Status of Mean Sea Surface preparation for SWOT

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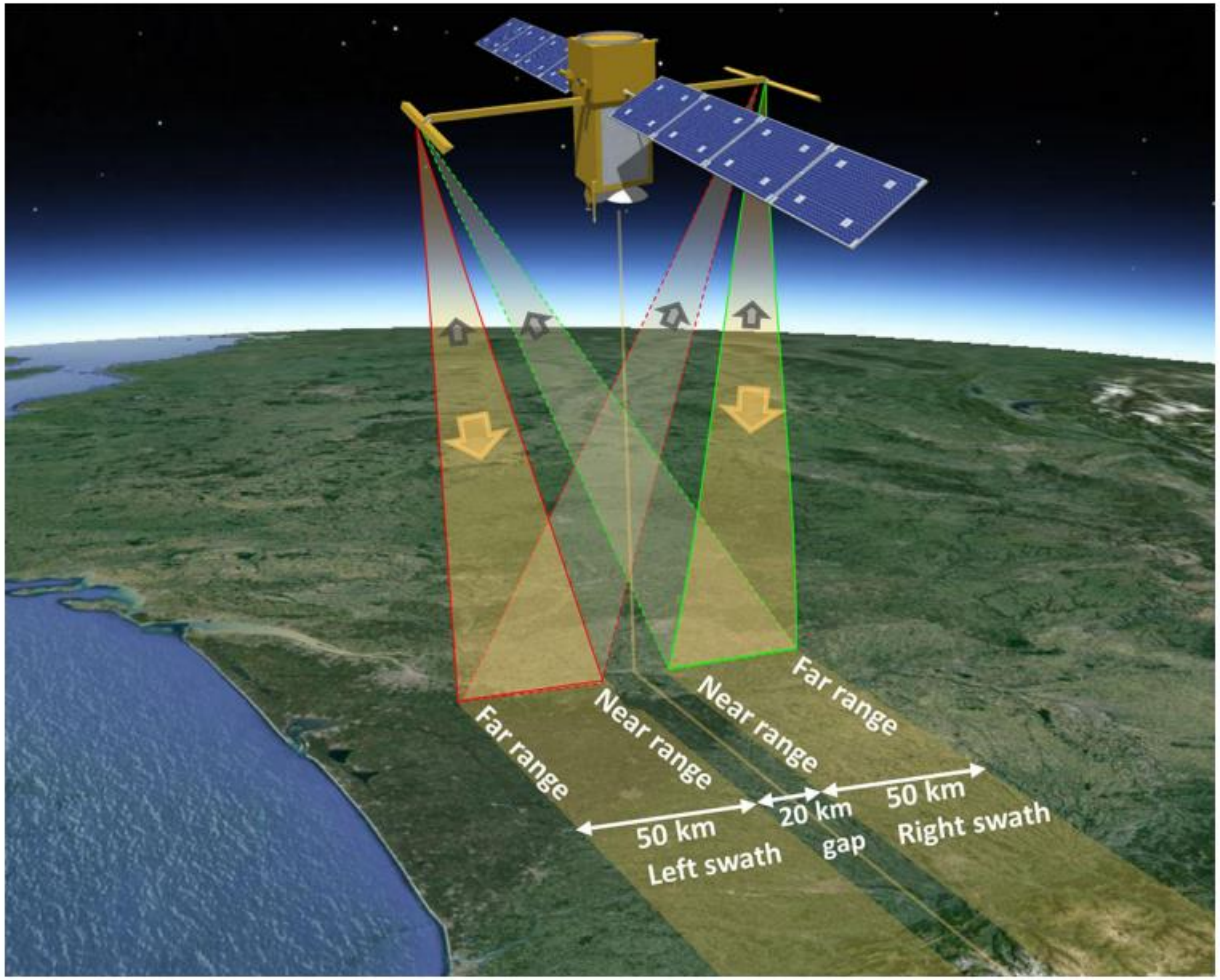
SWOT mission

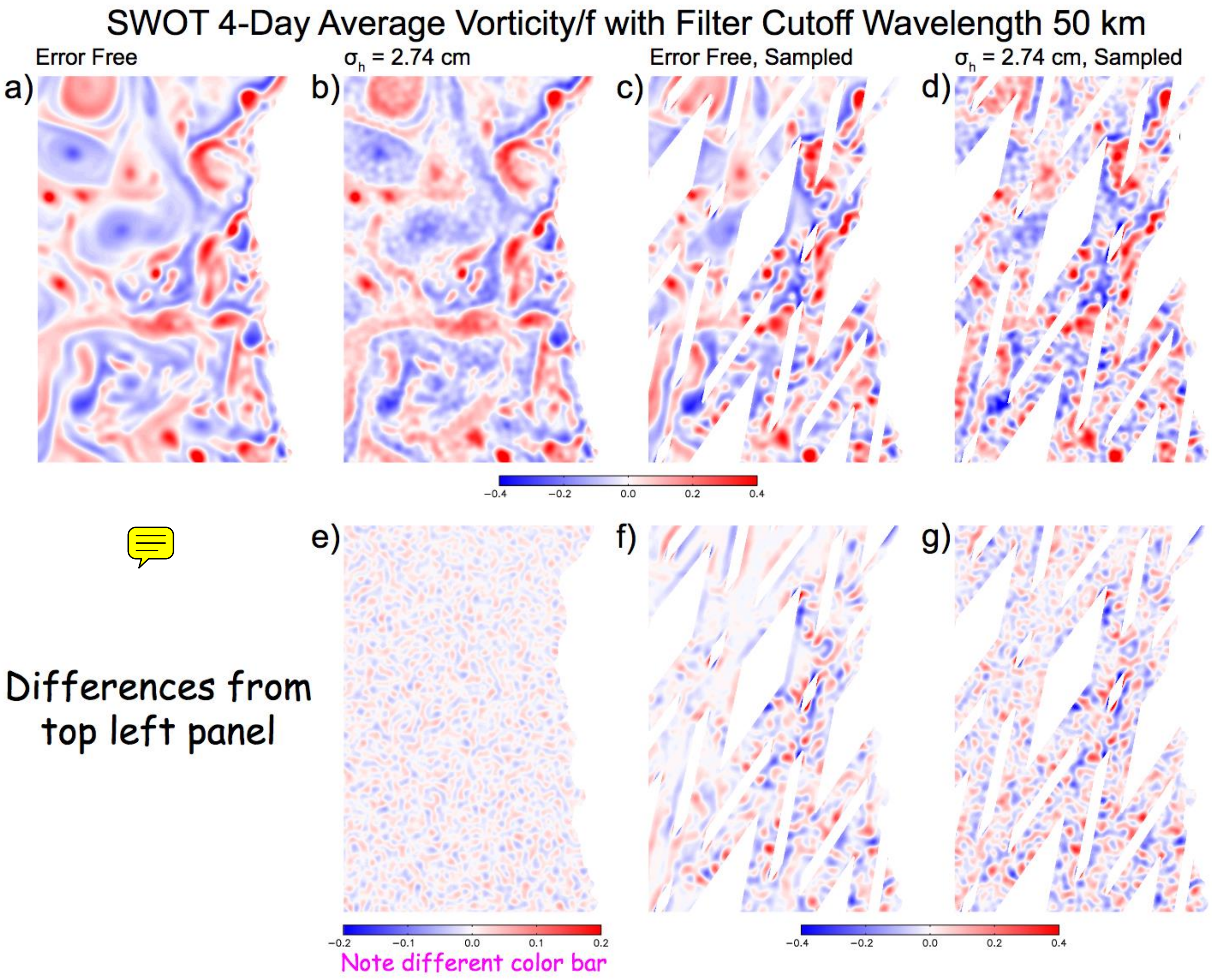
- To be launched in Feburary 2022
- Two antennas, wide swath altimetry
- Different from conventional or SAR altimeters



Biancamaria, S. et al., 2016

SWOT discoveries will be at small spatial scale

- Vorticity needs an extra derivative
- Amplifies noise
- Note VGG has 2 derivatives



Chelton, 2017 IOVWST

MSS model for SWOT

How do we isolate new information early in the mission?

- Need high resolution MSS for CAL/VAL early in the SWOT mission.

- MSS should have long wavelength accuracy from multi-decadal repeat-track altimetry (ERM) and short wavelength precision from geodetic mission (GM) phases.

- A joint effort between DTU, SIO, NOAA and CLS. Each organization working towards the best MSS and exploiting full-potential of all existing altimetry data

Methods for MSS modelling --- SIO approach

1) 2-pass retracking to suppress noise from gravity waves.
2) optimal derivative filters.
3) slope correction to range.
4) gridding - use height framework from ERM and **slope data** from GM.

Mothods for MSS modelling --- DTU approach

1) Start from DTU15MSS as a base

2) 2-pass retarcked ERM data since 2009 (Jason1/2-EM, Jason2/3 ERM, Cryosat-2, SARAL)

3) Mean profiles from above missions plus the GM data from Jason and SARAL/Altika

4) Crossoveradjustment and gridding to obtain the short wavelength features

5) Add back the DTU15MSS (as a long wavelength grid) to derive DTU2020MSS

Improved range precision for all pulse-limited altimeters

Altimeter	3-PAR @ 2 m (mm)	2-PAR @ 2 m (mm)
Geosat	88.0	57.0
ERS-1	93.6	61.8
Envisat	78.9	51.8
Jason-1	75.9	46.4
CryoSat-2	64.7	42.7
Jason-2	71.5	42.9
AltiKa	**34.3**	**20.5**

(Note these statistics are done at 20 Hz or 350 m along-track resolution.)

Smith [2015] showed standard GDR of AltiKa is 2 X more precise than Envisat

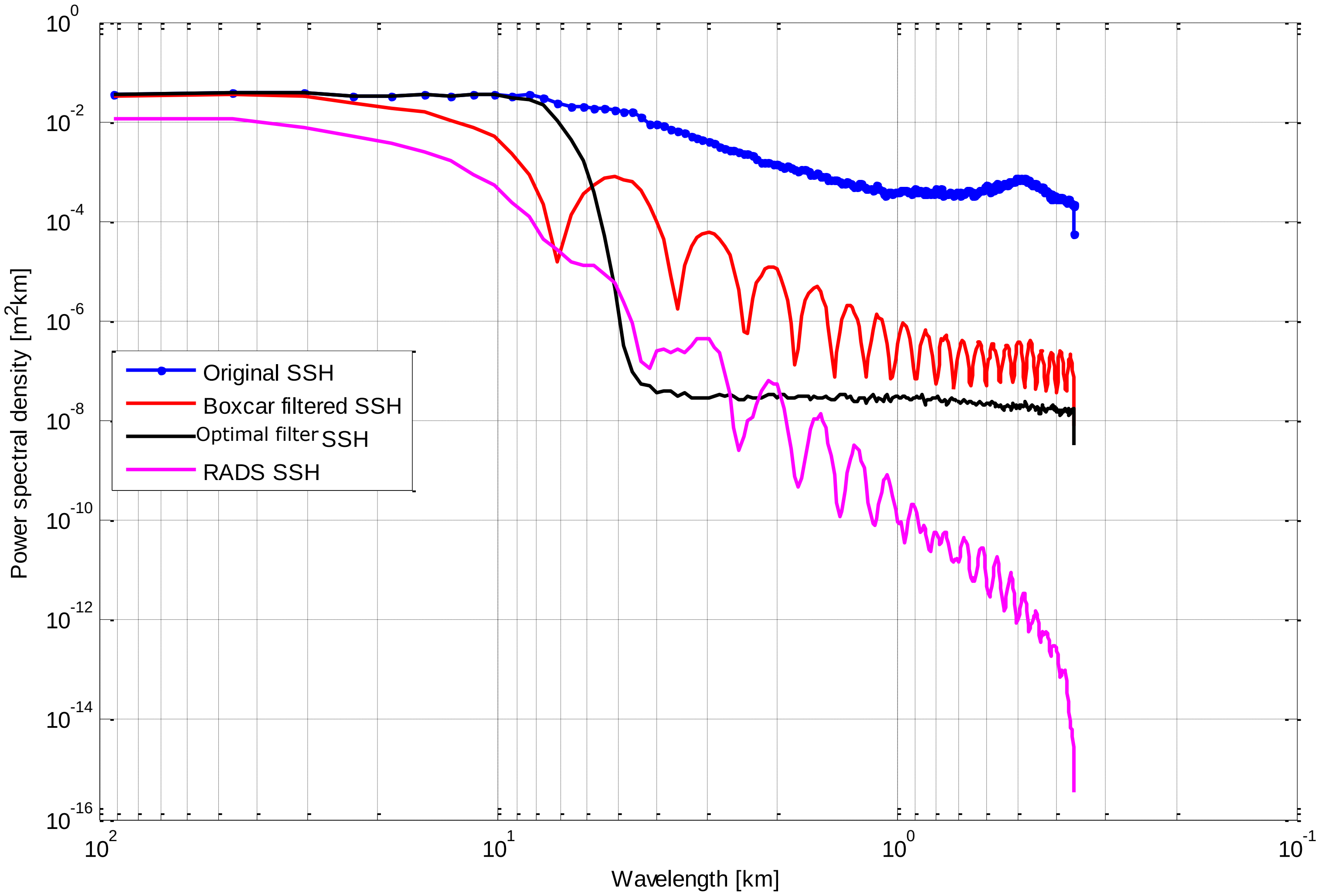
Zhang and Sandwell [2016] showed that AltiKa also benefits from 2-pass retracking.

In July 2016 AltiKa began geodetic mapping. Could achieve 1 mGal global marine gravity.

Impact of along track filtering (20 Hz → 1Hz)

- Boxcar (1 Hz moving average) filter results in the shorter wavelength noise to be aliased to into longer wavelength (This is typical in all 1 Hz GDR data and RADS)

- An optimal filter, Parks-McClellan filter, as being used by SIO, has the advantage of preserving all wavelength larger than 6.7 km, while supressing the short wavelength noise. (Black curve)



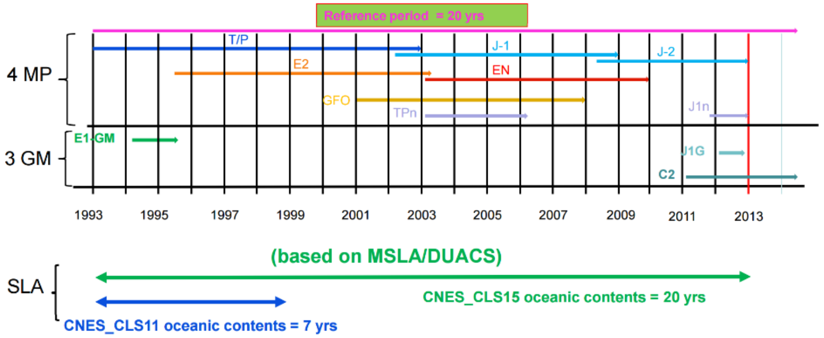
Power spactral of 20 Hz SLA(=SSH-DTU15MSS), For RADS, only 1 Hz SLAs are used

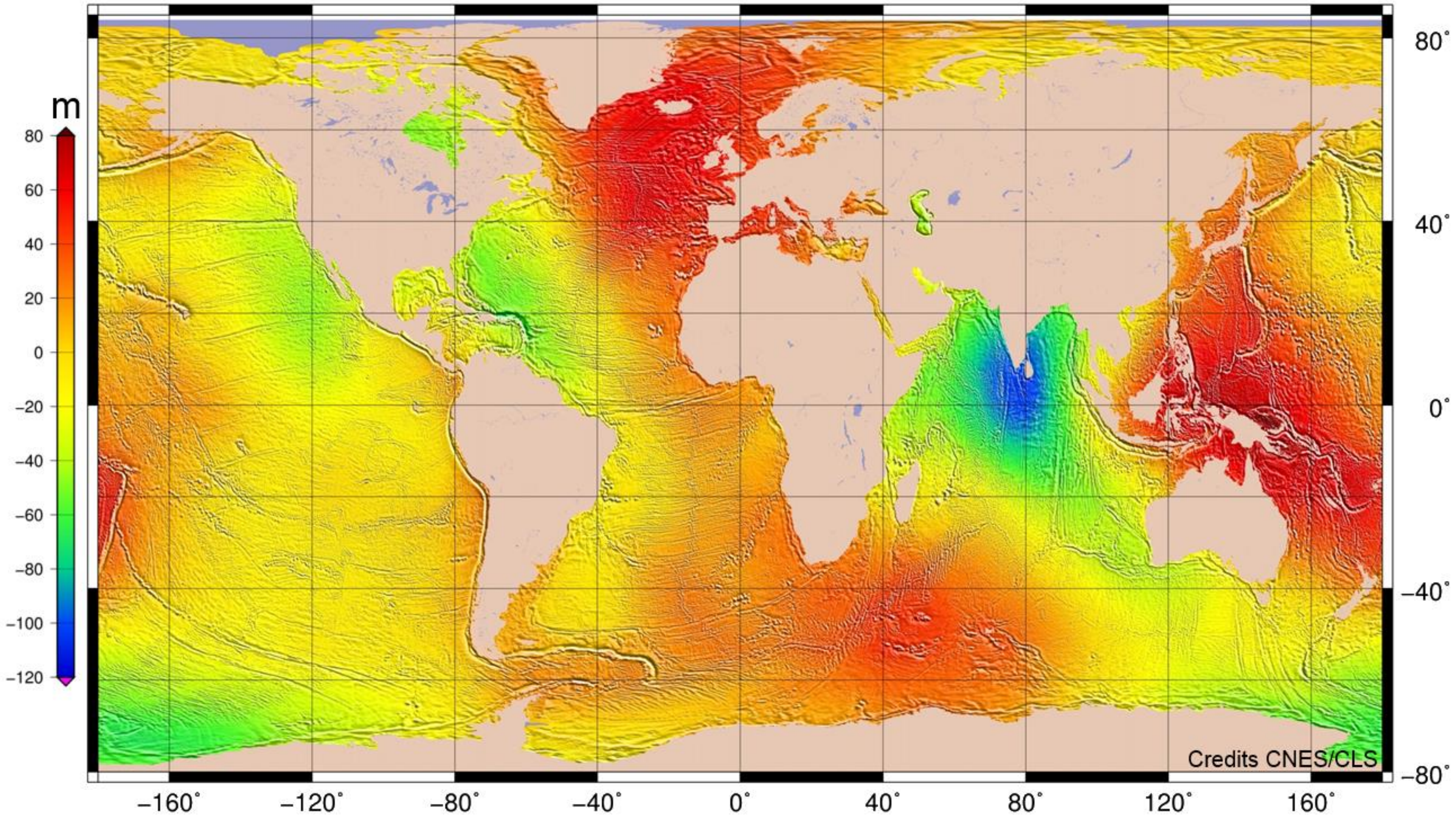
Comparison of 4 – MSS Models

height data	slope data	framework	other
CLS_2015	-	original CNES_CLS15 MSS	lacks short wavelengths
CLS_SIO	SIO	well constrained grid cells from CNES_CLS15	first combination attempt
CLS_MP	SIO	mean profiles from ERM: GFO, J1, J2, Envisat, AltiKa	long time period 1998 - now
RADS_S3	SIO	mean profiles from Sentinel-3A/B	recent 2017 - now

CLS_2015 MSS model

- Based on 20 years of altimetry data.
- All corrections applied to improve absolute height accuracy.
- 1 arcminute resolution.
- Uncertainty grid available.



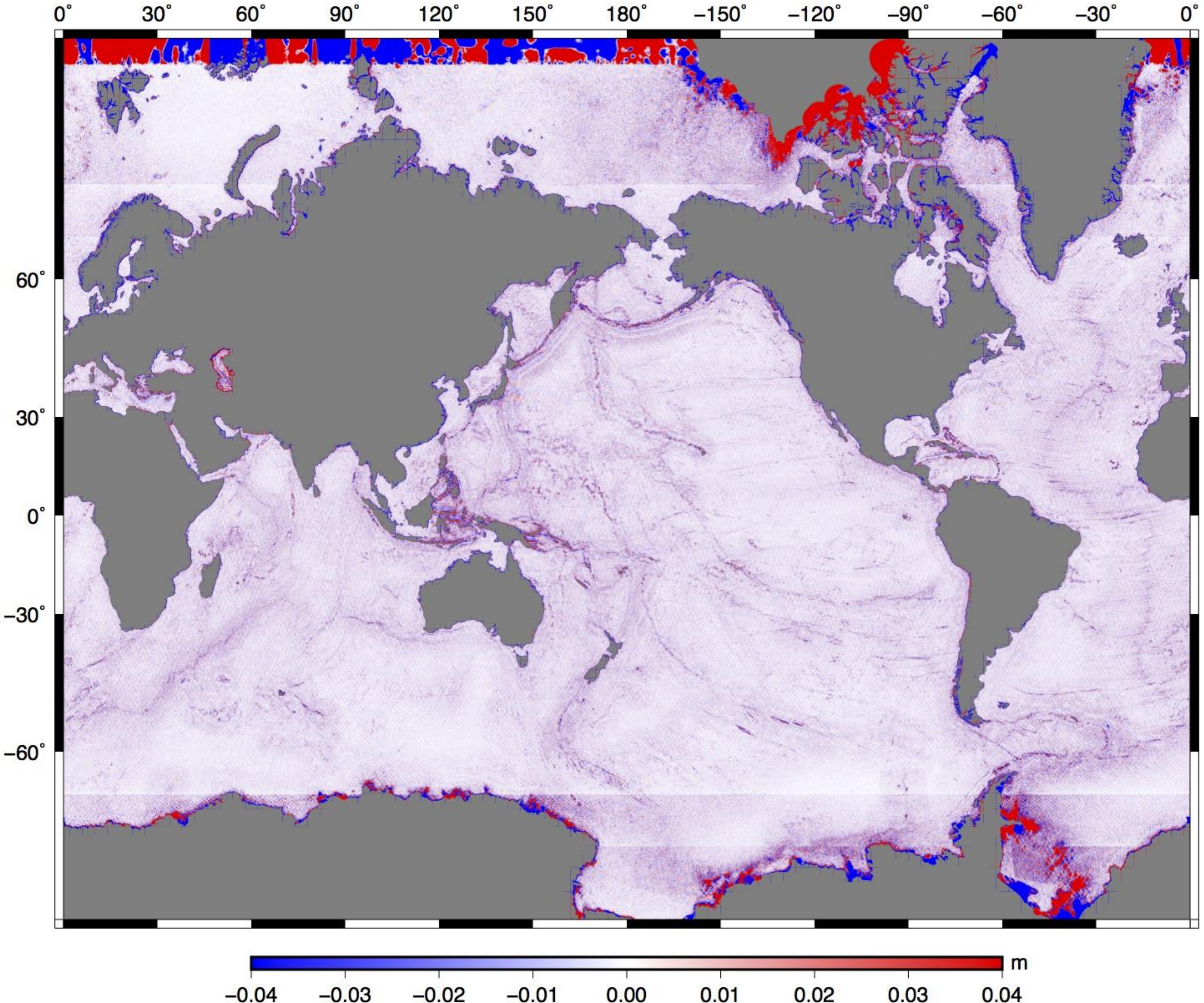


Attributes of SIO slope data

- Two-pass waveform retracking of Geosat-GM, ERS-1, Envisat, Jason-1, Cryosat-2, and SARAL/AltiKa.
- Identical filters are applied to all data. (0.5 gain at 10 km wavelength.)
- No corrections except for ocean tide **high precision but low accuracy**.
- Slope correction is applied to all data.

CLS_SIO minus CLS_2015

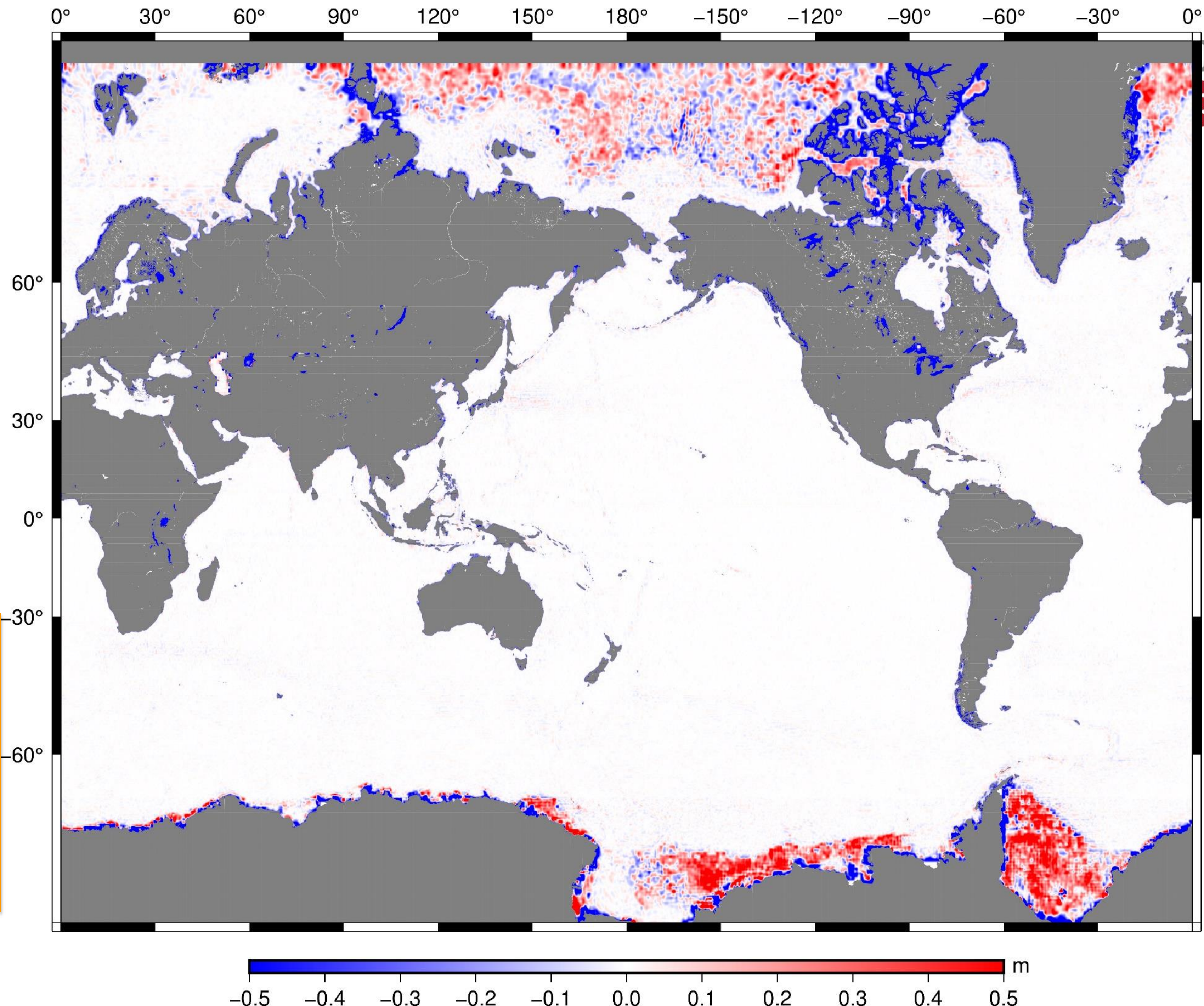
Slope data add short wavelengths



CLS_MP minus CLS_2015

both include SIO slopes

The CLS mean profile data are very close to the CLS_2015 grid.

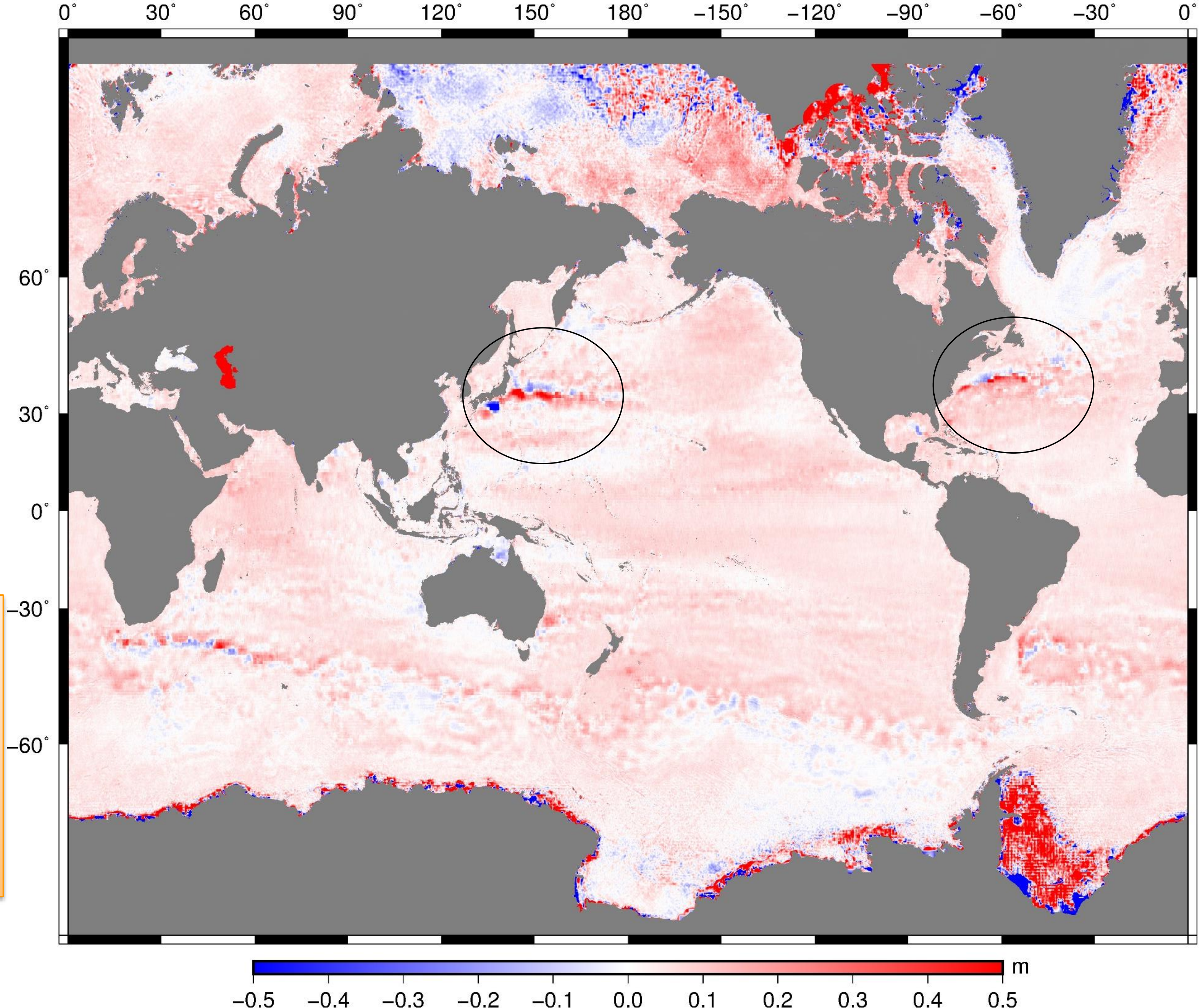


Phil Schaeffer says: each observation (1 Hz) is corrected from a spatial and temporal interpolation of the MSLA (Map of SLA) DUACS above the MSS (CLS2015).
HMP=(∑(SSH(t) – MSLA(t))-MSS15))/NbCycle (eq 1)
that's what gives a comparable mean ocean content even though we have different time periods!

RADS_S3 minus CLS_2015

both include SIO slopes

Positive difference due to the reference period of MSS (year 2003.0) and Sentinel data are obtained after year 2017.



What are the advantage of S3 data?

- Sentinel-3 data are all SAR acquisitons
- Has higher along track resolution and range precision than conventional altimeters
- Better coastal coverage

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

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

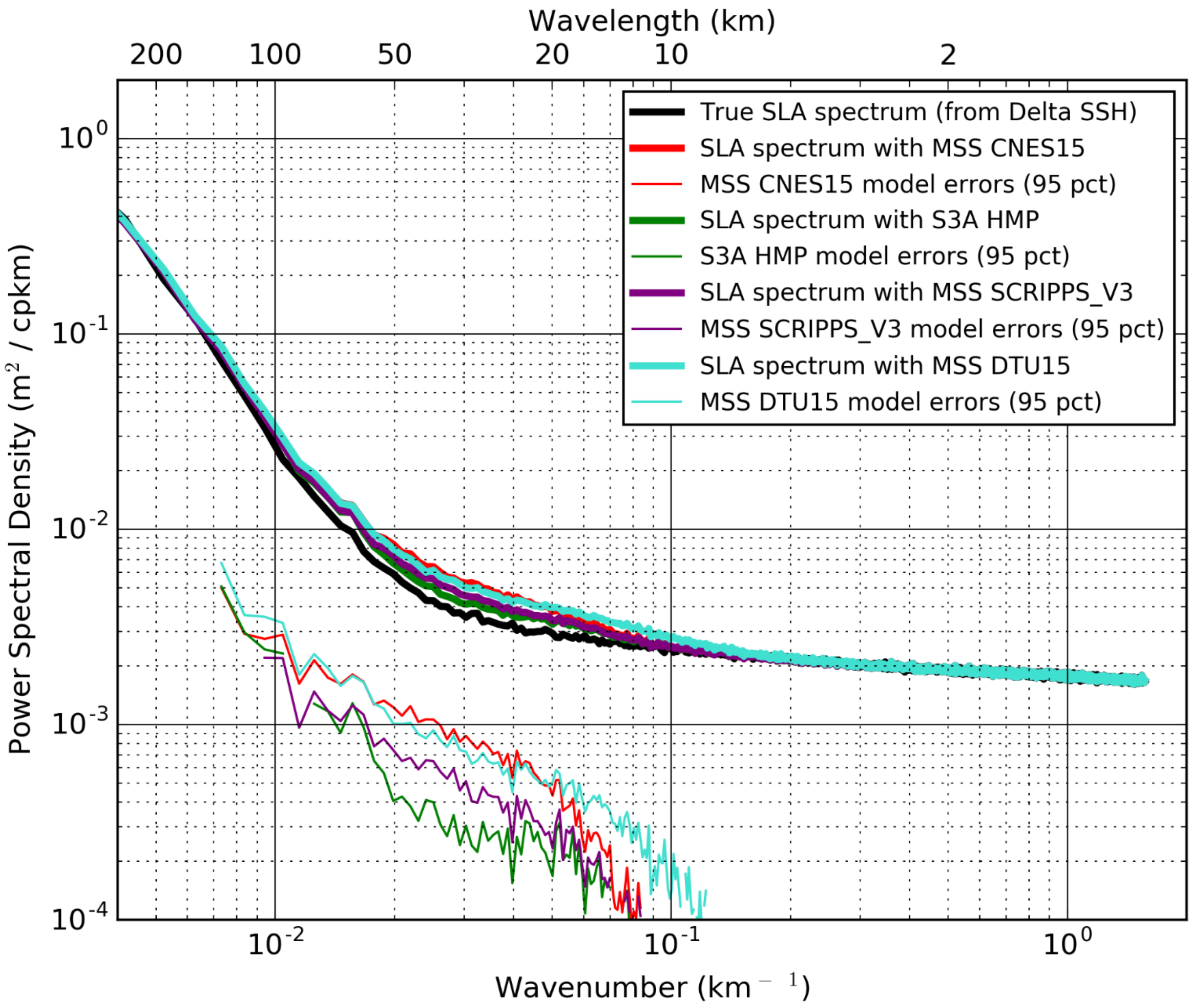
Mean spectral content of the h signal

Mean spectral content of the h+e signal

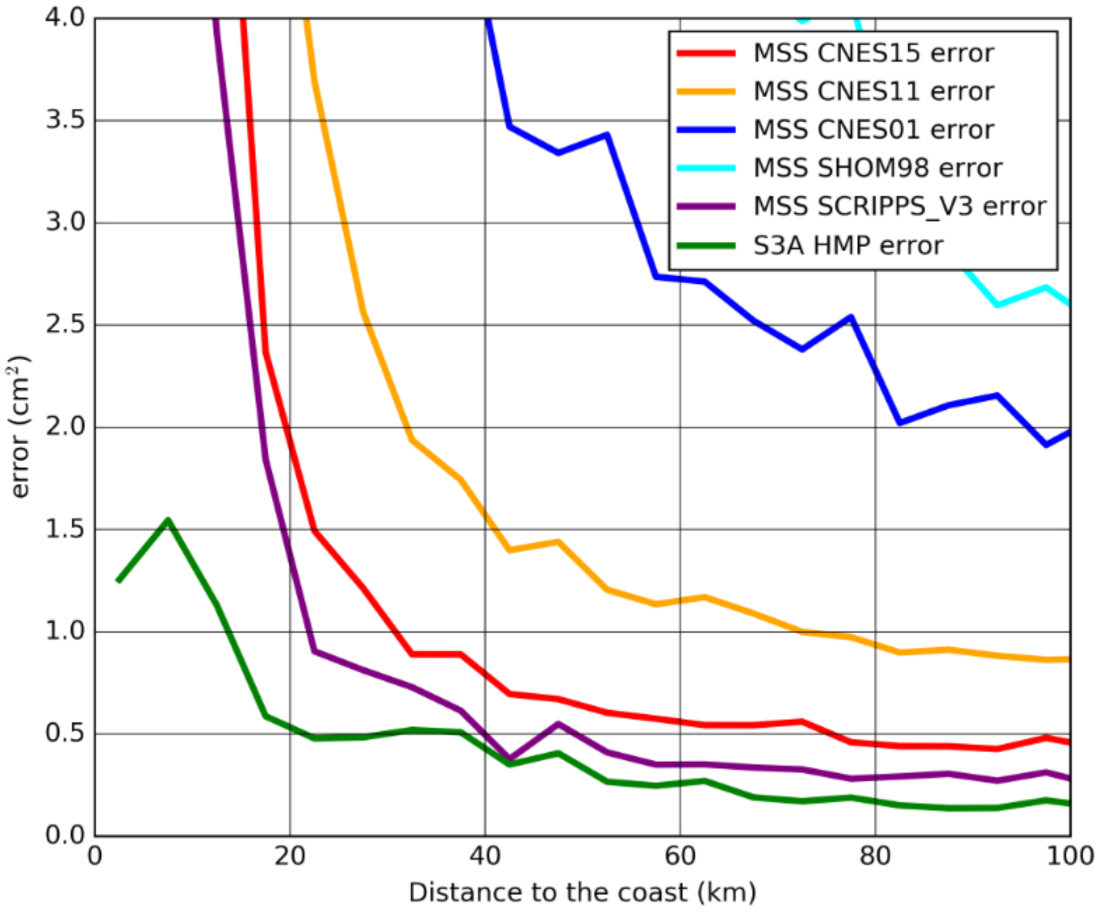
Pujol et al (JGR 2018; https://doi.org/10.1029/2017JC013503*)*

Assessment using S3A 20 Hz SAR data (not included in MSS)

Mean global SLA power spectral density (PSD) along S3A tracks when different MSS models are used.



Assessment near the coast using S3A 20 Hz SAR data



Error of the MSS along Sentinel-3A tracks (not used in these MSS) as a function of the distance to the coast (Latitudes > 60° are excluded).

New observations like S3A show improvements that can expected, especially near the cost !

Future actions

- Construct mean profile data from RADS to compare with the mean profile data from CLS.
- Apply the slope correction to the mean profiles.
- Investigate the SWH smoothing wavelength for the 2-pass retracking.
- Tune the biharmonic gridding – cell size, weights for height/slope data.
- Three MSS products: DTU2020MSS, CLS_SIO_2020, RADS_SIO_2020.

Remarks

- SWOT will require a MSS having both high accuracy and high spatial resolution.
- The slope correction is needed for SWOT and also for estimating dynamic topography using the new GOCE geoid models.
- Re-processed high-rate altimetry data and applied optimal filter to suppress noise and preserve desired (>10 km) wavelengths.
- Sentinal-3 data is a big asset and will be used for the new MSS development.
- SIO approach uses ERM mean profiles to constrain large scales (> 50 km) and the GM slope profiles to constrain small scales.
- DTU is working on mean profiles from 2-pass retracked recent (2009 -- now) satellite altimetry data from various missions to derive the DTU2020MSS.

The END !