June 05, 2008

Validation of 3TIER Simulations
Western U.S. Wind Resource Map — Tower 12111
for National Renewable Energy Laboratory

Copyright 2008 © 3TIER, Inc. All rights reserved. 3TIER claims a copyright in all proprietary and copyrightable text and graphics in this Report, the overall design of this Report, and the selection, arrangement and presentation of all materials in this Report, including information in the public domain. Reproduction and redistribution prohibited without written permission; requests for permission may be directed to rkrauze@3tiergroup.com.

ph: 206.325.1573
fax: 206.325.1618

info@3tiergroup.com
www.3tiergroup.com

2001 Sixth Avenue, Suite 2100
Seattle, WA 98121-2534

1 Executive Summary

3TIER has been retained by National Renewable Energy Laboratory (NREL) to assess the wind resource over the Western U.S. Wind Resource Map region utilizing a numerical weather prediction (NWP) model. This report examines the quality of the NWP simulations used for that assessment at a single point within the study area. For this report, the observations were taken at Tower 12111 in Idaho (latitude 43.4071, longitude -111.747).

The average observed wind speed (for all valid observational times) at 60 meters during the 16 months of the period of record (January, 2004 to April, 2005) is 6.50 m/s with an hourly standard deviation of 3.28 m/s at Tower 12111. This compares to a modeled 60m wind speed of 6.27 m/s with a 3.17 m/s standard deviation for these same times. After applying a statistical correction to the simulated data, the MOS-corrected mean is 6.10 m/s and hourly standard deviation is 3.08 m/s.

Section 2 of this report describes the on-site meteorological data sources used in this analysis. The numerical weather prediction model used is described in Section 3. Section 4 describes how well the on-site data collected at Tower 12111 compare to the simulated time series along the following metrics:

a. Monthly-mean wind speeds (Section 4.1)
b. Hourly distribution of wind speeds (Section 4.2)
c. Hourly distribution of wind direction (Section 4.3)
d. Diurnal-mean wind speeds (Section 4.4)

2 Observational Data

Approximately 16 months of data (January, 2004 to April, 2005) from a 60m meteorological tower (Tower 12111 at latitude 43.4071, longitude -111.747) at Western U.S. Wind Resource Map were used in this analysis. This tower will be referred to as the reference tower throughout this report. The data at 60m were used to assess the quality of the model simulations at 60m.

It should be noted that meteorological observations provided to 3TIER are not allowed to influence the raw model simulations.

3 Model simulations by 3TIER

3TIER has configured a mesoscale Numerical Weather Prediction (NWP) model to simulate the wind resource over the Western U.S. Wind Resource Map region. Nested 54 km, 18 km, 6 km, and 2 km grids are used to simulate the effect of local terrain and local-scale atmospheric circulations. Data from the innermost, highest resolution grid are used for this validation study. A map of the Western U.S. Wind Resource Map region is shown in Figure 1.

Based on a comparison of the NWP output with observations from Tower 12111, a linear statistical model was constructed to remove the bias of the raw NWP simulated winds.

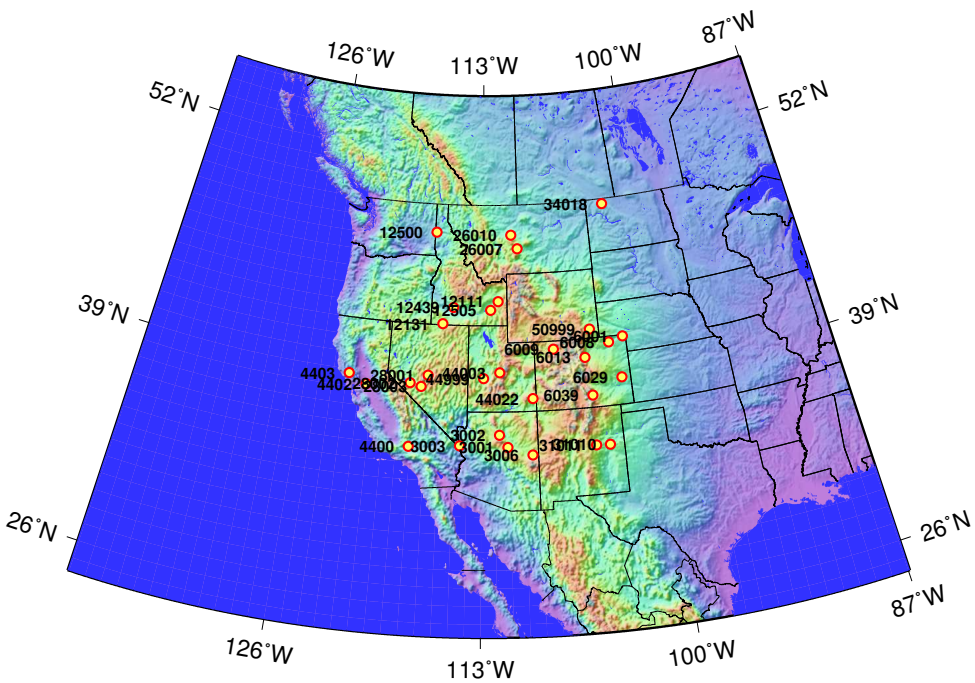

Figure 1: Towers used to validate the Western U.S. Wind Resource Map simulations are shown as yellow dots.

4 Model validation

This section presents a comparison of the simulated winds with the observations at the reference tower. The focus of the verification is on the model's ability to reproduce the observed variability of the wind resource at daily and monthly time scales, while preserving the distribution of hourly wind speeds and the diurnal characteristics of the wind.

Table 1 presents some basic statistical measures of the model performance relative to the measured winds at the reference tower during the observational period. Also shown are values (labeled 'MOS-corrected') for model data with the statistical model applied.

Table 1: Comparison of model simulations to on-site observations

Comparison	Value
Correlation of monthly-mean simulated winds to observed	0.81
RMS error of monthly-mean simulated winds	0.45 m/s
Correlation of monthly-mean MOS-corrected winds to observed	0.81
RMS error of monthly-mean MOS-corrected winds	0.55 m/s
Correlation of daily-mean simulated winds to observed	0.74
RMS error of daily-mean simulated winds	1.75 m/s
Correlation of daily-mean MOS-corrected winds to observed	0.74
RMS error of daily-mean MOS-corrected winds	1.76 m/s

4.1 Monthly-mean wind speeds

Figure 2 compares the observed and simulated monthly-mean wind speeds for each month during the period of record. Figure 2 also lists the explained variance (r^2) value of each data source relative to the monthly reference tower wind speeds. For reference, the correlation of the reference tower data to itself is perfect and hence the explained variance value is 1.0.

The observed and modeled wind speeds shown in Figure 2 represent the mean of all times during the month for which a valid wind speed observation was available. Therefore they should not be interpreted as estimates of the true monthly-mean wind speeds at the site, but rather a verification of the model's ability to reproduce the available observed wind speeds. Any month missing greater than 50% of the available observations is omitted from Figure 2. These month(s) are also not included in the monthly-mean statistics shown in Table 1 or the explained variance values displayed in Figure 2.

The average observed wind speed at the reference tower for all valid observational times during the period of record was 6.50 m/s. This compares to a modeled 60m wind speed of 6.27 m/s for these same times. The average MOS-corrected wind speed for times when observations are available is 6.10 m/s. Table 2 presents monthly-mean statistics comparing observational wind speed data to both the simulated and MOS-corrected model output.

4.2 Distribution of wind speeds

Figure 3 compares the hourly wind speed distributions for the period of record of the reference tower anemometer. Also shown in Figure 3 are the fitted Weibull distributions. The Weibull scale parameter, A, and shape parameter, k, are given in the legend. Tables 7 and 8 contain the observed and MOS-corrected values plotted in Figure 3. Distribution values binned by wind direction are also included in Tables 7 and 8.

4.3 Distribution of wind direction

Figure 4 compares the prevailing observed and simulated wind directions over the period of record. Tables 5 and 6 show the observed and simulated frequencies plotted in Figure 4. Tables 5 and 6 also contain mean wind speed values and Weibull parameters for each wind direction sector.

4.4 Diurnal-mean wind speeds

Figure 5 compares the diurnal characteristics of the observed and simulated winds over the period of record. Figure 6 presents the diurnal cycle of wind speed for each individual calendar month. Tables 3 and 4 show the diurnal cycle of observed and MOS-corrected wind speeds for each calendar month.

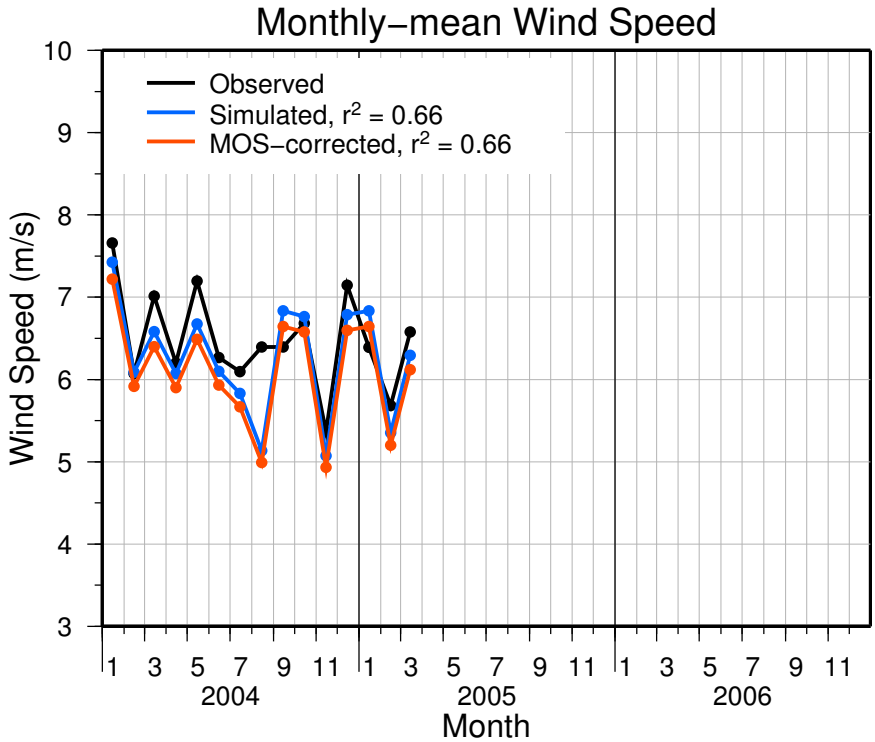

Figure 2: Time series of monthly-mean 60m wind speed at Tower 12111. Months missing greater than 50% of the available observations are not plotted. (Tabular formatted data listed in Table 2.)

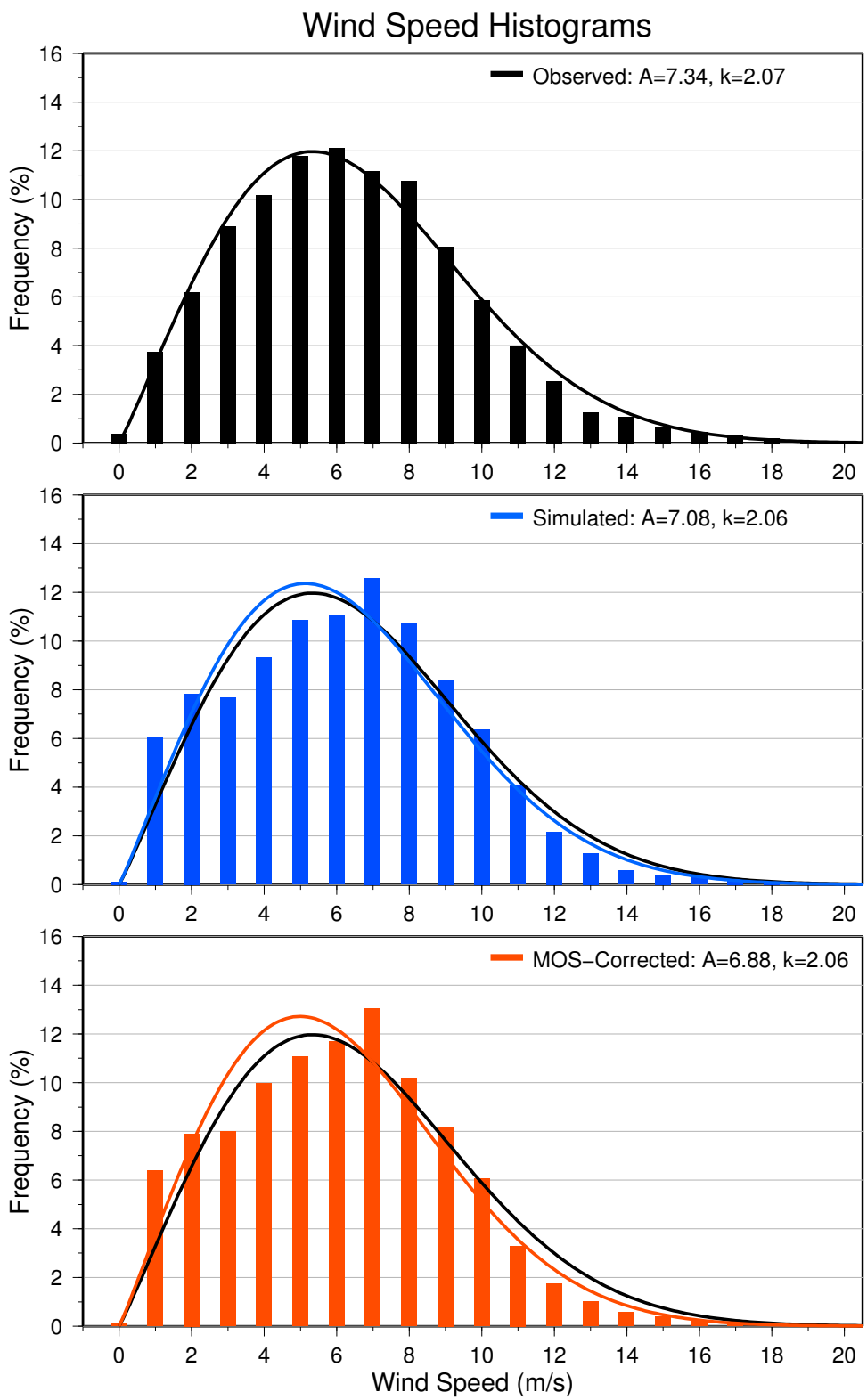

Figure 3: Hourly distributions of 60m wind speed at Tower 12111 using 1 m/s bins. (0 m/s bin contains only values $\leq$ 0.5) Fitted Weibull distributions are also displayed with the scale(A) and shape(k) parameters listed in the legend. (Tabular formatted data available in Tables 7 and 8.)

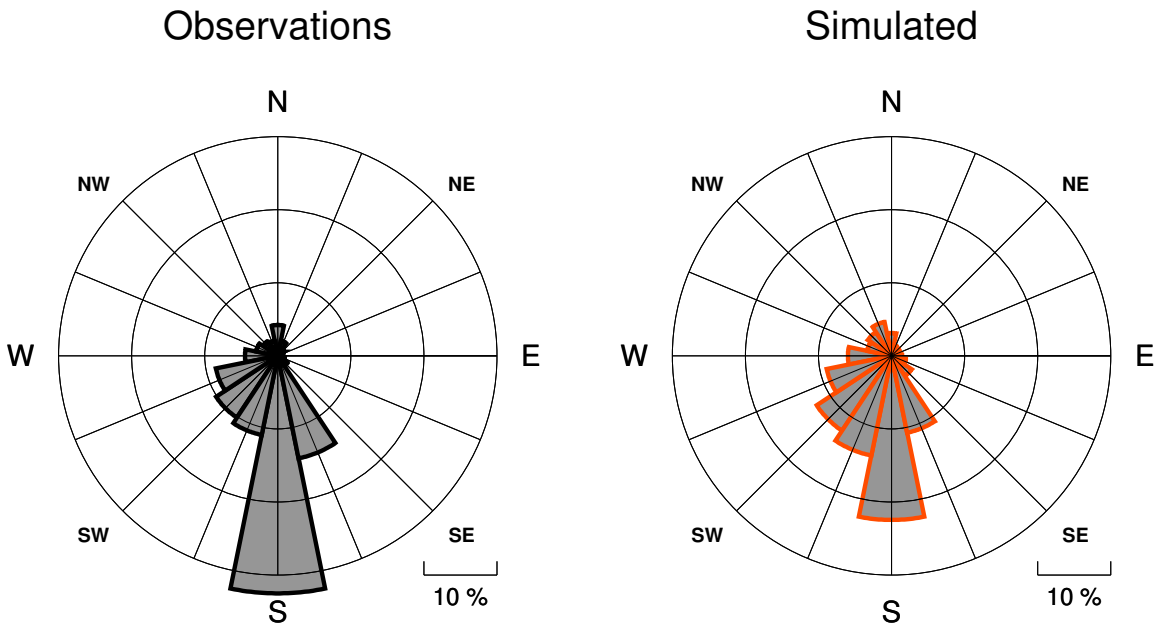

Figure 4: Wind roses at Tower 12111 for observations and simulated model output. Directional bins are 22.5° wide, and the radial contour interval is 10%. (Tabular formatted data available in Tables 5 and 6.)

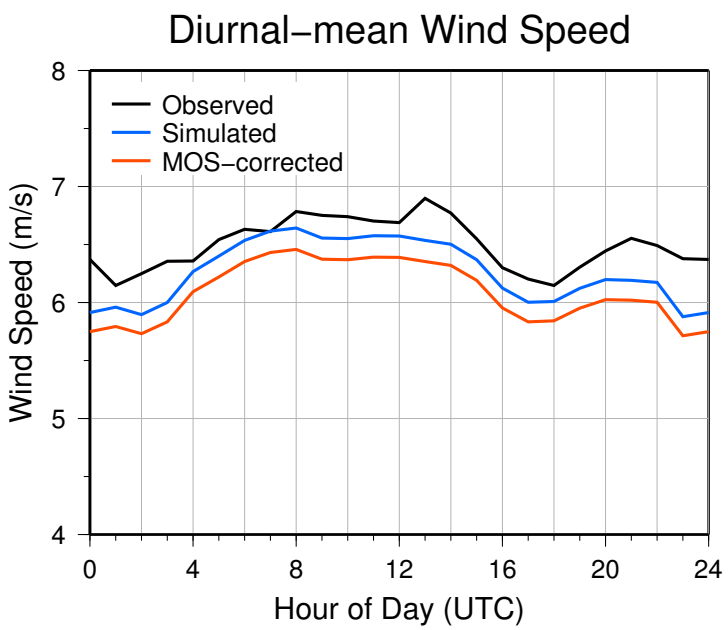

Figure 5: Diurnal cycle of 60m wind speed at Tower 12111. (Tabular formatted data available in Tables 3 and 4.)

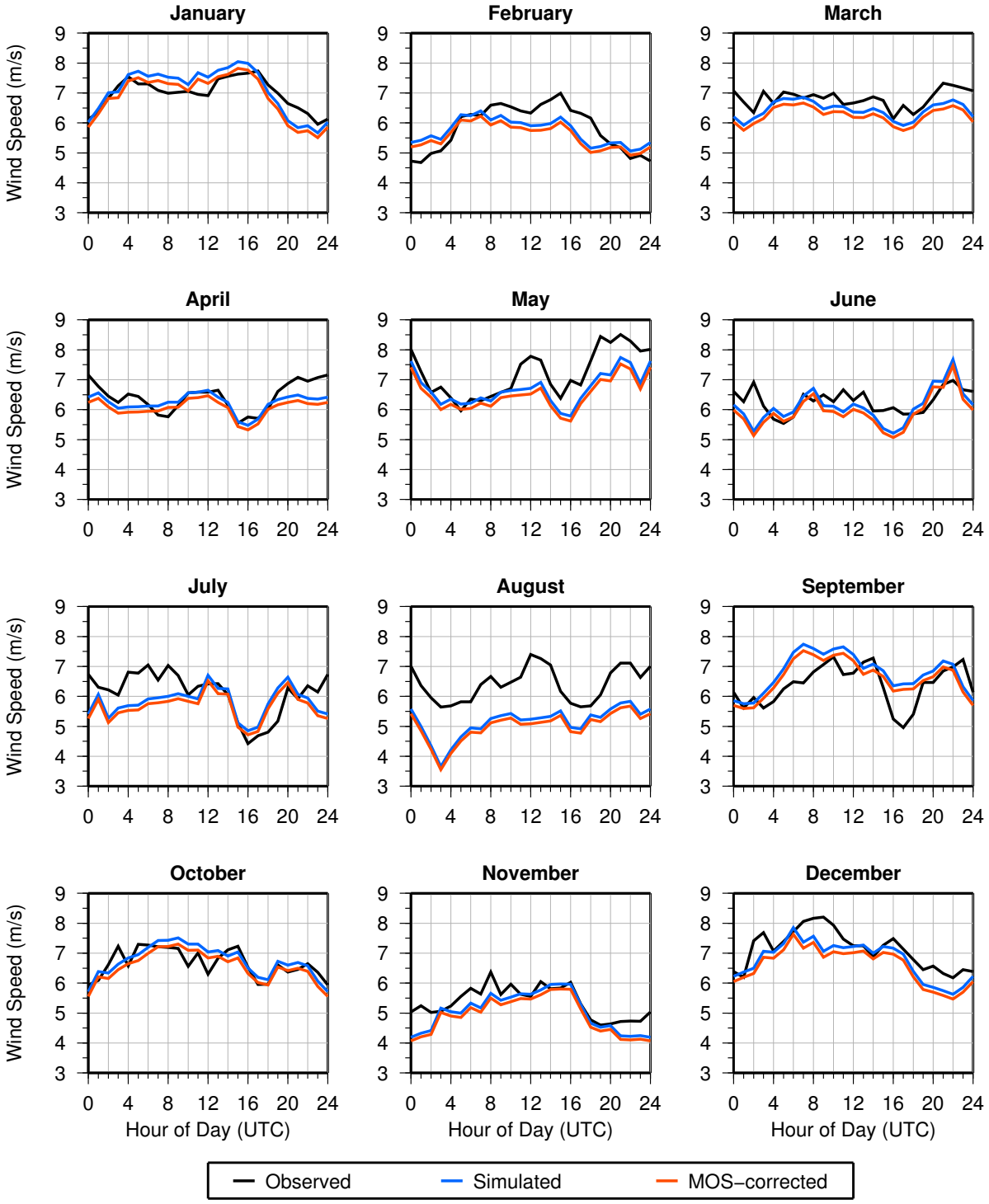

Figure 6: Diurnal cycle of observed, simulated, and MOS-corrected $60m$ wind speed for each month at Tower 12111. (Tabular formatted data available in Tables 3 and 4.)

Appendix A Tabular Formatted Data

Table 2: Monthly-mean 60m wind speeds (m/s) at Tower 12111

Month	Observed	Simulated	Bias	MOS-corrected	Data availability(%)
01/2004	7.66	7.43	-0.23	7.22	92.5
02/2004	6.07	6.09	0.01	5.92	93.7
03/2004	7.02	6.58	-0.43	6.40	98.0
04/2004	6.20	6.07	-0.13	5.90	94.6
05/2004	7.20	6.67	-0.52	6.49	95.8
06/2004	6.27	6.10	-0.16	5.93	97.8
07/2004	6.10	5.83	-0.27	5.67	98.5
08/2004	6.40	5.13	-1.26	4.99	97.7
09/2004	6.39	6.83	0.44	6.64	96.5
10/2004	6.68	6.77	0.08	6.58	98.5
11/2004	5.36	5.07	-0.29	4.93	94.4
12/2004	7.15	6.79	-0.36	6.60	93.5
01/2005	6.39	6.84	0.44	6.64	95.8
02/2005	5.69	5.35	-0.33	5.20	94.9
03/2005	6.58	6.29	-0.28	6.12	93.4
04/2005	7.47	7.06	-0.41	6.86	18.2
05/2005	–	–	–	–	0.0
06/2005	–	–	–	–	0.0
07/2005	–	–	–	–	0.0
08/2005	–	–	–	–	0.0
09/2005	–	–	–	–	0.0
10/2005	–	–	–	–	0.0
11/2005	–	–	–	–	0.0
12/2005	–	–	–	–	0.0
01/2006	–	–	–	–	0.0
02/2006	–	–	–	–	0.0
03/2006	–	–	–	–	0.0
04/2006	–	–	–	–	0.0
05/2006	–	–	–	–	0.0
06/2006	–	–	–	–	0.0
07/2006	–	–	–	–	0.0
08/2006	–	–	–	–	0.0
09/2006	–	–	–	–	0.0
10/2006	–	–	–	–	0.0
11/2006	–	–	–	–	0.0
12/2006	–	–	–	–	0.0
All	6.50	6.27	-0.22	6.10	40.4

Observed = mean of all available wind speed observations
Simulated = mean of simulated model output for times with observations
Bias = Simulated − Observed
MOS-corrected = mean of MOS-corrected output for times with observations

Observations

Hour of Day (UTC)	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Avg
0	6.13	4.72	7.07	7.16	8.02	6.61	6.74	7.01	6.14	5.94	5.03	6.38	6.37
1	6.34	4.68	6.70	6.78	7.27	6.27	6.30	6.36	5.61	6.09	5.25	6.20	6.15
2	6.82	4.98	6.34	6.45	6.58	6.92	6.22	5.95	5.97	6.62	5.02	7.42	6.25
3	7.24	5.06	7.06	6.24	6.75	6.12	6.04	5.64	5.61	7.23	5.06	7.69	6.35
4	7.54	5.42	6.66	6.52	6.39	5.68	6.81	5.68	5.82	6.58	5.24	7.07	6.36
5	7.30	6.21	7.03	6.44	5.96	5.54	6.77	5.81	6.25	7.29	5.55	7.39	6.54
6	7.31	6.28	6.96	6.17	6.35	5.75	7.05	5.82	6.49	7.27	5.83	7.72	6.63
7	7.09	6.24	6.83	5.82	6.30	6.51	6.54	6.40	6.45	7.21	5.64	8.06	6.61
8	6.99	6.59	6.94	5.76	6.44	6.29	7.04	6.66	6.81	7.19	6.37	8.16	6.78
9	7.03	6.65	6.83	6.14	6.58	6.50	6.69	6.31	7.06	7.16	5.62	8.21	6.75
10	7.06	6.53	6.99	6.56	6.71	6.27	6.05	6.48	7.32	6.56	5.96	7.93	6.74
11	6.96	6.40	6.62	6.58	7.52	6.66	6.34	6.64	6.73	7.00	5.63	7.47	6.70
12	6.92	6.33	6.66	6.59	7.78	6.31	6.42	7.40	6.78	6.30	5.55	7.25	6.69
13	7.47	6.62	6.74	6.65	7.65	6.59	6.43	7.26	7.14	6.83	6.05	7.25	6.90
14	7.56	6.78	6.87	6.15	6.85	5.95	6.06	7.05	7.28	7.11	5.81	6.88	6.77
15	7.63	6.99	6.75	5.55	6.38	5.97	5.12	6.17	6.30	7.23	5.84	7.26	6.55
16	7.66	6.42	6.13	5.75	6.98	6.06	4.42	5.77	5.24	6.53	6.02	7.49	6.30
17	7.73	6.32	6.58	5.71	6.83	5.85	4.68	5.65	4.96	5.96	5.31	7.14	6.20
18	7.27	6.16	6.28	6.02	7.63	5.86	4.81	5.68	5.41	5.96	4.78	6.78	6.15
19	6.99	5.58	6.53	6.61	8.44	5.91	5.17	6.05	6.47	6.61	4.60	6.45	6.31
20	6.65	5.30	6.93	6.87	8.24	6.33	6.28	6.79	6.47	6.37	4.64	6.57	6.44
21	6.51	5.17	7.32	7.08	8.51	6.84	5.92	7.11	6.85	6.46	4.72	6.32	6.55
22	6.31	4.81	7.25	6.95	8.29	6.97	6.36	7.11	6.98	6.65	4.73	6.18	6.49
23	5.96	4.91	7.17	7.07	7.96	6.66	6.15	6.63	7.23	6.36	4.73	6.45	6.38
Avg	7.01	5.88	6.80	6.41	7.20	6.27	6.10	6.40	6.39	6.68	5.36	7.15	6.50

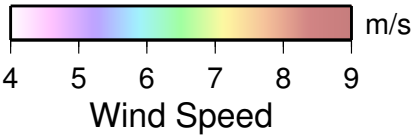

Table 3: Hourly-mean values of observed 60m wind speed at Tower 12111

MOS−Corrected

Hour of Day (UTC)	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Avg
0	5.85	5.20	6.03	6.24	7.41	5.99	5.26	5.42	5.69	5.56	4.07	6.05	5.75
1	6.30	5.27	5.76	6.37	6.71	5.69	5.89	4.85	5.59	6.21	4.21	6.19	5.79
2	6.81	5.41	5.98	6.09	6.41	5.13	5.12	4.23	5.62	6.16	4.29	6.32	5.73
3	6.84	5.30	6.15	5.88	6.00	5.58	5.45	3.55	5.93	6.45	5.02	6.87	5.83
4	7.40	5.68	6.51	5.92	6.18	5.87	5.53	4.10	6.28	6.65	4.90	6.83	6.09
5	7.51	6.10	6.62	5.92	6.01	5.61	5.55	4.51	6.73	6.75	4.86	7.11	6.22
6	7.35	6.07	6.60	5.95	6.04	5.75	5.75	4.81	7.26	6.99	5.18	7.63	6.35
7	7.42	6.22	6.67	5.95	6.22	6.28	5.79	4.78	7.52	7.22	5.03	7.16	6.43
8	7.31	5.93	6.53	6.08	6.11	6.53	5.84	5.11	7.39	7.22	5.50	7.36	6.46
9	7.29	6.07	6.28	6.08	6.40	5.96	5.92	5.20	7.20	7.30	5.27	6.87	6.37
10	7.08	5.86	6.38	6.38	6.45	5.94	5.84	5.28	7.37	7.10	5.38	7.05	6.37
11	7.46	5.84	6.37	6.40	6.49	5.76	5.75	5.07	7.44	7.10	5.48	6.98	6.39
12	7.32	5.74	6.19	6.47	6.52	6.01	6.52	5.09	7.19	6.84	5.47	7.02	6.39
13	7.54	5.76	6.18	6.24	6.72	5.89	6.09	5.13	6.74	6.89	5.61	7.07	6.35
14	7.62	5.81	6.30	6.06	6.13	5.65	6.08	5.18	6.88	6.71	5.79	6.81	6.32
15	7.82	6.02	6.17	5.44	5.71	5.22	4.97	5.36	6.66	6.84	5.80	7.02	6.19
16	7.77	5.74	5.88	5.32	5.62	5.07	4.72	4.82	6.17	6.32	5.80	6.97	5.95
17	7.47	5.31	5.75	5.52	6.20	5.25	4.83	4.78	6.24	6.02	5.14	6.77	5.83
18	6.82	5.01	5.86	6.01	6.61	5.85	5.59	5.23	6.25	5.94	4.53	6.21	5.84
19	6.46	5.07	6.19	6.16	7.01	6.03	6.11	5.15	6.53	6.54	4.40	5.79	5.95
20	5.90	5.18	6.42	6.24	6.96	6.76	6.46	5.42	6.66	6.42	4.45	5.70	6.02
21	5.68	5.19	6.46	6.31	7.53	6.74	5.90	5.62	6.99	6.50	4.12	5.58	6.02
22	5.74	4.92	6.58	6.20	7.36	7.47	5.78	5.67	6.87	6.39	4.11	5.47	6.00
23	5.51	4.98	6.43	6.17	6.69	6.34	5.36	5.26	6.14	5.89	4.13	5.70	5.71
Avg	6.93	5.56	6.26	6.06	6.49	5.93	5.67	4.99	6.64	6.58	4.93	6.60	6.10

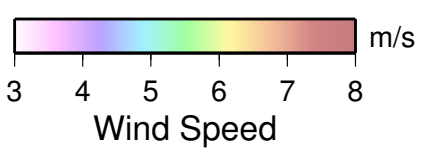

Table 4: Hourly-mean values of MOS-corrected 60m wind speed at Tower 12111. All model values are computed only for times with valid observations

Table 5: Observed 60m mean wind speed, Weibull parameters, and frequency at Tower 12111

Sector	Mean Speed(m/s)	Weibull Scale(A)	Weibull Shape(k)	Frequency(%)
N	4.57	5.11	1.66	4.22
NNE	4.66	5.21	1.61	2.07
NE	3.61	3.94	1.35	0.99
ENE	4.18	4.67	1.63	0.74
E	4.30	4.84	1.89	0.76
ESE	4.70	5.26	1.66	0.97
SE	4.90	5.48	1.69	1.65
SSE	7.34	8.26	2.62	14.31
S	7.06	7.95	2.55	32.50
SSW	5.98	6.75	2.26	11.05
SW	7.34	8.28	2.35	10.13
WSW	8.28	9.35	2.05	8.64
W	5.29	5.97	1.92	4.49
WNW	3.96	4.47	2.29	3.02
NW	3.66	4.14	2.06	2.37
NNW	3.49	3.94	2.02	2.07
ALL	6.50	7.34	2.07	100.0

Blank values correspond to times with less than 10 data points

Table 6: MOS-corrected 60m mean wind speed, Weibull parameters, and frequency at Tower 12111

Sector	Mean Speed(m/s)	Weibull Scale(A)	Weibull Shape(k)	Frequency(%)
N	5.22	5.89	2.09	3.11
NNE	4.21	4.70	1.63	1.41
NE	2.49	2.74	1.46	1.09
ENE	2.19	2.40	1.41	1.20
E	2.54	2.79	1.39	1.44
ESE	4.32	4.87	1.90	2.00
SE	4.70	5.31	2.16	3.30
SSE	7.25	8.13	2.91	10.73
S	7.05	7.90	2.99	22.45
SSW	6.60	7.45	2.19	13.91
SW	7.04	7.95	2.34	12.28
WSW	6.98	7.88	2.14	9.05
W	5.02	5.66	2.03	5.98
WNW	4.28	4.82	1.84	3.40
NW	3.77	4.26	2.02	3.90
NNW	3.69	4.17	2.23	4.73
ALL	6.10	6.88	2.06	100.0

All model values are computed only for times with valid observations
Blank values correspond to times with less than 10 data points

Table 7: Distribution of observed 60m wind speed by direction at Tower 12111

Wind Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
0 - 0.5	0.05	0.02	0.05	0.01	0.02	0.03	0.05	0.03	0.02	0.01	0.01	0.02	0.03	0.03	0.02	0.01	0.39
0.5 - 1.5	0.36	0.24	0.24	0.11	0.08	0.13	0.19	0.25	0.42	0.32	0.25	0.23	0.24	0.18	0.20	0.30	3.73
1.5 - 2.5	0.68	0.32	0.14	0.10	0.13	0.13	0.21	0.57	0.89	0.56	0.42	0.39	0.41	0.48	0.36	0.40	6.18
2.5 - 3.5	0.74	0.31	0.17	0.13	0.08	0.09	0.16	0.81	1.75	1.26	0.65	0.44	0.60	0.65	0.58	0.45	8.91
3.5 - 4.5	0.68	0.26	0.09	0.09	0.06	0.08	0.20	0.85	2.82	1.65	0.82	0.58	0.59	0.54	0.56	0.32	10.18
4.5 - 5.5	0.49	0.23	0.08	0.09	0.11	0.13	0.17	1.31	4.03	1.30	1.11	0.77	0.71	0.54	0.39	0.30	11.77
5.5 - 6.5	0.37	0.15	0.05	0.07	0.14	0.08	0.18	1.79	4.76	1.49	0.84	0.82	0.63	0.42	0.18	0.13	12.10
6.5 - 7.5	0.24	0.21	0.05	0.01	0.06	0.13	0.20	1.71	4.52	1.41	1.07	0.84	0.52	0.09	0.04	0.10	11.18
7.5 - 8.5	0.15	0.08	0.05	0.05	0.05	0.08	0.12	2.28	4.25	1.34	1.25	0.73	0.25	0.02	0.03	0.05	10.76
8.5 - 9.5	0.16	0.06	0.02	0.06	0.03	0.04	0.05	1.62	3.21	0.63	1.14	0.77	0.24	0.04	0.00	0.01	8.07
9.5 - 10.5	0.03	0.07	0.03	0.02	0.00	0.01	0.07	1.15	2.51	0.38	0.97	0.58	0.06	0.00	0.00	0.00	5.85
10.5 - 11.5	0.11	0.08	0.03	0.00	0.00	0.04	0.05	0.77	1.40	0.33	0.58	0.53	0.07	0.03	0.01	0.00	4.02
11.5 - 12.5	0.10	0.07	0.00	0.00	0.00	0.00	0.00	0.51	0.65	0.16	0.42	0.56	0.06	0.00	0.00	0.00	2.53
12.5 - 13.5	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.25	0.29	0.08	0.26	0.33	0.01	0.00	0.00	0.00	1.27
13.5 - 14.5	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.19	0.32	0.02	0.11	0.40	0.04	0.00	0.00	0.00	1.09
14.5 - 15.5	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.25	0.02	0.09	0.23	0.01	0.00	0.00	0.00	0.69
15.5 - 16.5	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.18	0.03	0.02	0.13	0.01	0.00	0.00	0.00	0.46
16.5 - 17.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.07	0.04	0.03	0.14	0.01	0.00	0.01	0.00	0.35
17.5 - 18.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.06	0.07	0.00	0.00	0.00	0.00	0.22
18.5 - 19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.01	0.00	0.04	0.01	0.00	0.00	0.00	0.09
19.5 - 20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03
20.5 - 21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.08
21.5 - 22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
22.5 - 23.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01
23.5 - 24.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
> 24.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.03

Table 8: Distribution of MOS-corrected 60m wind speed by direction at Tower 12111

Wind Speed (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	All
0 - 0.5	0.01	0.02	0.00	0.01	0.02	0.01	0.01	0.00	0.03	0.00	0.00	0.01	0.03	0.00	0.00	0.00	0.14
0.5 - 1.5	0.22	0.20	0.42	0.61	0.56	0.27	0.29	0.26	0.33	0.54	0.56	0.49	0.49	0.38	0.39	0.37	6.37
1.5 - 2.5	0.33	0.29	0.31	0.20	0.32	0.26	0.42	0.35	0.65	0.75	0.77	0.60	0.56	0.40	0.73	0.95	7.90
2.5 - 3.5	0.38	0.22	0.12	0.13	0.16	0.23	0.33	0.55	0.84	0.94	0.59	0.40	0.53	0.63	0.86	1.09	7.99
3.5 - 4.5	0.42	0.11	0.09	0.09	0.19	0.30	0.62	0.67	1.33	1.35	0.79	0.75	0.94	0.65	0.73	0.92	9.97
4.5 - 5.5	0.36	0.11	0.07	0.09	0.08	0.30	0.32	0.95	2.34	1.66	1.07	0.74	1.01	0.59	0.55	0.80	11.06
5.5 - 6.5	0.36	0.13	0.01	0.02	0.06	0.23	0.41	1.30	3.56	1.85	1.24	0.83	0.88	0.29	0.28	0.24	11.69
6.5 - 7.5	0.41	0.15	0.03	0.02	0.01	0.22	0.52	1.38	4.23	2.02	1.60	1.23	0.70	0.18	0.19	0.16	13.05
7.5 - 8.5	0.23	0.08	0.01	0.02	0.01	0.08	0.22	1.30	3.37	1.39	1.40	1.33	0.40	0.08	0.10	0.15	10.17
8.5 - 9.5	0.21	0.04	0.02	0.00	0.03	0.05	0.11	1.54	2.25	1.17	1.71	0.74	0.17	0.06	0.04	0.03	8.15
9.5 - 10.5	0.09	0.05	0.00	0.00	0.00	0.05	0.04	1.22	1.85	0.89	1.07	0.58	0.13	0.06	0.02	0.01	6.04
10.5 - 11.5	0.07	0.01	0.01	0.00	0.00	0.00	0.00	0.74	0.86	0.48	0.59	0.46	0.04	0.02	0.02	0.01	3.30
11.5 - 12.5	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.29	0.30	0.26	0.41	0.38	0.06	0.02	0.00	0.00	1.74
12.5 - 13.5	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.21	0.23	0.20	0.17	0.02	0.02	0.00	0.00	1.02
13.5 - 14.5	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.16	0.16	0.09	0.08	0.03	0.00	0.01	0.00	0.57
14.5 - 15.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.09	0.10	0.11	0.00	0.01	0.00	0.00	0.39
15.5 - 16.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.02	0.09	0.00	0.02	0.00	0.00	0.25
16.5 - 17.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.04	0.02	0.00	0.00	0.00	0.00	0.10
17.5 - 18.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.06
18.5 - 19.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02
19.5 - 20.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20.5 - 21.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.5 - 22.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
22.5 - 23.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23.5 - 24.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
> 24.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01

All model values are computed only for times with valid observations