Replies to RC2

Please find below:

- *In black, original comments by RC2*
- *In green, replies by the authors*

Summary and General Comments

This paper presents the WFDE5 dataset, an atmospheric forcing dataset which will further be used to drive and evaluate impact models. It is constructed by applying the WFD methodology to ERA5, the last generation of ECMWF reanalyses. WFDE5 is constructed with the same methodology as the WFDEI dataset, which has been constructed from the previous generation of ECMWF reanalyses, ERA-Interim.

WFDE5 is based on a monthly bias-correction of ERA5 by CRU TS4.03. It contains all the variables required by impact models at the conventional format (cf. ALMA conventions). In order to consider the high uncertainty of precipitation, WFDE5 is available with two different bias-adjustment of precipitation, one has been bias-adjusted by CRU and the other by GPCC. A derived daily dataset, W5E5, has also been created for upcoming ISIMIP phase 3, combining WFDE5 over the land to ERA5 over the ocean. This paper details the improvement and adjustment of the WFD method in order to fit with the ERA5 dataset.

WFDE5 benefits from the ERA5 improvements and in particular from its higher spatial and temporal resolution. Even if both WFDE5 and WFDEI have the same spatial resolution of 0.5°, the WFDE5 dataset integrates more spatial variability than WFDEI being constructed by aggregation instead of interpolation. It also integrates more temporal variability as WFDE5 is available at an hourly temporal resolution instead of 3-hourly for WFDEI The evaluation of the WFDE5 dataset is done in comparison with WFDEI and with ERA5. This is done by comparing (1) their performances over 13 FLUXNET2015 sites well distributed over the world and (2) their performance at forcing an hydrological model (WaterGAP) in order to have a first estimate of the capacity of WFDE5 to drive an hydrological model.

The manuscript is well written and well organized. This dataset is a good contribution to the land modeling community as it permits to use a bias-adjusted version of the last release of the ECMWF reanalyses , ERA5. It is promising as it will benefits from further improvement of ERA5 like, for example, from the future extensions of the period covered by ERA5. The code is publicly available so it will help the community to use the WFD method adjusted for this new version and to generate new forcings at higher resolution (when all the ground-based observation of the variables will be available at these resolutions).

I recommend the publication of this paper after some minor revisions.

Specific comments

Line 127 :

You explain how you process the grid points of CRU TS4.03 and GPCCv2018 that are not considered as land points in ERA5 and declare that "*In this way, the final WFDE5 dataset contains values only for all grid-points which are classified as land or lake by both ERA5 and CRU*".

Have you been confronted to the opposite, land points of ERA5 that are not considered as land points in CRU or GPCC ? If that was the case, how did you proceed to bias-adjust them?

Thank you for your question. CRU and GPCC datasets have non-missing values only for grid-points considered as land. In the aforementioned case, i.e. for land points of ERA5 that are not considered as land points in CRU or GPCC, having missing values for the latter datasets would result in not being able to perform any of the described corrections. As a consequence, all grid-points which are not considered as land points in CRU and GPCC datasets are automatically set as missing values in the WFDE5 dataset.

The only exception to this regards Antarctica region, which is completely missing from CRU and GPCC datasets. As specified at the end of Section 2.2, for ERA5 land-points belonging to this region, only elevation-correction (where required) and aggregation to 0.5° x 0.5° was applied.

Validation with a global hydrological model :

The simulations with the hydrological model WaterGAP are used to assess the capacity of WFDE5 to force an hydrological model compared to ERA5 and to WFDEI. The Figure 5 shows the annual cycle of the outflow of the 12 large river basins over the period 1981-2010.

For the basins with a FLUXNET2015 stations, if we can make the hypothesis that the bias over the FLUXNET2015 stations is representative catchment area, crossing the results from the WaterGAP simulation with the previous analysis of the FLUXNET2015 stations may allow to understand which variables are responsible of the differences between CRU/GPCC and between WFDE5/WFDEI.

I think that your analysis is already quite complete but have you considered crossing the results from the WaterGAP simulations with the previous analysis of the FLUXNET2015 stations ?

Thank you for this suggestion. Indeed, crossing the results from the meteorological and hydrological assessments would be of interest. However, we doubt this would be meaningful as the FLUXNET2015 stations represent point characteristics whereas the hydrological assessment is carried out at a much larger scale. Müller Schmied et al. (2016) assessed station measurements of radiation components with grid cell model output of WaterGAP. Even for this smaller scale gap, a scaling issue was identified (e.g. the observation stations represent in some cases a few 10 m² whereas a WaterGAP grid cell is 50x50 km at the equator). But this was solely an assessment of radiation components. For hydrological assessments, it has to be taken into consideration that hydrological models, especially those run globally, provide reasonable hydrological output for larger basins. The various uncertainties included in the model and the input data prevent a meaningful evaluation at one specific grid cell. As well as likely inconsistencies with land cover (and other physiographic input data), there are problems with: a) comparing grid cell specific

hydrological output with FLUXNET2015 (scale mismatch, no direct variable to compare with) and b) assessing the river basins where the FLUXNET2015 stations are included (FLUXNET2015 sites cannot be assumed to be representative for a whole basin). Hence, we retain the benefits of both assessments individually and do not intend to add crossing assessments. However, we do see a certain value of showing the basin outlines and FLUXNET2015 sites, hence we included the basin outlines in Fig. 1.

New caption of Fig. 1: Location of FLUXNET2015 sites used to evaluate ERA5, WFDE5 and WFDEI as well as basin outlines for the hydrological assessment.

References:

- Müller Schmied, H., Müller, R., Sanchez-Lorenzo, A., Ahrens, B. and Wild, M.: Evaluation of Radiation Components in a Global Freshwater Model with Station-Based Observations, Water, 8(10), 450, doi:10.3390/w8100450, 2016.

Technical corrections

Line 39 :
I suggest to add the reference of ERA-40 here. The reference is present but later in the text at l. 64.
Thanks. Done as suggested.

Line 118 :
I suppose that the "*validity date-time*" represents the start time of the time step, I suggest that you define "*validity date-time* " so the text would be clearer.
Thanks for your suggestion. Actually, the precise definition of ERA5 validity date-time depends upon the nature of each variable: for instantaneous variables, it represents the date and time at which a particular value is valid; for accumulated variables and mean rates, it represents the ending date and time of the interval over which the variable is cumulated or averaged, and hence over which each value can be considered valid.

In order to clarify this point, the paragraph starting with "They are distributed…" at line 117 and ending with "...CDS Toolbox." at line 121 has been replaced with the following:
"They are distributed at hourly resolution, and the date and time to which each value refers to is represented using the validity date/time: for instantaneous variables, it corresponds to the date and time at which each value is considered valid; for accumulated variables, it represents the ending date and time of the interval over which the variable is accumulated, and hence over which each value can be considered valid. Accumulation variables are aggregated over the hour ending at the validity date/time, and they are automatically converted to mean rates when retrieved from within the CDS Toolbox."

Furthermore Table 3 has been deleted, as it has been considered not necessary.

Line 245 :

I suggest to change: “since the assessment of the water balance components are highly dependent on it” to “since the water balance components are highly dependent on it”
Thanks. Done as suggested.

Line 255-259 :
I think you forgot to close the parenthesis opened before “*the latter*” in this phrase :
“*The model was driven by ERA5, WFDE5 and WFDEI (the latter ...* ”
Thanks. Lines 255-259 have been rewritten as follows:
“The model was driven by ERA5, WFDE5 and WFDEI (the latter two with both the precipitation separately scaled to GPCC and CRU monthly sums and the daily aggregation of WFDE5 (W5E5; Lange, 2019c), see Sect. 5) and was assessed in terms of resulting water balance components (Table 6), for model efficiency (Fig. 4) and for river discharge seasonality for selected large river basins (Fig. 5).”

Line 267-269 :
It is not clear that the variable you are comparing between the CRU and the GPCC version is the river discharge. I suggest to precise : “*difference of discharge : 1825 km 3 yr − 1 ...*”
Thanks. Done as suggested.

Line 311 :
Please change “*aggegated*” to “*aggregated*”
Thanks. Done as suggested.