Assessing Global Ocean and Continental Mass Change from 17 (18) years of GRACE/-FO
and the role of coastal buffer zones

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Ocean Mass Change 04-2002 / 02-2020

Monthly SH solutions (d/o 60)

- ITSG-Grace2018 (shown here)
- CSR RL06
- GFZ RL06
- JPL RL06

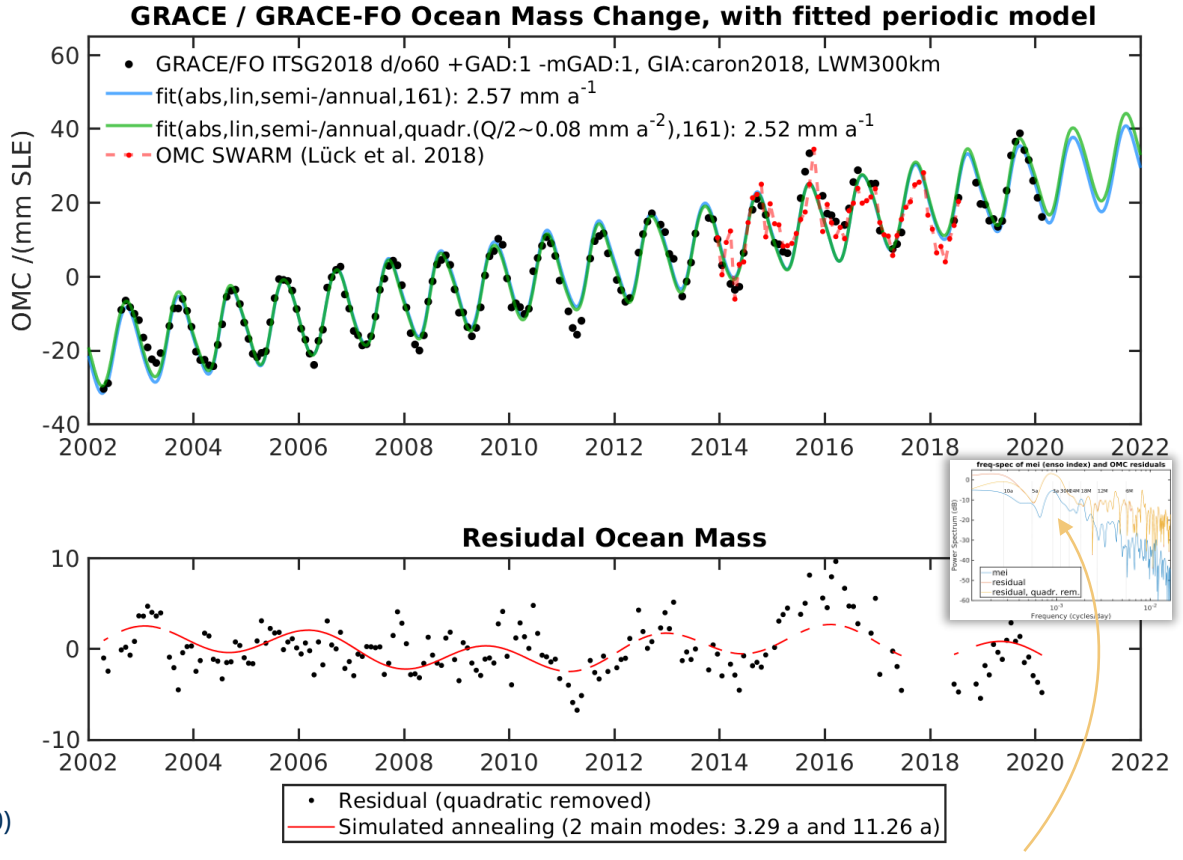
Corrections:

- Individual Degree 1 (after Swenson / Bergmann-Wolf)
- C20/C30 from TN-14
- GIA by Caron et al. (2018)
- GAD restored, mean atmospheric pressure over entire ocean subtracted
- 300 km coastal leakage buffer

Method:

- Global integration of buffered kernel
- Joint adjust fit function that includes absolute, linear, annual, semi-annual and 161-day terms; optionally quadratic fit

Result: 2.52 ± 0.22 mm/a (04-2002/02-2020)
Quadratic acceleration: 0.08 mm/a²



Continental (Land) Mass Change

2003—2016 analysis shown here; includes glaciers but no Greenland & Antarctica

Monthly SH solutions (d/o 60)

— Same as Ocean

Corrections:

— Same as ocean, but:

— ~300 km coastal leakage buffer extended onto the ocean to integrate out-leaking signal

— Exclude EQuakes and Caspian Sea

Method:

— Global integration over extended land-kernel

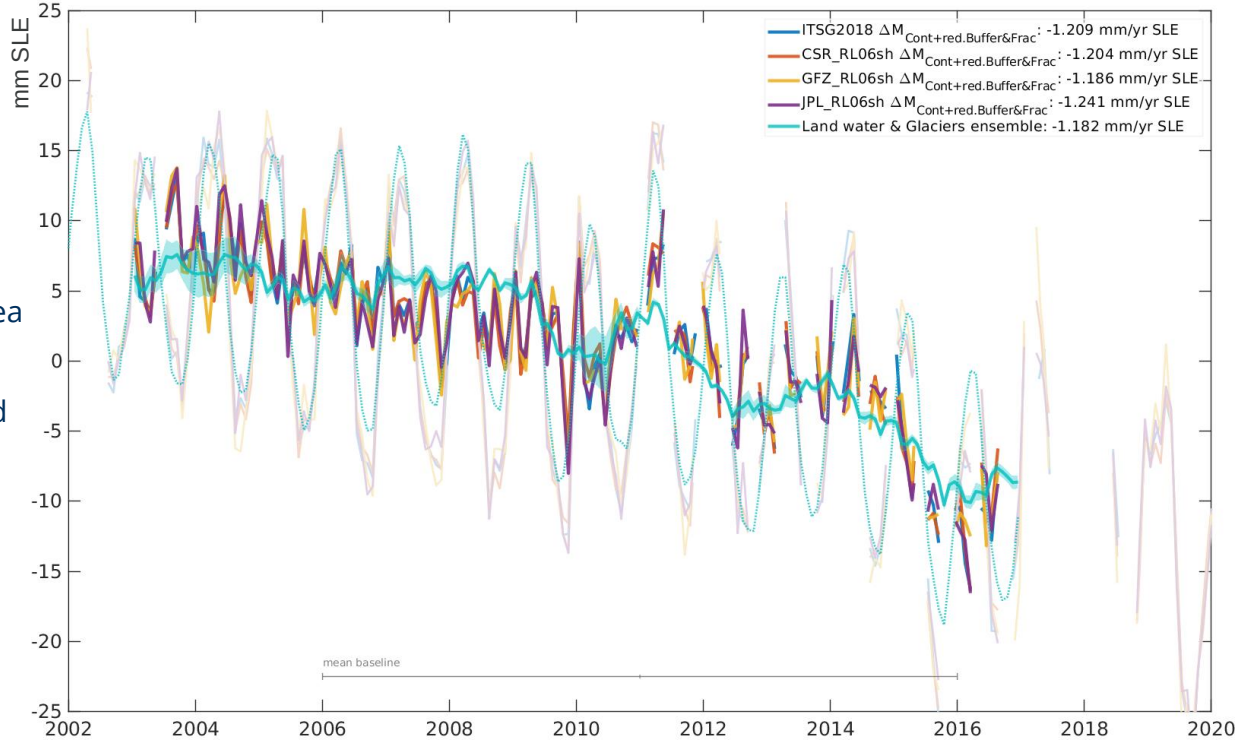
— Remove mean ocean in buffer

— Joint adjust fit function (here: no quadratic)

Result (01-2003/08-2016):

Grace: -1.21 ± 0.20 mmSLE/a

$TWSA_{ens.}$: -1.18 ± 0.10 mmSLE/a



TWSA here is a combined product (*Cáceres et al., 2020, under revision; in the ESA CCI SLBC Project, Horwath et al., 2020 tba*) that includes glaciers by *Marzeion et al. (2012,2015).* TWSA ensemble consists of 4 members /w different irrigation scenarios and climate forcings; its uncertainty (STD) is a low estimate and is expected to be higher with a larger number of model runs. TWSA and Grace both exclude the Caspian Sea here.

Continental (Land) Mass Trend Analysis 01-2003/08-2016

This figure shows the effect of the oceanic-side buffer-width on the linear trend of GRACE continental mass change (CMC).

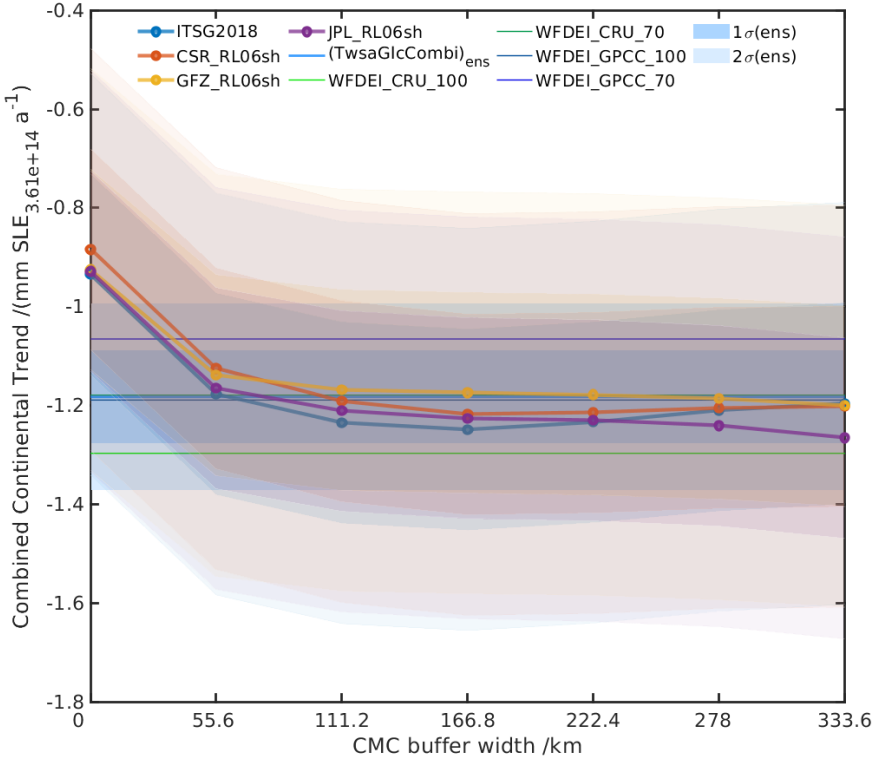
Reddish shaded areas are the 1- and 2σ uncertainty ranges of the individual GRACE-based solutions.

Blue-shaded is the combined uncertainty (1- and 2-STD) of the TWSA ensemble mean.

CMC including the Caspian Sea (surface area only) would lead to a down-shift of ~0.07 mm/a.

The linear behaviour at larger buffer-width is a good indicator for the effect of the mean-OMC correction.

However, this assumes OMC to be identical over buffer and inner ocean kernel (not entirely true, but cannot be assessed with GRACE).



Re-scaling effects from coastal buffer zones

Combined fingerprint effect of the ESA CCI SLBC products (linear trend)

Coastal zones and high-latitudes have lower trends (here: 2003—2016).

We applied a sea-level equation fingerprint solver in a quasi-spectral approach that includes a purely elastic response of the ocean as a consequence of mass change (following Clarke et al. 2005 and Blewitt & Clarke 2003).

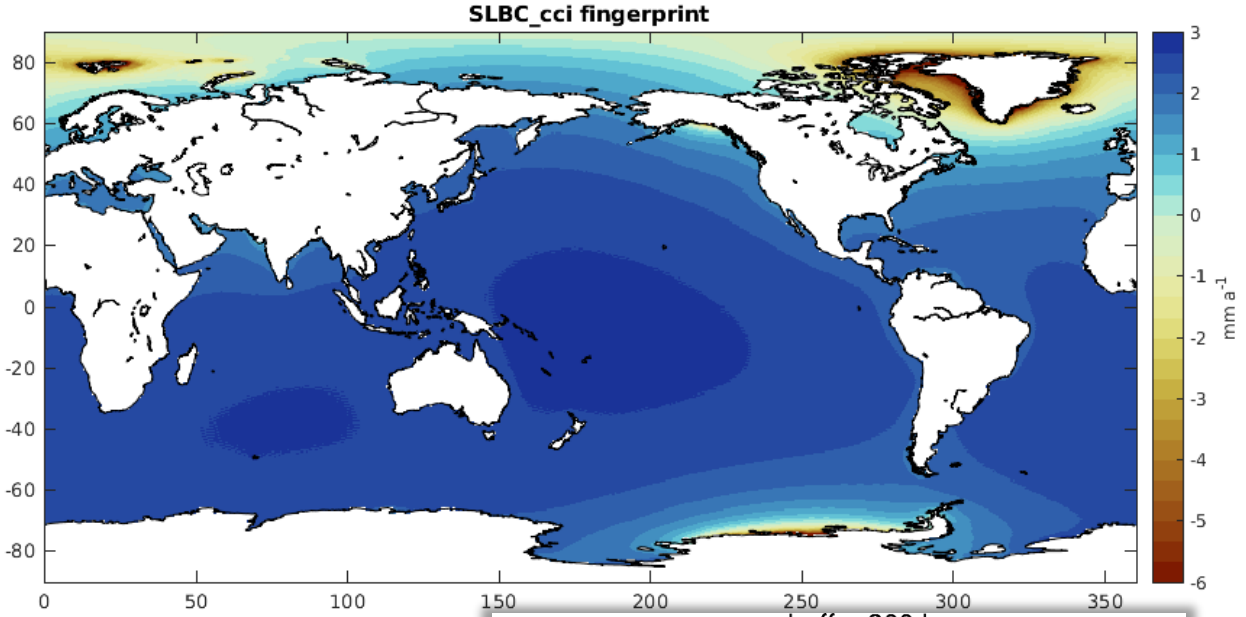
Up to degrees 60 ('observation') and 360 ('truth').

Input: monthly mass change data of glaciers, ice sheets and terrestrial water storage from ESA SLBC_cci

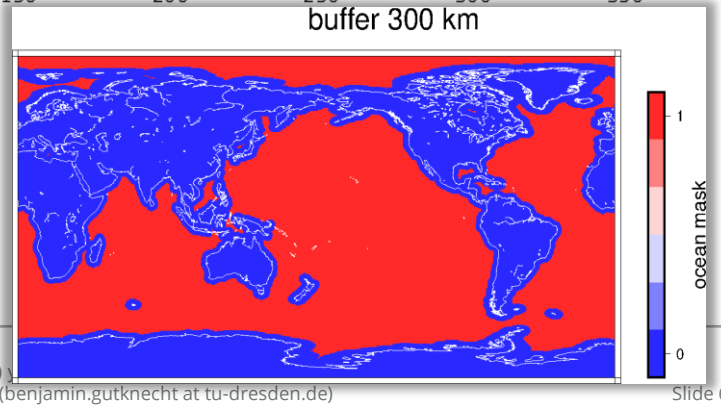
Analysis uses:

— Set of 14 buffer masks / kernels

— For each combination: optional ±65° latitudinal cut-off



→ How big is the error, if we re-scale results from the inner ocean integration kernel to the entire Global Ocean area?



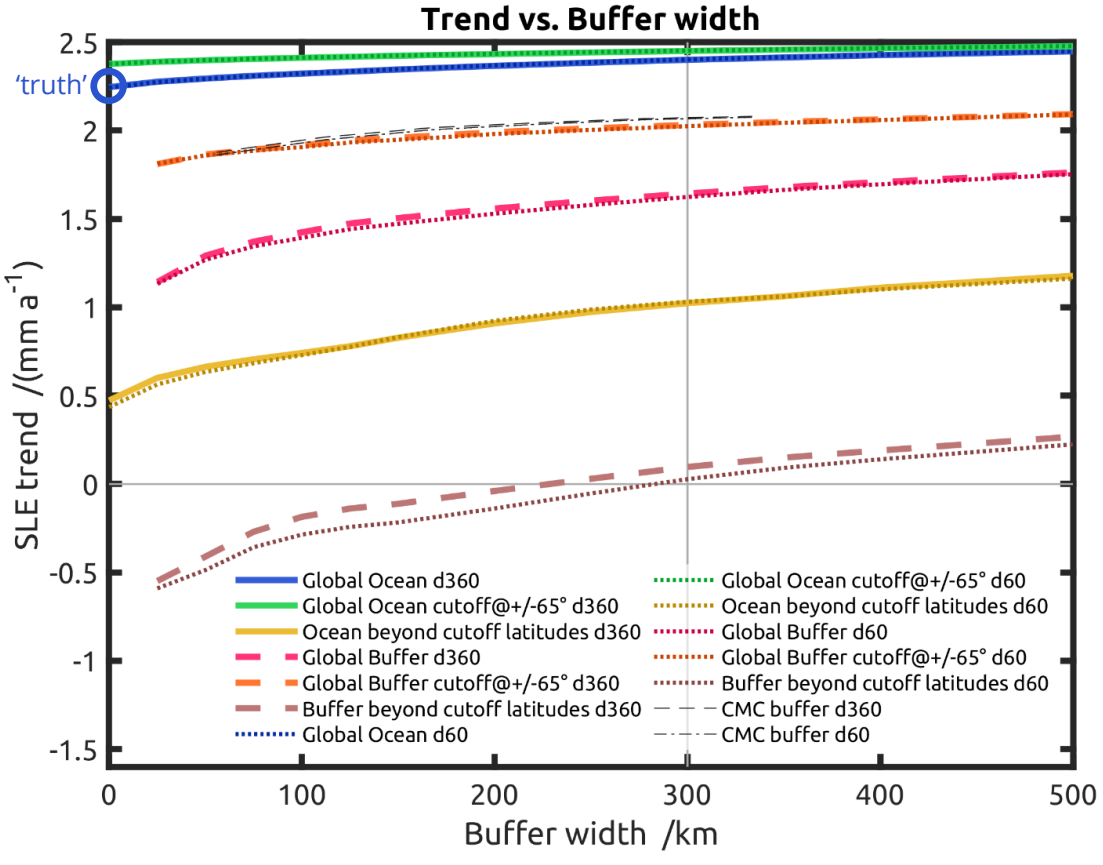
Combined fingerprint effect of the ESA CCI SLBC products

— Global Ocean Mass (blue curve) trend re-scaled from a 300 km buffer is **6.9% higher** than for the un-buffered full-resolution case ('truth'), e.g. a 2.5 mm/a assessed trend from GRACE were only 2.34 mm/a

— A latitudinal cut-off at ±65° together with 300 km buffer leads to **9.1% overestimation**

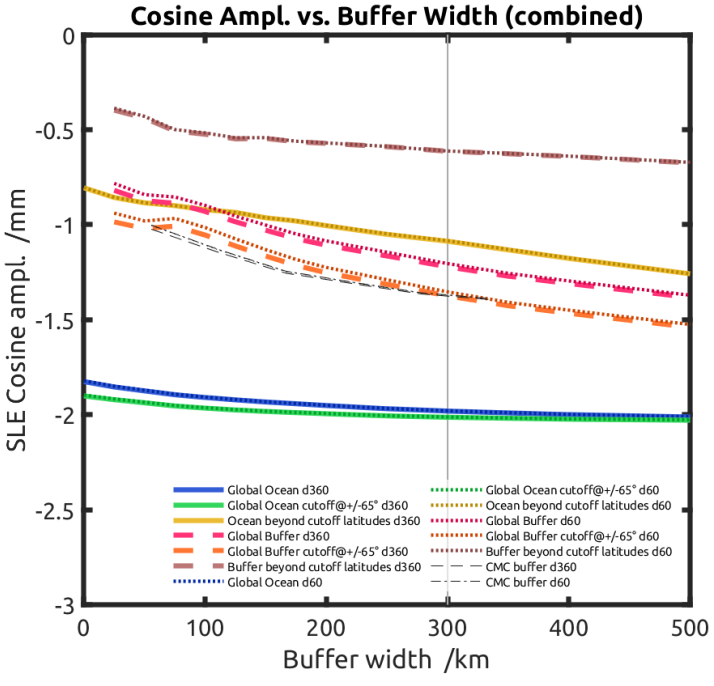
— Narrow buffers beyond ±65° have negative trends (Greenland coast etc.)

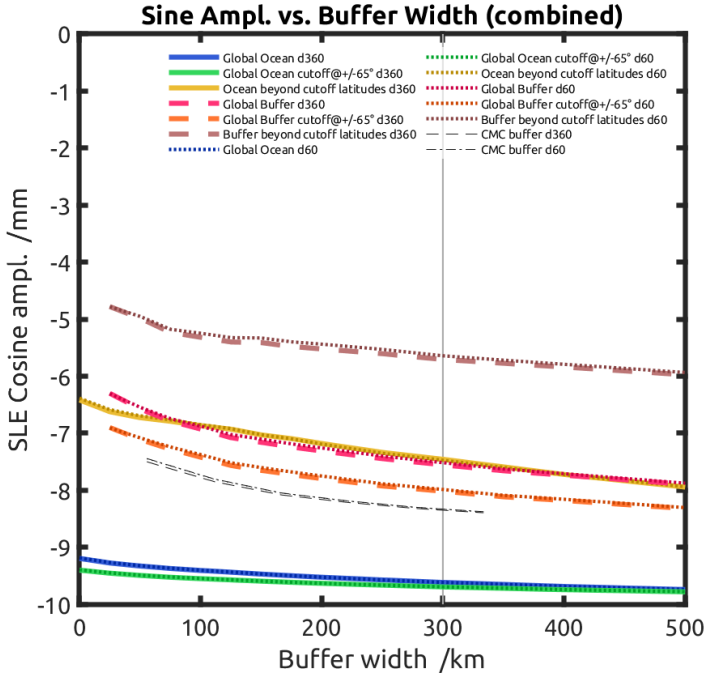
— Continental-mask extended buffer approach overshoots by ~15% (over ocean during the remove process only, not the entire trend)
→ CMC trends on slide 4 would be slightly weaker (less negative) than the TWSA ensemble mean, but still well within uncertainty bounds



Combined fingerprint effect of the ESA CCI SLBC products

→ Seasonal signal (phase) of the Global Ocean not much affected
→ Amplitude in the inner ocean slightly higher (~0.5 mm @ 300 km)





Fingerprint results based on ESA CCI SLBC data indicate: the annual mean ocean low occurs between day-of-year 80 and 81.

See an animation (~2MB) of the monthly fingerprint variability after removal of the linear trend here:
(colorbar units are millimetres of equivalent water height; colormap by Fabio Crameri)

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