Monitoring of soil moisture content in risky areas of Bulgaria
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The specific objectives of this research was to establish reliable correlation between SAR signal and the SMC for one specific region and to prove that it can provide information that could be used operationally by the local authorities as a precursor for water bodies areas increase and their better mapping. Other goal of this research is to provide a framework for provision of valuable information based on free and open data and software tools.

This information provided hereinafter is mainly based on SAR data from Sentinel-1 satellite, but auxiliary data being satellite borne (e.g. high and mid resolution optical images, passive microwave measurements) or other databases as such for soils properties, meteorological data were used as well. This scenarios investigated has several advantages since it makes use of the higher temporal and spatial resolution of the S-I data compared to other SMC missions and weather conditions independency. Some limitations due to unknown soil roughness and uncertain vegetation cover at time of the radar signal acquisition had to be overcome during this research.

Three scenarios were considered for this study:
1. Single rainy month followed by dry one
2. Year having evenly distributed rainy months
3. Single dry month in year having less rain

Data
SAR data were downloaded from ESA archives GRDHi scenes. (details provided in Table 1) Precipitation for in the area investigated data were obtained from NOAA archive the (Fig.1) that were used for selection of the months to fulfill the scenarios.

With regard to LC/LU most of the plots fall into class 211 (non-irrigated arable land) as in Corine CLC. 14 water bodies were investigated. Concerning the soil quality samples from 22 sampling points with 313 different samples were reported to EEA and made available as open data.

No data for soil moisture at the scale needed could be obtained from national authorities as open data so assumption about its values has been derived only from VV polarized SAR backscatter signal (σ0).

Results

Discussion
In all resulting images shown on figures 3, 4 and 5 the green color is used to emphasize the extreme event studied. The two small images in the lower part of the image are used for verification of the results obtained after processing the SAR data and should be interpreted by the color scale on fig.2. Those are provided by the online mapping services at EDO-IRC.

For year 2015 the green patches correspond to agricultural plots with little or no vegetation cover and can be used for estimation of SMC which is confirmed by the left small image corresponding to the extreme rain at the end month of June followed by a dry July. At end of March 2016 the high rain is endorsed by the large number of green areas seen as the violet color indicates areas with vegetation in spring and bare soil in autumn. The only dry month in 2017 has no influence on the total SMC evidenced by the large number of green spots which can be contributed to rainy months before it and the ability of the soil to retain the moisture for longer periods.

Two additional products were produced from the data for June 2015 after converting the σ0 to dB values. The one shown on fig.6 is an example for possible misinterpretation of agricultural land as water body based only on σ0 (left) which is easily seen on the GE image (right). The next figure provides an option to have one more interpretation key in detection of water bodies with high spatial resolution. Water areas can be easily differentiated from those covered by vegetation based only on σ0 values (left) while using only GE image (right) both can be attributed to one class.

Conclusions
From the results obtained it can be concluded that SAR data add more possibilities for SMC determination and in combination with the frequent revisit over the same area provide supplementary information concerning the status of the soil and vegetation. The scenarios studied give grounds to state that even single events such as in June 2015 can be reliably detected by the method used. One more advantage when considering SAR data is the addition of more features for the classification procedure which in turn can result in better thematic maps for LU/LC of the areas investigated. This way more detailed information is delivered to the local authorities at municipal level which could be used for better decision making and planning. Especially the dependably detection the size of the water bodies is of crucial importance for the area investigated which is predominantly flat and since several floodings have occurred in it the last years most of them being contributed to the dams and rivers present.