Characterizing Rain Cells as Measured by a Ka-band Nadir Radar Altimeter: First Results and Impact on Future Altimetry Missions

Bruno Picard, Fluctus, Rabastens, France
Nicolas Picot, CNES
Gérald Dibarboure, CNES
Nathalie Steunou, CNES

bpicard@satobsfluctus.eu

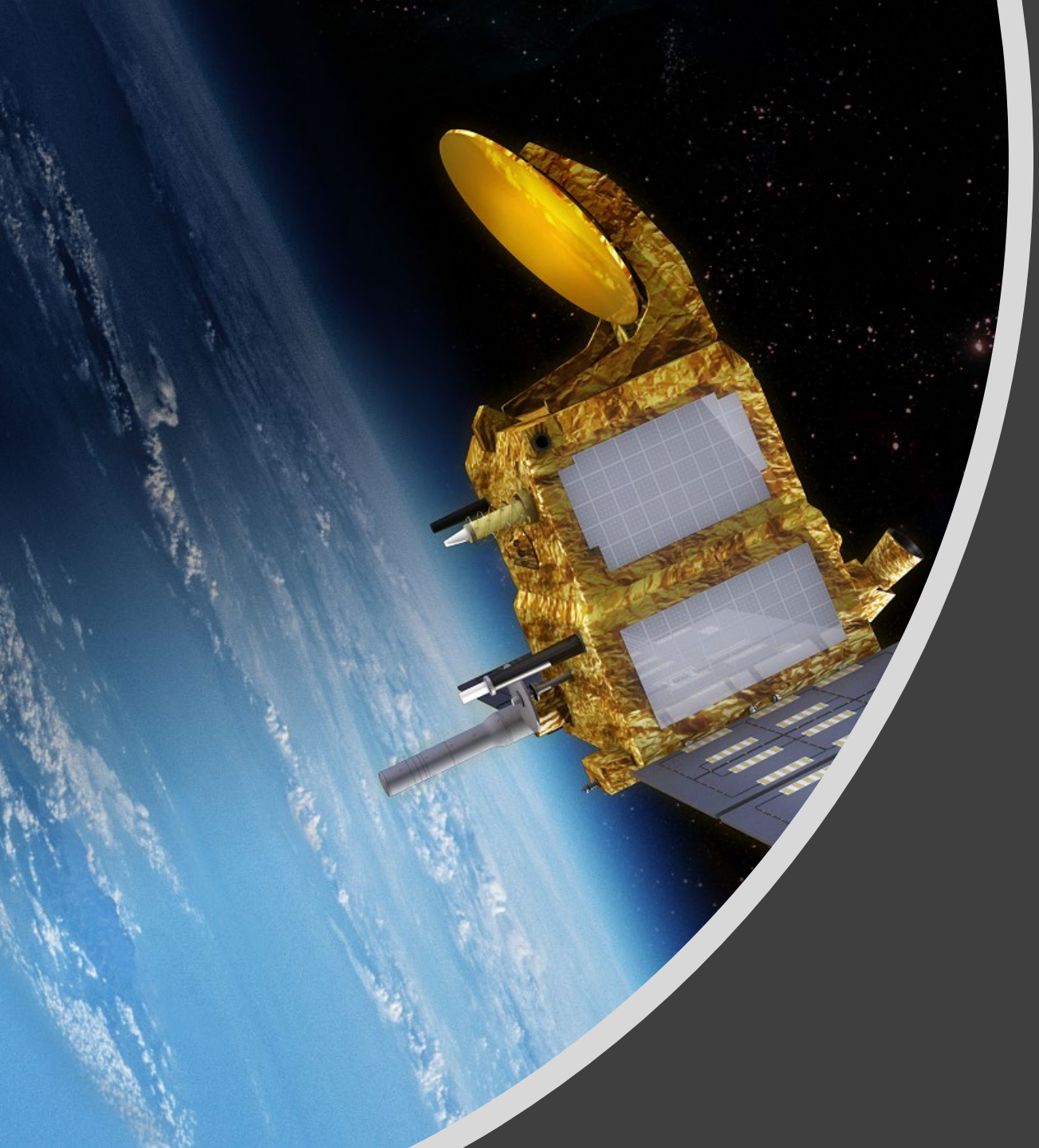
Question:

in the context of the future **SWOT altimetry mission**,

is it possible to detect the impact of **rain**

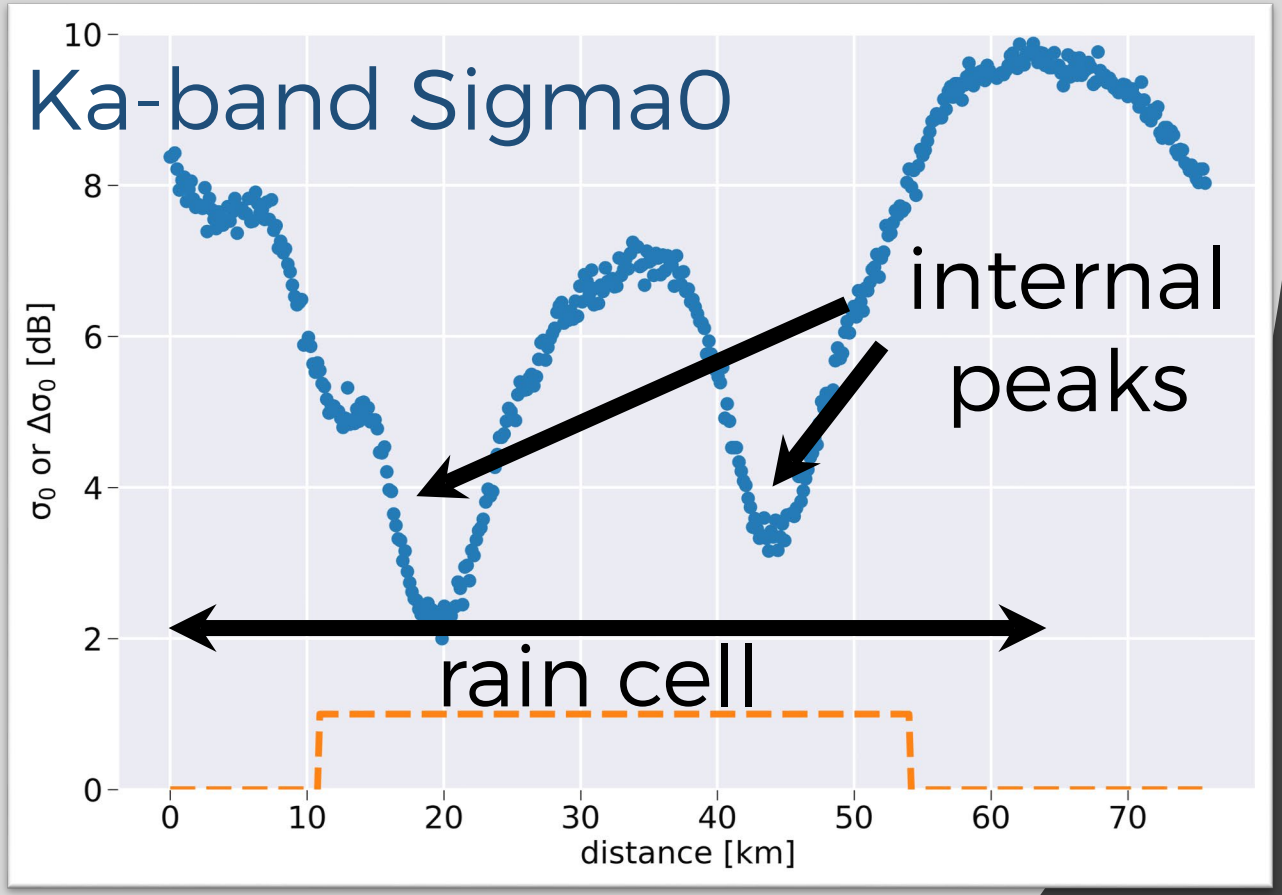
on **2D Ka-band** radar backscatter coefficient

?



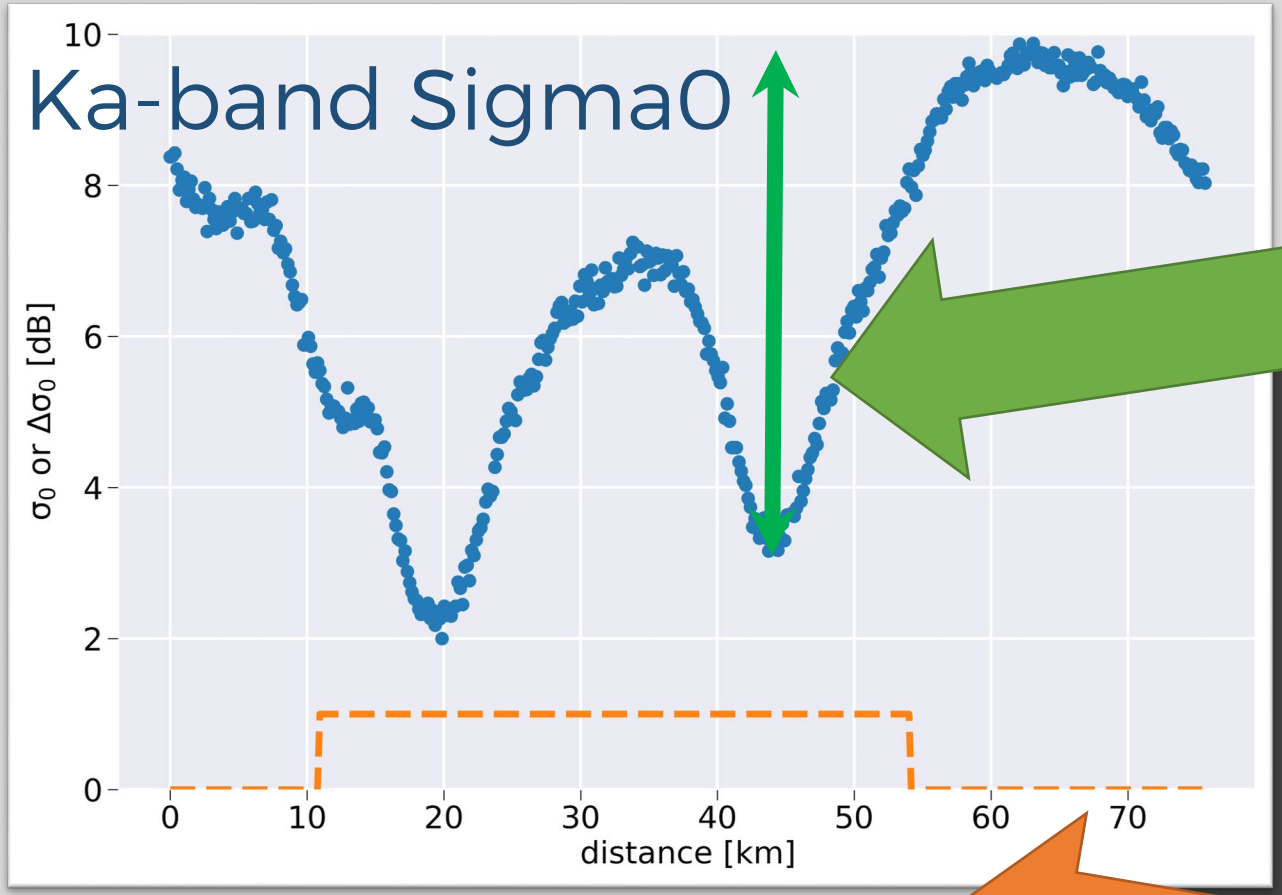
Saral/AltiKa altimeter:
- 35.75 GHz
- 4 km footprint
- 175 m sampling

an ideal context to anticipate the impact of the atmospheric condition on the future SWOT mission performances



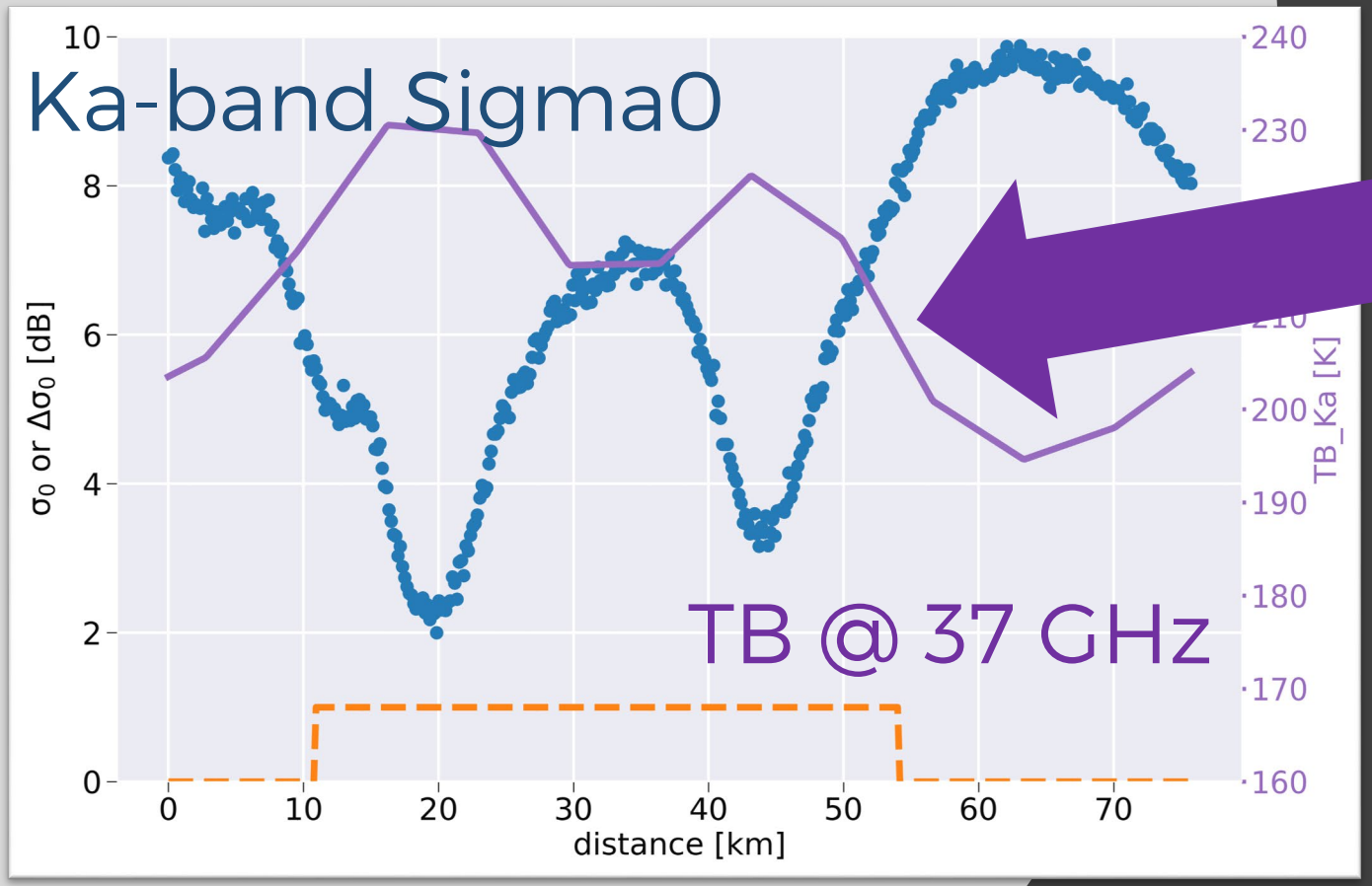
An illustration of the impact of precipitation on Ka-band sigma0.

The rain cell is composed by 2 internal peaks

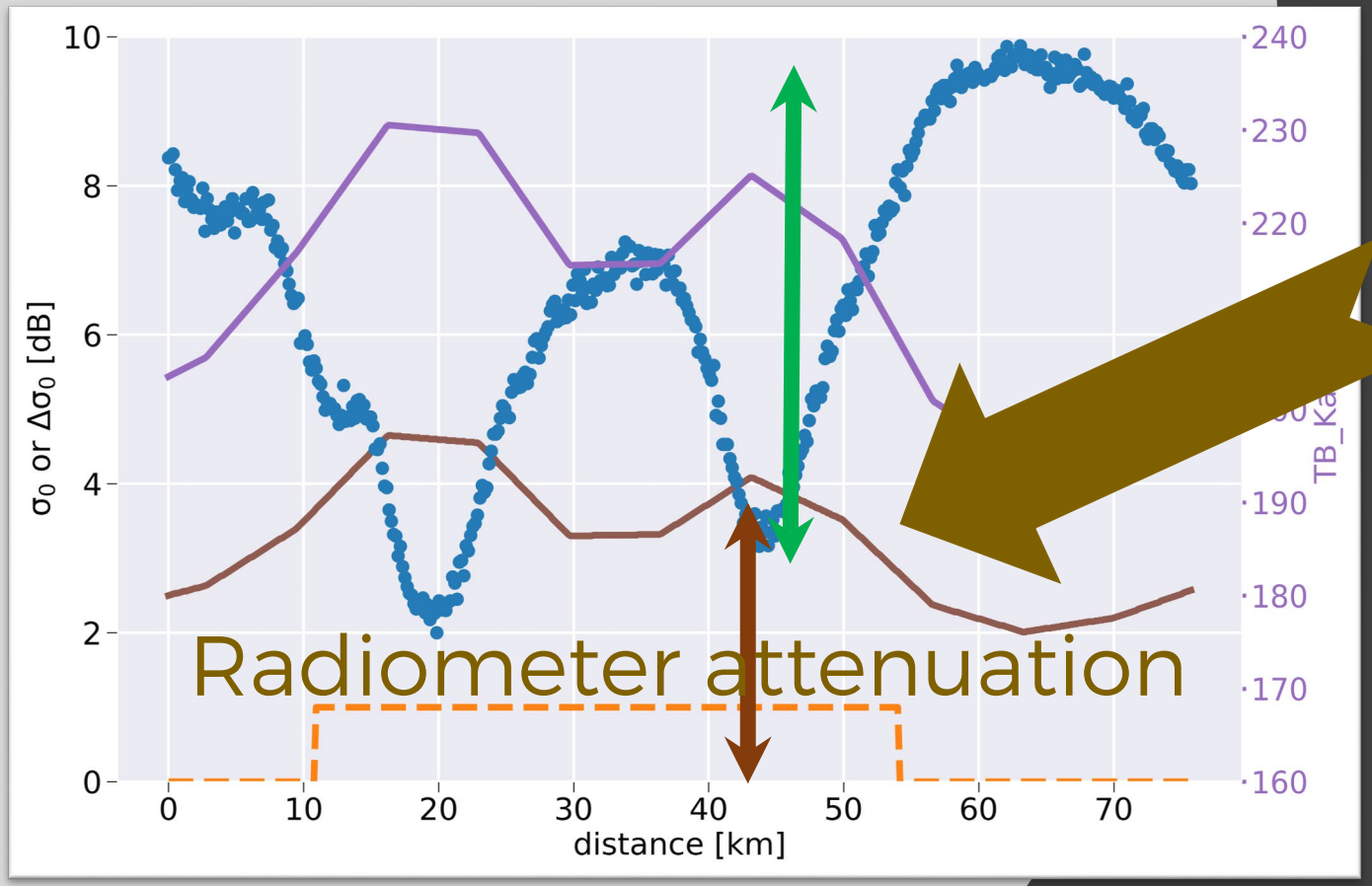


The atmospheric attenuation is 7 times larger at Ka-band than at Ku-band (Lillibridge et al 2014)

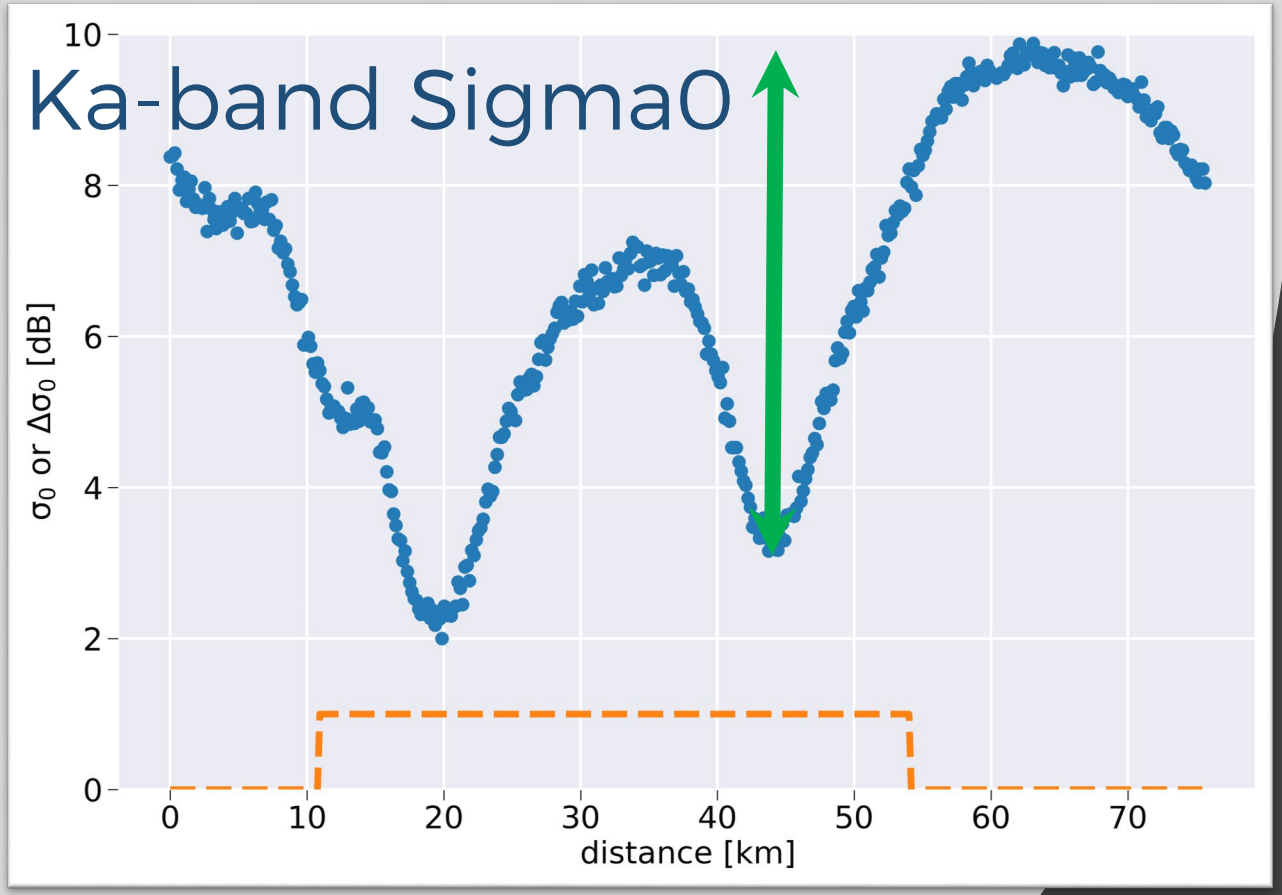
Identification of rainy conditions thanks to the rain flag developed by Tournadre (2009, 2015)



The on-board radiometer has a too coarse resolution (~12 km) and a too coarse sampling (~ 7 km) to catch small events



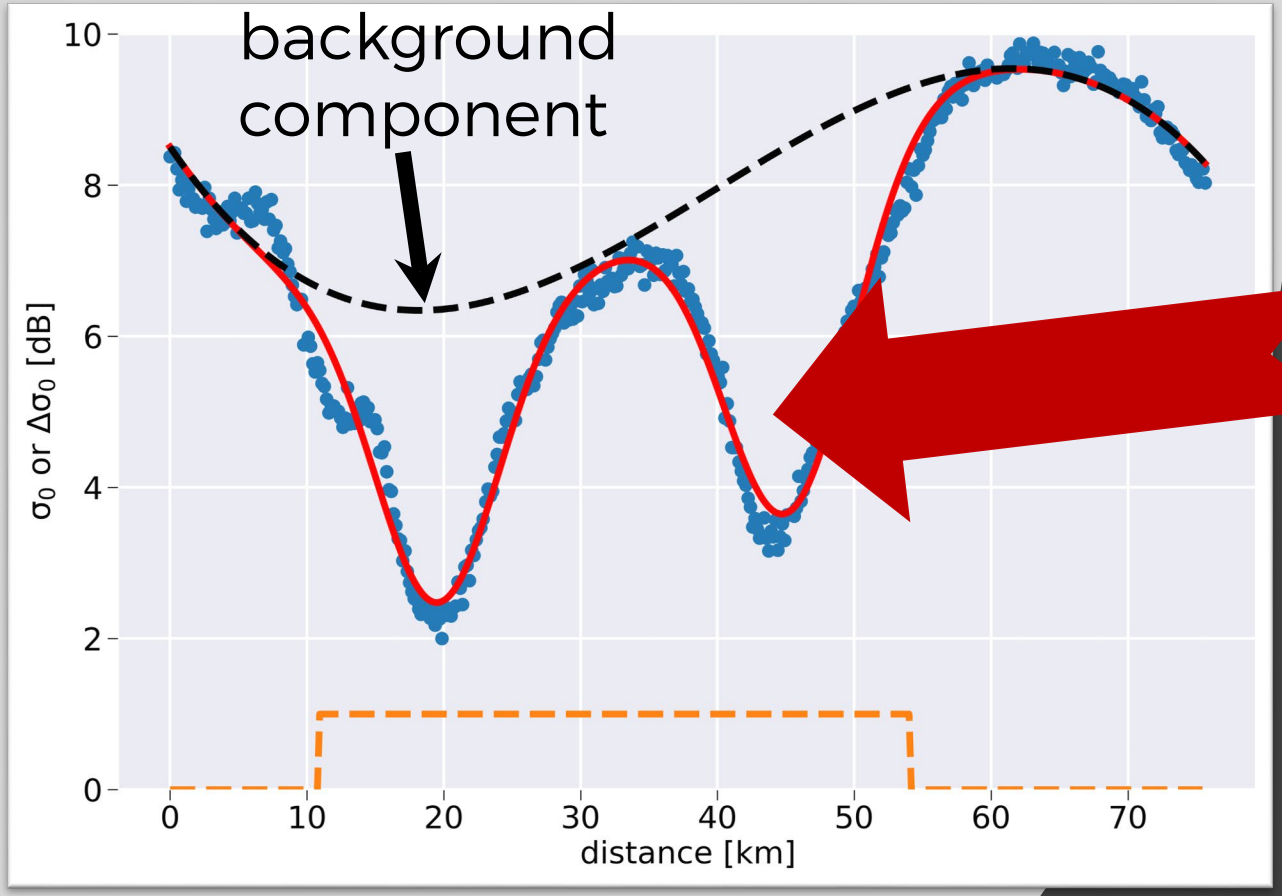
The atmospheric attenuation computed from the radiometer TB is thus too small compared to what is actually observed on the sigma0 timeseries



Is it possible to estimate the attenuation directly from the 175-m sigma0 signal ?

The PEACHI dataset (CNES):

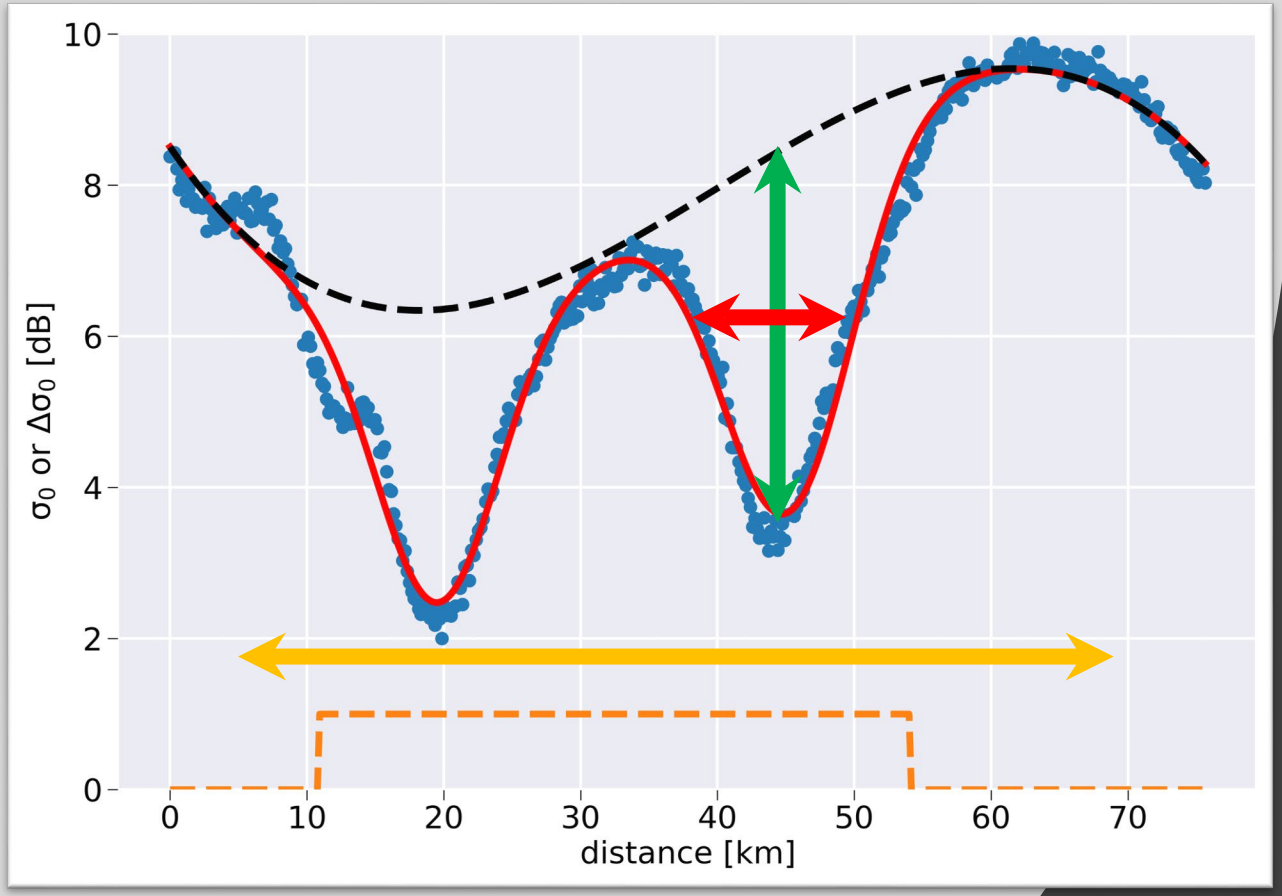
- 40 Hz record
- sigma0 = Adaptive retracking (more physical)
- Tournadre matching-pursuit rain flag
- colocated rain rate observations (SSMI/S…)
- whole year 2015



The Attenuation Cells Characterization ALgorithm (ACECAL) applies a non-linear least-square fit on the sigma0 timeseries

It is based on the combination of:

- a 3rd degree polynomial for the long-scale background variation
- N Gaussians fit for the internal peaks

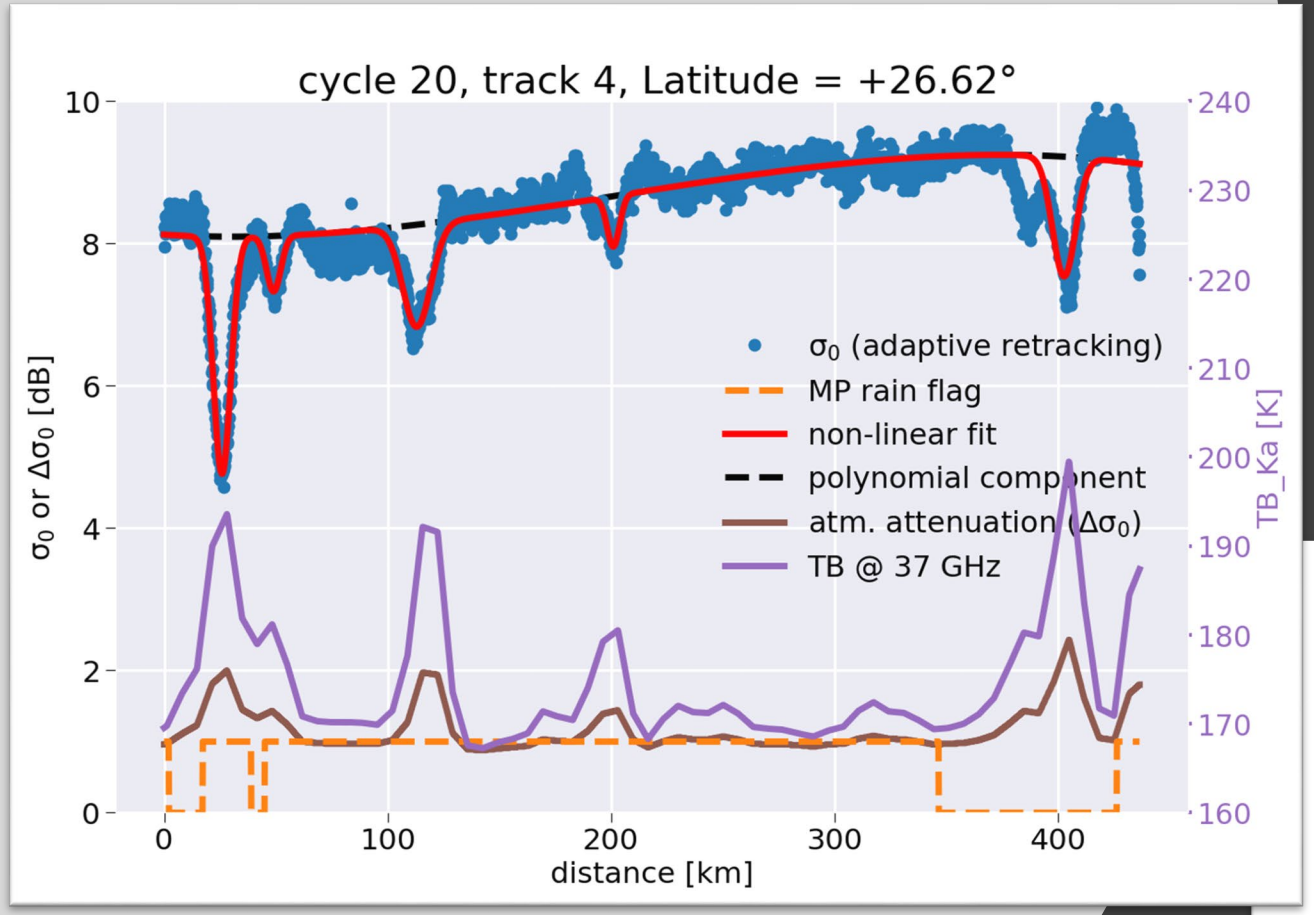


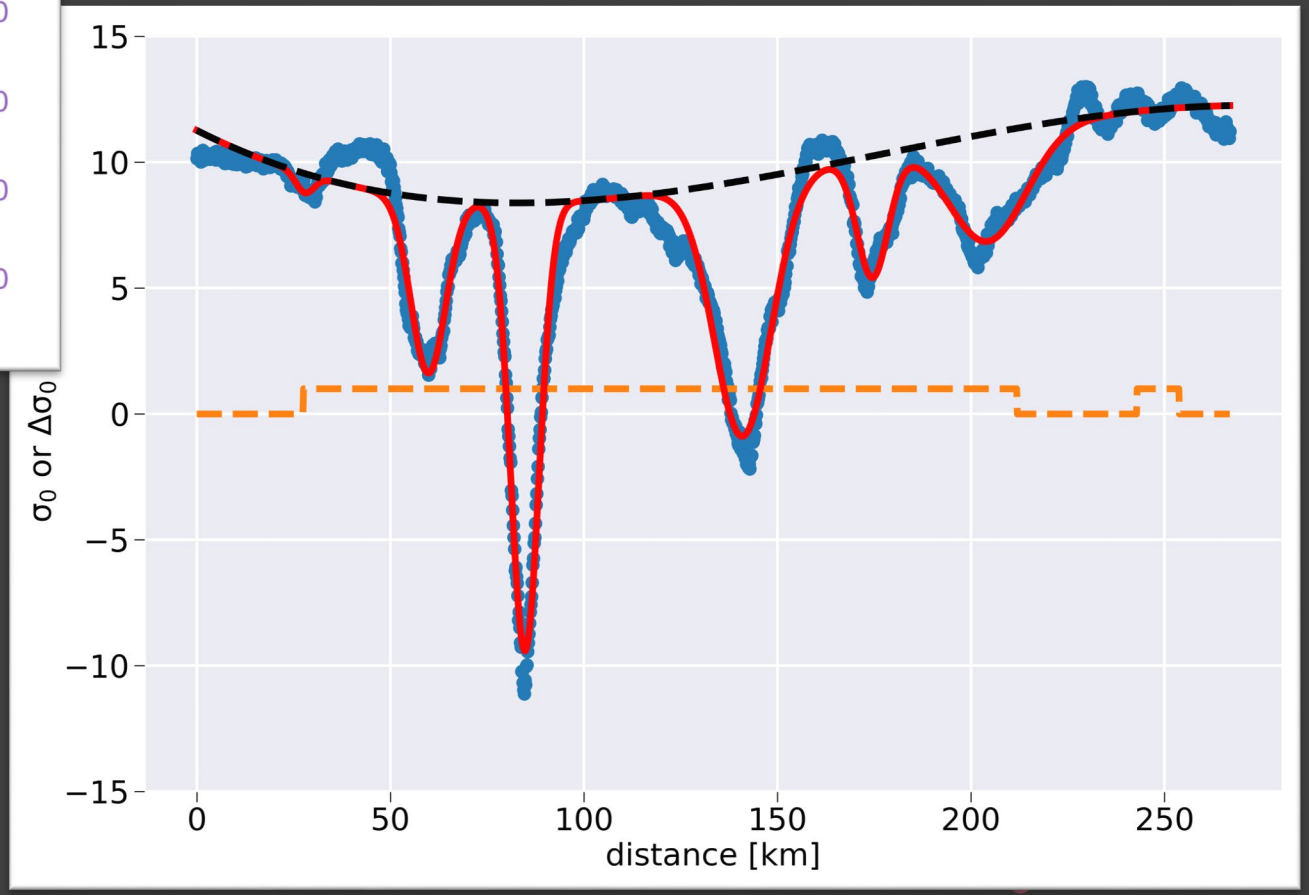
The attenuation is defined as the difference between the background and the maximum of the Gaussian

The peak width is the FWHM of the Gaussian

The rain cell width is the sum of the 6-sigma width of each individual peaks

ACECAL is a robust approach even for complex internal structure



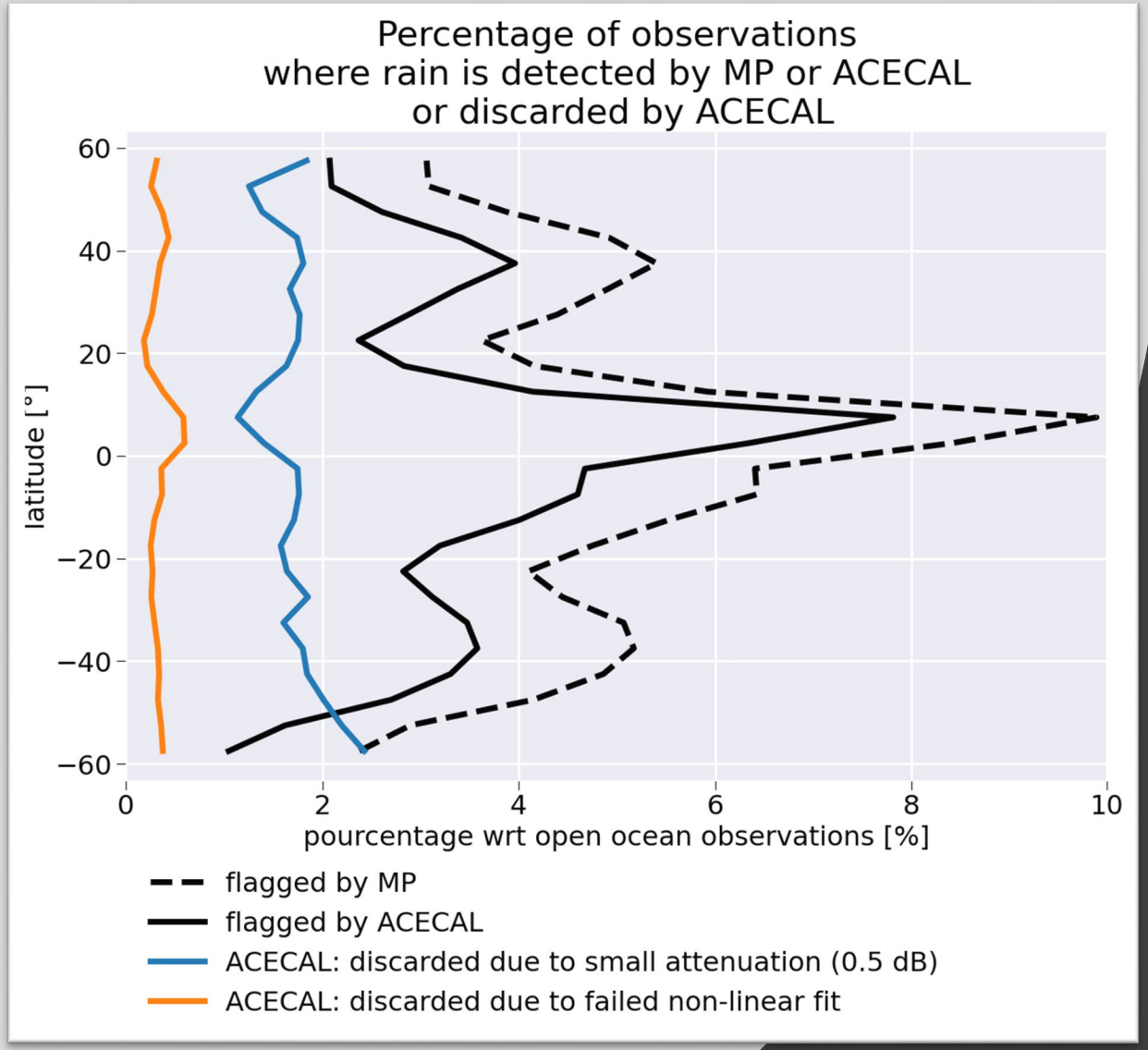


ACECAL applied to
the whole year 2015,
from AltiKa cycle 20 (2015/01/08)
to cycle 30 (2016/01/28)

56,000 rain cells detected

within these rain cells, 84,500
peaks were identified

2°x2° gridding average

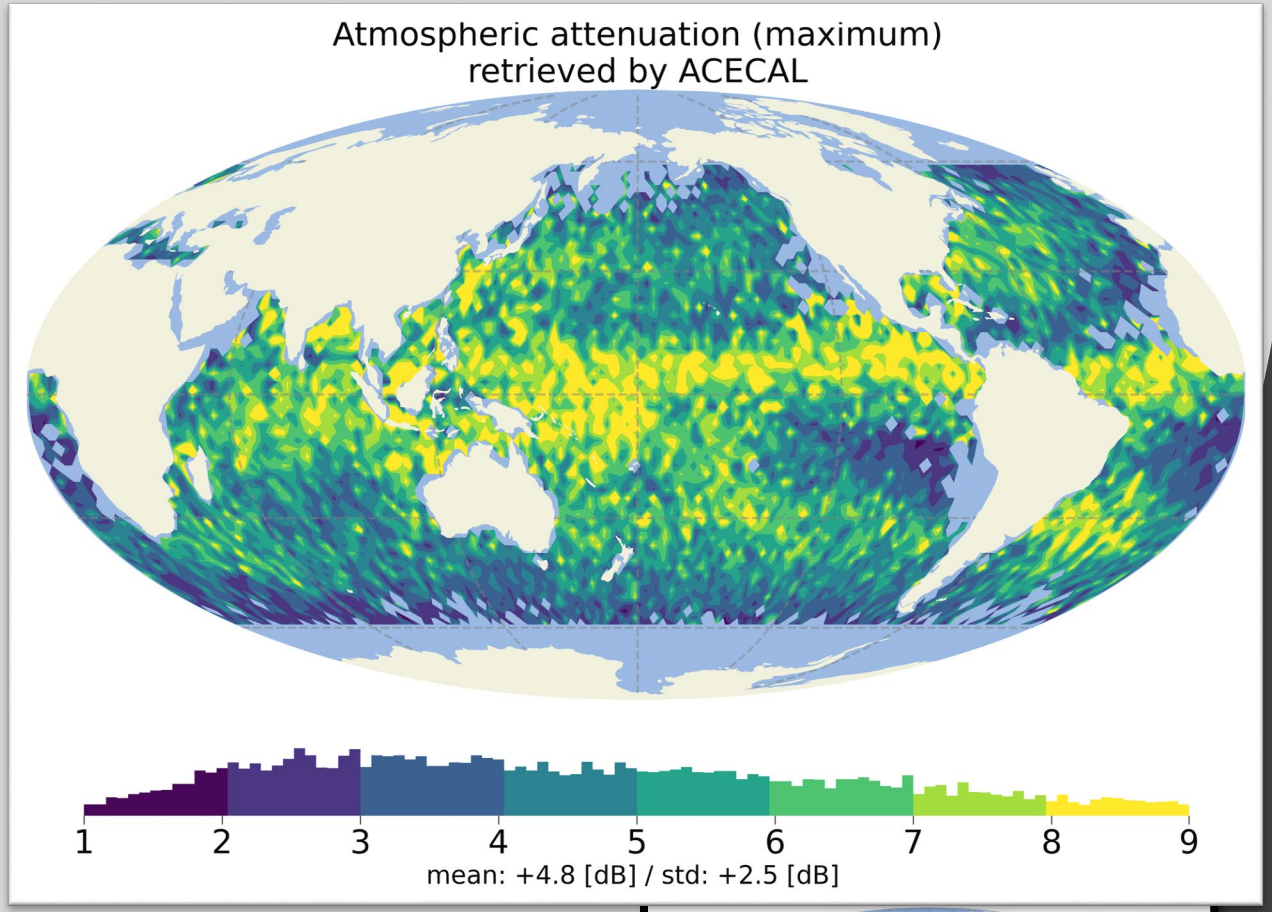


For this initial study, the ACECAL algorithm is applied whenever the Matching Pursuit flag is raised.

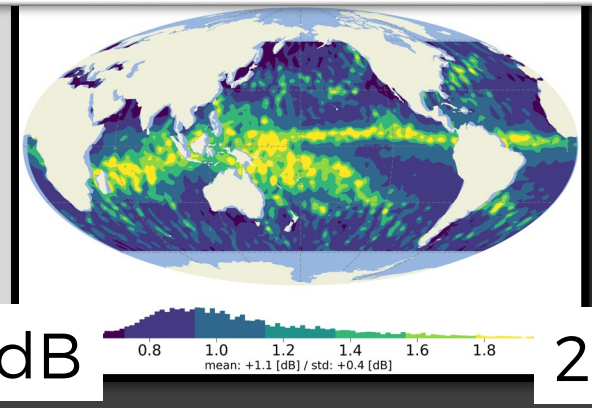
The MP flag is fully validated using Xovers with 3rd party missions dedicated to rain measurement.

#obs. Impacted by rain is 1% lower with ACECAL than MP

Output #1



Radiometer attenuation



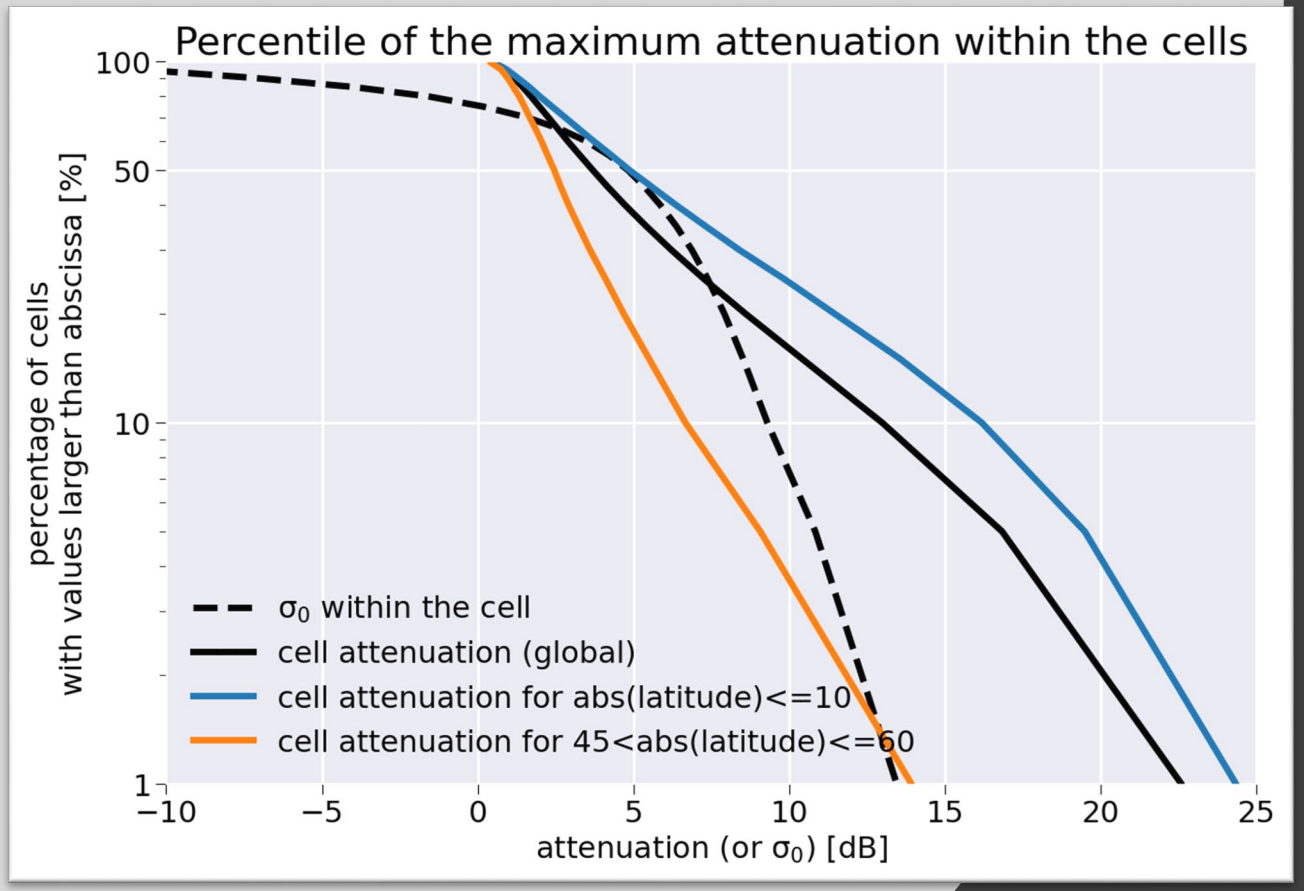
0.6 dB

2 dB

The **atmospheric attenuation** computed with ACECAL is based on **actual measurements**,

About **-5 dB** for rainy situations up to **-9 dB** Larger than what you would get from the radiometer or NWP models

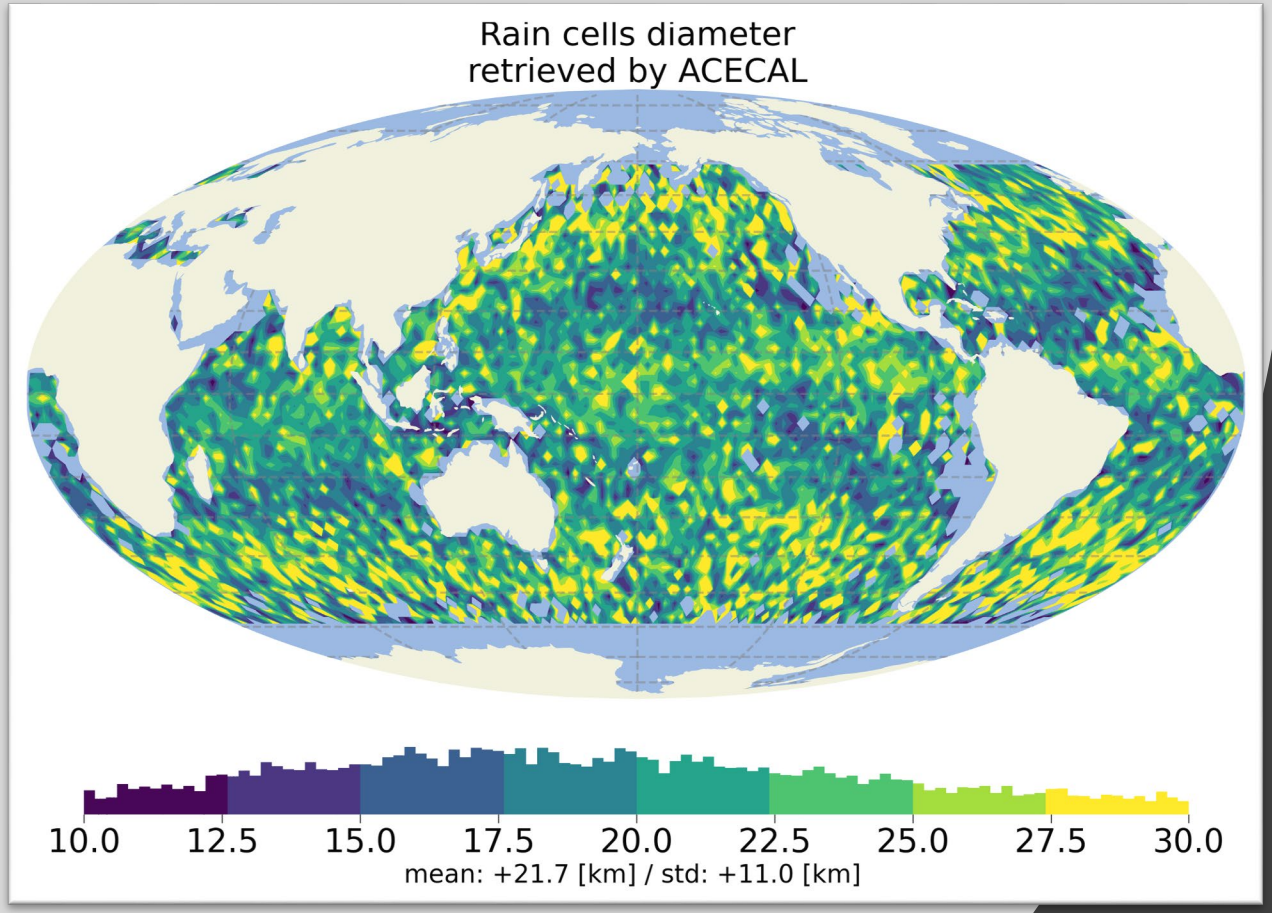
Output #1



Solid black: 10% = 13 dB attenuation

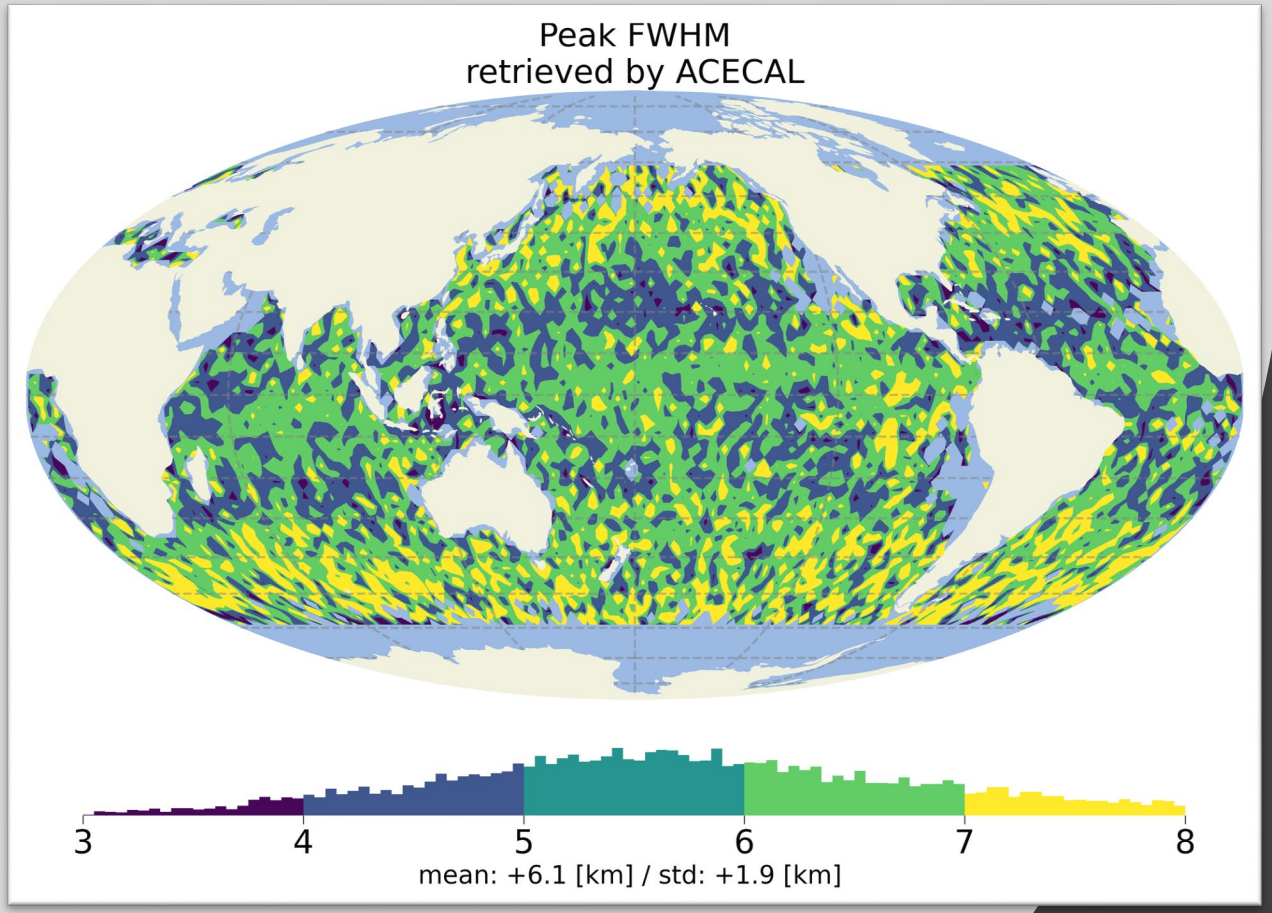
Orange: 10% = 15 dB in equatorial region

Output #2



The **width of the rain cells** is similar to previous studies, larger at **high latitudes (~ 30 km)** than over the **Tropics (~ 20 km)**

Output #3



The **width of the internal peaks** combined to the maximum attenuation provides useful information on **where and how** the future **SWOT** mission can be **impacted by large attenuation events.**

ACECAL approach provides:

- a precise estimation of the **size of rain cells**

- a **very accurate atmospheric attenuation** close to the actual impact on Ka-band sigma0

- **a very innovative and precise description of the internal fine structure of rain cells**

Lessons learned:

- some regions of particular interest for oceanography could be more systematically impacted by the atmosphere

- ACECAL statistics can be used to better define future Ka-band missions

Future:

- A learning database is now available for a more systematic detection of rain cells and characteristics using ML approach

- Adaptation to 2D SWOT

- towards the definition of side-product for SWOT ?

Thank you !

More details in

Picard, B.; Picot, N.; Dibarboure, G.; Steunou, N. Characterizing Rain Cells as Measured by a Ka-Band Nadir Radar Altimeter: First Results and Impact on Future Altimetry Missions. *Remote Sens.* 2021, *13*, 4861.

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bpicard@satobsfluctus.eu