CLS
COLLECTE LOCALISATION SATELLITES

On the role of 18.7 GHz channel on Wet Tropospheric Correction retrieval performance

<u>B. Picard,</u> M.Pardé

Context

- During the design of a new radiometer dedicated to altimetry mission, the question may be raised on whether or not a 18.7 GHz channel is required to fulfill the mission requirements on wet tropospheric correction accuracy

- As a low observation frequency, 18.7 GHz channel has a direct impact on the size of the reflector ➔ the weight ➔ the € / $

- Two situations:
  - fullfill spatial resolution requirement ➔ larger reflector ➔ larger weight
  - reflector size designed for 23.8 GHz ➔ larger FOV / spillover issues (may be mitigated by refl. design)

Context

- Two different frequency sets are currently used by altimetry MWR
  - Jason-2/Jason-3/Jason-CS: 18.7 GHz, 23.8 GHz, 34 GHz
  - AltiKa, Sentinel-3: 23.8 GHz, 37 GHz / 36.5 GHz

- What is the role of 18.7 GHz on WTC retrieval ?
  - from simulations
  - from actual measurements

- What are the current performances for these two configurations ?

What is the role of 18.7 GHz on WTC retrieval ?

- Thao, S., Eymard, L., Obligis, E., & Picard, B. (2015).
  Comparison of Regression Algorithms for the Retrieval of the Wet Tropospheric Path.
  IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 8(9). https://doi.org/10.1109/JSTARS.2015.2442416

- JPL approach
  - radiosondes + RTM database
  - log-linear regression
  - stratified approach (classes of WTC and windspeed)
  - Inputs: TB 18.7/23.8/34

- CLS/IPSL approach:
  - ECMWF analysis + RTM database
  - NN regression
  - global approach
  - Inputs: TB 23.8/37 + altimeter sigma0 + SST + atm. lapse rate

  ➔ **Assumption: (sigma0+SST) compensate for the lack of 18.7 GHz**

What is the role of 18.7 GHz on WTC retrieval ?

- Thao, S., Eymard, L., Obligis, E., & Picard, B. (2015).
  Comparison of Regression Algorithms for the Retrieval of the Wet Tropospheric Path.
  IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 8(9). https://doi.org/10.1109/JSTARS.2015.2442416

- Compare JPL and CLS/IPSL approaches

- Warning: results mainly based on simulations at global scale

➔ results may be different from measurements/regional scale, particular geophysical situations

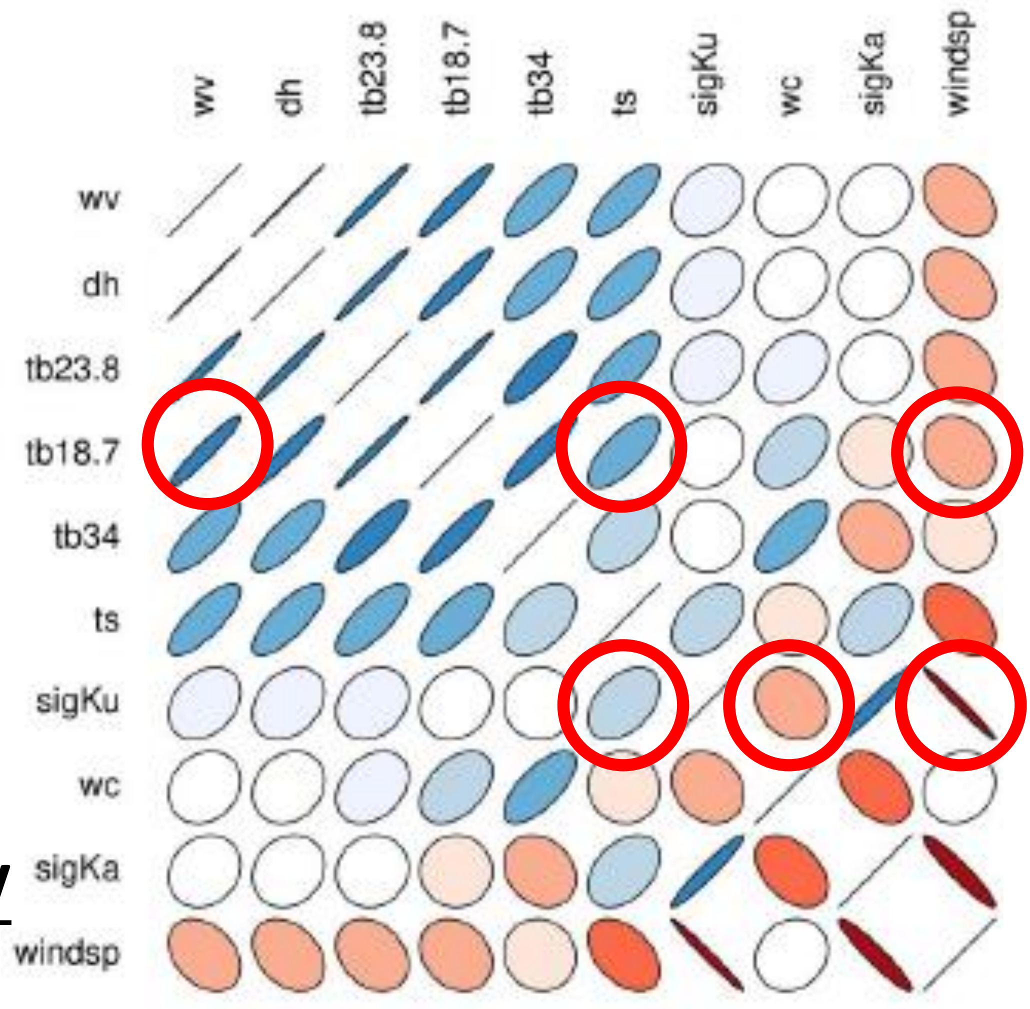
What is the role of 18.7 GHz on WTC retrieval ?

- Thao, S., Eymard, L., Obligis, E., & Picard, B. (2015).
  Comparison of Regression Algorithms for the Retrieval of the Wet Tropospheric Path.
  IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 8(9). https://doi.org/10.1109/JSTARS.2015.2442416

- Correlation matrix
  from PCA applied on simulated database

- 18.7 is correlated to WV, SST
  and windspeed at a lower level (global scale)

- Sigma0 is correlated to windspeed
  and WC and SST at a lower level

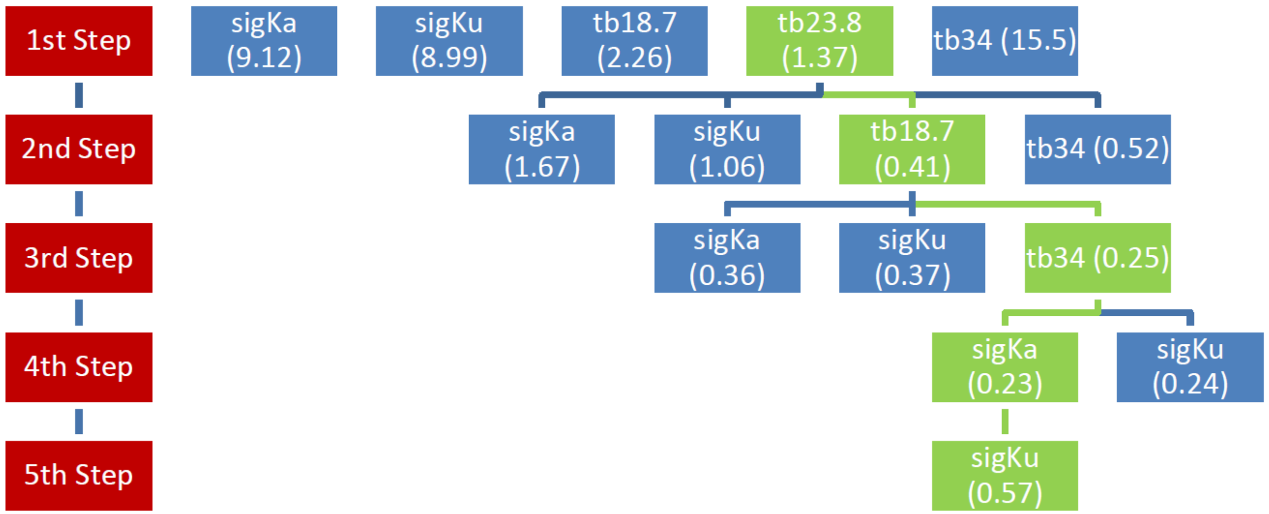


<u>→ 18.7 GHz brings additional information on WV</u>

What is the role of 18.7 GHz on WTC retrieval ?

- Thao, S., Eymard, L., Obligis, E., & Picard, B. (2015).
  Comparison of Regression Algorithms for the Retrieval of the Wet Tropospheric Path.
  IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 8(9). https://doi.org/10.1109/JSTARS.2015.2442416

- Optimal configuration selection
- NN applied on learning database
- Error = stdev (WTC_ref – WTC_est)



- 1^{st} Step: retrieval error with 1 input

➔ 23.8 minimizes the error (1.37 cm)

- 2^{nd} Step: retrieval error with 2 inputs

➔ (23.8 + 18.7) minimizes the error (0.41 cm)

➔ 18.7 GHz > 34 GHz > sigma0 Ka > sigma0 Ku

What is the role of 18.7 GHz on WTC retrieval ?

- Thao, S., Eymard, L., Obligis, E., & Picard, B. (2015).
  Comparison of Regression Algorithms for the Retrieval of the Wet Tropospheric Path.
  IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 8(9). https://doi.org/10.1109/JSTARS.2015.2442416

- The 18.7 GHz provides larger improvement to WTC retrieval compared to sigma0 due to its larger correlation to WV

- What about 18.7 GHz vs (sigma0 + SST) ?

What is the role of 18.7 GHz on WTC retrieval ?

- A typical altimetry metric is used to quantified WTC mesoscale performances [Evaluation of WTC, Legeais et al 2014]: **the variance of the SSH differences between ascending and descending passes.**

- for cross-over points with time lags less than 10 days, the altimeter is considered to measure near- identical sea state at the same place
- The best correction has the lower variance

- The difference (VARSSH_ETU – VARSSH_REF) is quantified in cm^2
- Here
  - ETU = SSH computed using radiometer WTC
  - REF = SSH computed using ECMWF WTC
- ETU performs better than REF when and where the difference < 0

What is the role of 18.7 GHz on WTC retrieval ?

- Picard, B., Frery, M.-L., Obligis, E., Eymard, L., Steunou, N., & Picot, N. (2015). SARAL/AltiKa WTC: In-Flight Calibration, Retrieval Strategies and Performances. Marine Geodesy, 38(sup1), 277–296. https://doi.org/10.1080/01490419.2015.1040903

(same approach applied to more recent measurements)

- Different configurations are compared on Jason-2:
  - 3TB = 18.7/23.8/34
  - 3E = 23.8/34 + sigma0_Ku
  - 5E = 23.8/34 + sigma0_Ku + SST (Model/L4) + atm. lapse rate (γ)
- In order to avoid consideration on algorithm differences (radiosonde vs ECMWF, log vs NN, stratified vs global) a NN is learned from (measurements *vs* ECMWF WTC) at global scale for each configurations
- **The presented performances are relative not absolute (the JPL GDR performs better)**

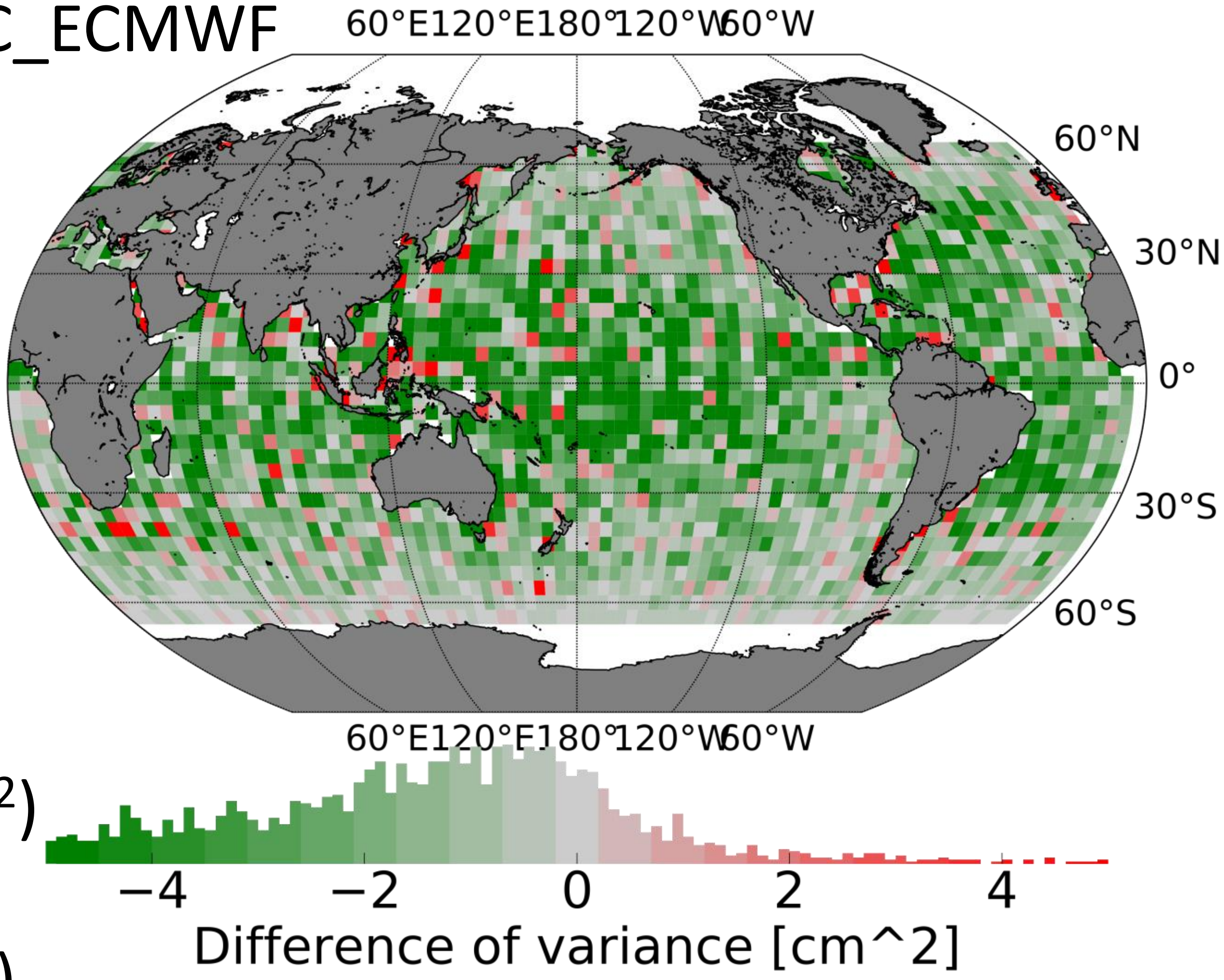
What is the role of 18.7 GHz on WTC retrieval ?

- Jason-2 over 2016
- VARSSH_WTC_RAD-3TB – VARSSH_WTC_ECMWF

- SSH computed with radiometer WTC has a lower variance than SSH compute with ECMWF WTC

➔ Radiometer WTC performs better than ECMWF WTC

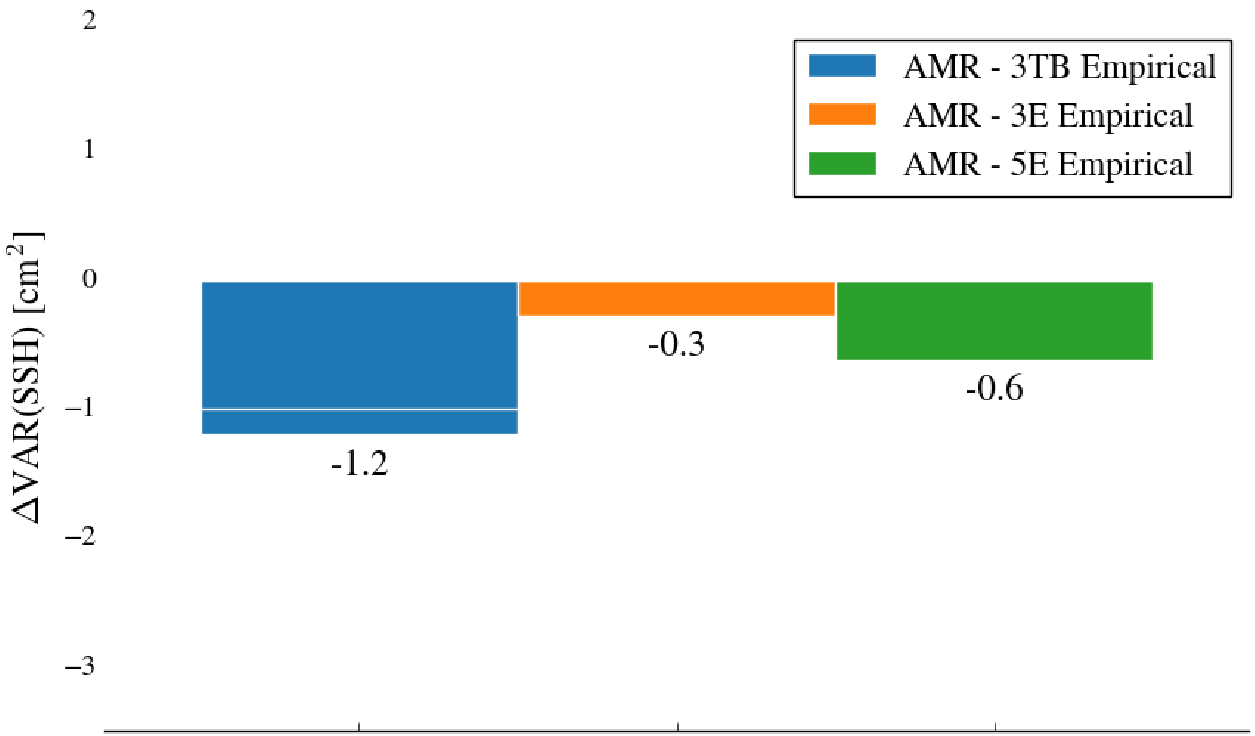
➔ variance gain: -1.2 cm^2 (GDR=-1.6 cm^2) with strong dependency on WTC (the larger the WTC the larger the gain)



What is the role of 18.7 GHz on WTC retrieval ?

- Jason-2 over 2016
- VARSSH_WTC_RAD – VARSSH_WTC_ECMWF
- RAD:
  - 3TB = 18.7/23.8/34
  - 3E = 23.8/34 + sigma0_Ku
  - 5E = 23.8/34 + sigma0_Ku + SST + γ

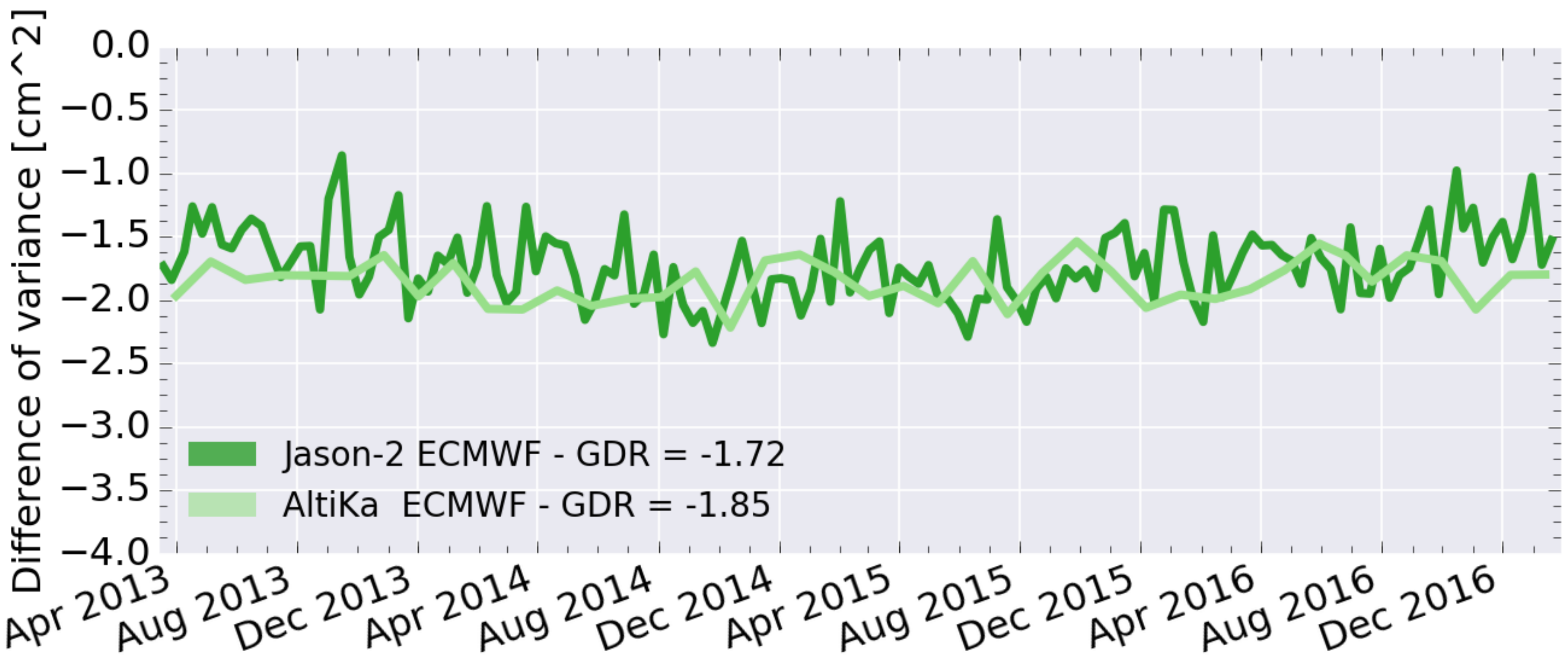
- 3TB performs better than 5E
- (SST+ γ) partially compensates for the lack of 18.7 GHz



<u>➔ 18.7 GHz > (sigma0 Ku + SST)</u>

What are the current performances ?

- AltiKa and Jason-2 from March 2013 to January 2017
- VARSSH_WTC_RAD – VARSSH_WTC_ECMWF
  - Jason-2 GDR (JPL)
    3TB = 18.7/23.8/34
  - AltiKa Expert (CLS/CNES)
    5E = 23.8/37 + **sigma0_Ka** + SST + γ

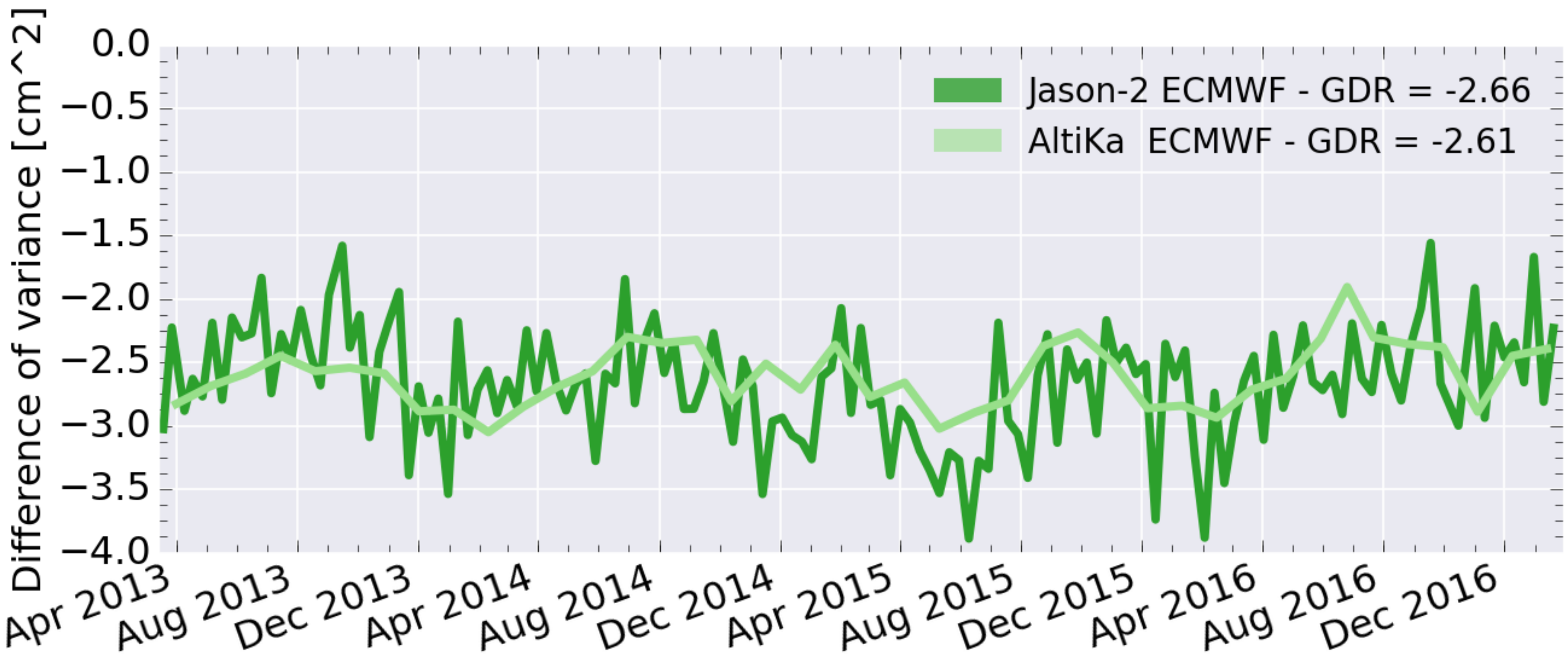


- Global (lat<66°)

- similar performances
- slightly better for AltiKa

What are the current performances ?

- AltiKa and Jason-2 from March 2013 to January 2017
- VARSSH_WTC_RAD – VARSSH_WTC_ECMWF
  - Jason-2 GDR (JPL)
    3TB = 18.7/23.8/34
  - AltiKa Expert (CLS/CNES)
    5E = 23.8/37 + **sigma0_Ka** + SST + γ



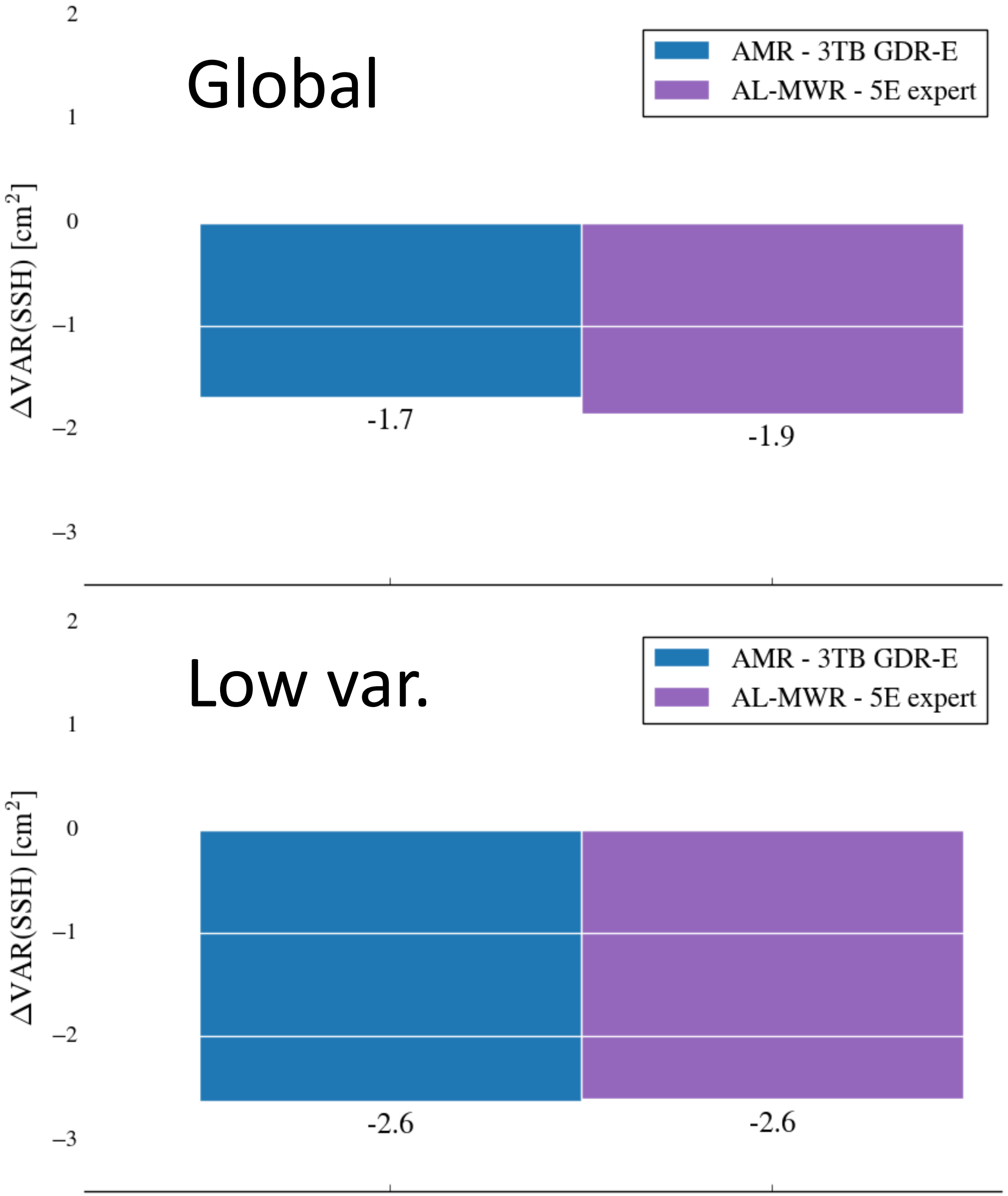
- Low ocean variability + (lat<50°)
- similar performances
- slightly better for Jason-2

What are the current performances ?

- AltiKa and Jason-2 from March 2013 to January 2017
- VARSSH_WTC_RAD – VARSSH_WTC_ECMWF
  - Jason-2 GDR (JPL)
    3TB = 18.7/23.8/34
  - AltiKa Expert (CLS/CNES)
    5E = 23.8/37 + **sigma0_Ka** + SST + γ

- sigma0_Ka is more sensitive to atm. content than sigma0_Ku (Lillibridge 2014)
- the lack of 18.7 GHz on AltiKa is compensated by (sigma0_Ka+SST)

➔ 18.7 GHz ~ (sigma0 Ka + SST)



Conclusion

- 18.7 GHz channels is sensitive to surface conditions (roughness + SST = emissivity) but also well sensitive to WV
- from a simulation point of view: 18.7 GHz > sigma0_Ka > sigma0_Ku

- Based on Jason-2 measurements,
  the lack of 18.7 GHz is **not compensated by (sigma0_Ku + SST)**
- Based on Jason-2 GDR and AltiKa Expert,
  the lack of 18.7 is **compensated by (sigma0_Ka + SST)**

- These conclusions are valid under the following limitations:
  - (18.7 GHz) vs sigma0+SST is evaluated with an empirical approach
  - It is true for mesoscale
    ➔ what about smaller scales / particular conditions (coastal ?)

Further investigations

- Is this conclusion still valid over region of large surface variability ? (roughness = wind or wave, SST)

➔ AltiKa vs Jason-2 performances need additional analysis with a selection over specific regions and against altimeter wind/wave and high resolution fields of SST

- Is this conclusion still valid over costal regions ?

18.7 GHz with large FOV vs Sigma0 with small FOV (5 km for LRM, 300m for SAR)

- What about the combination of 18/23/34 with 2D Ka-band sigma0 ?

(SWOT configuration)

- Some answers may be found using GMI + Ka/Ku PR observations on GPM ….