RÉPUBLIQUE
FRANÇAISE

Liberté
Égalité
Fraternité

ONERA

THE FRENCH AEROSPACE LAB

www.onera.fr

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

ONERA
THE FRENCH AEROSPACE LAB

Radiometric calibration for airborne bistatic SAR

Hubert Cantalloube
dept. of electromagnetism & radar, ONERA université Paris Saclay

Bistatic radiometric calibration alternatives

- direct computation from power amplifier gain, filter insertion losses, waveguide losses, propagation, antennae gains, digitiser's scale ... SAR synthesis algorithm "gain" (normalisation).

- bistatic transponder (itself calibrated in anechoic chamber).

- relative calibration of "near-monostatic" bistatic acquisition from calibrated monostatic image (typ. of isotropic clutter).

- direct calibration of bistatic acquisition from bistatic RCS modelling of model targets (top-hat, corner reflector, dihedral).

Bistatic radiometric calibration: relative to monostatic

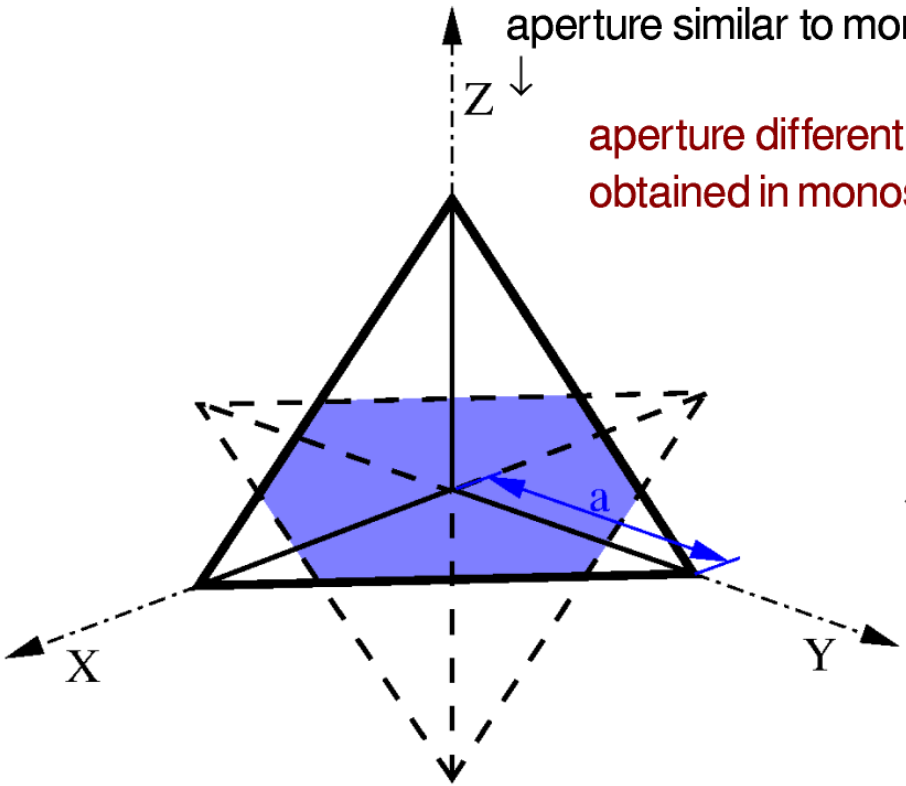
Quiz

which is which?
monostatic
or
bistatic @ 5°

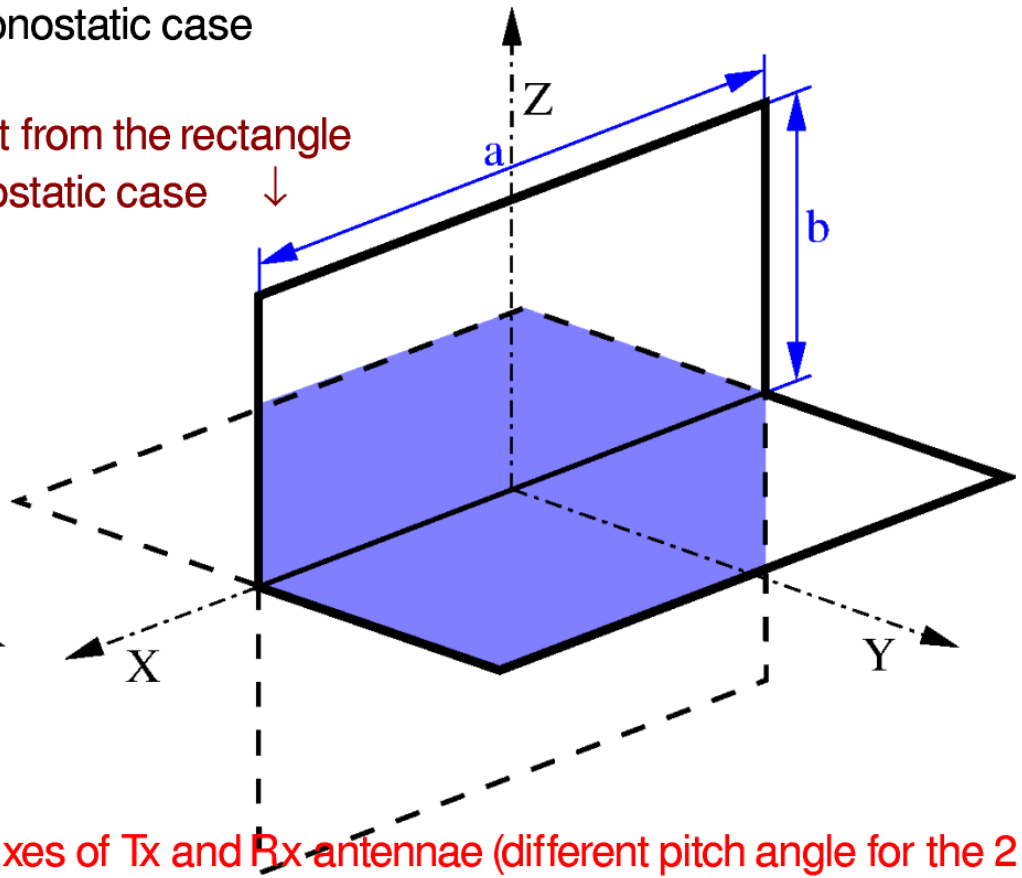
?

Hint: Rx only aircraft is 3 times closer to ROI, hence bistatic focus is closer to ROI than monostatic focus...

Bistatic G.O. RCS models for canonical targets



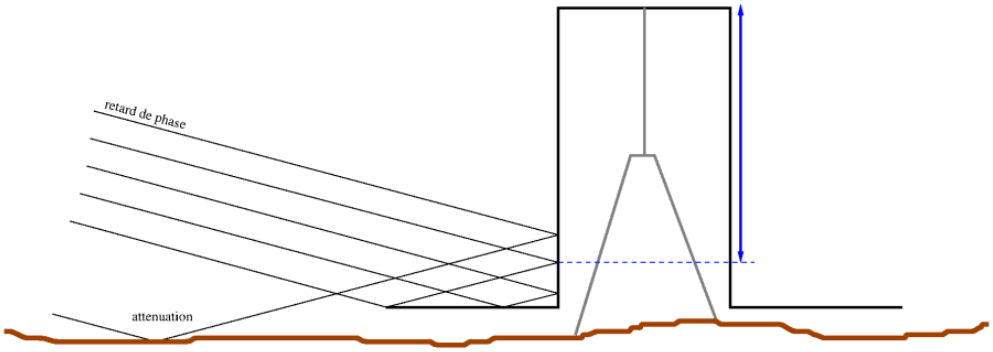
aperture different from the rectangle obtained in monostatic case

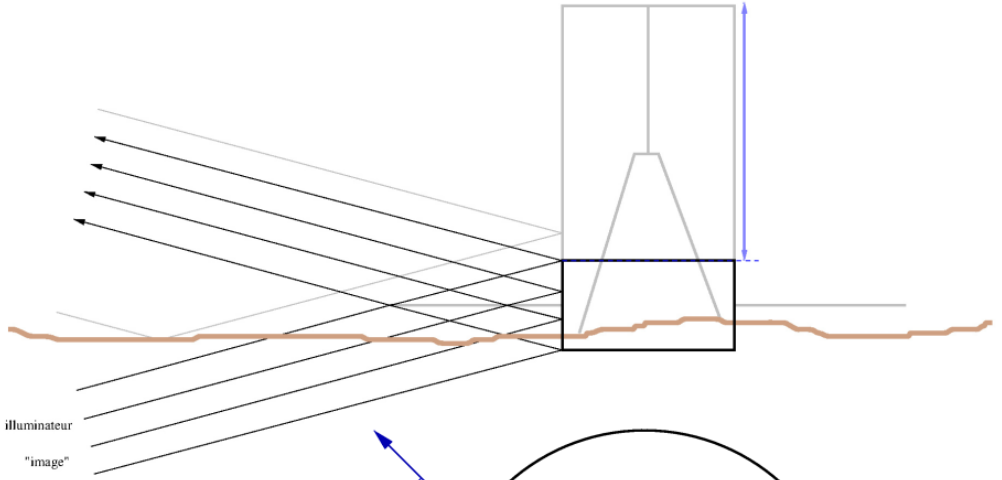


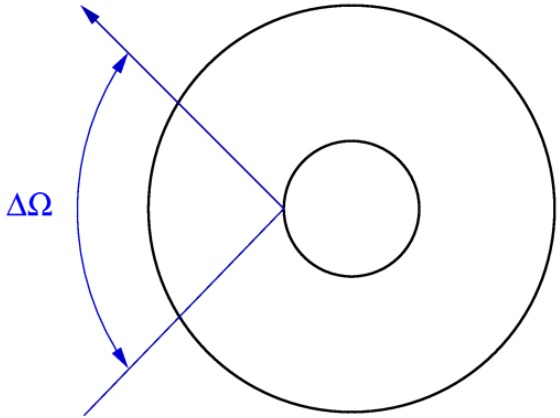
+ linear phase on aperture (bistatic angle)

+ angle between V-axes of Tx and Rx antennae (different pitch angle for the 2 aircraft)

Bistatic G.O. RCS models for canonical targets







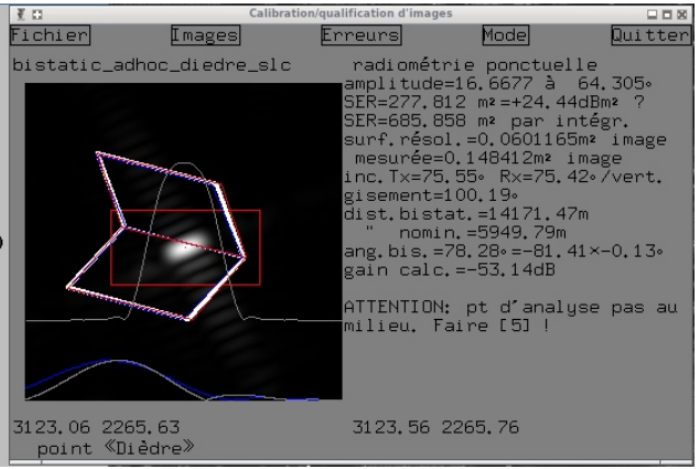
Bistatic G.O. RCS models for canonical targets

Orientation accuracy of the canonical target ≈ 1° elevation (mason level acc. ≈ 0.5°) and ≈ 8° heading (navy standard for magnetic compass).

Bistatic RCS highly sensitive to orientation. However relative Tx and Rx LOS known with extremely high accuracy (unit is µRd).

⇒ high RCS sensitivity allows to retrieve canonical target orientation.

```
#point étiqueté n° 1 (Dièdre) sur l'image bistatic_adhoc_diedre_slc
SER max pendant l'intégration: 2364.6 m² (+33.7376 dBm²)
SER intégrale=586.77 m² (+27.6847 dBm²)
réponse max I=-14.7932 Q=0
 amplitude=14.7932 section efficace=218.838 m²=+23.4012 dBm²
 phase=180 °
 aberration azimut=+0 m (vers l'avant)
 incertitude sur l'amplitude 100.289% (15.035 à 0.199092)
 incertitude sur la section efficace 103.277% (226.05 à 0.0396378 m²)
                                soit 37.5609 dB (-14.0189 à +23.542 dBm²)
 incertitude sur la phase 267.143 ° (-185.22 à 81.9231 °)
```



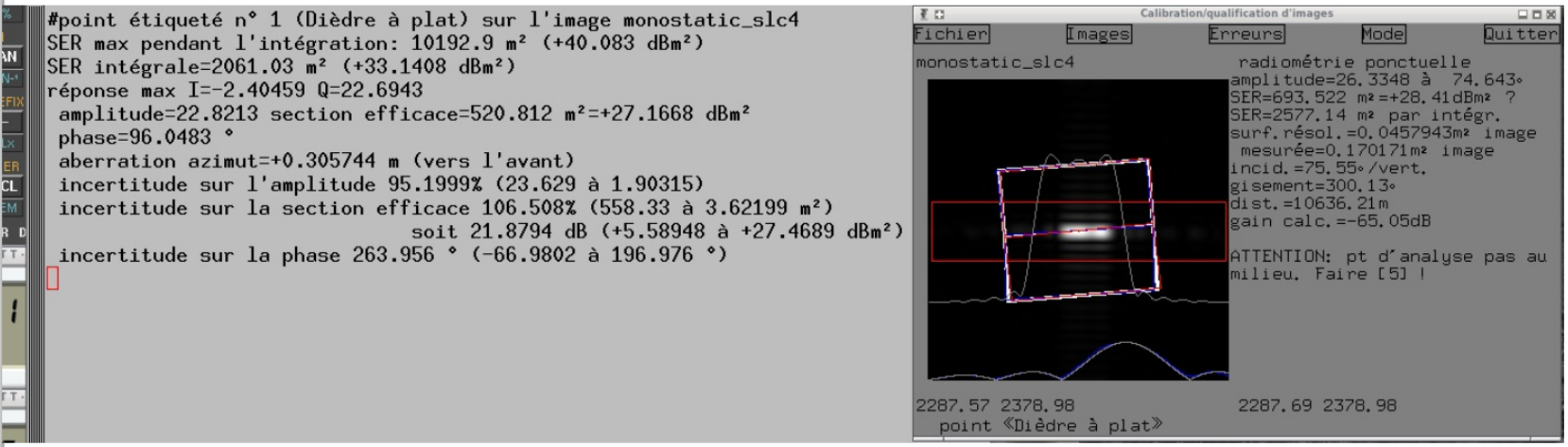
example of calibration with dithedral at 80° bistatism.

Bistatic G.O. RCS models for canonical targets

Orientation accuracy of the canonical target ≈ 1° elevation (mason level acc. ≈ 0.5°) and ≈ 8° heading (navy standard for magnetic compass).

Bistatic RCS highly sensitive to orientation. However relative Tx and Rx LOS known with extremely high accuracy (unit is µRd).

⇒ high RCS sensitivity allows to retrieve canonical target orientation.



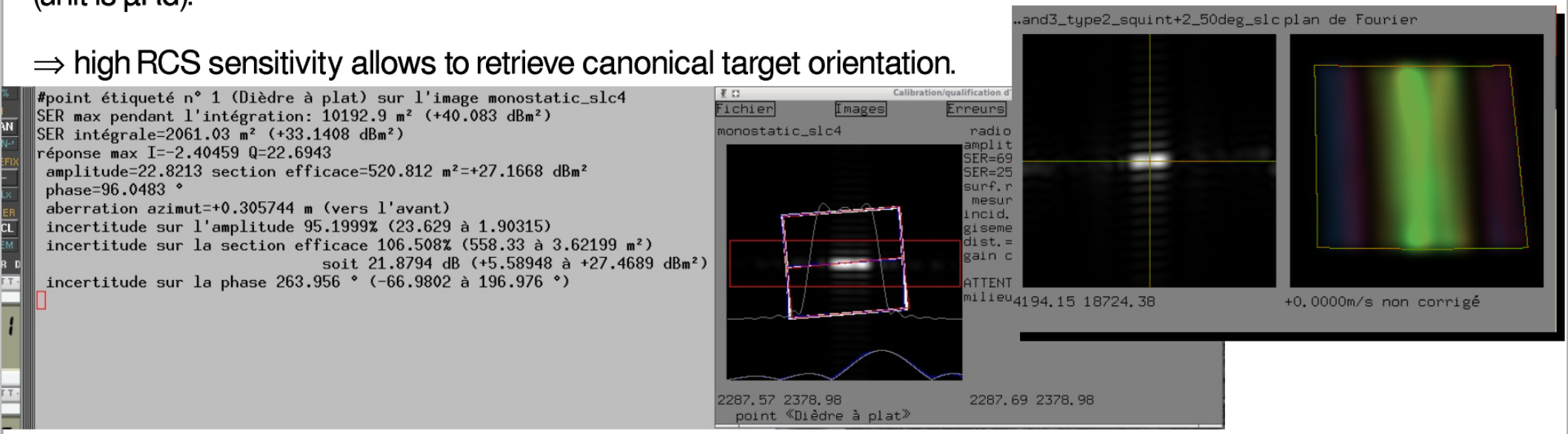
example of monostatic calibration with dithedral.

Bistatic G.O. RCS models for canonical targets

Orientation accuracy of the canonical target ≈ 1° elevation (mason level acc. ≈ 0.5°) and ≈ 8° heading (navy standard for magnetic compass).

Bistatic RCS highly sensitive to orientation. However relative Tx and Rx LOS known with extremely high accuracy (unit is µRd).

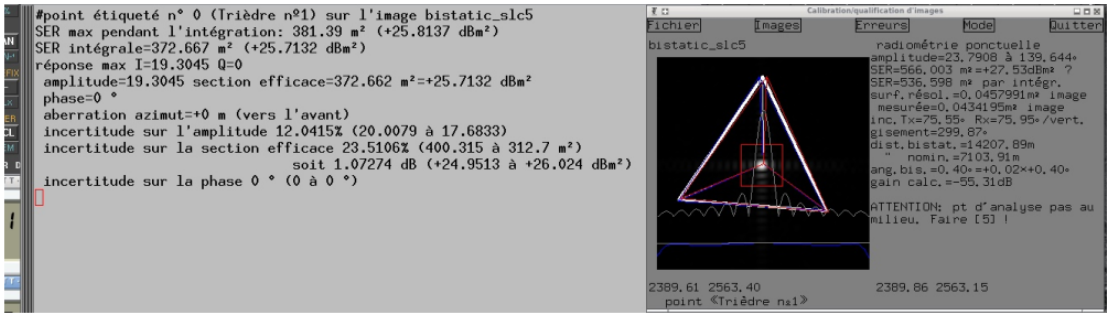
⇒ high RCS sensitivity allows to retrieve canonical target orientation.



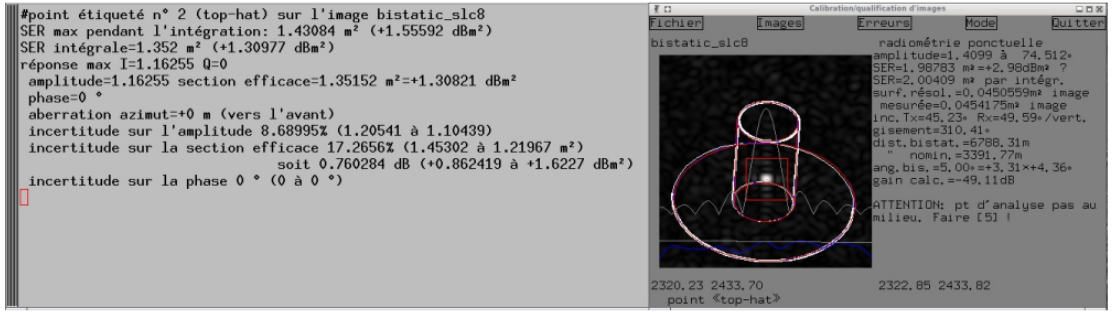
example of monostatic calibration with dithedral.

Bistatic G.O. RCS models for canonical targets

Dihedral prefered target (orientation recovery easier and top RCS). Corner reflector RCS collapses with even small bistatism, top-hat RCS is low, contaminated with clutter reflexion and sensitive to $\eta_T - \eta_R$.



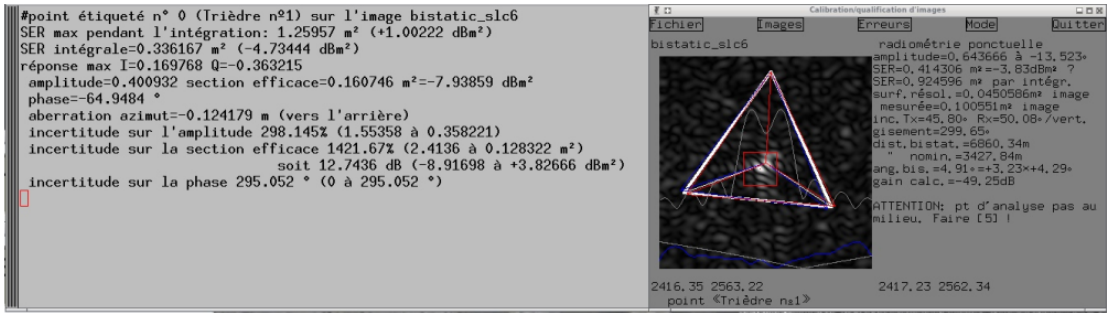
CR @ 15° w. 0° bistatism



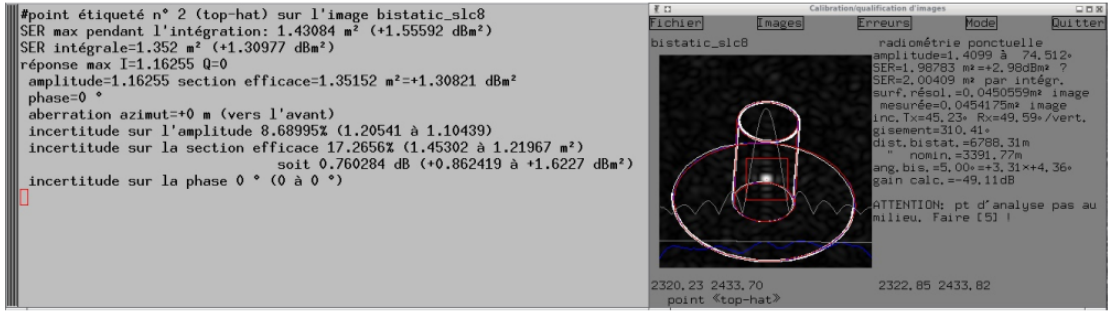
Top-hat @ 45° w. 0° bistatism

Bistatic G.O. RCS models for canonical targets

Dihedral prefered target (orientation recovery easier and top RCS). Corner reflector RCS collapses with even small bistatism, top-hat RCS is low, contaminated with clutter reflexion and sensitive to $\eta_T - \eta_R$.

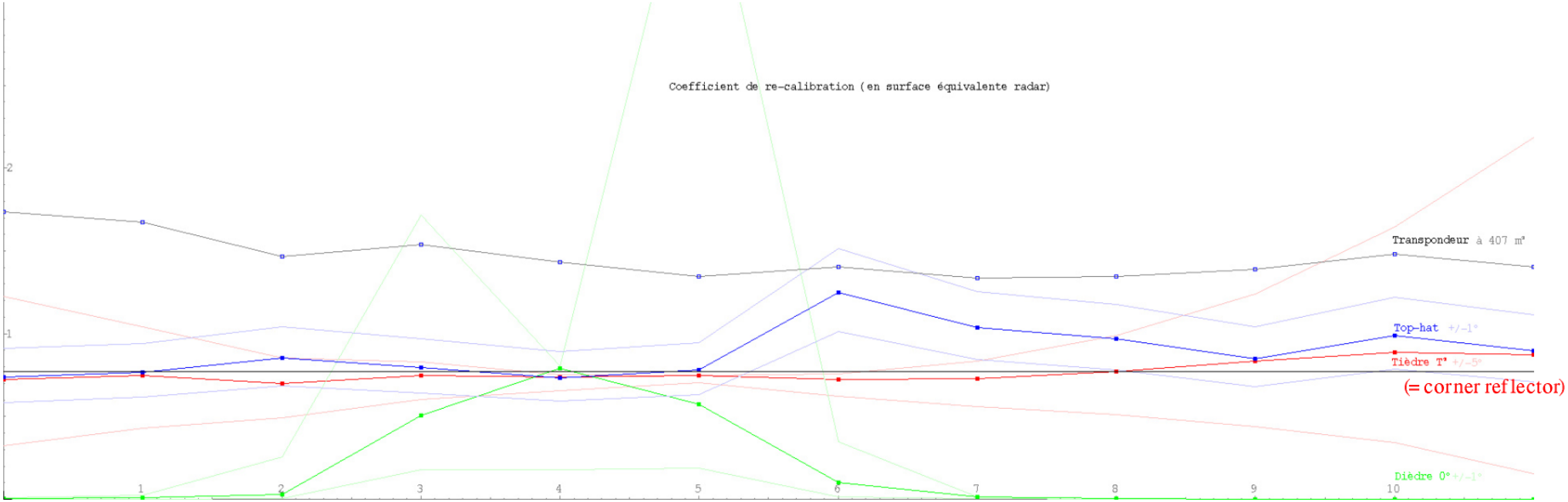


CR @ 45° w. 5° bistatism



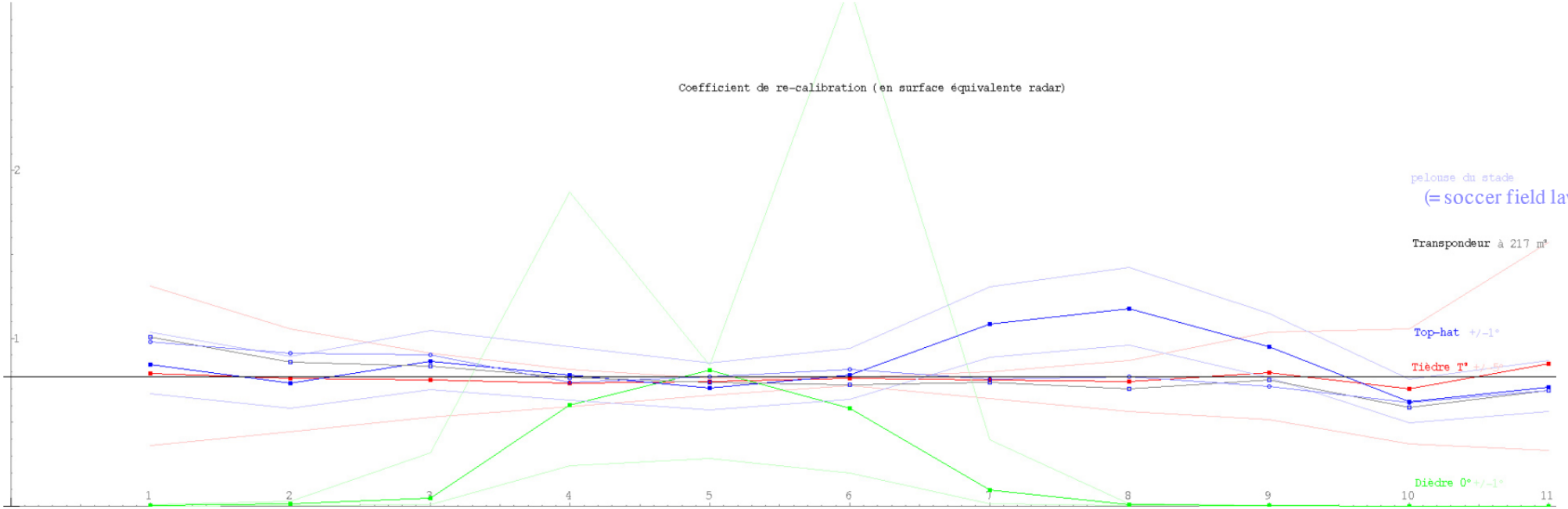
Top-hat @ 45° w. 0° bistatism

Bistatic radiometric calibration: summary



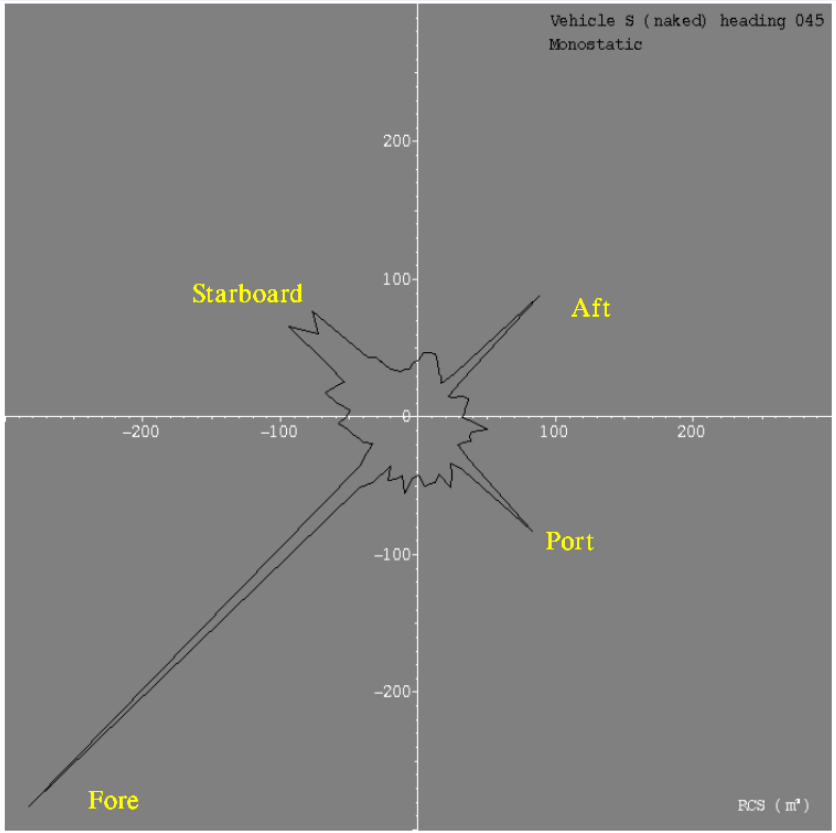
MONOstatic calibration (classical but transponder case) for reference.

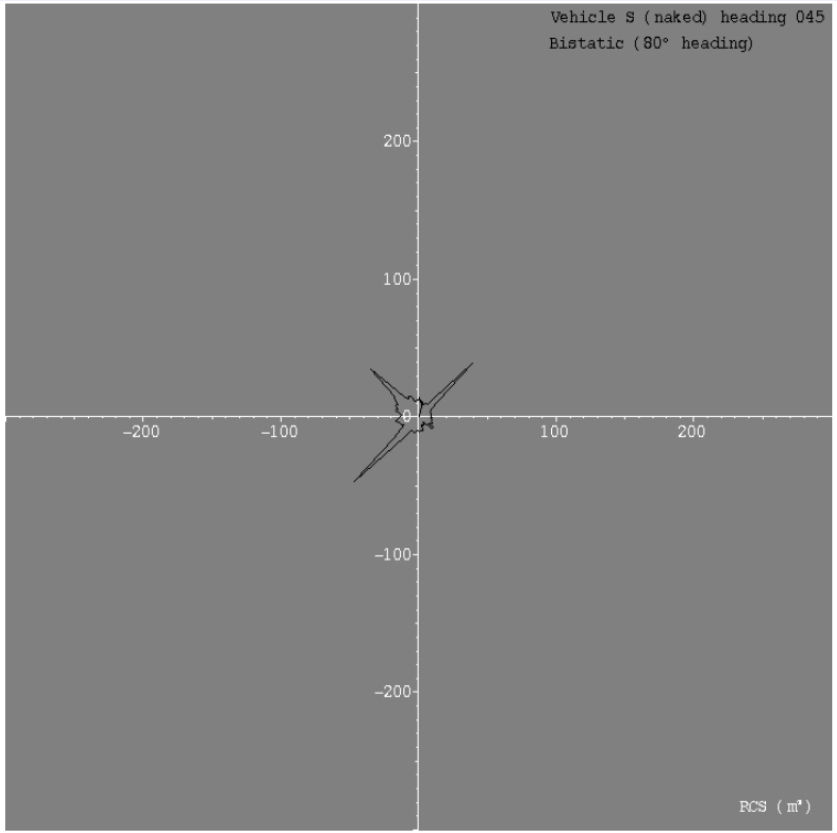
Bistatic radiometric calibration: summary



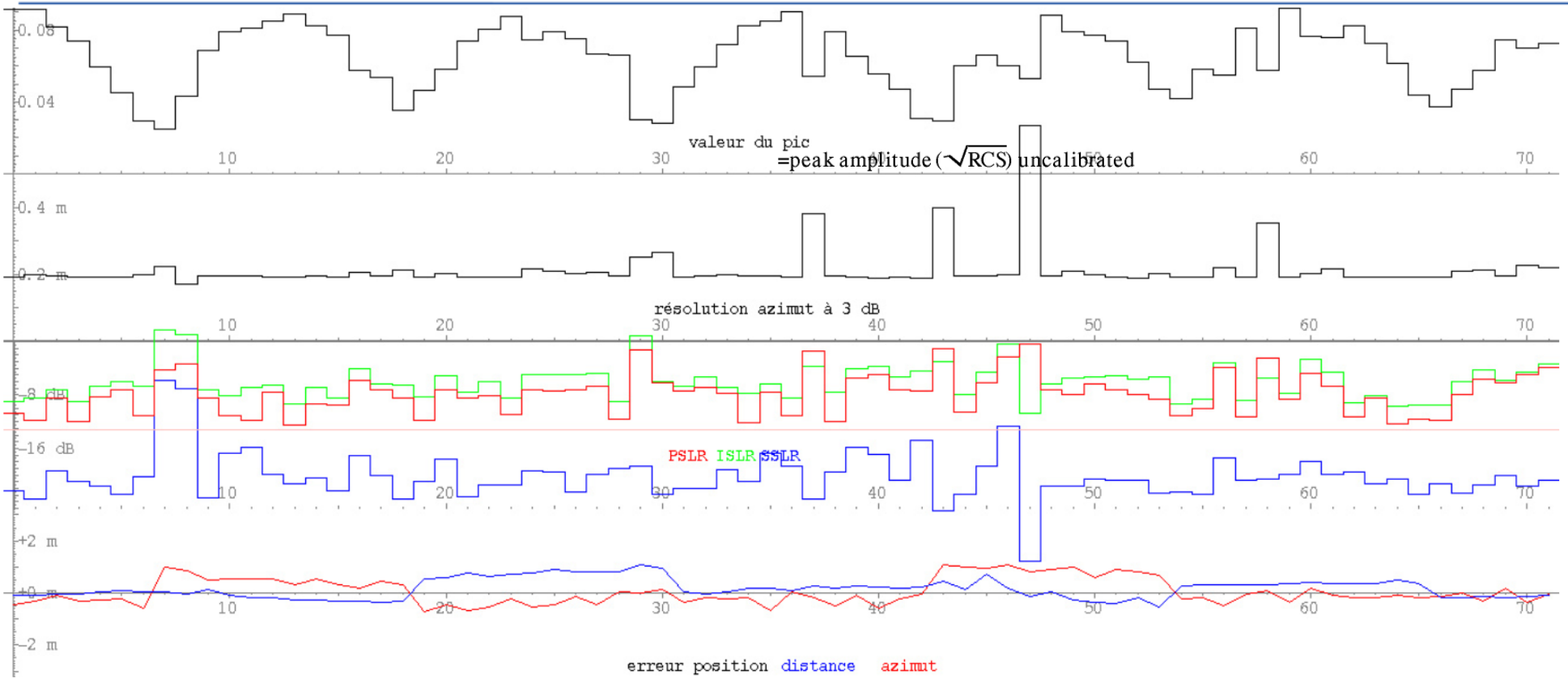
Bistatic calibration (comparison of calibrationg coefficient values & uncertainties)

Example of calibrated result: polar RCS of a ground vehicle





Quality assessment of (bistatic) images

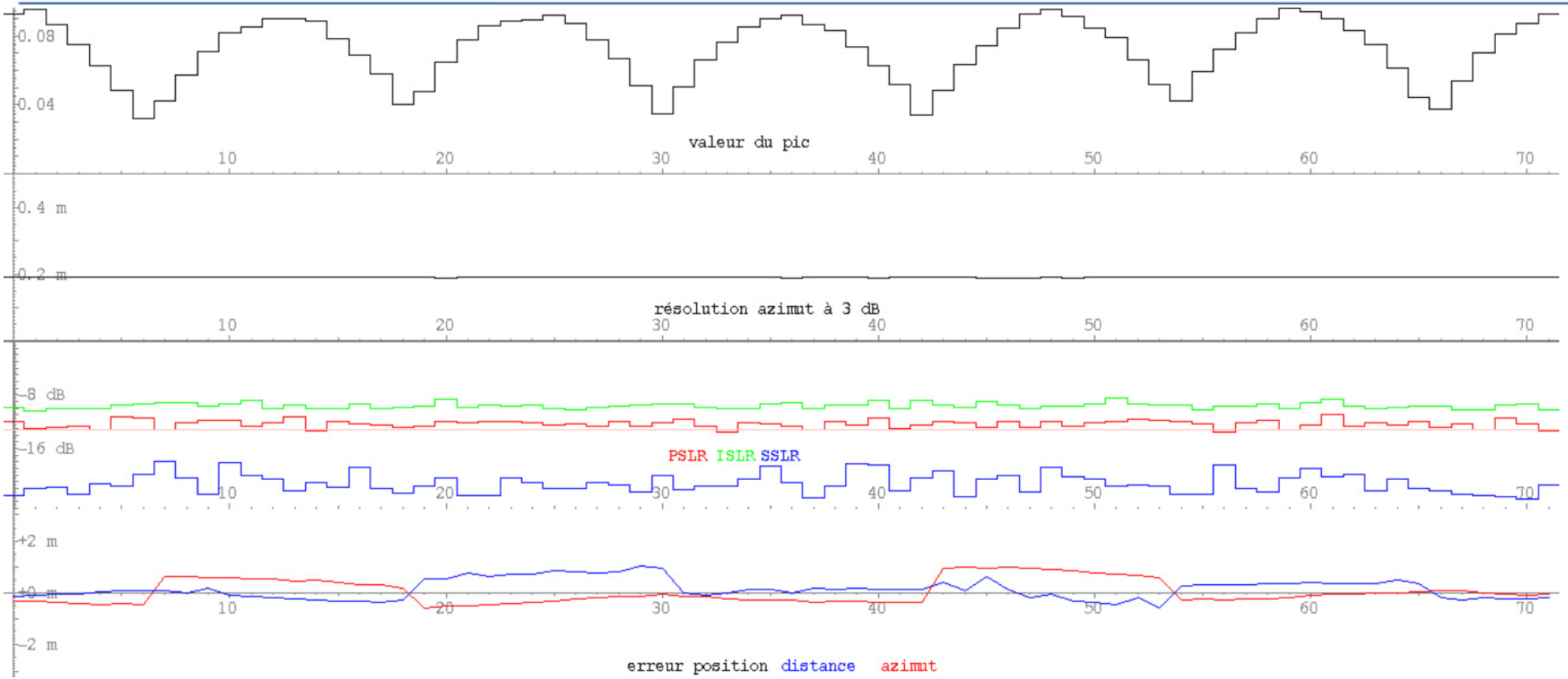


=peak amplitude ($\sqrt{RCS}$) uncalibrated

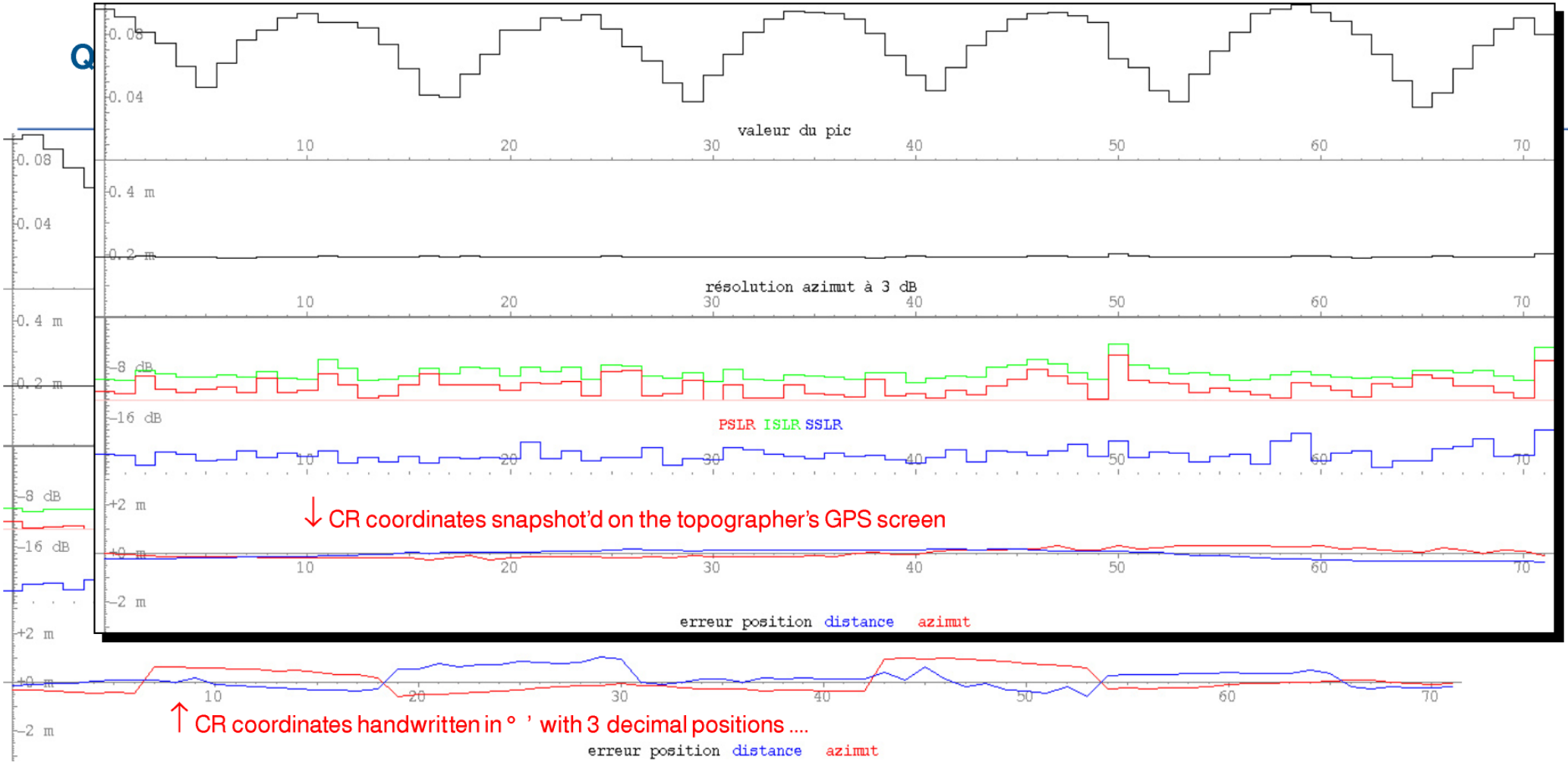
monostatic IQP's (@ 15°) prior to AF

= range/azimuth position error

Quality assessment of (bistatic) images

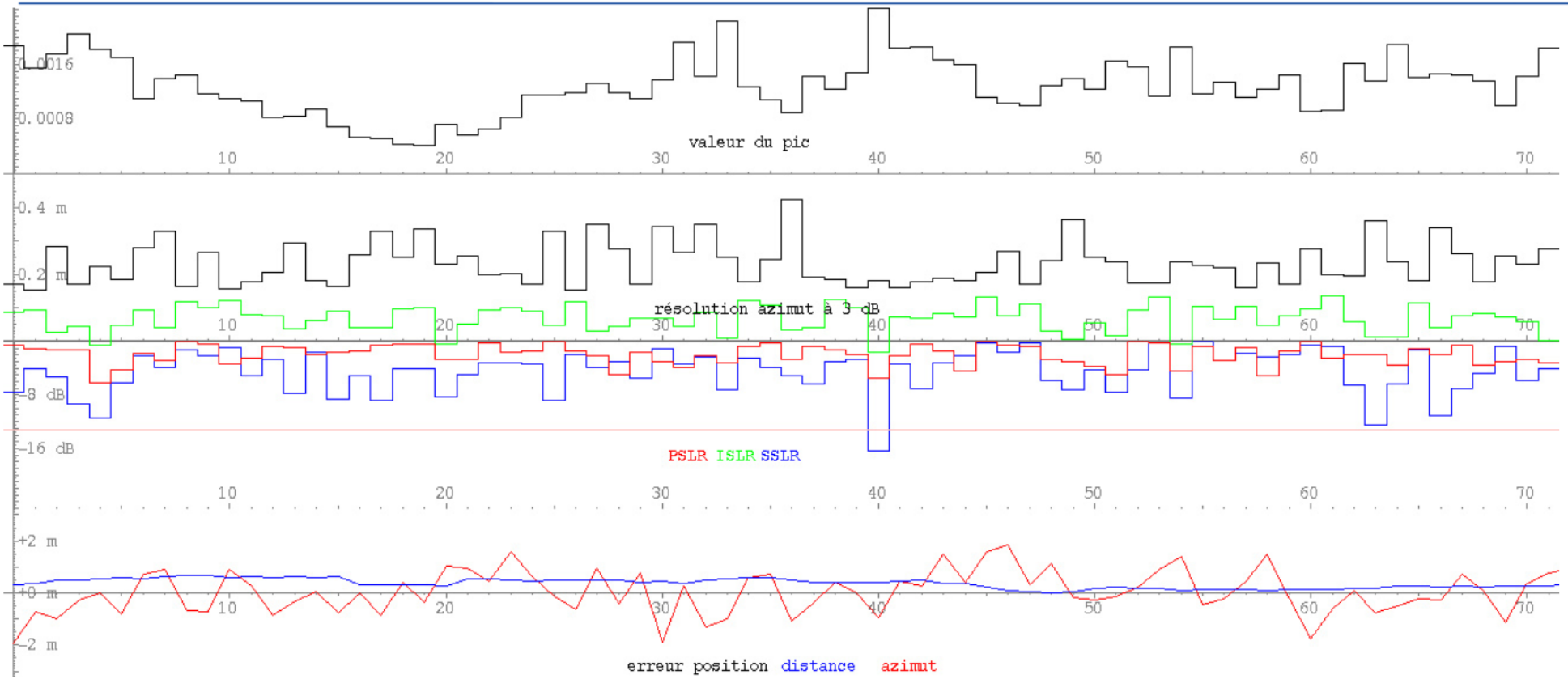


monostatic IQP's (@ 15°) after AF



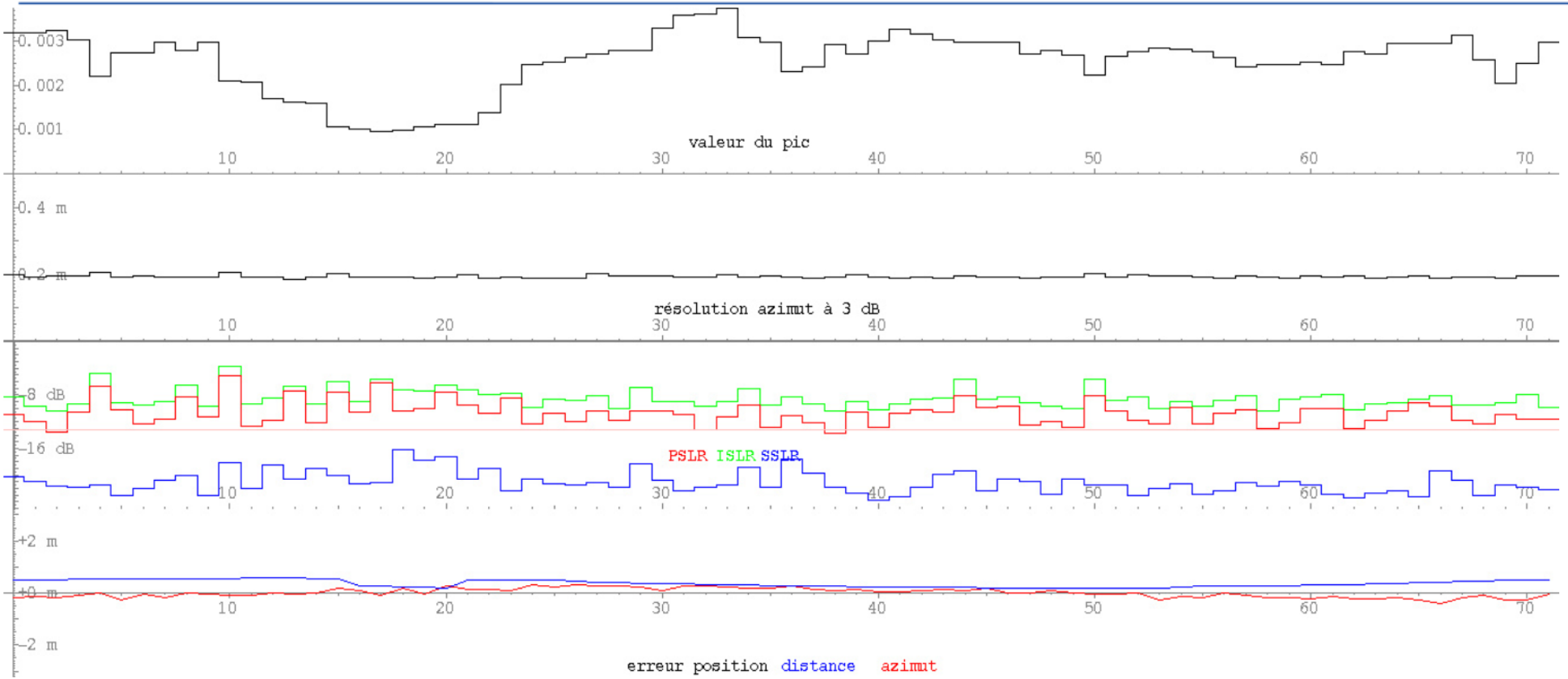
monostatic IQP's (@ 15°) after AF

Quality assessment of (bistatic) images

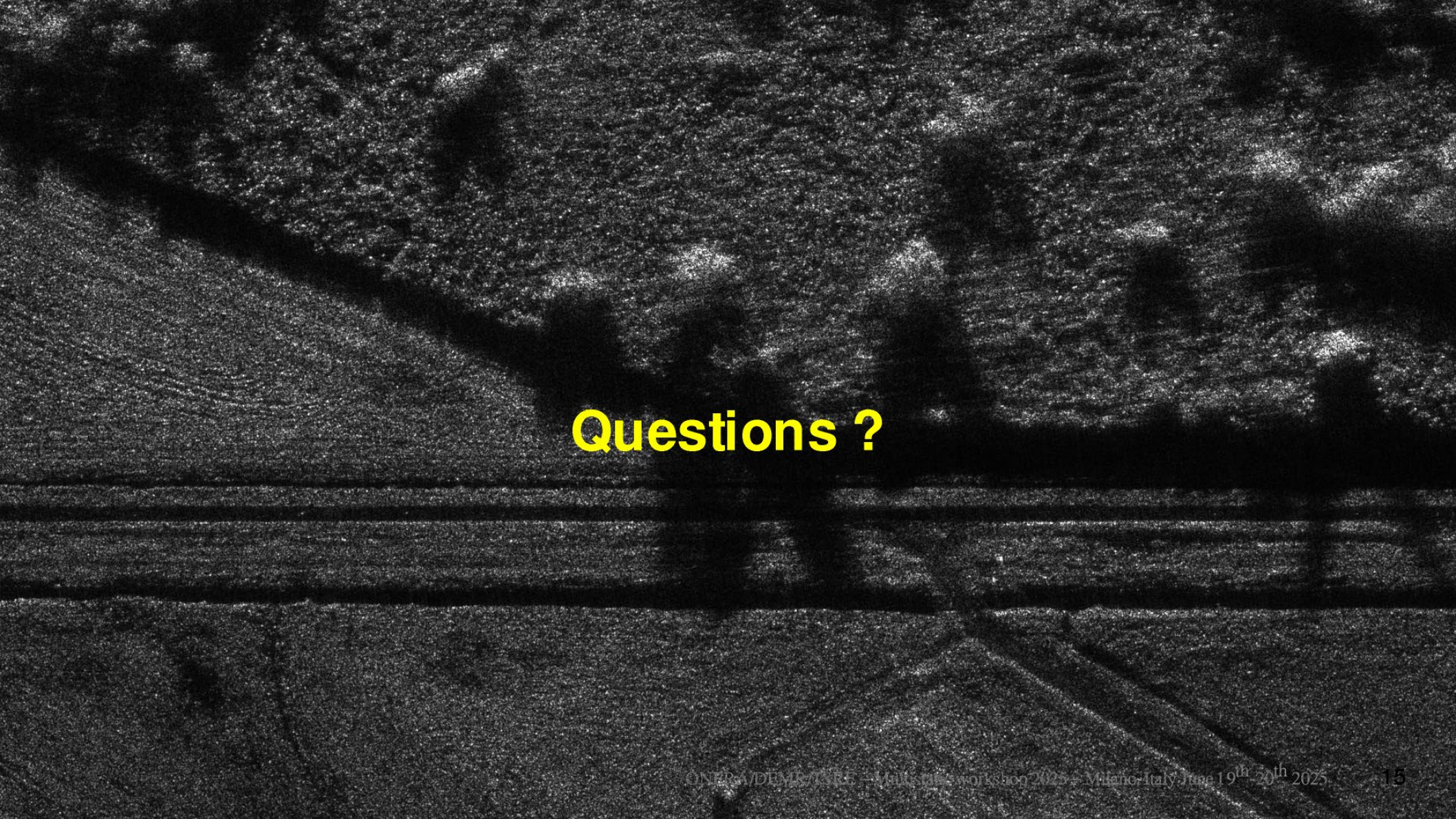


bistatic IQP's (@ 15°) GPS-discipline only

Quality assessment of (bistatic) images



bistatic IQP's (@ 15°) after AF


Questions ?