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Level-3 CNES ensemble solution, assessment with lake altimetry

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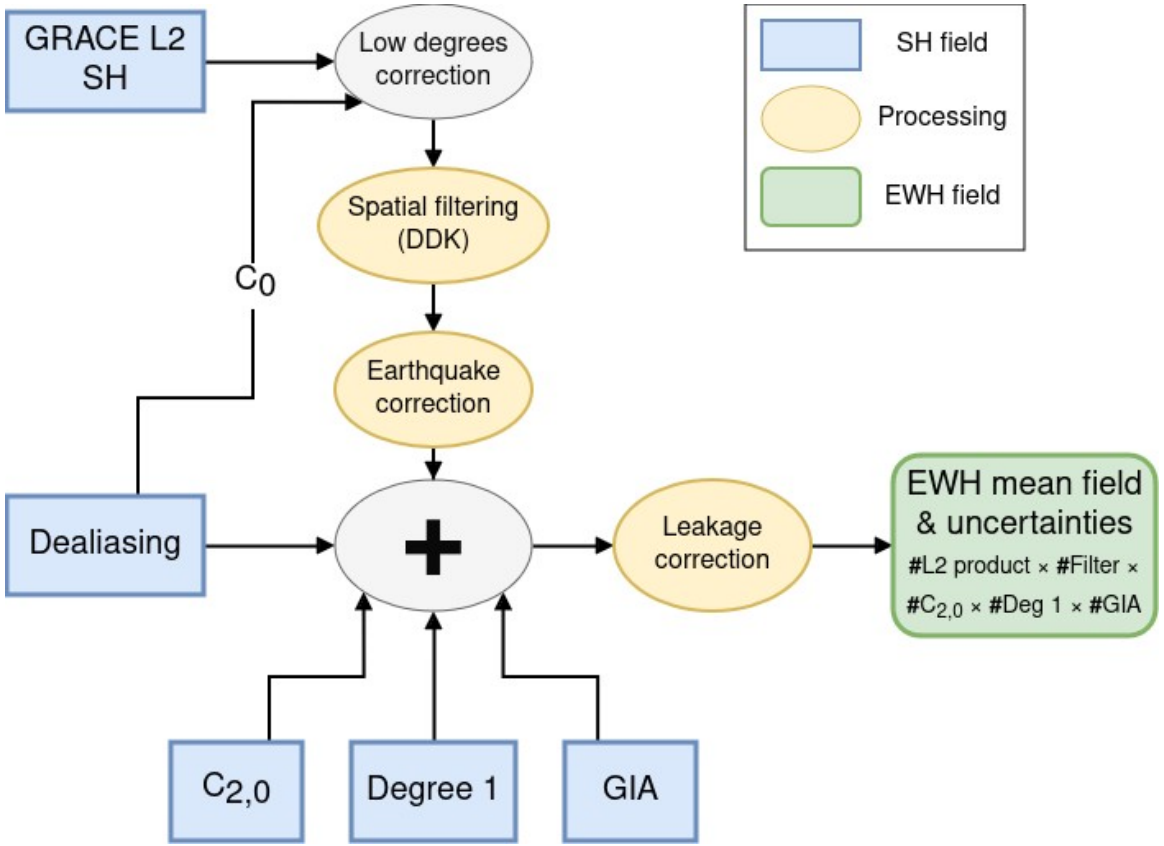
L3 CNES ensemble solution

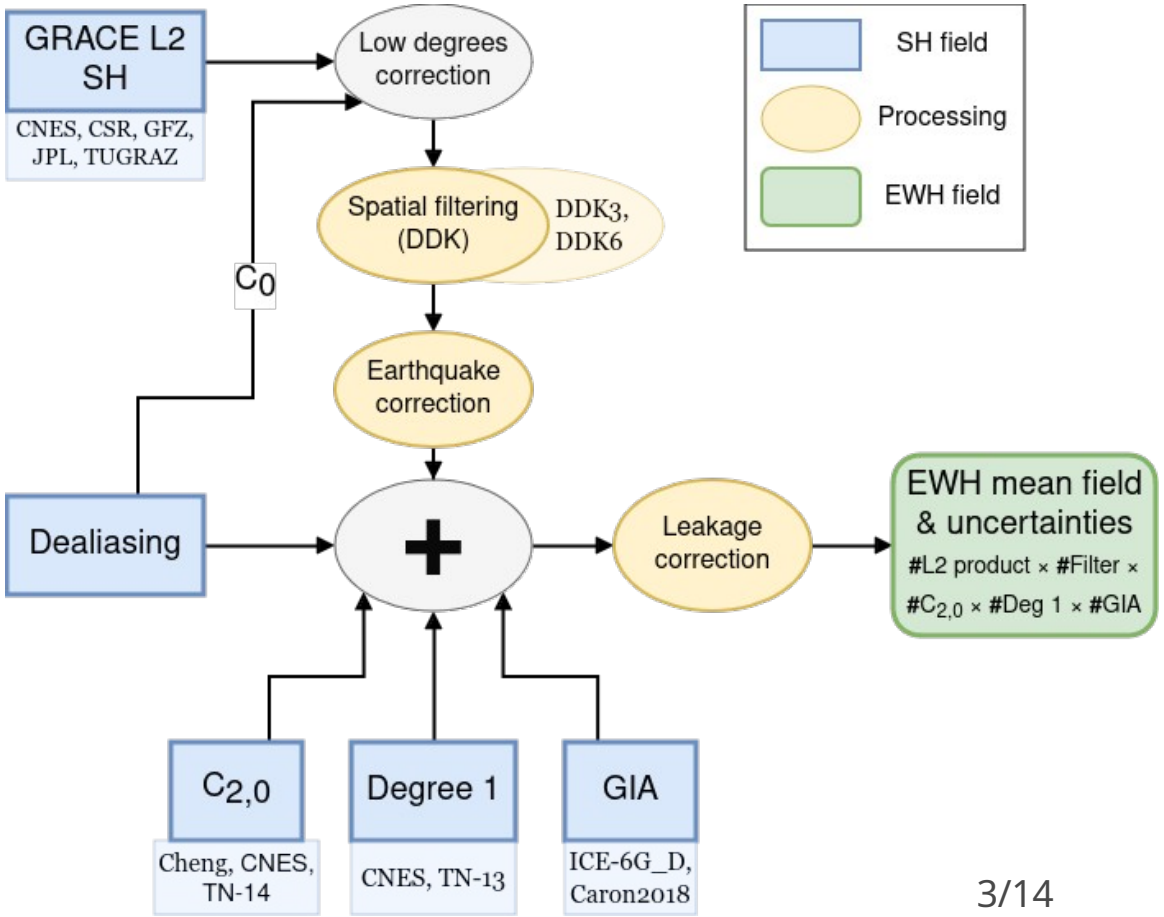
- Spherical Harmonics (SH) L2 products
  → L3 solution in Equivalent Water Height (EWH), 1°×1° grid
  Blazquez et al. (2018)

- Study of the global water cycle (glaciers, lakes, …) and of the ocean mass

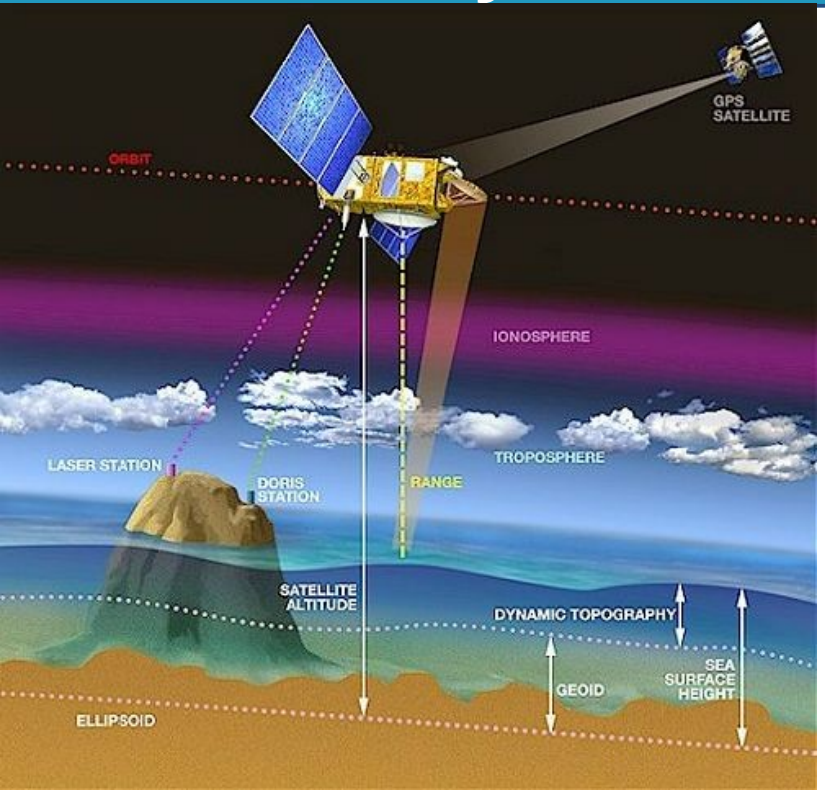


Uncertainties of the solution

- Total number # of 120 elements
- Dispersion between all the element of the solution ⇔ uncertainties
- **EWH × surface = Volume change**



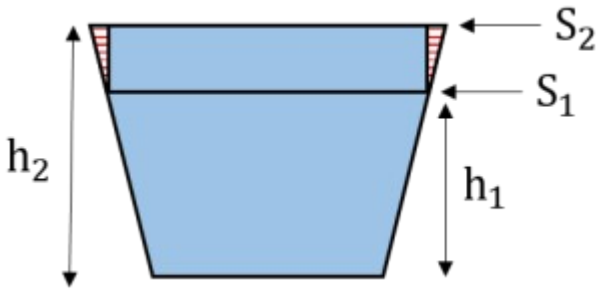
Altimetry over lake



@CNES

- Measured lake height ***h***
- Lake surface ***S(h)***
- Lake volume change :

$$\Delta V = \Delta h \times S$$



- Surface from bathymetry curve or remote sensing estimation

Altimetry Dataset

- HydroWEB datahub : https://hydroweb.next.theia-land.fr/

  Crétaux et al. (2011, 2016)

e.g.

Lake

Victoria

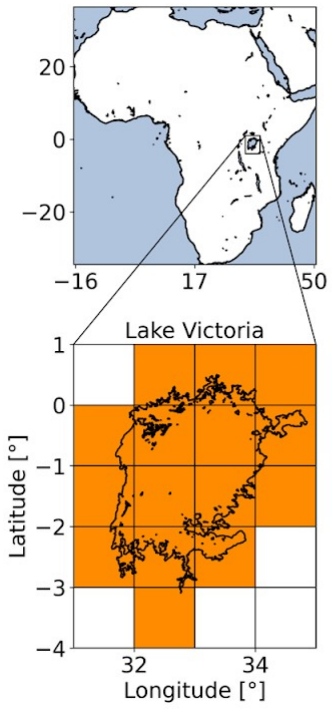
GRACE vs Altimetry

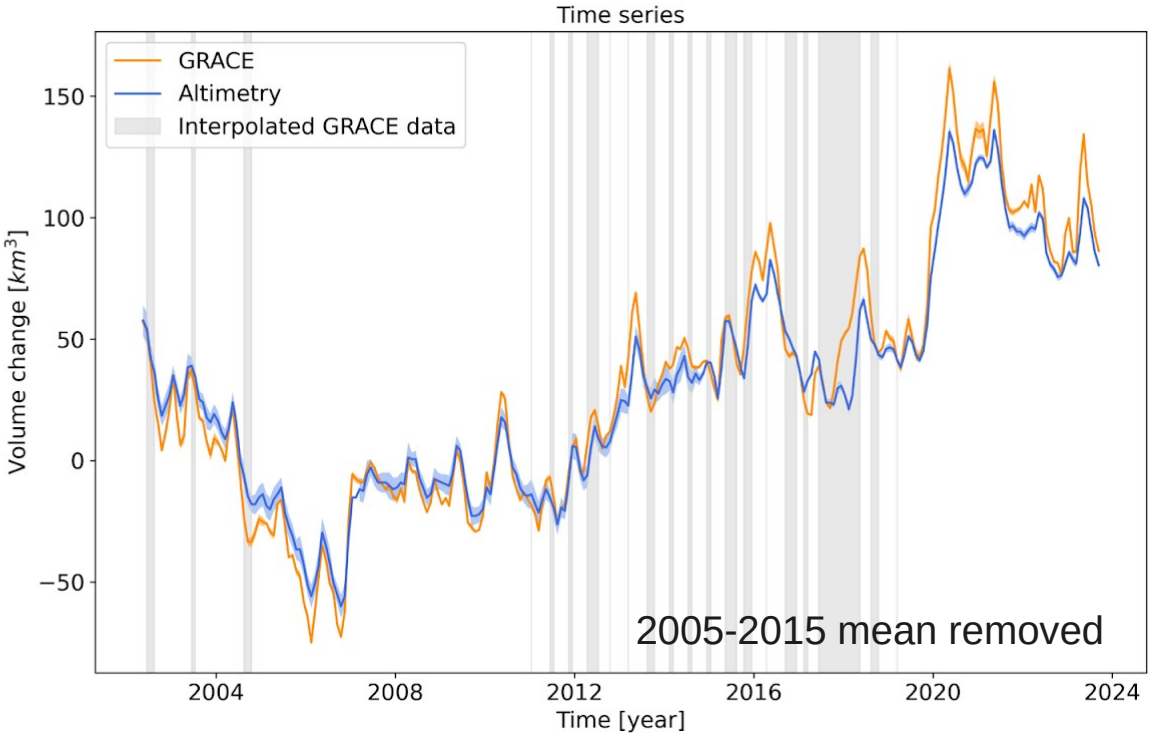
- Altimetry → surface water + land elevation
- GRACE → $\frac{dTWS}{dt} = surface\,water + ground\,water + soil\,moisture + solid\,earth$
- **Expected** correlation between GRACE & Altimetry obs.
  if none surface water + solid earth mass variations are negligeable
- Possible validation with GIA / hydrological models

Comparison for Lake Victoria

- Surface of 250×250 km
- Large amplitude of volume change dominated by the lake storage

Std = 10 km³ ≈ 5 cm EWH **Corr. = 0.95**





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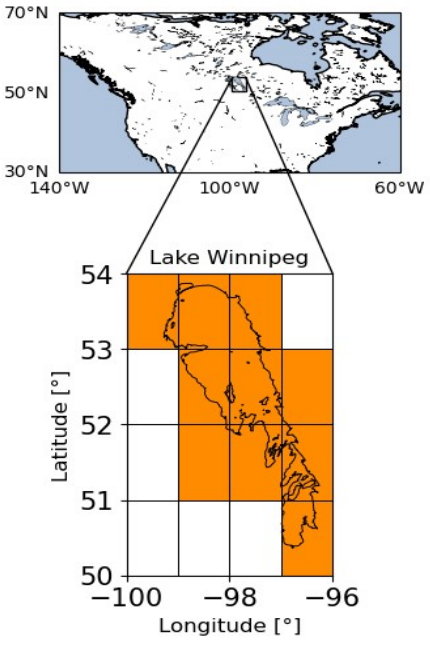
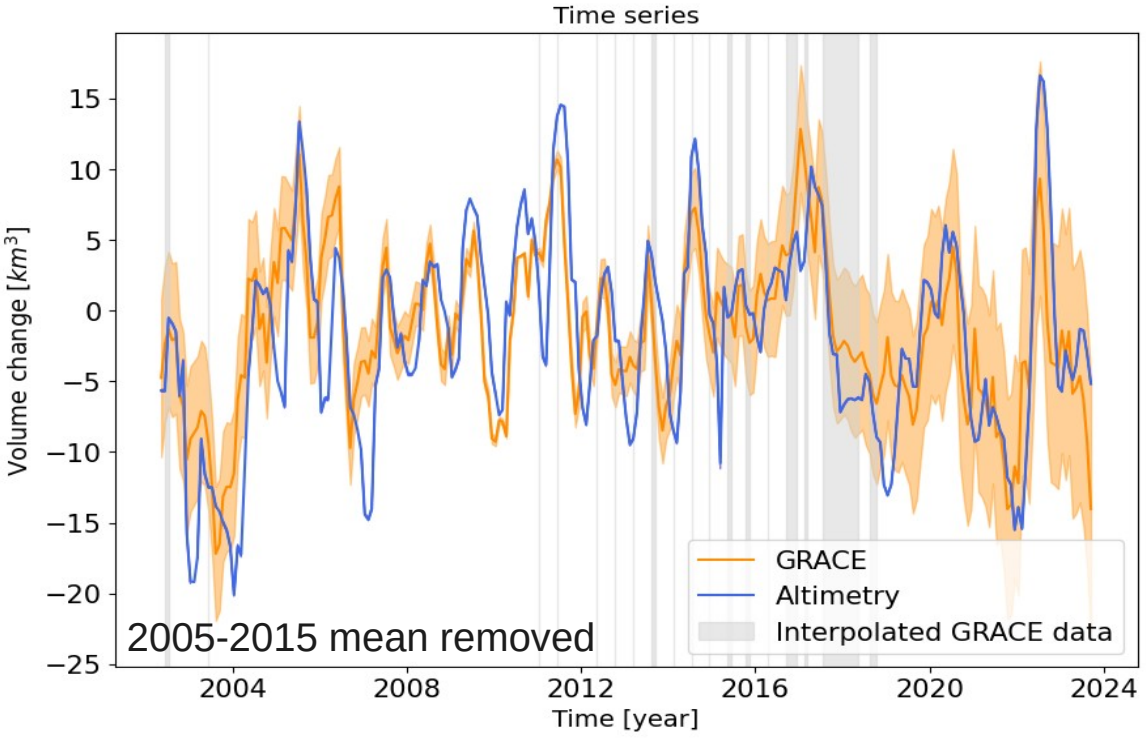
Comparison for Lake Winnipeg

- Surface of 250×100 km
- Small amplitude volume change
- GRACE uncertainties dominated by **GIA**

Std = 7 km³ ≈ 12 cm EWH **Corr. = 0.66**





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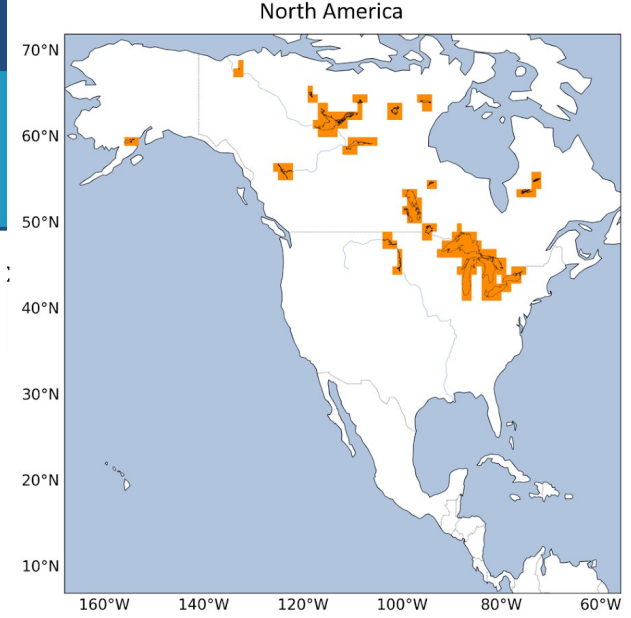
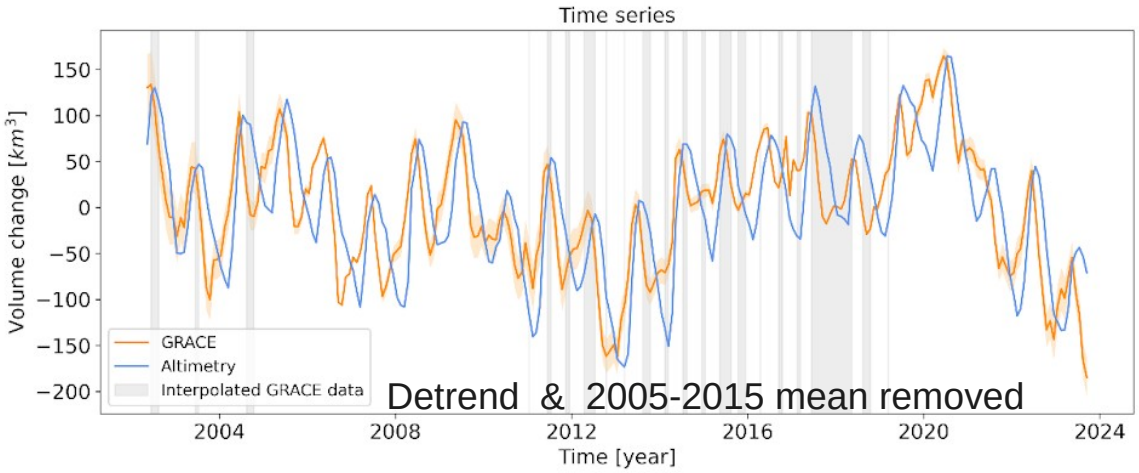
Global lake volume for GIA

- Cumulative volume change of large NA lakes
- Trend of GRACE - ICE6G_D close to altimetry trend
- 2 month phase shift between GRACE and altimetry

Std = 40 km³ ≈ 3 cm EWH **Corr. = 0.85**





	Trend [km^3/year]	GIA mass rate [km^3/year]
Altimetry estimation	**10.77**	
GRACE (-FO) - ICE-6G-D	**9.93**	13.69
GRACE (-FO) - Caron	**-0.89**	24.55

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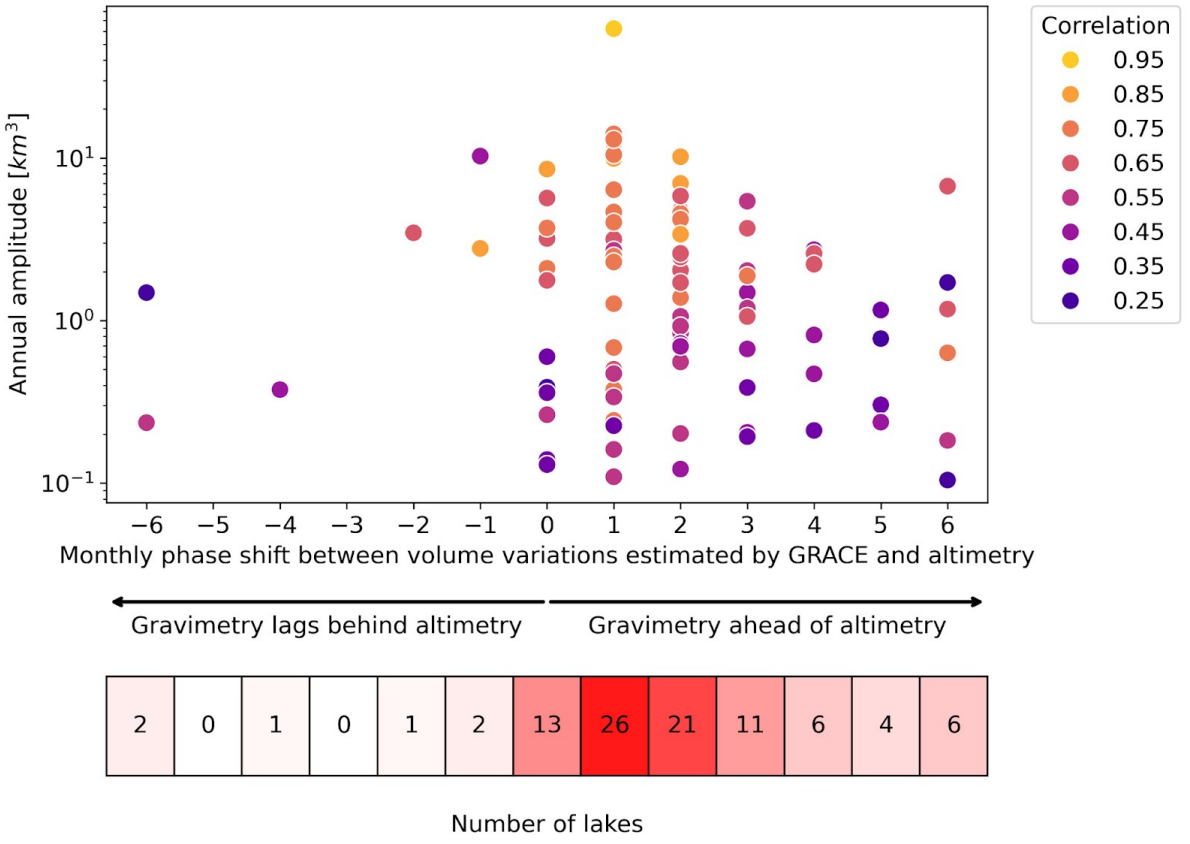
Phase shift with altimetry

- Monthly phase shift for each individual lake
- Correlation under 0.6-0.7 are hardly usable
- Gravimetry is mostly **ahead** of altimetry in time **by 1 to 2 month**



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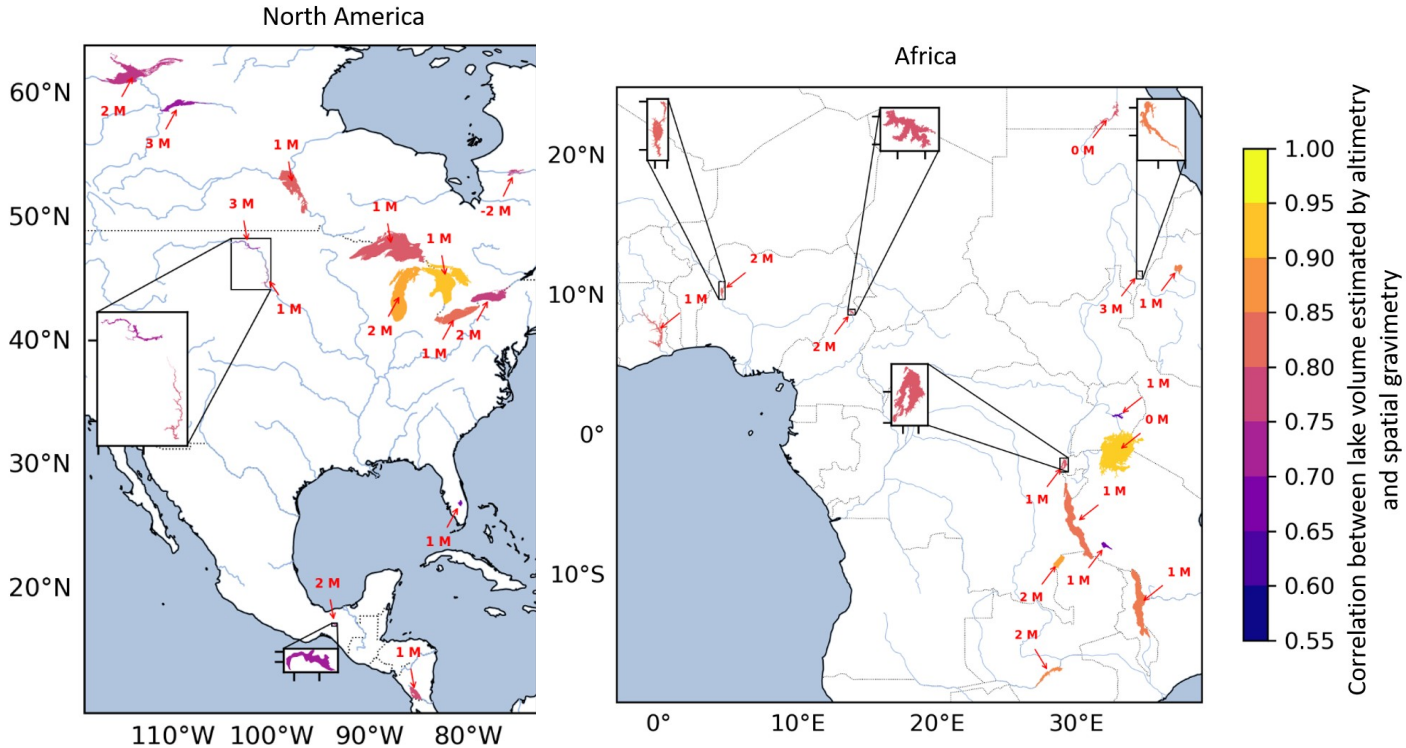
Lake phase shift (North America & Africa)

- Small lakes → smaller correlation & small amplitude
- Precipitation waters have **percolation time** to reach and store in aquifers/lakes
- e.g. Lake Tanganyika

  Gbetkom et al. (2024)



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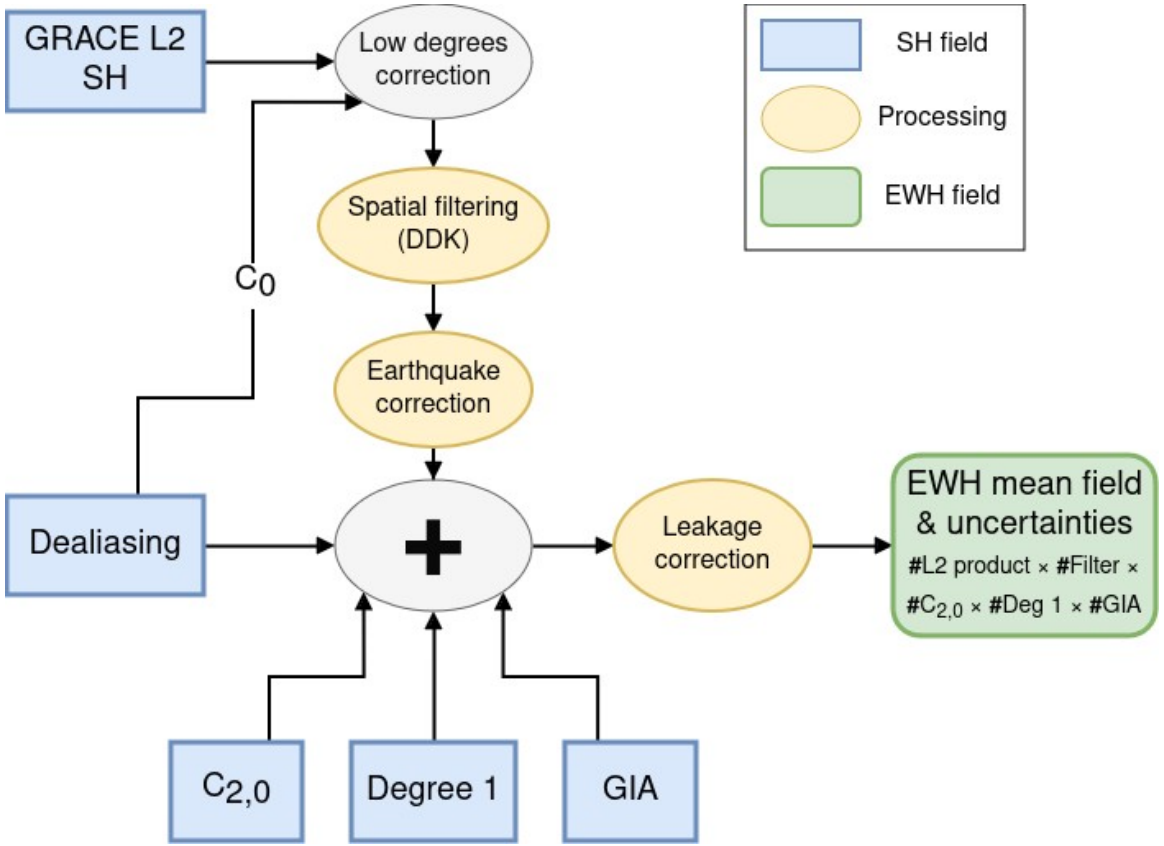
Conclusions & Perspectives

- Good correlation on area with mass volume change dominated by lake hydrology
- Promising temporal phase shift info for model of water cycle
- GRACE possible usage for **early flood warning** in (future) near real time



Thanks for your attention

- HydroWEB datahub for altimetry *Crétaux et al. (2011, 2016)*

  https://hydroweb.next.theia-land.fr/
- **Soon**, L3 CNES solution available on HydroWEB datahub

Bibliography

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