Measuring gravity changes for decades

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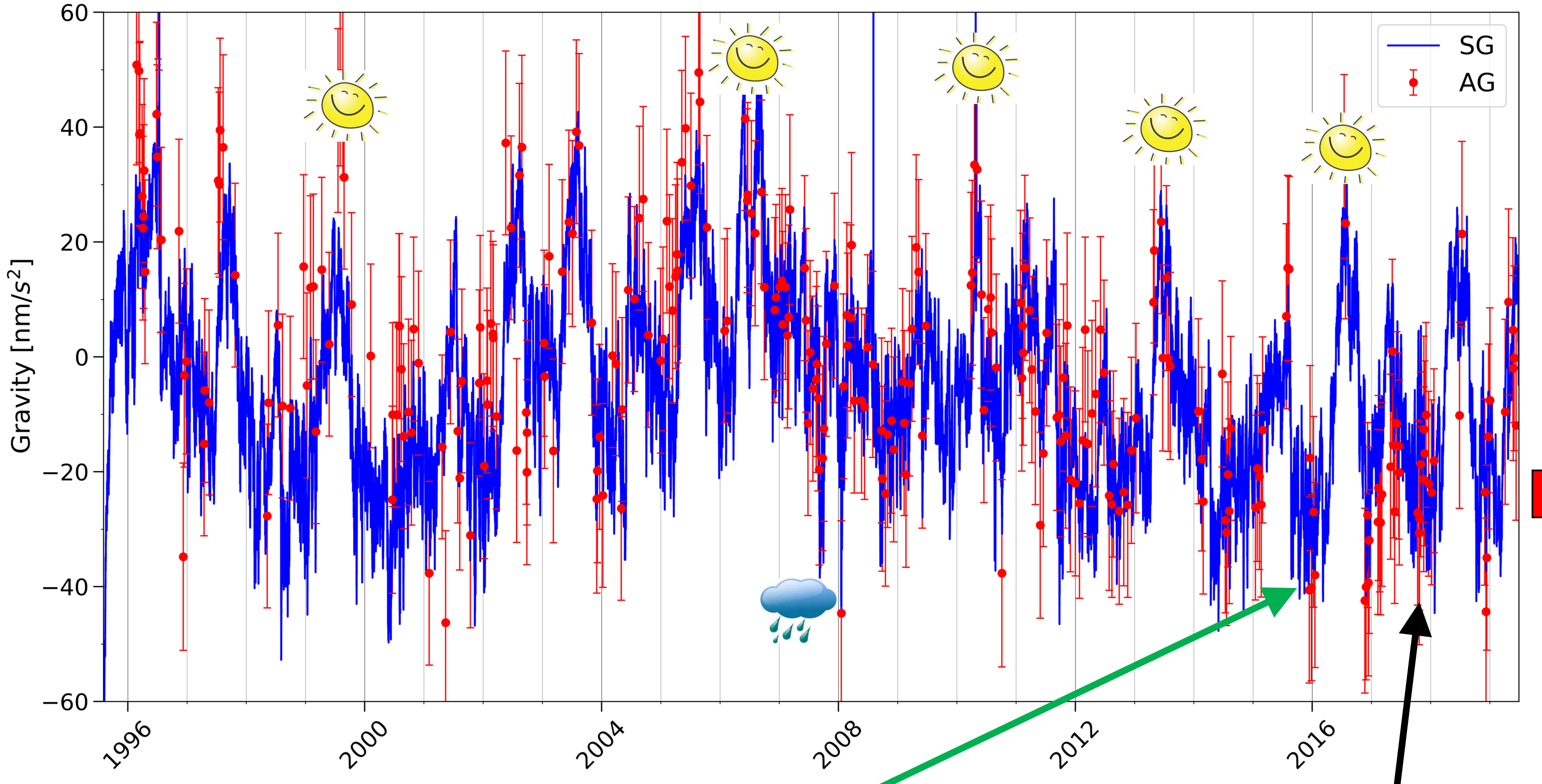
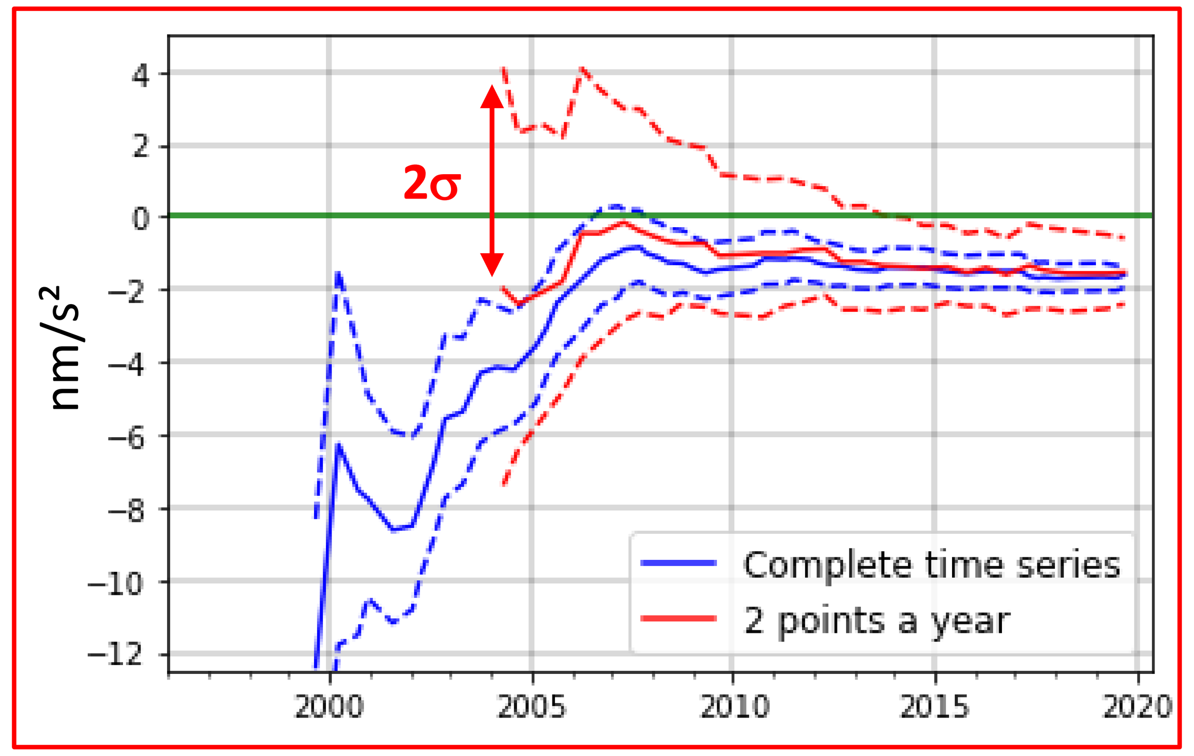
Membach ➔ Underground gravity measurements since 1995 (underground ⇔ gravity decreases when raining):
Superconducting gravimeter (SG) continuously + 300 repeated absolute gravity (AG) measurements



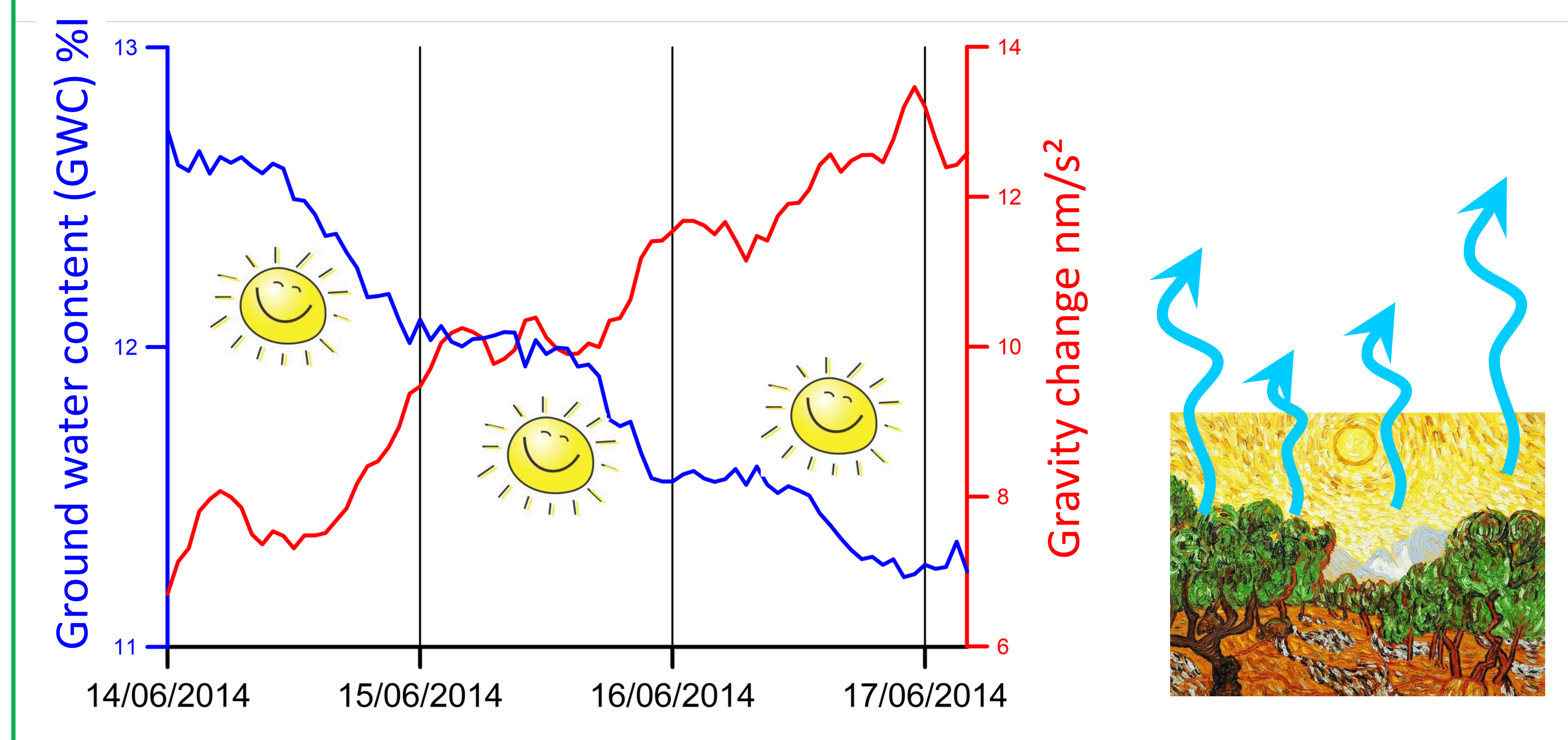
Terrestrial gravimetry allows the monitoring of many phenomena associated with mass change at the 10^{-10} g level (⇔ 1 nm/s²) such as Earth tides, groundwater content, tectonic deformation, or volcanic activity. This sensitivity is richness, but also a source of problems because data interpretation requires separating the signatures from the different sources, including possible measurement artefacts associated with high precision. Separating the signal from a given source requires a thorough knowledge of both the instrument and the phenomena.

Measuring for a long time allows separating phenomena, evidencing elusive signals (evapotranspiration, comparing RADAR and rainfall), looking at the fine structure of the tidal spectrum, and acquiring a comprehensive metrological knowledge of the instruments (drift, calibration, technical features).

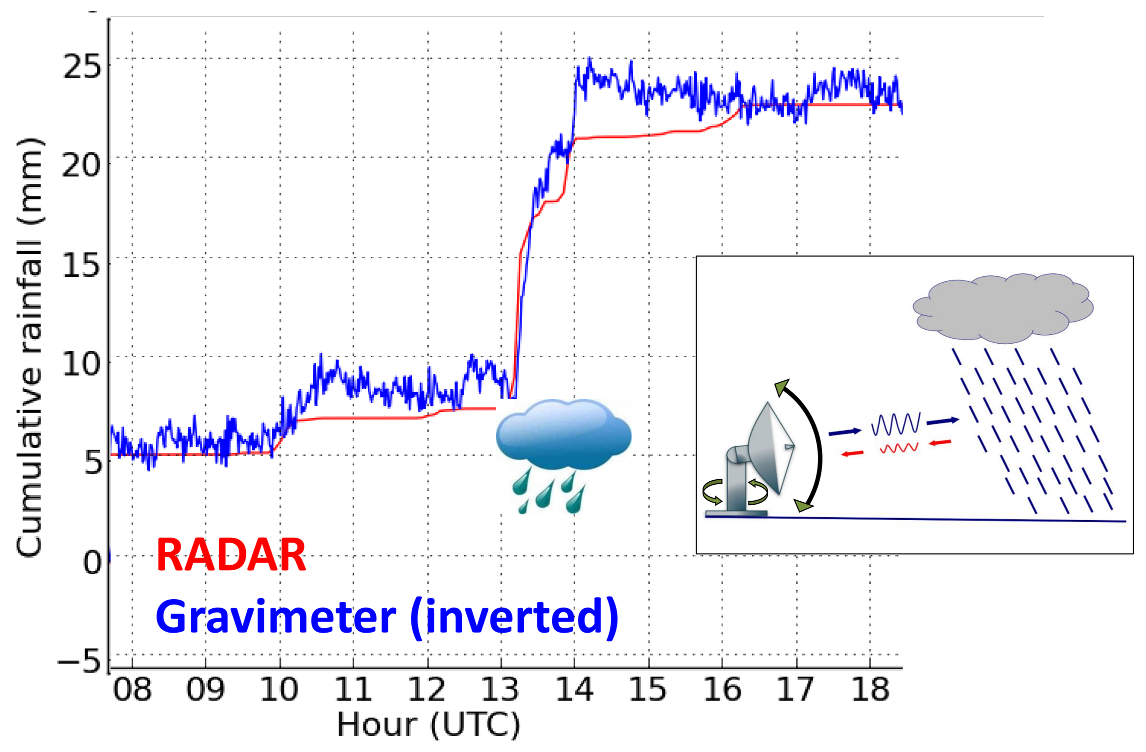
This knowledge could only by achieved throughout multi-instrumentation, multi-disciplinary collaborative studies, and 25 years of hard work.



Repeated AG measurements to measure long term gravity rate of change: stabilisation of the rate and diminishing error since the measurements started in 1996.
The long series mitigate for seasonal and transient hydrogeological effects.
Results with the whole series (300 AG measurements) and simulation with 2 AG measurements/year.
(Van Camp et al., JGR 2010, JGR 2011, GRL 2016)

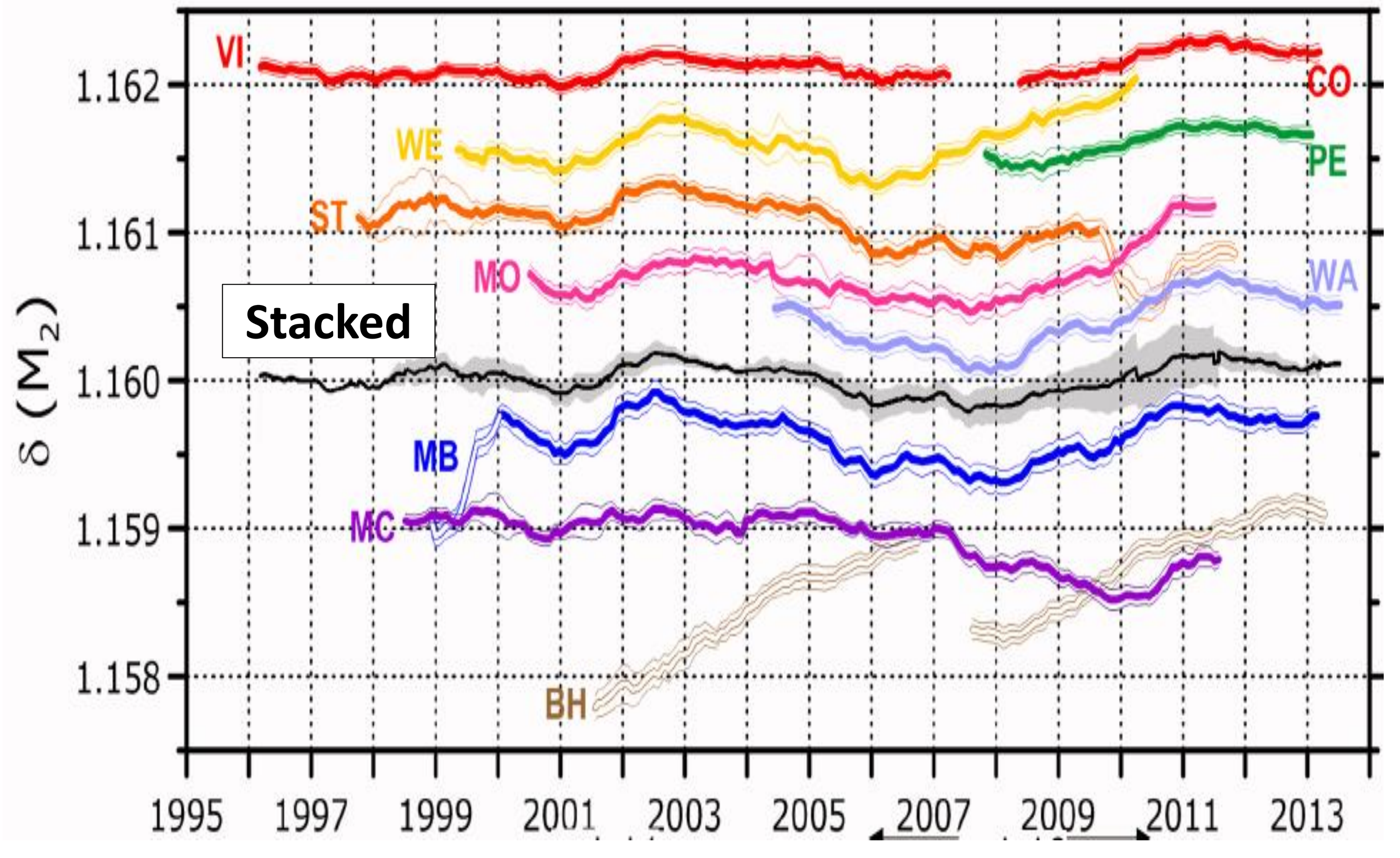


Mass change due to evapotranspiration (soil + vegetation)
~2 mm water/day ⇔ 1 nm/s²/day
(Van Camp et al., GRL 2016)



16 mm rain ⇔ 6 nm/s²
SG agrees with weather radar
(Delobbe et al., HESS 2019)

VI: Vienna (AT) CO: Conrad (AT) WE: Wettzell (DE) PE: Pecny (CZ)
ST: Strasbourg (FR) MO: Moxa (DE) WA: Walferdange (LU)
MB: Membach (BE) MC: Medicina (IT) BH: Bad Homburg (DE)



Fine structure of the tidal spectrum for different European SGs. Here: Temporal variation of M2 tidal parameters δ derived from 1-yr time series
Arbitrary offsets for clarity reasons. Same offsets for VI and CO.
Stack results are displayed as a black line.

Similar undulations of the amplitude factors are observed at almost all stations between 2000.5 and 2007.
The variations are of the order of ±0.02 %: This number sets:
(1) Upper accuracy limit for earth tide model validation based on 1-yr observation periods assuming perfectly calibrated gravimeters and perfect ocean models
(2)Estimates the stability level of SG scale factors.

→ These variations probably caused by insufficient frequency resolution of limited time-series as 2nd and 3rd degree constituents within the M2 group respond differently to ocean loading.
→Temporal variations of the ocean load are also possible (Meurers et al., GJI 2016)