EGSIEM	EGSIEM Minutes	

EGSIEM General Meeting			
Date(s) of Meeting:	18./19. January 2016	**Location:**	Salle des Conseils University of Luxembourg
Minutes Taken by:	K. Cann-Guthauser	**Doc ID:**	General_Assembly_Minutes_Jan2016

Distribution List		
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F. Flechtner / GFZ (FF)	A. Sušnik / UBERN (AS)	J. Kusche / U Bonn (JK)
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	Z. Li / UL (ZL)	*M. Koleva / EC REA*
	Q. Chen / UL (QC)	
	B. Klinger / TUG (BK)	
	A. Kvas / TUG (AK)	
	L. Poropat / GFZ (LP)	

List of Annexes: Presentations by members of EGSIEM and others

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Agenda Item Nr.	EGSIEM General Meeting, 18.& 19. January 2016	Action Item
1	**Welcome and purpose of Meeting [Jäggi & van Dam]**	
	Annex01: Welcome (AJ) AJ welcomed all (incl. Associate and Advisory Board members) to the General Meeting. TvD added her own welcome and gave logistical info on the room and arrangements for the evening meal. To begin, AJ reminded the consortium of the next upcoming project Deliverables, the first of which (D7.2 EGSIEM Brochure) has already been completed in October 2015 (M10): • ~~EGSIEM Brochure (M14)~~ • Teaser Lecture (M15) • GRACE/GRACE-FO Product Report (M18) • Concept of Scientific Service (M18) As the last Milestone (2 *Implementation and Preparation Review*) is still open, the due date was November 2015, we will aim to close it by end of February (so as to be able to report on it at the Review Meeting at the beginning of March, see below). AJ expanded on the Tasks necessary to achieve the milestone, CNES to provide feedback on T2.2, GFZ & LUH to give the status of T2.3	**AI#016**
	<u>Action Item Status review</u> AJ reported that the Action Item on Publication Plan ideas is still outstanding for some groups (see the end of this document), therefore the deadline has been amended. Otherwise, the following Action Items are still outstanding: AI#011 – awaiting feedback from CNES AI#012 – awaiting feedback from CNES AI#013 - GFZ to provide software for Arctic/Greenland by summer AI#014 – awaiting feedback from CNES	**AI#006**

	AI#015 – awaiting feedback from UL and G&C	
2	**Administrative Overview (KCG)**	
	Annex 02: WP1_Management (KCG) KCG provided information on a recent request originating from the EC to amend the administrative content of the standard Grant Agreement, and also gave advice on completing the financial sections of the Participant Portal.	
3	**WP2 Gravity Field Analysis (TMG)**	
	Annex 03: WP2_Processing_Improvements (UM) UM updated the consortium on developments at AIUB. TUG provided star camera plus angular accelerations sensor fusion data that have a significant impact on the geometric K Band correction UM said that there was little impact on the gravity field solutions at this stage of testing. Similar impact could be achieved by low pass filtering of the original Geometric K Band correction provided in the L1B K Band datafiles. *Annex04: EGSIEM_WP2* *All the following presentations can be found within Annex04* T2.2 GFZ Processing Tools (FF) GFZ has been testing the FES2014 model from CNES/GRGS, improvements have been found in Polar Regions (up to 2-3 cms). FES2014 shows no significant impact in terms of global wRMS. GFZ is happy to adopt FES2014. GFZ tested Sensor Fusion Data but GFZ report (based on only one test month of data) that it shows no significant impact on gravity field solutions. TUG Processing (BK) Since the last project meeting TUG have been making improvements to their solution, for instance Yaw turns have been removed from the data. Comparison of signals was completed for TUG reprocessed data compared to ITSG2014 & CSR RL05. CNES/GRGS Processing (JML) Hydroweb website is now available at hydroweb.theia-land.fr Please note that prior registration is required. FES2014 shows a reduction in residuals (compared to 2012) biggest improvement shown in Arctic ocean. KBR weighting better at degree 40, higher than 40 gives striping and adds artifacts to readings at the poles. Clarification was sought over what data was used, CNES are also testing with SLR data. JML- Are TUG using Encke's method? TMG-Yes, using an elliptical orbit as reference to improve the numerics of integration TG asked whether any conclusions could be drawn from all the different approaches – TMG responded by saying that no universal approach was intended. T2.3 GRACE reprocessing (TMG) TMG proposes all ACs compute and provide monthly mean of all background models adopted. TG queried the use of tide data, TMG answered that tides are also mass transport signals which can be investigated by GRACE gravity field solutions. Before opening the discussion on reprocessing data TMG made the case for working on	

	Level 2 data. TMG argues that there is no compelling reason why EGSIEM uses some models (Total mass change) and by the proposal there is a clear separation between observations and models, solutions from ACs are comparable & combinable. UM & AJ supported provision of monthly tidal mean models. FF supported the approach, but would advise implementation on a 'step by step' basis, starting at a GRACE science team meeting. AJ suggested providing presentations at the next project meeting. MW proposed writing a statement of intent. PD & JF raised concerns over the new L2 product on the Hydrological community – TMG responded that it would be possible to 'leave out' the new products. AG expressed his view that the higher processing (the 'cook book' approach) necessary with L2 products may put Hydrologists off this source.	**AI#017**
4	**WP3 Integration of complementary data (TvD)**	
	Annex 05: WP3_Reference_Frame_Products (AS) There is a problem with the existing RINEX data, (availability of less than 50% is high). AS reports that from Wednesday morning (20.1) the Reference Frame products will be removed from the ftp server, to be replaced by GRACE orbit data (at the end of January). *Annex06: WP3_Gravity_ Field_ Coefficients (AJ)* AJ presented the SLR analysis performed at UBERN (on behalf of work undertaken by Andrea Maier at AIUB, UBERN). Recently a bias in the UBERN C20 series has been discovered, investigations are ongoing, possibly not a simple re-scaling problem due to the use of the GM and AE values. After the bias problem has been solved the next step will be to extend the SLR time series to include the lifetime of GRACE data and to include more SLR satellites. TMG raised the possibility of a problem with the AOD model *Annex07: WP3_Validation_with_GNSS_loading (ZL)* SOPAC & JPL can now be used for validation purposes. TMG – AOD has to be added to the EGSIEM model going forward, AS to provide data including coordinates to ZL TMG how do you average GPS time? Average GNSS from daily to monthly. *Annex08: WP3_GRACE_Validation_with_OBP (LP)* RL05a variance gives a generally good performance over all frequency bands. TMG recommended using a different filter than DDK1, LP responded that subsequent filters are being investigated. *Annex09: WP3_GIA_correction_ for_ hydrology (HS)* The GIA model is being expanded to encompass the whole globe (Fennoscandian part to be unveiled at EGU2016), models in use currently have various constraints TMG, Earth rotation is included. *Annex10: WP3_Hydrology_at_CNES (JML)* JML presented work undertaken at GRGS on the oceanographic validation of time variable gravity solutions from GRACE. The GRGS team used the Caspian Sea and the Zapiola Gyre as test areas and compared GRACE data downloaded from ICGEM to AVISO+ and HYDROWEB. In the open sea ocean variability meant that the maximum	

	correlation was 79%, monthly time sampling is therefore not short enough. *Annex11: WP3_Historical_Flood_compilation (HZ)* 3 suitable test cases identified (Danube, Ganges/Brahmaputra & Mekong). Automated flood masks will be added and then the results compared with semi-automatic approaches. FF-why are we limiting flood data to 2006/7? HZ is willing to add suitable events. TG can you also look for drought events? This would be possible, depending on the length of time series (HZ)	
5	**WP4: Scientific Service (UM)**	
	Annex 12: WP4_Solution_Combination (YJ) YJ introduced work undertaken on Validation of a Combined Solution by using Hydrology, Cryology, GIA, & GPS Loading. A simulation study will be conducted to find the most promising strategy to combine different gravity field solutions on the combination. The Degree 90 solution from Graz is still better than the combined solution taken from the individual Analysis Centres. As the weighting scheme does not function for the whole spectrum, YJ is studying why the weighting does not function as expected. CG suggested looking at both variances and co-variances *Annex13: WP4_EGSIEM_Combination_Assessment (UM)* UM gave a presentation on behalf of the EGSIEM collaborator Martin Horwath at TUD who has been analyzing the EGSIEM experimental solution against other available solutions (CSR (96), truncated to degree 90, GFZ RL05a (90), ITSG 2014 (90), AIUB RL2 (90)). Analysis of the spatial domain shows EGSIEM outperforming other solutions (post smoothing). ITSG solution shows the least noise, so weighting should be tweaked to include more input form ITSG. Noise: EGSIEM shows lowest RMS. JML – Deserts are a better example for noise levels than oceans. UM responded that larger ocean areas offer better smoothing options, perhaps we can include the Sahara. JK – artificial reservoirs, though small, give much better levels UM to send time series to JK for further validation JK asked how the weighting was derived, UM said that individual contributions of all ACs are compared to the arithmetic mean of all contributions. Weights are defined as the inverse of the sum of squares of the differences. *Annex14: WP4_SLR_Activities_at_DGFI (MB)* The consortium would like to extend their thanks to Mathis Bloßfeld of TU München who was invited to present work being undertaken at DGFI, especially the multi-satellite approach. The DGFI-TUM can provide SLR NEQs with full variance/co-variance information in SINEX format back until 1972. AJ – degree 20 – constraint is made to the static field? *Annex15: WP4_GRACE_SLR_Combination (UM)* AIUB 10x10 SLR + GRACE combination SLR had some influence on degree 2, low degree sectorial and zonal coefficients. It was found that it is not necessary to replace C20 coefficients. First monthly gravity field solutions derived from GPS orbits of SWARM (JE)	

	Annex16: WP4_Swarm (JE) The consortium would like to extend their thanks to João Encarnação of TU Delft who was invited by the consortium to present the status of SWARM gravity field determination, which may act as a temporary solution until GRACE FO is fully operational. JK asked for clarification over the correlation coefficients, JE responded that the full (unprocessed) signal, confirmed that no accelerometer data has been used, but TU Delft will shortly release one year of accelerometer data for SWARM-C. *Annex17: WP4_SLR_Discussion (AJ)* After the presentation from JE AJ presented a discussion on incorporating SLR data into the EGSIEM project MW asked for a constraint free solution, MB said this would be possible and MW offered support for incorporating other SLR data JML and FF responded that they could provide data. MW suggested that TMG added a slide to his upcoming EGU presentation to invite other users TMG – degree 1 terms will need external data – so D1T should be provided as additional data FF – an SLR processing standard document should be written – AJ this will be added to Deliverable 2.1 AJ asked how GPS hl-SST could best be incorporated into the project: GPS hl-SST could act as a back-up in case of a problem with GRACE FO, FF we would then need to move quickly (c. 6 months). TMG - this is a complicated process to compare with GRACE, AJ there is certainly a lot to learn in terms of SWARM. AJ asked JE to lead effort on GPL hl-SST, AJ said that this would be a 'best effort' approach and may take c. 6 months to set up, JE responded that TU Delft could not commit to any timescale at the moment, and that the data originates from ESA AJ – the consortium is open to additional data, UBERN will present a plan at the next meeting on how to incorporate the 2 new data types and how to welcome new contributors.	**AI#018** **AI#019**
6	**WP5: NRT and Regional Service (FF)**	
	Annex 18: WP5_NRT_Regional_Service_at_TUG (AK) From their side TUG are happy to confirm milestone 2 as completed TG - in relation to biases AK stated that the hydrological model used 'does not matter' TMG interjected that differences are quite small. AG suggested using GLDAS as a hydrological model for testing purposes *Annex19: WP5_Status (CG)* CG presented to the consortium the work being undertaken at GFZ under WP5, currently the convergence of Graz and GFZ stochastic modeling is in progress. Work is being completed to Milestone 2 will be completed by the end of February PD queried using correlation patterns and suggested looking at longer time series	

7	**WP6: Hydrological Service – (AG)**	
	Annex20: WP6_Hydrological_Service (BG) *Annex 21: WP6_Flood_Volume_Estimation (HZ)* General discussion (JF/UM) about the discharge from basins and how the mass of water is counted. Discharge water for Ganges is taken from observed water level at gauging stations, whereas GRACE is showing more water mass (subsurface water included). AG advised that they want independent water mass change observations to evaluate the GARCE products JK - Radio telemetry of water levels from colleagues in Bangladesh should be due to come online shortly. Possibly use discharge derived from altimetry data. An idea could be to contact Faisal Hossein (Uni Washington) as he had a project funded under NASA SERVIR for developing a system for deriving operational discharge from altimetry over Indus, Ganges & Brahmaputra. MW – there appears to be a phase shift in the Danube readings, (BG) storage increases then discharge follows (at the Ganges). <u>Test Cases Ganges-Brahmaputra (HZ)</u> HZ proposed the following approach: a raster image is placed on the flood mask and then make a calculation of the water lever for each cell of the raster grid. DLR will then need to compare with altimetry data and define the size of the raster. JK – A general problem when comparing to observational data is that colleagues in India only provide such data above a level that is considered as 'dangerous'. <u>Seasonal forecasting of streamflow in central Asia (AG)</u> Using GRACE data and comparing to river discharge data in a series of models we can possibly provide a predictor. Different approaches followed which still showed large differences from discharge data. Combined solutions in 2005-10 offer accurate predictions (the EGSIEM combined solution was ranked 4th) GRACE water storage data alone is not useful as a predictor. JK queried accuracy over longer timescales – AG confirmed that 5 year predictions are much more accurate than 10 year timeframe (2003-12), longer EGSIEM combined solutions desirable (beyond the 2005-2010 period).	
8	**WP7: Dissemination and Exploitation (AJ)**	
	Annex22: WP7_Project_Website (KCG) Google Analytics data shows nearly 10,000 page hits on egsiem.eu since the beginning of March 2015, however, the engagement rate appears low. MW advised that the front page should cover an introduction of the project, as well as the blog. *Annex23: WP7_Competition (TB)* Will be called 'The EGSIEM Challenge' and planning is at an advanced stage. TB proposed that a separate/embedded website www.challenge.egsiem.eu should be created. As the prize for the competition will be an internship (x2) we need another institution (other than LUH) to host an internship. JK posed the question that students may require ECTS points as a 'reward', though such an arrangement was not foreseen. TG asked for clarification over who would be allowed to enter – this would be only EU residents.	

	As a general point YJ recommended a QR code be made and distributed to include on posters etcetera to provide a direct link to the project website. *Annex24: WP7_Summer_School (AJ)* AJ proposed that members of the executive board should form a Summer/Autumn School organising committee. This was accepted. JF asked who should act as lecturers – just EGSIEM, or external members? It was agreed that external lecturers would be invited. *Annex25: WP7_Dissemination_Activities (JF)* JF gave an overview of the dissemination activities that had taken place within the first year of EGSIEM. MW highlighted that the website publications page needs to be updated. JK suggested a specific area set aside on the website for journalists and high school students, thereby providing targeted information. SB suggested that an email should be sent to all when a new Blog entry is online Action Item: TvD to plan submissions for dedicated sessions at conferences (Task 7.5) It would be useful to create a link to the newsletter on the right hand side under the sign up section (TB) Tamara also took the opportunity to remind people of the deadline for Newspaper contributions (**NOW**)	
8	**External Guest Presentations**	
	TG gave a short oral presentation about future gravity mission planning and asked those present to provide support into the planning of such. Letter of Intent deadline 1st February Proposal Deadline mid-June MW advised consortium members to acquaint themselves with their national ESA representative.	
9	**Mid Term Review (KCG)**	
	KCG briefly advised the general meeting of the mid-term review meeting to be held in BRU on the 7th March 2016, this will involve: AJ/KCG/TvD/AG/TMG/UM/Project Officer(s) and René Forsberg of the Danish Technical University (External Expert Reviewer)	
13	**Meeting Review and Publication Plan (AJ)**	
	For the last topic AJ invited a general discussion about publications, he proposed the idea of a publication plan document and also proposed a special issue of the Journal of Geodesy (GRACE anniversary issue?) and asked for other suitable journal titles to be mentioned, specifically any Hydrological Journals which could be approached.	

	Next meeting: FF kindly offered to host the next project meeting in June at GFZ in Potsdam, Germany, **date confirmed as 2. – 3. June 2016**, the meeting is expected to start in the morning on Thursday, 2. and finish around lunchtime on Friday 3. June. AJ thanked UL for hosting the meeting and thanked everyone for their input.	

Action Item Status List (open and new AI's)

A.I.	Originator	Actionee	Action Description	Due Date
006	EGSIEM	WP Managers	Collect ideas for paper topics to set up a publication plan	31.03.2015
011	EGSIEM	GFZ (AG), DLR, CNES	Establish the interfaces between ZKI, Hydrology, and CNES to clarify the possibility to derive flood volumes and the potential role of altimetry (Hydroweb).	30.09.2015
012	EGSIEM	EGSIEM ACs	Each AC to provide a test SINEX file of a monthly GRACE solution (NEQ information). Still waiting for NEQ from CNES.	31.07.2015
013	EGSIEM	GFZ (FF), UL, GFZ (AG)	Compile a list of EGSIEM L3 products, Compile a list of sources for degree 1 terms and C20	30.09.2015
014	EGSIEM	CNES	Validation of GRACE solutions over oceans using altimetry and ocean surface topography	31.12.2015
015	EGSIEM	UL	Check availabilities of GRACE movies and possibilities (persons) to update them	31.12.2015
016	EGSIEM	All	Milestone 002 (*Implementation and Preparation Review)* to be completed.	29.02.2016
017	EGSIEM	TUG	TMG to provide a plan for the removal or restoration of background models	02.06.2016
018	EGSIEM	UBERN	SLR processing standard text will be added to Deliverable 2.1	02.06.2016
019	EGSIEM	UBERN	UBERN to draft a plan on how to incorporate SLR data and how to welcome new contributors.	02.06.2016
020	EGSIEM	UL	Submission plan to be created for dedicated sessions at conferences (see Task 7.5)	31.3.2016

EGSIEM
European Gravity Service for Improved Emergency Management

WP1: Management Update

Keith Cann-Guthauser
Astronomisches Institut, Universität Bern

EGSIEM General Meeting

18. & 19. January 2016, Luxembourg

WP1: Management
Overview

European Gravity Service for Improved Emergency Management

- Changes to Personnel
- Grant Agreement Amendment
- Project Reporting

WP1: Management
Structures

The ***Executive Board*** (Coordination Team in Proposal) is responsible for the:

- preparation of General Assembly meetings
- decisions taken by General Assembly
- monitor the progress of the Consortium Plan
- propose any necessary modifications to the Consortium Plan, and consists of:
  - Jäggi
  - Flechtner
  - Güntner
  - Mayer Gürr

EGSIEM Consortium Agreement, Section 6.3.2

WP1: Management
Structures

The ***Executive Board*** can also appoint a ***Management Support Team*** to assist them in their tasks, as set out on the previous slide.

The following were appointed on the 9. April 2015;

- Operations Manager; Dach
- Dissemination Manager; Flury
- Exploitation Manager; Weigelt

EGSIEM Consortium Agreement 6.5

WP1: Management

European Gravity Service for Improved Emergency Management

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6	*Centre National D'Etudes Spatiales*	CNES	Bruisma	Sean		sean.bruinsma@cnes.fr	(33) 561 332 841	CNES - DCT/SI/GS
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* - Administrative Staff

WP1: Management
GA Change

European Gravity Service for Improved Emergency Management

- The Commission adopted a Decision on 01/10/2014 to amend the H2020 Model Grant Agreements (MGAs) adopted on December 2013. These MGAs (version of September 2014) repair incoherences and clerical mistakes and introduce the following substantial changes.
- - Article 20.6 "Currency for financial statements and conversion into euro" in order to allow beneficiaries with accounts in other currencies than euro to convert into euro all costs incurred independently of the currency in which they were incurred (similar to FP7 projects).
- - Article 21.2 "Pre-financing payment - Amount - Amount retained for the Guarantee Fund" in order to give the possibility to the consortium to receive the pre-financing payment at an earlier date, namely 10 days prior to the starting date of the action.
- - Article 38.1.2 "Information on EU funding - Obligation and right to use the EU emblem" in order to ensure more visibility of EU funding for any communication activity related to any infrastructure, equipment used and to major results of a Horizon 2020 action.
- Since the above mentioned Decision applies as of 10 December 2013, the revised version of the MGAs must be applied to all H2020 grants signed from this date.

WP1: Management
GA Change

European Gravity Service for Improved Emergency Management

- No action required from partners
- The full ‘tracked’ changes can be found listed at:

http://ec.europa.eu/research/participants/data/ref/h2020/mga/gga/h2020-mga-gga-multi_en.pdf

WP1: Management

Reporting

Our first reporting period (**1.1.2015 – 31.12.2015)** has now ended;

We must submit the first periodic report within 60 days .

WP1: Management

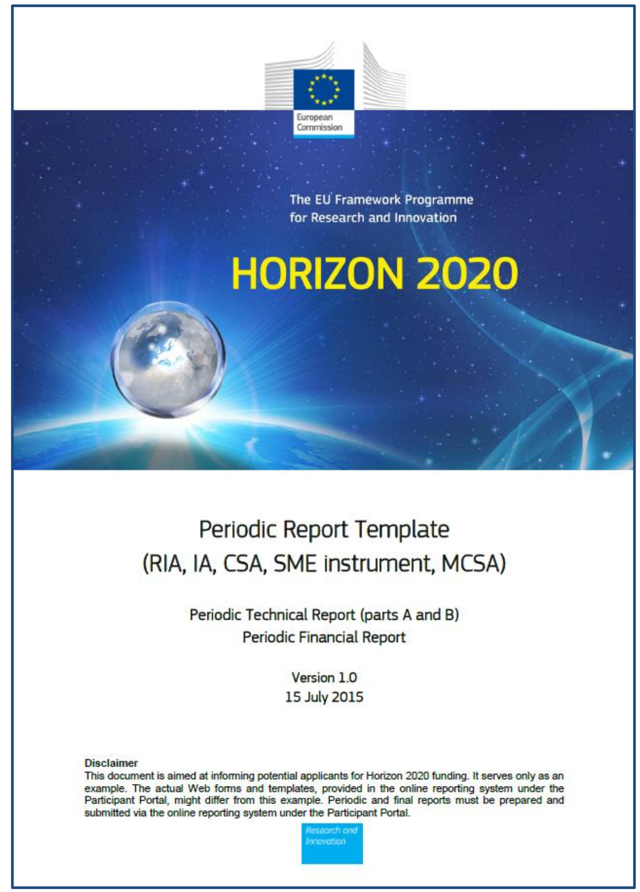
Reporting

European Gravity Service for Improved Emergency Management

In July 2015 the EU produced a template periodic report.

UBERN will be responsible for the majority of the report, but we need input from each partner, organised via Work Package Leaders

Submission consists of 3 parts;


European Commission

The EU Framework Programme for Research and Innovation

HORIZON 2020

Periodic Report Template
(RIA, IA, CSA, SME instrument, MCSA)

Periodic Technical Report (parts A and B)
Periodic Financial Report

Version 1.0
15 July 2015

Disclaimer
This document is aimed at informing potential applicants for Horizon 2020 funding. It serves only as an example. The actual Web forms and templates, provided in the online reporting system under the Participant Portal, might differ from this example. Periodic and final reports must be prepared and submitted via the online reporting system under the Participant Portal.

Research and Innovation

WP1: Management

Reporting

EGSIEM

European Gravity Service for Improved Emergency Management

- Part A (1) is mainly generated by the SyGMa grant management section within the Participant Portal (updated by UBERN)
- Part A (2) is the Periodic Technical Report, a separate document which requires input from **all**
- Deadline for first draft - **today**
- Part B is the periodic financial report which each partner has to complete
- Deadline - **12th February**

WP1: Management

Reporting

EGSIEM

European Gravity Service for Improved Emergency Management

Periodic Financial Report

(i) an 'individual financial statement' from each beneficiary, for the reporting period.

The individual financial statement must detail the eligible costs (actual costs, unit costs and flat rate costs; for each budget category and must certify that:

- the information provided is full, reliable and true;
- the costs declared are eligible (see Article 6);
- The costs can be substantiated by adequate records and supporting documentation that will be produced upon request… for the last reporting period: that all the receipts have been declared;

(ii) an explanation of the use of resources and information on subcontracting (see Article 13)

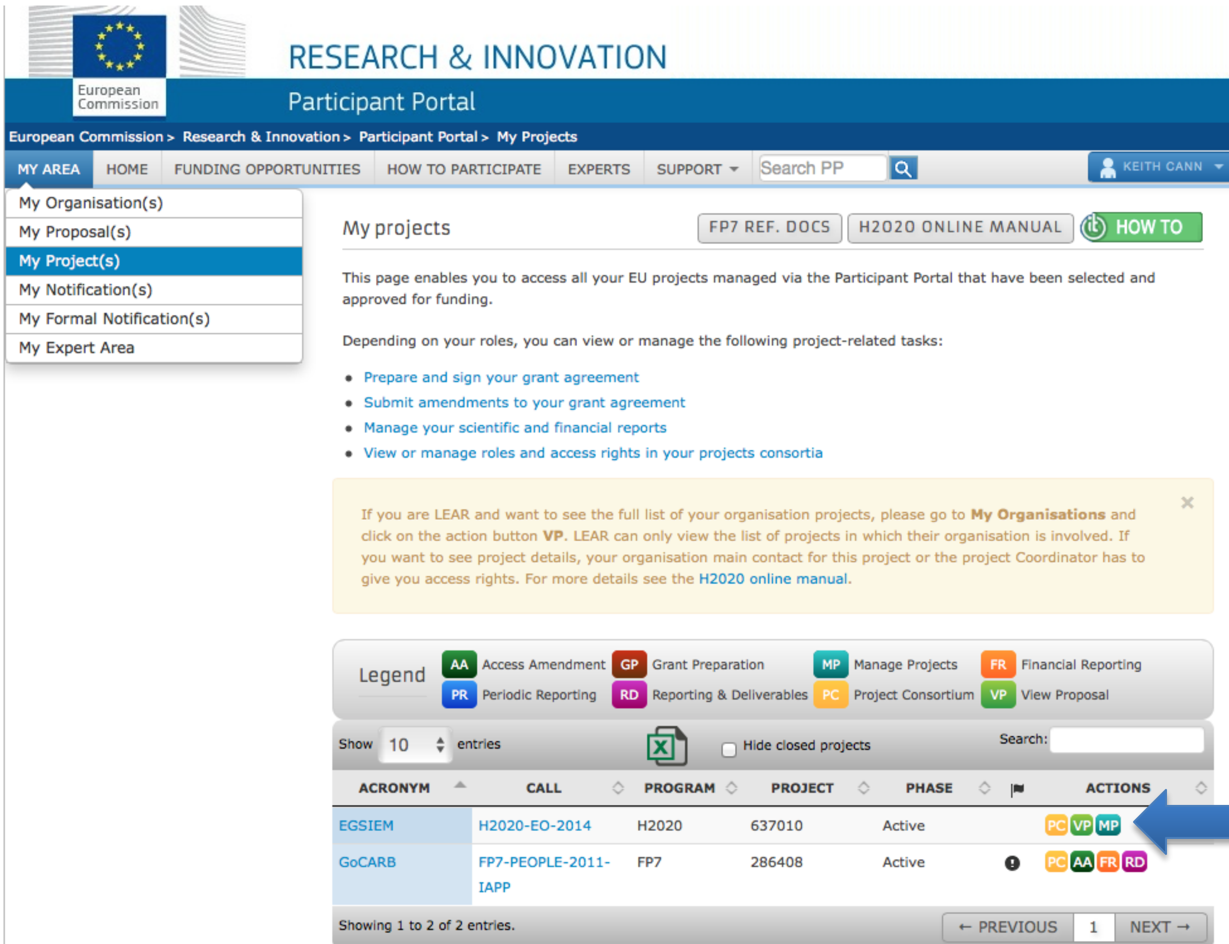
EGSIEM Grant Agreement, Article 20.3 (b)

WP1: Management

Reporting

EGSIEM

European Gravity Service for Improved Emergency Management



EGSIEM

HORIZON 2020

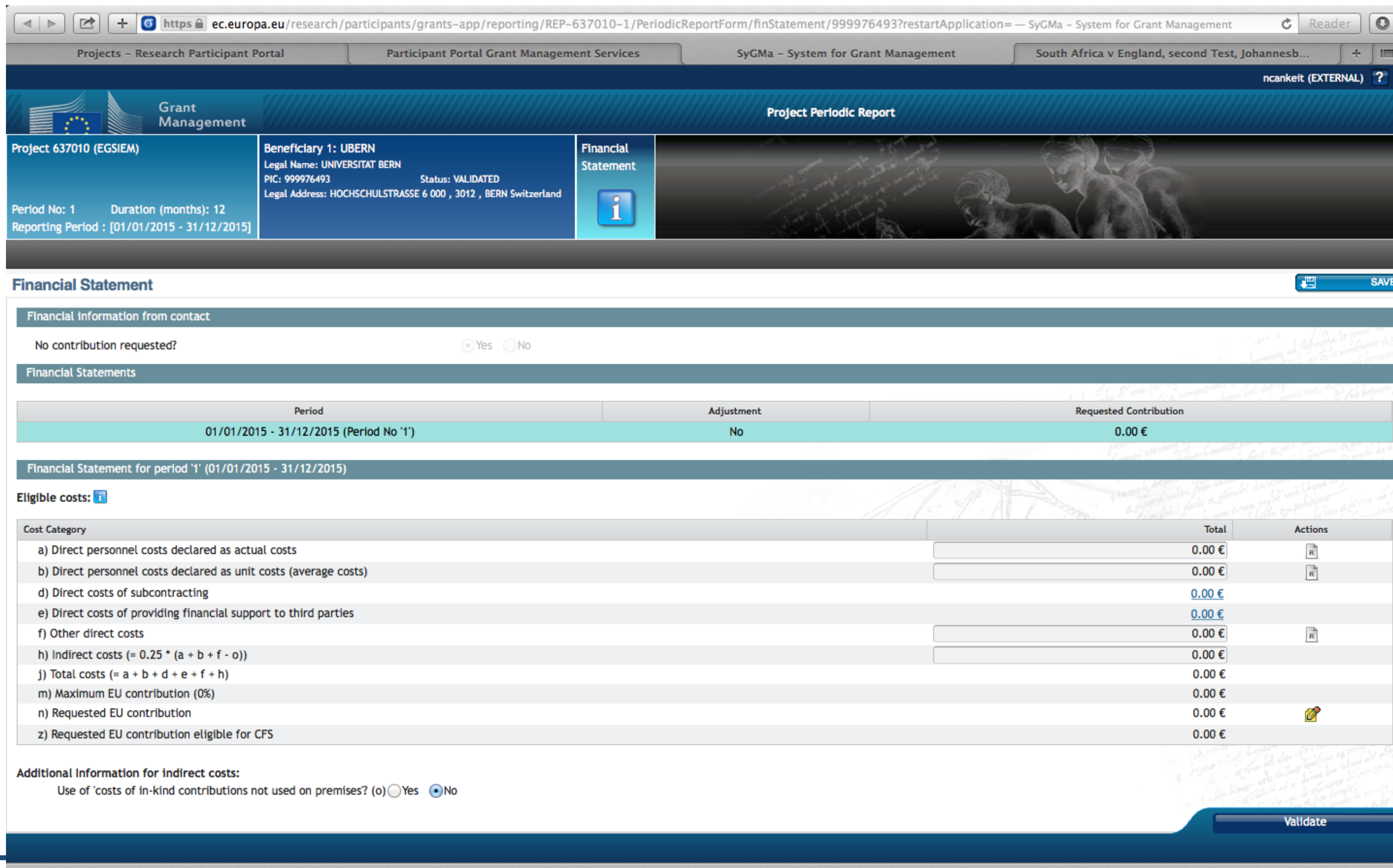
WP1: Management
Reporting

European Gravity Service for Improved Emergency Management

HORIZON 2020

WP1: Management
Reporting

European Gravity Service for Improved Emergency Management



HORIZON 2020

WP1: Management
Reporting

European Gravity Service for Improved Emergency Management

Salary calculations for the Periodic Reports

The basic calculation is:

Hourly rate (standard remuneration) x hours worked for the project + any additional remuneration received (but only for non-profit entities)

EGSIEM Grant Agreement, Article 6.2

WP1: Management

Reporting

European Gravity Service for Improved Emergency Management

The calculation of the hourly rate should be based on the data of the last closed financial year (eg. Jan – Dec 2015) and consists of;

- Basic salary
- social security
- taxes
- any other mandatory costs

WP1: Management

Reporting

European Gravity Service for Improved Emergency Management

The hours worked for the project have three alternative calculation methods!

Option 1: **1720 fixed hours**

- May be used by any beneficiary, *easy to use, no mistakes*

Option 2: **Individual annual productive hours**

- how many hours the person should work according to law, collective agreement and/ or individual contract + overtime – absences (such as sick Leave – but not holidays!)

Option 3: **Standard annual productive hours**

- Calculation made according to the usual cost accounting practice of the beneficiary
- Must be at least 90% of the standard annual workable hours
- If less than 90 % -> use 90 %

WP1: Management
Reporting

European Gravity Service for Improved Emergency Management

So we return to the basic salary calculation:

Hourly rate (standard remuneration) x hours worked for the project + any additional remuneration received (but only for non-profit entities)

WP1: Management

Reporting

- Where staff are employed less than 100% on EGSIEM there maybe a requirement to keep timesheets – check with your Finance office what local requirements are.
- However, our GA (Article 18) states that

*As an exception, **for persons working exclusively on the action**, there is no need to keep time records, if the beneficiary signs a declaration confirming that the persons concerned have worked exclusively on the action.*

HORIZON 2020

WP1: Management:
Audits

- A **Certificate on the Financial Statements** (Audit) is required by any partner receiving more than €325,000 from EGSIEM
- However, this is only required at the end of the project

WP1: Management

Payments

The payments from EGSIEM should be sent as follows;

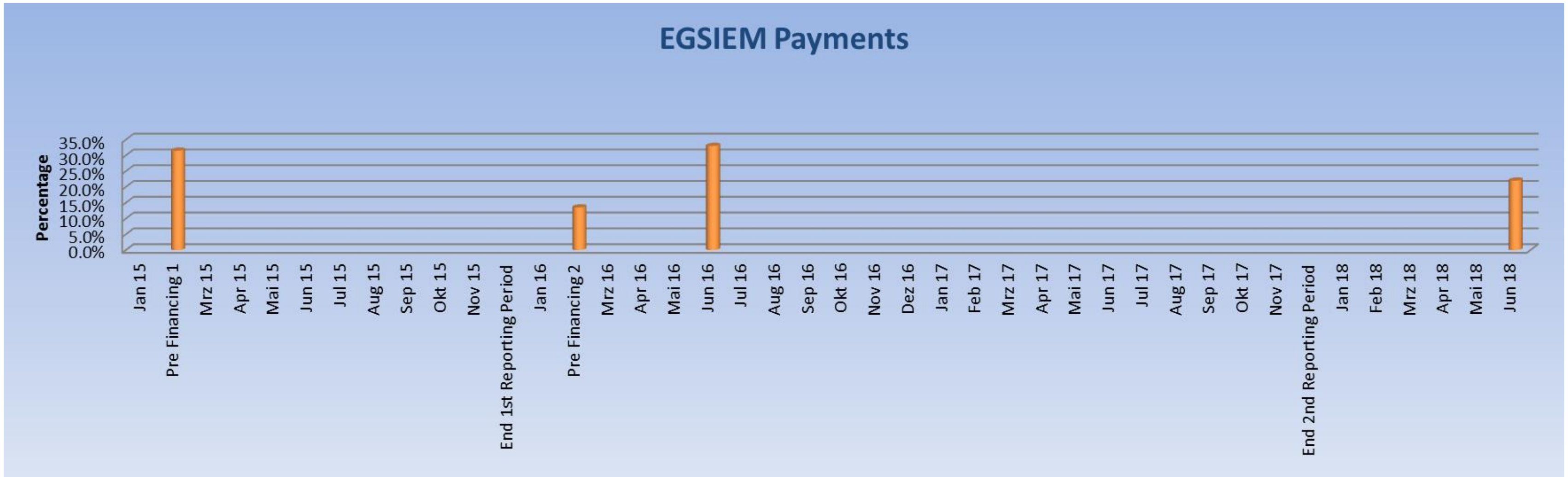
- January 2015 - Pre-Financing, paid out in 2 x instalments, the first 70% of this figure you have received (Late February/early March 2015)
- c. Jan-Feb 2016 - Pre-Financing, upon receipt of your input to the first periodic report you will be sent the remainder (30%) of the above

EGSIEM Consortium Agreement, Section 7.3.2

- mid 2016 - Interim Payment c. 33% of your budget, based on the expenditure reported in the first periodic report, submitted by the end of February 2016
- mid 2018 - Final Payment, remaining budget (including the 5% guarantee fund that the EU hold back from the Pre-Financing), this figure is based on the expenditure reported at the end of the grant by the end of February 2018

WP1: Management
Payments

The payment scenario as displayed on the previous slide will only be valid so long as we submit timely reports to the EC (with all necessary supporting documentation uploaded).



WP1: Management

EGSIEM

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THANK YOU!

EGSIEM

European Gravity Service for Improved Emergency Management

Processing improvements: AIUB

Ulrich Meyer

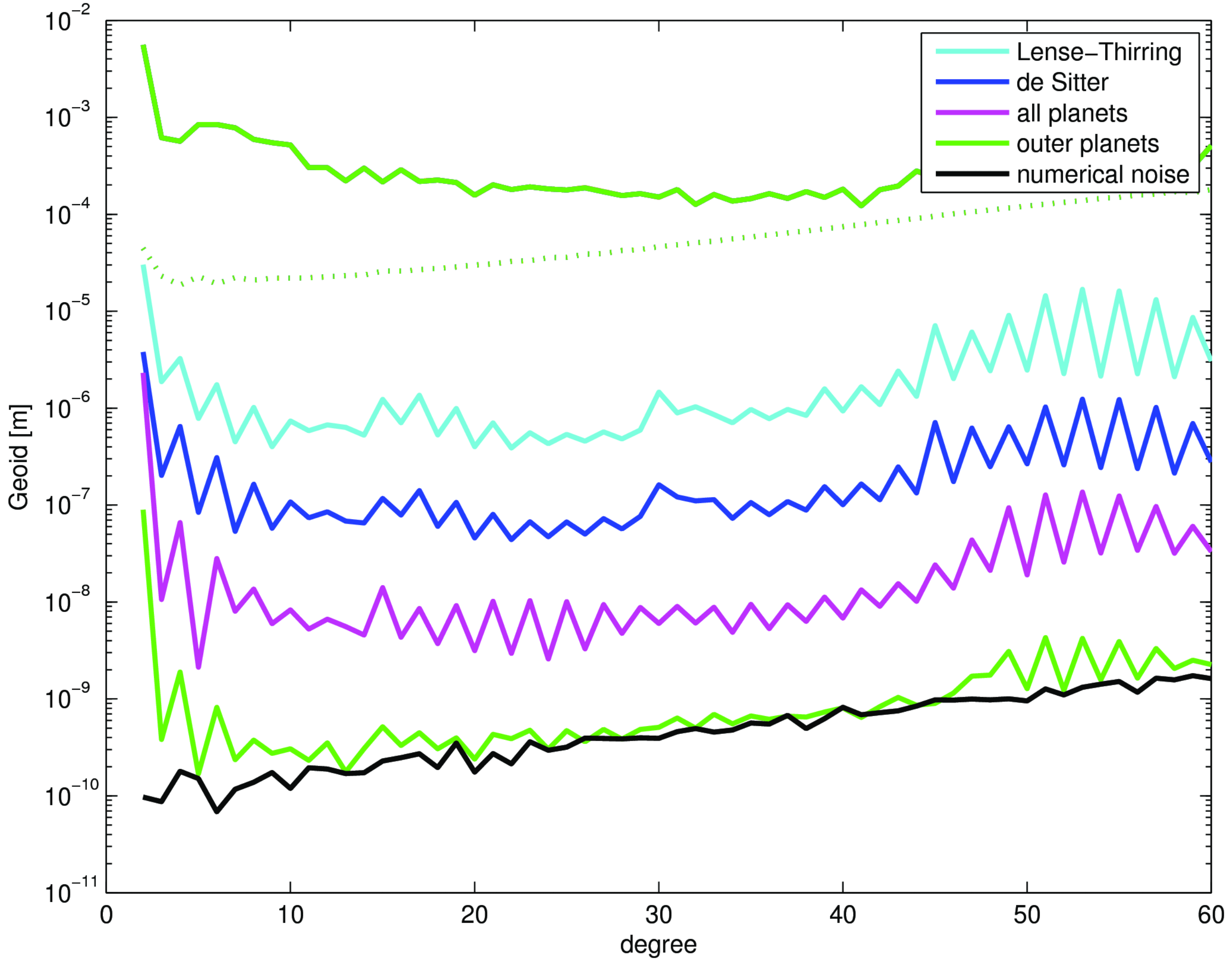
EGSIEM Progress Meeting # 2

University of Luxembourg

January 18 – 19, 2016

Horizon2020

Adaption of Standards: Relativity and third bodies



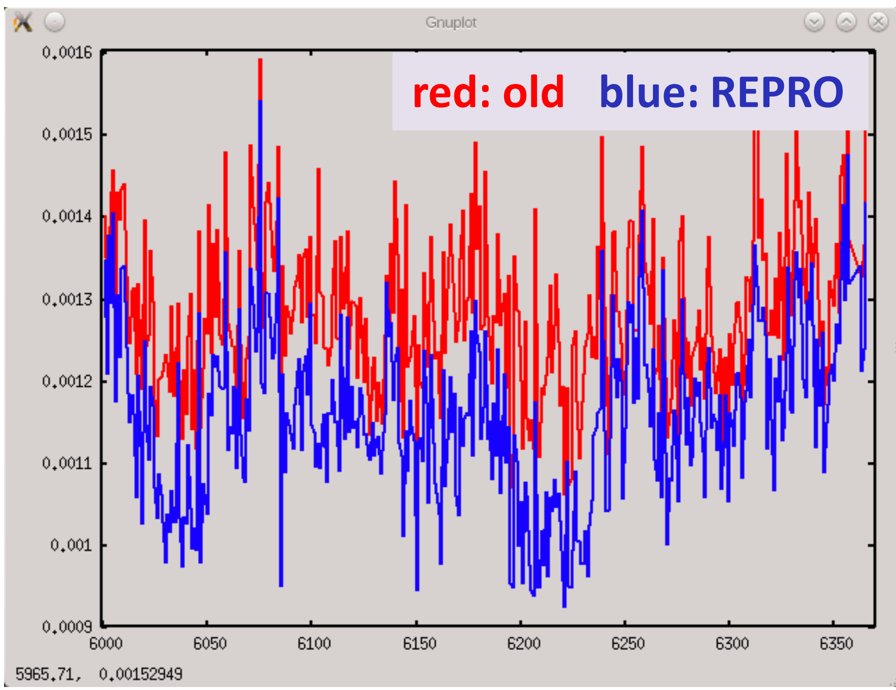
All effects well below formal errors.

Largest effect: Lense-Thirring (may be visible in degree 2).

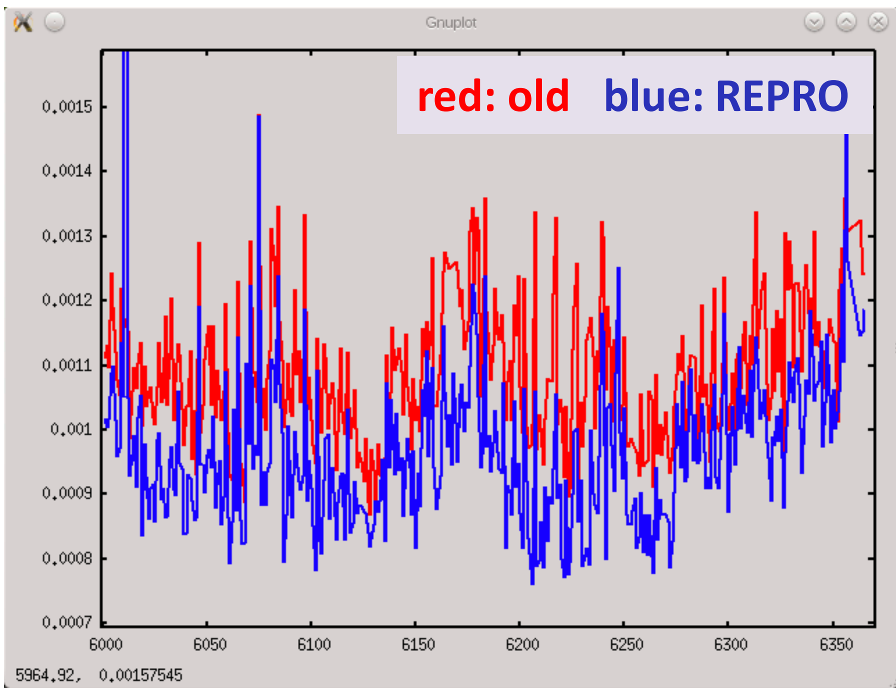
REPRO: GPS orbits and clock corrections (1/3)

Daily RMS of reduced-dynamic orbit fit to kinematic orbits (position fit transformed to phase fit): gain in consisteny of 10-20%

GRACE A: 2006

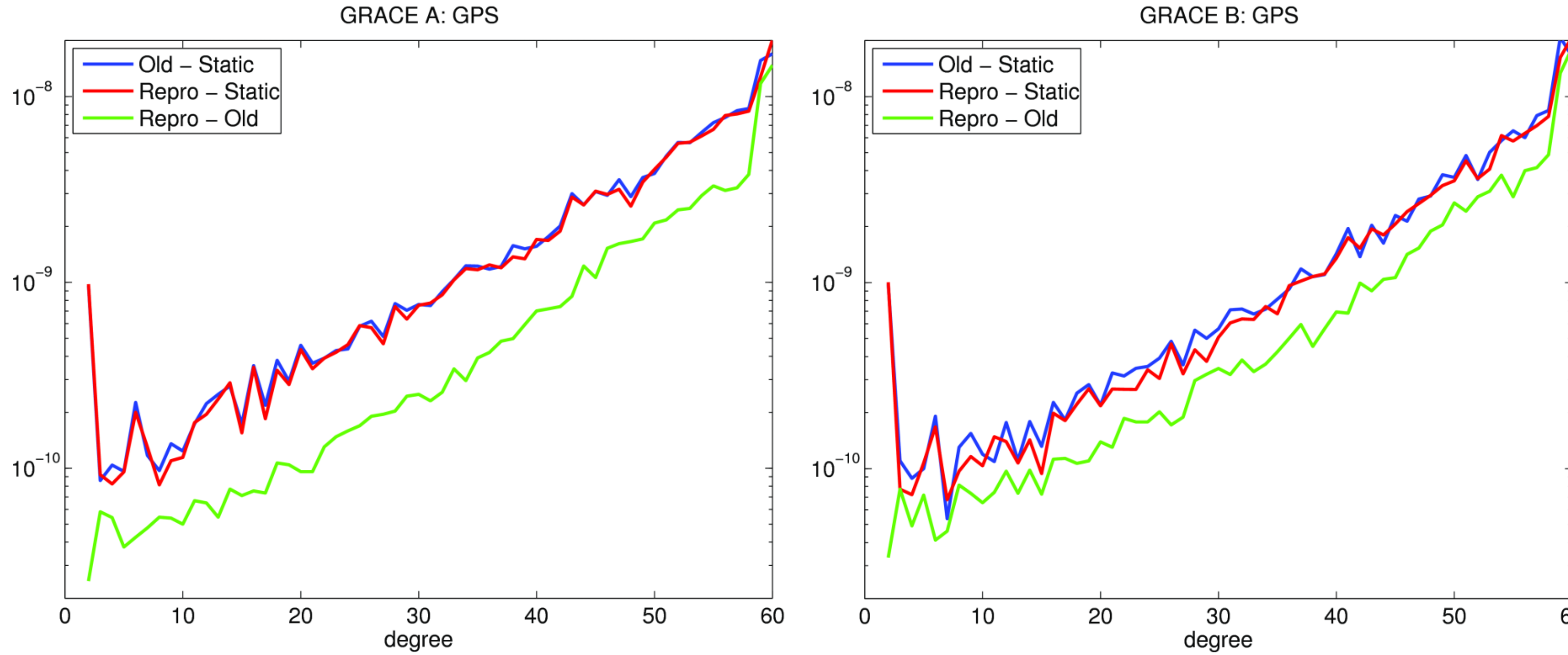


GRACE B: 2006

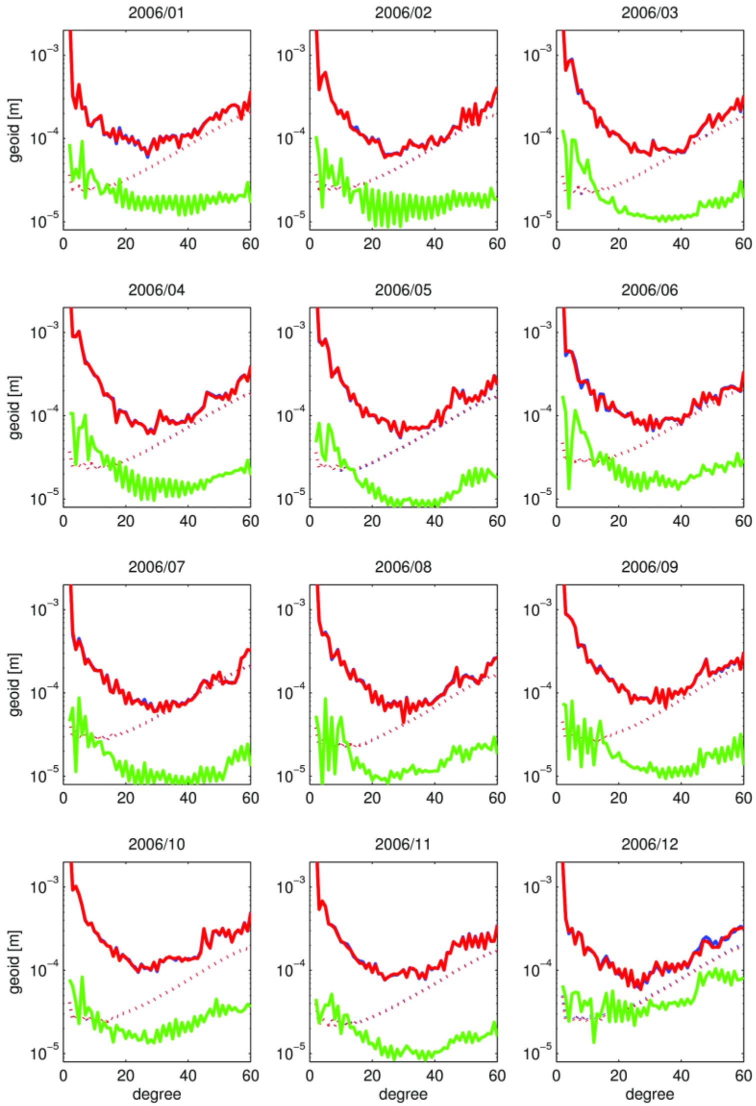


REPRO: GPS orbits and clock corrections (2/3)

Quality gain in 1-year GRACE GPS-only gravity fields (relative to static GPS + K-Band gravity field).



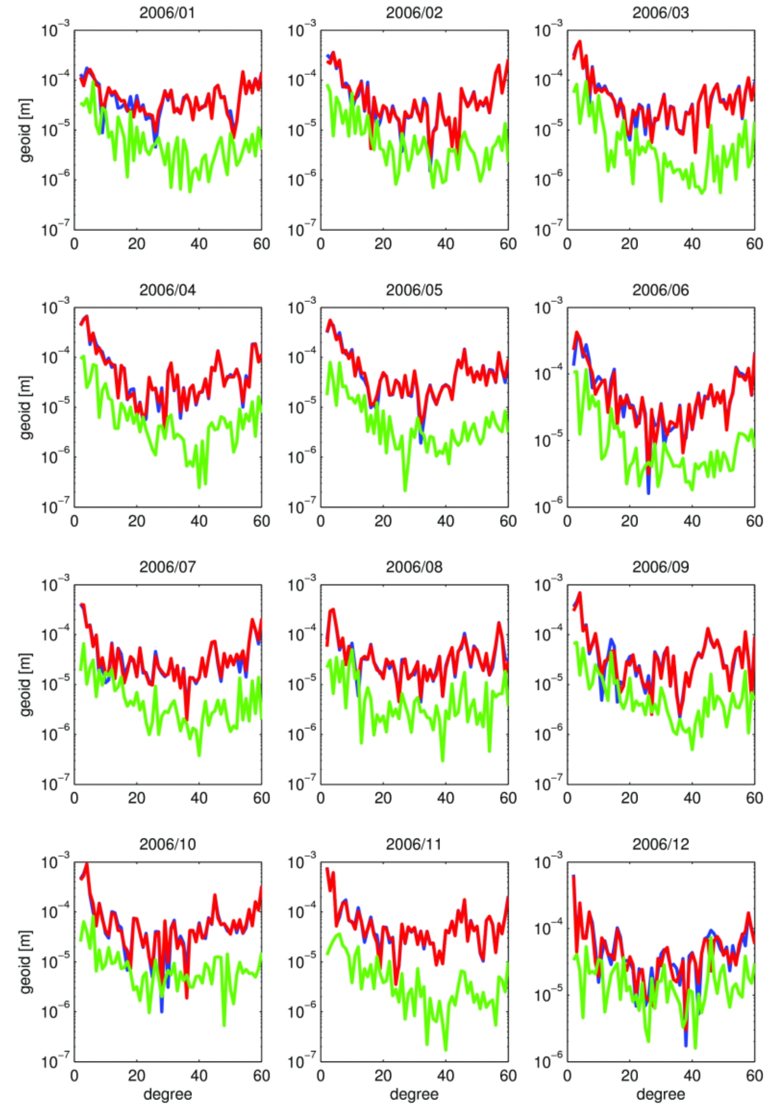
REPRO: GPS orbits and clock corrections (3/3)



Effect on monthly GRACE GPS + K-Band gravity fields.

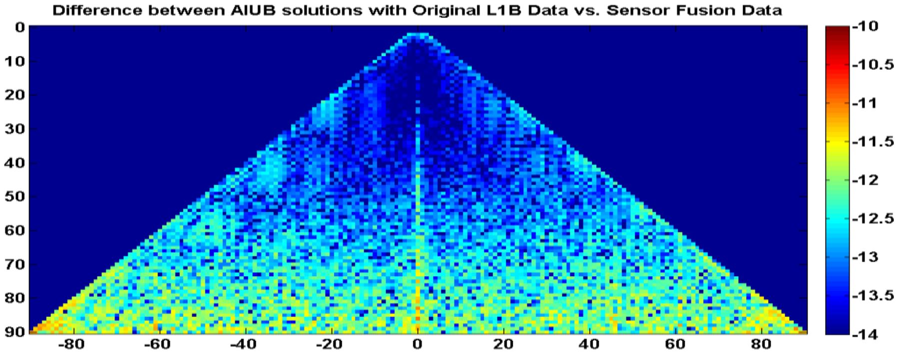
Left: difference degree amplitudes

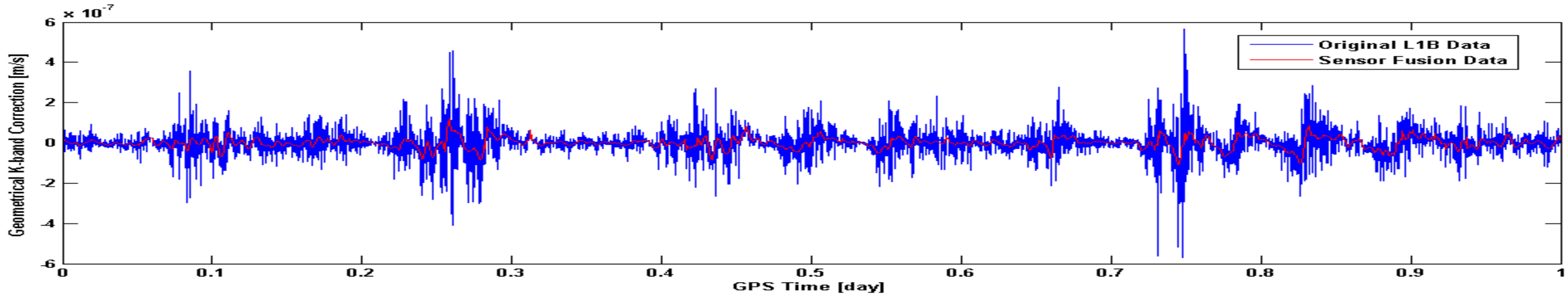
Right: sectorial terms only

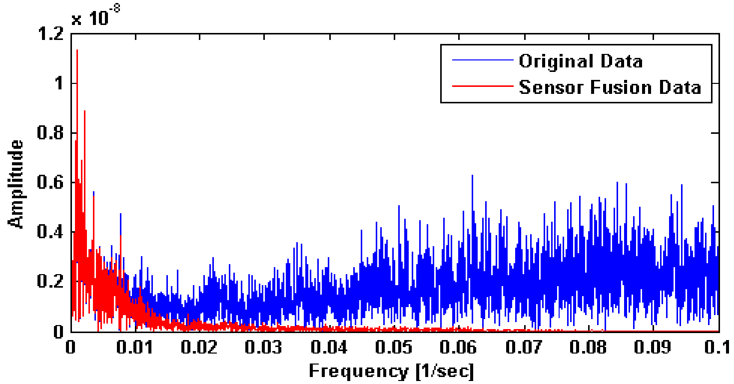


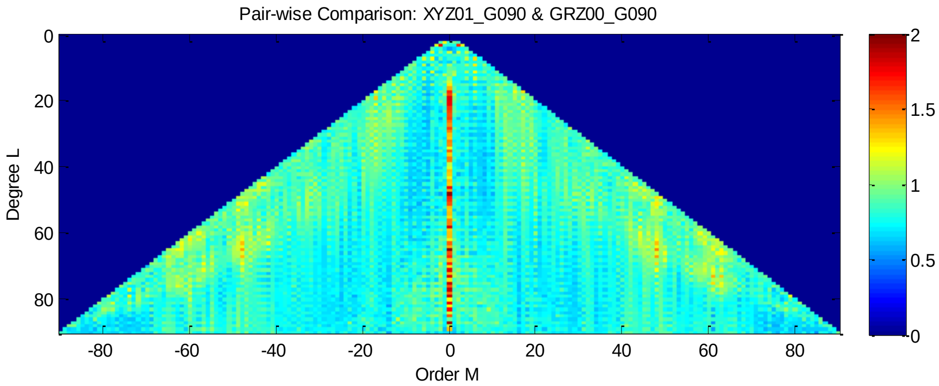
Sensor Fusion Data (1/2)

- Test period: January 2007
- processing method: CMA (AIUB)
  – Case 1: original L1B
  – Case 2: ITSG sensor fusion

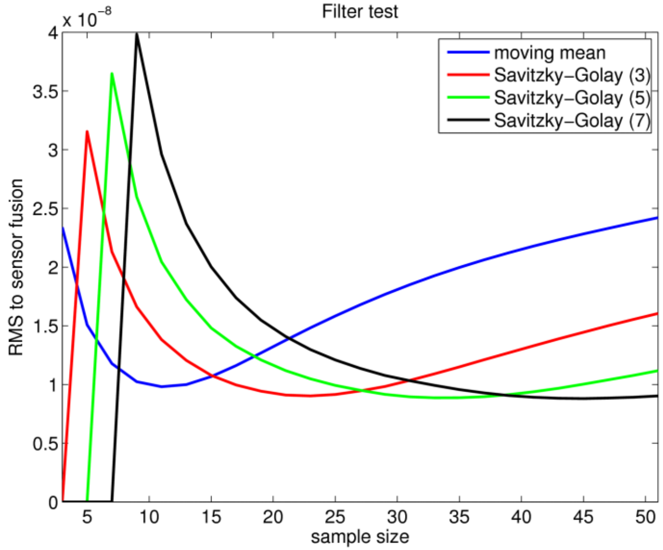


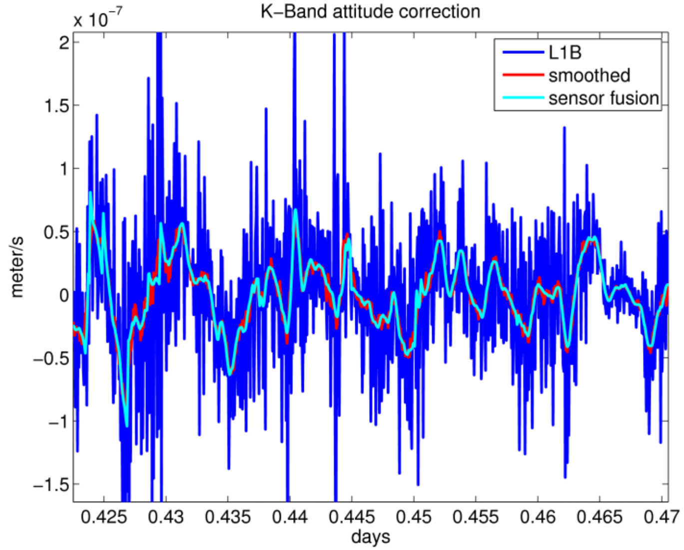






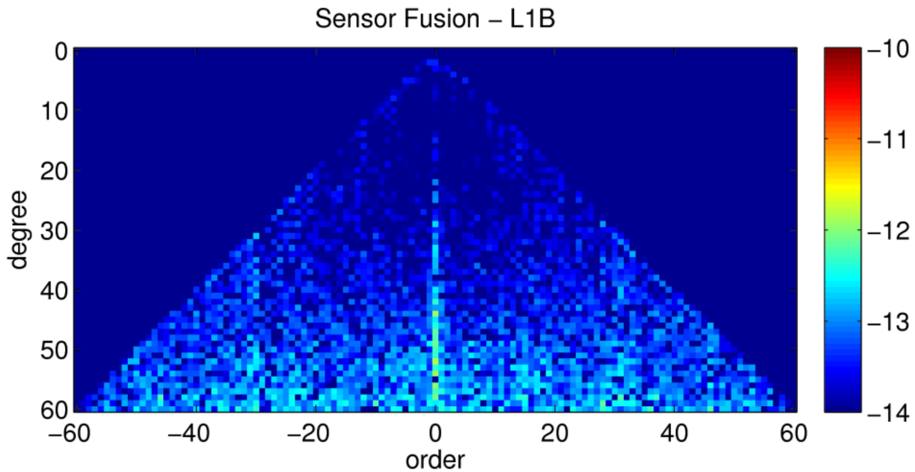
Sensor Fusion Data (2/2)

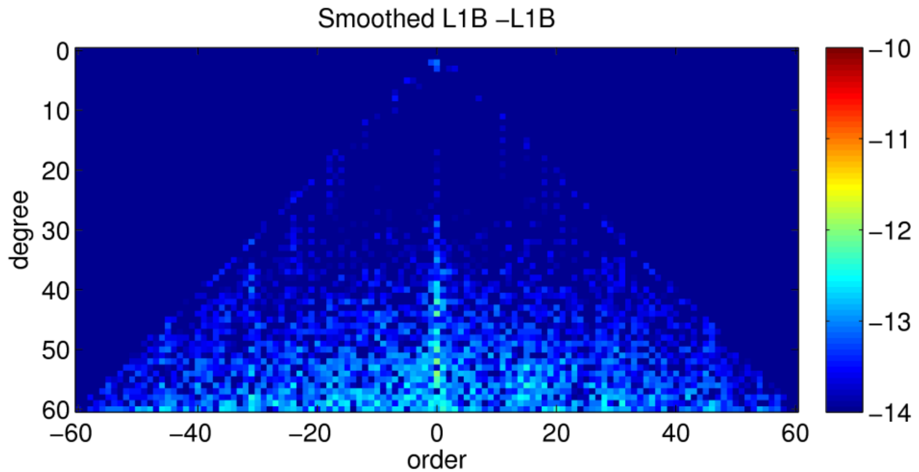




Main effect of sensor fusion data: K-Band attitude correction.

May be replaced by smoothed L1B attitude correction.





EGSIEM

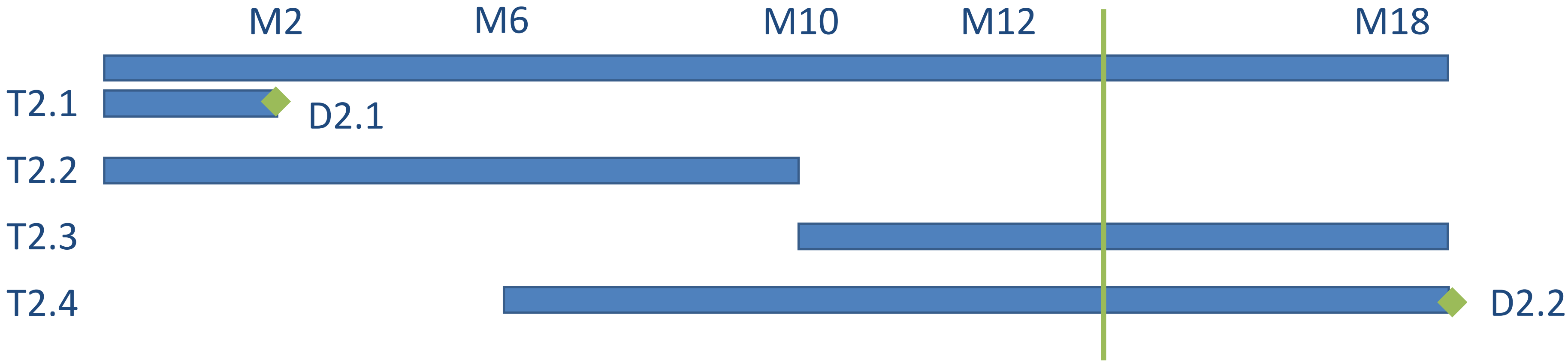
European Gravity Service for Improved Emergency Management

Title: **WP2 Gravity field analysis**

Presenter: Torsten Mayer-Gürr and all ACs

Affiliation: TUG

WP2 Gravity field analysis – Time Table



T2.1 Processing Standards and Models

Document delivered

T2.2 Improved processing tools

Presentation of results today: AIUB, GZF, TUG,CNES/GRGS, ULux

T2.3 Data analysis

Discussion today

T2.4 Instrumental behavior and End-to-end Simulator

EGSIEM

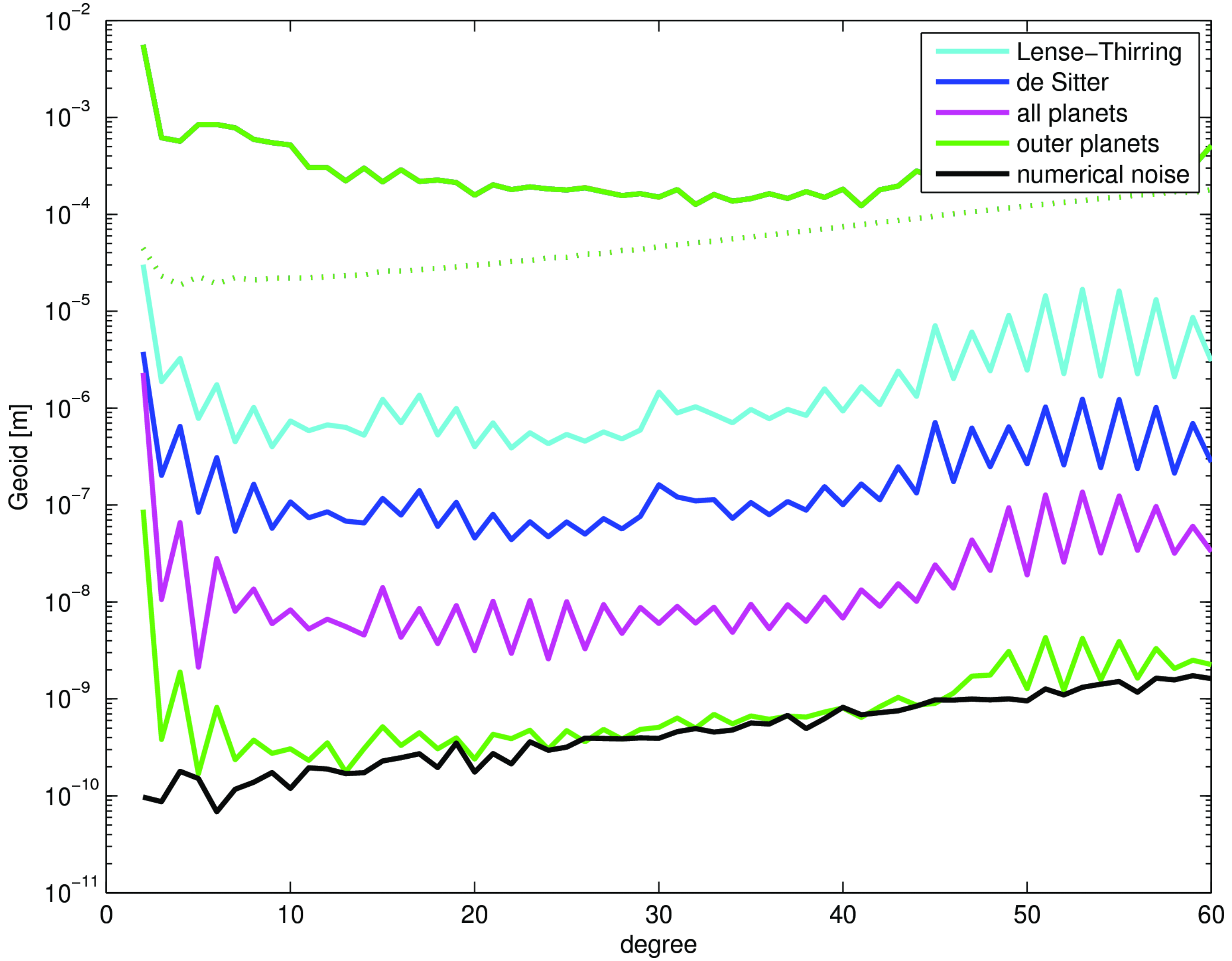
European Gravity Service for Improved Emergency Management

Title: **AIUB processing**

Presenter: Ulrich Meyer

Affiliation: AIUB

Adaption of Standards: Relativity and third bodies



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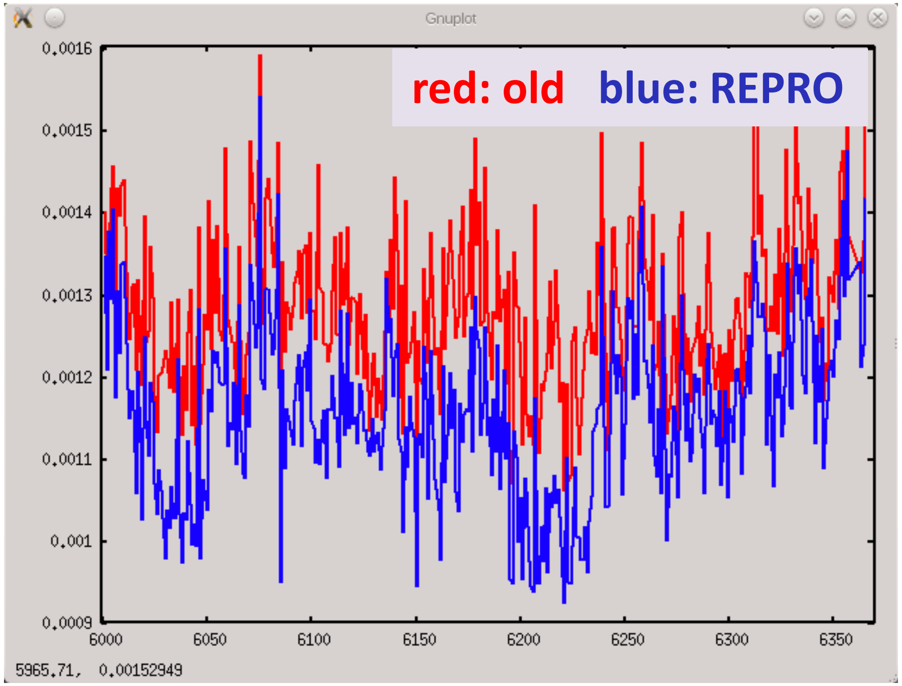

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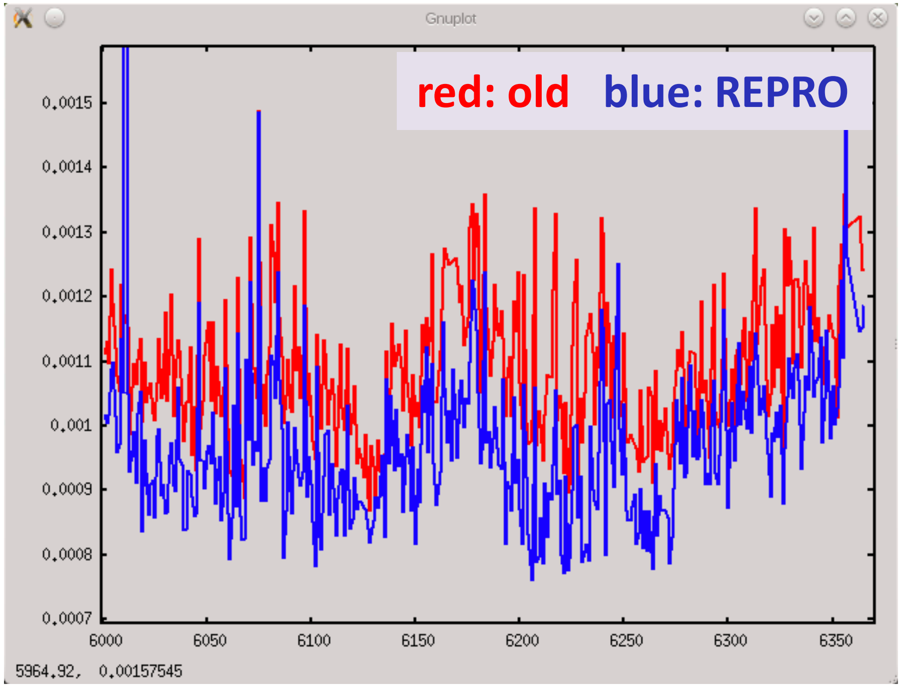

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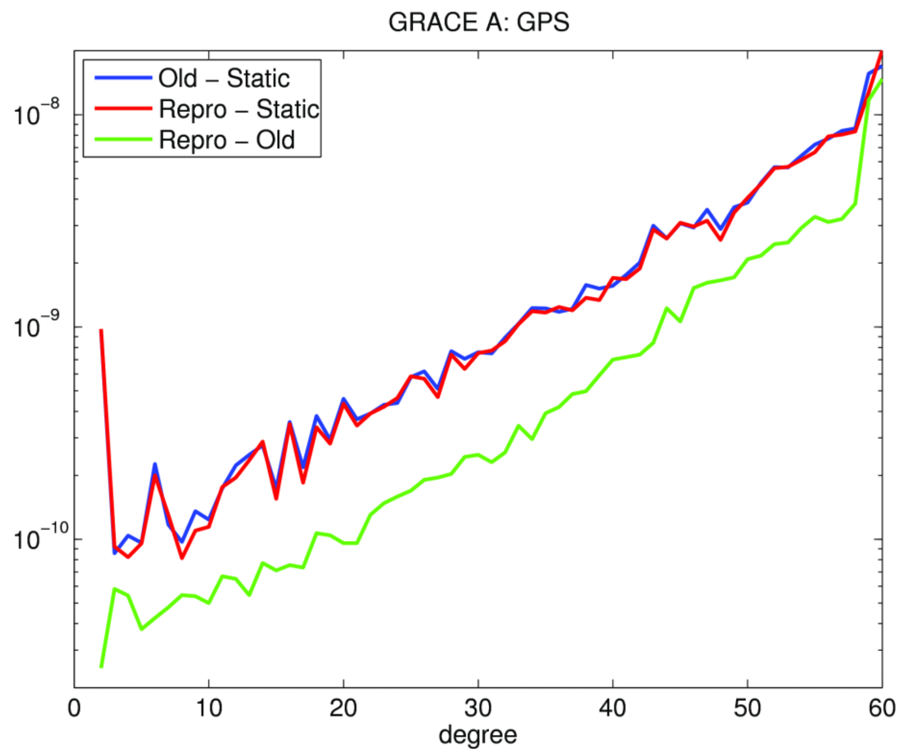
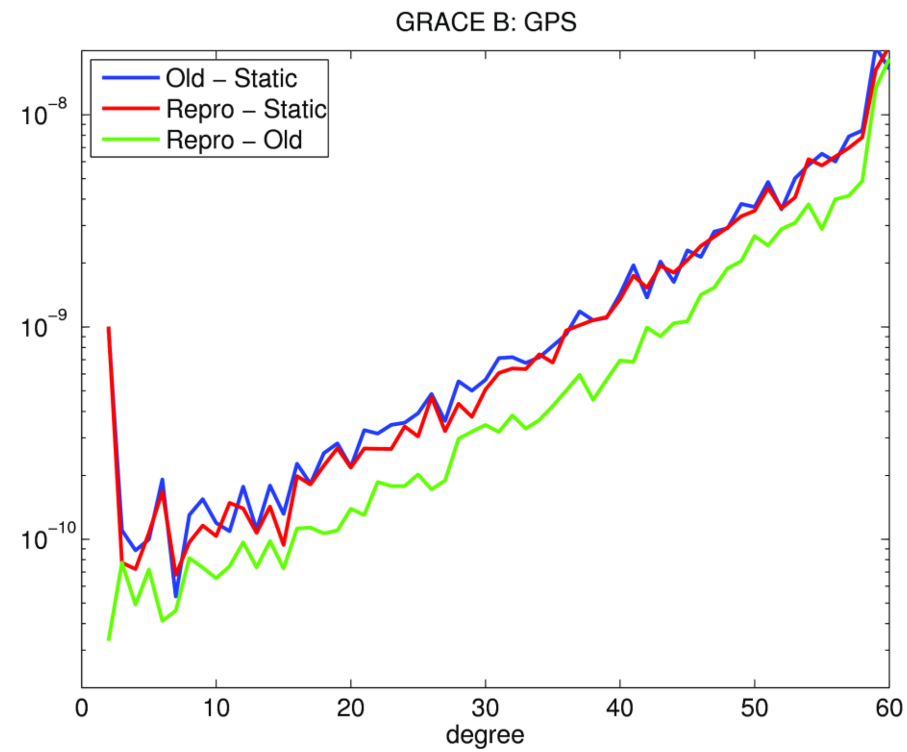
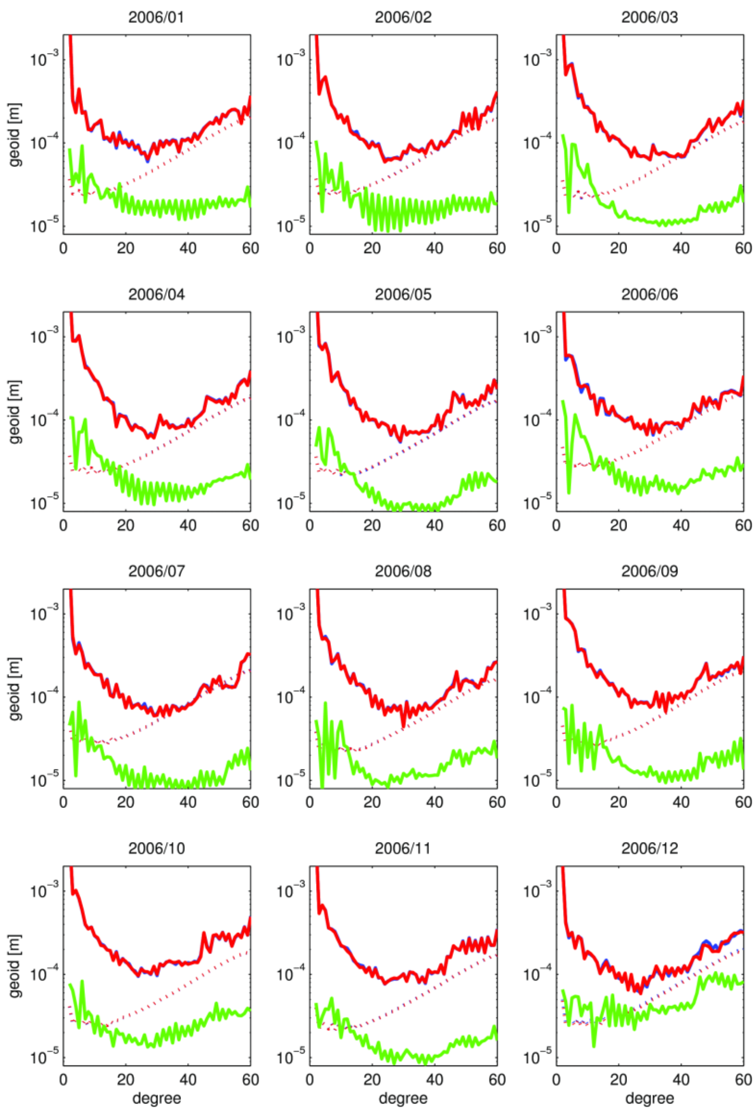




REPRO: GPS orbits and clock corrections (3/3)



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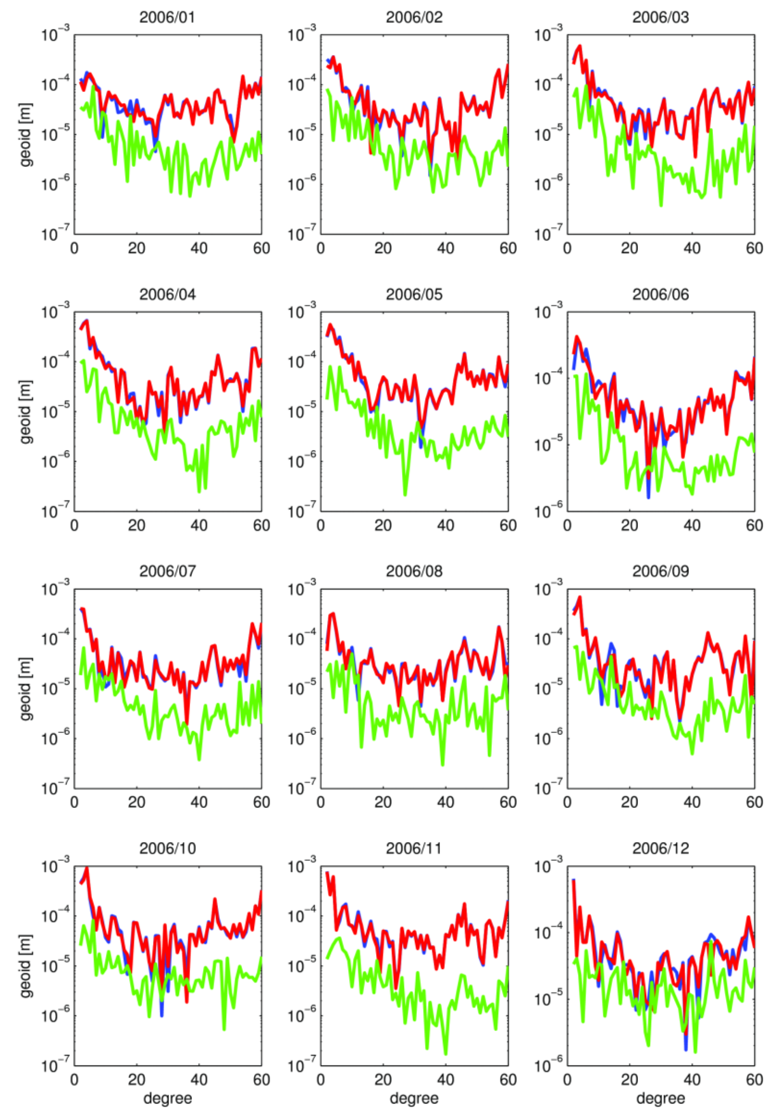

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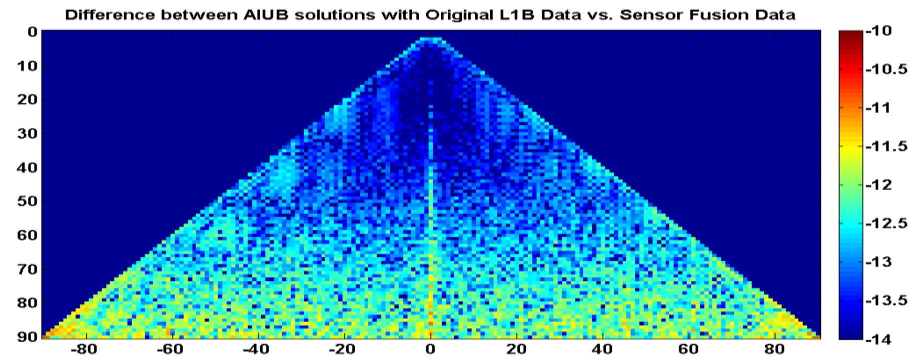
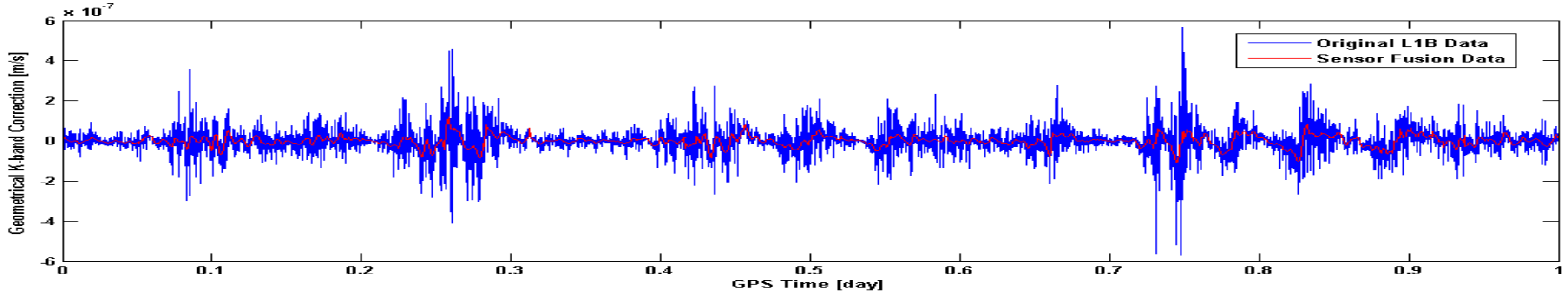
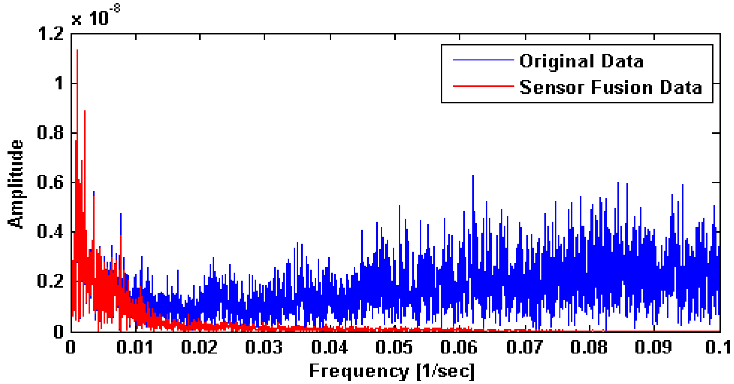
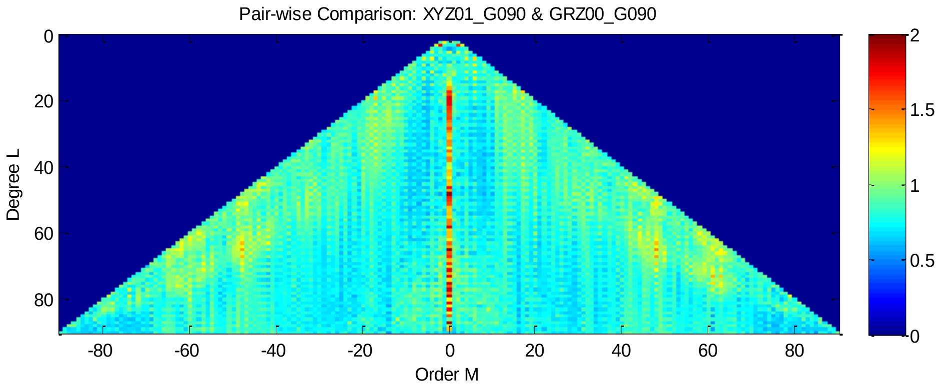
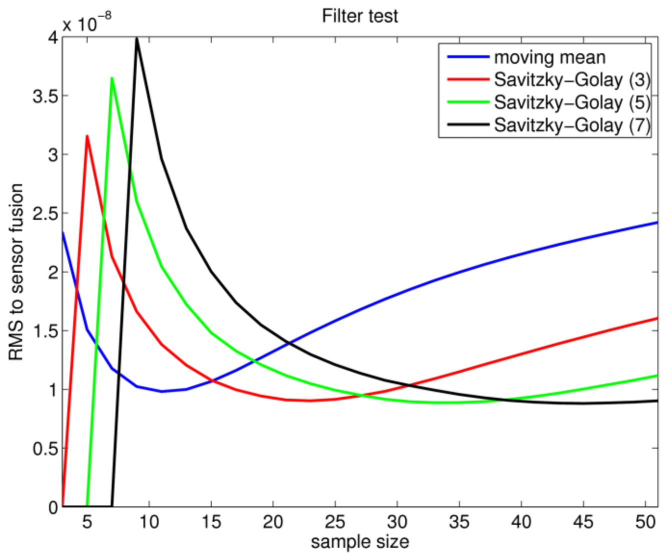


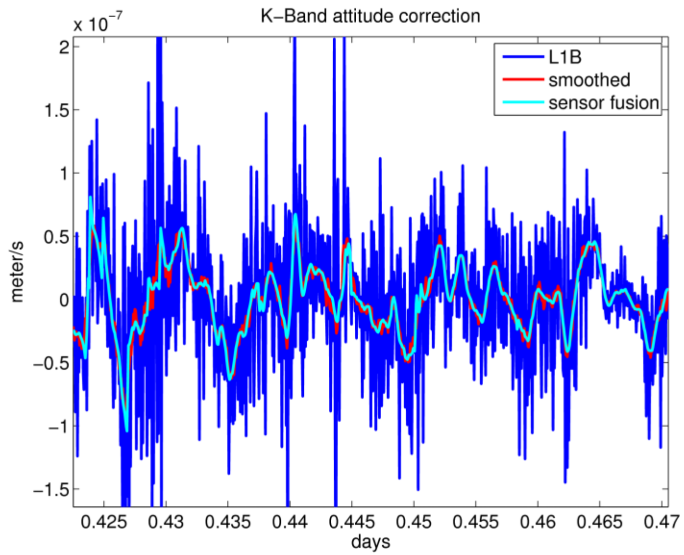






Sensor Fusion Data (2/2)





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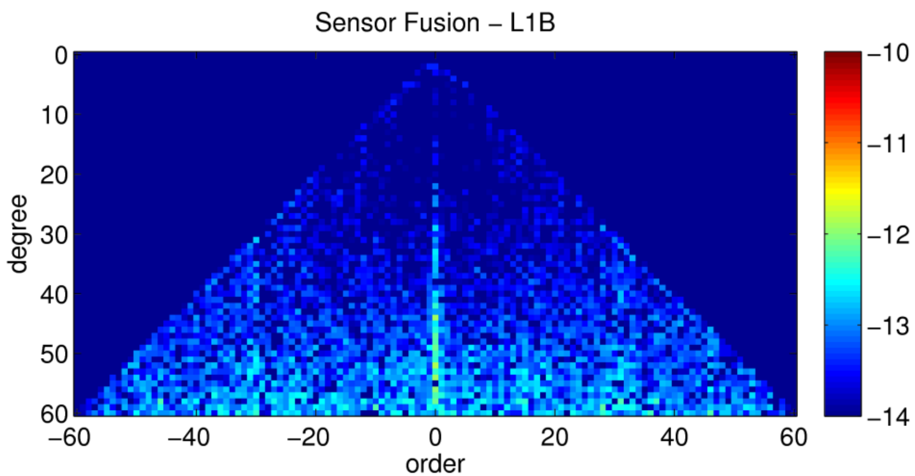
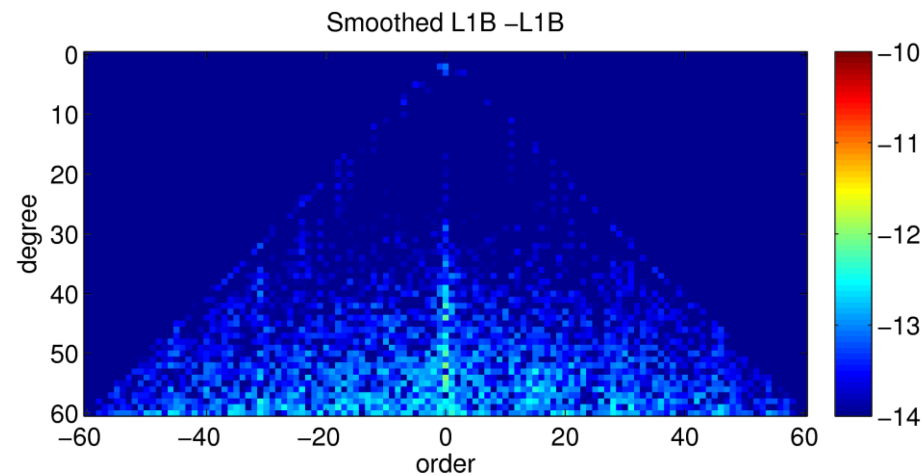




EGSIEM

European Gravity Service for Improved Emergency Management

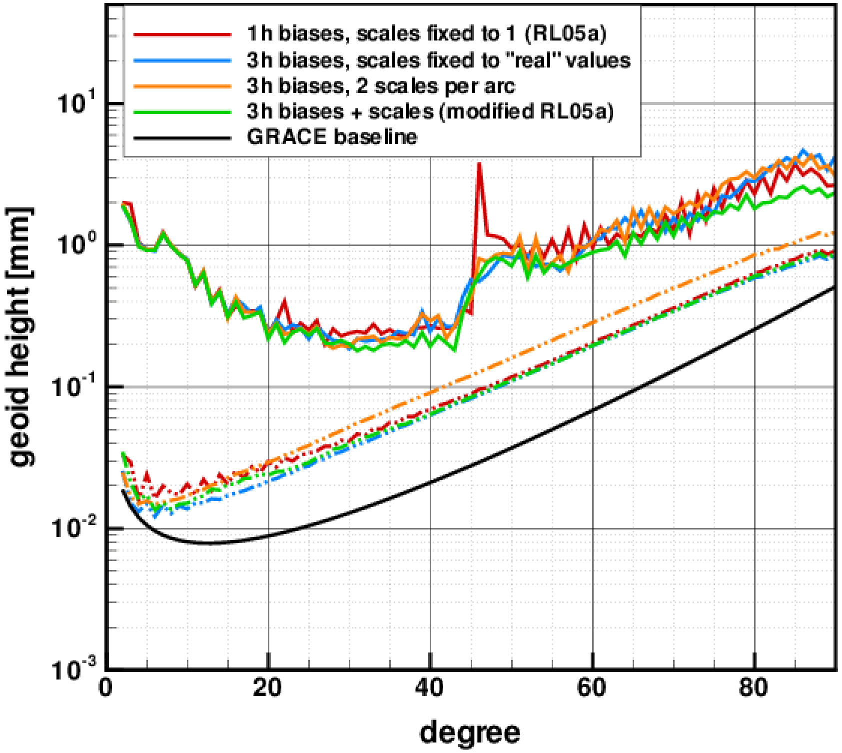
Title: **GFZ processing**

Presenter: Frank Flechtner

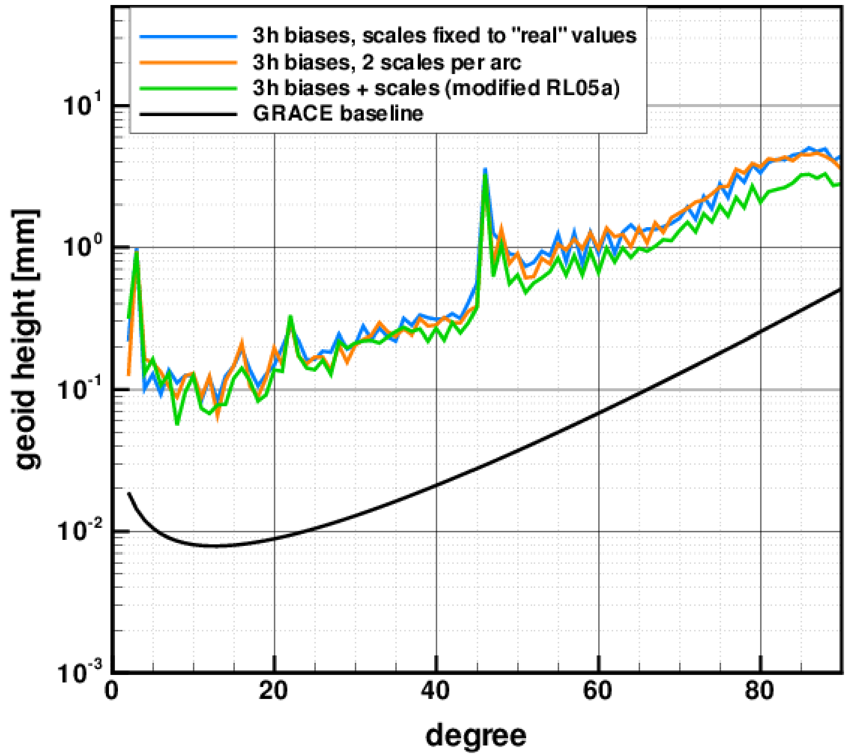
Affiliation: GFZ

ACC parameterization:

- Test month: 2012/07

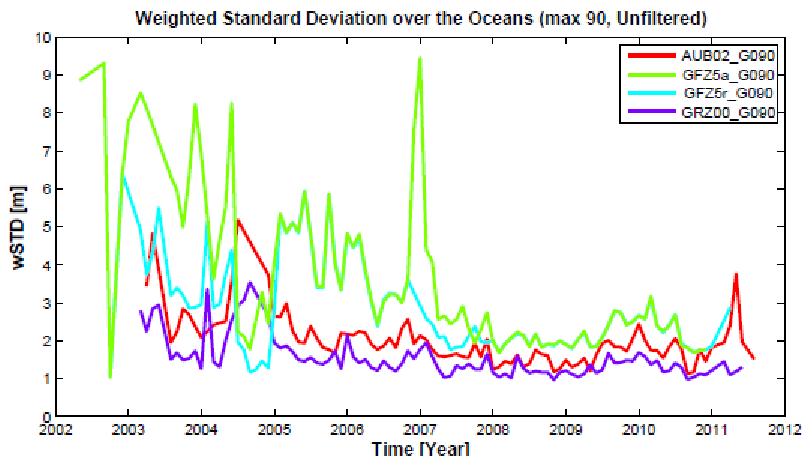


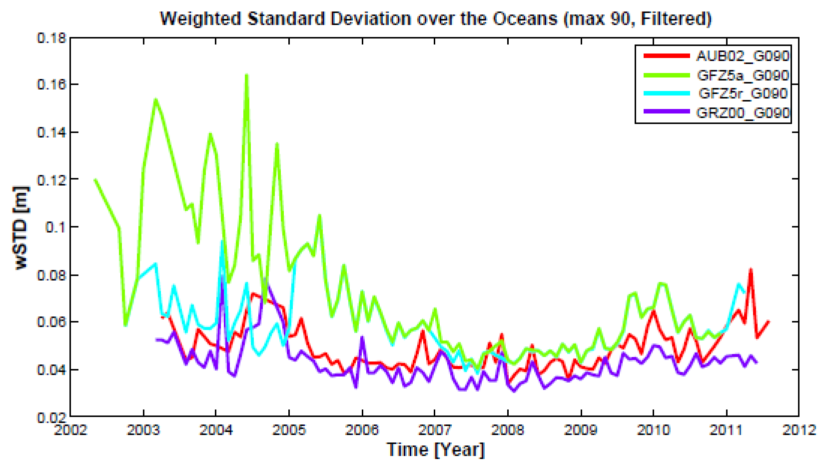
Differences relative to RL05a solution:



ACC parameterization (lessons learnt):

- Fixing ACC scales to 1 should be avoided
- Parameterization with 3h biases + scales shows least high-frequency noise and has been chosen for modified RL05a processing
- Impact of this parameterization on time-series is shown below:
  - Alternative RL05a solutions for the years 2003, 2004, 2007, 2012 & 2013 (Jan-May) have been reprocessed for comparison with official RL05a



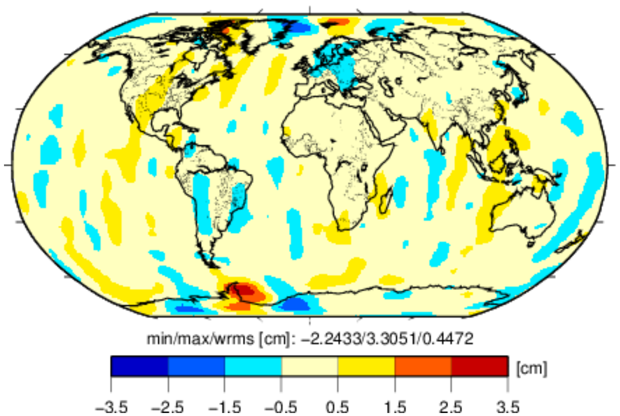


Figures provided by Yoomin Jean (AIUB)

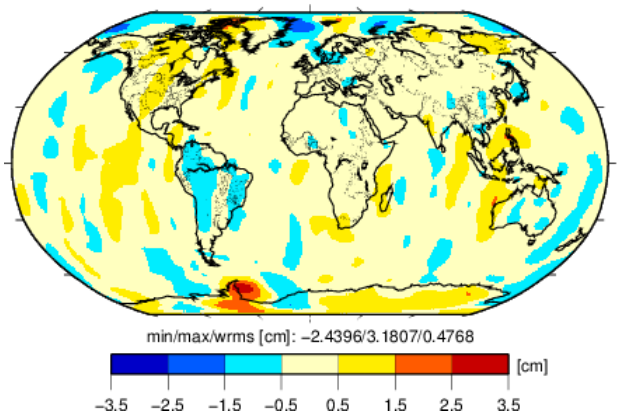
New ocean tide model FES 2014:

- Test month: 2007/12
- Case 1: FES2014 up to 80x80, Om1/Om2 from EOT11a up to 80x80 (source TMG)
- Case 2: FES2014 up to 80x80, only d/o (2,0) provided by GRGS for Om1/Om2
- Case 3: FES2014 up to 100x100, only d/o (2,0) provided by GRGS for Om1/Om2
- EWH differences (DDK2) relative to GFZ RL05a solution using EOT11a are largest where EOT11a is known to be less accurate (Stammer et al. 2014, Rev Geophys)

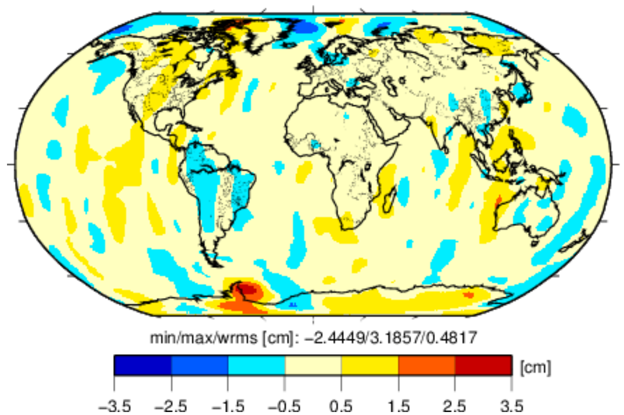
Case 1



Case 2



Case 3



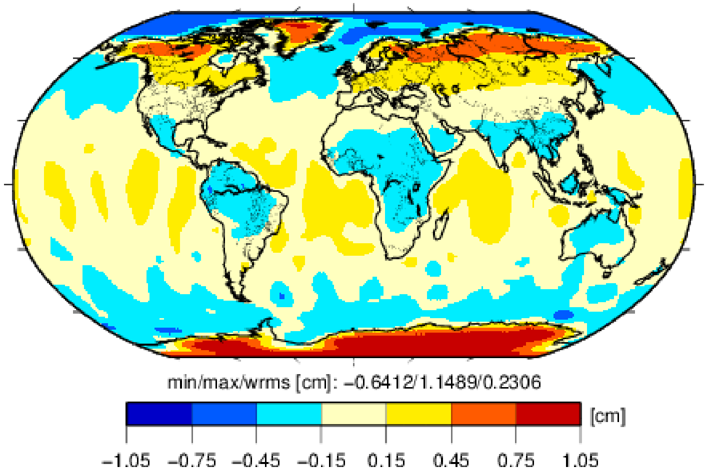
Task 2.2 Improved Processing Tools GFZ

EGSIEM

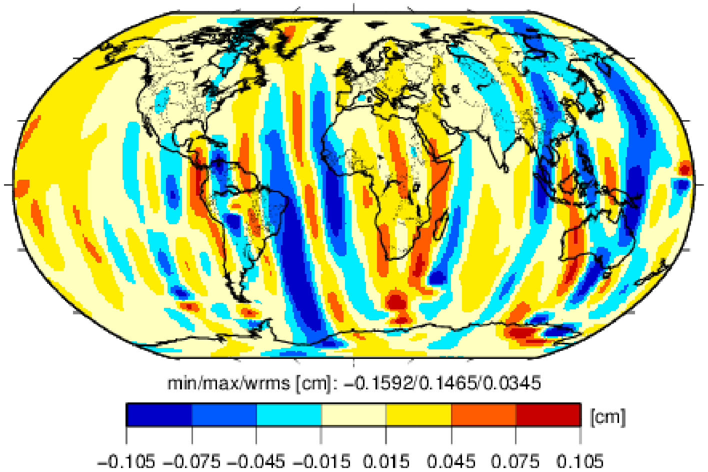
European Gravity Service for Improved Emergency Management

New ocean tide model FES 2014:

- Difference Case 1 – Case 2:
  - Might be on the edge of GRACE accuracy
  - Does it make sense to use d/o (2,0) only for Om1/Om2?



- Difference Case 2 – Case 3:
  - Well below GRACE accuracy level
  - Further test with FES2014 up to 180x180 planned



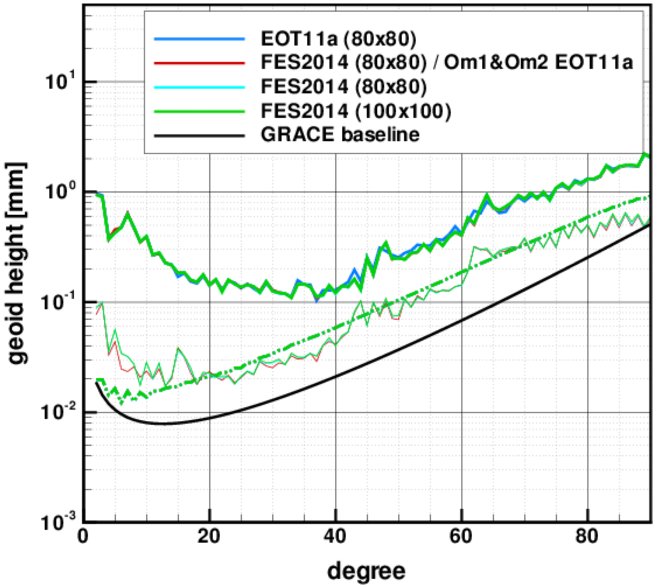
Task 2.2 Improved Processing Tools GFZ

EGSIEM

European Gravity Service for Improved Emergency Management

New ocean tide model FES 2014:

- Using FES2014 instead of EOT11a shows
  - No significant impact on KBR pre-fit residuals
  - Slightly decreased GPS phase pre-fit residuals (~1%)
  - No significant impact on wRMS over oceans



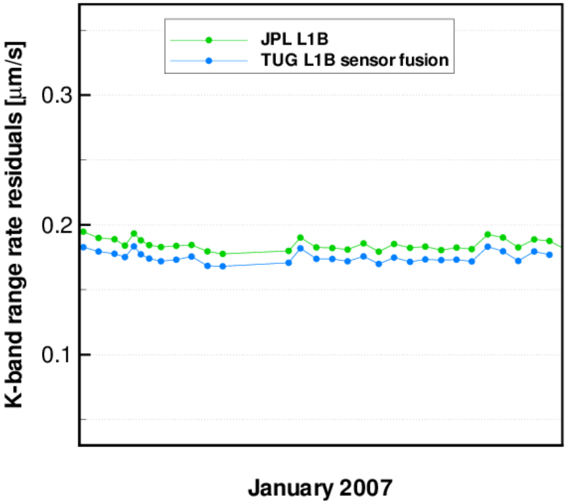
- Only minor differences visible in degree amplitudes, but differer lines in plot) are larger than (formal) errors (dashed lines) at le

- As shown above, regional effects are clearly visible!

- Max. degree of OM1/OM2 to be discussed with GRGS

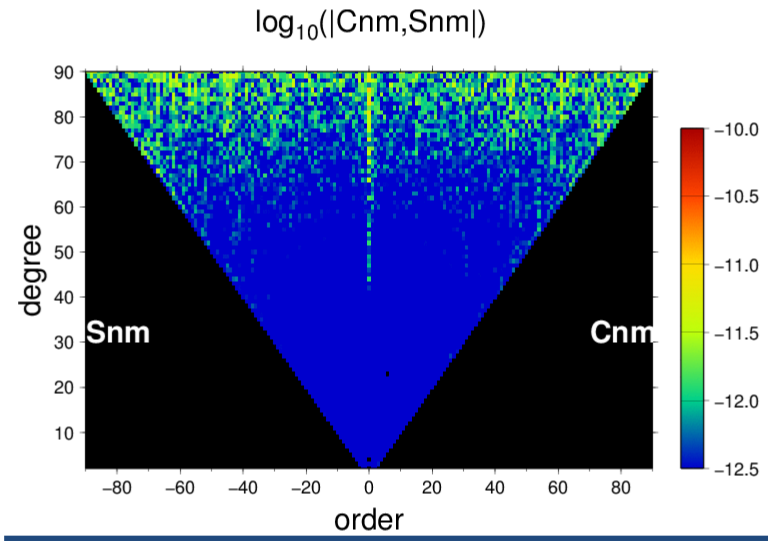
Alternative SCA1B/KBR1B data provided by TU Graz:

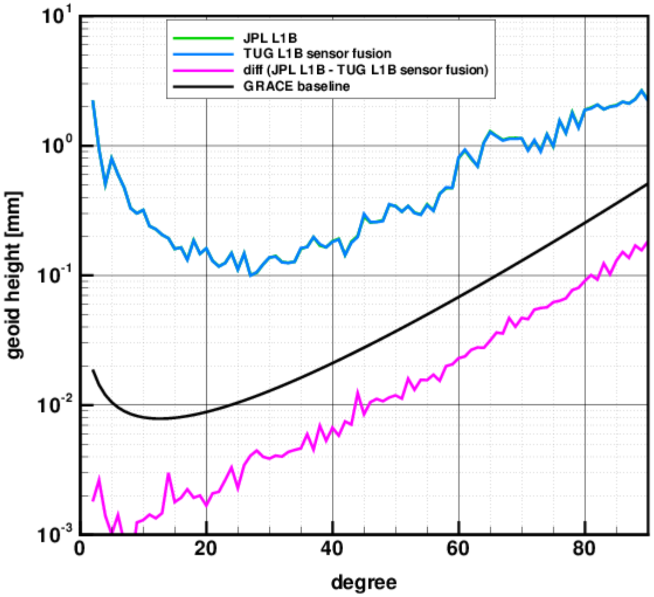
- Provided data: so-called "Sensor Fusion" data for 1 month (2007/01)
  - SCA1B: new attitude based on combination of L1B star camera data and angular accelerations
  - KBR1B: newly computed antenna center correction based on new attitude product
- KRR pre-fit residuals decrease by ~5%
  - mean JPL L1B: 0.185 microm/s
  - mean TUG L1B: 0.175 microm/s
  - slightly more (~0.8%) KRR observations remained after screening
- GPS pre-fit residuals are not affected



Alternative SCA1B/KBR1B data provided by TU Graz:

- No impact at all visible in degree amplitudes
  - Effect is well below GRACE baseline
- Differences (JPL L1B – TUG L1B sensor fusion) on coefficient level:
  - mainly zonal coefficients for n > 40 are affected





Alternative SCA1B/KBR1B data provided by TU Graz:

- Results are in line with results from similar tests at TU Graz
- But: For ITSG2014, in addition antenna center corrections have been estimated (using the recomputed values as a priori) → this affects even more zonal coefficients, in particular also for very low degrees (up to n = 7), but also quite many near-sectorial coefficients of higher degrees (approx. from n > 20)
- According to Torsten Mayer-Guerr, estimation of antenna center corrections alone (i.e. with official L1B data) does not improve the solutions, or even degrades them

⇒ "Sensor Fusion" data alone has no significant impact on gravity field solutions, but might be beneficial in combination with other processing details

⇒ Approach will not be followed, GFZ will wait for new JPL L1B data in the frame of RL06 reprocessing (end 2016)

Task 2.2 Improved Processing Tools GFZ

European Gravity Service for Improved Emergency Management

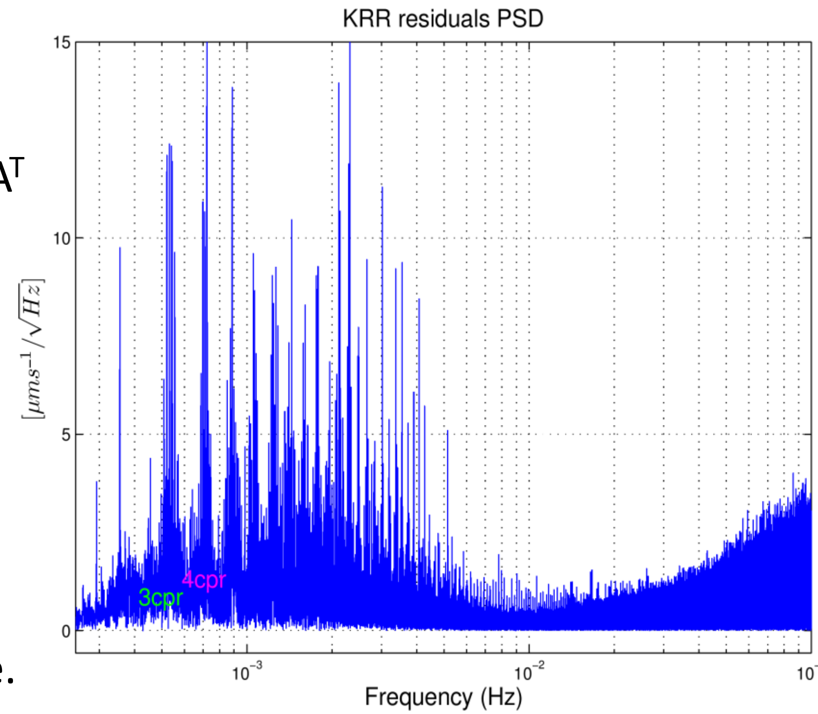
"Whitening" of residual noise

- Observation Equation (residuals): $v = A x - b$
- Covariance Matrix: $Q_{vv} = M\{v, v^T\} = Q_{bb} - AQ_{xx}A^T$
- Factorized Matrix: $F = chol(Q_{vv})^{-1}$

Leads to a new equation system (with F acting as filter) for each monthly model:

- $A_2 = F\ A$
- $x = (A_2^T A_2)^{-1} A_2^T b$

with (hopefully) de-correlated observation noise.



Software already available, thorough testing has started and shall be finished till February 28 to be used in reprocessing

HORIZON 2020

EGSIEM

European Gravity Service for Improved Emergency Management

Title: **TUG processing**

Presenter: Beate Klinger

Affiliation: TUG

Improvements since ITSG-Grace2014

Multiple improvements within the processing chain:

- Updated background models
- Instrument data screening & calibration
- Improved numerical orbit integration
- Improved covariance function estimation
- Co-estimation of constrained daily variations: constraints based on improved error estimates for the dealiasing models

Data screening

Instrument data screening step included:

- CoM and KBR calibration maneuvers are excluded:

  ⇒ based on SoE file

- Time periods around yaw-turns are excluded:

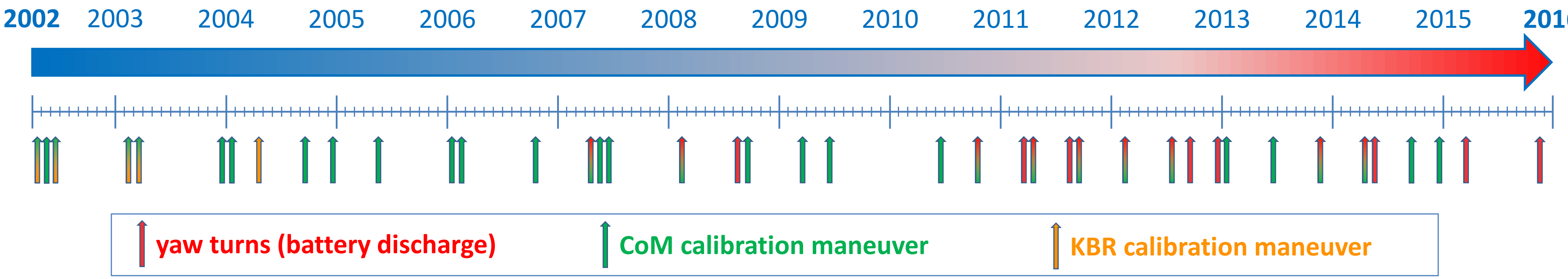
  ⇒ based on inter-satellite-pointing angles (yaw)

- Simulation of non-conservative forces (atmospheric drag, solar radiation pressure and albedo):

  ⇒ a-priori calibration of accelerometer bias

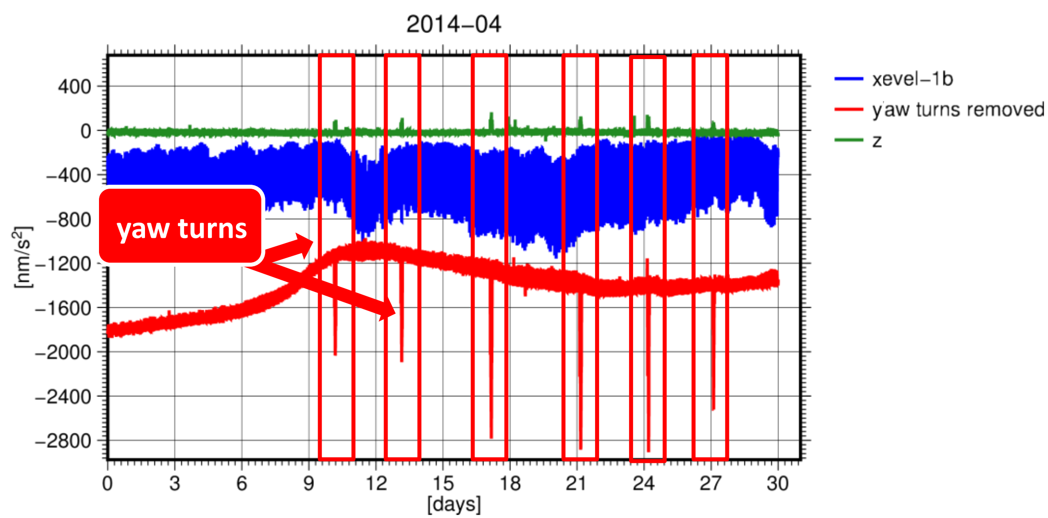
  ⇒ detection of large outliers

Data screening



Yaw turns:

- Necessary for battery maintenance
- No KBR data available, **but edge effects still visible.**



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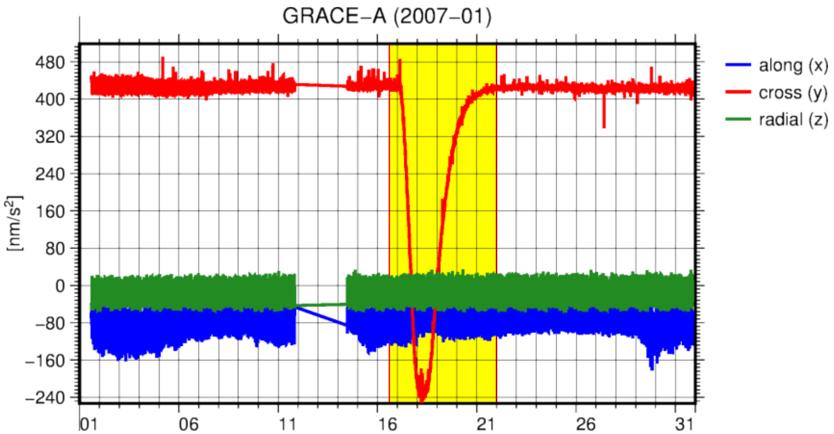
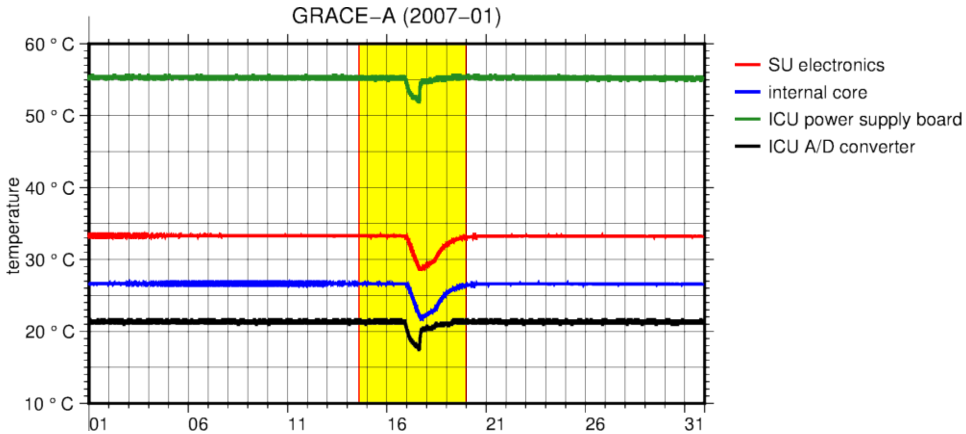
Data screening

Accelerometer calibration:

- Temperature-dependent effects (bias drift)
- Calibration based on simulated accelerometer data





Numerical orbit integration

- Elliptical reference orbit replaces linear motions:

  $\Rightarrow$ improved force model integration for dynamic orbit computation

  $\Rightarrow$ promising results for reducing processing artifacts in adjusted SST observations and residuals

Covariance estimation

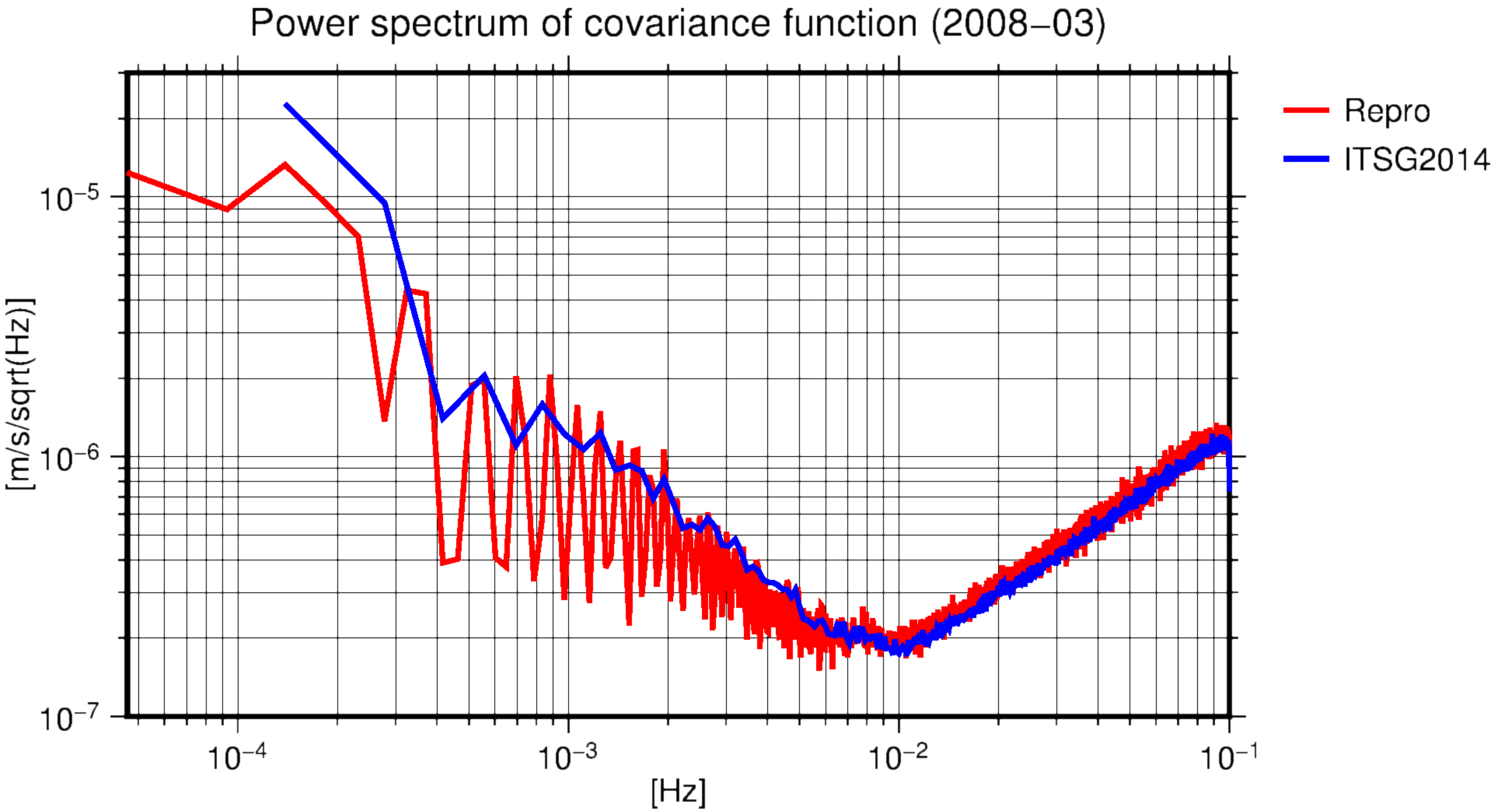
- Decorrelation of KBR range-rate data by an empirical covariance function

  $\Rightarrow$ length increased from 1 to 3 hours

- Robust covariance estimator

  $\Rightarrow$ guarantees that the covariance estimation is resistant to outliers

Covariance Estimation



Reprocessing

- **Reprocessed time series: 2003-03 to 2015-04**
  (Test run: only up to degree 60)

- Comparison with

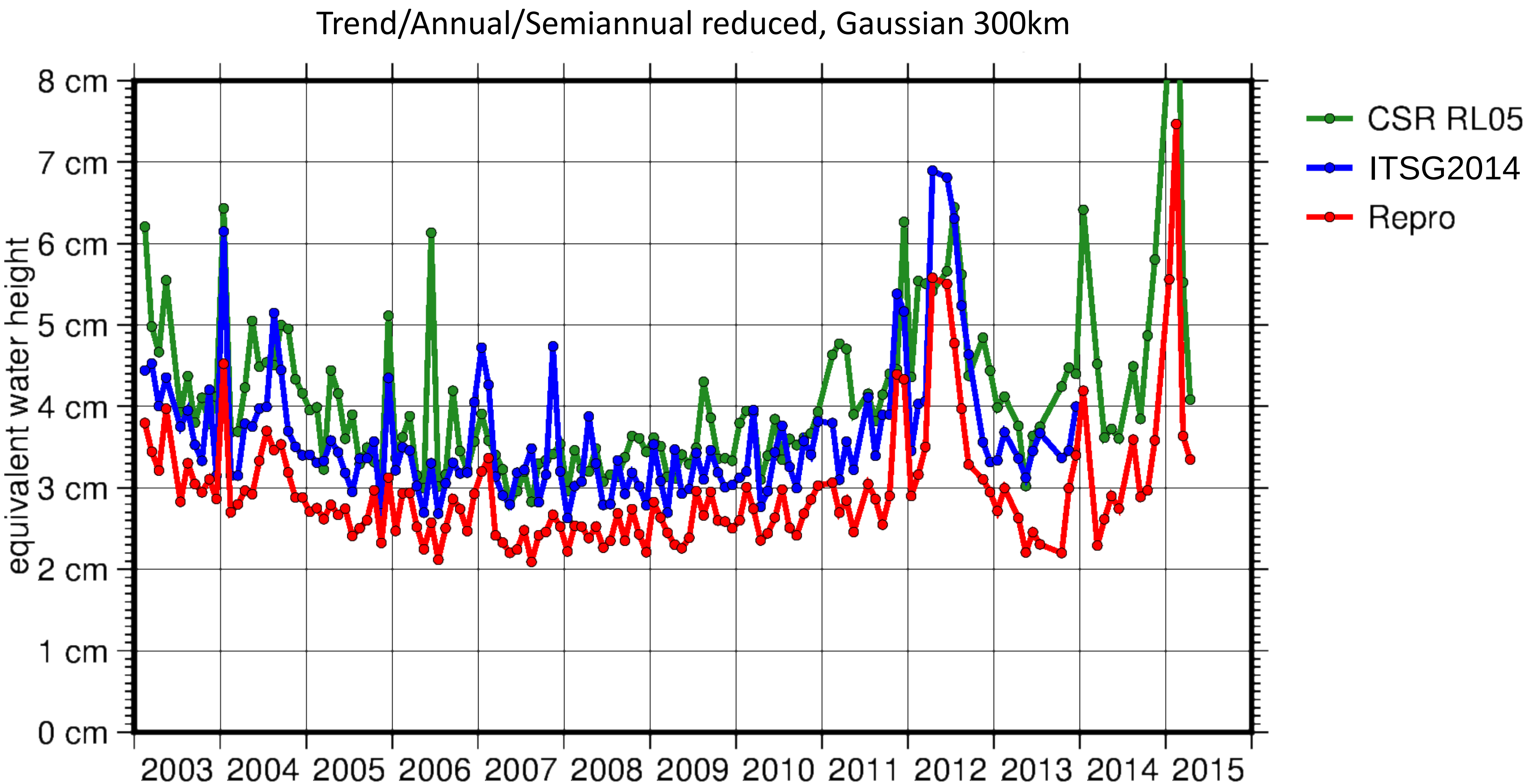
  $\Rightarrow$ ITSG-Grace2014 (degree 60)

  $\Rightarrow$ CSR RL05 (degree 60)

- For comparison: monthly time series from 2003-03 to 2013-07

  $\Rightarrow$ Following month are not included (data missing, repeat orbtis):
  2003-06
  2004-01, 2004-07, 2004-08, 2004-09, 2004-10
  2010-12
  2011-01, 2011-02, 2011-06
  2012-03, 2012-04, 2012-05, 2012-06, 2012-07, 2012-08, 2012-10
  2013-03

Variability over the oceans



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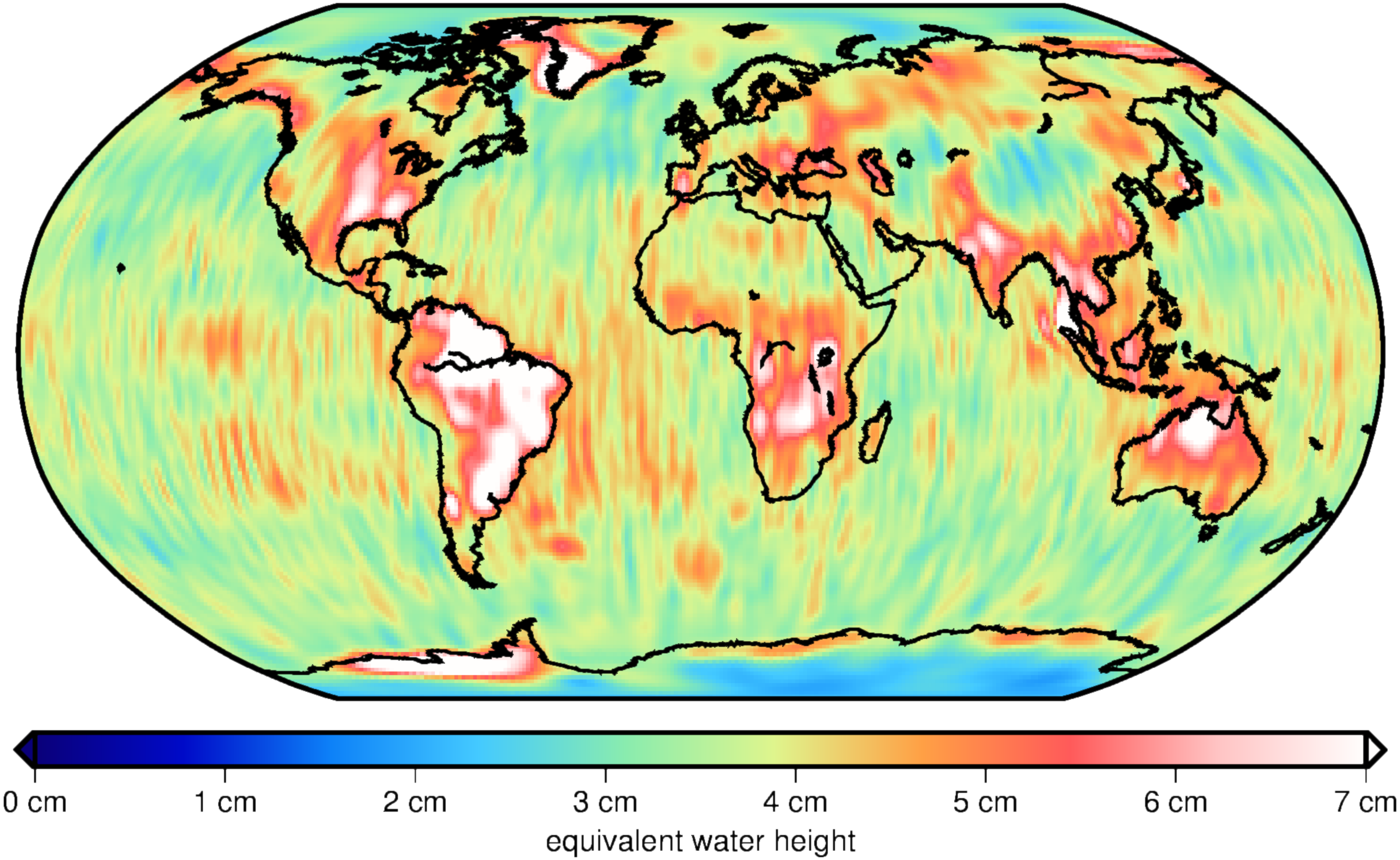
Temporal RMS

CSR RL05

Trend/Annual/Semiannual reduced, Gaussian 300km



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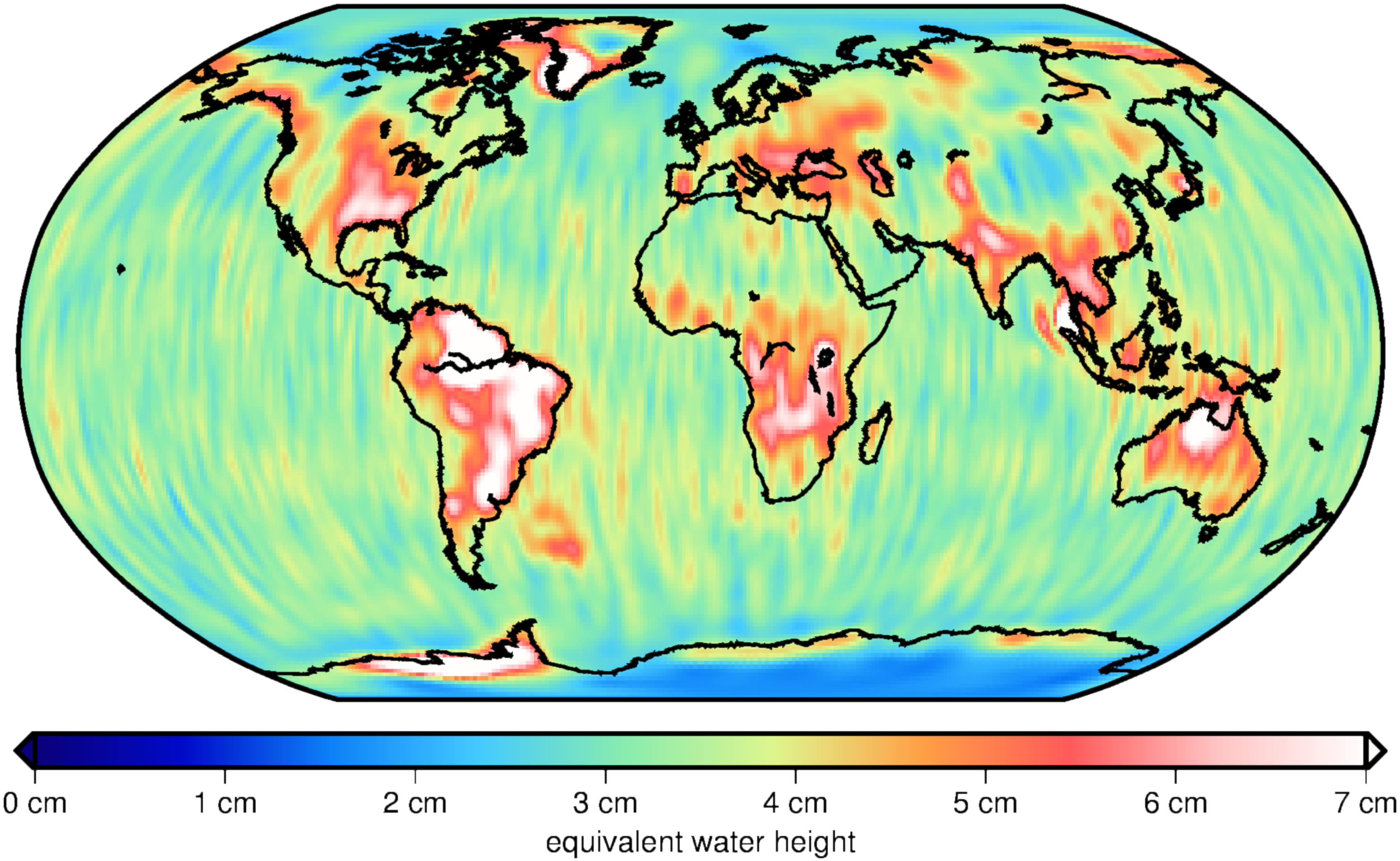
HORIZON 2020

Temporal RMS

ITSG2014

Trend/Annual/Semiannual reduced, Gaussian 300km



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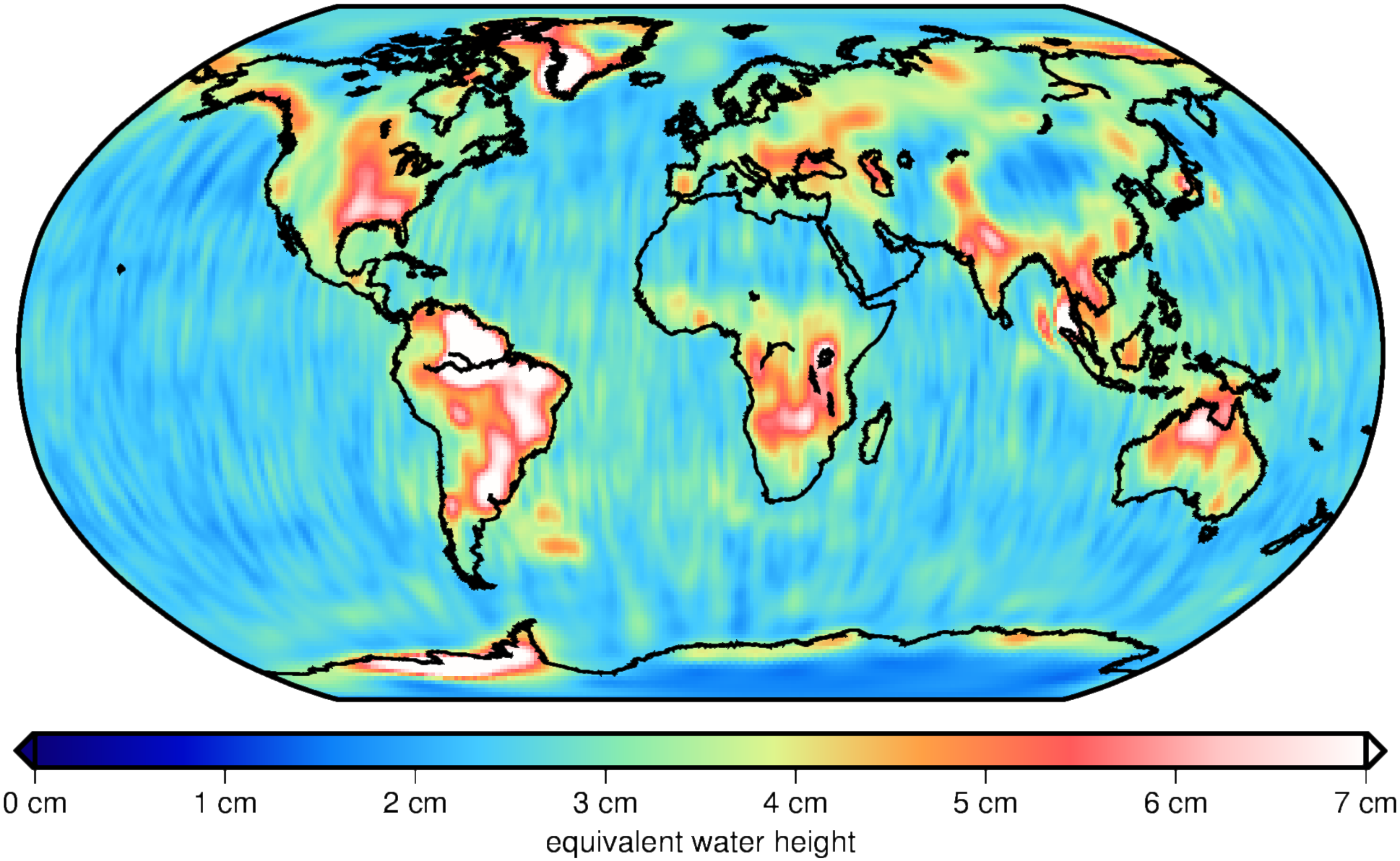
HORIZON 2020

Temporal RMS

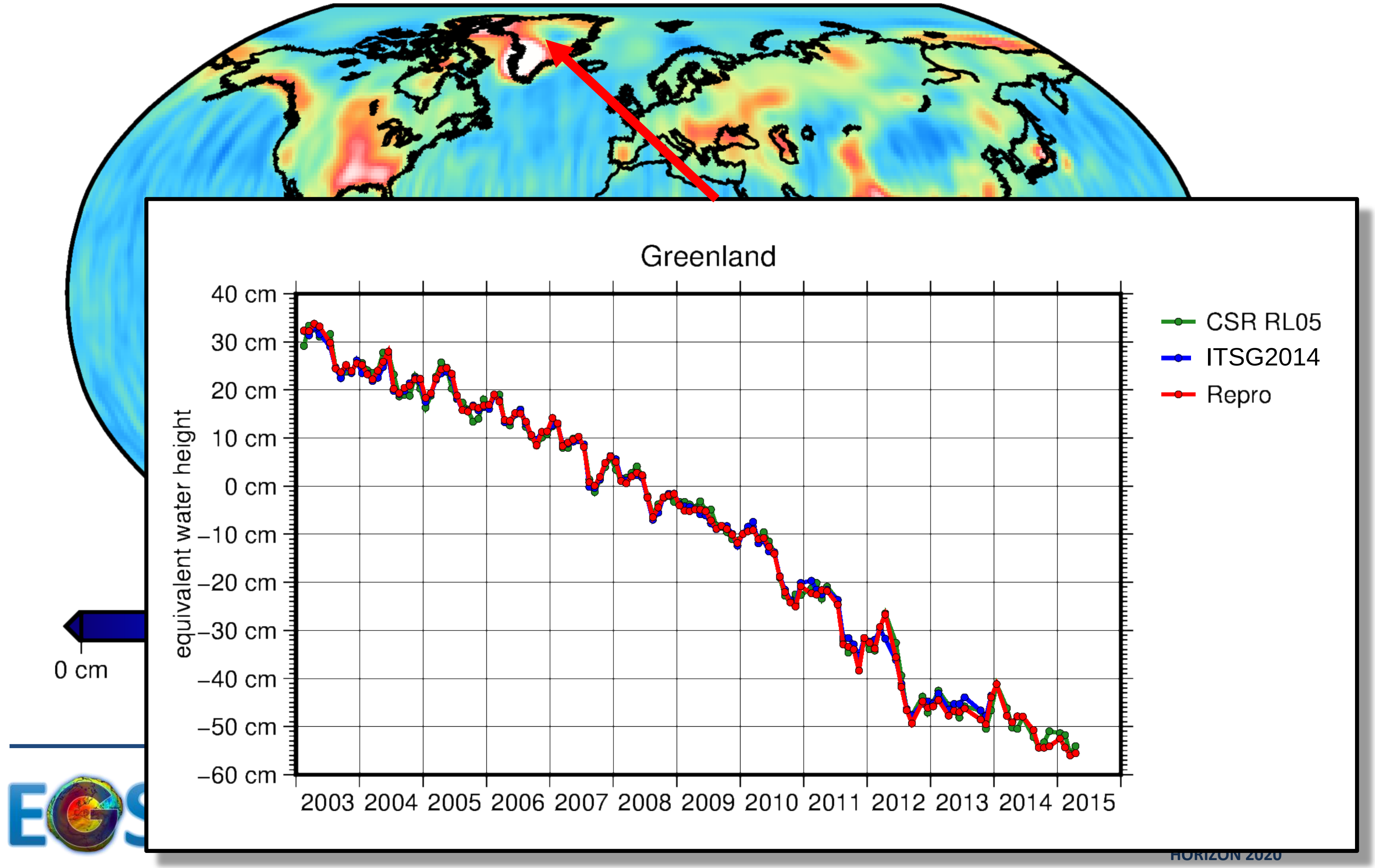
Repro

Trend/Annual/Semiannual reduced, Gaussian 300km



Comparison of signals

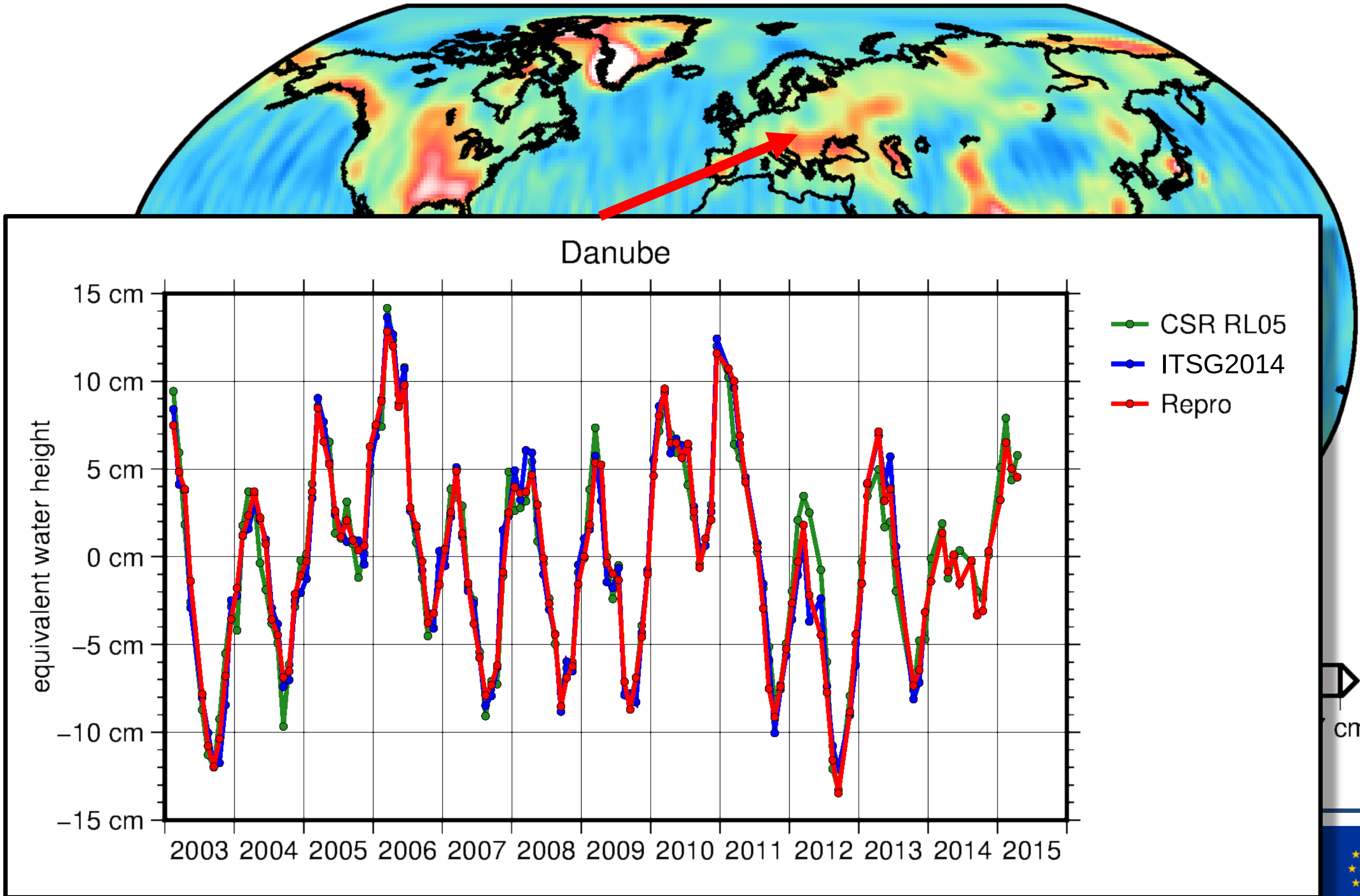
Repro
Trend/Annual/Semiannual reduced, Gaussian 300km



Comparison of signals

Repro

Trend/Annual/Semiannual reduced, Gaussian 300km

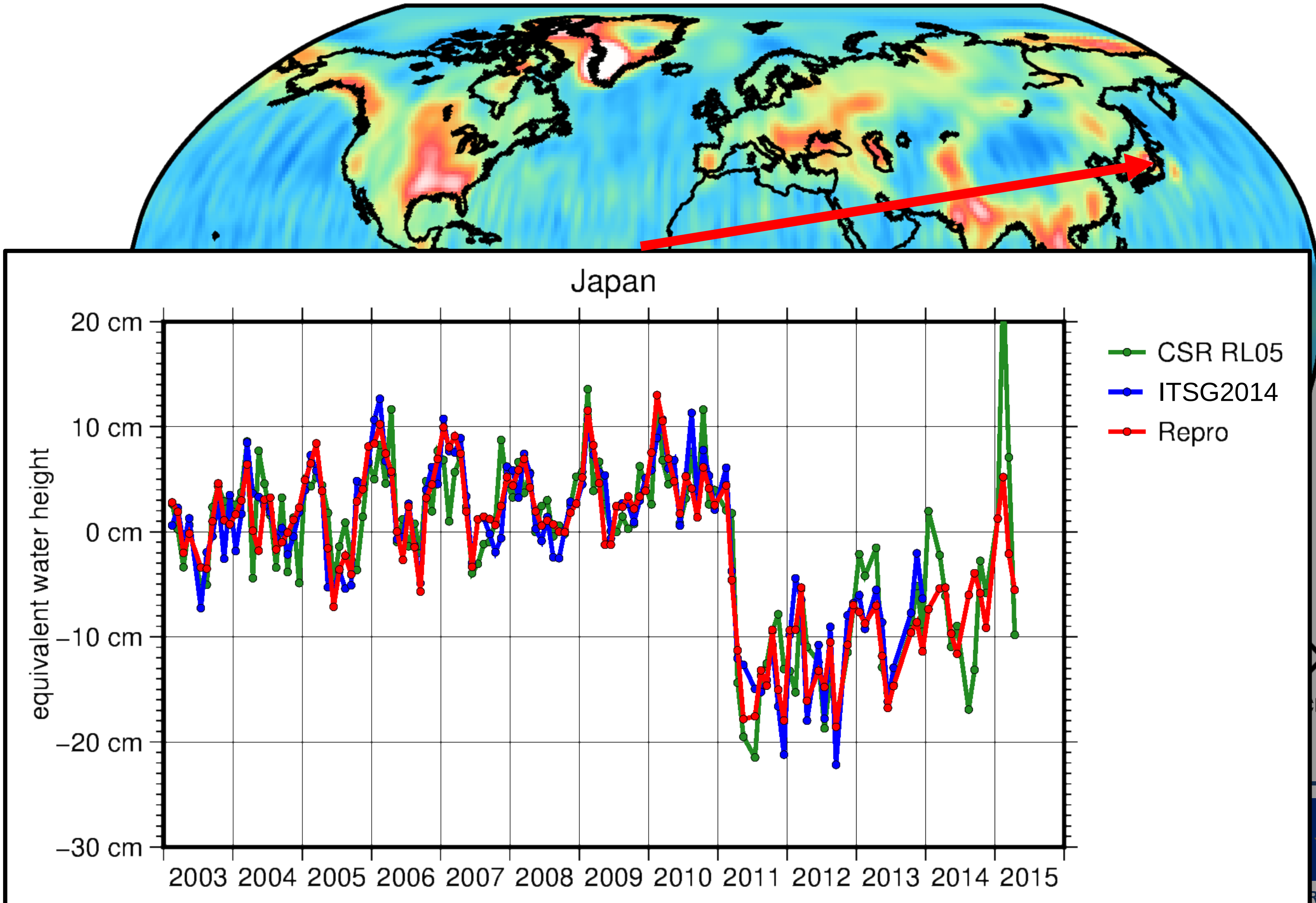


HORIZON 2020

Comparison of signals

Repro

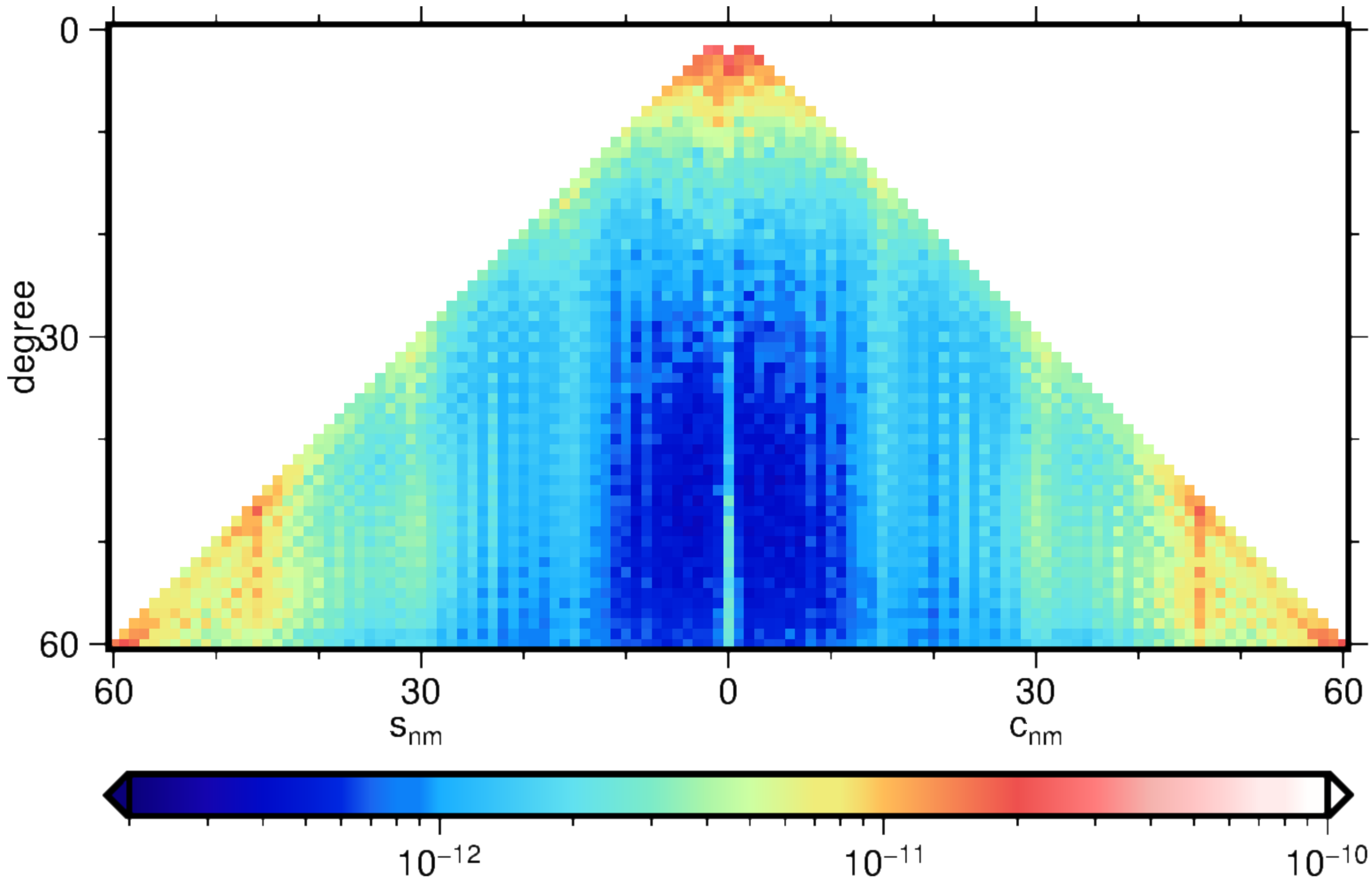
Trend/Annual/Semiannual reduced, Gaussian 300km



Temporal RMS

CSR RL05

Trend/Annual/Semiannual reduced, Gaussian 300km



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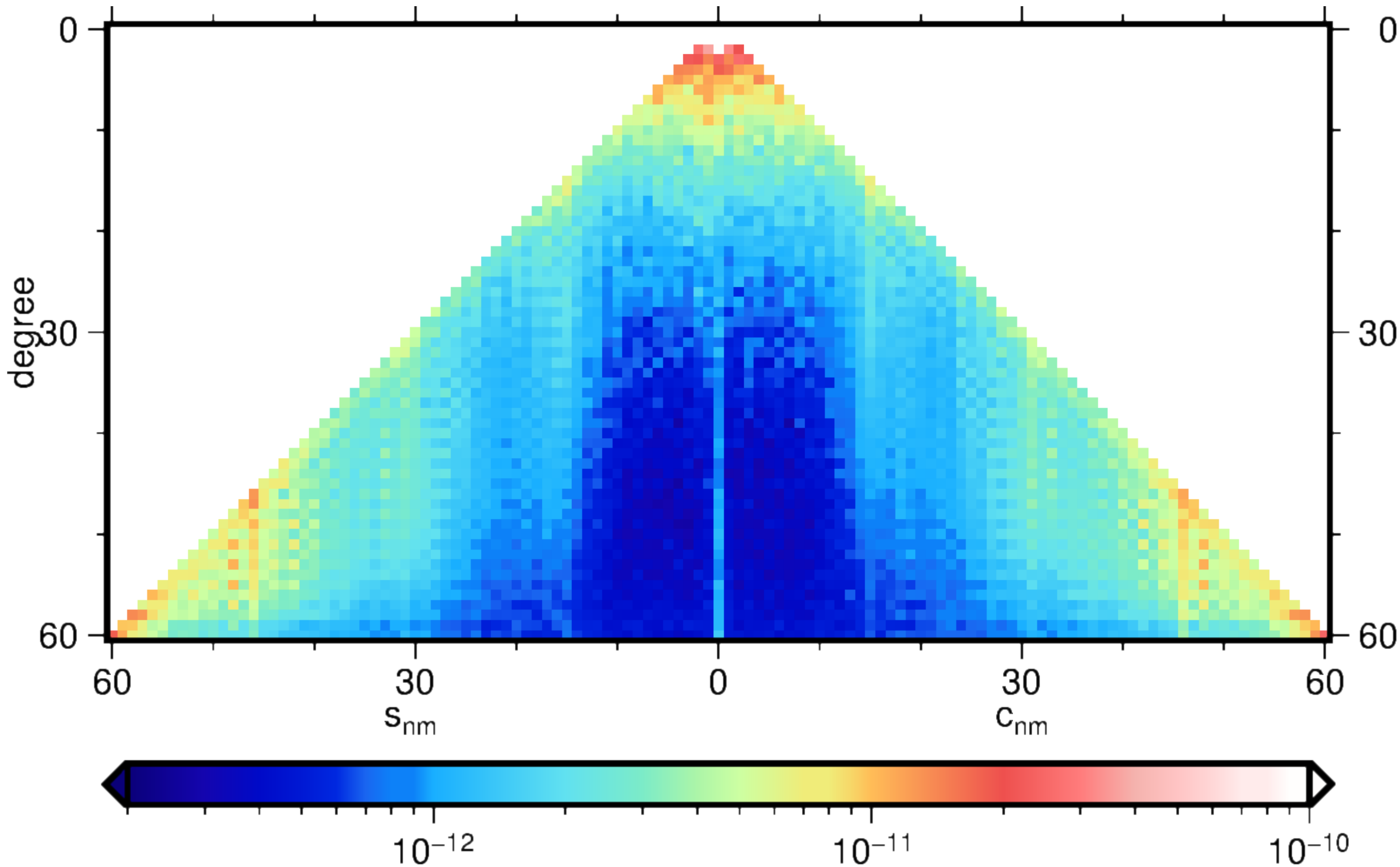
HORIZON 2020

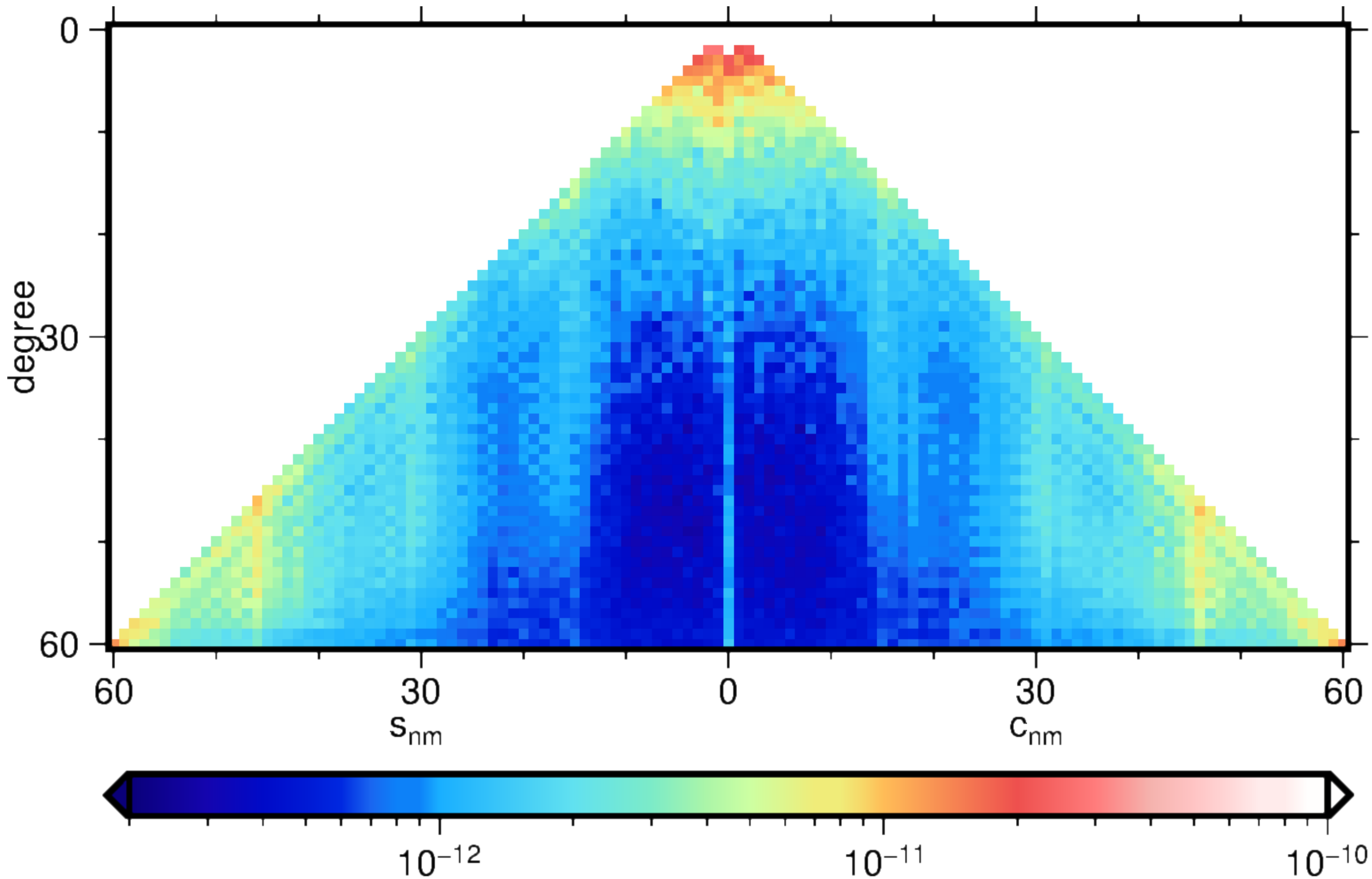
Temporal RMS

ITSG2014
Trend/Annual/Semiannual reduced, Gaussian 300km



Temporal RMS

Repro
Trend/Annual/Semiannual reduced, Gaussian 300km



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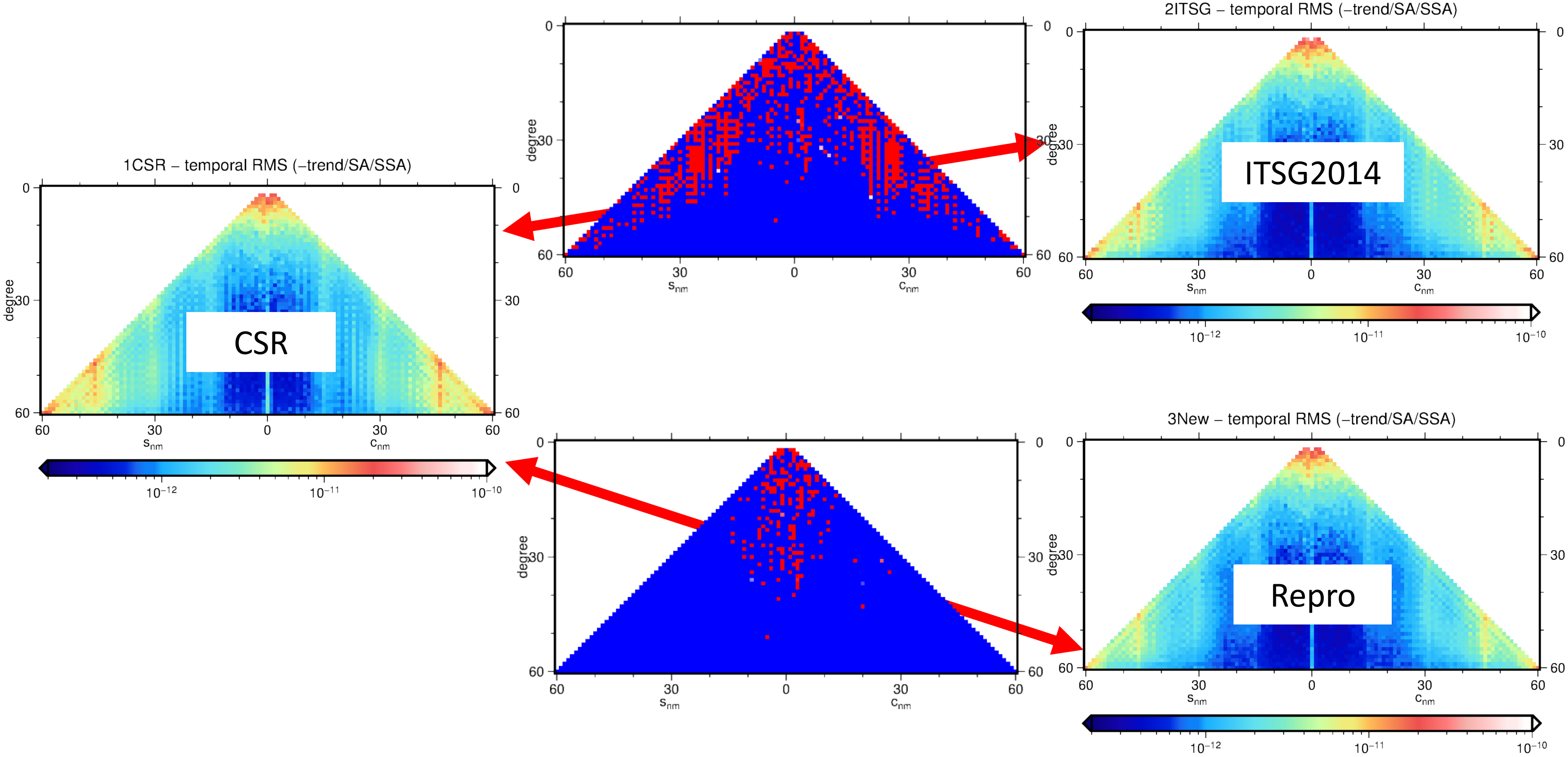
Temporal RMS

Red coeff.: CSR has less scatter



EGSIEM

HORIZON 2020

EGSIEM

European Gravity Service for Improved Emergency Management

Title: **CNES/GRGS processing**

Presenter: Richard Biancale / Jean-Michel Lemoine

Affiliation: CNES / GRGS / G &C

EGSIEM - WP2
CNES/GRGS GRACE processing

J.M. Lemoine [(1)], S. Bourgogne [(3)], R. Biancale [(1)], S. Bruinsma [(1)], P. Gégout [(2)]

(1) CNES/GRGS, Toulouse, France

(2) GET/UMR5563/OMP/GRGS, Toulouse, France

(3) Géode & Cie, Toulouse, France

Summary

1. Study of FES2014 ocean tide model
2. Study of GPS and KBR weighting
3. Explanation of problems at the poles

Validation of FES2014

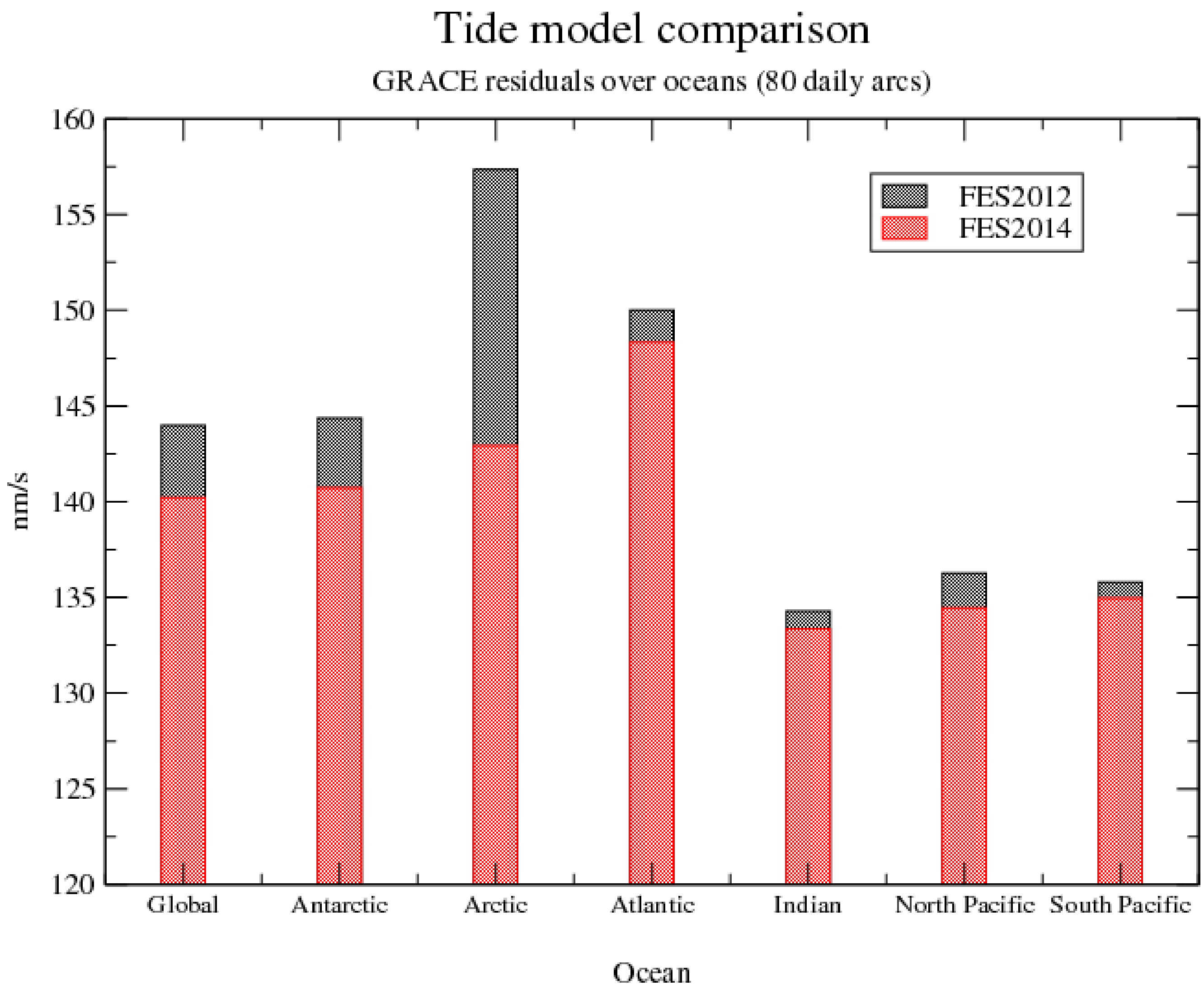
- **FES2014**: ocean tide model released by **LEGOS**, Toulouse, France
- Comparison of GRACE results using **FES2012** or **FES2014**:
  - Study of **GRACE residuals** over oceans
  - Study of differences in **gravity field** restitution

FES2014: GRACE residuals

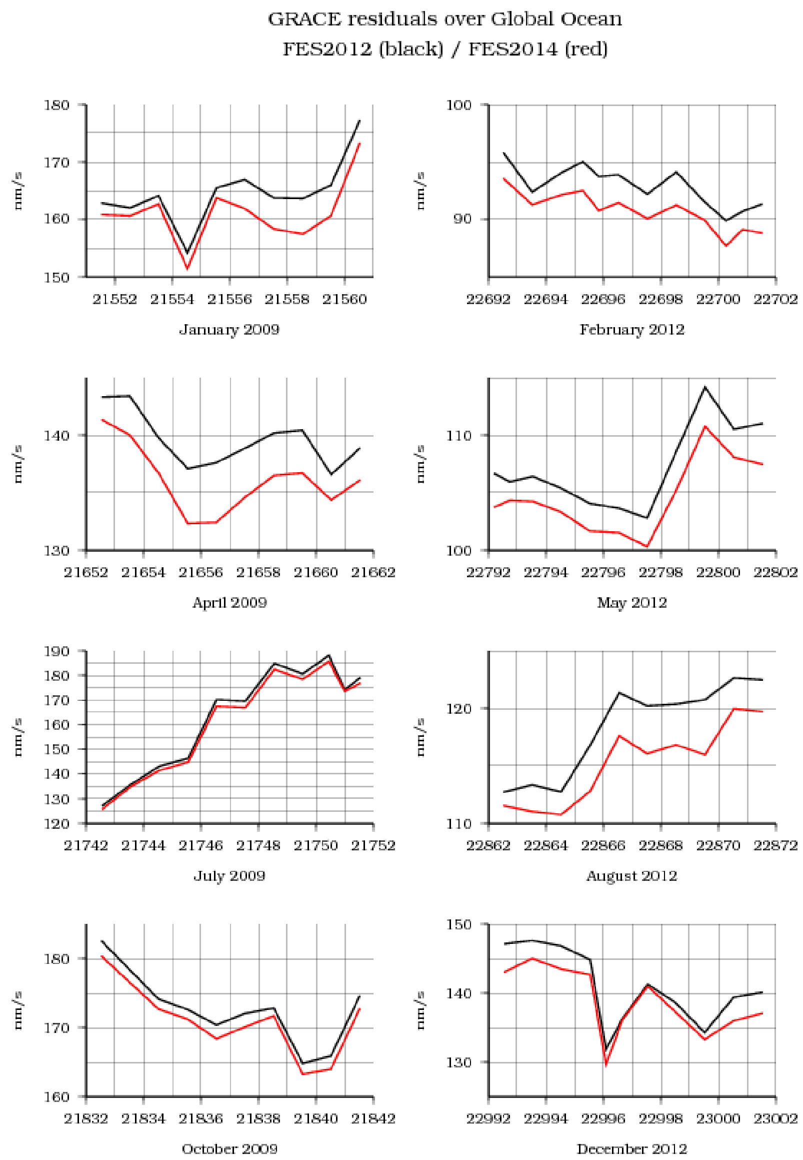
- Test on 8 10-day periods: January, April, July, October 2009 and February, May, August, December 2012.
- GRACE KBRR residuals (nm/s)

Ocean	FES2012	FES2014	Change
Global.dat	143.981	140.203	-2.62 %
Antarctic.dat	144.376	140.721	-2.53 %
Arctic.dat	157.366	142.939	-9.17 %
Atlantic.dat	150.002	148.318	-1.12 %
Indian.dat	134.272	133.367	-0.67 %
NPacific.dat	136.275	134.449	-1.34 %
SPacific.dat	135.807	134.965	-0.62 %

FES2014: GRACE residuals

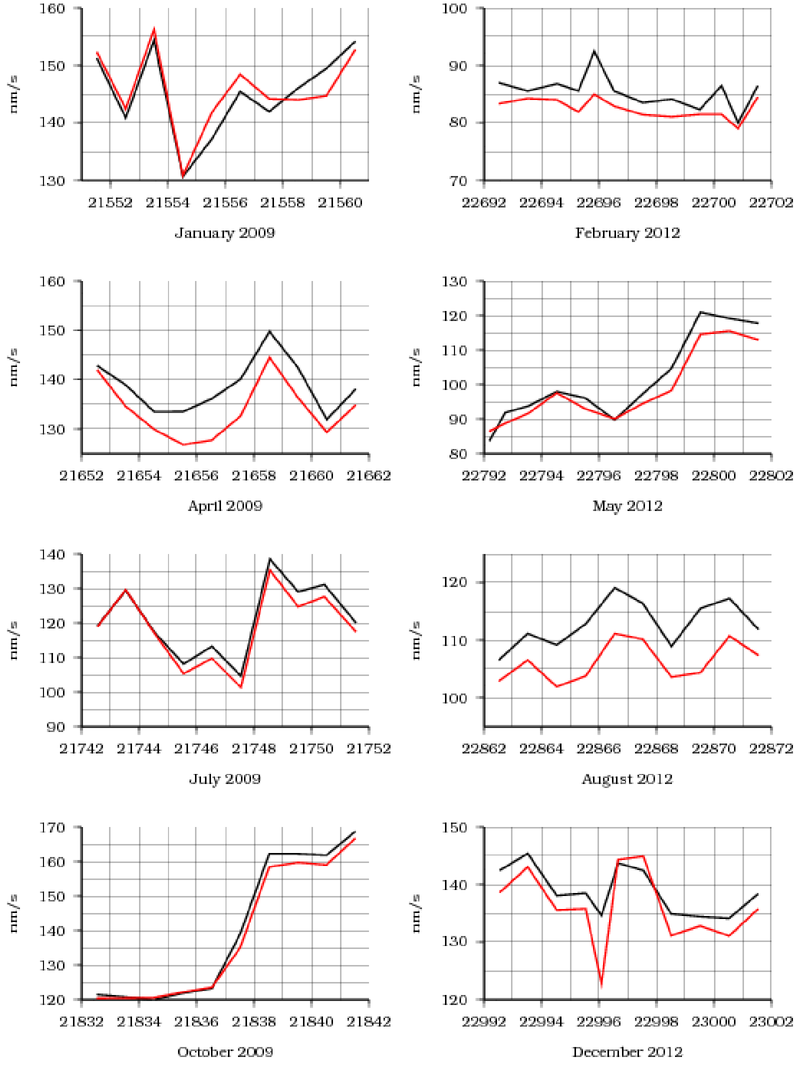


FES2014: GRACE residuals

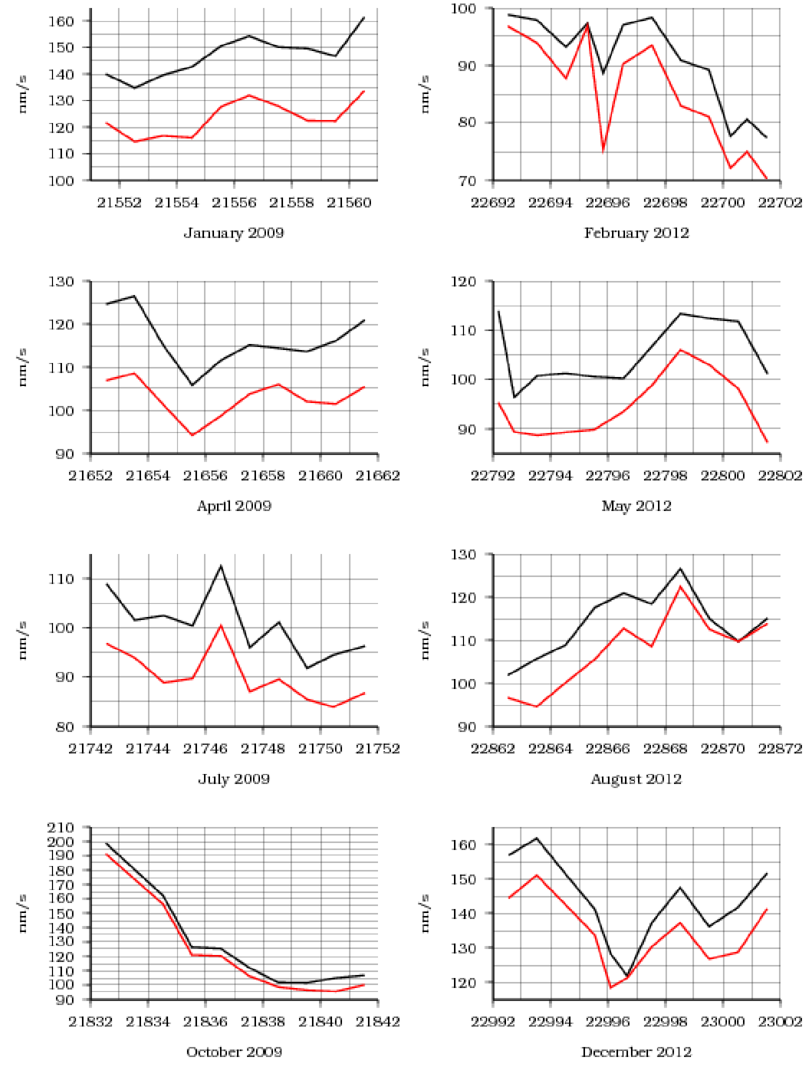


FES2014: GRACE residuals

GRACE residuals over Antarctic Ocean
FES2012 (black) / FES2014 (red)

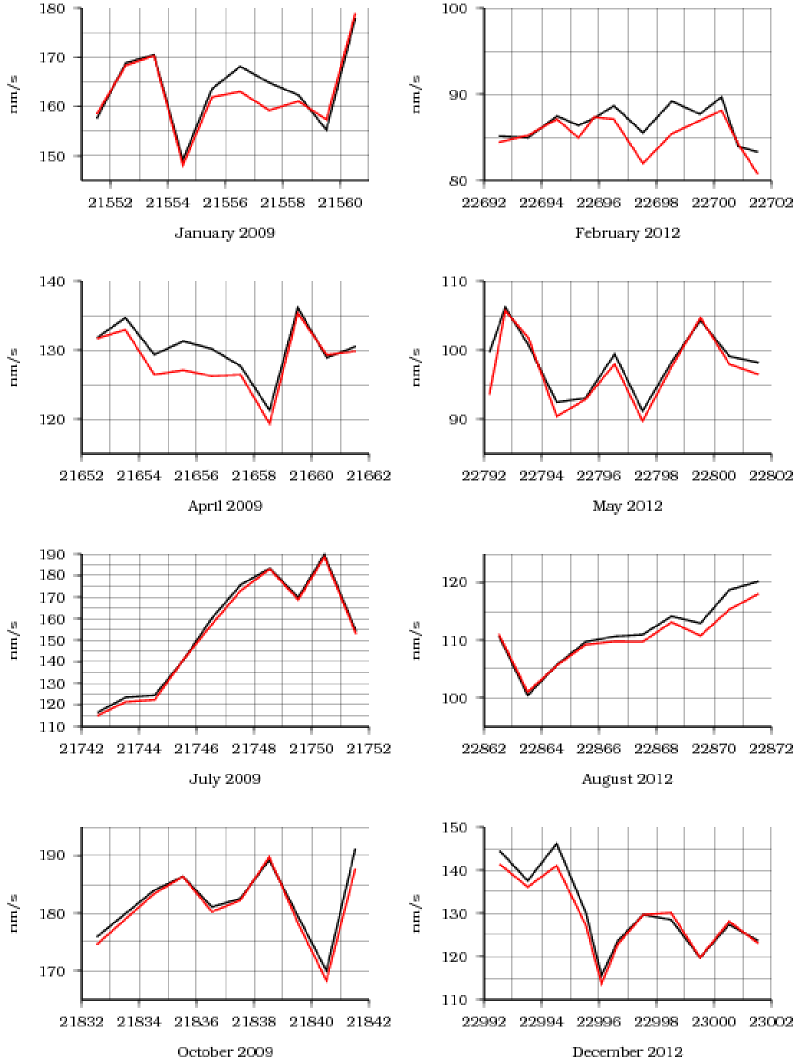


GRACE residuals over Arctic Ocean
FES2012 (black) / FES2014 (red)

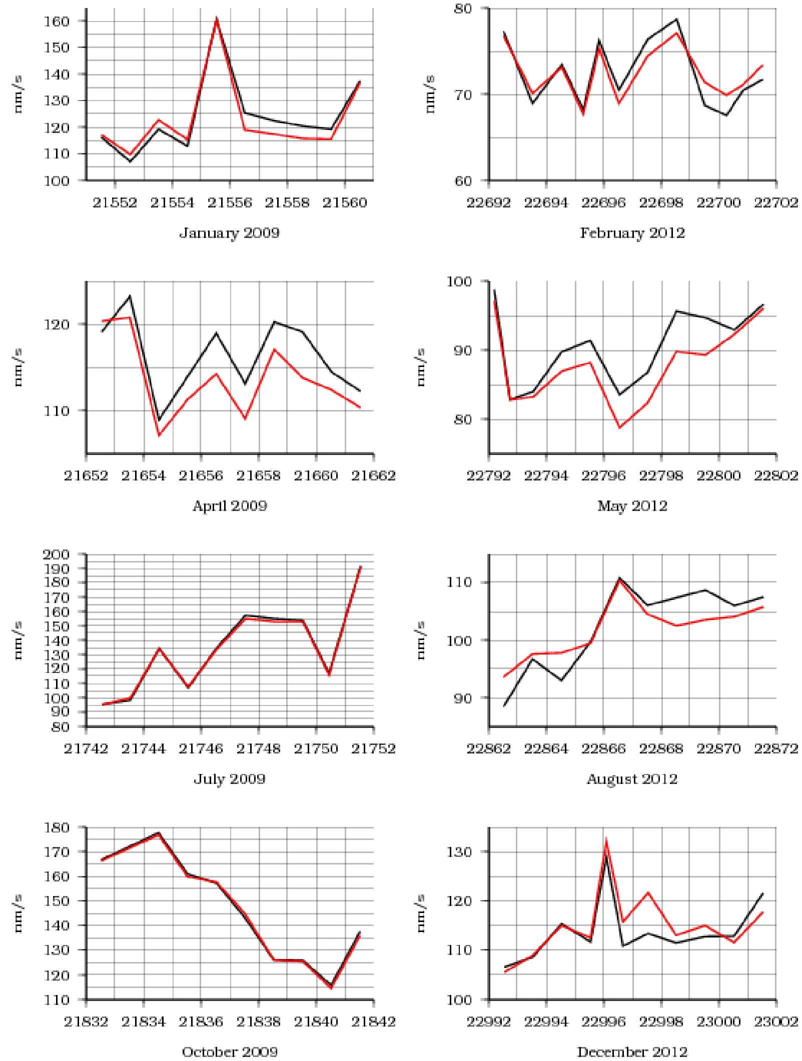


FES2014: GRACE residuals

GRACE residuals over Atlantic Ocean
FES2012 (black) / FES2014 (red)

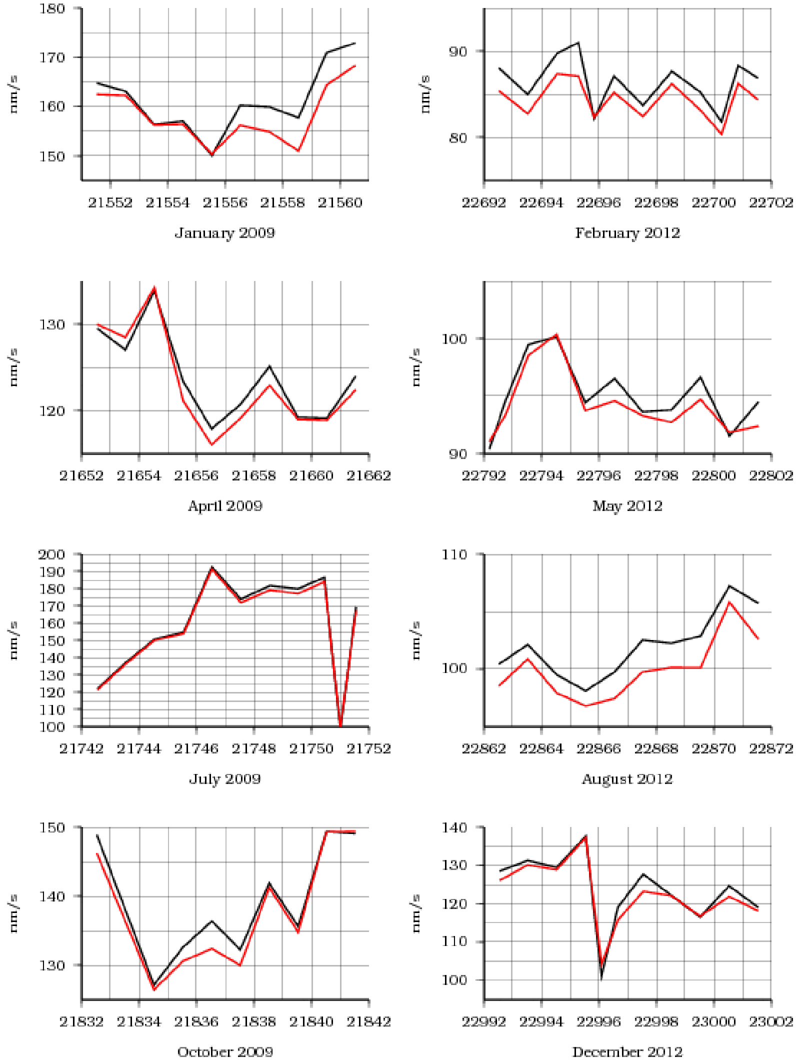


GRACE residuals over Indian Ocean
FES2012 (black) / FES2014 (red)

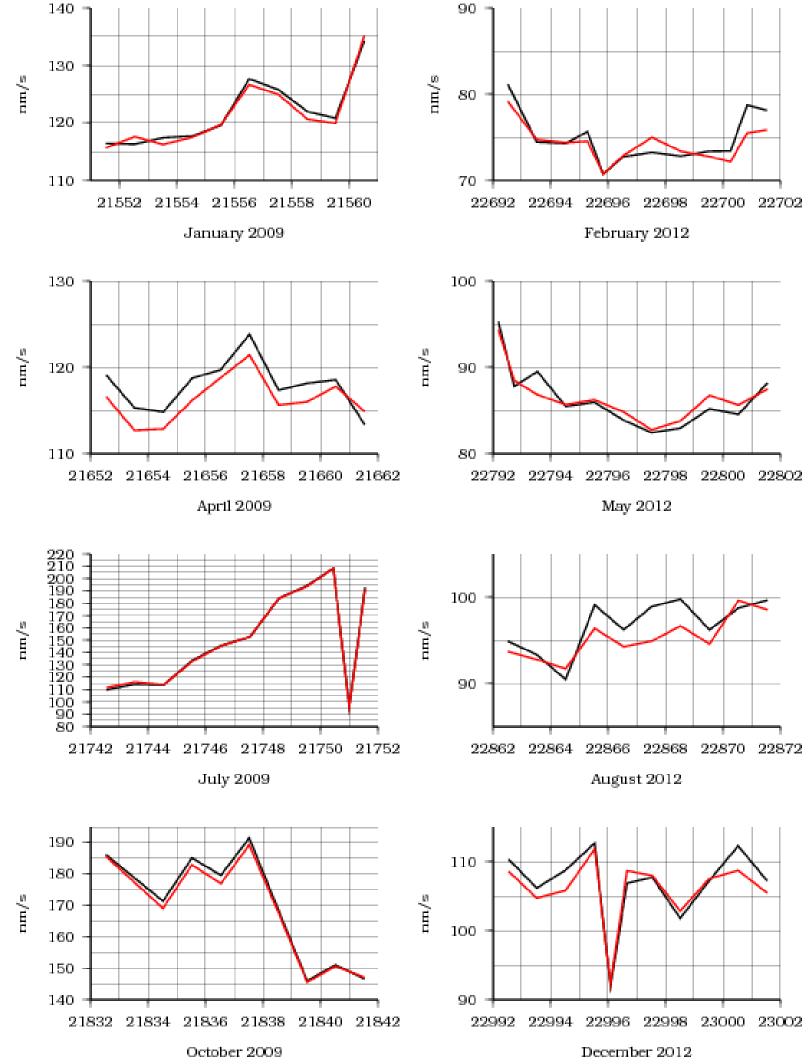


FES2014: GRACE residuals

GRACE residuals over NorthPacific Ocean
FES2012 (black) / FES2014 (red)

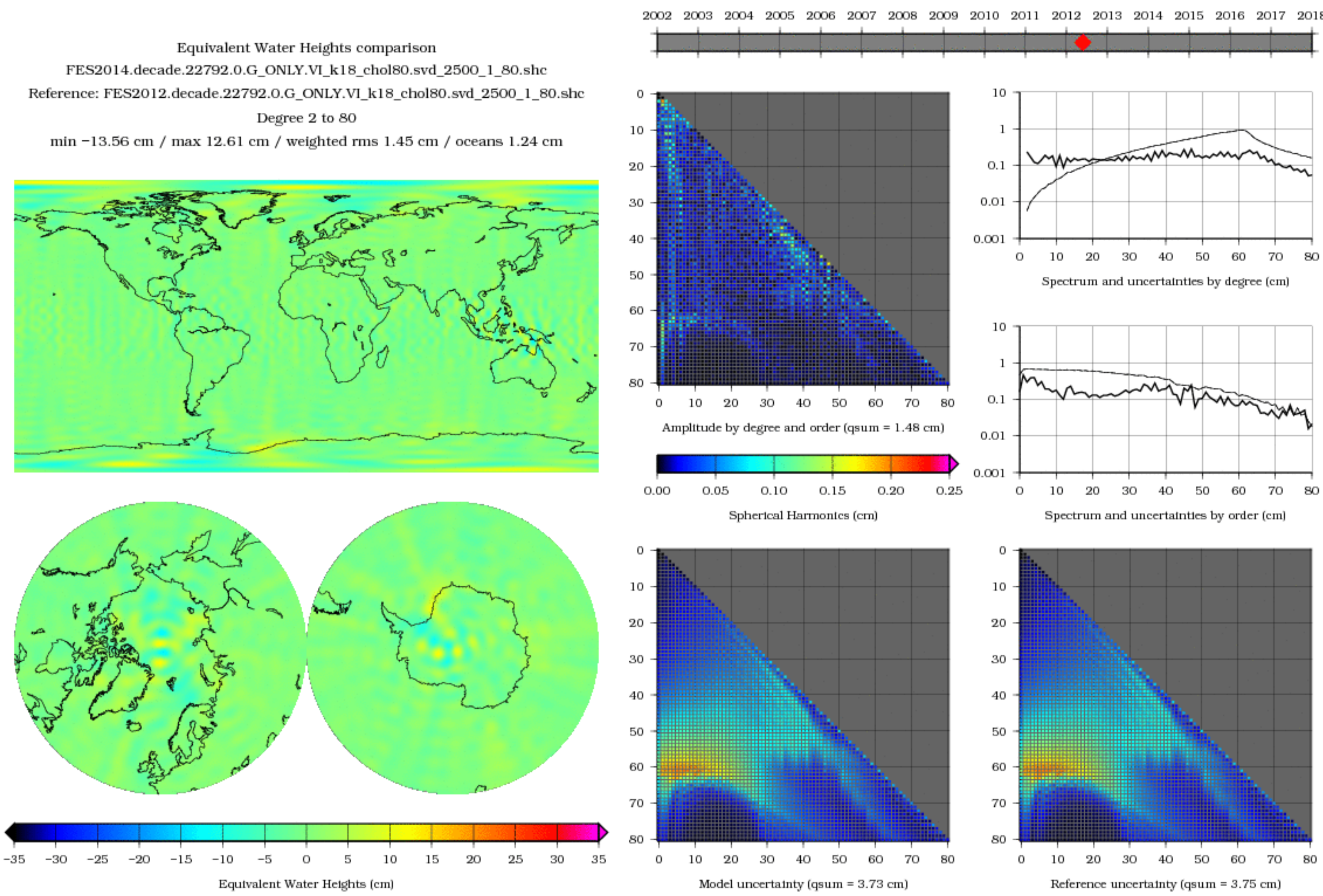


GRACE residuals over SouthPacific Ocean
FES2012 (black) / FES2014 (red)

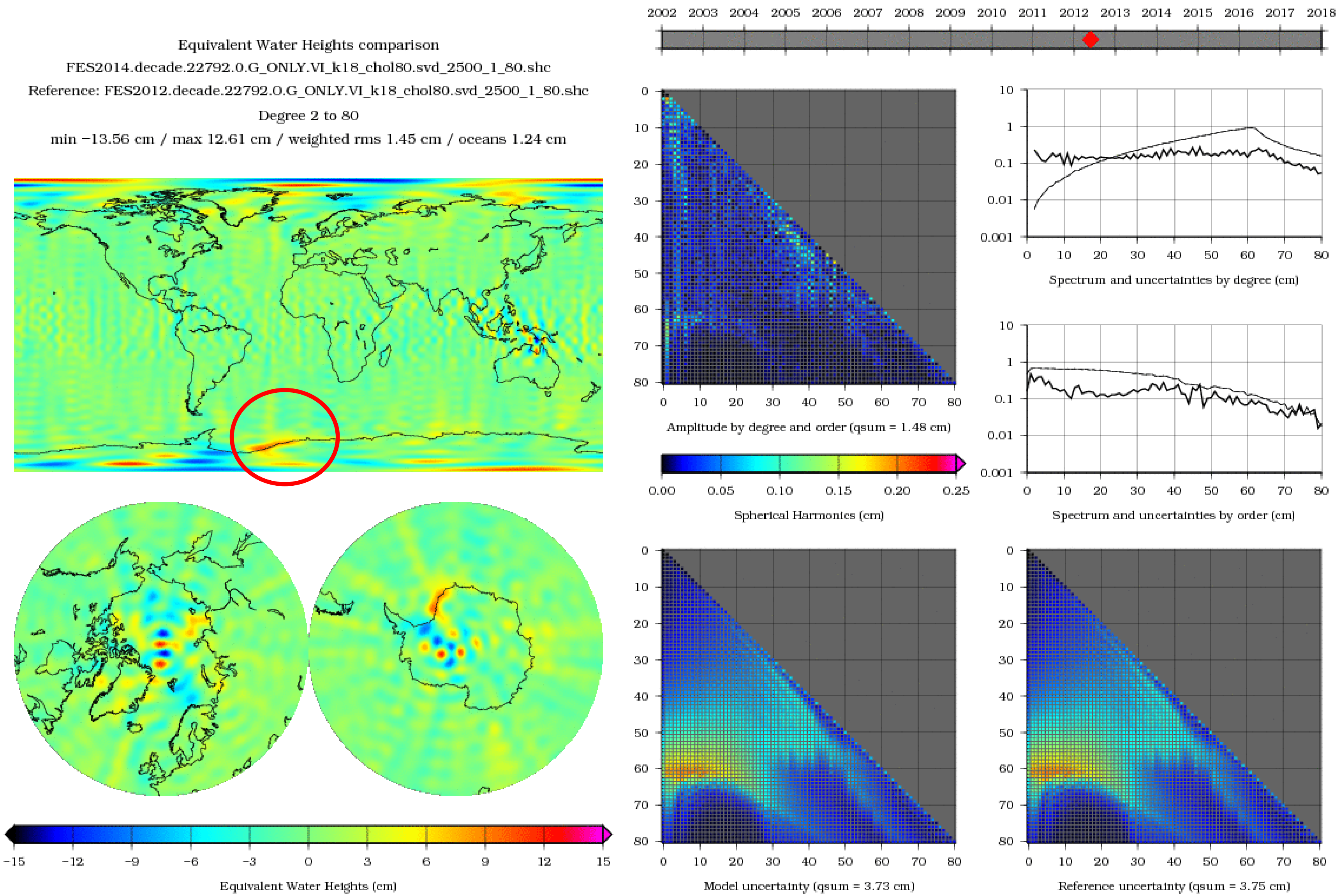


FES2014: Gravity field differences

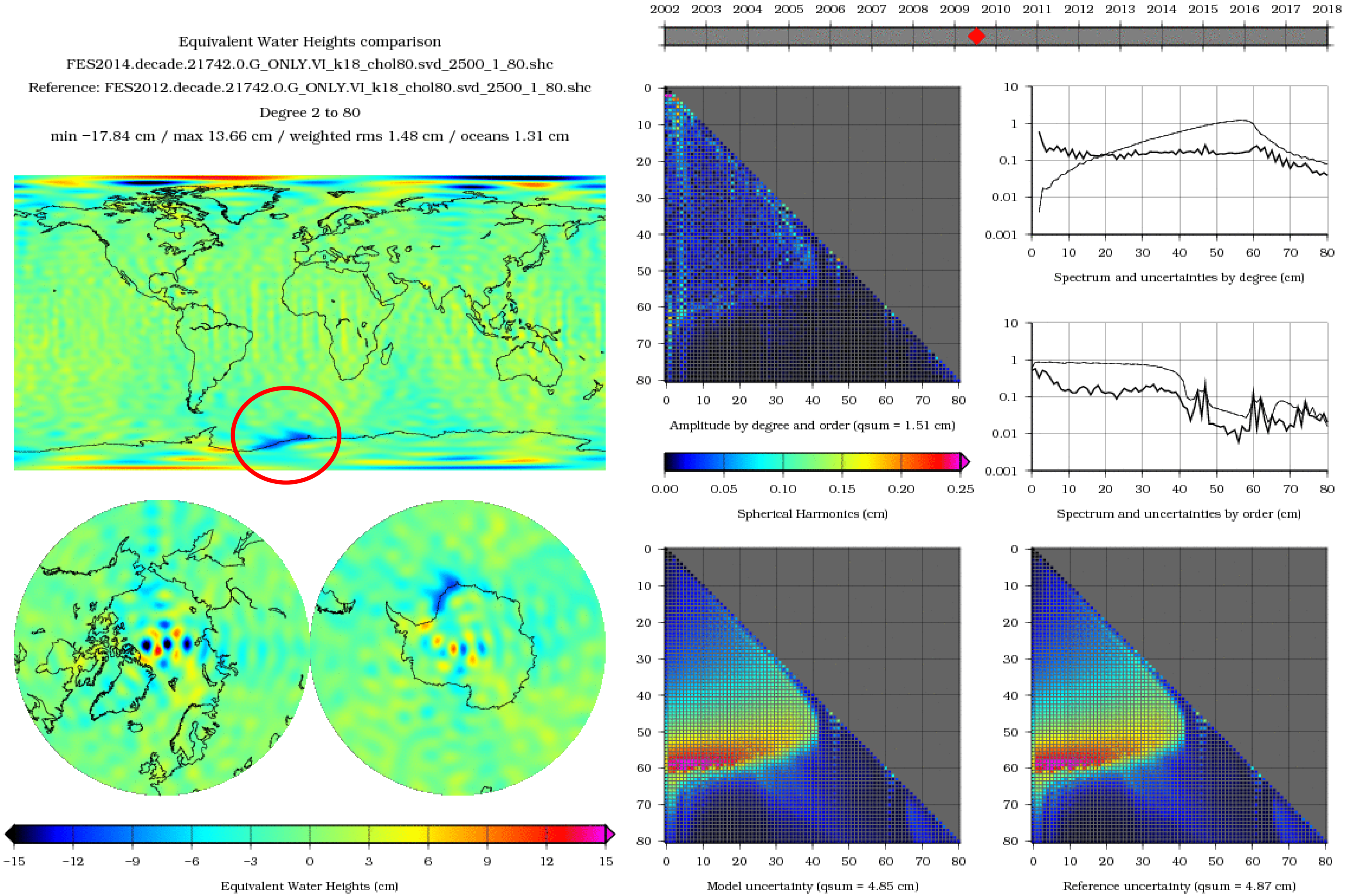
❖ Gravity field restitution : differences are light



FES2014: Gravity field differences (zoom)



FES2014: Gravity field differences (zoom)



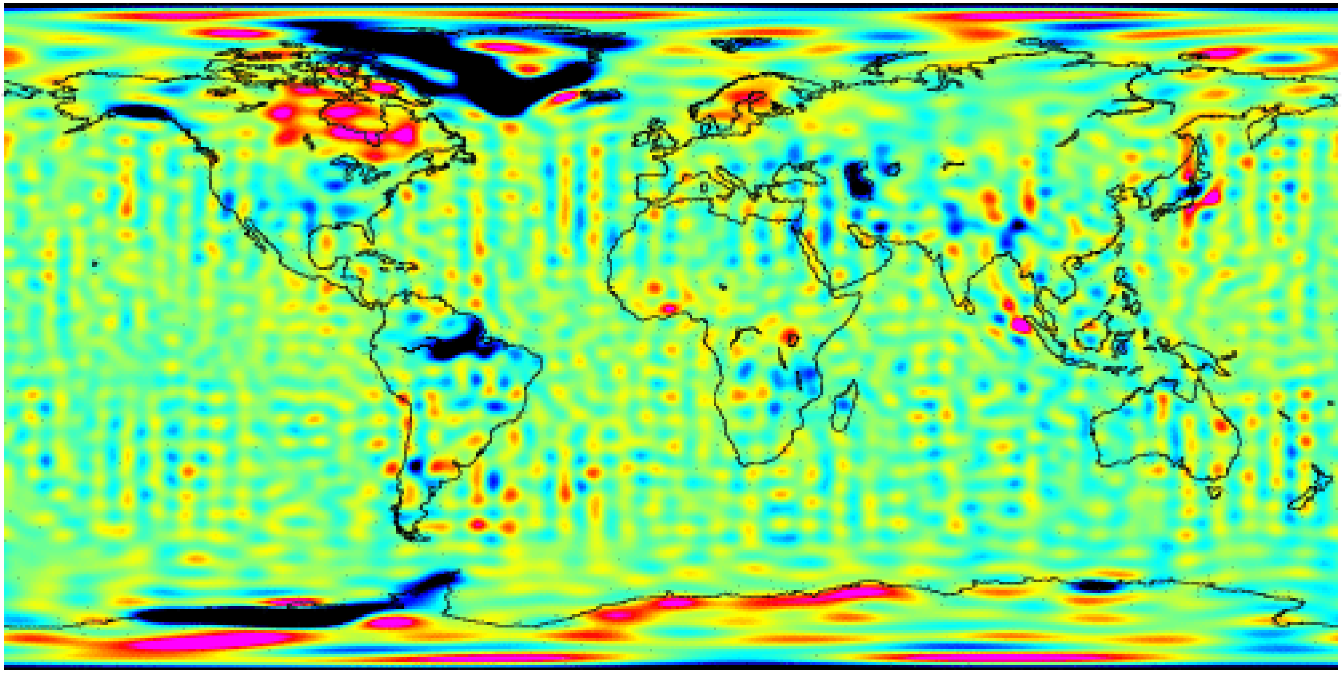
GPS KBR weighting

- GPS KBR relative weighting
  - Weights in orbit restitution step
  - Density of measurements (30s or 300s)
  - Weight in stacking of normal equations step
  - Choice of degree of normal equations for each measurement type

- Effects of relative weighting
  - GPS weight too high: too much striping in the solution (resonances)
  - GPS weight too low: orbit errors, and low sectorial coefficients badly determined

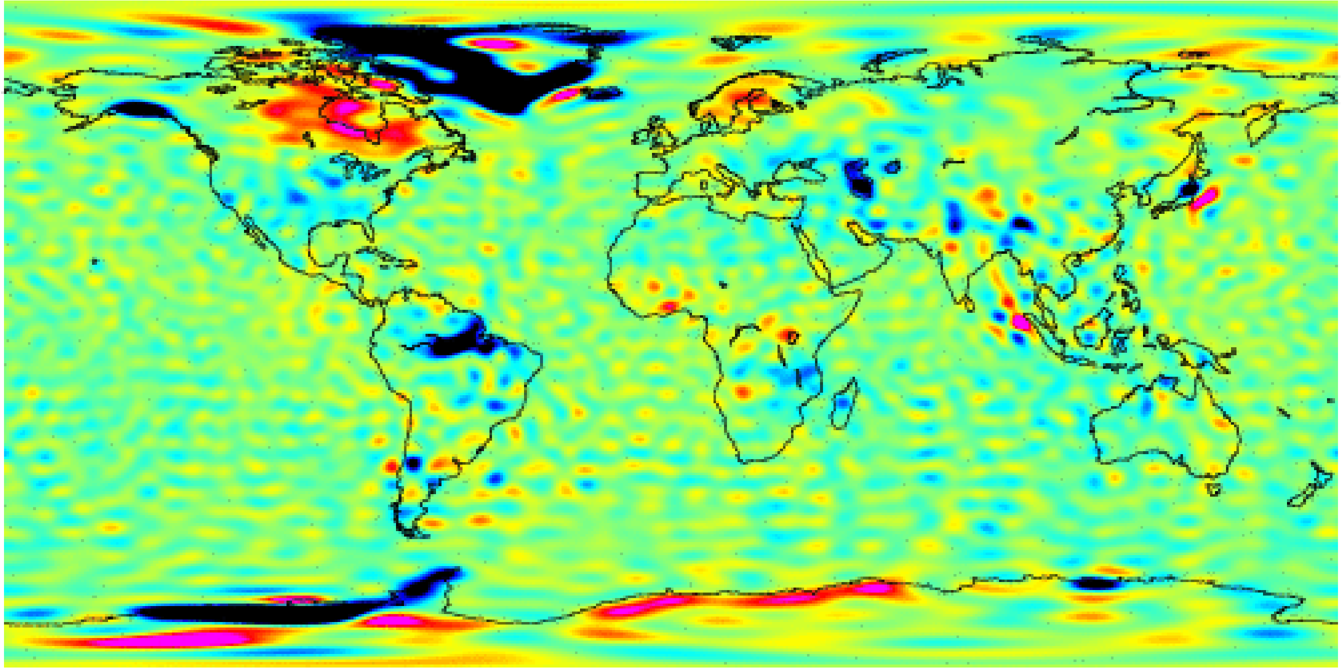
GPS KBR weighting

❖ **Sigma GPS : 8 mm (high weight)**



GPS KBR weighting

❖ **Sigma GPS : 2 cm (low weight)**



GPS KBR weighting

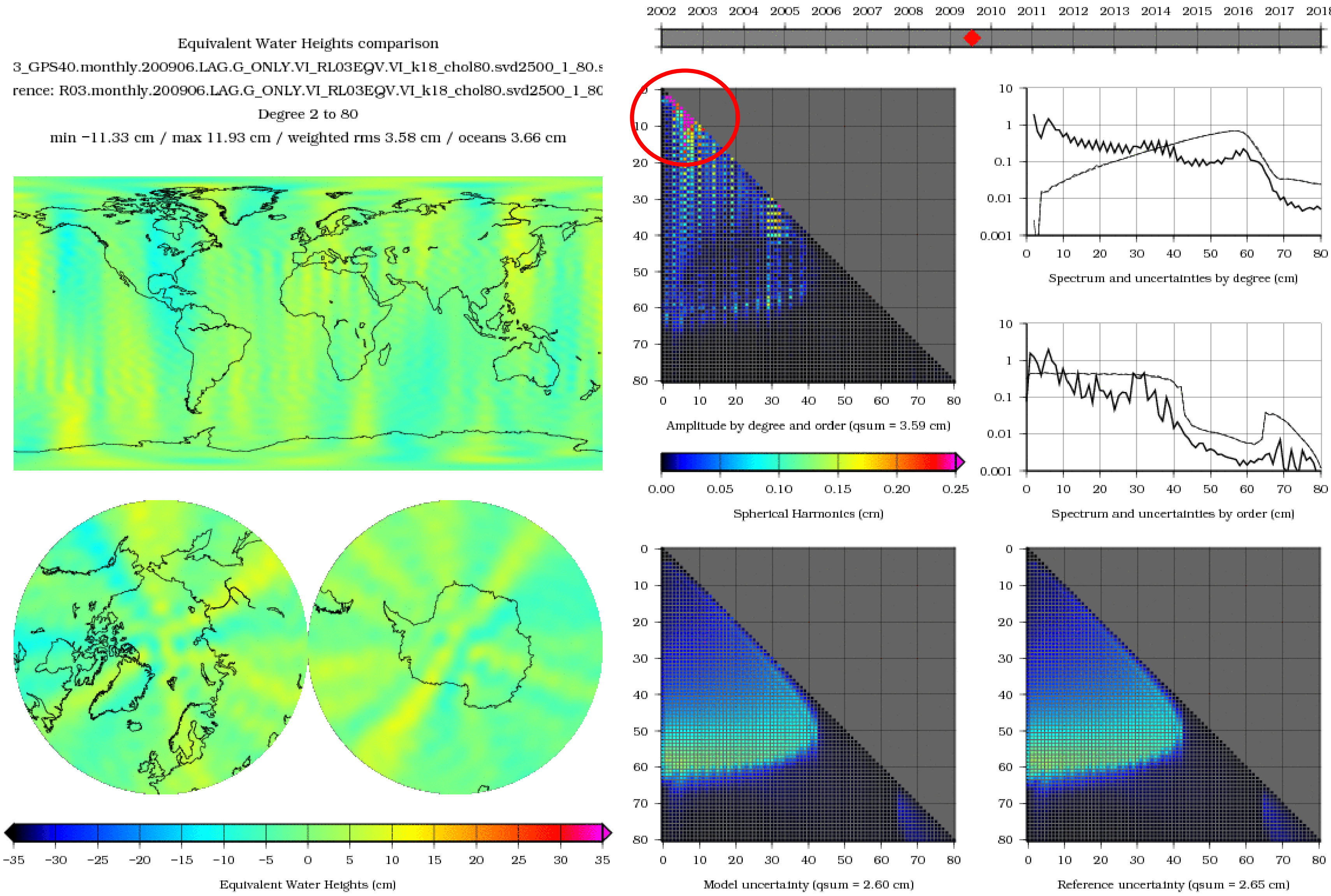
- Tests
  - [High/low density] x [high/low weight]
  - Separation of normal equations with different weights
  - Degree of GPS equation cut to 40

- Best solution
  - Best compromise : high density, low weight
  - Even better : cut GPS equation to degree 40, then the weight is not a problem anymore

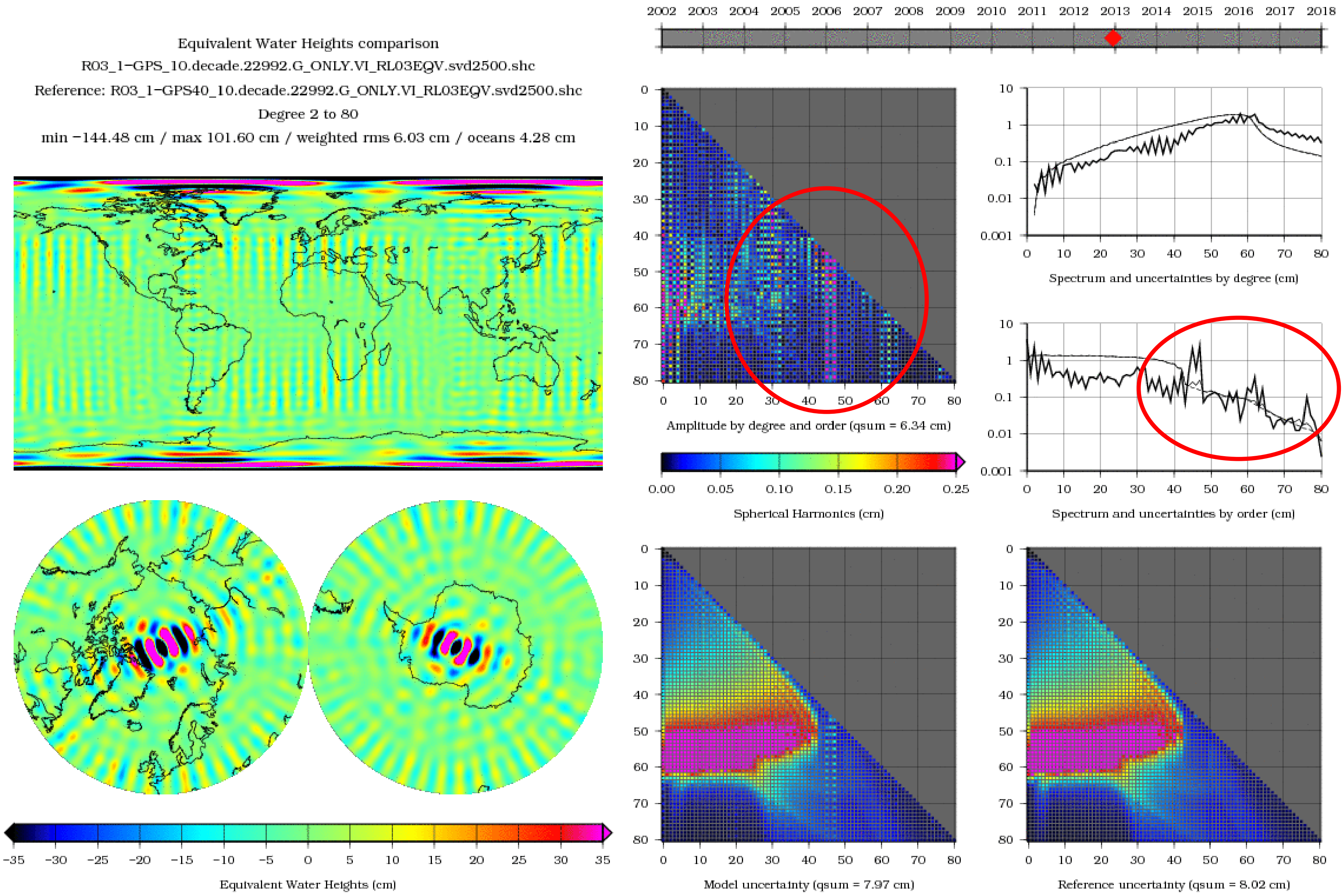
GPS KBR weighting

- From our RL03 equations (underweighted GPS)
  - Stack of GRACE-GPS normal equation up to 40
  - Stack of GRACE-GPS normal equation up to 80

Up to 40 : improves low degrees



From 40 to 80 : adds noise and striping

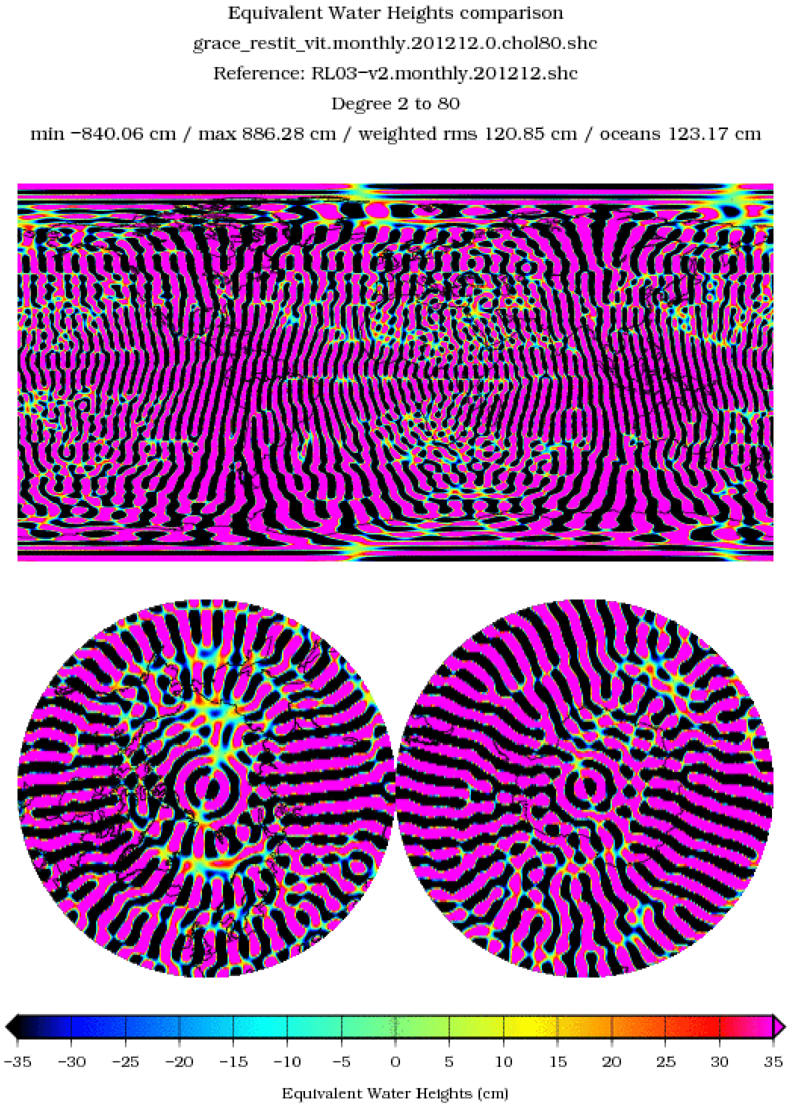


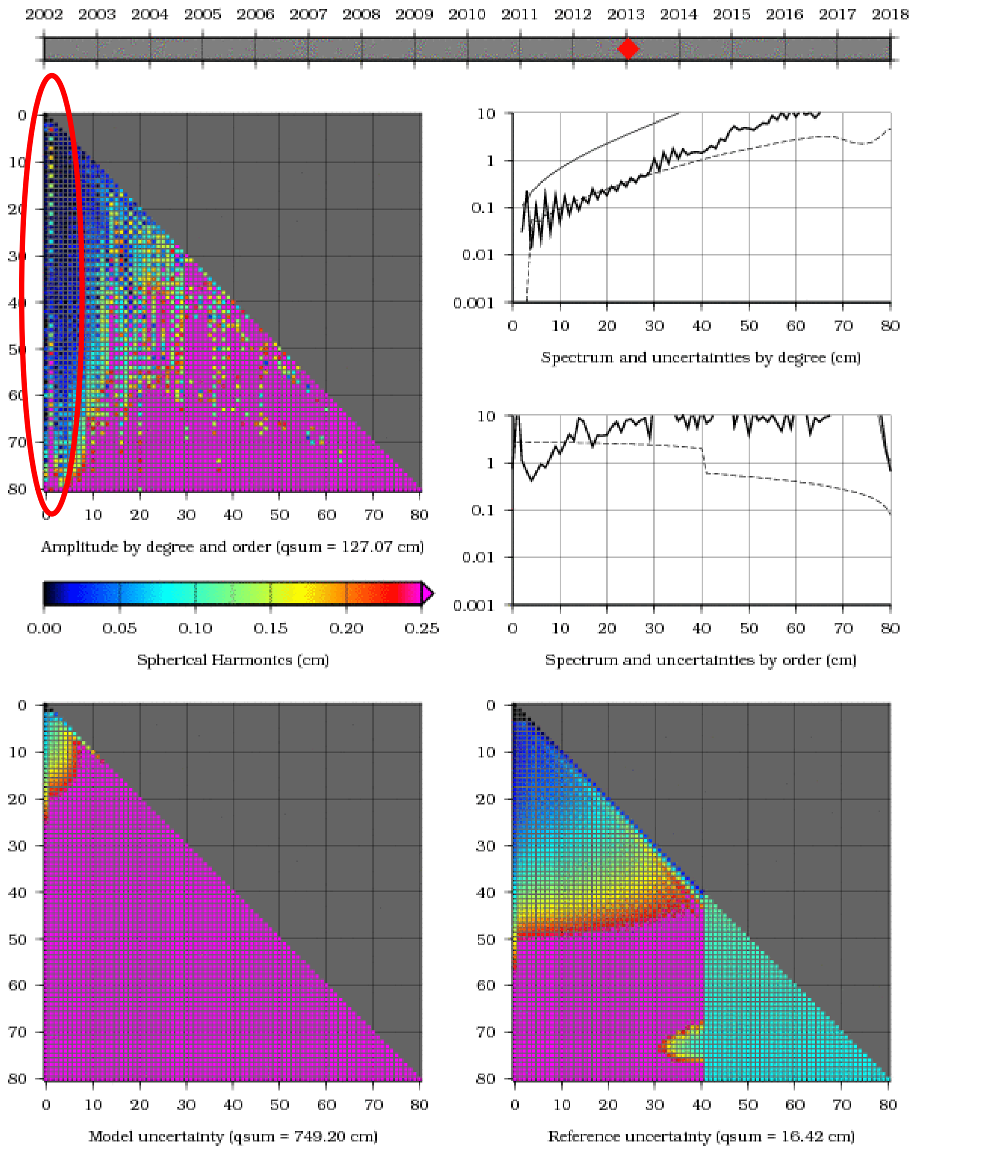
Problems at the poles

- **Problems at the poles**
  - **They are not immediately related to GPS**
  - **Appear when low sectorial coefficients are wrong (compensation on higher orders). This can be the case when those are fixed, or with SVD**

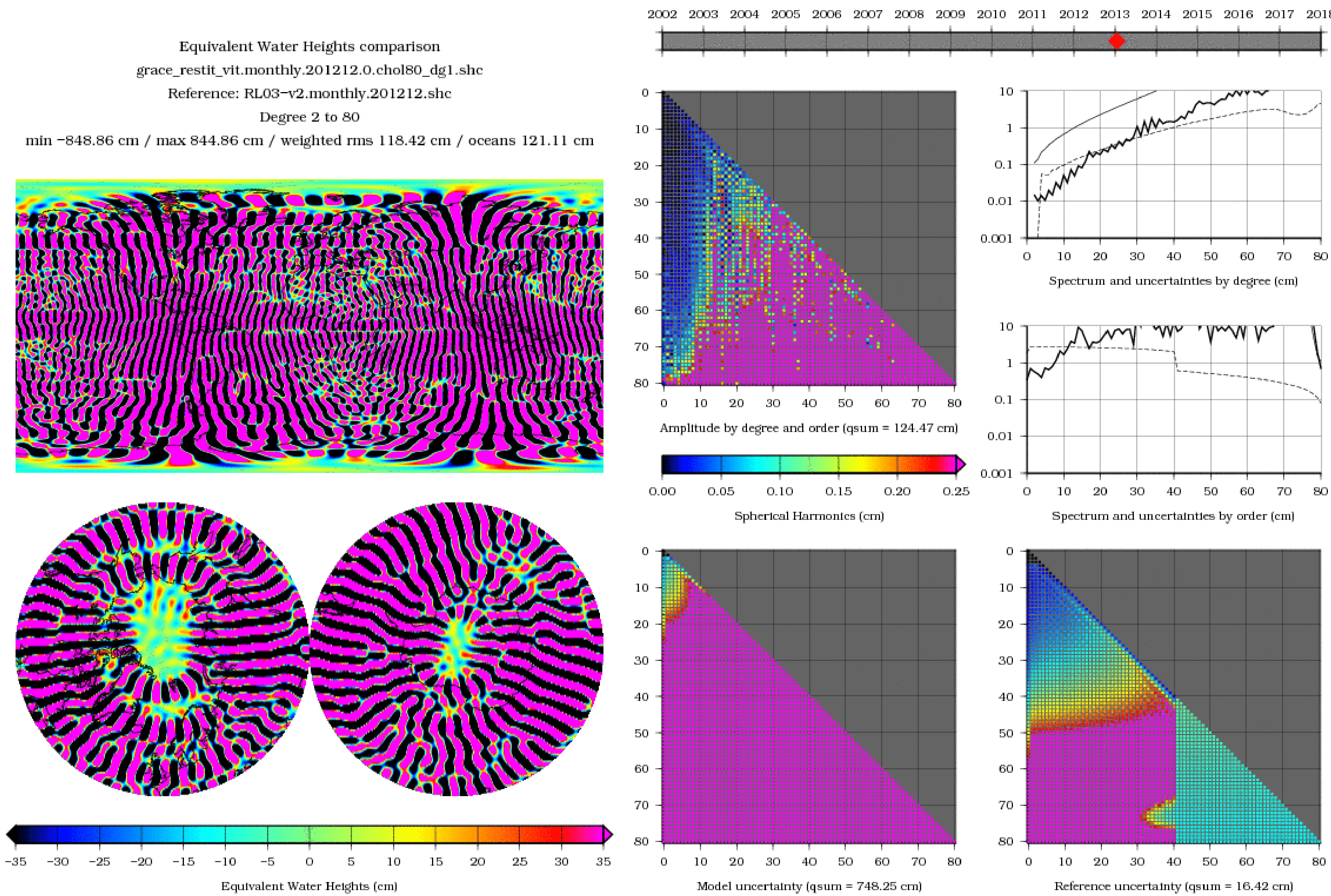
- **Examples**
  - **Cholesky inversion (no constraint), with degree 1 fixed or solved**
  - **Two step inversion (Cholesky + SVD)**

Degree 1 fixed

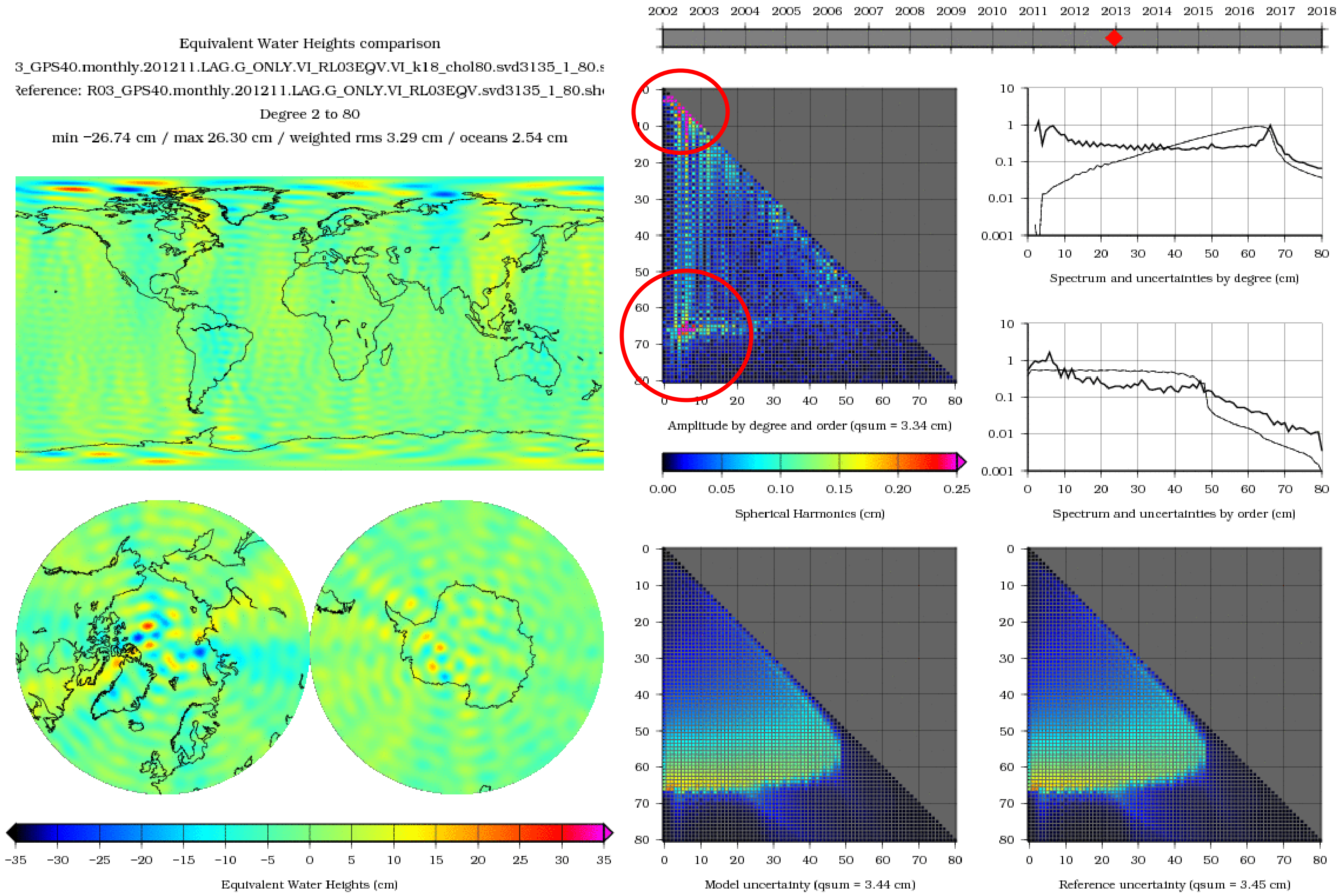




Degree 1 solved



Impact of wrong low-degree sectorials



Conclusions

❖ Conclusions

- ❖ FES2014 brings a clear improvement to the processing standards
- ❖ Cutting the GPS equations to degree 40 eliminates most of unwanted noise
- ❖ Problems are the pole can be avoided if low degree sectorials are correctly solved

EGSIEM

European Gravity Service for Improved Emergency Management

Title: **ULux processing**

Presenter:

Affiliation: ULux

Horizon2020

EGSIEM

European Gravity Service for Improved Emergency Management

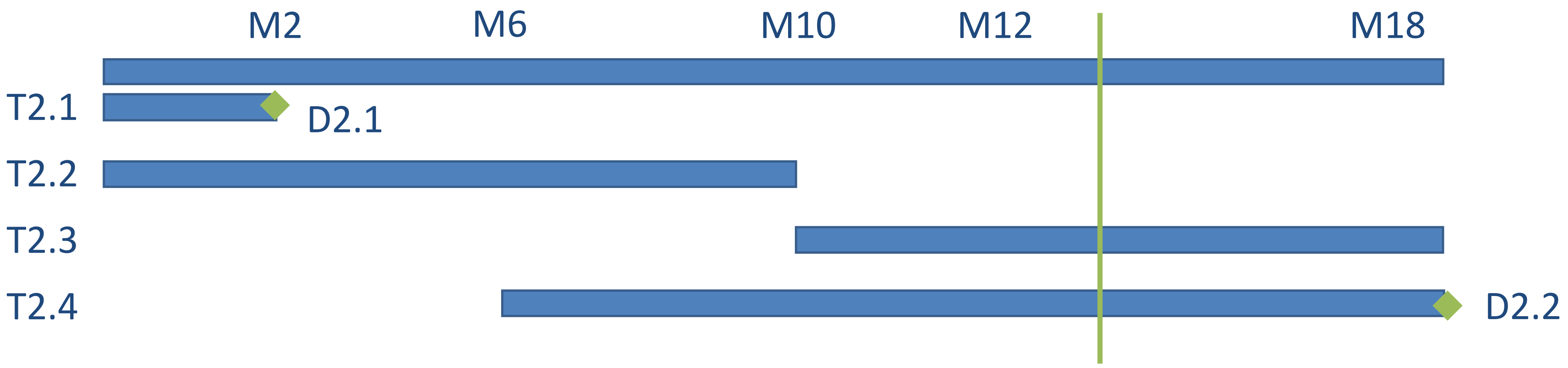
Title: **GRACE Reprocessing**

Presenter: TMG

Affiliation: TUG

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

WP2 Gravity field analysis – Time Table



T2.1 Processing Standards and Models

Document delivered

T2.2 Improved processing tools

Presentation of results today: AIUB, GZF, TUG,CNES/GRGS, ULux

T2.3 Data analysis

Discussion today

T2.4 Instrumental behavior and End-to-end Simulator

T2.3 Reprocessing

- Reprocessing of two years (2006 – 2007) of GRACE data
  - AIUB
  - GFZ
  - TUG
  - CNES/GRGRS
  - ULux

- Based on document
  D2.1_Processing Standards and Models_02.03.2015.pdf

- Based on AIUB GPS orbit and clock constellation
  or AIUB kinematic orbits

- 5 x 24 monthly normal equations in SINEX format

- What is about the additional Level 2 products: GAA, GAB, GAC, GAD ?

T2.3 Reprocessing: SINEX format

```
%=SNX 2.02
+FILE/REFERENCE
+FILE/COMMENT
+SOLUTION/STATISTICS
+SOLUTION/NORMAL_EQUATION_VECTOR
+SOLUTION/NORMAL_EQUATION_MATRIX U
+SOLUTION/ESTIMATE
+SOLUTION/APRIORI
%ENDSNX
```

Should contain the ICGEM header
earth_gravity_constant
radius
max_degree
tide_system

All information are related to the reduced observations

Must be added to **SOLUTION/ESTIMATE** to get the full solution

Monthly mean of all (?!) background models

- static, trend, (semi-) annual
- AOD1B
- Earth-, ocean-, pole tides

T2.3 Reprocessing: Apriori

APRIORI includes the reduced static gravity field, trend, annual, semiannual signal
And additional three options:

1.) Tides not included, AOD1B not included

- ⇒ Result is standard GSM file
- ⇒ Need also the combination of different GAA - GAD files

2.) Tides not included, AOD1B included

- ⇒ Selection of a GAA - GAD files for publication (OMCT vs MOG2D)

3.) Monthly mean of all models included (my preference)

- ⇒ Straight forward combination
- ⇒ Selection of a GAA - GAD files for publication

All centers should provide monthly mean of all reduced background models (ICGEM-format) for internal consistency check

- Earth tides, Pole tides, Ocean tides, Ocean pole tides
- Atmosphere, Ocean

EGSIEM

European Gravity Service for Improved Emergency Management

Title: **New definition of GRACE Level2 produtcs**

Presenter: Torsten Mayer-Gürr

Affiliation: TUG

Universität Bern
Université du Luxembourg
GFZ Helmholtz Centre Potsdam
TU Graz Graz University of Technology
Leibniz Universität Hannover
cnes
DLR
géode&cie
Horizon2020

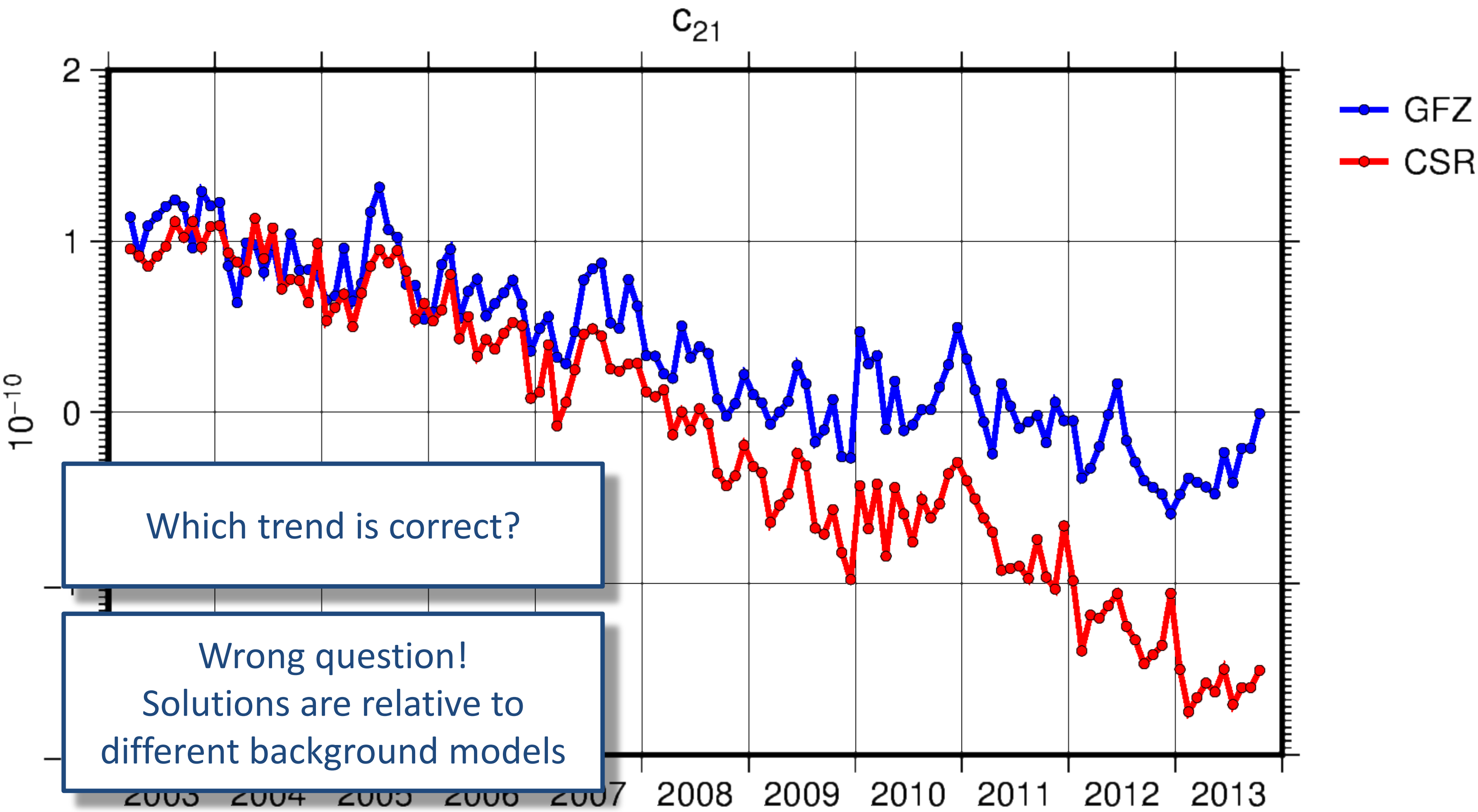
Motivation

GRACE Level 2 products are complicated to use!
$\Rightarrow$ Generation of user friendly Level 3 products

Can we make the Level 2 products more user friendly too?

Two examples about problems…

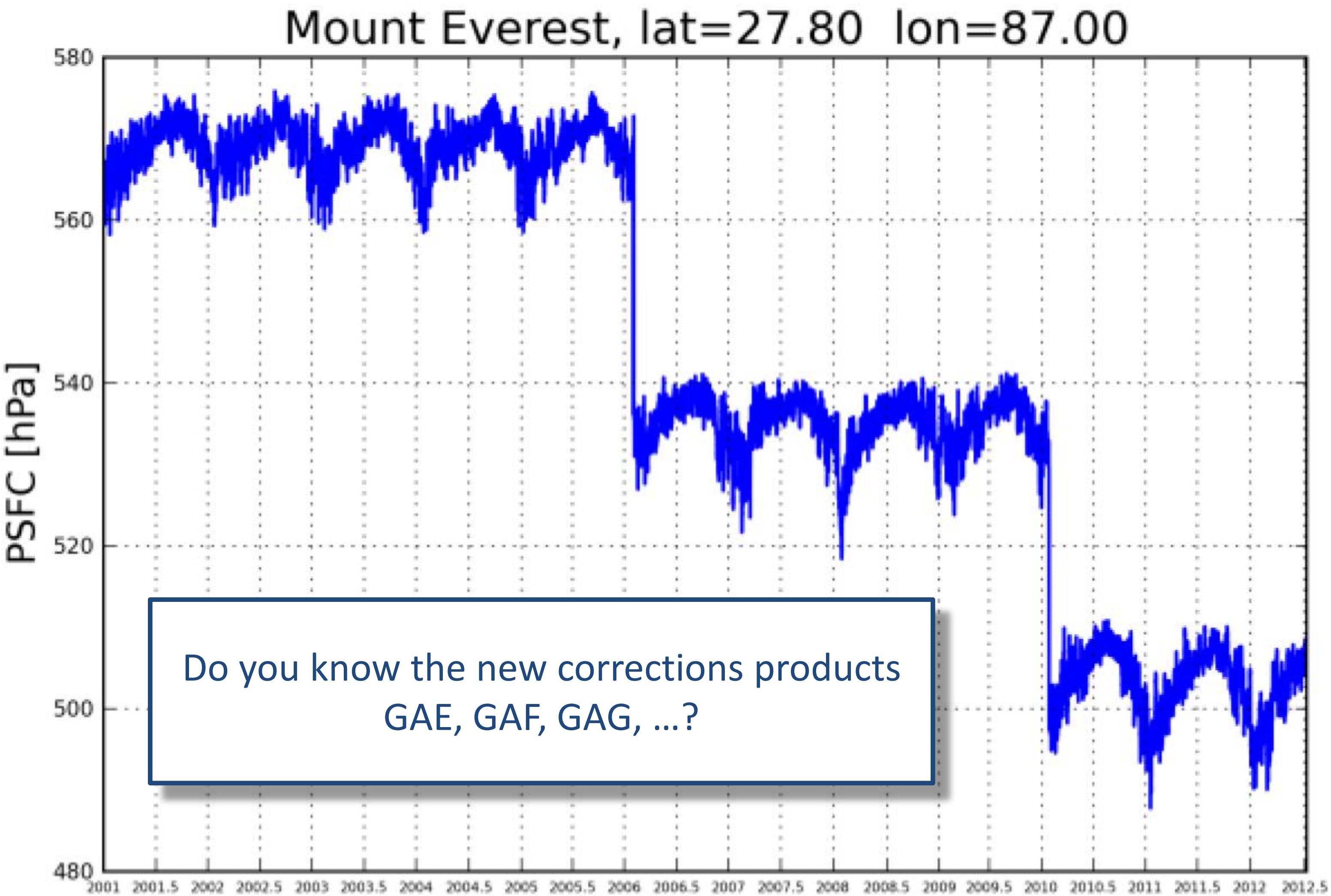
Trends in level 2 RL05 products



Which trend is correct?

Wrong question!
Solutions are relative to
different background models

Jumps in the Level 2 products



Do you know the new corrections products GAE, GAF, GAG, …?

Definition

GRACE Level 2 products are not GSM files only

Level 2 products consists of monthly

- GSM: Reduced GRACE coefficients
- GAA: Monthly mean of atmosphere
- GAB: Monthly mean of ocean
- GAC: GAA + GAB
- GAD: Monthly mean of ocean bottom pressure

Additionally jump corrections are provided

- GAE
- GAF
- GAG

Mass transports – a simulated world

- Hydrology
- Ice sheets
- Glaciers
- Permanent frost
- Ocean tides
- Ocean pole tides
- Barotropic ocean circulation
- Sea level rise (?)
- Atmospheric tides (S1, S2)
- Atmospheric mass redistribution
- Solid Earth tides
- Rotational deformation (pole tides)
- Glacial isostatic adjustment
- Loading deformation
- Degree 1 mass redistribution
- Earthquakes

Ice

Ocean

Atmosphere

Solid Earth

Mass transports – a simulated world

Hydrology	WGHM, LSDM, GLDAS, …
Ice sheets	RACMO2
Glaciers	Glaciers
Permanent frost	???
Ocean tides	EOT11a, FES2014, …
Ocean pole tides	Desai 2004
Barotropic ocean circulation	OMCT, MOG2D, ECCO, …
Sea level rise (?)	Altimetry - ARGO
Atmospheric tides (S1, S2)	Van Dam, 2010
Atmospheric mass redistribution	ECMWF, NCEP, …
Solid Earth tides	IERS 2010
Rotational deformation (pole tides)	IERS 2010
Glacial isostatic adjustment	Klemann 2008, …
Loading deformation	Love numbers, Farell 1972, …
Degree 1 mass redistribution	SLR, Joint inversion model, …
Earthquakes	Sabadini, Vermeersen, 1997

Mass transports – a simulated world

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- Earthquakes

=

Total mass change

(Observable by GRACE)

The equation is not exactly fullfilled as the models and the GRACE are not free of errors

Anyway the equation can be reordered…

Mass transports – a simulated world

- Hydrology

=

Total mass change
- Ice sheets
- Glaciers
- Permanent frost
- Ocean tides
- Ocean pole tides
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- Sea level rise (?)
- Atmospheric tides (S1, S2)
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- Loading deformation
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- Earthquakes

Signal separation

Different ways to separate the hydrological signal from other signals:
- Spatial patterns
- Frequency patterns
- Principal components
- …
- but in general models are needed

Hydrology is not the only interesting sinal, so the equation can be reordered to separate other signals

Mass transports – a simulated world

- Hydrology

(uncountable …)

Landerer et al 2015
Makowski et al 2015
Piecuch 2015, …

Mayer-Gürr et al 2012,
Killett 2011
Han et al 2010, …

Dieng et al 2015
IPCC 2015, …

Martinec et al 2015
Root et al 2015
Sutterley et al 2014, …

Wahr et al 2015

Broerse et al 2015
Zhang et al 2015
Tanaka et al 2015
Li et al 2015
Shahrisvand et al 2015
Han et al 2015, …

Bergmann-Wolf et al 2014
Wu et al 2012
Rietbroek et al 2012, …

=

Total mass change
- Ice sheets
- Glaciers
- Permanent frost
- Ocean tides
- Ocean pole tides
- Barotropic ocean circulation
- Sea level rise (?)
- Atmospheric tides (S1, S2)
- Atmospheric mass redistribution
- Solid Earth tides
- Rotational deformation (pole tides)
- Glacial isostatic adjustment
- Loading deformation
- Degree 1 mass redistribution
- Earthquakes

Mass transports – a simulated world

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The equation can be reordered once more …

Mass transports – a simulated world

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=

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– Ocean tides
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– Solid Earth tides
– Rotational deformation (pole tides)

Application: hydrology
⇒ GIA must be reduced (not part of level 2)
⇒ Degree 1 terms (not part of level 2)

Application: oceanography
⇒ Ocean model must be added back
⇒ GIA must be reduced (not part of level 2)
⇒ Degree 1 terms (not part of level 2)

Level 2 product (GSM)

⇒ Mixture of observations and models

⇒ Unclear why some models are reduced and others are not

Mass transports – a simulated world

- Hydrology
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- Rotational deformation (pole tides)
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=

Total mass change

A possible new definition of Level 2 products

GRACE Level 2 product (GSM)

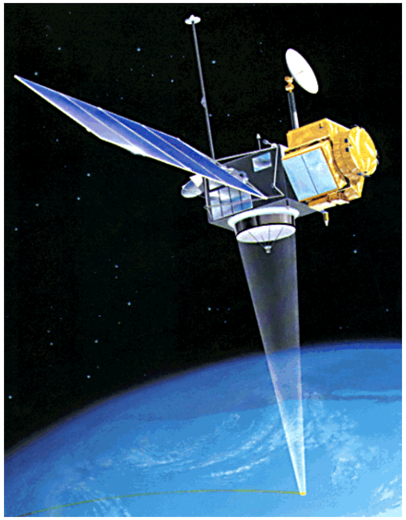
- Gravitational potential generated by the complete mass of the Earth

Part of the Level 2 products:
Monthly mean of models for signal separation

- Solid Earth tides
- Rotational deformation (pole tides)
- Glacial isostatic adjustment
- Degree 1 mass redistribution
- Ocean tides
- Ocean pole tides
- Barotropic ocean circulation
- Atmospheric mass redistribution
- Continental hydrology

Regularly used for Altimeter data. Each observation is supplemented by geophysical models, e.g.

- Inverse barometric effect
- Ocean tides
- Geoid



A possible new definition of Level 2 products

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Advantages

- Separation of obs. and models (Signals and noise/errors)
- Models can be exchanged without reprocessing
- Solutions of different ACs are comparable and combinable
- Future safe: new models can simply provided

Disadvantages

- Changed definition compared to release 5

But: Changes between releases, e.g.

- Pole tide model included
- Baroclinic to barotropic ocean model

Models for dealiasing and linearization

We still need models in the frame of GRACE processing!
Models for dealiasing: < 1month
Models for signal separation: > 1 month

Models used in processing:

1. Reduced and monthly mean provided as additional product
    - Atmosphere
    - Ocean
2. Reduced and monthly mean not provided
    - Earth tides
    - Ocean tides
    - Pole tides
3. Reduced but monthly mean added back
    - Static
    - Annual
    - Semiannual

Consistent method for all models

- Reduction
- Add back monthly mean
- Monthly mean as additional product

First Summary

- We need a discussion about the models used in GRACE processing!
  It should be clear beforehand which models are reduced and which are not.

- Level 2 should include the models needed for signal separation
  (these models are needed for Level 3 products too)
    - Glacial isostatic adjustment
    - Solid Earth degree 1 mass redistribution
    - Continental hydrology
    - …

Following slides:
Details about
- Geocenter
- Averaging interval (monthly mean)

Definition

In the reference system community:
Distinction between:

- "System": Theoretical definition (Goal: products without noise/errors/problems)
- "Frame": Realization (Instruments noise, Complicated space-time pattern, Aliasing)

GRACE: only realizations without theoretical definition

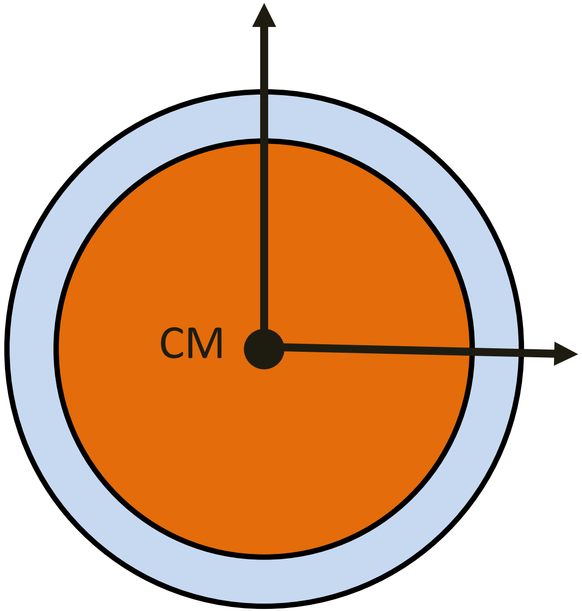
Proposal of a theoretical definition:
GRACE monthly solution

- Gravitational potential generated by the complete mass of the Earth
- Origin is the center of mass (CM)
- Orientation is aligned to ITRS
- Mean mass distribution of the complete month

Geocenter motion

Center of mass (CM)

- The degree 1 terms of the sum of all masses do not change (set to zero)
- If the degree 1 terms of the fluid envelope (ocean, atmosphere, hydrology, …) changes, the degree 1 terms of the solid Earth changes too



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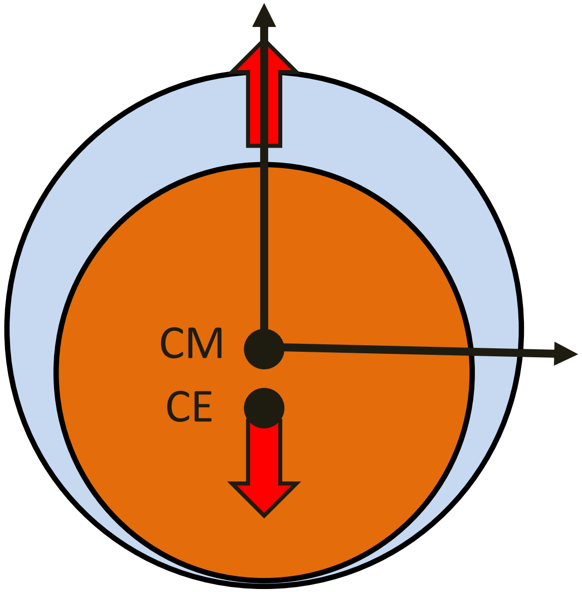

Center of solid Earth (CE) / Center of figure (CF)

- The degree 1 terms of the solid Earth do not change
- (only the terms of the fluid envelope changes)

Transformation from CM to CE

Must remove the degree 1 terms of the solid Earth from the degree 1 of the complete mass

⇒ Signal separation problem

⇒ Cannot provided by GRACE only

⇒ Model / external data needed

Temporal average

Current definition

Average over all days with GRACE data

$$\bar{c}_{nm} = \sum_{i\ with\ GRACE} \int_{t_i}^{t_{i+1}} c_{nm}(t)\, dt$$

Proposal of a new definition

Average over the complete month

$$\bar{c}_{nm} = \int_{t_0}^{t_1} c_{nm}(t)\, dt$$

Concerning only the mean of the background models (GAA, GAB, GAC, …)

GRACE processing: Observation model assumes constant gravity field coefficients
Trying to remove all high frequent (submonthly) variations by models
$\Rightarrow$ Reduced Gravity field (GSM) should be constant within the month regardless which days are observed

Example usage of GRACE: Validation/Comparison with other data

- Altimetry
- Ocean bottom pressure recorder
- GPS loading deformation
- Hydrological model

$\Rightarrow$ Computation the temporal average
$\Rightarrow$ Must use the same time span as GRACE data

Which definition did you used?

Summary

We should make the GRACE Level 2 products more user friendly

- With a clear theoretical definition

Theoretical definition:
GRACE monthly solution
- Gravitational potential generated by the complete mass of the Earth
- Origin is the center of mass (CM)
- Orientation is aligned to ITRS
- Mean mass distribution of the complete month

- With additional monthly mean of models for signal separation

• Glacial isostatic adjustment • Degree 1 mass redistribution • Barotropic ocean circulation • Atmospheric mass redistribution • Continental hydrology	• Solid Earth tides • Pole tides • Ocean tides • Ocean pole tides

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Reference Frame Products

Andreja Susnik, Rolf Dach, Andrea Maier, Daniel Arnold

UNIVERSITÄT BERN · UNIVERSITÉ DU LUXEMBOURG · GFZ Helmholtz Centre Potsdam · TU Graz · Leibniz Universität Hannover · cnes · DLR · géode & cie · HORIZON 2020

Introduction

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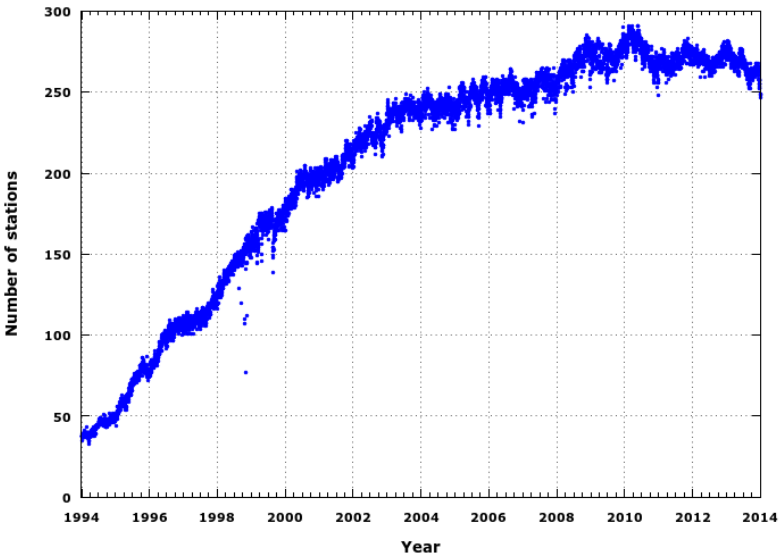
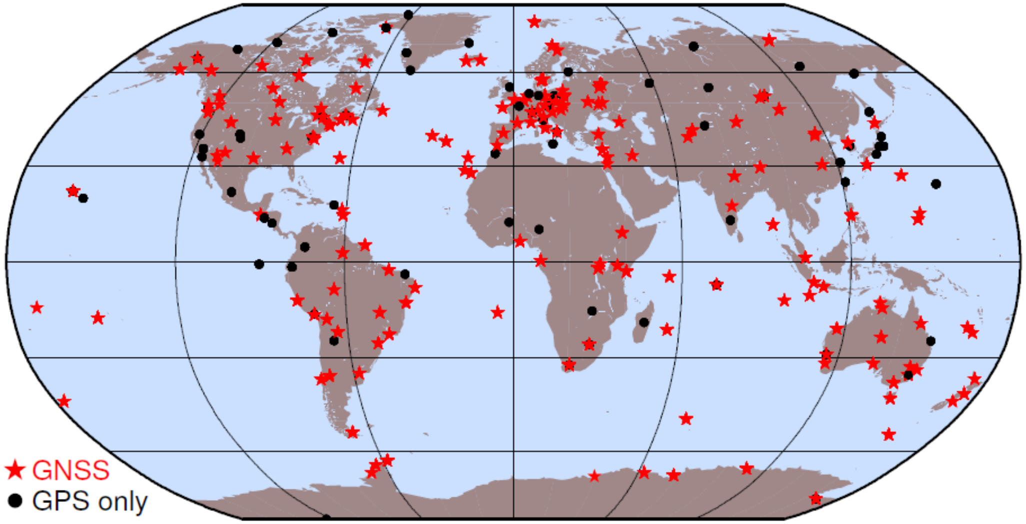
- for consistent series of GNSS satellite clock corrections, orbits, Earth rotation parameters and station coordinates were homogeneously processed for the interval between 2000 to the end of 2014, using the latest development version of the Bernese GNSS software





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Introduction

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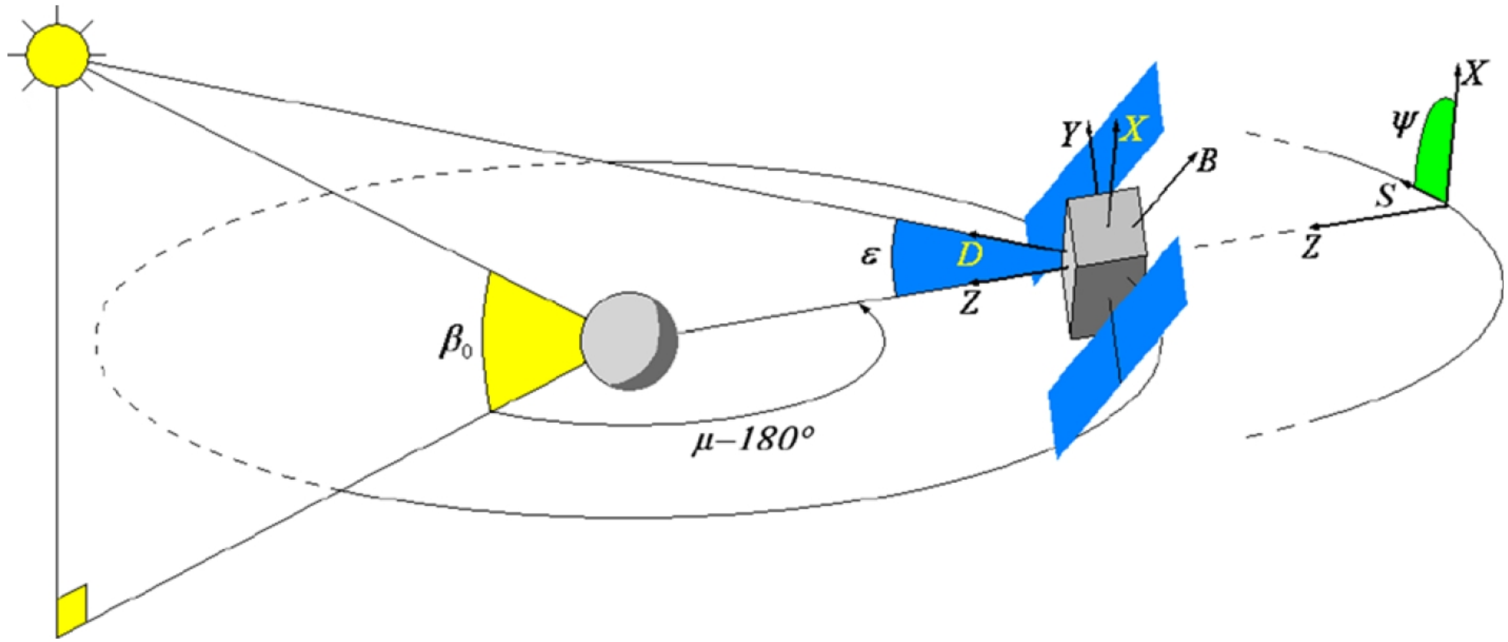
- in order to provide the best reference frame products, the latest GNSS orbit model was used (Arnold et al., 2015) for the full period of reprocessing efforts



	Parameters estimated in		
	D	*Y*	*B*
Original ECOM	constant	constant	constant, 1-cpr
Extended ECOM	constant, 2-cpr, 4-cpr	constant	constant, 1-cpr

Processing Scheme

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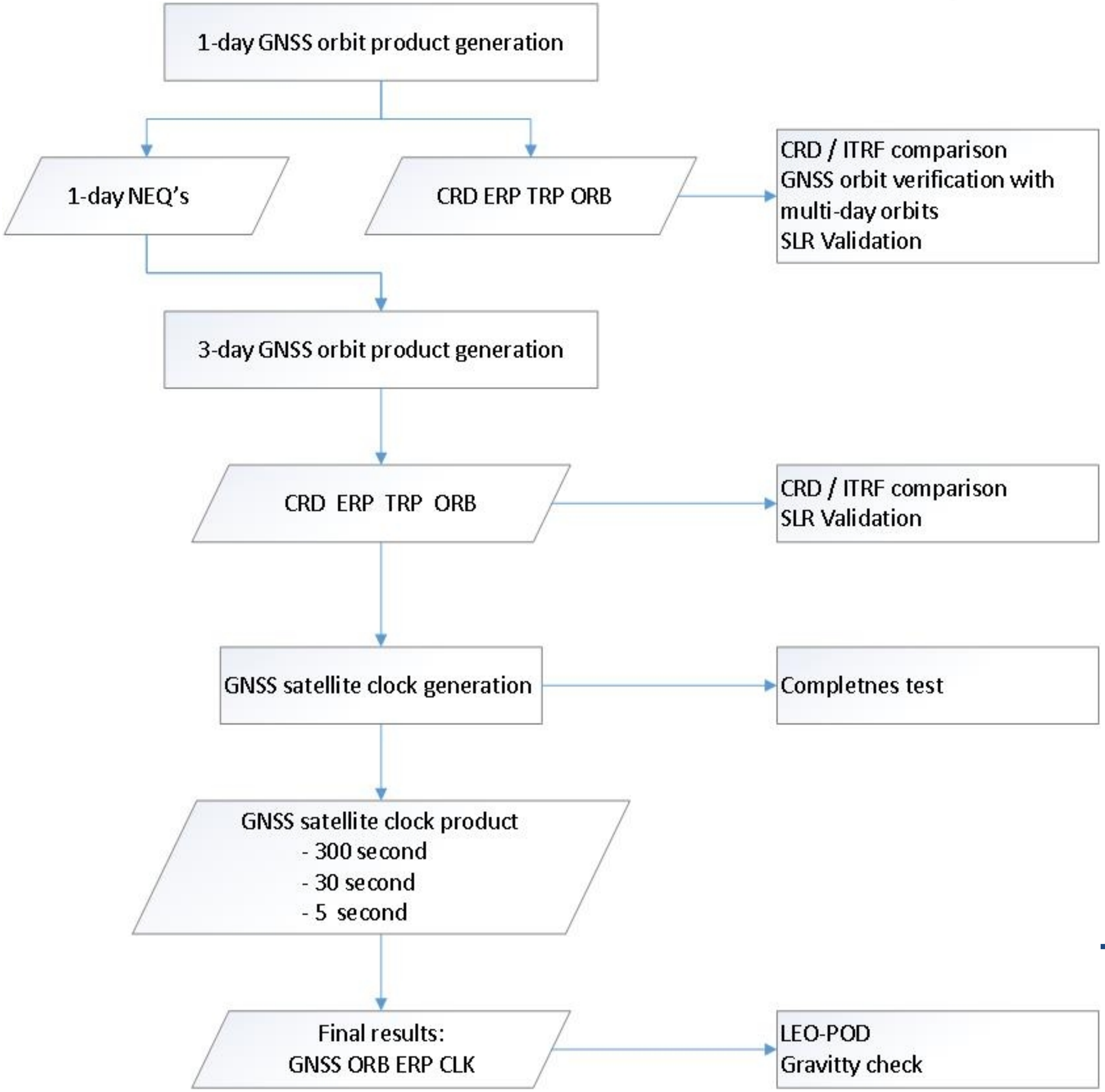

- as the basis for the GRACE orbit determination, based on its onboard GPS receivers, GNSS satellite orbits, Earth rotation parameters (ERP's) and GNSS satellite clock corrections (at 30 and 5 s sampling rate), attached to the IGb08 reference frame are computed
- during the processing several quality control steps were established

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Processing Scheme

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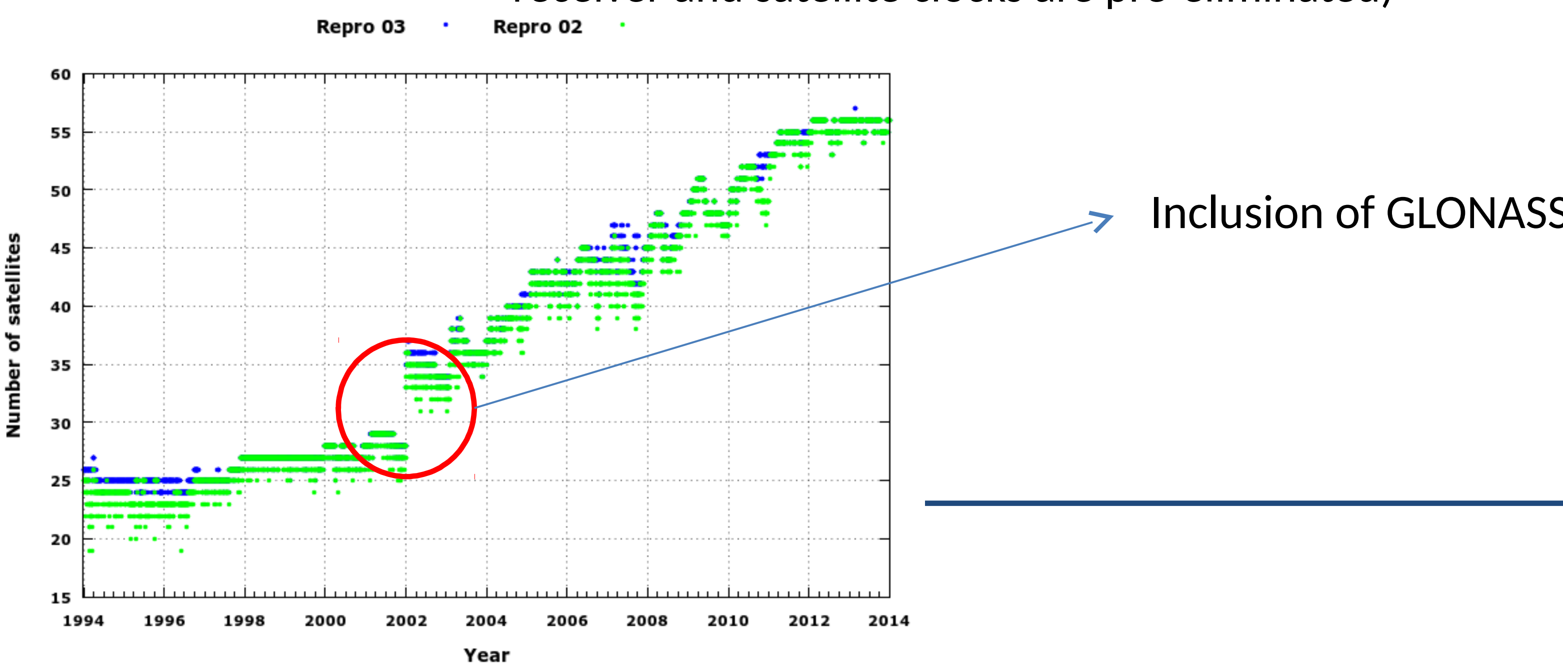
1-day GNSS orbit product generation

- original GNSS observations in RINEX files (RINEX2 format)
- as a priori orbit information the results from repro02 were used and completed with alternative sources (i.e., broadcast orbits)
- based on repro02, all known RINEX inconsistencies are corrected
- full pre-processing and ambiguity resolution scheme is applied (DD, receiver and satellite clocks are pre-eliminated)



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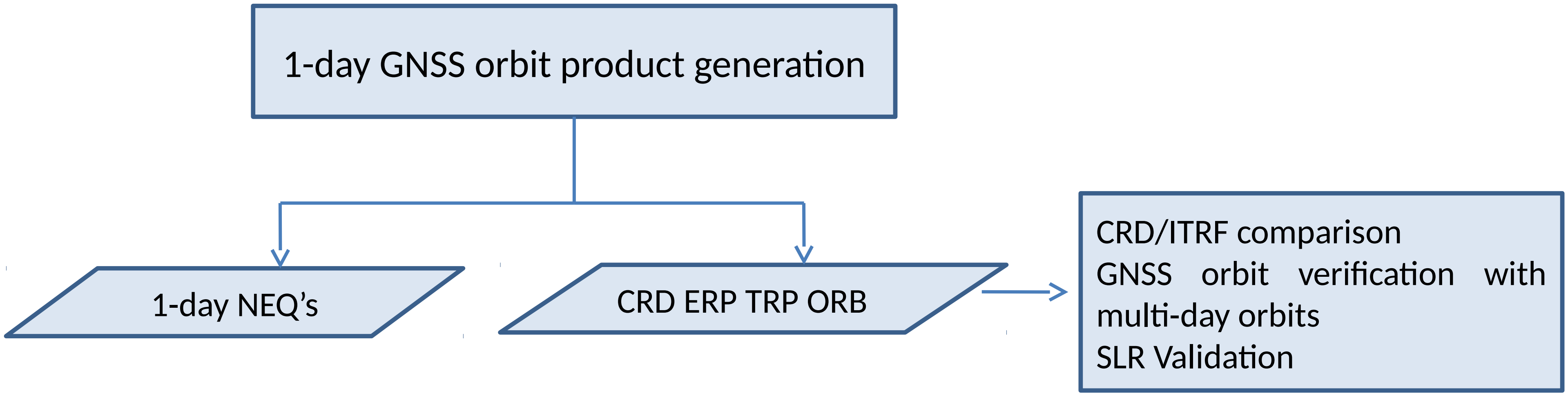
Processing Scheme



- main product are 1-day NEQ's, containing GNSS satellite orbit parameters, ERP's, coordinates and troposphere zenith path delay parameters

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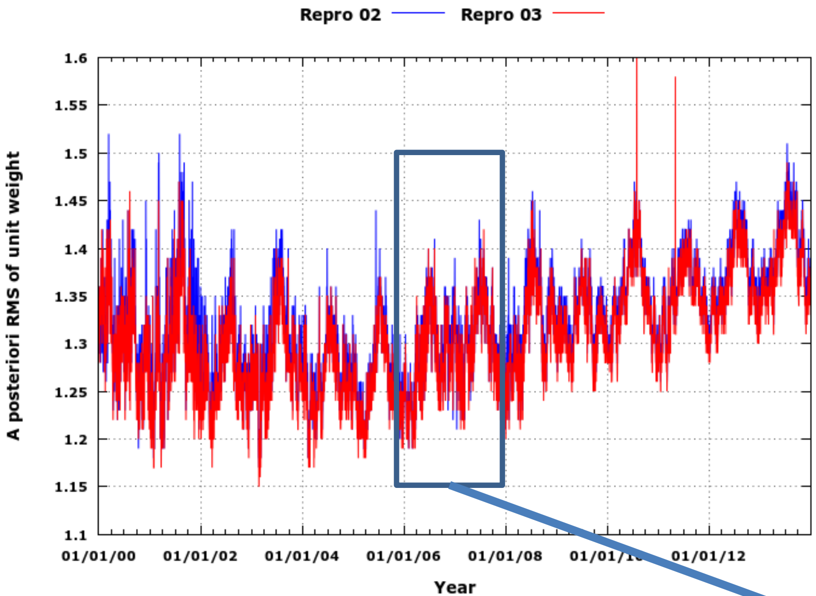

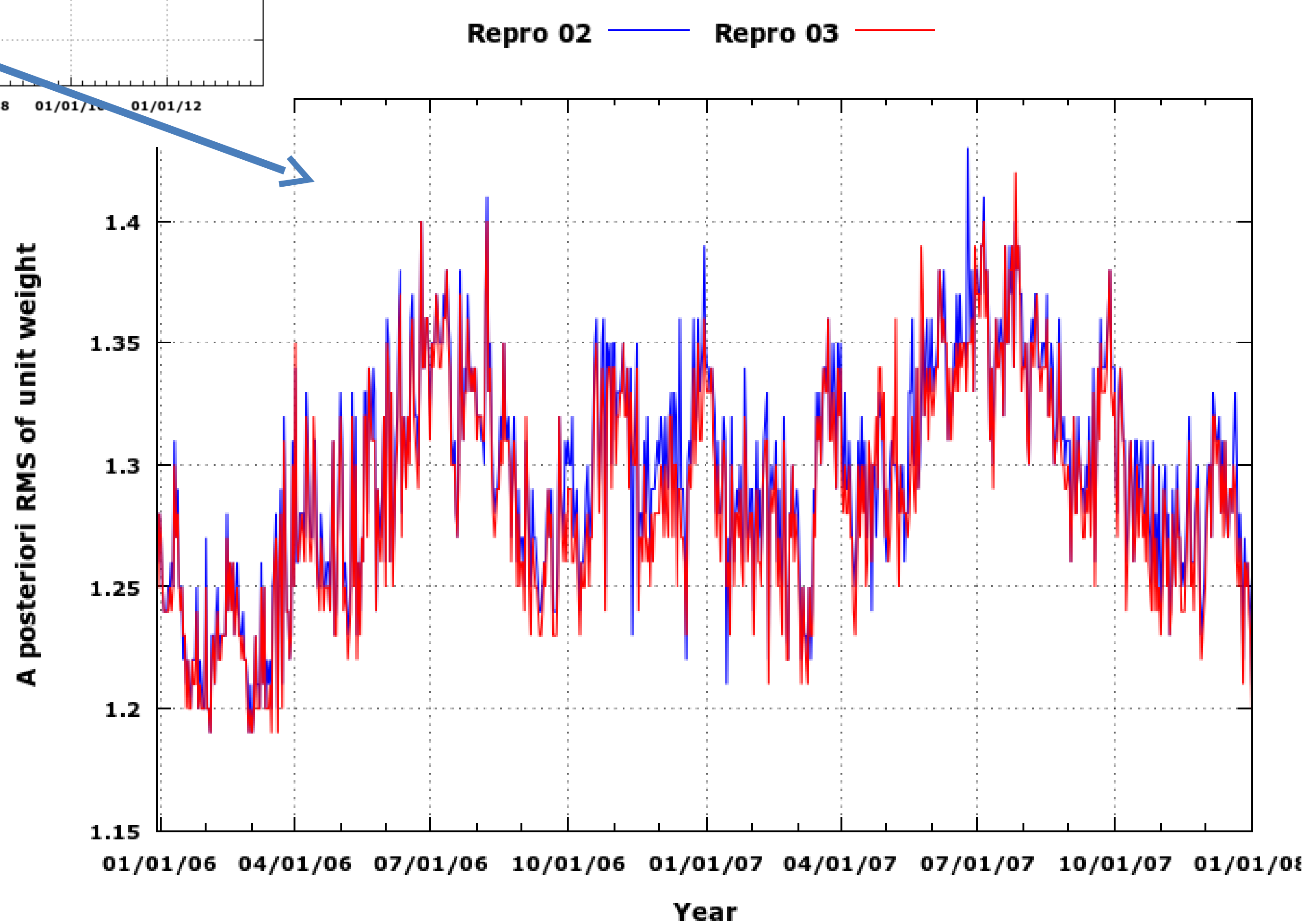

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SLR validation

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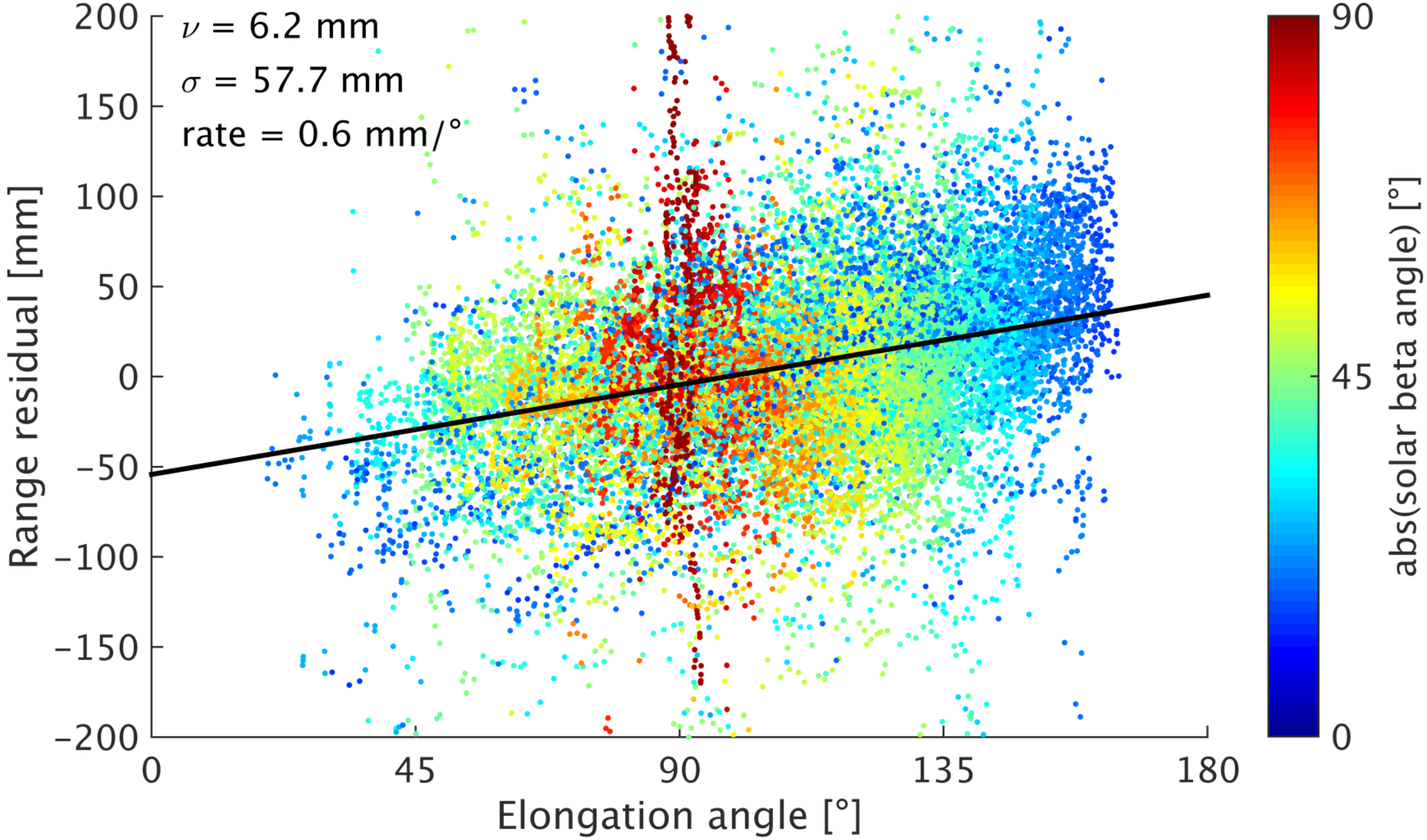

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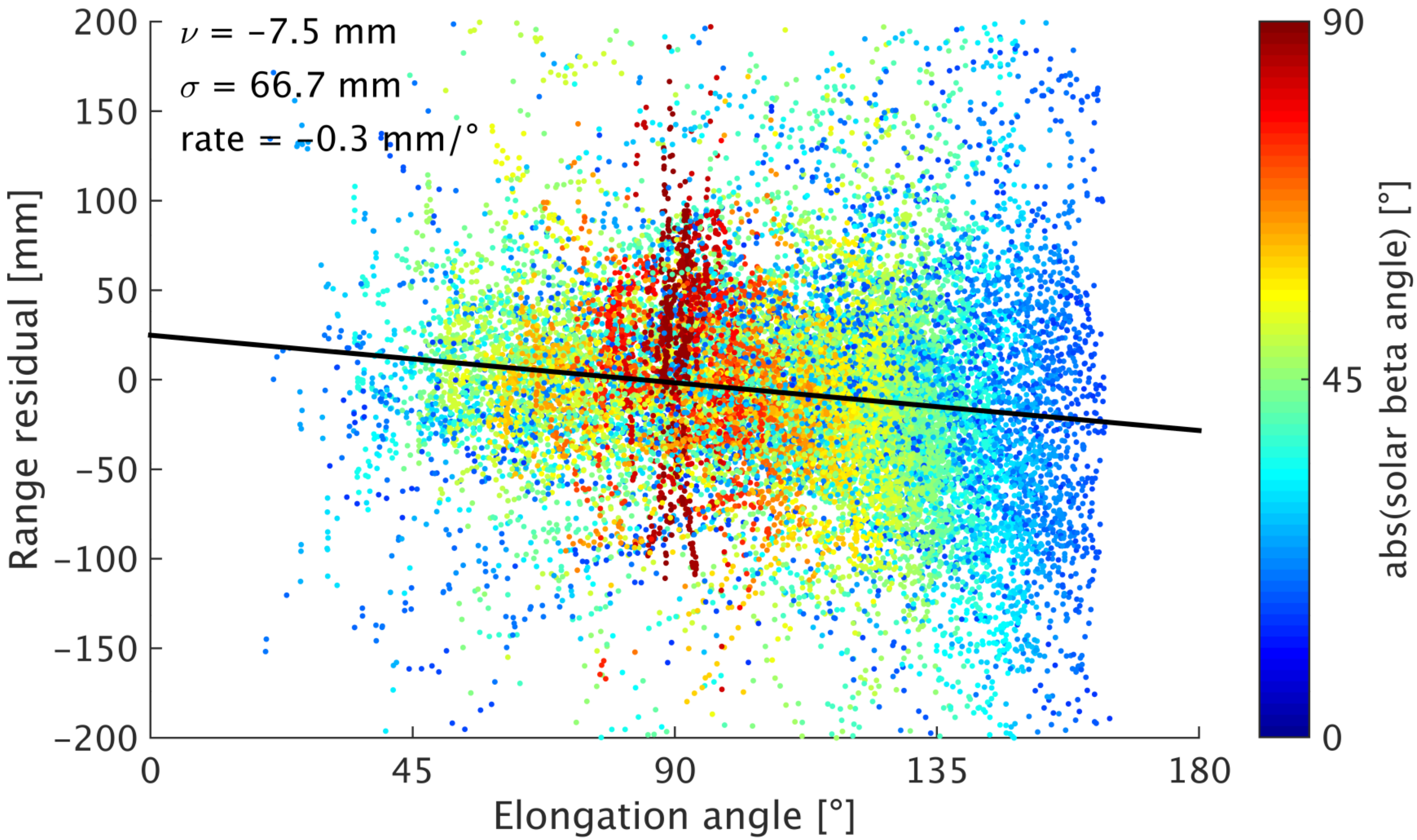
SLR validation



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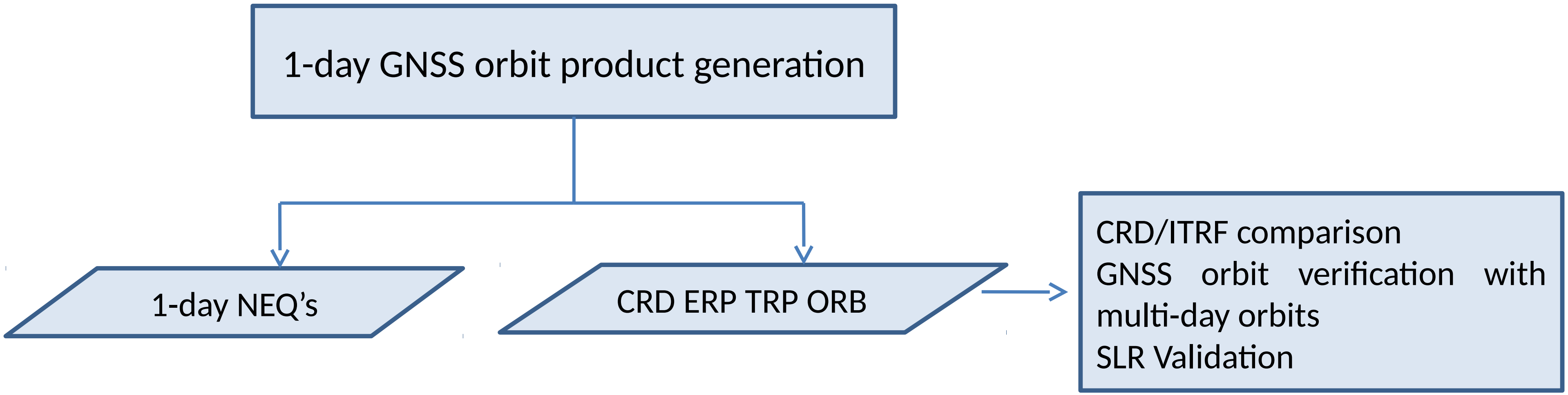
Processing Scheme



- in next step the consistency of three subsequent one-day orbits is verified
- additionally, a verification of the station related parameters is performed
- all remaining RINEX inconsistencies are corrected
- after these preparatory steps three subsequent NEQs are combined and solved to a three-day long-arc solution

Processing Scheme

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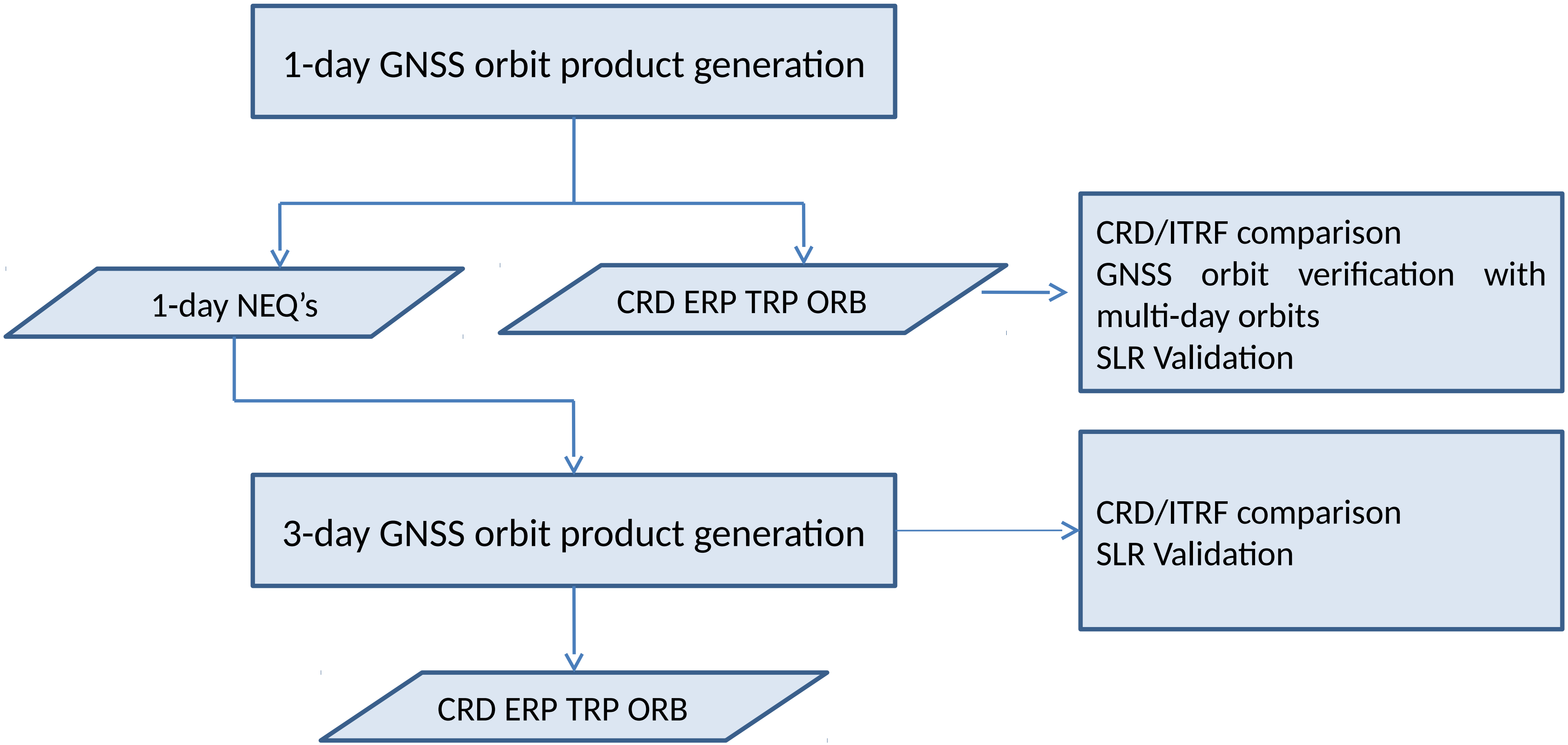

Processing Scheme

- in the next step, GNSS satellite clock generation is performed
- the procedure is based on Bock et al. (2009) and it has been extended in the frame of the project to a GPS and GLONASS combined processing scheme

Processing Scheme

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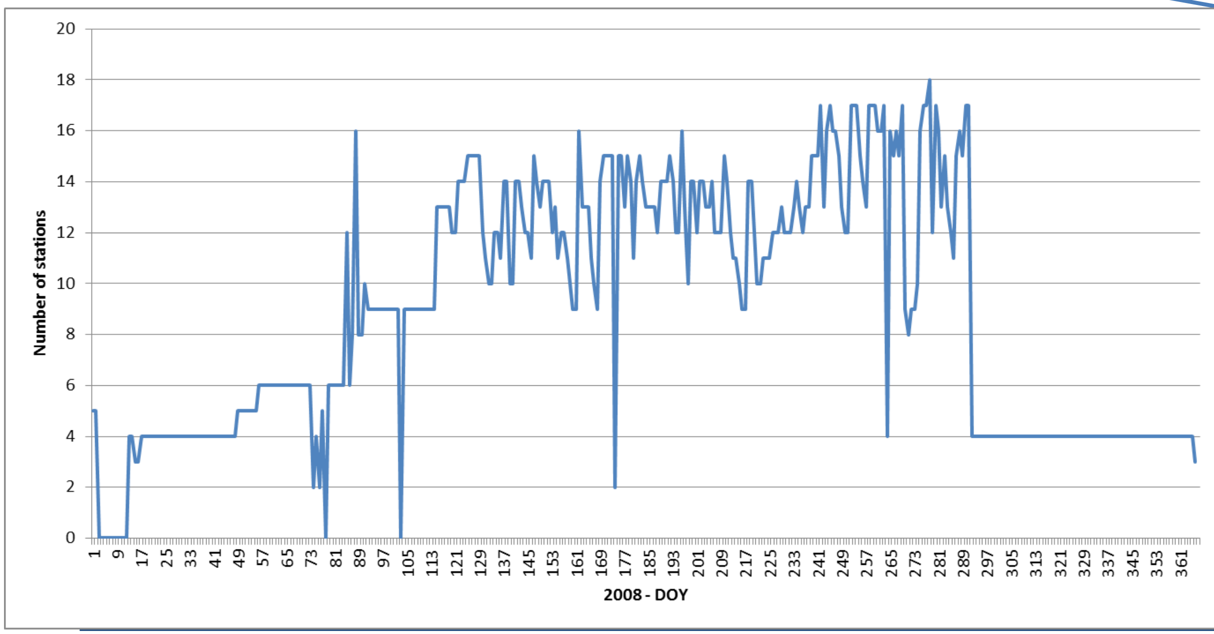

- due to very sparse availability of GLONASS data, we have included GLONASS from 2008 onwards in 30 s satellite corrections, while before 2009 GLONASS is completely excluded

GNSS satellite clock generation

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Pre-processing

Clean code + phase
Smooth code

screening of post-fit residuals

Screening
station-by –station

1. Phase only
2. Code only
3. Phase + Code

low-rate clock solution

3 global clusters
45 stations/cluster

combination +merging

5- min clocks

high-rate clock solution

EHRI from 5 min to 30 s

EHRI from 30 s min to 5 s

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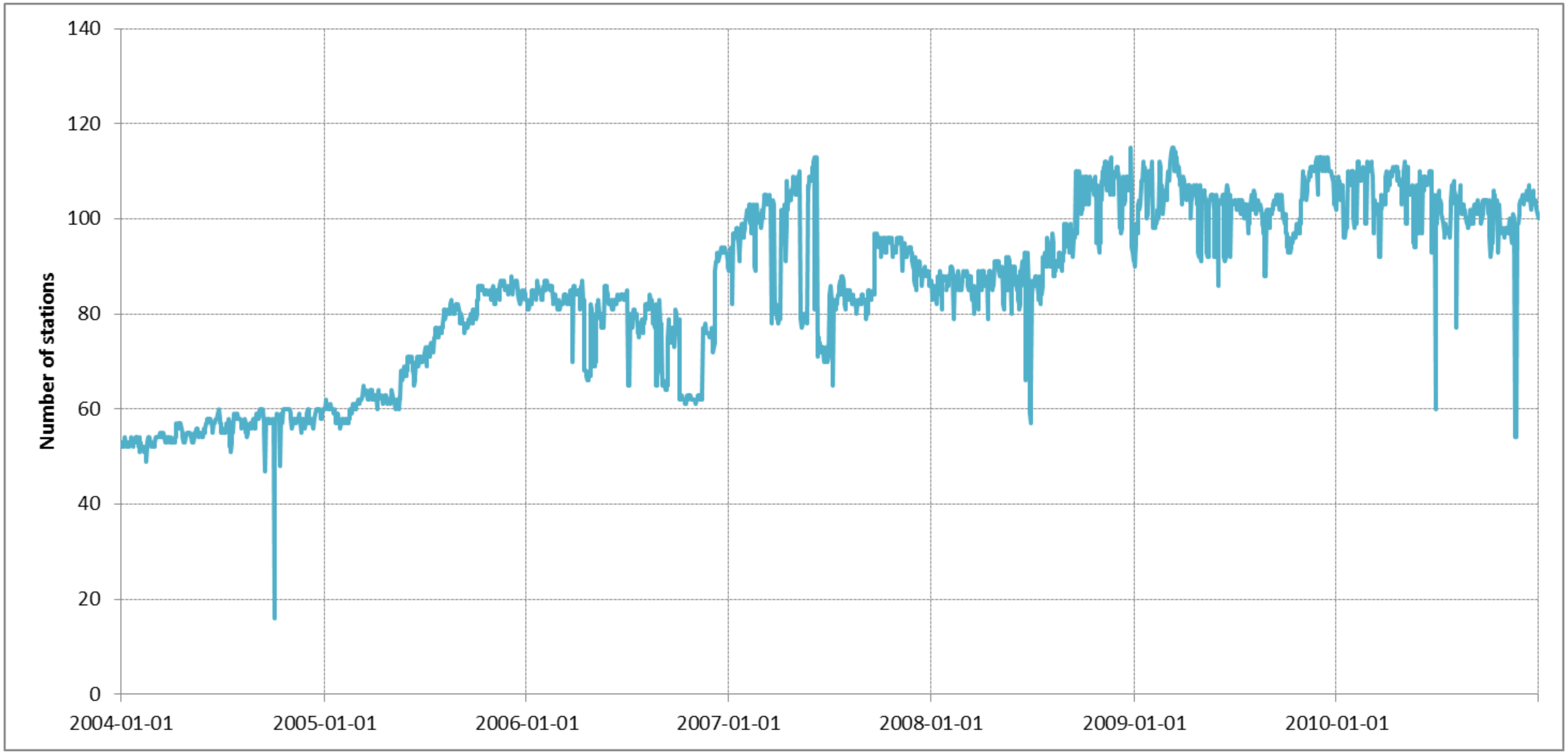
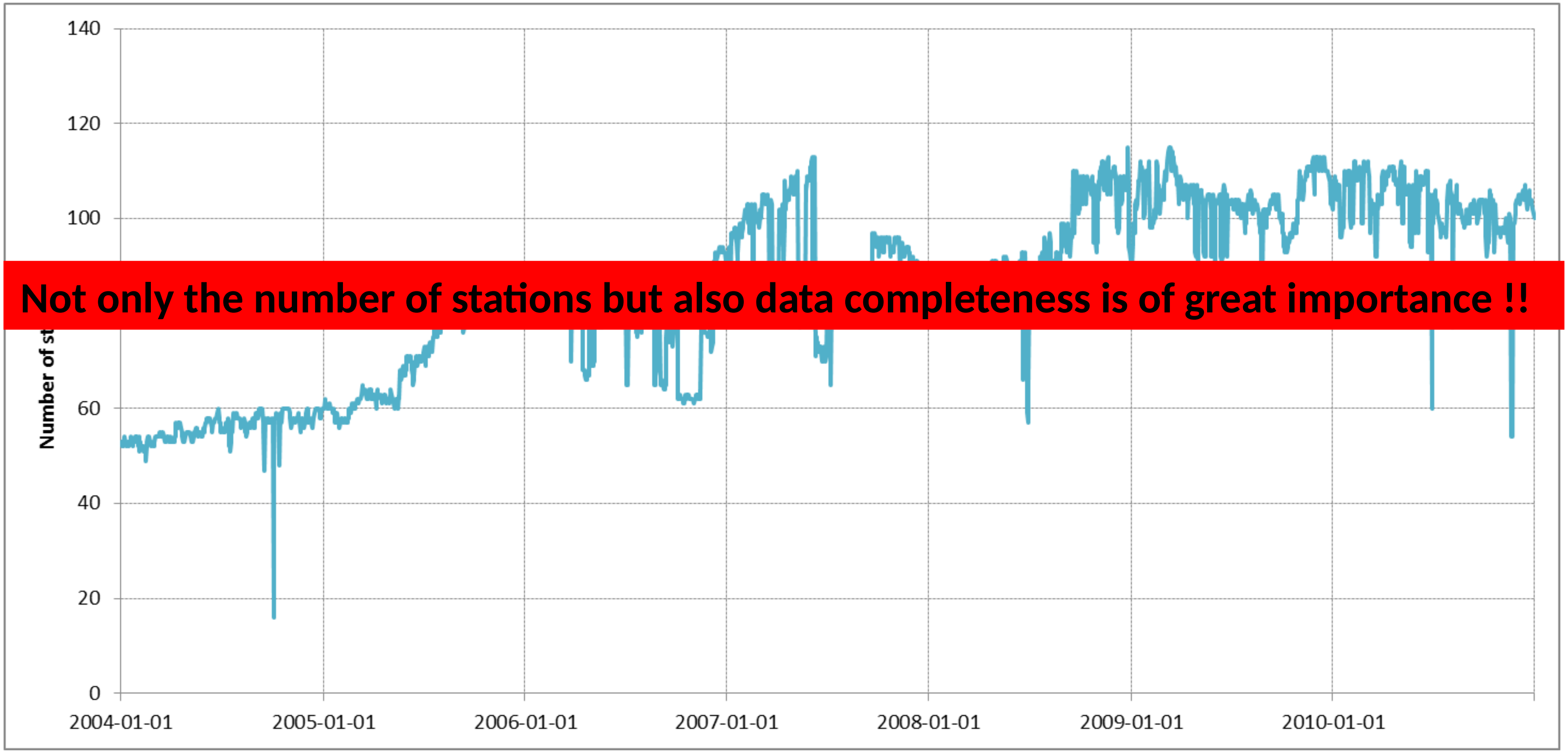


High-rate RINEX2 station data availability at AIUB datapool, for the period between 2004-2010



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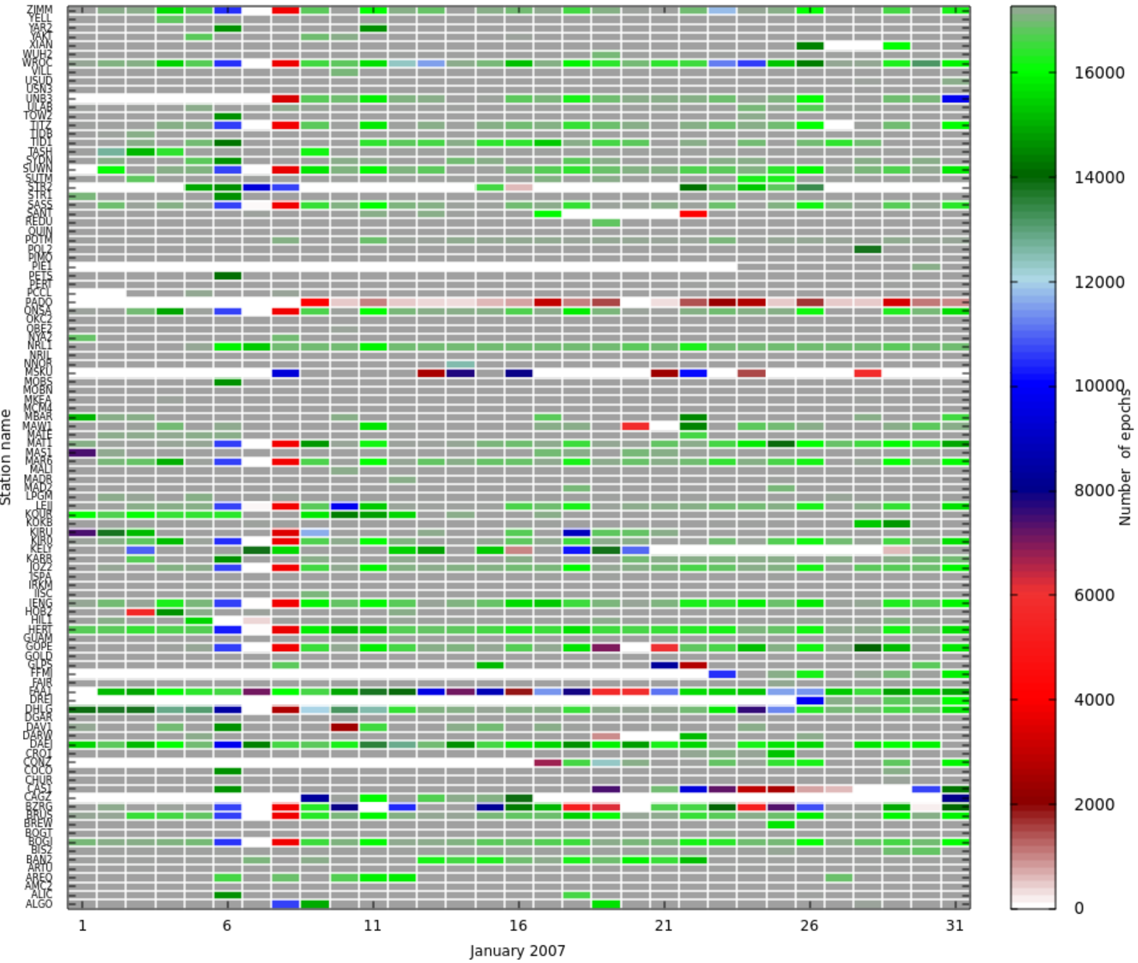
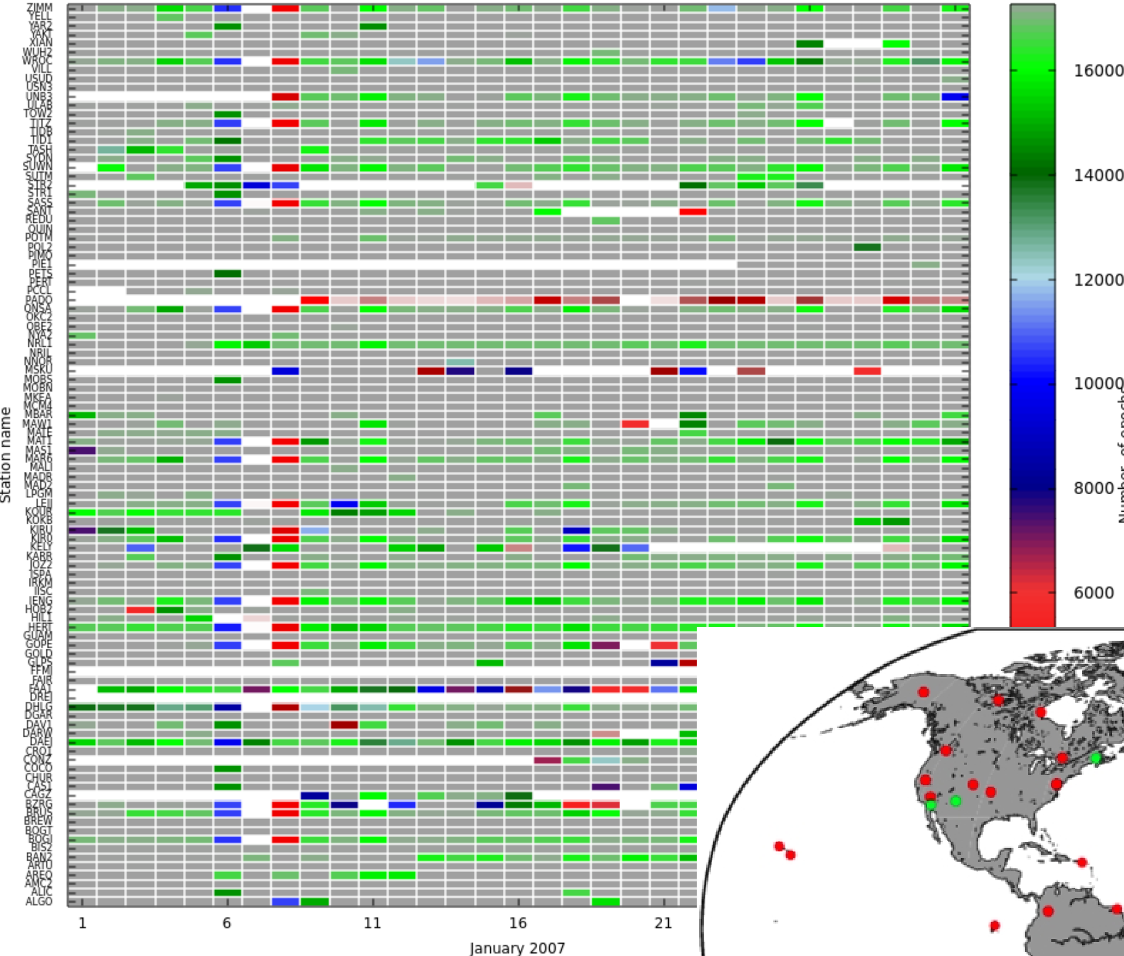


ity Service for Improved Emergency Management

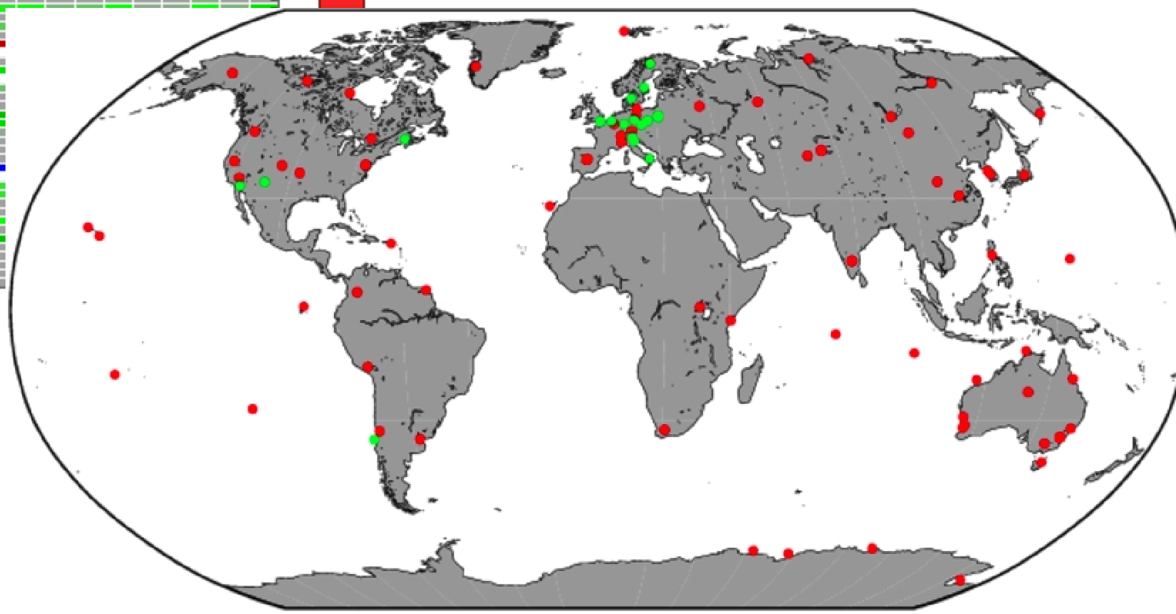
grey color present full completeness

ity Service for Improved Emergency Management



7 Januar 2007

27 Januar 2007



grey color present full completeness

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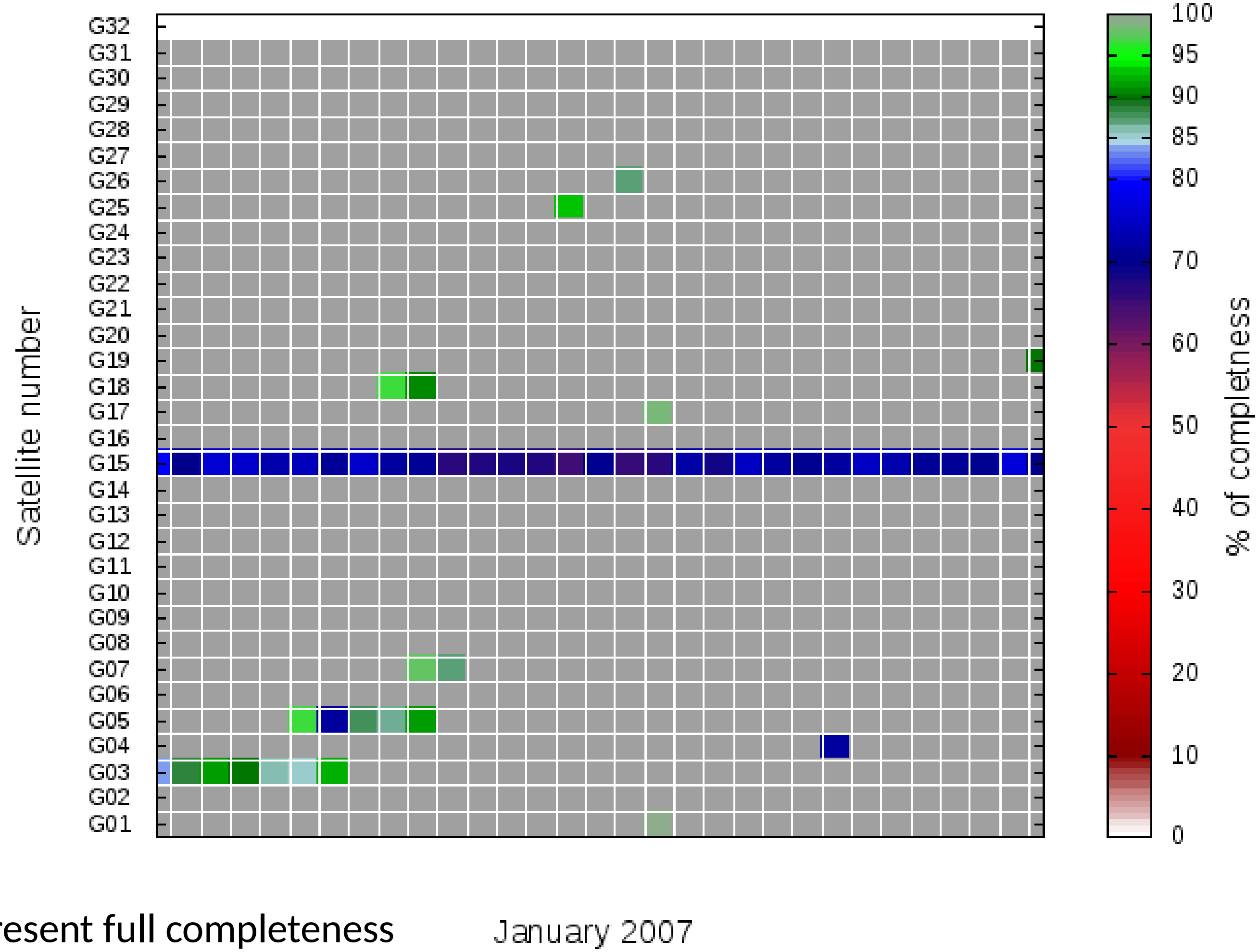
5s clock product completeness



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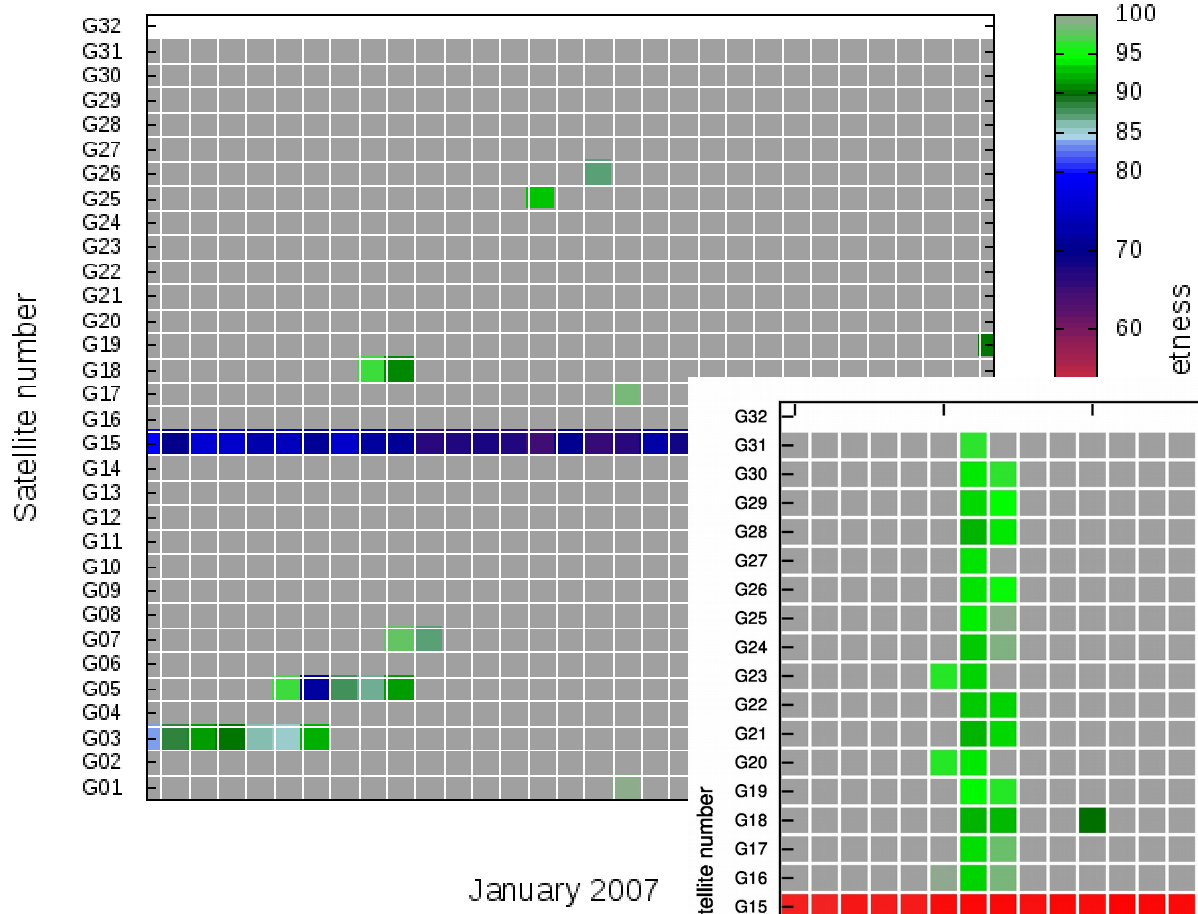

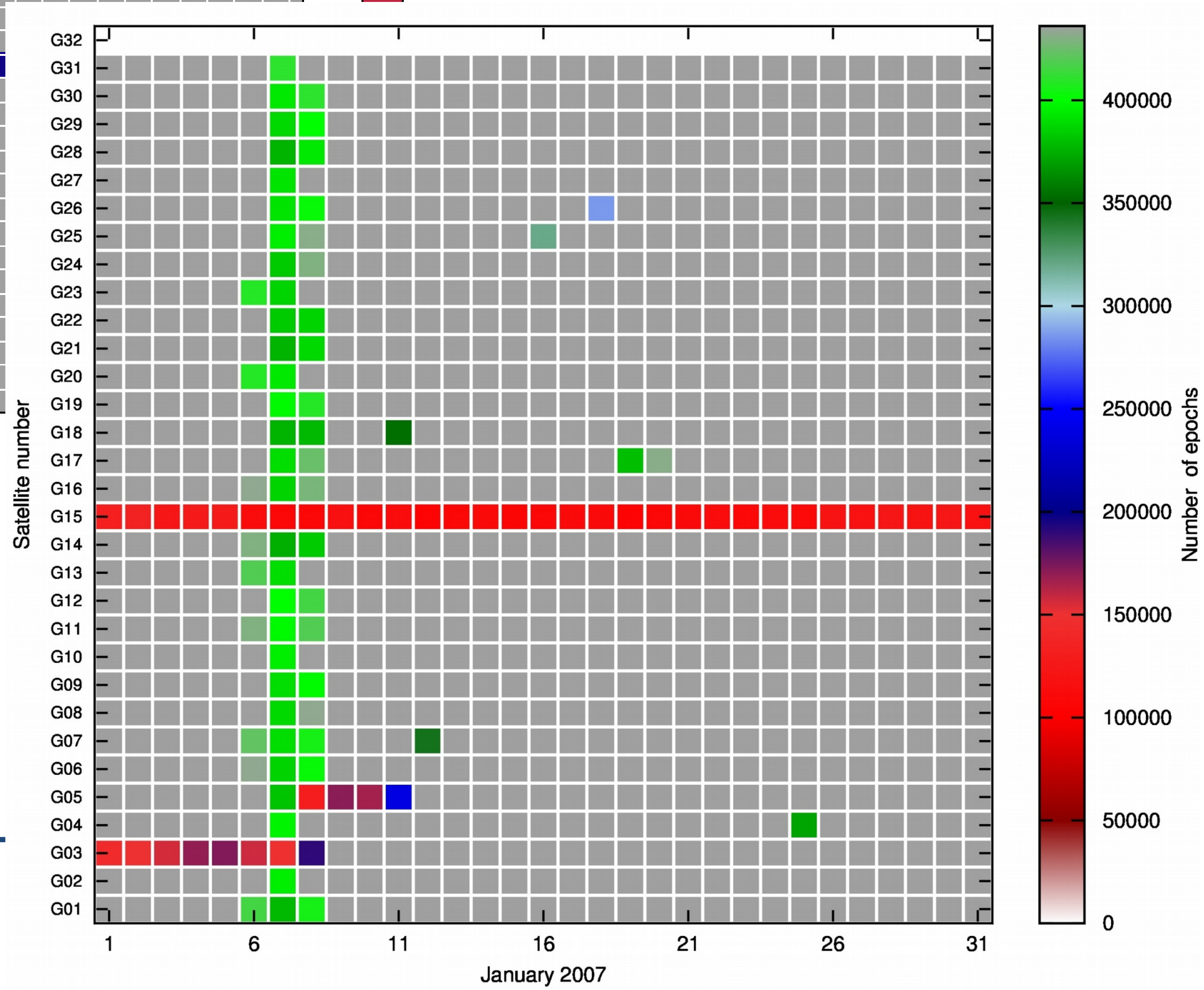

grey color present full completeness

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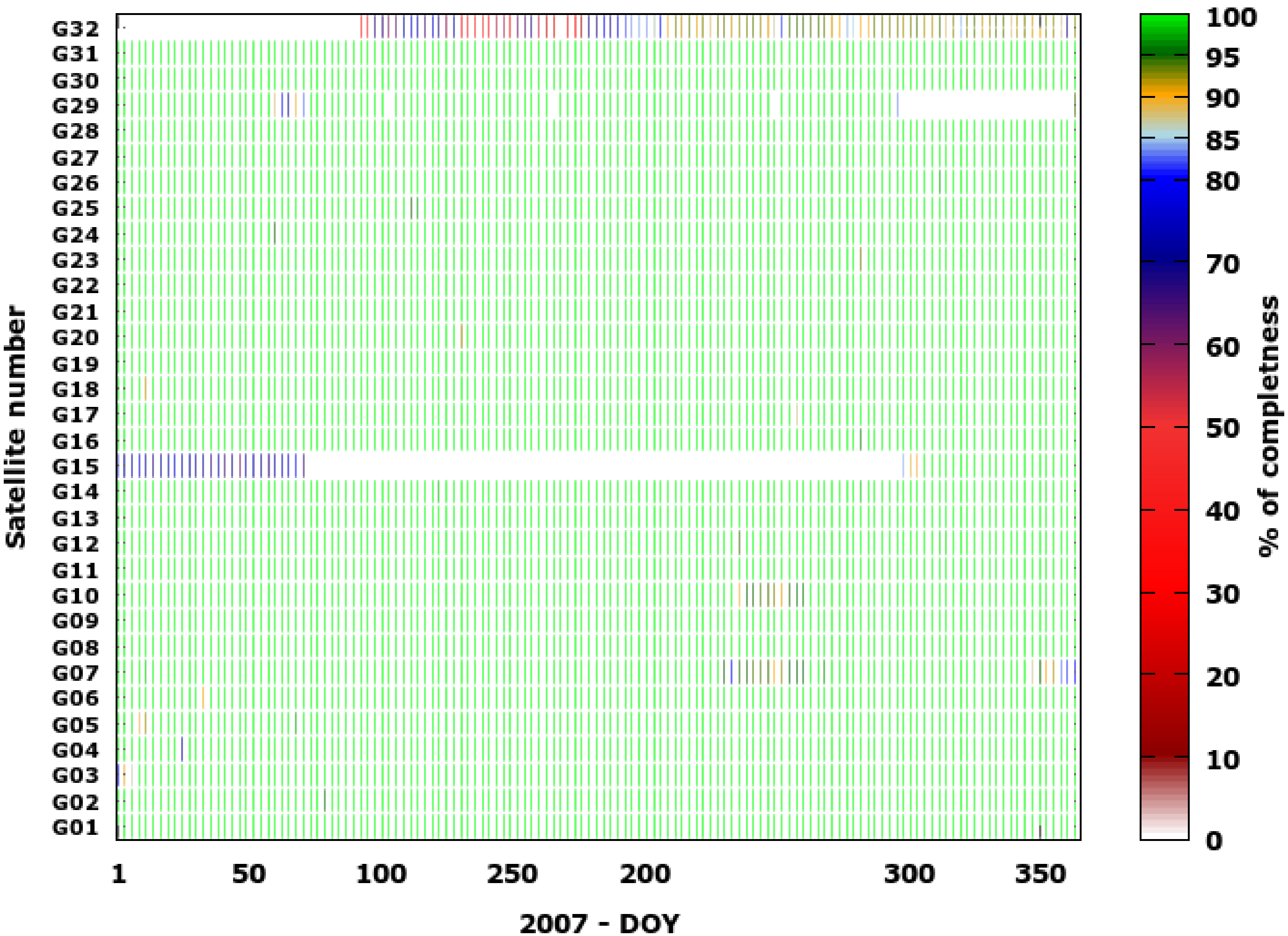
5s clock product completeness



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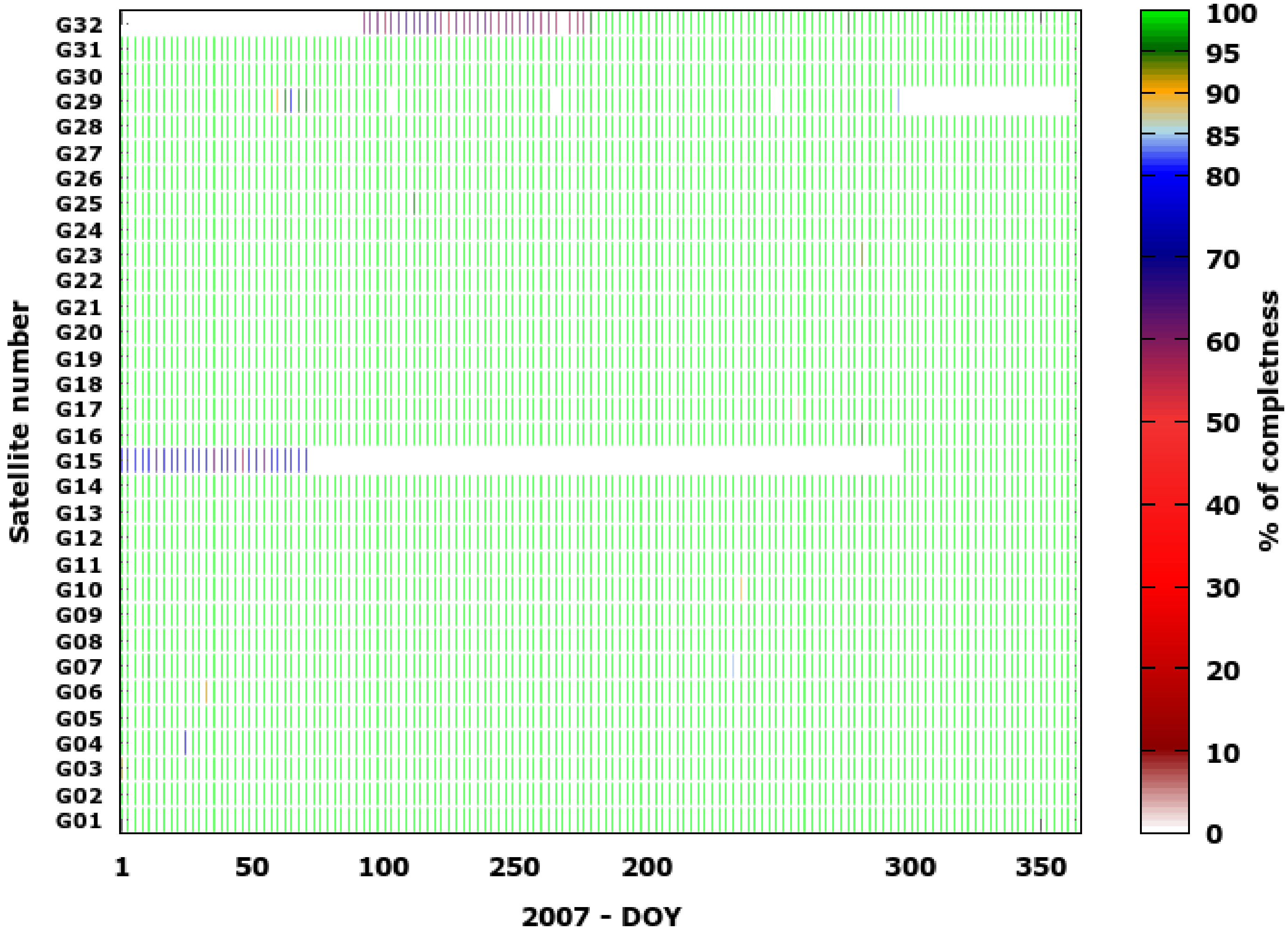
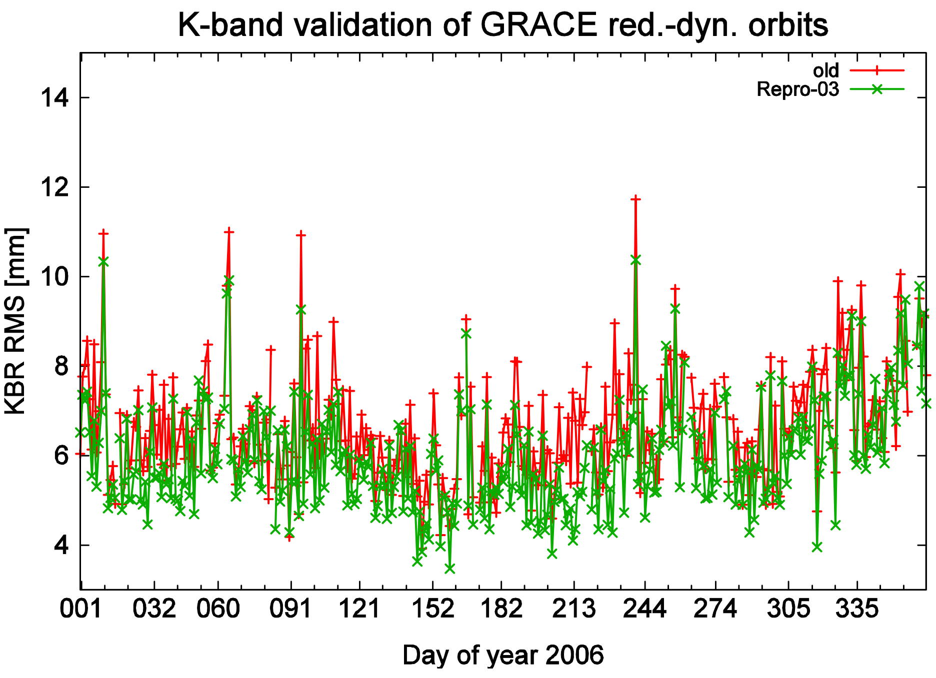
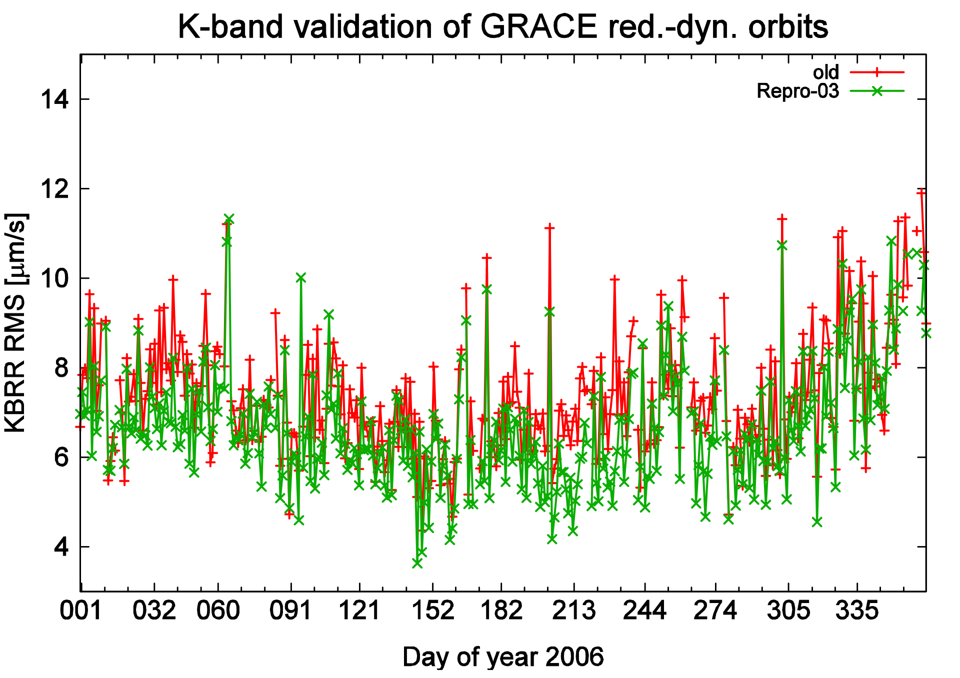
30s clock product completeness



/ Management

Validation by GRACE Orbit Determination





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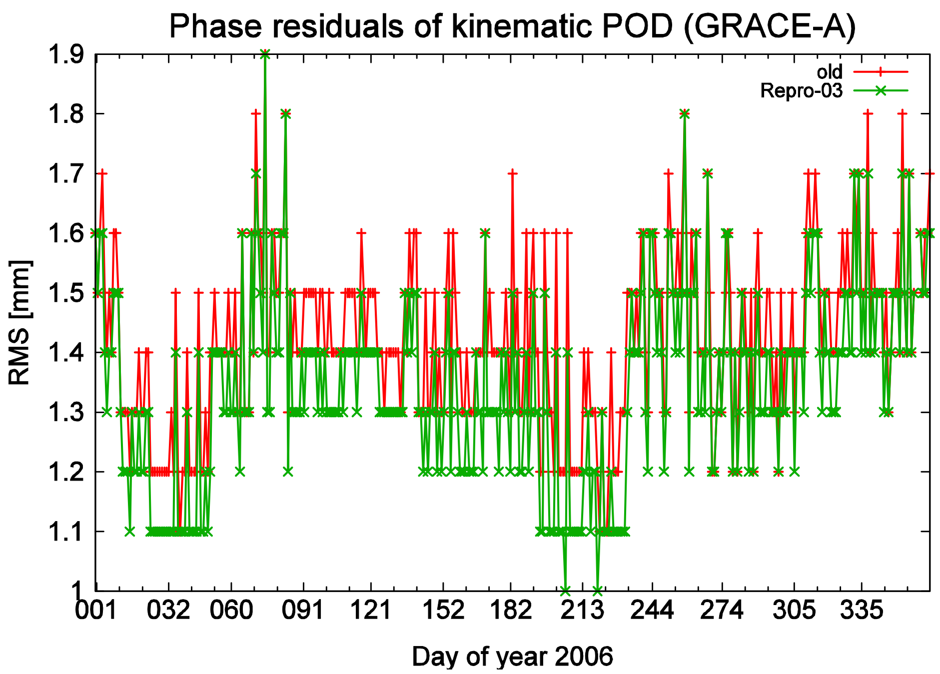

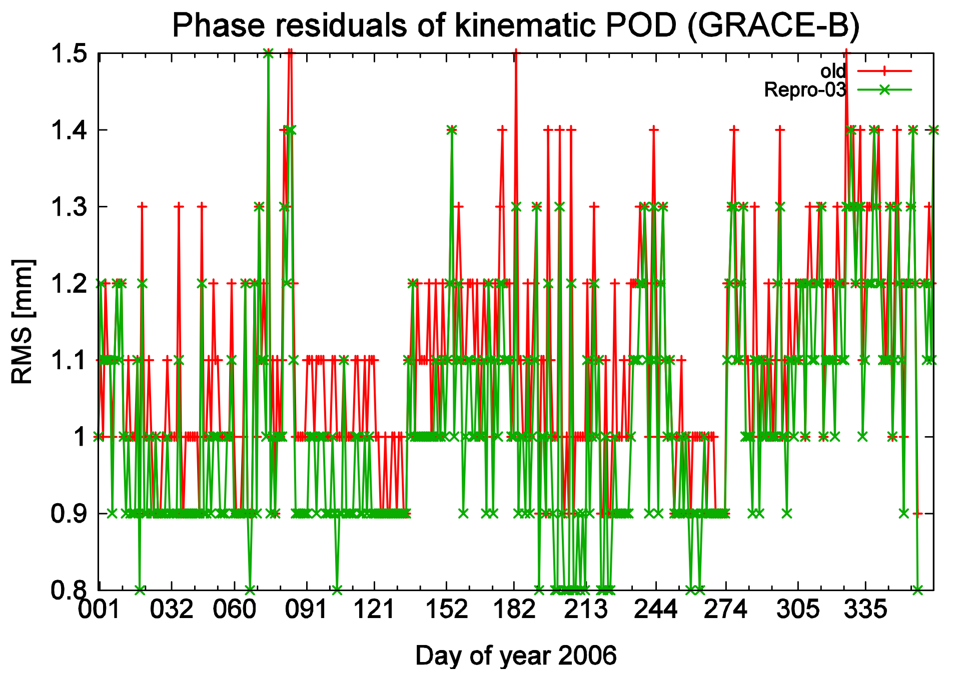

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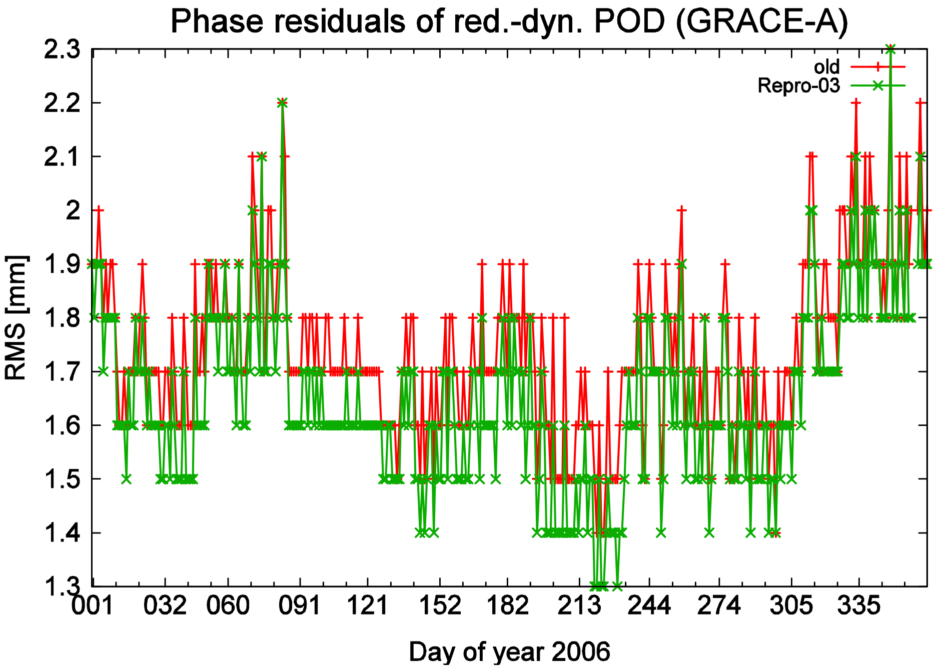
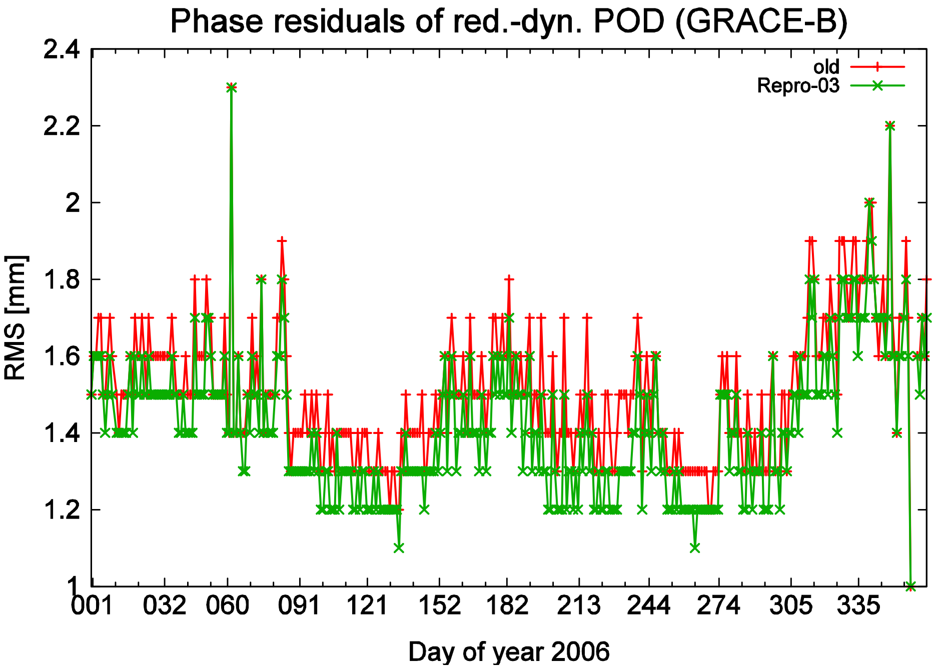
Validation by GRACE Orbit Determination





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Products

- Reference Frame Products:

  ftp://ftp.unibe.ch/aiub/users/susnik/.data/2006/

  ftp://ftp.unibe.ch/aiub/users/susnik/.data/2007/

- GRACE orbits:
  - will be available by the end of the month

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Gravity field coefficients from SLR data

Andrea Maier, AIUB (presented by Adrian)

Universität Bern · Université du Luxembourg · GFZ Helmholtz Centre Potsdam · TU Graz · Leibniz Universität Hannover · cnes · DLR · géode&cie · HORIZON 2020

Procedure (1)

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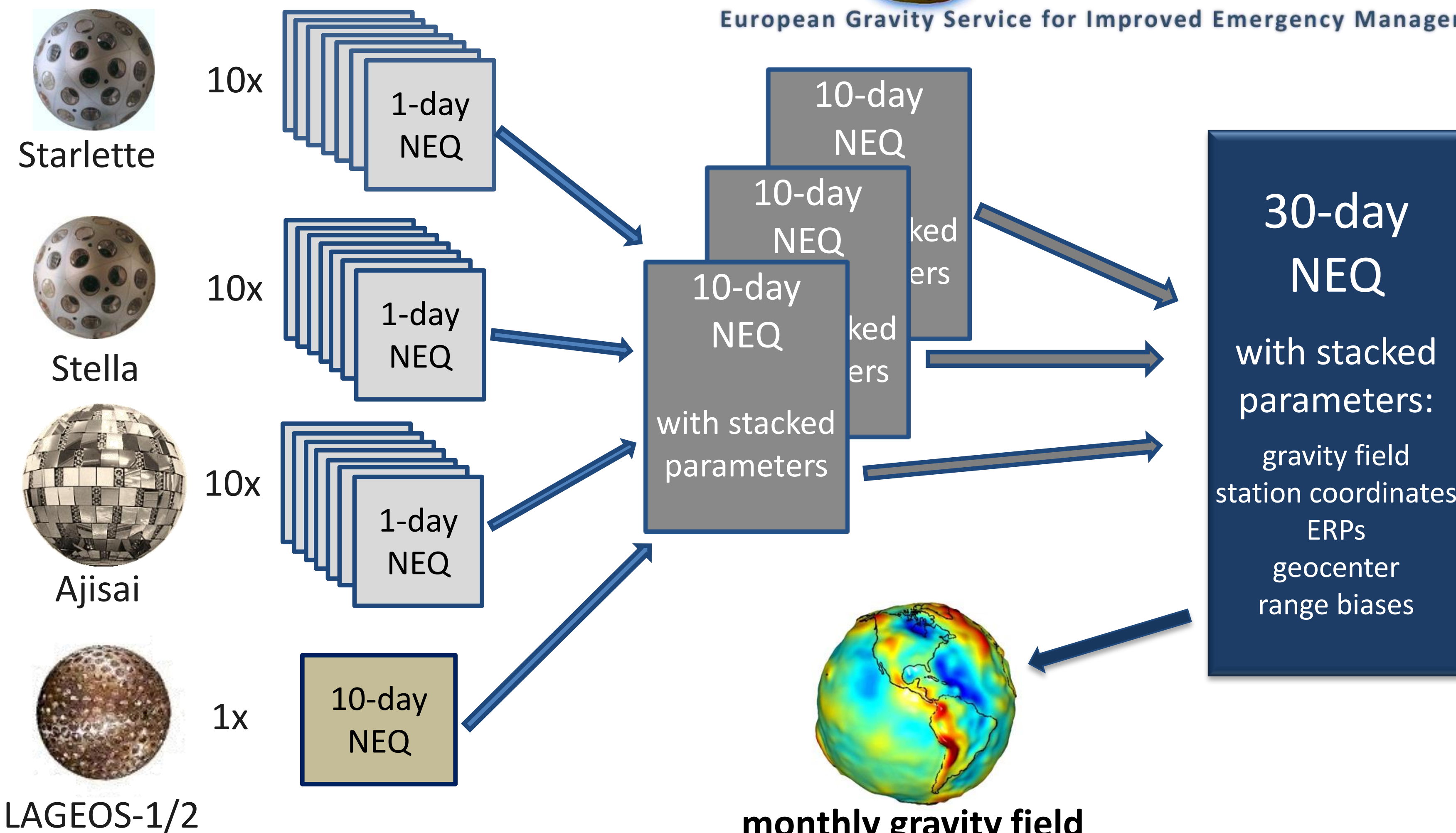

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Procedure (2)

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Reference frame	SLRF2008
A priori gravity field model	AIUB-GRACE03 (up to d/o 30 for LAGEOS, up to d/o 90 for LEOs)
Ocean tide model	EOT11a (up to d/o 30)
AOD applied at observation level	RL05
Atmospheric drag model (LEOs)	NRLMSISE-00
Albedo	monthly reflectivity coefficients in a 2.5 x 2.5 degree grid (CERES mission)
…	…
Weighting of satellite-specific NEQs	LAGEOS: 8mm Ajisai: 25mm Starlette/Stella: 20mm

Procedure (3)

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Estimated parameters		SLR solutions
		LAGEOS-1/2, Starlette, Stella, Ajisai (LEOs)
Orbits	Osculating elements	a, e, i, Ω, ω, u_0 (LAGEOS: 1 set per 10 days, LEOs: 1 set per day)
	Dynamical parameters	LAGEOS: const. and 1/rev along track (1 set per 10 days) LEOs: const. and 1/rev along track, 1/rev cross track (daily)
	Pseudo-stochastic pulses	LAGEOS: none LEOs: 1/rev in along track
Earth rotation parameters		X_P, Y_P, UT1-UTC (piecewise linear, 1 set per day)
Geocenter coordinates		1 set per 30 days
Earth gravity field		up to d/o 6 (1 set per 30 days)
Station coordinates		1 set per 30 days
Range biases		LAGEOS: for selected stations (1 set per 30 days) LEOs: for all stations (1 set per 30 days)

Results

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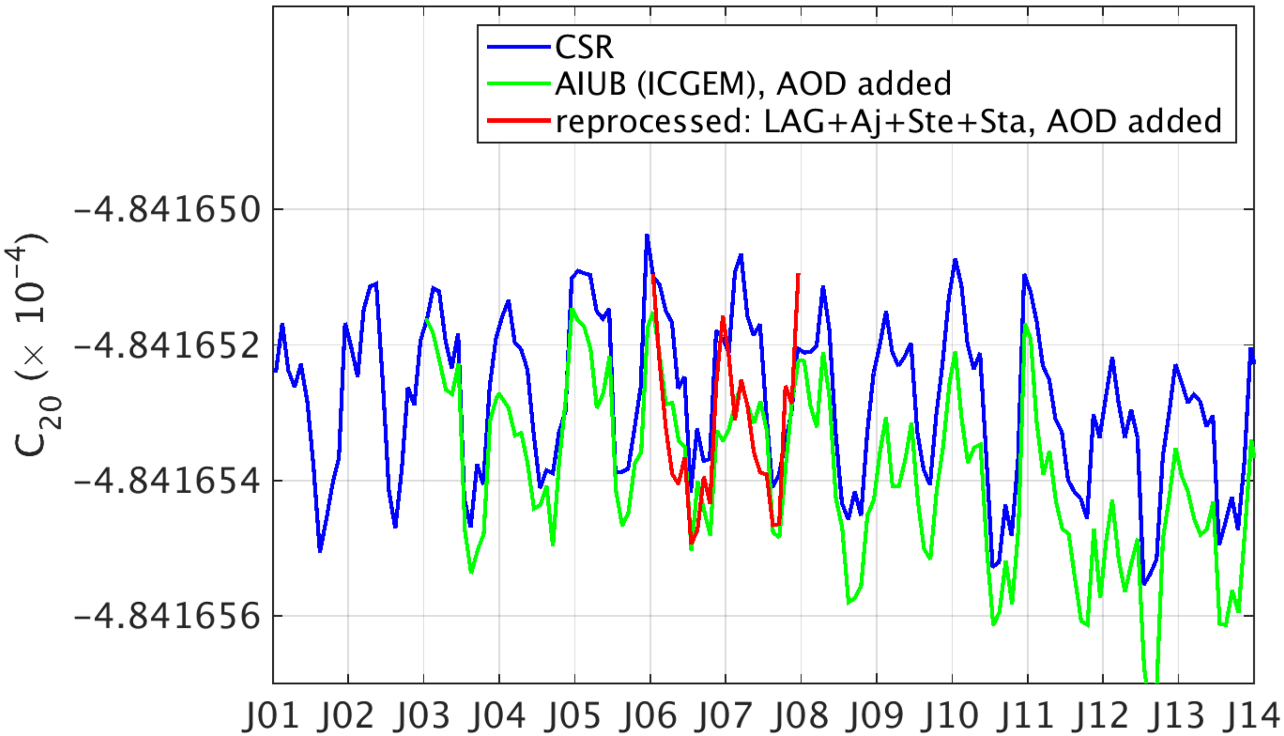
- AIUB C20 series is biased w.r.t. the CSR solution
  - difference between 01/01/2003 and 01/01/2012: ~1.03e-10

→ reprocessing is going on right now



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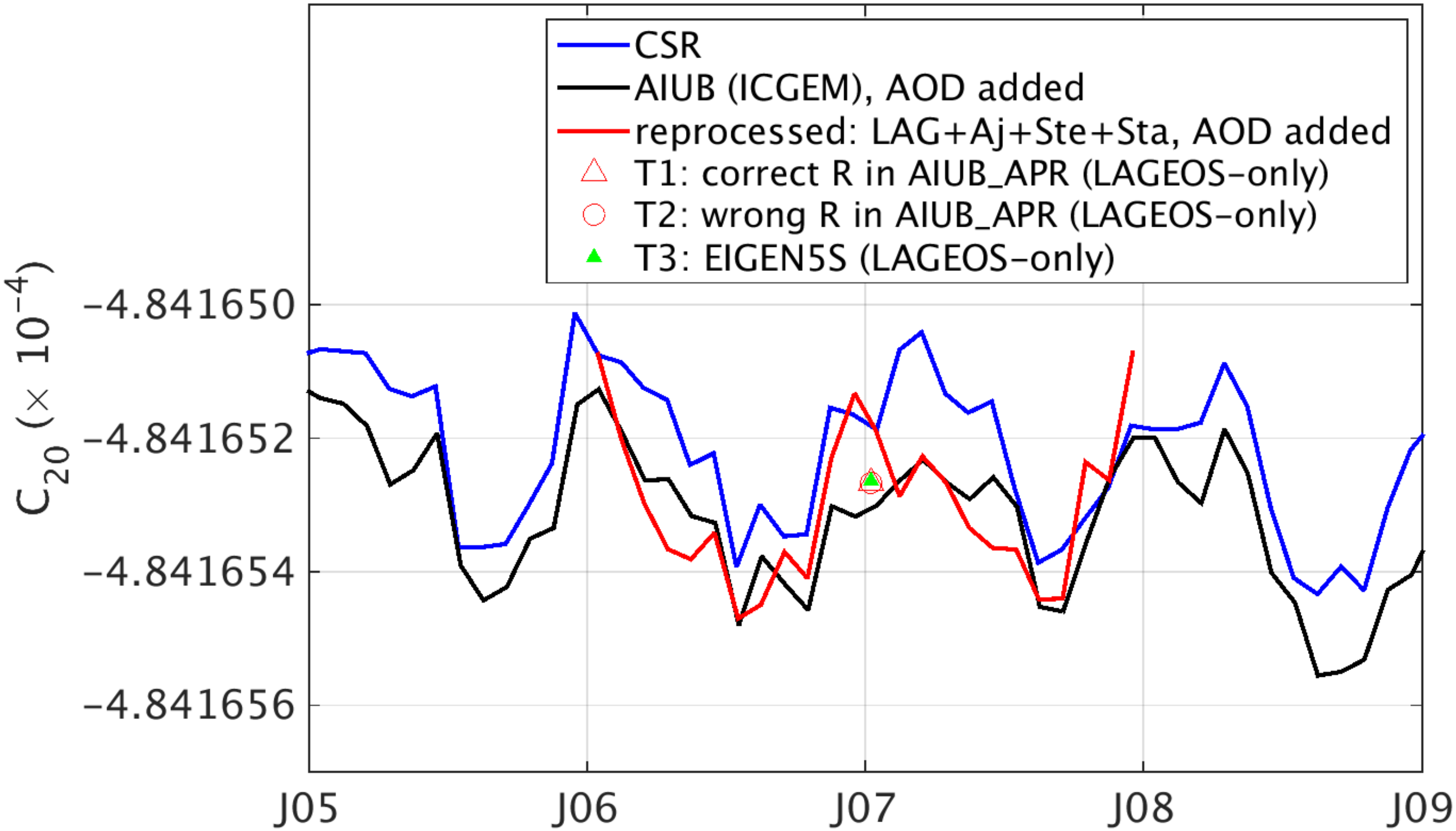
Tests



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Next steps

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- find reason for bias
- extend time series to match the mission lifetime of GRACE
- include more satellites

Available satellites:

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Satellite/Year	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Ajisai	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Beacon-C	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Blits								■	■	■	■	■		
Etalon-1	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Etalon-2	■	■	■	■	■	■	■	■	■	■	■	■	■	■
LAGEOS-1	■	■	■	■	■	■	■	■	■	■	■	■	■	■
LAGEOS-2	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Lares											■	■	■	■
Larets		■	■	■	■	■	■	■	■	■	■	■	■	■
Starlette	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Stella	■	■	■	■	■	■	■	■	■	■	■	■	■	■

EGSIEM
European Gravity Service for Improved Emergency Management

Validation with GNSS loading

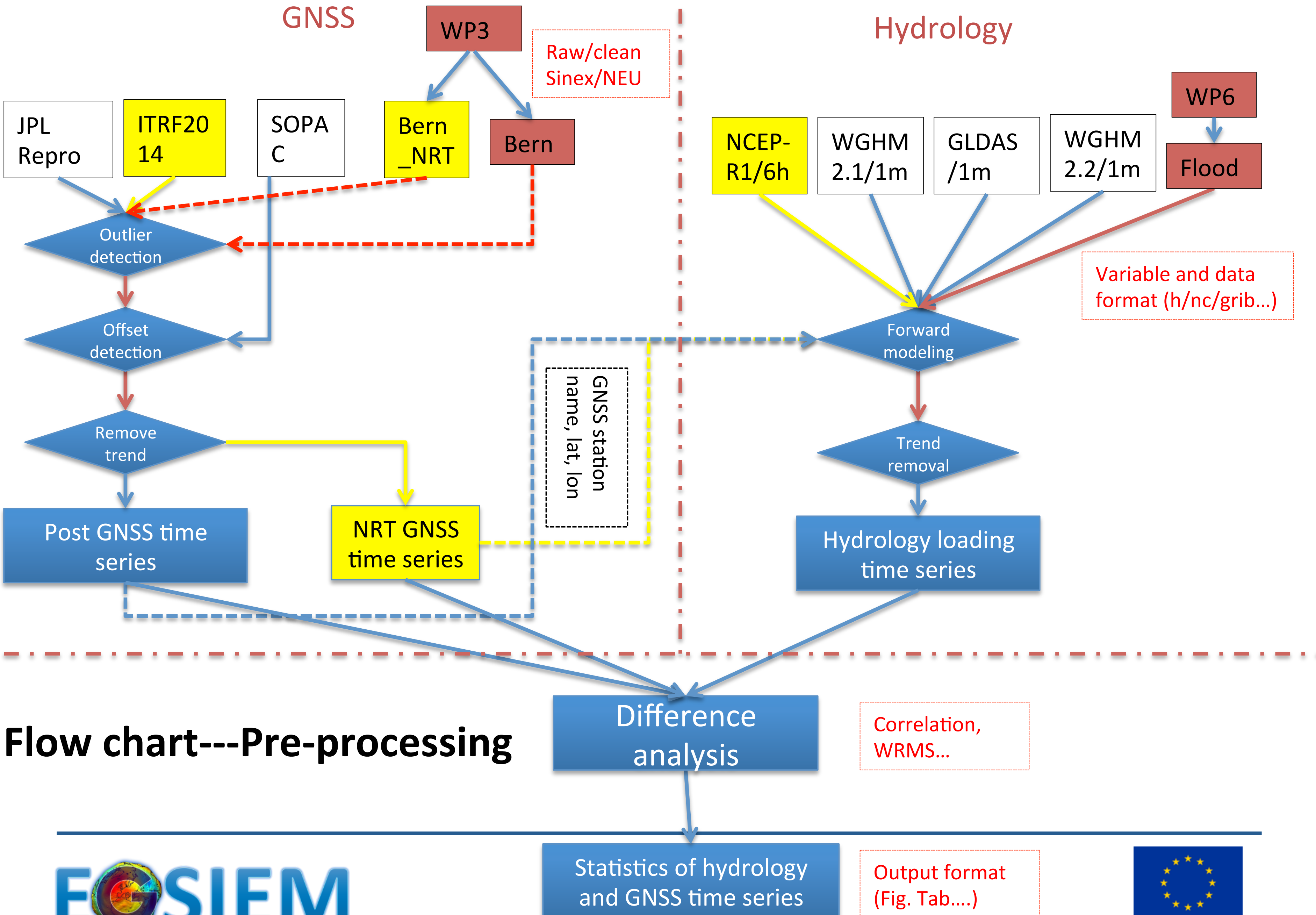
Ulux progress on WP3

Université du Luxembourg · GFZ Helmholtz Centre Potsdam · TU Graz · Leibniz Universität Hannover · cnes · DLR · géode&cie · HORIZON 2020

Validation with GNSS loading

- 3-step concept
  - Data pre-processing
  - Data processing
  - Output (Correlation coefficient, WRMS reduction...)

Flow chart---Pre-processing



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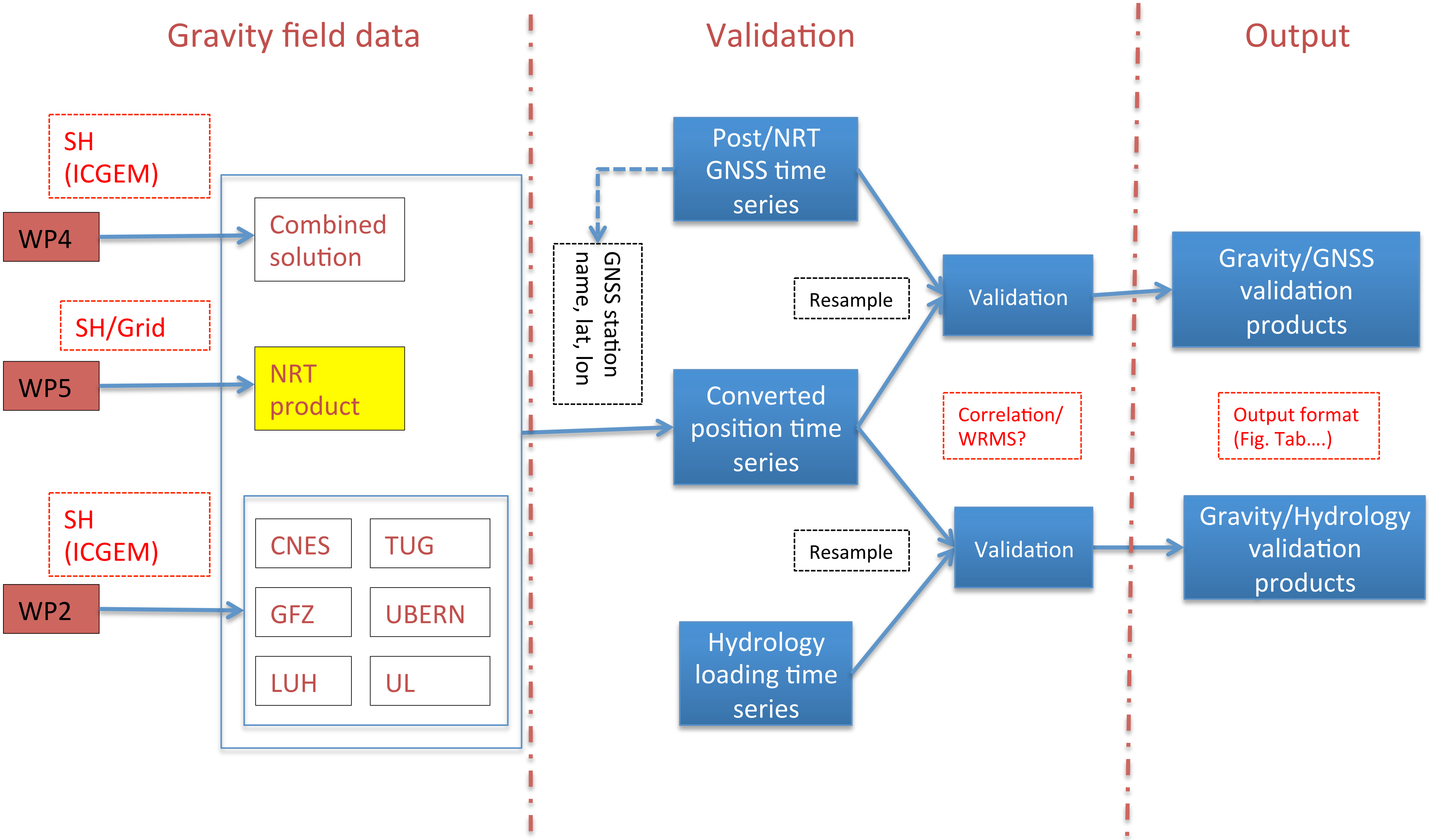
Flow chart---Data-processing and output



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Data

- GNSS data
  - Latest global daily GPS time series from JPL and SOPAC (ftp://garner.ucsd.edu/pub/timeseries/measures/ats/Global)
    - Cleaned,detrended, outlier removed
    - Nearly real time
  - Latest ITRF2014 GPS residuals (IGN)
    - Rigorously stacking the latest IGS repro2 solutions
- Continental Water Storage Models
  - GLDAS, monthly, 3-4m latency
  - WGHM_2.1f6, monthly, 2002-12/2013
  - WGHM_2.2_STANDARD, latest official version, 2002-10/2010, m and d
  - WGHM_2.2_STANDARD_CRU, a modification of 2.2standard, -12/2012,but not calibrated for the climate input
  - NCEP-R1
    - 3-4d latency, NRT validation only
- Gravity model
  - EGSIEM combined solution, 2003-2014
    - Global converted displacement both with GAC added back and without GAC

Hydrology .VS. GNSS

Percentage of JPL/SOPAC/ITRF stations with height WRMS reduced when GPS vertical observations are corrected for the various water storage models (528 Common stations)			
	JPL (458 effective stations)	**SOPAC (408 effective stations)**	**ITRF2014 (494 effective stations)**
GLDAS	58.73	77.94	79.55
WGHM_2.1f6	55.24	75.98	74.90
WGHM_2.2STANDARD	67.29	80.95	81.40
WGHM_2.2STANDARD_CRU	62.90	80.71	81.09

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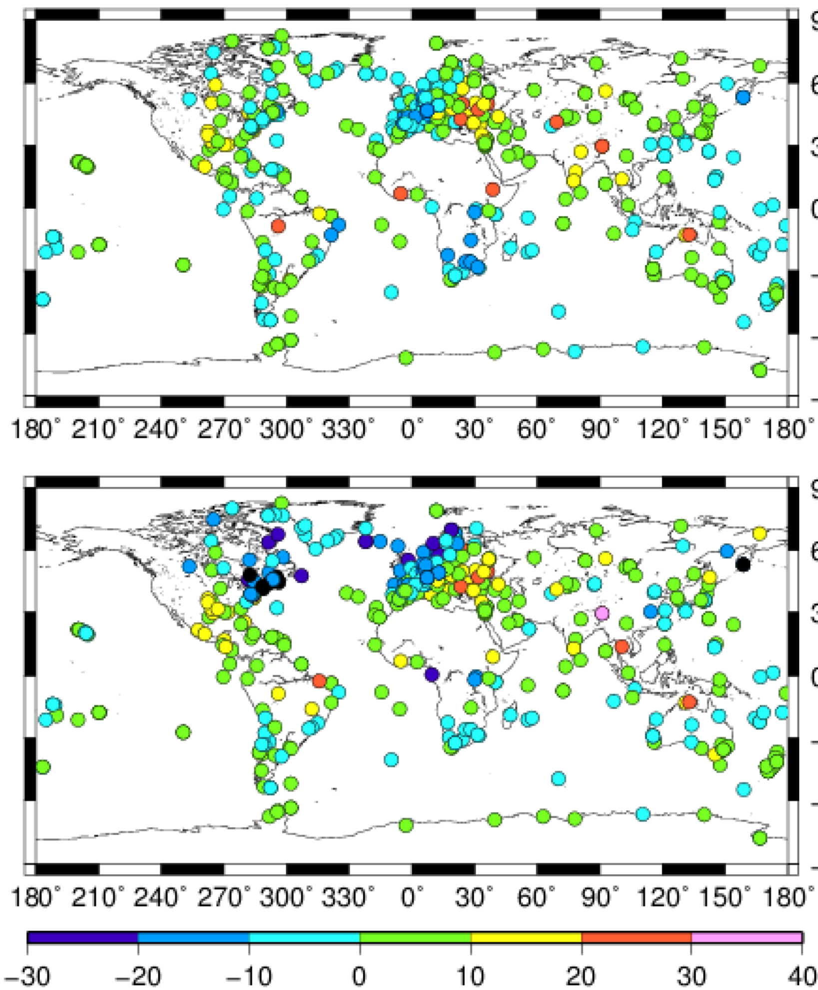
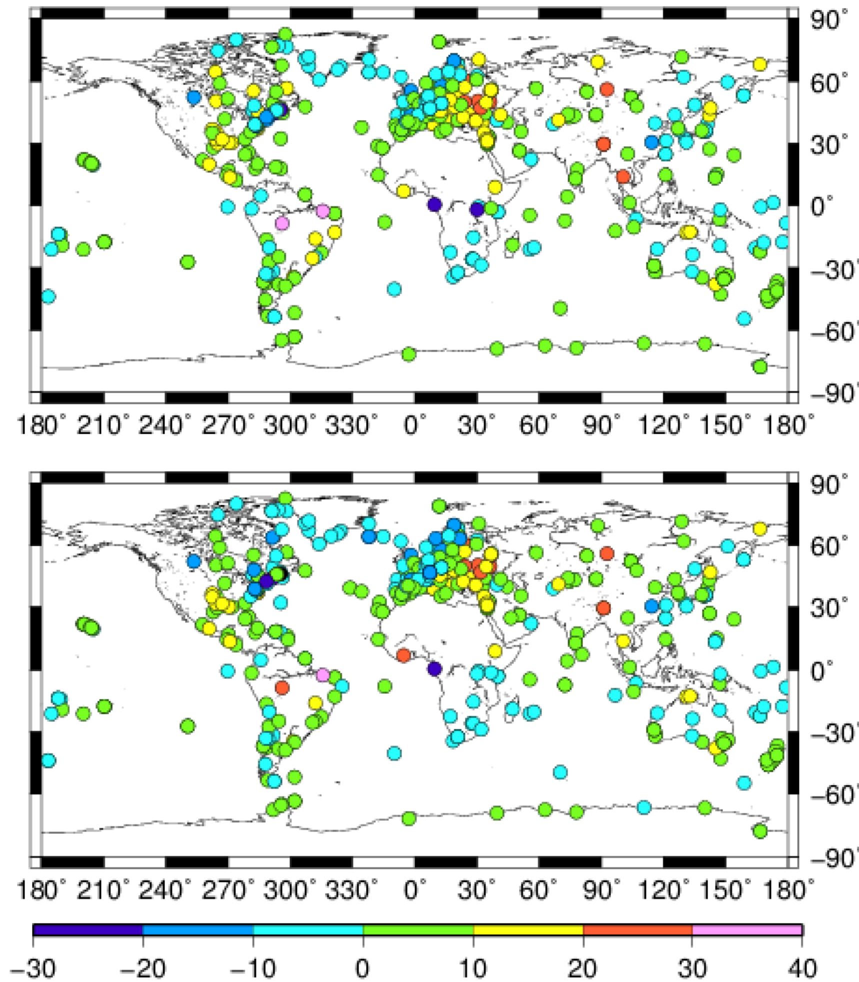
GNSS .VS. Hydrology (JPL)

gldas .vs. wghm2.1



wghm2.2standard .vs. standcru



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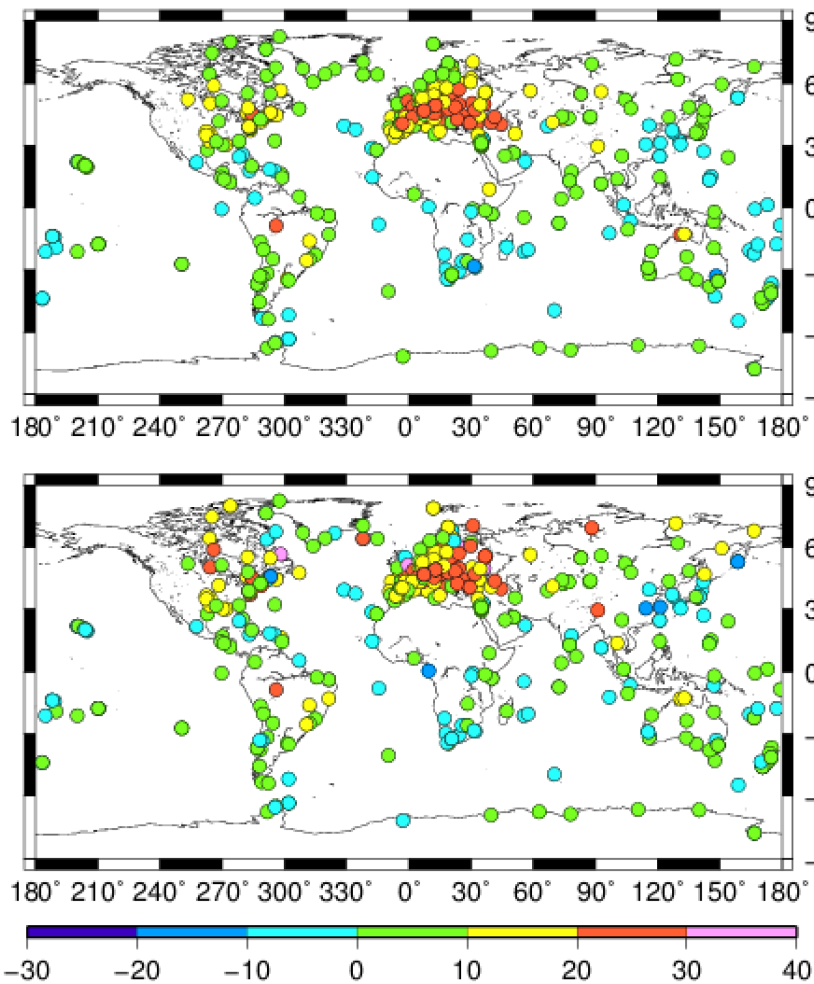
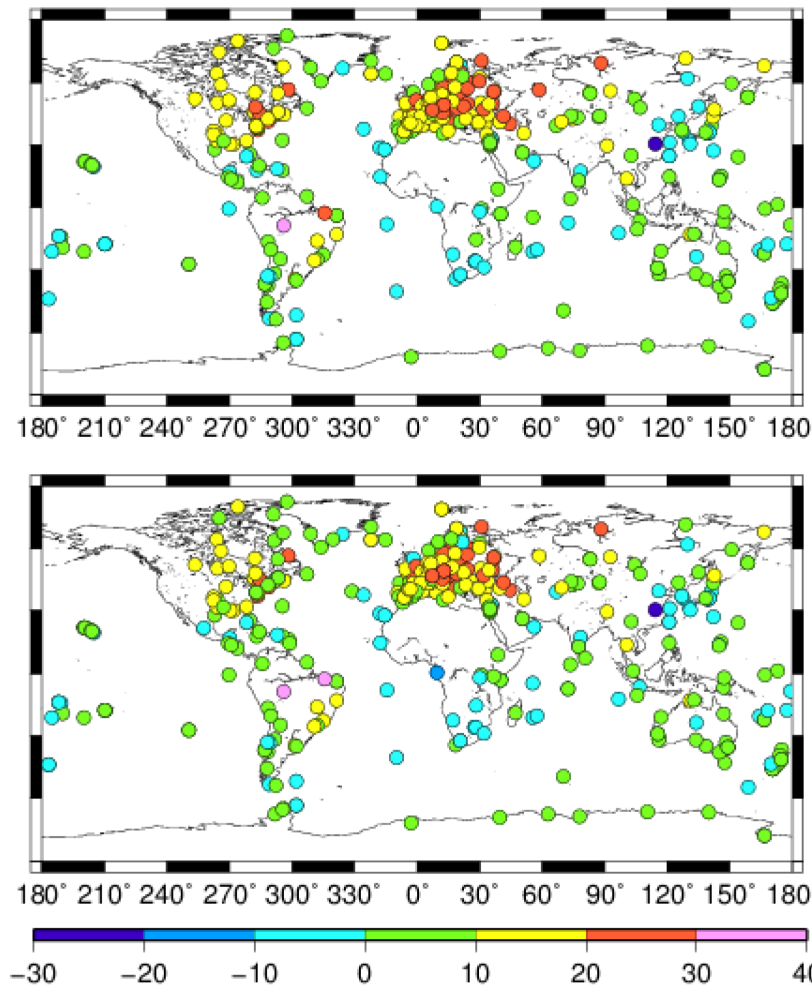
GNSS .VS. Hydrology (SOPAC)

gldas .vs. wghm2.1



wghm2.2standard .vs. standcru

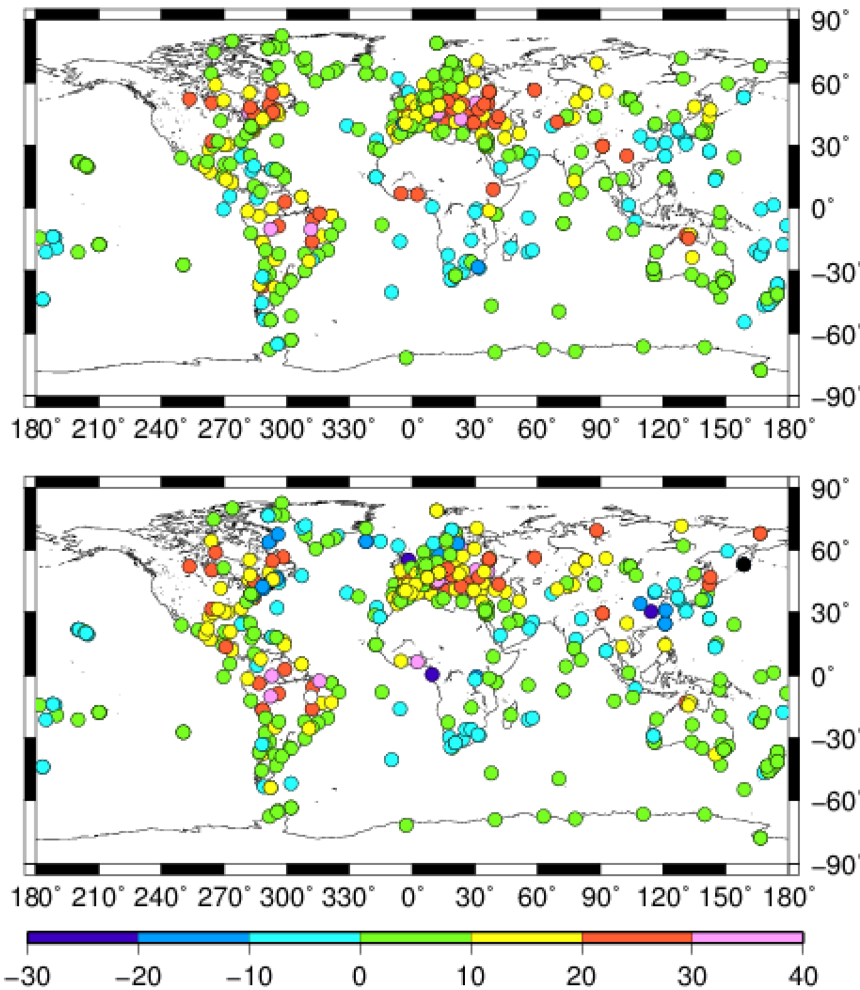


EGSIEM

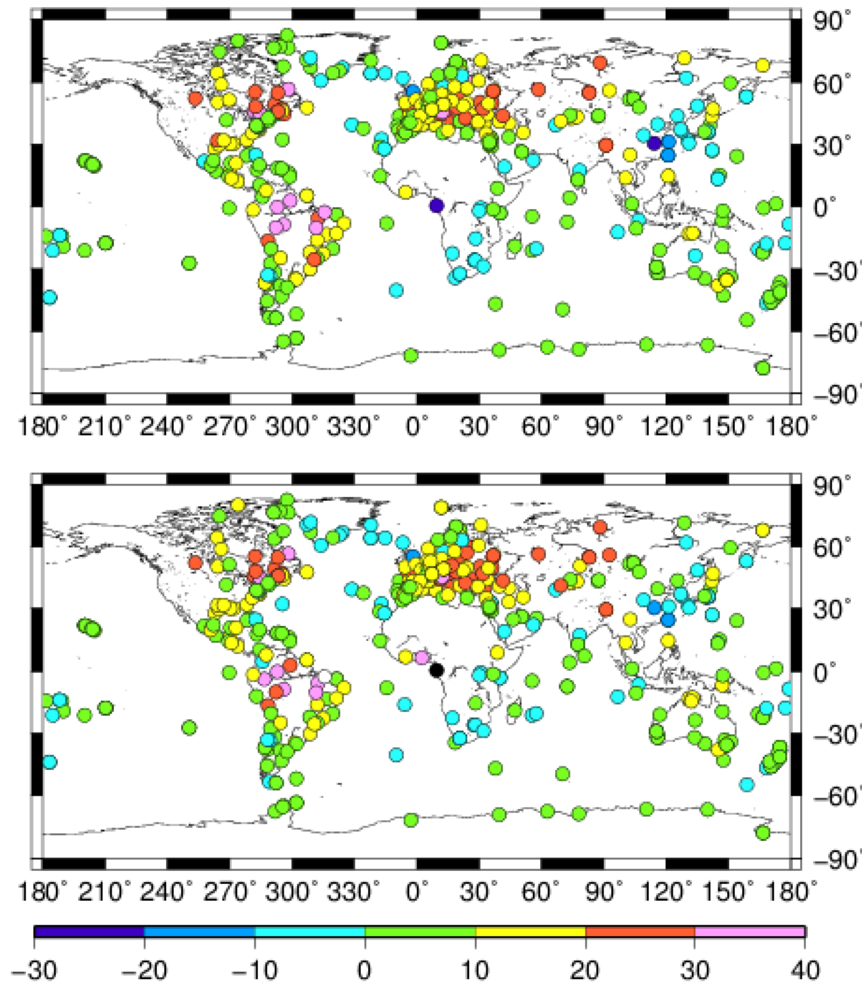
HORIZON 2020

GNSS .VS. Hydrology (ITRF2014)

gldas .vs. wghm2.1



wghm2.2standard .vs. standcru



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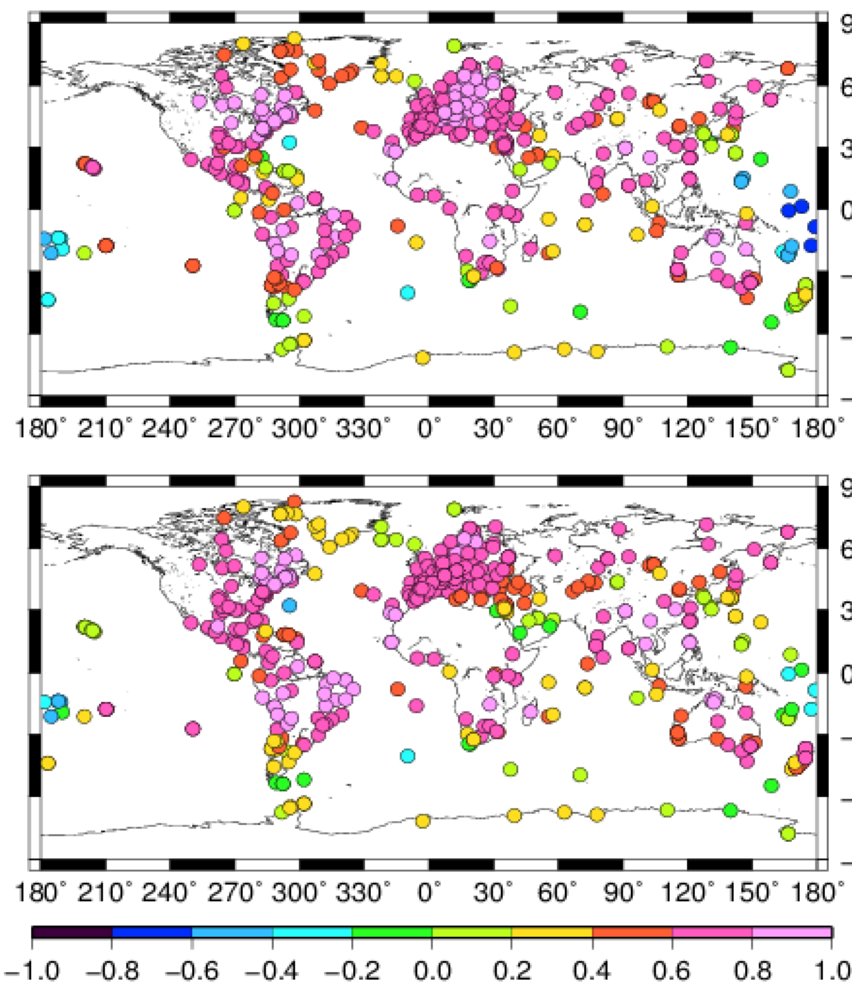
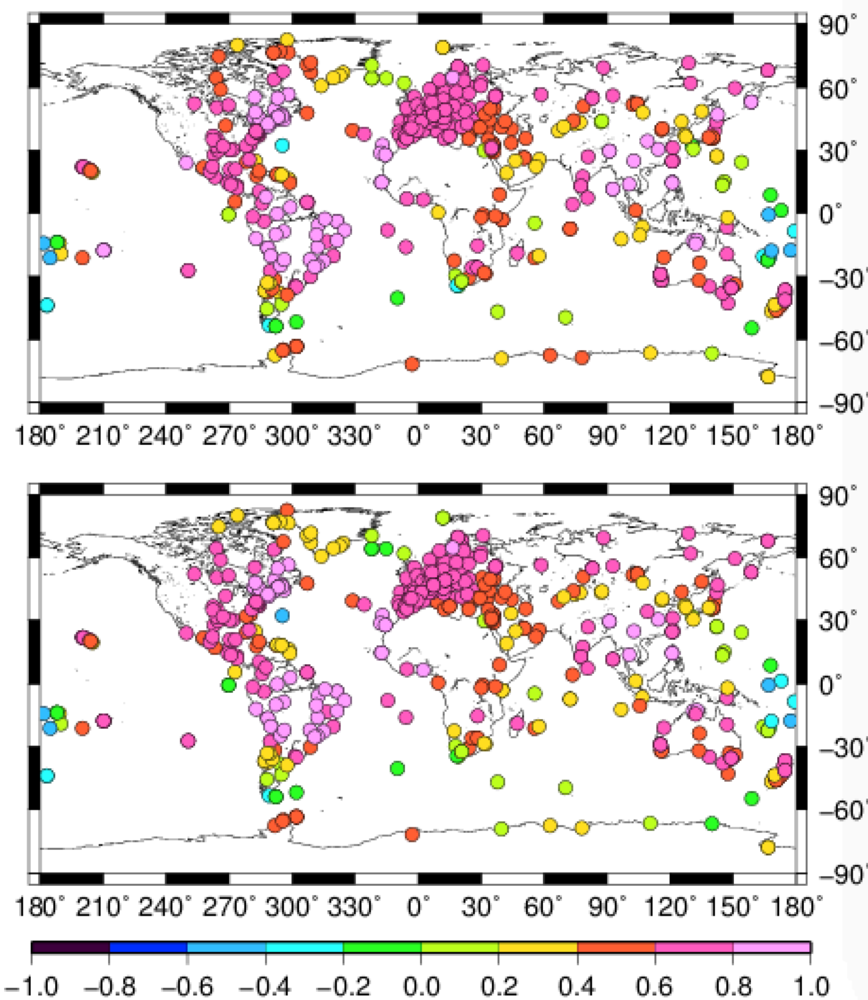
Hydrology .VS. EGSIEM

gldas_wghm2.1 .vs. egsiem



wghm2.2standard_cru .vs. egsiem



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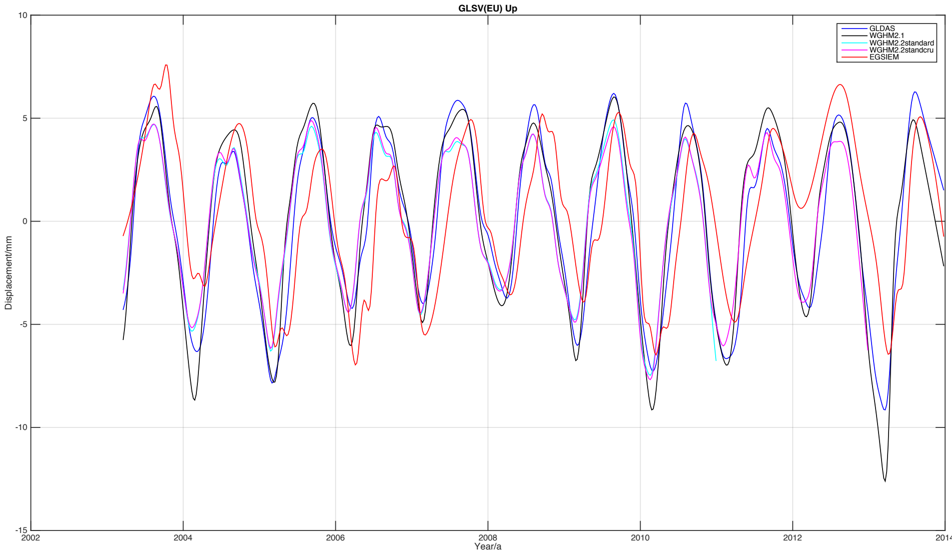
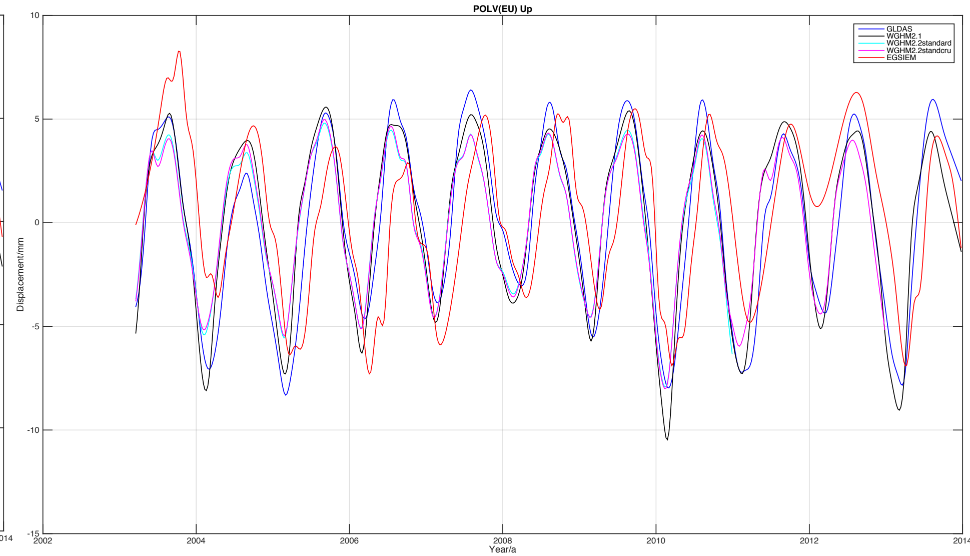
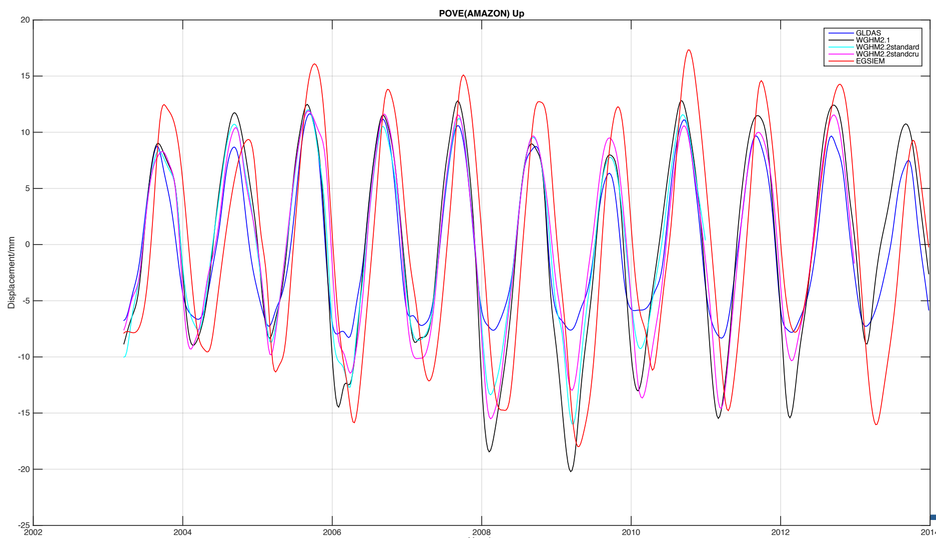
Hydrology .VS. EGSIEM

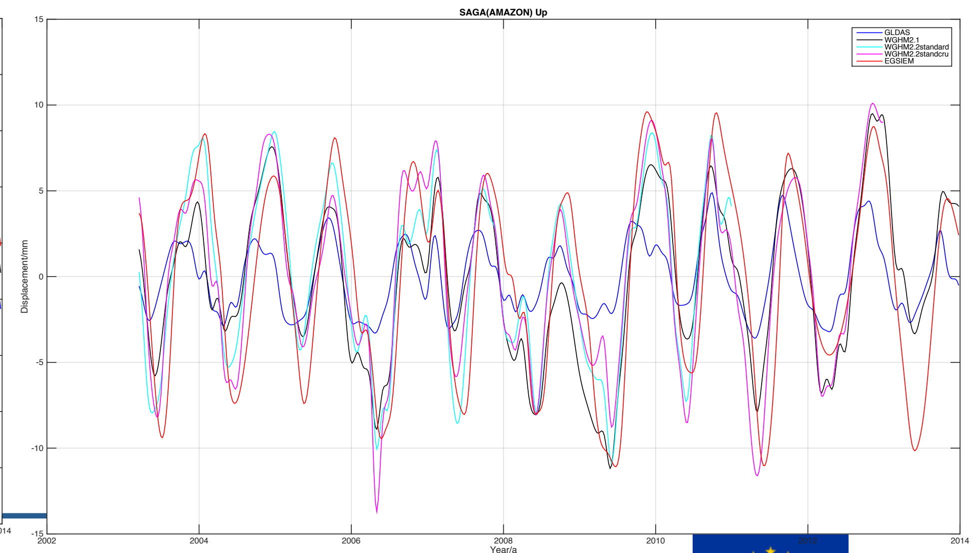
Hydrology .vs. EGSIEM (correlation coefficient)	mean	min	max	Percentage of stations with correlation > 0.6 (528 common stations totally)
GLDAS	0.5590	-0.6843	0.9079	63.45(335)
WGHM2.1	0.5489	-0.5783	0.9455	58.14(307)
WGHM2.2standard	0.5641	-0.5141	0.9425	59.66(315)
WGHM2.2standcru	0.5426	-0.5237	0.9306	55.30(292)

Hydrology .VS. EGSIEM









EGSIEM

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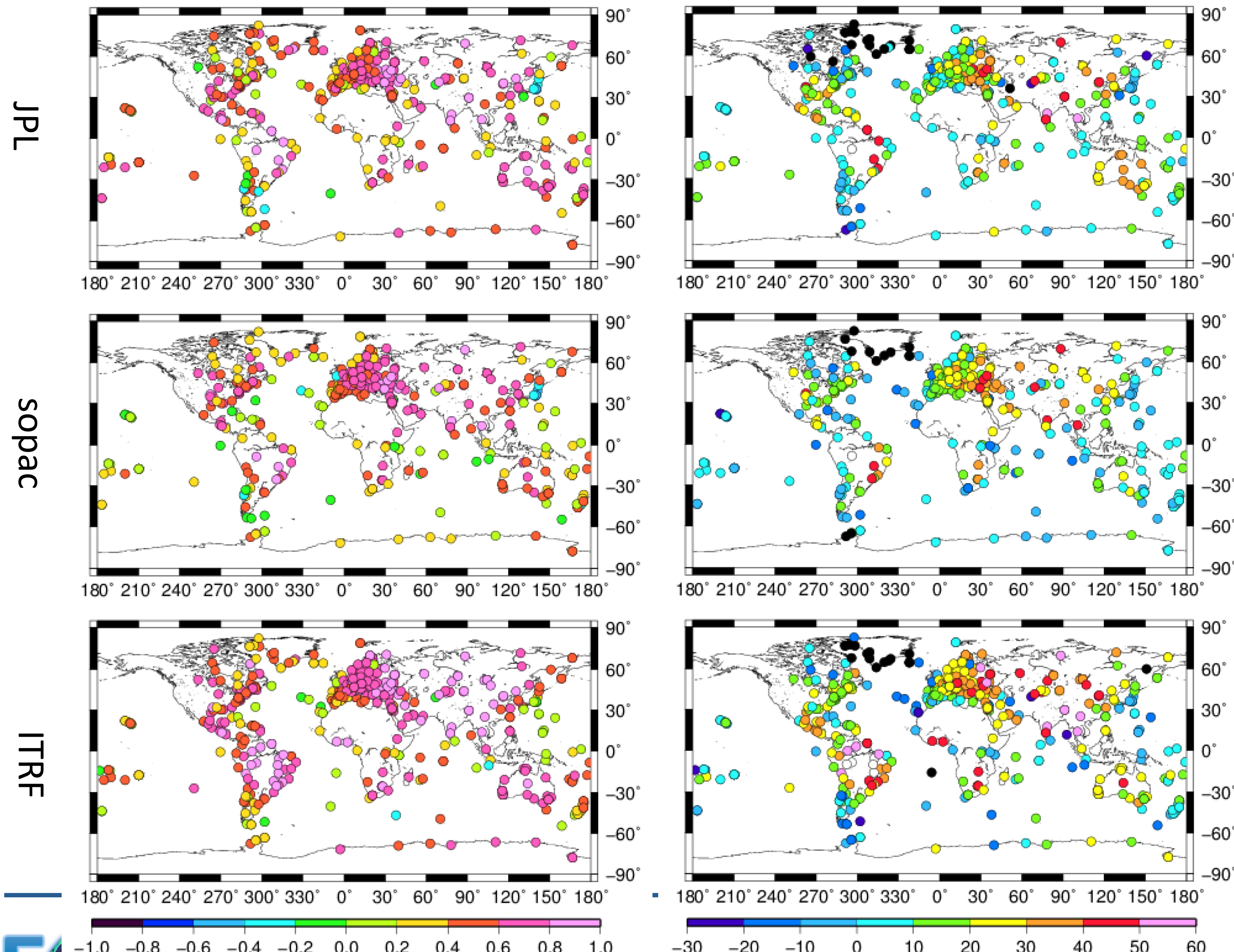
GNSS .VS. EGSIEM

GNSS .vs. EGSIEM (correlation coefficient/wrms reduction rate)	mean	min	max	Percentage of stations with correlation > 0.6 (528 common stations totally)	Percentage of stations with wrms reduced
JPL	0.4888	-0.5549	0.9766	39.58(171/432)	80.79(349/432)
SOPAC	0.4445	-0.5534	0.9674	38.56(150/389)	76.61(298/389)
ITRF2014	0.5438	-0.3085	0.9720	49.79(233/468)	79.06(370/468)

GNSS .VS. EGSIEM



EGSIEM

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Conclusions

- Post validation
  - Almost done
    - GNSS .vs. Hydrology
      - ITRF2014, WGHM_2.2_STANDARD, best; Sopac the second, JPL also works
    - GNSS .vs. EGSIEM
      - Very good consistency
    - Hydrology .vs. EGSIEM
      - EGSIEM has the best consistency with GLDAS, WGHM2.2_STANDARD the second
  - Latest ITRF2014 GPS residuals
    - Rigorously stacking the latest IGS repro2 solutions
- NRT validation
  - Partly done
    - CWS- NCEP-R1, WGHM?
    - GNSS-SOPAC, JPL
    - Gravity-waiting…
- Open questions
  - Treatment of atmospheric and non-tidal ocean loading

Validation of simulated and GRACE based ocean bottom pressure time series against in situ observations

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Henryk Dobslaw, Frank Flechtner

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Section 1.3: Earth System Modelling
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Motivation

Motivation

Motivation


GRACE
Gravity Recovery And Climate Experiment
Level-2 Products

Motivation


GRACE
Gravity Recovery And Climate Experiment
JPL
Level-2 Products

Motivation


GRACE
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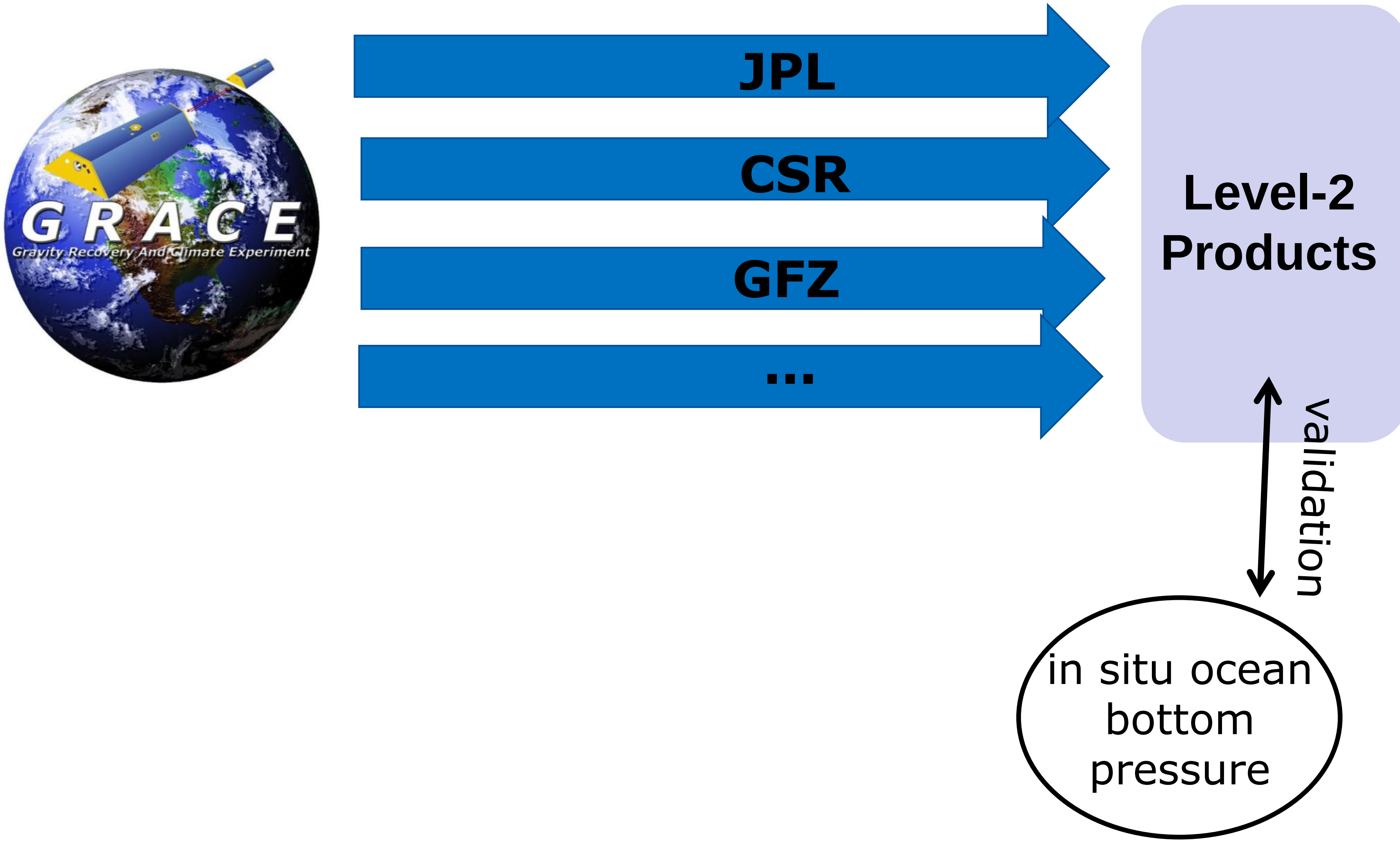
Motivation


GRACE
Gravity Recovery And Climate Experiment
JPL
CSR
GFZ
...
Level-2
Products
validation

Motivation


GRACE
Gravity Recovery And Climate Experiment
JPL
CSR
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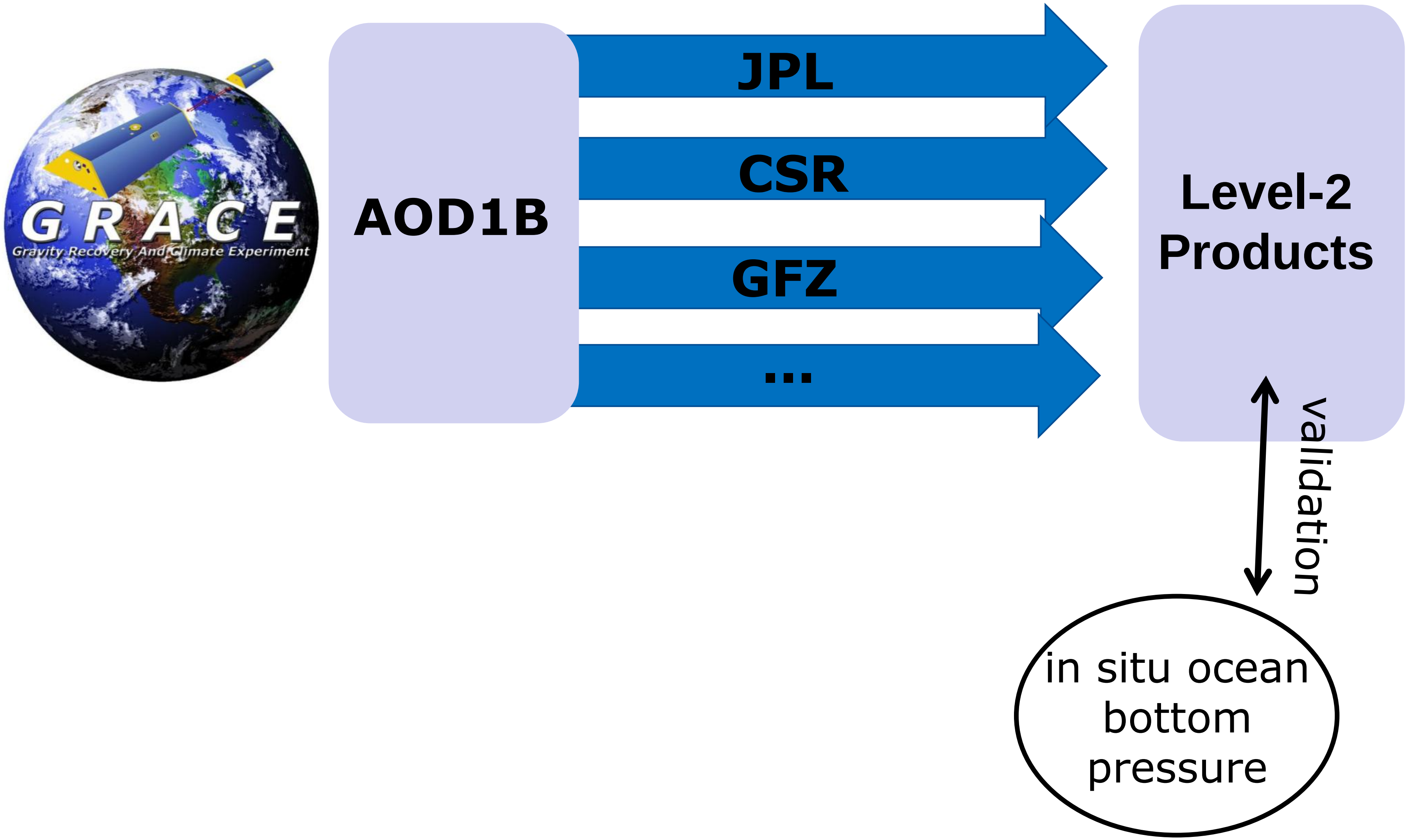
...
Level-2 Products
validation
in situ ocean bottom pressure

Motivation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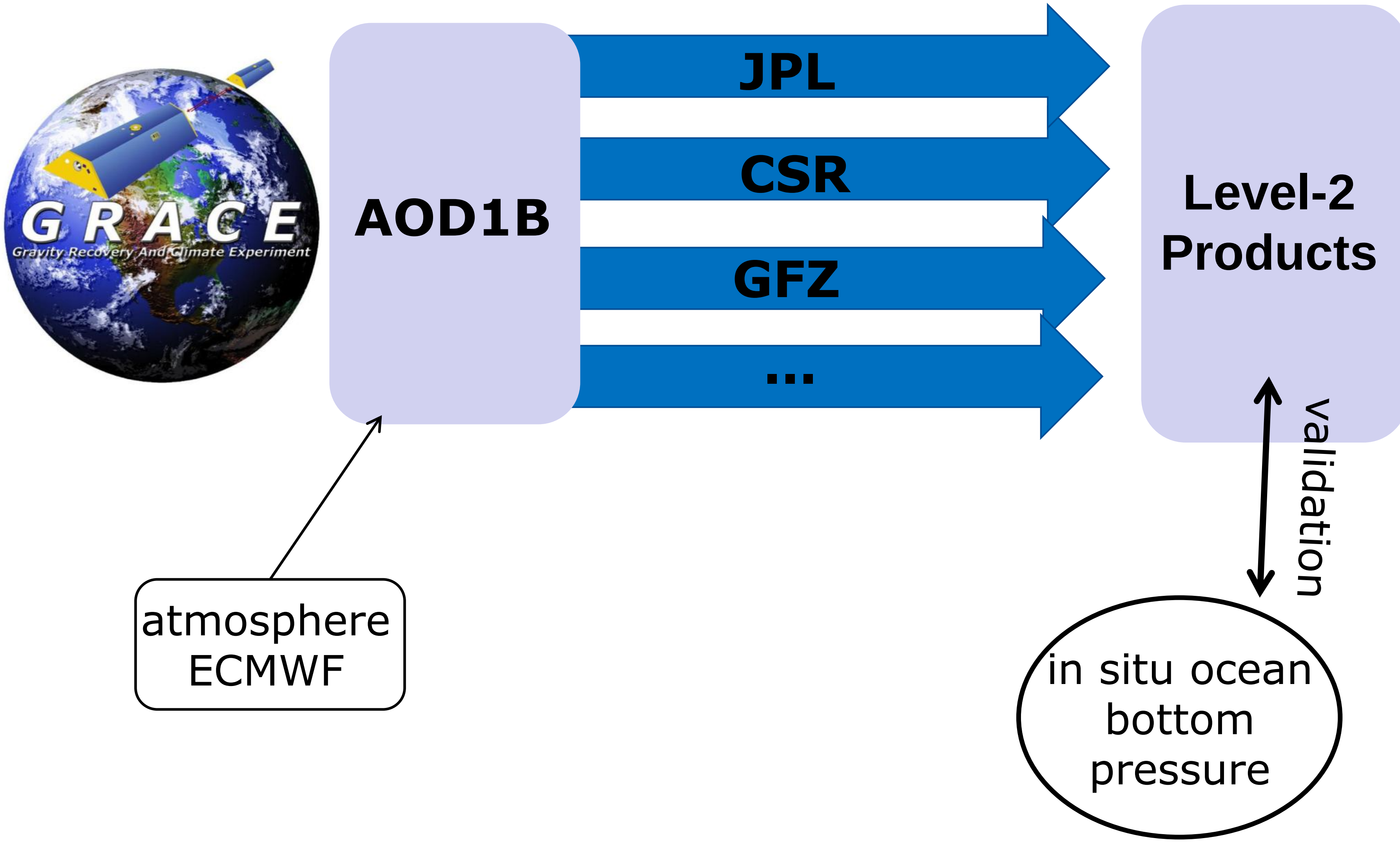
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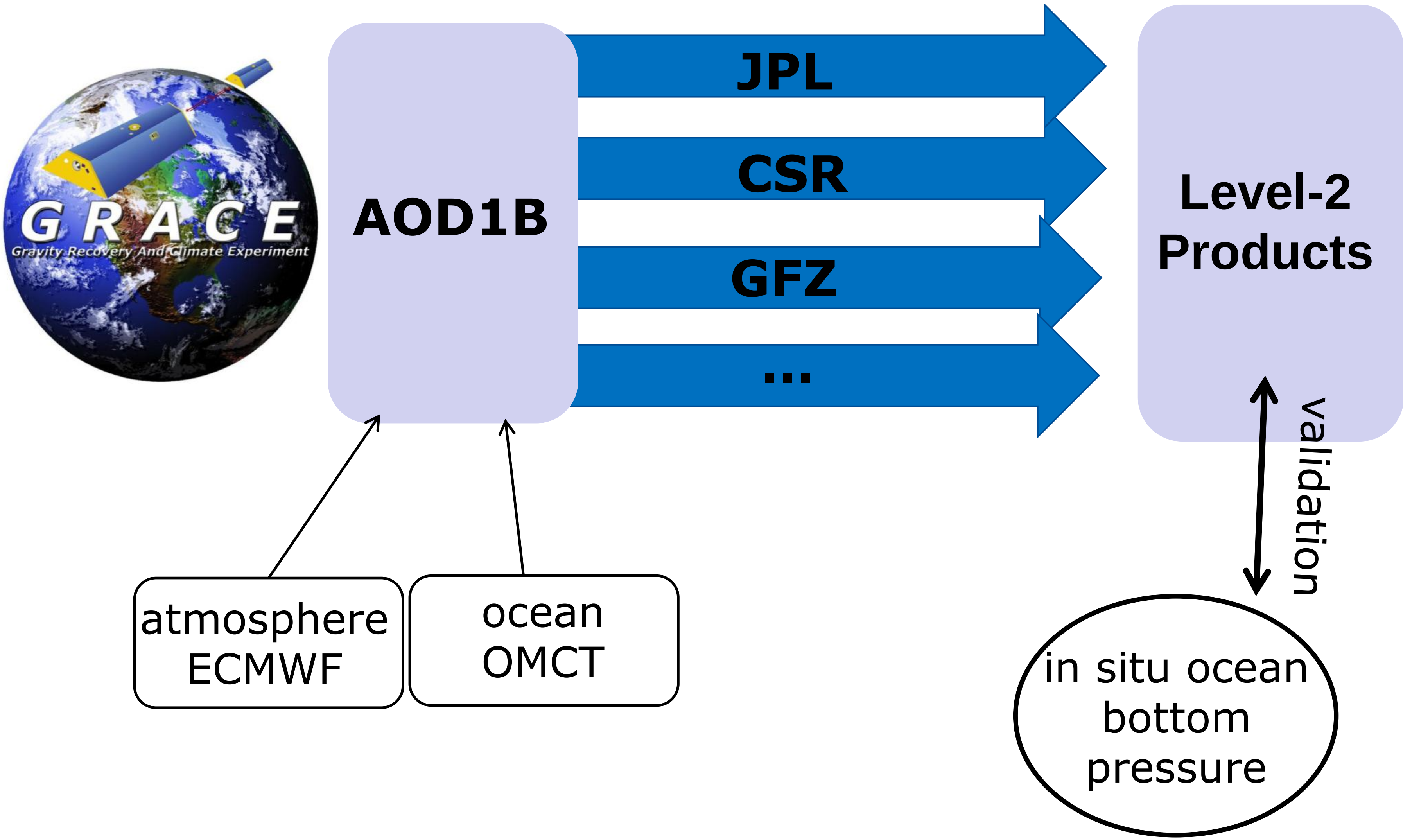
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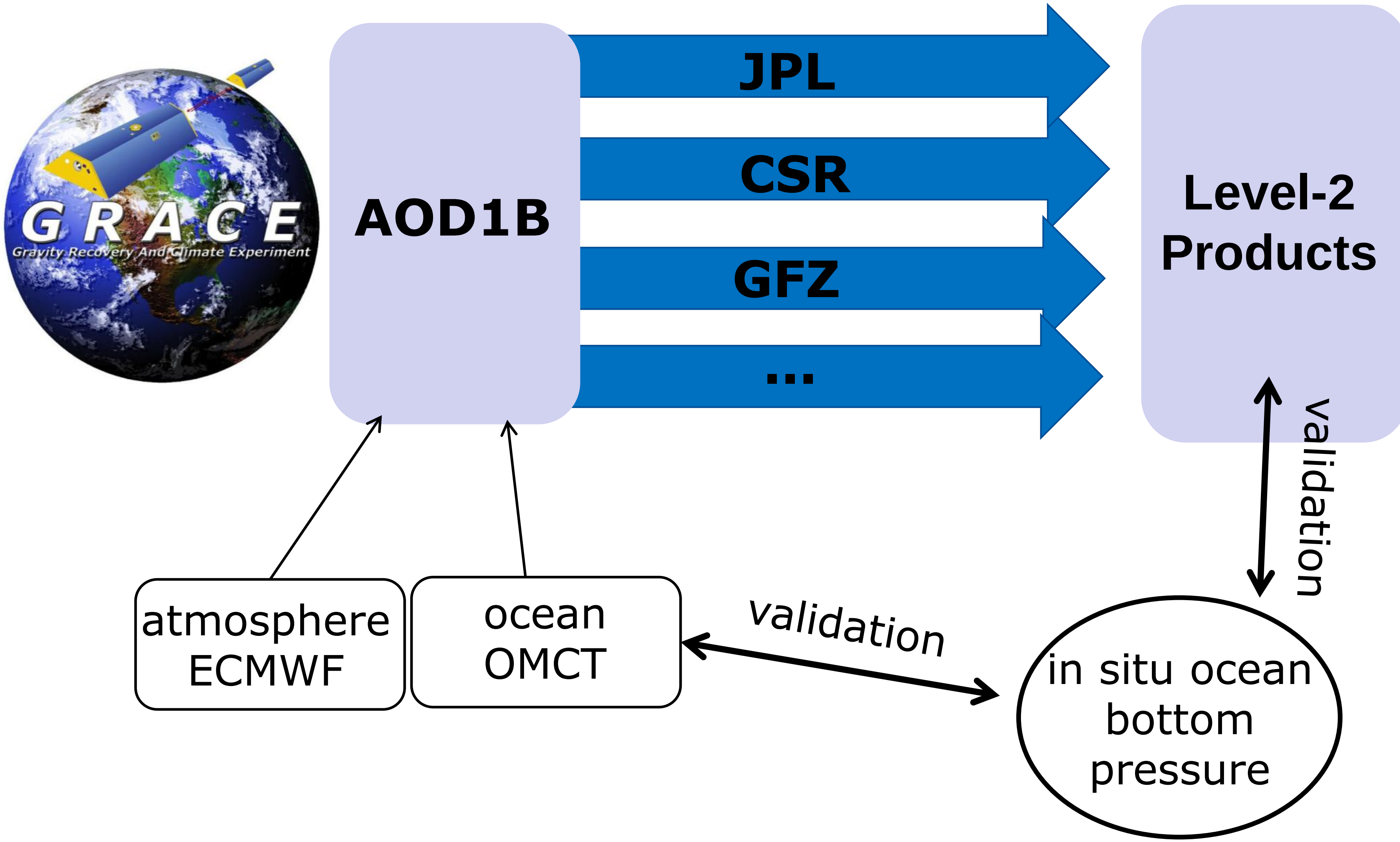
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Preprocessing of in situ data

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- removing outliers, drifts, jumps and trends
- changing time step to 1 hour

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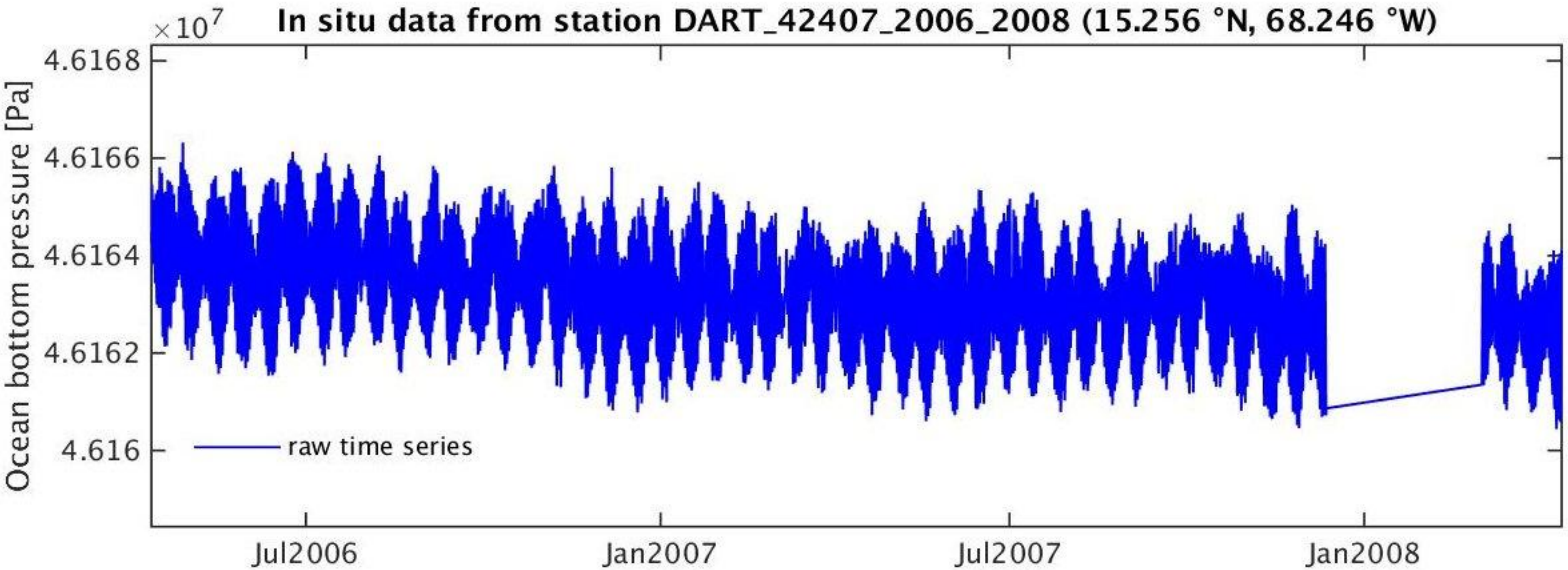

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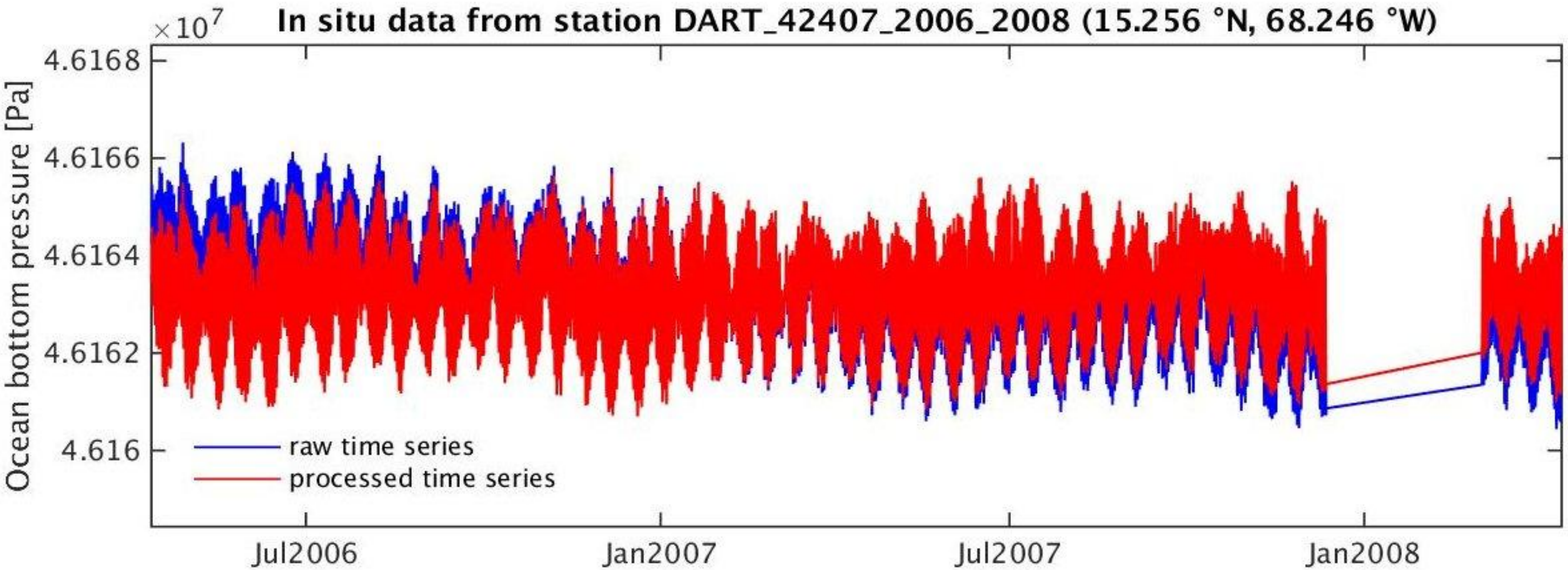

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Preprocessing of in situ data

- removing outliers, drifts,
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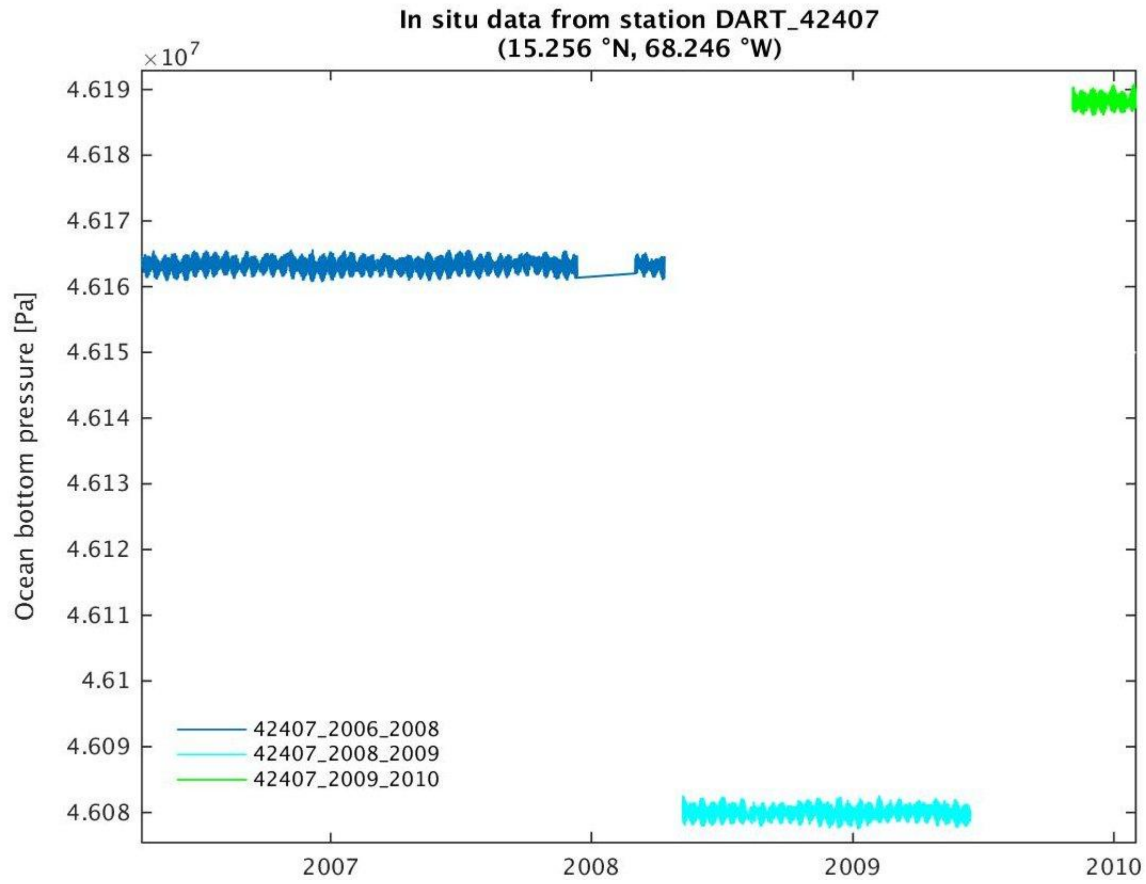

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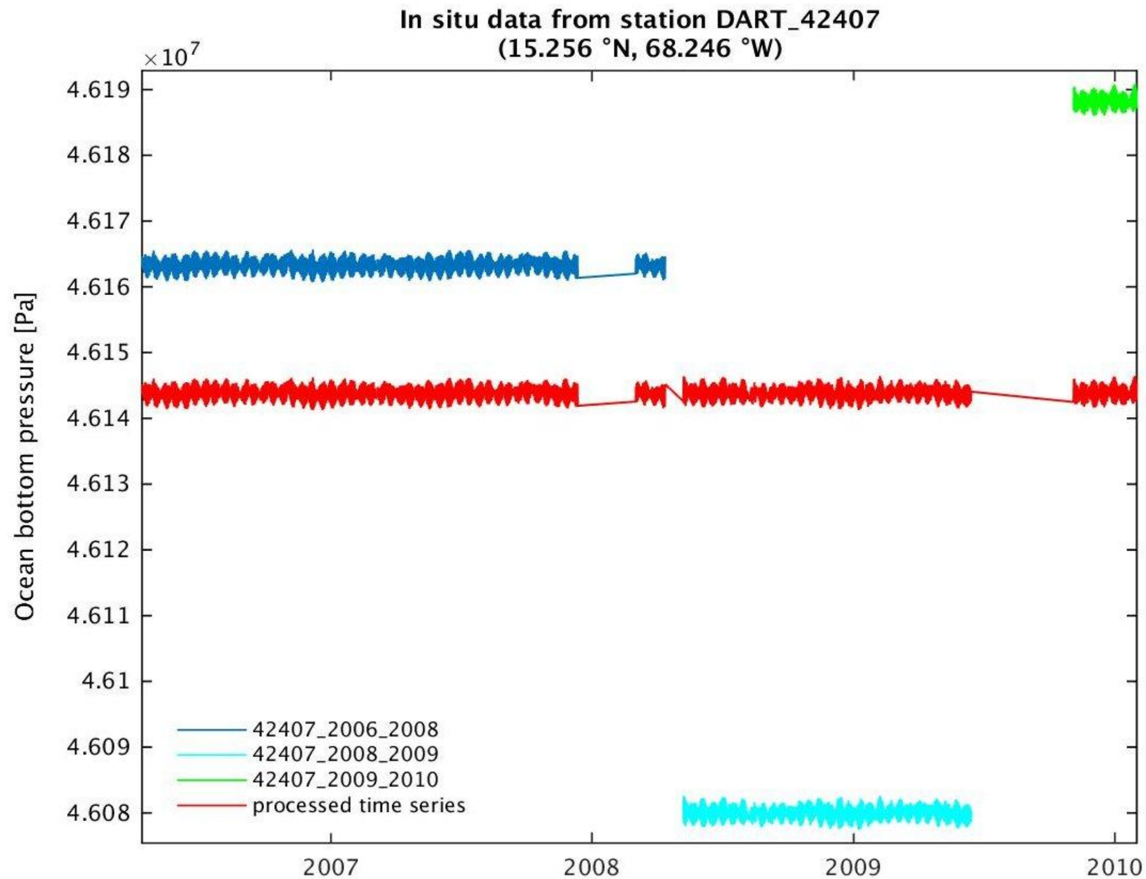

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- removing tidal signal → T_TIDE MATLAB package for classical harmonic analysis [Pawlowicz et al., 2002]

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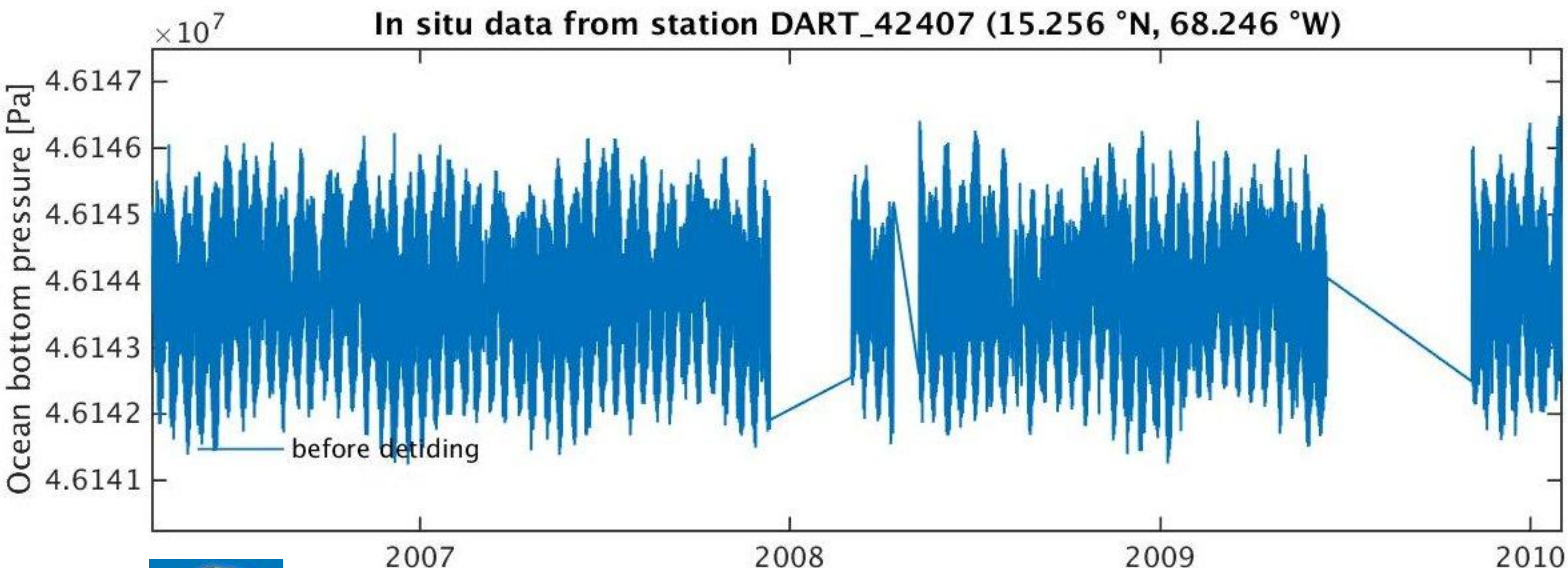

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Preprocessing of in situ data

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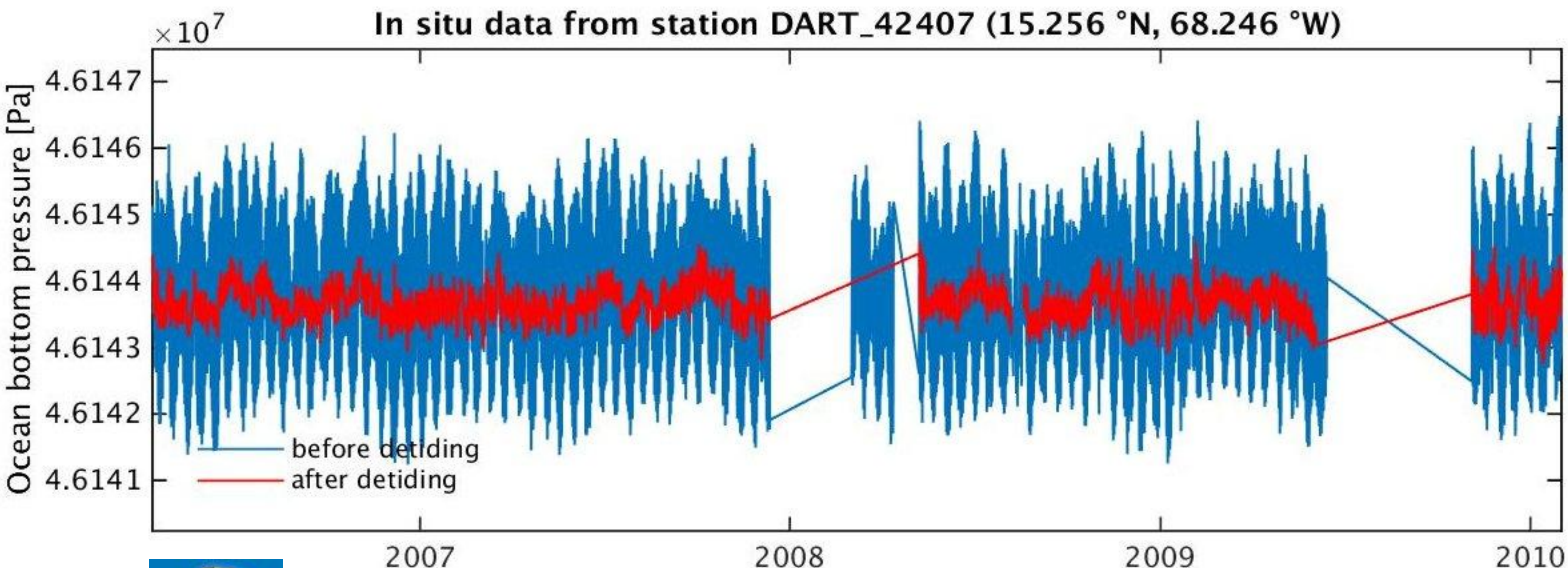

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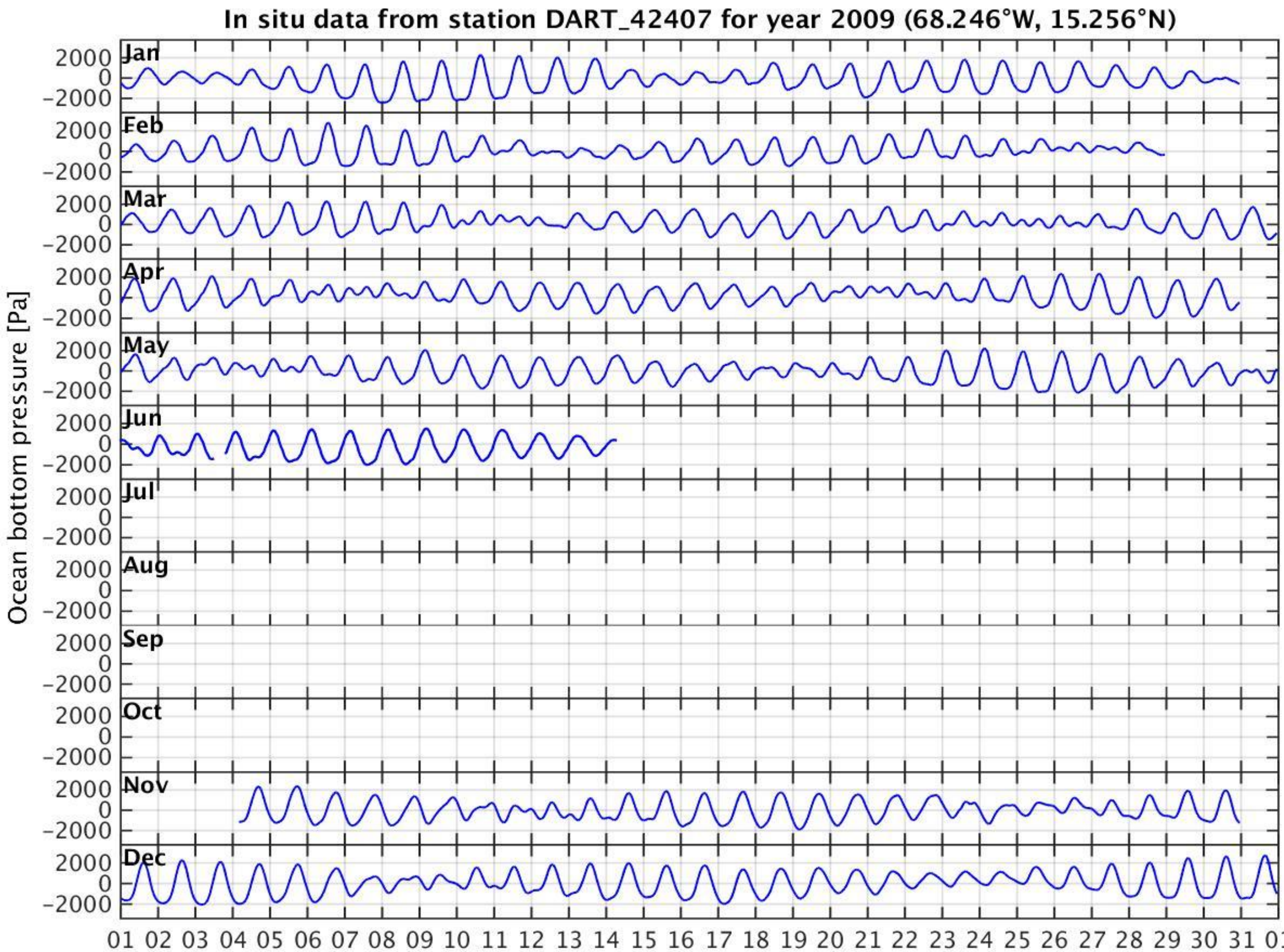

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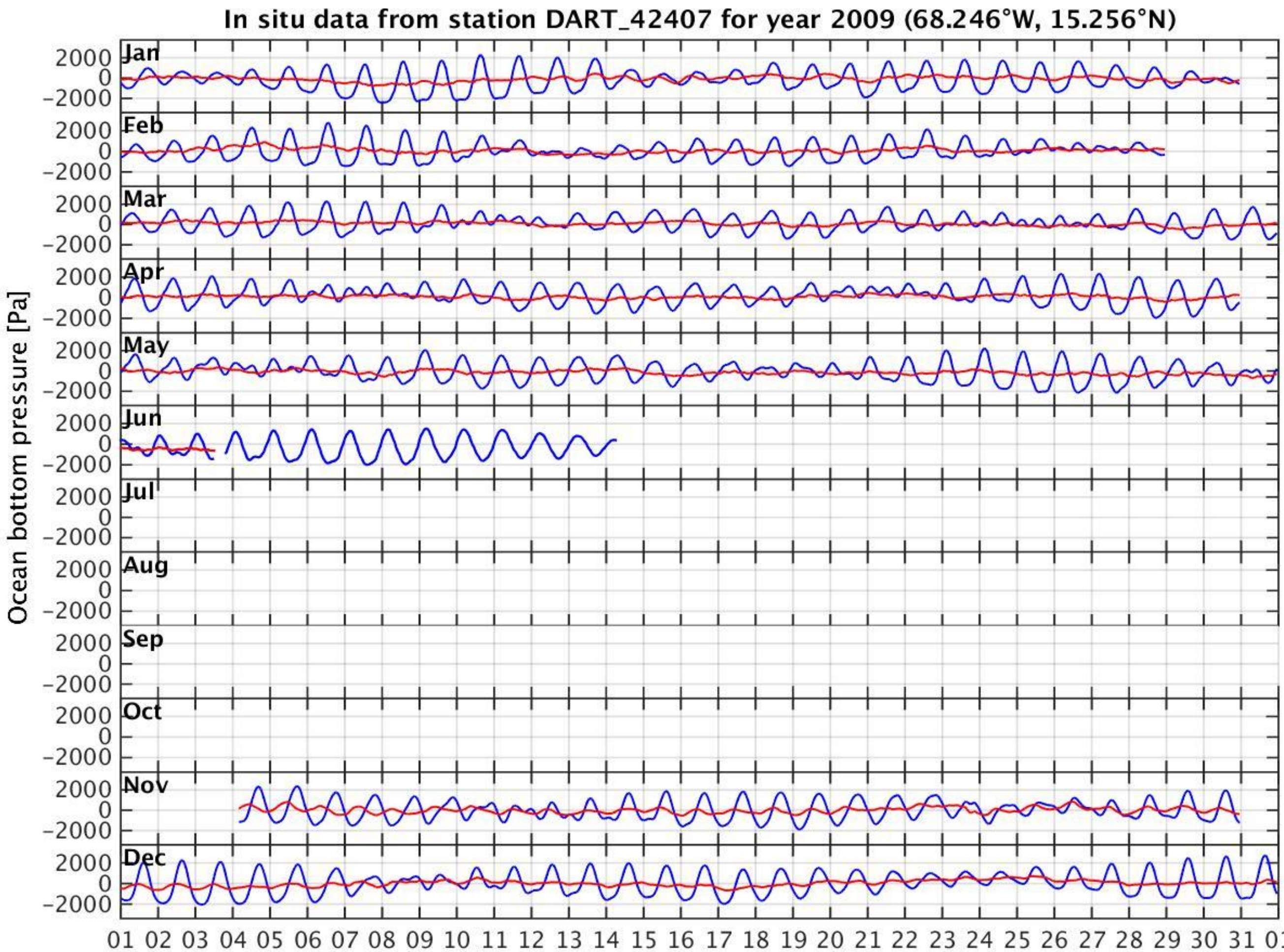

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Butterworth low pass filter

T_TIDE MATLAB package for classical harmonic analysis [Pawlowicz et al., 2002]

4 frequency bands:

•1-3 days
•3-10 days
•10-30 days
•1-30 days

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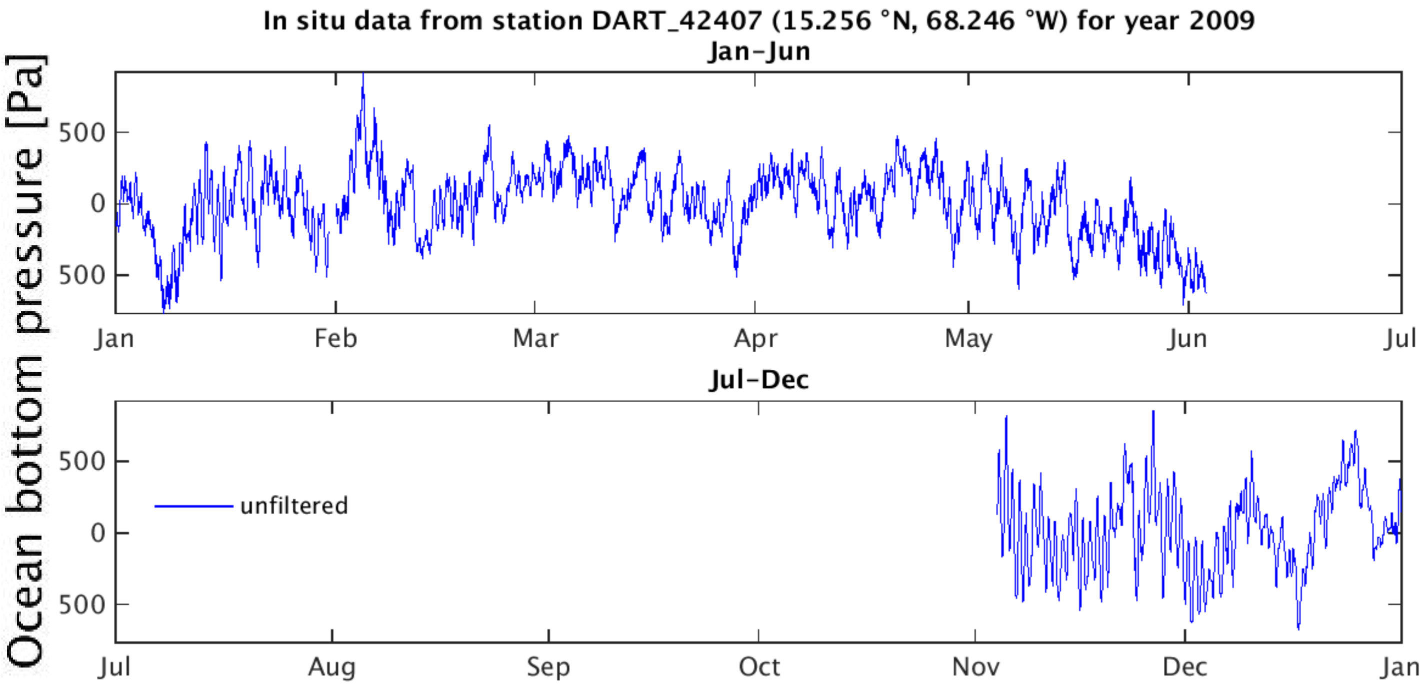

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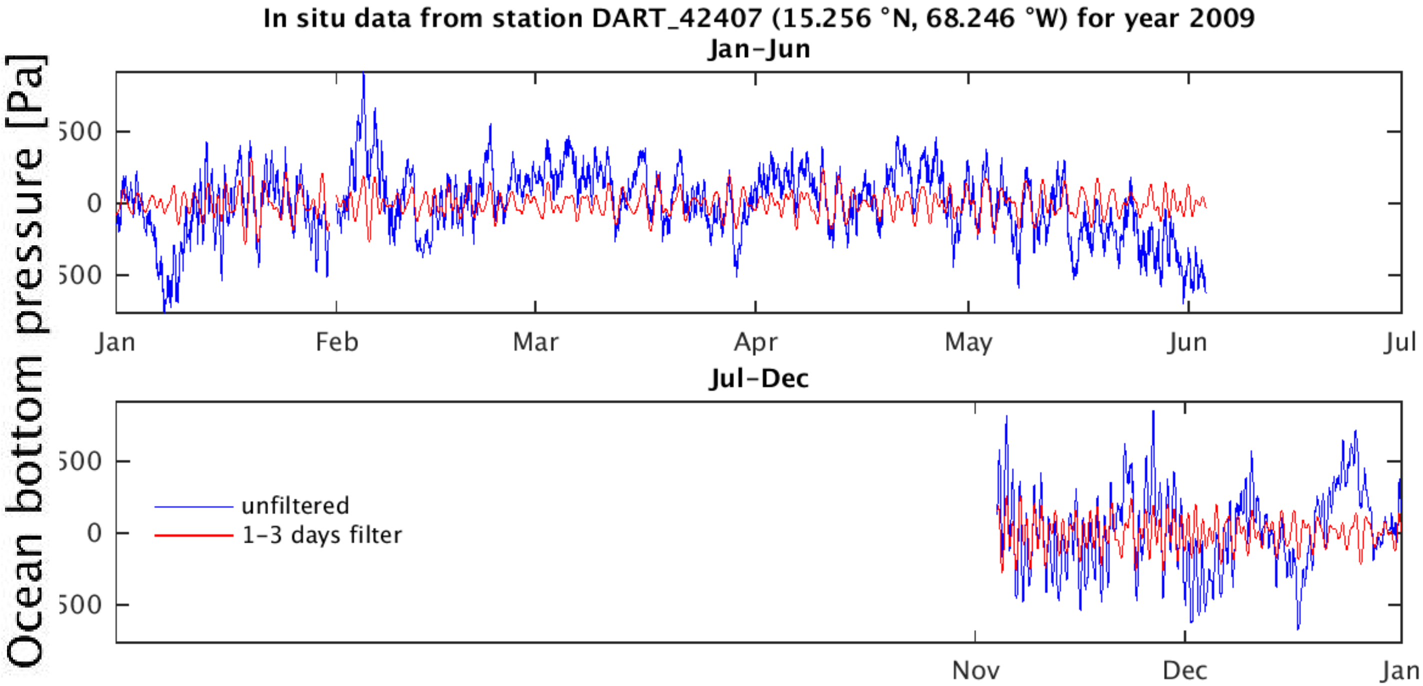

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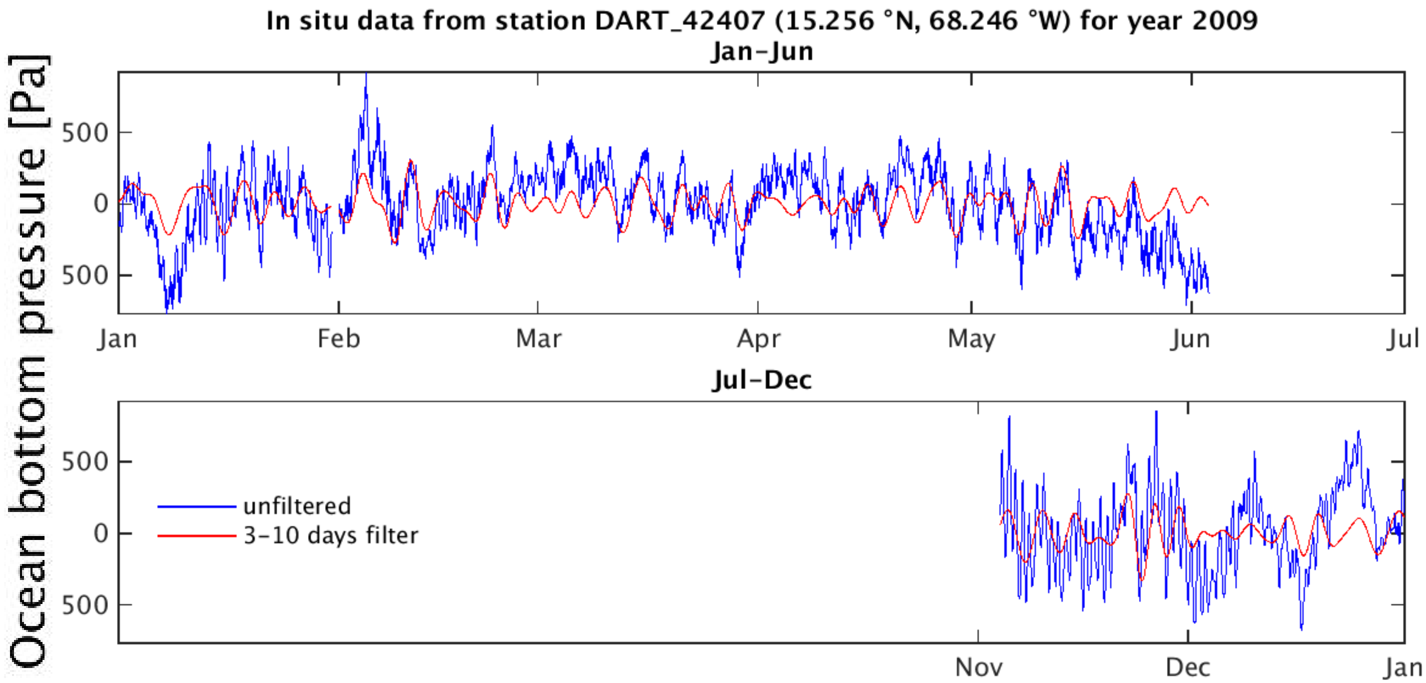

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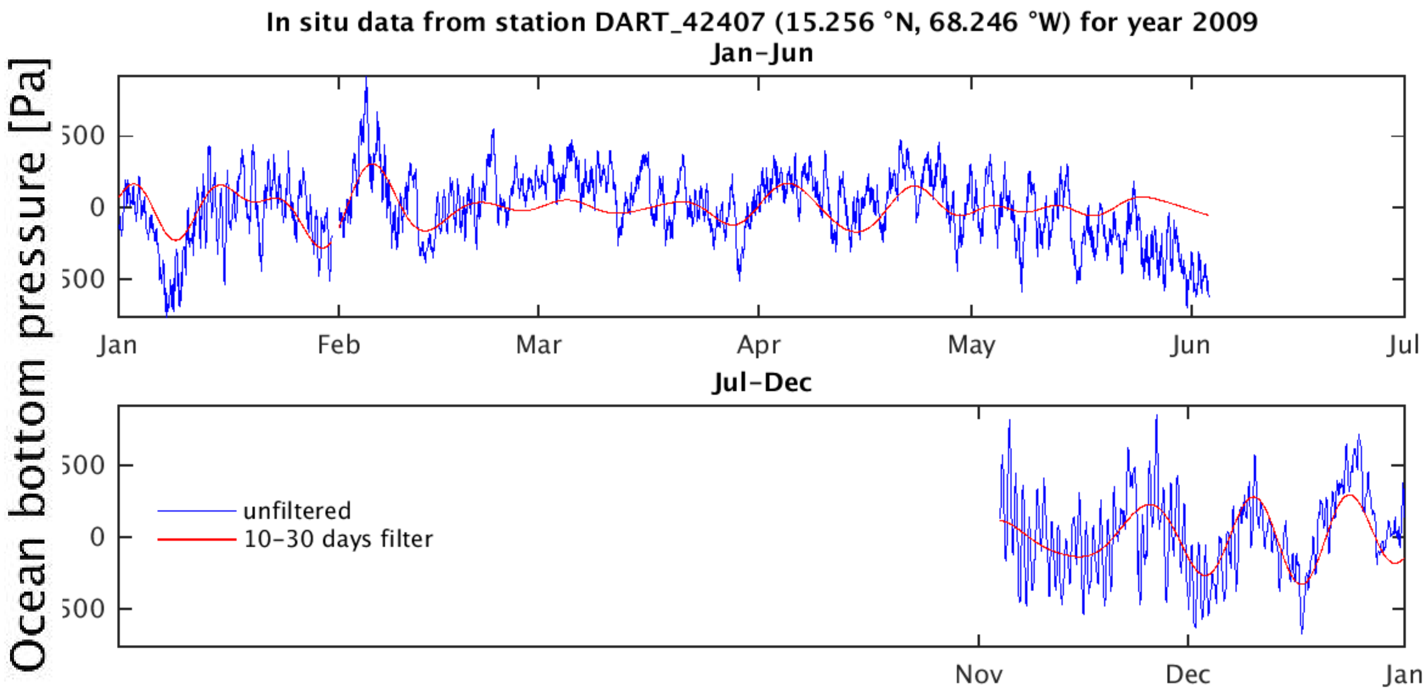

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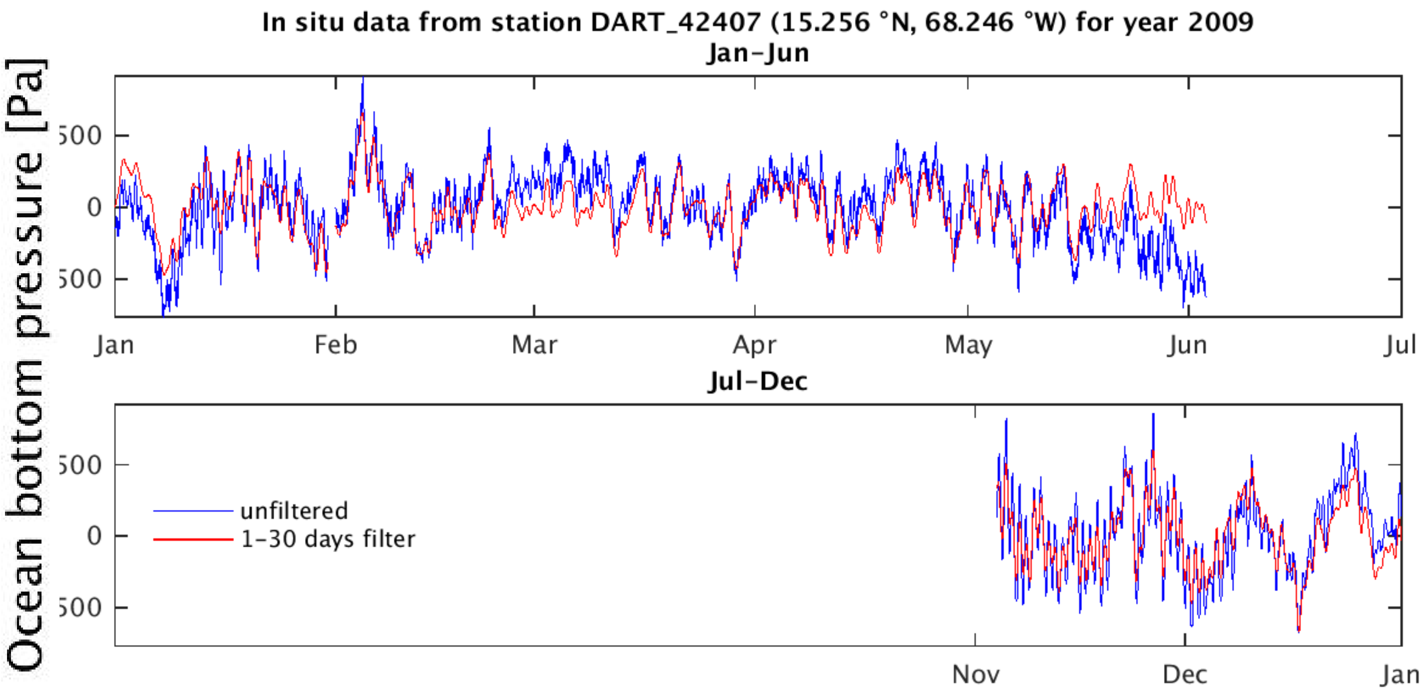

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Preprocessing of in situ data

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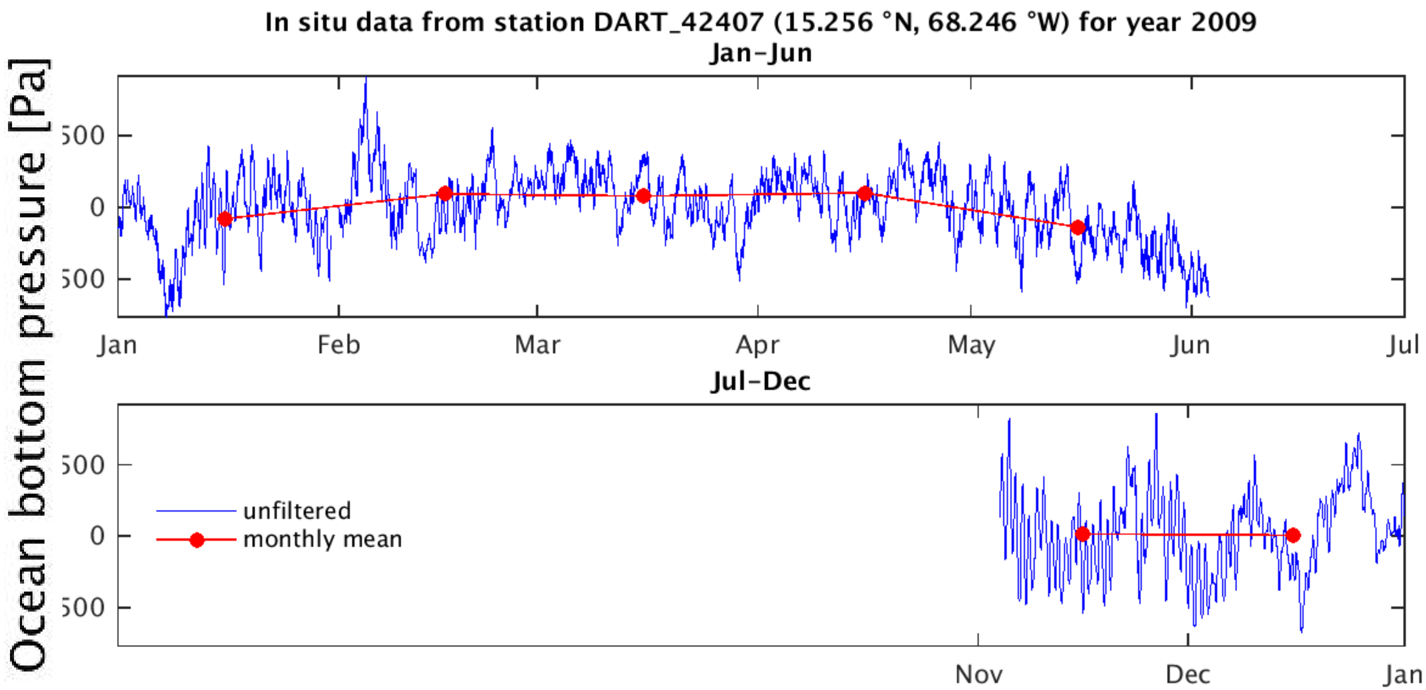
or

- monthly mean

T_TIDE MATLAB package for classical harmonic analysis [Pawlowicz et al., 2002]



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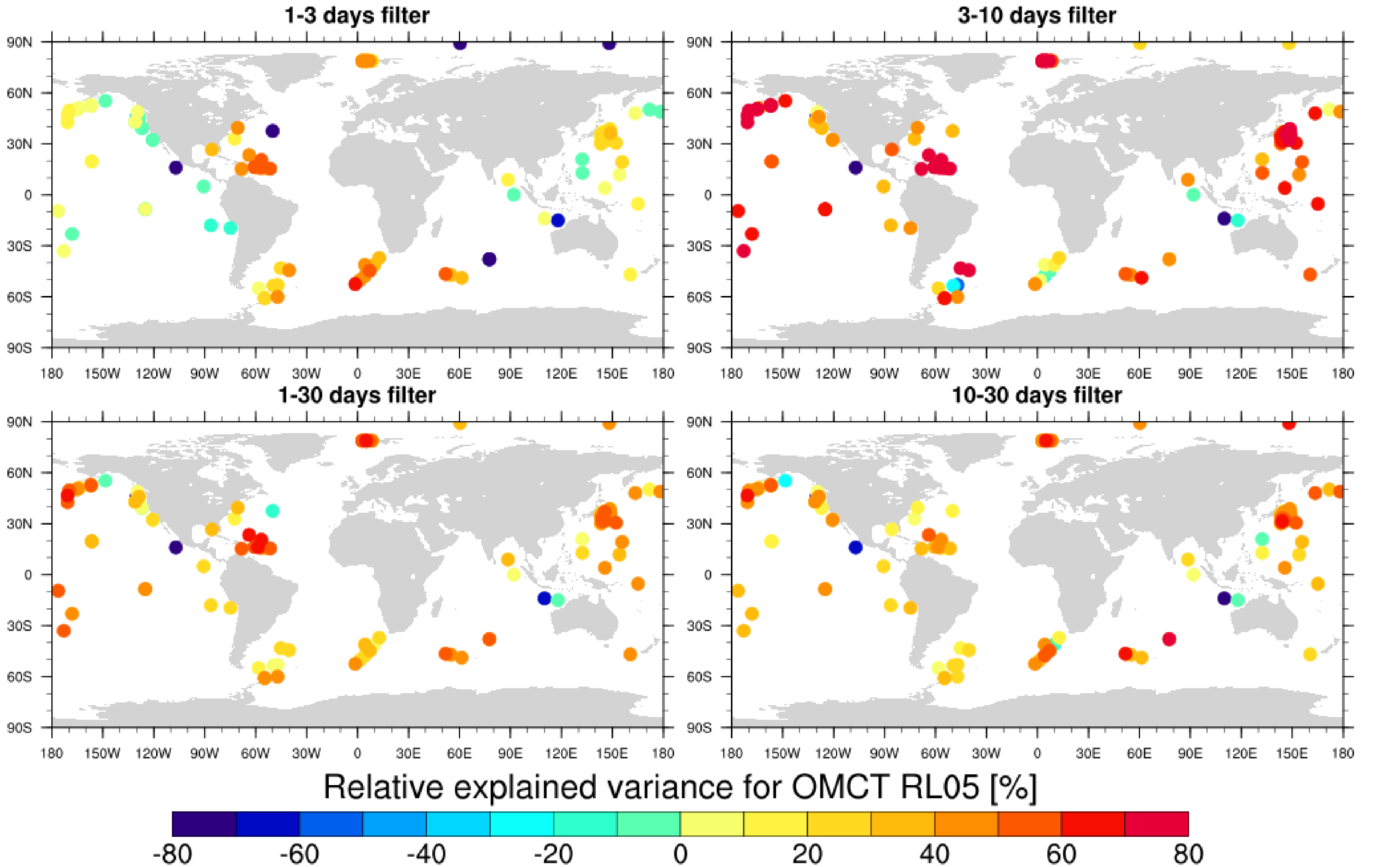
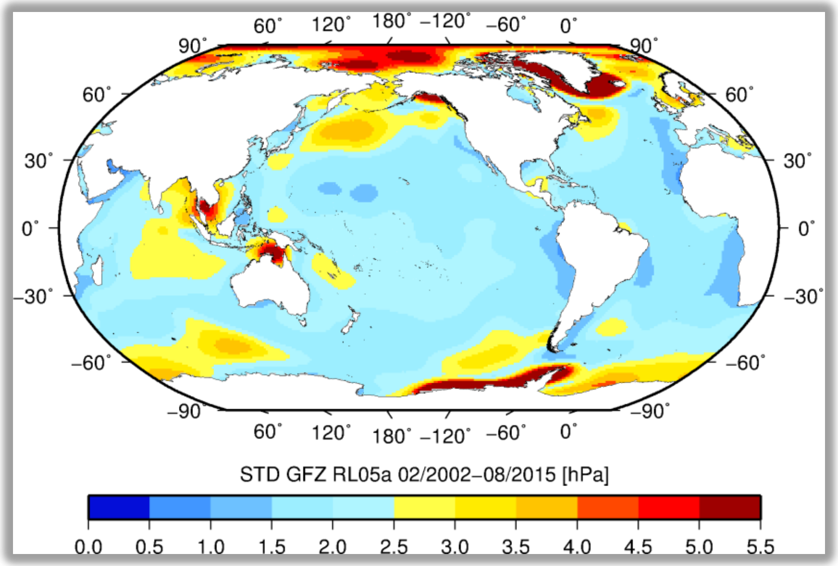
Relative explained variance for OMCT RL05



OBP fields from GRACE GFZ RL05a

- 04/2002 – 08/2015
- up to d/o=90
- atmospheric jumps corrected with GAE & GAF
- C20 replaced (Cheng et al., 2011)
- GIA correction (Paulson et al., 2007)
- Geocenter variations included acc. to Bergmann-Wolf et al. (2014)
- land leakage reduction acc. to Wahr et al. (1998)
- GAD added back
- Filtering with DDK1 (Kusche, 2007)
- grid: 1° x 1°



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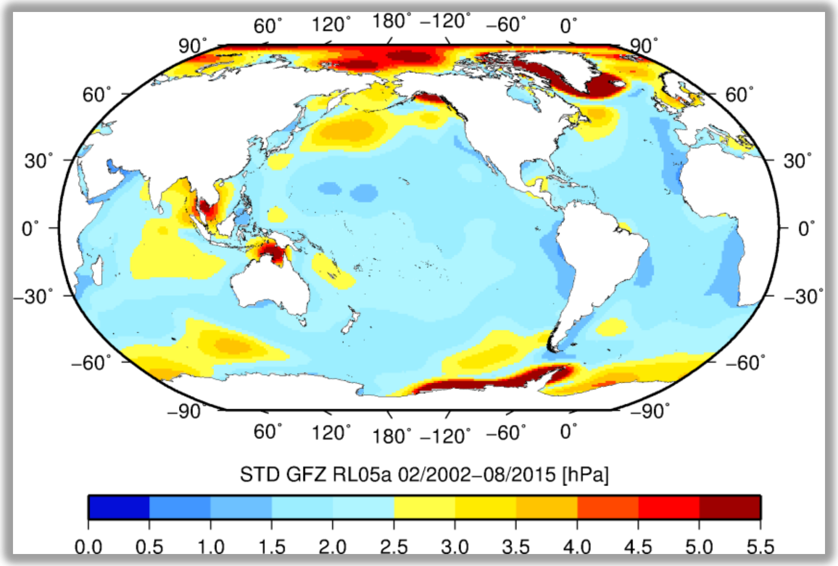

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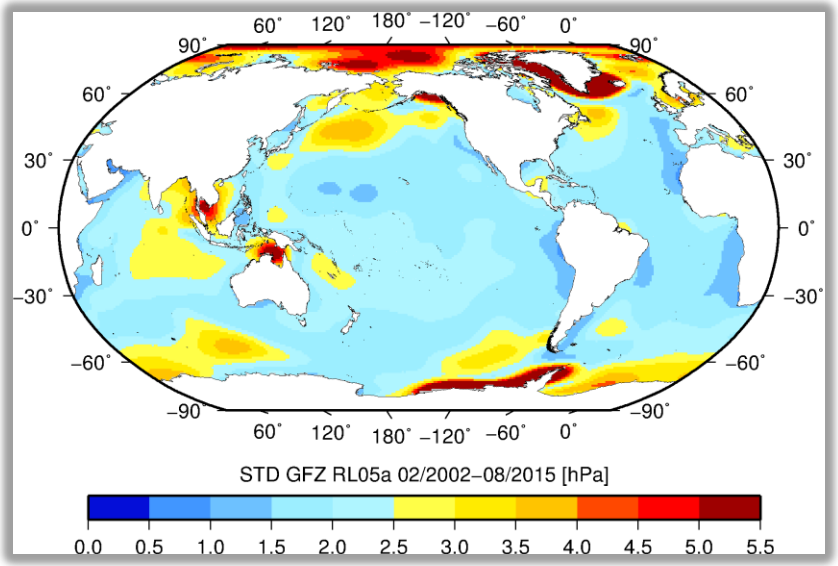

OBP fields from GRACE GFZ RL05a

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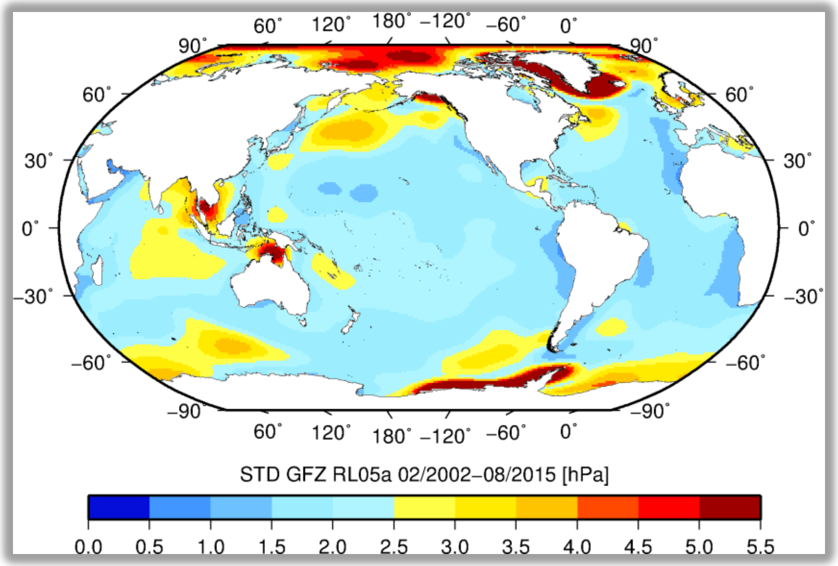

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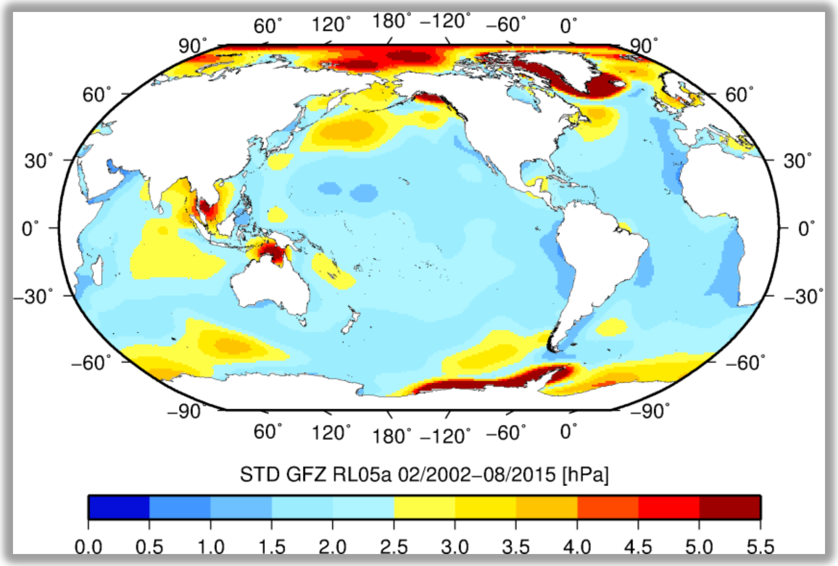

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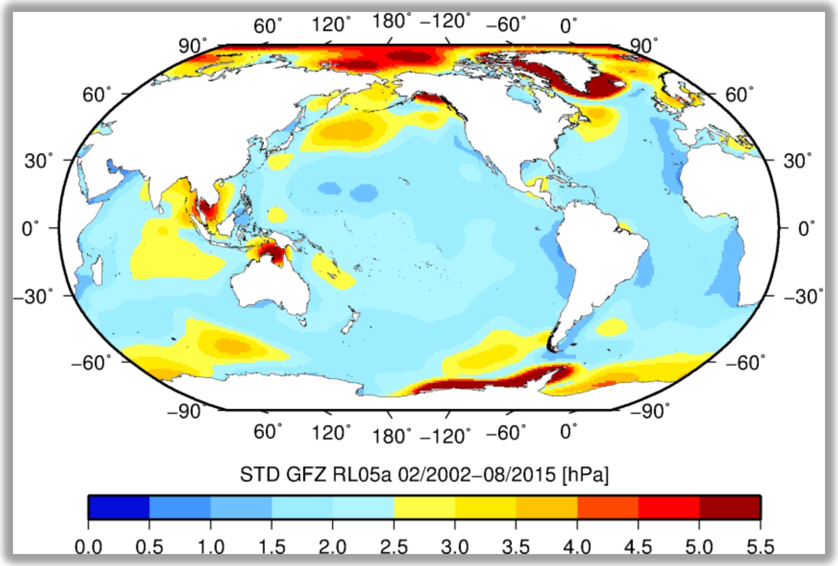

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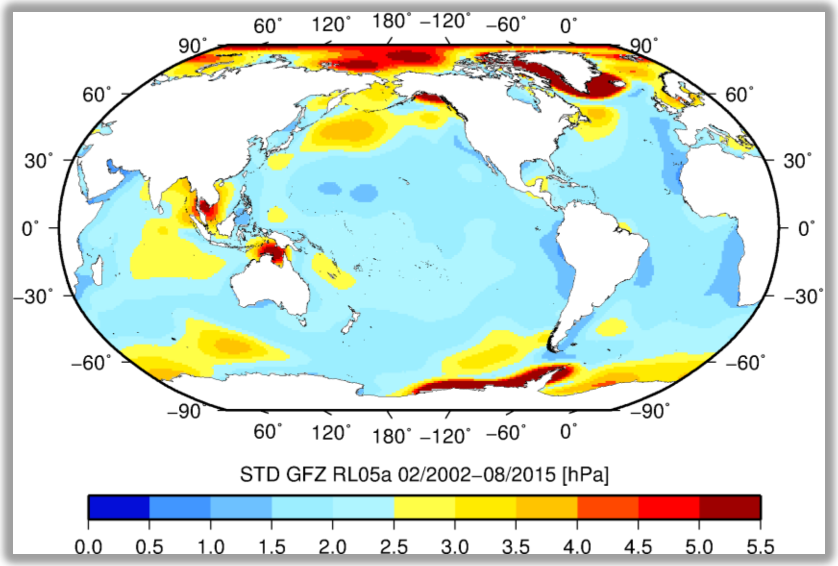

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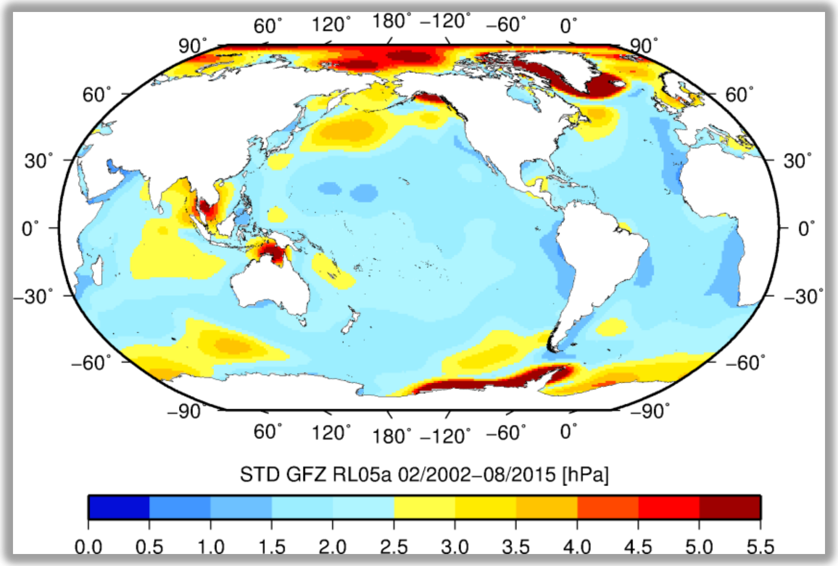

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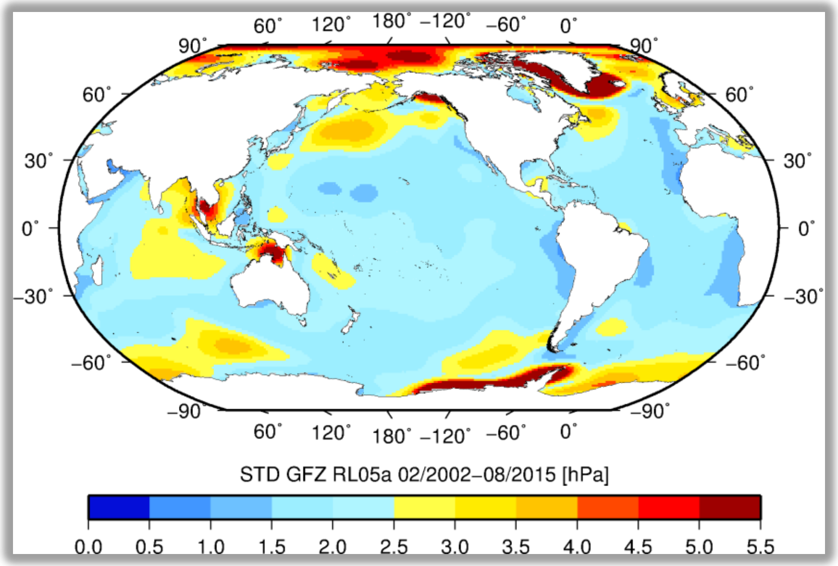

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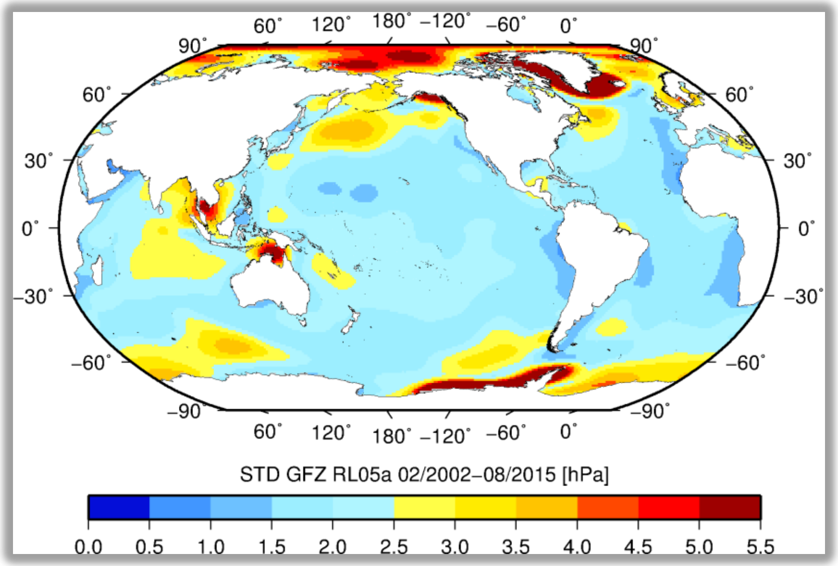

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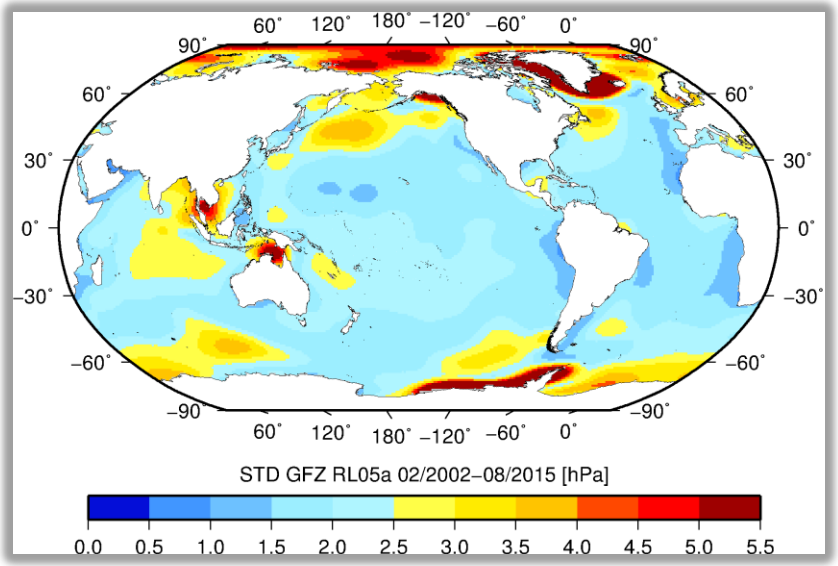

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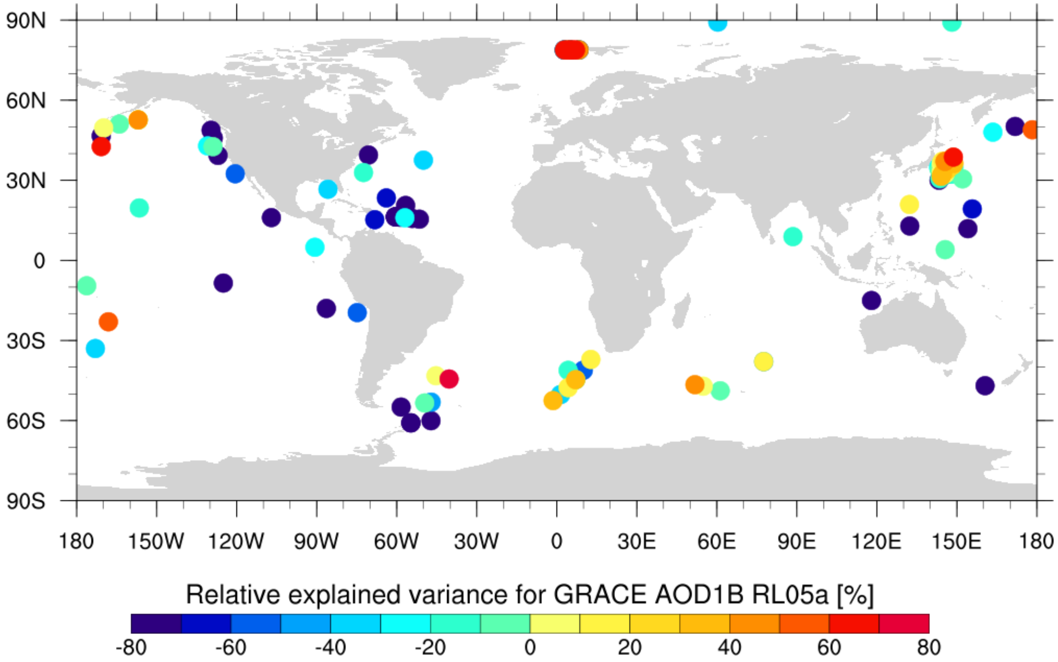
Relative explained variance for GRACE GFZ RL05a



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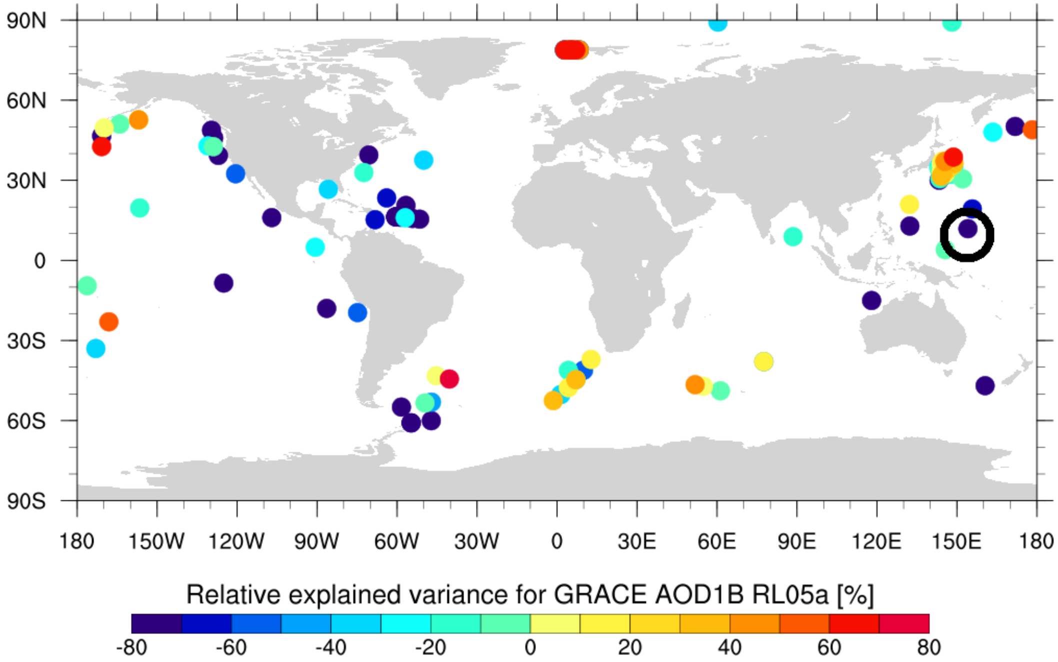

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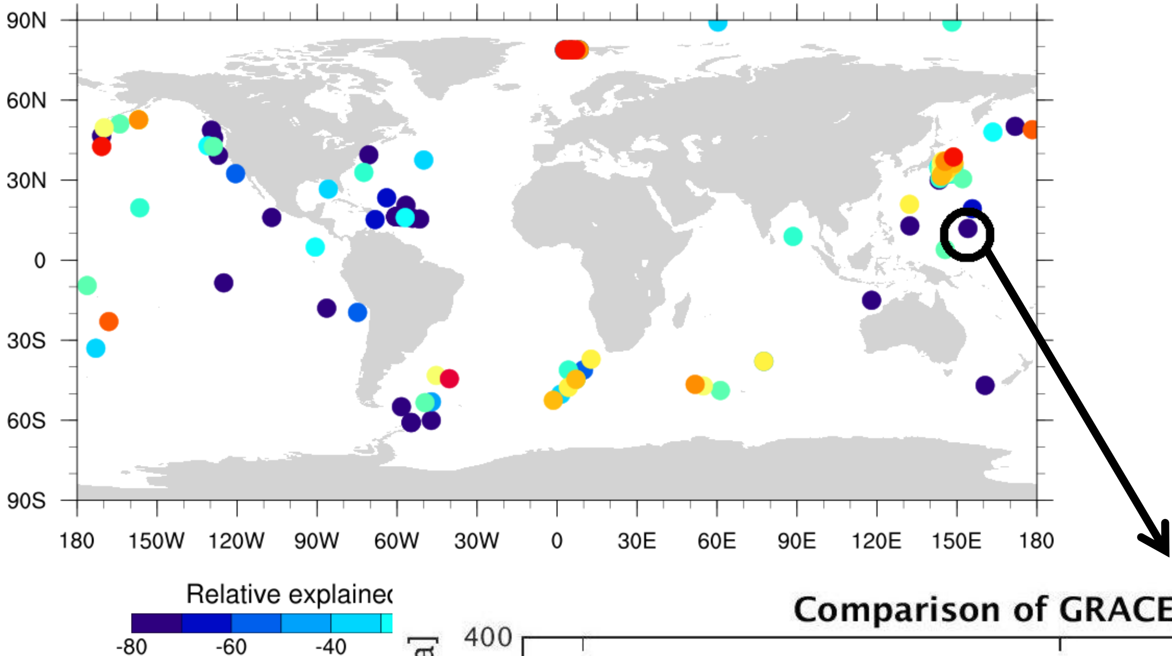

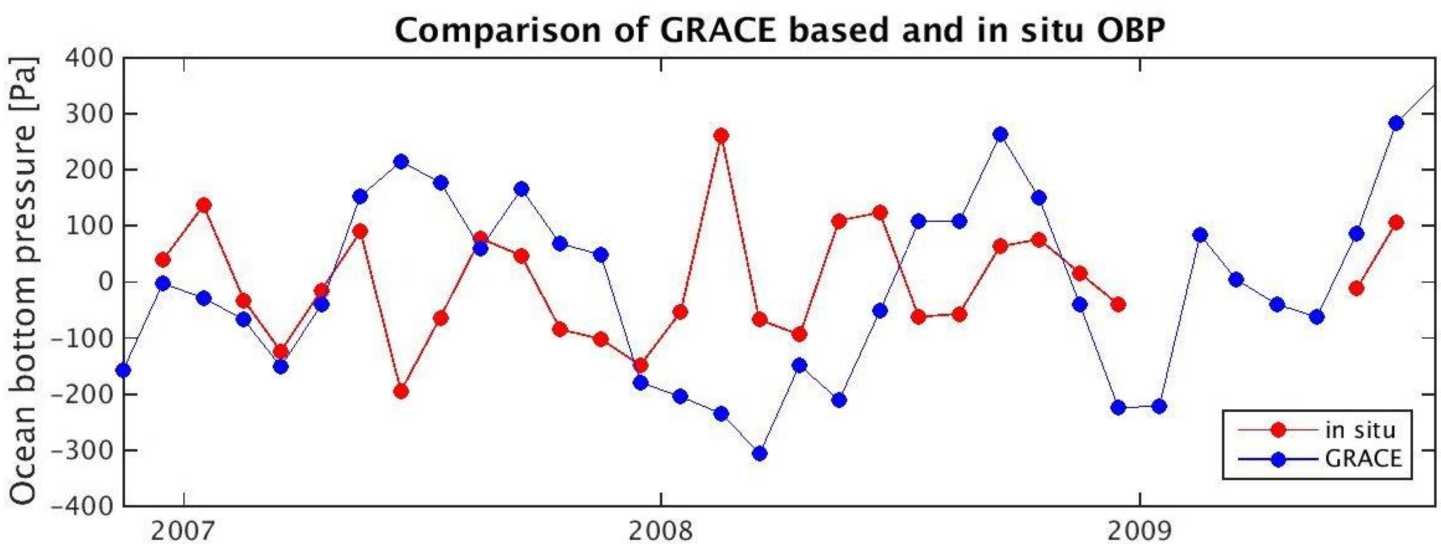

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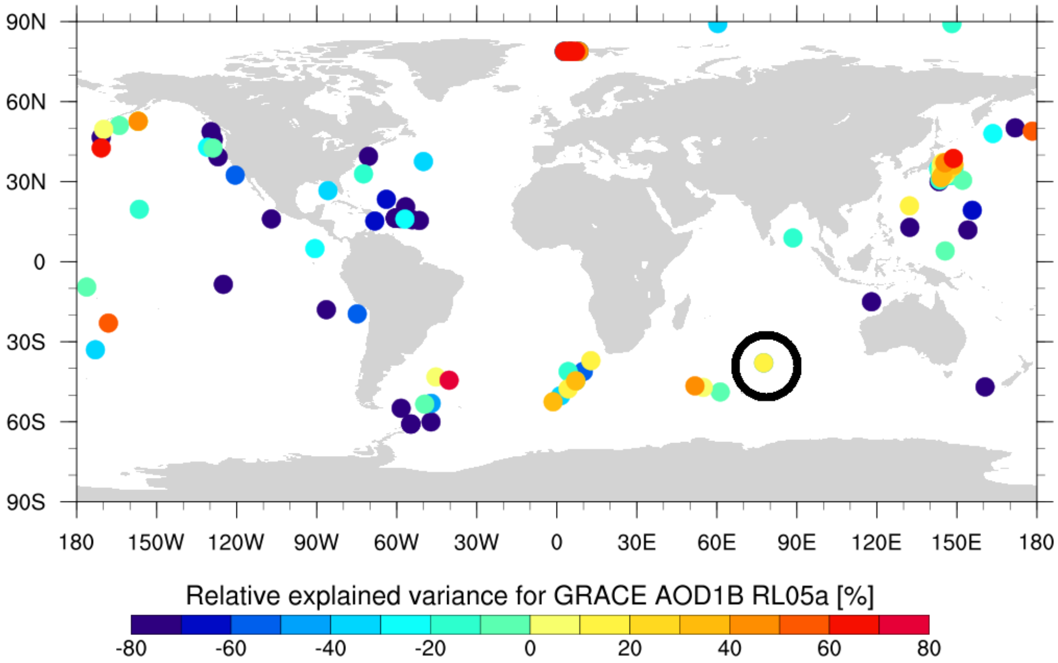

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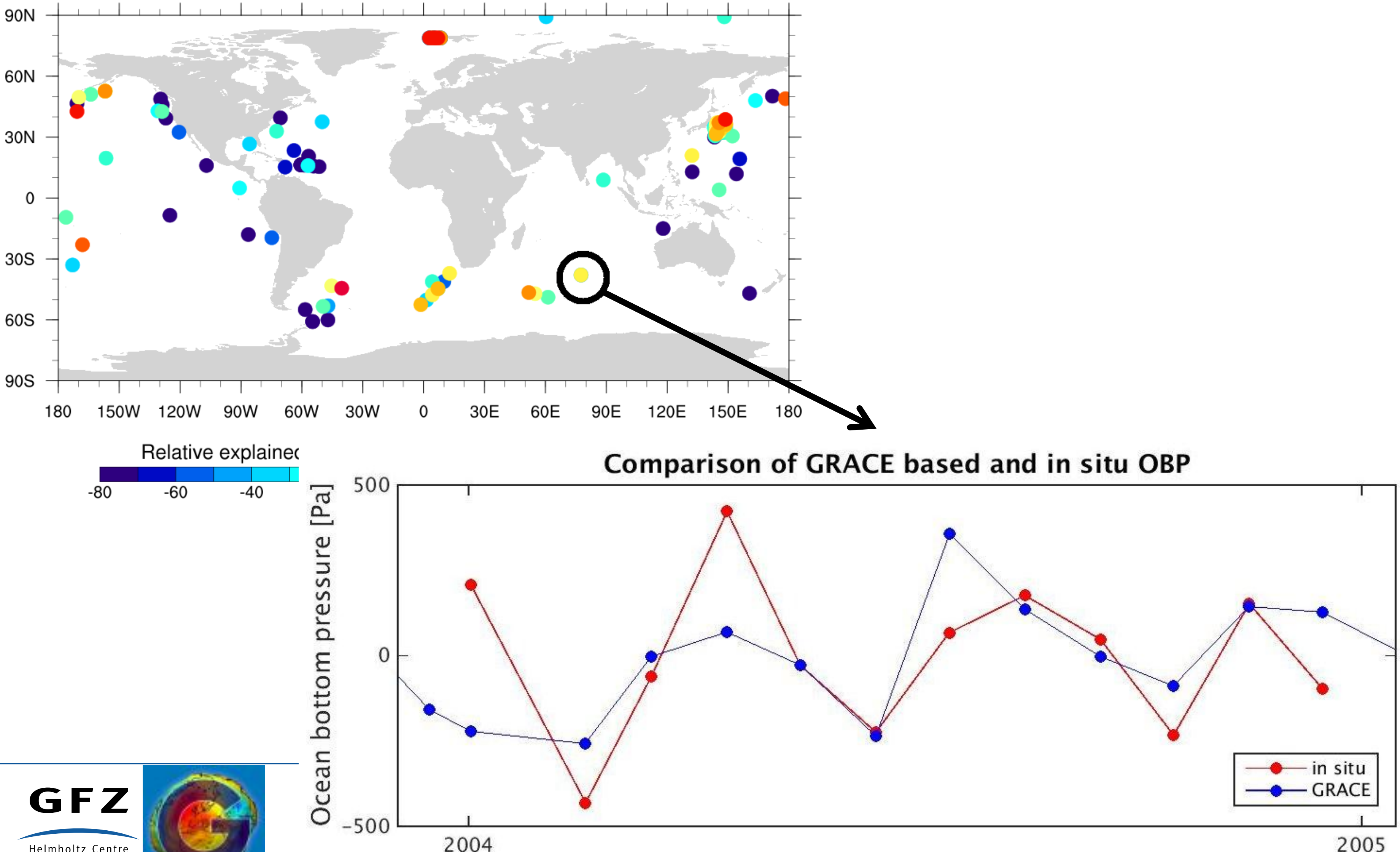

Summary

- available data:
  - ocean model validation - ~150 re-processed in situ ocean bottom pressure time series
  - GRACE monthly mean solutions - ~130 stations
- OMCT RL05 validation:
  - generally good performance of the current OMCT RL05 over all considered frequency bands
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  - too much noise in the lower latitudes
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Outlook

- validation work flow is non-interactive and fast:
  - rapid evaluation of new model experiments during the development of the model
  - comparison of GRACE solutions obtained in different institutions
  - evaluation of changes in data processing in preparation of a new data release
- validation results are considered during the ongoing development of AOD1B RL06 (planned for release in summer 2016)

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Thank you!

References

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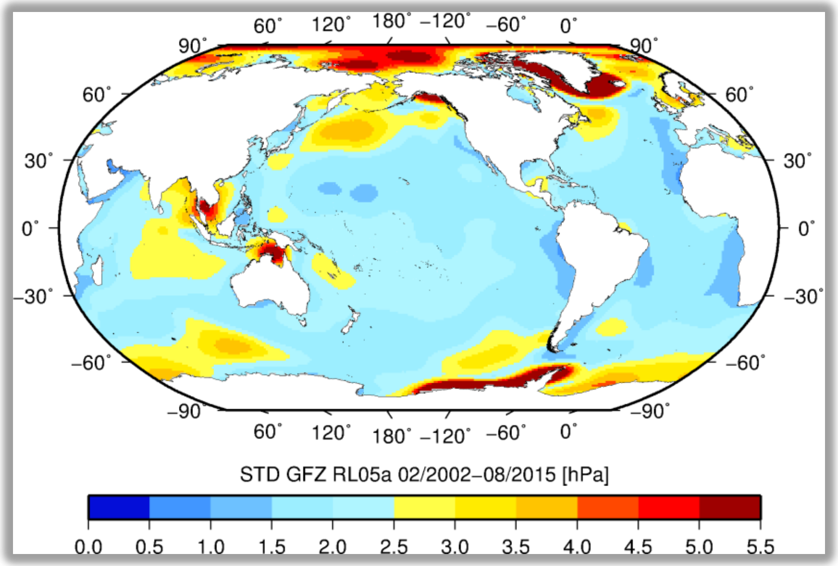
Relative explained variance

Explained variance – variance of in situ measurements explained by the model

$$V = \frac{\langle obs \rangle - \langle obs - \mathrm{mod} \rangle}{\langle obs \rangle}$$

OBP fields from GRACE GFZ RL05a

Work in progress



- improve leakage correction
- remove Sumatra-Andaman earthquake signature
- reconsider GIA model
- residual tidal signal assessment: Gulf of Carpentaria
- reconsider level of smoothing (DDK2, DDK3)

Task 3.8 – GIA (correction) for hydrology
Status January 2016

Holger Steffen, Evan Gowan, Erik Ivins, Benoit Lecavalier,

Glenn Milne, Lev Tarasov & Pippa Whitehouse

holger.steffen@lm.se

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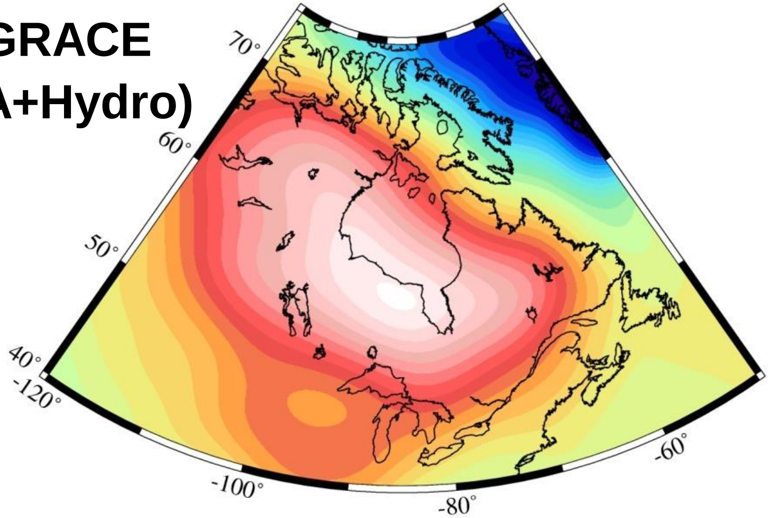
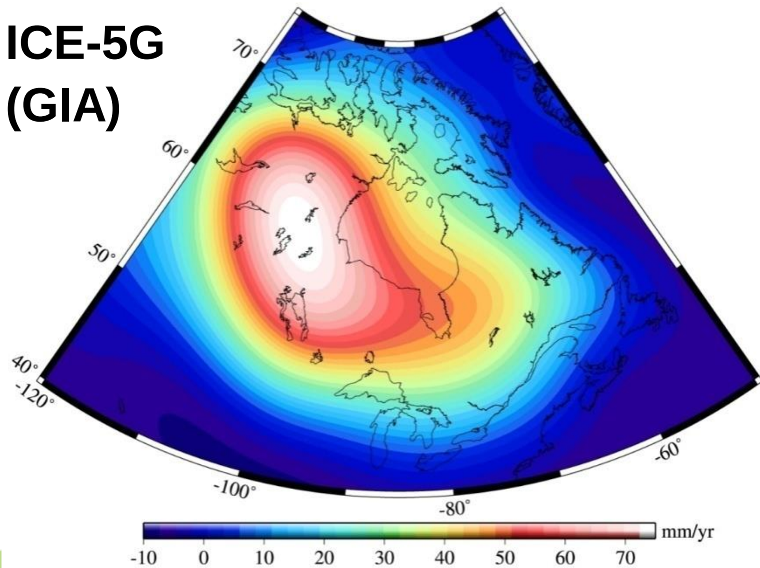
Background: water storage from GRACE

GRACE (GIA+Hydro)

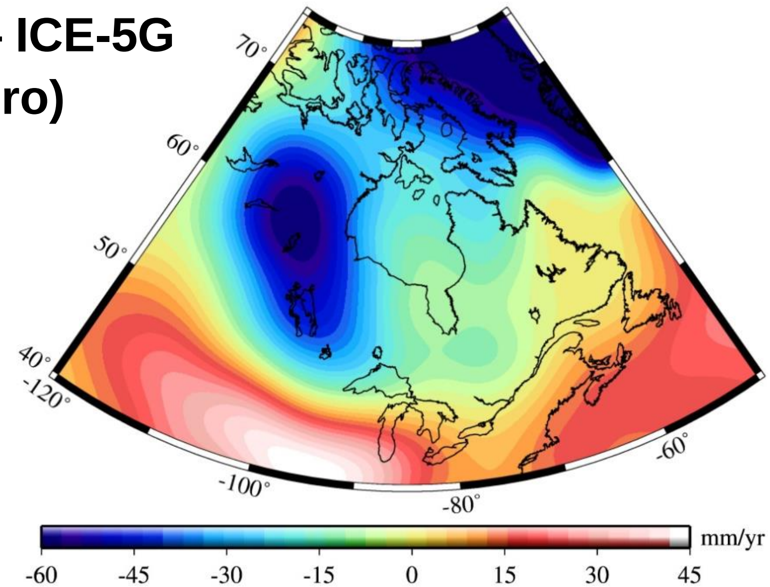


ICE-5G (GIA)



Common GIA correction using ICE-5G

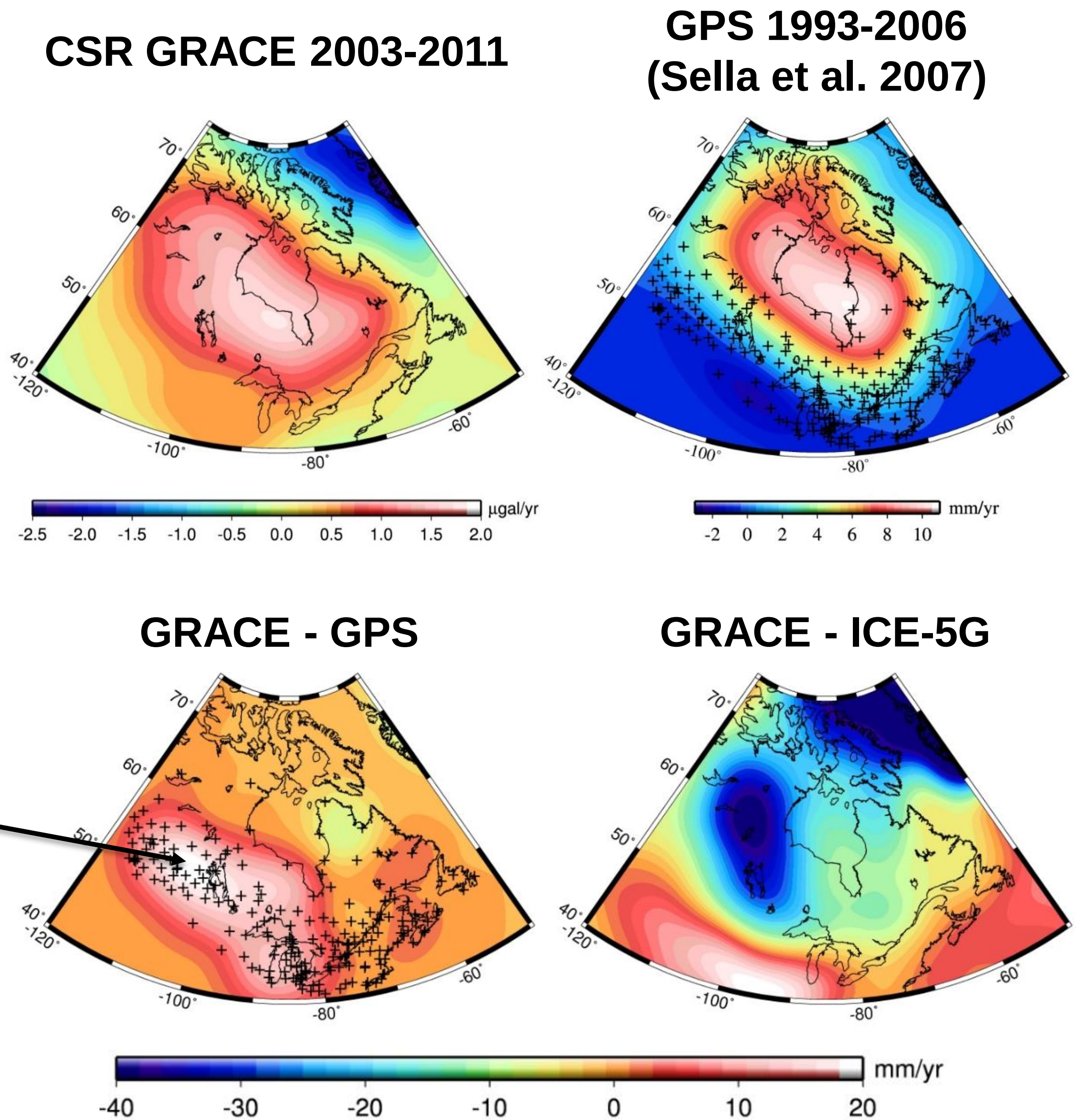
GRACE – ICE-5G (Hydro)



(Wang et al. 2013, Nature Geosci.)

Hydrological trend in North America

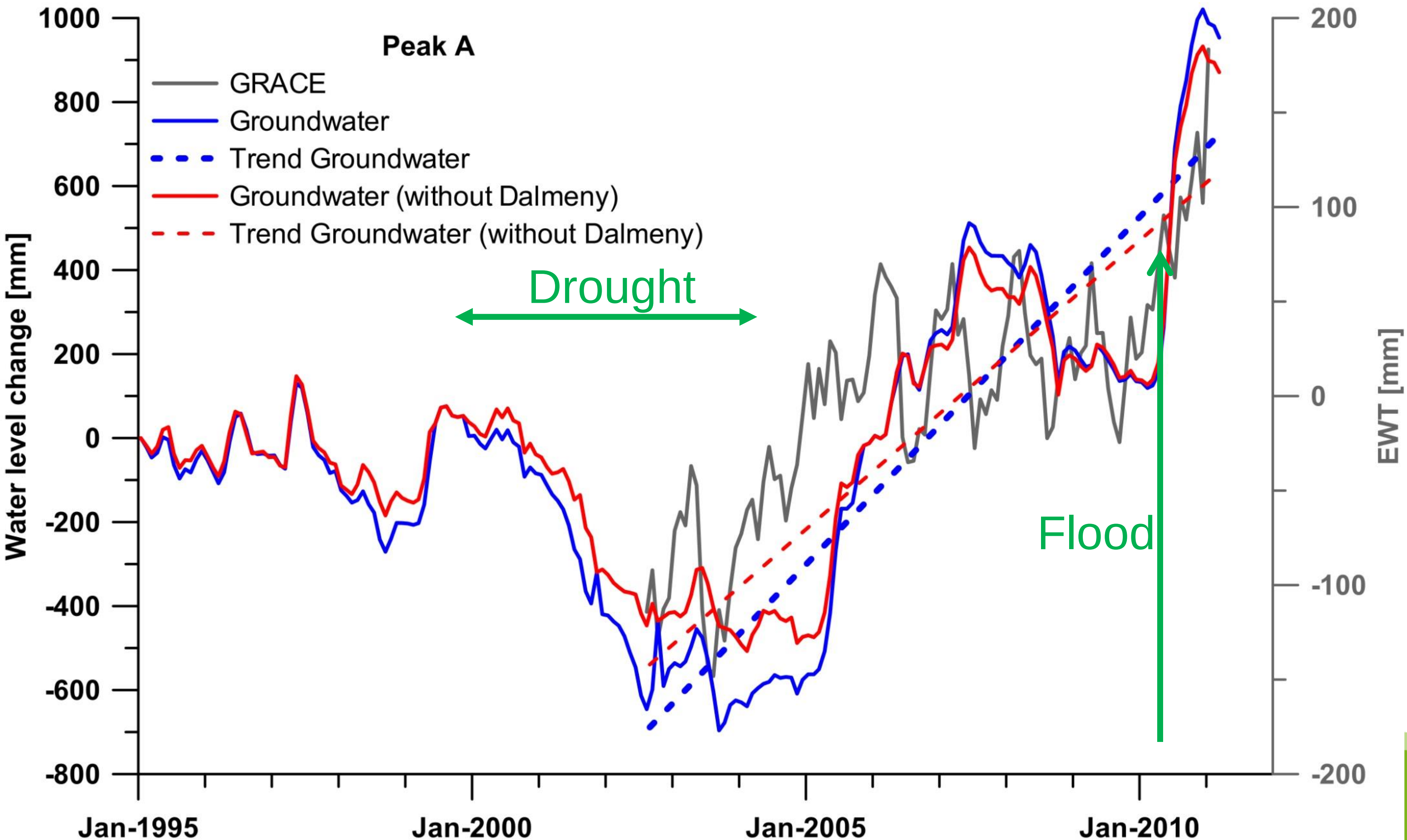
GIA correction using GPS-observed GIA



Peak A

(Wang et al. 2013, Nature Geosci.)

Averaged groundwater vs. GRACE



(Wang et al. 2013, Nature Geosci.)

NKG and land uplift/GIA models for Fennoscandia

- Existing empirical land uplift model NKG2005LU will be substituted with a new one (test model NKG2015LU_test circulated in the Nordic countries)
- NKG (Nordic Geodetic Commission) land uplift workshop in Reykjavik 2013 with a wish to support development of a NKG **GIA model for Fennoscandia**
- Participating modellers of the NKG community : Valentina Barletta (DK, USA), Matt Simpson (N), Maaria Nordman (FIN), Karin Kollo (EST), Per-Anders Olsson & Holger Steffen (S) + help by Glenn Milne (CA)
- Ice model support by Lev Tarasov (CA); GLAC ice model
- **First results** to be presented at **EGU2016**

Suggested model set-up for first EGSIEM GIA correction

From Kick-off meeting 2015

- Ice models:
  - Best GLAC for Fennoscandia/Barents Sea, ICE-6GC, GLAC or Gowan for North America, Updated W12 for Antarctica, Lecavalier et al. (2014) for Greenland, rest from RSES (Kurt Lambeck), but no Tibet
- Earth model:
  - Dedicated earth model for each region, Maxwell rheology, using Wu (2004) 3D spherical FE model approach
  - Other model parameters (ice/water density, Earth radius, moments of inertia, π, etc.) as used in COST benchmark activity (see Spada et al. 2010)
- Observations:
  - New BIFROST 2015/16 release (currently in preparation with 100+ GPS stations)
  - EGSIEM GRACE result
  - Global RSL data (e.g. Barbados etc.) and Fennoscandian RSL data

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Ice models

A series of regional ice models was kindly provided by colleagues for this purpose:

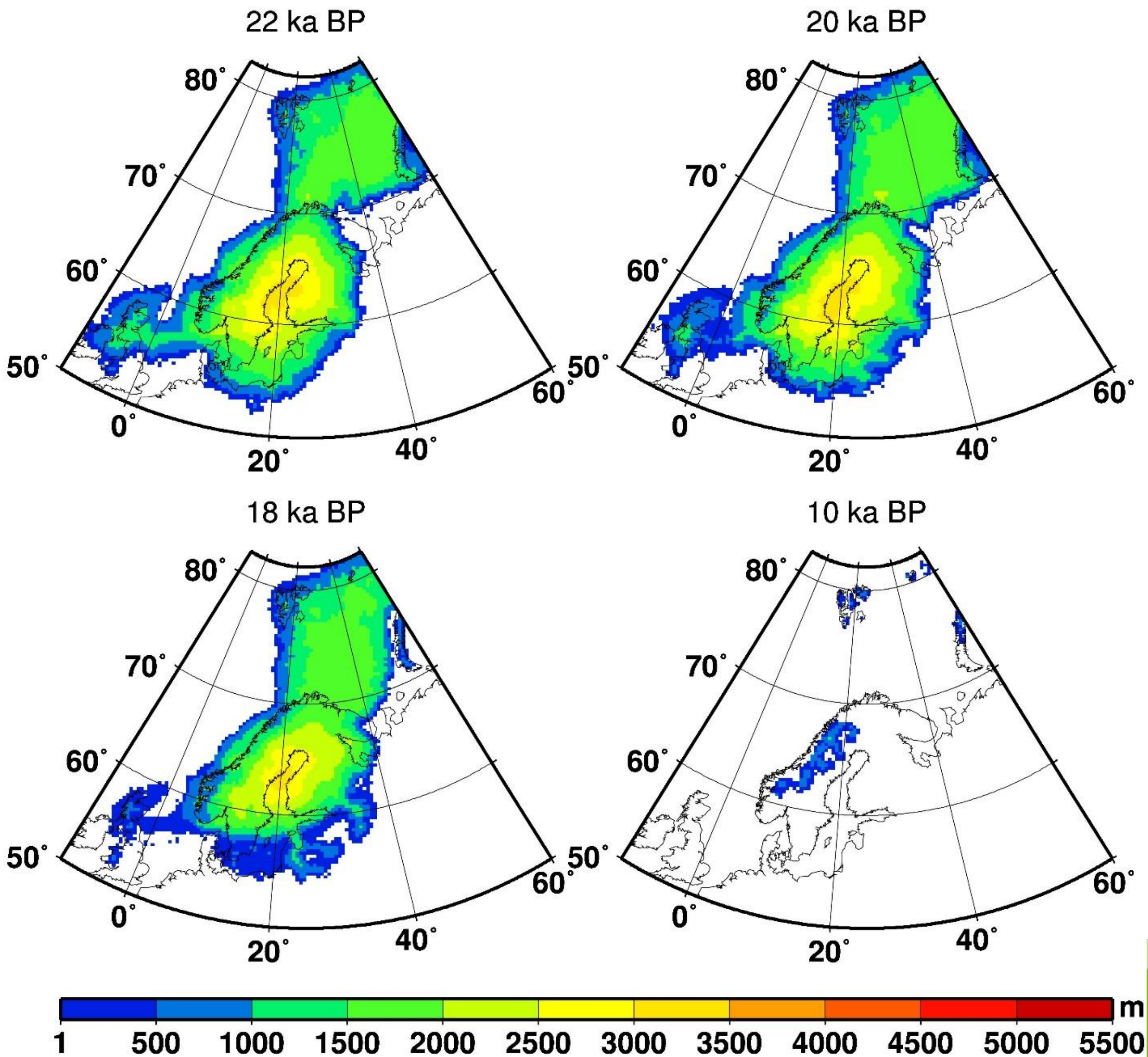
- Greenland: HUY3 (Lecavalier et al. 2014)
- Fennoscandia and Barents Sea: GLAC (Hughes et al. 2015, Nordman et al. 2015, Root et al. 2015; updated chronologies from Lev Tarasov)
- North America: GLAC (Tarasov et al. 2012) and NAIce (Gowan, pers. comm./submitted)
- Antarctica (including Antarctic Peninsula): W12 (Whitehouse et al. 2012), IJ05_R2 (Ivins et al. 2013), GLAC (Briggs et al. 2014)
- High Mountain Areas & Patagonia: ANU-ICE (Lambeck et al. 2014)

Under consideration:

- Antarctic Peninsula: new model from Erik Ivins
- Patagonia: new model from Erik Ivins

Each model will be implemented in the GIA model with its corresponding earth model → lateral variation in lithospheric thickness and mantle viscosity!

First step: define best GLAC for northern Europe



- Shown here: preliminary best-fitting ice history thickness [m] for four times applying VM2-like earth rheology
- 0.5x0.25 degree grid
- 120 ka – today
- Test with proglacial lake load in future

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Ice model combination is not easy

Ice models:

- Different grids (e.g. 0.5x0.25 vs. 0.7x0.7)
- Different start times and time intervals
- **The global combination will most likely not fit the expected sea-level equivalent of at least 120 m at LGM (missing ice problem)**

Corresponding earth models:

- Different lithospheric thicknesses
- Different mantle viscosities, different layers (number and/or depth interval)

- Which thicknesses and viscosities for the rest of the world?
- Shall we treat oceanic lithosphere separately?
- Inclusion of plate boundaries?
- Shall we use Maxwell rheology only?

Suggested model set-up for first EGSIEM GIA correction

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- Observations:
  - New BIFROST 2015/16 release (currently in preparation with 100+ GPS stations) Results ready (~200 stations), paper to be submitted soon
  - EGSIEM GRACE result Tests with first solution (see Yoomin's talk)
  - Global RSL data (e.g. Barbados etc.) and Fennoscandian RSL data

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Work in progress as planned!

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EGSIEM

European Gravity Service for Improved Emergency Management

Oceanographic validation of time variable gravity solutions from GRACE

J.M. Lemoine [1], S. Bourgogne [2], S. Bruinsma [1], P. Gégout [3], R. Biancale [1]

(1) CNES/GRGS, Toulouse, France
(2) Géode & Cie, Toulouse, France
(3) GET/UMR5563/OMP/GRGS, Toulouse, France

HORIZON 2020

Summary

❖ **Interest of using some oceanic areas as a validation tool for GRACE products:**

- Availability of precise and densely sampled time series from altimetry
- The oceanic structures are usually larger than the continental ones → more compatible with GRACE resolution

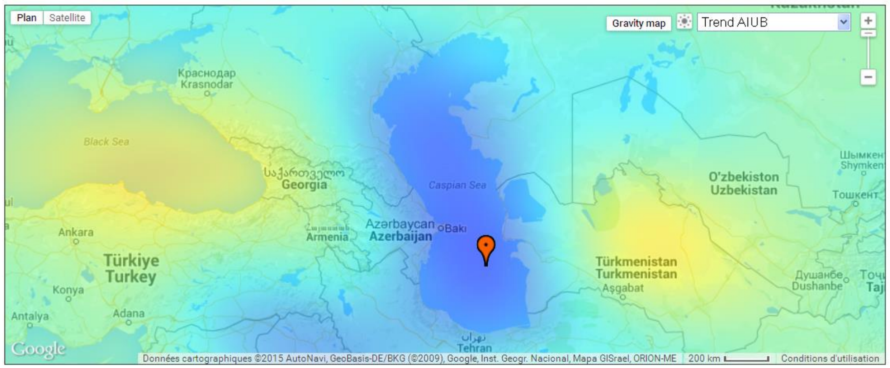
❖ **Conditions:**

- The presence of noticeable mass signal in the GRACE solutions
- Altimeter heights have to be corrected for the steric component and for the loading effect

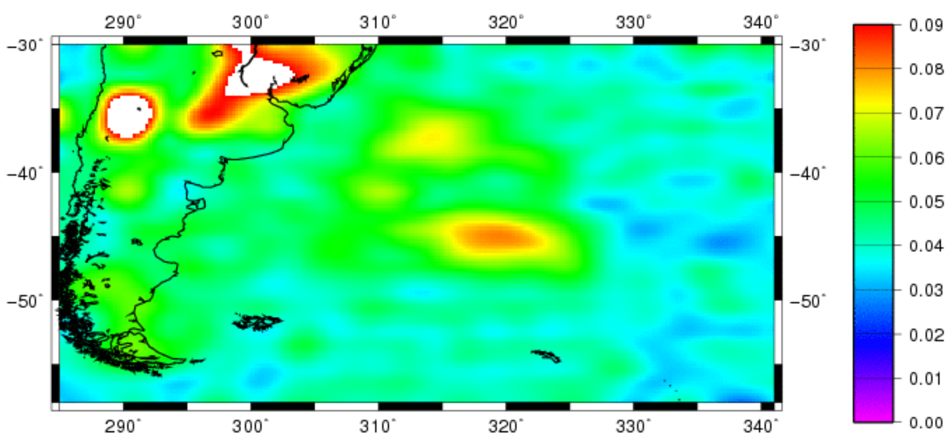
Summary

❖ Test zones:

- ➢ **Inland sea: the Caspian sea**



- ➢ **Open ocean: the Zapiola gyre**



Summary

❖ **Data used:**

➢ **Altimetry:**

- open ocean: **AVISO+** (Multi-satellite Gridded Sea Level Anomalies SSALTO/Duacs) daily
- inland seas: **HYDROWEB** (Cretaux et al. 2011) 10-day

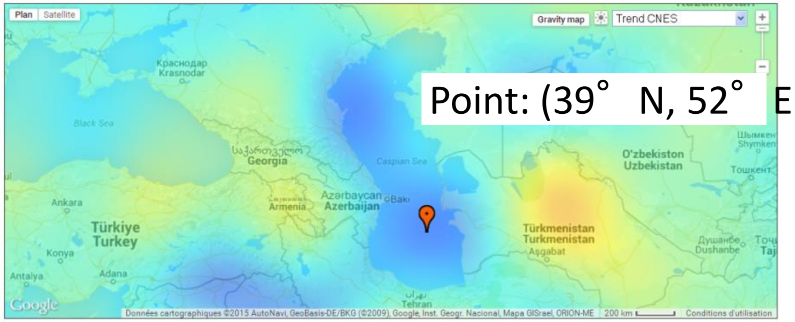
➢ **GRACE time series** (monthly solutions)*:

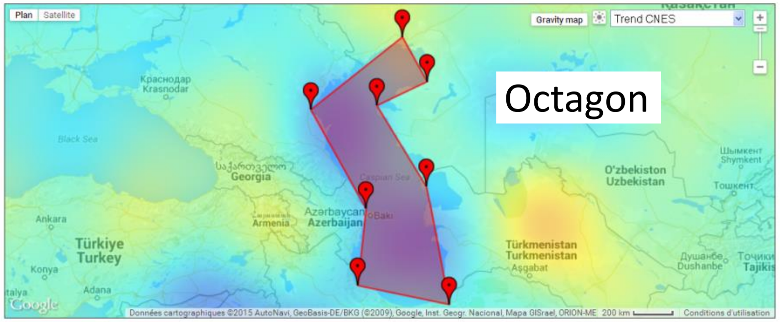
AIUB RL02	(DDK-5 filtered)
CNES/GRGS RL03-v1	(unfiltered)
CSR RL05	(DDK-5 filtered)
GFZ RL05a	(DDK-5 filtered)
JPL RL05	(DDK-5 filtered)
TUGRAZ ITSG14	(DDK-5 filtered)

* All available from the ICGEM web site in unfiltered and DDK-1/2/3/4/5 versions

1- Caspian sea

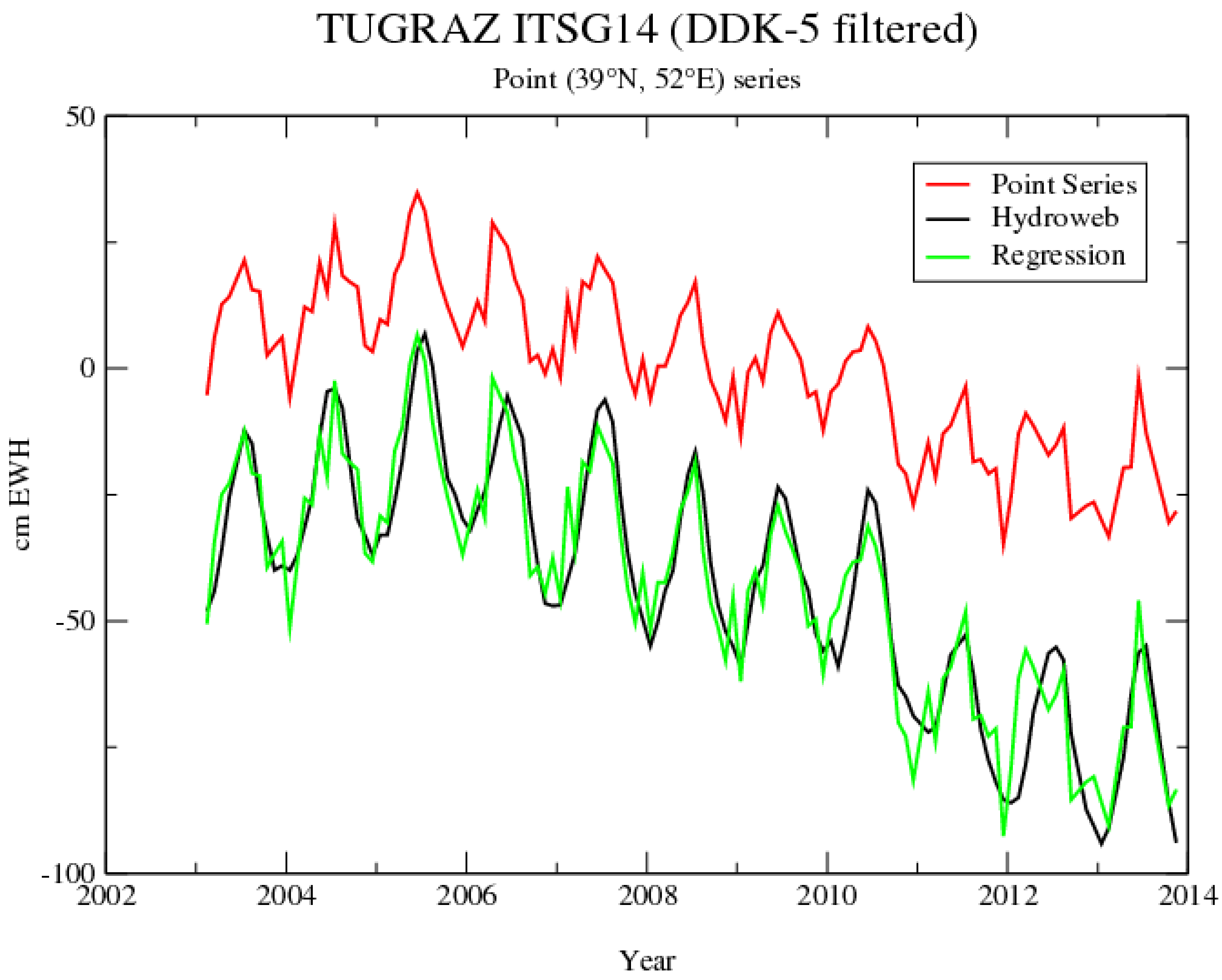
- The largest enclosed inland body of water on Earth: 370,000 km^2 (400 x 900 km)
- Accurate altimeter time series
- Can test the ability of the GRACE solutions to provide spatially pertinent information
- GRACE point-wise and basin-wise time series are tested:





- Test mostly valid in a relative sense; an absolute calibration would require more sophisticated methods (averaging kernel, land hydrology and steric effect removal, cf. Swenson & Wahr 2007)

1- Caspian sea



1- Caspian sea

	Correlation		Scale Factor	
	Point	Basin	Point	Basin
AIUB RL02	0.91	0.94	1.32	1.67
CNES/GRGS RL03-v1	0.96	0.98	1.27	1.75
CSR RL05	0.91	0.93	1.37	1.68
GFZ RL05a	0.86	0.80	1.28	1.39
JPL RL05	0.89	0.89	1.28	1.53
TUGRAZ ITSG14	0.95	0.96	1.43	1.69

- Correlation is slightly better for basin-average than for point

→ Less noise in the basin-average than in the point time series

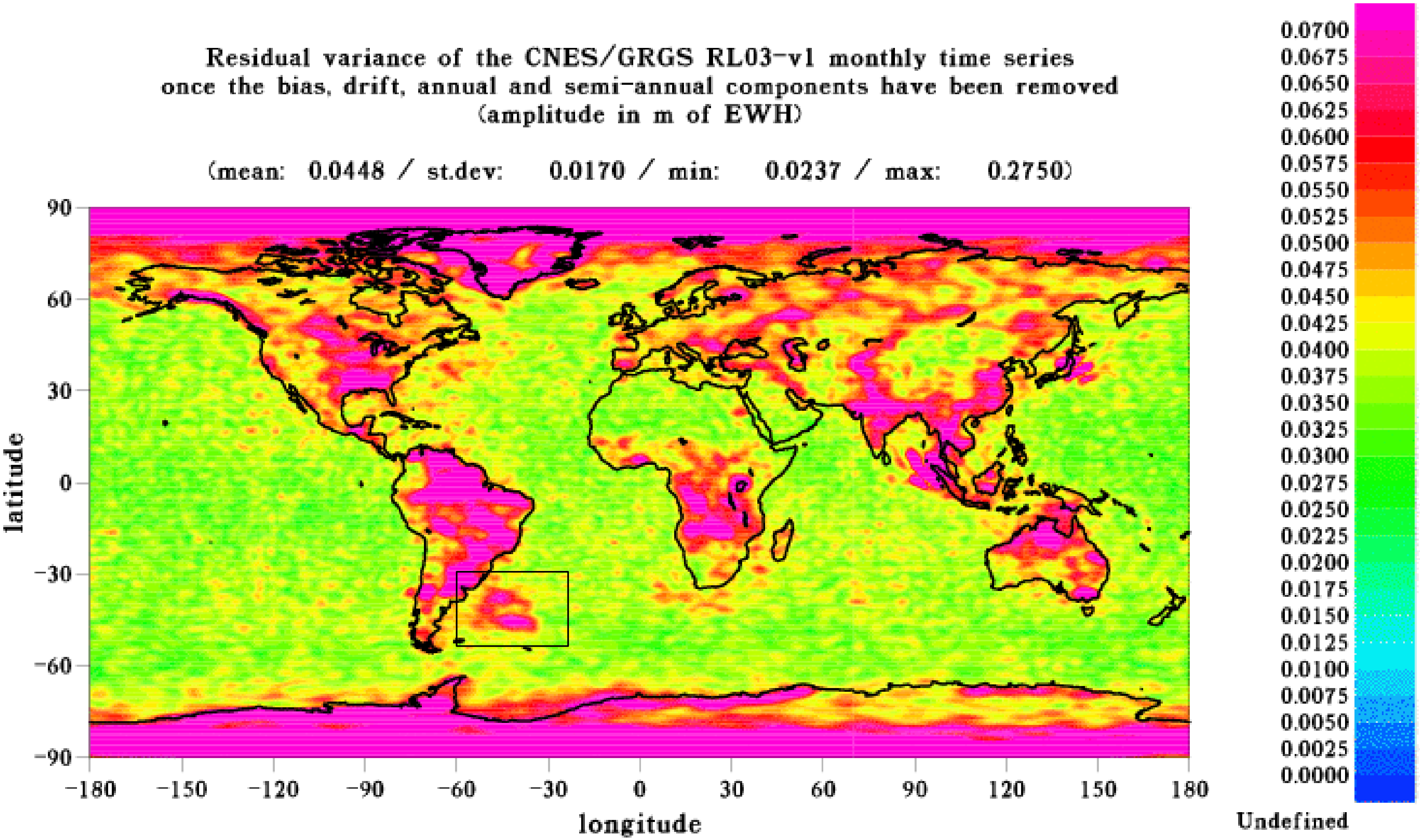
- BUT scale factor is much higher for basin-average than for point

→ The point time series is closer to the actual sea level

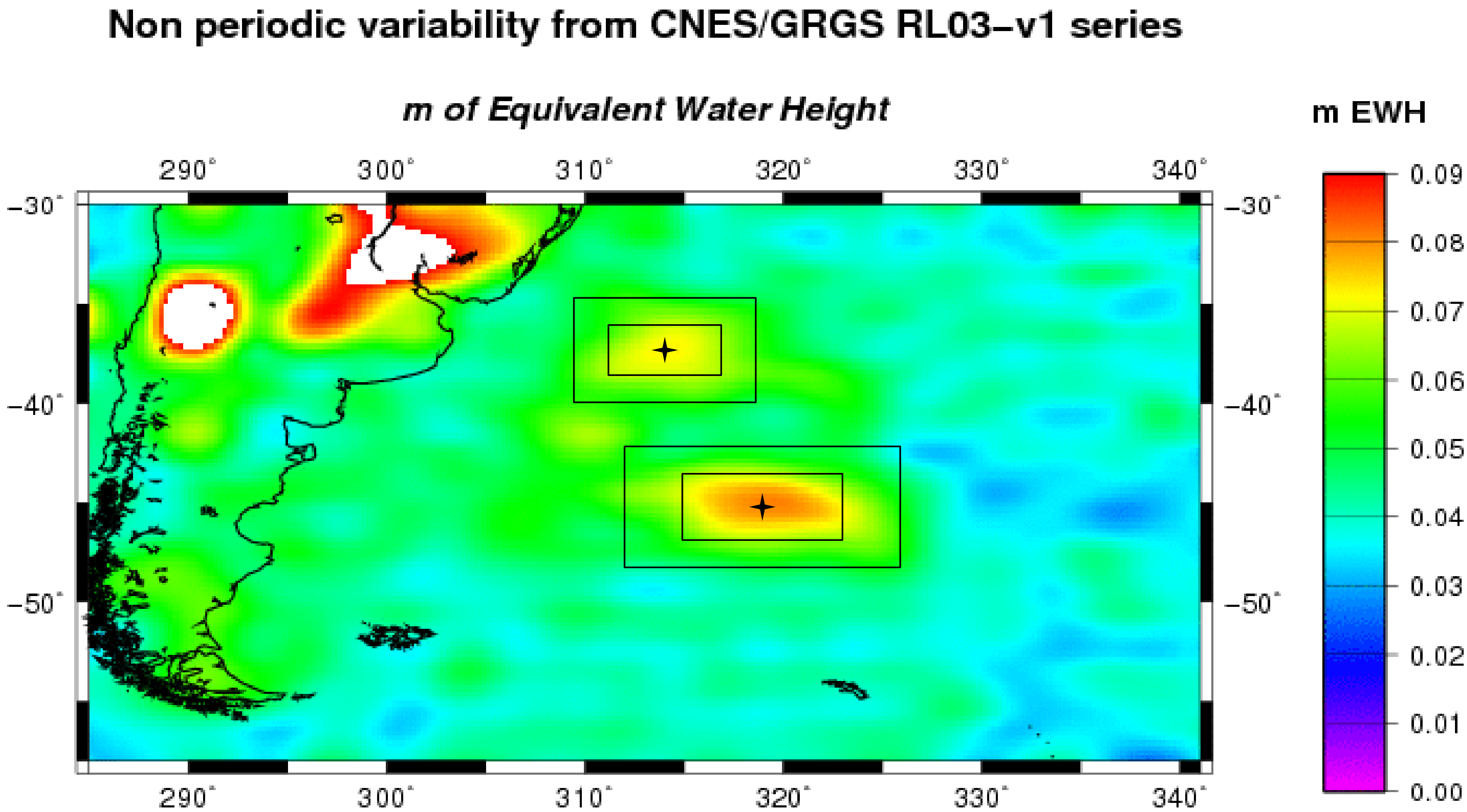
Best correlation is 98 %, best scale factor is 1.27

2- Zapiola gyre

❖ Large non-periodic mass signal in the GRACE series

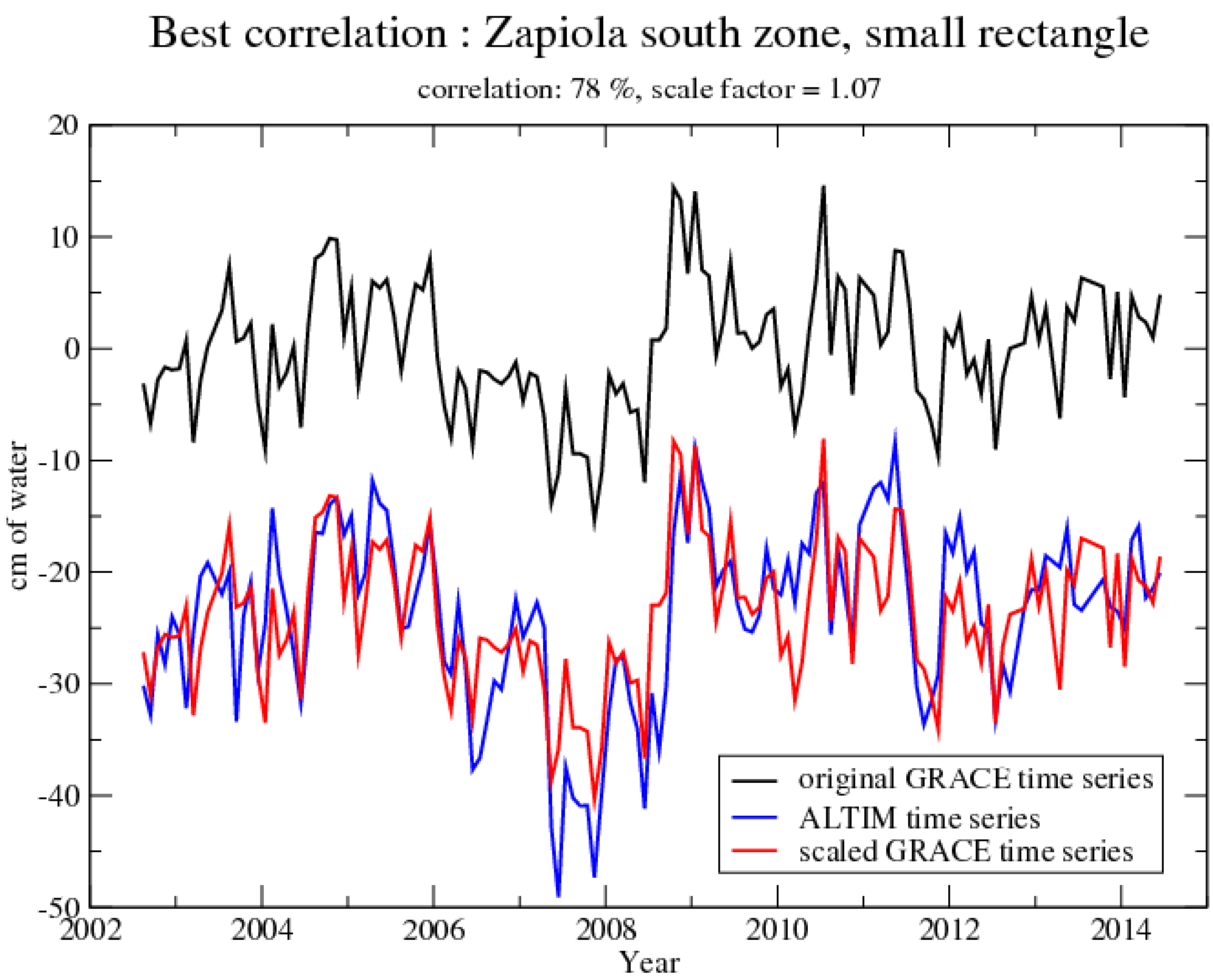


2- Zapiola gyre

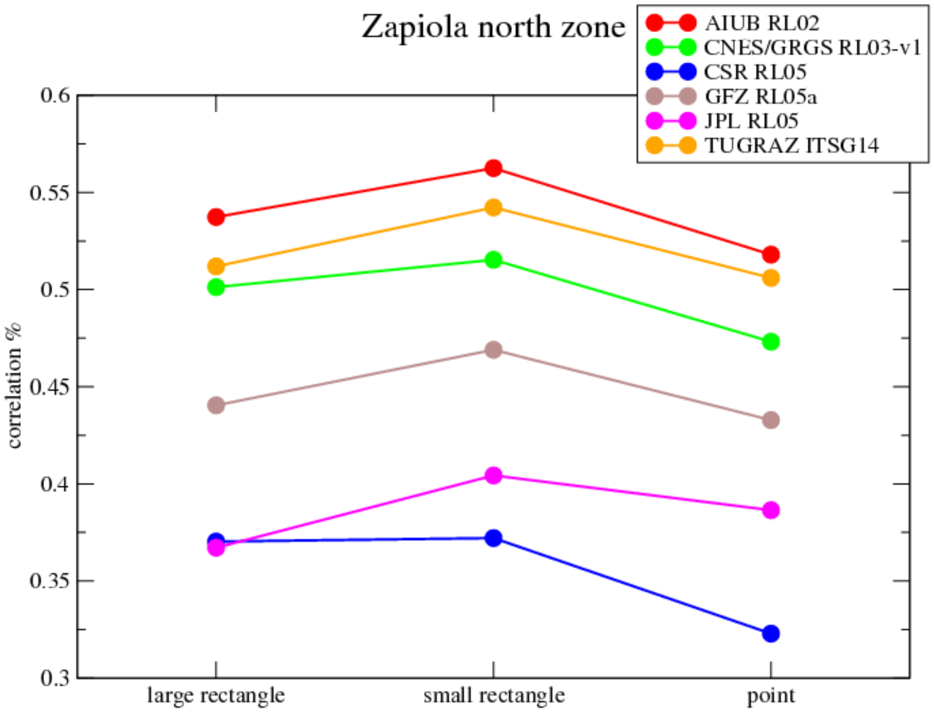


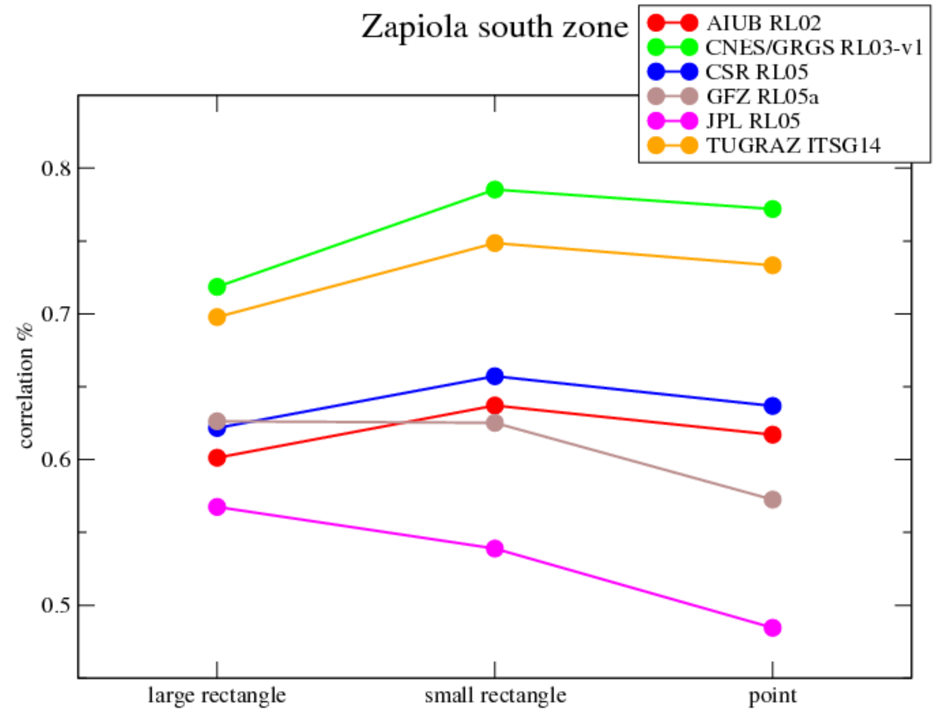
- Point coordinates: (37° S, 46° W) and (45° S, 41° W)
- Small rectangle area: north ~ 316,000 km², south ~ 280,000 km²
- Large rectangle area: north ~ 592,000 km², south ~ 1,120,000 km²

2- Zapiola gyre



2- Zapiola gyre





- **The best coherence between altimetry and GRACE is achieved for areas ~ 300,000 km^2**
- **Agreement is much better for the south zone than for the north zone**
- **Best coherence in the south zone = 79 % with a scale factor of 1.07**
- **Worst coherence in the north zone = 37 % with a scale factor of 0.66**

Conclusion

- Altimetry can be a precious tool for GRACE solutions validation
- The selected oceanic areas must present a large mass signal
- They can be far off-coast and therefore escape contamination from continental hydrology
- In the Caspian sea we can reach a very high level of coherence between altimetry and GRACE (98 %) although it is an enclosed sea
- For some time series, the low correlations do not come from the smoothing by DDK-5, but from the intrinsic noise of the time series
- In the Zapiola gyre the variability of the ocean is higher than in the Caspian – spatially and temporally - and is more difficult to capture it with monthly time series from GRACE (max. correlation 79 %)
- The example of the Zapiola gyre shows that in some cases (Zapiola north) the monthly time sampling is not sufficient
  We must go to a shorter time sampling…

Thank you for your attention

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European Gravity Service for Improved Emergency Management

Compilation of representative historical flood situations

WP3 – T3.9

Hendrik Zwenzner - DLR

Objectives

European Gravity Service for Improved Emergency Management

- Compilation of historical flooding situations for validation of GRACE derived flood and drought indices
- Identification of suitable test cases /basins (WP6)
  - Significant anomaly in daily GRACE solutions
  - Only within years 2006 and 2007 (GRACE reprocessing)
  - Flood regime and hydrological/environmental settings
  - Availablility of EO satellite data (Int. Charter, ZKI, ...)
  - 2-D flood masks derived from SAR (and optical) data
  - Estimation of flood volumes

Data retrieval

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European Gravity Service for Improved Emergency Management

- Medium resolution SAR data (MR1 [30-100m] & MR2 [100-300 m])
  - ENVISAT (2002-2012): ASAR wideswath mode 150 m resolution (via Copernicus/ESA DWH)
  - Radarsat-1 (1995-2013): ScanSAR wide (100m) narrow (50m)
  - ALOS (2006-2011): Palsar ScanSAR mode (100m)
- Medium and low resolution Optical data
  - TERRA/AQUA MODIS (250m)
  - ENVISAT MERIS (300m)
  - Landsat series, …
- Additional data
  - Satellite altimetry data (ENVISAT)
  - Water gauge, GPS,…

Test cases

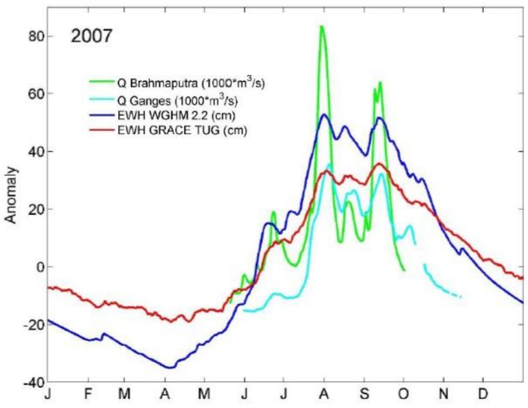
European Gravity Service for Improved Emergency Management

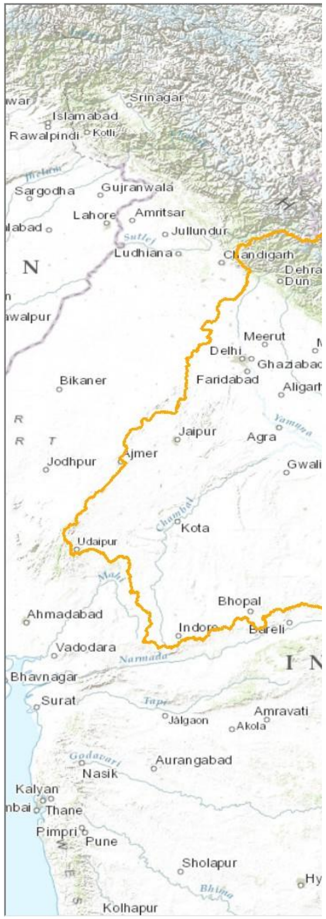
- Danube
  April 2006
- Ganges/Brahmaputra delta
  July-Sep 2007
- Mekong delta
  July-Oct 2006
  July-Oct 2007

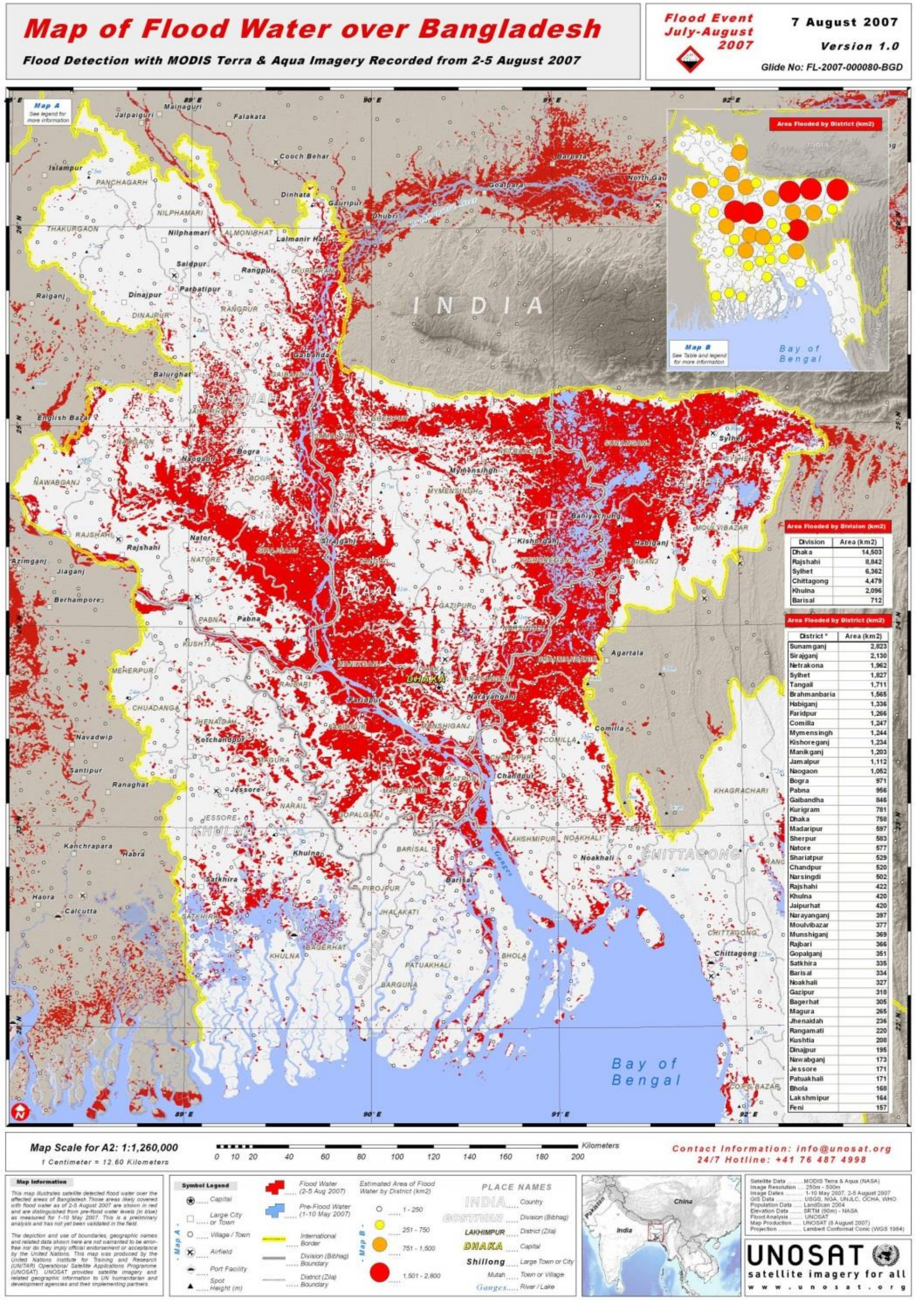
HORIZON 2020

Ganges/Brahmaputra

- Extreme flood event
- Size: ca. 220.000 km²







Division	Area (km2)
Dhaka	14,503
Rajshahi	8,842
Sylhet	6,362
Chittagong	4,479
Khulna	2,096
Barisal	712

District *	Area (km2)
Sunamganj	2,823
Sirajganj	2,130
Netrakona	1,962
Sylhet	1,827
Tangail	1,711
Brahmanbaria	1,565
Habiganj	1,336
Faridpur	1,266
Comilla	1,247
Mymensingh	1,244
Kishoreganj	1,234
Manikganj	1,203
Jamalpur	1,112
Naogaon	1,052
Bogra	971
Pabna	956
Gaibandha	846
Kurigram	781
Dhaka	758
Madaripur	597
Sherpur	583
Natore	577
Shariatpur	529
Chandpur	520
Narsingdi	502
Rajshahi	422
Khulna	420
Jaipurhat	420
Narayanganj	397
Moulvibazar	377
Munshiganj	369
Rajbari	366
Gopalganj	351
Satkhira	335
Barisal	334
Noakhali	327
Gazipur	318
Bagerhat	305
Magura	265
Jhenaidah	236
Rangamati	220
Kushtia	208
Dinajpur	195
Nawabganj	173
Jessore	171
Patuakhali	171
Bhola	168
Lakshmipur	164
Feni	157

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Ganges/Brahmaputra

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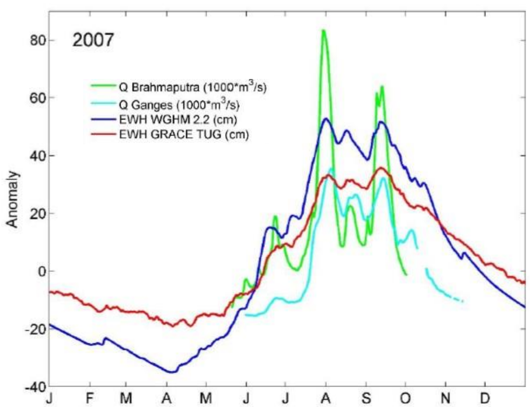
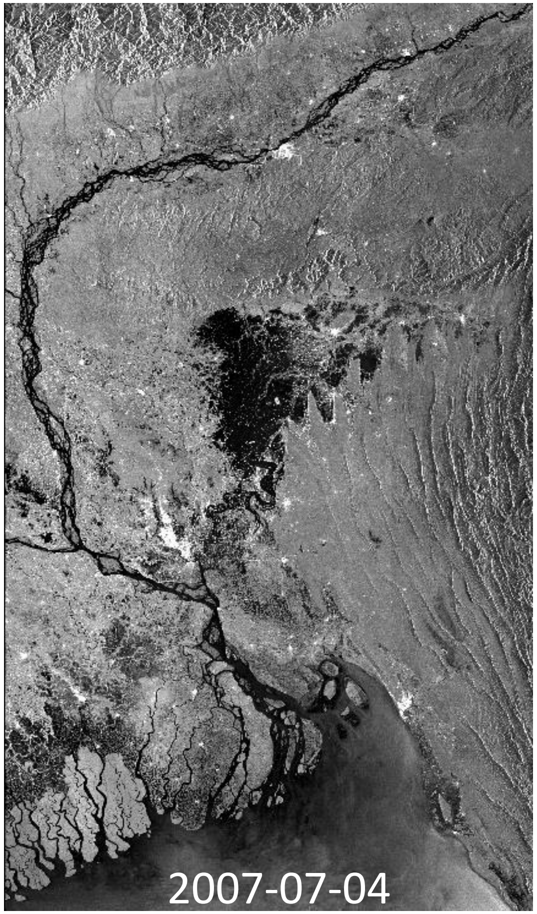
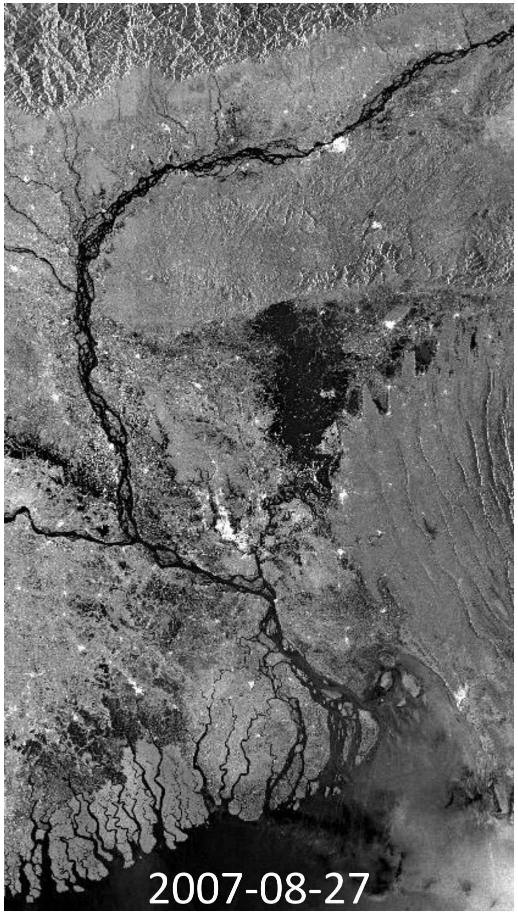
ENVISAT-ASAR wideswath (150m)

Id	Mission	Sensor	date	track	pass
1	ENVISAT-1	ASAR/WS	2007-07-04	319	D
2	ENVISAT-1	ASAR/WS	2007-07-23	90	D
3	ENVISAT-1	ASAR/WS	2007-08-11	362	D
4	ENVISAT-1	ASAR/WS	2007-08-27	90	D
5	ENVISAT-1	ASAR/WS	2007-09-04	212	A
6	ENVISAT-1	ASAR/WS	2007-09-07	255	A
7	ENVISAT-1	ASAR/WS	2007-09-23	484	A
8	ENVISAT-1	ASAR/WS	2007-10-09	212	A







Ganges/Brahmaputra

European Gravity Service for Improved Emergency Management

ALOS PALSAR

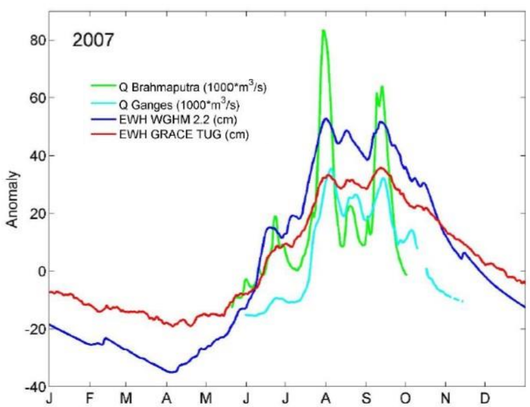
(ScanSAR mode)

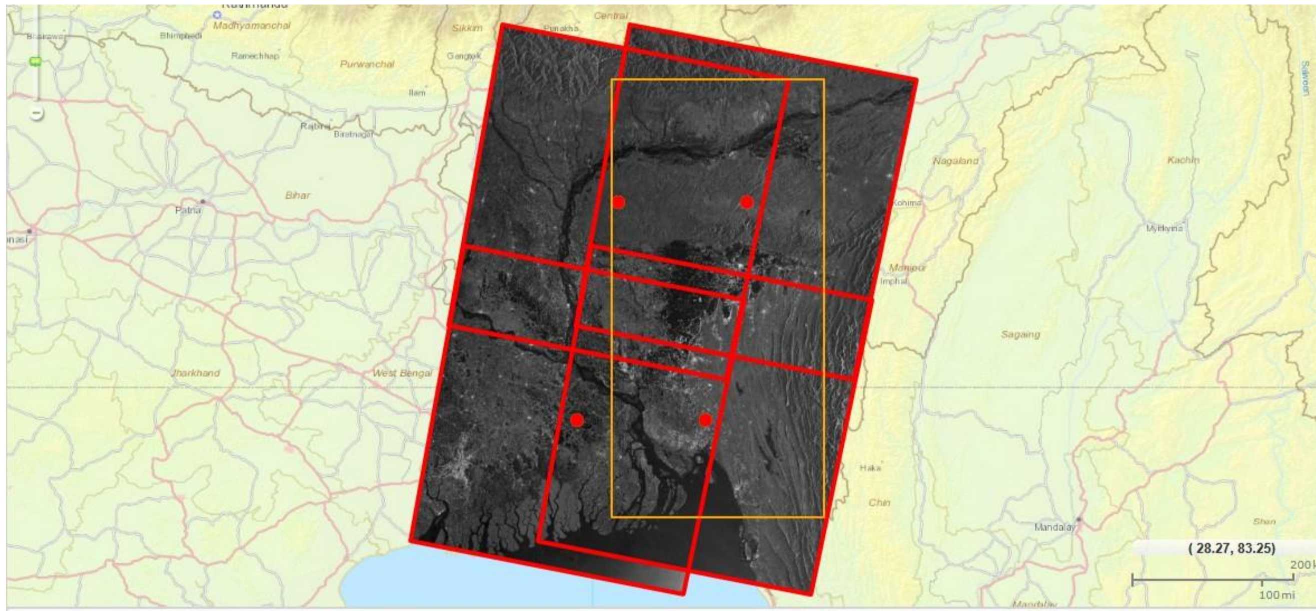
100 m resolution

350 km swath width

2007-08-12

2007-09-22





Search Results Total Result Matched: 10 Displaying: 4 Filtered: 6

Show Checked | Show Highlighted | Check Highlighted | Export

Scene ID	Sensor Name	Satellite Name	Observation Start Date	Observation End Date	Operation Mode	OBS Path Number	Centre Frame Number
ALPSRS082433100	PALSAR	ALOS	2007/08/12 04:27:27	2007/08/12 04:30:49	WB1	148	3100
ALPSRS082433150	PALSAR	ALOS	2007/08/12 04:27:27	2007/08/12 04:30:49	WB1	148	3150
ALPSRS088413100	PALSAR	ALOS	2007/09/22 04:20:50	2007/09/22 04:24:12	WB1	145	3100
ALPSRS088413150	PALSAR	ALOS	2007/09/22 04:20:50	2007/09/22 04:24:12	WB1	145	3150

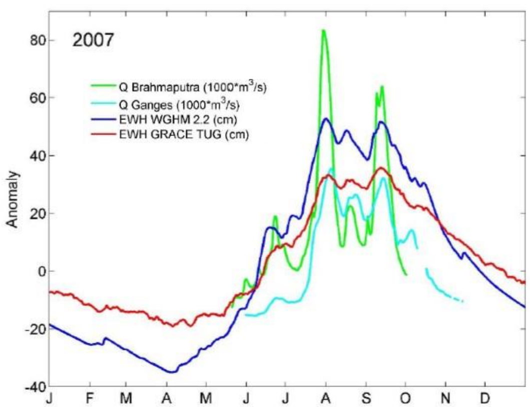
HORIZON 2020

Ganges/Brahmaputra

European Gravity Service for Improved Emergency Management

Radarsat-1
(ScanSAR mode)

Narrow: 50 m resolution
Wide: 100 m resolution



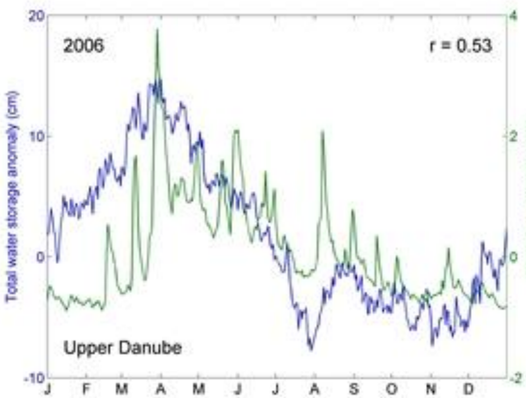
Id	Mission	Mode	Date	Beam
1	Radarsat-1	ScanSAR	2007-07-15	wide
2	Radarsat-1	ScanSAR	2007-07-16	narrow
3	Radarsat-1	ScanSAR	2007-08-02	wide
4	Radarsat-1	ScanSAR	2007-08-09	narrow
5	Radarsat-1	ScanSAR	2007-09-01	wide
6	Radarsat-1	ScanSAR	2007-09-02	narrow
7	Radarsat-1	ScanSAR	2007-09-18	wide
8	Radarsat-1	ScanSAR	2007-09-25	wide
9	Radarsat-1	ScanSAR	2007-10-12	wide
10	Radarsat-1	ScanSAR	2007-10-13	wide

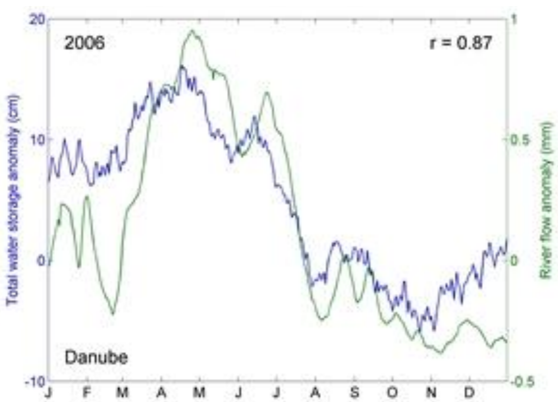
+ Cloud free optical MODIS image (250 m resolution) from 2007-08-20

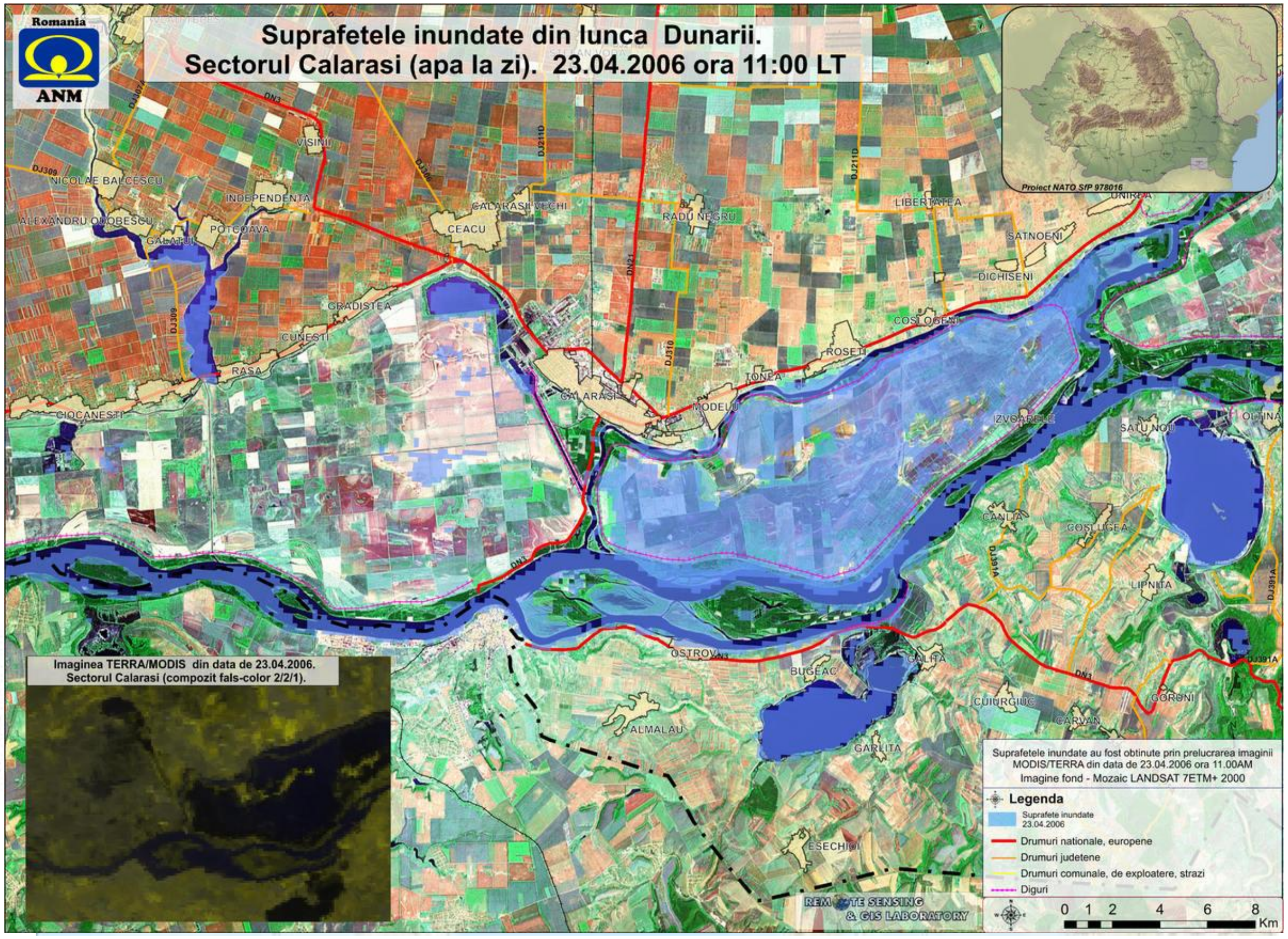
Danube

European Gravity Service for Improved Emergency Management

18 April	Flooding in Romania
14 April	Flooding in Hungary
07 April	Flooding in Austria

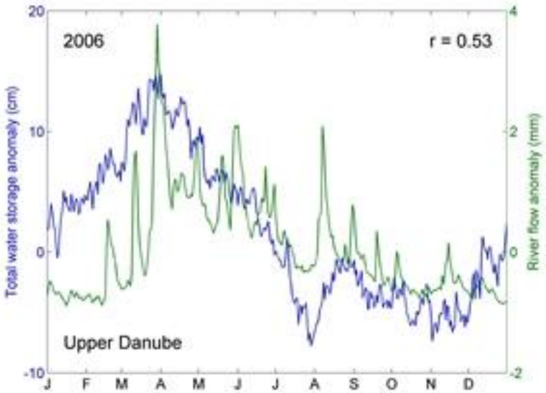


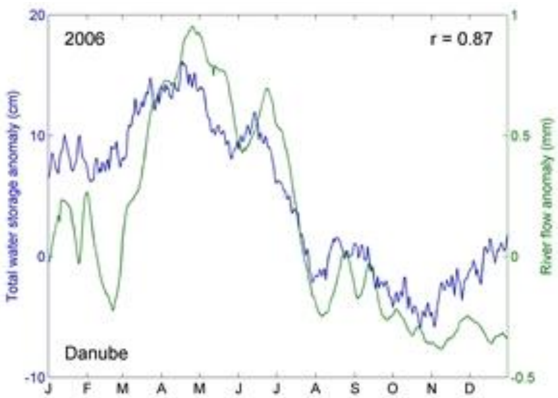




HORIZON 2020

Danube





Upper Danube

Id	Mission	Sensor	Date	Track	Pass
1	ENVISAT-1	ASAR/WS	2006-03-31	258	A
2	ENVISAT-1	ASAR/WS	2006-04-04	308	D
3	ENVISAT-1	ASAR/WS	2006-04-04	315	A
4	ENVISAT-1	ASAR/WS	2006-04-13	444	A
5	ENVISAT-1	ASAR/WS	2006-04-20	43	A

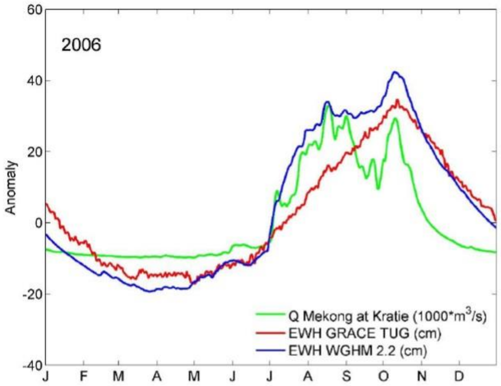
Lower Danube (Romania)

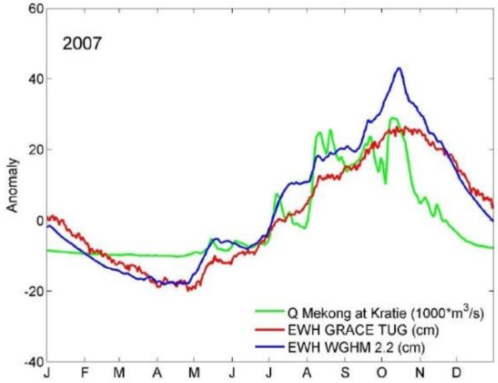
Id	Mission	Sensor	Date	Track	Pass
1	ENVISAT-1	ASAR/WS	2006-04-18	7	D
2	ENVISAT-1	ASAR/WS	2006-04-18	14	A
3	ENVISAT-1	ASAR/WS	2006-04-21	57	A
4	ENVISAT-1	ASAR/WS	2006-04-24	100	A
5	ENVISAT-1	ASAR/WS	2006-04-27	143	A

+ no ALOS Palsar, no Radarsat-1 data, lots of high res optical data

Mekong

European Gravity Service for Improved Emergency Management





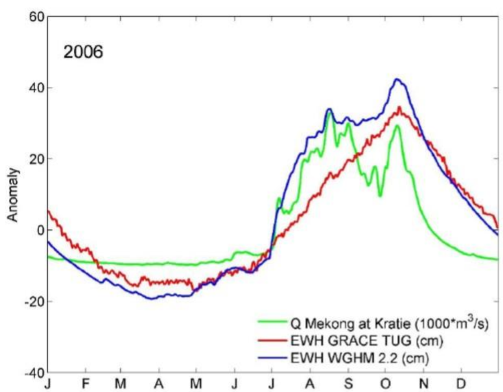
HORIZON 2020

Mekong

European Gravity Service for Improved Emergency Management

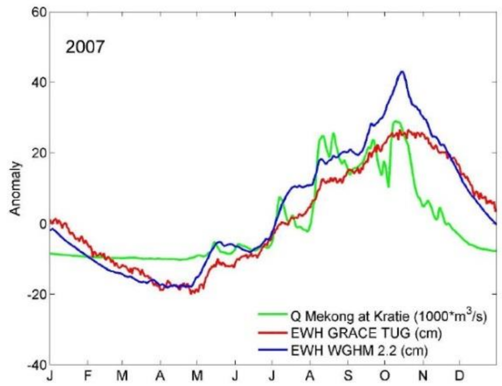
- ENVISAT ASAR (Wideswath mode)
- ALOS PALSAR (ScanSAR mode)

Id	Mission	Sensor	Date	Track	Pass
1	ENVISAT-1	ASAR/WS	2006-07-19	261	D
2	ENVISAT-1	ASAR/WS	2006-08-06	75	D
3	ENVISAT-1	ASAR/WS	2006-09-23	261	D
4	ENVISAT-1	ASAR/WS	2006-10-19	140	A



Id	Mission	Sensor	Date
1	ALOS	PALSAR/SC	2006-09-15
2	ALOS	PALSAR/SC	2006-09-27
3	ALOS	PALSAR/SC	2006-10-02
4	ALOS	PALSAR/SC	2006-10-14

HORIZON 2020



European Gravity Service for Improved Emergency Management

ENVISAT ASAR

Id	Mission	Sensor	Date	Track	Pass
1	ENVISAT-1	ASAR/WS	2007-07-03	304	D
2	ENVISAT-1	ASAR/WS	2007-07-10	412	A
3	ENVISAT-1	ASAR/WS	2007-07-19	32	D
4	ENVISAT-1	ASAR/WS	2007-07-23	97	A
5	ENVISAT-1	ASAR/WS	2007-07-29	183	A
6	ENVISAT-1	ASAR/WS	2007-08-07	304	D
7	ENVISAT-1	ASAR/WS	2007-08-14	412	A
8	ENVISAT-1	ASAR/WS	2007-08-23	32	D
9	ENVISAT-1	ASAR/WS	2007-09-02	183	A
10	ENVISAT-1	ASAR/WS	2007-09-11	304	D
11	ENVISAT-1	ASAR/WS	2007-09-18	412	A
12	ENVISAT-1	ASAR/WS	2007-10-16	304	D

ALOS PALSAR

Id	Mission	Sensor	Date
1	ALOS	PALSAR/SC	2007-07-05
2	ALOS	PALSAR/SC	2007-07-24
3	ALOS	PALSAR/SC	2007-07-29
4	ALOS	PALSAR/SC	2007-08-03
5	ALOS	PALSAR/SC	2007-08-15
6	ALOS	PALSAR/SC	2007-09-13
7	ALOS	PALSAR/SC	2007-09-18
8	ALOS	PALSAR/SC	2007-10-29
9	ALOS	PALSAR/SC	2007-09-02
10	ALOS	PALSAR/SC	2007-09-11
11	ALOS	PALSAR/SC	2007-09-18
12	ALOS	PALSAR/SC	2007-10-16

Next steps

European Gravity Service for Improved Emergency Management

- ENVISAT ASAR data will be obtained via Copernicus/ESA DWH (end of January 2016)
- Apply automated flood processing algorithm (developed for TerraSAR-X and Sentinel-1) to derive 2-D flood mask
- compare results from automated flood processing with semi-automatic approaches
- Test and apply flood volume estimation approach (WP6)

EGSIEM

European Gravity Service for Improved Emergency Management

WP4. Scientific Combination Service

Combination of GRACE Monthly Gravity Field Solutions

Yoomin Jean

Astronomical Institute, University of Bern

EGSIEM Progress Meeting # 2

University of Luxembourg

January 18 – 19, 2016

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

Introduction

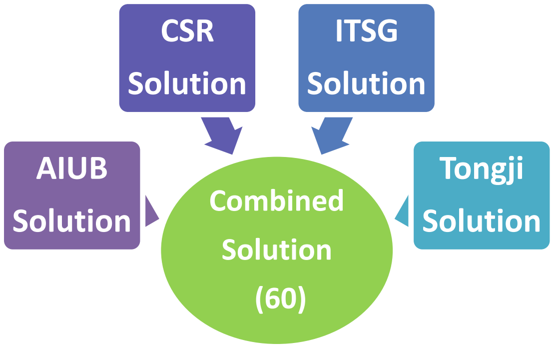
- In WP4 at AIUB
  - Scientific Combination Service :

    Combination of GRACE Monthly Gravity Field Solutions

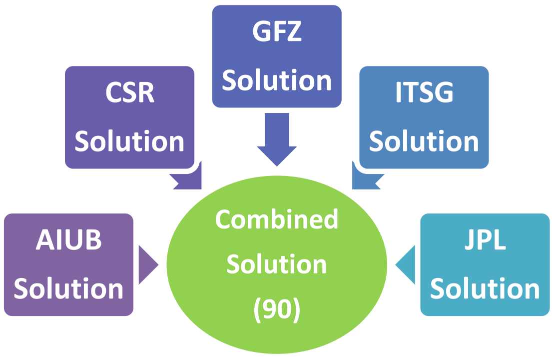
- Contents
  - Review: Combination of GRACE Monthly Solutions
  - Validation of a Combined Solution: Hydrology, Cryology, GIA, GPS Loading
  - Simulation study on the Combination

Review: Combination of GRACE Monthly Solutions

- GRACE Monthly Solutions
  – The solutions available at ICGEM website



- Comparison
  - Signal: MEWH of river basins
  - Variability: wSTD over the oceans
  - Spherical Harmonic Coefficients



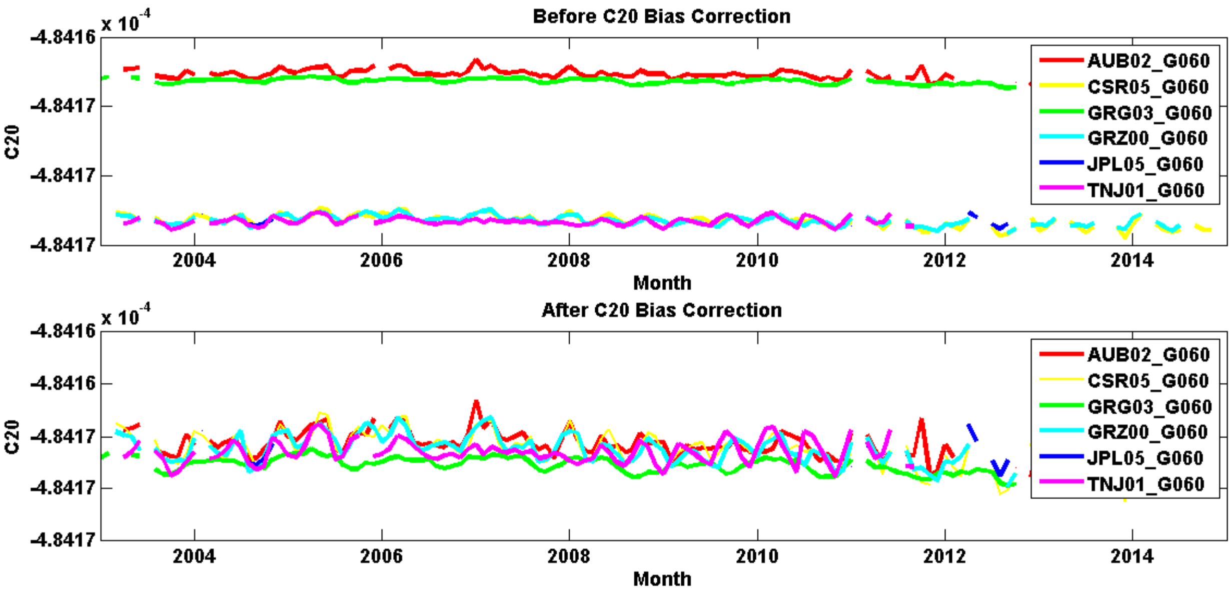
- Combination
  – Weighting schemes: 1/(Solution - Arithmetic Mean) ^{2}
  – Weighted combined solutions:

    One weight/month/gravity field

Corrections in Preprocessing Steps

- Correction of ***bias in C20*** coefficient:

  Zero-tide → Tide-free



* MEWH and wSTD over the oceans: C20 was excluded.

< C20 Bias >

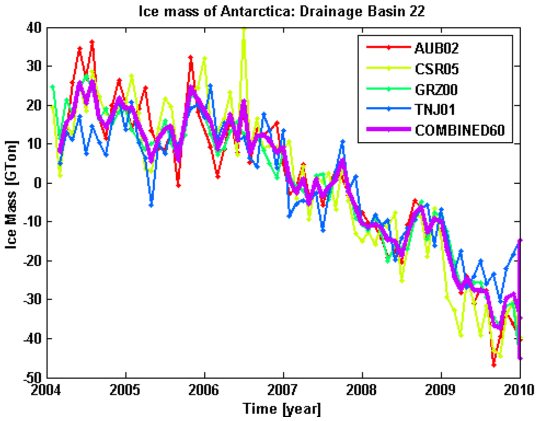
Mean(C20_Sol) — Mean(C20_CSR)

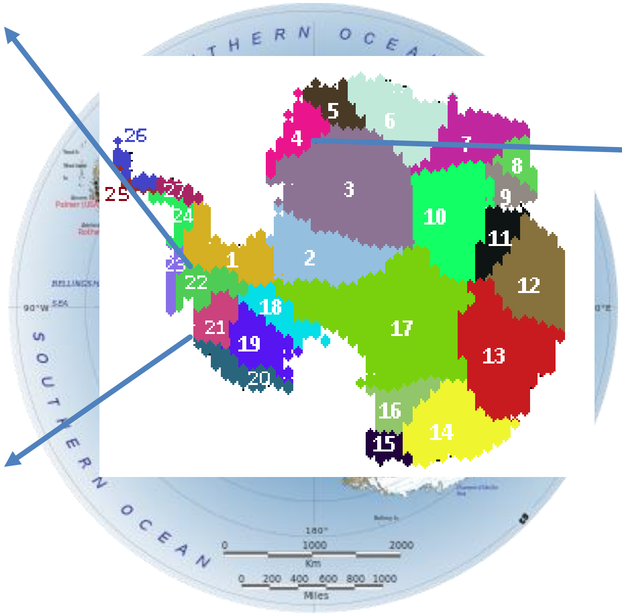
C20 Difference w.r.t. CSR	Degree 60	
	before	after
AIUB-CSR	3.05E-11	-7.58E-11
GRGS-CSR	-1.74E-10	-1.98E-10
ITSG-CSR	-1.77E-11	-1.77E-11
Tongji-CSR	-6.02E-11	-8.45E-11
C20 Difference w.r.t. CSR	**Degree 90**	
	before	**after**
AIUB-CSR	2.99E-11	-7.64E-11
GFZ-CSR	1.57E-10	1.33E-10
ITSG-CSR	-4.41E-12	-4.41E-12
JPL-CSR	2.33E-11	2.33E-11

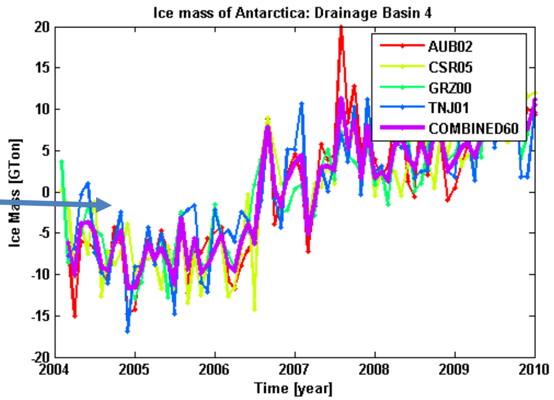
- ***Rescaling*** of spherical harmonic coefficients:
  - Reference value of the radius of Earth: *6,378,136.3* m

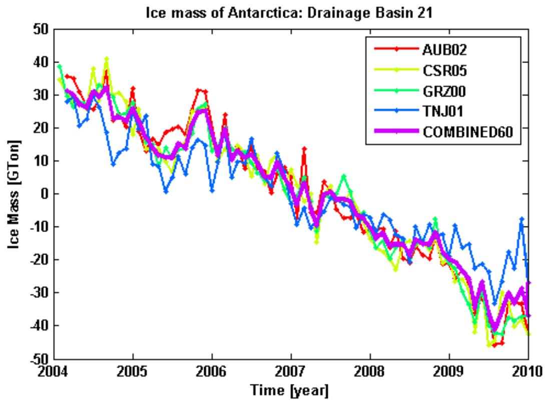
Internal Evaluation (1) : Ice Mass Change

- Ice Mass Change in Drainage Systems in Antarctica
- **Combined solution** (***unfiltered***) and individual solutions

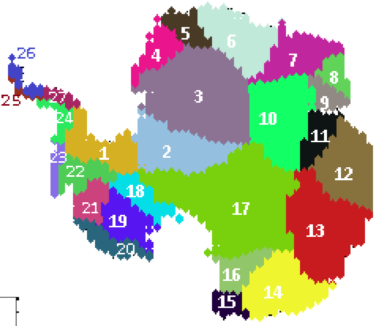




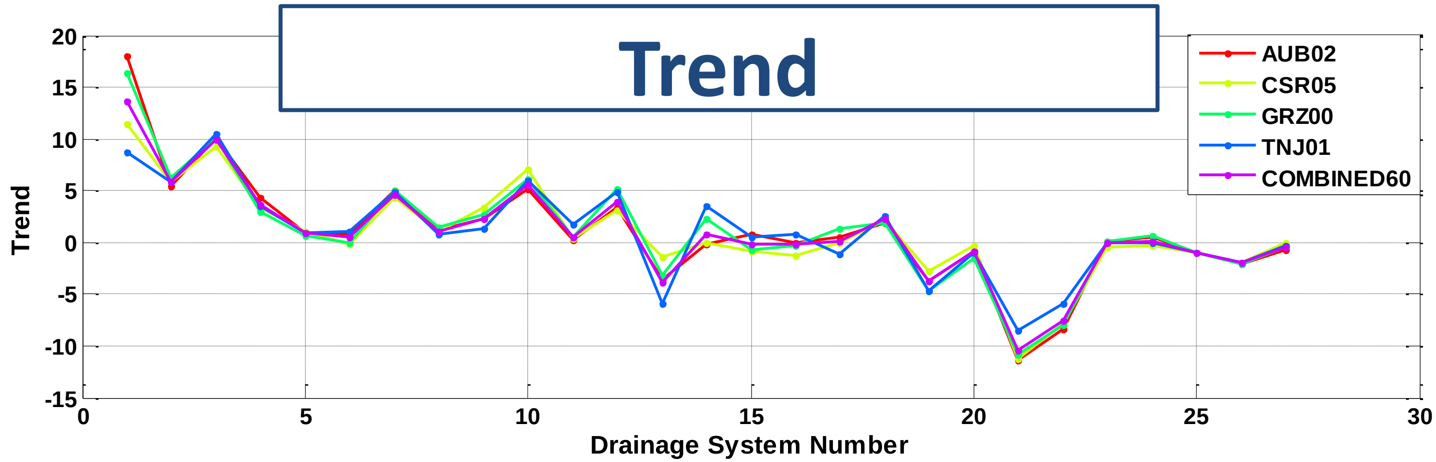


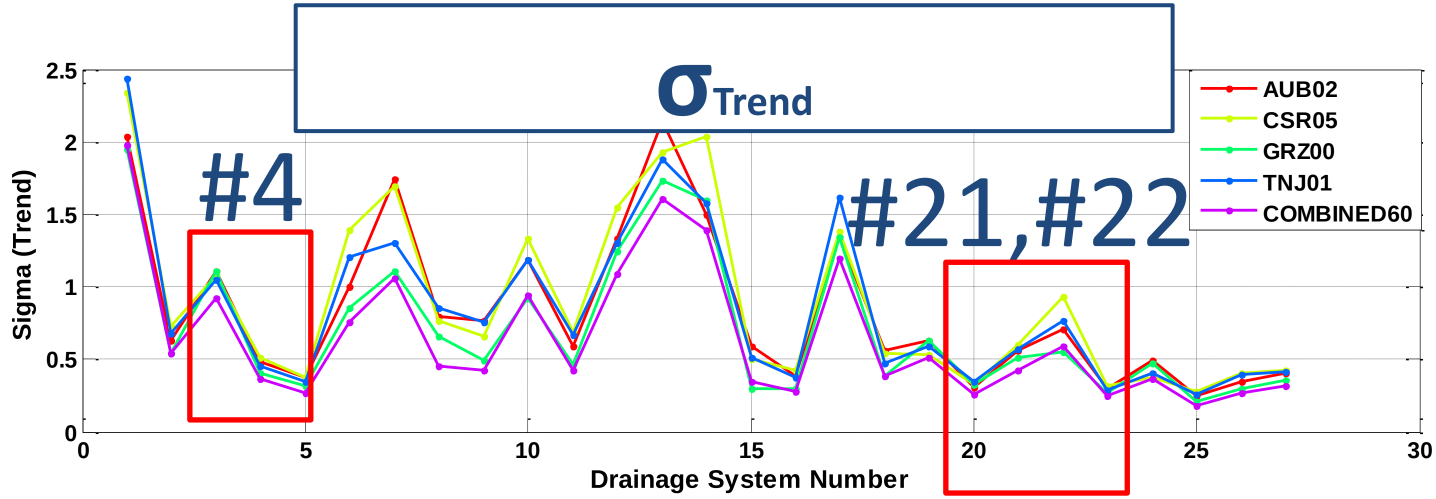


Internal Evaluation (1) : Ice Mass Change



Degree 60, Unfiltered





External Evaluation of the Combined Solution

- Combined solution: one weight/month/gravity field, degree 90
  - gfc file format
  - L3 grids (Thanks to *TU Graz*'s prompt conversion assistance)

Hydrology

Andreas Güntner, Ben Gouweleeuw

Hydrological Events

Cryology

Martin Horwath

Ice Mass in Antarctica

Combined Solution

GIA

Holger Steffen

Fennoscandia, Canada

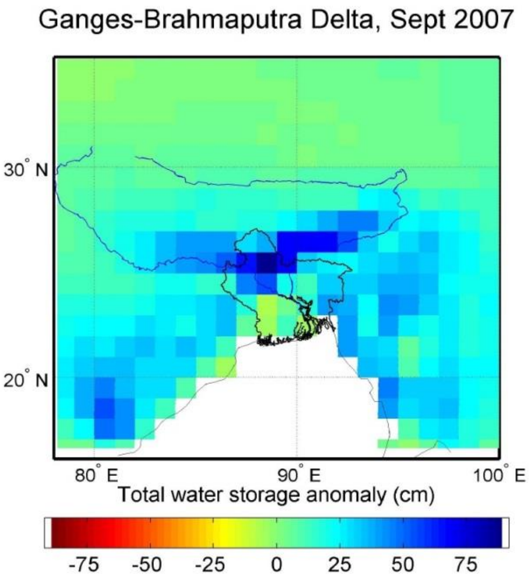
GPS Station Loading

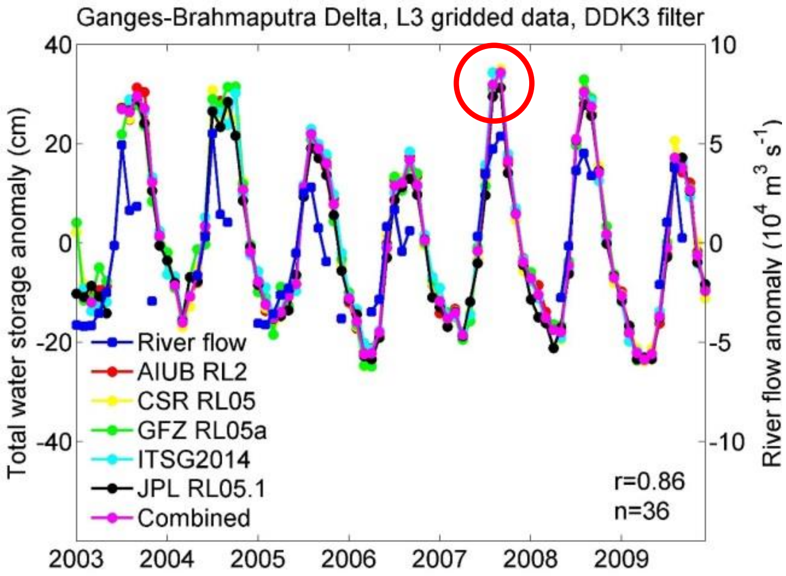
Tonie van Dam

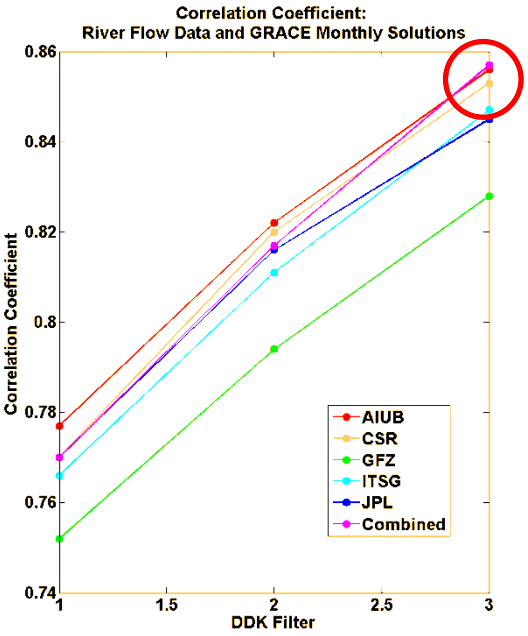
GPS stations

External Evaluation (1): Hydrology

- Hydrological events
- Tested by Dr. ***Ben Gouweleeuw*** and Prof. ***Andreas Güntner*** (GFZ)
- Individual solutions, Combined solutions, and River flow data
- River basin: Ganges-Brahmaputra (2007)
- Possible loss of benefits during conversion process (e.g. Filtering) into L3 grids

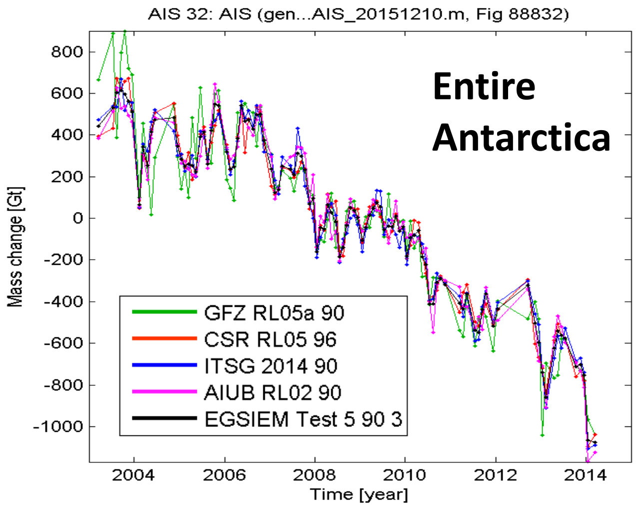




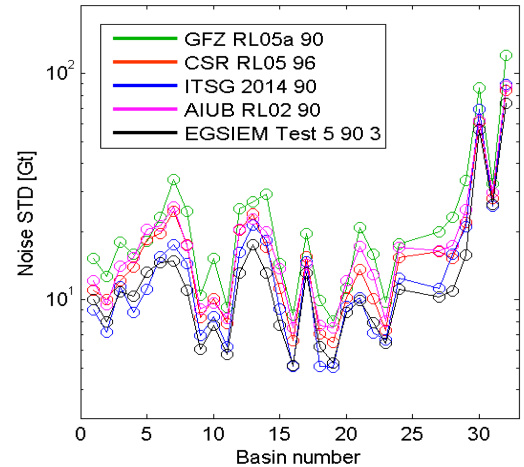


External Evaluation (2): Cryology

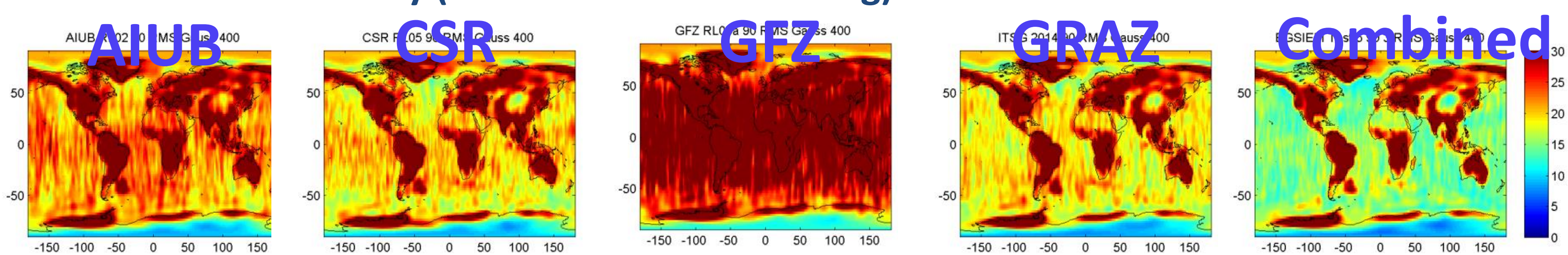
- Ice mass change in Antarctica and Greenland
- Tested by Prof. ***Martin Horwath*** (TU Dresden)



Noise levels per basin



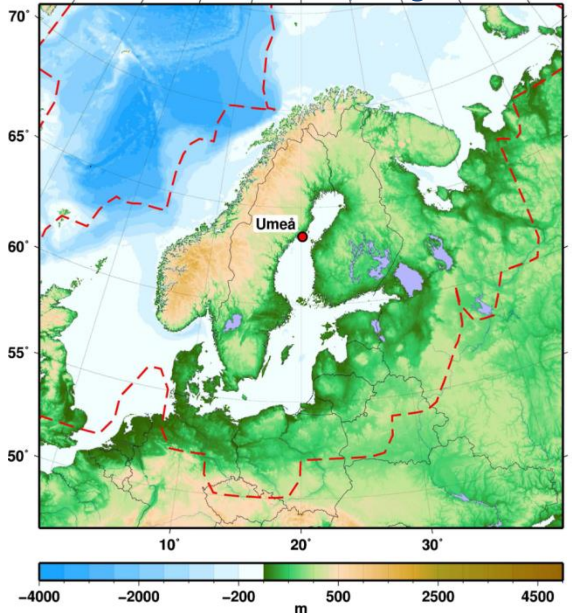
RMS of EWH variability (400km Gaussian filtering)



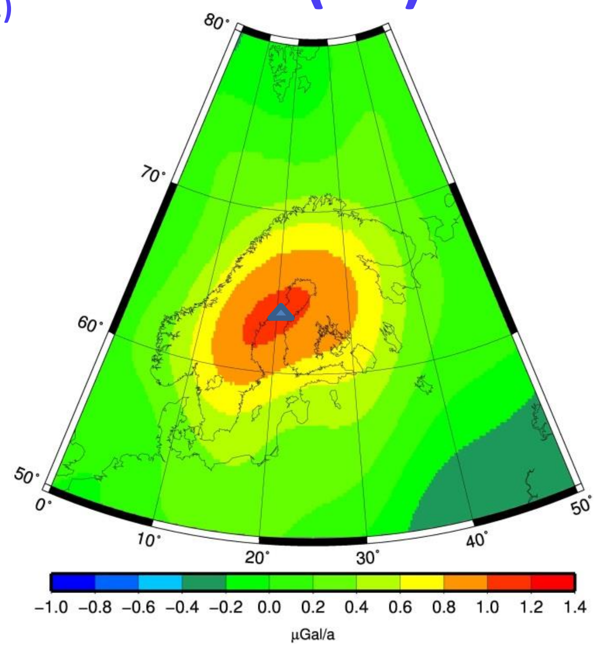
External Evaluation (3): GIA

- Post-glacial rebound
- Tested by Dr. ***Holger Steffen*** (Lantmäteriet)
- CSR and Combined solutions
- Fennoscandia (Northern Europe) and Canada (North America)

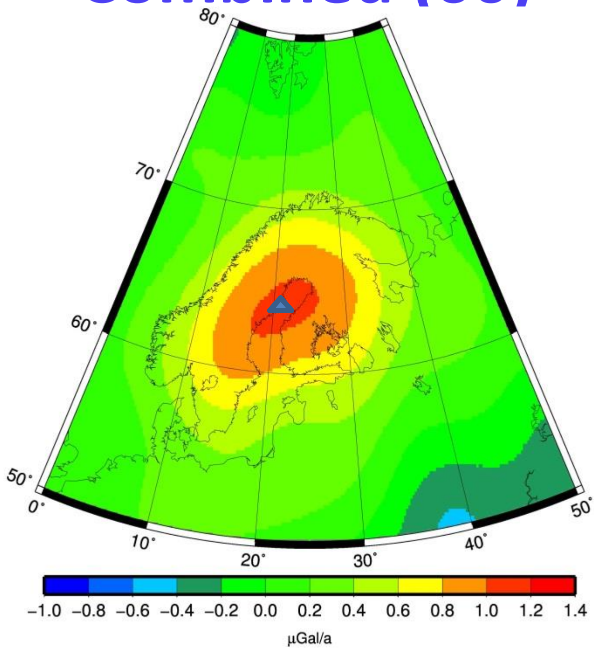
From Topograpy (ETOPO1; Amante and Eakins 2009; Holger and Wu 2011)



CSR (60)

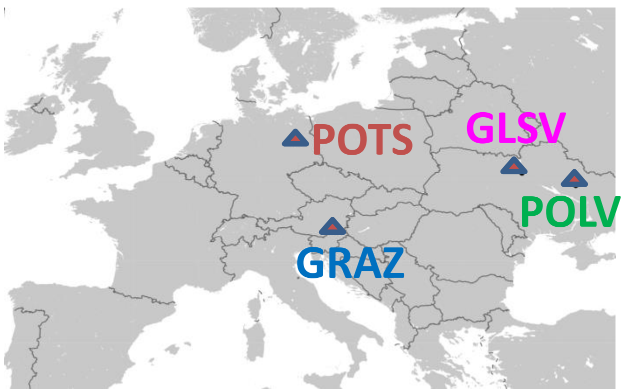


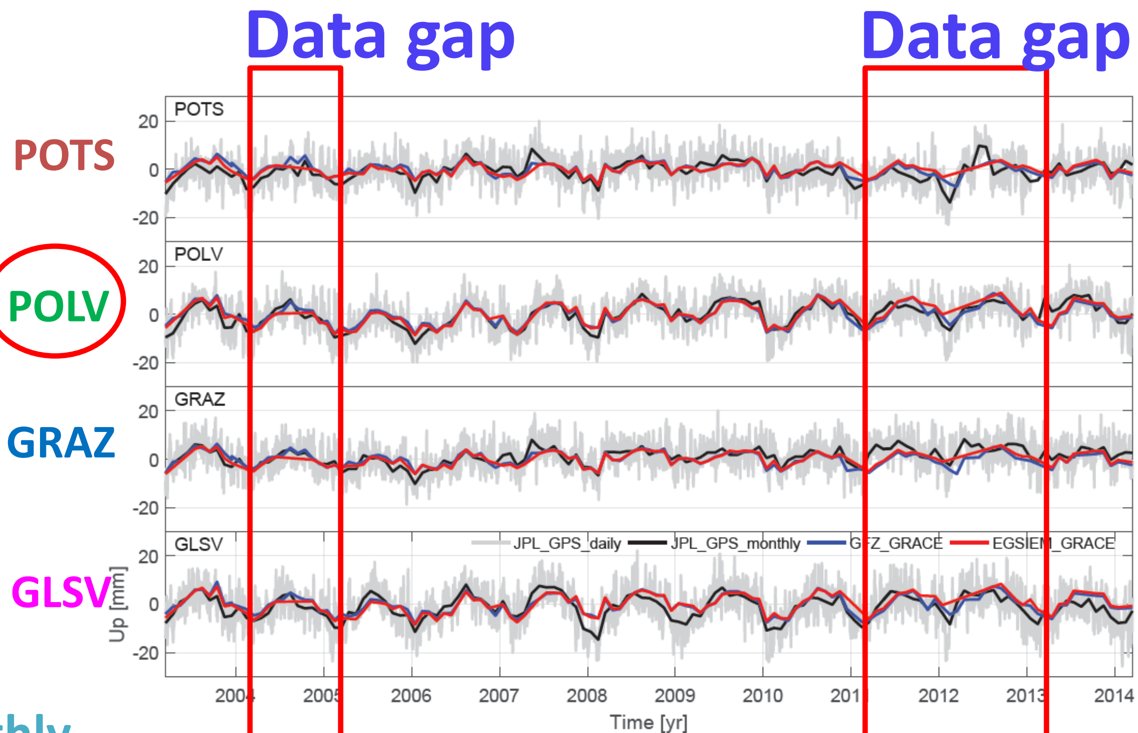
Combined (60)



External Evaluation (4): GPS Loading

- GPS station loading
- Tested by Prof. ***Tonie van Dam*** (U Luxembourg)
- Comparison: GPS and GRACE solutions
- GPS stations: POTS, POLV, GRAZ, GLSV





– GPS: JPL daily

JPL monthly

– GRACE: GFZ monthly

EGSIEM$_{combined}$ monthly

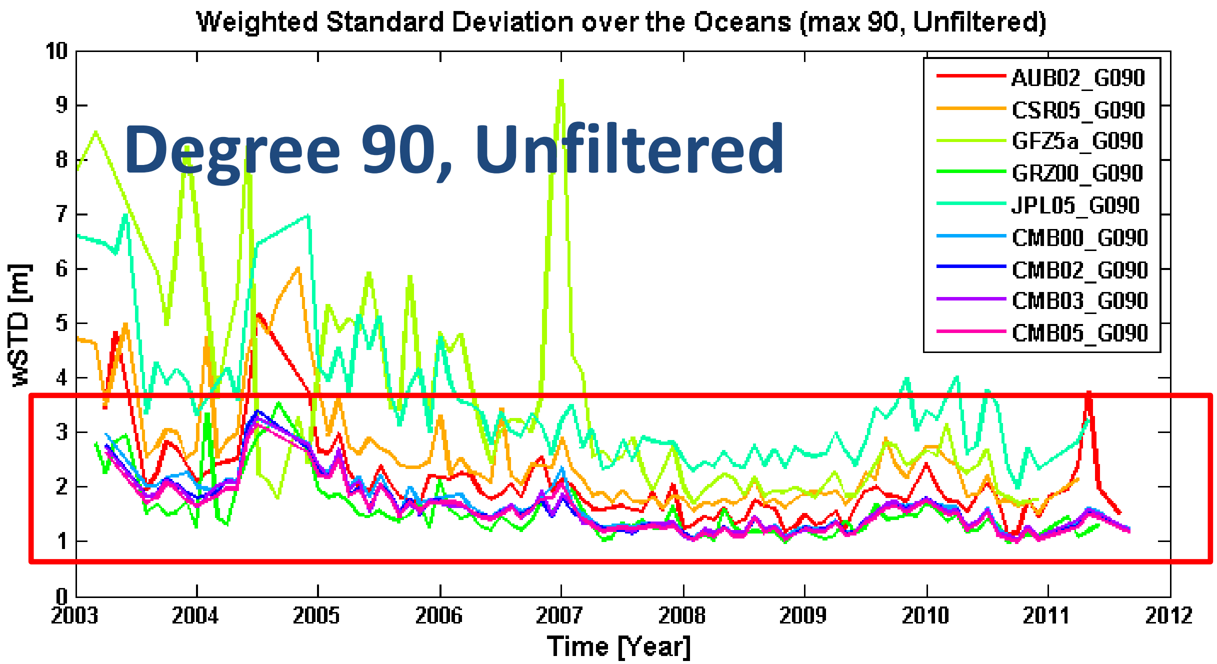
Simulation Study: Motivation

- Motivation:
  - Combined solution vs. a low-noise individual solution
  - Impact of a deviated individual solution
  - Investigation & Validation of the weighting scheme

Combined solution

vs.

Graz solution



Simulation Study

- Weighting scheme
  - Assumption: the arithmetic mean is close to the truth.
  - However, the reality may not be like that.
  - How to improve the weighting scheme?
  - Limits of the weighting scheme

- Simulated gravity fields:
  - Reference gravtiy field: extracted from a model
  - Added bias and noise

→ presentation in *EGU 2016*

Presentations / Publications

- **Presentation in the EGU 2015 (Apr. 2015)**
  - Comparison and combination of GRACE monthly gravity field solutions
- **Presentation in the Geodätische Woche 2015 (Sep. 2015)**
  - Combination of GRACE monthly gravity field solutions with different weighting schemes
- **Contribution to presentation by Prof. Adrian Jäggi in the AGU meeting 2015 (Dec. 2015)**
  - Combination service of GRACE monthly solutions
  - Contribution to validation of the weighted combined solution
- **Plans**
  - **Presentation in EGU 2016**
  - **Manuscript for a journal article (to be submitted in the first half of 2016)**

Assessment of experimental EGSIEM series

Martin Horwath, TUD (presented by Uli)

EGSIEM Progress Meeting # 2

University of Luxembourg

January 18 – 19, 2016

Introduction

Comparison of the following time series:

- CSR (96), truncated to degree 90
- GFZ RL05a (90)
- ITSG 2014 (90)
- AIUB RL2 (90)
- EGSIEM (90), test combination

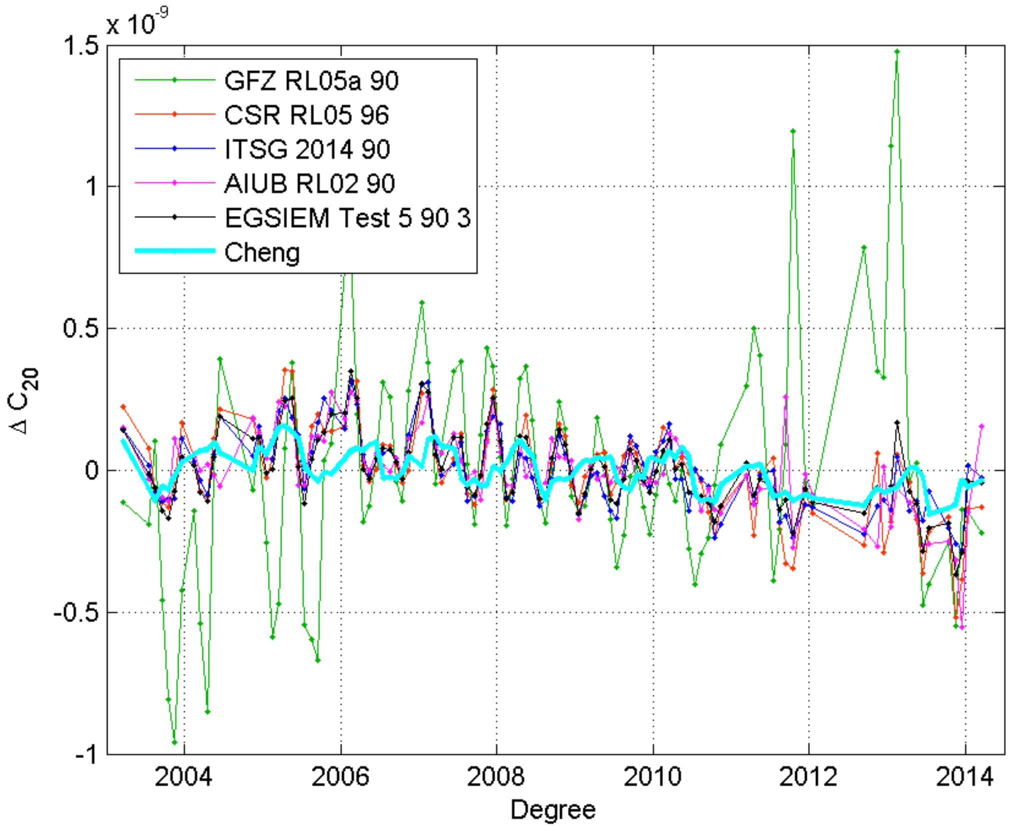
Only months that are common to all series were used.

1. **In the Spherical harmonic domain**

2. **In the Spatial Domain**

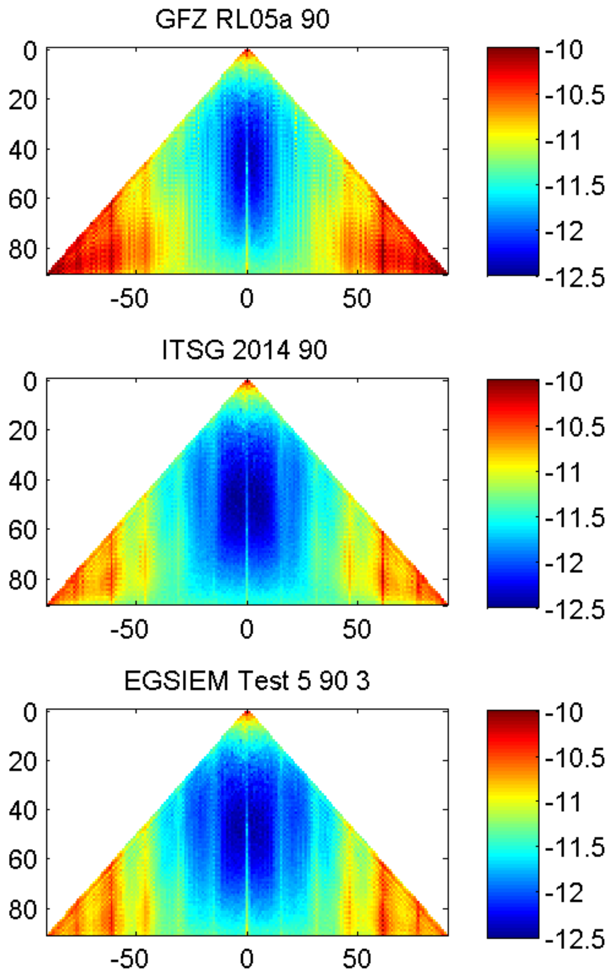
3. **Mass Changes in Antarctic Drainage Basins**

C_{20}



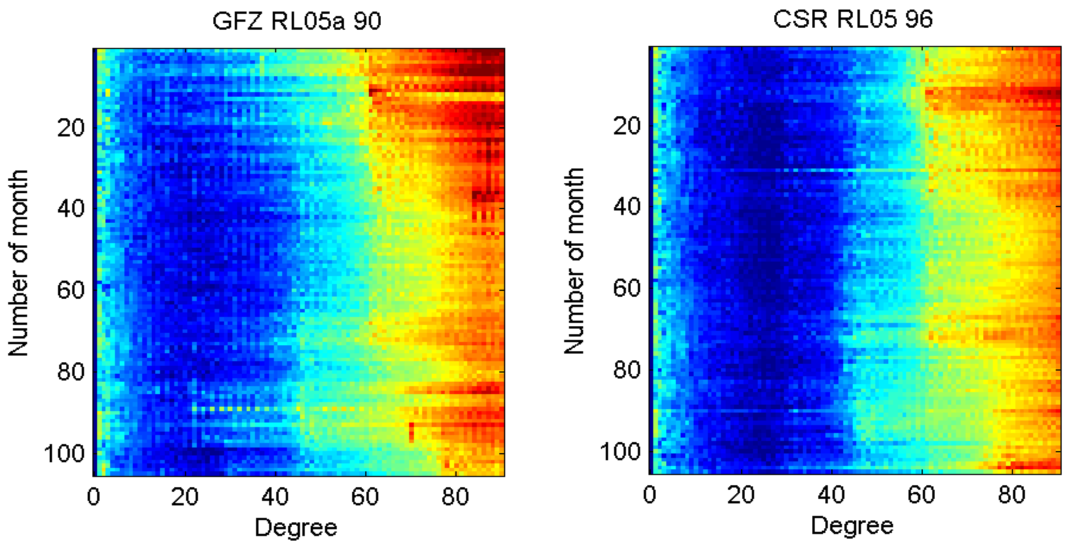
C_{20} is replaced by values from SLR (Cheng et al. CSR series) and degree-1 terms are added (Swenson, Chamber, Wahr series) to make the Antarctic mass balance results consistent.

Analyses in the Spherical harmonic domain (1/3).

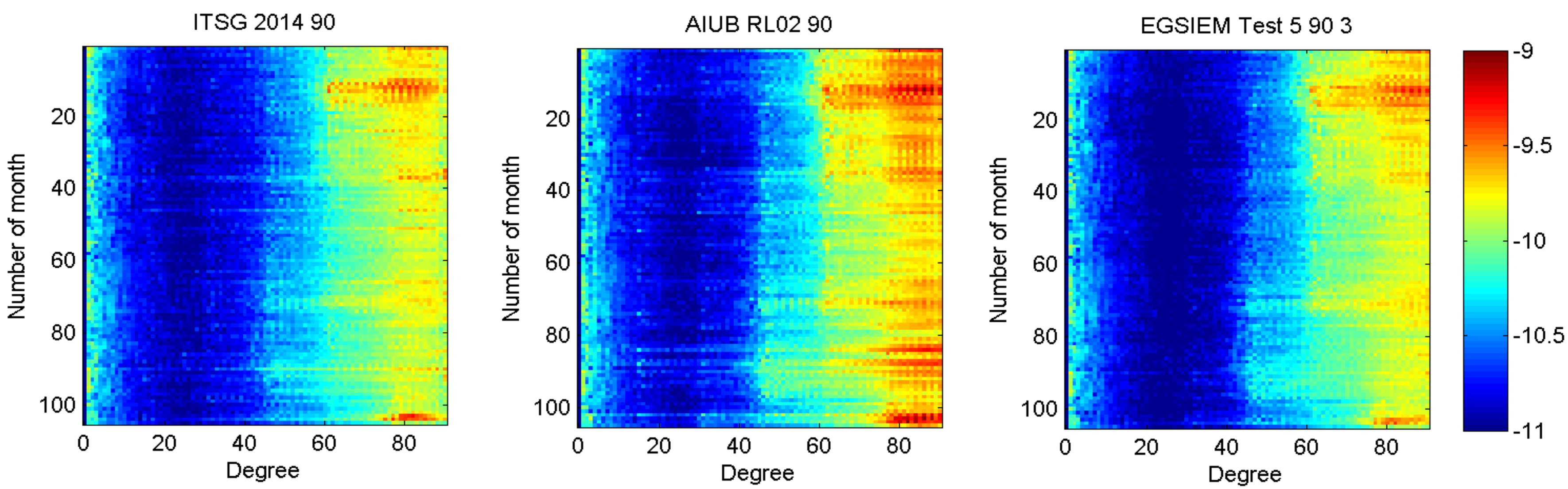


STD per coefficient (after fitting and subtracting const. + linear + annual + semi-annual signal)

Analyses in the Spherical harmonic domain (2/3).

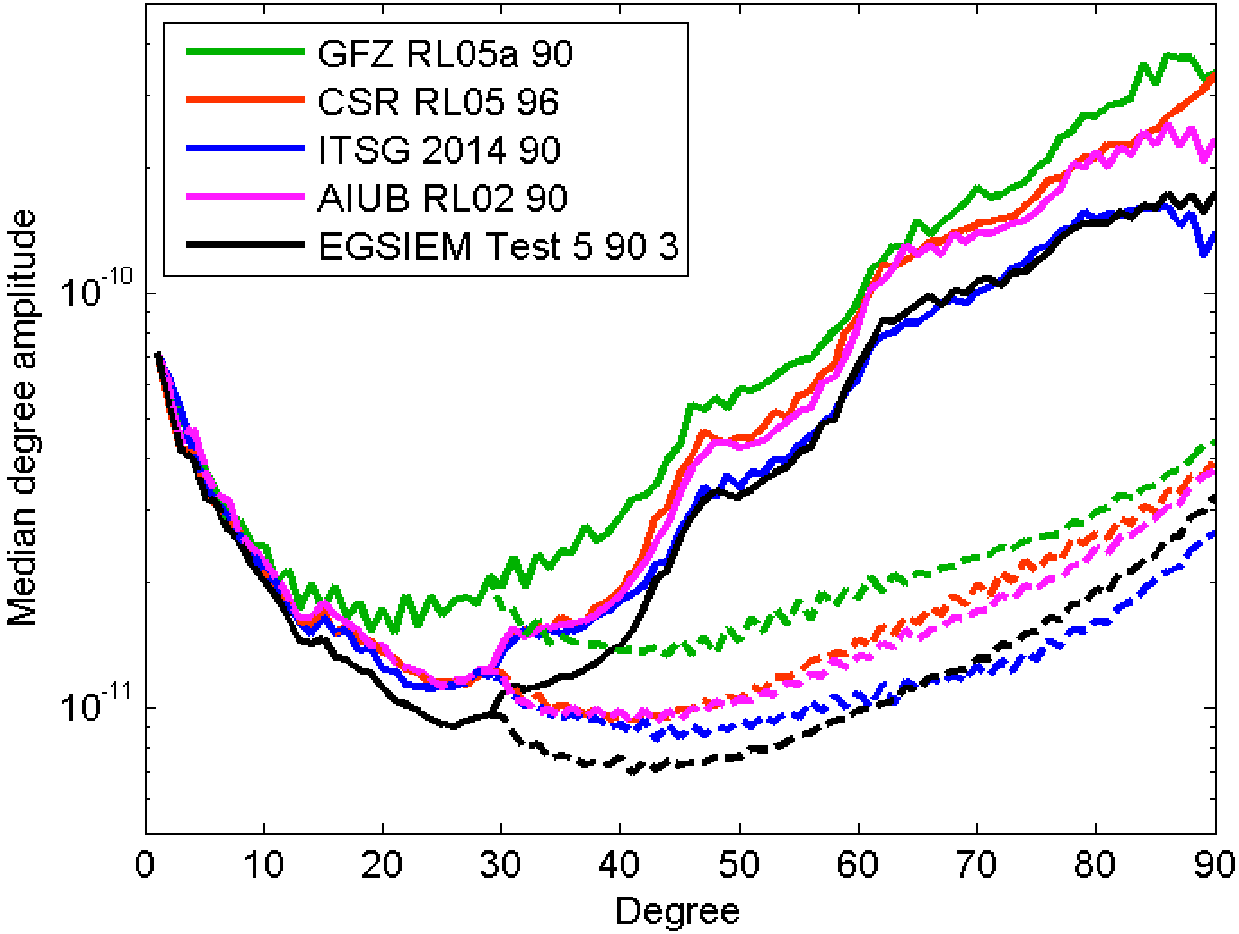


Degree amplitudes [log10] (after fitting and subtracting const. + linear + annual + semi-annual signal)



Analyses in the Spherical harmonic domain (3/3).

Median degree amplitudes



Dashed: Median degree amplitudes calculated for orders m = 0 … 29 only (these orders are most important for polar signals).

Analyses in the Spherical harmonic domain: conclusion

- From looking at the ascending (error-dominated) part of the degree amplitude curves, **ITSG** and **EGSIEM** show the **lowest noise levels**.

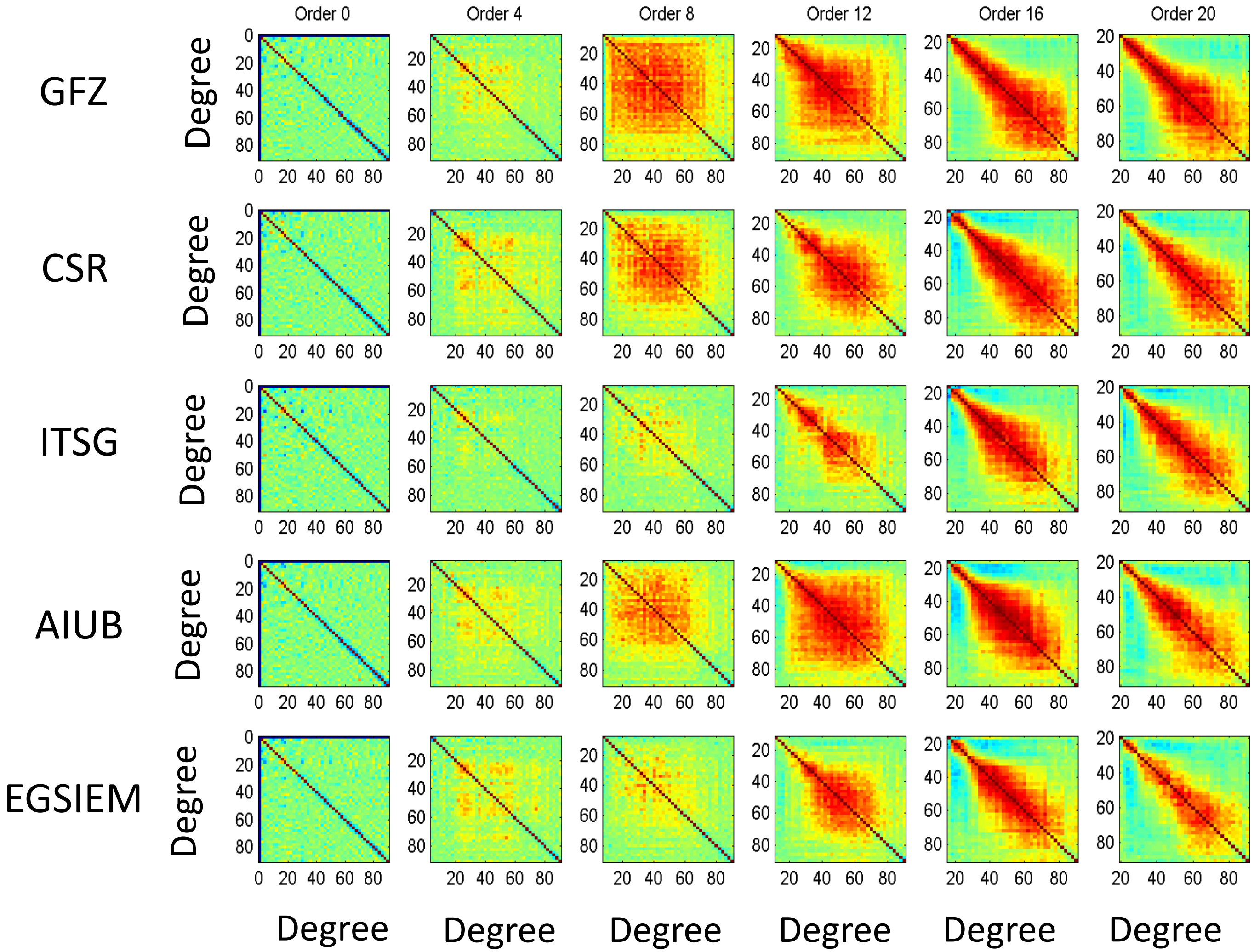
- **For n>60**, **ITSG** noise level is lower than EGSIEM noise level. This is particularly pronounced for the **near-zonals**, which are most important for polar signals.

- **For n<60**, **EGSIEM** has the lowest level of variability. This is visible even in the very low degrees. Later we will see that this is not related to signal attenuation.

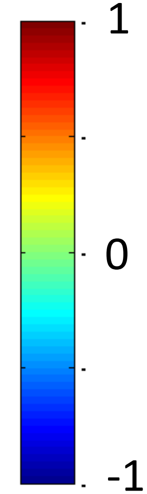
Empirical Correlations

- **EWH anomalies** = EWH coefficients – model (bias + trend + annual + semi-annual variation)
- **Empirical correlation matrices** between EWH anomaly coefficients of the same order and even (odd) degrees.
- Starting from order 8 or so we see the typical "**striping**" correlations.
- **ITSG** series shows **weaker correlations** than the other series.

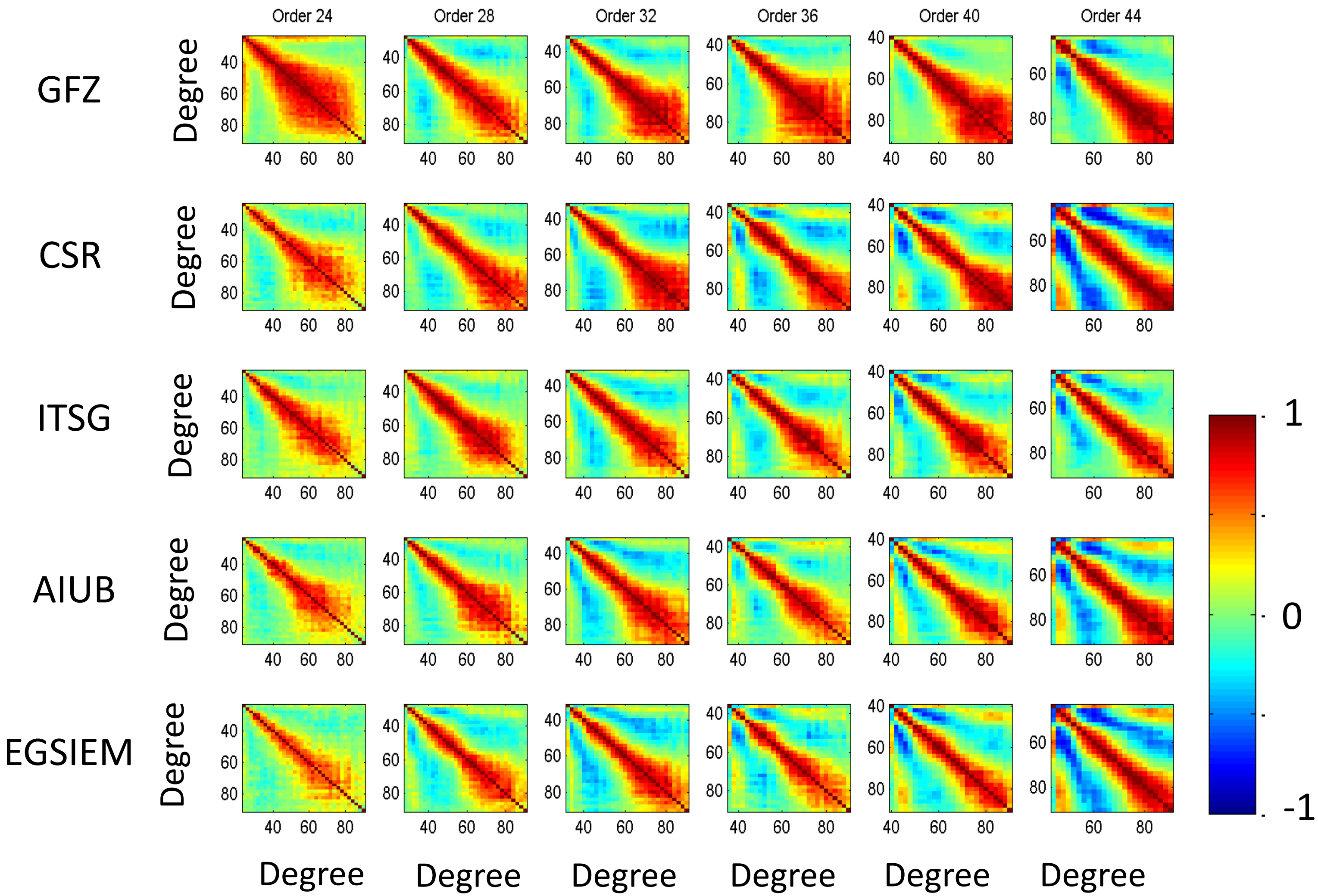
Empirical correlations (1/2)



Each column shows correlation matrices between degrees of equal parity for a particular order.



Empirical correlations (2/2)

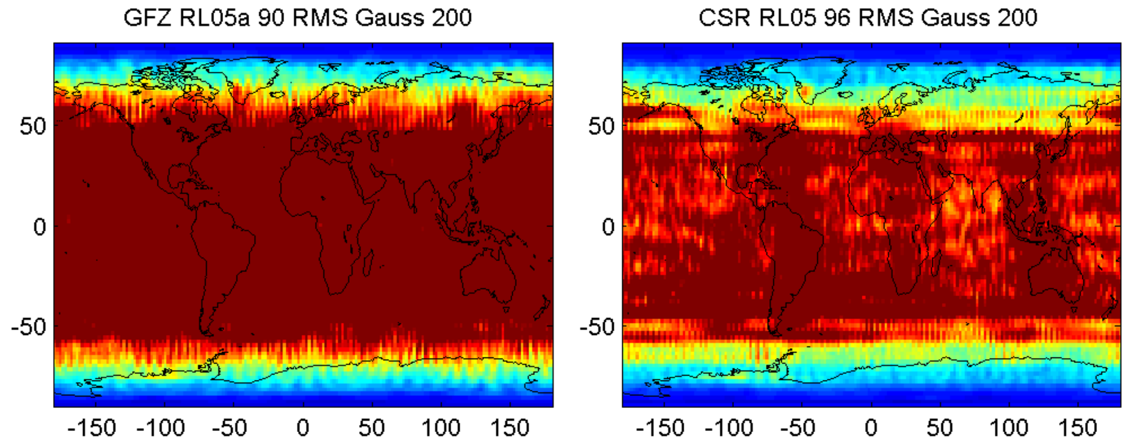


Analyses in the spatial domain

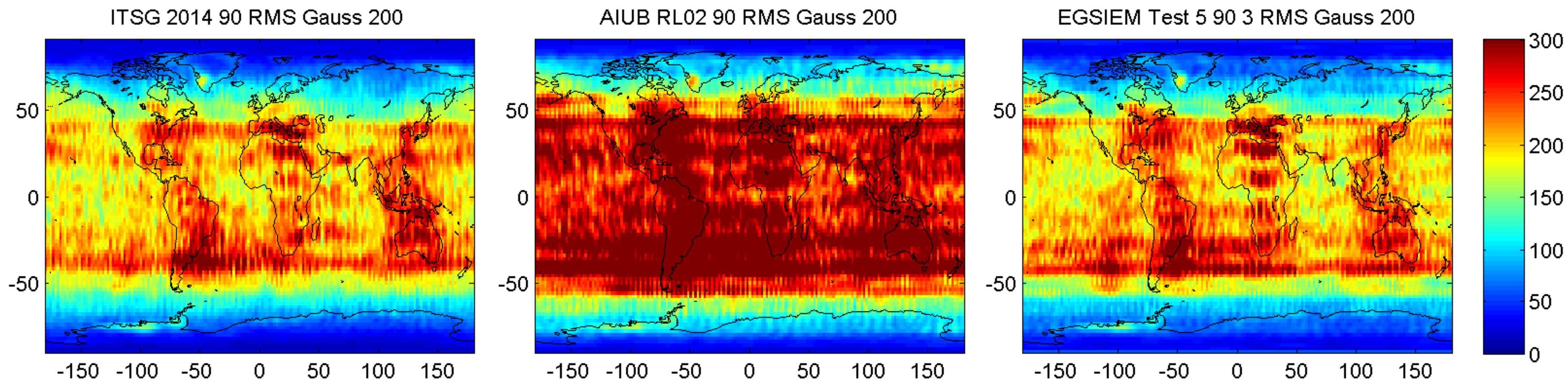
1. Fit and removal of Bias + Trend + annual + semi-annual signal,
2. filtering in the spectral domain: destriping, 200/400 km Gauss,
3. monthly maps of EWH-anomalies,
4. standard deviation or median of absolute temporal variability.

Noise is assessed over regions of low signal: oceans, inner Antarctica.

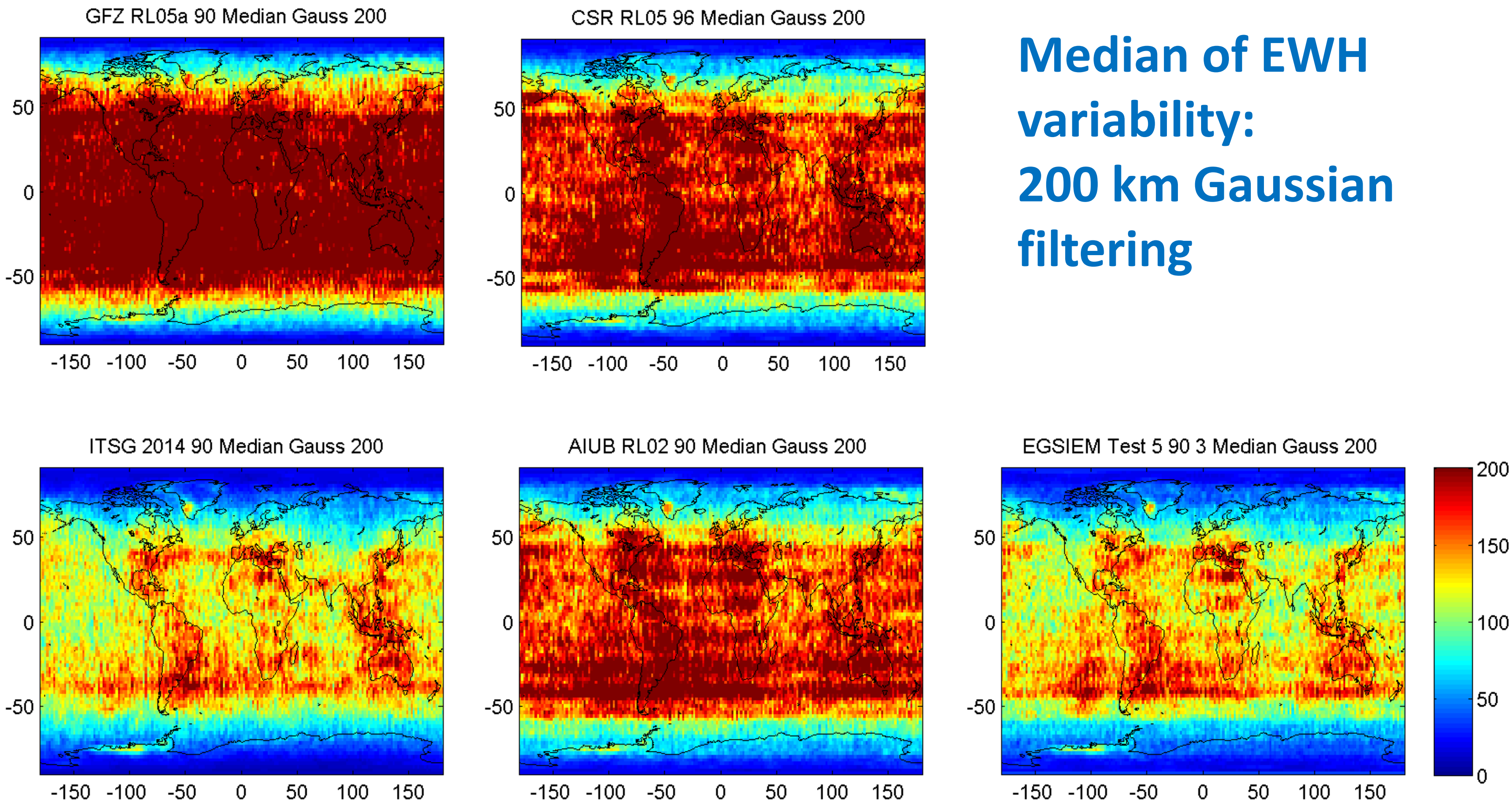
Analyses in the spatial domain (1/12)



RMS of EWH variability:
200 km Gaussian filtering

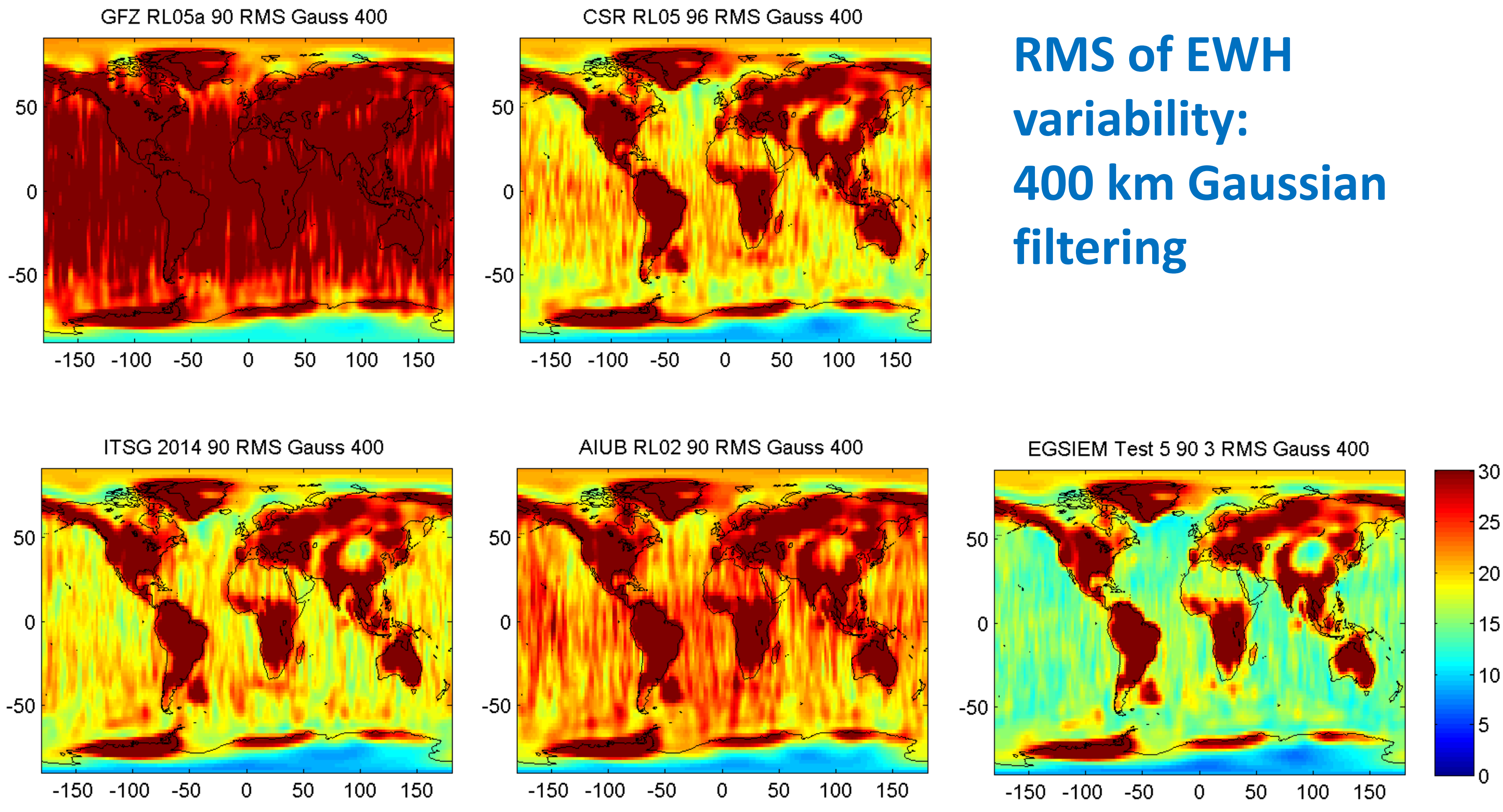


Analyses in the spatial domain (2/12)



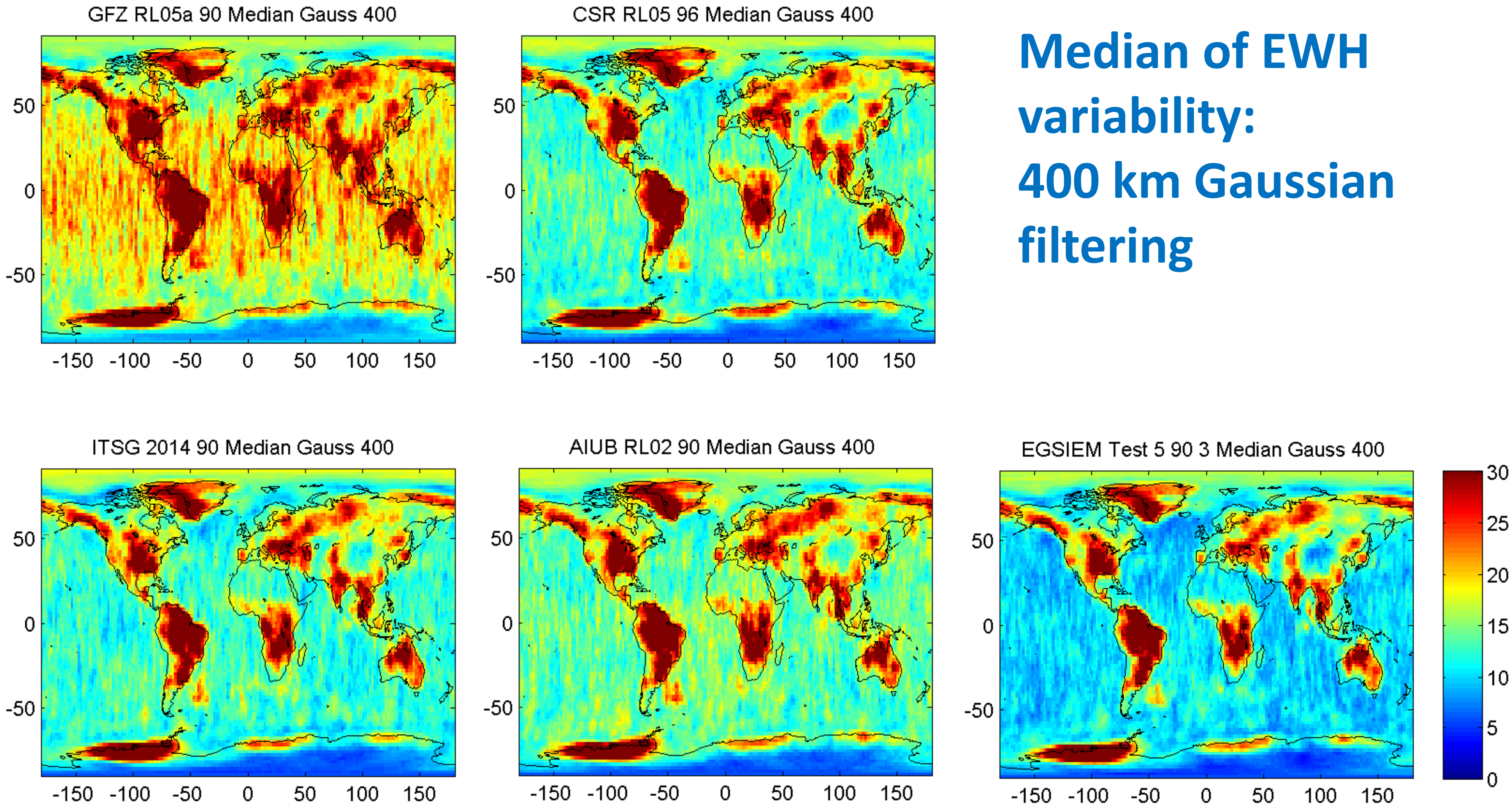
Median of EWH variability: 200 km Gaussian filtering

Analyses in the spatial domain (3/12)



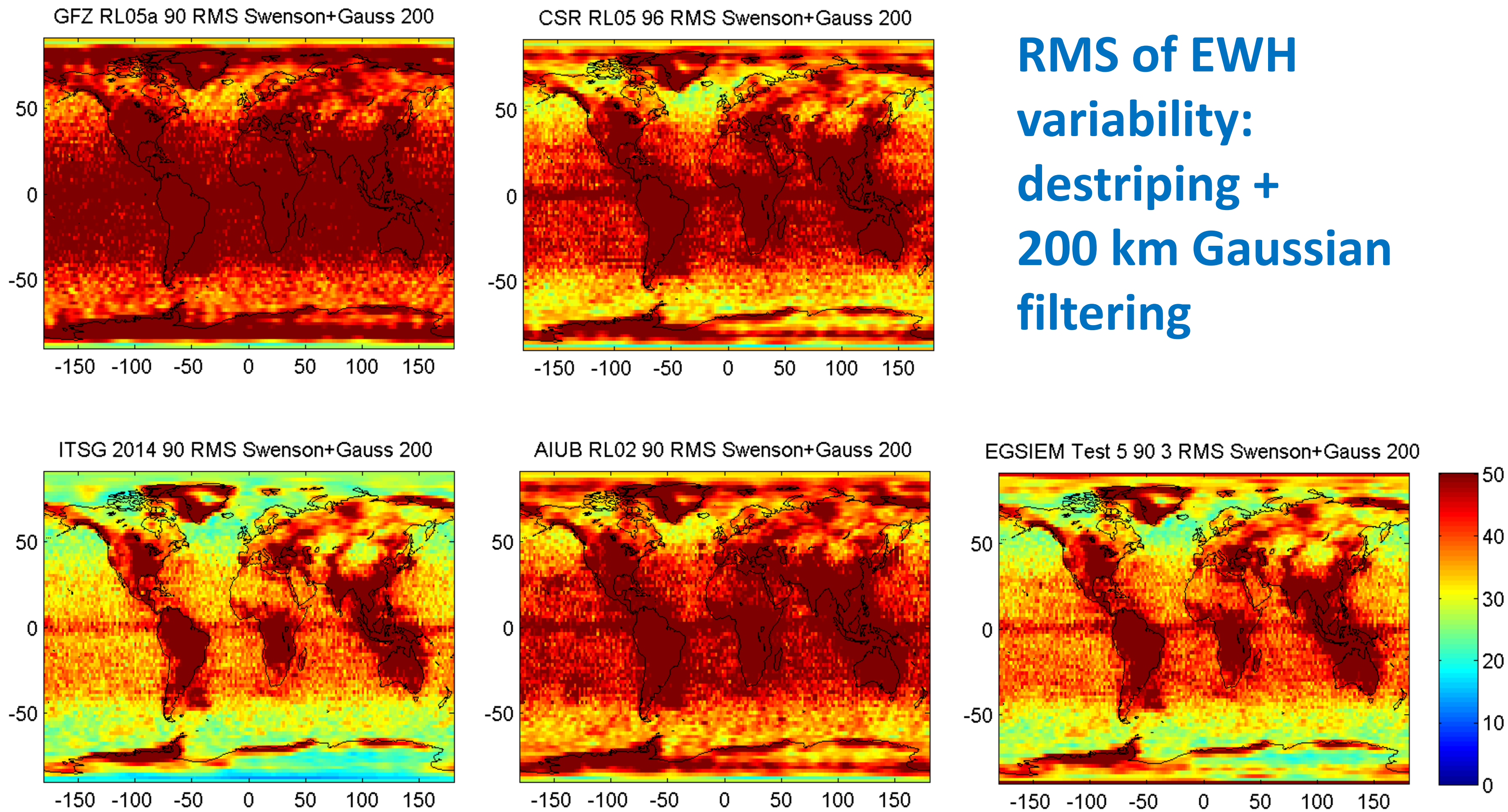
RMS of EWH variability:
400 km Gaussian filtering

Analyses in the spatial domain (4/12)



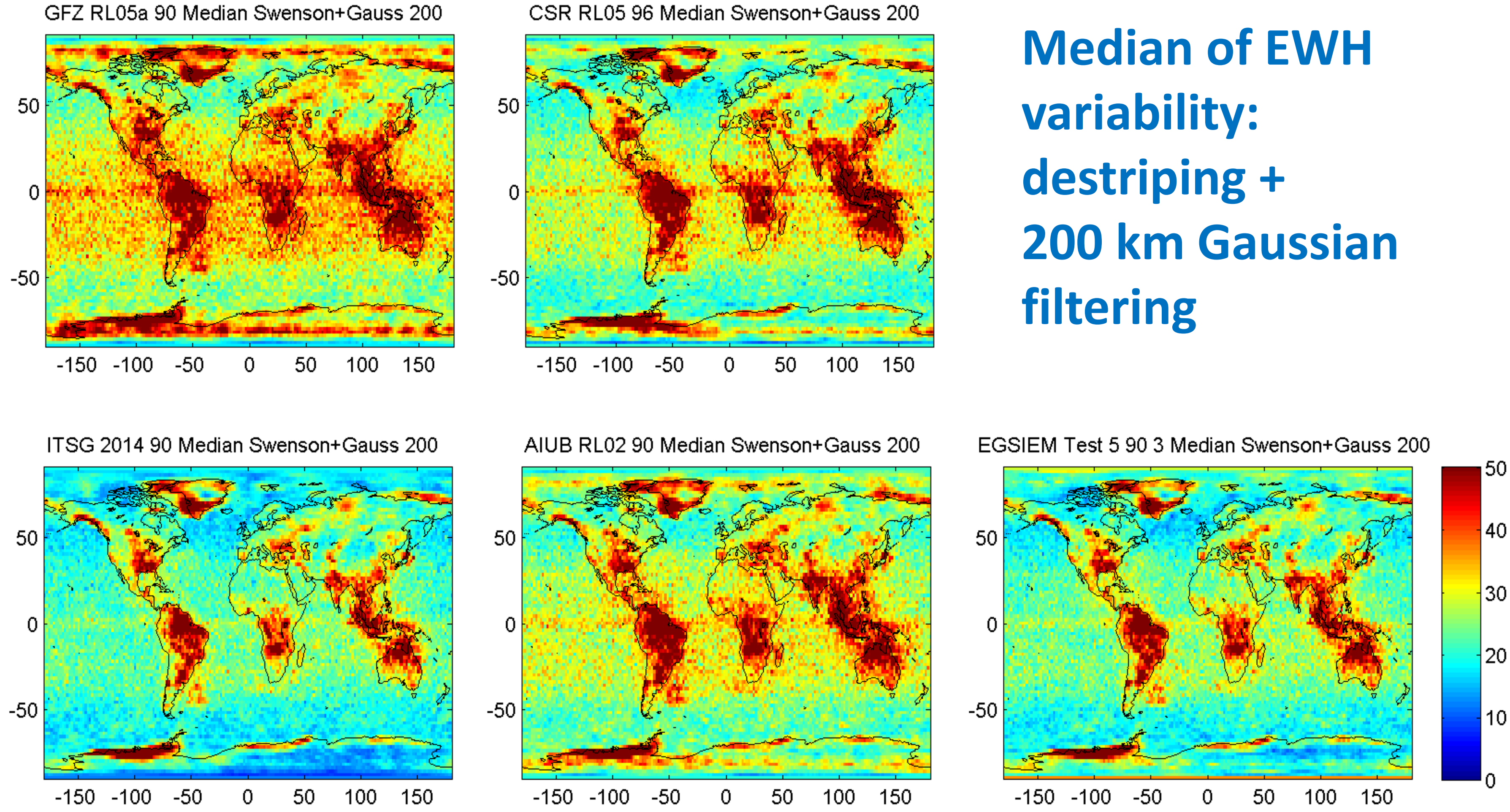
Median of EWH variability: 400 km Gaussian filtering

Analyses in the spatial domain (5/12)



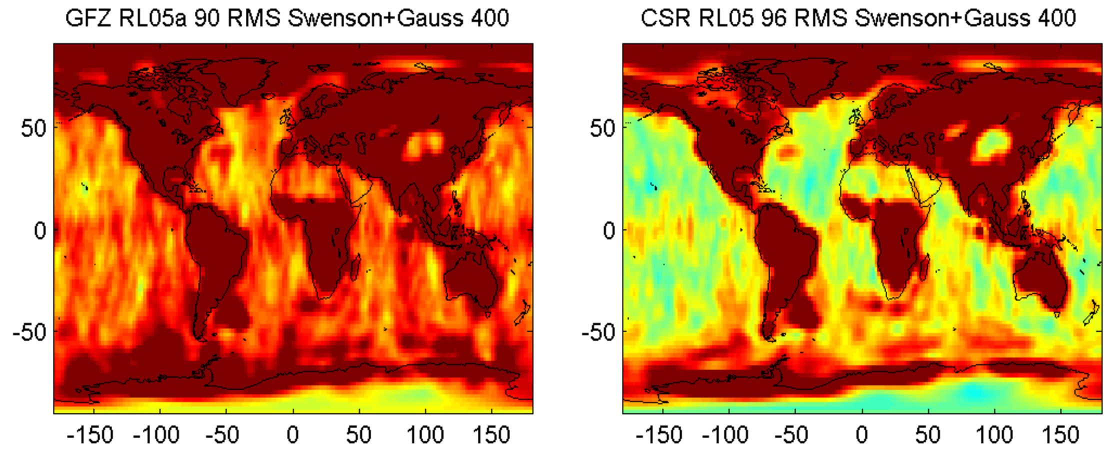
RMS of EWH variability: destriping + 200 km Gaussian filtering

Analyses in the spatial domain (6/12)

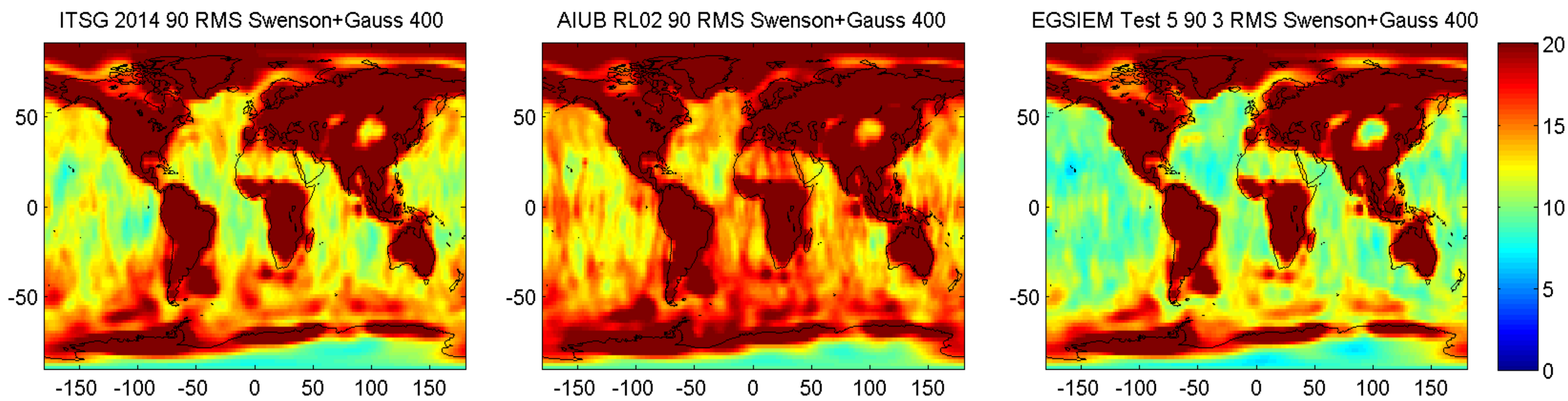


Median of EWH variability: destriping + 200 km Gaussian filtering

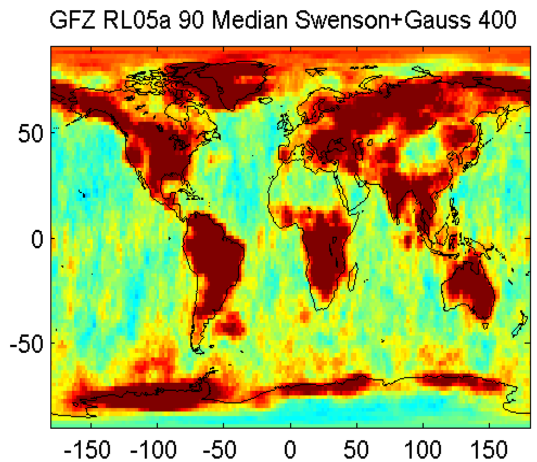
Analyses in the spatial domain (7/12)

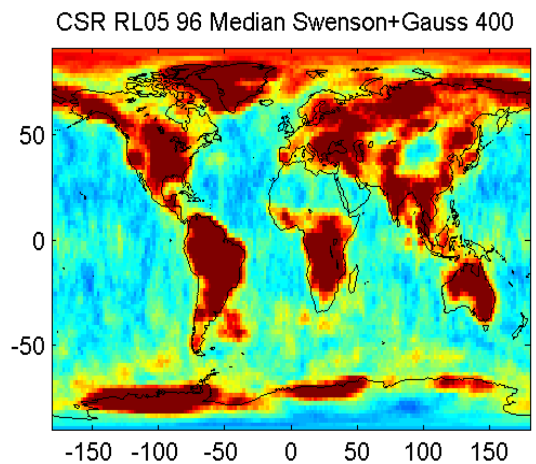


RMS of EWH variability: destriping + 400 km Gaussian filtering

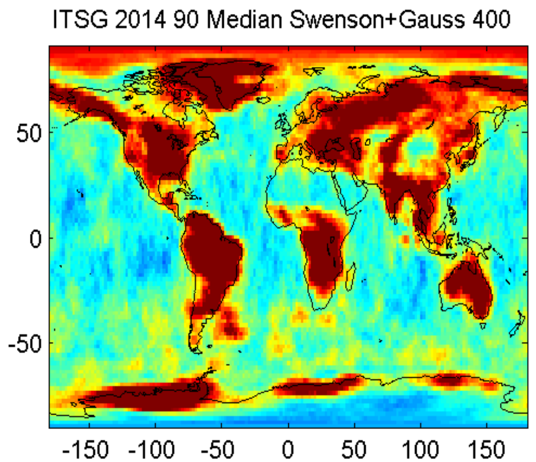


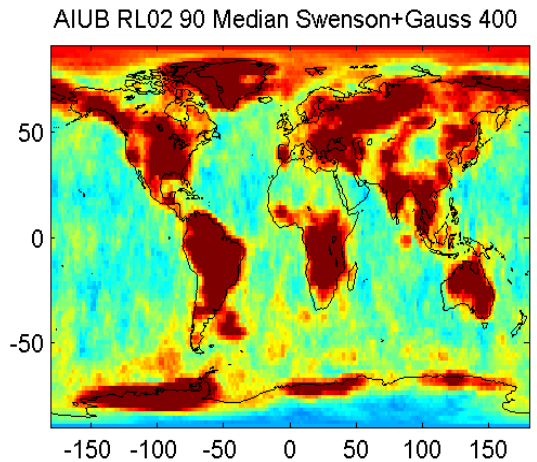
Analyses in the spatial domain (8/12)

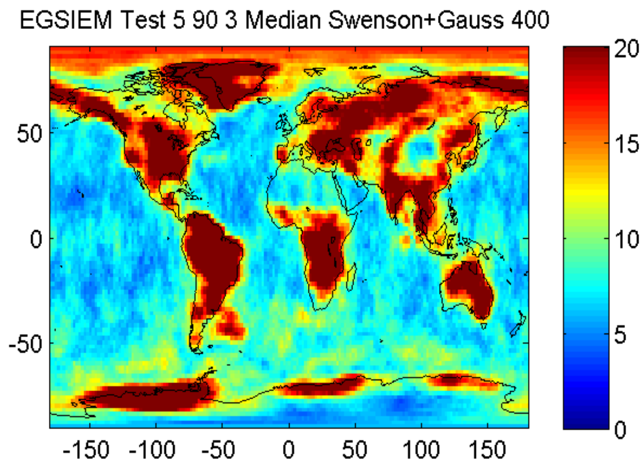




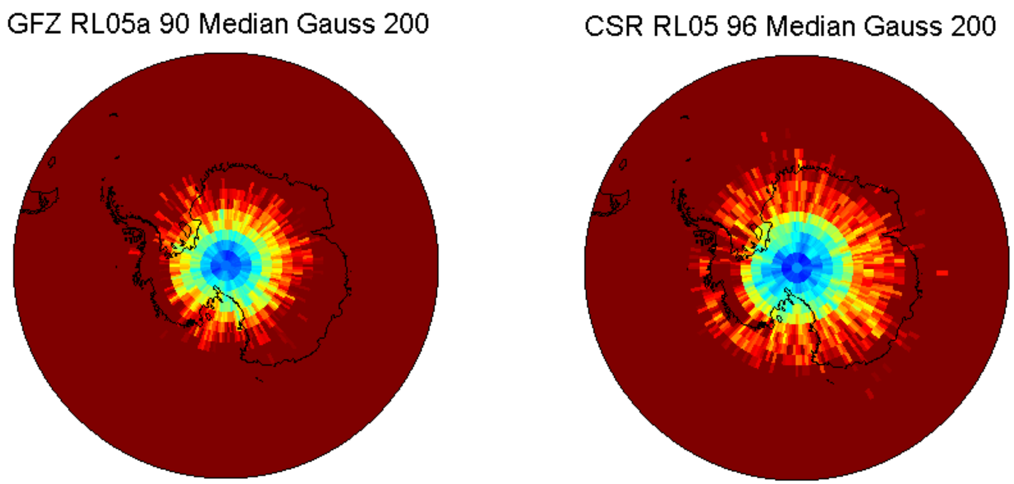
Median of EWH variability: destriping + 400 km Gaussian filtering



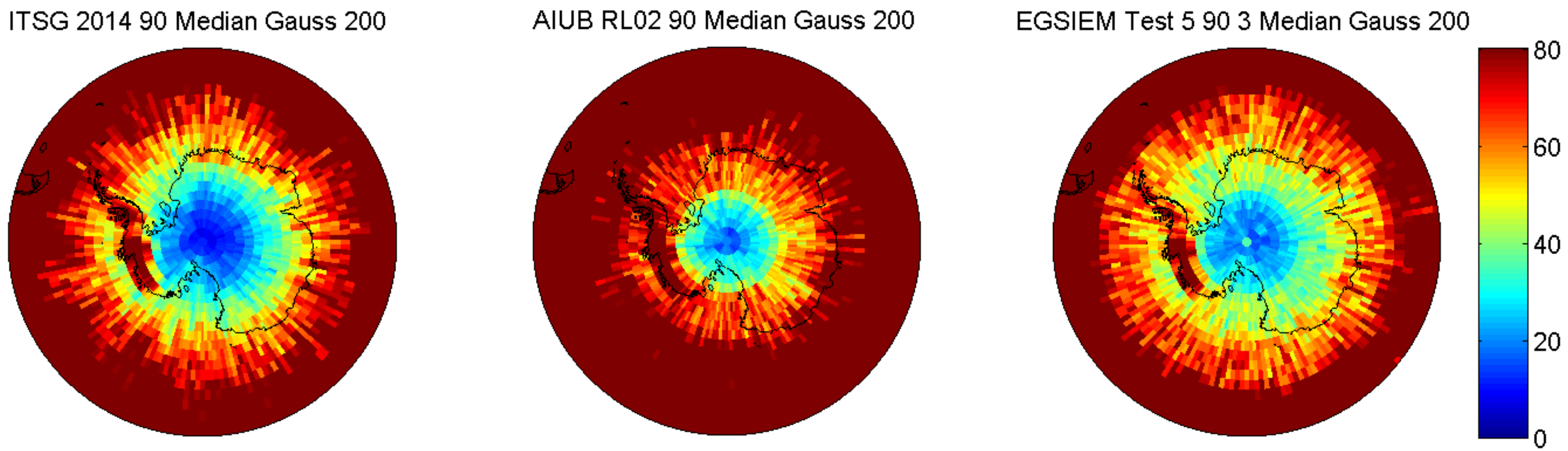




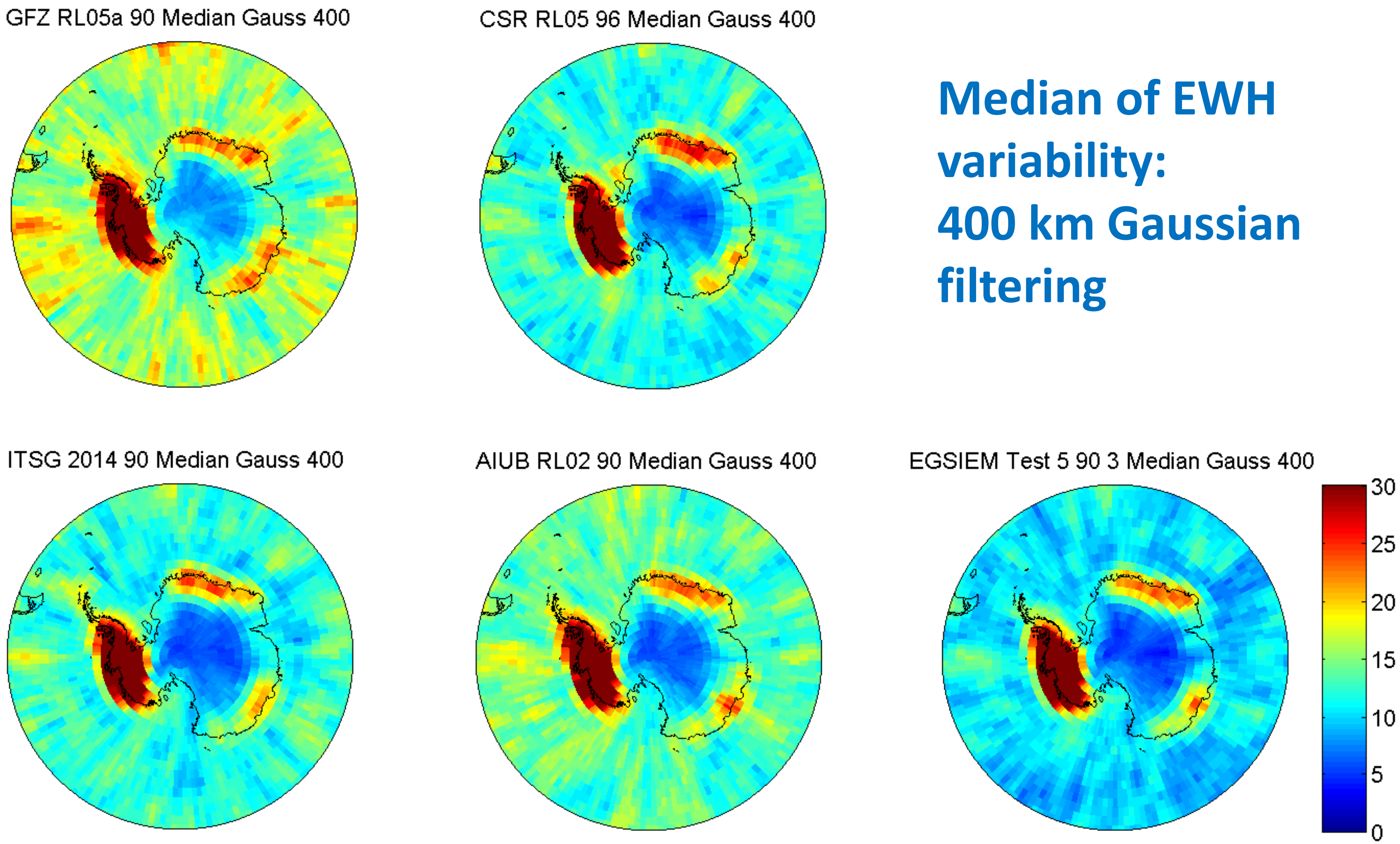
Analyses in the spatial domain (9/12)



Median of EWH variability:
200 km Gaussian filtering

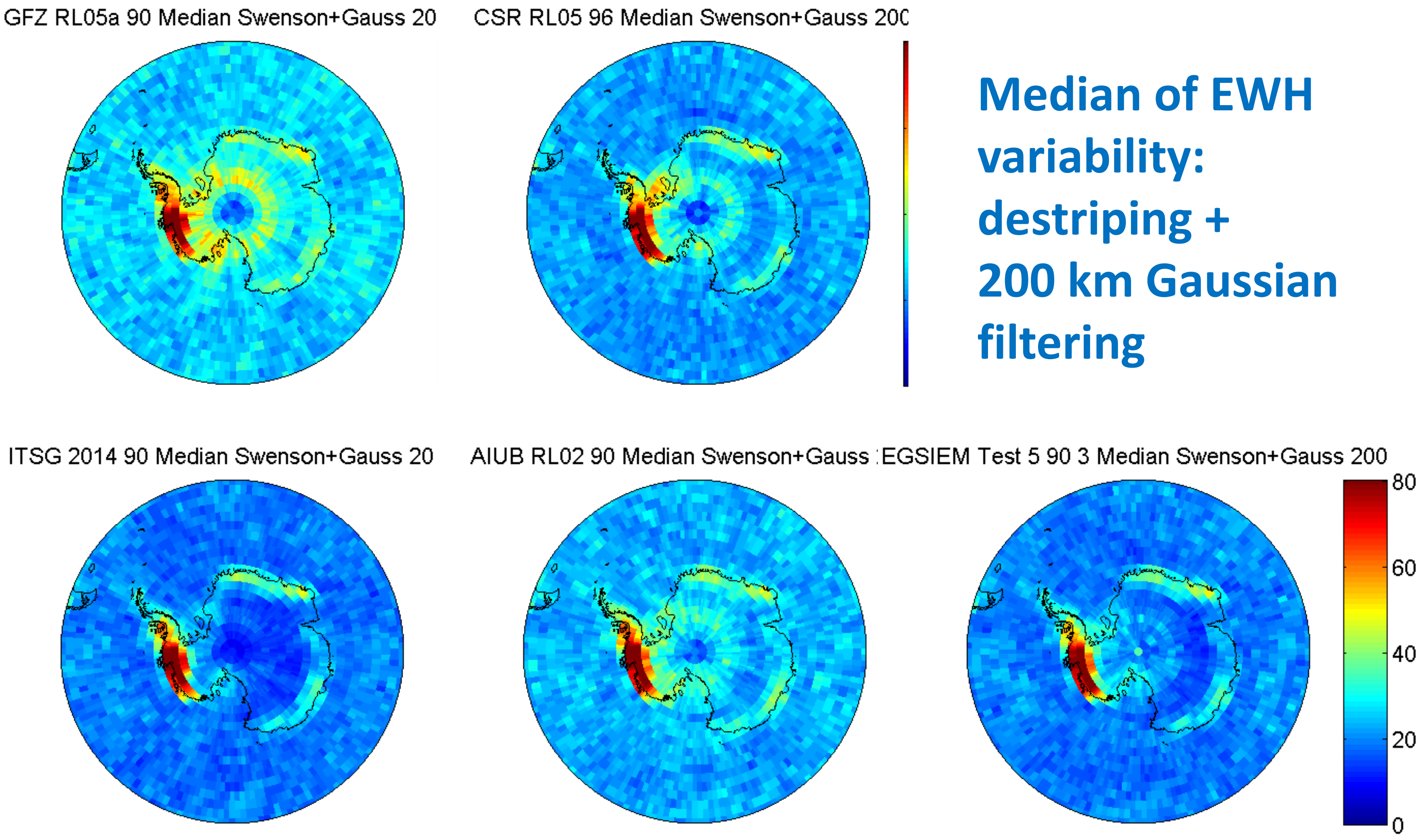


Analyses in the spatial domain (10/12)



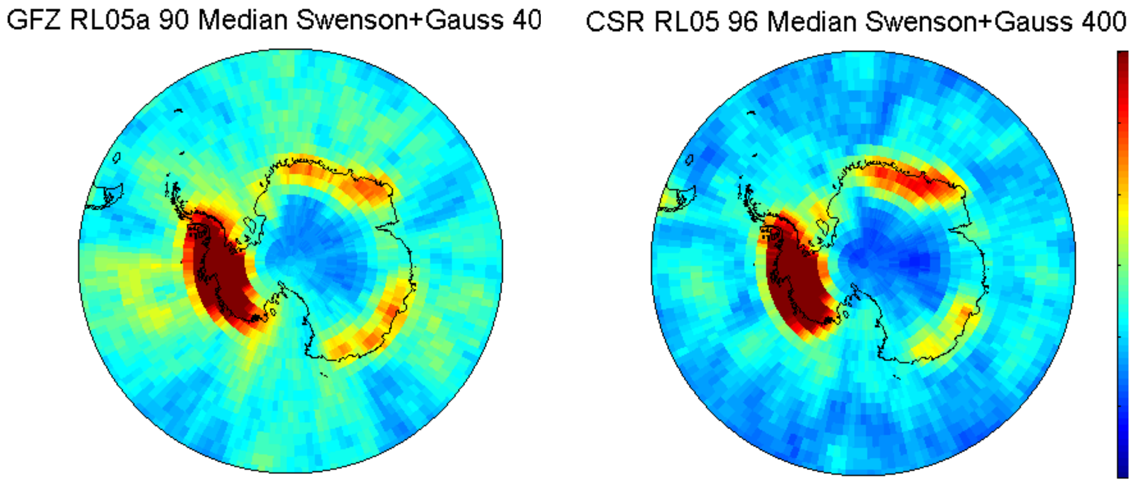
Median of EWH variability: 400 km Gaussian filtering

Analyses in the spatial domain (11/12)

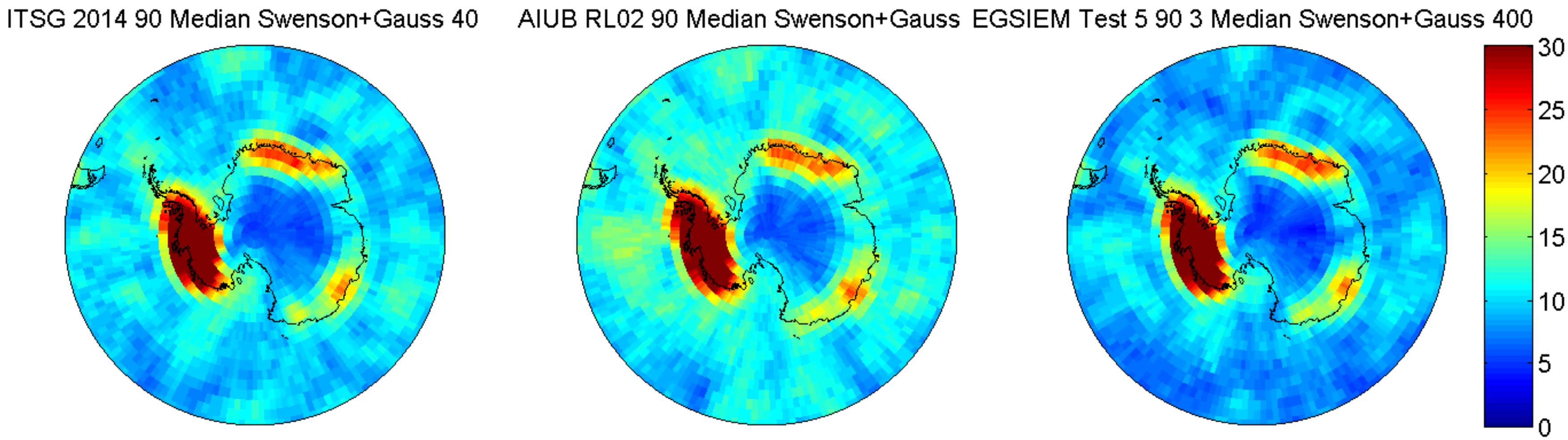


Median of EWH variability: destriping + 200 km Gaussian filtering

Analyses in the spatial domain (12/12)



Median of EWH variability: destriping + 400 km Gaussian filtering



Analyses in the spatial domain: conclusion

200 km Gaussian filter:

- **ITSG** and **EGSIEM** show the lowest noise levels.
- **ITSG** noise level < **EGSIEM** noise level.

This is **consistent with the assessment in the spectral domain**, where **ITSG** has the lowest noise level in the high degrees

400 km Gaussian filter:

- **EGSIEM**, **ITSG** and **CSR** show the lowest noise levels.
- **EGSIEM** noise level < **ITSG, CSR** noise level.

The relative differences between releases remain the same irrespective of STD or Median and destriping or not.

Mass changes of Antarctic drainage basins

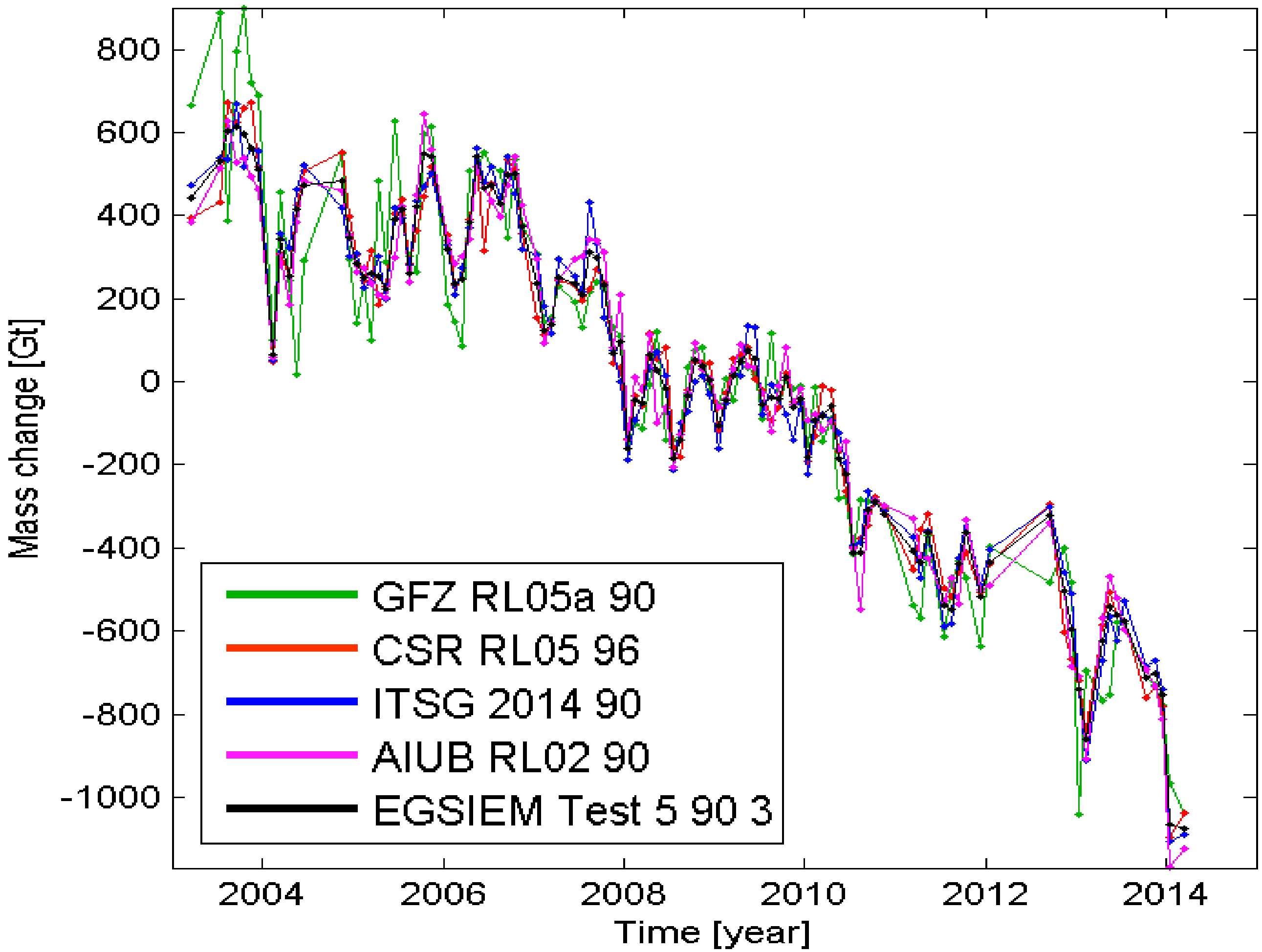
Basin masses are computed using an **integration kernel** (in the spectral domain) which is designed to attain a compromise between leakage errors and propagated GRACE errors.

The kernel design depends on empirical GRACE error covariances that are specific for each series. To achieve comparable results kernels were derived for all series and then averaged.

GIA models as in Shepherd et al. (2012).

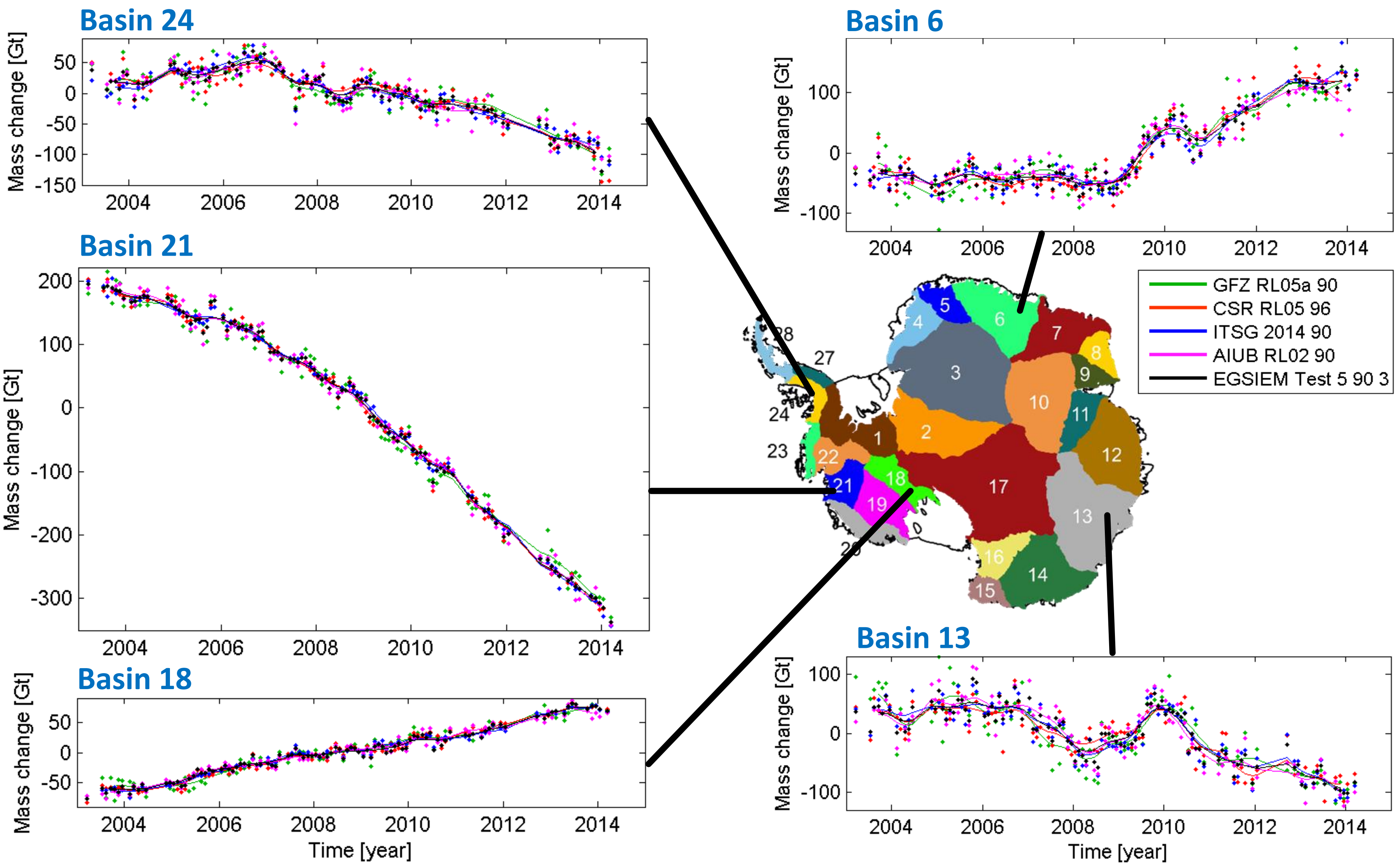
Mass changes of Antarctic drainage basins (1/4)

Entire Antarctica



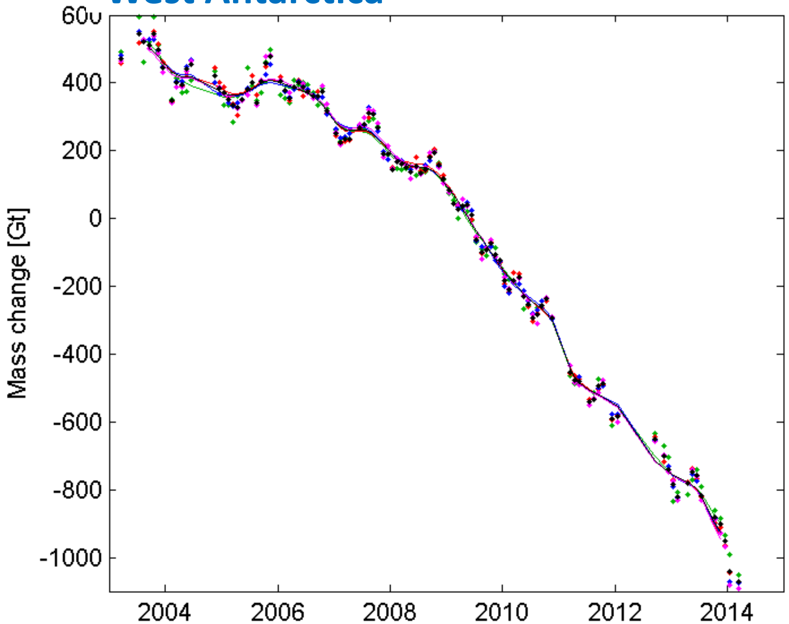
- **No signal attenuation!**
- **Different noise levels.**

Mass changes of Antarctic drainage basins (2/4)

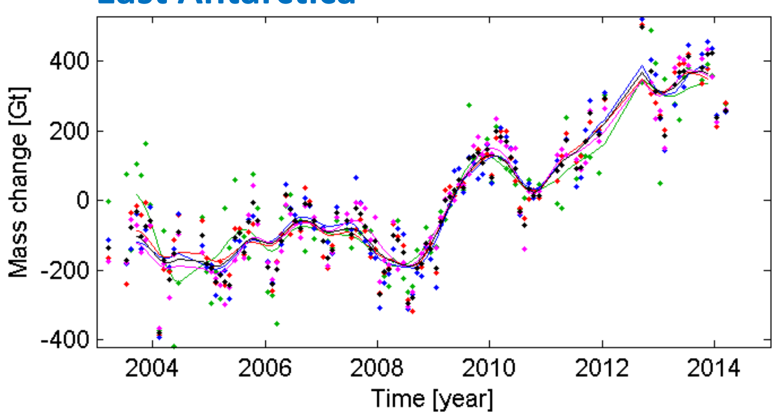


Mass changes of Antarctic drainage basins (3/4)

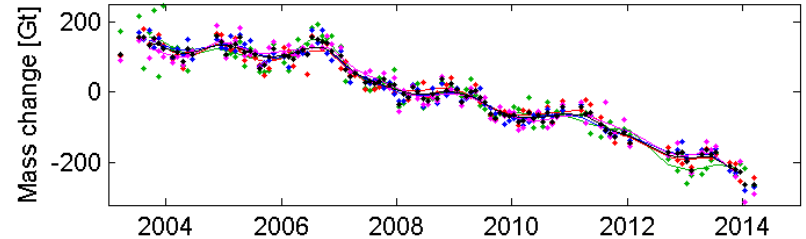
West Antarctica



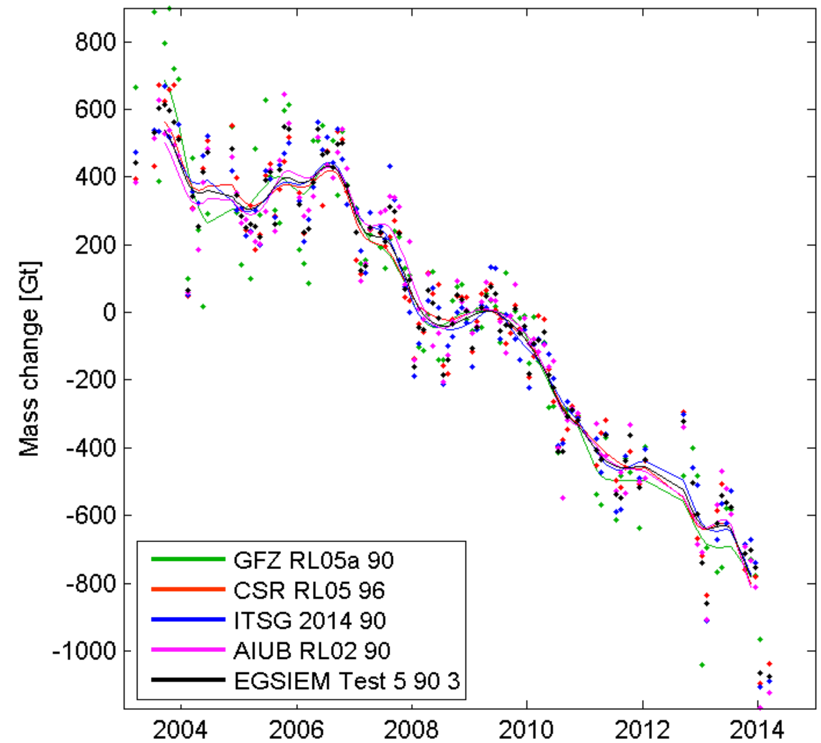
East Antarctica



Antarctic Peninsula



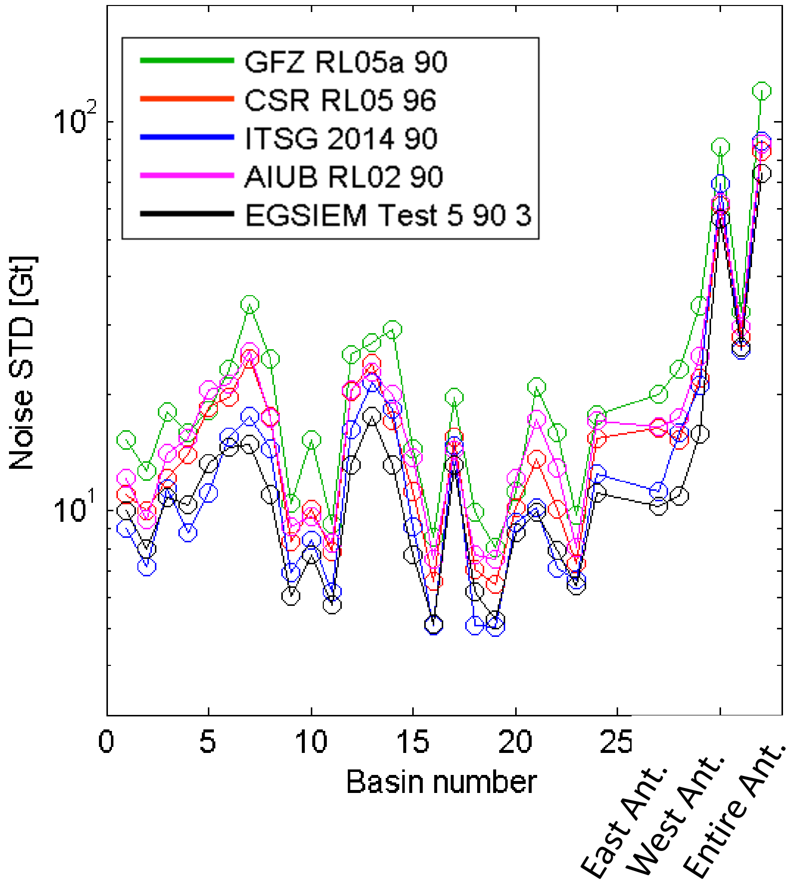
Entire Antarctica



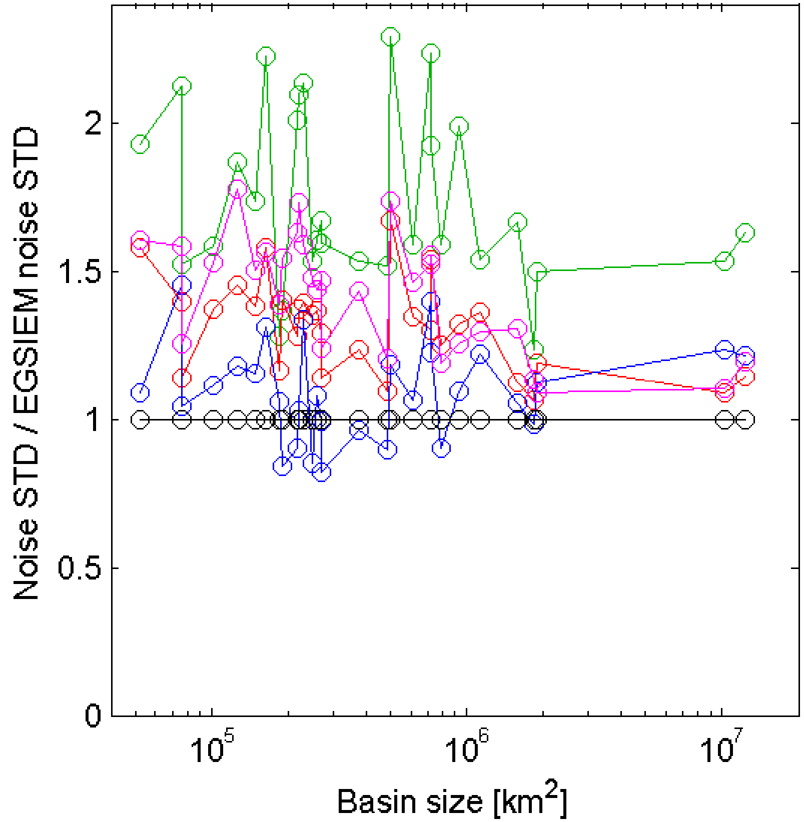
Mass changes of Antarctic drainage basins (4/4)

The uncorrelated (white) noise content was assessed based on the STD of high-pass filtered time series.

Noise levels per basin



Noise levels relative to EGSIEM



Mass changes of Antarctic drainage basins: conclusion

- Differences in noise STD between the series are on the order of 10% to 50%
- For most basins (including the large aggregations), **EGSIEM has the lowest noise level** (dependent on attenuation of high-degree noise by integration kernel; ITSG may benefit from less aggressive dampening).

SLR research activities and products @ DGFI-TUM

Mathis Bloßfeld

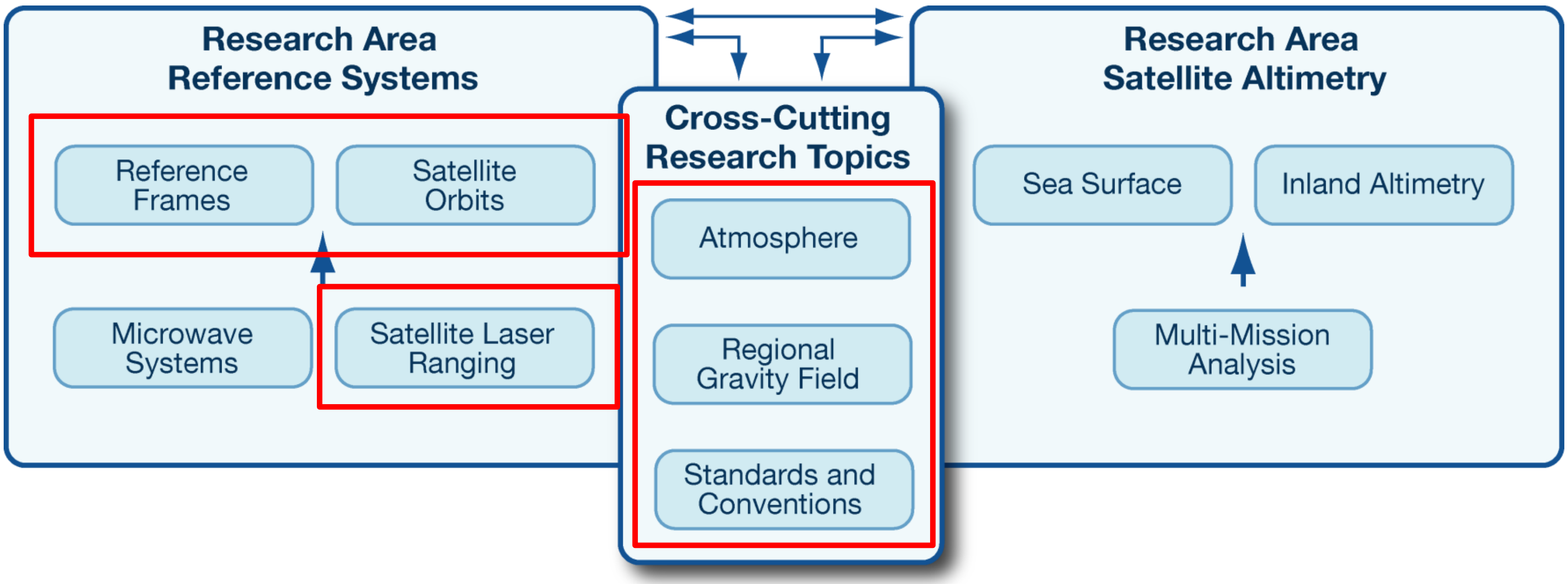
Deutsches Geodätisches Forschungsinstitut der
Technischen Universität München (DGFI-TUM)

website: www.dgfi.tum.de

EGSIEM General Assembly 2016, Luxembourg, 2016-01-18/19

DGFI-TUM research program & scientific services

- SLR-related topics (red boxes) within the DGFI-TUM research program



- DGFI-TUM serves the **IAG-ILRS** as an **official analysis center** (AC) for many years
  - **ILRS Quality Control Center** (frequent bias estimation, SLRF station coordinate updates, performance feedback to SLR stations)
  - **ILRS Governing Board** member & **Data Center (DC) representative**
  - ILRS Data Formats and Procedures working group/several ILRS pilot projects
- **Eurolas Data Center (EDC)** and **ILRS Operation Center**

DGFI-TUM SLR software DOGS-OC/CS

- DGFI-TUM developed its own software to analyze SLR observations called DGFI Orbit and Geodetic parameter estimation Software (DOGS)
  - **DOGS-OC** (Orbit Computation): dynamic orbit integration, simulation of SLR observations/stations/satellites, POD
  - **DOGS-CS** (Combination and Solution): combination of satellite-/technique-specific NEQs, computation of minimum-/loose-constrained solutions (e.g., DTRF2008/DTRF2014)

- With DOGS-OC/CS, it is possible to compute SLR normal equations (NEQs) …

  … which comprise SLR observations to **numerous spherical** and **non-spherical satellites** (altitudes between 250 km and 20000 km)

  … which cover a time span from **1972 until 2016**

  … based on different arc lengths (**daily, weekly, 2-weekly, monthly**)

  … which include station coordinates, EOP, Stokes coefficients, etc.

  … which are based on various geophysical a priori models (ocean tides, ...)

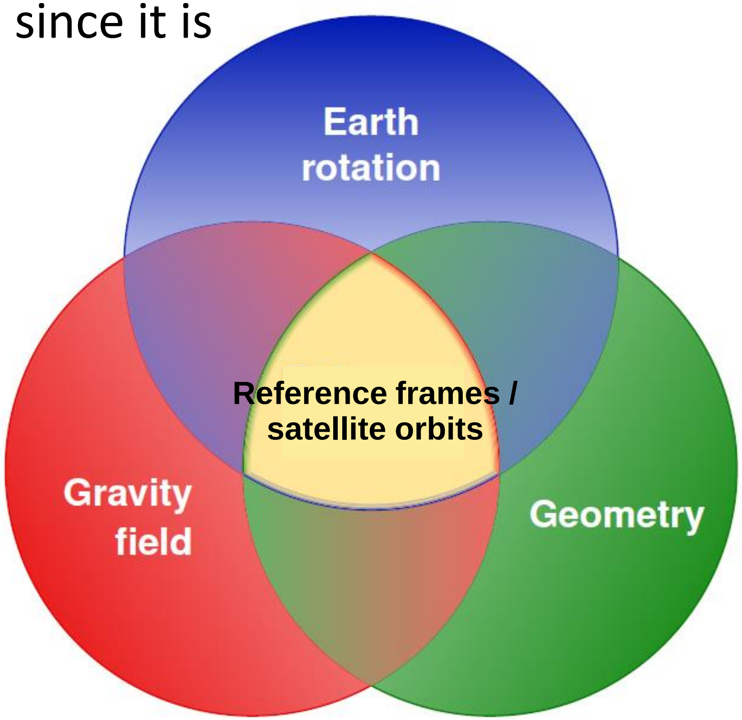
Bloßfeld M.: **The key role of Satellite Laser Ranging towards the integrated estimation of geometry, rotation and gravitational field of the Earth**. Dissertation, Technical University of Munich and Reihe C of the Deutsche Geodätische Kommission ISBN: 978-3-7696-5157-7, 2015

The key role of SLR for GGOS

- SLR is capable to determine the fundamental geodetic parameters of the Global Geodetic Observing System with high accuracy, since it is

sensitive w.r.t. the reference frames (ITRF/satellite orbits) and EOP:
measurement principle: 2-way light travel time measurements from crust-fixed stations to satellites in the inertial frame

sensitive to the long wavelengths of the Earth's gravity field (Stokes coefficients):
measured orbit disturbances of spherical satellites



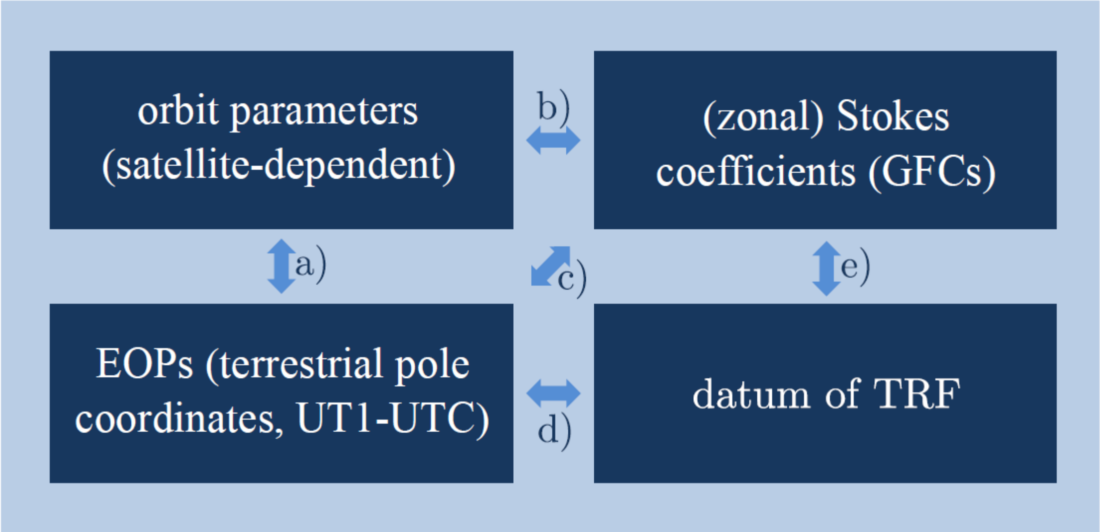
[acc. Rummel, 2000; Plag & Pearlman, 2009]

- **SLR is the unique measurement technique which allows an accurate and consistent estimation of TRF, EOP and Stokes coefficients**
- **BUT: if all parameters are estimated together, correlations might corrupt reliable estimates**

Bloßfeld M., Stefka V., Müller H., Gerstl M.: **Satellite laser ranging - a tool to realize GGOS?**. IAG Symposia 143, DOI: 10.1007/1345_2015_202, 2015

The key role of SLR for GGOS - correlations

- Parameter correlations related to Stokes coefficients

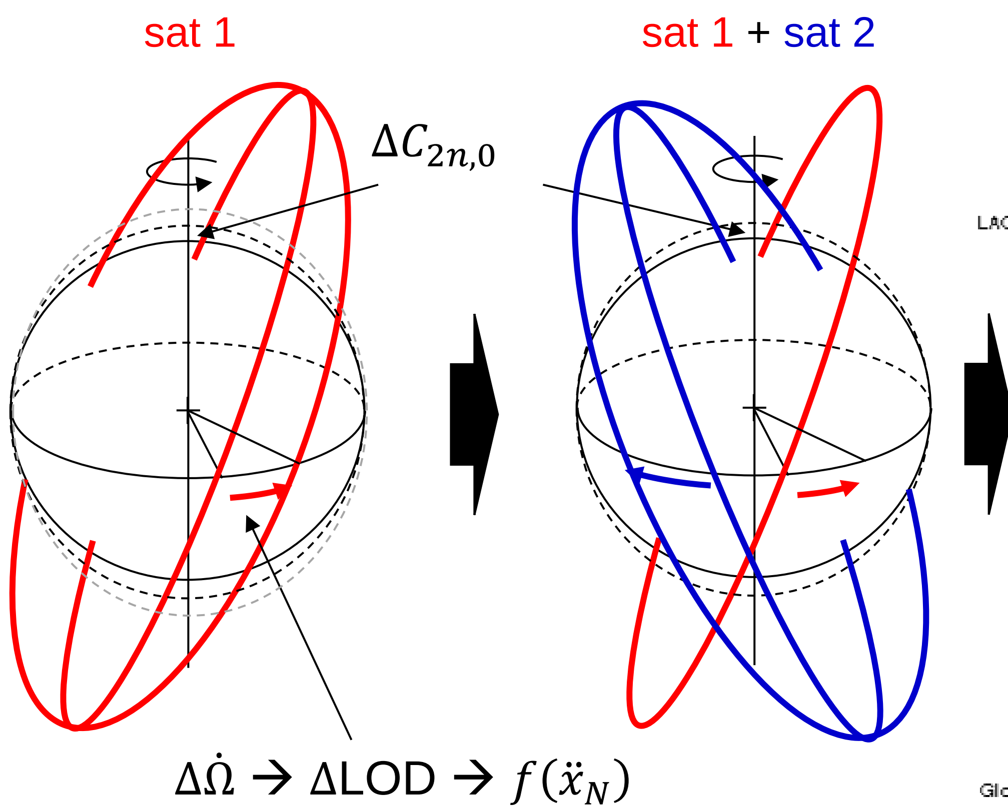


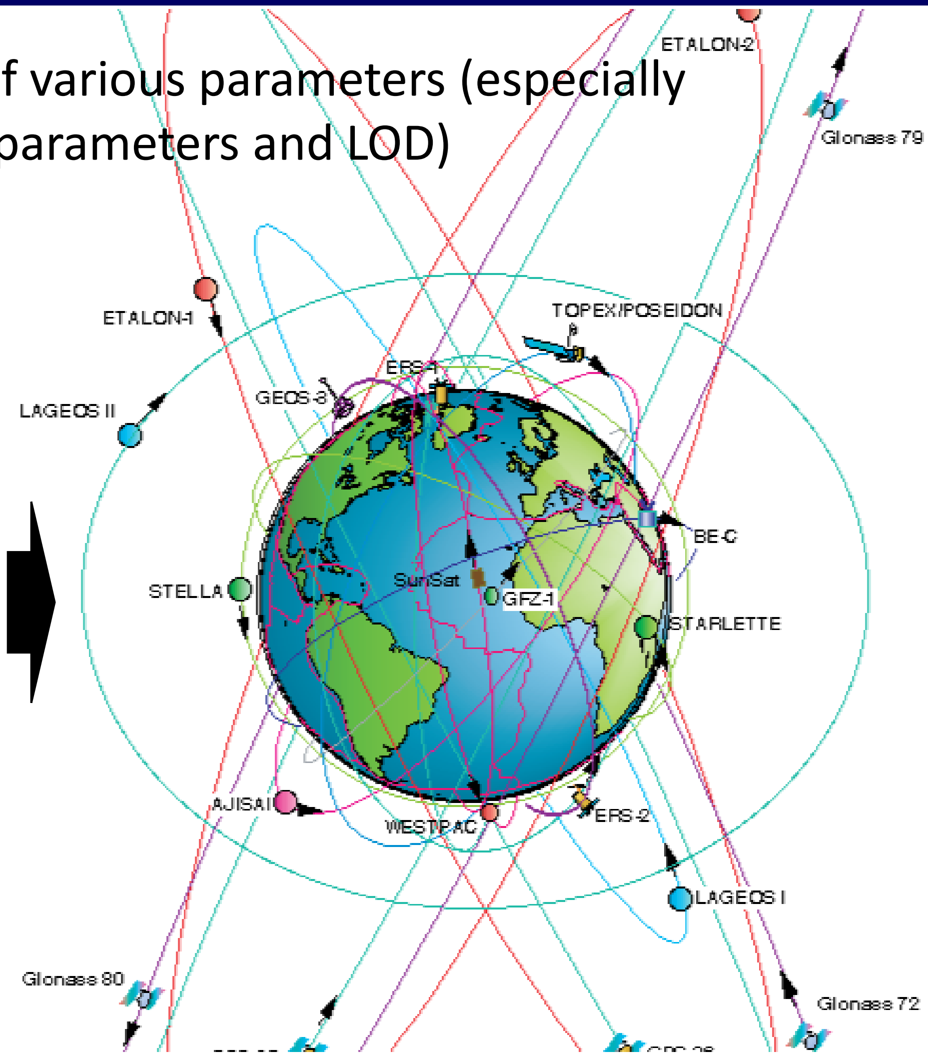
- b) correlations of orbit parameters and Stokes coefficients
- c) correlations of LOD and C_{l0}; x_p/y_p with C_{21}/S_{21}
- e) correlation of TRF scale with C_{00}; origin with $C_{10}/C_{11}/S_{11}$; orientation with $C_{21}/S_{21}/C_{22}/S_{22}$

Bloßfeld M.: **The key role of Satellite Laser Ranging towards the integrated estimation of geometry, rotation and gravitational field of the Earth**. Dissertation, Technical University of Munich and Reihe C of the Deutsche Geodätische Kommission ISBN: 978-3-7696-5157-7, 2015

DGFI-TUM SLR multi-satellite solution

- Single-satellite solution: high correlation of various parameters (especially between zonal coefficients, satellite orbit parameters and LOD)



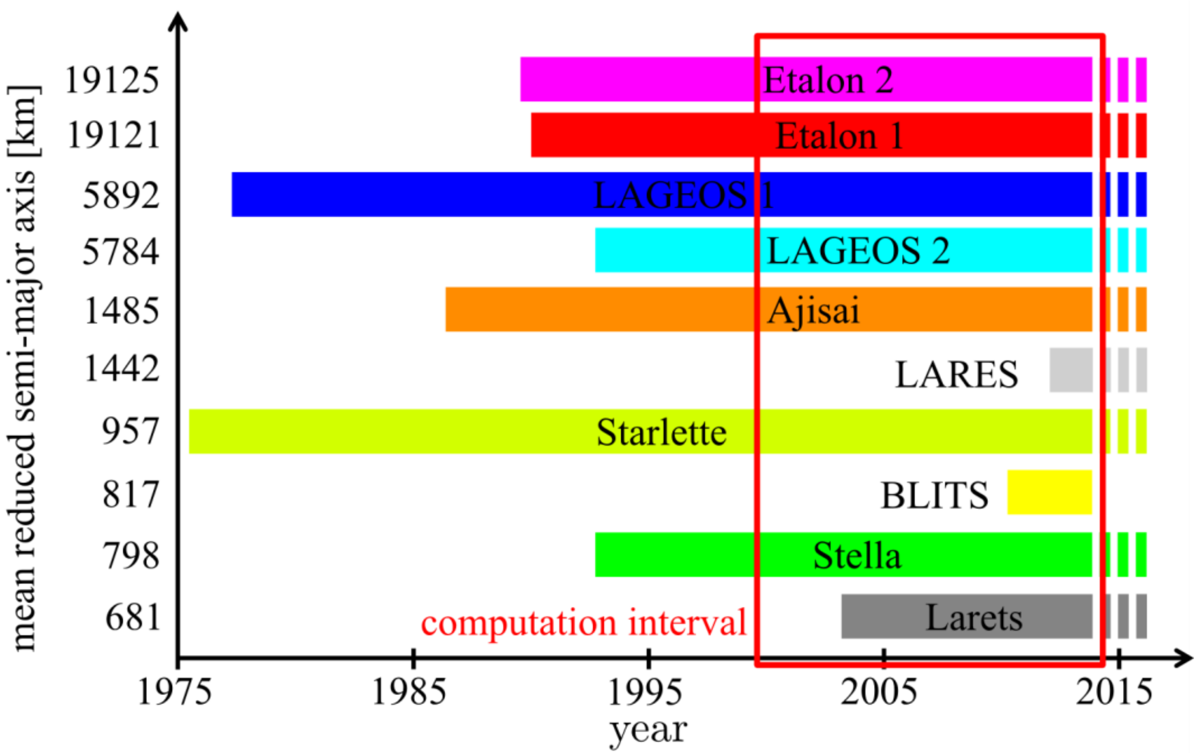


- Multi-satellite solution (MSS): de-correlation of parameters due to combination of inclinations (e.g. C_{l0} and Ω) → reliable estimates of zonal coefficients

Bloßfeld M., Gerstl M., Hugentobler U., Angermann D., Müller H.: **Systematic effects in LOD from SLR observations**. Advances in Space Research 54(6): 1049-1063, 10.1016/j.asr.2014.06.009, 2014

DGFI-TUM SLR MSS – de-correlation of C_{l0} and Ω

- DGFI-TUM SLR MSS comprises SLR observations to up to 10 spherical satellites
- relative weighting realized via Variance Component Estimation (VCE)
- Etalon1/2, BLITS and Larets do not help to significantly decrease $\rho(C_{20}, \Omega)$

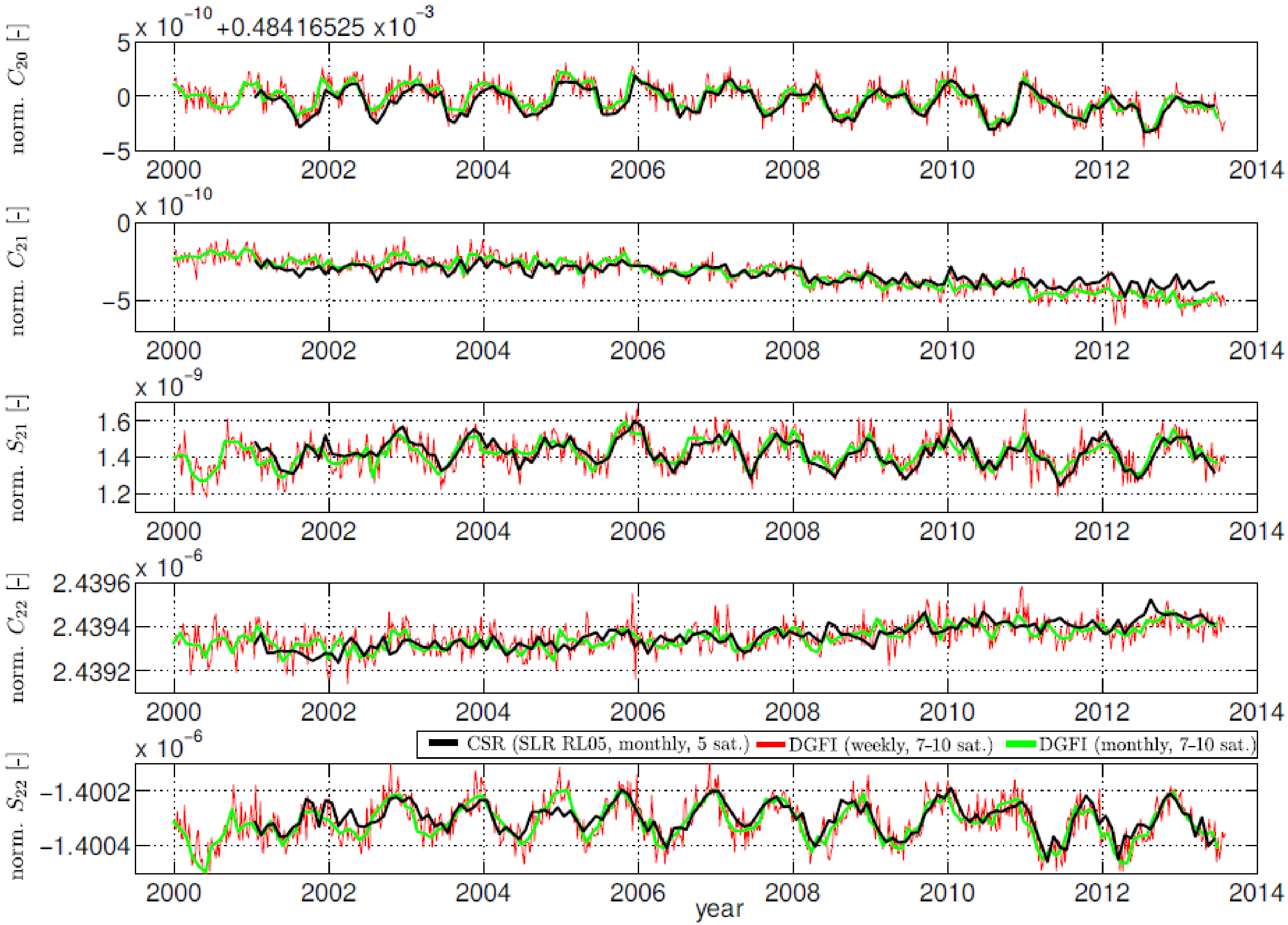


solution	$\rho(C_{20}, \Omega)$
LA 1	1.00
LA 1/2	0.44
LA 1/2 + ET 1/2	0.44
4-sat. + BTS	0.43
4-sat. + LTS	0.41
4-sat. + STE	0.31
4-sat. + STA	0.28
4-sat. + AJI	0.24
4-sat. + LRS	0.24
10-sat.	0.08

Bloßfeld M., Müller H., Gerstl M., Stefka V., Bouman J., Göttl F., Horwath M.: **Second-degree Stokes coefficients from multi-satellite SLR**. Journal of Geodesy 89(9): 857-871, 10.1007/s00190-015-0819-z, 2015

DGFI-TUM SLR MSS – C_{2m} estimates

- DGFI-TUM SLR MSS C_{2m} estimates



Bloßfeld M., Müller H., Gerstl M., Stefka V., Bouman J., Göttl F., Horwath M.: **Second-degree Stokes coefficients from multi-satellite SLR**. Journal of Geodesy 89(9): 857-871, 10.1007/s00190-015-0819-z, 2015

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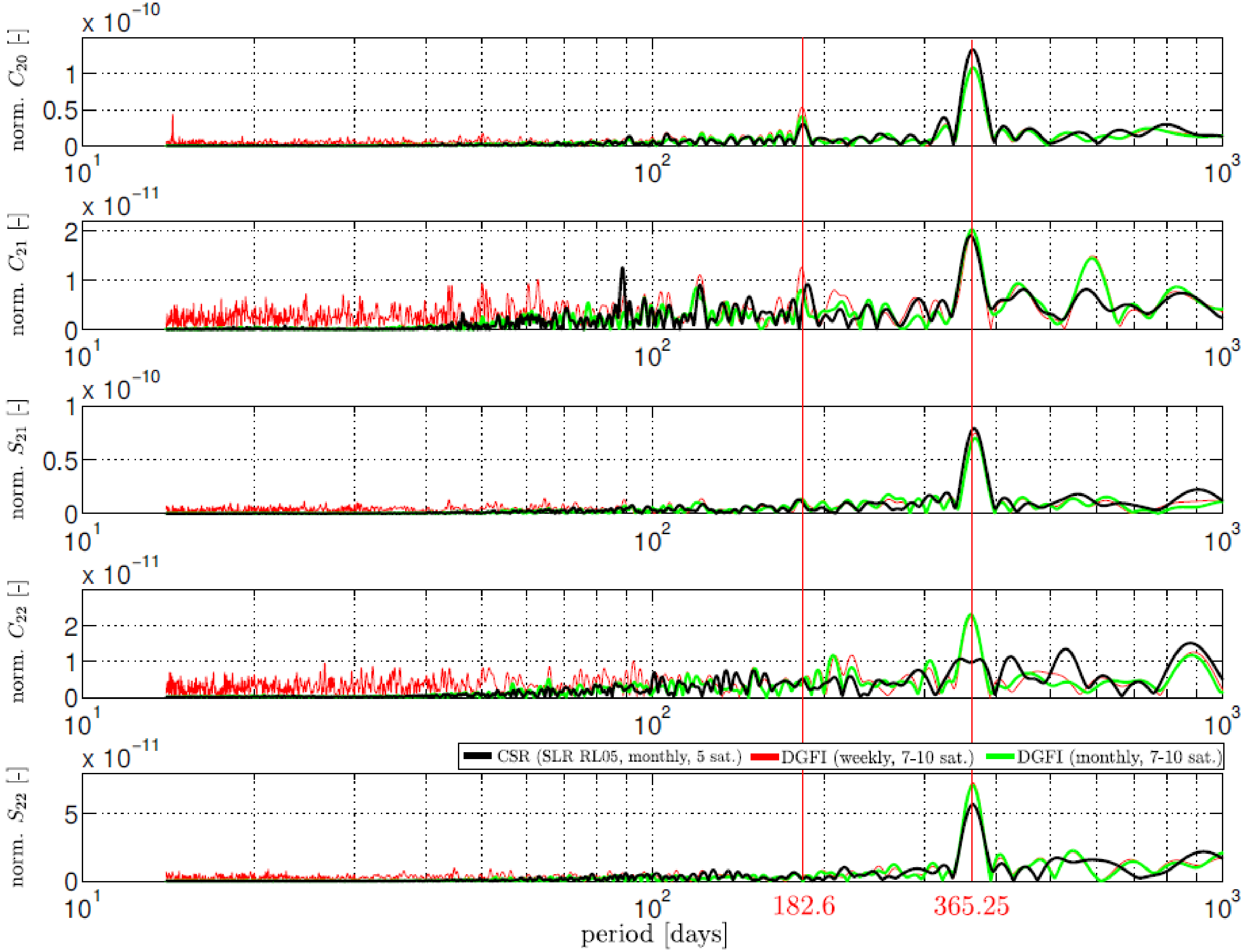
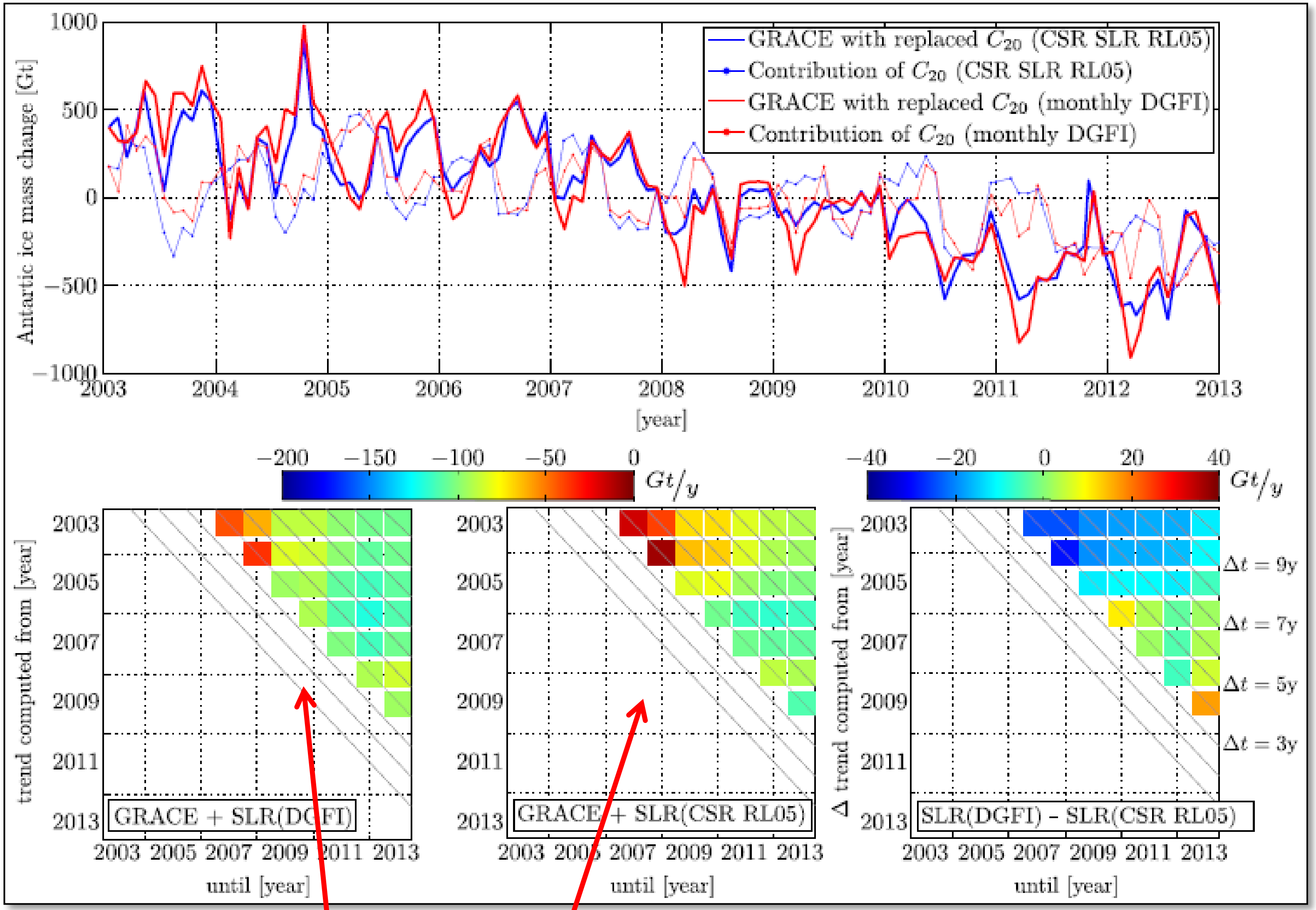
- DGFI-TUM SLR MSS C_{2m} estimates



Bloßfeld M., Müller H., Gerstl M., Stefka V., Bouman J., Göttl F., Horwath M.: **Second-degree Stokes coefficients from multi-satellite SLR**. Journal of Geodesy 89(9): 857-871, 10.1007/s00190-015-0819-z, 2015

Different estimates of C_{20} – geophysical interpretation

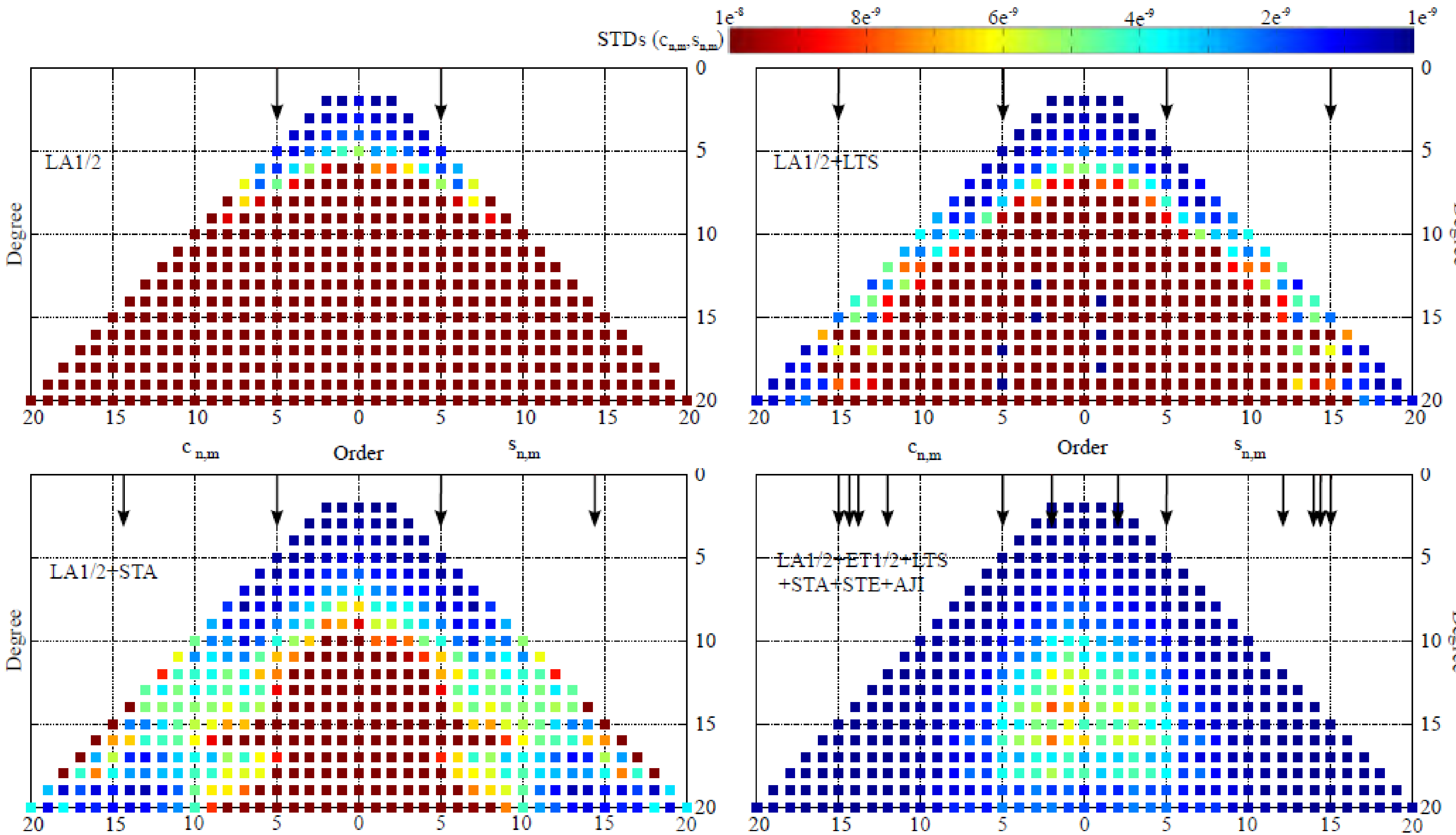


Larger acceleration of ice mass loss in CSR solution compared to DGFI solution

Bloßfeld M., Müller H., Gerstl M., Stefka V., Bouman J., Göttl F., Horwath M.: **Second-degree Stokes coefficients from multi-satellite SLR**. Journal of Geodesy 89(9): 857-871, 10.1007/s00190-015-0819-z, 2015

DGFI-TUM SLR MSS – Stokes coefficients

- Estimated STDs of Stokes coefficients (stabilized) up to d/o 20 for January 2007



Bloßfeld M., Müller H., Gerstl M., Stefka V., Bouman J., Göttl F., Horwath M.: **Second-degree Stokes coefficients from multi-satellite SLR**. Journal of Geodesy 89(9): 857-871, 10.1007/s00190-015-0819-z, 2015

Combination of SLR and GRACE @ DGFI-TUM

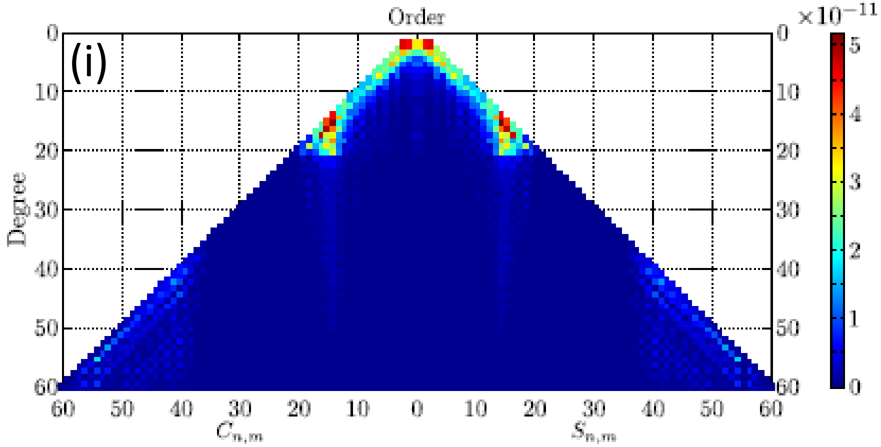


Fig. 4 STDs of the GRACE-only solution minus STDs of the combined solution. $\hat{\sigma}^2_{GRACE} = 8.8 \cdot 10^{-11}$ and $\hat{\sigma}^2_{SLR} = 7.9 \cdot 10^{-1}$.

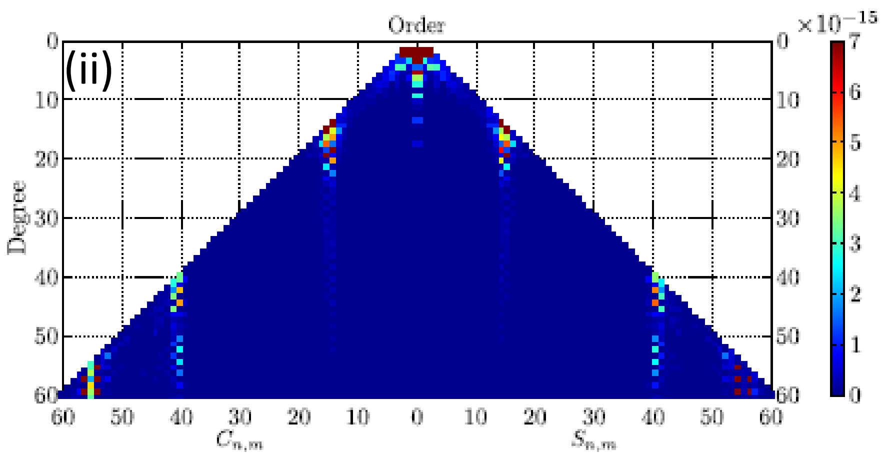


Fig. 5 STDs of the GRACE-only solution minus STDs of the combined solution. $\hat{\sigma}^2_{GRACE} = 1.6 \cdot 10^{-14}$ and $\hat{\sigma}^2_{SLR} = 7.9 \cdot 10^{-1}$.

- Combination of SLR and GRACE NEQs
- GRACE: monthly arc based on IEA approach (KBR-data only)
- 2 scenarios:
  - (i) **optimistic rel. weight** of GRACE NEQ:
    large improvements of STDs caused by SLR especially on degree 2 and tesseral coefficients
  - (ii) **realistic rel. weight** of GRACE NEQ:
    still improvements on degree 2 coefficients and satellite resonance frequencies are visible

Haberkorn C., Bloßfeld M., Bouman J., Fuchs M., Schmidt M.: **Towards a consistent estimation of the Earth`s gravity field by combining normal equation matrices from GRACE and SLR**. IAG Symposia 143, DOI: 10.1007/1345_2015_76, 2015

Possible contributions to EGSIEM (e.g., validation) …

- DGFI-TUM can provide SLR NEQs with full variance/co-variance information in SINEX format …

  … which comprise SLR observations to **numerous spherical** and/or **non-spherical satellites** with altitudes between 250 km and 20000 km

  … which cover a time span from **1972 until 2016**

  … which are based on various arc lengths (**daily, weekly, 2-weekly, monthly**)

  … which include (station coordinates, EOP), **Stokes coefficients (up to d/o 60)**, etc…

  … which are based on **numerous different a priori models** (ocean tides, non-tidal loading effects, relativistic effects, …) → EGSIEM standards?

name	paraı
orbital elements	initial set of osculatiı
empirical accelerations	daily offsets at 0 h in ; sine-/cosine-term* in ;
solar radiation scaling coef.	weekly offset
atmospheric drag scaling coef. (for LEOs)	daily of
station coordinates (in SLRF2008)	weekly offsets
station coordinates (not in SLRF2008)	weekly offsets
station dependent range bias	weekly offsets
terrestrial pole coordinates	daily of
Length-Of-Day (LOD)	daily offs
Stokes coefficients with degree/order ≤ 6	weekly offsets
Stokes coefficients with degree/order > 6	weekly offsets

effect	model
station coordinates	updated SLRF2008
EOPs	IERS 08 C04
mean pole	(*Petit and Luzum*, 2010)
solid Earth tides (station)	IERS2003, anelastic
solid Earth tides (orbit)	IERS2003, anelastic
ocean tides (station)	FES2004 (*Lyard et al.*, 2006)
ocean tides (orbit)	FES2004 + BB2003 (*Biancale and Bode*, 2006) + 62 adm. waves (*Petit and Luzum*, 2010)
ocean pole tide (station)	*Desai* (2002)
ocean pole tide (orbit)	*Desai* (2002)
Earth's gravitational field	EIGEN-6s ($n, m \leq 120$)
atmospheric density model	JB2008 (*Bowman et al.*, 2008)
atmospheric tides (station)	*Ray and Ponte* (2003)

In the table, (E) means estimated, (L) means eliminated and (R) means reduced. * once-per-revolution

SLR research activities and products @ DGFI-TUM

Mathis Bloßfeld

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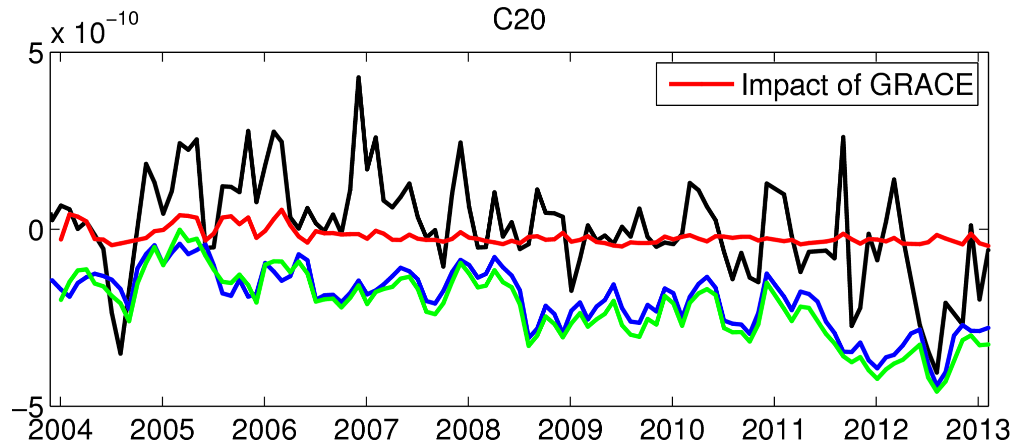
website: www.dgfi.tum.de

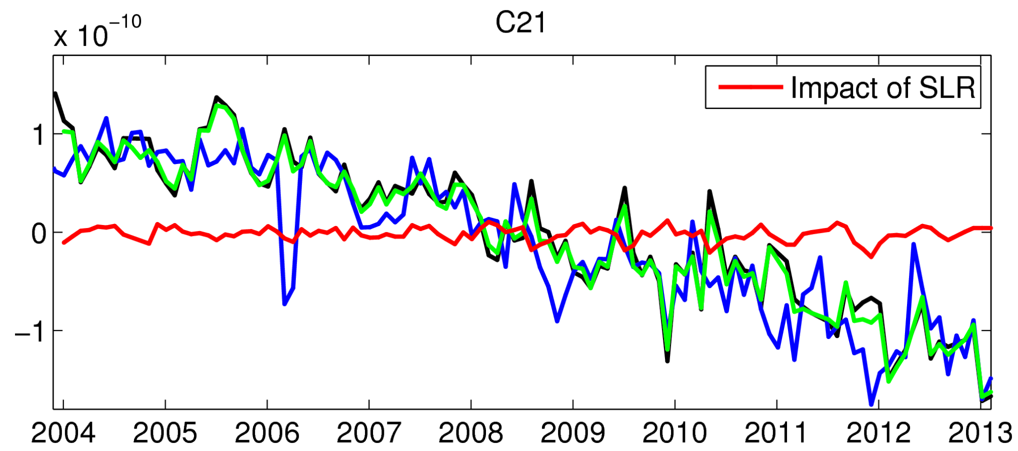
EGSIEM General Assembly 2016, Luxembourg, 2016-01-18/19

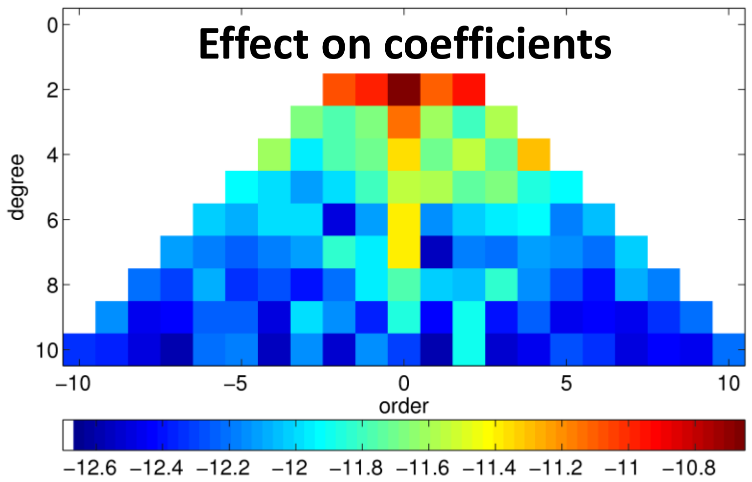
GRACE / SLR - Combination (1/2)

In AIUB 10^{-10}*SLR + GRACE combination SLR had some influence on degree 2, low degree sectorial and zonal coefficients.

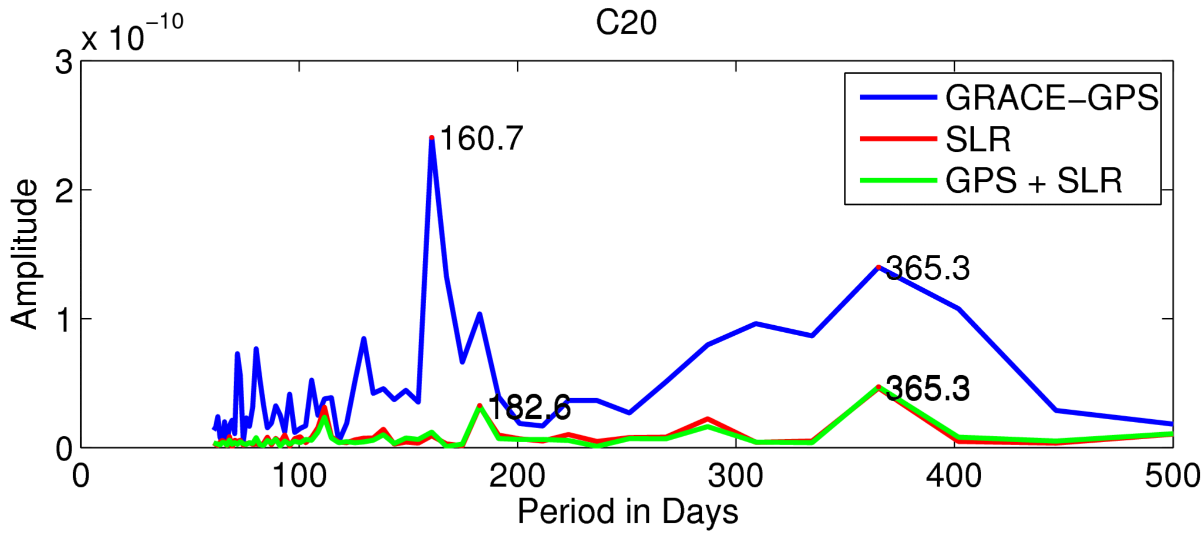
Main effects are a bias $dC_{20} = 2*10^{-10}$ and attenuation of 161 d –signal.



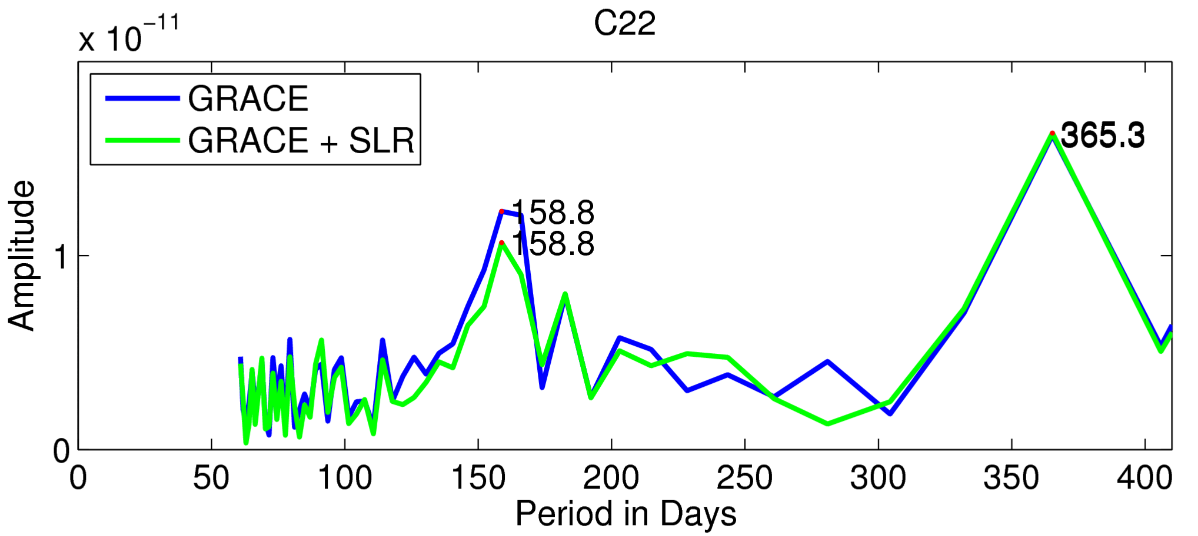




GRACE / SLR - Combination (2/2)



Attenuation of 161 d – signal is most pronounced in C20 (here in GRACE GPS + 0.01*SLR combination).



But it is also visible in other coefficients, e.g., C22 (in GRACE K-Band + 10^{-10}*SLR combination).

Discussion

European Gravity Service for Improved Emergency Management

How should SLR be handled in the frame of EGSIEM?

- Simple replacement of C_{20}
- Simple replacement of C_{20} and degree 1 terms
- Combination of combined GRACE normal equations with SLR normal equations?
- Should other groups contribute to get a combined SLR solution?

Who could contribute SLR solutions / normal equations

- TUG, GFZ, …?
- SLA for other groups (TUM-DGFI, …)?

Discussion

EGSIEM
European Gravity Service for Improved Emergency Management

Should EGSIEM contribute to GPS hl-SST combination studies?

- All interfaces are available
- Additional combinations could be done with almost no extra-work
- Flexibility could be an important argument for a future integration of the scientific combination service into the IAG services

Who could contribute GPS hl-SST solutions / normal equations?

- TUG, UBERN, …?
- SLA for other groups (TU Delft, Czech Academy of Sciences, …)?

How should this activity be coordinated?

EGSIEM

European Gravity Service for Improved Emergency Management

Title: **Status of NRT & Regional Service at TUG**

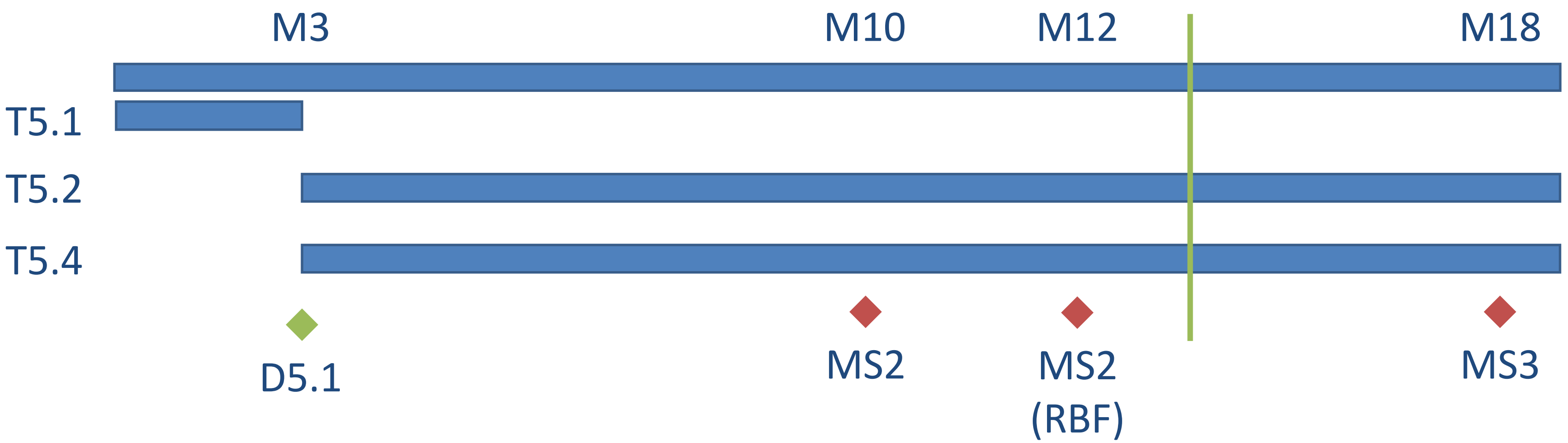
Presenter: AK

Affiliation: TUG

EGSIEM Meeting

Luxembourg, 19.01.2016

Status of NRT – Time Table and Milestones

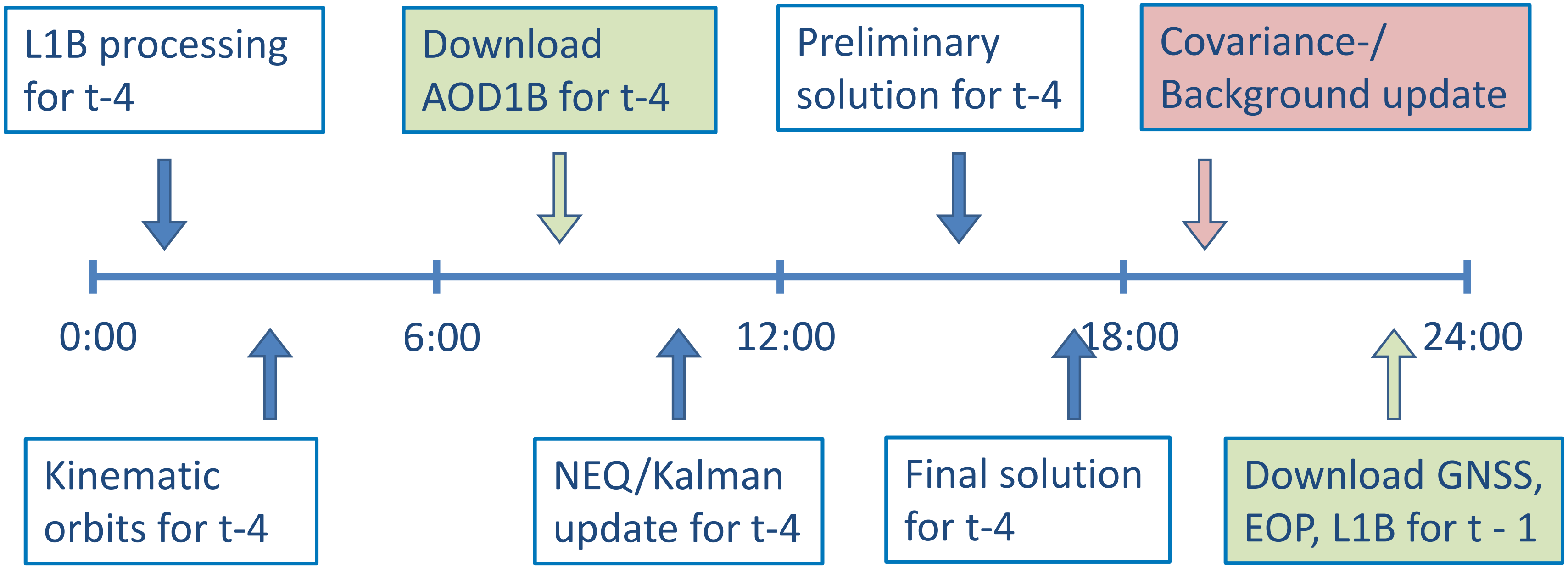


- Milestone 2 (Implementation and Preparation Review) reached
  - Implementations for NRT capability finished
  - First radial basis function (RBF) post-processing time series computed in M12 at TUG (delay of one month compared to proposal)

- Upcoming: Milestone 3 (Service Readiness, M18)
  - Marks the begin of T5.5 (Generation of Area Mean Values, M19) and 5.6 (Validation/Feedback, M19)

Status of NRT – Processing Schedule

- Processing sequence executed daily
- Slight departure from D5.1:
  - Data acquisition is detached from processing



Status of NRT – Regional (RBF) Representations

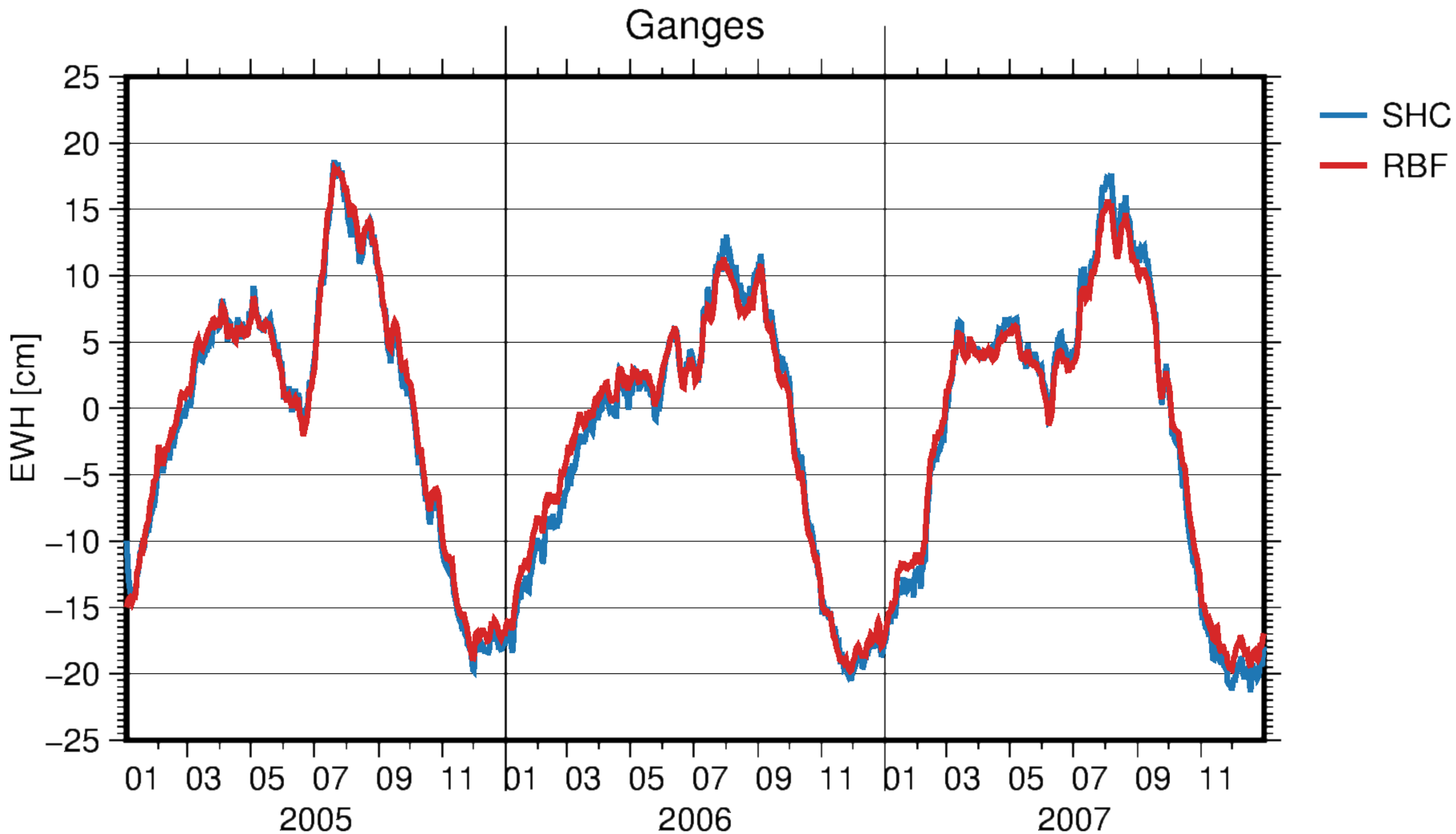
- Radial basis functions representations fully implemented for gravity field solutions and process model

- Evaluated using a post-processing time series from 2003-02 to 2015-04

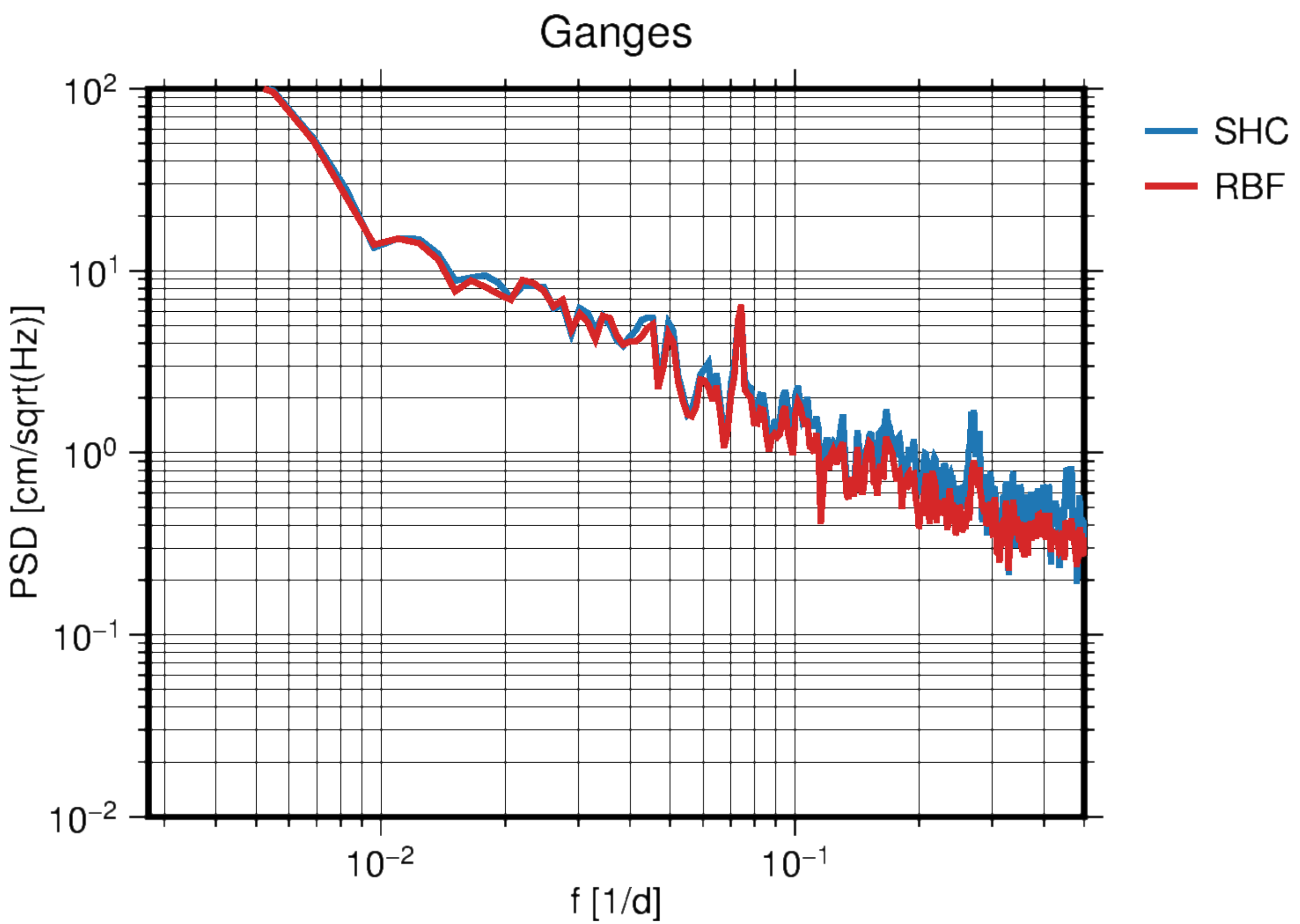
- Very good agreement with SHC solutions

- Kalman filter operates on normal equation level:
  - RBF representations can be easily integrated and run in parallel with SHC solutions

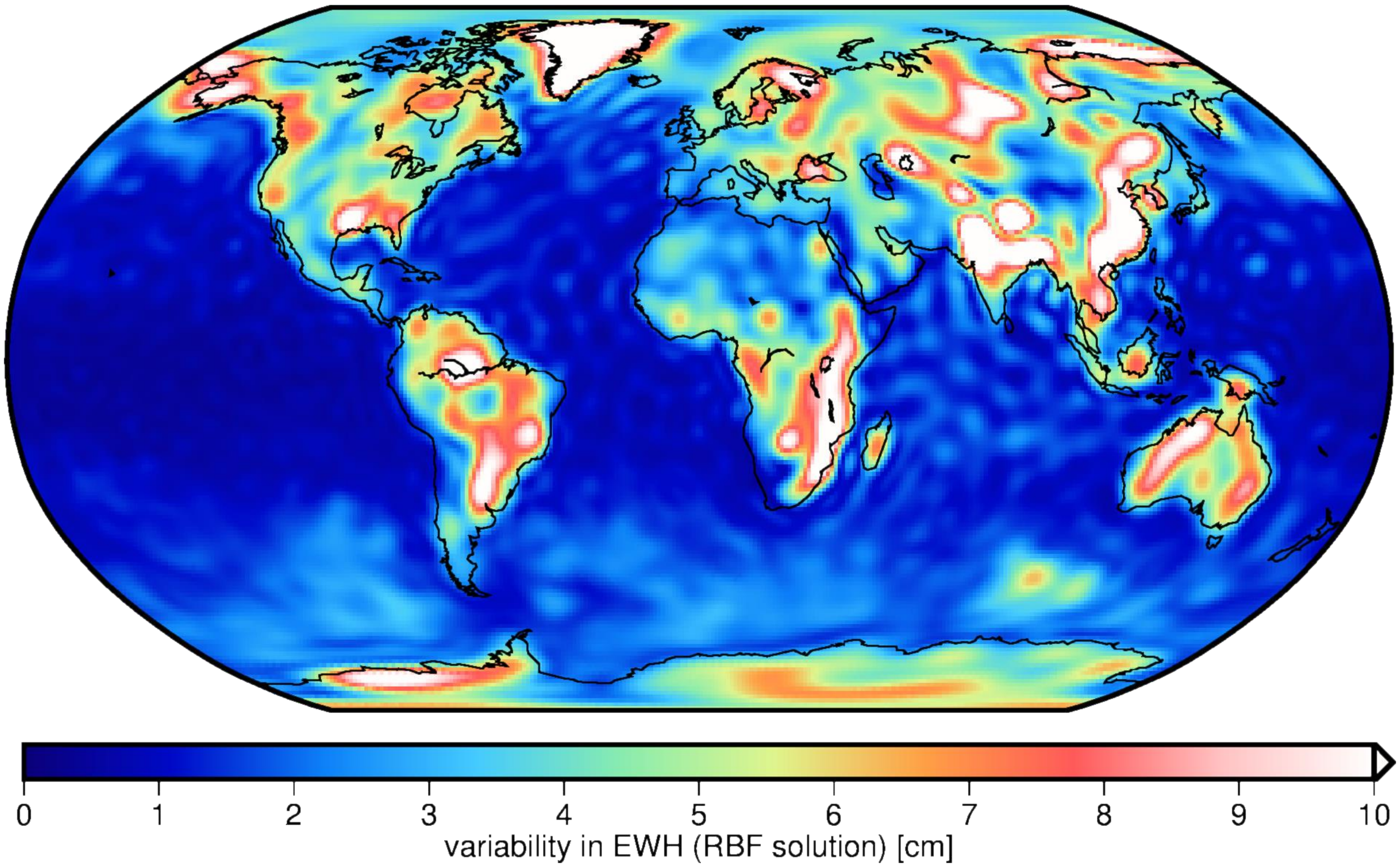
Status of NRT – Regional (RBF) Representations



Status of NRT – Regional (RBF) Representations



Status of NRT – Regional (RBF) Representations



Status of NRT – Processing Methods

- Improved processing methods from task T2.2 implemented
  - Exception: accelerometer calibration values based on force models (solar flux not available in NRT)

- Kinematic Orbits
  - Estimated daily, using three days of clocks and orbits including previous and following epoch

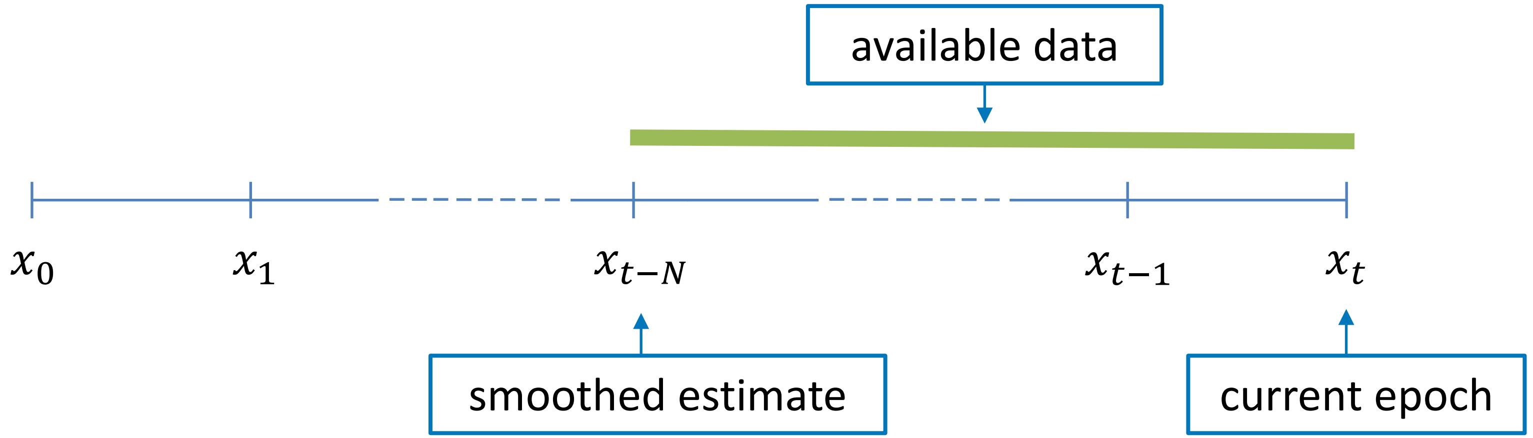
- Instrument Error covariance estimation from one month of data
  - Continued 14 days into the future
  - Daily estimation of arc weights with fixed covariance function

- Background model update
  - Annual/secular variations estimated for complete time span (2003-today)
  - Updated every 14 days using daily normal equations

Status of NRT – Processing Methods

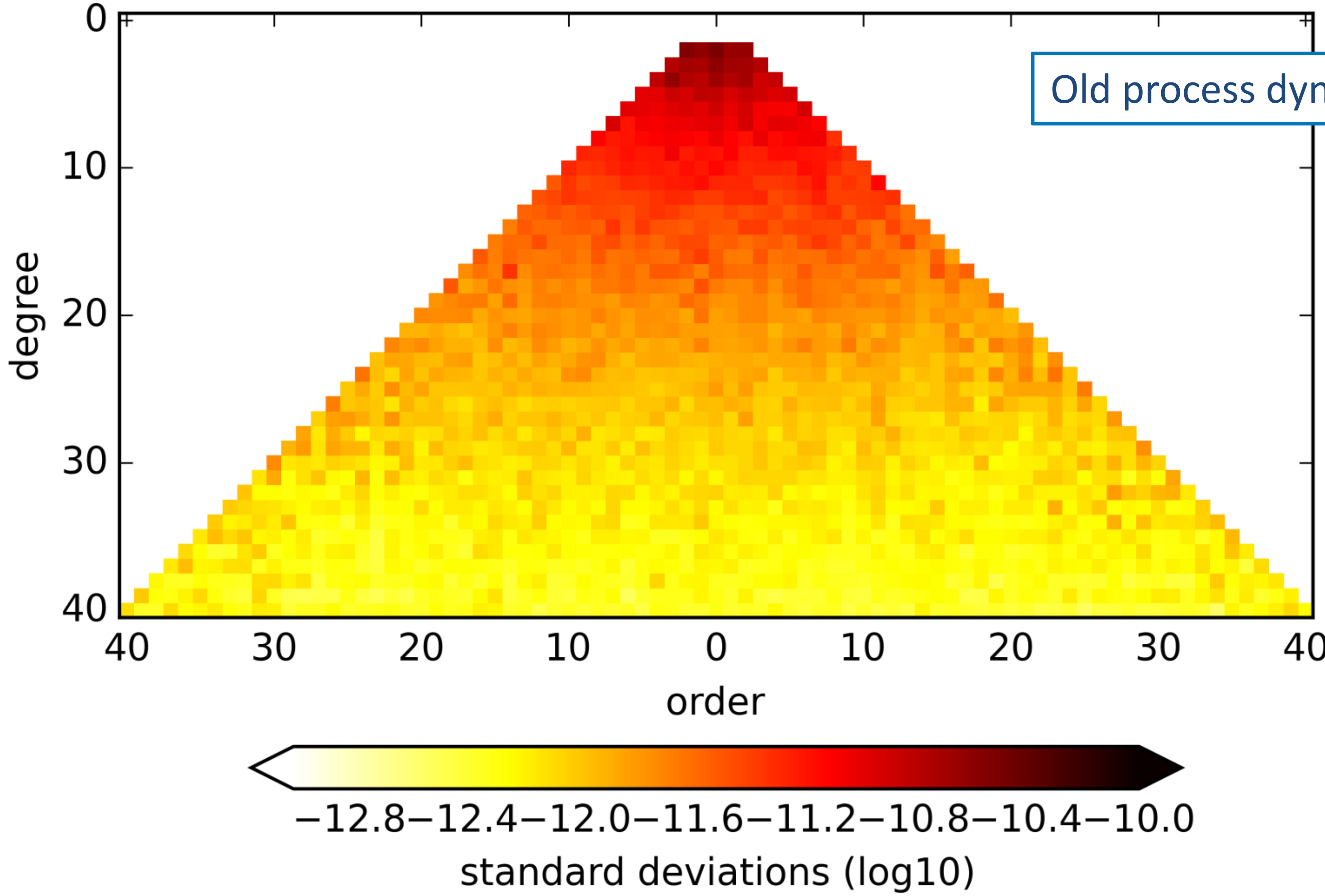
- Improved state-space model:
  - Regional constraints to increase redundancy
  - Improved prediction/less filter artifacts

- Current estimated latency possibly allows for fixed-lag smoothing with one lag epoch



Status of NRT – Processing Methods

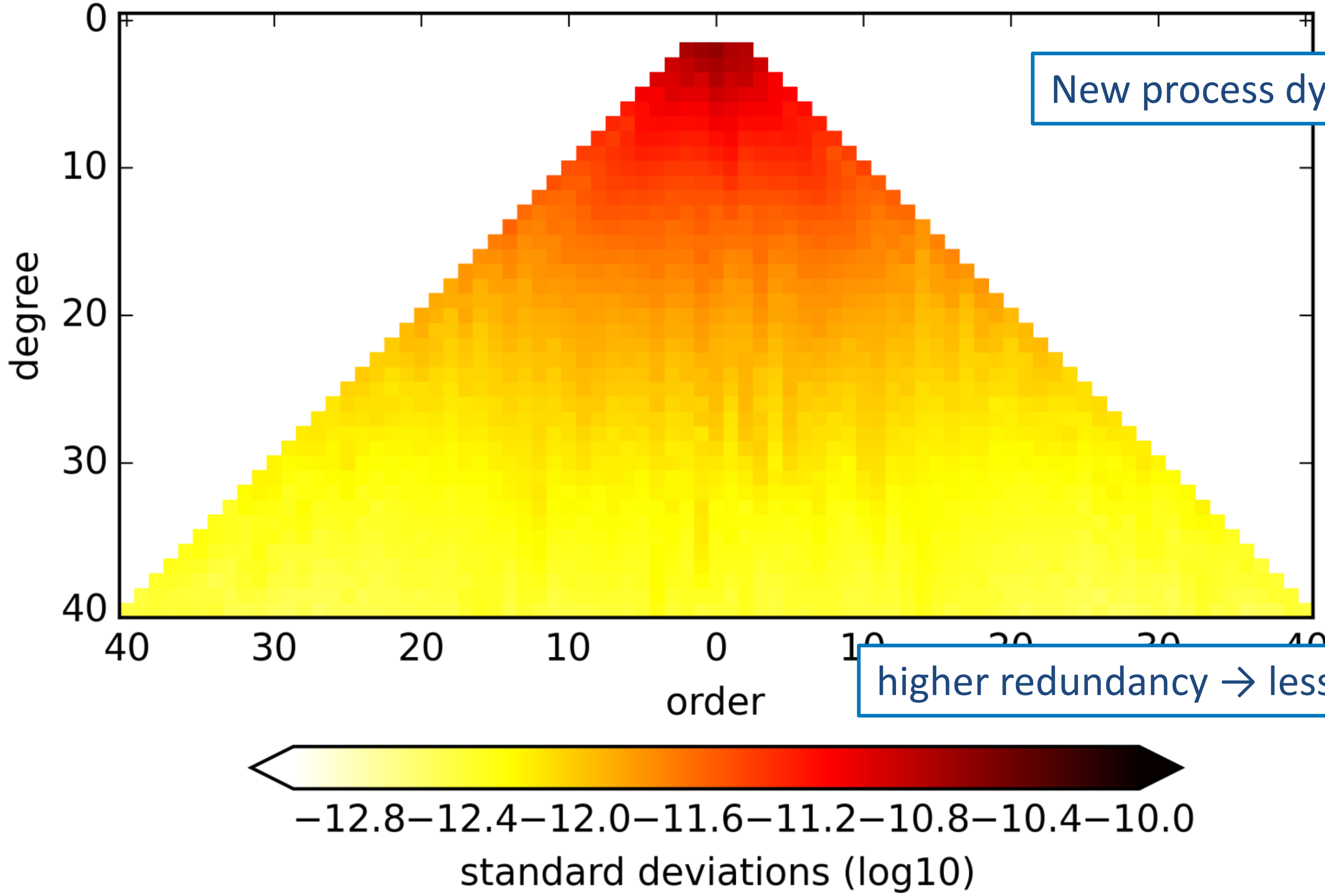
main diagonal of auto-covariance



Status of NRT – Processing Methods

main diagonal of auto-covariance

New process dynamic



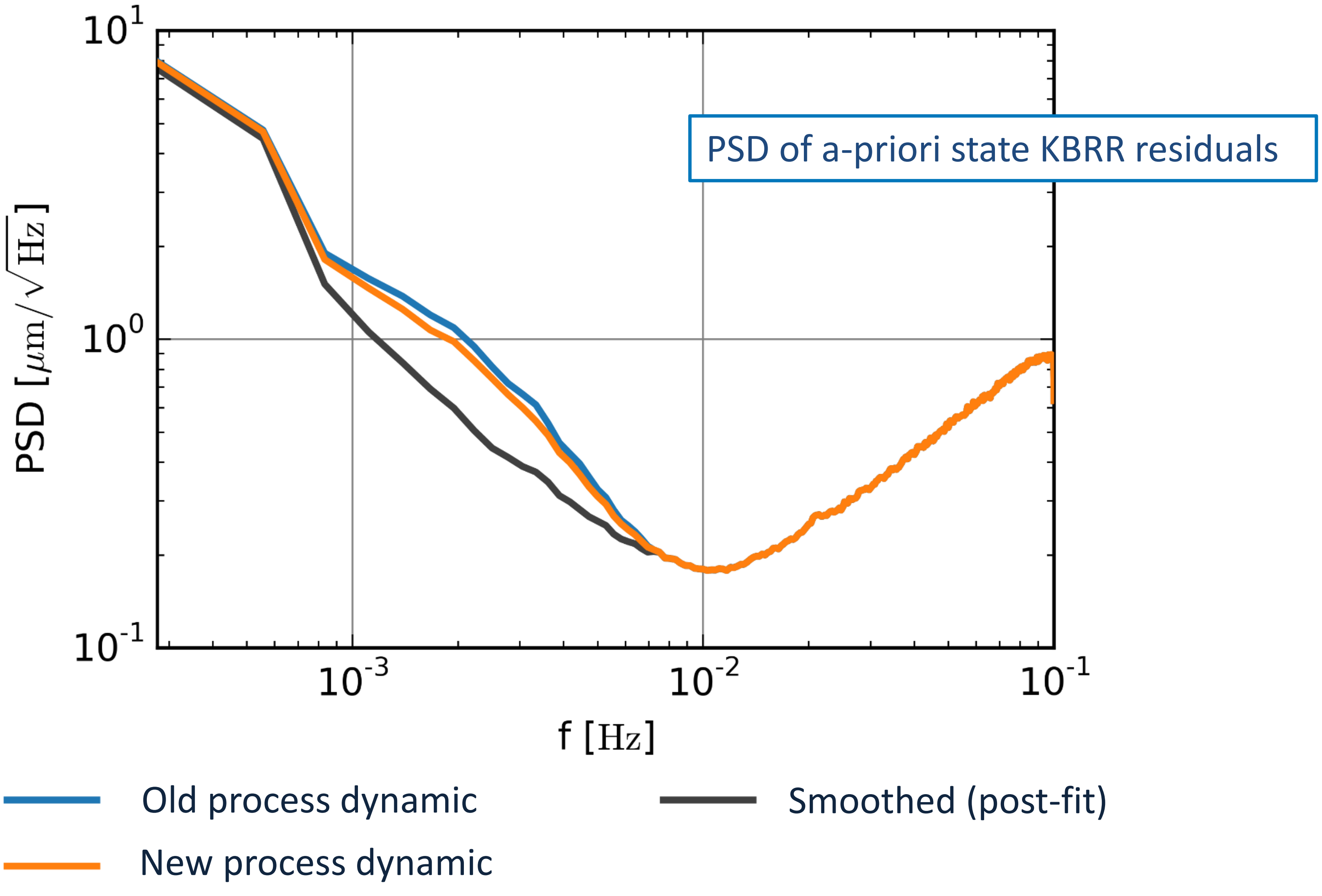
higher redundancy → less noise

Status of NRT – Processing Methods

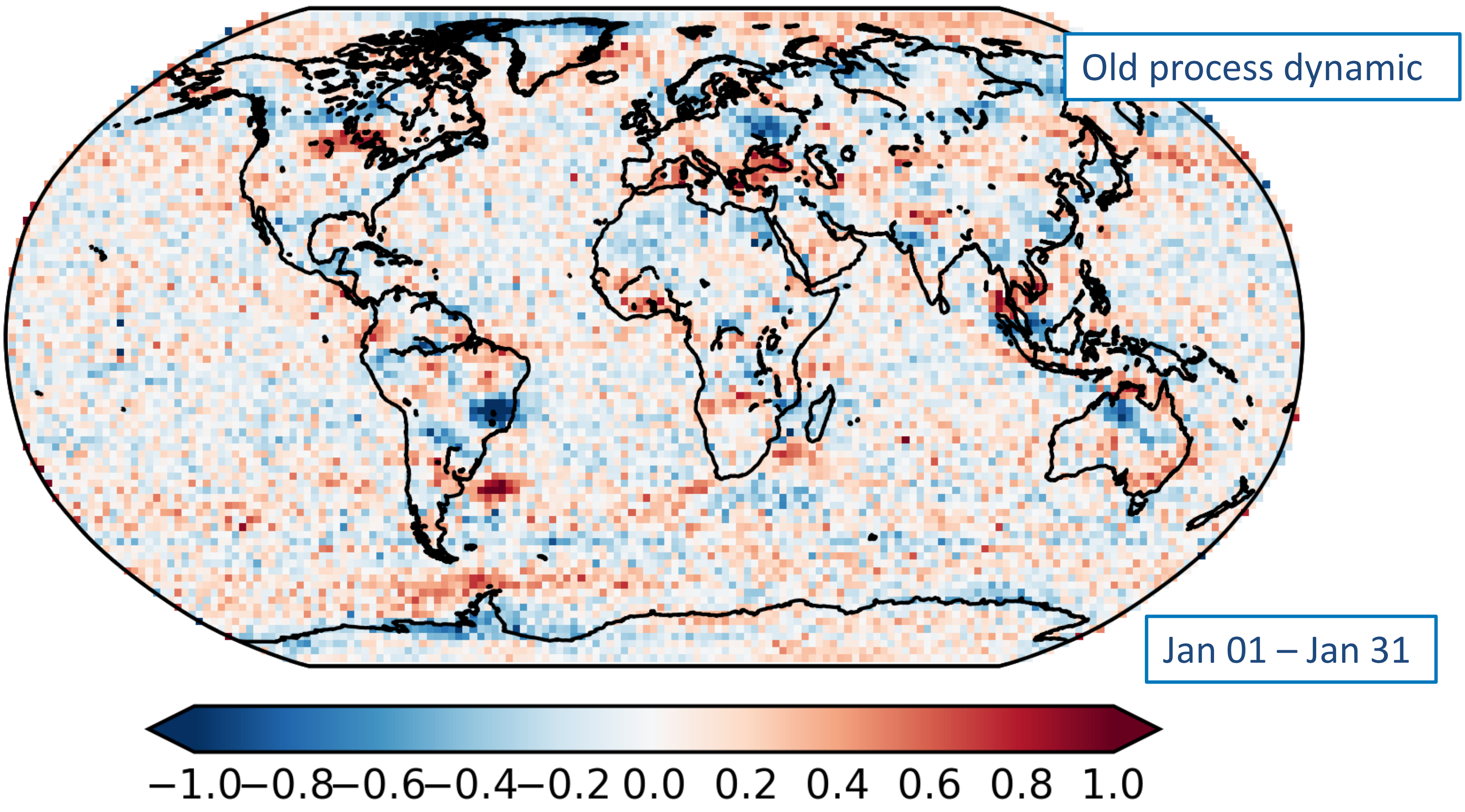
- Question 1:
  - How well does the predicted state fit the GRACE observations?
  - Comparison of a-priori range rate residuals in time and space domain

- Question 2:
  - Are there Kalman filter artifacts in the computed gravity field solutions?
  - Non-geophysical signals in area mean time series

Status of NRT – Processing Methods

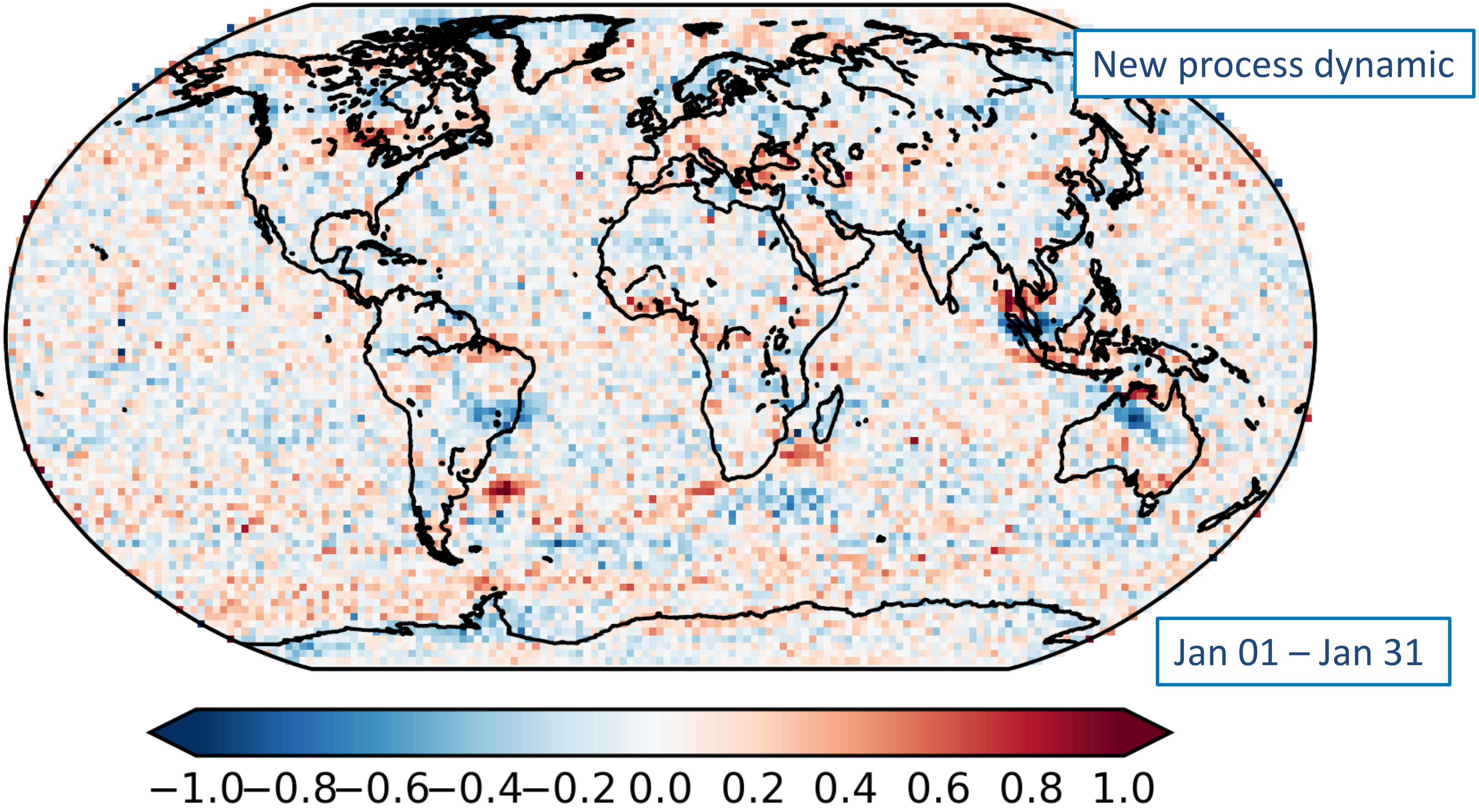


Status of NRT – Processing Improvements



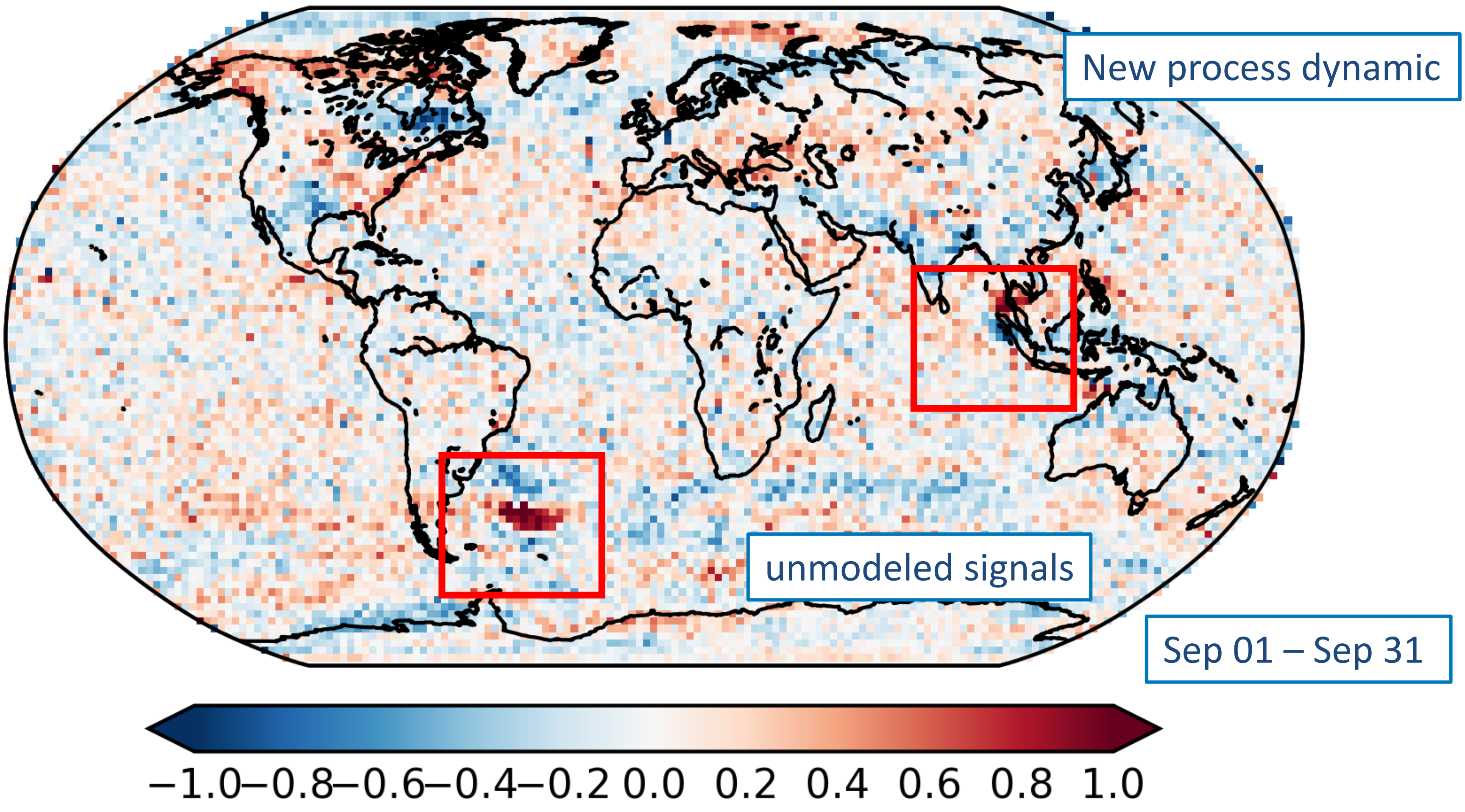
decorrelated daily KBRR residuals, monthly 2x2 degree bins

Status of NRT – Processing Improvements



decorrelated daily KBRR residuals, monthly 2x2 degree bins

Status of NRT – Processing Improvements



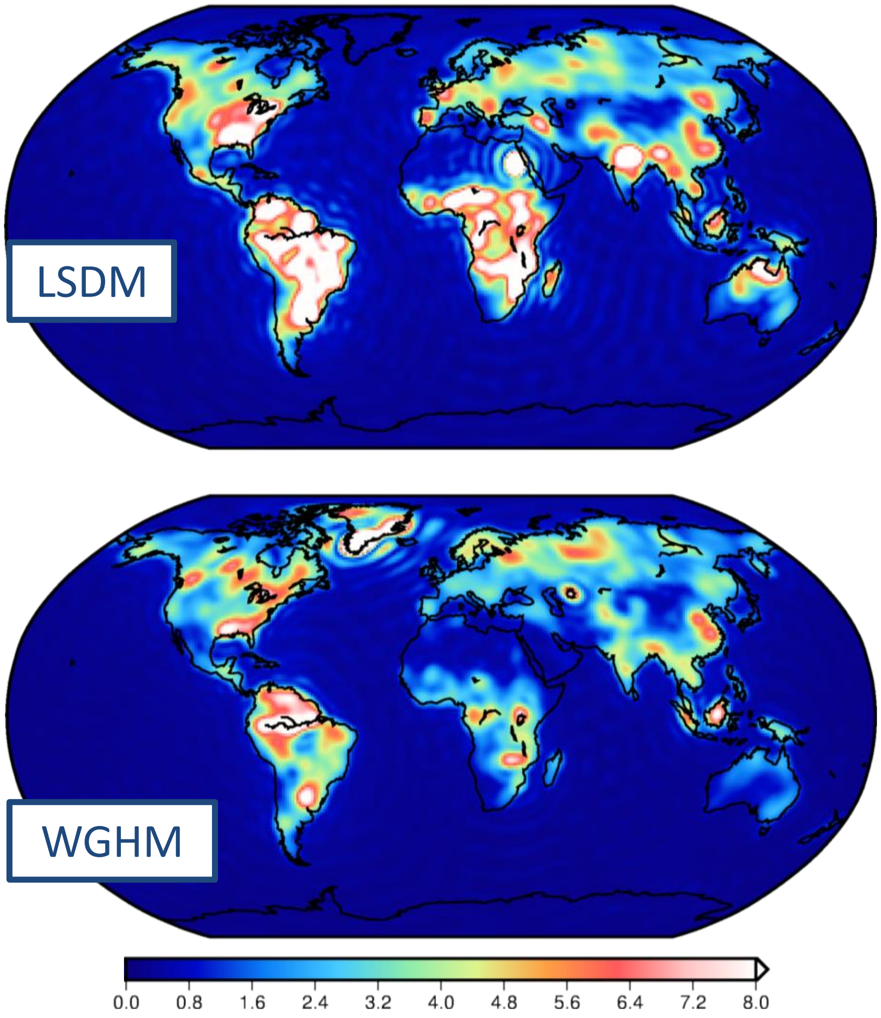
decorrelated daily KBRR residuals, monthly 2x2 degree bins

Process Dynamic Comparison

- Setup: two Kalman smoothed time series from 2003-02 to 2008-12
- Process dynamic computed from 1995-01 to 2003-01
  - Identical setup, just swap of hydrological model
  - GRACE_WGHM: process dynamic from ESA ESM AOI + WGHM
  - GRACE_LSDM: process dynamic from ESA ESM AOI + LSDM

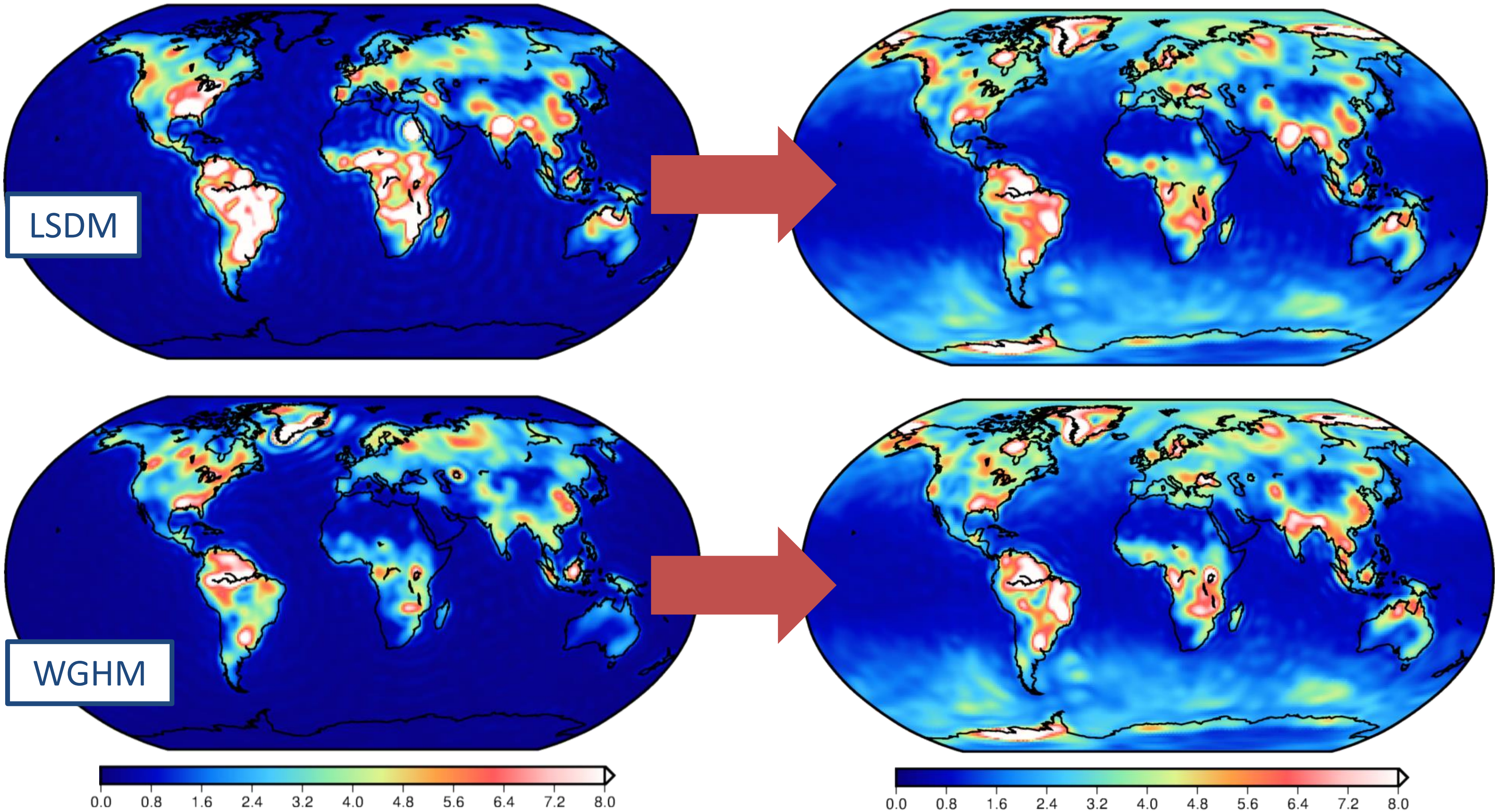
- Comparison with monthly GRACE solutions (CSR) and model values

Process Dynamic Comparison



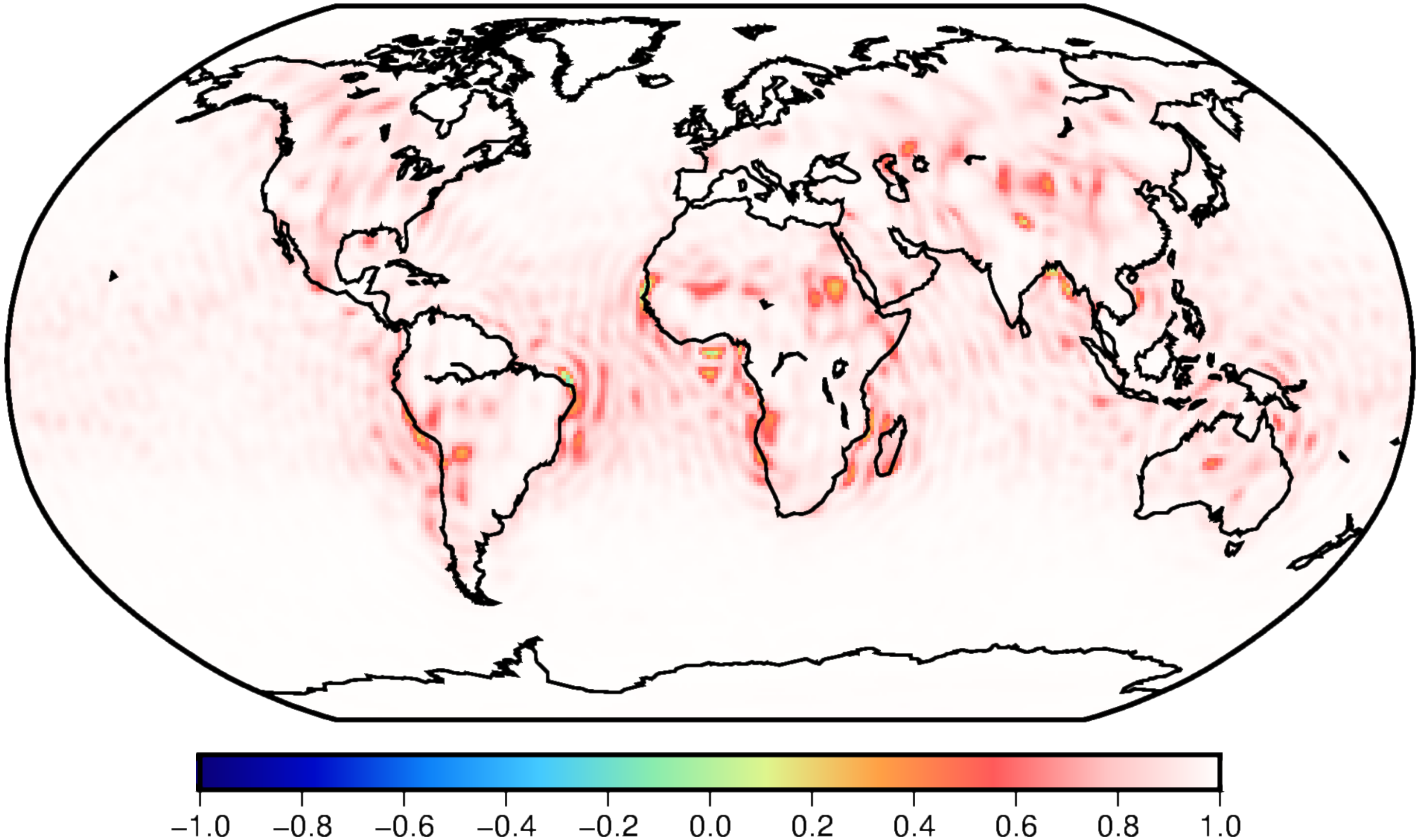
Variability from 1995 to 2003 in EWH [cm]

Process Dynamic Comparison



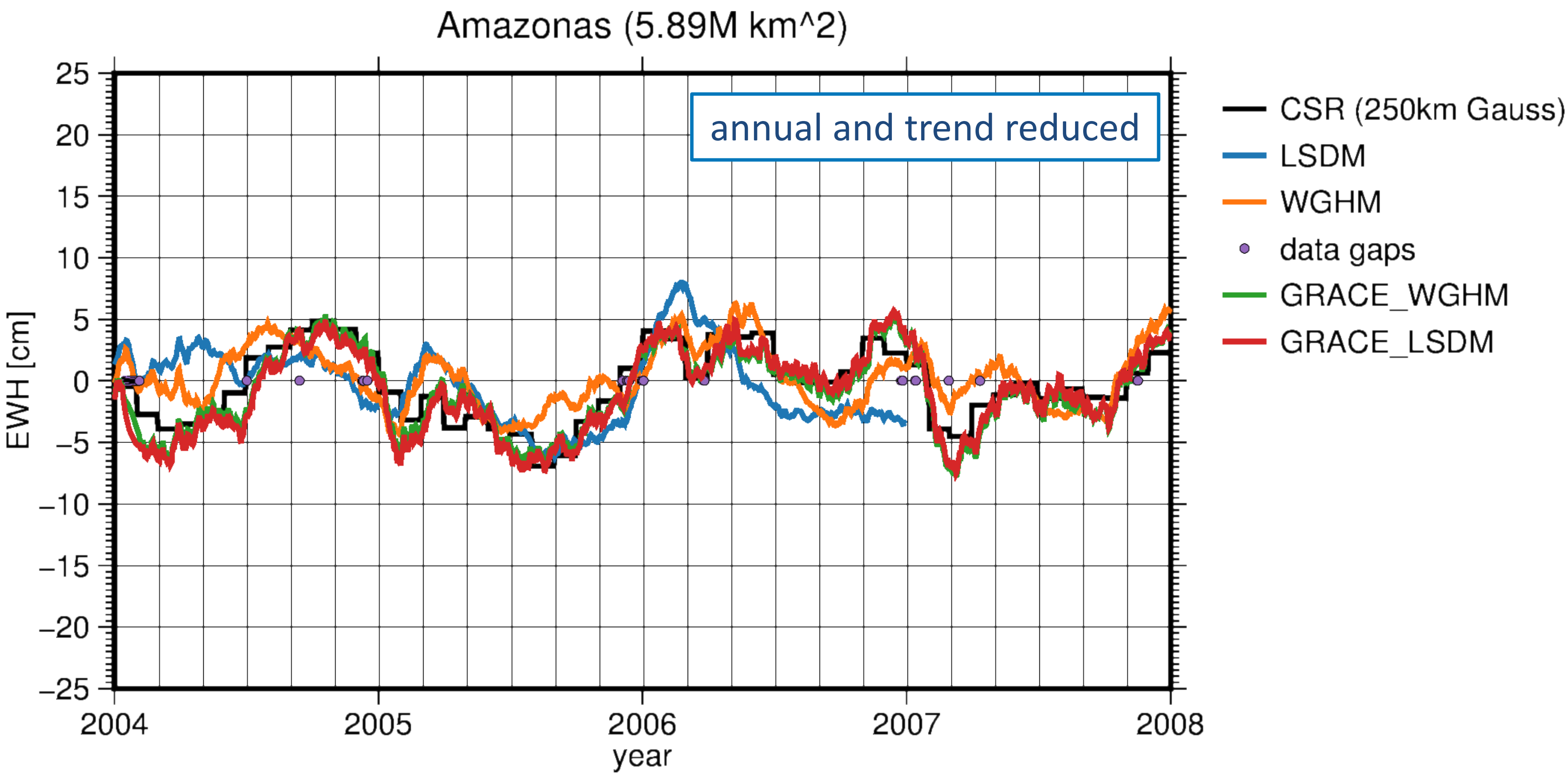
Variability from 1995 to 2003 in EWH [cm]

Process Dynamic Comparison

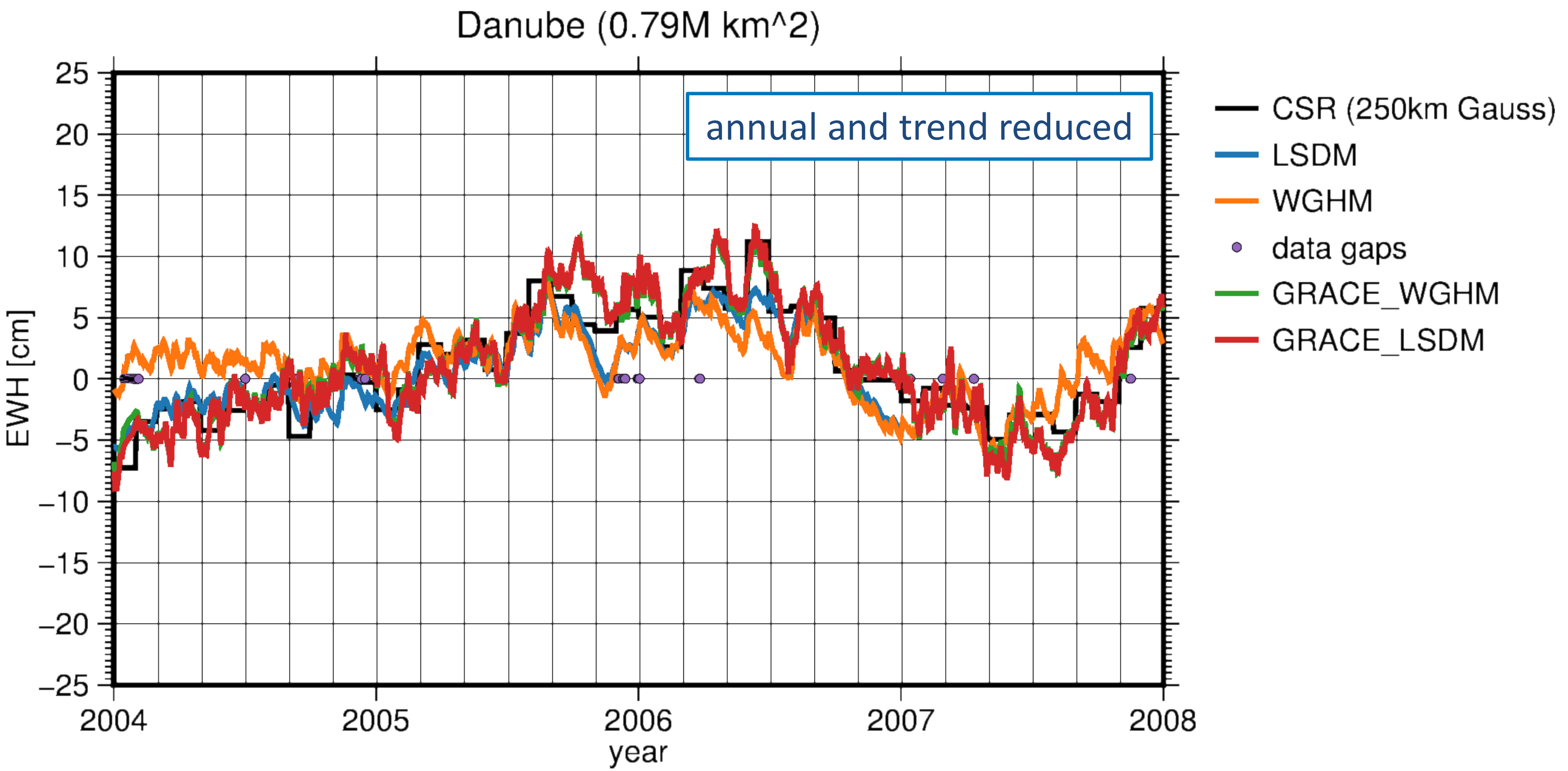


Correlation coefficient between both GRACE time series (2003 to 2008)

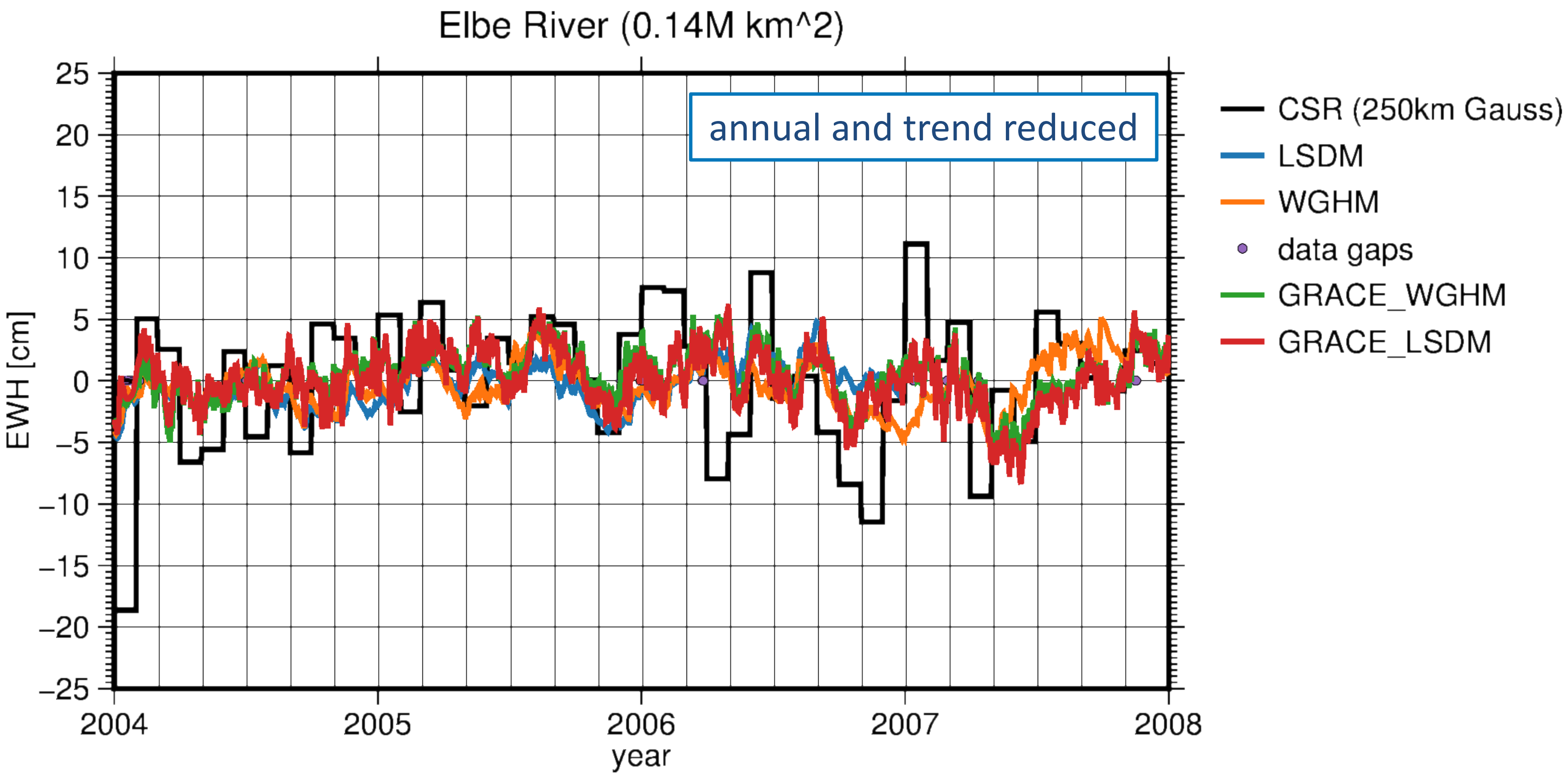
Process Dynamic Comparison



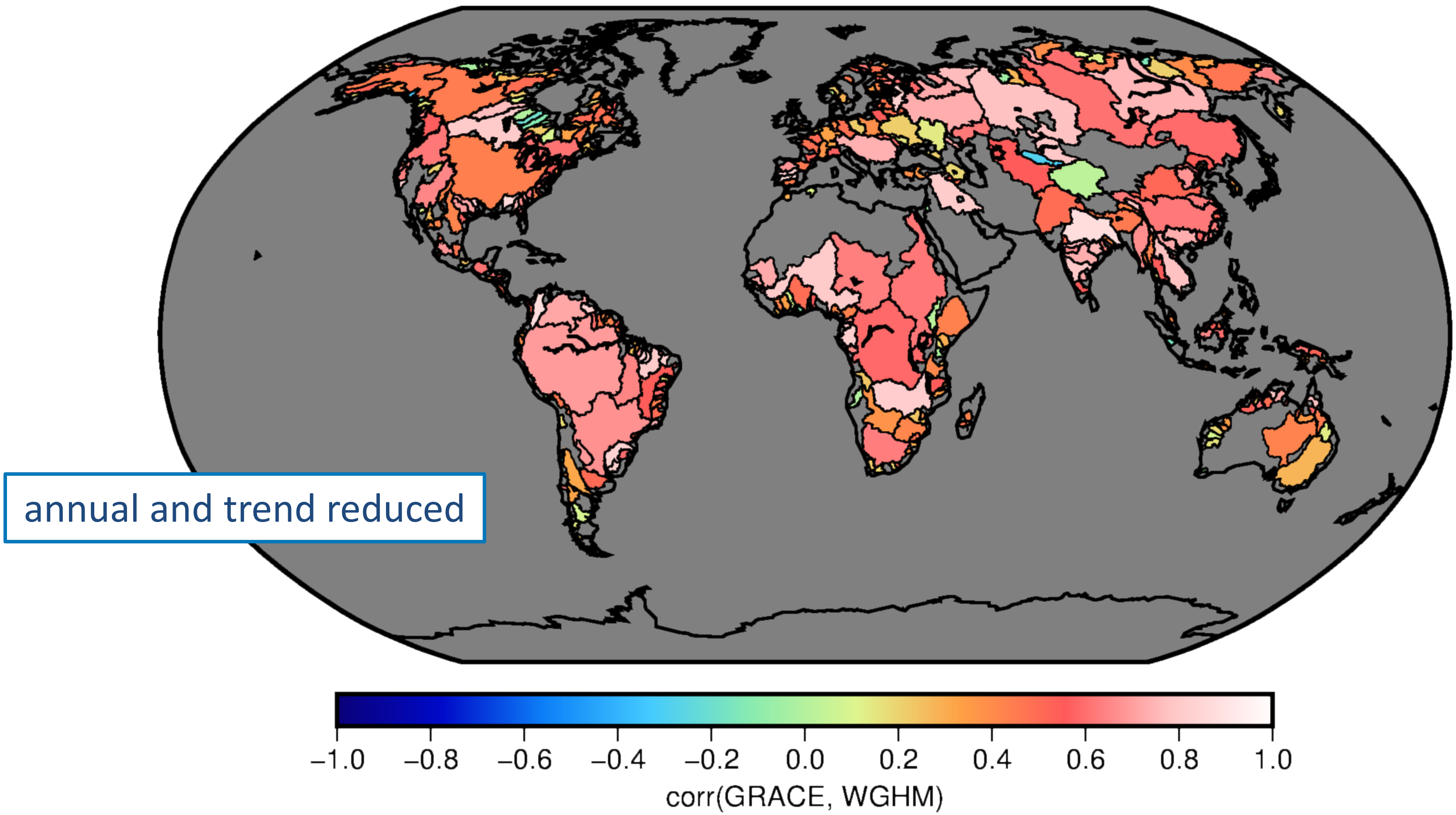
Process Dynamic Comparison



Process Dynamic Comparison



Process Dynamic Comparison



Correlation coefficient of area mean values from 2003 to 2008

Preparations for Service Readiness at TUG

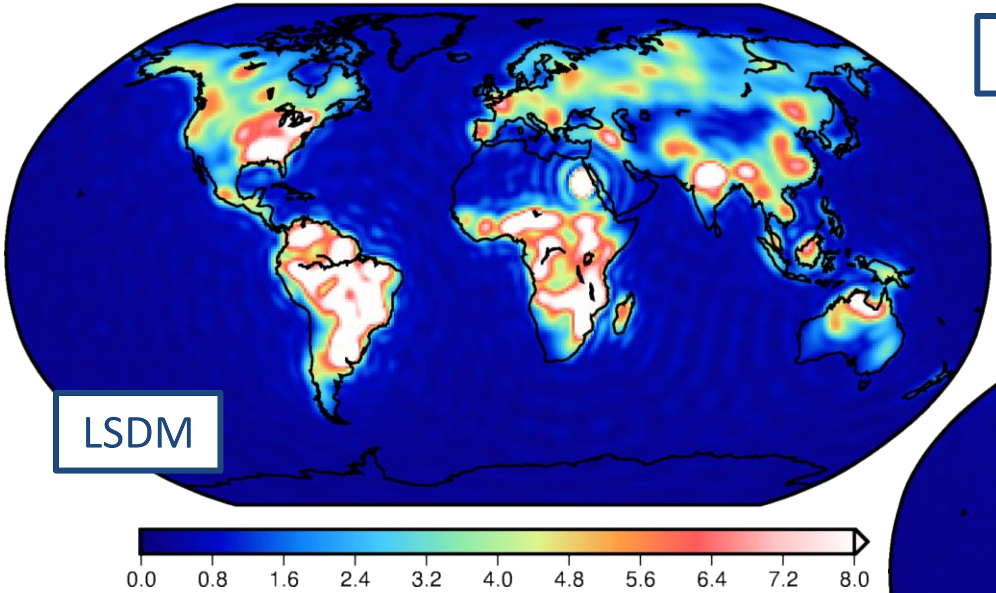
- Continuous run with final data (M13-)

- Migrate software framework from testing to production environment (M17-M18)
  - Software freeze of both automation and processing parts
  - Deployment on production hardware

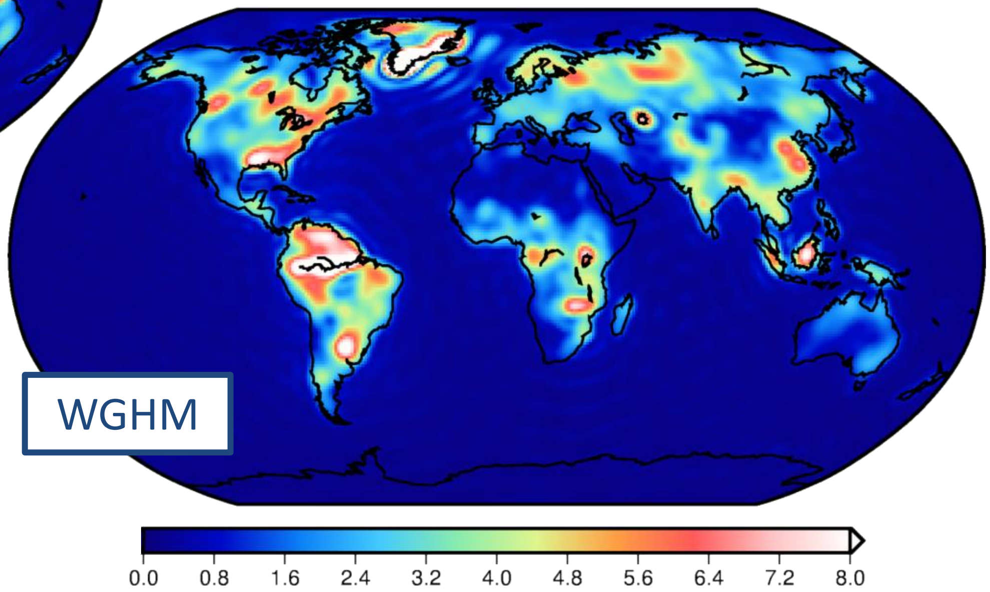
- Generate test data sets (EWH grids and SHC) for T5.5 and T5.6
  - Evaluate NRT L3 processing chain

- Milestone 3 will be reached on time

Process Dynamic Comparison (Backup)

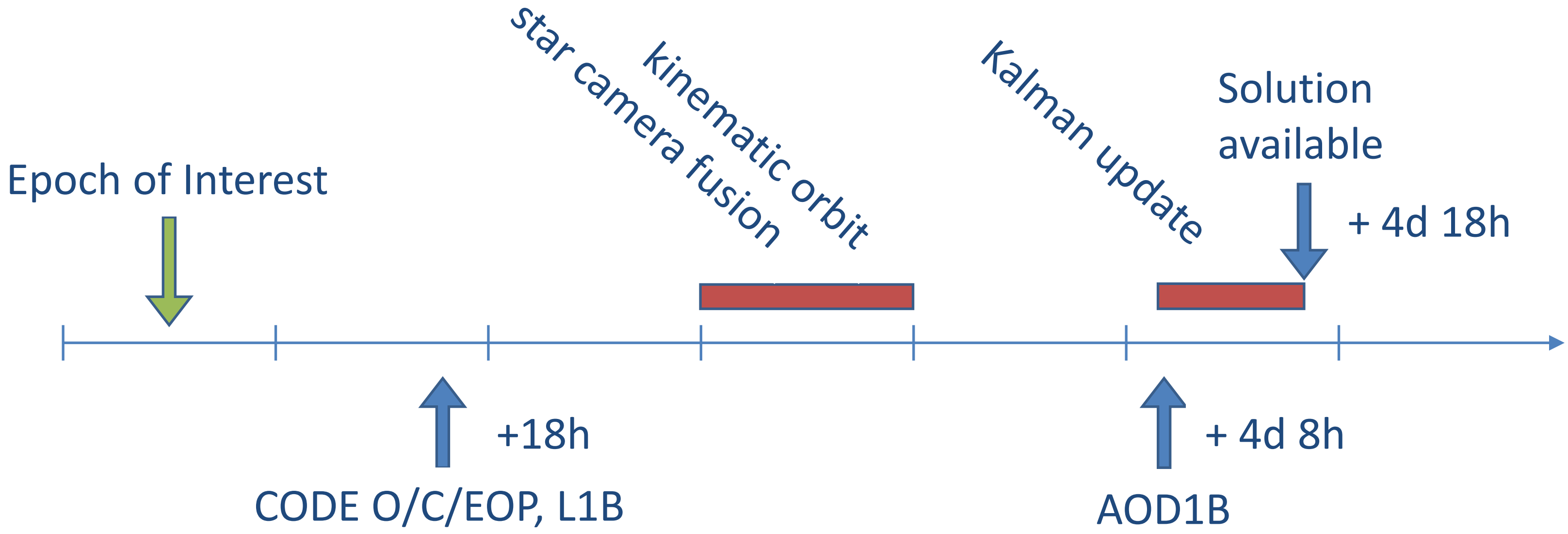


Variability from 1995 to 2003 in EWH [cm]



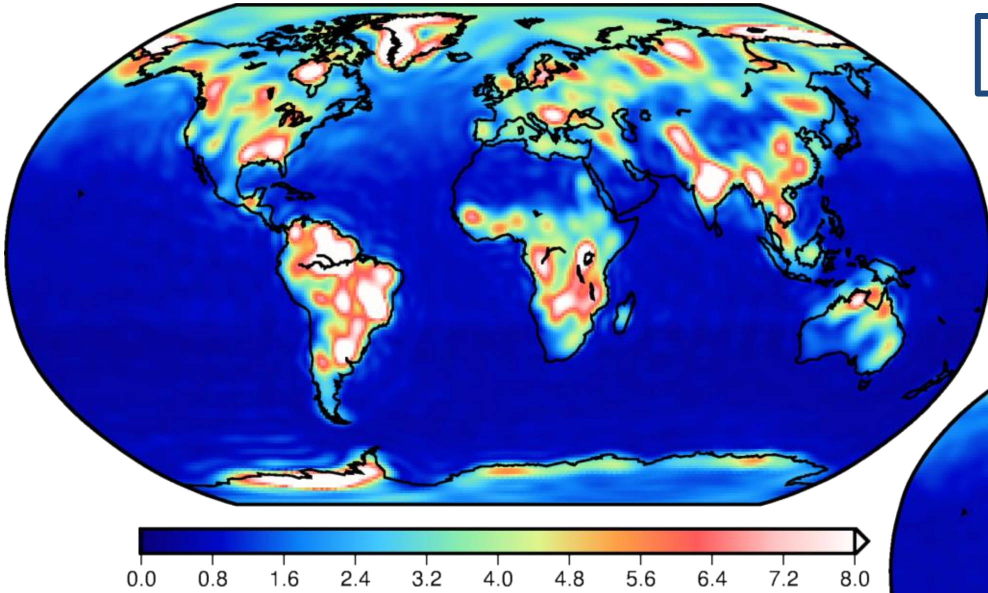
In General: LSDM has larger amplitudes

Status of NRT – Data Availability

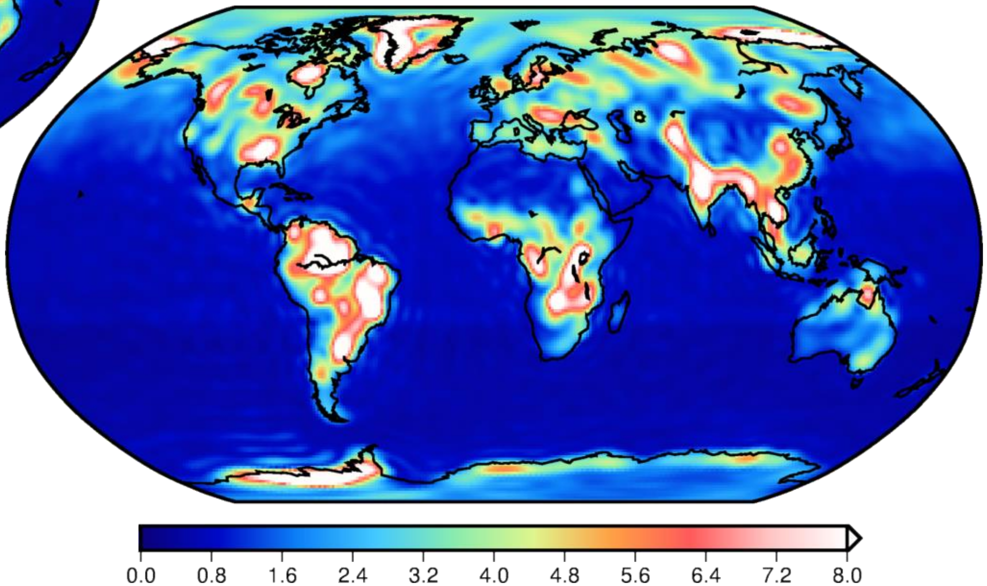


Process Dynamic Comparison (Backup)

Variability from 1995 to 2003 in EWH [cm]



GRACE (LSDM Process Dynamic)



GRACE (WGHM Process Dynamic)

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European Gravity Service for Improved Emergency Management

WP5: Status & Milestones

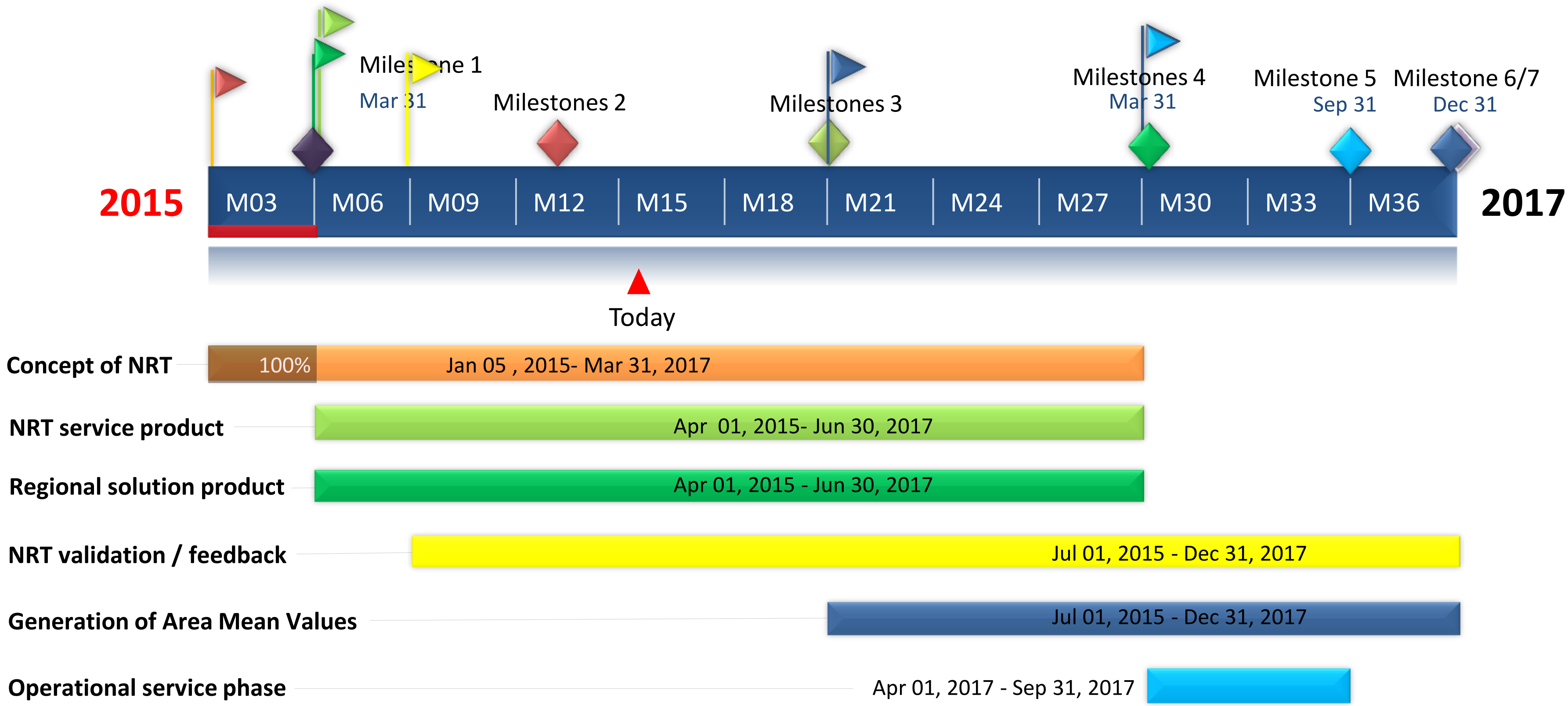
Deliverable 5.1: NRT service concept

EGSIEM Meeting, University of Luxembourg

Jan 17 – Jan 18, 2016

Project Plan

European Gravity Service for Improved Emergency Management



Input data for gravity recovery and latencies

European Gravity Service for Improved Emergency Management

Product	Source	Current Latency (IP)	Required Latency (OP)
EOP	IERS/UBERN	IERS: 1-3 days, UBERN: 14 days	IERS: 1-3days, UBERN: 17 hours
GPS Orbits/Clocks	UBERN (T3.4)	14 days	17 hours
GRACE L1B Data	JPL, Backup: GFZ	11 days	1 day *
Dealiasing Product (AOD1B) **Specific hydrological basin (upon request)**	GFZ WP3/6	7 days Not available	3-4 days 1 day

*Needs to be clarified with GRACE-FO SDS

Production-flow

European Gravity Service for Improved Emergency Management

Last day 00:00

1	GFZ GPS constellations	13:00
	UB: CODE constellations, EOPs	18:00
2	L1B data availability	18:00
	first day 00:00	
3	GFZ: preliminary dynamic orbit	1d+12:00
4	LSC/ Kalman update preliminary, QL	1d+18:00
	second-fourth day 00:00	
5	3-hourly Atmosphere and Ocean Estimates	4d+8:00
6	GFZ: final dynamic orbit	4d+12:00
	TUG: kinematic orbit	
7	LSC/ Kalman update final	4d+12:00
8	plausibility test/ evaluation	4d+16:00
9	grid release /SH –coefficients	4d+18:00

NRT@GFZ

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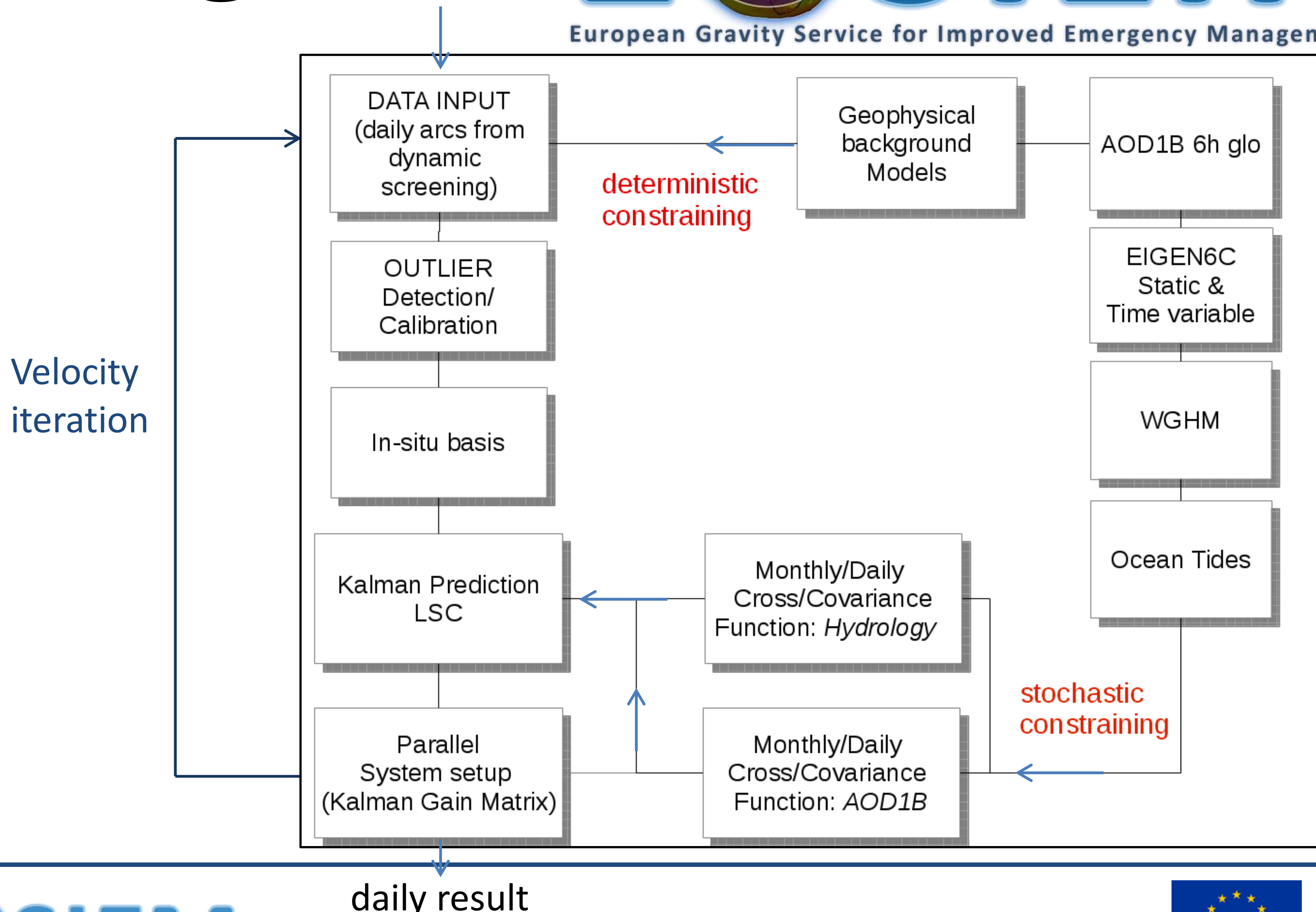

INPUT

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- Ocean tides (EOT11a)
- Atm tides S1,S2 (Bode/Biancale)
- Solid Earth & Pole Tides (Desai)
- 3rd body ephemerides (JPL de421)
- EOP's (Susnik et al.)
- GPS clock's (Susnik et al.)
- GAC (glo, daily, RL6: ellipsoidal approximation)

STOCHASTIC MODELLING

- GAC (glo, daily, RL6: ellipsoidal approximation, improved OMCT)
- WGHM (Döll et al., 2002-2013)
- GRACE RL05a (2002-2015)

Output

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- 2x2 daily grid
- 2x2 operational anomaly to sec/seasonal model
- 1x1 grid regional product for refined areas of interest
- Error estimates for state vector / grid values

Process noise

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Standard auto/cross covariance estimates

- mean{ GAC(daily) – meanGAC } → weight:50%
- de-seasoned HYDROL. model → weight:100%
- GRACE(monthly) residuals and formal errors from sec/seas model → weight:100%

Addional RMS to construct non- stationary (variances)

- + 20% GAC
- + 25% de-seasoned HYDROL. model
- + 30% GRACE residuals (and sec/seasonal model errors)

- secular and seasonal model = fitted reference model over past 7yrs

Program start

- Data acquisition
  - date/time, perturbation forces (*acc/o-tides/e-tides/ lunisol/aod*), coordinates(*cis/cts*), Kband ranges
- Blunder detection (*acc*)
- Background model (gravity)
  - Static, SLR deg2, time-var (sec/seas. GRACE model: 50%, last Kalman day 50%)
- Proxy observation assembly I (pert. forces, sec/seas. model)
- Blunders, cycle/rev-param estimation (*kim*)

Linear system Equations

- target grid (Reuter), corresponding to 2x2 deg
  - conversion between SH/grid
- radial basis functions assembly in grid points
- Cov-estimation
  - Proxy obs auto-correlations
  - Monthly auto/cross covariances for LS prediction
- Kalman filtering
- monthly inversion

Least Squares Prediction

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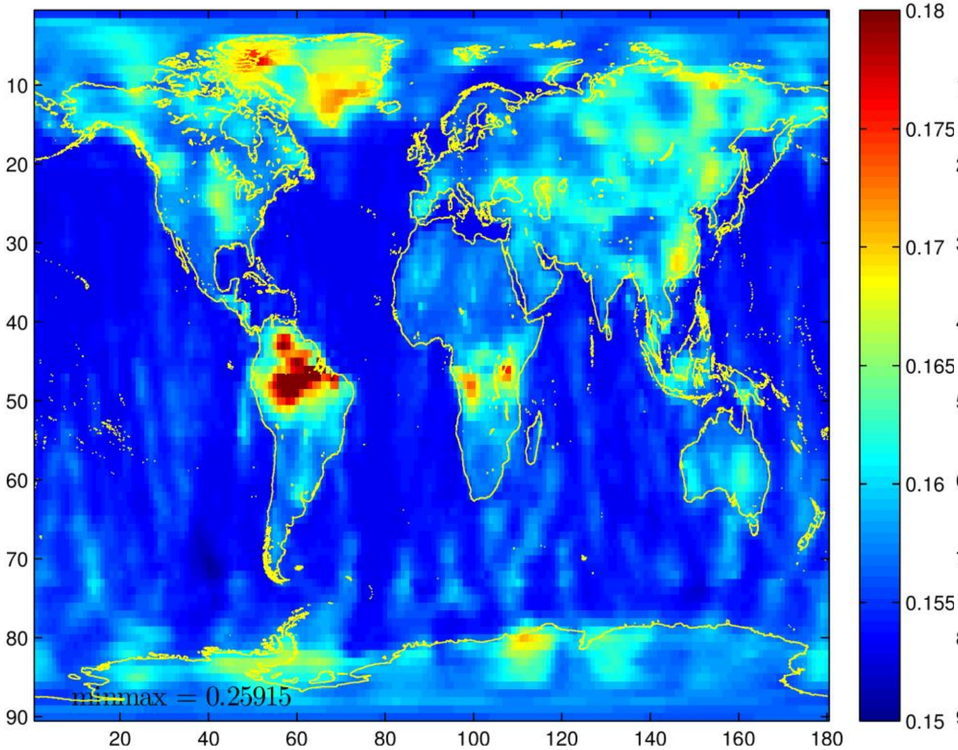
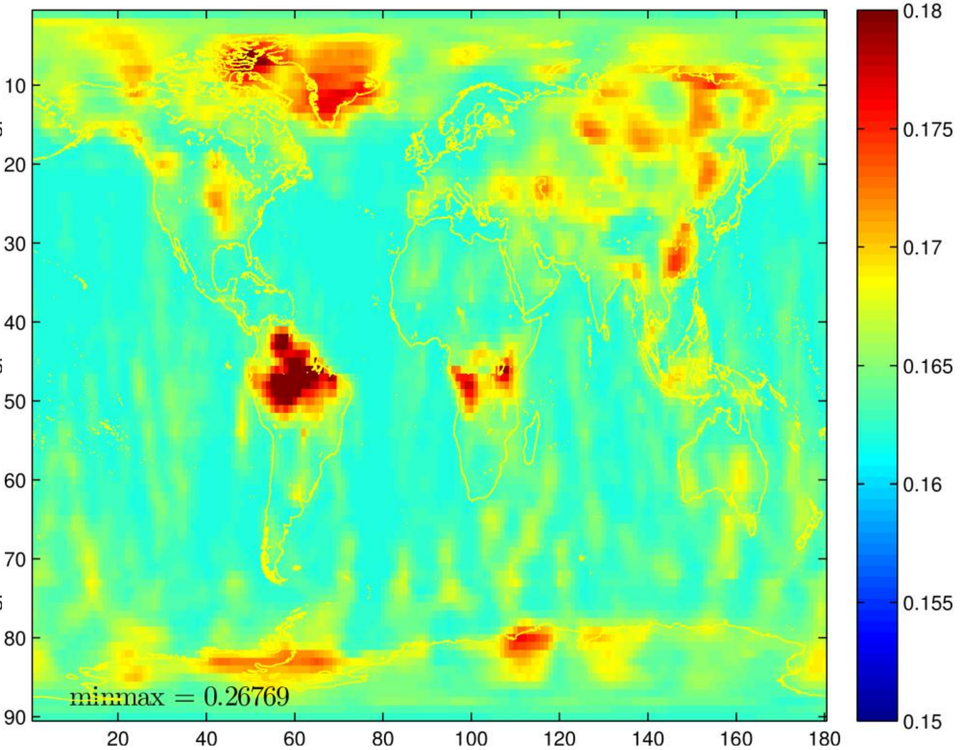


Cross-Co/Variances (06/2005)



Auto-Co/Variances (06/2005)

Kalman Process

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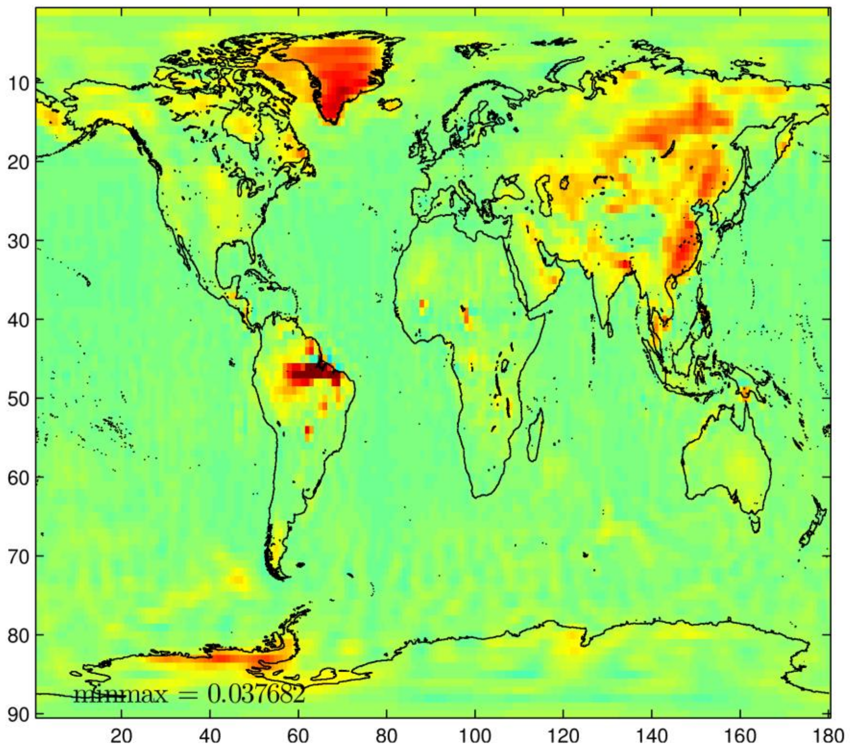
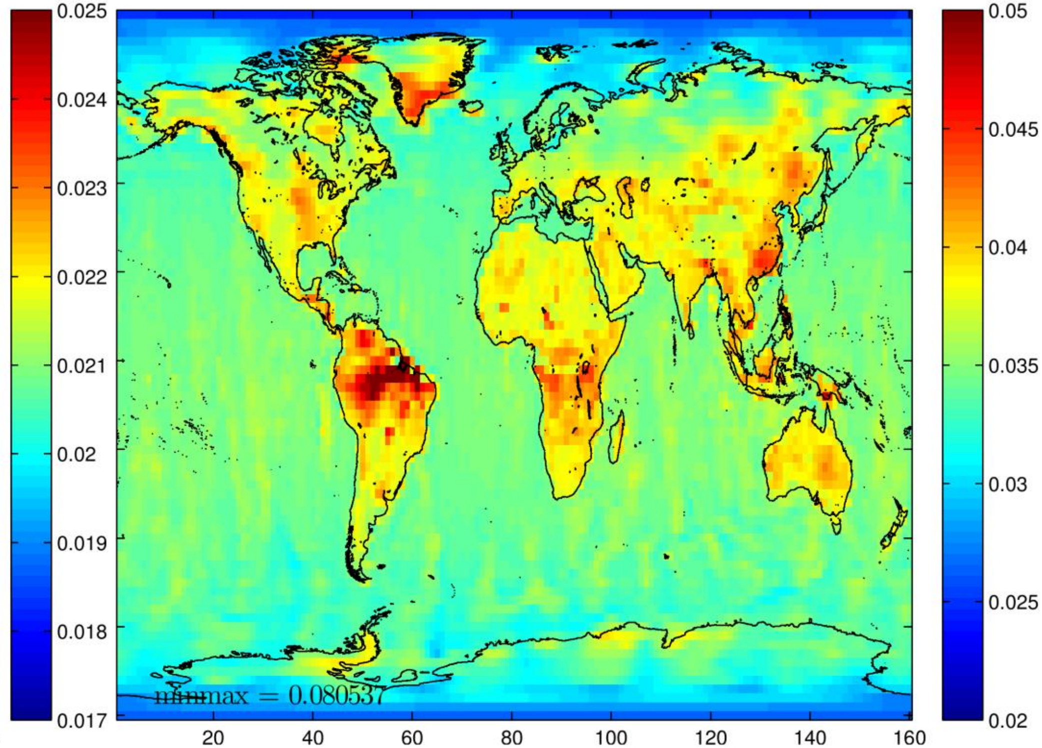


Kalman process-variances (06/2005)



Kalman state-variances (2005/06/13)
after measurement update

Covariances over time

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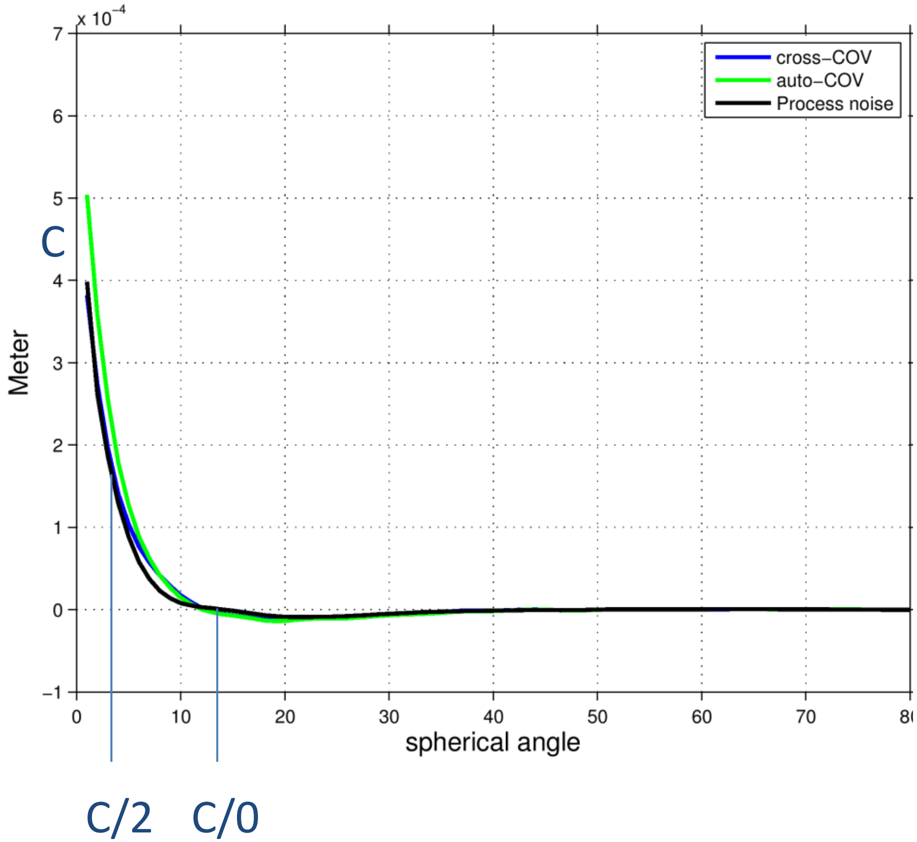

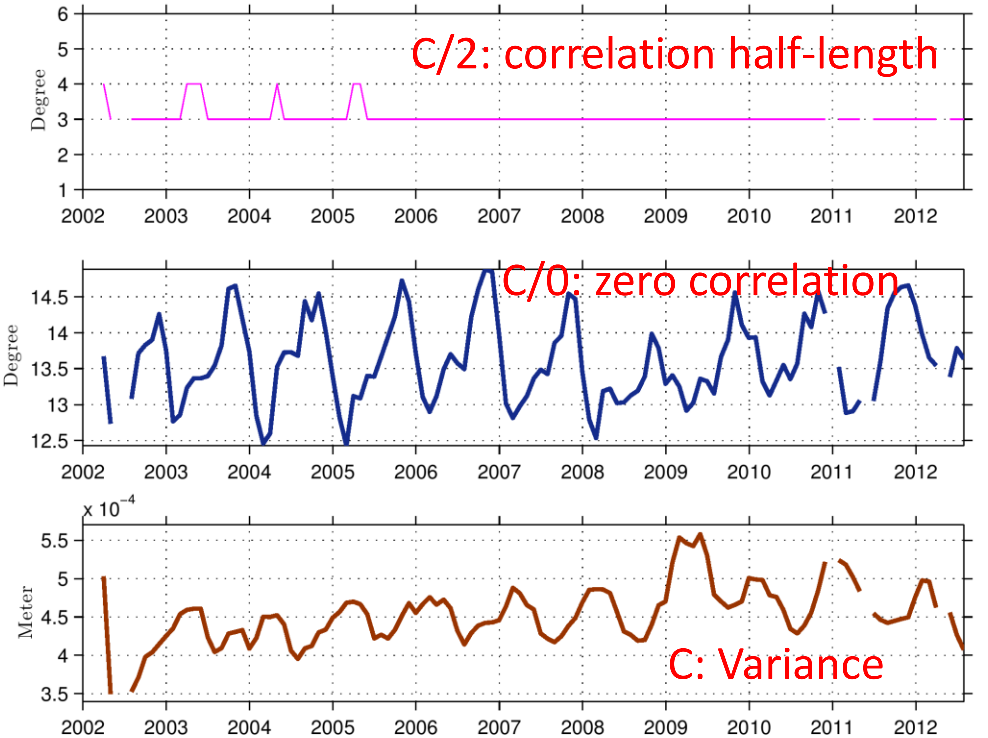

GRACE Day vs. TV- modeling (7yr – sec/seas.)

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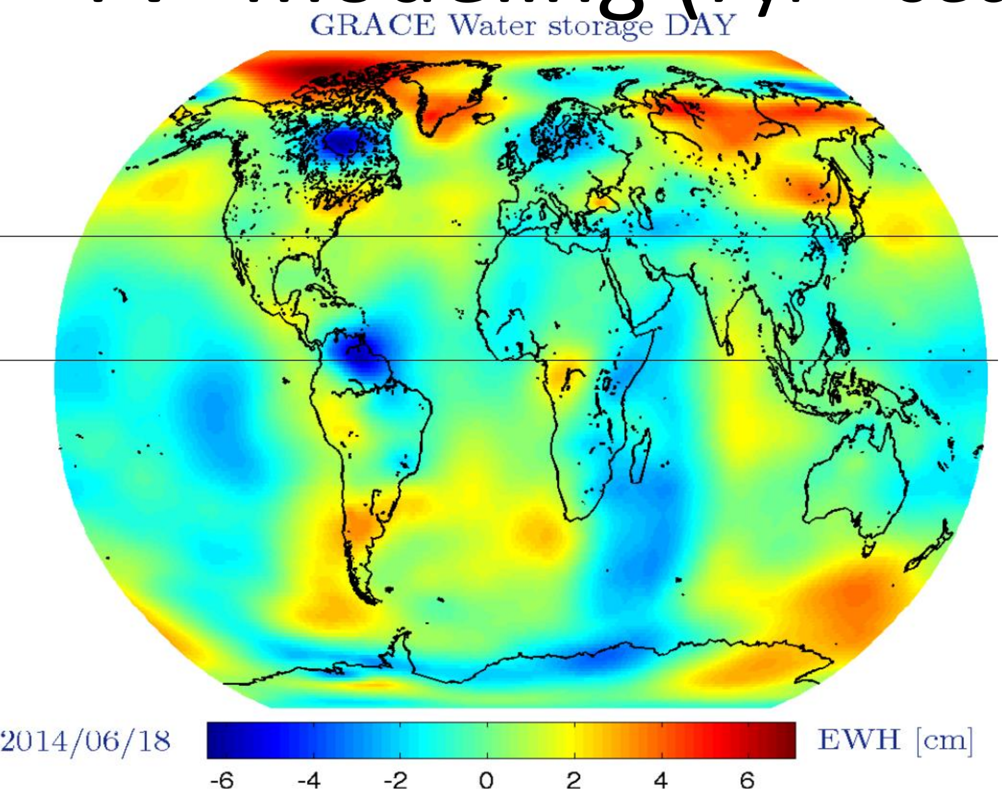

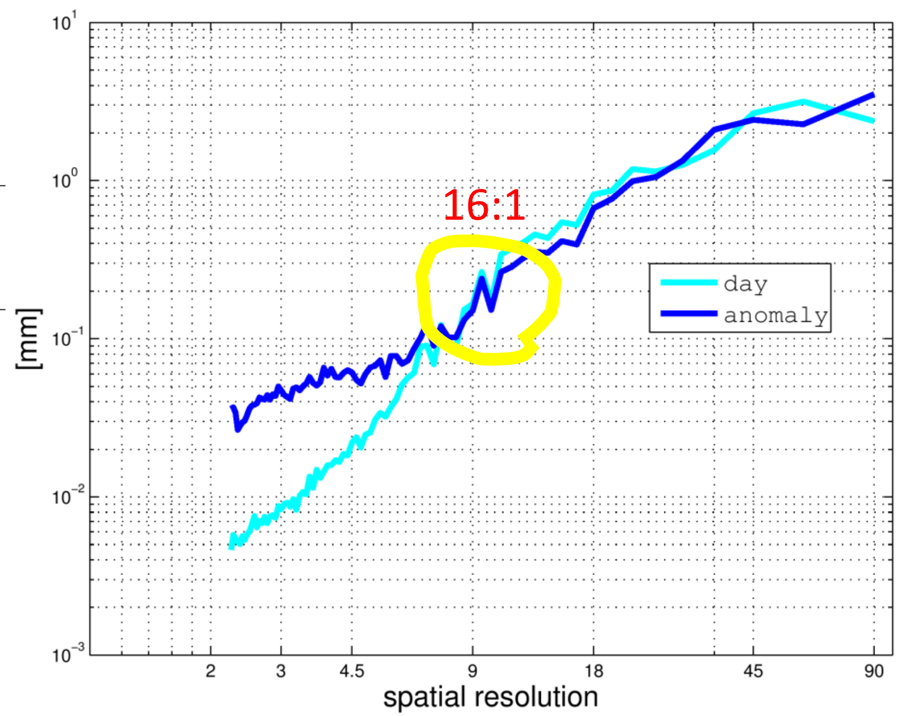

Anomalies vs. TV- modeling (7yr – sec/seas.)

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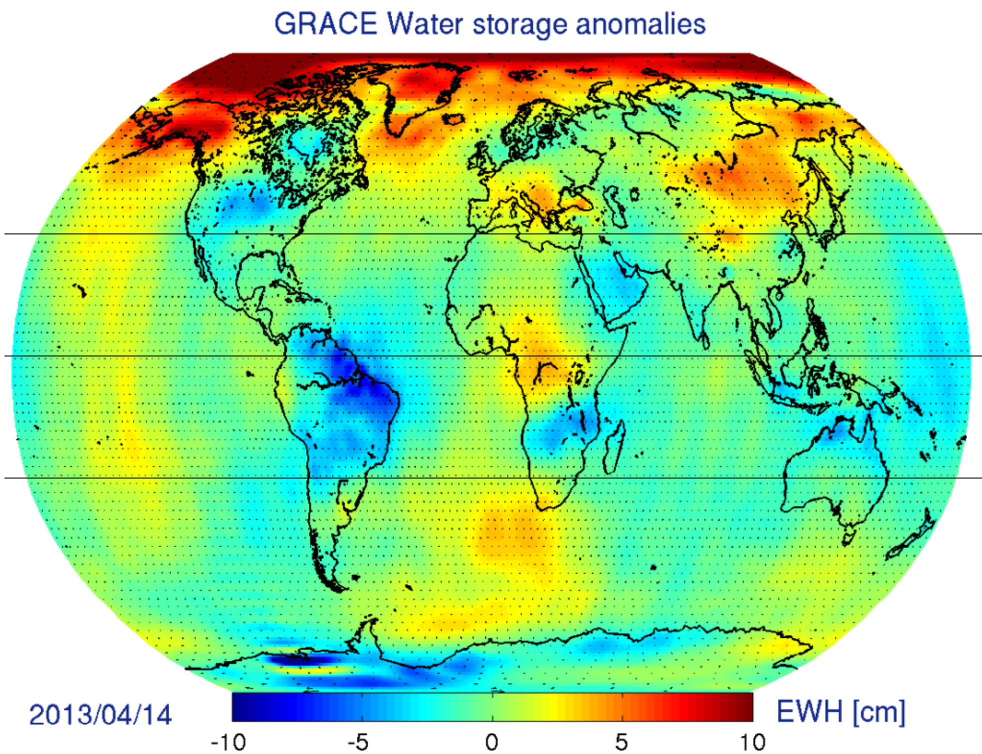

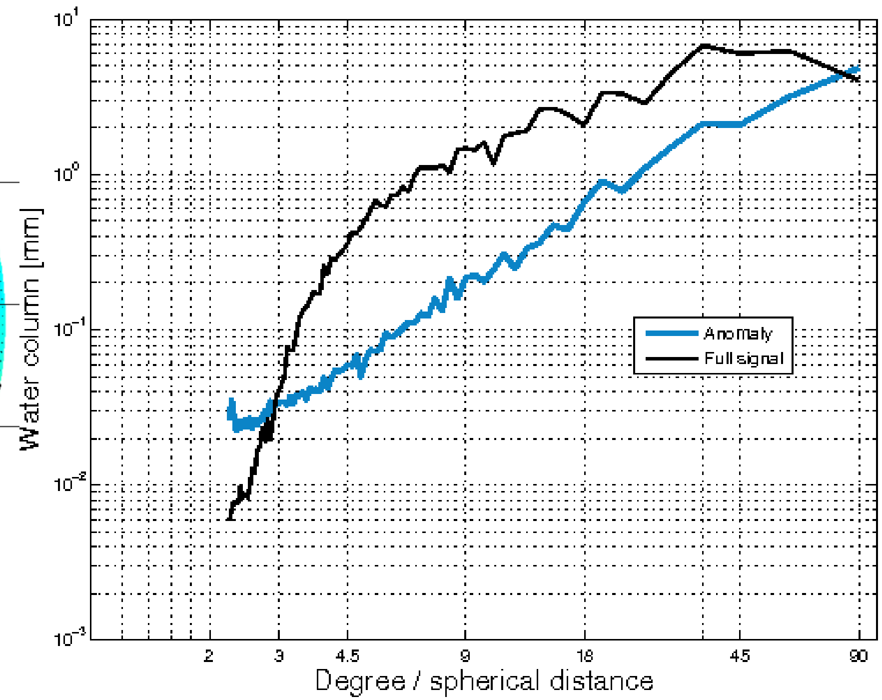

Internal evaluation

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- Envisat/Jason arc-overlaps/SLR-fits
- WGHM basins coherence
- SLR deg2, (until deg4)
- GPS-GreenlandNET,
- GPS-CODE
- OBP evaluation
- Mekong in-situ inundation volumes
- EGSIEM hydrological evaluation WP6

Internal Hydro-basin comparison

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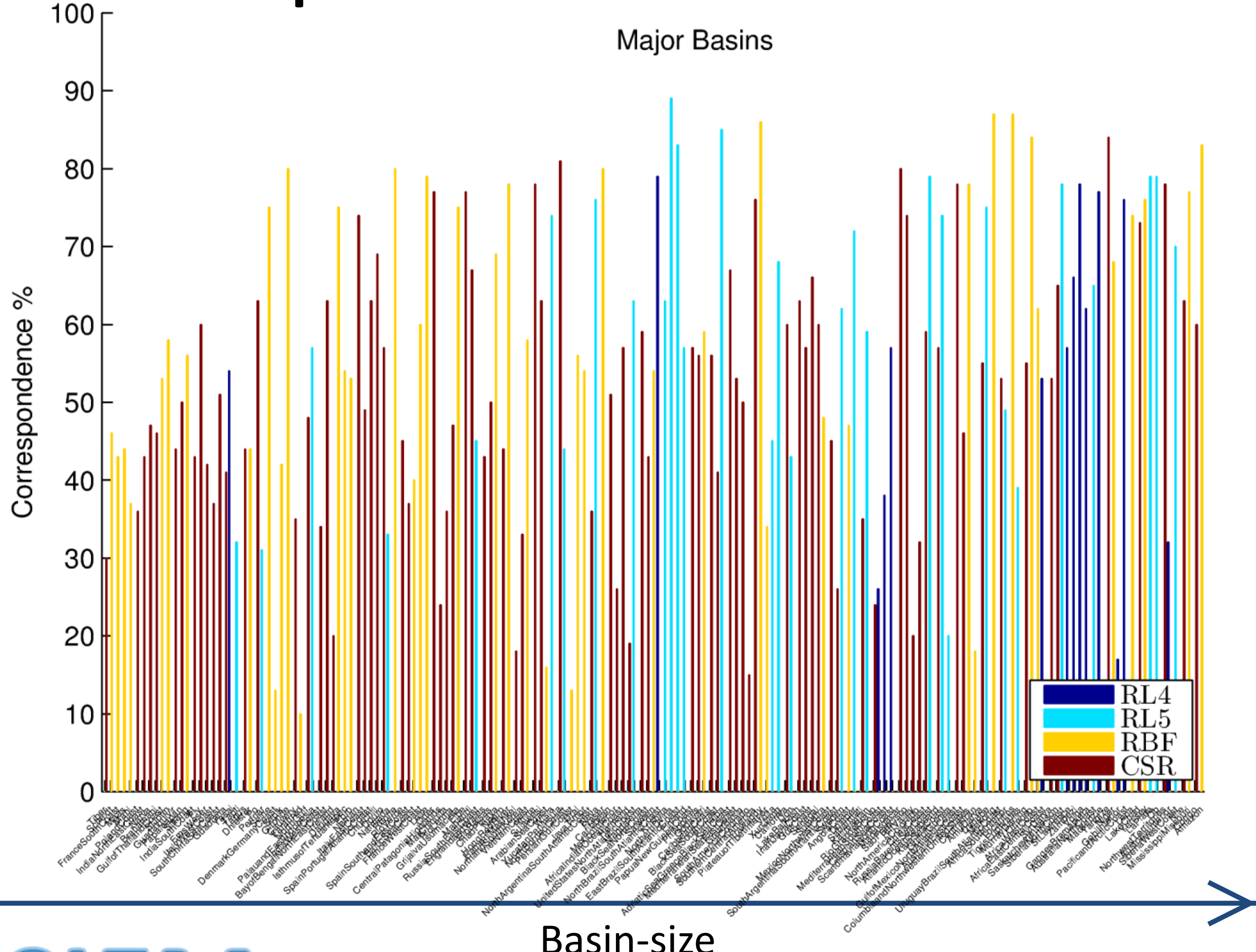

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Internal GPS sites comparison

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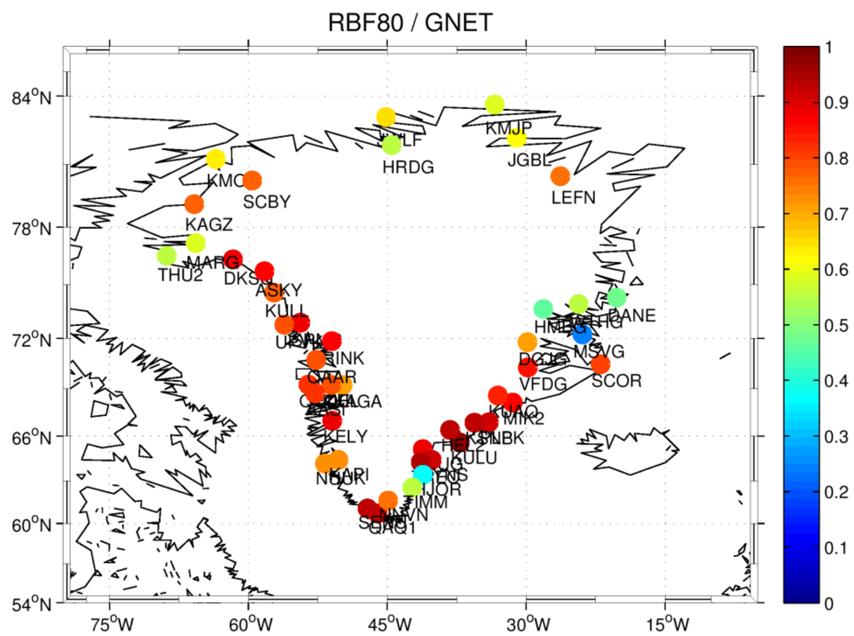
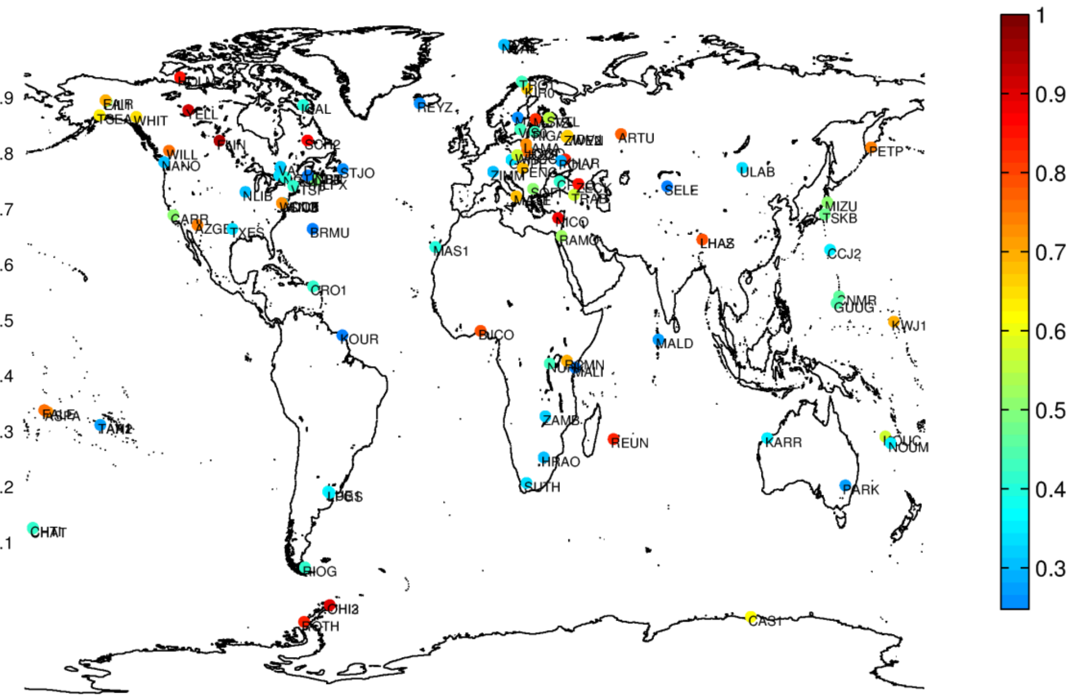


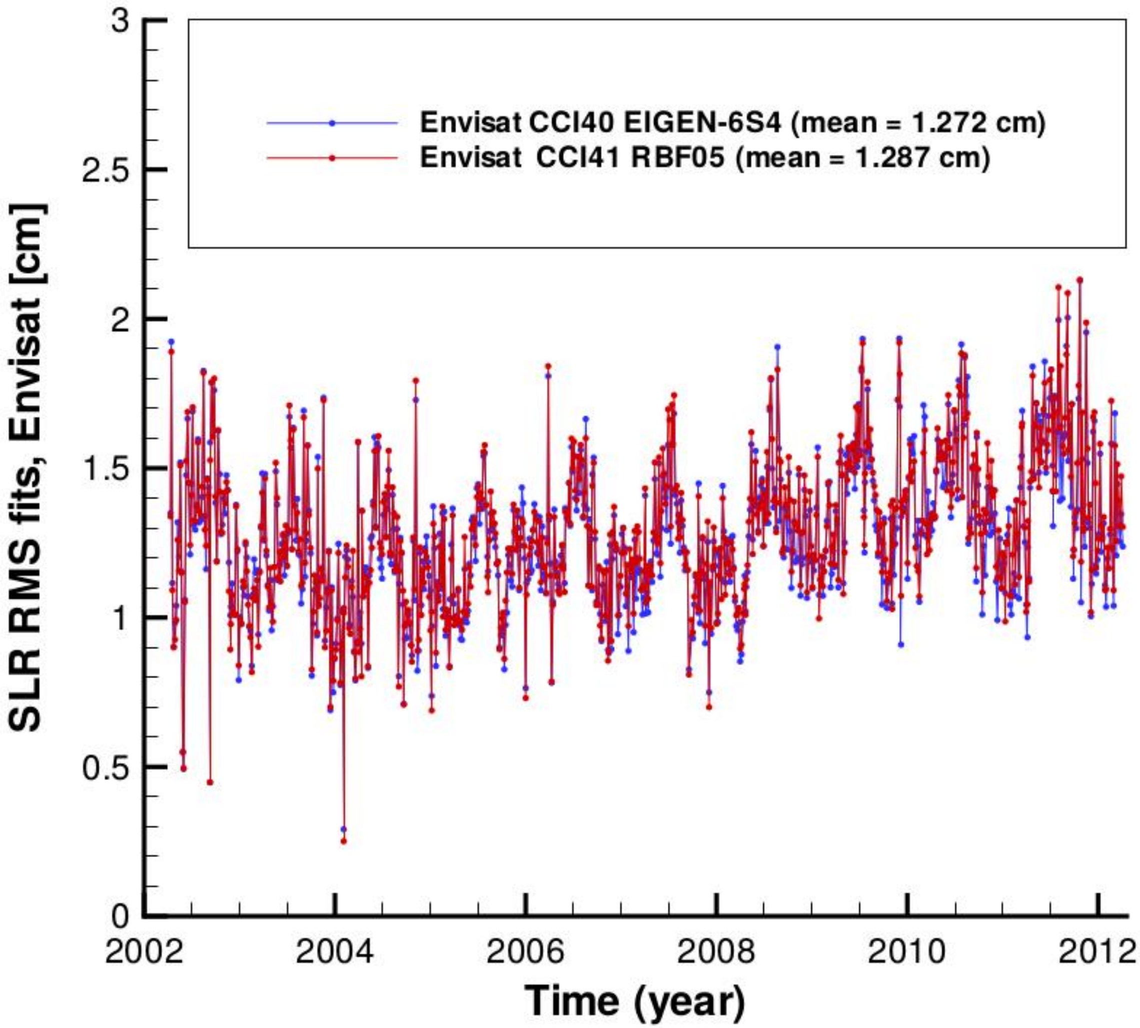
Greenland Network



CODE Network

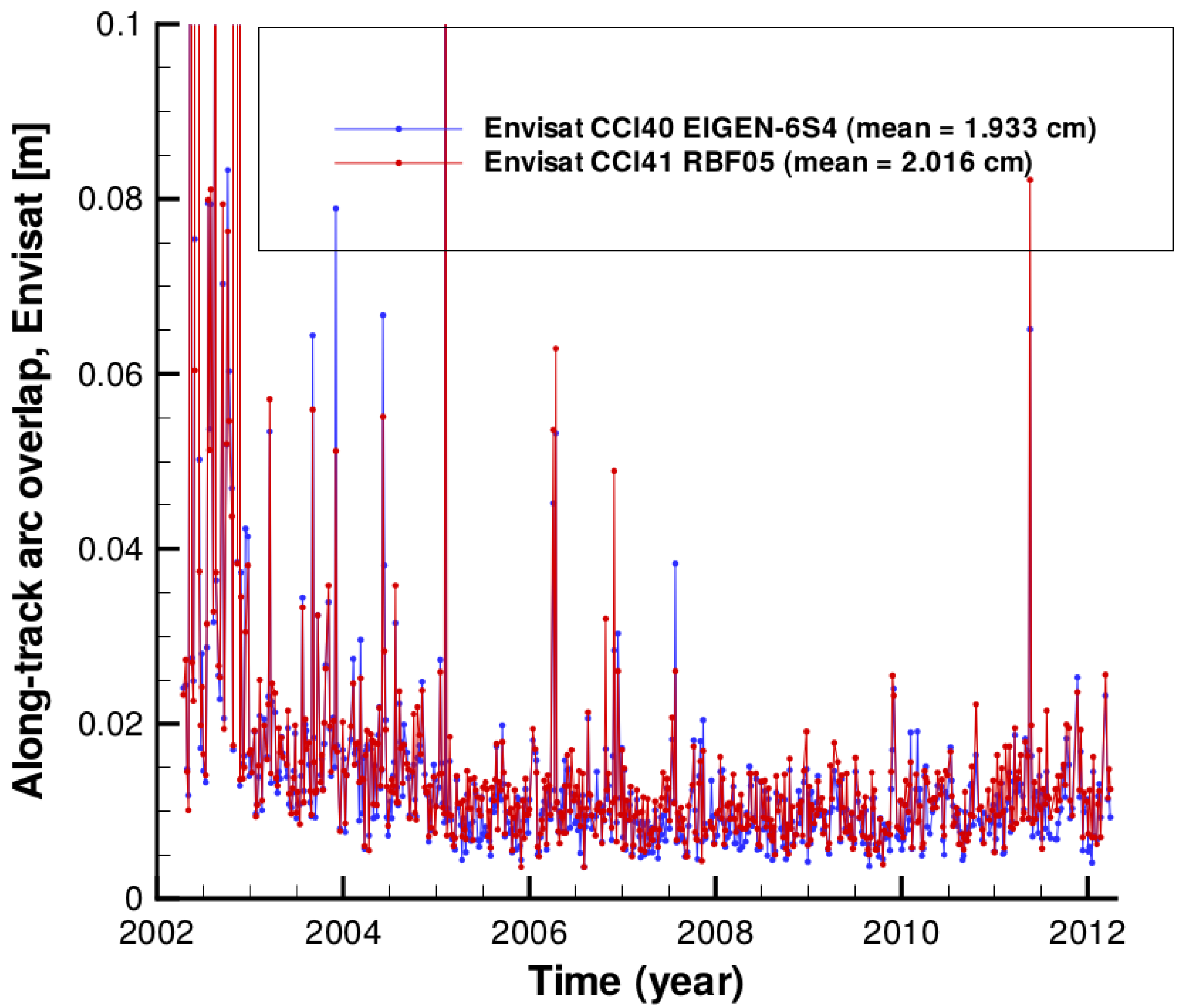
Internal Altimetry satellites orbit (SLR-fits)

SLR RMS fits



Internal Altimetry satellites orbit (SLR-fits)

Arc overlaps,
along-track



summary

- Convergence of Graz and GFZ stochastic modeling in progress…
- Newly construction of "anisotropic" Cov. functions by combination of isotropic Cov. functs and error variances
- Non-ergodic by seasonal Covariance functions
- Use of GRACE reference model stochastic for process noise estimates
- Dynamic orbits (including K-band obs) are iterated towards the last background (day)
- Strong convergence of regularized solutions with the monthly (SDS) fields (w/o regularization)
- Further improvements expected from enhanced time-var modeling and outlier handling

Plans for service run

European Gravity Service for Improved Emergency Management

- Implementation of NRT and Regional Service
  - cascading solution after global solution (far zone reduction)
  - improvements in time-var background modeling
  - full switch to EGSIEM NRT products (clocks / EOP's)
- Refinements of Cov modeling and Regional Concept
  - seasonal process model / tests with Graz process model
  - improve observation de-correlation
- Interface and automized data receivement
- Feedback loop (internal/external)

European Gravity Service for Improved Emergency Management

Thank you for your attention!

Test Data soon available on dedicated ftp-site.

European Gravity Service for Improved Emergency Management

Title: WP6 (Hydrological Service)

Ben Gouweleeuw, Andreas Güntner (GFZ)

Henryk Zwenzner, Sandro Martinis (DLR)

EGSIEM Annual Meeting

University of Luxembourg

January 18-19.2016

HORIZON 2020

Task 6.1
Evaluation of historical flood events (M07-M30)

Task 6.2

Development and evaluation of gravity-based indicators for flood forecasting and drought monitoring (M01-M36)

Task 6.3

Rapid mapping concept (M07-M36)

WP6: Hydrological Service

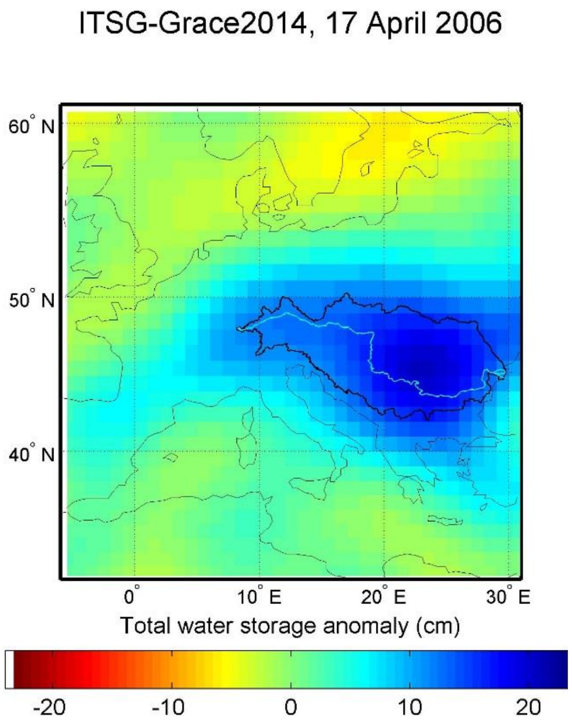
European Gravity Service for Improved Emergency Management

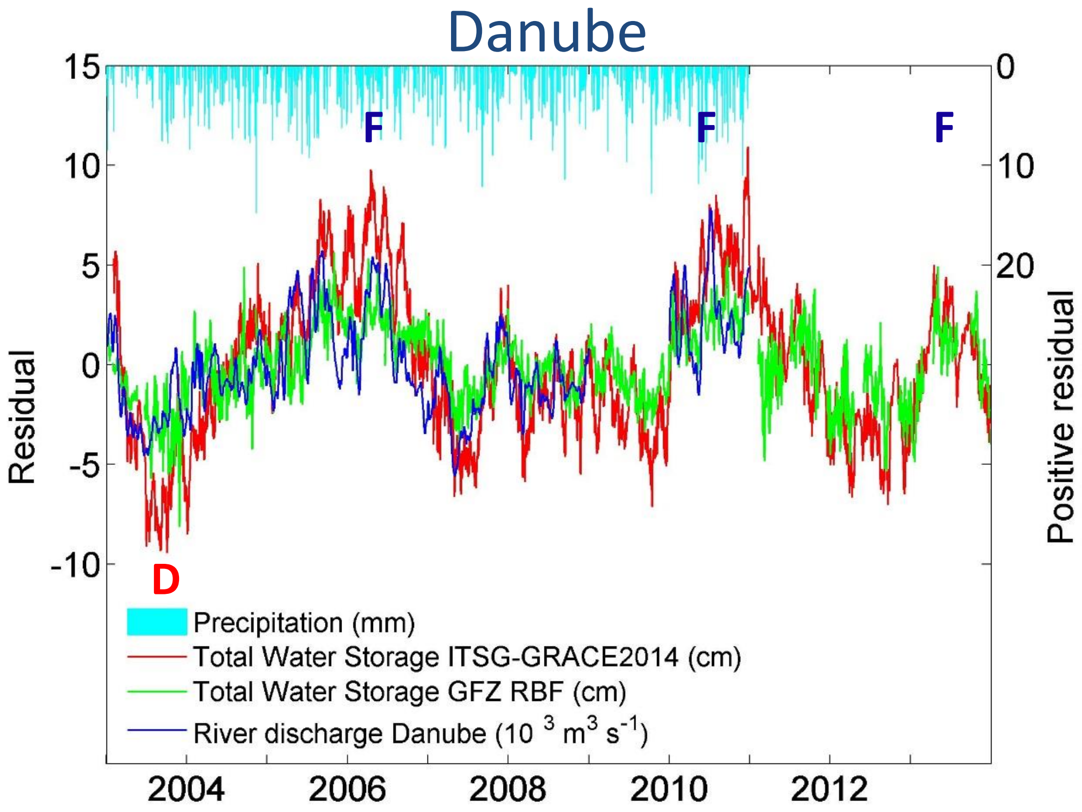
Evaluation of GRACE daily and combined monthly solutions against river discharge and hydrological model simulations for selected river basins

WP6: Hydrological Service

European Gravity Service for Improved Emergency Management

daily GRACE solutions vs. river discharge



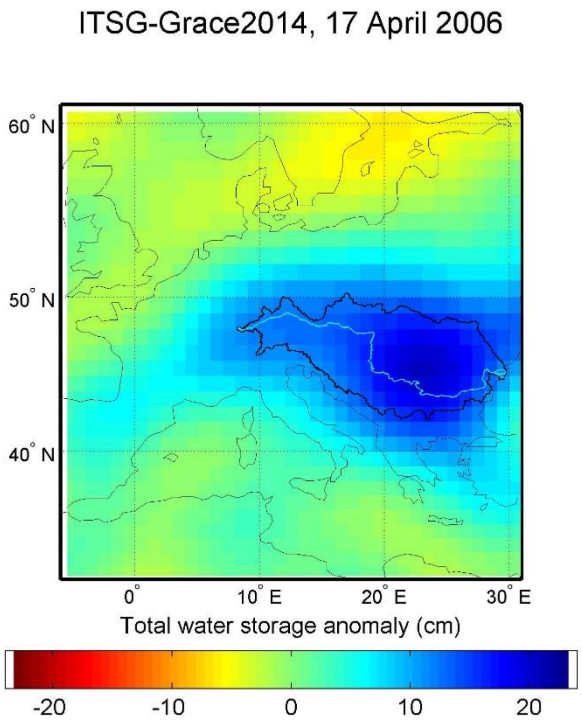


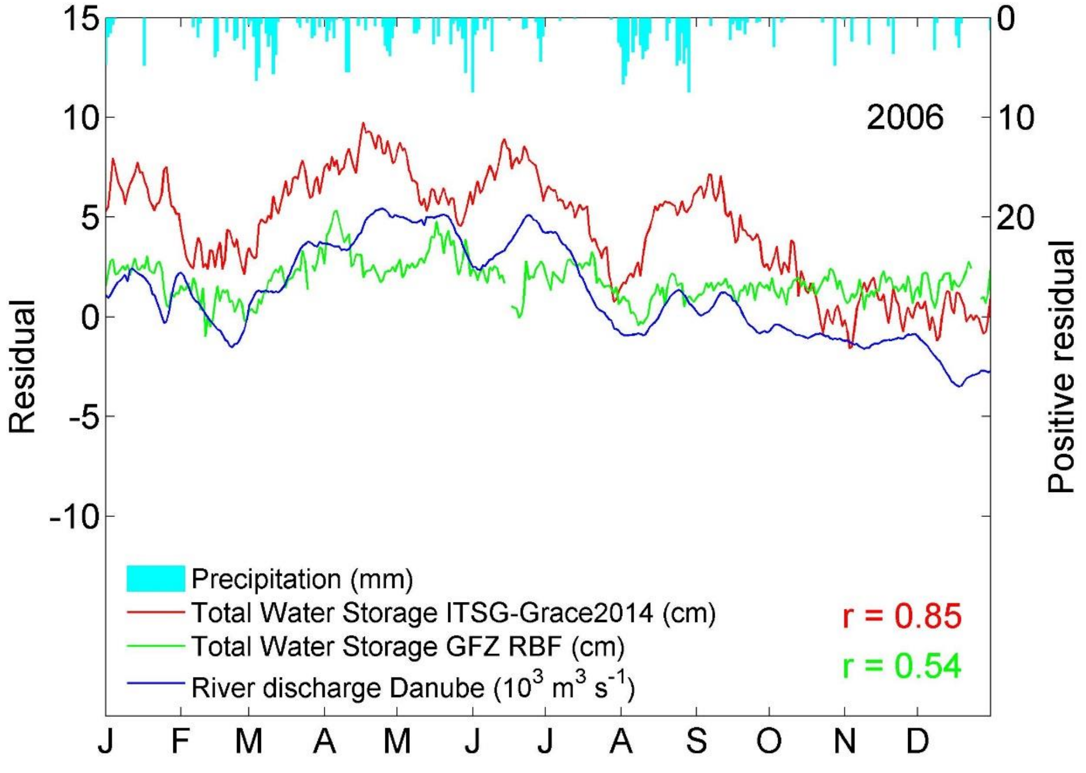
HORIZON 2020

WP6: Hydrological Service

European Gravity Service for Improved Emergency Management

daily GRACE solutions vs. river discharge





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WP6: Hydrological Service

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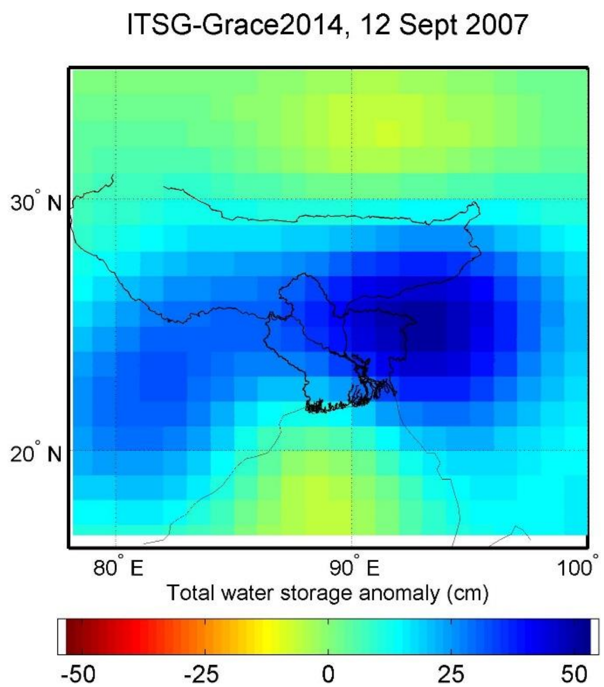
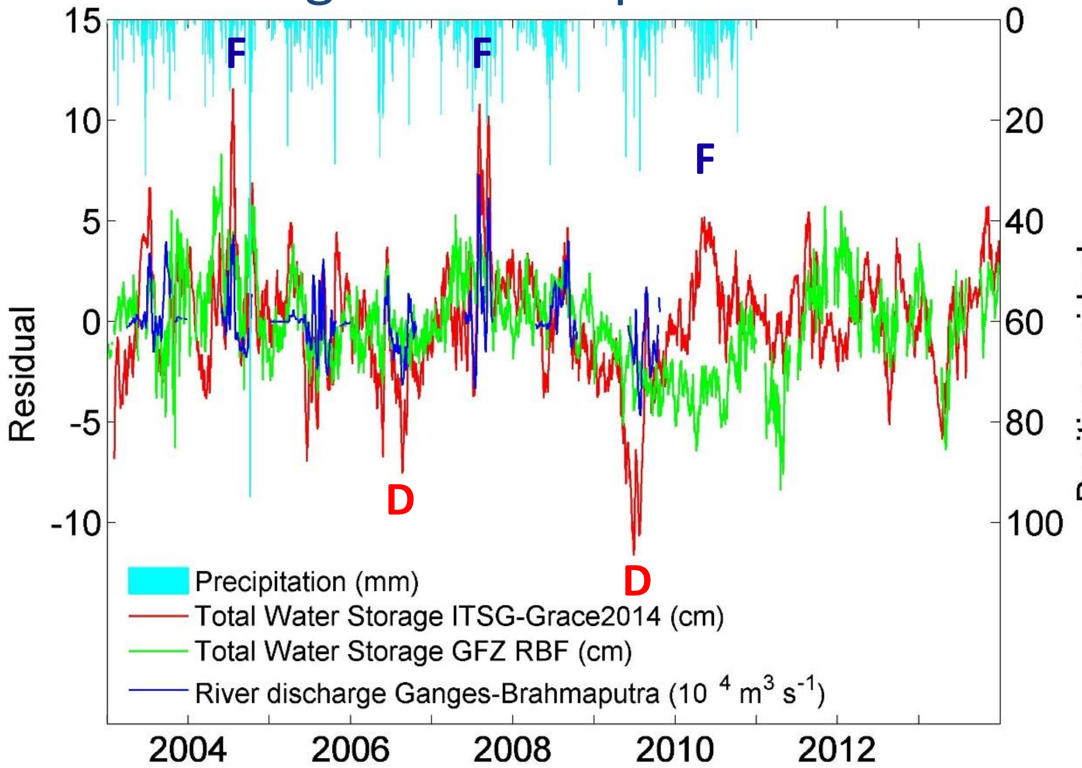
European Gravity Service for Improved Emergency Management

daily GRACE solutions vs. river discharge



Ganges-Brahmaputra Delta

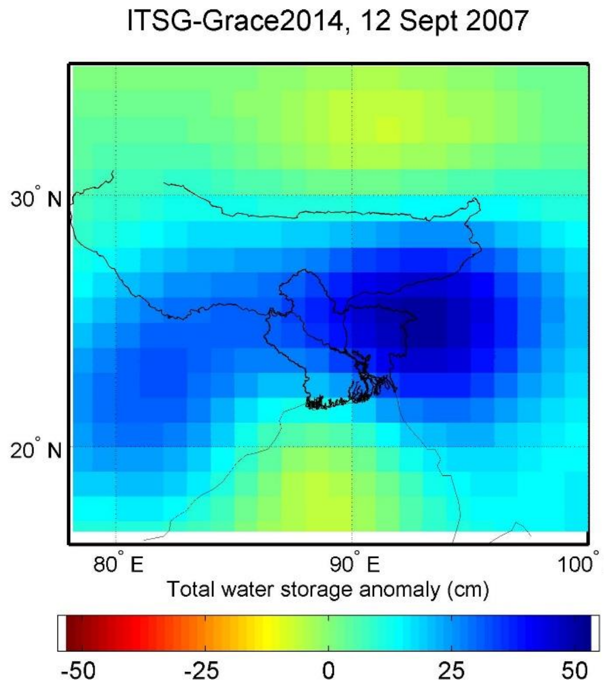


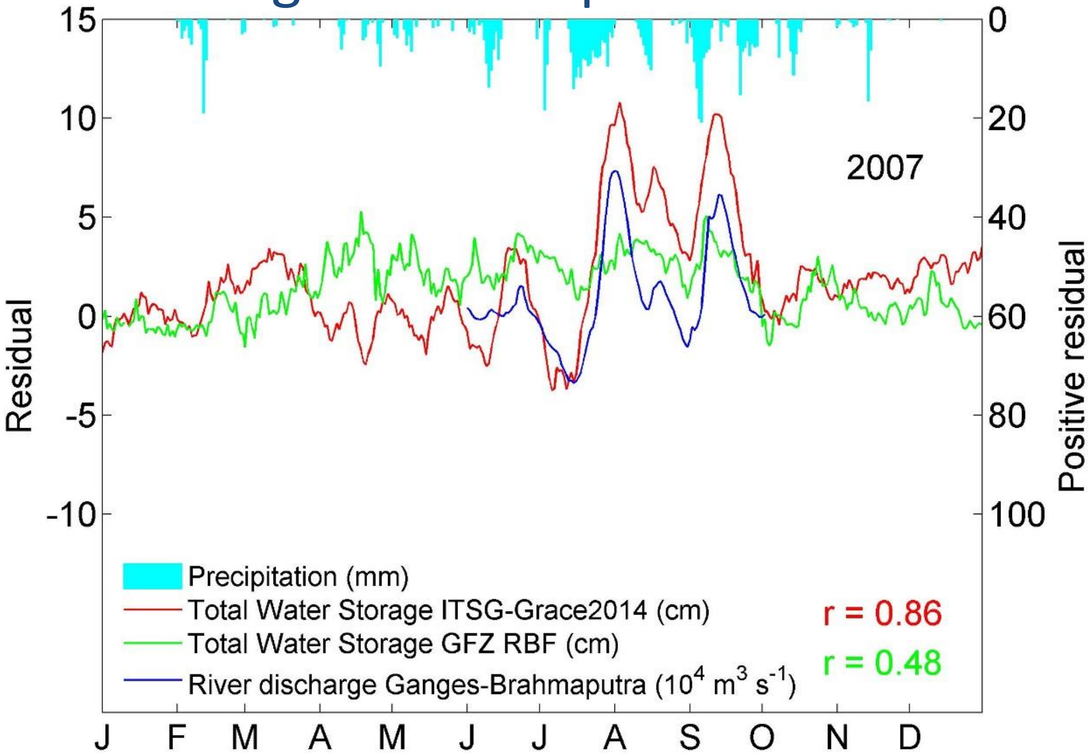
WP6: Hydrological Service

European Gravity Service for Improved Emergency Management

daily GRACE solutions vs. river discharge time series

Ganges-Brahmaputra Delta





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WP6: Hydrological Service

European Gravity Service for Improved Emergency Management

Evaluation of GRACE daily and combined monthly solutions against river discharge and hydrological model simulations for selected river basins

HORIZON 2020

WP6: Hydrological Service

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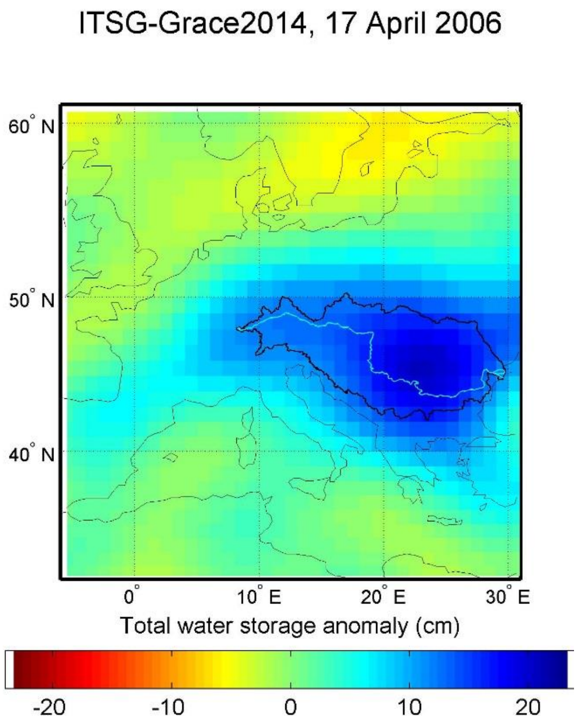
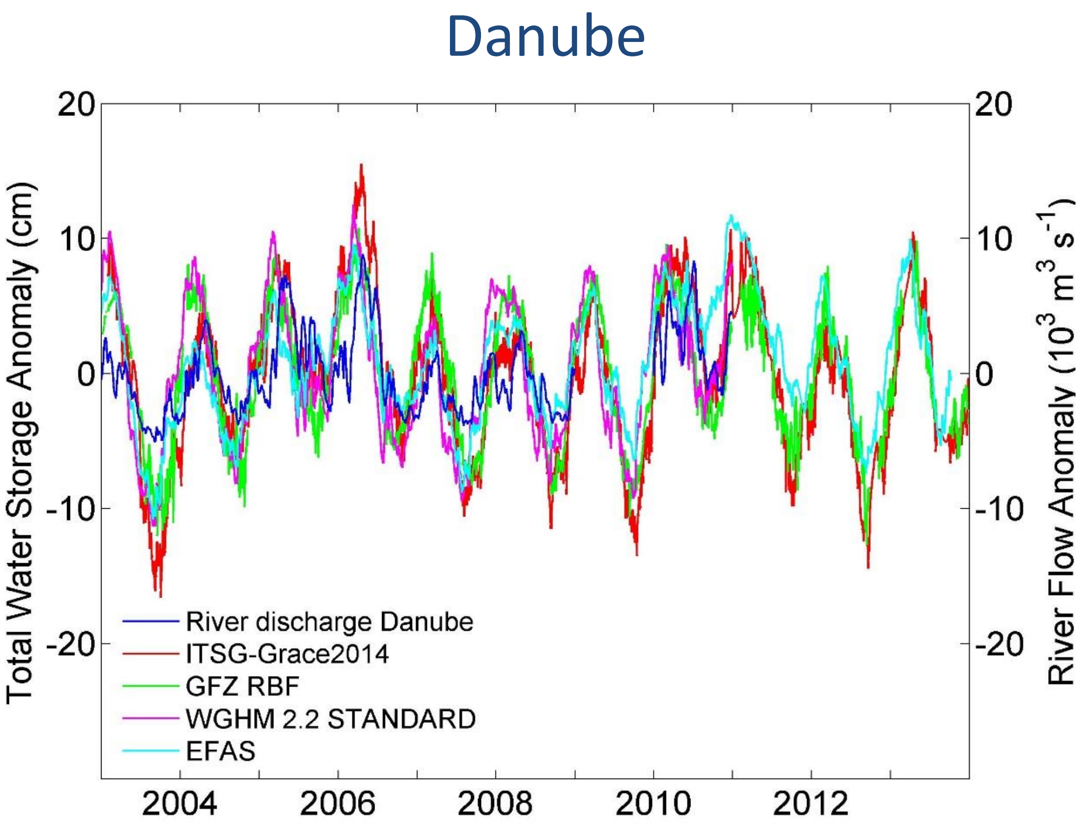
European Gravity Service for Improved Emergency Management

daily GRACE solutions vs. hydrological model simulations



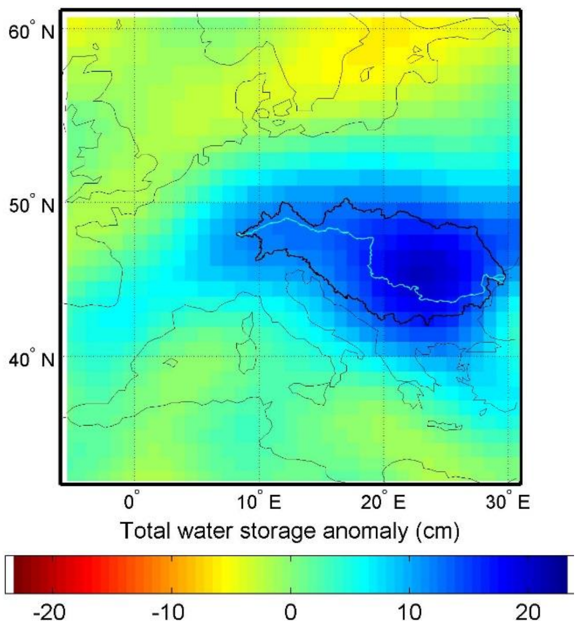


WP6: Hydrological Service

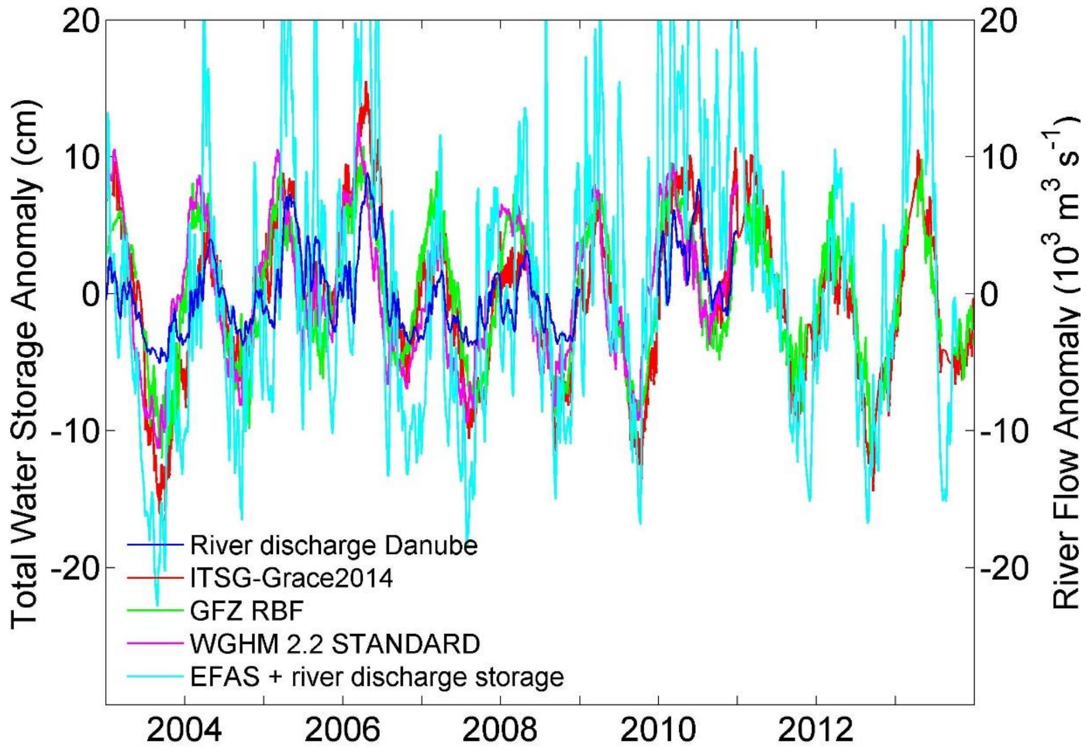
European Gravity Service for Improved Emergency Management

daily GRACE solutions vs. hydrological model simulations

ITSG-Grace2014, 17 April 2006



Danube

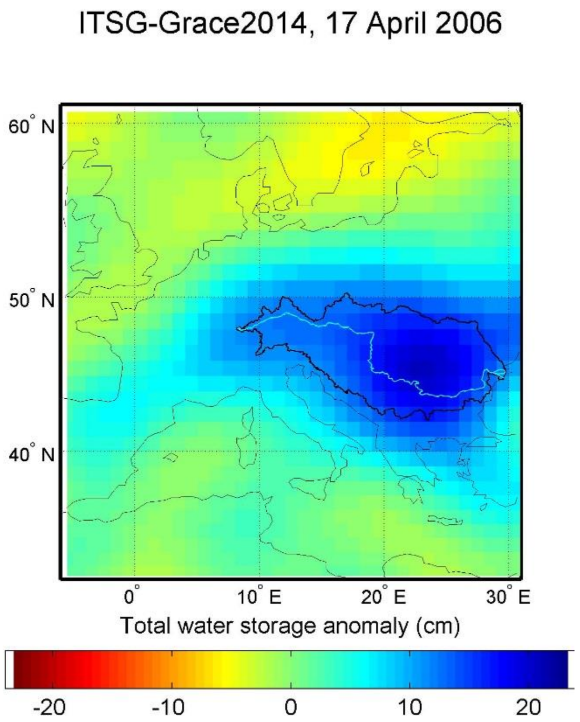


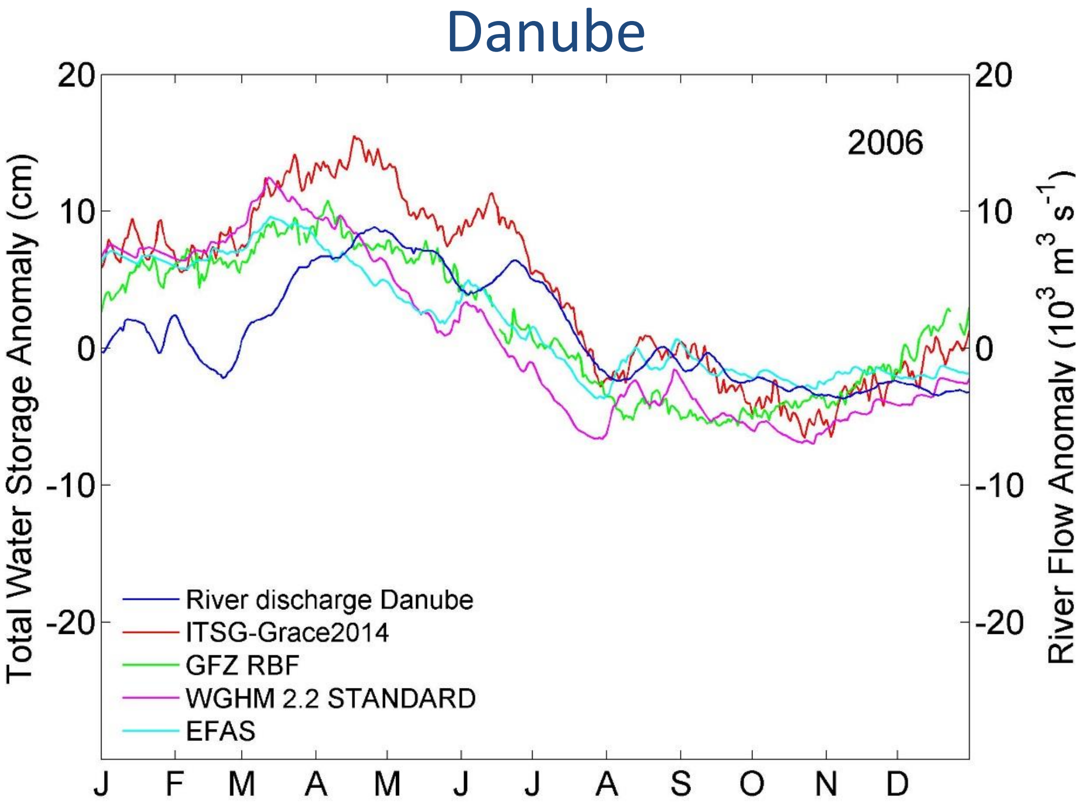
HORIZON 2020

WP6: Hydrological Service

European Gravity Service for Improved Emergency Management

daily GRACE solutions vs. hydrological model simulations





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WP6: Hydrological Service

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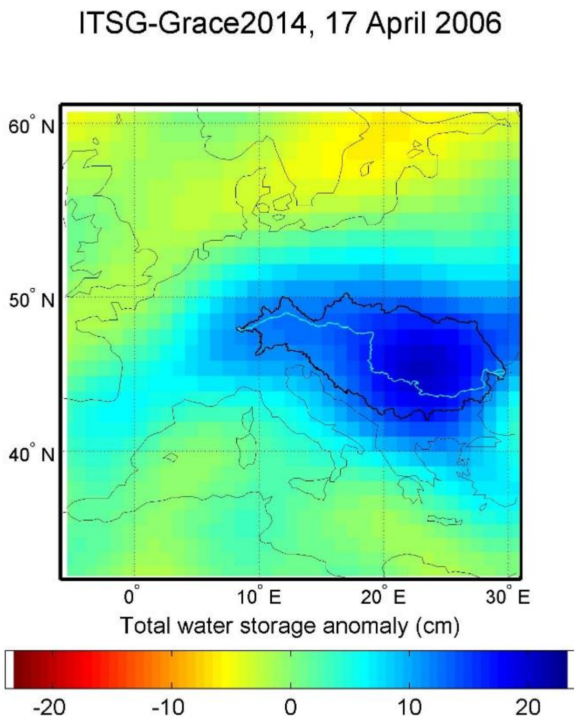
European Gravity Service for Improved Emergency Management

daily GRACE solutions vs. hydrological model simulations



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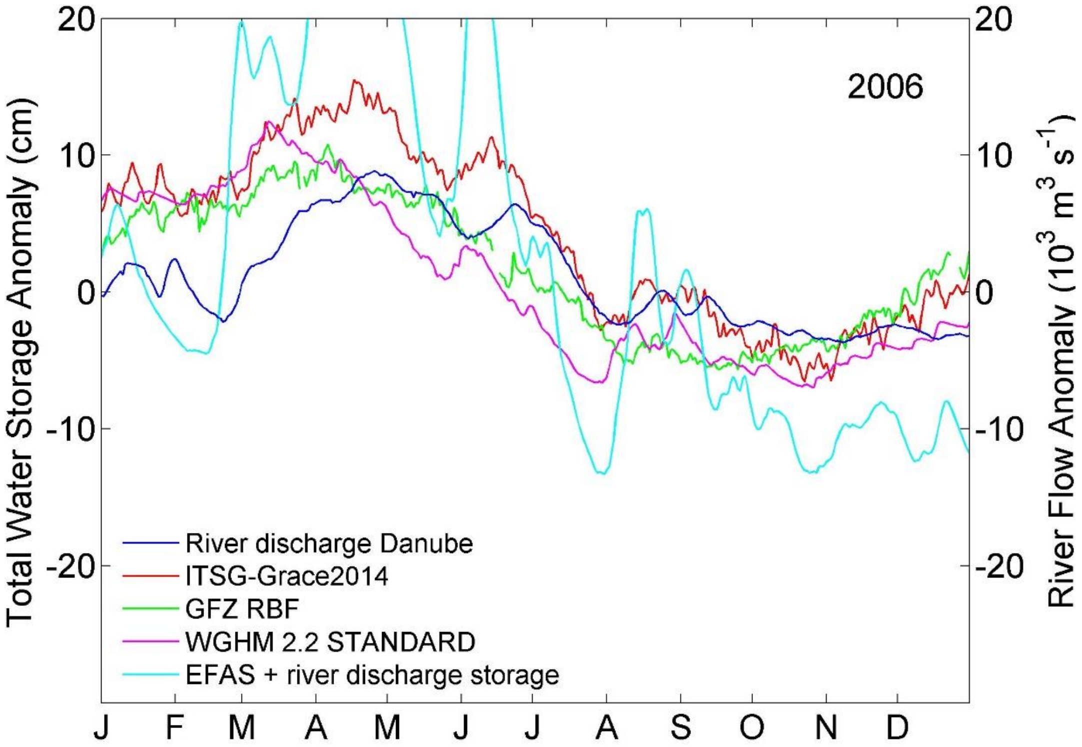
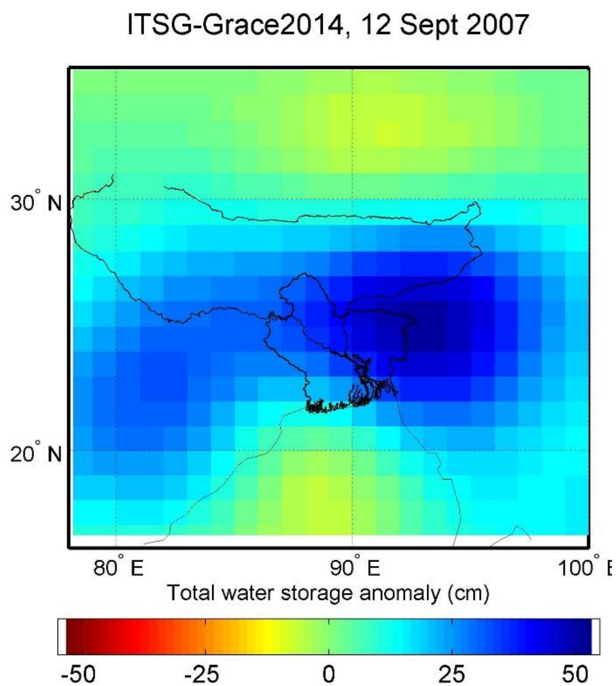


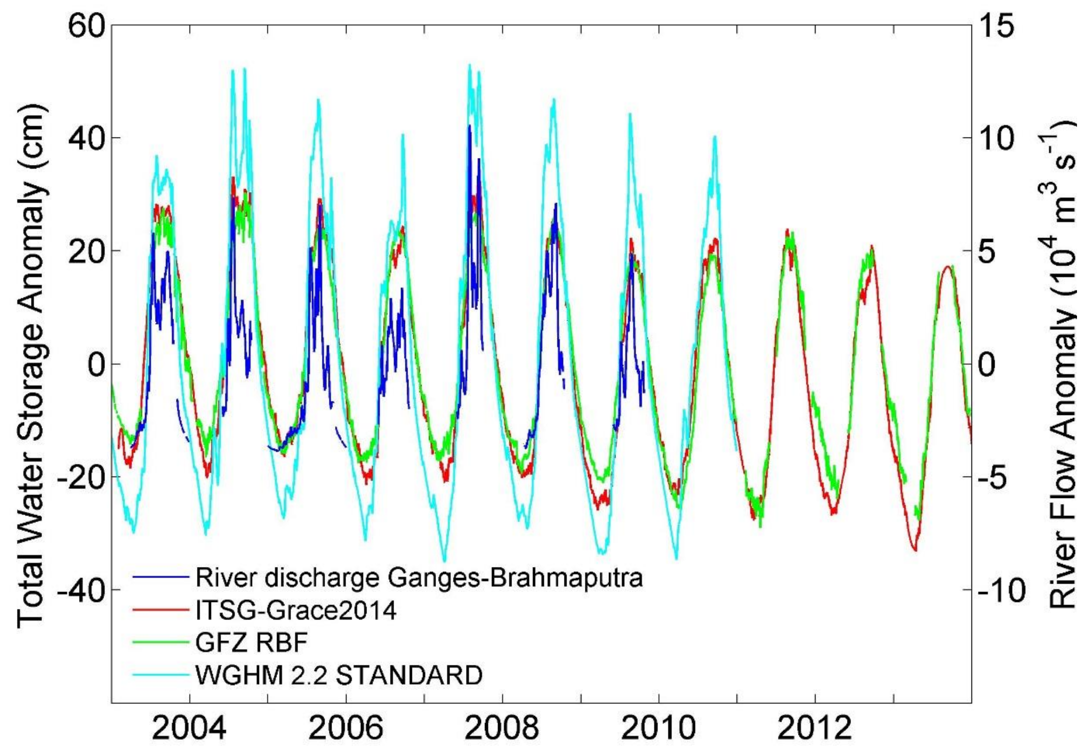
WP6: Hydrological Service

European Gravity Service for Improved Emergency Management

daily GRACE solutions vs. hydrological model simulations

Ganges-Brahmaputra Delta





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WP6: Hydrological Service

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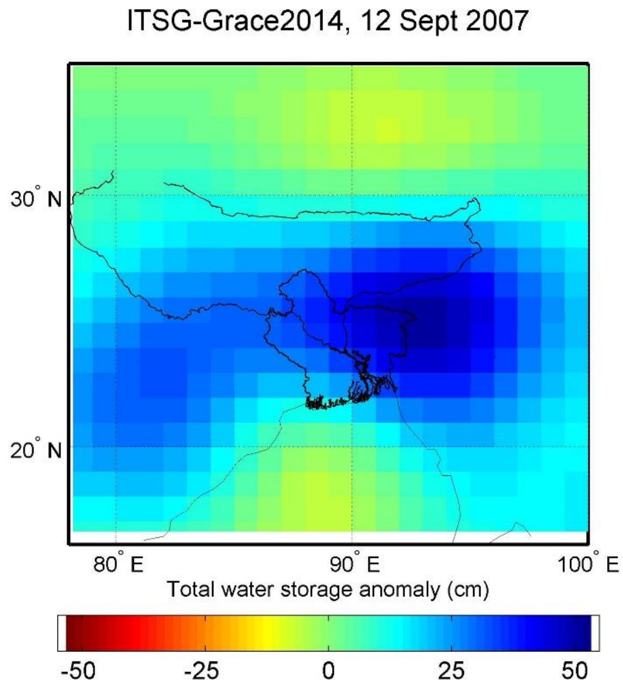
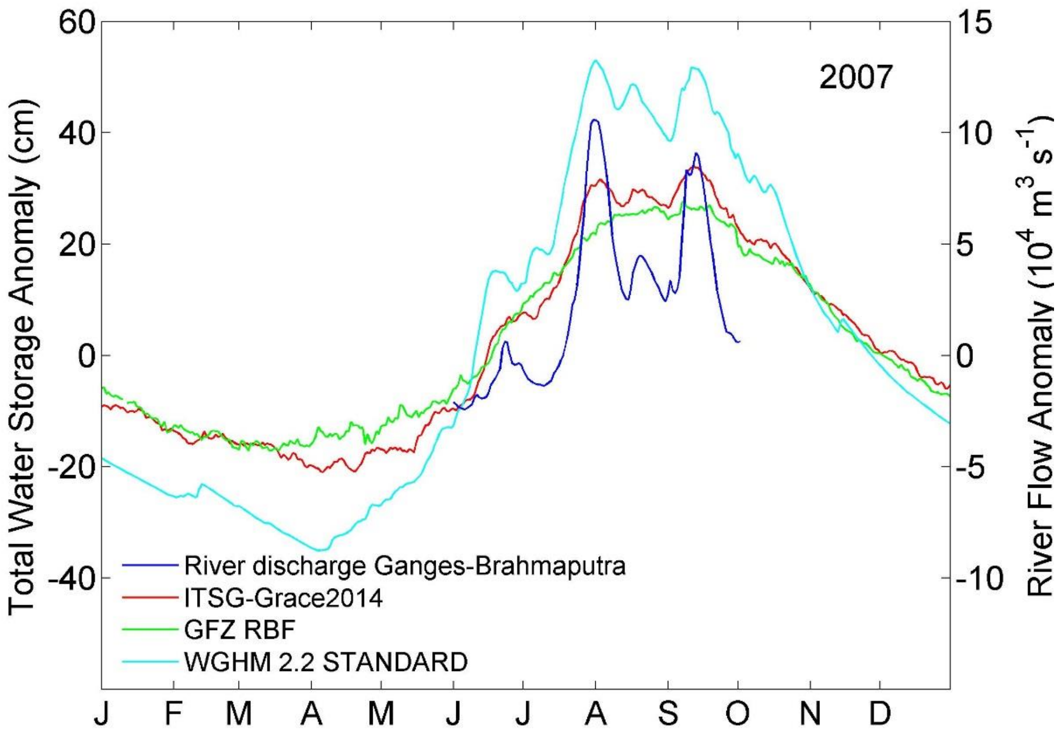
daily GRACE solutions vs. hydrological model simulations

Ganges-Brahmaputra Delta





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WP6: Hydrological Service

European Gravity Service for Improved Emergency Management

Evaluation of GRACE daily and combined monthly solutions against river discharge and hydrological model simulations for selected river basins

WP6: Hydrological Service

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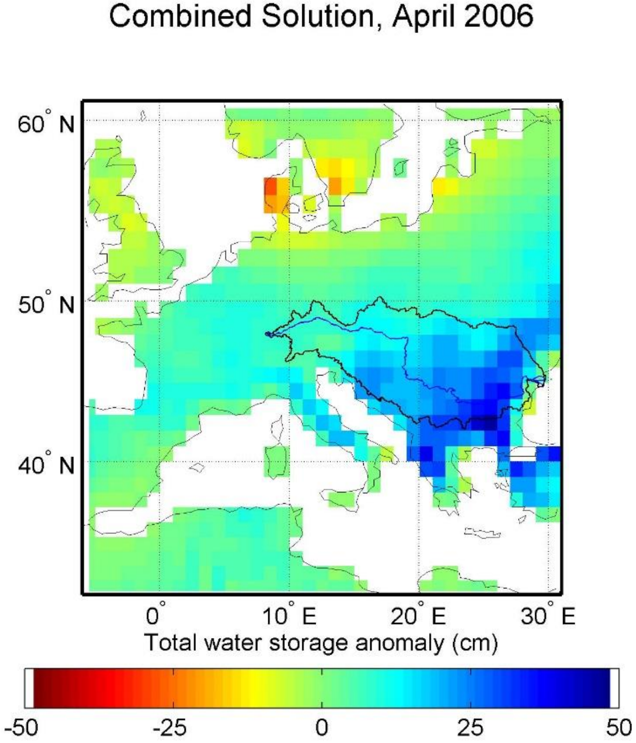
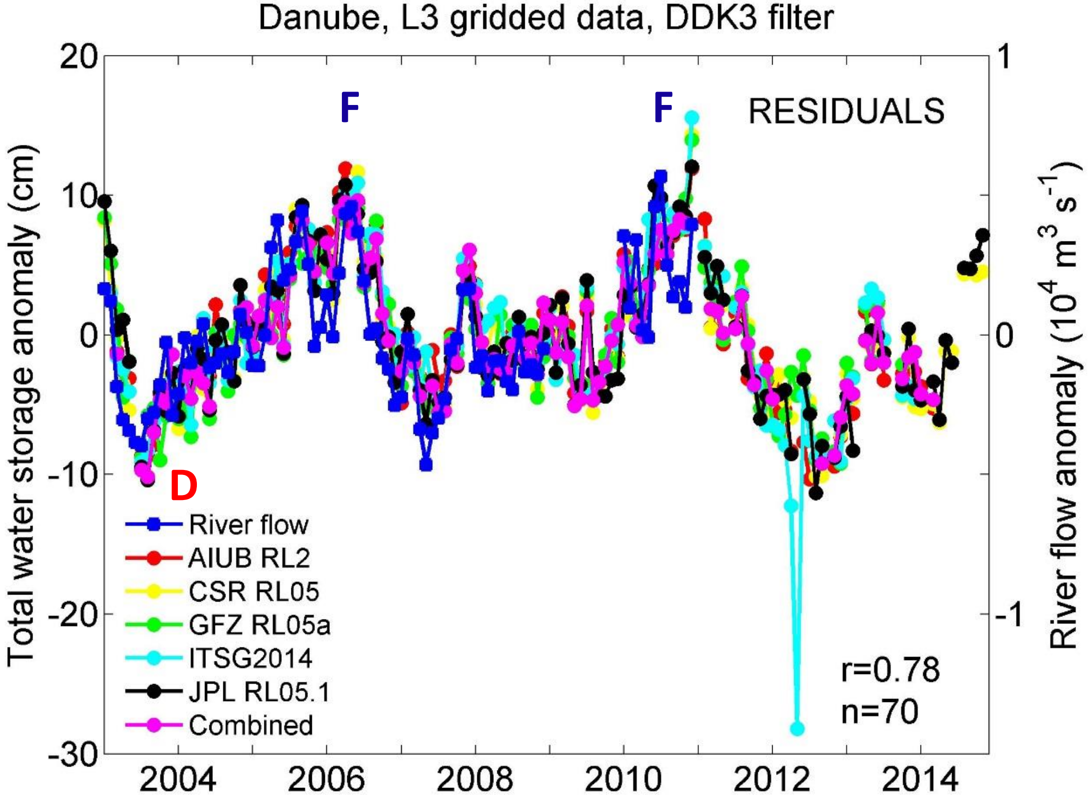
European Gravity Service for Improved Emergency Management

Combined monthly GRACE solution vs. river discharge





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WP6: Hydrological Service

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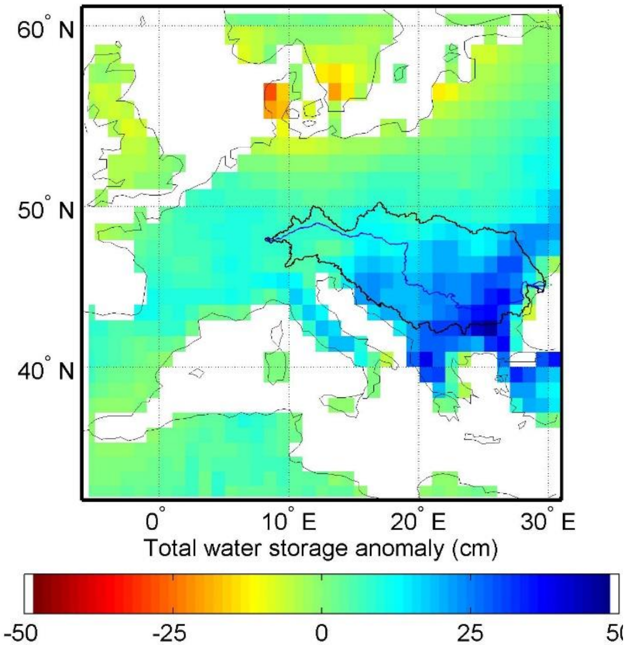
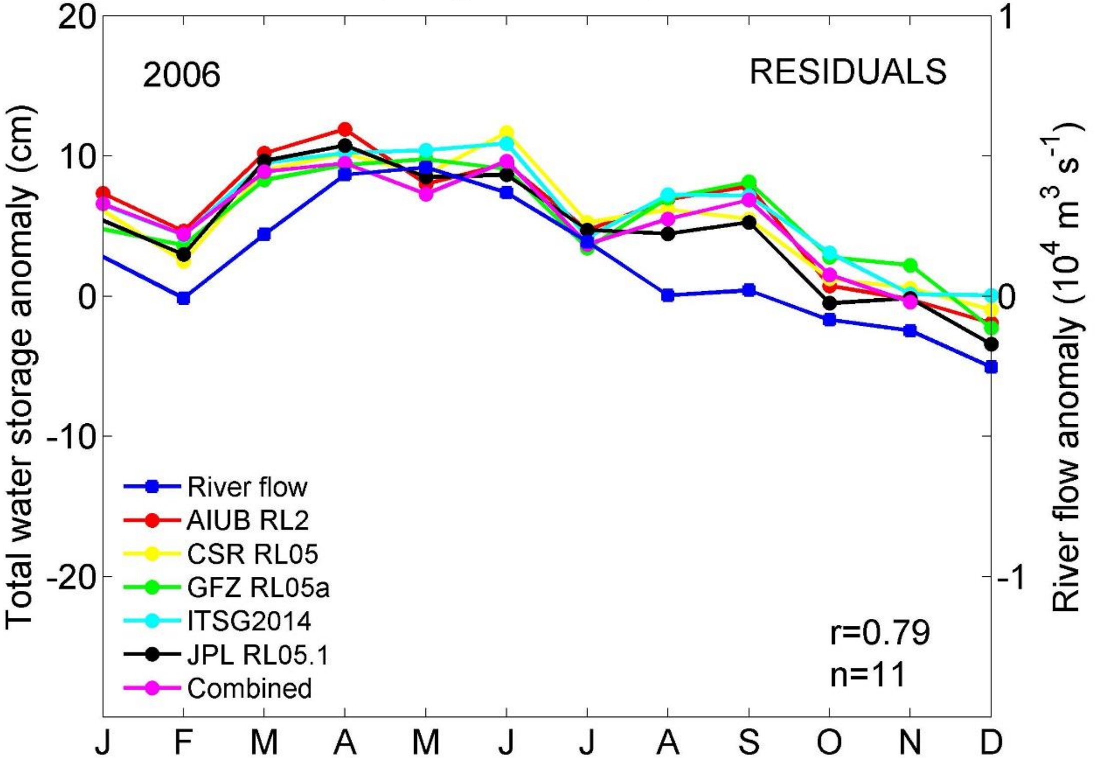
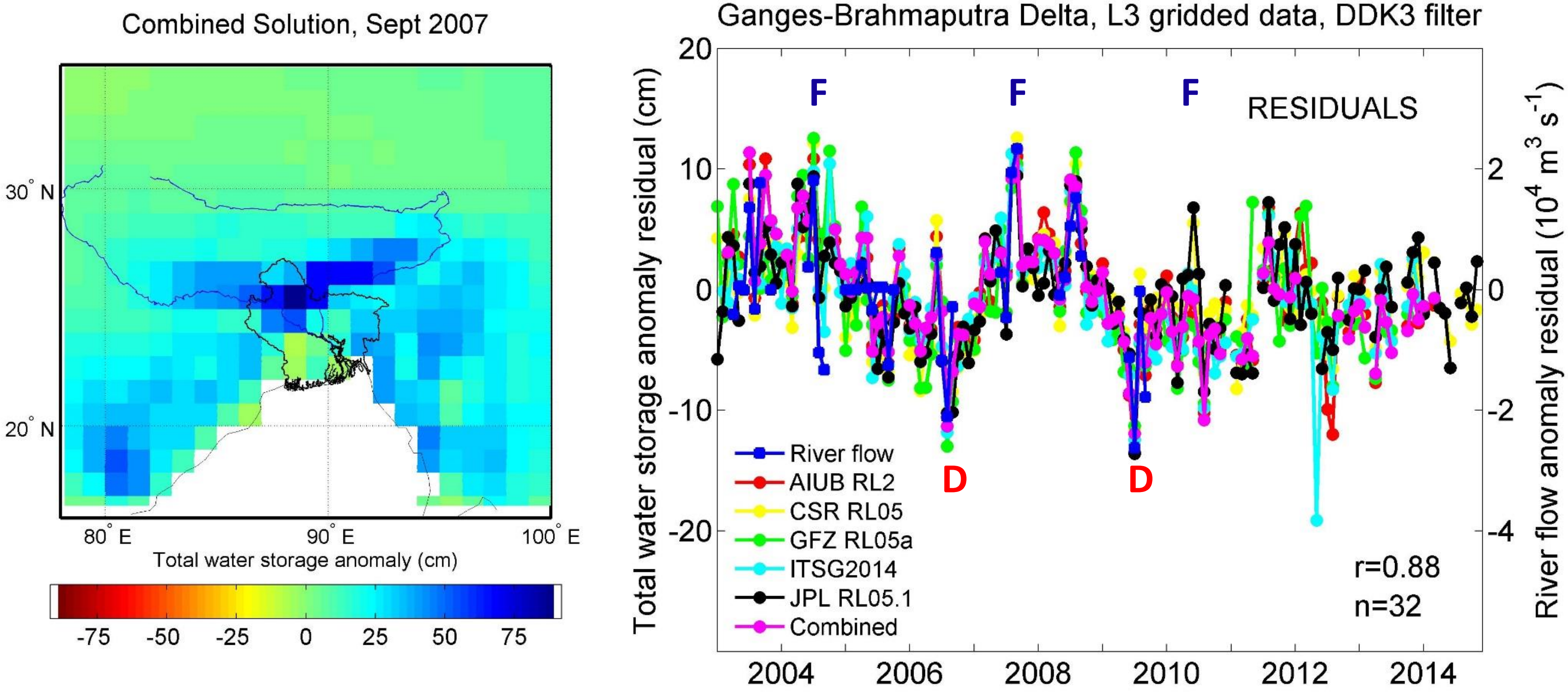
Combined monthly GRACE solution vs. river discharge





WP6: Hydrological Service

Combined monthly GRACE solution vs. river discharge



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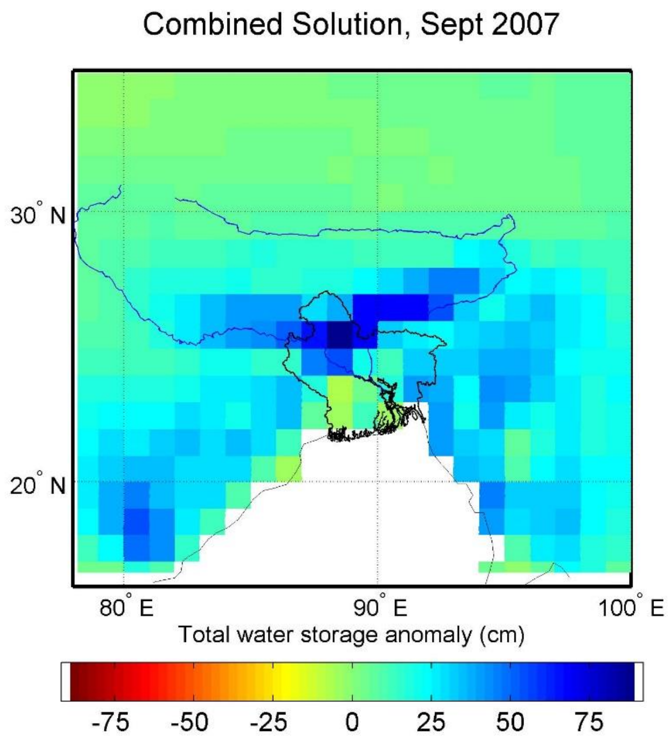
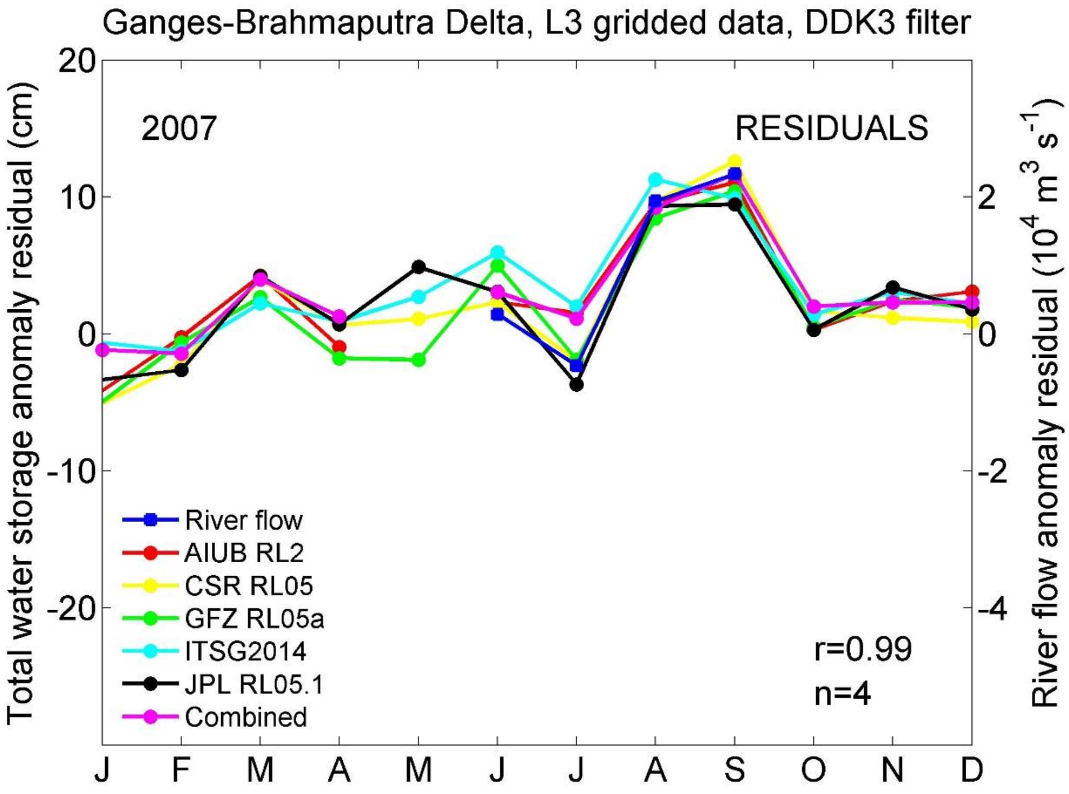
HORIZON 2020

Combined monthly GRACE solution vs. river discharge





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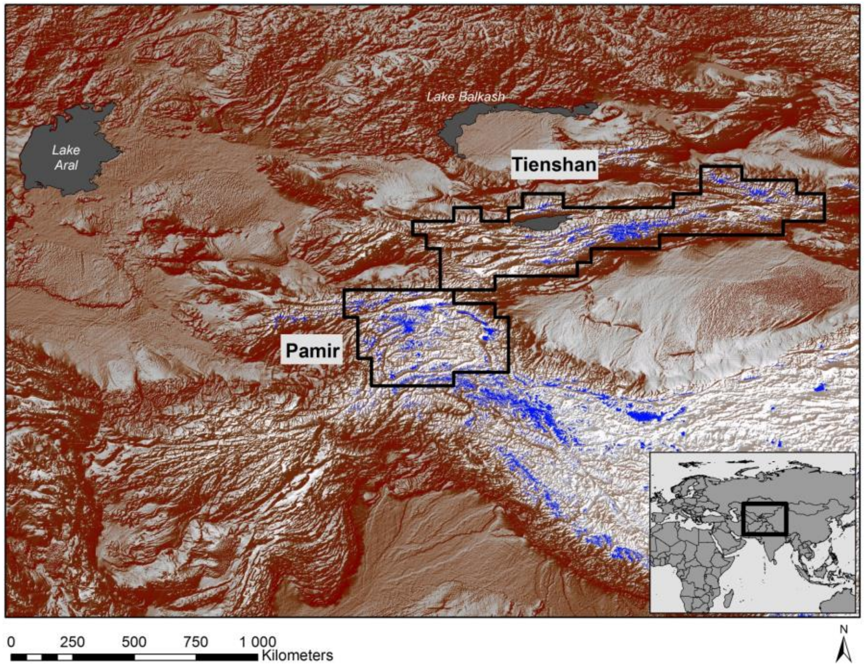
Other activities & outlook

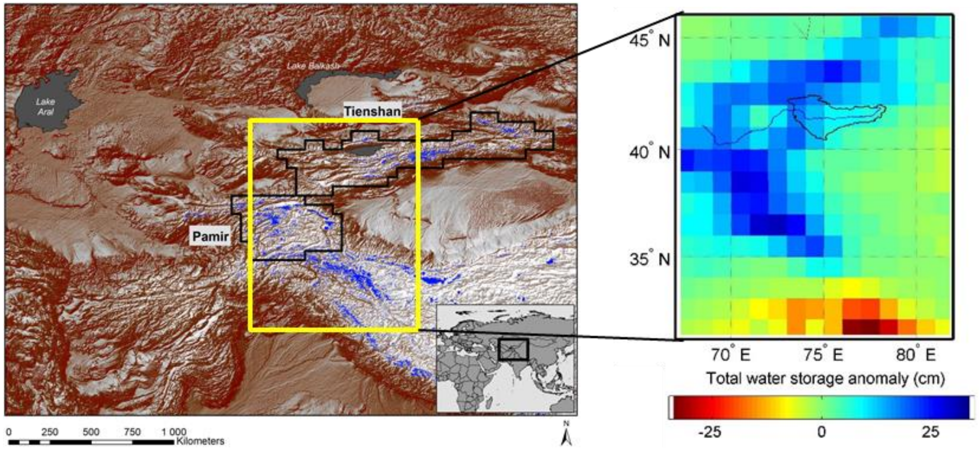
- Paper on evaluation of GRACE daily gravity solutions for hydrological extremes in selected river basins (Gouweleeuw et al., GRL, in prep.)
- Collection of complimentary hydrological data (groundwater level, surface water level, river discharge) for Ganges-Brahmaputra Delta.
- Planned research stay at IGG, Bonn to set up DA framework for assimilation of EGSIEM data products into WGHM for Ganges-Brahmaputra Basin.

Seasonal forecasting of summer streamflow in Central Asia



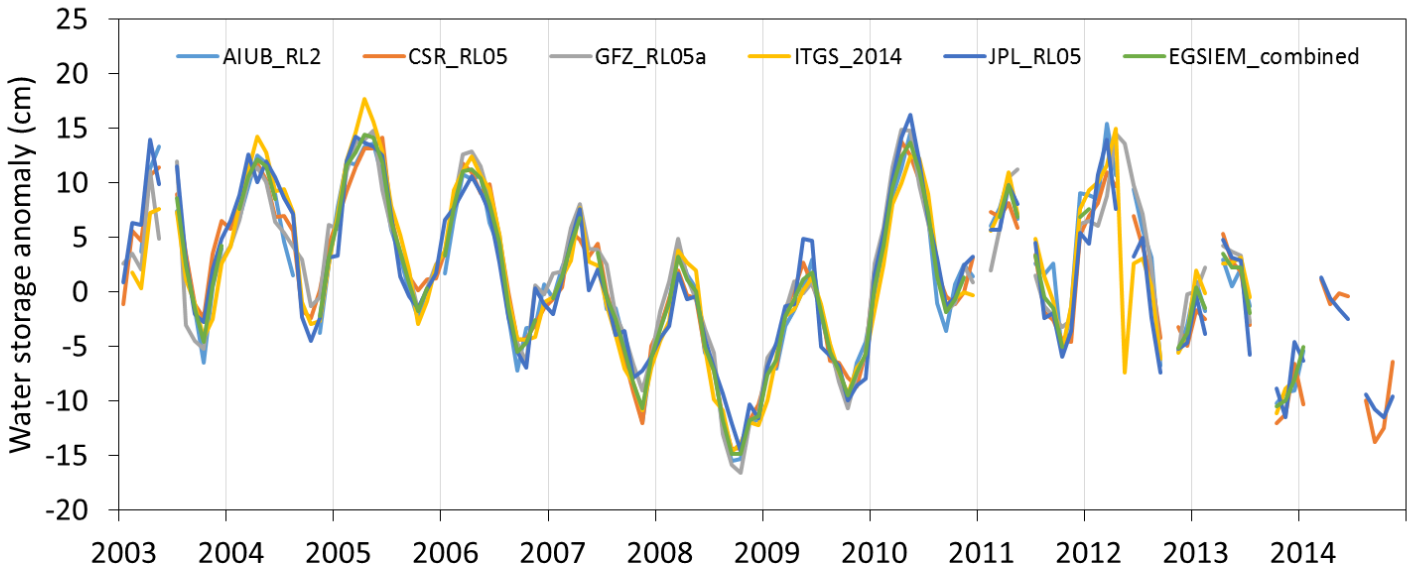
Water resources in Central Asia depend on snowmelt and glacier melt from mountain ranges such as Pamir and Tien Shan

Seasonal forecasting of summer streamflow in Central Asia



Naryn river basin
River gauging station Uchterek
Basin size ~50000km²

April 2010 total water storage (TWS) anomaly (CSR-RL05 with DDK2 and re-scaling)



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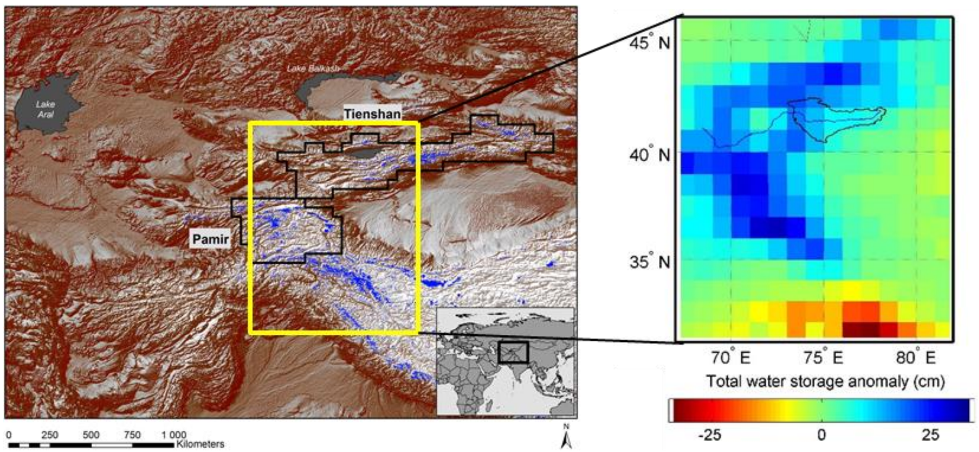
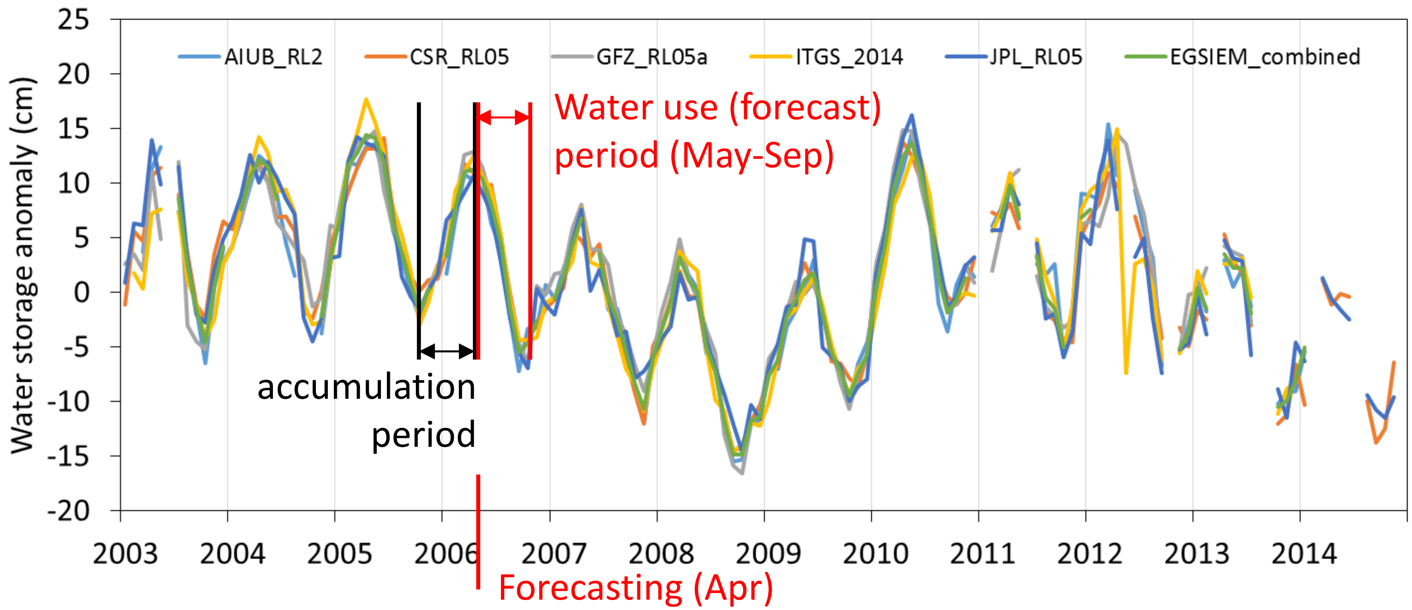
WP6: Hydrological Service

HORIZON 2020

Seasonal forecasting of summer streamflow in Central Asia



Naryn river basin
River gauging station Uchterek
Basin size ~50000km²



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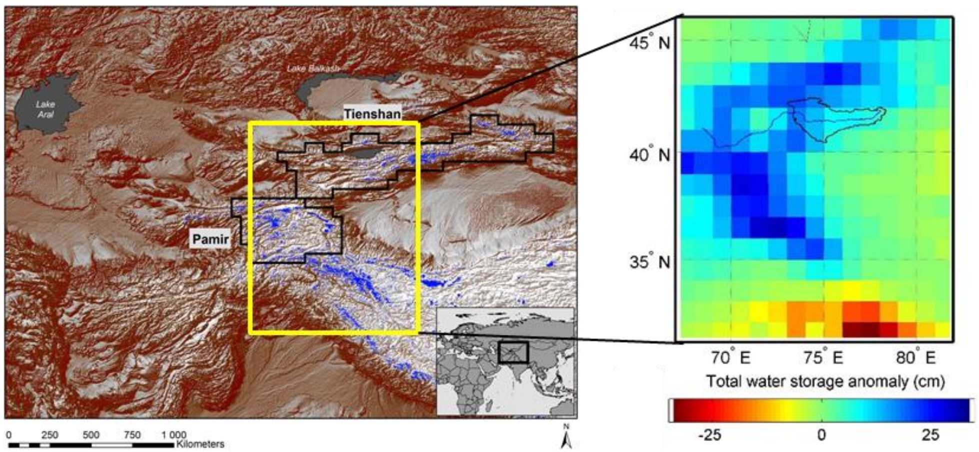
HORIZON 2020

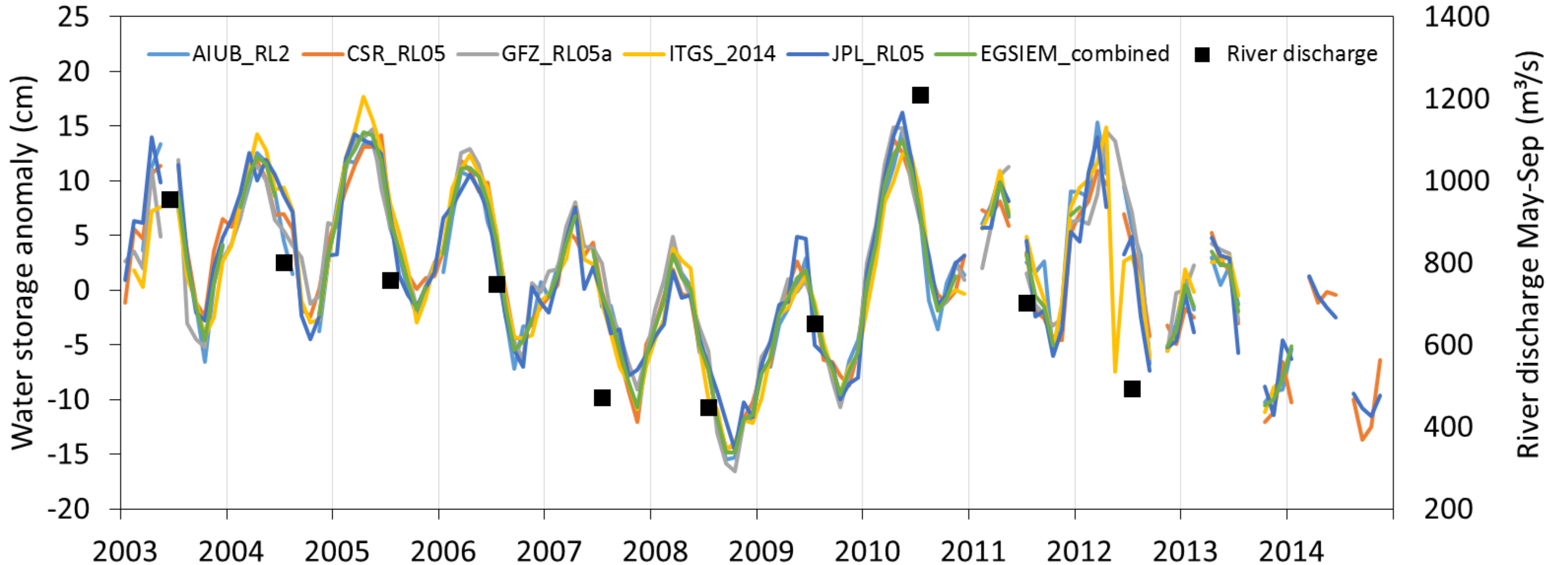
Seasonal forecasting of summer streamflow in Central Asia



Naryn river basin

River gauging station Uchterek

Basin size ~50000km²



Seasonal forecasting of summer streamflow in Central Asia

Linear forecast models

Forecast variable:

- Summer streamflow (May-Sep)

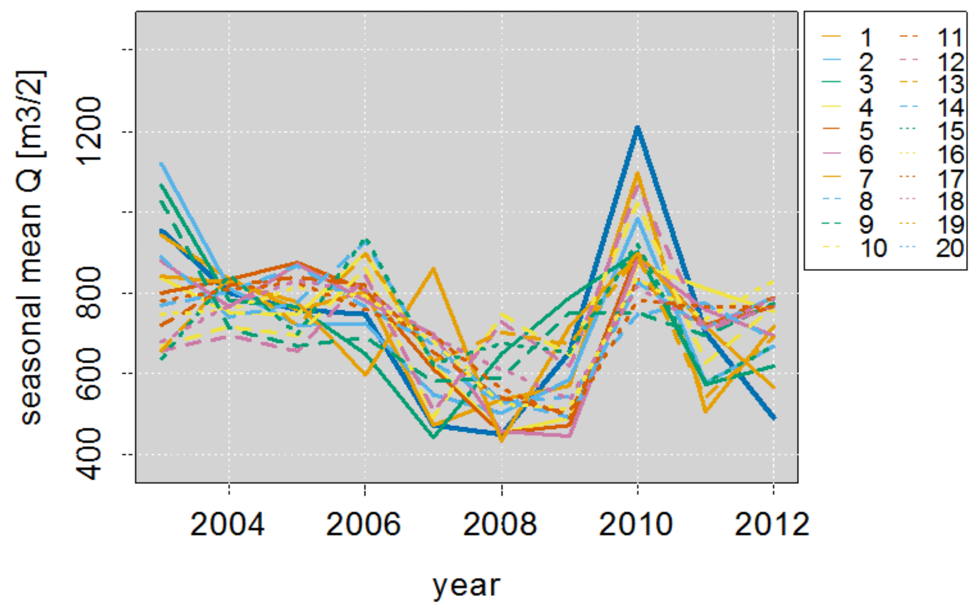
Predictors:

- Precipitation
- Standardized Precipitation Index (SPI)
- Air temperature
- River discharge
- Snow cover
- GRACE TWS anomaly

Seasonal forecasting of summer streamflow in Central Asia

Linear forecast model (1 predictor) (2003-2012)

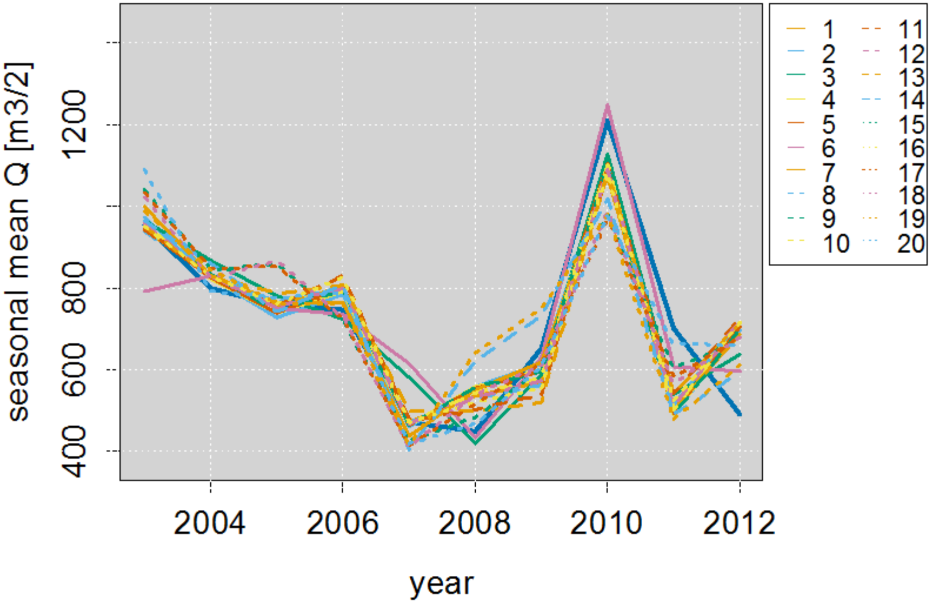
	Predictor	R2
1	SPI_JanApr	0.726
2	Precip_JanApr	0.424
3	SnowCover	0.355
4	Runoff_MarApr	0.141
5	CSR_RL05_DDK2s_TWS_Apr	0.128
6	JPL_RL05_1_DDK2s_TWS_Apr	0.084
7	Temp_Jan	0.040
8	Runoff_JanApr	0.030
9	Temp_MarApr	-0.091
10	SPI_JanFeb	-0.107
11	CSR_RL05_DDK2s_TWS_MarApr	-0.127
12	Precip_JanFeb	-0.128
13	SPI_Jan	-0.141
14	JPL_RL05_1_DDK2s_TWS_MarApr	-0.147
15	Precip_Jan	-0.186
16	GFZ_RL05a_DDK2s_TWS_Apr	-0.188
17	AIUB_RL2_DDK2s_TWS_Apr	-0.277
18	GFZ_RL05a_DDK2s_TWS_MarApr	-0.284



Seasonal forecasting of summer streamflow in Central Asia

Linear forecast model (2 predictors) (2003-2012)

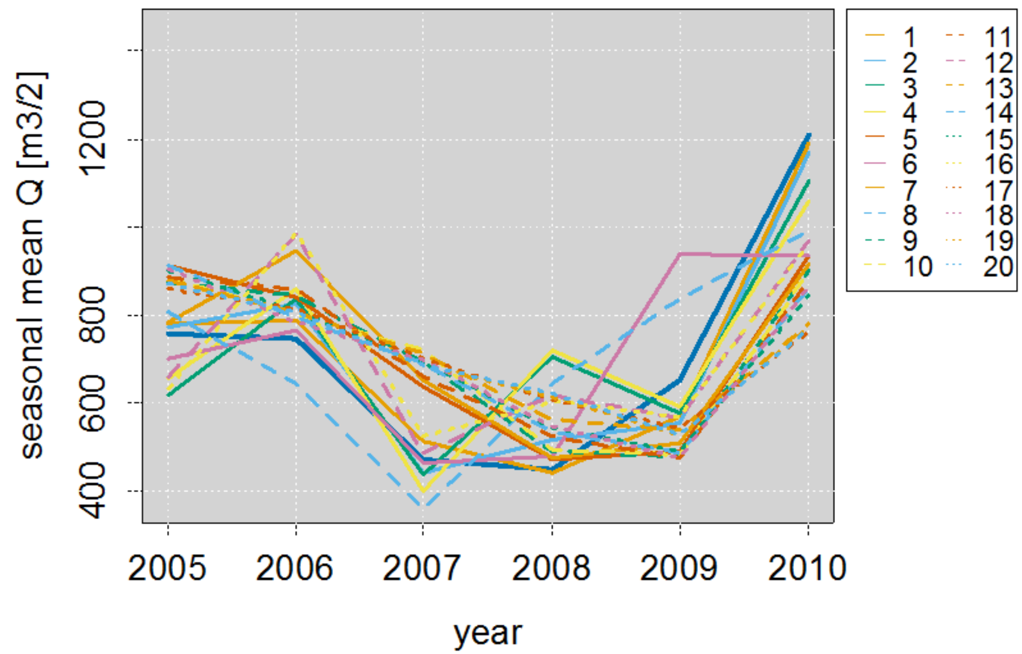
	Predictor	R2
1	SPI_JanApr	0.726
2	SPI_JanApr + GFZ_RL05a_DDK2s_TWS_MarApr	0.720
3	Temp_Jan + SPI_JanApr	0.714
4	SPI_JanApr + CSR_RL05_DDK2s_TWS_MarApr	0.696
5	SPI_JanApr + JPL_RL05_1_DDK2s_TWS_MarApr	0.681
6	Temp_Jan + SPI_JanFeb	0.670
7	SnowCover + SPI_JanApr	0.657
8	SPI_JanApr + CSR_RL05_DDK2s_TWS_Apr	0.650
9	SPI_JanApr + GFZ_RL05a_DDK2s_TWS_Apr	0.646
10	SPI_JanApr + AIUB_RL2_DDK2s_TWS_Apr	0.643
11	Runoff_MarApr + SPI_JanApr	0.637
12	Temp_MarApr + SPI_JanApr	0.628
13	SPI_JanApr + JPL_RL05_1_DDK2s_TWS_Apr	0.608
14	SnowCover + Precip_Jan	0.595
15	SnowCover + CSR_RL05_DDK2s_TWS_Apr	0.558
16	Runoff_JanApr + SPI_JanApr	0.552
17	SnowCover + CSR_RL05_DDK2s_TWS_MarApr	0.531
18	SnowCover + GFZ_RL05a_DDK2s_TWS_MarApr	0.530
19	SnowCover + SPI_Jan	0.529
20	SnowCover + Runoff_MarApr	0.525



Seasonal forecasting of summer streamflow in Central Asia

Linear forecast model (1 predictor) (2005-2010)

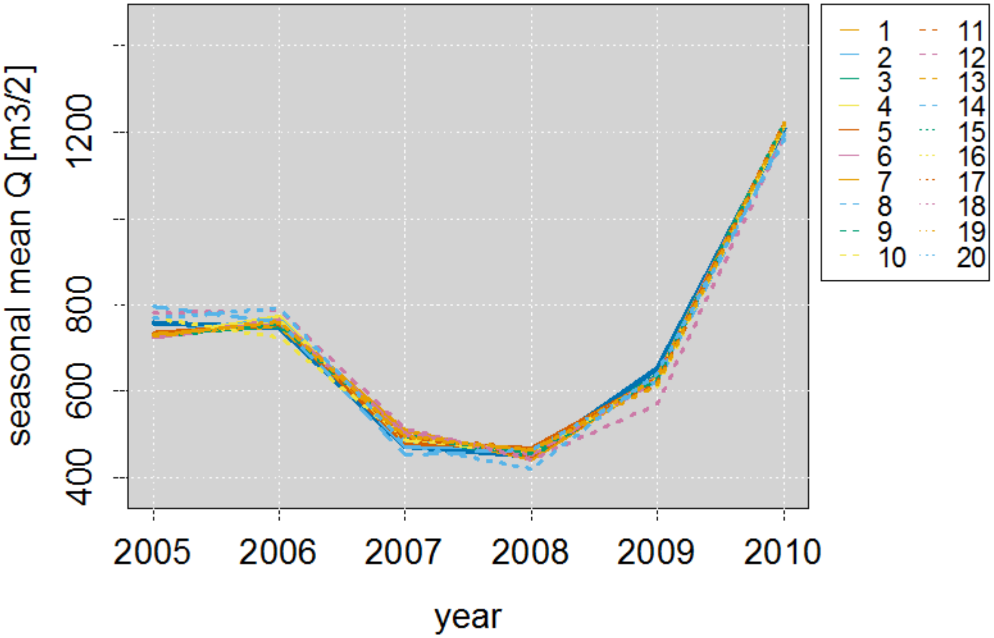
	Predictor	R2
1	Precip_JanApr	0.936
2	SPI_JanApr	0.831
3	Precip_JanFeb	0.209
4	SPI_JanFeb	0.106
5	CSR_RL05_DDK2s_TWS_Apr	-0.019
6	Temp_MarApr	-0.152
7	Runoff_MarApr	-0.155
8	SnowCover	-0.198
9	GFZ_RL05a_DDK2s_TWS_Apr	-0.202
10	JPL_RL05_1_DDK2s_TWS_Apr	-0.260
11	CSR_RL05_DDK2s_TWS_MarApr	-0.273
12	SPI_Jan	-0.285
13	EGSIEM_DDK1s_TWS_Apr	-0.380
14	JPL_RL05_1_DDK2s_TWS_MarApr	-0.390
15	EGSIEM_DDK2s_TWS_Apr	-0.392
16	Precip_Jan	-0.408
17	EGSIEM_DDK1s_TWS_MarApr	-0.441
18	EGSIEM_DDK3s_TWS_Apr	-0.481
19	EGSIEM_DDK3s_TWS_janApr	-0.496
20	EGSIEM_DDK2s_TWS_janApr	-0.515



Seasonal forecasting of summer streamflow in Central Asia

Linear forecast model (2 predictors) (2005-2010)

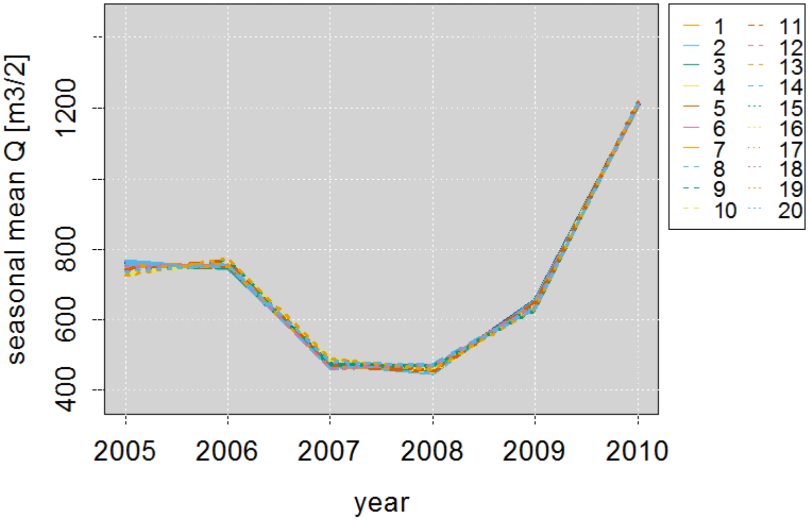
	Predictor	R2
1	Precip_JanApr + AIUB_RL2_DDK2s_TWS_Apr	0.980
2	Precip_JanApr + JPL_RL05_1_DDK2s_TWS_Apr	0.977
3	Precip_JanApr + GFZ_RL05a_DDK2s_TWS_MarApr	0.976
4	Precip_JanApr + EGSIEM_DDK3s_TWS_Apr	0.971
5	Precip_JanApr + GFZ_RL05a_DDK2s_TWS_Apr	0.971
6	Precip_JanApr + EGSIEM_DDK3s_TWS_MarApr	0.967
7	Precip_JanApr + EGSIEM_DDK3s_TWS_Mar	0.963
8	Precip_JanApr + JPL_RL05_1_DDK2s_TWS_MarApr	0.963
9	Precip_JanApr + EGSIEM_DDK2s_TWS_MarApr	0.963
10	Precip_JanApr + EGSIEM_DDK2s_TWS_Apr	0.962
11	Precip_JanApr + EGSIEM_DDK2s_TWS_janApr	0.956
12	Precip_JanApr + EGSIEM_DDK3s_TWS_janApr	0.952
13	Precip_JanApr + CSR_RL05_DDK2s_TWS_MarApr	0.951
14	SnowCover + Precip_JanApr	0.951
15	Precip_JanApr + EGSIEM_DDK1s_TWS_MarApr	0.947
16	Precip_JanApr + Runoff_MarApr	0.947
17	Precip_JanApr + EGSIEM_DDK1s_TWS_Apr	0.945
18	Precip_JanApr	0.936
19	Precip_JanApr + CSR_RL05_DDK2s_TWS_Apr	0.934
20	Temp_MarApr + Precip_JanApr	0.890



Seasonal forecasting of summer streamflow in Central Asia

Linear forecast model (3 predictors) (2005-2010)

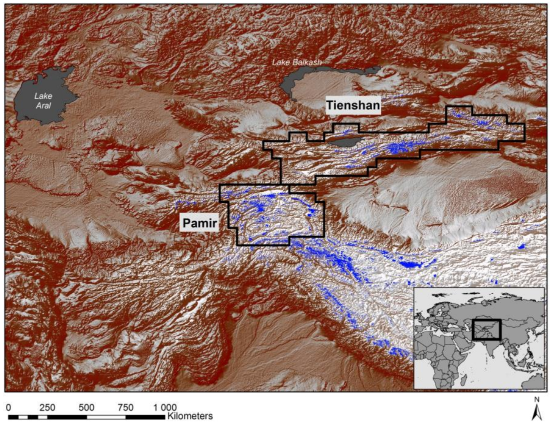
	Predictor	R2
1	SnowCover + Precip_JanApr + EGSIEM_DDK3s_TWS_Mar	0.997
2	Temp_MarApr + Precip_JanApr + Runoff_MarApr	0.996
3	SnowCover + Precip_JanApr + GFZ_RL05a_DDK2s_TWS_MarApr	0.993
4	SnowCover + Precip_JanApr + EGSIEM_DDK2s_TWS_MarApr	0.991
5	SnowCover + Precip_JanApr + EGSIEM_DDK2s_TWS_janApr	0.990
6	SnowCover + Precip_JanApr + EGSIEM_DDK3s_TWS_MarApr	0.990
7	SnowCover + Precip_JanApr + EGSIEM_DDK3s_TWS_janApr	0.988
8	SnowCover + Precip_JanApr + EGSIEM_DDK1s_TWS_MarApr	0.983
9	SnowCover + Precip_JanApr + CSR_RL05_DDK2s_TWS_MarApr	0.981
10	Precip_JanApr + AIUB_RL2_DDK2s_TWS_Apr	0.980
11	Temp_MarApr + Precip_JanApr + GFZ_RL05a_DDK2s_TWS_Apr	0.980
12	SnowCover + Precip_JanApr + GFZ_RL05a_DDK2s_TWS_Apr	0.978
13	SnowCover + Precip_JanApr + EGSIEM_DDK1s_TWS_Apr	0.978
14	SnowCover + Precip_JanApr + CSR_RL05_DDK2s_TWS_Apr	0.977
15	Precip_JanApr + JPL_RL05_1_DDK2s_TWS_Apr	0.977
16	Precip_JanApr + GFZ_RL05a_DDK2s_TWS_MarApr	0.976
17	Temp_Jan + SPI_JanApr + AIUB_RL2_DDK2s_TWS_Apr	0.972
18	SnowCover + Precip_JanApr + EGSIEM_DDK2s_TWS_Apr	0.972
19	Precip_JanApr + EGSIEM_DDK3s_TWS_Apr	0.971
20	Precip_JanApr + GFZ_RL05a_DDK2s_TWS_Apr	0.971



Seasonal forecasting of summer streamflow in Central Asia

Summary

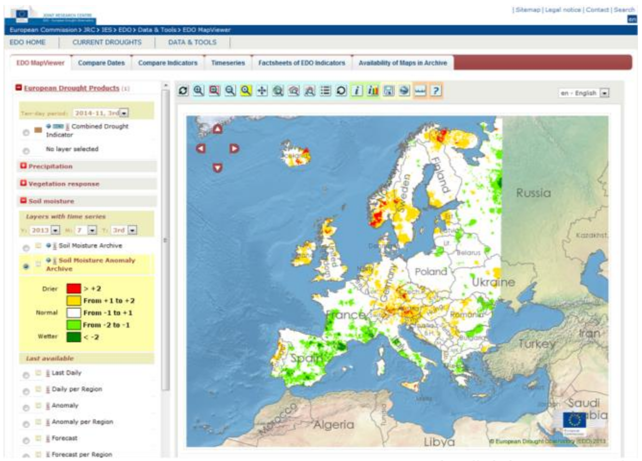
- GRACE TWS alone is not a good predictor for summer streamflow
- But forecasts can be improved by GRACE TWS as additional predictor (in addition to, e.g., precipitation, snow cover)
- EGSIEM combined monthly solution performs similar to individual solutions
- Short test period (2005-2010) due to missing months in EGSIEM combined solutions



WP6: Hydrological Service

European Gravity Service for Improved Emergency Management

Cooperation JRC - Outlook 2016

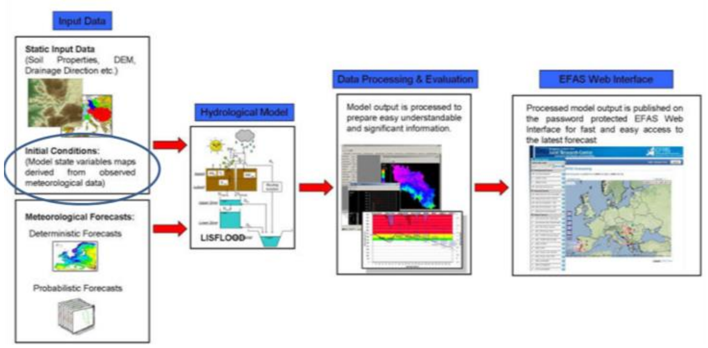


http://edo.jrc.ec.europa.eu/

Define requirements of GRACE-based water storage anomalies as flood and drought indicators for

comparison, evaluation and possible future inclusion into

- EFAS (European Flood Awareness System)
- GloFAS (Global Flood Awareness System)
- EDO (European Drought Observatory)



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Flood volume estimation

- Test case Ganges-Brahmaputra basin -

WP6 – T6.1

Hendrik Zwenzner - DLR

Objectives

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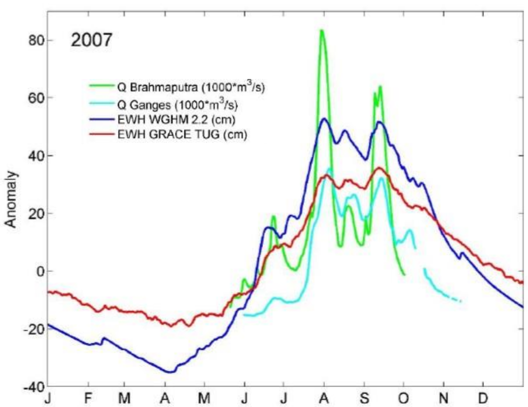
- Compare gravity measurements from space with flood information derived from EO satellites
- 2D flood mask ➔ 3D flood information
  - Integration of a DEM
  - Absolute **height of water surface** is required for each pixel
  - ➔ Water depth (water level – terrain elevation)
  - ➔ Flood volume

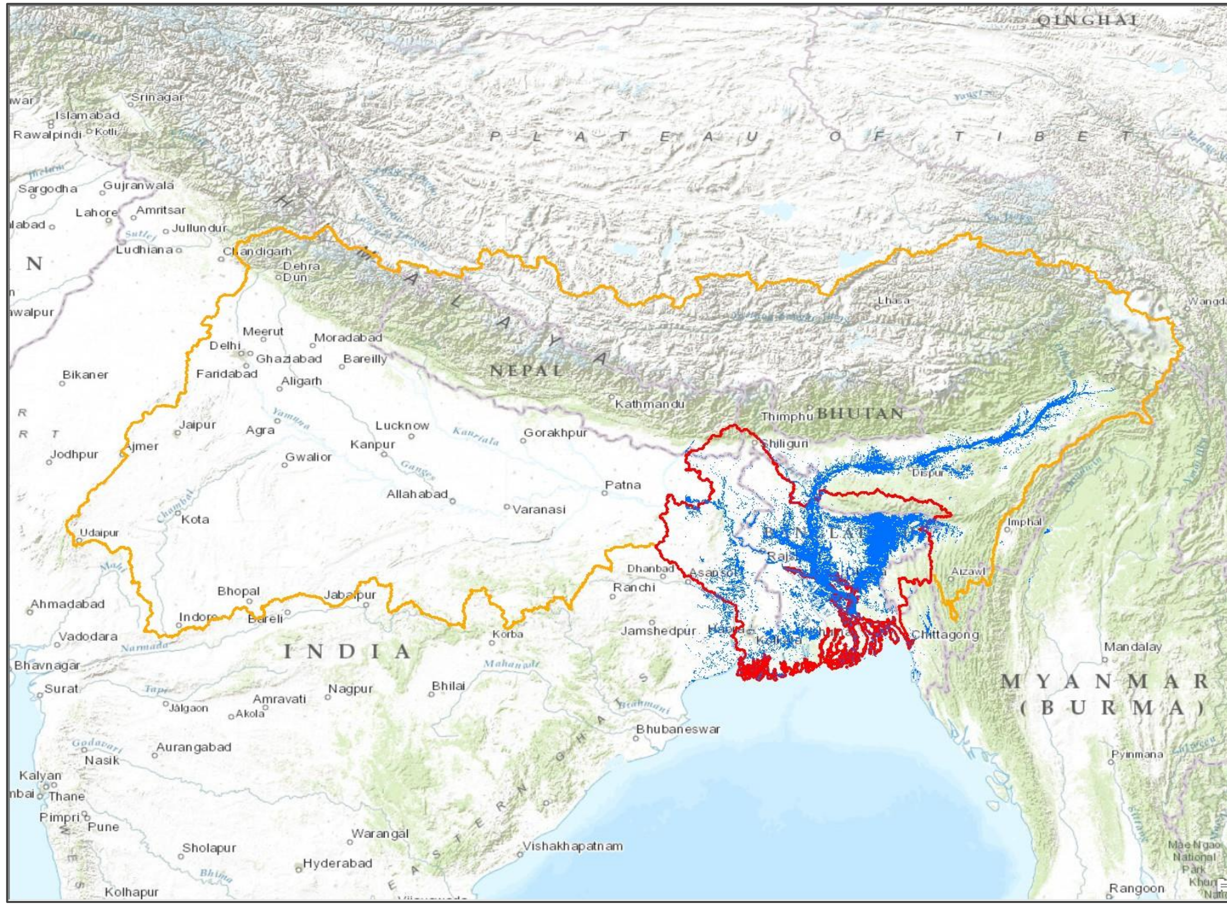
Ganges/Brahmaputra

European Gravity Service for Improved Emergency Management

MODIS flood mask (250m)
from 2007-08-20

Ganges: 42.811 m³/s
Brahmaputra: 48.012 m³/s





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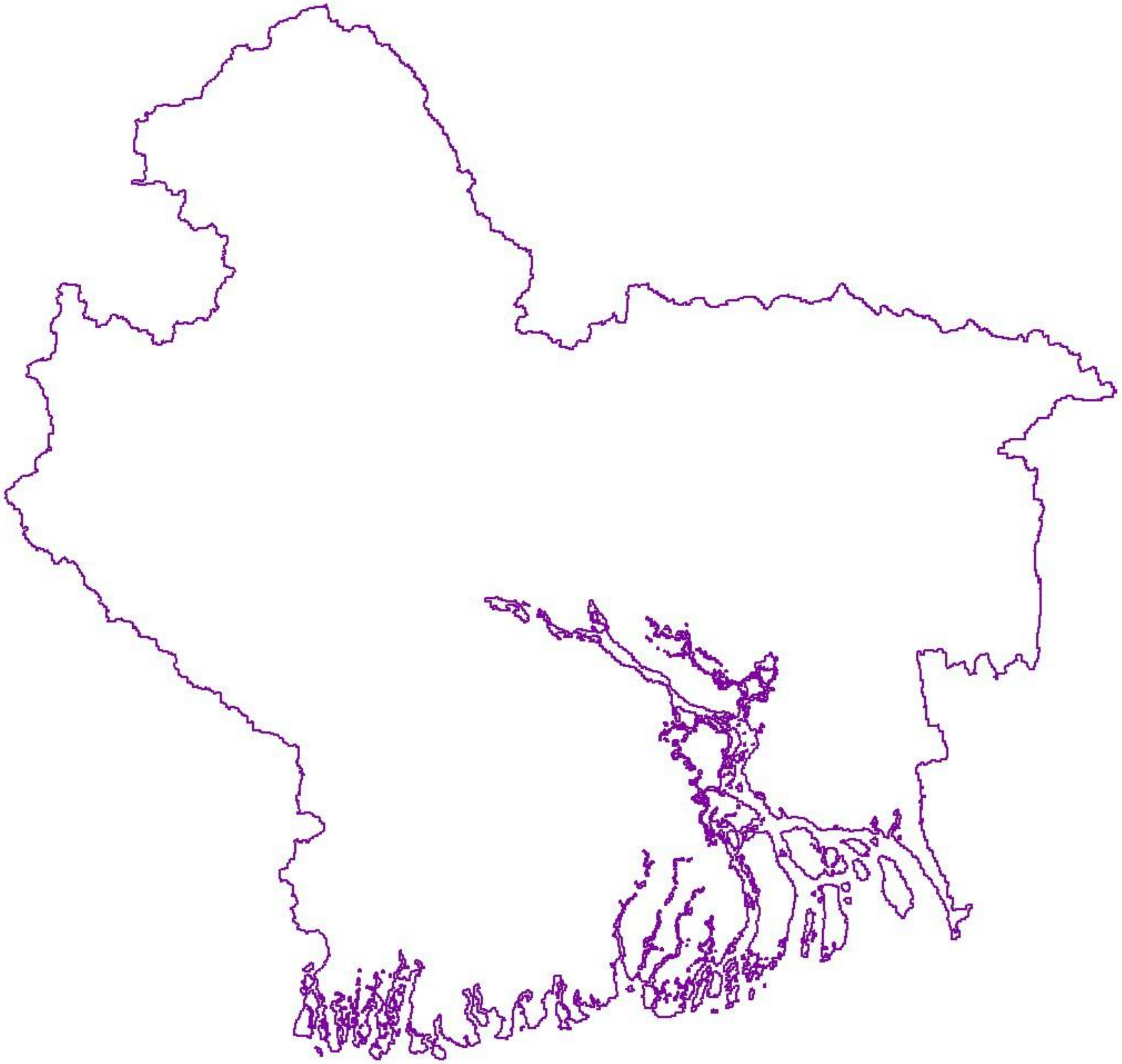
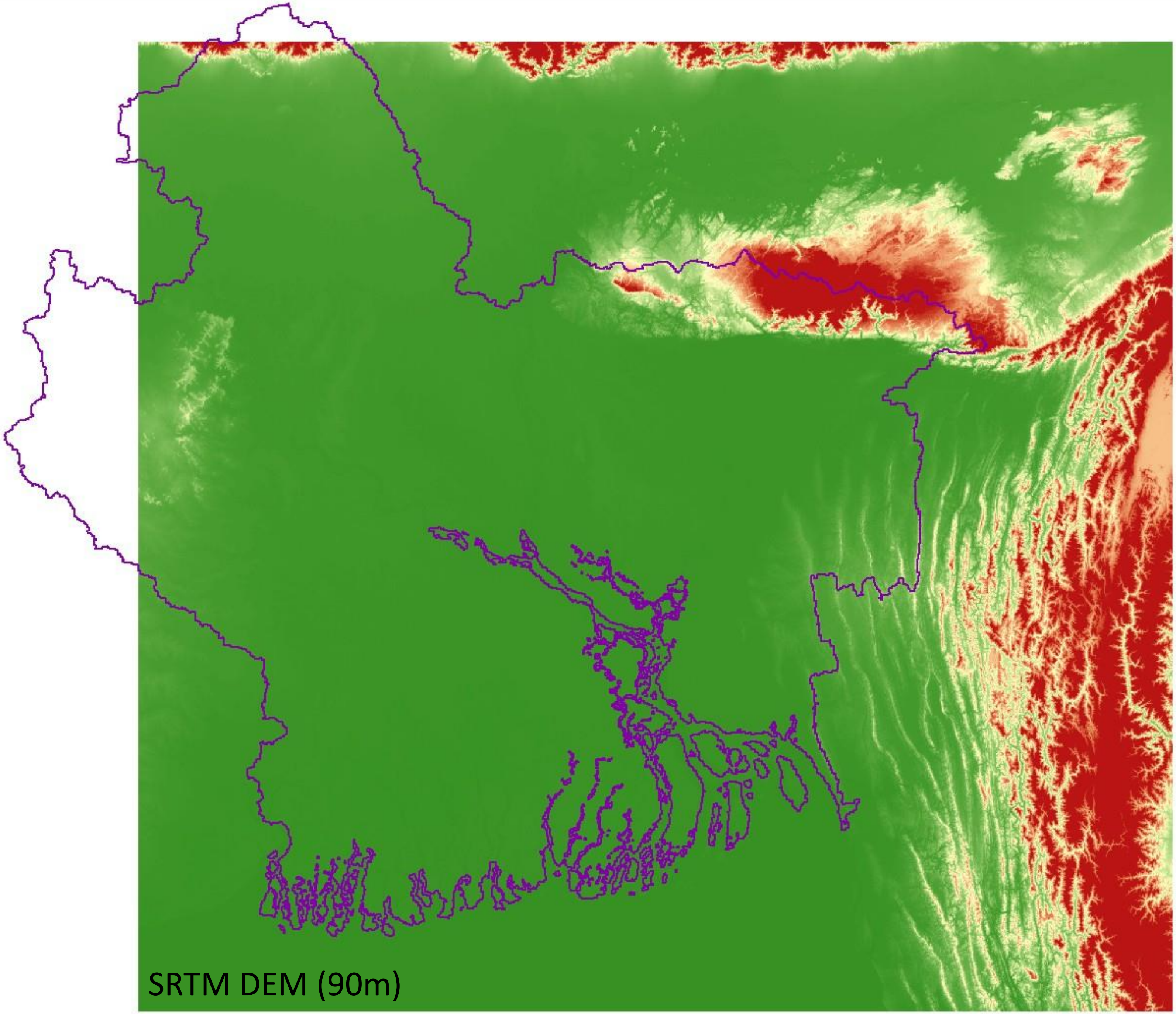
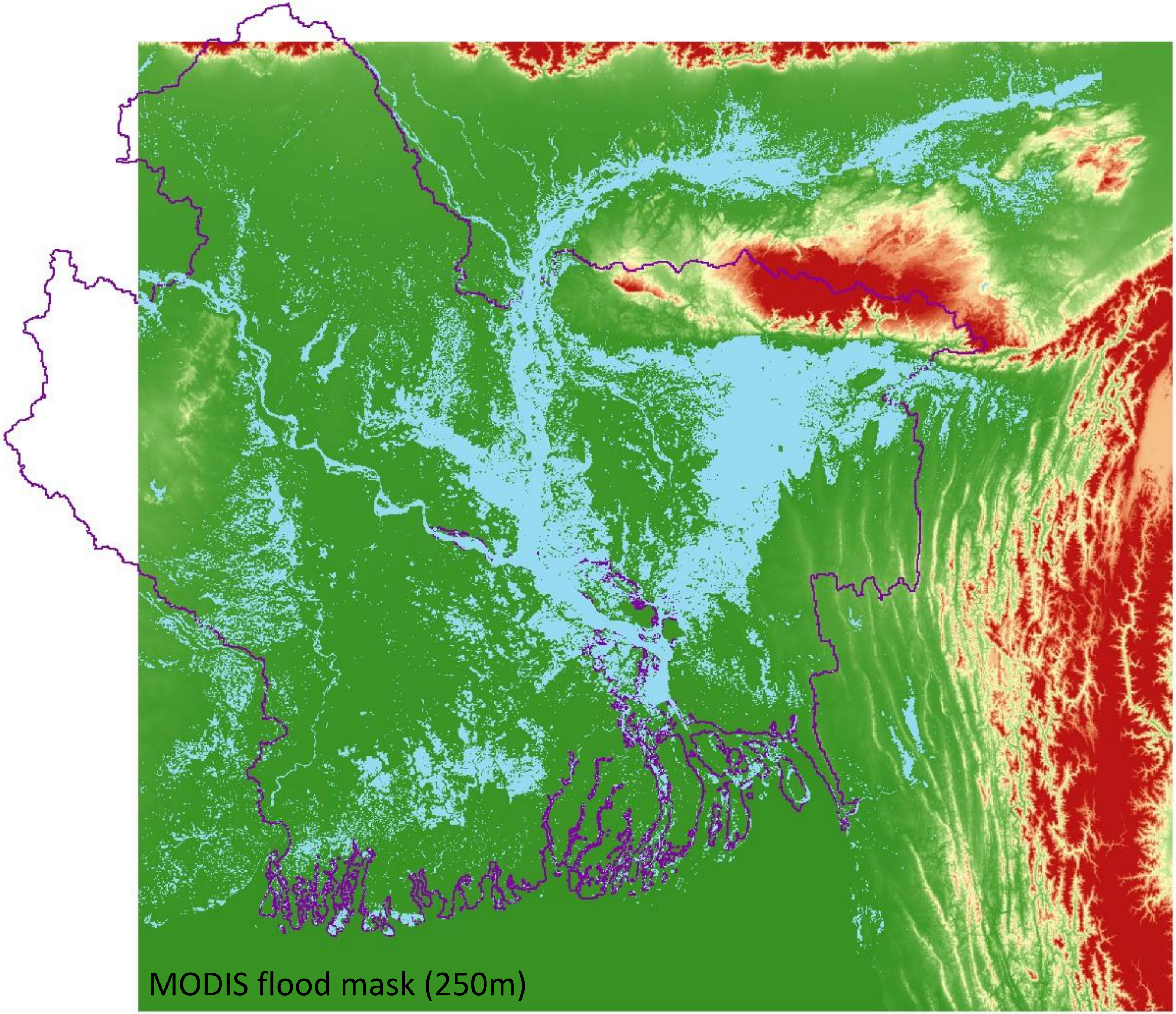
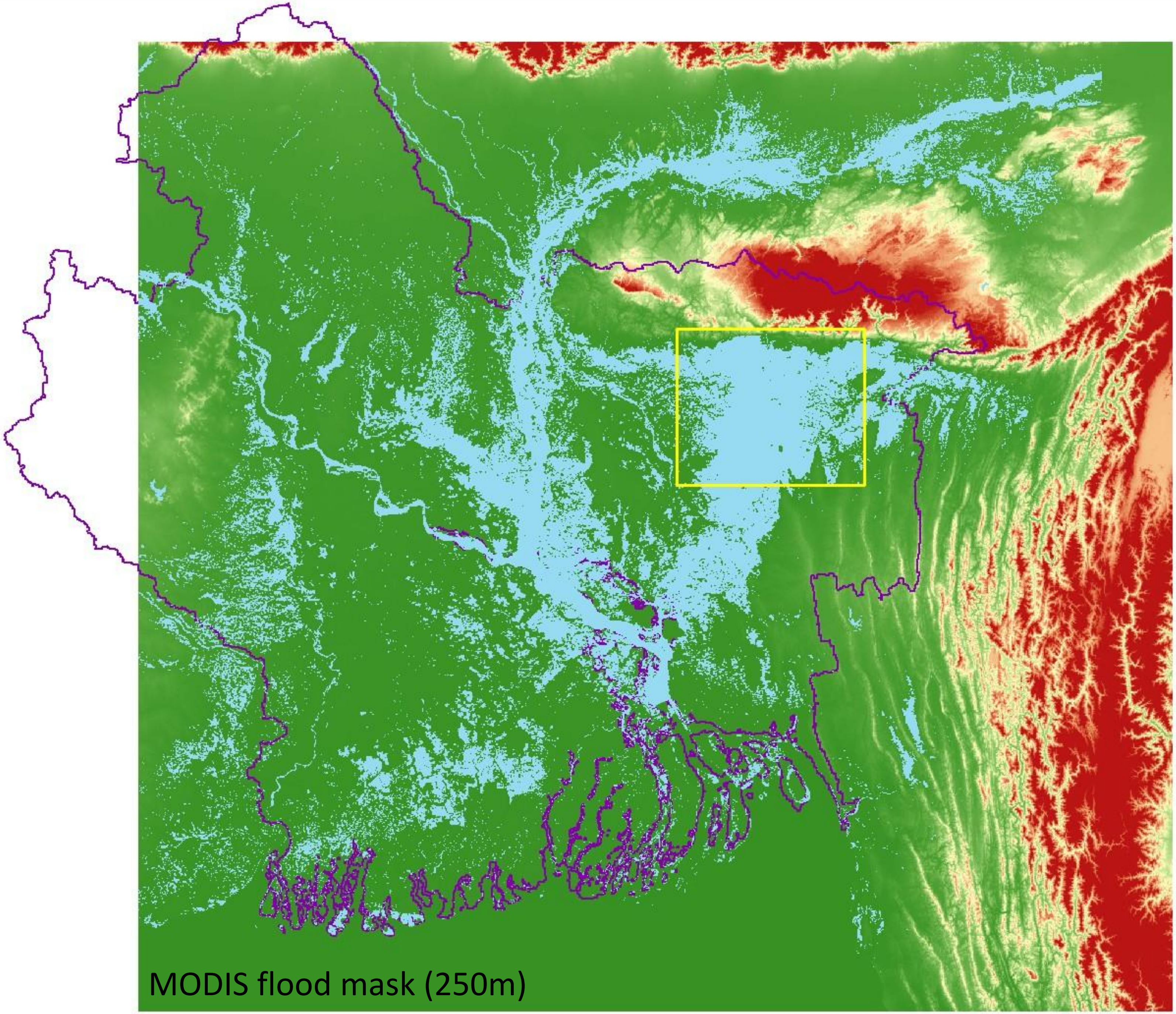


Ganges – Brahmaputra delta


SRTM DEM (90m)


MODIS flood mask (250m)


MODIS flood mask (250m)

Data integration

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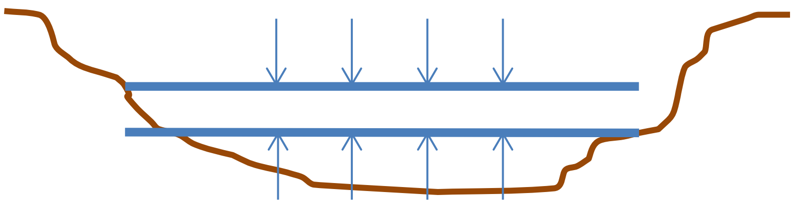
- Combination of flood mask and DEM (both datasets resampled to 100m)



Plain water surface is assumed (no slope)

- Coarse resolution and inconsistencies between both datasets do not allow for accurate determination of vertical water profile

Data integration

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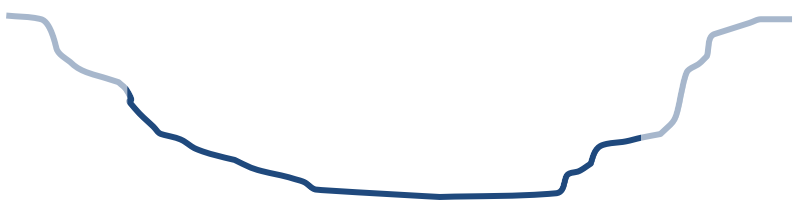
European Gravity Service for Improved Emergency Management

- Combination of flood mask and DEM (both datasets resampled to 100m)



Plain water surface is assumed (no slope)

- Coarse resolution and inconsistencies between both datasets do not allow for accurate determination of vertical water profile

Histogram

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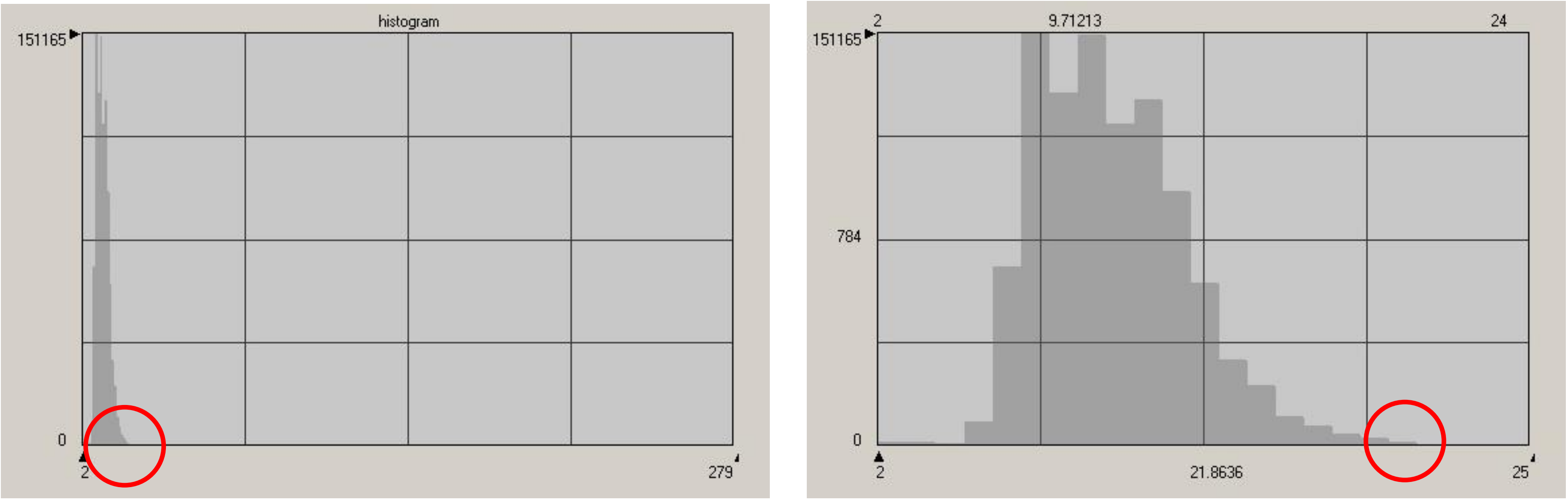

- Histogram shows distribution of elevation of flood pixels
- Optimal threshold for water surface level has to be found

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Ganges/Brahmaputra

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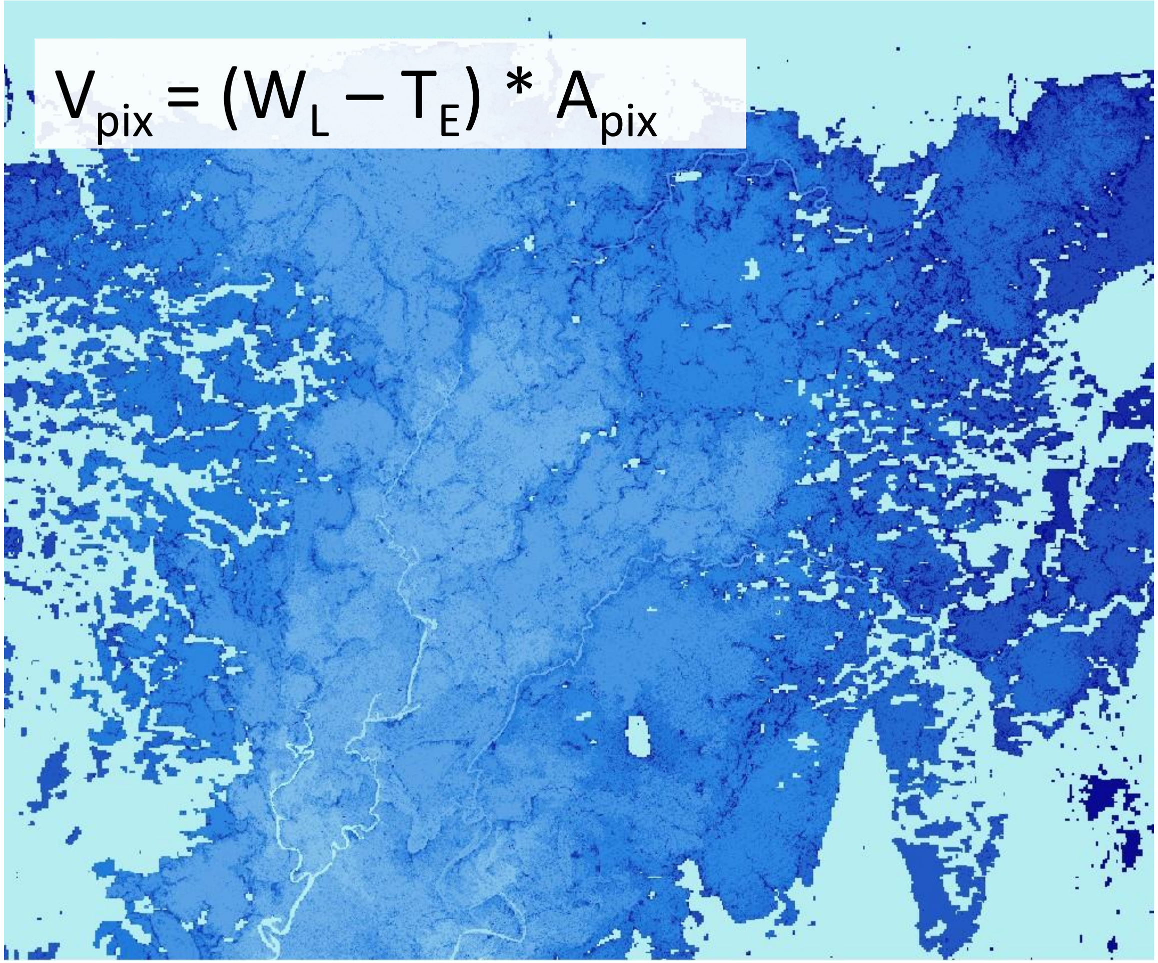
DEM value	Number of pixels	Water depth	Volume per pixel
0	1740	22	38280
1	1468	21	30828
2	1013	20	20260
3	8339	19	158441
4	59922	18	1078596
5	151165	17	2569805
6	117605	16	1881680
7	136905	15	2053575
8	107278	14	1501892
9	115144	13	1496872
10	84677	12	1016124
11	54211	11	596321
12	28983	10	289830
13	20357	9	183213
14	10165	8	81320
15	7016	7	49112
16	4288	6	25728
17	3034	5	15170
18	1479	4	5916
19	784	3	2352
20	355	2	710
21	183	1	183
22	424	0	0
		sum	130,96 km³

$$V_{pix} = (W_L - T_E) * A_{pix}$$



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V_{pix} Volume per pixel
W_L Water level
T_E Terrain elevation
A_{pix} Area per pixel

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Ganges/Brahmaputra

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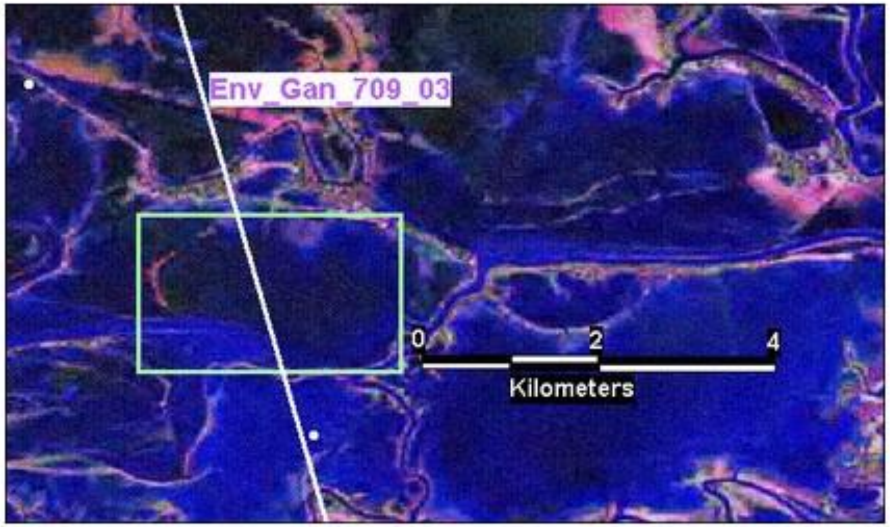
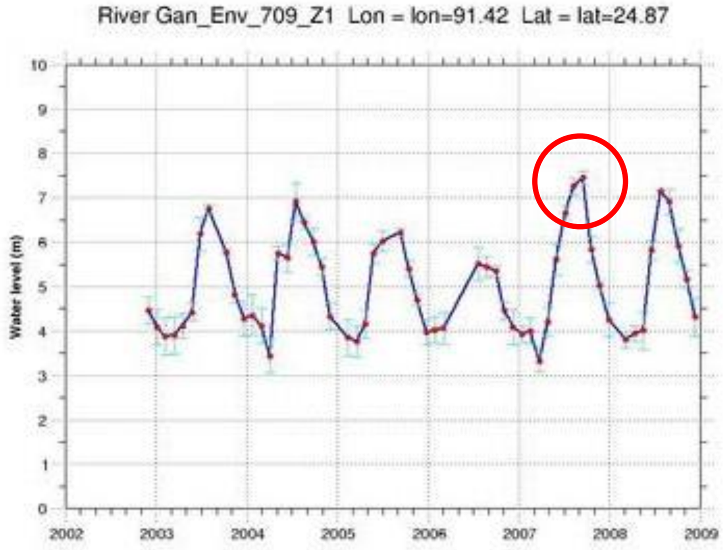
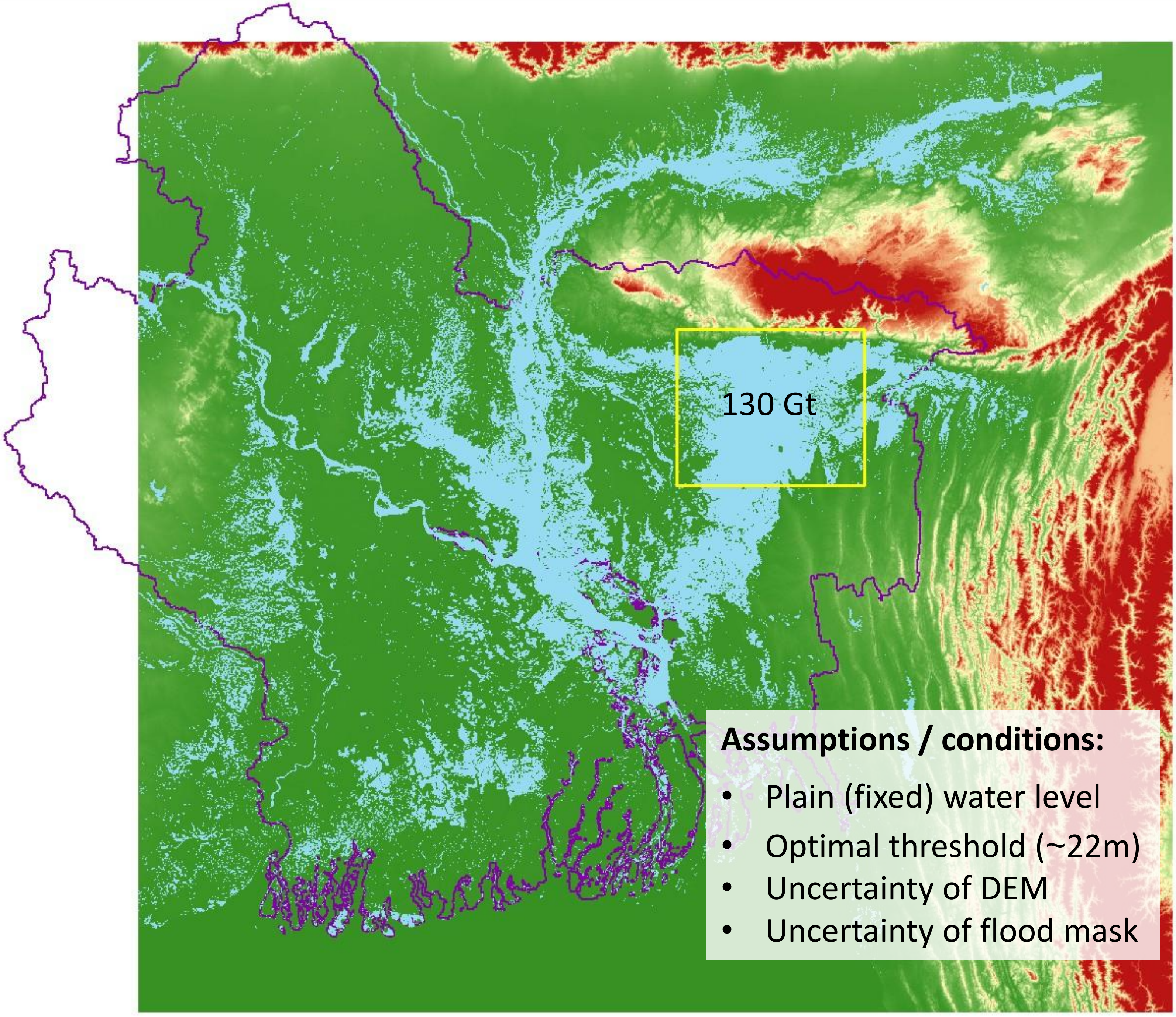
Virtual stations computed under the Envisat ground tracks

(*) using the standard processing



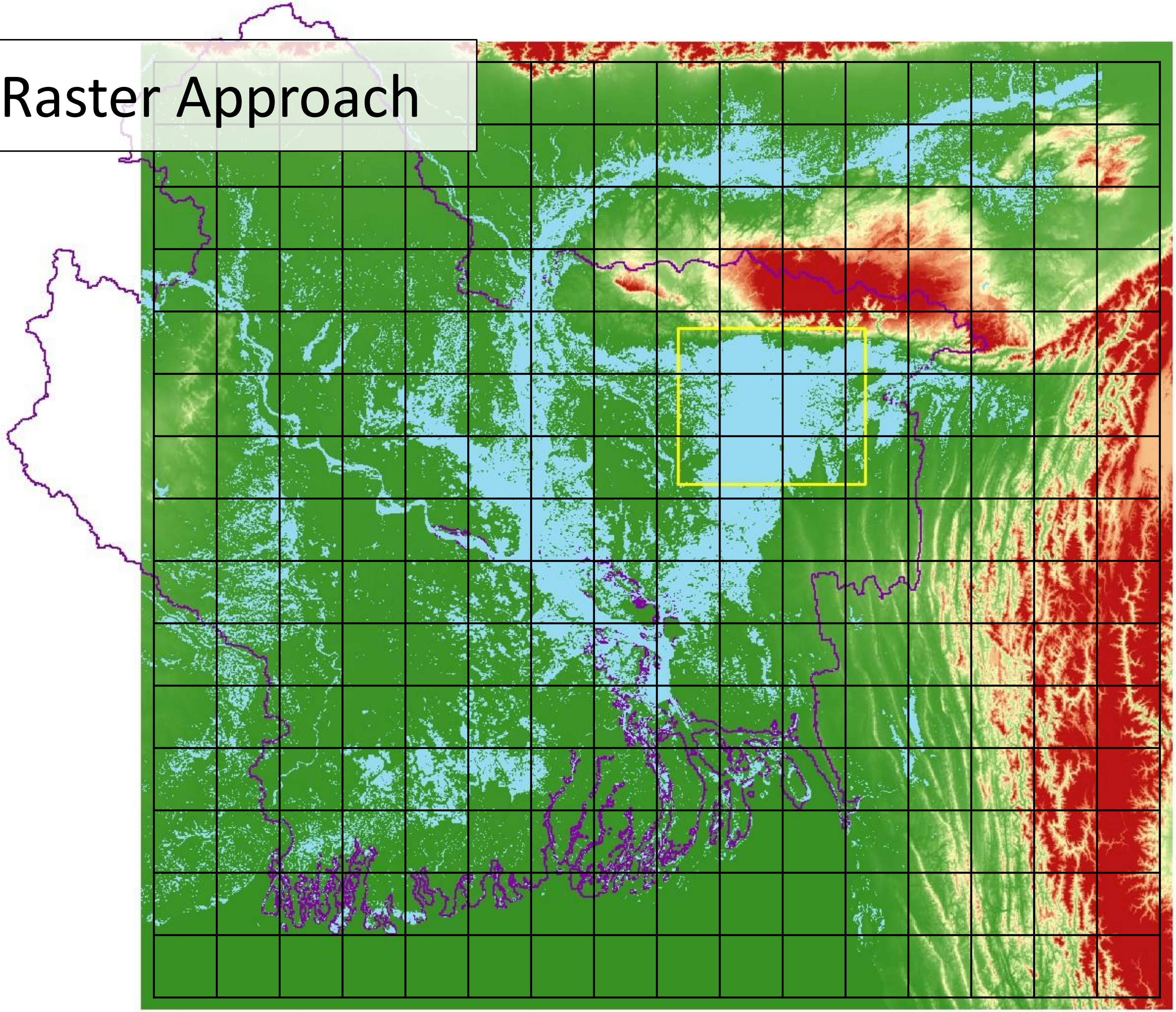


http://www.legos.obs-mip.fr/en/soa/hydrologie/hydroweb/Page_2.html



130 Gt
Assumptions / conditions:
• Plain (fixed) water level
• Optimal threshold (~22m)
• Uncertainty of DEM
• Uncertainty of flood mask

Raster Approach



Next steps

European Gravity Service for Improved Emergency Management

- Assess accuracy of derived water levels (threshold)
  - compare with altimetry data and water gauge data
- Define optimal raster size for the flood volume estimation based on
  - the spatial resolution of the flood mask
  - flood shape
  - topography of the basin

Next steps

European Gravity Service for Improved Emergency Management

- Analysis of ENVISAT-ASAR time series for pre-defined flood events (Ganges-Brahmaputra, Danube, Mekong)
- Validation / improvement of derived flood volumes
  - Compare with hydraulic model results
  - Tests with higher resolution DEMs and flood masks

EGSIEM

European Gravity Service for Improved Emergency Management

WP7: Project Website

Keith Cann-Guthauser

Astronomisches Institut, Universität Bern

EGSIEM General Meeting

18. & 19. January 2016, Luxembourg

WP7: Project Website

EGSIEM
European Gravity Service for Improved Emergency Management

- egsiem.eu has been live since March 2015
- Deliverable 7.1
- Work is ongoing updating content
- THANK YOU for your contributions!

WP7: Project Website

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European Gravity Service for Improved Emergency Management

Some highlights (March 2015 – Jan 2016):

- **9,761 Page Views**
- **5,467 Distinct user 'sessions'**
- **Majority of viewers are from USA**
- **However, low engagement rate**

WP7: Project Website

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European Gravity Service for Improved Emergency Management

To compare (last months stats):

671 Page Views

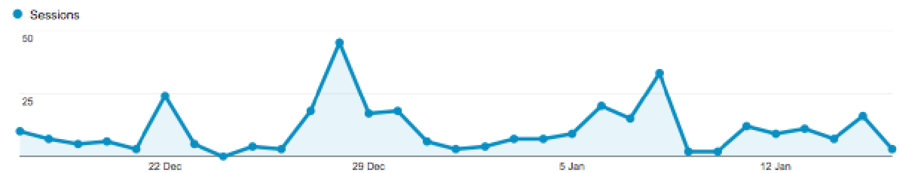
331 Sessions

Audience Overview

17 Dec 2015 - 16 Jan 2016

All Sessions
100.00%

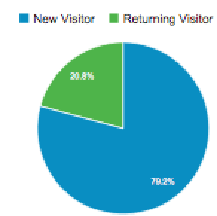
Overview



Sessions	Users	Page Views
331	280	671

Pages/Session	Avg. Session Duration	Bounce Rate
2.03	00:00:55	78.85%

% New Sessions
79.15%



	Country	Sessions	% Sessions
1.	United States	57	17.22%
2.	Germany	40	12.08%
3.	(not set)	35	10.57%
4.	Switzerland	24	7.25%
5.	China	14	4.23%
6.	France	13	3.93%
7.	Italy	13	3.93%
8.	Austria	9	2.72%
9.	Ireland	9	2.72%
10.	Brazil	8	2.42%

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WP7: Project Website

European Gravity Service for Improved Emergency Management

- EGSIEM is also on social media:

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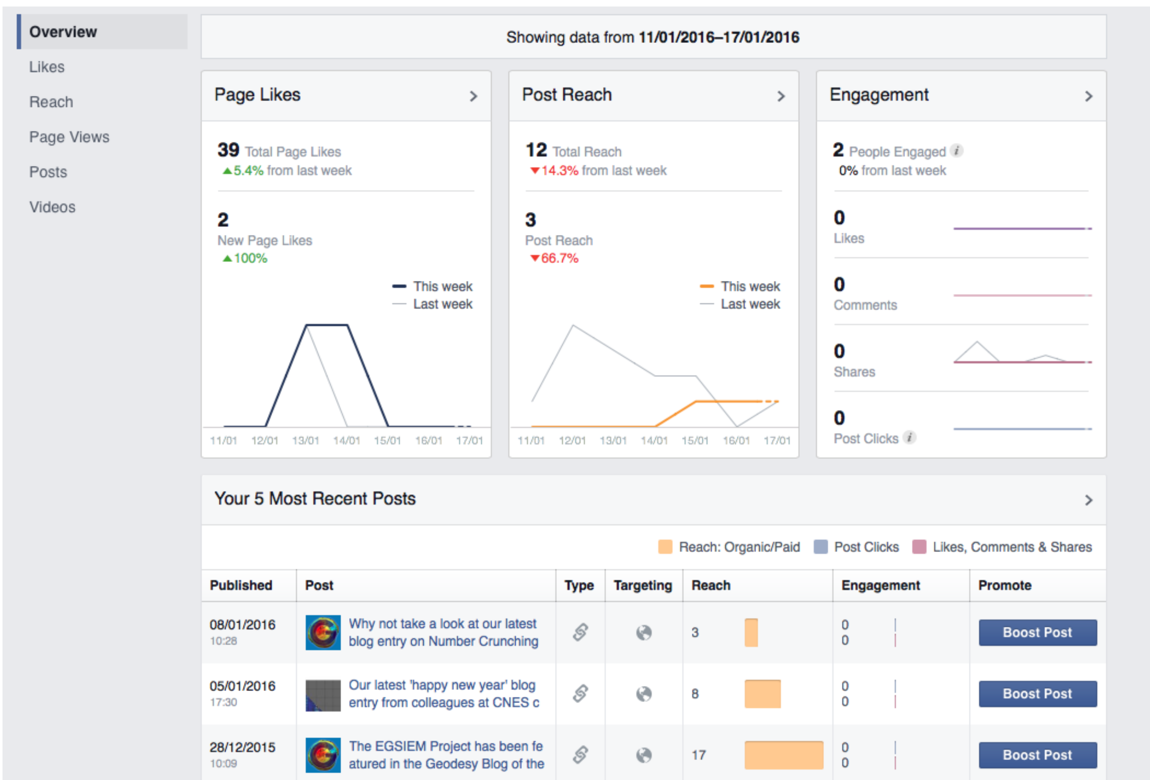
- Similar data available from Facebook



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Student Competition
The EGSIEM Challenge

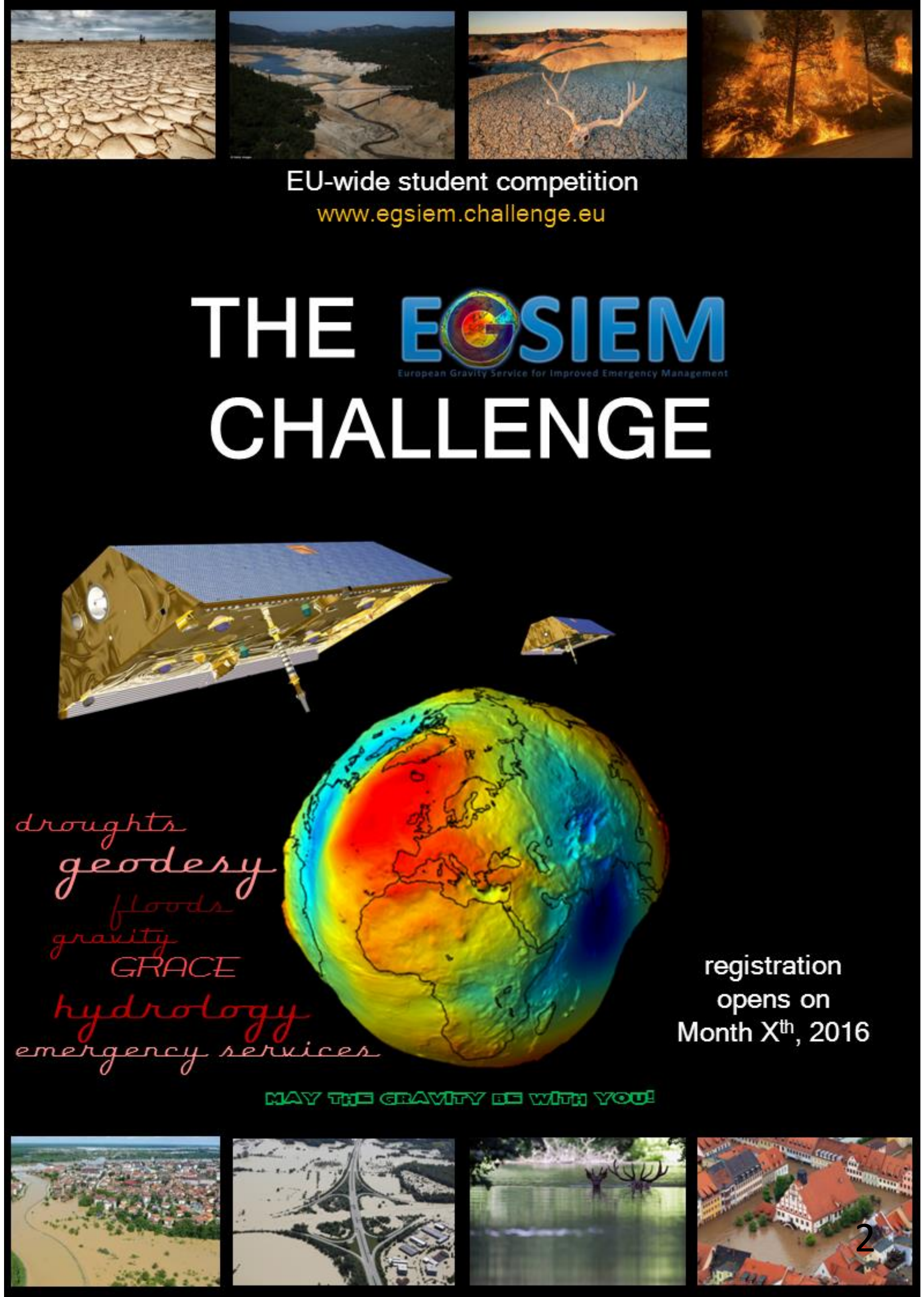
Tamara Bandikova

Institut für Erdmessung, Leibniz Universität Hannover

January 19th, 2016

EGSIEM Meeting, Luxembourg

UNIVERSITÄT BERN · UNIVERSITÉ DU LUXEMBOURG · GFZ Helmholtz Centre Potsdam · TU Graz · Leibniz Universität Hannover · cnes · DLR · géode&cie · HORIZON 2020


EU-wide student competition
www.egsiem.challenge.eu
THE EGSIEM
European Gravity Service for Improved Emergency Management
CHALLENGE
droughts
geodesy
floods
gravity
GRACE
hydrology
emergency services
registration opens on Month X^th, 2016
MAY THE GRAVITY BE WITH YOU!

About the competition
- The goal -

European Gravity Service for Improved Emergency Management

- **to educate students** in geodesy, hydrology and emergency services, with focus on EGSIEM research topics
- to **increase students' attention** about the importance of Earth observation and the data usage for motoring and forecasting of natural hazards
- to awake students' interest, curiosity, awareness about this field, **to open their consciousness** in this research area
- to provide students with may be **their first research opportunity** in terms of the EGSIEM summer school or a research internship

About the competition
- Target group -

European Gravity Service for Improved Emergency Management

Target group

- university students, both undergraduates and graduates (BSc + MSc)
- focus on students studying geodesy and/or hydrology study programs, but others are welcomed as well
- age 19-28
- residents of EU countries or CH
- as the students will come from different backgrounds and also from different semesters (1.-10. semester), the difficulty must be appropriate ... the goal is open their consciousness, not to test their technical skills in difficult computation tasks!!!

About the competition

- What should the students learn -

- GRACE
  - Fundamentals about the satellite mission; Measurement principle; Measurement accuracy; Meaning of the gravity data; GRACE results; Indicators for drought/flood monitoring derived from GRACE data; The importance of the gravity data for Earth observation
- Hydrology
  - Groundwater resources; Groundwater measurement; Natural disasters; California and north India drought; Danube floods 2006, their causes and consequences
- Floods/Droughts monitoring
  - European satellite missions for Earth observation; Copernicus Emergency Management Service; Early warning systems; EGSIEM

About the competition

- Competition rounds -

European Gravity Service for Improved Emergency Management

- **1st round** based on multiple choice test (20 questions)
  - the information necessary for solving the test can be found in online resources
  - anybody who solves 15+ questions successfully passes automatically to the 2nd round

About the competition
- Competition rounds -

EGSIEM
European Gravity Service for Improved Emergency Management

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- **2nd round** based on 20 open questions
  - the goal is to gain a deeper understanding of the topic and to get a clear picture of what, why and how is done
  - the geodesists should learn something more about hydrology, and the hydrologists should learn something more about geodesy
  - the task is to answer as many questions as accurate as possible

About the competition - Schedule -

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European Gravity Service for Improved Emergency Management

Month1, 1st, 2016	Registration opens
	1st round questions published
	1st round begins
Month2, 10th, 2016	End of registration
	Deadline for 1st round answers
Month2, 12th, 2016	Announcement of 1st round results
	1st round correct answers published
	2nd round begins
	2nd round questions published
Month3, 20th, 2016	Deadline for 2nd round answers
Month4, 13th, 2016	Announcement of finalists/winners
tbd	EGSIEM Summerschool
tbd	Research internship

Work for the students
2.5 months

Competition duration
3.5 months

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About the competition
- Awards -

European Gravity Service for Improved Emergency Management

- **Research internship (1st prize)**
  - Two internships at one of the EGSIEM member institutes
  - Internships will last from 6 to 8 weeks
  - The students will be granted with their travel expenses; health, accident and personal liability insurance; and a monthly allowance covering their living expanses

- **Scholarship for the EGSIEM summer school (2nd prize)**
  - Two scholarships for the EGSIEM summer school
  - The scholarship covers traveling expenses; health, accident and personal liability insurance; accommodation; meals; participation fee

About the competition
- Awards -

European Gravity Service for Improved Emergency Management

- All students successfully passing the 1st round will be additionally awarded with:
  - a certificate of participation in the EGSIEM challenge
  - giveaways (e.g. travel mug with EGSIEM logo)


EGSIEM European Gravity Service for Improved Emergency Management

Certificate of Participation

is hereby granted to

No Name

for successful participation in

The EGSIEM Challenge

MAY THE GRAVITY BE WITH YOU!

Signature — Prof. Dr. Adrian Jäggi, EGSIEM coordinator

Signature — N.N., Competition organisor

Hannover Month DD, YYYY

www.egsiem.challenge.eu

About the competition
- Internal motivation -

EGSIEM
European Gravity Service for Improved Emergency Management

- **EGSIEM goes public!**
- a unique opportunity to **advertise EGSIEM** Europe- (world-)wide
- a unique opportunity to **inspire and motive young students** to pursue their career in geodetic/hydrological research
- **what does it mean for us:**
  - delivery of high quality products required --> **internal review process** necessary
  - **research internship**:
    - --> research projects of high quality required (challenging, but realistic and clearly defined research tasks)
    - --> enthusiasm and time for working with students

Advertisment
-Communication platforms-

European Gravity Service for Improved Emergency Management

- **www.egsiem.challenge.eu**
- **EGSIEM Facebook page**

Advertisment
- Channels -

European Gravity Service for Improved Emergency Management

- **Universities with focus on geodesy and hydrology**
  - contact persons: professors and heads of departments
  - medium: direct communication with students, website ad, poster

- **non-university research institutes**
  - contact persons: heads of departments
  - website ad

- **student groups and organizations**
  - via Facebook

- **EGU (?) or other conferences**
  - flyers

- **teaser lecture, press releases**

Advertisment
- Channels -

European Gravity Service for Improved Emergency Management

- E-mail list of universities with focus on geodesy ☑

29 countries
69 universities
139 contact persons

- other e-mail lists ☐ in progress

HORIZON 2020

Organisation

EGSIEM
European Gravity Service for Improved Emergency Management

- Definition of the competition ☑
- Rules ☑
- Prizes ☐ (in progress)
- Questions 1st round ☑
- Questions 2nd round ☐ (in progress)
- Internal review ☒ (to be done)
- Advertisement ☐ (in progress
- Website ☒ (to be done)

Current open questions

- Research internship

    2 projects 1. LUH

    2. ???

Current open questions

- Research internship

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  2. ???

- Scholarship for the summer school ... timing ok???

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- Review process - questions for 1st and 2nd round

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  2 projects 1. LUH
  2. ???

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- Start of the competition ???

Current open questions

EGSIEM
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- Website - who will create it??? (content will be provided by IfE!)

Current open questions

EGSIEM
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- Research internship
  2 projects 1. LUH
  2. ???

- Scholarship for the summer school ... timing ok???

- Review process - questions for 1st and 2nd round

- Start of the competition ???

- Website - who will create it??? (content will be provided by IfE!)

- Budget: total cost estimate 8000 €
  (Posters/Flyers+giveaways 1000 €, Internship 2x 2400 €, SS 2 x 1200 €)
  paid from LUH budget or from UBern central budget ?

Summer School

EGSIEM
European Gravity Service for Improved Emergency Management

Nomination of an Organising Committee

Application to W. & E. Heraeus Foundation

- Genereous financial support for students: costs of about 100 EUR
- Time slot: 30.10. – 3.11. 2017 ?
- Application Deadline: 1st April 2016

Other options?

- Schweizerische Studienstiftung (to be checked)
- … ?

EGSIEM

European Gravity Service for Improved Emergency Management

EGSIEM dissemination activities: status

J. Flury, T. Bandikova

General Assembly, 18-19 Jan 2016

Newsletter

European Gravity Service for Improved Emergency Management

- No 1 April 2015
- No 2 July 2015
- No 3 Oct 2015
- No 4 upcoming

Blog

EGSIEM
European Gravity Service for Improved Emergency Management

www.egsiem.eu - news

2015	week 1	week 2	week 3	week 4
Jan	-	-	-	-
Feb	-	-	-	-
Mar	Ubern	DLR	CNES	TUG
Apr	LU	G&C	GFZ	LUH
May	Ubern	DLR	CNES	TUG
Jun	LU	G&C	GFZ	LUH
Jul	Ubern	DLR	CNES	TUG
Aug	LU	G&C	GFZ	LUH
Sep	Ubern	DLR	CNES	TUG
Nov	LU	G&C	GFZ	LUH
Dec	Ubern	DLR	CNES	TUG

EGSIE
European Gravity Service for Improved Emerg

News Project Tools Documents Consortium Contact Search Calen

Blog Entry: EGSIEM at geoday 2015

Andreas Kvas 29 May 2015

Each year, the geodesy institutes at TU Graz host the ***geoday***, an outreach event targeted at students about to graduate high school. This year over 200 students from schools all over Styria took the opportunity to get to know the courses of study, the geodesy institutes at TUG, and their current research topics. Besides regional and lunar gravity field recovery, GRACE and the monitoring of the time variable gravity field were hot topics at our booth. We engaged the students with interactive displays of satellite models and gravity products which sparked many interesting discussions.

Read more ... Add new comment

Blog Entry: How EGSIEM will support flood monitoring and mapping

Hendrik Zwenzner 15 May 2015

Severe and very large flood events, such as the floods in central Europe in 2002 and 2013 or the flood in Pakistan in 2010 for example, are amongst the most devastating catastrophes for the Earth's population, economy and environment. According to the number of activations of the **International Charter Space and Major Disasters**, almost 50 percent of all major disasters during the last 15 years have been flood events

Late

Blog E
geoda

Blog Entry: How EGSIEM will support flood monitoring and mapping

Blog Entry: EGSIEM @ EGU (Part II)

Blog Entry: EGSIEM Gravity and Time

Blog Entry: Test Areas for Flood Monitoring

Login

Hi Jakob Flury,

Log out

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Conference contributions

- AGU 2015
- EGU 2016
- Living Planet 2016?
- COSPAR Jul 30 – Aug 7, 2016 Istanbul?
- GGHS Sep 19-23, 2016 Thessaloniki?
- others?

Journal papers

European Gravity Service for Improved Emergency Management

Teaser lectures

EGSIEM
European Gravity Service for Improved Emergency Management

upcoming (March 2016 in Bern), material being collected, input from Frank, Hendrik, Torsten, Jakob

- didactic slides
- water
- ice
- gravity
- environmental change

Press

European Gravity Service for Improved Emergency Management

HORIZON 2020

Facebook

EGSIEM
European Gravity Service for Improved Emergency Management

HORIZON 2020

Other

European Gravity Service for Improved Emergency Management

- EGSIEM brochure
- Twitter
- Hot stories

EGSIEM

European Gravity Service for Improved Emergency Management

EGSIEM Project Review

Keith Cann-Guthauser
Astronomisches Institut, Universität Bern

EGSIEM General Meeting

18. & 19. January 2016, Luxembourg

EGSIEM Project Review

European Gravity Service for Improved Emergency Management

Article 19 of the Grant Agreement states “The coordinator must… organise a ‘mid-term review meeting’ between the beneficiaries, the partner organisation(s) and the Agency before the deadline for the submission of the report for RP 1 (reporting period 1)… “

However, the original plan (given that the first report period is only after one year) was to hold a small meeting with the Project Officer, the External Expert, Adrian & myself in Bern on the 7th March.

Two weeks ago we were told that a new Project Officer would be taking over liaison with EGSIEM and a more formal review will now take place in Brussels on the same day.

European Gravity Service for Improved Emergency Management

Attendees:

- The new (co) Project Officer has requested that Adrian & the other WP leaders meet her in BRU along with the external expert
- Prof. Rene Forsberg of Technical University of Denmark

EGSIEM Project Review

EGSIEM

European Gravity Service for Improved Emergency Management

The PO & external expert will review the first periodic report and submitted deliverables, and be given a project overview and a more detailed presentation of each WP.

We will then receive initial oral feedback at the end of the meeting on any areas which might need improving, as well as a more formal written report which we will then need to respond to in the next report (Progress Report due February 2017).

EGSIEM

European Gravity Service for Improved Emergency Management

Publication & Presentation Plan

EGSIEM General Meeting

Luxembourg, 18. & 19. January 2016

Universität Bern | Université du Luxembourg | GFZ Helmholtz Centre Potsdam | TU Graz | Leibniz Universität Hannover | cnes | DLR | géode&cie | HORIZON 2020

Presentation plan

EGSIEM
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EGU 2016

- AIUB: Maier et al.: SLR in the framework of the EGSIEM project
- AIUB: Meyer et al.: Combination of GRACE monthly gravity models on normal equation level
- AIUB: Jean et al.: Simulation study on combination of GRACE monthly gravity field solutions
- ULUX: Li et al.: Validation of the EGSIEM combined monthly GRACE gravity fields
- GFZ: Gruber et al.: GFZ NRT approach and validation
- GFZ: Gouweleeuw et al.: Evaluation of GRACE daily gravity solutions for the Ganges-Brahmaputra Delta flooding in 2007

Presentation plan

European Gravity Service for Improved Emergency Management

EGU 2016 (cont.)

- GFZ: Poropat et al.: Validation of GRACE daily/monthly products with in-situ and model Ocean Bottom Pressure data
- TUG: Klinger et al.: Status of GRACE data analysis and reprocessing
- TUG: Kvas et al.: TUG results of the NRT daily solutions
- TUG: Mayer-Gürr et al.: European Gravity Service for Improved Emergency Management - Status and project highlights
- TU Dresden: Horwath et al.: Evaluation of recent GRACE monthly solution series with an ice sheet perspective

- TU Delft: Encarnacao et al.: Gravity field models derived from Swarm GPS data

Upcoming meetings

European Gravity Service for Improved Emergency Management

ESA Living Planet Symposium, 9 – 13 May, Prague, Czech Republic

COSPAR, 30 Jul – 7 Aug, Istanbul, Turkey

IAG GGHS, 19 – 23 Sep, Thessaloniki, Greece

AGU, 12 – 16 Dec, San Francisco, California

Other meetings?

Publication plan

European Gravity Service for Improved Emergency Management

GFZ

- Evaluation of on-line smoothing algorithms for near real-time daily gravity field solutions, Journal NN, Kvas et al., planned for ?
- Monitoring of regional continental and residual non-tidal atmospheric and ocean mass variations by satellite gravity observations, Journal NN, Gruber et al., planned for ?
- Evaluation of enhanced spatio-temporal gravity solutions compared to Brahmaputra Delta flooding in 2007 and additional examples, GRL, Gouweleeuw et al., planned for ?
- Derivation of Var/Covariance Models for Kalmanfiltering of time variable GRACE solutions, Journal NN, Kvas/Gruber et al., planned for ?
- Validation with OBP, Journal NN, Dobslaw et al., planned for ?
- Level-3 scale factors, Journal NN, Dahle et al., planned for fall 2016

Publication plan

European Gravity Service for Improved Emergency Management

AIUB

- EGSIEM Project Overview and First Results, Journal of Geodesy, Jäggi et al., planned for spring/summer 2016
- AIUB GRACE solutions, Geophysical Journal International, Meyer et al., submitted
- Establishment of Combined Monthly GRACE Solutions, Journal NN, planned for spring 2016
- EGSIEM GNSS re-processing, Journal of Geodesy, Short Note ?, Susnik et al., planned for spring 2016

Others?

Publication plan

EGSIEM
European Gravity Service for Improved Emergency Management

Which publication strategies shall be followed in the future?

- Special issue in the Journal of Geodesy
- Springer book with a collection of papers
- Springer book related to the Summer School contributions
- Other ideas?

Publications

European Gravity Service for Improved Emergency Management

Official disclaimer

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 637010.

Do we need/want an additional disclaimer?

- EGSIEM is a consortium between the Astronomical Institute of the University of Bern, the Geophysics Laboratory of the University of Luxembourg, the German Research Centre for Geosciences, the Institute of Theoretical Geodesy and Satellite Geodesy of the Technical University of Graz, the Deutsches Zentrum für Luft- und Raumfahrt, the Group de Recherche de Geodesie Spatiale, the Institute of Geodesy of the University of Hannover, and Géode & Cie.

- Other ideas?