

Supplementary Materials: Estimating Daily Reference Evapotranspiration in a Semi-Arid Region Using Remote Sensing Data

Peshawa M. Najmaddin ^{1,2,*}, Mick J. Whelan ¹ and Heiko Balzter ^{1,3}

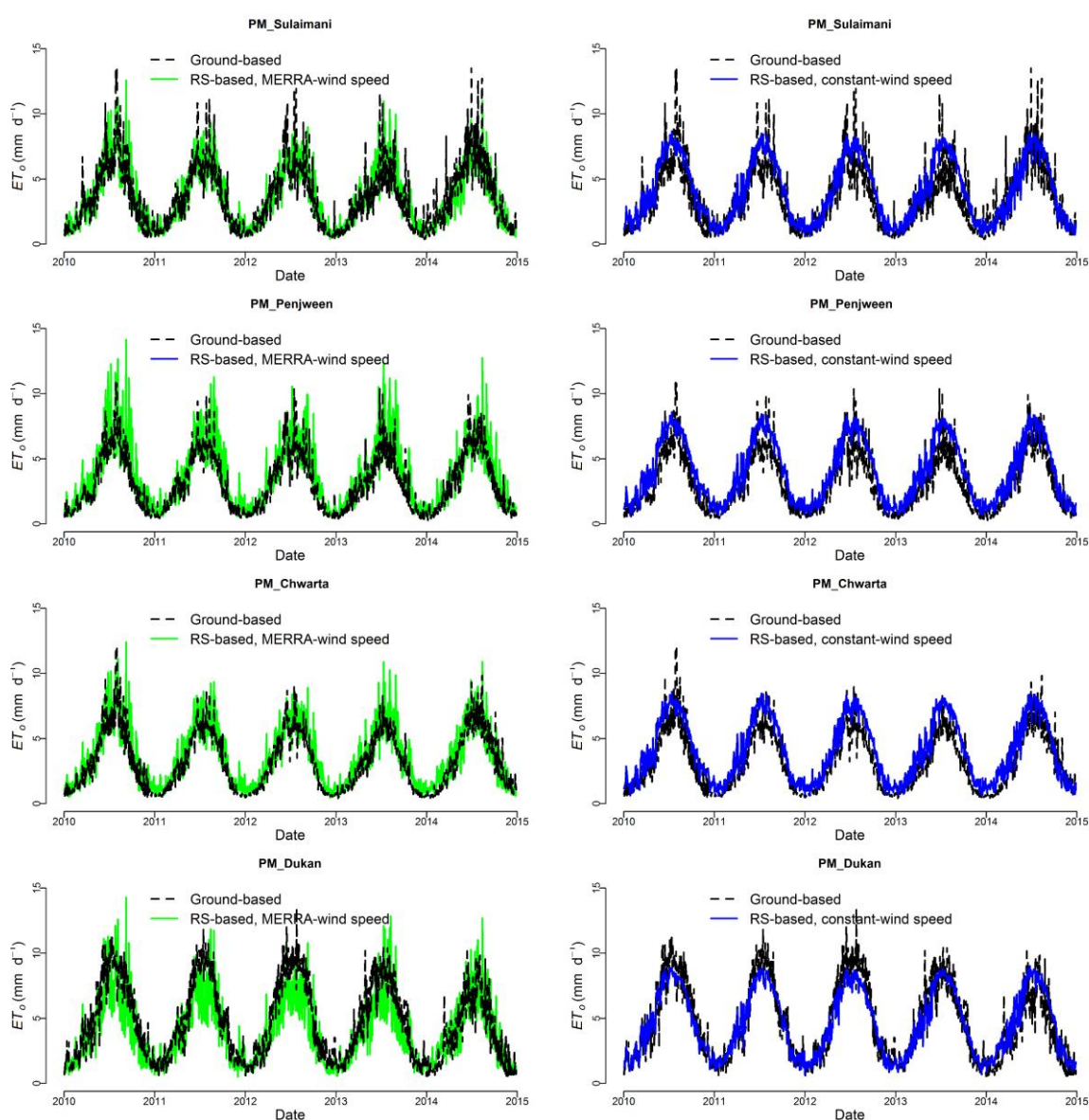


Figure S1. Plot of daily ET_o estimates derived from ground-based measurements (ET_{o-G}) and remote sensing data (ET_{o-RS}) using PM method from 2010–2014 for Sulaimani, Penjween, Chwarta and Dukan stations. The black line presents the ET_{o-G} . The blue line presents the ET_{o-RS} when the PM model driven by constant-wind speed. The green line presents the ET_{o-RS} when the PM model driven by MERRA-wind speed.

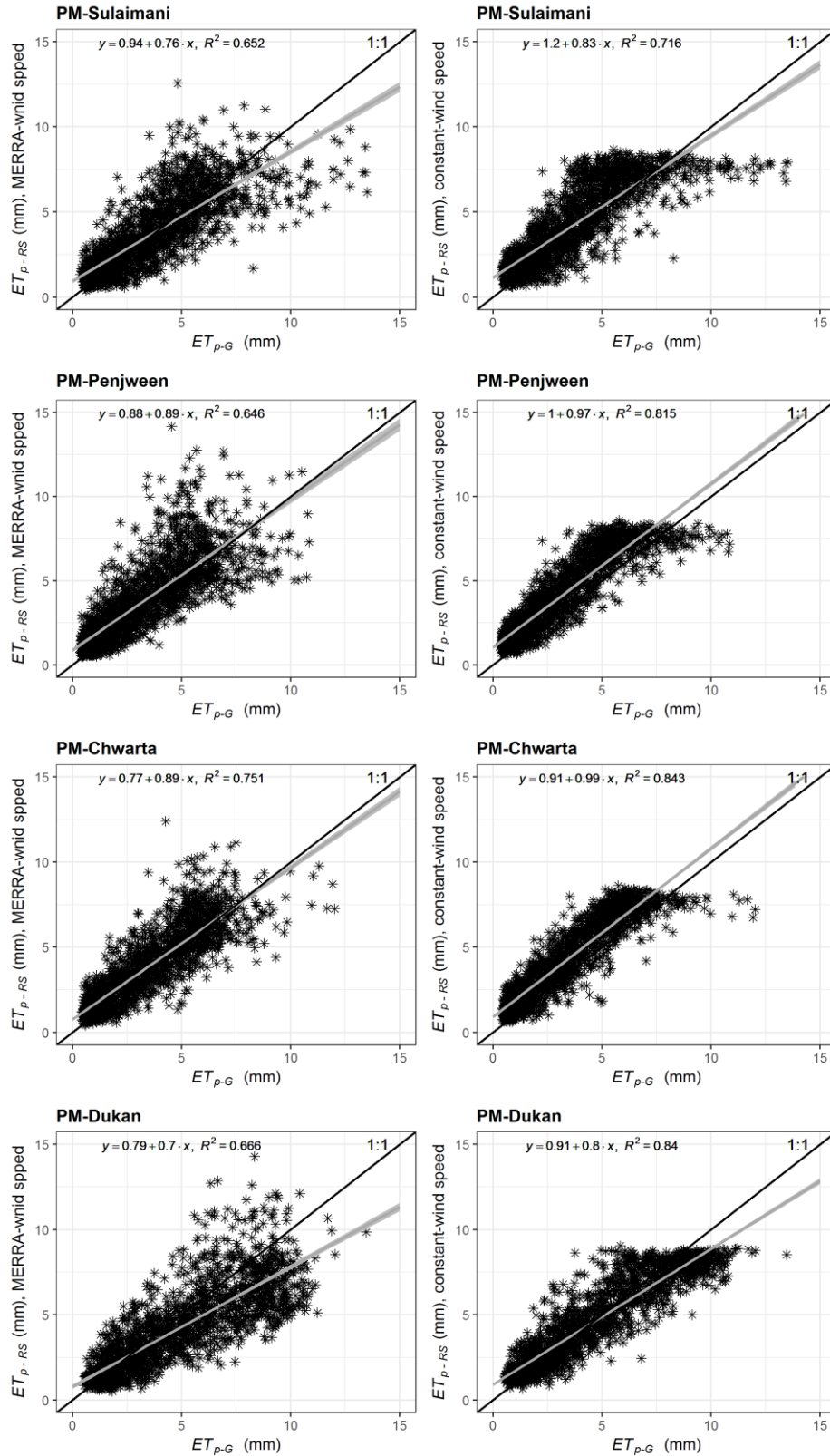


Figure S2. Scatterplots of estimated daily reference evapotranspiration using ground-based measurements using PM method (ET_{p-G}) versus estimated reference evapotranspiration using remote sensing data (ET_{p-RS}) using PM method when the PM was driven by with MERRA-wind speed and constant-wind speed at four different stations (Sulaimani, Penjween, Chwarta, and Dukan). The solid black line indicates the 1:1 relationship. The grey line shows the best-fit regression with 95% confidence interval (equations and R^2 also shown).

Table S1. Statistical summary of comparisons between estimated daily reference evapotranspiration using ground-based measurements (ET_{o-G}) and remote sensing data (ET_{o-RS}) with MERRA-wind speed and constant-wind speed data for PM methods at four different stations (Sulaimani, Penjween, Chwarta, and Dukan) over the study period 2010–2014. * means significant at $p < 0.05$.

Station	Variable	RMSE	BIAS (%)	R
Sulaimani	(MERRA-wind speed)	1.47	2.5	0.8 *
	(constant-wind speed)	1.45	15.7	0.85 *
Penjween	(MERRA-wind speed)	1.57	17.2	0.8 *
	(constant-wind speed)	1.4	30	0.91 *
Chwarta	(MERRA-wind speed)	1.23	12.8	0.86 *
	(constant-wind speed)	1.2	27	0.92 *
Dukan	(MERRA-wind speed)	1.78	-13	0.81 *
	(constant-wind speed)	1.1	-1.1	0.492 *

Table S2. Statistical summary of (BIAS %) between daily ground-measured and remotely-sensed values of T_a , RH%, DS and U_2 and BIAS% summary of estimated daily reference evapotranspiration using remote sensing data (ET_{o-RS}) for four different methods against the benchmark data set (PM method using ground-based measurements: ET_{o-G} : PM) for four different stations (Sulaimani, Penjween, Chwarta, and Dukan) over the study period 2010–2014. * means significant at $p < 0.05$.

Station	Bias for ET_o (%)				Bias for meteorological variables (%)			
	PM	HS	JH	MB	T_a	RH	DS	U_2
Sulaimani	2.5	-9	21.4	24.5	-14.2	-0.6	27.8	16.1
Penjween	17.7	-1.9	37	40	28.4	-13.4	34.8	10.2
Chwarta	12.8	-0.6	33.3	37	-0.1	-26	24.5	9.1
Dukan	-13	-2.6	11.2	8.6	-2.8	-7.3	-47.7	21.8
Bias for ET_o vs bias for meteorological variables								
	PM vs T_a	HS vs T_a	JH vs T_a	MB vs T_a				
R ²	0.36	0.35	0.43	0.33				
P-value	0.64	0.65	0.57	0.67				
	PM vs DS	JH vs DS	MB vs DS					
R ²	0.94	0.956	0.969					
P-value	0.06	0.04 *	0.031 *					
	PM vs RH%							
R ²	0.29							
P-value	0.71							
	PM vs U_2							
R ²	0.81							
P-value	0.19							

Table S3. Summary of annual ET_{o-G} and ET_{o-RS} (with MERRA-wind speed and constant-wind speed data) for PM method at four different stations (Sulaimani, Penjween, Chwarta, and Dukan) over the study period 2010–2014.

Station	variable	Year				
		2010	2011	2012	2013	2014
Sulaimani	ET_{o-G} mm y^{-1}	1385	1269	1290	1109	1482
	ET_{o-RS} mm y^{-1} (MERRA-wind speed)	1439	1304	1316	1285	1328
	ET_{o-RS} mm y^{-1} (constant-wind speed)	1577	1473	1497	1485	1499
Penjween		1183	1150	1154	1054	121
	ET_{o-RS} mm y^{-1} (MERRA-wind speed)	1474	1329	1305	1321	1323
	ET_{o-RS} mm y^{-1} (constant-wind speed)	1561	1471	1495	1484	1497
Chwarta	ET_{o-G} mm y^{-1}	1274	1133	1144	1091	1275
	ET_{o-RS} mm y^{-1} (MERRA-wind speed)	1430	1307	1318	1290	1331
	ET_{o-RS} mm y^{-1} (constant-wind speed)	1560	1472	1496	1484	1498
Dukan	ET_{o-G} mm y^{-1}	1864	1767	1848	1706	1372
	ET_{o-RS} mm y^{-1} (MERRA-wind speed)	1588	1479	1479	1435	1460
	ET_{o-RS} mm y^{-1} (constant-wind speed)	1762	1678	1675	1674	1677



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