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The hydrological cycle in three state-of-the-art reanalyses: Intercomparison and performance analysis

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The three state-of-the-art global atmospheric reanalysis models ERA-Interim (ECMWF), MERRA (NASA) and CFSR (NCEP) are analyzed and compared with independent observations in the period between 1989 and 2006. The comparison of precipitation and temperature estimates from the three models with gridded observations reveals large differences between the reanalyses and also between the observation datasets. A significant source of uncertainty in the observations is due to the spatial distribution and the temporal change in the number of gauges. For South America, a drop of active measuring stations from 4267 to 390 (GPCC v4.0 dataset) could be observed. The performance of precipitation estimates from the reanalyses strongly depends on the geographic location as there are significant differences especially in tropical regions.
The closure of the large-scale water cycle in the three reanalyses is analyzed by estimating long-term mean values for precipitation, evaportranspiration, surface runoff and vertically integrated moisture flux divergence. Several large-scale water budget equations like, for example, the terrestrial or combined atmospheric-terrestrial water budget are analyzed. This allows to separately quantify the performance of the reanalyses in closing the water budgets for different regimes. The analysis reveals that there are still significant shortcomings in the modeled moisture budgets mainly due to inconsistencies in the exchange of water between the oceans and the landmasses. A large part of this imbalance originates from the assimilation of radiance sounding data from the NOAA-15 satellite over the oceans, which results in an unrealistic increase of oceanic precipitation minus evaporation in the MERRA and CFSR budgets. Thus, the reanalyses are still sensitive to the introduction of observational data which complicates the distinction between the true physical signal and effects due to the assimilation of new observations.
Overall, ERA-Interim shows both a comparatively reasonable closure of the terrestrial and atmospheric water balance and a reasonable agreement with the observation datasets.
But the presented limitations in the performance of the three reanalyses in reproducing the hydrological cycle still questions the use of these models for climate trend analyses and long-term water budget studies.