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Interactive comment on "Challenges of soil carbon sequestration in NENA Region" *by* Talal Darwish et al.

Talal Darwish et al.

tdarwich@cnrs.edu.lb

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Reply to Reviewer 2. Interactive comment on "Challenges of soil carbon sequestration in NENA Region" by Talal Darwish et al. Anonymous Referee #2 Received and published: 6 March 2018

This paper addresses a very important topic for soil degradation and food security. This topic could potentially interest a wide audience readership and is well suited to the journal 'SOIL'. However I have several concerns about the paper, which I explain below.

I was rather disappointed by the method used by the authors, which is basically populating large soil map units with mean values taken from profiles. I'm not sure at all it is relevant and new to do so.

Thank you the Reviewer 2 for your important and deep remarks. The issue of producing a global soil organic carbon map is a priority on the agenda of FAO Global Soil Partnership and the Intergovernmental Technical Panel on Soils (ITPS). Only in December 5 2017, the FAO launched the version 0.1 of the Global Soil OC map of the topsoil (0-30 cm). The subsoil map is still pending securing the soil information from member states. Our article was based on available and accessible digital soil information.

Data on SOC and soil inorganic carbon (SIC) contents in soils of the NENA region were retrieved from the soil database of the FAO-UNESCO digital soil map of the world (DSMW) at 1:5 Million. The database contains 1700 georeferenced soil profiles collected and harmonized from each member state. These were excavated, sampled by horizon, down to the rock, and analyzed in the laboratory according to the standard world accepted methods (FAO, 2007). The soil map was prepared using the topographic map series of the American Geographical Society of New York, as a base, at a nominal scale of 1:5.000.000. Country boundaries were checked and adjusted using the FAO-UNESCO Soil Map of the World, on the basis of FAO and UN conventions. Soil classification was based on horizon designation, depth, texture, slope gradient and soil physico-chemical and chemical properties. Statistical (weighted) average was calculated for the topsoil (0-30 cm) and for the subsoil (30-100 cm) for the full series of chemical and physical parameters sufficient to assess main agricultural soil properties. To fill the gap in some attributes and complete the fields for which no data were available, an expert opinion internationally known soil scientists was used.

I would have expected that at least climate data and land use data are added to the dominant soil type information to do this exercise. I know of course that from a very global point of view, soil types and climate are related but this is not always the case (e.g. you can find rendzinas, fluviosols, cambisols, lithosols, arenosols, etc. in nearly all parts of the World).

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The land cover /land use (LCLU) map was produced from ESA information and the soil data were linked to the relevant land cover to show the relevant SOC accumulation as affected by LCLU. The LCLU map is available (beside the SIC maps) and we did not include them because this will multiply the number of maps. But, we will include the LCLU map in the final version of the paper with the surface relevant to each type.

I'm also disappointed by the fact that C1 SOILD Interactive comment Printer-friendly version Discussion paper the authors do not integrate land-use in their mapping, though they show it has a major effect. This seems to me contradictory. I would have expected a more novel approach in mapping such as the use of Digital Soil Mapping. By the way, there have several attempts to map SOC at the global scale and the authors seem to ignore them (e.g. maps from Stockmann et al; Hengl et al; and the recent exercise under the umbrella of the FAO). I would at least compare the results from this study with previous ones in a discussion part.

We used the available and accessible digital soil map of the world done by FAO and UNESCO in 2003 and updated in 2007. This map provide very detailed soil information that can be used in GIS to calculate the SOC and SIC stock (Tons) and density (Ton/ha) in a given country of NENA region. Data on SOC and soil inorganic carbon (SIC) contents in soils of the NENA region were retrieved from the soil database of the FAO-UNESCO digital soil map of the world (DSMW) at 1:5 Million. The database contains 1700 georeferenced soil profiles collected and harmonized from each member state. These were excavated, sampled by horizon, down to the rock, and analyzed in the laboratory according to the standard world accepted methods (FAO, 2007). The soil map was prepared using the topographic map series of the American Geographical Society of New York, as a base, at a nominal scale of 1:5.000.000. Country boundaries were checked and adjusted using the FAO-UNESCO Soil Map of the World, on the basis of FAO and UN conventions. Soil classification was based on horizon designation, depth, texture, slope gradient and soil physico-chemical and chemical properties. Statistical (weighted) average was calculated for the topsoil (0-30 cm) and for the subsoil

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(30-100 cm) for the full series of chemical and physical parameters sufficient to assess main agricultural soil properties. To fill the gap in some attributes and complete the fields for which no data were available, an expert opinion internationally known soil scientists was used.

We did not compare the produced map with that of Hengl et al., 2015 (which is also based on point profiles) because the global SOC map in Hengl soilGrids1km layers shows the soil organic carbon content in permille in 0-5 cm (Figure 7A) and the Predicted global distribution of the soil organic carbon stock in tonnes per ha for 0–200 centimetres (Figure 10). In our paper we followed the standard methodology of the measured SOC stock and density in topsoil (0-30 cm) and subsoil (30-100 cm). The first Global SOC Map was launched on December 5, 2017. I contributed to the production of this map based on profile data provided by member states. But this map shows SOC stock in 0-30 cm. Long way to go to complement the whole soil depth until 100 cm. Actually, there is no need to go deeper than 100 cm in the SOC mapping as most crops have their active roots in the layer 20-50 cm (annual crops) and 30-100 cm (fruit trees). But a comparison of values of SOC content (%) and SOC stock revealed comparable values for the C content (1-2%) and stock (density) between 20 and 204 ton/ha. We will add this adapted paragraph to the discussion referring to Hengl T, de Jesus JM, MacMillan RA, Batjes NH, Heuvelink GBM, et al. (2014) SoilGrids1km-Global Soil Information Based on Automated Mapping. PLoS ONE 9(8): e105992. doi:10.1371/journal.pone.0105992. AS for the paper of Stockmann et al we requested a copy from the authors to discuss the two maps.

There is quite no discussion about uncertainty, no error bars or box-plots in results, and this is a serious concern. Validation against Lebanon may induce a serious bias as Lebanon soils have been much more known and investigated for a very long time than soils from some other countries. Subsequently it may be that the DSMW is much more precise in Lebanon than in other regions.

Mapping was done on a small scale, which could be a source of a loss of information.

To test this, the results of the current estimation (1:5 Million) of SOC stocks in Lebanon, were compared with the large scale mapping (1:50,000). This comparison showed discrepancies between 11% for the topsoil and 14% for the subsoil (Darwish and Fadel, 2017). Therefore, the level of uncertainty falls within the admitted diagnostic power of soil mapping, estimated to be close enough to the reported range of map units' purity in reference areas, i.e., a matching between 65% and 70% (Finke et al., 2000). Loss of information related to small, non-mapable soil units in small scale mapping (1:5 Million or 1:1 Million) could be corrected by national and subregional large scale soil mapping (1:50,000 and 1:20,000). The soil data from Lebanon were retrieved from the digital soil map of Lebanon at 1:50,000 georeferenced database produced in 2006 based on 450 excavated, described and analyzed soil profiles. I am the main author of this map. The issue of less soil studies in other NENA countries might be relevant but I visited the portal of the FAO and found 1228 legacy soil maps (http://www.fao.org/soils-portal/en/).

The Mat&Meth section is not enough detailed. We don't know how many profiles were used (a 'large number'), how many per soil type, if they were georeferenced or not and, if so, with which accuracy, when these profiles were taken (they might be no more representative of SOC stocks if they were taken 50 years ago). We also do not know how the calculations by land use were done. By a geographical way, or by extracting soil use classes from the DSMW? There is also here a question of matching observations both in space and time.

Data on SOC and soil inorganic carbon (SIC) contents in soils of the NENA region were retrieved from the soil database of the FAO-UNESCO digital soil map of the world (DSMW) at 1:5 Million. The database contains large number of 1700 georeferenced soil profiles collected and harmonized from each member state. These were excavated, sampled by horizon, down to the rock, and analyzed in the laboratory according to the standard world accepted methods (FAO, 2007). The soil map was prepared using the topographic map series of the American Geographical Society of New York, as a base, at a nominal scale of 1:5.000.000. Country boundaries were checked and adjusted using the FAO-UNESCO Soil Map of the World, on the basis of FAO and UN conventions. Soil classification was based on horizon designation, depth, texture, slope gradient and soil physico-chemical and chemical properties. Statistical (weighted) average was calculated for the topsoil (0-30 cm) and for the subsoil (30-100 cm) for the full series of chemical and physical parameters sufficient to assess main agricultural soil properties. To fill the gap in some attributes and complete the fields for which no data were available, an expert opinion internationally known soil scientists was used.

Using the DSMW and its updated attribute database maps of the SOC and SIC stock and distribution in 20 NENA states were produced. The scale used in the DSMW is 1:5 Million (FAO, 2007). The soil map was prepared using the topographic map series of the American Geographical Society of New York, as a base, at a nominal scale of 1:5.000.000. Country boundaries were checked and adjusted using the FAO-UNESCO Soil Map of the World, on the basis of FAO and UN conventions. To produce the maps representing the spatial distribution of SOC and SIC, ArcMap 10.3 was used to join the symbology of the C stocks and density with quantities classified into five numerical categories with natural breaks. The explicative note to the DSMW indicates that the data was collected from 1995 up to 2003 when the soil map was first produced. It was thereafter updated with new information in 2007.

The calculation of SOC by land cover /land use was done by intersecting the relative LCLU with the soil type using GIS. The ESA LCLU map was produced in 2016. The soil type is not changed like land use might change.

Finally the general discussion about the challenges is rather interesting but quite fully disconnected from the results.

We modified the discussion in this part to link it more to the challenges and prcatices.

More detailed comments

The legend of Fig 2 is unclear (Mega ton on which area?)

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Mega ton per country (the total SOC stock in each country). Fig 2 presents the spatial view of total soil organic carbon stock (mega ton) across the countries of NENA region

The threshold of 30 tons is highly questionable There is twice the same sentence lines 90-92 and lines 101-103.

This threshold is what available in literature. We used it to stress the need to enhance C sequestration in drylands.

There is a problem with the labelling of countries (Fig. 5 top) Corrected

Abstract first word shoul be Near and not North Corrected

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