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Validation of CERES earth radiation budget estimations

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The Clouds and the Earth's Radiant Energy System (CERES) provides a long-term estimation of shortwave and longwave radiation over the entire globe to better understand the role of radiation, clouds and condensation for climate change. Since in situ radiation measurements are sparse, the surface energy budget estimations require a carefully validation to assess uncertainties of CERES radiation products. This study compared and evaluated all surface energy budget components estimated using CERES data (shortwave flux down (RS↓), shortwave flux up (RS↑), longwave flux down (RL↓), longwave flux up (RL↑) and photosynthetically active radiation (PAR)), against measurements recorded in 15 monitoring sites located in Brazil. Our analysis was carried out on different time scales (three-hourly, daily and monthly time steps), according to CERES products. Our results indicate that CERES estimations are accurate for the three time-scale evaluated, yielding better results at monthly time scales. For all evaluated products, the three-hourly validation metrics yielded, on average, $R^2 > 0.5$, bias of 10.7 W m^{-2} and root mean squared errors (RMSE) of 80.9 W m^{-2}; whilst at daily time-scale, we found, on average, $R^2 > 0.6$, bias of 10.9 W m^{-2} and RMSE of 21.1 W m^{-2} and at monthly time-scale, validations metrics yielded, on average, $R^2 > 0.7$, bias of 10.9 W m^{-2} and RMSE of 12.5 W m^{-2}. Once CERES products have been validated and knowing that the products can be systematically affected by atmospheric and land surface conditions, we have also evaluated the main driving factors to provide evidences to understand the surface energy balance components variance. Our results show that for the sites located in the Pampa biome, the variance in the evaluated components were explained especially by albedo, land surface temperature and total precipitable water vapor in the atmosphere. For the sites located in Mata Atlantica biome, total precipitable water vapor, land surface temperature and air humidity yielded higher influence. For the Cerrado biome, the main drivers were albedo, vegetation indices and cloud cover. Sites located in the Amazon biome were most influenced by air humidity, total precipitable water vapor in the atmosphere, land surface temperature and cloud cover. The results highlight the influence of climate conditions and biome properties on the estimation of surface energy budget components by CERES. The radiation data provided by CERES has proved to be a good alternative for regions where meteorological information is not available or regions where the radiation are poorly monitored.