

Reassessment of the DDK-filter method with actual error covariance information

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1.2 Global Geomonitoring and Gravity Field

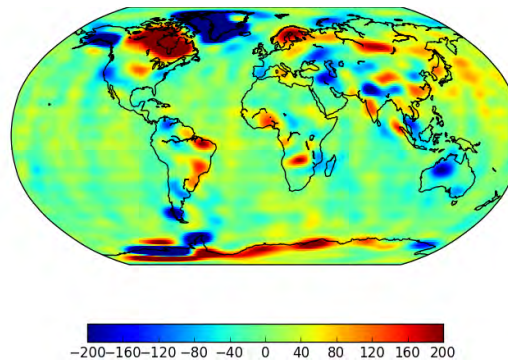
GSTM 2017, Austin

Outline

- Post-processing GRACE
- DDK and its reassessment
- Simulated data
- Real data
- Conclusion

Post-processing GRACE

- Gaussian smoothing
- Destriping (Swenson and Wahr 2006)
- DDK (Kusche 2007)
- Regularization techniques during Level-2 processing



It leads to: attenuation of the signal amplitude and leakage-in.
What else?

DDK

$$x \downarrow \alpha = W \downarrow \alpha x = (N + \alpha M)^{-1} N x$$

$x \downarrow \alpha$ filtered fully normalized spherical harmonic coefficients

$W \downarrow \alpha$ filter matrix

N inverse of the error-covariance matrix

α scaling factor

M inverse of the signal-covariance matrix

N is static (August 2003), block diagonal, and based on GFZ RL03 data.

Reassessment of DDK

1. data quality and orbits configuration change in time;
2. different N are provided from different centers (i.e. GFZ, CSR, ITSG).

Time-variable N from GFZ RL05a in order to filter GFZ RL05a solutions

VADER (Horwath, Murböck and Pail GSTM 2016).

DDK: block diagonal and static

V: full and variable

S: full and static

SG300: Swenson and Gauss 300 km

<i>strong</i>	DDK1	V 1e21 = V1
	DDK2	V 1e20 = V2
	DDK3	V 1e19 = V3
	DDK4	V 5e18 = V4
<i>weak</i>	DDK5	V 1e18 = V5

Simulation

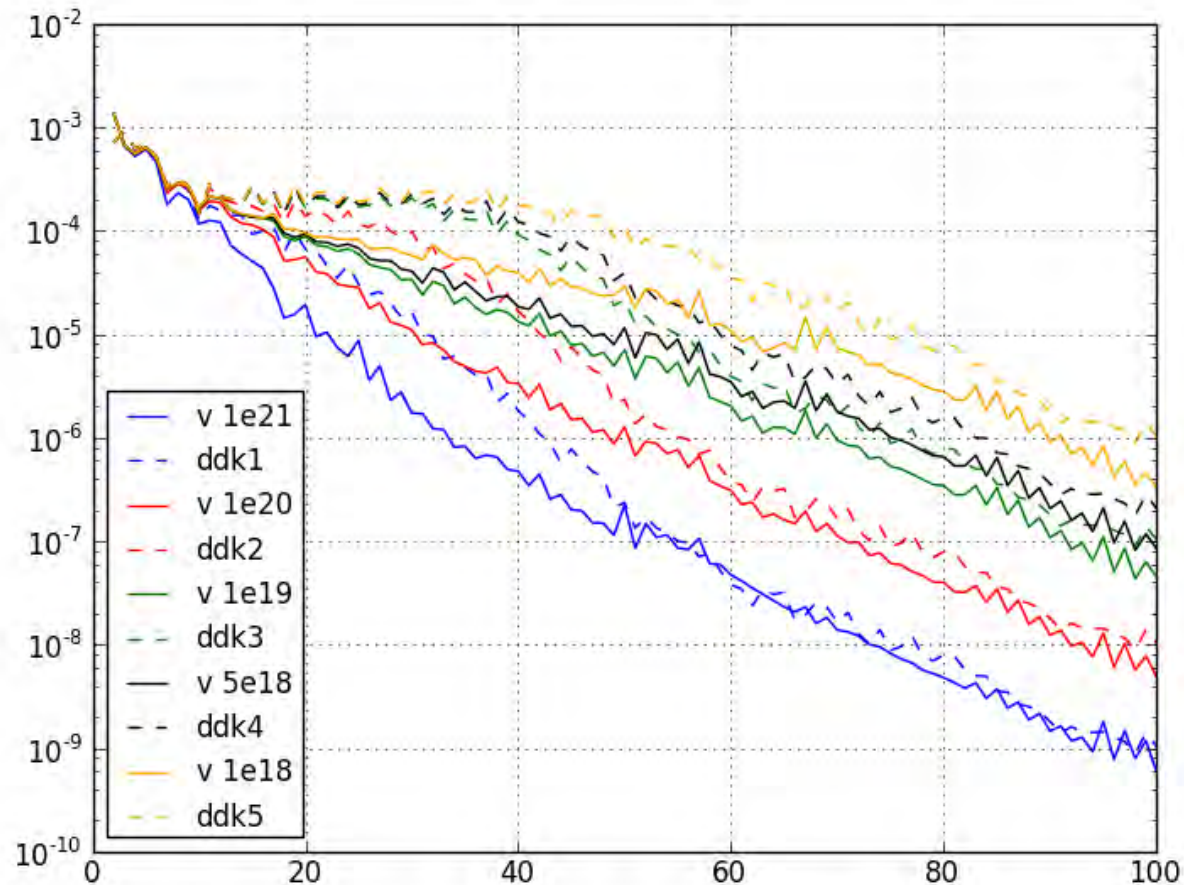
Simulation loop

- Five years 01/2002-12/2006 based on GRACE-like mission design
- Initial altitude 490 km, final altitude 450 km
- Realistic instrument and background model errors applied
- Ground truth: ESA Earth system model AOHIS (Dobslaw et al. 2015)
- Software: GFZ 's Earth Parameters and Orbits System (EPOS)
- Up to degree and order 100

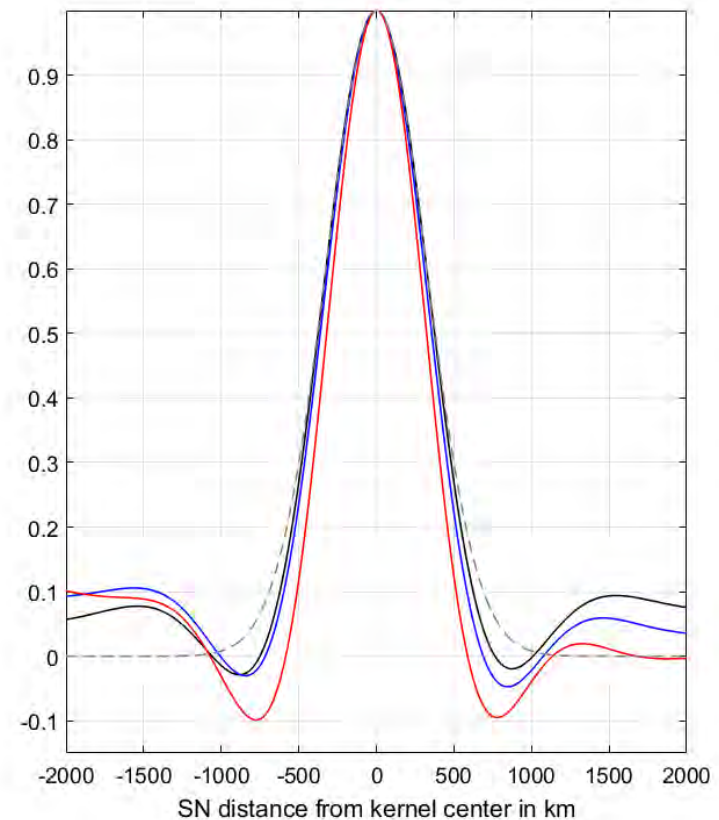
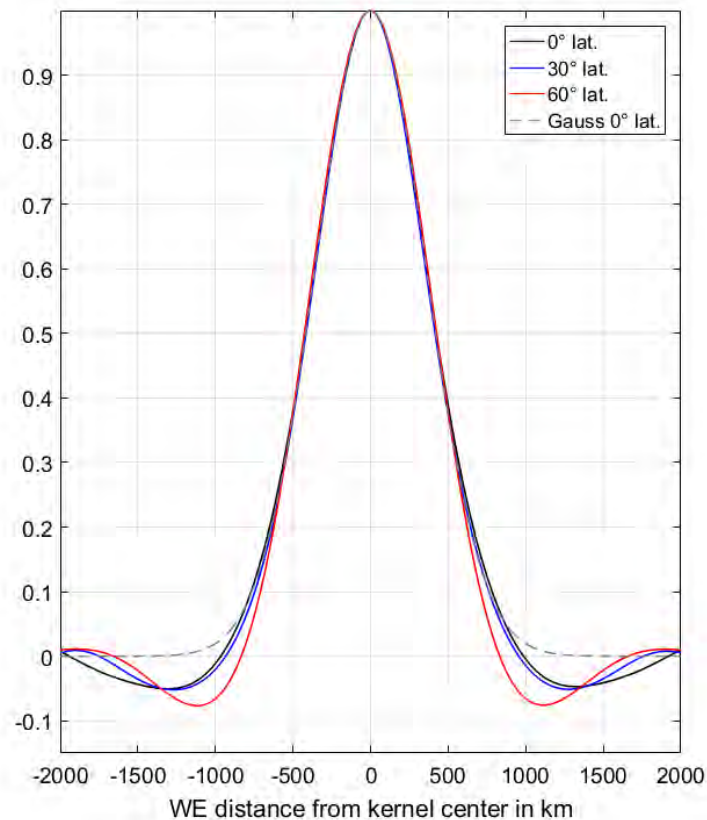
Further details in Flechtner et al. (2016): *What Can be Expected from the GRACE-FO Laser Ranging Interferometer for Earth Science Applications?*

SH degree amplitude

We choose the α_s that minimize the degree amplitude differences:

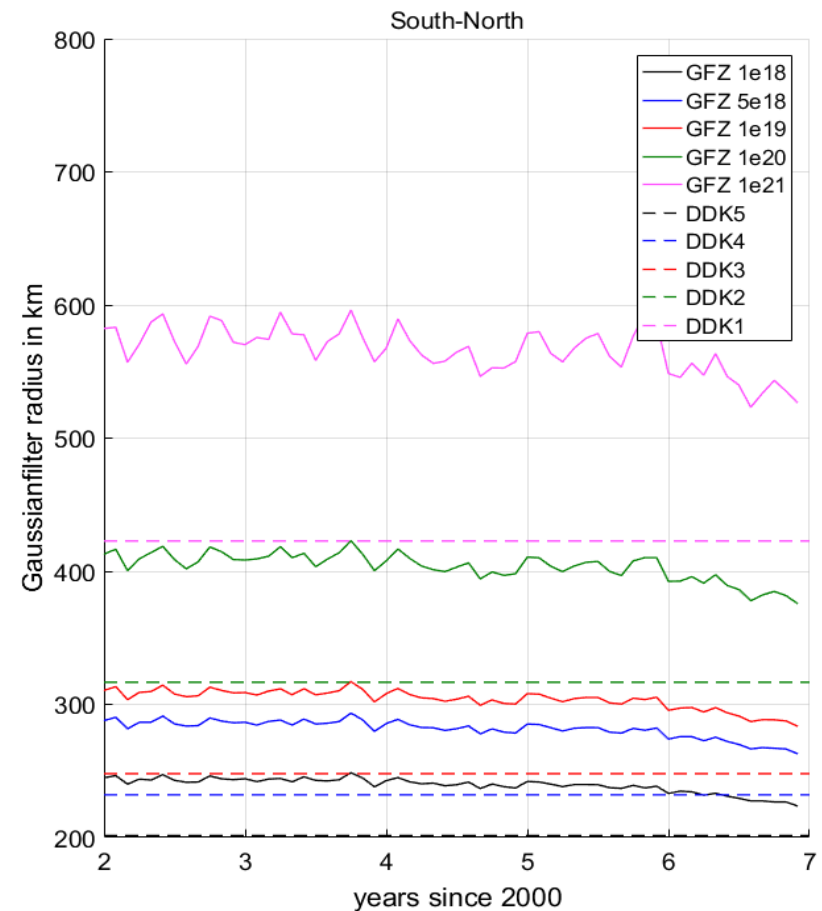
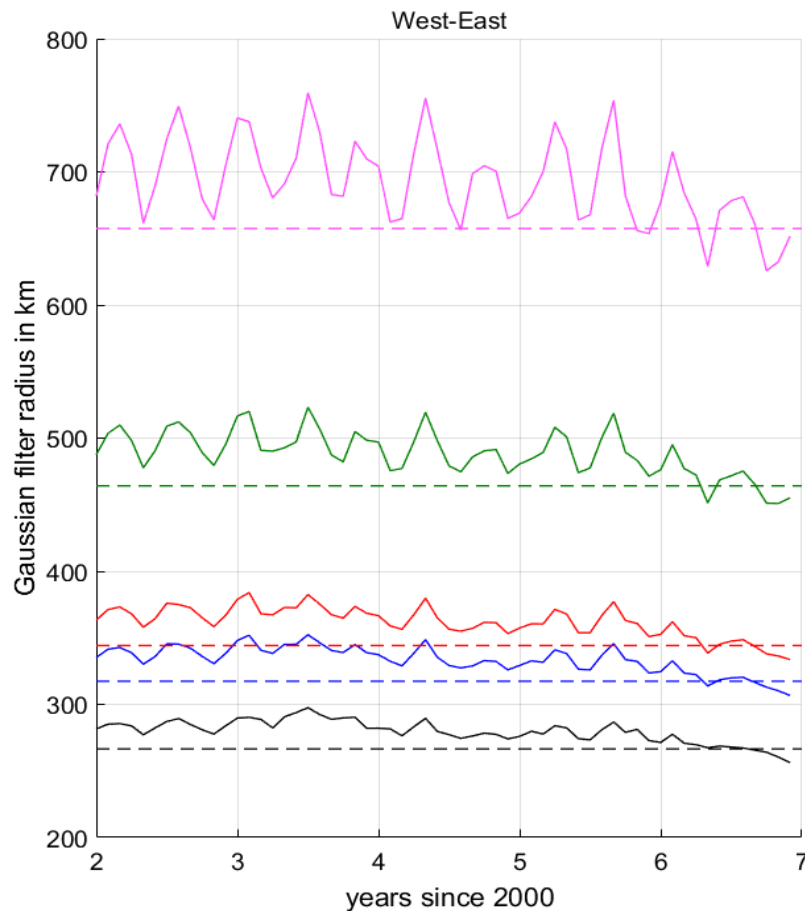


Kernel of V3



- Shape similar to DDK

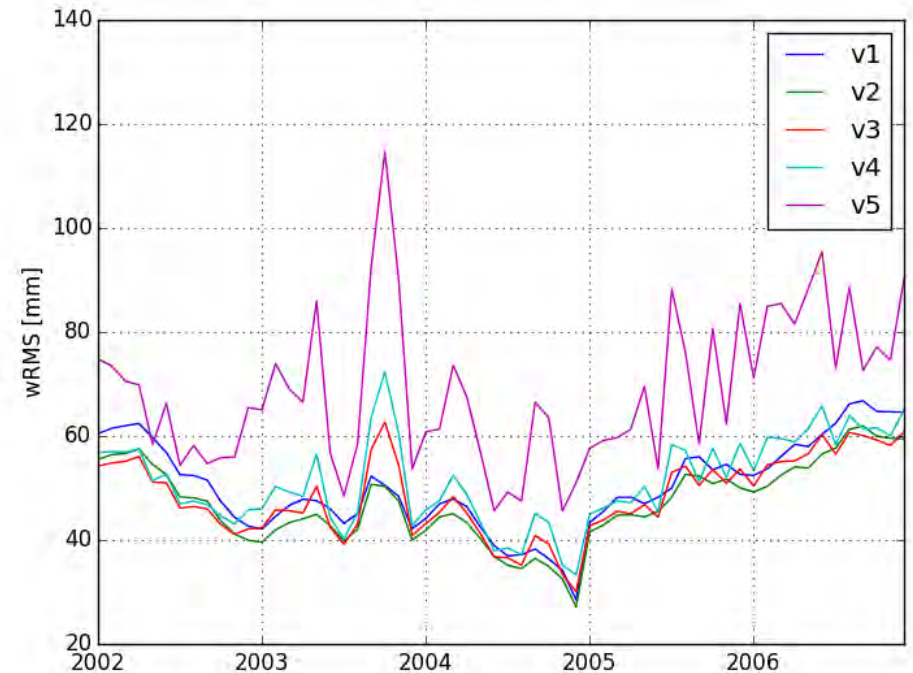
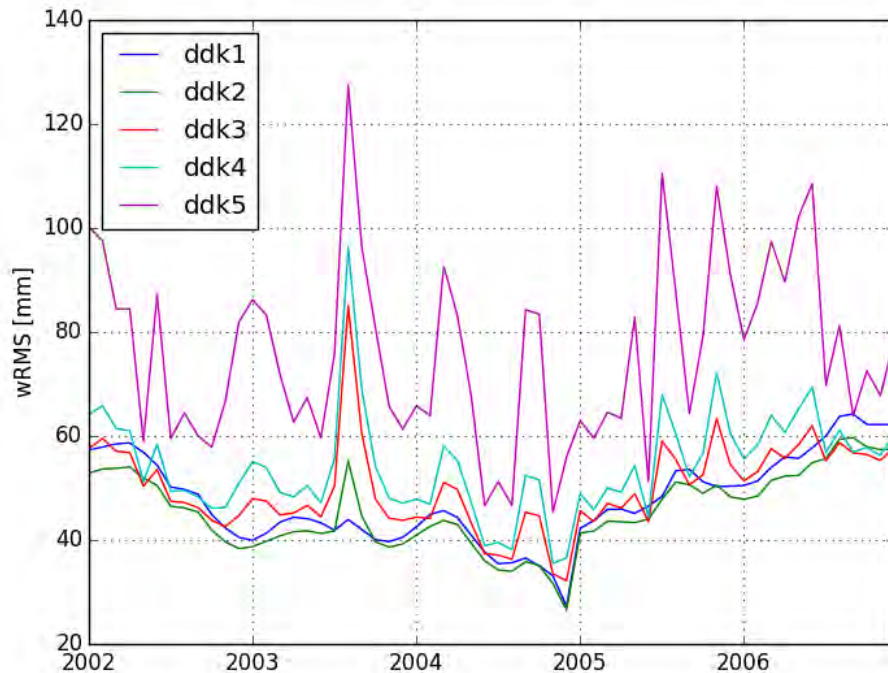
Gaussian radius in time



- Biggest difference in the South-North direction -> V largest

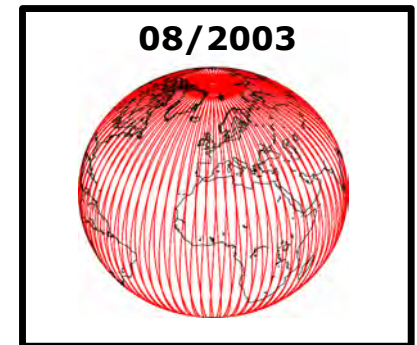
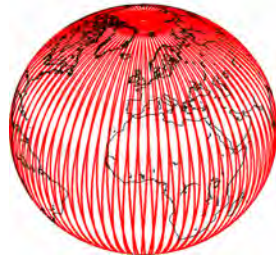
Global wRMS

wRMS deviation of filtered solutions from ground-truth HIS



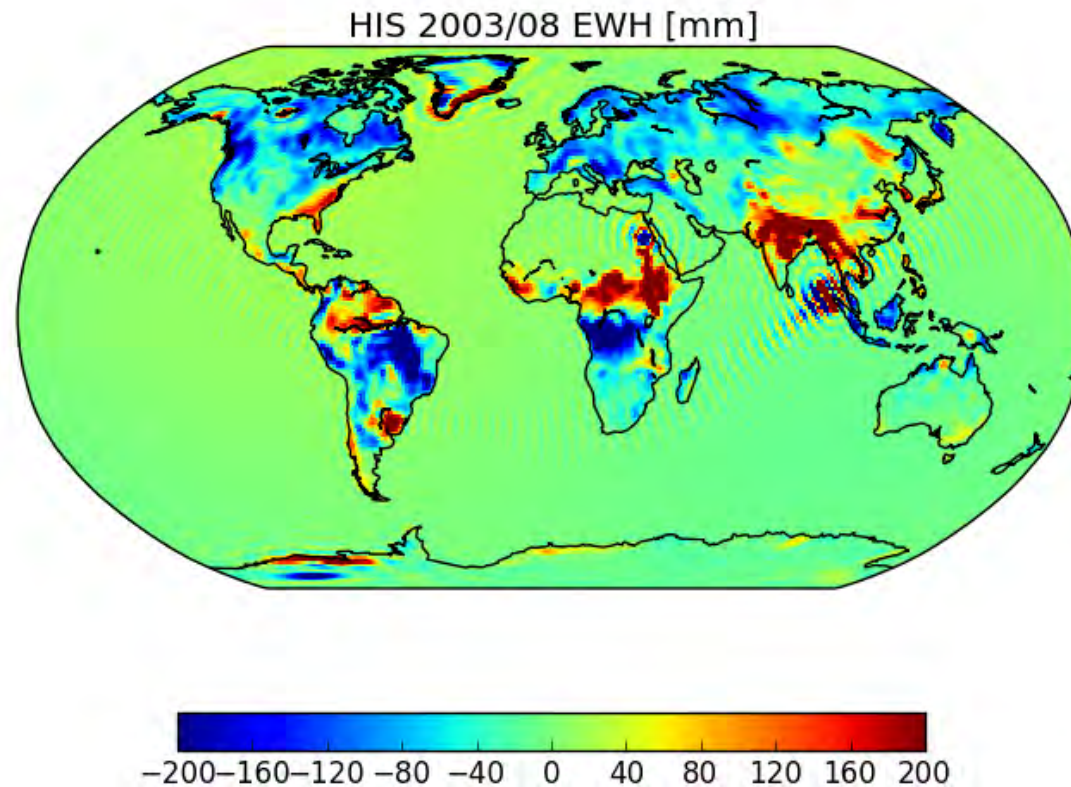
- V shows general lower RMS.
- Growing RMS because of simulated lowering altitude.
- Peaks around 2003/08 because of simulated repeat cycle.

Simulated orbits

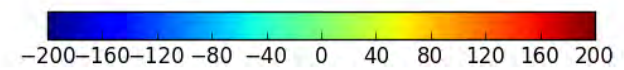
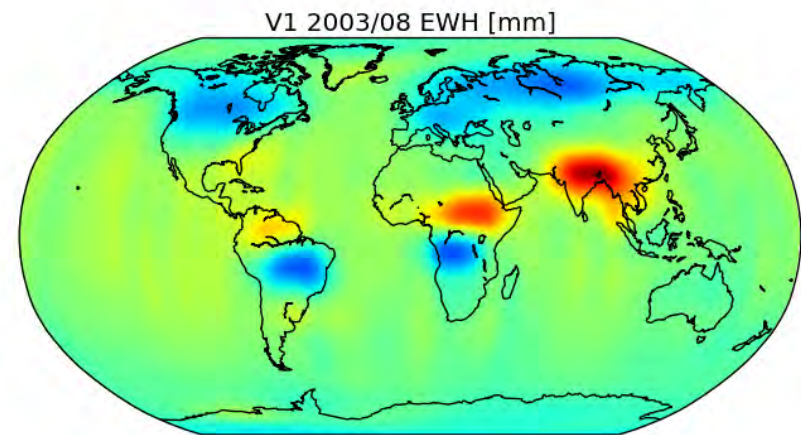
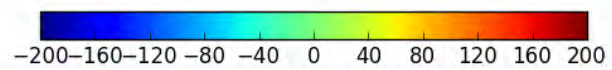
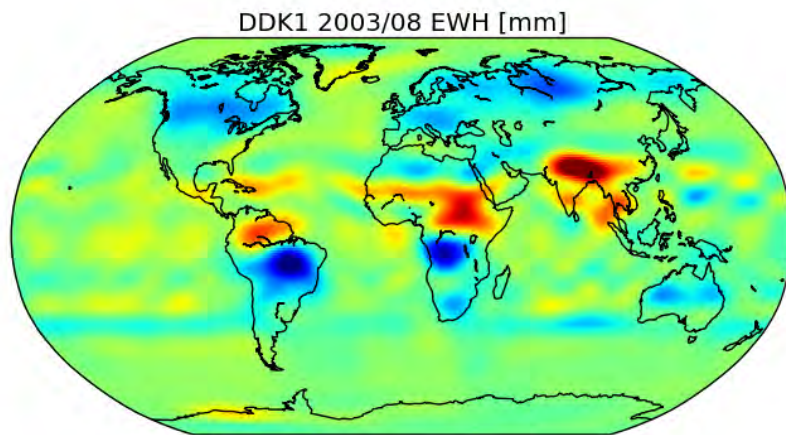


2003/08

Hydrology+Ice+Solid Earth -> ground-truth

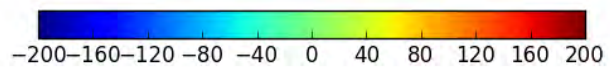
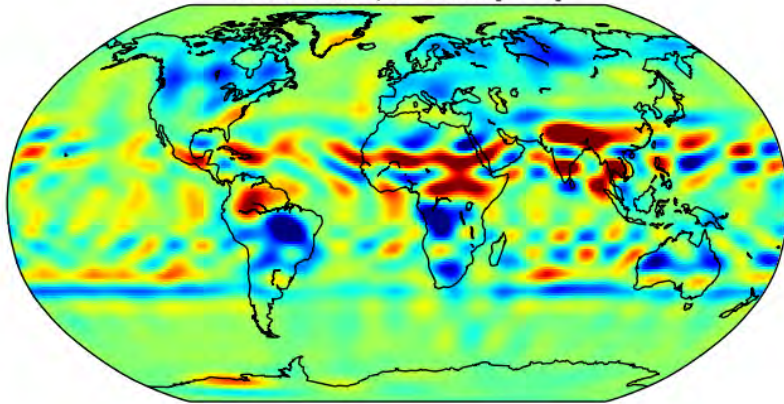


2003/08

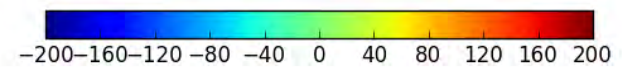
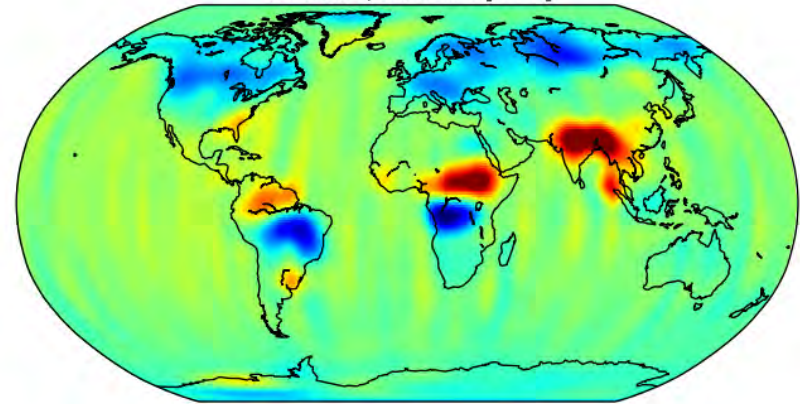


2003/08

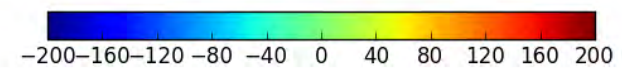
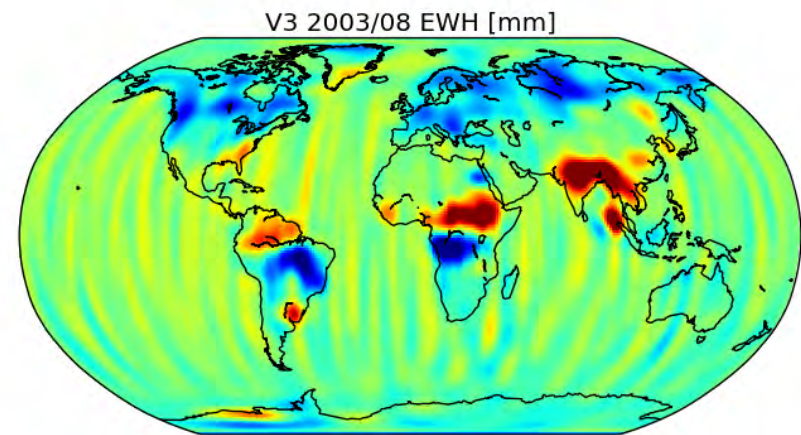
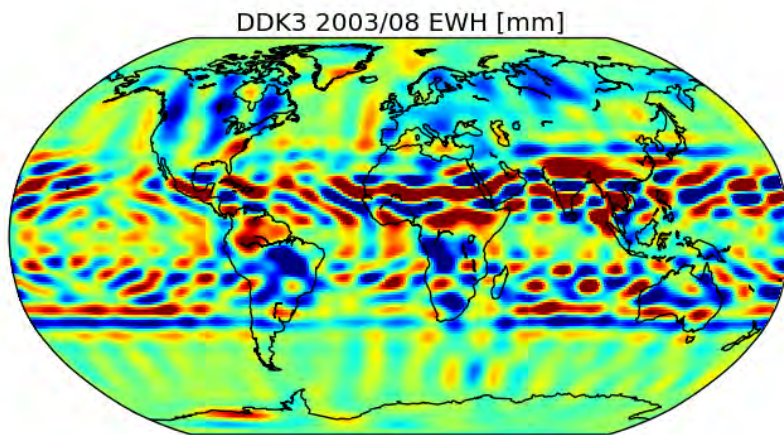
DDK2 2003/08 EWH [mm]



V2 2003/08 EWH [mm]

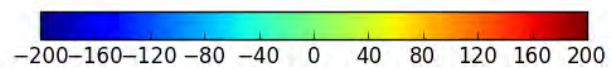
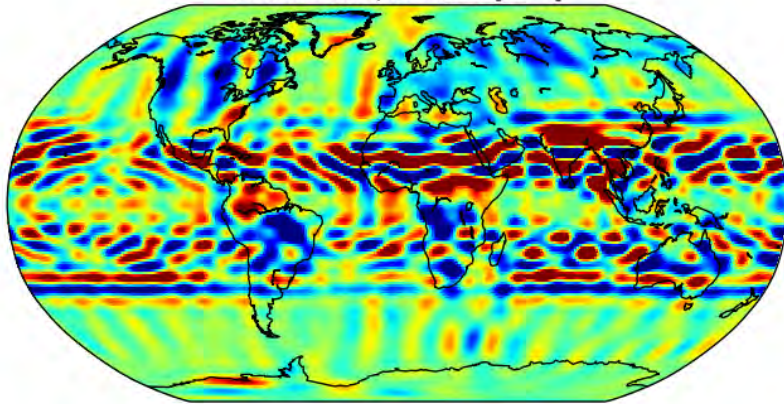


2003/08

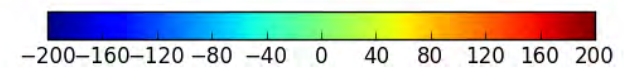
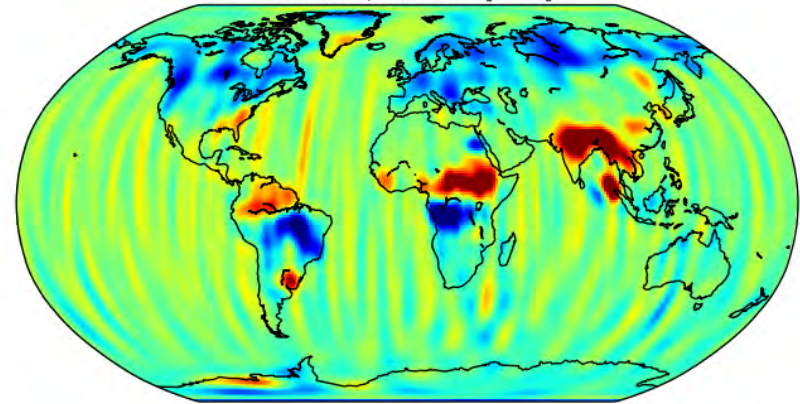


2003/08

DDK4 2003/08 EWH [mm]

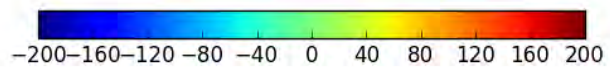
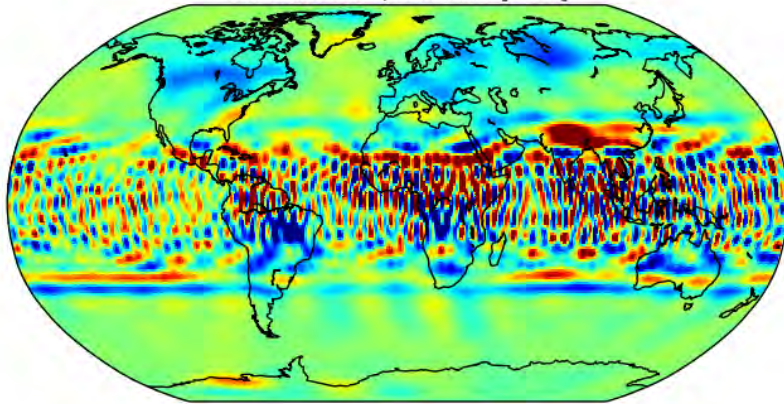


V4 2003/08 EWH [mm]

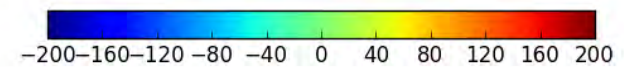
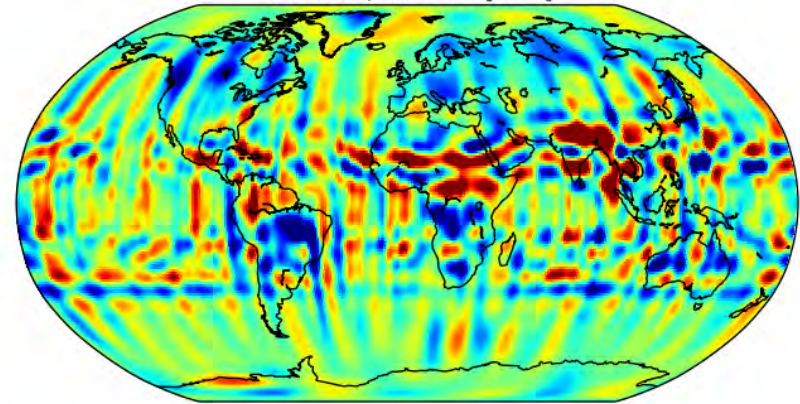


2003/08

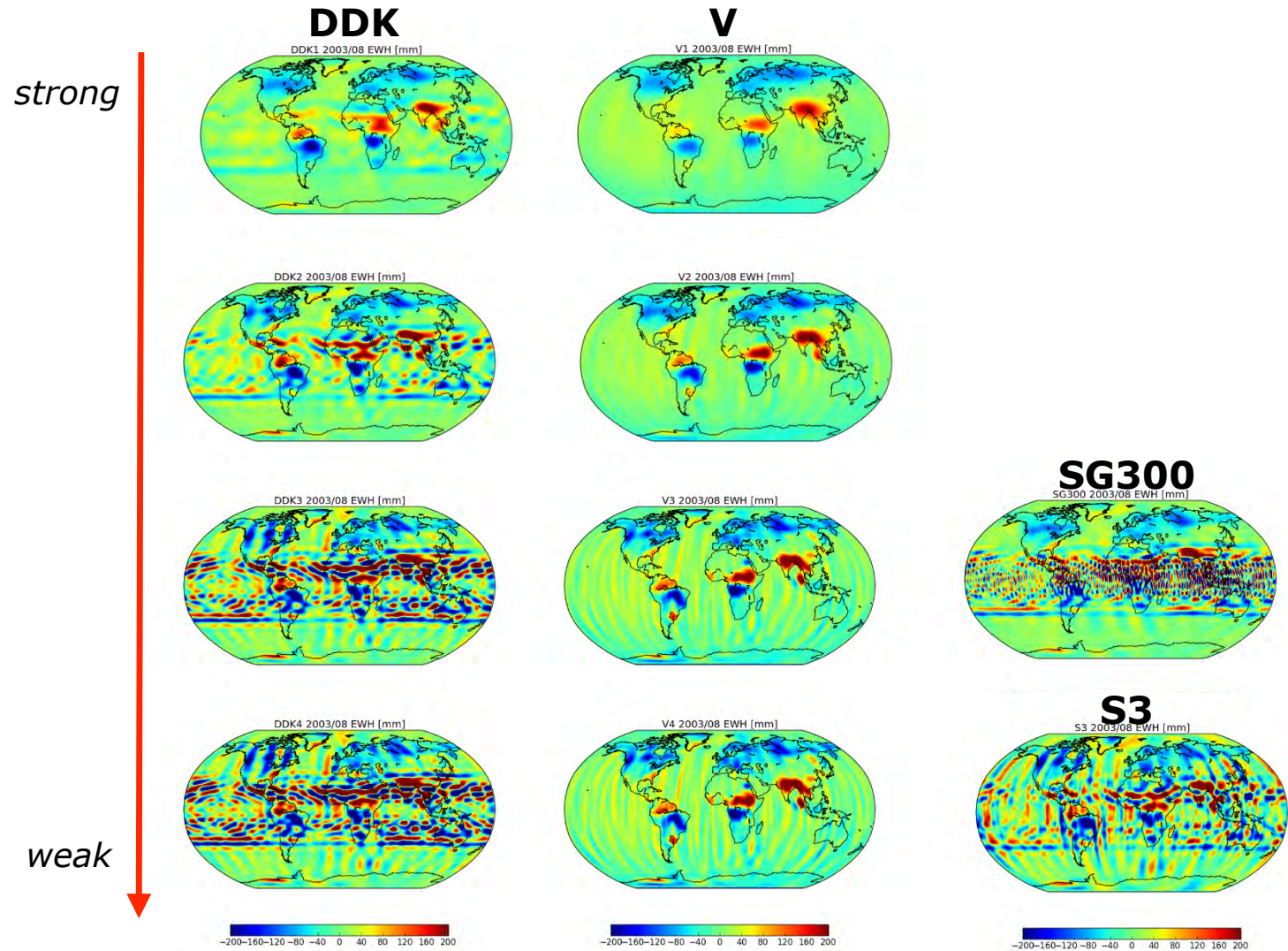
SG300 2003/08 EWH [mm]



S3 2003/08 EWH [mm]



08/2003



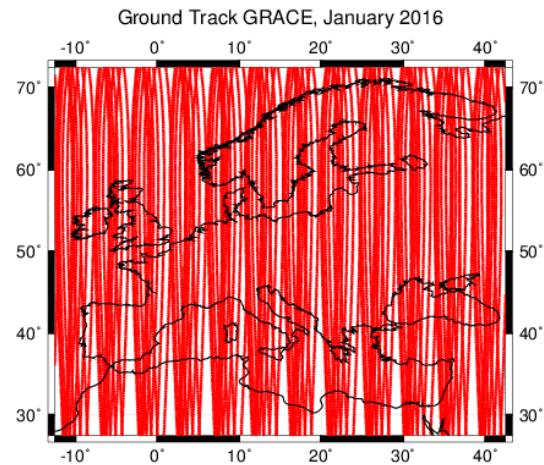
Basin analysis

RMSD of basin averaged filtered solutions and HIS in mm EWH

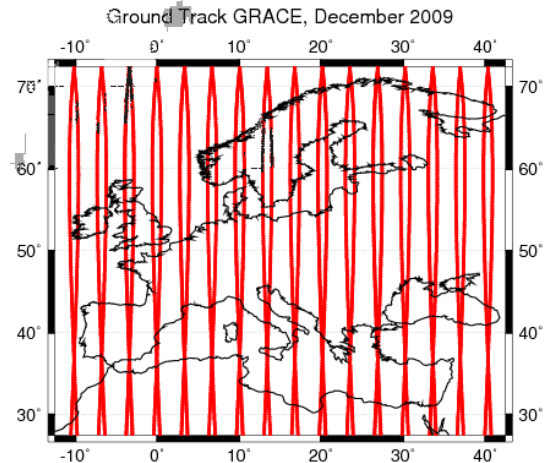
Basin #grid points	Basin Name	DDK1	DDK2	DDK3	DDK4	DDK5	V1	V2	V3	V4	V5	SG300
497	Amazon	7.6	6.7	6.5	6.6	7.0	7.6	6.6	<u>6.2</u>	6.3	6.5	6.9
450	Ob	9.5	6.8	<u>6.5</u>	7.3	10.0	12.7	9.7	8.6	8.6	9.2	7.0
358	Mississippi-Missouri	9.2	7.4	7.2	7.2	7.2	10.7	8.2	7.2	<u>7.1</u>	7.2	8.6
311	Congo	18.2	11.0	9.9	<u>9.8</u>	10.2	27.2	14.1	11.2	10.9	11.0	13.6
263	Nile	27.4	23.1	21.5	20.9	19.5	29.1	19.1	16.5	<u>16.4</u>	17.1	26.6
188	Niger	14.3	11.7	10.8	10.8	12.1	17.8	13.1	<u>10.5</u>	10.6	11.8	13.0
158	Ganges-Bramap.	28.1	15.3	13.7	13.8	14.7	42.2	17.6	7.4	<u>6.7</u>	7.1	19.4
94	Danube	14.8	10.3	9.3	9.2	9.1	17.8	13.8	<u>9.1</u>	8.8	8.6	8.5
89	Indus	24.5	14.2	14.0	14.8	17.0	36.8	20.2	12.8	<u>12.4</u>	13.1	18.2
81	Orinoco	58.0	30.0	23.8	22.0	20.0	87.0	45.0	26.0	23.2	<u>19.6</u>	40.4
74	Mekong	36.5	23.2	20.5	21.0	23.6	45.7	28.8	18.8	<u>17.3</u>	17.4	29.7
30	Parnaiba	46.3	32.3	29.2	28.8	28.6	55.7	43.3	28.8	27.7	<u>27.1</u>	26.8
25	Rhine	20.8	18.5	29.1	33.8	49.0	31.0	16.4	24.3	27.6	35.6	<u>16.0</u>
	MEAN	24.2	16.1	15.8	15.8	17.5	31.0	19.7	<u>14.4</u>	<u>13.6</u>	<u>14.7</u>	18.1

Real Data

Ground Track

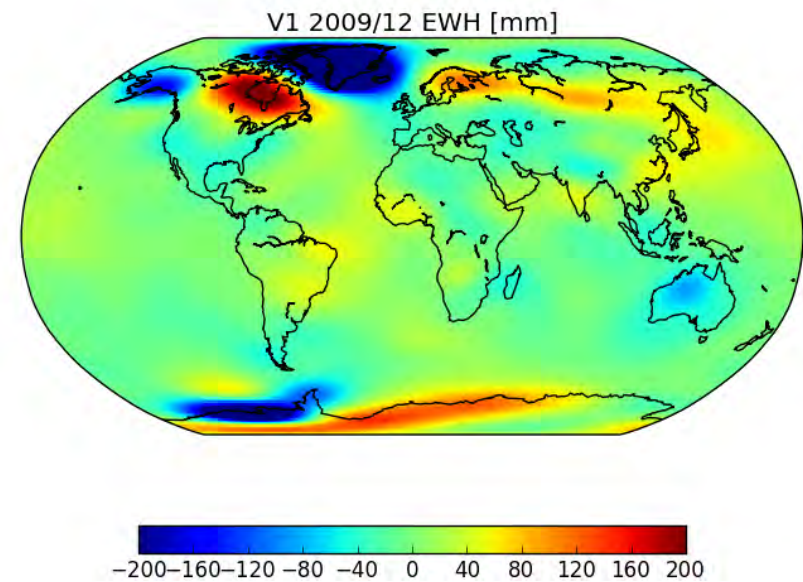
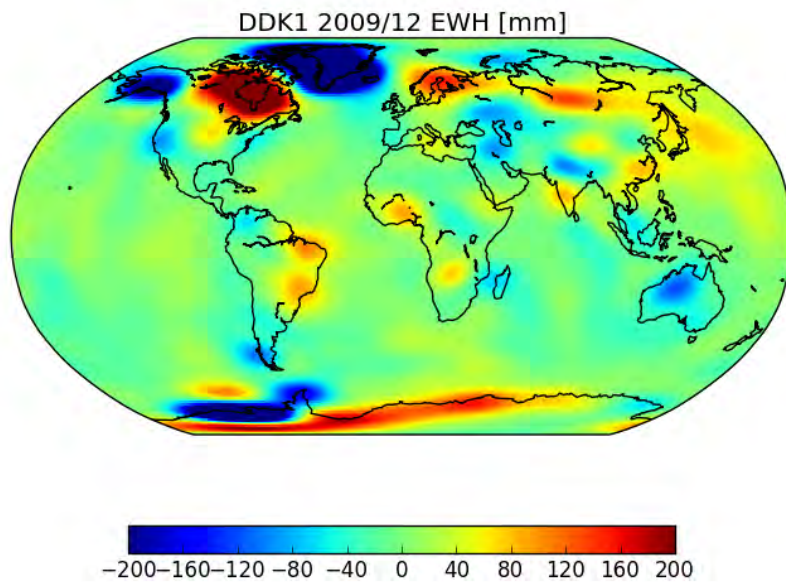


7 days repeat cycle:

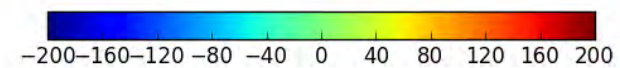
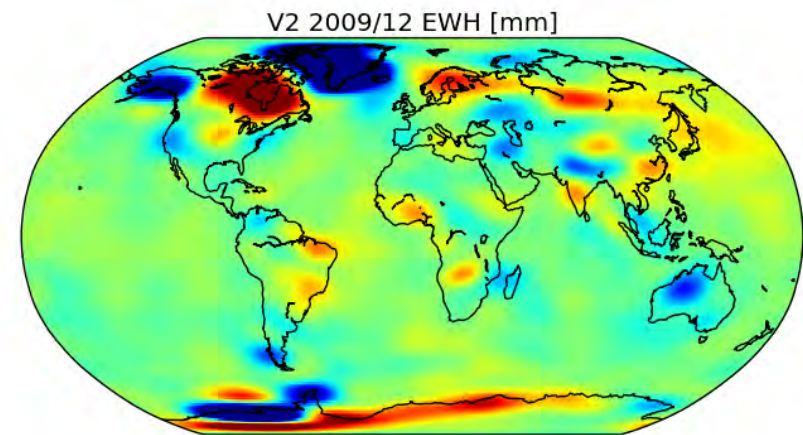
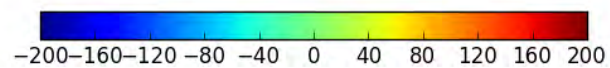
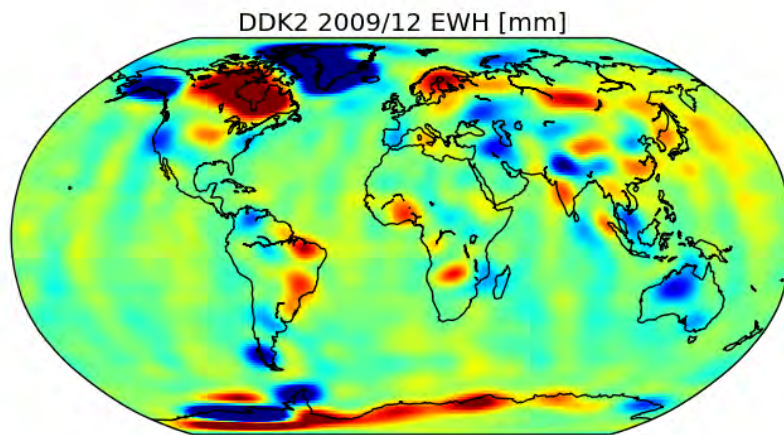


not regularized during GFZ RL05a processing

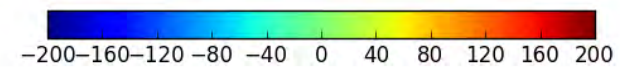
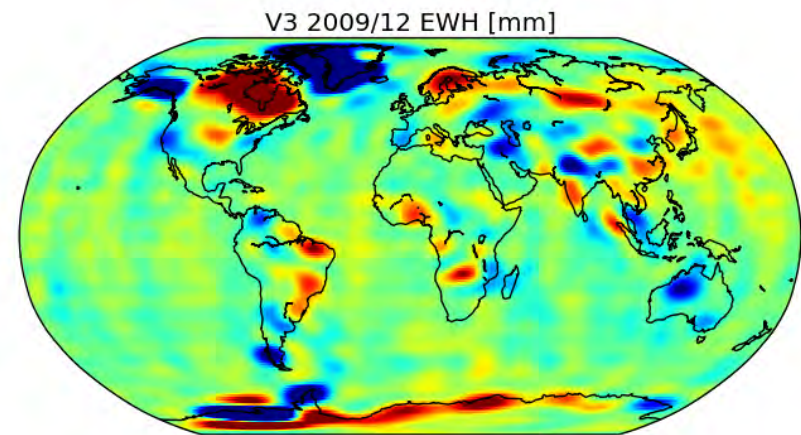
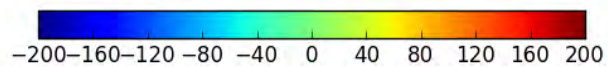
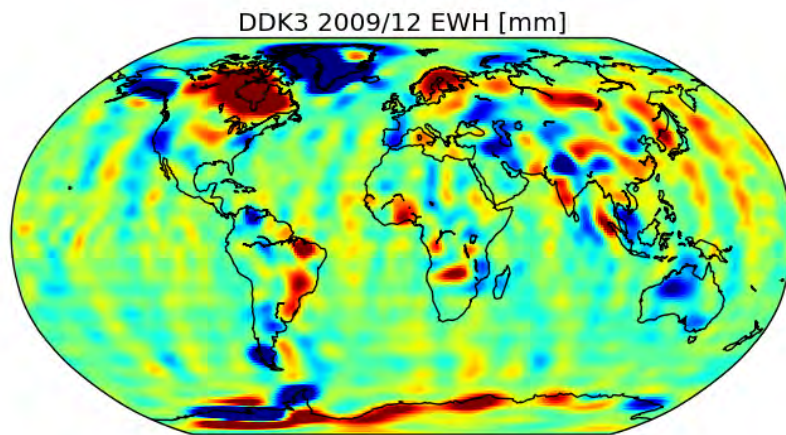
2009/12, 7 days repeat cycle



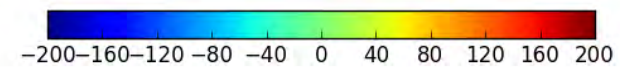
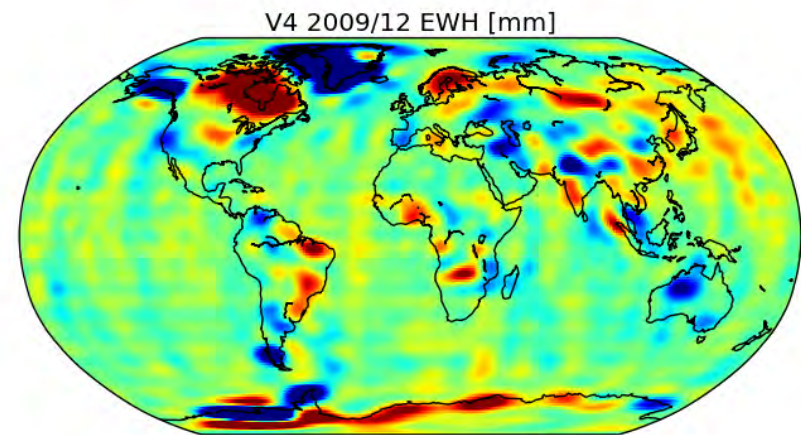
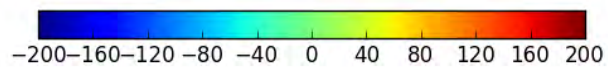
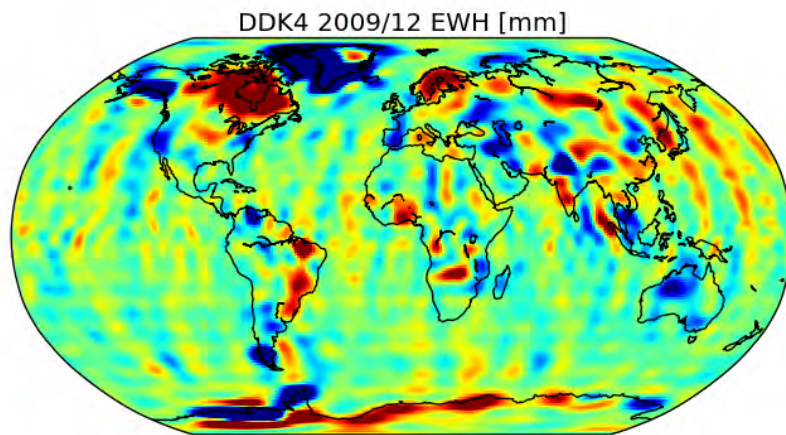
2009/12, 7 days repeat cycle



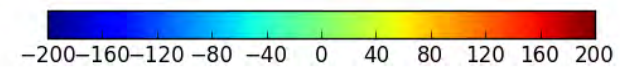
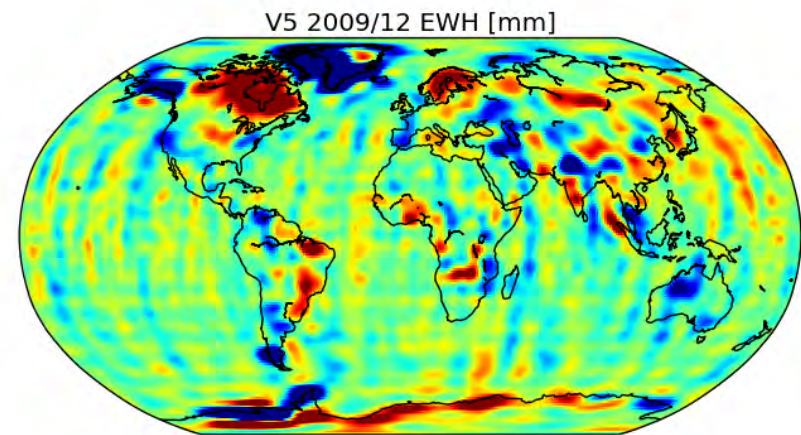
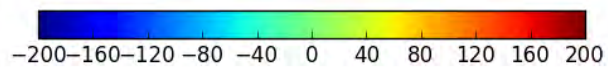
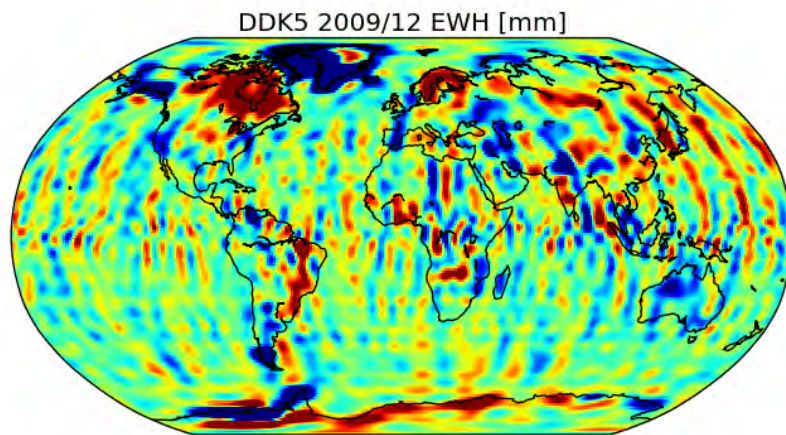
2009/12, 7 days repeat cycle



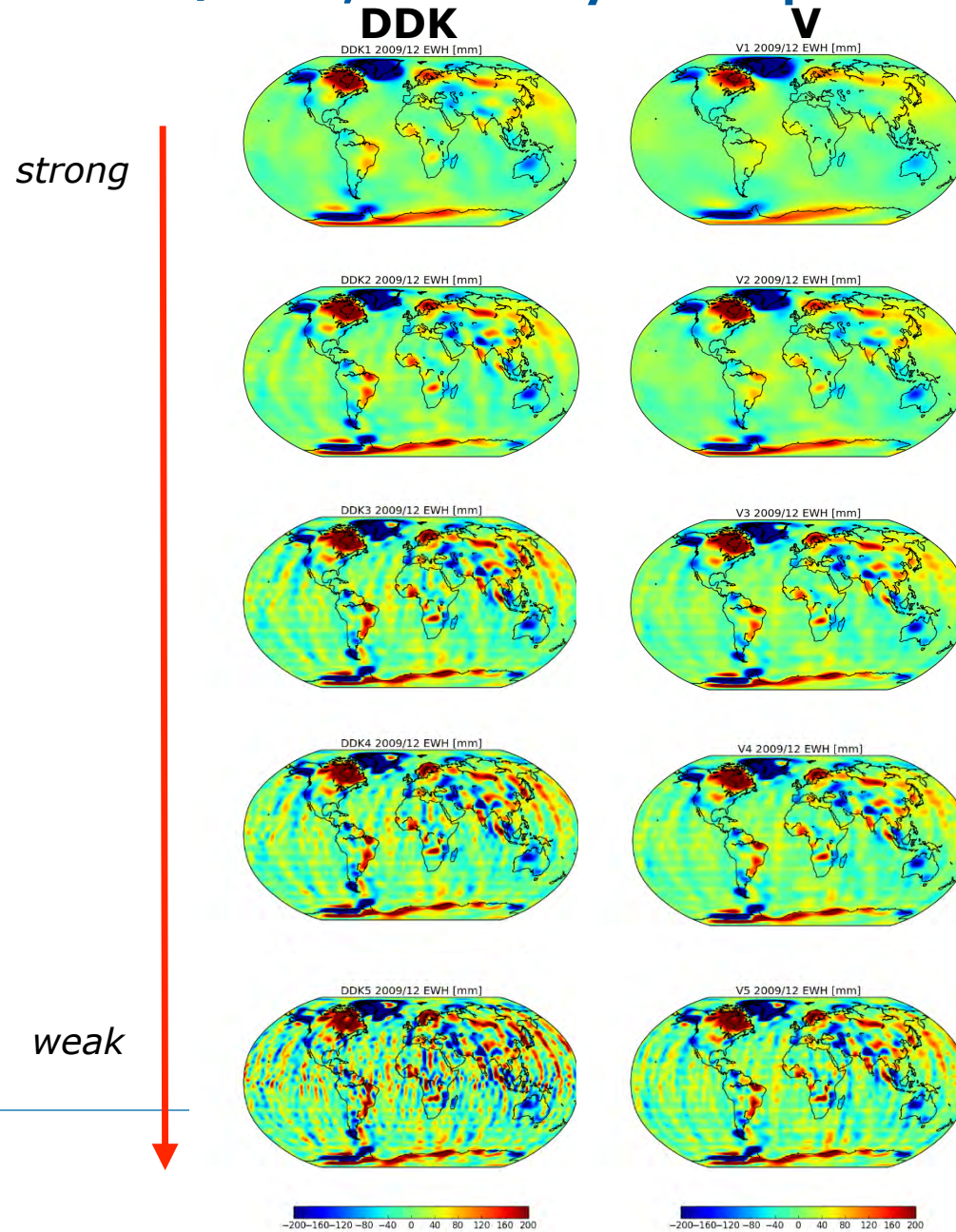
2009/12, 7 days repeat cycle



2009/12, 7 days repeat cycle



2009/12, 7 days repeat cycle



Conclusions

Conclusions

- Static DDK might introduces artifacts.
- Variable DDK:
 - better results with simulated as well with real data
 - adaptive to data and orbit geometry
 - alternative to regularization during Level-2 processing
 - no need of changing filter strategy