


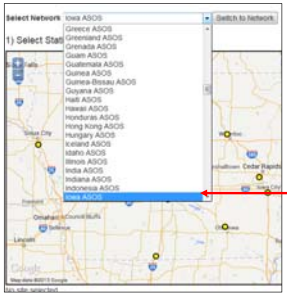
Wind Data

Wind Power Management



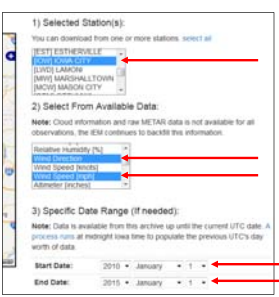
THE UNIVERSITY OF IOWA

Finding Historical Wind Data




- Go to: <http://mesonet.agron.iastate.edu/request/download.phtml>
- Select the location of the automated surface observing system (ASOS) you are interested in

Finding Historical Wind Data



- Select the station or city you are interested in
- Select the weather data you are interested in (hold alt while clicking to select multiple parameters)
- Select the date range you want data for (choose several years if you want to capture the inter-annual wind patterns)

Finding Historical Wind Data



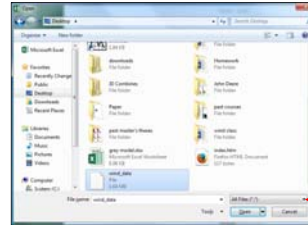
- Select a time zone (the default UTC time is fine for most applications)
- Select the file format (Microsoft Excel can open both tab and comma delimited files)
- If using a GIS software such as Openwind, include latitude and longitude. We don't need it today.
- Get data

Finding Historical Wind Data

```
#DEB00: Format Typ --> tdf
#DEB00: Time Period --> 2010-01-01 00:00:00+00
#DEB00: Time Zone --> EST/UTC
#DEB00: Data Contact --> Daryl Herrmann akzhne
#DEB00: Station Found --> 54151
station valid dnet speed
TOW 2010-01-01 00:15Z 310.00 13.7
TOW 2010-01-01 01:15Z 310.00 14.9
TOW 2010-01-01 02:15Z 310.00 11.4
TOW 2010-01-01 03:15Z 320.00 11.4
TOW 2010-01-01 04:15Z 310.00 10.3
TOW 2010-01-01 05:15Z 300.00 8.0
TOW 2010-01-01 06:15Z 300.00 10.3
TOW 2010-01-01 07:15Z 300.00 8.0
TOW 2010-01-01 08:15Z 320.00 10.3
TOW 2010-01-01 09:15Z 310.00 8.7
TOW 2010-01-01 10:15Z 310.00 9.1
TOW 2010-01-01 11:15Z 310.00 8.7
TOW 2010-01-01 12:15Z 310.00 8.6
TOW 2010-01-01 13:15Z 310.00 8.0
TOW 2010-01-01 14:15Z 310.00 8.1
TOW 2010-01-01 15:15Z 310.3 10.3
TOW 2010-01-01 16:15Z 310.3 10.3
TOW 2010-01-01 17:15Z 310.3 10.3
TOW 2010-01-01 18:15Z 310.3 10.3
TOW 2010-01-01 19:15Z 310.3 11.4
TOW 2010-01-01 20:15Z 310.00 8.0
```

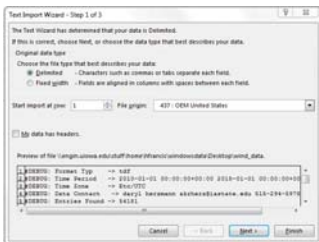
- Right click anywhere on the page and select "Save Page As..."
- Save as .txt file
- Select file name and location
- Select "Save"

Wind Distribution in Excel



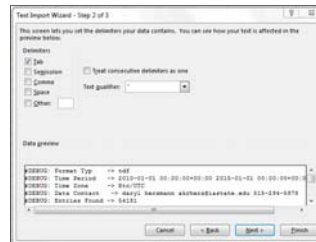
- Open Microsoft Excel
- Select "File" -> "Open"
- Change file type to "All Files"
- Locate the saved file and select "Open"

Wind Distribution in Excel



- Verify that "Delimited" is selected
- Click "Next"

Wind Distribution in Excel



- Verify that the correct delimiter is selected. If "Tab Delimited" data was obtained from the Mesonet website, select "Tab"
- Click "Finish"

Wind Distribution in Excel

	A	B	C	D	E
2	drct	sped			
3	310	13.7			
4	310	14.8			
5	310	11.4			
6	320	11.4			
7	310	10.3			
8	300	8			
9	300	10.3			
10	300	8			
11	310	10.3			
12	290	5.7			
13	0	0			
14	310	9.1			
15	310	5.7			
16	290	4.6			

- The first five rows of data contain header information and are not needed. Highlight the first five rows, right click, and select delete.

Wind Distribution in Excel

	A	B	C	D	E	F	G
3	station	valid	drct	sped			
4	KOW	1/1/2010 1:52	310	13.7	0.44704		
5	KOW	1/1/2010 1:52	310	14.8			
6	KOW	1/1/2010 2:52	310	11.4			
7	KOW	1/1/2010 3:52	310	11.4			
8	KOW	1/1/2010 4:52	310	10.3			
9	KOW	1/1/2010 5:52	300	8			
10	KOW	1/1/2010 6:52	300	10.3			

- Real data often contains errors
- Go to the "DATA" tab and select "Filter" to see all values in each column
- The "sped" column contains several errors including values of 165.3 mph
- The value "M" is likely a default error output for the anemometer
- "M" occurs in both the direction and speed columns

Wind Distribution in Excel

	A	B	C	D	E
34	1010 7:52 M	3.4			
35	1010 19:52 M	3.4			
36	1010 1:52 M	5.7			
37	1010 19:52 M	4.6			
38	1010 5:52 M	6.8			
39	1010 19:52 M	5.7			
40	1010 7:52 M	3.4			
41	1010 14:52 M	4.6			
42	1010 18:45 M	4.6			
43	1010 19:52 M	4.6			
44	1010 15:52 M	3.4			
45	1010 7:52 M	3.4			
46	1010 20:52 M	5.7			
47	1010 15:27 M	3.4			
48	1010 17:52 M	5.7			
49	1010 12:52 M	3.4			
50	KOW 4/19/2010 17:52 M	4.6			
51	KOW 4/20/2010 15:52 M	3.4			

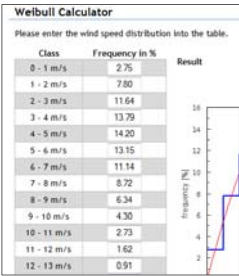
- Use the "Filter" feature to select only values of "M" in column "drct"
- Highlight all rows containing "M"
- Right click and select "Delete Row"
- Use the "Filter" feature to show all values
- Repeat the process for column "sped"
- The remaining data should no longer contain speed or direction values of "M"

Wind Distribution in Excel

	A	B	C	D	E	F
1	station	valid	drct	sped	speed (m/s)	
2	IOW	1/1/2010 0:52	310	13.7	=0.44704	
3	IOW	1/1/2010 1:52	310	14.8		
4	IOW	1/1/2010 2:52	310	11.4		
5	IOW	1/1/2010 3:52	310	11.4		
6	IOW	1/1/2010 4:52	310	10.3		
7	IOW	1/1/2010 5:52	300	8		
8	IOW	1/1/2010 6:52	300	10.3		

- The data was collected hourly over a five year period
- Let's create a histogram of the data
- First, convert the wind speed from mph to m/s using a conversion factor of 0.44704
- Double click the green square to compute the conversion for all rows

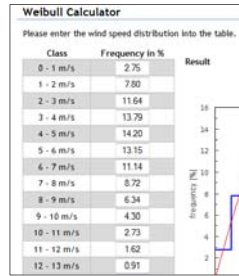
Wind Distribution in Excel



- The Weibull calculator requires frequency in bins of 1 m/s at:
- Use excel to determine the inter-annual frequency for each wind speed range

<http://www.wind-data.ch/tools/weibull.php?lng=en>

Wind Distribution in Excel



- The Weibull calculator requires frequency in bins of 1 m/s at:
- Use excel to determine the inter-annual frequency for each wind speed range

Wind Distribution in Excel

D	E	F	G	H	I	J	K	L	M	N
speed	speed (m/s)				Class	Hours				
11.7	6.124448				0-1	=COUNTIF(E2:E52970,">=0")-COUNTIF(E2:E52970,">1")				
14.8	6.618192				1-2					
11.4	5.096256				2-3					
11.4	5.096256				3-4					
10.3	4.804512				4-5					
8	3.57832				5-6					

- To accomplish this, use the COUNTIF function
- For a value between 0 and 1, use the following formula:
=COUNTIF(E2:E52970,">=0")-COUNTIF(E2:E52970,">1")

Wind Distribution in Excel

Note: in case of a cell reference, you have to enclose the operator in quotes and add an ampersand (&) before the cell reference. For example, to count cells in the range D2:D9 with values greater than a value in cell D3, you use this formula =COUNTIF(D2:D9,">"&D3):

=COUNTIF(D2:D9,">"&D3)

- It is possible to save time by using cell references instead of actual numerical values
- If done this way, you can write the equation once and let excel autofill the remaining equations

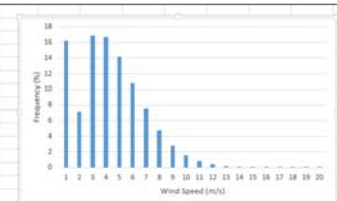
Wind Distribution in Excel

Class	Hours	Frequency
0-1	8596	$= (F523) * 100$
1-2	3779	
2-3	8921	
3-4	8836	
4-5	7507	
5-6	5733	
6-7	3956	
7-8	2493	
8-9	1497	
9-10	813	
10-11	455	
11-12	214	
12-13	100	
13-14	34	
14-15	18	
15-16	5	
16-17	11	
17-18	2	
18-19	1	
19-20	1	
total	52966	

- To determine the frequency, divide the hours for each bin by the total hours and multiply by 100
- Double click the green square to autofill the rest of the values
- "\$J\$23" keeps the total hours (denominator) constant while the numerator changes for each bin

Wind Distribution in Excel

Class	Hours	Frequency
0-1	8596	16.217551
1-2	3779	7.1347657
2-3	8921	16.84288
3-4	8836	16.6824
4-5	7507	14.175243
5-6	5733	10.823925
6-7	3956	7.4689423
7-8	2493	4.706793
8-9	1497	2.8263414
9-10	813	1.5349469
10-11	455	0.8590416
11-12	214	0.4040328
12-13	100	0.1888004
13-14	34	0.0641921
14-15	18	0.0339841
15-16	5	0.00944
16-17	11	0.020768
17-18	2	0.003776
18-19	1	0.001888
19-20	1	0.001888
total	52966	100

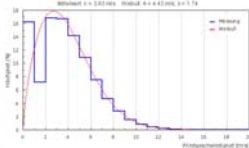


Wind Distribution Online

Wind Distribution Online

Please enter the wind speed distribution into the table.

Class	Frequency %
0 - 1 m/s	16.21
1 - 2 m/s	7.13
2 - 3 m/s	16.84
3 - 4 m/s	16.68
4 - 5 m/s	14.17
5 - 6 m/s	10.82
6 - 7 m/s	7.47
7 - 8 m/s	4.71
8 - 9 m/s	2.83
9 - 10 m/s	1.53
10 - 11 m/s	0.86
11 - 12 m/s	0.40
12 - 13 m/s	0.19
13 - 14 m/s	0.06
14 - 15 m/s	0.03
15 - 16 m/s	0.01
16 - 17 m/s	0.02
17 - 18 m/s	0.00
18 - 19 m/s	0.00
19 - 20 m/s	0.00
Sum	98.87



Note: You may get slightly different values depending on which outliers were removed.

Shape Parameter = 1.74
 Scale Parameter = 4.43
 Mean Wind Speed = 3.83 m/s

<http://www.wind-data.ch/tools/weibull.php?lng=en>

Weibull Energy Calculator

Power Calculator

Wind speed distribution

Either you can estimate the weibull distribution for your site with the weibull calculator or the power calculator approximates a distribution for the mean wind speed that is entered.

weibull parameters: $k = 4.43$ m/s $\alpha = 1.74$

Mean wind speed: $v = 3.83$ m/s

Air Density: You can calculate the air density for your site with the air density calculator.

Power curve

Choose a turbine type from the list or choose "user-defined power curve" and enter your own power curve in the table.

WE Wind Energy (2) 12.50 (1000 kWh)

Wind Speed (m/s)	Power (kW)
1 m/s	0
2 m/s	0
3 m/s	0
4 m/s	11
5 m/s	77
6 m/s	104
7 m/s	244
8 m/s	528
9 m/s	978
10 m/s	1620
11 m/s	2444
12 m/s	3460
13 m/s	4688
14 m/s	6128
15 m/s	7880
16 m/s	9944
17 m/s	12320
18 m/s	15008
19 m/s	18000
20 m/s	21304

WE Wind Energy (2) 12.50 (1000 kWh)

Power curve

→ Wind speed distribution
 → power production
 → power curve

Calculate production

<http://www.wind-data.ch/tools/powercalc.php?lng=en>

Excel Energy Calculators

- An energy estimation can also be made in Excel without fitting the data to a Weibull distribution
- Multiply the frequency at each wind speed by the power produced by a specific turbine at each wind speed by the number of hours in a year
- Sum the total energy at each wind speed to estimate the power produced by a turbine at a location per year
- The estimation will likely be different than the Weibull curve estimation



Excel Power Calculator

Class	Hours	Frequency	GE 1.5-70 Wind Turbine		
			Wind Speed	Power	Energy
0-1	8590	16.217951	0-1	0	0
1-2	3779	7.1347657	1-2	0	0
2-3	8921	16.84288	2-3	0	0
3-4	8826	16.6524	3-4	11	16083.82
4-5	7507	14.171243	4-5	77	95664.77
5-6	5733	10.823925	5-6	194	184068.1
6-7	3956	7.4689423	6-7	344	225221.4
7-8	2493	4.706793	7-8	528	217846.7
8-9	1497	2.8263414	8-9	774	191759.8
9-10	813	1.5349469	9-10	1079	145180
10-11	455	0.8590416	10-11	1342	101055.2
11-12	214	0.4040328	11-12	1460	51708.45
12-13	100	0.1888004	12-13	1494	24725.52
13-14	34	0.0641921	13-14	1500	8440.439
14-15	18	0.0339841	14-15	1500	4468.468
15-16	5	0.00994	15-16	1500	1241.241
16-17	11	0.020768	16-17	1500	2730.73
17-18	2	0.003776	17-18	1500	496.4964
18-19	1	0.001888	18-19	1500	248.2482
19-20	1	0.001888	19-20	1500	248.2482
total	52966	100			1271190 kWh/year

Note: You may get slightly different values depending on which outliers were removed.