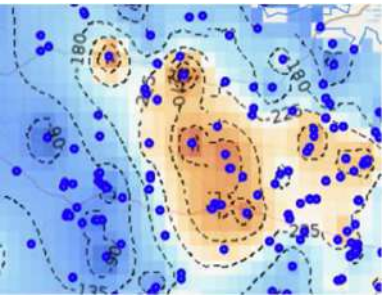
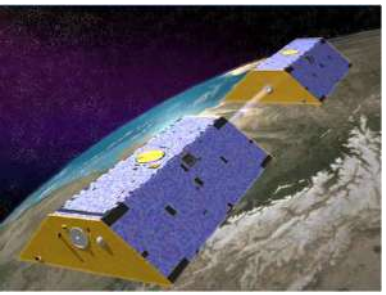
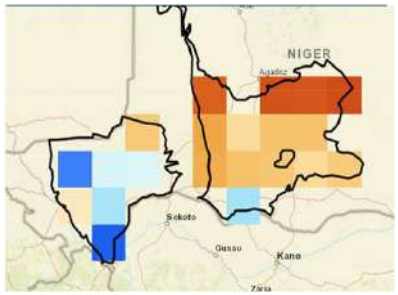
GROUNDWATER ANALYSIS

Assessment of groundwater storage change and recharge using GRACE data in West Africa

Norm Jones, PhD







BYU Civil & Construction Engineering
IRA A. FULTON COLLEGE OF ENGINEERING

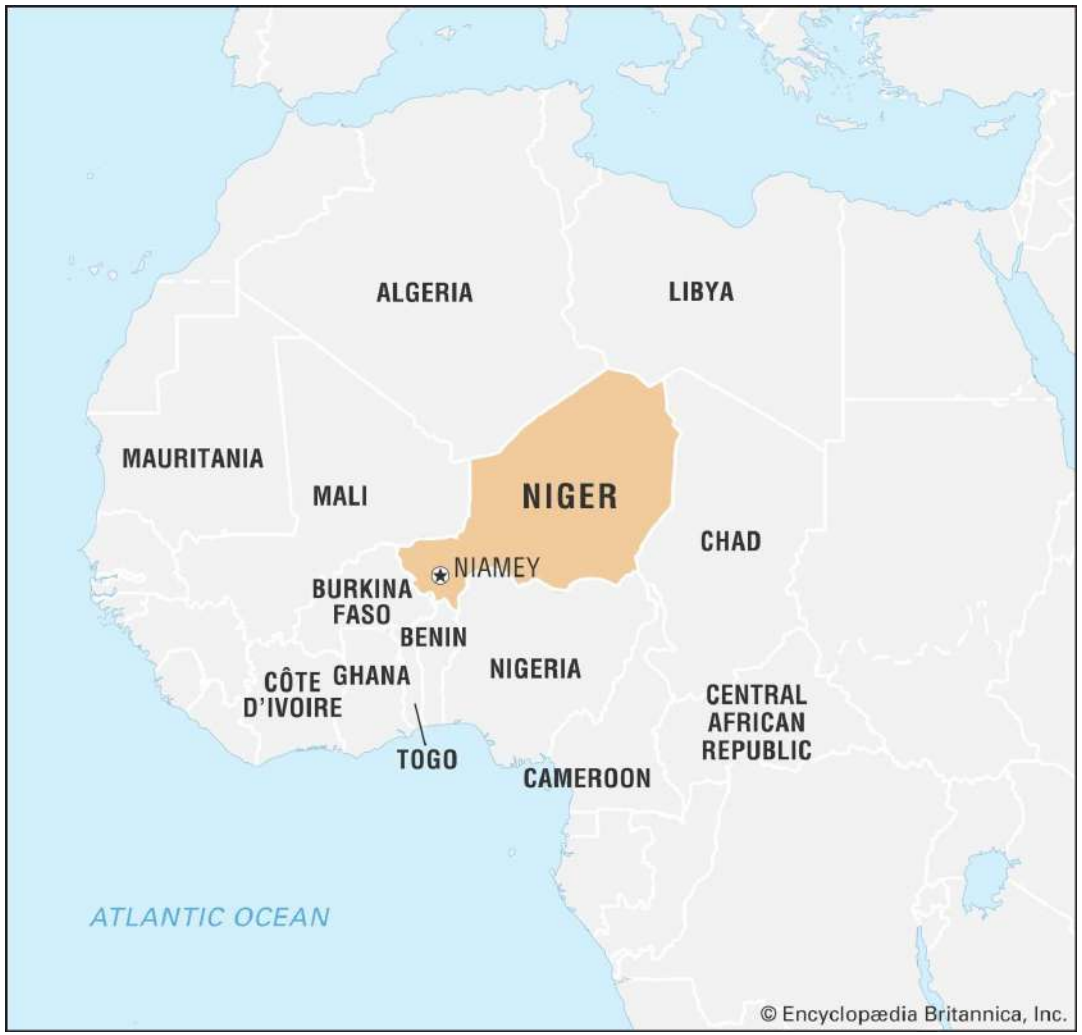
NASA SERVIR Research Project (2019-2023)

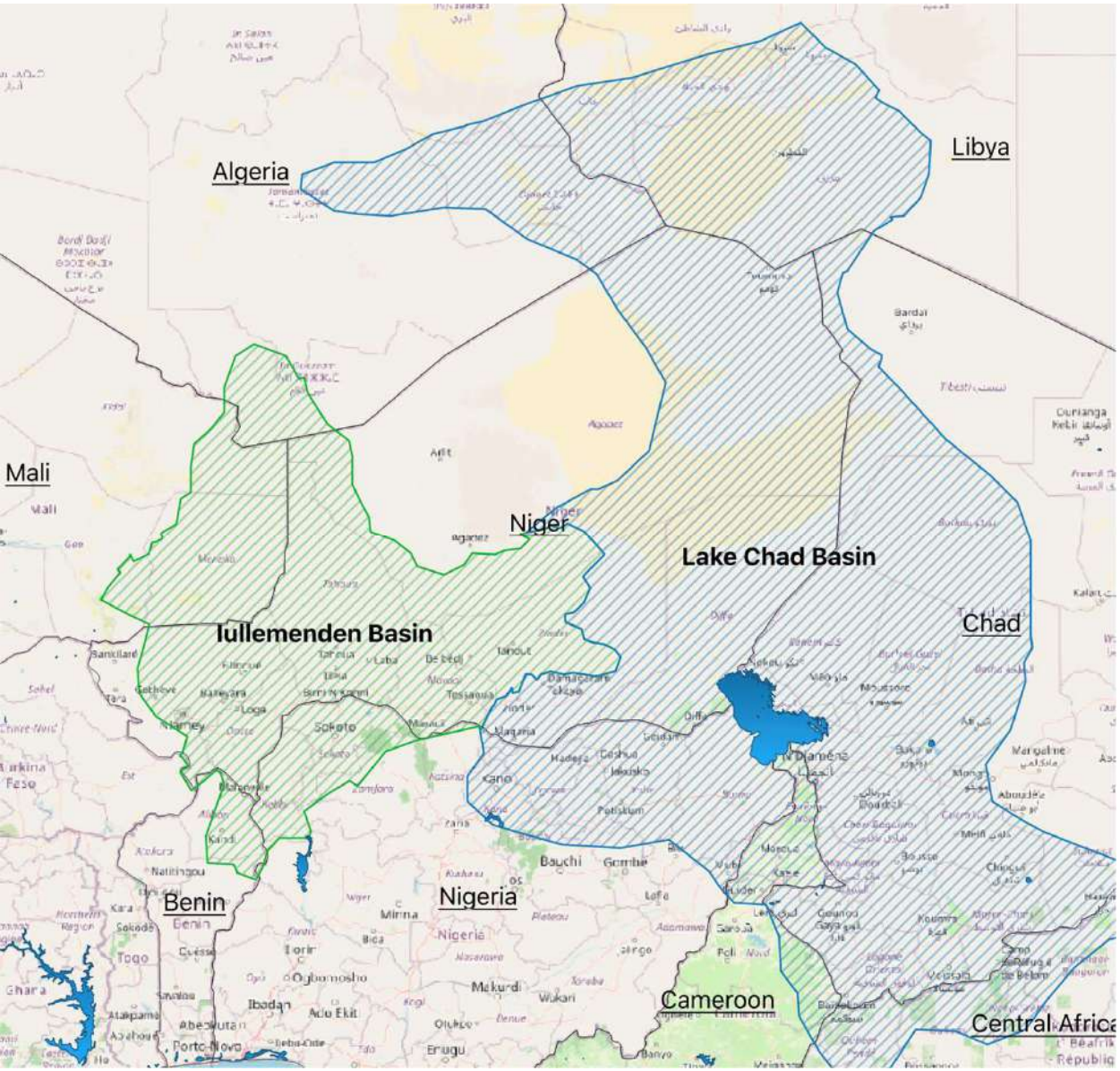
Objective: Assist stakeholders and water managers in West Africa to assess, characterize, and sustainably manage **groundwater resources** for **economic development** and **drought resilience**.

http://hydroinf.groups.et.byu.net/servir-wa/

PART 1

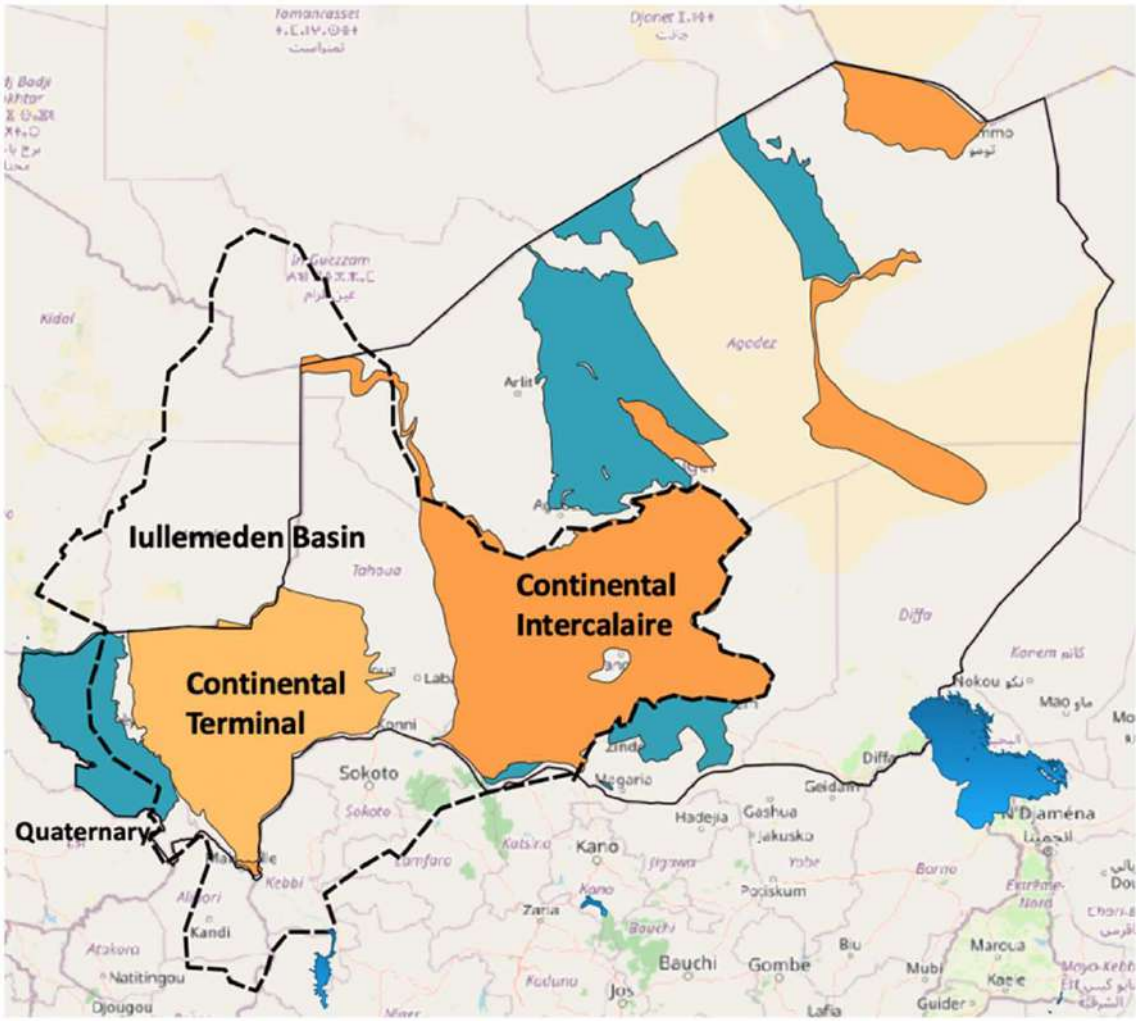
Niger Basins



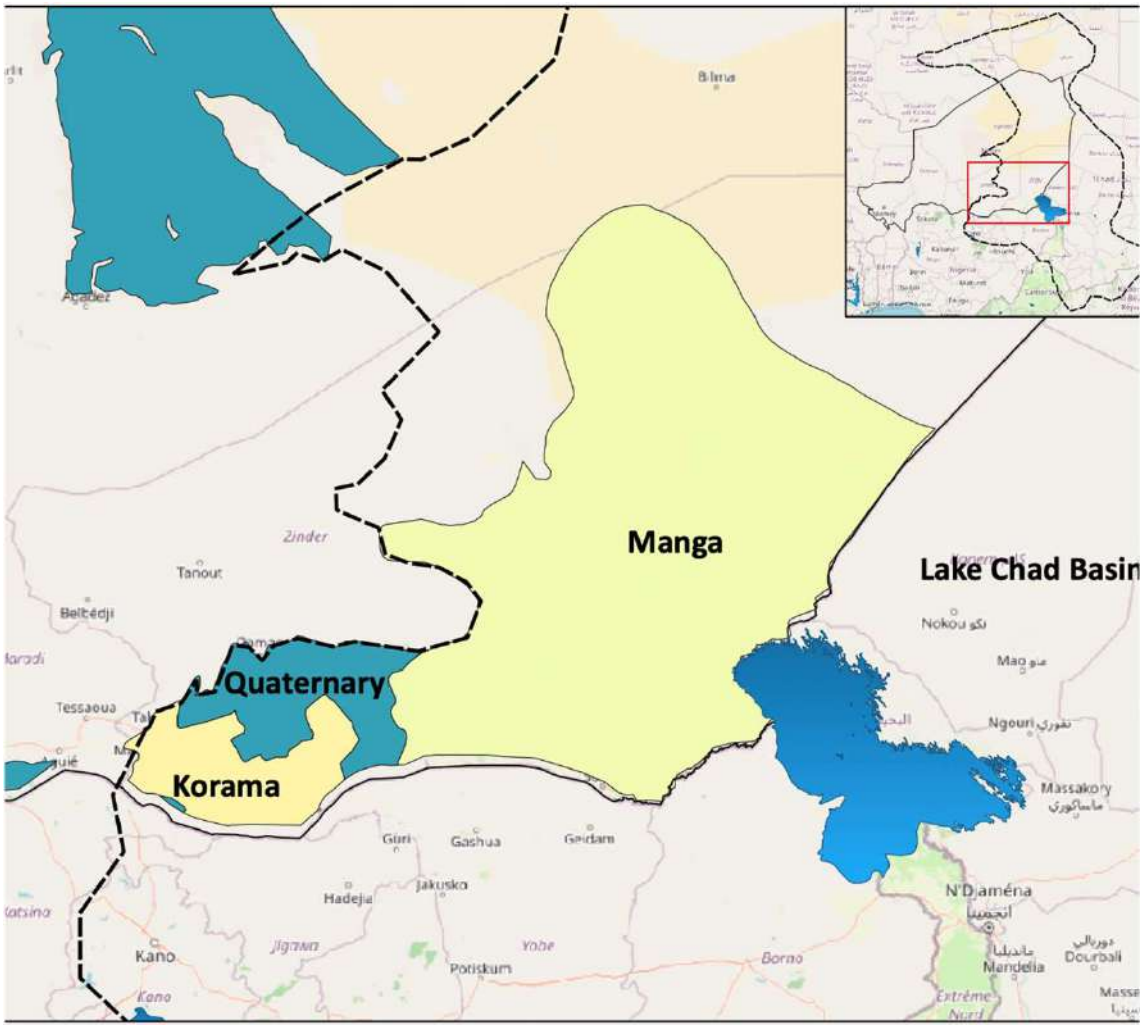


Hydrogeologic Setting

Iullemeden Basin



Chad Basin

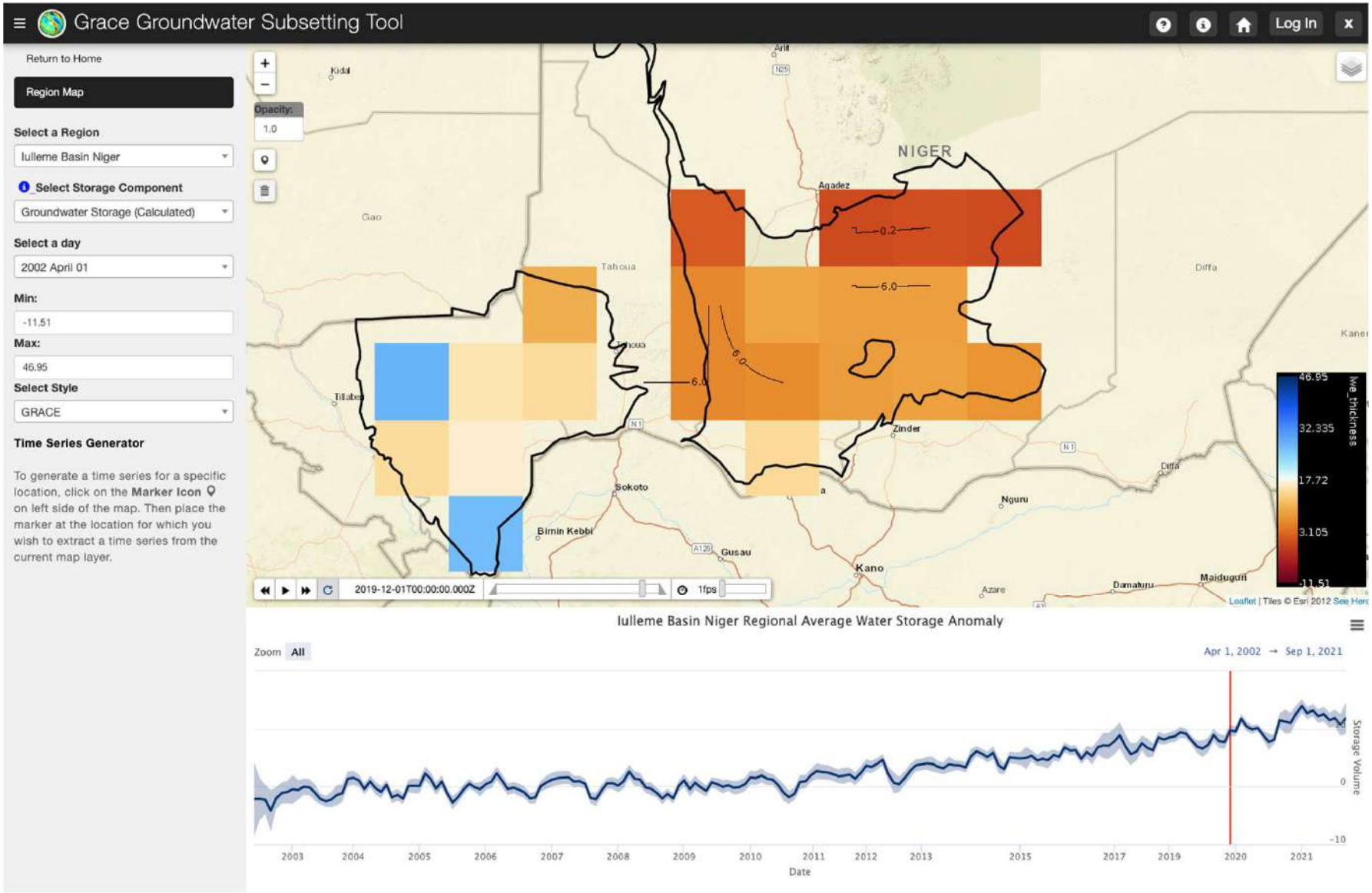

Manga
Lake Chad Basin
Quaternary
Korama
Tanout
Zinder
Tessaoua
Hadeja
Kano
Jakusko
Gashua
Ngouri
Massakory
N'Djaména
Mandelia
Dourbali
Poriskum
Yobe
Borno

GRACE analysis for Southern Niger

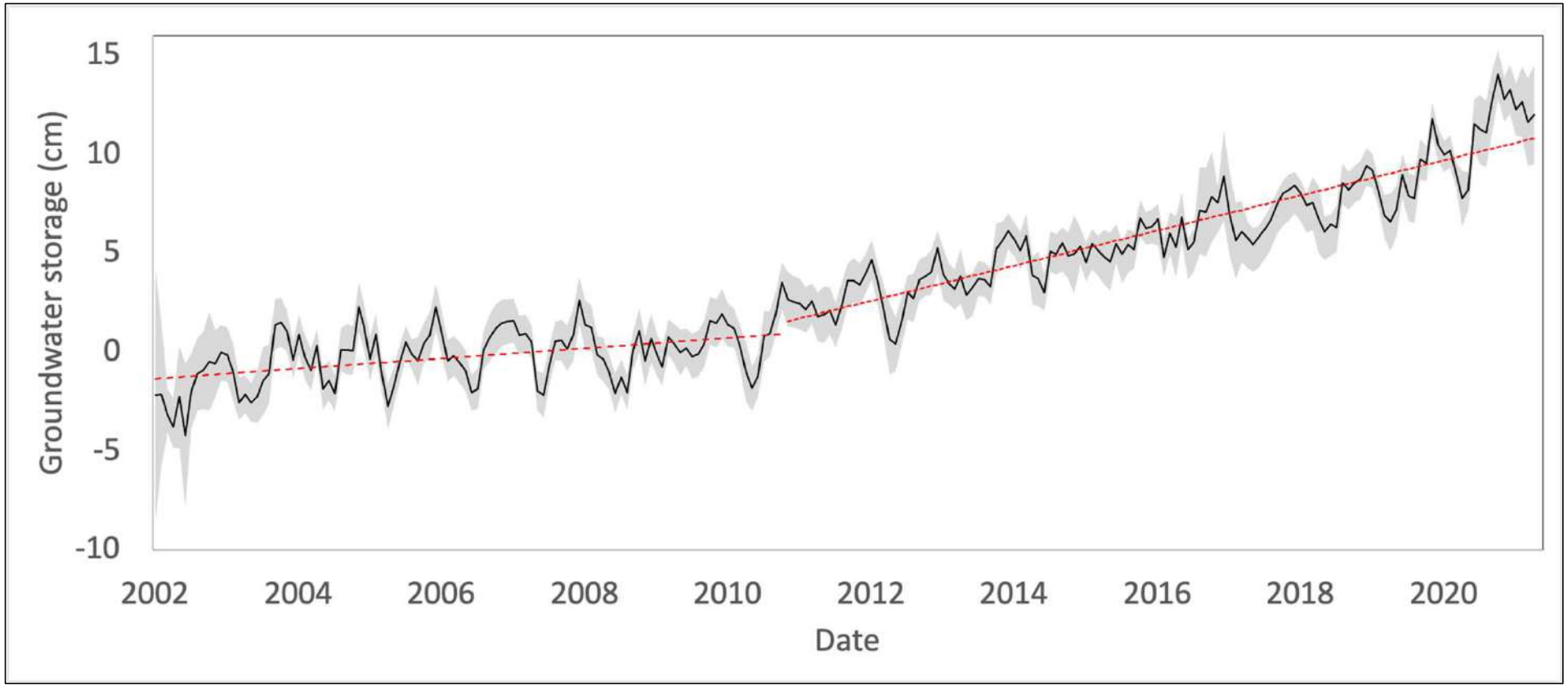
$$GWSa = TWSa - (SWEa + CANa + SMa)$$

Uncertainty bands

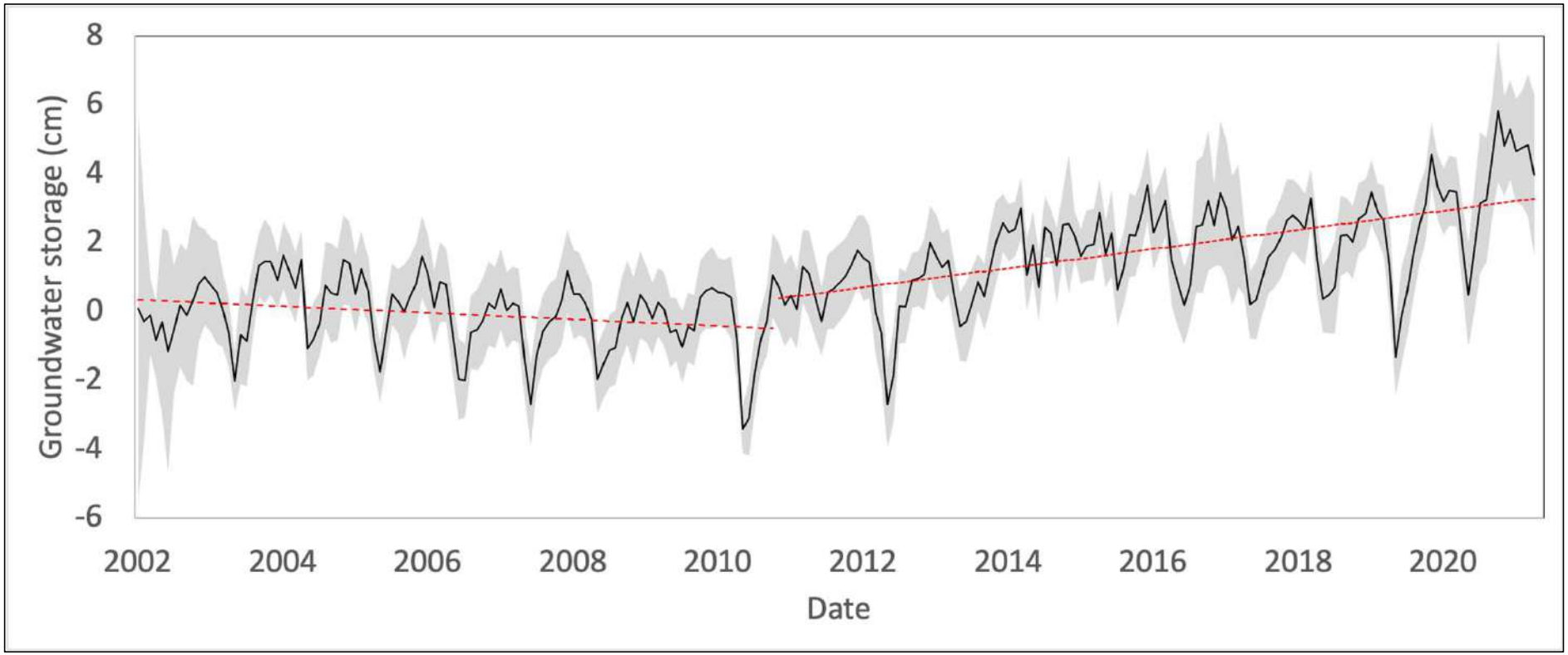
$$\sigma GWSa = \sqrt{(\sigma TWSa)^2 - (\sigma SWEa)^2 - (\sigma CANa)^2 - (\sigma SMa)^2}$$


Grace Groundwater Subsetting Tool
Log In
Return to Home
Region Map
Select a Region
Iulleme Basin Niger
Select Storage Component
Groundwater Storage (Calculated)
Select a day
2002 April 01
Min:
-11.51
Max:
46.95
Select Style
GRACE
Time Series Generator
To generate a time series for a specific location, click on the Marker Icon on left side of the map. Then place the marker at the location for which you wish to extract a time series from the current map layer.
Opacity:
1.0
NIGER
Agadez
Gao
Tahoua
Diffa
Zinder
Sokoto
Birnin Kebbi
Gusau
Kano
Nguru
Maiduguri
Damaturu
Tillabéri
Kidal
Arlit
0.2
6.0
6.0
6.0
46.95
32.335
17.72
3.105
-11.51
lwe_thickness
2019-12-01T00:00:00.000Z
1fps
Leaflet | Tiles © Esri 2012 See Here
Iulleme Basin Niger Regional Average Water Storage Anomaly
Zoom All
Apr 1, 2002 → Sep 1, 2021
Storage Volume
0
-10
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2015
2017
2019
2020
2021
Date

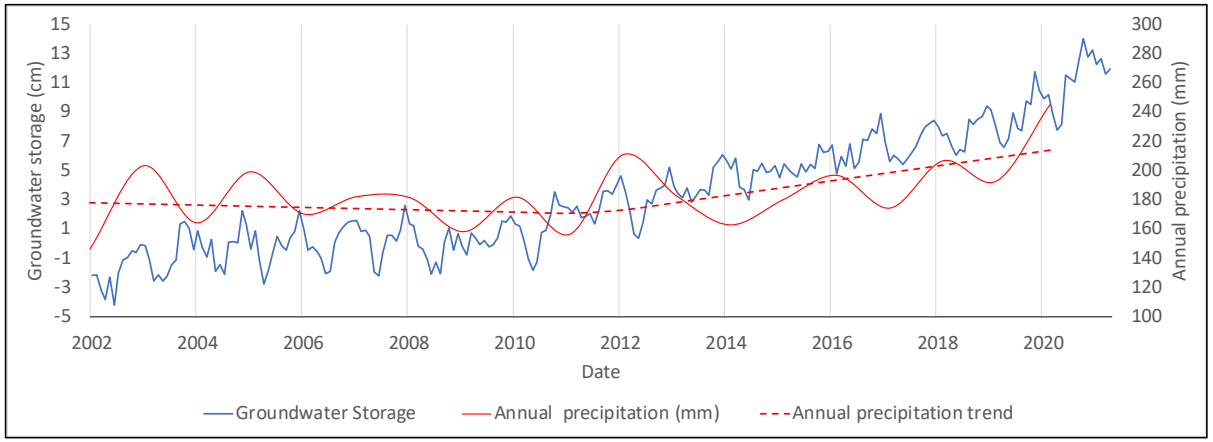
Iullemeden Basin - Groundwater Storage Anomaly



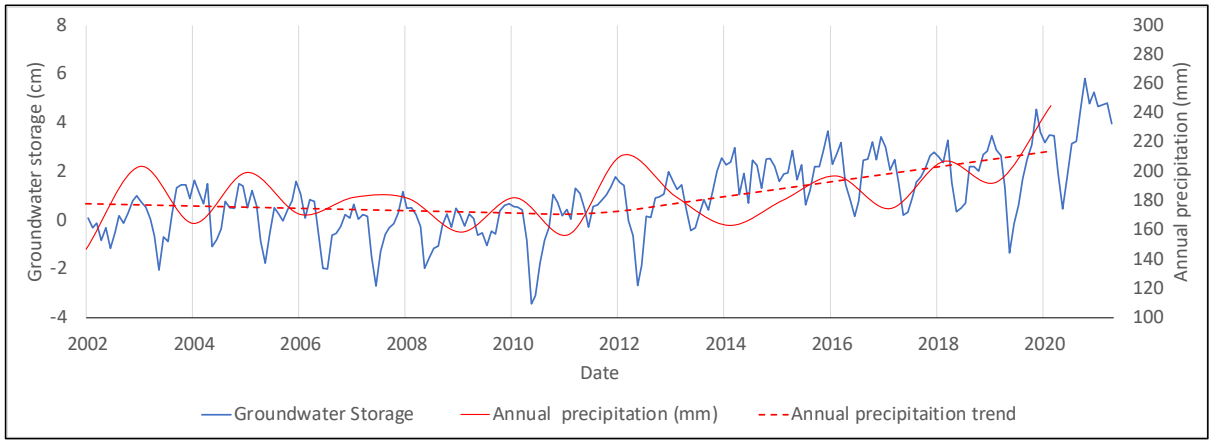
Chad Basin - Groundwater Storage Anomaly



Correlation with Precipitation

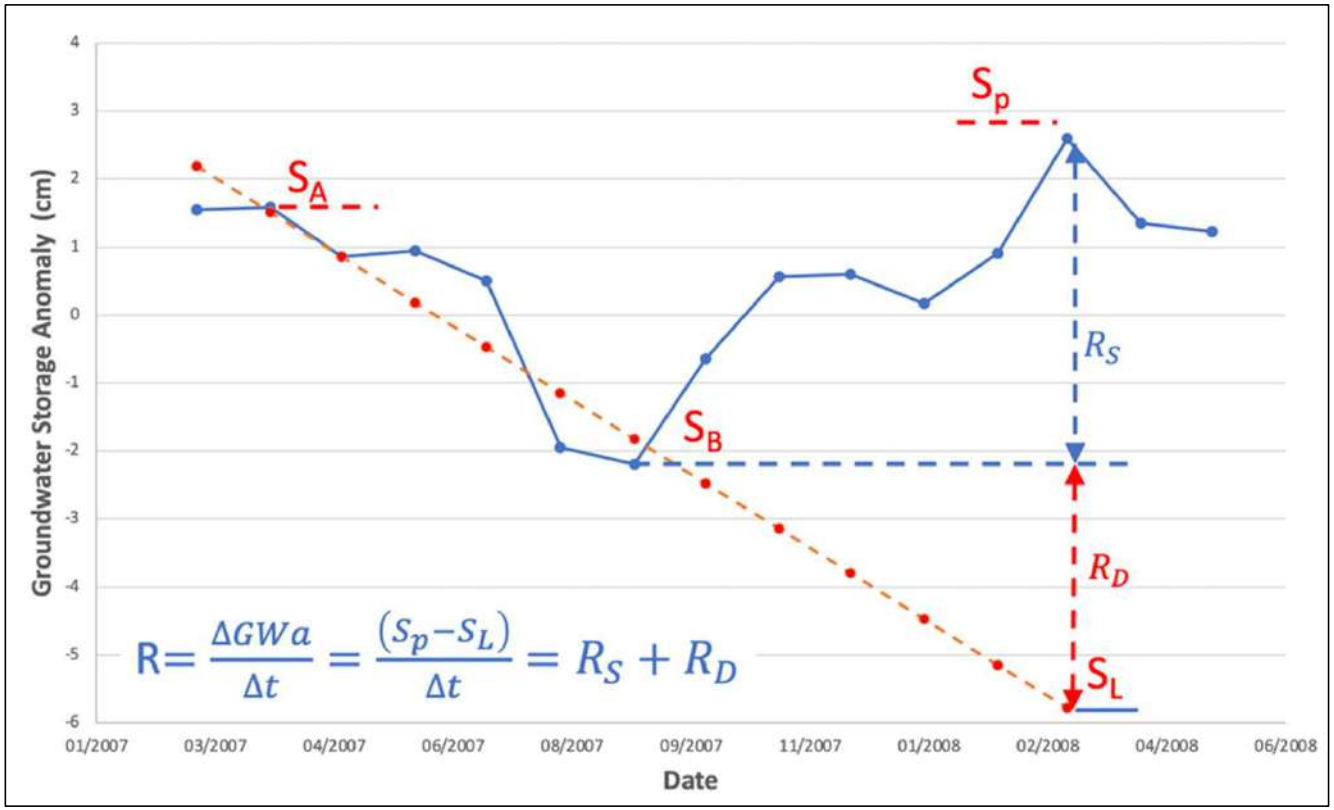


Iullemeden Basin



Chad Basin

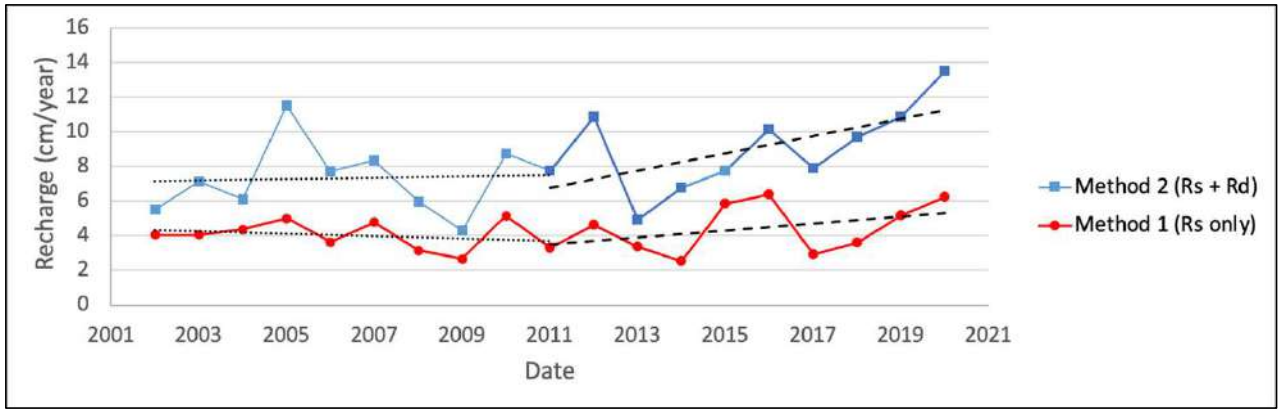
Recharge Analysis – Water Table Fluctuation Method



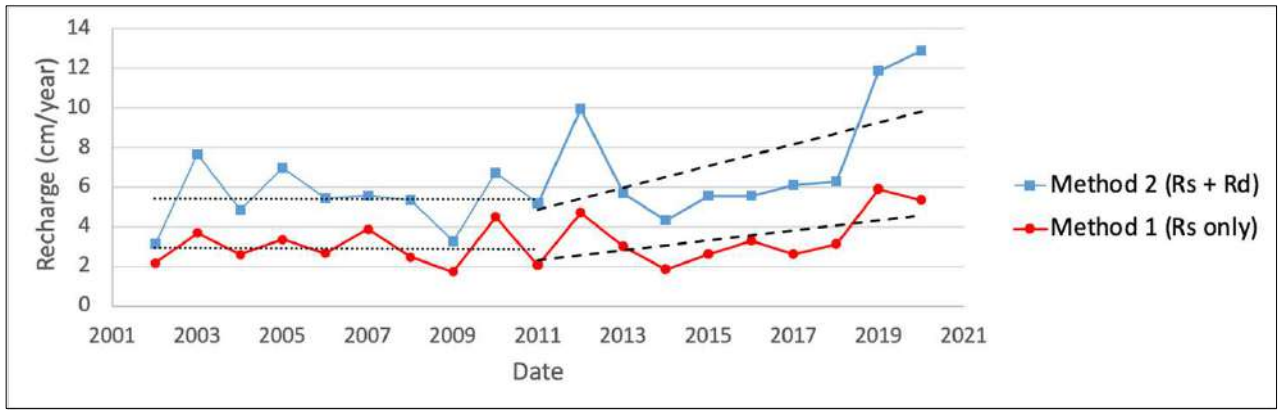
Water Table Fluctuation Method

Seasonal variation in groundwater storage anomaly

Derived Recharge



Iullemeden Basin



Chad Basin

Reference	Country/Region	Method	Time	Recharge (cm/year)
Estimated values in this project	Iullemeden Basin	WTF	2002-2011	4.0 - 7.3
	Iullemeden Basin	WTF	2012-2021	4.5 - 9.2
Estimated values in this project	Chad Basin	WTF	2002-2011	2.9 - 5.4
	Chad Basin	WTF	2012-2021	4.1 - 7.6
Bromley et al., 1997	Southwest Niger	CMB (Chloride mass balance)	1992	1.3
Leduc et al. 1997	Southern Niger	WTF	1991	5 to 6
(Leduc et al., 2001) and (Favreau et al., 2002)	Southwest Niger	Radioisotopes (14C and 3H)	1950s–2000s	0.1 to 0.5
(Leduc et al., 2001)	Southwest Niger	WTF	1990s–2000s	2 to 5
(Vouillamoz et al., 2008)	Southwest Niger	WTF	1990s–2000s	2 to 5

https://doi.org/10.3390/rs14071532

remote sensing

MDPI

Article

Evaluating Groundwater Storage Change and Recharge Using GRACE Data: A Case Study of Aquifers in Niger, West Africa

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2 Department of Civil Engineering, University of Mississippi, University, MS 38677, USA; stpulla@go.olemiss.edu
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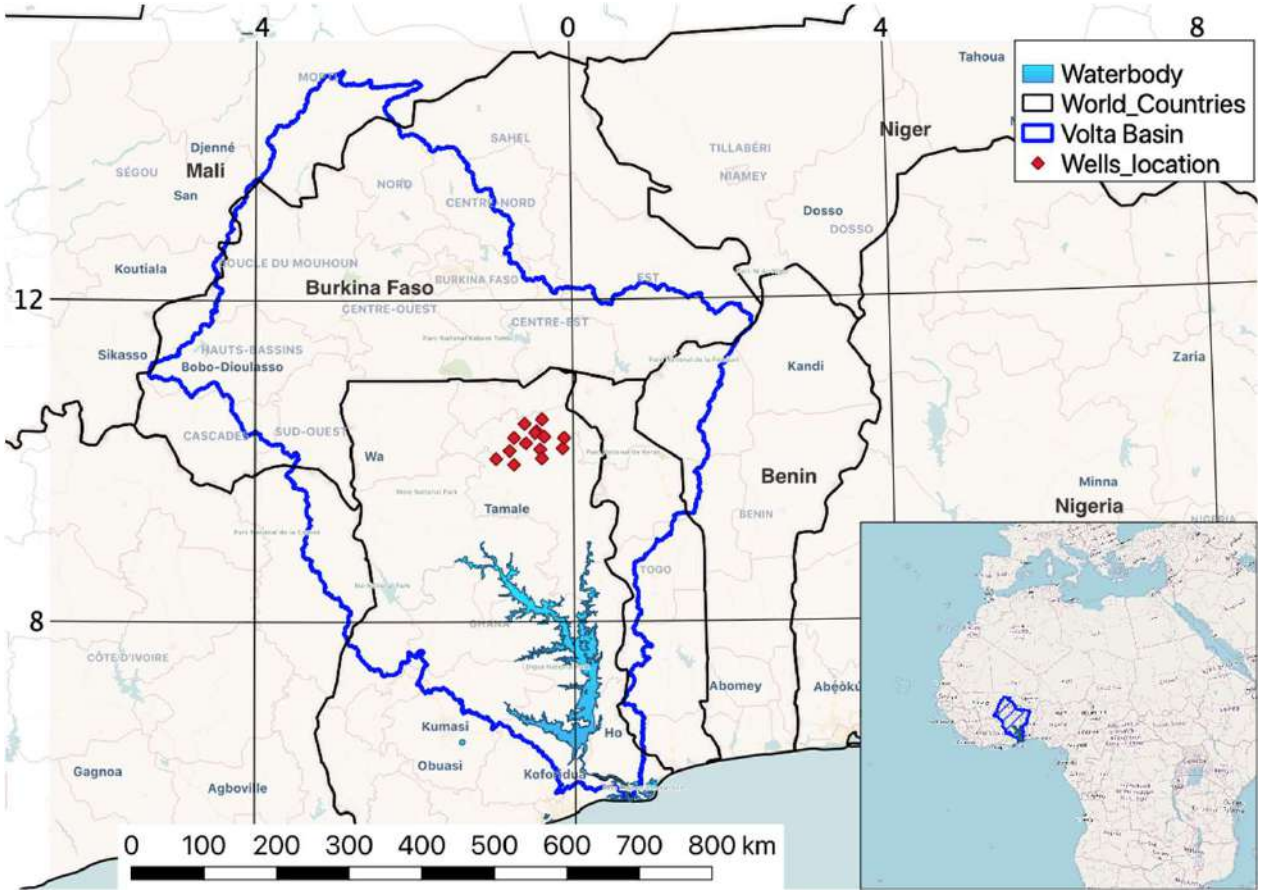
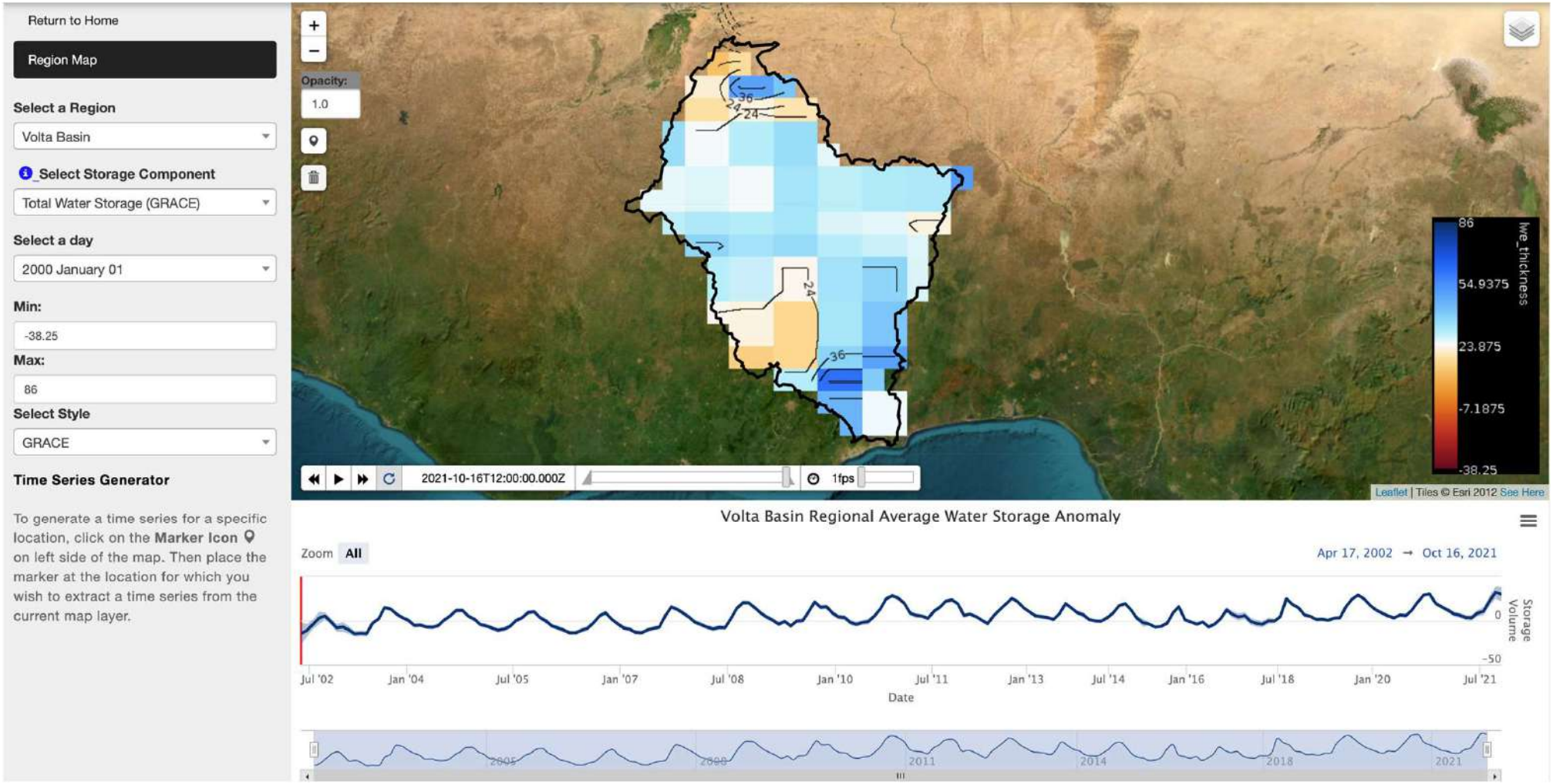
Abstract: Accurately assessing groundwater storage changes in Niger is critical for long-term water resource management but is difficult due to sparse field data. We present a study of groundwater storage changes and recharge in Southern Niger, computed using data from NASA Gravity Recovery and Climate Experiment (GRACE) mission. We compute a groundwater storage anomaly estimate by subtracting the surface water anomaly provided by the Global Land Data Assimilation System (GLDAS) model from the GRACE total water storage anomaly. We use a statistical model to fill gaps in the GRACE data. We analyze the time period from 2002 to 2021, which corresponds to the life span of the GRACE mission, and show that there is little change in groundwater storage from 2002–2010, but a steep rise in storage from 2010–2021, which can partially be explained by a period

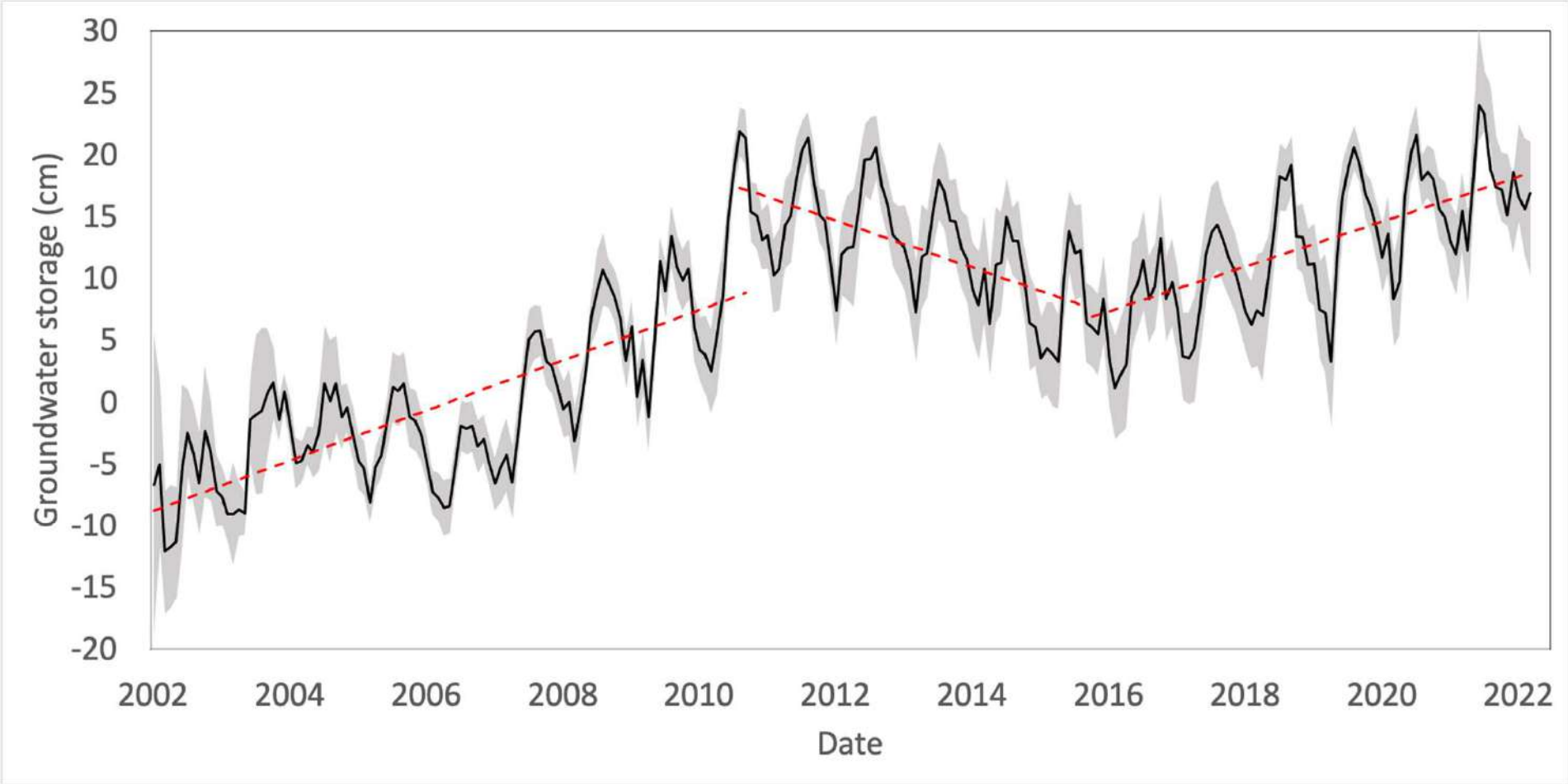
PART 2

Volta Basin

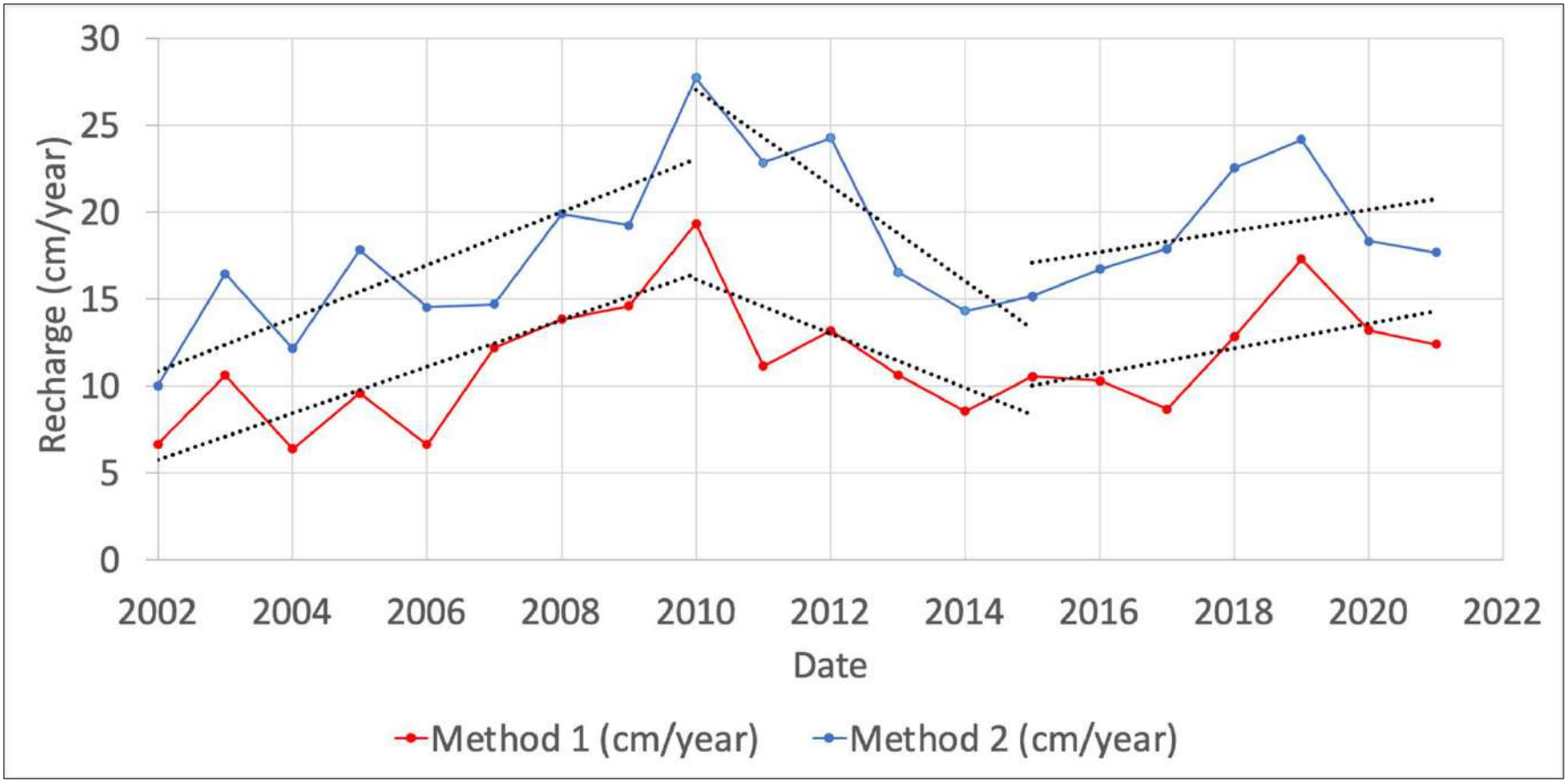



Return to Home
Region Map
Select a Region
Volta Basin
Select Storage Component
Total Water Storage (GRACE)
Select a day
2000 January 01
Min:
-38.25
Max:
86
Select Style
GRACE
Time Series Generator
To generate a time series for a specific location, click on the Marker Icon on left side of the map. Then place the marker at the location for which you wish to extract a time series from the current map layer.
Opacity:
1.0
2021-10-16T12:00:00.000Z
1fps
lwe_thickness
86
54.9375
23.875
-7.1875
-38.25
Leaflet | Tiles © Esri 2012 See Here
Volta Basin Regional Average Water Storage Anomaly
Zoom All
Apr 17, 2002 → Oct 16, 2021
Storage Volume
0
-50
Jul '02
Jan '04
Jul '05
Jan '07
Jul '08
Jan '10
Jul '11
Jan '13
Jul '14
Jan '16
Jul '18
Jan '20
Jul '21
Date
2005
2008
2011
2014
2018
2021

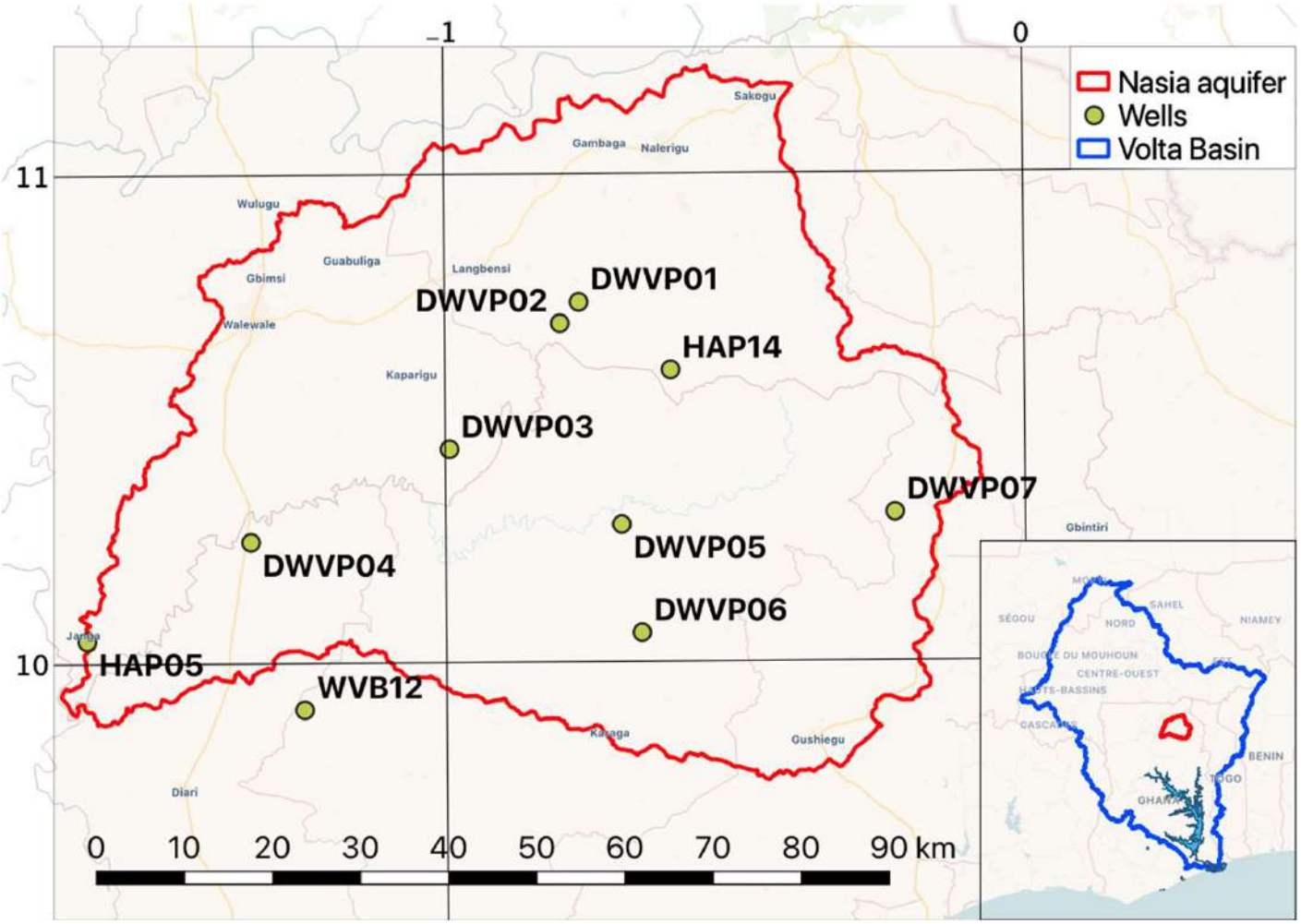
Results – Groundwater Storage Anomaly



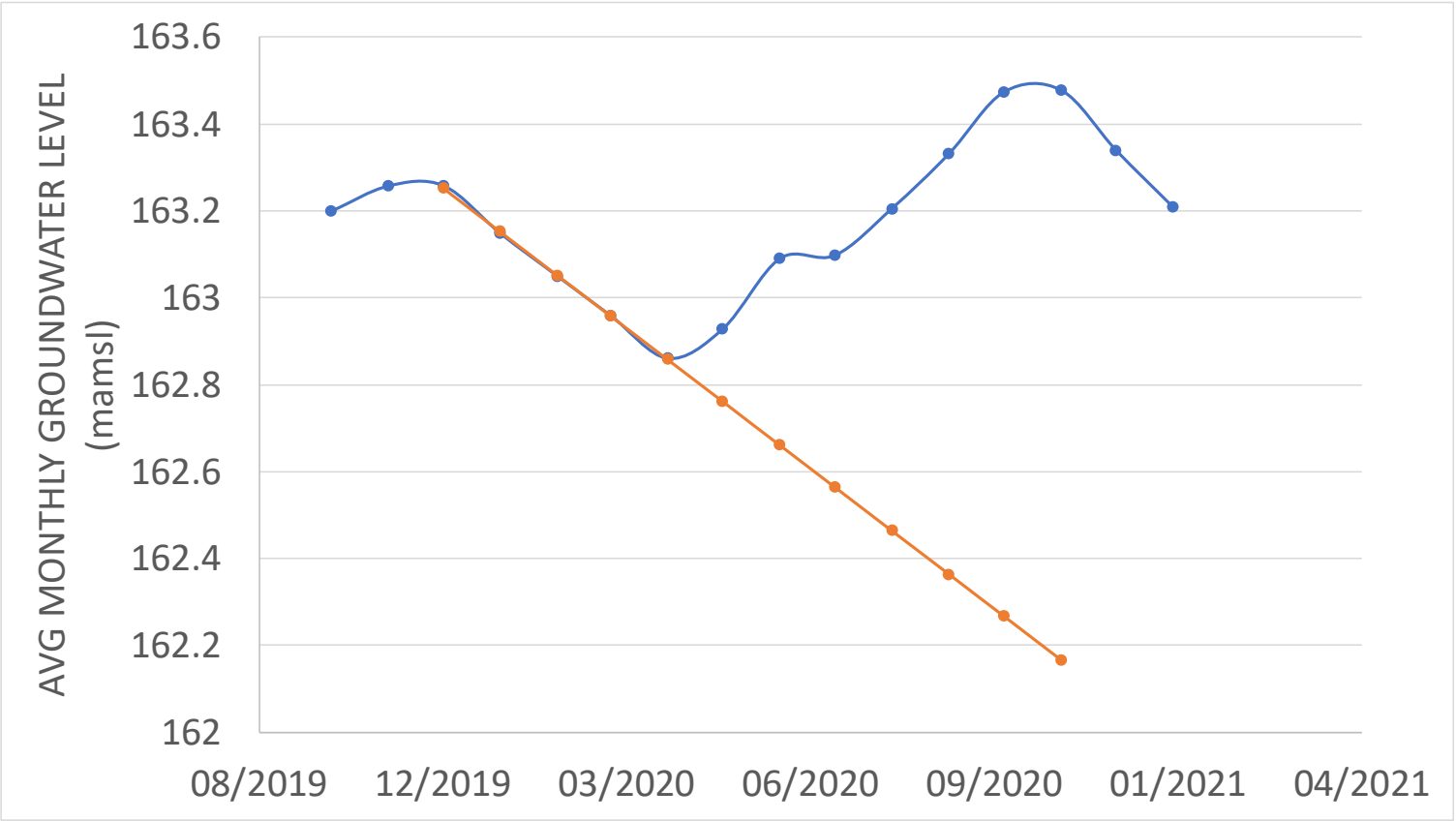
GRACE-Derived Recharge Estimates – WTF Method



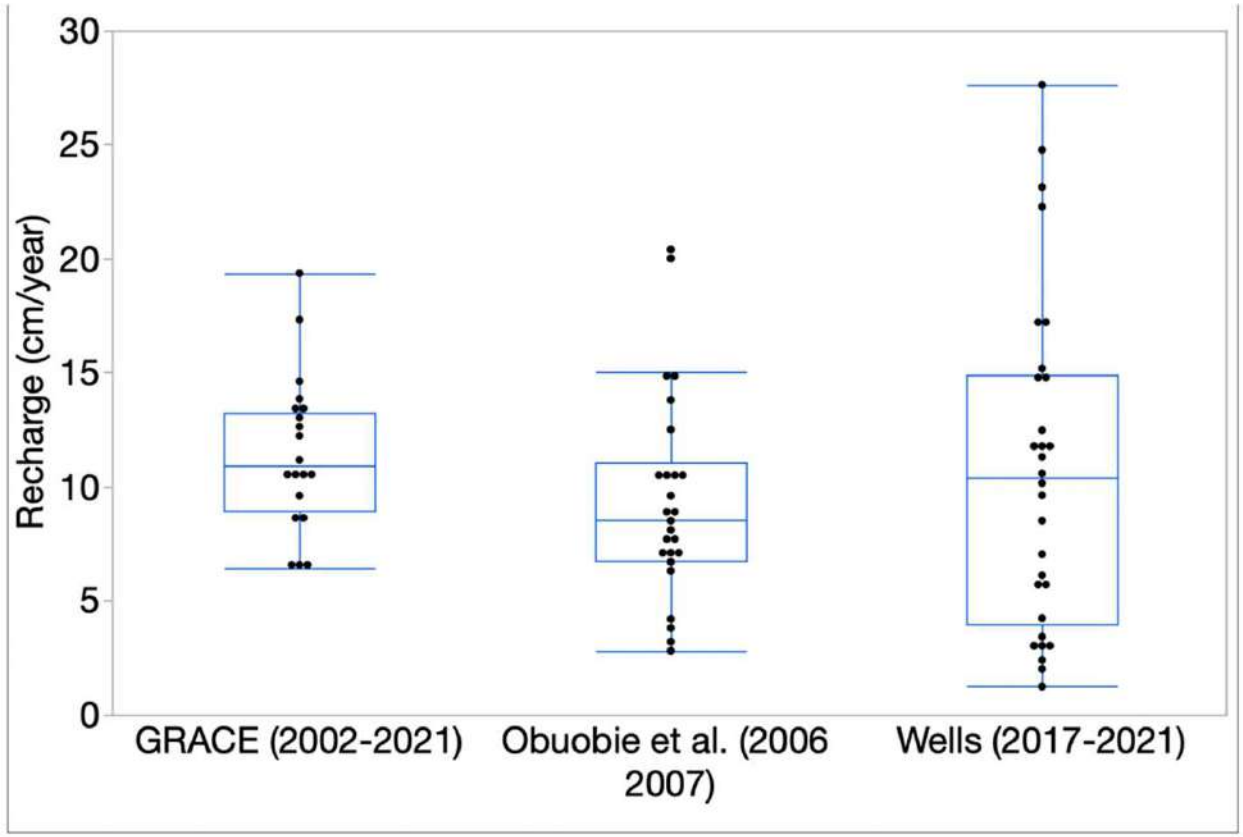
Groundwater Recharge Estimates using Observed Data



WTF method – in situ example

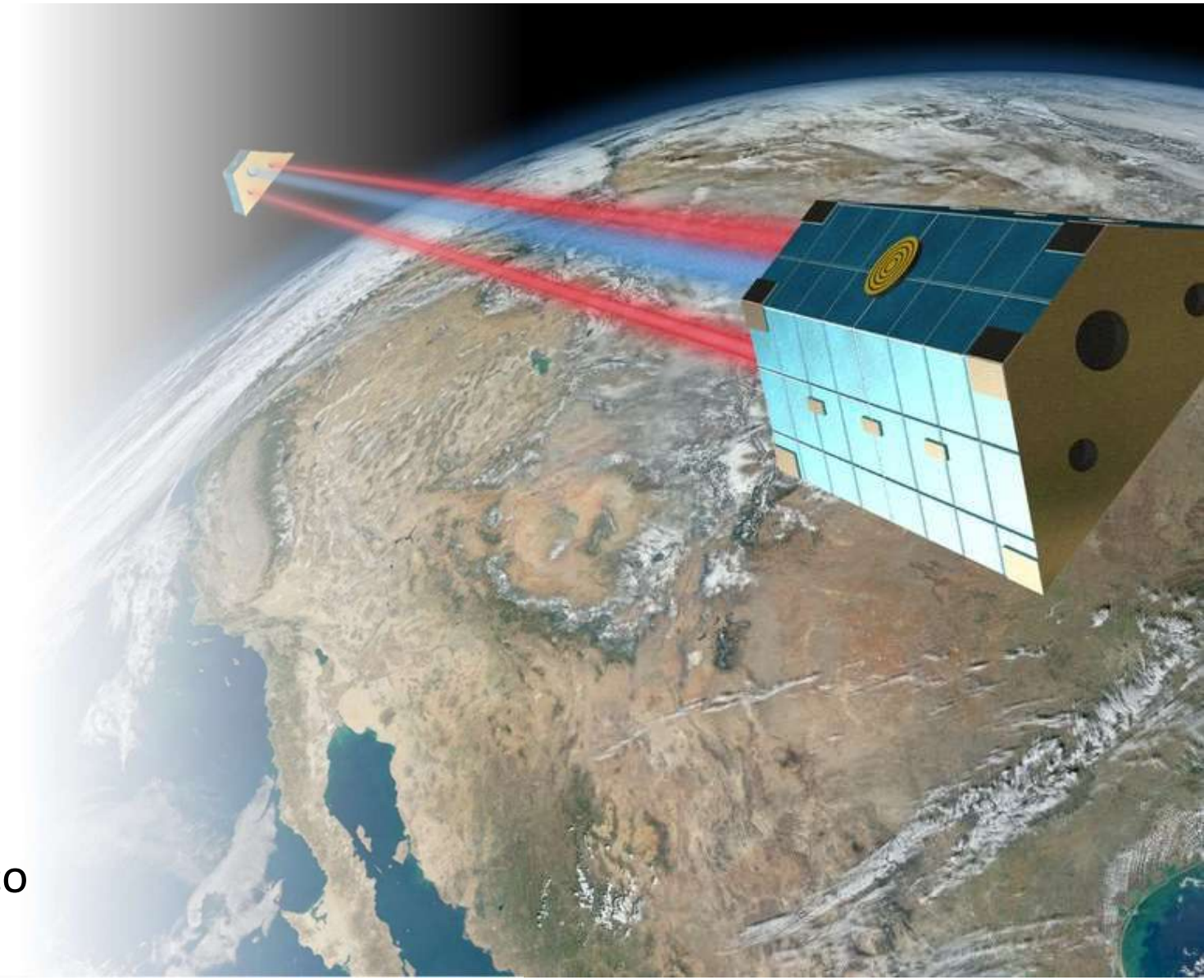


$$R = S_y\left(\frac{\Delta h}{t}\right)$$



Estimated Groundwater Recharge Values Comparison

Thank you!



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