Large-scale variations of the global gravity field from high-low SST only

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Motivation

- **GRACE** mission
  - provides unique information about time-variations of the Earth's gravity field especially benefiting from its K-band link (low-low SST)
  - has exceeded its designated life-time of 5 years by far
  - limitations in data processing due to switch-off of instruments caused by battery problems are already present, situation might even get worse and also a complete end of the mission might happen in the nearer future
- **GRACE-FO** mission is in preparation, but will be in space August 2017 at the earliest

➢ **Notable gap between GRACE and GRACE-FO is likely!**

In order to provide at least information about large-scale gravity field variations during this gap, time-variable gravity field solutions based on high-low SST only might be an option

Experiments

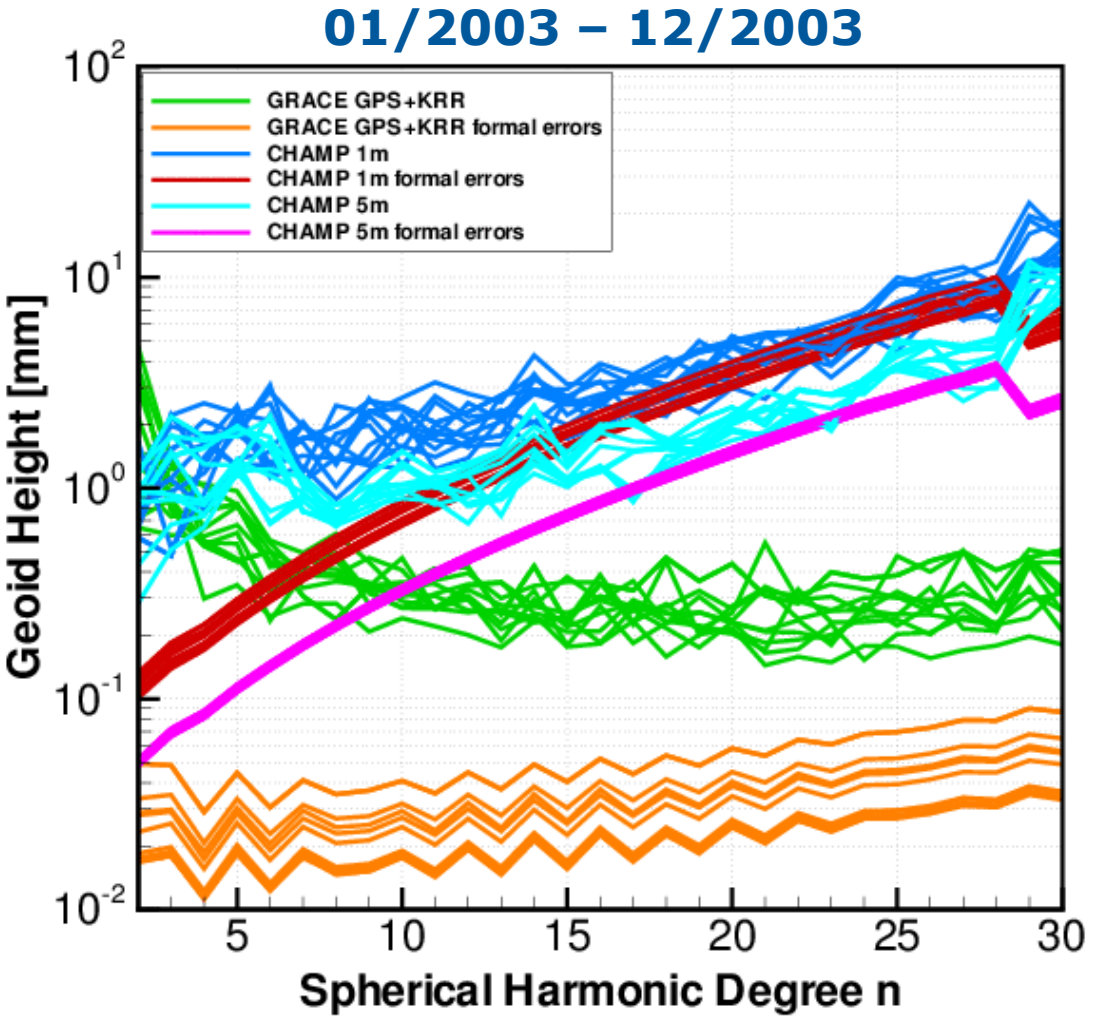
Beside its ongoing GRACE/GRACE-FO activities, GFZ has started some very first experiments to assess possible gap filler products:

- available real data from different GPS-equipped missions has been processed
  - **CHAMP** (92 solutions from 01/2003 – 08/2010)
  - **GRACE** (7 solutions: 09/2009 – 12/2009; 02/2010 - 04/2010)
- these "GPS-only" time-series have been generated using the Dynamic Method
- background models and standards are consistent with GFZ RL05
- all solutions could be processed operationally, i.e. distributed to users month by month

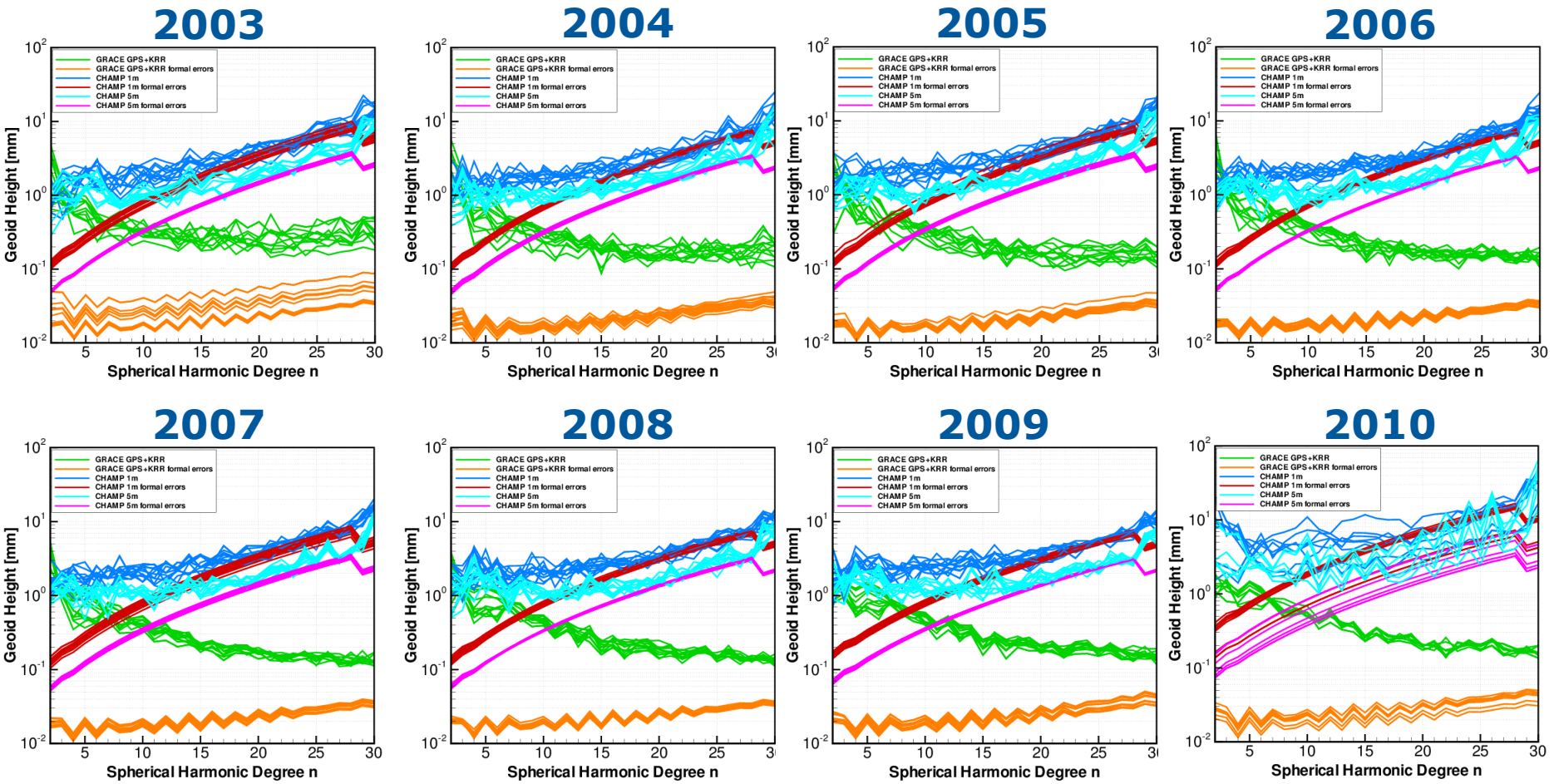
Results: Degree variances **CHAMP**

Degree variances wrt static background model (EIGEN-6C):

- Much more noise and large formal errors compared to GRACE RL05
- Comparable signal only for very low degrees
- Better results are achieved by calculating 5-month solutions



Results: Degree variances **CHAMP**



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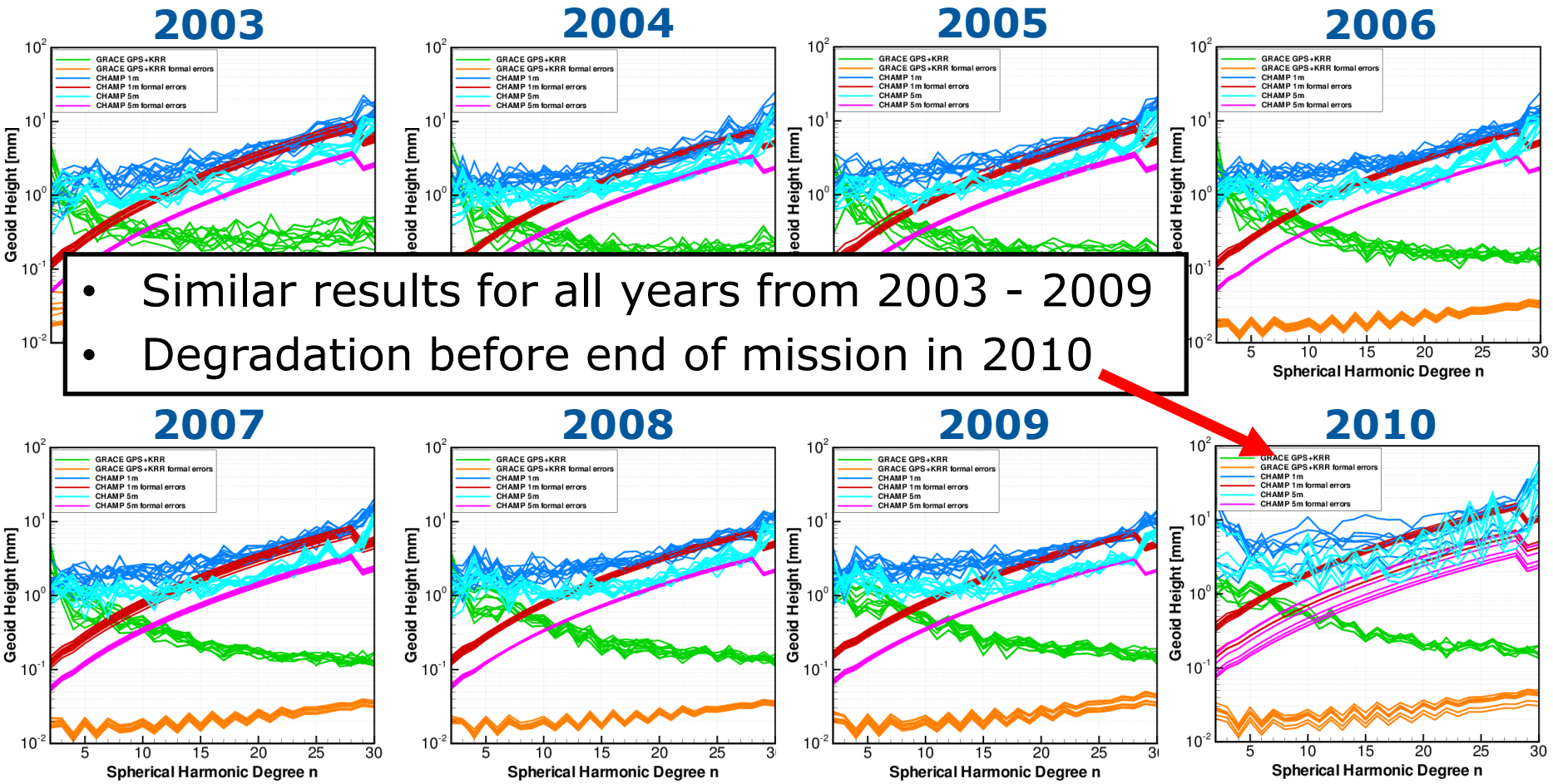
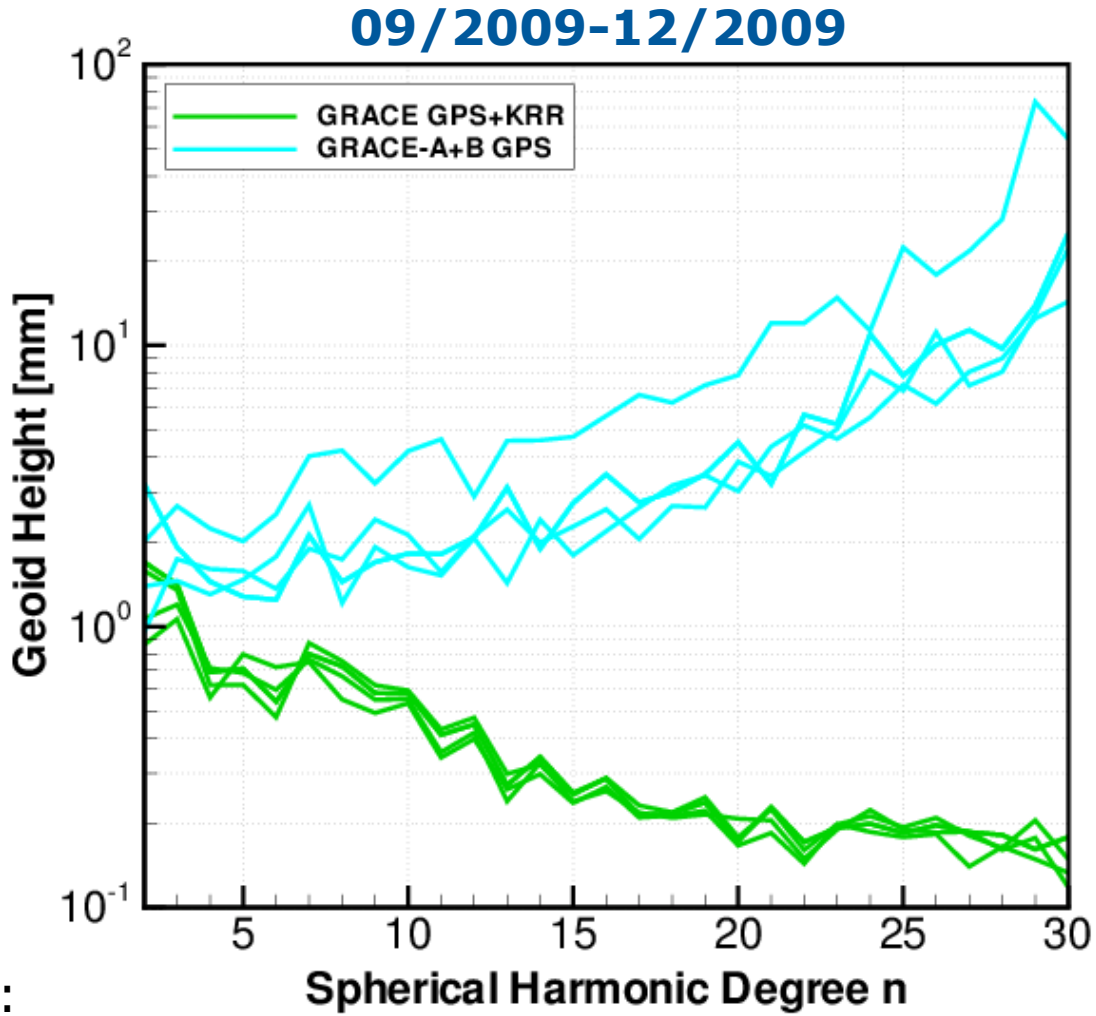


- Similar results for all years from 2003 - 2009
- Degradation before end of mission in 2010

Results: Degree variances **GRACE**

Degree variances wrt static background model (EIGEN-6C):

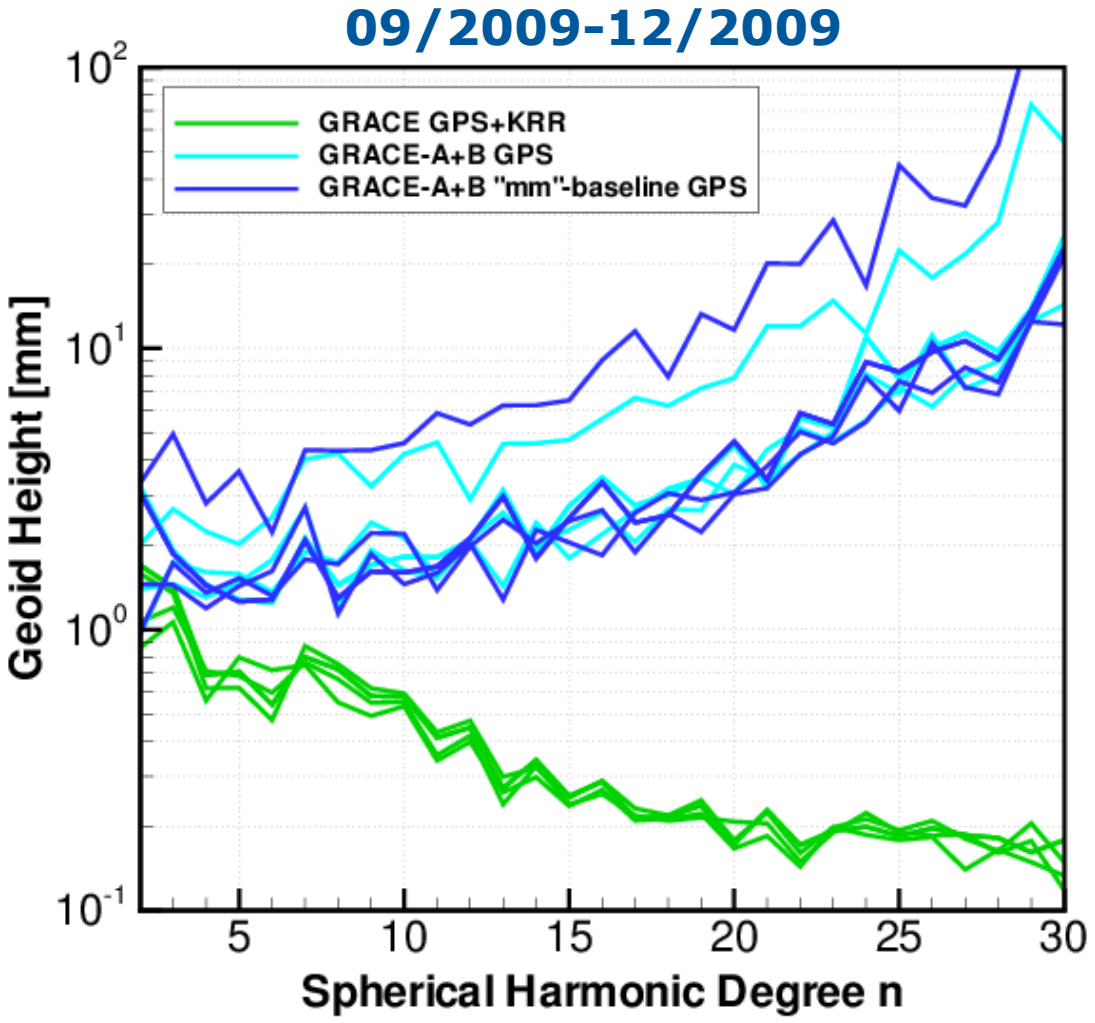
- Combined GRACE-A + GRACE-B solutions comparable to CHAMP 1-month solutions
- Baseline accuracy: ~10mm
- Improved baseline = improved gravity field?
- Baseline accuracy after applying integer ambiguity fixing to GRACE GPS observations: ~1-2mm



Results: Degree variances **GRACE**

Degree variances wrt static background model (EIGEN-6C):

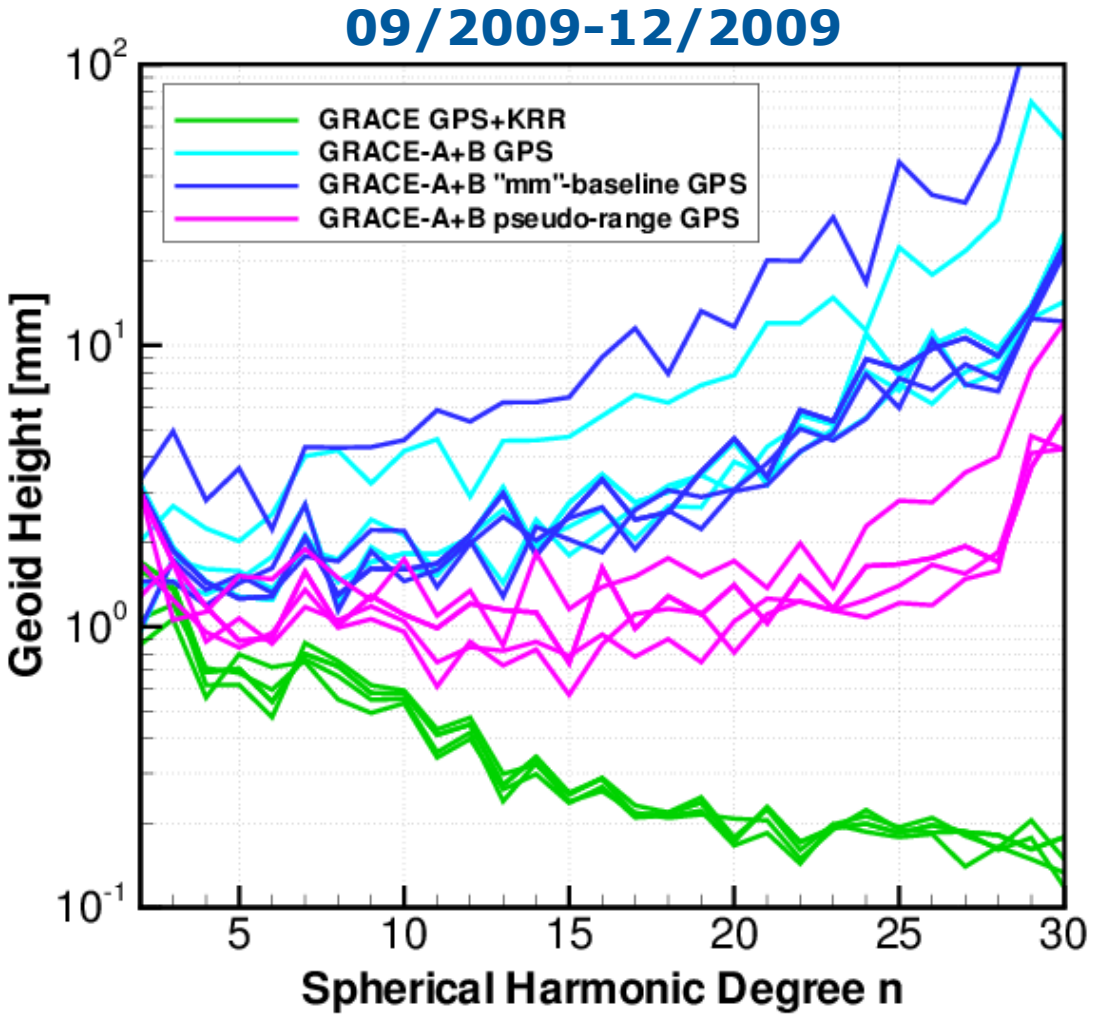
- Improved baseline does not improve gravity field!
- Introducing baseline as pseudo-range observation = improved gravity field?



Results: Degree variances **GRACE**

Degree variances wrt static background model (EIGEN-6C):

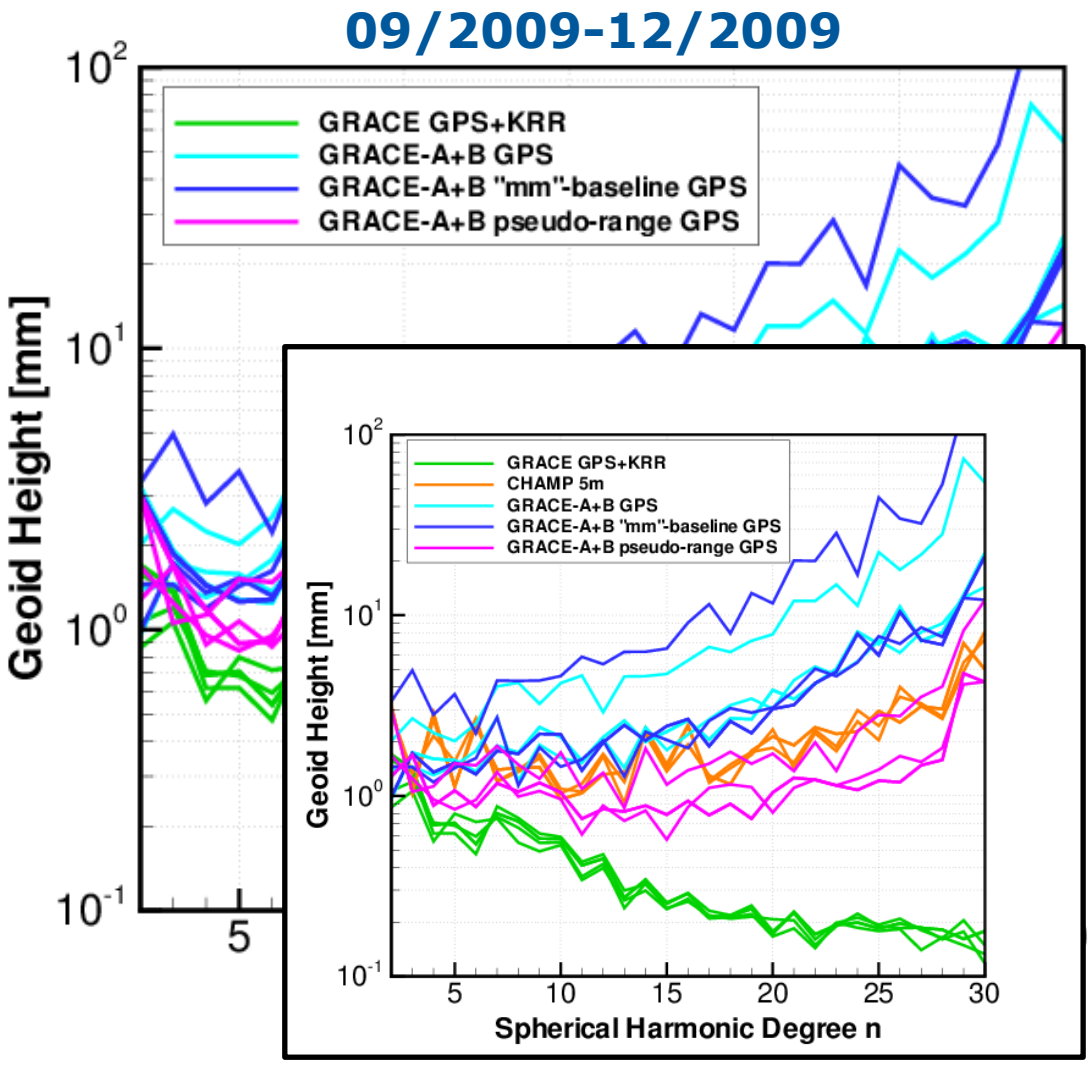
- Introducing baseline as pseudo-range observation seems to significantly improve gravity field solution!



Results: Degree variances **GRACE**

Degree variances wrt static background model (EIGEN-6C):

- Introducing baseline as pseudo-range observation seems to significantly improve gravity field solution!
- Combined GRACE-A + GRACE-B solutions better than CHAMP 5-month solutions



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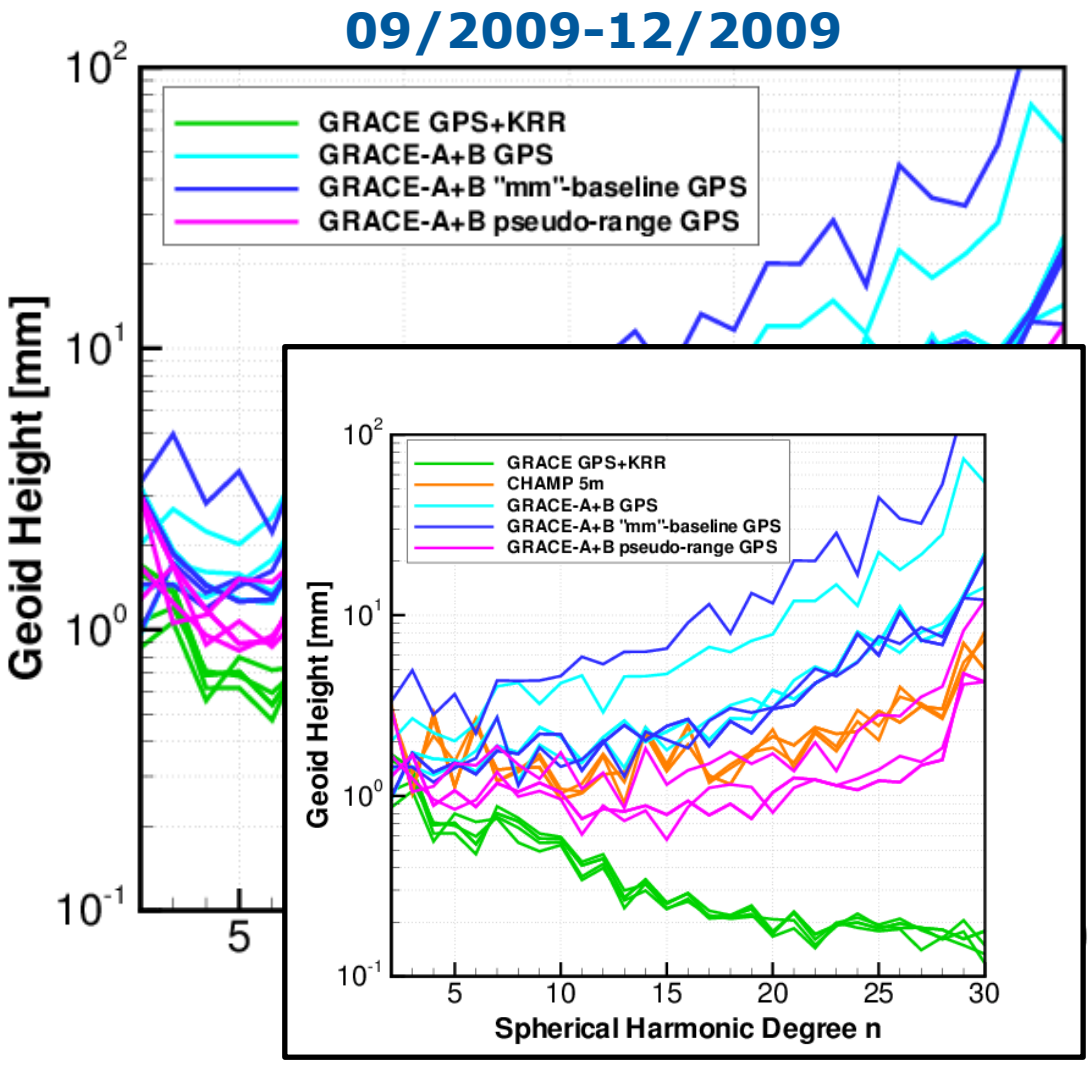
Degree variances wrt static background model (EIGEN-6C):

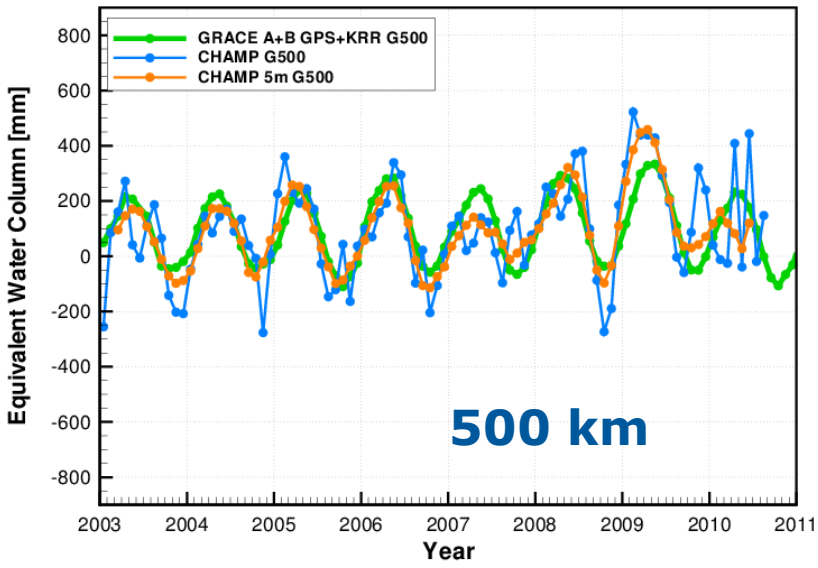
- Introducing baseline as pseudo-range observation seems to significantly improve gravity field solution!
- Combined GRACE-A + GRACE-B solutions better than CHAMP 5-month solutions
- Results have to be further verified (use of kinematic orbits, change of background model)

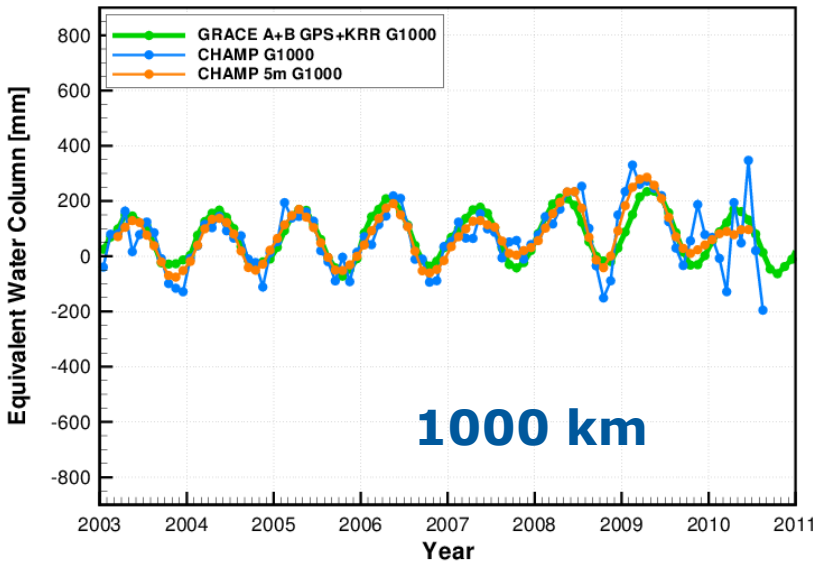


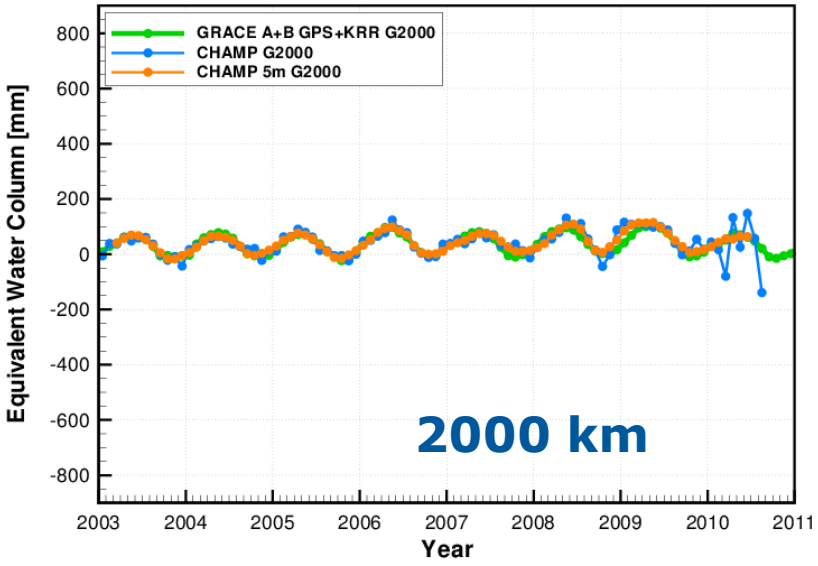
Results: Basin Averages

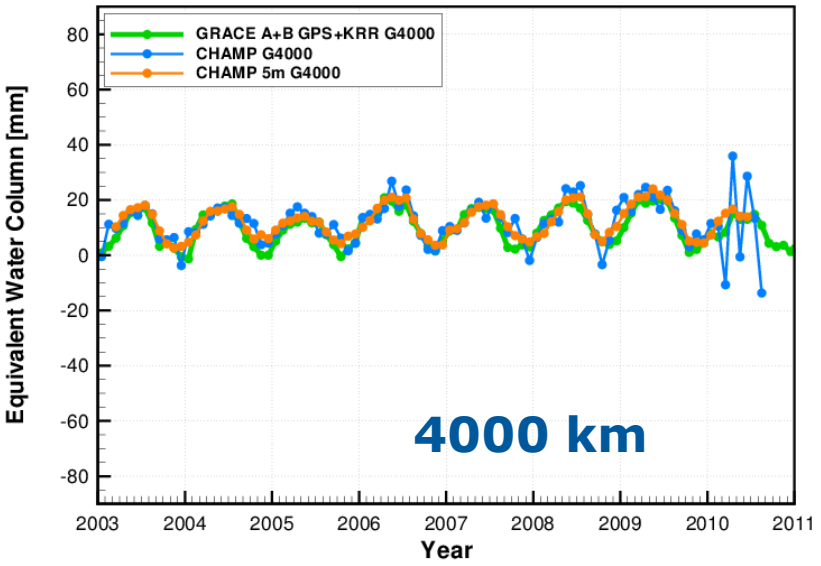
- Basin averages from CHAMP and GRACE GPS-only time-series are compared with GRACE RL05
- Evaluated basins:
  - Amazon: large seasonal signal & large basin
  - Ganges: large seasonal signal & smaller basin
  - Greenland: large trend & large basin
- Different Gaussian Averages have been applied:
  - 500 km = max. d/o 40x40
  - 1000 km = max. d/o 20x20
  - 2000 km = max. d/o 10x10
  - 4000 km = max. d/o 5x5
- C20 replaced by CSR SLR RL05 (http://grace.jpl.nasa.gov, Cheng et al. 2011)

Results: Basin Averages **Amazon**









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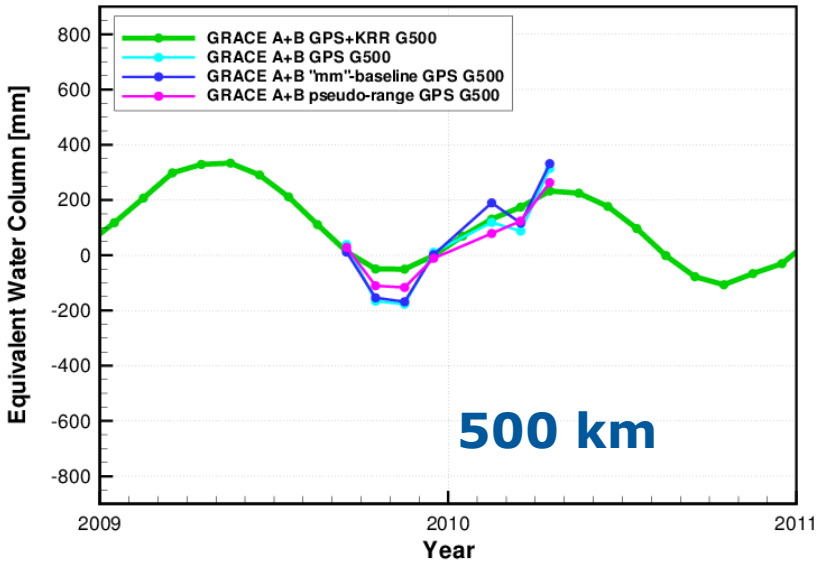
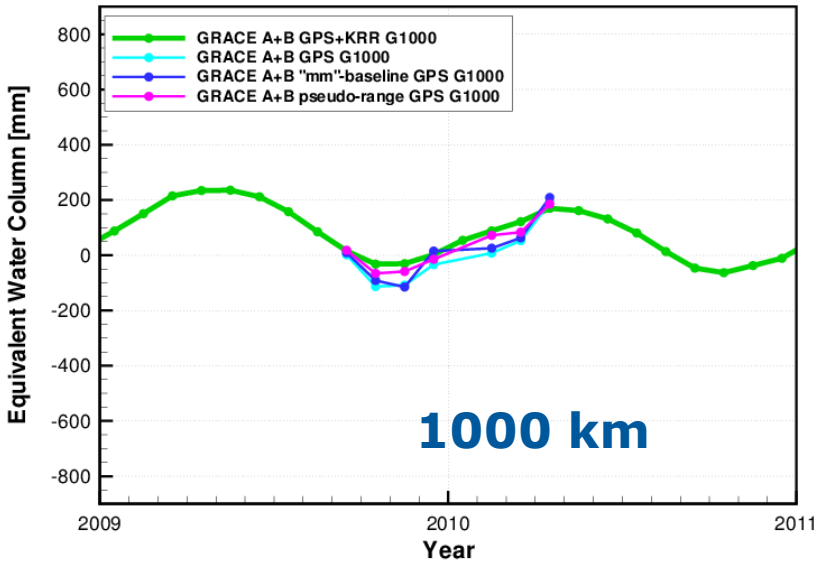
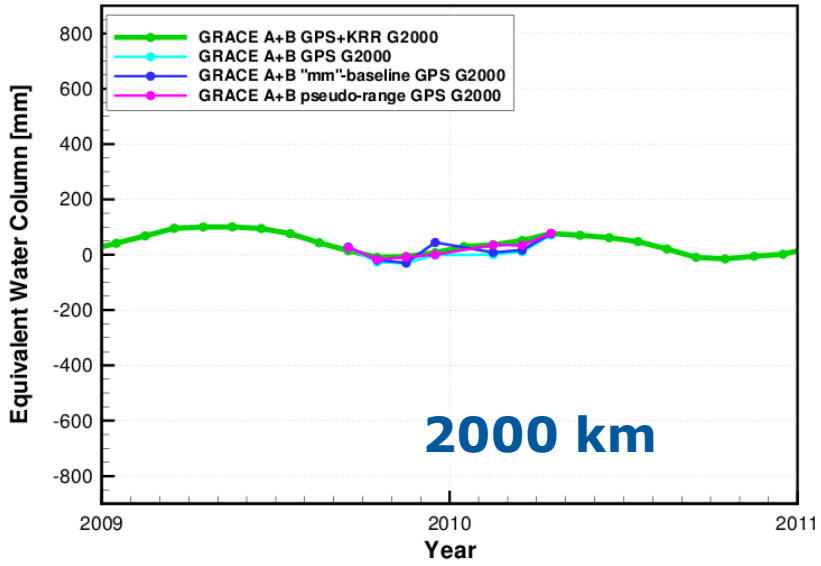
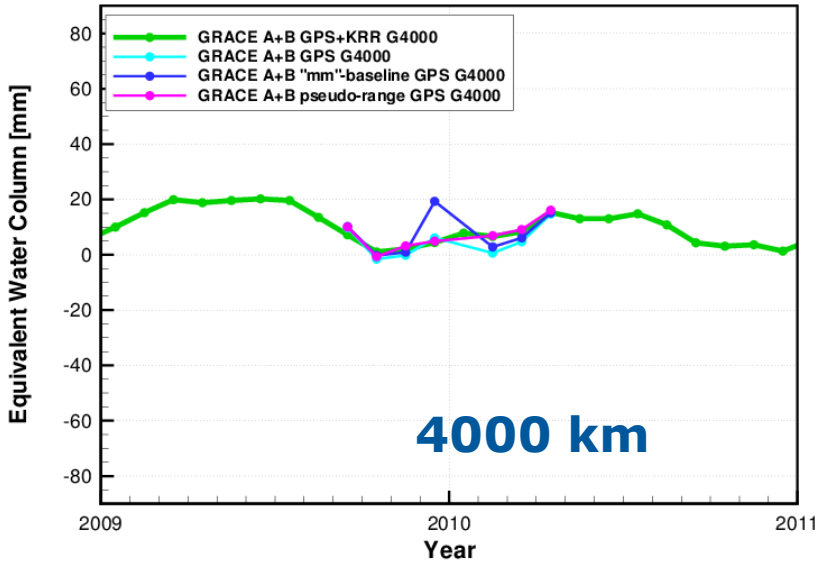
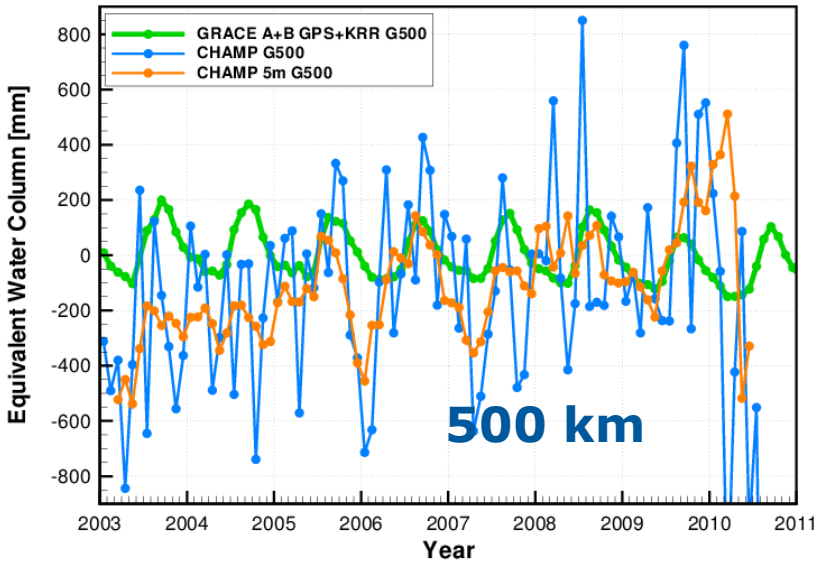


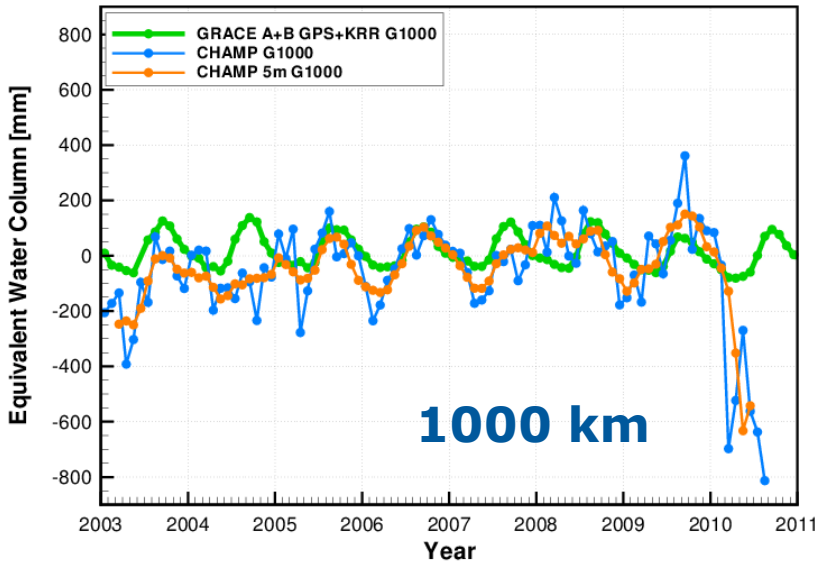


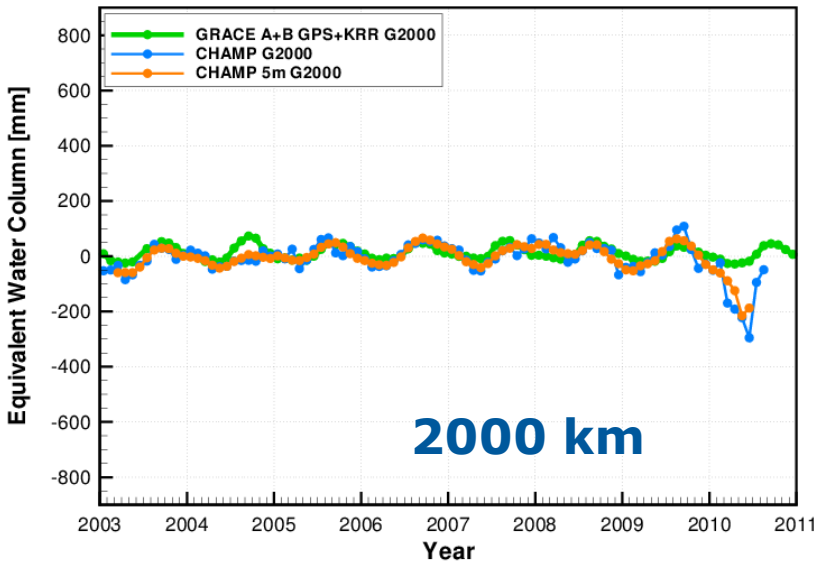


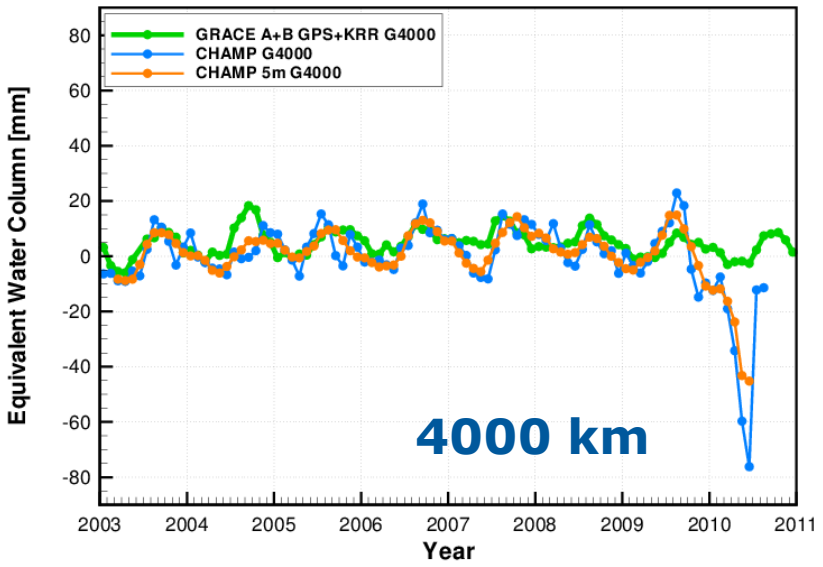


Results: Basin Averages **Ganges**

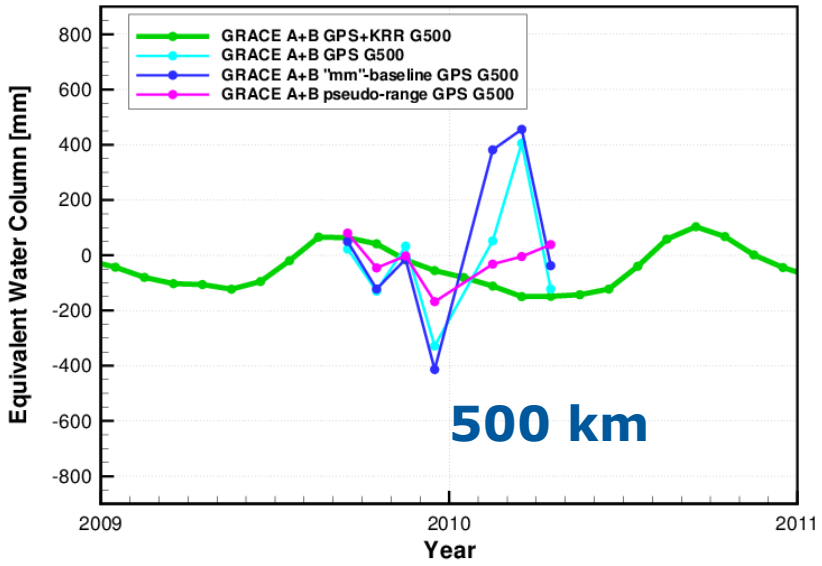


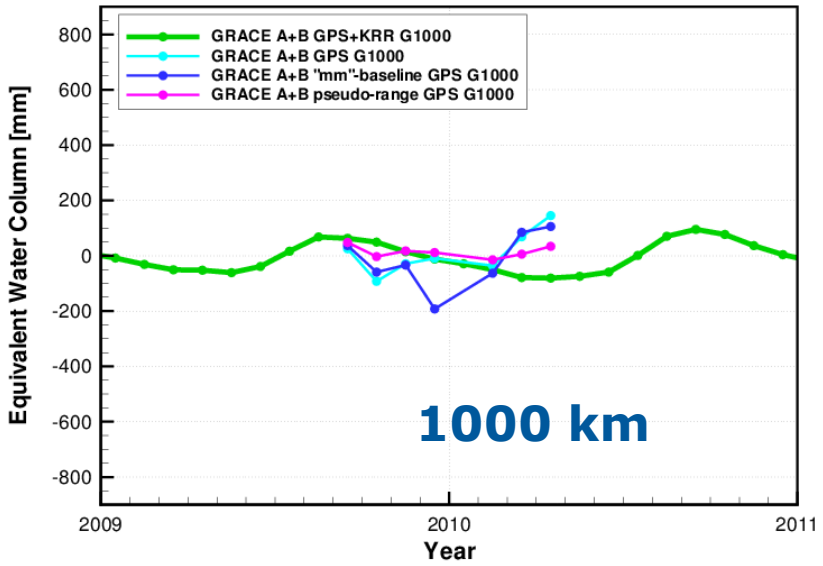


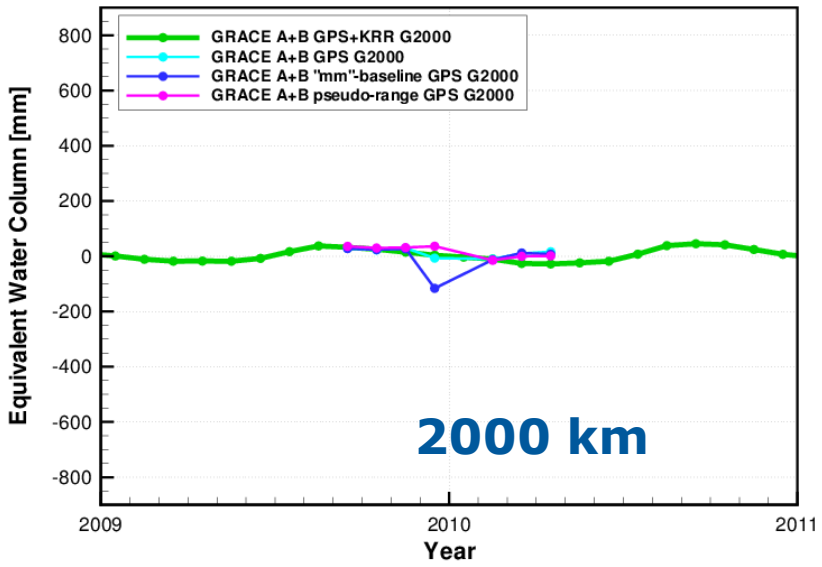


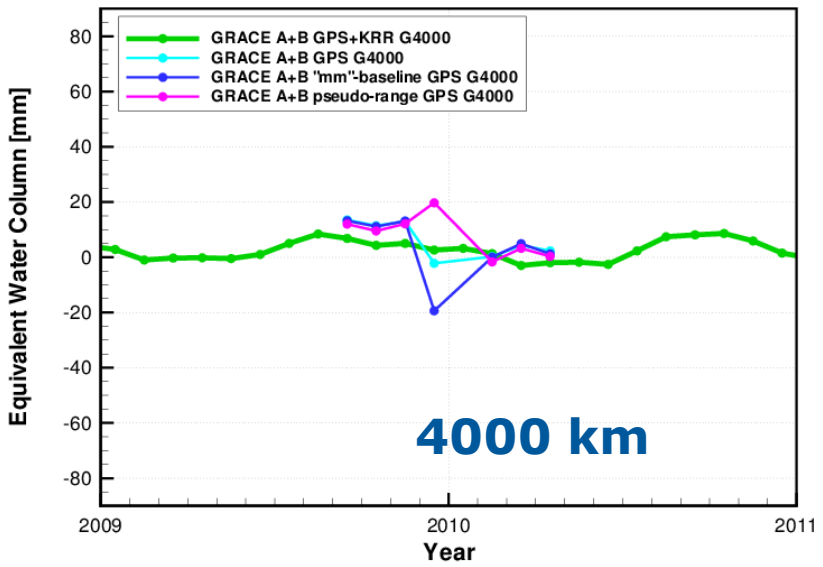


Results: Basin Averages **Ganges**

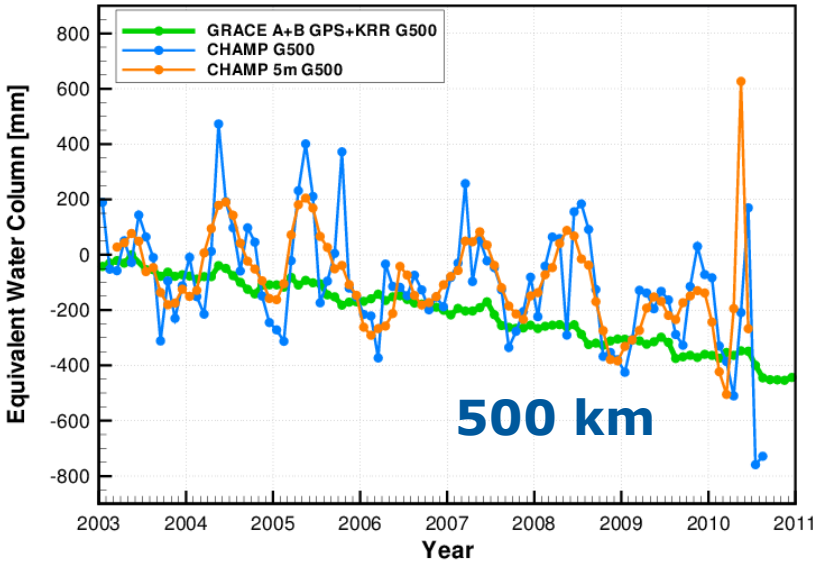


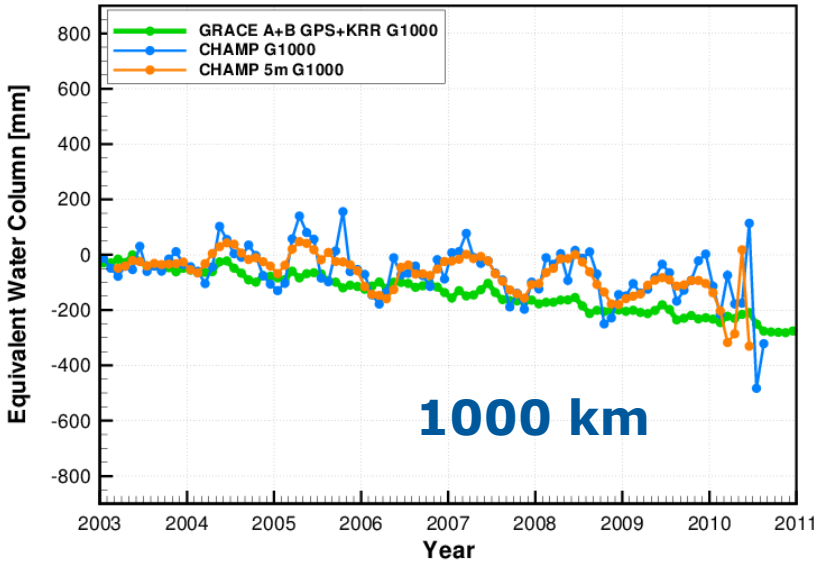


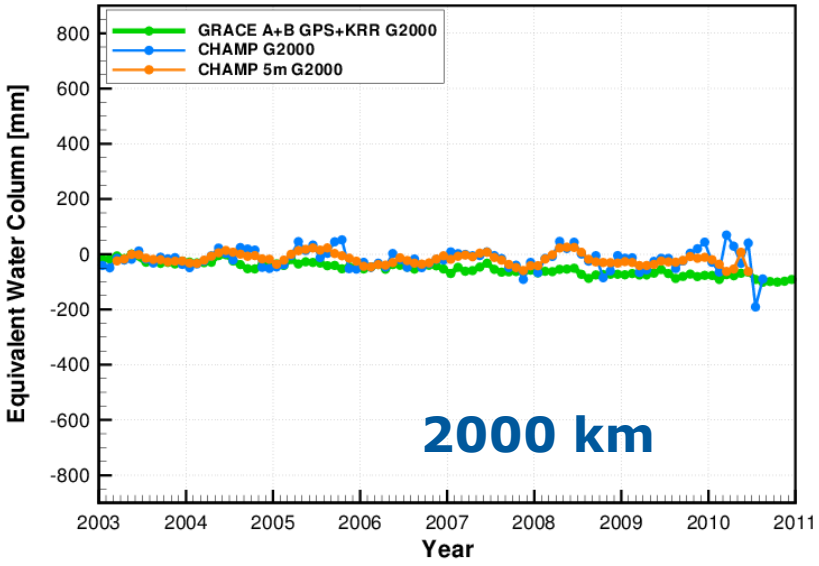


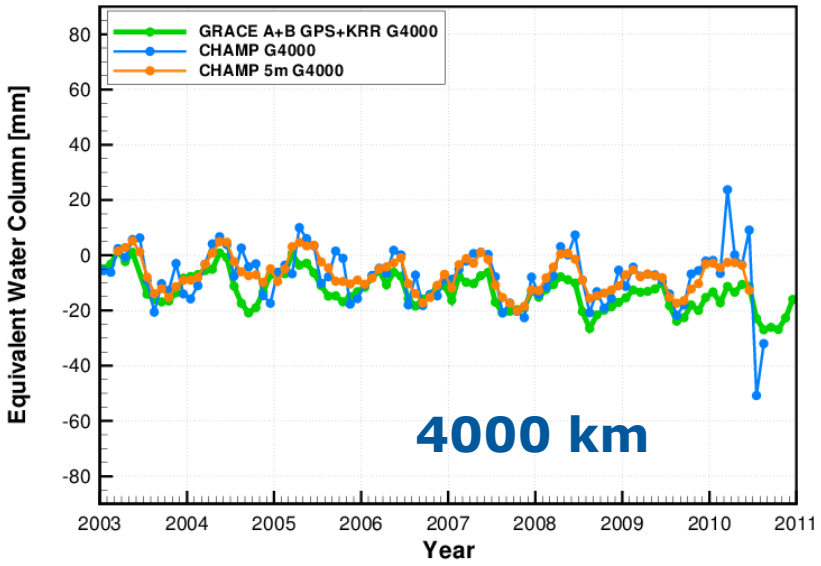


Results: Basin Averages **Greenland**









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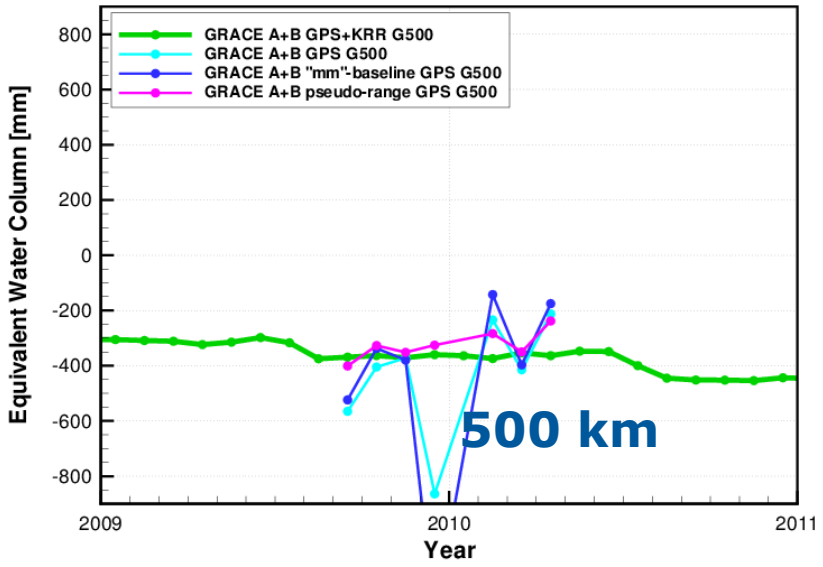

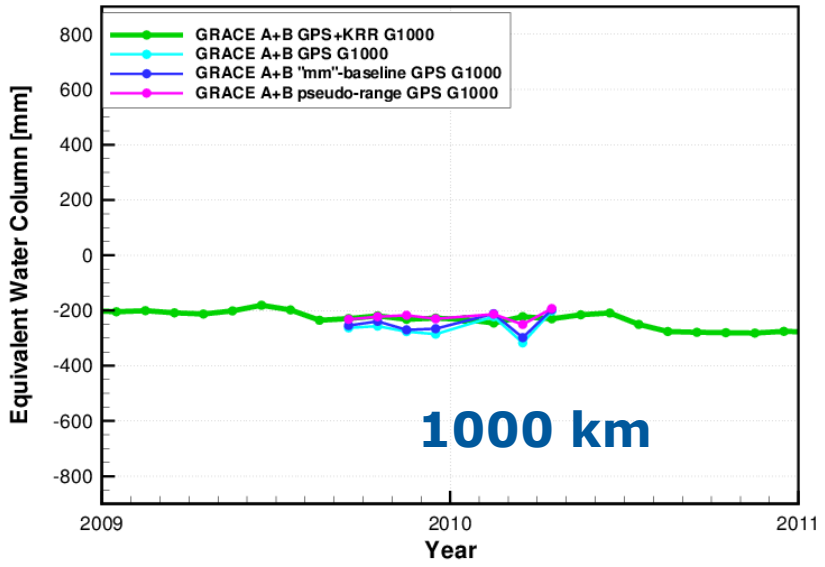

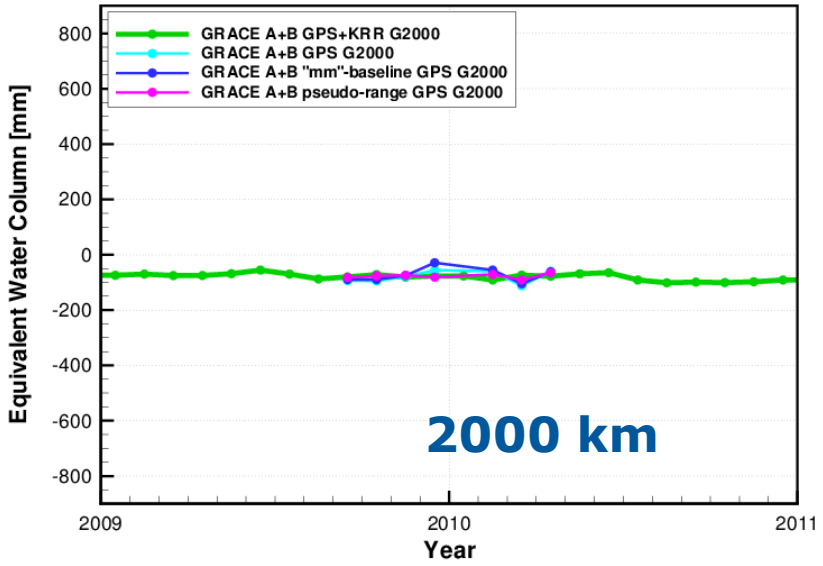

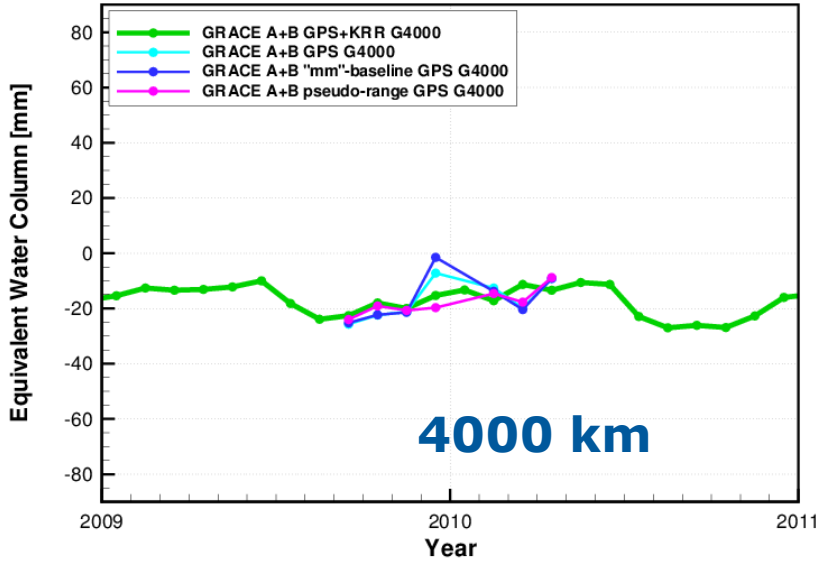

Summary & Outlook

- CHAMP and GRACE GPS-only time-variable gravity fields have been generated in order to assess the potential of high-low SST observations to fill the gap between GRACE and GRACE-FO
- Generally satisfying results at spatial scales of ~4000km (d/o 5x5)
- Depending on amplitude and spatial extent of analyzed signals, spatial resolution up to 500km (d/o 40x40) can be achieved
- Possible ways to improve such solutions:
  - calculate 5-month solutions instead of pure monthly solutions
  - use baselines between satellites as pseudo-range observations

- **SWARM** seems to be the most promising gap filling mission:
  - GPS receivers, accelerometers and star cameras on board
  - 3 satellites → multiple baselines can be used
- **TerraSAR-X/TanDEM-X** also worth to be investigated, although no accelerometers on board and quite short baseline