Mean Sea Surface (MSS) for SWOT

SIO
David Sandwell
Yao Yu
Hugh Harper

CLS/CNES
Philippe Schaeffer
Yannice Faugere
Isabelle Pujol
Gerald Dibarboure
Nicolas Picot

DTU
Ole Andersen
Per Knudsen
Adeli Abulaitijiang
Shengjun Zhang

NOAA
Eric Leuliette
Walter Smith

- Need high resolution MSS for CAL/VAL early in the mission.
- MSS should have long wavelength accuracy from multidecadal repeat-track altimetry (ERM) and short wavelength precision from geodetic mission (GM) phases.
- MSS should vary with time as sea level rises.

MSS(time) for SWOT

MSS(t) = high spatial resolution MSS

+ low spatial resolution MSS (t)

Three groups working on MSS(t) for SWOT:

1) CLS constructs MSS2022 = MSS CNES_CLS2021 plus MSS LEADS in Arctic area.

2) SIO adds short wavelength MSS from double retracked SSS data.

3) DTU develops independent MSS (DTU21), with Arctic focus, and adds lower spatial resolution MSS(t).

MSS(time) for SWOT

Three presentations:

- High spatial resolution MSS (Sandwell – US; Schaeffer – EU)
- Assessment of errors in MSS models (Schaeffer)
- Adding long-wavelength, time - dependent MSS (Andersen)

- Discussion:
  - How important is adding MSS(t)?
  - Would a mean sea surface slope model be useful (along- and cross-track slope)?
  - Does one the MSS need to be embedded in the SWOT product?
  - Will SWOT measure the nadir SSH or the closest reflection SSH?

High Resolution Mean Sea Surface for SWOT

Philippe Schaeffer – CLS
David Sandwell – SIO
Isabelle Pujol – CLS
Ole Andersen – DTU

Improve the shortest wavelengths using Hight Resolution data

- Goal is to improve wavelengths < 50 km
- Use of GM and drifting data, especially C2 & AltiKa filtered at 5 Hz (~1,4 km along track)

Collaborative analysis between CLS & Scripps

HR MSS determination => 2 ways : 2 different dataset and 2 mapping methods are used !

CLS (first step)

Removing oceanic variability

Mean Profiles = all ERM Missions (TP/J1/J2/J3 (& interleave), E2/En/Aka, GFO)

HR Data

Integration of: C2 + AltiKa: **one pass RTK + 5Hz filtering**

S3 => for validation

Observation

SSH – MSLA DUACS

Mapping

Optimal interpolation + noises budget (white & correlated) + noise optimal filtering

Scripps(second step)

Improving Short wavelengths

Based on CNES_CLS MSS for λ > 100 Km

HR Data

Integration of: Geosat/J1/J2/En + C2 + AltiKa + S3 **: two-pass RTK + 5 Hz filtering**

Observation

SLOPE combined with **HEIGTH**

Mapping

Biharmonic splines in tension

SSH – MSLA DUACS : the treatment of the oceanic variability

- MSS CLS construction characteristics => **correct each observation for oceanic variability by space-time interpolation of SLA (Map of SLA DUACS = 1 map /day)**

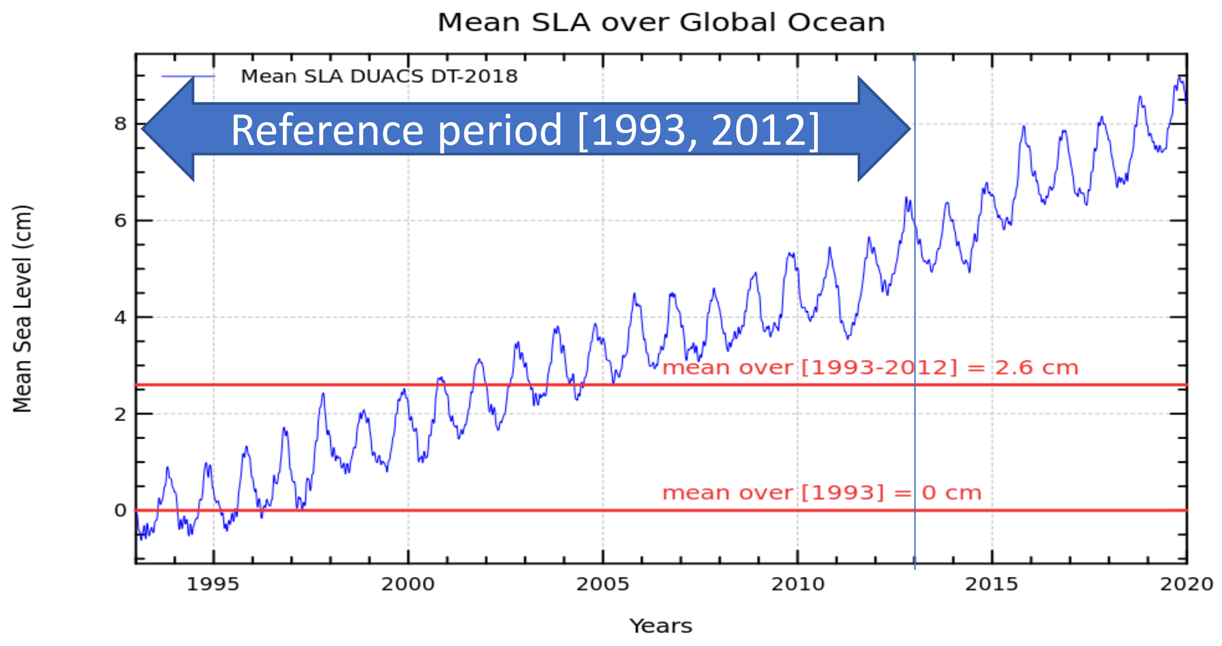
  1. Remove (large and meso-scale) seasonal and interannual oceanic variability
  2. Remove Sea Level Trend (referenced at an arbitrary time / **mid-1993**)

  } Provided by Mean Profiles (1Hz)

  3. obtain an optimal compromise between mean oceanic content and high-resolution topographic structures

  } Provided by C2 & AltiKa

- **goal is to converge towards the "steady state" of the ocean**



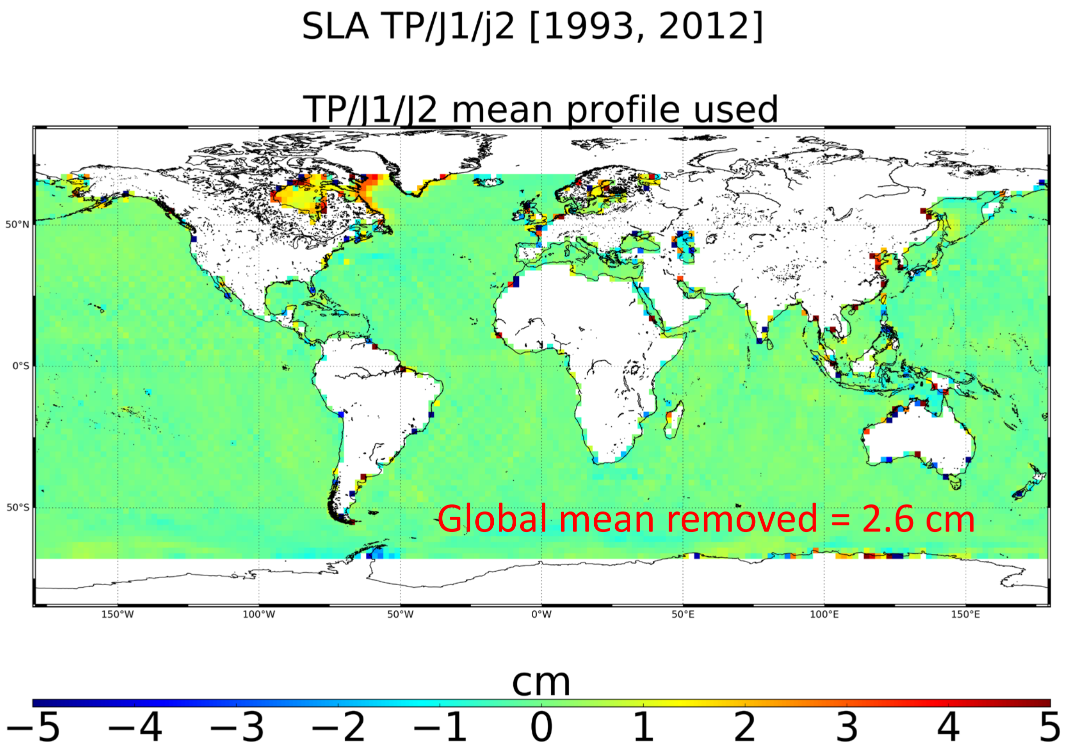
- DUACS uses the 20y reference period [1993, 2012]
- **DUACS convention : $< SLA_{20y} >_{1993} = 0$**
- $< SLA_{20y} >_{20y}$ = Cst value that represents of the MSL increase over the 20y reference period

- **Mean SLA over the reference period should be close to 0 (or constant value for DUACS convention) ≈ "steady state"**

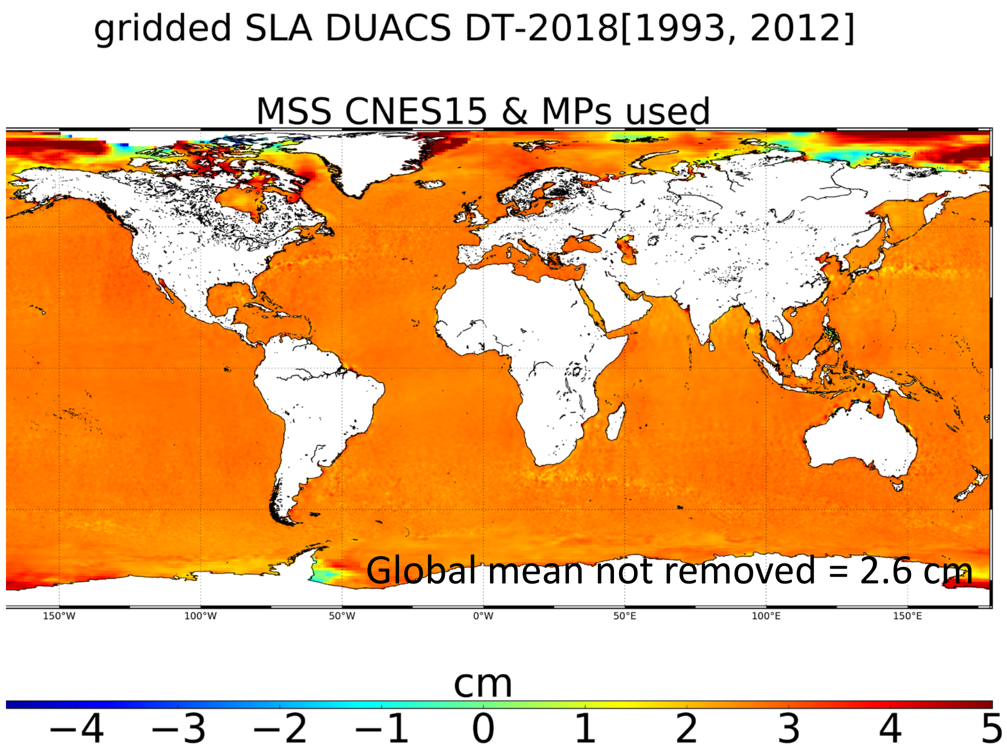
SSH – MSLA DUACS : the treatment of the oceanic variability

- Mean SLA over the reference period should be close to 0 (or constant value for DUACS convention)

Boxed mean SLA TP/J1/J2 over the MSS reference period [1993, 2012]



Mean of multi-mission DUACS gridded products the MSS reference period [1993, 2012]

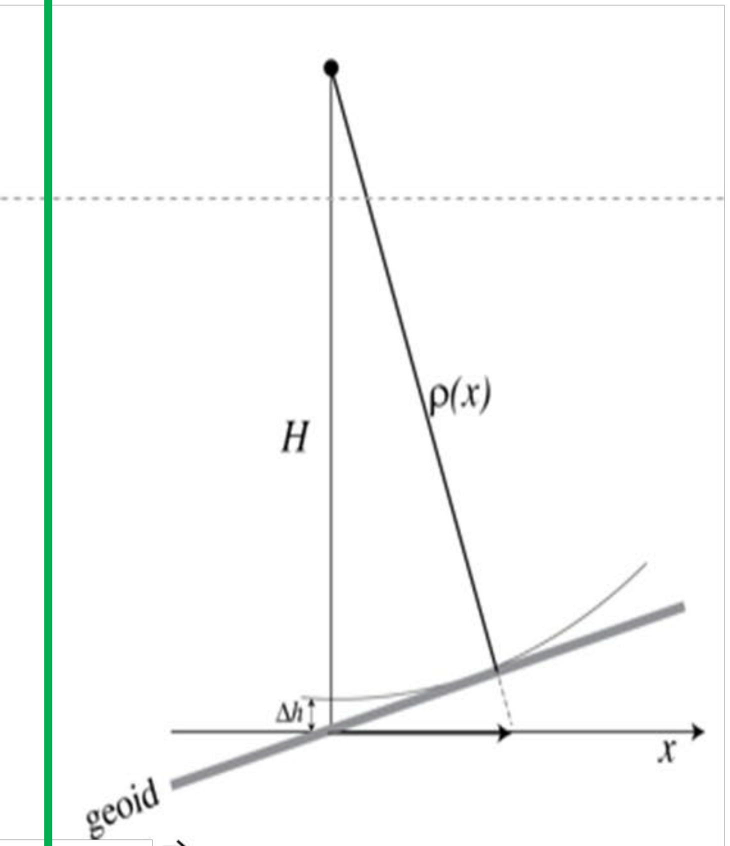


- **nearly cst map as expected => This means that an average calculated over 20 years brings us closer to the steady state !**

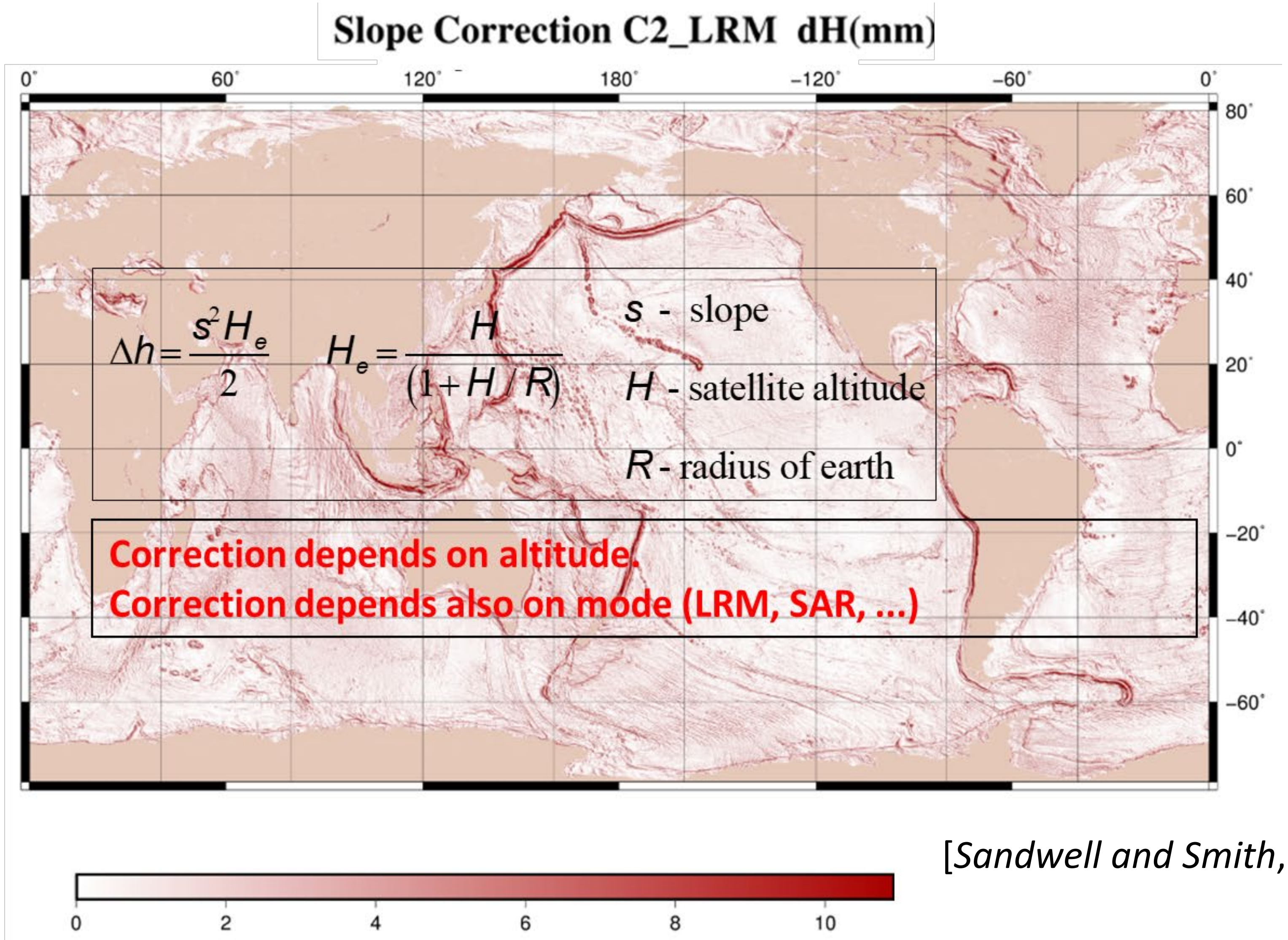
Rq: mapping method of SLA is limited in high latitude !

SWOT - MSS must be corrected for slope effect

- New MSS will result from a combination of **various altimeter** that are not affected in the same way by the slope of the sea surface.



$\vec{x}$: in direction of the maximum slope (from nadir)



$$\Delta h = \frac{s^2 H_e}{2} \qquad H_e = \frac{H}{(1 + H/R)}$$

s - slope

H - satellite altitude

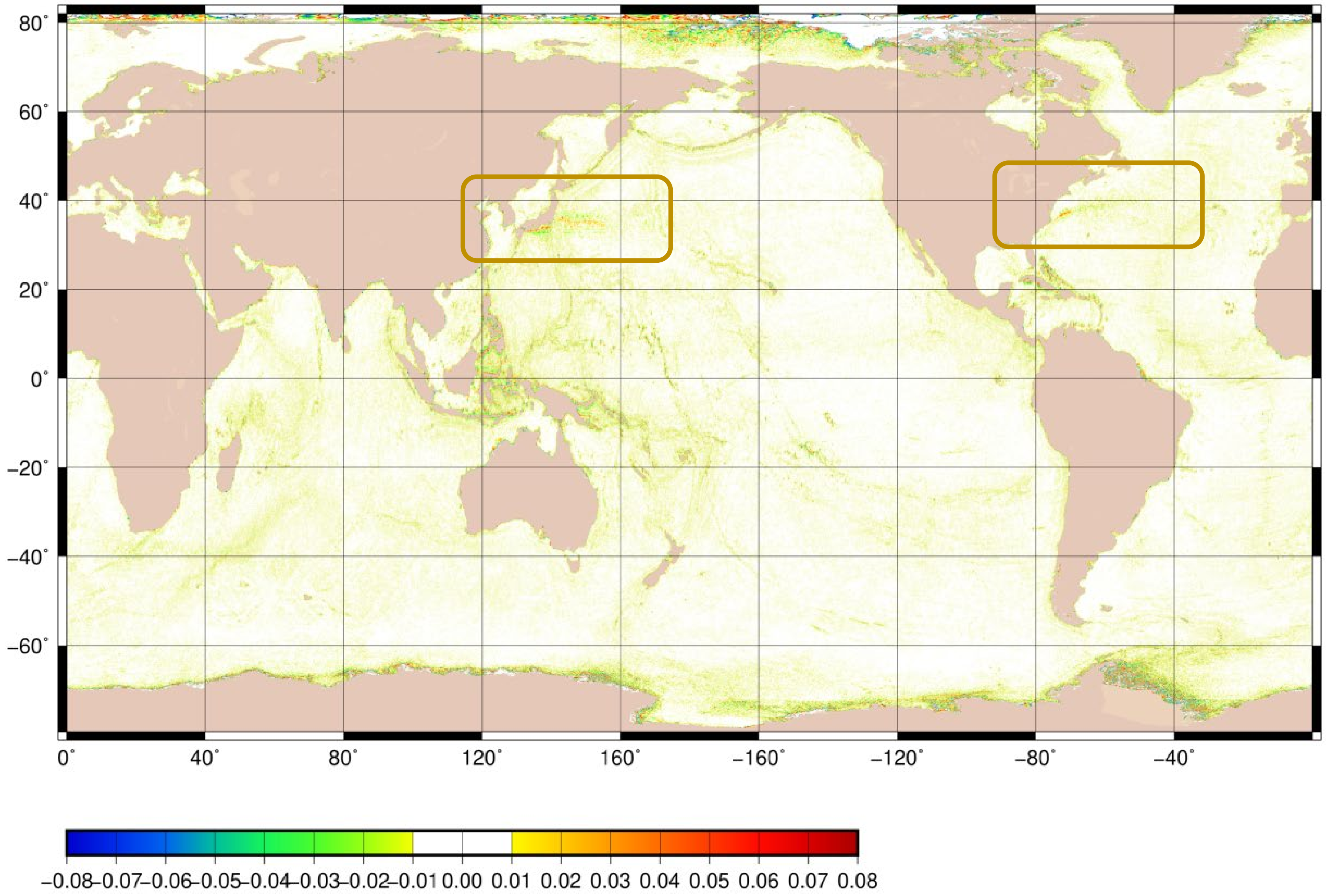
R - radius of earth

Correction depends on altitude.
Correction depends also on mode (LRM, SAR, ...)

[*Sandwell and Smith*, 2014]

Differences between HR MSS

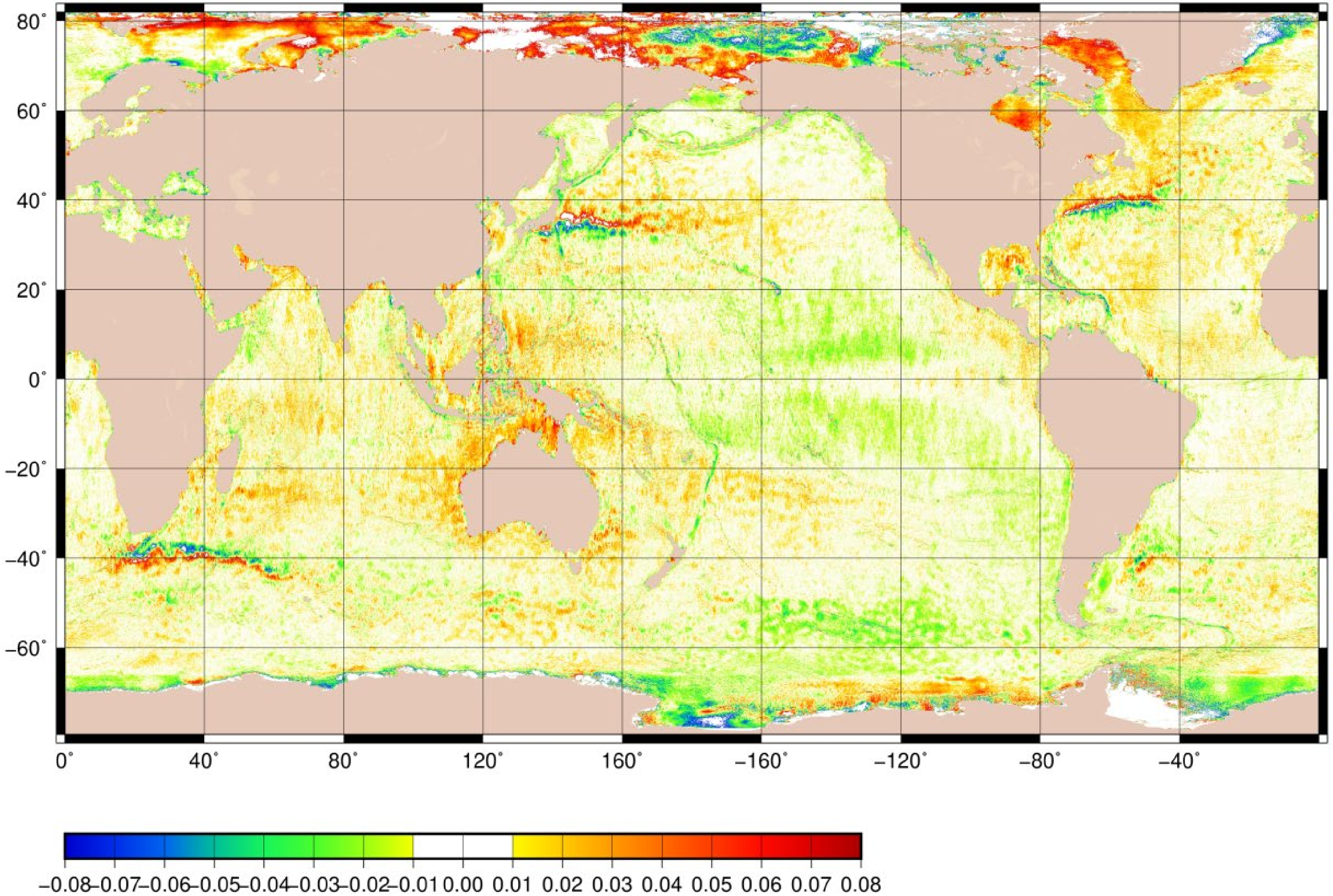
Scripps_CLS22 (S3) – CNES_CLS22 dH(m)



- These two solutions are very close.
- Differences in amplitude of 1 to 2 cm appear along the geophysical structures that suggest more HR for Scripps model.
- There is a slight impact of ocean variability on areas of strong currents.

Differences between HR MSS

Scripps_CLS22 (S3) – DTU21 dH(m)



- These two solutions remain close in terms of short wavelength content.
- The difference due to the oceanic variability is more significant.

Differences between HR MSS

- Differences are calculated on grids at 1 min resolution.

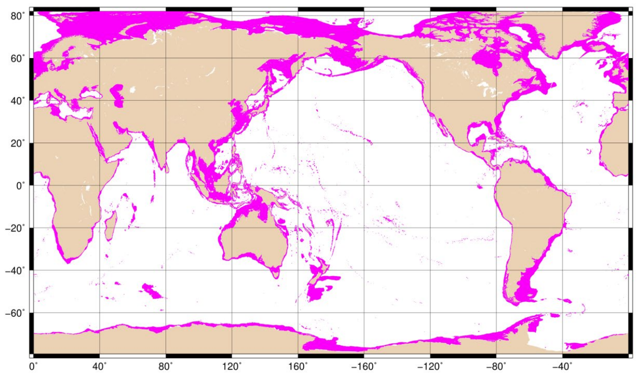
Bathy > 1000 m

Diff	Nb Points	Mean (cm)	Std (cm) [3σ]
Scripps – CLS	119 439 521	0,06	0,80
CLS - DTU	118 365 843	0,09	1,38
Scripps – DTU	118 861 025	0,02	1,46

Bathy < 1000 m

Diff	Nb Points	Mean (cm)	Std (cm) [3σ]
Scripps – CLS	12 542 354	0,63	3,38
CLS - DTU	12 599 451	0,40	4,99
Scripps – DTU	12 535 188	-0,25	5,22

Pts Involved => Bathy > −1000 m p(1/60)



- The low values of the averages imply that these MSS are "centered" and therefore consistent in term of Sea Level Rise.
- The standard deviation values show that these MSS are close in terms of high-resolution content and also consistent with the expected accuracy of SWOT.
- We note a relative degradation of the accuracy near the coasts which remains one of the major difficulties concerning the processing of altimetric data.
- excluding latitudes higher than 60 degrees gives the same results

Conclusion

- The 3 MSS are "centered in time" and therefore consistent in term of Sea Level Rise.
- In open ocean: MSS are close in terms of high-resolution content and consistent with the expected accuracy of SWOT
- Less consistence near the coast …

WG MSS recommendation

- The joint use of the SCRIPPS-CLS and DTU MSS for the Cal/Val SWOT activities can allow to decorrelate the imperfections linked to the MSS and to these of SWOT data.

Please look at: Assessment of errors in MSS models presentation for further comparisons