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Reply to the comment on "The new assessment of soil loss by water erosion in Europe" by Fiener & Auerswald

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ABSTRACT

The new assessment of soil loss by water erosion in Europe based on RUSLE2015 (Panagos et al., 2015a) was criticized in a comment by Fiener and Auerswald (2015). The objective of the pan-European assessment was not to challenge any regional- or national-scale modelling but to develop a harmonized assessment aiming to improve our knowledge and understanding of soil erosion by water across the European Union and to accentuate the differences and similarities between different regions and countries beyond national borders and nationally adapted models. The main points of critique of Fiener and Auerswald (2015) were: (i) the ambition of this assessment to become a benchmark, ii) the absence of soil erosion community in this work, (iii) the K-factor and R-factor models (iv) the non-transparent origin of the cover management factor, (v) the lack of any validation process, and (vi) the non-comparability of this new data set to previous published data. We reply as follows:

(i) We never expressed statements or opinions to set the study as a benchmark and we invite the scientific community to evaluate our study and judge if this pan-European assessment is an improvement compared to past soil erosion assessments at this scale. (ii) It is not true that the soil erosion community was not consulted and involved as many scientists have participated both in the soil erosion assessment and the analysis of erosion factors described in recent papers. (iii) The published K-factor map for Europe has been modelled with the latest state of the art soil data (LUCAS) and a robust geo-statistical model with valid simplifications which were necessary at European scale. (iv) The C-factor map for Europe has been published with a detailed description of the applied methodology which takes into account crop composition and management practices at the best available spatial resolution. (v) Modelled soil loss data was compared with the European Environment Information and Observation Network (EIONET) dataset.(vi) Our model outputs compared well both with national soil loss data in Germany and the European EIONET data. The direct comparison of predicted soil loss data with measured plot data lacks comprehension and needs solving of scaling issues related to the comparison of large-scale long-term data with small-scale plot studies.

1. Introduction: regional and continental scale modelling as a clash of philosophies

Fiener and Auerswald raise concerns regarding our assessment of soil loss by water erosion in Europe, stating that our study clearly aims to set a new benchmark on large-scale soil erosion modeling in Europe. In addition, the authors criticize modeling assumptions implemented into this pan-European assessment. We appreciate this discussion since it stimulates reflections on soil erosion and we take the concerns of Fiener and Auerswald seriously and we hope to clarify some misunderstandings. Nonetheless, we are convinced that our model provides an effective means to create a harmonized assessment to predict soil loss potential over the European Union area, and that the proposed model, thanks to the improvements implemented, can enhance our understanding and knowledge on soil erosion risk in Europe. In the end, all the discussions about the new soil erosion assessments boil down to the question whether or not it is valid to apply erosion models at regional to continental scales. Basically all models are constrained when it comes to regional or continental scale assessments but if

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we like it or not these types of assessments are needed and regularly receive great attention in the science community. The science community itself seems to follow different philosophies, one that focuses on local scale assessments (e.g. plots or hillslopes or small catchments) to optimize parameterization and process understanding and another that tries to produce the best estimates with regional or continental scale data currently at hand even though the results are not perfect. Obviously we need assessments at both scales and in an ideal science world they should fit each other while helping to improve the other. In this way we would finally provide the best basis for decision makers.

2. Critiques and replies

2.1. Ambition to set a new benchmark

One of the first concerns of Fiener and Auerswald, is that through this study we are aiming "to set the published assessment of soil loss by water erosion as a benchmark". In the article, as well as in the many studies preceding it, we never expressed such statements nor opinions that may induce such thoughts. The scientific community is welcome to evaluate our study and to judge if this pan-European assessment is improving or not past soil erosion assessments (carried out by the European Soil Bureau Network or others e.g., van der Knijff et al., 2000; Kirkby et al., 2008; Bosco et al., 2015). This new study proposed a modified RUSLE approach using the latest state of the art input data. Each of the factor maps has been individually peer reviewed by the scientific community before they were published in well-known scientific journals. The final soil erosion assessment (Panagos et al., 2015a) is also thoroughly peer reviewed, published and the input data are freely available from the European Soil Data Centre (ESDAC) (Panagos et al., 2012). As such we have made the final product, i.e. the assessment of soil loss by water erosion in Europe, as transparent as possible.

2.2. *The best we* – the soil erosion community – *can provide for Europe?*

Fiener and Auerswald state that "*this European erosion map will potentially have tremendous effects on political and administrative decisions and allocation of funds, and should therefore represent the best we – the soil erosion community – can provide for Europe*".

We fully agree that the soil erosion community should be involved to further improve the pan-European assessment. A large number of well-known scientists have been actively involved in this study over the last three years, contributing with scientific proposals, datasets and data modelling. The Joint Research Centre (JRC) is the European Commission's in-house science service and employs scientists from all over Europe to carry out research in order to provide independent scientific advice and support to the EU policy. The JRC scientists collaborated with 25 scientists from the most prominent European universities and institutes to develop both the individual factor maps (Panagos et al., 2015b,c,d,e,f, 2014a) and the final erosion map (Panagos et al., 2015a).

To gather and consult the entire European soil erosion community to discuss and improve this new pan-European assessment sounds promising and this could be an ambitious European project. Nevertheless, at this point we are wondering how successful Fiener and Auerswald, which are certainly esteemed colleagues, were so far to gather the European soil erosion community to work jointly on this topic. However, simply integrating the views of different groups, schools and opinions would in itself already be a huge achievement. One example for this difficulty and also proof of the effort of the JRC to involve the knowledge and experts of the Member States is for sure the European Environment Information and Observation Network (EIONET): Here we followed a bottom up approach, asking the Member States for their available data on soil erosion rates. The result was far from being a pan-European map of soil erosion as only eight countries supplied data (Panagos et al., 2014b).

2.3. (R)USLE is widely accepted

We share the same opinion of Fiener and Auerswald when they state that the (R)USLE is a widely accepted approach and much research in adapting the model was accomplished in Germany. It is important to emphasize that the objective of the pan-European assessment was not to challenge any regional- or national-scale modelling but to develop a harmonized assessment aiming to improve our knowledge and understanding of soil erosion by water across the European Union and to accentuate the differences and similarities between different regions and countries beyond national borders and nationally adapted models. Nonetheless, we would like to highlight that our assessment compares well with the German models cited by Fiener and Auerswald, i.e., EIONET data collection (Panagos et al., 2014b) and the recently published soil erosion map of Germany (DIN 2005, 2015,5). A detailed comparison is presented below.

The main focus of the Pan-European assessment is on agricultural areas since also the LUCAS soil module, which is the basis for the calculation of the K-factor focuses on agricultural soils (Panagos et al., 2015a). Moreover, Panagos et al. (2015a) provided extensive statistics for arable lands and focused in modelling the soil loss by water erosion in the agricultural areas. In addition, the core message of the Pan-European assessment (impact of Common Agricultural Policy in reducing soil erosion in arable lands) has subsequently been published recently in Nature (Panagos et al., 2015g, *Nature* 526, 195). It was not our intention to suggest the validity of RUSLE in the highlands and Alps by presenting unmasked maps. We are currently working on an improvement to model soil loss rates in Alpine grasslands with RUSLE (Renard et al., 1997). Still regarding the applicability of RUSLE, Meusburger et al. (2010) and Konz et al. (2010) reported that RUSLE provides better estimates compared to the WEPP and PESERA models (the latter was also presented unmasked (Kirkby et al., 2008)).

2.4. Critique on the K-factor and R-factor maps

Fiener and Auerswald criticize the uncertainty involved in the assessment of the K-factor and the R-factor. The R-factor was already extensively commented on by Auerswald et al. (2015) and we already provided a detailed reply (Panagos et al., 2015f). To avoid redundancy we will not repeat the arguments provided there; we just want to remark again that for both factors the limitations and the uncertainties were discussed in the respective original publications and that both underwent a thorough scientific review process.

Regarding the K-factor, our results were verified against 21 studies at regional and local level in 13 European Countries (Panagos et al., 2014a). Auerswald et al. (2014) published a paper on the use and misuse of the K factor equation in soil erosion modeling. They present modified equations that fully emulate the nomograph of Wischmeier and Smith (1978) and Wischmeier et al. (1971). Based on a large German dataset, Auerswald et al. (2014) support that "failure by using the classical K-factor equation can be large and may amount to half of the K-factor". Just a side note, we think that the term "failure" is misleading here as this is not a statistical or mathematical term (unless you deal with boolean variables, which do not apply here and where the term "misclassification" should be used). What Auerswald et al. (2014) probably want to refer to is the error which should expressed as the Root Mean Square Error (RMSE) in the evaluation of environmental models (Moriasi et al., 2007; Willmott, 1981). The error cannot be quantified as good or bad outside the concept of data or model variance. So when Fiener and Auerswald state that 45% of the cases are failure, this statement makes no sense since their concept of "failure" is not defined in statistical terms.

The application of the classical K-factor equation (Wischmeier and Smith, 1978; Renard et al., 1997) is constrained regarding four aspects: i.e. soils with high silt or high organic matter content, low erodibility and soils with rock fragments. The latter restriction was handled by Panagos et al. (2014b) as the effect of stoniness on soil loss was incorporated into the Pan-European model. As to the other soil types, we did not neglect them but we made adaptions (page 192 of Panagos et al., 2014b) which we consider valid in the light of continental-scale modelling. The 45% error stated by Fiener and Auerswald is again a "homemade" estimation as according to LUCAS database for Europe, fewer soils were affected by the restrictions for calculating their K-value (e.g. 2% of point soil data with a high silt content were excluded in our K-estimation). As the study of Auerswald et al. (2014) and our K-factor map were published at the same time, we could not consider the results of their study. Fiener and Auerswald might want to compare the K-factor values proposed by Panagos et al. (2014a) with their estimates using the LUCAS-soil database.

The K-factor values for soils in Romania and Bulgaria was based on a subset of an additional LUCAS campaign (Toth et al., 2015) and the application of geo-statistical modelling (Ballabio et al., 2016) was also used to produce the original soil erodibility map of Europe (Panagos et al., 2014a). Details about the K-factor for soils in Romania and Bulgaria data were not provided in Panagos et al. (2014a) as the LUCAS data for these countries were then not available (this extension was addressed in the European Soil Data Centre newsletter; March 2015). In the original soil erodibility map of Europe, spatial interpolation of the K-factor with Cubist model performed well as $R^2 = 0.4$ and RMSE = 0.0102 t ha h ha^{-1} MJ^{-1} mm^{-1} in k-fold cross validation (Panagos et al., 2014a). The interpolation using Multilevel B-Splines (MBS) (Lee et al., 1997) further increased the prediction performance of the K-factor to an R^2 of 0.94 for the fitting dataset (Panagos et al., 2014a). Cross-validation reveals a less good performance (R^2 of 0.74), given that part of the original LUCAS points are left out for the prediction. The use of the geo-spatial model extrapolation was the optimal solution to predict the K-factor of Croatia as there were no other alternatives.

2.5. Critique on the crop and cover factor (C-factor)

Fiener and Auerswald commented that "*the approach of* Panagos et al. (2015c)*, to estimate the crop and cover factor (C-factor) has not yet been critically evaluated*". The approach to model the C-factor has been peer reviewed thoroughly and published and the data are freely available from European Soil Data Centre (ESDAC) (Panagos et al., 2015c).

A major misunderstanding is that the C-factor is not averaged at European level as stated by Fiener and Auerswald. Based on crop composition extracted from EUROSTAT agricultural production statistics (Eurostat, 2014) and the C-factor assigned to each crop (see the cited studies below), the C-factor for arable lands is assigned at regional NUTS2 (Nomenclature of Territorial Units for Statistics) level. Panagos et al. (2015c) proposed a NUTS2 average C-factor values for arable lands based on an extensive literature research which allowed the best use of the available information. The C-factor values for crops are based on experimental data from previous studies (i.e. Bollinne, 1985; Onchev et al., 1988; NS, 2001; Rousseva, 2004; Biesemans et al., 2000; Wischmeier et al., 1971; David, 1988; Cai, 1998; Palmquist and Danielson, 1989; Roose, 1977; Nyakatawa et al., 2007; Gabriels et al., 2003; Boellstorff and Benito, 2005; Antronico et al., 2005; Vezina et al., 2006; Bazzoffi, 2007; Junakova and Balintova, 2012) and applications of the proposed C-factor values (i.e. van Rompaey and Govers, 2002; Wall et al., 2002; Shi et al., 2004; Basic et al., 2004; Morgan, 2005; Bakker et al., 2008; Marker et al., 2008; Terranova et al., 2009; de Vente et al., 2009; Diodato et al., 2011; Borrelli et al., 2014). Further we take into account the impact of vegetation density in the cover-management factor estimation using the 10-days remote sensing images of vegetation density that originated from COPERNICUS (Copernicus, 2012). Obviously, our modelling approach would be more precise with crop statistics available at finer scale (province or municipality). But the best harmonized data currently available for arable land in the European Union (1.1×10^6 km^2) are the NUTS2 level cropping database. However, our approach represents a major improvement compared with previous RUSLE-based pan-European assessments (e.g. van der Knijff et al., 2000; Bosco et al., 2015). In addition, we include for the first time statistical data (Eurostat, 2014) and earth observation data (LUCAS, 2012) on tillage practices, cover crops and plant residues for the prediction of the C-factor and data on contouring, stone walls and grass margins for the modelling of the P-factor.

Fiener and Auerswald state that we modelled the lowest C-factor in Germany for Bavaria which is not correct. Our data show that the C-factor in Bavaria is the second highest in Germany (see Panagos et al., 2015c) based on the reported data from EUROSTAT. Bavaria covers 70,547 km^2 from which 20,633 km^2 is arable land (Eurostat, 2014). Those numbers correspond to those of Auerswald et al. (2003). In this arable land area, 27.1% is common wheat and spelt, 2.3% rye, 19.1% barley, 6.4% grain maize, 0.8% dried pulses and protein crops, 2.3% potatoes, 8.8% sugar beets, 3.4% oil seeds, 7.7% rapes, 0.1% sunflowers, 19.5% green maize and 2.5% fallow land. These figures are the mean areas covered by these crops during the period 2008–2012 (Source: Eurostat; Table: Areas harvested, yields, production by NUTS2 regions [agr_r_crops]; last update: 30.4.2014; extracted 10.9.2014). If Fiener and Auerswald disagree with these numbers or with the respective C-factor values they should have stated that clearly and give the reasoning behind.

Fiener and Auerswald criticized the absence of crop rotations in the C-factor estimation which again is not true. In our C-factor assessment (Panagos et al., 2015c), an important aspect is crop composition which was assessed over a five-year period (2008–2012). The crop composition describes the share of each crop in the agricultural land area of a region at NUTS2 level. LANDUM (Panagos et al., 2015c) is the first model to incorporate both the crop composition and the conservation management practices in C-factor estimation at the European scale. Compared to assigning a single C-factor value (0.335 or 0.2) to all European arable lands (Bosco et al., 2015), LANDUM focuses on the regional level and assigns C-factors based on the crop composition (Panagos et al., 2015c). According to the crop composition in Bavaria, this region has a mean C-factor equal to 0.283 which is the second highest among the German regions. LANDUM is proposed as a model for C-factor estimation at pan-European scale and it is not intended to substitute local C-factor maps that are based on spatial crop statistics and higher resolution remote sensing data.

The crop rotation in each agricultural field is an important issue. At this stage it is impossible to predict crop rotations across Europe as such cropping records are currently not available at European scale. But it is important to be aware that the overall share of crops at regional level (NUTS2) is generally stable.

Fiener and Auerswald speculate that our C-factor values for Germany are largely misleading but do not deliver any justification or convincing arguments. Moreover, they do not propose a C-factor map of Germany. We would be interested to learn of their alternative approaches for the estimation of crop management and erosion control practices (i.e. reduced tillage, crop residues, grass margins, cover crops, stone walls and contouring). However, we would like emphasize that our study focuses on the continental scale whereas Fiener and Auerswald focus on the regional (Bavaria). They are used to work with very detailed datasets of Bavaria which offers them one of the most comprehensive and well-structured agricultural inventory available in Europe. By contrast, we model soil erosion at continental scale (4.3×10^6 km^2 in the European Union). Fiener and Auerswald criticize our assumptions based on their regional-scale field experience, but fail to provide solutions or alternative methods which could potentially improve our current continental-scale modelling approach.

2.6. Lack of seasonality in C and R factor maps

One of the main comments regarding the C-factor addressed by Fiener and Auerswald is the absence of a combination of seasonal C- and seasonal R-factor maps. We are fully aware of this lack. Data on the seasonality of C-factor and R-factor would allow an improvement in soil erosion mapping. Unfortunately, seasonal data from which the C-factor can be calculated is not available yet. The first step to close this gap are seasonal rainfall erosivity maps for Europe (Panagos et al., in review) as a follow up and an advancement of the recently published Rainfall Erosivity Database at European Scale (REDES) and the respective mean annual R-factor map (Panagos et al., 2015b). Here we have to repeat our earlier reply about the R-factor map for Europe to Auerswald et al. (2015) (Panagos et al., 2015f). The regionalization of the R-factor on a monthly basis was not a task that was easily completed because the different seasons and regions within Europe required different spatial predictors. During 2015, the monthly dimension was developed in REDES and the first assessment of rainfall erosivity at monthly scale for the European Union (Panagos et al., in review). Therefore, we are well aware of the differences in the seasonality between Italy and Austria (Fig. 1). We disagree with the data proposed by Fiener and Auerswald (their Fig. 1) and would like to point out that our values are valid for the whole of Italy while their data only apply to Central Italy. We have the most updated and extensive dataset on rainfall erosivity in Europe (REDES). According to REDES, which includes an updated list of rainfall stations with high temporal resolution data, the 84 REDES stations of Austria have 12.5% of their annual erosivity in the period November to April (Panagos et al., in review). As to the Italian data, Diodato (2005) whose R-factor data were quoted to illustrate the contradiction with our R-factor database, actually contributed to the REDES database, but REDES hosts 10-times more stations (250 in Italy). According to REDES, 34.8% of the total annual erosivity in Italy occurs during the winter months. A first regional spatio-temporal analysis of the erosivity factor covering Greece was recently produced (Panagos et al., 2016).

Even more challenging and difficult is the assessment of the C-factor on a monthly basis at European scale. As described in the introduction of the C-factor paper, soil loss ratios in combination with temporal variations in R-factor values are needed in order to calculate the C-factor. Deriving these soil loss ratios (SLRs) at European scale is almost impossible (SLRs are computed as a product of five sub-factors: prior land use, canopy cover, surface cover, surface roughness and soil moisture; Renard et al., 1997). We are surprised to learn that Fiener and Auerswald consider this to be an easy task to accomplish, and look forward to seeing their work in the near future.

2.7. Validation and comparison to national and pan-European assessments

A major point of critique by Fiener and Auerswald was that they thought we did not validate the modelling. Panagos et al. (2015a) verified the plausibility of the RUSLE2015 results with the EIONET data collection. In 2010, the European Soil Data Centre (ESDAC) of the European Commission collected soil loss data from national institutes in Europe through the European Environment Information and Observation Network (EIONET). The result of this data collection exercise was the EIONET-SOIL database which includes data at 1-km pixel size for eight countries: Austria, Belgium, Bulgaria, Germany, Italy, the Netherlands, Poland, and Slovakia (Panagos et al., 2014a). Denmark was included in a later phase. Those 9 national datasets were the only available data comparable to the RUSLE2015 outputs (Panagos et al., 2015a) and the data verification was satisfactory. The EIONET data from Germany at

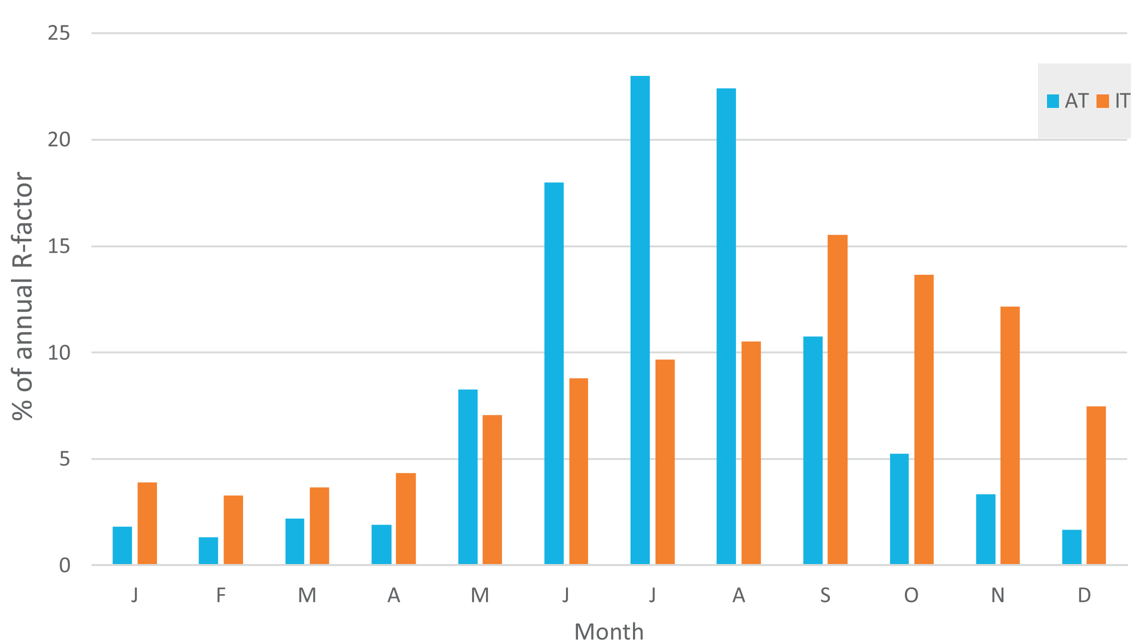

Fig. 1. Monthly distribution of annual erosivity (R-factor) for Austria (AT) and Italy (IT) according to the REDES database.

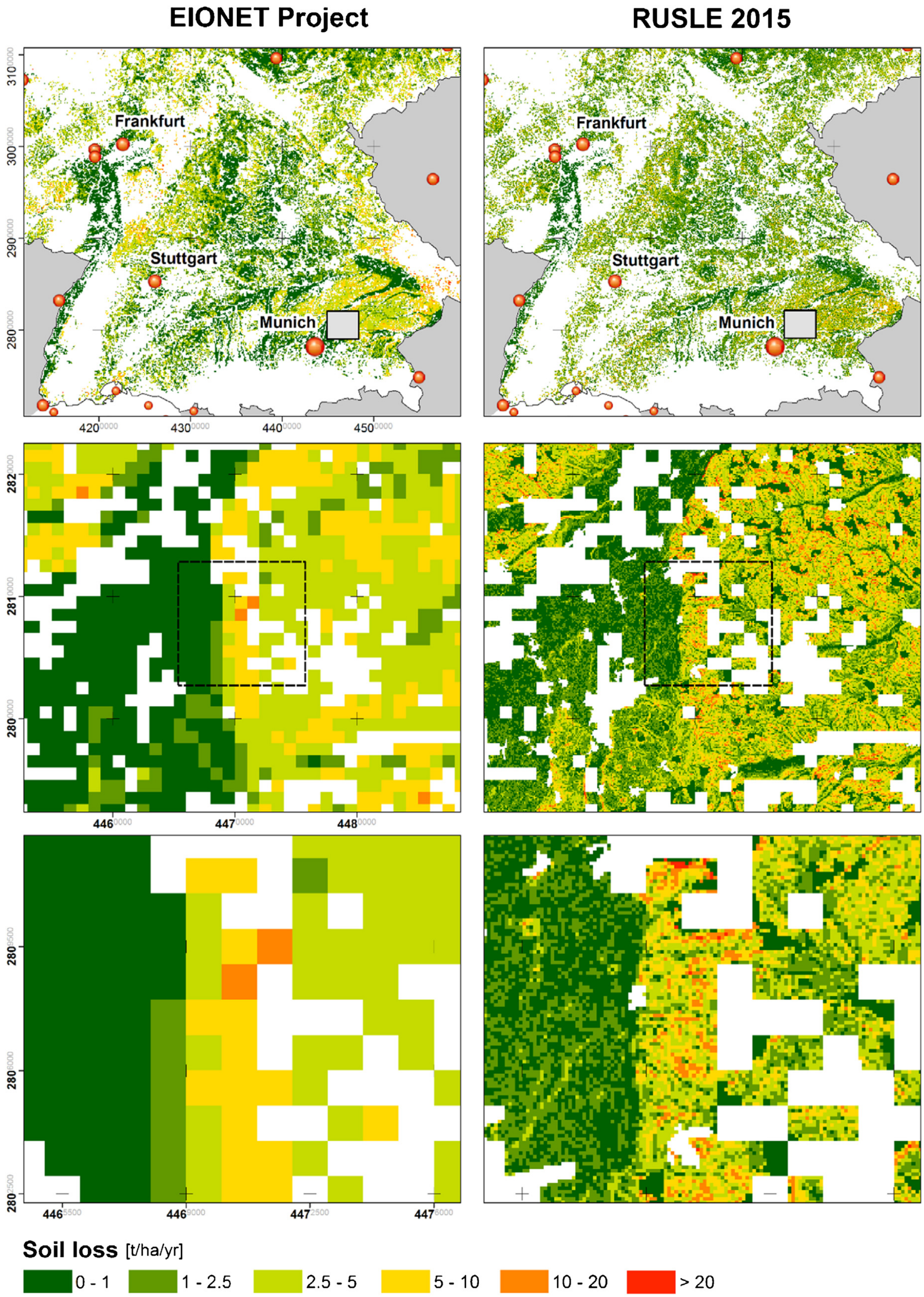

Fig. 2. Comparison of soil loss rates at three spatial scales in Germany from EIONET (left map) with RUSLE 2015 (right map).

three spatial scales provided by the Federal Environment Agency (Panagos et al., 2014b) correspond very well with the RUSLE2015 output (Fig. 2) (Panagos et al., 2015a).

Panagos et al. (2015b) provided the error on the estimates of the R-factor values which includes areas where the uncertainty is high. In addition, Panagos et al. (2015c) expressed their concerns about the areas under the "sparse vegetation" CORINE class which may have large uncertainty of C-factor estimates due to the ambiguity of the class in CORINE mapping. The K-factor has also been verified against local/regional studies (Panagos et al., 2014a).

The interpolation of the input factors of RUSLE 2015 model have been validated in the respective papers following guidelines and principles of characterizing the performance of environmental models (Pierce et al., 2013). The K-factor model performance was tested for both the fitting and a cross validation dataset. The Cubist regression model predicted the pan-European distribution of the K-factor with a good performance as $R^2 = 0.4$ and RMSE = 0.0102 t ha h ha^{-1} MJ^{-1} mm^{-1} in k-fold cross validation. The interpolation using MBS further increased the prediction performance of the K-factor to an R^2 of 0.94 for the fitting dataset. Cross-validation gives a less good performance (R^2 of 0.74), given that part of the original LUCAS datapoints are left out for the prediction (Panagos et al., 2014a). The R-factor GPR spatial interpolation model performance was tested for both a fitting and a cross-validation dataset. The cross-validation is carried out by random sampling with 10% replacement of the original dataset used for validation. The Gaussian Process Regression (GPR) model used to interpolate the R-factor point values to a map showed a good performance for both the cross-validation dataset ($R^2 = 0.63$) and the fitting dataset ($R^2 = 0.72$) (Panagos et al., 2015b). We also presented and made available the uncertainty of the R-factor prediction calculated with the GPR spatial interpolation model. The LANDUM C-factor estimations have been based on an extensive literature review (Panagos et al., 2015c).

Another major aspect that appears several times throughout the comment of Fiener and Auerswald is the comparability of the pan-European assessment to other assessments. As a case study they chose Germany. We believe that the German 'Bundesanstalt für Geowissenschaften und Rohstoffe' (BGR) produced thorough soil erosion risk maps for Germany (DIN, 2005, 2015). Today, the soil map of Germany is probably one of the most comprehensive in Europe (Jones et al., 2005), and the deriving RUSLE-based erosion risk assessments are excellent (DIN, 2005, 2015). Nevertheless Auerswald et al., (2009) proposed an alternative methodology for modelling soil erosion in Germany but their model output is not proposed by BGR as a soil erosion map in Germany (DIN, 2015). However, we believe that although the BGR has good datasets available, they are facing similar limitations for their regional modelling exercises. We noted that for the DIN (2005, 2015),) maps, erosion factor data at a coarser resolution were used (K-factor based on 1:1,000,000 soil map; LS-factor based on DEM 50m, R-factor based on coarse temporal resolution) compared to our data set. We are not sure if Fiener and Auerswald actually noted that the German study presents the potential soil erosion risk, thus the cover-management and support practices (C- and P-factor) were not considered in the model. We wonder if Fiener and Auerswald are aware that potential and actual soil erosion risk cannot be compared directly.

The rather simplistic operation in correlating average soil loss values predicted by Cerdan et al. (2010) with our data obviously led to a poor and insignificant correlation ($p = 0.41$, Fiener and Auerswald 2015). We wondered about the scientific rationale of this approach. Mean soil loss rates measured at the plot scale should be compared with modelling outcomes representing similar environmental conditions at the plot scale, i.e. topography, rainfall erosivity, soil characteristics, vegetation coverage and conservation practices. Plot measurements and RUSLE outcomes should undergo sub-setting and normalization operations before being compared. Obviously, you cannot expect that a soil loss measured over a certain (limited) period and at specific site conditions, would correlate well with long-term and spatial average of soil loss, such as predicted by the RUSLE model (Renard et al., 1997). Moreover, the way Cerdan et al. (2010) and Panagos et al., (2015a)grouped the different land use types are not the same and therefore not comparable. We are sure that a proper correlation of the great data set of Cerdan et al. (2010) with its 2741 plot-years and the RUSLE modelling outcomes (Panagos et al., 2015a) would certainly offer better results. In this context another misunderstanding regarding the reference to Cerdan et al. (2010) might be clarified. RUSLE 2015 is modeling long-term averages of soil erosion based on long-term rainfall erosivity, which due to the high variability of rainfall erosivity not only within the year but also between years, cannot be compared with highly variable plot data collection.

2.8. Future scenarios

Fiener and Auerswald complain that climate-driven shifts in the seasonality of rain erosivity and crop phenology were not considered in our future scenarios. We have to remind Fiener and Auerswald that seasonality of the corresponding factors (R- and C-factor) was not considered in our assessment yet, therefore these seasonal changes could not be incorporated in future scenarios.

The modelling framework proposed by Panagos et al. (2015a) allows to develop land use and climate scenarios as inputs to impact assessments, policy formulation and evaluation. The projection of REDES combined with climate change scenarios (HADGEM2, RCP4.5) and using a robust geo-statistical model resulted in a 10–20% increase of the R-factor. We are currently working on a model re-run with more advanced knowledge on the boundary conditions in order to project the R-factor changes foreseen in 2050.

With respect to changes in crop phenology, Fiener and Auerswald proposed the studies of Estrella et al. (2007) and Menzel and Fabian (1999) which are very interesting regarding the extension of the growing season. Even though those studies can be very useful in future studies of soil erosion seasonality (which has not been studied yet at European scale) they have little to do with land use projections. Fiener and Auerswald further proposed the study of Hatch et al. (1999) which investigates the climate-induced crop yield changes at farm scale. However, this study cannot be linked to the impact of land use/cover changes (e.g. afforestation/deforestation, expansion of arable lands, urbanization, and reduction of sparsely vegetated areas) in Europe to the future soil erosion estimates. We would have also liked to analyze the study of Becenetti et al. (2014) but no full reference was given by Fiener and Auerswald. Today, the pan-European Land Use Modelling Platform (LUMP) provides valid projections of land use changes in Europe (Lavalle et al., 2013) and this was used in our scenario. Concluding the response to this comment, Fiener and Auerswald propose a number of papers which cannot be considered yet in RUSLE 2015. Panagos et al. (2015a) showed the possible applications of RUSLE 2015 by simulating future climate change and land use/cover change scenarios plus policy interventions.

3. Conclusions: more effort is needed?

Finally, Fiener and Auerswald call for more efforts to be taken by the European soil erosion community in best use of data and knowledge. We fully agree with this statement and that is why we used the latest state of the art available datasets and we have followed a participatory approach. Panagos et al. (2015a) have maximized the use of available homogeneous, updated, pan-European datasets (LUCAS topsoil, LUCAS survey, GAEC, Eurostat crops, Eurostat Management Practices, REDES, DEM 25m, CORINE, European Soil Database) and have used the best suited approach at European scale for modelling soil erosion.

Fiener and Auerswald failed to notice that the approach followed by Panagos et al. (2015a) was a participatory one with the contributions (direct or indirect) of many scientists and institutions:

- Soil erodibility was checked against 21 national/regional studies in Europe
- Rainfall erosivity was modelled with high temporal resolution data involving national/regional meteorological services and Environmental Institutions (see the acknowledgements page 511 of Panagos et al., 2015a) of all European Union countries.
- The topographic factor was calculated based on the recently high resolution DEM at 25m for the whole Europe.
- The crop statistics and the management practices (given by Member states to EUROSTAT) have been incorporated in the cover-Management factor.
- The support practices are modelled based on 270,000 earth observations with LUCAS survey data and Good Agricultural Environmental Condition (GAEC) introduced by Member States.

We are looking forward to a more comprehensive approach by Fiener and Auerswald, where participation of the EU member and non-member states will be increased and validation of the model intensified. As stated above, we will continue improving our modelling platform and aim to optimize the basis for decision-makers step by step.

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