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Interactive comment on "Future climate variability impacts on potential erosion and soil organic carbon in European croplands" *by* M. van der Velde et al.

M. van der Velde et al.

marijnvandervelde@gmail.com

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Reviewer comments

This study by van der Velde M. et al. is an interesting contribution, modeling the effects of future climate variability scenarios on soil erosion and dynamics of soil organic carbon pools in European croplands. Overall, the study is of high quality, and its results can be considered an important addition to the broad field of modeling of the effects of climatic change on geochemical cycles.

We thank both reviewers for their comments and we address their comments in our responses below. Common elements in the two reviews are the remarks related to the

impact of management and the fate of the eroded soil carbon.

Yet, similarly to other modeling studies, the major uncertainty confronting the obtained data is the inability, at many times, to predict the fate of the detached soil organic carbon, i.e., whether the predominant process it goes through is emission as carbon dioxide to the atmosphere (Lal R. et al. (2004) Science, 304, 393), or sequestration through burying in deeper soil layers / deposition in surface water bodies. This uncertainty is clearly demonstrated by the authors, who cite Van Oost K. et al. (2007, Science, 318, 626-629), regarding the possible trapping of the detached soil organic carbon in certain structures, increasing its residence times compared to that under the original soil, and making erosional processes as net carbon sink derivers. Yet, regardless of the fate of the detached soil organic carbon, it is important to mention that its decreased concentrations in the uppermost soil layer degrade the quality of soil and decrease the potential productivity of the agro-ecosystem (Lal R. and Pimentel D. (2008) Science, 319, 1040-1042).

We agree and now acknowledge this explicitly in the manuscript. 'Determining the fate of the eroded carbon was not the purpose of this study and has not been addressed here. The deposition and subsequent residence time of soil organic carbon (SOC) removed with eroded soil determines the actual contribution of SOC loss to CO2 levels' in the Introduction and have included a reference to the publication by Berhe et al., 2012.

On the latter point, also, we write 'At the same time, an agricultural soil degraded through erosion and suffering from depleted nutrient and organic carbon pools will not be able to reach its production potential, thereby negating potential future carbon sequestration (Lal and Pimentel, 2008)'.

The major comment as regards this manuscript is the repeated statement by van der Velde M. et al. in the Abstract, Implications (sub-section 3.4), and in the beginning of the Discussion (section 4), stating that erosion rates depend on the spatial conjunction of expected changes in climate variability and the relevant physiographic conditions. Such a statement seems to be

inaccurate and could be misleading. It is well acknowledged that croplands' management practices considerably affect their soil's erodibility, and consequently, also the dynamics of their soil organic carbon. Even in this manuscript, the authors mention (in the Discussion [section 4]) that soil erosion is also related to management practices. However, beyond this mere statement, the authors do not expand the discussion on this topic. The only exception is the mention (also in this section) of two specific adaptation interventions to be undertaken by farmers, including: (1) increasing irrigation rates, aimed at augmenting crop root growth; and (2) the avoidance of harvesting failed crops in order to enable the incorporation of their biomass to the soil. The main obstacle related to the 1st means is the lack of access to water, as experienced in extensive continental, Mediterranean, and semi-arid climatic regions across Europe (and moreover, in other continents). The main drawback regards the 2nd means is the potentially confusing perception embedded in it.

Agreed. Cropland and soil management is a critical factor in determining soil erodibility and thus soil organic carbon. Different soil management strategies can have a large impact on erosion and soil organic carbon.

The reviewer is correct to note that in the factorial experiment we performed, we chose not to include management. To acknowledge the importance of soil management we have included a sentence 'Naturally, a critical role is played by soil management practices and possible changes therein in response to altered conditions.' directly after the opening sentence of the Discussion.

Re (1): We have added '(provided water is available)' in that example. Re (2): In most cases, the incorporation will not be the result of a purposeful action but rather an indirect consequence.

It is stressed that consecutive, rational, intentional, and active decision-making by the farmers related to implementation of conservation agricultural practices is of great importance in terms of soil erosion control and soil organic carbon sequestration (FAO, The economics of conservation agriculture. ftp://ftp.fao.org/agl/agll/docs/econsagr.pdf). As shown in previous studies,

such conservation practices, and particularly reduced tillage systems (e.g., non-inversion tillage [such as paraplowing], strip tillage, occasional tillage, or no-tillage), can effectively decrease soil erosion and reduce loss of soil organic carbon, both during the growing season and the subsequent off-season (e.g., Bernoux M. et al. (2006) Agronomy for Sustainable Development, 26, 1-8). Also, in conjunction with such reduced tillage systems, the implementation of complementary conservation agricultural practices would further decrease rates of soil erosion, minimize soil organic carbon detachment, and reduce the environmental footprint of crop production. Such practices could include several combinations of on-site retention of crop residues, manuring or composting, implementing of crop rotation, inter-cropping, cover cropping, and the growing of perennial forages (Stavi I. and Argaman E. (2014) Carbon Management, accepted). Therefore, despite being outside of the focus of this study, the authors may want to elaborate on some generic information about the potential of conservation agricultural practices in mitigating soil erosion, with the resultant decreased rates of decomposition (or burying in depositional sites) of soil organic carbon. It seems that this would best fit into the last paragraph of the Discussion (section 4), where the authors mention the study limitations and uncertainties.

We agree that soil management is, and will be, a critical factor. We emphasize this further by including the following statement in the Discussion section:

'In addition, agricultural soil management can lessen, amplify or mediate the interaction between physiographic terrain characteristics and changes in climate variability (Bernoux M. et al. (2006) Agronomy for Sustainable Development, 26, 1-8). Several location specific conservation practices are known to reduce erosion and transport of sediments downslope

(http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/home/?cid=nrcs143_026849),

including contour farming, filter strips, vegetative barriers, sediment basins and conversion to pasture. In addition, many measures are expected to increase SOC content and overall soil quality by managing crop residue on the soil surface year round while reducing till operations prior to planting, such as minimum and reduced tillage, and

by producing sufficient and timely quantities of crop residue from conservation crop rotations.'

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