

Interactive comment on “ERA-Interim/Land: a global land water resources dataset” by G. Balsamo et al.

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The Authors wish to thank the Reviewer for the detailed set of comments and for the identified shortcomings and proposed improvements. We believe that as a consequence the revised manuscript is considerably improved. We took care to clarify the origin of ERA-Interim/Land improvements in the text, while preserving a concise presentation, and point to the relevant literature and results. All the Figures have been re-edited and improved for clarity. The Reviewer has identified 8 major issues (numbered) and 15 minor issues in the presentation of results (indicated as letter a) to o)), that have been considered and addressed following a point-by-point response (R:) after each comment, as detailed in the following:

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Major comments:

1) Throughout the paper, the authors only discuss two datasets, ERA-Interim/Land and ERA-Interim. By comparing only those two datasets, it is never really clear whether the differences between ERA-Interim/Land and ERA-Interim are due to the changes in the land surface model or whether they are due to changes in the precipitation forcing (GPCPv2.1 corrections). In many cases, the text just states that differences are due to model changes (eg., page 14716, lines 8, 10; page 14717, lines 5-7) when it is not clear at all what role the changes in the precipitation forcing might play. Ideally, this could be resolved by adding a third dataset, say HTESSEL forced with ERA-Interim (without precipitation corrections). Such a dataset was analyzed in Albergel et al (2013) (see page 14722, lines 4-6). Why isn't the skill of those data included in the present paper?

R: Yes the Reviewer observation is correct, we concentrate on the ERA-Interim/Land to ERA-Interim comparison. There are several years of research and several publications in support of the ERA-Interim/Land and it is not possible to report results in those publications in the current one. The results in Albergel et al. (2013) are duly cited for this purpose.

2) For a user in search of a global land reanalysis dataset suitable for their application, it would be tremendously helpful to include other available datasets in the comparison. Primarily, I would think that this should include MERRA-Land.

R: The article is meant to provide a reference for ERA-Interim/Land with description of its components and a selection of results. The comparison with MERRA-Land is very informative as well as other global datasets, but this has to necessarily realized in other studies.

3) The title and the last sentence of the abstract mention "water resources". While soil moisture and SWE can be considered water resources, the perhaps more common understanding would also include lakes and reservoirs as well as groundwater. The latter components are not part of ERA-Interim/Land, however, and I think the term

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"water resources" is not appropriate here. How about "a global land surface reanalysis dataset"?

R: We believe the proposed title would be also appropriate but we would prefer to keep the current version that put the accent on water. The word "reanalysis" can however be added and we leave the decision with the Editor recommendations. We clarify in the abstract that this intent comes with the limitations of the modeling system utilized, and such limitations can be found in all global datasets. We also stress this point in the conclusions and mention ongoing research at ECMWF to embrace a more holistic representation of the land surface via a modeling cascade and an improved representation of bio-geo-physical processes.

4) Section 2.1.4, Fig 9, Table 3: Why is the validation vs. in situ soil moisture observations limited to a single year (2010)? Many of the in situ datasets cover much longer periods that should be used for validation.

R: In the soil moisture verification section, 2010 was chosen as the most recent year in this verification dataset coinciding with ERA-Interim/Land and also as the year with the largest amount of available observations. The same criteria was chosen also for identify good years for observation availability of other networks. Extended soil moisture verification is certainly possible and a very important component. This is realized in other studies (e.g. Albergel et al. 2013) but if redone here would change the balance of the topics. In this paper we aim at providing verification material for the different water cycle components within the land surface, both water fluxes and water reservoirs (those represented) to provide an overview of the surface water cycle performance in ERA-Interim/Land.

5) Figure 2: If the underlying distribution is based on the 32 values for January 1 (or July 1) 1979-2010, then the 95th percentile is essentially the same as the second-largest value (because of the granularity of the distribution). It does not make sense to me to derive the "95th percentile" from just 32 values.

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R: We tend to disagree, as Figure 2 is a meaningful illustration. For instance it provides visual information on which portion of land would be snow-covered in an exceptional year. Or similarly which area of the globe might be subject to extreme (note that also the median is provided in Figure 1, therefore 2 points in the distribution). Note that the 95th percentile is calculated for each grid-point independently and the resulting global map is not a predictable or trivial pattern. We agree however that 32-years is probably not an ideal length for reaching statistical robustness in extremes characterization and we clarify this caveat in the text. The length of the considered period is related to ERA-Interim availability and one should recognize that a 32-year reanalysis is a non-negligible effort requiring sizeable computational and research resources. Seasonal forecasting systems (e.g. EUROSIP participating systems) normally consider shorter hindcasts of the order of 16 to 20 years. To further address the Reviewer concern, in the conclusion a sentence is added to point to statistical robustness introduced by new and ongoing reanalysis in the ERA-CLIM project (such as ERA-20C) and illustrated in Dee et al. (2013).

6) Eg., page 14717, lines 1-2; page 14720, lines 18-20; caption of Fig 11: It is not always clear whether the "ERA-Interim" data that are analyzed here are from the original ERA-Interim dataset (derived with the coupled atmosphere-land modeling and assimilation system) or from offline simulations of TESSEL with ERA-Interim forcing. The latter should be very similar to the original ERA-Interim dataset, but it cannot be identical. At the very least, the difference needs to be mentioned clearly. The authors should also state how different the two "ERA-Interim" dataset are.

R: The differences are shown in the Figure 4 that allow the appreciation of the magnitude of the land surface revision introduced in ERA-Interim/Land. The text above is now included.

7) page 14718, line 21 - page 14719, line 2 and Figure 7: While the improvement in soil moisture at this particular site is impressive, it is a bit misleading since on average, soil moisture from ERA-Interim/Land does *not* appear to be much improved w.r.t.

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soil moisture from ERA-Interim, except perhaps in the variability (Table 3, Fig 8). Per Table 3, for a number of networks and metrics, ERA-Interim actually outperforms ERA-Interim/Land. It would be useful to understand why that is.

R: The misrepresentation of soil moisture at particular sites can be an indicator of issues in the model description of the site (e.g. soil texture or vegetation properties) or misrepresentation of processes in the model (e.g. freezing/melting are particularly challenging) or systematic errors in the meteorological forcing that are not addressed by the bias correction. The more remote sites where observations are rarely available have been shown in recent studies to present shortcomings. Those can be addressed in future studies as stated in the perspectives.

8) Figure 9 includes confidence intervals and nicely demonstrates that for soil moisture, ERA-Interim/Land and ERA-Interim have essentially the same skill in terms of R. The same information is not available for other comparisons, e.g., Table 2, Fig 5, Fig 6, where it is not clear whether the skill differences between ERA-Interim/Land and ERA-Interim are significant.

R: We have now included confidence intervals in Table 2 consistently with the statistical significance method used for soil moisture results and reported in Table 3. We have not included confidence interval when single station Root-Mean-Squared-Differences were displayed (Fig.5) or when Cumulative-Distribution-Functions are used (Fig. 6, 8, 11).

Minor comments:

a) Abstract line 9: Replace "makes it suitable" with "makes it more suitable" or "makes it potentially suitable". There is no proof that ERA-Interim/Land is in fact suitable for climate studies.

R: The word "more" is added as suggested.

b) Abstract lines 10-13: This sentence is very generic. Please rewrite and provide the

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most important quantitative results.

R: The quantitative results are detailed in the verification sections. The verification tries to cover the different compartments of the water cycle (fluxes, soil and snow water content) therefore the quantitative results and their explanation would not fit the abstract words constraints. The abstract intends to give the reader the wish to read the entire paper.

c) Page 14709, line 22: replace "present" with "are subject to"

R: Reworded accordingly

d) Page 14709, line 23: replace "effects," with "effects on the offline land surface simulation,"

R: Rephrased as: To avoid possible spin-up effects of precipitation and radiation (as documented in Kållberg 2011) on the offline land surface simulations, the 3-hourly surface fluxes correspond to the 09-21h forecast intervals from initial conditions at 00 and 12 UTC.

e) I do not understand the caption of Figure 1. Is the top panel for SWE on 1 January and the bottom panel for soil moisture on 1 July? I guess the "(a)" and "(b)" are in the wrong places.

R: Rephrased as: Median of the land water reservoirs in the 1979-2010 period: (a) Snow Water Equivalent (mm or kg/m²) and (b) Top 1m Soil Moisture (mm or kg/m²), for 2 different dates: (a) 15 January (b) 15 July.

f) I do not understand Figure 6 and page 14717, lines 16-17): If the y-axis shows the cdf, then a horizontal line through $y=0.5$ should intersect the dotted blue line where the correlation is at the median value (x-axis). Similarly for the red line. But then the fact that the dotted blue line is "above" the red line would suggest that ERA-Interim has higher skill. Put differently, a cdf that rises more slowly has fewer low (correlation) values. I am getting this wrong? Or is the figure mislabeled? Also, why do some of the

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cdfs not end up at $y=1$ (for $x=1$)??

R: We believe the doubts on the interpretation are due to missing information on our side and this is now added in the text. Note that the CDF frequency curves do not start necessarily at 0 and end up at 1 in all cases (this is very evident for Asia) because the range of correlations obtained by the river discharge comparison with measurements can obtain also negative values that are excluded from the graph and the statistics as not meaningful. Large-scale models face enormous challenges when compared to point observations at river outlet (here the size of river catchment is not a criteria for exclusion from the comparison). The plot (now better explained in the text) is however very informative, in our view, of the general impact that ERA-Interim/Land revisions bring to water cycle at rivers level. The area comprised between the blue and red curve thus defines the figure of merit for ERA-Interim/Land. If the blue curve is above and the area is large this is a genuine improvement of skill at continental scale.

g) page 14718, lines 1-2: Perhaps mention that deeper soil layers/groundwater is also harder to verify because of the lack of suitable observations at the global scale?

R: Sentence added.

h) page 14718, lines 11-20. Are the RMSD values cited here quoted from Albergel et al 2013, or are they for the datasets analyzed here? Please rephrase to clarify the text.

R: The values have been recalculated and not simply reported.

i) page 14720, lines 15 and 27: The best value for FCA is 1, but below FCA values are 80, 86, 76, and 83. I suppose the latter are in "percent"?

R: That is correct and is reflected now in the text.

j) Figure 12 should show only land north of 45N. Why include the Sahara desert in a discussion of snow?

R: The plotted area is chosen to extend south to permit inclusion of the Himalayas, the

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inclusion of Sahara desert is simply a consequence of this.

k) page 14722: "reducing the bias over [the] US" Bias of what? Please clarify.

R: The sentence is referring to precipitation. This is further clarified in the text.

l) Table 3: Metric "E" (header of last column) should be tied to the "centered RMSD" in the caption. (My best guess for the meaning of E.)

R: That is correct and added in the Table description

m) Fig 3,4: The axis labels are too small and essentially unreadable.

R: The axis labels are enhanced for clarity in the new version.

n) Fig 8: Are the "black solid curve" and "black dots" labels in the caption switched by accident? I would have expected the RMSD values to be the "black dots".

R: That is correct the black dots are indeed referring to the RMSD. The misleading caption has been corrected. The figure has been completely revisited for uniformity of labels and clarity. The use of color-dots permit to better distinguish the 2 different informations provided.

o) Fig 10, caption, 2nd sentence: "Circles are for the operational..." This seems to have been copied verbatim (and erroneously) from another paper or report. Also, replace "delta" with "inverted triangle"?

R: Figure 10 has been completed re-edited and improved for clarity and graphical rendering. The caption has been rephrased and corrected. It reads now as: "Taylor diagrams illustrating the statistics from the comparison between ERA-Interim/Land in red and ERA-Interim in blue, compared to situ observations for 2010. Each symbol indicates the correlation value (angle), the normalized SDV (radial distance to the origin point), and the normalized centred root mean square error (distance to the point marked "In situ"). Circles are for the stations of the AMMA network (3 stations), square for that of the OZNET network (36 stations), stars for that of the SMOSMANIA network

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(12 stations), triangles for that of the REMEDHUS network (17 stations), diamonds for that of the SCAN network (119 stations) and inverted triangle for that of the SNOTEL network (193 stations). Only stations with significant correlations values are considered."

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 14705, 2013.

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