Impact of the antenna diagram approximation in conventional altimetry WF processing

Application to SARAL/AltiKa data

Sophie Le Gac, F. Boy, A. Guillot, J.D. Desjonqueres, N. Picot (CNES)
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OSTST – Reston, VA, USA – October 20-23, 2015

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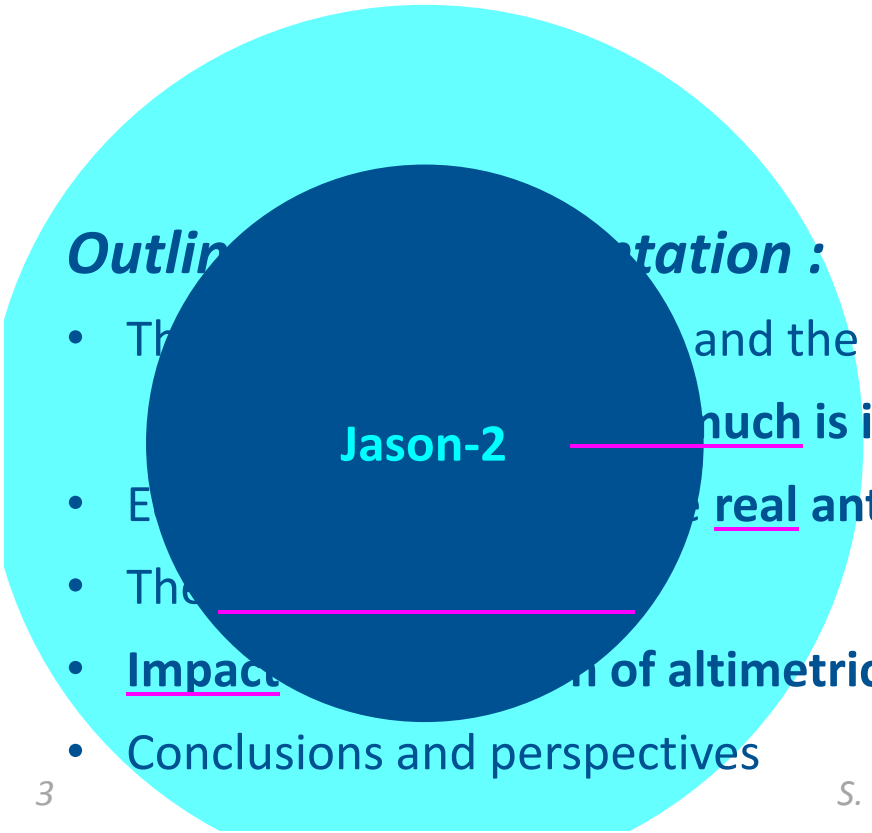
Introduction

In current ocean retrackers using the Brown model :

Altimeter's antenna diagram ≈ Gaussian

What about **possible distorsions** in the antenna diagram ? Or **narrow antenna beamwidth** ?

Antenna beamwidth footprint (« θ_{3dB} ») ≠ Waveform footprint



Outlin tation :

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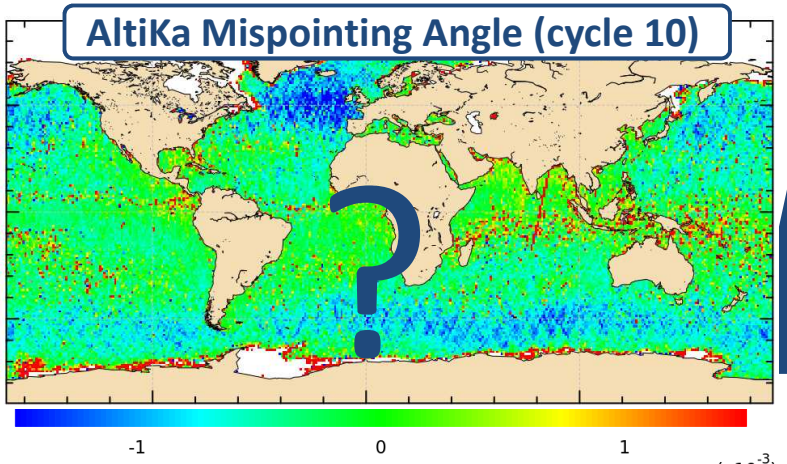
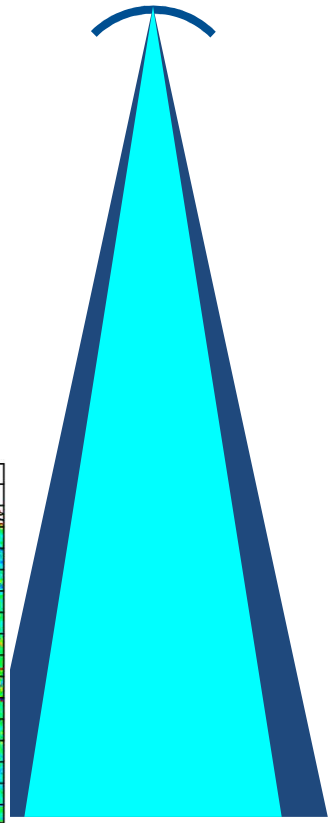
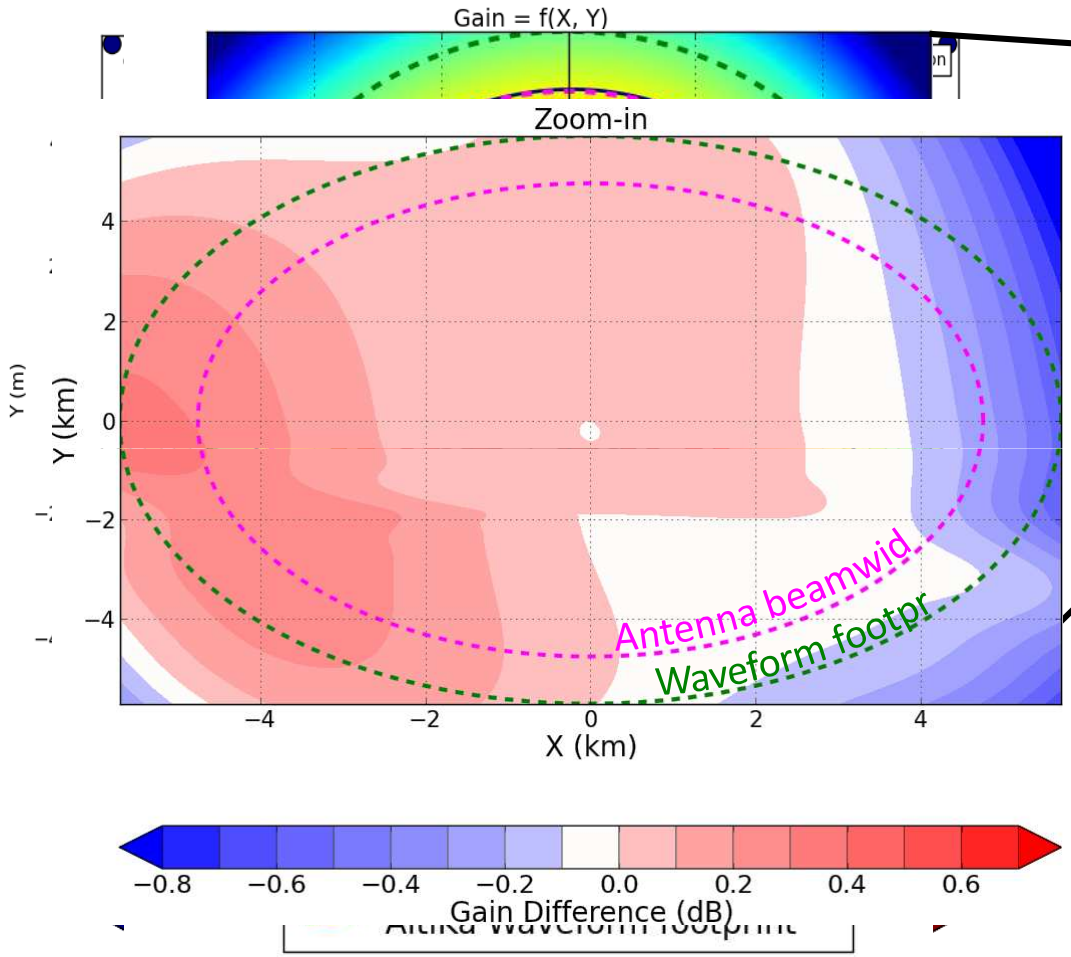
- **Impact n of altimetric p**
- Conclusions and perspectives



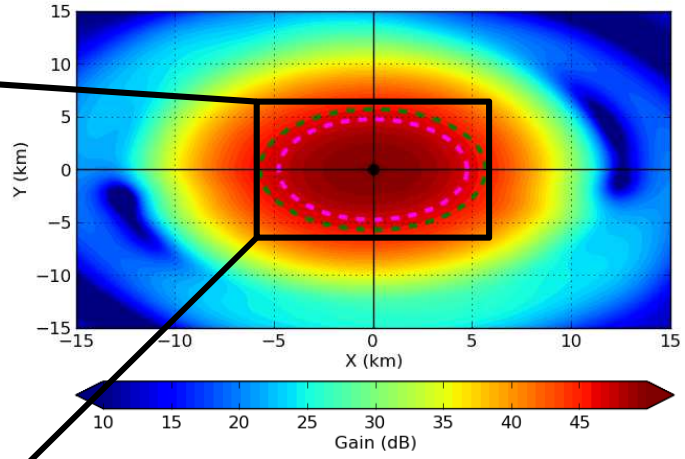


What does AltiKa antenna diagram look like ?

- **Measurement** during AIT tests in TAS facilities in Cannes



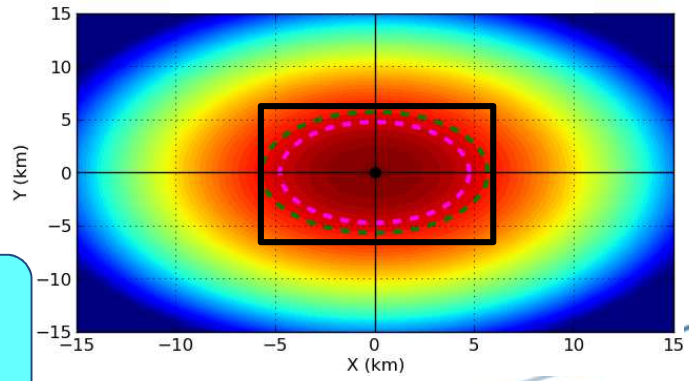
- **Interpolation**



→ Max gain position at nadir

→ *Max-3dB* does not perfectly match the theoretical θ_{3dB} ring

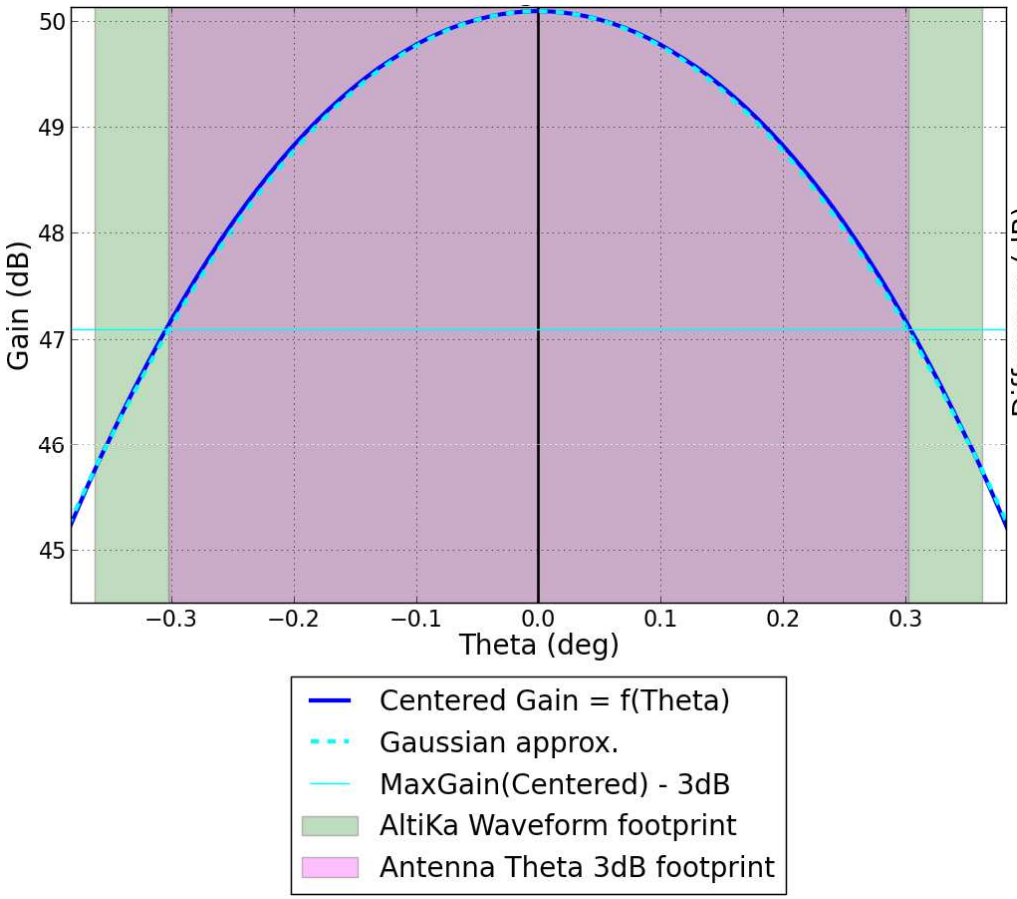
- **Comparison** with a Gaussian diagram



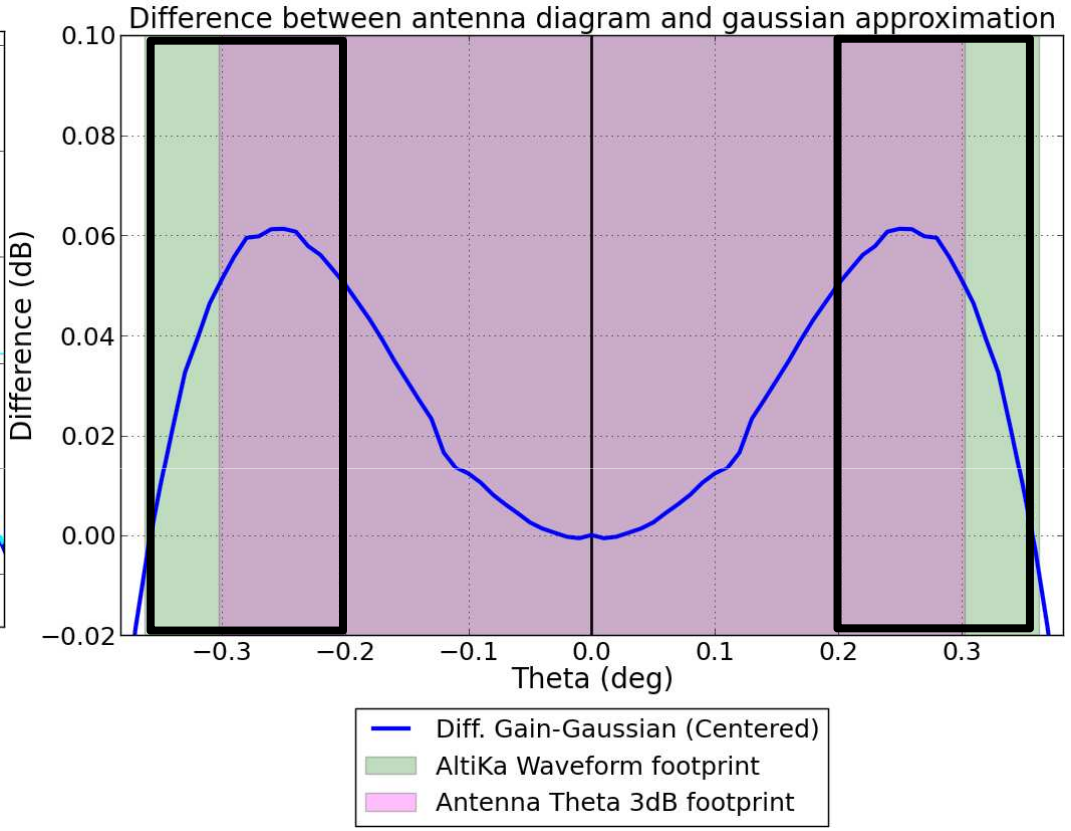
Gain difference reaches 0.5 dB locally
Gain difference is not homogeneous in the waveform footprint

The antenna diagram and the Gaussian approximation

- **1-D Projection** on Theta angles :



- **Difference :**



Average gain difference in function of view angle reaches 0.06 dB on the edges of the waveform footprint

Echo simulations [1/3]

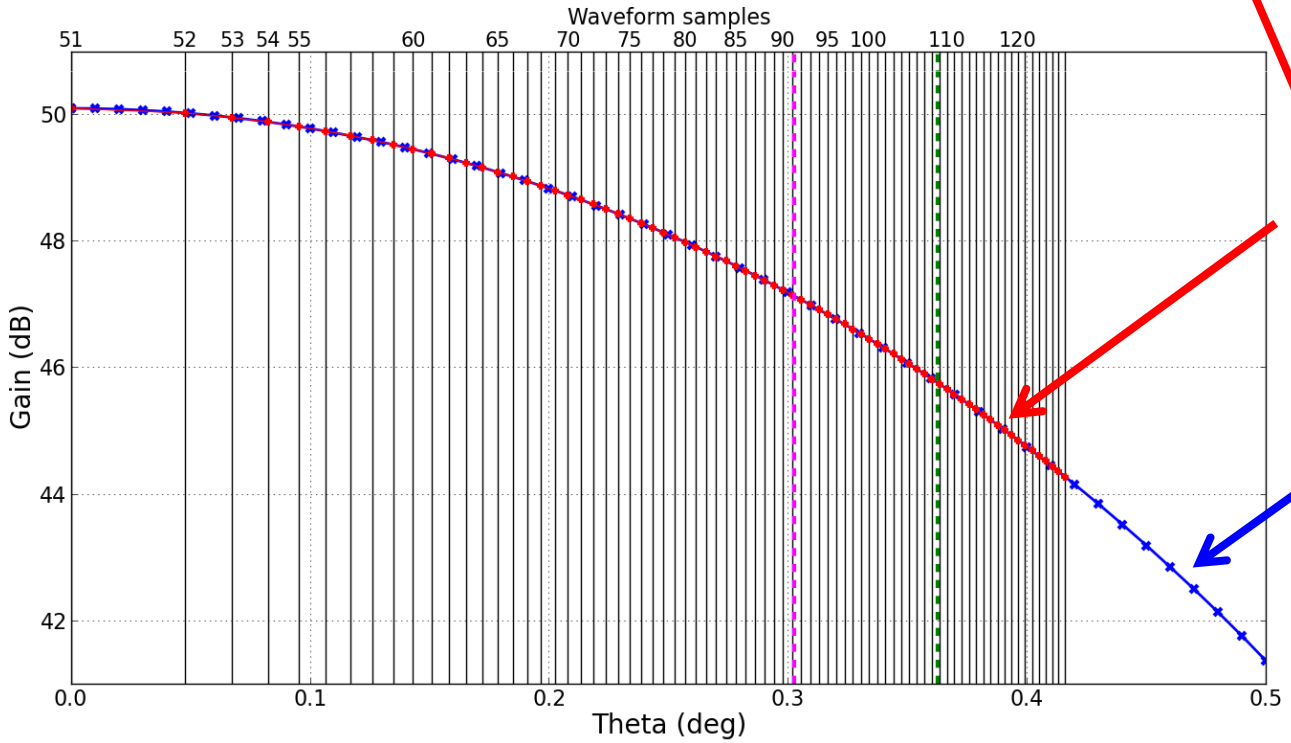
$$S(t) = \boxed{FSSR(t)} \otimes PTR(t) \otimes PDF(t)$$

PTR: Point Target Response
PDF: Probability Density Function

- The antenna gain is in the **Flat Sea Surface Response** (FSSR) function of the Brown Model

$$\mathrm{FSSR}_{\mathrm{theo}} = \mathrm{Ampl} \times \exp(f(\theta_{3dB})) \times \exp(-\alpha T) \times I_0(\ldots)$$

→ 1-D Projection of the real antenna gain on the waveform samples (range gates) :



Polynomial approx.

Measured antenna gain

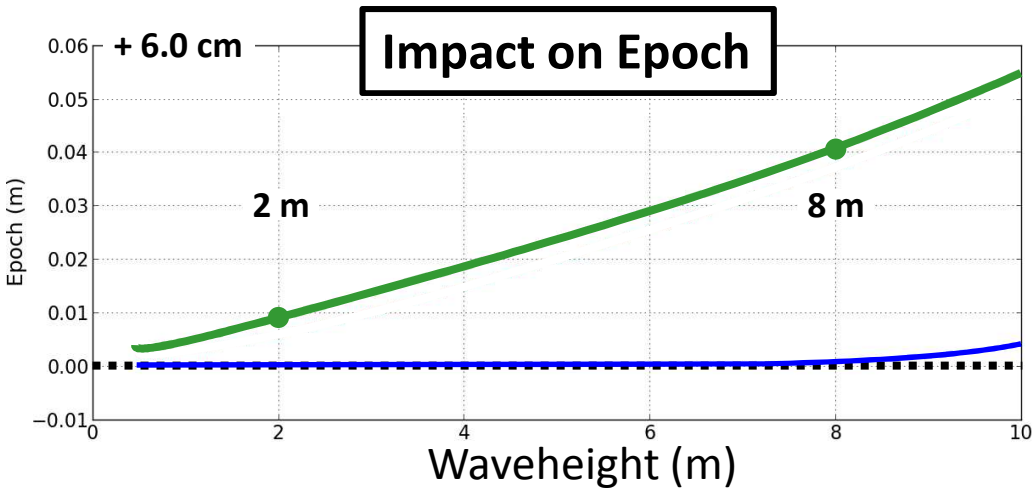
Echo simulations [2/3]

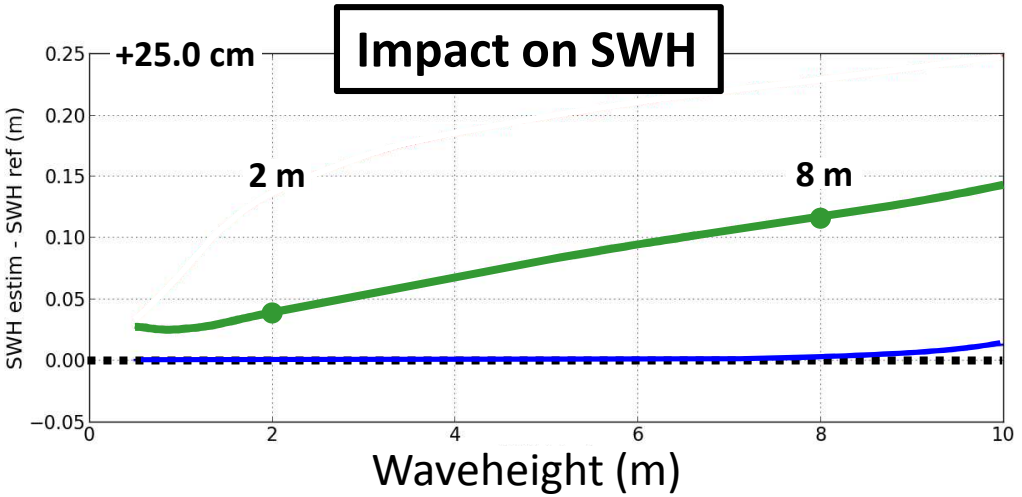
Different echoes are simulated using **double convolution** : $S(t) = FSSR(t) \otimes PTR(t) \otimes PDF(t)$

Gaussian Gain ⊗ Gaussian PTR ⊗ PDF ⇔ current

Real Gain ⊗ Gaussian PTR ⊗ PDF ⇔ impact of AltiKa antenna gain

The impact is the difference between MLE-4 estimate and expected (input) value :





Direct impact of the antenna diagram on Epoch (range) :
1 cm @2m SWH
4 cm @8m SWH
0.5% SWH

Direct impact of the antenna diagram on SWH :
4 cm @2m SWH
12 cm @8m SWH
1.3% SWH

Echo simulations [3/3]

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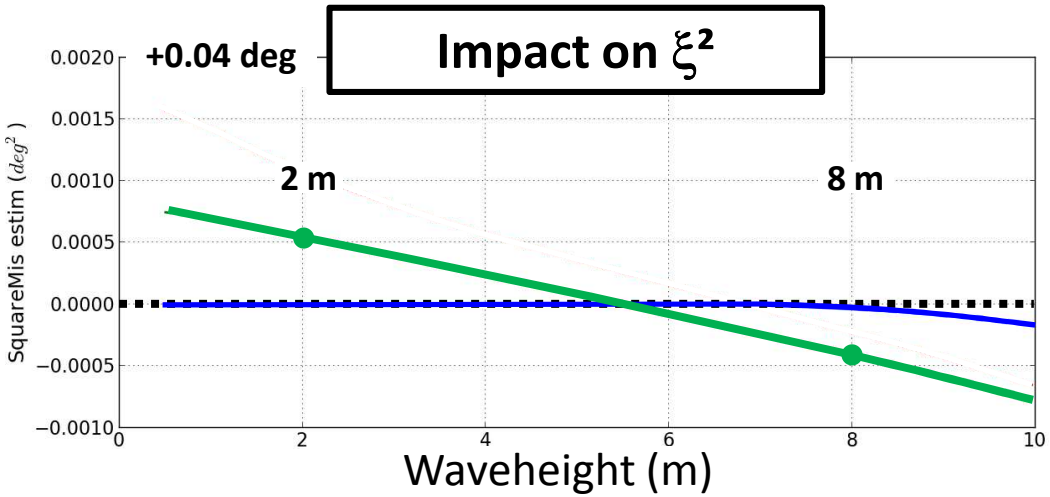


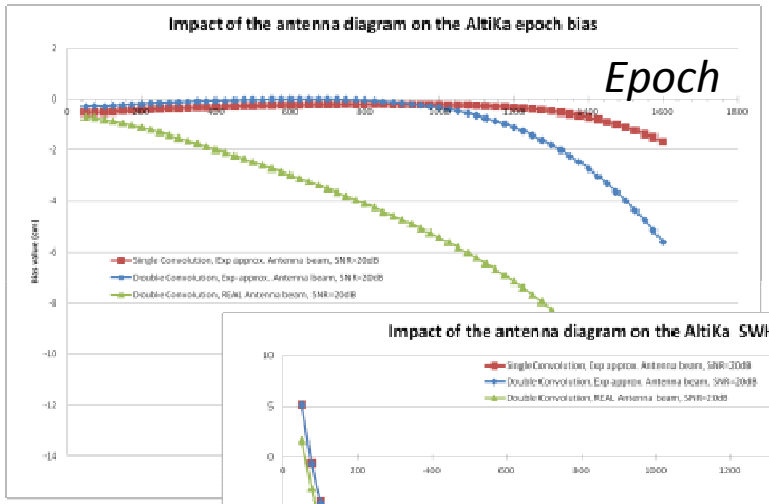
Direct impact of the antenna diagram on mispointing angle :
+ 0.02° @2m SWH
– 0.02° @8m SWH

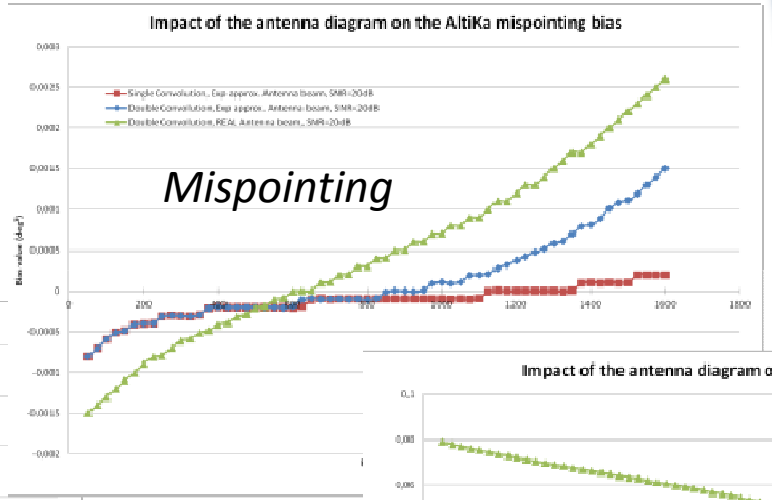
The impacts are important !
How do we take them into account ?

Correction strategy : Update of the Look-Up Tables

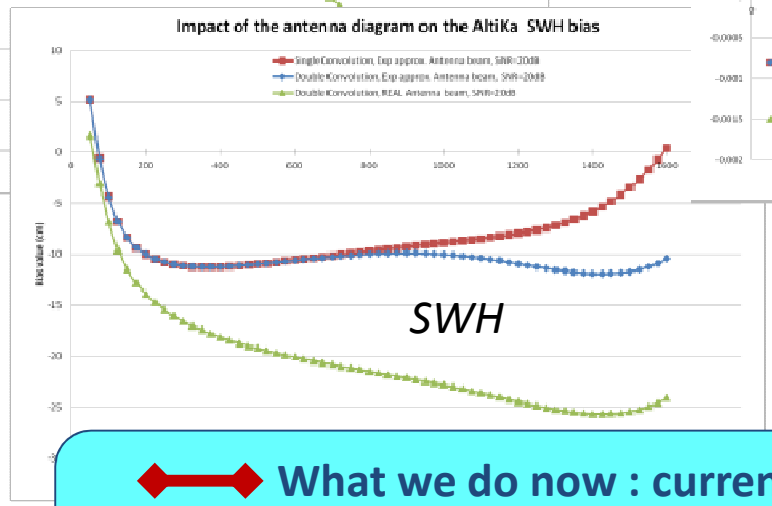
In the **PEACHI product**, a correction will be applied to account for AltiKa antenna diagram impact :

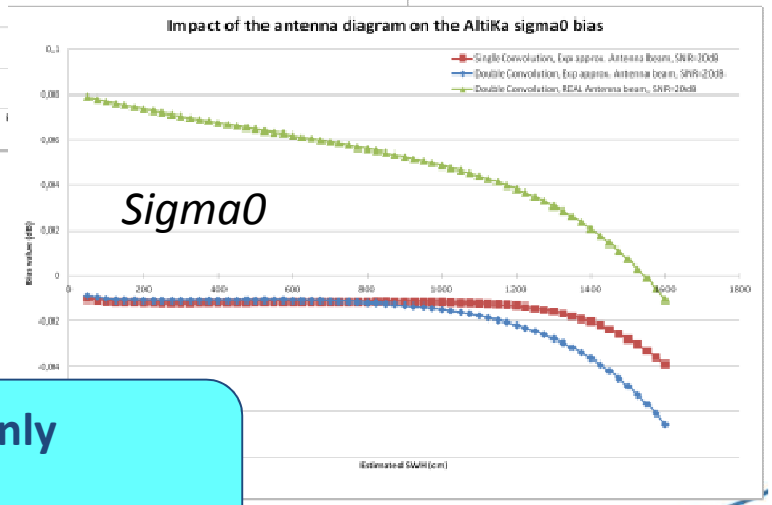
- Antenna diagram used as polynomial interpolation projected on the waveform samples
- LUT computation
- Correction of MLE-4 estimates : **Epoch, SWH, as well as Mispointing and Sigma0**





Different from PTR LUTs only !



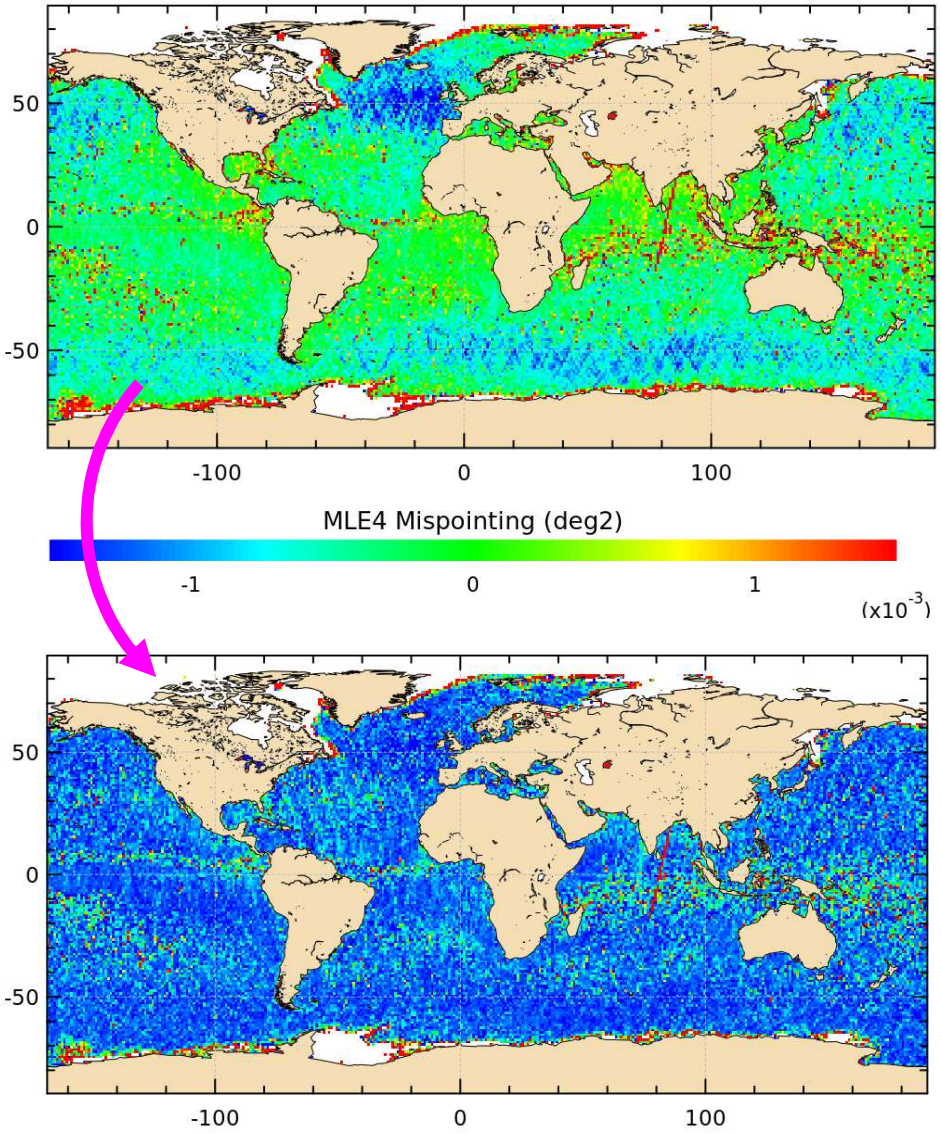


What we do now : current LUTs, PTR only

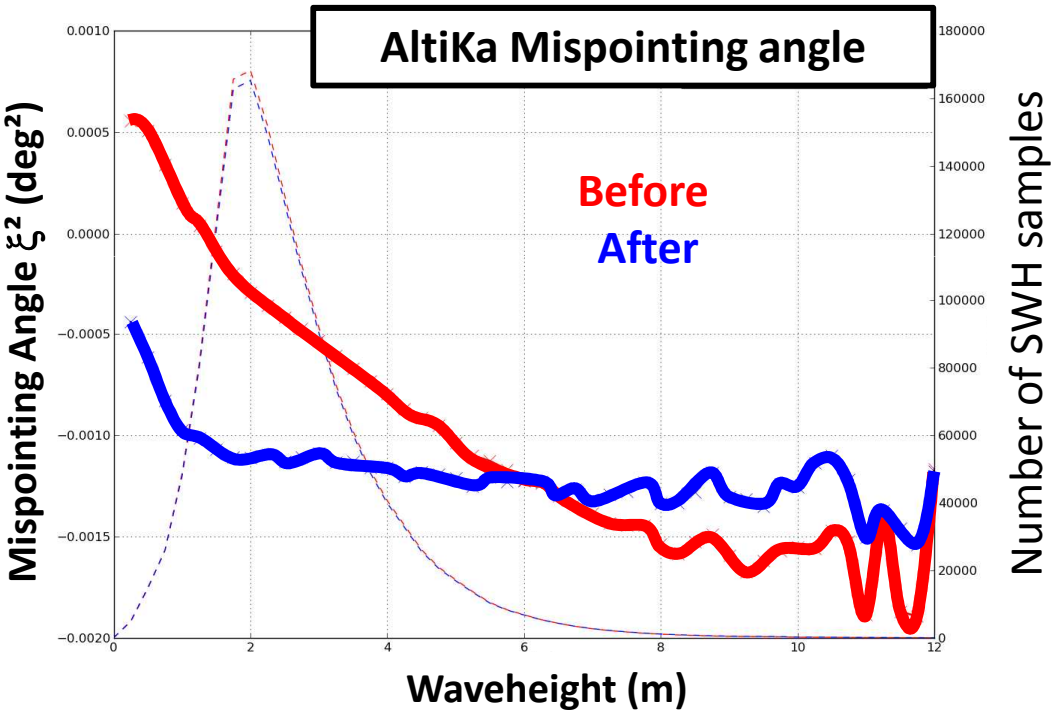
… What we can (and will) do :

Correction of both PTR and antenna diagram

Results on AltiKa data (Cycle 10) : mispointing angle



In the current product, a **high dependency in function of the waveheight** is observed on the **mispointing angle** estimation (not explained by platform mispointing)



Dependency highly reduced

cnes

Conclusions and perspectives [1/2]

Gaussian approximation and the case of AltiKa

- The antenna diagram is currently approximated using Gaussian distribution (in the FSSR of the Brown Model)
- AltiKa's antenna has a small footprint : narrower than the waveform footprint
- AltiKa real antenna pattern shows differences with the Gaussian approximation (up to 0.6 dB locally in the waveform footprint)
- AltiKa antenna diagram has been interpolated on the waveform samples and included in the Brown model

Impact on MLE4 retracking estimates :

- The impact of the Gaussian approximation is **important** :
  - → **0.5% SWH on Epoch (1-4 cm)**
  - → **1.3% SWH on SWH (4-12cm)**
  - → **Up to 0.02° on mispointing**

Results on AltiKa

- Look-up tables have been computed, using the real AltiKa antenna diagram, to correct for this impact
- The retrieved mispointing angle dependency wrt SWH has been **strongly reduced**

Le Gac et al. Paper in prep

→ The PEACHI prototype, delivering experimental AltiKa products, will include this correction in its next release

See PEACHI poster (G. Valladeau)

Conclusions and perspectives [2/2]

Current understanding

- **The SLA products are OK !**
- … Because the impact of the antenna diagram is « absorbed » in the Sea State Bias (SSB) correction
- With the antenna taken into account, we foresee that Ka SSB < Ku SSB, as expected from theory

Antenna diagram correction strategy

→ Correction using Look-Up Tables (cf. PEACHI)

- LUT approach is relevant because the antenna diagram is stable
- Offline computation, easy to implement in the ground segment processing
- As a result, SSB correction closer to expected physical behavior (cf. SSB computed for PEACHI)

→ Numerical retracking

- Would be the finest solution
- Convolution with real antenna pattern is highly time consuming (requires oversampling by 16000)

See PEACHI_J3 poster (S. Le Gac)

What about Ku-band altimeters ? E.g. Cryosat-2, Jason-3, Sentinel-3…

- Same study has been conducted on Jason-3 :
  → **impact on retracked estimates is much lower than AltiKa**: **0.1% SWH on Epoch**, **0.4% SWH on SWH**
- It has to be studied on Cryosat-2 because of the ellipticity of its antenna pattern (according to ESA)

This correction is a potential candidate for future updates of GDR standards on AltiKa and Jason.
High potential for all altimetry missions, LRM and SAR modes

Thank you for your attention

Don’t forget on Thursday,
IPM poster session…

PEACHI_Jason-3
Sophie Le Gac
=> IPM_003

PEACHI (AltiKa)
Guillaume Valladeau
=> IPM_004

Echo simulations [2/3]

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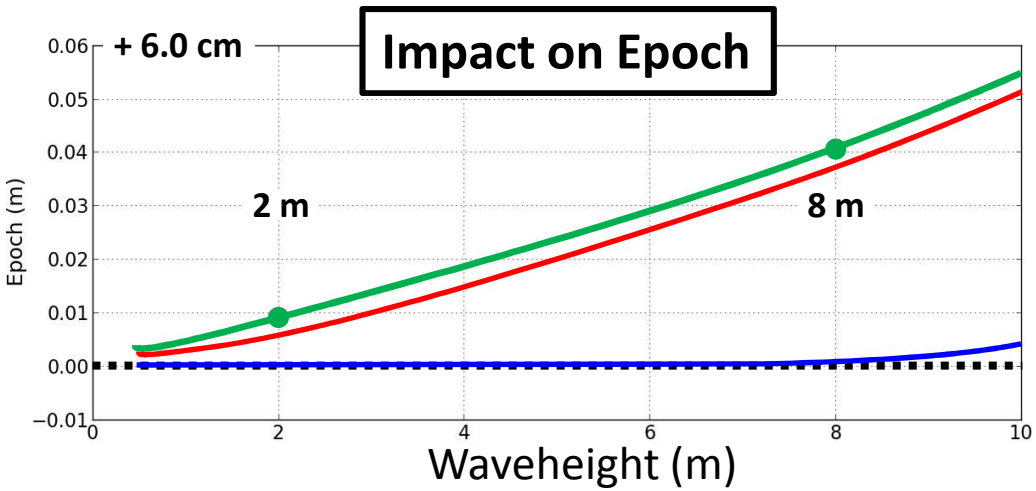

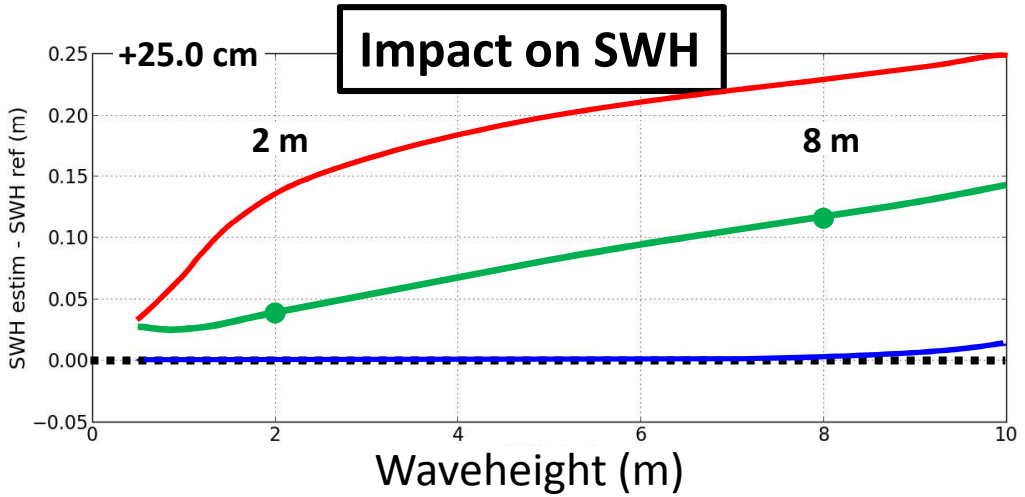

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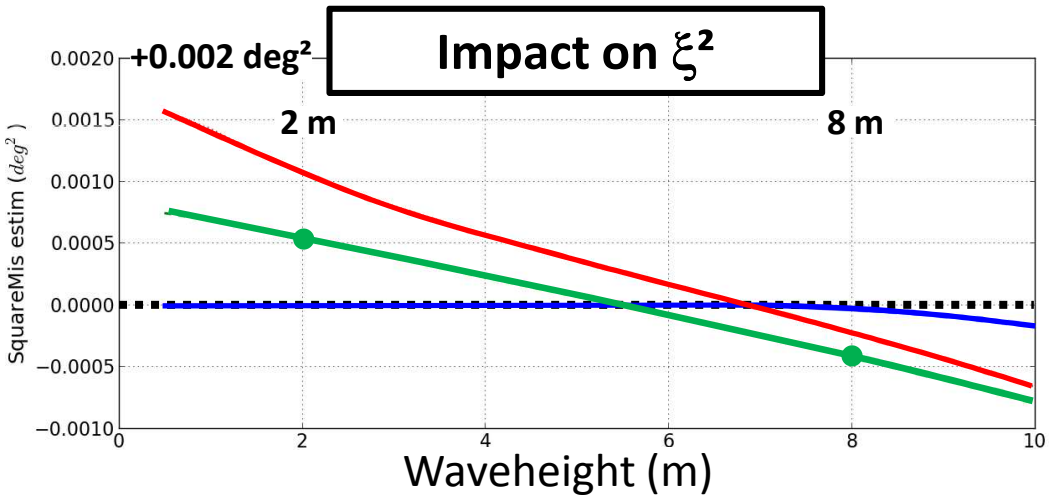

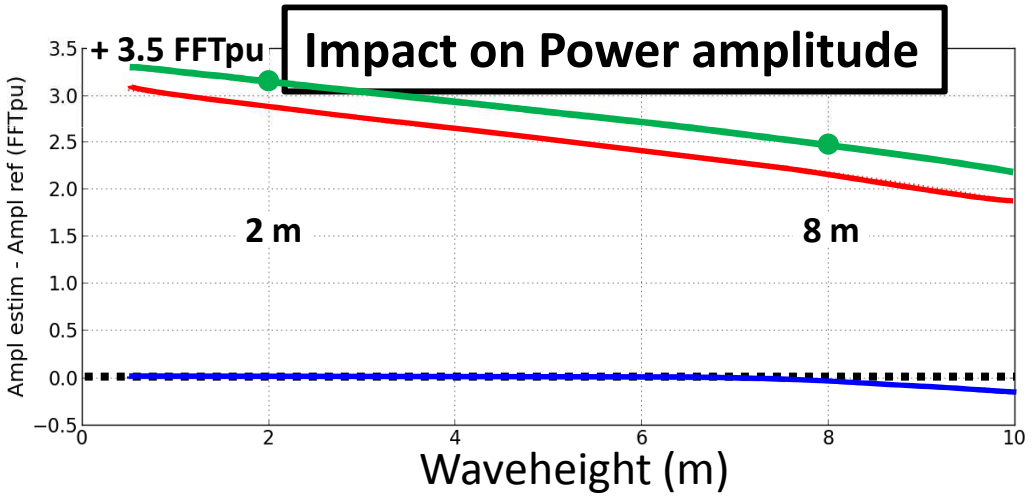

Direct impact of the antenna diagram on mispointing angle :
+5.0e^{-4} deg² @2m SWH
-5.0e^{-4} deg² @8m SWH

Direct impact of the antenna diagram on Power amplitude (Sigma0) :
3.1 FFTpu @2m SWH
2.5 FFTpu @8m SWH