



Global land water storage data set

Recent updates and applications of a global GRACE/-FO data assimilation

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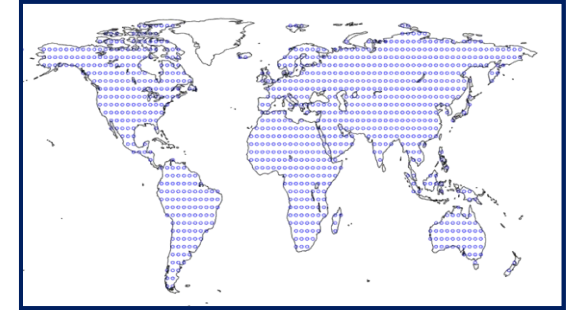
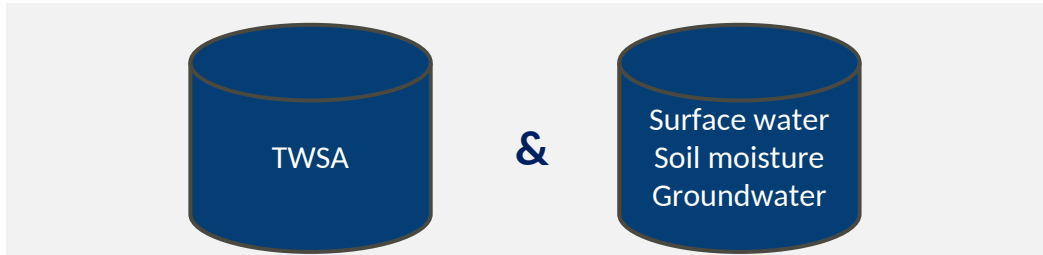
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09.10.2024, Potsdam, GSTM



GLWS 2 - GLOBAL LAND WATER STORAGE

A monthly global 0.5° data set from 2003 to 2019 for:



Global assimilation of 4° GRACE/-FO into WaterGAP 2.2.e

- Based on regional Eicker et al. (2014) approach
- EnKF: PDAF, 32-member ensemble (Nerger and Hiller, 2013)
- Perturb forcing data (W5E5 forcing) and (some) model parameters
- GRACE/-FO L2 SHCs ITSG (GFZ, CSR), DDK3
- Propagated from SHC VCM

Gerdener et al. (2023), JoG

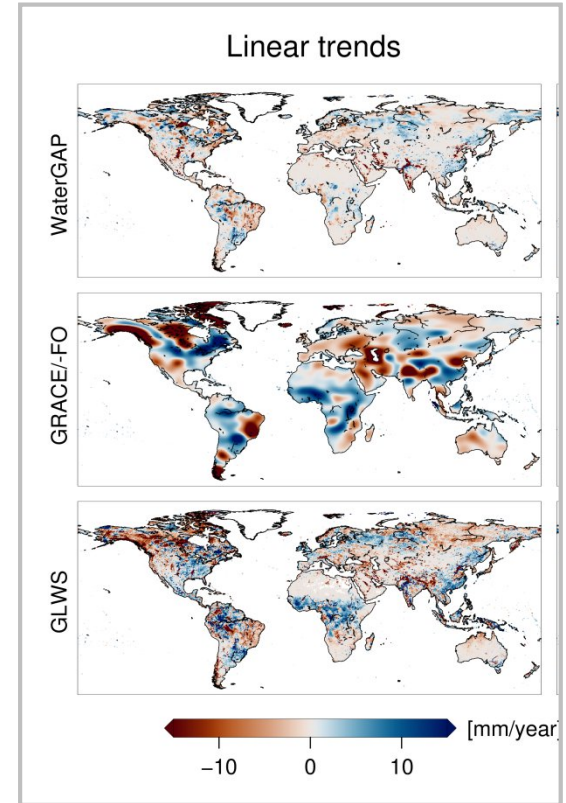
<https://doi.org/10.1594/PA/NGAEA.954742>



GLWS 2 - GLOBAL LAND WATER STORAGE

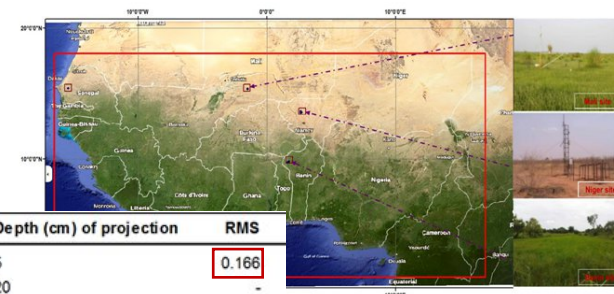
Advantages of GLWS

- Resulting monthly fields have no temporal gaps
- Higher spatial resolution as compared to GRACE/-FO;
~ 50km (no simple statistical downscaling)
- Underestimation of simulated linear trends (Scanlon et al., 2018) in WaterGAP is improved in GLWS

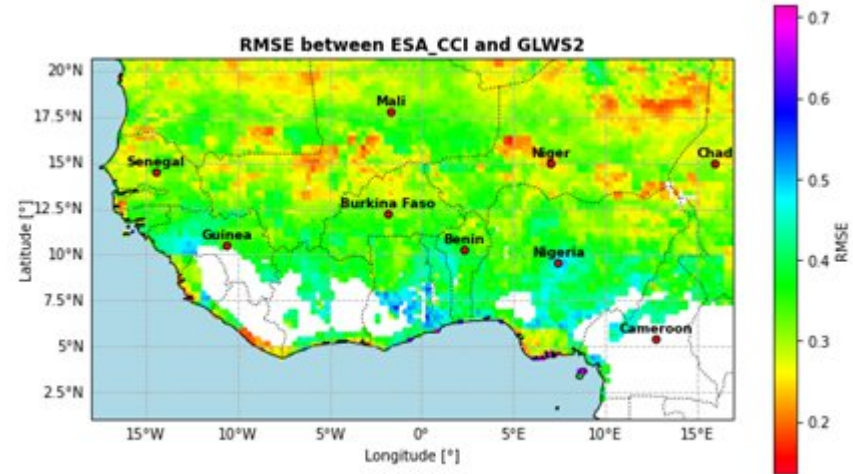
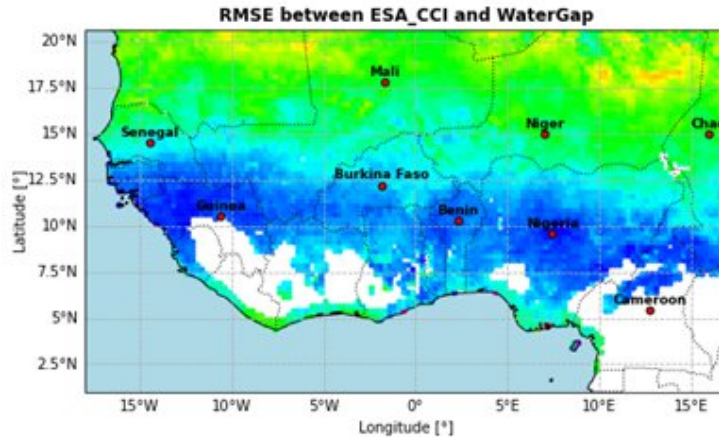


SOIL MOISTURE VALIDATION

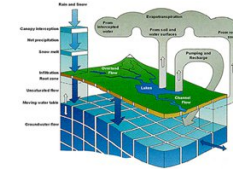
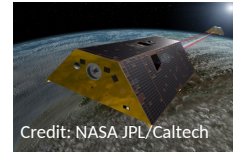
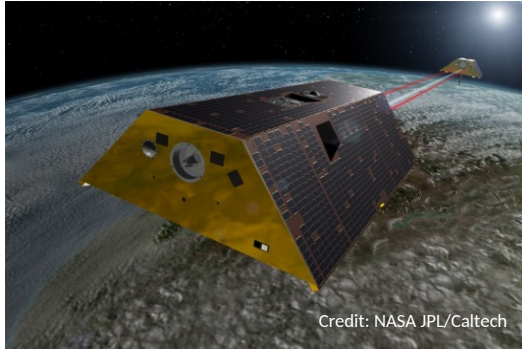
- Soil moisture normalization
- Richards equation approach to project soil moisture to different depths
- Colleague Yap Loudi performed comparison



Model/Dataset	Depth (cm) of projection	RMS
ESA CCI	5	0.166
	20	-
	100	-
GLWS2.0	5	0.233
	20	0.296
	100	0.415
WaterGap	5	0.334
	20	0.464
	100	0.424
CLM5	5	0.356
	20	0.232
	100	0.463



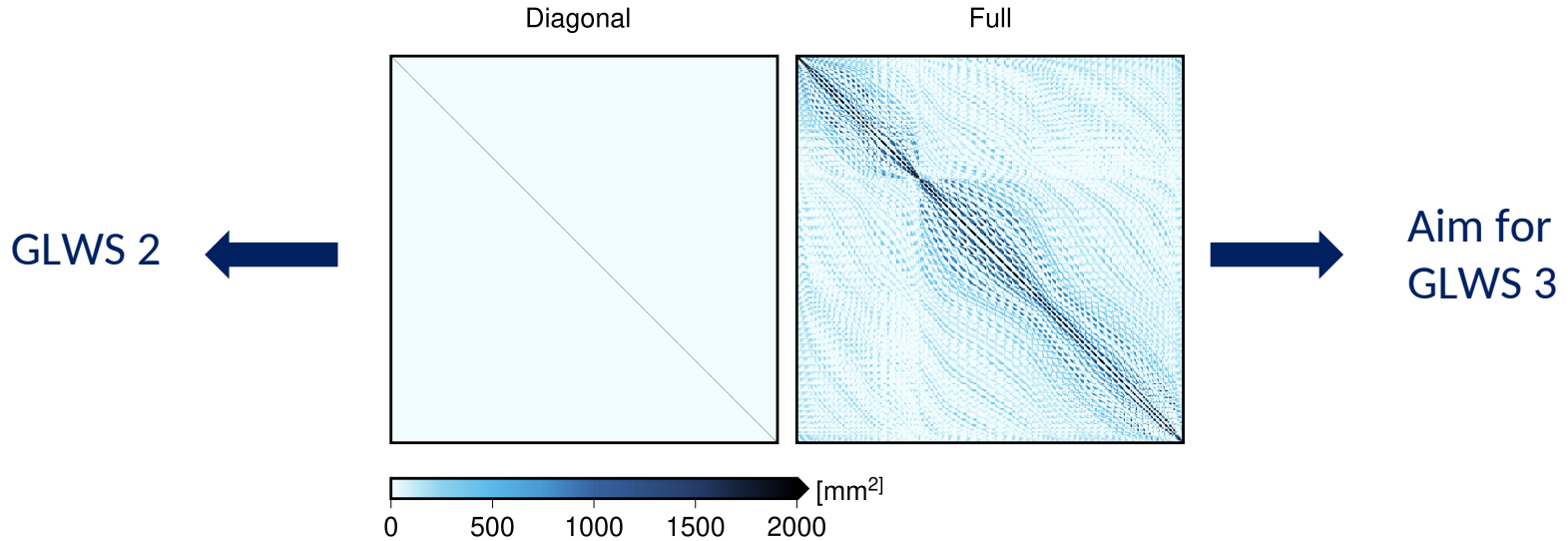
SETTINGS TESTED FOR GLWS 3



- Earthquake correction for large earthquakes
- Leakage correction via rescaling or RECOG correction data set for large lakes and reservoirs

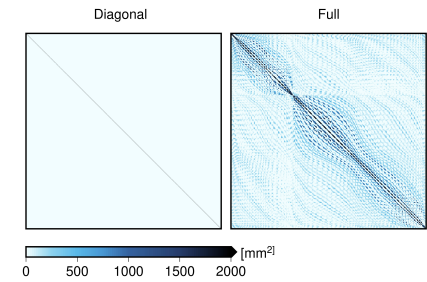
- Sensitivity towards filter algorithm
- Localization to include observation correlations
 - Inflation factor variations

INCLUDING OBSERVATION CORRELATIONS



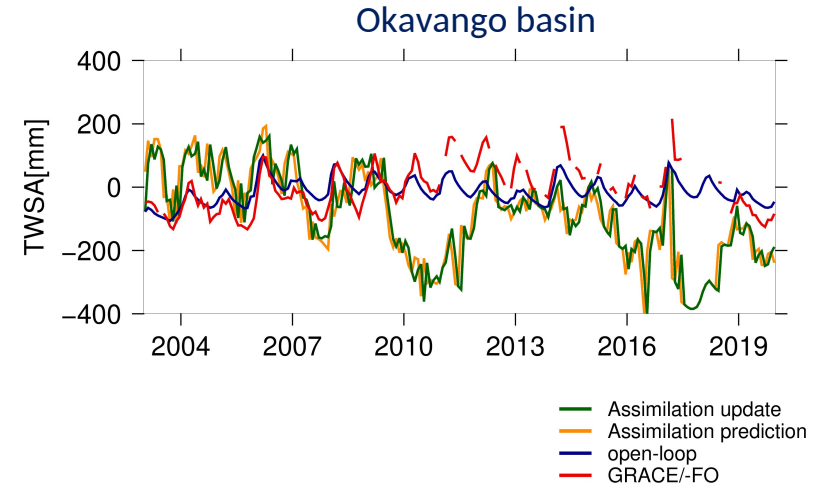
- example for January 2004
- correlation of neighboring cells 0.83 on spatial average
- correlation of next-neighboring cells 0.54 on spatial average

GLWS 3 SIGNATURES

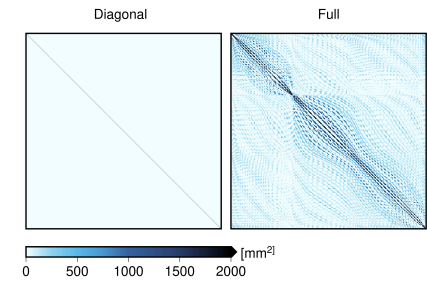


GLWS 2

- Ensemble Kalman Filter (EnKF)
—> Including full observation
VCM: filter off-track



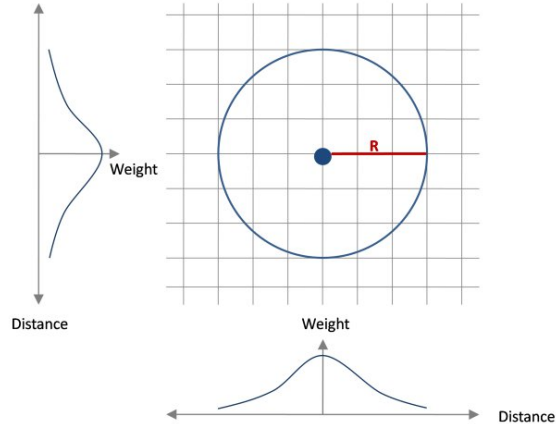
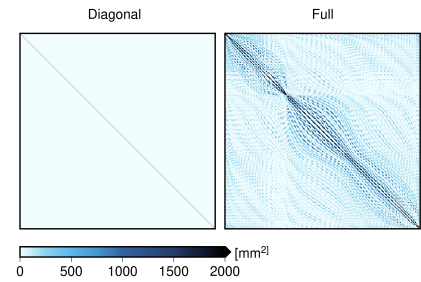
GLWS 3 SIGNATURES



GLWS 2

- Ensemble Kalman Filter (EnKF)
 - > Including full observation
 - VCM: filter off-track
- PDAF: Covariance localization :
modification of forecast
covariance matrix
 - > **LEnKF not successful**

GLWS 3 SIGNATURES

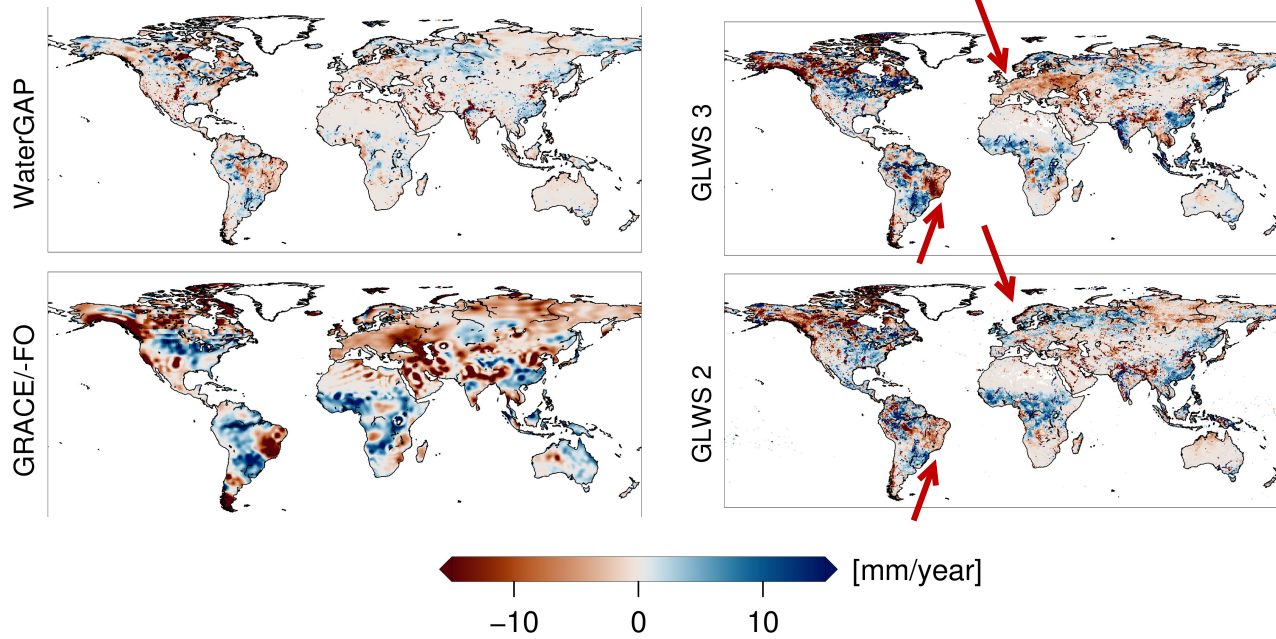


GLWS 3

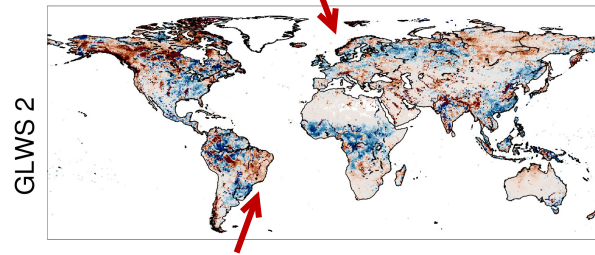
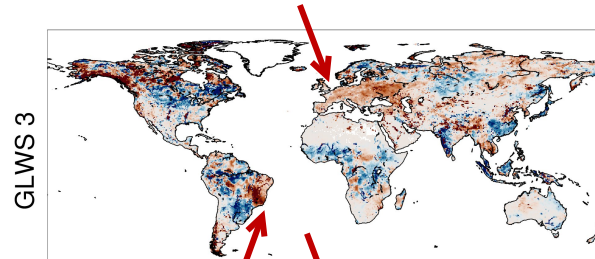
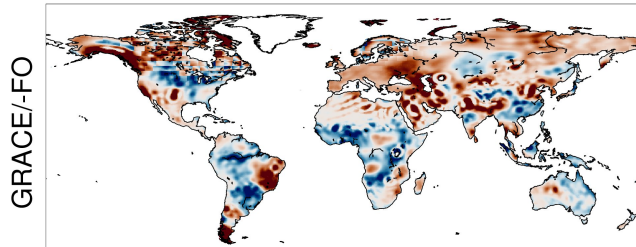
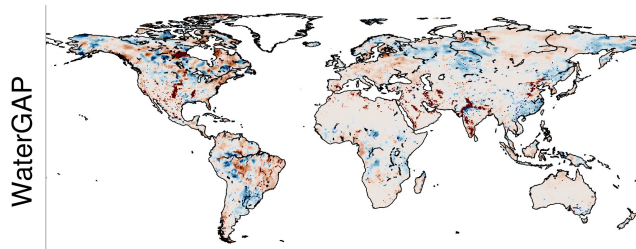
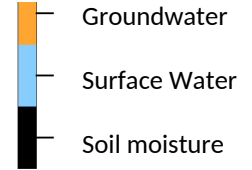
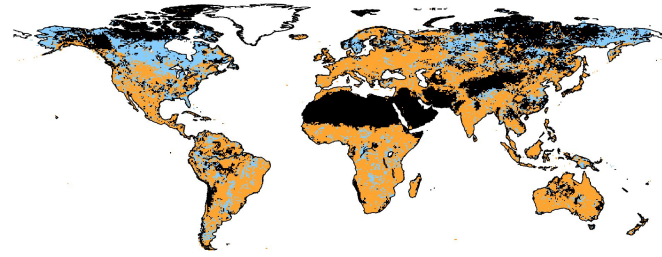
- Ensemble Subspace Transform Kalman Filter (ESTKF)
- PDAF: Domain localization
- Modification of observation covariance matrix

—> **successful**

TWSA LINEAR TRENDS 2003 - 2019



LINEAR TRENDS 2003 - 2019



- Groundwater linear trends dominating for ~50% of global land area
- For high latitudes soil moisture and surface water are more dominant

EXTRACT HYDROLOGICAL DROUGHT EVENTS

Hydrological drought

... is one of the processes GRACE can observe

—> Characterize drought with drought indicators

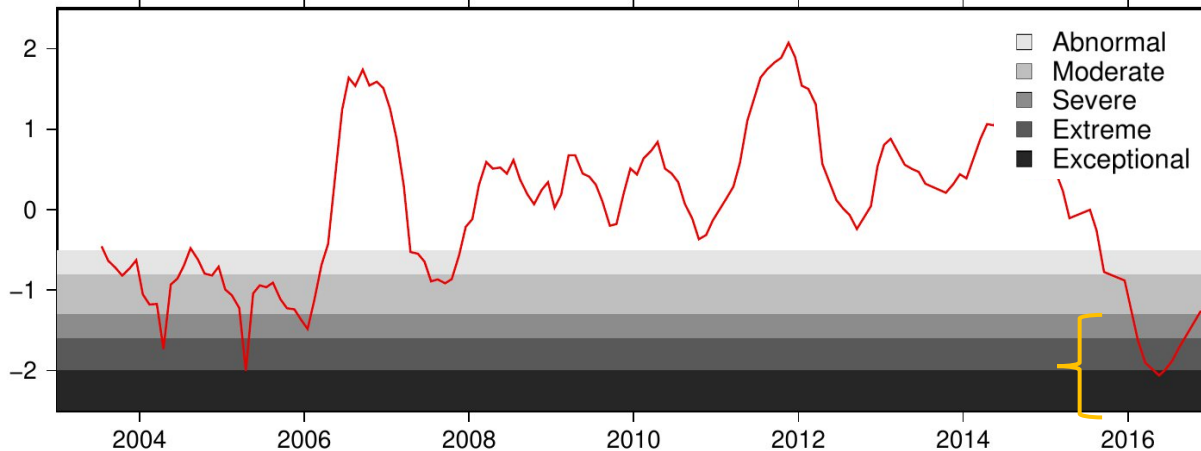
Drought Severity Index (DSI)

Zhao et al. (2017)

$$DSI_{i,j} = \frac{TWSA_{i,j} - \overline{TWSA_j}}{\sigma_{TWSA_j}}$$

Drought severity level	TWS-DSI [-]	
	Min.	Max.
Abnormal	-0.8	-0.5
Moderate	-1.3	-0.8
Severe	-1.6	-1.3
Extreme	-2.0	-1.6
Exceptional		-2.0

TWSA DSI computed based on GLWS



Criteria:

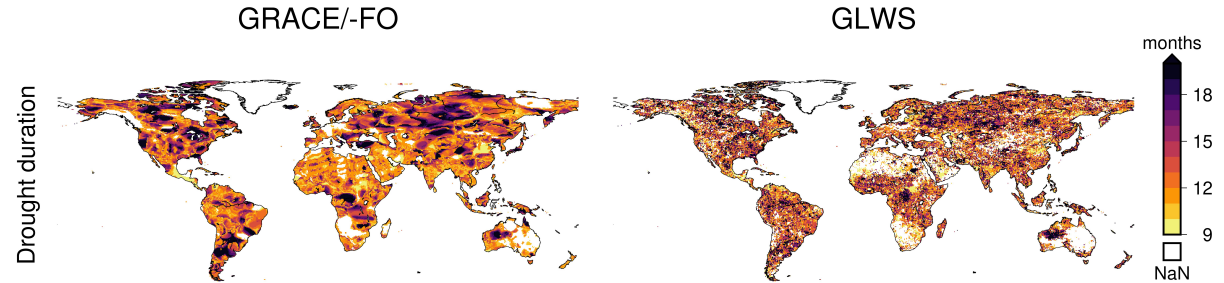
- Drought starts DSI below threshold (-1.3)
- Min. duration: 9 months to isolate strongest events
- Interruption after 2 consecutive months above threshold

CONSECUTIVE DROUGHT EVENTS TWSA

Extracted the longest drought per grid cell

- Agreements with literature e.g.,
 - 2003/2004 India Sinha et al. (2017)
 - 2006 Zambezi basin Thomas et al. (2014)

9 months min. duration
DSI threshold = -1.3



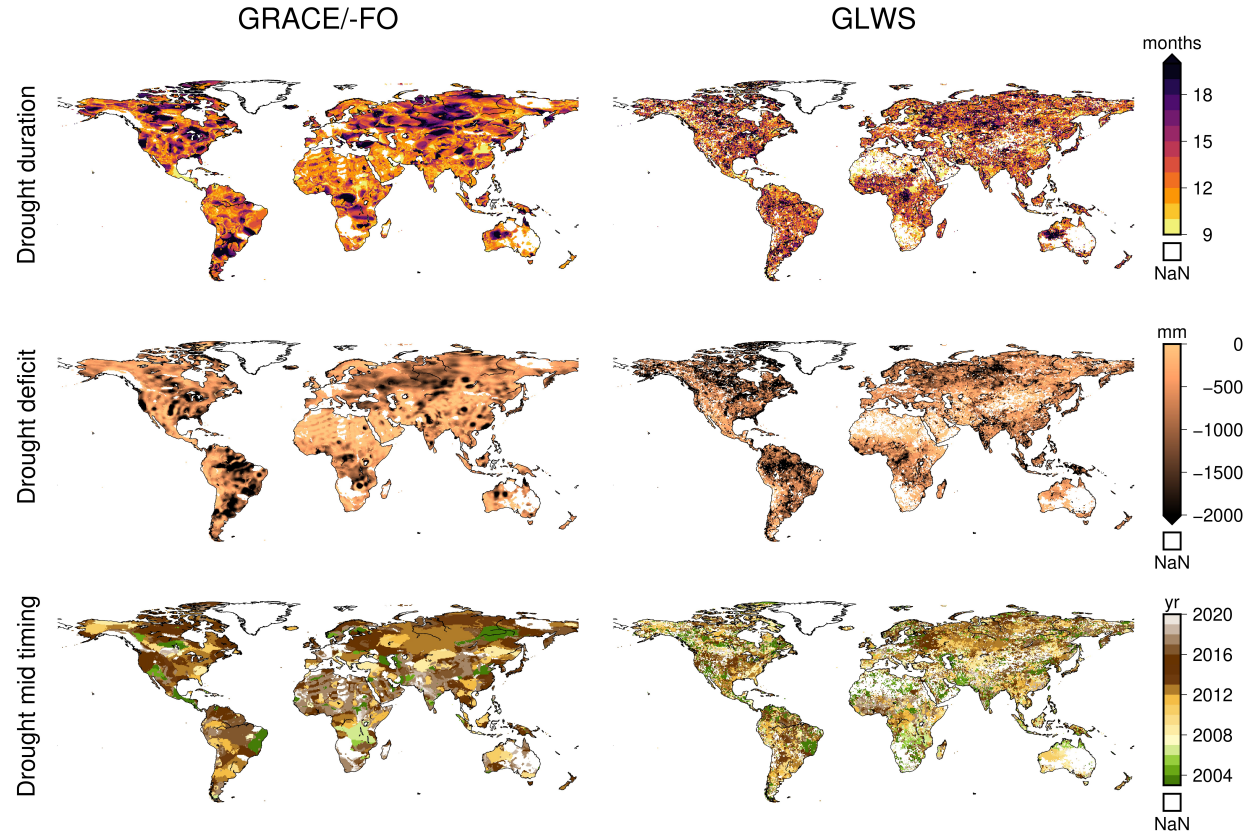
- Increased spatial resolution for GLWS (~50km) compared to GRACE (~300km)
- Different spatial extent for drought
- Extraction of further information possible, e.g., drought timing and deficit

CONSECUTIVE DROUGHT EVENTS TWSA

Extracted the longest drought per grid cell

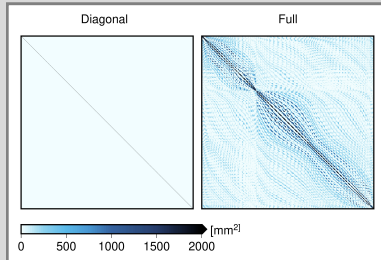
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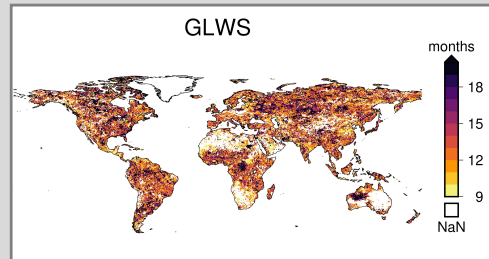
Global Land Water Storage 3

Update of GLWS 2 to GLWS 3 that includes new settings, e.g. observation correlations



Applications of GLWS3

More realistic linear trends
Consecutive drought events in TWSA agree with literature



Outlook

Consecutive droughts in e.g. groundwater
Drought risk assessments and warning alert systems

