Echo Contamination in SAR Mode in coastal zone and calm waters

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SUMMARY

- Introduction
- ESRIN SAR L1B Prototype
- Focus on the COASTAL CALM WATERS/IN LAND WATERS
- Conclusion & Open Points

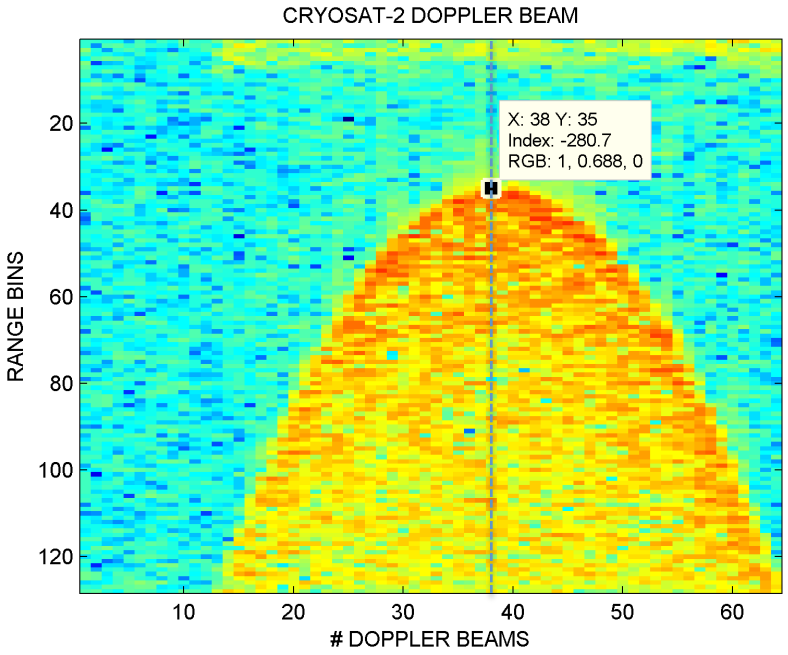
ESRIN SAR L1B Processor Prototype

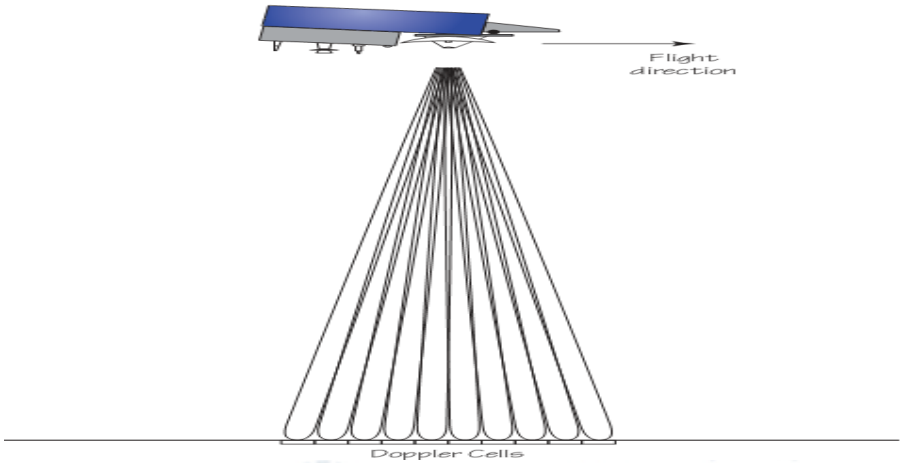
At ESRIN/ESA, we (me) developed a independent and modular SAR L1b Processor Prototype

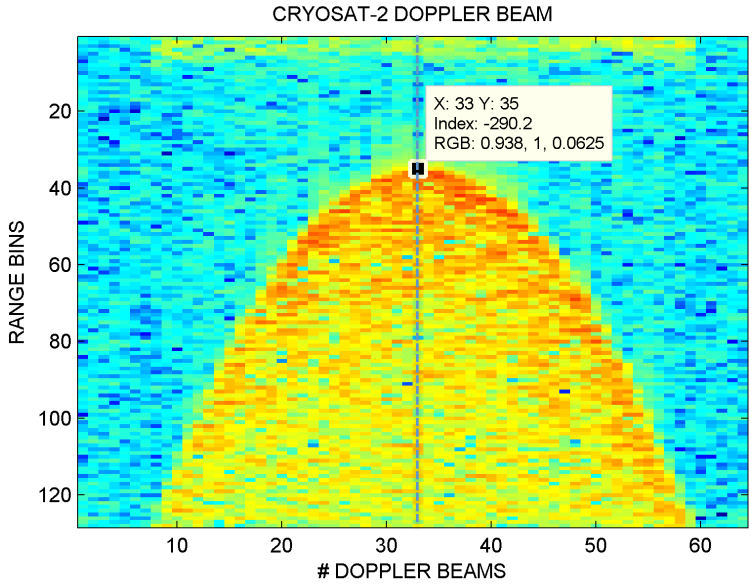
Input: CRYOSAR SAR FBR DATA
CODING LANGUAGE: MATLAB
TESTED against Transponder DATA and Comparison with CRYOSAT PDGS L1b SAR DATA
Performances: at least same range/ SWH noise of CRYOSAT PDGS Processor

DOPPLER BEAM FORMING

For an **efficient** SAR L1b Processor, very precise compensation for Doppler Centroid and Beam Steering is mandatory

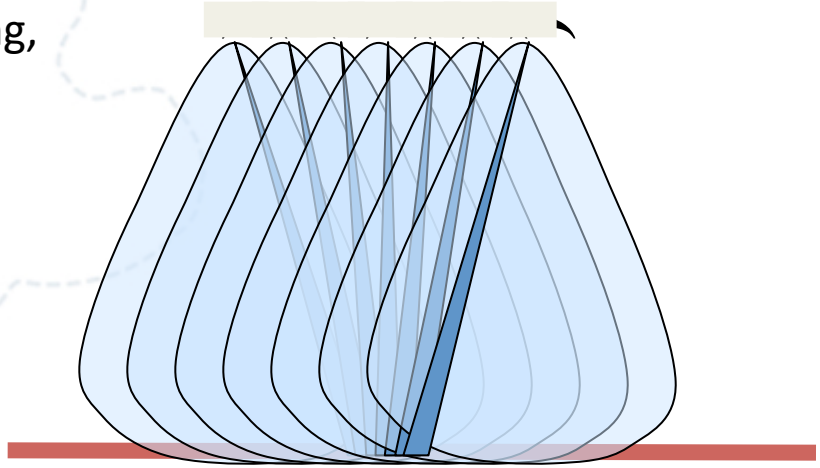




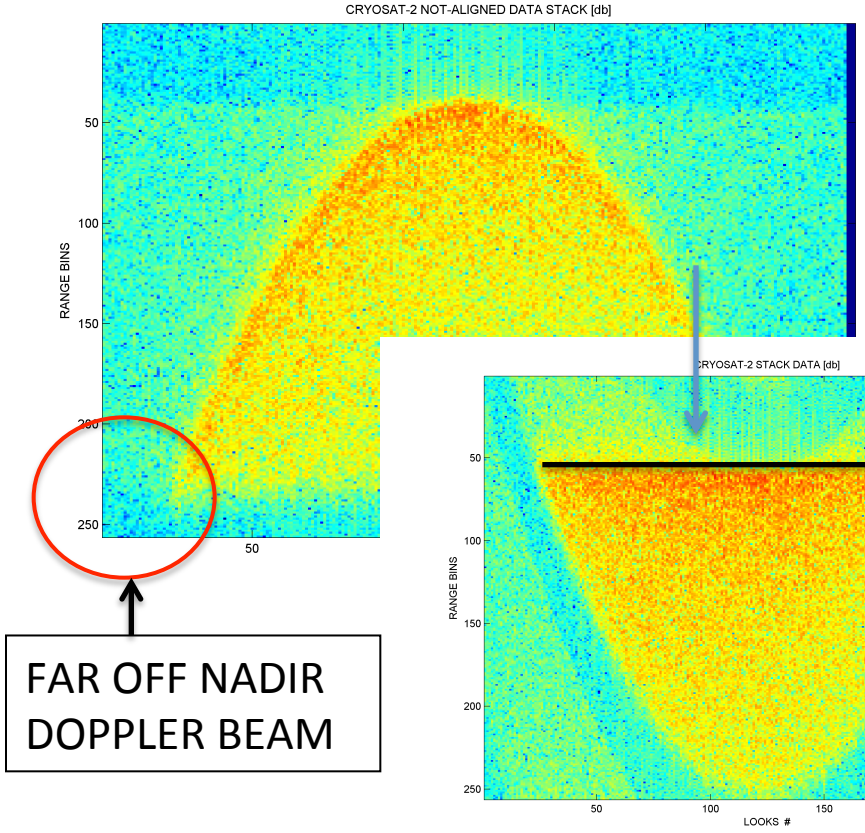


STACK RANGE ALIGNMENT

For an **efficient** SAR L1b Processor, after Stacking, a **precise** alignment in range is mandatory

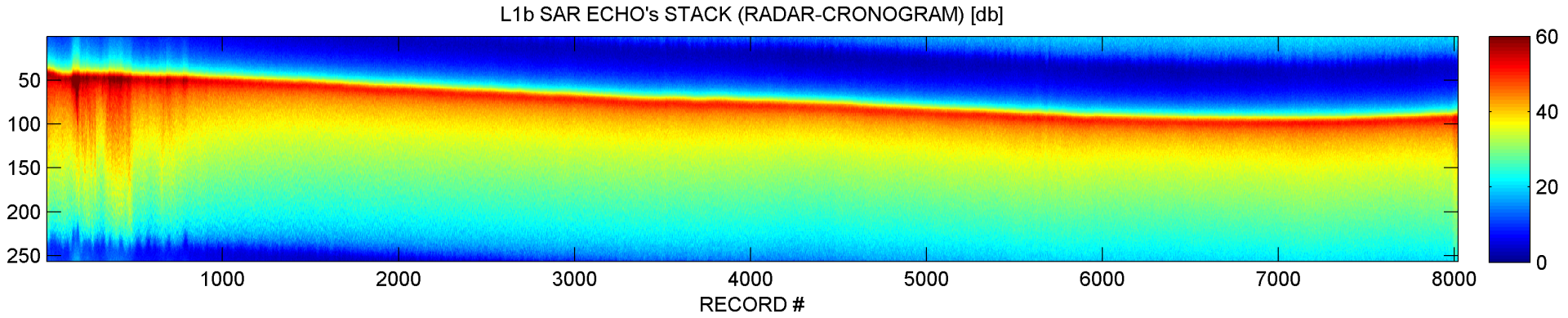


From K. Raney

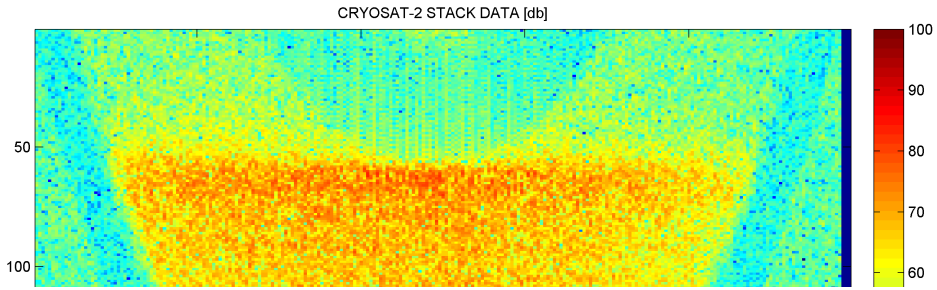


OUTPUT RADAR-CRONOGRAM

One Tracker Distance (minimum) for all the pass,
Double Sampling Step,
AGC Compensation\Calibration Applied

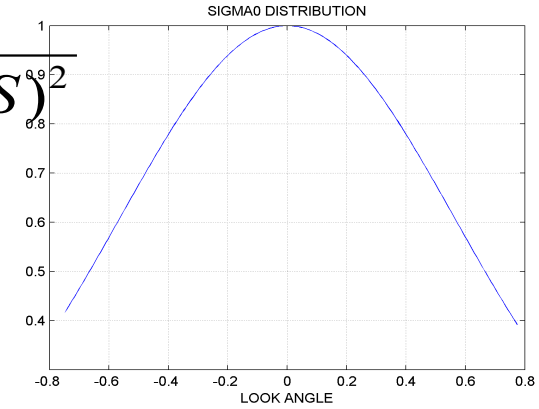


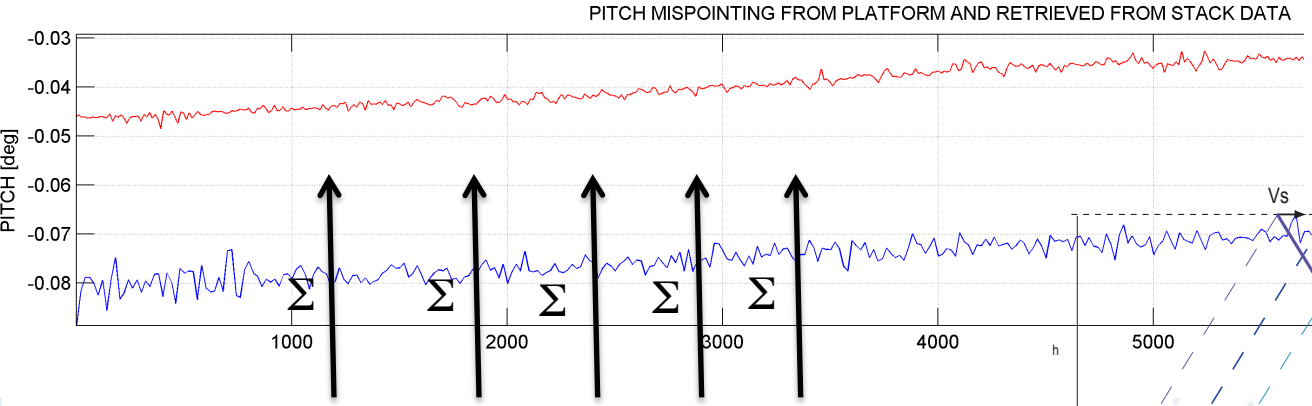
So far, SAR users are starting to be famialiar with FBR DATA or with L1b Multilooked Waveforms DATA but indeed a third type of data could be exploited: **the STACK DATA**

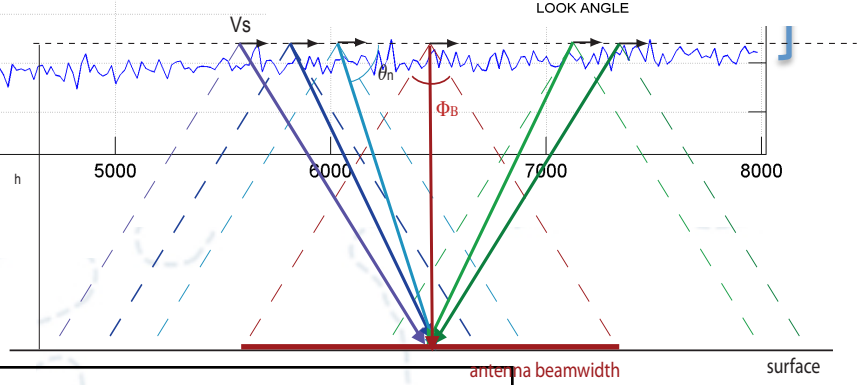


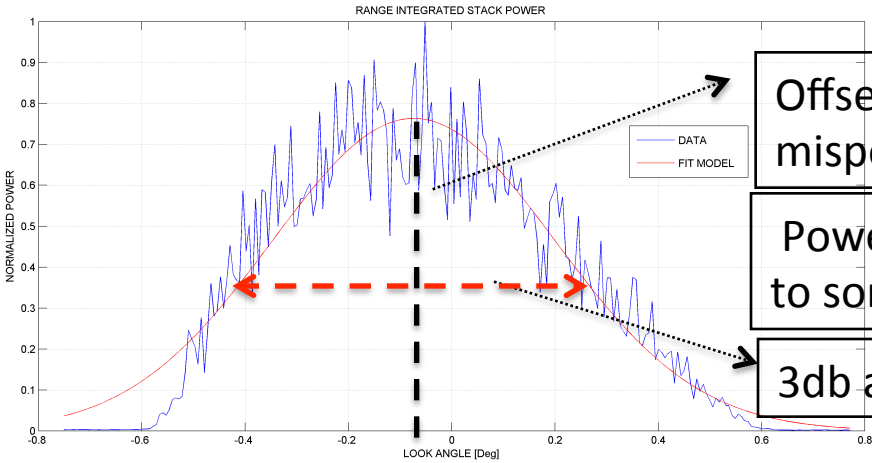
$$\sigma_0(\theta) = \sigma_0(0°) \cdot \exp\left(-\nu \cdot \tan^2 \theta\right)$$

$$\nu = \frac{1}{(RMSS)^2}$$





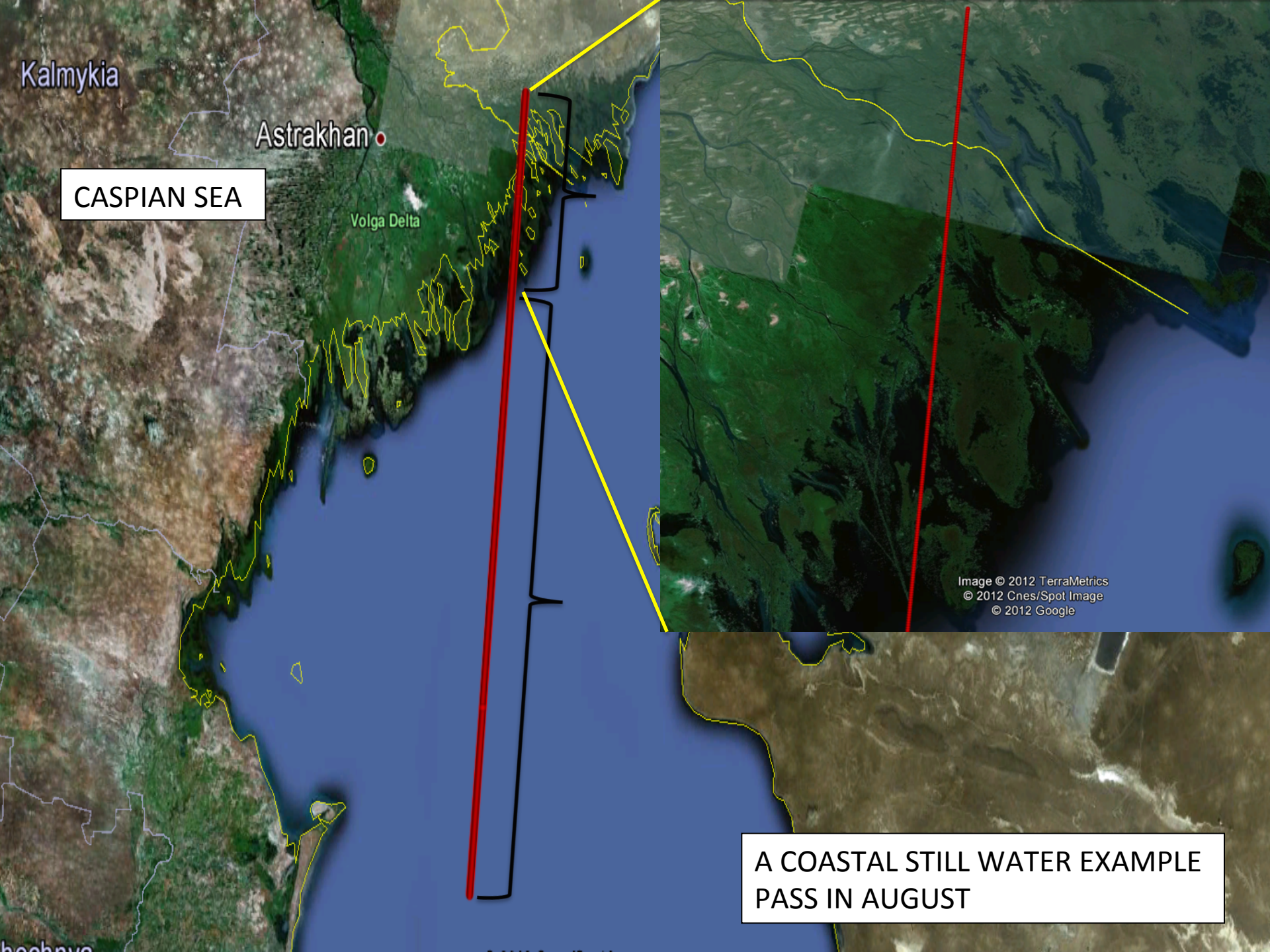




Offset depending on pitch mispointing

Power Distribution is skewness.. Is this connected to something geophysical for the ocean surface ?

3db aperture depending on sea surface RMS Slope


Kalmykia
Astrakhan
CASPIAN SEA
Volga Delta
Image © 2012 TerraMetrics
© 2012 Cnes/Spot Image
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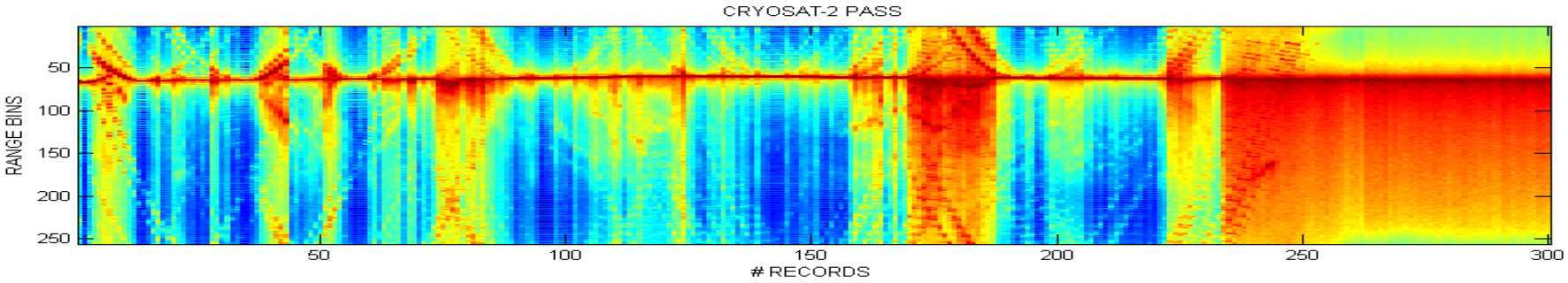
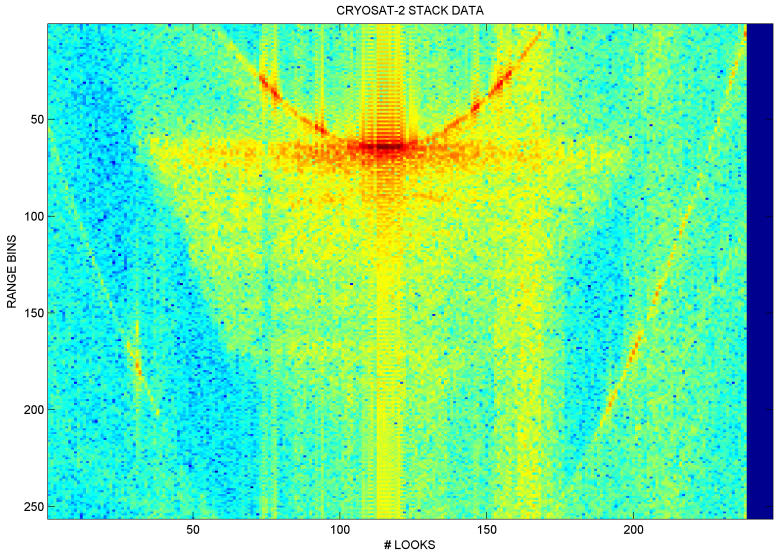
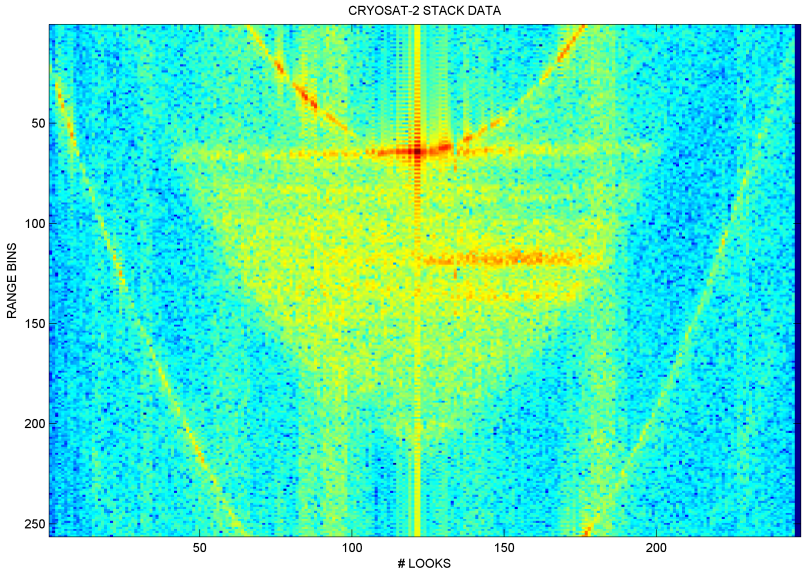
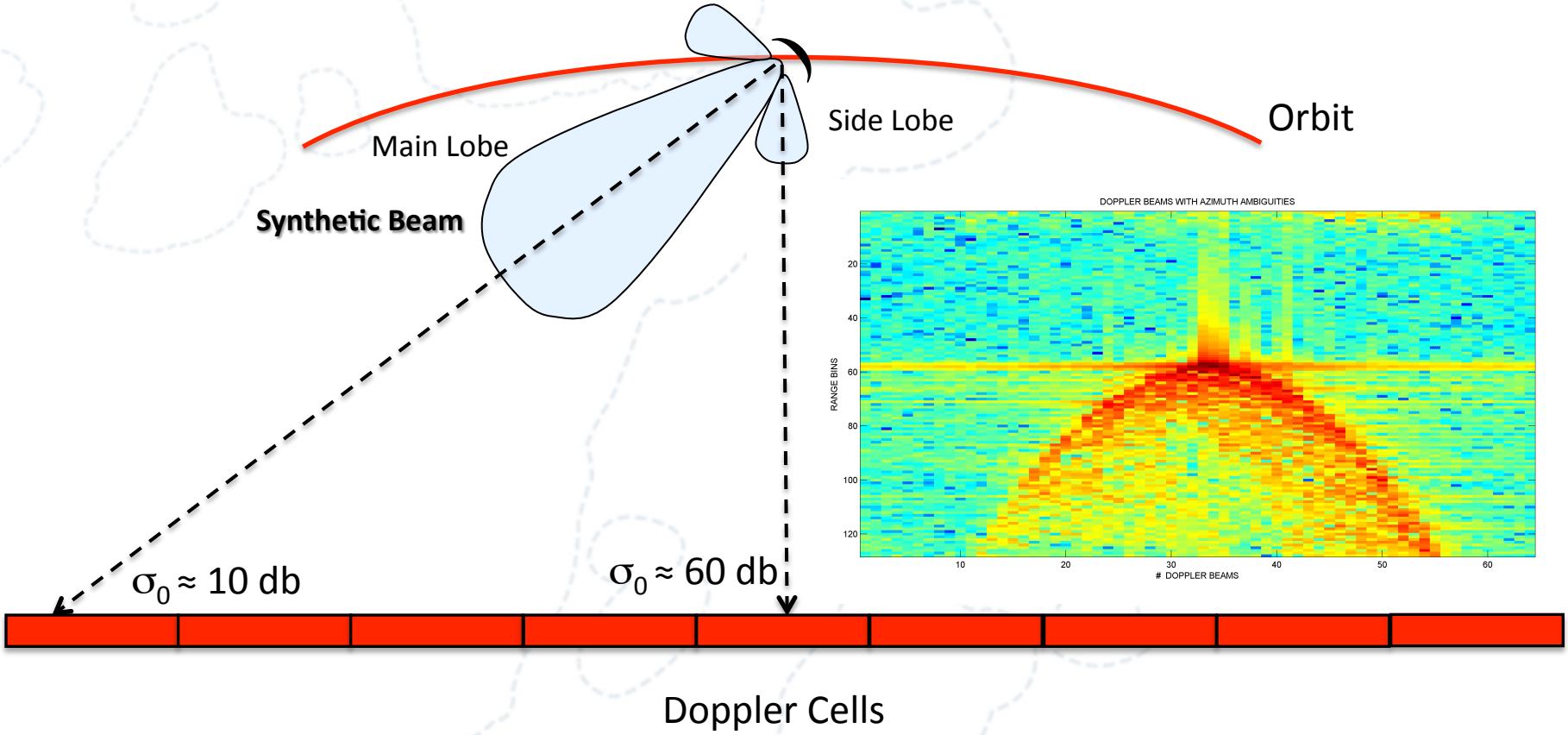
A COASTAL STILL WATER EXAMPLE
PASS IN AUGUST


CRYOSAT-2 PASS
RANGE BINS
50
100
150
200
250
50
100
150
200
250
300
RECORDS

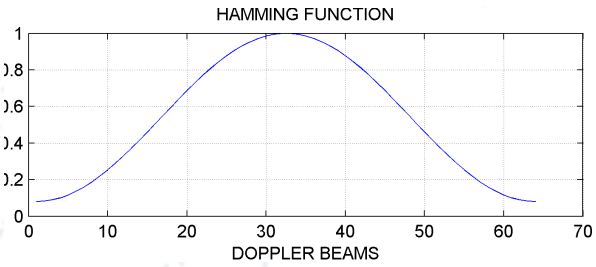

CRYOSAT-2 STACK DATA
RANGE BINS
50
100
150
200
250
50
100
150
200
LOOKS

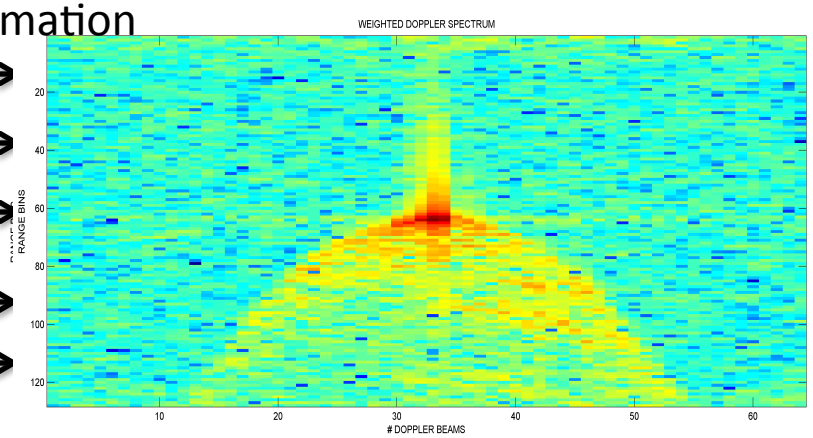

CRYOSAT-2 STACK DATA
RANGE BINS
50
100
150
200
250
50
100
150
200
LOOKS

AZIMUTH AMBIGUITIES OVER SPECULAR WATER SURFACES



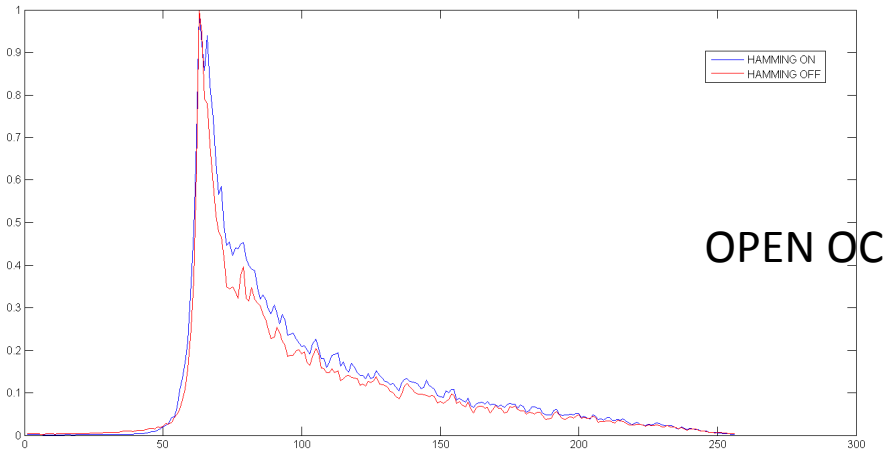
To compesante this effect => application of Weighting Function (Hamming) in Doppler Domain to Doppler Spectrum before the beam formation





Consequences:

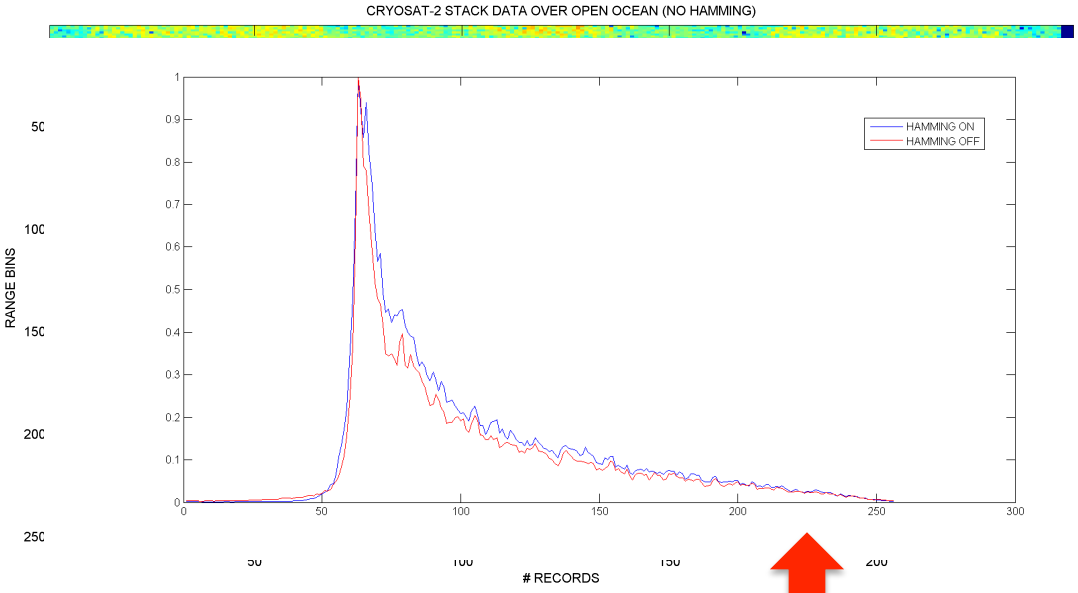
- Degradation of Cryosat Resolution by 1.5 factor (from 300 m to 450)
- Introduction of possible bias in SWH retrieval
- Distortion of the leading edge
- Degradation of range noise and introduction of bias in range ??



OPEN OCEAN

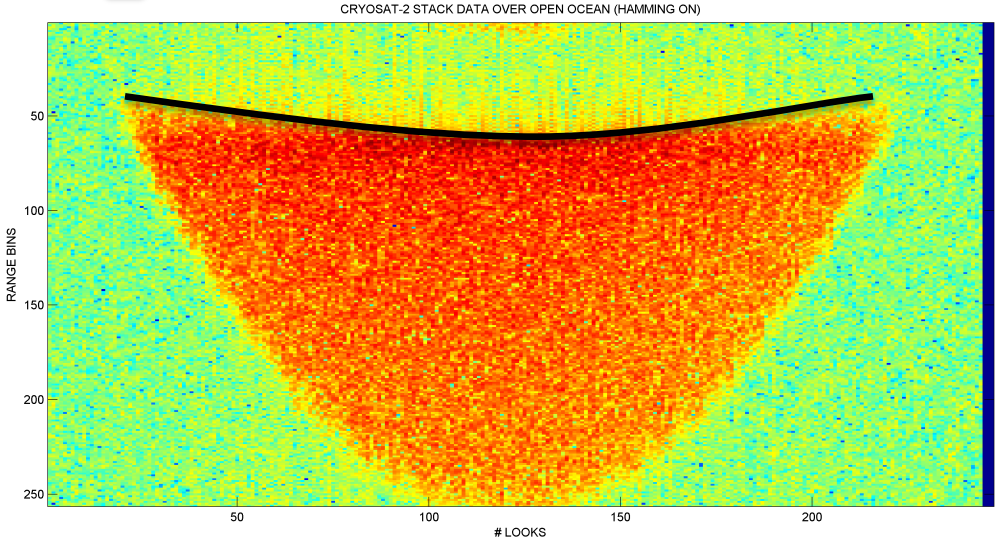
And raise a question: what is the best weighting function ?

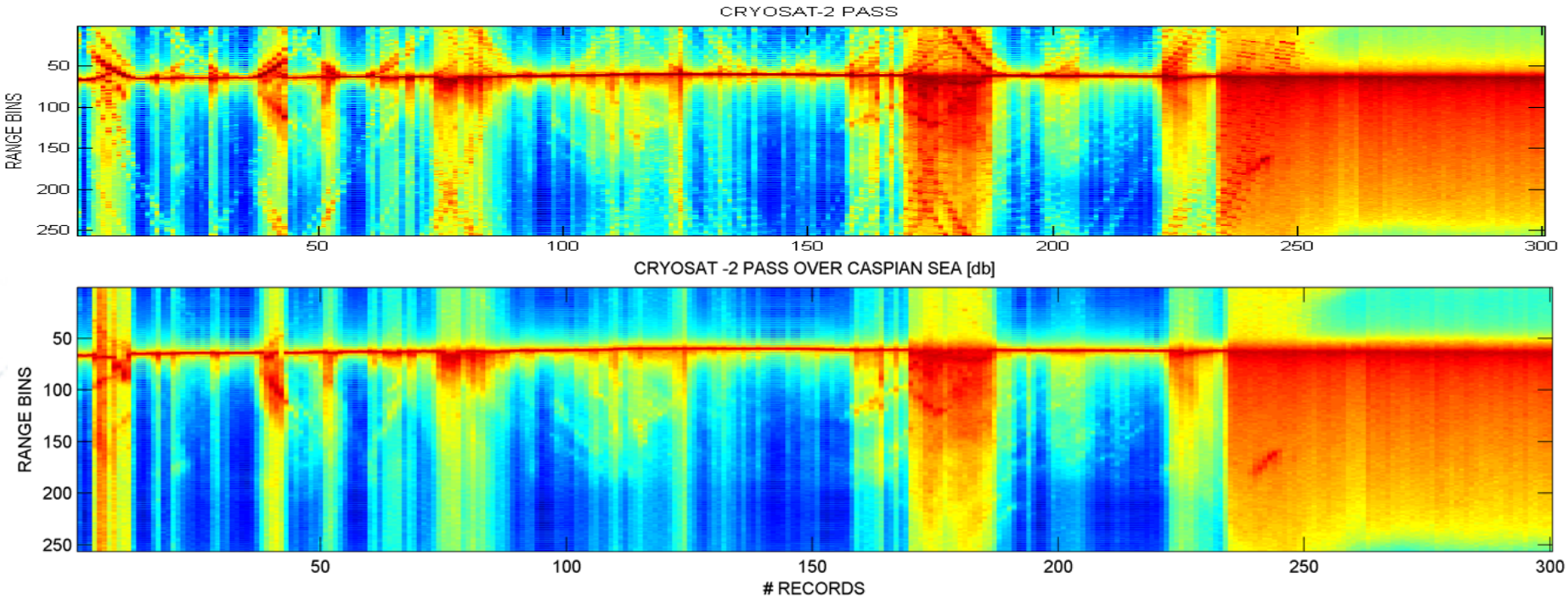
WEIGHTING EFFECT ON THE STACK DATA FRONT

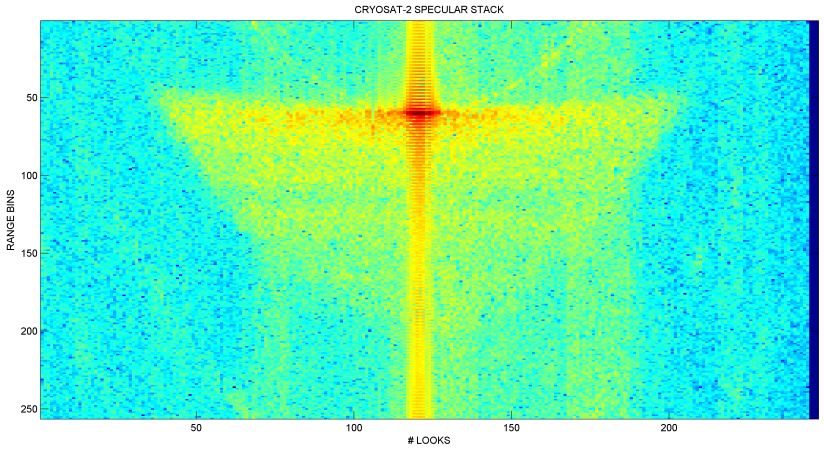


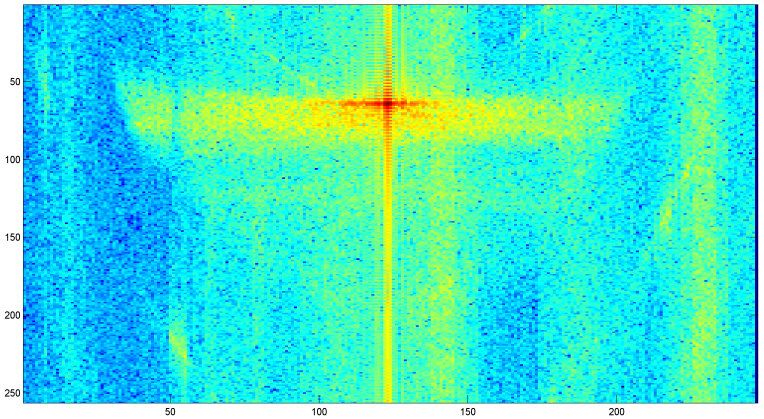
NO HAMMING

HAMMING ON

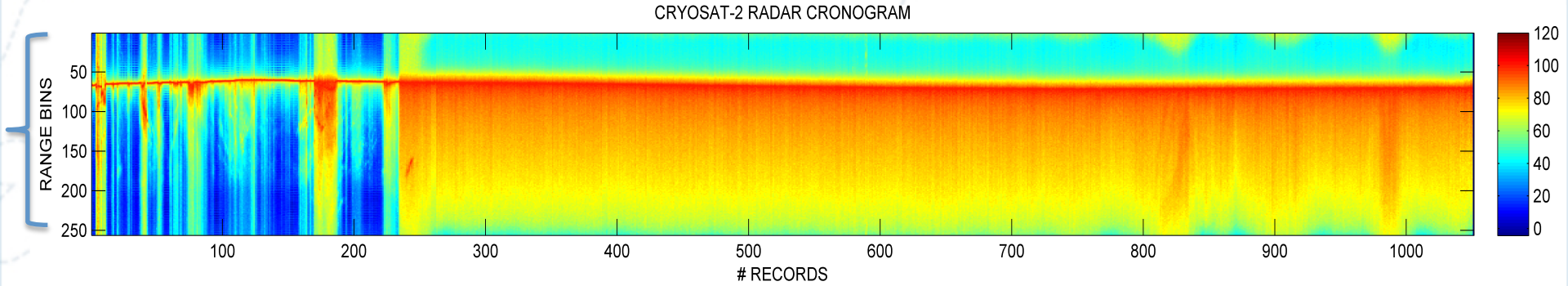


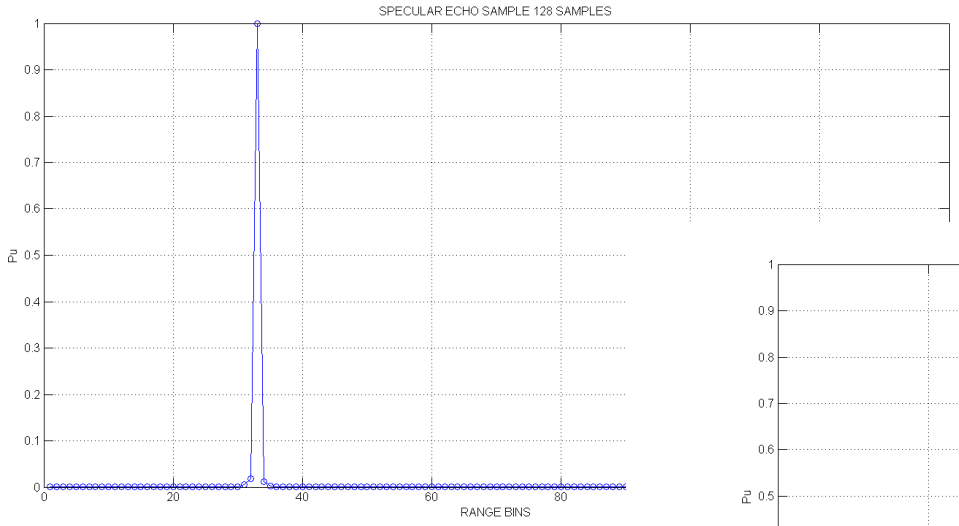

CRYOSAT-2 PASS
RANGE BINS
50
100
150
200
250
300
CRYOSAT -2 PASS OVER CASPIAN SEA [db]
RANGE BINS
RECORDS

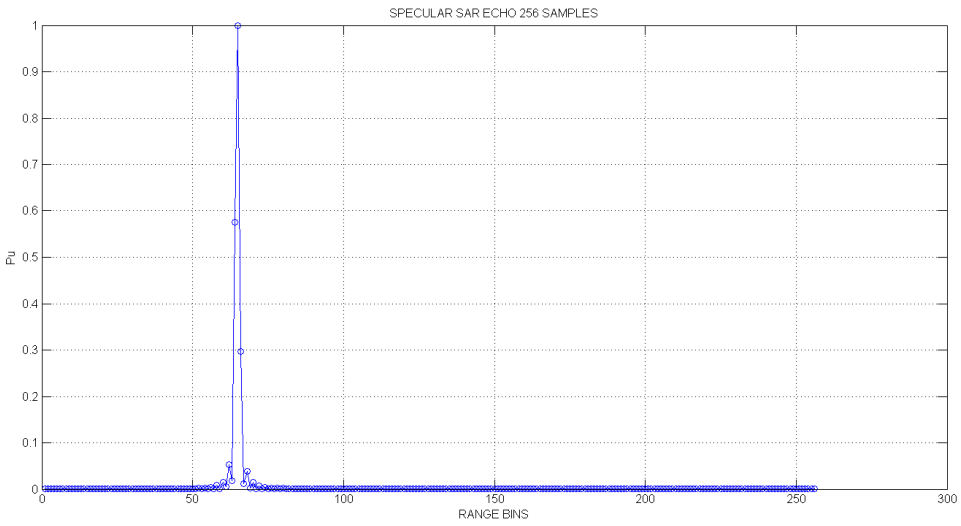

CRYOSAT-2 SPECULAR STACK
RANGE BINS
LOOKS

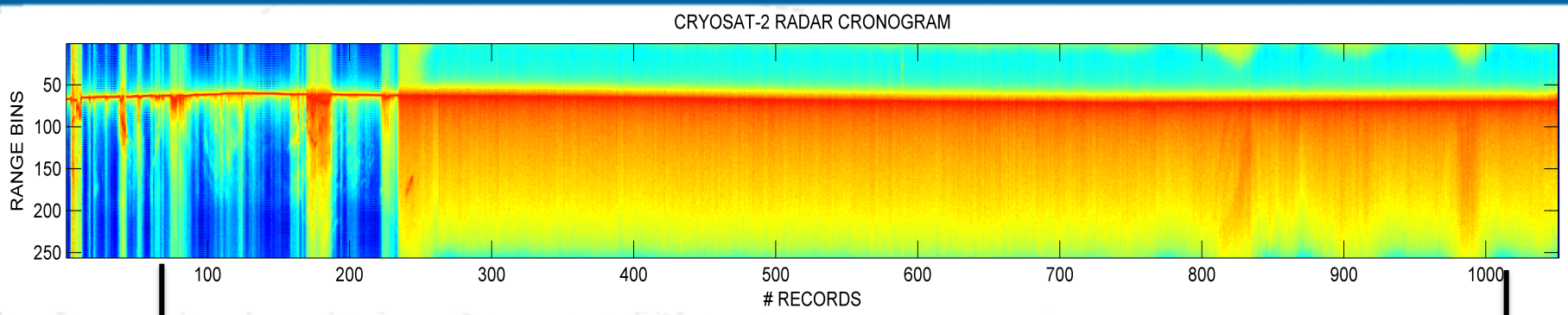


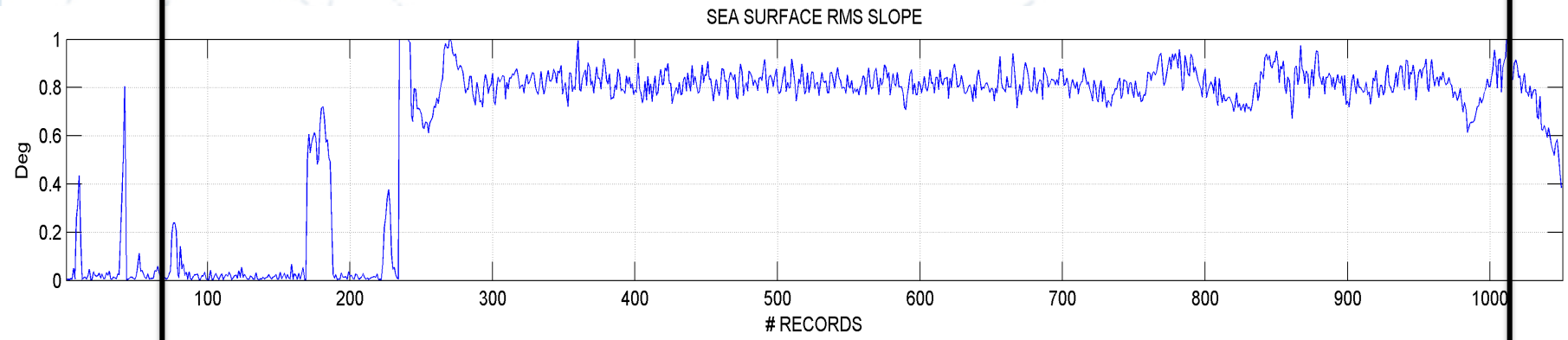
DOUBLE SAMPLING STEP





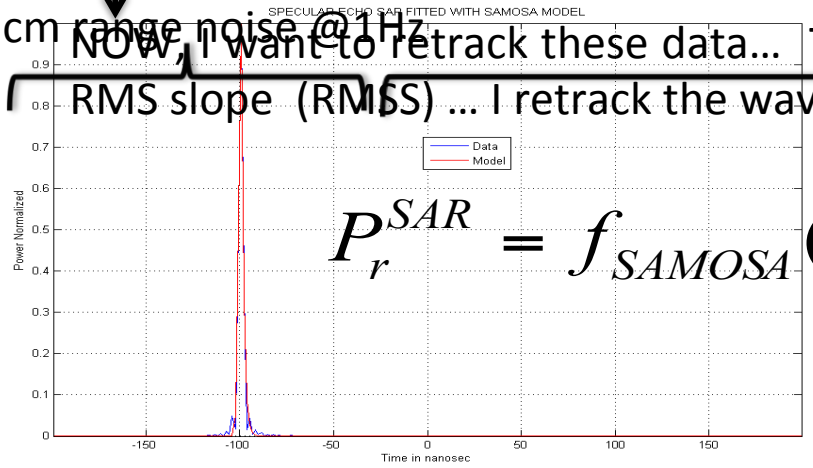






5 cm range noise @1Hz

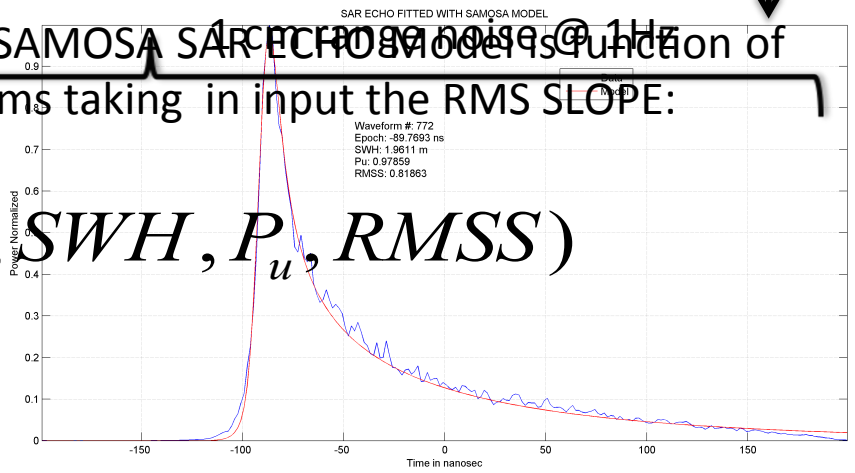
NOW, I want to retrack these data…

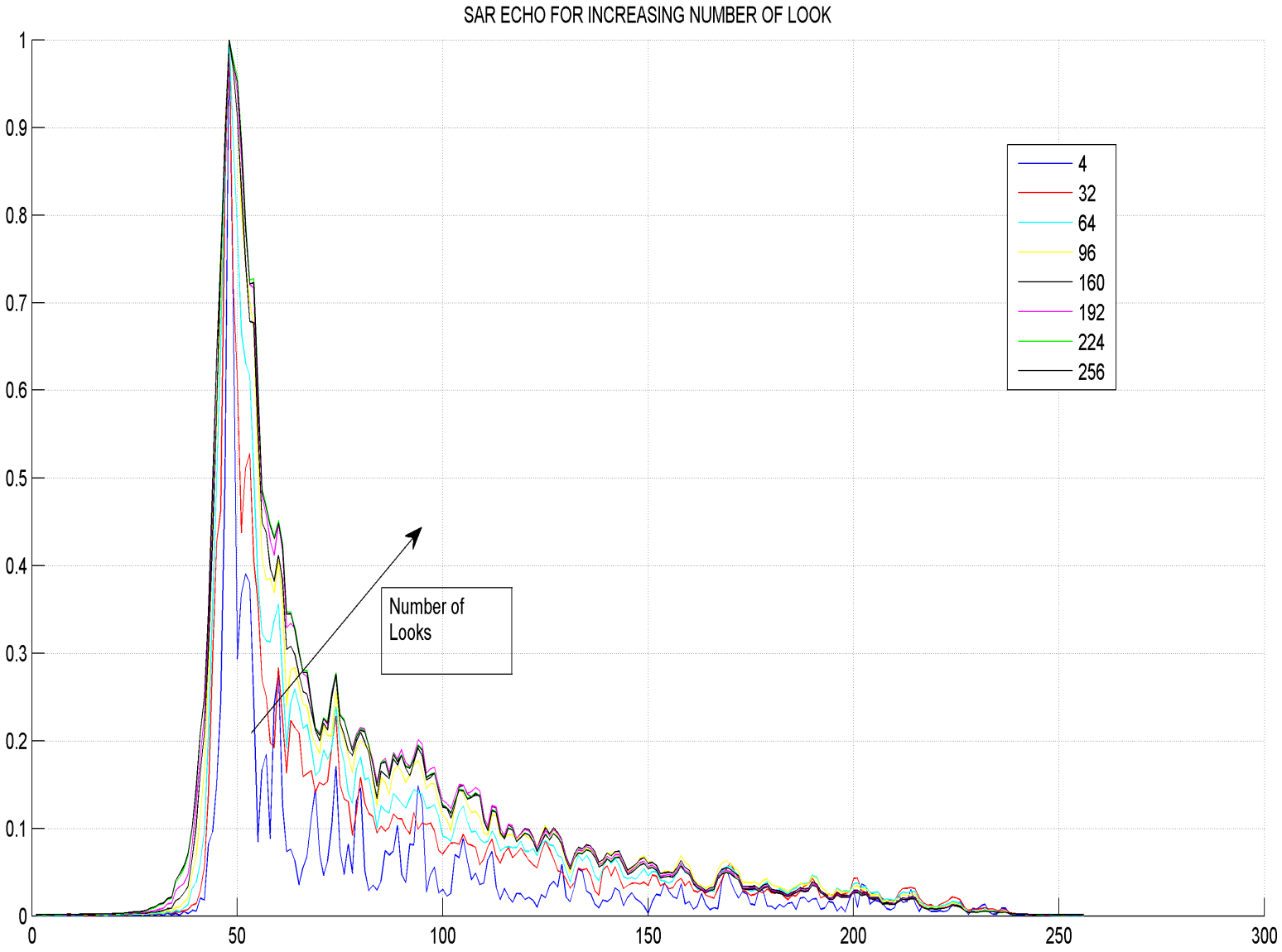


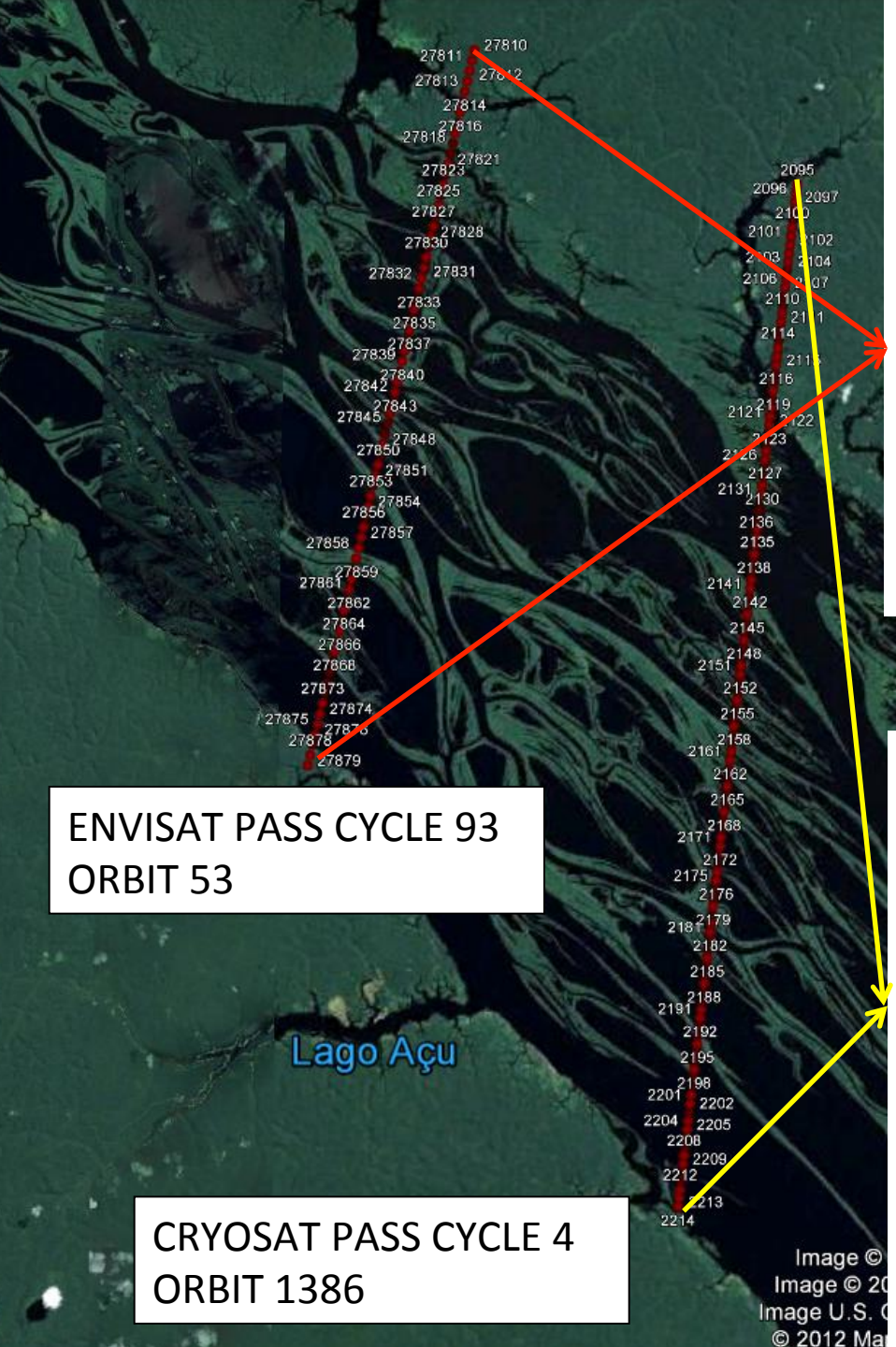
The SAMOSA SAR ECHO Model is function of RMS slope (RMSS) … I retrack the waveforms taking in input the RMS SLOPE:

$$P_r^{SAR} = f_{SAMOSA}(t_0, SWH, P_u, RMSS)$$

1 cm range noise @ 1Hz

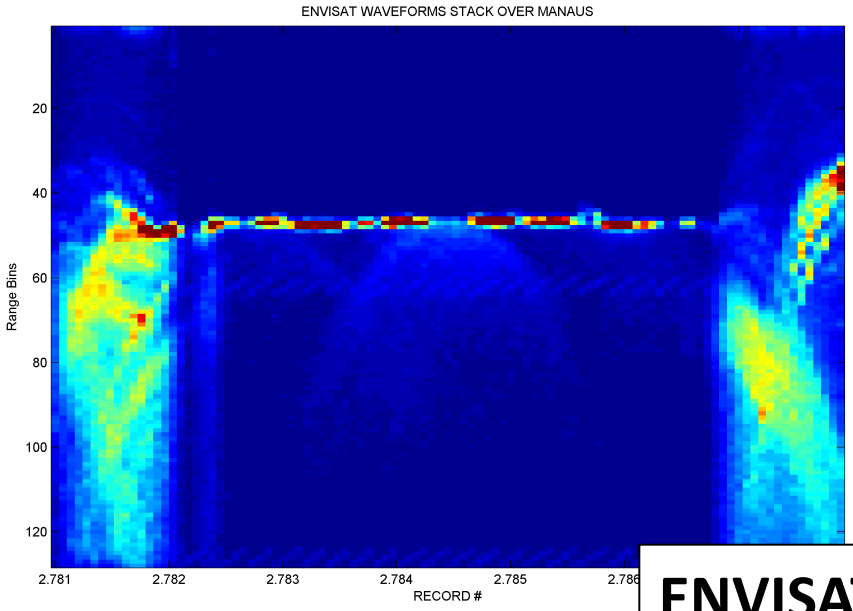



SAR ECHO FOR INCREASING NUMBER OF LOOK
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
200
250
300
4
32
64
96
160
192
224
256
Number of Looks

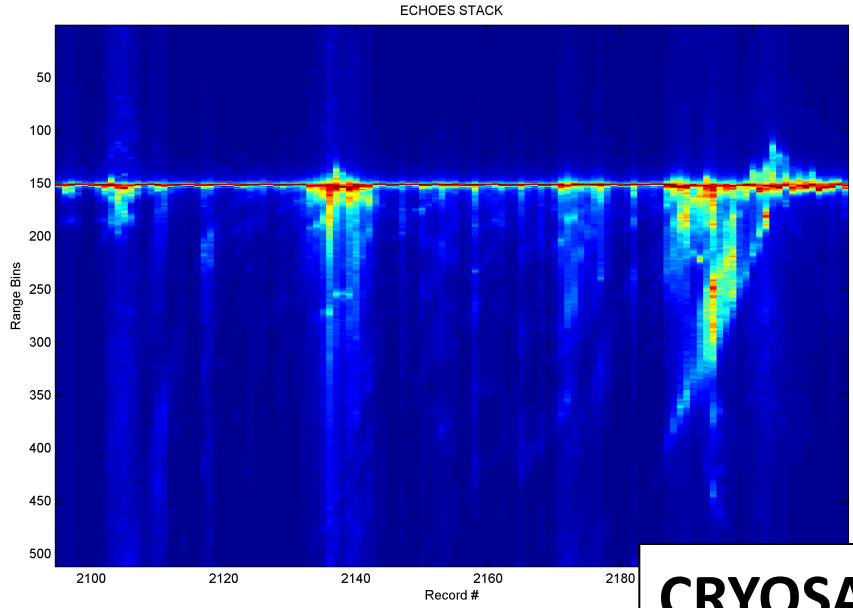


ENVISAT PASS CYCLE 93
ORBIT 53

CRYOSAT PASS CYCLE 4
ORBIT 1386



ENVISAT



CRYOSAT

CONCLUSIONS AND OPEN POINTS

STACK DATA AVAILABILITY FOR ADVANCED USERS?

Many secondary geophisical parameters can be derived from Stack data : RMS SLOPE, PITCH Mispointings, skewness and, having Stack data, different Multilooking approach can be advised

WEIGHTING FUNCTION YES/NO

not necessary on open ocean, It must be used on sea ice and inland water , what is the best weight function to use ?

ZERO-PADDING/OVERSAMPLING

Necessary to be applied on specular surfaces (inland waters) to sample properly the echoes, any impact on range noise over open ocean ?

SELECTIVE/TAILORED MULTILOOKING

The far off nadir doppler beams are just noise and sometimes all the stack energy is concentrated in few look or some looks can be land-contaminated, what is the best number of looks to sum up in the multilooking stage? The multilook algorithm must be the same for all the aplications (coastal zones, open ocean inland water ?)

RMS SLOPE AS INPUT PARAMETER IN THE RETRACKING

The physical-based SAR models are depending also from RMS Slope .. Taking RMS slope in input does improve the goodness of fit ? …same geophysical model and retracker can be used to retrack open ocean and still inland waters, no transition/jumps issues when switching retrackers