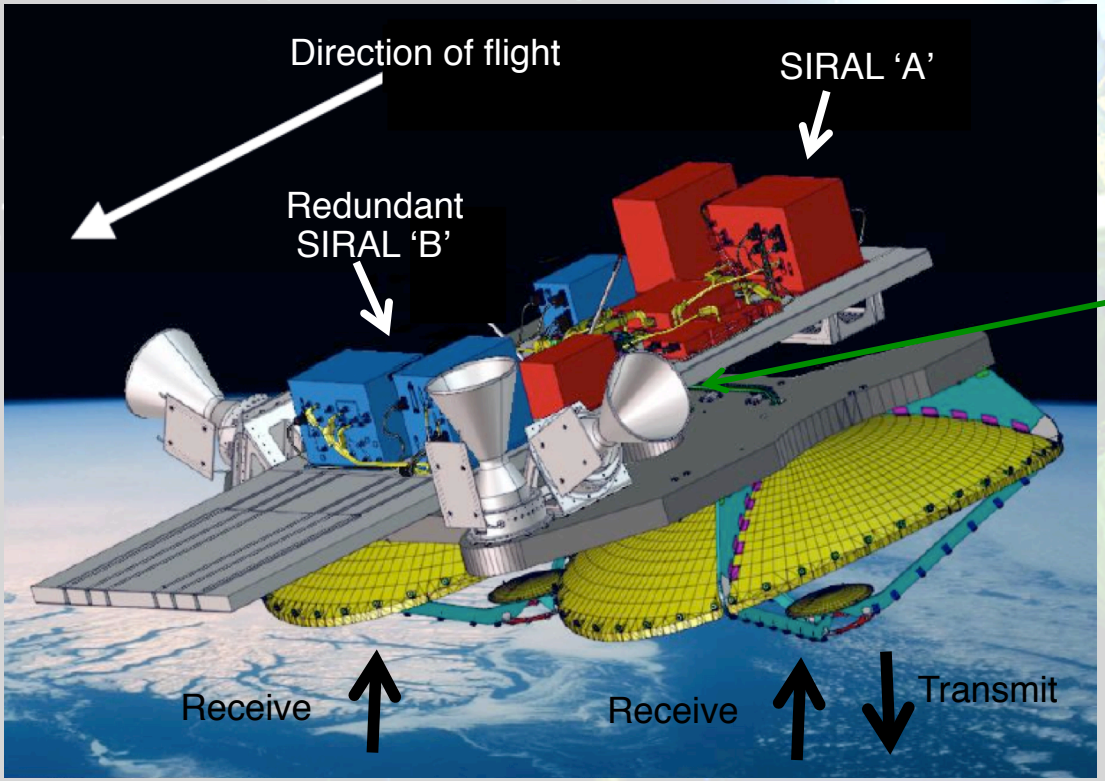
Models of the echo from the ocean surface observed by the CryoSat-2 pulse-limited, SAR and SAR-interferometric altimeters.

Duncan Wingham
CPOM, Earth Sciences,
University College London

The CryoSat-2 Payload and Operating Modes.



- "SARIN mode"

  Illuminated area narrowed along-track by synthetic aperture processing & second receiving antenna forms an across-track interferometer. Star trackers determine baseline orientation.

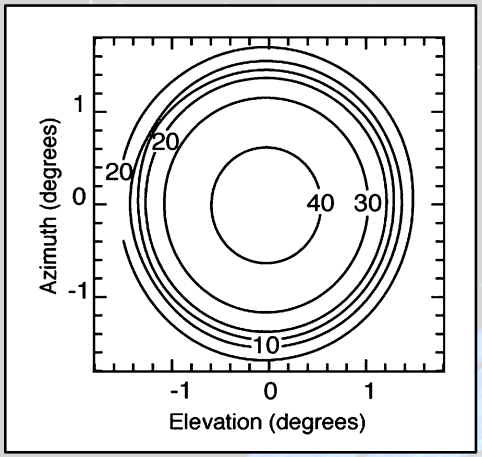
- "SAR mode" (SAR)

  Illuminated area narrowed along-track by synthetic aperture processing

- "Low resolution mode" (LRM)

  Conventional pulse-limited altimeter but with a slightly elliptical antenna

CryoSat-2 pulse-limited echoes



CryoSat has a slightly elliptical antenna pattern with an ellipticity of 0.98.

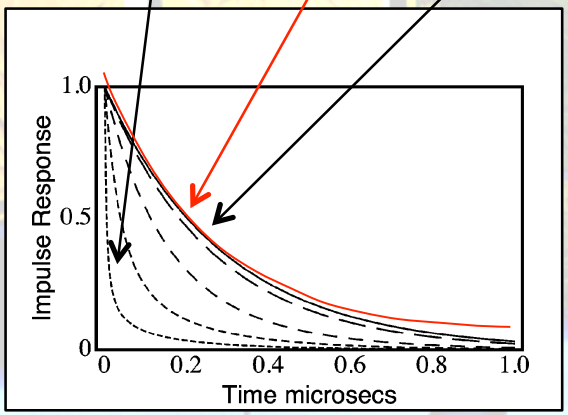
The effect is to alter (slightly) the surface impulse response from that of a circular pattern

If an elliptical pattern is written generally as:

$$G_0 exp\left[-\psi^2\left(\frac{cos^2\chi}{\gamma_1^2}+\frac{sin^2\chi}{\gamma_2^2}\right)\right]$$

Highly elliptical impulse response

Circular (Brown) impulse response



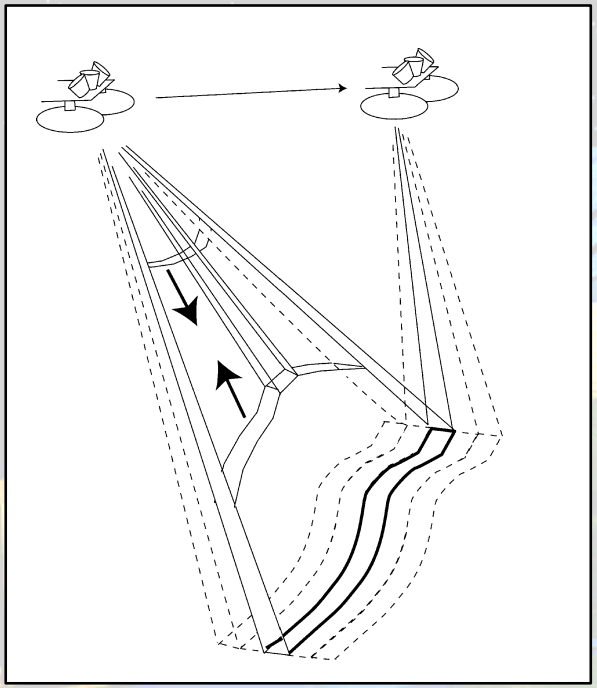
Then, for CryoSat-2, the effect can be described to an accuracy of 0.7 % for mispointing angles up to 0.2˚ by Brown's impulse response provided one uses the harmonic mean $\bar{\gamma}$

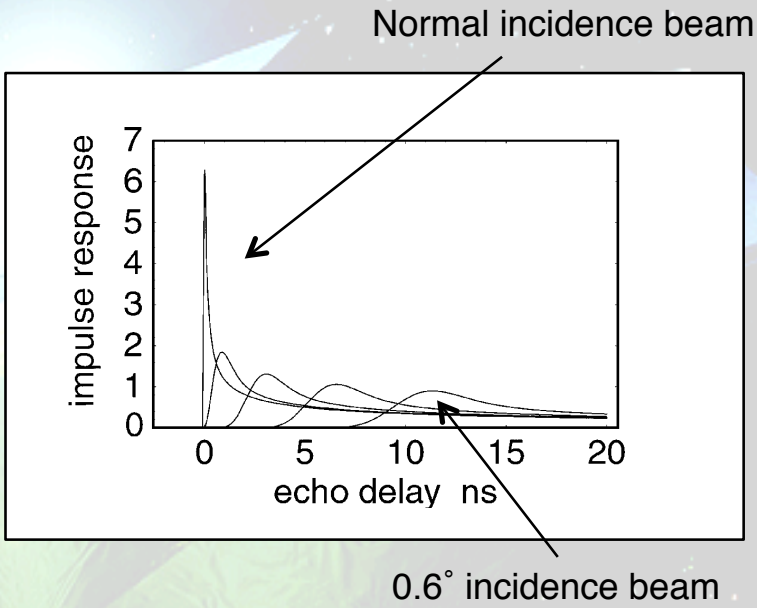
$$\frac{2}{\bar{\gamma}^2}=\frac{1}{\gamma_2^2}+\frac{1}{\gamma_1^2}$$

to describe the antenna decay.

Wingham & Wallis, *IEEE Trans. Geosci. Remote Sensing*, 2010

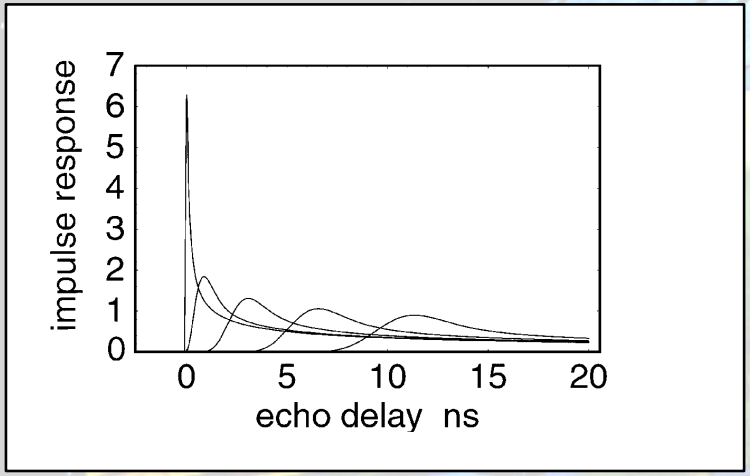
CryoSat-2 SAR Mode echoes

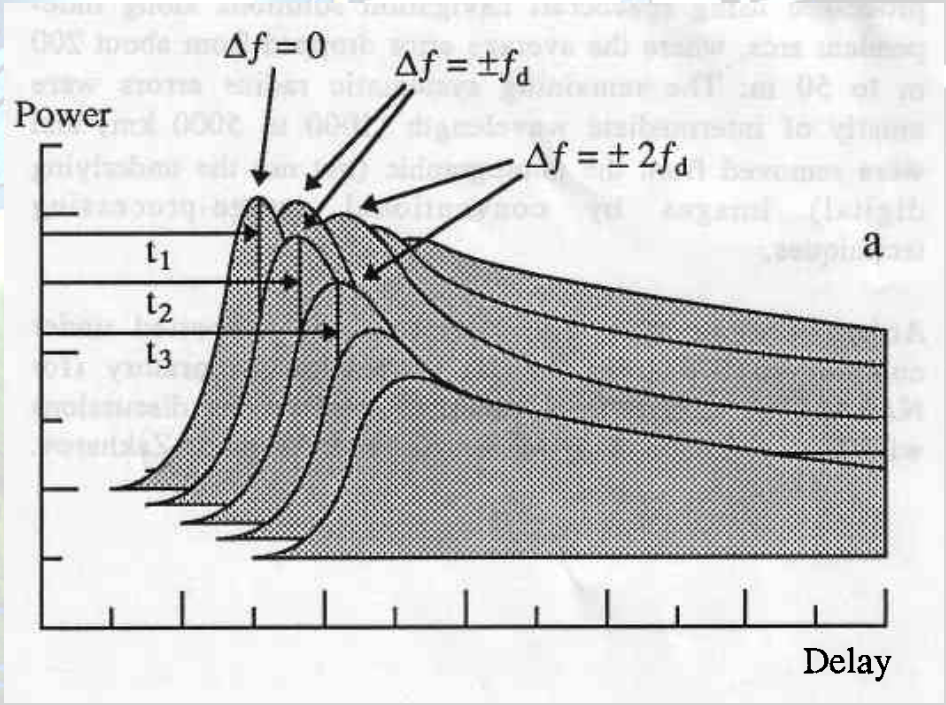




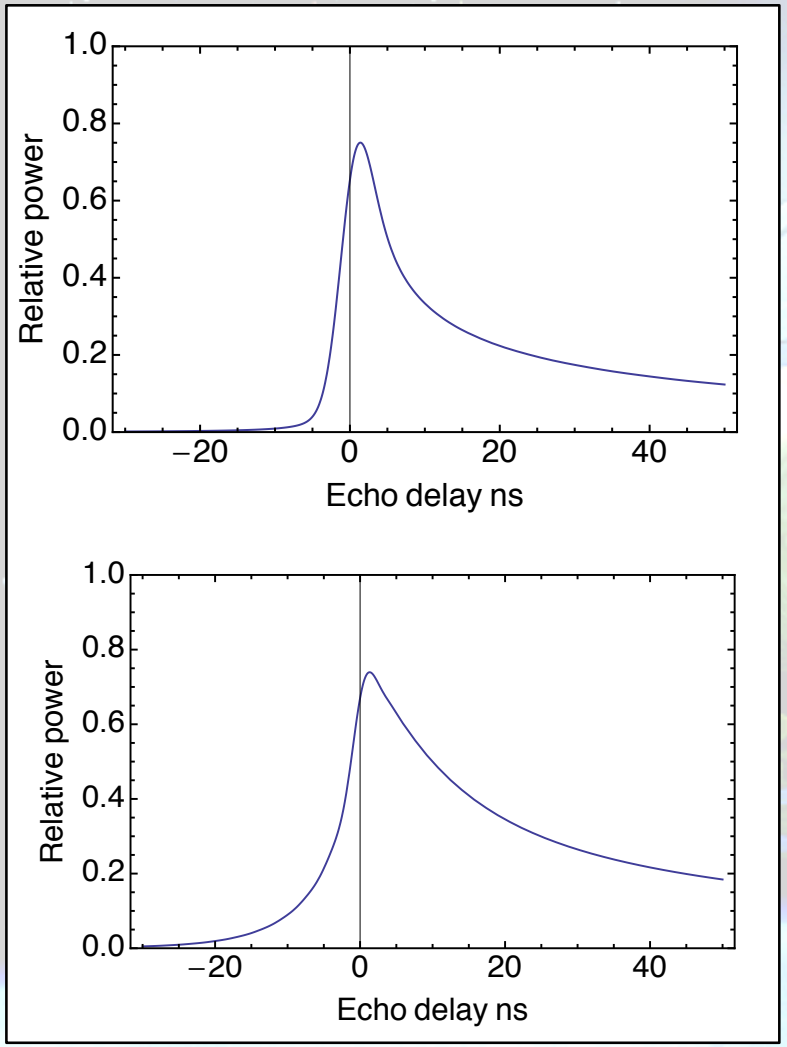
Ford & Pettengill, J. Geophys. Res., 1992

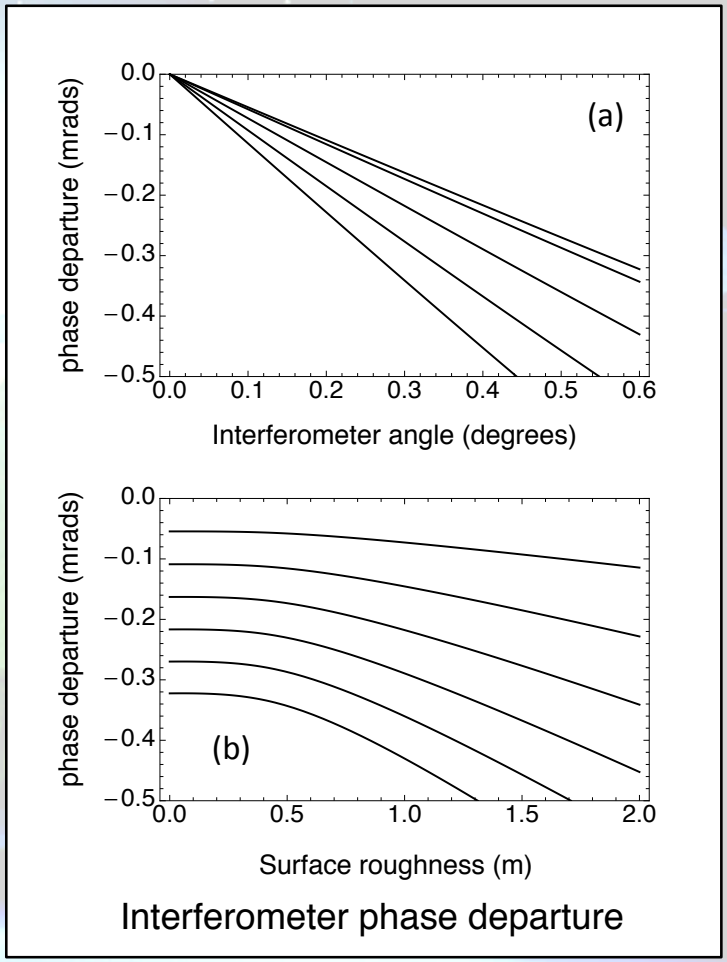
Wingham *et al., IEEE Trans. Geosci. Remote Sensing*, 2004


impulse response
7
6
5
4
3
2
1
0
0
5
10
15
20
echo delay ns


Δf = 0
Δf = ±f_d
Power
Δf = ± 2f_d
t1
t2
t3
a
Delay

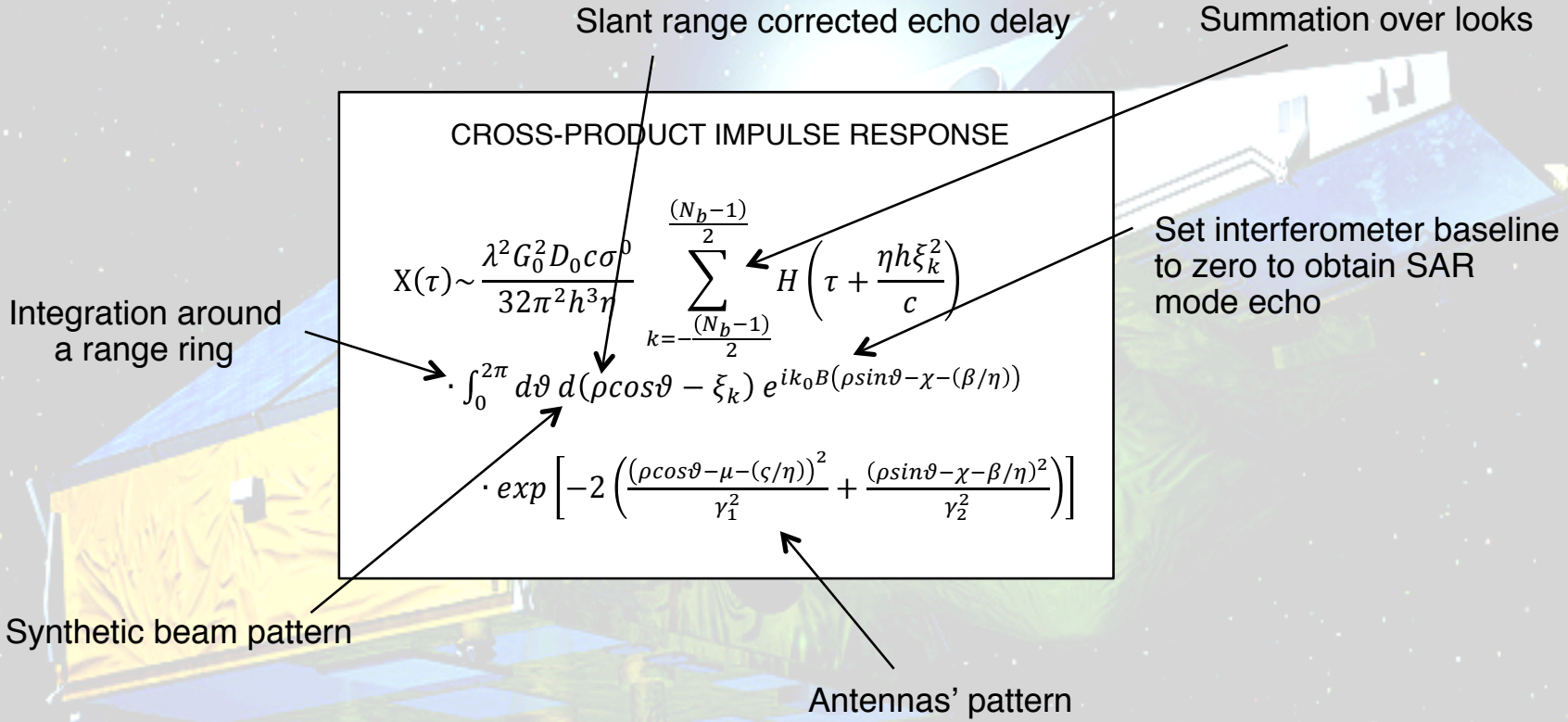
Impact of multi-looking on power and phase difference





Galin *et al., IEEE Trans. Geosci. Remote Sensing*, Submitted

Model Implementation



Presently taking approximately 4 days on a laptop (in interpreted Mathematica!) to generate lookup tables for useful ranges of pointing values and significant wave heights.

Galin *et al., IEEE Trans. Geosci. Remote Sensing*, Submitted

Summary

- *The ellipticity of the CryoSa-2 antennas introduces small effects in low resolution mode (LRM). However, these can be described by conventional (Brown) models, provided the trailing edge is correctly parameterised.*

- *SAR and SARIN mode echoes are distinct in character from pulse-limited echoes. Their close description requires accounting for the multi-looking, and in particular for the arrival-time distribution of off nadir echoes. Simple models based on analytic models of the normal incidence beam will bias estimates of ocean surface parameters.*

- *Modelling the multi-looked echoes requires the calculation of look-up tables provided by a numerical model. Equally, look-up tables ranging over all parameters of interest can be calculated without undue computer effort.*