Assessment of prediction skill for land water storage in CMIP5 models based on GRACE satellite observations

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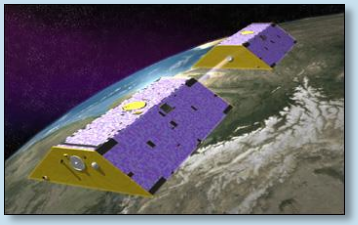
Introduction

Are CMIP5 (and CMIP6) decadal predictions suitable to forecast anomalous dry and wet conditions in terrestrial water storage (TWS)?

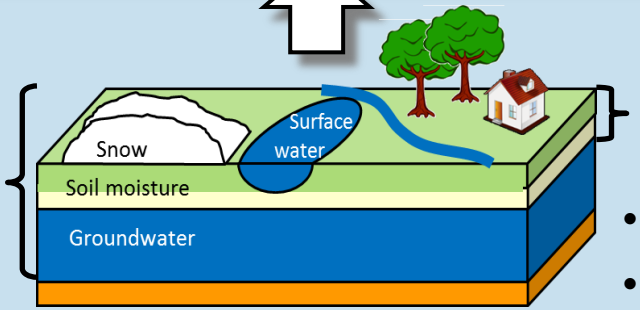
Observations

GRACE (03/2002-10/2017)



GRACE-FO (since 05/2018)

Terrestrial water storage (TWS)



CMIP5 models

Total Soil Moisture Content (mrso) and Surface Snow Amount (snw)

- 5 models initialized every year
- mrso + snw = modeled TWS
- Forecast year time series and historical runs (as reference)

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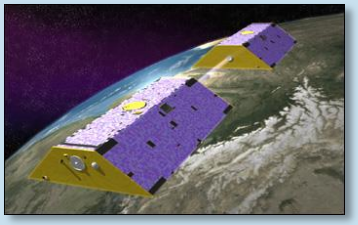

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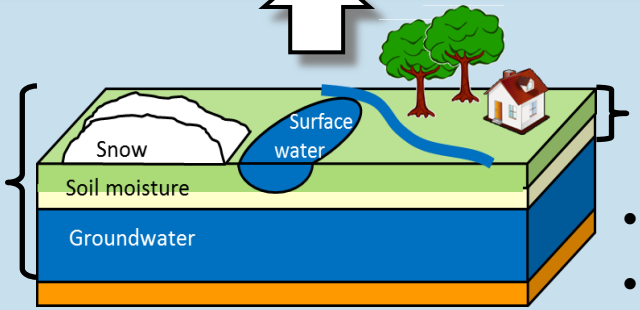

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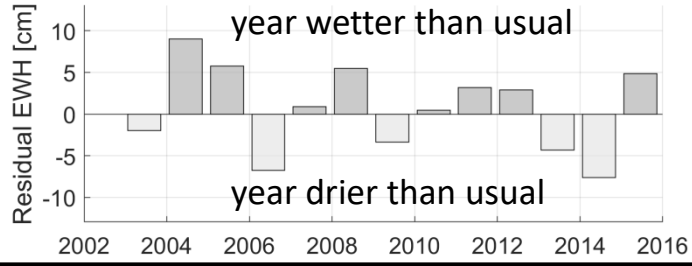
evaluation of annual anomalies
(= bias and linear trend removed)

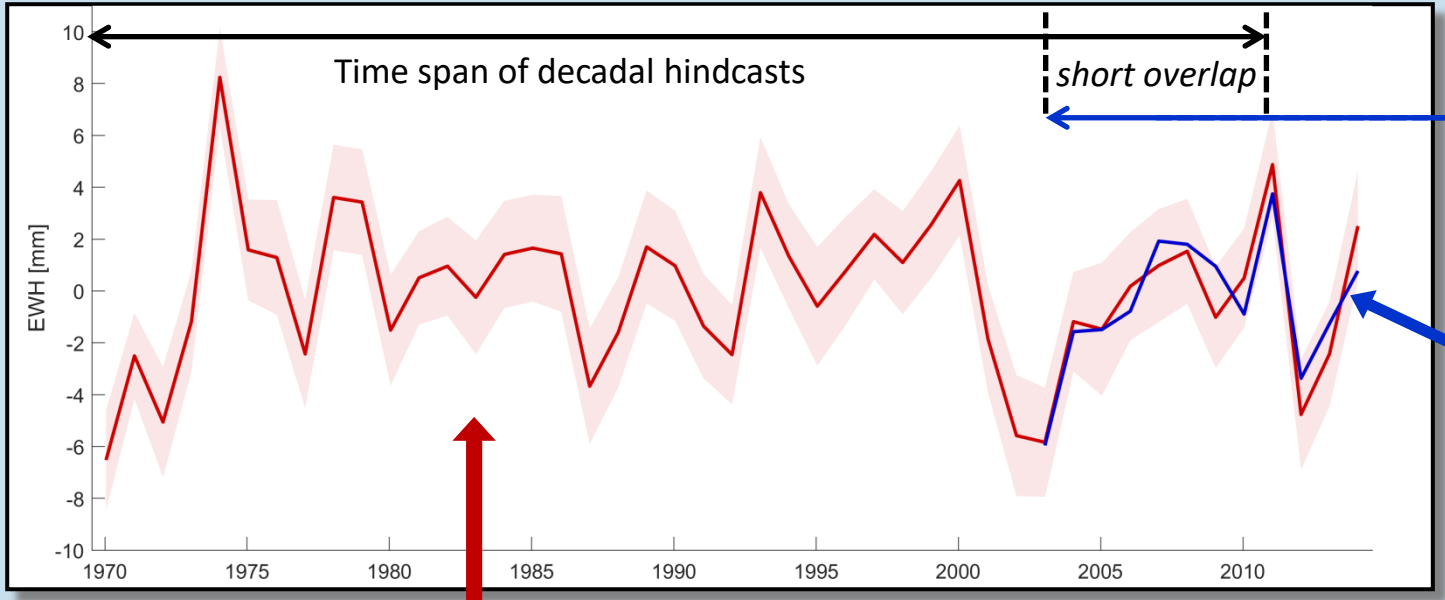


Results shown for:

1. Global land average
2. Regional analysis

Problem:
Overlap time of GRACE and hindcasts only 9 years
→ too short! → next slide

Extension of observation time series



Time span of GRACE observations

Annual anomalies of **GRACE observations**

TWS reconstruction (GRACE-REC) by *Humphrey and Gudmundsson (2019)*

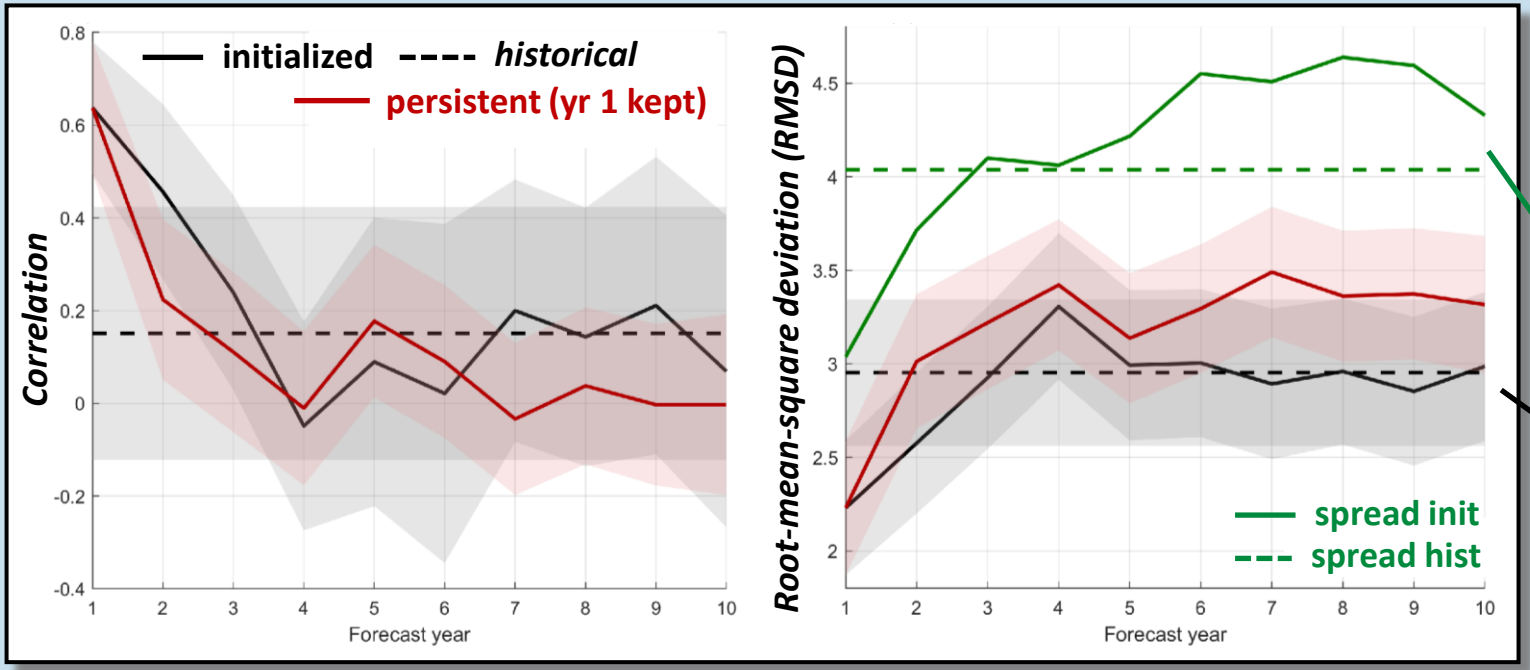
- derived from precipitation and temperature data

Humphrey, V., Gudmundsson, L., 2019. GRACE-REC: a reconstruction of climate-driven water storage changes over the last century. Earth System Science Data 11, 1153–1170. https://doi.org/10.5194/essd-11-1153-2019

Use **GRACE-REC** as a proxy for TWS observations to demonstrate value of long TWS time series for model evaluation!

1 - Global land average: CMIP5

Results from **multi-model mean** (MMM) of 5 CMIP5 models* w.r.t. GRACE-REC (1970-2010)



* CanCM4, HadCM3, GFDL-CM2p1, MPI-ESM-LR, MIROC5 = all models where yearly initialized mrso & snw is available

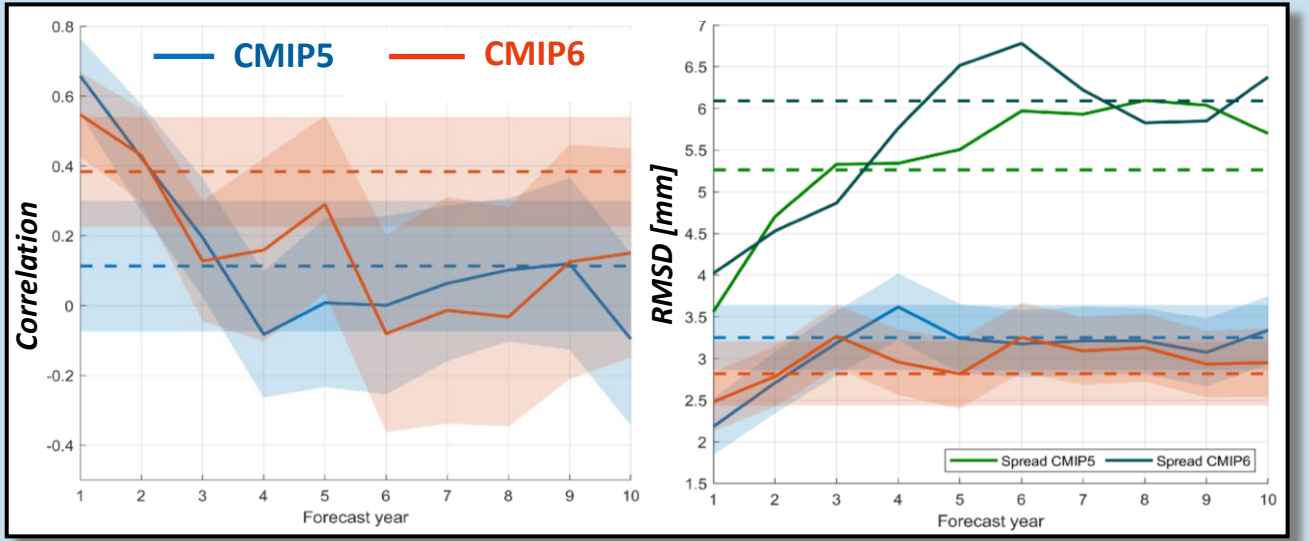
mean model spread overestimates **RMSD** by factor of about 1.5 → predictions not particularly reliable

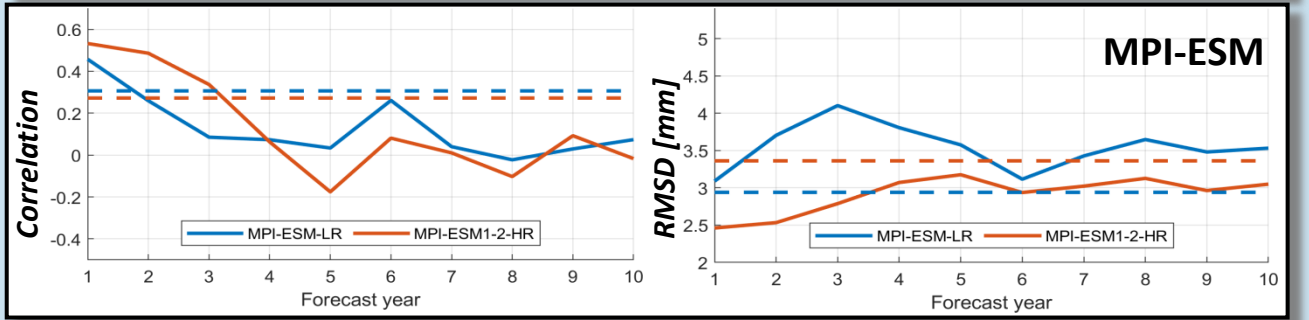
- MMM of **initialized** runs outperforms ***historical*** and **persistent** runs in forecast years 1 - 3
- Uncertainties (derived from spread of GRACE-REC (100 members) and MMM (39 members)) are large

1 - Global land average: CMIP5 vs. CMIP6

Results from MMM of 3 **CMIP6** models* vs. predecessor **CMIP5** models

* CanCM5, MPI-ESM1-2-HR, MIROC6 = all models where yearly initialized mrso & snw is available yet

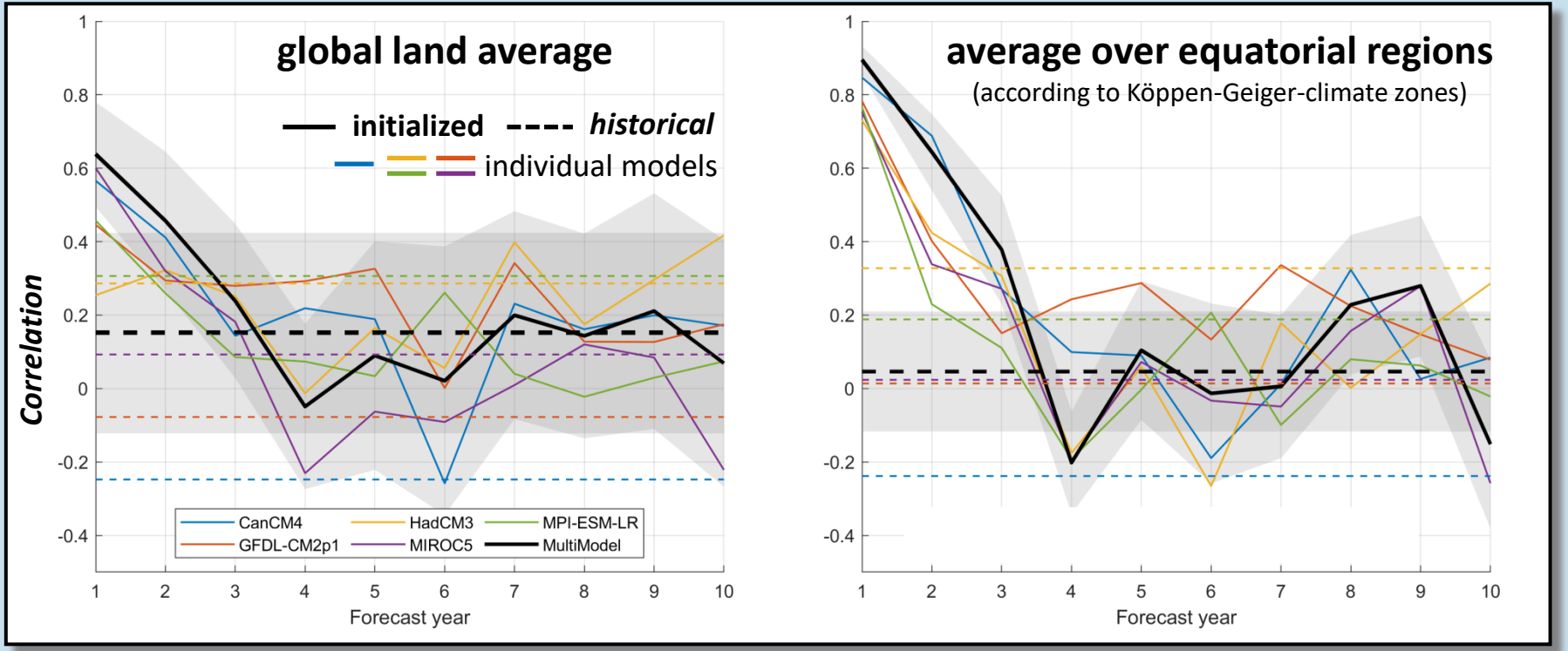




- Similar forecast skill for CMIP5 and CMIP6 in first 3 years
- Improved skill for forecast years 4 - 5??
- Need for more CMIP6 results

- Large improvements for **MPI-ESM** → due to improved land surface component (more layers, deeper soil)

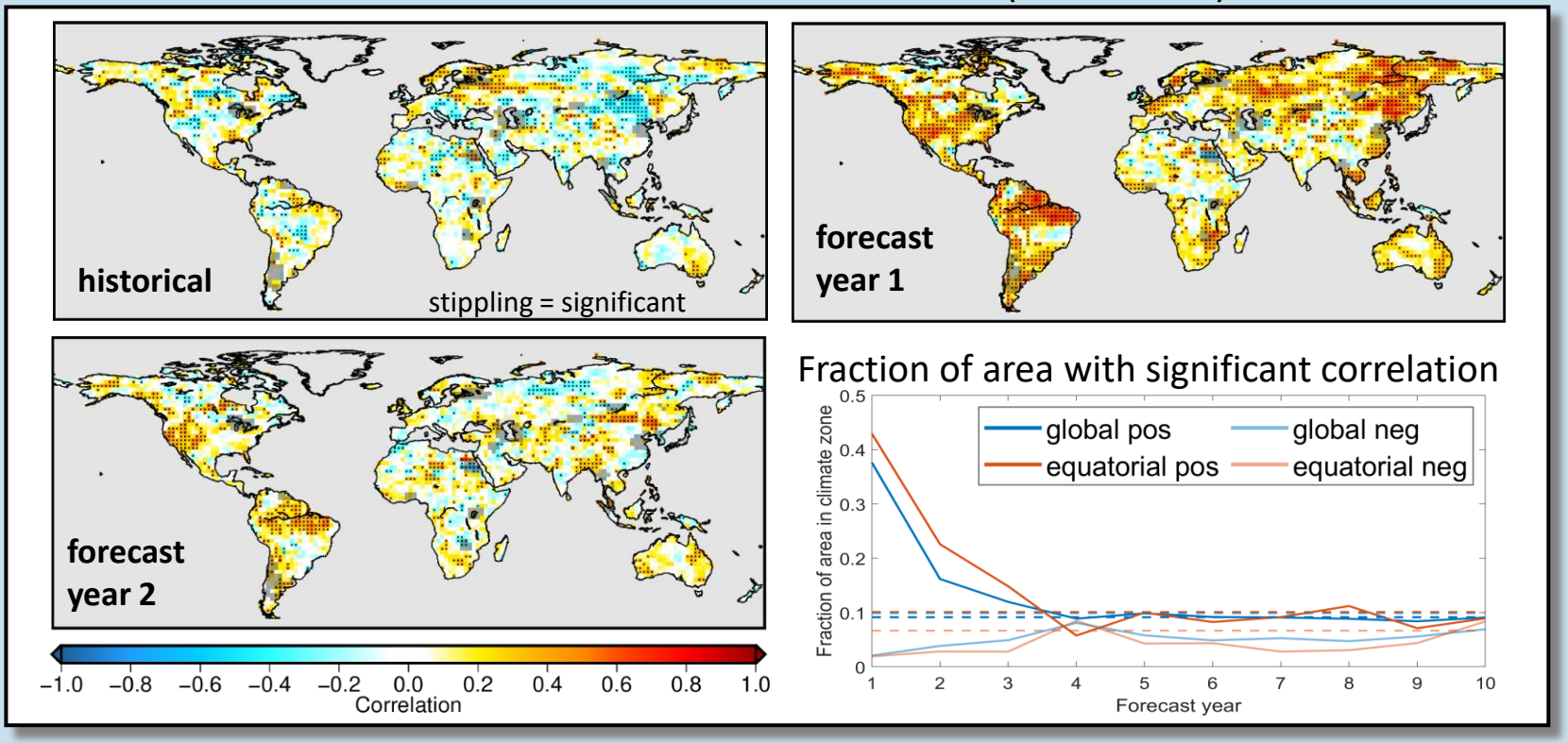
2 - Regional analysis: global vs. equatorial



- Improved skill and reduced uncertainty in equatorial regions, even for forecast year 3
- MMM outperforms individual models in first three years

2 - Regional analysis: global maps

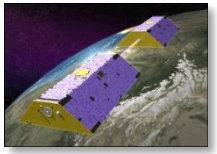
Correlation of MMM from 5 CMIP5 models and GRACE-REC (1970-2010)

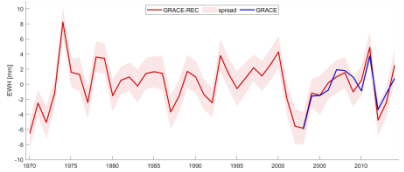


- general success of initialization in forecast year 1, only regional for forecast year 2 - 3.

Summary

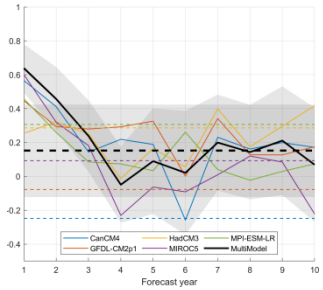
- Evaluation of decadal predictions regarding TWS
- Usage of GRACE-REC as proxy for observations as overlap time of hindcasts and GRACE observations is too short





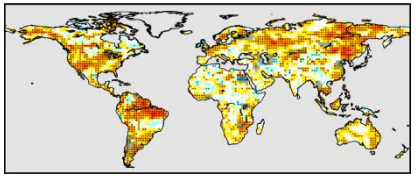
Global mean

- Initialized runs outperform historical and persistent runs in forecast years 1 - 3, but uncertainty is large and reliability could be improved.
- CMIP6 comparable to CMIP5, but indications for improvements (e.g. for MPI-ESM).



Regional

- Improved skill and reduced uncertainty in equatorial regions, even for forecast year 3.
- General success of initialization only in forecast year 1, regional for forecast year 2 - 3.



Questions? laura.jensen@hcu-hamburg.de

Jensen, L., Eicker, A., Stacke,T., Dobslaw, H. (under review): Predictive skill assessment for land water storage in CMIP5 decadal hindcasts based on global GRACE satellite gravity data, *Journal of Climate*