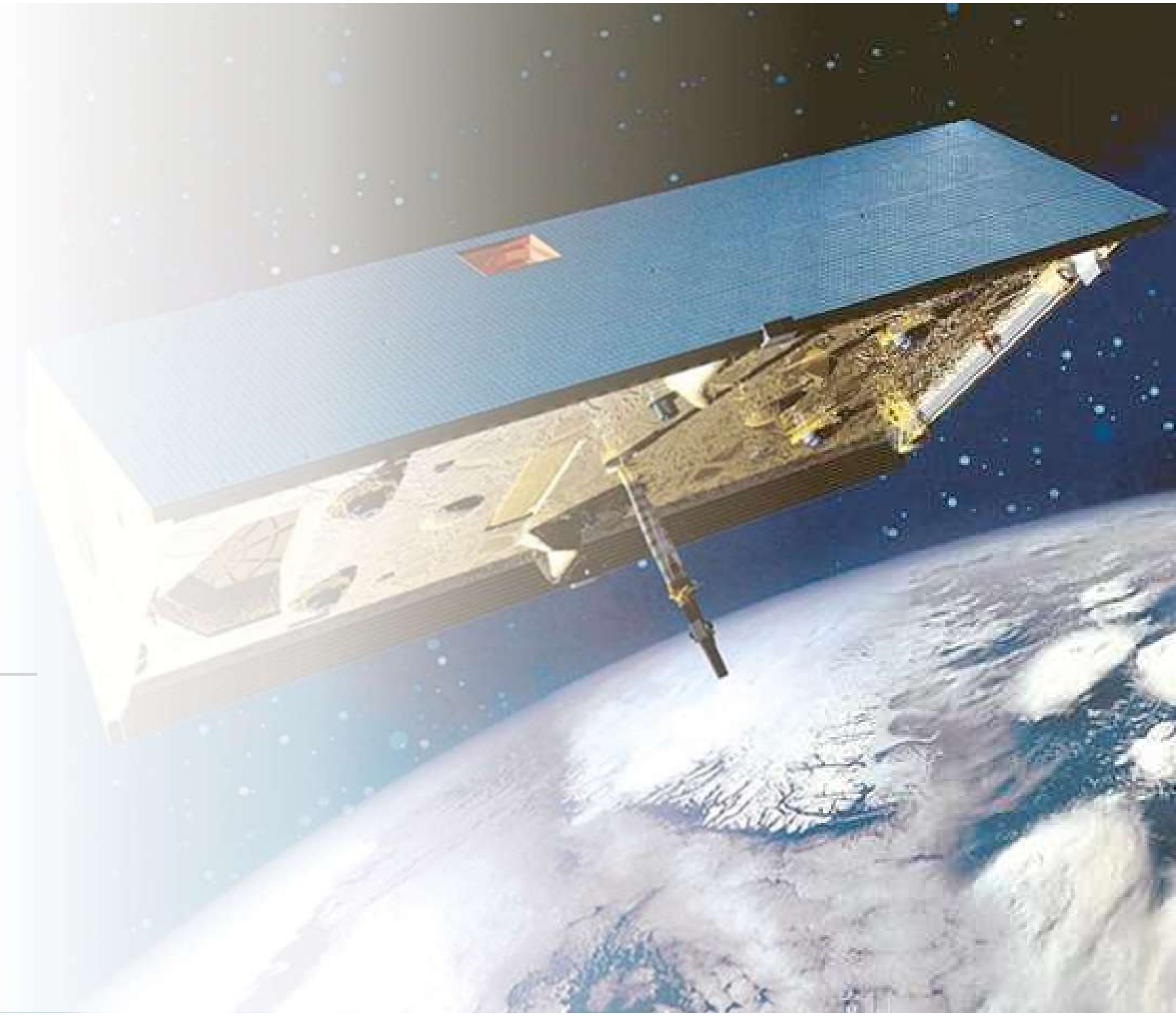
GRACE Groundwater Subsetting Tool

Analyzing Groundwater Resources Using Data From the GRACE Mission



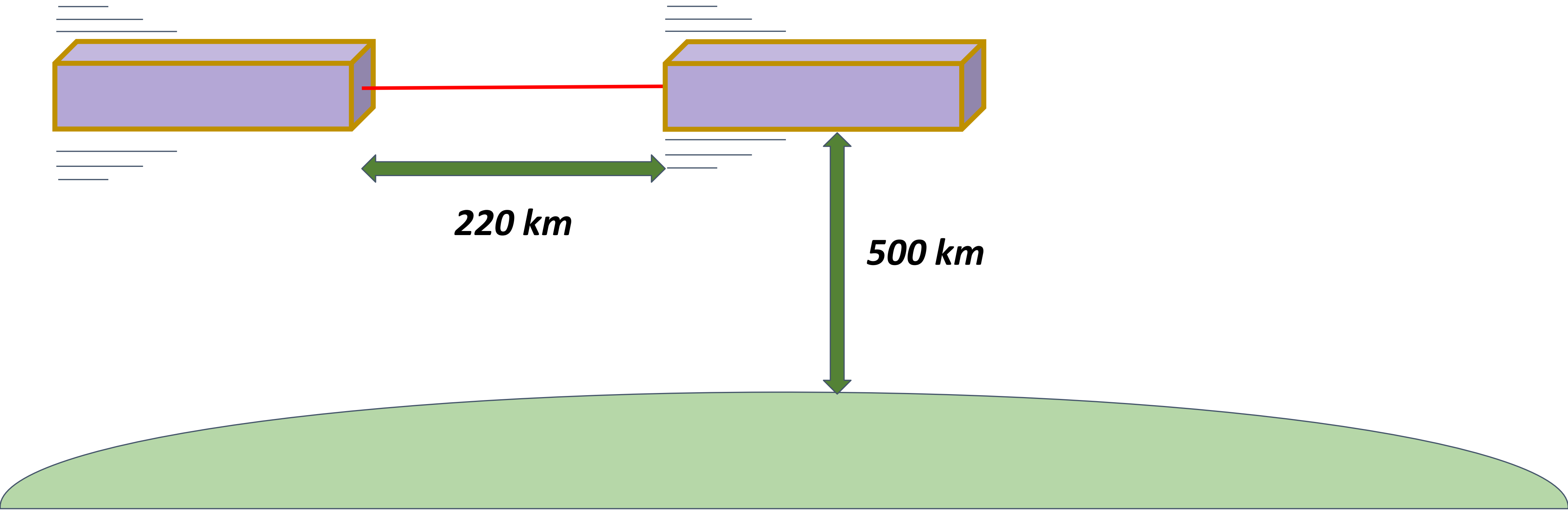
Sarva Pulla – ArchGeo

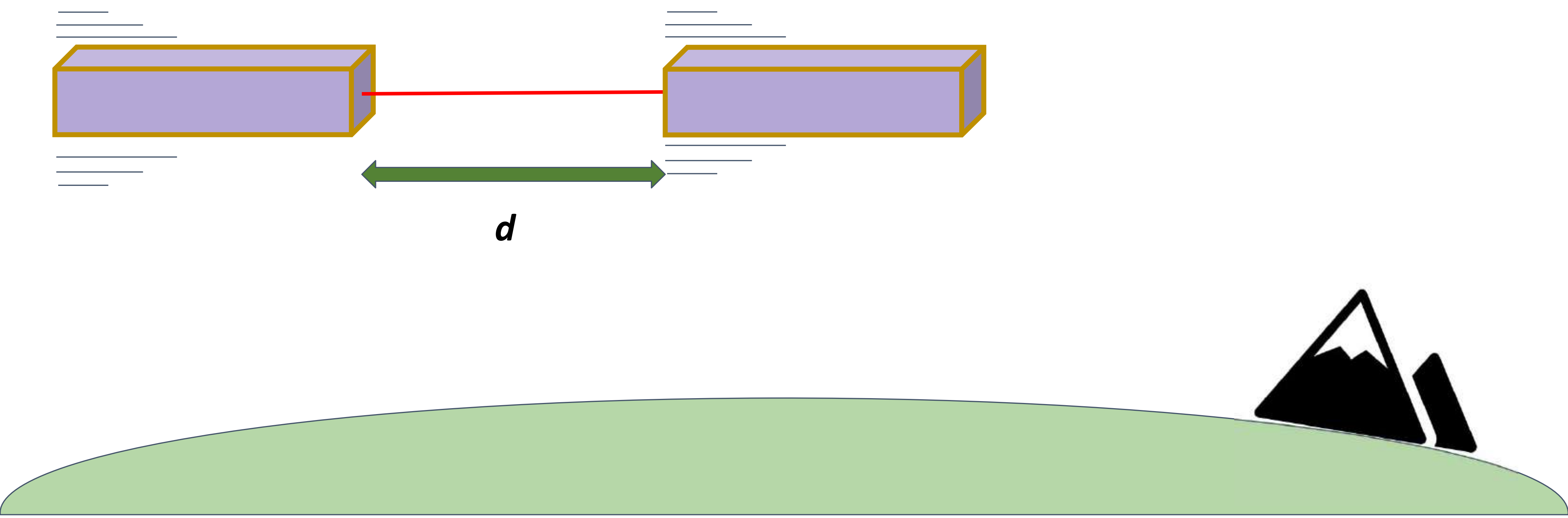
Presentation Outline

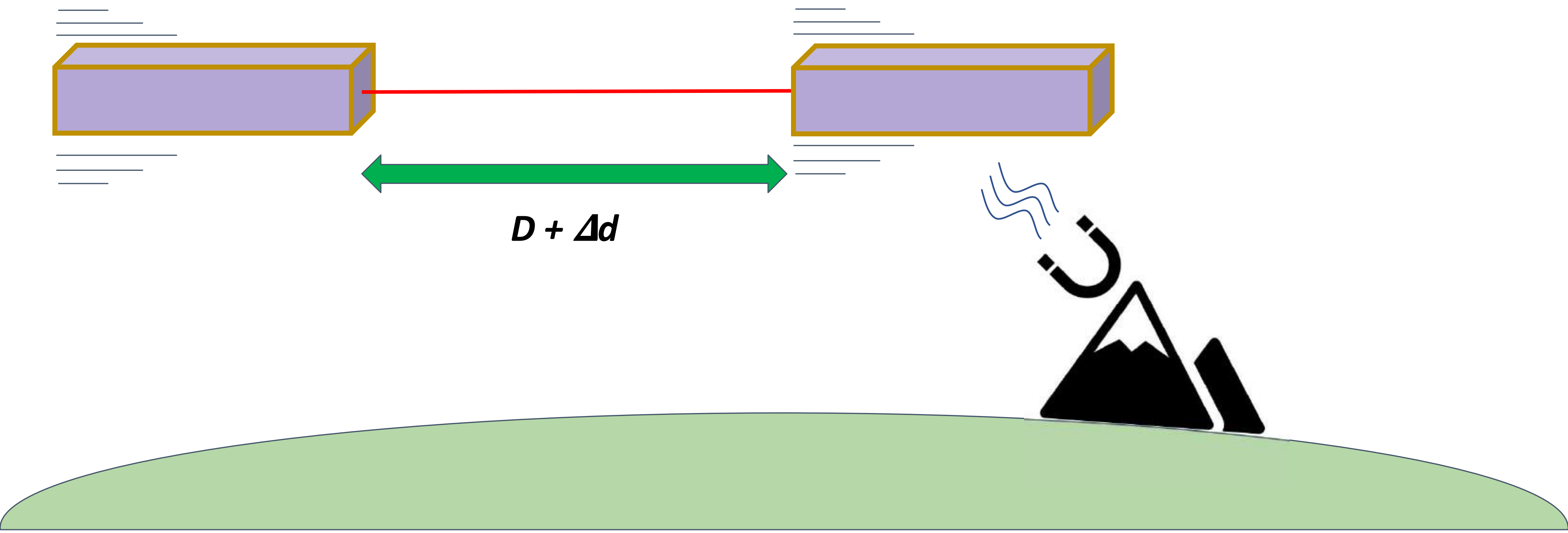
- Overview of GRACE Mission
- Algorithm for deriving groundwater storage change
- Tethys App: GRACE Groundwater Subsetting Tool (GGST)
- GGST Application Programming Interface (API)
- Google Colab Python Code

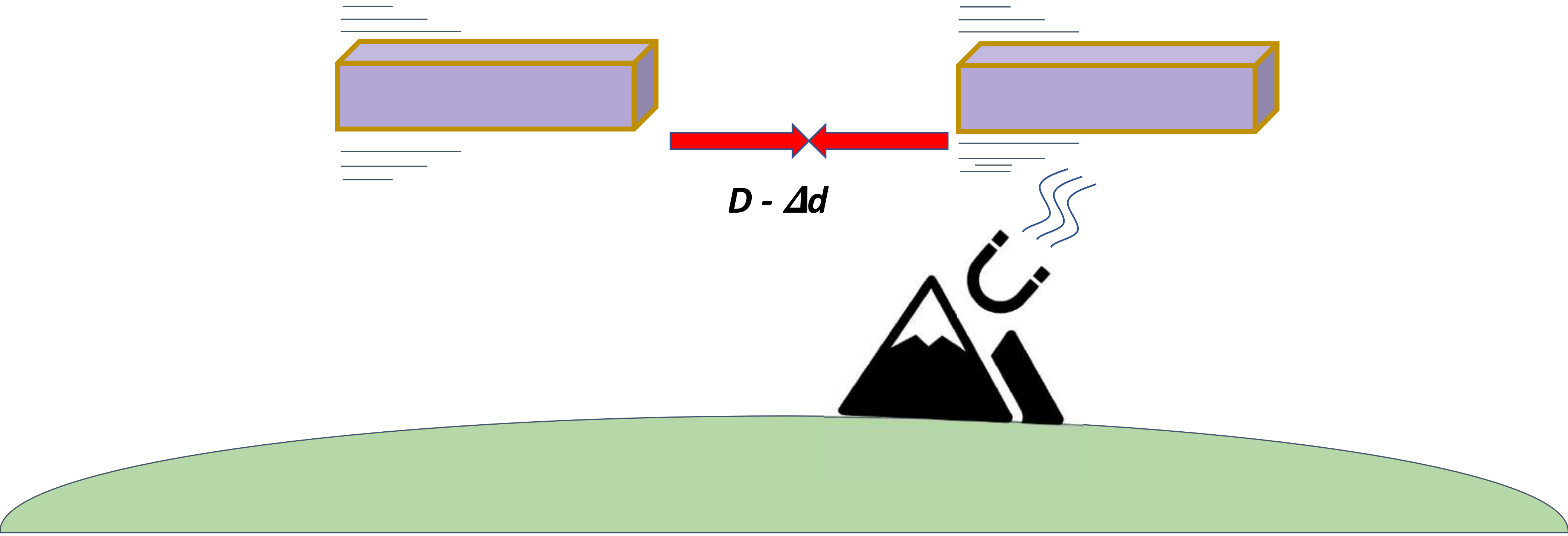
Gravity Recovery and Climate Experiment (GRACE)

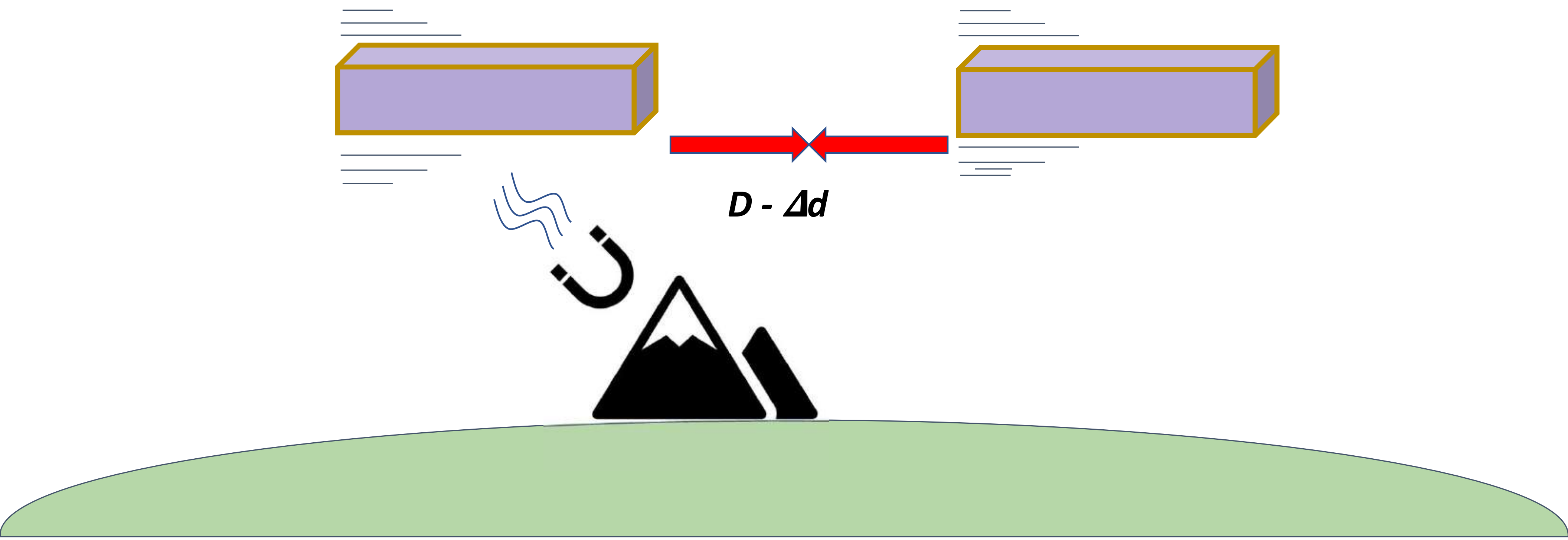
- Original Mission: 2002 – 2017
- GRACE-FO Mission: 2018 - Current

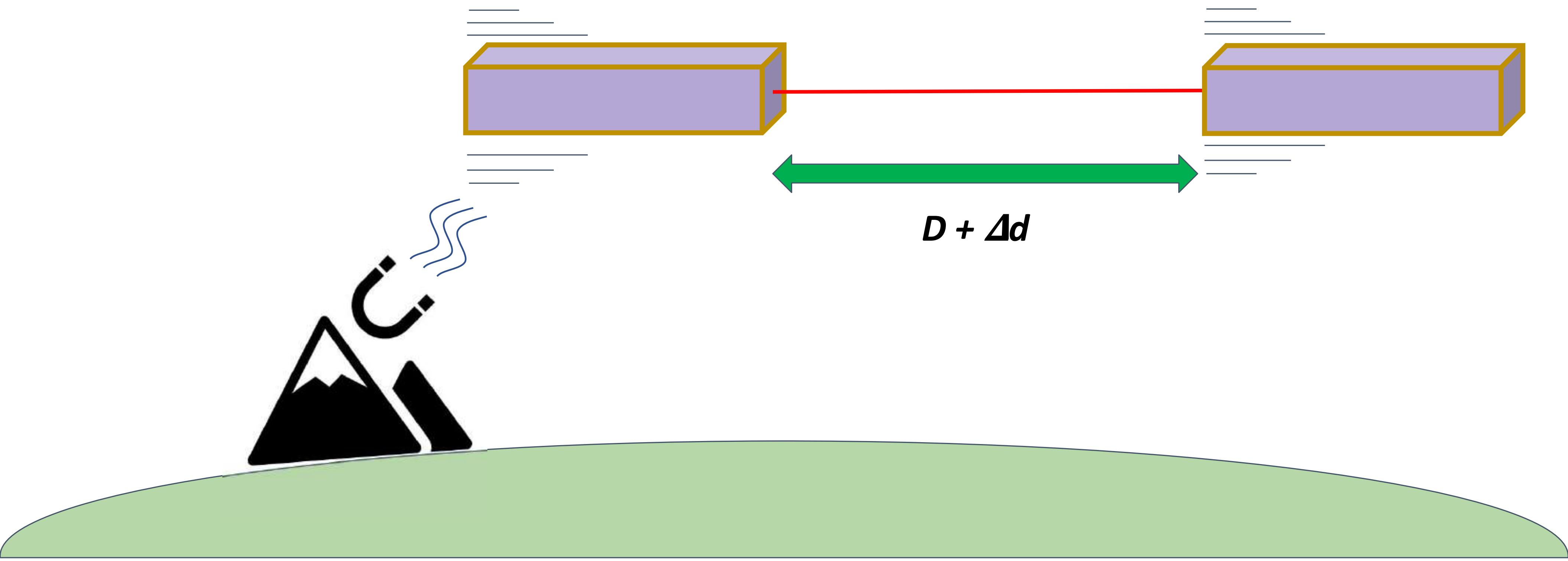

220 km
500 km


d

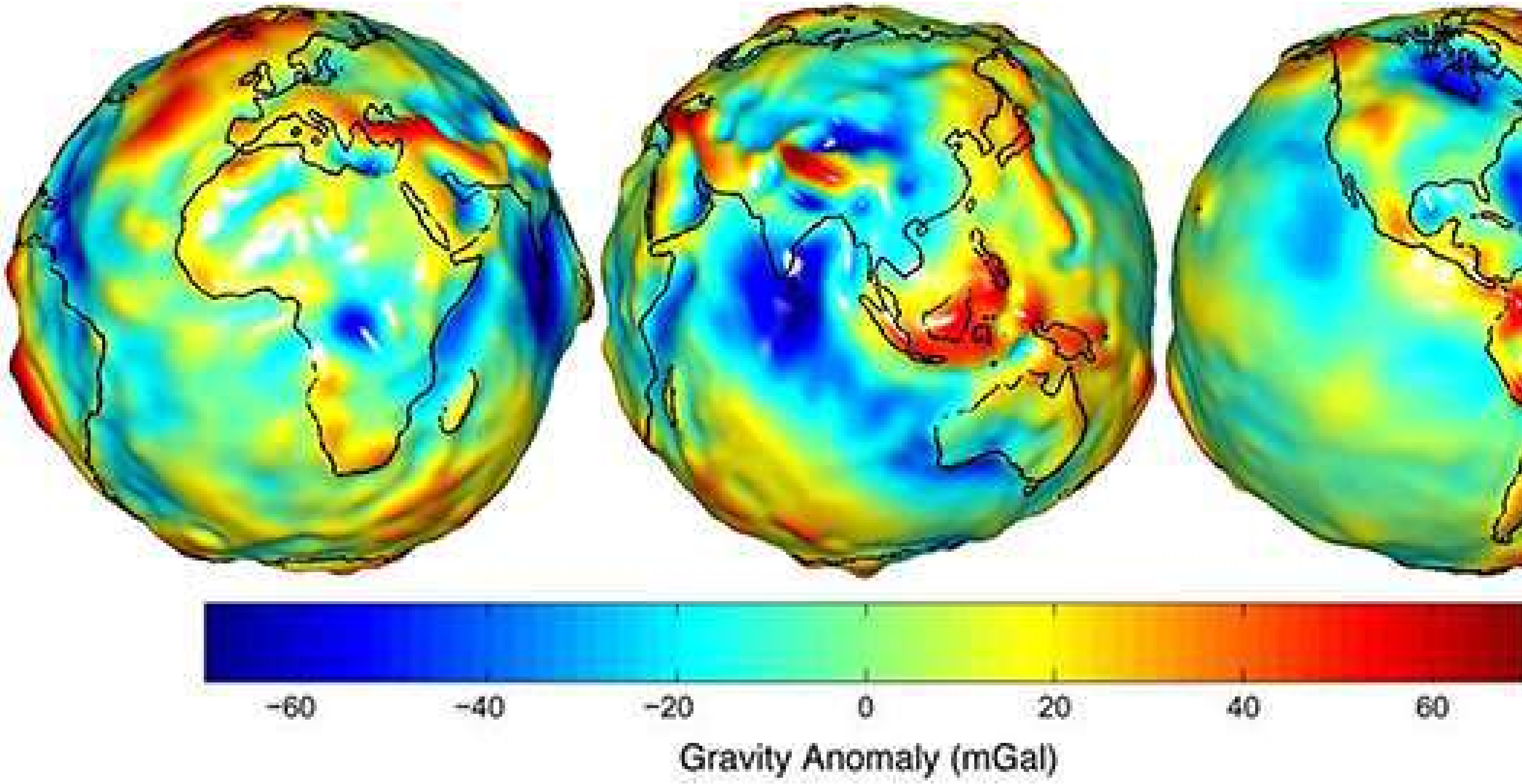

D + Δd


D - Δd

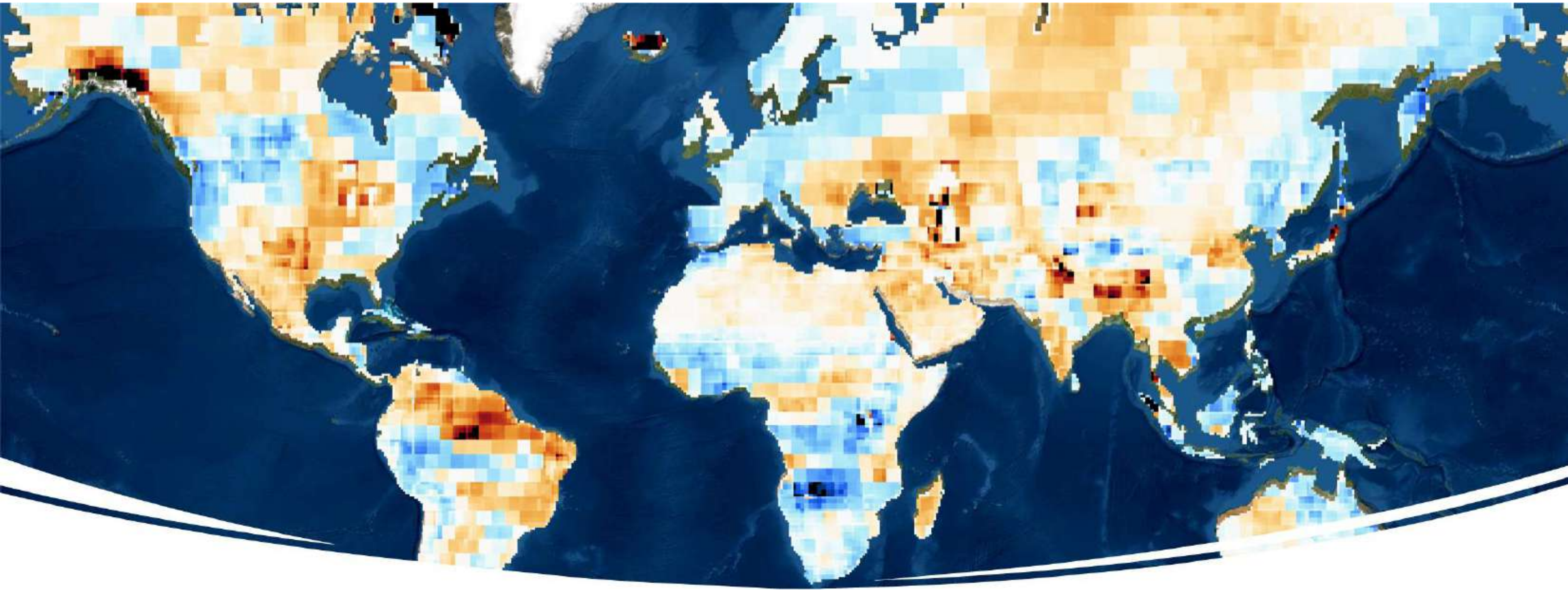

D - Δd



D + Δd



−60
−40
−20
0
20
40
60
Gravity Anomaly (mGal)



Total Water Storage Anomaly

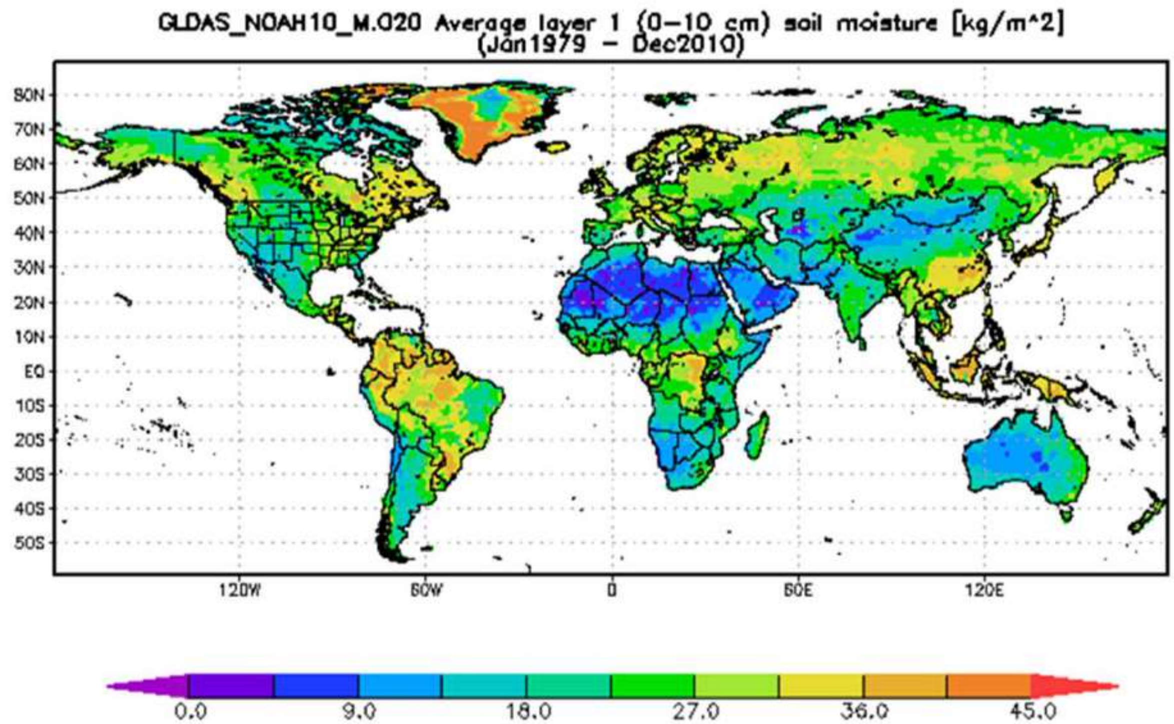
- Represented as liquid water equivalent (LWE) in cm
- Anomaly computed from 2005-2009 baseline

Land Surface Models

- **Noah**
- **VIC**
- **CLSM**

Terrestrial Water Components

- Plant canopy storage
- Snow water equivalent
- Surface water (small)
- Soil moisture



**Monthly mean calculated for each variable

∑Tot_Storage - ∑Mean_Storage = Storage Anomaly

Methodology

GWa = TWSa – (SWEa + CANa + SMa)

GWa = Derived groundwater storage anomaly

TWSa = **GRACE** total water storage anomaly

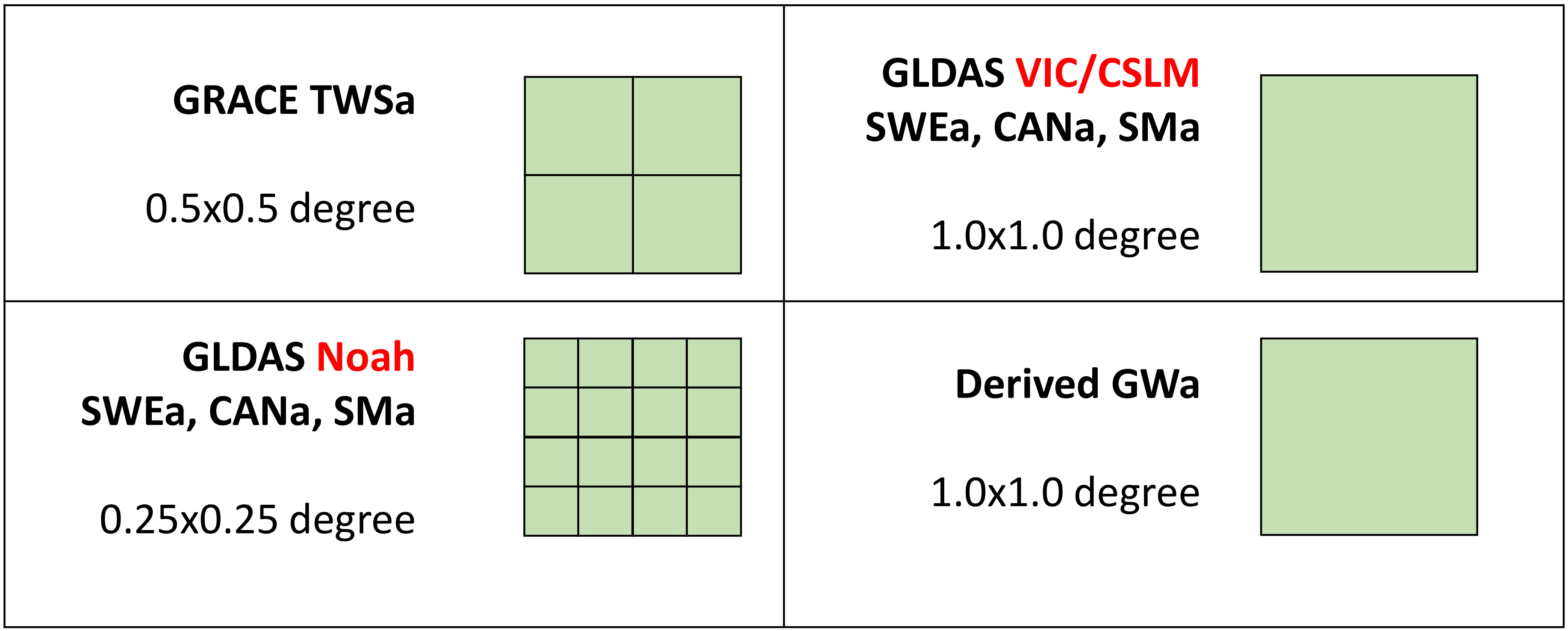
SWEa = **GLDAS** snow water equivalent anomaly

CANa = **GLDAS** canopy storage anomaly

SMa = **GLDAS** soil moisture anomaly

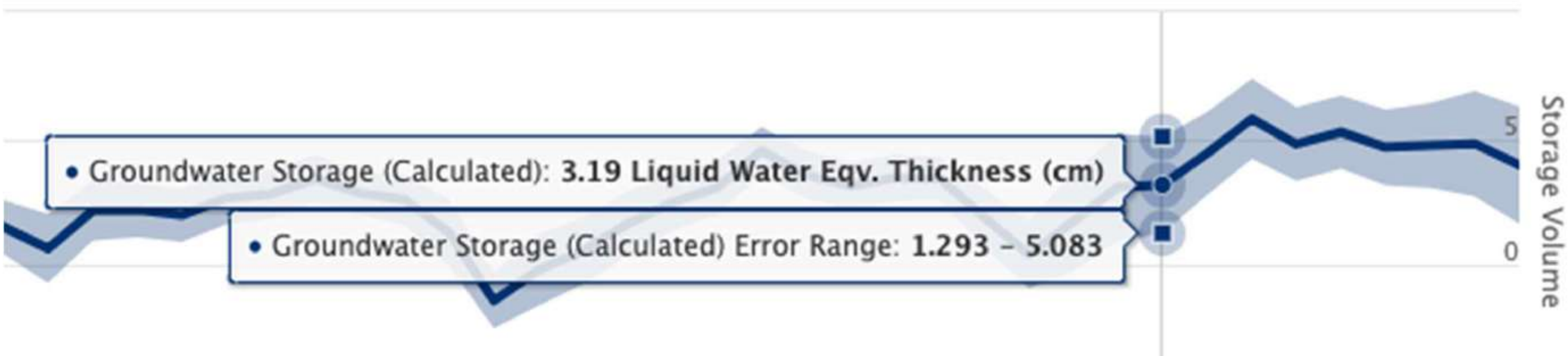
GLDAS Soil Moisture Component

Surface Model	Soil Moisture Storage Components
CLSM	SoilMoist_P_inst (Profile – includes Surface and Root Zone layers)
Noah	SoilMoi0_10cm_inst (0 – 10 cm) SoilMoi10_40cm_inst (10 – 40 cm) SoilMoi40_100cm_inst (40 – 100 cm) SoilMoi100_200cm_inst (100 – 200 cm)
VIC	SoilMoi0_30cm_inst (0 – 30 cm) SoilMoi_depth2_inst (depth varies spatially) SoilMoi_depth3_inst (depth varies spatially)

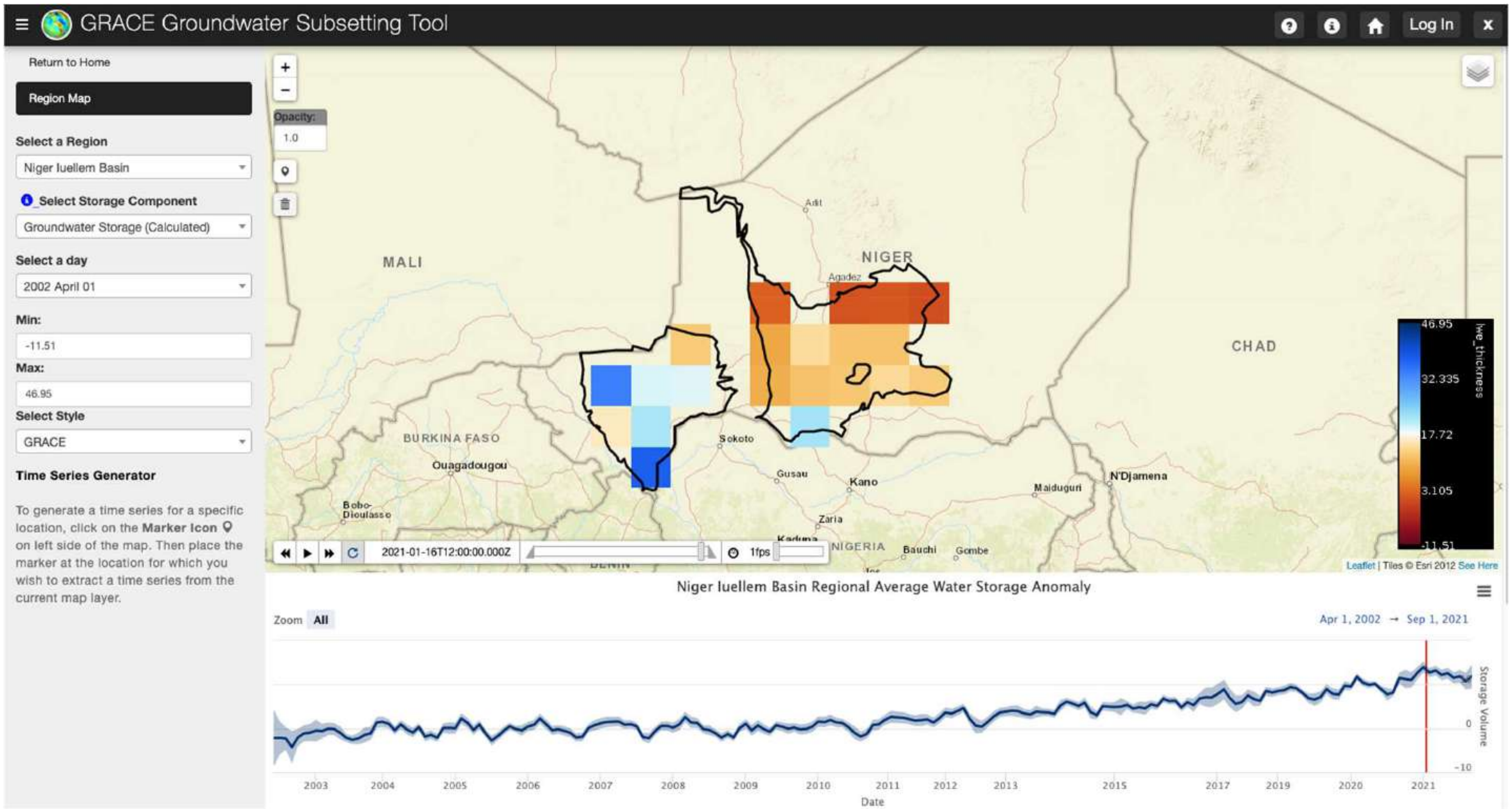

GRACE TWSa
0.5x0.5 degree
GLDAS VIC/CSLM
SWEa, CANa, SMa
1.0x1.0 degree
GLDAS Noah
SWEa, CANa, SMa
0.25x0.25 degree
Derived GWa
1.0x1.0 degree

For the GLDAS components, we use the mean of three embedded land surface models: Noah, VIC, CLSM. This allows us to compute uncertainty as follows:

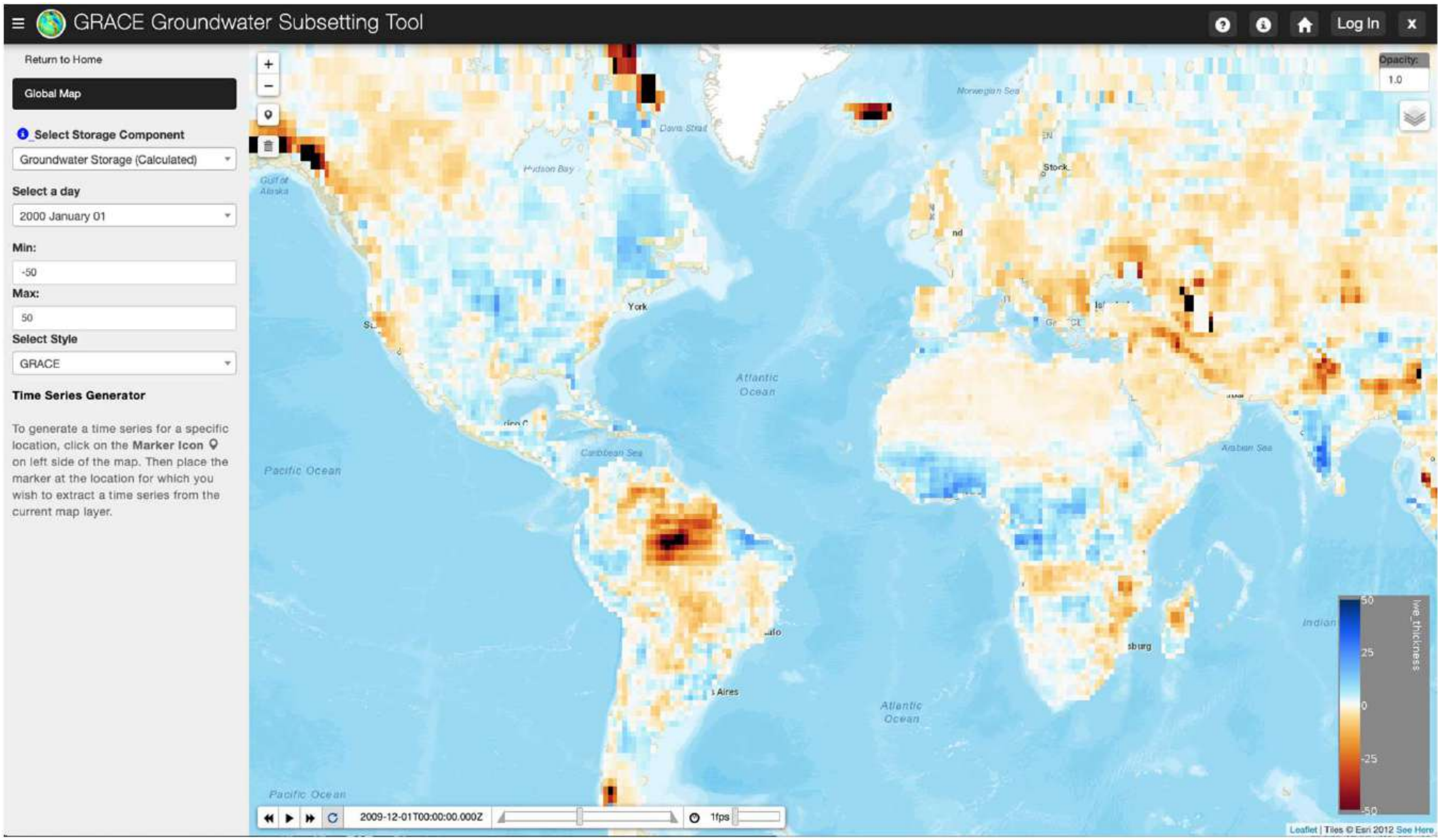
$$\sigma GWa = \sqrt{(\sigma TWSa)^2 - (\sigma SWEa)^2 - (\sigma CANa)^2 - (\sigma SMa)^2}$$

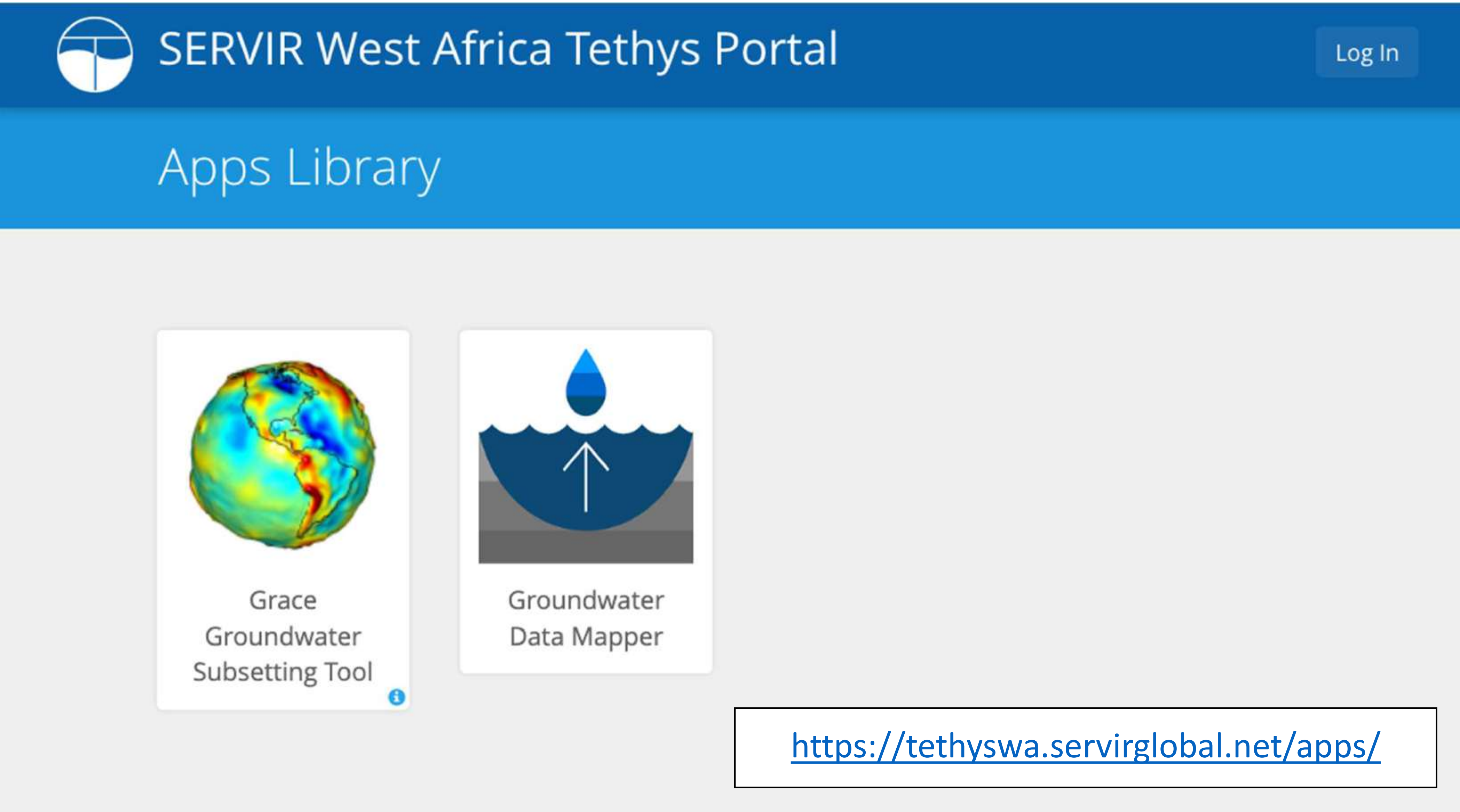


GRACE Analysis of GW Storage in Southern Niger



GRACE Groundwater Subsetting Tool





https://tethyswa.servirglobal.net/apps/

Online Documentation

GRACE Groundwater Subsetting Tool

latest

Search docs

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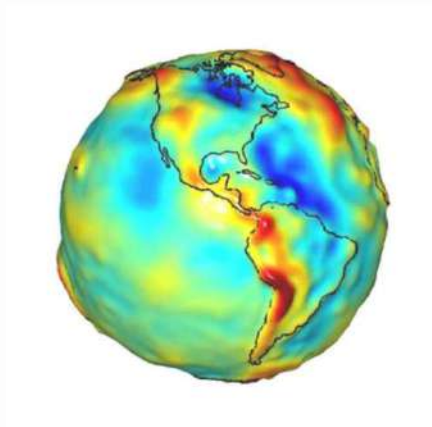
Introduction



The GRACE Groundwater Subsetting Tool (GGST) uses data from the NASA Gravity Recovery And Climate Experiment (GRACE) mission to analyze long-term groundwater storage change for selected regions. GGST can be used to identify and characterize conditions in data-poor areas or identify trends in other regions where trends can be obscured by noise from well data. GGST uses GRACE mission data to compute and display changes in water storage in a web-based mapping system and integrates data from both the GRACE and GRACE-FO missions. GGST uses NASA GLDAS surface water data to derive groundwater storage changes. It accepts shapefiles to define regions representing countries, basins, or aquifers. It then aggregates the water volume changes in those regions and displays the results as time series plots for the whole region or at selected points. It also displays an animated map of the storage change anomalies.

Objective

The GGST app uses GRACE data to generate time series and animated maps of groundwater storage changes. GRACE provides monthly estimates of water storage anomalies in equivalent water height and has provided monthly gravity field solutions since April 2002. Estimates of mass variability and associated observational errors are available on a global 300 km grid. GRACE has proved an effective tool for characterizing groundwater storage changes in large regions (J. Famiglietti et al., 2011; J. S. Famiglietti, 2014; Rodell, Velicogna, & Famiglietti, 2009; Thomas, Reager, Famiglietti, & Rodell, 2014).

While a number of tools have been developed for processing and visualizing GRACE data, our tool is designed specifically to support groundwater resource management by regional stakeholders and decision-makers. We accomplish this by carefully processing the raw GRACE data to remove anomalies and to improve resolution. This is done by separating the groundwater component from the other water storage components using GLDAS, by subsetting the data to specific regions of interest, and by presenting the results in a simple, intuitive interface. The algorithm we use to process the GRACE and GLDAS data to produce groundwater anomalies on both a global and regional scale is described in detail on the Algorithm page.

You can access GGST using the Tethys Web Application or by using the API and the associated Google Colab Notebook that makes the API intuitive to use. A brief introduction to these two methods is provided below.

https://ggst.readthedocs.io/en/latest/

Application Programming Interface (API)

Select Language

Powered by Google Translate

Introduction

The API for the GGST allows users to retrieve ground water information about a point or region without having administrative privileges to the GGST web application. The GGST API has four functions. Each of these functions requires different inputs and returns different results as desired by the user. The name of each function gives a glimpse of what each accomplishes. The four functions are:

- getStorageOptions
- getPointValues
- getRegionTimeseries
- subsetRegionZipfile

To run some of the functions listed above, the user will need an authentication token. Please refer to the third section of this documentation on how to obtain the said token. The API can be implemented in many ways using a variety of coding languages and platforms. We have provided an example implementation using the Python code language in a Google Colab notebook. Our example notebook is hosted on GitHub and can be access through a link at the bottom of this page. If you choose to use Python to call the API, we recommend the xarray and geopandas Python packages be used to process your data. The former helps in visualizing and interacting with the raw netCDF data returned while the latter helps in uploading the shapefile(s) for the subsetting.

To launch the code, please click on this button. The notebook will open in a new tab.

Open in Colab

API Methods

All four functions follow the same pattern as shown by the URL examples below. Each of the terms in brackets along with the parameters and values would be replaced by string values.

 https://tethys-staging.byu.edu/apps/[parent-app]/api/[MethodName]/?param1=value1&param2=value2&...paramN=valueN

To test the API, the user will need a zip file of the region of interest. We have provided an example of files in the appropriate format. You may use your own zip ggst-api.ipynb

File Edit View Insert Runtime Tools Help

+ Code + Text Copy to Drive

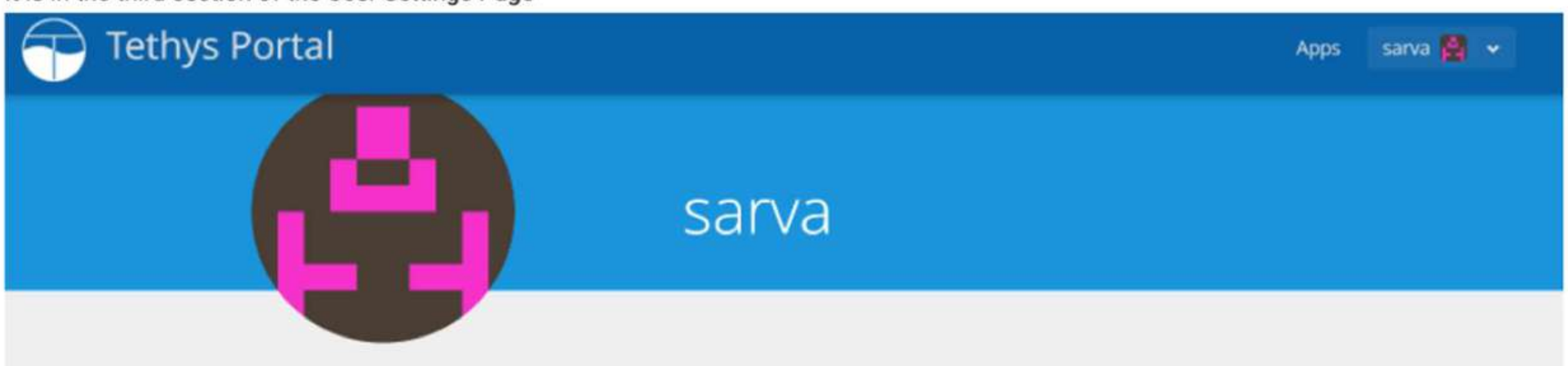
Grace Groundwater Subsetting Tool (GGST) API Walk through

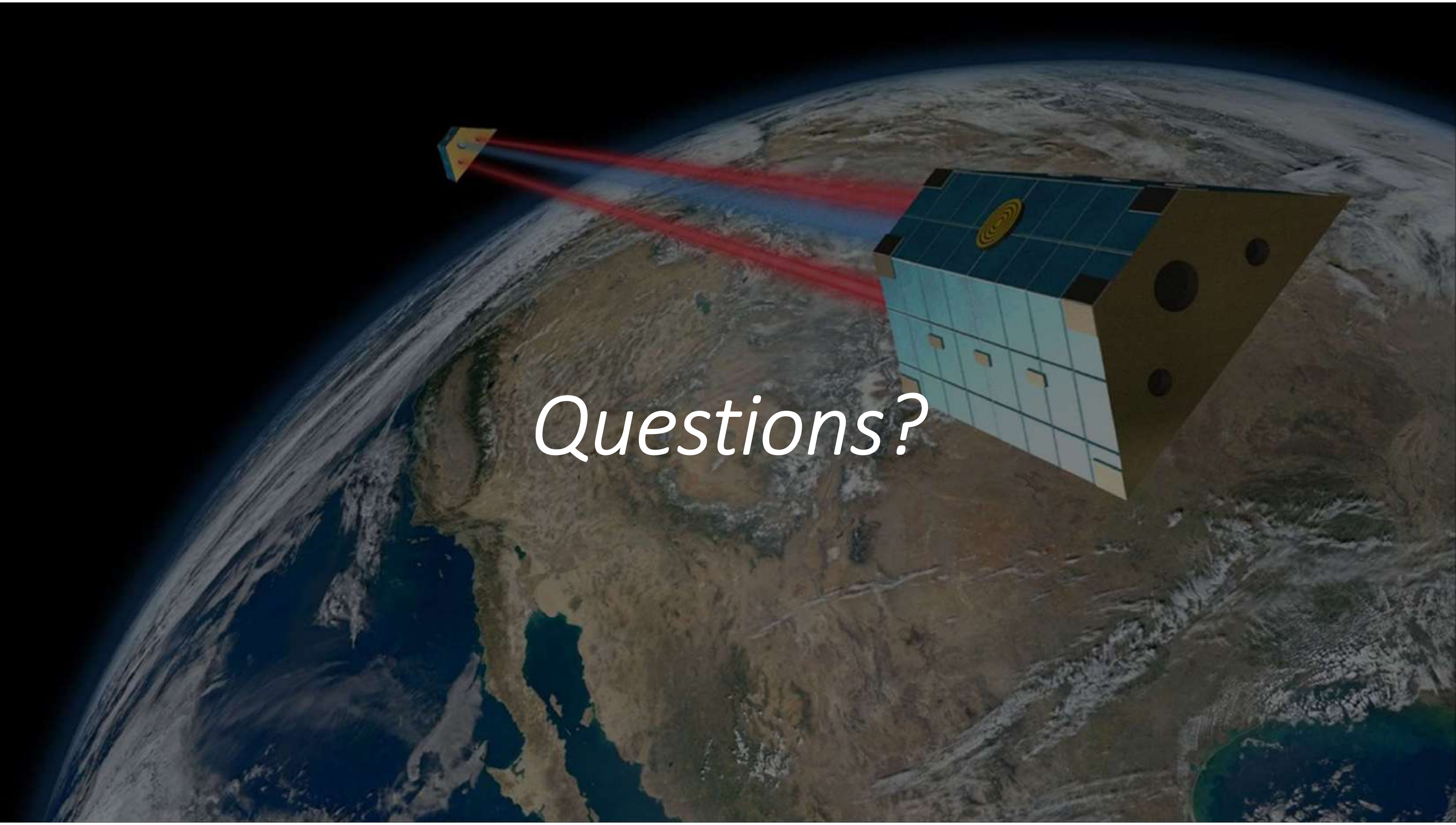
This notebook will walk you through the various API calls in the GGST Tethys app and illustrated how to access the API from Python code. The API is documented in more detail here:

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

In order to run this notebook the user will have to sign up for an account on tethys-staging.byu.edu. Use the login button to get a sign-up prompt. After signing in you can retrieve your API authentication token via the User Settings.

It is in the third section of the User Settings Page




Questions?