INNOVATION: TOTAL WATER STORAGE CHANGE ANALYSIS FROM GRACE AND HYDROLOGICAL MODELING

Overview of the GRACE satellite mission, potentials and limitations using GRACE for hydrological monitoring

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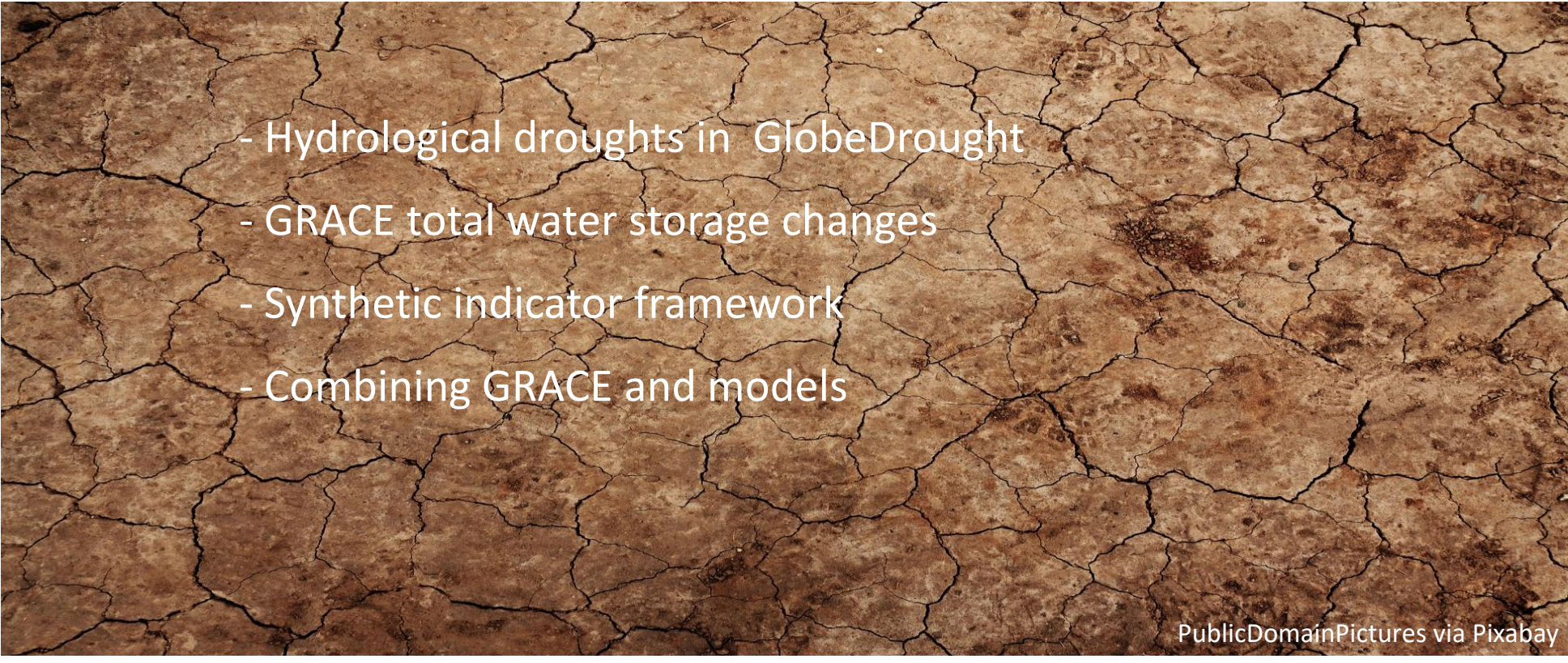
6th Webinar

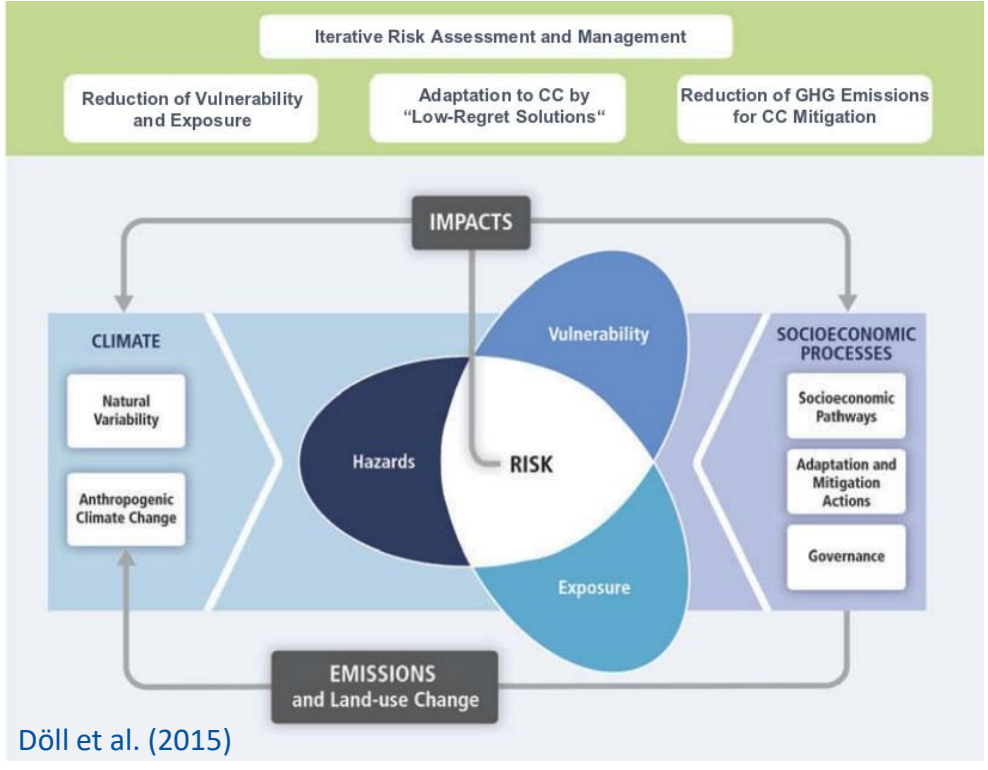
OBJECTIVES



- Hydrological droughts in GlobeDrought
- GRACE total water storage changes
- Synthetic indicator framework
- Combining GRACE and models

PublicDomainPictures via Pixabay

GLOBE DROUGHT



Döll et al. (2015)

- Web based drought information system
- Use GRACE for considering hydrological drought

Globe Drought

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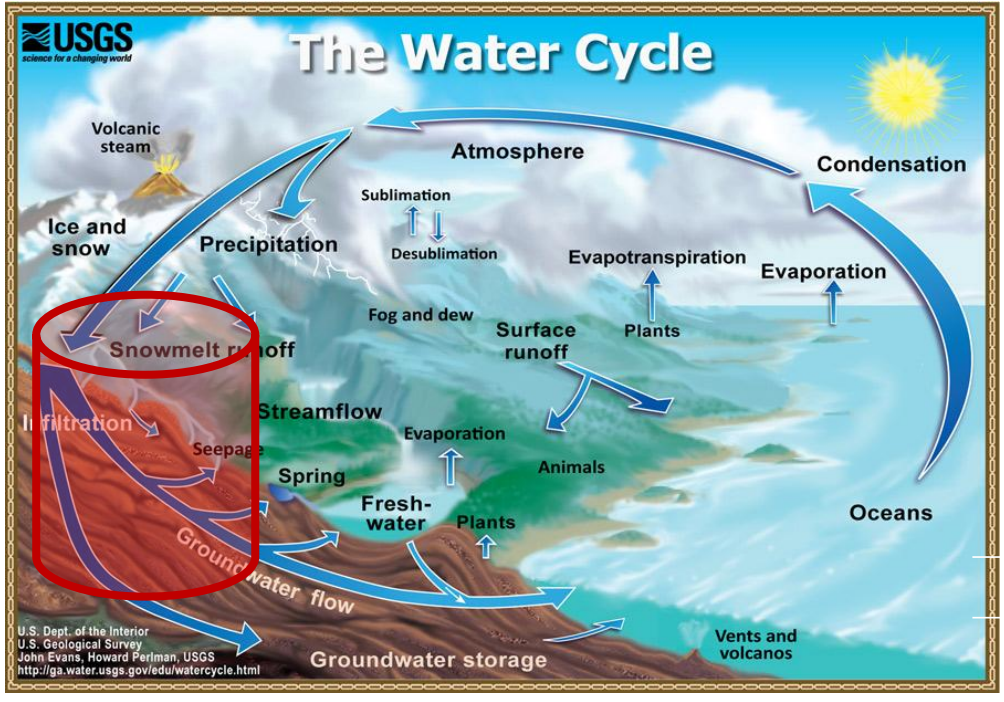
GLOBAL WATER CYCLE

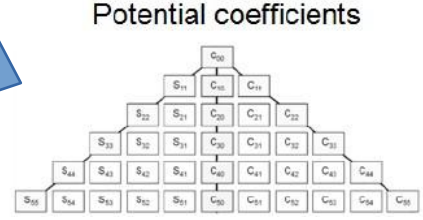


- In-situ streamflow and groundwater measurements difficult to retrieve
- Only using single storage could lead to not detecting the drought

POTENTIAL: GRACE satellite mission considers the sum of the water storages

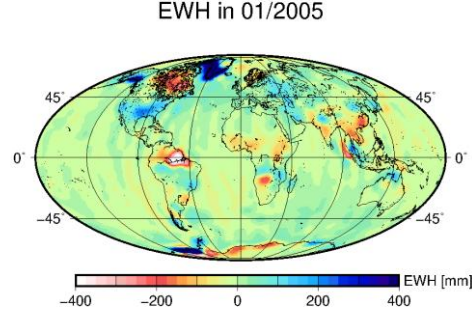
GRACE PROCESSING

L2



Schumacher (2016)

L3

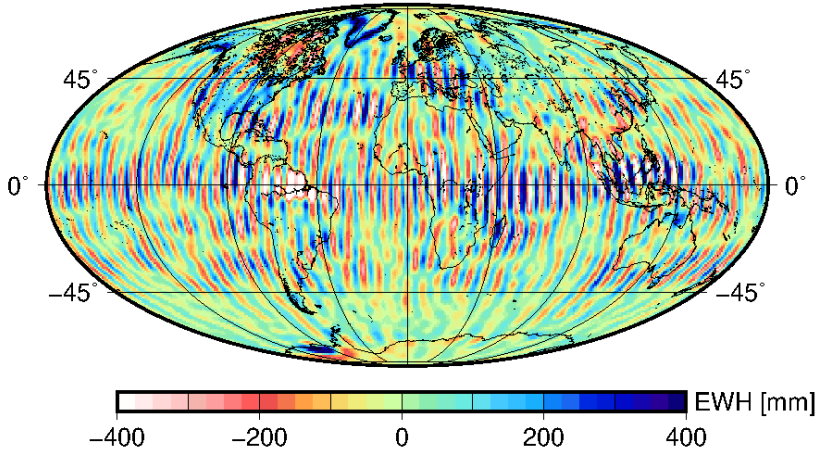


Transformation to L3:
- Replace degree-1 and c_{20}coefficients
- spatial filtering
- averaging

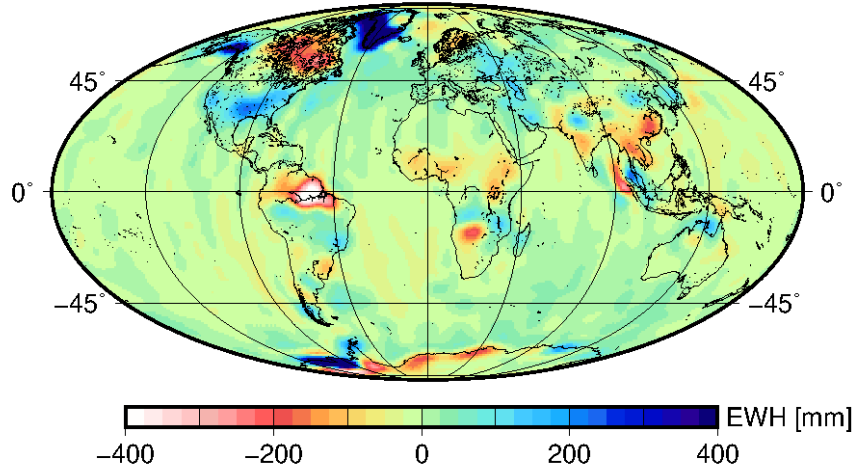
Additional:
- GIA removal
- Earthquake removal

SPATIAL FILTERING JAN. 2005

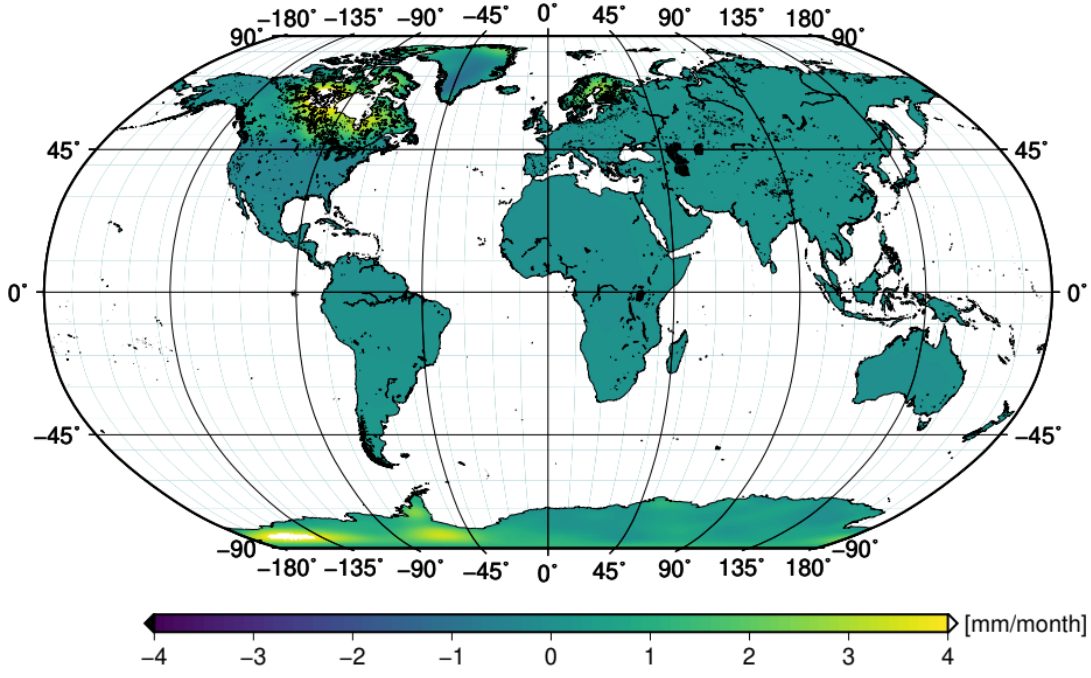
UNFILTERED



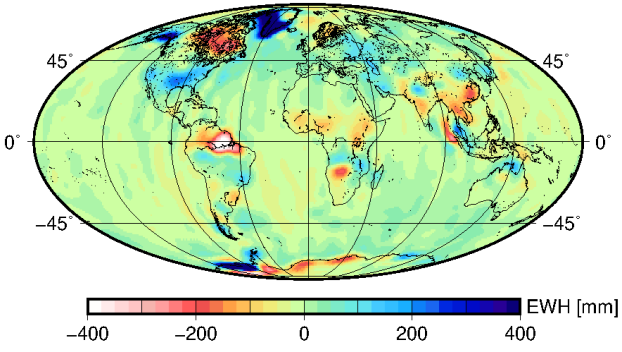
FILTERED

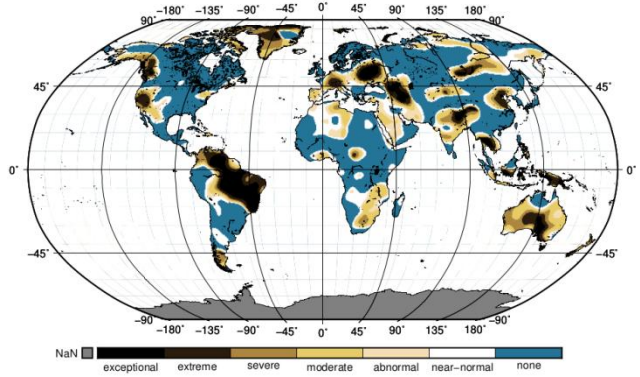


GLACIAL ISOSTATIC ADJUSTMENT

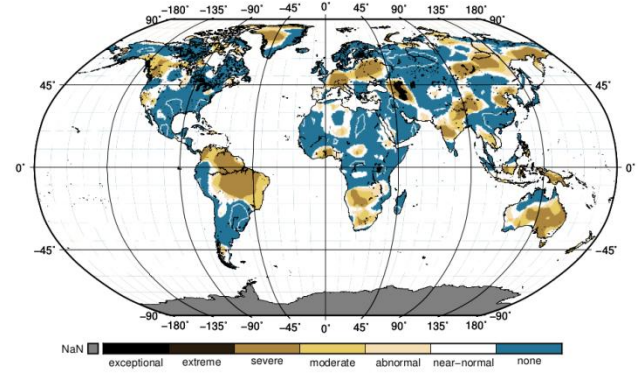


GRACE-BASED DROUGHT INDICATORS: TWO EXAMPLES 12/2015





DSI - Standardization



DI - Percentiles

- Drought intensity of DSI higher than DI
- Spatial but also temporal differences in indicators
- No universal methodology of drought indicators (e.g. for defining „normal“)

OBJECTIVES SYNTHETIC FRAMEWORK

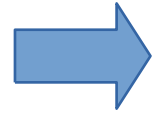
OBJECTIVES

1) Comparison and extension of GRACE-based indicators

2) Propagation of drought signal through drought indicators

3) Detect GRACE-related signals that might bias drought detection

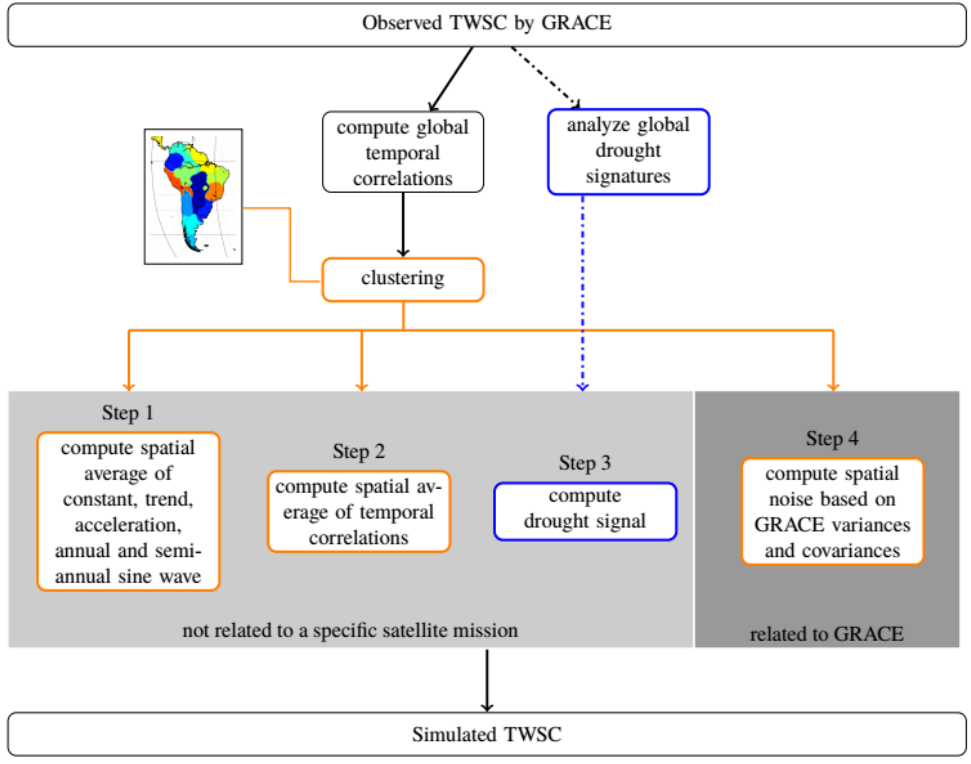
- Linear trend, acceleration, seasonal signals …
- Spatial noise



Synthetic framework

Gerdener et al. (2019): A framework for deriving drought indicators from GRACE (discussion paper)

SYNTHETIC FRAMEWORK



EXTENSION OF HYDROLOGICAL DROUGHT INDICATORS

1) accumulated TWSC

$$TWSC^{+}_{i,j,q} = \sum_{k=1}^{q} TWSC\left(t_{i,j+1-q}\right)$$

2) differenced TWSC

$$TWSC^{-}_{i,j,q} = TWSC\left(t_{i,j}\right) - TWSC\left(t_{i,j+1-q}\right)$$

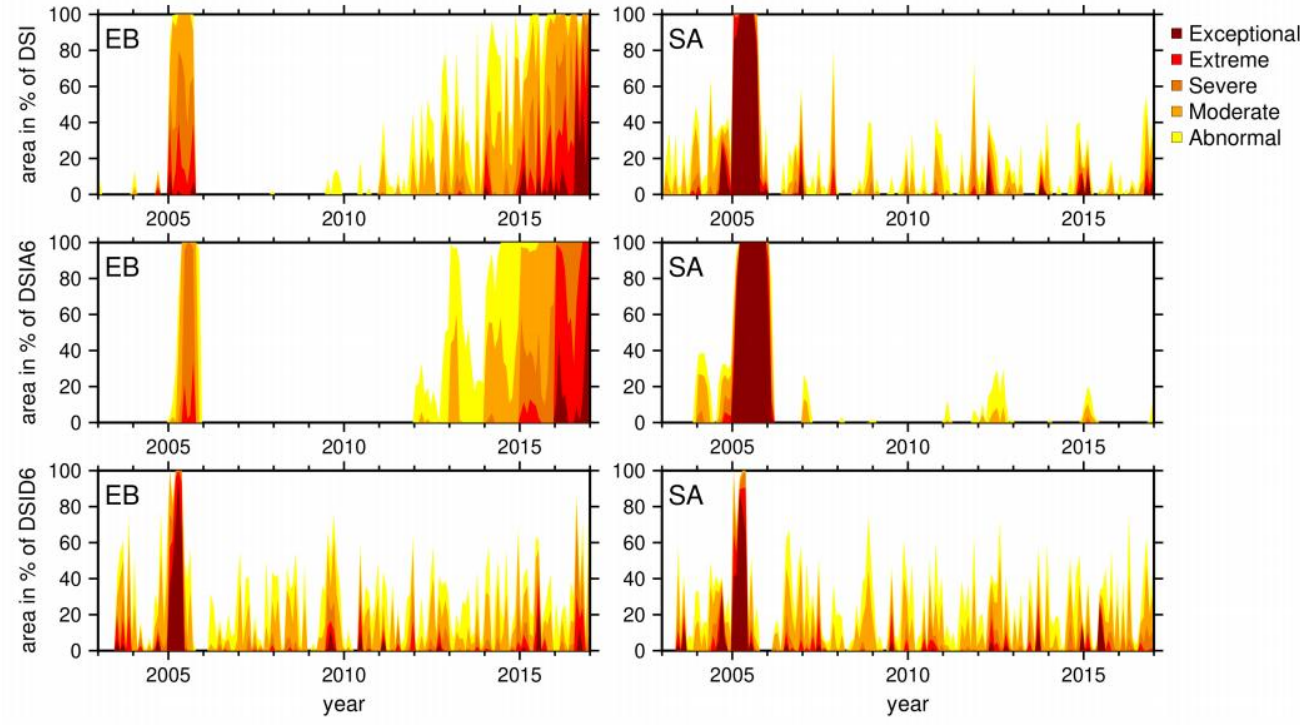
→ replace TWSC in DSI and DI with accumulated and differenced TWSC

NEW:

$$TWSC - DSIA_{i,j} \qquad TWSC - DIA_{i,j}$$

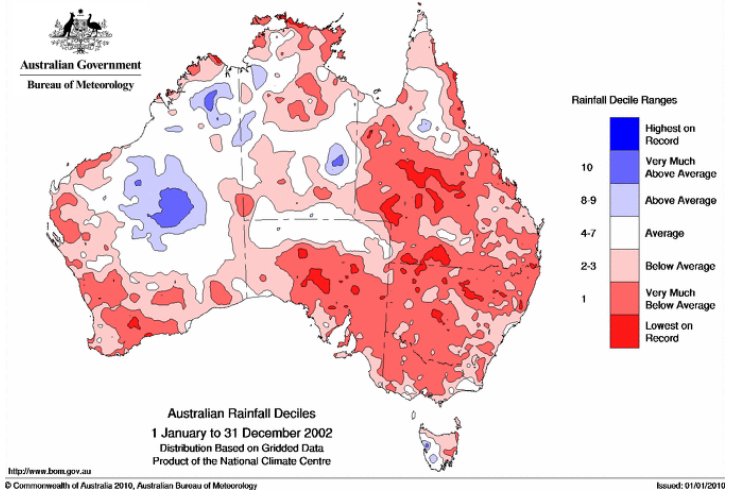
$$TWSC - DSID_{i,j} \qquad TWSC - DID_{i,j}$$

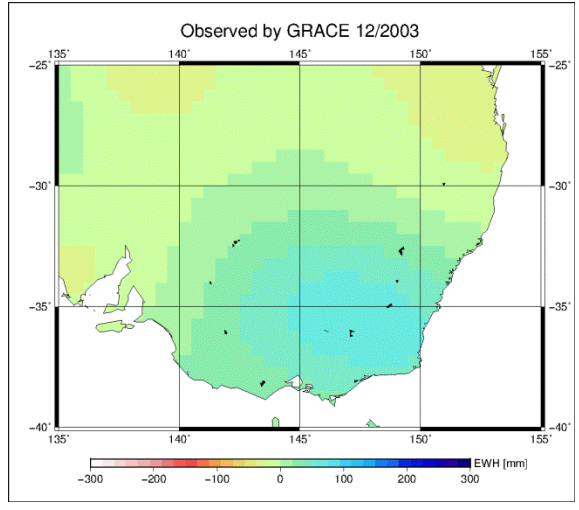
SYNTHETIC HYDROLOGICAL DROUGHT INDICATORS



CHALLENGES

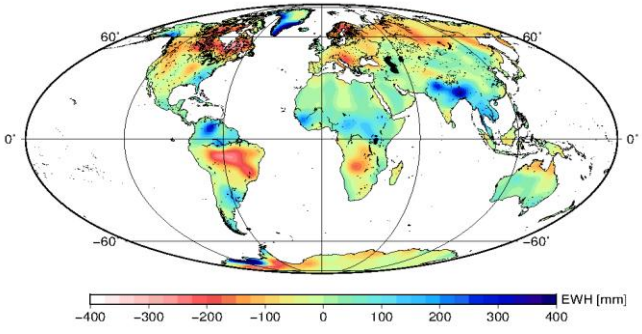
- Precipitation is very local, drought can be local
- GRACE resolution (~300 km) too coarse for use in drought monitoring and forecasting system
- Example: Australia Millenium Drought



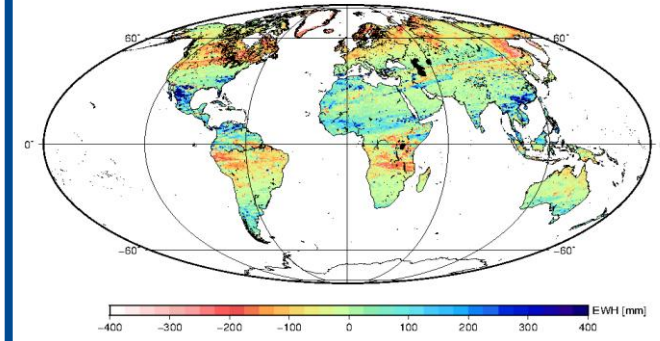


CHALLENGES

GRACE- Observations



Hydrological model WGHM

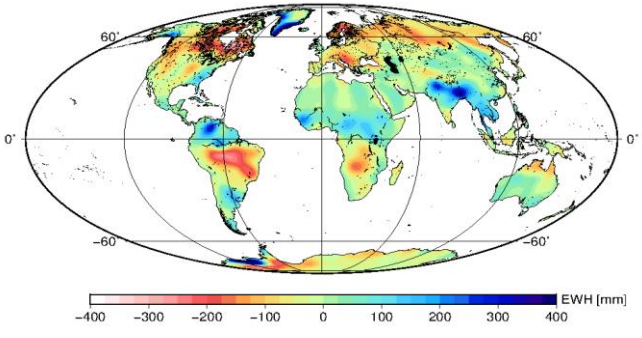


TWS

- surface water
- snow
- soil
- ...
- groundwater

ADDRESSING THE GRACE SCALE PROBLEM

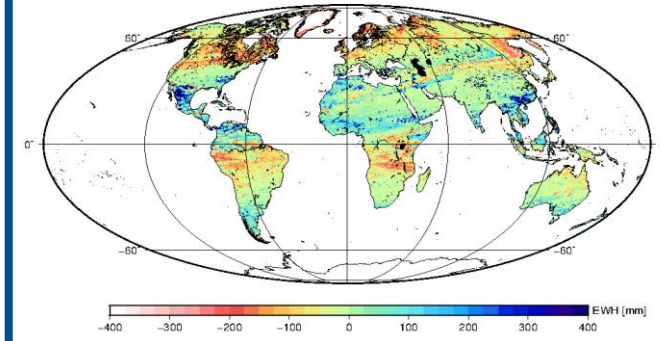
GRACE- Observations



- TWSA
- Spatial resolution: ca. 300 km
- Monthly
- Real observations

Data Assimilation

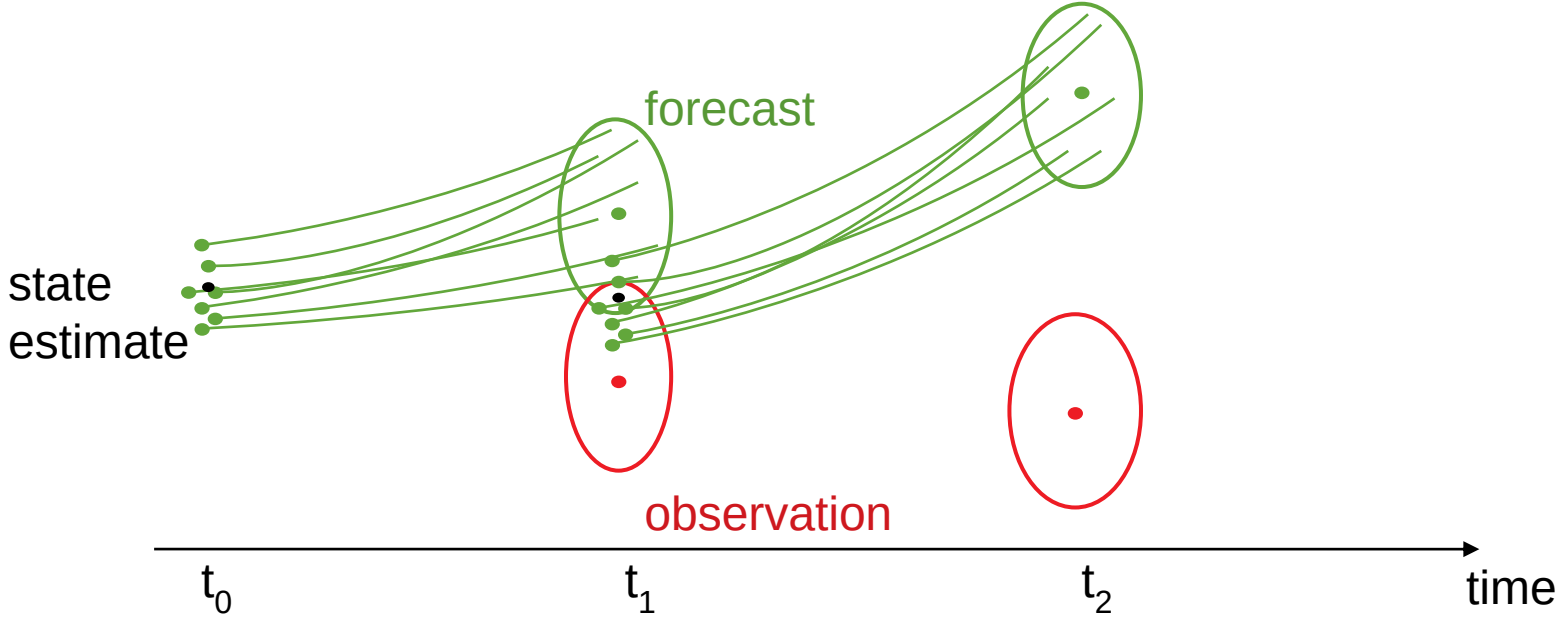
Hydrological model WGHM



- All compartments (vertical resolution)
- Spatial resolution: ca. 50 km
- Daily

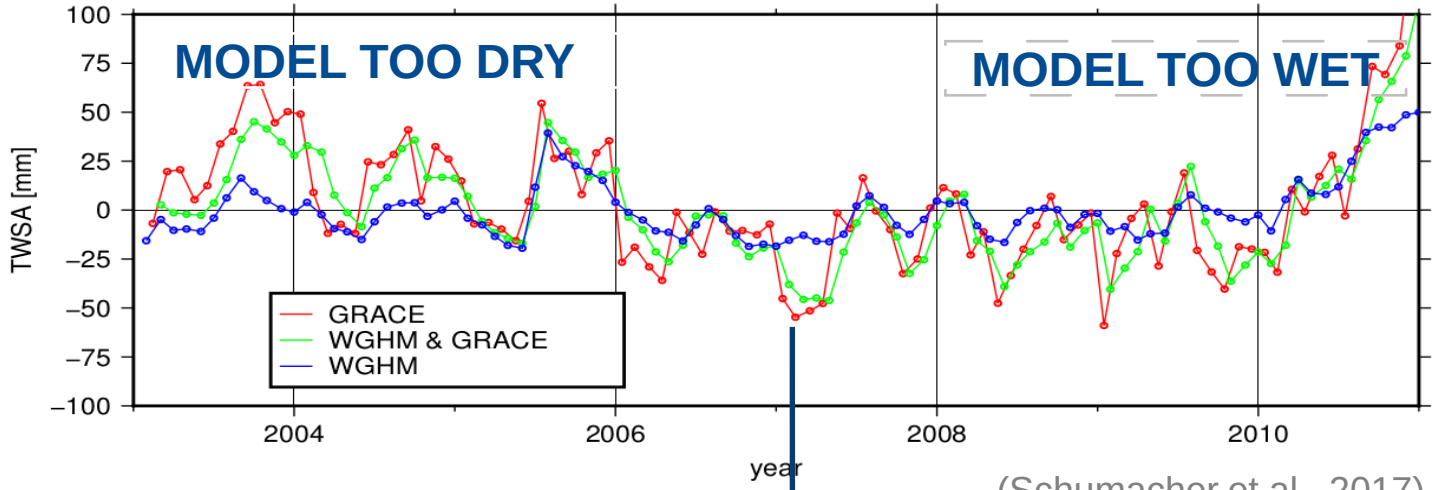
DATA ASSIMILATION

Optimal state estimation using Ensemble-based Kalman Filter



More about EnKF: Evensen, J. Geophys. Res. (1994)

DATA ASSIMILATION MURRAY-DARLING RIVER BASIN

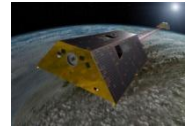


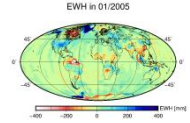
(Schumacher et al. ,2017)

Misses extreme drought 2007

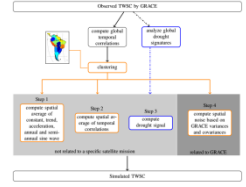
CONCLUSION

1) Processing chain to derive TWSC

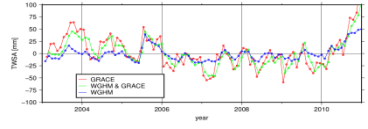




2) Detection of biasing signals on drought indicators



3) Data assimilation to combine advantages of real observations and model outputs



Next learning block:
Soil moisture droughts