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**esa<sub>c</sub>ci<sub>s</sub>m***Documentation*  
***Release 0.1.post0.dev13+ng826455f***

**TU Wien**

**Jan 22, 2019**



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Reading and reshuffling of CCI soil moisture Written in Python.



# CHAPTER 1

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## Installation

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Installing the package can be done via pip:

```
pip install esa_cci_sm
```

Setup of a complete development environment with [conda](#) can be performed using the following commands:

```
git clone git@github.com:TUW-GEO/esa_cci_sm.git esa_cci_sm
cd esa_cci_sm
conda env create -f environment.yml
source activate esa_cci_sm
```





## CHAPTER 2

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### Supported Products

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At the moment this package supports ESA CCI soil moisture data version v02.x and v03.x and v04.x in netCDF format (reading and time series creation) with a spatial sampling of 0.25 degrees.



We are happy if you want to contribute. Please raise an issue explaining what is missing or if you find a bug. We will also gladly accept pull requests against our master branch for new features or bug fixes.

### 3.1 Development setup

For Development we also recommend a conda environment. You can create one including test dependencies and debugger by running `conda env create -f environment.yml`. This will create a new `esa_cci_sm` environment which you can activate by using `source activate esa_cci_sm`.

### 3.2 Guidelines

If you want to contribute please follow these steps:

- Fork the `esa_cci_sm` repository to your account
- Clone the repository, make sure you use `git clone --recursive` to also get the test data repository.
- make a new feature branch from the `esa_cci_sm` master branch
- Add your feature
- Please include tests for your contributions in one of the test directories. We use `py.test` so a simple function called `test_my_feature` is enough
- submit a pull request to our master branch



This project has been set up using PyScaffold 2.5. For details and usage information on PyScaffold see <http://pyscaffold.readthedocs.org/>.

## 4.1 Reading ESA CCI SM images

Reading of the ESA CCI SM raw netcdf files can be done in two ways.

### 4.1.1 Reading by file name

```
import os
from datetime import datetime
from esa_cci_sm.interface import CCI_SM_025Img
import numpy.testing as nptest

# read several parameters
parameter = ['sm', 'sm_uncertainty']
# the class is initialized with the exact filename.
image_path = os.path.join(os.path.dirname(__file__), 'tests', 'esa_cci_sm-test-data',
                           'esa_cci_sm_dailyImages', 'v04.2', 'combined', '2016')
image_file = 'ESACCI-SOILMOISTURE-L3S-SSMV-COMBINED-20160607000000-fv04.2.nc'
img = CCI_SM_025Img(os.path.join(image_path, image_file), parameter=parameter)

# reading returns an image object which contains a data dictionary
# with one array per parameter. The returned data is a global 0.25 degree
# image/array.
image = img.read()
```

### 4.1.2 Reading by date

All the ESA CCI SM data in a directory structure can be accessed by date. The filename is automatically built from the given date.

```
from esa_cci_sm.interface import CCI_SM_025Ds

parameter = 'sm'
img = CCI_SM_025Ds(data_path=os.path.join(os.path.dirname(__file__),
                                           'tests', 'esa_cci_sm-test-data', 'esa_
↪cci_sm_dailyImages',
                                           'v04.2', 'combined'),
                   parameter=parameter)

image = img.read(datetime(2016, 6, 7, 0))
```

For reading all image between two dates the `c3s_sm.interface.CCI_SM_025Ds.iter_images()` iterator can be used.

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## Variable names for ESA CCI Soil Moisture

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ESA CCI SM variables as in the netcdf image files (and time series from netcdf images) for different products and versions

short_name	Parameter	Units
dnflag	Day / Night Flag	
flag	Flag	
freqbandID*	Frequency Band Identification	
lat	Latitude	[degrees_north]
lon	Longitude	[degrees_east]
mode	Satellite Mode	
sensor	Sensor Flag	
sm	Volumetric Soil Moisture	[m3 m-3]
sm_uncertainty	Volumetric Soil Moisture Uncertainty	[m3 m-3]
t0	Observation Timestamp	[days since 1970-01-01 00:00:00 UTC]
time	Time	[days since 1970-01-01 00:00:00 UTC]

- “freqbandID” is named “freqband” in older versions (before v3) of the data set.





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### Conversion to time series format

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For a lot of applications it is favorable to convert the image based format into a format which is optimized for fast time series retrieval. This is what we often need for e.g. validation studies. This can be done by stacking the images into a netCDF file and choosing the correct chunk sizes or a lot of other methods. We have chosen to do it in the following way:

- Store only the reduced gaussian grid points since that saves space.
- Further reduction the amount of stored data by saving only land points if selected.
- Store the time series in netCDF4 in the Climate and Forecast convention [Orthogonal multidimensional array representation](#)
- Store the time series in 5x5 degree cells. This means there will be 2566 cell files (1001 with reduction to land points) and a file called `grid.nc` which contains the information about which grid point is stored in which file. This allows us to read a whole 5x5 degree area into memory and iterate over the time series quickly.

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## 7.1 Reading ESA CCI SM images

Reading of the ESA CCI SM raw netcdf files can be done in two ways.

### 7.1.1 Reading by file name

```
import os
from datetime import datetime
from esa_cci_sm.interface import CCI_SM_025Img
import numpy.testing as nptest

# read several parameters
parameter = ['sm', 'sm_uncertainty']
# the class is initialized with the exact filename.
image_path = os.path.join(os.path.dirname(__file__), 'tests', 'esa_cci_sm-test-data',
                           'esa_cci_sm_dailyImages', 'v04.2', 'combined', '2016')
image_file = 'ESACCI-SOILMOISTURE-L3S-SSMV-COMBINED-20160607000000-fv04.2.nc'
img = CCI_SM_025Img(os.path.join(image_path, image_file), parameter=parameter)

# reading returns an image object which contains a data dictionary
# with one array per parameter. The returned data is a global 0.25 degree
# image/array.
image = img.read()
```

### 7.1.2 Reading by date

All the ESA CCI SM data in a directory structure can be accessed by date. The filename is automatically built from the given date.

```
from esa_cci_sm.interface import CCI_SM_025Ds

parameter = 'sm'
img = CCI_SM_025Ds(data_path=os.path.join(os.path.dirname(__file__),
                                         'tests', 'esa_cci_sm-test-data', 'esa_
↪ cci_sm_dailyImages',
                                         'v04.2', 'combined'),
                  parameter=parameter)

image = img.read(datetime(2016, 6, 7, 0))
```

For reading all image between two dates the `c3s_sm.interface.CCI_SM_025Ds.iter_images()` iterator can be used.

## 7.2 Variable names for ESA CCI Soil Moisture

ESA CCI SM variables as in the netcdf image files (and time series from netcdf images) for different products and versions

short_name	Parameter	Units
dnflag	Day / Night Flag	
flag	Flag	
freqbandID*	Frequency Band Identification	
lat	Latitude	[degrees_north]
lon	Longitude	[degrees_east]
mode	Satellite Mode	
sensor	Sensor Flag	
sm	Volumetric Soil Moisture	[m3 m-3]
sm_uncertainty	Volumetric Soil Moisture Uncertainty	[m3 m-3]
t0	Observation Timestamp	[days since 1970-01-01 00:00:00 UTC]
time	Time	[days since 1970-01-01 00:00:00 UTC]

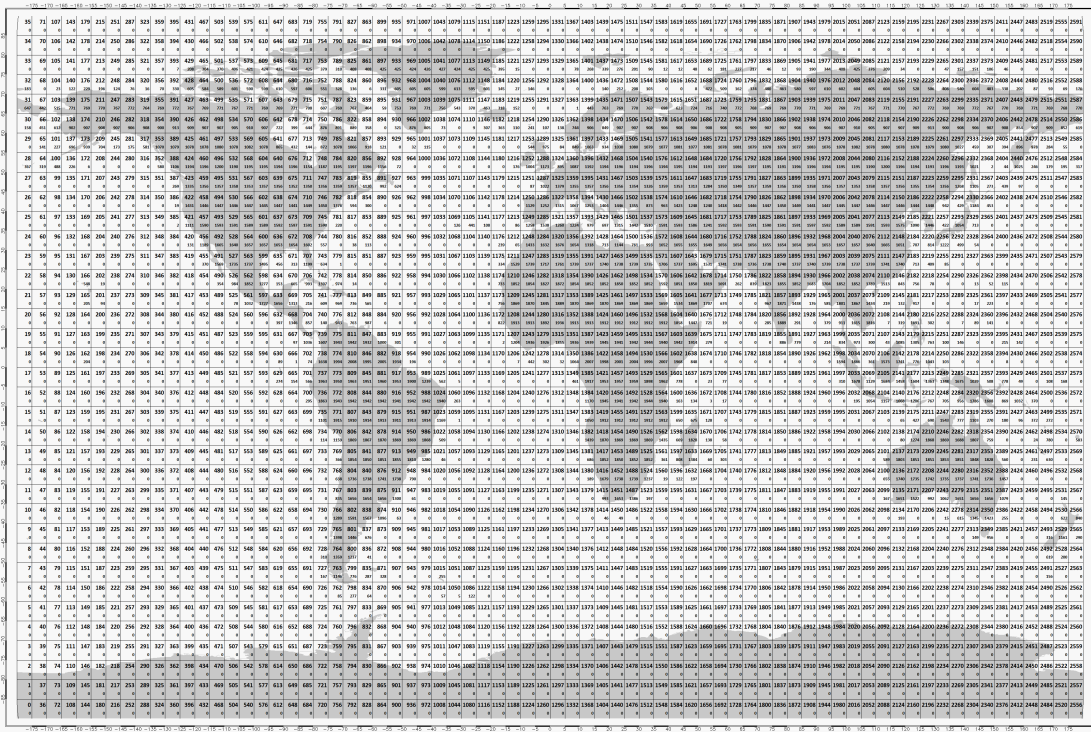
- “freqbandID” is named “freqband” in older versions (before v3) of the data set.

## 7.3 Conversion to time series format

For a lot of applications it is favorable to convert the image based format into a format which is optimized for fast time series retrieval. This is what we often need for e.g. validation studies. This can be done by stacking the images into a netCDF file and choosing the correct chunk sizes or a lot of other methods. We have chosen to do it in the following way:

- Store only the reduced gaussian grid points since that saves space.
- Further reduction the amount of stored data by saving only land points if selected.
- Store the time series in netCDF4 in the Climate and Forecast convention [Orthogonal multidimensional array representation](#)
- Store the time series in 5x5 degree cells. This means there will be 2566 cell files (1001 with reduction to land points) and a file called `grid.nc` which contains the information about which grid point is stored in which

file. This allows us to read a whole 5x5 degree area into memory and iterate over the time series quickly.



This conversion can be performed using the `ccism_reshuffle` command line program. An example would be:

```
ccism_reshuffle /cci_images /timeseries/data 2000-01-01 2001-01-02 --parameters sm sm_
↳uncertainty --land_points True
```

Which would take ESA CCI SM data stored in `/cci_images` over land from January 1st 2000 to January 2nd 2001 and store the parameters for soil moisture and its uncertainty as time series in the folder `/timeseries/data`.

**Note:** If a `RuntimeError: NetCDF: Bad chunk sizes.` appears during reshuffling, consider downgrading the `netcdf4` C-library via:

```
conda install -c conda-forge libnetcdf==4.3.3.1 --yes
```

Conversion to time series is performed by the `repurpose` package in the background. For custom settings or other options see the `repurpose` documentation and the code in `esa_cci_sm.reshuffle`.

## 7.3.1 Reading converted time series data

For reading the data the `ccism_reshuffle` command produces the class `CCITs` can be used:

```
from esa_cci_sm.interface import CCITs
ds = CCITs(ts_path)
# read_ts takes either lon, lat coordinates or a grid point indices.
# and returns a pandas.DataFrame with all reshuffled variables.
# e.g. timeseries for lon=45°, lat=15°:
ts = ds.read_ts(45, 15)
```

## 7.4 License

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## 7.5 Developers

- Manuel Schmitzer <manuel.schmitzer@geo.tuwien.ac.at>
- Wolfgang Preimesberger <wolfgang.preimesberger@geo.tuwien.ac.at>

## 7.6 Changelog

### 7.6.1 Version v0.x

- 

### 7.6.2 Version v0.1.1

- Update time series reader class
- Unmask smecv grid
- Separate libnetcdf version for python3

### 7.6.3 Version v0.1

- pypi release
- Homogenize classes for past ESA CCI SM versions
- Update Readme and Documentation

- Change submodule with testdata

## 7.6.4 Version v0.0.2

- Changing point of origin of gpis to bottom left corner

## 7.6.5 Version v0.0.1

- Initial version
- Add CCI reshuffle function
- Add CCI readers

# 7.7 esa\_cci\_sm

## 7.7.1 esa\_cci\_sm package

### Submodules

esa\_cci\_sm.grid module

esa\_cci\_sm.interface module

esa\_cci\_sm.reshuffle module

### Module contents





## CHAPTER 8

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### Indices and tables

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- `genindex`
- `modindex`
- `search`



**e**

`esa_cci_sm`, [19](#)



## E

`esa_cci_sm` (module), [19](#)