Hydrology and Earth System Sciences Discussions

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Comment on hess-2021-318

Anonymous Referee #1

Referee comment on "Diagnostic evaluation of river discharge into the Arctic Ocean and its impact on oceanic volume transports" by Susanna Winkelbauer et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-318-RC1, 2021

General Comments:

This is an interesting, comprehensive, and useful paper on runoff from land to the Arctic Ocean. The Arctic hydrological cycle is uncertain and changing, so the paper should be of interest to a large community of climate dynamicists working on the Arctic. The use of multiple reanalysis data products and observational products is an advantage and the paper is a state-of-the-science summary of the best existing runoff and river discharge data products.

The main results in the Conclusions are important and appear to be robust. The results on runoff and discharge seasonality (Figures 2, 4, 5) are useful. The corresponding trend results over the last 40 years (Figure 3, 6) are also useful. It's interesting and surprising that the ERA5 and related products show runoff decreases, contradicting the observations from gauged rivers. There are several other valuable lessons for individual reanalysis/assimilation data products. The revised mean Arctic hydrological cycle (Figure 12) is useful too and improves earlier estimates because it uses better data products and treats the uncertainties carefully (to construct a balanced water budget within errors). The uncertainties in the revised hydrological cycle are improved over earlier estimates too.

A couple of general/overarching comments:

- Although river discharge data and land/ocean water storage data are used carefully, the paper doesn't use oceanographic data to estimate the marine water fluxes (it only uses reanalysis data). This isn't a major problem because the paper focuses on runoff and river discharge, but it should be mentioned and discussed somewhere (Conclusions?).
- Related to point 1: What's the scope/opportunity for future improvements on the the

Arctic water budget analysis? What model and data assimilation improvements would help? What data are needed to refine the budget estimates? Again, this isn't a major omission, but it will help set the context for future work if this point is discussed somewhere (Conclusions?).

I think the paper needs a major revision although all the comments are straightforward.

Specific Comments:

- Line 50: Cite where it says the ERA5 runoff features spurious trends.
- Figures 1 and 2: What is the source of catchment data in Figures 1 and 2?
- Section 2: Add a table containing information on the runoff and discharge sources (ERA5, ERA5-Land, GloFAS…, GREP etc.)
- Line 70: "river discharge" includes both liquid water and ice (presumably)?
- Line 73: For clarity, say that "associated domain" means the catchment area.
- Line 104: It talks about "different bulk formulas and differences in the data assimilation…" Different to what? Be specific.
- Line 105: The sentence starting "We also look into….ORCA025" appears out of place. Move up to line 72?
- Line 130: "additional area" needs to be clarified. Is this a catchment area?
- Section 3: Many math terms aren't defined clearly. E.g., S_A, S_L, S_O, F. \sigma^2_k. Make sure all terms are carefully defined.
- Line 142: Justify the neglect of atmospheric liquid water and ice.
- Line 151: What does A_total represent? The Arctic Ocean? The Arctic Ocean plus terrestrial catchments?
- Line 158: What about groundwater contributions to the land water budget? (And their changes in time).
- Line 178: It says "we assume sea-ice to be transported by the ocean currents…" but sea ice moves (somewhat) independently from the surface ocean current. More explanation/justification is needed.
- Line 219: Equation (10) and the text about it are unclear.
- Line 257: The sentence starting "Cuchi et al. (2020) run the hydrological model…." is out of place. Cut?
- Line 259: It says "Model runs with ERA5 forcing show similar river discharge seasonalities at the Lena catchment as GloFASERA5new." This isn't what I see in Figure 2 for the Lena. Check and cut or clarify.
- Line 278: "Again this could be caused by delayed river ice breakup and backwater that is considered in GRACE, but not in ERA5" is a bit misleading. GRACE observes the natural system, which includes delayed river ice breakup. The ERA5 model excludes does not represent these processes. Instead, maybe end the sentence with "that is observed by GRACE, but not considered in ERA5".
- Line 309: Say that the "hydrological analogy" means extrapolation to the un-gauged rivers and streams.
- Figure 3: The legend identifies "GloFAS_{ERA5}" and similar, but the legends in Figure 2 call it "Glo_{E5}" (also Table 3). Use consistent notation throughout.
- Line 341: The sentence "Additionally Greenland features a storage decline of -134 km3 per year, accounting for roughly 50% of the total storage change" is unclear. Clarify and cite.
- Figure 5: Remind the reader that the dashed lines sum to the brown line.

- Table 4: Add a column with units (applies to other tables too, trends in particular have an unclear unit). The “m3 s−1 □ 10−3” unit contradicts Table 3.
- Section 4.2.3: The discussion on the ERA5 runoff glitches is useful. Speculate on how they could be fixed?
- Figure 9: Explain what the different lines in the right panel mean.
- Line 512: It says “both F and runoff R feature adjustments beyond their a priori spreads, demonstrating that the a priori uncertainties are larger than indicated as systematic biases are not incorporated”. What are the likely systematic biases?
- Line 535: State briefly the origin of the ERA5-Land runoff declines of 5-6% and comment on their realism.
- Line 552: It says “With oceanic and land storage declining…”, yet many papers exist on the accumulation of freshwater in the western Arctic Ocean (e.g., see Proshutinsky et al., 2019, 10.1029/2019JC015281). Mention and comment on this issue.

Technical Corrections:

- Many places: Apostrophes are not used correctly and there are spelling and grammar errors.
- Abstract, line 16: Reword “look into Greenlandic discharge”
- Abstract, line 22: Which “data-sets”? Be specific for clarity.
- Line 169: “reference salinity” should read “reference density” I think.
- Figure 2: What are R and \mu in Figure 2 legends?