Direct Water Balance 2

Regional modeling of atmospheric water budgets and comparison to hydrological data and GRACE

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Concept

- Using atmospheric moisture flux divergence for continental scale water budget estimations
- Improvement of atmospheric water budgets from global models with dynamic downscaling

Objectives Phase I

- Estimation of P-ET_a from atmospheric moisture budgets
- Evaluation of global and regional atmospheric model data sets for continental scale water budget estimations
- Evaluation with hydrological datasets and comparison to GRACE

Methods

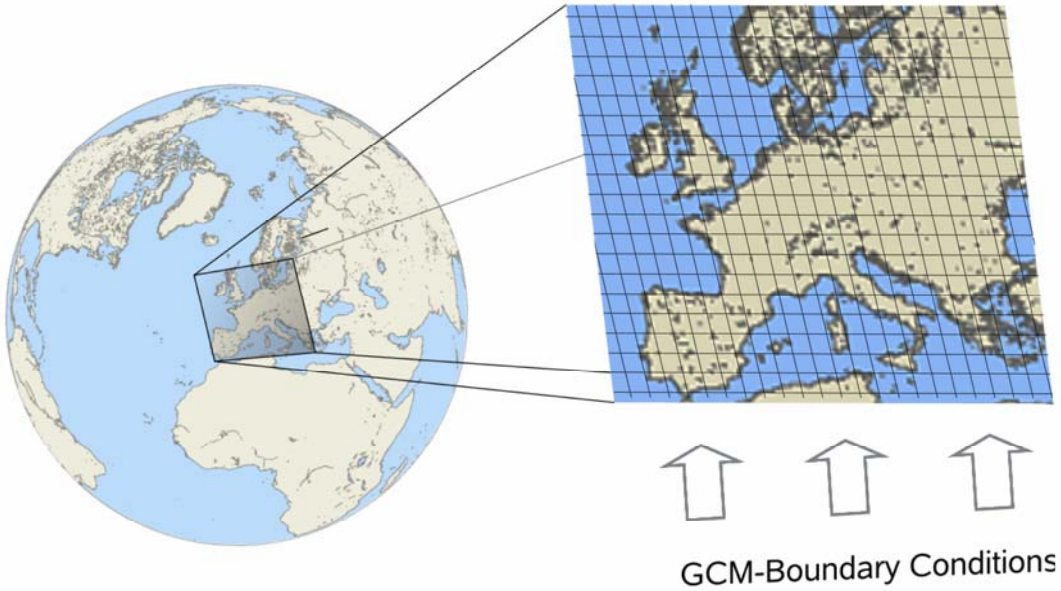
(1) $$\underbrace{R+\frac{\partial S}{\partial t}}_{\text{Terrestrial water budget}} = \underbrace{P-ET_a}_{\text{Exchange}} = \underbrace{-\nabla\cdot\vec{Q}+\frac{\partial W}{\partial t}}_{\text{Atmospheric water budget}} \approx -\nabla\cdot\vec{Q}$$

(2) $$\nabla\cdot\vec{Q} = \nabla\cdot\int_{p=0}^{p=p_{sfc}} \nu(p)q(p)\frac{dp}{g}$$

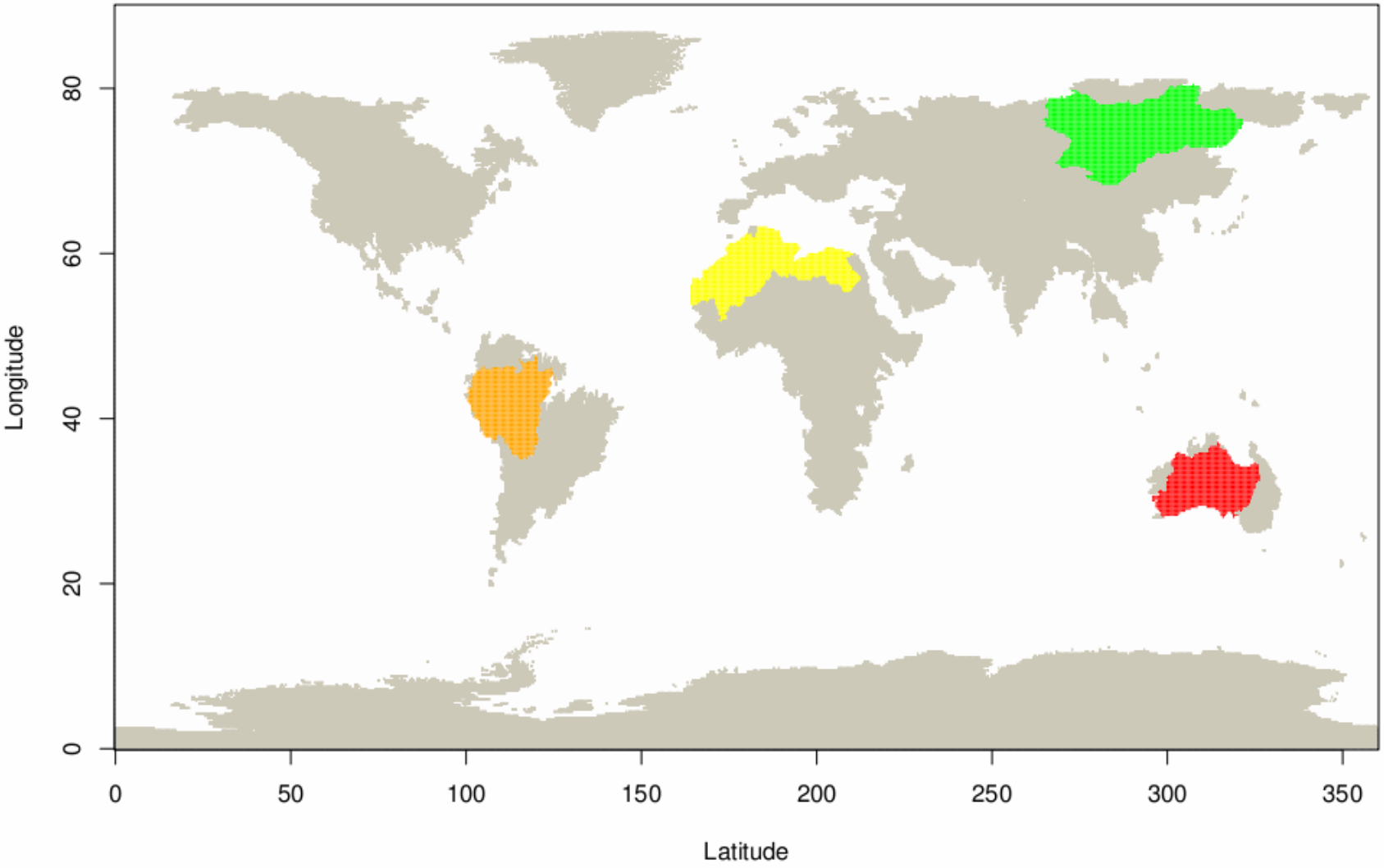
Vertically Integrated Moisture Flux Divergence (*VIMFD)*

Dynamic Downscaling Approach

- Regional atmospheric circulation model (WRF)
- Non hydrostatic, fully compressible, conservative
- High resolution topography and land-use
- Boundary conditions from **G**lobal **C**irculation **M**odel

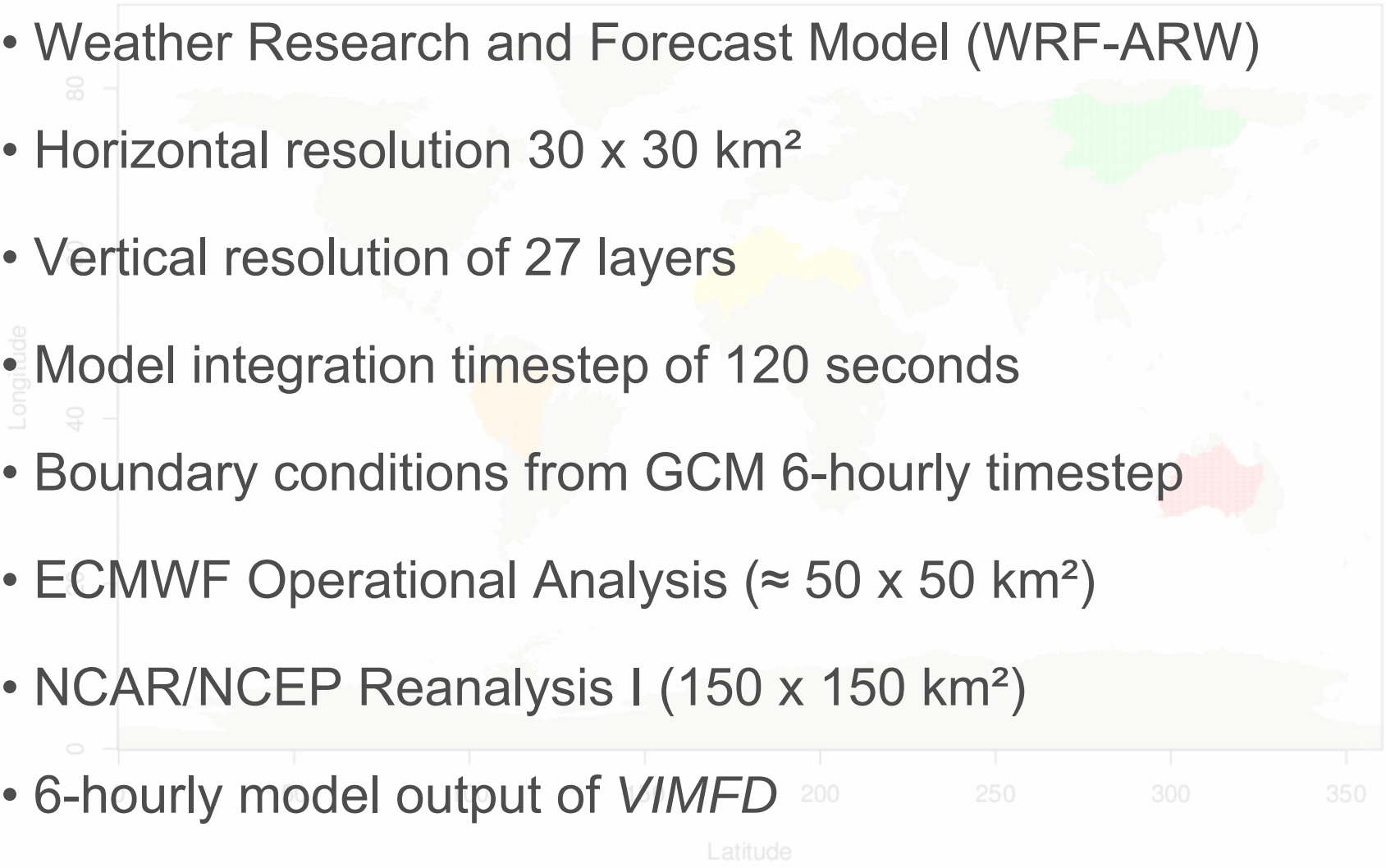


Regional atmospheric Model Setup

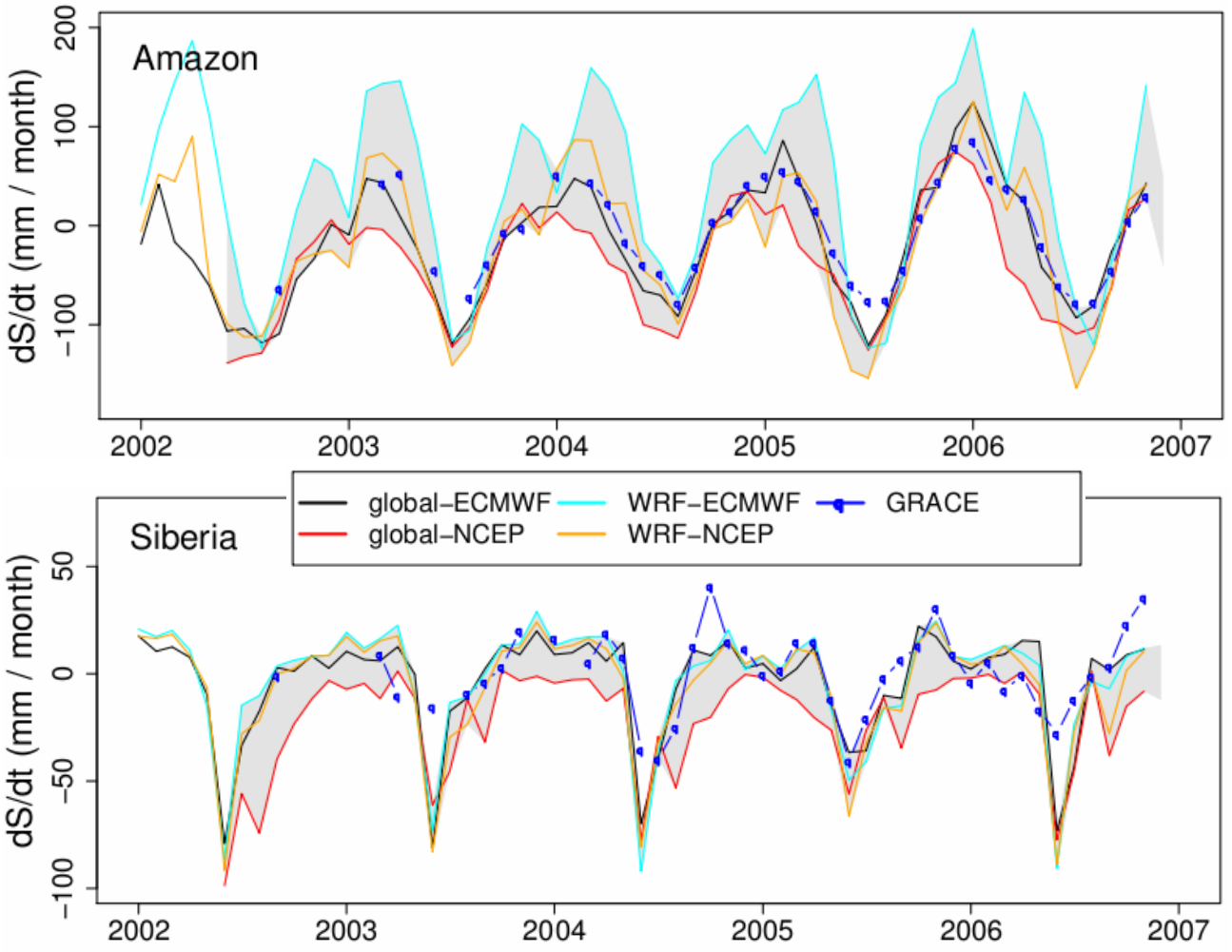


Regional atmospheric Model Setup

- Weather Research and Forecast Model (WRF-ARW)
- Horizontal resolution 30 x 30 km²
- Vertical resolution of 27 layers
- Model integration timestep of 120 seconds
- Boundary conditions from GCM 6-hourly timestep
- ECMWF Operational Analysis (≈ 50 x 50 km²)
- NCAR/NCEP Reanalysis I (150 x 150 km²)
- 6-hourly model output of *VIMFD*

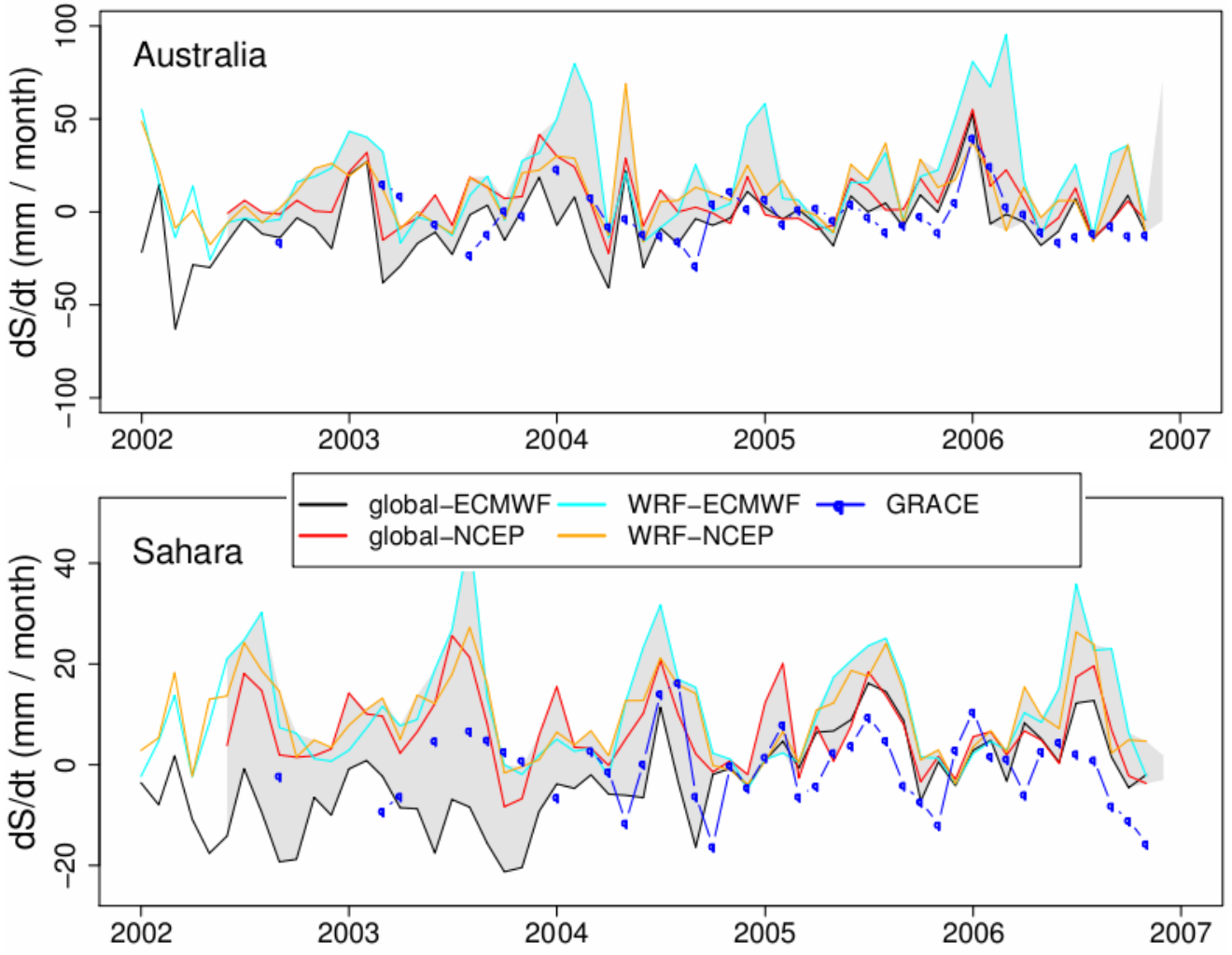


Results



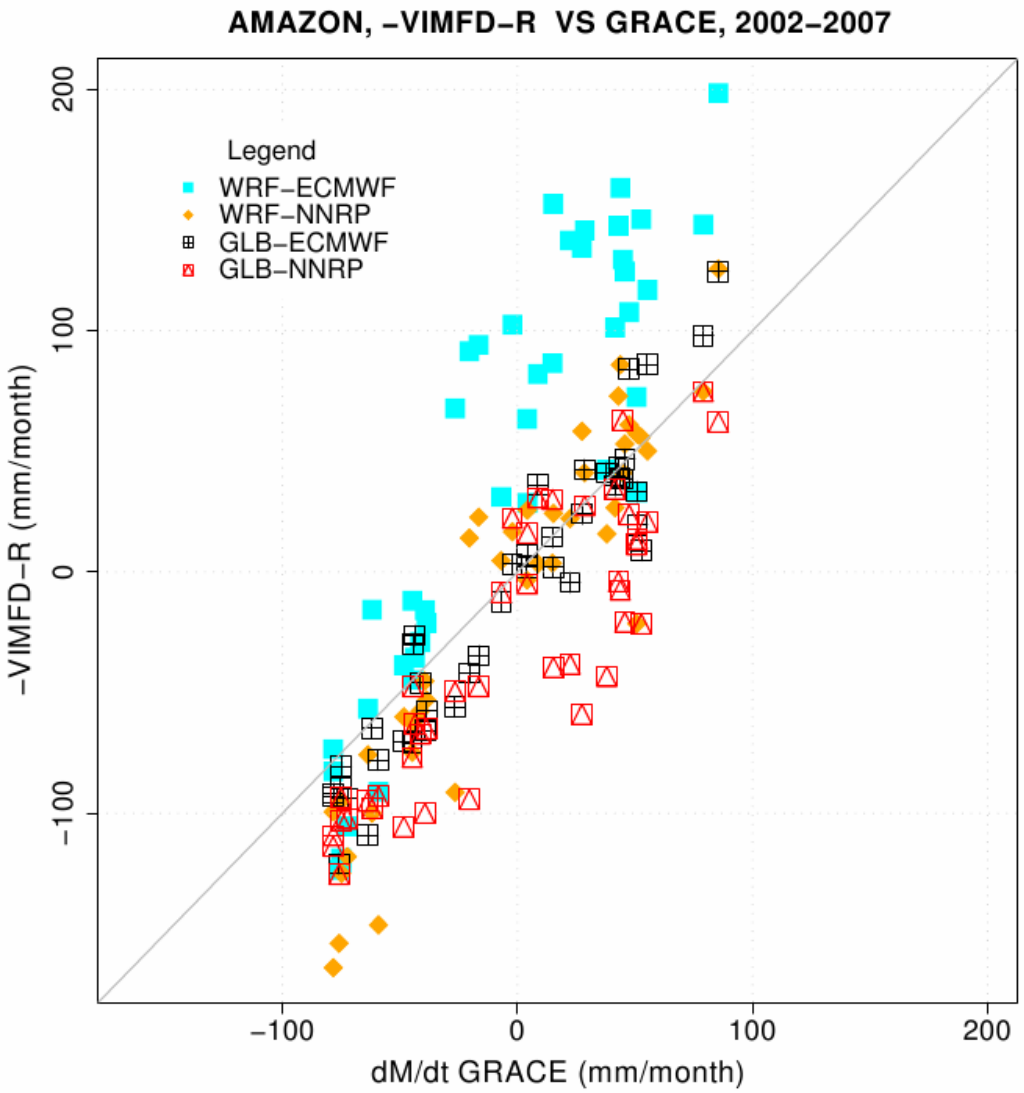
In general agreement in phase and amplitude for strong mass signals

Results



But: deviations between GRACE and atmospheric moisture constraints for dry regions

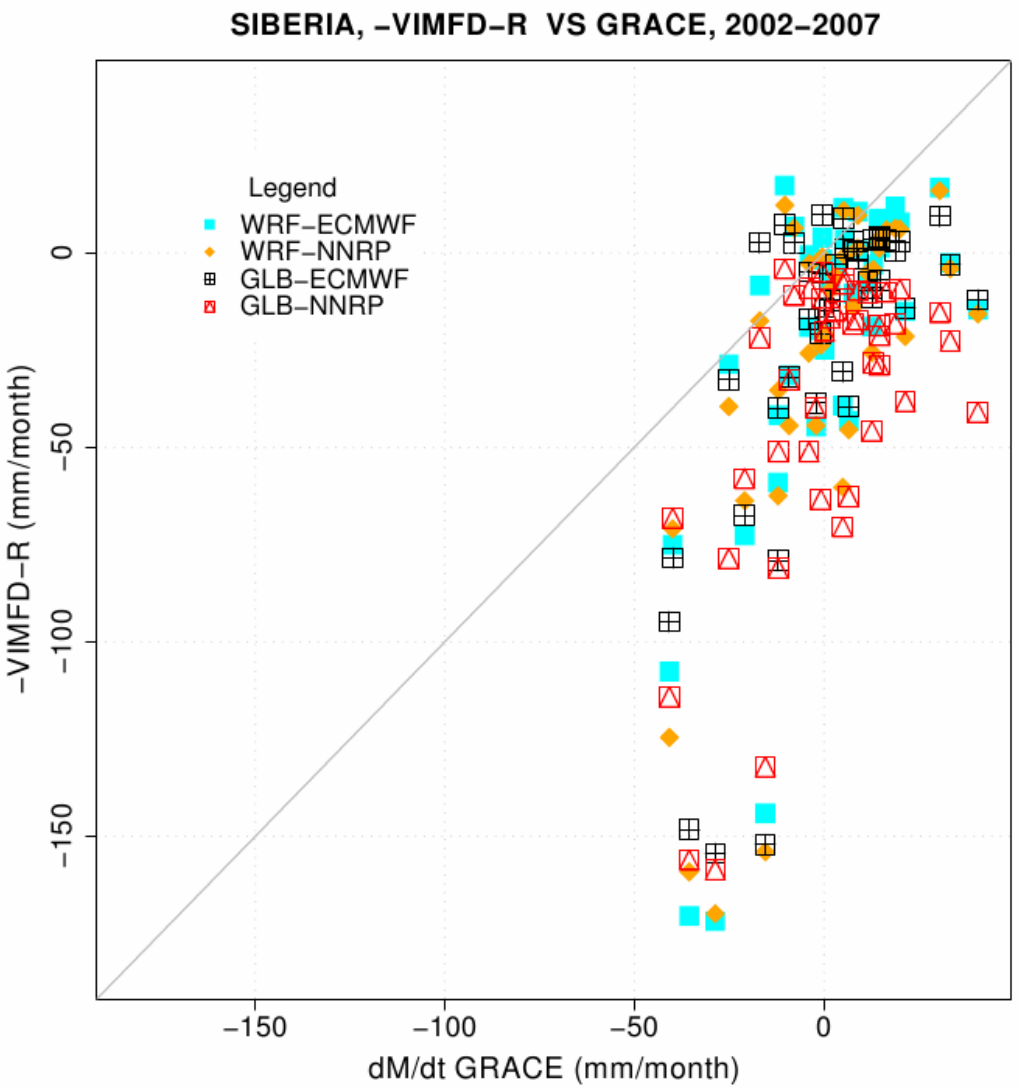
Results



Good correlation for global and regional *VIMFD*

Decreased bias e.g. for WRF-NNRP

Results

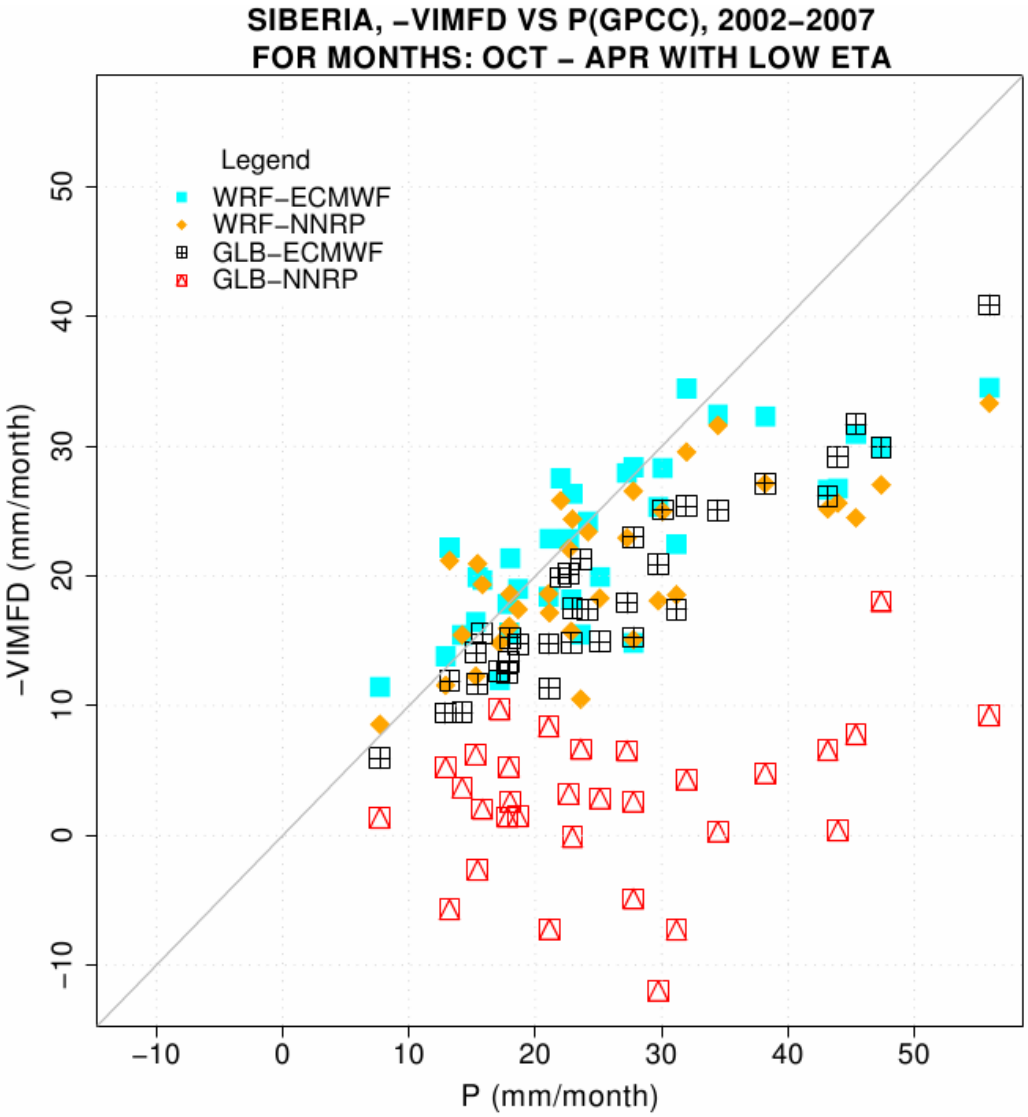


Both, regional and global *VIMFD*:

Uncorrelated for small signals

Large bias for stronger signals

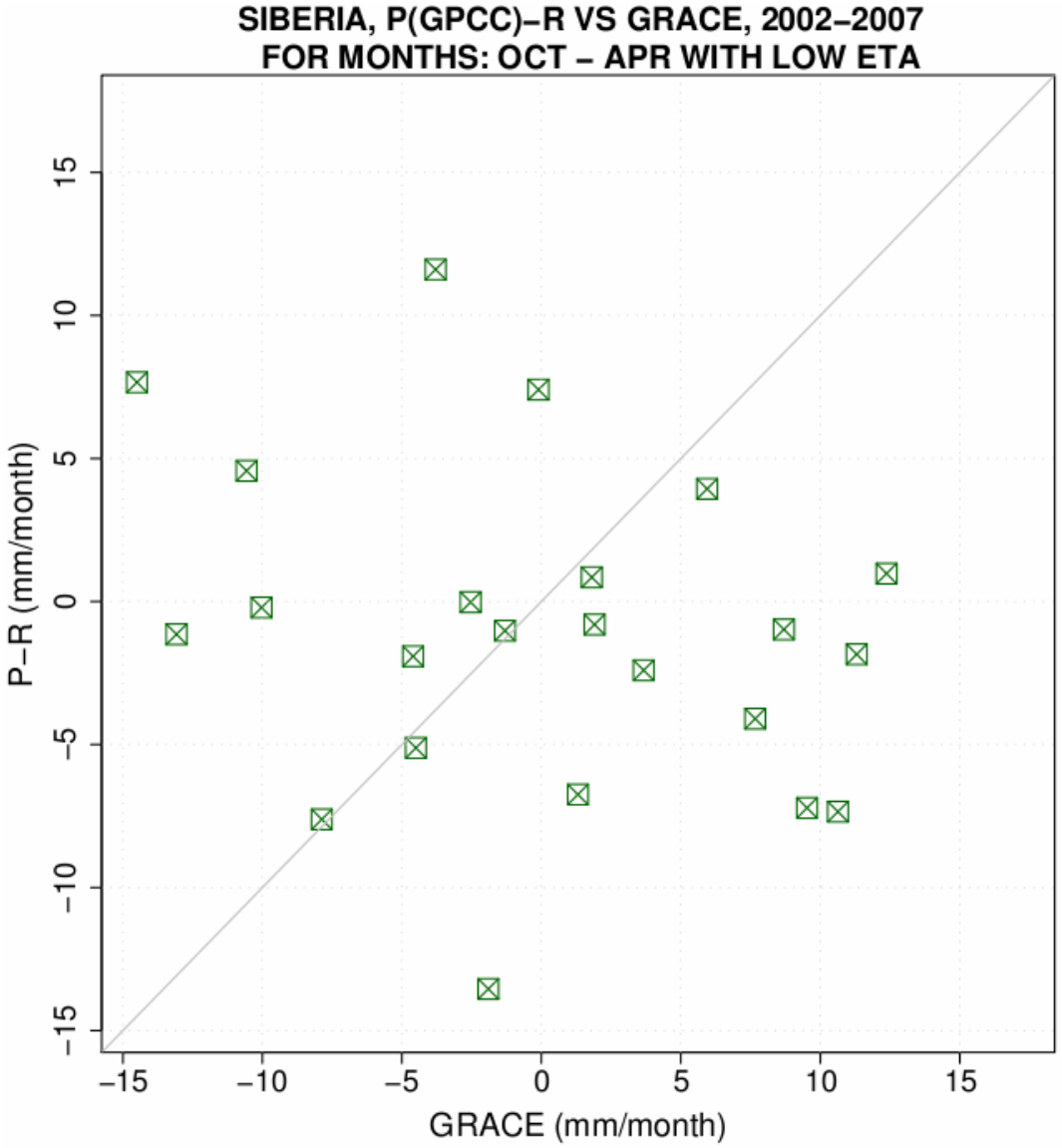
Results



Regional modeling:

Reduced bias for *VIMFD* with respect to GPCC precipitation

Results



No correlation between *P-R* and GRACE for Siberian domain (months with *Eta* ≈ 0)

Conclusions

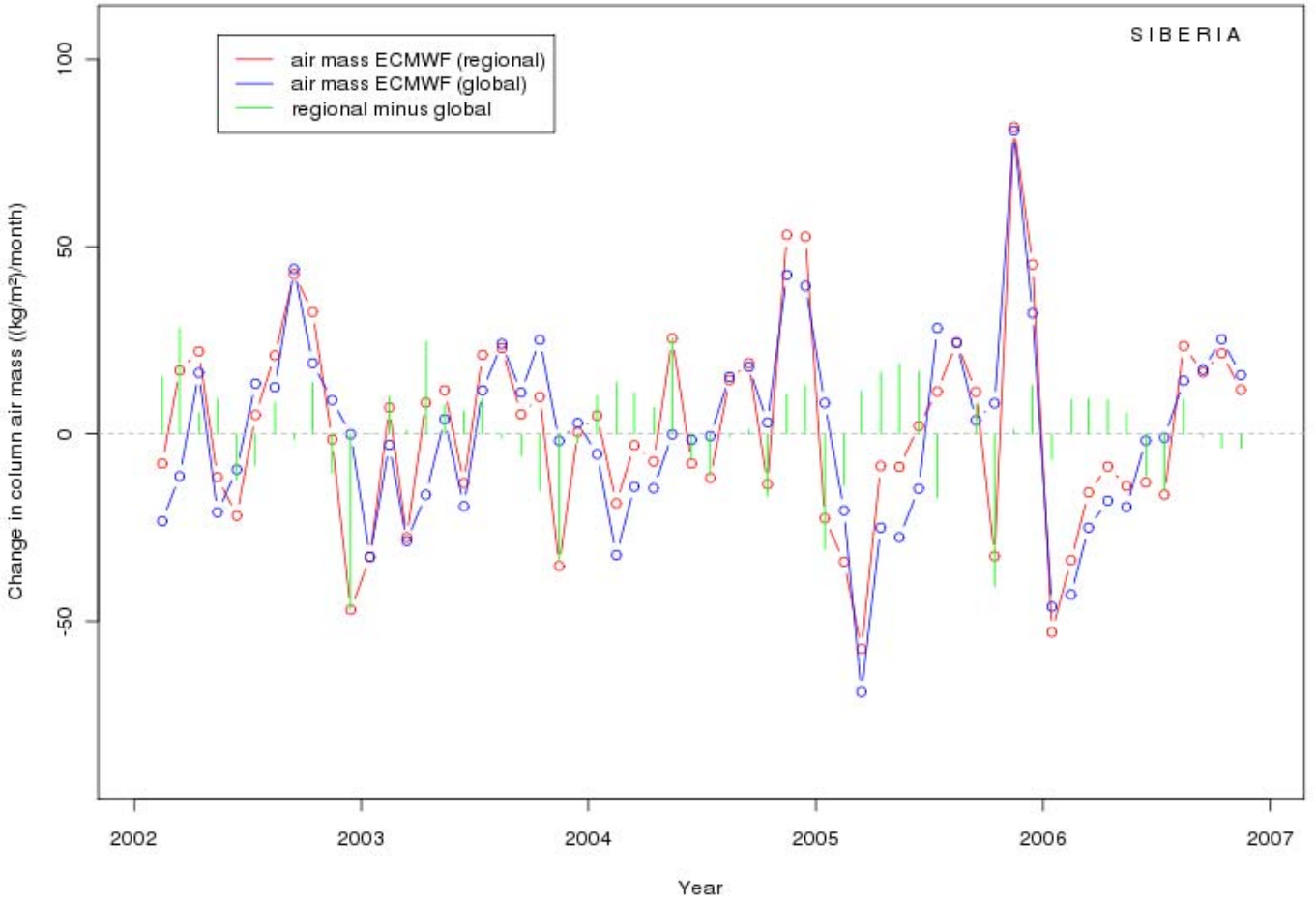
- Dynamic downscaling can improve estimates of *VIMFD* with respect to *P* (GPCC)
- *VIMFD-R* and *P-R* (GPCC) show systematic disagreement with GRACE
- Quantification of uncertainty bounds arising from atmospheric uncertainties
- Validation of DWB concept:

  - *VIMFD* suits as a proxy for *P-ET* and evaluation with GRACE water storage changes

  - Regional atmospheric modeling allows refined GRACE analysis

Thanks for your attention.

Appendix


SIBERIA
air mass ECMWF (regional)
air mass ECMWF (global)
regional minus global
Change in column air mass ((kg/m²)/month)
100
50
0
-50
2002
2003
2004
2005
2006
2007
Year

Outlook Phase II

- Extension to further regions and catchments
  - Central Europe, North America, Asia
- Evaluation of new ECMWF INTERIM Reanalysis data
- Comparison of regional atmospheric water budgets with different GRACE filters and other products
  - Weekly / 10-day GRACE solutions
  - Regional GRACE solutions (short arc)

  ⇒ **Extended analysis of uncertainty bounds**