Mapping remote sensed soil moisture data lab

Objective

This lab exposes students to the concepts of soil moisture, remote sensing data, and GIS mapping.

Objectives:

- Understand the concept of volumetric soil moisture
- Learn how to download Soil Moisture Active Passive (SMAP) remote sensing data
- Learn how to map SMAP data

Required Materials:

- Computer with ArcMap
- Internet

Introduction

Soil moisture is an important tool for monitoring droughts, predicting floods, estimating crop growth, etc. However, it would be costly to measure on-site soil moisture data in the field for a wide study area. NASA's Soil Moisture Active Passive (SMAP) mission collects soil moisture data from an Earth-orbiting observatory and makes it available to the public. Figure 1 shows the SMAP satellite.

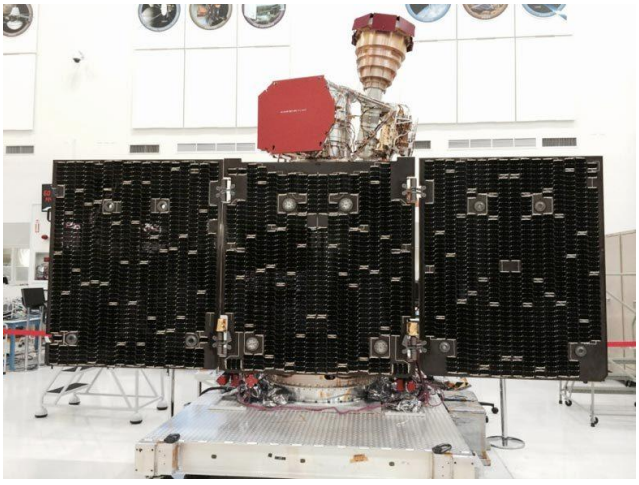


Figure 1. The SMAP satellite (Image source: https://smap.jpl.nasa.gov/mission/description/).

NASA scientists use remote sensing data and mathematical analysis techniques to estimate soil moisture. This analyzed data is called "SMAP L4 Global 3-hourly 9 km EASE-Grid Surface and Root Zone Soil Moisture Analysis Update, Version 4." Since this data set covers the entire world, its resolution is

not high (only 9 km). However, this data set is very important for monitoring regional droughts and estimate the productivity of soils.

This level 4 SMAP data set provides volumetric soil moisture data. What is volumetric soil moisture? Volumetric soil moisture θ is defined as

$$\theta = \frac{V_w}{V_s + V_v + V_w}$$

where V_s, V_v, and V_w are the volumes of soil particles, void, and water, respectively. In this equation, if void is filled with water, V_v becomes 0 and V_w becomes V_v+V_w. Rewriting this condition yields

$$\rho = \frac{V_v + V_w}{V_s + V_v + V_w}$$

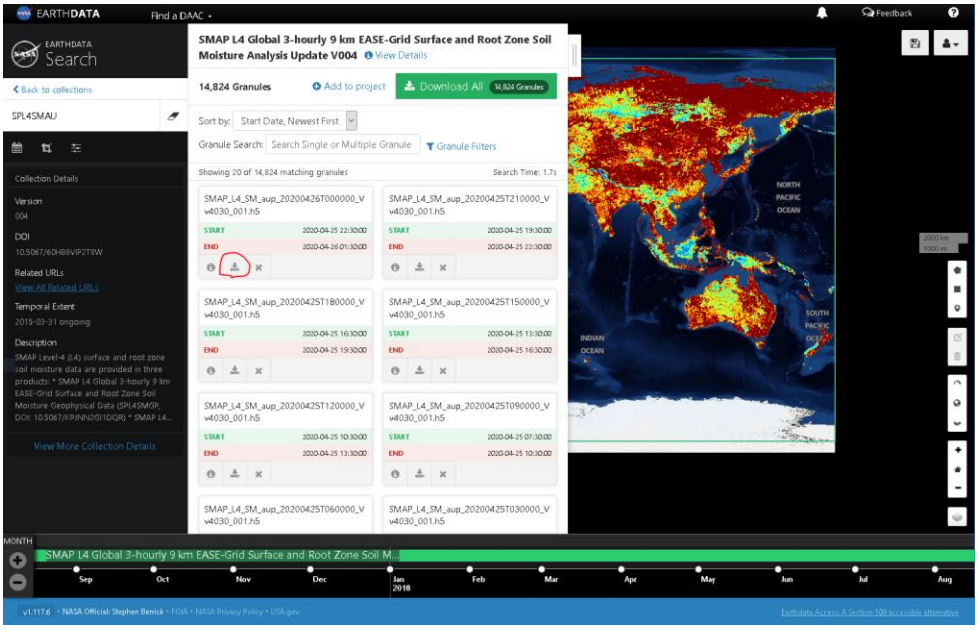
where ρ is soil porosity. What it means is that when soil becomes fully saturated, its volumetric soil moisture reaches the porosity of soil.

In this lab, our objective is to download the SMAP soil moisture data and map it in ArcMap.

Procedure

1. Download the level 4 SMAP surface moisture data

You need to create an account on Earthdata (https://nsidc.org/data/SPL4SMAU/versions/4 ➔ Download Data ➔ Login to Earthdata). Login and come back. Click Other Access Options ➔ Earthdata Search. Don't worry about zooming in and select an area. I've tried that, but it didn't do anything useful. This worldwide data file is not big at all because of a low resolution (only 86MB per temporal snapshot). Click the download button in red below. Record the date and time.



Alternatively, you can copy this file from U:\Shared\GIS\ClassFiles\hcho\Archive\GISData\SMAP\SMAP_L4_SM_aup_20200426T000000_Vv4030_001.h5.

2. HDF5 file format

Its file extension is .h5, which is the file format for HDF5 files. HDF stands for Hierarchical Data Format. This file format is used to store data in a hierarchical structure. For example, the HDF5 file you downloaded stores more than one map layers.

3. Find the layer for surface soil moisture

You need to know which of those layers you want to visualize in ArcMap. Where can you find that information? Click the User Guide tab from the level 4 data URL (https://nsidc.org/data/SPL4SMAU/versions/4). Remember that we're using the level 4 analysis data, so scroll down to the Analysis_Data section. Find sm_surface_analysis from Table A2 and click the link, which will bring you to https://nsidc.org/data/SPL4SMAU/versions/4#sm_surface_wetness_analysis. What is that data? Yes, Analysis surface soil moisture (0-5 cm; wetness units[5]) (sm_surface_wetness_analysis). What does it mean? 0-5 cm does not mean the range of data is 0-5 cm. This range is the depth of the top soil layer for which analysis was performed, so the maximum soil depth was 5 cm and the minimum was 0 (surface soil). Find the footnote 5 for units.

> *Soil moisture output in the Analysis Update (*aup*) group is provided only in m3/m3 (volumetric percent)*

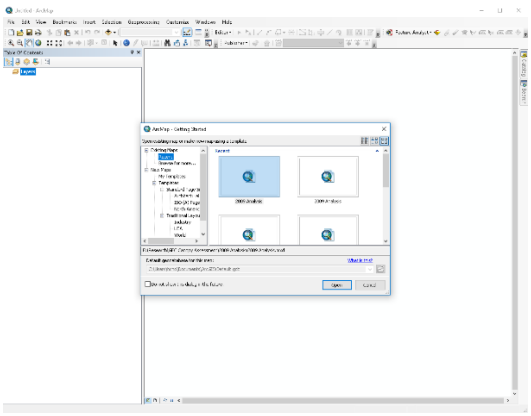
It's volumetric m^3/m^3 meaning unitless. The Product Specification Document defines volumetric soil moisture units as

> *The volume of (liquid or frozen) soil water per total (bulk) soil volume, with a minimum possible value of zero and a maximum possible value given by the soil porosity.*

In other words, it means the total volume of liquid or frozen water divided by the total volume of soil including soil particles, water, and void. Multiplying this unit by 100 would give you volumetric percentage.

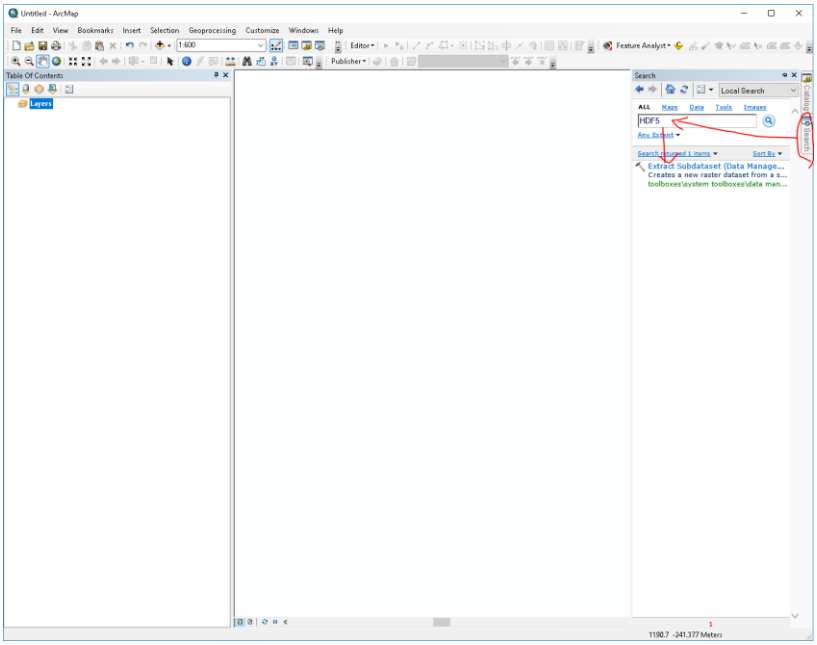
4. Start ArcMap

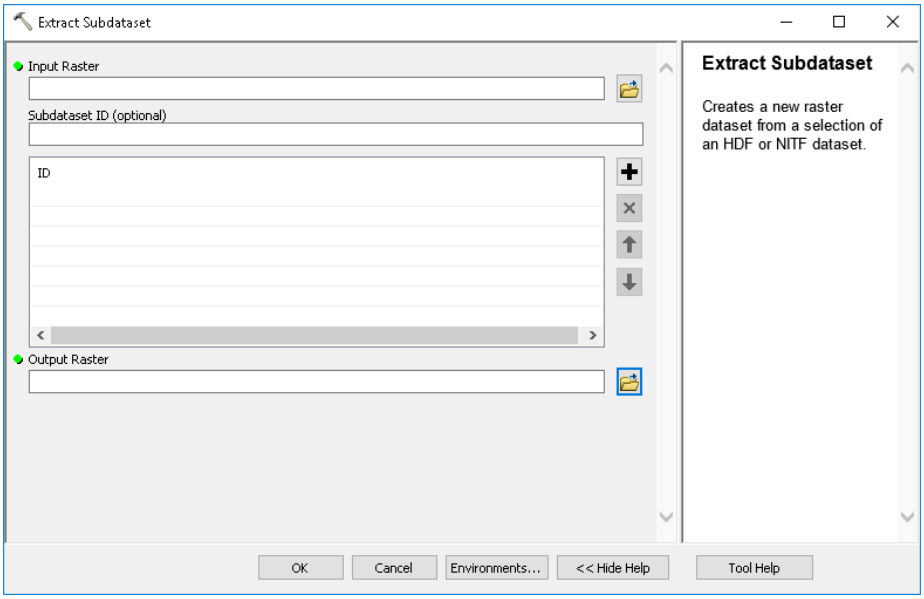
Start ArcMap and click Cancel because you want to create a new map.



5. Find the Extract Subdataset tool

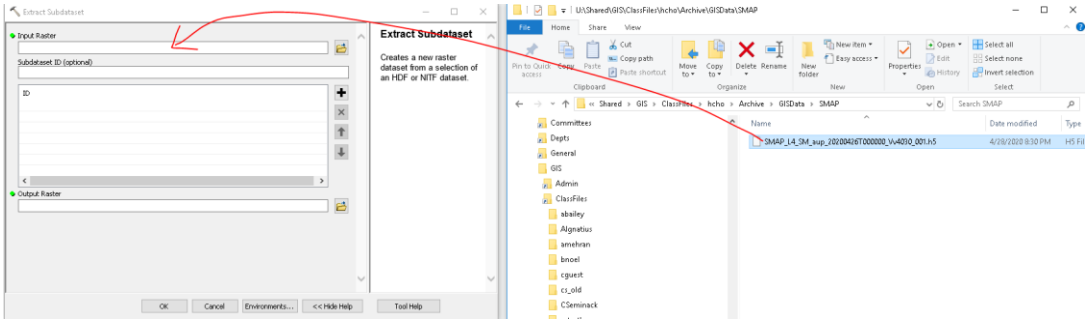
ArcMap provides a built-in tool for reading HDF5 files. Find and start this tool. Search ➔ Type “HDF5” ➔ Extract Subdataset.



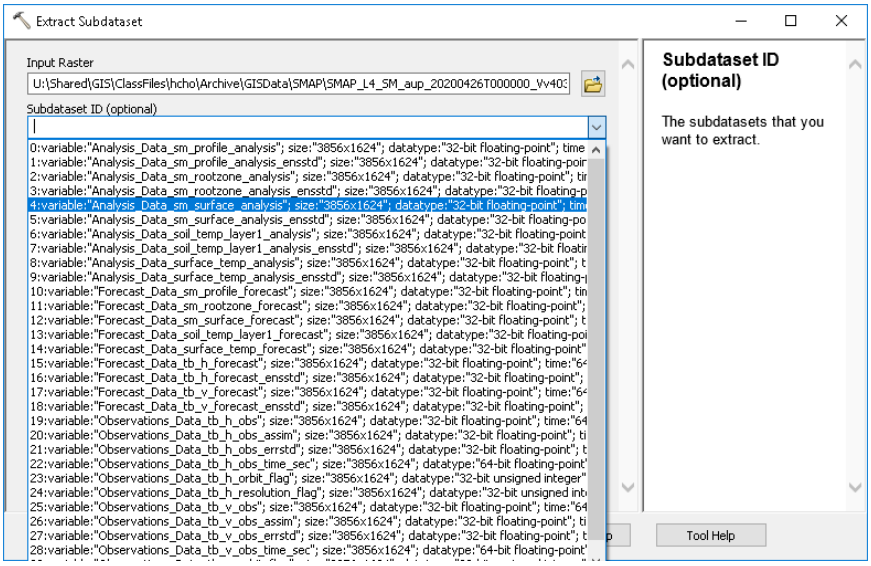


6. Drag and drop the HDF5 file to Input Raster

Open the File Explorer ad browse to your data folder where you downloaded the HDF5 file. Drag and drop the file into Input Raster.

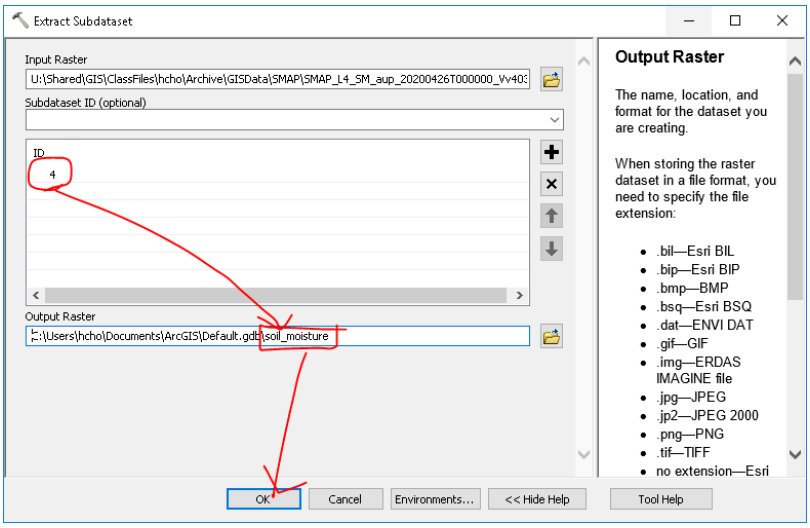


7. Select the sm_surface_analysis layer



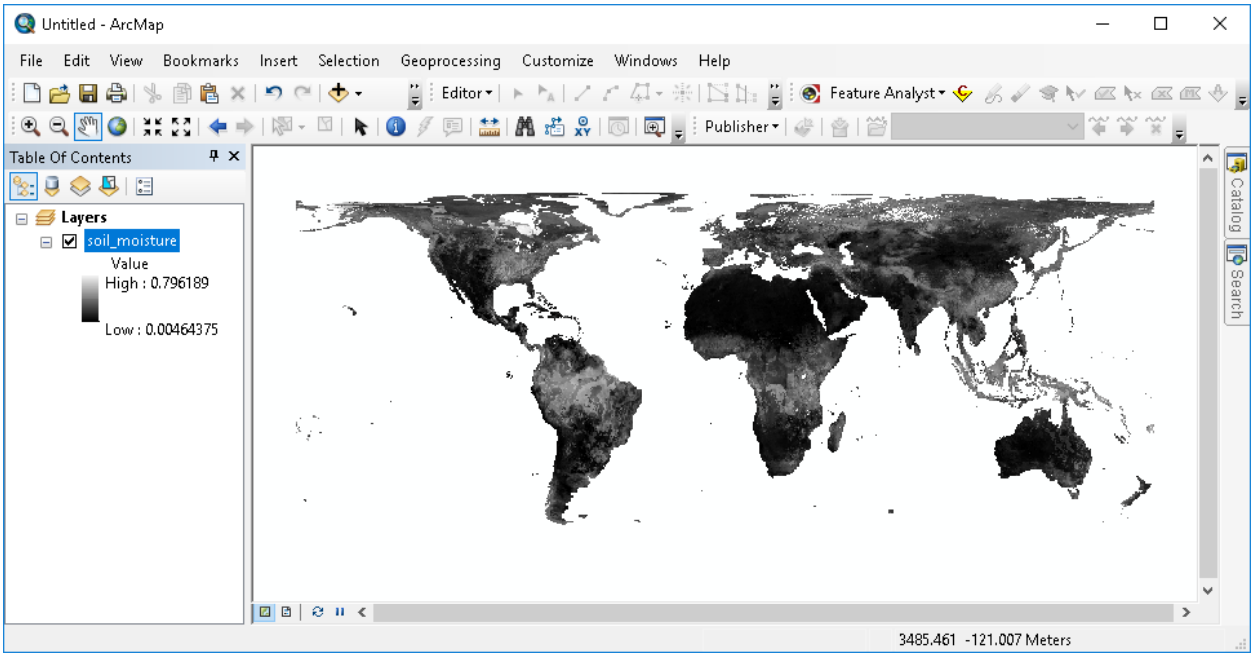
8. Rename Output Raster and run it

Rename the output raster to soil_moisture and click OK.



9. Surface soil moisture layer

The final layer for surface soil moisture will look like the following:



In this case, the volumetric percentage of soil moisture varies from 0.5 to 79.6%. You can now easily spot areas with extreme droughts and areas with highly saturated surface soil, which may be associated with potential floods depending on weather forecasting.