



CCI Sea Level Budget Closure

Martin Horwath and the SLBC_cci consortium



Introduction

Science questions

How well do we *know* and *understand* sea level change and its causes?

CCI projects related to sea level



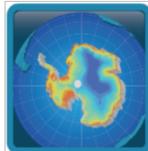
sea level
cci



sst
cci



ice sheets
greenland
cci



antarctic
ice sheet
cci

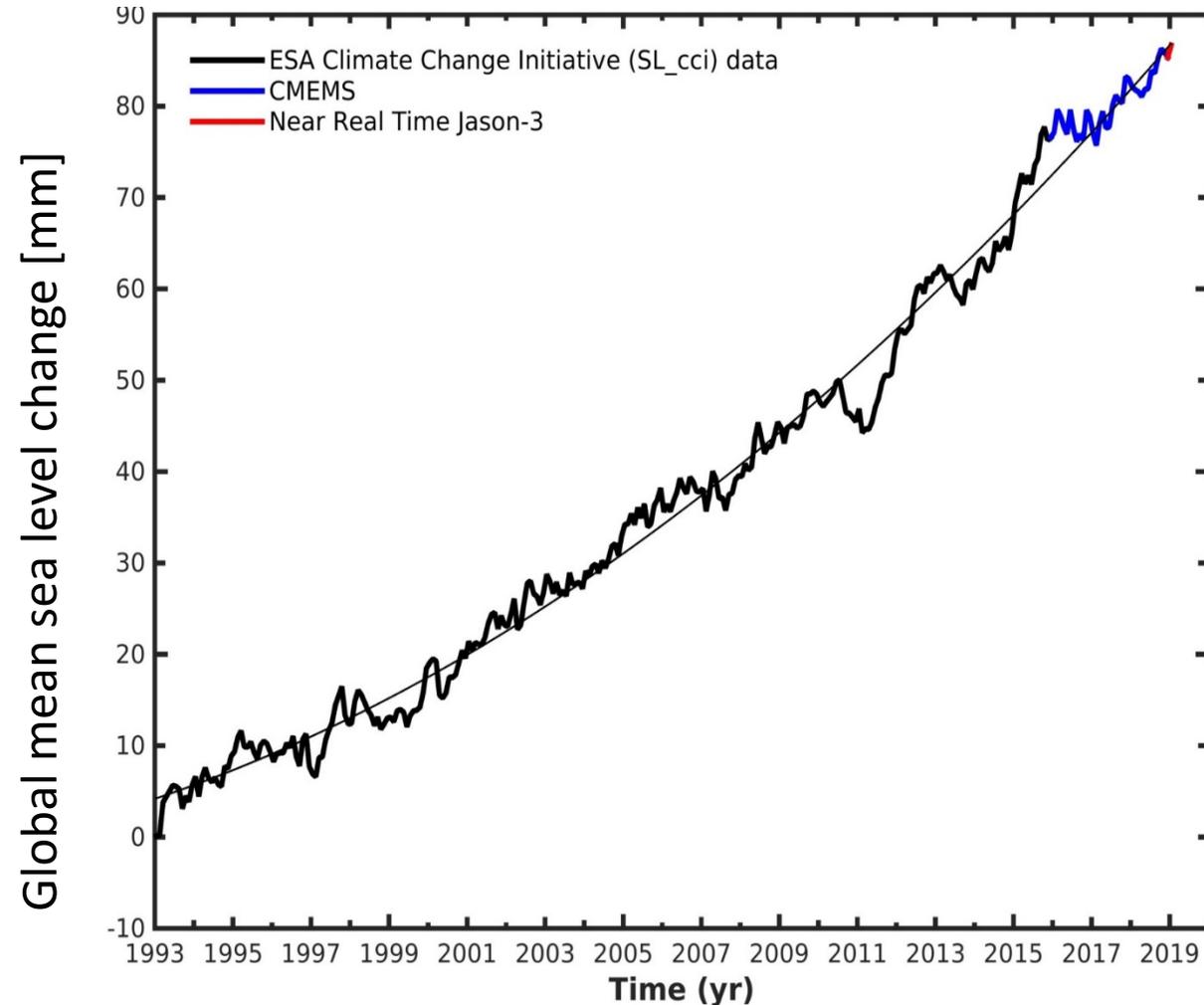


glaciers
cci

“CCI questions”

How useful are CCI products to answer the above science question?

→ quality → consistency → uncertainty characterization



- Investigate in a coherent way the **closure of the global mean sea level budget**
- Thereby assess the quality of **CCI products**
- More generally, concentrate on products that the consortium partners understand best (including their uncertainties)
- Do a regional study for the **Arctic Ocean**.
- **Prepare the way** to more comprehensive and more operational assessments of the global and regional sea level budget

2-year project 04/2017 – 03/2019 (Final Meeting was last week)

Some work needs to be finished in the next months

Sea level budget elements (using GRACE for ocean mass)



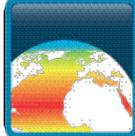
sea level
budget closure
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sea level
cci

Satellite altimetry

Argo & other in-situ sensors



sst
cci

Sea surface temperature

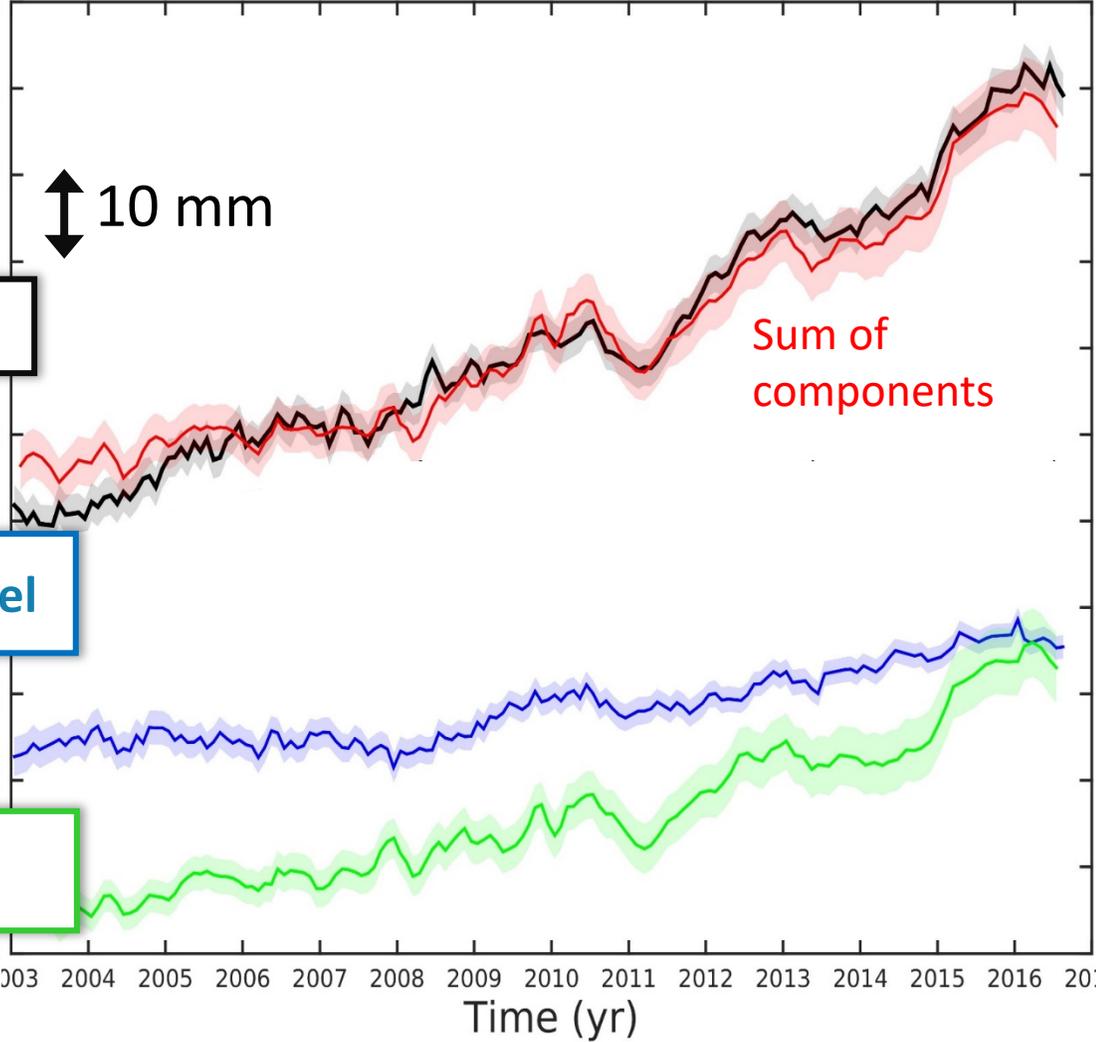
GRACE satellite gravimetry

Δ sea level

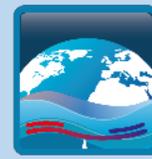
Δ steric sea level

Δ ocean mass

Global mean sea level change



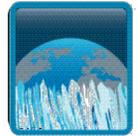
Ocean mass budget elements



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GRACE satellite gravimetry

Open Global Glacier Model OGCM



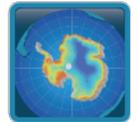
glaciers
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Glacier outlines,
mass balance obs.



ice sheets
greenland
cci

Mass balance (GRACE)



antarctic
ice sheet
cci

Mass balance (altimetry)

Global hydrology model WGHM

Δ ocean mass

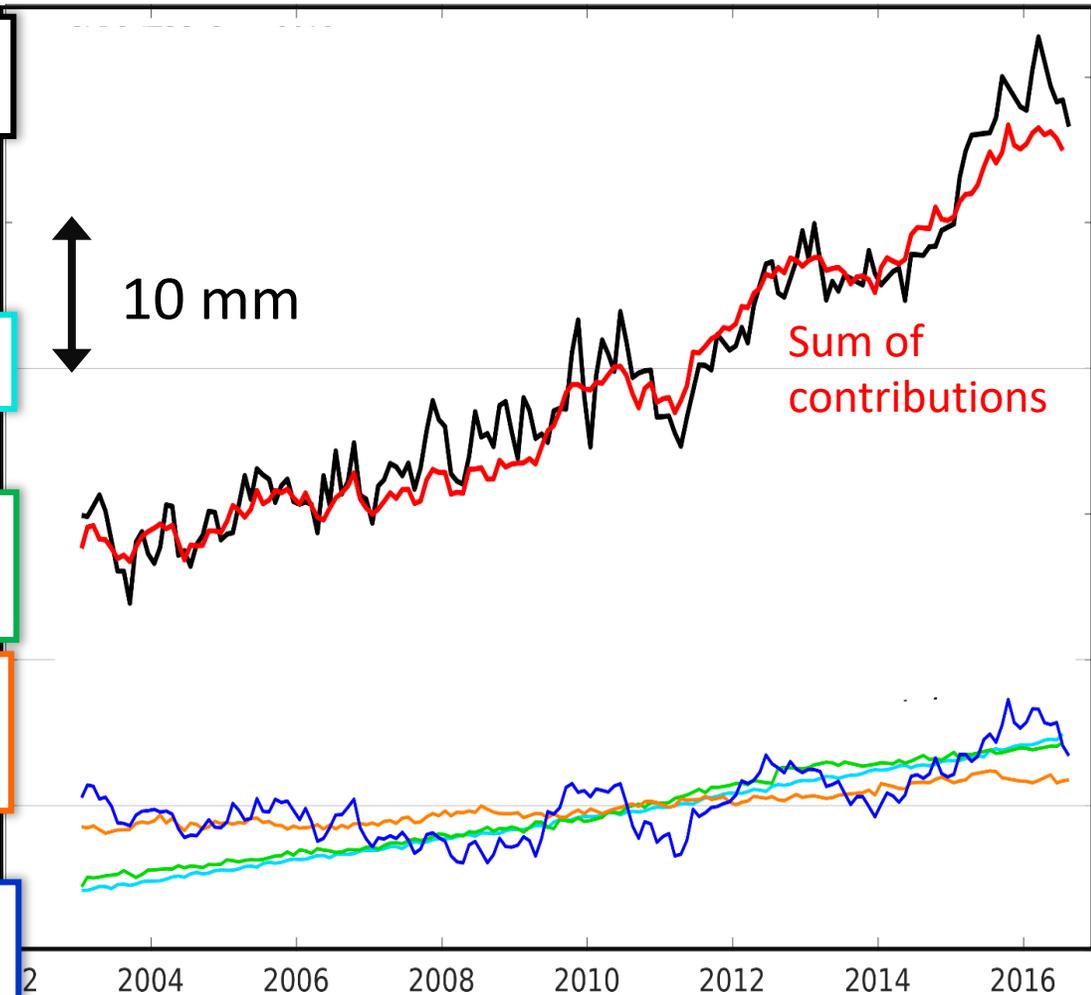
Δ glacier mass

Δ Greenland
ice mass

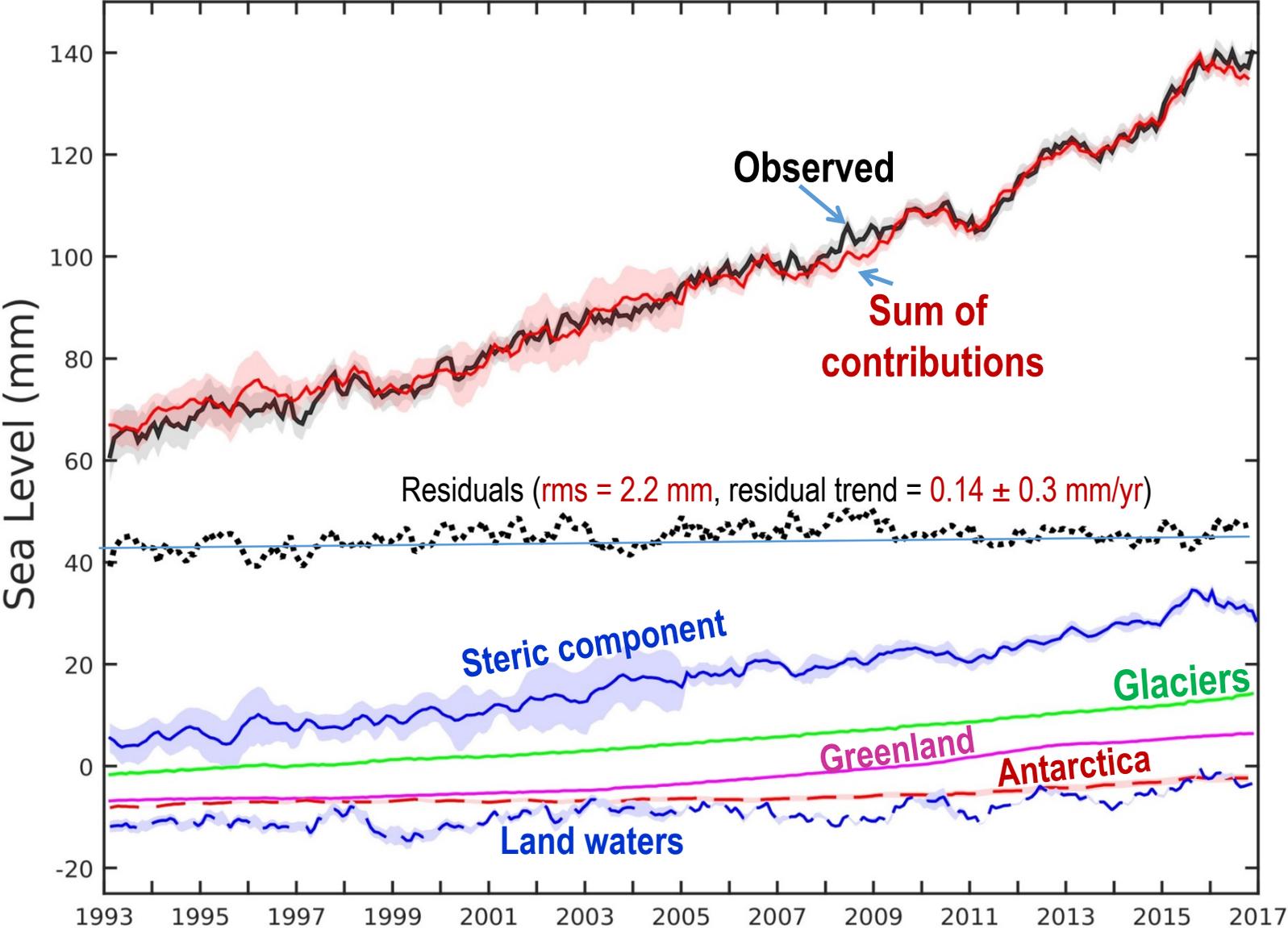
Δ Antarctic
ice mass

Δ land water
& snow

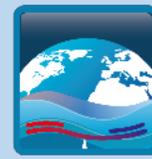
Global mean sea level change: mass contributions



Sea level budget elements (using individual mass contributions)



Trend budget 1993-2016 [mm/yr] with 1- σ uncertainties



sea level
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Total sea level	3.05 ± 0.24
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Steric (Dieng et al. 2017)	1.15 ± 0.12
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Glaciers	0.64 ± 0.03
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Antarctica: Altimetry	0.20 ± 0.03
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Greenland: Altimetry	0.60 ± 0.09
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Land water:	0.32 ± 0.10
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Sum of mass contributions	1.76 ± 0.16
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Sum of contributions	2.91 ± 0.20
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Misclosure (total budget)	0.14 ± 0.31
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Trend budget **2003-2016** [mm/yr] with 1- σ uncertainties



sea level
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Trend budget 2003-2016 [mm/yr] with 1- σ uncertainties



sea level
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Total sea level 3.64 ± 0.24

Steric 1.09 ± 0.10

Glaciers 0.77 ± 0.03
 Antarctica: GRACE / Altim. 0.27 ± 0.10 / 0.34 ± 0.02
 Greenland: GRACE/ Altim. 0.74 ± 0.02 / 0.89 ± 0.12
 Land water: 0.40 ± 0.10

Sum of mass contributions 2.19 ± 0.15 / 2.40 ± 0.16

Sum of contributions 3.28 ± 0.18 / 3.49 ± 0.19

Misclosure (total budget) 0.36 ± 0.30 / 0.15 ± 0.31

Ocean mass (GRACE) 2.19 ± 0.22

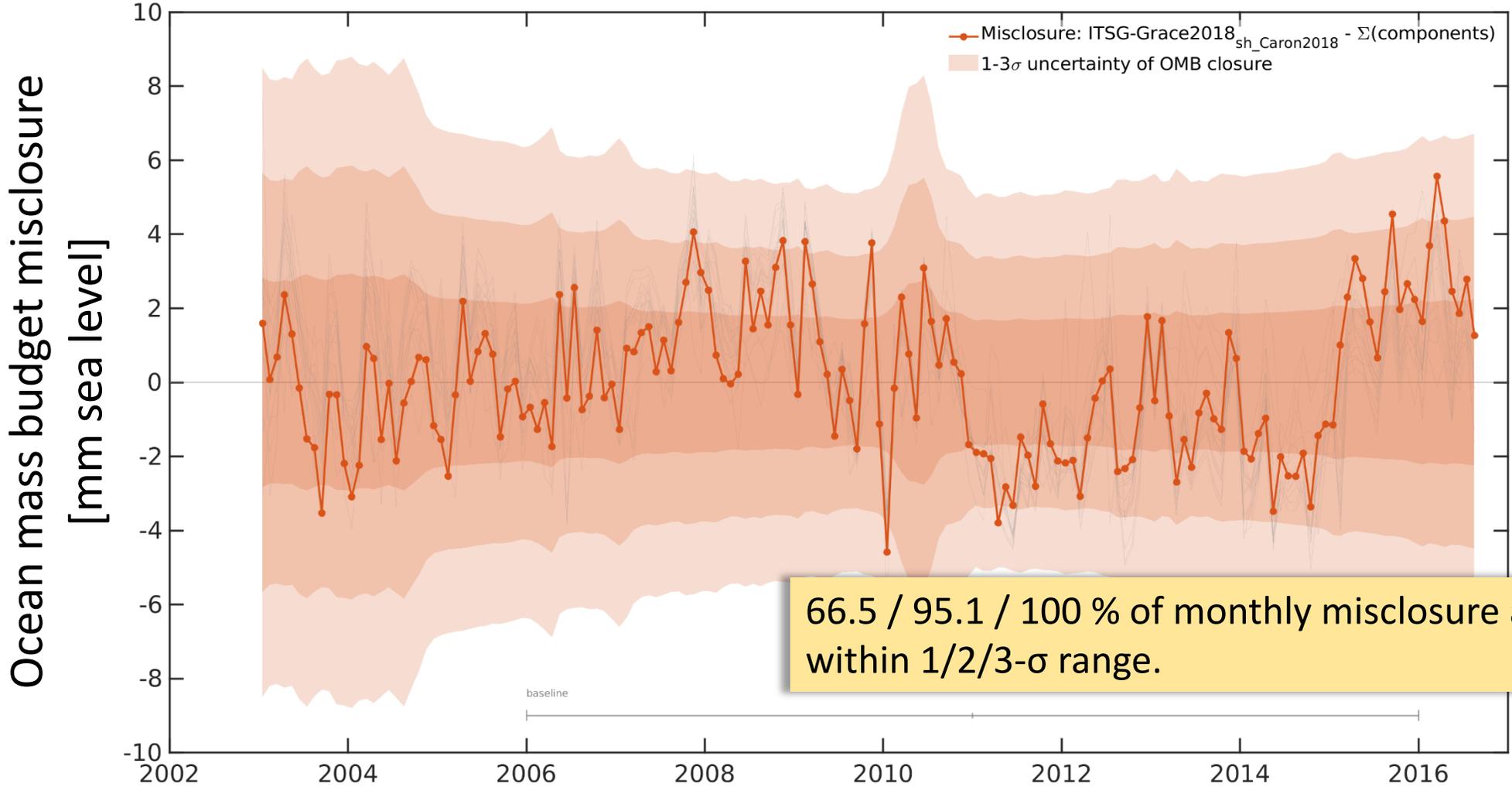
Sum of contributions 3.28 ± 0.24

Misclosure (total budget) 0.36 ± 0.34

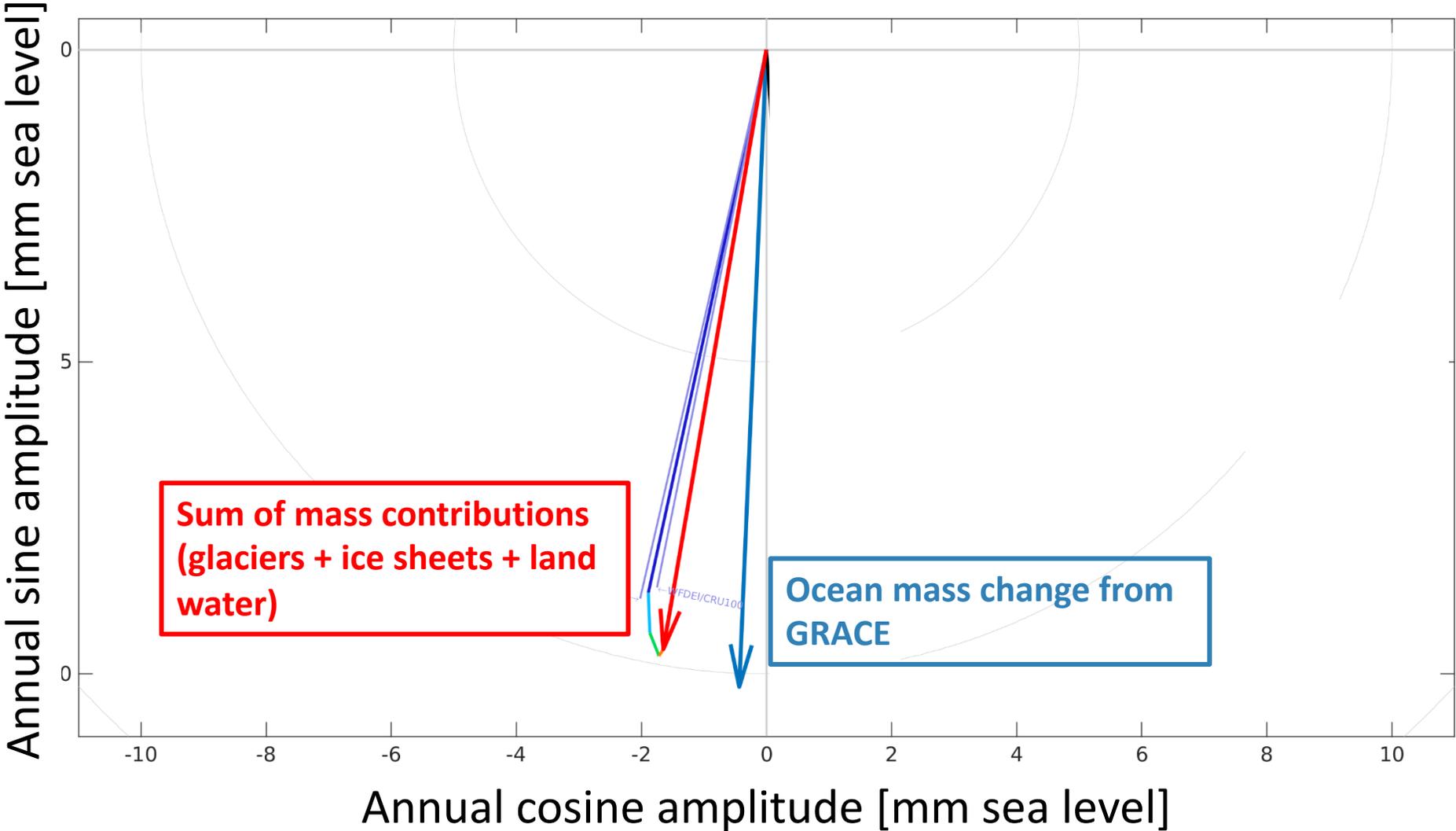
Misclosure
(mass budget)
 0.00 ± 0.29 / -0.21 ± 0.30



Ocean mass budget misclosure time series



Seasonal mass budget





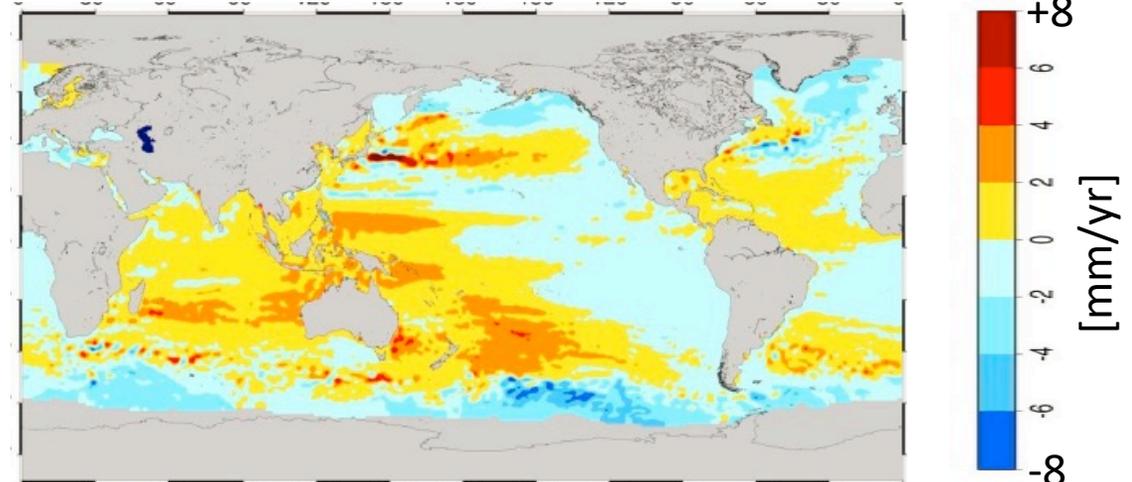
- Uncertainties on trends of global mean sea level and some of its contributions are on the order of 0.2 ... 0.3 mm/yr (1-sigma).
- Global mean sea level budget (1993-2016) and ocean mass budget (2003-2016) are closed on the order of uncertainties.
- (Any more precise closure may be just an incidental cancellation of systematic errors.)
- Assessment extended to seasonal signal and interannual signal.
- We can attribute some features of misclosure.
- We are working on some known remaining inconsistencies.

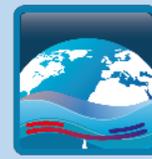


- Development of improved products and uncertainty characterization for every element of the budget
- Significant efforts made by the multidisciplinary consortium to converge to a unified framework
- Budget assessment result of new rigor, and some of new kind
- Fields of further work identified.
- *However, for the time being, there are no provisions in CCI+ to continue that activity*

Potential directions of future work

- Extension of time series
- methodological improvements
- Integration of more CCI ECVs, e.g.
 - Atmospheric water content (water vapor and clouds)
 - EO for snow cover, soil moisture, lake levels, river runoff to aid hydrological modeling
- Extend focus to regional sea level change and on signal detection & attribution.
 - Regional steric effects
 - Solid Earth deformations and gravity changes in response to mass redistribution
 - Atmospheric loading
- Become part of more comprehensive water cycle (and energy budget) studies. (SLBC_cci has not looked at fluxes but just at variations of state.)





Thank you for your attention
Questions? Comments?

