First year of the microwave radiometer aboard SARAL/AltiKa : In flight calibration, processing and validation

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COLLECTE LOCALISATION SATELLITES

CENTRE NATIONAL D'ÉTUDES SPATIALES

SERVICE ALTIMETRIE & LOCALISATION PRECISE

Ocean Surface Topography Science Team

October, 2014
Konstanz, Germany

Context

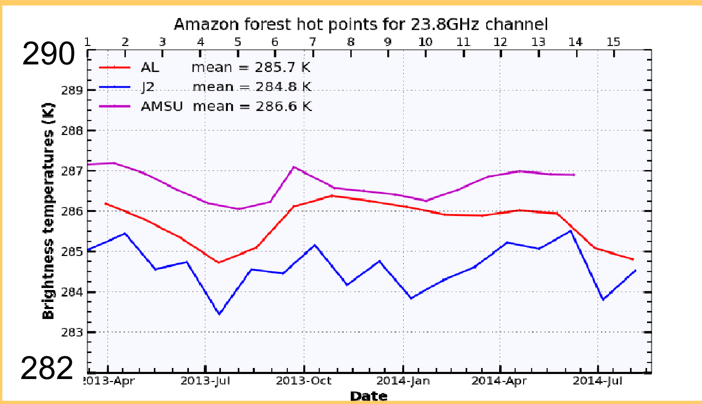
- SARAL/AltiKa radiometer characteristics:
  - dual frequency 23.8 GHz / 37 GHz (total power)
  - fine spatial resolution : 8km / 12km
  - very good thermal stability

  ref: Steunou et al 2014, MG special issue
- Since launch:
  - In flight calibration and monitoring to assess the quality and stability of the MWR measurements :
    1. Vicarious calibrations
    2. Comparison at crossover points
    3. Double difference using vicarious cold calibration
  - Evaluation of the performances and Improvement of the wet tropo. correction
    4. Inversion algorithm: the classical approach
    5. Inversion algorithm: the empirical approach

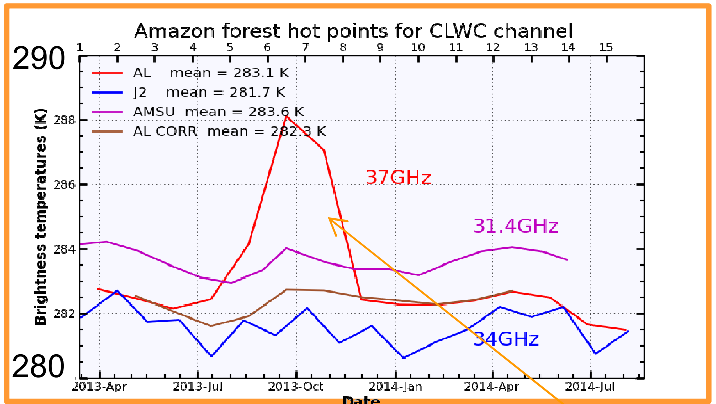
1. Vicarious calibrations

2 selections (geographic and statistic) **known to be stable**

23.8GHz channel	LWC channel	37 / 34 / 31.4 GHz

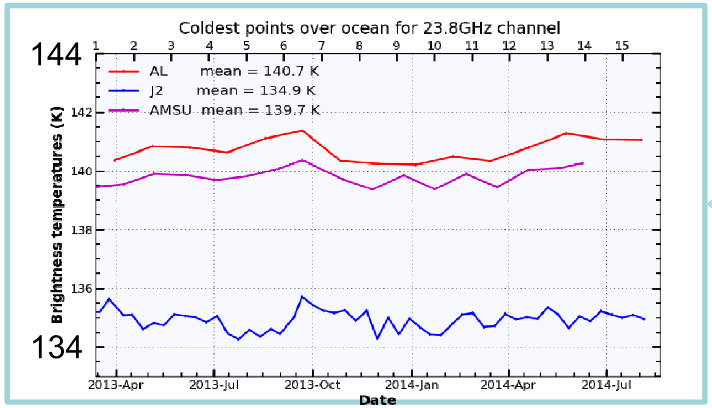


Selection of BTs over Amazon forest

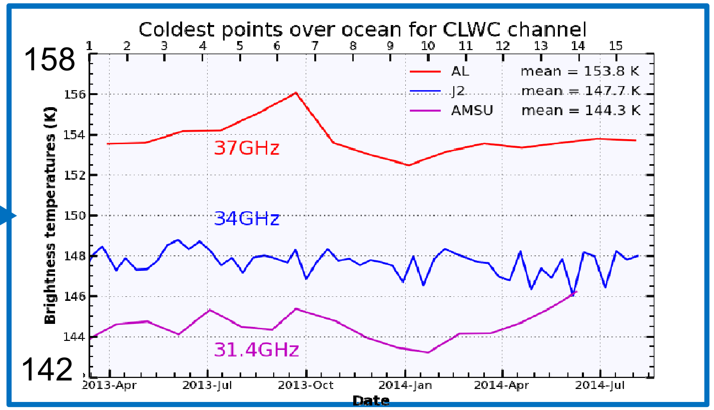


Hot calib. Counts saturation

	23.8GHz AL	23.8GHz AMSU	23.8GHz J2	LWC AL	LWC AMSU	LWC J2
Mean Ama BT (K)	285.7	284.8	286.6	283.1	283.6	281.7
Mean Cold BT (K)	140.7	139.7	134.9	153.8	144.3	147.7



Selection of coldest ocean BTs



1. Vicarious calibrations

2 selections (geographic and statistic) **known to be stable**

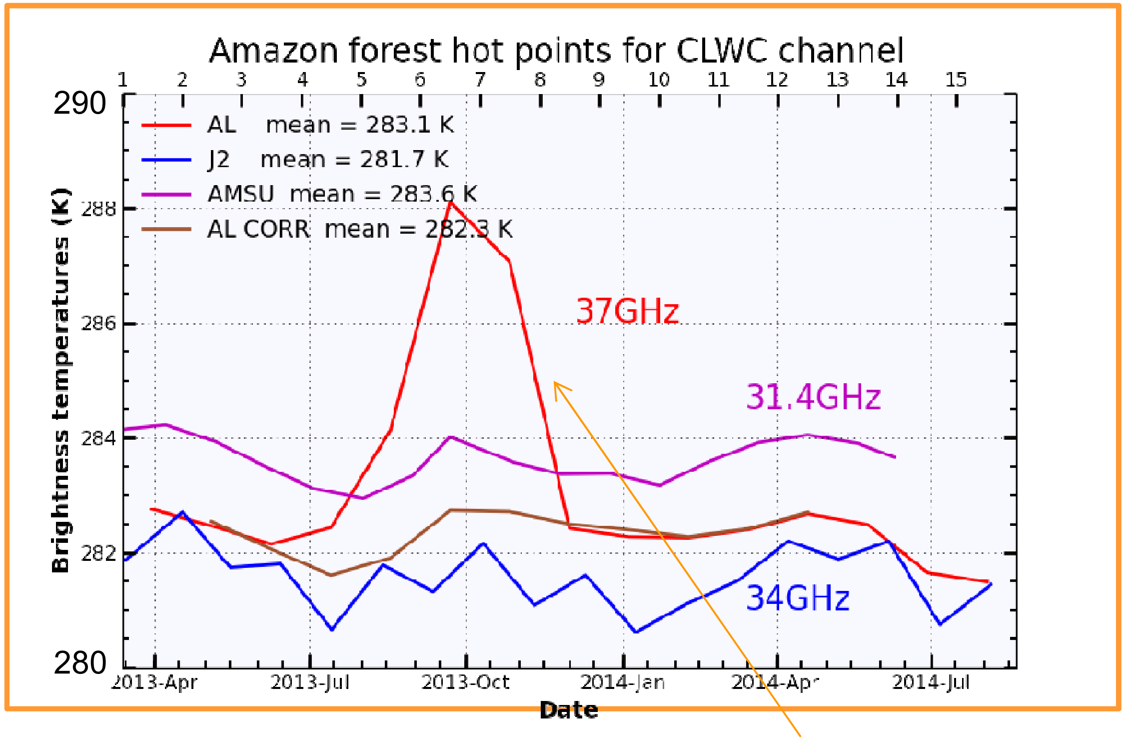
LWC channel

Selection of BTs over Amazon forest

- No instrumental anomaly, but saturation at the conversion of voltage in digital counts
- voltage offset easily updated on the on-board database on Oct 2013 (during cycle 7)

- A correction proposed for the impacted period

- See poster : **Microwave radiometer aboard SARAL/ALtiKa: Correction of 37GHz channel**



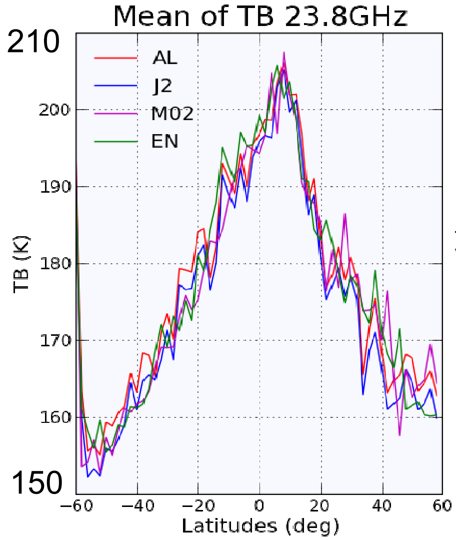
Hot calib. Counts saturation

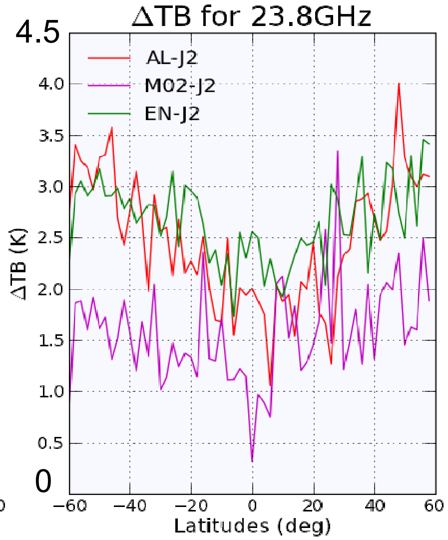
2. Comparison at crossover points

- Crossover points with a time threshold of ±30min
  - over 11 cycles for Jason-2 / AL / AMSU (M02)
  - year 2009 for J2/EN

23.8GHz channel

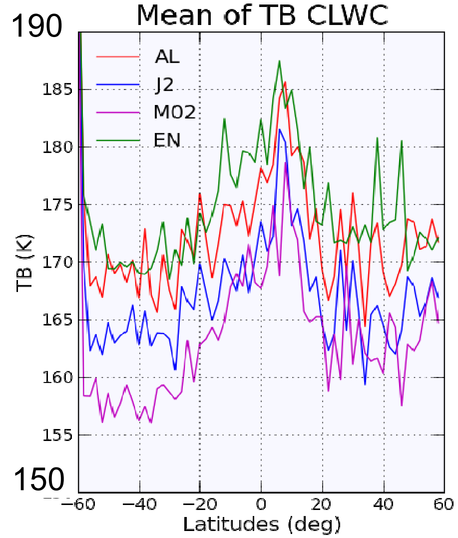
➢ Dependency of ΔBTs with the latitudes

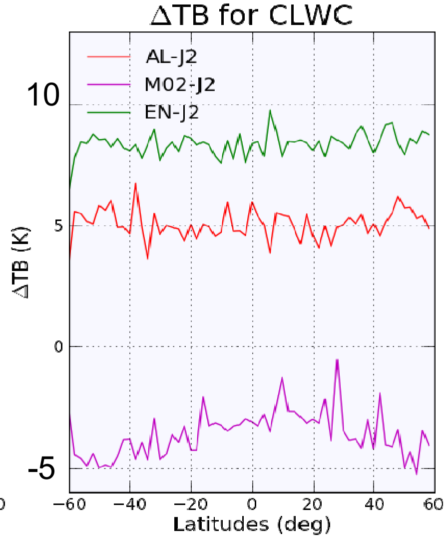




LWC channel

➢ No dependency but for Metop02 (AMSU)

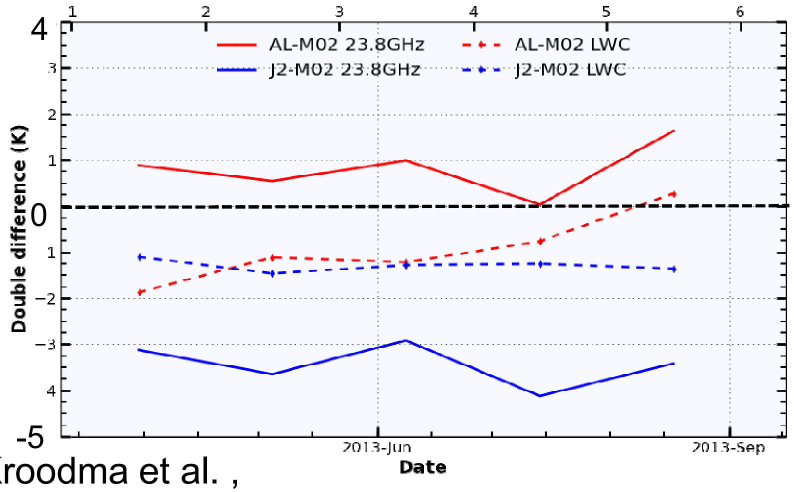




consistent with results in Bin Zhang et al. ,
“Assessing the measurement consistency between the Jason-2/AMR and SARAL/Altika/DFMR microwave radiometers using simultaneous nadir observations” , *Marine Geodesy Saral Special Issue*, 2014

3. Double difference using vicarious cold calibration

- Method:
  - Use the coldest ocean points to minimize the impact of the geophysical variability
  - Single difference: remove the impact of the geophysic
  - Double difference: assess the calibration difference between two radiometers
- Implementation:
  1. Coldest ocean points on measurements (TB_{cold}^{Meas}) and simulations (TB_{cold}^{Sim}) (ECMWF + UCL) <u>colocalised</u> (area = ±60° of latitudes, 5 cycles of AltiKa)
  2. Single difference: $SD_{instr\ 1} = (TB_{cold}^{Meas} - TB_{cold}^{Sim})\big|_{instr\ 1}$
  3. Double difference: $DD = SD_{instr\ 2} - SD_{instr\ 1}$



DD (K)	AL-M02		J2-M02	
	23.8GHz	LWC	23.8GHz	LWC
	0.8	-0.9	-3.4	-1.3

(1) : Kroodma et al. , "Inter-Calibration of Microwave Radiometers Using the Vicarious Cold calibration Double Difference Method" IEEE Applied Earth Observations and Remote Sensing, vol. 5, no. 3, pp. 1939–1404, Jun. 2012.

MWR measurements assessment

- Vicarious calibrations:
  - Very good consistency between AL/AMSU/J2 for 23.8GHz channel for the hottest BTs
  - Coldest points over ocean: AL/AMSU stand at +5K of J2 for 23.8GHz channel.

	AL-AMSU		J2-AMSU	
	WV	LWC	WV	LWC
AMA	+0.9	+0.5	+1.8	-1.9
Cold	+1	+9.5	-4.8	+3.4

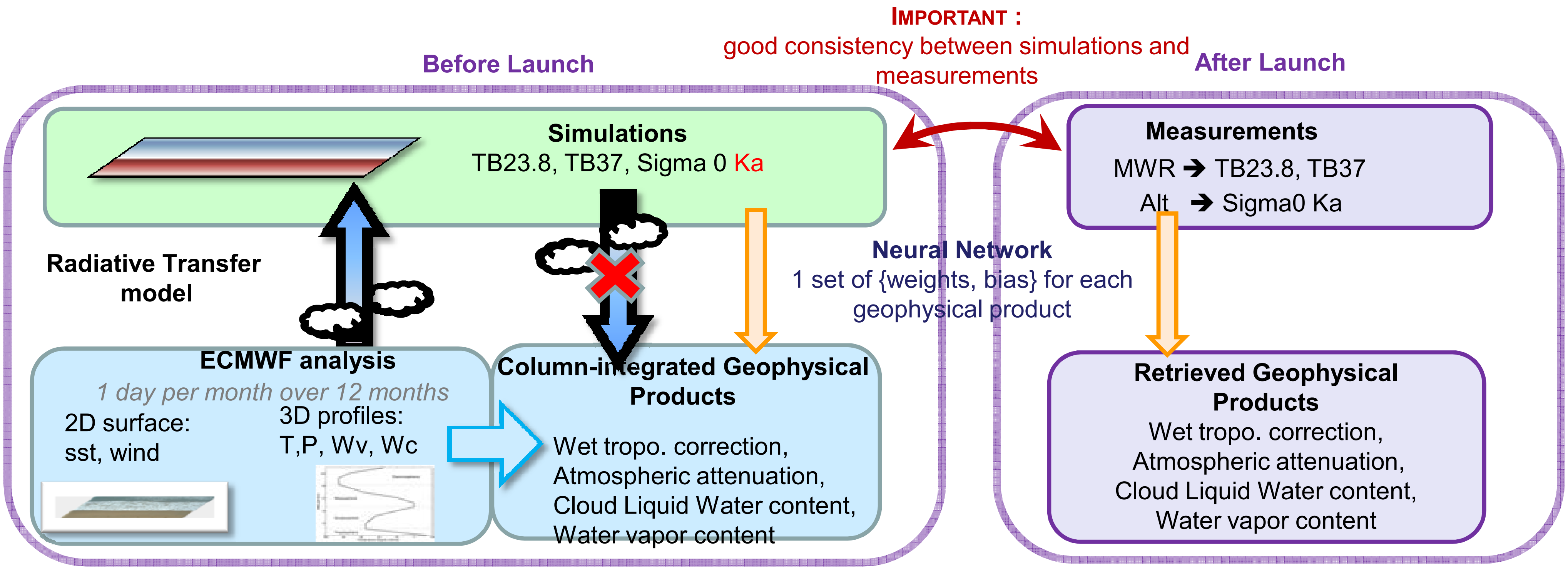
  - Coldest points over ocean : for the LWC channel, stronger differences due to the differences of frequencies
- Cross over points:
  - Dependency with the latitudes for AL/AMSU/EN BTs for 23.8GHz at crossover points with Jason-2
- Double difference:
  - Good consistency between AL/AMSU for both channels
  - J2 stands at +3.4K for 23.8GHz channel

	AL-AMSU		J2-AMSU	
	WV	LWC	WV	LWC
DD (K)	+0.8	-0.9	-3.4	-1.3

4. Inversion algorithm: The classical approach

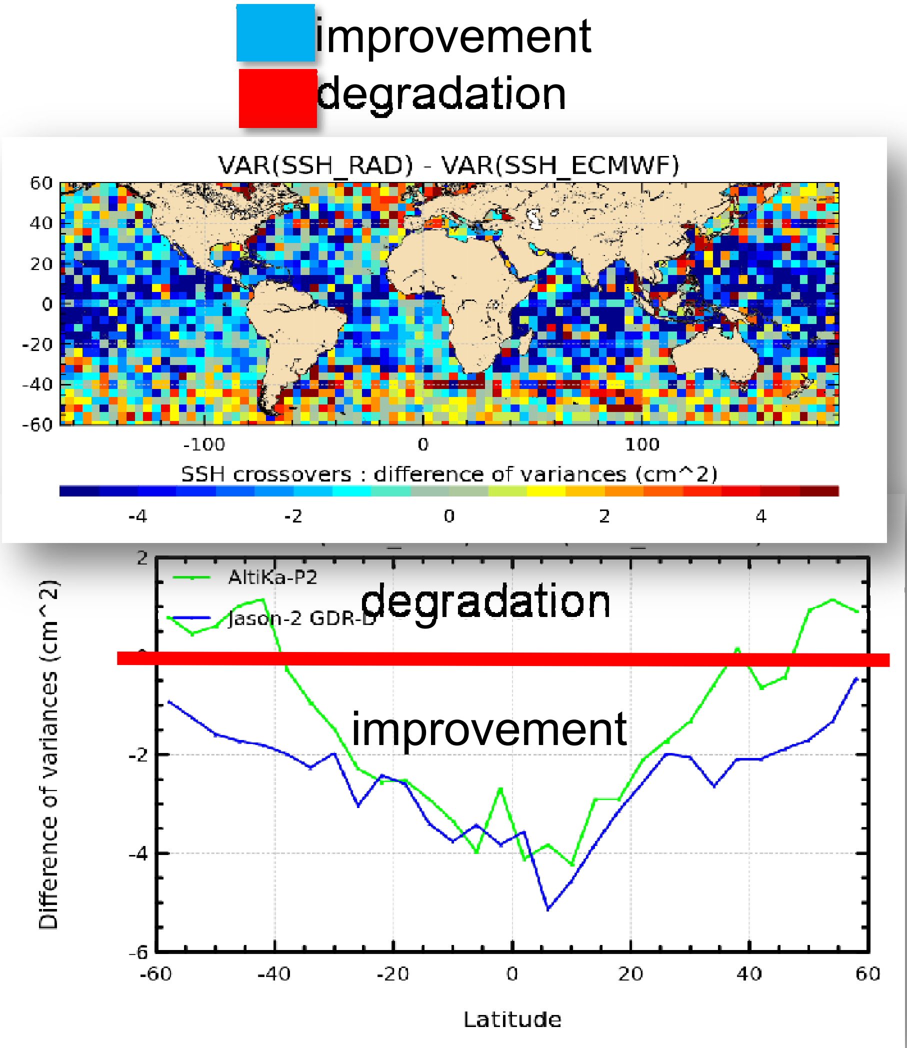
This approach has been successfully applied for ERS1/2 and Envisat (σ_0 in Ku band).

• Simulated TBs and sig0 are completely consistent with the atmospheric conditions of the model within the limit of the Radiative Transfer Model
• The learning dataset is statistically representative of all realistic atmospheric conditions



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.

4. Inversion algorithm: The classical approach



Quality of wet tropospheric correction (WTC) is evaluated by differences of variances of SSH at Xovers (radiometer vs ECMWF WTC)

The better the correction, the smaller the variance

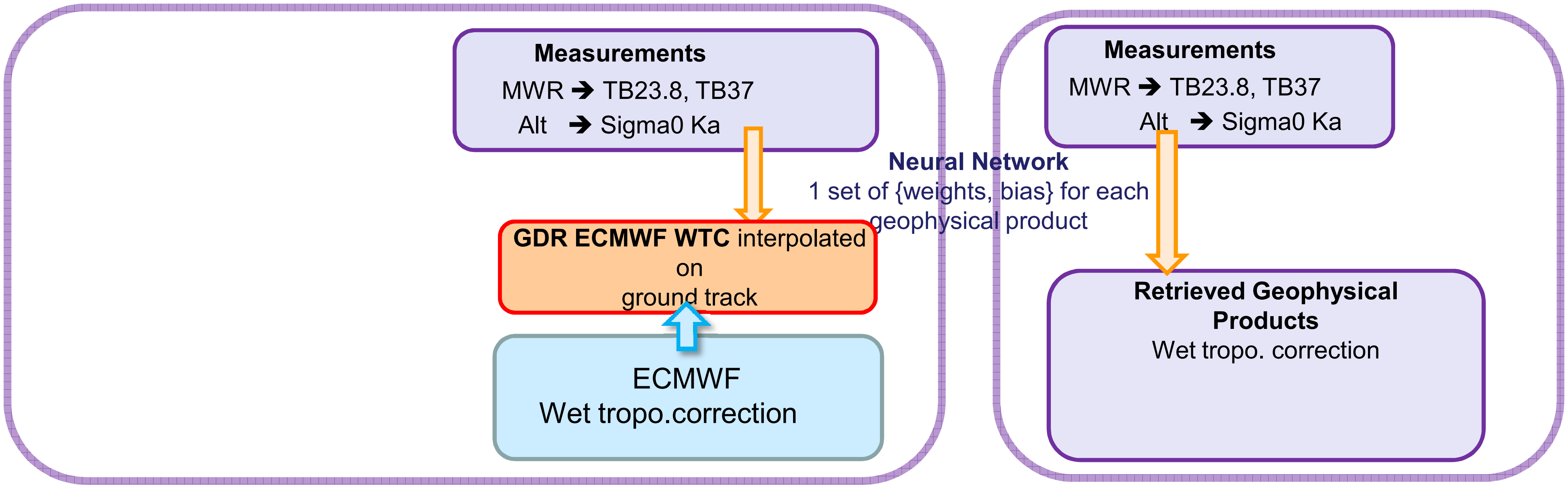
Radiometer wet tropo. corr. (WTC) is expected t reduce the variance at Xovers compared to ECMWF wet tropo. corr.

Patch2 WTC quality is similar to AMR Jason-2 WTC for LAT [-20°,20°]

The quality is not optimal for ABS(LAT) > 20°

5. Empirical approach

- The **empirical** approach is based on:
  - learning database ~~= simulation~~ = measurements (TBs, sigma0)
    ➔ no simulation = no physic
  - output = ECMWF wet. tropo. **interpolated** on AL track



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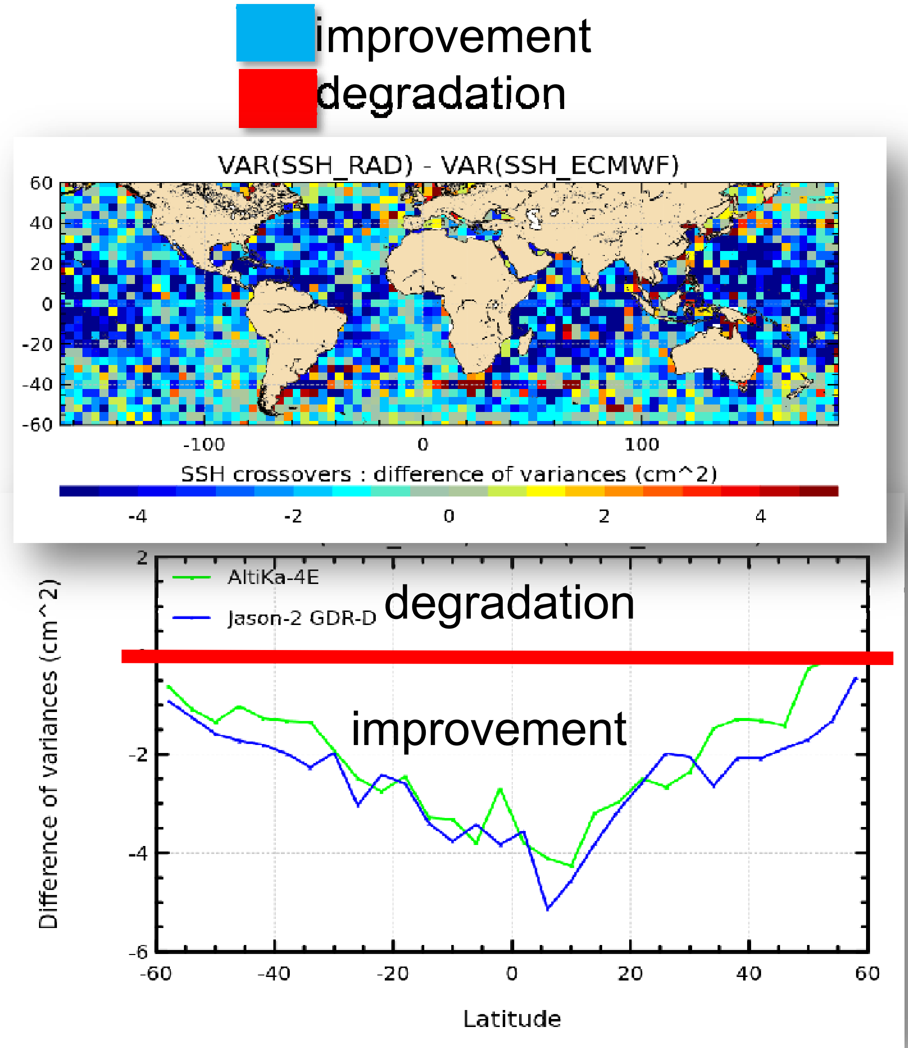
➔ due to the spatial/temporal interpolation and physical limitation of the model (for instance location and intensity of clouds), measured TBs/sigma0 will **not** be consistent with the WTC

CONS : quality is not expected to be as good as with classical approach

PROS : we do not rely on the simulations

5. Empirical approach



- Performances of empirical approach with '4E' = 4 inputs = TBs + sig0 + SST for AltiKA are close to Jason-2

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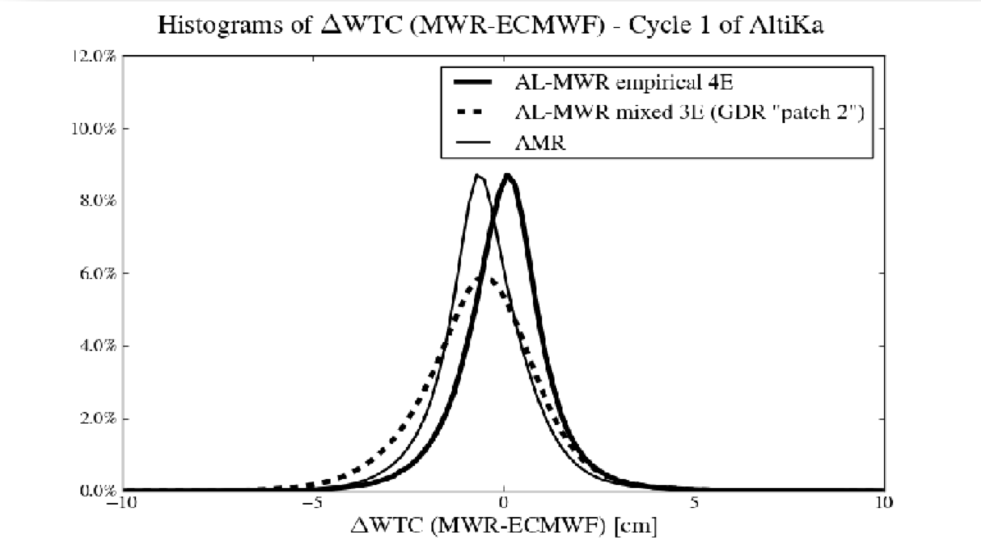
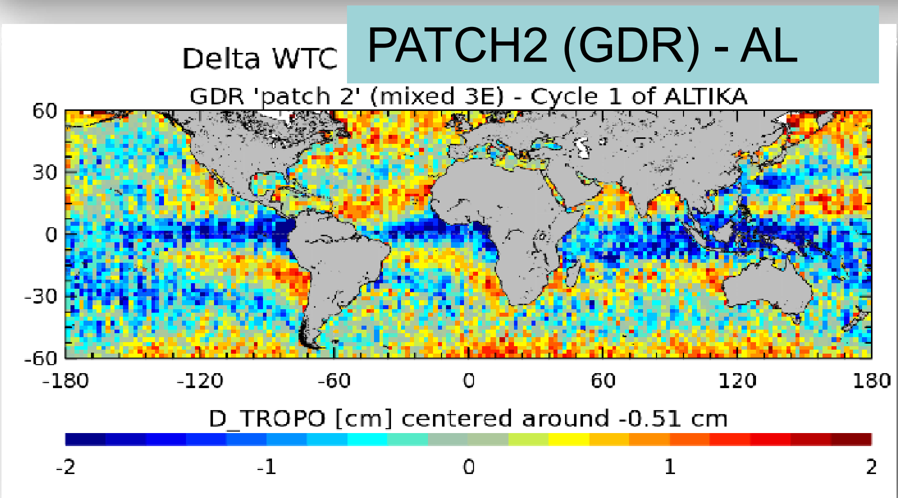
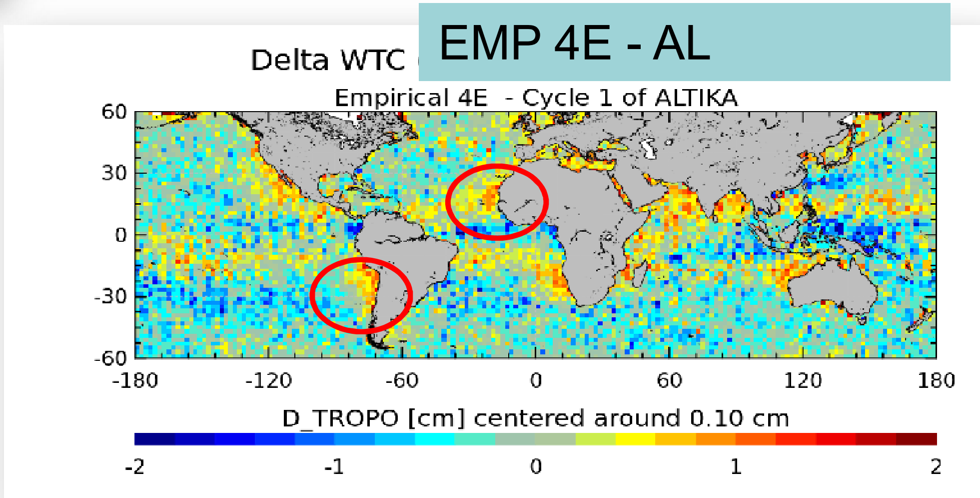


- Performances of empirical approach with '4E' = 4 inputs = TBs + sig0 + SST for AltiKA are close to Jason-2

- further improvements are foreseen adding temperature lapse rate for upwelling areas





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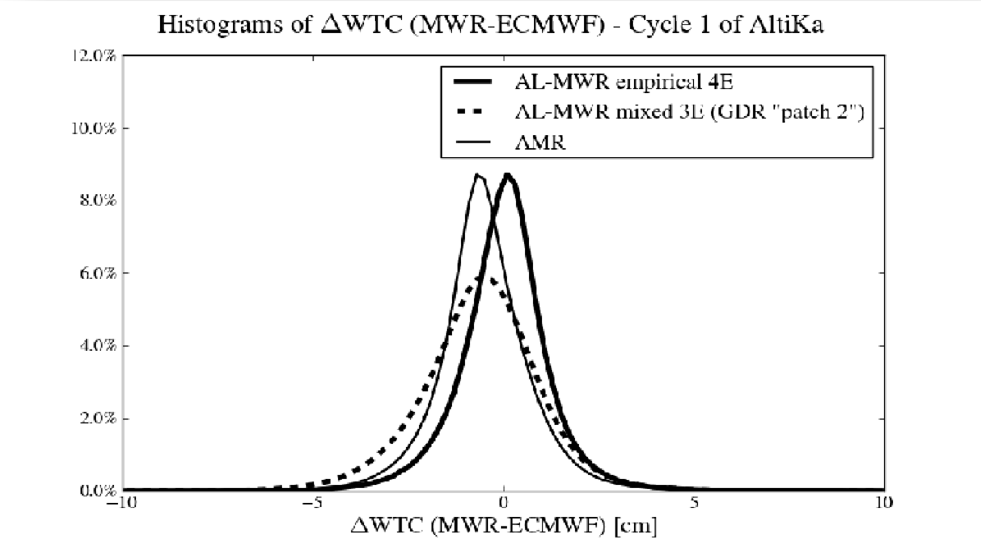

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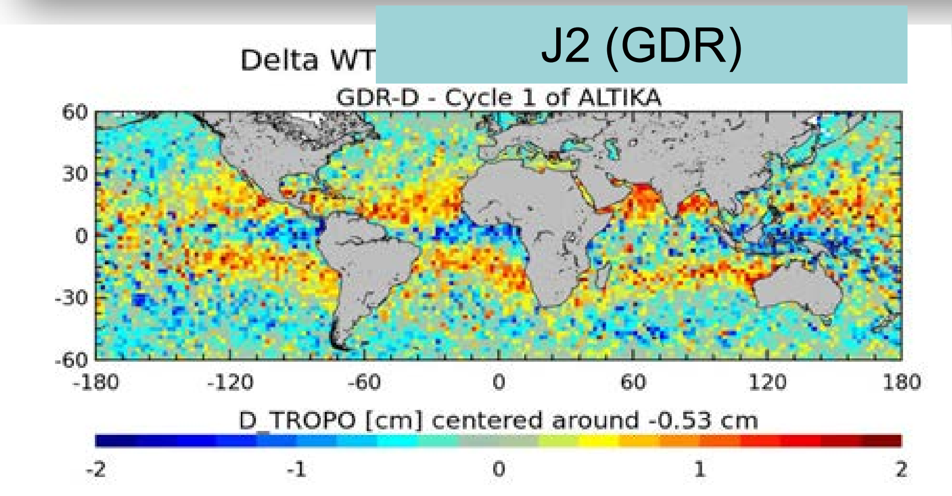

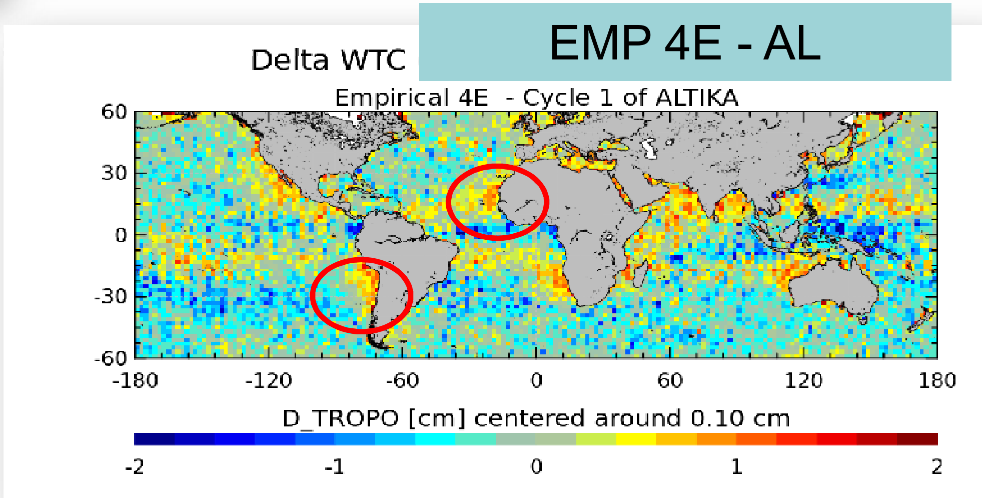

Conclusions

- Instrumental performances of SARAL/AltiKa radiometer are excellent
- Comparison with other instruments performed with brightness temperatures
  - Very good agreement with other instruments (AMSU-A/J2) on Amazon forest
  - Cold vicarious calibration and double difference shows a good agreement between AL and AMSU (|Δ|~1K) for both channels
  - At crossover points, the results show a dependency of the difference of BT between AL/AMSU/EN wrt J2 for the 23.8GHz.

Conclusion & Perspectives

- Empirical '4E' retrieval performances are close to Jason-2; further improvements are foreseen adding temperature lapse rate
- Instrumental performances of SARAL/AltiKa radiometer are **excellent** and we are now in position to provide **even better geophysical products.**

➔ same approach should be applied to atm. attenuation

- Ref: **Picard et al**, *Marine Geodesy Saral Special Issue*, 2014
- Empirical '4E' WTC will be available on PEACHI dataset on http://odes.altimetry.cnes.fr

Conclusion & Perspectives

- Empirical approach is a very good alternative to the classical approach but not entirely satisfactory
- An effort should be put on the simulation of the backscattering coefficient in Ka band in order to:
  - improve our knowledge on atmospheric & surface interaction at this frequency
  - continue to improve our understanding of the statistics of the Sigma0 in Ka band in the perspective of the SWOT mission