Table S1. Site information for sites used in model parameter calibration and validation.

Site Name	Peatland Type	Lat	Long	Logger Type	Monitoring Period	Monitoring Interval
AMET13	Permafrost Bog	53.709901	-57.007506	Hobo Pro U23-003	2014-2021	2 hours
AMET20	Permafrost Bog	51.755946	-56.413699	Hobo Pro U23-003	2015-2021	2 hours
Belcher Burn	Permafrost Bog	57.95409	-94.16935	Hobo U12-013 Hobo Pro U23-003	Sept-23 to Aug-24	2 hours
Belcher Lake DL	Permafrost Fen	57.92839	-94.1735	Hobo U12-013 Hobo Pro U23-003	Sept-23 to Aug-24	2 hours
Belcher Plateau	Permafrost Bog	57.95269	-94.1626	Hobo U12-013 Hobo Pro U23-003	Aug-22 to May-23	2 hours
Big Slip Forest	Permafrost Bog	57.76736	-94.21721	Hobo U12-013 Hobo Pro U23-003	2022-2023	2 hours
Bog	Bog	59.484875	-117.176827	Hobo Pendant MX2201	Jul-23 to Sept-24	1 hour
Burn Plateau	Permafrost Bog	58.03062	-94.15858	Hobo U12-013 Hobo Pro U23-003	2023	2 hours
Bylot Forest	Permafrost Bog	58.43879	-94.13525	Hobo U12-013 Hobo Pro U23-003	Sept-23 to Aug-24	2 hours
Bylot Plateau	Permafrost Bog	58.43897	-94.13419	Hobo U12-013 Hobo Pro U23-003	Sept-23 to Aug-24	2 hours
Chesnaye DL	Permafrost Fen	58.1636	-94.15665	Hobo U12-013 Hobo Pro U23-003	2022-2023	2 hours
Chesnaye Fen	Permafrost Fen	58.161767	-94.147897	Hobo U12-013 Hobo Pro U23-003	2022-2023	2 hours
Chesnaye Plateau	Permafrost Bog	58.16173	-94.1488	Hobo U12-013 Hobo Pro U23-003	2022-2023	2 hours
Chesnaye Trough	Permafrost Bog	58.16171	-94.1489	Hobo U12-013 Hobo Pro U23-003	2023	2 hours
EM1 Hollow	Bog	47.50285	-93.48283	Cambell Scientific CR1000	2011-2016	30 min
EM1 Hummock	Bog	47.50285	-93.48283	Cambell Scientific CR1000	2011-2016	30 min
EM2 Hollow	Bog	47.50285	-93.48283	Cambell Scientific CR1000	2011-2016	30 min
EM2 Hummock	Bog	47.50285	-93.48283	Cambell Scientific CR1000	2011-2016	30 min

EM3 Hollow	Bog	47.50285	-93.48283	Cambell Scientific CR1000	2011-2013	30 min
EM3 Hummock	Bog	47.50285	-93.48283	Cambell Scientific CR1000	2011-2013	30 min
Extreme Rich Fen	Fen	59.483120	-117.181246	Hobo Pendant MX2201	Jul-23 to Sept-24	1 hour
KINOMET101	Bog	51.549479	-81.815939	Cambell Scientific 107 temperature probe 44033 RC Precision Thermistor	2010-2018	30 min
KINOPEAT101	Permafrost Bog	51.588298	-81.769323	Cambell Scientific 107 temperature probe 44033 RC Precision Thermistor	2010-2018	30 min
Lamprey Fen	Permafrost Fen	58.33461	-94.15899	Hobo U12-013 Hobo Pro U23-003	Sept-23 to Aug-24	2 hours
Lamprey Plateau	Permafrost Bog	58.32135	-94.1586	Hobo U12-013 Hobo Pro U23-003	2023	2 hours
Lamprey Trough	Permafrost Bog	58.3214	-94.15846	Hobo U12-013 Hobo Pro U23-003	Aug-22 to Jul-23	2 hours
Macmillan Pass	Permafrost Bog	63.181972	-130.186275	Hobo Pro U23-002 RBR	2018-2020	4 hours
Mile 222	Permafrost Bog	63.296011	-129.834797	Hobo Pro U23-002 RBR	2017-2020	4 hours
PBPP PEAT101	Permafrost Bog	55.139525	-85.787279	Cambell Scientific 107 temperature probe 44033 RC Precision Thermistor	2010-2016	30 min
PFSCNF1	Permafrost Fen	55.24013	-84.32046	Cambell Scientific CS225	2018-2021	1 hour
PFSCNF2	Fen	55.04201	-82.86165	Cambell Scientific CS225	2018-2021	1 hour
PFSCNP1	Permafrost Bog	54.8273	-83.04869	Cambell Scientific CS225	2018-2021	1 hour
PFSCSF1	Fen	54.88209	-84.82505	Cambell Scientific CS225	2017-2021	1 hour
PFSCSP1	Permafrost Bog	55.1863	-85.71915	Cambell Scientific CS225	2017-2019	1 hour
PFSDNP1	Permafrost Bog	54.48866	-84.70289	Cambell Scientific CS225	2017-2020	1 hour
Poor Fen	Fen	59.484403	-117.175089	Hobo Pendant MX2201	Jul-23 to Sept-24	1 hour

Red Creek	Bog	65.153097	-138.365555	Hobo Pro U23-002 RBR	2015-2020	4 hours
Rich Fen	Fen	59.484151	-117.174925	Hobo Pendant MX2201	Jul-23 to Sept-24	1 hour
SS33 9a U	Permafrost Bog	60.94149	-117.36552	Hobo Pro U12-008 Hobo Pro U23-003	2016-2017	2 hours
TBD2 Forest	Permafrost Bog	57.8582	-94.20221	Hobo U12-013 Hobo Pro U23-003	Sept-23 to Aug-24	2 hours
TBD2 Plateau	Permafrost Bog	57.85743	-94.20231	Hobo U12-013 Hobo Pro U23-003	Sept-23 to Aug-24	2 hours
UB1	Permafrost Bog	62.45825	-114.53159	Hobo Pro U12-008 Hobo Pro U23-003	2016-2018	2 hours
VICM101	Bog	52.720936	-83.940921	Cambell Scientific 107 temperature probe 44033 RC Precision Thermistor	2010-2016	30 min
VICM102	Fen	52.720441	-83.937429	Cambell Scientific 107 temperature probe 44033 RC Precision Thermistor	2010-2018	30 min
VICM103	Permafrost Bog	52.697263	-83.891776	Cambell Scientific 107 temperature probe 44033 RC Precision Thermistor	2010-2018	30 min
VICM105	Bog	52.706576	-84.183415	Cambell Scientific 107 temperature probe 44033 RC Precision Thermistor	2012-2018	30 min
VICM107	Permafrost Bog	52.648337	-84.215602	Cambell Scientific 107 temperature probe 44033 RC Precision Thermistor	2012-2013	30 min
West Severn	Permafrost Bog	56.28615	-87.97692	Cambell Scientific CS225	2020-2021	1 hour
ZF20 34B U	Bog	61.6075	-117.15356	Hobo Pro U12-008 Hobo Pro U23-003	2016-2017	2 hours

Permafro	Permafro	Fen	Bog		Landcov
0.78 *0.62*	0.61 *0.69*	1.27 *1.12*	1.06 *1.07*	Average	Damping Depth
0.26	0.54	1.05	0.90	2.5th	
1.24	0.68	1.59	1.23	97.5th	
8.27 x 10^{-3} *6.96 x 10^{-3}*	3.59 x 10^{-3} *6.72 x 10^{-3}*	1.66 x 10^{-3} *1.24 x 10^{-3}*	3.31 x 10^{-3} *8.46 x 10^{-4}*	Average	Annual temperature decay
5.529 x 10^{-3}	3.01 x 10^{-3}	4.51 x 10^{-4}	2.07 x 10^{-3}	2.5th Percentile	
9.90 x 10^{-2}	4.16 x 10^{-3}	2.96 x 10^{-3}	4.58 x 10^{-3}	97.5th Percentile	
2.25	2.25	2.25	2.25	Average	Amplitude Modifier
2.14	2.14	2.14	2.14	2.5th Percentile	
2.36	2.36	2.36	2.36	97.5th Percentile	
0.87	0.87	0.87	0.87	Average	Period Modifier
0.82	0.82	0.82	0.82	2.5th	
0.91	0.91	0.91	0.91	97.5th	

Table S1. Average calibrated parameter value and the 95% confidence interval for each landcover class. Damping depth and annual temperature decay for each landcover class were significantly different ($p < 0.001$). Italicized values are the average of the parameter values which were reported or calculated from temperatures reported in other studies for peatlands in North America, Finland, and Russia (Nichols, 1998; Weiss et al., 2006; Friesen et al., 2021; Roudina et al., 2025).

Table S2. Correlation matrix for the CaMPground model parameters k and d for each peatland class.

	Bog	Fen	Permafrost Bog	Permafrost Fen
Correlation d & k	-0.52	0.08	-0.42	0.54

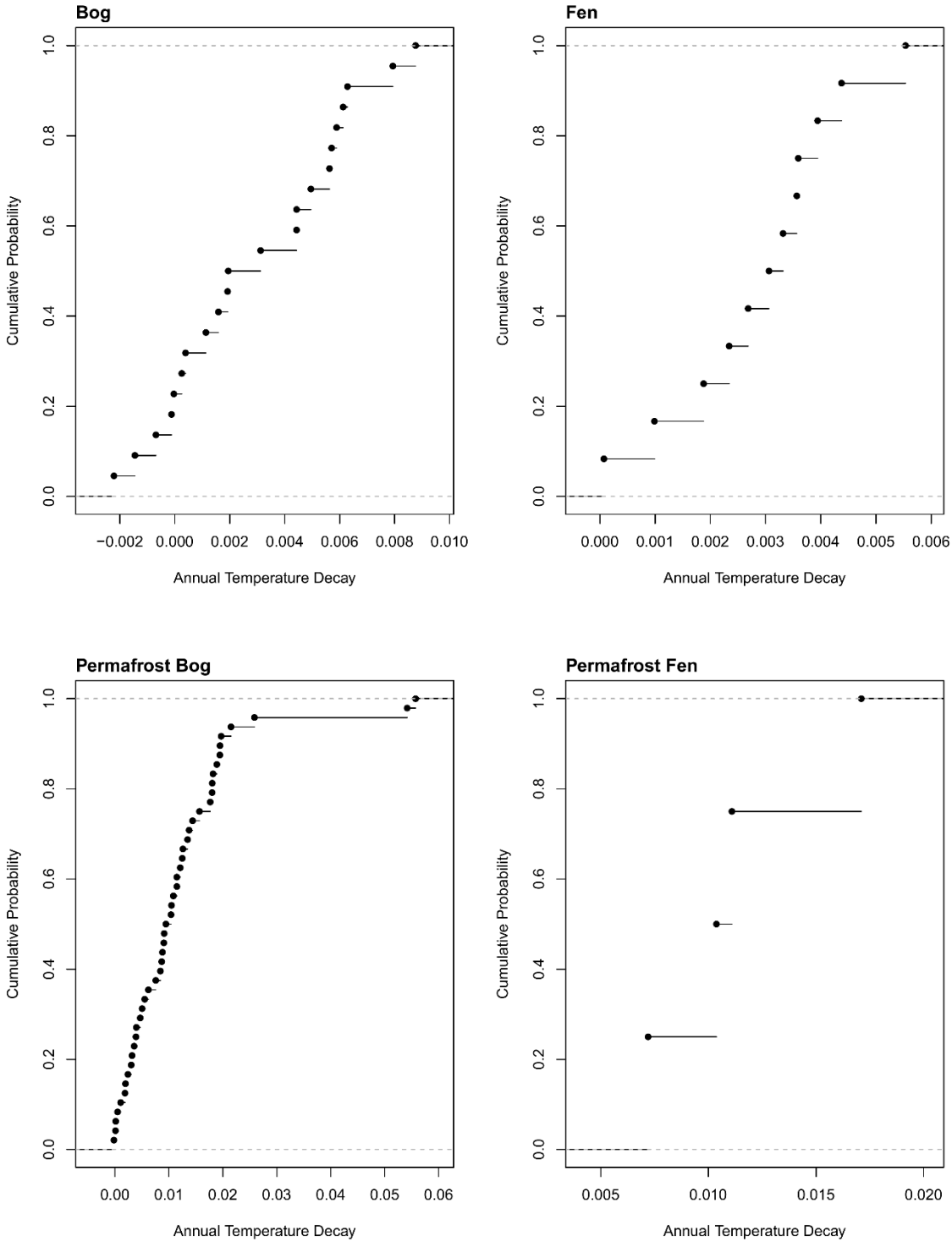


Figure S1. Cumulative distribution functions for annual temperature decay (k) for A) bog, B) fen, C) palsa, and D) permafrost fen.

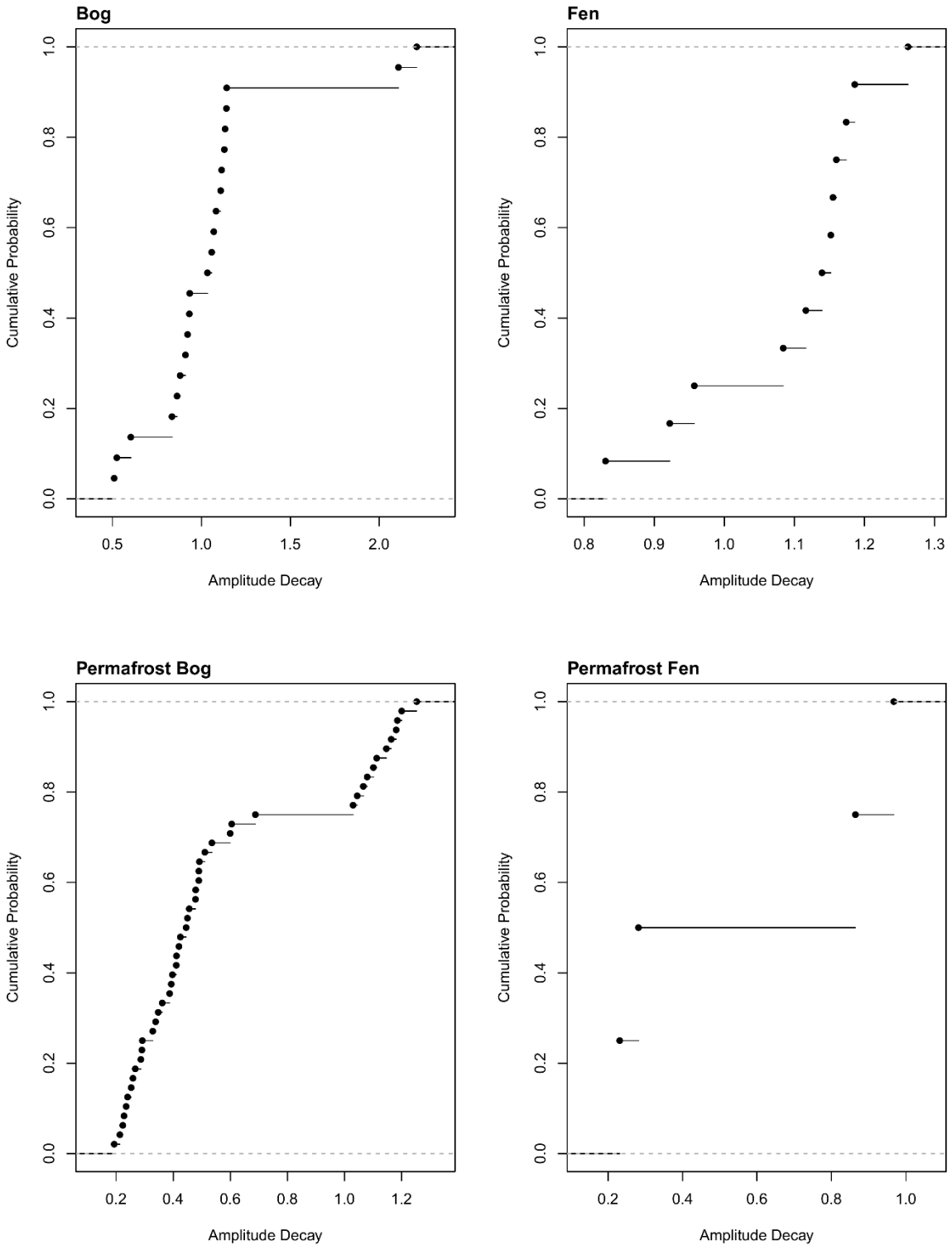


Figure S2. Cumulative distribution functions for damping depth (d) for A) bog, B) fen, C) palsa, and D) permafrost fen.

Soil Moisture Analysis

To assess if soil moisture could be included in the model, we compared two soil moisture products (ERA5 Depth 2 soil volumetric water content and SMAP soil moisture) and soil moisture measurements at 8 sites to model error. However, no relationship was found (Figure S3) except at permafrost fens for the soil moisture products. There were a limited number of sites and showed an inverse relationship between model error and soil moisture depending on the product (Figure S3 D-G). As a result of this analysis soil moisture was not considered in the model at this time, although it likely does have an impact on soil temperature with depth.

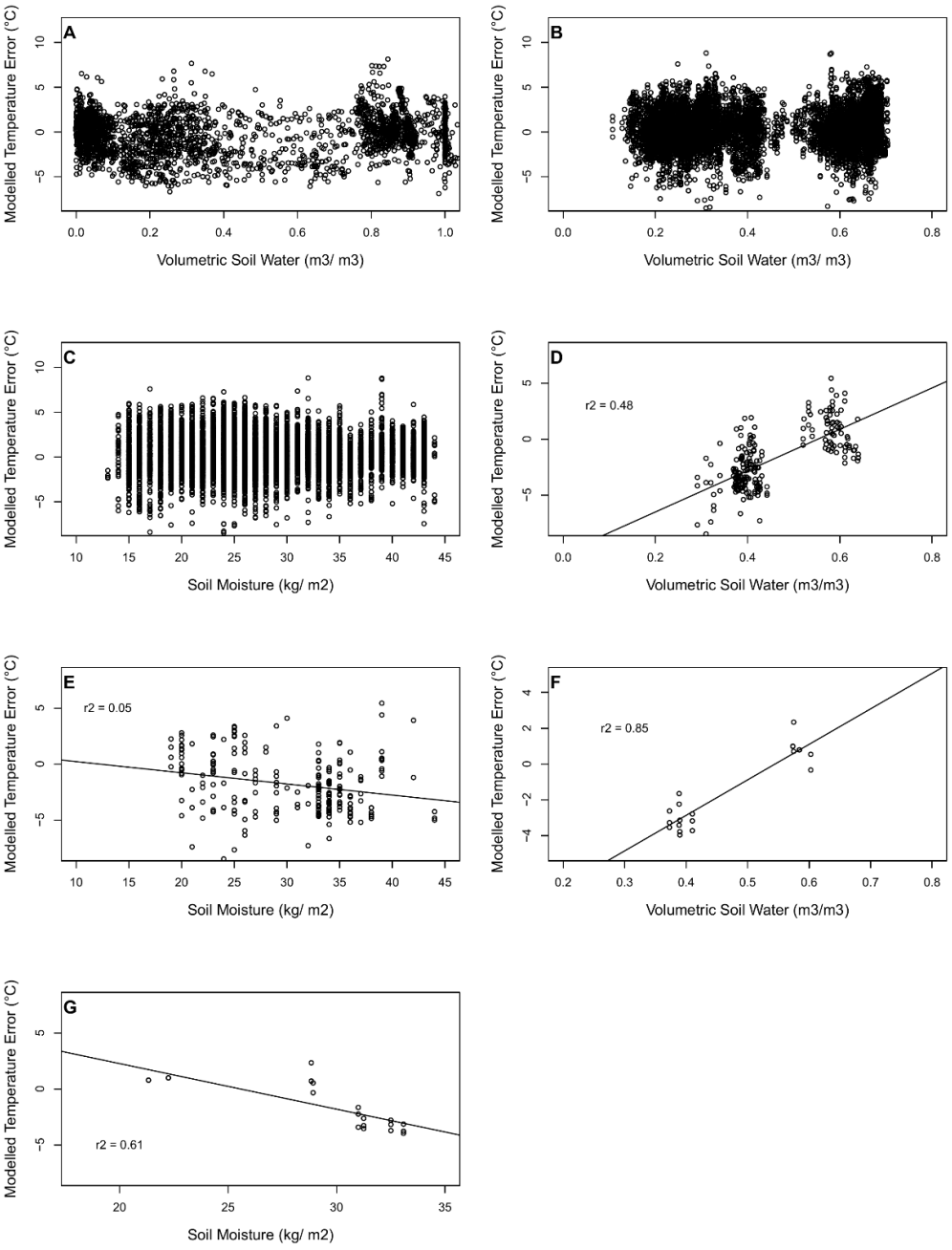


Figure S3. A) Measured volumetric soil water compared to monthly temperature error. B) ERA5 volumetric soil water (at depth 2) compared to monthly temperature error. C) SMAP soil moisture compared to monthly temperature error. D) ERA5 volumetric soil water (at depth 2) compared to monthly temperature error for permafrost fens. E) SMAP soil moisture compared to monthly temperature error for permafrost fens. F) ERA5 volumetric soil water (at depth 2) compared to annual temperature error for permafrost fens. G) SMAP soil moisture compared to annual temperature error for permafrost fens.

Supplemental Model Performance Plots

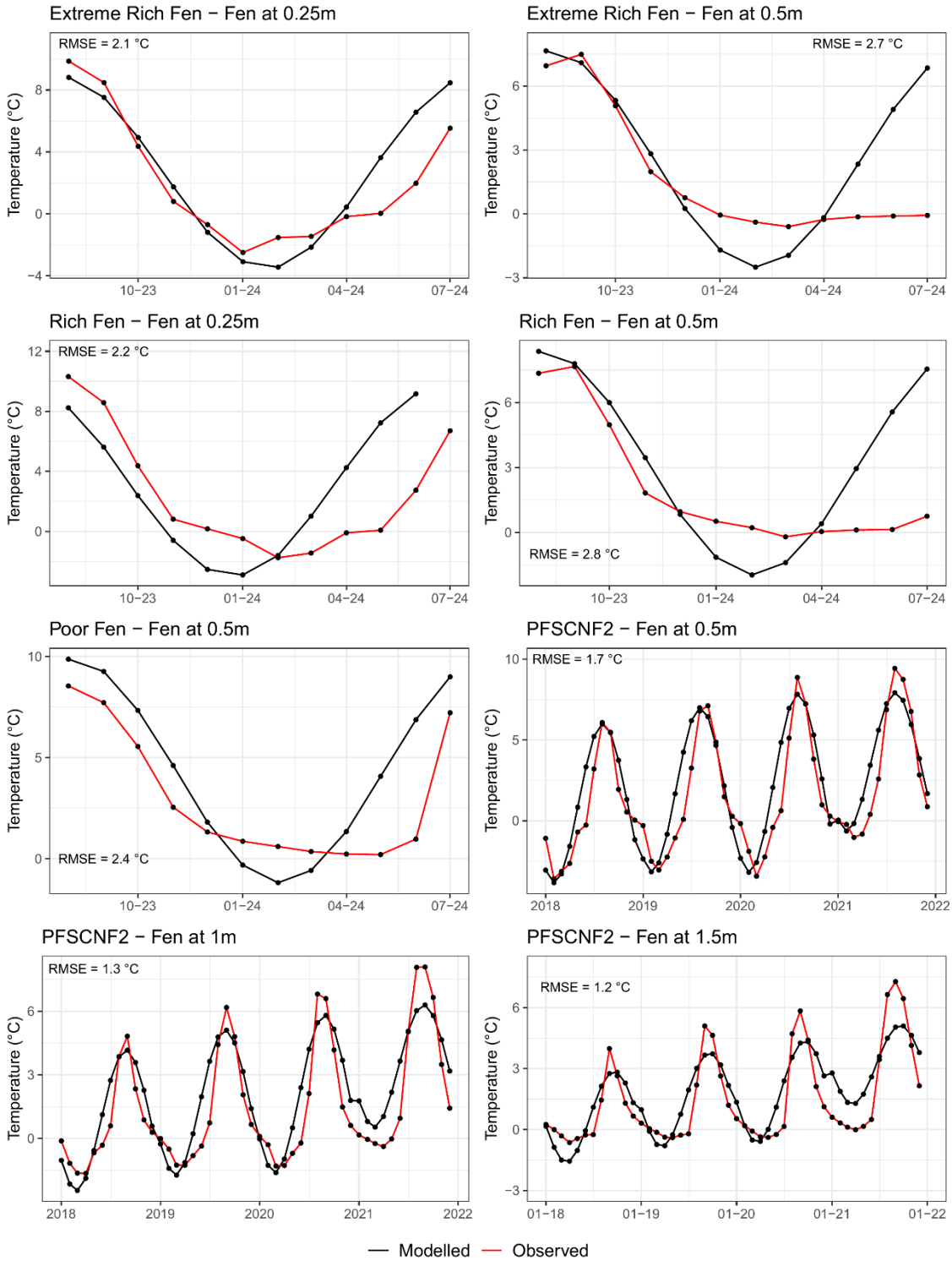


Figure S4. Time series plots for model performance when compared to the observed temperature. Note the variability of the y axis scale between plots. Monthly root mean square error (RMSE) is given for each plot.

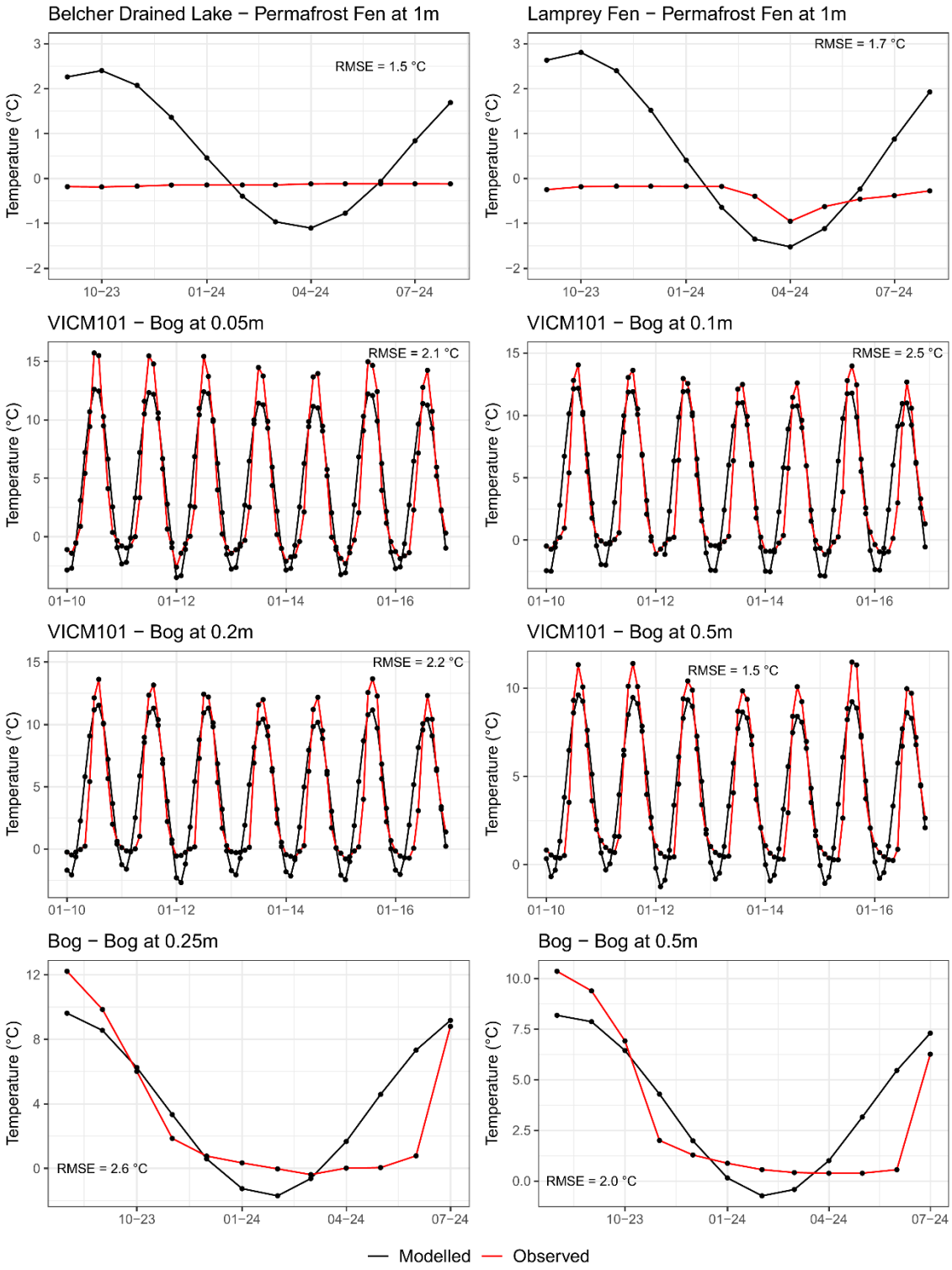


Figure S5. Time series plots for model performance when compared to the observed temperature. Note the variability of the y axis scale between plots. Monthly root mean square error (RMSE) is given for each plot. Permafrost fens are noted as P Fens.

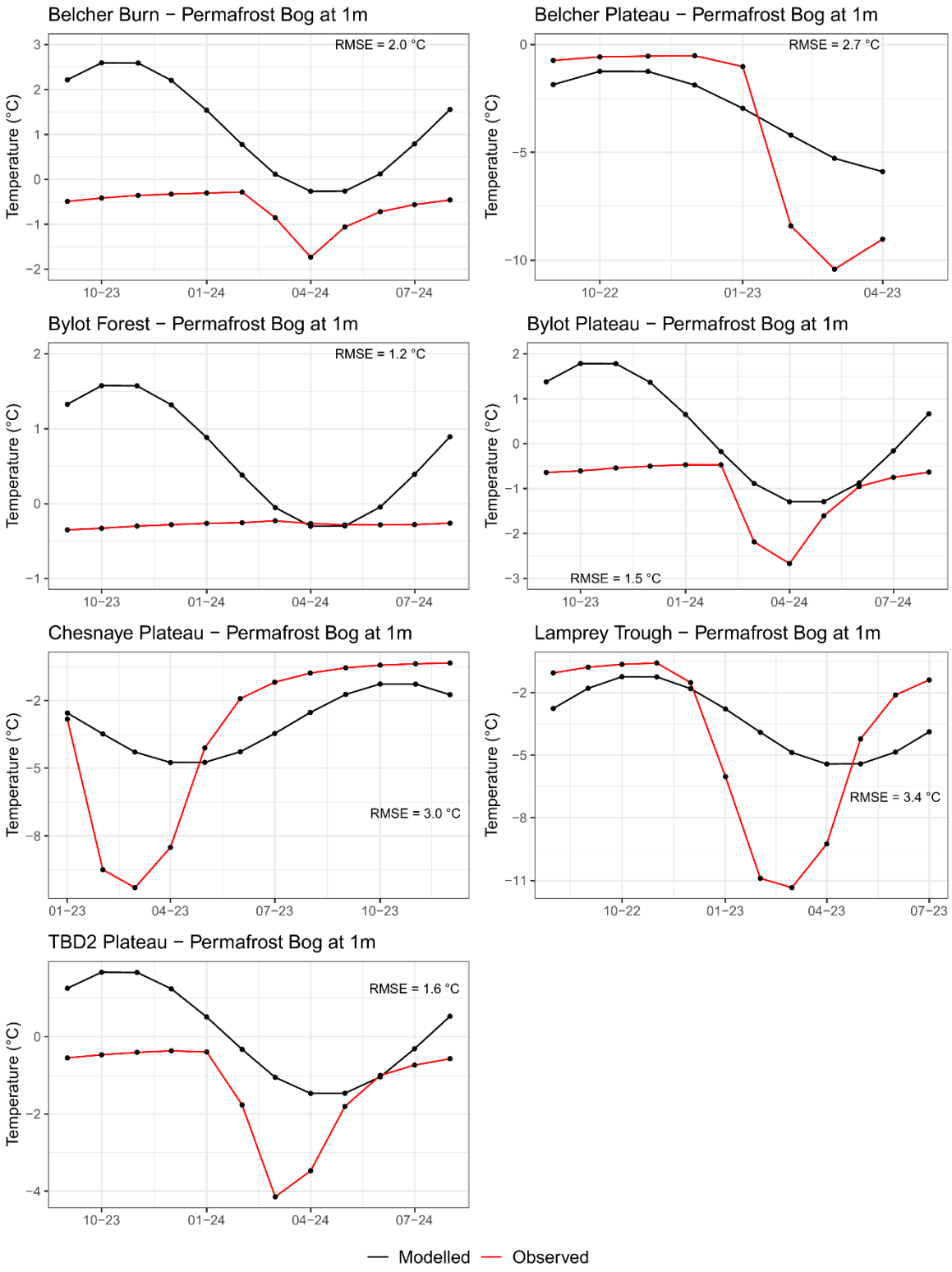


Figure S6. Time series plots for model performance when compared to the observed temperature. Note the variability of the y axis scale between plots. Monthly root mean square error (RMSE) is given for each plot.

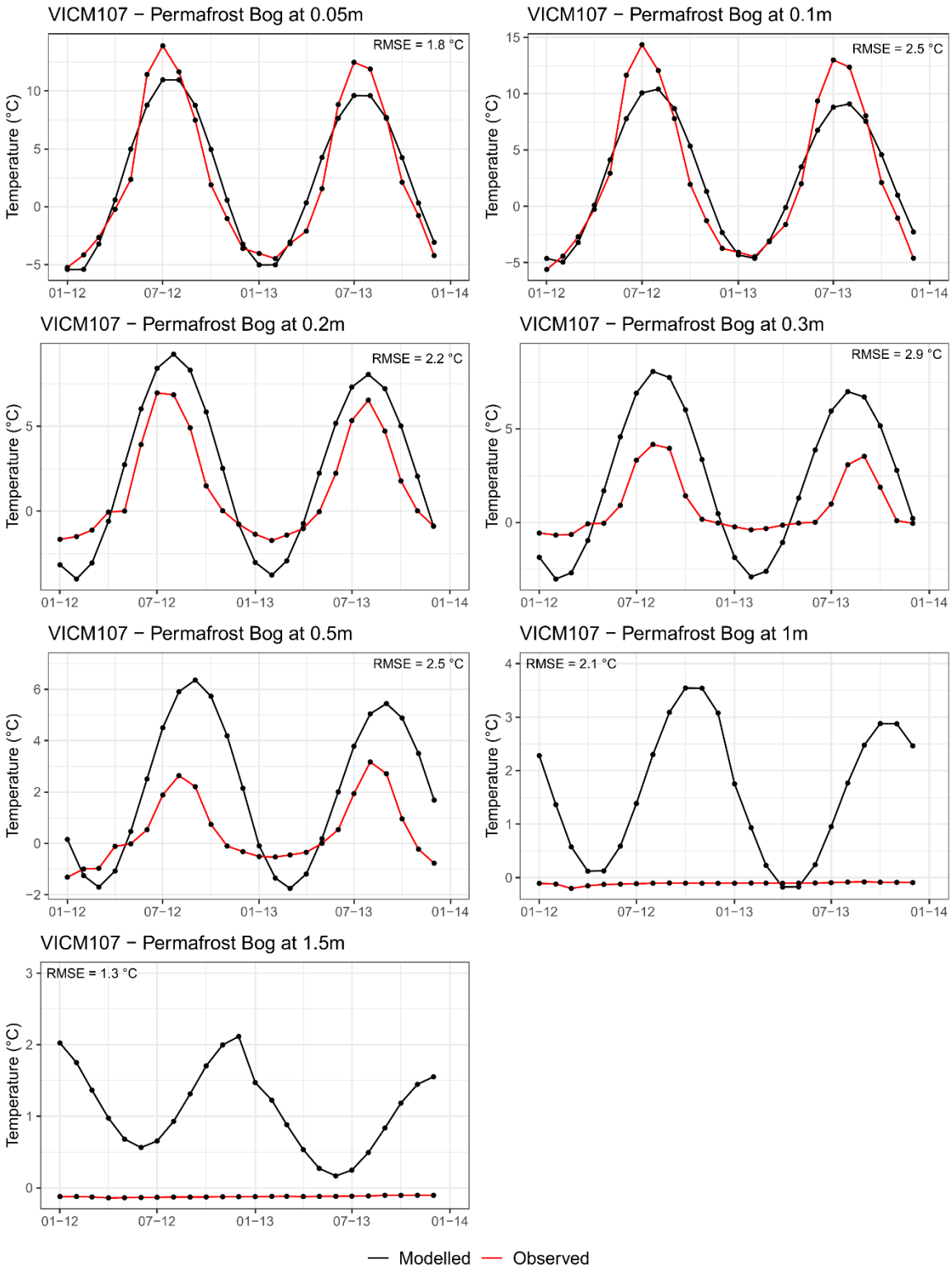


Figure S7. Time series plots for model performance when compared to the observed temperature. Note the variability of the y axis scale between plots. Monthly root mean square error (RMSE) is given for each plot.

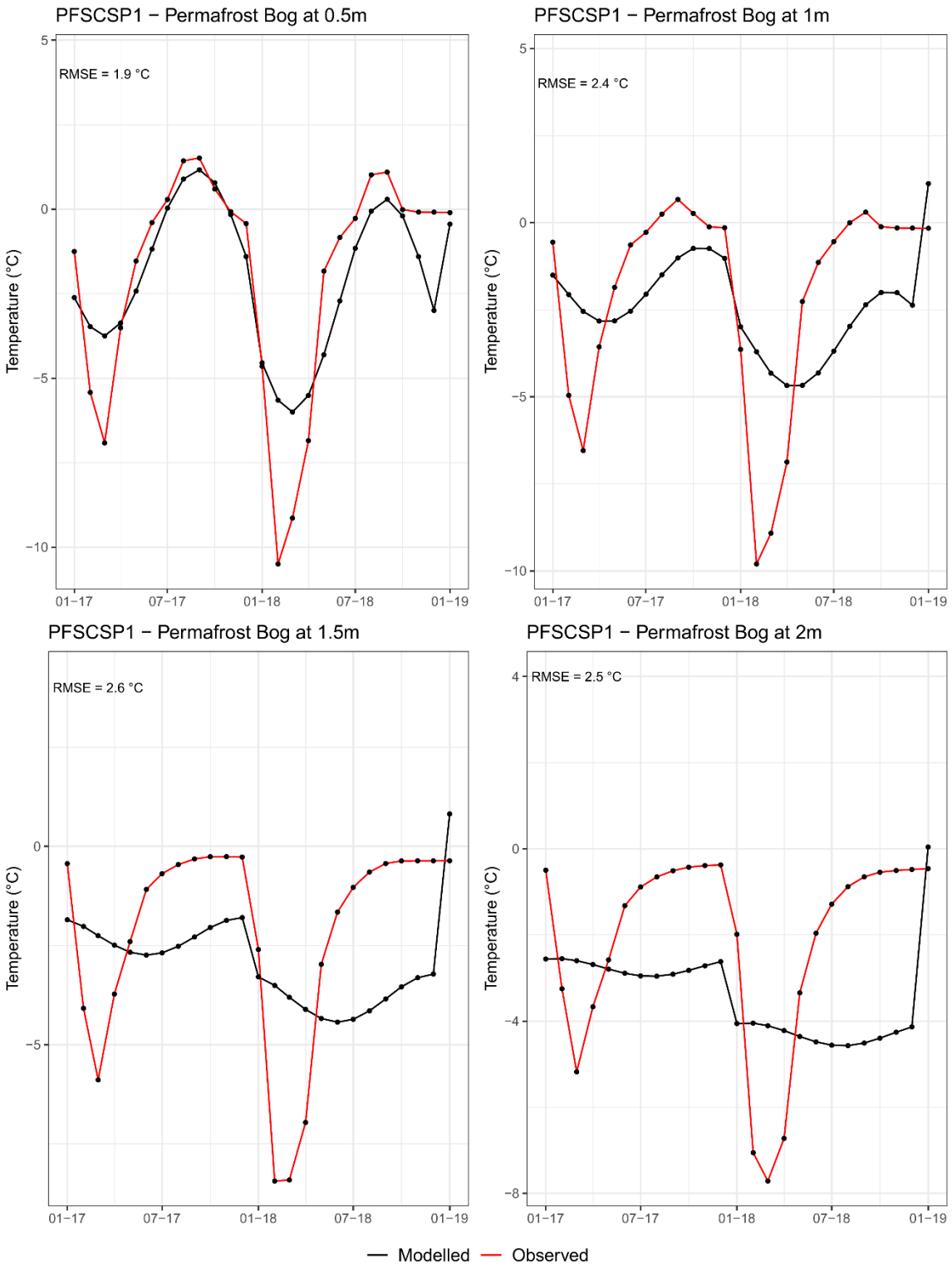


Figure S8. Time series plots for model performance when compared to the observed temperature. Note the variability of the y axis scale between plots. Monthly root mean square error (RMSE) is given for each plot.

Supplemental NEST Comparison Plots

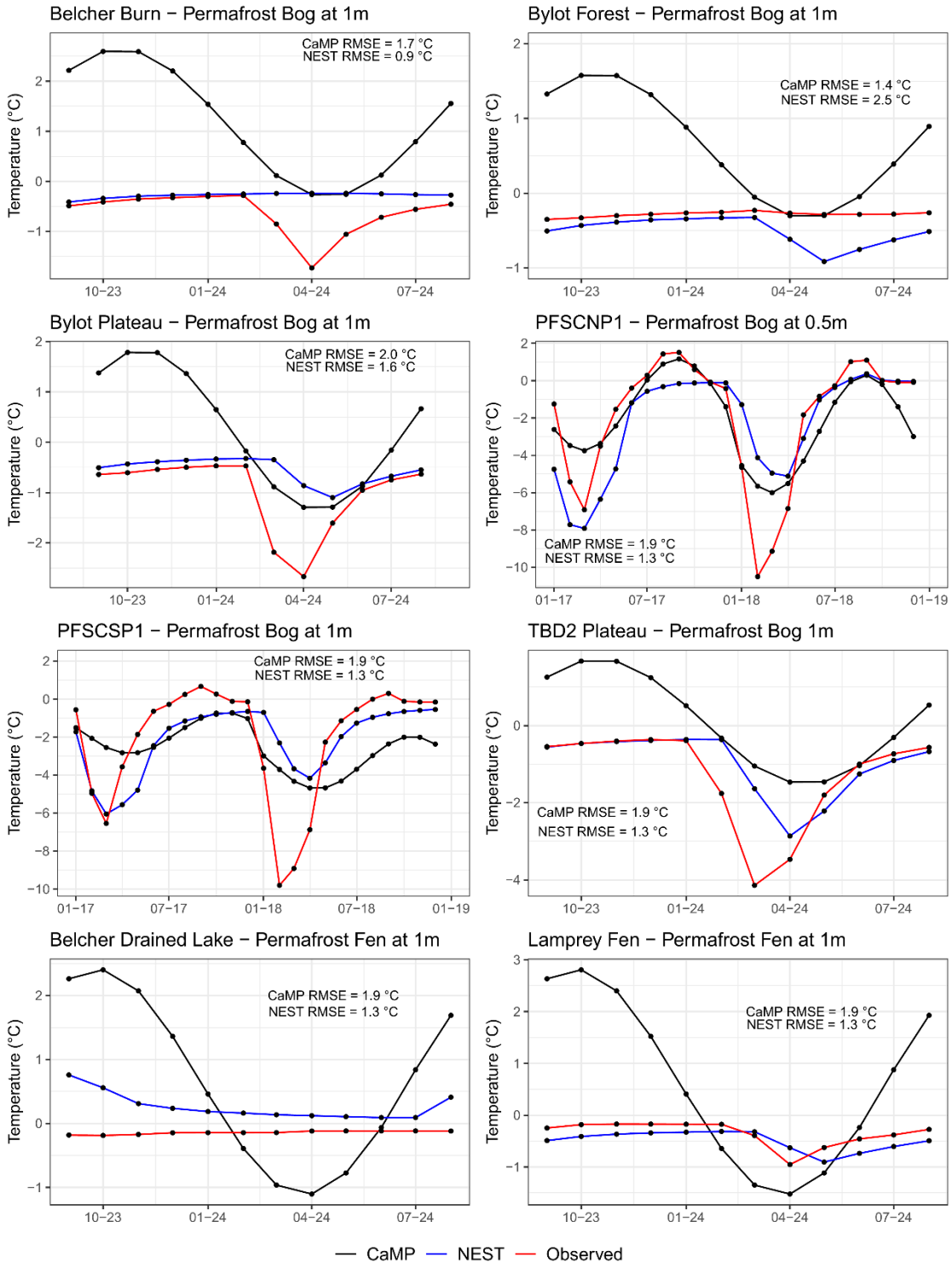


Figure S9. Time series plots for select sites comparing CaMPground and NEST predictions to observed temperature. Note the variability of the y axis scale between plots. Monthly root mean square error (RMSE) is given for each plot.