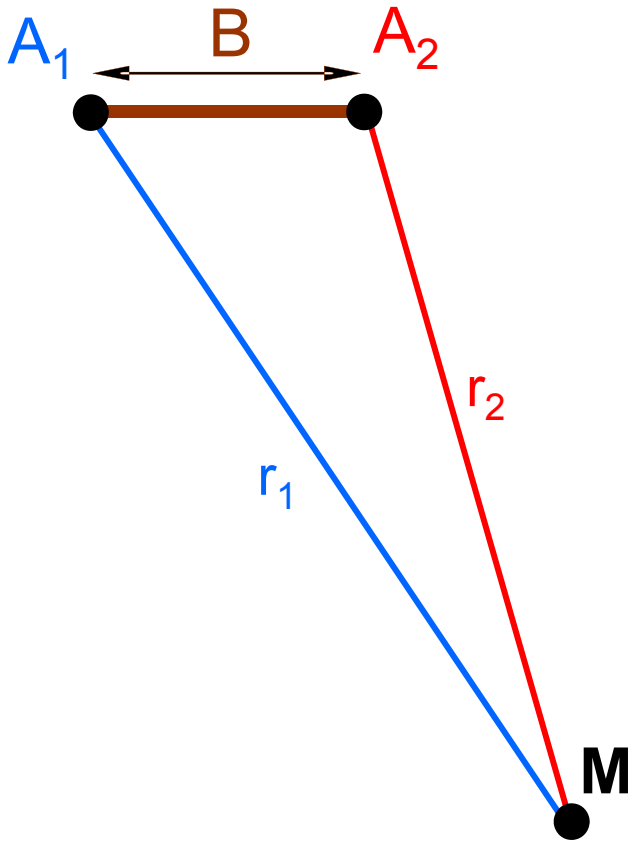


Roll impact : α = 0.1 arcs → height error : 50 cm

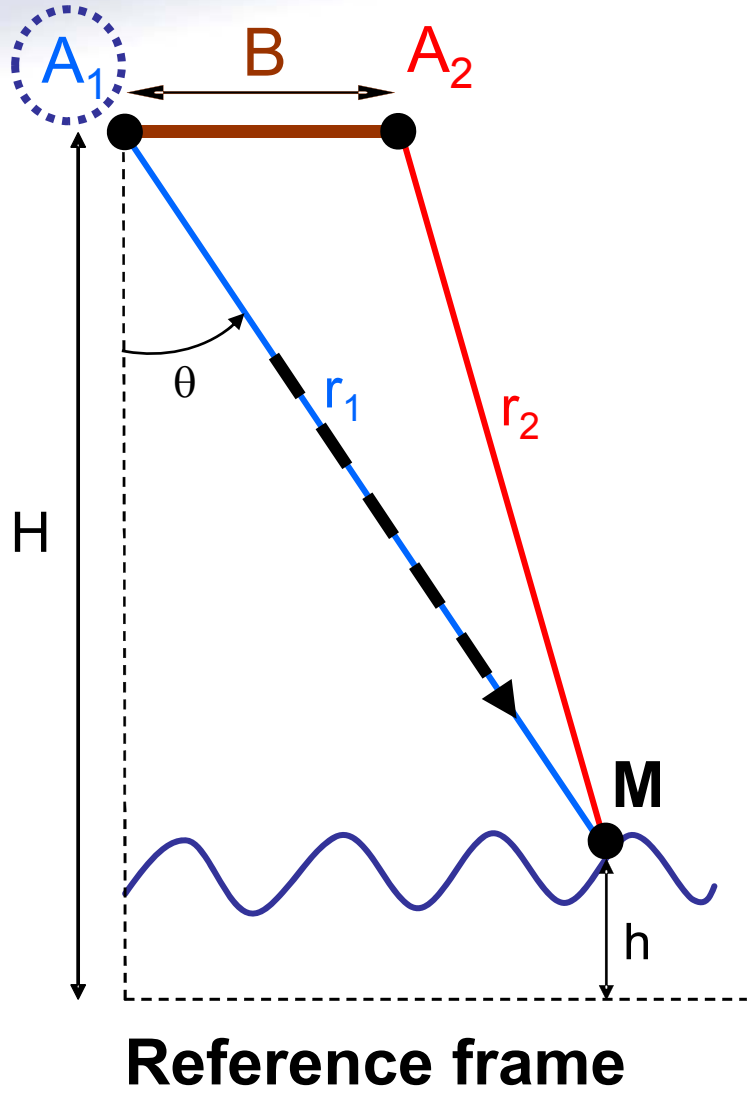
From relative to absolute height : “tying” the triangle …



… to the reference frame



From relative to absolute height : “tying” the triangle



OPTION 1 :

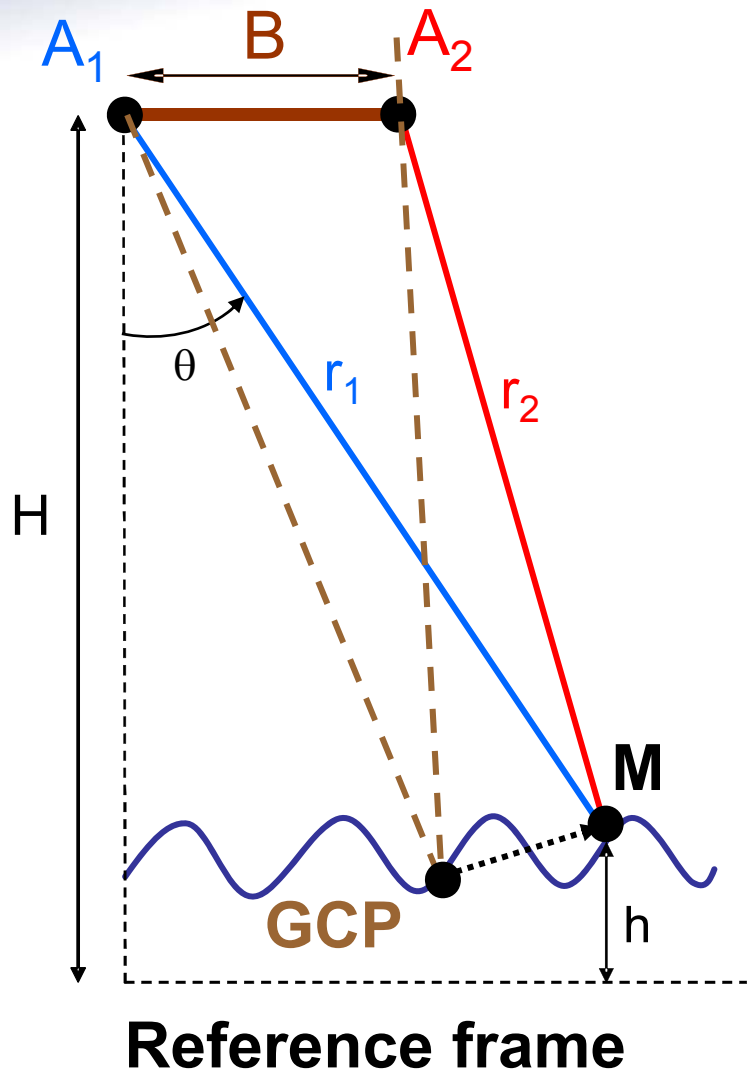
- Reference : A1 (satellite)

→ Precise Orbit Determination (POD)

→ Tropospheric correction (r1 knowledge)

→ Processing Pixel by Pixel

From relative to absolute height : “tying” the triangle

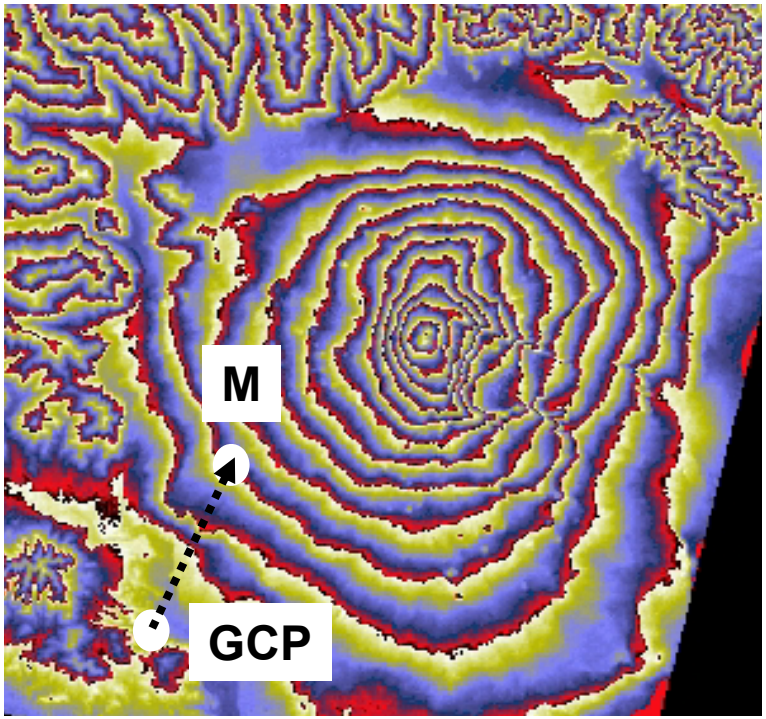


OPTION 2 :

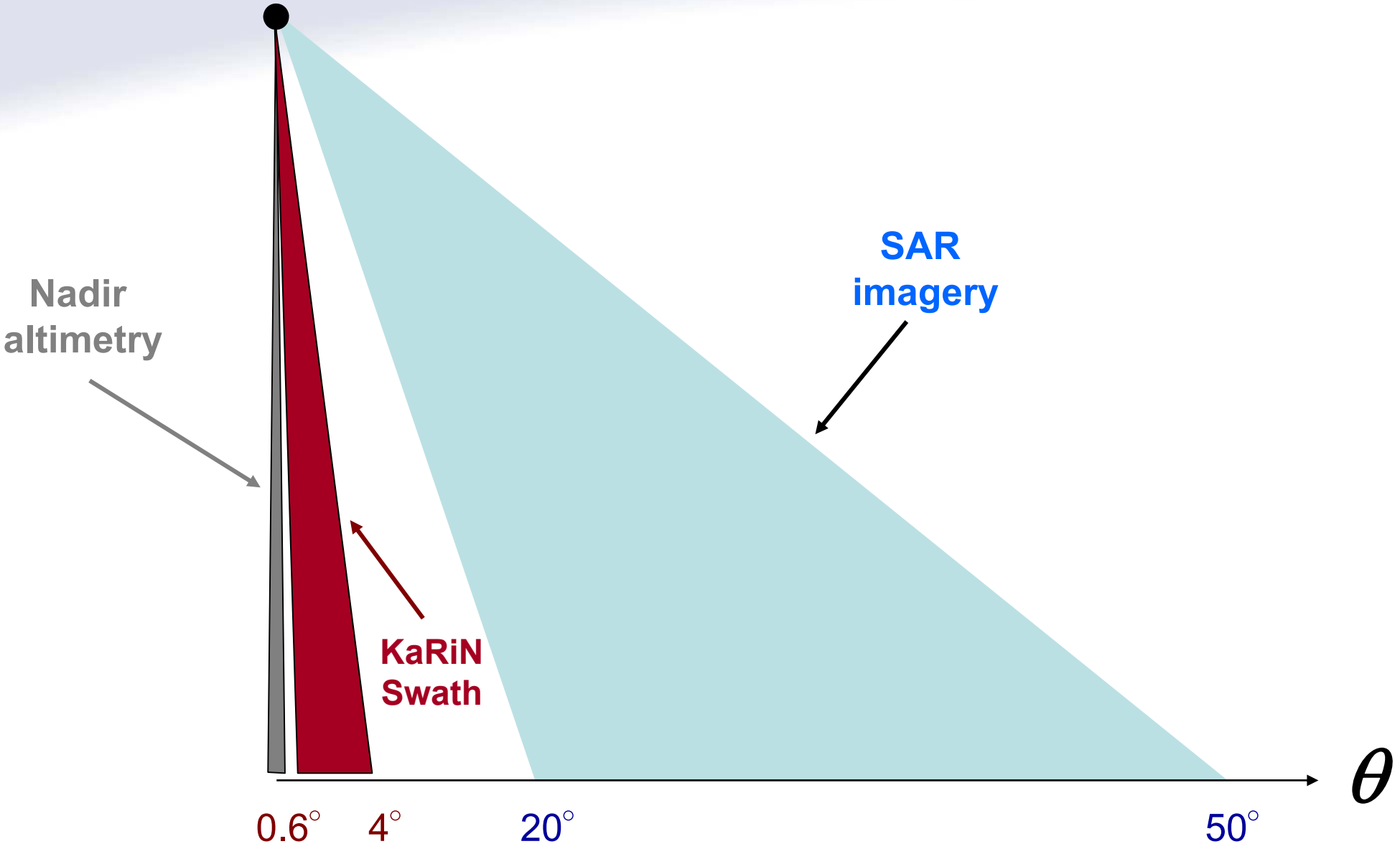
- Reference : Ground Control Point (e.g. GPS)

→ « Phase unwrapping » from GCP
(« continental » approach)

→ Tropospheric correction not necessary



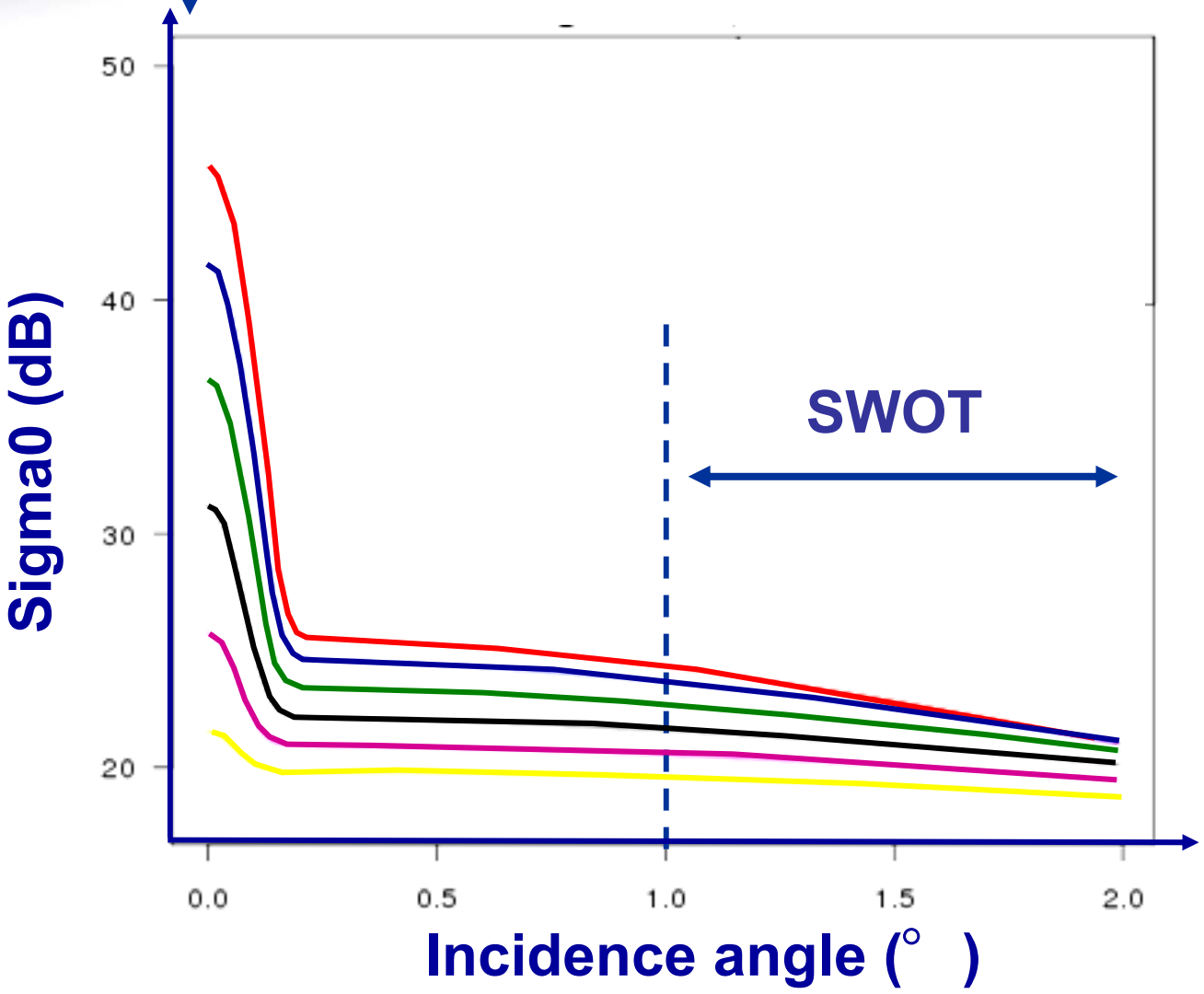
SWOT radiometry : not nadir, not classic SAR, not Ku !



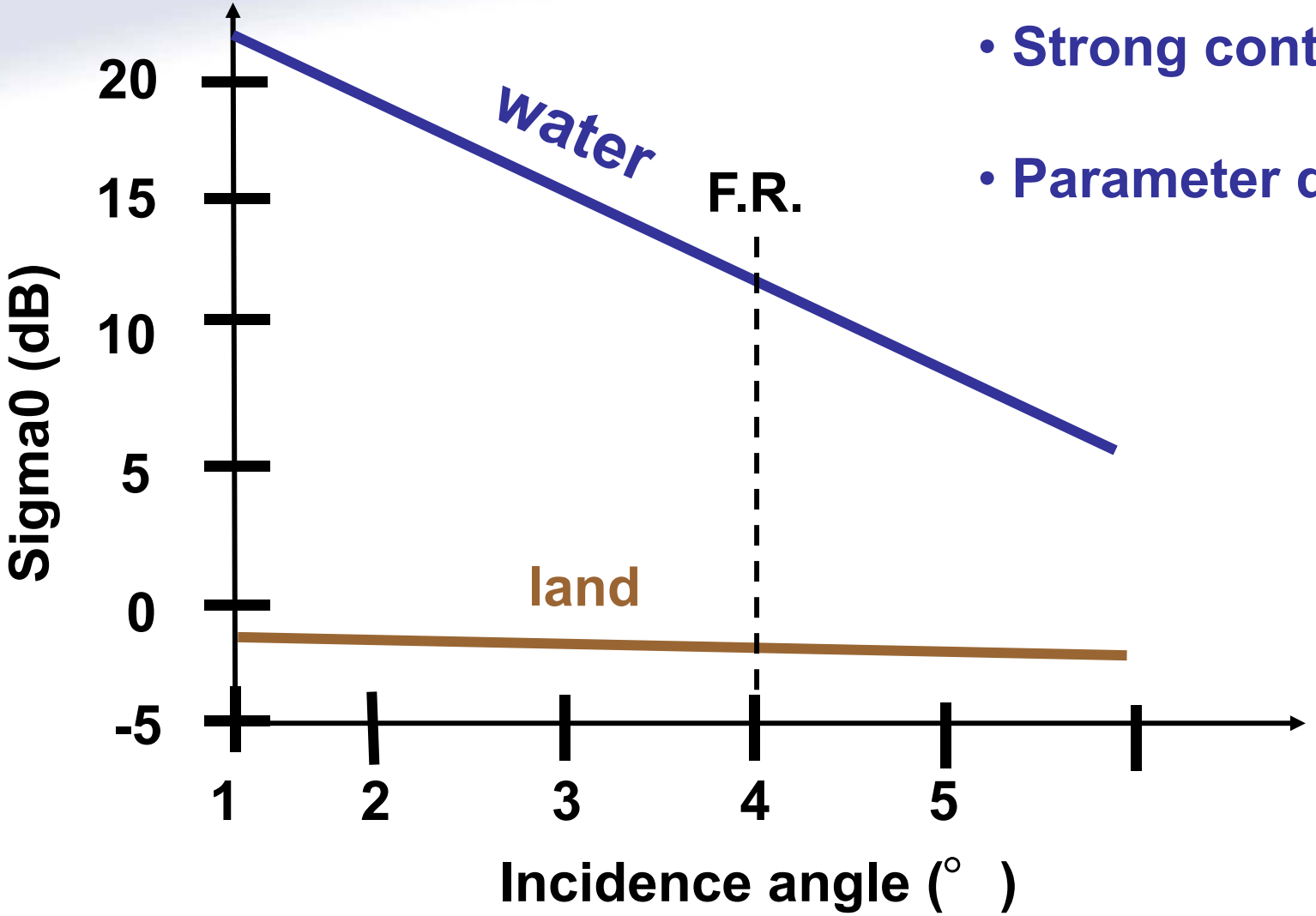
Ka band water signature

AltiKa

Varying surfaces conditions (▲ : smooth ▲ : rough)

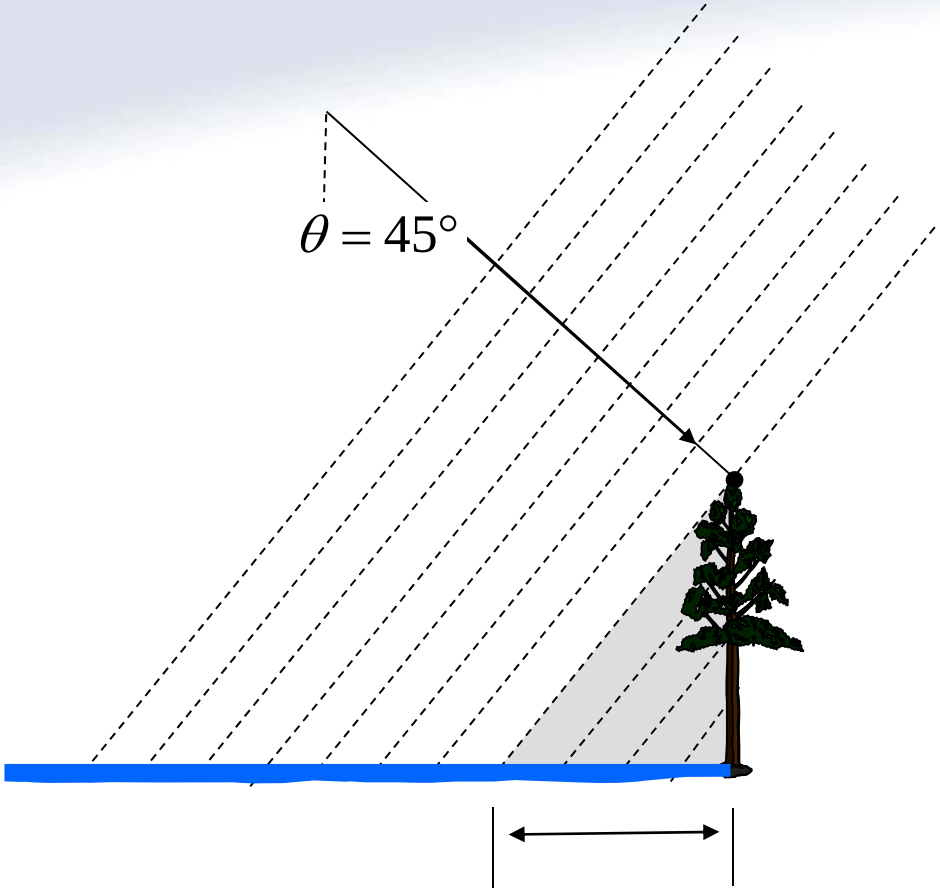


Ka band water / land contrast

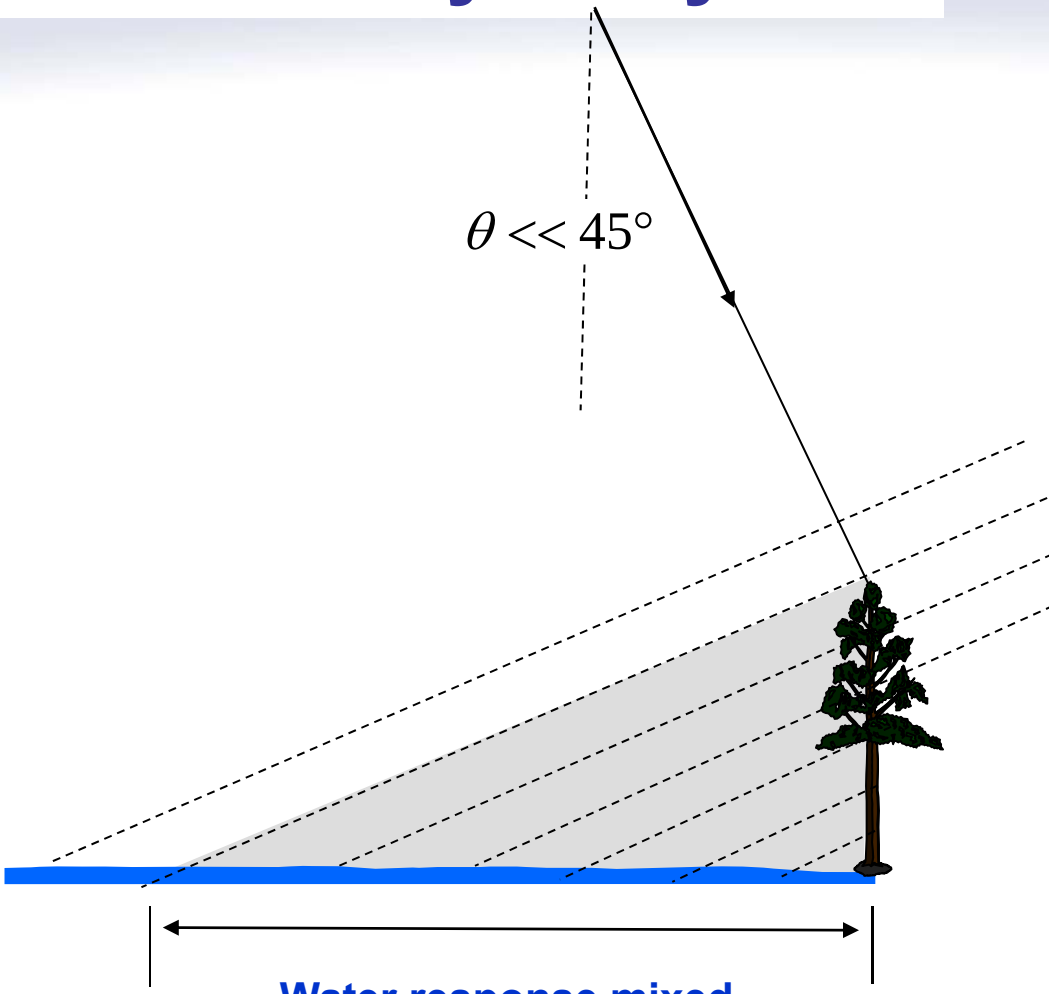


- Strong contrast (> 10 dB)
- Parameter dependant

Between geometry and radiometry : Layover



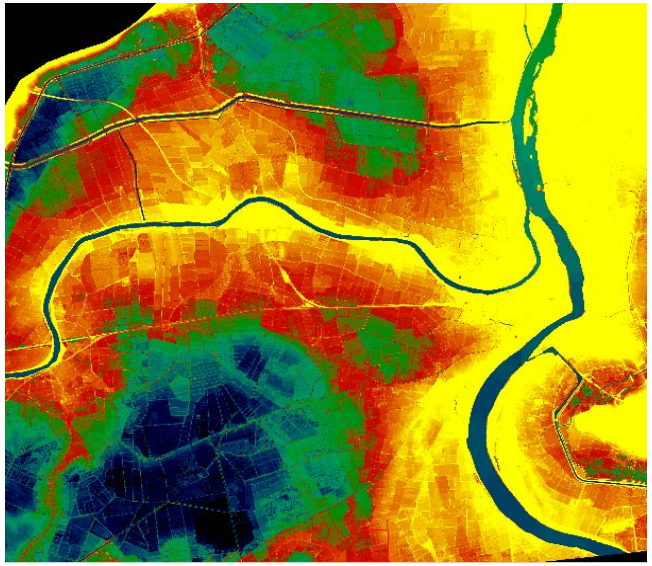
Water response mixed with forest response



Water response mixed with forest response

LAYOVER ↗ when θ ↘

SWOT Layover (4° → 1°)



DEM

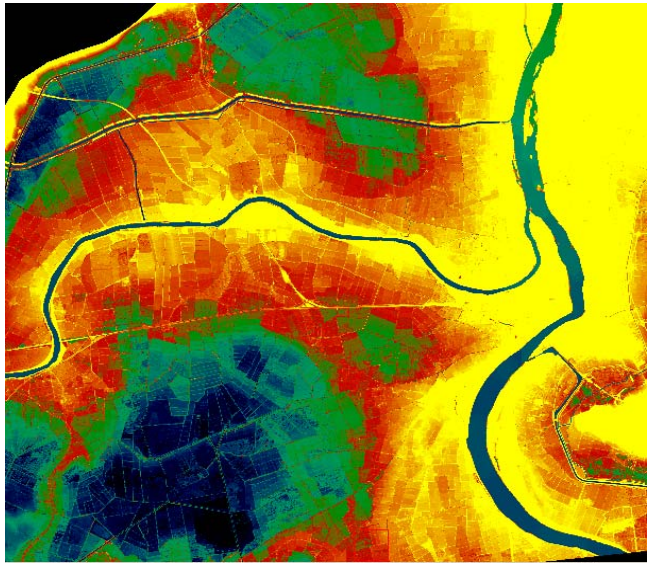
-2m 56m

4°

Layover zones

altamira INFORMATION

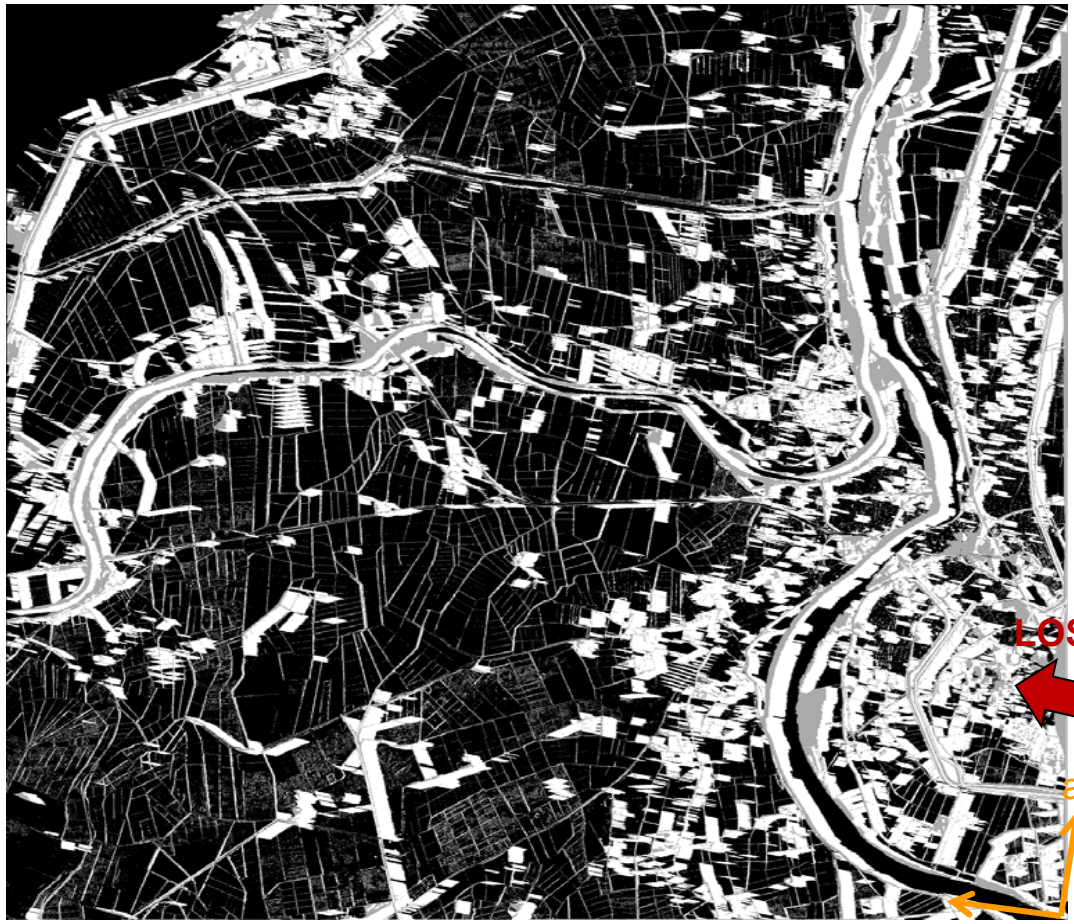
SWOT Layover (4° → 1°)



DEM

-2m 56m

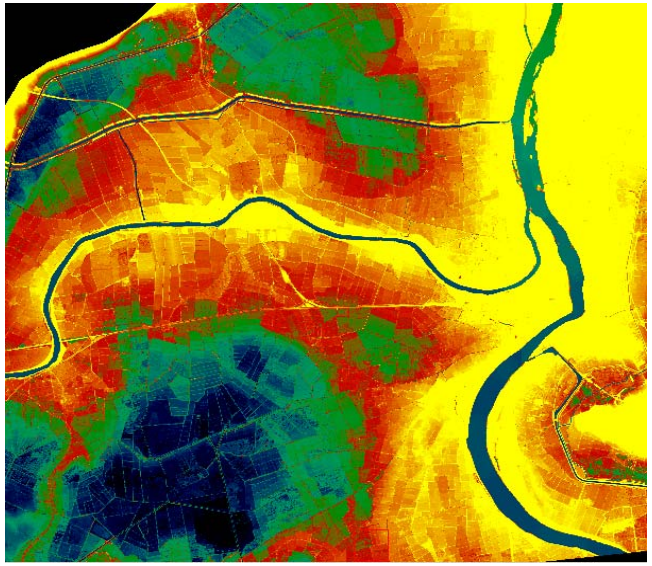
3°



Layover zones

altamira INFORMATION

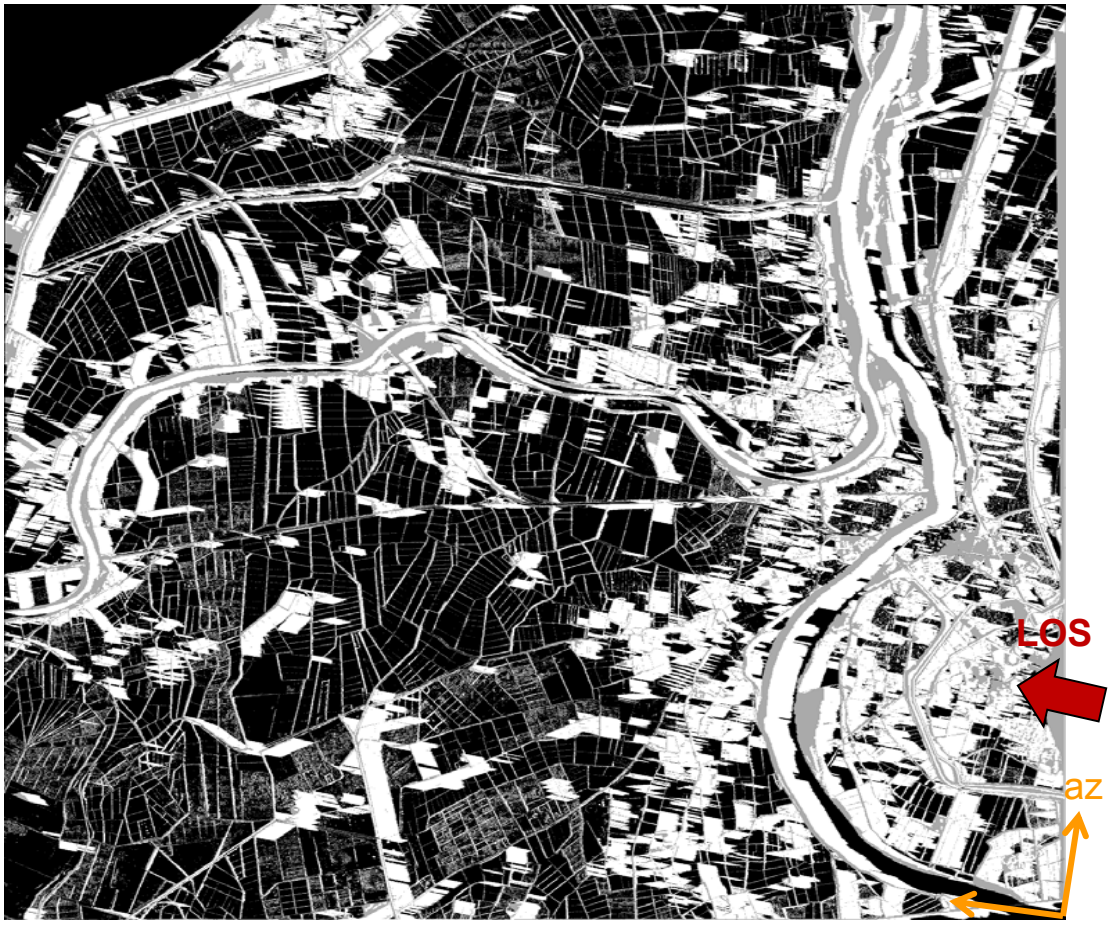
SWOT Layover (4° → 1°)



DEM

-2m 56m

2°

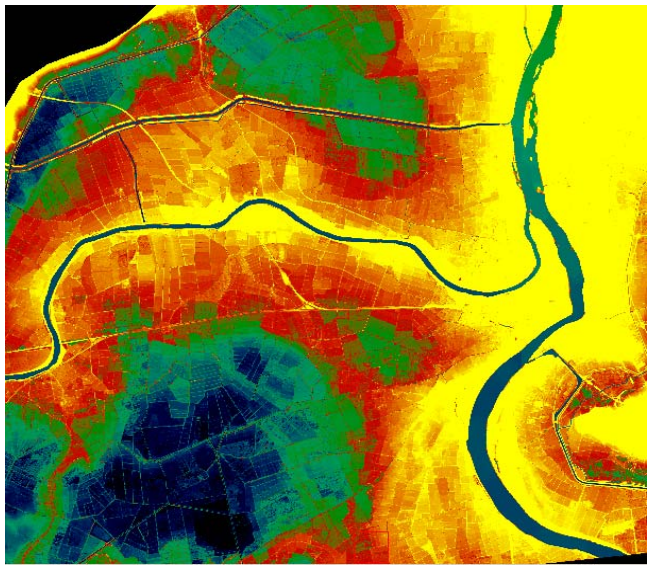


Layover zones

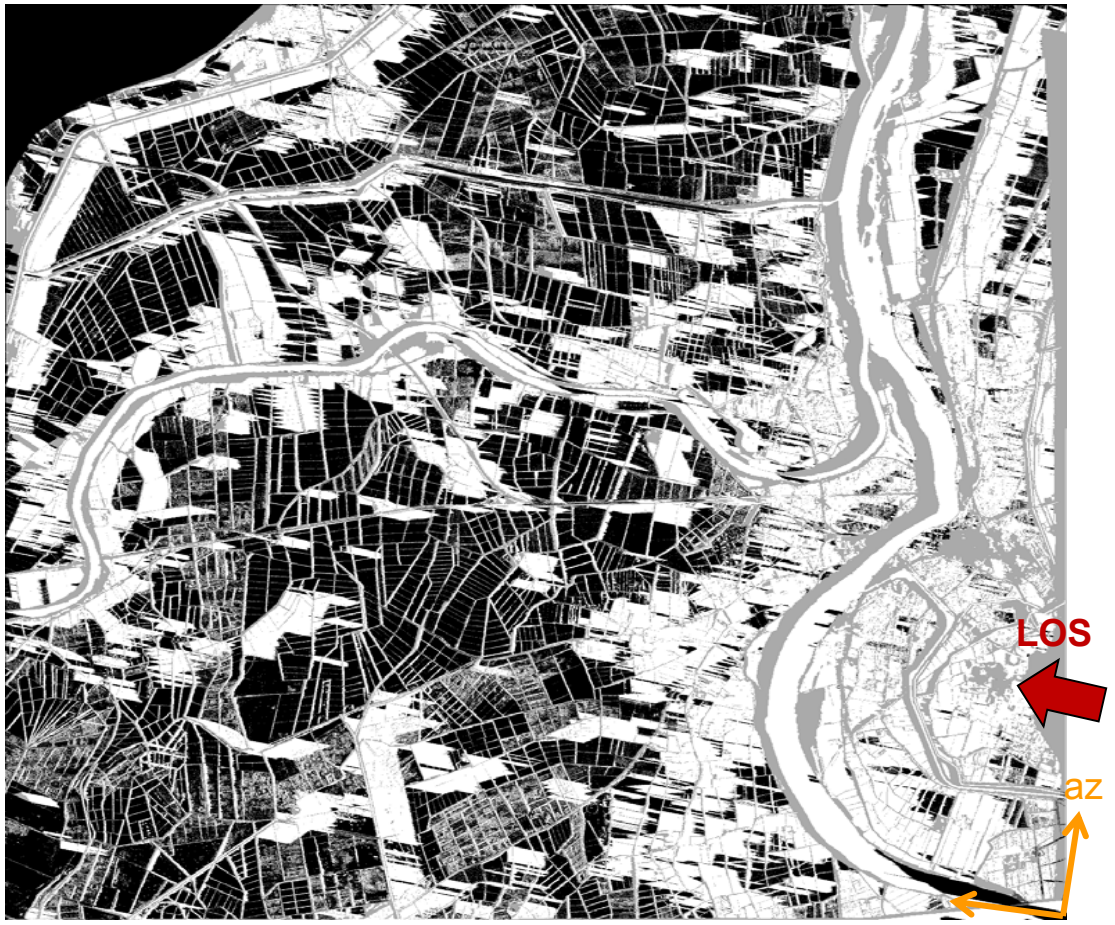
altamira INFORMATION

SWOT Layover (4° → 1°)

Lay-over impact reduced tks to strong Water / Land contrast



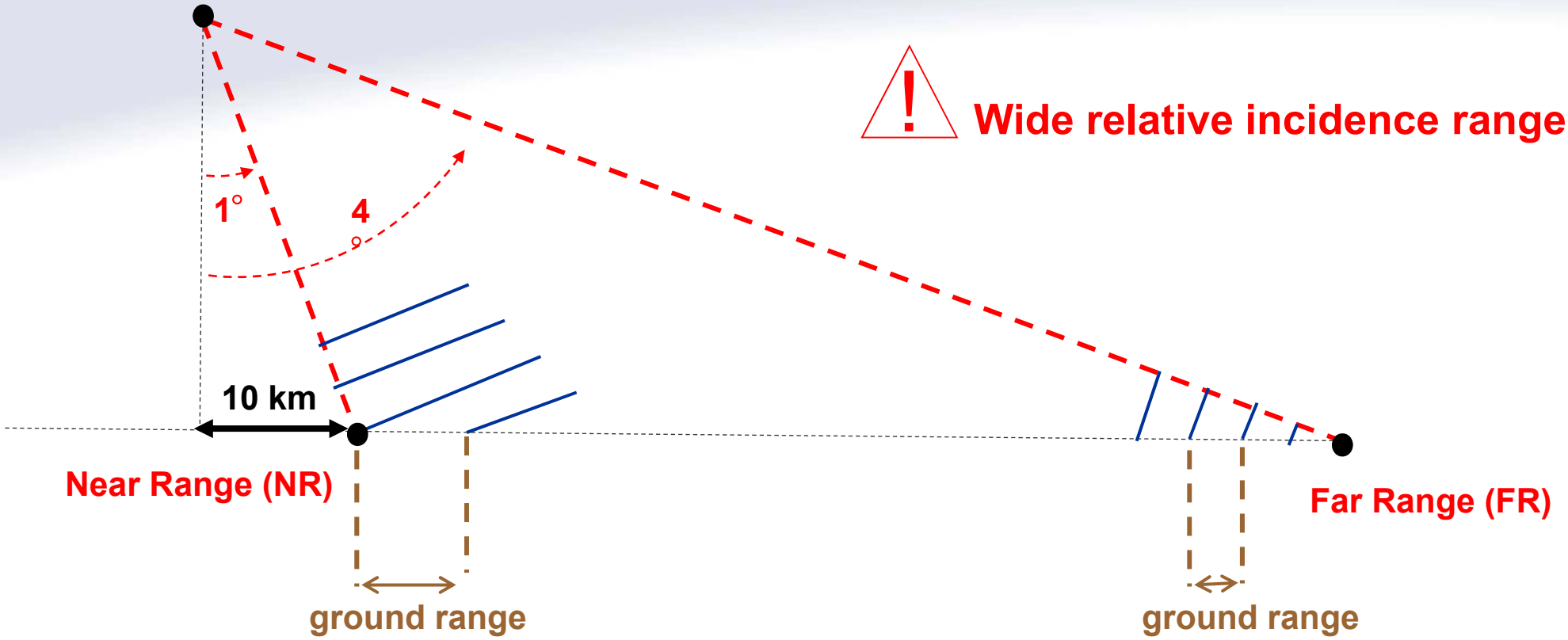
1°



Layover zones

altamira INFORMATION

Incidence variability effects



- Resolution loss @ N.R. → Interferometric performance reduced
  → 20 km blind zone around nadir

- Land / water contrast reduced @ F.R.

SUMMARY

- **Several challenges attached to Ka band :**
  - **AltiKa / SARAL and the upcoming Ka band nadir altimetry (ISRO / CNES)**
  - **SWOT : Wide Swath altimetry inc. SAR + Interferometry (NASA / CNES)**
    - **Measurement concept understood and concurrent issues identified**
    - **Physics of measurement needs clarification**

    →Importance for airborne experiments (AIRSWOT, BUSARD, …)