Aquifer Response and Groundwater Flow: Inferences from GRACE, GGMs, Field, and RS data

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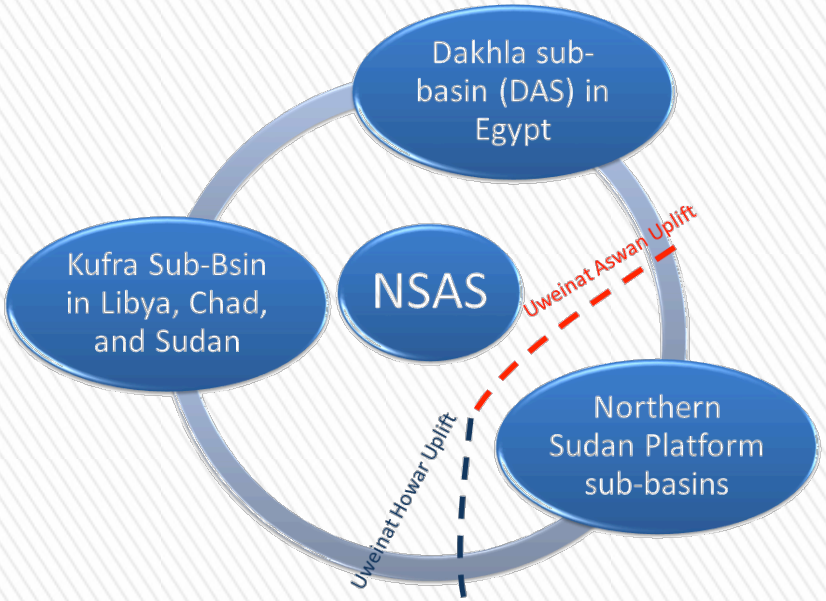
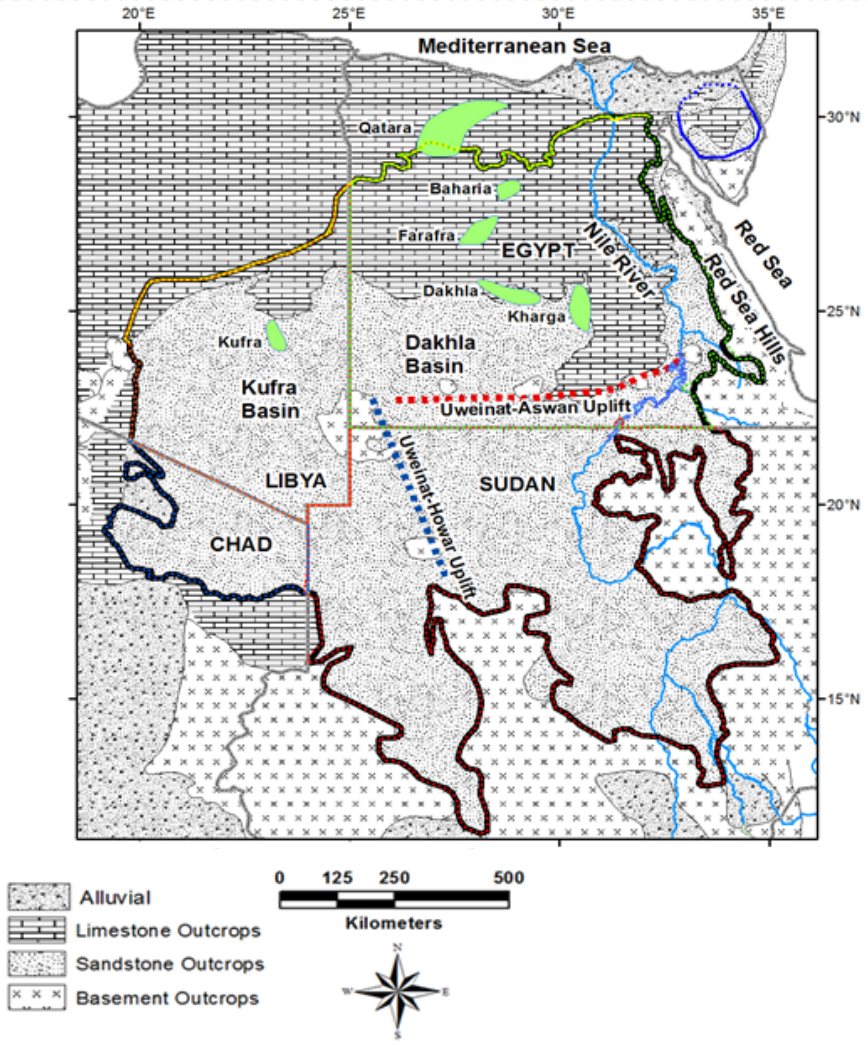
NUBIAN SANDSTONE AQUIFER SYSTEM (NSAS)

- NSAS shared by Egypt, Libya, Chad and Sudan (~ 2.2 x $10^6 km^2$).
- Aquifer thickness (up to 3 km)
- Three main sub-basins: Dakhla, Kufra, and N. Sudan Platform
- Recharged during previous wet climatic periods.





OBJECTIVES

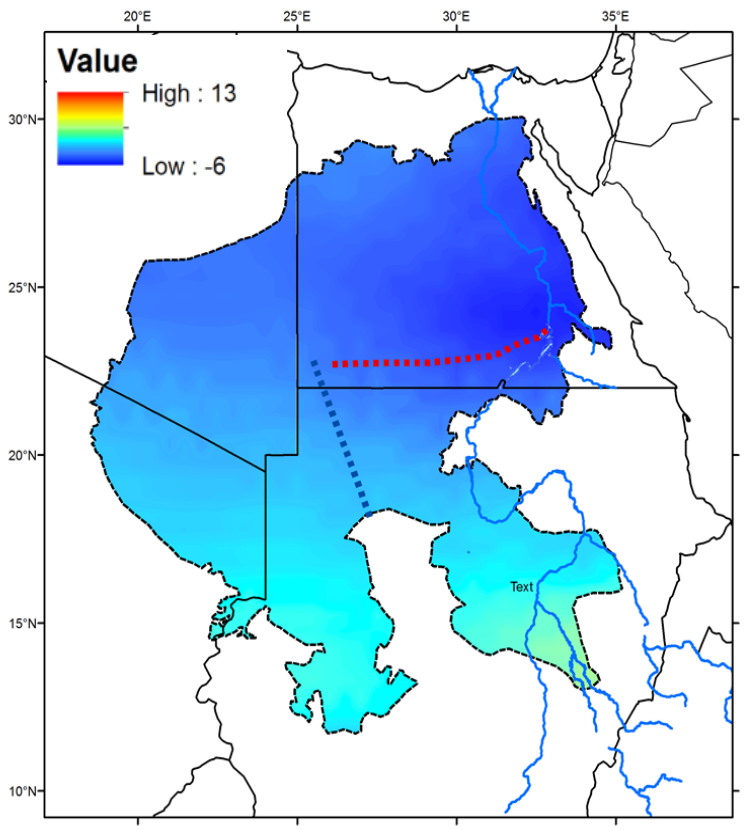
- Identify source locations of recharge from CSR Mascon
- Understand the aquifers' response to wet & dry periods (rapid aquifer response)
- Identify preferred pathways for groundwater flow
- Structural control on mass movement
- Develop and provide evidence for a conceptual model for mass movement in the NSAS

Dry and Wet Periods over Nubian Basin

2002-2012 TWS TREND: A LOSING SYSTEM

DRY PERIOD

Water Mass

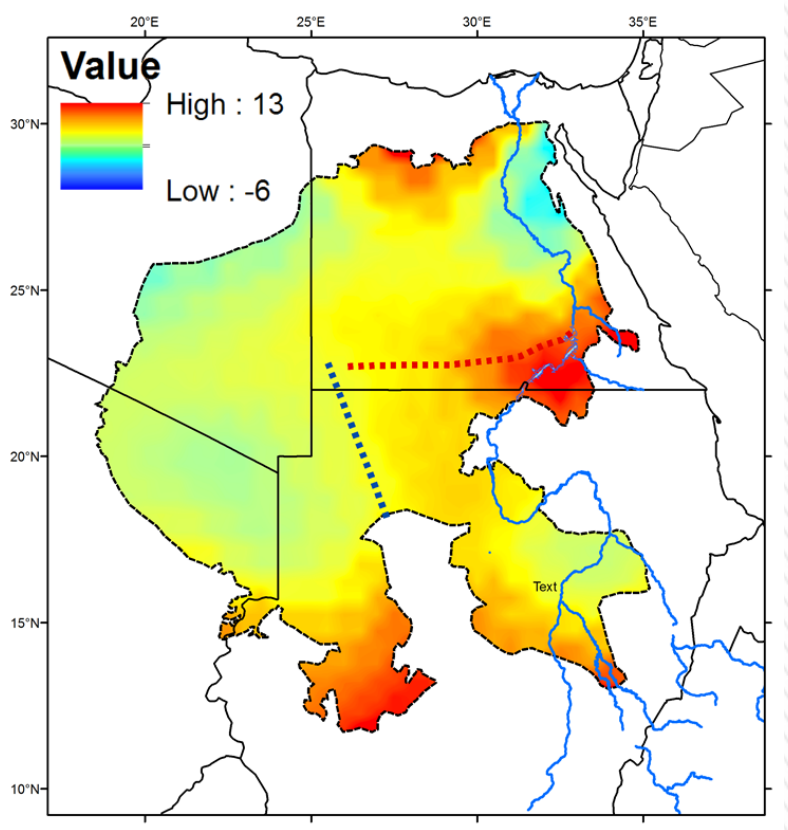


GRACE TWS in mm/yr

2013-2016 TWS TREND: A GAINING SYSTEM

WET PERIOD

Water Mass



GRACE TWS in mm/yr

Dry and Wet Periods over Nubian Basin

DRY PERIOD

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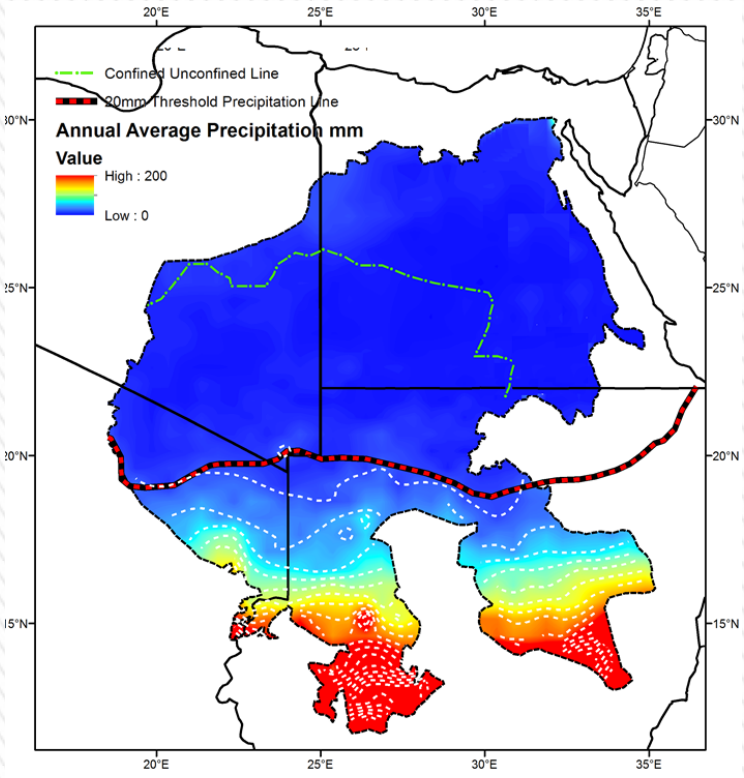
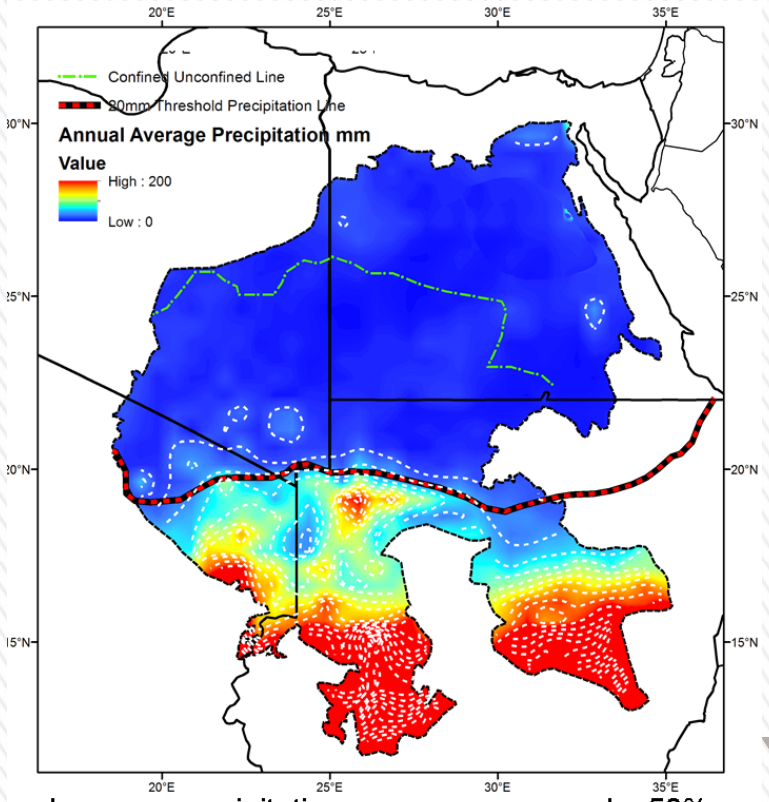


Precipitation concentrated on source areas

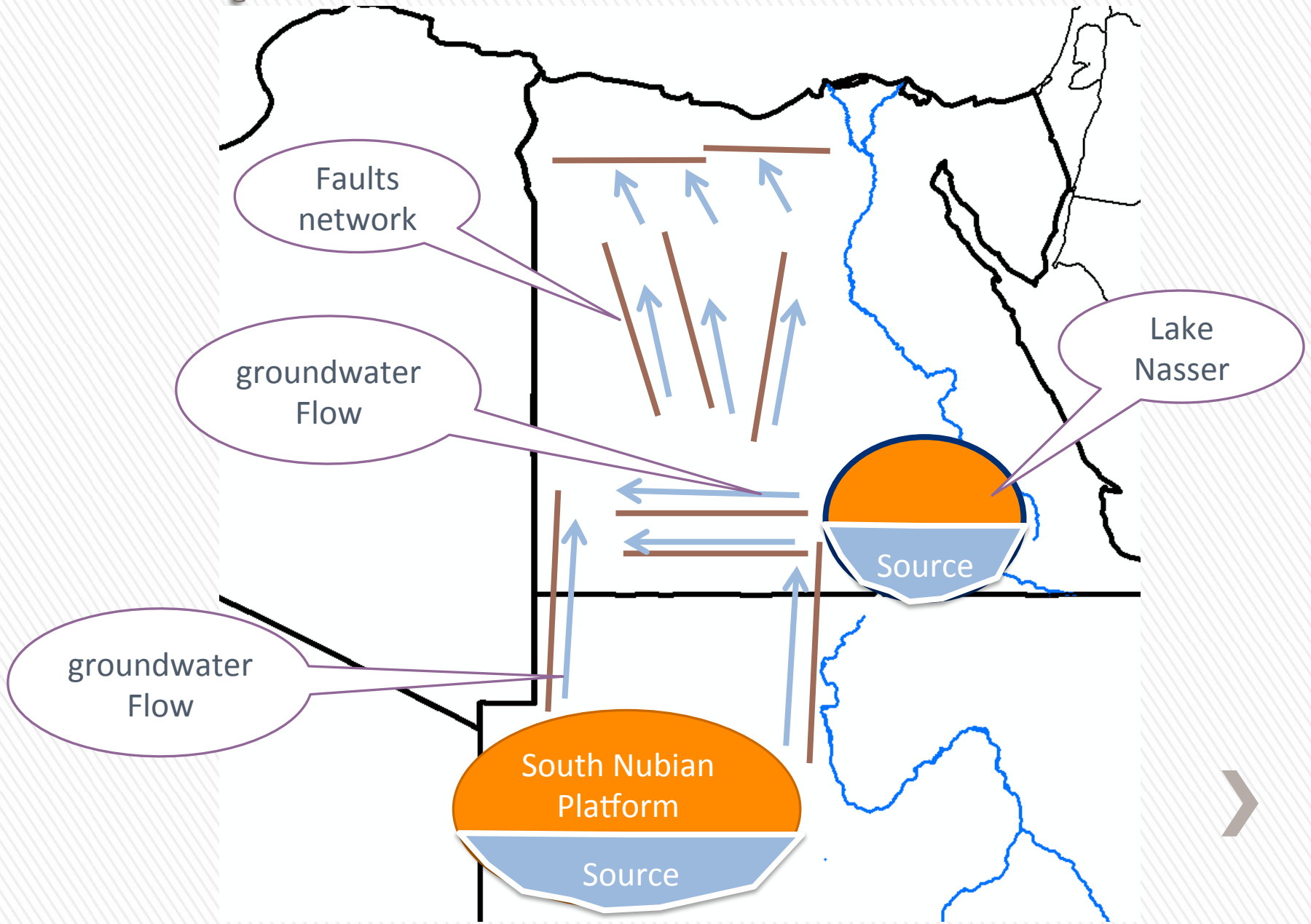
Water Mass

WET PERIOD



Increase precipitation over source areas by 50%

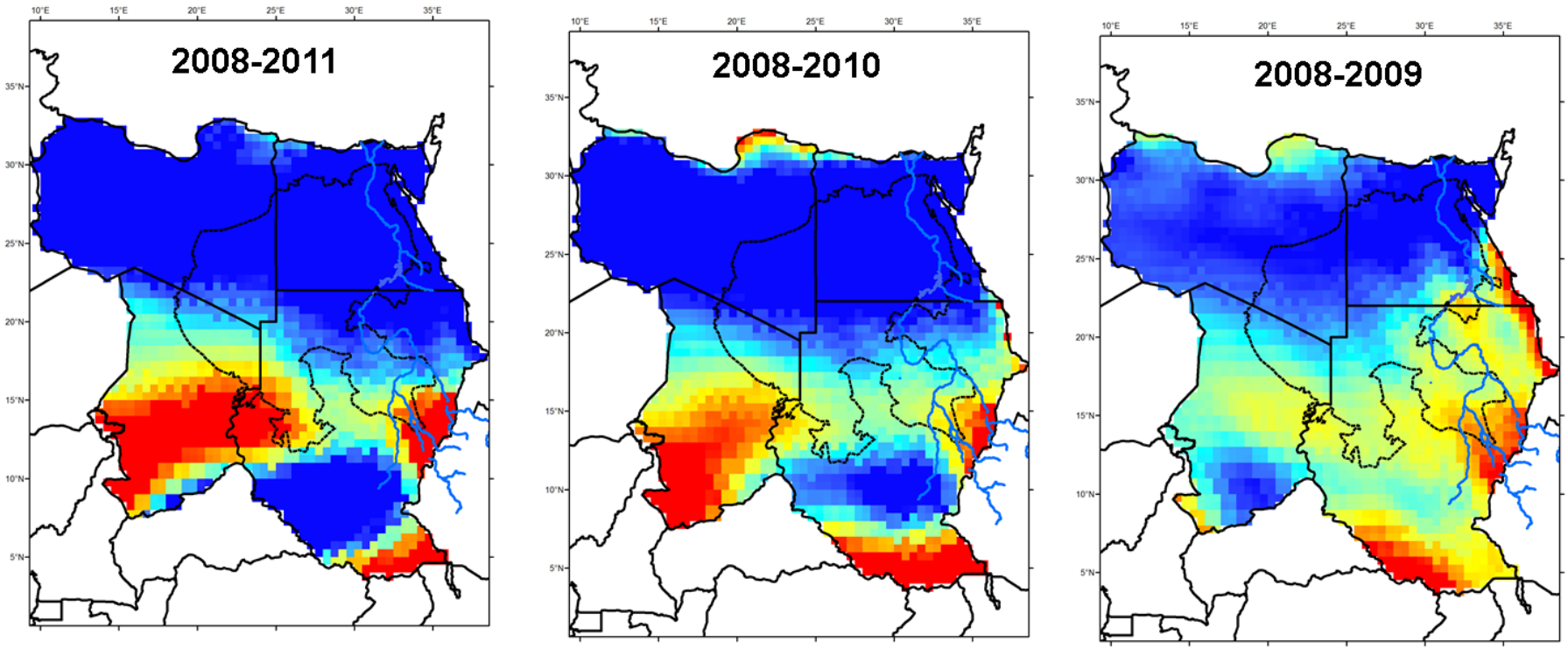
Conceptual Model



Evidences in support of the conceptual model for mass movement in the NSAS

- GRACE difference images
- Surface and subsurface structures
- GRACE time series along and across faults
- Soil moisture time series along faults in low lands
- Isotopic composition of groundwater along faults (ongoing)

Mass Movement into DAS (Dry period)

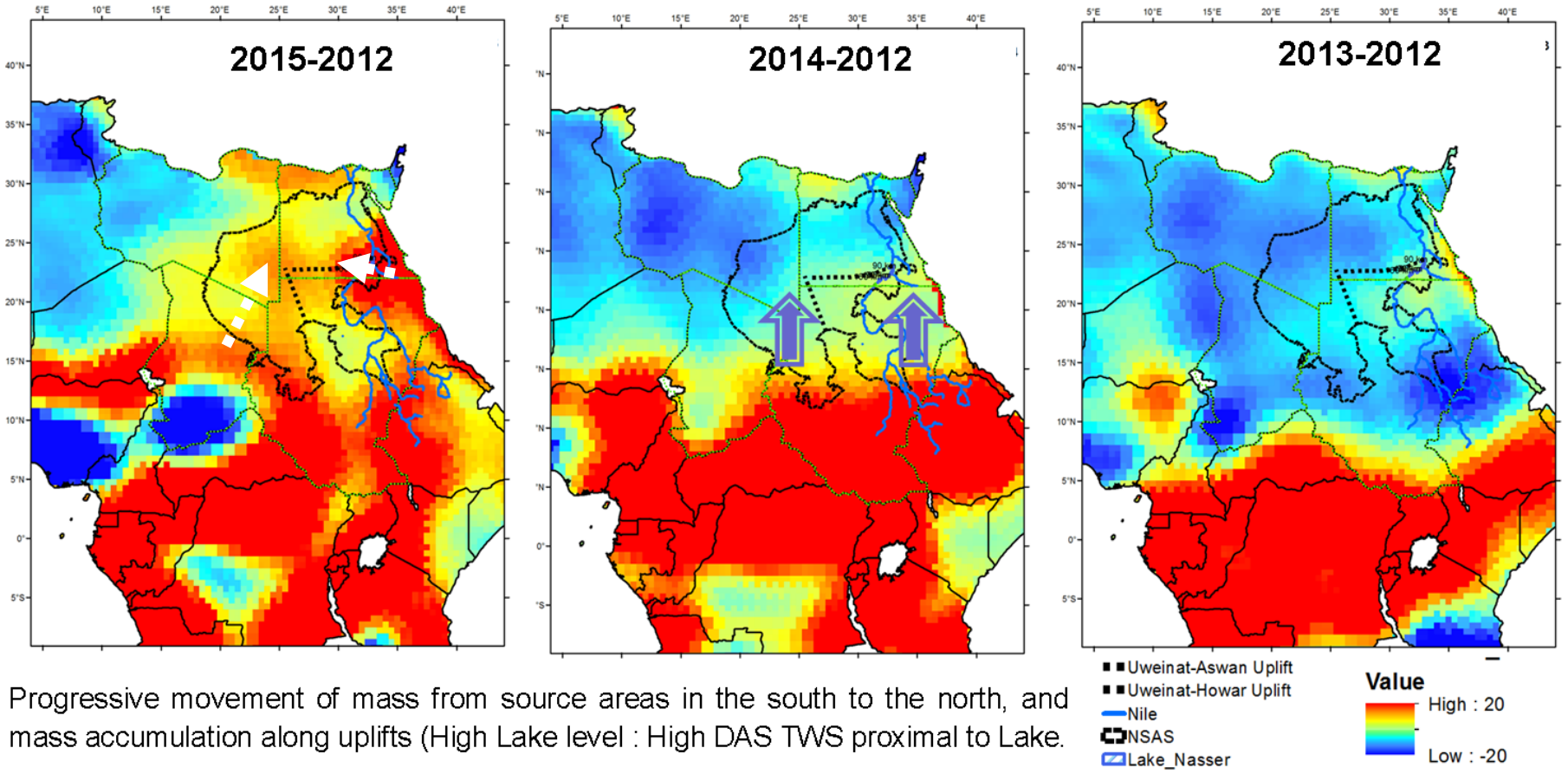


No observed movement of mass from south to north. TWS in DAS largely controlled by Lake Nasser (Low Lake level : Low TWS in DAS)

Nile
NSAS
Lake_Nasser

Value mm
High : 100
Low : -150

Mass Movement into DAS (Wet Period

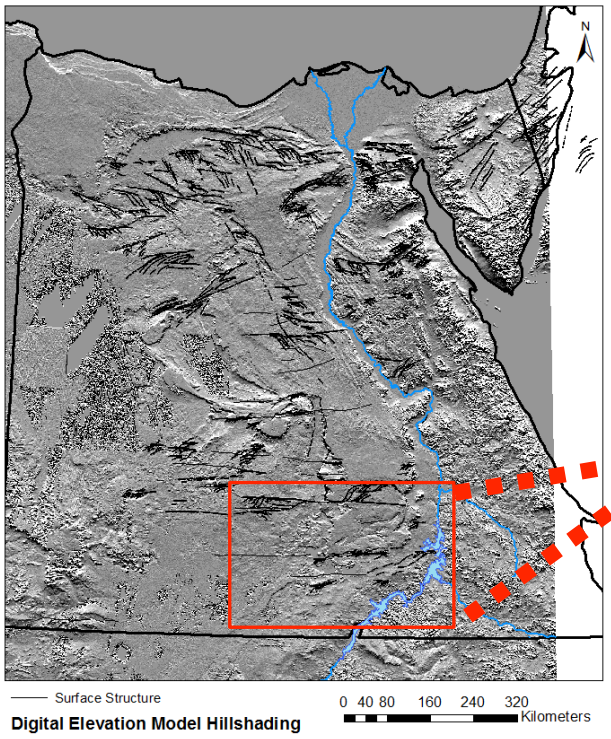


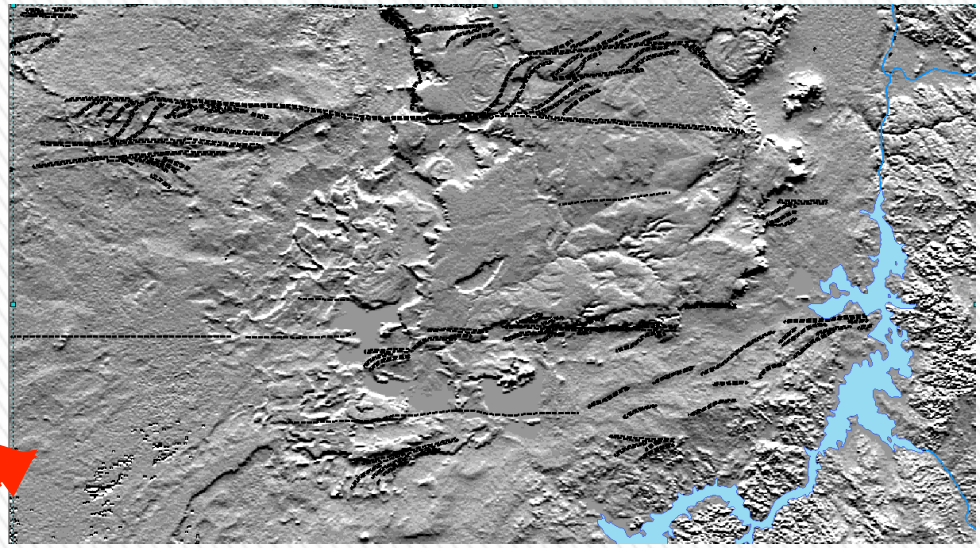
Progressive movement of mass from source areas in the south to the north, and mass accumulation along uplifts (High Lake level : High DAS TWS proximal to Lake.

Structural Control

Preferred Pathways From Surface data

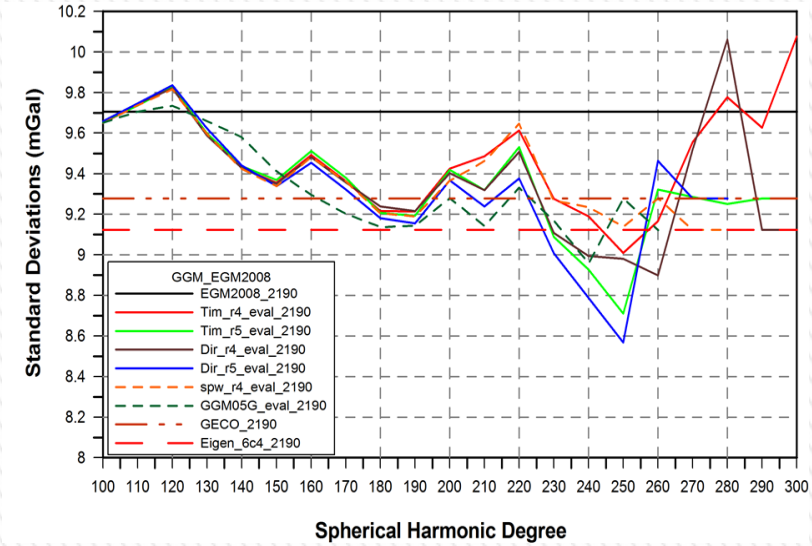
E-W faults: preferred pathway for groundwater flow from Lake Nasser to DAS .

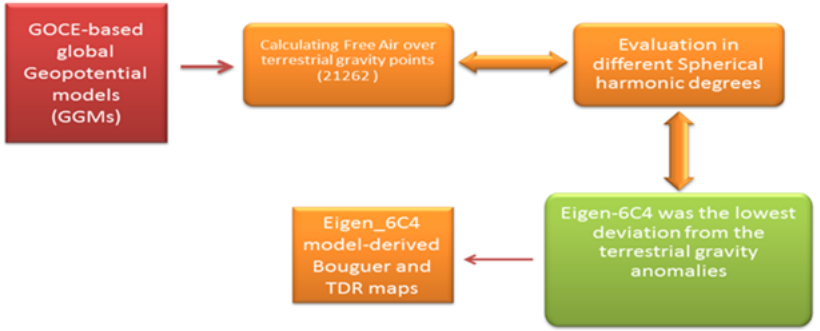




Sources of Recharge for DAS

Preferred Pathways From Subsurface data

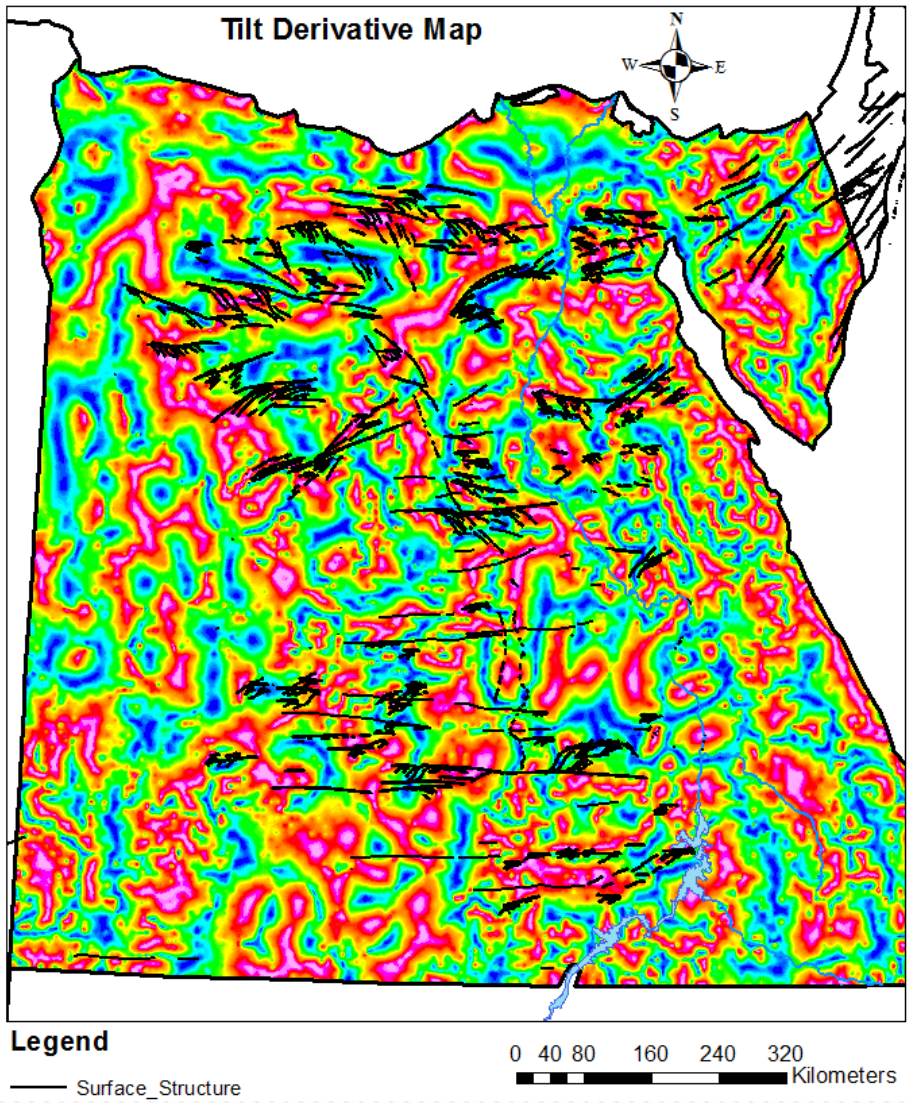




Sources of Recharge for DAS

Preferred Pathways From Surface and Subsurface Strucures

Tilt derivative map (TDR) (Verduzco et al. 2004) filter of gravity anomaly were used to enhance the geophysical signal of the basement structures and to provide detailed distribution of the deep-seated structures.



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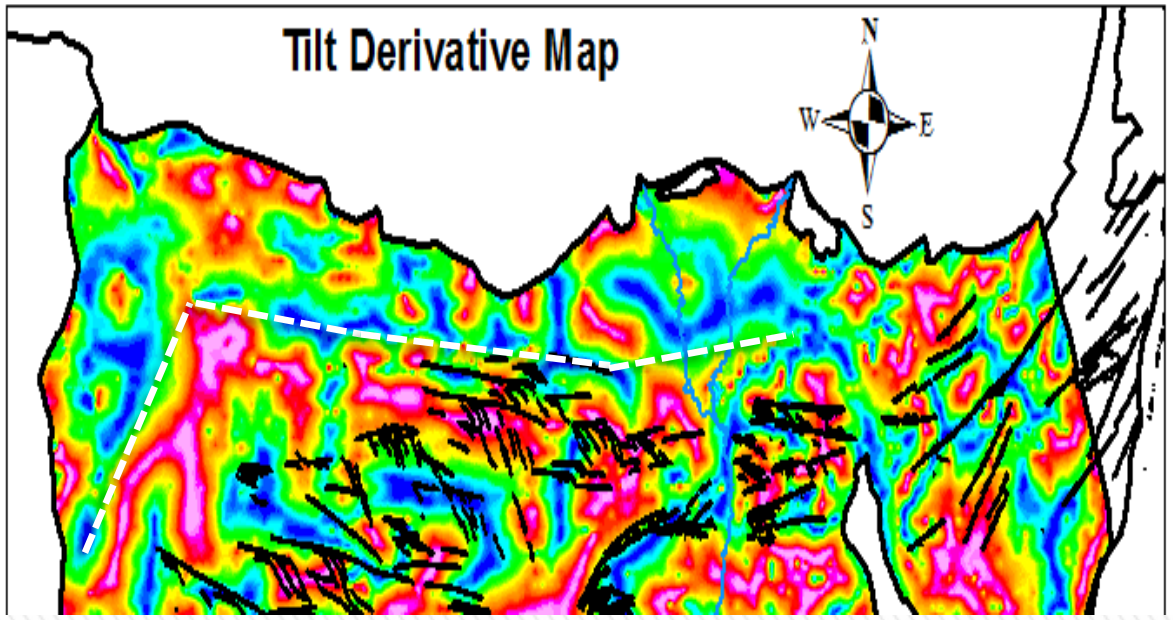
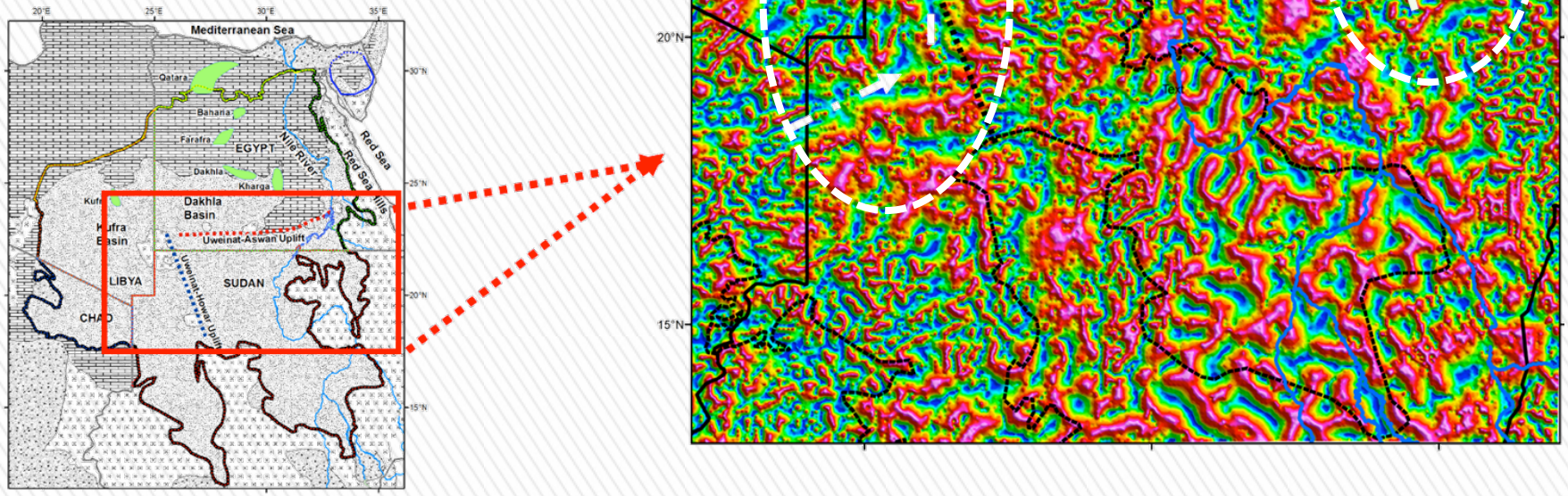


Sources of Recharge for DAS

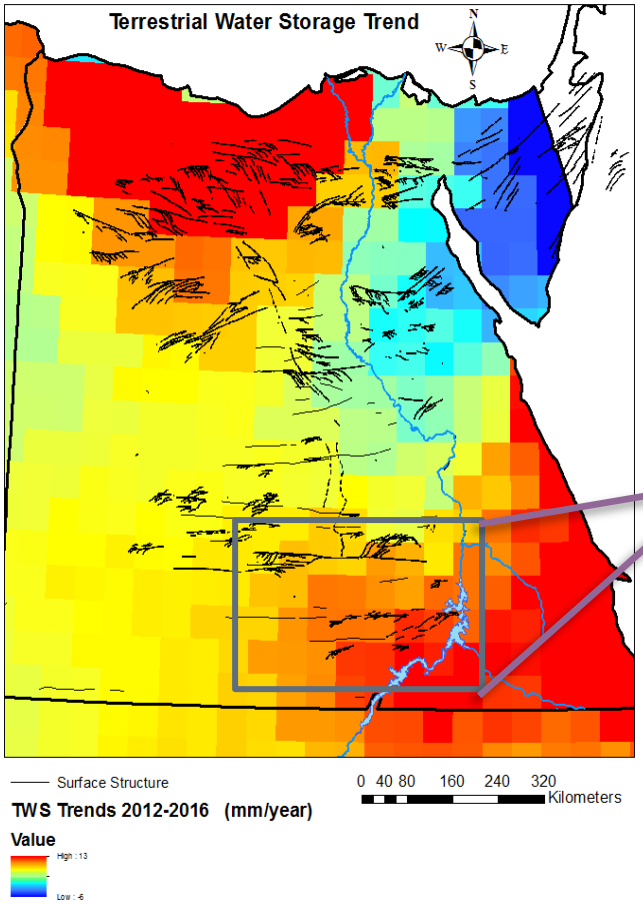
Preferred Pathways From Surface and Subsurface Structures

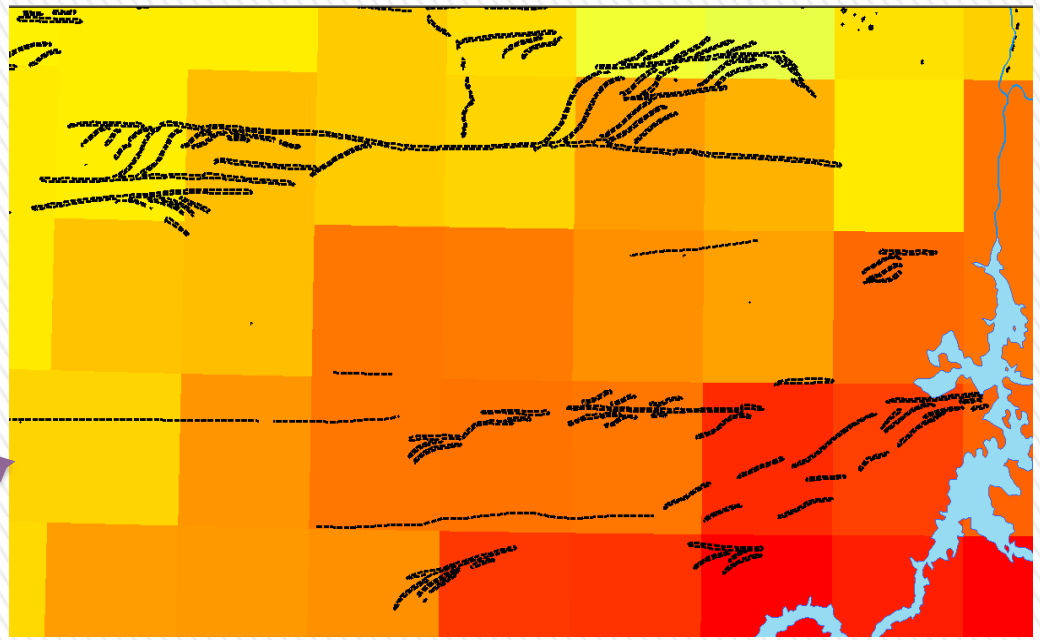
N-S structures: preferred pathway for groundwater flow from source areas in the south to the north.



the aquifers' response to wet period

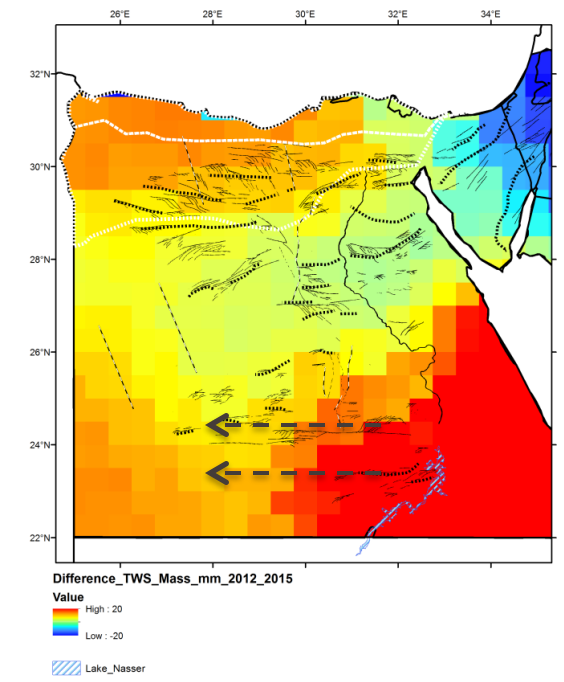
DAS DOMINATED BY GROUNDWATER FLOW FROM LAKE NASSER

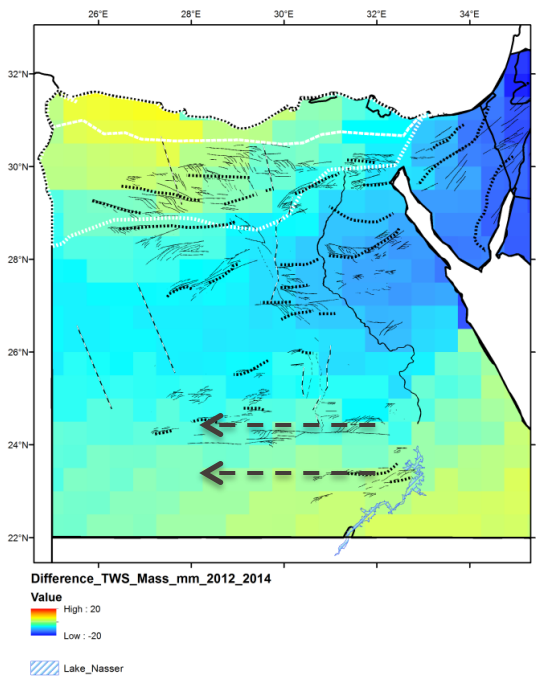


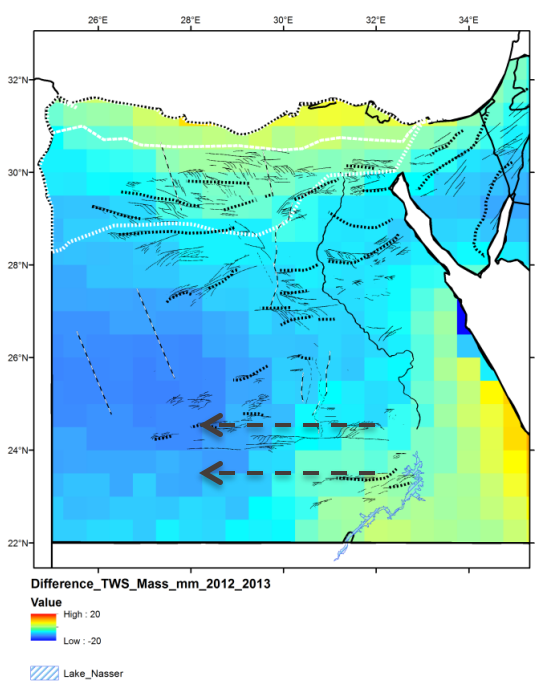


Hydrological setting and the aquifers' response to wet and dry periods

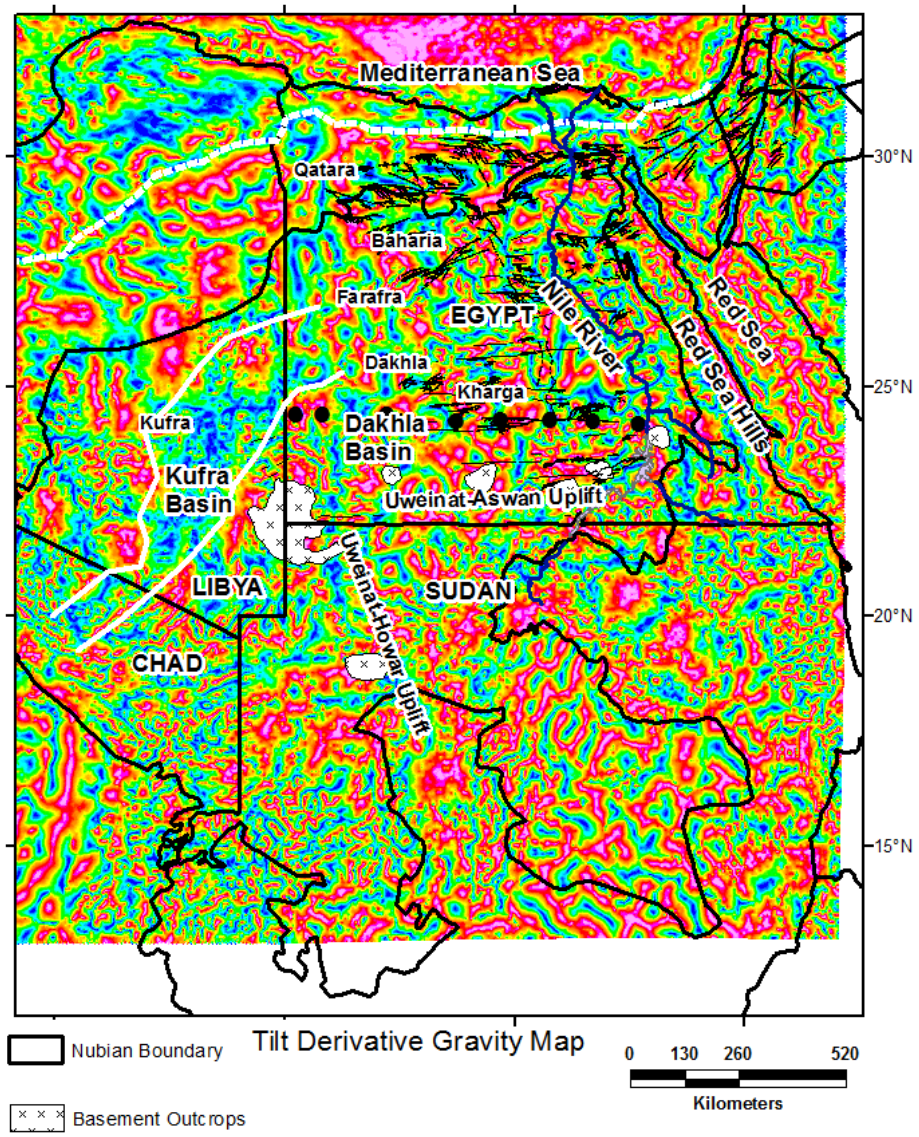
DAS DOMINATED BY GROUNDWATER FLOW FROM LAKE NASSER



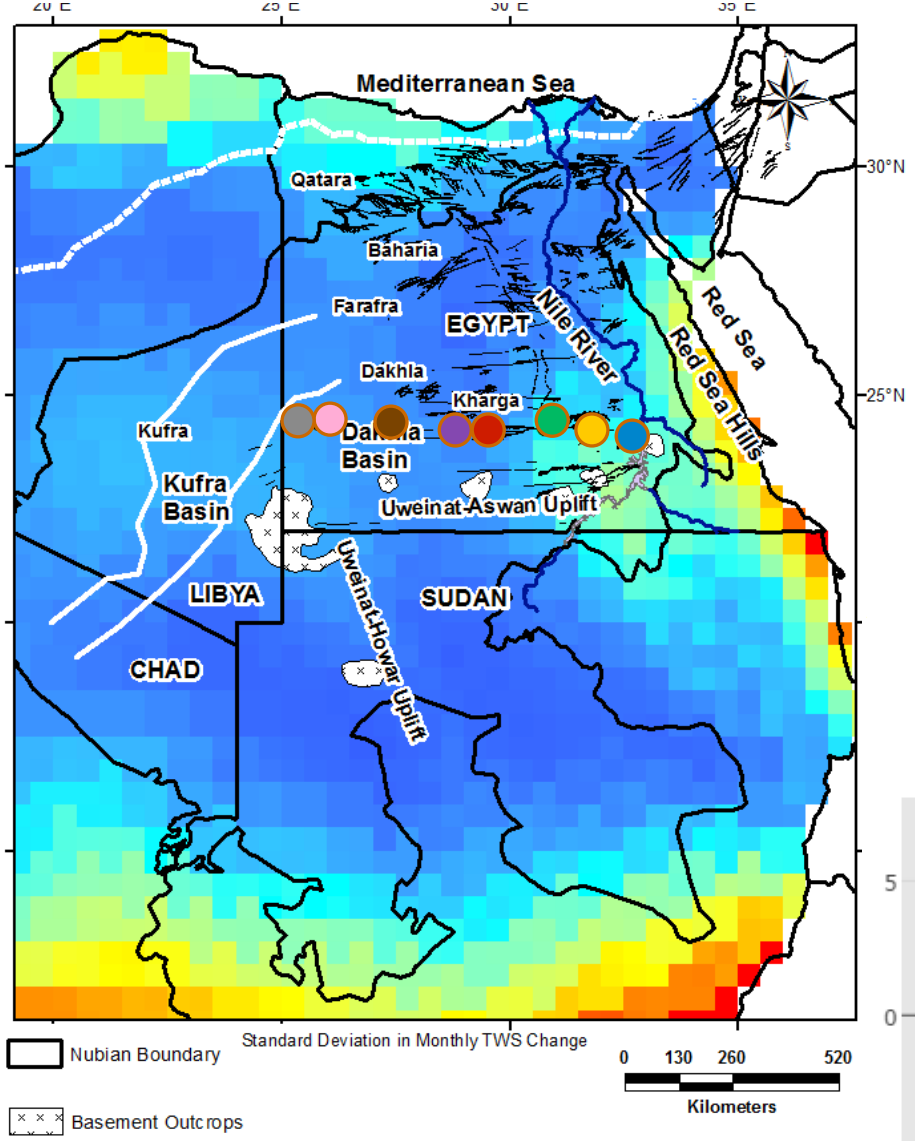




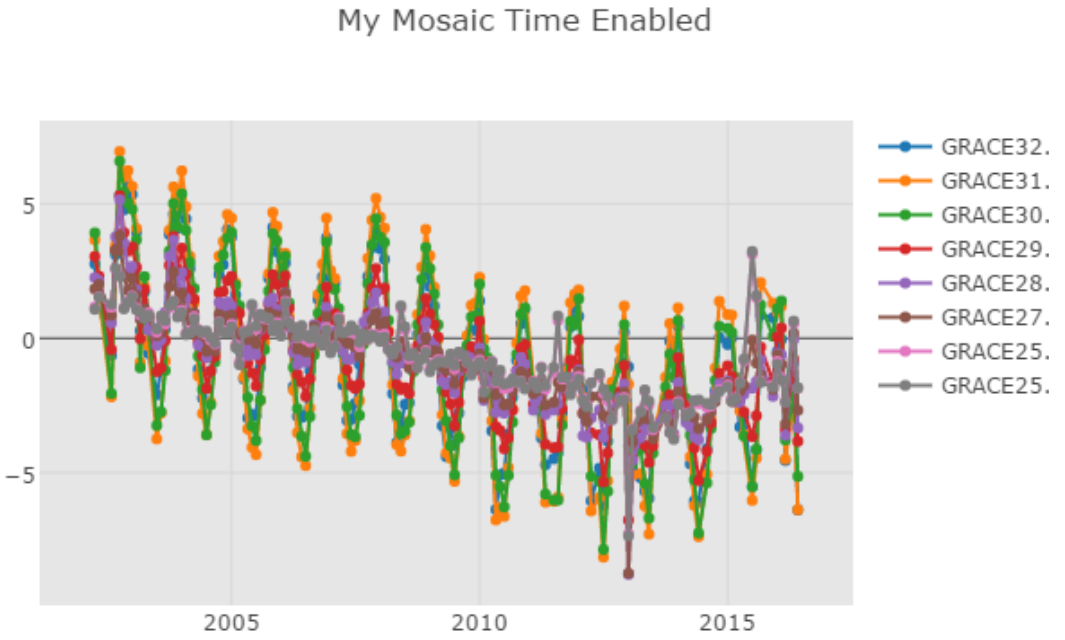
Water mass accumulation over time (2012-2015). The major pattern of mass distribution is dominated by Structure trends

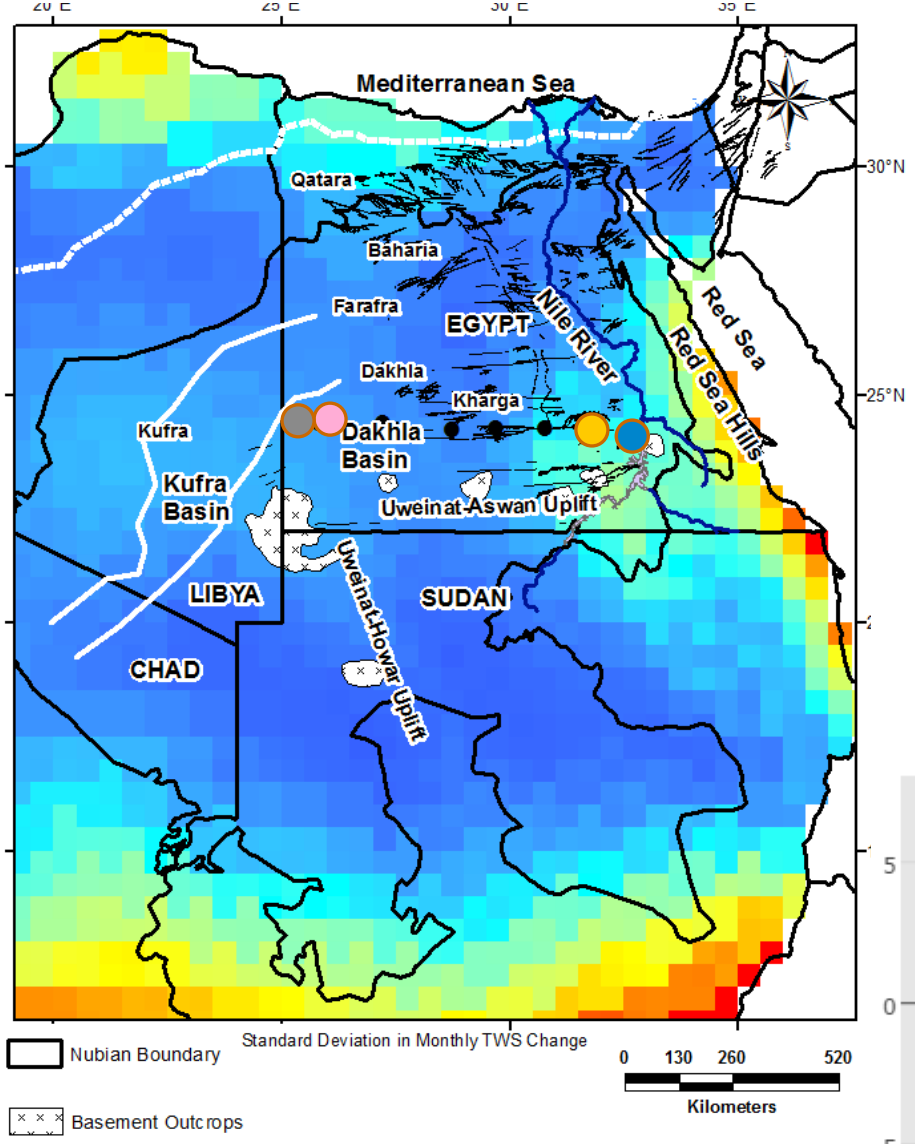


TWS time series along cross section on Libya's Syrian Arc



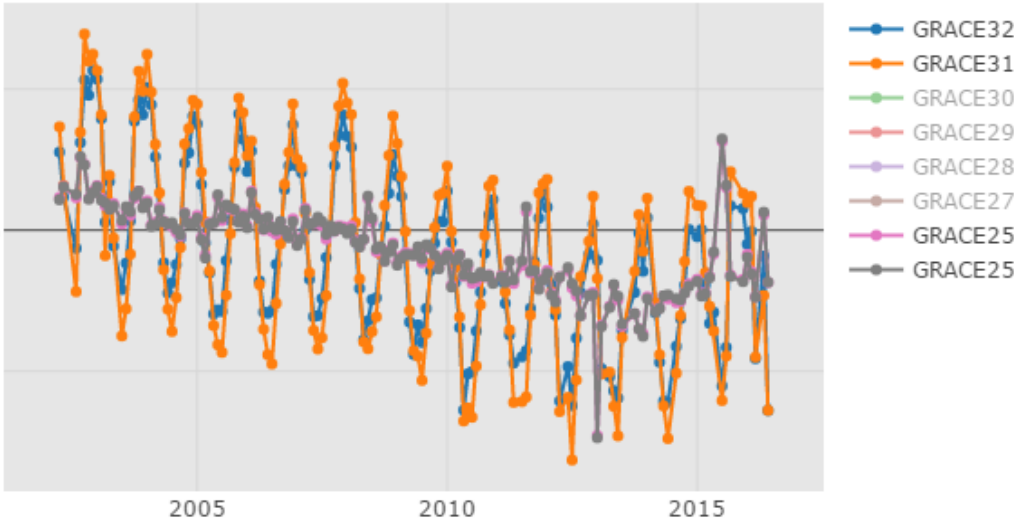
Propagation of water mass from Lake Nasser to DAK along E-W fracture zones

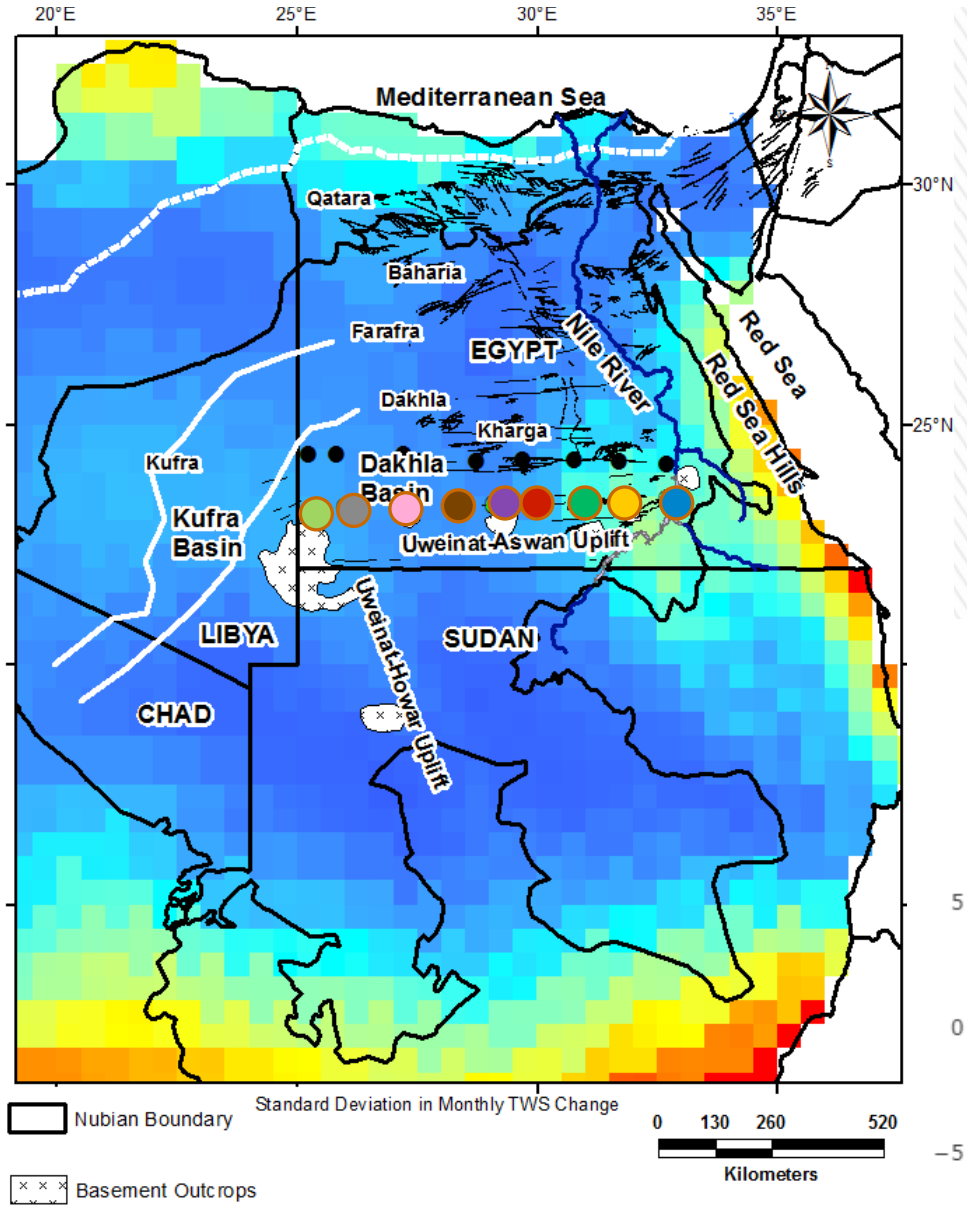




Propagation of water mass from Lake Nasser to DAK along E-W fracture zones

My Mosaic Time Enabled





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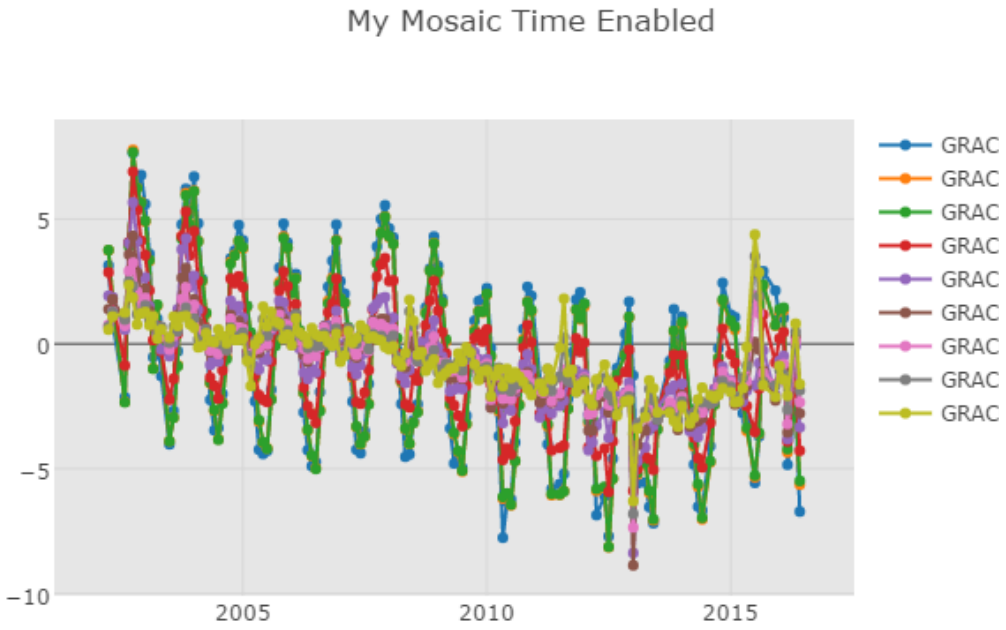

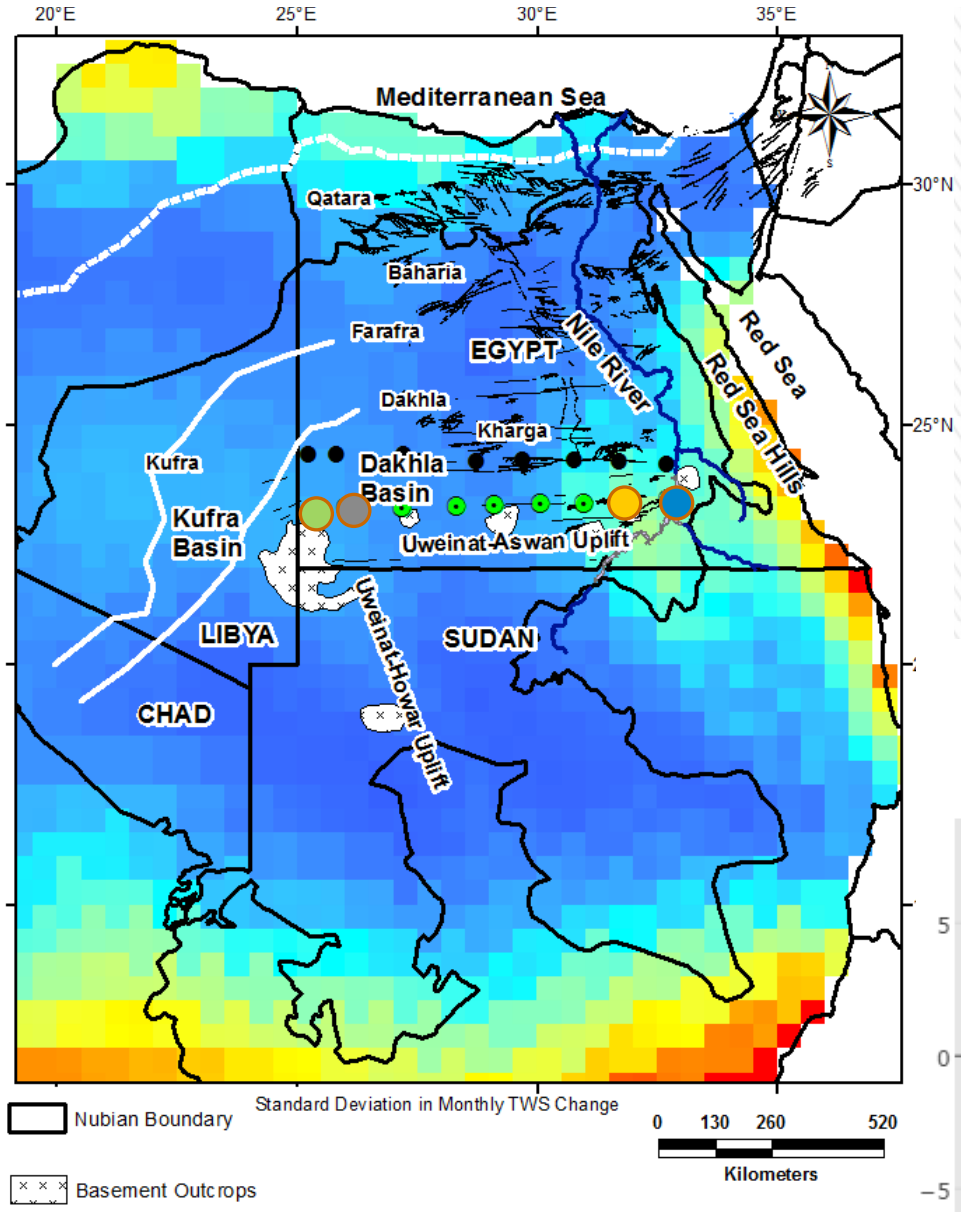

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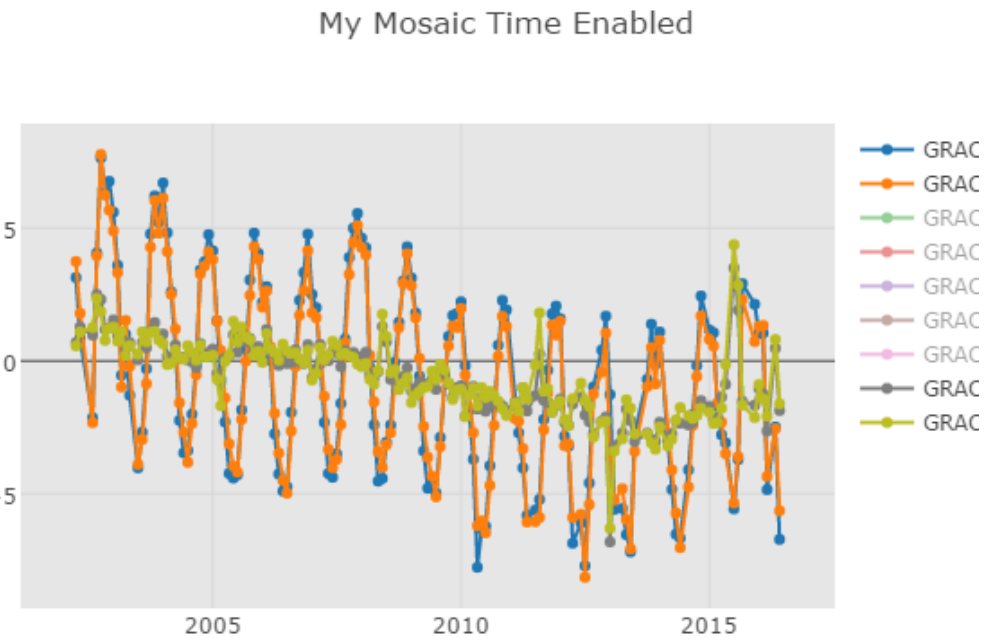
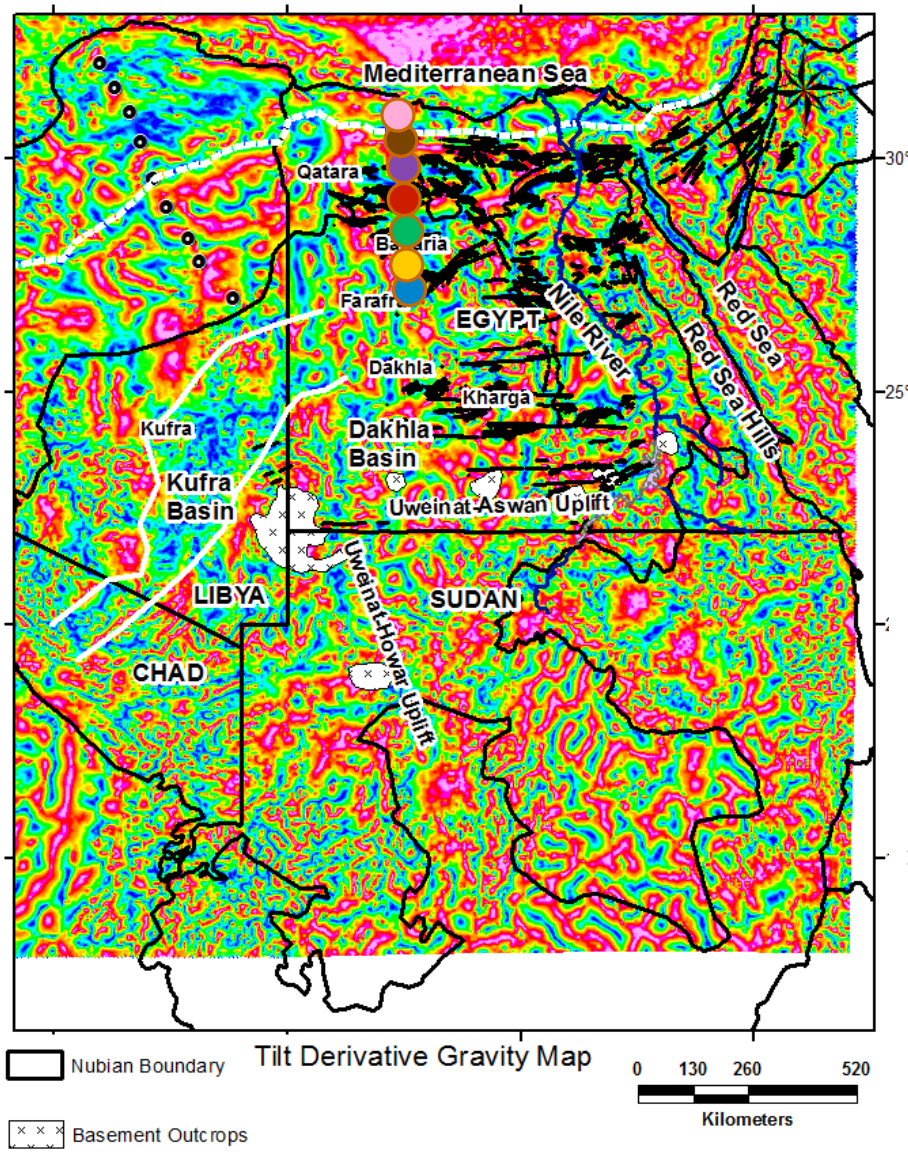
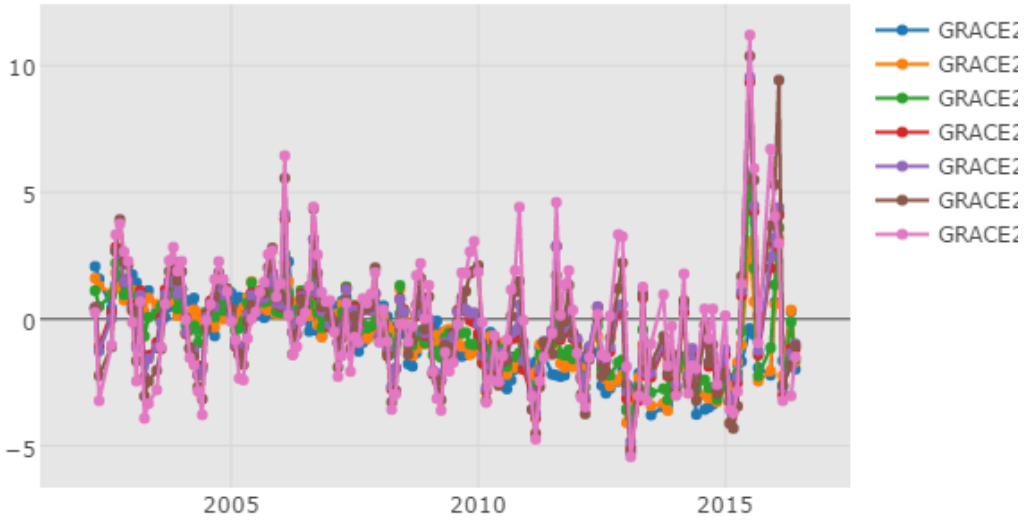
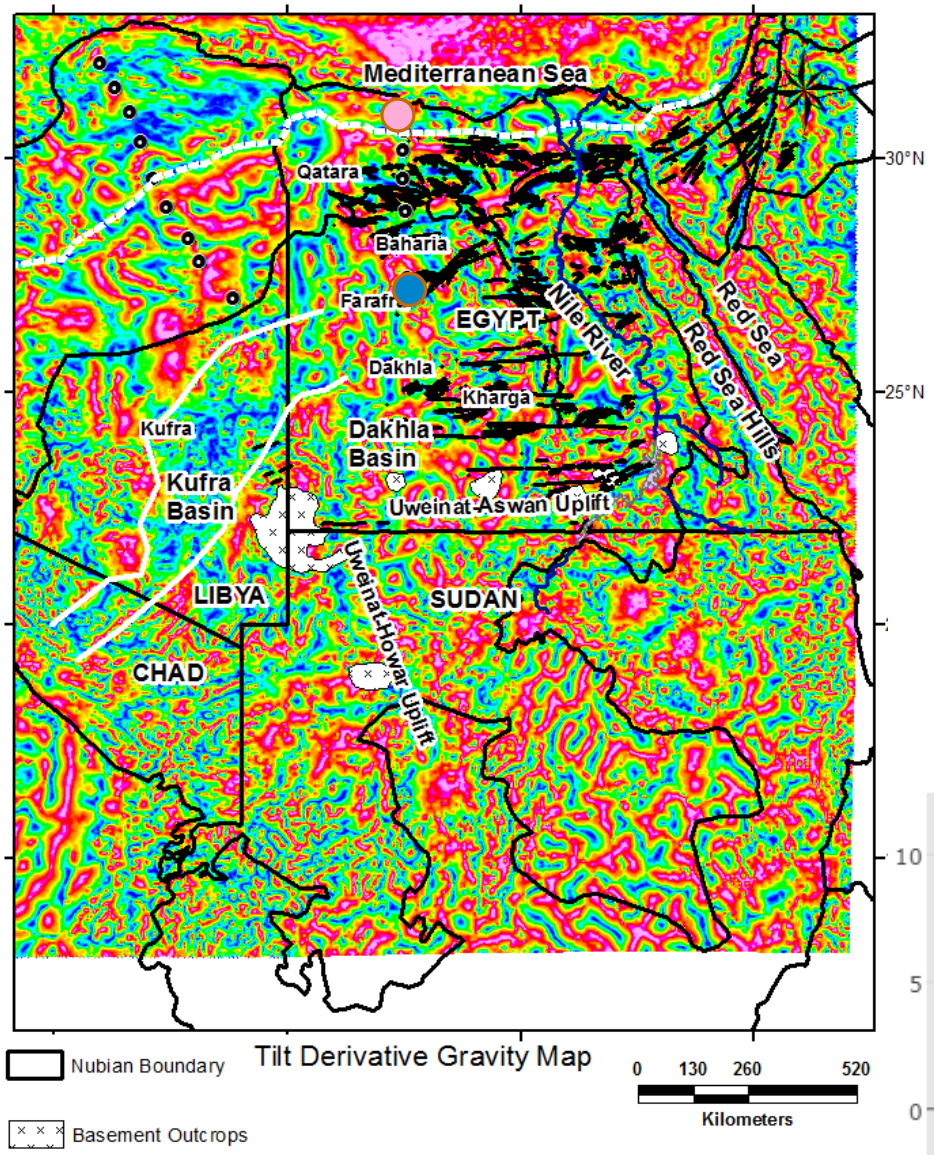




TWS time series along cross section on Egypt's Syrian Arc





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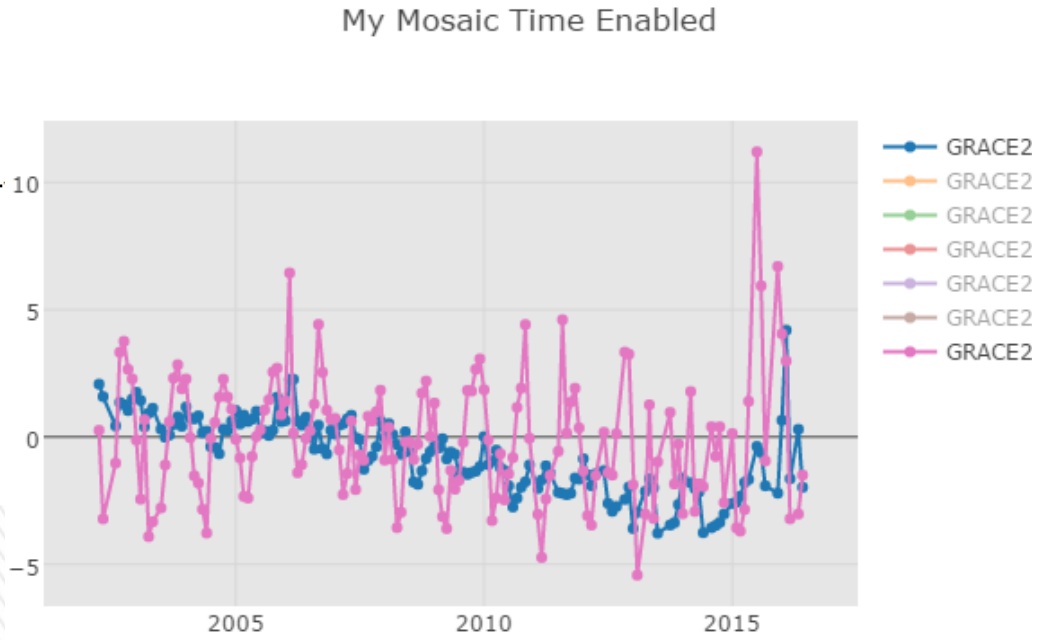
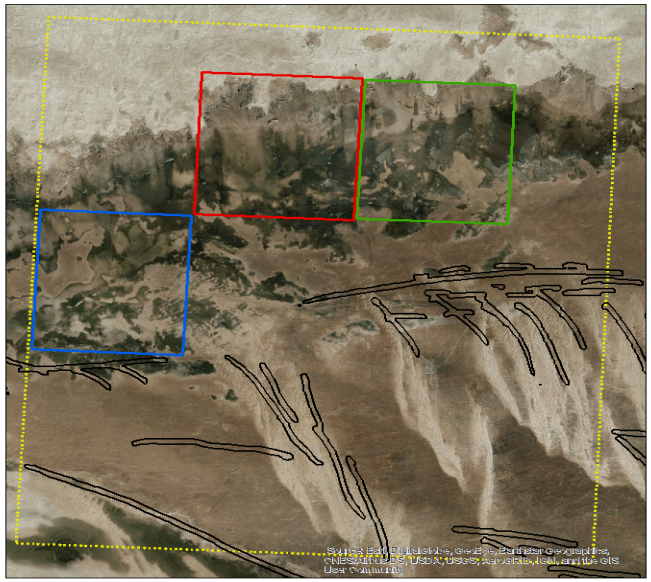
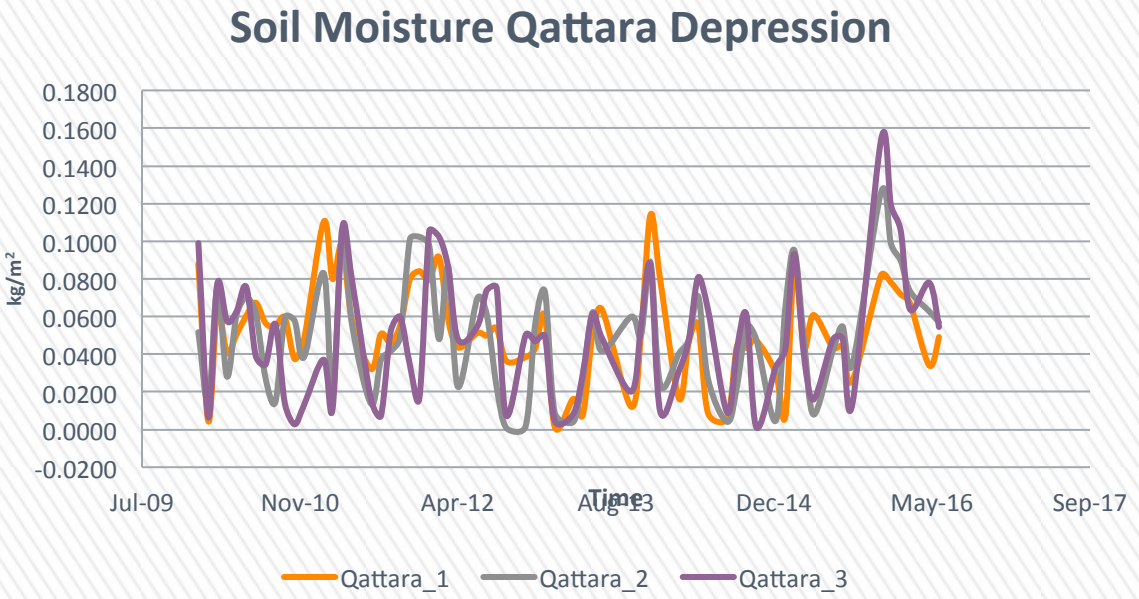
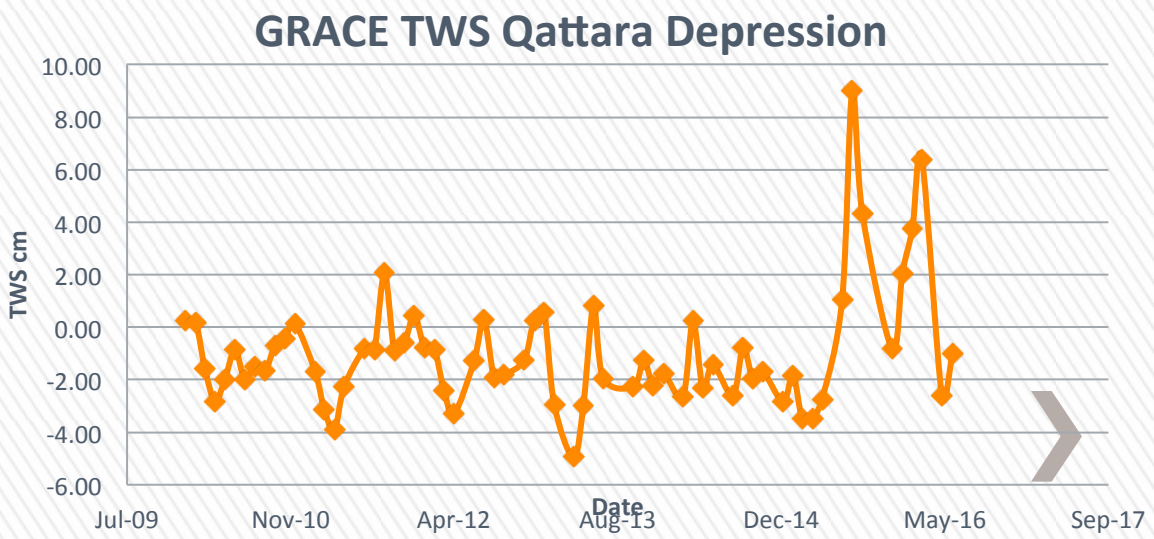


SOIL MOISTURE AND TWS TIME SERIES OVER DAS







Findings

- The TWS in DAS sub-basin is controlled by groundwater flow from the south (N Sudan platform), from east (Lake Nasser), and from the west (Kufra basin)

- Extraction should be concentrated on The fracture zones close Tushka and lake Naseser along the preferred pathways of groundwater flow& away from the central and eastern DAS.

- Wet periods are characterized by high lake Nasser levels, and rapid groundwater flow from Lake Nasser & from the North Sudan Platform along fault networks.