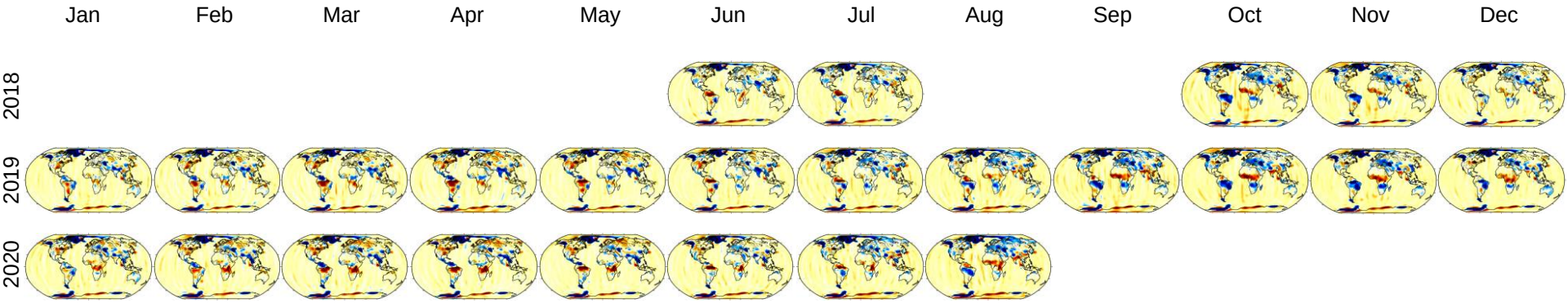
SDS Level-2/-3 GFZ

Christoph Dahle
&
GFZ GRACE/GRACE-FO SDS Team

GRACE/GRACE-FO Science Team Meeting
Online meeting, October 26-29, 2020



GFZ GRACE-FO RL06 Operational Level-2 Processing

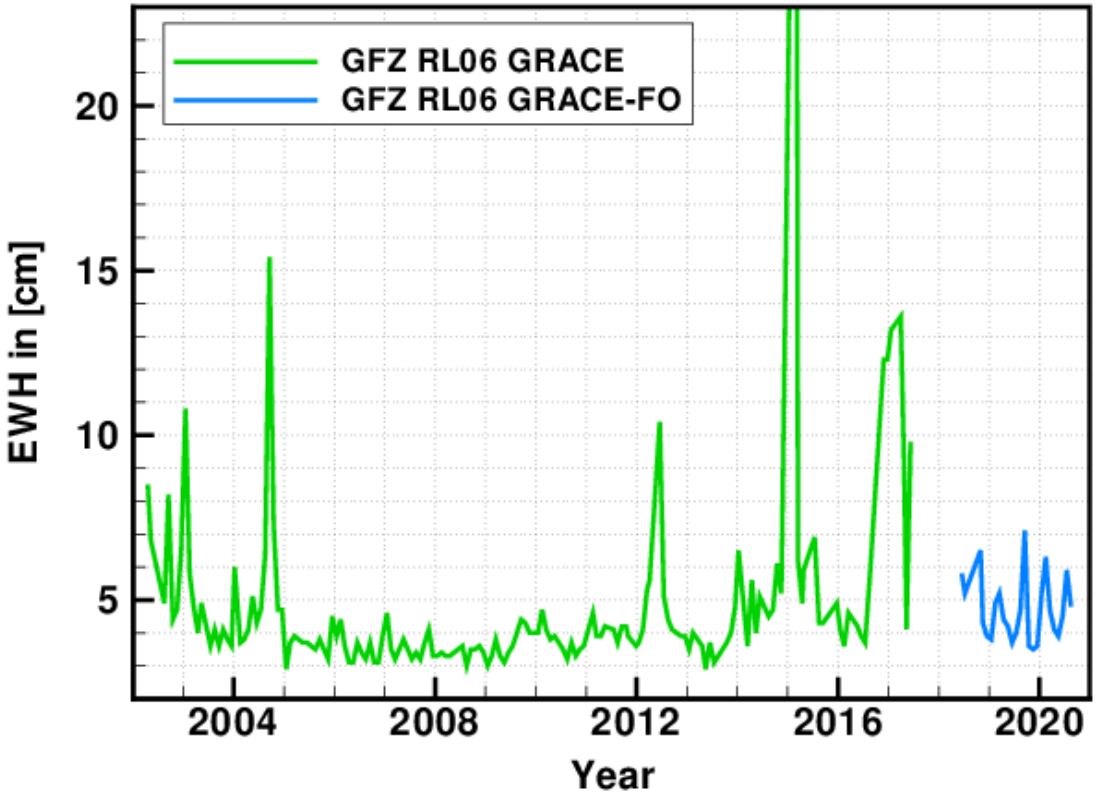


- Current processing status: 25 monthly solutions from June 2018 through August 2020
  - Available at ISDC and PO.DAAC archives
  - Usual latency about 30-40 days (September 2020 solution is currently being processed)
- Consistent processing standards for GFZ GRACE RL06
- GFZ RL06 normal equations in SINEX format provided at ISDC

GRACE-FO: ftp://isdcftp.gfz-potsdam.de/grace-fo/Level-2/GFZ/RL06_NEQs_SINEX/
GRACE: ftp://isdcftp.gfz-potsdam.de/grace/Level-2/GFZ/RL06_NEQs_SINEX/

GFZ GRACE-FO RL06 Operational Level-2 Processing

- Weighted RMS over the ocean relative to 6-parameter-model fit (bias, linear trend, annual and semi-annual signals) after decorrelation and smoothing with DDK5 filter

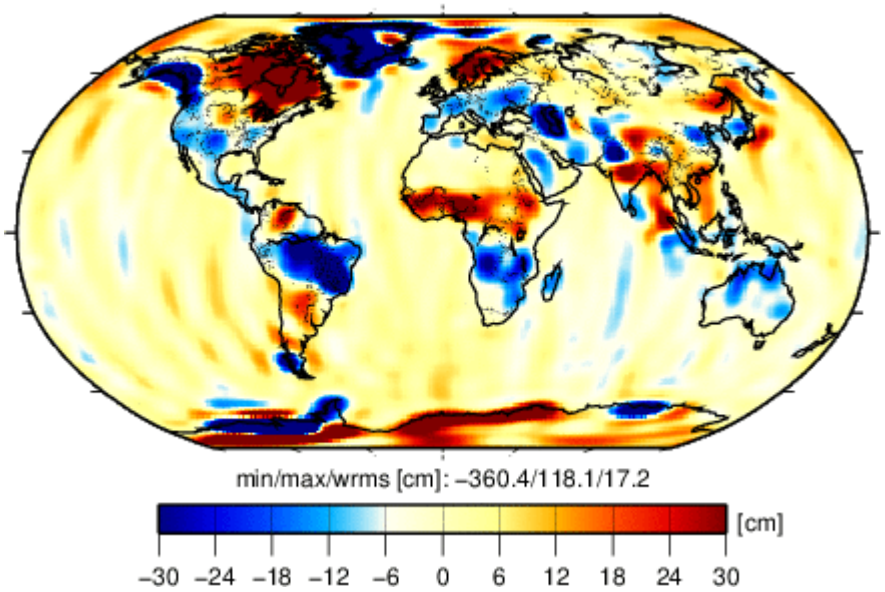


GFZ GRACE-FO Level-2 Processing Experiments

- Impact of ACT1B data on estimated gravity field

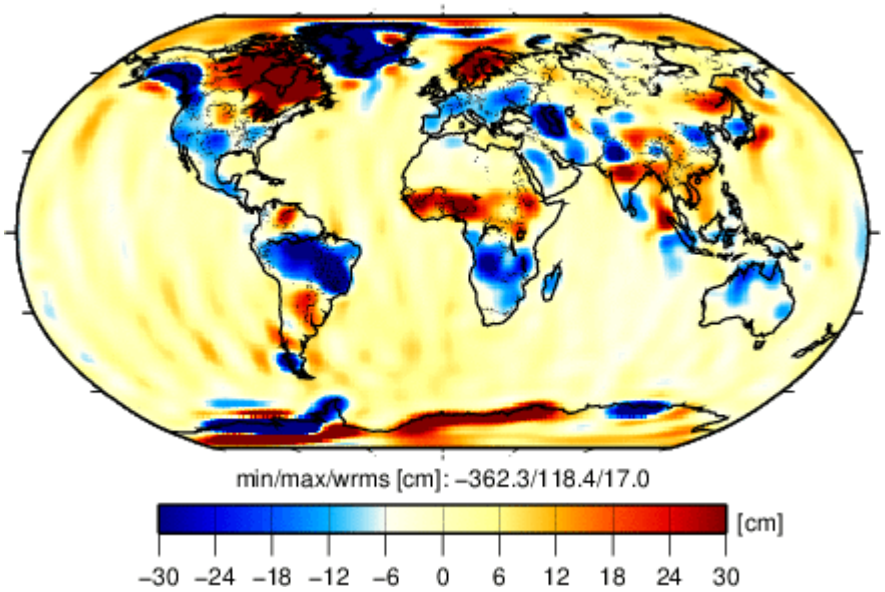
2019/09 solution

with GF2 ACT1B from official Level-1B release



ocean wRMS: 4.6 cm

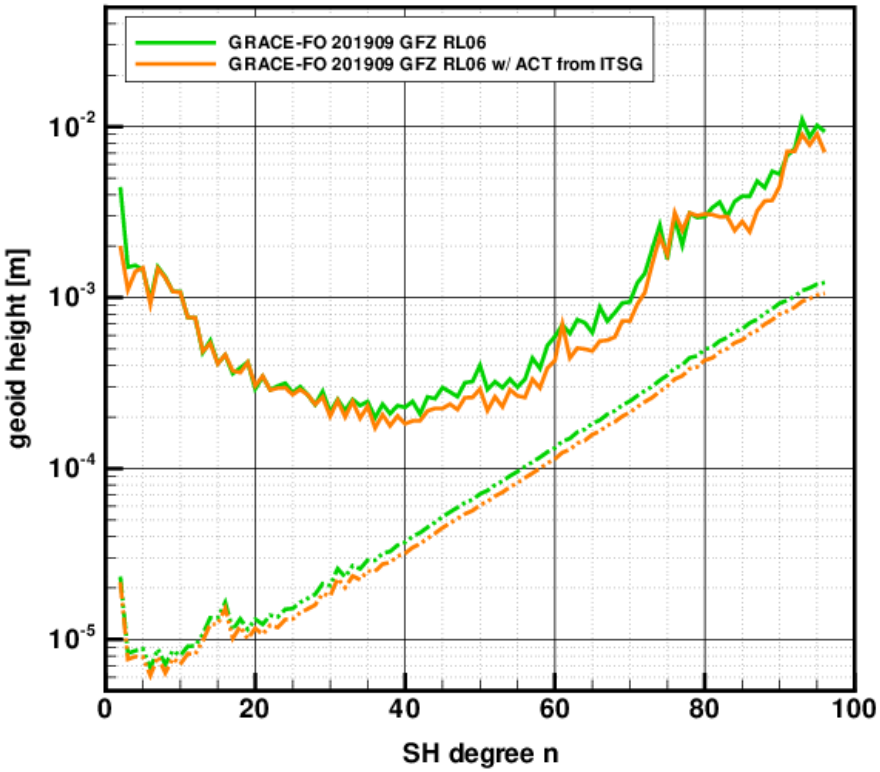
with alternative GF2 ACT1B from ITSG



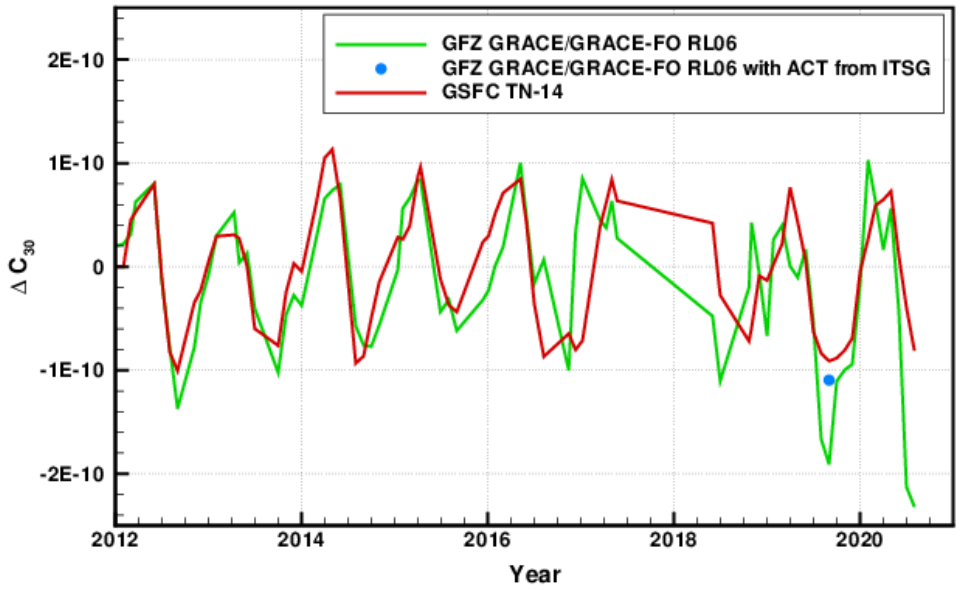
ocean wRMS: 4.3 cm

GFZ GRACE-FO Level-2 Processing Experiments

- Impact of ACT1B data on estimated gravity field



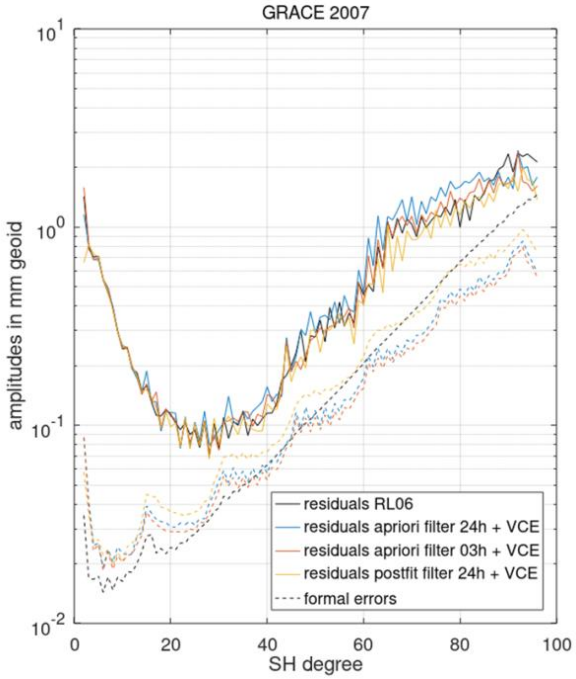
Impact on C_{30}:

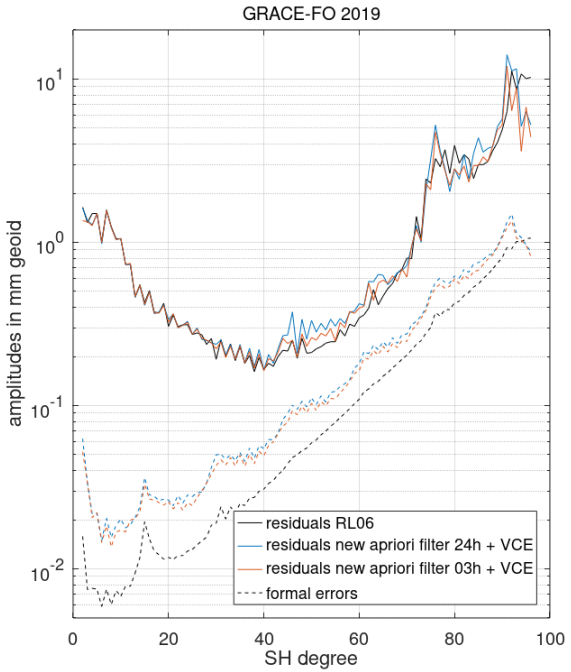


solid curves: differences w.r.t. EIGEN-6C4;
dashed curves: formal errors

GFZ Level-2 Reprocessing Plans

- Research Unit NEROGRAV
  - Improved parametrization (tbd)
  - Improved stochastic modelling of observations and background models
    - Use of an a priori noise model for ACC and KBR/LRI
    - VCE weighting of monthly KBR normal equation





- More realistic formal errors
- Reduced noise in higher SH degrees (if iterative filter procedure based on postfit residuals is applied)

- More details: Panafidina et al., **GSTM2020-65**, A.2, offline display

GFZ Level-2 Reprocessing Plans

- Research Unit NEROGRAV
  - Improved ocean tide solutions
    - More details: Sulzbach et al., **GSTM2020-39**, B.3, offline display

- General reprocessing time line
  - GRACE/GRACE-FO RL07 reprocessing not before significant improvements compared to RL06 can be achieved
  - In case of GFZ: likely after end of first phase of NEROGRAV which is mid 2022

GFZ Level-3 Products: GravIS

- GravIS (**Grav**ity **I**nformation **S**ervice): Level-3 portal of GFZ in collaboration with TU Dresden and AWI

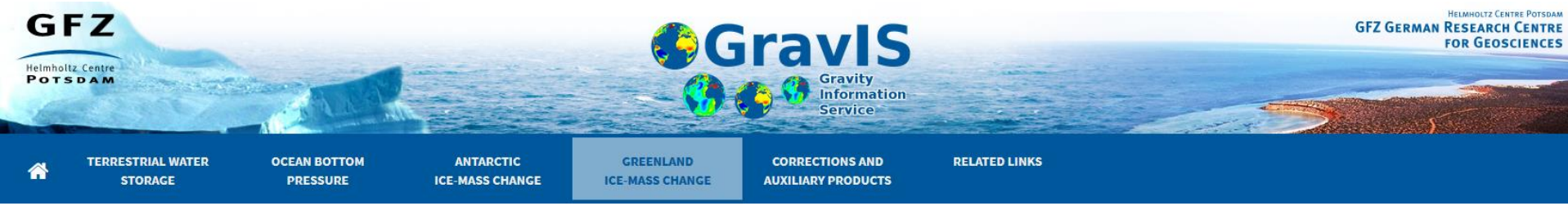
- User-friendly mass anomaly products based on:
  - Most recent GFZ release of GRACE/GRACE-FO monthly Level-2 products
  - Level-2 products of the International Combination Service for Time-variable Gravity Fields (COST-G)

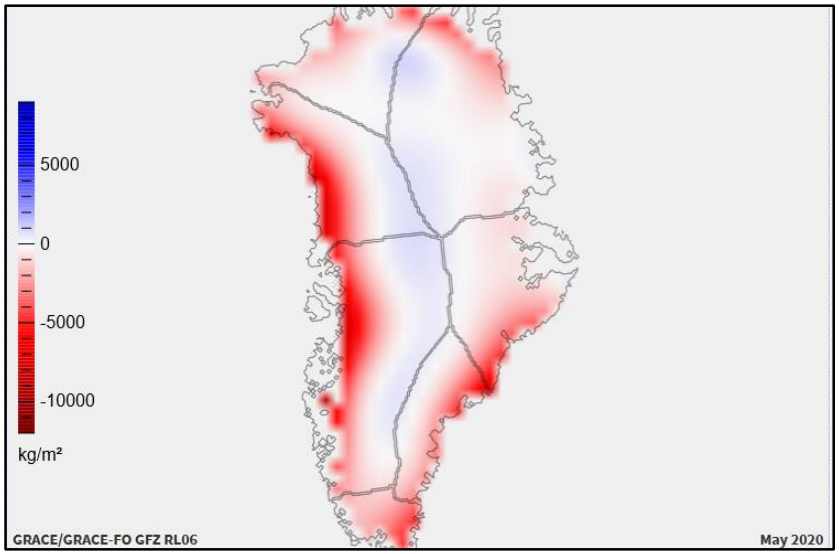
- Dedicated products for:
  - terrestrial water storage over non-glaciated regions
  - bottom pressure variations in the oceans
  - ice-mass changes in Antarctica and Greenland

GFZ Level-3 Products: GravIS

- Update cycle of GravIS Level-3 products more frequent as for Level-2 products
  - Product filenames indicate both release of underlying Level-2 product and version of Level-3 product
    - e.g.: `GRAVIS-3_2020-----------_GFZOP_0600_TWS_GRID_GFZ_0003.nc`
  - Updates are documented in changelog files linked at corresponding DOI landing pages
  - Products directly accessible at ISDC are always the most recent version, older versions are zipped and stored in subdirectories 'old_versions/'
- Update history during the last 12 months:
  - June 2020: Update from Version 0001 to 0002
    - Larger update including all kind of products
    - Initial version of COST-G Level-3 products
    - Relaunch of GravIS website
  - September 2020: Update from Version 0002 to 0003
    - Affects only TWS and OBP Level-3 products

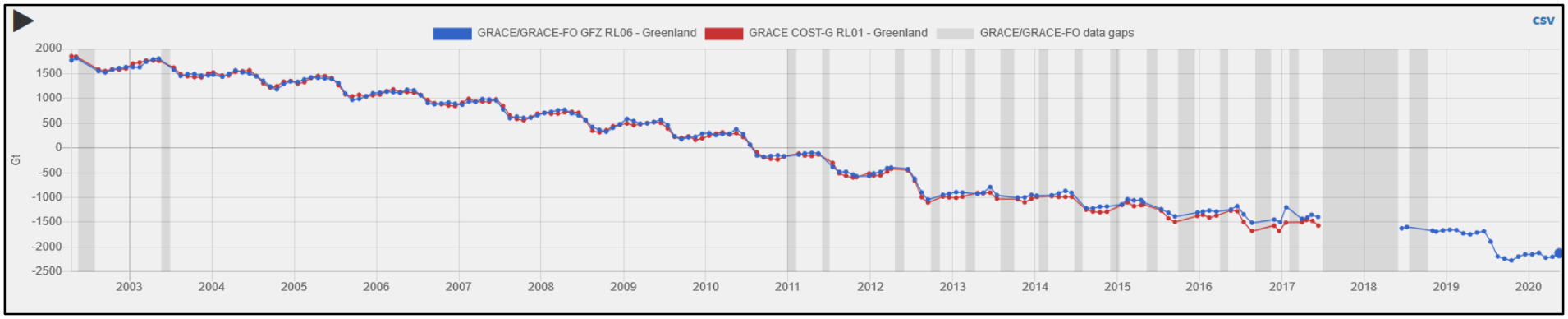
GFZ Level-3 Products: GravIS



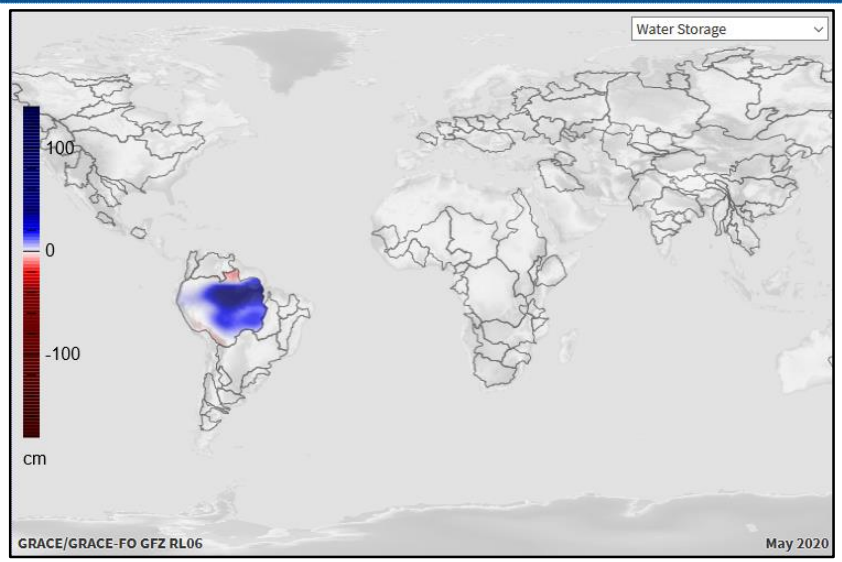


- Interactive spatial plot
  - Possibility to select pre-defined basins
- Time series plot shows GFZ RL06 Level-3 products as well as COST-G RL01 Level-3 products
  - Extension of COST-G with GRACE-FO planned within next few weeks

images taken from gravis.gfz-potsdam.de

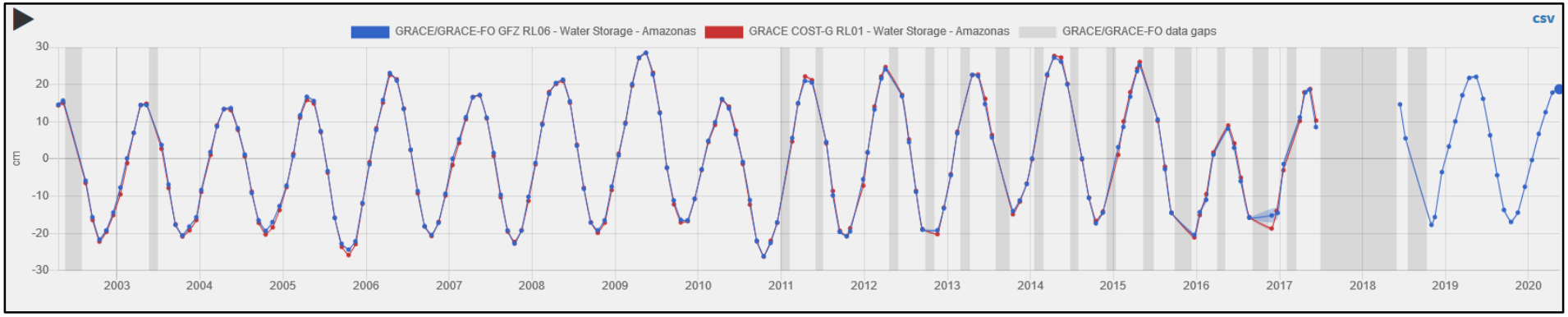


GFZ Level-3 Products: GravIS



- Since Version 0002, usage of a new spatial covariance model for TWS
  - More details: Boergens et al., **GSTM2020-24**, B.4, live display on Thursday, 09:15 – 09:30
- Medium-term plan: cover whole continents with pre-defined basins

images taken from gravis.gfz-potsdam.de



GFZ Level-3 Products: GravIS

- GravIS products are available at ISDC:
  ftp://isdcftp.gfz-potsdam.de/grace/GravIS/
  - Level-3 products (NetCDF grids for TWS/OBP/ice-mass change, basin averages for ice-mass change)
  - Level-2B products (corrected Level-2 coefficients)
  - Auxiliary products: Reference mean field, applied GIA model, low degree replacement time series, geocenter time series

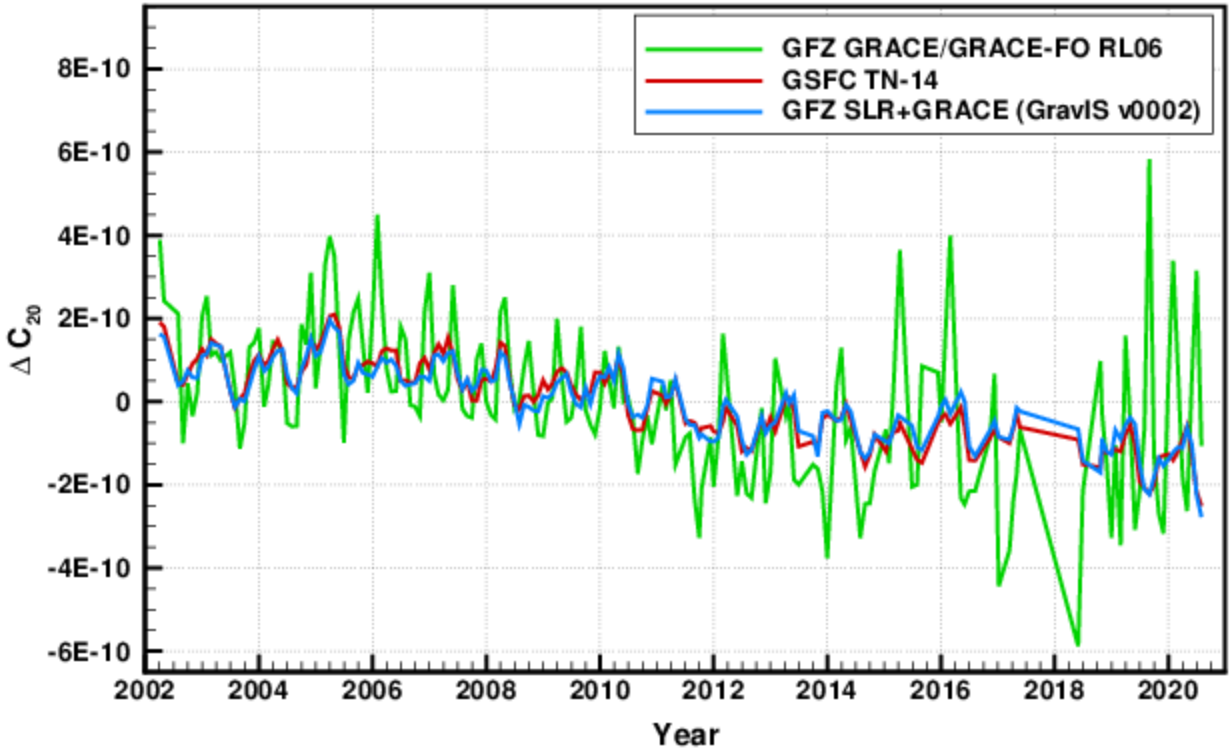
- Several corrections are applied to the Level-2 spherical harmonic coefficients before the mass anomaly inversion:
  - Anisotropic VDK (= time-variable DDK) filtering
  - Replacement of particular low degree harmonics: C_{20}, C_{30}, C_{21}, S_{21}
  - GIA correction
  - Insertion of degree 1 (geocenter) coefficients
  - Removal of aliased signal of the S2 Tide

Low Degree Coefficients: SLR+GRACE/GRACE-FO Combination

- Combination of Satellite Laser Ranging (SLR) and GRACE/GRACE-FO on the level of normal equations (NEQs)
  - SLR contribution:
    - Includes observations to six geodetic satellites: LAGEOS-1/-2, AJISAI, Stella, Starlette, and LARES (starting from March 2012)
    - Relative weighting of the individual SLR NEQs by means of variance component estimation
    - Background models and standards are consistent with GFZ's RL06 GRACE/GRACE-FO processing ➔ no time-variable a priori information of the Earth's gravity field is used
  - GRACE/GRACE-FO contribution:
    - From GFZ RL06 operational processing
  - SLR+GRACE/GRACE-FO combination:
    - NEQs are combined using empirical relative weights
    - Gravity field coefficients up to degree and order 6x6 are estimated independently for each month

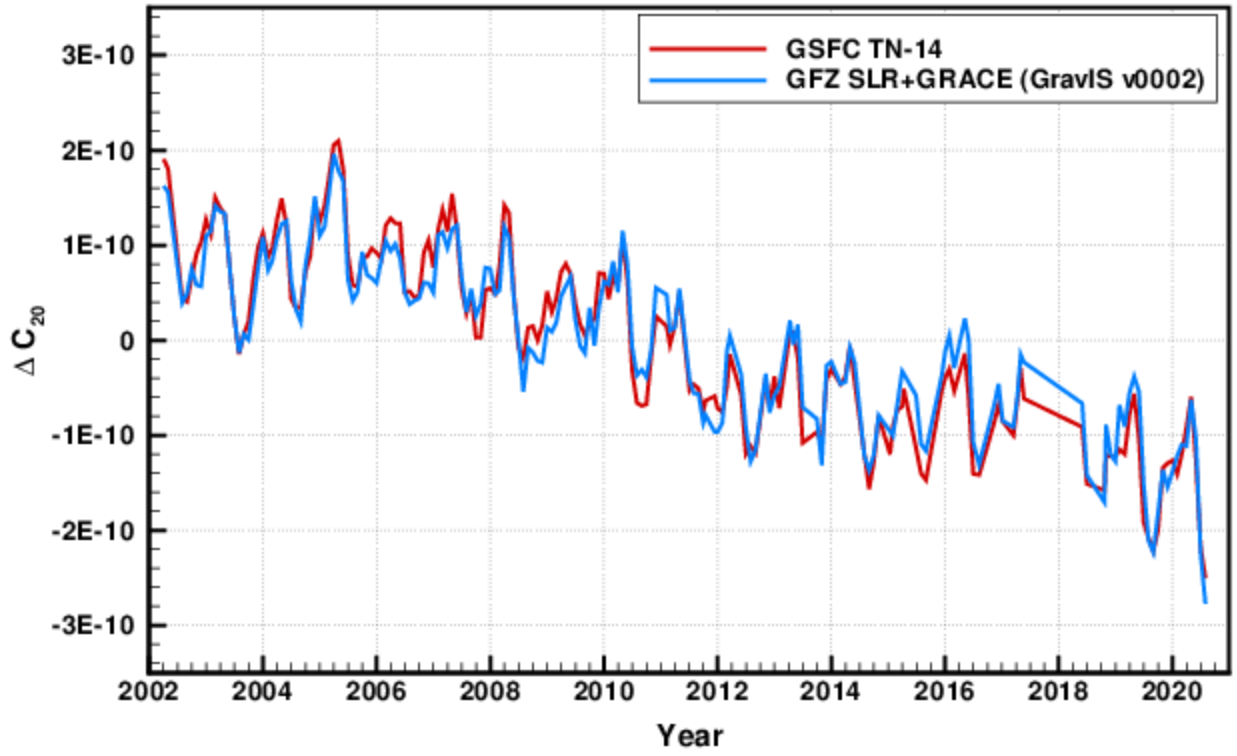
ftp://isdcftp.gfz-potsdam.de/grace/GravIS/GFZ/Level-2B/aux_data/GRAVIS-2B_GFZOP_GRACE+SLR_LOW_DEGREES_0002.dat

Low Degree Coefficients: C_{20}



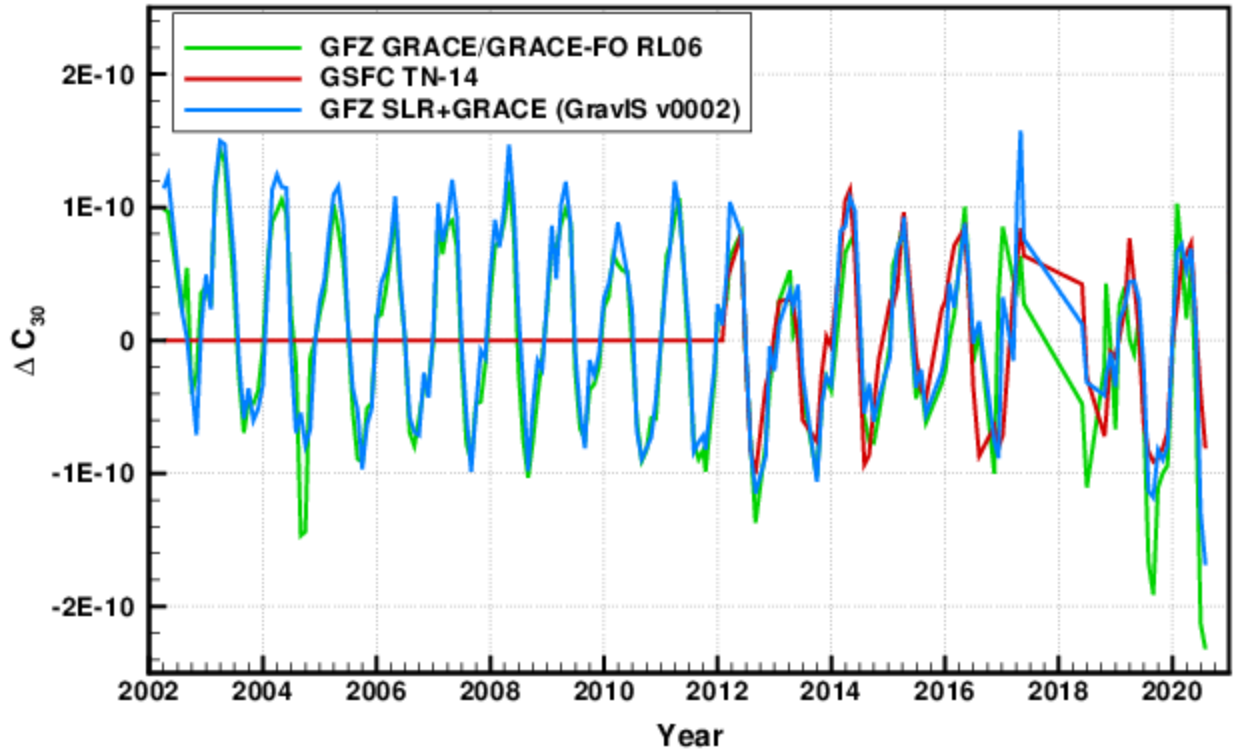
- GFZ GRACE/GRACE-FO RL06 time series shows large deviations from GFZ SLR+GRACE time series as well as from SLR-only based TN-14 ➔ replacement of C_{20} definitely recommended

Low Degree Coefficients: C_{20}



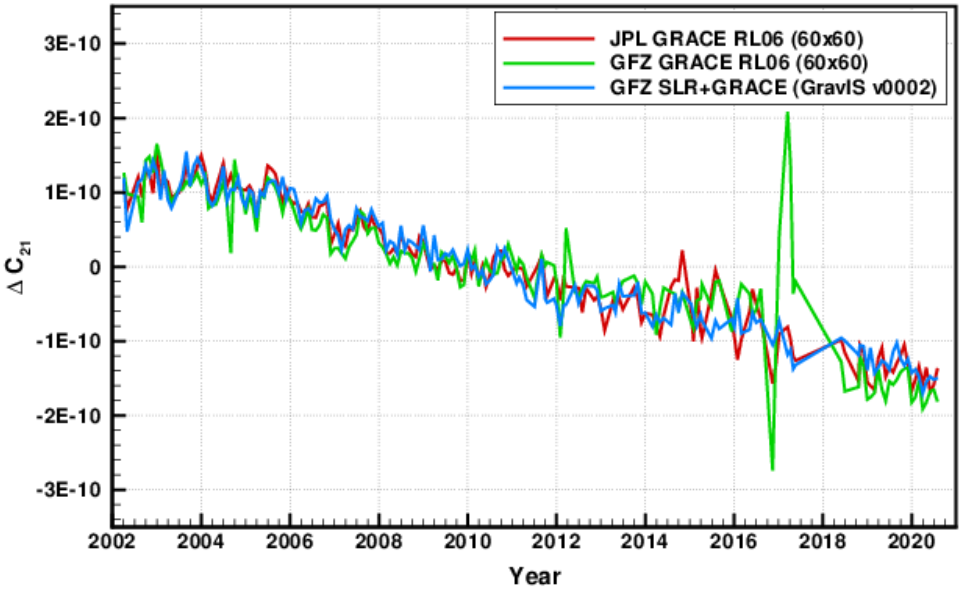
- GFZ SLR+GRACE time series in good agreement with TN-14, in particular for GRACE-FO

Low Degree Coefficients: C_{30}



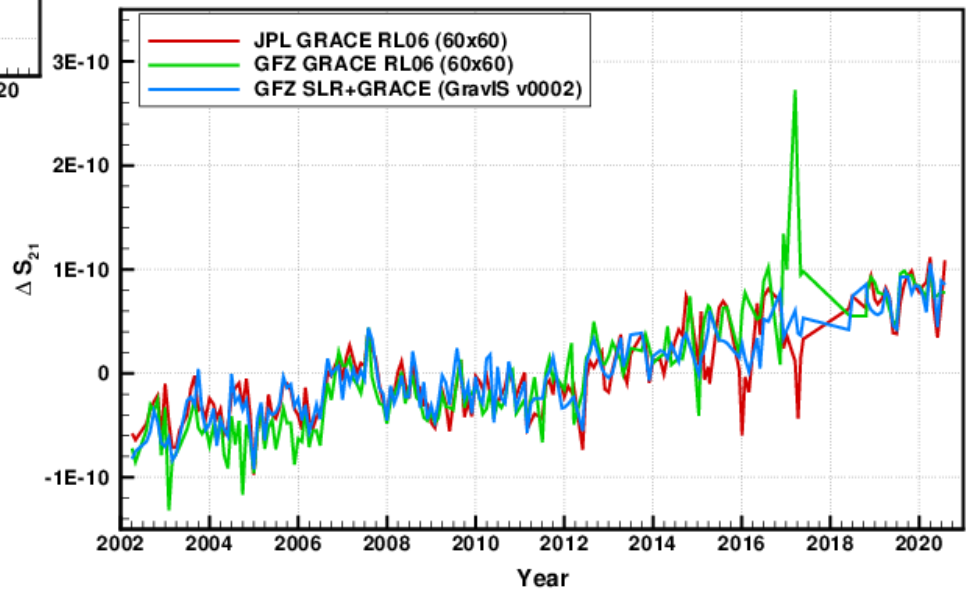
- GFZ SLR+GRACE time series in good agreement with TN-14
- C_{30} values in TN-14 start in 2012 (with LARES), whereas the SLR+GRACE combination is available for the complete GRACE period

Low Degree Coefficients: C_{21}/S_{21}



Recommendation if using GFZ RL06 Level-2 products:
Replace C_{21}/S_{21} with our SLR+GRACE combination

GFZ RL06 Level-2B products at GravIS are already corrected



- GFZ SLR+GRACE time series serves well as replacement for the degraded GFZ RL06 GRACE-only C_{21} time series

ftp://isdcftp.gfz-potsdam.de/grace/GravIS/GFZ/Level-2B/aux_data/GRAVIS-2B_GFZOP_GRACE+SLR_LOW_DEGREES_0002.dat

Further Activities at GFZ Related to GRACE-FO

- AOD1B Processing:
  - Operational processing of AOD1B RL06
    - Spatial resolution d/o 180, temporal resolution 3 hours
    - Provided via ISDC with a latency < 24 hours
  - Plans for AOD1B RL07
    - Updated ocean model (new 1-hourly forcing, improved bathymetry around Antarctica, implementation of SLA effects)
    - Preliminary data set will be provided soon for testing purposes
    - More details: Shihora & Dobslaw, **GSTM2020-29**, B.3, offline display

Further Activities at GFZ Related to GRACE-FO

- Radio Occultation Data Processing:
  - About 250-280 GF1 RO daily profiles routinely collected since 2019/170
  - Operational use of GRACE-FO RO data should start by end of 2020
    - Based on in-house near-real time orbits (< 1 hour latency)
    - More details: Schmidt et al., **GSTM2020-76**, B.5, offline display

- Magnetic and Ionospheric Monitoring:
  - Data from non-dedicated observations extend scientific applications of GRACE-FO to monitoring of space weather
    - Earth's magnetic environment, TEC in upper ionosphere, in-situ electron density
    - Calibrated magnetometer data is provided via ISDC: https://isdc.gfz-potsdam.de/grace-fo-isdc/grace-fo-magnetic-field-data/
    - More details: Stolle et al., **GSTM2020-42**, B.5, offline display

Thanks for your attention