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Temporal variability of inferred surface energy fluxes derived from the ERA5 energy budget

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We use the new Copernicus ERA5 reanalysis dataset to evaluate the global atmospheric energy budget using a consistent diagnostic framework and improved numerical methods. A main outcome of this work are mass consistent divergences of moist static plus kinetic energy fluxes. These divergences are combined with top-of-the-atmosphere fluxes based on satellite observations and reconstructions back to 1985 to obtain net surface energy fluxes (F_S) with unprecedented accuracy. The global mean of these F_S fields is unbiased by construction. Hence, this product is well-suited for climate studies and model evaluations. Here, the temporal variability and stability of inferred F_S, the land-ocean energy transport and the corresponding water cycle are presented and compared with previous evaluations, which used ERA-Interim.

The inferred F_S fields exhibit a much smaller noise level, and sampling errors are drastically reduced due to the high temporal resolution (hourly) of the ERA5 dataset. Energy budget residuals over land are on the order of 17.0 Wm^{-2}, which represents a 63 % reduction compared to ERA-Interim. We also present time series of F_S averaged over the global ocean. Its global mean is 2.0 Wm^{-2}, which is in much better agreement with ocean heat uptake than widely used satellite-derived surface flux products. Moreover, it exhibits reasonable temporal stability at least from 2000 onwards. We compare the annual cycles of F_S over the ocean and ocean heat content variations derived from ocean reanalysis products and find good agreement. Overall, our results demonstrate clear improvements over earlier evaluations, but more work is needed to optimally use the available data and further reduce uncertainties.