

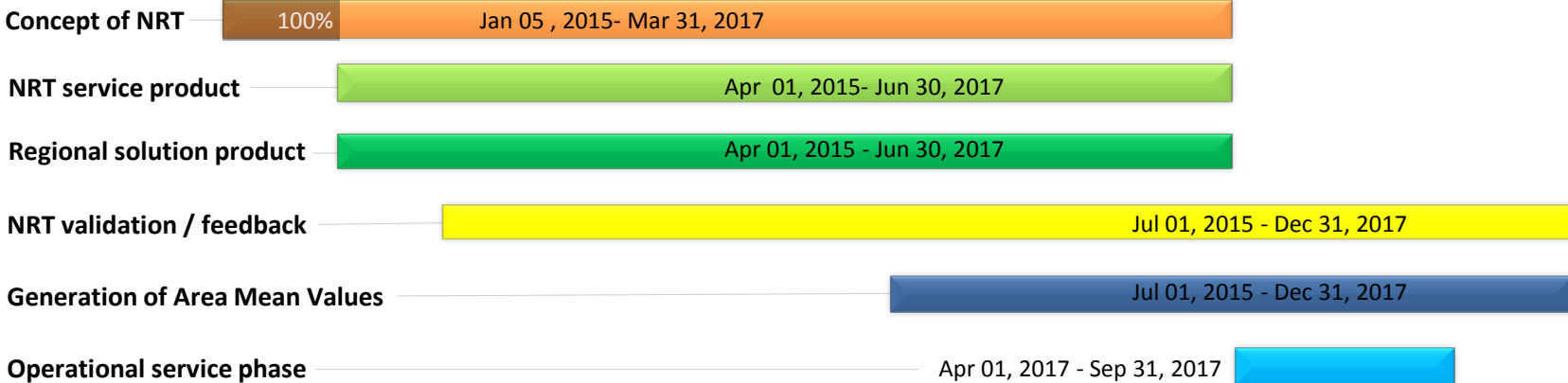
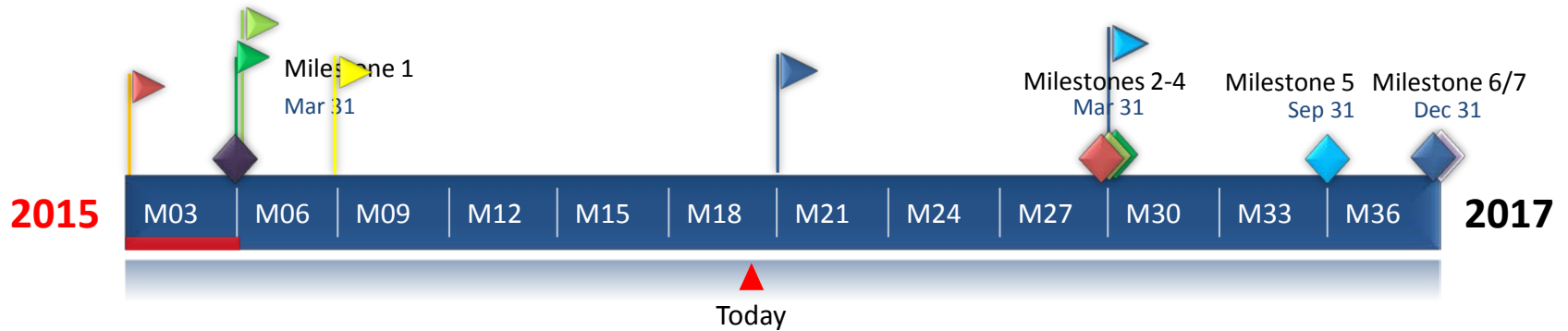
WP5: Status & Milestones

Christian Gruber - GFZ

EGSIEM Meeting, GeoForschungsZentrum, Potsdam

Jun 2 – Jun 3, 2016

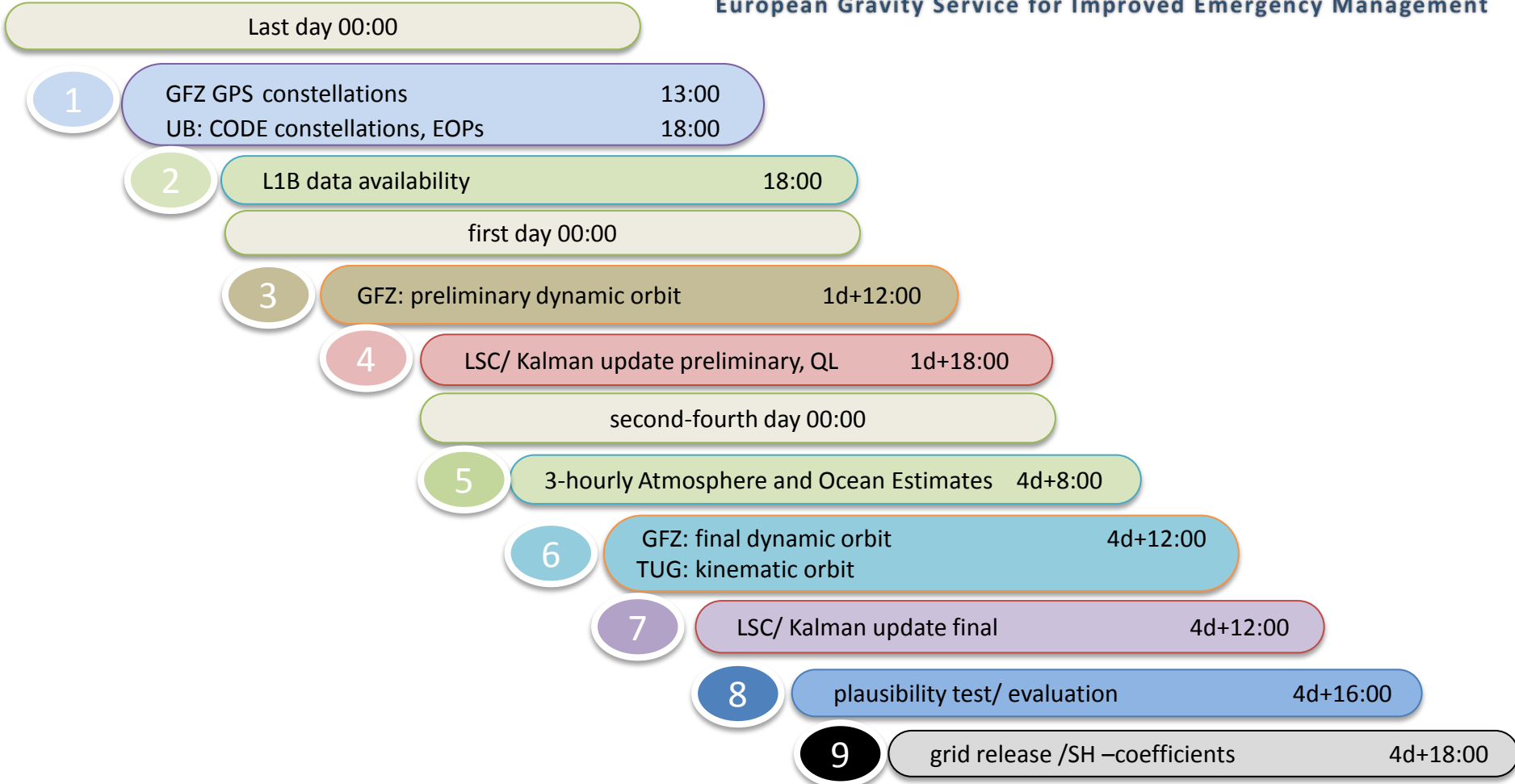
Project Plan



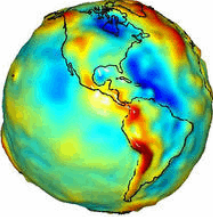
Input data and latencies

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)	GFZ	7 days	3-4 days
Specific hydrological basin (upon request)	WP3/6	Not available	1 day

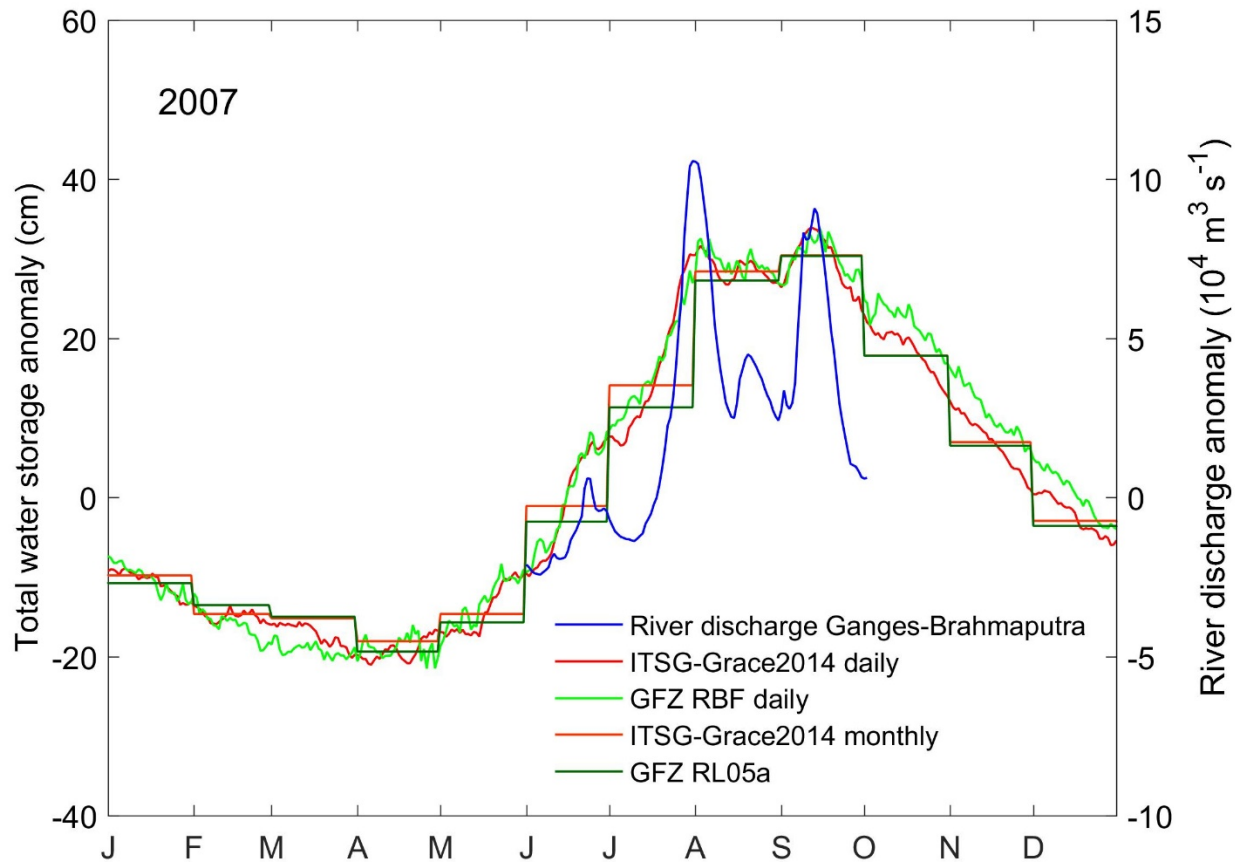
Production-flow



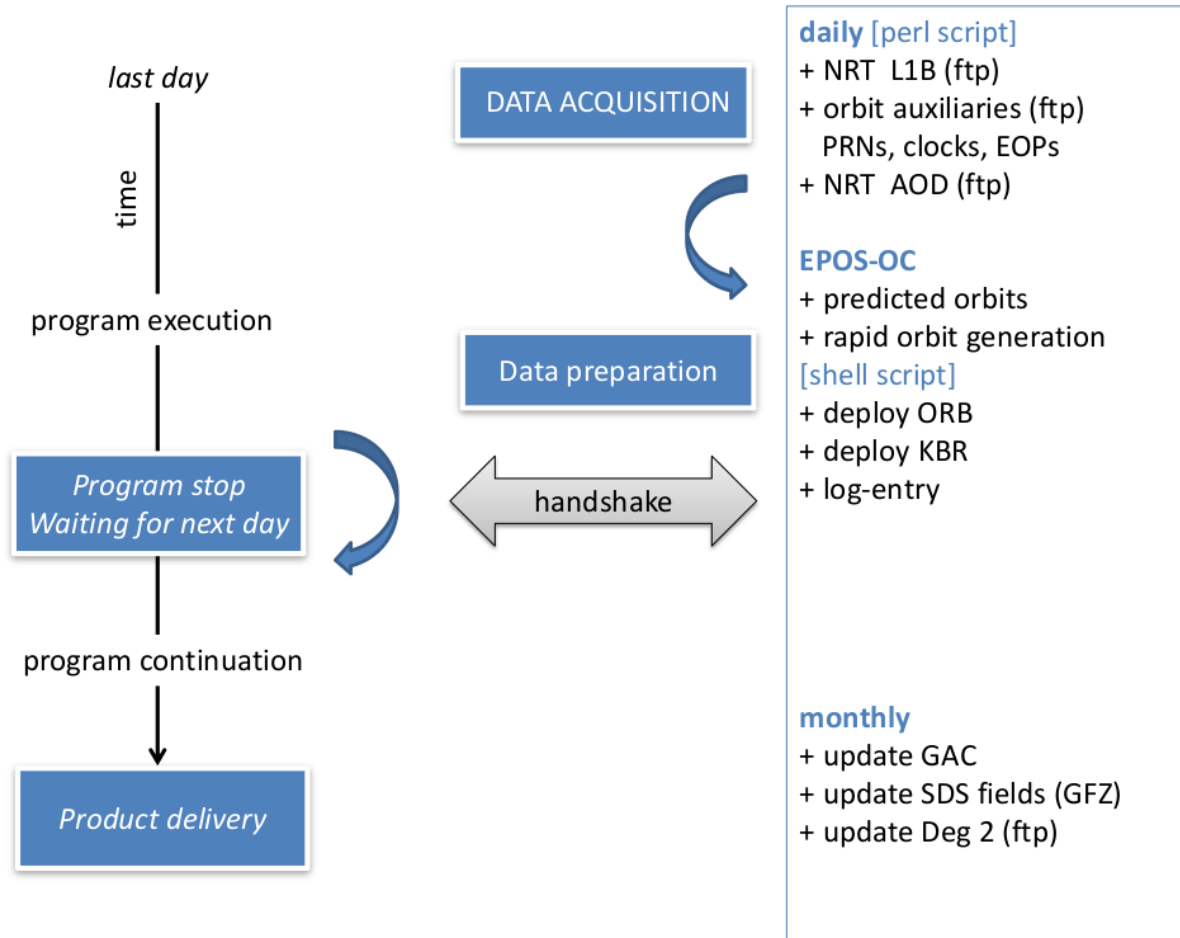
RBF Status

- good news: the RBF solution works and is well on its way to provide a full time series of GRACE days 
- main keys to success:
 - limit observation de-correlation to < 5 rev. (5000epochs)
 - vast limitation of (previously considered) outliers: none
 - accelerometer calibration
 - some improvements to the process model (stability)
- all necessary NRT interfaces for service readiness have been developed
 - ftp, shell/perl scripts, conversions, formating, etc.

RBF Success



Service mode

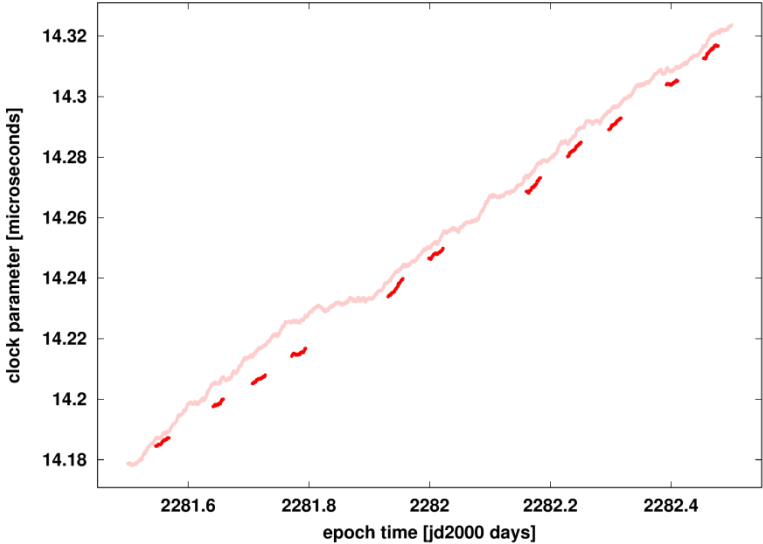


Background models

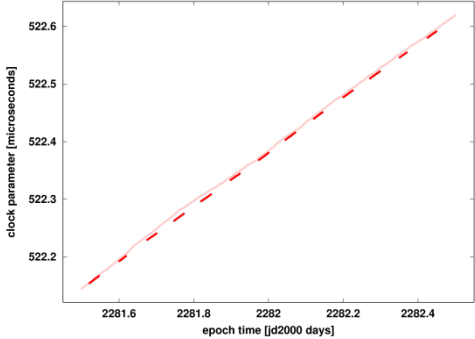
- Ocean tides (EOT11a),
- Atm tides S1,S2 (Bode/Biancale)
- Solid Earth & Pole Tides (Desai)
- 3rd body ephemerides (JPL de421)
- EOP's (Susnik et al.)
- GPS clock's (Susnik et al.)
- no nutation/precession correction terms ($\Delta\epsilon/\Delta\psi$)
- GAC (glo, daily, *RL6*: 3D-Earth)
- WGHM (Döll et al., 2002-2013)
- GRACE RL05a (2002-2015)

NRT CLOCKS

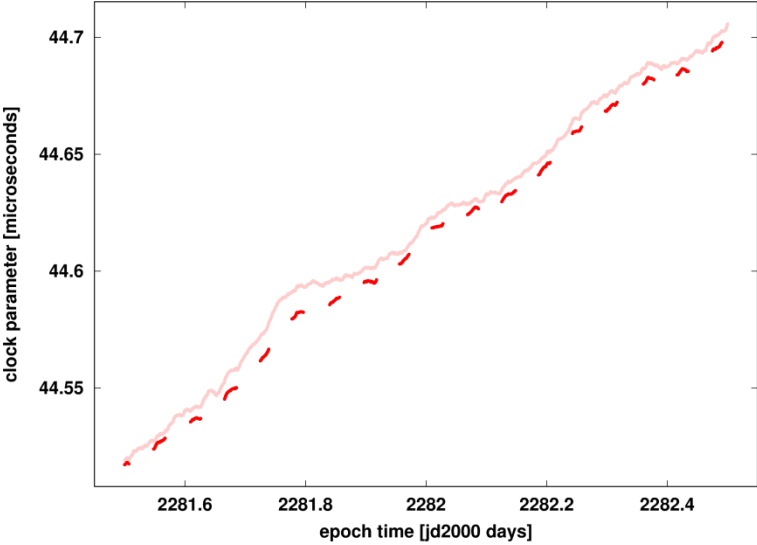
clock parameters for sender prn = 9



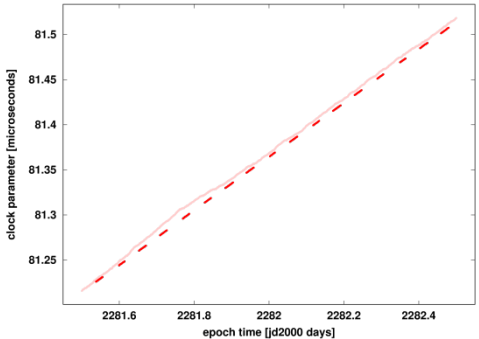
clock parameters for sender prn = 7



clock parameters for sender prn = 1



clock parameters for sender prn = 22



Offset: $1e-8$ sec



Output

- daily solution on 2x2 deg grid (in ewh)
- 2x2 deg operational anomaly w.r.t average model
- 2x2 deg operational average model
- 1x1 deg grid regional product for defined areas of interest
- error estimates for solution vector / grid values

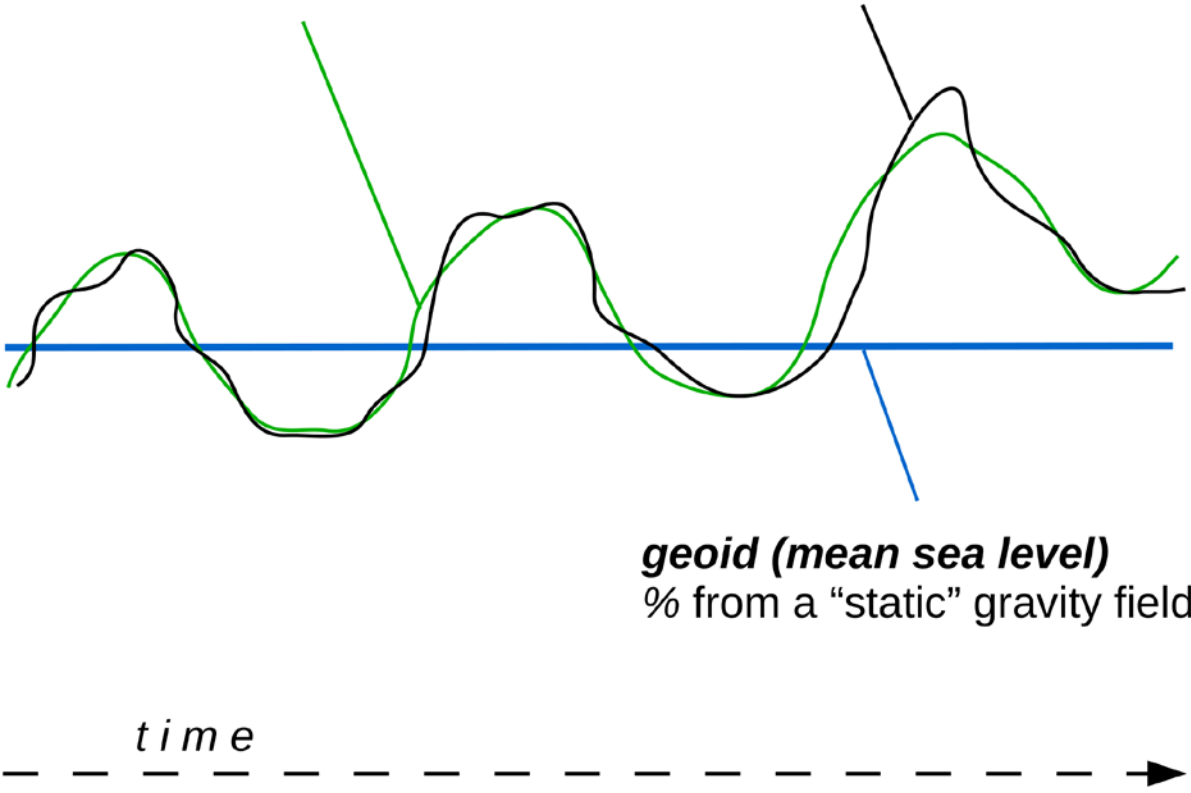
Linear system
Equations

- integration grid (\sim Reuter), corresponding to 2×2 deg
 - conversion between Spherical Harmonics/grid
- radial basis functions assembly in grid points
- cov-estimation
 - obs auto-correlations for weighting/filtering
 - monthly auto/cross covariances for LS prediction
- Kalman filtering
- monthly inversion

Kalman solutions

bias + trend + seasonal fit
% time-dependent average model

Kalman filter
% time dependent daily results



geoid (mean sea level)
% from a "static" gravity field

Process
noise

auto/cross covariance estimates (isotropic average operator)

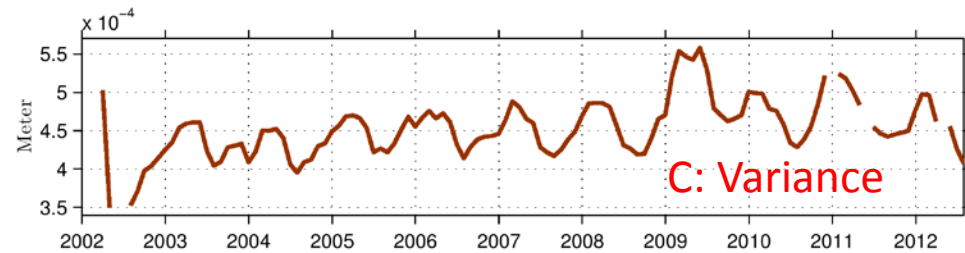
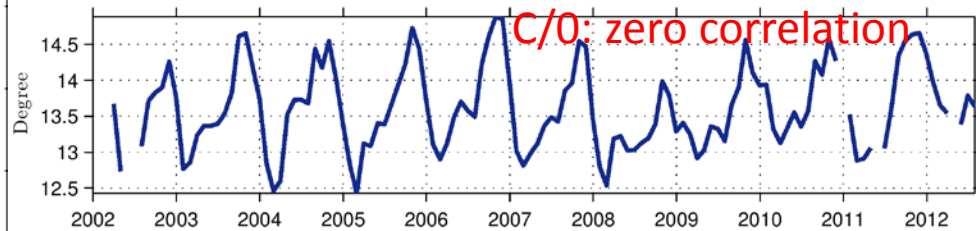
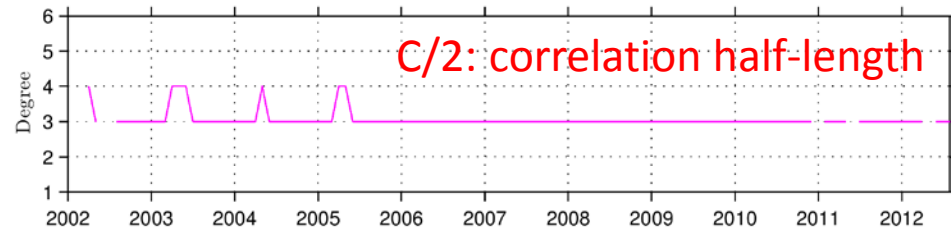
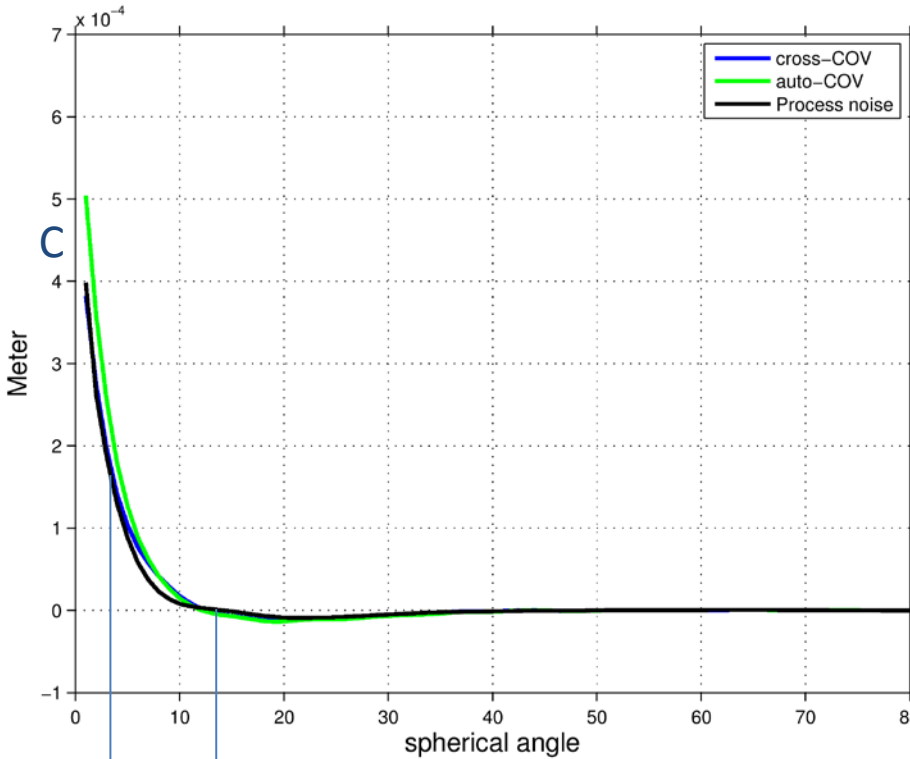
- $\text{mean}\{ \text{GAC}(\text{daily}) - \text{meanGAC} \}$ → 30%
- de-seasoned hydrology model → 20%
- GRACE residuals w.r.t average model → 50%

Use of GRACE average model stochastic for process noise estimates

Additional signal RMS to construct non- stationary variances

- average model = fitted secular/ seasonal function over available GRACE years

Covariances
over time

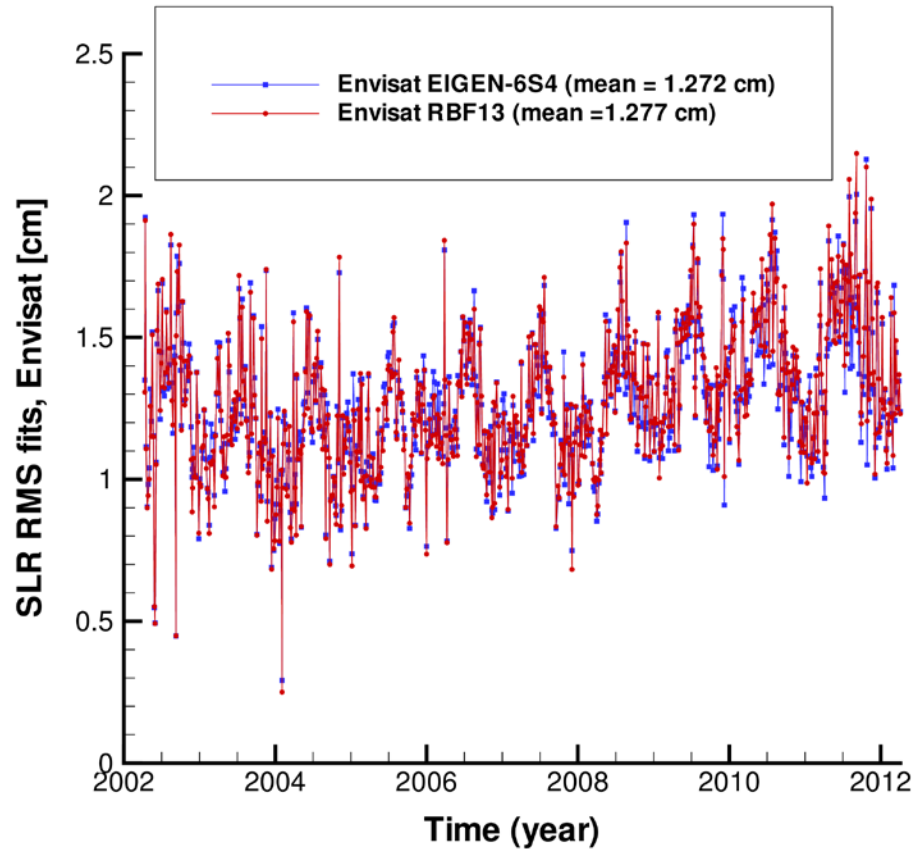


C/2 C/0

- Envisat/Jason arc-overlaps/SLR/Doris-fits
- WGHM basin coherence
- GPS-GreenlandNET(*Abbas-Khan*), GPS-CODE
- SLR deg2
- OBP evaluation (*Poropat et al.*)
- EGSIEM evaluation

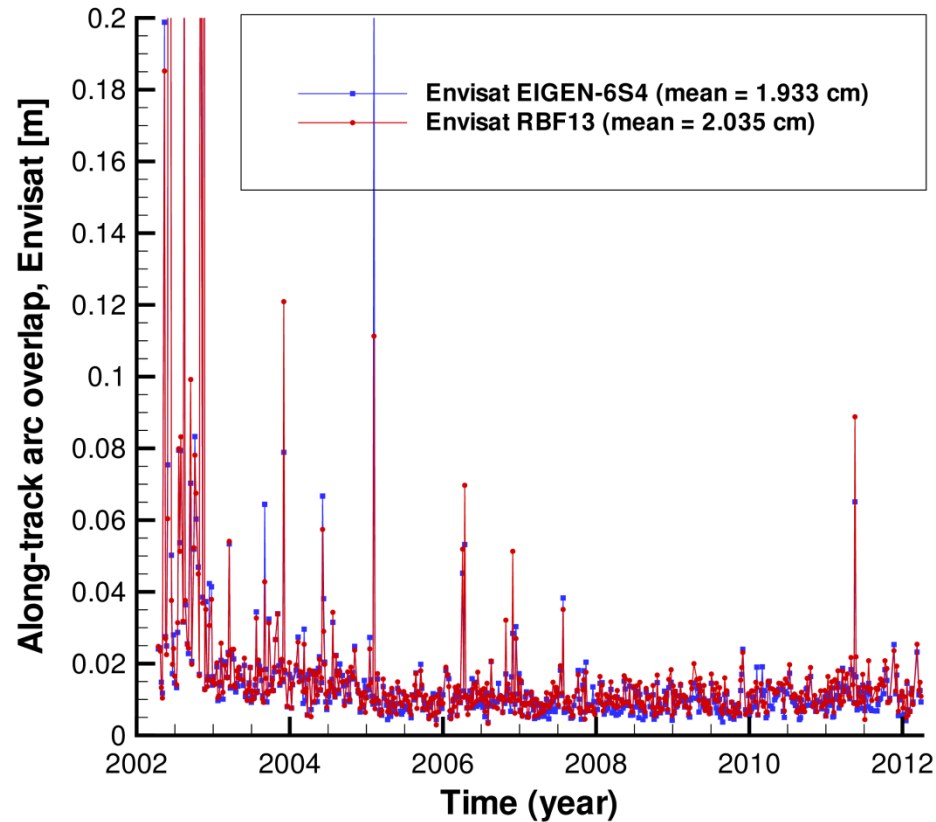
Envisat orbit

SLR RMS fits

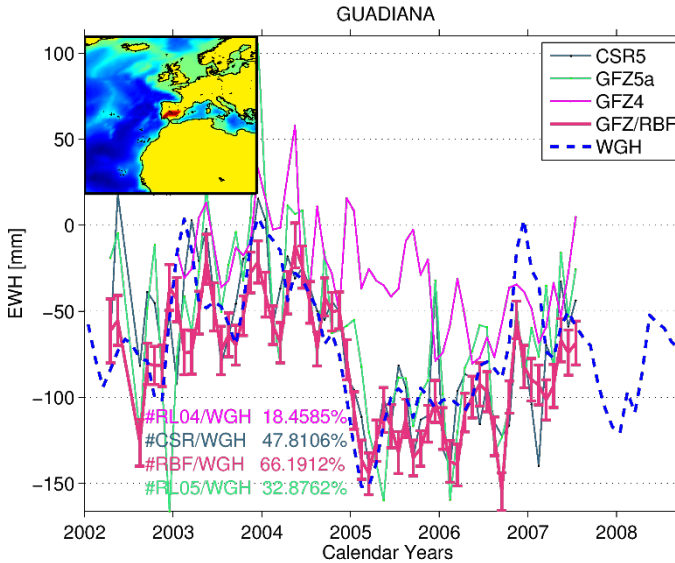
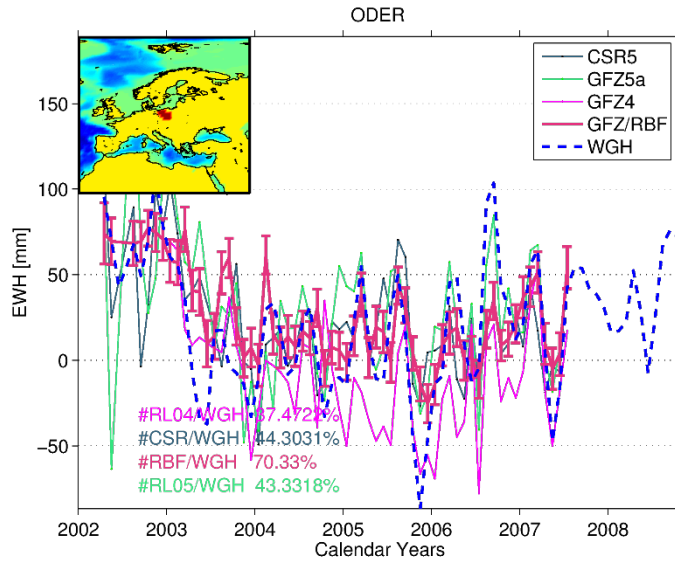


Envisat orbits

Arc overlaps,
along-track

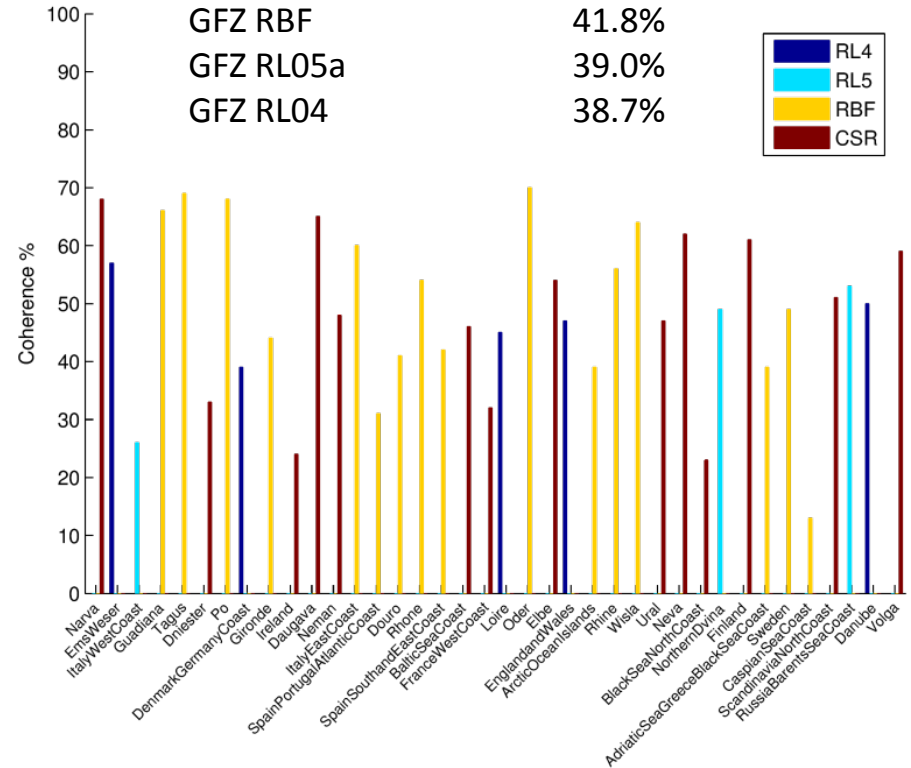


Hydro-basin comparison



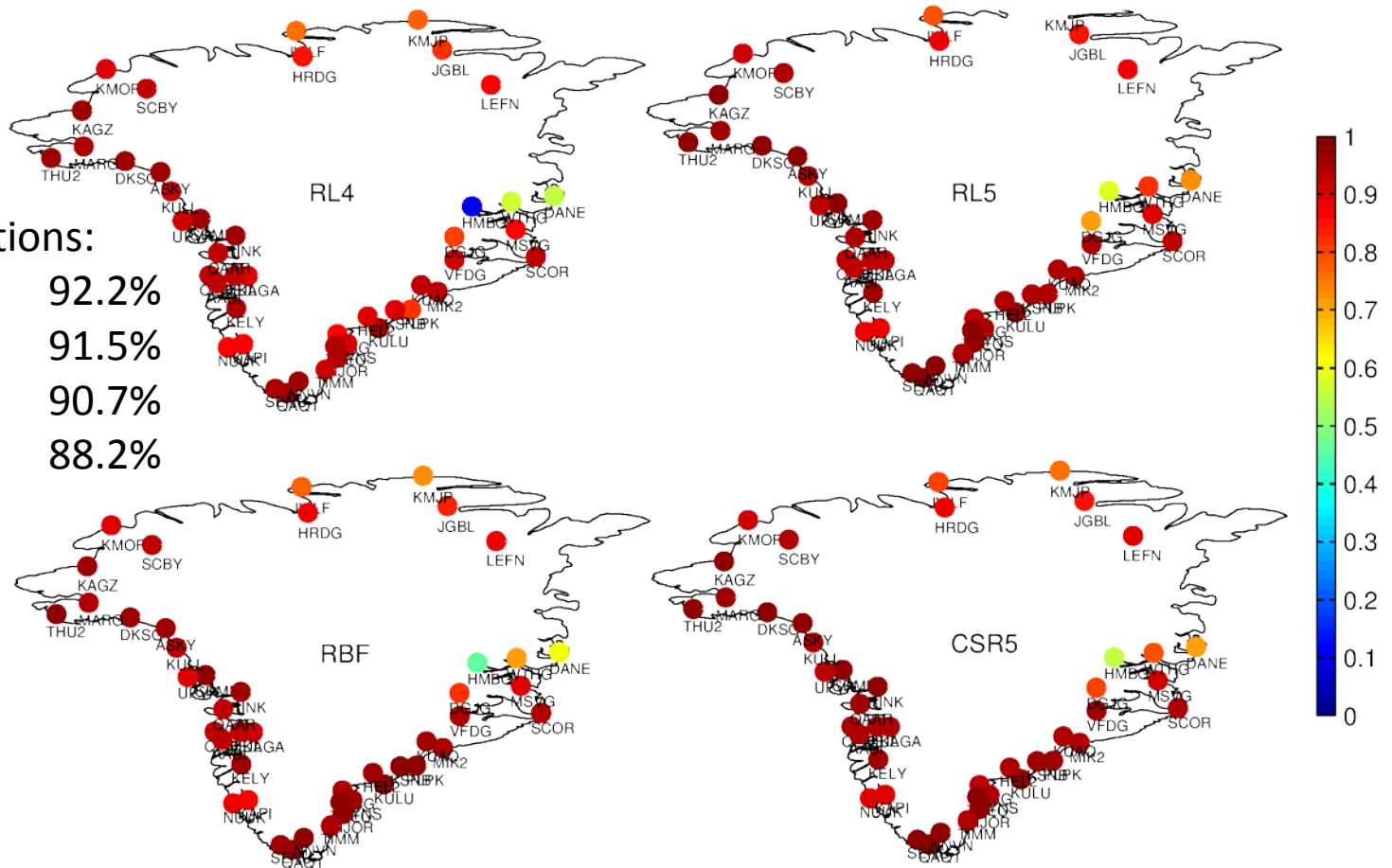
Averaged coherence for Europe
(de-seasoned, weighted by basin size)

CSR RL05	44.7%
GFZ RBF	41.8%
GFZ RL05a	39.0%
GFZ RL04	38.7%



GPS Validation

Greenland station network (GNET):

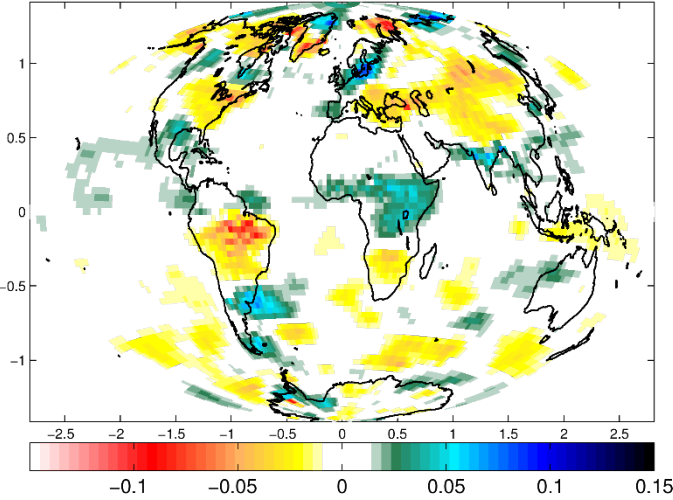


averaged correlations:

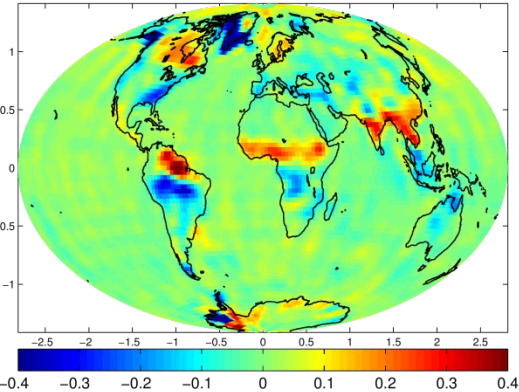
CSR RL05	92.2%
GFZ RL05a	91.5%
GFZ RBF	90.7%
GFZ RL04	88.2%

Monitor

A
N
O
M
A
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E
S



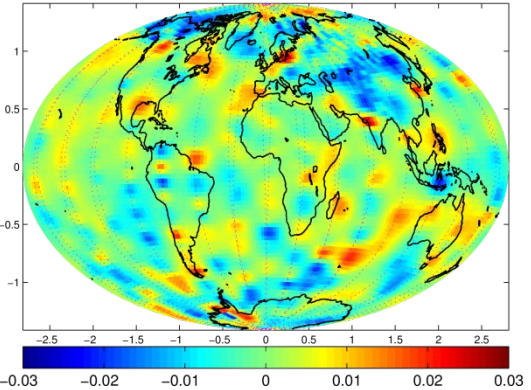
2007/09/30 height [m]



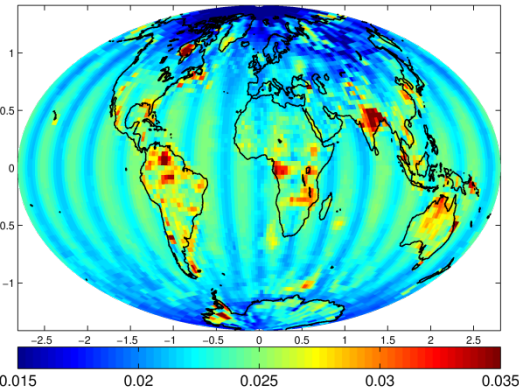
2007/09/30 height [m]

*Full State
After restore*

*Last Day
(measurement
update)*



2007/09/30 height [m]



2007/09/30 rms [m]

*formal RMS
error*



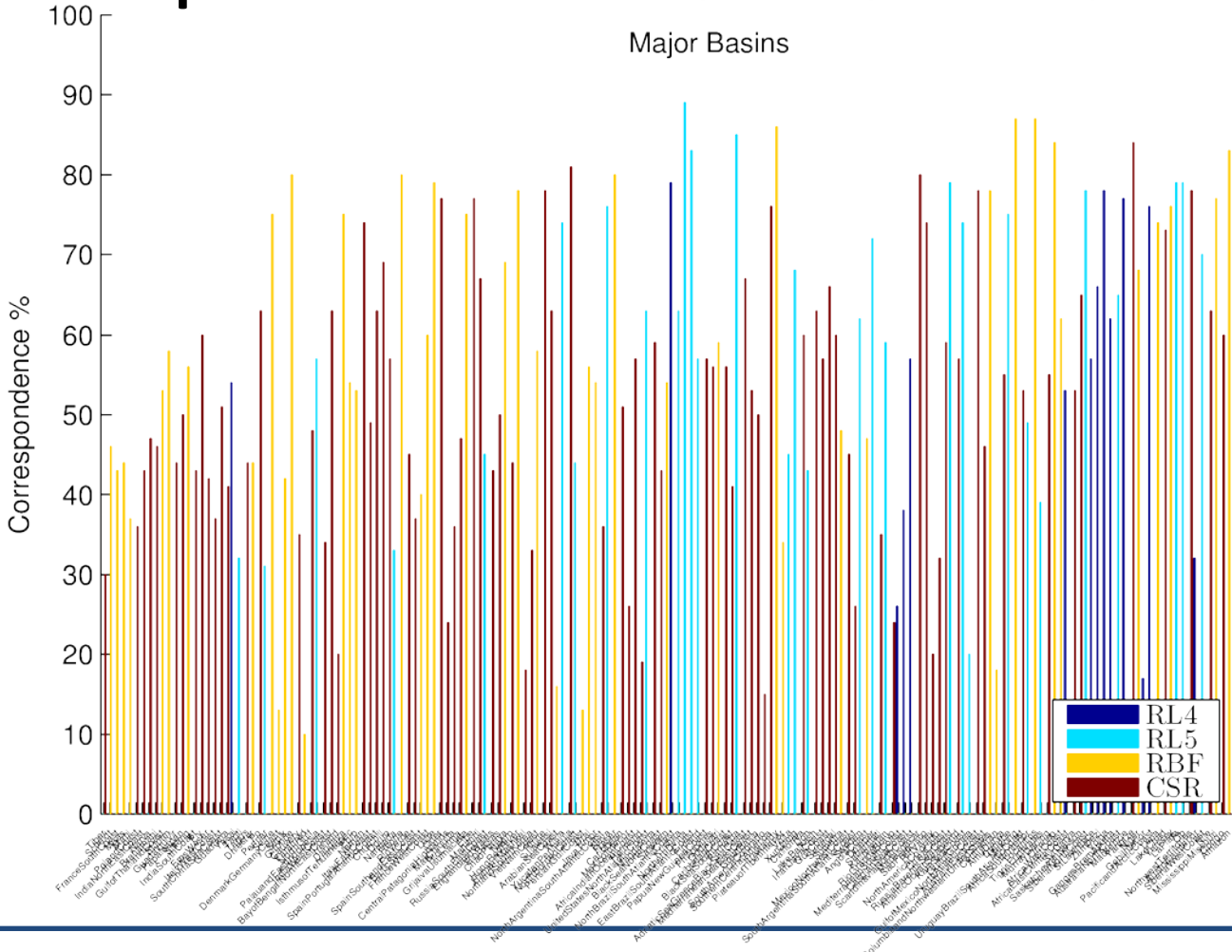
until operational readiness (M27) focus will be put on:

- convergence of daily results and used stochastic models between Graz and GFZ
- further research on the impact of seasonal Covariance functions
- quantify difference between using NRT data vs. historical data
- what is the impact of the iterated dynamic orbit with the actual (Kalman) day against using the average background ?
- show the convergence of regularized solutions w.r.t the monthly (SDS) fields w/o regularization

Data will be soon available

<ftp://egsiem@gfzop.gfz-potsdam.de>

Hydro-basin comparison



Monthly
COV

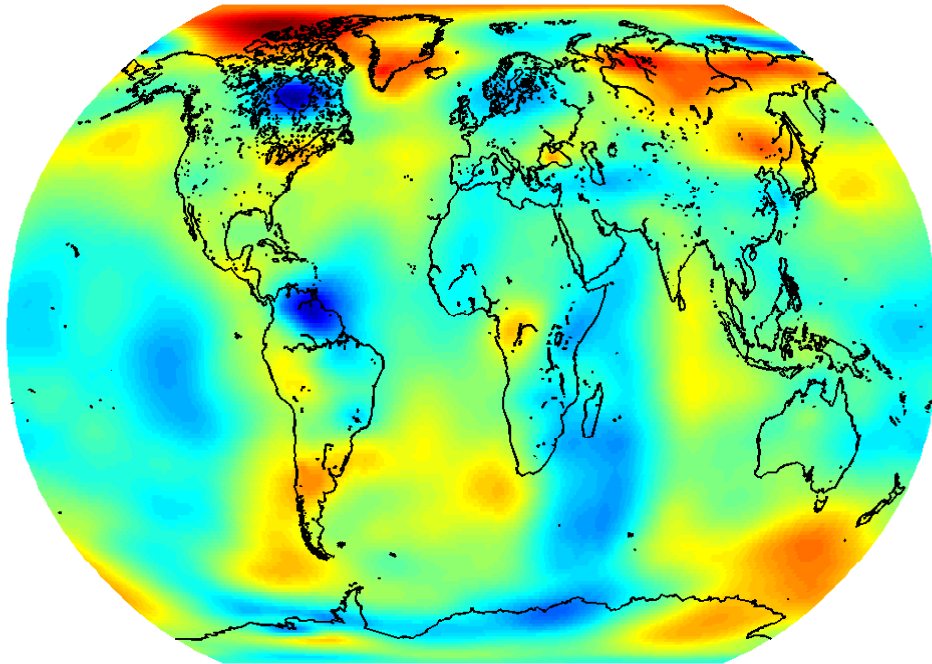
- GRACE de-saisoned + sec/seas. model errors
- WGHM, de-seasoned
- $\text{VAR}\{\text{GAC-mean}(\text{GAC})\}$
additional (non-stationary) signal
- 30% GRACE, 20% HYD, 15% GAC

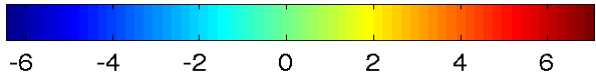
Program start

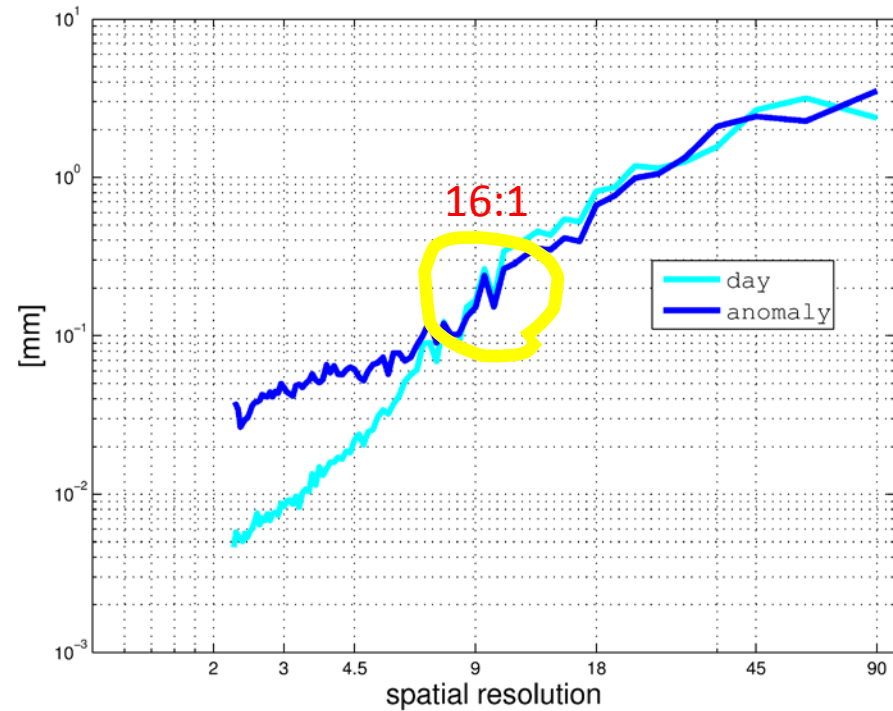
- Data acquisition
 - date/time, perturbation forces (*acc/o-tides/e-tides/lunisol/aod*), coordinates(*cis/cts*), Kband ranges
- Blunder detection (*acc*)
- Background model (gravity)
 - Static, SLR deg2, time-var (sec/seas. GRACE model: 50%, last Kalman day 50%)
- Proxy observation assembly I (pert.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

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

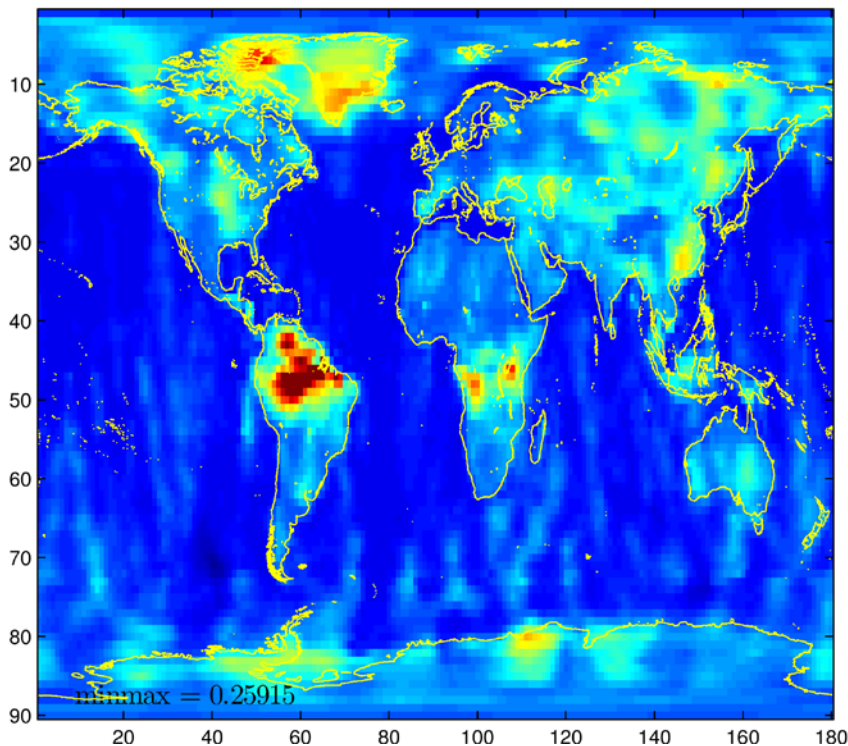
GRACE Water storage DAY



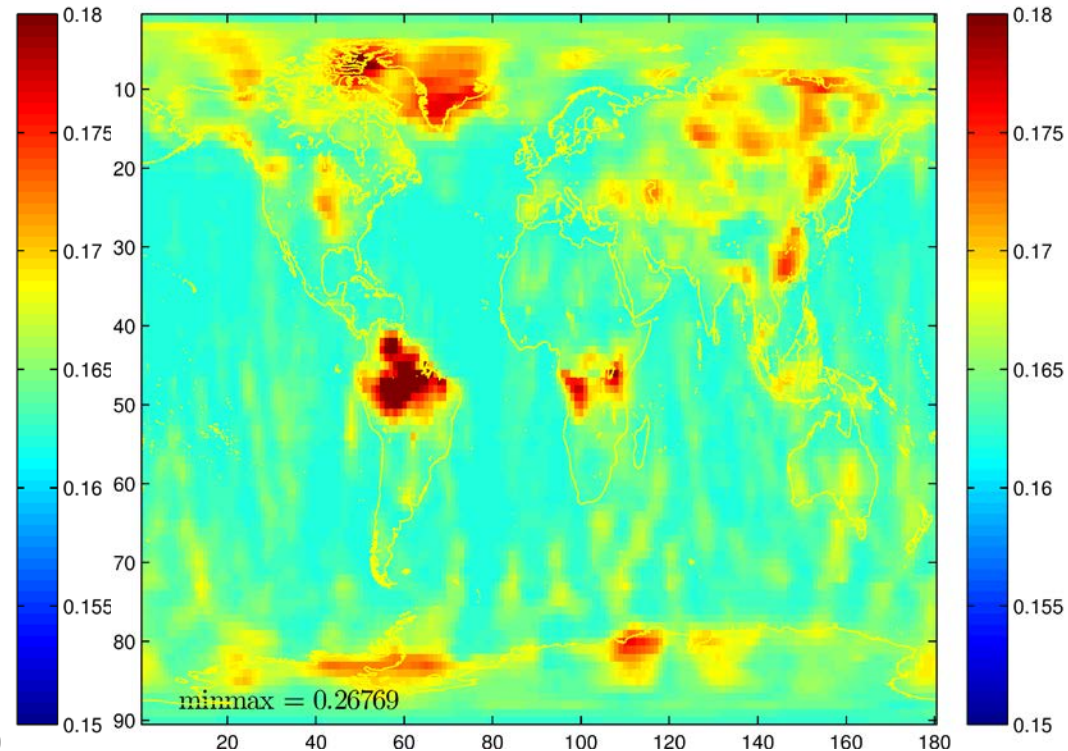
2014/06/18  EWS [cm]



Least Squares
Prediction



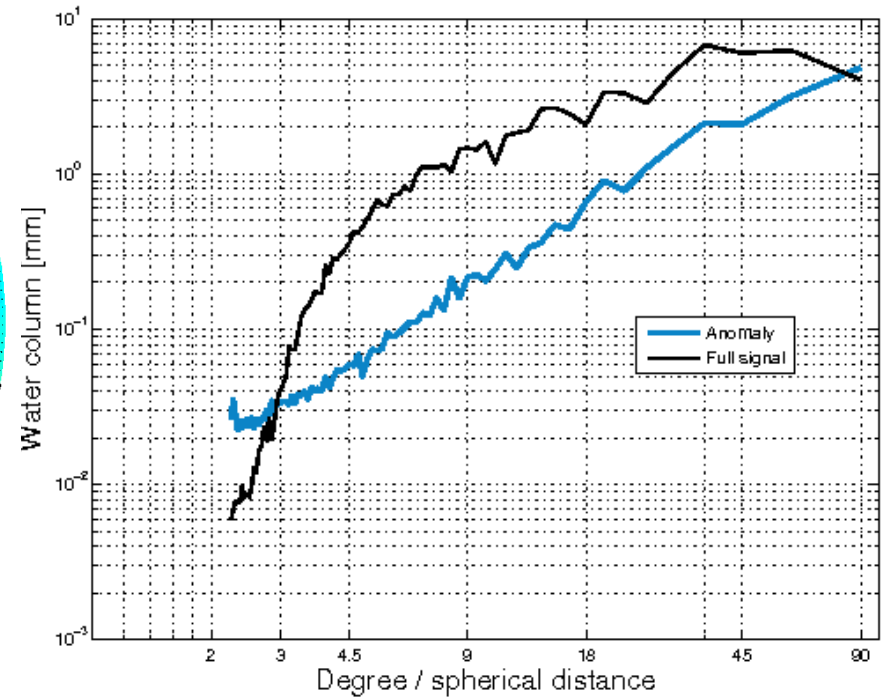
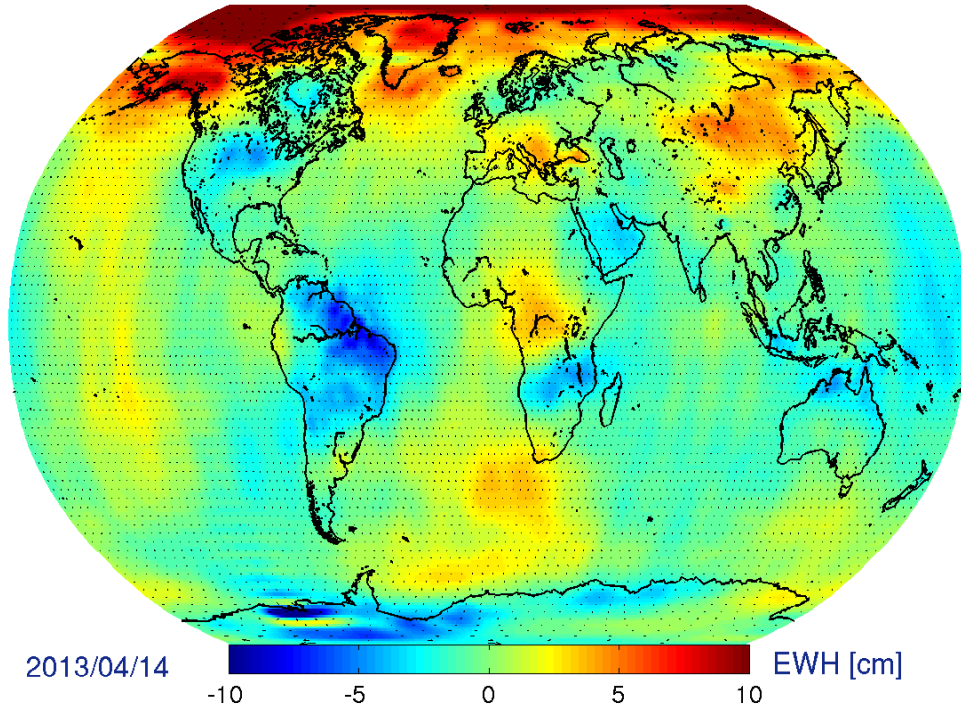
Cross-Co/Variations (06/2005)



Auto-Co/Variations (06/2005)

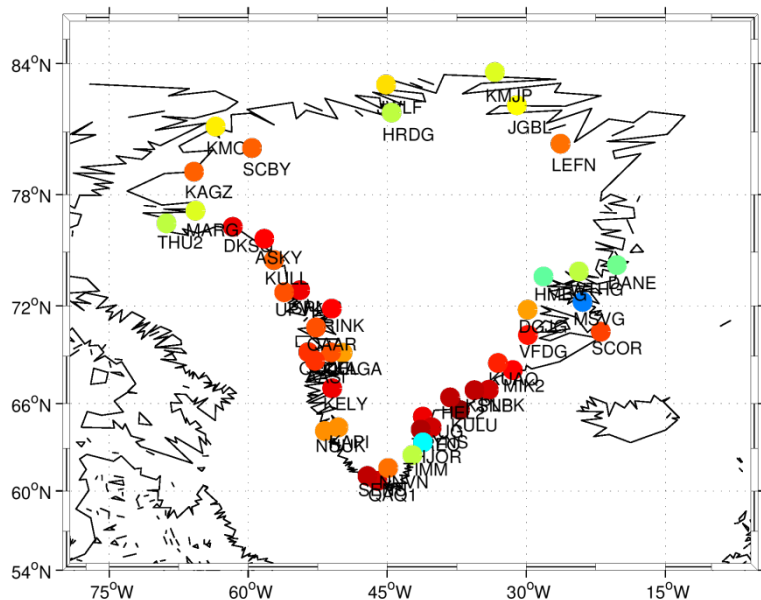
Anomalies vs. TV- modeling (7yr – sec/seas.)

GRACE Water storage anomalies

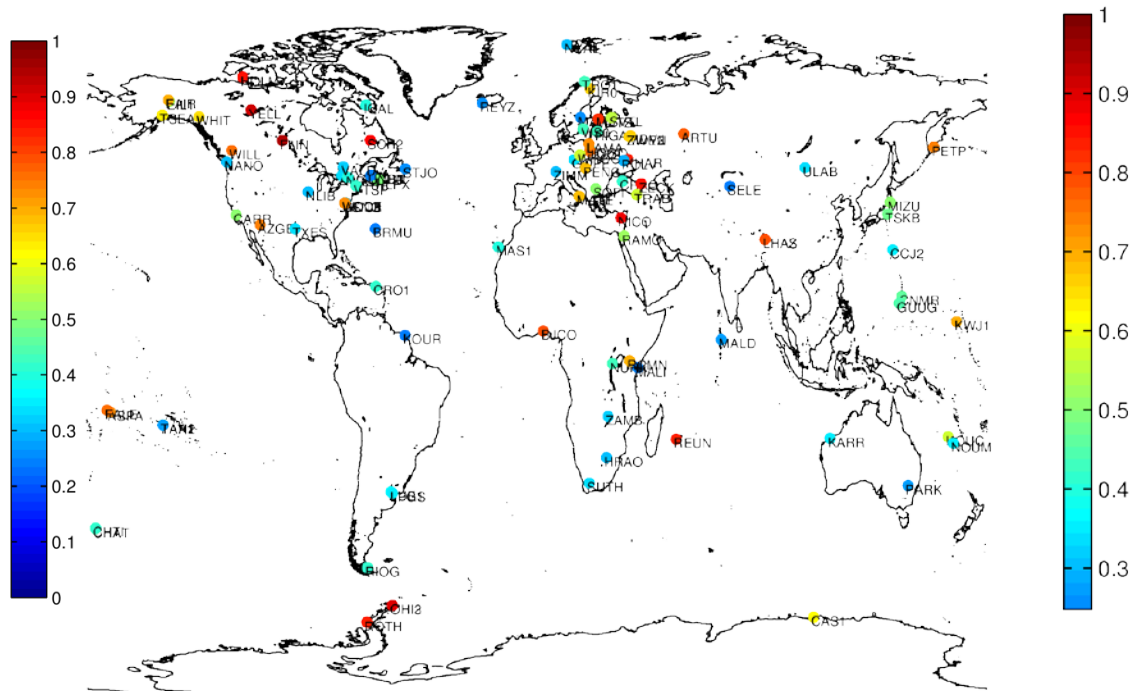


GPS sites comparison

RBF80 / GNET

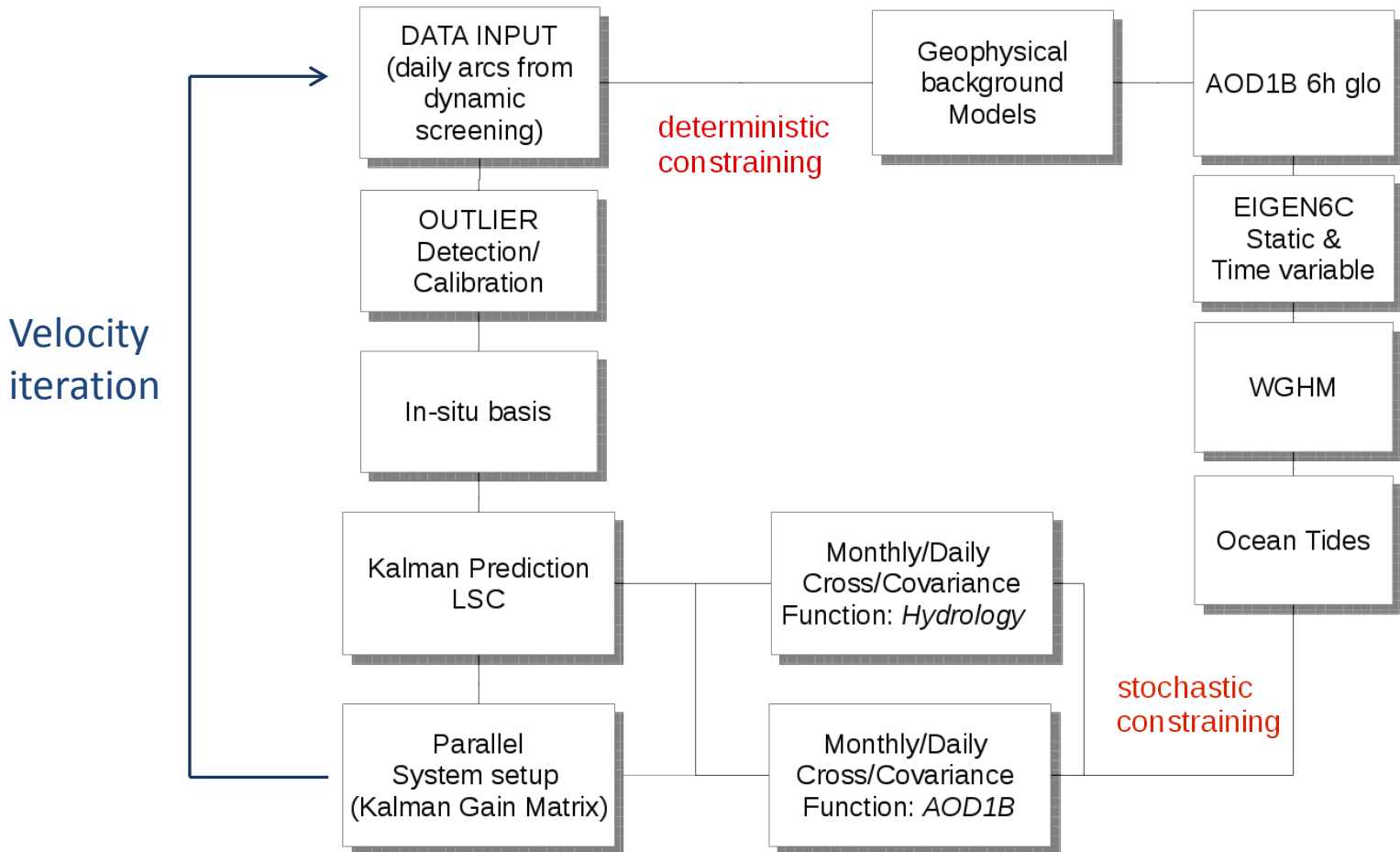


Greenland Network

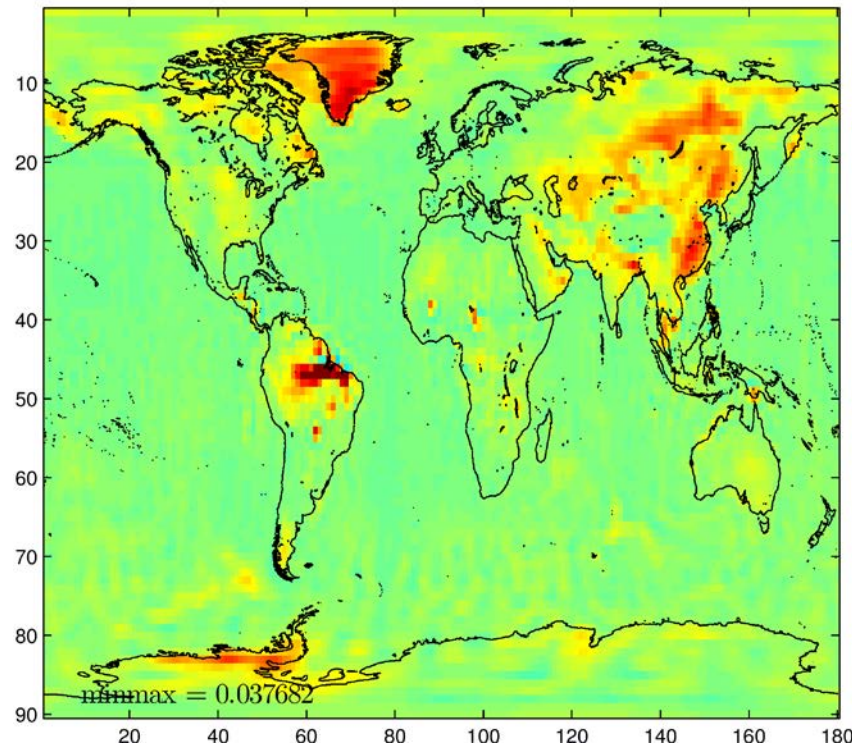


CODE Network

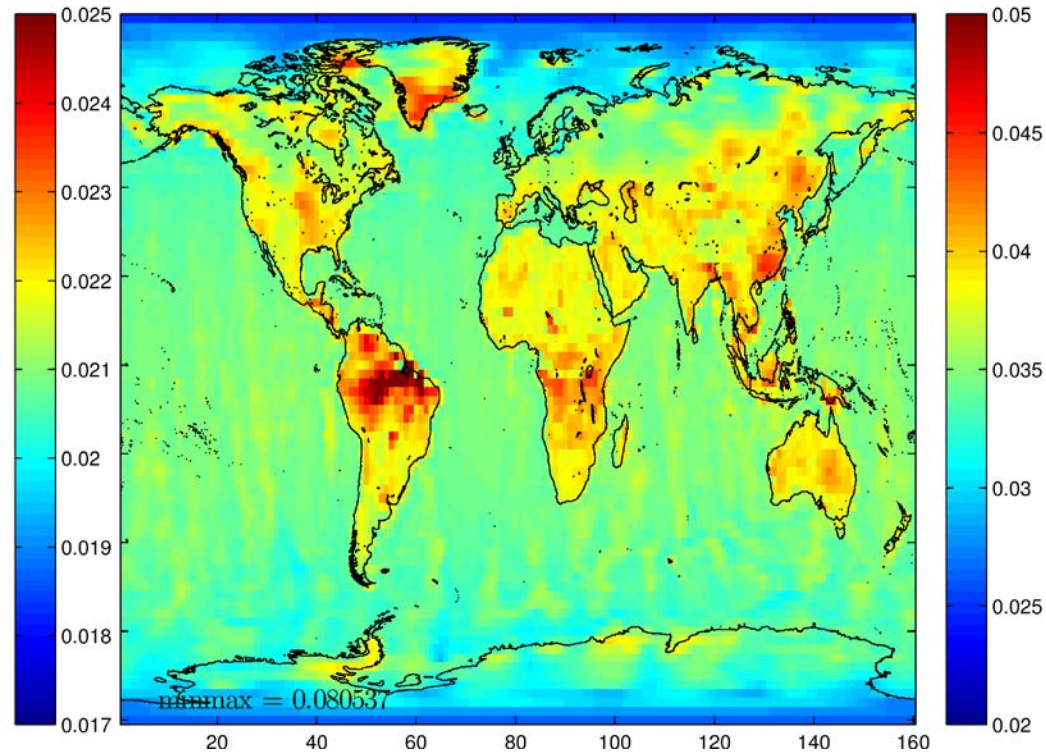
NRT@GFZ



Kalman Process



Kalman process-variances (06/2005)



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