MOSES replication
Weather and Soil data

Fausto Tomei ftomei@arpae.it
Giulia Villani giulia.villani@agromet.it

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1.Weather

1.1 How to upload

Observed, forecast and climate data should be uploaded on the MOSES platform by an FTP server, that can be reached by means of the following account:

IP: 84.253.153.145
port: 21
user: provider
pwd: mosesProvider

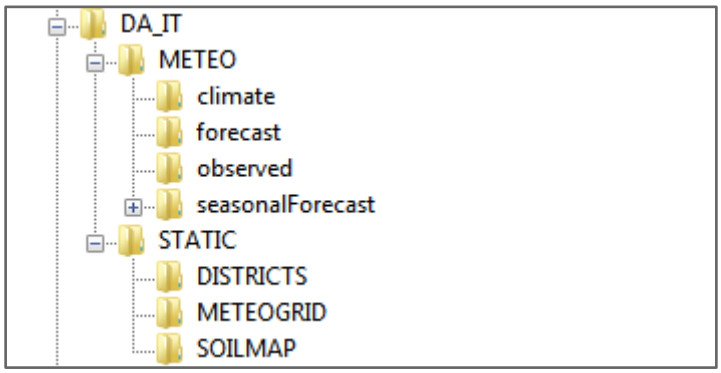
In the main FTP folder you will find 4 subfolders, one for each Demonstration Area, named DA_IT (Italy), DA_MO (Morocco), DA_RO (Romania) and DA_ES (Spain), as shown in the screenshot below.

MOSES FTP main folder

At this time the account is one for all the users, thus we ask you to use only your own folder. Every DA folder is divided in two subfolders: METEO for the meteorological input data that will be regularly updated and STATIC for the other local data (not only meteo data) that are steady over time (i.e. the soil map or the meteo grid).

The METEO folder for each DA has to be organized in 4 sub-folders, as shown in the following figure:

- climate
- forecast
- observed
- seasonalForecast



FTP folder structure for the Italian DA

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FTP script

Example for windows

It is worthy to automate the FTP session and to collect all the file transfers in a single script file. This can be run (on windows) with the *ftp* command:

- ftp script_filename ftp_address

Therefore, for the MOSES FTP:

- ftp script_filename 84.253.153.145

The following is the script that daily upload observed and forecast data on the MOSES platform for the italian DA.
In the Italian DA everyday Arpae produces observed and short-term forecast daily data on the local meteo grid of 5x5 km resolution and upload the files in the FTP folders *DA_IT/METEO/observed* and *DA_IT/METEO/forecast*.

```
provider
mosesProvider

lcd \\praga-smr\MOSES\DA_ITALY\SWB\shortTermForecast\input\observed
cd DA_IT/METEO/observed
mput *

lcd \\praga-smr\MOSES\DA_ITALY\SWB\shortTermForecast\input\forecast
cd DA_IT/METEO/forecast
mput *

quit
```

FTP script (windows) for the italian DA

File and command description of the FTP script:

- first row: **user**
- second row: **password**
- **lcd** change local working directory
- **cd** change remote working directory
- **mput** send multiple files from the local directory to the remote directory
- **mput *** send all the file of the local directory into the remote directory
- **quit** disconnect from the FTP server

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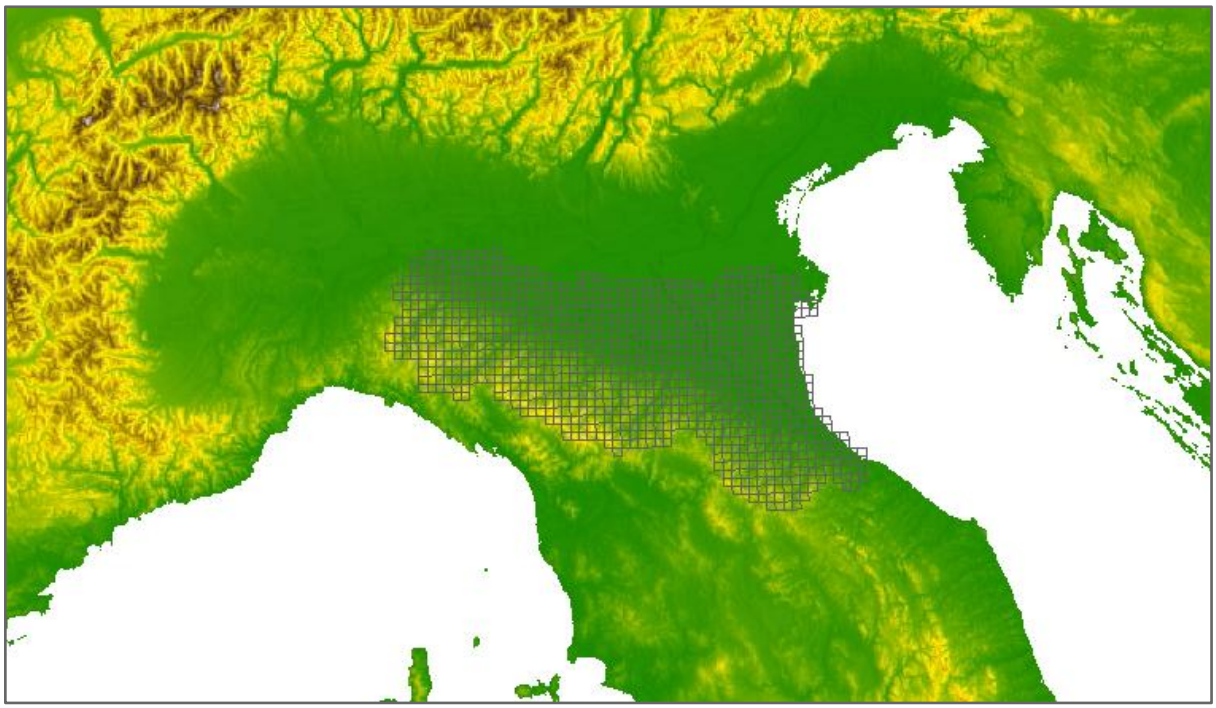
1.2 Meteo grid

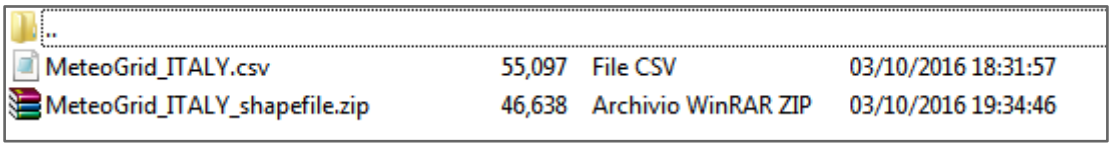
The meteo analysis grid should be the same for all the weather and climate data sources (observed, forecast, climate and seasonal forecast).



The 5x5 km meteo analysis grid for the italian DA

The meteo analysis grid files have to be put in the folder:
DA_XX\STATIC\METEOGRID\

The required files are:
- a shapefile referenced to the WGS84 datum (.zip file)
- an identifier table (.csv file)



Meteo grid files for the italian DA

Identifier table

The identifier table must be a comma separated value file (.csv) with the following format:

- **id_meteo**: a unique text identifier for the grid cell, it must be the same ID of the shapefile polygons. In DA_IT it is a 5 digits number, but it can have different digits or alphanumeric values.
- **table_name**: the same of **id_meteo** with the prefix 'GRD_'
- **meteo_name**: name of the cell

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- **longitude**: WGS84 longitude of cell center, unit of measure: decimal degrees
- **latitude**: WGS84 latitude of cell center, unit of measure: decimal degrees
- **height**: average height of the cell, unit of measure: m.

```
id_meteo,table_name,meteo_name,longitude,latitude,height
01878,GRD_01878,VALSAVIGNONE,12.033825,43.7325,816.26
01918,GRD_01918,MONTE DELLA ZUCCA,12.096875,43.7325,915.44
01958,GRD_01958,SAN PATRIGNANO,12.159925,43.7325,781.15
01998,GRD_01998,POGGIO DELLE CAMPANE,12.222975,43.7325,575.14
01797,GRD_01797,BADIA PRATAGLIA,11.907725,43.7775,979.62
01837,GRD_01837,VERGHERETO,11.970775,43.7775,844.81
01877,GRD_01877,MONTECORONARO,12.033825,43.7775,922.14
01917,GRD_01917,MONTE FUMAIOLO,12.096875,43.7775,1052.27
01957,GRD_01957,CASTELDELCI,12.159925,43.7775,758.5
01997,GRD_01997,MIRATOIO,12.222975,43.7775,621.36
02037,GRD_02037,MONTE CARPEGNA OVEST,12.286025,43.7775,888.79
01716,GRD_01716,POGGIO SCALI,11.781625,43.8225,1181.85
01756,GRD_01756,LA LAMA,11.844675,43.8225,978.44
...
```

Meteo grid identifier table for the Italian DA

1.3 MOSES weather file format

Each MOSES weather file is a comma separated value (.csv) of daily data, with the following format:

- **Date**: ISO8601 (YYYY-MM-DD) format *
- **Tmin**: daily minimum air temperature, unit of measure: °C *
- **Tmax**: daily maximum air temperature, unit of measure: °C *
- **Tavg**: daily average air temperature, unit of measure: °C
- **Prec**: daily total precipitation, unit of measure: mm *
- **Et0**: potential evapotranspiration, unit of measure: mm;
- **Watertable**: watertable depth (positive values), unit of measure: m
- **RHmin**: daily minimum relative air humidity in percentage *
- **RHmax**: daily maximum relative air humidity in percentage *
- **RHavg** daily average relative air humidity in percentage, *
- **Windspeed**: daily average wind speed, unit of measure: m/s *
- **Rad**: daily global radiation, unit of measure: MJ *

***** The variables marked with a star are mandatory.

For each variable the lack of data can be identified by a void or a -9999 (nodata) value.
Pay attention: Lack of data for a mandatory variable could cause a computation block in some processors.

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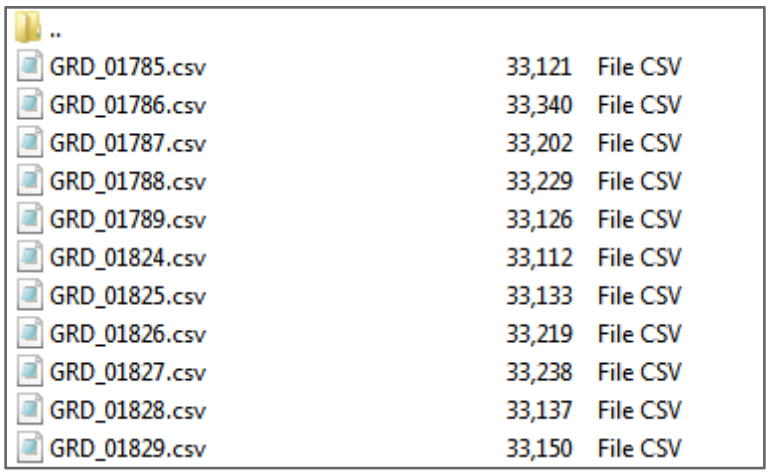
The only not mandatory data are:

- **Tavg** - if missing, it will be computed from Tmax and Tmin;
- **Et0** - it will be computed with Hargreaves-Samani equation using temperatures and latitude of the meteo cell;
- **Watertable** - if missing the Soil Water Balance model simulates free drainage at the soil bottom.

1.4 Observed and Forecast data

The input of observed and short-term forecast data follows these common rules:

1. one file has to be uploaded for each cell of weather grid
2. each file has to be named as the corresponding cell **table_name,** i.e.: GRD_01785.csv for the cell '01785'
3. The files have to be formatted in the MOSES weather file format (see previous paragraph)



Observed folder for the Italian DA - files are daily updated

Observed data

- the files have to cover the period from January 1st of the previous year until the day of forecast;
- the files have to be regularly updated (daily or weekly) in: DA_XX\METEO\Observed\

Short-term forecast

- the files have to cover the period of 7 days following the last observed data;
- the files have to be regularly updated (daily or weekly) in: DA_XX\METEO\Forecast\

```
Date, Tmin (C), Tmax (C), Tavg (C), Prec (mm), Et0 (mm), Watertable (m), RHmin (%),
RHmax (%), RHavg (%), Windspeed (m/s), Rad (MJ)
2016-10-19,11.1,19.2,15.2,0,1.7,,61.8,93.4,79.4,1.6,5.1
2016-10-20,12.6,18.1,14.4,1,1.4,,60.9,93.1,82.4,1.6,3.1
2016-10-21,8.9,15.9,12.6,0,1.4,,59.1,89.7,77.5,2.3,5.8
2016-10-22,5.9,16.6,10.2,0,1.6,,55,90.1,79.3,1.6,11.3
```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```
2016-10-23,8.1,12.2,10.6,1.9,1,,84.3,92.4,88.5,1.5,3
2016-10-24,10.5,16.5,13.2,0.1,1.3,,83.2,99.3,92.6,0.9,3
2016-10-25,12.4,18.8,15.1,0,1.4,,79.9,99.1,92.8,0.5,2.9
```

Example of short-term forecast file (7 days) with watertable data missing data (not mandatory) and the two last variables excluded

1.5 Climate data

Climate data are needed only by the Soil Water Balance processor to compute the seasonal irrigation forecast, therefore they contain less variables with respect to the other weather files:

- **Date**: ISO 8601 (YYYY-MM-DD) format *
- **Tmin**: daily minimum air temperature, unit of measure: °C *
- **Tmax**: daily maximum air temperature, unit of measure: °C *
- **Tavg**: daily average air temperature, unit of measure: °C;
- **Prec**: daily total precipitation, unit of measure: mm *
- **Et0**: potential evapotranspiration, unit of measure: mm;
- **Watertable**: watertable depth (positive values), unit of measure: m

***** The variables marked with a star are mandatory.

Rules for data providing

1. Each file has to be named as the corresponding cell **table_name** (as the observed or short-term forecast files), i.e.: GRD_01878.csv for the cell '01878'
2. Each file has to cover at least 20 years of daily data
3. The files have to be uploaded in: DA_XX\METEO\Climate\
4. They can be updated, if possible, once a year, but it is not mandatory.

```
date,tmin,tmax,tavg,prec,et0,watertable
1991-01-01,2.7,6.7,,8.1,,
1991-01-02,-2.7,7.4,,0.5,,
1991-01-03,-1.7,6.2,,0,,
1991-01-04,-2.1,4.2,,0,,
1991-01-05,-0.3,6,,0,,
1991-01-06,-2.6,3.6,,0,,
1991-01-07,-1,4.3,,0,,
1991-01-08,2.2,6,,0.4,,
1991-01-09,-0.6,7.6,,0,,
1991-01-10,0.7,9.4,,0,,
...
```

Example of climate .csv file, with Tavg and watertable data missing (not mandatory)

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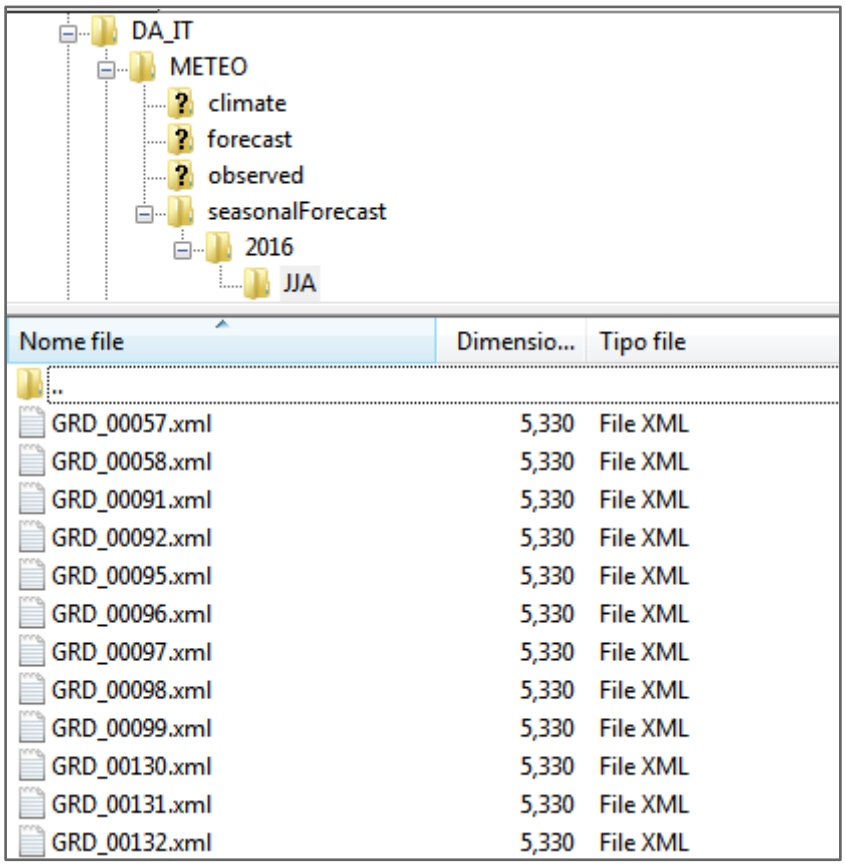
1.6 Seasonal forecast anomalies

The seasonal forecast anomalies are an intermediate product of MOSES, unlike the weather data previously described. They are XML files, as explained in the next paragraph.
This type of data can be produced by means of two methodologies: the *default* seasonal forecast procedure or a *specific* procedure set up by the DAs.

In case of *default* methodology, XML files are produced and saved in their specific product directory (not available by FTP) and the only required input is the meteo grid identifier table uploaded in the FTP folder DA_XX\STATIC\METEOGRID\ (see paragraph 2).

If a DA has developed a *specific* methodology, the output have to follow these rules:

- one file has to be uploaded for each cell of the weather grid
- each file has to be named as the corresponding cell **table_name**, i.e.: GRD_00057.xml for the cell '00057'
- the files have to be uploaded in the folder: DA_XX/METEO/seasonalForecast/YYYY/MMM/
  where YYYY is the forecast year and MMM is the season, i.e.: JJA for June, July and August
- the files have to follow the XML format explained in the next paragraph



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1.7 Seasonal forecast XML format

The output of downscaled seasonal forecast is an ensemble of predicted anomalies for six climate seasonal indices on each cell of the local meteo grid, in the format of a XML file. The following is an example of the xml file generated for the cell '01785' of the Italian DA on May 2016 (JJA season).

```
<xml version="1.0" encoding="ISO-8859-1">

<point>
    <name>FAENZA_CASELLO</name>
    <code>01785</code>
    <lon>11.908</lon>
    <lat>44.318</lat>
    <info>Italian_DA</info>
</point>

<climate>
    <from>1991</from>
    <to>2015</to>
</climate>

<models>
    <number>2</number>
    <name>SFEC,LFPW</name>
    <members>51,51</members>
    <repetitions>1</repetitions>
    <year>2016</year>
    <season>JJA</season>
</models>
<forecast>
    <var>
        <type>Prec3M</type>
        <attribute>anomaly</attribute>
        <value> 18.32, -4.58,-45.07,30.66,-18.37,-10.33,-55.06,-4.16,-14.76,-26.44,-21.18,-14.96,-39.05,
    </var>
    <var>
        <type>WetDaysFrequency</type>
        <attribute>anomaly</attribute>
        <value>  0.07, -0.07,  0.03,  0.02,  0.00,  0.03, -0.05, 0.02,  0.03,  0.01, -0.01,  0.07,  0.00,
    </var>
    <var>
        <type>WetWetDaysFrequency</type>
        <attribute>anomaly</attribute>
        <value> -0.04,  0.05, -0.01,  0.00,  0.02, -0.03,  0.01, -0.01,  0.01,  0.00,  0.02, -0.02,  0.00,
    </var>
```


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```
    <var>
        <type>Tmin</type>
        <attribute>anomaly</attribute>
        <value> -0.23,  0.15, -0.24, -0.33, -0.30, -0.22, -0.15, -0.15, -0.44, -0.18, -0.13, -0.20, -0.32,
    </var>
    <var>
        <type>Tmax</type>
        <attribute>anomaly</attribute>
        <value>  0.78, -0.93,  0.60, -0.13,  2.07,  1.01,  2.19, -0.10,  1.92,  1.25,  0.16,  0.66,  0.55,
    </var>
    <var>
        <type>DeltaTmaxDryWet</type>
        <attribute>anomaly</attribute>
        <value> -0.51,  0.23,  0.25,  0.34,  0.20, -0.21,  0.47,  0.12, -0.84,  0.14, -0.17, -0.58,  0.82,
    </var>
</forecast>

</xml>
```

The XML files contain the following elements and corresponding attributes:

- **point**: description of the computation area to which forecasts refers
  - **name** – geographical name of location
  - **code** – identifier point code (the same of **id_meteo** of meteo grid identifier table)
  - **lon** – WGS84 longitude of cell center
  - **lat** – WGS84 latitude of cell center
  - **info** – more information
- **climate**: description of reference climate
  - **from** – year in which reference climate begins
  - **to** – year in which the reference climate ends
- **models**: description of the systems contributing to the multi-model ensemble
  - **number** – number of systems contributing to the ensemble
  - **name** – acronym for all the systems contributing to the ensemble
  - **members** – number of ensemble members for each system
  - **repetitions** – number of repetitions (typically 1)
  - **year** – year to which the seasonal forecast refers
  - **season** – acronym of the season to which the seasonal forecast refers
- **forecast**: includes all ensemble member forecast values for the 6 climate index anomalies
  - **var** – describe each forecast field including:
    - **type** – acronym of the field
    - **attribute** – 'full field' or 'anomaly' (anomalies in our case)
    - **value** – all ensemble member values for the field

Variables acronym and unit of measure:

- **PREC3M**: total precipitation, mm
- **WetDaysFrequency**: fraction of wet days, %
- **WetWetDaysFrequency**: probability of a wet day after a wet day, %
- **Tmin**: minimum temperature, °C
- **Tmax**: maximum temperature, °C

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- **DeltaTmaxDryWet**: difference between max temperatures on dry and wet days, °C

1.8 Other meteo data

Arpae is working on availability of these variables in the MOSES platform for all the DAs. These variables are needed for atmospheric correction in the in season satellite image processing:

Visibility[1]: daily visibility, unit of measure: Km
Prec_WC[2]: daily Precipitable water, unit of measure: mm

[1] **Visibility** is a measure of the distance at which an object or light can be clearly discerned. It is reported within surface weather observations and METAR code either in meters or statute miles, depending upon the country.

[2] **Precipitable water** is the depth of water in a column of the atmosphere, if all the water in that column were precipitated as rain.It is measured in millimeters or inches.

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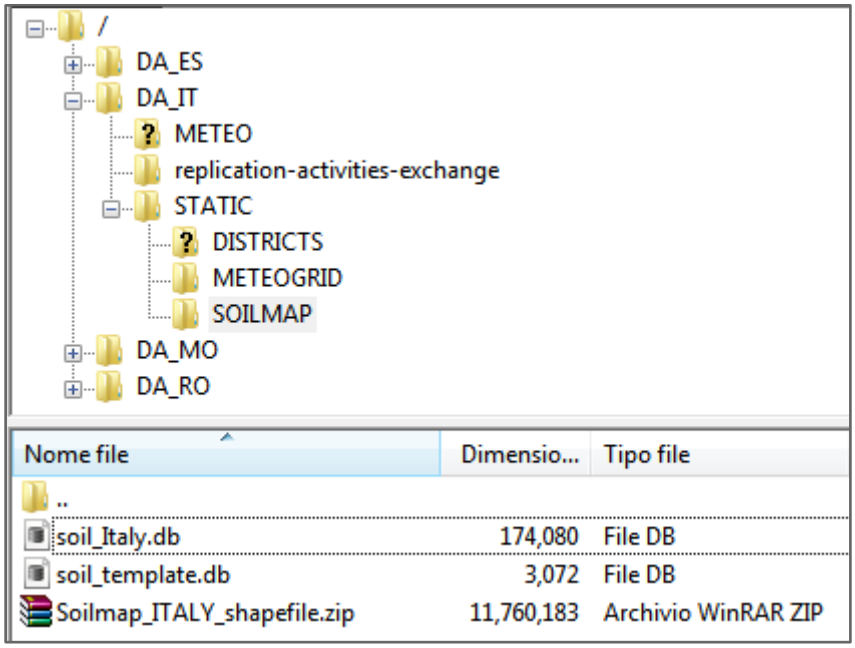
2. Soil

2.1 How to upload

Soil map and data have to be uploaded in the FTP folder:
DA_XX\STATIC\SOILMAP\

Two files have to be uploaded:

1. Soil map (shapefile)
2. Soil data (SQLite database)



SOILMAP folder for the Italian DA

See chapter 1.1 for the FTP credentials.

2.2 Soil map

Soil map has to be a shapefile, with each polygon defined by an *id_soil* (integer number). MOSES platform requires a single soil map for each DA; if your area is subdivided in more separate districts with separate soil maps, please join them in a single map.

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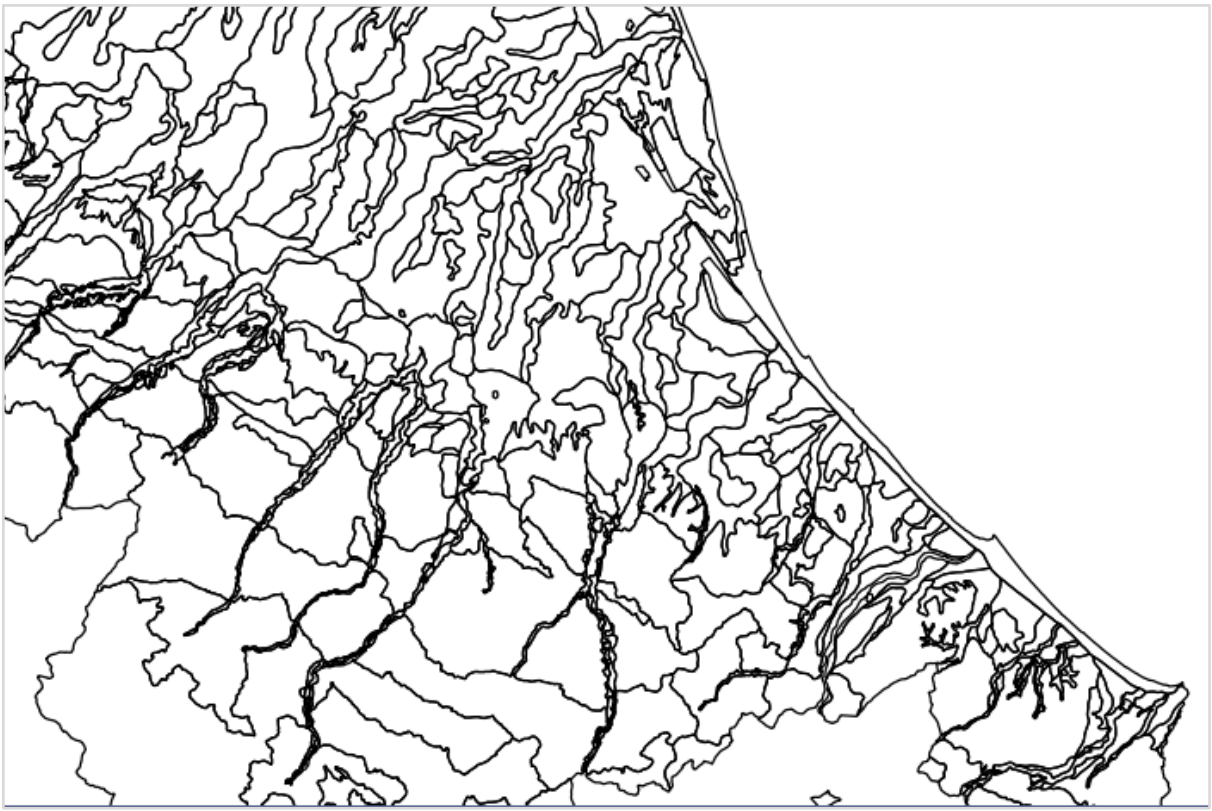

Example of soil map for Italian DA

2.3 Soil data

The soil data, referred to the soil map, have to be stored in a SQLite database; you can download the template **soil_template.db** from your ftp folder: DA_XX\STATIC\SOILMAP
After data entries, rename the db **soil_XX.db** where XX is the code of the DA.

The SQLite databases can be easily managed by the **sqlitebrowser** open source software, that you can download at:
https://github.com/sqlitebrowser/sqlitebrowser

The SQLite database is organized in two tables: **soils** and **horizons**.

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Name	Type	Schema
Tables (2)		
horizons		CREATE TABLE "horizons" (`soil_code` TEXT, `horizon_nr` INTEGER, `upper_depth` INTEGER, `lower_depth` INTEGER, `coarse_fragment` REAL, `organic_matter` REAL, `sand` REAL, `silt` REAL, `clay` REAL, `bulk_density` REAL, `theta_sat` REAL, `ksat` REAL)
soils		CREATE TABLE "soils" (`id_soil` INTEGER, `soil_code` TEXT, PRIMARY KEY(id_soil))

soil_template.db structure

The table **soils** is an identifier table where each soil has to be defined by an alphanumerical code (*soil_code*) linked to the integer field *id_soil* of the soil map shapefile.

Table: soils

	id_soil	soil_code
	Filter	Filter
1	1	AGO1
2	2	AGOz
3	3	ARC1
4	4	ARC2
5	5	BAD
6	6	ban1
7	7	BAR1

soils table for the Italian DA

Each soil is typically composed by several pedological horizons, described in the **horizons** table, where each record describes the horizon in terms of pedological features as texture, structure, and organic matter content, that determines the shape of the soil water retention curve in the Soil Water Balance model.

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In more details, each record of the **horizons** table contains:

- **soil_code**: univocal alphanumerical code to identify the soil *
- **horizon_nr**: number of horizon *
- **upper_depth**: upper depth of the horizon, [cm] *
- **lower_depth**: lower depth of the horizon, [cm] *
- **coarse_fragment**: percentage of soil particles > 2 mm
- **organic_matter**: percentage of organic matter
- **sand**: fraction of sand, [-] *
- **silt**: fraction of silt, [-] *
- **clay**: fraction of clay, [-] *
- **bulk_density**. Bulk density, [g cm^{-3}]
- **theta_sat**: water content at saturation, [m^3 m^{-3}]
- **ksat**: water conductivity at saturation, [cm day^{-1}]

***** The data marked with a star are mandatory.

soil_code	horizon_nr	upper_depth	lower_depth	coarse_fragment	organic_matter	sand	silt	clay	bulk_density	theta_sat	ksat
Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter	Filter
AGO1	1	0	60	0.0	32.4	0.66	0.25	0.09	0.6		
AGO1	2	60	80	0.0	8.6	0.23	0.49	0.28	0.8		
AGO1	3	80	110	0.0	2.0	0.44	0.46	0.1	1.42		
AGO1	4	110	150	0.0	0.8	0.83	0.13	0.04	1.76		
AGOz	1	0	50	0.0	11.96	0.426	0.334	0.24	0.7		
AGOz	2	50	65	0.0	6.08	0.252	0.35	0.398	0.9		
AGOz	3	65	74	0.0	24.35	0.722	0.198	0.08	0.7		
AGOz	4	74	85	0.0	10.42	0.668	0.262	0.07	0.8		
AGOz	5	85	150	0.0	2.46	0.778	0.149	0.073	1.76		
ARC1	1	0	50	10.0	1.2	0.189	0.414	0.397	1.35		
ARC1	2	50	75	0.0	0.1	0.189	0.417	0.394	1.4		
ARC1	3	75	150	0.0	0.1	0.116	0.48	0.404	1.45		
ARC2	1	0	50	10.0	1.2	0.189	0.414	0.397	1.35		
ARC2	2	50	75	0.0	0.1	0.189	0.417	0.394	1.4		
ARC2	3	75	150	0.0	0.1	0.116	0.48	0.404	1.45		
BAD	1	0	35	10.0	1.2	0.48	0.3	0.22	1.35		
BAD	2	35	125	80.0	0.5	0.67	0.22	0.11			

horizons table for the Italian DA

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