

# Validating hourly satellite based and reanalysis based global horizontal irradiance datasets over South Africa

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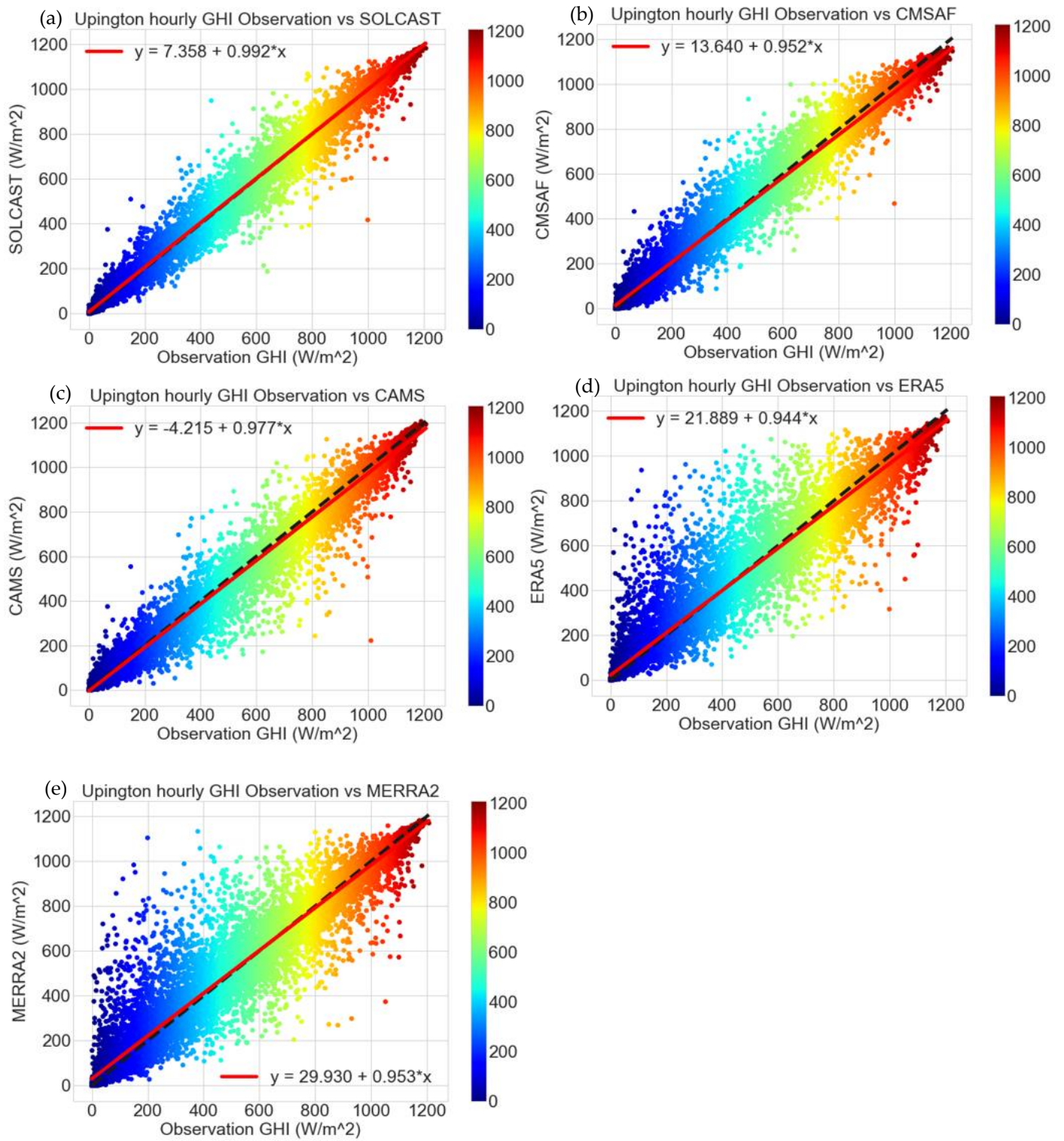
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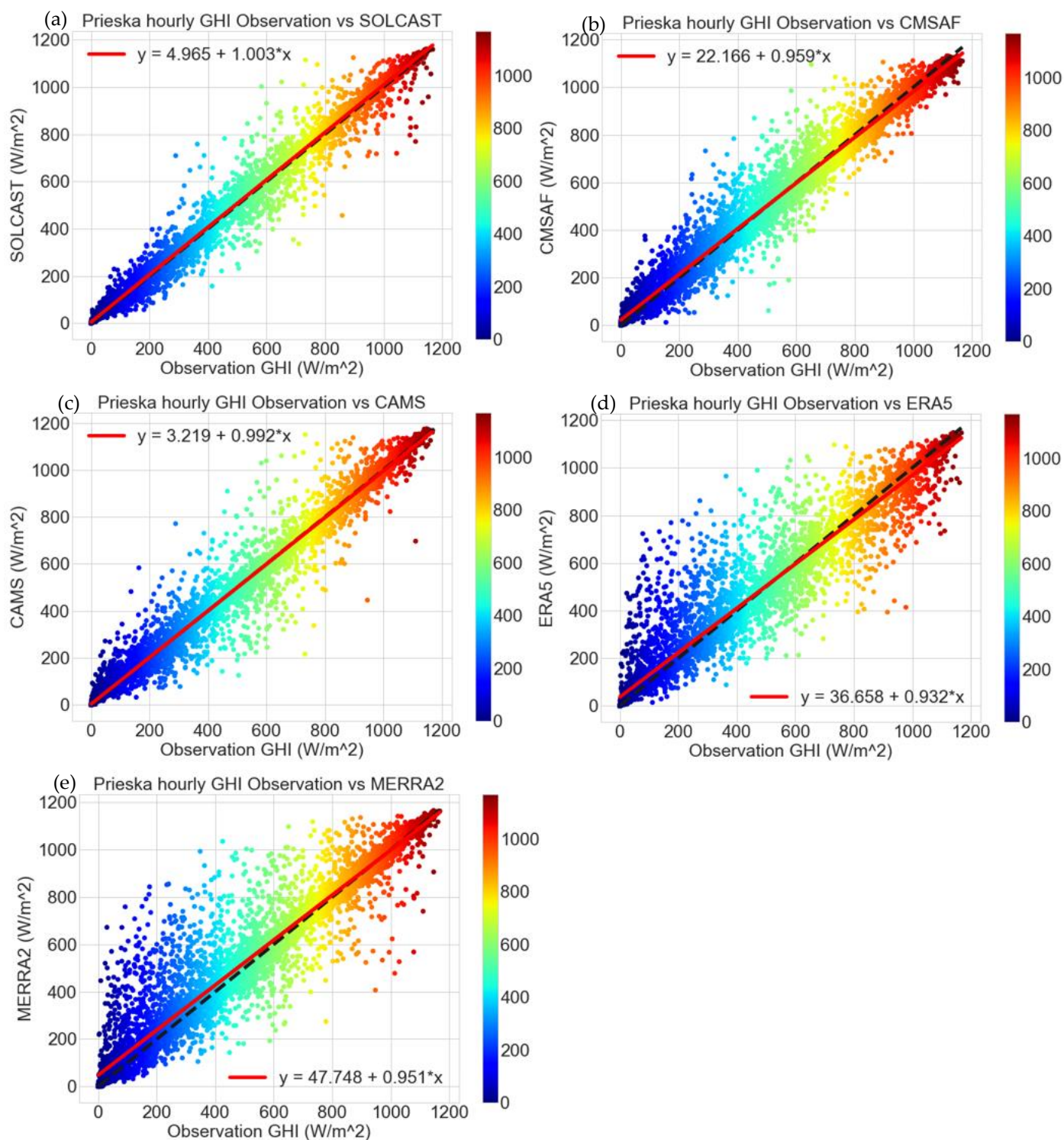
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**Abstract:** The study validates the hourly satellite based and reanalysis based global horizontal irradiance (GHI) for sites in South Africa. Hourly GHI satellite based namely: SOLCAST, Copernicus Atmosphere Monitoring Service (CAMS) and Satellite Application Facility on Climate Monitoring (CMSAF SARA) and two reanalysis based namely: Fifth generation European Centre for Medium-Range Weather Forecasts atmospheric reanalysis (ERA5) and Modern-Era Retrospective analysis for Research and Applications (MERRA2) were assessed by comparing in-situ measured data from 13 South African Weather Service radiometric stations, located in the country's six macro climatological regions, for the period 2013–2019. The in-situ data is first quality controlled using the Baseline Surface Radiation Network methodology. Data visualization and statistical metrics relative Mean Bias Error (rMBE), relative Root Mean Square Error (rRMSE), relative Mean Absolute Error (rMAE) and the coefficient of determination ( $R^2$ ) were used to evaluate the performance of the data sets. There was very good correlation against in-situ GHI for the satellite based GHI, all with  $R^2$  above 0.95. The  $R^2$  correlations for the reanalysis based GHI were less than 0.95 (0.931 for ERA5 and 0.888 for MERRA2). The satellite and reanalysis based GHI show a positive rMBE (SOLCAST 0.81%, CAMS 2.14%, CMSAF 2.13%, ERA5 1.7% and MERRA2 11%) suggesting consistent overestimation over the country. SOLCAST satellite based GHI showed the best rRMSE (14%) and rMAE (9%) combinations. MERRA2 reanalysis based GHI showed the weakest rRMSE (37%) and rMAE (22%) combinations. SOLCAST satellite based GHI showed the best overall performance. When considering only the freely available datasets CAMS and CMSAF performed better with the same overall rMBE (2%), however CAMS showed slightly better rRMSE (16%), rMAE (10%) and  $R^2$  (0.98) combinations than CMSAF rRMSE (17%), rMAE (11%) and  $R^2$  (0.97). CAMS and CMSAF are viable freely available data sources for South African locations.

**Keywords:** satellite; reanalysis; global horizontal irradiance; SOLCAST; Copernicus Atmosphere Monitoring Service (CAMS); Satellite Application Facility on Climate Monitoring (CMSAF); Fifth generation European Centre for Medium-Range Weather Forecasts atmospheric reanalysis (ERA5); Modern-Era Retrospective analysis for Research and Applications (MERRA2)

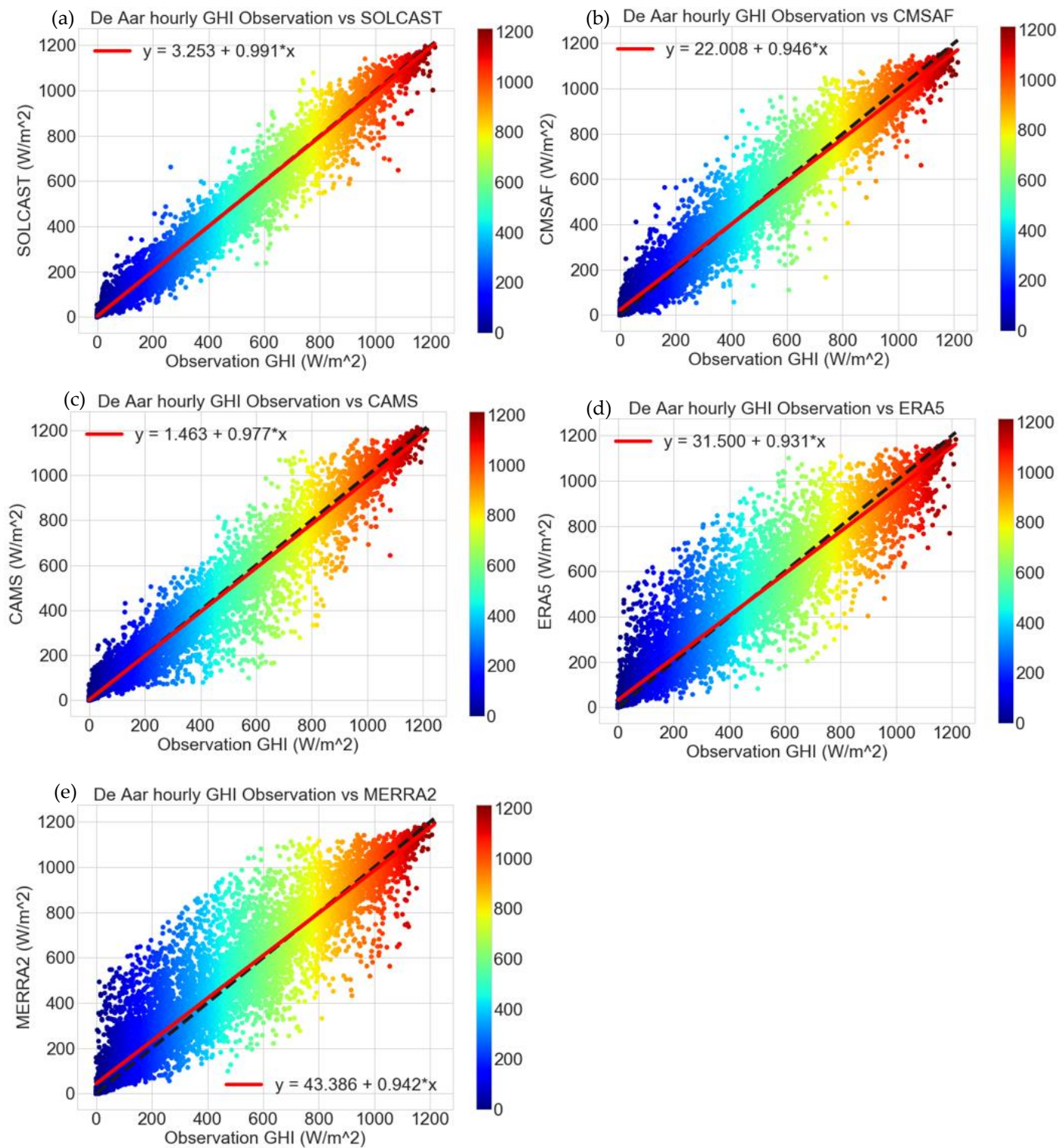


**Figure S1.** Scatter plot of measured and estimated daily global irradiance at Upington station, SOLCAST (a), CMSAF (b), CAMS (c), ERA5 (d) and MERRA2 (e).

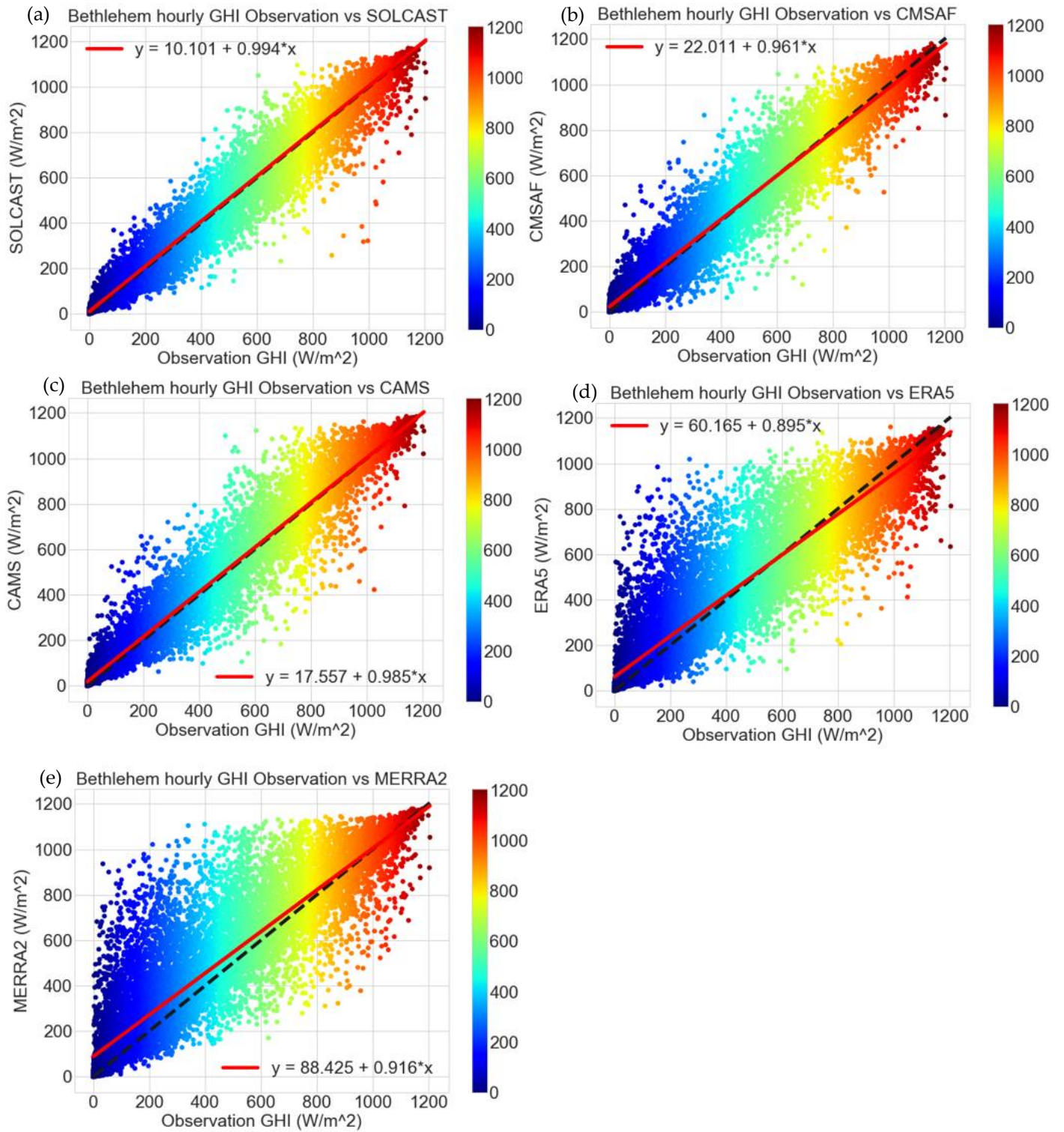


**Figure S2.** Scatter plot of measured and estimated daily global irradiance at Prieska station, SOLCAST (a), CMSAF (b), CAMS (c), ERA5 (d) and MERRA2 (e).



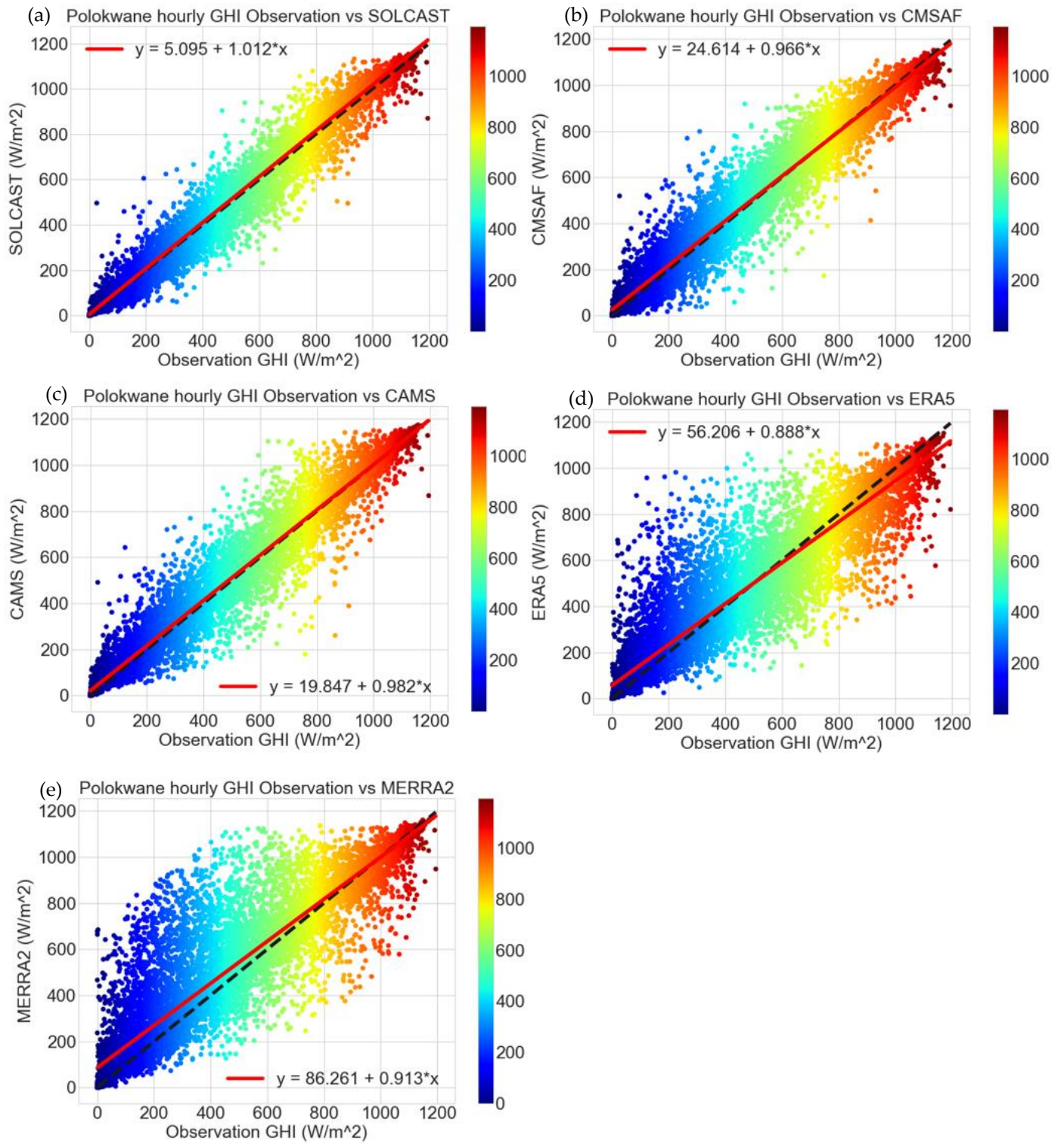


**Figure S3.** Scatter plot of measured and estimated daily global irradiance at De Aar station, SOLCAST (a), CMSAF (b), CAMS (c), ERA5 (d) and MERRA2 (e).

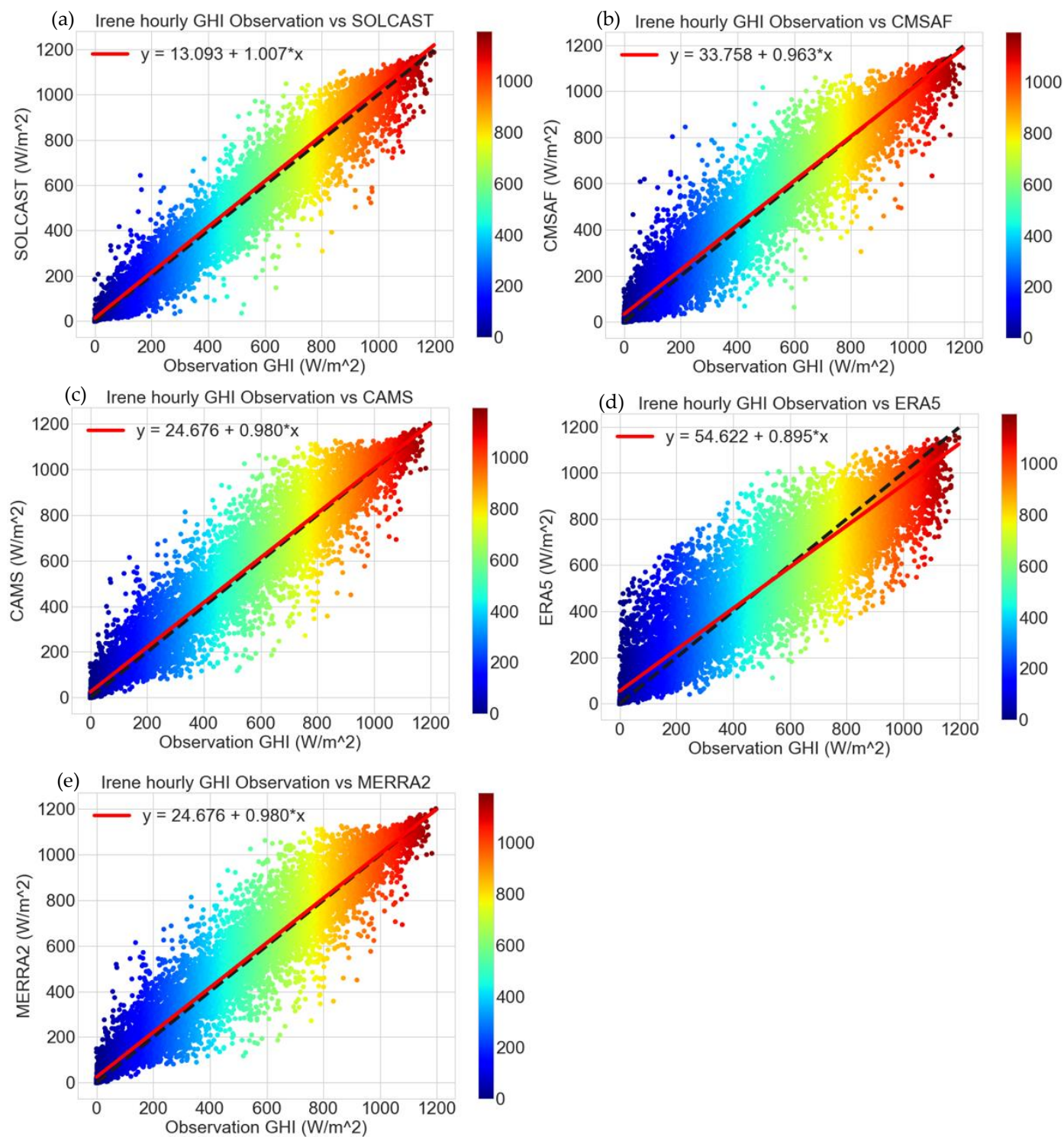


**Figure S4.** Scatter plot of measured and estimated daily global irradiance at Bethlehem station, SOLCAST (a), CMSAF (b), CAMS (c), ERA5 (d) and MERRA2 (e).



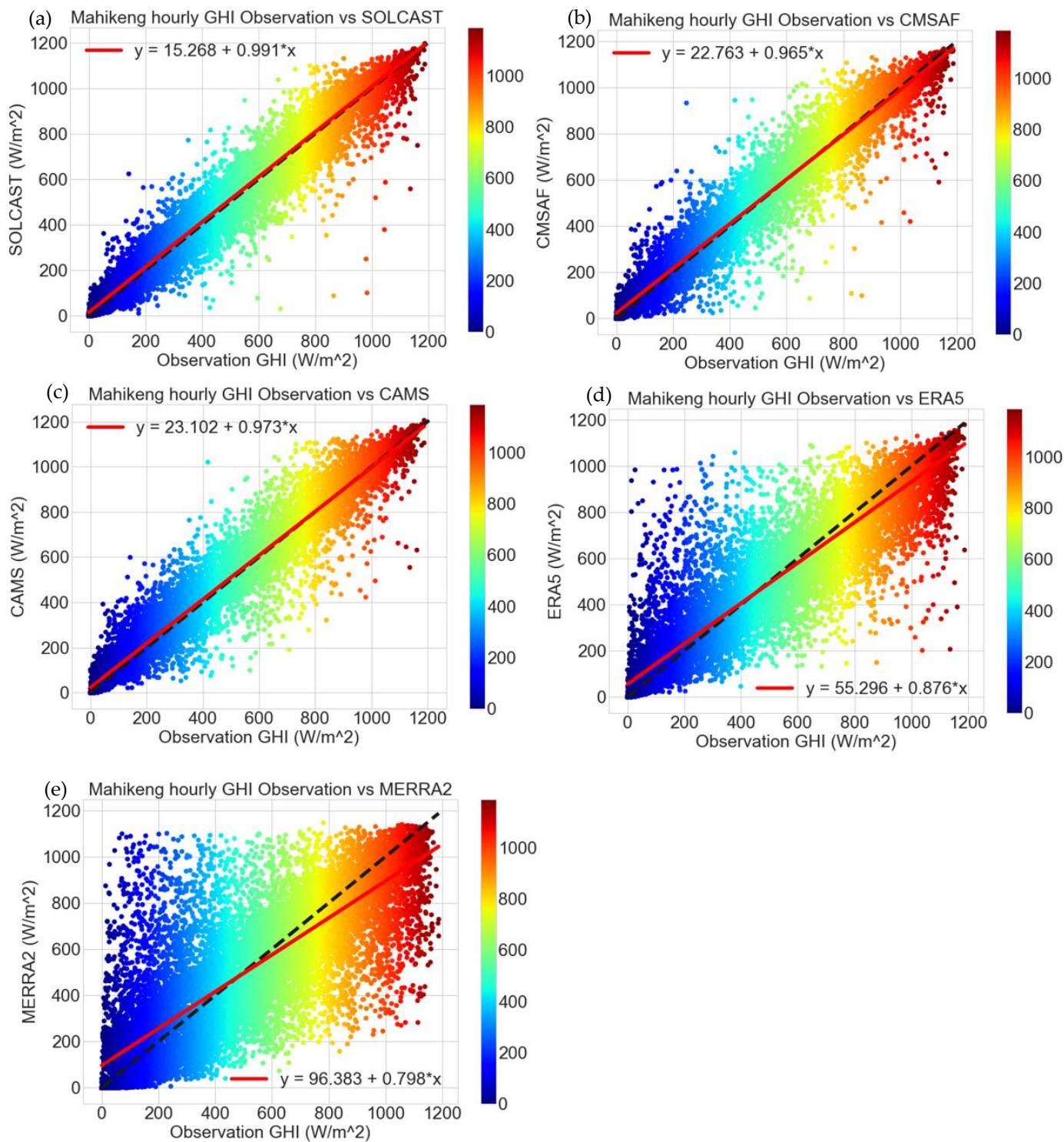


**Figure S5.** Scatter plot of measured and estimated daily global irradiance at Polokwane station, SOLCAST (a), CMSAF (b), CAMS (c), ERA5 (d) and MERRA2 (e).



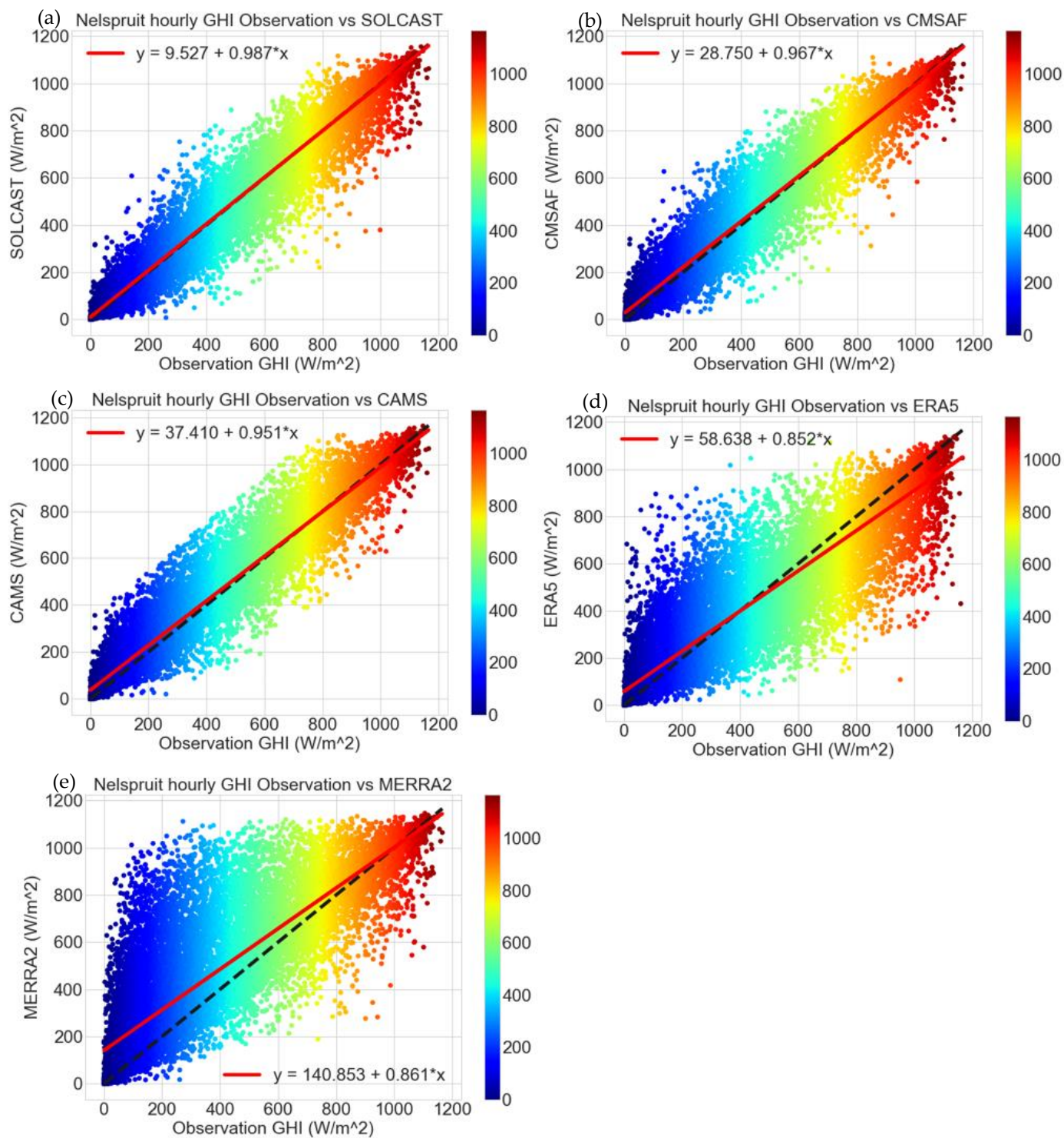
**Figure S6.** Scatter plot of measured and estimated daily global irradiance at Irene station, SOLCAST (a), CMSAF (b), CAMS (c), ERA5 (d) and MERRA2 (e).



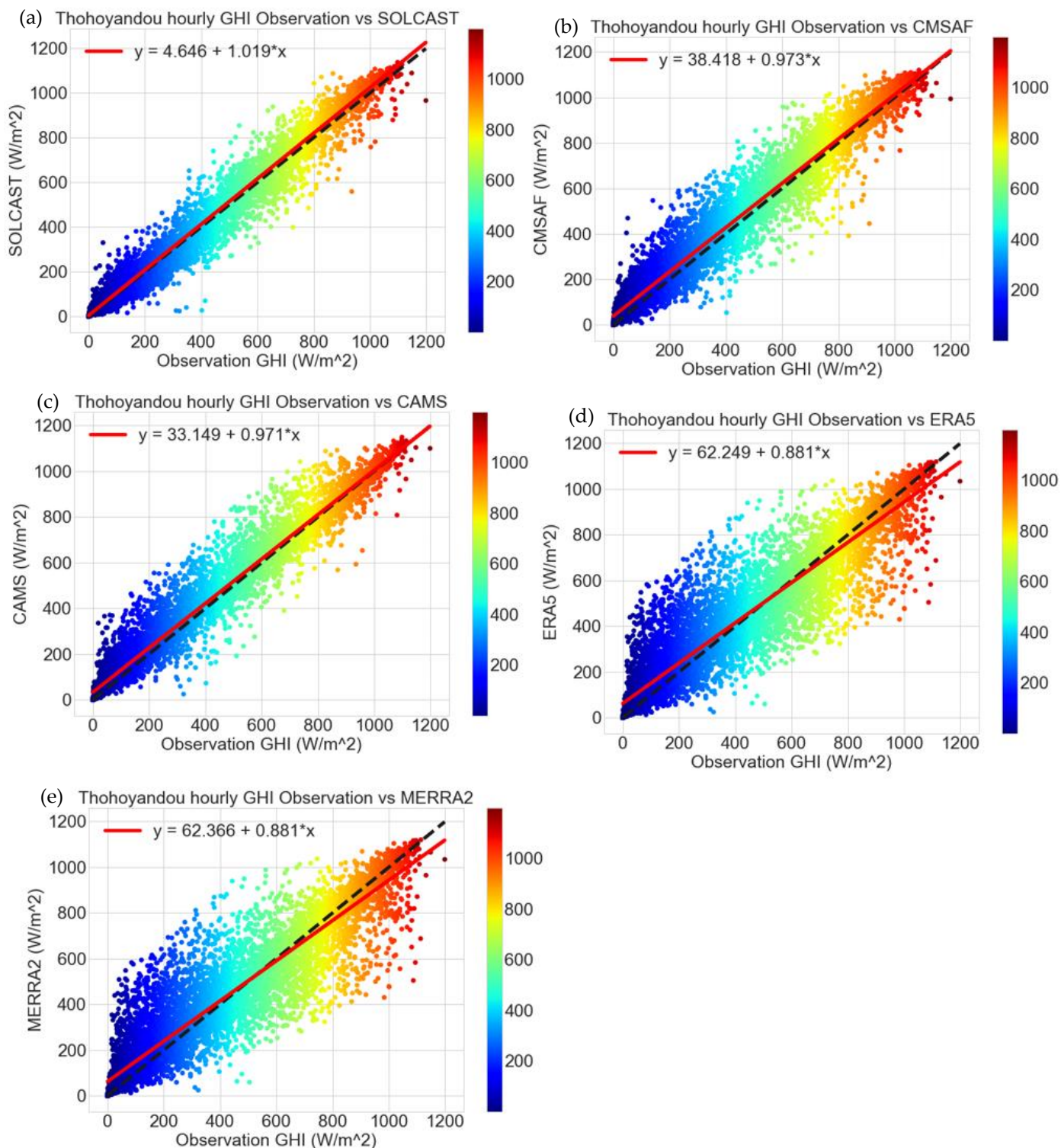


**Figure S7.** Scatter plot of measured and estimated daily global irradiance at Mahikeng station, SOLCAST (a), CMSAF (b), CAMS (c), ERA5 (d) and MERRA2 (e).



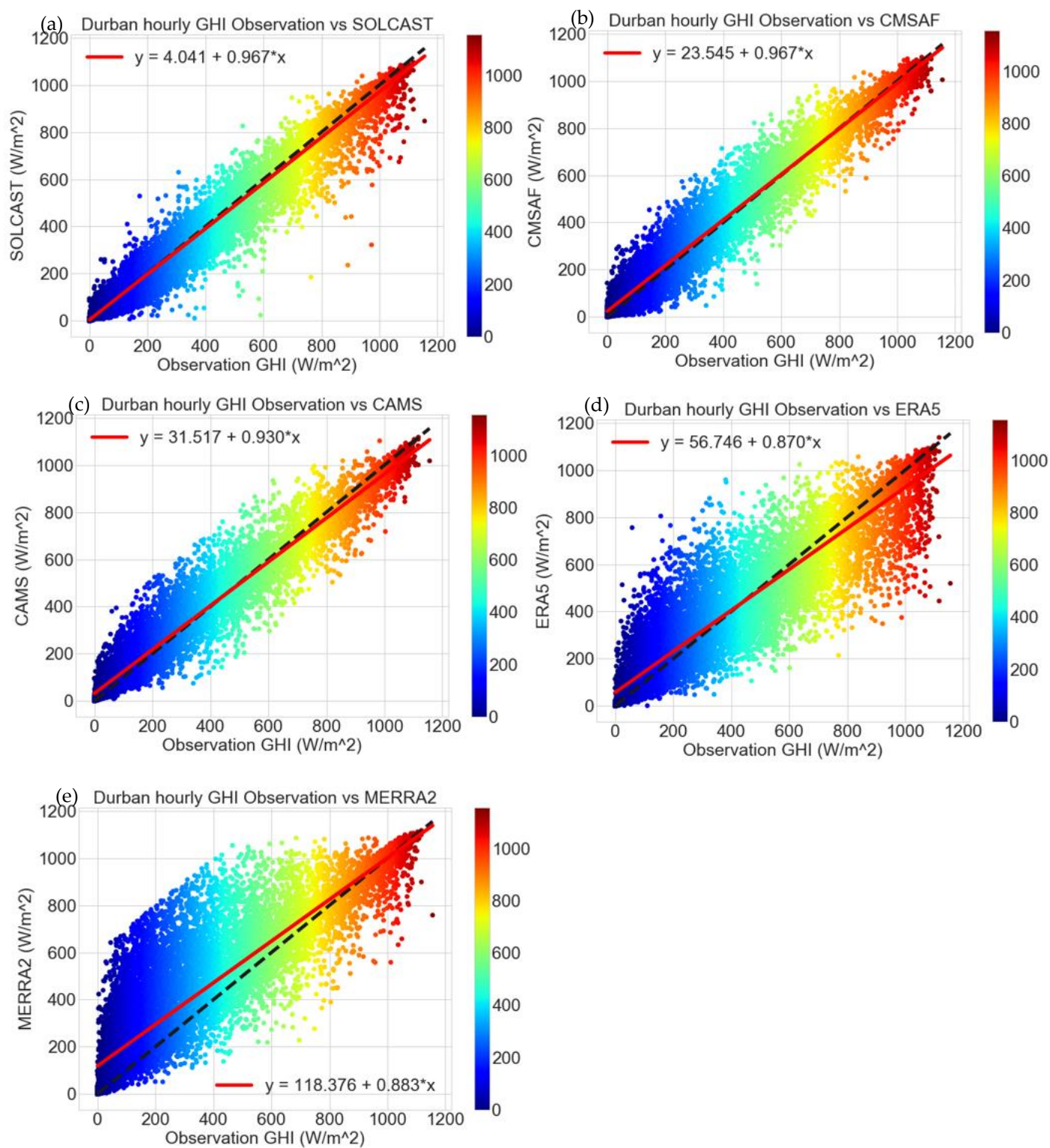


**Figure S8.** Scatter plot of measured and estimated hourly global irradiance at Nelspruit station, SOLCAST (a), CMSAF (b), CAMS (c), ERA5 (d) and MERRA2 (e).

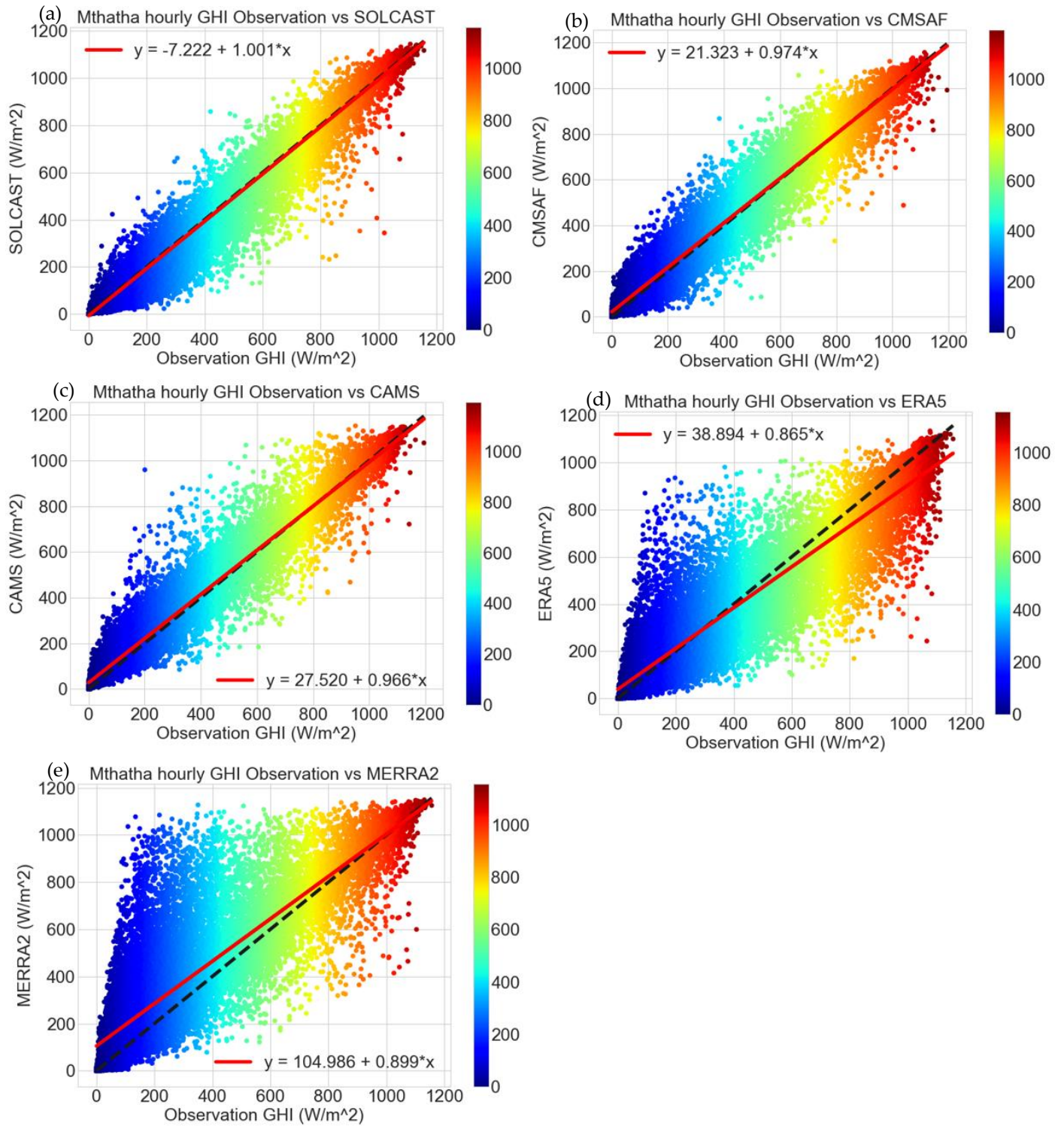


**Figure S9.** Scatter plot of measured and estimated hourly global irradiance at Thohoyandou station, SOLCAST (a), CMSAF (b), CAMS (c), ERA5 (d) and MERRA2 (e).



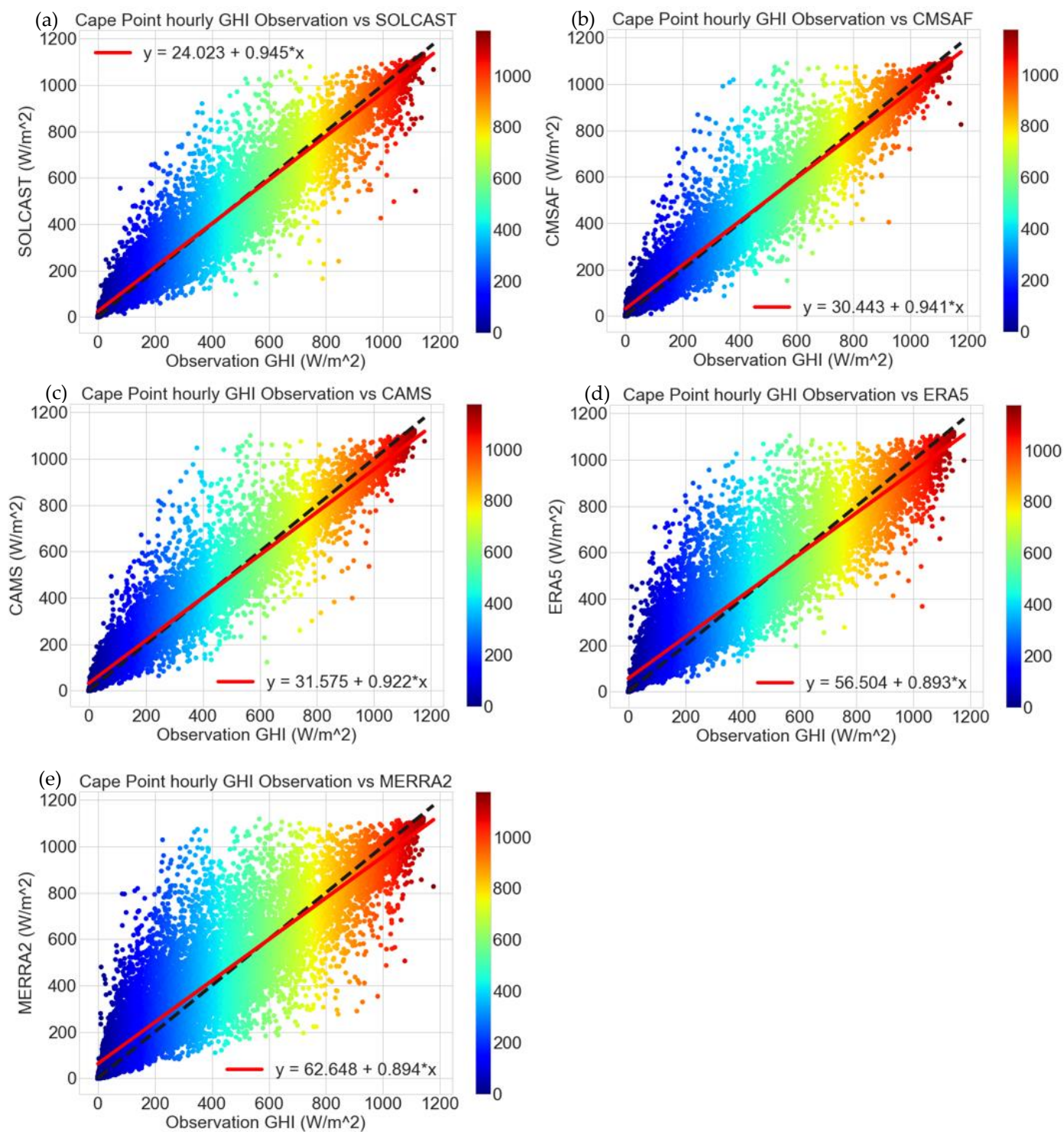


**Figure S10.** Scatter plot of measured and estimated hourly global irradiance at Durban station, SOLCAST (a), CMSAF (b), CAMS (c), ERA5 (d) and MERRA2 (e).

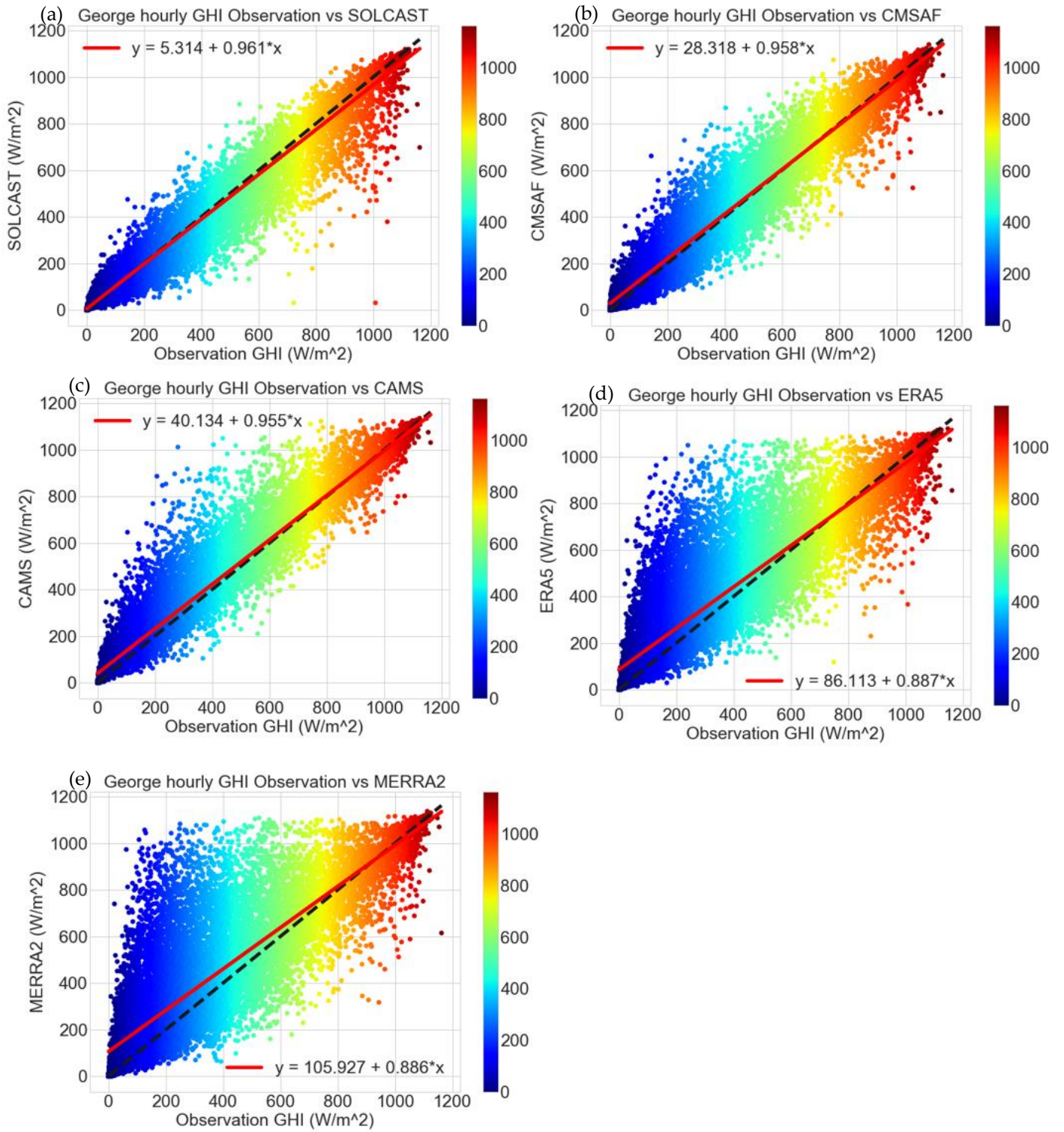


**Figure S11.** Scatter plot of measured and estimated hourly global irradiance at Mthatha station, SOLCAST (a), CMSAF (b), CAMS (c), ERA5 (d) and MERRA2 (e).





**Figure S12.** Scatter plot of measured and estimated hourly global irradiance at Cape Point station, SOLCAST (a), CMSAF (b), CAMS (c), ERA5 (d) and MERRA2 (e).



**Figure S13.** Scatter plot of measured and estimated hourly global irradiance at George station, SOLCAST (a), CMSAF (b), CAMS (c), ERA5 (d) and MERRA2 (e).