EARTH OBSERVATION CLIMATE INFORMATION SERVICE

Quick Start Guide

Africa soil moisture and related variables

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1. Quick Start: Africa-wide soil moisture and related variables

The following will provide you with sufficient information to quickly get to grips with the Africa-wide soil moisture and related variables dataset product(s) and to gain some familiarity with the information available.

The Africa-wide soil moisture and related variables product (1983 to present) is generated by assimilating NASA SMAP soil moisture data into the JULES land surface model and forced with TAMSAT satellite rainfall estimates.

1.1 What products are available?

Product name and acronym	Filename example	Version
Africa soil moisture and related variables	EOCIS-SM-L4-WB-AFRICA-TAMSAT-20240101-fv2.3.0.nc	2.3.0

Table 1 Dataset Product covered in this document

1.2 Summary information

Product Name	Africa soil moisture and related variables
Main variable(s)	Soil moisture
Geographical range of dataset	Africa including Madagascar
Temporal range of dataset	01/01/1983-present
Spatial resolution / gridding	0.25° x 0.25°
Temporal sampling characteristics	Daily average
Level of processing	L4 modelled data
Main auxiliary content	None
Dataset citation	TBC
Dataset journal reference	Pinnington, E., Quaife, T., and Black, E.: Impact of remotely sensed soil moisture and precipitation on soil moisture prediction in a data assimilation system with the JULES land surface model, Hydrol. Earth Syst. Sci., 22, 2575–2588, https://doi.org/10.5194/hess-22-2575-2018, 2018.

Table 2 Summary Information for Africa-wide soil moisture and related variables

1.2.1 Variables summary information

Variable name	Description	Units
fsmc	Plant function type soil moisture availability factor	beta (unitless)
fsmc_gb	Gridbox soil moisture availability factor	beta (unitless)
smcl	Moisture content of each soil layer	kg m^{-2}
smcl_avail_top	Gridbox available moisture in top 1.0 m of soil	kg m^{-2}

runoff	Gridbox runoff rate	kg m^{-2} s^{-1}
precip	Gridbox precipitation rate (TAMSAT rainfall)	kg m^{-2} s^{-1}
ecan_gb	Gridbox mean evaporation from canopy/surface store	kg m^{-2} s^{-1}
gpp	Plant function type gross primary productivity	kg C m^{-2} s^{-1}
gpp_gb	Gridbox gross primary productivity	kg C m^{-2} s^{-1}

Table 3 Summary information for each variable for Africa-wide soil moisture and related variables

1.3 What can these products be used for?

The TAMSAT soil moisture product provides rooting depth soil moisture and other related water balance variables since 1983 and is updated in near-real time. As such, the product can be useful in many operational and research applications.

It is useful for agricultural drought monitoring and can forewarn to poor crop growing conditions (soil moisture deficits precedes reduced crop growth). The data are also consistent with the TAMSAT-ALERT platform which provides seasonal forecasts of soil moisture, allowing for historical soil moisture data to be seamlessly integrated into probabilistic forecasts. The longevity of the dataset also makes it well suited for trend analysis of soil moisture and drought risk assessments.

1.4 Where to find these products for download

The Africa-wide soil moisture and related variables dataset can be accessed from JASMIN using the following URL: https://gws-access.jasmin.ac.uk/public/tamsat/soil_moisture/eocis/

One of the soil moisture variables (fsmc – soil moisture availability factor) is also served through the TAMSAT website (https://www.tamsat.org.uk/data) which provides subsetting capability as well as visualisation (maps) of the data and their anomalies (see Section 1.6). The TAMSAT rainfall product can also be accessed here, providing users access to both soil moisture and rainfall on the same platform.

No registration is needed to access the data.

1.5 Using downloaded data

The Africa-wide soil moisture and related variables product is provided in netCDF format (about 2Mb per daily file) and can be easily read by many computing programmes. Here, Python examples of importing, subsetting, creating area-average time-series and visualising the data are given, exploiting the strengths of the Python libraries - xarray and pandas.

1.5.1 Import Data

Example Code:

```
import xarray as xr

# Open soil moisture daily file for 1st January 2020
filename = 'EOCIS-SM-L4-WB-AFRICA-TAMSAT-20200101-fv2.3.0.nc'
ds = xr.open_dataset(filename)
print(ds)
```

Illustrative Results:

```
<xarray.Dataset>
Dimensions:        (lon: 278, lat: 292, time: 1, soil: 4, pft: 5)
Coordinates:
  * lon            (lon) float64 -17.88 -17.62 -17.38 ... 50.88 51.12 51.38
  * lat            (lat) float64 -35.38 -35.12 -34.88 ... 36.88 37.12 37.38
  * time           (time) datetime64[ns] 2020-01-01
Dimensions without coordinates: soil, pft
Data variables:
    smcl           (time, soil, lat, lon) float32 ...
    smc_avail_top  (time, lat, lon) float32 ...
    fsmc           (time, pft, lat, lon) float32 ...
    fsmc_gb        (time, lat, lon) float32 ...
    precip         (time, lat, lon) float32 ...
    ecan_gb        (time, lat, lon) float32 ...
    runoff         (time, lat, lon) float32 ...
    gpp            (time, pft, lat, lon) float32 ...
    gpp_gb         (time, lat, lon) float32 ...
Attributes:
    title:         TAMSAT soil moisture and related water budget variables
    version:       2.3.0
    institution:   TAMSAT Research Group, Meteorology Department, University...
    contact:       tamsat@reading.ac.uk
    Conventions:   CF-1.8
    history:       Soil moisture and related variables derived using the...
    latmin:        -35.375
    latmax:        37.375
    lonmin:        -17.875
    lonmax:        51.375
    latres:        0.25
    lonres:        0.25
```

```
# Plot the fsmc (beta) variable for PFT=3
ax = ds.fsmc.sel(pft=3)[0].plot.imshow()
ax.axes.set_aspect('equal')
plt.show()
```

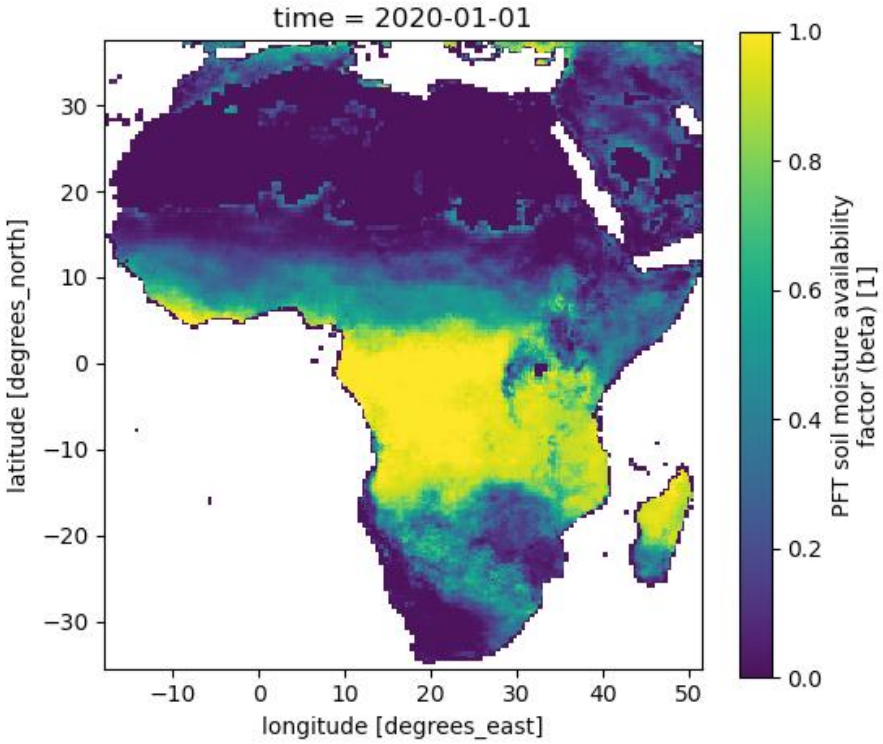


Figure 1. TAMSAT soil moisture availability factor for 1st January 2020.

1.5.2 Data spatial subsetting

In the example below, the soil moisture array has been subset to a longitude range of 20°E to 40°E and a latitude range of –10°S to 10°N.

Example Code:

```
subset = ds.fsmc.sel(pft=3, lon=slice(20, 40), lat=slice(-10, 10))
print(subset)
```

Illustrative Results:

```
<xarray.DataArray 'fsmc' (time: 1, lat: 80, lon: 80)>
array([[[1.      , 1.      , ..., 0.930766, 0.      ],
        [1.      , 1.      , ..., 0.92856 , 0.      ],
        ...,
        [0.207228, 0.230153, ..., 0.051482, 0.090026],
        [0.213595, 0.21147 , ..., 0.070876, 0.122062]]], dtype=float32)
Coordinates:
  * lon      (lon) float64 20.12 20.38 20.62 20.88 ... 39.12 39.38 39.62 39.88
  * lat      (lat) float64 -9.875 -9.625 -9.375 -9.125 ... 9.375 9.625 9.875
  * time     (time) datetime64[ns] 2020-01-01
Attributes:
    units:       1
    long_name:   PFT soil moisture availability factor (beta)
    short_name:  fsmc
```

```
# Plot the fsmc variable spatial subset
bx = subset[0].plot.imshow()
bx.axes.set_aspect('equal')
```

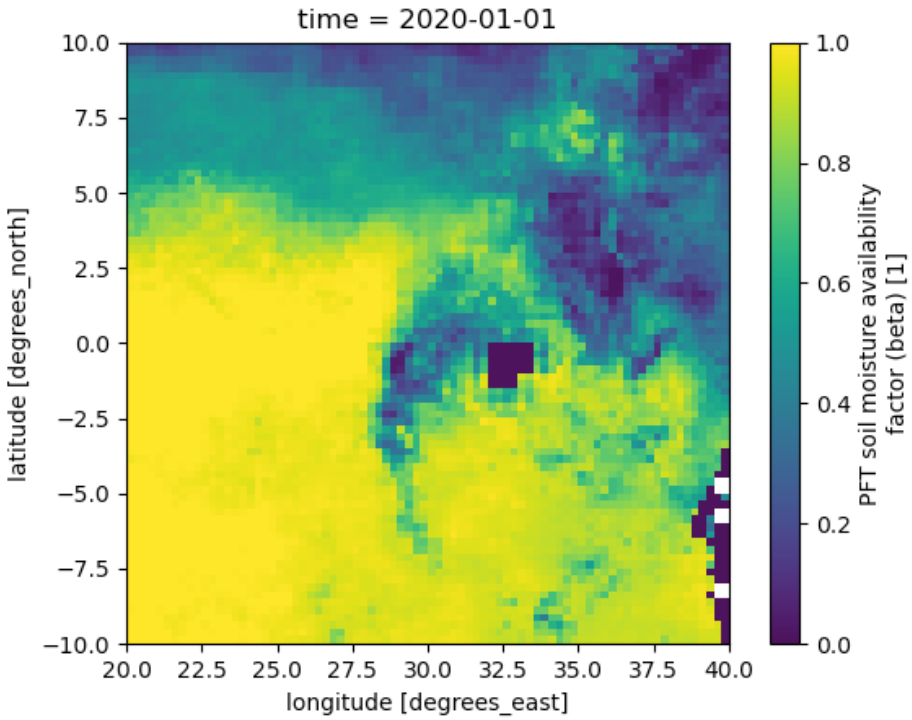


Figure 2. Spatial subset of soil moisture availability factor for the region specified in the example.

1.5.3 Creating area-average time-series

Often, users will need to extract time-series of the data, spatially averaged over a region of interest. The example below extracts the area-average daily time-series for the region specified above (section 1.5.2) for the year 2020. The script assumes that your daily soil moisture files are located in directory 'datadir', separated into yearly subfolders (e.g. '2020', '2021', '2022' etc).

```
# List JULES files for given year
file_list = []
for root, dirs, files in os.walk(os.path.join(datadir, '2020')):
    for f in files:
        if f.endswith('.nc'):
            if 'EOCIS-SM-L4-WB-AFRICA-TAMSAT' in f:
                file_list.append(os.path.join(root, f))

# Read file
ds = xr.open_mfdataset(flist)

# Subset
subset = ds.fsmc.sel(pft=3, lon=slice(20, 40), lat=slice(-10, 10))

# Compute area-average
ts = subset.mean(dim=['lon', 'lat']).to_dataframe()
```

```
# Plot
ts.plot()
```

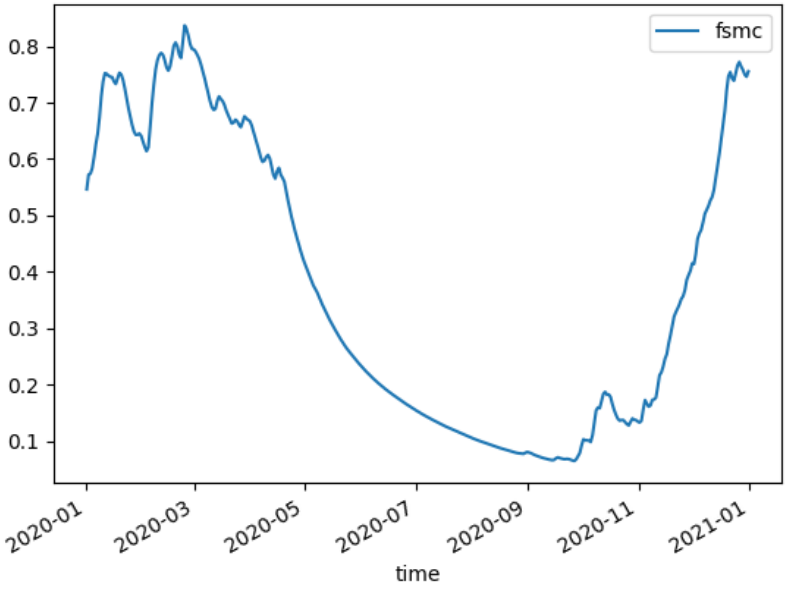


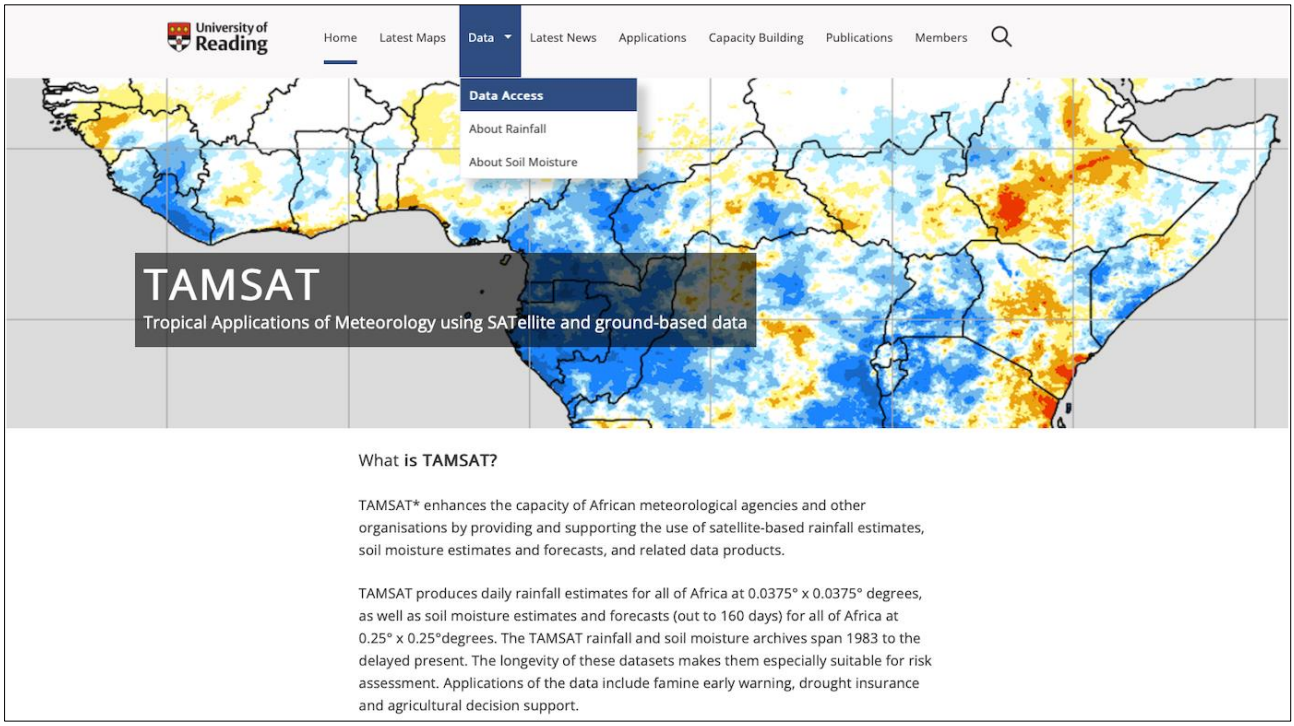
Figure 3. Area-average daily time-series of soil moisture availability factor for the region specified in the example.

1.6 Interactive visualisation / data access

The TAMSAT website (https://www.tamsat.org.uk/) provides users with a range of data access and visualisation options (see Figure 4). These are:

- Time and area subsetting tool (see Figure 5)
- Visualisation tool to quickly view maps of soil moisture (see Figure 6)
- Link to the raw data files (HTTP file listing) (see Figure 5)

All these options provide access to the soil moisture availability factor (fsmc) at the daily, pentadal (5-day), dekadal (10-day), monthly and seasonal time-step with respective anomalies. Currently, only the soil moisture availability factor is provided through these tools as this is the variable most often required by stakeholders (i.e. a direct measure of agricultural drought).



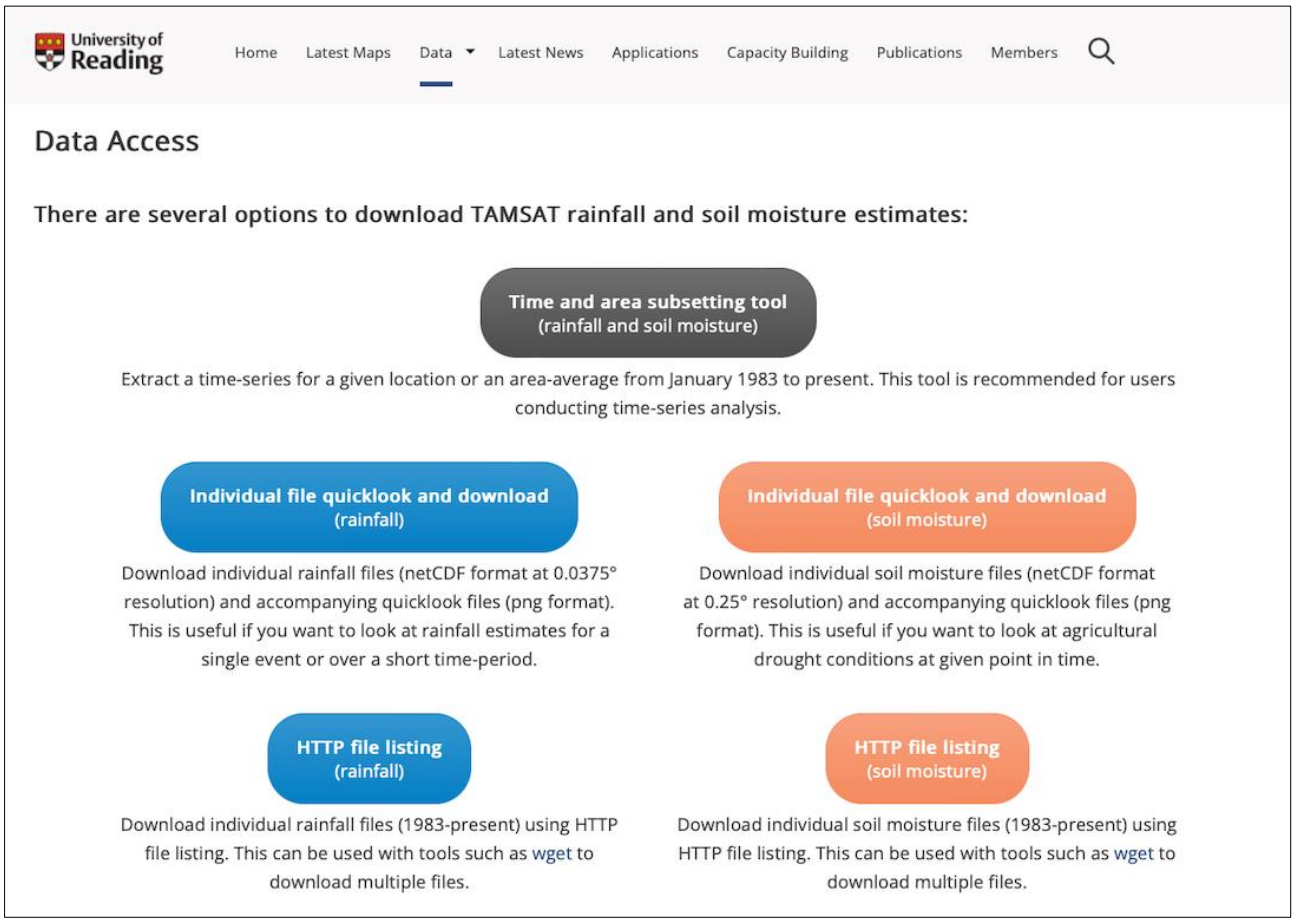


Figure 4. (Top) TAMSAT website showing data access tab. (Bottom) Buttons showing data access options for both soil moisture and rainfall.

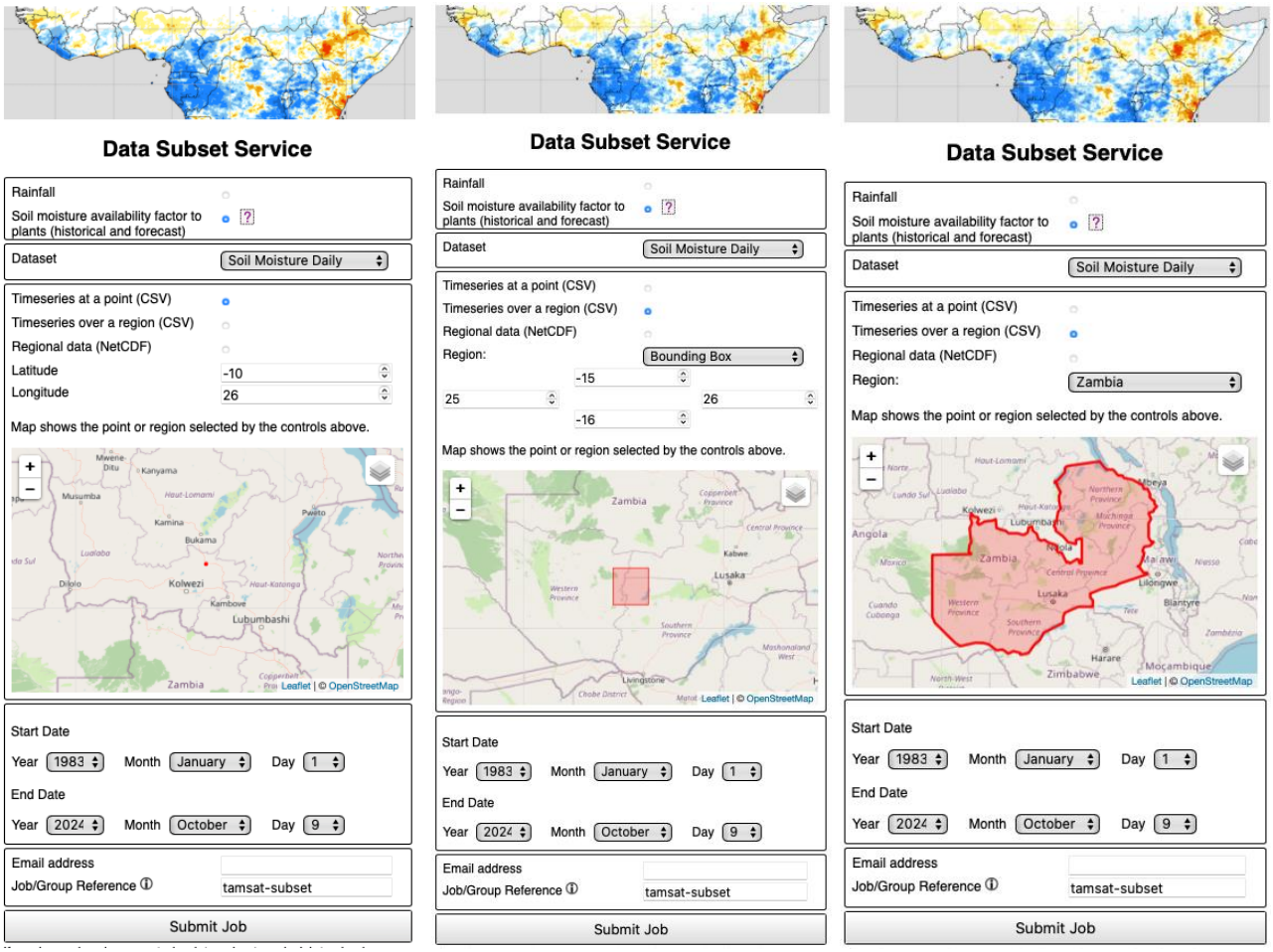


Figure 5. Example screenshots of the TAMSAT subsetting tool which provides users the ability to extract time-series or gridded data for bespoke regions. Users can subset data at a point (left), a user-defined rectangle (middle) or at country-level (right).

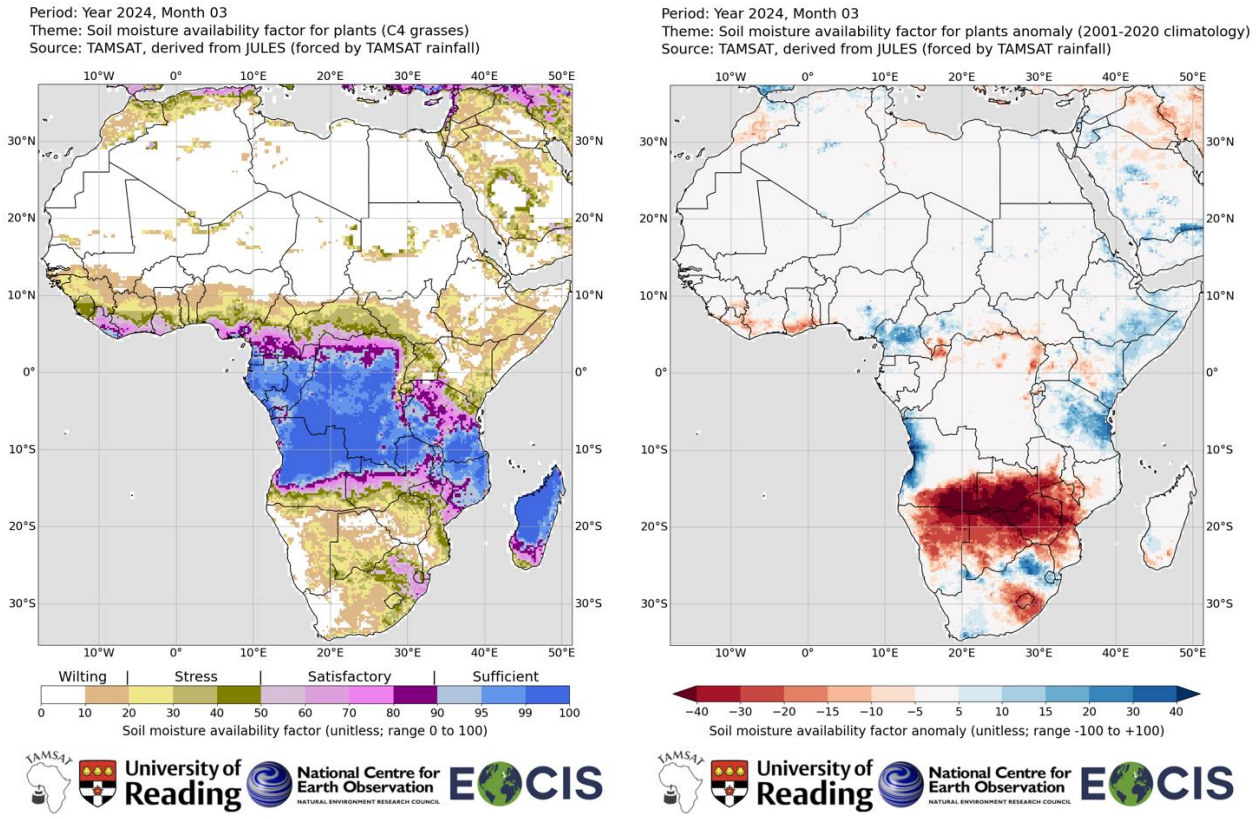


Figure 6. Example soil moisture maps available from the TAMSAT website – (left) soil moisture availability factor for March 2024 and (right) the corresponding anomaly with respect to the 2001-2020 climatology.

1.7 Your obligations when using these products

The data are free to use and are released for operational, research and commercial use under a creative commons license. Please cite the corresponding journal article describing the dataset every time you publish results obtained in whole or in part by use of UK EOCIS products. The citation is given under Summary Information.

The reference to the dataset should mention "created by the UK Earth Observation Climate Information Service". The product name and acronym in Table 1 and should be used to avoid confusion and enable traceability.

1.8 Further Information

TAMSAT soil moisture provides data from 1st January 1983 to the delayed present. Typical latency is around 7 days. As the operational production of the dataset is now integrated into TAMSAT operations, production of the product is expected to continue indefinitely. As this is a new dataset, further revisions to the products are expected over the next few years, including the potential for new variables to be added.

History of modifications / Change Log

Version	Date	Changes	Person
1.1	23rd June 2023	Initial Draft	RM
1.2	9th May 2024	Updated to reflect new product version	RM

Related Documents / Reference Documents

Document	Author	Reference

Acronyms and/or Abbreviations

Acronym / Abbreviation	Definition
TAMSAT	Tropical Applications of Meteorology using SATellite data and ground-based observations
JULES	Joint UK Land Environment Simulator
SMAP	Soil Moisture Active Passive

General definitions

Term	Definition