Investigation of ALMIP zone total water storage variations using GRACE

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Context

- GRACE satellite, the first satellite of its kind

Measures time-variable gravity variations at spatial scales above 333 km with 10-day to monthly sampling

Gravity variations are interpreted as total water storage variations after correction of atmospheric and oceanic contributions (i.e. Surface water + soil moisture + groundwater storages)

Not a regular remote sensing instrument
Support of GRACE measurements are not grids, even if it can be provided as grids

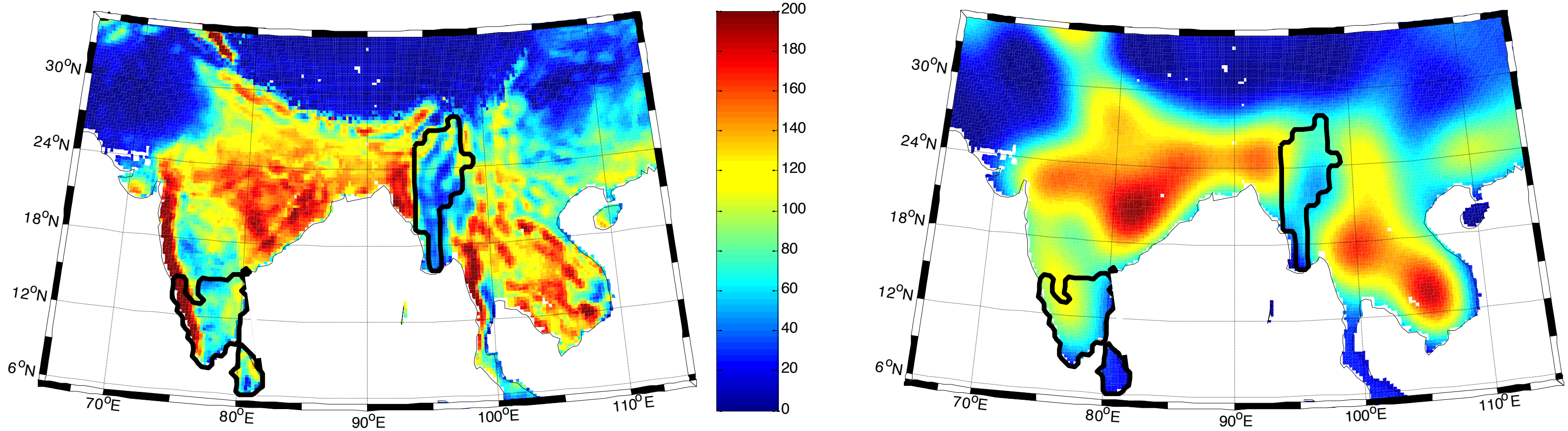
- Previous works over the AMMA region

Grippa et al. 2012 : comparison between GRACE and ALMIP models

Points out the ability of GRACE to monitor water storage variations
Highlights the importance of slow reservoir & ET modeling

Difficulty in using GRACE

- GRACE provide a spatially filtered image of reality



Amplitude of seasonal water storage variations

Modeled by GLDAS-NOAH hydro-meteorological model

Same map, considering only large-scale variations seen by GRACE

- 2 ways to use GRACE

1. Continent-scale studies, models are filtered as GRACE
2. Space-limited areas (e.g. basin or region), GRACE requires corrections

Difficulty in using GRACE

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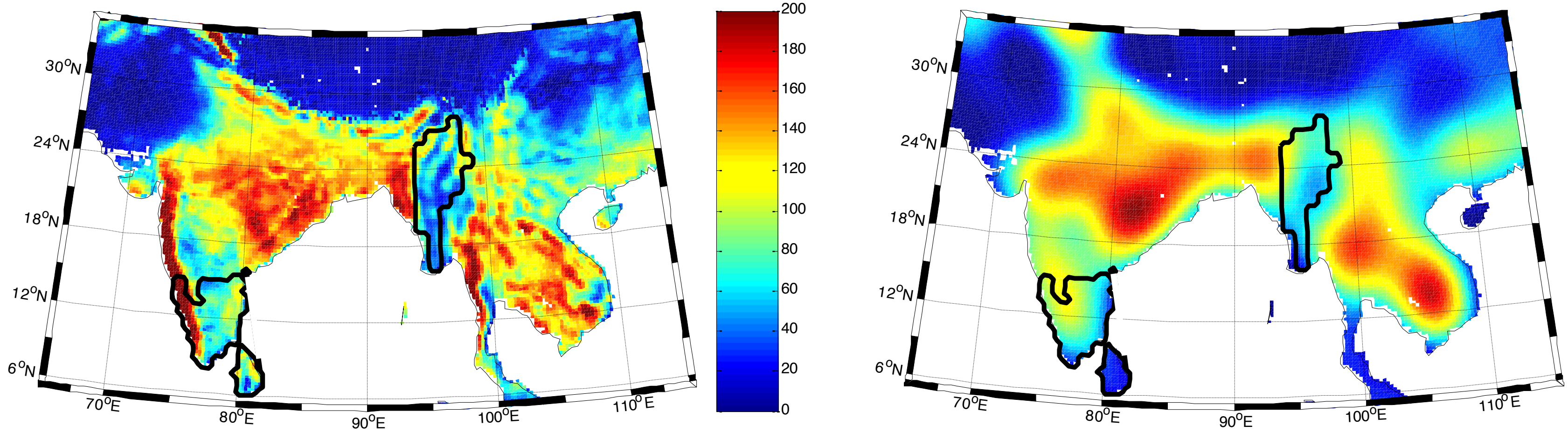

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Objectives of the study

- 1. Compare GRACE and ALMIP models

    - ALMIP models first turned to GRACE resolution for an optimal use of information contained in GRACE data

    - Requires first nesting of ALMIP models (limited extend) into a global model GLDAS-NOAH to avoid border effects

    - GRACE solutions : CSR, GRGS and new regularized CSR

- 2. Interpret differences between GRACE and models

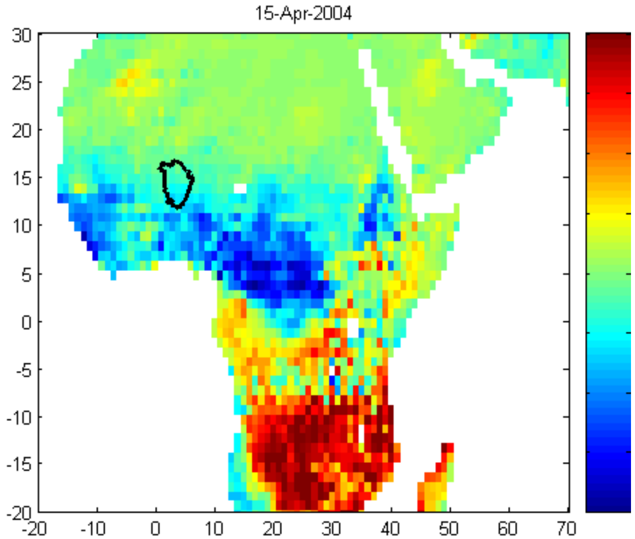
    1. GRACE errors -> estimated in the ocean

    2. LSM errors -> comparison among models

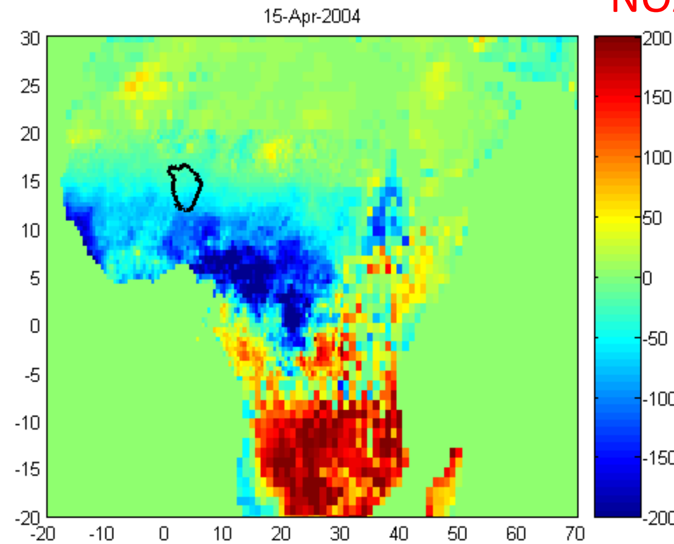
    3. Unmodeled contributions -> groundwater contribution

Nesting ALMIP models into GLDAS-NOAH

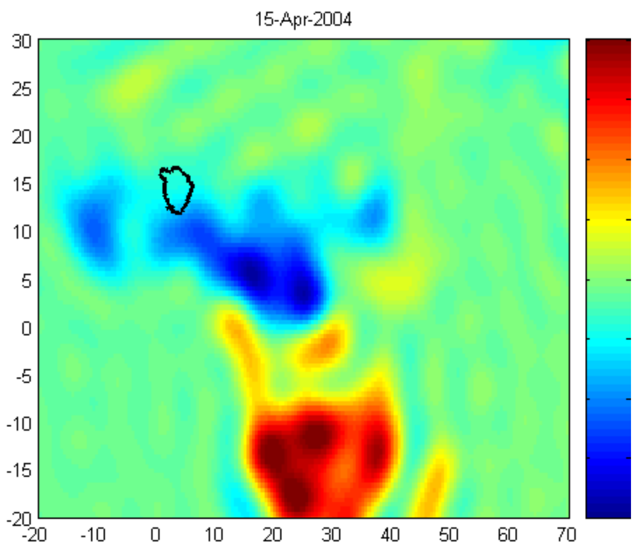
Original NOAH 1° model



NOAH 1° + nested ALMIP model



Original NOAH 1° model, spatial scales > 400 km



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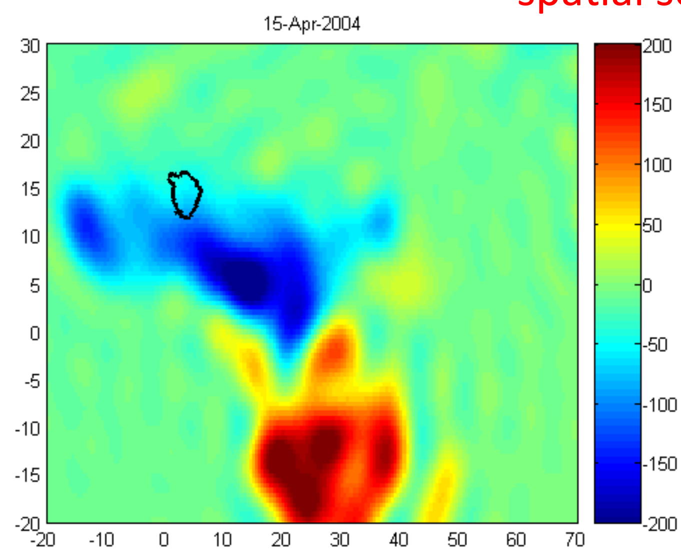


Variability between GRACE and models

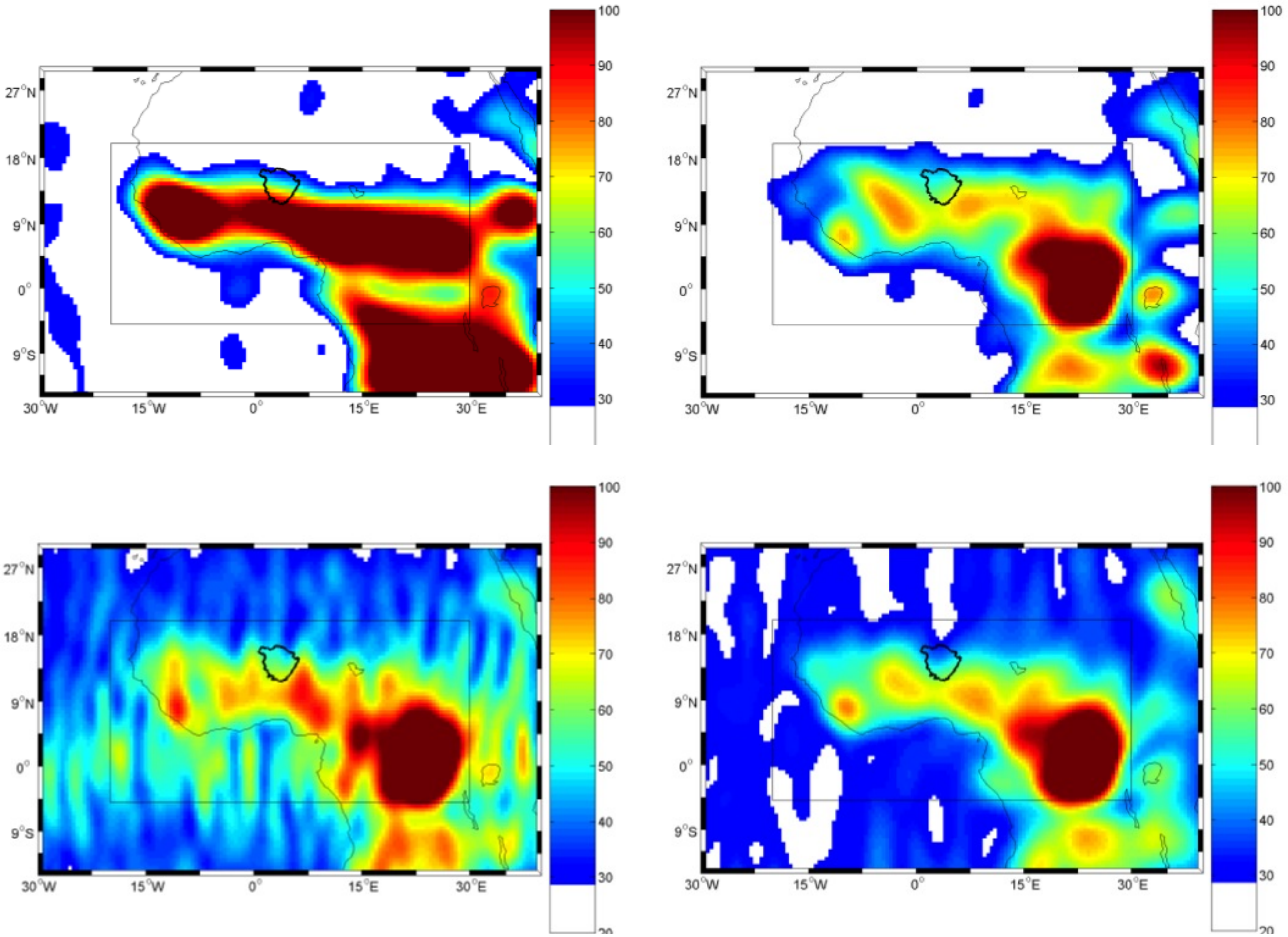
- Example of CLSM model

GRACE GRGS variability

Residuals GRGS – CLSM variability

Residuals CSR – CLSM variability

Residuals regularized CSR - CLSM

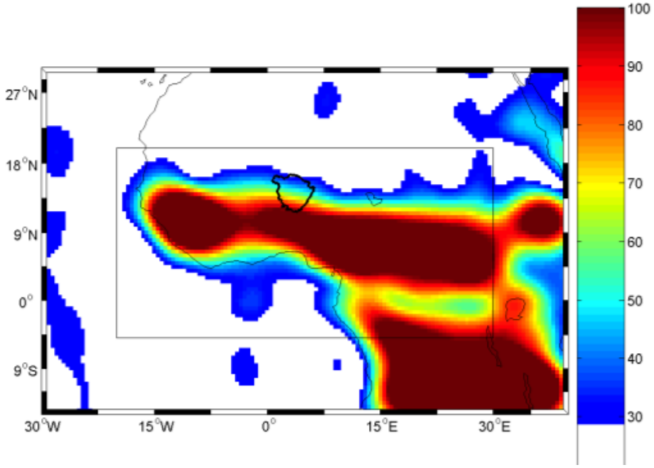


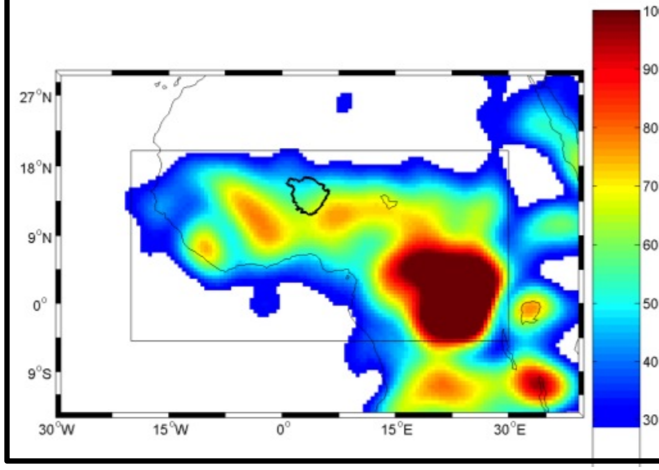
GRACE noise level ~30 mm, white color is non-significative

Variability between GRACE and models

- Example of CLSM model

GRACE GRGS variability

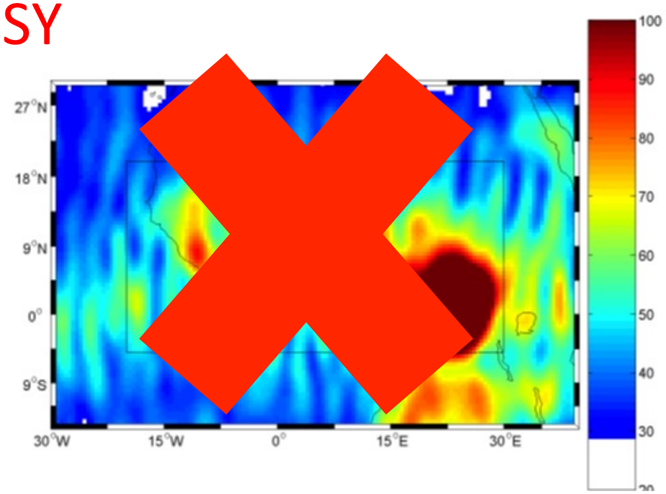


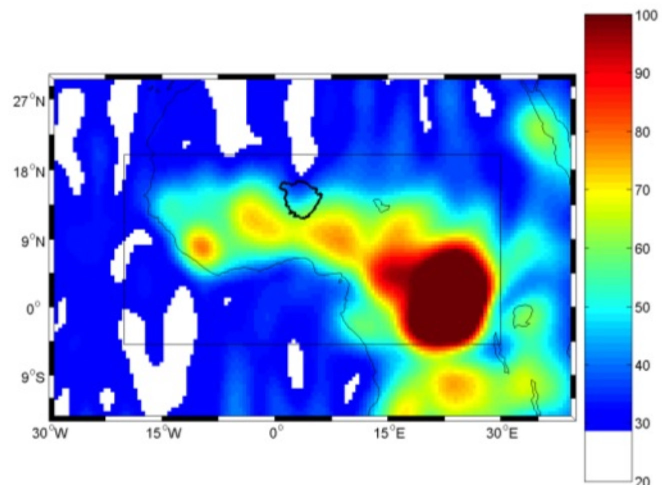


Residuals GRGS – CLSM variability

TOO NOISY

Residuals CSR – CLSM variability





Residuals regularized CSR - CLSM

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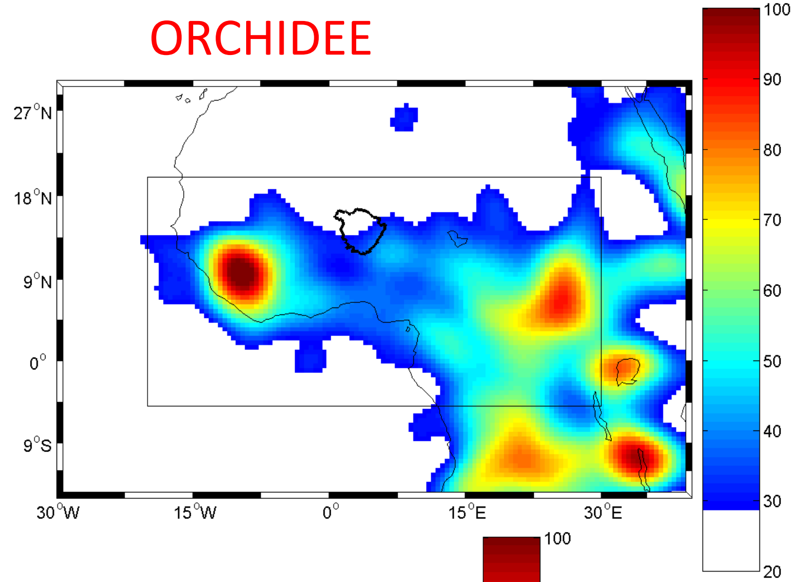
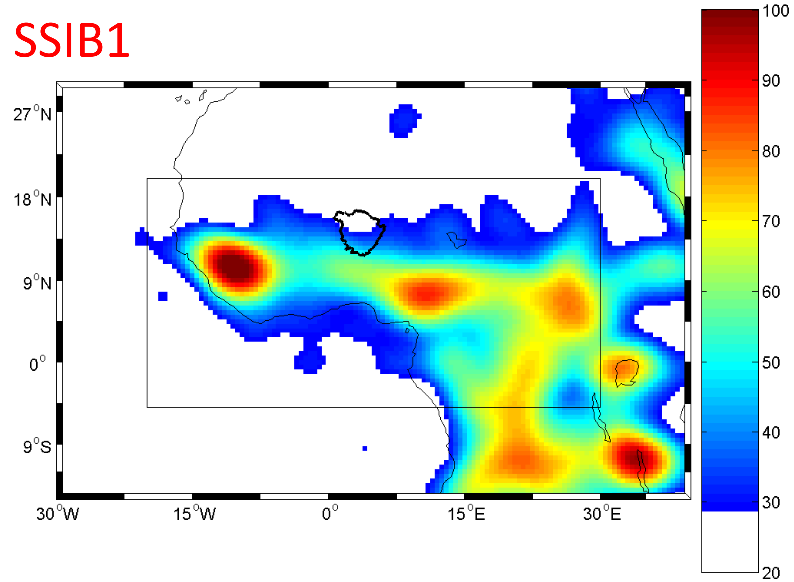
Variability between GRACE and models

- ALMIP model comparison: residuals in GRACE GRGS - MODEL

ORCHIDEE



SSIB1

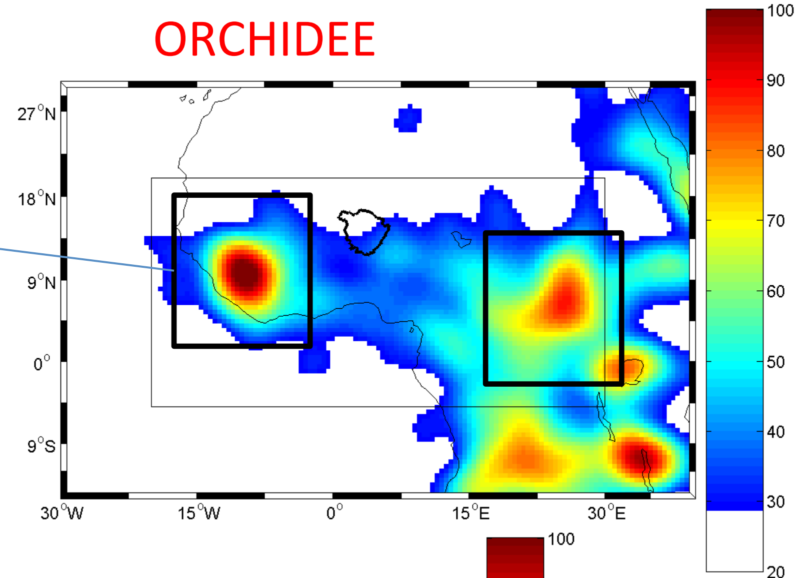


Variability between GRACE and models

- ALMIP model comparison: residuals in GRACE GRGS - MODEL

Fouta-Dialon
&
Sudan

ORCHIDEE



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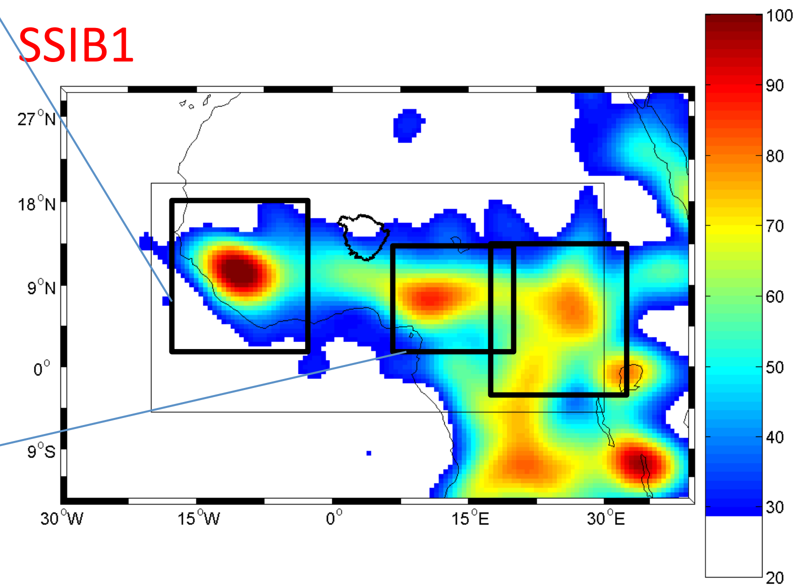
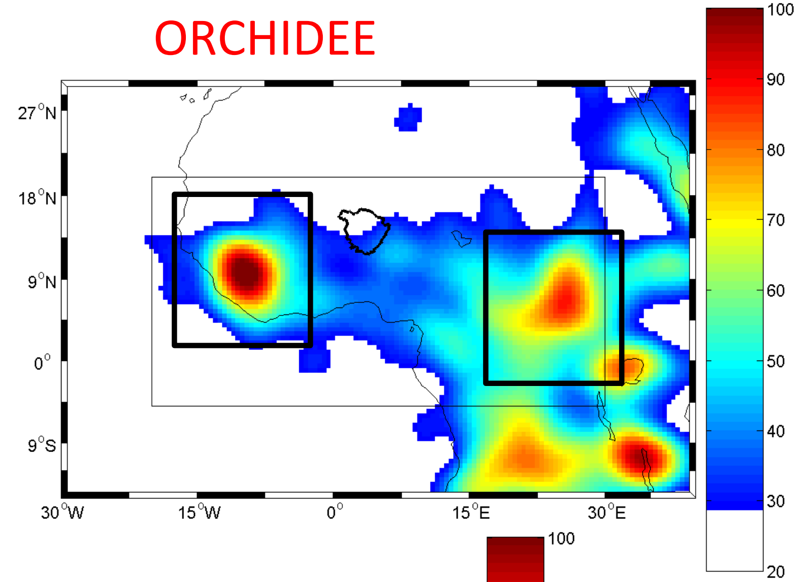


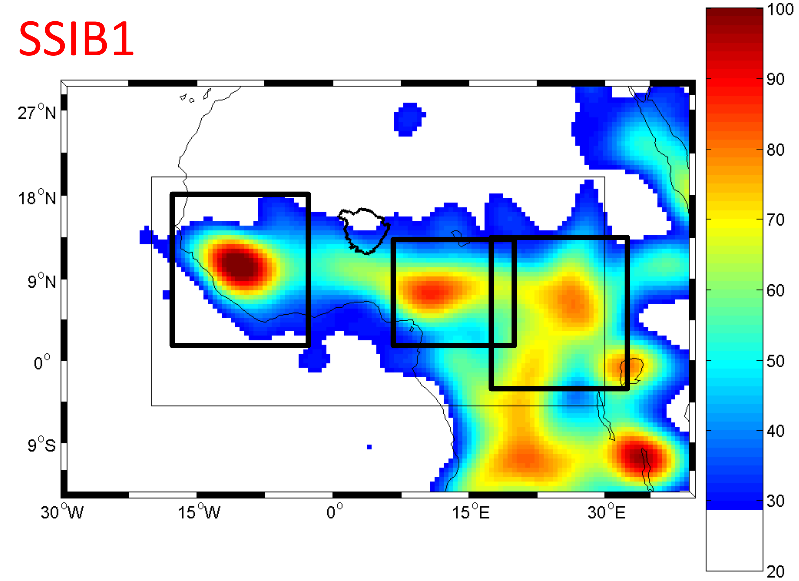
Jos plateau

Variability between GRACE and models

- ALMIP model comparison: residuals in GRACE GRGS - MODEL

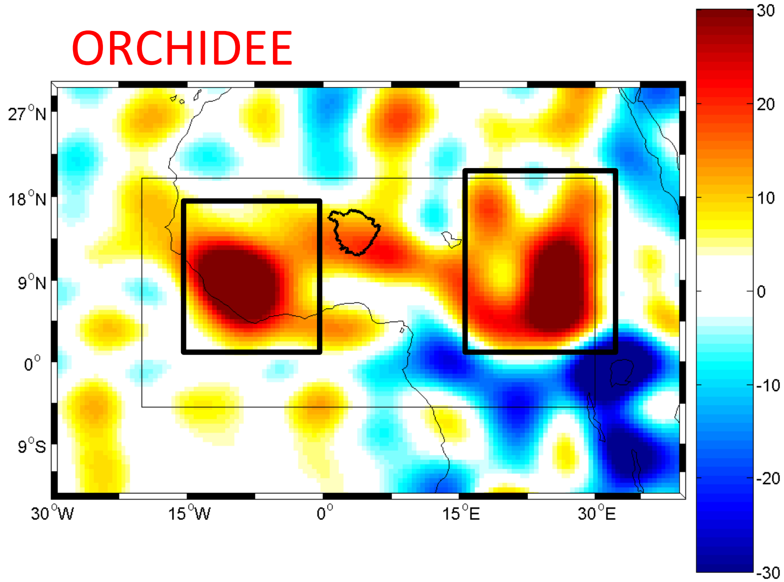
	Residual variability [mm]	Residual Seasonal cycle [mm]
CLSM	48	28
HTESSEL	**40**	**25**
ISBA	41	28
ISBA_DIF	47	27
JULES	40	26
NOAH	40	28
ORCHIDEE	40	26
ORCHIDEE WILT	**40**	**25**
SETHYS	45	27
SSIB1	41	29
SWAP	41	30
GRACE error	**30**	**10**





Long-term variations : GRACE minus models

ORCHIDEE

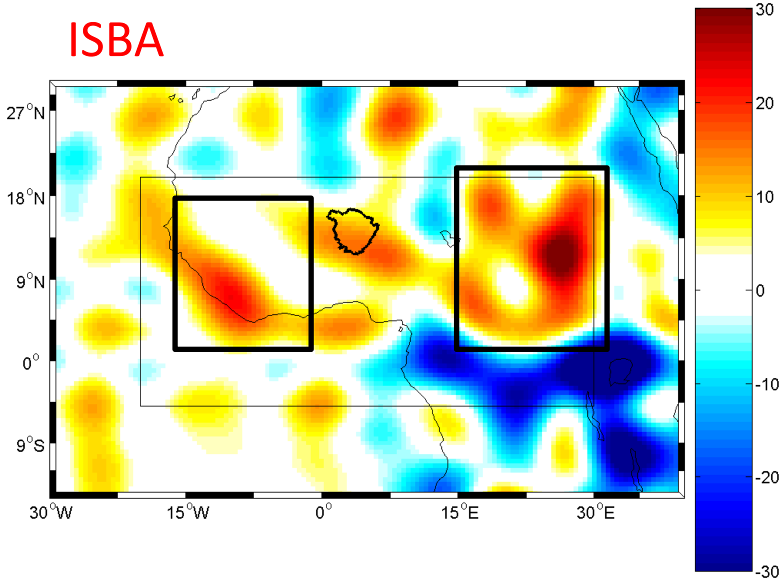


+30 mm/yr

Water storage increase :
Largely depends on model

-30 mm/yr

ISBA



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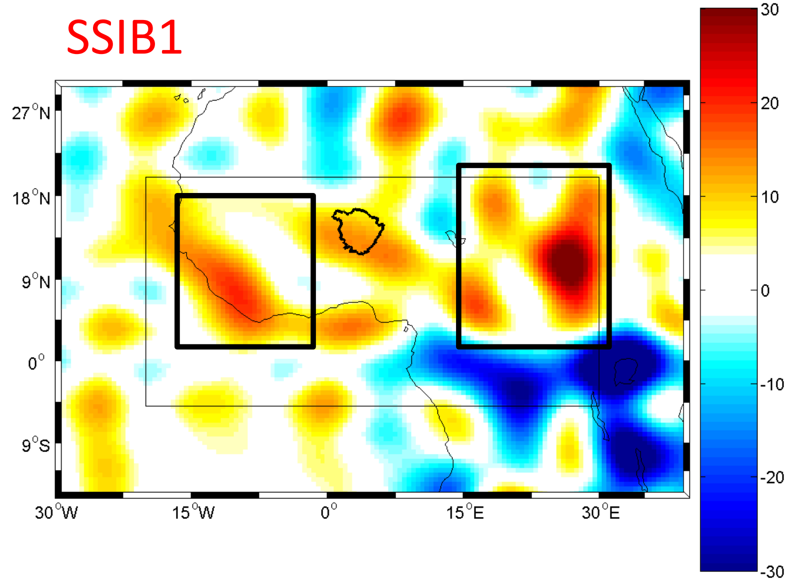

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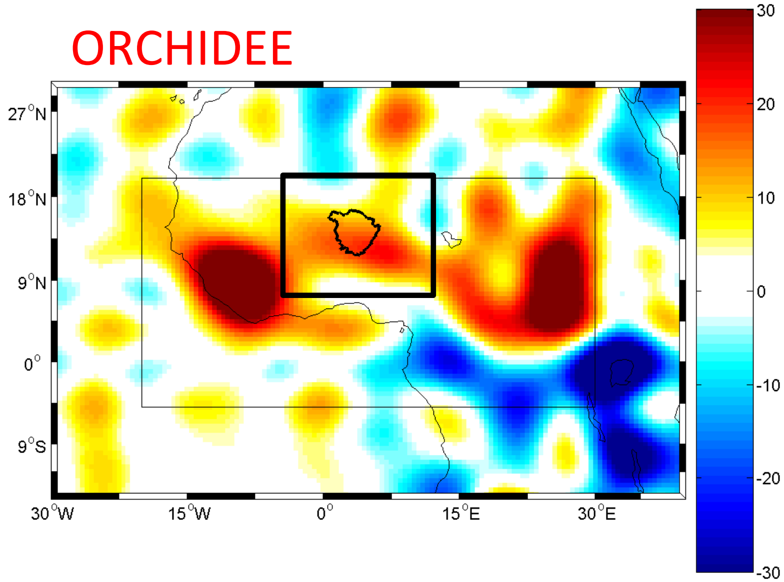


+30 mm/yr

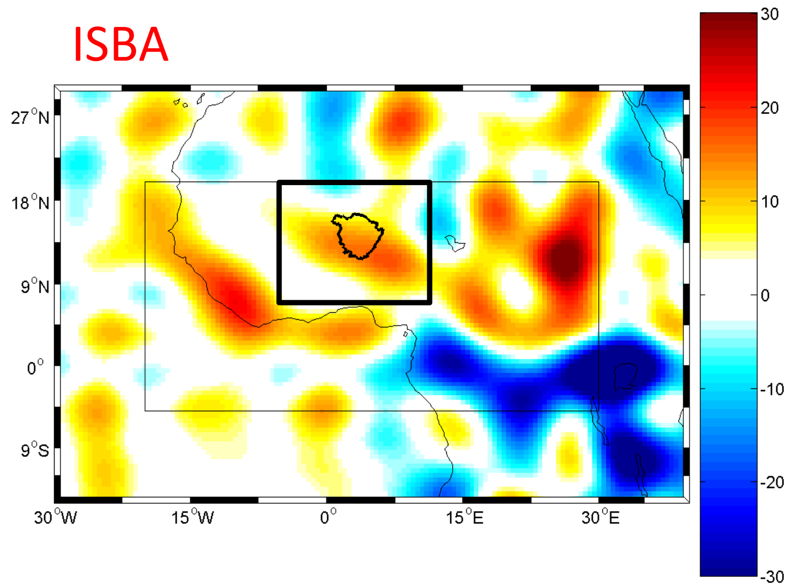
Water storage increase :

- Largely depends on model
- Sahel region systematically showing up

→ **Groundwater contribution ?**

-30 mm/yr

ISBA



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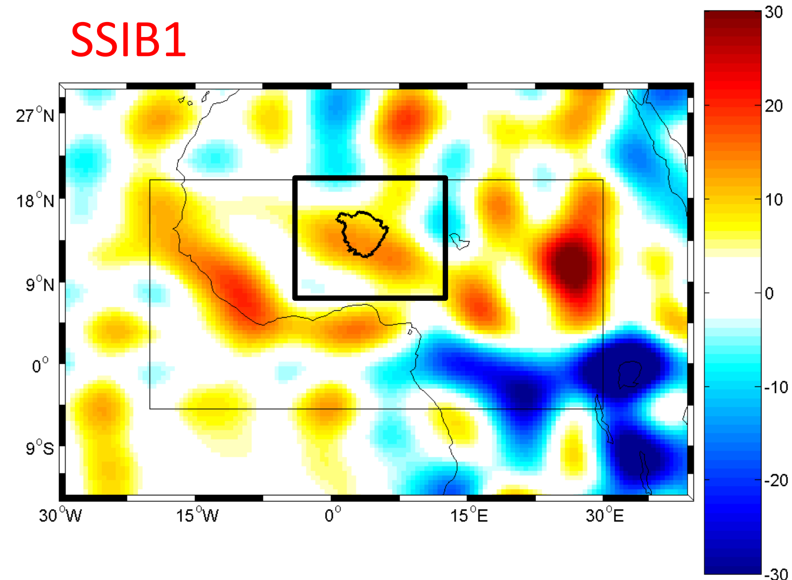
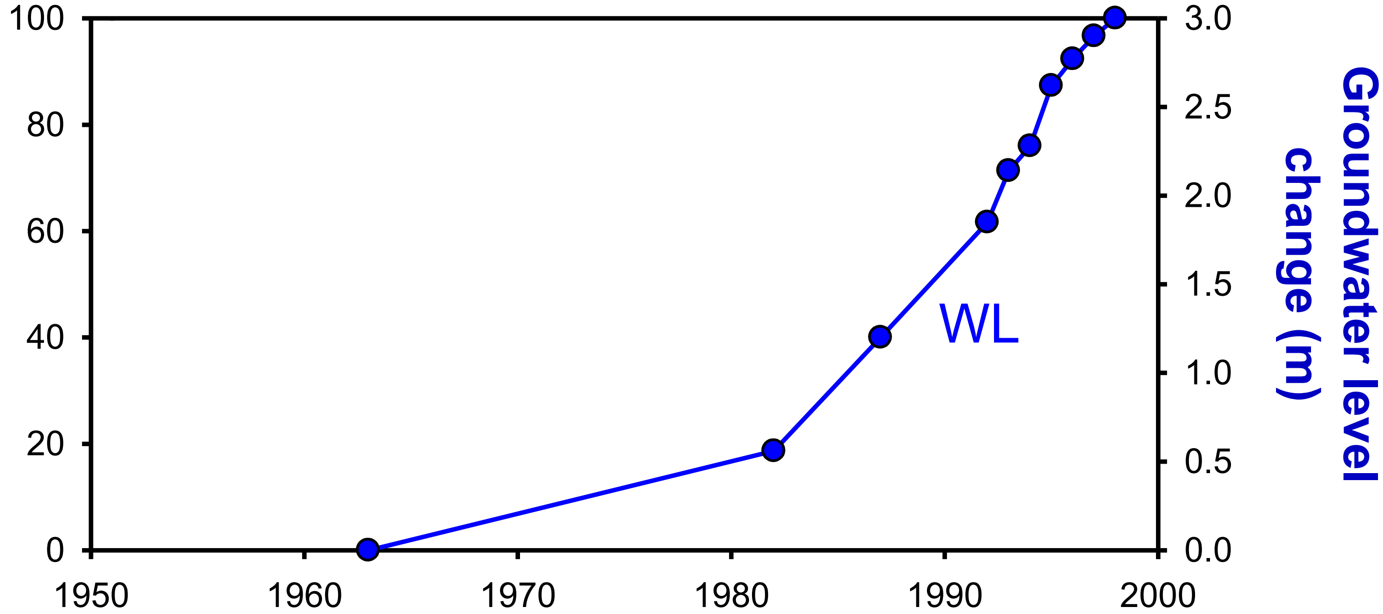


The Continental Terminal aquifer

Studied since 1990s
International AMMA project

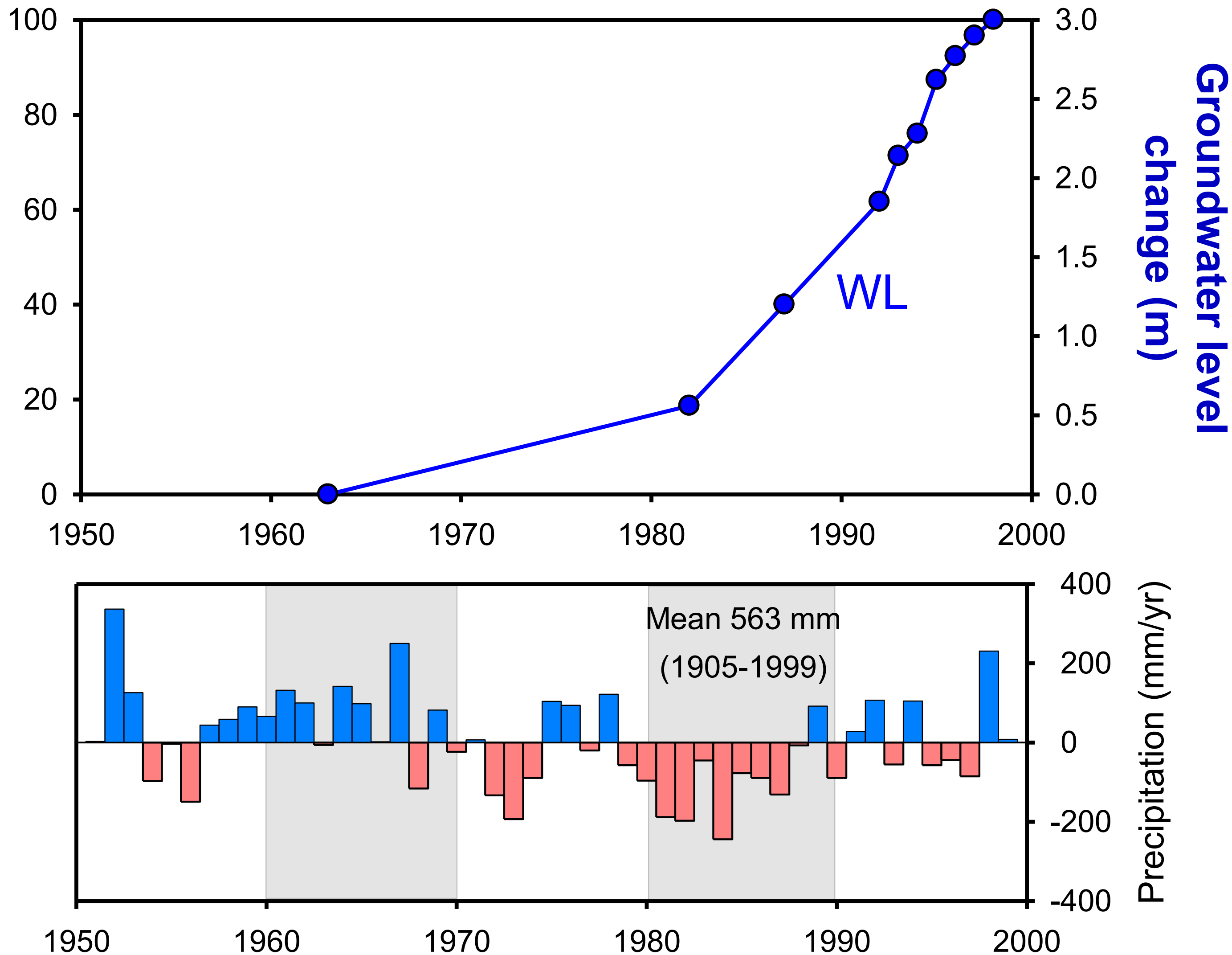
Favreau et al., 2009

GW level rising



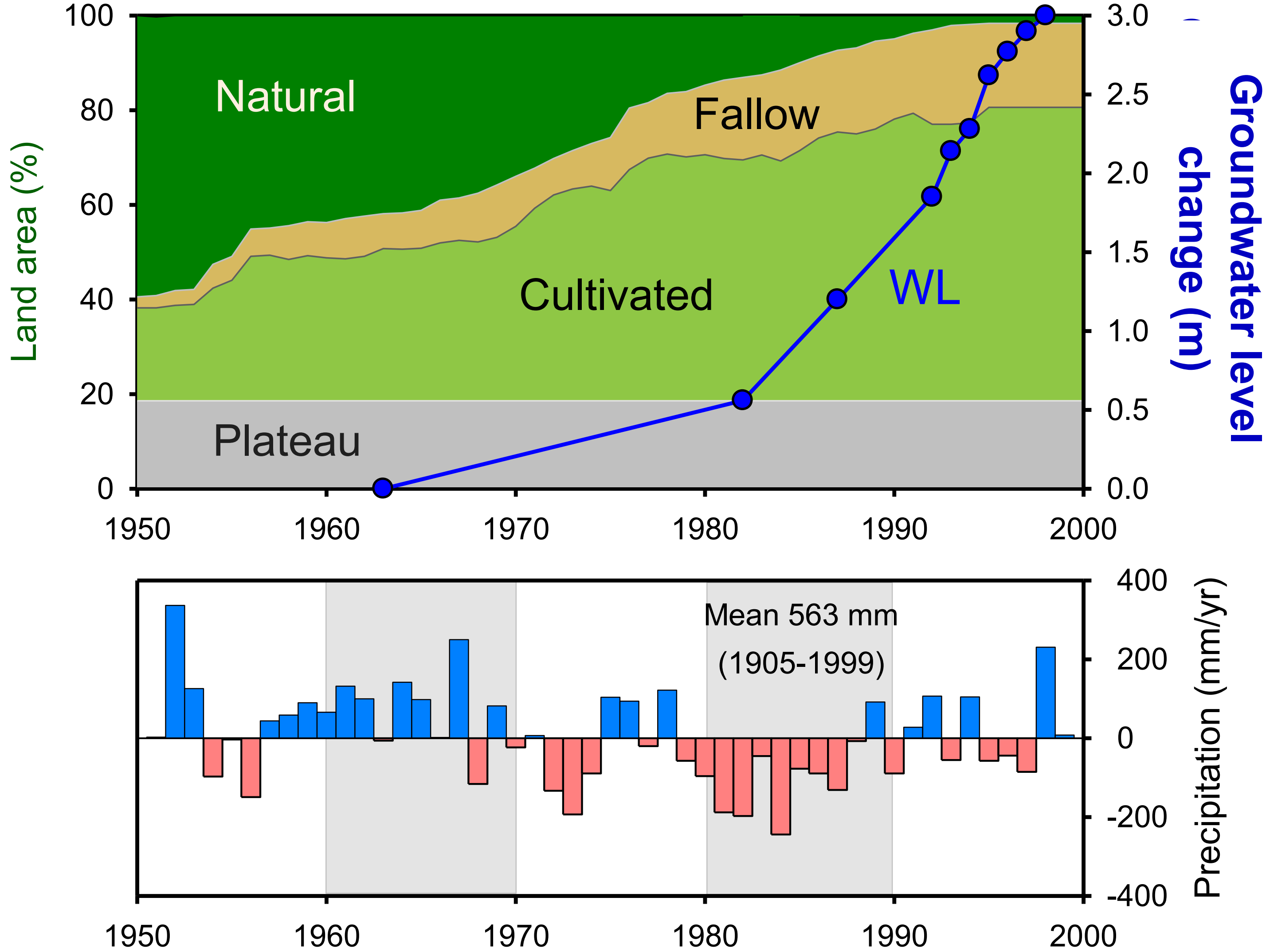
Favreau et al., 2002, GW

GW level rising, no link to climate



Favreau et al., 2002, GW

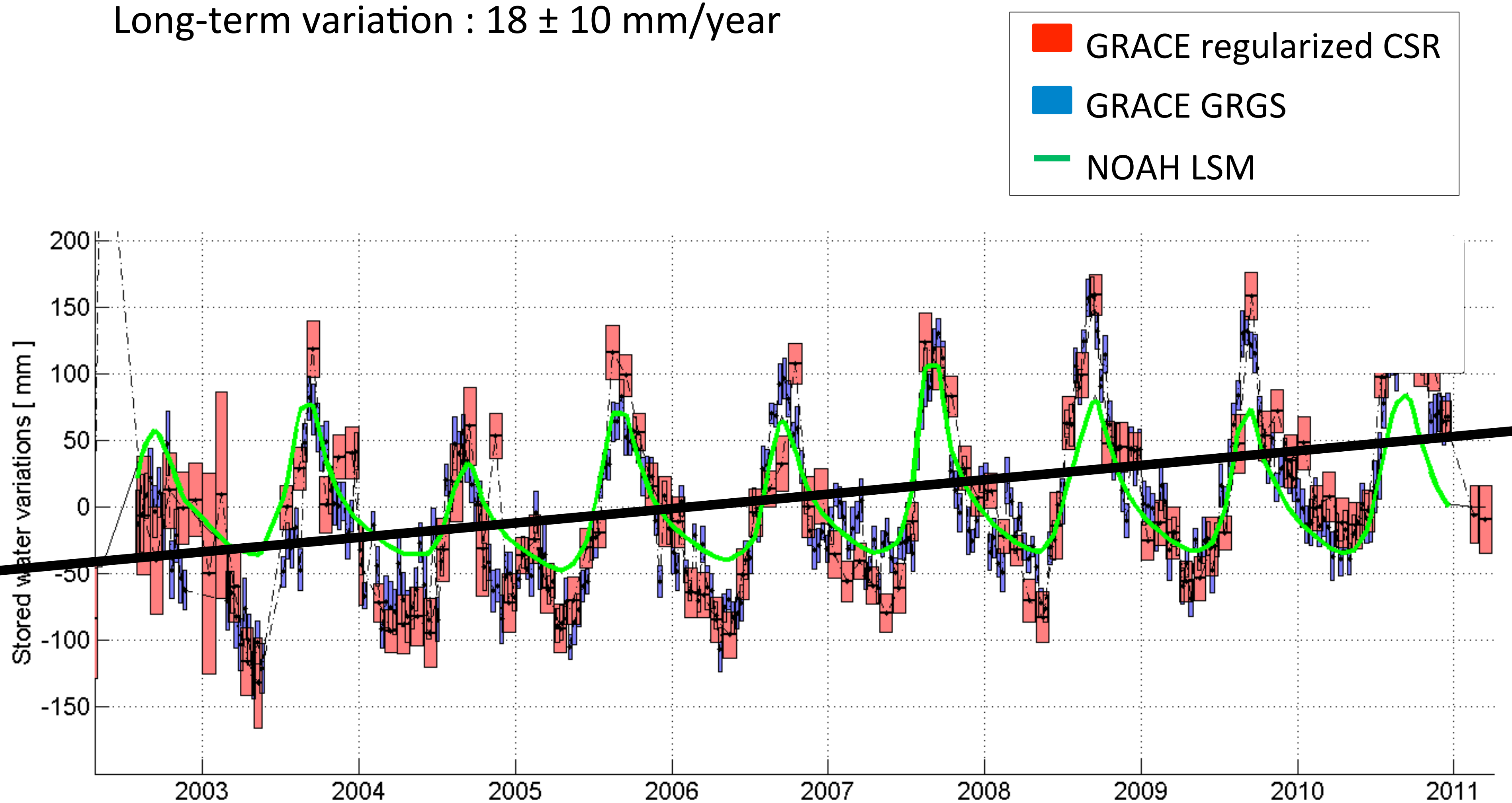
GW level rising, related to land use changes



Favreau et al., 2002, GW

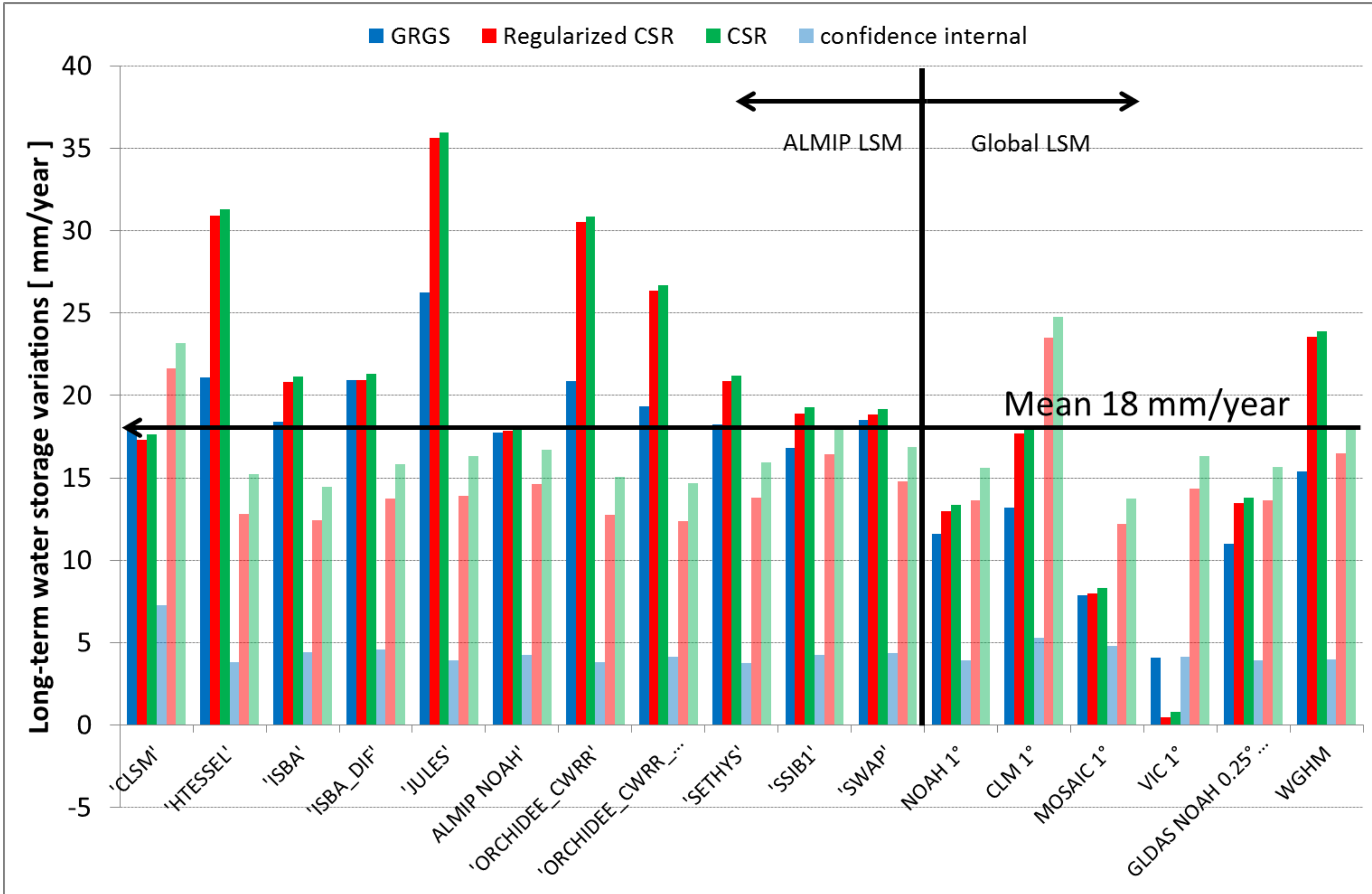
GRACE monitoring of the CT region

Long-term variation : 18 ± 10 mm/year



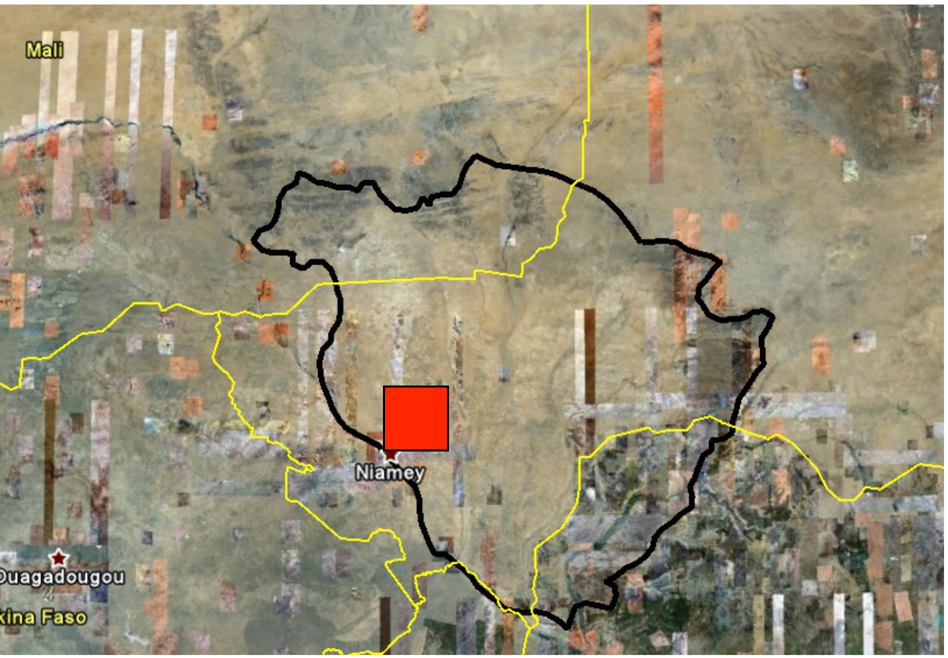
Interannual water accumulation on CT

- Long-term evolution of GRACE (3 solutions) minus LSM (17 LSM)



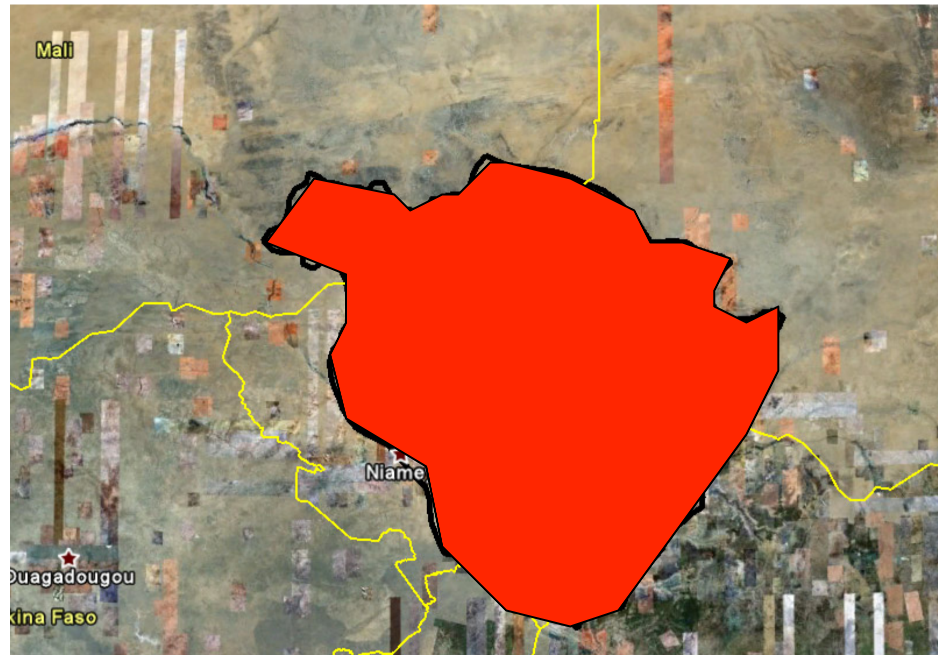
Synthesis on CT aquifer

Groundwater results



Area: 10 000 km²
Trend: +23 mm/yr

GRACE results



Area: 150 000 km²
Trend: +18 mm/yr

GRACE can be used to regionalize trends

Conclusions

- 1. Comparison GRACE – ALMIP models
    - Large variability among models as compared to GRACE
    - Water towers concentrate most model errors
    - A good model for seasonal variations is not necessarily a good model for describing long-term variations

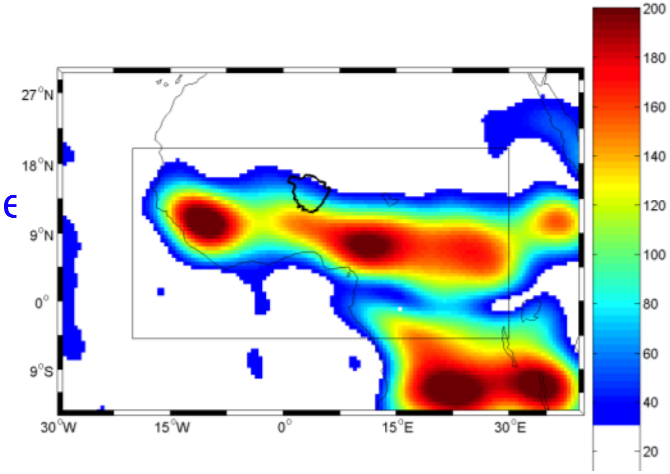
- 2. Extraction of groundwater contribution
    - Over the Continental Aquifer System, long-term groundwater level rise ~ 18 mm/year
    - Spatially, the GW level rise extends beyond the CT aquifer according to GRACE

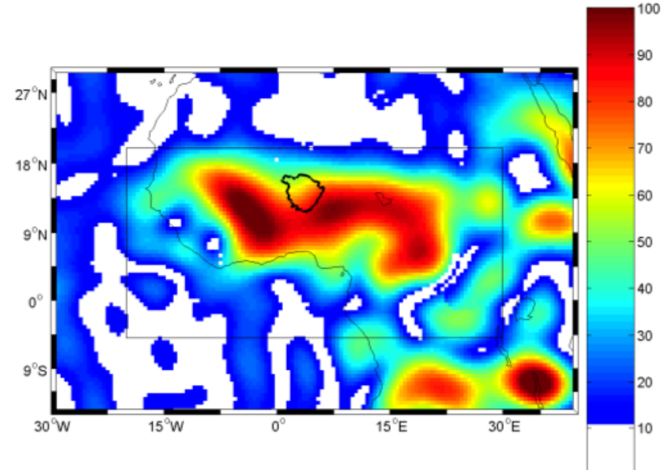
Thanks for attention

Amplitude of seasonal, cycle GRACE and models

- Example of CLSM model

GRACE GRGS amplitude of seasonal cycle



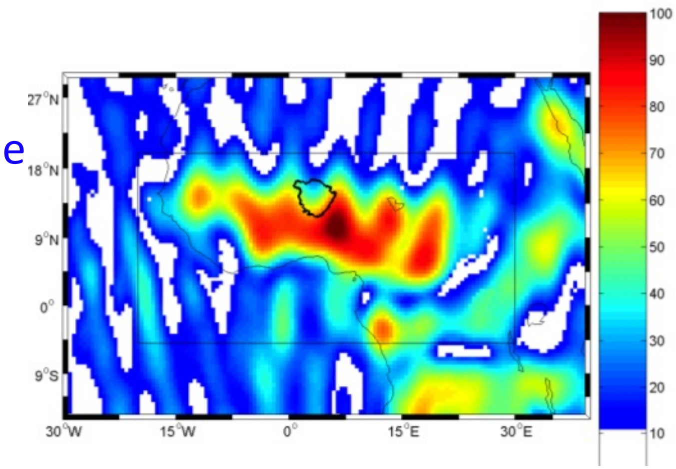


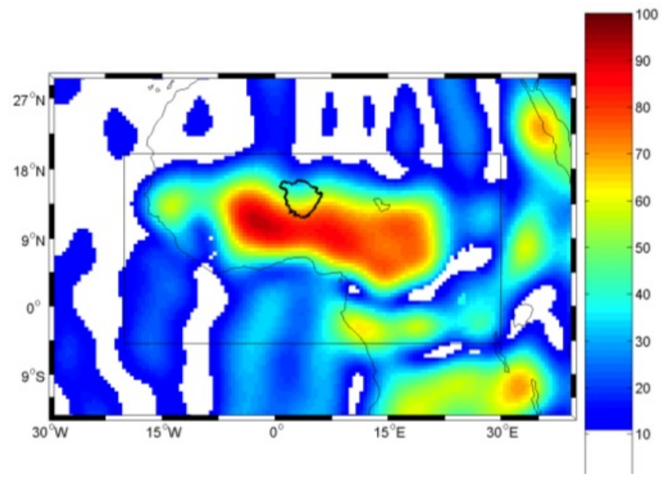
Residual seasonal cycle

GRGS – CLSM

Residual seasonal cycle

CSR – CLSM variability





Residual seasonal cycl

regularized CSR - CLSM

GRACE noise level ~10 mm, white color is non-significative