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WROCŁAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCES

Insights into hydrological and ice mass change studies from the perspective of GNSS displacements

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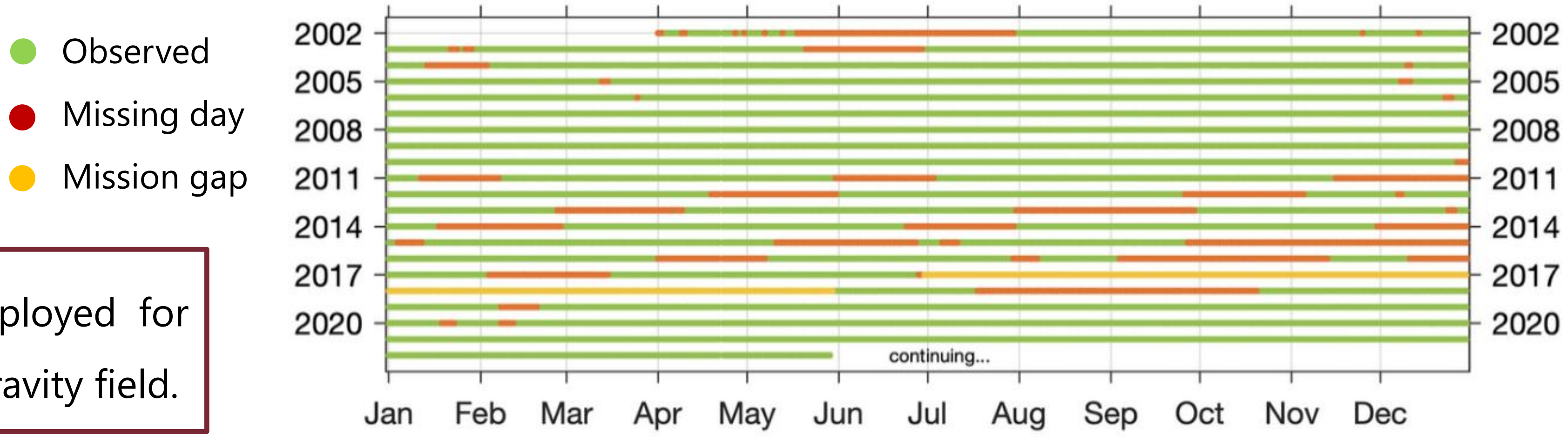
Presentation outline

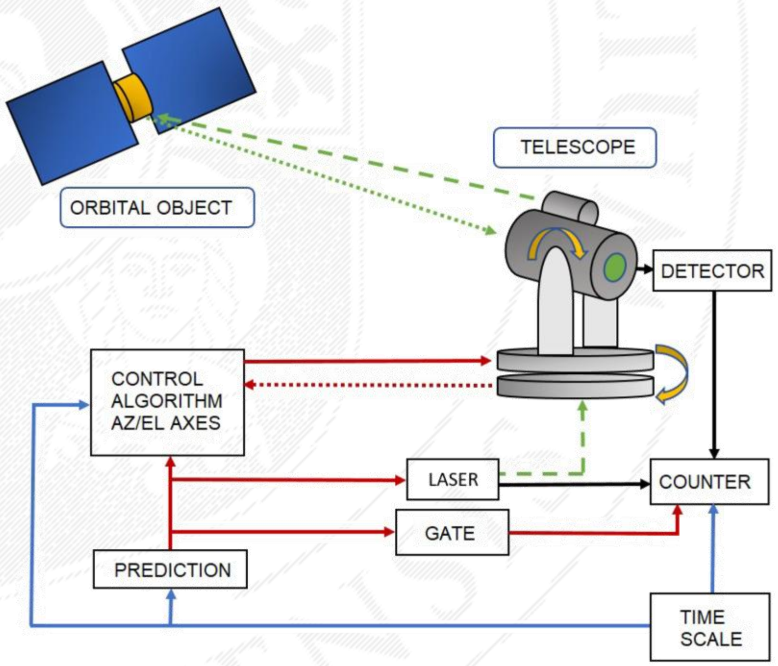
- GNSS Repro3 Data
- Inverse GNSS Approach
- Ice Mass Change Studies
- Hydrological Studies
- Summary

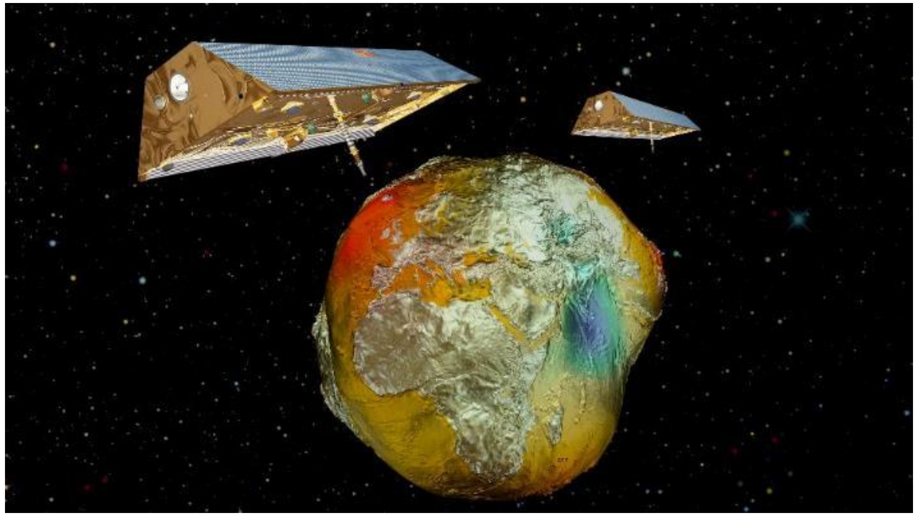
Motivation



Various geodetic techniques can be employed for the recovery of the time-variable Earth's gravity field.

Satellite Laser Ranging





GRACE

2002.04 – 2017.06

GRACE-FO

2018.06 – now

The main motivation is the need to provide an independent technique that will allow validation of models describing large-scale mass changes in the Earth system.

GNSS Repro 3 Data

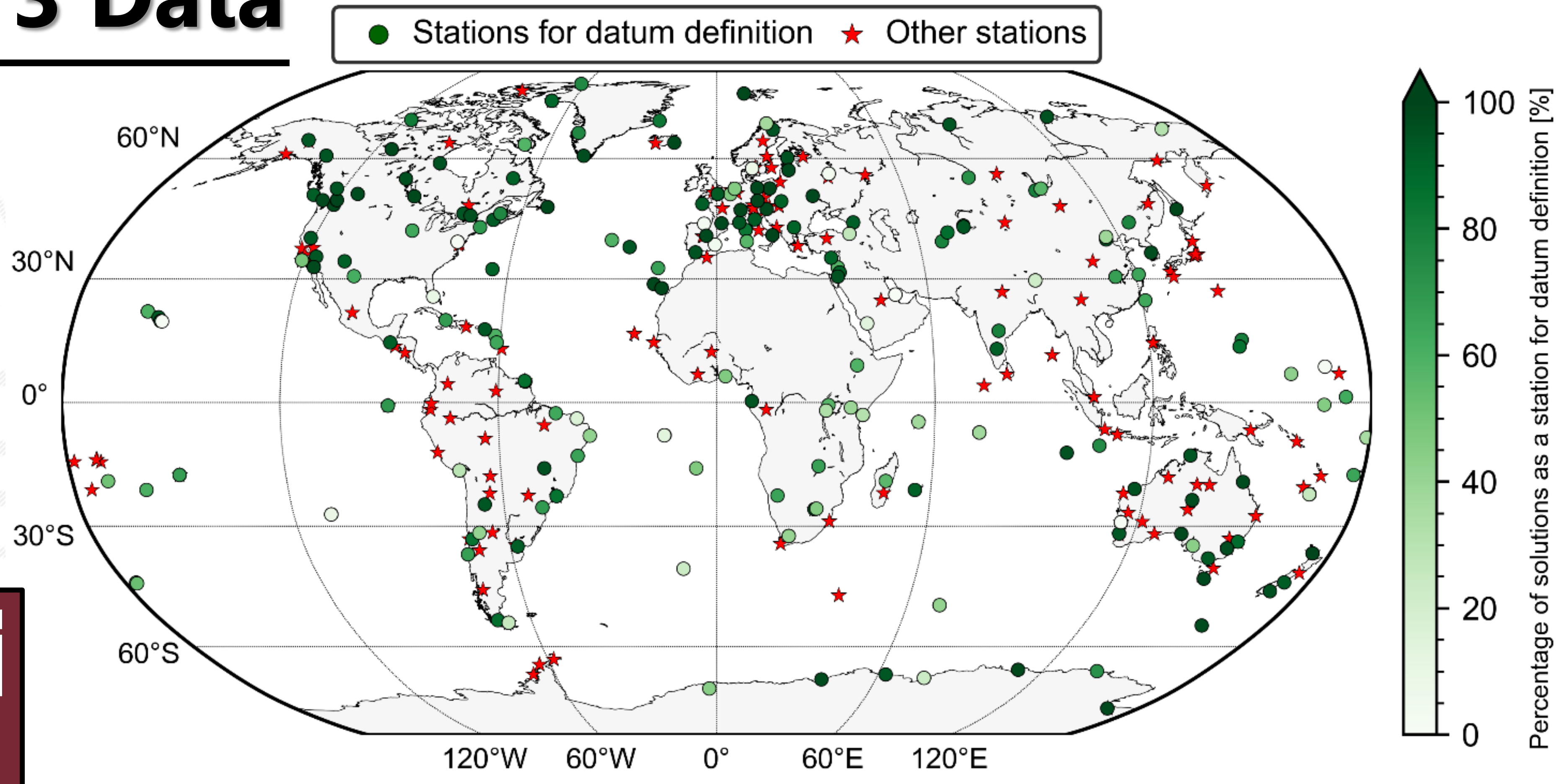
IGS INTERNATIONAL GNSS SERVICE

CODE

6850 Days

GLOBAL GNSS SOLUTIONS

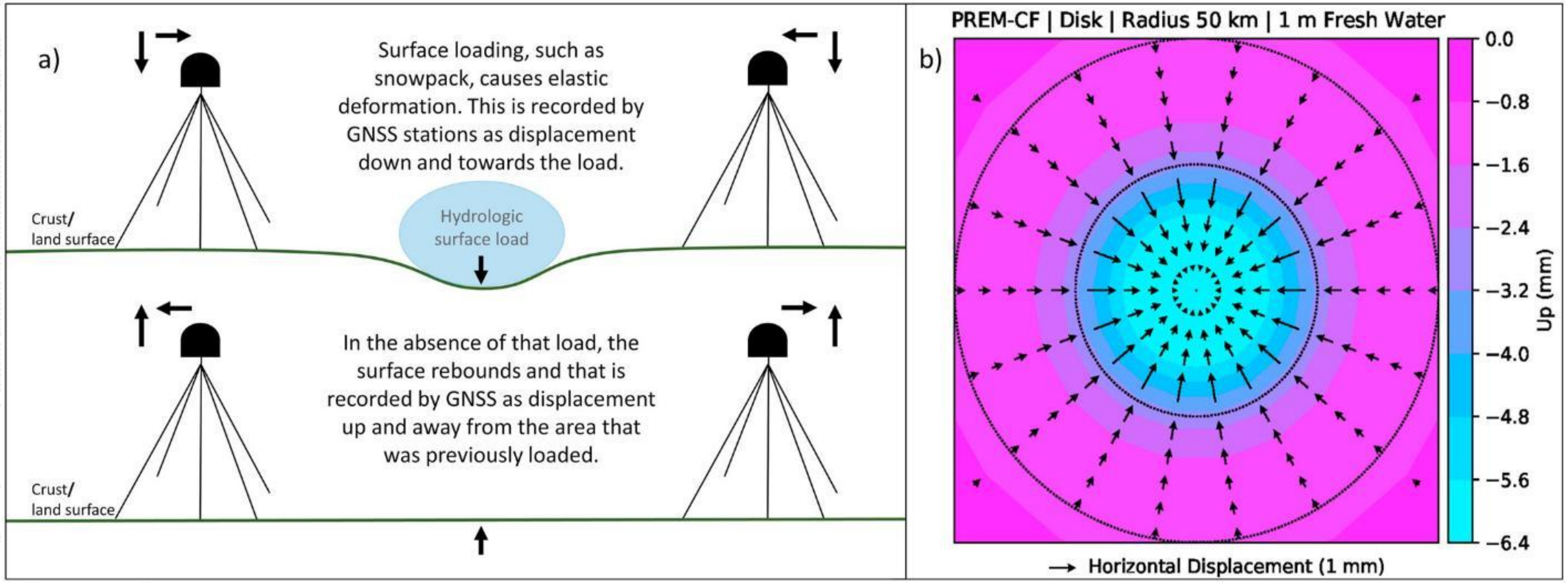
2002.04 - 2020.12



The distribution of GNSS stations is divided into two groups of stations whose coordinates are **estimated with constraints (datum-defining)** and **without constraints**.

Inverse GNSS Approach

- Surface loading, such as surface water, ice, or snow, exerts forces on the surface of the Earth, which causes the Earth to deform.
- The relative **displacements of the ground stations** from a global network of GNSS sites can be used to recover the time series of low-degree gravity field coefficients.



White, A. et al. (2022). A review of GNSS/GPS in hydrogeodesy: Hydrologic loading applications and their implications for water resource research.

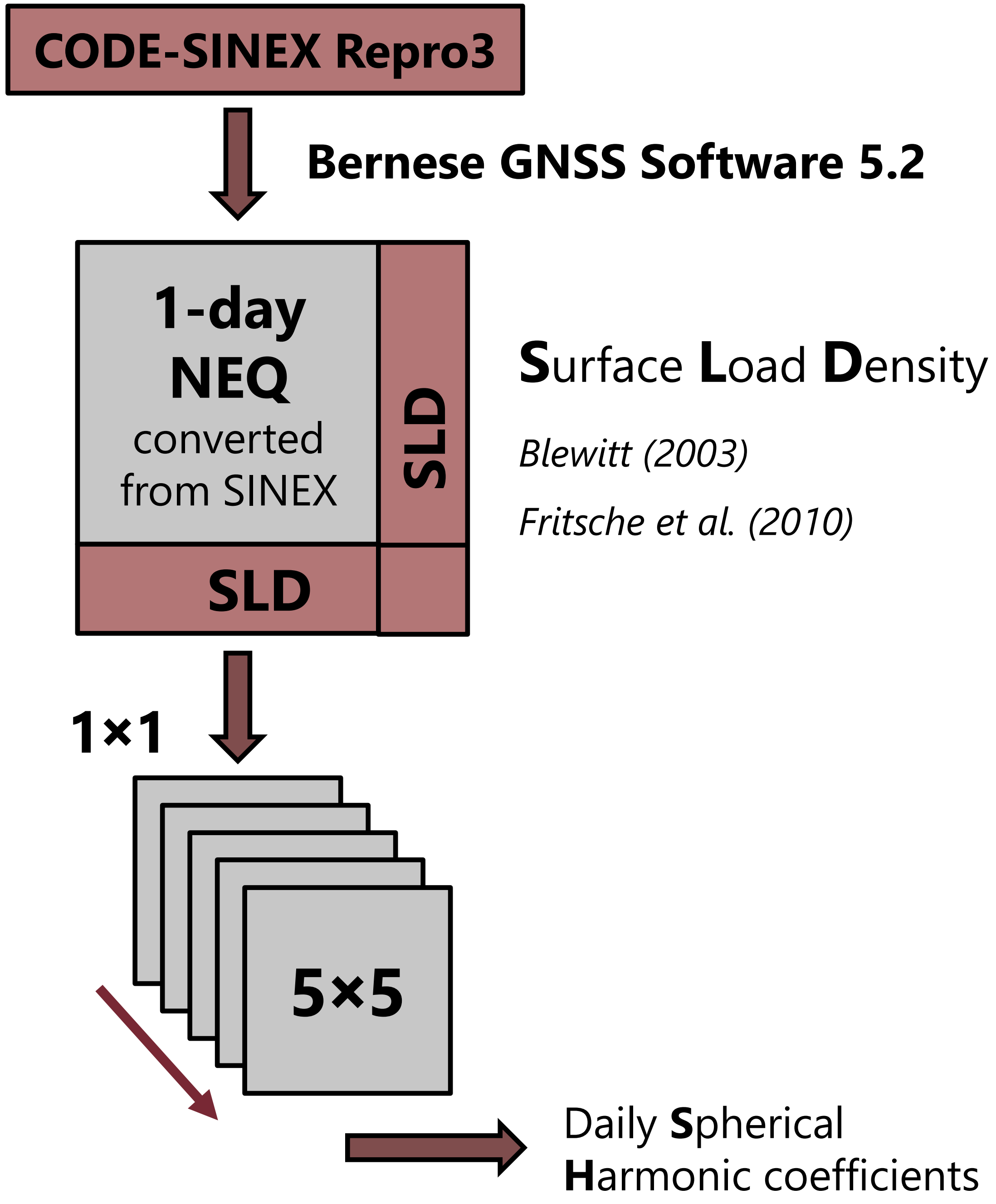
Processing Strategy

1) SINEX files are employed for an independent inversion of the **N**ormal **EQ**uation systems.

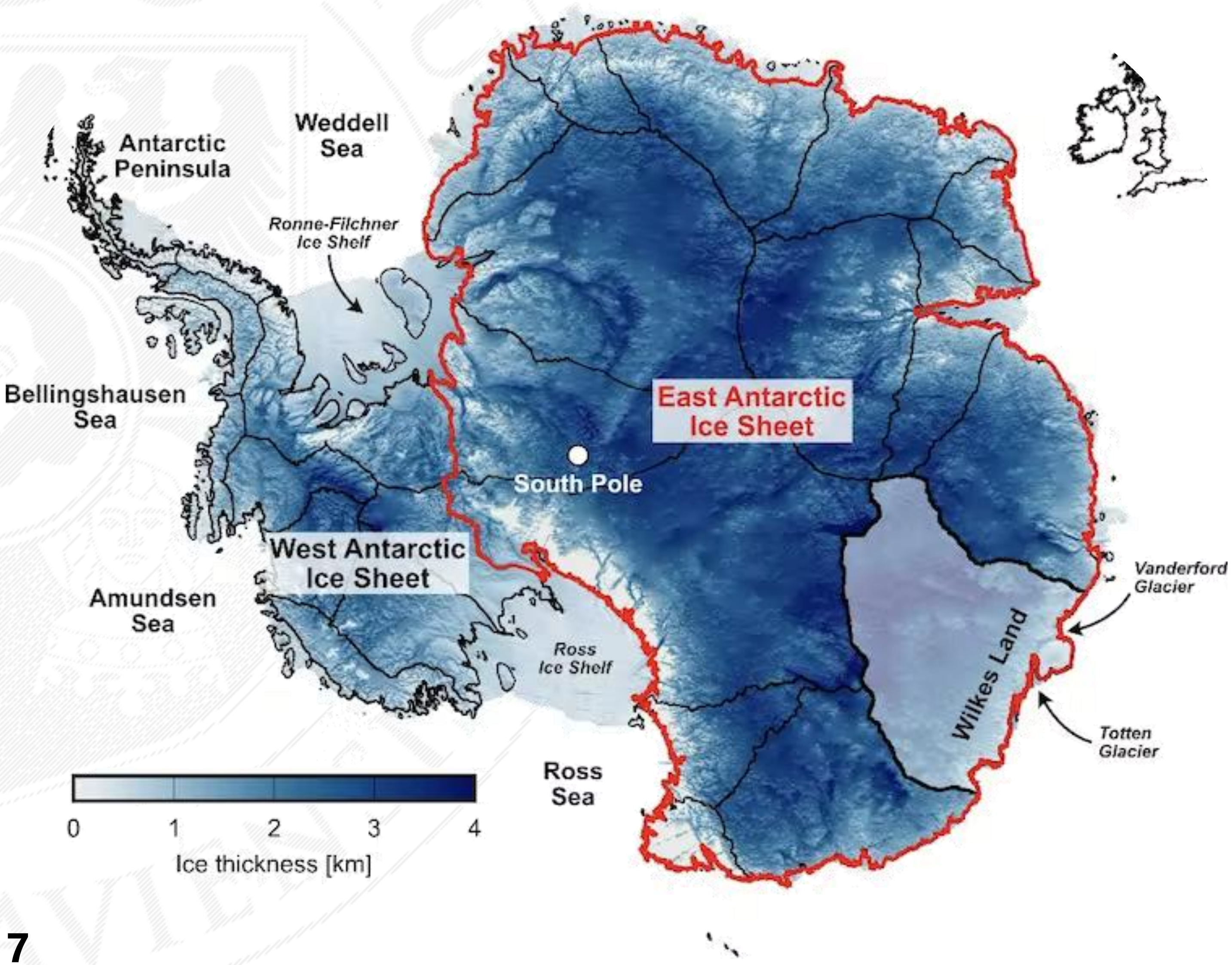
2) The **reference frame** is defined at each epoch by **constraining the coordinates** of reference stations to their a priori values.

3) The daily GNSS solutions are obtained by adjusting all **SLD coefficients up to the maximum degree and order 5**.

4) Solutions are averaged into **monthly models**, from which the **analyzed C_{30} coefficient** is extracted.



Antarctic Ice Sheet

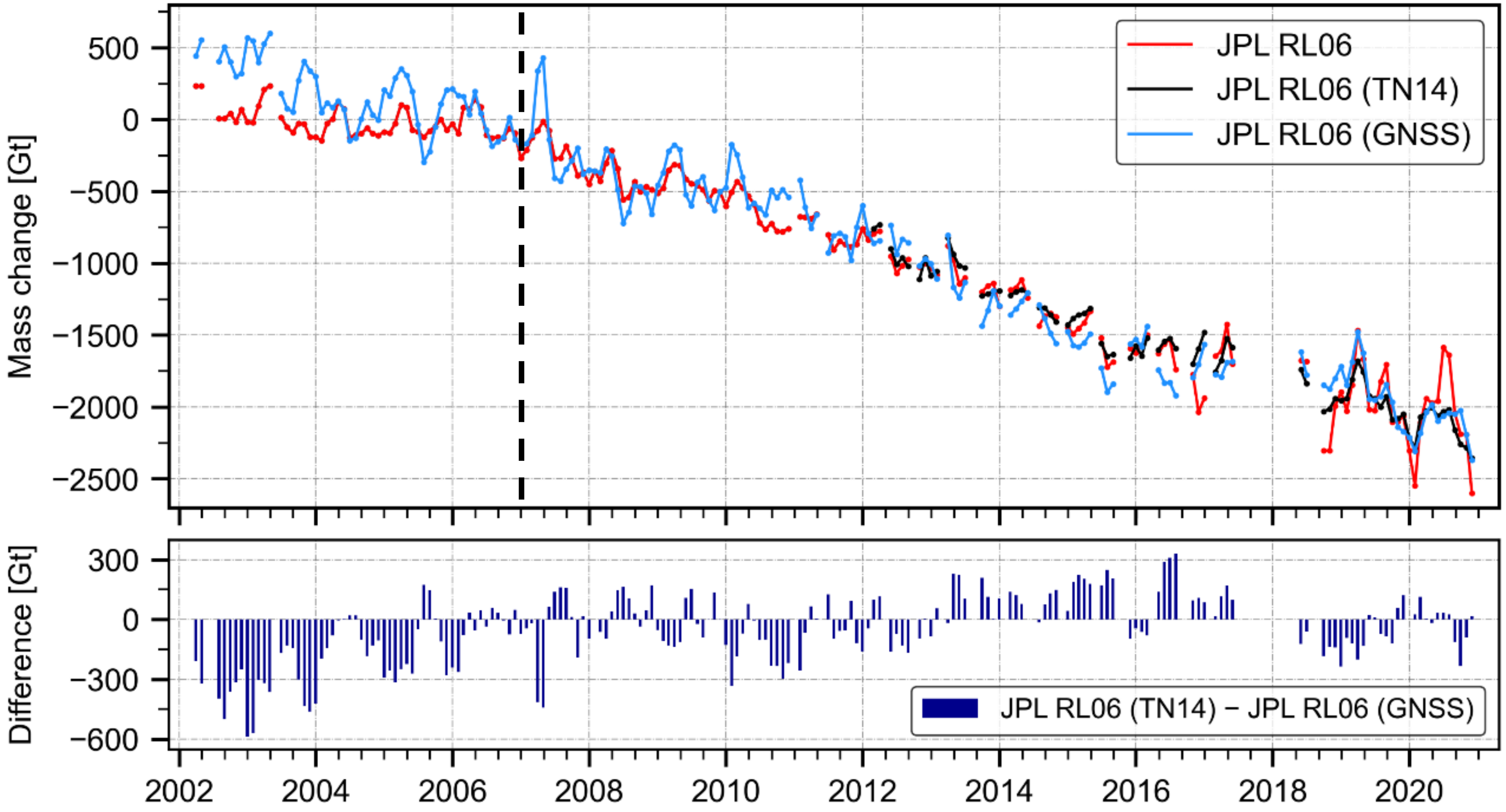


Case study

The accurate recovery of changes to the Antarctic Ice Sheet (AIS) is very important, as the ice contained therein has the potential to **impact sea level rise in the coming decades and centuries**.

Continued monitoring of AIS mass changes is among the key priorities for Earth Science and Applications from Space and is an essential goal for the GRACE-FO mission.

Antarctic Ice Sheet



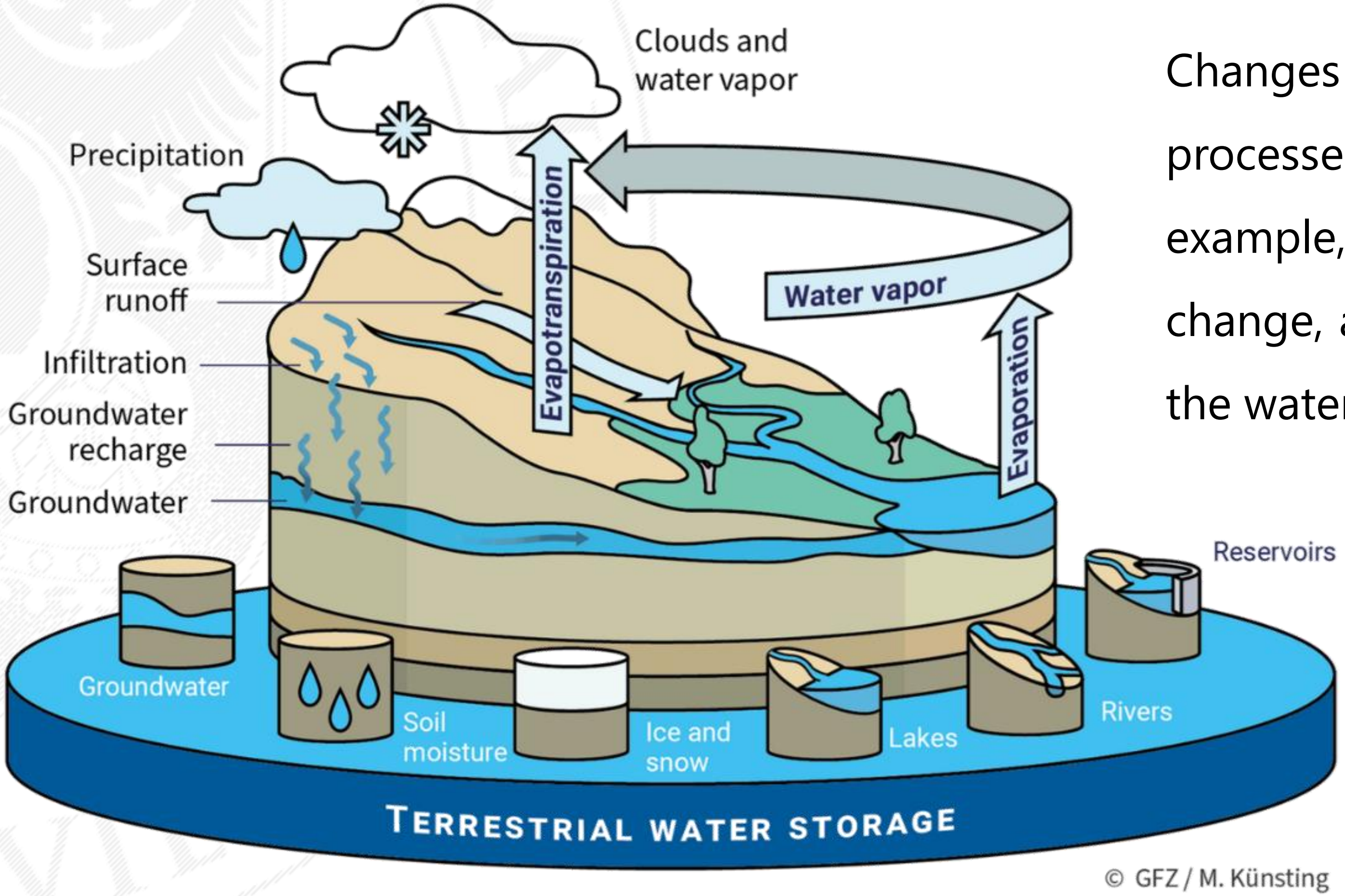
❖ The study highlights the potential of GNSS-GRACE integration as a promising avenue for enhancing gravity models and improving the representation of mass changes within the Earth system.

Area	Period	Parameter [unit]	JPL RL06 original	JPL RL06 TN-14	JPL RL06 GNSS
Antarctica	2007.01 - 2020.12	Trend [Gt/year]	−148 ± 3	−149 ± 2	**−152 ± 4**

TWS

What does **Terrestrial Water Storage** (TWS) mean?

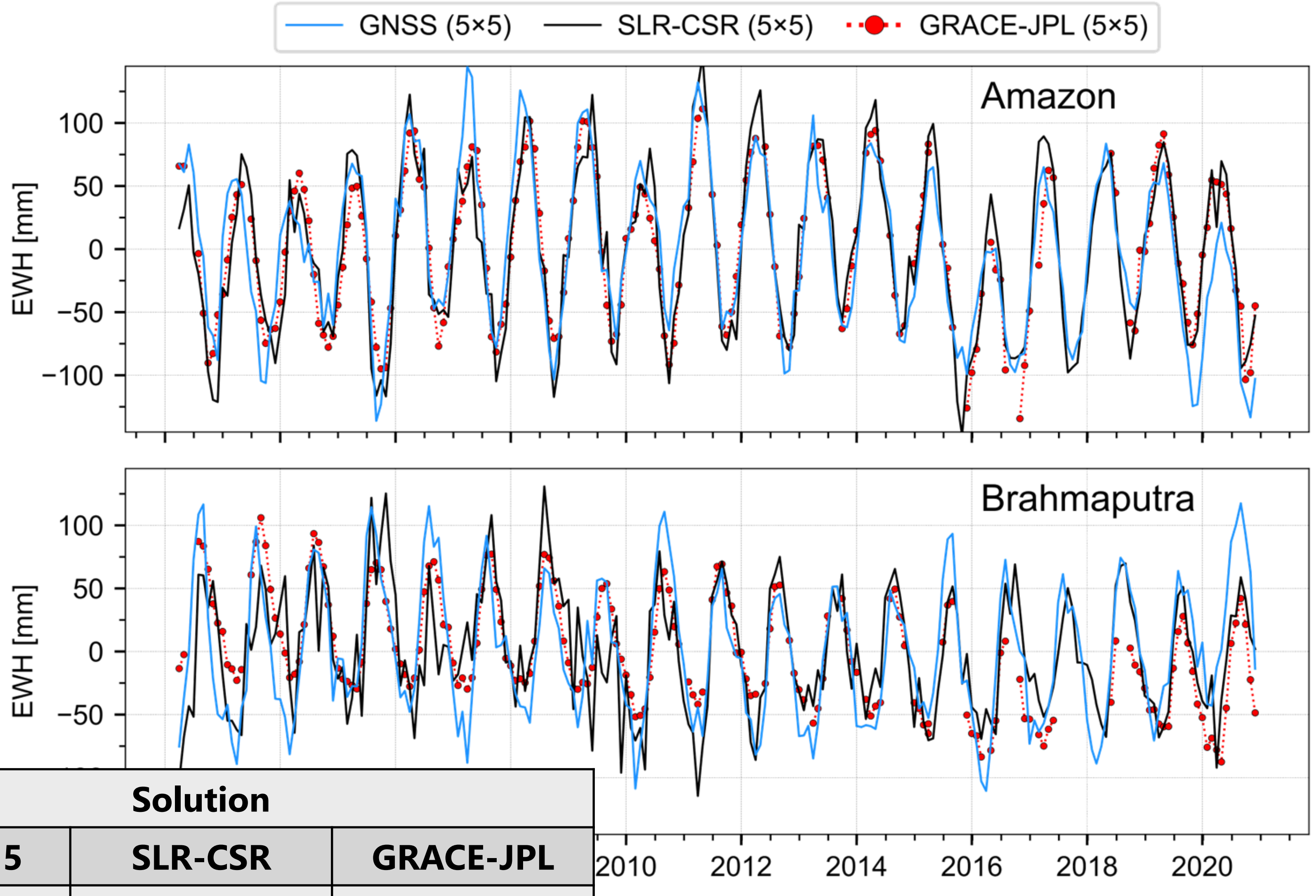
TWS is of particular importance for **understanding the global water cycle**. It gives an overall balance of the water fluxes in precipitation, evaporation, and runoff.



Changes in water storage show how a wide variety of processes **impact the distribution of water**, for example, seasonal change, climate change, land use change, and human consumption, and how this affects the water cycle and ultimately, water availability.

TWS

❖ Gravity field solutions from GNSS are **transformed into variations of the TWS** to prove **the capability of the GNSS technique to track seasonal fluctuations in TWS** within specific local regions.



2002.04 - 2020.12

Area	[mm]	Solution		
	[°]	GNSS 5×5	SLR-CSR	GRACE-JPL
Amazon	Amplitude	**74.7 ± 2.8**	80.8 ± 2.8	**73.9 ± 2.6**
	Phase	99 ± 2	105 ± 2	106 ± 2
Brahmaputra	Amplitude	**66.6 ± 2.4**	50.8 ± 2.9	50.5 ± 1.4
	Phase	234 ± 2	249 ± 3	242 ± 2

Summary

1. The results indicate that GNSS-based C_{30} values have the potential to provide independent estimates to be replaced in the GRACE/GRACE-FO series and to derive polar mass changes.

2. GNSS-derived TWS changes agree with GRACE/GRACE-FO and SLR solutions at a single-millimeter level but show slightly larger annual amplitudes, notably in the Brahmaputra basin.

3. Incomplete global coverage, polar gaps, and uneven hemispheric data distribution could result in biases and challenges for precise estimation of zonal SH coefficients from GNSS data.

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Low-degree gravity field coefficients based on inverse GNSS method: insights into hydrological and ice mass change studies

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