Optimization of the Ice-2 algorithm for the AltiKa waveform retracking over ice sheets

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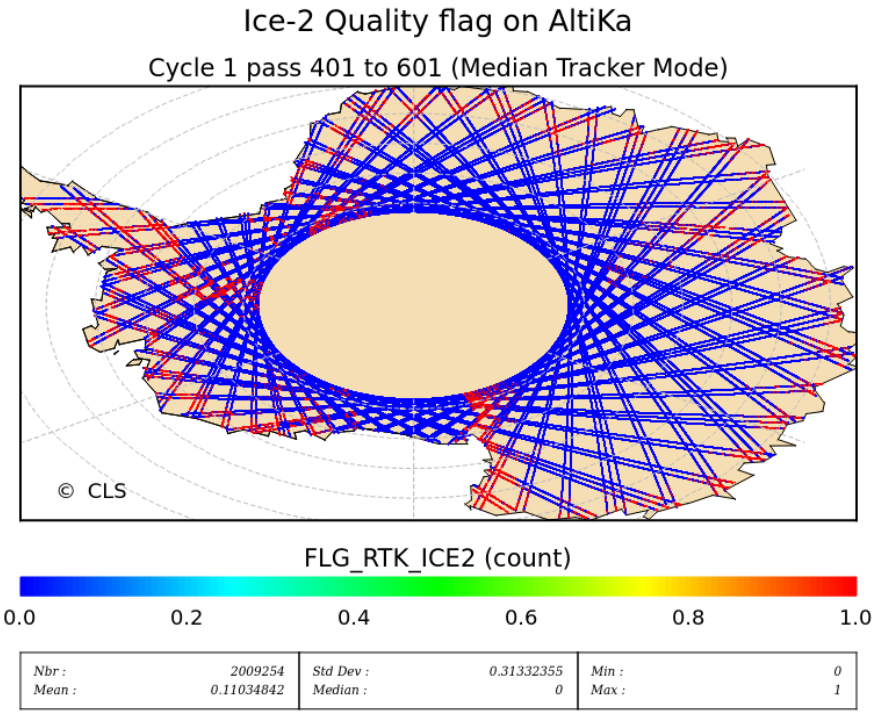
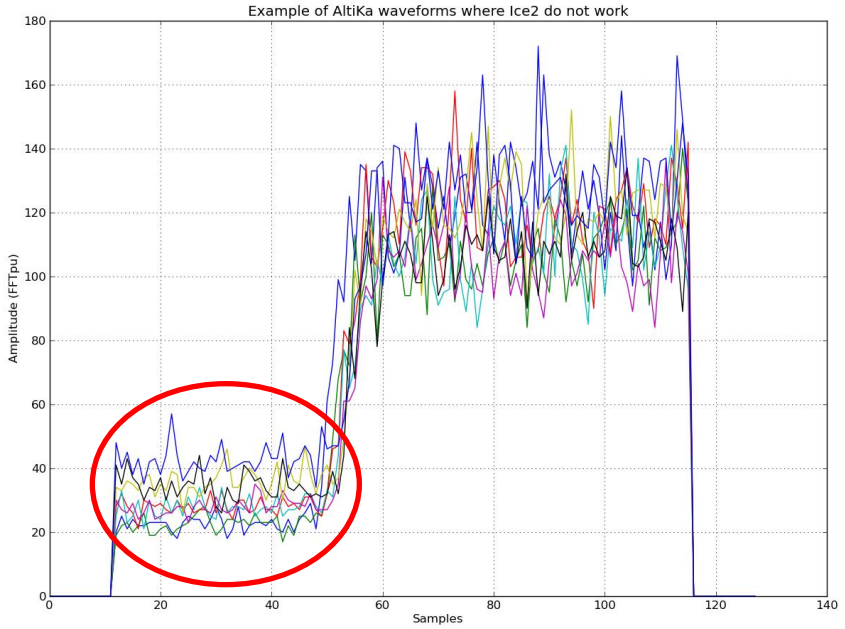
Objectives of this study

- As Ice-2 was implemented in the SARAL ground segment with ENVISAT settings, several limitations in the estimates have been identified in AltiKa products.

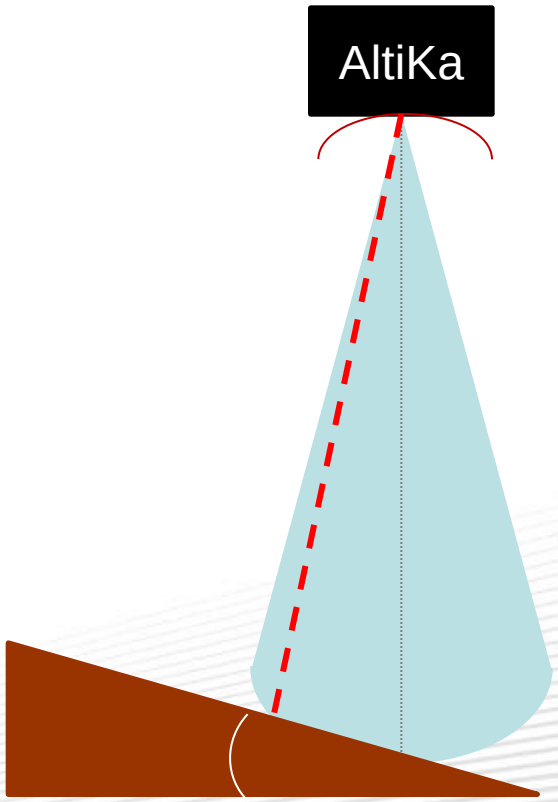




The Ice-2 quality flag is NOK mainly on steep terrain. Most of the time over these areas, the thermal noise is strong (~ 30-40 FFTpu)

Origin of the limitations

- On slopping terrain, the returned power is weak because the signal comes from off-nadir reflection (attenuation due to the antenna pattern)



AltiKa θ_{3dB}= 0.6°

➔ Sensitivity to the slope of the observed surface higher than Envisat (θ_{3dB} = 1.3°)

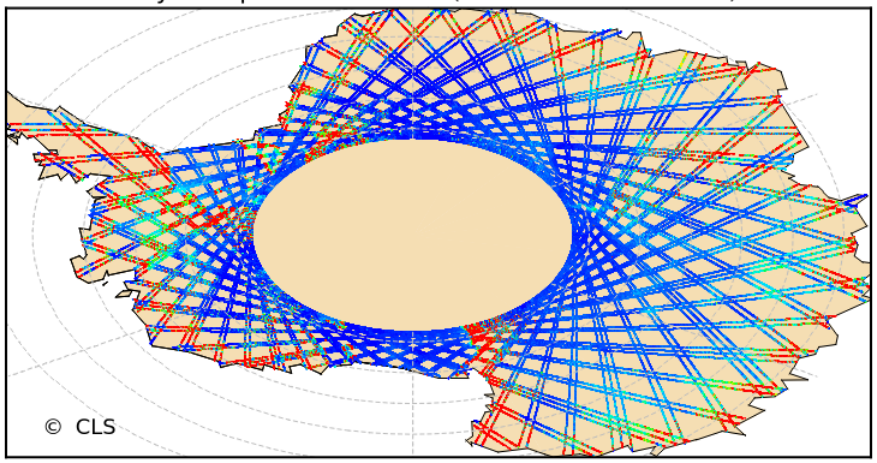
➔ Cf D. Blumstein's talk

Origin of the limitations

- On slopping terrain, the returned power is weak because the signal comes from off-nadir reflection (attenuation due to the antenna pattern)
  ➔ AGC increases the waveform amplitude and so the thermal noise

Ice-2 Thermal Noise on AltiKa

Cycle 1 pass 401 to 601 (Median Tracker Mode)



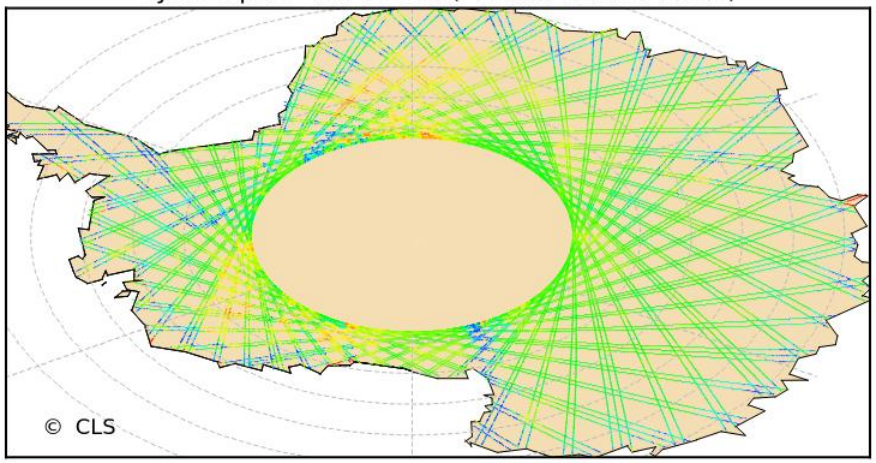
THN_ICE2 (count)

0 5 10 15 20 25

Nbr :	2009254	Std Dev :	24.834501	Min :	0
Mean :	9.5126618	Median :	2.06741	Max :	1290.6679

AGC values on AltiKa

Cycle 1 pass 401 to 601 (Median Tracker Mode)



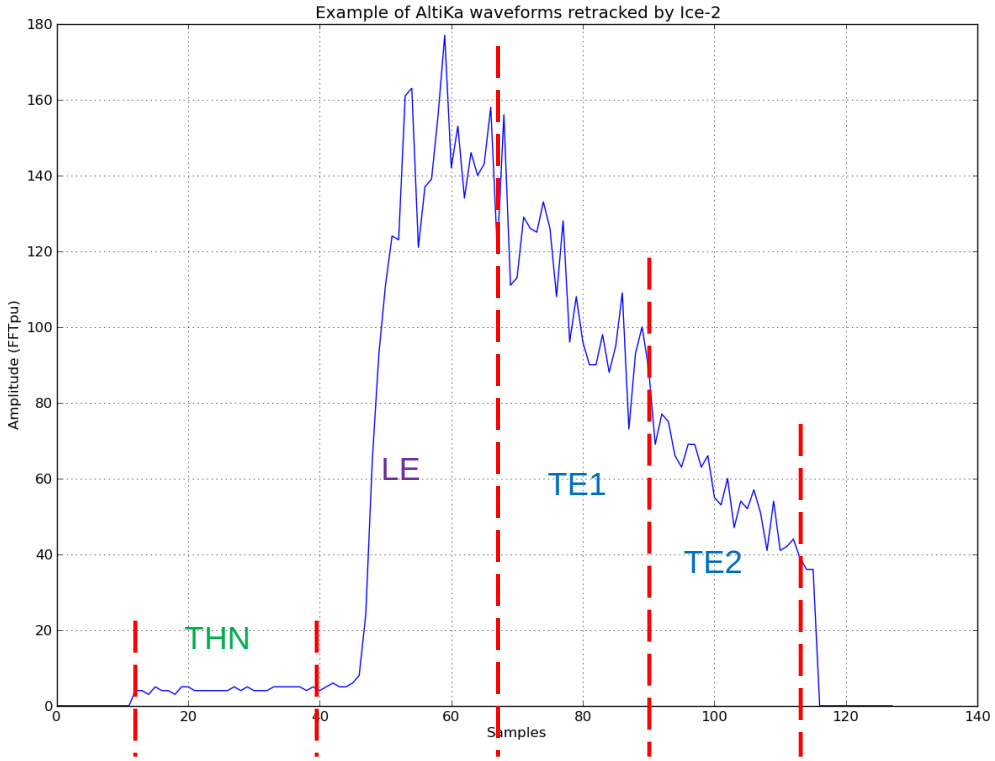
AGC (count)

10 20 30 40

Nbr :	51505	Std Dev :	4.8693834	Min :	9.16
Mean :	25.318564	Median :	26.1	Max :	57.71

The Ice-2 algorithm

- Principle: The Ice-2 algorithm divides the waveform into 4 estimation windows:



The outputs estimates are:

- Thermal noise
- Epoch
- SigmaL (Width of the LE)
- Amplitude
- Slope of the first part of the TE
- Slope of the second part of the TE
- Mean Amplitude
- Mean Slope
- Quality flags

Historically this algorithm was designed and configured to process Ku-Band waveforms ➔ It is therefore necessary to optimize the algorithm to process Ka waveforms.

Studied optimizations

- In the frame of the PEACHI project, which aims to improve the ground processing in coastal and hydrological areas and high latitudes, we have studied 3 different improvements of the Ice-2 algorithm :

  1. Test 1: A new set of Ice-2 parameters ➔ the easiest modification to implement in the AltiKa ground segment
  2. Test 2 : A new set of Ice-2 parameter + an improvement in the fit of the LE ➔ induced a source code modification
  3. Test 3 : A new set of Ice-2 parameter + an improvement in the fit of the LE with a different normalization ➔ induced a source code modification

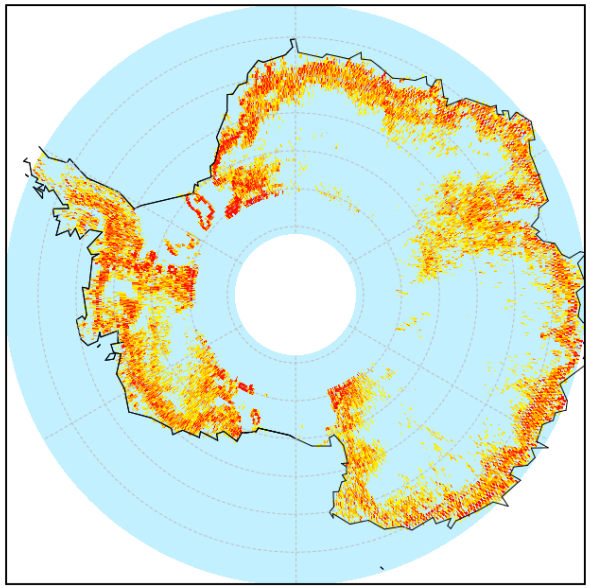
- The purpose of these 3 tests are:

  1. At least, not degrade the Ice-2 performances when the quality flag is OK
  2. Increase the number of retracked measurements (especially on slopping terrain)
  3. Bring improvements in the leading edge estimation

Results: Nb of retracked waveforms

AltiKa Cycles 2-3

umber of samples per grid box diff. ICE2 TEST



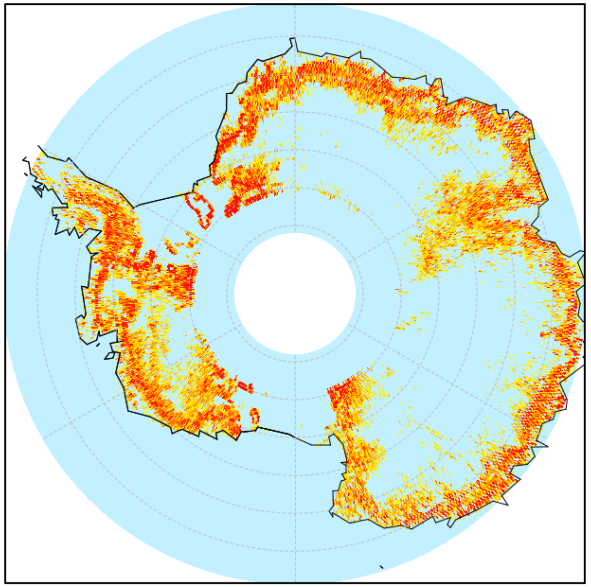
DiffNBR_ICE2TEST1_ICE2

-40 -20 0 20 40

Nbr :	109440	Std Dev :	10.594173	Min :	-59
Mean :	3.092955	Median :	0	Max :	331

AltiKa Cycles 2-3

umber of samples per grid box diff. ICE2 TEST



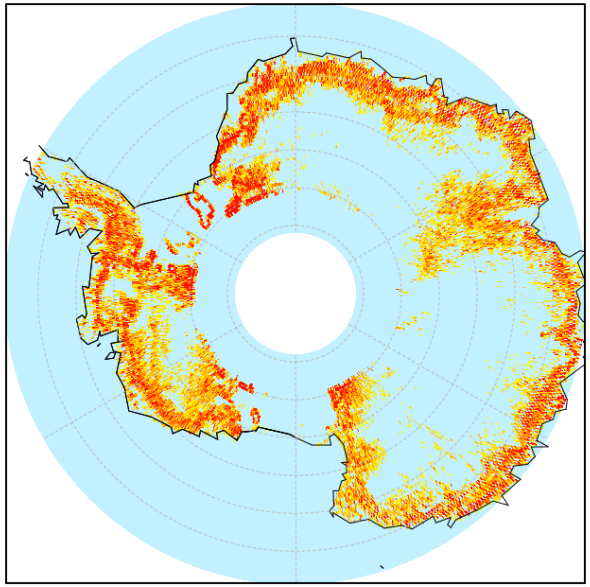
DiffNBR_ICE2TEST2_ICE2

-40 -20 0 20 40

Nbr :	109440	Std Dev :	12.1164	Min :	-3
Mean :	3.6937591	Median :	0	Max :	381

AltiKa Cycles 2-3

umber of samples per grid box diff. ICE2 TEST



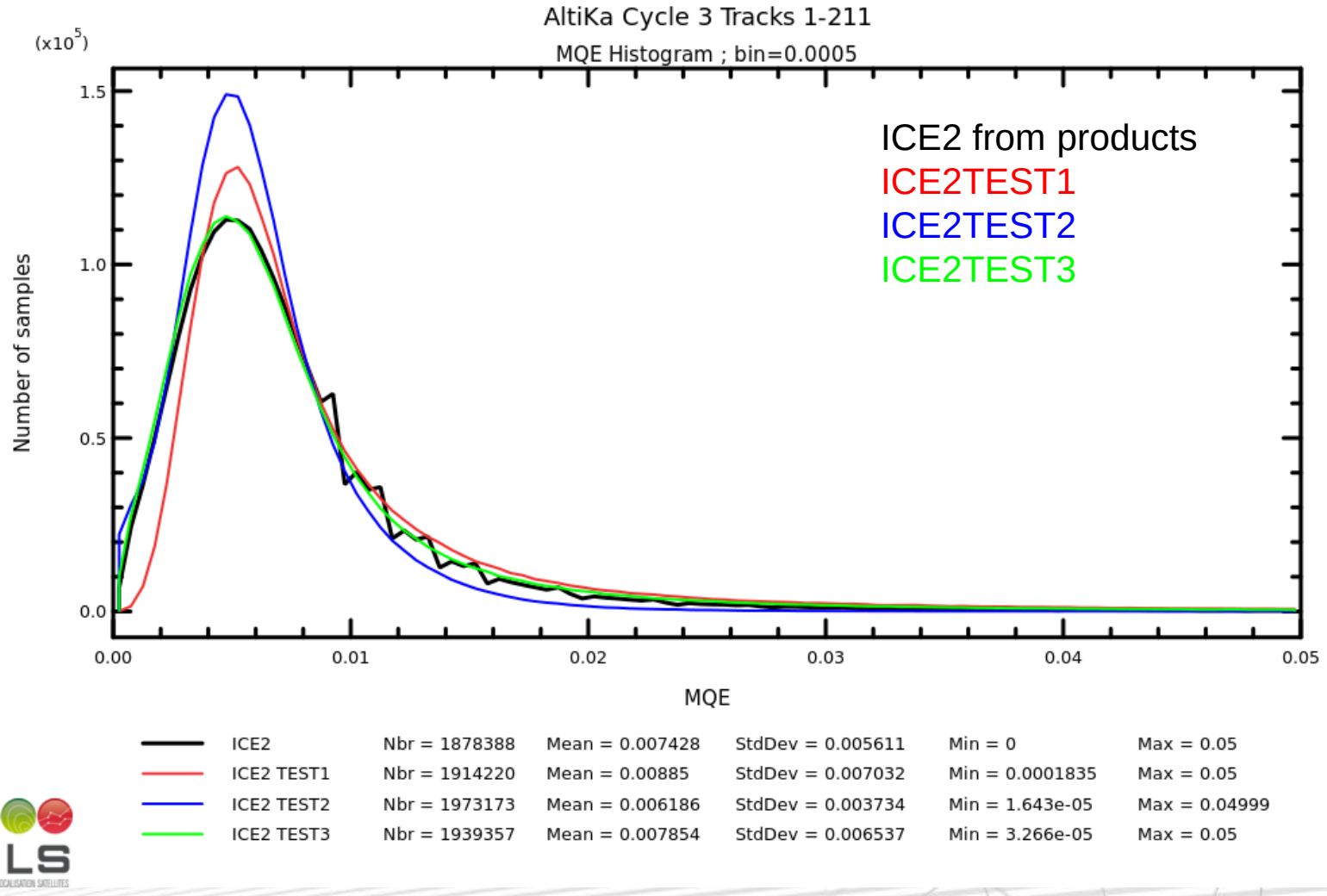
DiffNBR_ICE2TEST3_ICE2

-40 -20 0 20 40

Nbr :	109440	Std Dev :	12.114675	Min :	-3
Mean :	3.6929368	Median :	0	Max :	381

- The difference is positive for each test case, meaning that we retrieve more samples using the new Ice-2 parameters. Test 2 retrieves the more measurements than the others.

Results: MQE

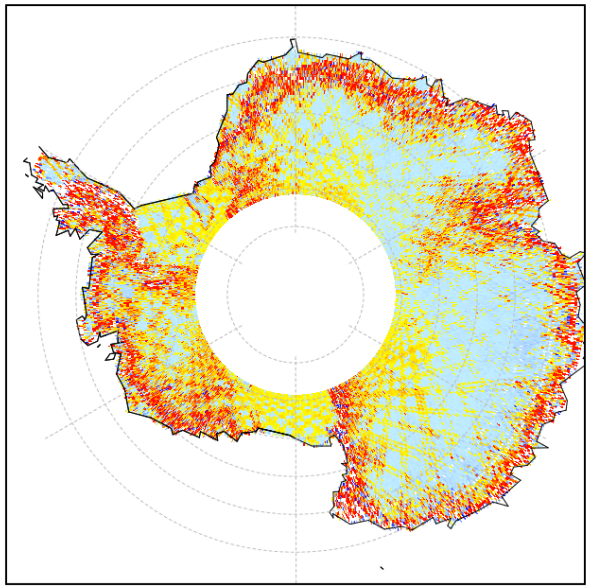


- The MQE of test 2 is the lowest MQE. The MQE of tests 1 and 3 is slightly higher.

Results: MQE

AltiKa Cycles 2-3

Mean, MQE Diff. ICE2TEST1 - ICE2



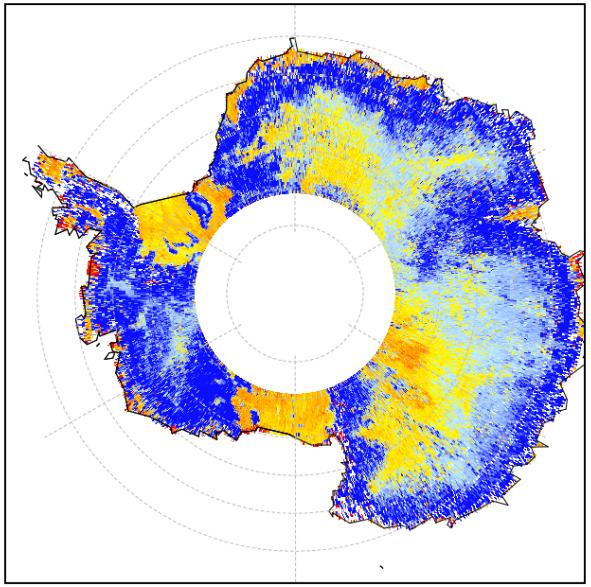
DiffMQE_ICE2TEST_ICE2

-4 -2 0 2 4 (x10^{-3})

Nbr :	57525	Std Dev :	0.0086128355	Min :	-0.089848859
Mean :	0.0013857885	Median :	2.7815125e-05	Max :	1.0238721

AltiKa Cycles 2-3

Mean, MQE Diff. ICE2 TEST2 - ICE2



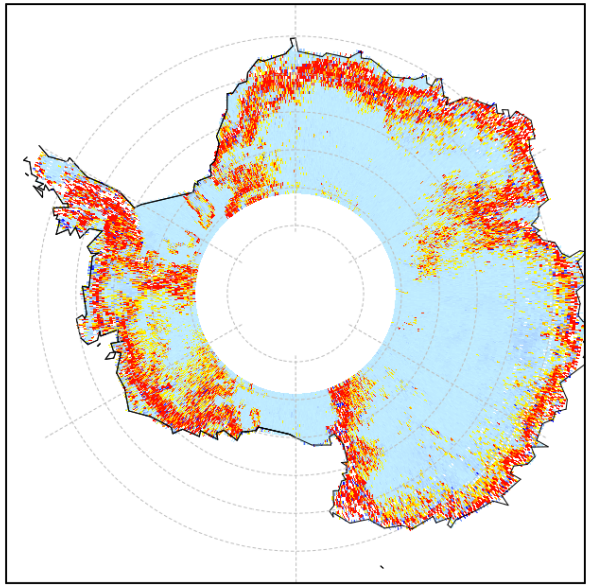
DiffMQE_ICE2TEST2_ICE2

-4 -2 0 2 4 (x10^{-3})

Nbr :	57600	Std Dev :	0.0054545492	Min :	-0.27125437
Mean :	-0.0025203639	Median :	-0.00078900553	Max :	0.04286058

AltiKa Cycles 2-3

Mean, MQE Diff. ICE2 TEST3 - ICE2



DiffMQE_ICE2TEST3_ICE2

-4 -2 0 2 4 (x10^{-3})

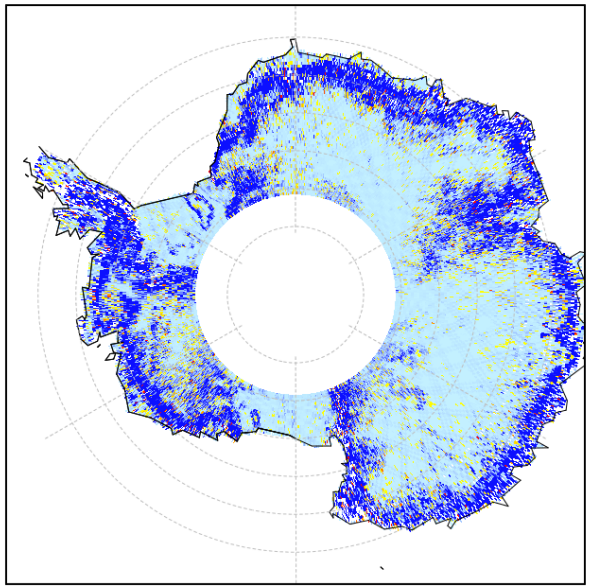
Nbr :	57600	Std Dev :	4053850.1	Min :	-0.089848859
Mean :	39094.71	Median :	-7.2288362e-05	Max :	6.6666667e+08

- Test 1 and 3 : most of the red boxes are due to measurements retrieved.
- Test 2: The MQE is clearly lower on slopping terrain, but other zones appear a little bit higher.

Results: Epoch

AltiKa Cycles 2-3

Mean, EPOCH Diff. ICE2TEST1 - ICE2



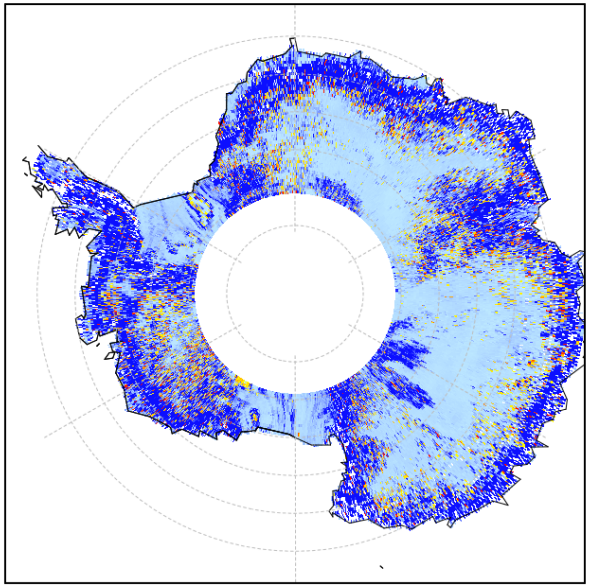
DiffEPOCH_ICE2TEST_ICE2

-0.4 -0.2 0.0 0.2 0.4

Nbr :	57525	Std Dev :	1.4820446	Min :	-27.370254
Mean :	-0.43550255	Median :	-0.019781136	Max :	3.3871226

AltiKa Cycles 2-3

Mean, EPOCH Diff. ICE2TEST2 - ICE2



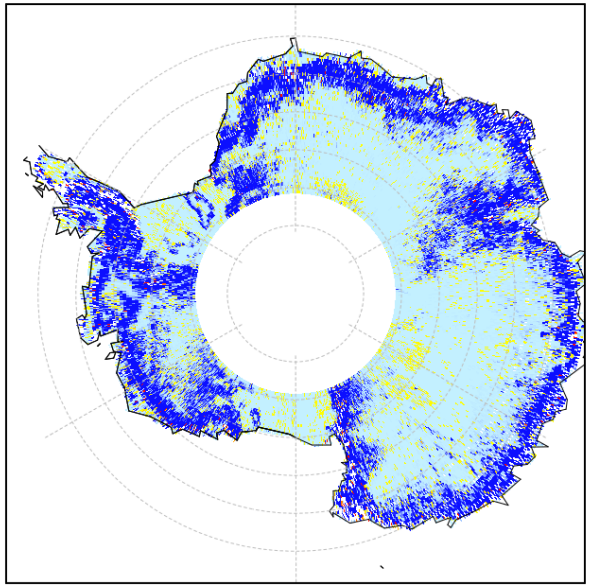
DiffEPOCH_ICE2TEST2_ICE2

-0.4 -0.2 0.0 0.2 0.4

Nbr :	57600	Std Dev :	1.7977857	Min :	-28.057259
Mean :	-0.58582636	Median :	-0.079604899	Max :	9.7109647

AltiKa Cycles 2-3

Mean, EPOCH Diff. ICE2TEST3 - ICE2



DiffEPOCH_ICE2TEST3_ICE2

-0.4 -0.2 0.0 0.2 0.4

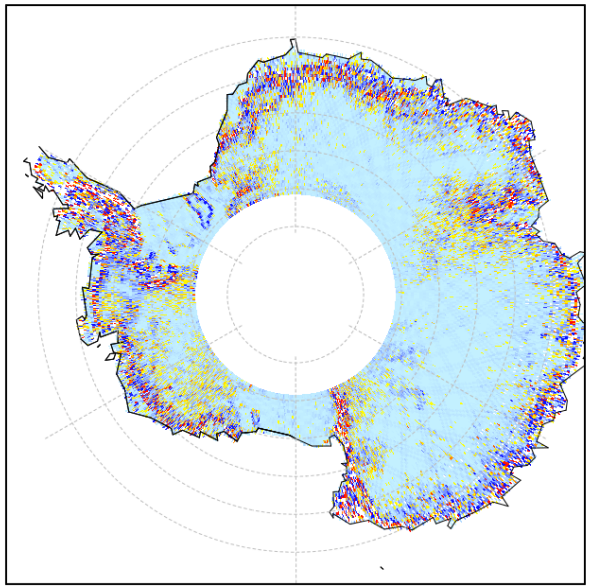
Nbr :	57600	Std Dev :	1.8947126	Min :	-27.854307
Mean :	-0.59039382	Median :	-0.0043491038	Max :	3.0274966

- The estimated epoch is lower over steep areas in each test case compared to Ice-2 products. Geophysical validation is in progress at LEGOS.
- Test 2: The same areas previously identified with a higher MQE also appear to be weaker

Results: SigmaL (width of LE)

AltiKa Cycles 2-3

Mean, SIGL Diff. ICE2TEST1 - ICE2



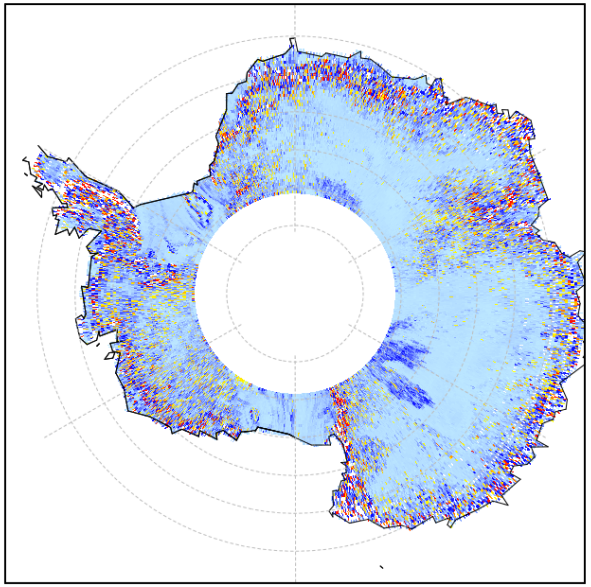
DiffSIGC_ICE2TEST_ICE2

-1.0 -0.5 0.0 0.5 1.0

Nbr :	57525	Std Dev :	0.47177178	Min :	-7.2133194
Mean :	-0.066939812	Median :	-0.019620466	Max :	6.7912824

AltiKa Cycles 2-3

Mean, SIGL Diff. ICE2TEST2 - ICE2



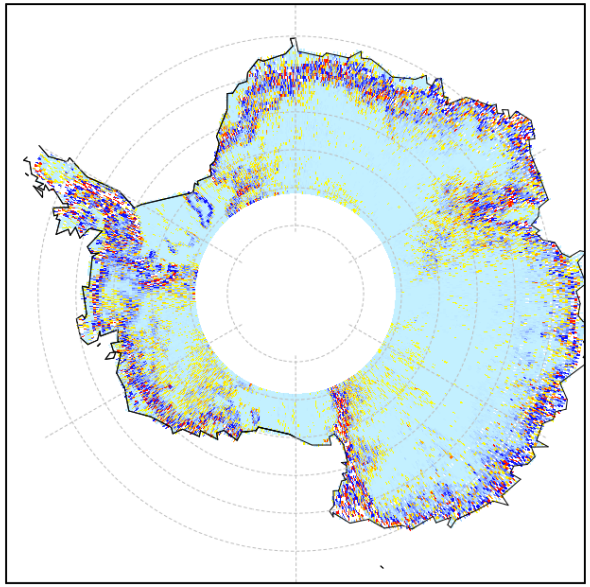
DiffSIGC_ICE2TEST2_ICE2

-1.0 -0.5 0.0 0.5 1.0

Nbr :	57600	Std Dev :	0.47404073	Min :	-7.2609895
Mean :	-0.16591293	Median :	-0.091750598	Max :	7.2592824

AltiKa Cycles 2-3

Mean, SIGL Diff. ICE2TEST3 - ICE2



DiffSIGC_ICE2TEST3_ICE2

-1.0 -0.5 0.0 0.5 1.0

Nbr :	57600	Std Dev :	0.48755103	Min :	-7.4014948
Mean :	-0.060177835	Median :	-0.0024825105	Max :	6.7912824

- The SigmaL is greater over steep areas in each test case compared to Ice-2 products. This is mainly due to the retrieved waveforms. Geophysical validation is in progress at LEGOS.
- Test 2: The same areas previously identified with a higher MQE also appear weaker.

Conclusions

- The 3 tests can retrieve a lot of measurements previously rejected by Ice-2.
- The MQE seems to be better with test 2 whereas test 1 and 3 have a MQE slightly higher on reliefs.
- The test 1 is the easiest to implement into the ground segment. Tests 2 and 3 require a modification of the source code of the algorithm.
- A cycle of AltiKa data has been reprocessed for each version of the Ice-2 retracking and the outputs have been provided to LEGOS for deeper analysis.
- After evaluation by the LEGOS team, the most efficient solution will be chosen.

Thank you for your attention !