

# Long-Term Hydrological Monitoring with Active and Passive Microwave Missions

## Practical

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### Scope of this exercise

In this exercise we would like to increase your understanding of the potential and characteristics of the long-term satellite data records of soil moisture. We will do this using a couple of online tools.

### Tools

Various online tools exist to either display the data or perform basic statistical analyses. There is some overlap between the online tools, but each tool serves a specific purpose:

**ESA CCI Soil Moisture data viewer:** [http://rs.geo.tuwien.ac.at/data\\_viewer/](http://rs.geo.tuwien.ac.at/data_viewer/)

- *Purpose:* display the most recent ESA CCI SM products, and differences with precursor products
- *Contains:* ESA CCI SM PASSIVE only, ACTIVE only, and COMBINED ACTIVE+PASSIVE, version 02.2 and v03.2

**ESA CCI Soil Moisture Validation Tool:** [http://python.ipf.tuwien.ac.at/cci\\_validation\\_tool/](http://python.ipf.tuwien.ac.at/cci_validation_tool/)

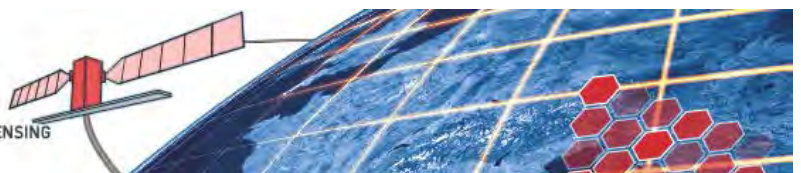
- *Purpose:* Evaluate ESA CCI SM against in-situ soil moisture data, assess impact of preprocessing on validation results
- *Contains:* ESA CCI SM COMBINED v03.2, in-situ data from ESA's International Soil Moisture Network (ISMN: <http://ismn.geo.tuwien.ac.at/>)

**TU Wien C3S Soil Moisture data viewer:** [http://rs.geo.tuwien.ac.at/data\\_viewer/c3s/](http://rs.geo.tuwien.ac.at/data_viewer/c3s/)

- *Purpose:* Display current soil moisture conditions
- *Contains:* C3S Soil Moisture COMBINED in monthly and 10-day resolution + Soil moisture anomalies

**Earth2observe data viewer:** <https://wci.earth2observe.eu/>

- *Purpose:* Display and evaluate the most recent ESA CCI SM product along with many other water cycle products (e.g. precipitation, Evapotranspiration, ground water) from Earth observation and models
- *Contains:* C3S Soil Moisture COMBINED v03.2 and many other water cycle products



## Exercise 1 – Evaluating spatial data properties

Open the ESA CCI Soil Moisture data viewer at [http://rs.geo.tuwien.ac.at/data\\_viewer/](http://rs.geo.tuwien.ac.at/data_viewer/) and open the “Volumetric Soil Moisture” layer from the latest ESA CCI SM PASSIVE product.

**Q1.1:** Name 3 reasons why there is no global coverage

Display the data from 2016-07-26 and see what happens to the coverage.

**Q1.2:** Where does the data coverage improve, and where not?

Zoom to India and change in the “layer settings” (control box symbol) the maximum value to 0.5. You see dry and wet patterns.

**Q1.3:** What is the dry region in north-western India called? Would you expect the rest of India to be that wet? Why (not)?

Open the layer “Volumetric Soil Moisture Uncertainty v03.2” and change in the “layer settings” the maximum value to 0.1. In the same “layer settings” tab you can change the opacity of the layer.

**Q1.4:** Where are uncertainties generally higher? Why? How does this relate to the soil moisture patterns you saw before? To facilitate latter comparison you can toggle between soil moisture and the soil moisture error by clicking on the eye symbol.

Zoom out again to the global view and load the latest COMBINED product (v03.2). Make sure the layer “PASSIVE Volumetric Soil Moisture Error” is switched to invisible using the eye symbol. Toggle between the PASSIVE and COMBINED products. We notice that the global coverage improves with respect to the PASSIVE only product.

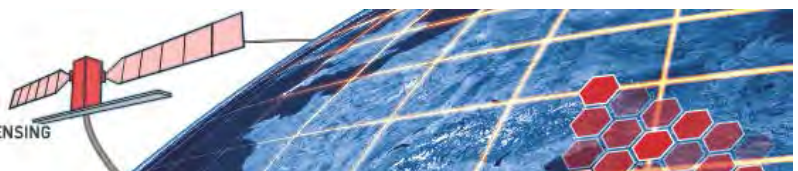
**Q1.5:** in what type of areas COMBINED provides the largest gain in coverage with respect to PASSIVE? Have the soil moisture values themselves changed? (Make sure that the COMBINED and PASSIVE are scaled between the same minimum and maximum values for this comparison).

Open the layer “ESA CCI SM v03.2 COMBINED Sensor”.

**Q1.6:** Which sensors are being used on this day (see table below for the exact description)?

Value	Sensor Combination	Value	Sensor Combination
0	NaN	264	AMSRE+ASCATA
1	SMMR	272	WindSat+ASCATA
2	SSMI	280	AMSRE+WindSat+ASCATA
4	TMI	288	AMSR2+ASCATA
8	AMSRE	320	SMOS+ASCATA
16	WindSat	328	AMSRE+SMOS+ASCATA
24	AMSRE+WindSat	336	WindSat+SMOS+ASCATA
32	AMSR2	344	AMSRE+WindSat+SMOS+ASCATA
64	SMOS	352	AMSR2+SMOS+ASCATA
72	AMSRE+SMOS	512	ASCATB
80	WindSat+SMOS	544	AMSR2+ASCATB
88	AMSRE+WindSat+SMOS	576	SMOS+ASCATB
96	AMSR2+SMOS	608	AMSR2+SMOS+ASCATB
128	AMIWS	768	ASCATA+ASCATB
130	SSMI+AMIWS	800	AMSR2+ASCATA+ASCATB
132	TMI+AMIWS	832	SMOS+ASCATA+ASCATB
136	AMSRE+AMIWS	864	AMSR2+SMOS+ASCATA+ASCATB
256	ASCATA		

Close all layers but the PASSIVE “Volumetric Soil Moisture Uncertainty v03.2” layer. Open the layer “ESA CCI SM v03.2 COMBINED uncertainty” and set the maximum value for this layer to 0.1. Zoom in again to India. Toggle between the layers and notice how the uncertainty reduces in COMBINED.



## Exercise 2 – looking at historical events

Open in a new tab the C3S data viewer ([http://rs.geo.tuwien.ac.at/data\\_viewer/c3s/](http://rs.geo.tuwien.ac.at/data_viewer/c3s/)). Open the layer “C3S TCDR/ICDR 201706 COMBINED DEKADAL – Volumetric Soil Moisture”. Notice the nearly continuous coverage with respect to the daily images from the previous exercise. Scale the soil moisture values between 0 and 0.4.

The image that you see is the average soil moisture content from 21-31 August 2017, indicated by the starting date of the dekade at the lower right. Go back in time a few dekades (to 2017-05-21) to the beginning of July by clicking the small arrow.

**Q2.1:** *The soil moisture patterns over Europe do not change that much during this period. Why?*

One of the unique features of the CCI/C3S Soil Moisture datasets is their availability for almost 40 years, which is enough to provide a robust historical baseline for computing average long-term soil moisture conditions. The deviations from these normal conditions are shown in the layer “C3S TCDR/ICDR 201706 COMBINED DEKADAL ANOMALY– Dekadal Soil Moisture Anomaly”. In this map, most parts of Western Europe appear much drier than normal in this period, which has been confirmed by many sources.

Zoom in to Italy and go forward in time. It appears that for many months in a row conditions have been drier than normal in central and southern Italy, which has also been widely confirmed in the media.

**Q2.2:** *Has the ongoing drought in Italy led to increased wildfire activity in the region? (Tip: check the seasonal trend analysis tool at [http://effis.jrc.ec.europa.eu/static/effis\\_current\\_situation/public/index.html](http://effis.jrc.ec.europa.eu/static/effis_current_situation/public/index.html)). And has wildfire activity in Greece this year higher or lower than normal? What is the soil moisture situation in Greece this summer?*

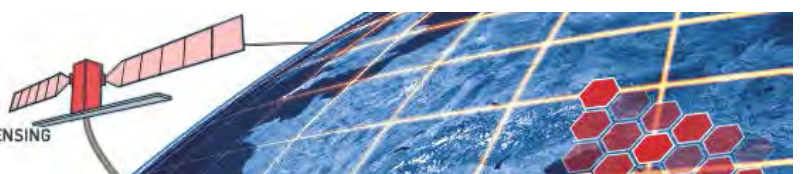
To assess whether recent droughts are exceptional, we need to confront it with historical soil moisture conditions. Let’s have a look at the recent dry conditions in Southeastern Europe. Zoom into Hungary in the anomaly layer until you can clearly identify the individual pixels. Then, click on the tab “Layer Analysis” (graph symbol) -> “Draw polygon” and digitize a small polygon in central Hungary around the coordinates [lon=18, lat=47]. Click “make new plot” -> “Timeseries” -> “Create plot” (neglect potential error message...). You have various options to zoom and save the plot.

**Q2.3:** *Is the current year exceptionally dry in Hungary? Which recent years have seen worse soil moisture conditions? Check with one of our Hungarian colleagues if they can confirm this...*

## Exercise 3 - Validation and comparison with external data

Open the ESA CCI SM validation tool at [http://python.ipf.tuwien.ac.at/cci\\_validation\\_tool/](http://python.ipf.tuwien.ac.at/cci_validation_tool/). Each dot represents a single measurement station from the International Soil Moisture network. Notice the uneven global distribution of stations.

Zoom in to Romanian-Hungarian border and click on the Sannicolau\_Mare station close to Szeged. Click on “View data”. You can view soil moisture from various depths and other climatic variables (precipitation, temperature, etc., if available for given station and time range).



**Q3.1:** The in situ soil moisture time series seems to show some curious behaviour besides the natural rises and dry downs. What could be the reason for the severe drops in January 2016? And why do we see a daily fluctuation?

Close the plot and click “Compare to CCI”). In the upper panel you can change the masking options (e.g. for temperatures below freezing point). The middle panel shows the time series of soil moisture measured in situ in the upper soil layer (5 cm in this case) and that produced by ESA CCI SM. With the cursor you can zoom into sections of the time series.

**Q3.2:** The time series seem to match well, but there is one big difference, which?

At the bottom you can find the main comparison statistics between in situ data and ESA CCI SM. Left of these basic statistics you can find a scatter plot of the two data sets.

**Q3.3:** Does the scatter plot confirm your finding of Q3.2? How large is the Pearson correlation coefficient?

At the lower left you can see how the Pearson correlation coefficient performs with respect to the assessment criterions of EUMETSAT/H-SAF. You can see that ESA CCI at this location meets the target requirement.

In most cases, a bias exists between two observed datasets because of differences in sensing depth, equipment used, etc. Go back to the middle panel and choose the “linear regression” scaling method to remove the bias of ESA CCI SM. Press “Refresh results”. The middle panel now shows the scaled ESA CCI SM data.

**Q3.4:** How large is the Pearson correlation coefficient after scaling? Is this what you would expect?

Repeat the same procedure for the “piecewise CDF matching and check what happens to the scatter plots.

### EXTRA validation exercise

On <https://wci.earth2observe.eu/> you can compare the ESA CCI SM data to soil moisture from hydrological and reanalysis models. You can find ESA CCI soil moisture under “sub-surface water” -> “soil moisture”. The modelled soil moisture data can be found under “Water Resource Re-analysis v2” -> surface soil moisture” -> pick one of the models. Select the daily “resolution” if you want to directly compare it to ESA CCI SM.

For ESA CCI SM, make a spatial selection of a single pixel close to the DAHRA station (**NOTICE:** Increasing the polygon size will strongly increase the processing time!). Click “create plot”. Then go to the selected model dataset and click “Add to plot”. Go back to initial plot window and reduce the date range to **maximum 2 years**. -> “Create plot” (ignore the “estimated time remaining”)

**Q3.4:** What is the major difference between the ESA CCI SM and the modelled soil moisture time series (hint: look at the end of the wet season)?

On this portal you can access an enormous number of other datasets (e.g. precipitation) and tools (e.g. make scatter plots) to further assess the characteristics of the ESA CCI soil moisture data.

