

# ***Interactive comment on “Evaluation of three new surface irrigation parameterizations in the WRF-ARW v3.8.1 model: the Po Valley (Italy) case study” by Arianna Valmassoi et al.***

**Arianna Valmassoi et al.**

avalmass@uni-bonn.de

Received and published: 31 January 2020

R1:

Major remarks, answers:

1. **C:** Many details are provided with regard to the effect of irrigation and partially it seems that they are sold as new results. However, effects are neither new nor surprising as they can be expected from process knowledge and previous studies.

**A:** The physical explanation of the irrigation impact is not intended as new, rather a cross-check of the performance of the schemes with respect to previous global

studies. This part is important as older studies (Sacks et al, 2009 and Boucher et al. 2004) found that irrigation increases the surface temperatures in the Po Valley, and Thiery et al. 2017 found a decrease. The aim of this paper is to introduce and validate the irrigation parameterization, in the context of a regional model. The physical responses are discussed in two others paper due to length constraints (one can be found at: <https://www.mdpi.com/2073-4433/11/1/72> while the other is accepted pending revisions). New aspects are also the comparison of the impacts of timing as well as the evaporative loss.

2. C: I am wondering why the study's results have been submitted to GMD. The study comprises the results of a set of sensitivity studies that have been conducted with an existing regional climate model using three types of simplified irrigation parameterizations. I would not consider the respective simplified equations as new model development.

A: The current work is submitted in GMD as it addresses three new parameterizations that were not previously included in WRF, to be released in the model such schemes have to be properly documented in journal publication. Moreover, there is no current irrigation parameterization in mesoscale models which is available for studies that constrains water used and allows timing as input. The parameterizations' limitations has to be contextualized with LAM models and their limitations in representing the water cycle. Also, past equations (which consider just soil moisture saturation,e.g.) are not suitable to represent irrigation processes at the regional scale, especially when going towards convection-permitting ones.

Minor remarks, answers:

1. C: However, recently deVrese and Hagemann (2018)investigated uncertainties related to the representation of irrigation characteristics with respect to irrigation effectiveness and the timing of the delivery.

A: We are going to add the new references of the previous studies, as it further

Printer-friendly version

Discussion paper



helps to prove the point of the need for a timing investigations: de Vrese et al, 2018 only investigates the differences between irrigating every model timestep (not realistic) and bi-weekly. The assumptions of previous global studies are likely correct at the investigated resolution of order-100 km, but can be improved at the regional scales and for mesoscale studies.

2. C: I do not agree with this statement as several climate model studies exists where the water for irrigation is withdrawn from existing reservoirs within the respective model framework (e.g., from reservoirs of the river routing scheme such as in Guimberteau et al. 2012, de Vrese et al. 2018), or where the amount of irrigation is limited by using information from observed river runoff

A: For “explicit water amount”, a volumetric estimation of water used for irrigation is intended (in this case: VI). This quantity is crucial, as the reviewer correctly pointed out later in the comments, as the impact of irrigation might differ between models or simulations despite identical assumptions. Thus, the importance of this quantity, which is directly related to irrigation and that can be used to compare studies. Irrigation water volume can also be used to compare country-wise estimations, which are independent from the atmospheric/soil models. The lack of this estimation is considered a limitation of the reliability of the irrigation impacts and its magnitude from different studies (Sack et al, 2009 and Wada et al, 2013).

3. C: Does this mean that (as irrigation water is added to precipitation) also the actual precipitation is not intercepted? This would introduce an erroneous model change that makes the comparison to the control simulation invalid as effects on model results are not only caused by irrigation itself.

A: In the CHANNEL method, the water coming from the irrigation only does not interact with the canopy. The rain produced by the atmospheric processes does interact with the canopy normally. The sentence is changed in the new manuscript to clarify this point.

[Printer-friendly version](#)[Discussion paper](#)

4. C: Why a non-reproducible option is given as default, and not the reproducible one? This makes a potential code debugging more difficult.

A: The term non-reproducible is associated to across-compilers, which is related to the random number generator that might be architecture-dependant. While a random number option ensures that the resulting field is randomly distributed, the non-random option ensures that such field has no specific spatial pattern. Neither option is the default, the default is the synchronous activation.

5. C: eq. 1 and line 127-128, Table 2 I don't understand the definition of .Why a frequency is characterized with the difference symbol ? Why a frequency is expressed in number of days and not number per days? If irrigation is conducted once per week, I would expect a frequency of 1/7 days, and not 7 days such as it is defined.

A: We have changed the term frequency to interval to avoid this confusion.

6. p. 21 – Fig. 11 and 12 Figures are too busy. Showing 28 different curves, the curves are not distinguishable.

Fig. 11 has been adapted to highlight better the runs. New figure (Fig. 1, at the end of the document) and the old one (Fig.2, at the end of the document) are here shown. However, it is important to show how all the different timing options behave with respect to the control run. The shading of Fig. 12 and 11 (left) is crucial to highlight the spatial variability.

7. p. 22, 23, 24 – Fig. 13 (upper panels) and 14, 15 (upper panels) Figures are too busy and blurry with all these curves. The light-dashed lines do not provide any additive value and strongly distort the figures.

The upper panels dashed lines are included to highlight the fact that, while the differences with respect to the control runs increase with time, the differences between timing do not. This implies that irrigation itself influences the physical quantities beyond the diurnal timescale of its application. However, the timing

[Printer-friendly version](#)[Discussion paper](#)

of irrigation does affect these atmospheric/soil variables only within the diurnal cycle.

We thank the reviewer for useful comments and suggestions for further references. The minor remarks corrections are made to the new manuscript.

**GMDD**

---

[Interactive  
comment](#)

[Printer-friendly version](#)

[Discussion paper](#)



R2:

1. [C: add the secondary effects in the Introduction.](#)

A: the introduction has been modified accordingly.

2. [C: How does the development here differ from the paper by Lawston et al., 2015, J.Hydrometeor., 1135–1154](#)

First of all, all the schemes in Lawston differs in irrigation timing, frequency and type of water application. Our schemes differ only in the type of application, making the comparison between methods possible. The drip scheme in Lawson is completely different from the one presented here, as our water is intercepted by the canopy and in the other the evapotranspiration is modified as if there was no soil moisture stress. The only similarity with the sprinkler schemes is that there is an explicit irrigation amount. Lawson affirm that their scheme is not driven by crop-water demand, however, the water application is activated and stopped depending on the root-zone soil moisture availability only. Our scheme fulfills this requirement, as the timing of irrigation and the water applied is defined through user-defined parameters. In our scheme the water is applied to the rain water mixing ratio of the lowest model level, in Lawson it is applied as rain rate, therefore already in the surface driver scheme. Therefore, it would resemble more the DRIP scheme presented here. However, it differs as the method presented in our paper has both timing and water amount controlled by the user. The flood method by Lawston applies the water at the root-zone until the top layer is saturated for 30 minutes. The channel method here applies the water at the surface with a prescribed rate and duration, which are controlled by the user. Generally speaking, the three methods described in Lawston do not include any specific information of total water amount used for the schemes as a priori information or timing, which is not realistic. Regarding the decision of the area to irrigate, Lawston relies on the USGS (which is derived from satellite data from 1992 to 1993) to irrigate the whole grid point or half. In this parameterization development, we

GMDD

Interactive  
comment

Printer-friendly version

Discussion paper



use the global FAO dataset of area equipped for irrigation. This allows the application of irrigation to different land use data sources (e.g. MODIS), irrigation on high-rise vegetation (e.g. orchard) and ad-hoc mask modifications (in case of high resolution information available).

3. **C: Does the scheme consider the evaporation of water on the leaves (and so the cooling effect)? Does the temperature of irrigated water matter?**

The schemes consider evaporation from the leaves only when the schemes allow water to be intercepted, i.e. for both DRIP and sprinkler. The temperature of the water does not matter in the canopy water equation from Noah, therefore is not accounted. The same happens for any possible difference between droplet and soil temperatures differences in the energy budget. This opens to broader investigations topics that go beyond the scope of these parameterizations, and it would require further work from the Land Surface Modelling communities.

4. **C: the central pivot irrigation that is the main method for many parts of framing in United States. In addition, over the central Great plains, underground water is pumped for irrigation, and that water can be 10-20C lower than the surface water. Can the three irrigation schemes be applied to the central pivot irrigation from ground water?**

A: The sprinkler scheme can be applied for high resolution studies that model such area, for coarse resolution runs (especially in the vertical levels), the DRIP scheme can be more suitable. However, it is not able to represent the potential effect of the difference in temperature in the water used. This is caused by the fact that the microphysics parameterizations assume that rain water is in immediate equilibrium with the air temperature. While this might be a strong assumption for the irrigation case, it allows the sprinkler scheme to work with the microphysics parameterizations without modifying all of them. The issue brought up here might help defining the path to be taken in future studies.

5. **C: Irrigation mask field.** The work here is similar as Aegerter et al., 2017 in which MODIS-based USDA irrigation database was used. However, it remains unclear how the fraction/percentage of irrigation in a model gridbox is factored into the Noah Land Surface Model in terms of surface properties for that gridbox as whole.

The irrigation mask is used only for factoring the irrigation water applied, and it is done at the surface driver level (for both DRIP and CHAN) and at the microphysic driver (for SPRI). Therefore, the irrigation water is passed to Noah (and the other LSM) as for the precipitation. The surface properties are defined solely by the land use categories.

6. **C: Does the crop types matter over the irrigated area?** Aegerter et al. designate that as irrigated cropland and pasture for CLM. How the albedo, leaf area index or NDVI are specified for crops over the irrigated area in NOAH? Obviously, these are the parameters/questions that the present manuscript is not trying to address, but it is important to be clear about it

No, the crop types do not matter over the irrigated area. All parameters are defined by the standard land use categories which are used by Noah. While this might not be completely realistic, it is used to exactly quantify the response of the model to irrigation alone.

7. **C: What surface type database is used?** In Figure 2, there are 12 croplands. Are all these croplands irrigated? Does Noah treat these 12 croplands differently in terms of their albedo, leaf area index or NDVI?

A: This study uses MODIS land use data which has 21 categories, which is shown by the 20 colors in Fig.2 (plus an unassigned category, which is not shown). In Fig. 2 (right), there is only one cropland category (yellow) but it is the number 12 in MODIS dataset, and the land use table employed in the model. The caption of the figure has been changed to not create any misunderstanding.

[Printer-friendly version](#)[Discussion paper](#)



8. [C: Where does 7mm/day come from? Should there be more irrigation in the early stage of growing season?](#)

The 5.7 mm/day is derived from the Eurostat data (as shown in the text), assuming a constant application throughout the period. We know this is not realistic, but we lack any information about sub-seasonal/monthly water application data. Uniform application is used in previous studies that use any static/non prognostic vegetation. A uniform application helps quantifying the impact of irrigation on the model at the zero-order modification. A varying irrigation amount should be employed in future studies, with dynamic vegetation, to better capture the impact of irrigation and agriculture on the studied areas.

9. [C: No irrigation and no crops should be the baseline experiment on top of which the irrigation effect can be fully studied.](#)

The baseline has to be defined depending on the research question that is addressing. In this case, we aim to introduce the irrigation parameterizations and to show how its usage improves the model. The baseline suggested might be more realistic in some of the study regions, e.g. very arid areas. However, first it should be assessed whether the agricultural area can still exist if it were rainfed. This might be done only through a complex LSM that allow dynamic vegetation representation, which is not the scope of the current work. Simulations made of the current region with the default WRF-ARW model do not include irrigation (but still have agricultural areas), which is not realistic. Also, our baseline choice is in agreement to what performed in previous studies as Thiery et al. 2017, Sacks et al. 2009, Puma et al. 2010, Saeed et. al 2009 (etc).

10. [C: Figure 8. Why the colors are different between legend and bar color?](#)

The colorbar explicitly shows all the control runs (LR1,LR2,SR) and MODIS data. It also report the shading legend used to differentiate the irrigated schemes.

11. [C: Figure 14. What is shown here is the difference with respect to the control?](#)

[Printer-friendly version](#)[Discussion paper](#)

How about the difference with respect to the observed T (averaged over all stations)?

We did not show any validation/comparison with measures at the diurnal scale as we lack any information about irrigation timing.

12. C: The irrigation efficiency does depend on the leaf area. In the early growing season, the crop height is low and leaves are small. The efficiency should be similar. With all the assumptions made, it is questionable if the parametrization schemes here have the fidelity to address the issue of irrigation efficiency. From an economic point of view, farmers use irrigation to grow crops, and so, the irrigation amount is unlikely uniform throughout the growing season (as assumed by the model here).

A: The definition used here for irrigation efficiency is added in Sect. 5.4; in this study it aims only to quantify the water loss (in terms of soil moisture changes) depending on the evaporation processes that the water undergoes. Since both the irrigation parameterizations and the other components involved have limitations, the aim is to understand how important each of these evaporative processes is at the convection-permitting scales. No parts of this work aims to tackle the efficiency at the single farm scale. The full impact of irrigation as coupled with vegetation is not addressed here as the model does not have the ability to represent dynamical vegetation. This study, however, might give a starting point for further development in future studies.

---

Interactive comment on Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2019-223>, 2019.

Printer-friendly version

Discussion paper



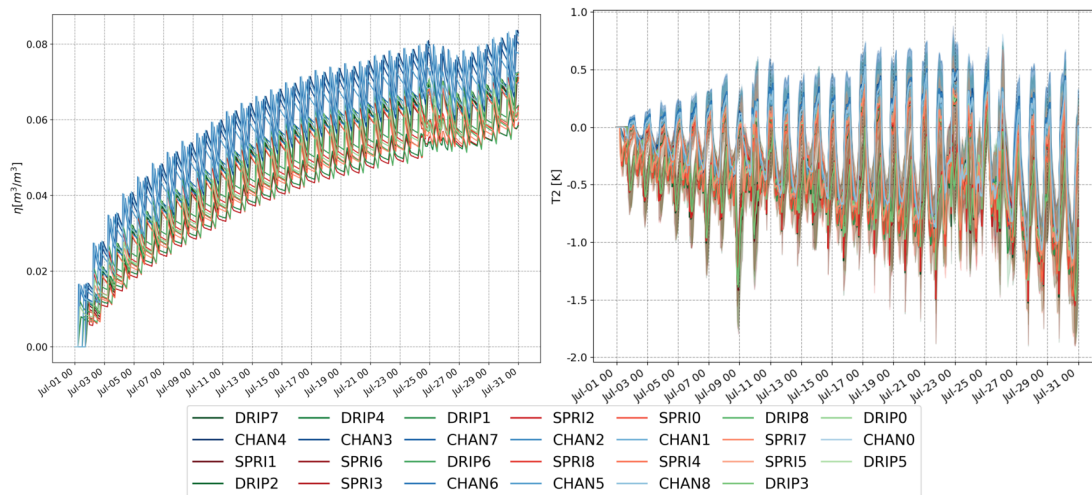


Fig. 1.

Printer-friendly version

Discussion paper



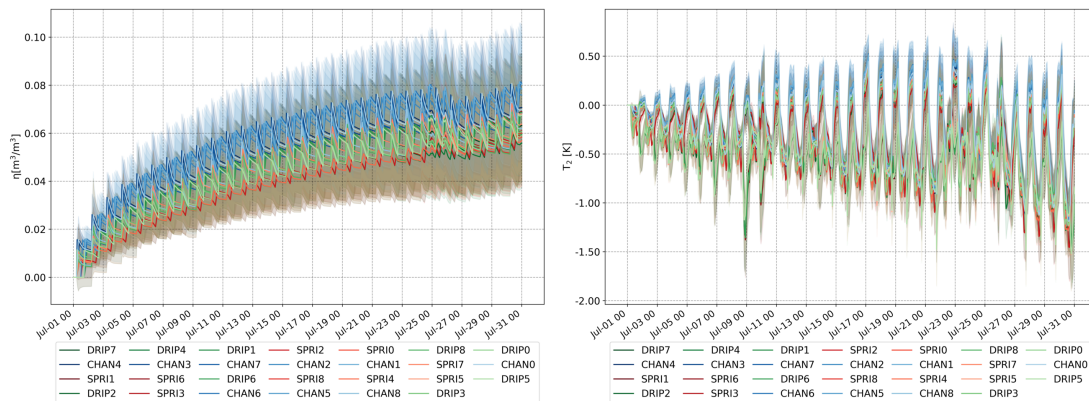


Fig. 2.

Printer-friendly version

Discussion paper

