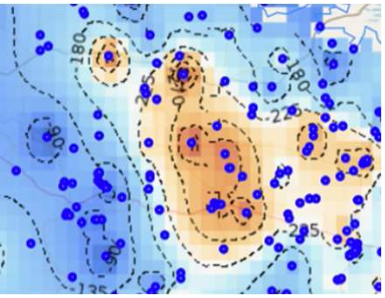
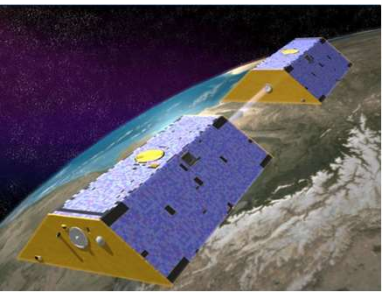
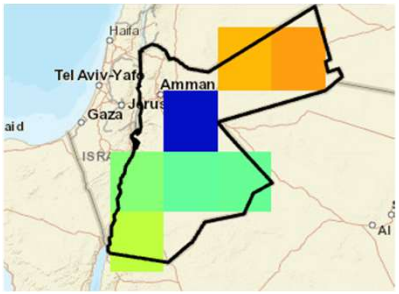
The GRACE Groundwater Subsetting Tool (GGST)

Use of the Gravity Recovery and Climate Experiment (GRACE) mission to monitor groundwater storage change: National workshop for Jordan and State of Palestine

Amman Jordan, February 25-26



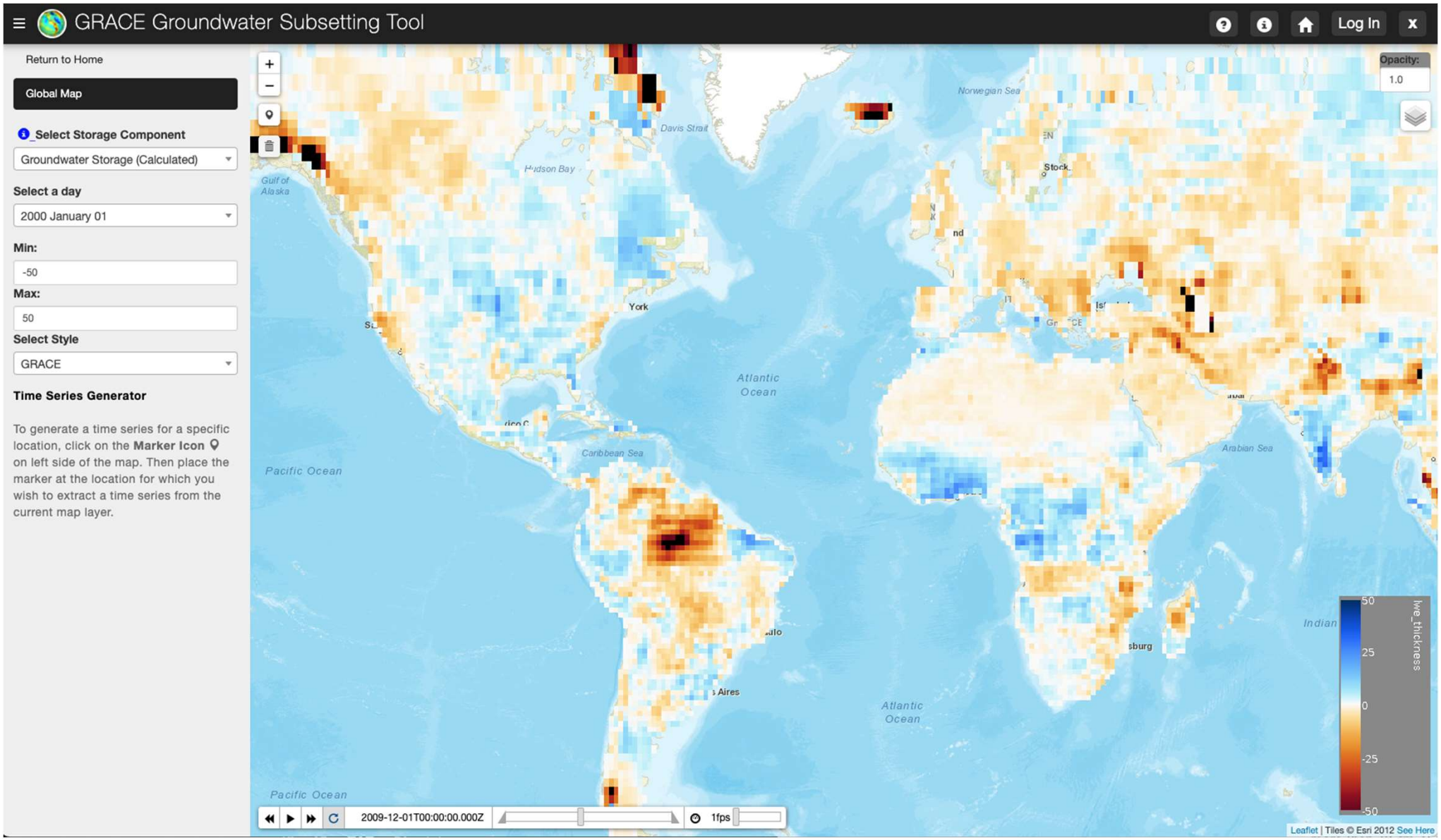


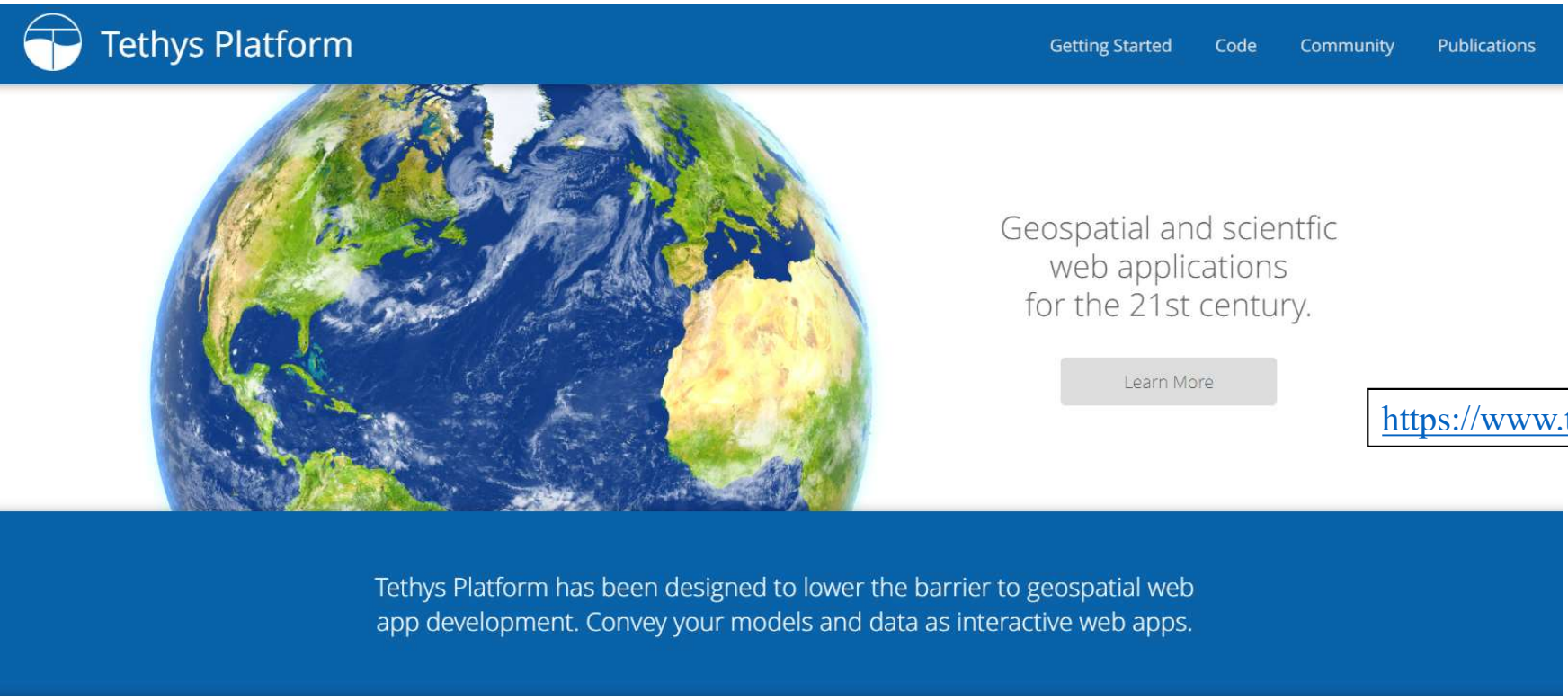


UNITED NATIONS
ESCWA
الاسكوا

Shared Prosperity Dignified Life

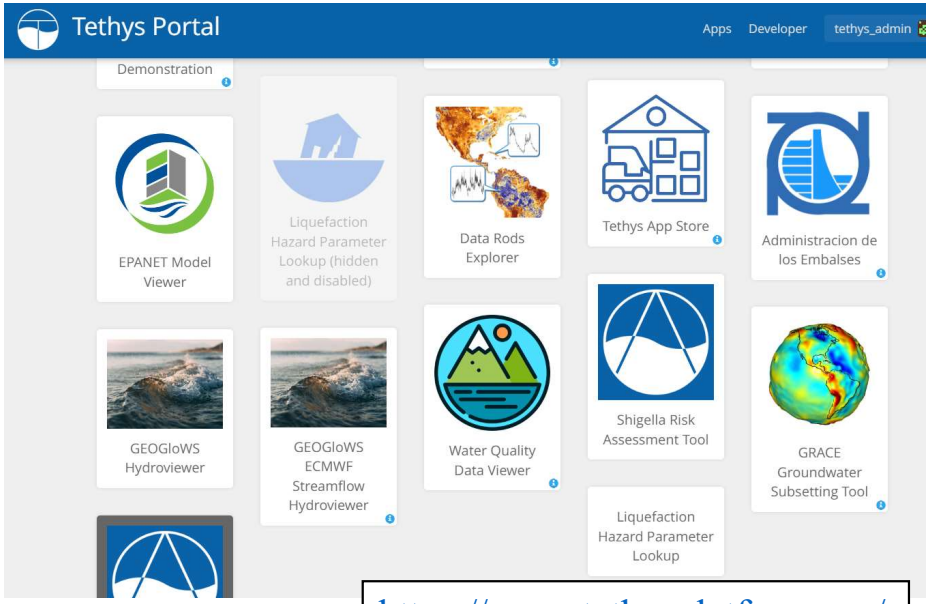
Sweden
Sverige


GRACE Groundwater Subsetting Tool
Log In
Return to Home
Global Map
Select Storage Component
Groundwater Storage (Calculated)
Select a day
2000 January 01
Min:
-50
Max:
50
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
Norwegian Sea
Davis Strait
Hudson Bay
Gulf of Alaska
York
Atlantic Ocean
Caribbean Sea
Pacific Ocean
Arabian Sea
Indian
Atlantic Ocean
Pacific Ocean
2009-12-01T00:00:00.000Z
1fps
50
25
0
-25
-50
lwe_thickness
Leaflet | Tiles © Esri 2012 See Here

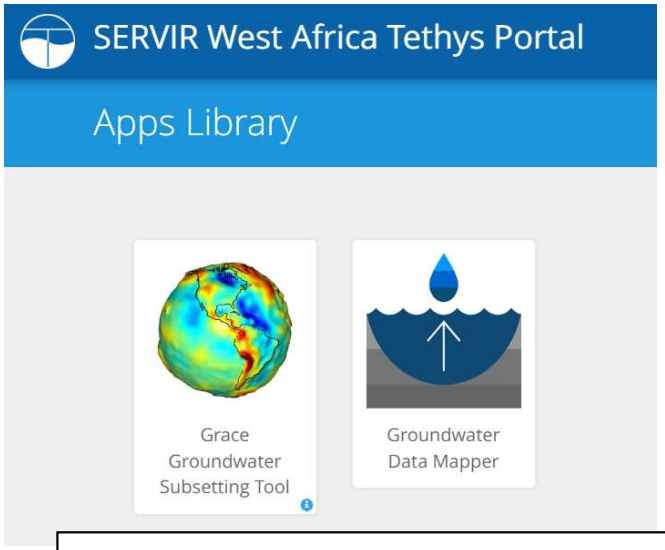


https://www.tethysplatform.org/

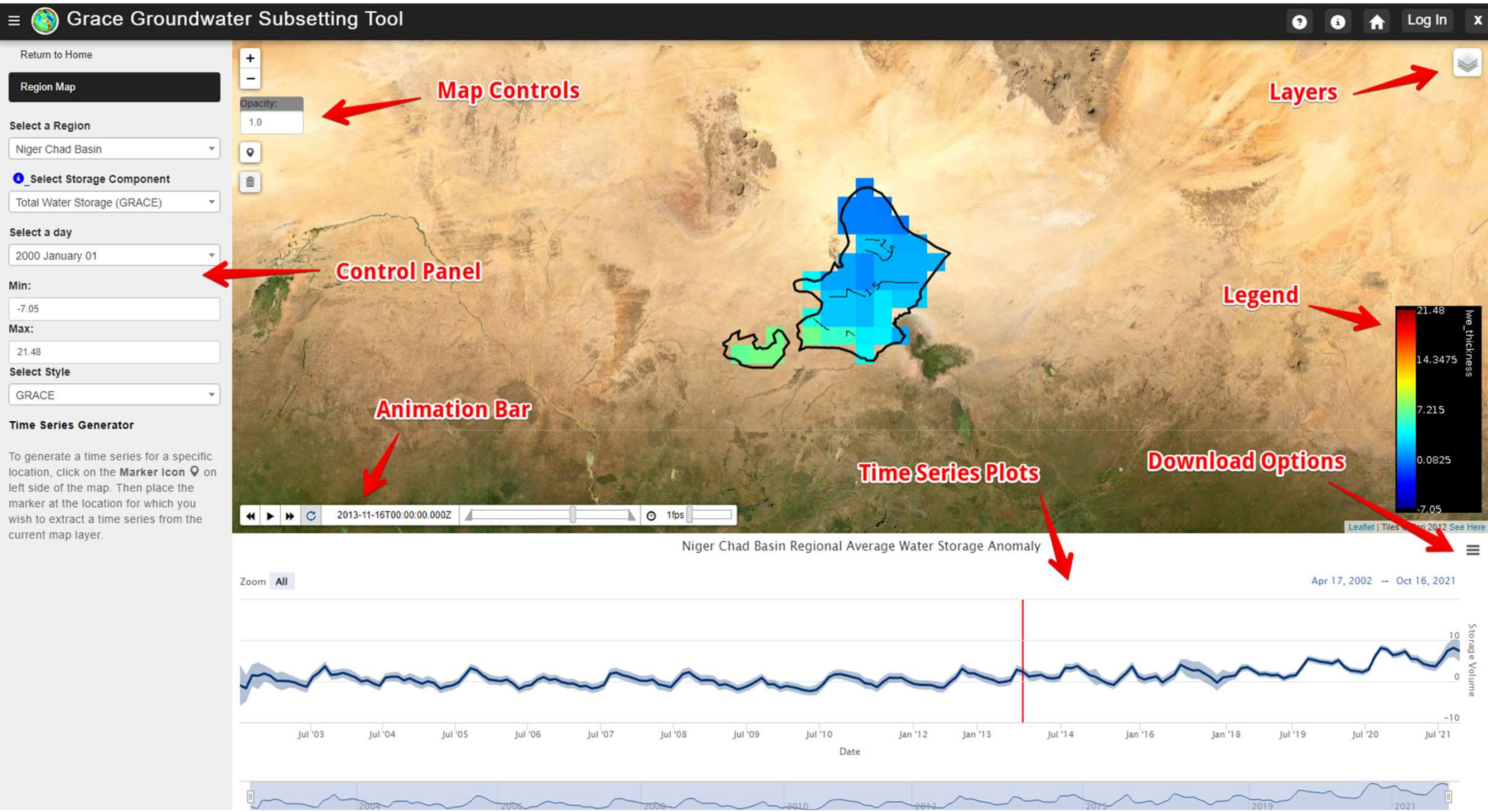
https://apps.geoglows.org/



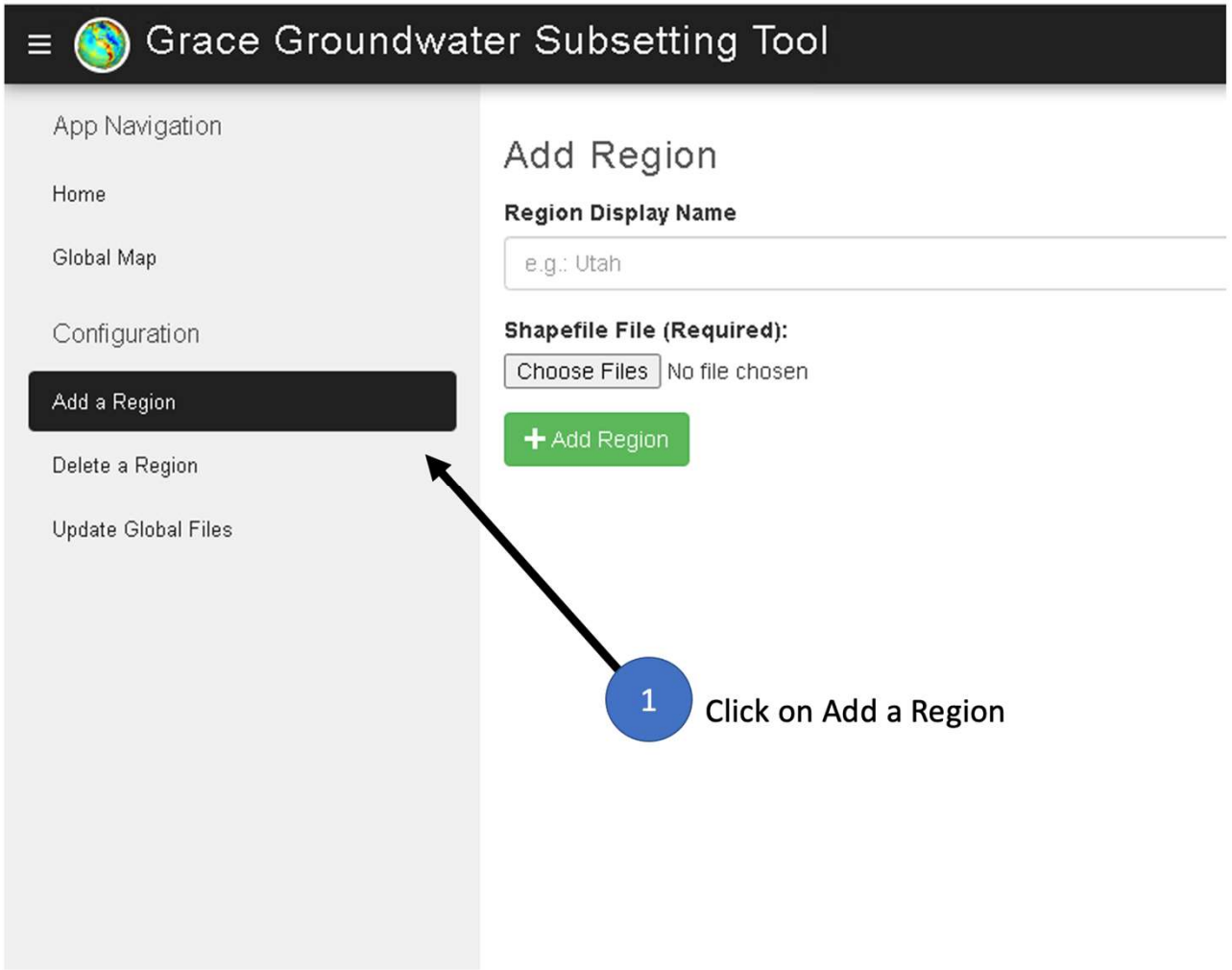
https://www.tethysplatform.org/



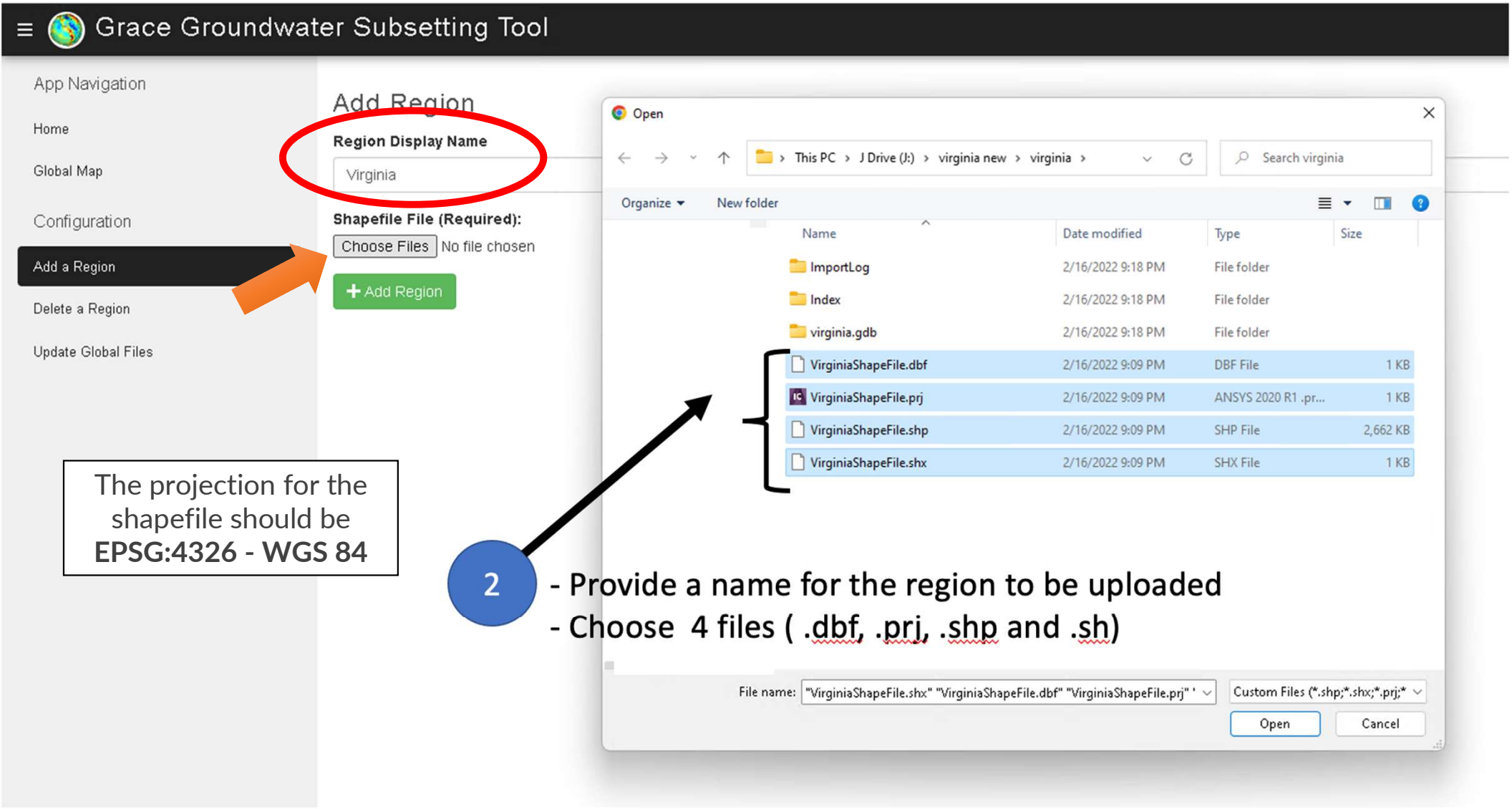
https://tethyswa.servirglobal.net/apps/

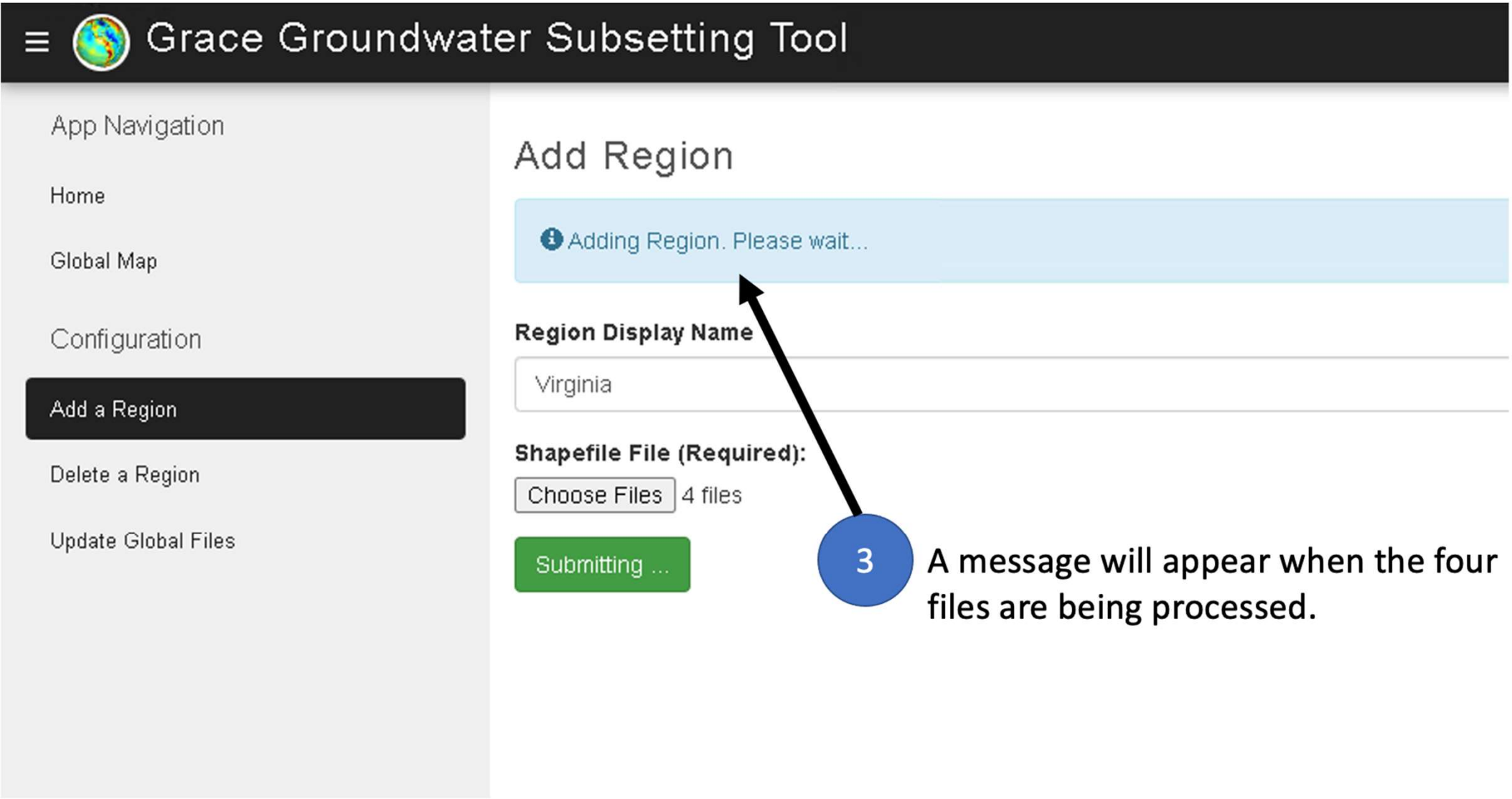

Grace Groundwater Subsetting Tool
Log In
Return to Home
Region Map
Select a Region
Niger Chad Basin
Select Storage Component
Total Water Storage (GRACE)
Select a day
2000 January 01
Min:
-7.05
Max:
21.48
Select Style
GRACE
Time Series Generator
To generate a time series for a specific location, click 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.
Map Controls
Layers
Control Panel
Legend
Animation Bar
Time Series Plots
Download Options
Opacity:
1.0
2013-11-16T00:00:00.000Z
1fps
21.48
14.3475
7.215
0.0825
-7.05
lwe_thickness
Niger Chad Basin Regional Average Water Storage Anomaly
Zoom All
Apr 17, 2002 – Oct 16, 2021
Storage Volume
Jul '03
Jul '04
Jul '05
Jul '06
Jul '07
Jul '08
Jul '09
Jul '10
Jan '12
Jan '13
Jul '14
Jan '16
Jan '18
Jul '19
Jul '20
Jul '21
Date

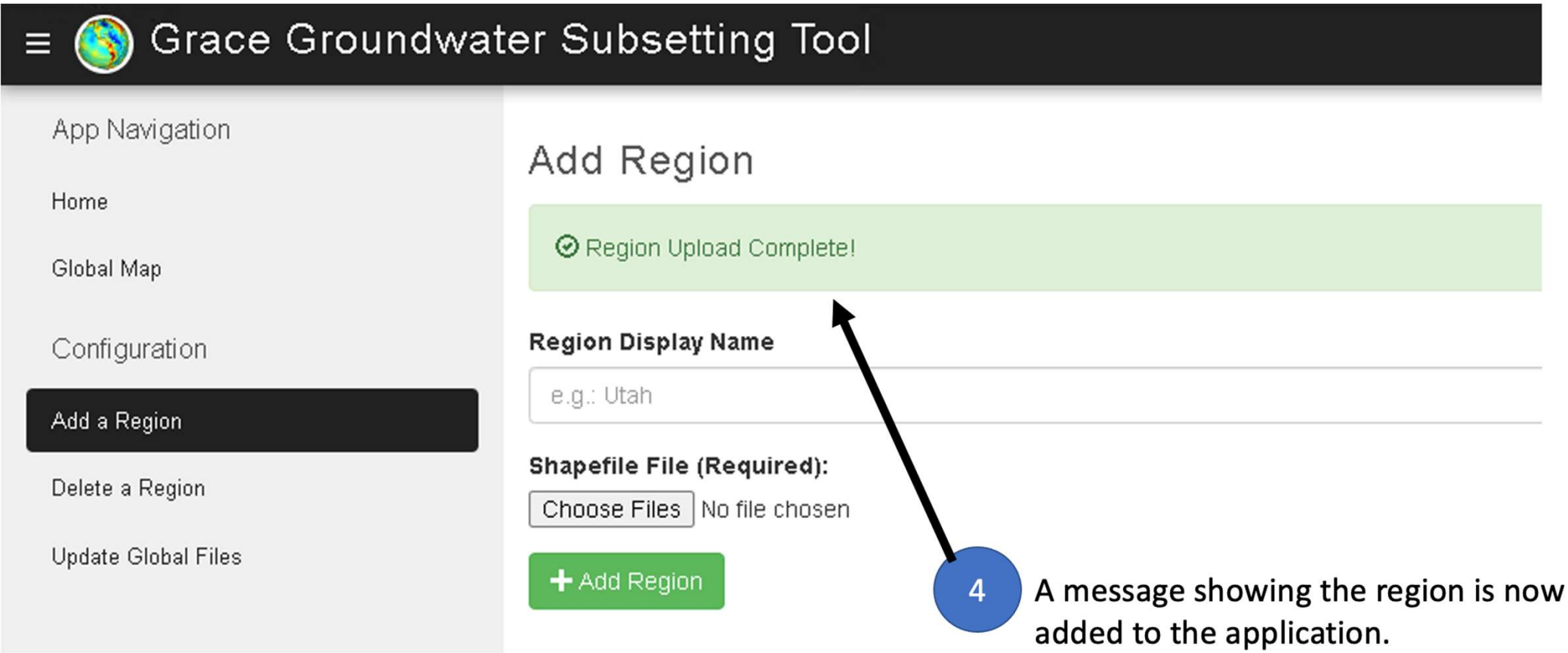
Adding and Deleting Regions

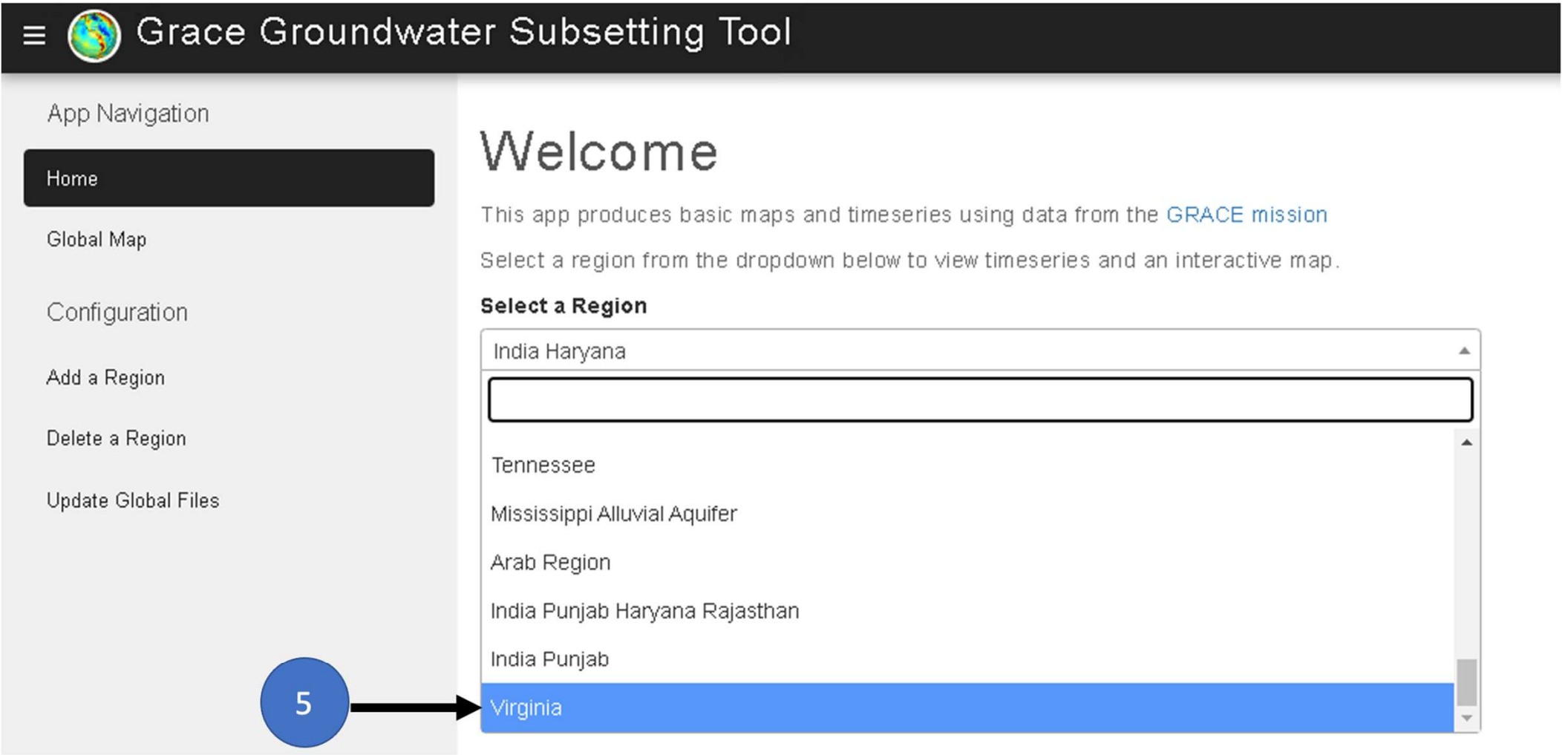


To add or delete regions, you must be logged in to the portal with a user account. Otherwise, the admin control panel on the left is hidden.

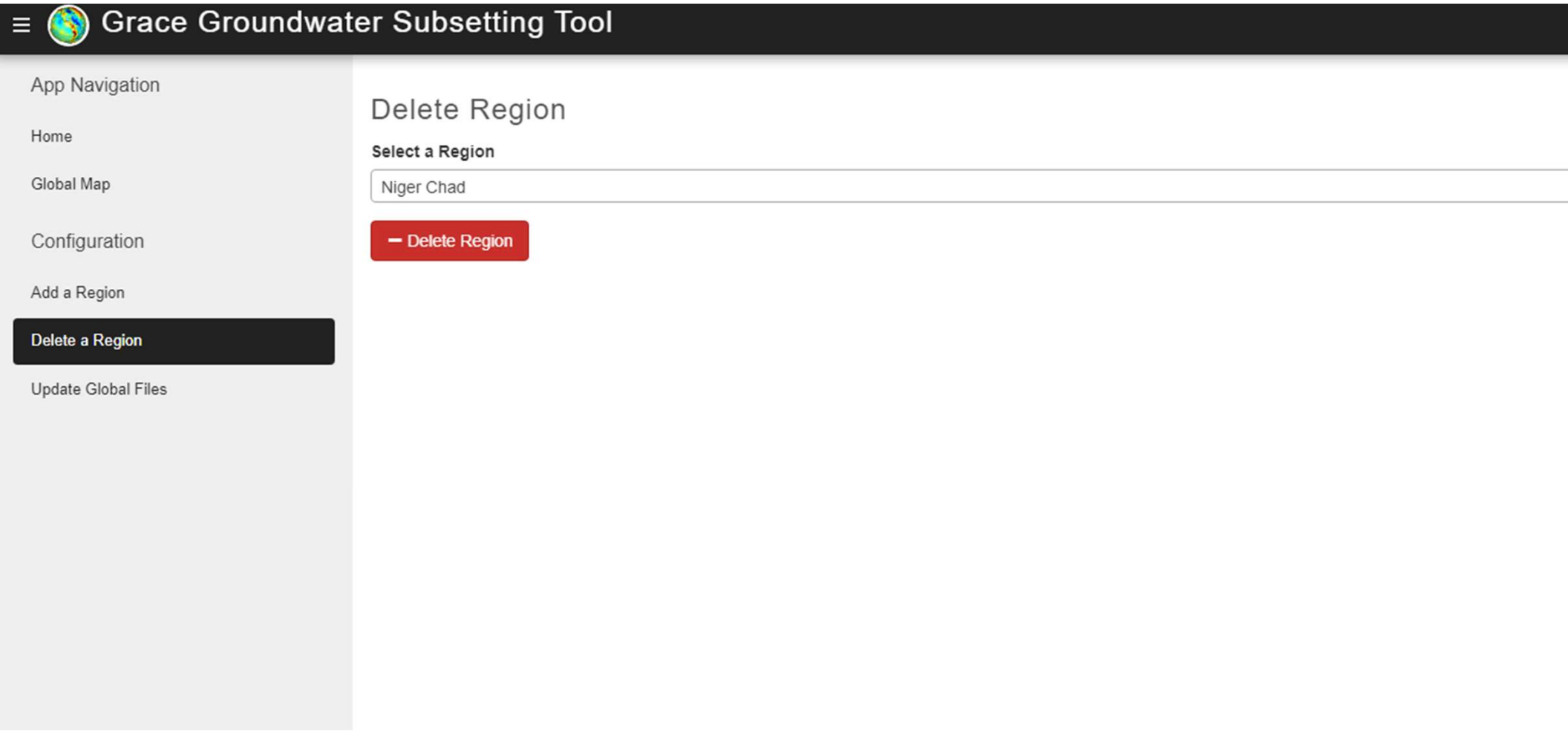

Grace Groundwater Subsetting Tool
App Navigation
Home
Global Map
Configuration
Add a Region
Delete a Region
Update Global Files
Add Region
Region Display Name
Virginia
Shapefile File (Required):
Choose Files
No file chosen
Add Region
Open
This PC › J Drive (J:) › virginia new › virginia ›
Search virginia
Organize
New folder
Name
Date modified
Type
Size
ImportLog 2/16/2022 9:18 PM File folder
Index 2/16/2022 9:18 PM File folder
virginia.gdb 2/16/2022 9:18 PM File folder
VirginiaShapeFile.dbf 2/16/2022 9:09 PM DBF File 1 KB
VirginiaShapeFile.prj 2/16/2022 9:09 PM ANSYS 2020 R1 .pr... 1 KB
VirginiaShapeFile.shp 2/16/2022 9:09 PM SHP File 2,662 KB
VirginiaShapeFile.shx 2/16/2022 9:09 PM SHX File 1 KB
File name: "VirginiaShapeFile.shx" "VirginiaShapeFile.dbf" "VirginiaShapeFile.prj" '
Custom Files (*.shp;*.shx;*.prj;*
Open
Cancel
The projection for the shapefile should be EPSG:4326 - WGS 84
2
- Provide a name for the region to be uploaded
- Choose 4 files (.dbf, .prj, .shp and .sh)


Grace Groundwater Subsetting Tool
App Navigation
Home
Global Map
Configuration
Add a Region
Delete a Region
Update Global Files
Add Region
Adding Region. Please wait...
Region Display Name
Virginia
Shapefile File (Required):
Choose Files
4 files
Submitting ...
3
A message will appear when the four files are being processed.


Grace Groundwater Subsetting Tool
App Navigation
Home
Global Map
Configuration
Add a Region
Delete a Region
Update Global Files
Add Region
Region Upload Complete!
Region Display Name
e.g.: Utah
Shapefile File (Required):
Choose Files
No file chosen
Add Region
4
A message showing the region is now added to the application.



The region can be accessed through the Home ribbon


Grace Groundwater Subsetting Tool
App Navigation
Home
Global Map
Configuration
Add a Region
Delete a Region
Update Global Files
Delete Region
Select a Region
Niger Chad
Delete Region

Application Programming Interface (API)

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.

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

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Connect Colab AI

```
# View available storage types
storage_options = requests.get(portal+ "/apps/ggst/api/getStorageOptions/")
storage_options.json()
```

Function 2: getPointValues

```
#@markdown ### **Set desired inputs for getPointValues function and run this cell**
Latitude =  33#@param {type:"number"}
Lat = str(Latitude)
Longitude = -80 #@param {type:"number"}
Lon = str(Longitude)
F2_Storage_Option = "gw" #@param ["gw", "sm", "sw", "swe", "tws", "canopy", "grace"]

#Run getPointValues function with your inputs
pointvalues = requests.get(portal + "/apps/ggst/api/getPointValues/?latitude="+Lat+"&longitude='
```

Set desired inputs for getPointValues function and run this cell

Latitude: 33

Longitude: -80

F2_Storage_Option: gw

```
#@markdown ### **Run this cell to convert the request to a dataframe and view the timeseries tal
# Get the json object from the request
pointvalues_json = pointvalues.json()
# Create a dataframe from the JSON for plotting
point_ts = (pandas.DataFrame(columns=["date", "ts"], data=pointvalues_json["values"])
            .merge(pandas.DataFrame(columns=["date", "error_min", "error_max"], data=pointvalue
point_ts["date"] =  pandas.to_datetime(point_ts.date*1000000)
point_ts
```

Run this cell to convert the request to a dataframe and view the timeseries table

```
#@markdown ### **Run this cell to plot the dataframe**
# Plot the dataframe with error range
fig, ax = plt.subplots(1, 1, figsize=(25,5))
ax.plot(point_ts.date, point_ts.ts)
ax.fill_between(point_ts.date, point_ts.error_min, point_ts.error_max, alpha=0.35)
ax.set_title(F2_Storage_Option+' Anomaly Timeseries at Point ' +Lat+', '+Lon)
```

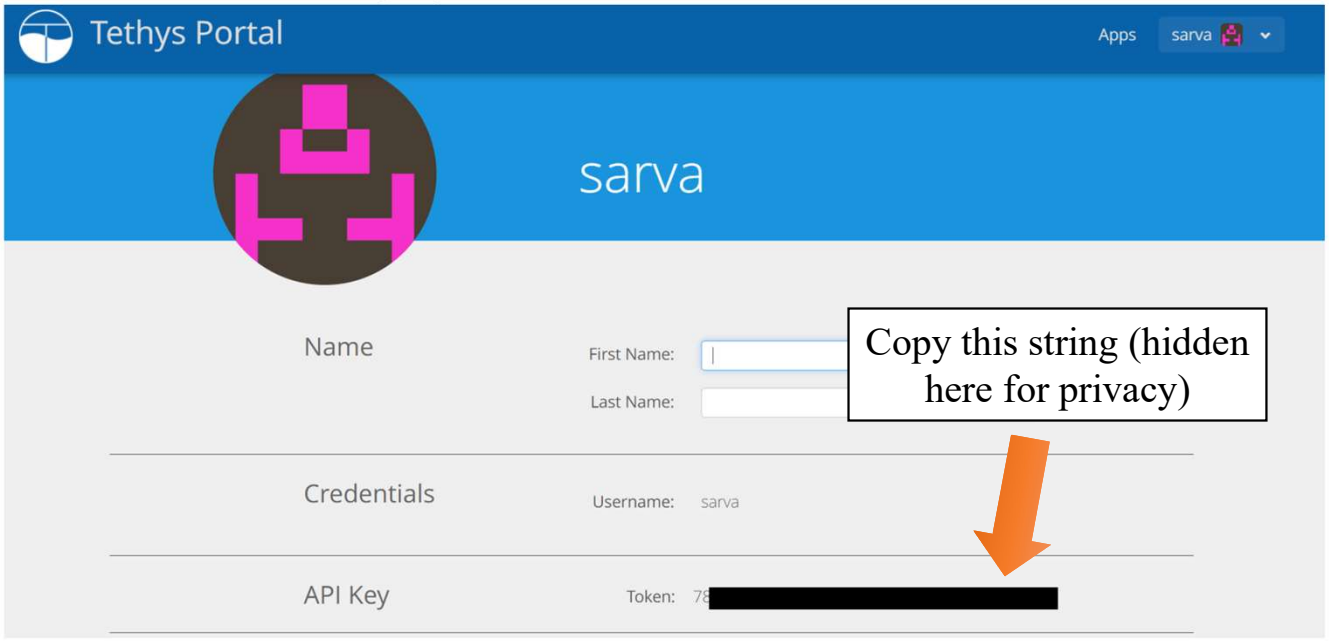
Run this cell to plot the dataframe

```
#@markdown ### **Run this cell to create timeseries CSV**
#@markdown  You can download the CSV from the files panel on the left side of the window
#Export timeseries to CSV
point_ts.to_csv('PointTimeseries_'+Lat+'_'+Lon+".csv")
```

Run this cell to create timeseries CSV

You can download the CSV from the files panel on the left side of the window

Obtaining an Authentication Token



In order to perform regional subsetting with a shapefile using the API, you will need an authentication token from a user account on the server you are using. This is entered in the API script.

ggst_api.ipynb

File Edit View Insert Runtime Tools Help Cannot save changes

Share

Files

..

sample_data

PointTimeseries_33_-80.csv

CSV file for download

+ Code + Text Copy to Drive

RAM Disk

Colab AI

Next steps: Generate code with point_ts View recommended plots

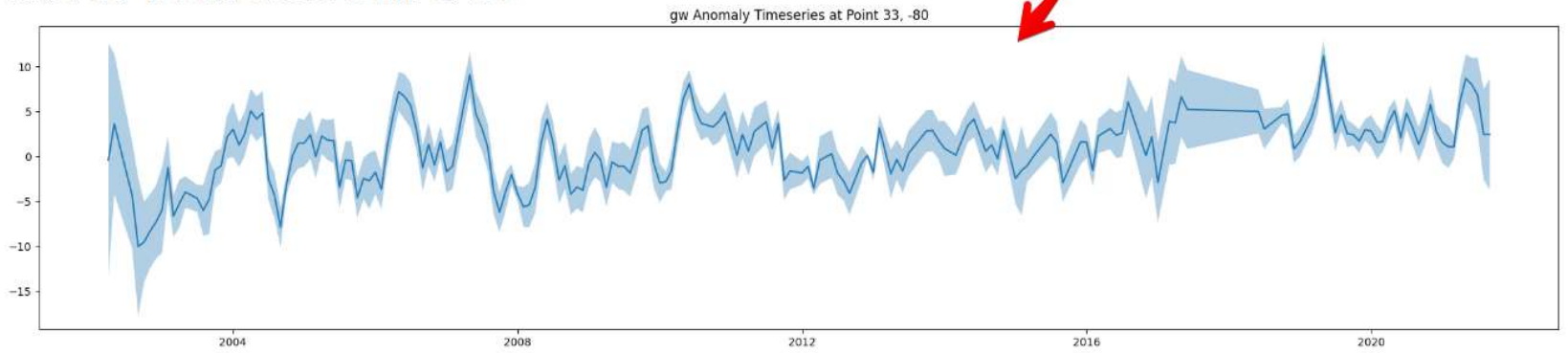
[7]

```
#@markdown ### **Run this cell to plot the dataframe**
# Plot the dataframe with error range
fig, ax = plt.subplots(1, 1, figsize=(25,5))
ax.plot(point_ts.date, point_ts.ts)
ax.fill_between(point_ts.date, point_ts.error_min, point_ts.error_max, alpha=0.
ax.set_title(F2_Storage_Option+' Anomaly Timeseries at Point ' +Lat+', '+Lon)
```

Run this cell to plot the dataframe

Interactive charting of results

```
Text(0.5, 1.0, 'gw Anomaly Timeseries at Point 33, -80')
```




```
#@markdown ### **Run this cell to create timeseries CSV**
#@markdown  You can download the CSV from the files panel on the left side of t
#Export timeseries to CSV
point_ts.to_csv('PointTimeseries_'+Lat+'_'+Lon+".csv")
```

Run this cell to create timeseries CSV

You can download the CSV from the files panel on the left side of the window

Requesting Info for Regional Functions 3 and 4

42 cells hidden

Online Documentation

Overview

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 several tools have been developed for processing and visualizing GRACE data, GGST 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 improve resolution. This is done by separating the groundwater component from the other water storage components using GLDAS, 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 Colaboratory Notebook that makes the API intuitive to use. A brief introduction to these two methods is provided below.

GGST Web Application

The GGST web application was built using Tethys Platform. Tethys is a web-based application development framework for rapid deployment of end-user-focused tools that follow modern, consistent, scalable, cross-platform, reusable, web programming paradigms. Tethys is built on commonly used web programming frameworks (e.g., Django, GeoServer, PostGIS, OpenLayers). It is an open-source platform which allows anyone to observe and use the GGST as a decision support system to ensure sustainable usage of groundwater. It was developed in the BYU Hydroinformatics Laboratory and is now supported by a growing user and developer community. To access the GGST web application, visit https://tethys.byu.edu/apps/ggst/.

Anyone can open the app to view the currently uploaded regions and download the timeseries plots. View the screenshot below to see how to manipulate the map and download the data. Users can change the storage component displayed and the color bar style. Use the animation bar to view the storage change over time. Users can also download the time series plots as an image or as a table. The web app does not yet support downloading the NETCDF file raster that is displayed but this can be downloaded using the API.

https://ggst.readthedocs.io/

ملخص

تقديرات شهرية لتشوذات تخزين المياه في ارتفاع المياه المكافئ ويقدم حلولاً شهرية لمجال الجاذبية منذ أبريل 2002. تتوفر GRACE لإنشاء سلاسل زمنية وخرائط متحركة لتغييرات تخزين المياه الجوفية. يوفر GRACE بيانات GGST يستخدم تطبيق (J. Famiglietti et al., 2011 ; JS Famiglietti, 2014 ; Rodell, Velicogna, & Famiglietti, 2009 ; Thomas, Reager, Famiglietti, & Rodell, 2014) أنه أداة فعالة لتوصيف التغيرات في تخزين المياه الجوفية في المناطق الكبيرة GRACE تقديرات التباين الشامل وأخطاء المراقبة المرتبطة به على شبكة عالمية بطول 300 كيلومتر. لقد أثبت

الأولية بعناية GRACE خصيصًا لدعم إدارة موارد المياه الجوفية من قبل أصحاب المصلحة الإقليميين وصناع القرار. نحن نحقق ذلك من خلال معالجة بيانات GGST تم تصميم GRACE، في حين تم تطوير العديد من الأدوات لمعالجة وتصور بيانات وتقسيم البيانات إلى مناطق محددة محل الاهتمام، ومن خلال تقديم النتائج في واجهة بسيطة وبديهية. الخوارزمية GLDAS، لإزالة الحالات الشاذة وتحسين الدقة. ويتم ذلك عن طريق فصل مكون المياه الجوفية عن مكونات تخزين المياه الأخرى باستخدام لإنتاج شذوذات المياه الجوفية على المستويين العالمي والإقليمي موصوفة بالتفصيل في صفحة الخوارزمية GLDASو GRACE التي نستخدمها لمعالجة بيانات.

سهلة الاستخدام. ويرد أدناه مقدمة موجزة لهاتين الطريقتين (API) التعاونية المرتبطة بها والتي تجعل واجهة برمجة التطبيقات Google ومفكرة (API) أو باستخدام واجهة برمجة التطبيقات Tethys باستخدام تطبيق الويب GGST يمكنك الوصول إلى

GGST تطبيق ويب

هو إطار عمل لتطوير التطبيقات على شبكة الإنترنت من أجل النشر السريع للأدوات التي تركز على المستخدم النهائي والتي تتبع نماذج برمجة ويب حديثة ومتسقة وقابلة للتطوير Tethys . Tethys باستخدام منصة GGST تم إنشاء تطبيق الويب كنظام GGST إنها منصة مفتوحة المصدر تسمح لأي شخص بمراقبة واستخدام .(OpenLayersو PostGISو GeoServerو Django مثل) على أطر برمجة الويب الشائعة الاستخدام Tethys ومتعددة المنصات وقابلة لإعادة الاستخدام. تم بناء تفضل بزيارة GGST. ويدعمه الآن مجتمع متزايد من المستخدمين والمطورين. للوصول إلى تطبيق الويب BYU Hydroinformatics لدعم القرار لضمان الاستخدام المستدام للمياه الجوفية. تم تطويره في مختبر https://tethys.byu.edu/apps/ggst/ .

يمكن لأي شخص فتح التطبيق لعرض المناطق التي تم تحميلها حاليًا وتنزيل مخططات السلاسل الزمنية. شاهد لقطة الشاشة أدناه لمعرفة كيفية التعامل مع الخريطة وتنزيل البيانات. يمكن للمستخدمين تغيير مكون التخزين المعروض ونمط شريط الألوان. النقطي الذي يتم عرضه ولكن يمكن تنزيله باستخدام NETCDF استخدم شريط الرسوم المتحركة لعرض تغيير التخزين بمرور الوقت. يمكن للمستخدمين أيضًا تنزيل مخططات السلاسل الزمنية كصورة أو كجدول. لا يدعم تطبيق الويب بعد تنزيل ملف واجهة برمجة التطبيقات.

Questions?