CALVAL S6

03/2022

CNES on behalf of MPWG members (EUMETSAT, ESA, NOAA, NASA, CNES)
With the support from CLS

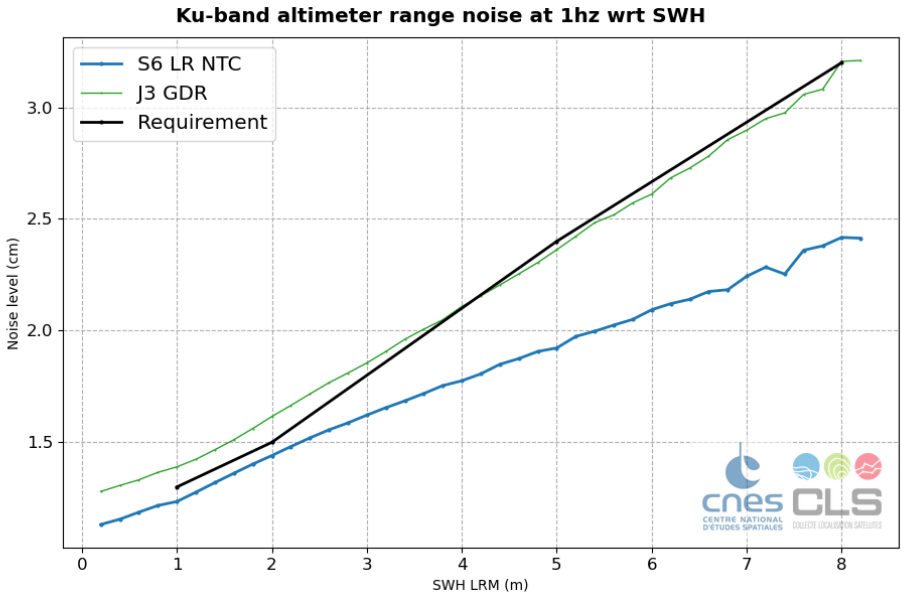
LR NTC altimeter range noise

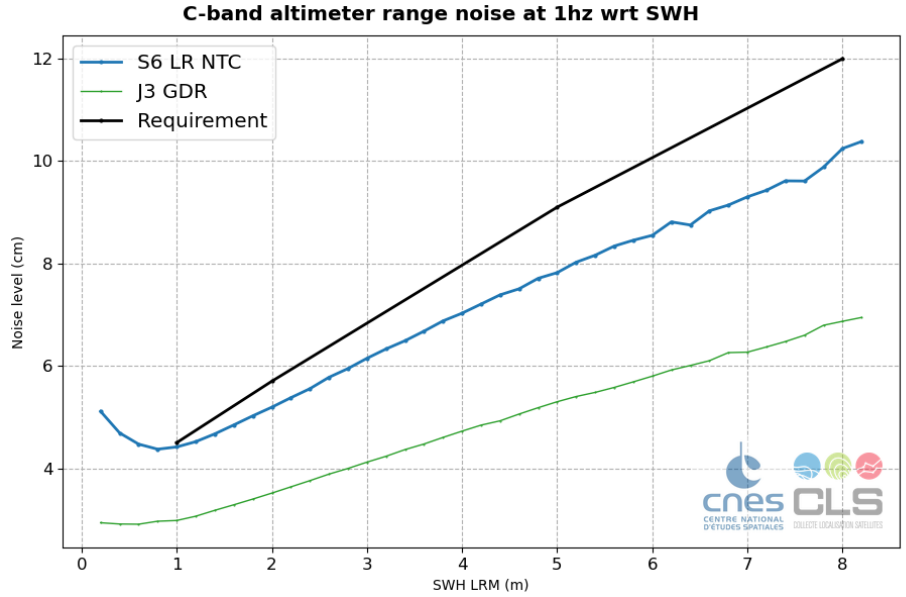
Ku Band

- **Lower noise on S6 with lower SWH dependency**
  - Due to better sampling and higher PRF

C band

- **Higher noise on S6 than J3**
  - Expected (less pulses in radar cycle)
- **Within specification**

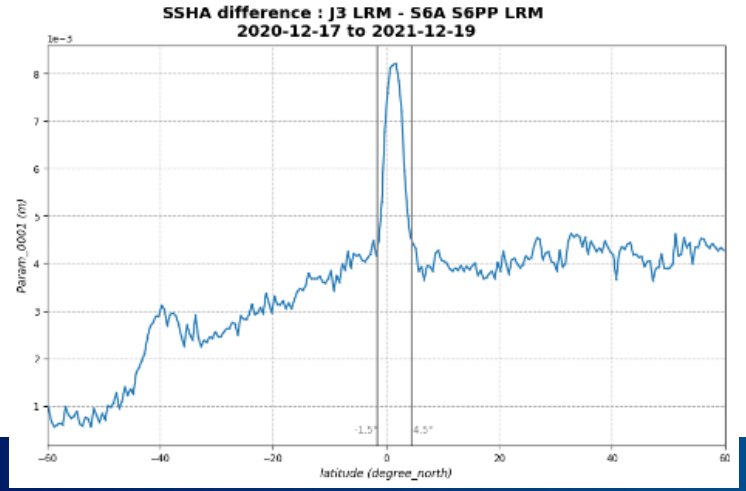


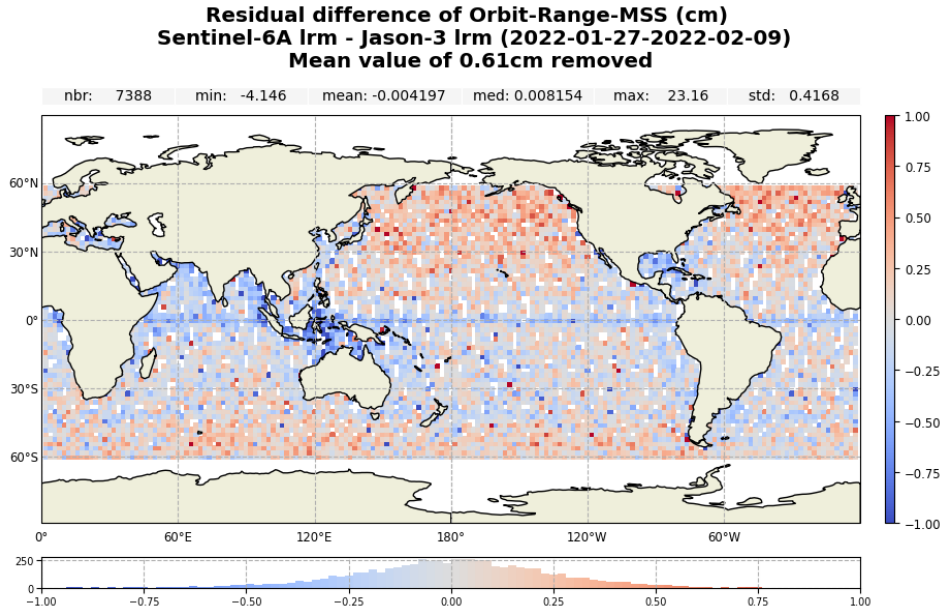


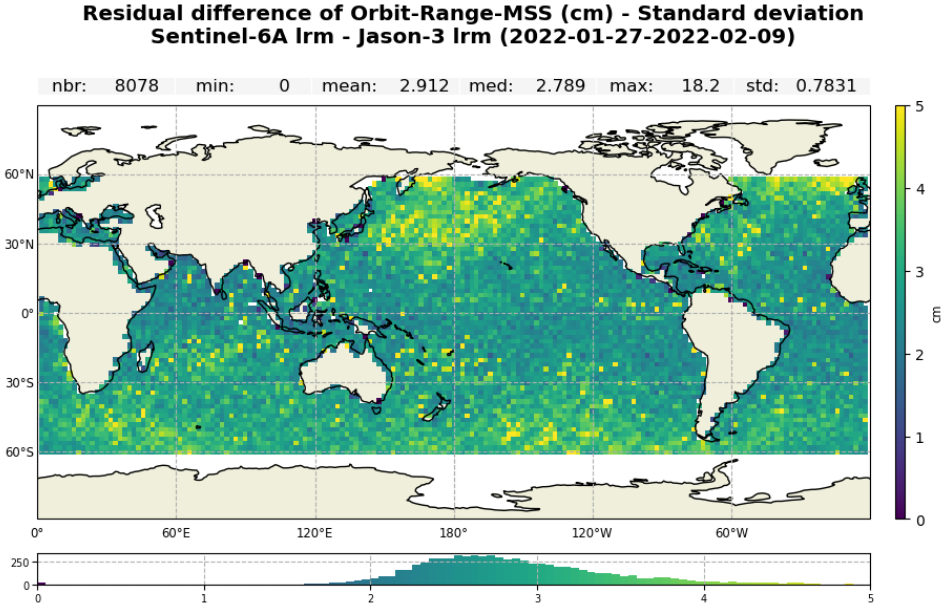
LR NTC altimeter range

Ku Band

- **Very good consistency with J3**
  - Bias < cm
  - Very low standard deviation
- **No hemispheric bias → validation of orbit quality**
- **Equatorial signature**
  - Also seen with JPL orbits (Shailen Desai, S6VT)
  - On-going investigation, only observed on range retracking estimates not on the other parameters (SWH, sig0 and miss pointing).

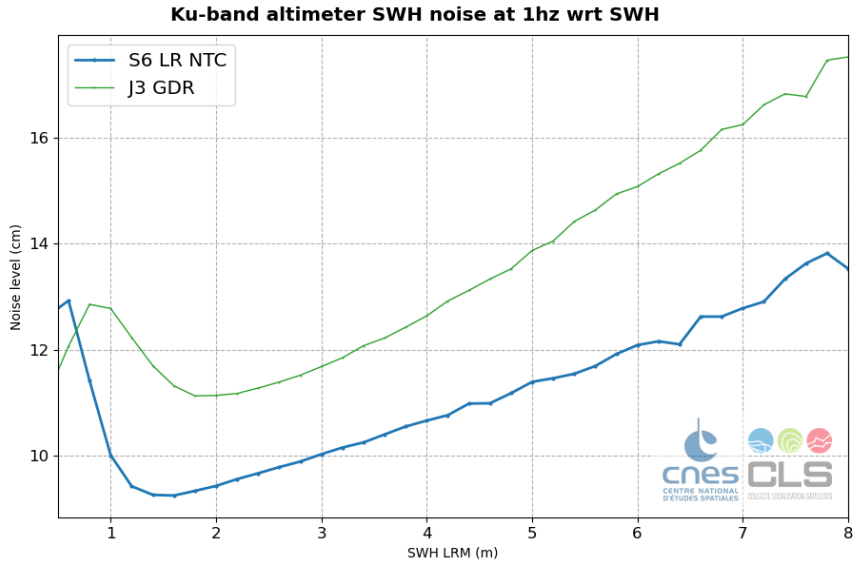


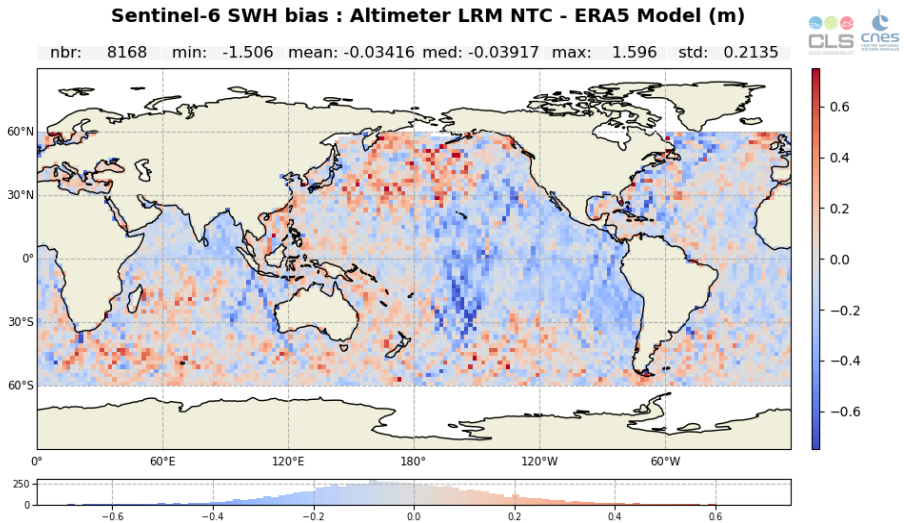


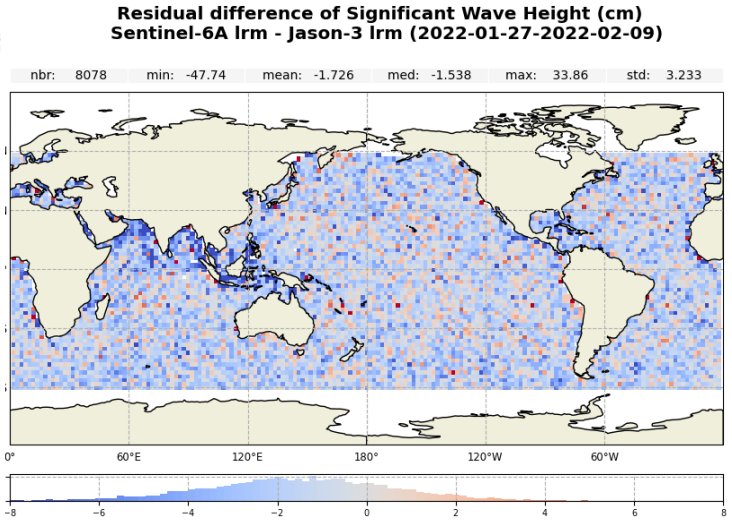


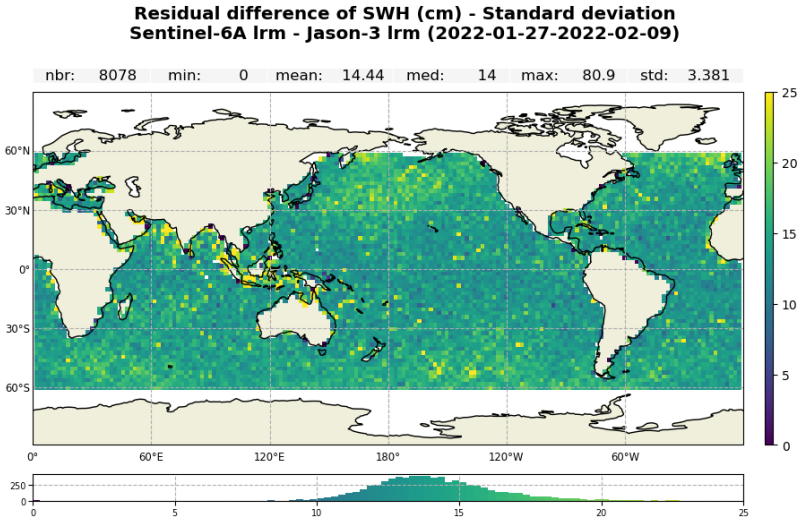
LR NTC SWH

- **Lower noise on S6**
  - Differences at low SWH linked to different negative SWH value management
  - Small dependency wrt SWH
- **Excellent agreement with J3**
  - Mean difference centered around -1.7 cm **only**
  - No geographical pattern
- **Good match with models**



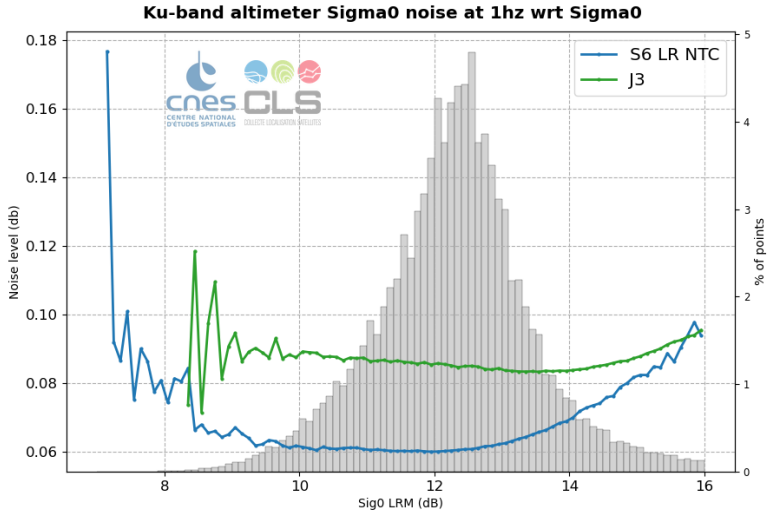


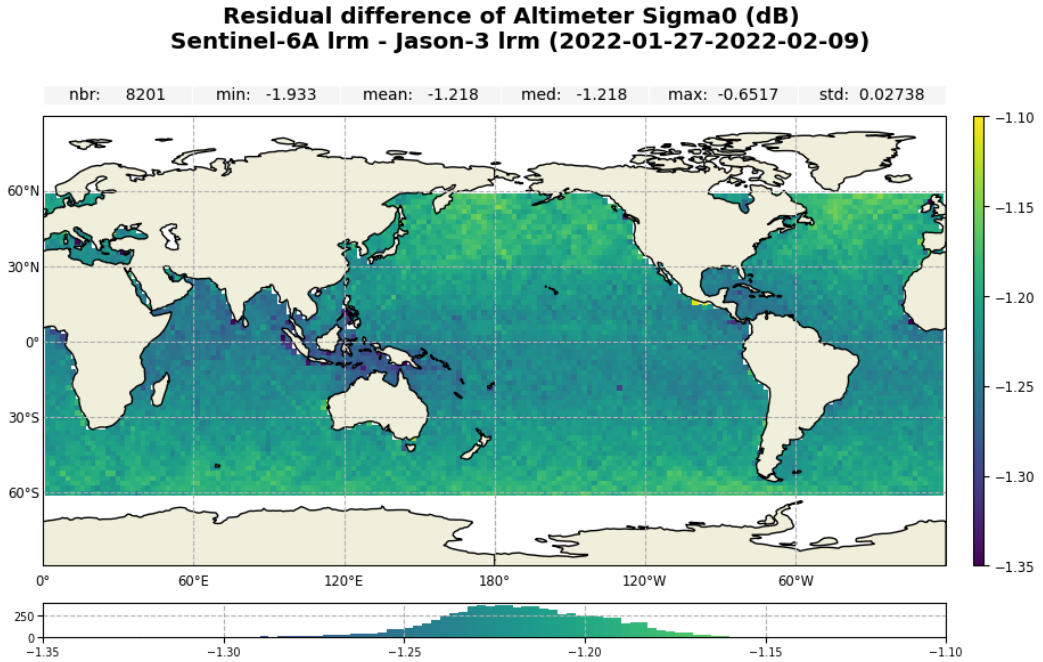


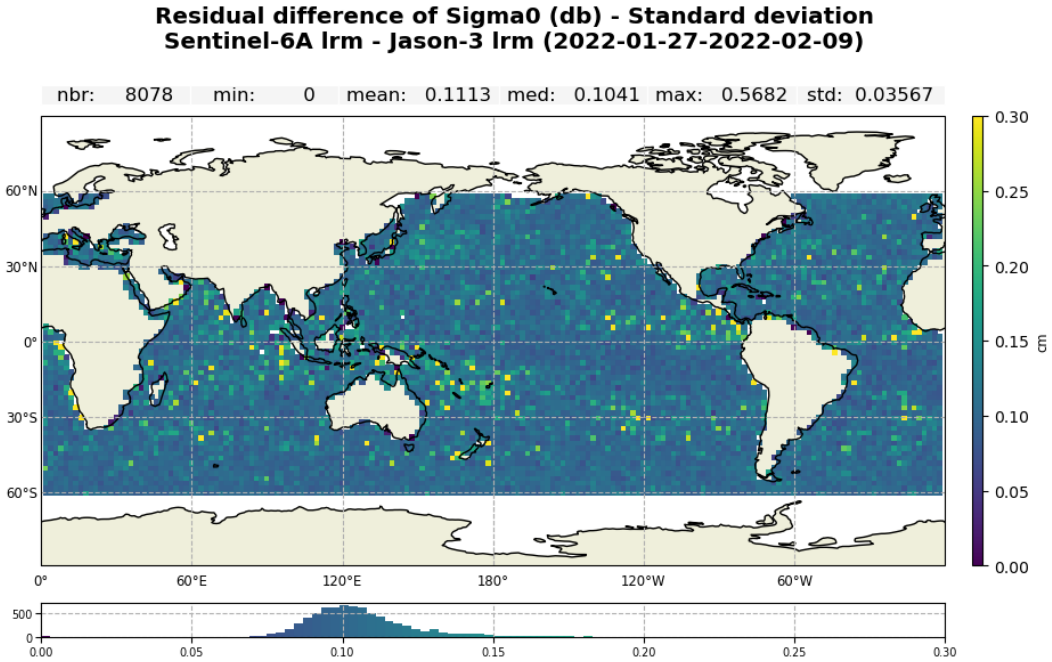


LR NTC sigma0

- **Lower noise on S6, largely improved**
  - Due to better radiometric resolution
- **Bias of -1.22 dB on side B**
  - Note: bias taken into account before wind computation
- **Excellent agreement with J3**

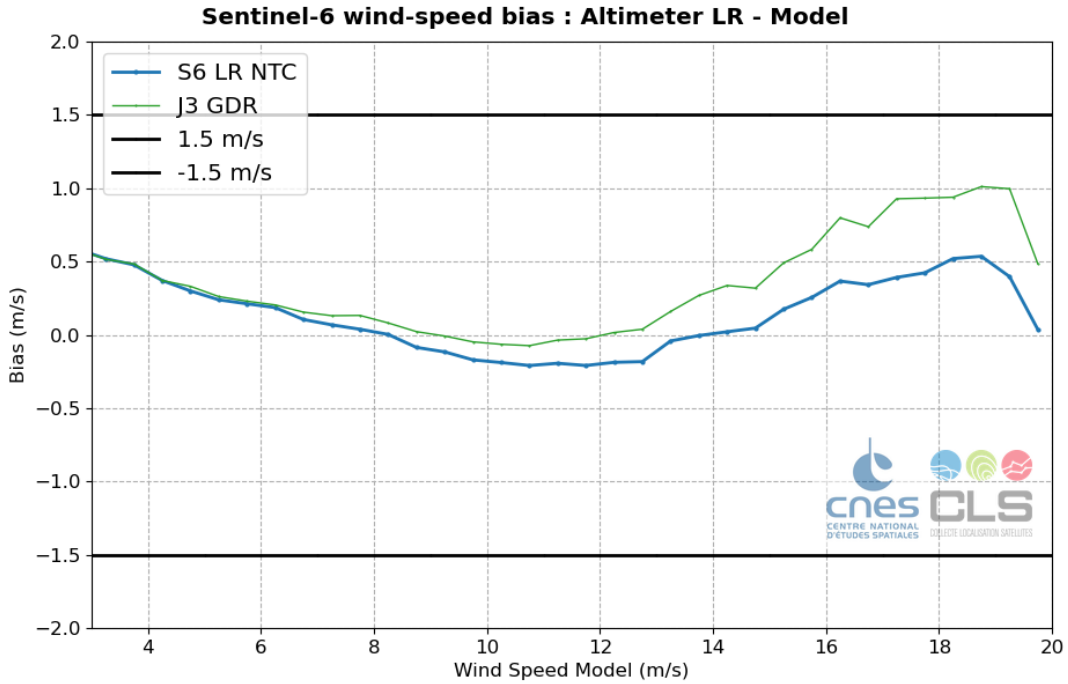


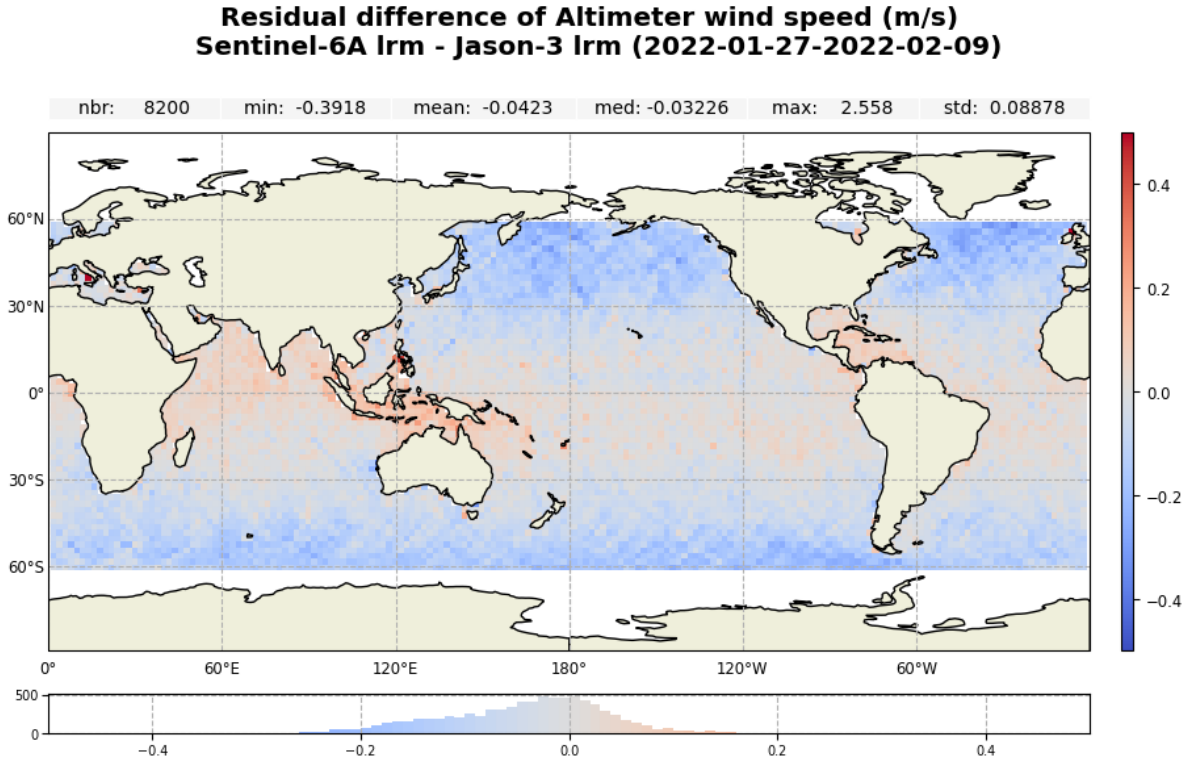




Wind speed

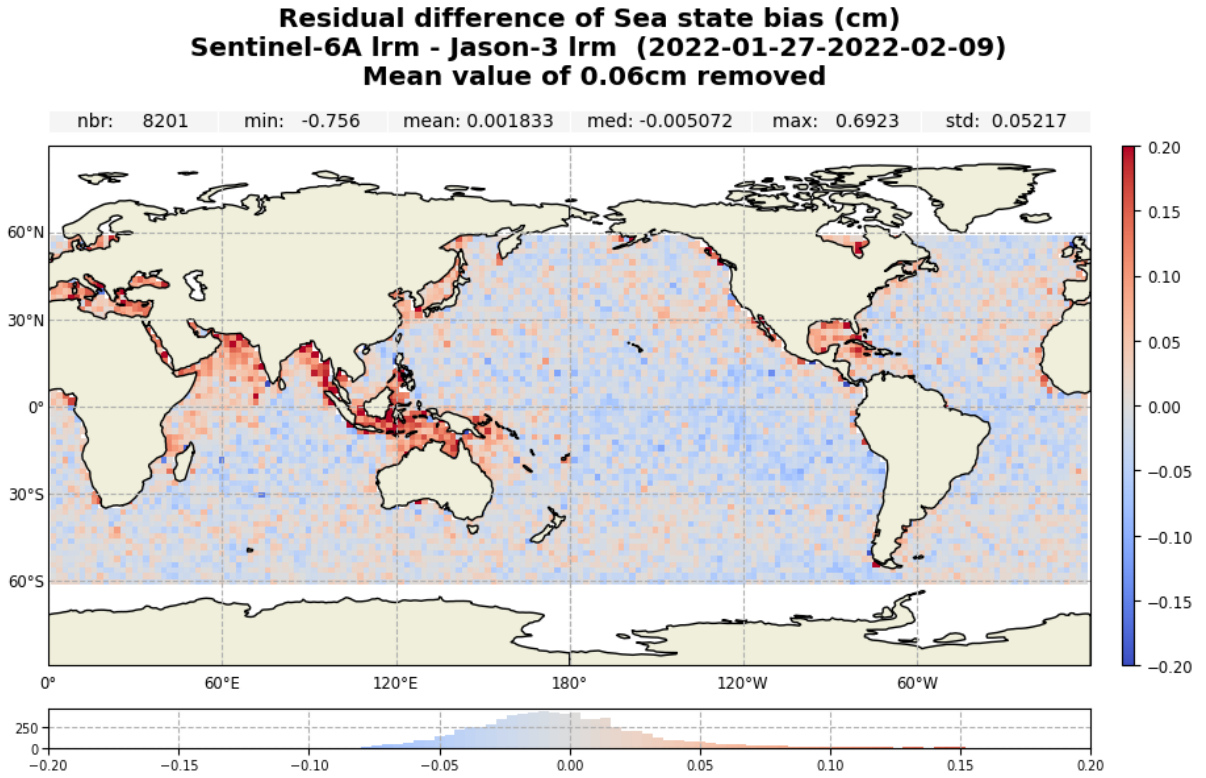
- Collard wind model for both S6 and J3
- S6 in line with J3 (bias < 5 cm/s)





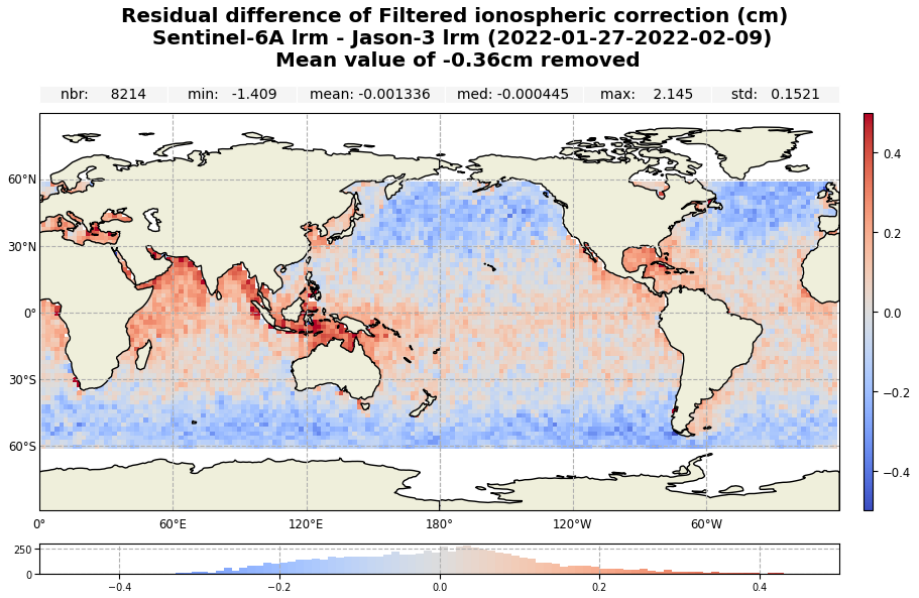
LR NTC SSB

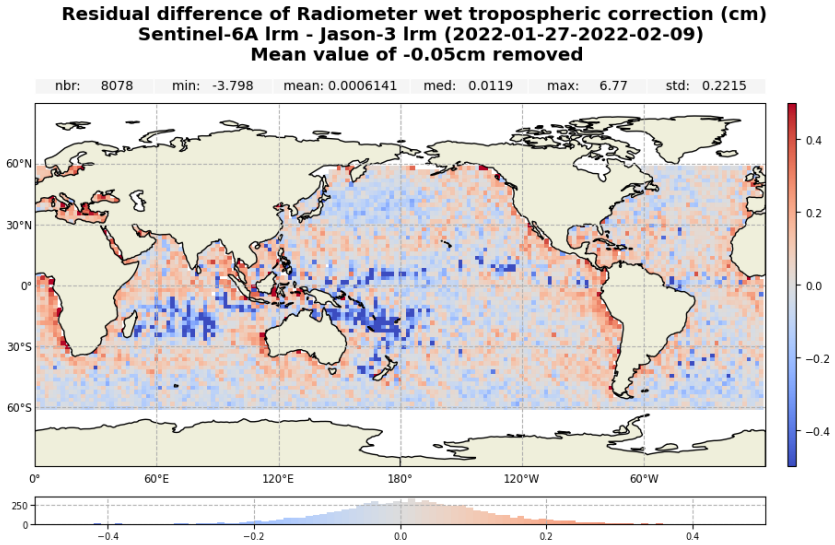
- **S6 and J3 share the same J3 GRD-F SSB**
  - <cm bias
  - Small discrepancies in bloom regions
  - J3 SSB very consistent elsewhere

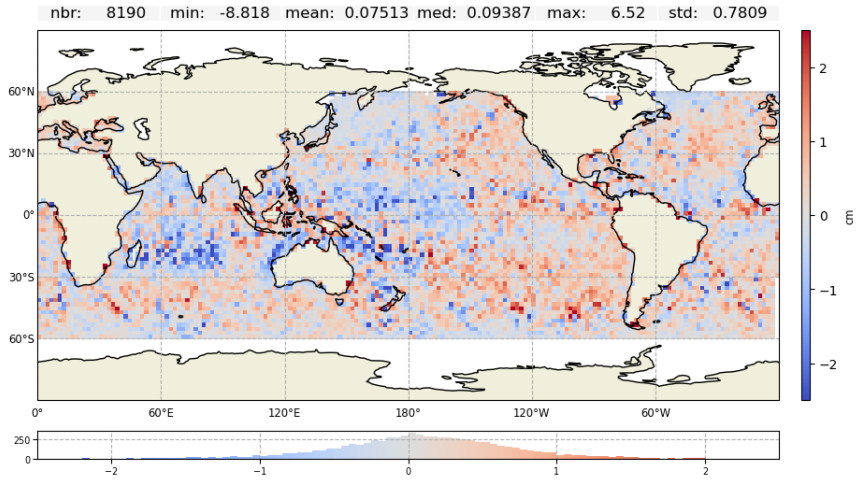


LR & HR NTC geophysical corrections

- **Ionospheric correction**
  - In line with J3
  - <cm bias
- **Dry troposphere**
  - Not shown. In line with J3
- **Wet troposphere from radiometer**
  - In line with J3
  - Negligible bias wrt ECMWF model

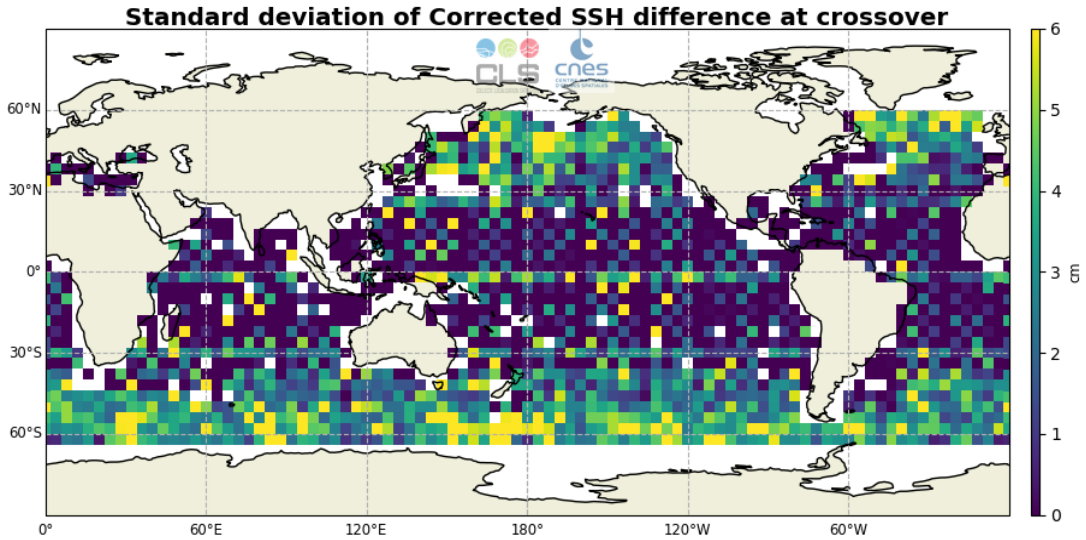


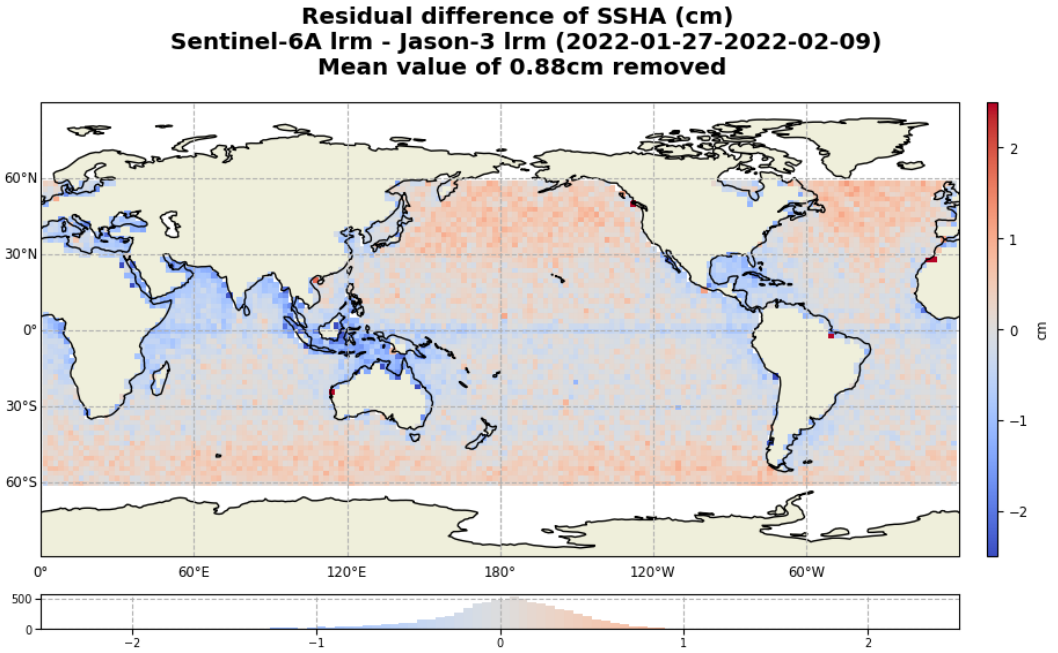




LR NTC corrected SSH

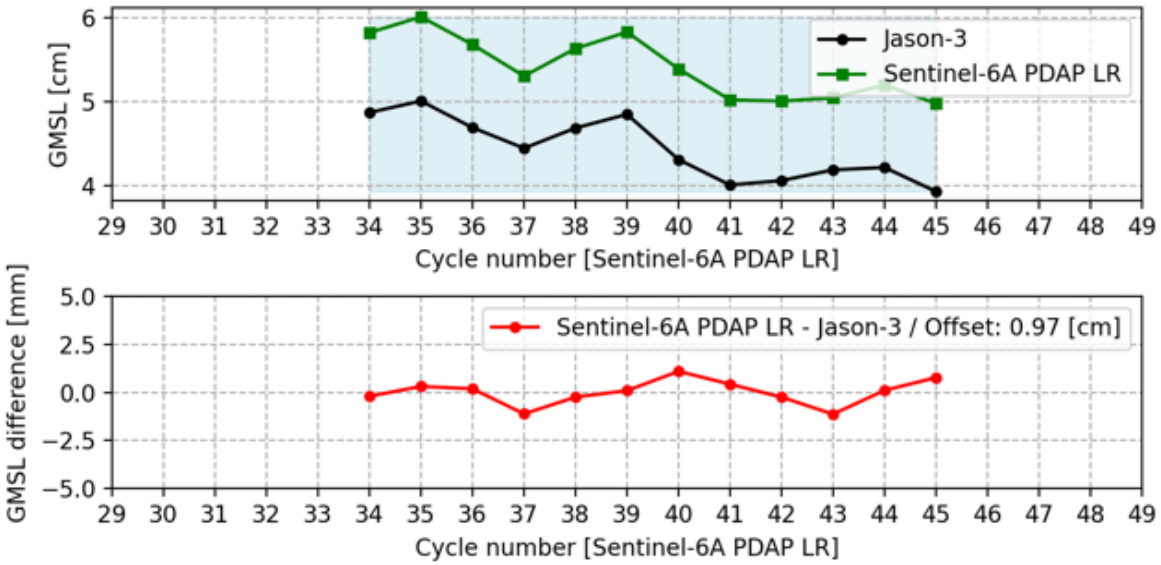
- **Corrected SSH error at Xovers**
  - Within specification
    - Global = 3.57 cm
    - Over Pacific ocean = 2.68 cm
  - Low values in area with small waves
  - Metric impacted by geophysical effects in high SWH regions
- **Very consistent with Ja3**
  - SSHA geographical differences of the order of +/-1 cm

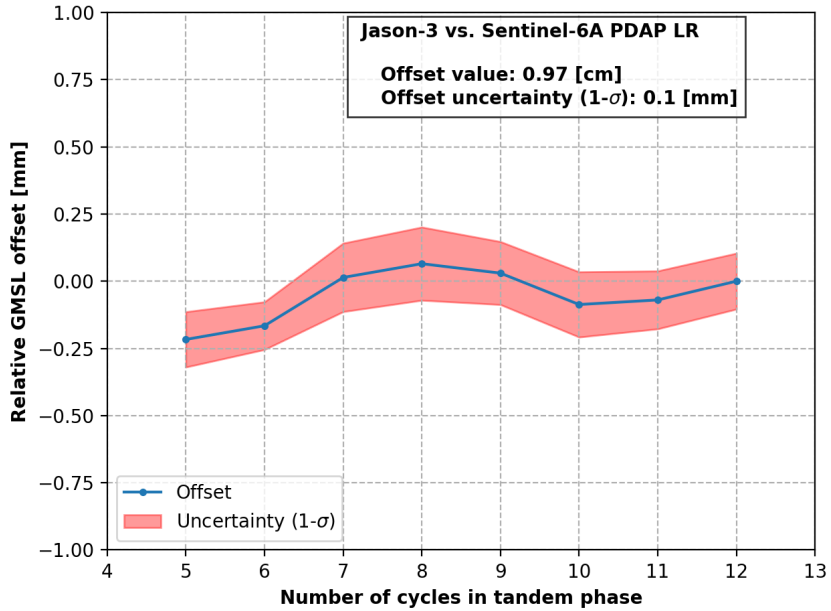




LR NTC – stability and drift

- **Inter-mission bias (side-B)**
  - Stable with max oscillation amplitude around +/-2 mm
  - Offset of 0.97 cm
  - Benefits from
    - PDAP evolutions during the first phase of CalVal
    - PDAP stable version over the side-B period
    - POE-F over the period
- **Uncertainty on the GMSL bias (side-B)**
  - Can be a large contributor to the total GMSL trend uncertainty between two consecutive missions
  - Key result of the tandem phase
  - Very stable bias and uncertainty about 0.1 mm (1-σ)
  - NB same order of magnitude that for Jason-1/-2/-3 missions (~0.2 mm)
- **Impact of instrumental drift on GMSL**
  - Impact on long term times series
  - Numerical retracking needed

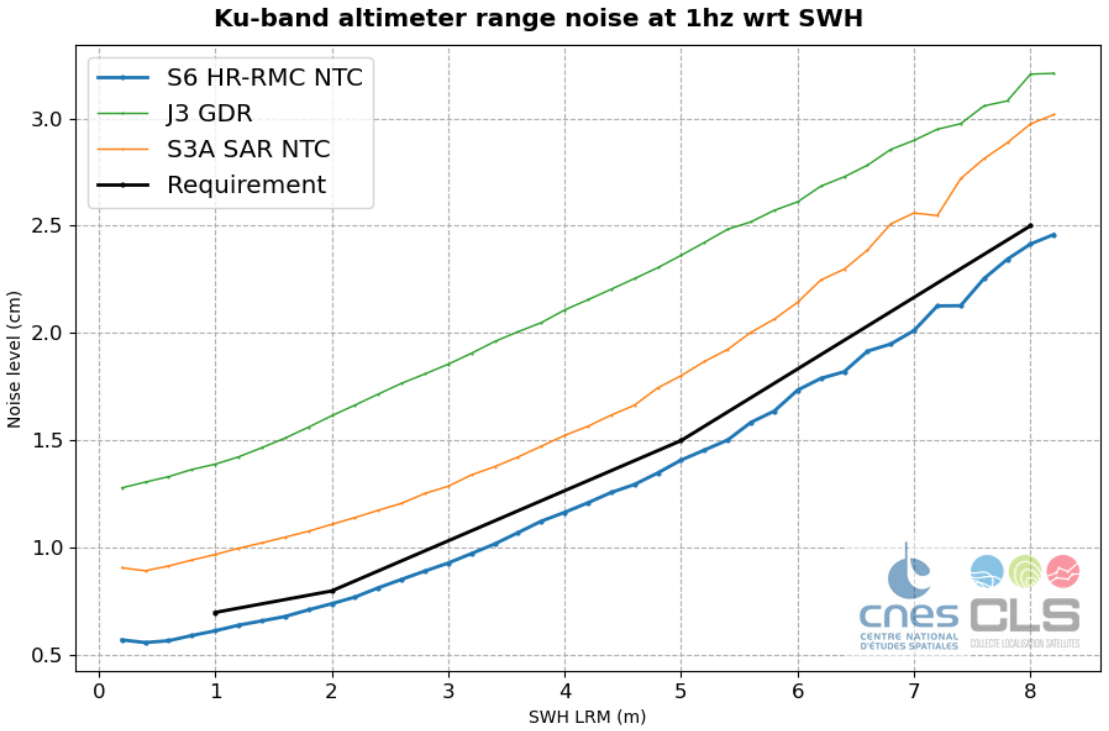




HR altimeter range – Ku band - noise

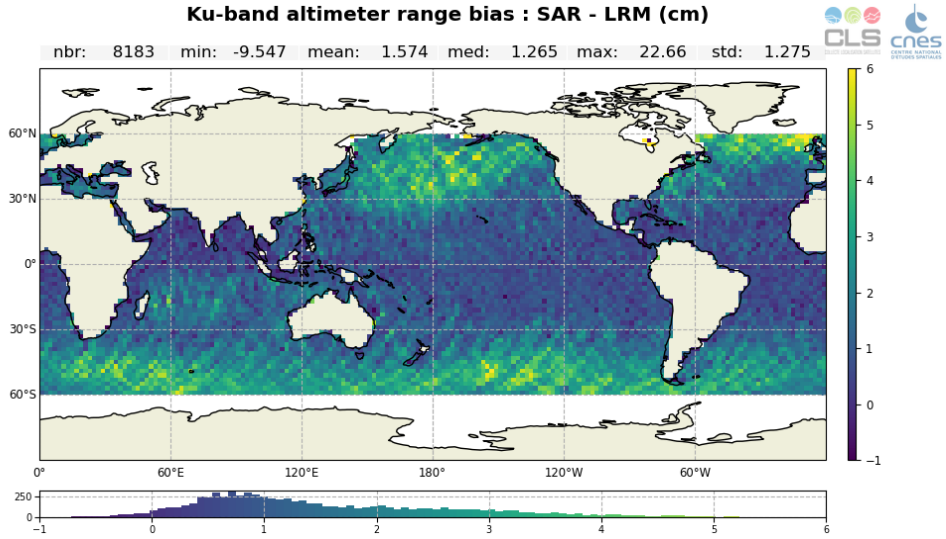
- **Excellent performances for noise (well below S3)**
  - Higher number of looks
  - Slight deviation for highest swh (swell sensitivity)

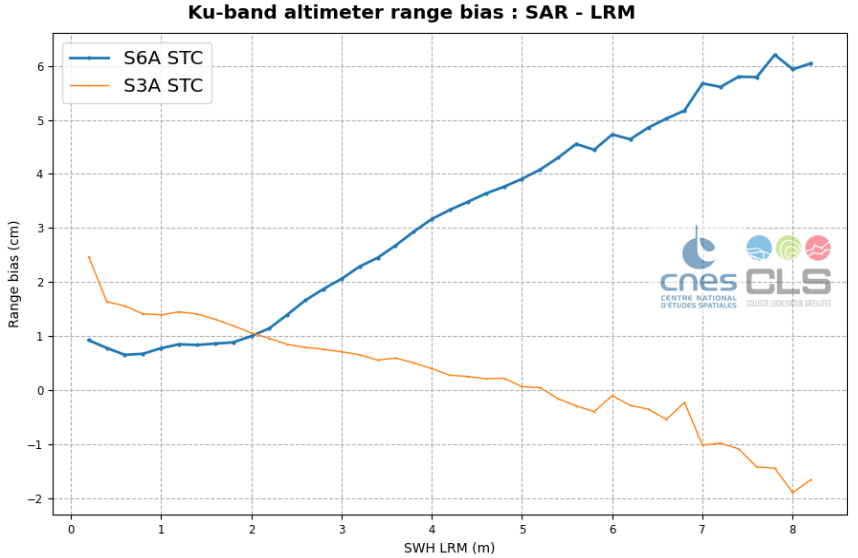
- **RMC noise equivalent to RAW noise**



HR altimeter range – Ku band

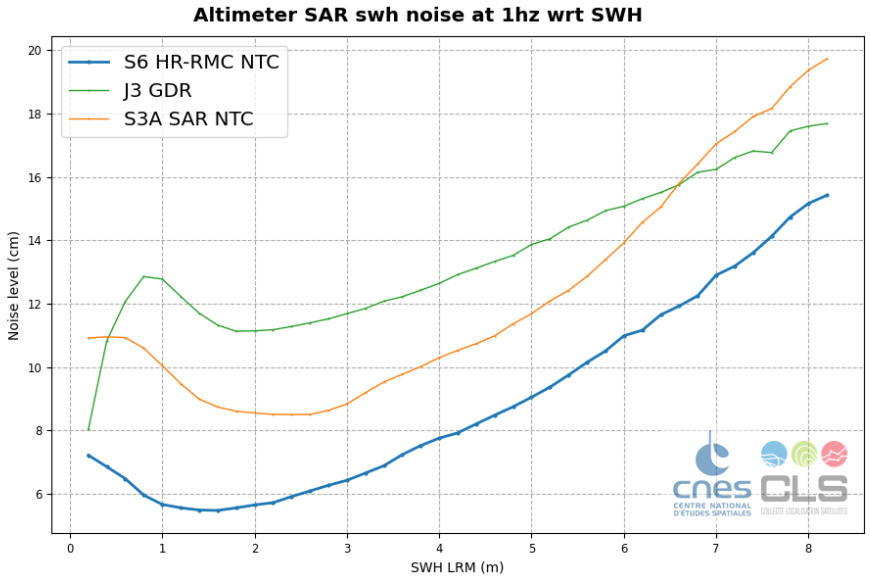
- **Up to 6 cm bias between HR-LR**
  - Skewness to be aligned with LR (see IP presentation)
  - Impact of Doppler ambiguities management to be assessed
  - processing optimizations required (skewness, SWH, SSB) before full use of S6 HR promising capabilities

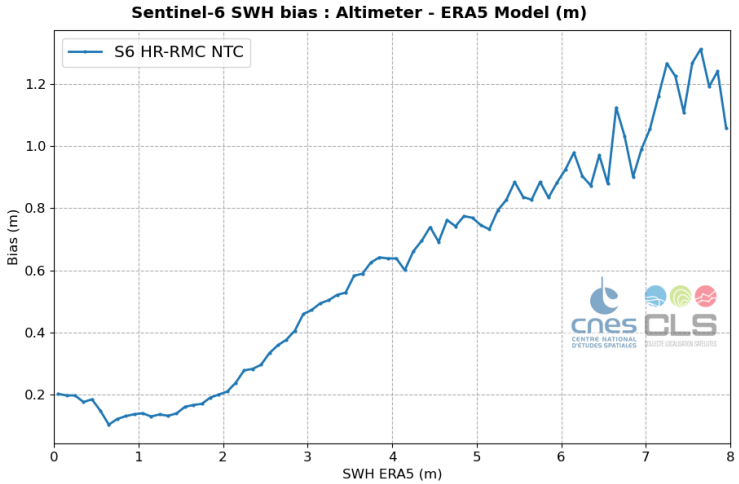


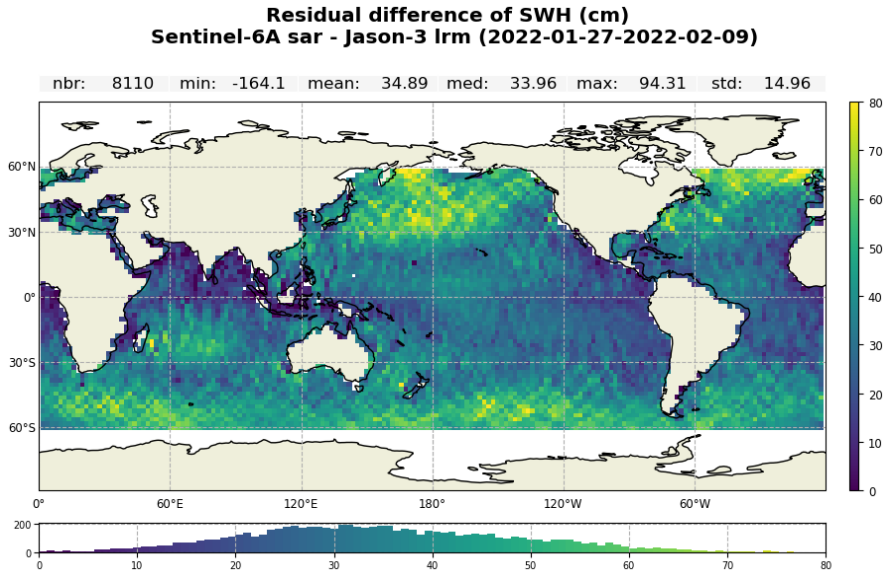


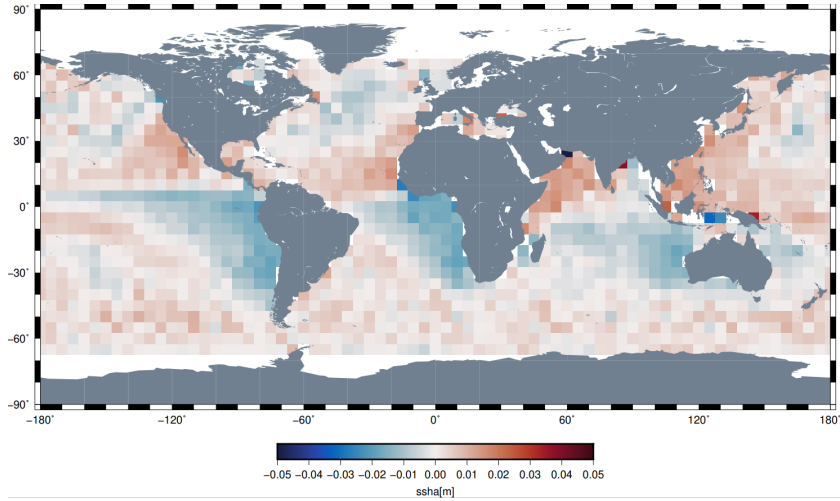
HR SWH

- **Excellent performances for noise (well below S3)**
  - Differences at low SWH linked to different negative SWH value management
- **Up to 80cm bias between HR-LR**
  - Vertical waves motion impact (known issue observed on S3 too)
  - Impact on SSHA via SSB
- **Ascending/Descending tracks bias link to meridional wind component (known issue observed on S3 too, see IP presentation)**

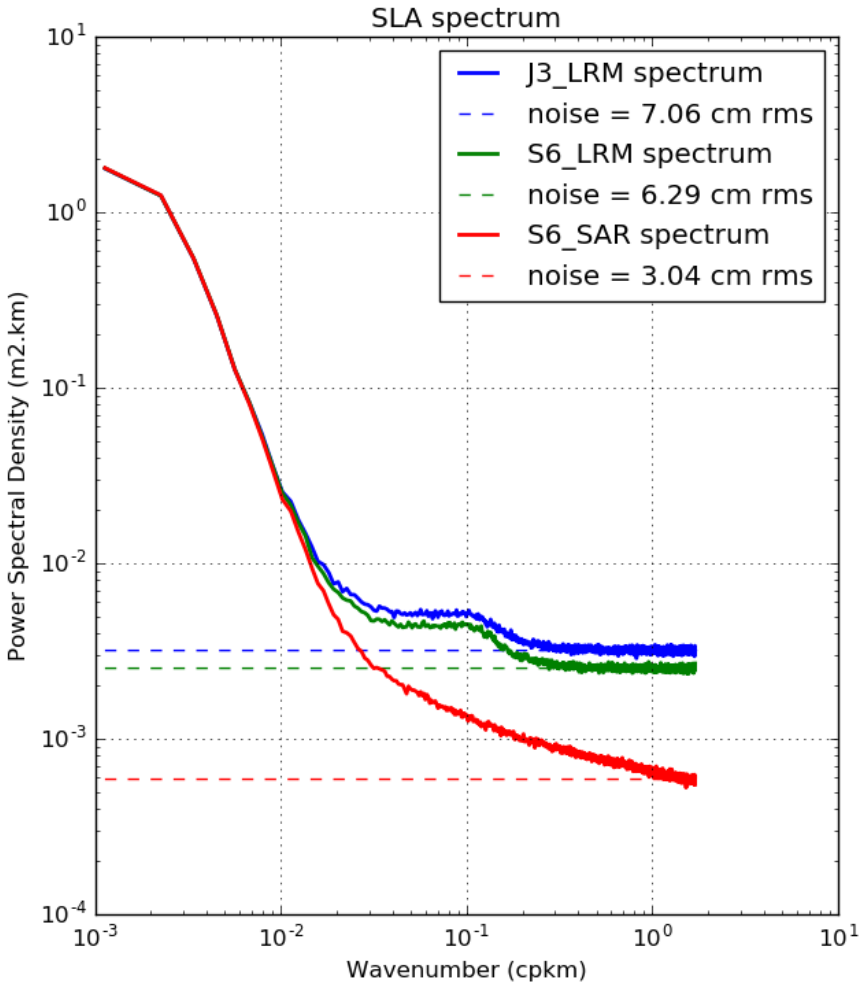


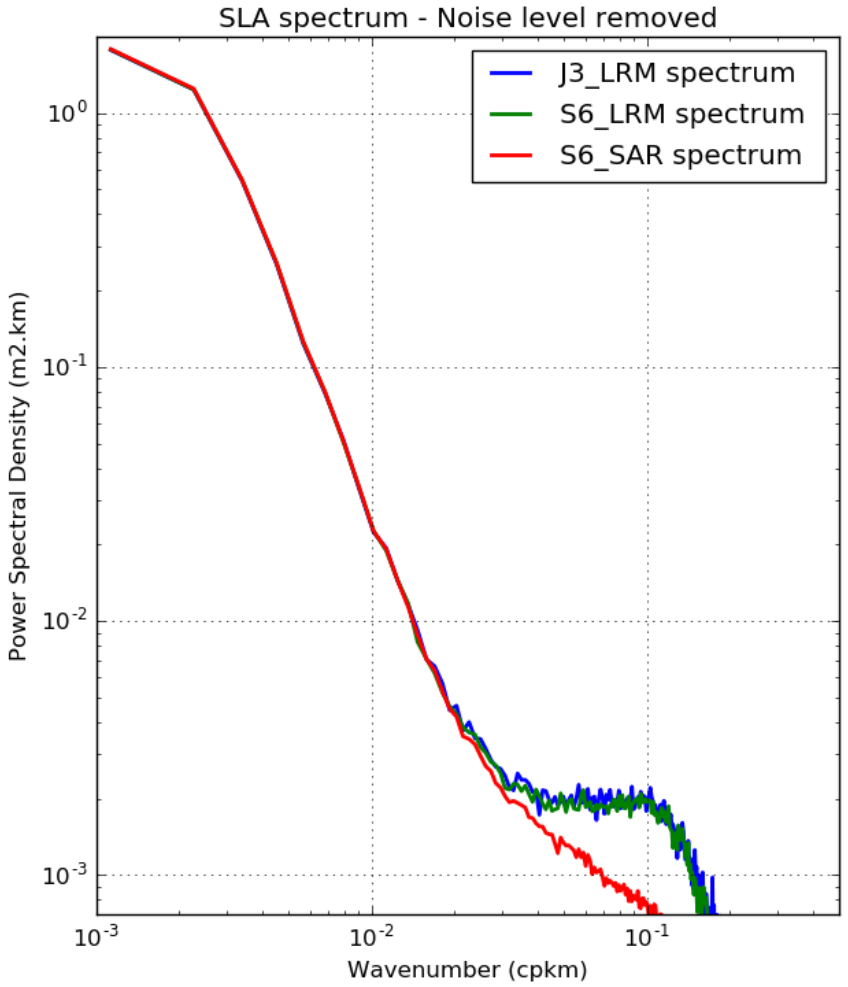






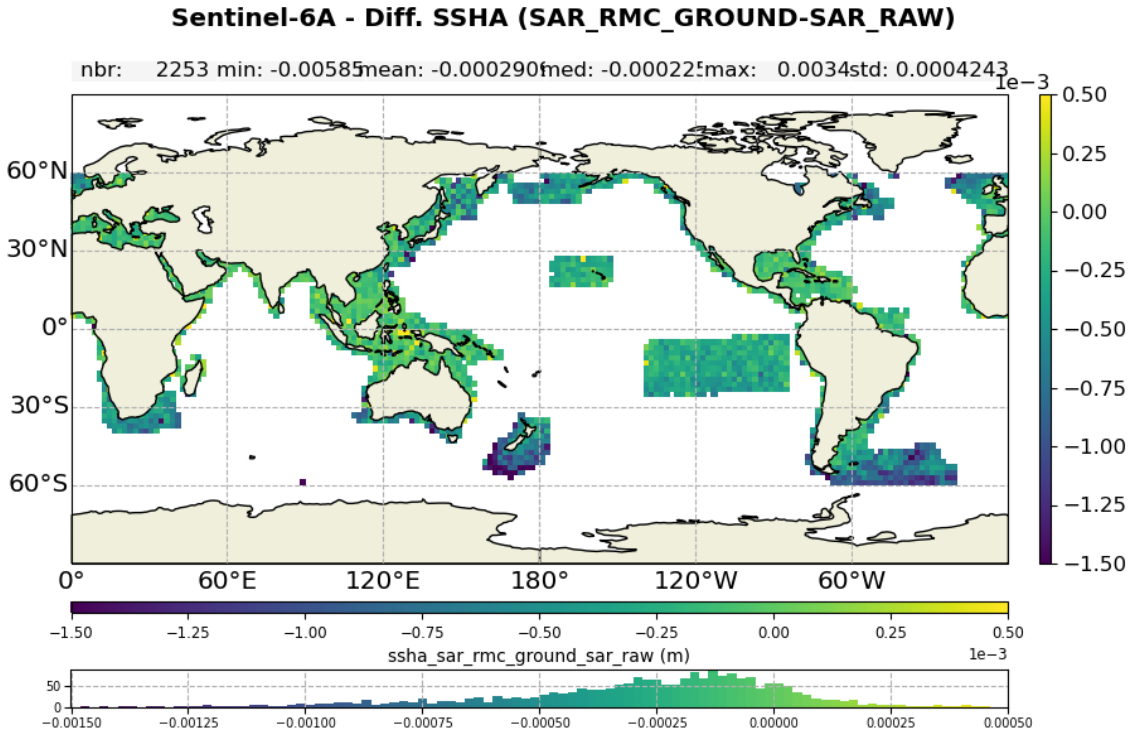
HR corrected SSH spectra





HR – RMC mode validation over ocean

- **No sensitivity observed wrt the mean sea surface slopes & the distance to the coast**
  - Range differences have a slight SWH dependency (from 0 to 2.5mm) but it will be absorbed with SSB
- **Negligible RAW-RMC differences**
  - Retracked parameters
    - <2mm on range
    - <1cm on SWH
    - <0.02dB on sigma0
  - Negligible differences over open ocean and coastal areas
  - Negligible differences for inland waters
    - E.g. Over Amazon basin: 95% of measurements with range discrepancies <2cm.
  - Over sea ice: to be analyzed
- **→ RMC everywhere as operational mode**



Conclusion #01 – Missions requirement

Requirement ID	LR	HR
Range	OK	HR/LR bias: up to few cm (different skewness)
SWH	OK	Bias due to vertical velocities, known issue
Sigma0	OK	OK
Wind speed	OK	OK
SSB	OK	HR SWH impacted by vertical velocities LR SSB used → dedicated HR SSB ?
Iono	OK	OK
Dry and Wet tropo	OK	OK
Corrected sea surface height	OK	Bias from range bias and SSB (indirect impact from vertical velocities)
Stability	Very stable bias and uncertainty about 0.1 mm (1-σ) Numerical retracking needed for long term trends (see IP presentation)	Not addressed Range Walk needed for long term trends (see IP presentation)

Conclusion #02 – Take home message

- **S6-MF data of very high quality**
- **Very good inter-mission bias between JA3 data and S6-MF Altimeter SideB data**
  - a spurious and not explained jump of about 3mm observed between JA3 and S6-MF Altimeter SideA data
  - Future PDAP evolutions will ensure GMSL trend continuity with JA3
- **RMC and RAW data inline**

- **Some remaining processing improvements required, in particular on the HR data (Vertical waves motion, wind effects, …) but also on LR (remaining differences with JA3 as a function of SWH and other features). Application of small Look up Tables at higher level to merge S6-MF with other data is still required.**

CALVAL S6
SEED QUESTIONS

03/2022

CNES on behalf of MPWG members (EUMETSAT, ESA, NOAA, NASA, CNES)
With the support from CLS

Seed questions

- Has Sentinel-6 MF reach sufficient accuracy and stability to take over as the reference mission?
- Should we revisit the way the error budget is currently written down and adopt/recommend an approach similar to the one used on SWOT mission (spectra envelop instead of 1Hz rms for ocean surfaces) ?
- Very few teams are currently working on Hydro processing approaches using S6-MF data. How can this improved in the near future ?
- How long should last S6B / S6-MF tandem phase ? Based on S6-MF SideB analysis is seems that 5-6 months could be enough ? How can we consolidate this figure ? Lesson learnt push toward assessing also sides A/B for S6B and maybe a second tandem as planned for S6A ?
- What HR data brings for GMSL studies ?
- In which area S6-MF will provide new insights that will help improving JA3 and former LRM mission processing ?