Evaluation of 3D SSB models on Jason-1 and Envisat time-series: 2002-2009

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Overview: SSB solutions

- Development of 3D SSB (SWH, Ualt, Tm) to better model SSB behavior with improved description of the sea state.

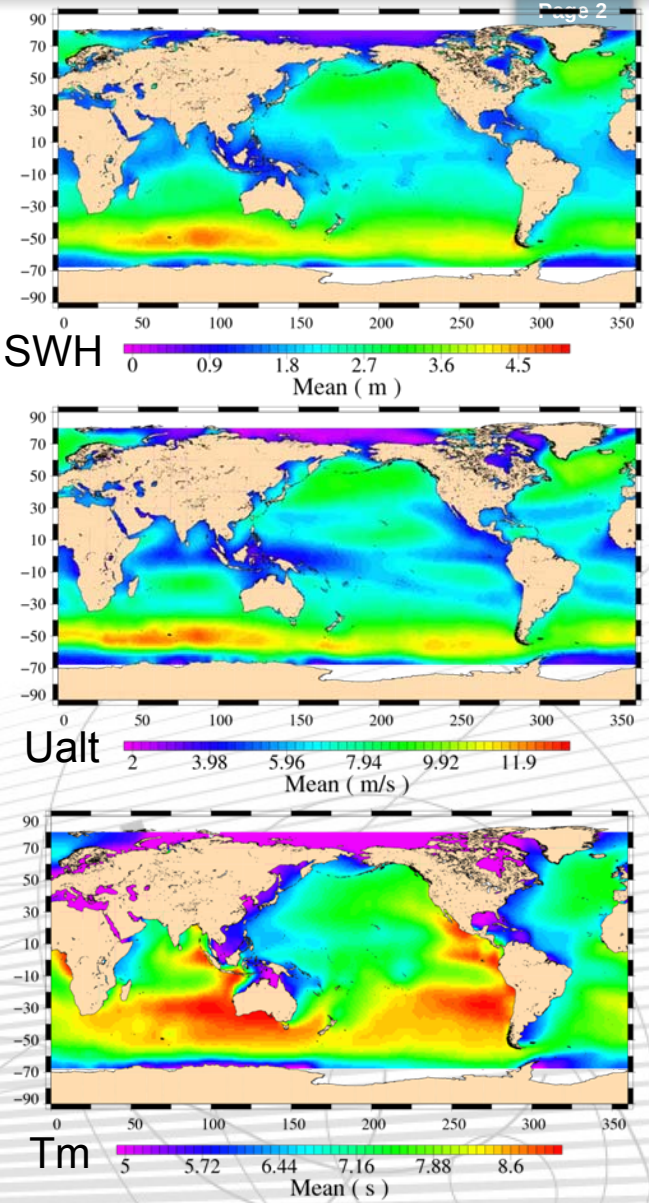
- Tm : mean wave period from a numerical wave model (WAVEWATCH-III, v3.14b released in 2009, [Tolman, 2002] used operationally at NOAA/NCEP).

- WW-III predictions provided on a global 1°x1° grid at a 6 hourly time step, and forced with synoptic winds from ECMWF. Runs performed at the UNH (2001-2010 available).

- 3D SSB model computed with direct method based on SLA [Vandemark et al, 2002] from 2-year dataset (2002-2003 for Jason-1 and 2006-2007 for Envisat).

- 2D SSB models used for comparison are operational versions (Jason-1 GDR_C, Envisat reprocessing v2.1).

method	Jason-1	Envisat
2D SSB	collinear ΔSSH (10-day)	crossover ΔSSH (≤10-day)
3D SSB	direct SLA	direct SLA



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1. Model comparison criteria:

    - Maps of SSB differences
    - Variance reduction of crossover SSH differences
    - Variance reduction of collinear SSH differences
    - Variance reduction of along track SLA
    - Coastal SLA (<100 km)

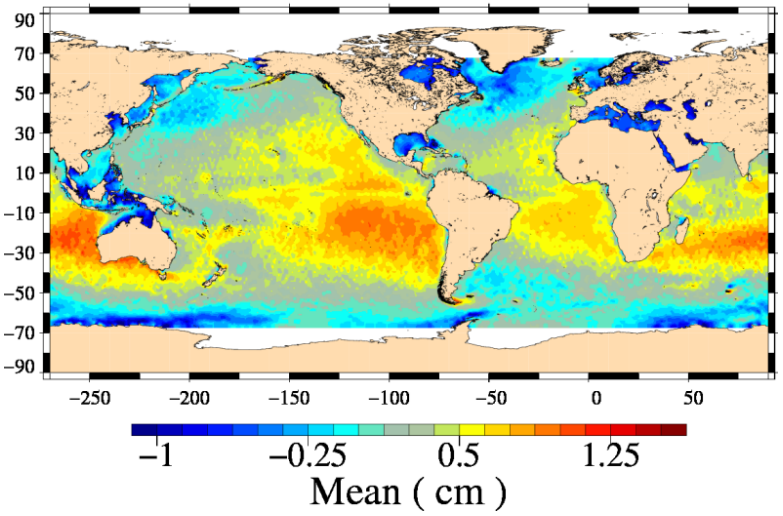
2. MSL impact:

    - Global trends
    - Regional trends
    - Comparison with tide gauges data

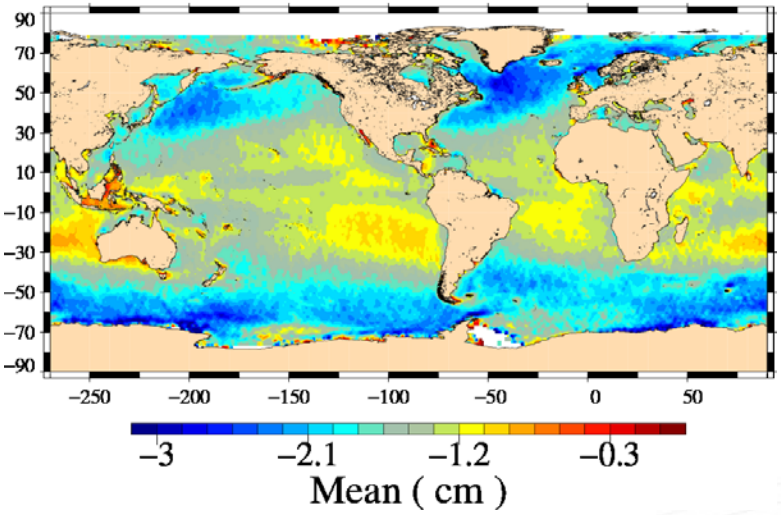
3. Summary & Conclusions

Comparison 3D vs 2D SSB

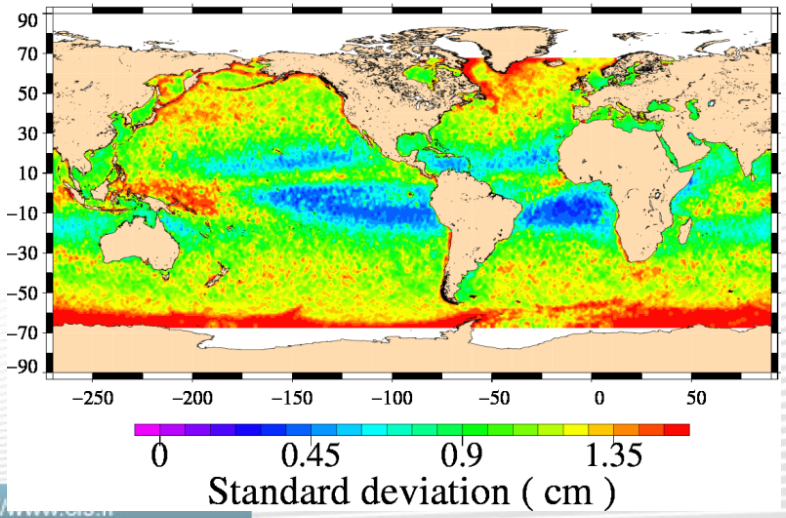
Mean of 3D SSB – 2D SSB
Mission j1, cycles 1 to 293



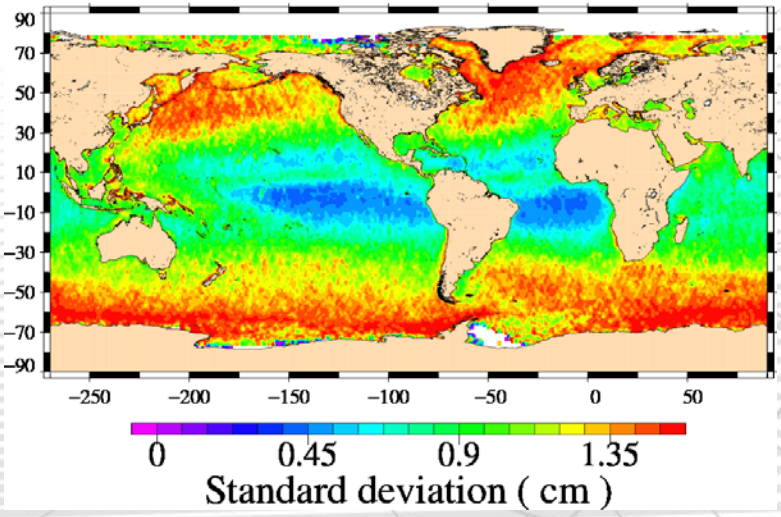
Mean of 3D SSB – 2D SSB
Mission en, cycles 9 to 83



Standard deviation of 3D SSB – 2D SSB
Mission j1, cycles 1 to 293

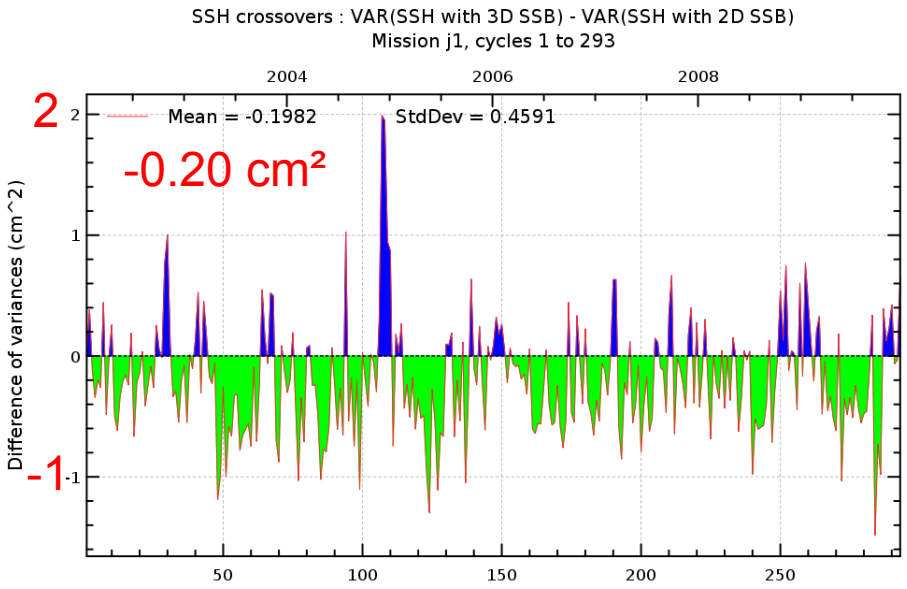


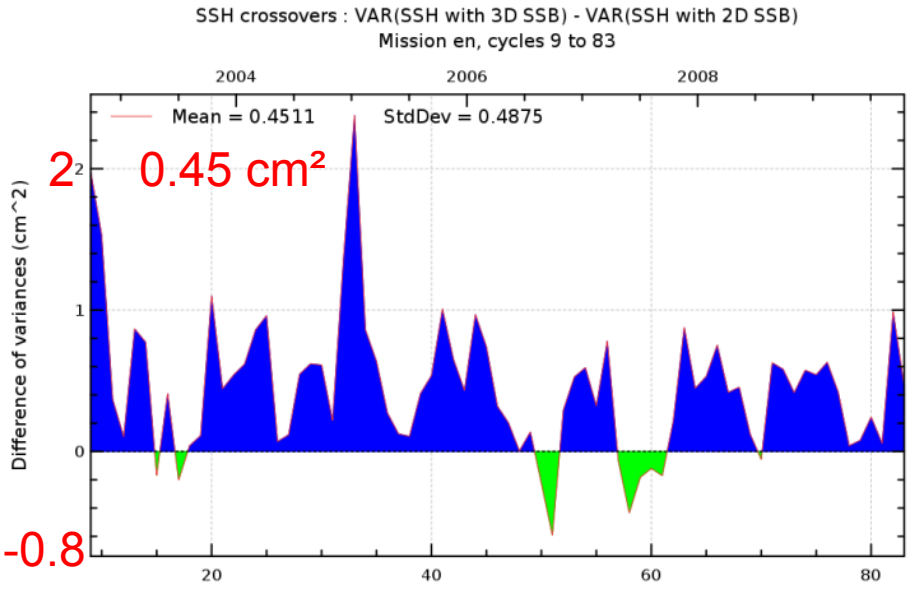
Standard deviation of 3D SSB – 2D SSB
Mission en, cycles 9 to 83



Crossover SSH differences (1/2)

Jason-1 (≤10-day) & Envisat (≤10-day)



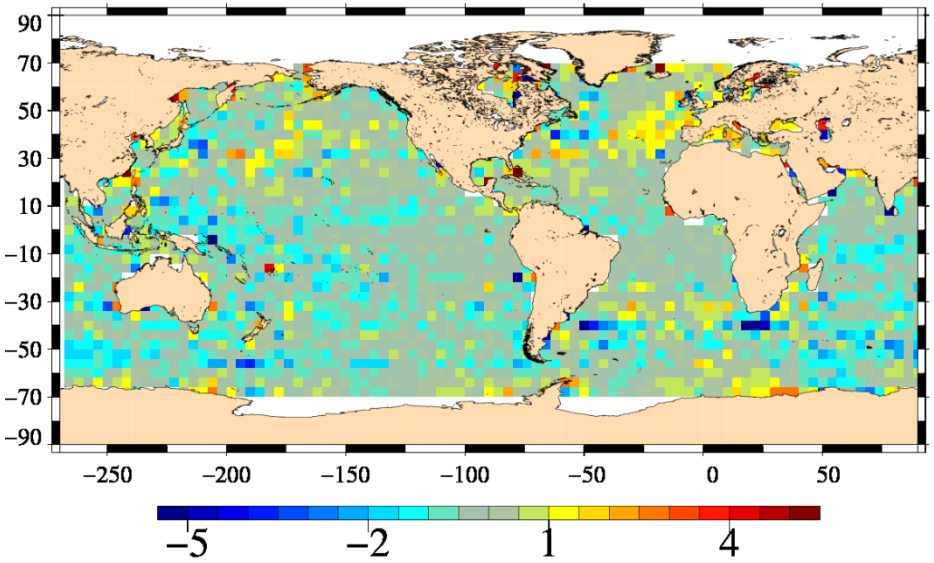


- Selection of crossover SSH differences with ΔT ≤10 days to reduce the effect of the oceanic variability.
- Results are different for Jason-1 and Envisat.
- Slight reduction in variance for Jason-1 but degraded performances are observed for Envisat. Difficult to conclude on such results.

Crossover SSH differences (2/2)

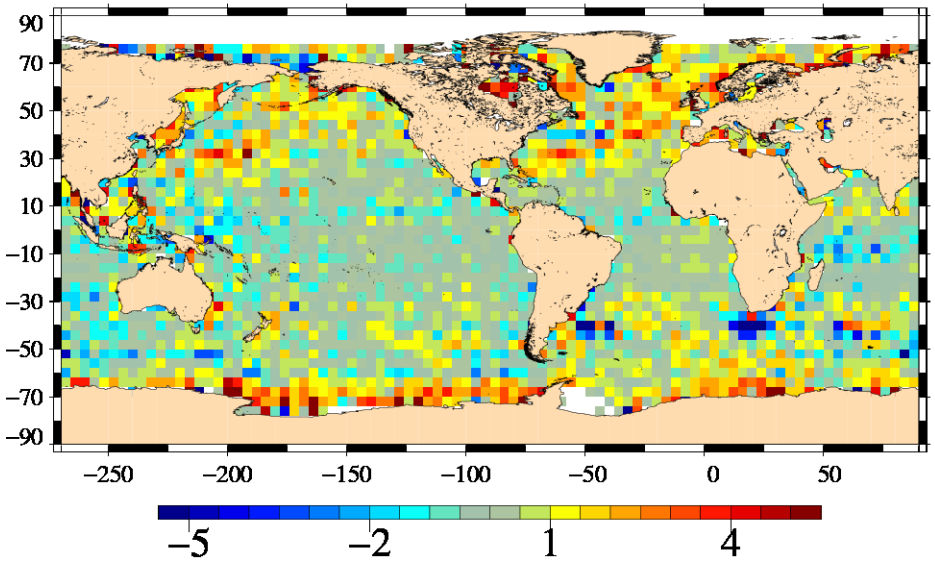
Jason-1 (≤10-day) & Envisat (≤10-day)

VAR(SSH with 3D SSB) – VAR(SSH with 2D SSB)
Mission j1, cycles 1 to 293



SSH crossovers : difference of variances (cm^2

VAR(SSH with 3D SSB) – VAR(SSH with 2D SSB)
Mission en, cycles 9 to 83



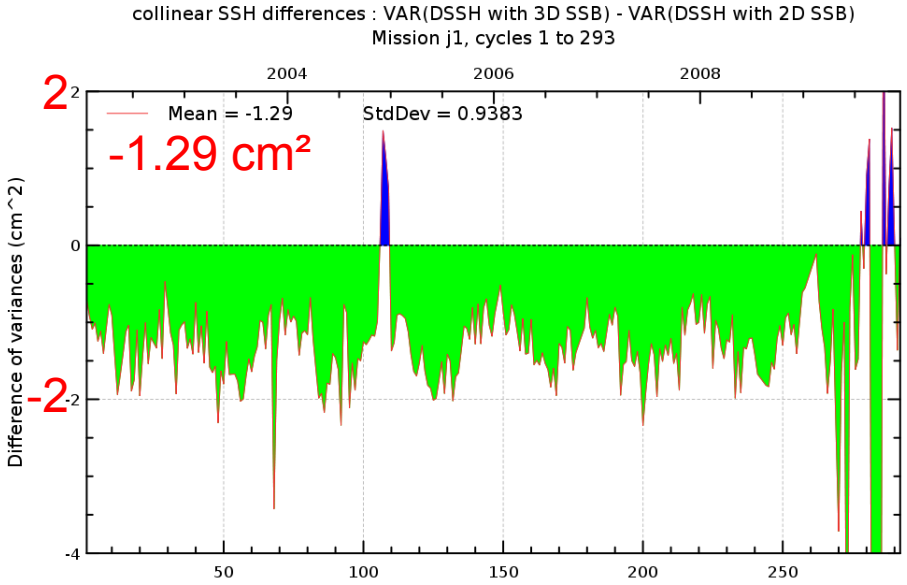
SSH crossovers : difference of variances (cm^2)

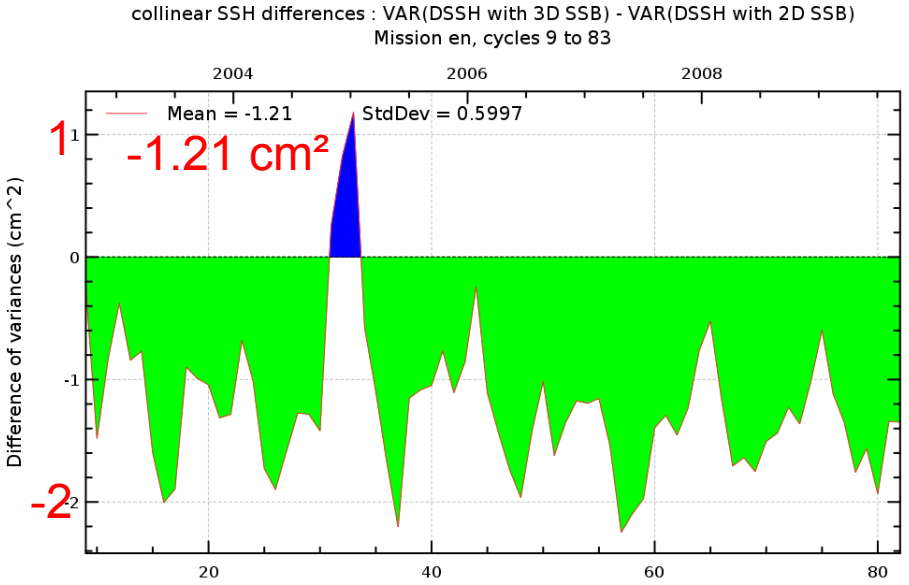
- No highlight of particular area for Jason-1

- For Envisat, degradation occurs in regions marked with yellow-red colors (larger occurrences in polar areas. Is it related to sea-ice contaminated data flagging, Tm estimates in such areas, or use of CLS01 MSS in 3D SSB model development ? Investigation to do).

Collinear SSH differences (1/2)

Jason-1 (10-day cycle) & Envisat (35-day cycle)



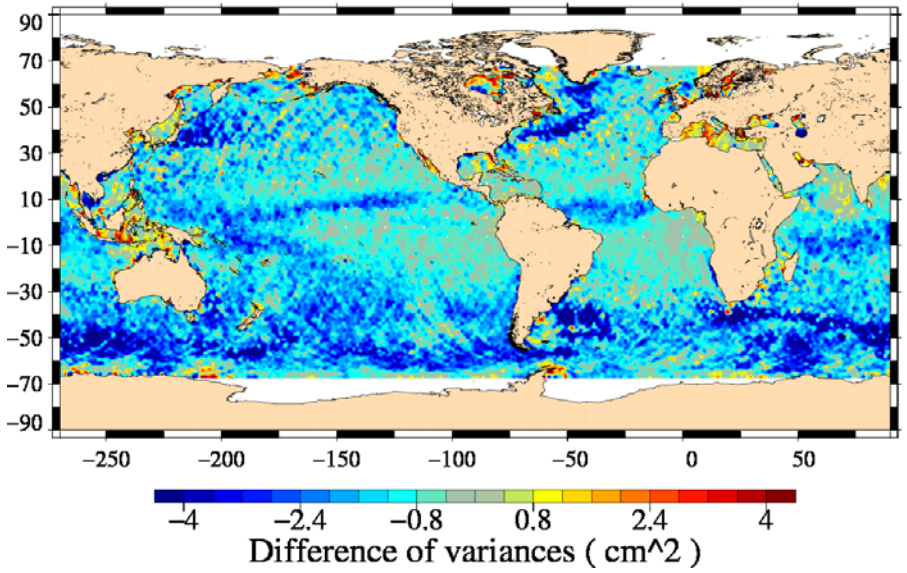


- Similar results for Jason-1 and Envisat.
- Variance reduction gains are around 1.25 cm². Lower gain during boreal winter. Note there are annual cycles on collinear SSH differences characteristics (mean and std).
- Improvements of the SSB correction with the 3D model at short temporal scales (< 2 months)

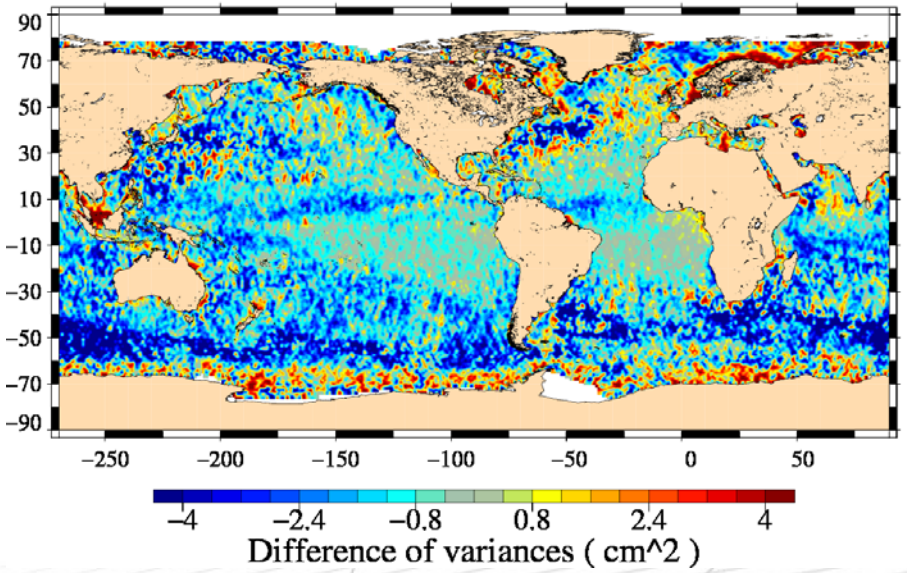
Collinear SSH differences (2/2)

Jason-1 (10-day cycle) & Envisat (35-day cycle)

VAR(col. DSSH with 3D SSB) – VAR(col. DSSH with 2D SSB)
Mission j1, cycles 1 to 293

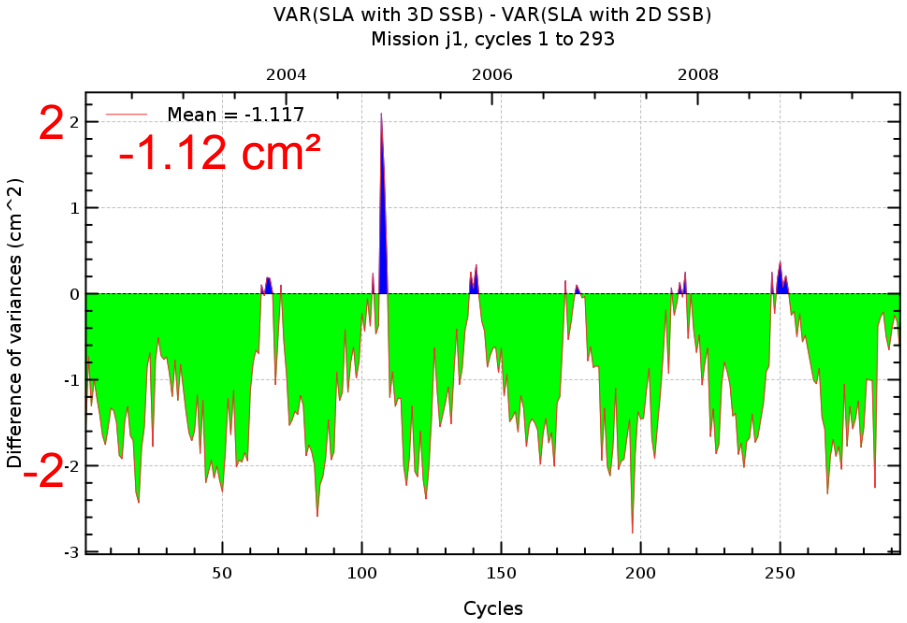


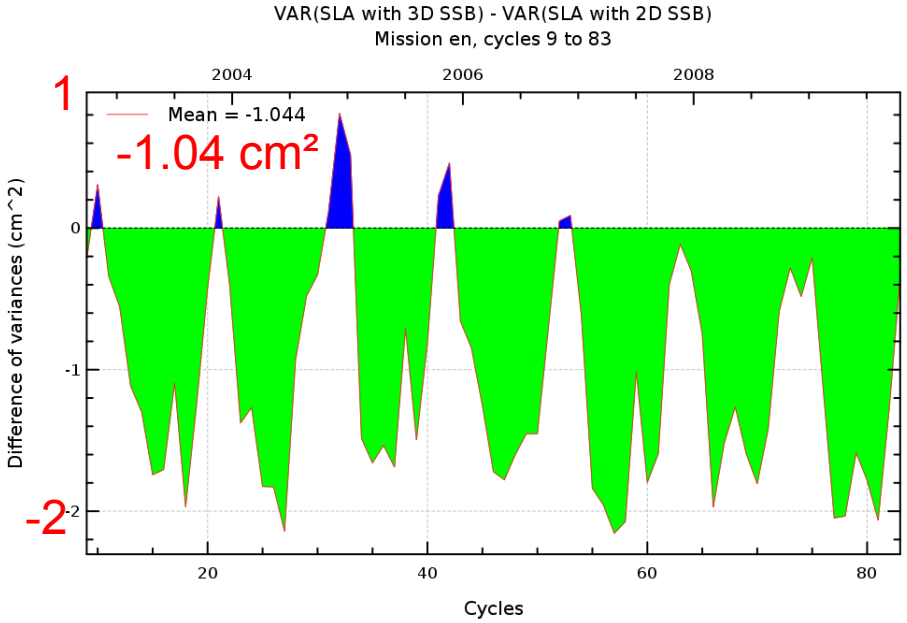
VAR(col. DSSH with 3D SSB) – VAR(col. DSSH with 2D SSB)
Mission en, cycles 9 to 83



- Similar features for Jason-1 and Envisat. Mostly same regions of high oceanic variability are impacted (improvement in blue).
- Some issues in polar regions for Envisat.
- Significant impact for mesoscale applications.

SLA / MSS CLS01 (1/2)





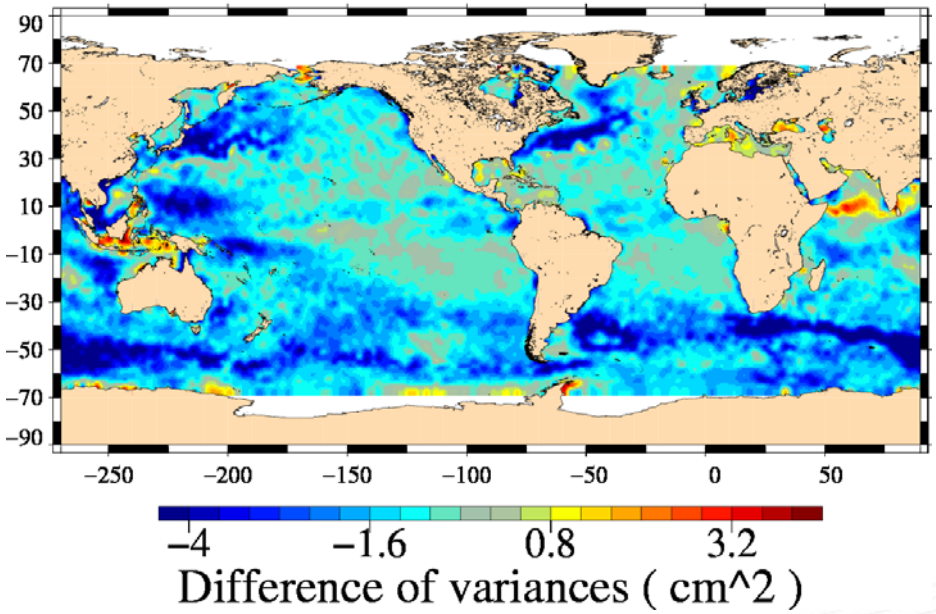
- Similar results for Jason-1 and Envisat.

- Variance reduction gains are around 1.08 cm². Lower gain during winter, some degradation occurs above 40°N. Note there are annual cycles on SLA characteristics (mean and std).

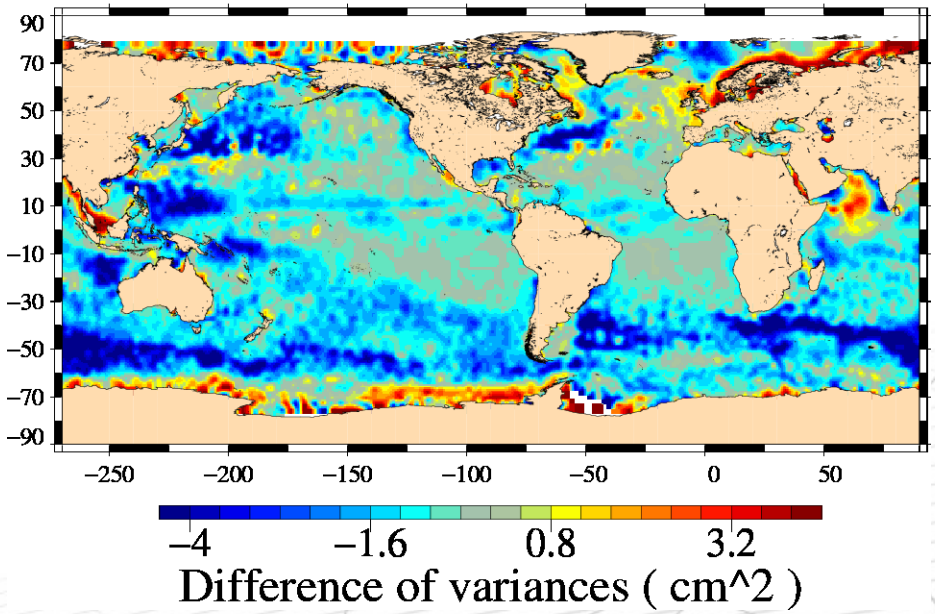
- Improvements of the SSB correction with the 3D model for SLA computation.

SLA / MSS CLS01 (2/2)

VAR(SLA with 3D SSB) – VAR(SLA with 2D SSB)
Mission j1, cycles 1 to 293

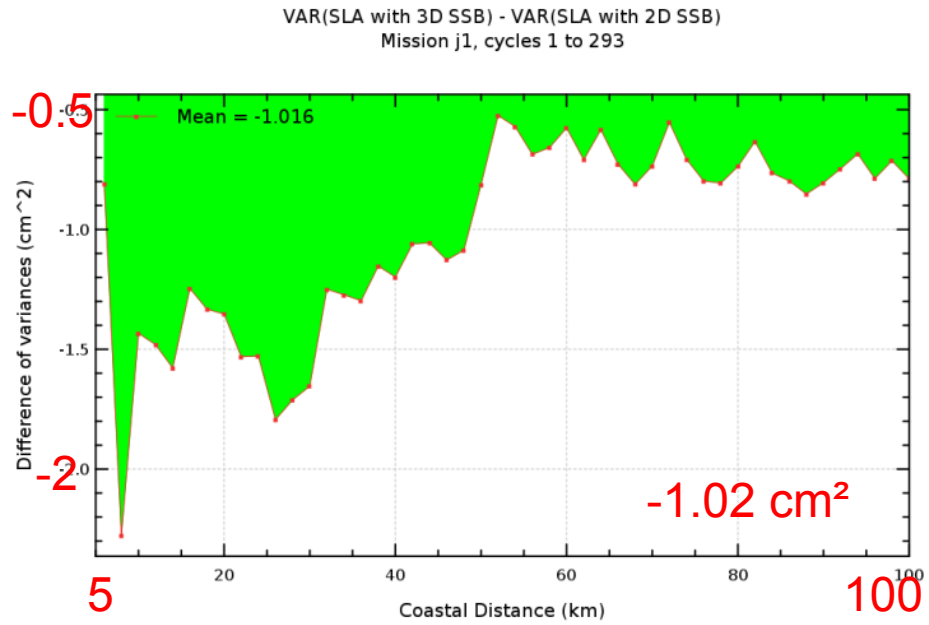


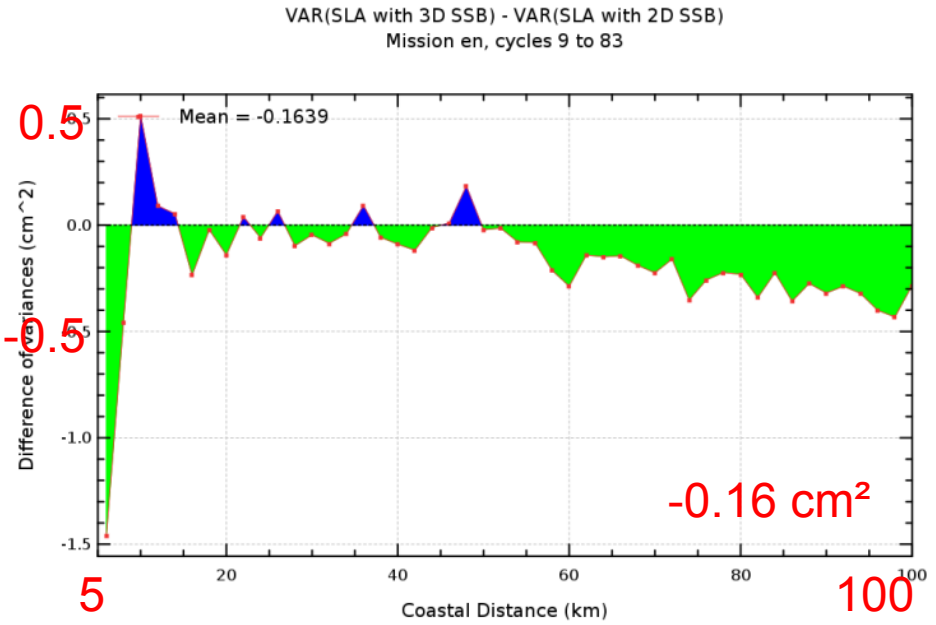
VAR(SLA with 3D SSB) – VAR(SLA with 2D SSB)
Mission en, cycles 9 to 83



- Similar features for Jason-1 and Envisat. Mostly same regions of high oceanic variability are impacted (improvement in blue).
- Some issues in high latitudes for Envisat to investigate.
- Significant impact for mesoscale applications.

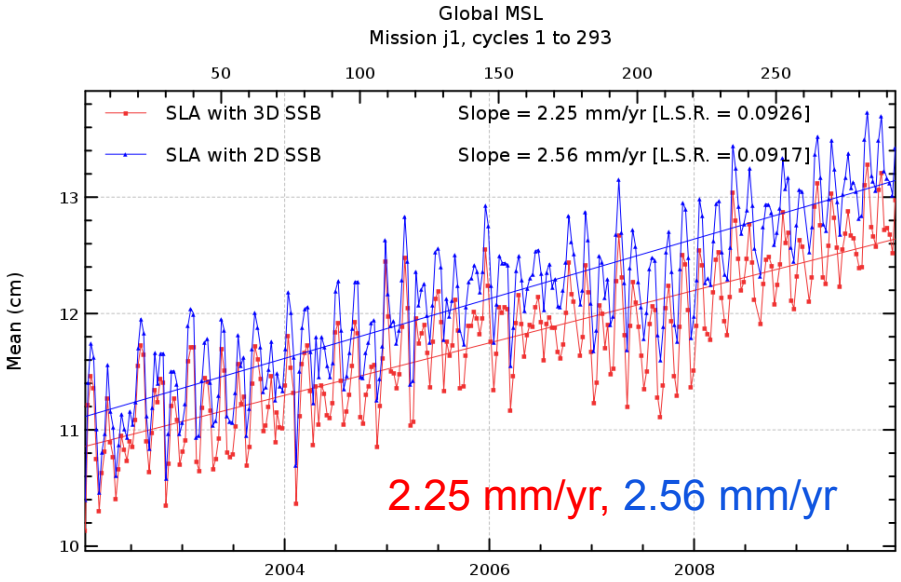
Coastal SLA

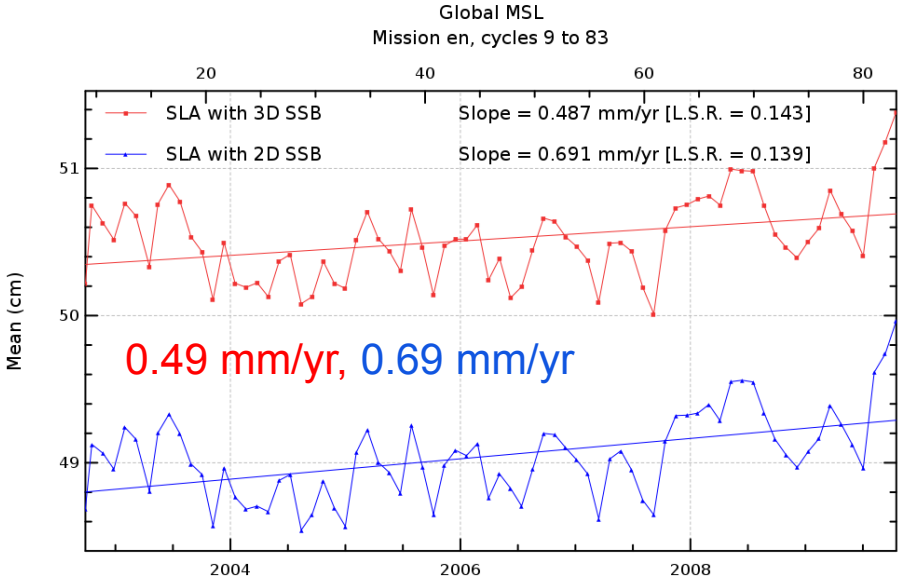




- Change in behavior around 50 km for the two missions.
- Larger variance reduction for Jason-1.

MSL impact: global SLA trends

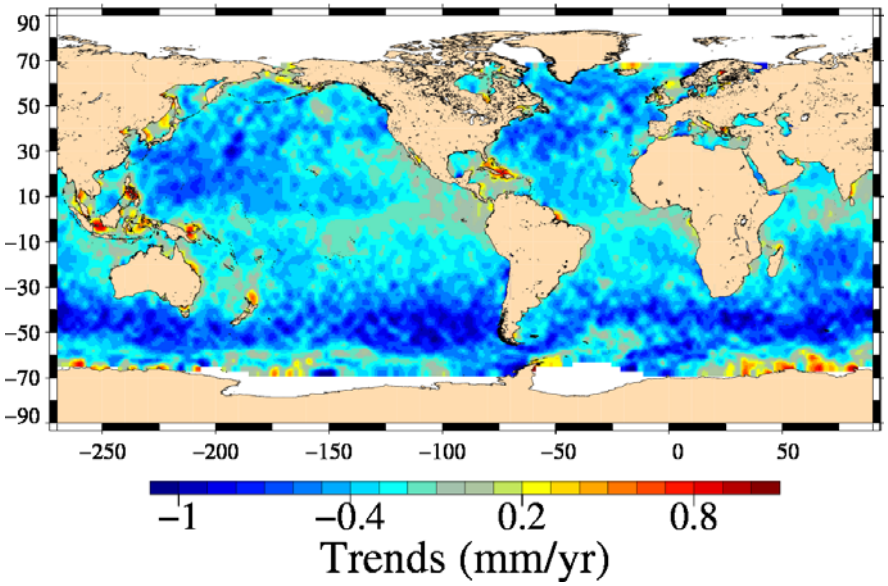




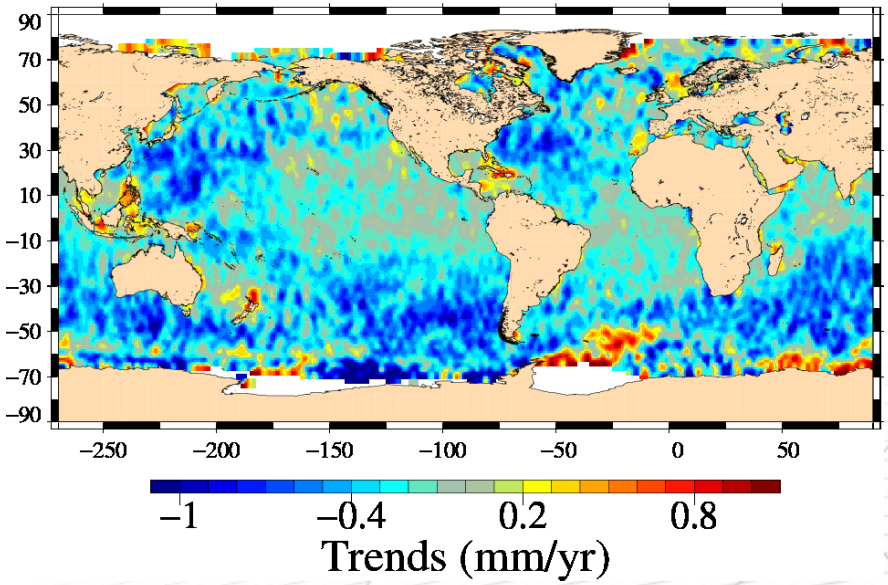
- Significant impact of the change of SSB model on long-term global sea level evolution
- Decrease of the trend by -0.31 mm/yr for Jason-1 and -0.2 mm/yr for Envisat
- Note that any instrumental drift on SWH, U, or Tm will change the linear SLA trend through SSB and we will need to correct for that error. If the drift comes from geophysical effects, the change in trend will be meaningful.

MSL impact: regional SLA trends

SLA with 3D SSB trends – SLA with 2D SSB trends
Mission j1, cycles 1 to 293

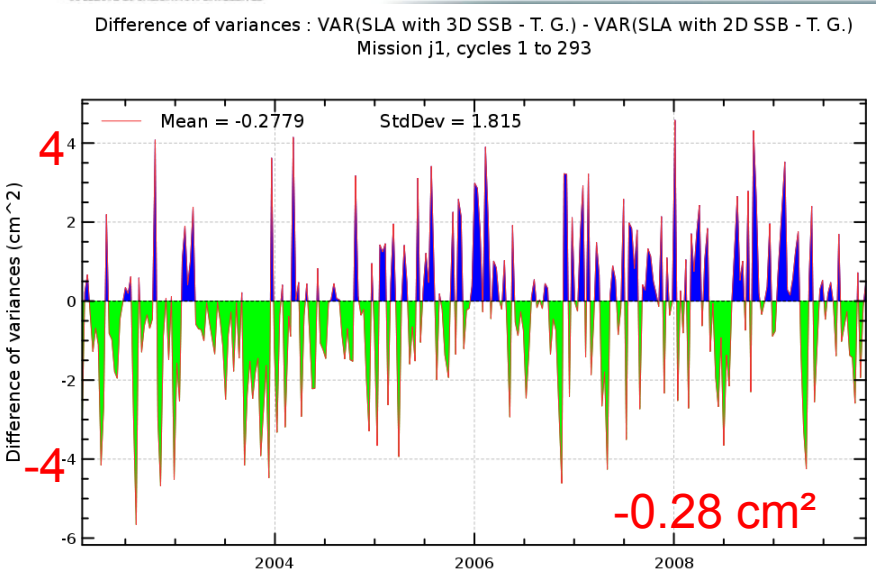


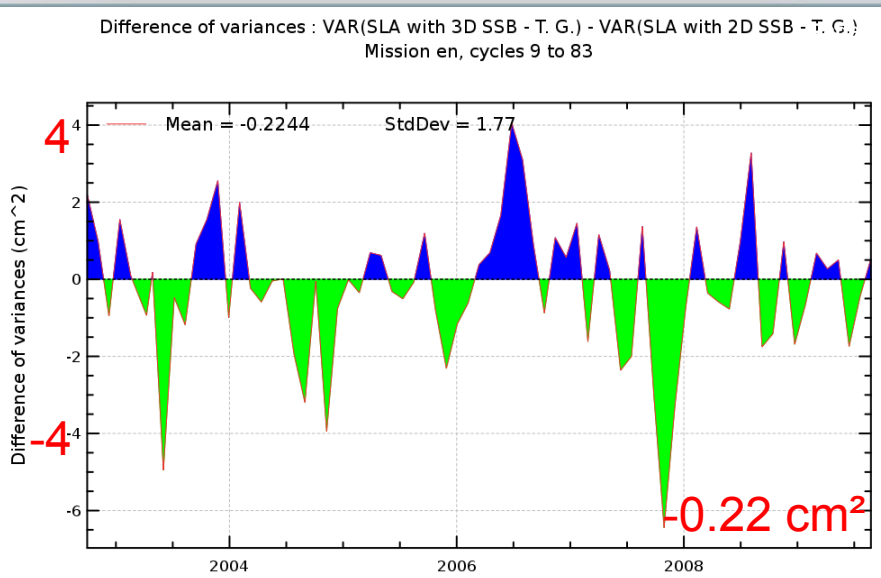
SLA with 3D SSB trends – SLA with 2D SSB trends
Mission en, cycles 9 to 83

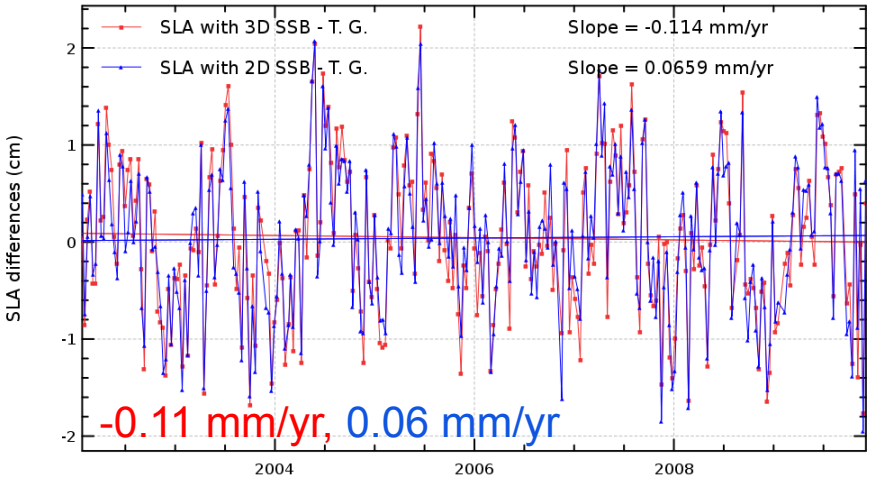


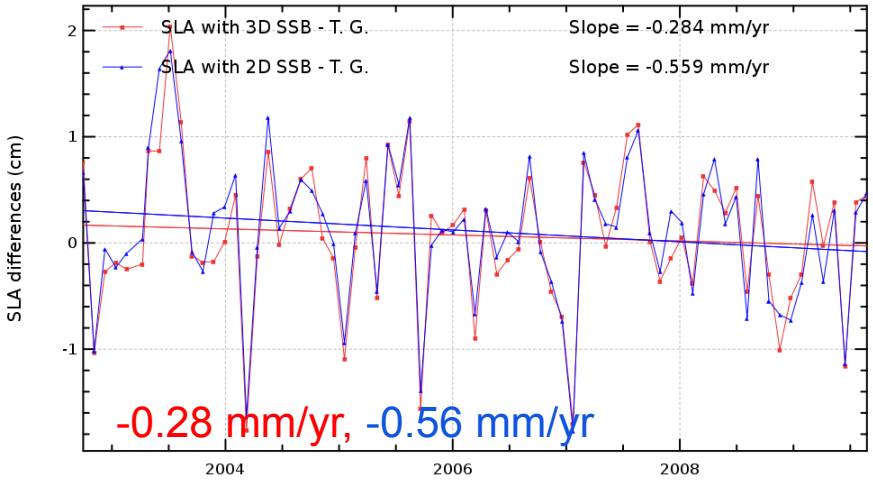
- Significant impact of the change of SSB model on long-term regional sea level evolution
- Similar features for Jason-1 and Envisat
- Regional trends with 3D SSB are mostly lower than those obtained with 2D SSB (blue patches) explaining the overall decrease of global MSL trend.

MSL impact: Altimeter – Tide Gauges









- Difficult to conclude on such results.

Summary and Conclusions

- For most of the evaluations, similar results are obtained for Jason-1 and Envisat.

- Variance of collinear ΔSSH and SLA are reduced with the 3D SSB version by ~1.20 cm².

- There are also improvement in coastal SSB estimations for Jason-1.

- There are some remaining issues in polar regions for Envisat that need to be investigated.

- The 3D SSB correction has a significant impact on the estimation of the long-term evolution of the global MSL trend and the impact is also detected regionally.

- Changes in SLA estimates have effects on mesoscale applications.