Rain flags for SWIM on-board CFOSAT: methods and assessment

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Rain Flags: what for ?

- Rain events have a direct impact on radar signal propagation, from light attenuation to extinction (or large distorsion of waveforms)

- Rain flag is a mature component of Nadir Altimetry since Topex-Poseidon (Tournadre, Quartly)

- The ultimate objective of rain flags is to improve the quality of Wave Spectra (off-nadir) and SSH (nadir) by discarding observations too impacted

Atmospheric impact on sigma0

Rain / Ku-band attenuation : orders of magnitude

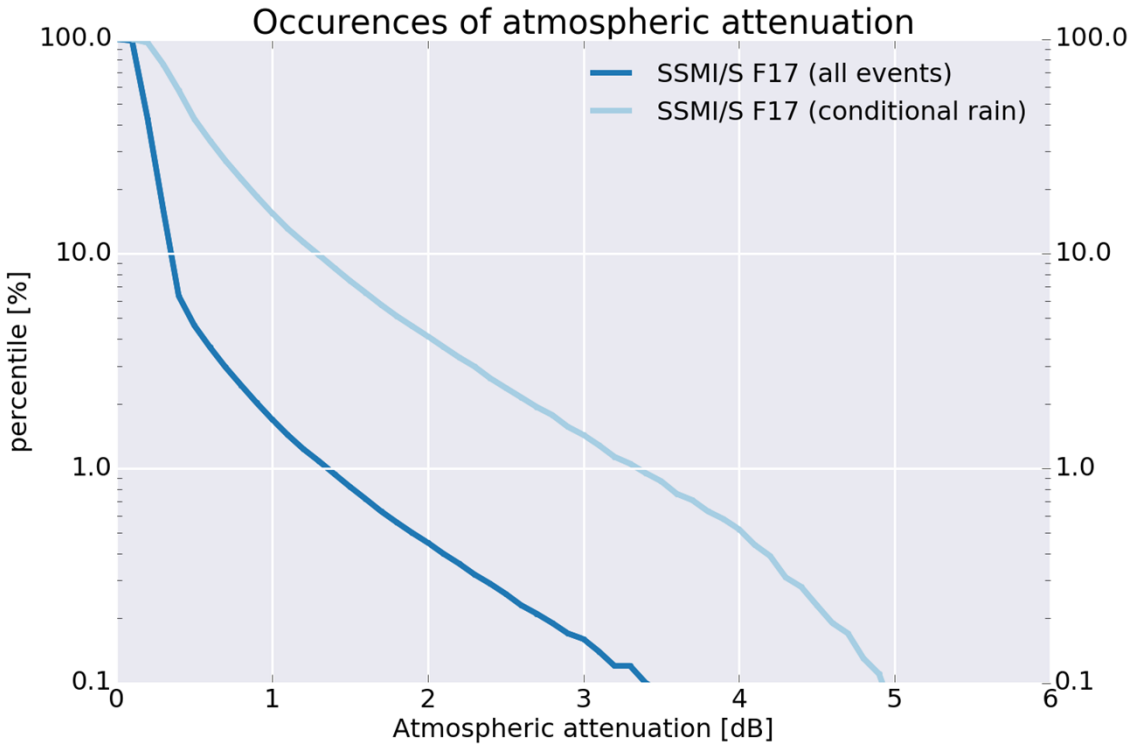
Occurrences percentiles over a day:

- 10% of rain events
- 2% of rain rate > 3 mm/hr

Median = 0.2 dB

- 2% of observations > 1 dB
- 0.1% > 3 dB

With a strong geographical distribution

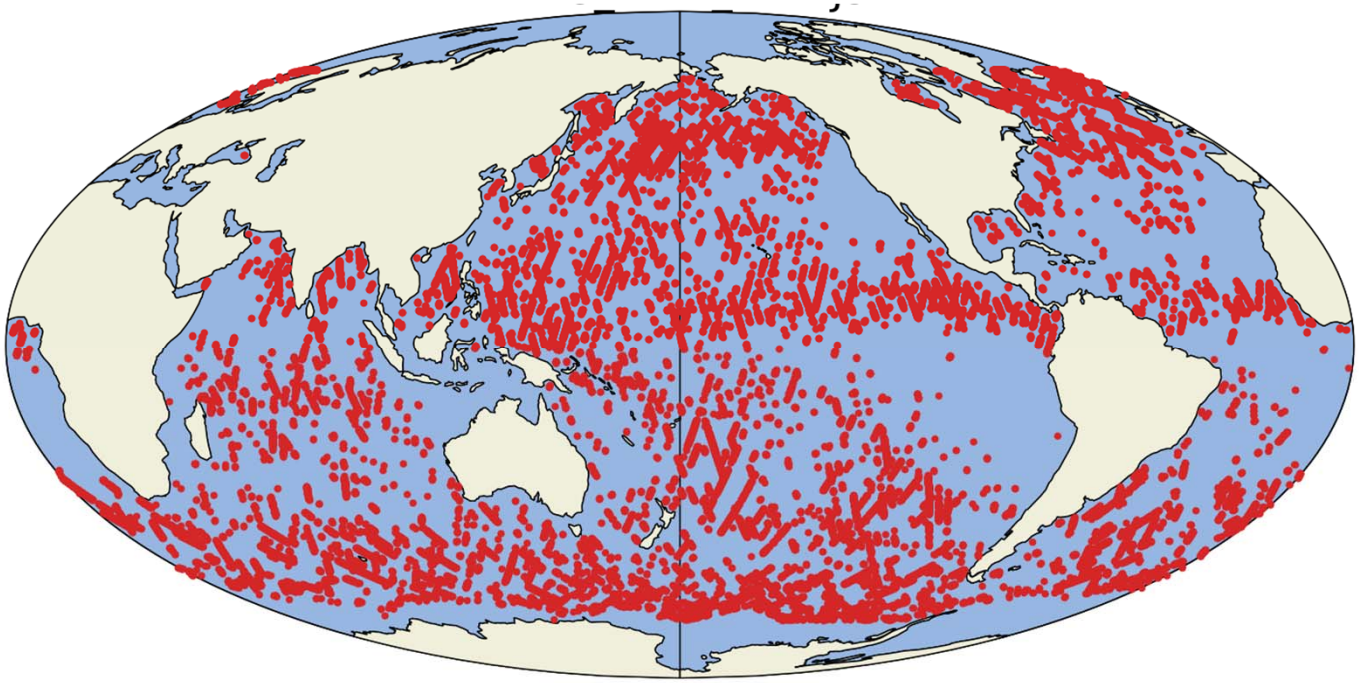


Atmospheric attenuation computed from actual measurements (SSMI/S F17)

Atmospheric impact on sigma0

Double-band S/Ku rain flag over Jason-3 : orders of magnitude

- Altimeter rain flag : 6% of the observations over ocean

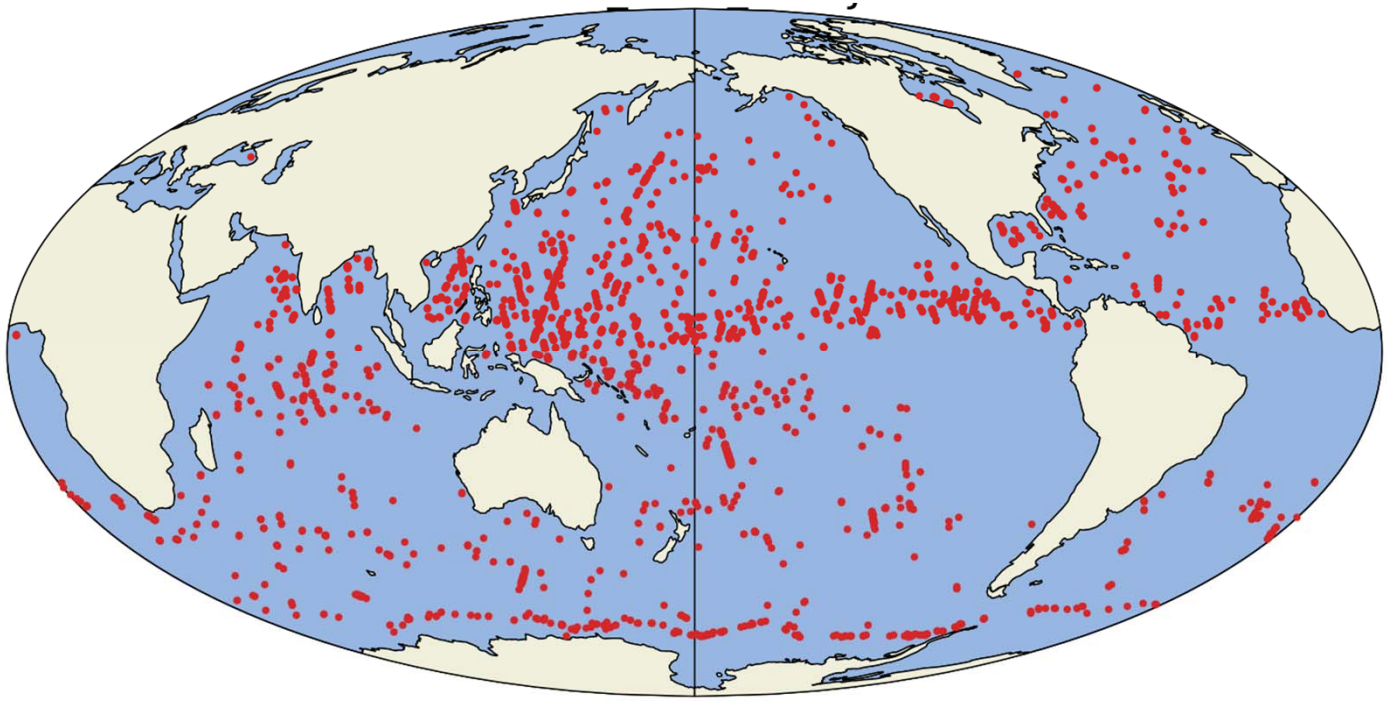


Atmospheric impact on sigma0

Double-band S/Ku rain flag over Jason-3 : orders of magnitude

- Altimeter rain flag : 6% of the observations over ocean

- Rain Flag + Invalid : 1% of the observations over ocean



The current presentation gathers the work by the different teams involved in the validation of CFOSAT products

- Nadir rain flag
- Atmosphere and Microwave expertise

- Off-Nadir rain flag
- Wave expertise

- Atmosphere and Microwave expertise

Overview

Aim: compute a rain flag to discard CFOSAT data affected by rain

- Rain flagging at nadir: the CWT flag
- Rain flagging off-nadir: the LS_Var flag

Overview

Aim: compute a rain flag to discard CFOFAT data affected by rain

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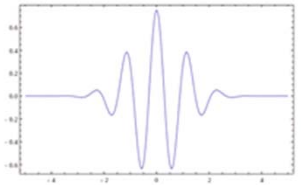
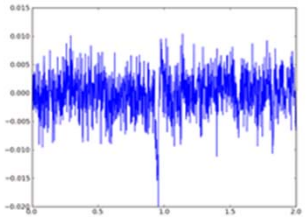
Nadir Rain/ Bloom flag: approach – JC Poisson, JA Daguze, CLS

- The Rain/Bloom flag for SWIM is based on the **Continuous Wavelet Transform** approach
- It is directly inherited from the Matching Pursuit Algorithm applied on SARAL/AltiKa (see Tournadre et al., Marine Geodesy 2015):
  - The waveform trailing edge is directly impacted when the altimeter footprint crosses a rain cell or a sigma bloom
  - The idea is to find signatures in the pseudo-mispointing using a wavelet transform (the CWT is the integration of the wavelet power over all the wavelet scales) (fft and convolution)
- It has been adapted to the specificity of SWIM: specific waveform, retracking...

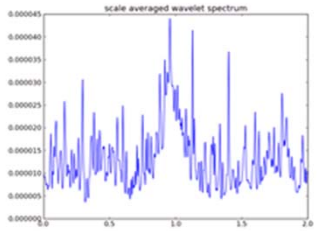
Wavelet (ex. Morlet)



Signal (ex. mispointing angle)



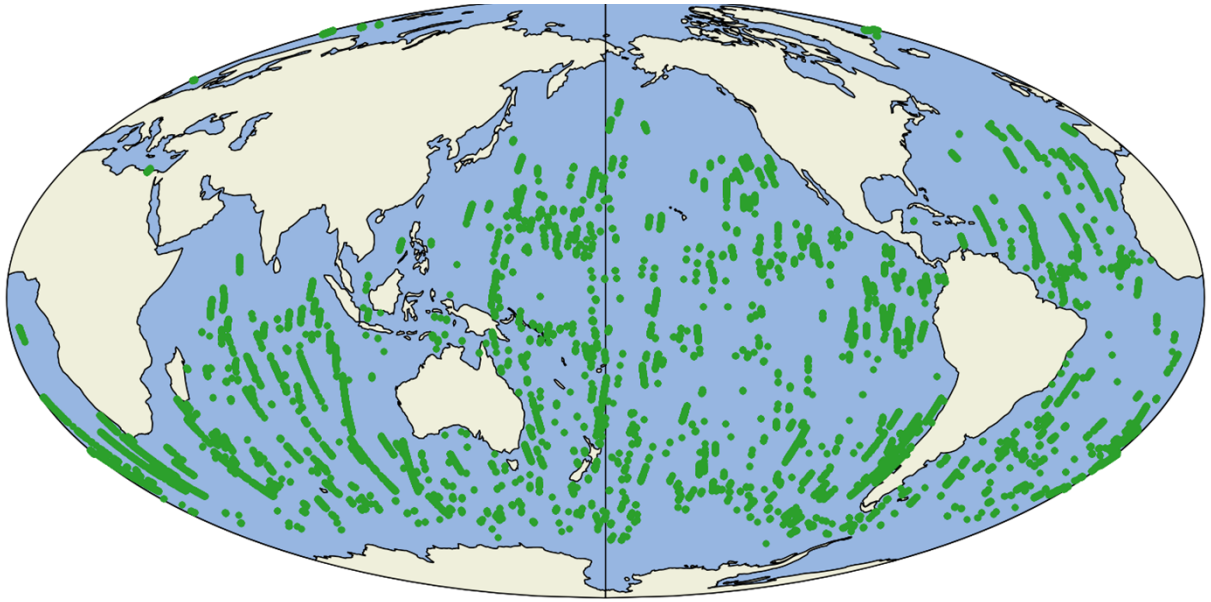
Wavelet Power Spectrum (WPS)



Nadir Rain/ Bloom flag: validation

- **Current version** of the product is not optimal
- Spatial distribution weakly correlated to rain, "drooling" effects

Cycle 21

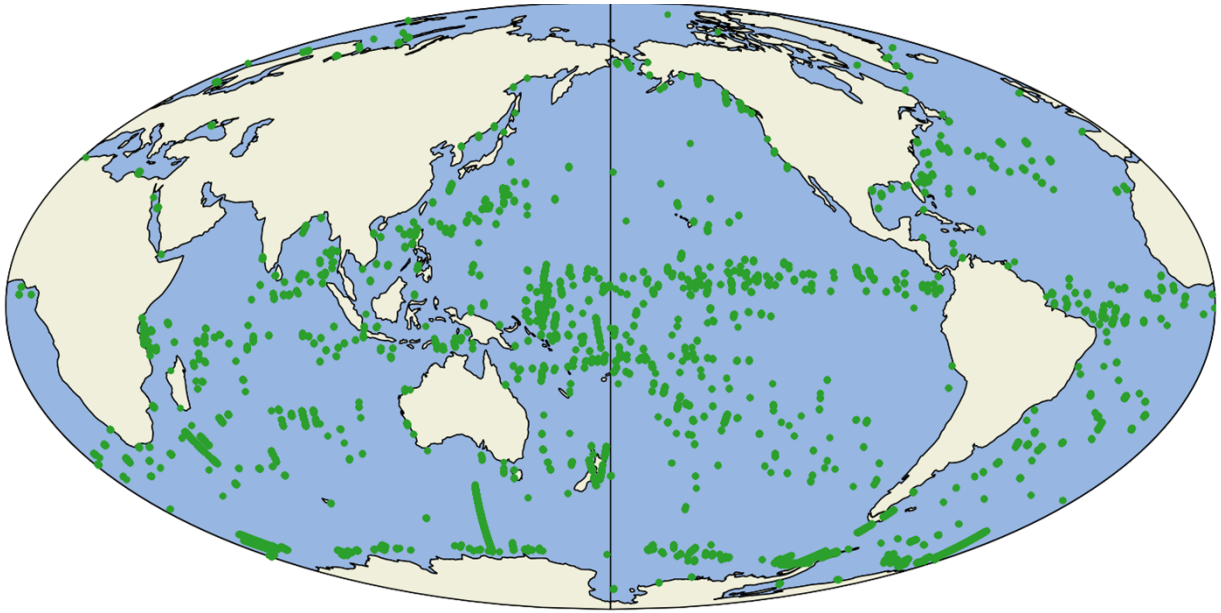


● Rain impact detected

Nadir Rain/ Bloom flag: validation

- **Future version** would allow to improve the detection of rain and bloom (would require some ground processing evolution)
- Note that only 1% of the measurements are impacted by rain (Jason-3: 6% detected , 1% invalid)

Cycle 15

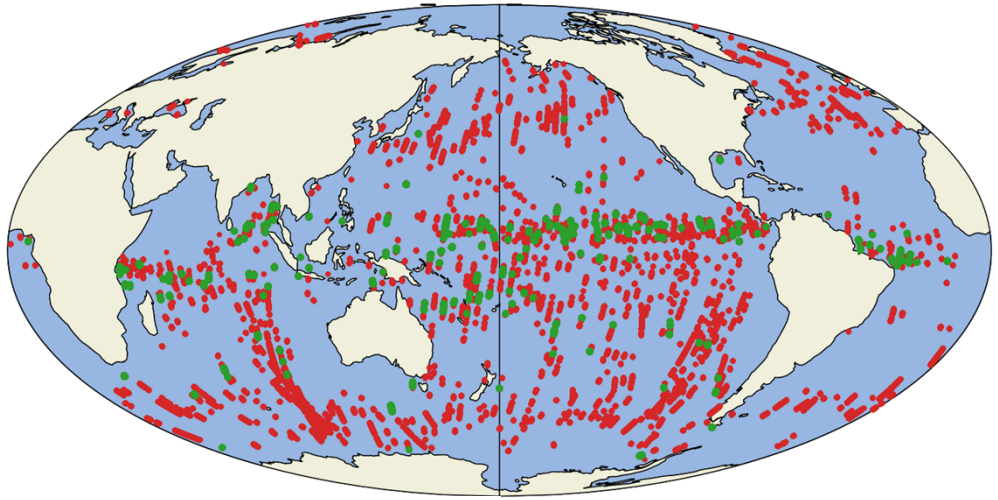


Rain impact detected

Nadir Rain/ Bloom flag: validation

- **Future version validation**: colocated rain events observed by dedicated radiometer missions
  - Strong rain events over ITCZ are well detected but some are missing
  - Lower rain rates at higher latitudes are also not flagged

Cycle 15



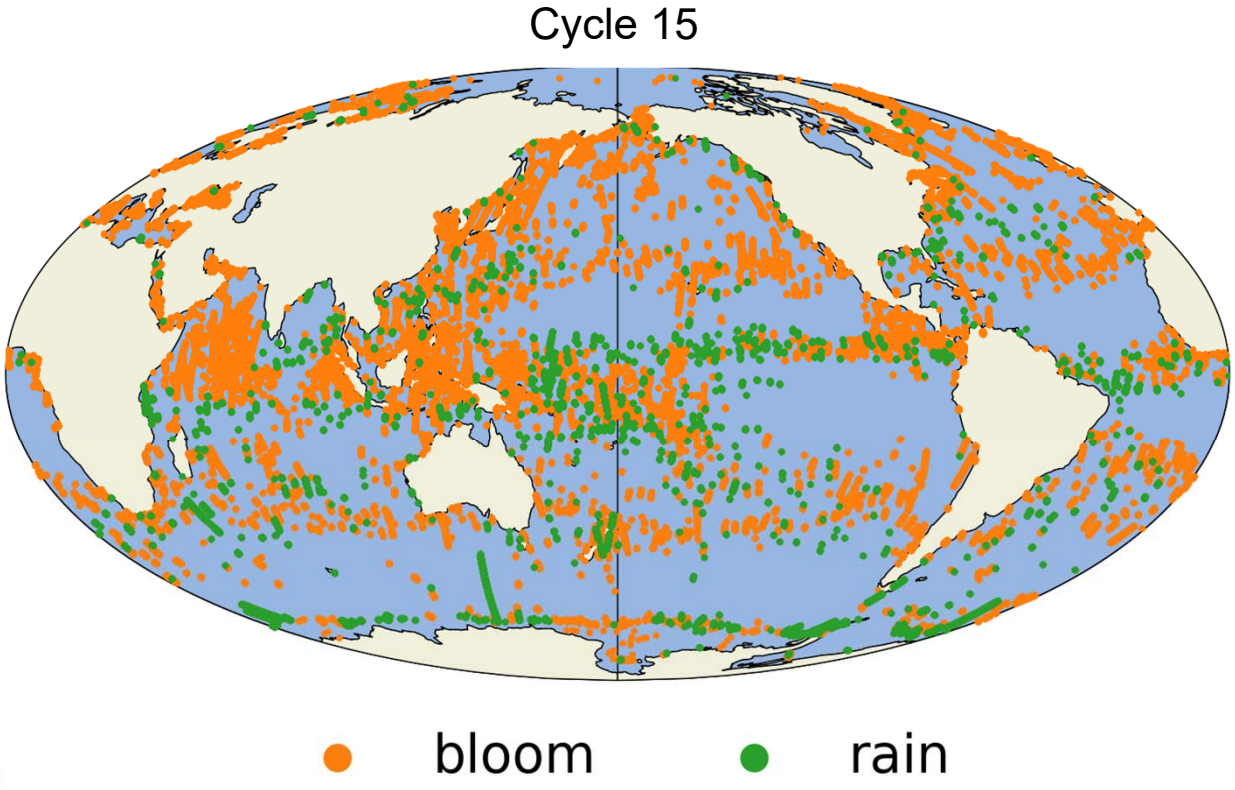
Colocated rain but not detected

Colocated rain and detected

- **Under sensitivity of the flag ?**
- **Robustness of SWIM to rainy areas thanks to its good SNR?**
- **Capability of CWT to focus on strong impact (compared to J3) ? (Yes!)**
- Needs detailed validation focusing on nadir waveforms

Nadir Rain/ Bloom flag: validation

- **Future version validation:** blooms are detected in realistic areas
- This should be further validated but could be used to discriminate information for OFF nadir profiles



Overview

Aim: compute a rain flag to discard CFOFAT data affected by rain

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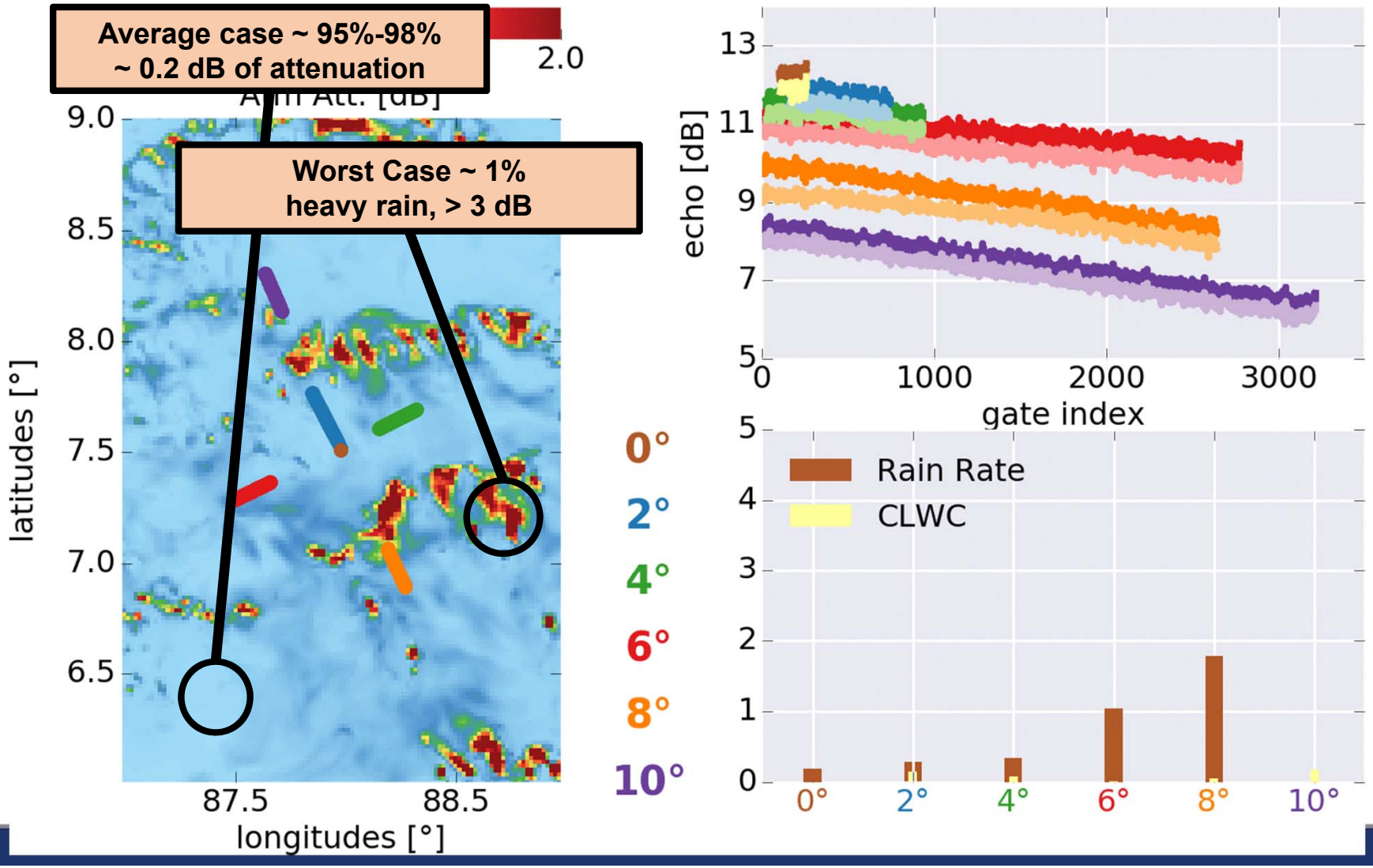
- Rain flagging off-nadir: the LS_Var flag

Atmospheric impact off-nadir

Sigma0 off-nadir and rain effect: Simulations



Sigma0 off-nadir and rain effect

Towards a future rain flag for off-nadir measurements

- **The ultimate goal** will be to propose a flag that eventually improve the wave spectra by editing the profiles disturbed by atmospheric effects

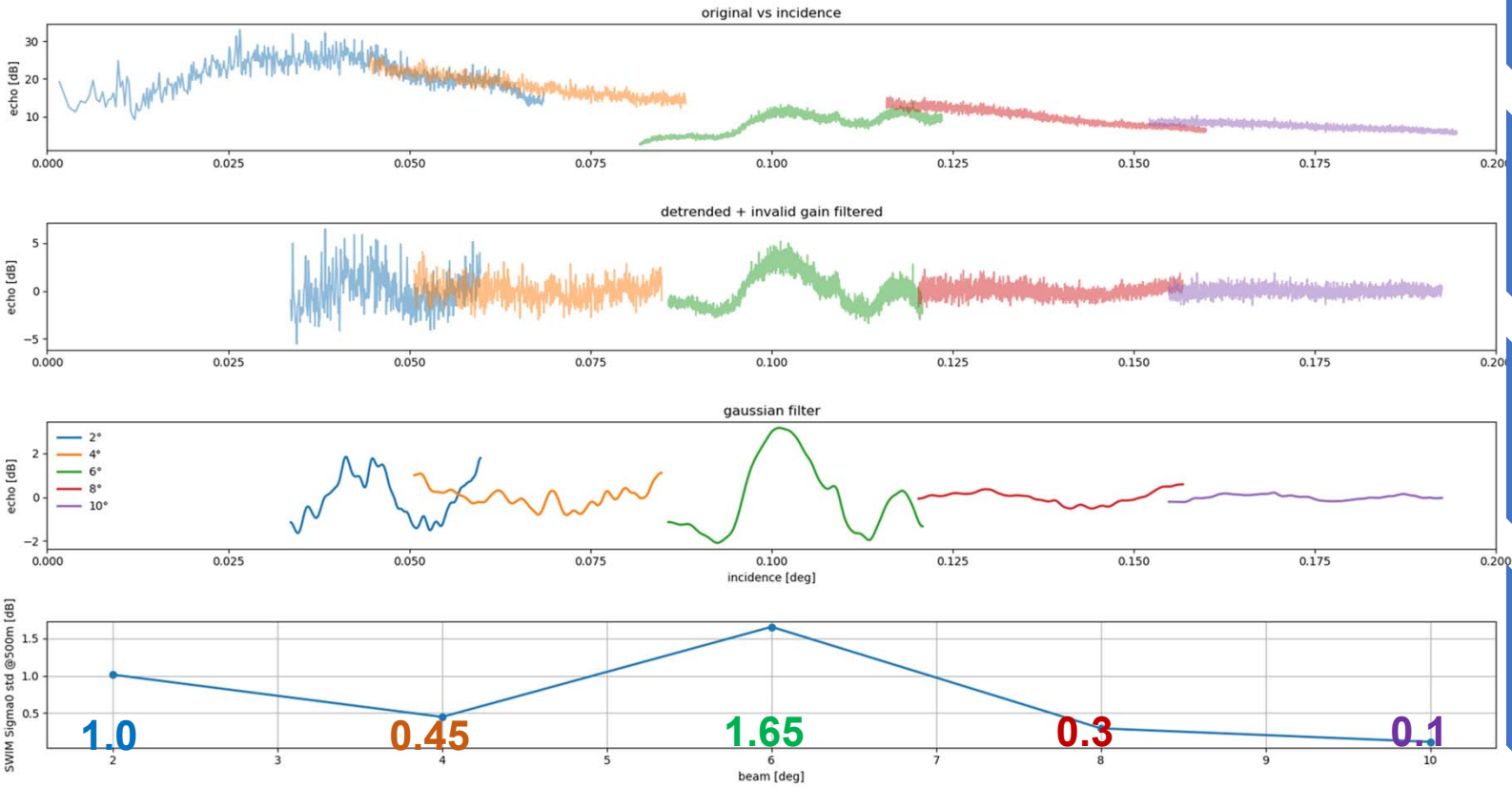
- The first steps consist in
  - selecting the profiles potentially impacted by those effects
  - analyse the impact on the waves
  - looping between these two steps in order to propose an optimal selection

Atmospheric impact off-nadir

Sigma0 off-nadir and rain effect: real data (Victor Gressani et al., IFREMER)

Scalar parameter related to the heterogeneity of the profiles computed: **L**ow **S**cale **VAR**iance **LS_Var**

Based on **the variance of a fit of detrended profiles** that enable to highlight the variability not directly related to the wave variability.



Original echo
- Trend estimation
- Removal invalid gain data

Detrended echo
- Gaussian filtering @250m of n gates std
- N = 250* n_swath/ Δground_range

Filtered echo
- Standard deviation computation

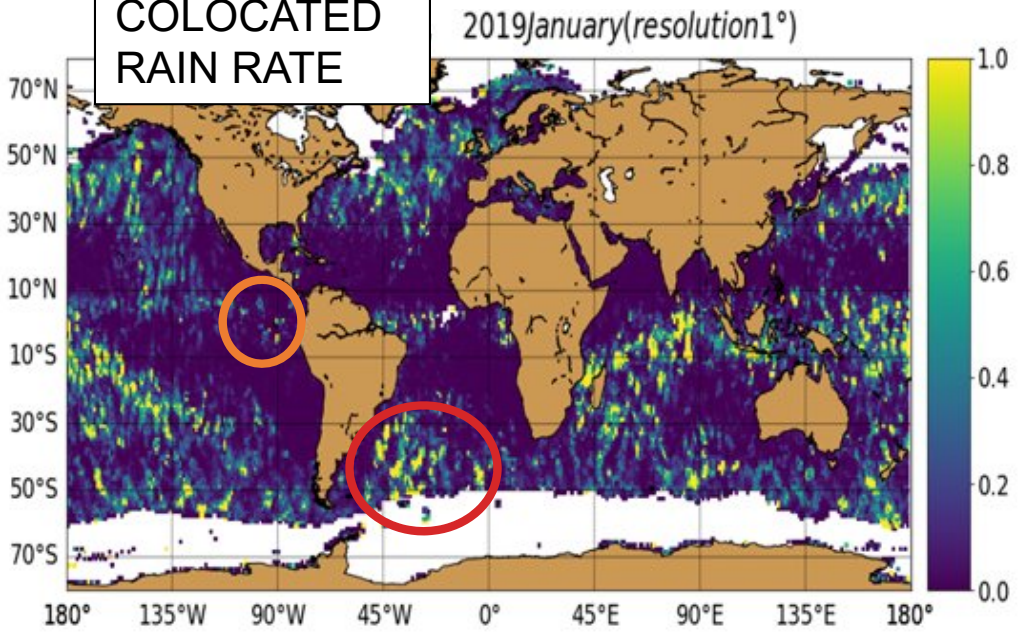
LS_VAR
- LS_VAR variation range depend on beam

LS_VAR tuning and validation (M. Siméon CLS - V. Gressani)

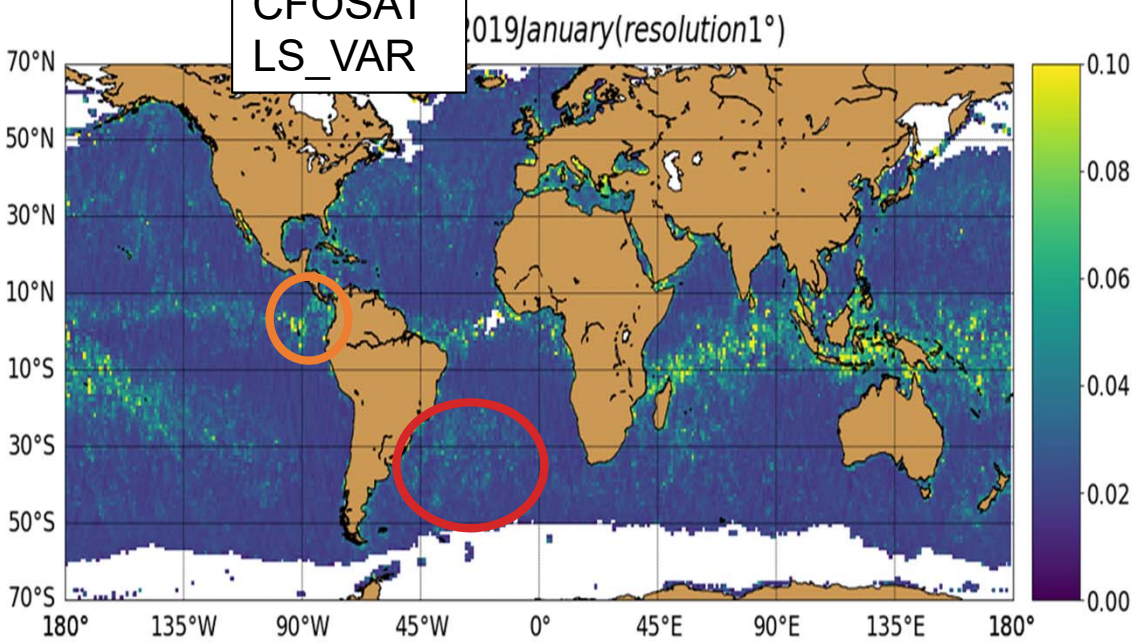
Similar geographical pattern of LS_VAR and rain (IMERG 30mn/15km colocated)

- Qualitative spatial correlation over ITCZ / convective cells
- But not everywhere…

COLOCATED RAIN RATE



CFOSAT LS_VAR



No rain but apparent impact on LS_VAR

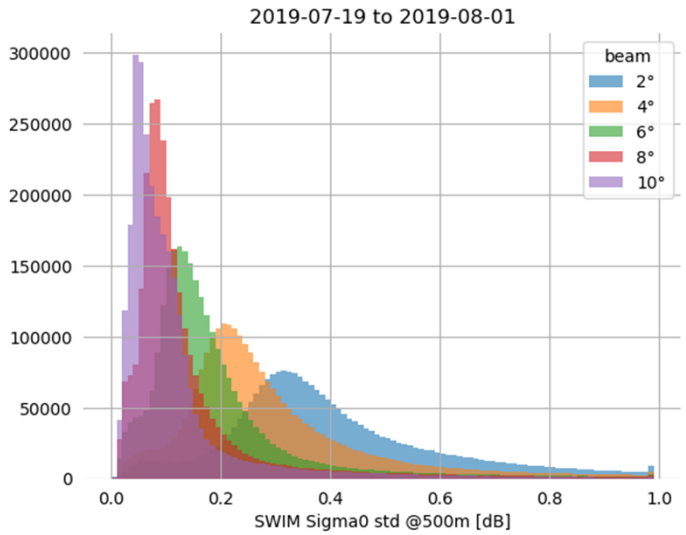
Rainy areas with no impact on LS_VAR

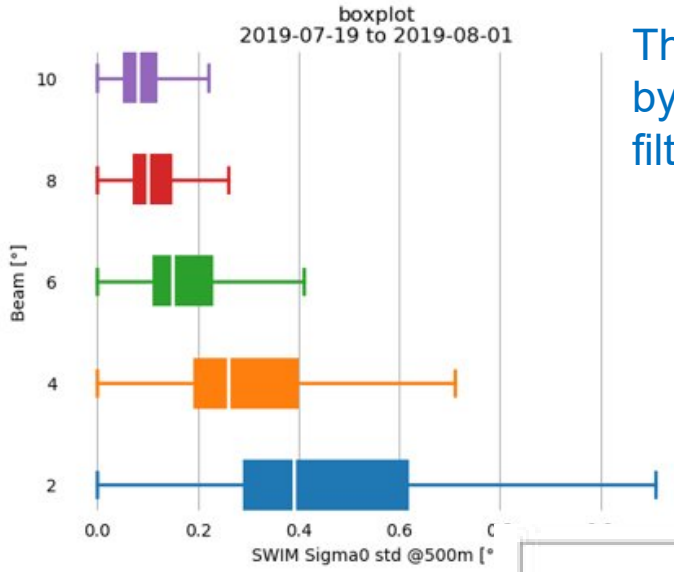
Diapositive 17

OA1 Ollivier Annabelle; 23/09/2019

Identifying the outliers

LS_VAR tuning and validation (M. Siméon CLS)



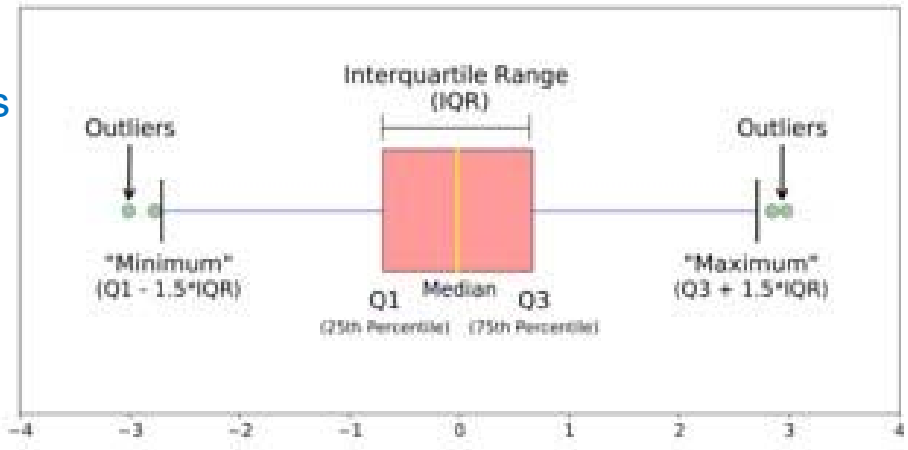


The selection of the profiles impacted by rain would be based on statistical filtering of the distributions of LS_VAR

Statistical identification of outliers, robust to distribution skewness

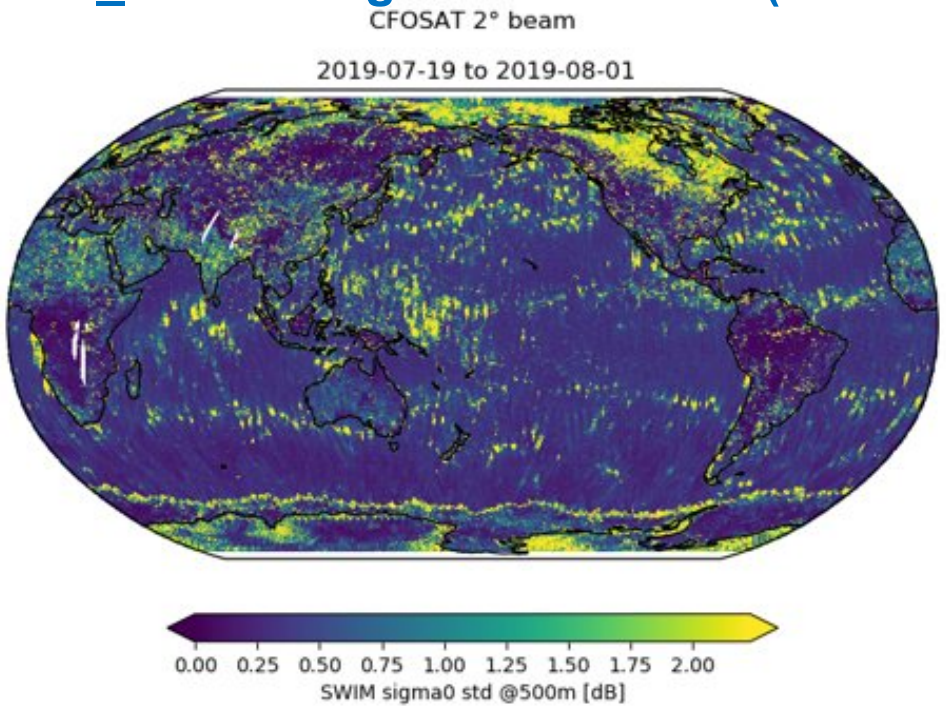
- 40% of the distribution is located in the IQR.
- Q3 is the third quartile (75% of data)

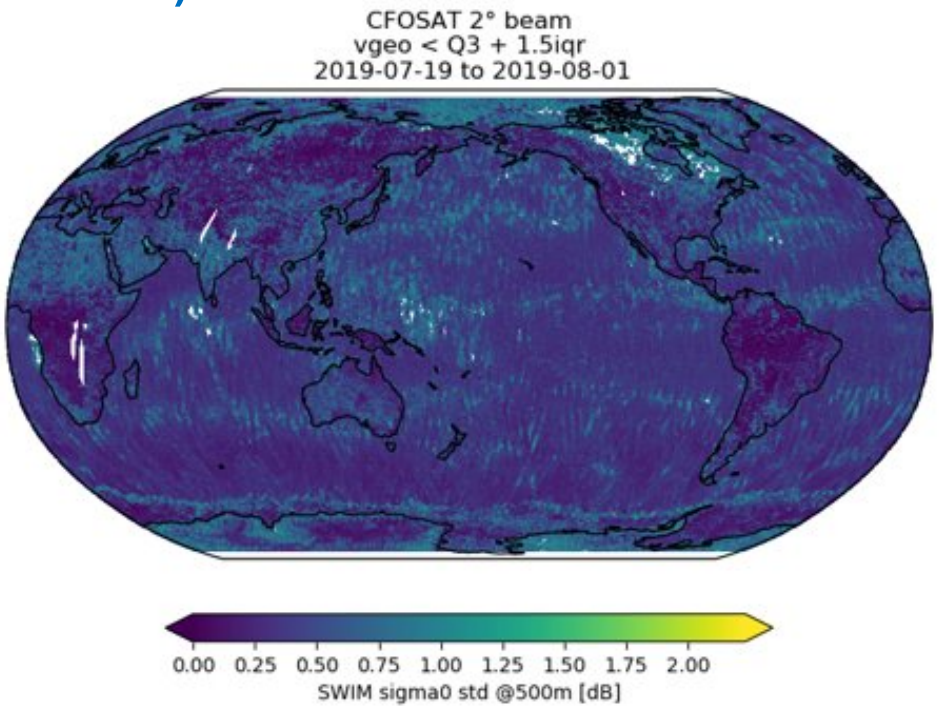
➔Outliers would lie above LS_VAR_max = Q3+1.5.IQR



Editing using vmax=Q3+1.5IQR

LS_VAR tuning and validation (M. Siméon CLS)





WORK IN PROGRESS …..

- Good filtering of strong events.
- Outliers represents 10-12% of the data with |latitude|<50.
- Some remaining dynamic is still visible.

CONCLUSIONS

- NADIR : CWT **FLAG**
  - Improved version in preparation
  - Validation objectives (on-going):
    - To confirm the good behaviour the flag
    - To confirm the good robustness of CFOSAT Nadir to light rain
- OFF-NADIR: LS_VAR **FIELD**
  - is a good candidate for detecting variability on the profiles due to rain
  - Validation objectives (on-going):
    - **To define a future FLAG that will improve the Wave Spectra**

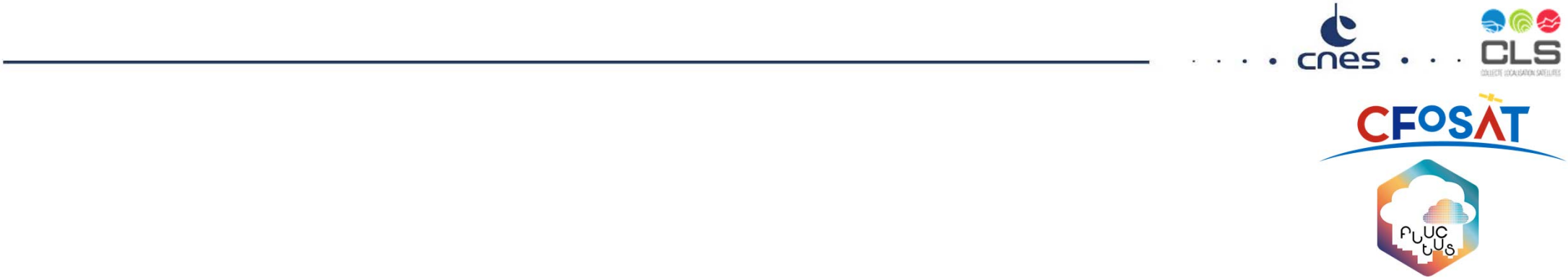
CONCLUSIONS

Next version of the product

- NADIR: **FLAG** CWT, improved
- OFF-NADIR: **FIELD** LS_VAR based on sigma0 profiles variability

Future version of the product

- OFF-NADIR: **FLAG** based on threshold applied to LS_VAR



谢谢, Merci

Click to add text

Thank you!