AltiKa MWR
Early in-flight calibration and validation of geophysical products

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Summary

1. In flight calibration adjustment
2. Development of new inversion algorithms for the retrieval of geophysical products

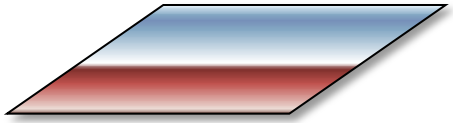
IN-FLIGHT CALIBRATION ADJUSTMENT

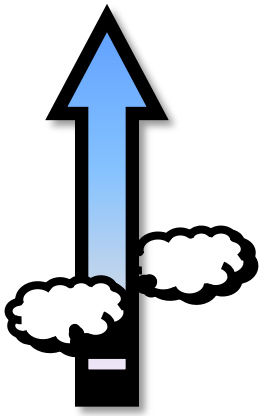
Inversion algorithm development

E. Obligis, L. Eymard, et al,
"*First three years of the microwave radiometer aboard ENVISAT: In flight calibration, processing, and validation of the geophysical products,*"
J. Atmos. Ocean. Technol., vol. 23, no. 6, pp. 802–814, Jun. 2006.

BEFORE LAUNCH

Simulated
TB23.8, TB37
Sigma 0 Ka





Radiative Transfer model

Simulated
TB23.8, TB37
Sigma 0 Ka

Neural Network
(Weights, Bias)

ECMWF analysis:
2D surface: sst, wind
3D profiles:T,P, Wv, Wc

column-integrated
Dh, Att, Wc, Wv

Inversion algorithm application

AFTER LAUNCH

MWR ➔ TB23.8, TB37

Alt ➔ Sigma0 Ka

Neural Network
(Weights, Bias)

Dh,Att,Wc,Wv

Consistency required for a good quality of the geophysical products

BEFORE LAUNCH

Simulated
TB23.8, TB37
Sigma 0 Ka

Neural Network
(Weights, Bias)

column-integrated
Dh, Att, Wc, Wv

In-flight calibration

- A linear adjustment relation has to be applied to the brightness temperatures and to the altimeter basckscattering coefficient in order to get inputs of the L2 retrieval algorithm consistent with what is expected (ie what has been used to formulate the algorithm)

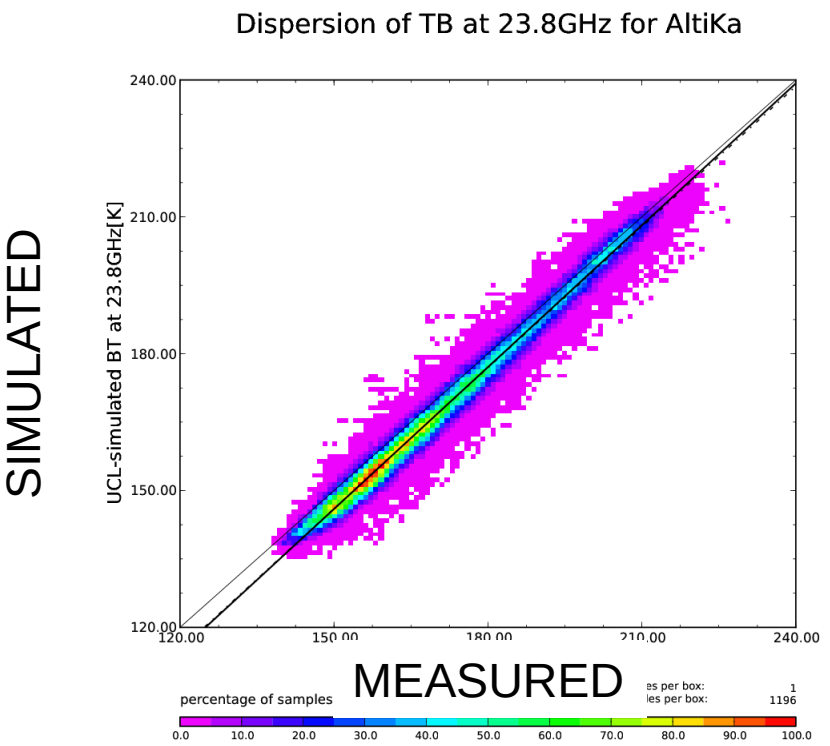
- Usually this adjustment is performed at the end of the commissionning phase. For SARAL/AltiKa, CNES proposed to perform an intermediate adjustment that is available in the GDR-T products

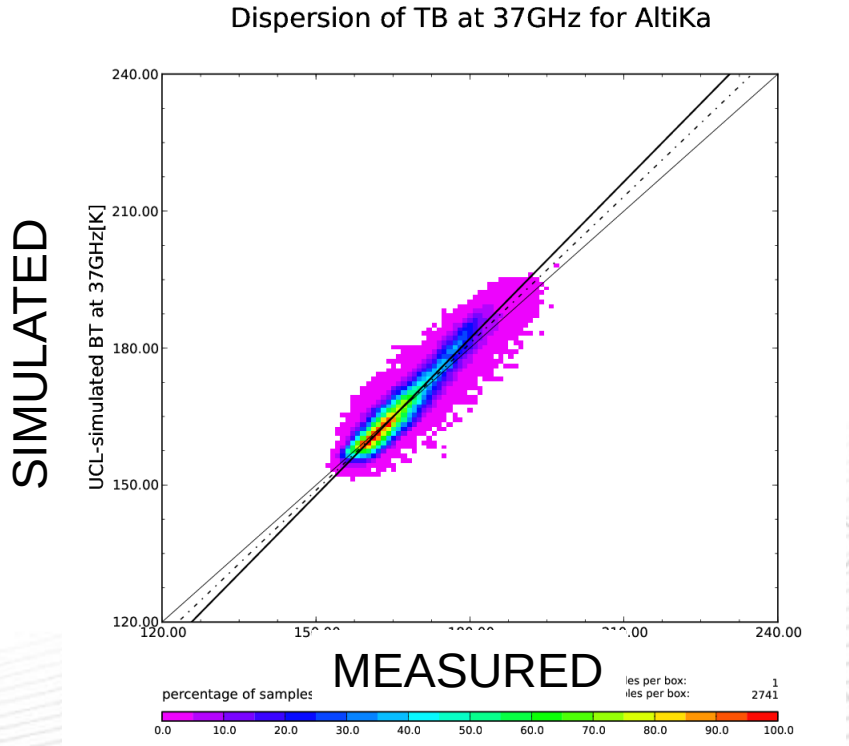
Determination of the linear relation for the intermediate adjustment

- Determination of the linear adjustment by comparison of simulated brightness temperatures and sigma0 with colocalised AltiKa measurements (+/-1h,0.25°)
- Simulation of brightness temperatures and Sigma0 Ka with the UCL radiative transfer model from ECMWF analysis:
  - 4 ECMWF analyses / day
  - Area : latitude +/-60° (to remove ice surface), resolution 0.25°
- Selection of open ocean and clear sky situations by filtering MWR and simulated data
- Almost two months (April-May 2013) of data have been processed

Comparison of MWR TB with Simulated TB

Good agreement between measured TBs and simulated TBs





23.8 GHz : Mean bias = -3.23 K
: Std = 2.77 K

37 GHz : Mean bias = 0.23 K
: Std = 2.96 K

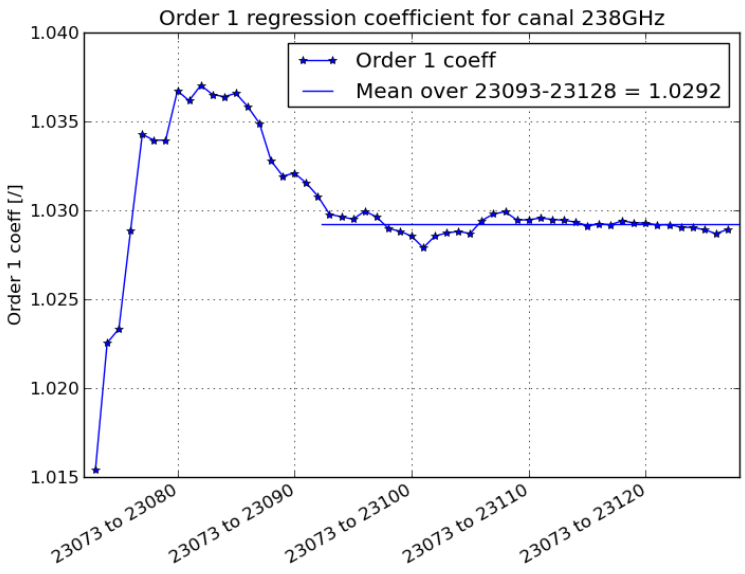
For the intermediate adjustment, only the 23.8GHz channel will be corrected

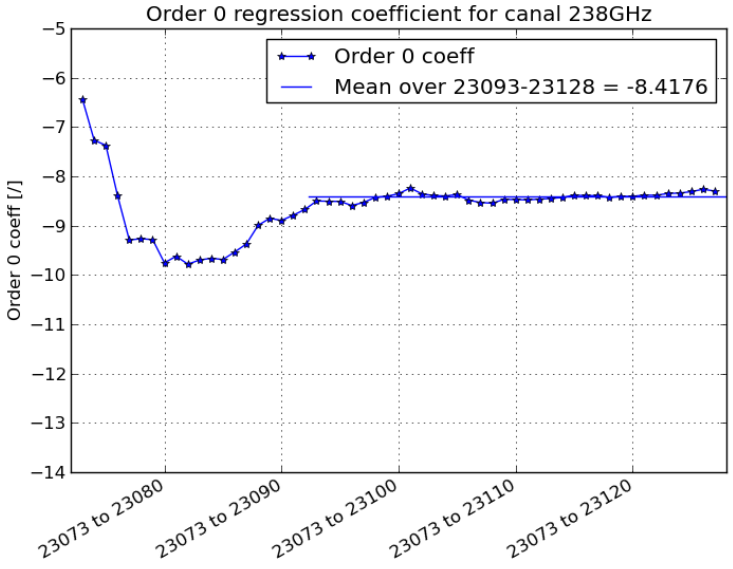
Assessment of the statiscal representativity

- Usually about 6 months of data is processed for the adjustment of brightness temperatures (to catch seasonal cycle impact)
- As the intermediate calibration is performed at the beginning of the commissionning phase, only 2 months of data were available at the time of the study
- To assess the statistical representativity of the data set, an iterative concatenation of 1 day of data is performed over the period of study
- For each iteration, a linear regression on the scatterplot is applied and regression coefficients are monitored

Evolution of regression coefficients – 23.8 GHz

- The results show that the accumulation of approx. 1 month of data is statistically representative
- Correction given by taking the average of the coefficients over the second month of data





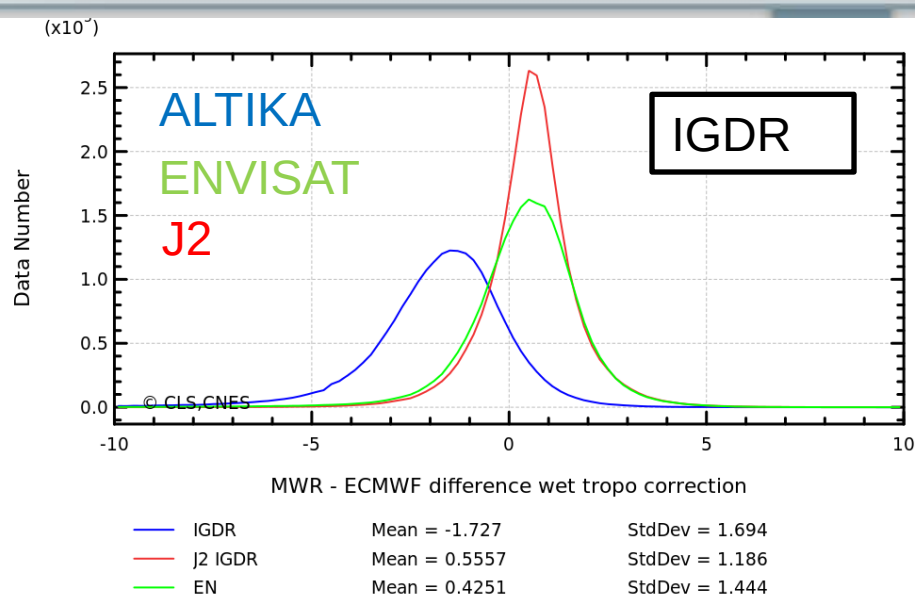
MWR –ECMWF Difference of wet tropospheric after correction

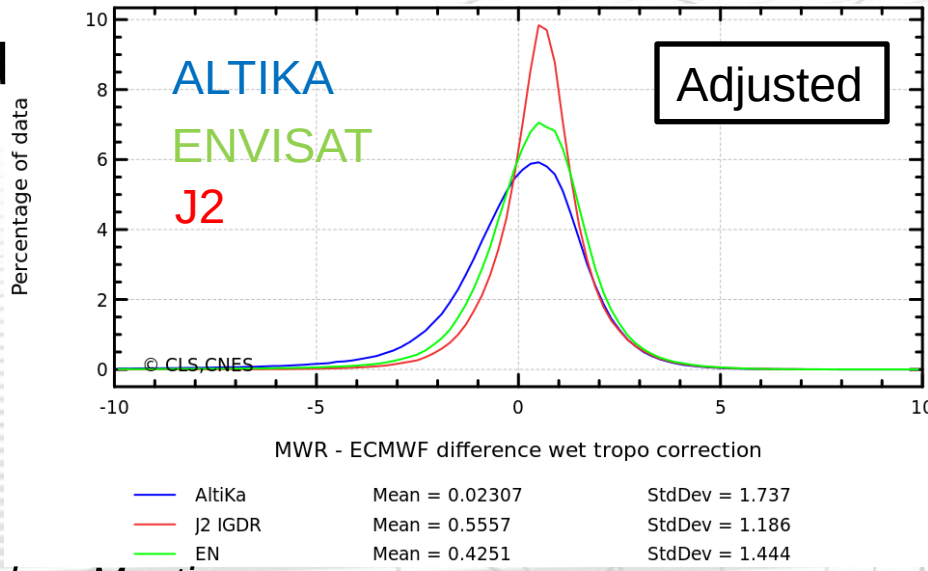
- Offline Adjusment of 23.8 GHz TBs applied on 2 months of data
- Application of the NN to evaluate the impact on the final geophys. products

➢ MWR wet tropo correction bias w/t ECMWF correction is reduced when using the adjusted 23.8GHz TB in input of the NN

-1.727 cm (IGDR) ➔ 0.02 cm (Adj.)

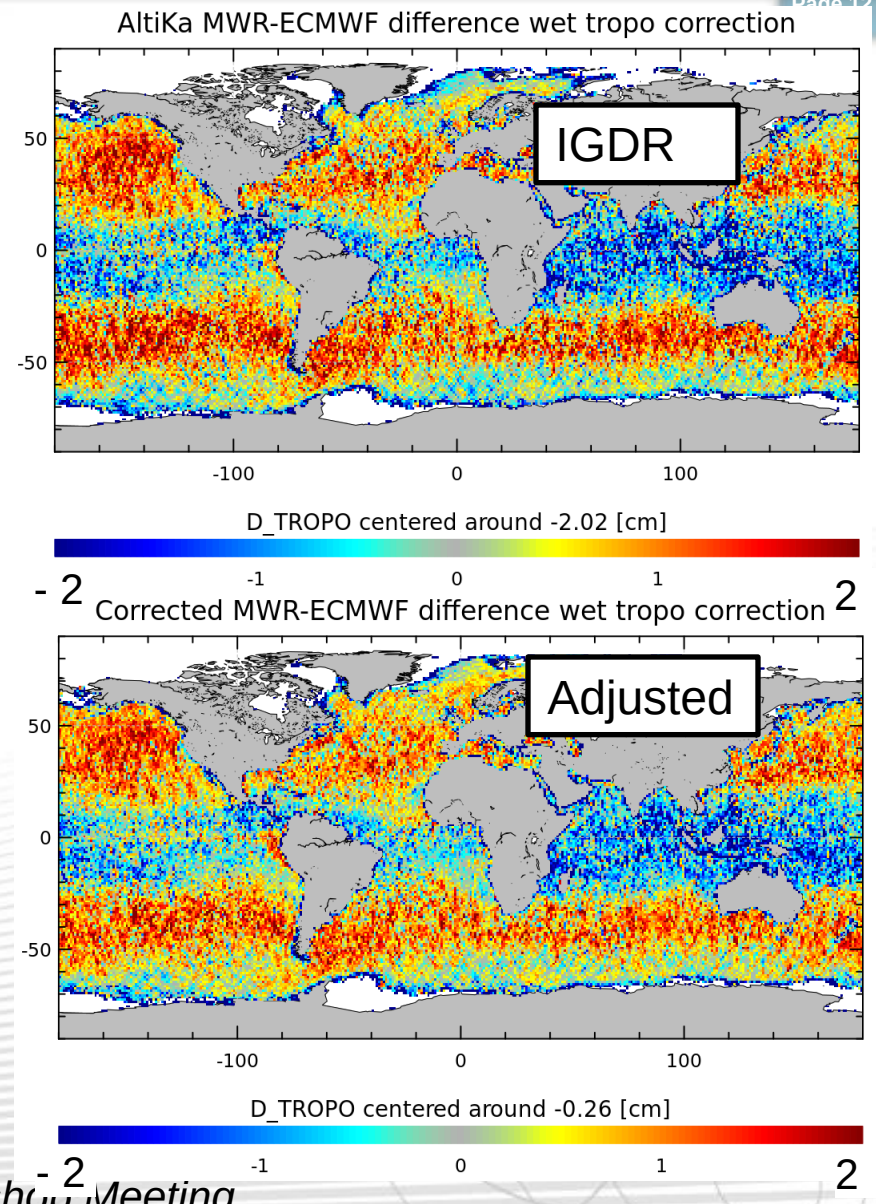
➢ Small impact on standard deviation





MWR –ECMWF Difference of wet tropospheric after correction

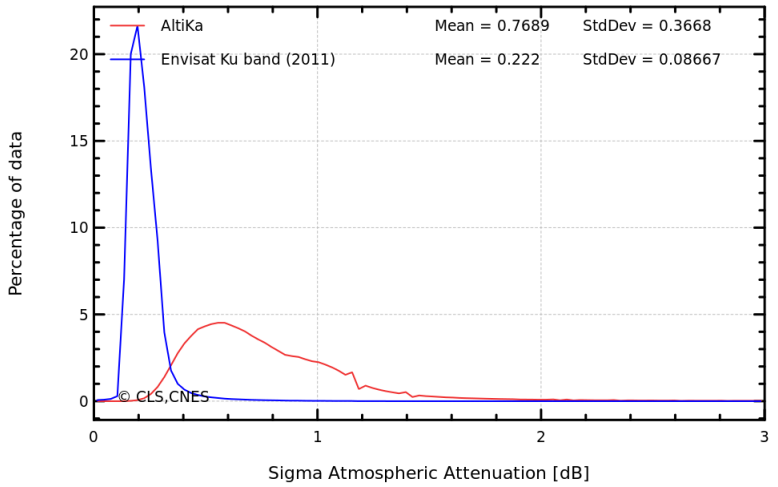
- MWR wet tropo correction bias w/t ECMWF correction is reduced when using the adjusted 23.8GHz TB in input of the NN
- Small impact on geographical patterns

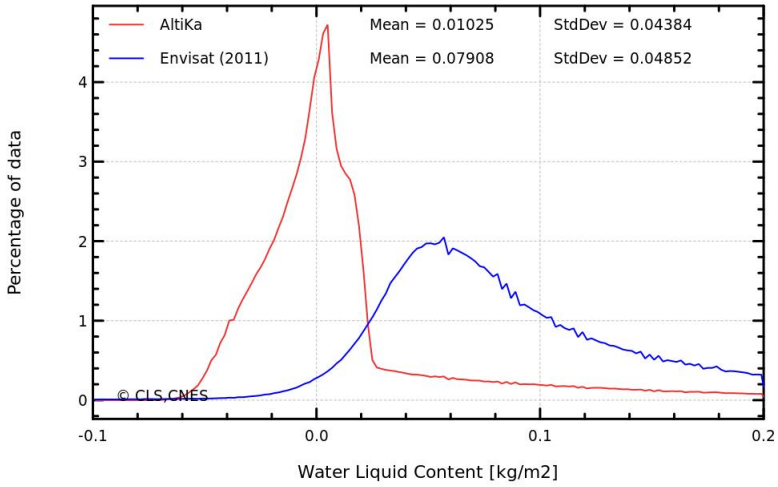


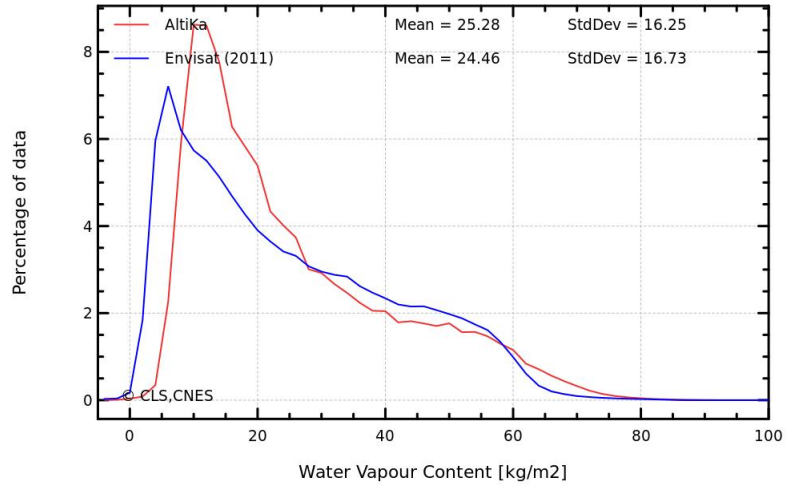
DEVELOPMENT OF NEW INVERSION ALGORITHMS FOR THE RETRIEVAL OF GEOPHYSICAL PRODUCTS

Status of other geophysical products before P1

- Units of Wc and wv are incorrect in the L2 products
- Wv and att histograms are close to what was expected. Wc histogram is incorrect
- A problem has been identified in the retrieval algorithm for the wc
- Impact on other geophysical products assumed to be small. To be confirmed







2013 27th-29th August Workshop Meeting

Envisat data : 2 cycles in 2011

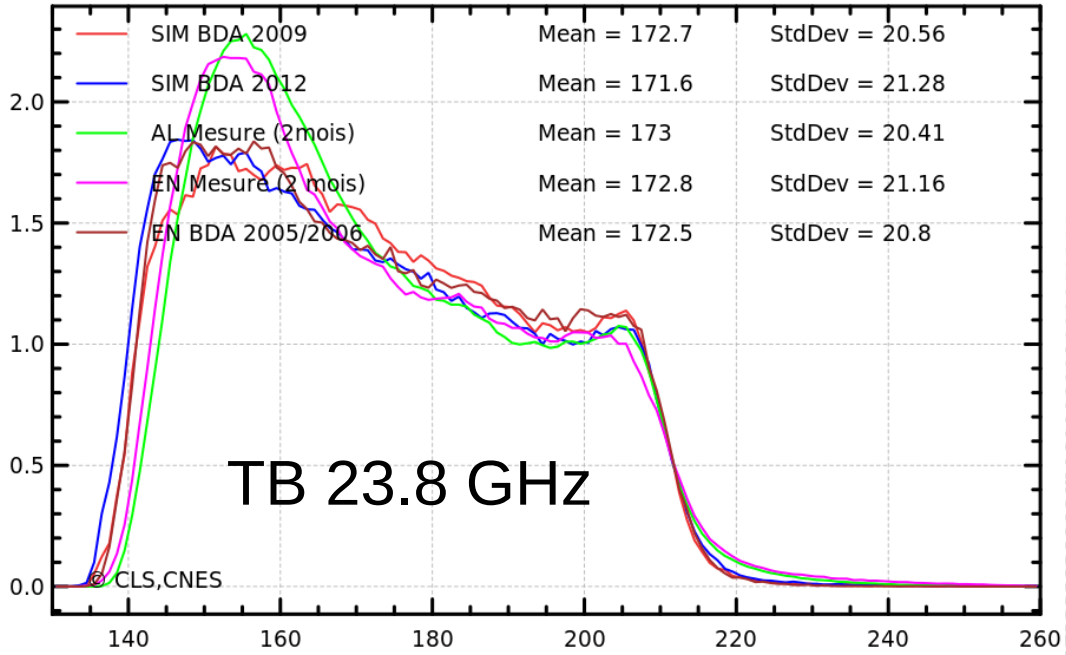
Performed investigations

- The origin of the problem degrading the cloud liquid water content and possibly the other geophysical products with a lesser impact, has been found in the learning database (BDA 2009)

➔ The next version (end of 2013) of the inversion algorithm will be based on a new consolidated learning database (BDA 2012)

Comparison of simulations and measurements for TBs of 23.8GHz channel

- For the channel 23.8GHz, the comparison of simulations and measurements shows :
  - ➢ a good consistency between the simulations (performed for Envisat and AltiKa) and the measurements
  - ➢ Differences of shape between measurements and simulations due to the fact that we compare 2 months of measured data to simulated data over one year (BDA)



BDA = learning database of NN (subset of total database)

BDA 2009 : Initial version

BDA 2012 : New version

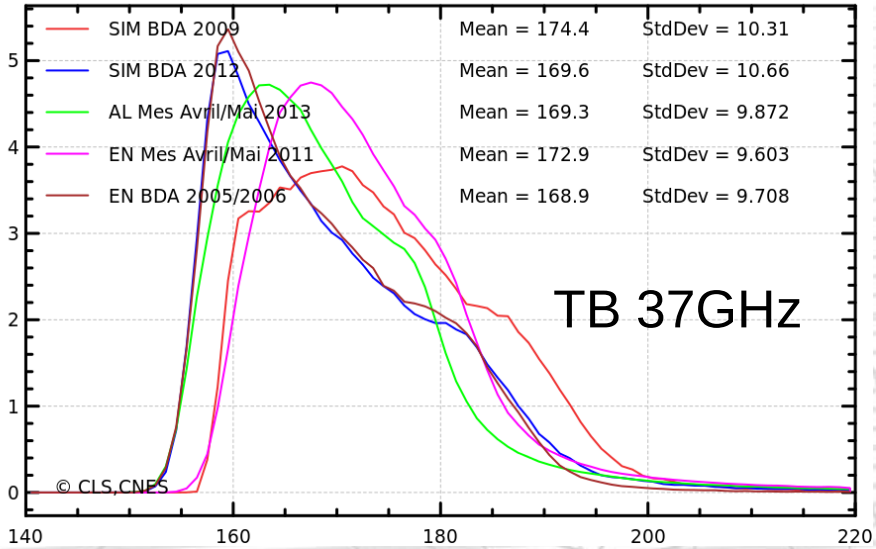
Comparison of simulations and measurements for TBs of 37GHz channel

- For the channel 37 GHz , the comparison of simulations and measurements shows :
  - ➢ AltiKa measurements are consistent with Envisat measurements.
  - ➢ TBs simulated using data of 2009 and used for the development of the inversion algorithm are not correct.
  - ➢ TB 37GHz is the input parameter with the most important weight in the retrieval of the water liquid content.

    ➔ this parameter was strongly impacted.

BDA = learning database of NN
(subset of total database)

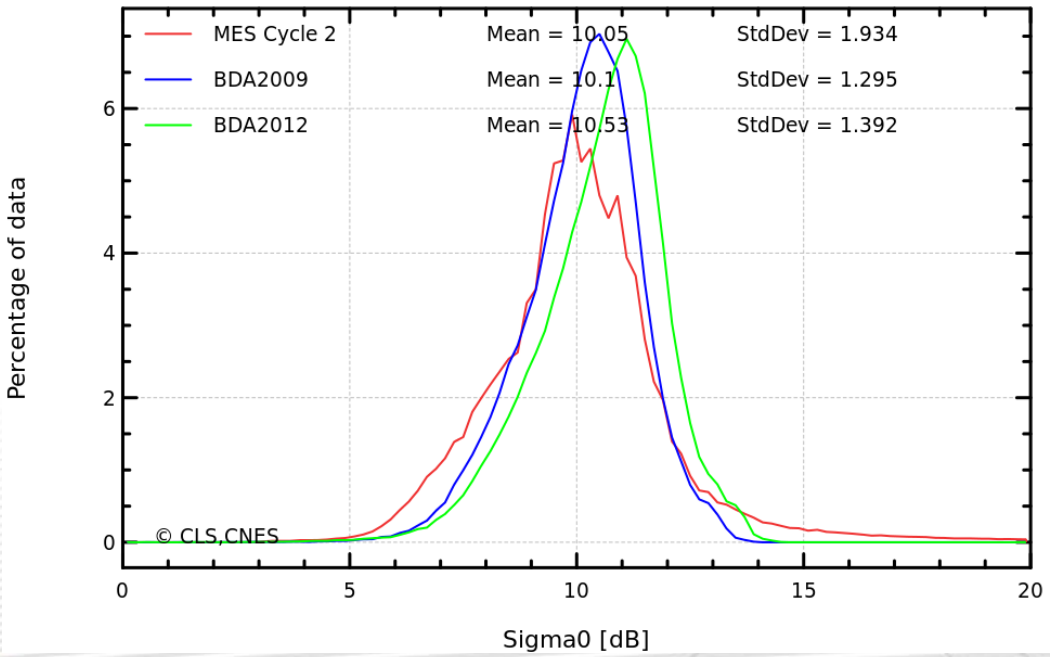
BDA 2009 : Initial version
BDA 2012 : New version



Comparison of simulations and measurements for Sigma0 Ka

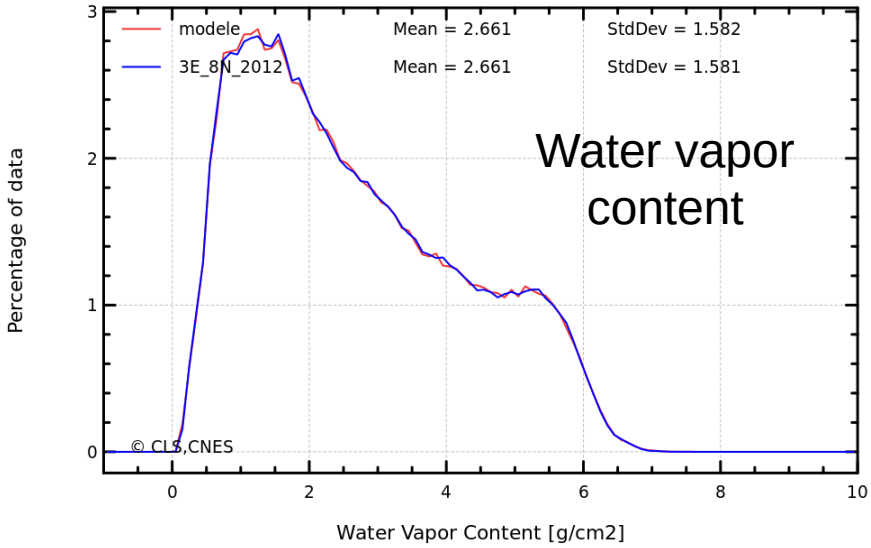
For the Sigma0 Ka, the comparison of simulations and measurements shows :

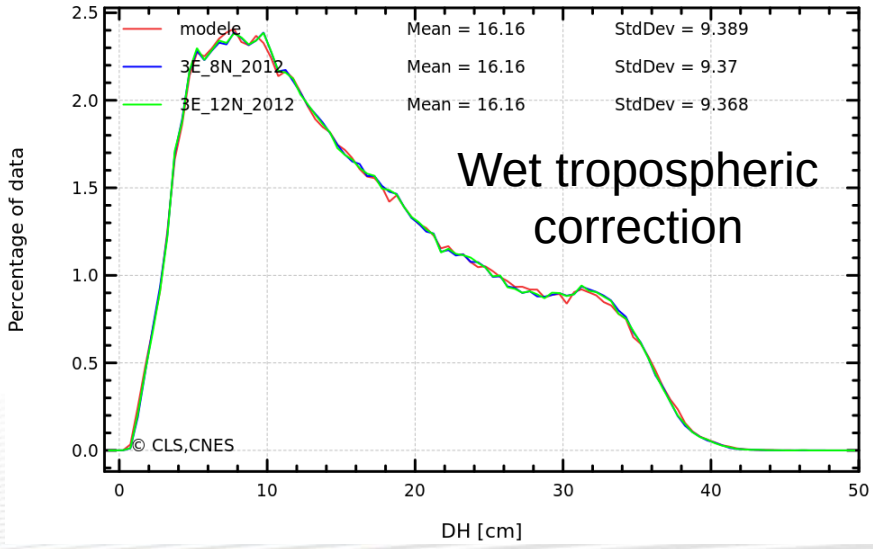
- the histogram of the simulated data is close to the histogram of measured data
- But, in the data base of simulated Sigma0, no value > 14dB when measured Sigma0 can have values up to 25dB.
- The simulation of Sigma0 in Ka Band may be not straightforward.
- This may have an impact on L2 geophysical performances.
- On-going investigations on possible alternative to simulated sigma0 (modeled wind, altimeter wind, measured sigma0)

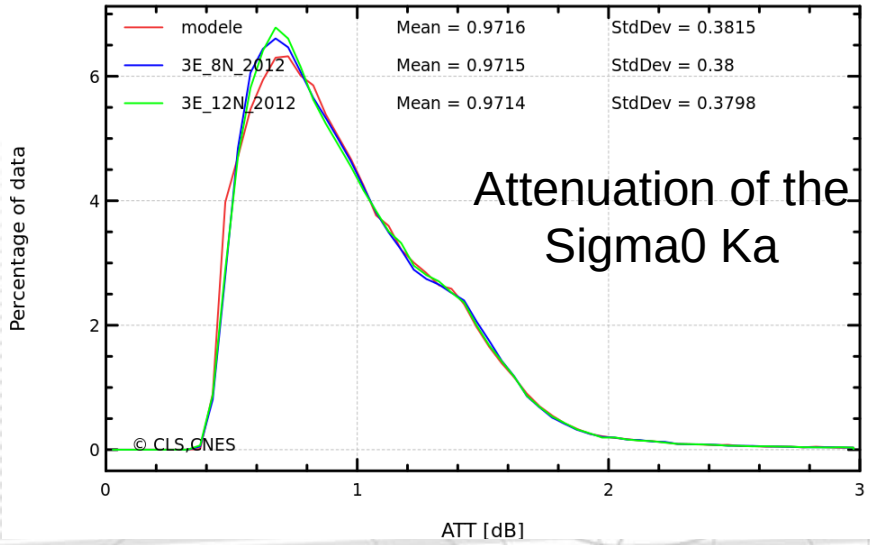


Validation of the inversion algorithm generated with the database 2012

- The wet tropo. Correction, the water vapor content and the atmospheric attenuation of the Sigma 0 Ka are correctly retrieved by the neural network
- Use of more neurons to restitute these products is not necessary

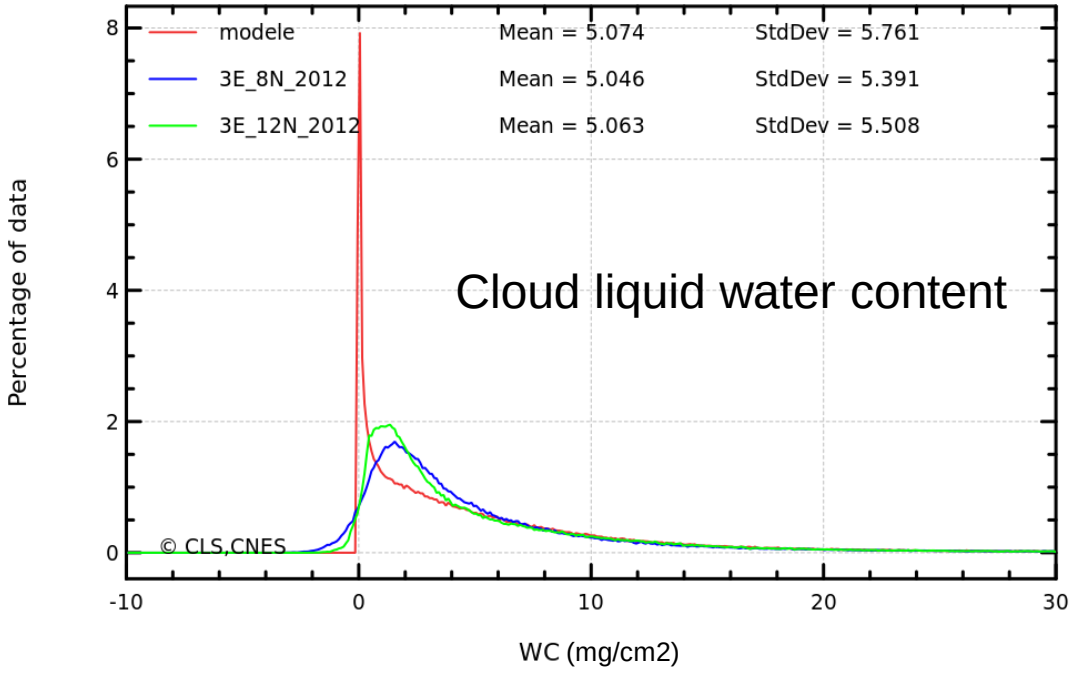






Validation of the inversion algorithm based on the database 2012

- The retrieval is more difficult for the cloud liquid water content.
- The relation between the inputs (TBs 23.8GHz, 37GHz, Sigma0 Ka) and the product (wc) is more complex.
  - An algorithm with 12 neurons gives better results than one with 8 neurons (less negative values)
  - More inputs necessary to enhance the retrieval



Test of several versions of inversion algorithm

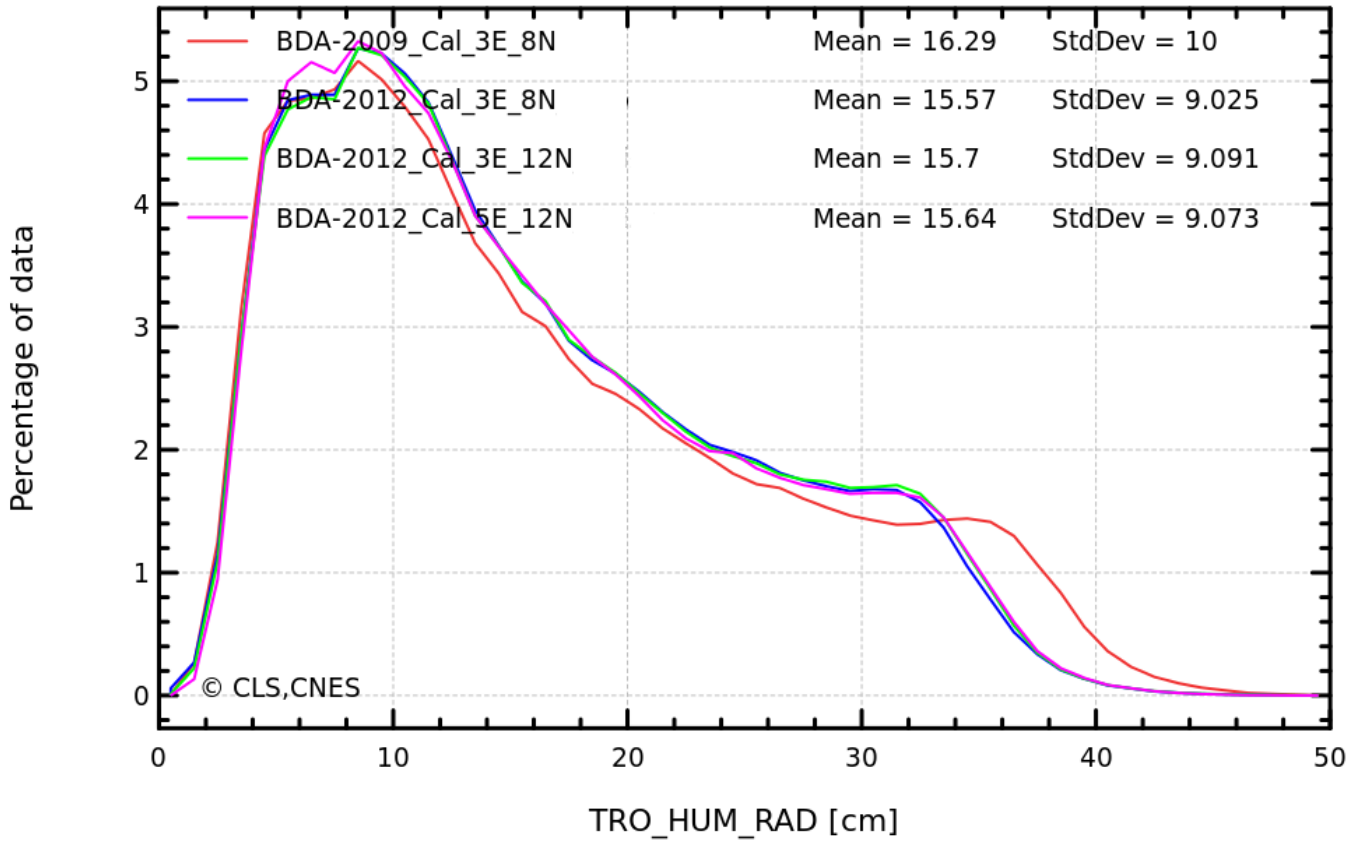
- Comparison of inversion algorithms generated with different versions of learning database
  - With adjustment of TB 23.8GHz

	Year of Meteo data	Number of neurons	Nb of inputs	
BDA-2009_Cal_3E_8N	2009	8	3	TB 23, TB 37, Sigma0
BDA-2012_Cal_3E_8N	2012	8	3	TB 23, TB 37, Sigma0
BDA-2012_Cal_3E_12N	2012	12	3	TB 23, TB 37, Sigma0
BDA-2012_Cal_5E_12N	2012	12	5	TB 23, TB 37, Sigma0, SST, γ800

Application to AltiKa MWR measurements: Wet tropospheric correction

MWR WET TROPO. CORR.

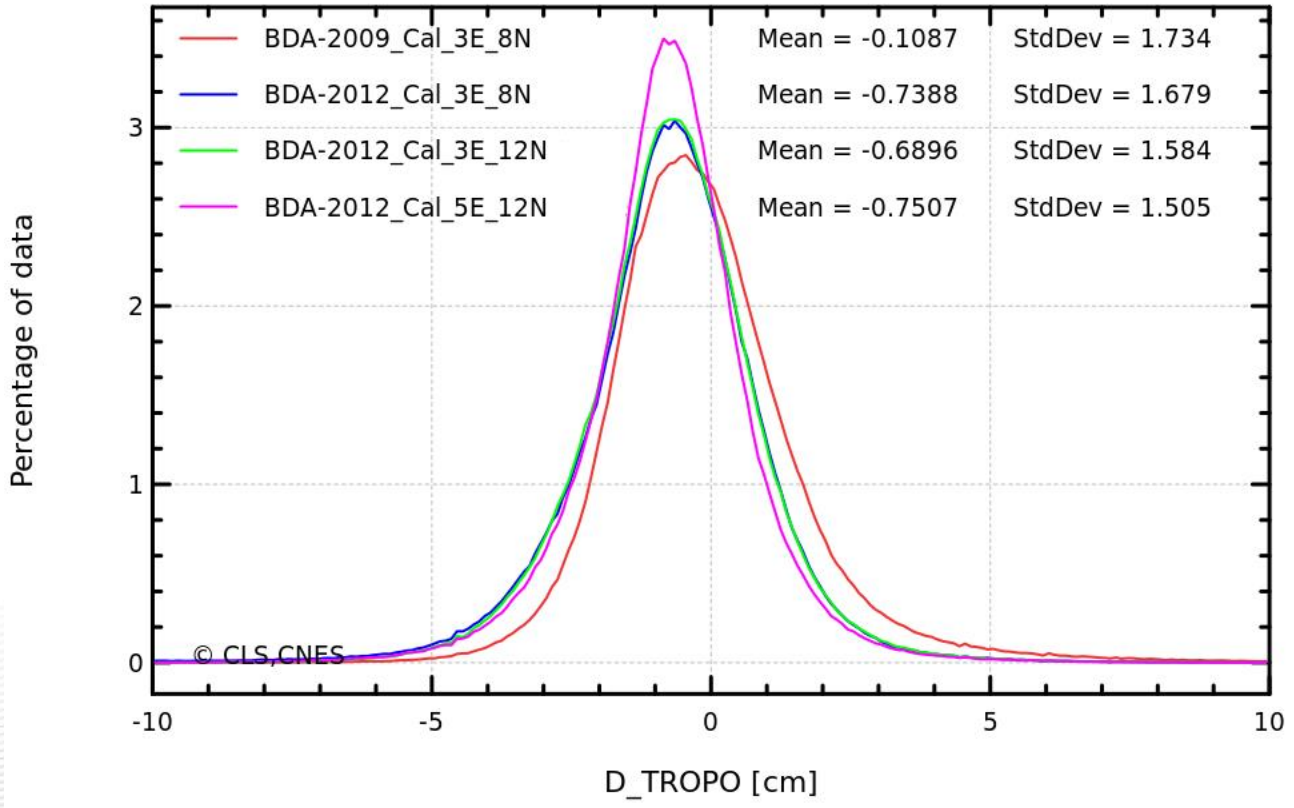
- Difference between 2009 and 2012 for high values of wet tropo. corr,
- No significant differences for algorithms generated with BDA 2012 (same mean, same standard deviation)



Application to AltiKa MWR measurements: Difference MWR-ECMWF wet tropo. corr.

DIFFERENCE ECMWF – MWR WET TROPO. CORR.

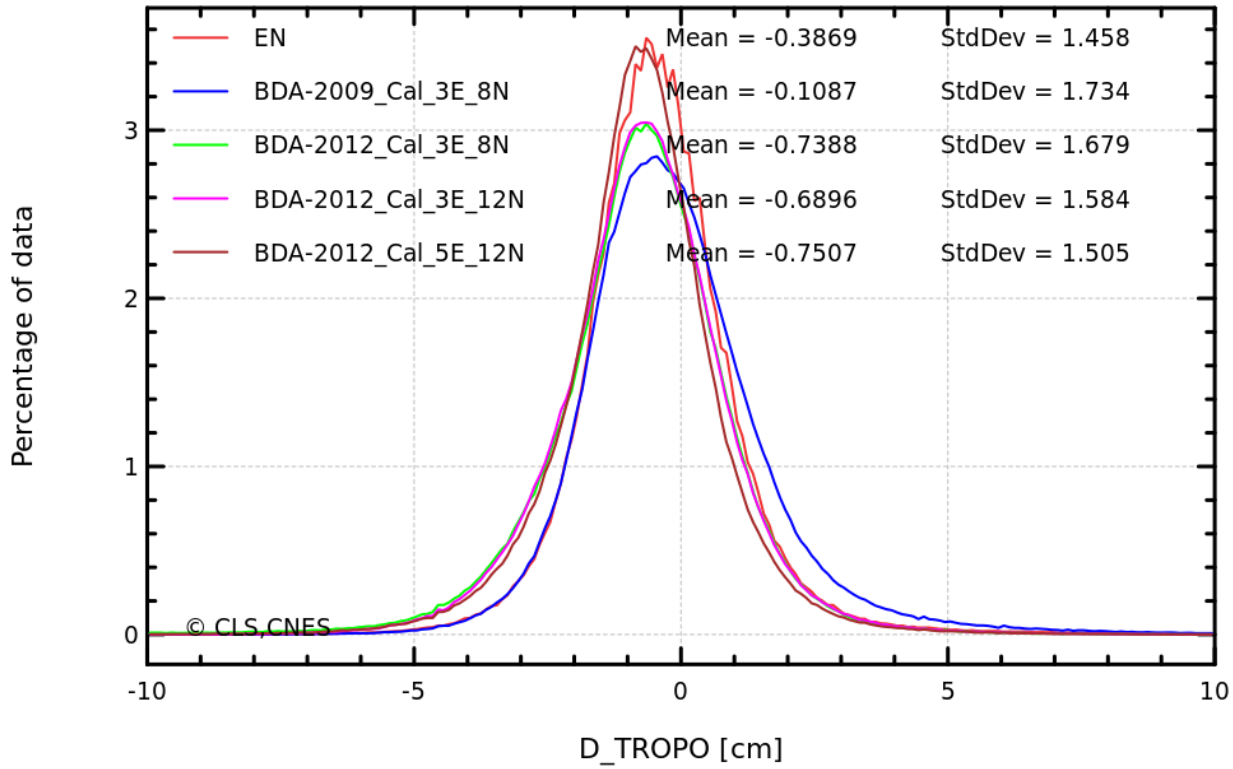
- 2009➔2012 : Diminution of standard deviation
- Best results with the algorithm using 5 inputs (TB 23,8, TB 37, Sigma0 Ka, SST, γ800)



Application to AltiKa MWR measurements: Difference MWR-ECMWF wet tropo. corr.

DIFFERENCE ECMWF – MWR WET TROPO. CORR.

– Comparison with Envisat D_TROPO (inversion algorithm using 3 inputs) ➔ results close to the results obtained for AltiKa with the inversion algorithm with 5 inputs



Application to AltiKa MWR measurements: Difference MWR-ECMWF wet tropo. corr.

DIFFERENCE ECMWF – MWR WET TROPO. CORR.

Impact of patch P1:

- No impact of adjustment of TB 23.8 GHz on geographic patterns
- Only reduction of the bias

BDA-2009_NO-Cal_3E_8N

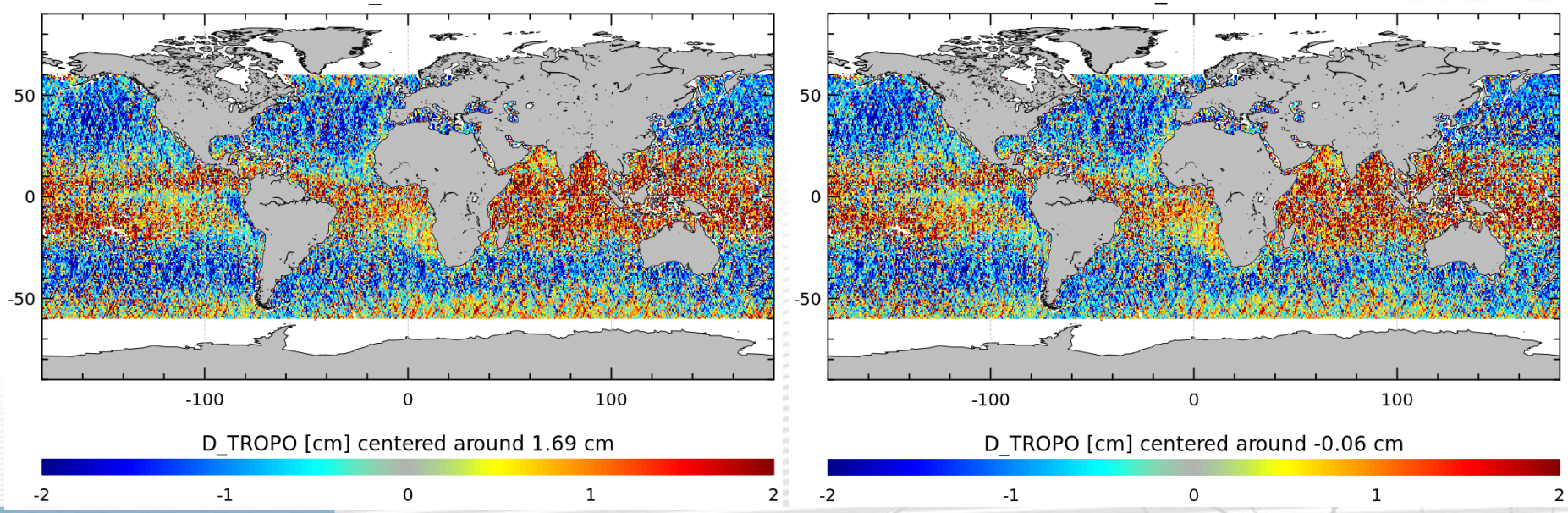
Before Patch P1

CYCLE 2

Coast Distance > 50 km

BDA-2009_Cal_3E_8N

After Patch P1 (GDR)



Application to AltiKa MWR measurements: Difference MWR-ECMWF wet tropo. corr.

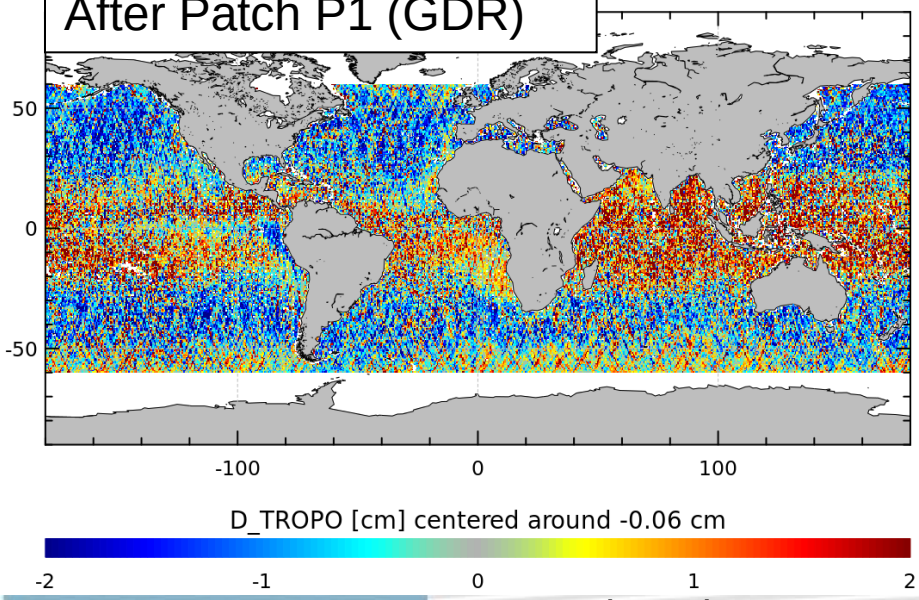
DIFFERENCE ECMWF – MWR WET TROPO. CORR.

Impact of BDA 2012:

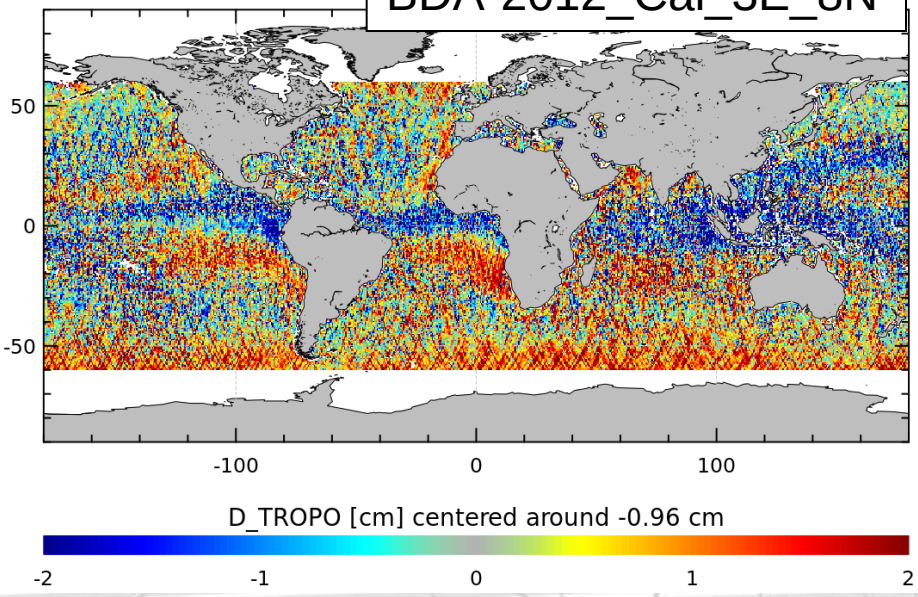
- Clear impact of inversion algorithm generated with database 2012 on geographic patterns
- Improvement of the quality of the product (std 1.74 cm ➔ 1.68 cm)

CYCLE 2
Coast Distance > 50 km

BDA-2009_Cal_3E_8N
After Patch P1 (GDR)



BDA-2012_Cal_3E_8N



Application to AltiKa MWR measurements: Difference MWR-ECMWF wet tropo. corr.

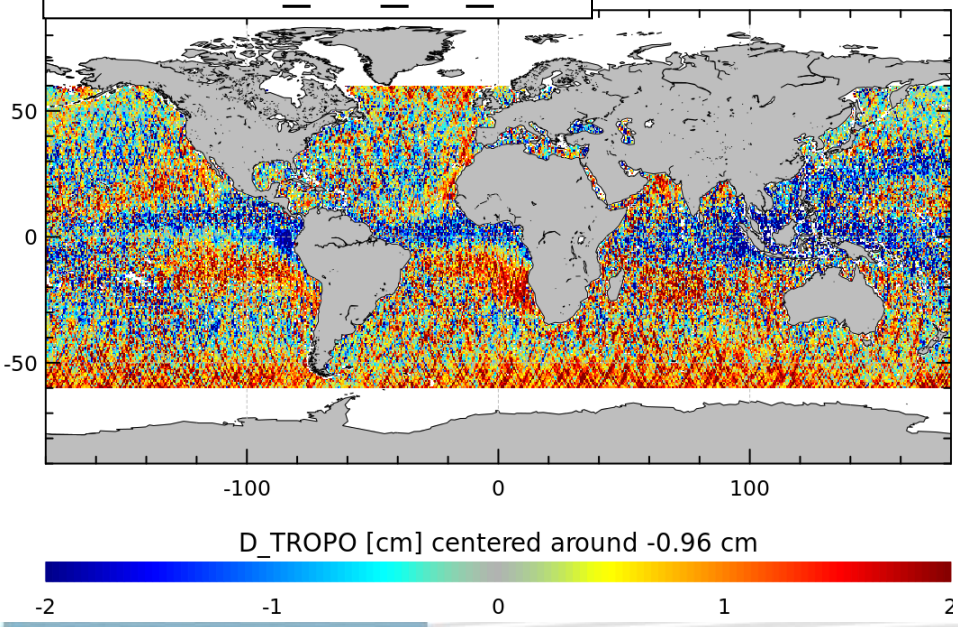
DIFFERENCE ECMWF – MWR WET TROPO. CORR.

Impact of the number of neurons:

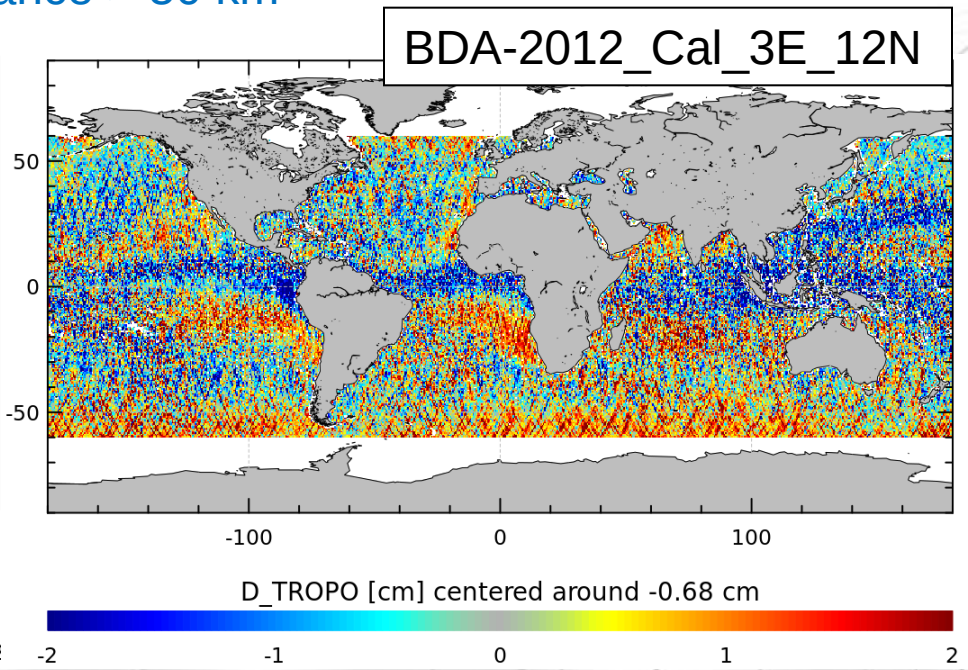
- Improvement at mid-latitudes

CYCLE 2
Coast Distance > 50 km

BDA-2012_Cal_3E_8N



BDA-2012_Cal_3E_12N



Application to AltiKa MWR measurements: Difference MWR-ECMWF wet tropo. corr.

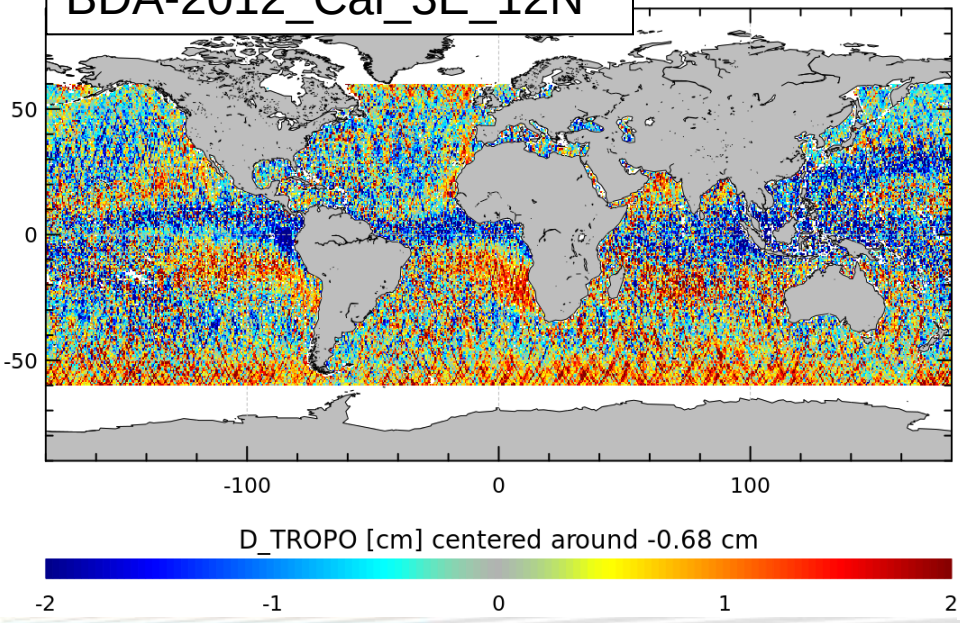
DIFFERENCE ECMWF – MWR WET TROPO. CORR.

Impact of the number of input parameters:

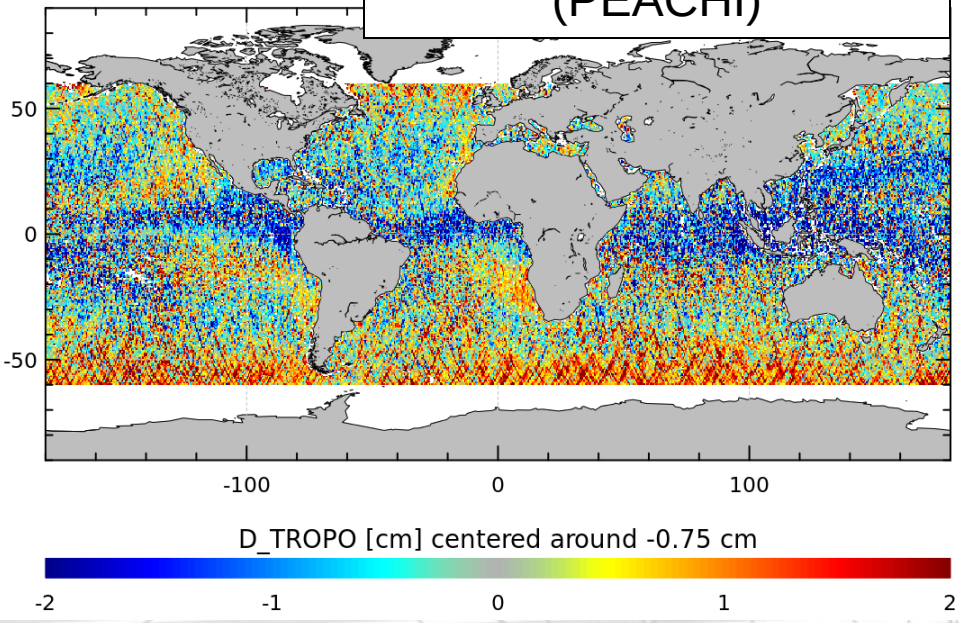
- Clear impact of 5 inputs algorithm on upwelling areas

CYCLE 2
Coast Distance > 50 km

BDA-2012_Cal_3E_12N



BDA-2012_Cal_5E_12N
(PEACHI)

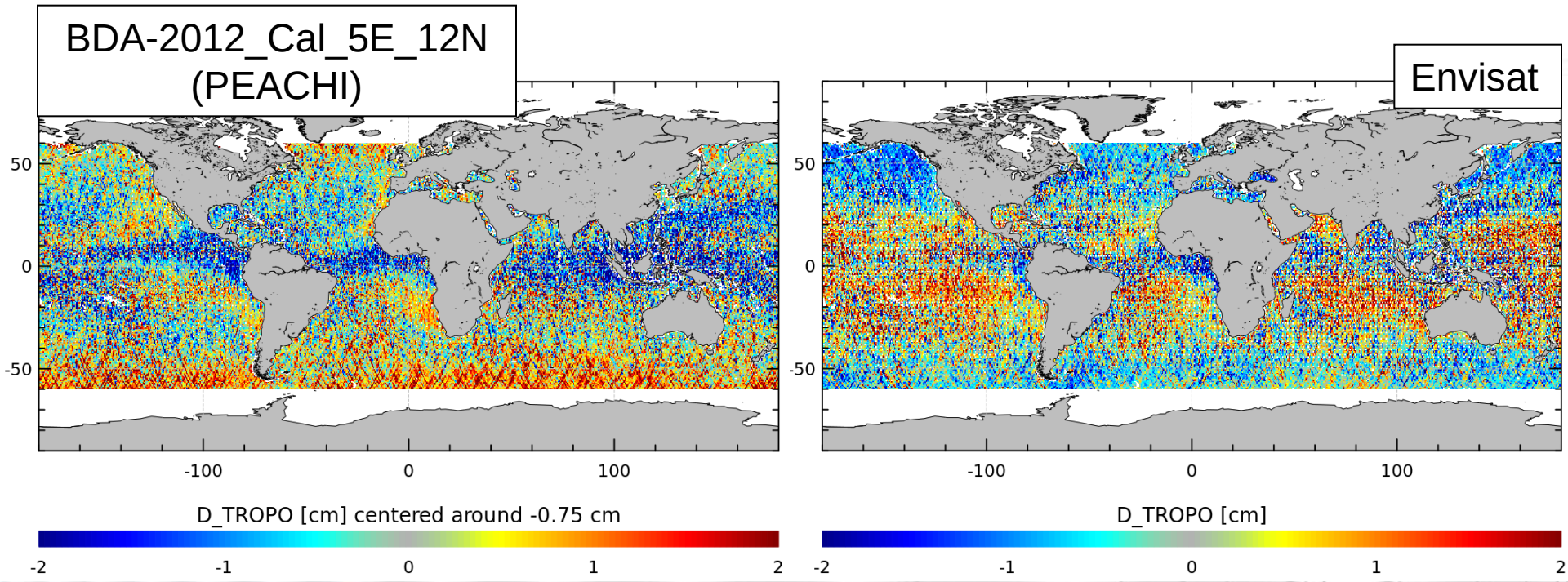


Application to AltiKa MWR measurements: Difference MWR-ECMWF wet tropo. corr.

DIFFERENCE ECMWF – MWR WET TROPO. CORR.

Performances with respect to Envisat:

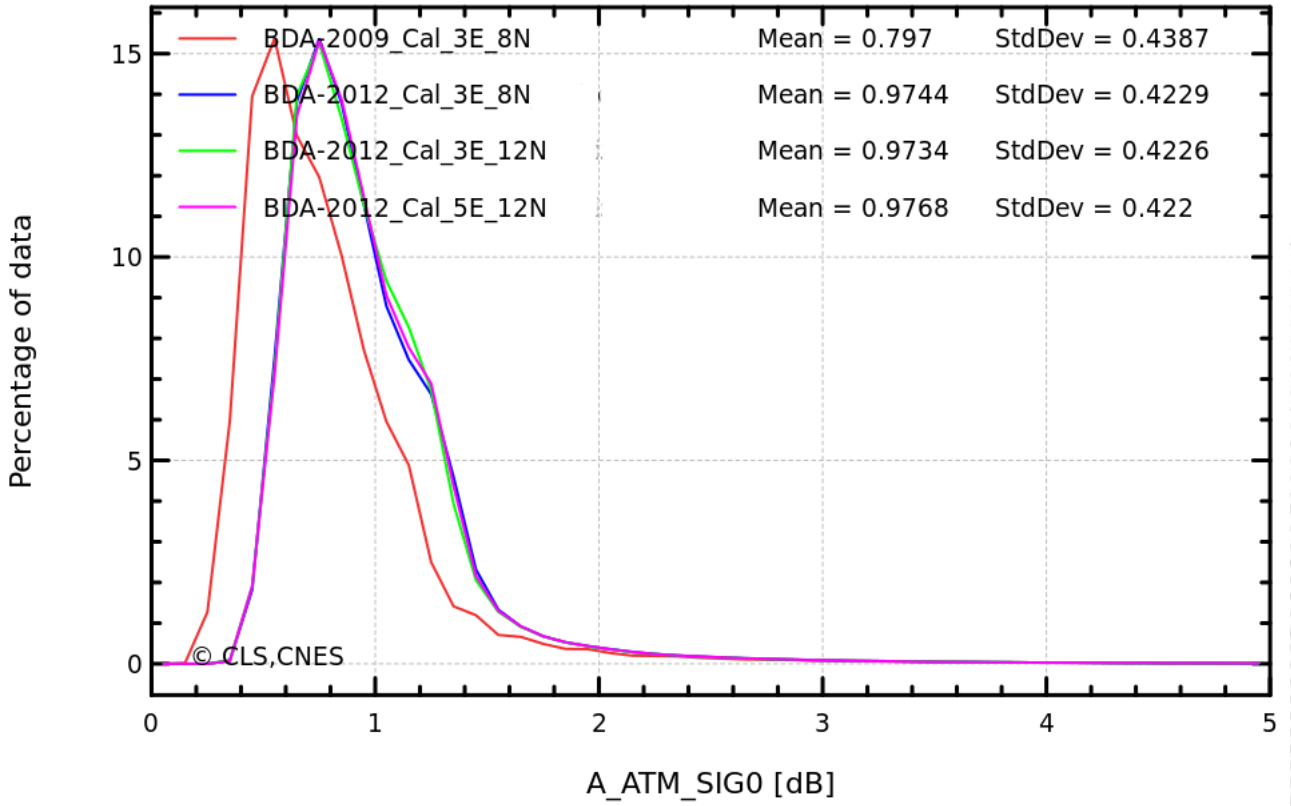
- Even with 5 parameters algorithm, AltiKa wet tropo. does not yet reach Envisat level of quality ➔ may be related to Sigma0 simulation issues.



Application to AltiKa MWR measurements: Attenuation of Sigma0 Ka

ATTENUATION OF THE SIGMA 0 Ka

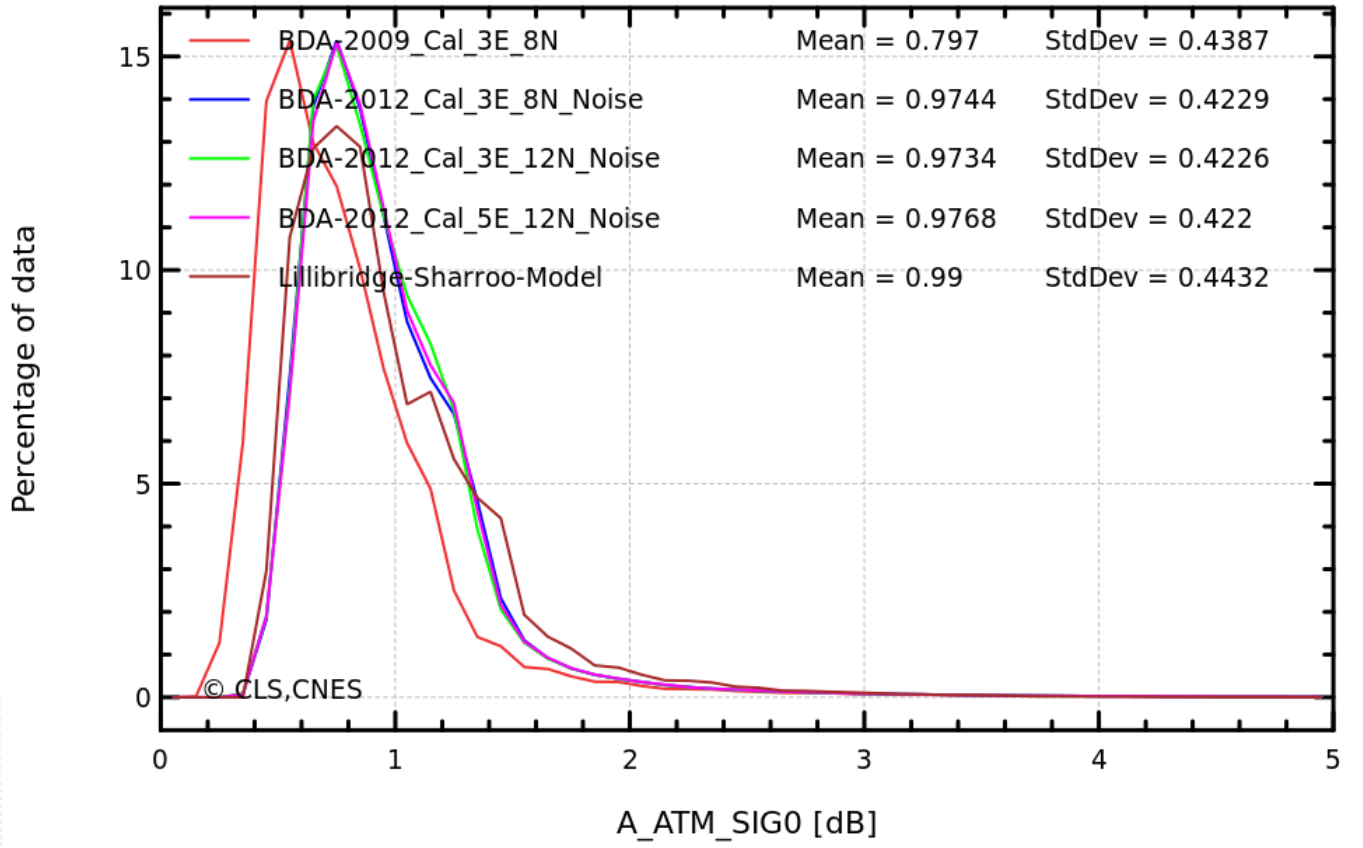
- Use of algorithm generated from database 2012 ➔ mean increased of 0.2dB
- No significant differences between algorithms generated with BDA 2012 (same mean, same standard deviation)



Attenuation of Sigma0 Ka : Comparison to Lillibridge-Sharoo model

ATTENUATION OF THE SIGMA 0 Ka

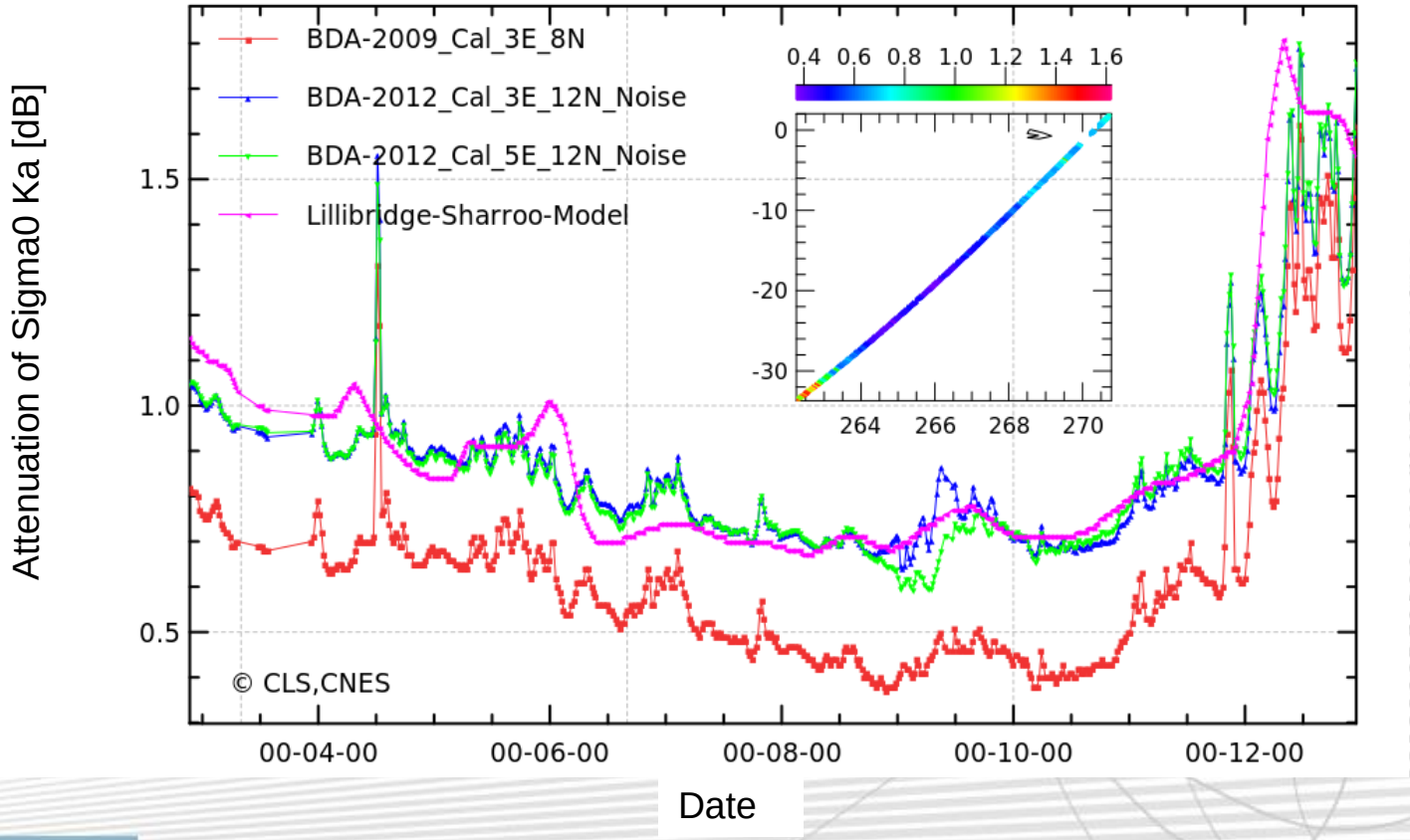
– Mean of retrieved attenuation with algorithm generated with BDA 2012 is close to the mean of lillibridge-Sharoo model



Attenuation of Sigma0 Ka : Comparison to Lillibridge-Sharoo model

ATTENUATION OF THE SIGMA 0 Ka

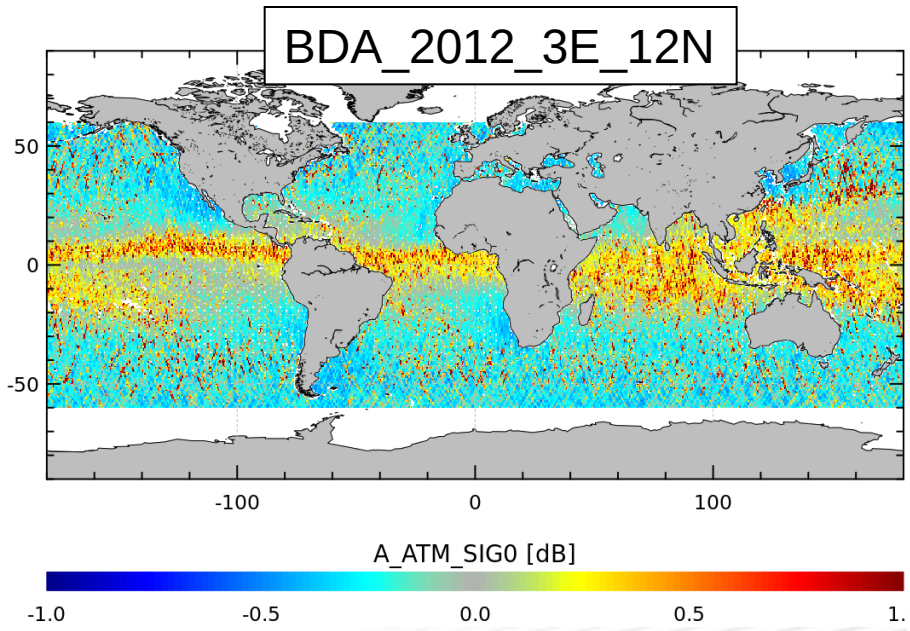
- As expected, Lillibridge-Sharoo model attenuation is smoother than MWR attenuation
- Level of attenuation retrieved with the new version of the inversion algorithm (2012) is closer to the level of the model

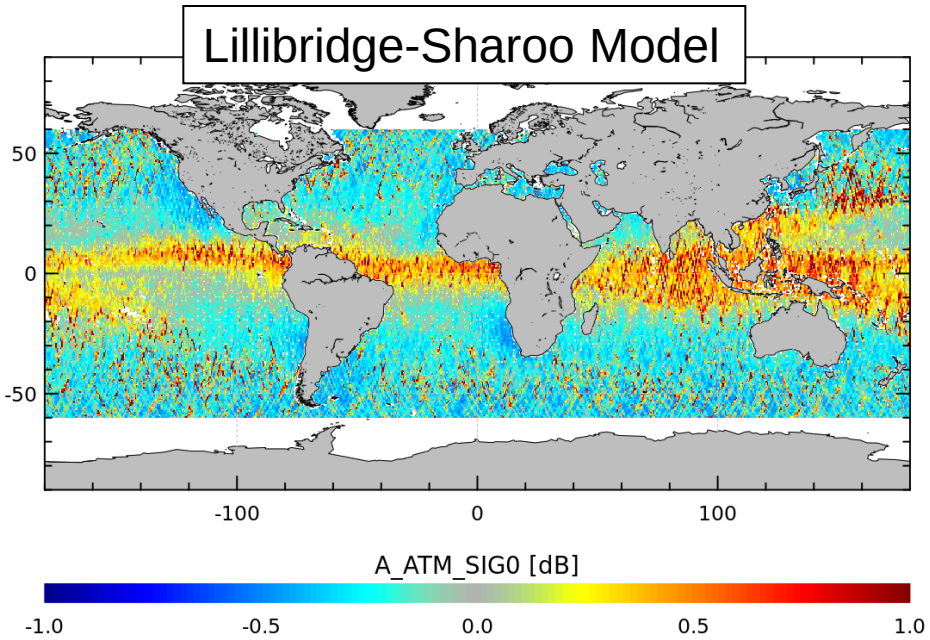


Attenuation of Sigma0 Ka : Comparison to Lillibridge-Sharoo model

ATTENUATION OF THE SIGMA 0 Ka

– Differences Model – MWR mainly on the tropical area

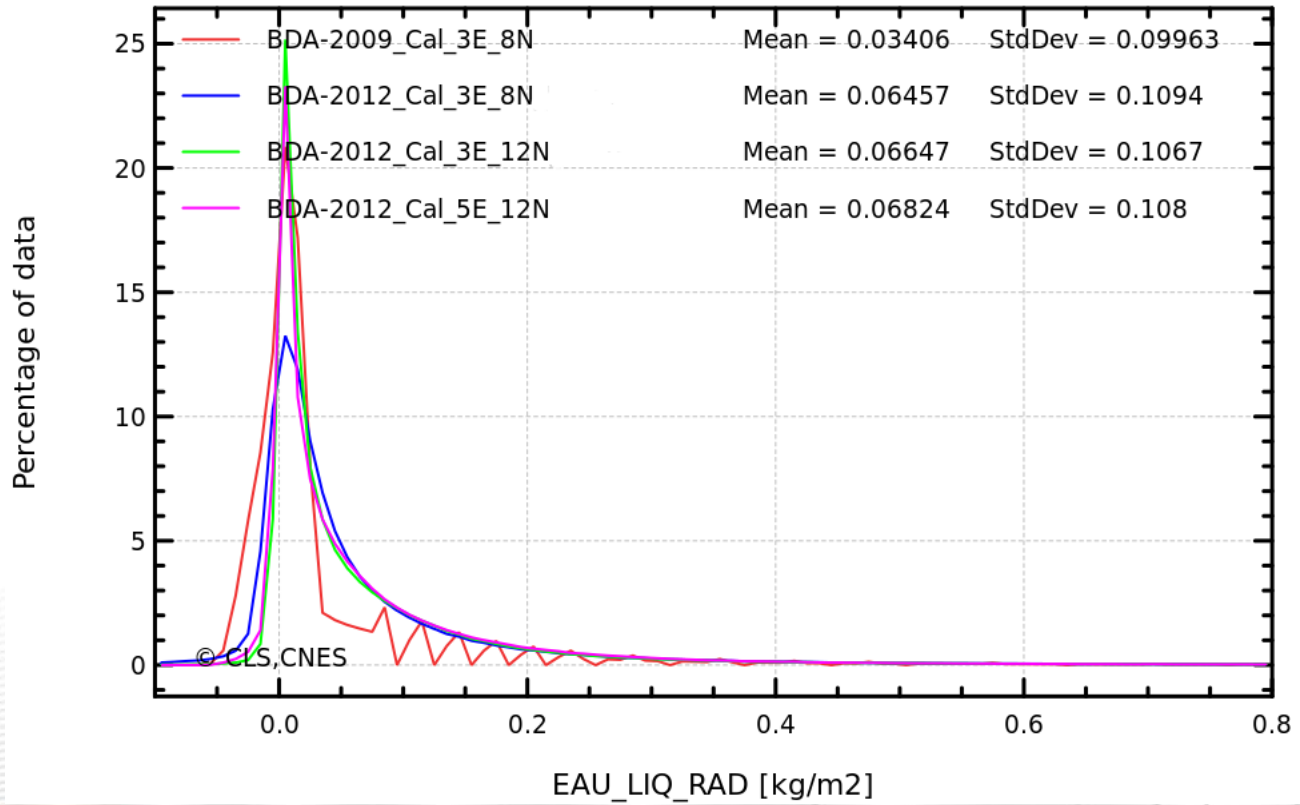




Application to AltiKa MWR measurements: Cloud liquid water content

CLOUD LIQUID WATER CONTENT

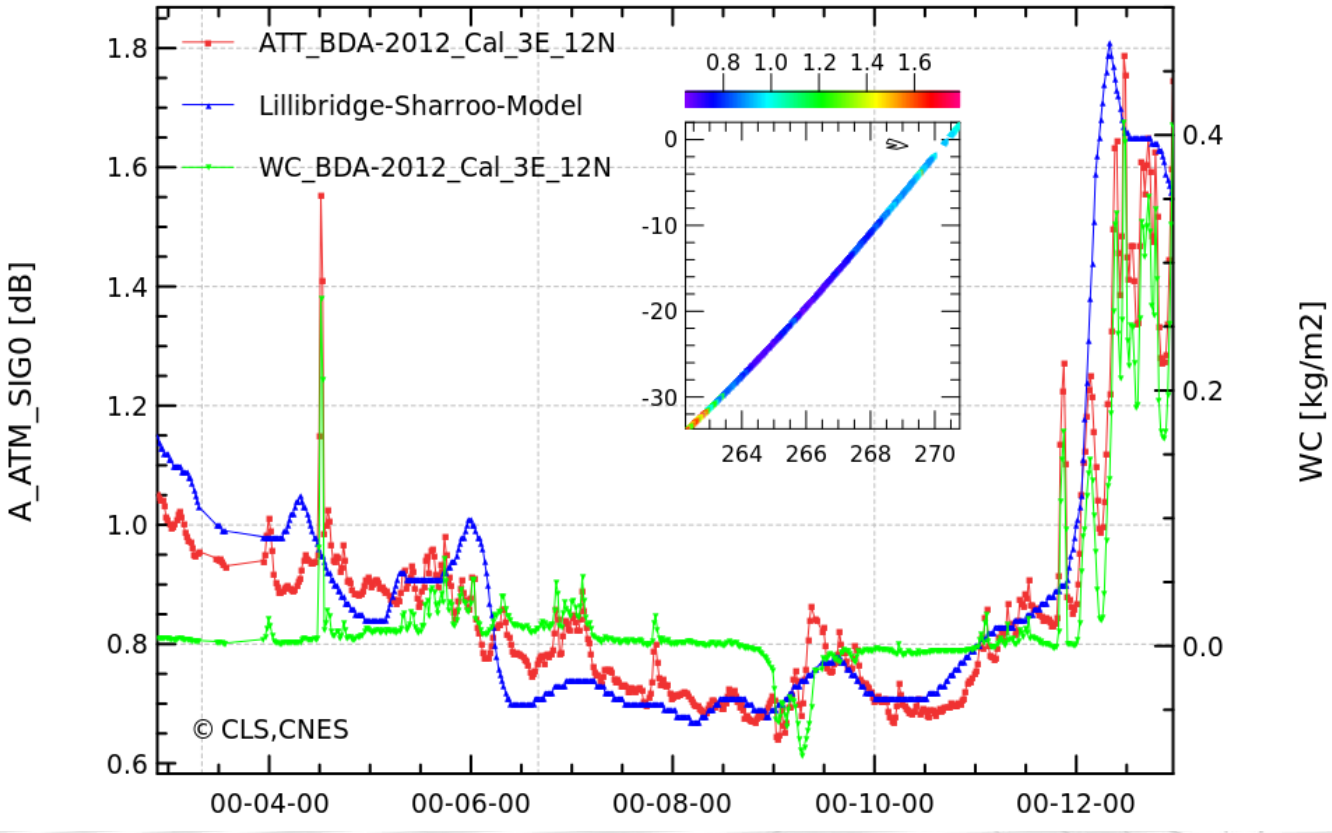
- Use of algorithm generated from database 2012 ➔ less negative values
- No significant differences between algorithms generated with BDA 2012 (same mean, same standard deviation)



Application to AltiKa MWR measurements: Cloud liquid water content

CLOUD LIQUID WATER CONTENT

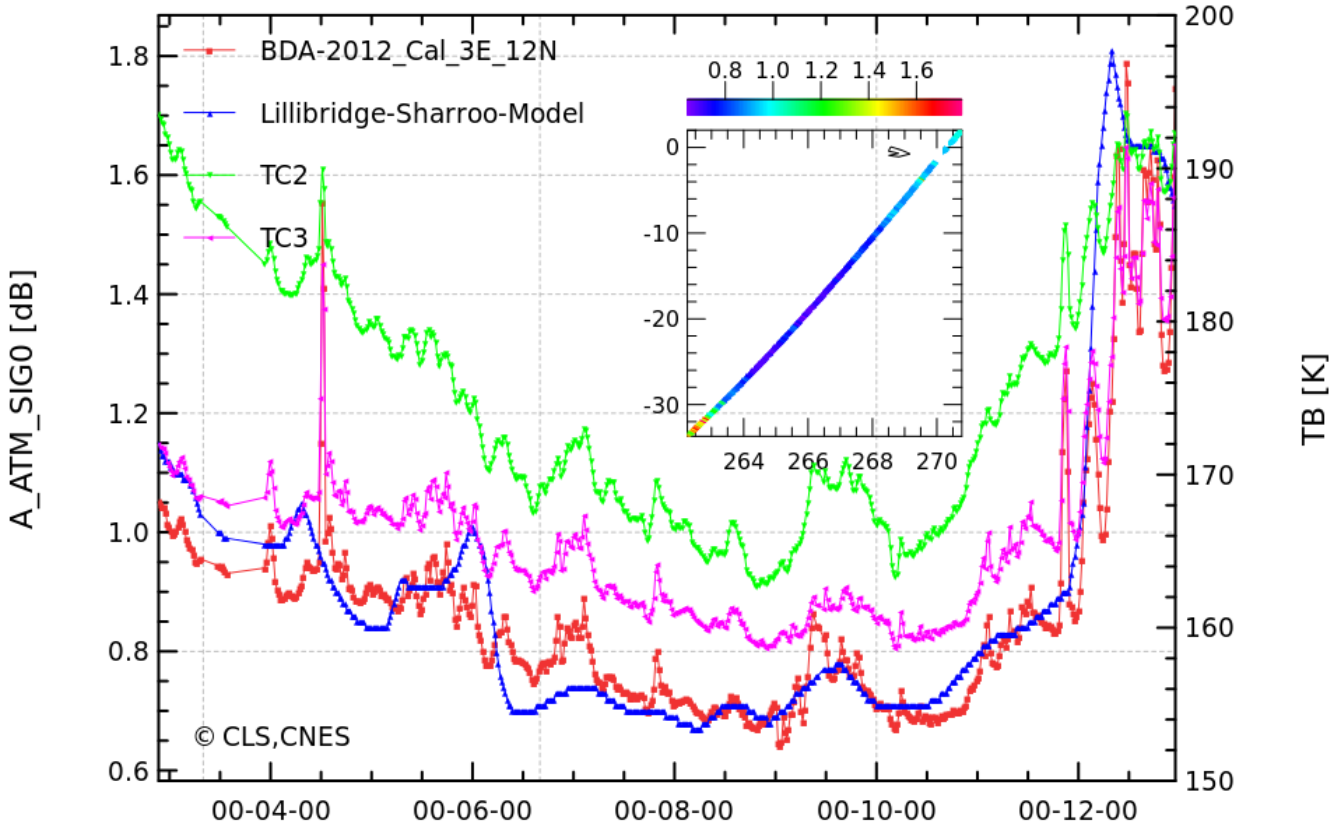
- This piece of pass shows the case of negative retrieved values for the cloud liquid water content.
- The cloud liquid water content is small around the negative values



Application to AltiKa MWR measurements: Cloud liquid water content

CLOUD LIQUID WATER CONTENT

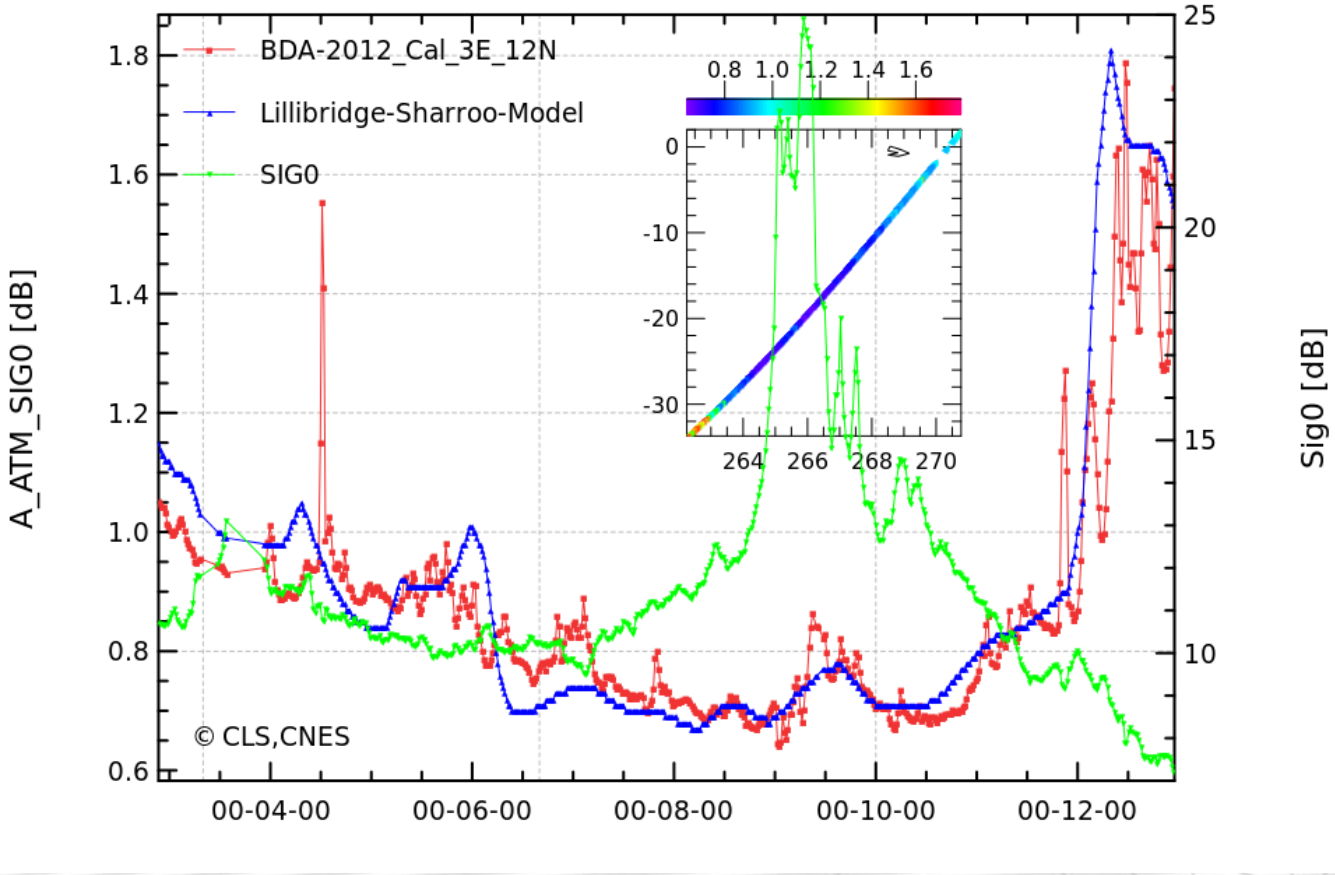
– The brightess temperatures of both channels have physical values when the cloud liquid water content have negative values



Application to AltiKa MWR measurements: Cloud liquid water content

CLOUD LIQUID WATER CONTENT

– The Sigma0 Ka has strong values (up to 25 dB) , much stronger than the Sigma0 simulated and used to generate the inversion algorithm

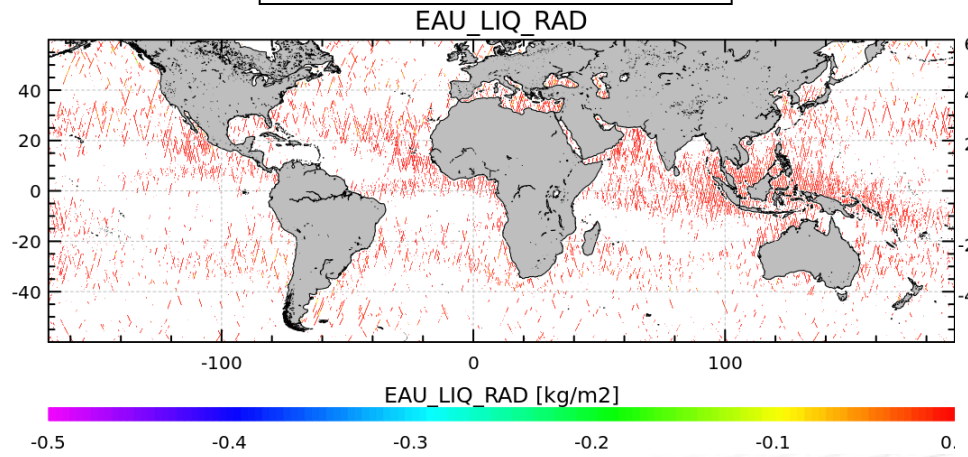


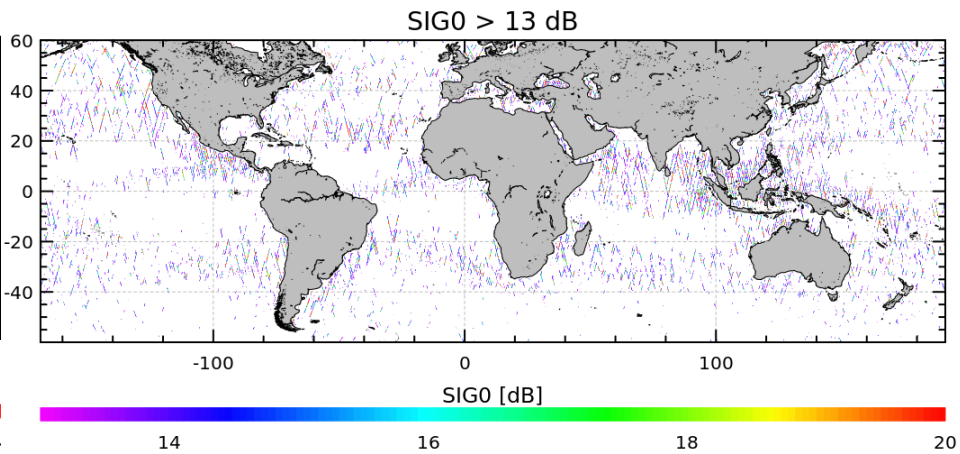
Application to AltiKa MWR measurements: Cloud liquid water content

CLOUD LIQUID WATER CONTENT

– Some of the negative values seem to be correlated to strong values of Sigma0

BDA_2012_3E_12N





Conclusions

- Very good quality of the instrument
- Study of inversion algorithms for the retrieval of the MWR geophysical products :
  - The algorithm generated with 2012 database will generate geophysical products with much better quality than the current algorithm
  - Simulations of the Sigma0 must be further studied

Future activities

- **Patch P2** will include:
  - New inversion algorithm (2012) => will improve the quality of the geophysical products
  - wet troposheric correction with less geographical patch
  - Attenuation bias will be reduced
  - Water liquid content will have much better quality
  - An updated adjustment of the Brightness temperatures and sigma0