SAMOSA
Final Project Presentation

Session 5

Further development of SARM waveform model and data re-tracking applications with the refined model

Project funded by ESA under the STSE programme:

SAMOSA

Session 5.1
- Refined model: Overview

Session 5.2
- Numerical assessment of improvements due to return waveform model evolution

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Refined model: Overview

SAMOSA2 waveform model

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Motivation

From the results shown under session 4.2 we have seen:

–SAMOSA1 waveform model has an almost two-fold improvement compared to LRM for range retrieval (simulations)

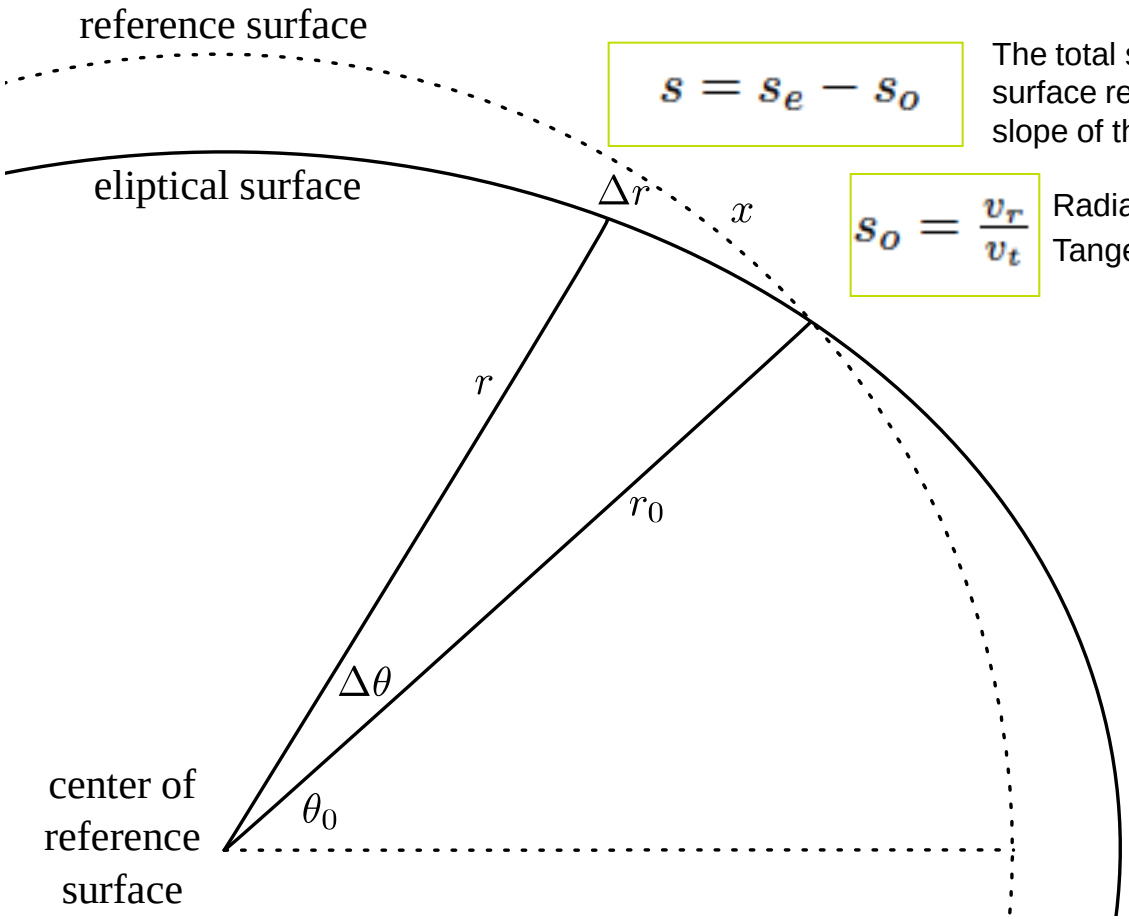
–But this model performance in terms of SWH is not yet clearly assessed

–In addition, SAMOSA1 waveform model does not account for:

- Radial velocity effects
- Across-track curvature effects
- Non-Gaussian Ocean surface statistics
- Elliptical antenna pattern
  - Mispointing effects

Radial velocity effects

Elliptical surface relative to spherical reference surface



$$s = s_e - s_o$$

The total slope is equal to the slope of the Earth surface relative to the reference sphere minus the slope of the orbit relative to a circular orbit.

$$s_o = \frac{v_r}{v_t}$$

Radial velocity
Tangential velocity

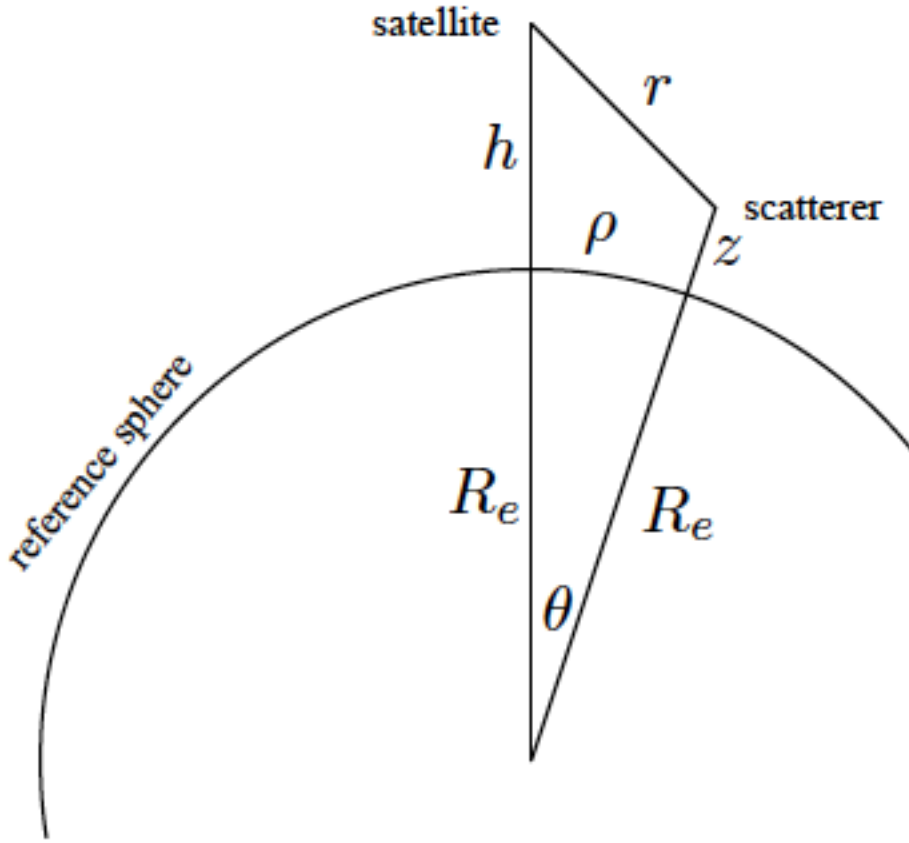
$$\epsilon_0 \sin 2\theta_0 \equiv s_e$$

$$\epsilon \equiv \frac{a^2 - b^2}{2r^2}$$

Latitud e

From WGS84
a → 6378137 m
b → 6356752.3142 m
r depends on:
-Parametric latitude measured from the equator
-Planetographic longitude
-And elevation

Across-track curvature effects



$$r = h - z + \frac{\alpha}{2h}\rho^2 + \mathcal{O}[1\text{mm}]$$

$$\alpha = 1 + \frac{h}{R_e}$$

Non-Gaussian Ocean surface statistics

E. Rodriguez, “Altimetry for non-Gaussian Oceans: Height Biases and Estimation of Parameters” 1988

Surface skewness

$$p(\eta) = \frac{1}{\sqrt{2\pi}} \left(1 + \frac{\lambda_s}{6}(\eta^3 - 3\eta)\right) e^{-\eta^2/2}$$

Mean Sea Height

$$\eta = \frac{z_0 - \langle z_0 \rangle + z_{\mathrm{EM}}}{\sigma_z}$$

Elec. Bias

Standard deviation of the sea height

Elliptical antenna pattern – Mispointing effects

$$G^2(x,y) \approx G_0^2 \exp\left(-4\ln(2)\frac{x^2}{h^2\theta_x^2} - 4\ln(2)\frac{y^2}{h^2\theta_y^2}\right)$$

Along-track 3db Beamwidth

Across-track 3db Beamwidth

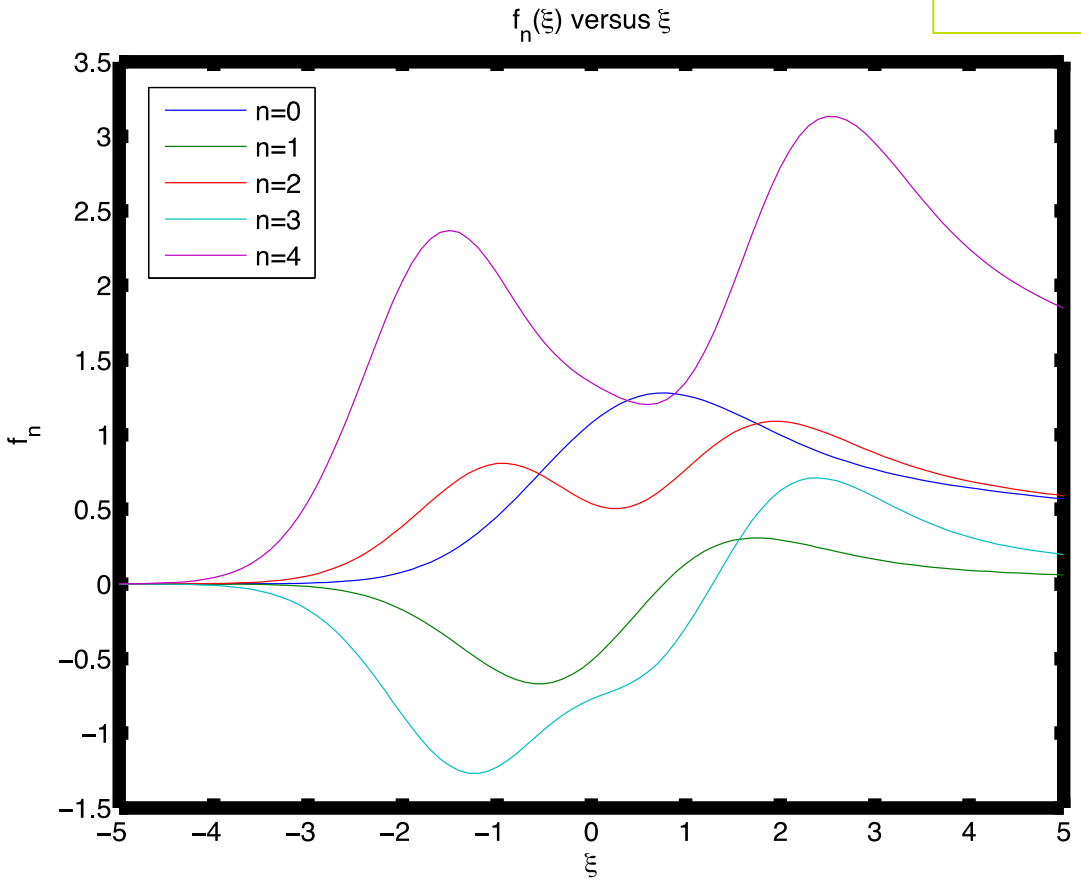
$$G^2(x,y) \approx G_0^2 e^{-\alpha_x(x-x_p)^2-\alpha_y(y-y_p)^2}$$

Including miss-pointing

$$\alpha_x = \frac{4\ln(2)}{h^2\theta_x^2}$$

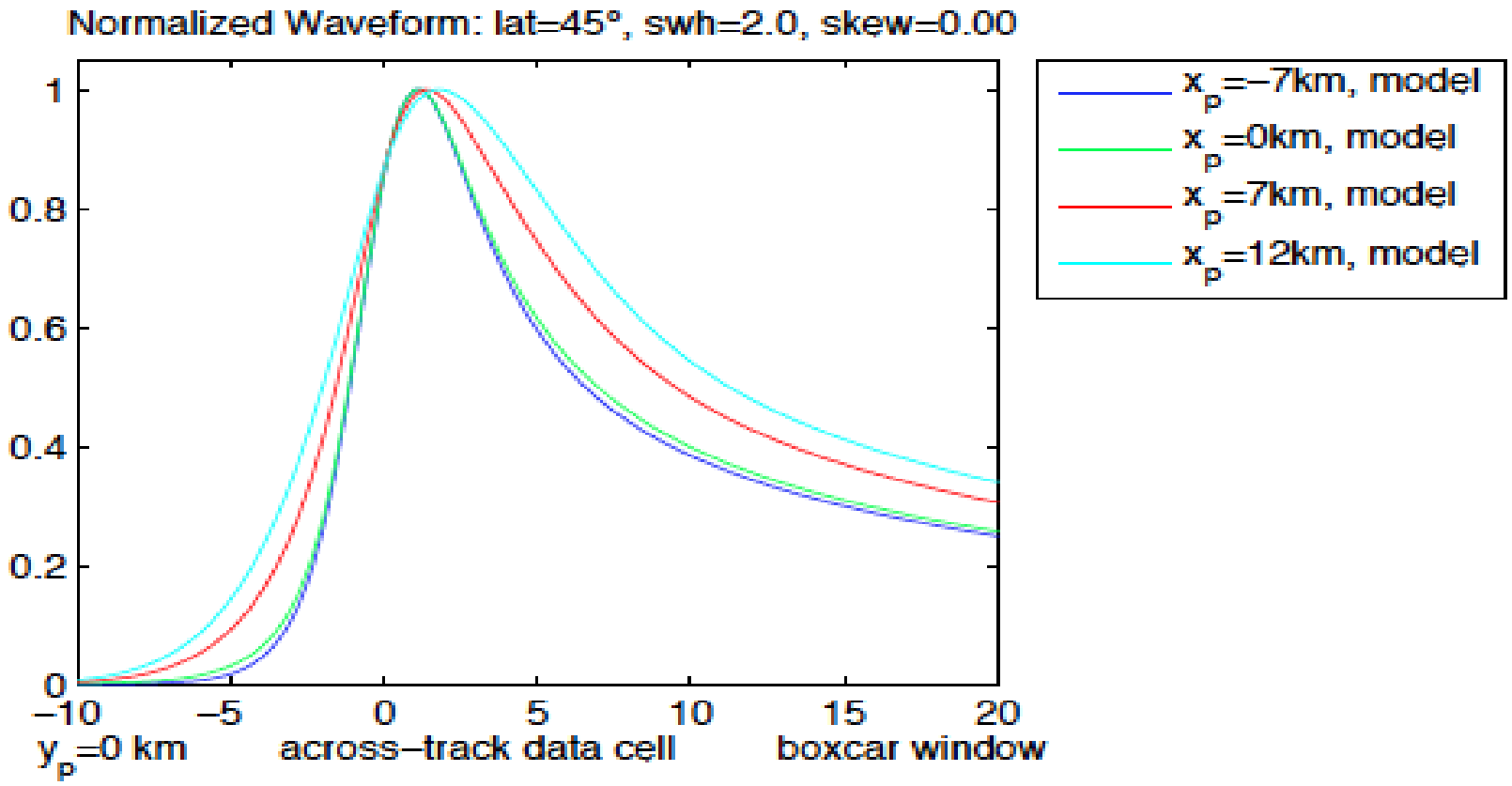
Combination of Basis functions

$$f_n(\xi) = \int_0^\infty (\xi - u^2)^n e^{-(\xi - u^2)^2/2} du$$

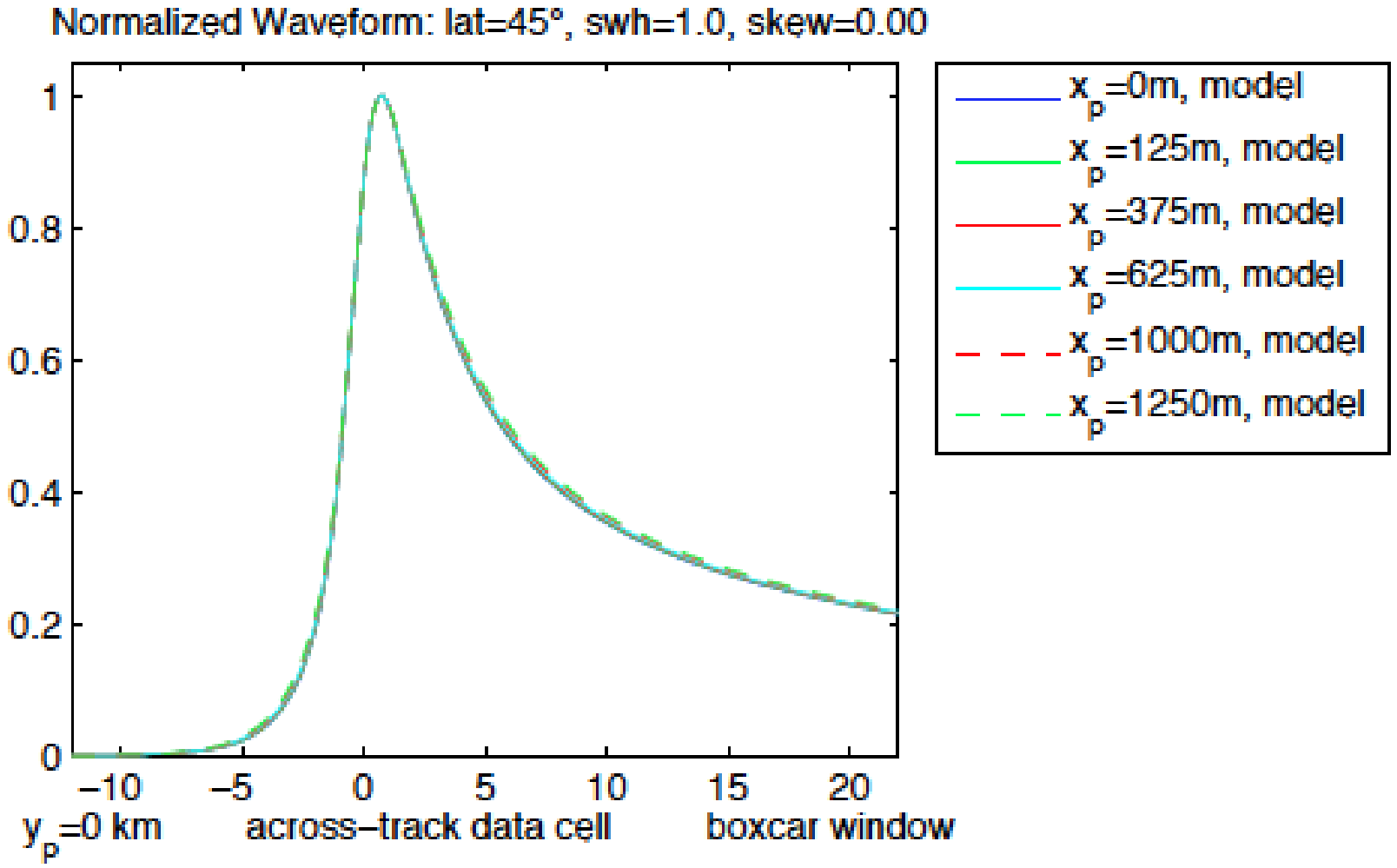


SAMOSA2 waveform model

large mispointing



Small mispointing



Retracker performance with CryoSat-2 data

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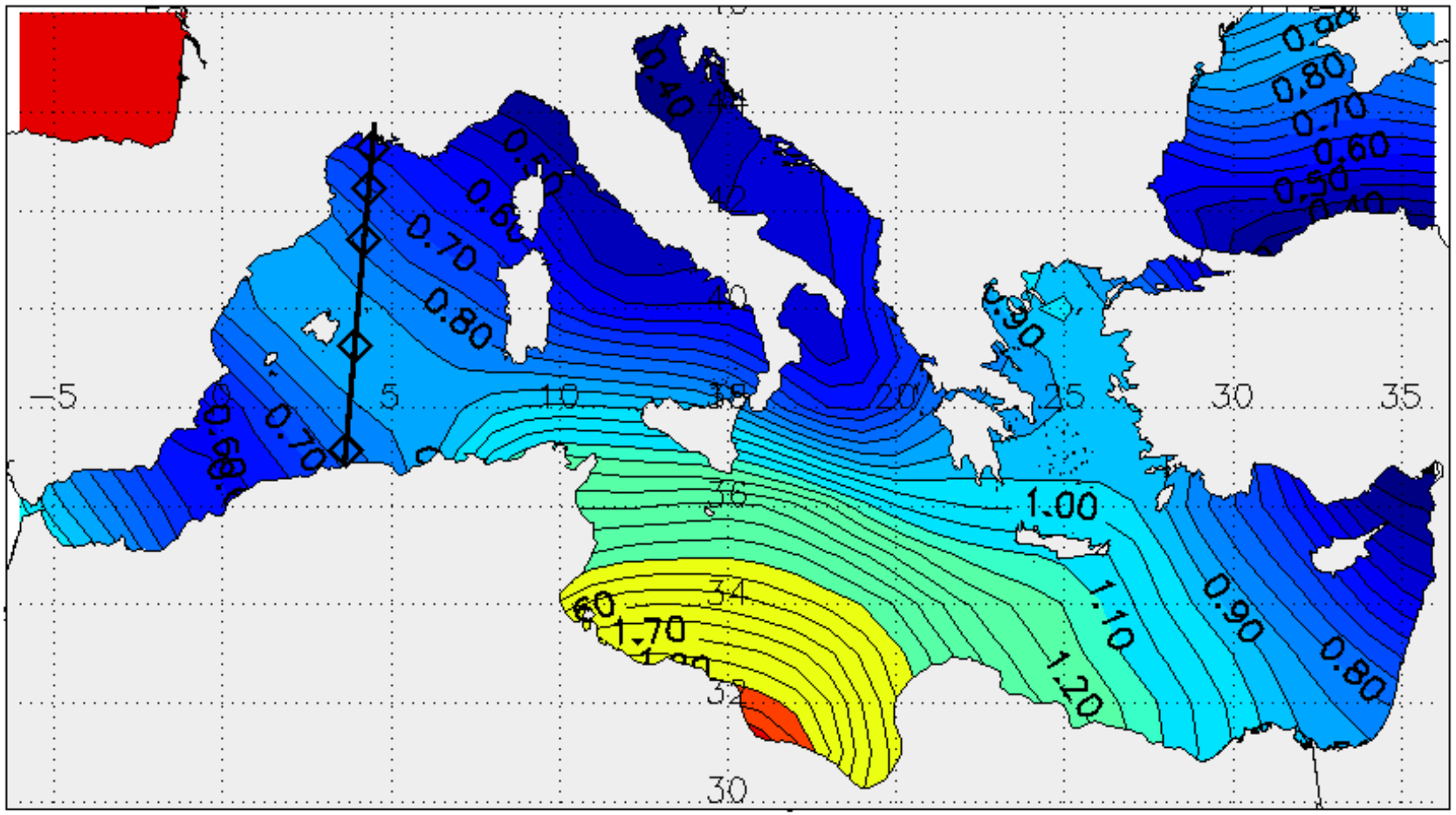
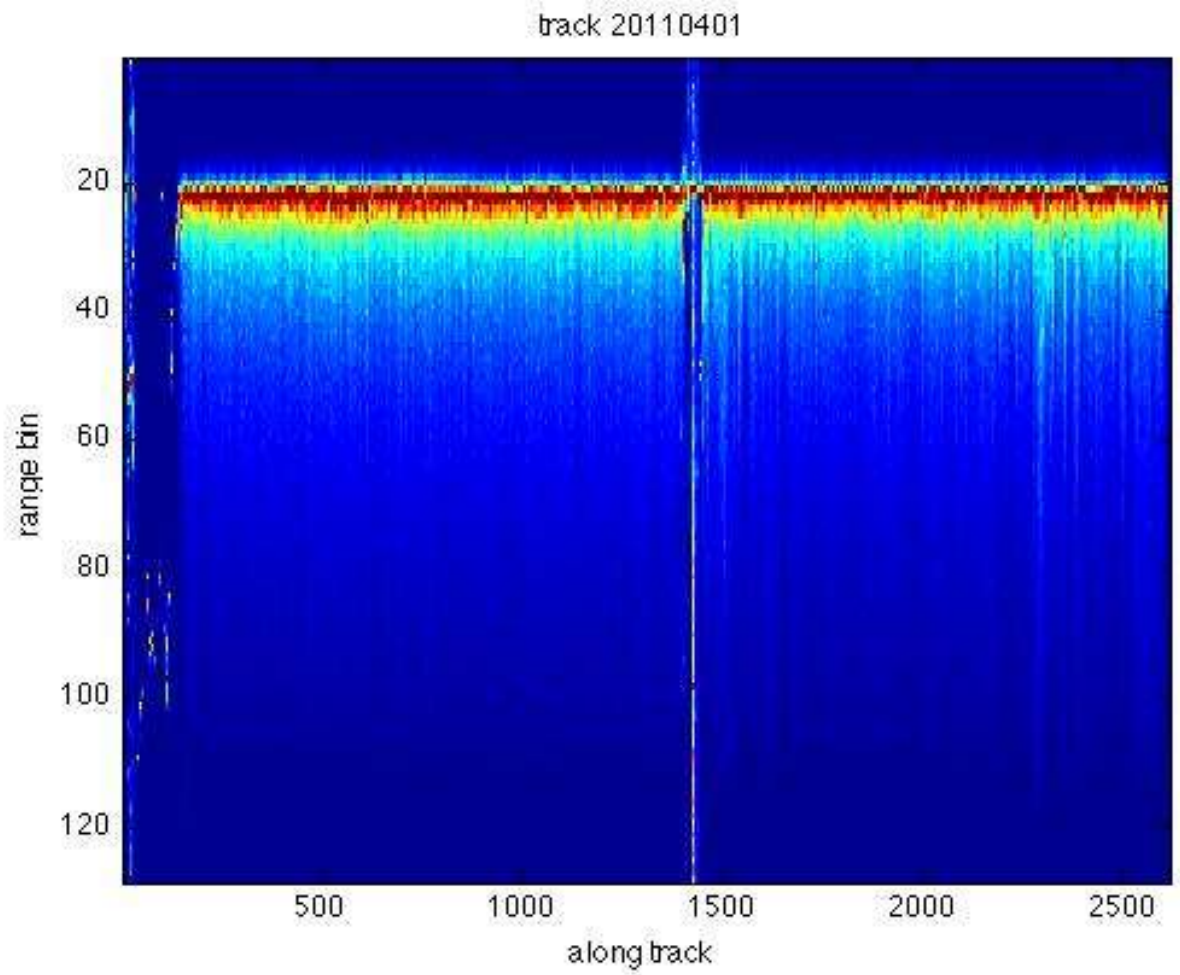
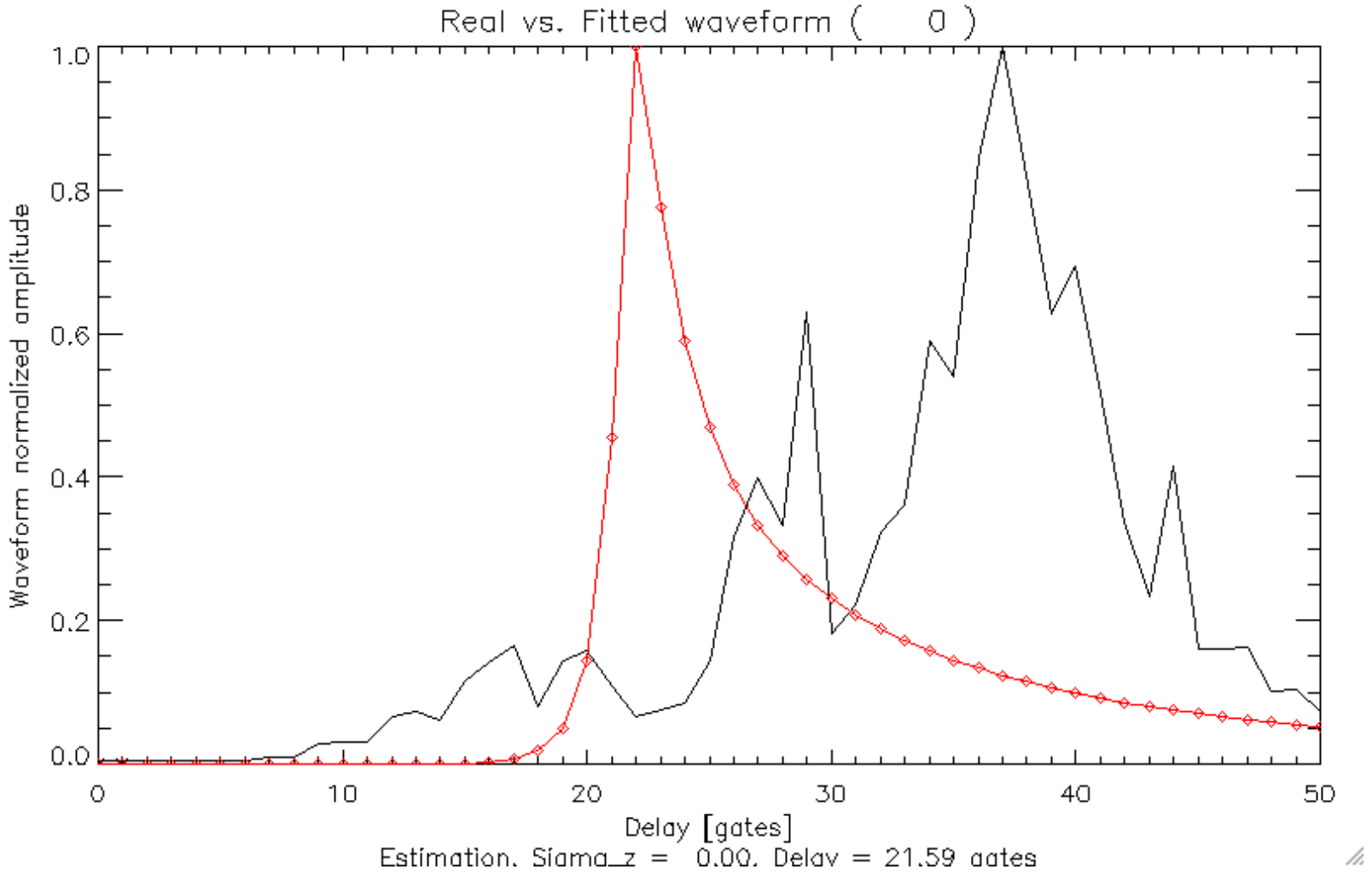
CryoSat-2 dataset



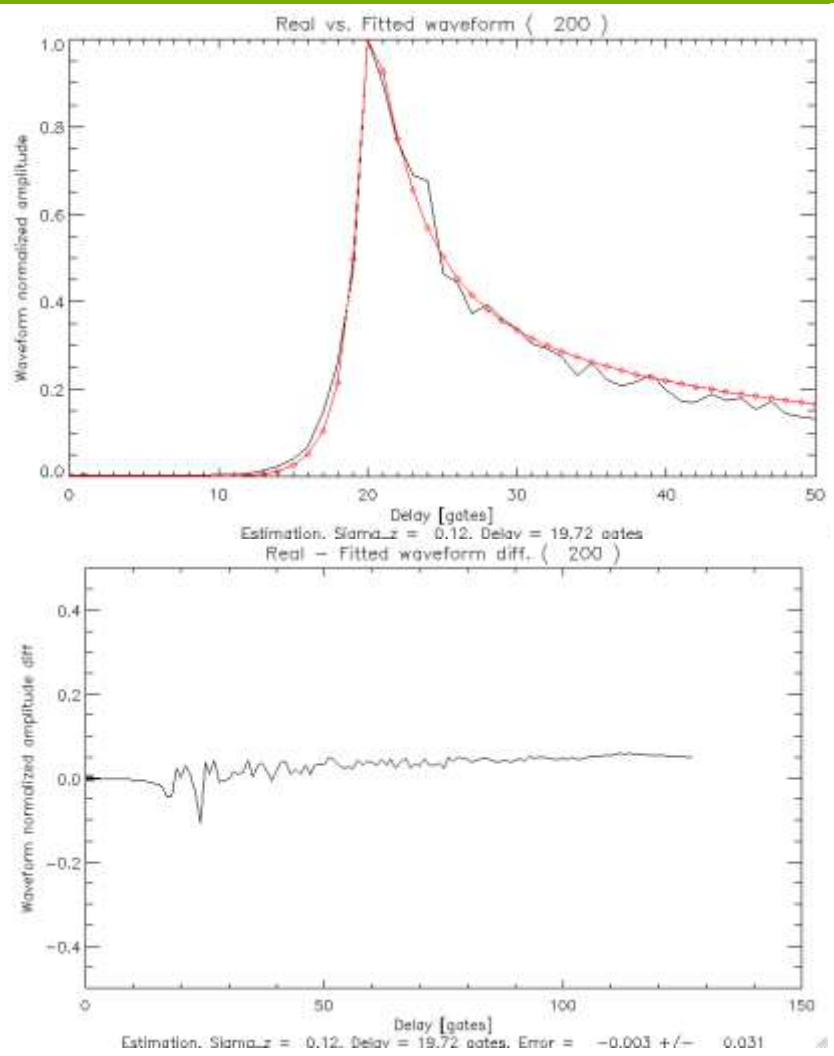
Track plane view

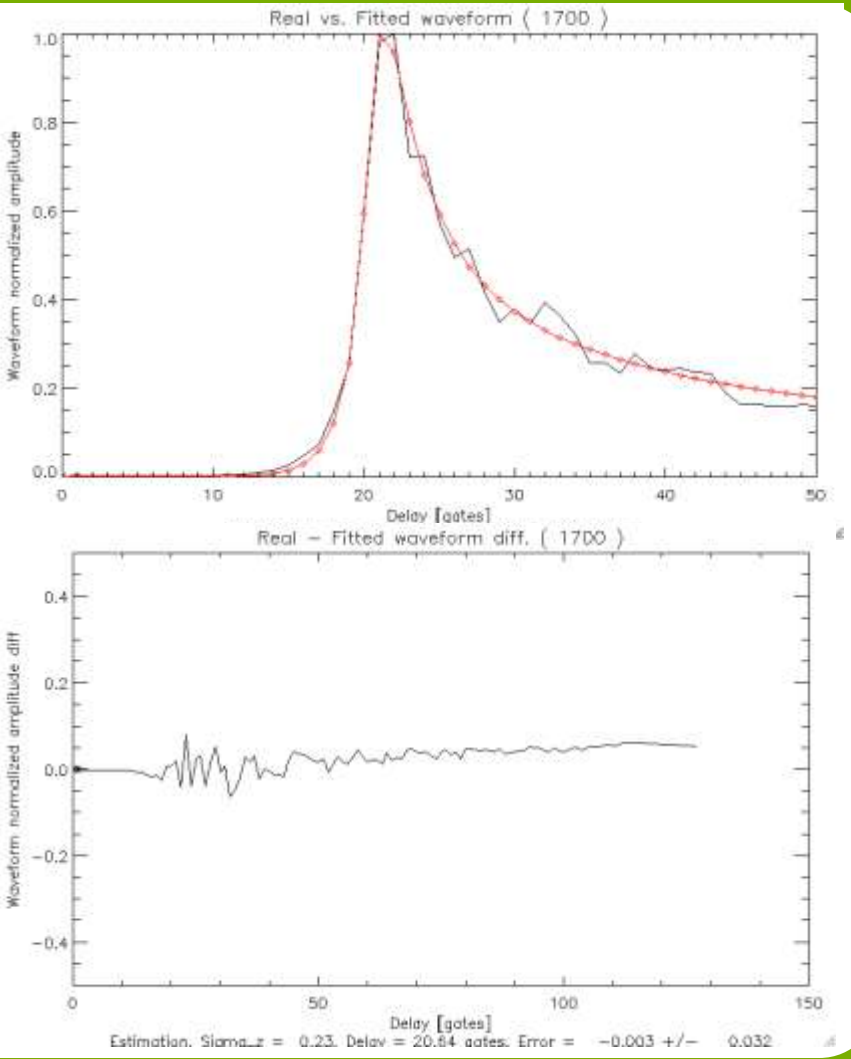


Tracker performance



Some waveform fits





Numerical assessment of improvements due to return waveform model evolution

Precision Estimation

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Precision Estimation (range)

Estimation theory

- Cramér-Rao lower bound (CRLB)
  - min variance for an unbiased estimator is given by the inverse of the fisher information

$$var[\hat{\theta}] \geq \frac{1}{I(\theta)} = \mathrm{CRLB}$$

  - We assumed: Normal statistics for the SARM waveforms, thus under such assumption the Fisher information shall be expressed as:

$$I(\theta) = \sum_{i=1}^{n} \left(\frac{1}{\Gamma_i} \frac{\partial \Gamma_i}{\partial \theta} \right)^2$$

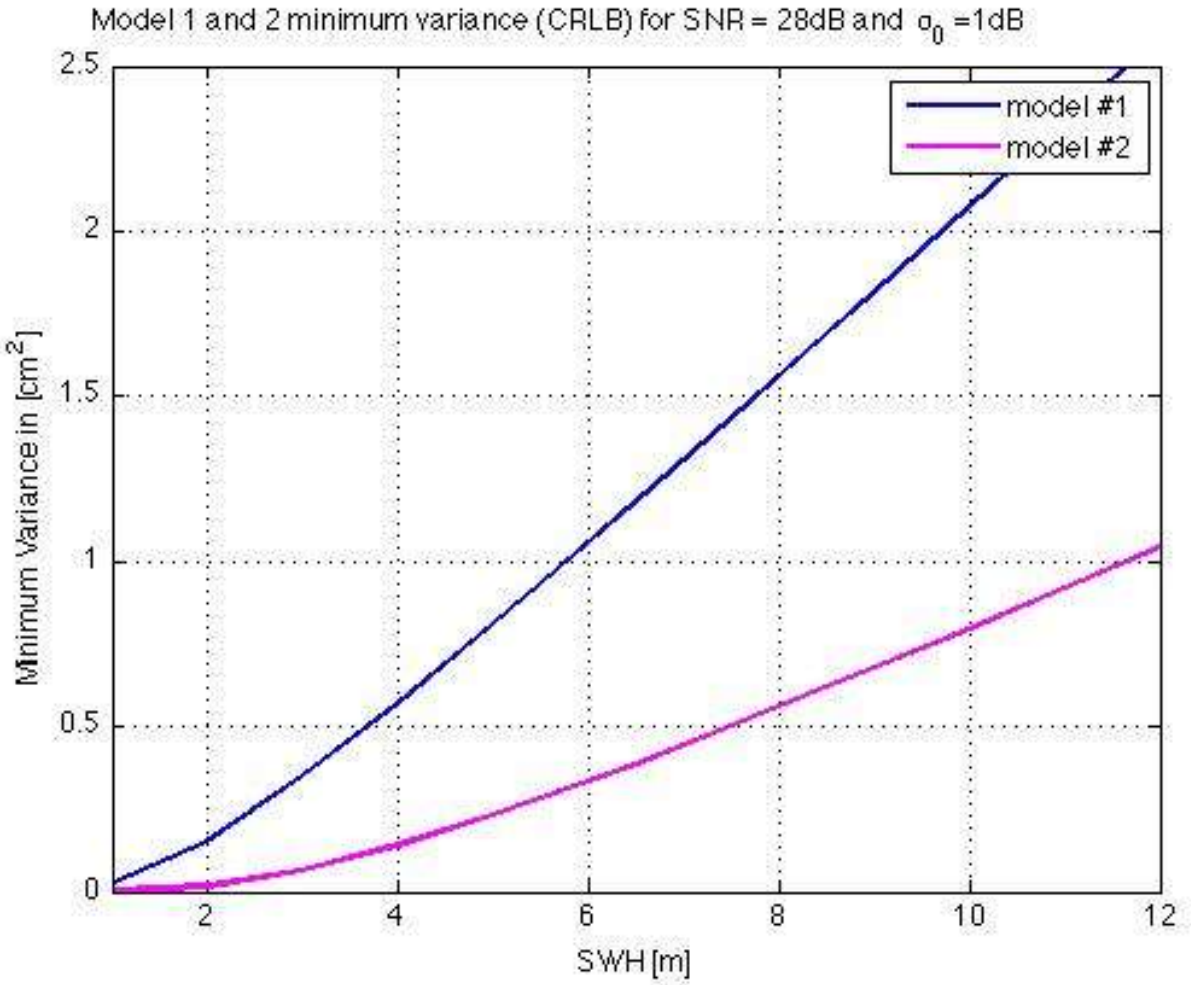
$$\Gamma_i \approx W_i + \mathrm{fon}(\mathrm{SNR}_N)$$

Precision Estimation (range)

Model 2 implementation

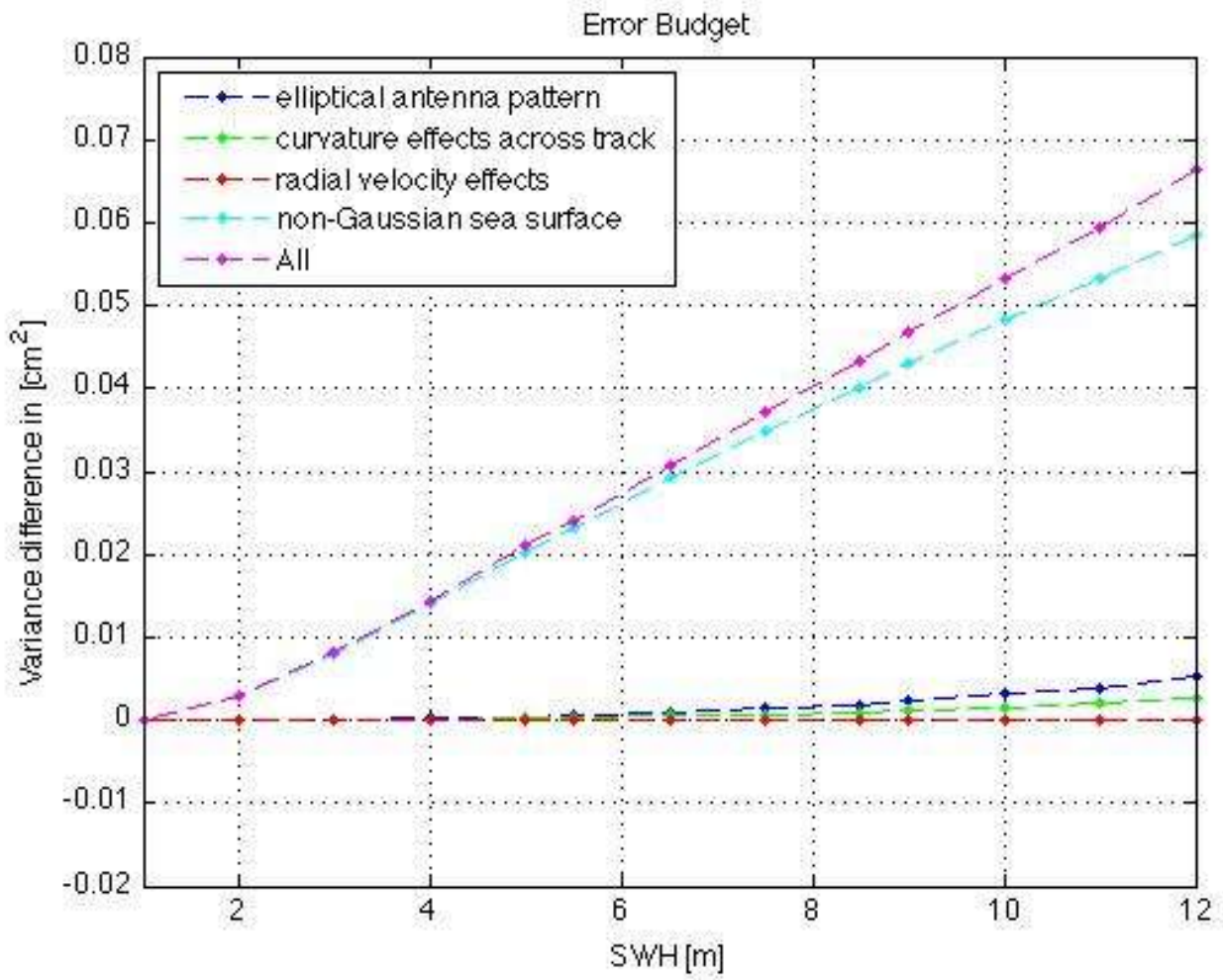
- Model 2 has been implemented in such a way that the user is capable to tune a wide variety of parameters which allow for the consideration / or non-consideration of the improvements with respect to model 1
- Thus allows to chose in between:
  - Gaussian or Non-Gaussian Ocean Surface Statistics
  - Elliptical or circular antenna pattern
  - Radial velocity effects yes-no
  - Across track curvature effects yes-no
  - Mispointing angle across-track yes-no
- When model 2 excludes all the modifications, we refer to it as **model 2 plain**

Model 1 vs model 2 plain after multi-look



Precision Estimation (range)

Model 2 plain vs model 2 accounting for the different improvement



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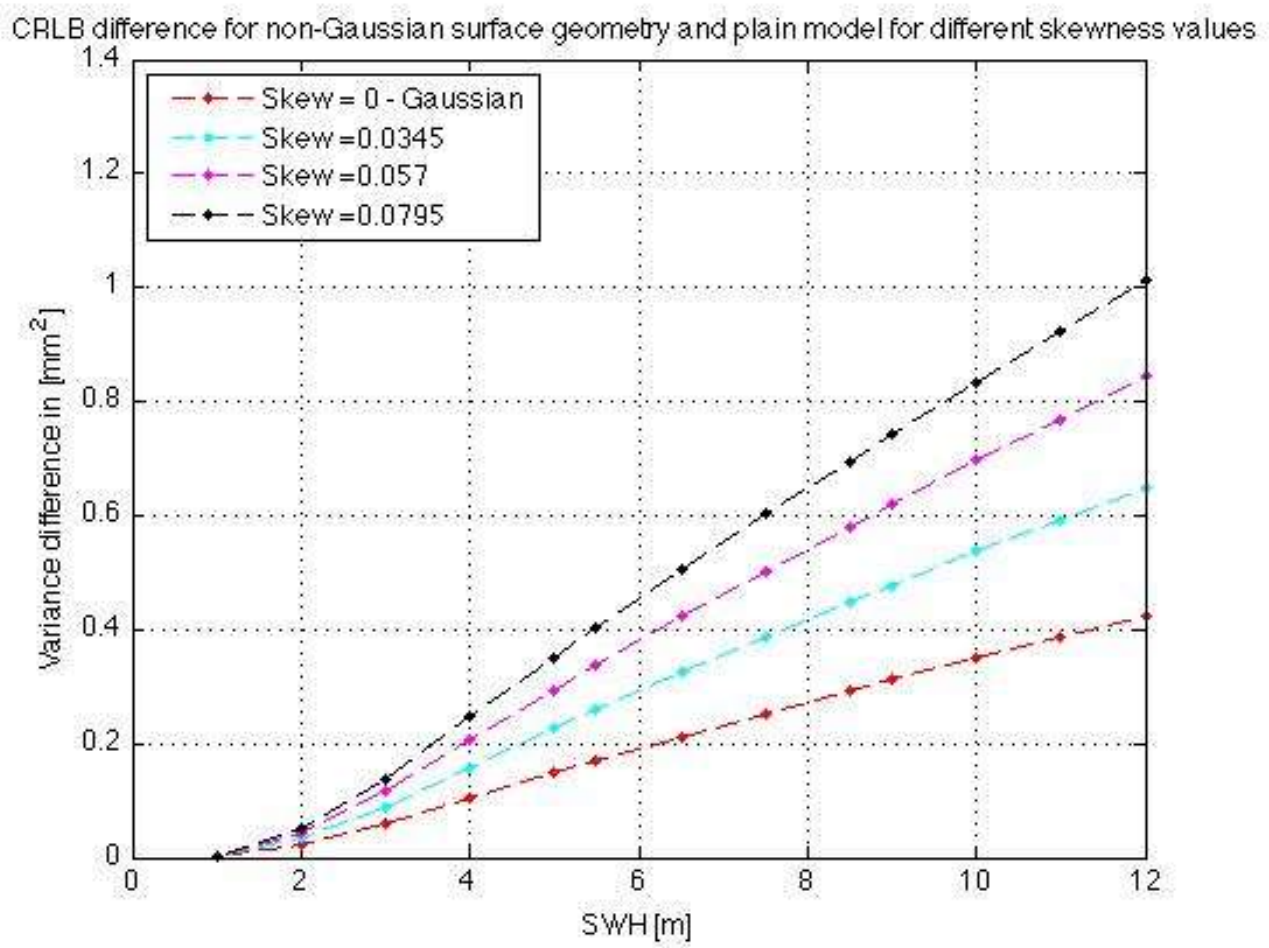
Precision Estimation (range)

Model 2 for different skew values



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Thanks for your attention!

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