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Interactive comment on "Virtual water trade and water footprint of agricultural goods: the 1961–2016 CWASI database" *by* Stefania Tamea et al.

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We thank the Reviewer for recognizing the hard work on the large amount of data. We address below the points as they have been raised.

- ESTIMATION OF TEMPORAL CHANGES OF WATER CONSUMPTION FOR CROP PRODUCTION

Of course the issue raised by this Reviewer is a relevant one, and at a first sight one could be surprised by the fact that the temporal variations of the water footprint are dominated by yield variations rather that by the temporal variations of evapotranspi-

ration at the yearly scale (by considering the two factors composing the crop water footprint). This finding has been already substantiated in Tuninetti et al. (2017) via a robust data-based analysis (further details and extensions are found below), but some comments are indeed deserved regarding the reason why this occurs, which are mainly two in our understanding: (i) Evapotranspiration fluctuates more intensely in space than in time, due to its strong relation with the radiation balance; in the method we adopt, spatial variations of evapotranspiration are accounted for by referring to the data by Mekonnen and Hoekstra (2010). (ii) In contrast, crop yield fluctuations are very intense both in space and in time, since crop yield variations adsorb the variability of agronomical techniques, mechanization, soil fertility, and also water availability (among others). By getting back to the comment "Water consumption is highly dependent on the climate condition of the production area (e.g. precipitation amount and pattern, temperature, soil conditions, etc.), which can temporally vary in a production area. The approach adopted by authors ignores such crucial aspects of water demand for crop.", we can reassure this Reviewer that indeed our approach does not ignore such crucial aspects. We are sorry for not having clearly outlined these points in the previous version of the manuscript: the text will be amended to better explain our approach. Some additional details on this issue are reported below.

The method used to estimate the temporal evolution of the unit water footprint, or Fast-Track method, is a simplified method introduced in a peer reviewed publication (Tuninetti et al., 2017). There, the Fast-Track method has been verified by comparing the unit water footprint obtained with the simplified approach with estimates obtained by applying a complete water footprint estimation model based on a daily soil water balance fed by year-specific hydro-climatic variables. Despite year to year variations, errors associated to the Fast-Track method, i.e. to the hypothesis of keeping a constant evapotranspiration and let only agricultural yield change, are within a 10% range. This error is comparable to the one affecting estimates based on different models and is therefore negligible in practical terms. We refer to the original paper (Tuninetti et al., 2017) for details and specifications. The Tuninetti's paper has been the basis for the database presented in this manuscript; it underwent a full peer review process and it is now well regarded in the relevant literature, with none of the citing papers highlighting problems with the method. For the Reviewer's reference, we are able to include here some additional material about the Fast Track method, further reinforcing our point. We attach below a Figure showing a validation for some additional crops, considering years 1961, 1971, 1981 and all years in the range 1991-2004. The choice of additional crops aims at covering a large fraction of food production worldwide and at diversifying the crops' characteristics (growing seasons, sensibility to water stress and fraction of irrigated production). The differences in unit WF are comparable to the results in Tuninetti et al (2017) and although the variability (error) may occasionally be larger than 10%, the results further confirm the great performance of the Fast Track approach on a wide range of crops.

In addition to the above considerations, another point should be mentioned. We agree with the Reviewer that water consumption of crops (evapotranspiration) is dependent on hydro-climatic conditions (precipitation, temperature, . . .). However the unit water footprint is less sensitive to them, because it is defined as the ratio between evapotranspiration and agricultural yield, both reacting to hydro-climatic fluctuations with equal signs (see, e.g., Doorenbos et al, 1979). Furthermore, it should be noticed that the sum of green and blue water volumes (the "consumptive" water footprint) is considered in the present database. While the separate contributions of green and blue water may be more affected by year-specific hydro-climatic conditions, the sum of the two terms is less sensitive to these conditions, further reducing the overall error associated to the simplified estimation of uWF with the Fast Track method. As mentioned, the strengths and weaknesses in the approach used to derive the database have now been stated more clearly in Section 3.1 and in the Conclusions. Also, we have added a cautionary note in the Conclusions to use single-year data with care and to put them in a temporal perspective or multi-year average, in order to avoid misinterpretations of year-specific results.

- THE VALUE OF TEMPORAL ANALYSIS OF WATER CONSUMPTION OF A CROP

A large body of literature based on the WaterStat database uses values averaged over a decade centered on year 2000. The time-varying database that we are proposing enables quantitative analyses in different periods, and in particular it enables analyses about more recent years, with updated unit water footprint values. The water footprint and virtual water trade literature includes many contributions that address a temporal evolution without including the time-varying unit WF: these studies can be updated and discussed in view of the new data and additional knowledge that is becoming available to the scientific community. Moreover, some literature ("at its infancy", cit. from Hoekstra, 2017) is moving in the direction of making projections and future scenarios of water use for food production and trade. How can we try to predict the future without knowing about the past evolution? The database may therefore serve as a unique starting point for any analyses considering the temporal evolution in the past and in the future of the crop water footprint, with very significant potential implication for the users of the database.

- CROP WATER CONSUMPTION IS NOT WATER FOOTPRINT

The database includes, for as many products and years as possible, a differentiation between the unit WF of production and the unit WF of consumption. The latter takes into account, besides the locally produced goods, also the imported fraction of goods considering their country of origin, based on the procedure proposed by Kastner et al (2011). In this way, the unit WF takes into account the unit WF of the goods in the countries of production and the role of international trade. As for the use of the "Water Footprint" terms, we are aware of the ISO standard, which has now been mentioned in the manuscript but we are also aware of the large body of literature about the water footprint that originated from prof. Hoekstra's work and the Water Footprint Network. We are following his same approach, taking a bottom-up approach as specified in the Introduction. However, with the important improvements introduced in this manuscript (i.e., the separation between the production and supply unit WF and the tracing back of origin country of traded goods) we are improving upon previous limitations of this approach, bridging towards the top-down approach and offering a new database at the state-of-the-art in the field.

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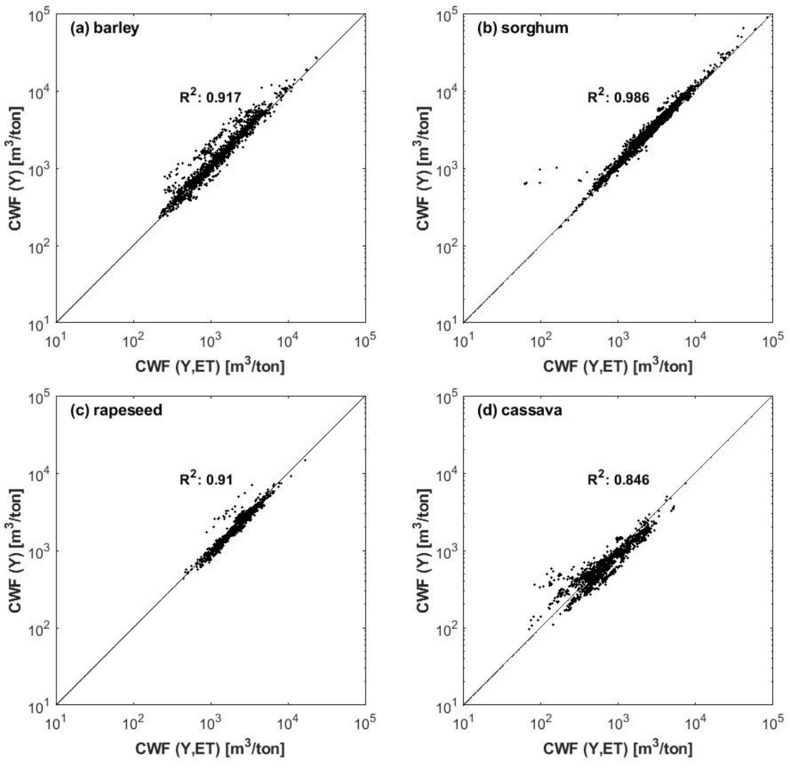

Fig. 1. Country-scale comparison of the annual unit WF estimates obtained by the FastTrack approach, CWF(Y), with the values from the detailed methodology accounting for both yield and ET variations,CWF(Y,ET)