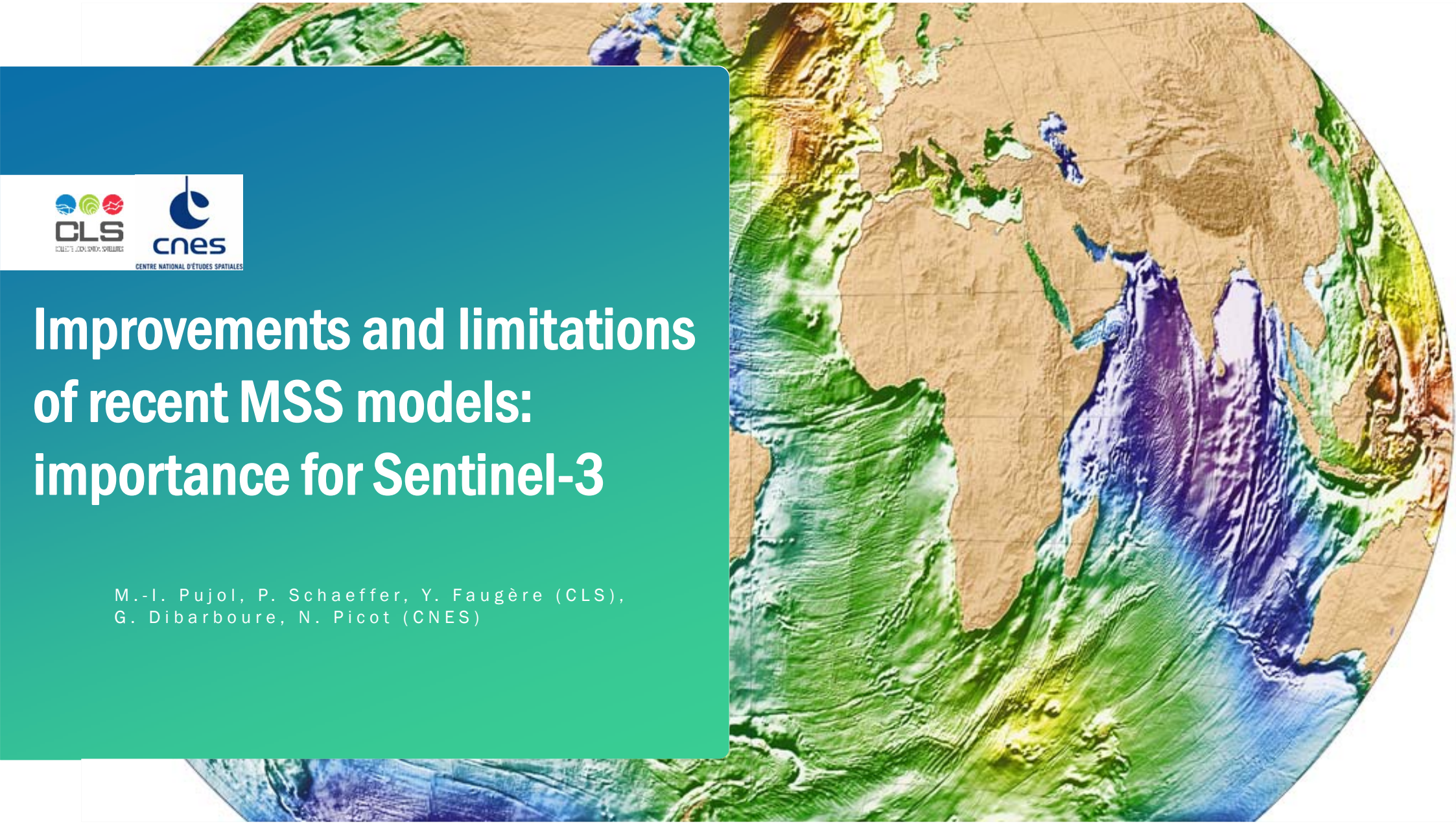


Improvements and limitations of recent MSS models: importance for Sentinel-3

M.-I. Pujol, P. Schaeffer, Y. Faugère (CLS),
G. Dibarboure, N. Picot (CNES)

Overview

- MSS models error estimation at short wavelengths :
  - CNES_CLS_2015
  - DTU_2018
  - SCRIPPS_2016

- Specific Sentinel-3A Hybrid Mean Profile (HMP) estimation.

- Perspectives for HMP and MSS models improvement

Gridded MSSs errors at short WL

methodology:

- Based on SLA comparison between 2 cycles
- Sentinel-3A used as independent measurement
- Focus on WL [15, 100km]

3 assumptions:

1) There is no covariance between the SLA signal and the MSS errors → We use a mission/period independent from MSS computation: S3PP/CNES Sentinel-3A (20Hz)

2) The SLA signal is completely decorrelated between the two cycles considered → We chose A and B far enough from each other

3) The MSS error is the same whatever the cycle considered → we use a repetitive mission

We consider :

- **H** = SLA signal including the MSS errors (**e**) and the SLA signal free from MSS errors (**h**)
- **A** and **B** = two different cycles

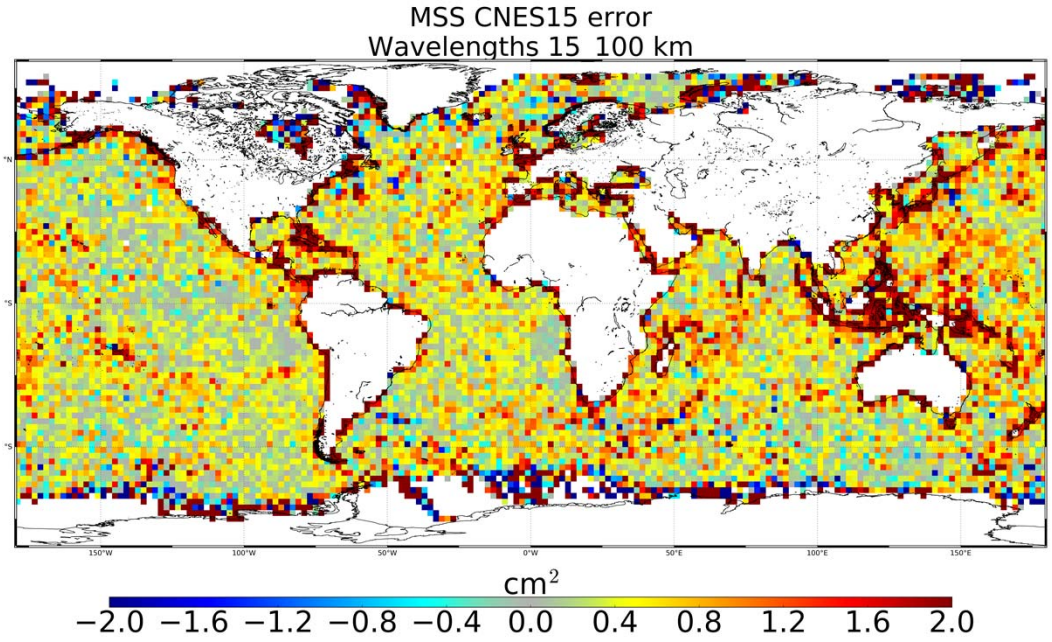
$$0.5\,\sigma^2(H_A - H_B) - 0.5\,\sigma^2(H_A + H_B) = 2\,\sigma^2(e)$$

Mean spectral content of the h signal

Mean spectral content of the h+e signal

Pujol et al (JGR 2018; https://doi.org/10.1029/2017JC013503*)*

Gridded MSSs errors at short WL



CNES_CLS_2015 (Schaeffer et al, 2015):

Based on combination of altimeter measurement from repetitive missions Topex/Jason-1/Jason2, Topex/Jason-1 interleaved, ERS1/ERS-2/Envisat/SARAL-Altika and non-repetitive missions Cryosat-2/Jason-1GM

CNES_CLS_2015 model error description :

- Globally 0,46 cm² of error estimated for wavelengths ranging from 15 to 100km:
  - 38% of the “noise-free” SLA variance
  - dominated by omission errors
- Locally, error can reach more than 1 cm²

Pujol et al (JGR 2018; https://doi.org/10.1029/2017JC013503)

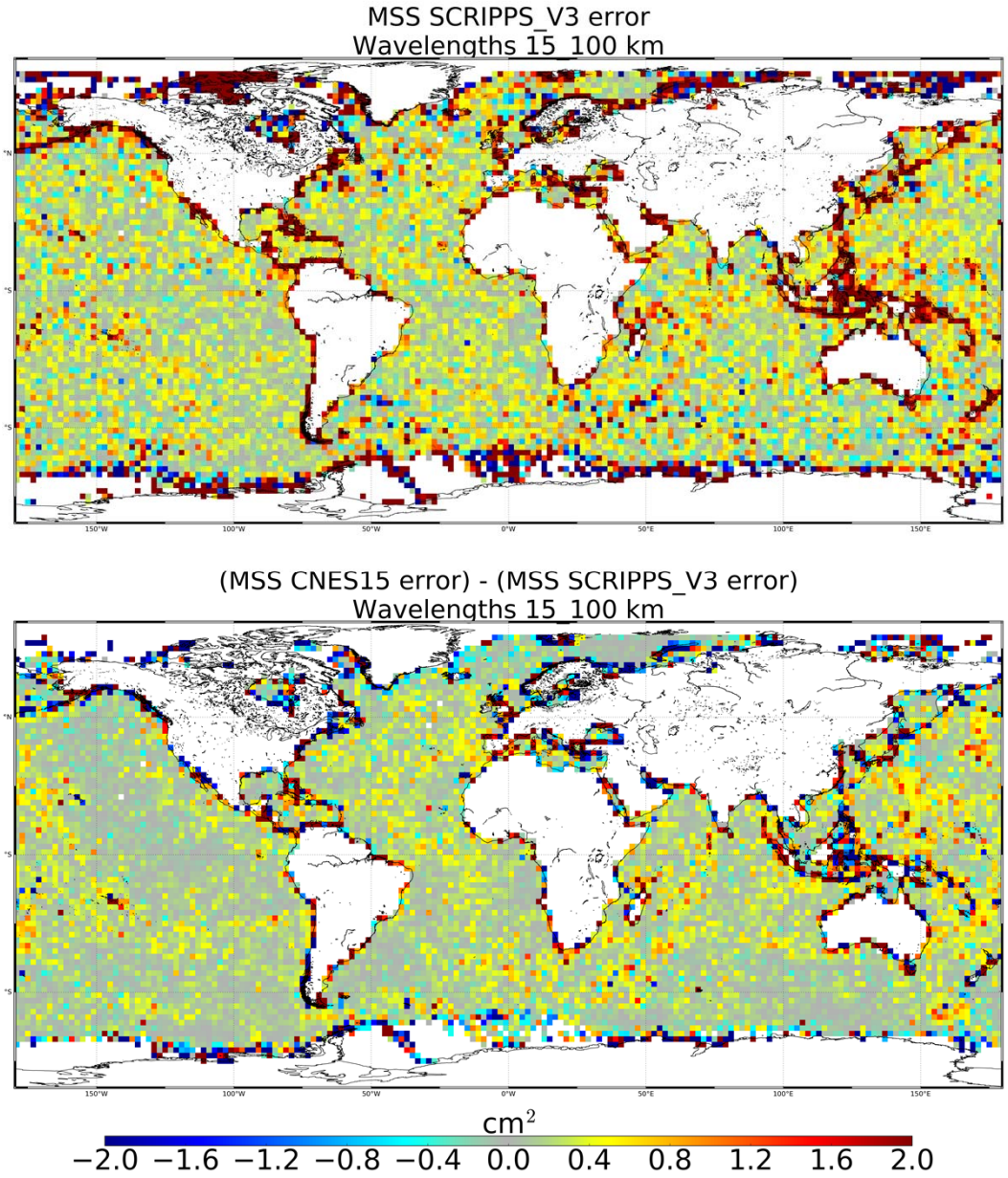
Gridded MSSs errors at short WL

2 others MSS models tested:

- **SCRIPPS** (Sandwell, 2016):
  - Based on CNES_CLS_2015 MSS for long-wavelengths (>30km); based on Cryosat-2; Jason-1GM, SARAL-DP/Altika for the short wavelengths
- **DTU_2018** (Andersen, 2018):
  - Based on combination of altimeter measurement from repetitive missions Topex/Jason-1/Jason2, ERS1/ERS-2/Envisat/SARAL-Altika and Cryosat-2/Jason-1GM/Sentinel-3A for short wavelengths and coastal areas

➔ Same methodology applied for MSSs error estimation along Sentinel-3A tracks

➔ Analysis completed with one cycle of Sentinel-3B measurement

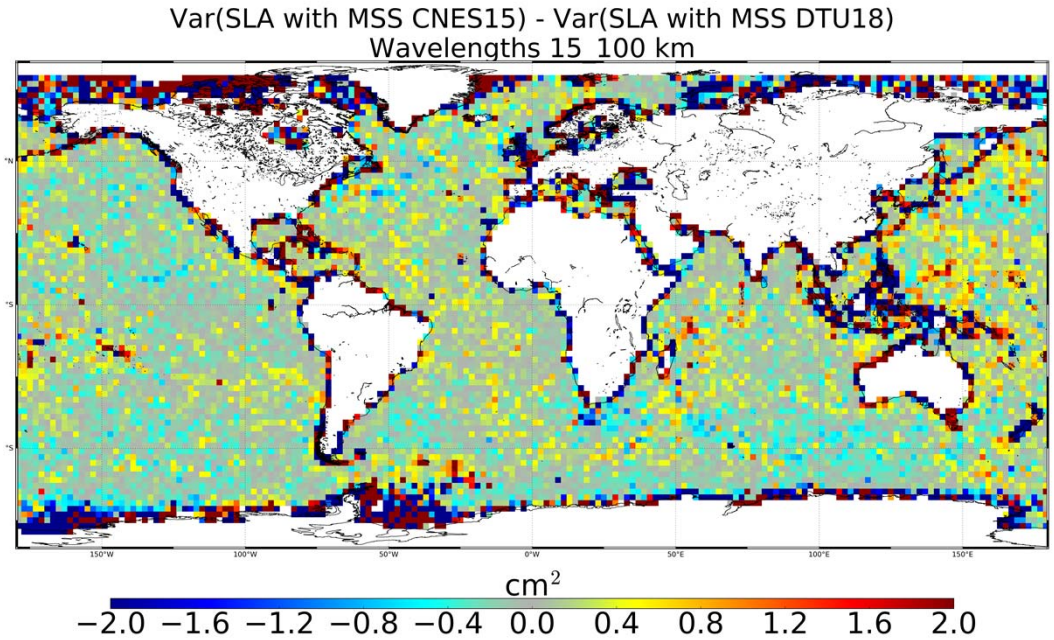


Gridded MSSs errors at short WL

SCRIPPS MSS error description along S3A tracks:

- Globally 0,29 cm² (24% of the 'noise-free' SLA variance) at WL 15-100km
- -37% reduction of the omission errors vs CNES_CLS-2015:
  - Off-shore geodetic structures better resolved
  - Costal areas are also globally improved

Gridded MSSs errors at short WL

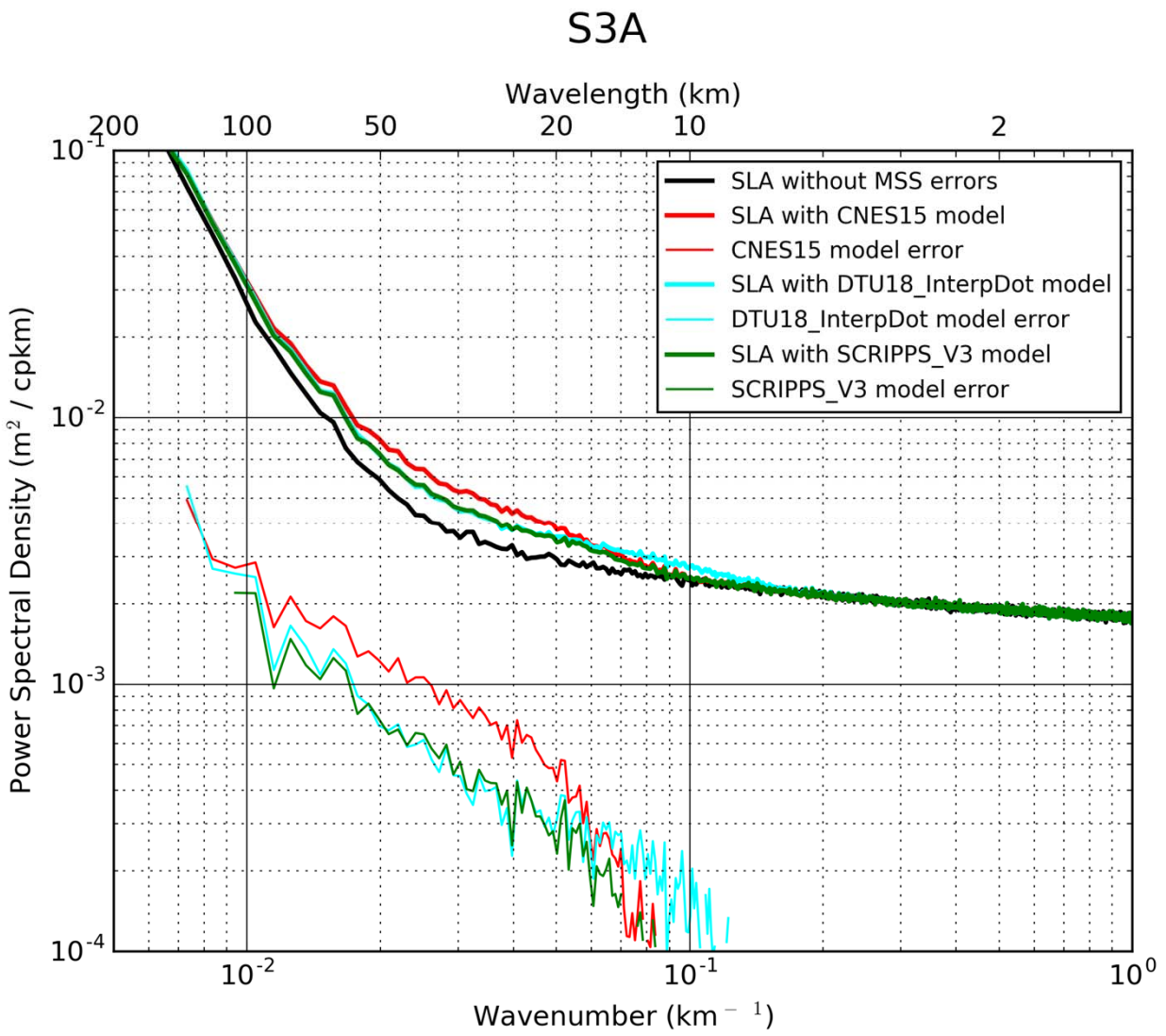


DTU_2018 MSS error signature along S3B tracks:

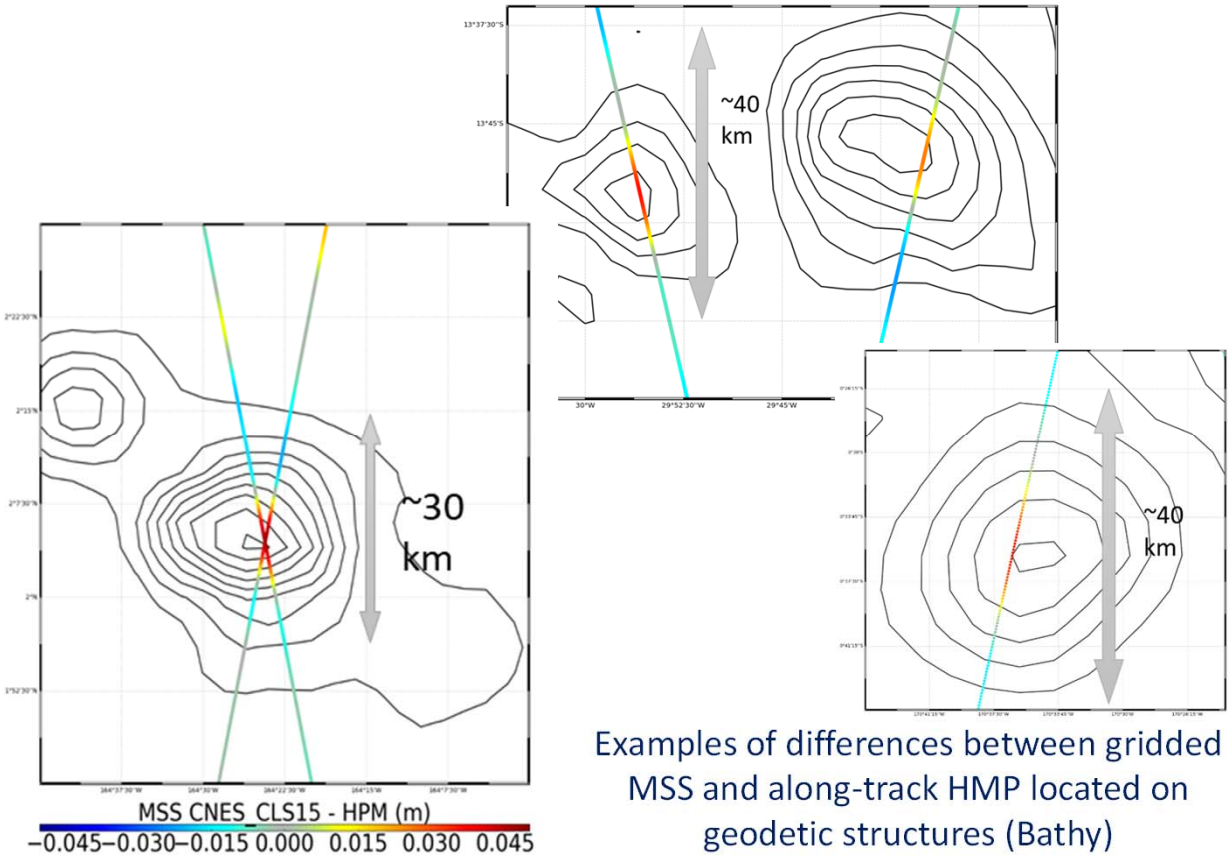
- Reduction of the omission errors vs CNES_CLS_2015 model along geodetic structures → local reduction of the SLA variance ~-0,5 cm², mainly at WL [25, 100km]

- Local increase of the SLA variance probably due to commission error in DTU_2018 MSS model (ocean variability + residual noises) → ~+0,5 cm² , mainly at WL [15, 25km]

Gridded


S3A
Wavelength (km)
200
100
50
20
10
2
SLA without MSS errors
SLA with CNES15 model
CNES15 model error
SLA with DTU18_InterpDot model
DTU18_InterpDot model error
SLA with SCRIPPS_V3 model
SCRIPPS_V3 model error
Power Spectral Density (m² / cpkm)
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻²
10⁻¹
10⁰
Wavenumber (km⁻¹)

MSS estimation improved along the Sentinel-3 tracks



Examples of differences between gridded MSS and along-track HMP located on geodetic structures (Bathy)

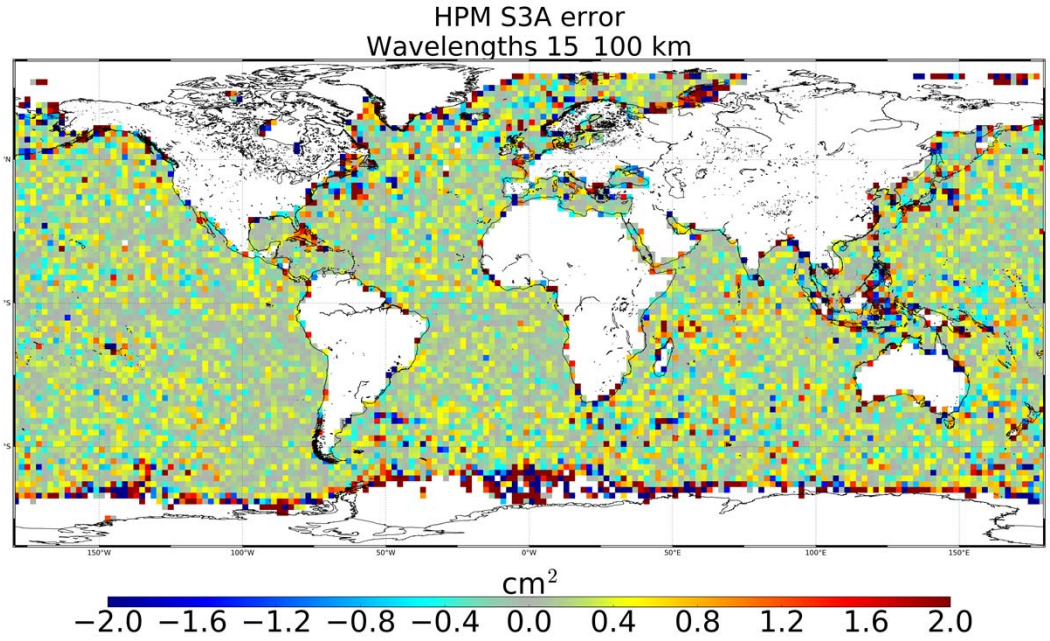
A Hybrid Mean Profile as been estimated along Sentinel-3A tracks:

- Temporal mean of Sentinel-3A measurements over 17 cycles resolves the wavelengths 15-100km
- Combined with the CNES_CLS_2015 for retrieving the wavelengths > 100km

➔ The HMP can better resolve small geodetic structures than the gridded MSS CNES_CLS15 → reduction of the omission errors

Dibarboure et Pujol (ASR, 2019; https://doi.org/10.1016/j.asr.2019.06.018)

MSS estimation improved along the Sentinel-3 tracks

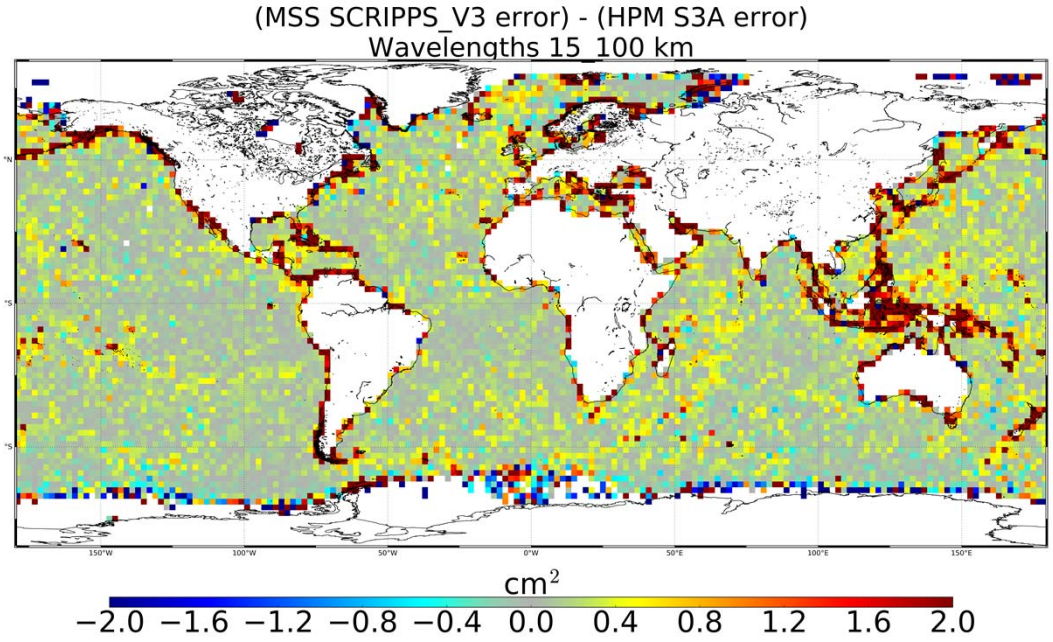


The HPM was assessed using two independent cycles of Sentinel-3A measurement:

- MP errors is 0,2 cm² i.e. 17% of the estimated noise free SLA variance or less than 50% of the gridded MSS CNES_CLS_2015 model error at WL 15-100km
- Significant reduction of the errors also observed in coastal areas: reduction by a factor 2 to 10
- Commission errors explain 75% of the HMP errors

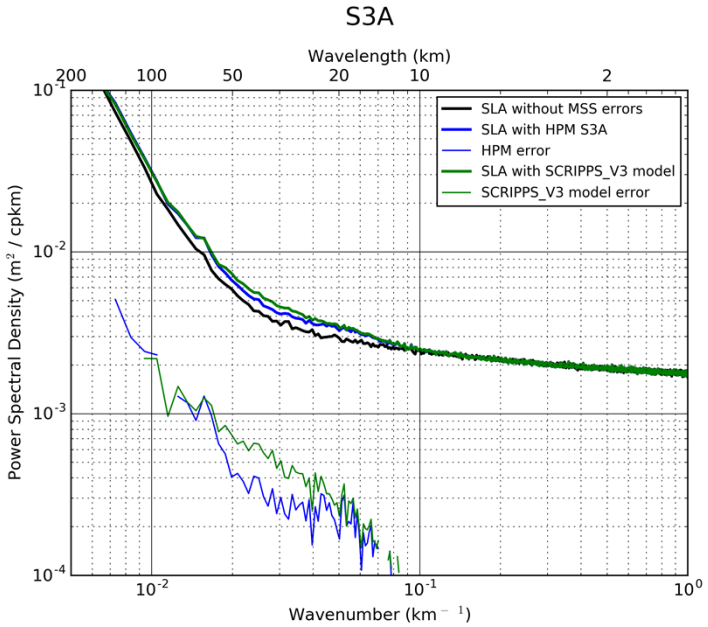
Dibarboure et Pujol (ASR, 2019; https://doi.org/10.1016/j.asr.2019.06.018)

MSS estimation improved along the Sentinel-3 tracks



HPM better resolves the short wavelength signal than the most recent MSS (SCRIPPS and DTU2018)

- Globally - 0,5 cm² reduction at WL 15-100km
- Locally up to 1 cm² (offshore) and 2 cm² (coast)



Perspectives of improvement of the MSS solutions

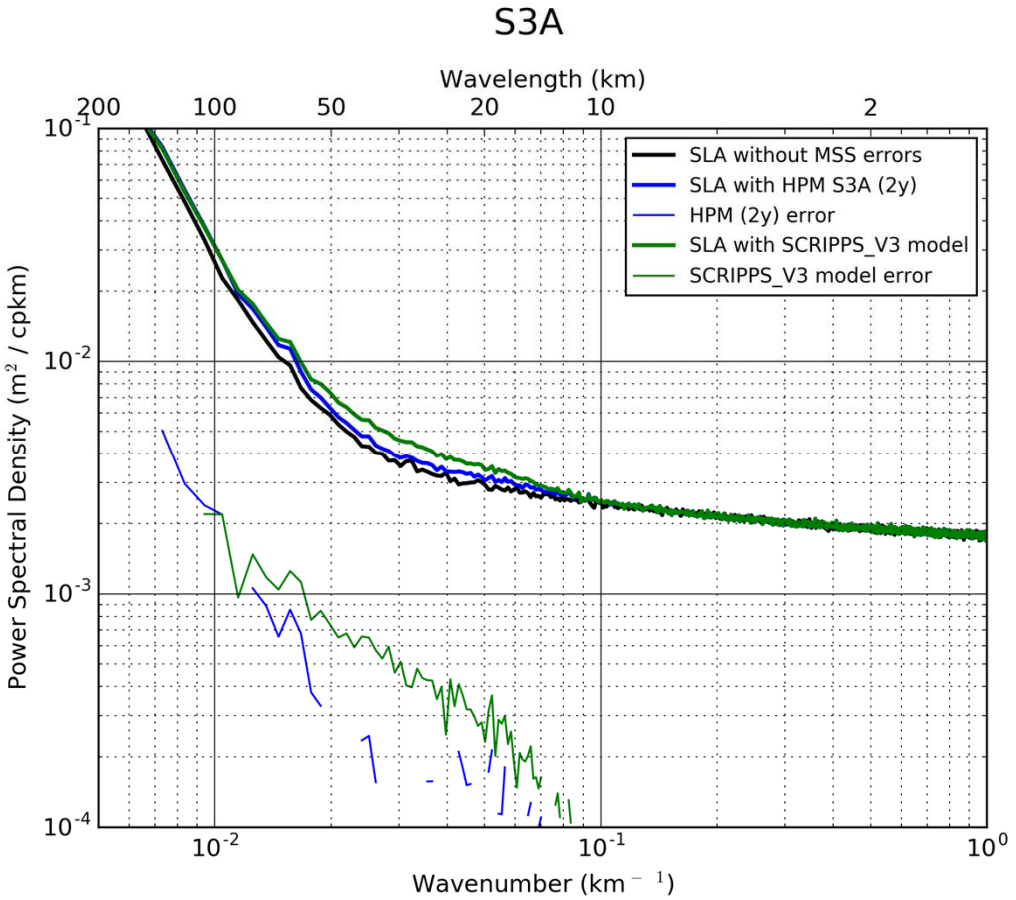
Improve the Sentinel-3A HMP estimation:

- Use additional measurement accumulated since the beginning of the mission : **more than 3-years of measurements now available**

HMP computed using nearly 2 years of measurements yet available with SAR processing :

– 0,12 cm² error (10% of the estimated noise free SLA variance)

– 1Hz version used in operational along-track L3 Sentinel-3A production (available on CMEMS) since April 2019



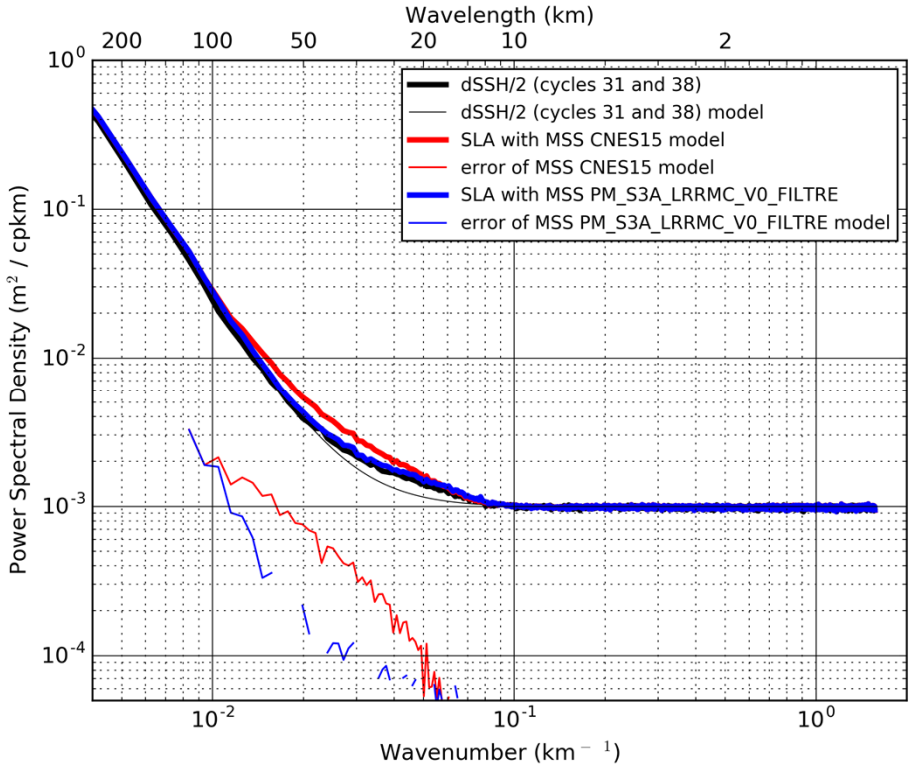
Perspectives of improvement of the MSS solutions

Improve the Sentinel-3A HMP estimation:

- **Use up-to-date processing & standards**: e.g. LR-RMC processing [Boy, 2017]

➔ Preliminary results with ~2,5y of LR-RMC measurements show a HMP error at WL [100, 15km] of 0,09 cm² (7,5% of the estimated noise free SLA variance)

Preliminary results to be consolidated



conclusions

- Good performances of recent MSS models tested at short wavelengths ([100, 15km])
  - Significant reduction of the omission errors vs CNES_CLS_2015 model
  - Residual commission errors observed on DTU_2018

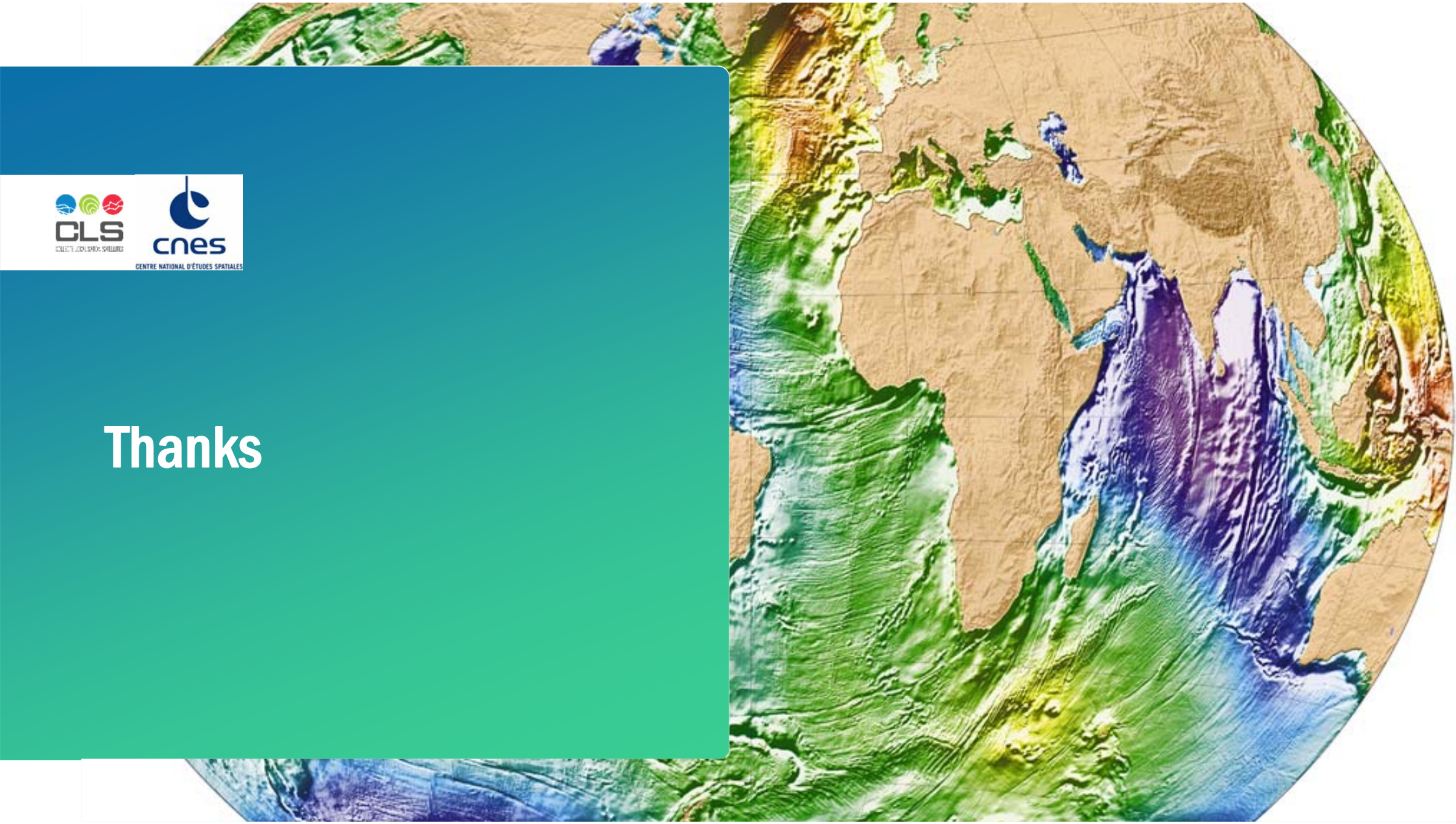
- Hybrid Mean Profiles defined along uncharted tracks still remain more performant than the grid MSS models
  - ➔ Sentinel-3A HMP implemented in operation L3 processing since April 2019

conclusions

- HMP and MSS models can still be improved:
  - Promising results obtained with Sentinel-3A LR-RMC processing
  - First HMP could be estimated for Sentinel-3B from spring 2020 (need to accumulated cycles) for NRT application
  - New MSS CNES_CLS model is in preparation

- **Future contribution of the SWOT mission:**
  - Important to reduce the MSSs error in order to access to the small scale signal with SWOT during the first months of the mission
  - ~10months of 21-day orbit measurement needed to reach the breakthrough MSS error level (Dibarboure et Pujol, 2019)

Dibarboure et Pujol (ASR, 2019; https://doi.org/10.1016/j.asr.2019.06.018)



Thanks