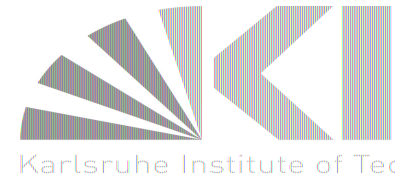


# Continental Scale Atmospheric and Terrestrial Water Budget Modeling and Comparison to GRACE

**Benjamin Fersch, Harald Kunstmann**

Institute for Meteorology und Climate Research (IMK-IFU)  
Karlsruhe Institute of Technology (KIT), Forschungszentrum Karlsruhe



**Nico Sneeuw, Balaji Devaraju**

Institute of Geodesy, University of Stuttgart



DFG SPP1257  
Mass Transport and Mass  
Distribution in the System  
Earth



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# Introduction

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- Water budget estimations for continental scale catchments and dischargeless basins
- Approximation of  $P-ET$  from atmospheric moisture budgets
- Improvement of global atmospheric moisture budgets with the regional atmospheric model WRF
- Definition of uncertainties that emerge from different atmospheric model driving of global and regional models
- Evaluation of atmospheric water budgets with terrestrial hydrological observations and comparison to GRACE

# Vertically Integrated Moisture Convergence (MC)

$$\begin{aligned}
 MC = & \underbrace{R + \frac{\partial S}{\partial t}}_{\text{Terrestrial water budget}} = \underbrace{P - ET_a}_{\text{Exchange}} = \underbrace{-\nabla \cdot \vec{Q} + \frac{\partial W}{\partial t}}_{\text{Atmospheric water budget}} \approx -\nabla \cdot \vec{Q}
 \end{aligned}$$

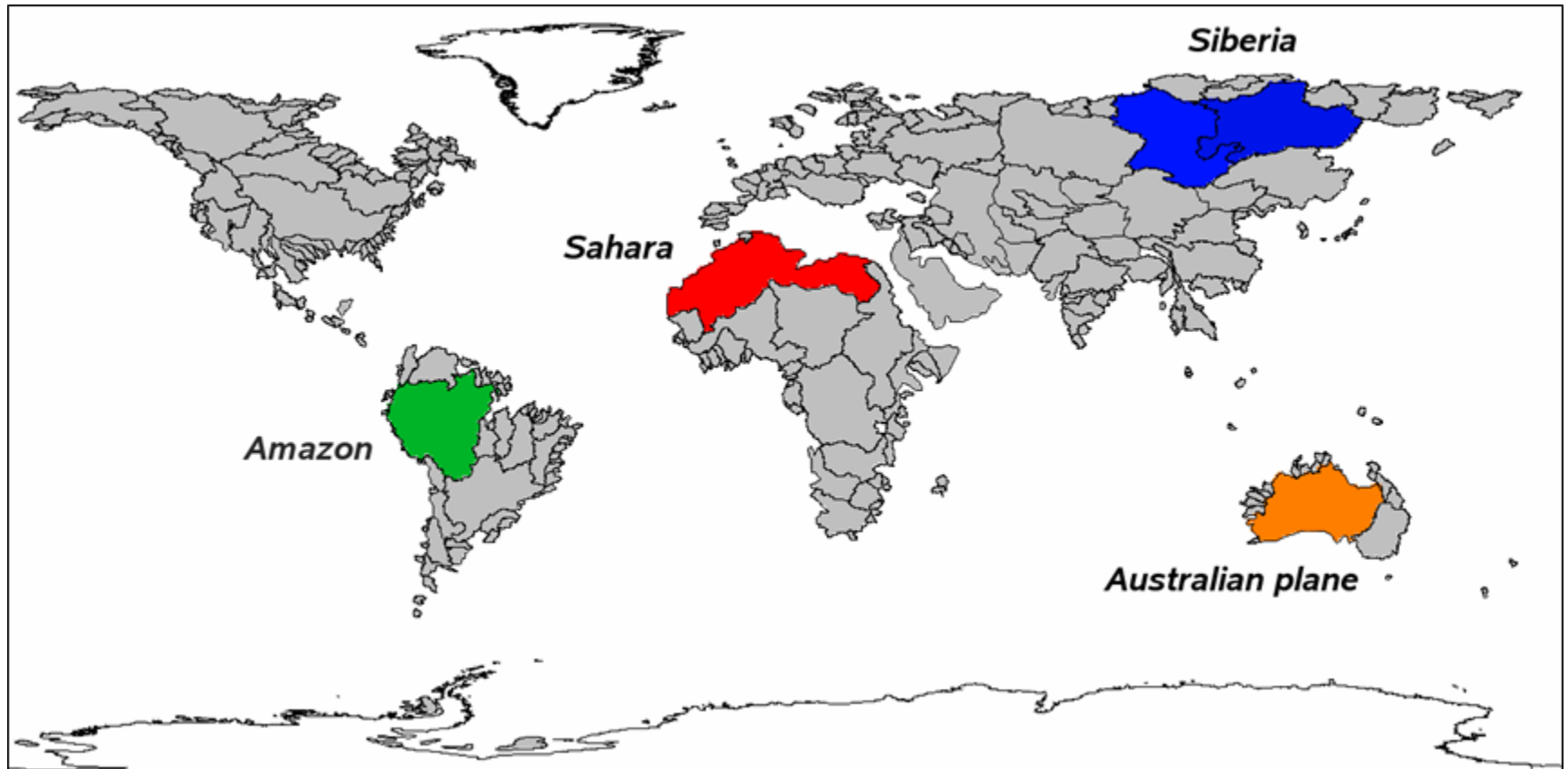
$$\nabla \cdot \vec{Q} = \nabla \cdot \int_{p=0}^{p=p_{sfc}} \vec{v} q \frac{dp}{g}$$

# Evaluation

$$P - ET - R = \underbrace{\frac{dS}{dt}}_{\text{water storage}} = MC - R \approx \underbrace{\frac{dM}{dt}}_{\text{GRACE GSM}}$$

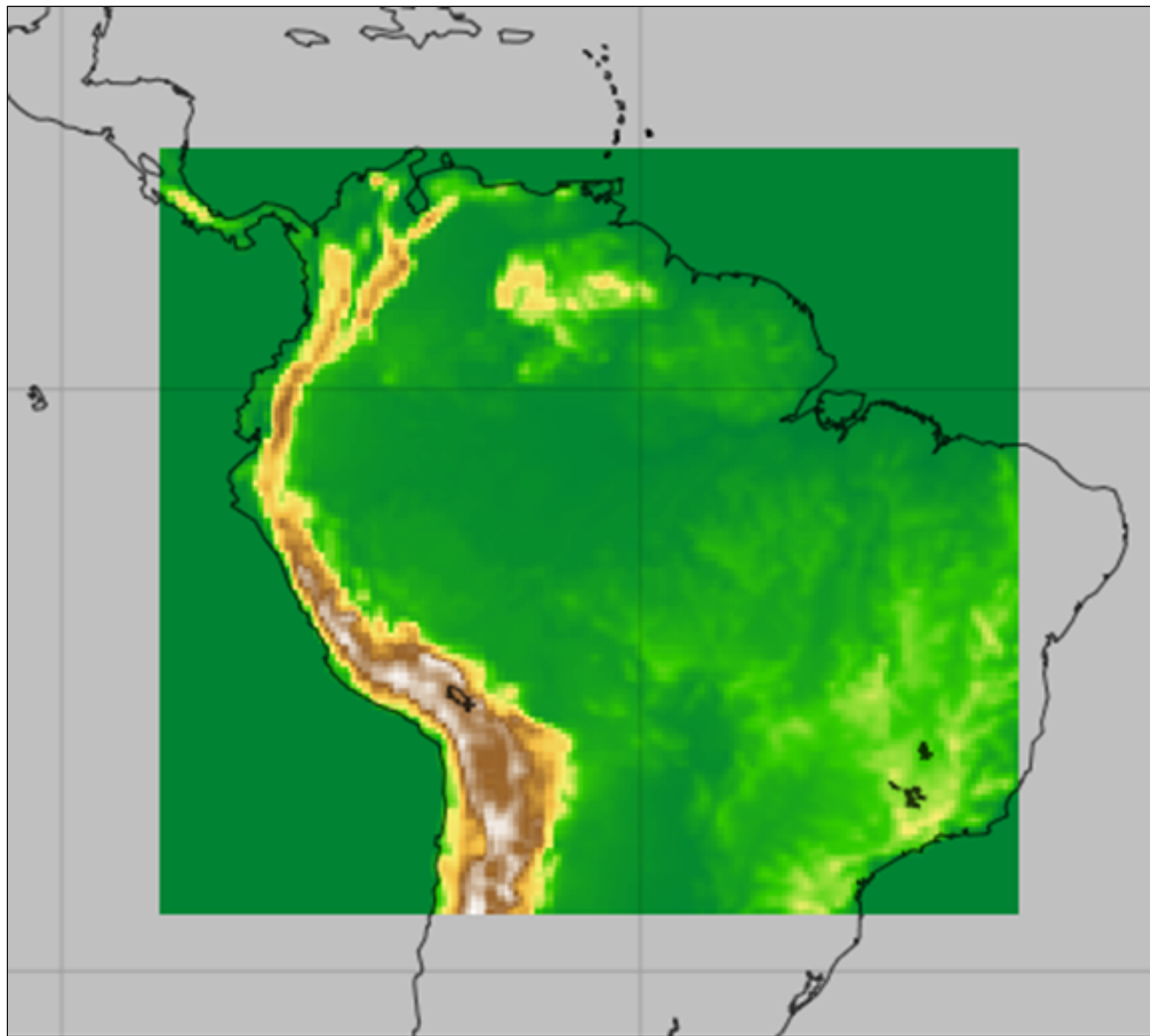
- Modeled terrestrial water storage change with GRACE
- Model precipitation with Global Precipitation Climatology Center (GPCC) data
- $MC$  with GPCC for periods with negligible evapotranspiration

# Modeled Regions

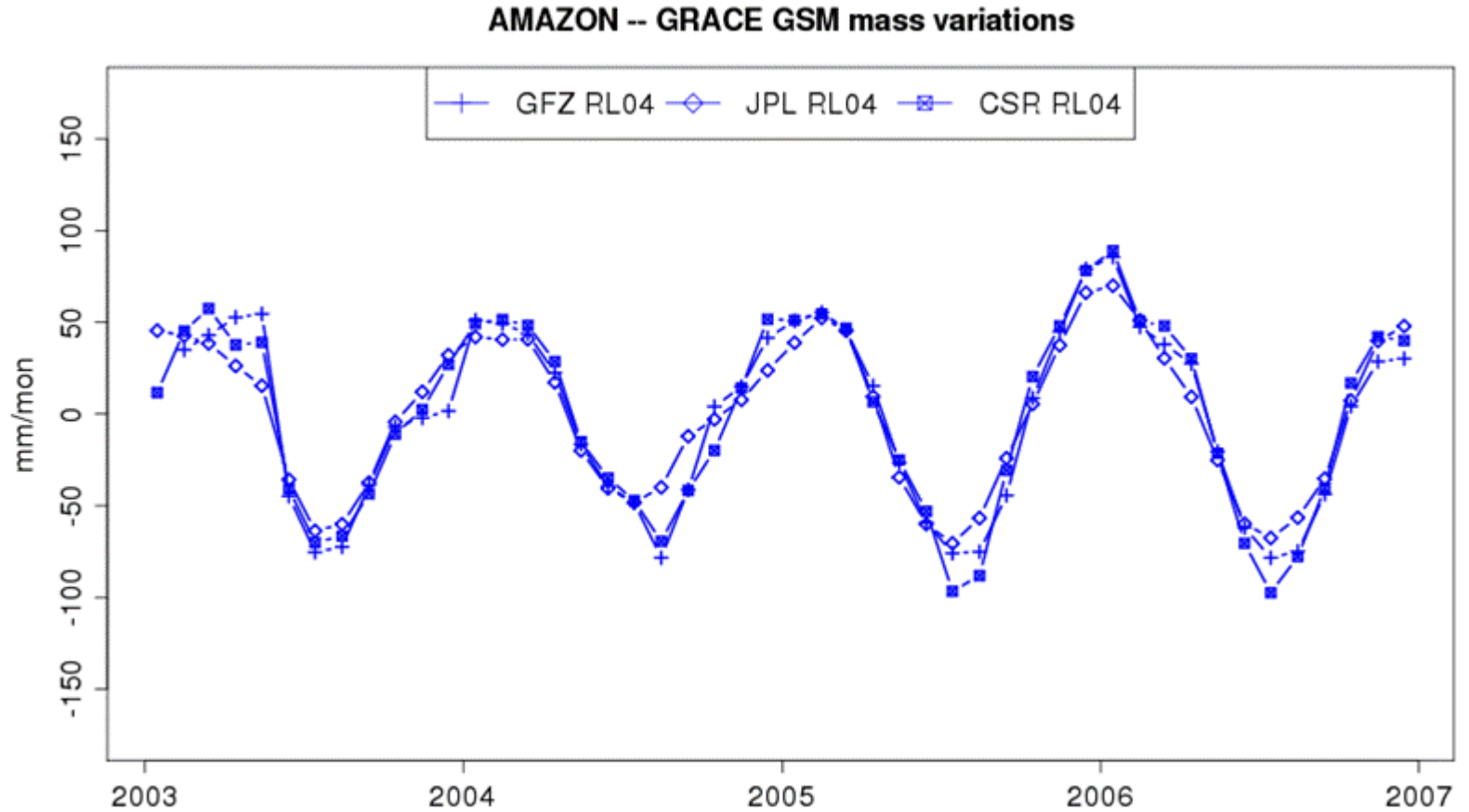


- WRF (Weather Research and Forecast Model)
- 30x30 km<sup>2</sup> horizontal resolution

# Amazon

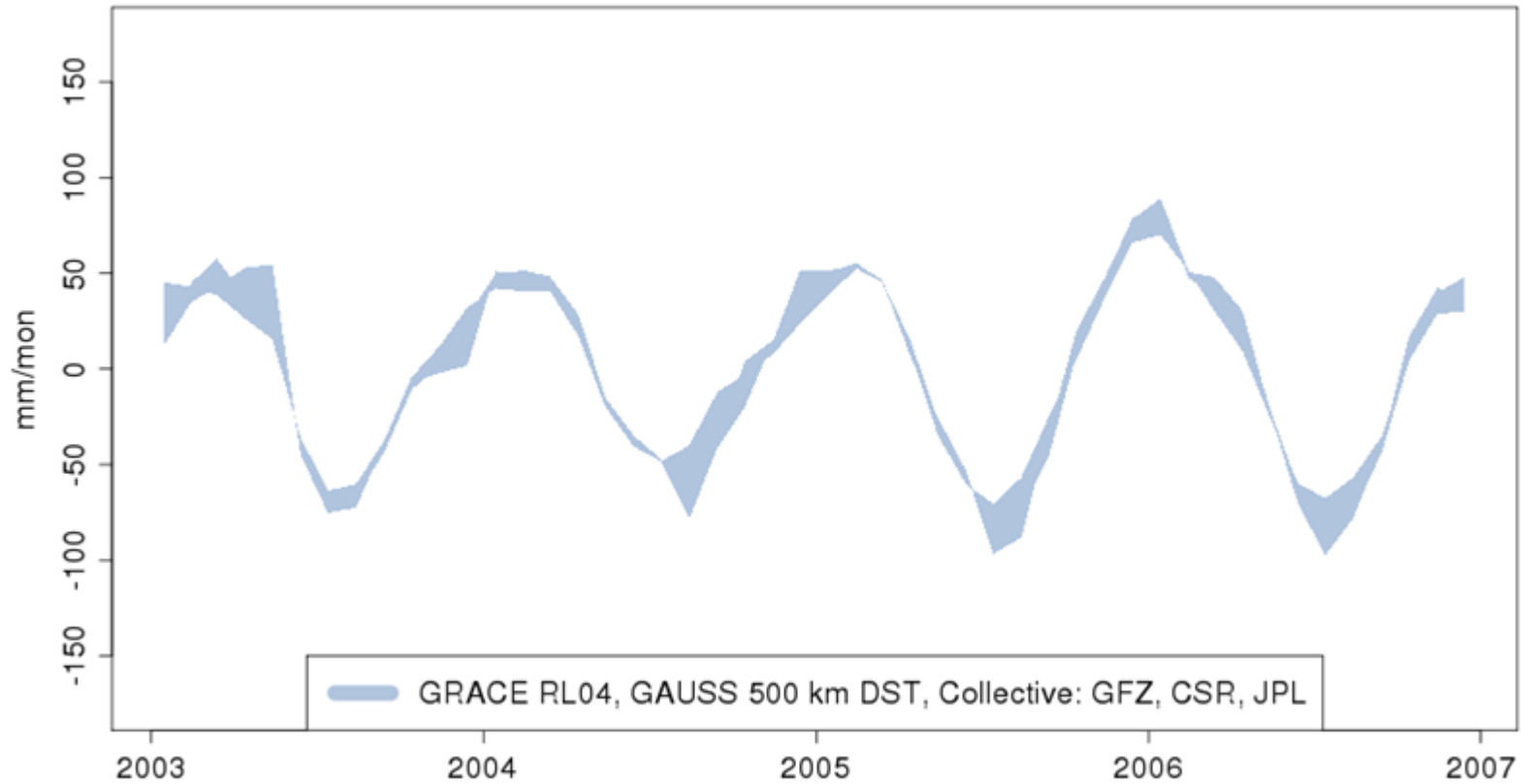


# GRACE RL04 Datasets



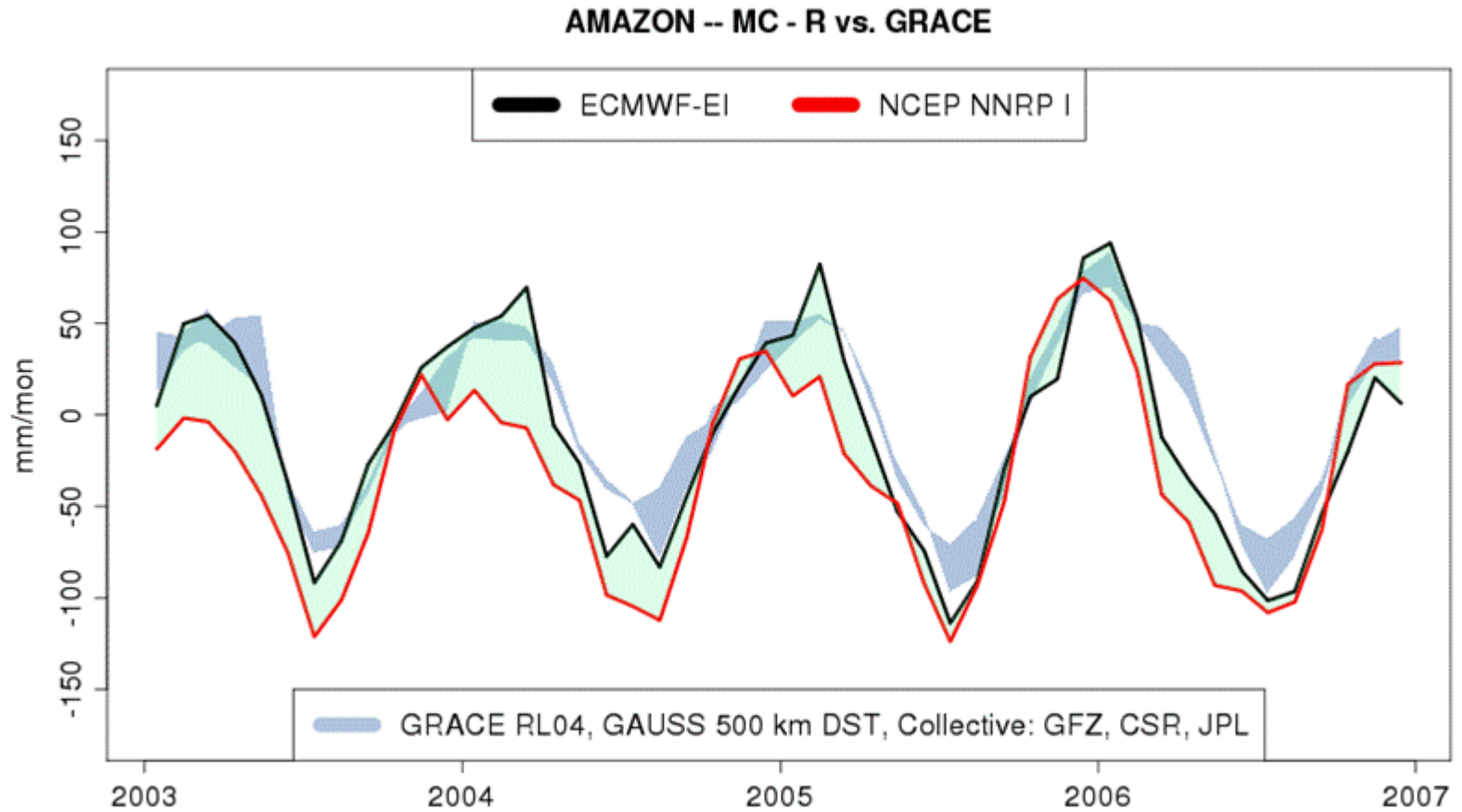
# GRACE Ensemble

AMAZON -- GRACE GSM mass variations

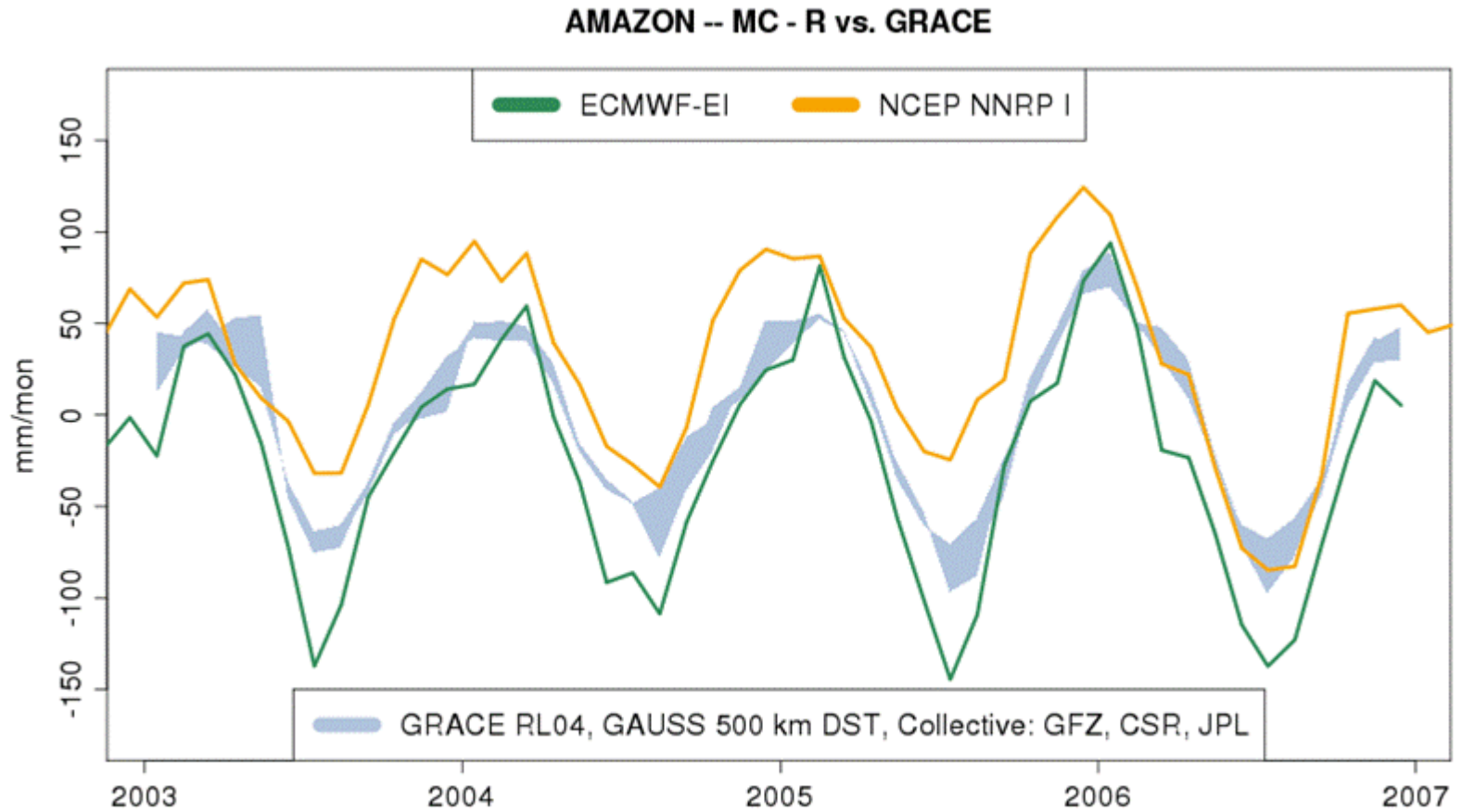




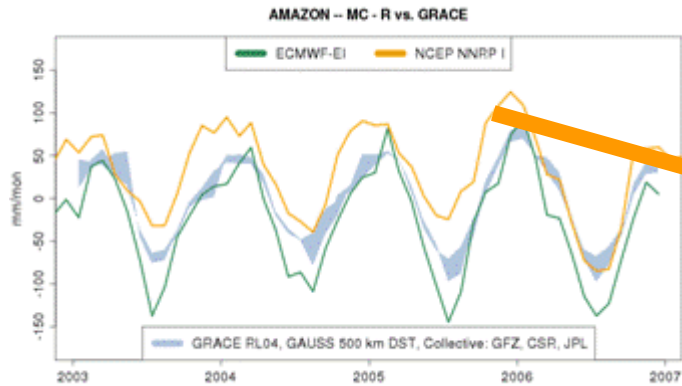
# Global Atmospheric Models



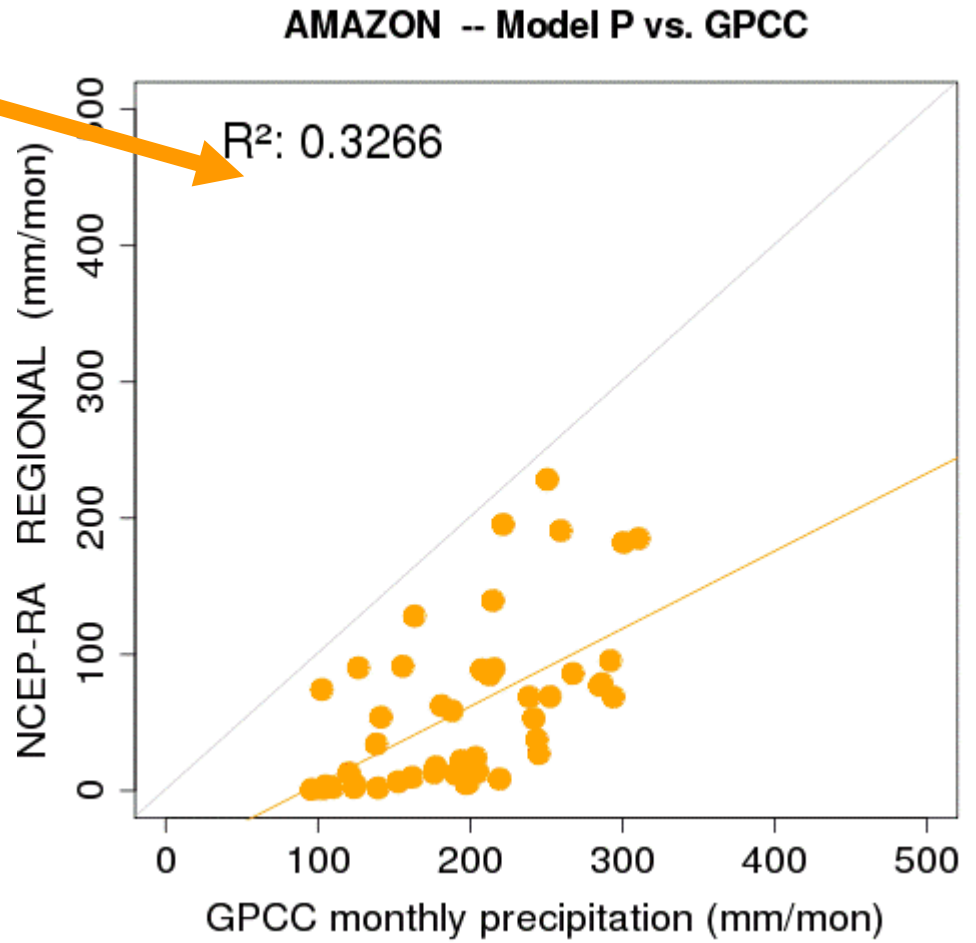
# Regional Downscaling (WRF)



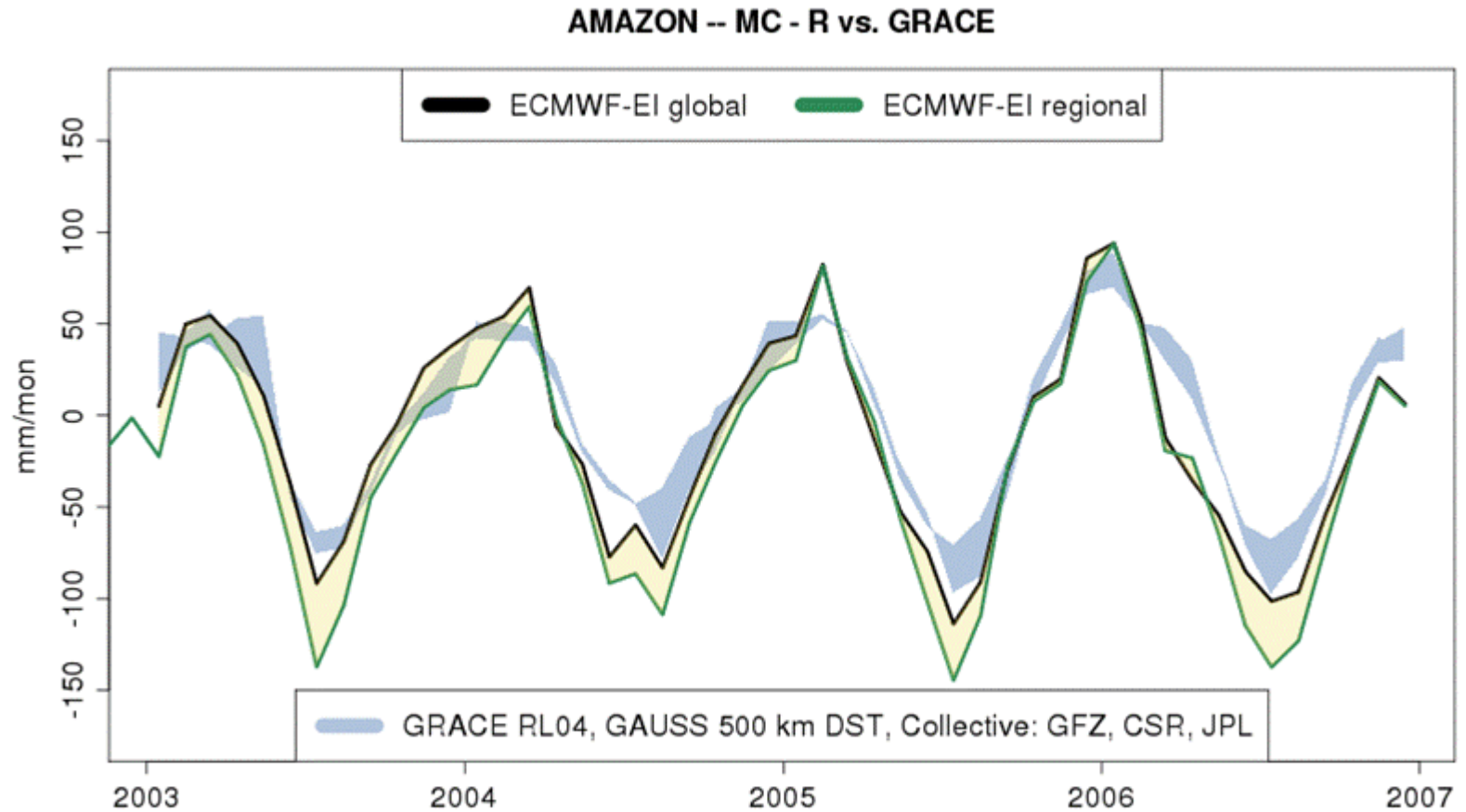
# Regional Atmospheric Model (WRF)



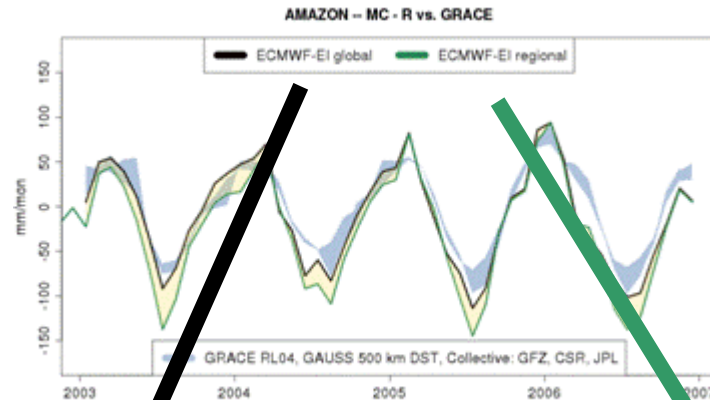
NCEP driving data



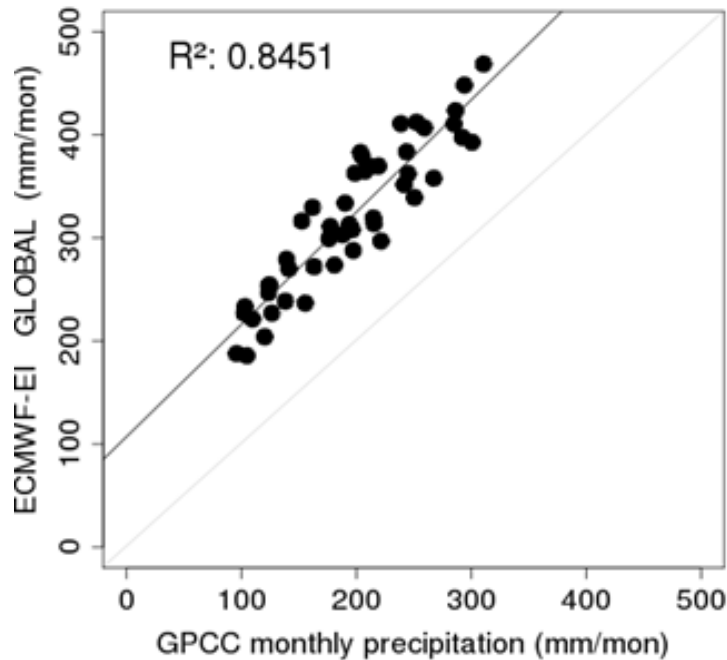
# ECMWF, Global and Downscaled (WRF) dS/dt



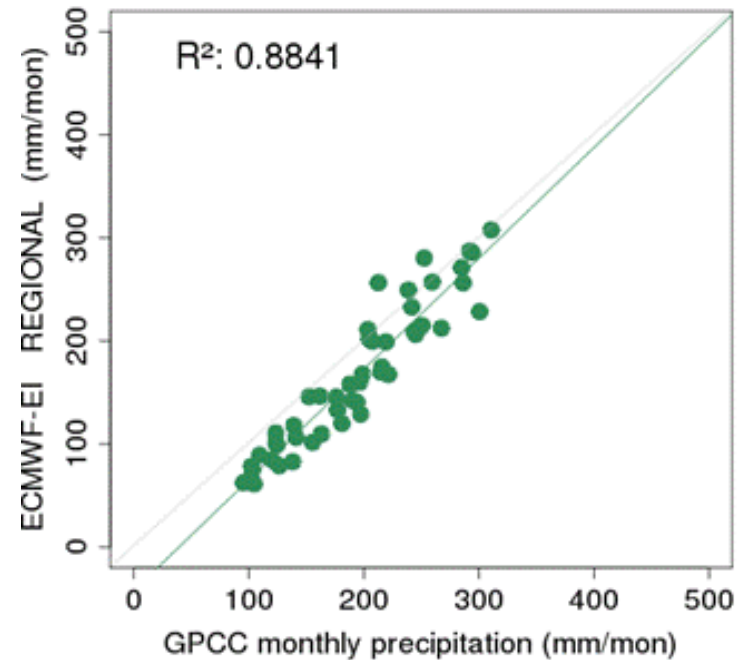
# ECMWF, Global and Downscaled (WRF) Precipitation



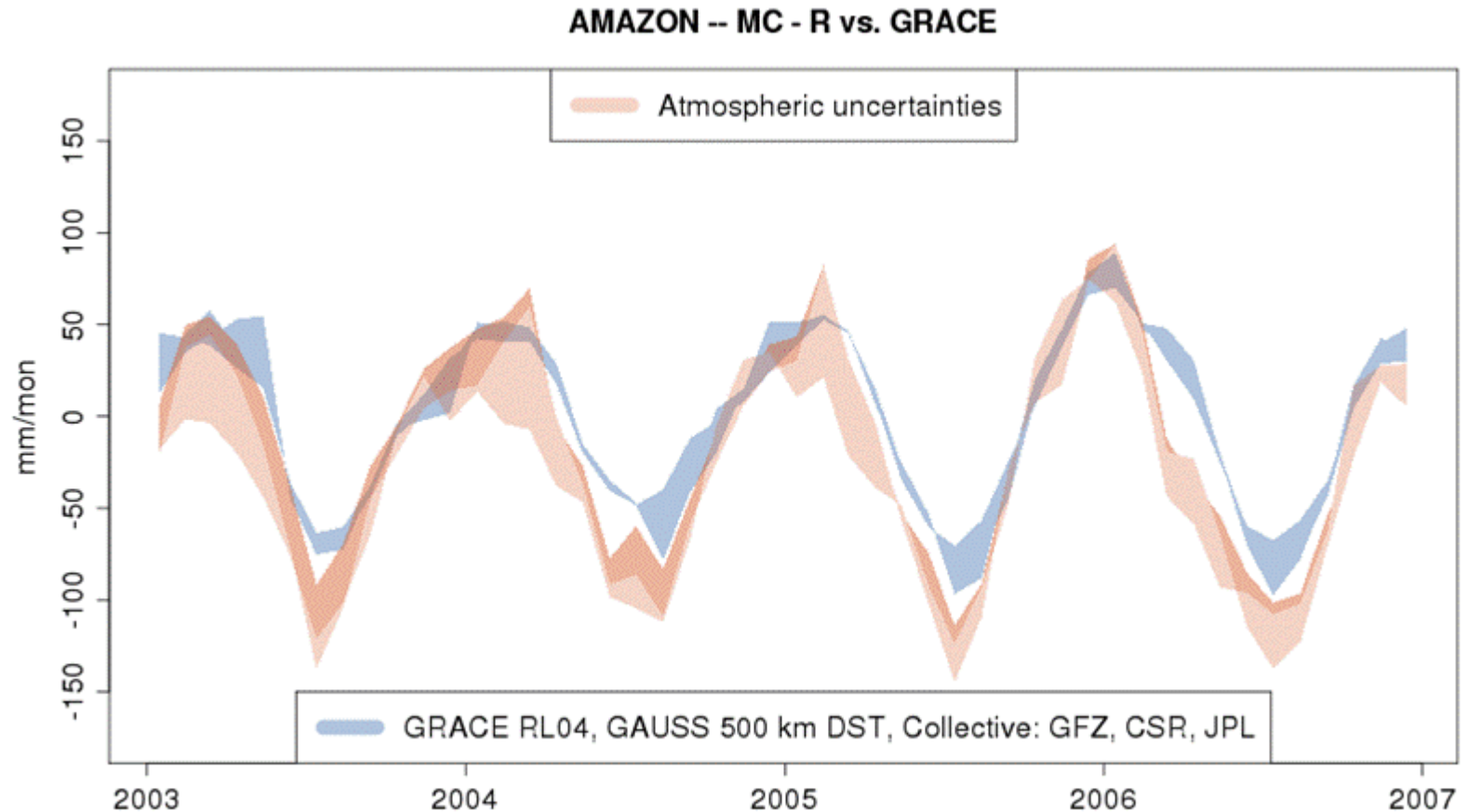
AMAZON -- Model P vs. GPCC



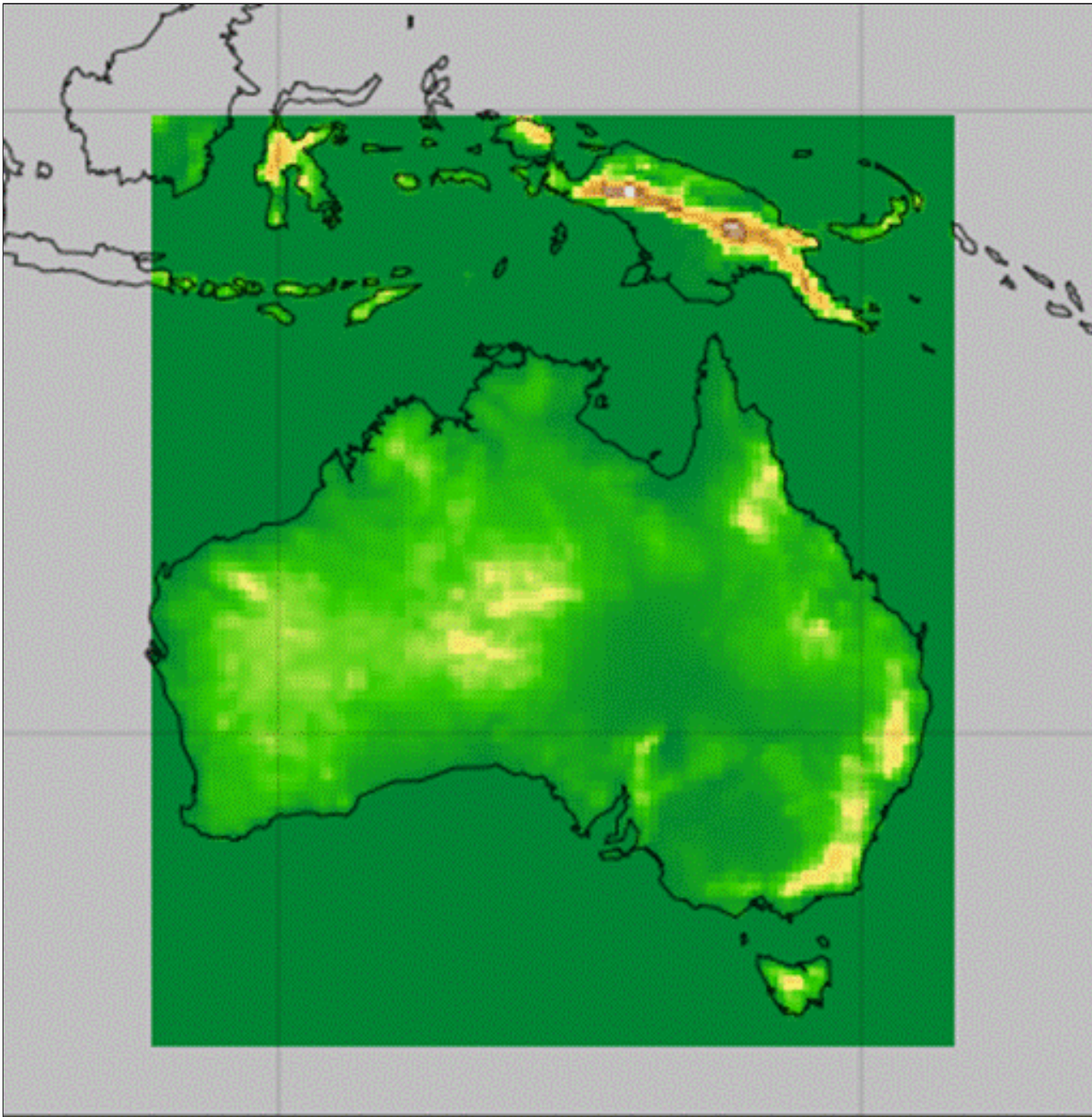
AMAZON -- Model P vs. GPCC



# Atmospheric Uncertainties

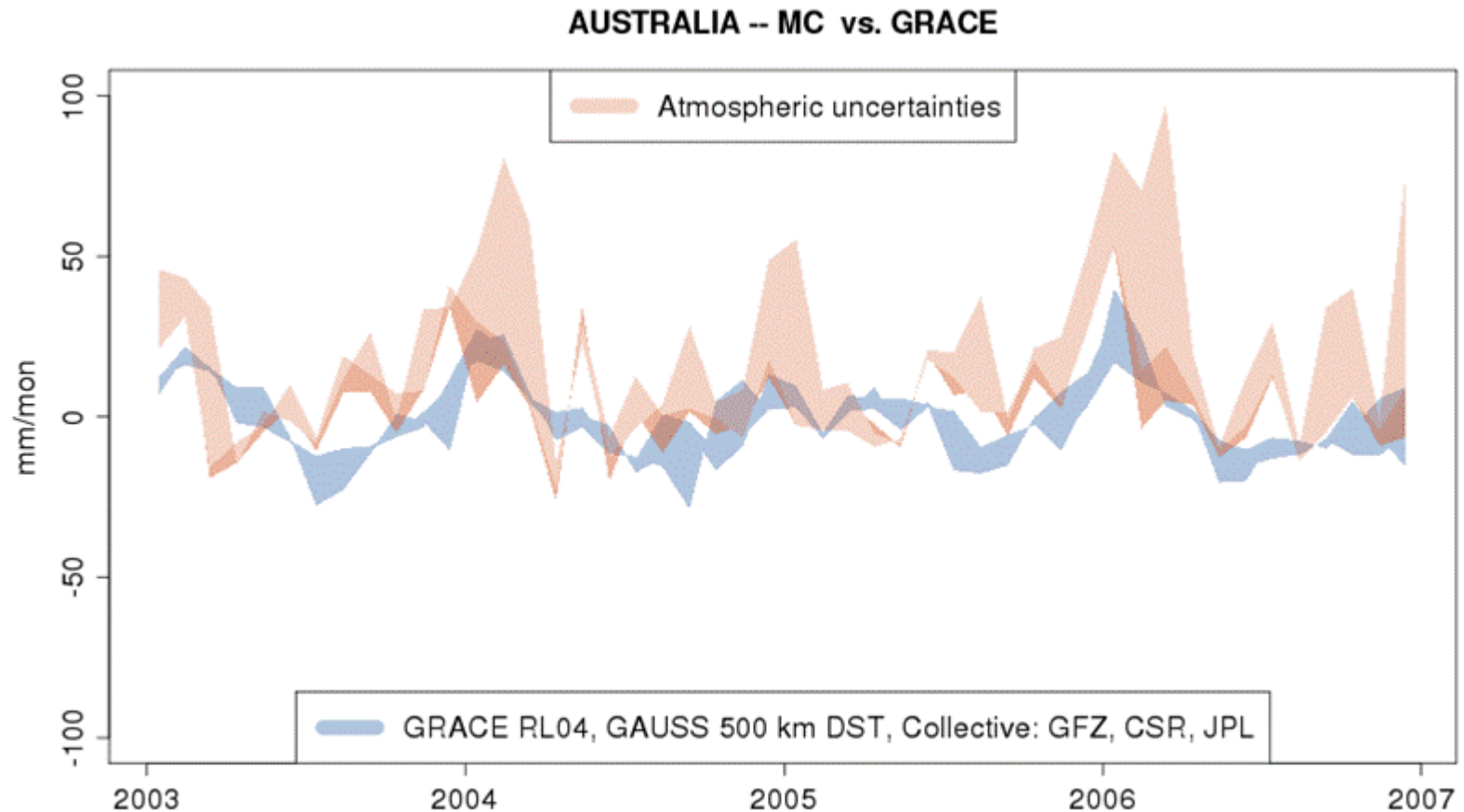


Uncertainty bounds for terrestrial water storage change  
global and regional (WRF) models  
with ECMWF-EI and NCEP-RA data



**Australia**

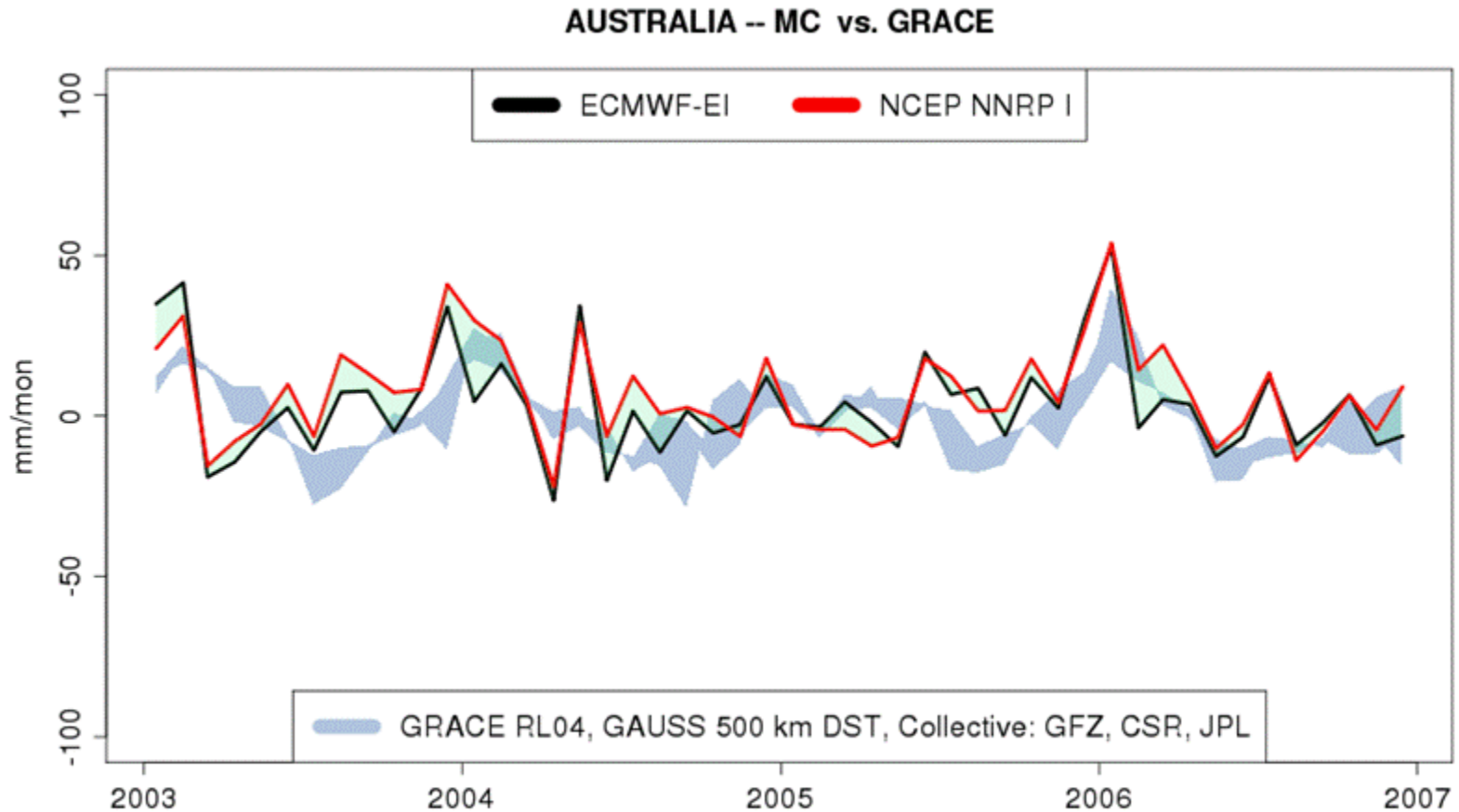
# Atmospheric Uncertainties



Uncertainty bounds for terrestrial water storage change  
global and regional (WRF) models  
with ECMWF-EI and NCEP-RA data

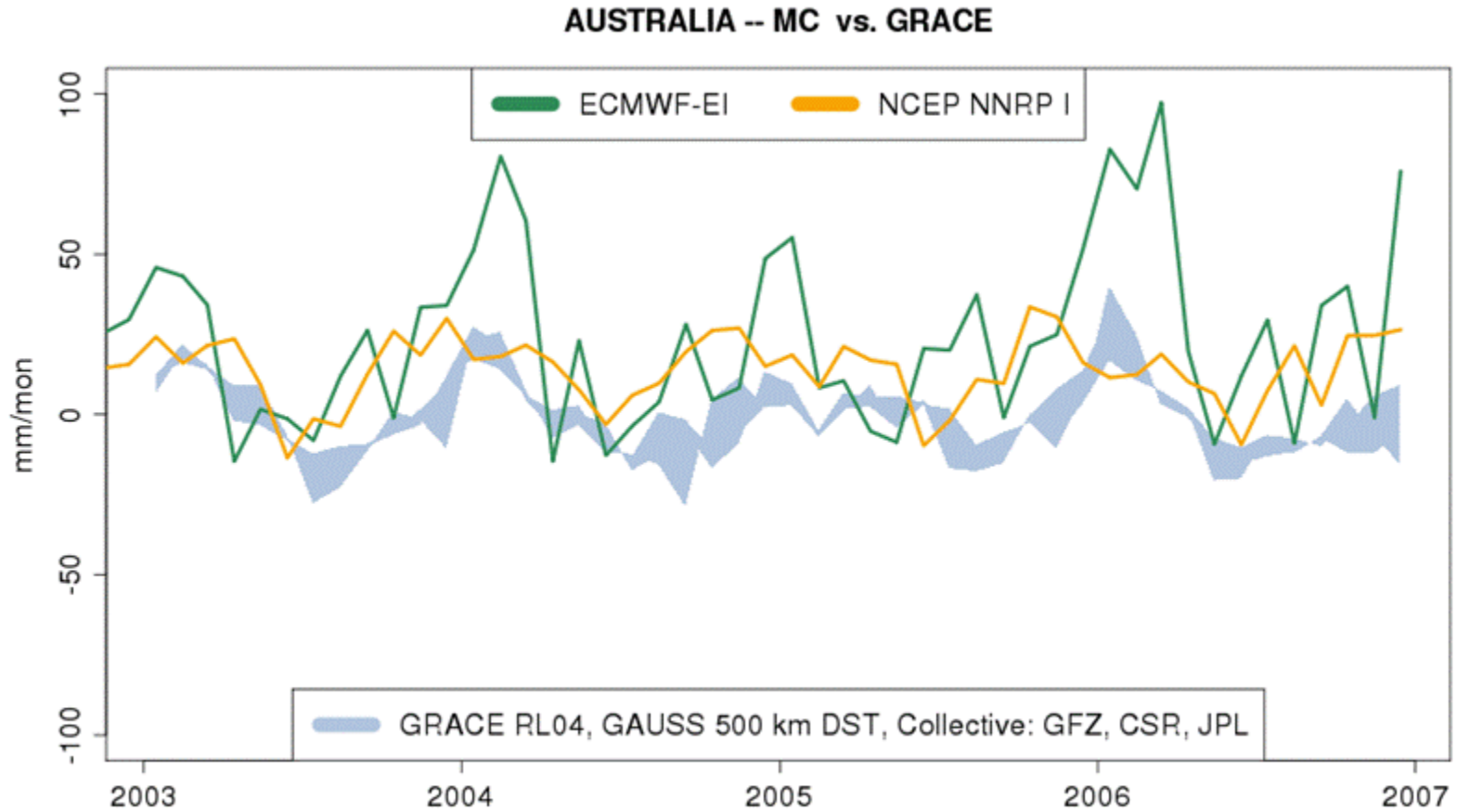


# Global Atmospheric Models



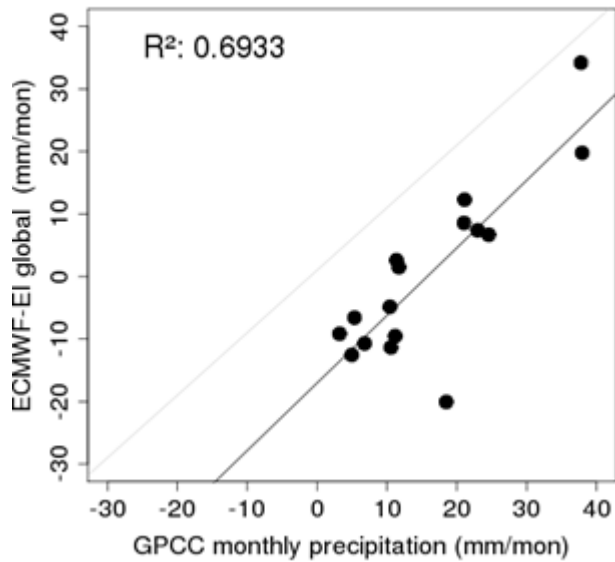
Dischargeless basin:  $R \approx 0$

# Sahara – atmospheric uncertainties

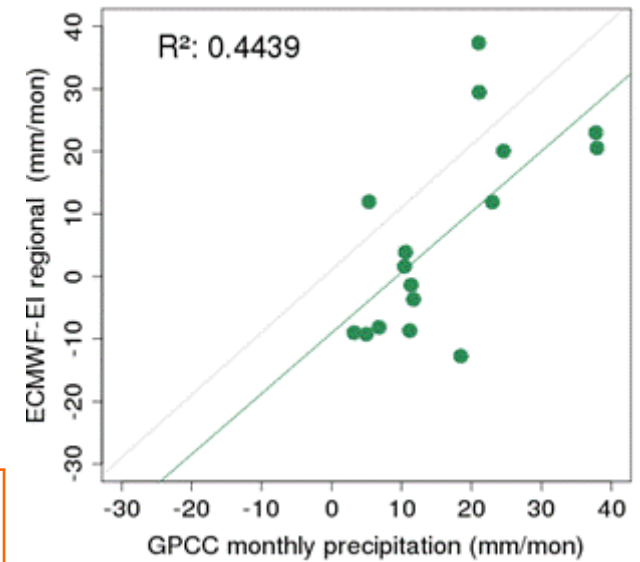


# Performance of MC with respect to GPCC, $ET \approx 0$

**AUSTRALIA global -- P vs. MC**

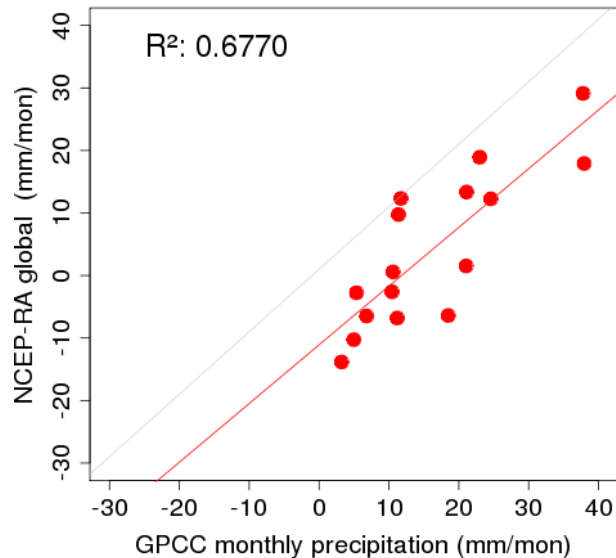


**AUSTRALIA regional -- P vs. MC**

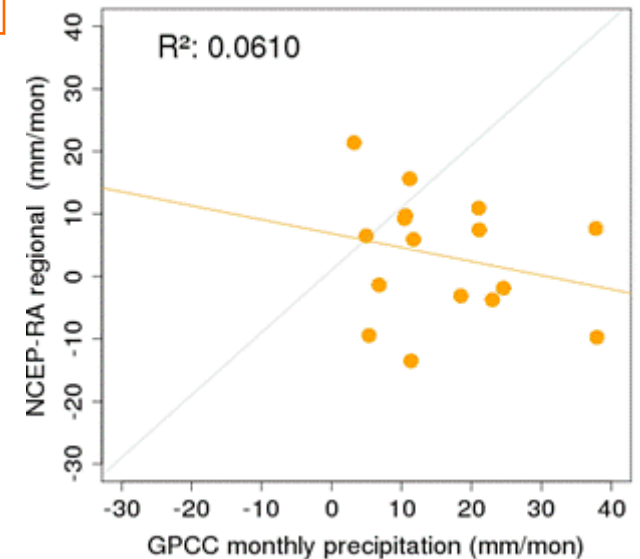


May – Aug.  
2003 – 2006

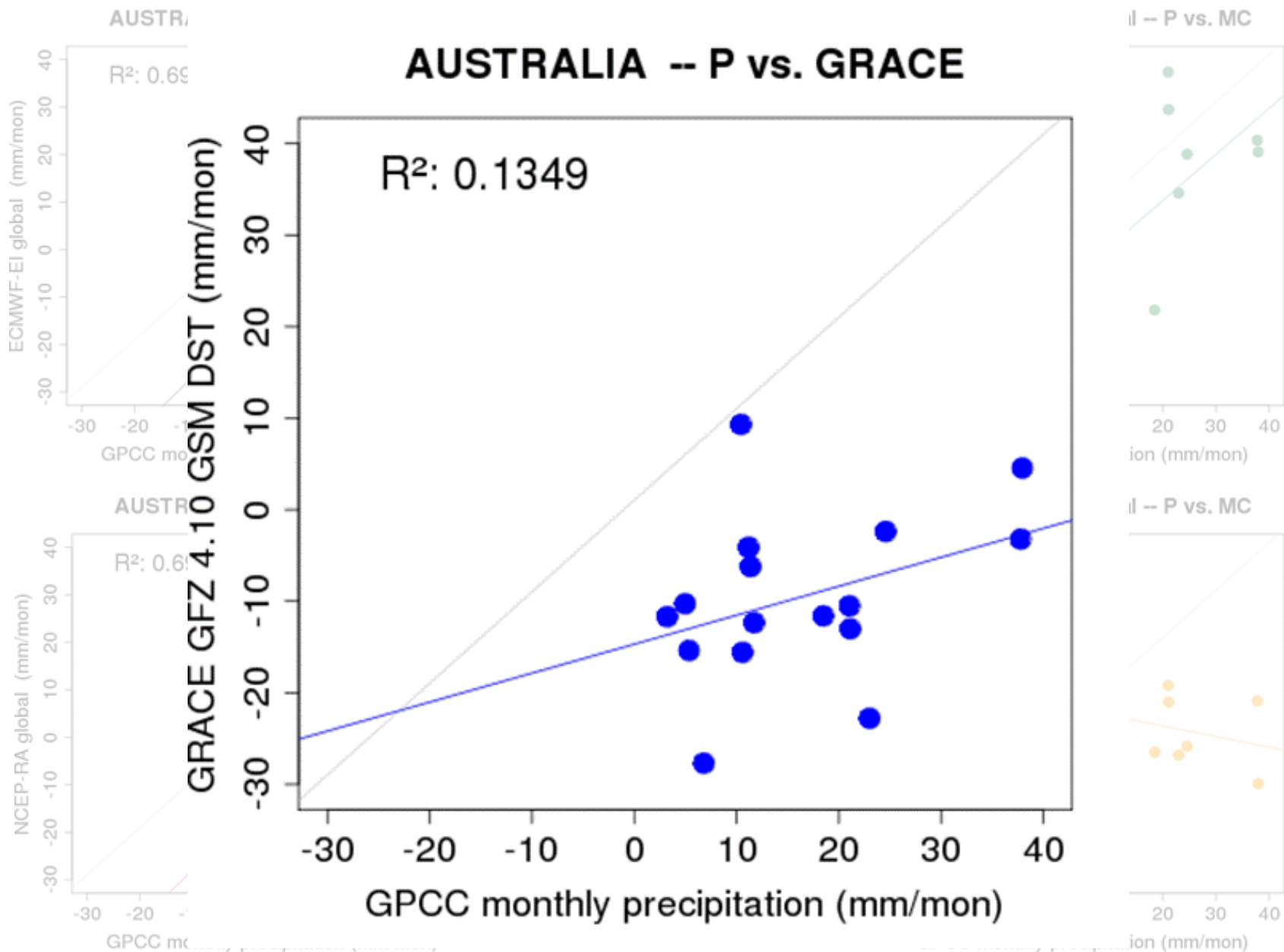
**AUSTRALIA global -- P vs. MC**



**AUSTRALIA regional -- P vs. MC**



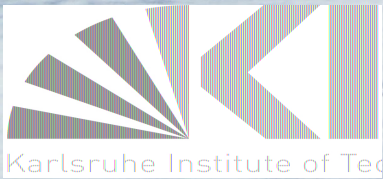
# Australia – Months with negligible Evaporation



# Summary

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- With respect to  $P$  (GPCC) the regional atmospheric model WRF is capable to improve global fields of  $MC$  and  $P$  for continental scale river basins
- However, for the Saharan and the Australian Domain the regional model could not add value to global simulations
- For months with negligible  $ET$ , correlation of model  $MC$  and  $P$  (GPCC) is good, but for GPCC and GRACE it is weak
- For many periods the atmospheric uncertainties have a only a small range but do not coincide with GRACE



Karlsruhe Institute of Technology

**IMK-IFU, Garmisch-Partenkirchen**