EGSIEM

European Gravity Service for Improved Emergency Management

WP4. Combination of GRACE Monthly Gravity Field Solutions from Different Processing Centers

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

Introduction

- In WP4 at AIUB
  - Combination of GRACE Monthly Gravity Field Solutions
- Contents
  - Availability of GRACE Monthly Gravity Field Solutions
  - Comparision of each Individual Solution
  - Combined Solutions with Diffferent Weighting Schemes
- Poster Presentation in the EGU Meeting 2015

GRACE Monthly Gravity Solutions: List

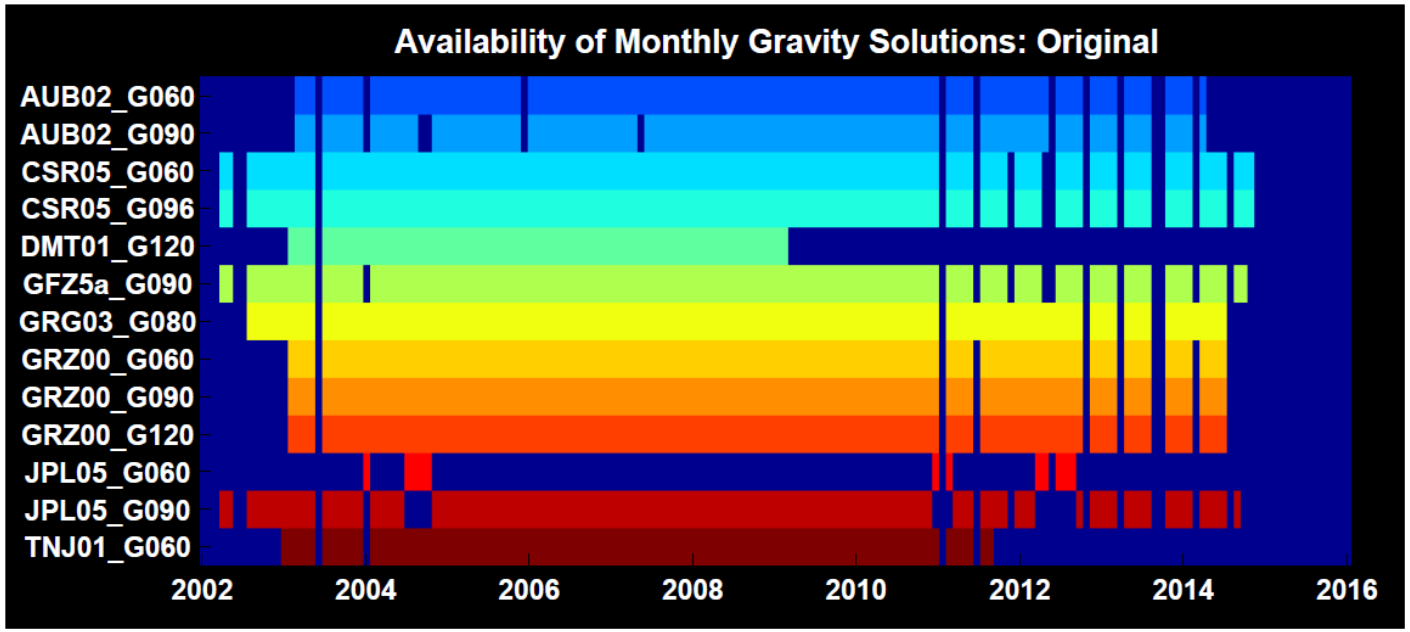
The official GRACE monthly gravity solutions available at the ICGEM website (`http://icgem.gfz-potsdam.de/ICGEM`):

Label	Solution Name	Institution	Max.deg.	Note
AUB02_G060* **AUB02_G090****	AIUB Release 2	AIUB	60 90	Celestial Mechanics Approach
CSR05_G060* **CSR05_G096****	UTCSR Release 5	CSR	60 96	Direct approach
DMT01_G120	DMT–1	TU Delft	120	Acceleration approach (pre-filtered)
GFZ5a_G090**	GFZ Release 5	GFZ	90	Direct approach
GRG03_G080	GRGS Release 3	GRGS	80	Direct approach (regularized)
GRZ00_G060* **GRZ00_G090**** **GRZ00_G120**	ITSG 2014	ITSG, TU Graz	60 90 120	Short arc approach (stochastic covariances)
JPL05_G060 **JPL05_G090****	JPL Release 5	JPL	60 90	Direct approach
TNJ01_G060*	Tongji Release 1	Tongji Univ.	60	Modified short arc approach

*: included in the combined solution of maximum degree 60
**: included in the combined solution of maximum degree 90

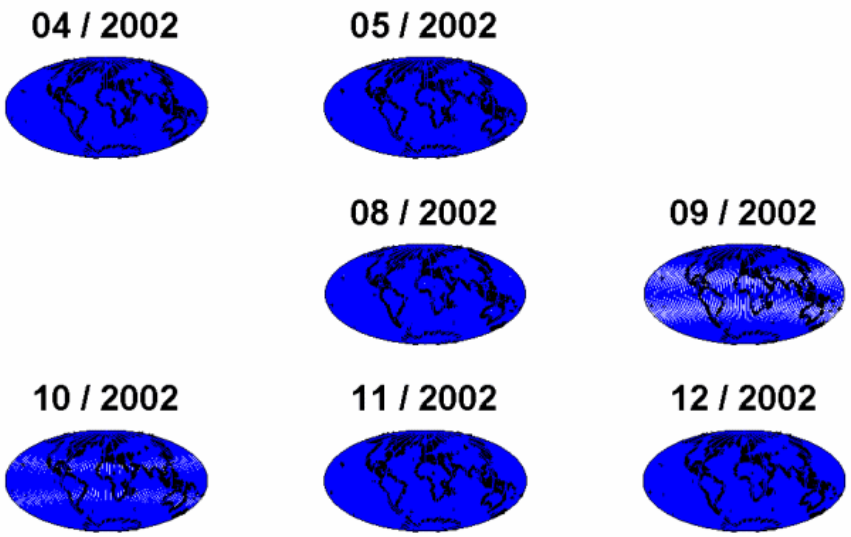
GRACE Monthly Gravity Solutions: Availabilty, Screening

- Availability of the monthly solutions



- Data Screening: wSTD over the oceans, 3-sigma (x 2)
  - First screening: 1.62%
  - Second screening: 2.05%

Ground Track of GRACE–A Satellite: 2002–2014



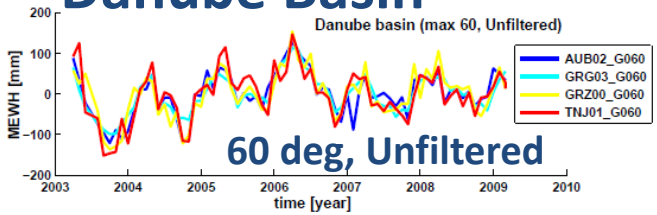
- **Information for users/visitors of EGSIEM website**

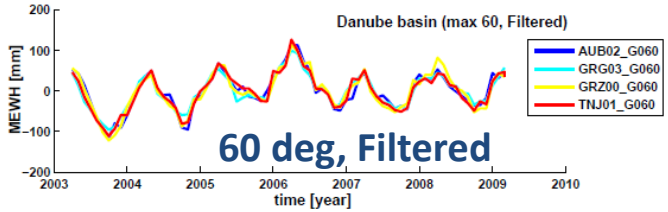
→ short discussion at the end of this presentation

Comparison of the Individual Solutions: Signal

- EWH in two river basins: Danube, Amazon basins

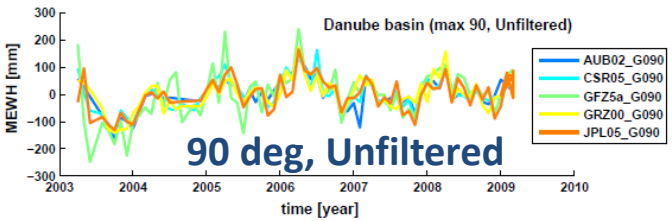
Danube Basin

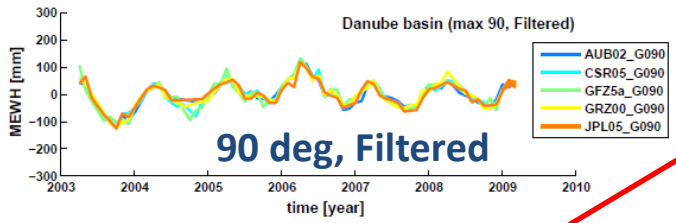




$$MEWH = \frac{\sum EWH * \sin\theta}{\sum \sin\theta}$$

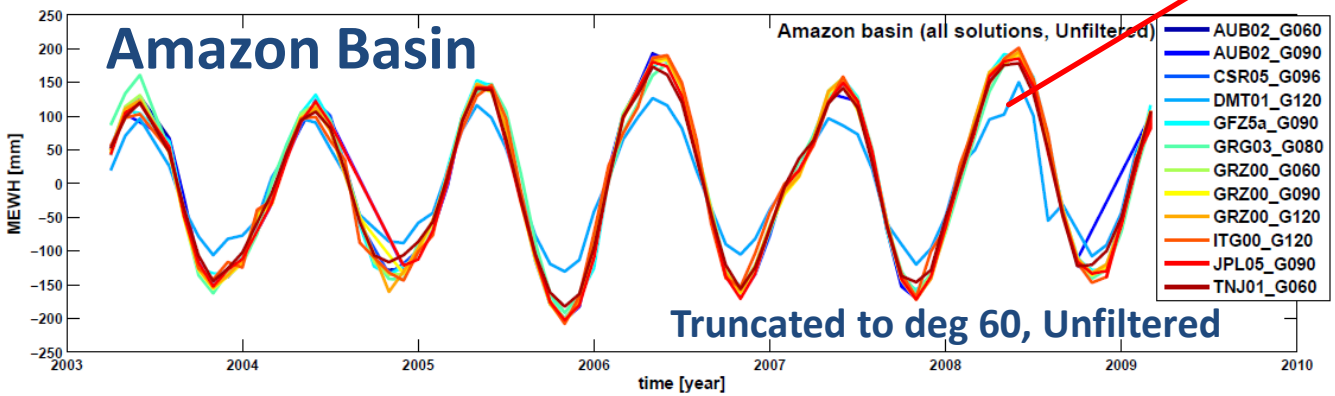
θ: colatitude





DMT solution: Dampened Signal due to pre-filtering

Amazon Basin



Comparison of the Individual Solutions: Noise

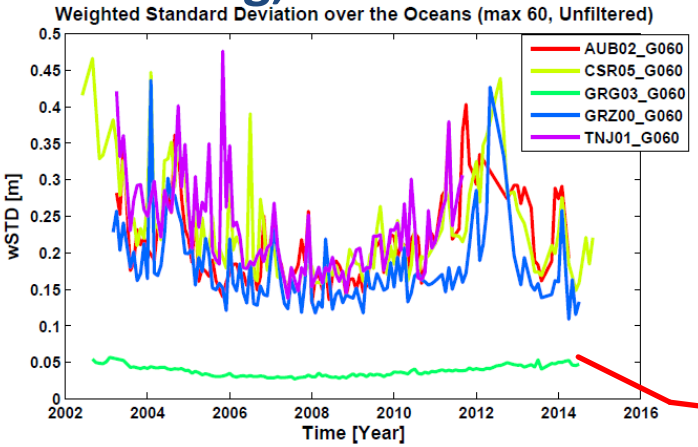
- Weighted standard deviations (wSTD) over the Oceans

$$wSTD = STD \cdot \sin\theta$$

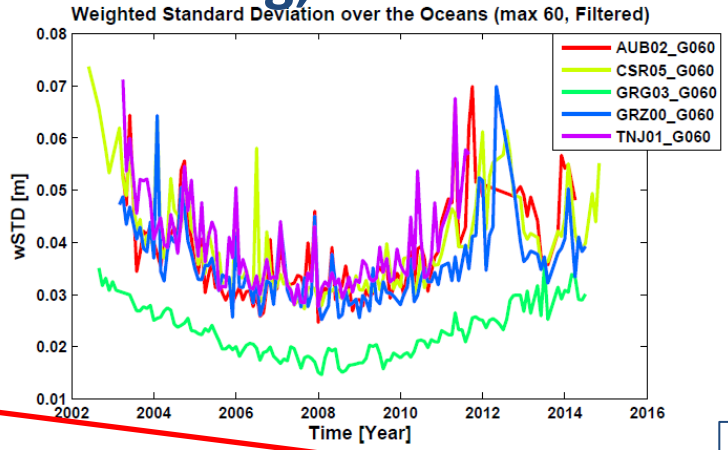
θ: colatitude

STD: Standard Deviation

60 deg, Unfiltered

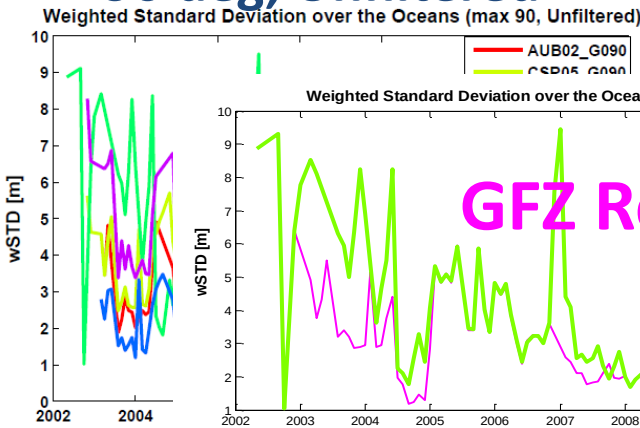


60 deg, Filtered

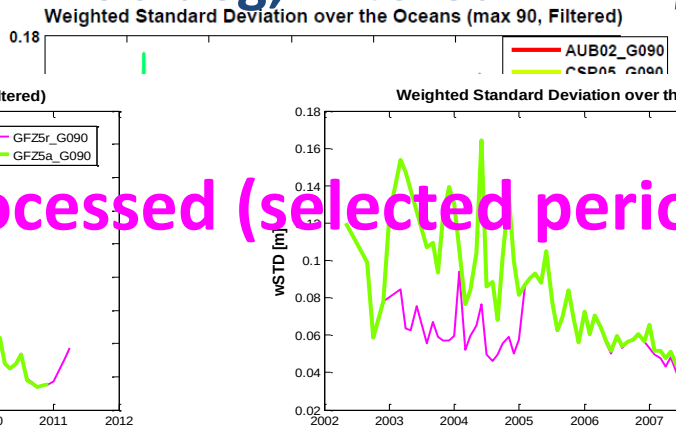


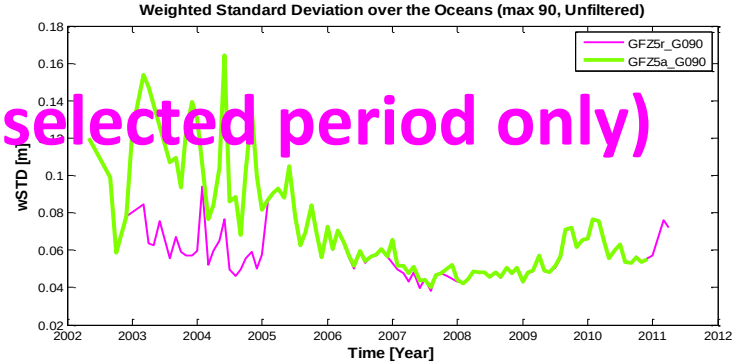
Different level of Noise in GRGS solution

90 deg, Unfiltered



90 deg, Filtered





GFZ Reprocessed (selected period only)

Combined Solutions

- Included Individual Solutions:

Degree 60 Combined Solution	
AUB02_G060	*AIUB 60*
CSR05_G060	*CSR 60*
GRZ00_G060	*GRAZ 60*
TNJ01_G060	*Tongji 60*

Degree 90 Combined Solution		
AUB02_G090		*AIUB 90*
CSR05_G090	(96 → 90)	*CSR 96*
GFZ5a_G090		*GFZ 90*
GRZ00_G090		*GRAZ 90*
JPL01_G090		*JPL 90*

Not included:

- DMT *Pre-filtered*
- GRGS *Different Solution Space*

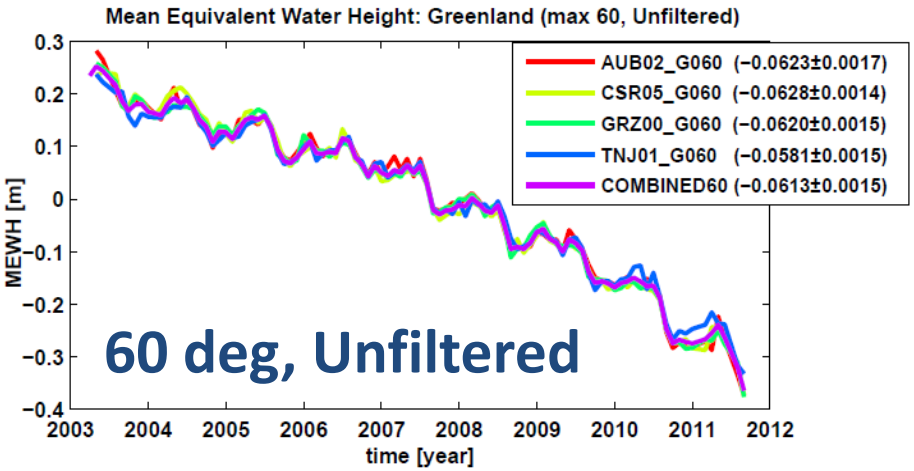
Weights are based on
(Individual Solution – Arithmetic Mean)$^{-2}$

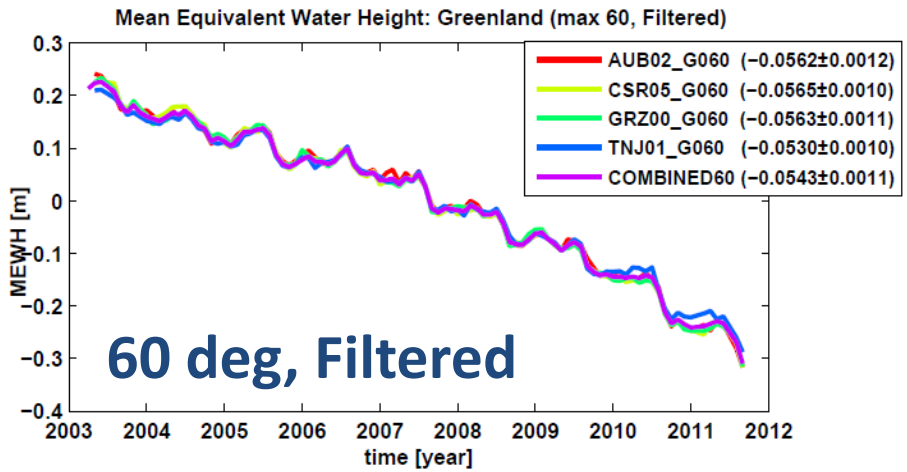
- Combined Solutions:

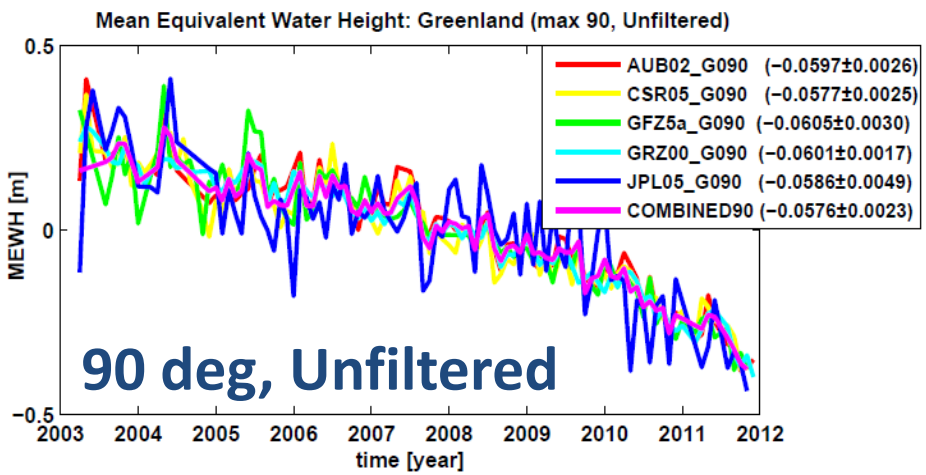
	Label	Type of Combined Solution	Weight
1	**CMB00**	**Simple Arithmetic Mean**	Identical weights
2	**CMB02**	Coefficient–wise **Weighted Mean**	Each **L** and each **M** in each **Month**
3	**CMB03**	Order–wise **Weighted Mean**	Each **M** in each **Month**
4	**CMB05**	Month–wise **Weighted Mean**	Each **Month**

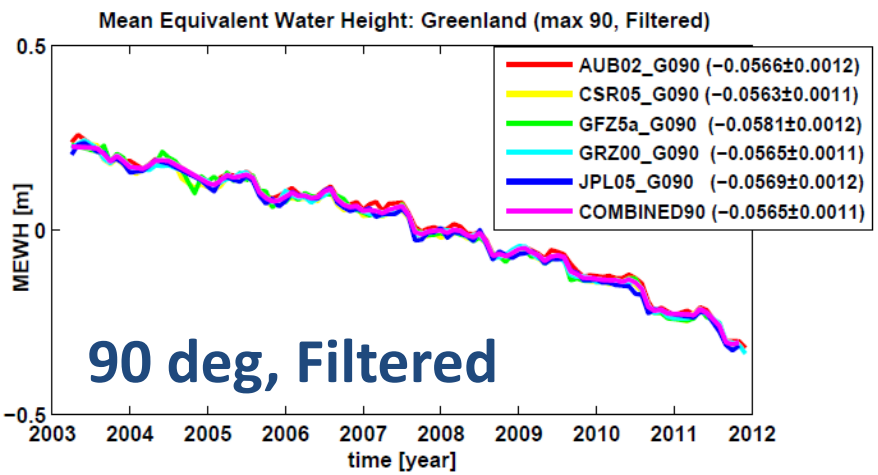
Combined Solution 1: without Weight

- MEWH in Greenland (Signal)









Combined Solution 2: Coefficient-wise Comparison (60 deg)

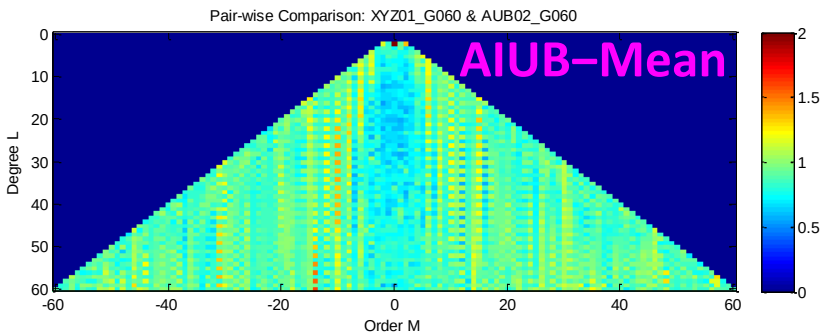
Nsol*(normalized RMS w.r.t. Mean)

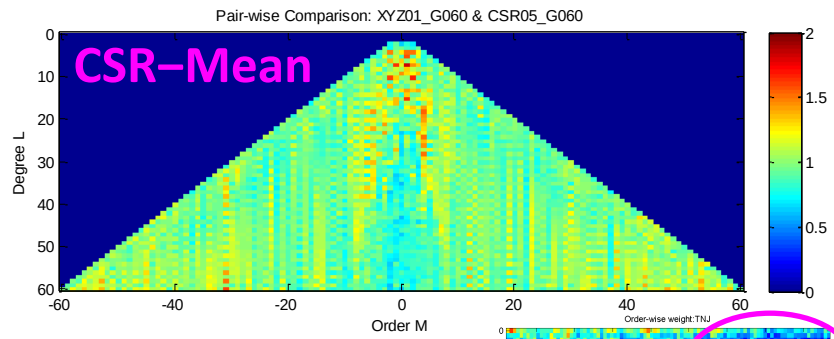
→ Difference from Mean

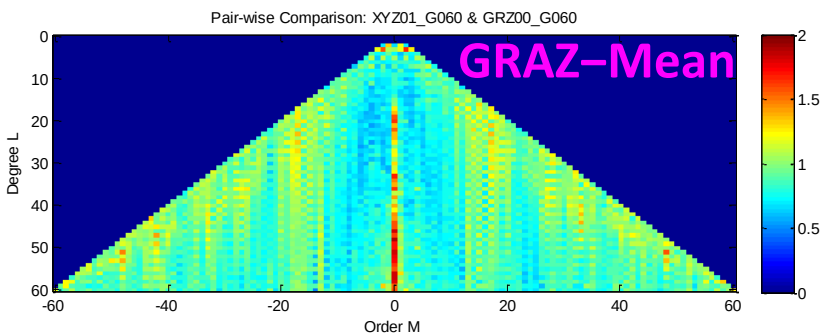
1 : Expected level

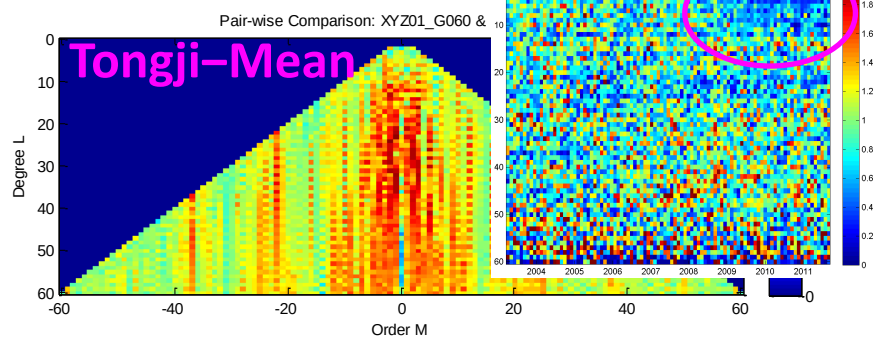
>1 : Larger difference from mean

Solution	Problems in
AIUB	Resonance Orders
CSR	Low Degrees & Low Order
GRAZ	Degree 3 and Zonal Coefficients
Tongji	Low Orders

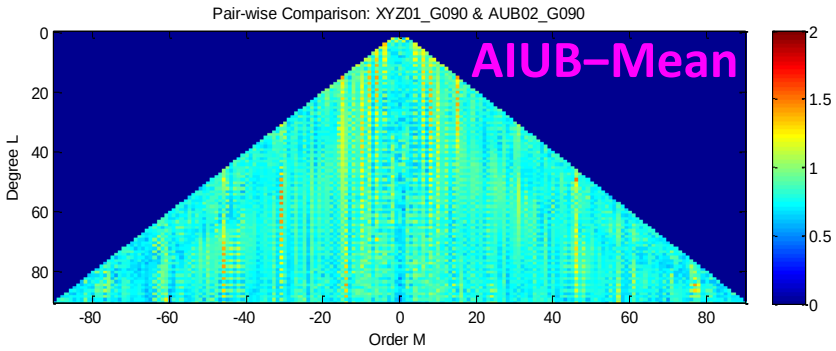


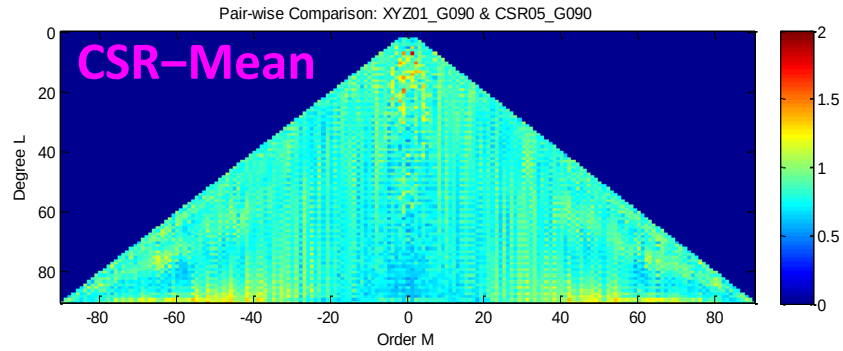


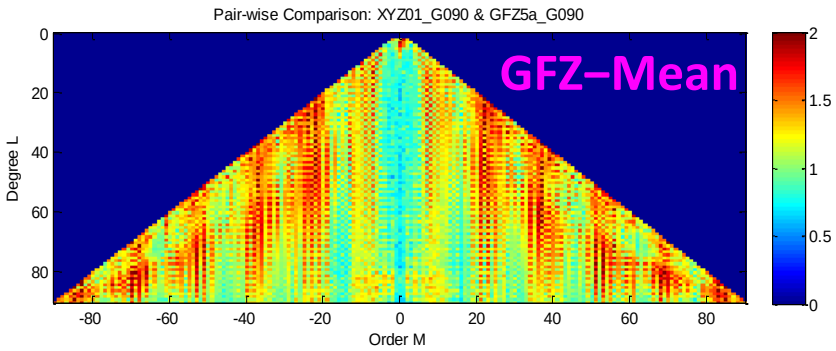


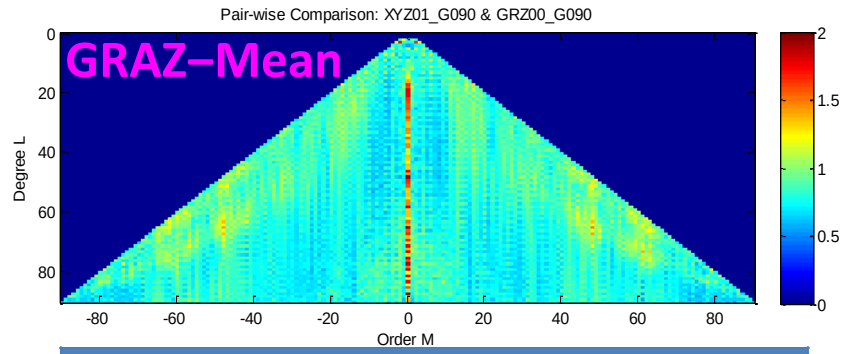


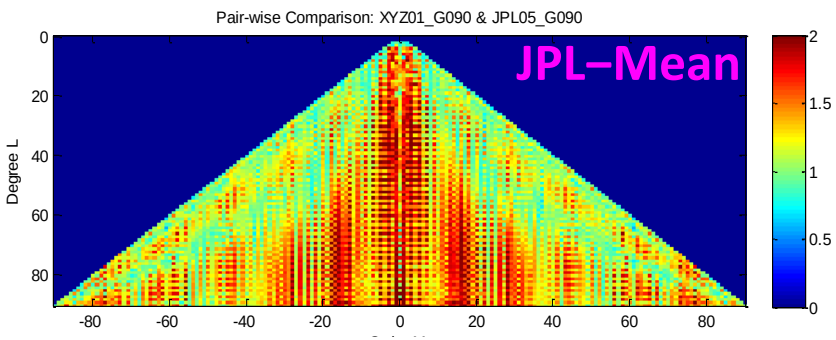
Combined Solution 2: Coefficient-wise Comparison (90 deg)







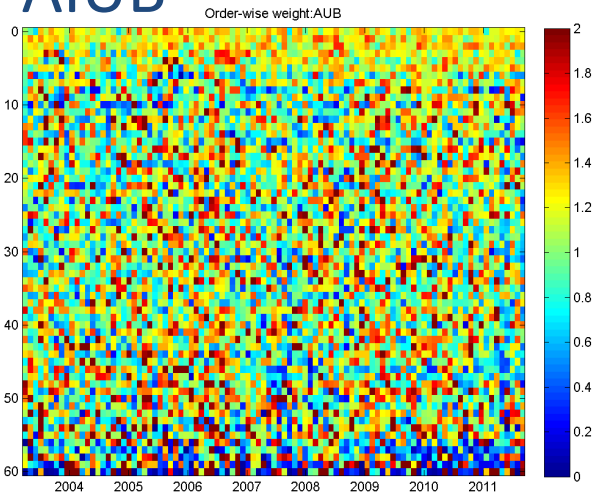




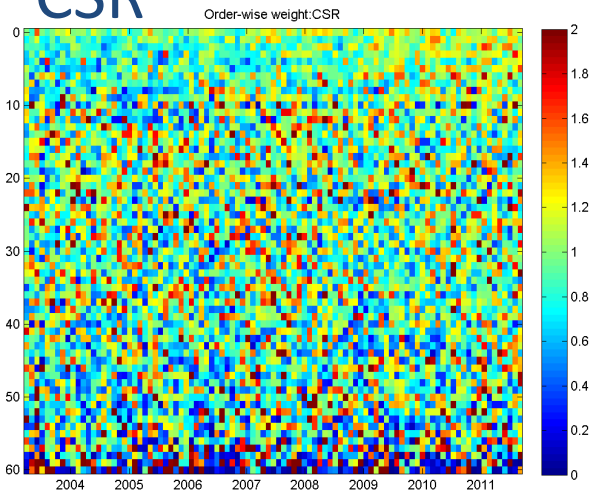
Solution	Problem in
AIUB	Resonance Orders
CSR	Low Degrees & Low Orders
GFZ	Periodic Order-specific
GRAZ	Degree 3, Zonal Coeff.
JPL	Under the *JPL-Curtain*

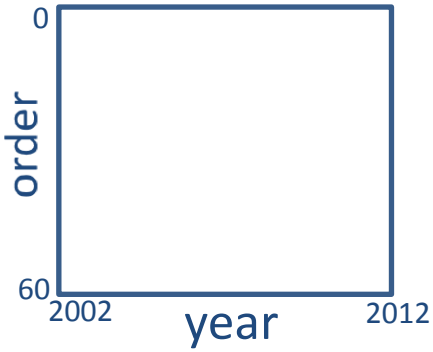
Combined Solution 3: Order-wise Weights (60 deg)

AIUB

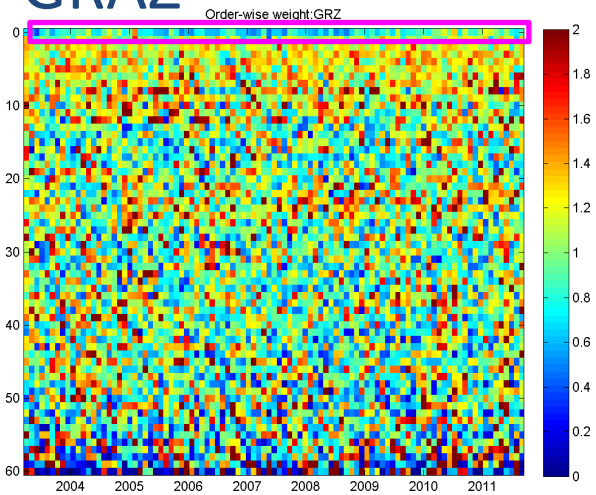


CSR

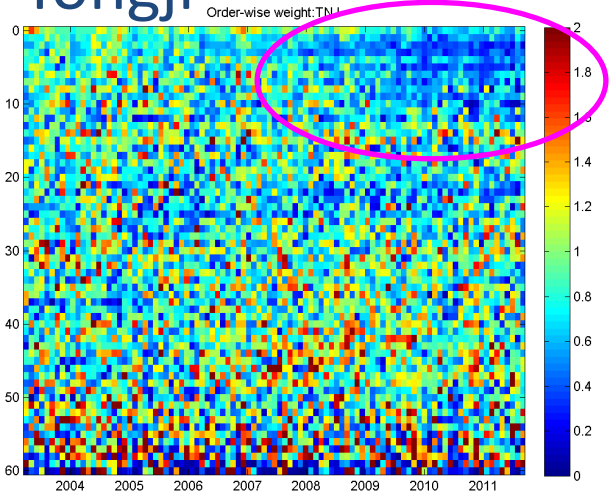




GRAZ



Tongji

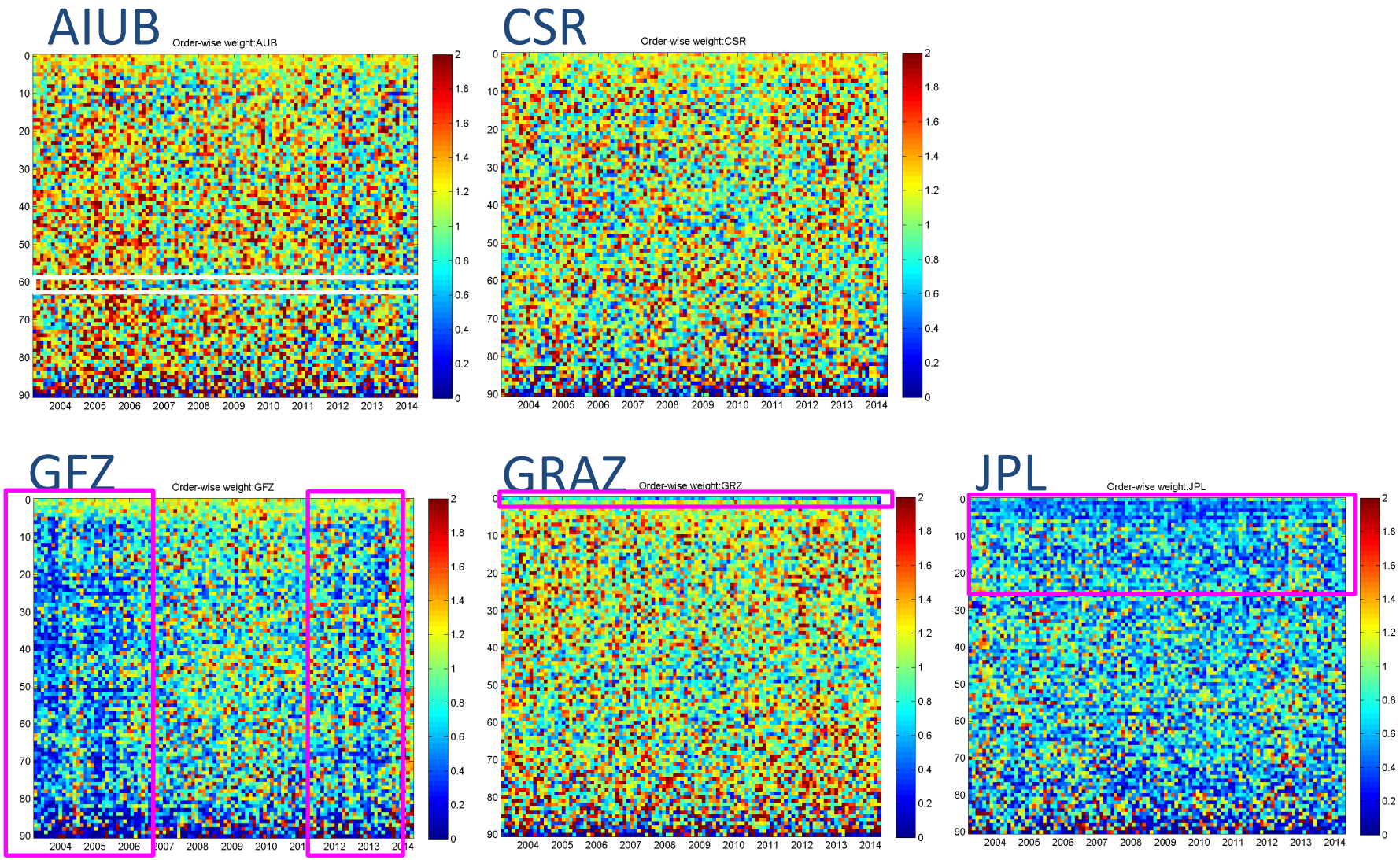


- Computed using
  (Nsol*)
  $[(\text{Indiv. Sol.}) - (\text{Mean Sol.})]^{-2}$
  $/\Sigma\ [(\text{Indiv. Sol.}) - (\text{Mean Sol.})]^{-2}$

- Nominal Weight
  → Scaled to 1

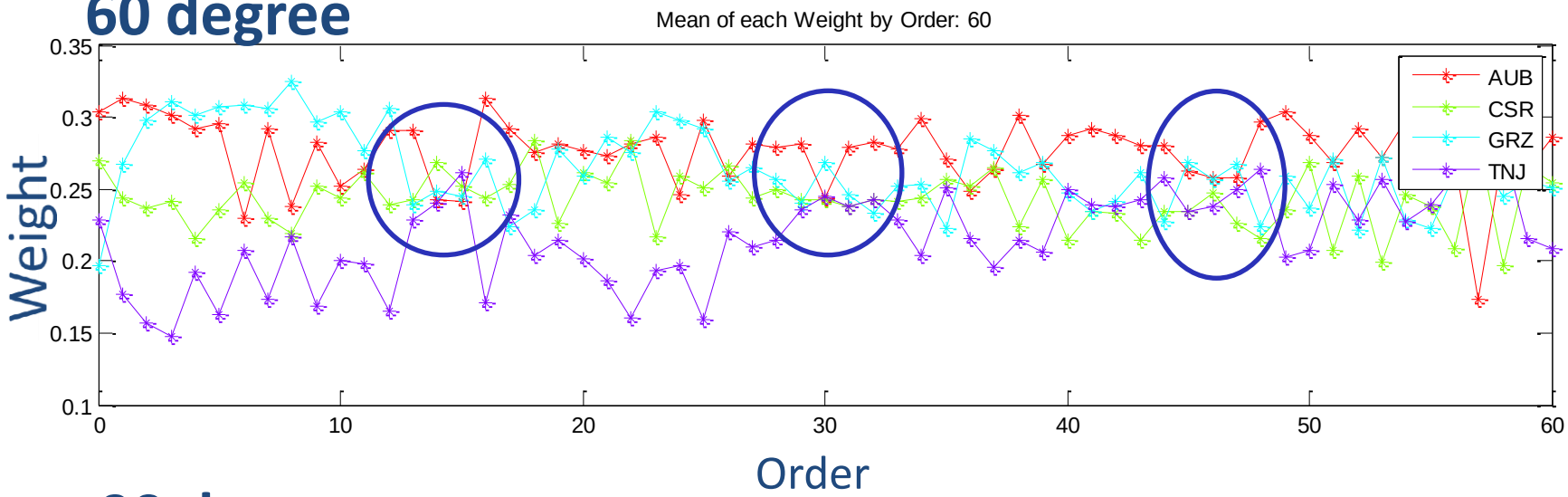
- Weight < 1 : Down-weighted

Combined Solution 3: Order-wise Weights (90 deg)

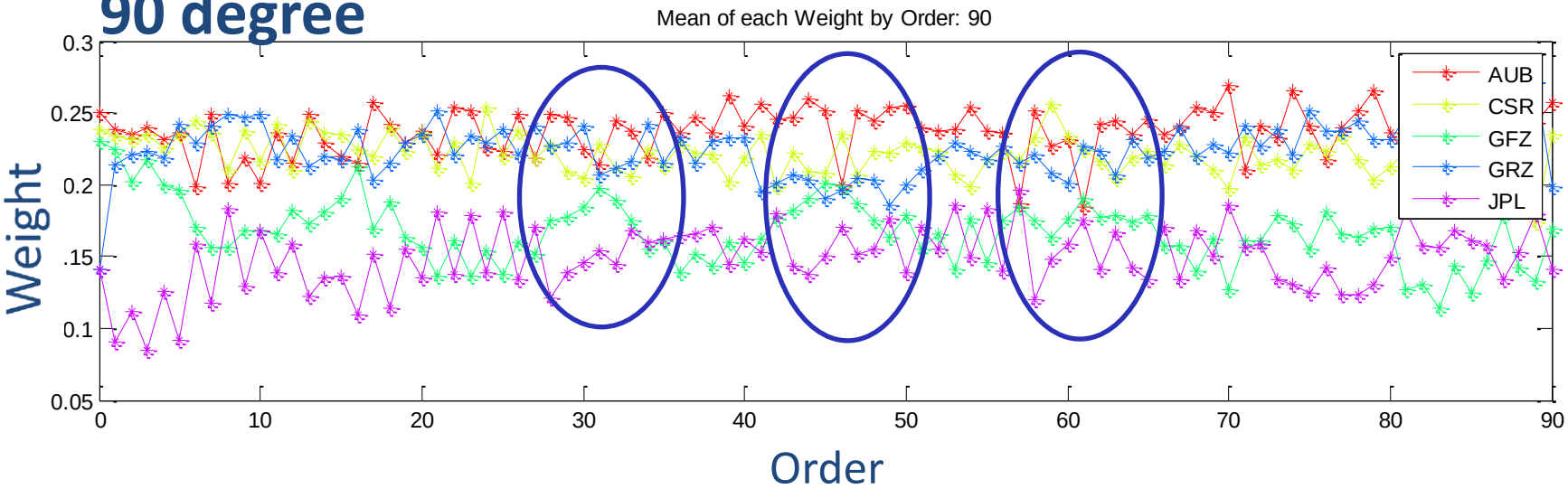


Combined Solution 3: Order-wise Weights

60 degree

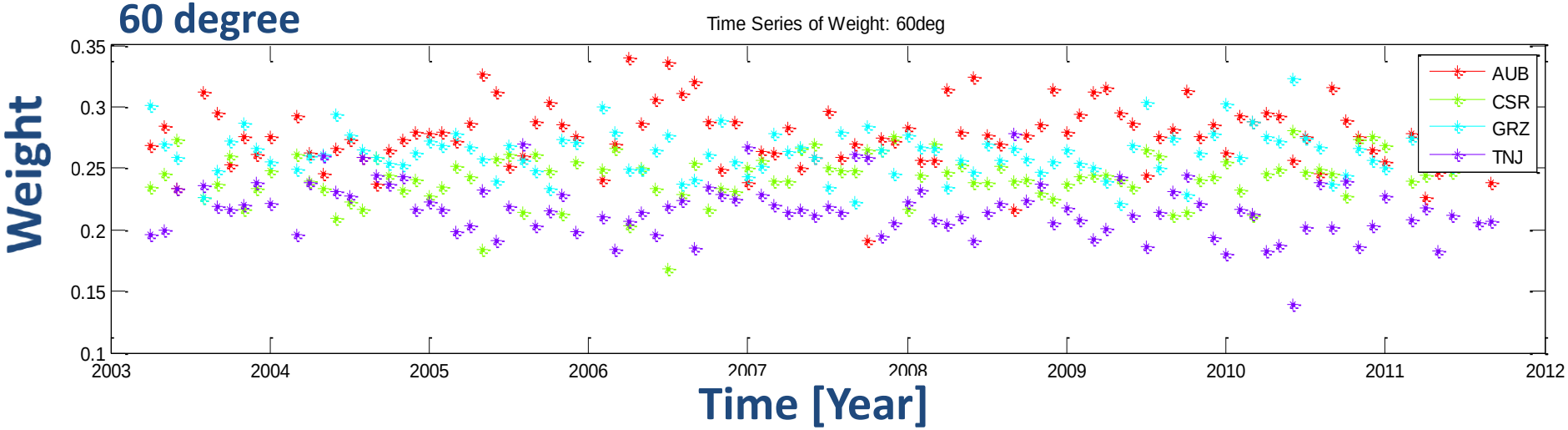


90 degree

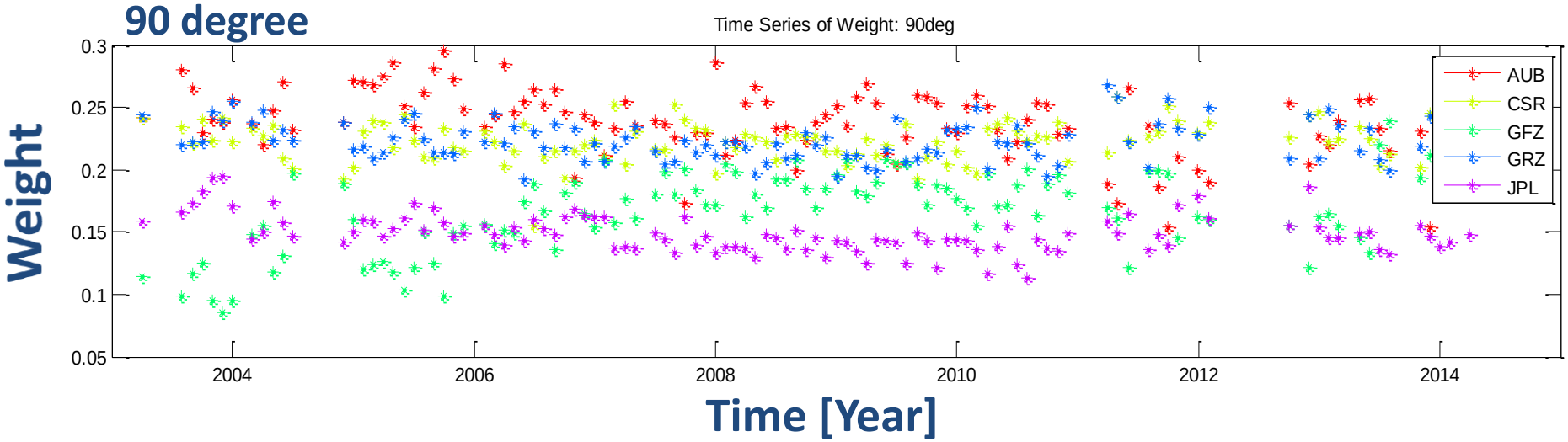


Combined Solution 4: Month-wise Weight

60 degree

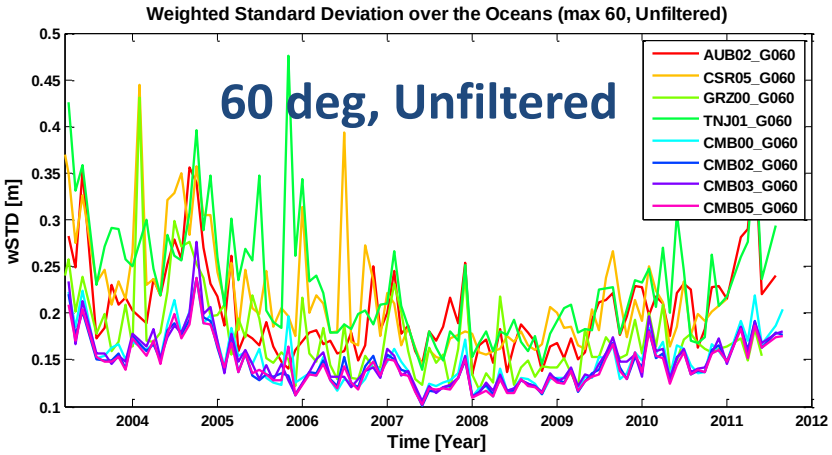


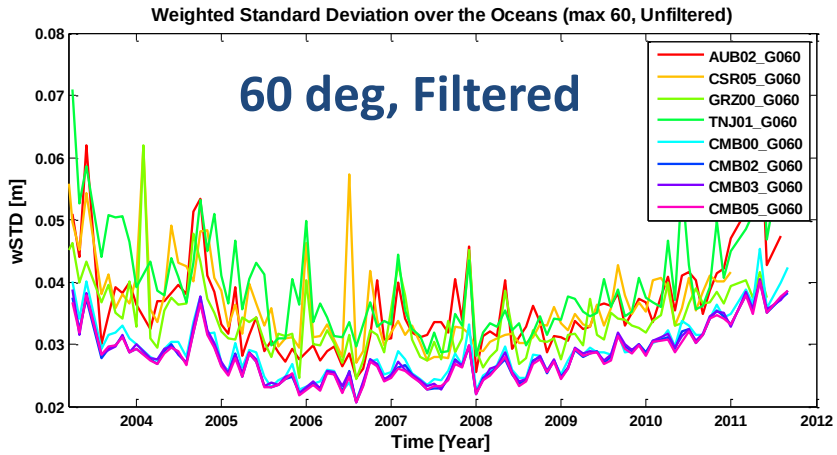
90 degree

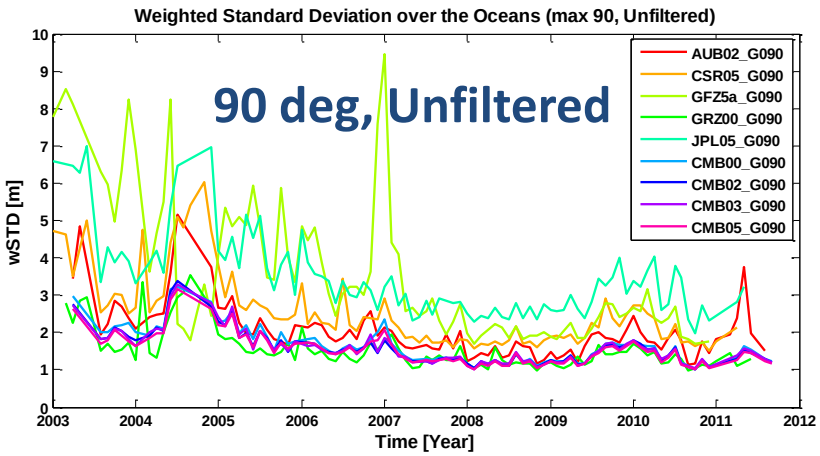


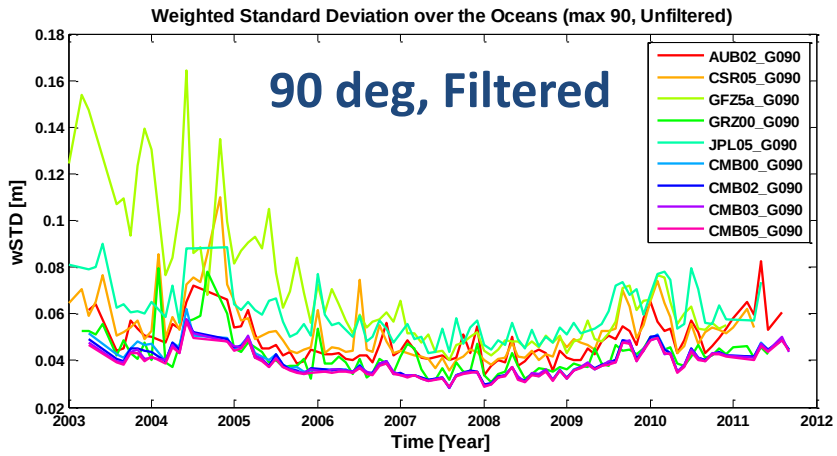
Individual and Combined Solutions: Noise

- wSTD over the oceans









Conclusions

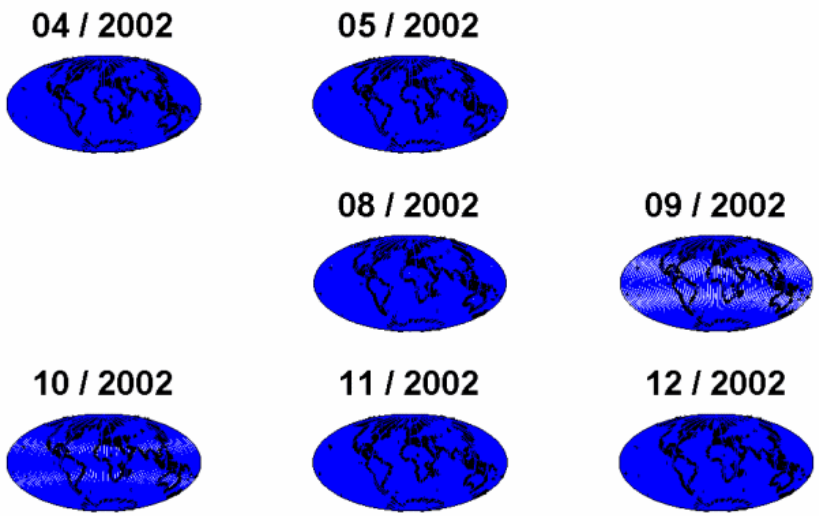
- Comparison
  - AIUB, CSR, GFZ, GRAZ, JPL, Tongji
    : comparable processing strategies, signal/noise
  - DMT, GRGS: different characteristics

- Combined Solution
  - Different weighting schemes including simple average with equal weights
  - *Is weighted combined solutions better than simple mean solution* ?
  - *Coefficient-wise weight / Month-wise Weight* ?

- Validation

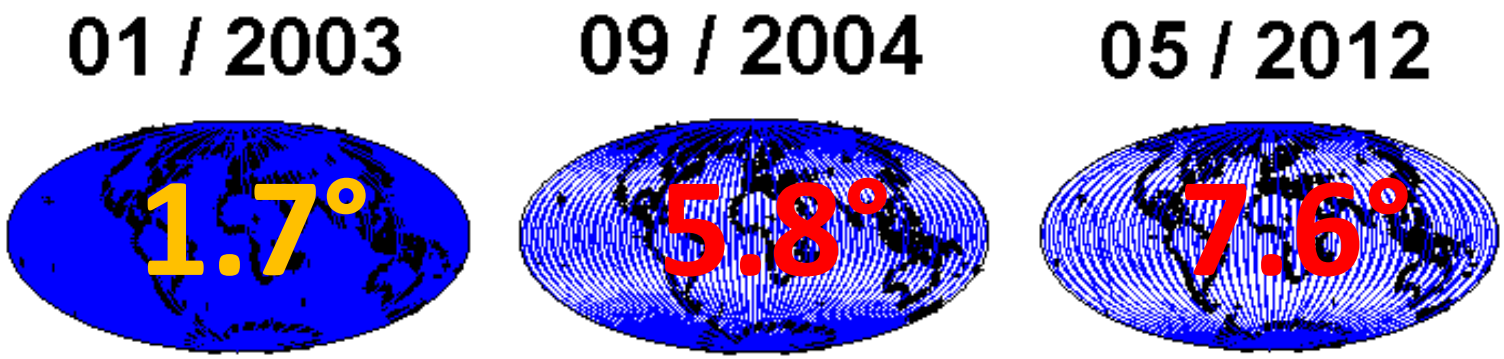
(Short Discussion) Ground-Track of GRACE Orbit: next slides

Ground Track of GRACE–A Satellite: 2002–2014



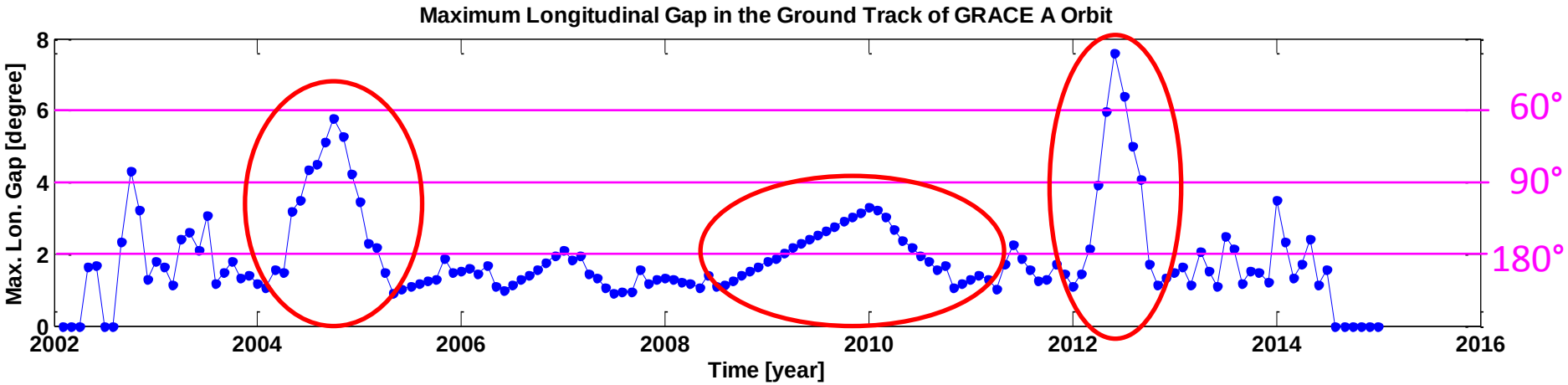
- **Plan** to provide the **ground-track** images through the **EGSIEM website**
- *Question: Where to put this on the EGSIEM website?*
- A Quality Indicator: ***Maximum longitudinal gap in ground track***

Maximum Longitudinal Gap in Ground Track: 2002–2006



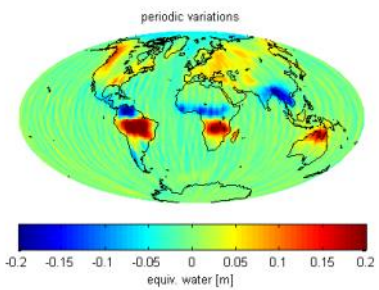
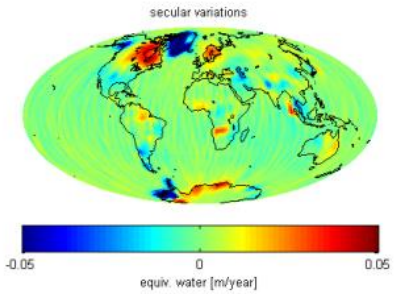
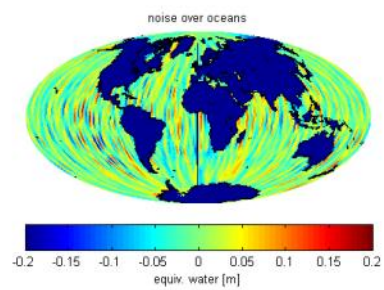
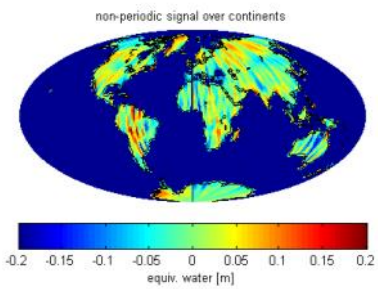
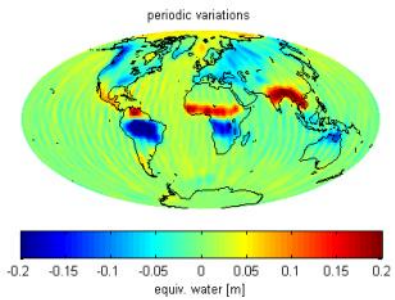
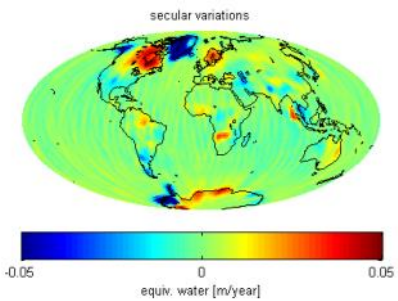
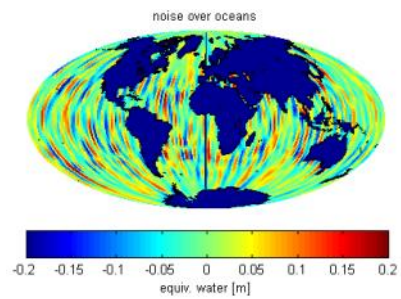
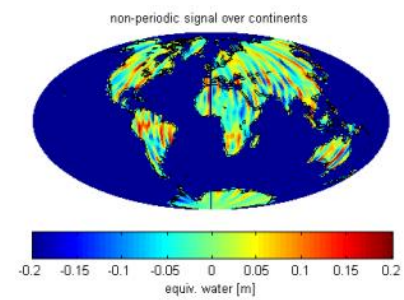
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002				04-2002 1.6	05-2002 1.7			08-2002 2.3	09-2002 4.3	10-2002 3.2	11-2002 1.3	12-2002 1.8
2003	01-2003 1.7	02-2003 1.3	03-2003 2.4	04-2003 2.6	05-2003 2.1	06-2003 3.1	07-2003 1.2	08-2003 1.5	09-2003 1.8	10-2003 1.3	11-2003 1.4	12-2003 1.2
2004	01-2004 1.9	02-2004 1.6	03-2004 1.5	04-2004 3.2	05-2004 3.5	06-2004 4.3	07-2004 4.5	08-2004 5.1	09-2004 5.8	10-2004 5.3	11-2004 4.2	12-2004 3.5
2005	01-2005 2.3	02-2005 2.2	03-2005 1.5	04-2005 1.0	05-2005 1.1	06-2005 1.1	07-2005 1.2	08-2005 1.3	09-2005 1.3	10-2005 1.9	11-2005 1.5	12-2005 1.5
2006	01-2006 1.6	02-2006 1.4	03-2006 1.7	04-2006 1.1	05-2006 1.0	06-2006 1.1	07-2006 1.3	08-2006 1.4	09-2006 1.6	10-2006 1.8	11-2006 2.0	12-2006 2.2

Maximum Longitudinal Gap in Ground Track: 2007–2014



2010	3.2	3.0	2.7	2.4	2.2	1.9	1.8	1.6	1.7	1.0	1.2	1.4
	01-2011	02-2011	03-2011	04-2011	05-2011	06-2011	07-2011	08-2011	09-2011	10-2011	11-2011	12-2011
2011	1.4	1.3	1.0	1.7	2.3	1.9	1.6	1.3	1.3	1.8	1.4	1.1
	01-2012	02-2012	03-2012	04-2012	05-2012	06-2012	07-2012	08-2012	09-2012	10-2012	11-2012	12-2012
2012	1.5	2.3	3.9	6.0	7.6	6.4	5.0	4.1	1.7	1.1	1.3	1.5
	01-2013	02-2013	03-2013	04-2013	05-2013	06-2013	07-2013	08-2013	09-2013	10-2013	11-2013	12-2013
2013	1.6	1.1	2.1	1.5	1.1	2.5	2.1	1.2	1.6	1.6	1.2	3.5
	01-2014	02-2014	03-2014	04-2014	05-2014	06-2014						
2014	2.3	1.3	1.7	2.6	1.1	1.6						

Quality Check (for Website)

	Periodic Variation	Secular Variation	Noise over Oceans	Non-periodic signal & noise over continents
03/2008 *Normal (90°)*				
09/2004 *Resonance (60°)*				
09/2004 *Resonance (90°)*