



Supplement of

Evaluation of high-resolution meteorological data products using flux tower observations across Brazil

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Supplementary material:

Table S1: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site K34 (daily)
K34

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.69	2.51	3.0	65.6	-	12.8	1.87E-02
ERA5-Land	0.67	1.16	6.9	48.7	11.1	13.0	2.91E-03
GLDAS2.0	1.25	2.29	12.0	56.1	12.8	13.4	2.21E-03
GLDAS2.1	0.73	1.43	6.1	54.3	16.4	12.5	3.29E-03
MSWEPv2.2	-	-	-	-	-	12.3	-

Time step: Daily

Table S2: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site FNS (daily)
FNS

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	2.06	2.28	14.6	57.5	-	10.3	1.66E-02
ERA5-Land	1.80	1.22	8.3	48.5	9.9	10.1	2.30E-03
GLDAS2.0	2.21	1.78	21.6	52.8	16.3	11.0	2.87E-03
GLDAS2.1	2.00	1.60	14.0	50.5	16.1	10.3	2.88E-03
MSWEPv2.2	-	-	-	-	-	9.8	-

Time step: Daily

Table S3: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site RJA (daily)
RJA

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.65	2.10	18.3	58.4	-	13.0	1.44E-02
ERA5-Land	0.48	1.18	17.3	45.2	11.6	12.9	3.94E-03
GLDAS2.0	0.73	1.91	19.7	50.5	15.7	13.8	3.16E-03
GLDAS2.1	0.50	1.81	19.3	48.6	16.0	12.8	4.97E-03
MSWEPv2.2	-	-	-	-	-	10.8	-

Time step: Daily

5

Table S4: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site PDG (daily)
PDG

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	1.55	1.95	3.1	62.4	-	7.2	9.44E-03
ERA5-Land	0.87	1.14	5.4	39.5	-	8.3	9.21E-04
GLDAS2.0	0.96	2.15	2.4	53.1	-	9.2	4.64E-03
GLDAS2.1	0.63	1.82	10.1	41.8	-	8.1	2.53E-03
MSWEPv2.2	-	-	-	-	-	6.4	-

Time step: Daily

Table S5: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site K67 (daily)
K67

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.59	2.00	22.7	75.9	-	10.6	1.47E-02
ERA5-Land	1.15	1.35	20.9	59.2	-	11.8	1.42E-03
GLDAS2.0	1.09	2.33	24.5	63.0	-	11.5	3.01E-03
GLDAS2.1	0.55	1.70	24.6	70.3	-	9.8	2.88E-03
MSWEPv2.2	-	-	-	-	-	10.4	-

Time step: Daily

Table S6: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site K77 (daily)
K77

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.65	1.31	2.4	61.5	-	9.5	1.52E-02
ERA5-Land	0.64	1.04	0.4	48.9	14.8	9.3	1.64E-03
GLDAS2.0	0.94	1.66	3.2	51.7	17.0	10.0	2.74E-03
GLDAS2.1	0.68	1.28	4.3	54.6	18.7	9.0	2.88E-03
MSWEPv2.2	-	-	-	-	-	9.1	-

Time step: Daily

Table S7: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site K83 (daily)
K83

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.50	1.57	11.8	50.4	-	9.8	1.75E-02
ERA5-Land	0.97	1.24	8.7	58.3	7.2	12.1	1.31E-03
GLDAS2.0	1.19	1.96	14.4	51.8	10.6	10.4	4.78E-03
GLDAS2.1	0.70	1.45	14.8	61.5	15.7	11.9	2.30E-03
MSWEPv2.2	-	-	-	-	-	13.3	-

Time step: Daily

Table S8: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site BAN (daily)
BAN

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.67	2.05	8.2	53.4	-	11.0	1.67E-02
ERA5-Land	0.63	1.41	0.7	47.6	-	11.6	1.78E-03
GLDAS2.0	1.06	2.28	2.5	47.5	-	12.0	5.12E-03
GLDAS2.1	0.87	1.68	0.8	56.4	-	11.3	2.13E-03
MSWEPv2.2	-	-	-	-	-	11.4	-

Time step: Daily

Table S9: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site CRA (daily)

CRA							
	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	1.70	3.63	4.9	101.4	-	15.7	6.73E-03
ERA5-Land	1.55	2.27	3.7	81.6	-	13.7	1.92E-03
GLDAS2.0	1.71	3.16	3.1	79.5	-	14.9	4.46E-03
GLDAS2.1	1.79	2.12	5.1	82.1	-	16.4	2.04E-03
MSWEPv2.2	-	-	-	-	-	15.2	-

Time step: Daily

Table S10: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site VCP (daily)

VCP							
	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.75	2.41	5.9	55.3	-	6.2	8.21E-03
ERA5-Land	0.51	1.44	7.7	40.5	-	7.8	8.06E-04
GLDAS2.0	0.60	2.52	1.3	56.5	-	8.7	3.60E-03
GLDAS2.1	0.61	1.84	9.8	47.5	-	8.4	1.17E-03
MSWEPv2.2	-	-	-	-	-	6.7	-

Time step: Daily

Table S11: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site USR (daily)

USR							
	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.86	2.92	4.2	69.9	-	8.9	7.44E-03
ERA5-Land	0.82	2.70	6.3	62.7	-	8.9	2.82E-03
GLDAS2.0	0.81	3.04	14.5	63.0	-	9.4	4.83E-03
GLDAS2.1	0.86	2.80	6.0	64.3	-	9.8	2.97E-03
MSWEPv2.2	-	-	-	-	-	8.5	-

Time step: Daily

Table S12: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site K34 (monthly)

K34							
	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.45	2.14	2.8	15.6	-	59.7	1.86E-02
ERA5-Land	0.56	0.70	6.9	18.5	8.6	87.0	2.76E-03
GLDAS2.0	1.18	1.77	11.9	14.6	10.1	84.2	1.93E-03
GLDAS2.1	0.63	0.85	6.1	14.5	12.3	71.8	3.08E-03
MSWEPv2.2	-	-	-	-	-	71.4	-

Time step: Monthly

Table S13: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site FNS (monthly)

FNS	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	1.81	2.03	14.4	21.8	-	58.4	1.63E-02
ERA5-Land	1.62	0.80	8.3	19.2	7.0	58.2	2.16E-03
GLDAS2.0	2.00	0.90	21.5	9.4	11.0	57.8	2.05E-03
GLDAS2.1	1.84	1.04	14.1	8.9	10.9	67.4	2.46E-03
MSWEPv2.2	-	-	-	-	-	64.4	-

Time step: Monthly

Table S14: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site RJA (monthly)

RJA	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.42	1.81	18.2	23.1	-	68.9	1.44E-02
ERA5-Land	0.32	0.63	17.3	13.3	9.3	97.7	3.67E-03
GLDAS2.0	0.60	1.21	19.6	11.9	11.4	93.5	2.49E-03
GLDAS2.1	0.34	1.31	19.3	8.1	9.8	81.8	4.72E-03
MSWEPv2.2	-	-	-	-	-	64.1	-

Time step: Monthly

Table S15: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site PDG (monthly)

PDG	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	1.33	0.97	2.4	9.2	-	41.7	8.70E-03
ERA5-Land	0.75	0.40	5.4	13.0	-	47.8	6.03E-04
GLDAS2.0	0.75	0.79	2.0	8.1	-	54.6	4.28E-03
GLDAS2.1	0.37	1.22	10.1	10.3	-	41.6	2.17E-03
MSWEPv2.2	-	-	-	-	-	37.5	-

Time step: Monthly

Table S16: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site K67 (monthly)

K67	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.33	1.79	22.7	58.2	-	73.2	1.46E-02
ERA5-Land	0.98	1.15	20.9	45.6	-	144.5	1.26E-03
GLDAS2.0	1.04	2.02	24.5	49.3	-	82.1	2.89E-03
GLDAS2.1	0.43	1.34	24.6	52.8	-	71.2	2.51E-03
MSWEPv2.2	-	-	-	-	-	75.8	-

Time step: Monthly

Table S17: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site K77 (monthly)
K77

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.37	1.05	2.1	27.1	-	50.3	1.51E-02
ERA5-Land	0.46	0.73	0.3	22.2	13.2	87.0	1.59E-03
GLDAS2.0	0.83	1.19	3.1	20.5	15.5	59.1	2.54E-03
GLDAS2.1	0.50	0.84	4.3	21.7	15.1	53.4	2.71E-03
MSWEPv2.2	-	-	-	-	-	49.3	-

Time step: Monthly

Table S18: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site K83 (monthly)
K83

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.31	1.41	11.8	37.0	-	49.6	1.73E-02
ERA5-Land	0.72	0.74	8.7	29.0	3.1	103.1	1.13E-03
GLDAS2.0	1.14	1.47	14.4	26.8	8.1	50.2	4.67E-03
GLDAS2.1	0.57	0.83	14.7	28.3	9.0	46.1	1.99E-03
MSWEPv2.2	-	-	-	-	-	49.6	-

Time step: Monthly

Table S19: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site BAN (monthly)
BAN

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.35	1.63	8.1	13.8	-	58.7	1.64E-02
ERA5-Land	0.49	1.06	0.6	15.8	-	63.6	1.61E-03
GLDAS2.0	0.96	1.83	2.4	13.8	-	65.8	4.98E-03
GLDAS2.1	0.74	1.07	0.7	14.5	-	75.0	1.72E-03
MSWEPv2.2	-	-	-	-	-	81.6	-

Time step: Monthly

Table S20: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site CRA (monthly)
CRA

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.93	1.06	3.5	9.7	-	30.2	5.30E-03
ERA5-Land	0.81	0.63	2.5	11.9	-	43.9	9.02E-04
GLDAS2.0	1.12	1.70	1.1	22.0	-	48.7	4.13E-03
GLDAS2.1	1.21	0.70	4.4	13.5	-	47.8	1.28E-03
MSWEPv2.2	-	-	-	-	-	37.8	-

Time step: Monthly

Table S21: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site VCP (monthly)
VCP

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.46	1.73	5.4	8.9	-	46.3	7.87E-03
ERA5-Land	0.33	0.96	7.7	17.5	-	59.6	5.26E-04
GLDAS2.0	0.38	1.57	0.6	23.4	-	80.3	3.36E-03
GLDAS2.1	0.40	1.21	9.8	24.1	-	50.2	8.34E-04
MSWEPv2.2	-	-	-	-	-	47.9	-

Time step: Monthly

Table S22: Normalised MSE (by dividing the MSE by the RMSE) for each variable and each gridded product analysed in the study at site USR (monthly)
USR

	Wind Speed (m s ⁻¹)	Air Temperature (°C)	Pressure (hPa)	Solar rdn in (W m ⁻²)	Thermal rdn in (W m ⁻²)	Precipitation (mm)	Specific Humidity (kg kg ⁻¹)
Xavier	0.36	1.08	3.1	15.1	-	71.6	6.41E-03
ERA5-Land	0.48	1.05	5.5	19.1	-	67.7	1.39E-03
GLDAS2.0	0.40	1.58	14.2	18.6	-	76.8	4.10E-03
GLDAS2.1	0.51	1.13	5.1	18.9	-	67.7	1.71E-03
MSWEPv2.2	-	-	-	-	-	54.4	-

Time step: Monthly

30 Figure S1 – Partial contributions to decomposed MSE scaled to the RMSE for precipitation for each gridded product and flux tower, using daily data, averaged for each month of the year.

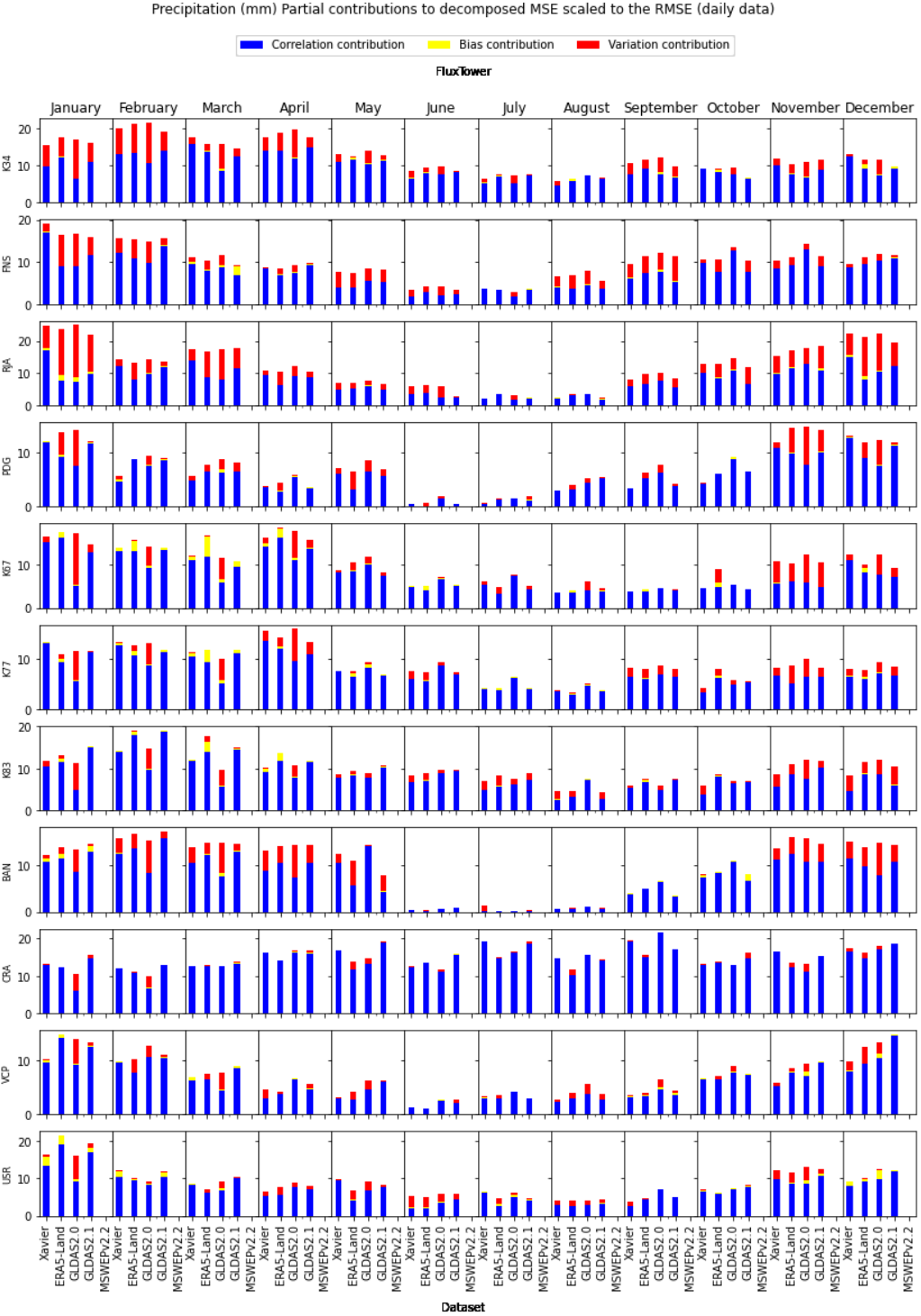
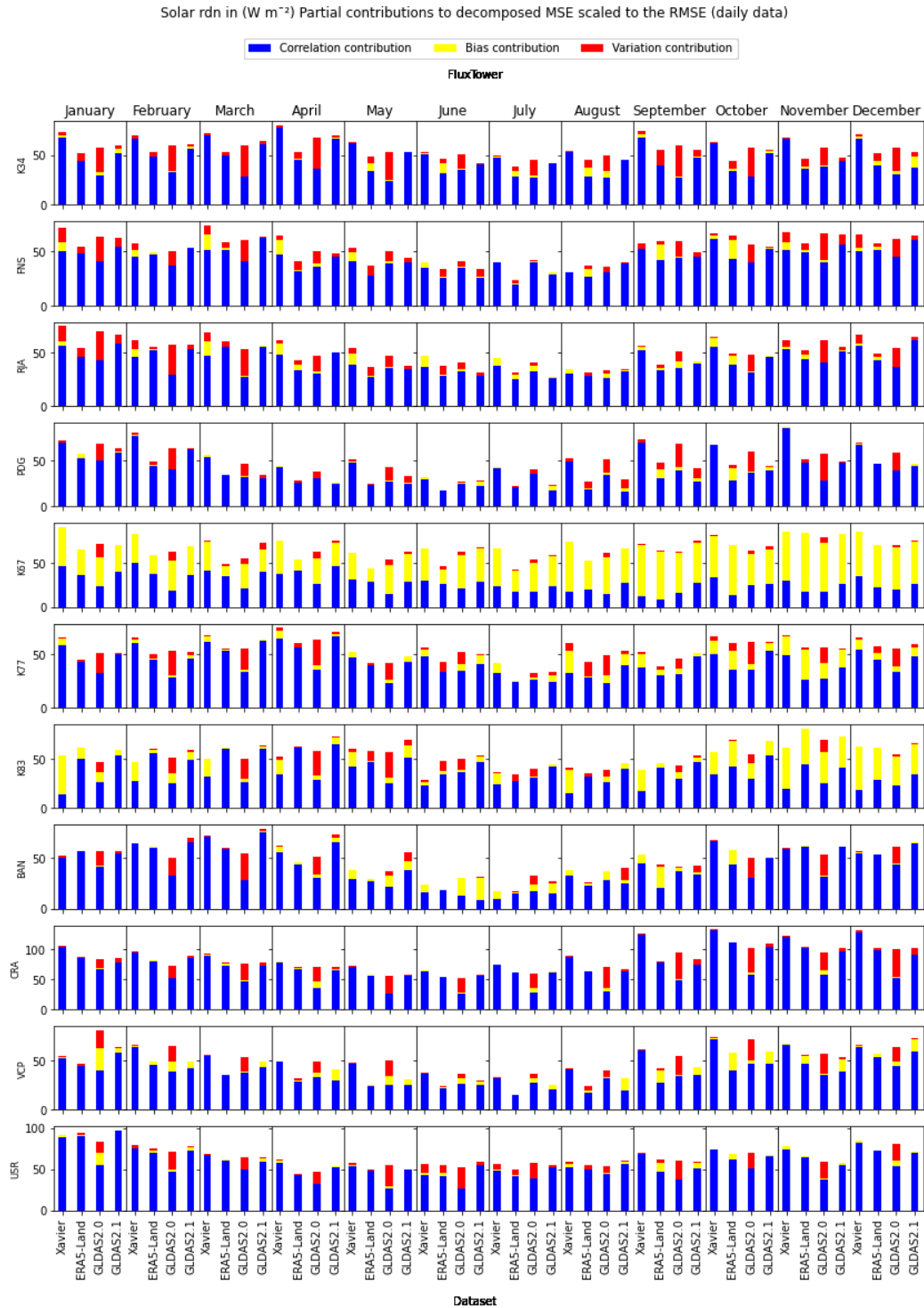


Figure S2 – Partial contributions to decomposed MSE scaled to the RMSE for incoming solar radiation for each gridded product and flux tower, using daily data, averaged for each month of the year.

35



Figures S3-6 present additional analysis on the influence of observational record length. The analysis uses subsets of longer Flux Tower datasets (K34, K77, CRA, and VCP) to assess how the length of record affects errors in comparison with gridded products for each variable. The percentage error relative to the observational mean was calculated ($RMSE/\mu_o$) was calculated, and the maximum and minimum values across all gridded products are plotted for each subset. To aid interpretation, gridded products were combined in the plots to enhance visual clarity.

Figure S3 – difference in % error between the full observational record and the shorter subsets (2- or 4-year samples) for Flux Tower K34.

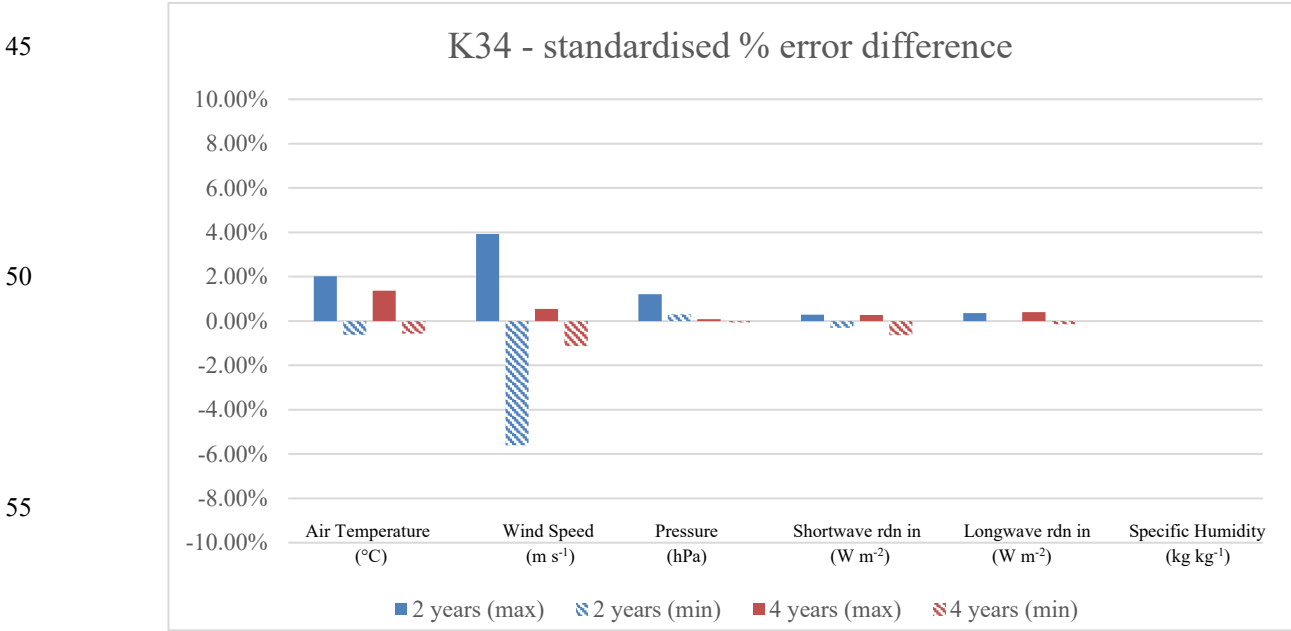


Figure S4 – difference in % error between the full observational record and the shorter subsets (2- or 4-year samples) for Flux Tower K37

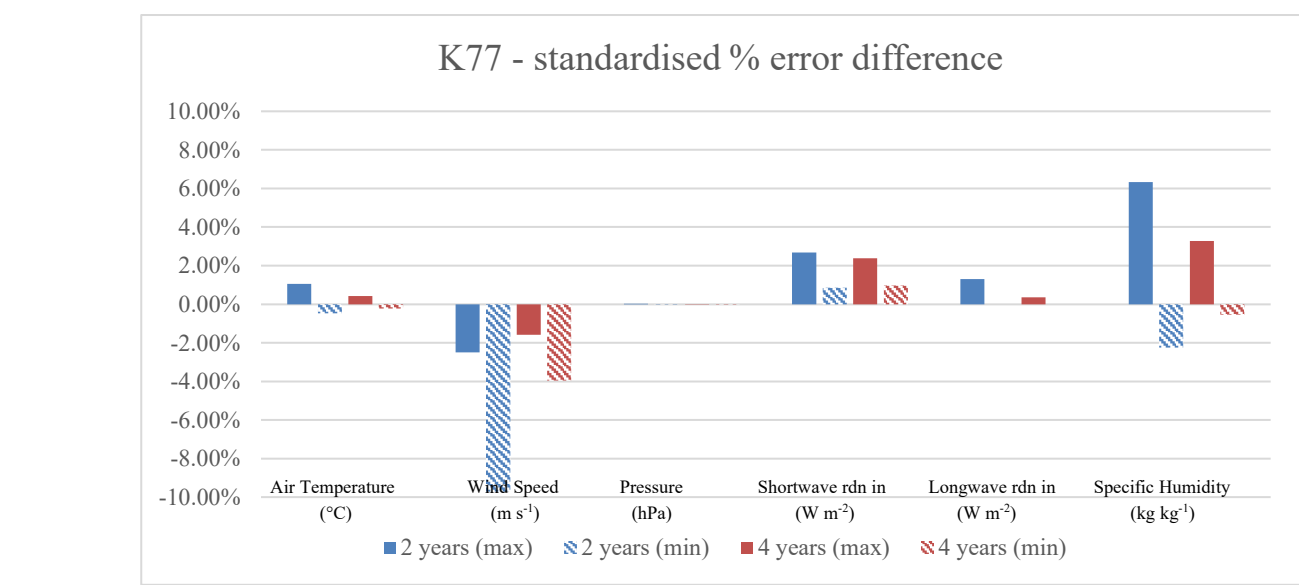


Figure S5 – difference in % error between the full observational record and the shorter subsets (2- or 4-year samples) for Flux Tower CRA.

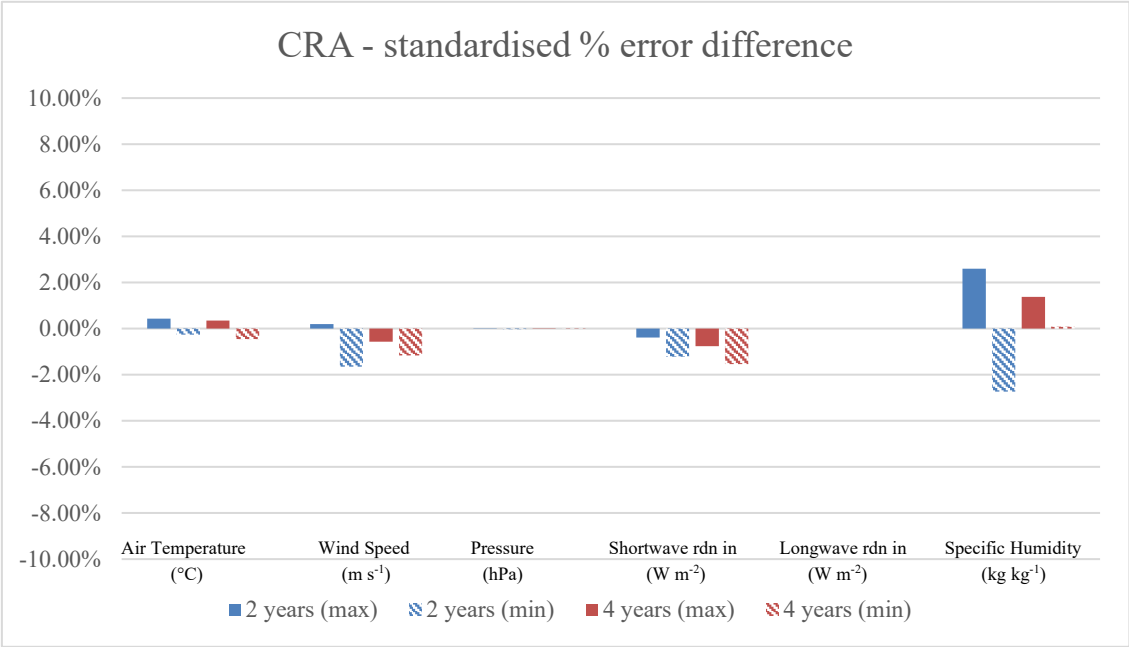


Figure S6 – difference in % error between the full observational record and the shorter subsets (2- or 4-year samples) for Flux Tower VCP.

