EGSIEM

European Gravity Service for Improved Emergency Management

First results of the EGSIEM Near Real-Time Service

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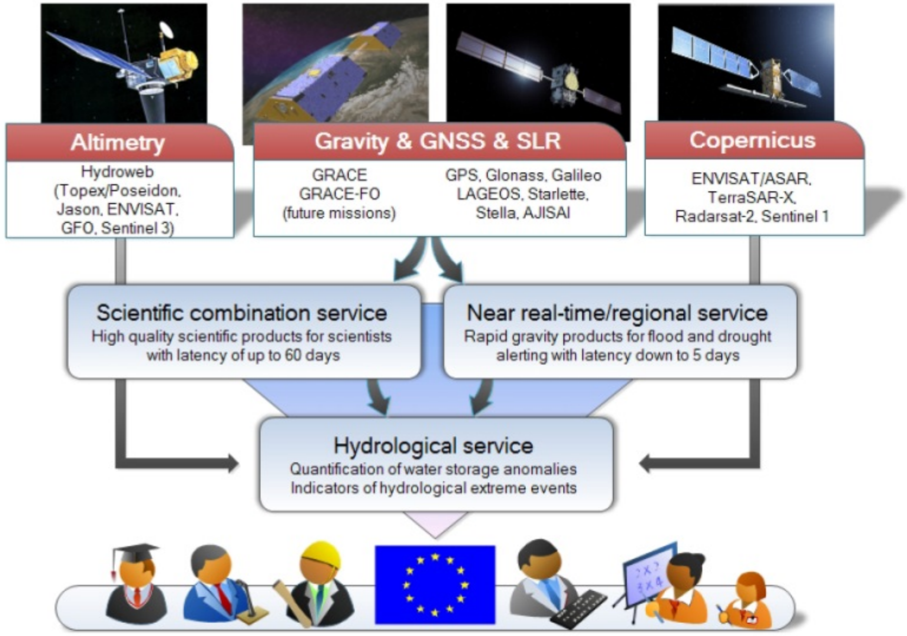
Background

- To show the added value of rapid mass transport products for flood and drought prediction, the Horizon2020 funded EGSIEM project established tech demonstrators for a Near Real-Time (NRT) and Regional Service and a Hydrological Service
- The goal of these services is to reduce the latency of gravity products to less than five days (essentially near real-time) and provide gravity based flood and drought indicators
- The services are jointly run by GFZ, TU Graz and ZKI/DLR
- An operational test run started on April 1st and will continue up to six months, depending on GRACE health status



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Outline

- GRACE gravity fields in near real-time
  - NRT approaches at GFZ and TU Graz
- Tests and validation
  - GNSS loading
  - Historical flood events
- Service data flow
  - Gravity service - NRT GRACE solutions
  - Hydrological service – flood/drought indicators
  - Application of flood indicators at DLR ZKI and JRC/GloFAS

GRACE gravity fields in near real time

GRACE gravity fields in near real time – GFZ

- Kalman filtered solutions using an acceleration approach and surface integral equations

- GRACE data processing follows two-step strategy (Gruber (2015,) Gruber (2017, submitted))
  - Reduced dynamic LEO orbits (reduction of empirical parameters per revolution), constraint by K-Band ranging
  - Observations are gradient differences in line-of-sight

- Kalman filter processing details:
  - Seasonally dependent stochastic process model
  - Background models (annual and secular variation) derived from monthly GRACE fields

GRACE gravity fields in near real time – TU Graz

- Kalman filtered solutions following the approach of Kurtenbach et al. (2012)

- GRACE data processing follows the strategy used in ITSG-Grace2016
  - Kinematic orbits based on the raw observation approach (Zehentner and Mayer-Gürr, 2015)
  - Smoothed star camera product by fusion with accelerometer data (Klinger and Mayer-Gürr, 2014)

- Necessary adaptions (selected):
  - Bi-monthly re-estimation of empirical instrument noise covariance function
  - Outlier detection in Kalman update step using variance component estimation

Test and validation

Test and validation – GNSS loading

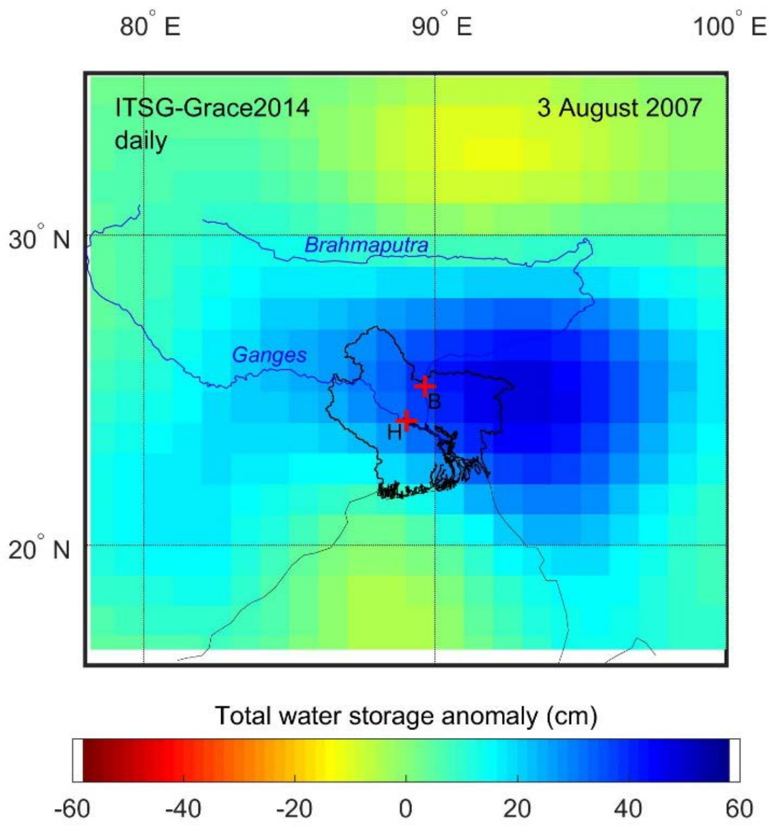
- Input data:
  - Daily ITRF2014 GNSS residuals 1994-2015 (courtesy: IGN)
  - Cleaned and de-trended; selected 394 stations
  - TUG and GFZ daily solutions 04.04.2002-31.08.2016

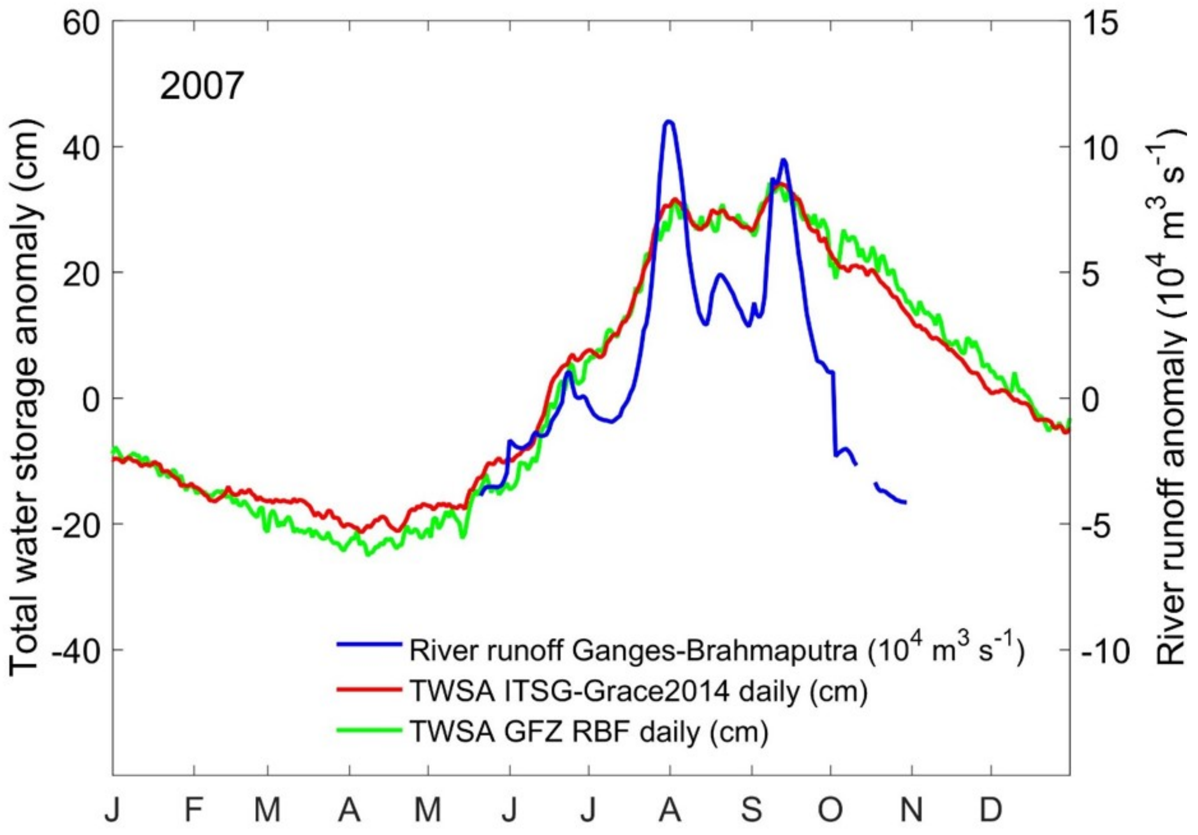
- Comparison over common 13 years period: high and similar WRMS reduction for both, TUG and GFZ solutions

	WRMS reduction [%]				**Positive WRMS reduction [%]**
	min	max	mean	median	
GFZ	-20.06	63.54	5.11	3.66	81.73
GFZ with GAC	-10.85	64.83	16.71	17.12	93.15
TUG	-19.24	64.47	6.43	5.64	81.73
TUG with GAC	-9.74	66.87	17.79	17.53	94.42

Test and validation – Historical flood events

- 2007 Ganges-Brahmaputra floods as seen by GRACE (Gouweleeuw et al., Discussion Paper, doi:10.5194/hess-2016-653): Daily GRACE gravity solutions track major flood events in the GB Delta)





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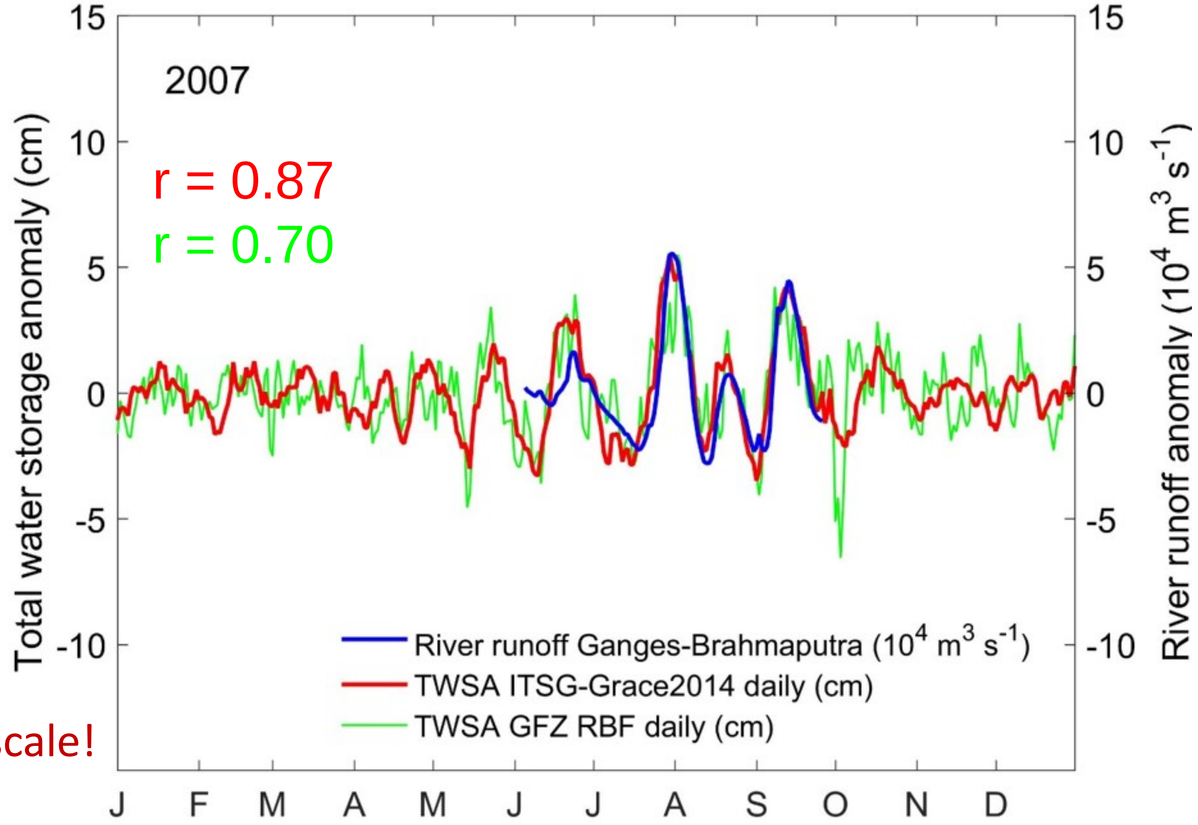
- 31d high-pass filter applied to GRACE solutions and river runoff

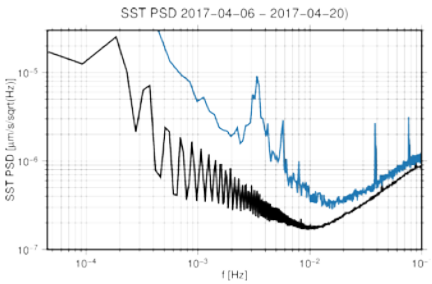
- GRACE TWSA agrees very well with runoff anomalies



Different scale!

NRT service data flow

NRT service data flow

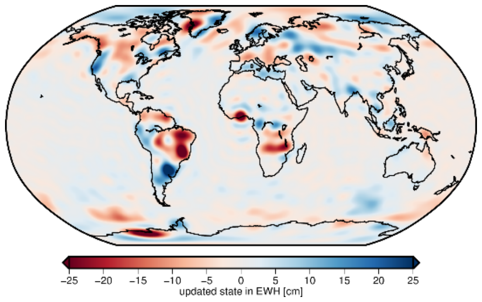


Rapid/quick-look data

- GNSS constellation (CODE)
- GRACE Q/L data (JPL)
- AOD1B RL06 (GFZ)
- EOPs (IERS)

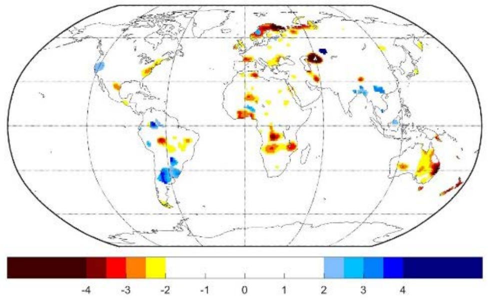
Gravity Service

- Daily gravity field solution
- Quality estimates



Hydrological Service

- Global flood/drought indicators



Rapid Mapping Service at ZKI

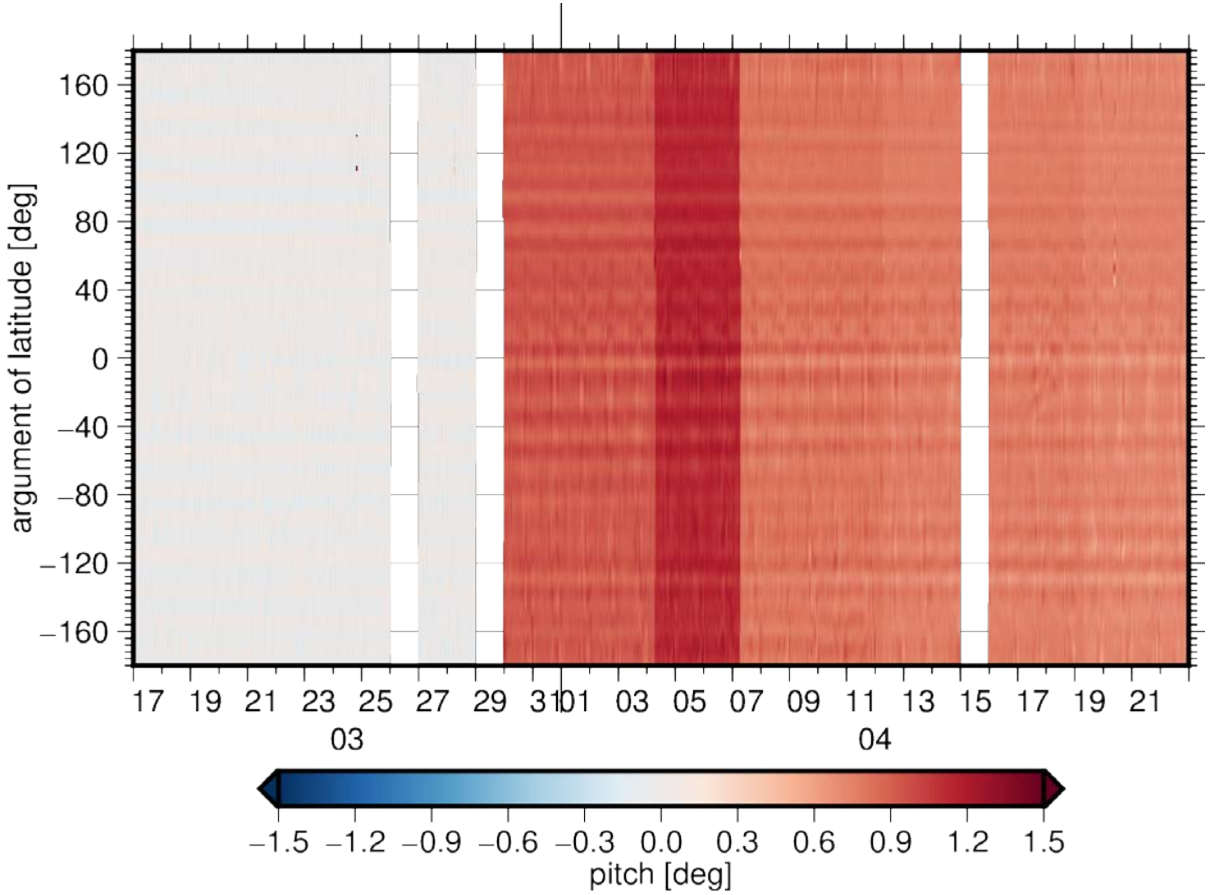
- Satellite tasking
- Archive search
- Map production

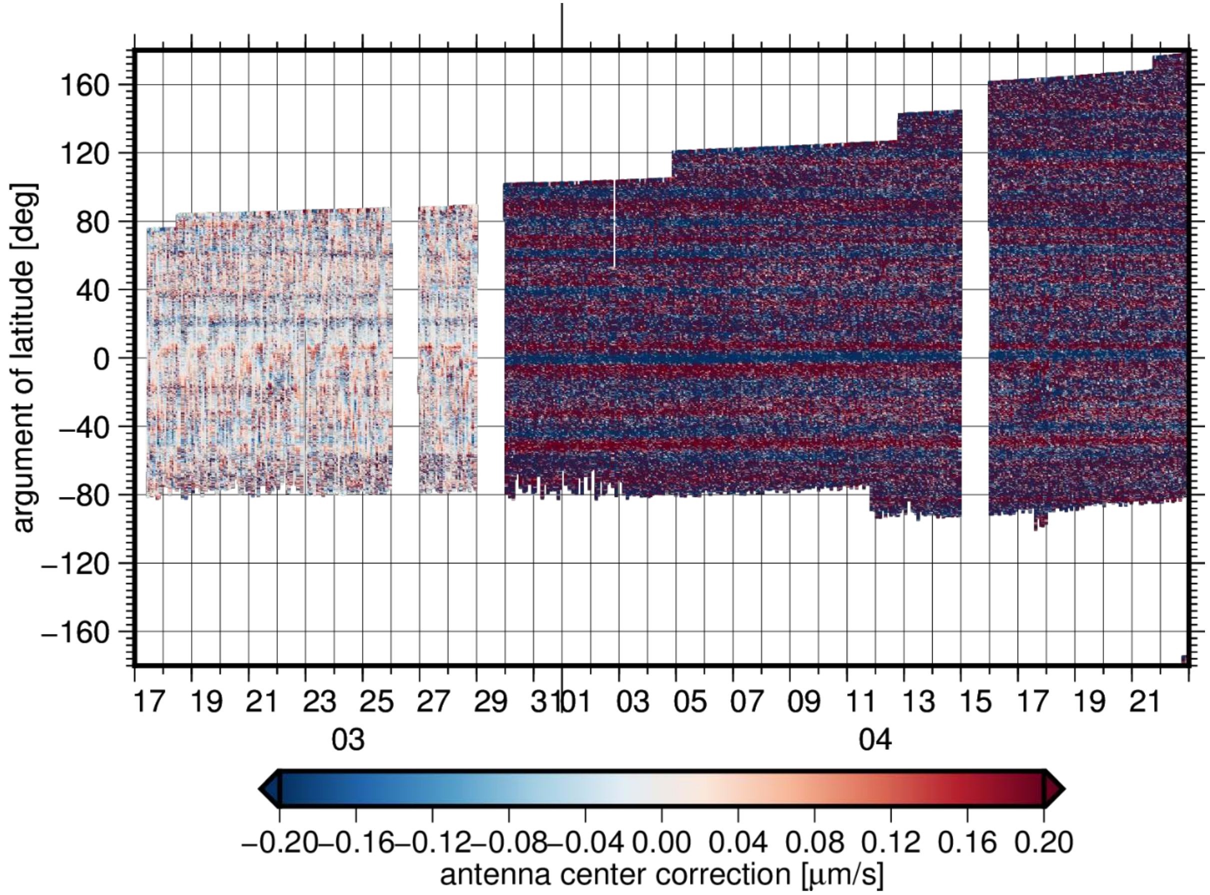
JRC/GloFAS

- GloFAS Forecast Viewer

NRT service data flow – Gravity Service

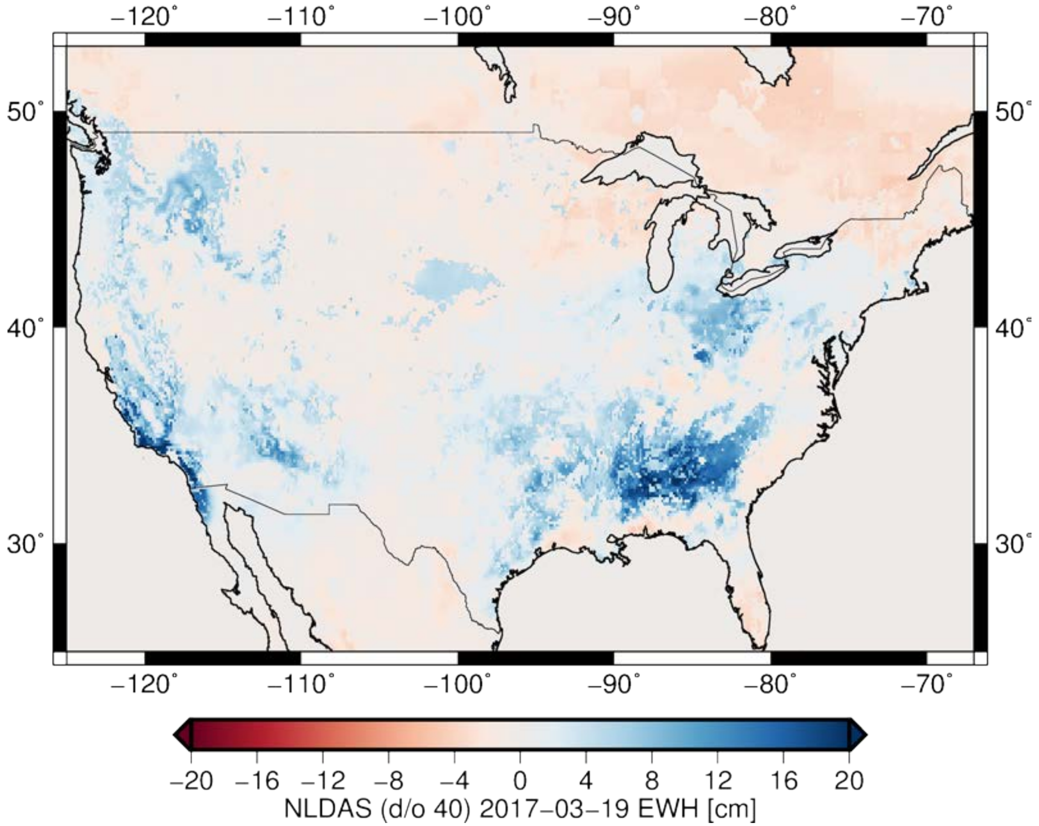
- Inter-satellite pointing currently poses the largest challenge
  - Increased pitch angle result in large antenna center correction, which partially maps into the gravity field

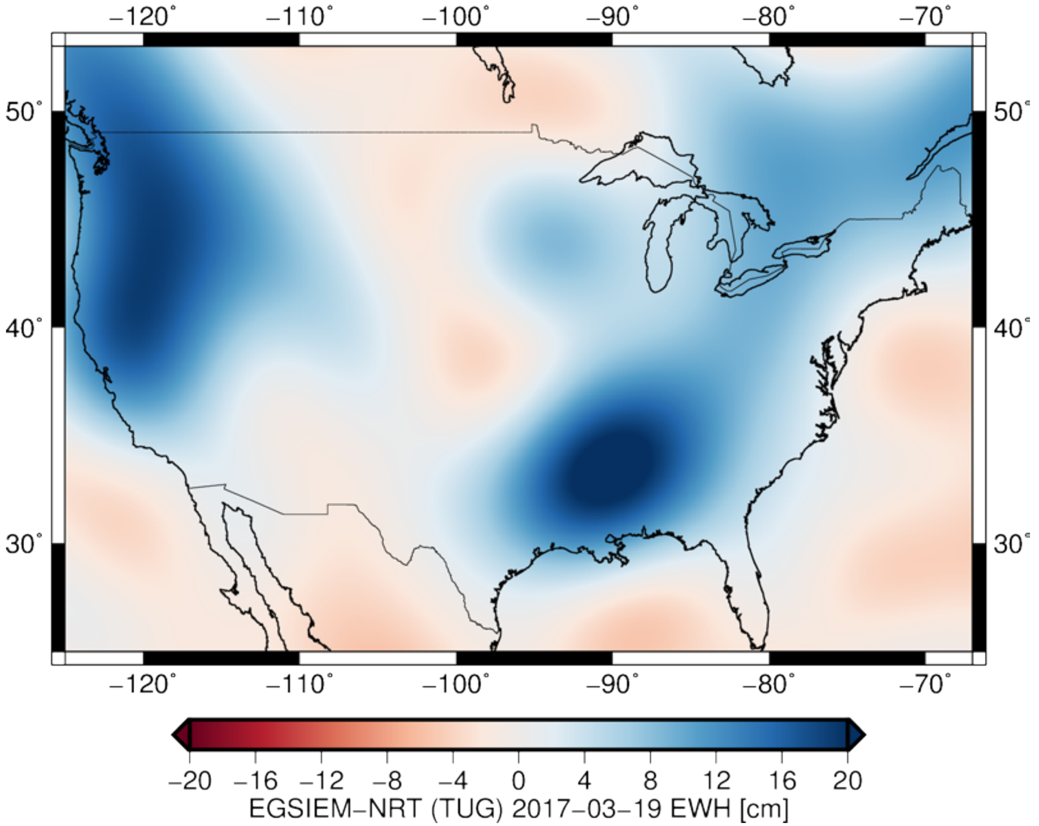




NRT service data flow – Gravity Service

- Regional evaluation: comparison with NLDAS





NRT service data flow – Gravity Service

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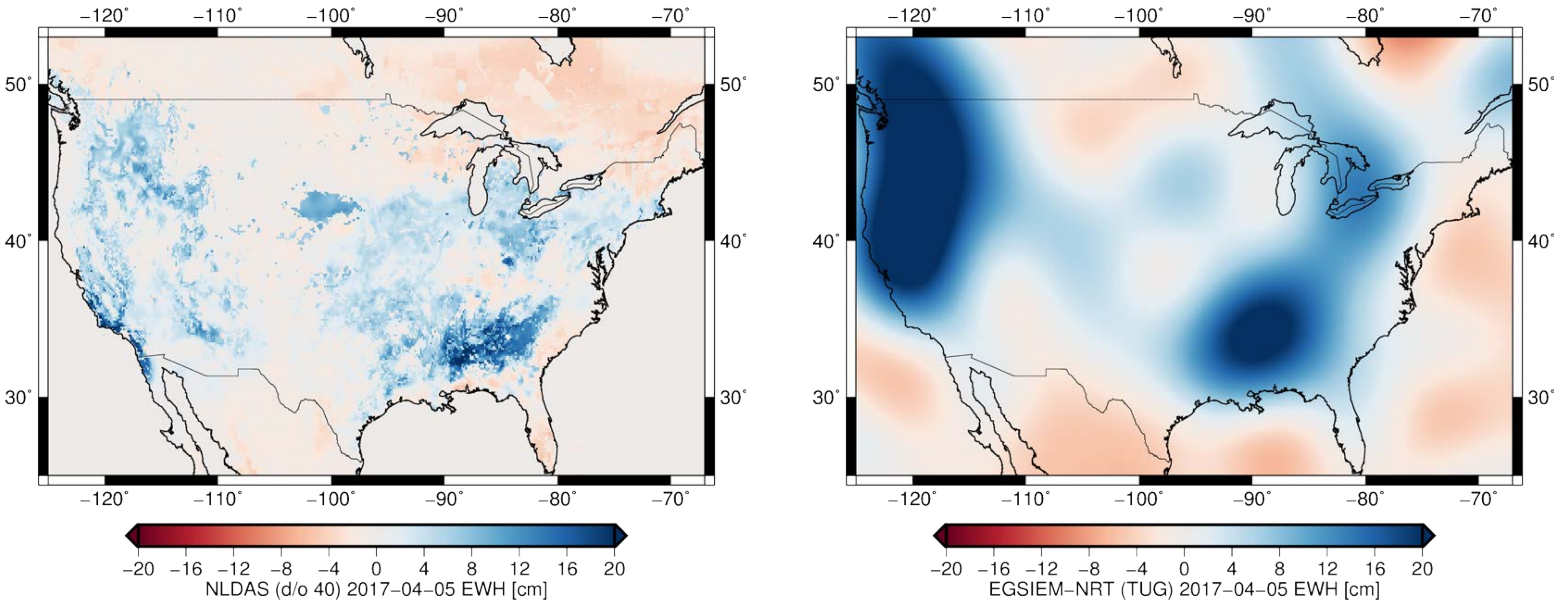

NRT service data flow – Gravity Service

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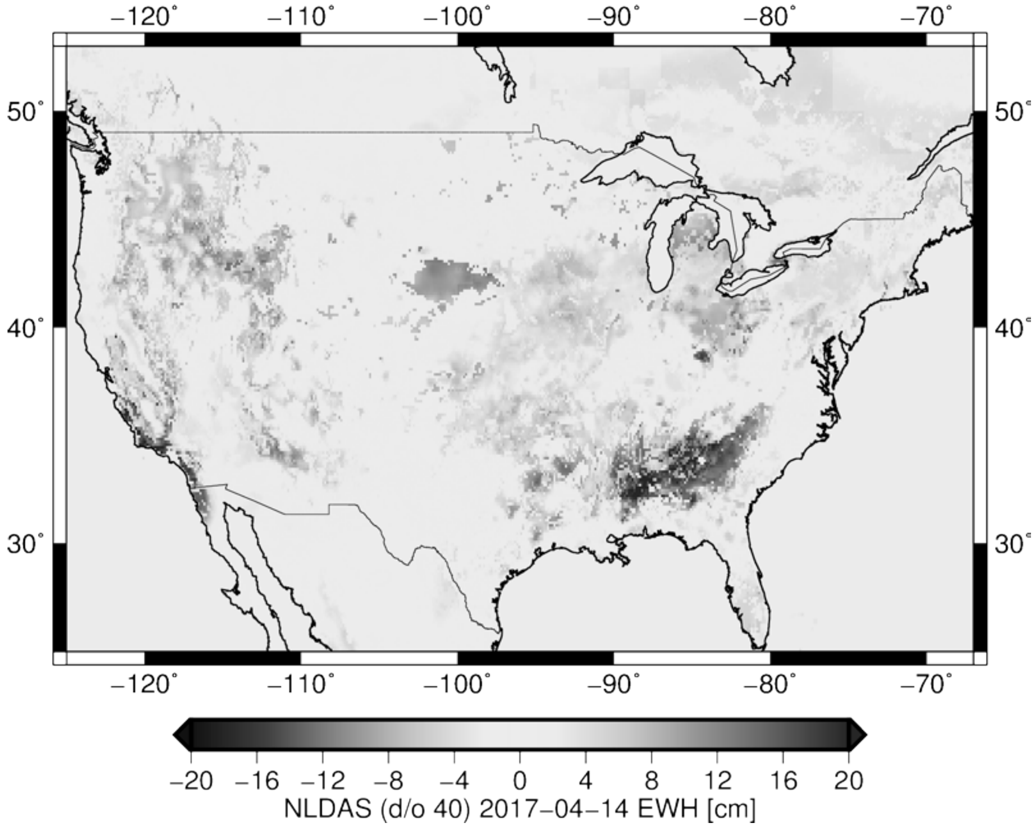
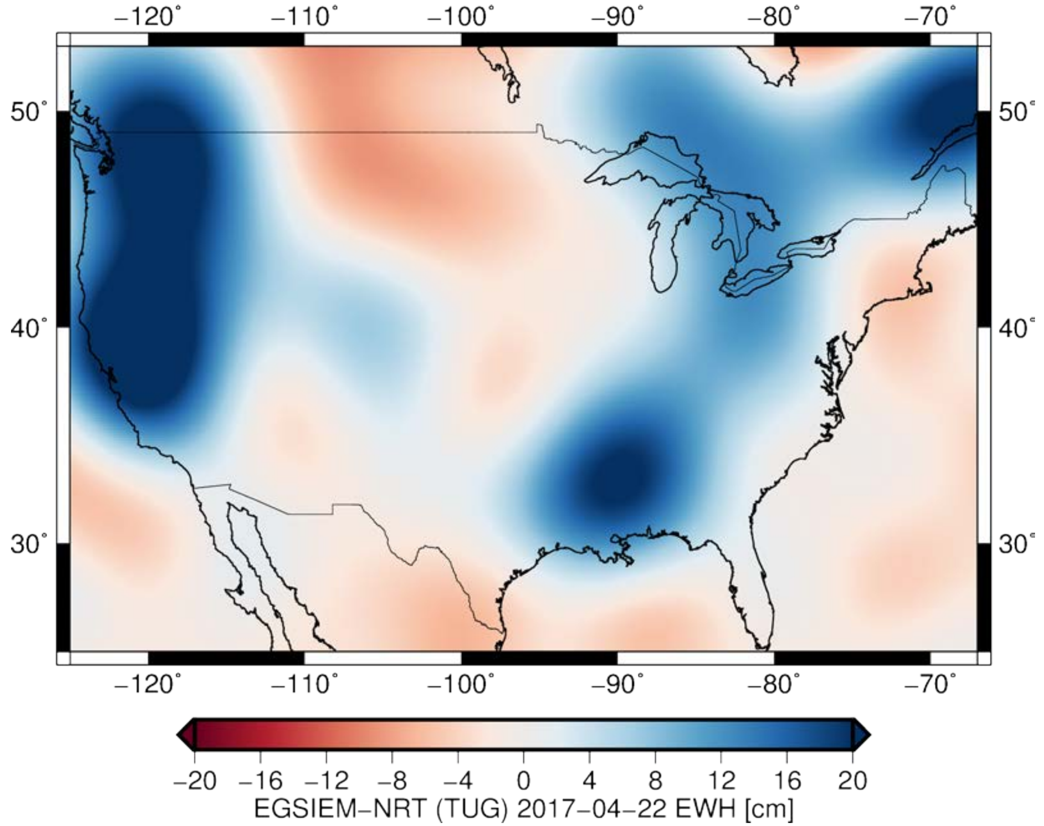
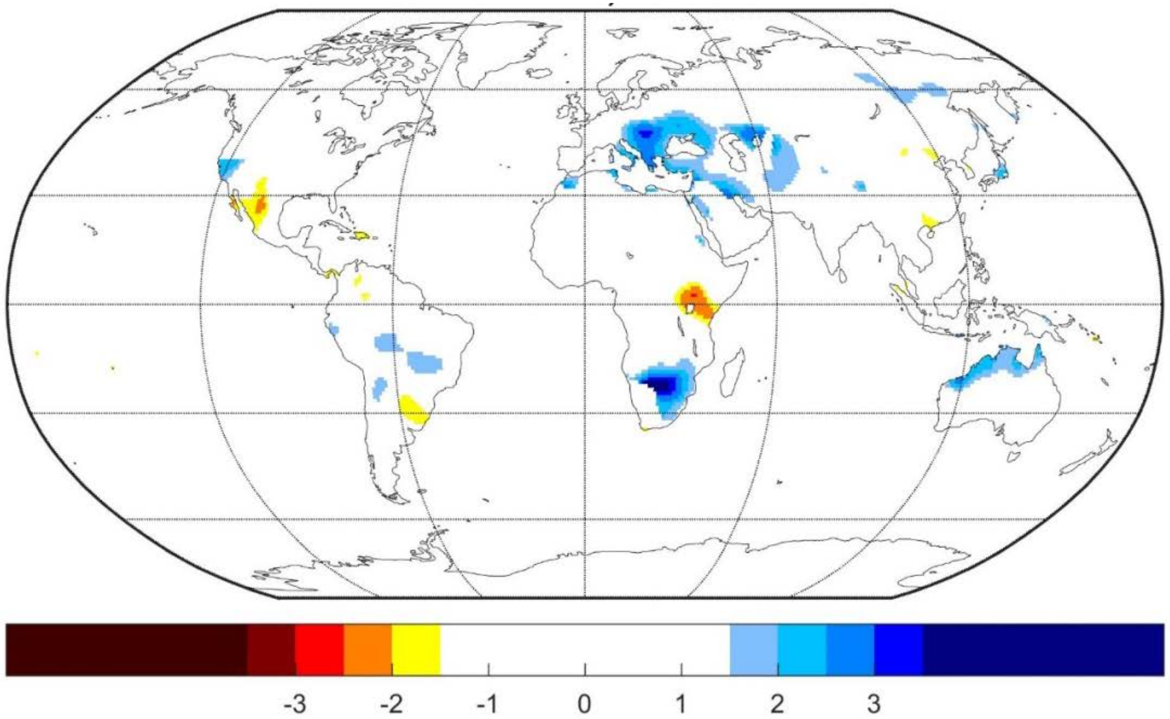




NRT service data flow – Hydrological Service

- Based on the daily gravity field solutions, a wetness index is computed
- Input: gridded total water storage anomaly in center of figure, GIA reduced
- For each pixel:
  - Correct seasonal cycle and secular variations
  - Divide pixel by standard deviation
- Result: unitless index for each pixel

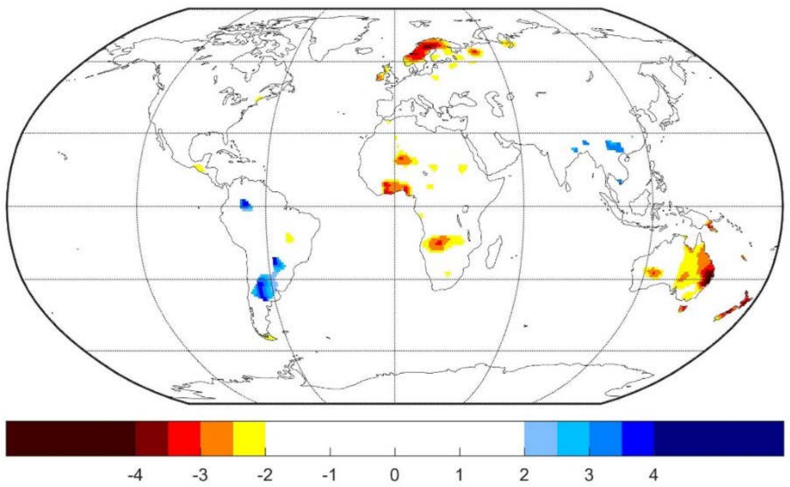
EGSIEM Wetness Index, 19 March 2006



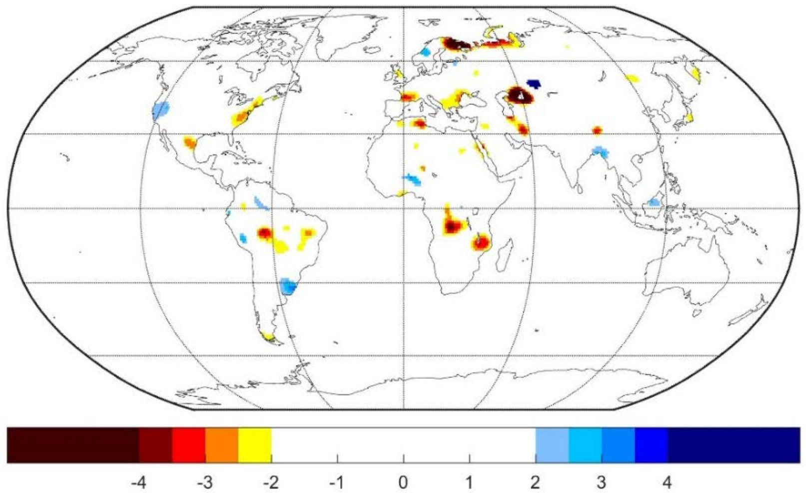
- Wetter than normal conditions (2.5-3 times the standard deviation) are indicated for the Danube basin in March 2006, before the floods in April

NRT service data flow – Hydrological Service

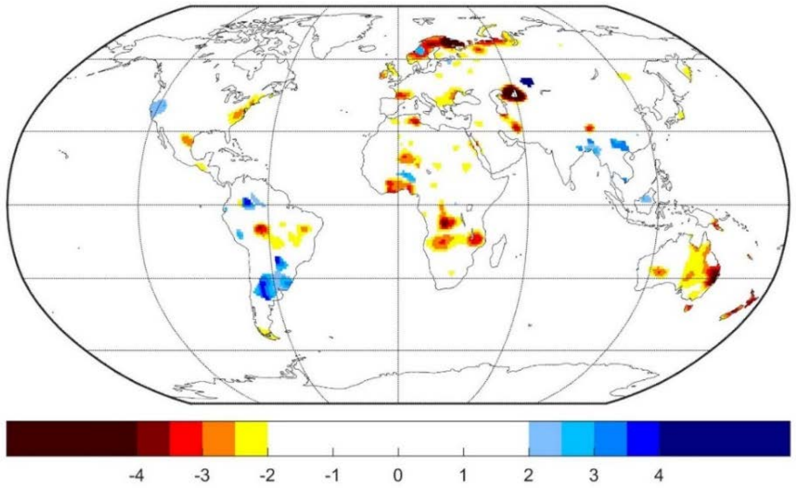
GFZ 18.04.2017

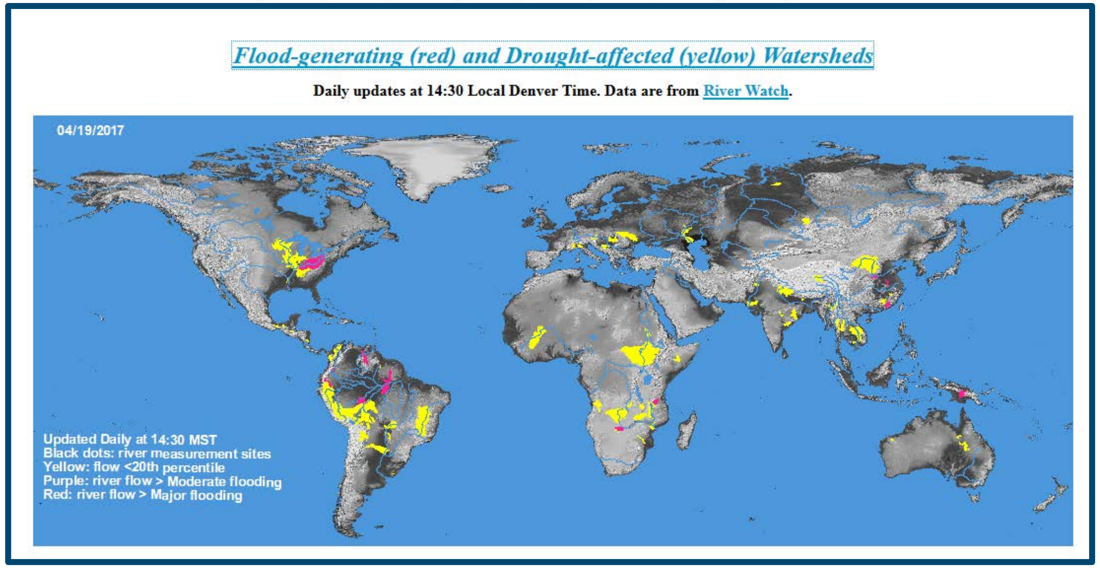


TUG 18.04.2017



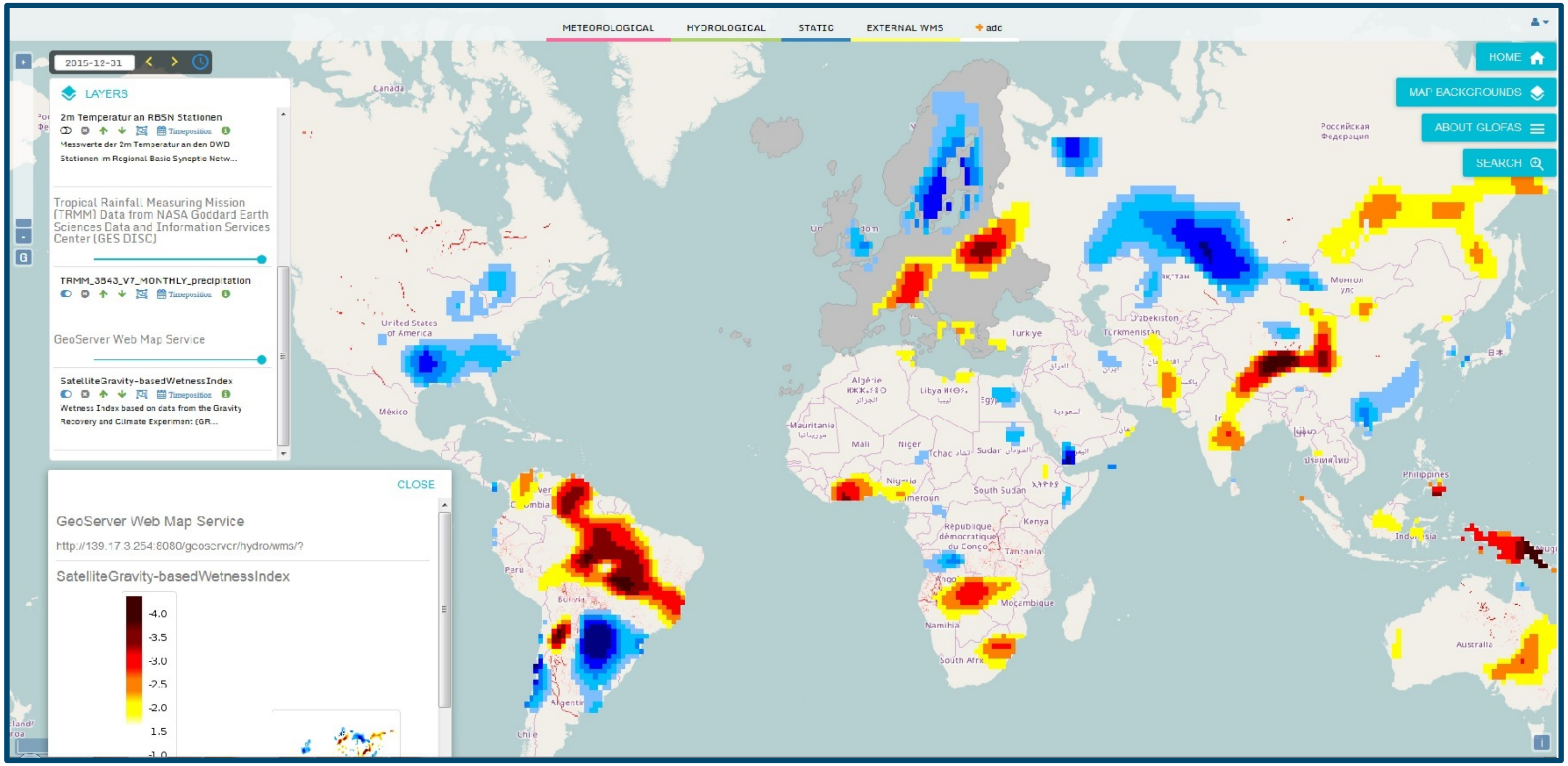
Combination 18.04.2017





NRT service data flow – Use of indicators at JRC

- Ongoing testing in GloFAS comparing flood occurrences/warnings with increased water storage conditions
- NRT products ready for implementation



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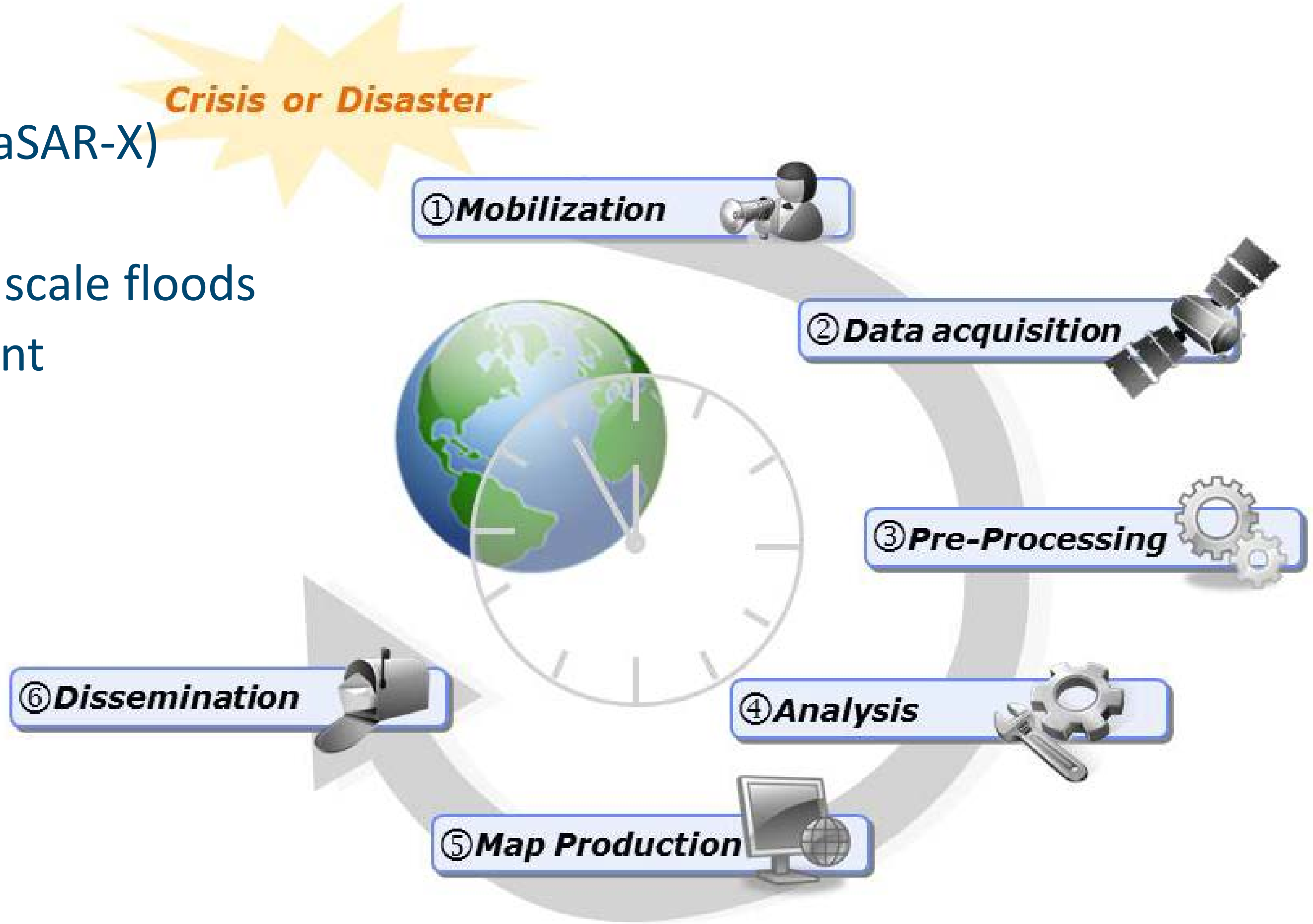
NRT service data flow – Use of indicators at ZKI

- The tech demonstrator will be used as an early-warning component for large scale floods
- Increases lead time for satellite tasking (e.g. TerraSAR-X)
- Enhances the satellite-based monitoring of large scale floods
  - Better crisis response and disaster management



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Summary

Summary

- EGSIEM NRT Gravity and Hydrological Services have been implemented and are up and running
- Evaluation of the daily gravity field solutions during major historical flood events show that short-term temporal variations in river runoff can be picked up by GRACE
- Currently, gravity field solution quality is not on the level of historical data
- Details about the wetness index: Poster by Gouweleeuw et al. in HS6.3 on Tuesday
- Summary paper for historical evaluation “Daily GRACE gravity field solutions track major flood events in the Ganges-Brahmaputra Delta“ is currently in HESS discussion
  - Interactive comments cordially invited on **doi:10.5194/hess-2016-653**

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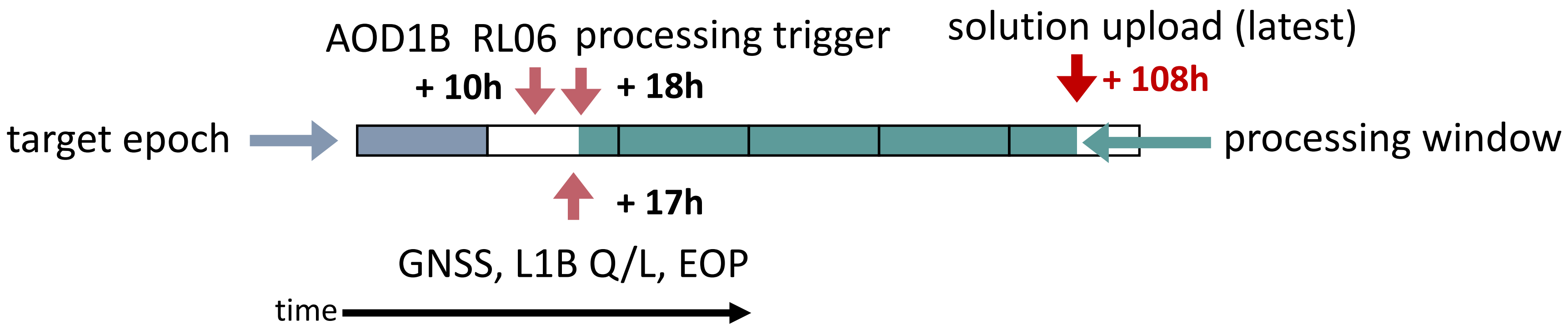
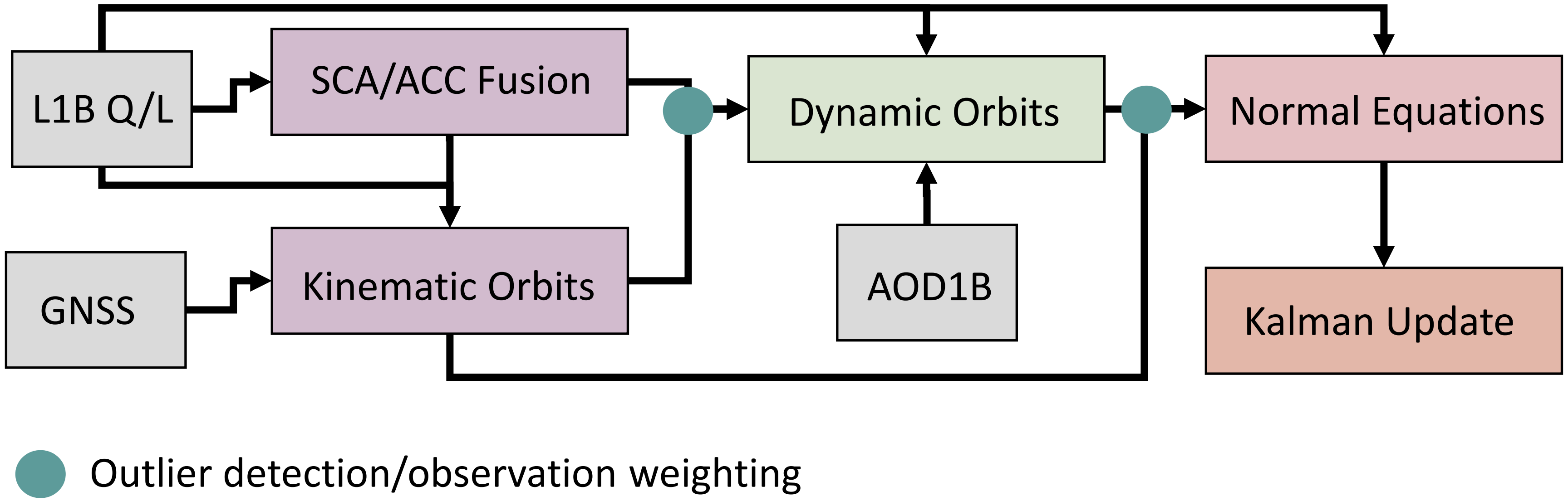
UNIVERSITÄT BERN | UNIVERSITÉ DU LUXEMBOURG | GFZ Helmholtz Centre POTSDAM | TU Graz Graz University of Technology | Leibniz Universität Hannover | cnes | DLR | géode & cie | Horizon2020

GRACE gravity fields in near real time – TU Graz

- Processing schedule:



- NRT processing flow:



GRACE gravity fields in near real time – GFZ

- NRT scheduling at GFZ :

Day of event 24:00

- **UB: CODE constellations, EOPs** +17:00
- **L1B QL data (KBR, SCA, ACC)** +18:00

1 day 24:00

- **Stochastic prediction** 1d+18:00

1-4 day 24:00

- **3-hourly AOD1B RL06** 4d+08:00
- **Dynamic orbit (iterated)** 4d+12:00
- **Kalman update** 4d+12:00
- **Plausibility test/ Evaluation** 4d+12:00
- **Grid release /coefficients upload** 4d+12:00