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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Intercomparison of freshwater fluxes over ocean and investigations into water budget closure" *by* Marloes Gutenstein et al.

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In the course of the discussion on non-zero global total VIMD, Paul Berrisford and Michael Mayer (both ECMWF) recommended the use of the vertical integral of divergence of moisture flux (VIWVD) instead of, or in addition to, VIMD. VIWVD is similar to VIMD, but it is calculated from hourly instantaneous reanalysis fields, hence in spectral space. We verified that globally, VIWVD is a factor of 10 closer to zero than VIMD, and the remaining deviation from zero is due to our use of 1° x 1° interpolated fields. Moreover, over-ocean VIWVD is very close to $(E-P)_{ocean}$, and the ocean and land totals are in agreement with other estimates in Table 4.

Nevertheless, we decided not to substitute VIMD by VIWVD in the manuscript, because VIMD is a better-known variable appearing in various studies. Moreover, VIMD is computed in the same way as E and P (i.e., from forecasts). Lastly, we think it is important to users of ERA5 VIMD to know its limitations and alternatives.

To acknowledge these facts, we changed the statement on lines 497–499 to:

"As observed above, the fact that ERA5 VIMD is calculated in grid point space causes global total $\nabla \cdot (vq)$ to be about $10 \cdot 10^3$ km^3 yr^{-1}, and not zero. In addition, due to the tighter observational control over land, analysis increments may be larger over ocean than over land and may cause net $\nabla \cdot (vq)$ to be close to net E-P over land, but less so over ocean (P. Berrisford, personal communication, Oct. 2020). There is another field in the ERA5 archive, the vertical integral of divergence of moisture flux (VIWVD, parameter ID p84.162), which is very similar to VIMD but is computed from hourly instantaneous reanalysis fields (and contains no contributions from liquid or solid water — but these can be neglected for our purposes). Globally VIWVD adds up to $0.9 \cdot 10^3$ km^3 yr^{-1} (0.003 mm d^{-1}]), a factor of 10 smaller than total VIMD. In addition, the agreement between over-ocean VIWVD and $(E-P)_{ocean}$ is much better than that found for VIMD and $(E-P)_{ocean}$, and at $41.6 \cdot 10^3$ km^3 yr^{-1} and $-40.7 \cdot 10^3$ km^3 yr^{-1}, respectively, over-ocean VIWVD and over-land VIWVD are also in agreement with other values in the five right-most columns of Table 4."

And added the following recommendation to line 551 in the discussion section:

"Global total VIMD, however, does not equal zero, which is due to the numerical method used to compute VIMD. For studies of the global water cycle using ERA5 data, we recommend the use of VIWVD instead, as its global total is closer to zero and its totals over land and ocean are in better agreement with each other and with results from our and previous studies (Table 4)."

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