Final Report
Award Number: DE-EE0002517

Wind Energy Resource Assessment on Alaska Native Lands in Cordova Region of Prince William Sound

Prepared by John C. Whissel and Matt J. Piche
Native Village of Eyak

Executive Summary: The Native Village of Eyak (NVE) has been monitoring wind resources around Cordova, Alaska to determine whether there is a role for wind energy to play in the city's energy scheme, which is now supplied entirely by two run-of-the-river hydro plants and a set of three diesel generators. Hydro-power is seasonally abundant in Cordova with a drastic decline in availability during winter months and/or dry periods. Fortunately, during winter months when hydro-power is reduced, Cordova's wind resources increase, suggesting wind is perhaps an ideal counterpart to round out Cordova's renewable energy portfolio. Wind alone cannot supply Cordova's energy; however, the development of a holistic energy scheme with wind as one of several components may provide the stability needed to eliminate Cordova's dependence upon diesel fuel for power generation. The result of this four year monitoring and planning effort suggests that this is the case, wind resources are abundant in Cordova during winter months (Appendix A, Appendix B); however, obstacles were identified in this study that would need to be addressed in order to develop the wind resource such as grid integration and the high cost of road and transmission line development to remote areas. These wind data are reported in Appendices A and B.

Background: The cost of energy in Cordova is a burden to our tribal members and non-native community members alike. During summer months' electricity costs are generally double the rates in Anchorage, and five times greater in the winter months as streams freeze up and hydroelectric generation is reduced. Home heating oil and transportation fuel costs are substantially more expensive because the products must be barged in.

At the same time, the Cordova region is blessed with many natural sources of energy, including hydroelectric, wind, biomass, fish waste and tidal energy. The Native Village of Eyak's (NVE) Department of the Environment and Natural Resources (DENR) is working with other community organizations to harness more of these locally available resources in order to offset the fossil fuels now being used to meet energy demand, without additional environmental degradation. Achieving this goal will allow residents of Cordova to meet their energy needs at a lower cost, and with a reduced environmental impact, and move our community toward sustainability and self-sufficiency.

Toward this end, DENR is assessing local wind resources, which seasonally increase as hydroelectric resources decrease. Data collected at 26.5 meters above ground level indicates Class 4 wind resources at Camp Hill with Class 4-5 winds during the winter months when hydroelectric power resources are at a minimum and diesel power is at a maximum. Wind resource maps indicate additional potential Class 4 to 5 sites between Camp Hill and the current power grid terminus although current wind maps are calculated using mesoscale terrain models based on wind data from the airport and harbor meteorological sites. As such, the portable anemometer wind energy program will validate the current wind resource maps by correlating 10-meter data at Class 4 and 5 sites on the maps with known 10.7 and 26.5-meter data from the met tower at Camp Hill along with 1 50 meter towers that will be constructed. Current 26.5-meter data indicates turbulence of 0.2, which may affect which models of turbines are suitable for the Camp Hill location. Part of the grid intertie analysis will be to determine

what percentage of the total power demand can be accepted onto the grid given seasonally varying wind speeds and power demand.

While more assessment is still needed prior to development, several sites have been identified as having developable resources. The most ideal of these sites will be discussed below, as well as the obstacles to their development:

27 mile: This site has the most wind resource but lies 14 miles past the end of the current transmission lines. The site is characterized by heavy airborne silt loads and extreme cold not found in the rest of the monitoring area.

Meals Reservoir: This site has excellent resources, and many areas are owned by cooperative entities, however its proximity to the City Airport will present challenges and require a variance to develop.

Pt. Whitshed/Camp Hill: Lies will past transmission lines, and crosses several anadramous streams. Transmission lines will eventually reach the area, at which point development will be more reasonable, however it is not certain at this point whether development should await the installation of lines to serve the subdivision, or development of wind resources should drive the laying of these transmission lines.

Other areas may be viable as well, but not yet measured. Using the equipment purchased from this grant NVE will continue to monitor several sites, and deploy anemometers to other potential sites.

Conclusions and Recommendations: In order to determine our next steps toward developing wind resources, we have applied for Technical Assistance funding from the START program, among others. These funds will be utilized to create an analysis of any data gaps that need to be filled, and evaluate these data to develop a strategy to pursue developing wind energy. We are very encouraged by these results and look forward to using them to move Cordova away from diesel fuel use to generate electricity.

Lessons Learned: This project has been one of the Tribe's most prized and important, it has suffered from staffing turnover and instabilities that came along with that. An error made at the onset of this project was to use it to fund a discreet position that would work toward developing this resource. What occurred was a stream of people who used the position as a stepping stone to other opportunities. Were we to do this again, the workload would be carried out by the department's existing project managers and their technicians. Any positions hired would be short-term and seasonal, as that represents the nature of the work. The larger tower erections would be handled by contractors better equipped for such tasks until some institutional experience had been gained. Further, the various managers of this project lacked a cohesive vision, which caused the work to drift in different directions at different points. Despite these challenges, the outcome has been very positive and we have good evidence that wind energy is a good fit for Cordova's electrical grid.

Assessment of original project objectives vs. actual accomplishments

- Complete the Camp Hill wind farm project design and permits
    - Wind modeling was conducted for the camp hill site using NREL'a HOMER optimization modeling software. Initial models are using between 100-700 kW of wind energy. With 990kW of wind energy capacity diesel consumption is decreased by 146,132 gallons. When this is coupled with a 1,500 kWh battery storage system diesel consumption is decreased by 299,605 gallons. The wind/battery system also allows for 1,155,030 kWh/yr from being wasted by storing this energy in the battery system.

    - Avian surveys were conducted at Pt. Whitshed (Camp Hill site) during the spring of 2011 details from this survey are located in appendix C. In summary it was determined that a wind generator may need to be shut down from 7-20 days per year during peak bird migration.
    - Currently there is still no road to the camp hill site, roughly 5 miles of road and transmission lines would need to be built in order to transport turbines, blades and cranes to the site. Estimated cost for road installation in 2012 was nearly 1 million dollars per mile, adding considerable cost to the project. Planning is underway to potentially develop a road allowing access to several private lots, if this road project occurs wind development would be much more feasible.
    - Perhaps the most significant limiting factor for development of the camp hill wind project is grid integration. Options for penetration into the power system are limited. The current power grid would allow 200 – 300kW of wind energy to be utilized in the system. Considering the average winter load of 4500 kW, 200 kW – 300kW would save 21,000 – 32,000 gallons of diesel with an annual savings of 100-160k in offset diesel.
- Improve wind data maps through a mobile 10-meter anemometer tower project
    - Initially NVE proposed to monitor wind speed and wind direction extensively at 15 sites for short periods of time (3 months) with mobile 10 meter MET towers. This methodology shifted early in the project to better suit the project goal of improving local wind maps. Instead of an extensive dataset with limited monitoring at each site we shifted to monitoring four sites intensively through a multi-year effort. Using one mobile 10-meter tower and mounting NRG data loggers to existing tower infrastructure we obtained wind speed and wind direction data in an effort to improve the accuracy of our local wind map. This objective was accomplished and data analysis is presented in appendix A. FAA permits were obtained for each tower location.
- Initiate a wind farm pilot project and a marine-based pilot project
    - This objective was deemed unfeasible with the amount of funding provided given the issues identified during the camp hill design assessment.
- Drive community involvement and education
    - NVE successfully established the workgroup known as the CREW or Cordova Renewable Energy Workgroup. CREW provided an excellent forum to disseminate information, establish relationships between invested parties such as NVE and Cordova Electric Company, while engaging the community in open discussion regarding the potential for renewable energy in Cordova along with obstacles.
- Adopt best-known methods from other successful wind projects.
    - A thorough review of current literature as well as a site visit to Kodiak by Alternative Energy Coordinator Casey Paper were conducted.
- Determine whether the wind farm will be built and operated by Native Village of Eyak or Cordova Electric Co-Op.
    - This objective was not addressed given the issues identified with the camp hill wind site.
- Set the stage for construction and implementation. The project will provide low-cost electricity for all members of the Cordova Electric Co-Operative power grid
    - Alternative sites in the Cordova area should be explored for wind farm development. If a road is installed to near the camp hill site a thorough feasibility and cost assessment review should be conducted.

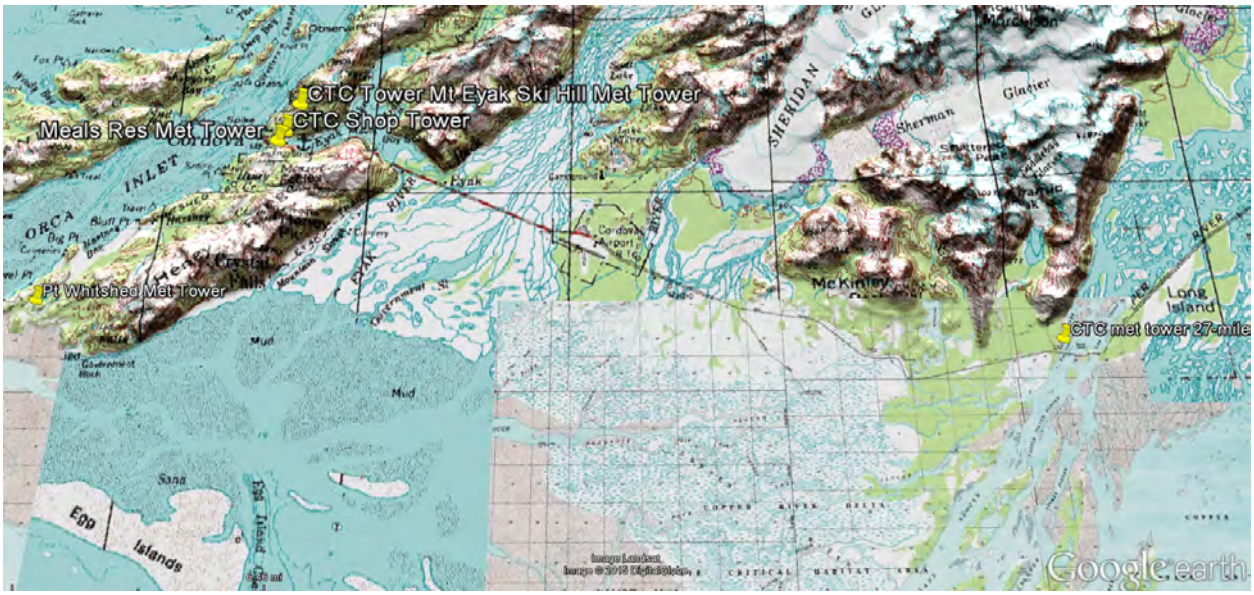
Appendix A. Cordova 10-m MET tower analysis & wind resource assessment

Rich Stromberg
Alaska Energy Authority, Alternative Energy and Energy Efficiency Group

OVERVIEW

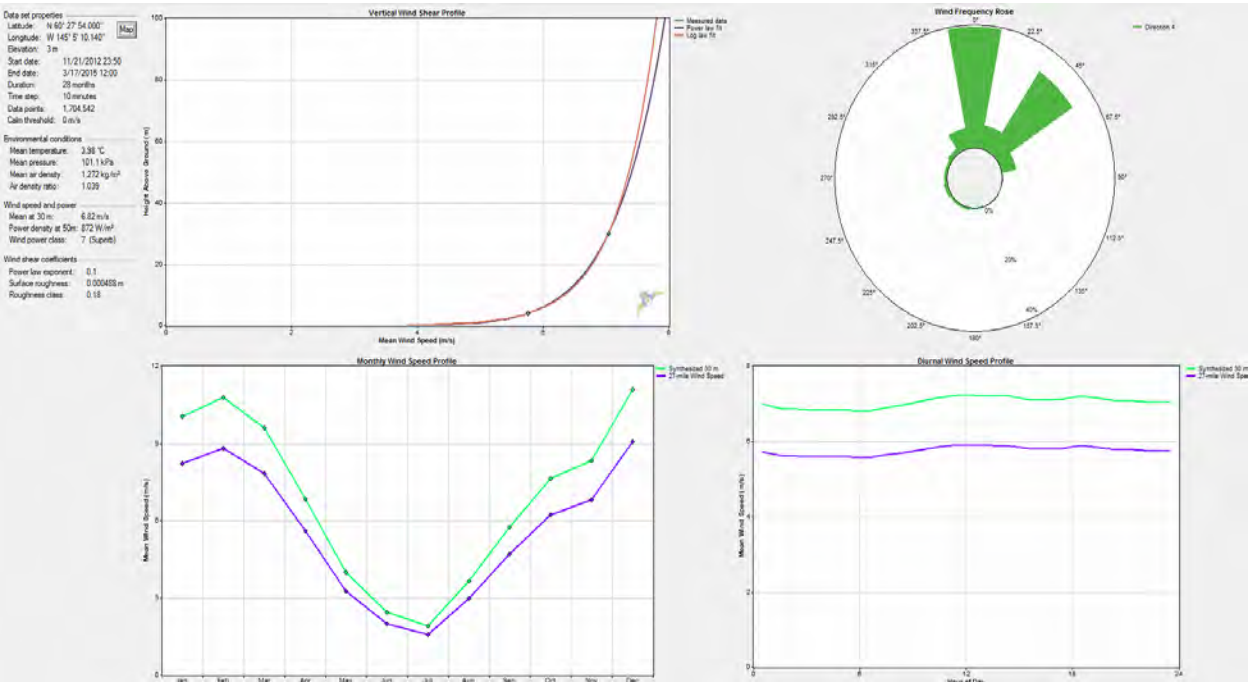
NVE deployed an array of small met towers at sites around the Cordova region to better quantify potential wind energy development sites. The purpose of the array of 10-meter met towers was to better validate the wind resource map for the region and identify locations closer to the existing power grid that might be suitable for development. Met towers have been placed above the surrounding vegetation at the east end of the Copper River Hwy (27-mile), the Cordova Telephone Company Shop in town, a hill overlooking Meals Reservoir just south of town and at the top of the Mt. Eyak Ski Hill.

To estimate wind speeds at higher levels above ground, a conservative power law exponent of 0.1 was assumed. Temperature data from the Cordova airport was appended to each data set to calculate air density.



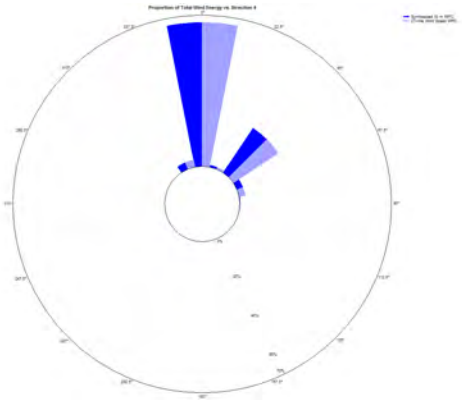
DATA SUMMARY – 27-MILE

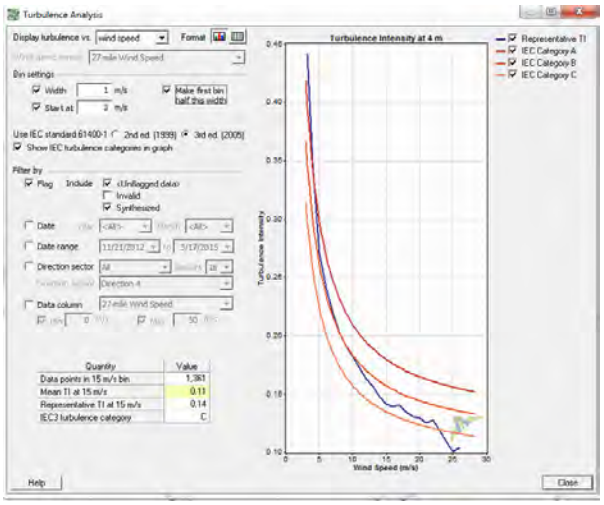
27-Mile Met Tower Native Village of Eyak Application/Grant #		
Average Wind Speed @ 30 m:	6.825	m/s
Average Power Density @ 50 m:	872	W/m^2
Average Power Density @ 30 m:	748	W/m^2
Air Density:	1.039	kg/m^3
Weibull k:	0.91	
Shear Factor:	Unk	
Roughness Class:		
Turbulence Intensity @ 15 m/s:	0.140	
IEC Turbine Class:	II-B	
Wind Class @ 30 m:	7	
Associated CF:	36.2%	
Predicted CF:	30.0%	



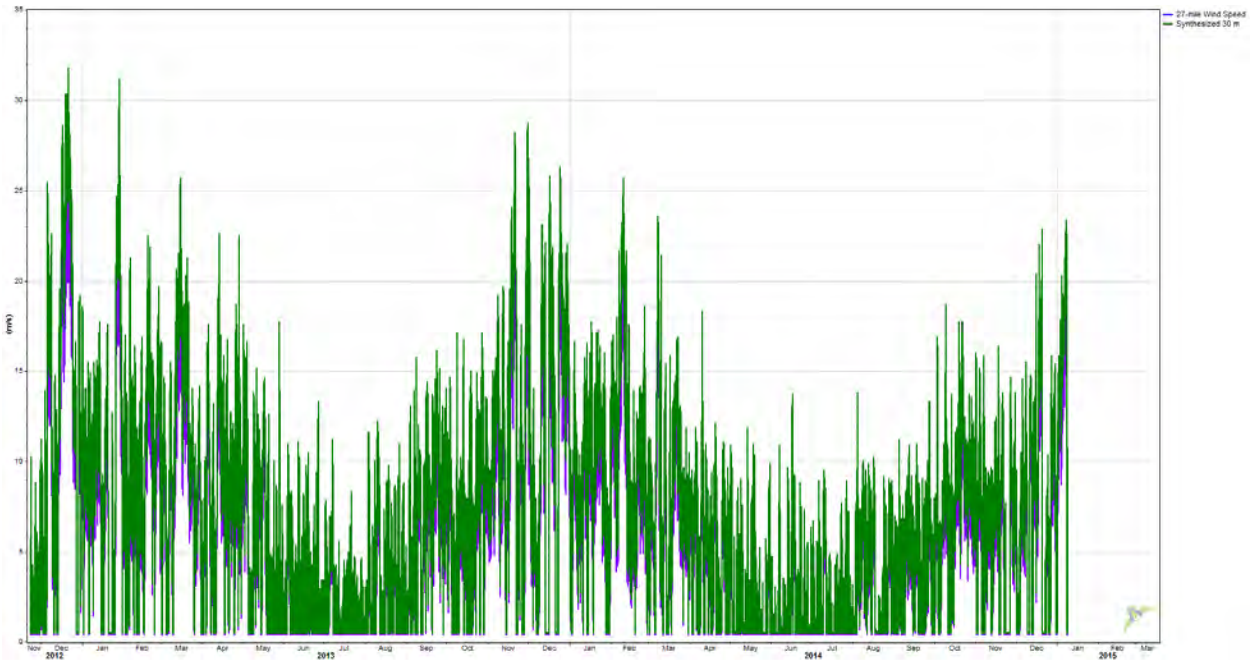
Variable	Synthesized 50 m	Synthesized 30 m	27-mile Wind Speed
Measurement height (m)	50	30	4
Mean wind speed (m/s)	7.408	7.043	5.756
MoMM wind speed (m/s)	7.182	6.825	5.579
Median wind speed (m/s)	6.694	6.361	5.200
Min wind speed (m/s)	0.515	0.489	0.400
Max wind speed (m/s)	33.471	31.804	26.000
Weibull k	0.907	0.907	0.907
Weibull c (m/s)	7.088	6.735	5.506
Mean power density (W/m²)	959	822	449
MoMM power density (W/m²)	872	748	409
Mean energy content (kWh/m²/yr)	8,397	7,204	3,936
MoMM energy content (kWh/m²/yr)	7,641	6,556	3,582
Energy pattern factor	3.616	3.610	3.613
Frequency of calms (%)	0.00	0.00	0.00
Possible data points	121,753	121,753	121,753
Valid data points	111,838	111,838	111,838
Missing data points	9,915	9,915	9,915
Data recovery rate (%)	91.86	91.86	91.86

This installation consists of a large lattice communications tower owned by Cordova Telephone Company. The instruments are up high enough to be above the surrounding vegetation while being below the communication dishes that could create excessive turbulence. Winds are strong at a mean 50-meter wind power density of 872 watts per square meter. 50-m annual average wind speed of 7.182 m/s places this site toward the upper edge of IEC turbine class III. Since a modest wind shear value of 0.1 was assumed in the extrapolation, the more stringent turbine class II will be assumed. A Weibull K of 0.907 versus a more normal 2.0 is unexpected for such a strong wind regime and is driven by very low summer winds. Average winds are robust at 6.8 meters per second estimated for 30 meters AGL.

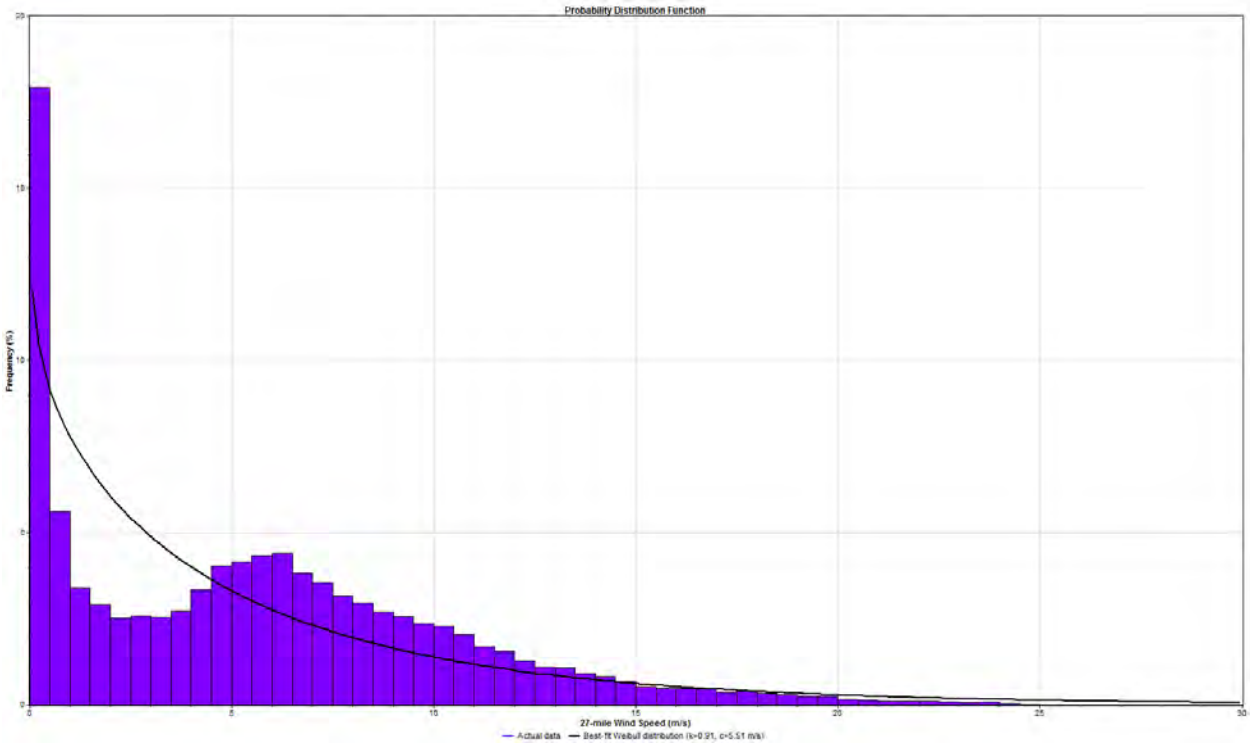




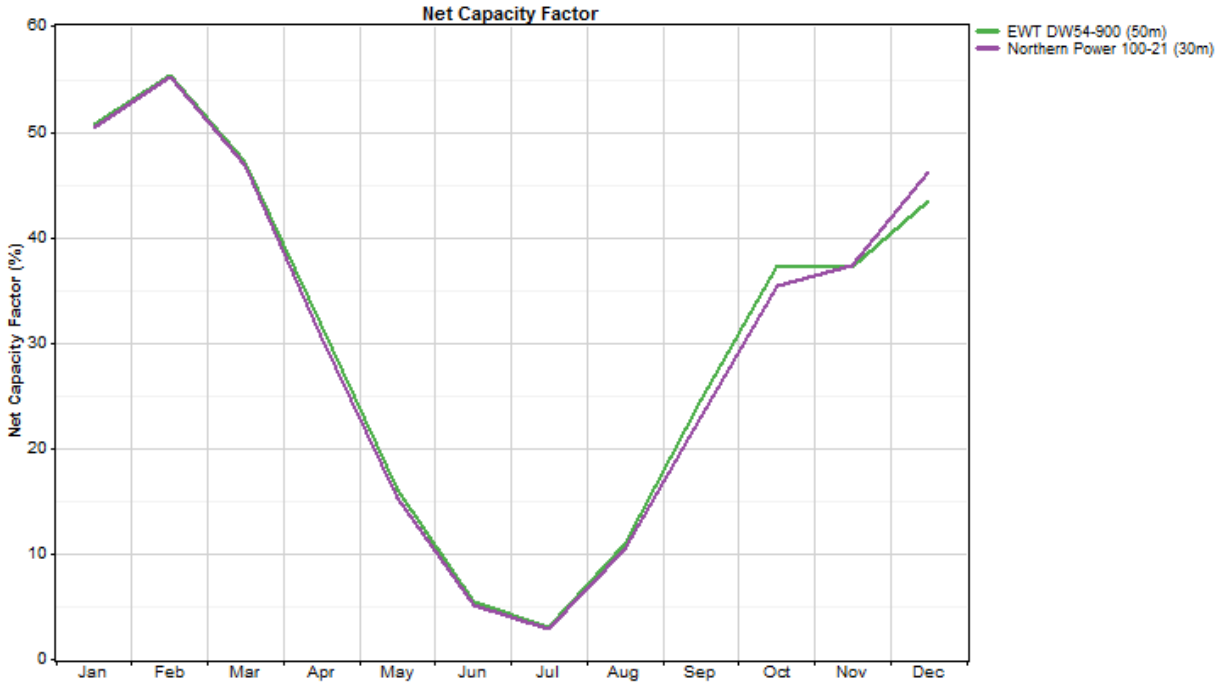
The wind speed trend indicates a very strong and consistent seasonal pattern with only a few periods driven by stronger storm-based systems. Summertime winds yield very little wind energy potential while wintertime winds are very productive. Most wind energy is out of the north and northeast coming down the Copper River drainage from mountains, glaciers and snowfields to the north.



While multiple hoar frost events were observed during both winter periods, only one 5-day event was observed during each winter season. Most frost/ice events ranged between a few hours and a few days. This is expected at a site that sits at near sea level. Most of what drives the shape of the probability distribution and the low Weibull K value (half of a normal distribution) is the very calm winds during the summer months.



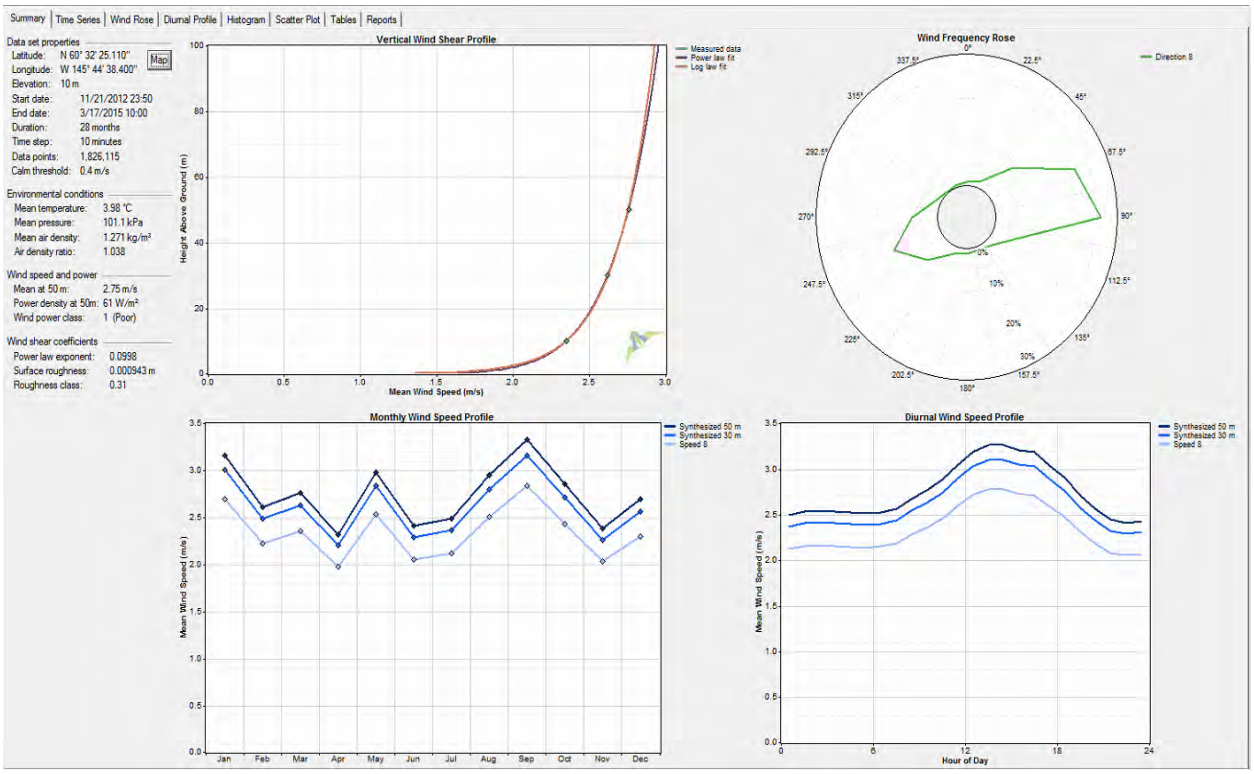
Low Weibull K distribution driven by minimal frost/icing in the winter, plus frequent calm summertime winds



Net Capacity Factor by month of year – 27-mile

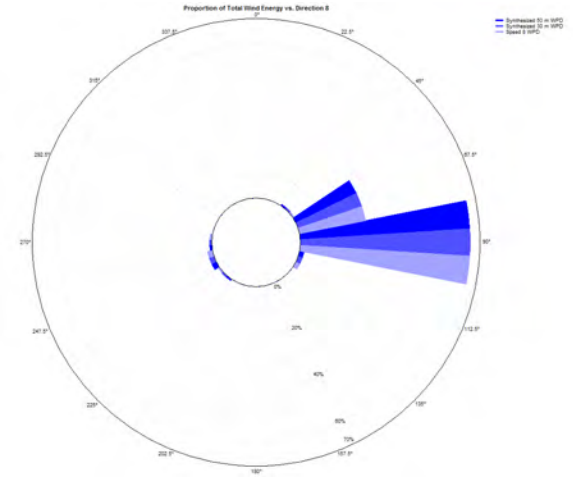
DATA SUMMARY – CORDOVA ELECTRIC CO SHOP TOWER

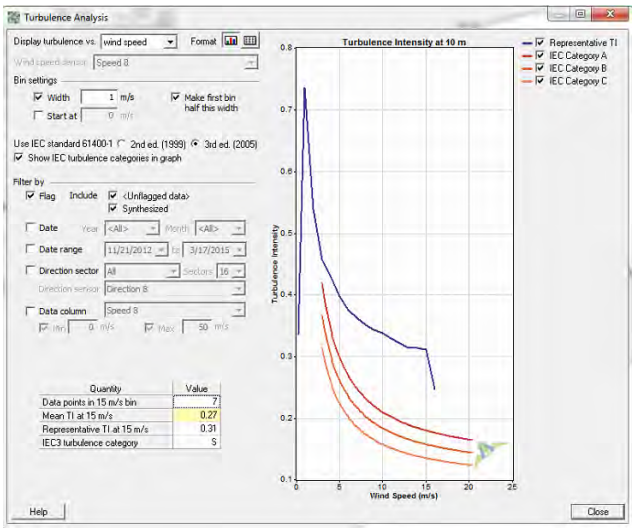
CEC Shop Tower Native Village of Eyak Application/Grant #		
Average Wind Speed @ 30 m:	2.612	m/s
Average Power Density @ 50 m:	61	W/m^2
Average Power Density @ 30 m:	52	W/m^2
Air Density:	1.038	kg/m^3
Weibull k:	0.92	
Shear Factor:	Unk	
Roughness Class:		
Turbulence Intensity @ 15 m/s:	0.310	
IEC Turbine Class:	III-A	Exceeds
Wind Class @ 30 m:	1	
Associated CF:	10.0%	
Predicted CF:	5.4%	



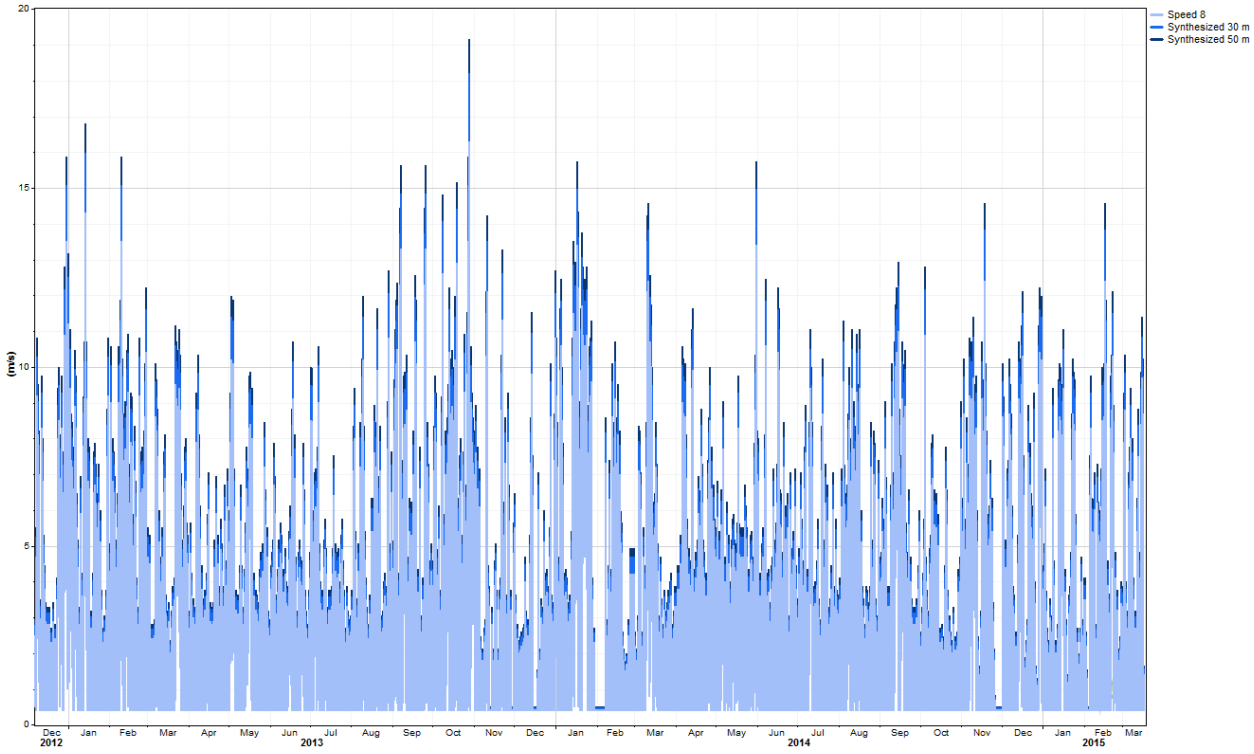
Variable	Synthesized 50 m	Synthesized 30 m	Speed 8
Measurement height (m)	50	30	10
Mean wind speed (m/s)	2.759	2.622	2.349
MoMM wind speed (m/s)	2.749	2.612	2.341
Median wind speed (m/s)	1.879	1.786	1.600
Min wind speed (m/s)	0.470	0.446	0.400
Max wind speed (m/s)	19.146	18.193	16.300
Weibull k	0.921	0.921	0.921
Weibull c (m/s)	2.607	2.477	2.219
Mean power density (W/m²)	63	54	39
MoMM power density (W/m²)	61	52	38
Mean energy content (kWh/m²/yr)	555	476	342
MoMM energy content (kWh/m²/yr)	536	460	331
Energy pattern factor	4.787	4.786	4.783
Frequency of calms (%)	0.00	0.00	22.07
Possible data points	121,741	121,741	121,741
Valid data points	119,485	119,485	119,485
Missing data points	2,256	2,256	2,256
Data recovery rate (%)	98.15	98.15	98.15

This location in town was selected solely to validate the wind map and because the site has a lattice tower that facilitates easy installation of an anemometer, vane and datalogger. As expected, winds are very weak at 50-meters with a wind power density of 61 watts per square meter. 50-m annual average wind speed are only 2.75 meters per second. A Weibull K of 0.921 versus a more normal 2.0 is indicative of a low wind regime. Average winds are weak at 2.6 meters per second estimated for 30 meters AGL.





The consistent easterly winds are caused by an east-west channel between Mt. Eyak to the north and Heney Ridge to the south. Winds come across Eyak Lake from the Copper River flats. Very high turbulence should be attributed to air flow around the CEC shop building and nearby trees.

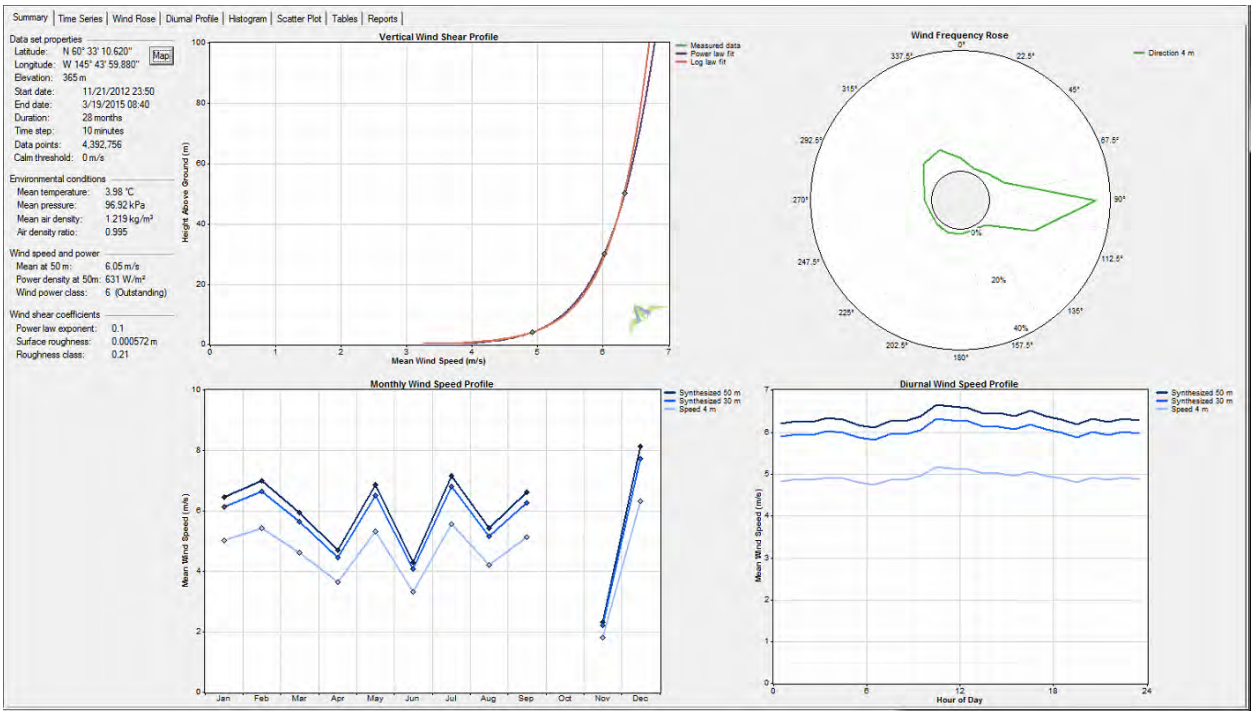


Multiple 2- to 3-day hoar frost events were observed during each winter periods with one 8-day event observed during January 2014. The CEC shop winds track the airport readings closely, despite the airport being 12 miles to the east out toward the Copper River Flats. Correlation to the Mile 27 met tower is much lower. Data recovery was very high (98.4%) at this met tower.

DATA SUMMARY – MT. EYAK SKI HILL

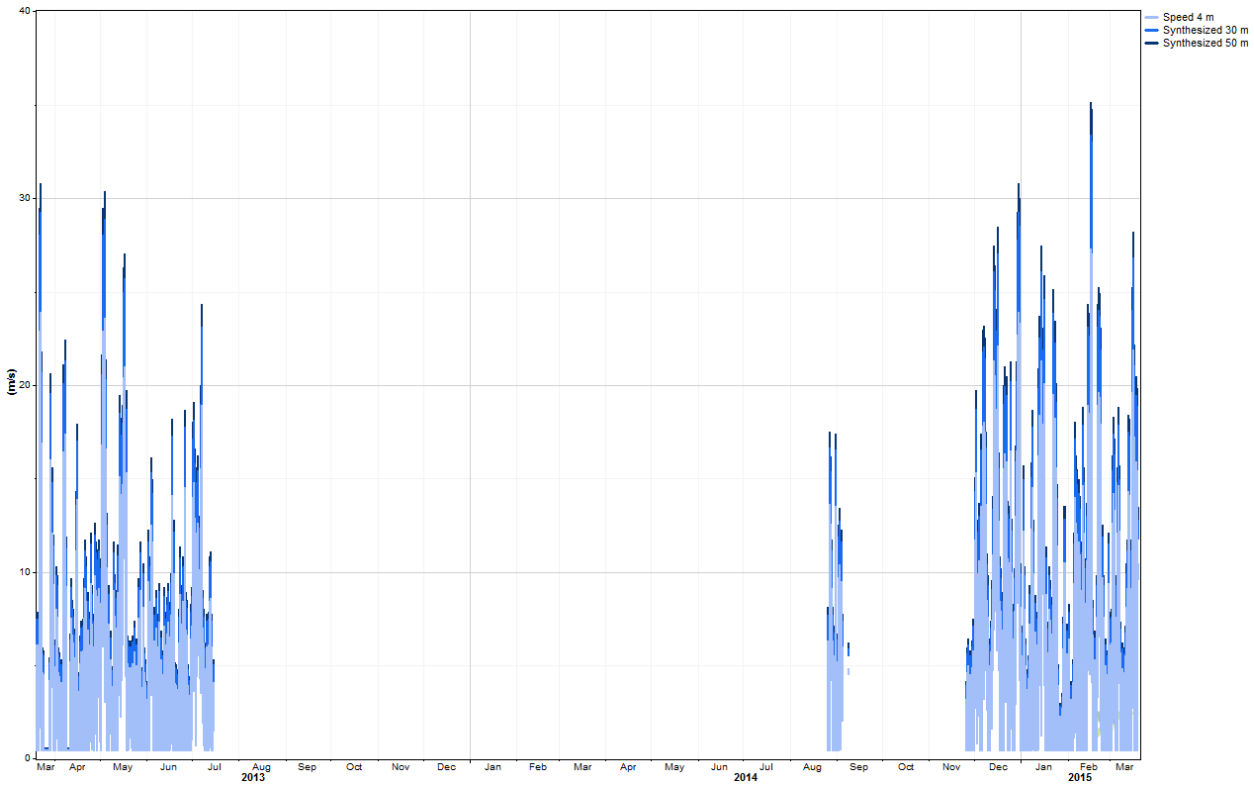
Data recovery for the ski hill is low at 42%, driven by a large gap in data from mid-July 2013 through mid-August 2014 and again from early September through mid-November 2014. Because of this gap, there is no data from mid-September through mid-November for any year.

Mt Eyak Skil Hill Native Village of Eyak Application/Grant #		
Average Wind Speed @ 30 m:	5.750	m/s
Average Power Density @ 50 m:	631	W/m^2
Average Power Density @ 30 m:	542	W/m^2
Air Density:	0.995	kg/m^3
Weibull k:	0.90	
Shear Factor:	Unk	
Roughness Class:		
Turbulence Intensity @ 15 m/s:	0.200	
IEC Turbine Class:	III-A	Exceeds
Wind Class @ 30 m:	5	
Associated CF:	28.0%	
Predicted CF:	21.5%	



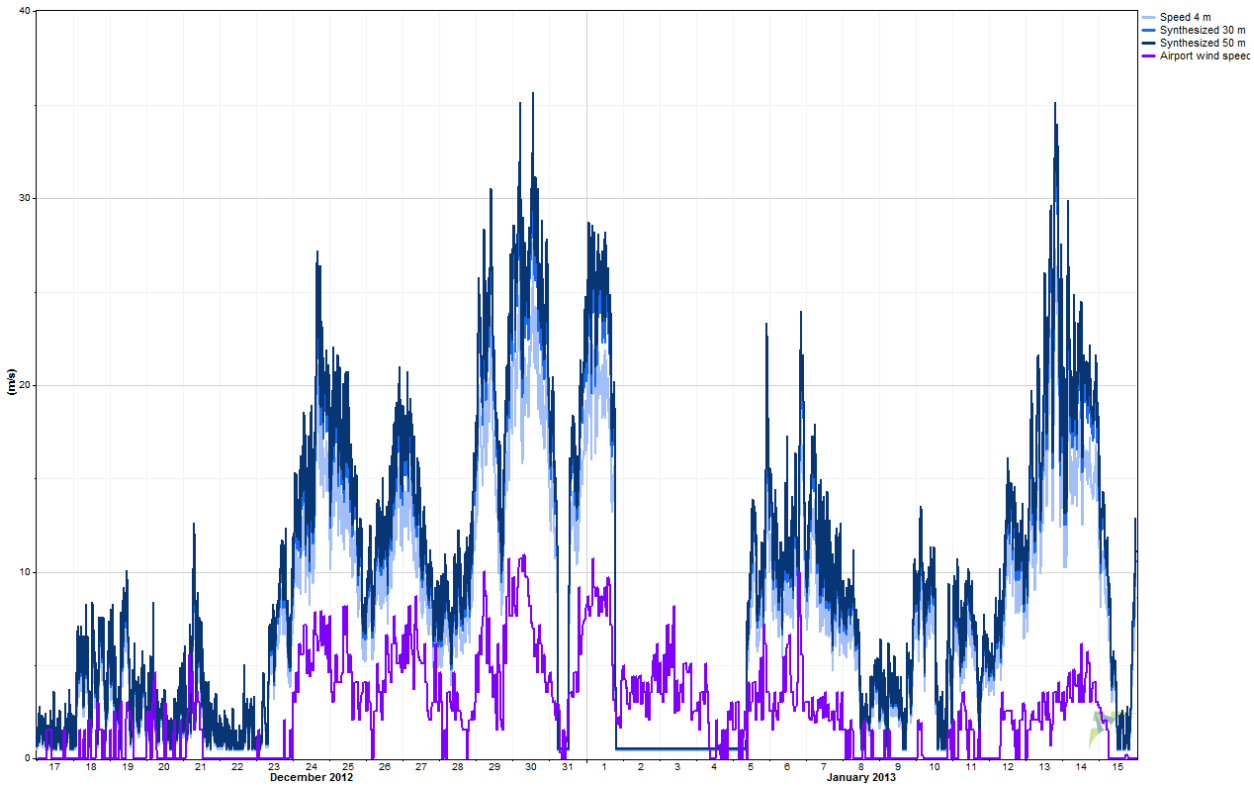
Variable	Synthesized 50 m	Synthesized 30 m	Speed 4 m
Measurement height (m)	50	30	4
Mean wind speed (m/s)	6.337	6.022	4.923
MoMM wind speed (m/s)	6.051	5.750	4.700
Median wind speed (m/s)	4.763	4.526	3.700
Min wind speed (m/s)	0.515	0.489	0.400
Max wind speed (m/s)	35.659	33.883	27.700
Weibull k	0.899	0.899	0.899
Weibull c (m/s)	6.012	5.713	4.670
Mean power density (W/m²)	721	619	338
MoMM power density (W/m²)	631	542	296
Mean energy content (kWh/m²/yr)	6,318	5,420	2,961
MoMM energy content (kWh/m²/yr)	5,531	4,745	2,593
Energy pattern factor	4.653	4.652	4.652
Frequency of calms (%)	0.00	0.00	0.00
Possible data points	122,021	122,021	122,021
Valid data points	51,508	51,508	51,508
Missing data points	70,513	70,513	70,513
Data recovery rate (%)	42.21	42.21	42.21

This installation consists of a lattice communications tower owned by Cordova Telephone Company just uphill from the top of the chairlift at Mt. Eyak Ski Hill at an elevation of 365 meters above sea level. The instruments (vane is hidden from view in this photo) are up high enough to be above the surrounding vegetation but still experience turbulence from other equipment on the lattice tower. Winds are strong at a mean 50-meter wind power density of 542 watts per square meter. 50-m annual average wind speed is 5.75 m/s. Since a modest wind shear value of 0.1 was assumed in the extrapolation, the more stringent turbine class II will be assumed. A Weibull K of 0.9 is driven by moderate frost/icing and periods of relative calm.

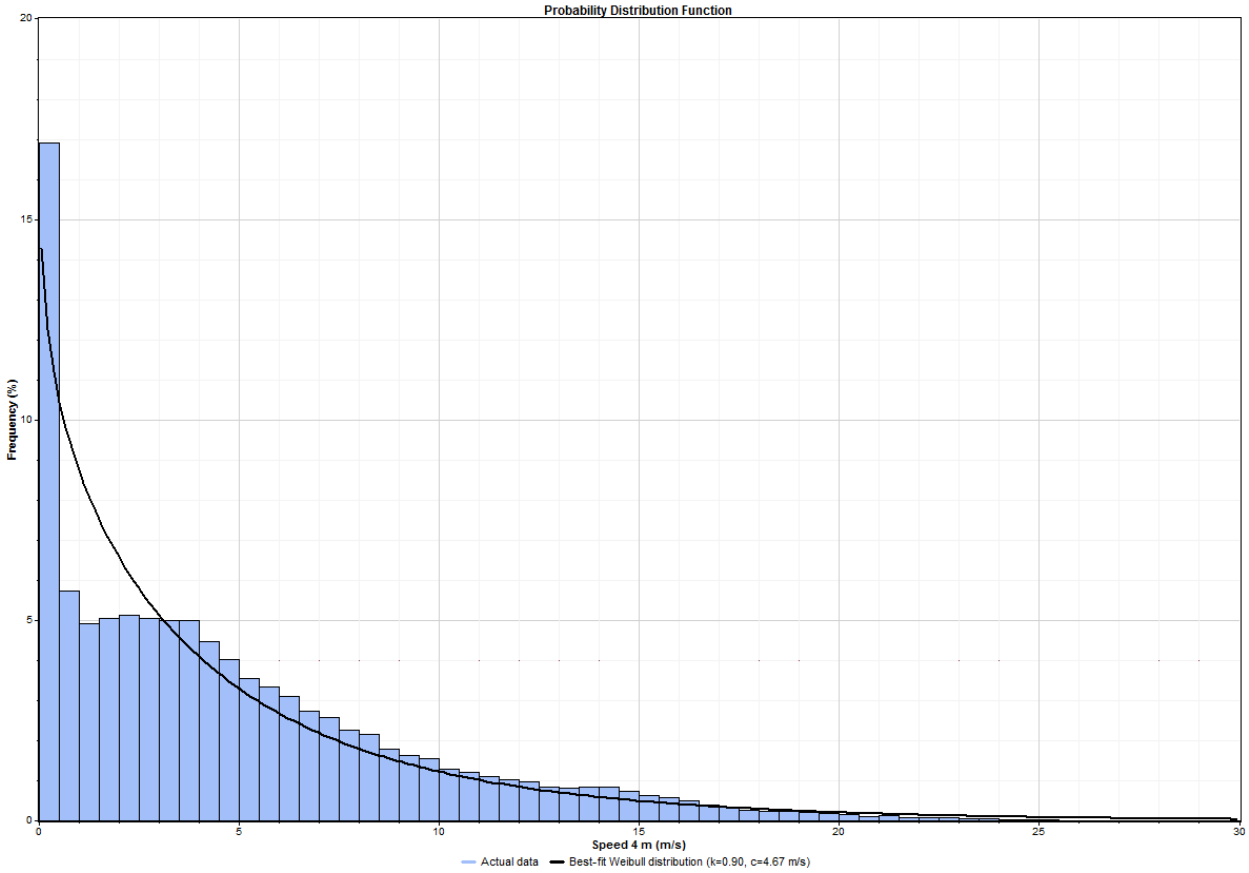


Time series showing large gap in data

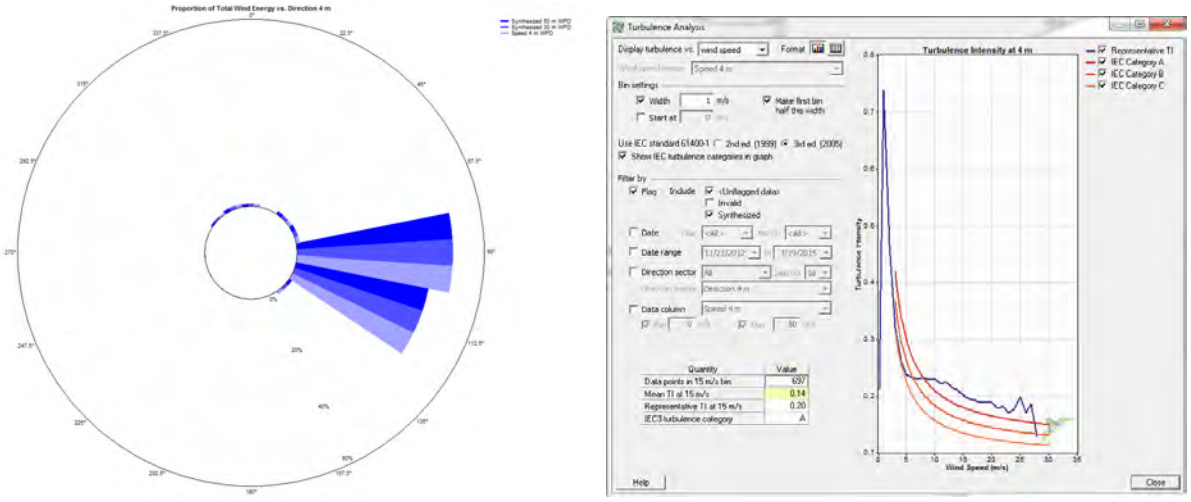
Multiple periods of frost/icing were observed during the winter of 2013 with far less icing seen in 2015, which was warmer and drier than average. The large gaps in data do not provide for any meaningful gap filling simulation. This site correlates well with the airport ASOS station with the exception of frost/icing periods where the airport still indicates slow wind speeds.



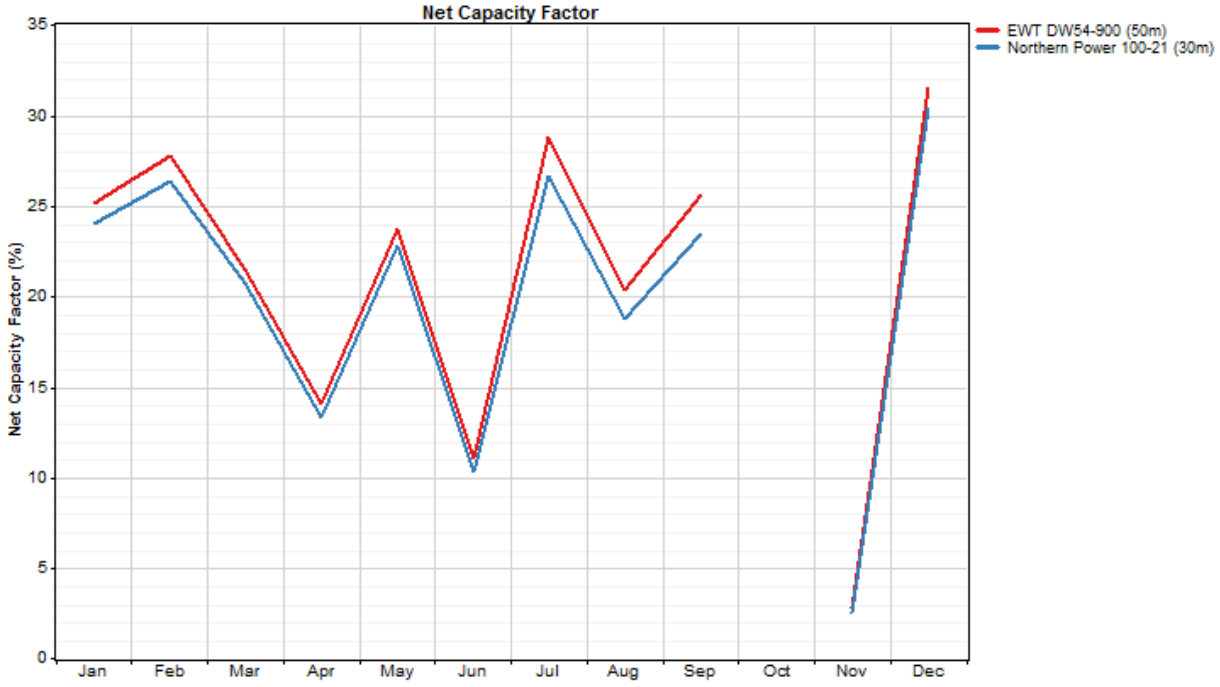
Met tower and synthesized wind speed (blue) compared with airport wind speed (purple)



Of note in the histogram are frost/icing periods piled up at the left side of the graph and high wind events exceeding 25 m/s which result in turbine shutdown periods for extreme wind events. These help to explain why a relatively high wind power density of 542 W/m2 results in a somewhat lower-than-expected net capacity factor of 21.5%.



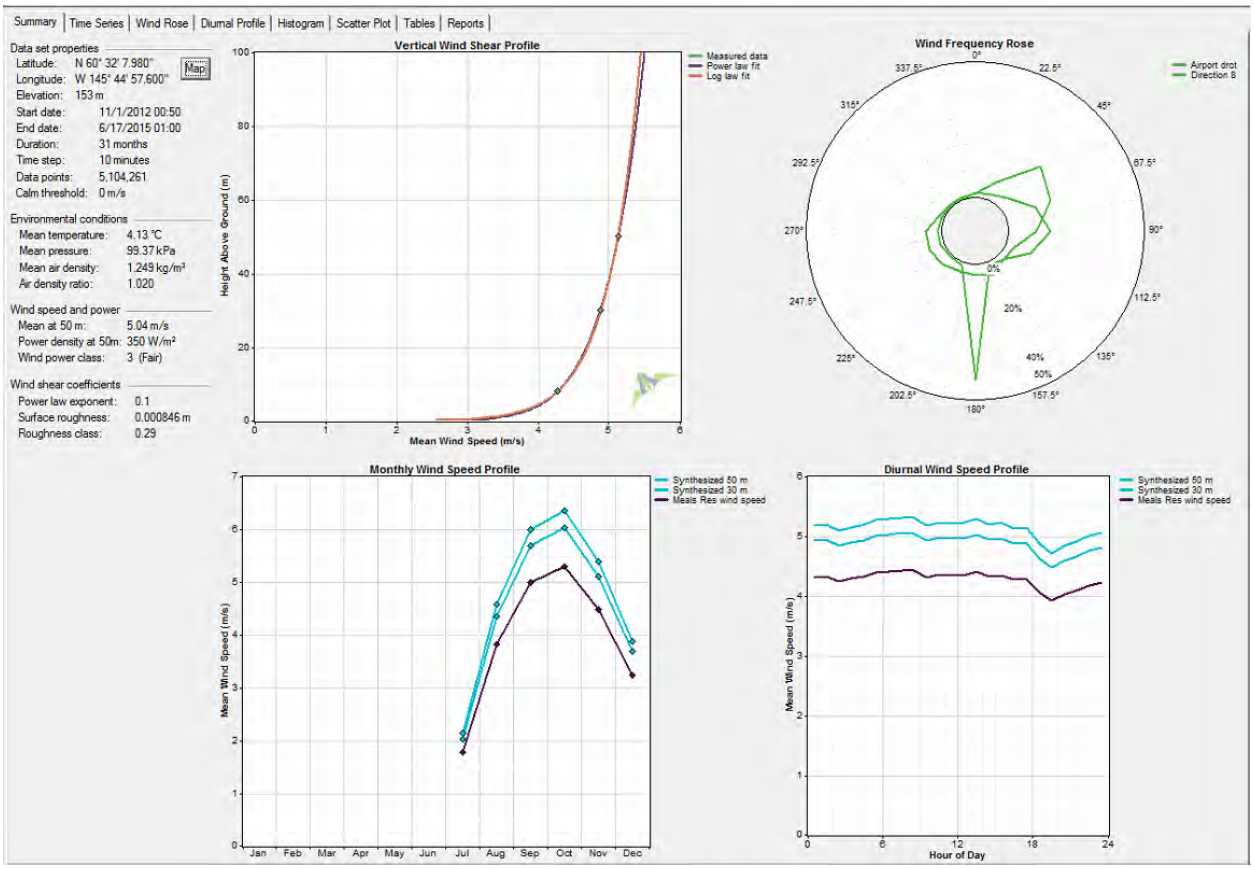
Predminant wind energy is out of the east in the direction of the Copper River Flats.



DATA SUMMARY – MEALS RESERVOIR

This met tower operated for more than a year with a malfunctioning anemometer. A site visit in summer of 2013 swapped out the anemometer and changed the channel on the datalogger. Since then, there has been a period of 11 months from mid-Nov 2013 through mid-Oct 2014 where no data can be found. This is unfortunate as the proximity to town and access to the site would allow for development if the wind regime can be properly validated.

Meals Reservoir Native Village of Eyak Application/Grant #		
Average Wind Speed @ 30 m:	4.793	m/s
Average Power Density @ 50 m:	350	W/m^2
Average Power Density @ 30 m:	300	W/m^2
Air Density:	1.020	kg/m^3
Weibull k:	1.09	
Shear Factor:	Unk	
Roughness Class:		
Turbulence Intensity @ 15 m/s:	0.200	
IEC Turbine Class:	III-A	Exceeds
Wind Class @ 30 m:	3	
Associated CF:	19.7%	
Predicted CF:	17.8%	

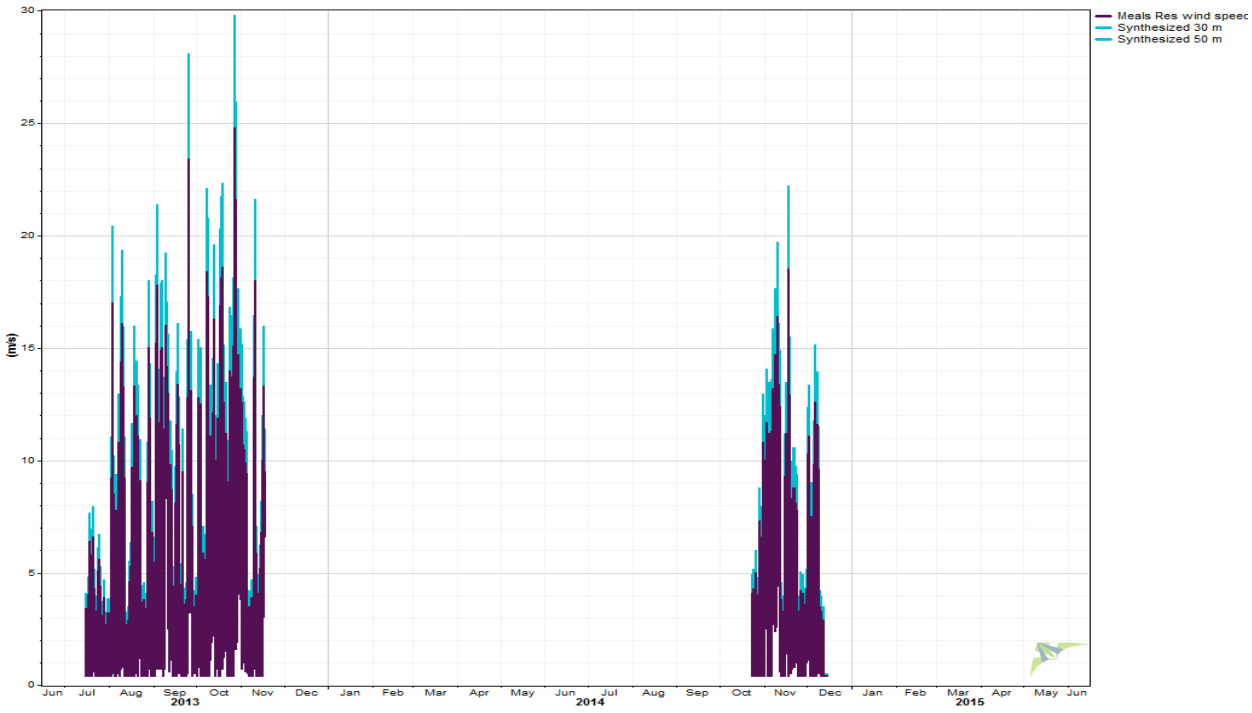


Variable	Synthesized 50 m	Synthesized 30 m	Meals Res wind spee
Measurement height (m)	50	30	8
Mean wind speed (m/s)	5.138	4.882	4.278
MoMM wind speed (m/s)	5.044	4.793	4.199
Median wind speed (m/s)	3.483	3.310	2.900
Min wind speed (m/s)	0.480	0.457	0.400
Max wind speed (m/s)	29.788	28.304	24.800
Weibull k	1.089	1.089	1.089
Weibull c (m/s)	5.289	5.025	4.403
Mean power density (W/m²)	360	309	208
MoMM power density (W/m²)	350	300	202
Mean energy content (kWh/m²/yr)	3,152	2,704	1,819
MoMM energy content (kWh/m²/yr)	3,068	2,632	1,770
Energy pattern factor	4.316	4.316	4.316
Frequency of calms (%)	0.00	0.00	0.00
Possible data points	137,953	137,953	137,953
Valid data points	25,622	25,622	25,622
Missing data points	112,331	112,331	112,331
Data recovery rate (%)	18.57	18.57	18.57

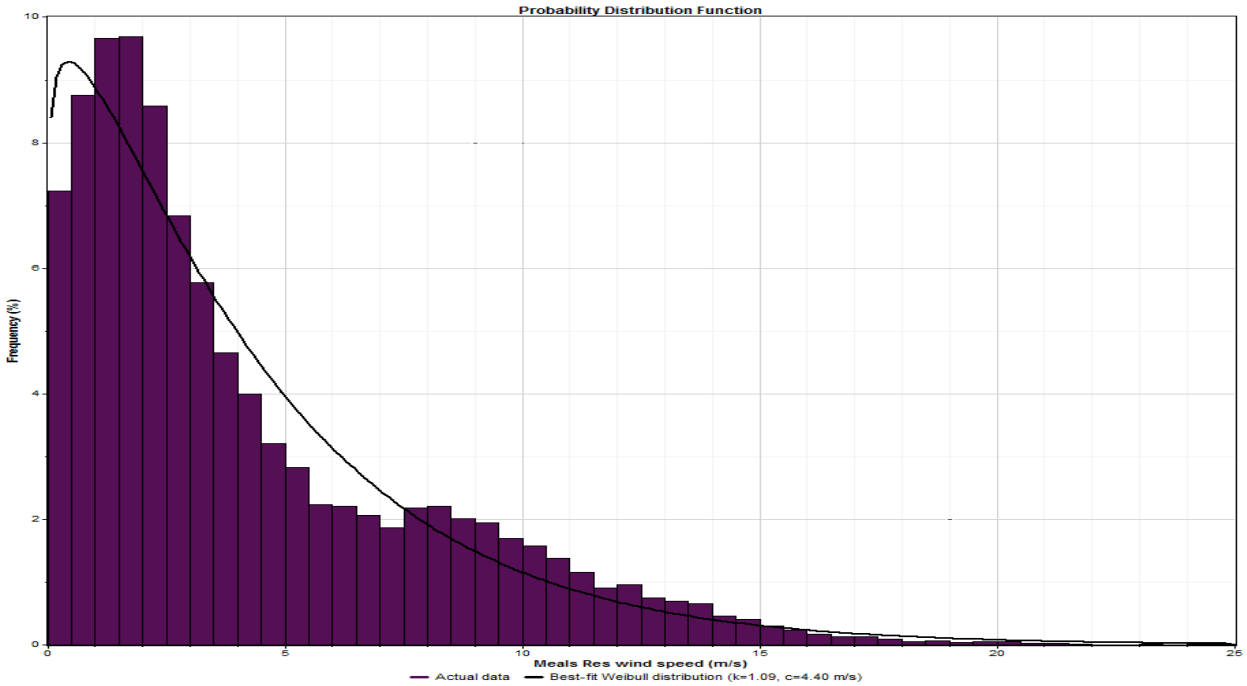
This installation consists of a guyed tubular tower uphill and to the northeast of Meals Reservoir. The site overlooks the Cordova town site, harbor and Eyak Lake from a ridge at 153 meters. While more data collection is needed at this site, a 50-meter met tower is proposed to for installation just down the hill closer to Meals Reservoir due to road/trail access and a sizeable area in which to assemble and erect a tall tower.

There is moderate correlation to the winds measured at the main airport at mile 13 of the highway, but this site catches more and stronger wind events due to the higher terrain and lower surrounding vegetation. No appreciable frost/icing has been observed, although many winter months are missing from the dataset.

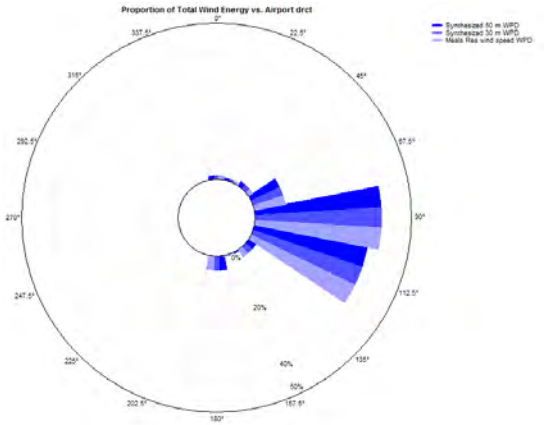
Net capacity factor estimate of 18% is likely low given the dearth of winter data collected.

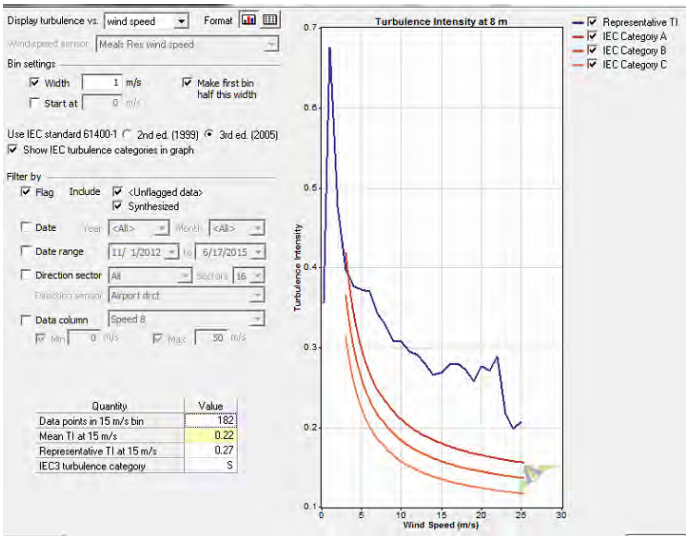


Time series showing large gap in data



Histogram does not show a pile up of values neat zero m/s that would indicate frost/icing. A slight bimodal distribution is observed.



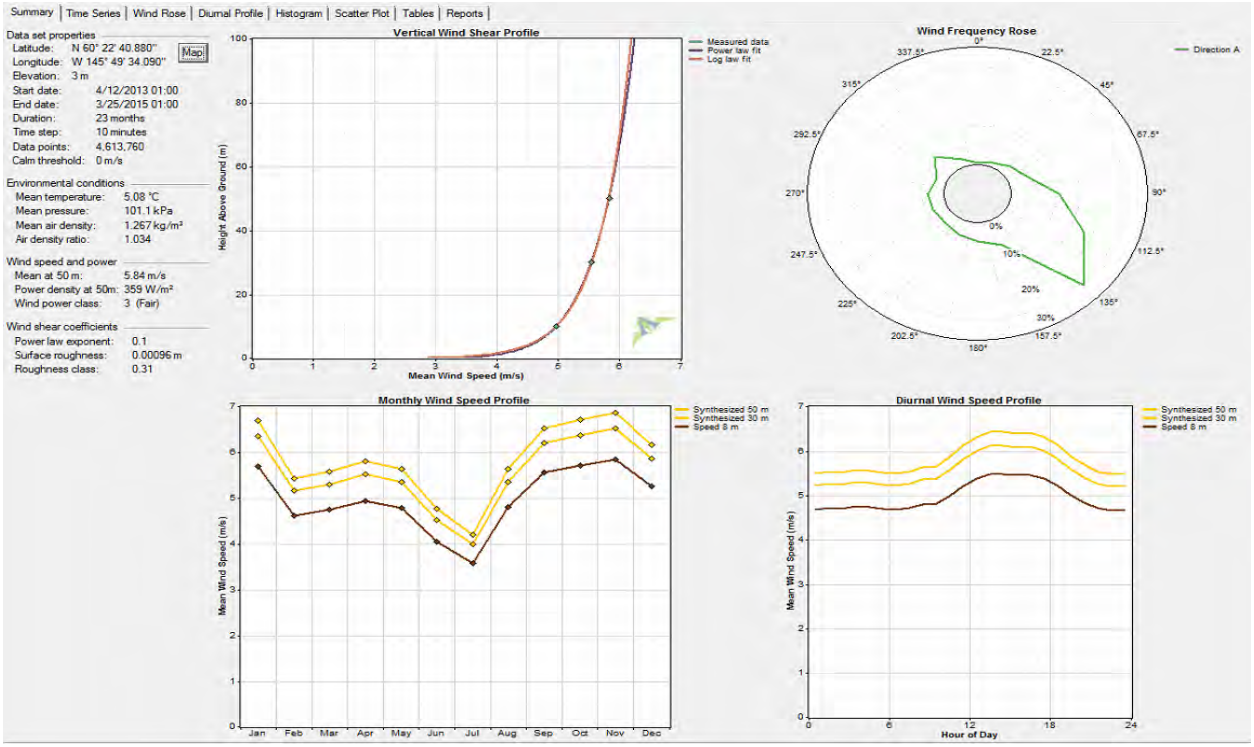


Winds are generally out of the east through a gap in the mountains at the eastern end of Eyak Lake with a view to the Copper River Flats.

DATA SUMMARY – EGG ISLAND

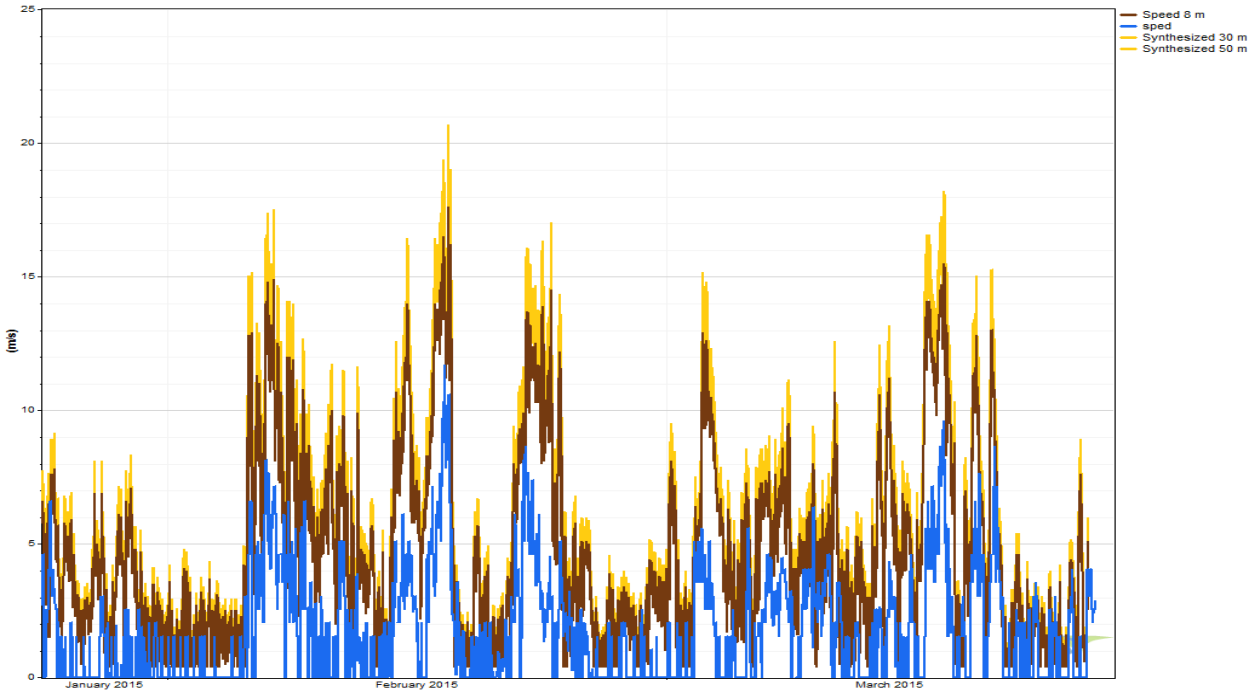
This installation is mounted on a US Coast Guard navigation aid on Egg Island, 9 miles southeast of the Pt. Whitshed 30-meter met tower and 13 miles due south of Cordova. Due to avian nesting on the island, it is not a developable wind energy site, but rather serves to validate the wind resource model. Data collection rate was very high at 99.87%.

Egg Island Native Village of Eyak Application/Grant #		
Average Wind Speed @ 30 m:	5.545	m/s
Average Power Density @ 50 m:	359	W/m^2
Average Power Density @ 30 m:	308	W/m^2
Air Density:	1.038	kg/m^3
Weibull k:	1.35	
Shear Factor:	Unk	
Roughness Class:		
Turbulence Intensity @ 15 m/s:	0.120	
IEC Turbine Class:	III-B	
Wind Class @ 30 m:	3	
Associated CF:	19.7%	
Predicted CF:	22.1%	

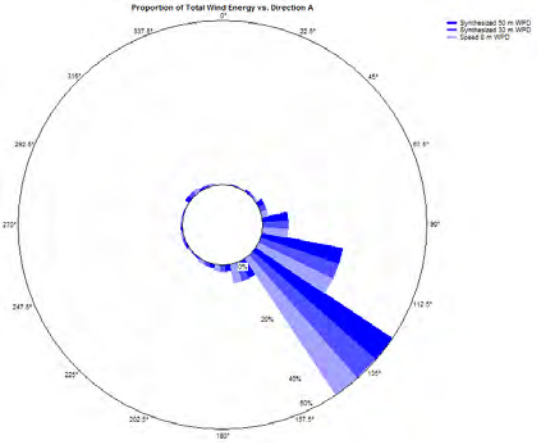


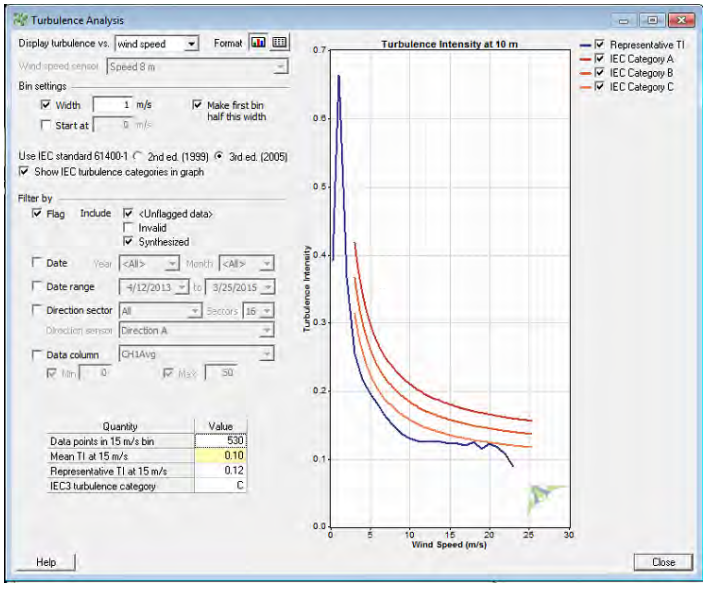
Variable	Synthesized 50 m	Synthesized 30 m	Speed 8 m
Measurement height (m)	50	30	10
Mean wind speed (m/s)	5.839	5.548	4.971
MoMM wind speed (m/s)	5.836	5.545	4.968
Median wind speed (m/s)	4.816	4.576	4.100
Min wind speed (m/s)	0.470	0.446	0.400
Max wind speed (m/s)	26.781	25.448	22.800
Weibull k	1.345	1.345	1.345
Weibull c (m/s)	6.334	6.019	5.392
Mean power density (W/m²)	360	309	222
MoMM power density (W/m²)	359	308	221
Mean energy content (kWh/m²/yr)	3,155	2,707	1,947
MoMM energy content (kWh/m²/yr)	3,143	2,697	1,939
Energy pattern factor	2.869	2.869	2.869
Frequency of calms (%)	0.00	0.00	0.00
Possible data points	102,528	102,528	102,528
Valid data points	102,395	102,395	102,395
Missing data points	133	133	133
Data recovery rate (%)	99.87	99.87	99.87

Winds are quite consistent over time with occasional storms from the Gulf of Alaska driving additional wind events. No frost or icing signal was seen at this site as is expected for a maritime climate at sea level. The winds correlate very closely to the airport anemometer, although at higher wind speeds. General winds are out of the southeast. As expected for flat terrain, turbulence is low.



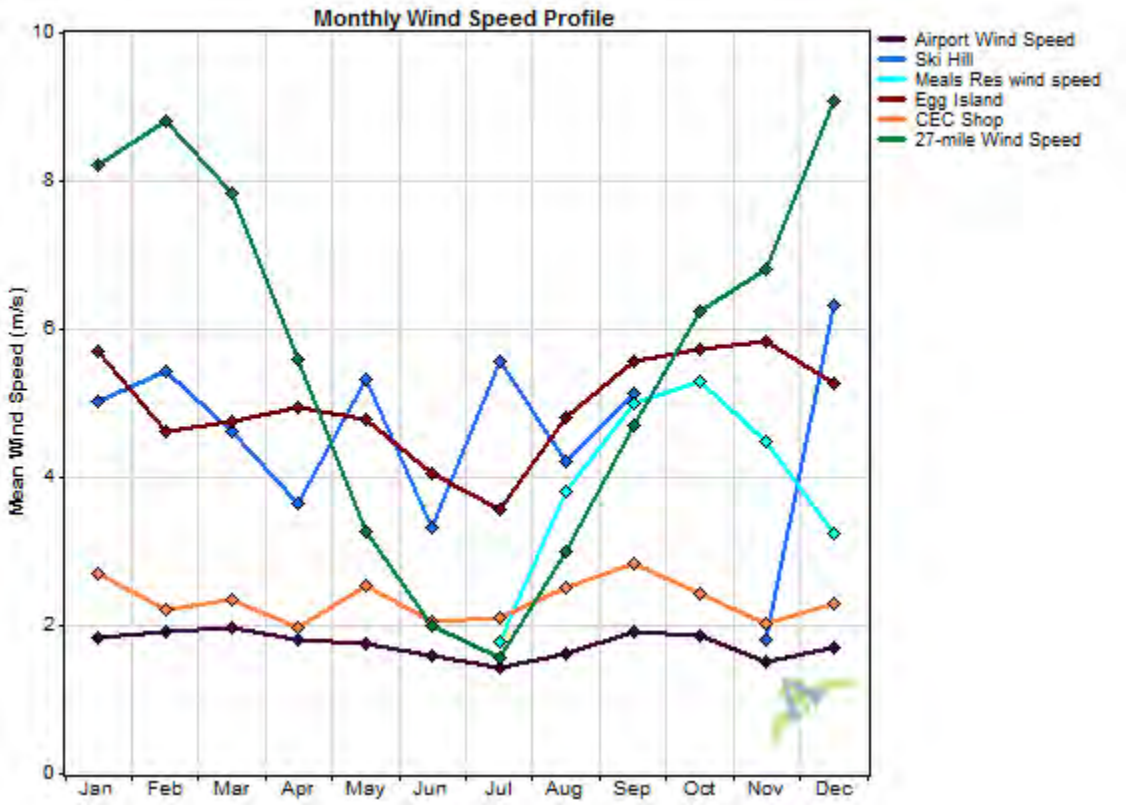
Egg Island wind speed trend correlates to airport





WIND TURBINE SITING CONSIDERATIONS

Siting constraints will be driven primarily by land ownership issues, distance to existing transmission infrastructure, avian concerns, anadromous streams and FAA permitting. FAA permitting issues did arise at Meals Reservoir due to proximity to the airport at Eyak Lake. Any site development would require a request to vary the flight path. Mile 27 is located in the Copper River Delta State Game Refuge and is a major avian nesting area. More information can be found at http://www.adfg.alaska.gov/index.cfm?adfg=copperriverdelta.main . The ski hill is located on terrain that would be difficult to develop. The Meals Reservoir site would allow for close connection to existing transmission and development of an access road to wind turbines should the resource prove out.



Comparison of wind speed for all sites in the study

Site	Wind Resource Model @ 30m	Actual Measured @ 30m	Under (-) /Over (+) Predict
Airport	3.241	1.748	1.493
Ski Hill	6.202	5.75	0.452
Meals Res	3.767	4.793	-1.026
Egg Island	5.112	5.545	-0.433
CEC Shop	3.385	2.612	0.773
27-Mile	5.535	6.825	-1.29

INTEGRATED POWER SYSTEM CONSIDERATIONS

The 3.1 MW size of the Cordova Electric average load would allow for several megawatts of variable wind energy on the grid. Average annual wind energy exceeding 8-10 percent of the load would require the presence of more complex integration controls or storage. At the present time, none of the hydroelectric facilities in Cordova contain a water storage component.

BARRIERS

- Several anadromous stream crossings existing along the proposed route to the Pt. Whitshed site.
- A flight pattern variance would be needed for the Meals Reservoir site.
- Land ownership and steep terrain are issues at the ski hill.
- Critical avian habitat is ubiquitous across the Copper River Delta from the airport to Mile 27 and beyond.

CONCLUSIONS

Wind energy development is a possibility on the Cordova Electric grid. Terrain and permitting will likely be the largest barriers to development other than project financing. Additional study is needed with tall met towers at the proposed site. NVE currently has a 50-meter met tower. Borrowing or leasing a LIDAR unit for placement next to the met tower might also be beneficial to quantify the actual expected energy production across the rotor swept area of larger, megawatt-plus scale wind turbines before moving forward with expensive design and permitting of a project.

CONTACT INFORMATION

Rich Stromberg, Wind Program Manager, Alaska Energy Authority rstromberg@aidea.org 907-771-3053

ACKNOWLEDGMENTS

Native Village of Eyak provided the data set used for analysis.

Appendix B. Camp Hill @ Pt. Whitshed Wind Analysis

Report Outline
Project Overview/Summary of Results
Project Location
Project Instrumentation
Discussion of Wind Resource
Appendix

Project Overview/Summary of Results
As part of the NREL Native American Anemometer Loan Program an anemometers was installed near Whitshed in cooperation with the native Village of Eyak, Alaska to assess the area's wind energy potential. This report describes the wind resource measured at this location. The monitoring period ran from 13 November 2007 to 31July 2009.

The measured average power density and wind speed, measured at 26m (85ft), are 346 W/m^2 and 5.9 m/s (13.1 mph) respectively. This is consistent with the resource indicated by publically available wind maps. For example, the 3Tier wind map (Figure 2) (http://firstlook.3tiergroup.com/) estimates the average wind speed at the site (@ 20m AGL) at between 5.9 and 10.6 m/s. (13.1 mph – 23.6 mph)

The wind data for this site was processed using three different software packages. The first is a package, referred to as the NREL Package" that has been developed at NREL for internal use. The advantage of this software package it that it provides values for the power density. The values provided by this package will be used in the main body of the report. The next package, WindPro, has been the software used to provide the interim plots during the monitoring period. Windpro provides the capability to exclude zero's (for wind speed) when calculating the average wind speed and the analyzing the wind speed distribution. Finally, Windographer provides nice rose plots of both frequency versus wind direction and relative energy versus wind direction. The values provided by the NREL package will be used in the main body of the report, but occasionally, the Windpro and Windographer values will be provided as well. The Windpro plots are provided in the back of this report.

Project Location
The monitoring site is located approximately 8.5 miles southwest of Cordova, Alaska. Approximate grid coordinates are (N 60.46610°, W 145.95303°). The elevation is approximately 90m (300 ft). The monitoring location is shown in Figures 1A – 1E. Figure 2 shows the 3Tier wind map; Figure 3 shows the state wind map.

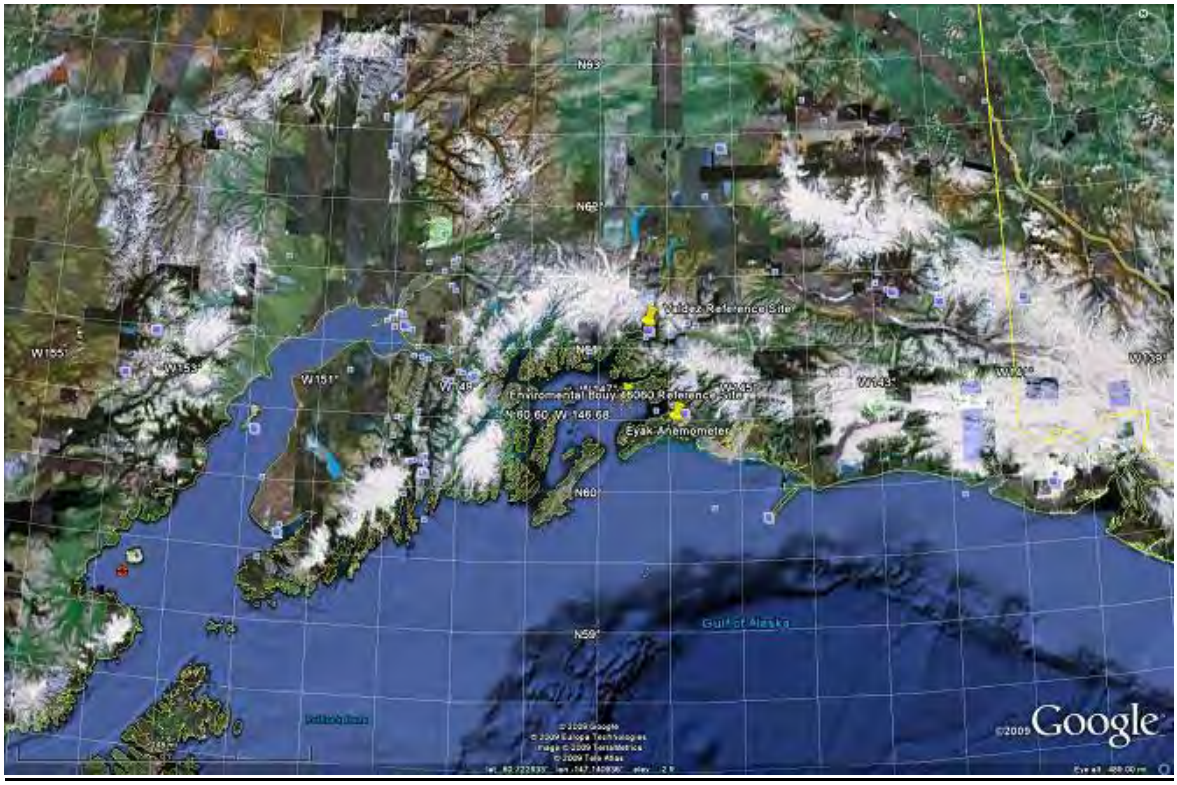


Figure 1A: Project Location (Regional)

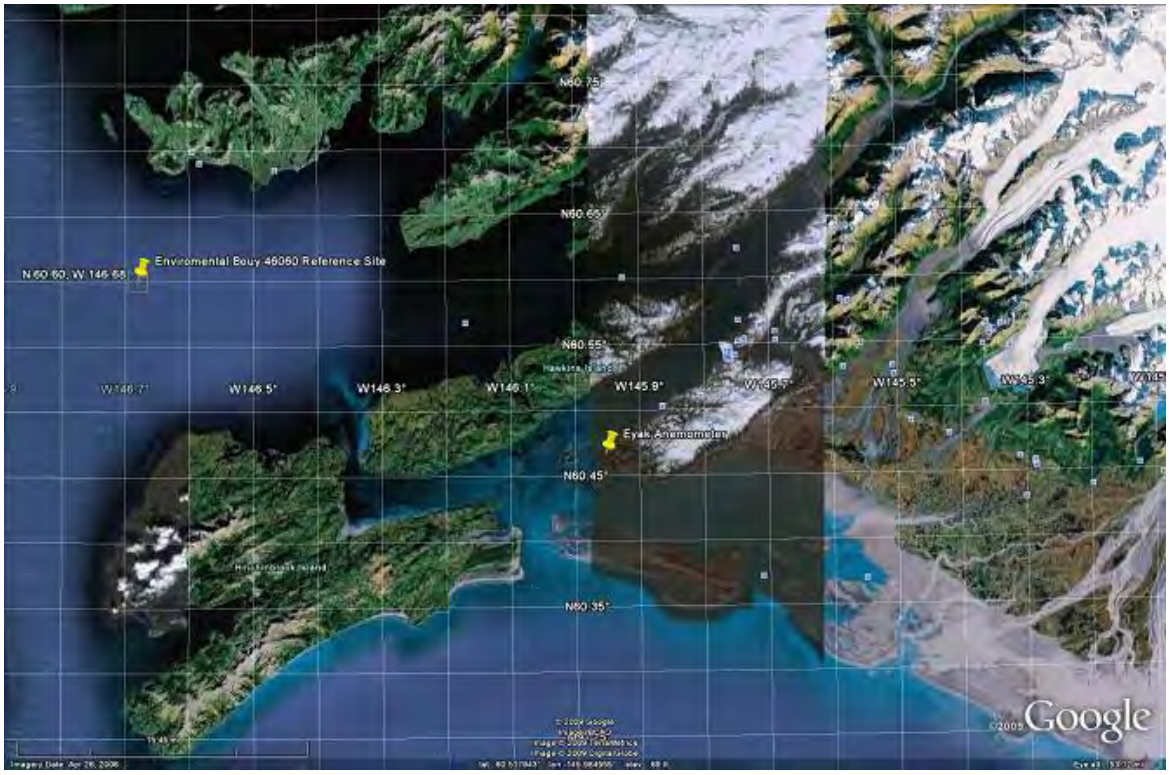


Figure 1B: Project Location (Mid Scale 2)

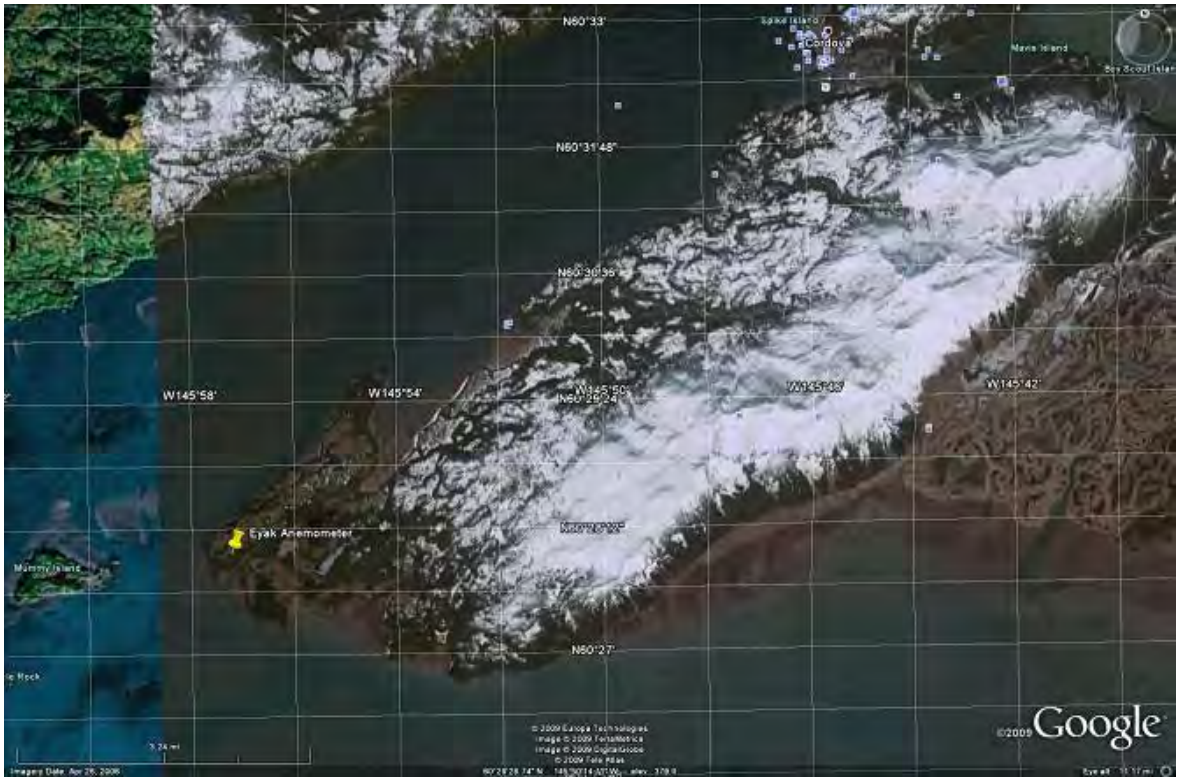


Figure 1C: Project Location (Mid Scale 1)

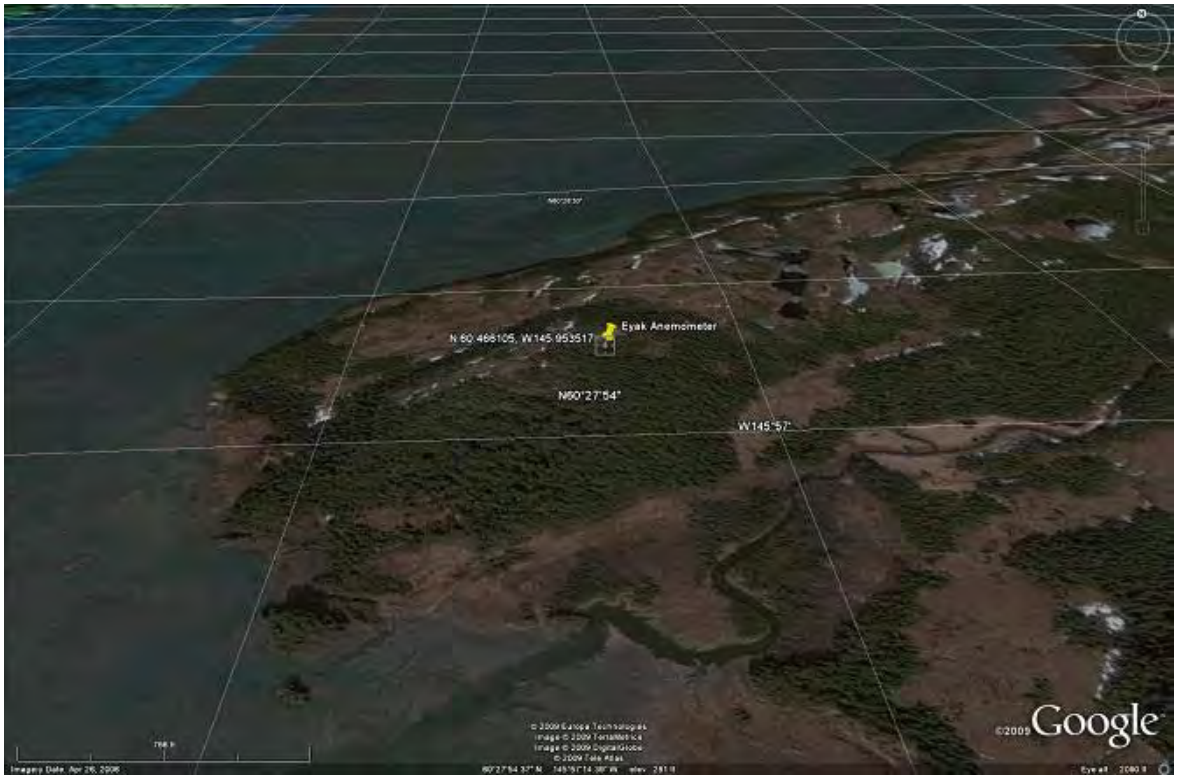


Figure 1D: Project Location (Close Up)

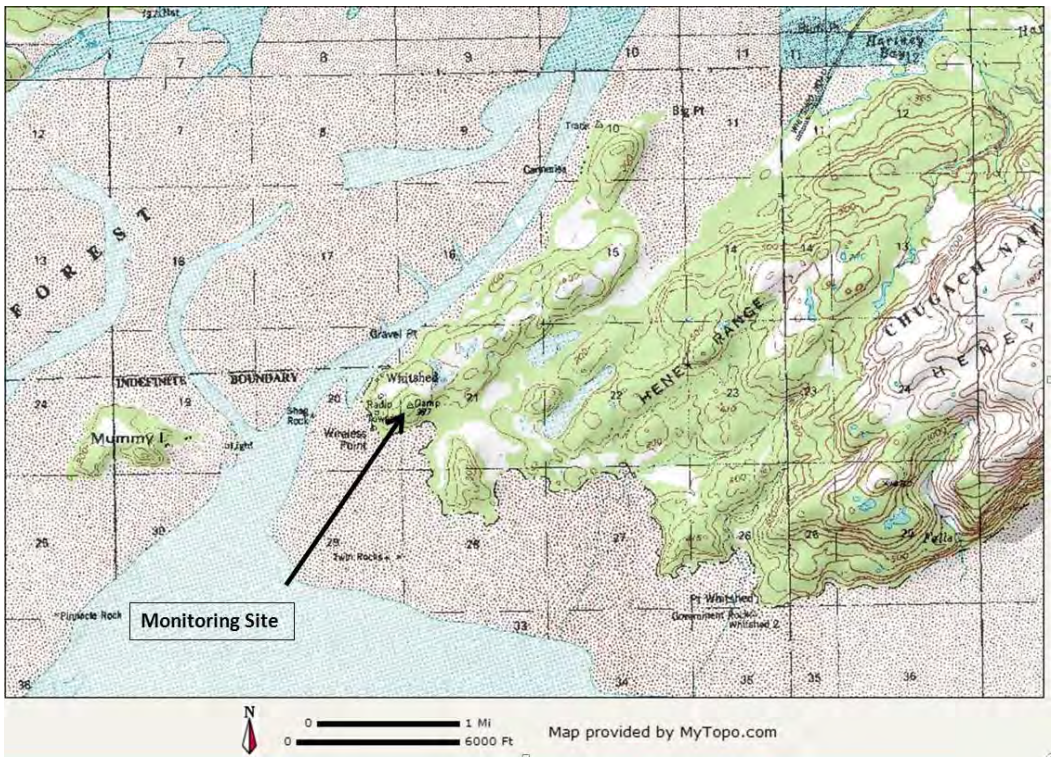
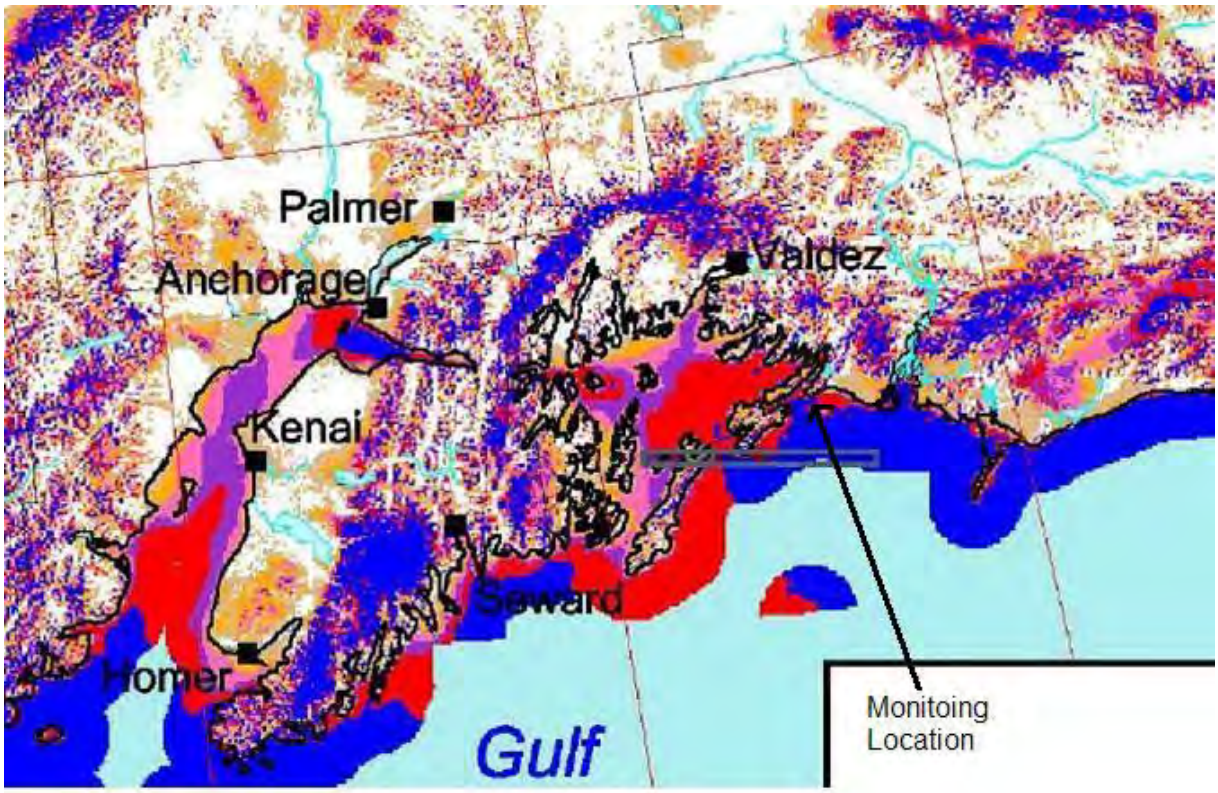


Figure 1E: Project Location (Topographic)

Figure 2: 3Tier Wind Map **(**Source: http://firstlook.3tiergroup.com/**)**



Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m²	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
1	Poor	0 - 200	0.0 - 5.3	0.0 - 11.9
2	Marginal	200 - 300	5.3 - 6.1	11.9 - 13.7
3	Fair	300 - 400	6.1 - 6.7	13.7 - 15.0
4	Good	400 - 500	6.7 - 7.3	15.0 - 16.4
5	Excellent	500 - 600	7.3 - 7.7	16.4 - 17.2
6	Outstanding	600 - 800	7.7 - 8.5	17.2 - 19.0
7	Superb	> 800	> 8.5	> 19.0

[a]Wind speeds are based on a Weibull K of 1.8. Weibull K values in Alaska vary from 1.4 to 2.0.

Figure 3: State Wind Map

Project Instrumentation

The instrumentation consisted of an NRG Wind Explorer system. This included cup anemometers mounted at three different heights, a wind vane, and data logger. The instruments were mounted as shown in Figure 4 on a tilt-up tubular tower. The collected data consisted of 10-minute average wind speed, including wind speed standard deviation and wind direction.

Channel	Height	Sensor	Notes
1	26.5 m	H40 (speed sensor)	
2	18.6 m	H40 (speed sensor)	
3	10.7 m	H40 (speed sensor)	
4		None	
5		None	
6		None	
7	26.8 m	#200P Wind Vane	
8	20.0 m	#200P Wind Vane	Non operational
9	2.0 m	#110S Temp	
10		None	
11		None	
12		None	

Figure 4: Tower/Sensor Configuration

Discussion of Wind Resource

Figure5 summarizes the collected wind data for 26m AGL (Above Ground Level)

The values for the 50-meter wind speed and power density are conservative estimates using a wind shear factor of 0.10.

	Average Wind Speed (m/s)	Average Power Density (W/m^2)
Average Annual Wind Speed & power density	5.9 m/s (13.1 mph)	346 W/m^2
Average wind speed & power density for best month (November)	8.2 m/s (18.2 mph)	714 W/m^2
Average wind speed & power density for worst month (Aug)	4.0 m/s (8.9 mph)	112 W/m^2
Estimated Resource @ 50 meters	6.3 m/s (14.0 mph)	410 W/m^2

Figure 5: Wind Data Summary (26m AGL)

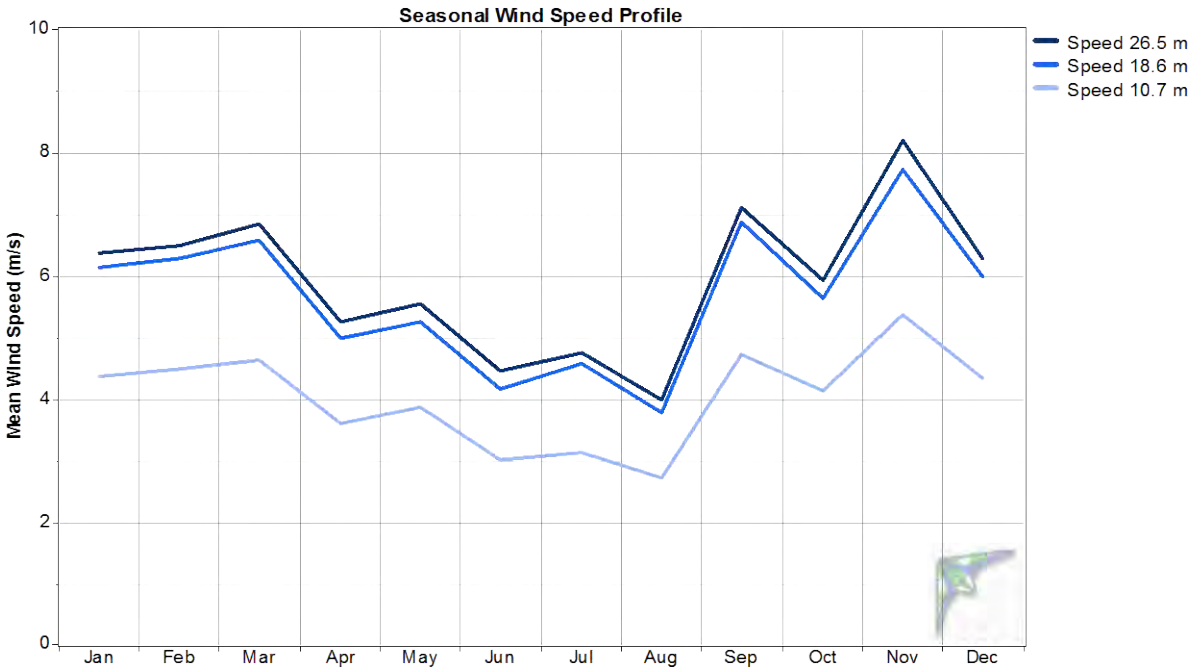


Figure 6: Monthly average and annual average wind speed.

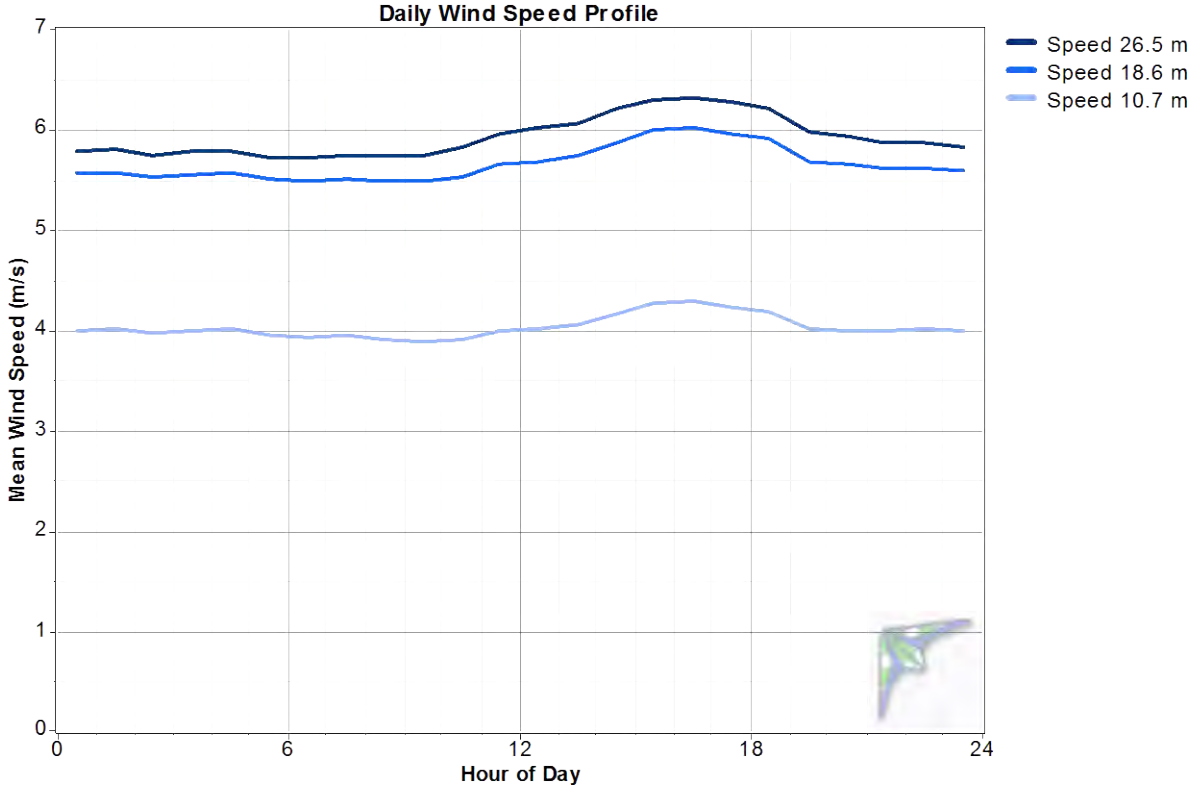


Figure 7: Average annual daily wind profile.

Speed and Power by Month

Figure 6 shows the seasonal wind profile for the three speed sensor heights. The autumn and winter months have the greatest wind resource while the summer has the lowest wind resource. The wind resource at this site is extremely seasonal, with the average wind speed varying by a factor of two between the lowest and highest wind

speed months. As expected the wind speeds increase with increasing height above the ground. However, while there is a significant increase in wind speed going from 10m to 19m, there is only a small increase in wind speed going from 19m to 26m. This increase in wind speed with increasing height is known as shear. The high shear at the lower heights is probably due to surface roughness. Surface roughness (also known as ground clutter) includes things such as trees and buildings. The effects of surface roughness fade as one goes higher above the ground. According to the NREL wind resource expert who assisted with this report, in general the wind shear is low in Alaska up to heights of 30-40 meters.

Speed and Power by Hour

Figure 7 shows the annual average diurnal (daily) profile for the site. In general the winds are highest in the mid afternoon and weakest in the very early morning. As with the graph of the seasonal profiles, the wind speed increases with increasing height. Compared to most other sites examined by this author, the diurnal profile at this site is fairly weak. The general shape of the diurnal profile is the same at all three heights. It is possible that the diurnal profile may shift (i.e. the peak may move to different time of day) at heights greater than 26m.

Frequency and Speed by Direction

Both Figure 8A and 8B show the prevailing & energetic winds coming from the ENE and the SSW. Figure 8B shows how on an energy basis the winds from these two directions supply dominate. There results assume that thee is no offset on the direction data (i.e. the notch on the direction vane was set due north).

Figures 9A and 9B show prevailing and energy roses for each month. In general the ENE winds predominate in the summer and early fall, while the SSW winds predominate from late fall through spring. The one notable exception to this pattern is January where the predominant winds are from the ENE.

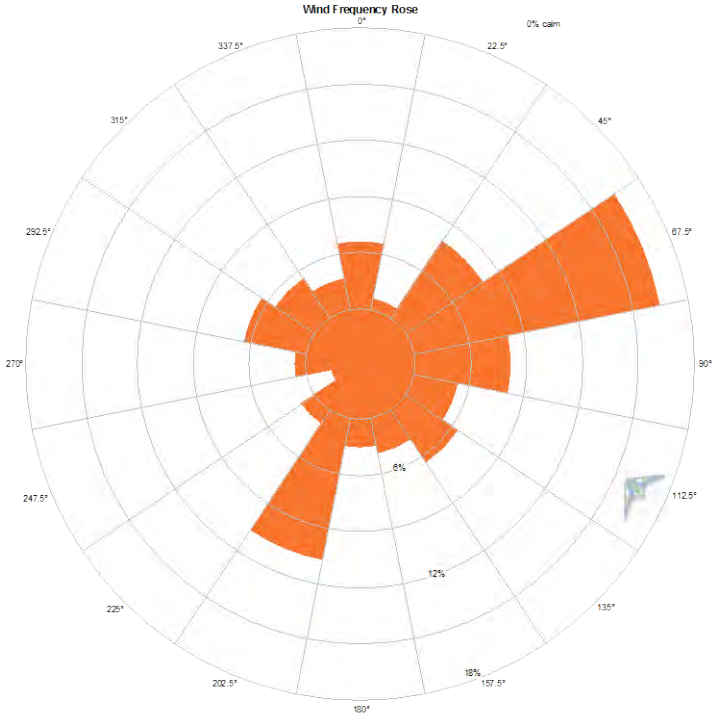


Figure 8A: Frequency by direction.

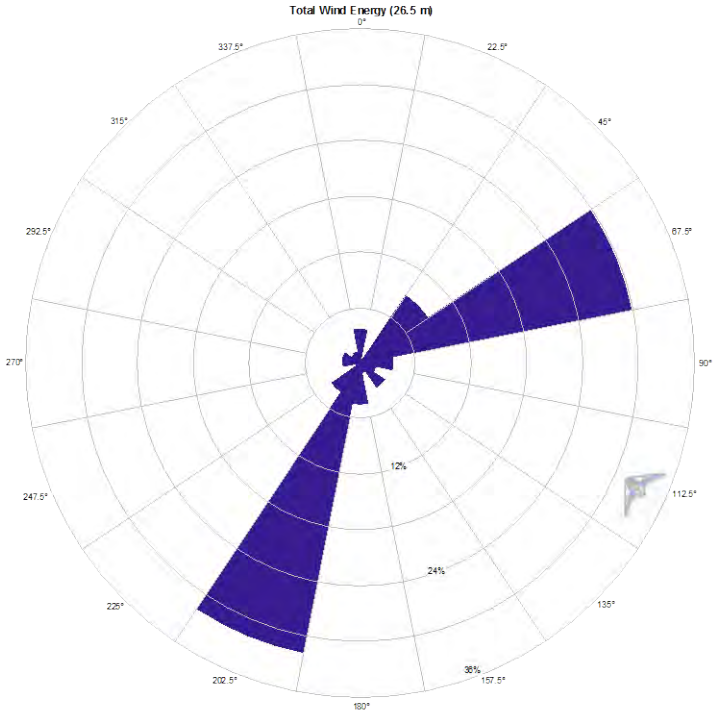


Figure 8B: Energy by direction.

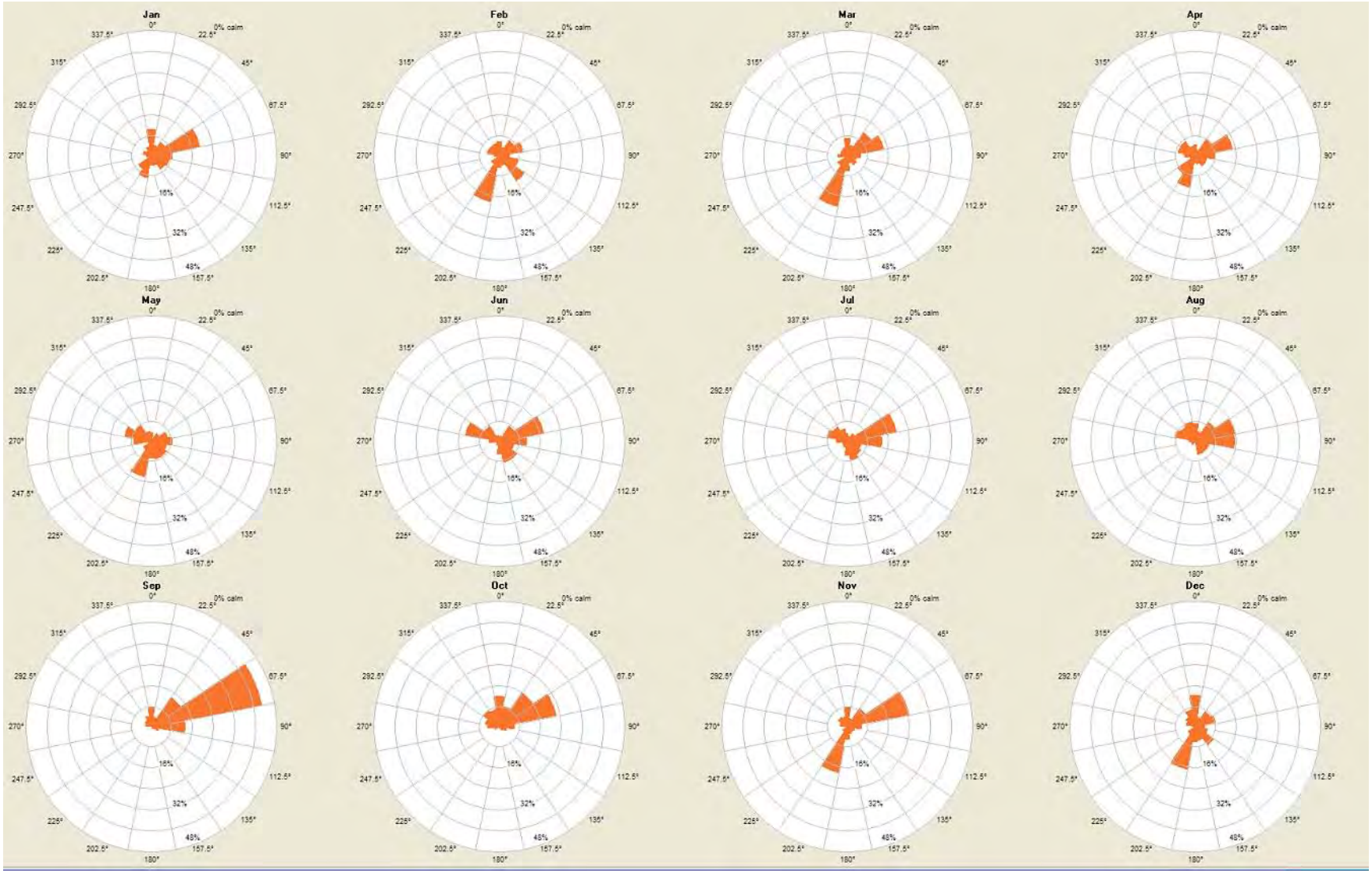


Figure 9A: Frequency by direction (monthly)

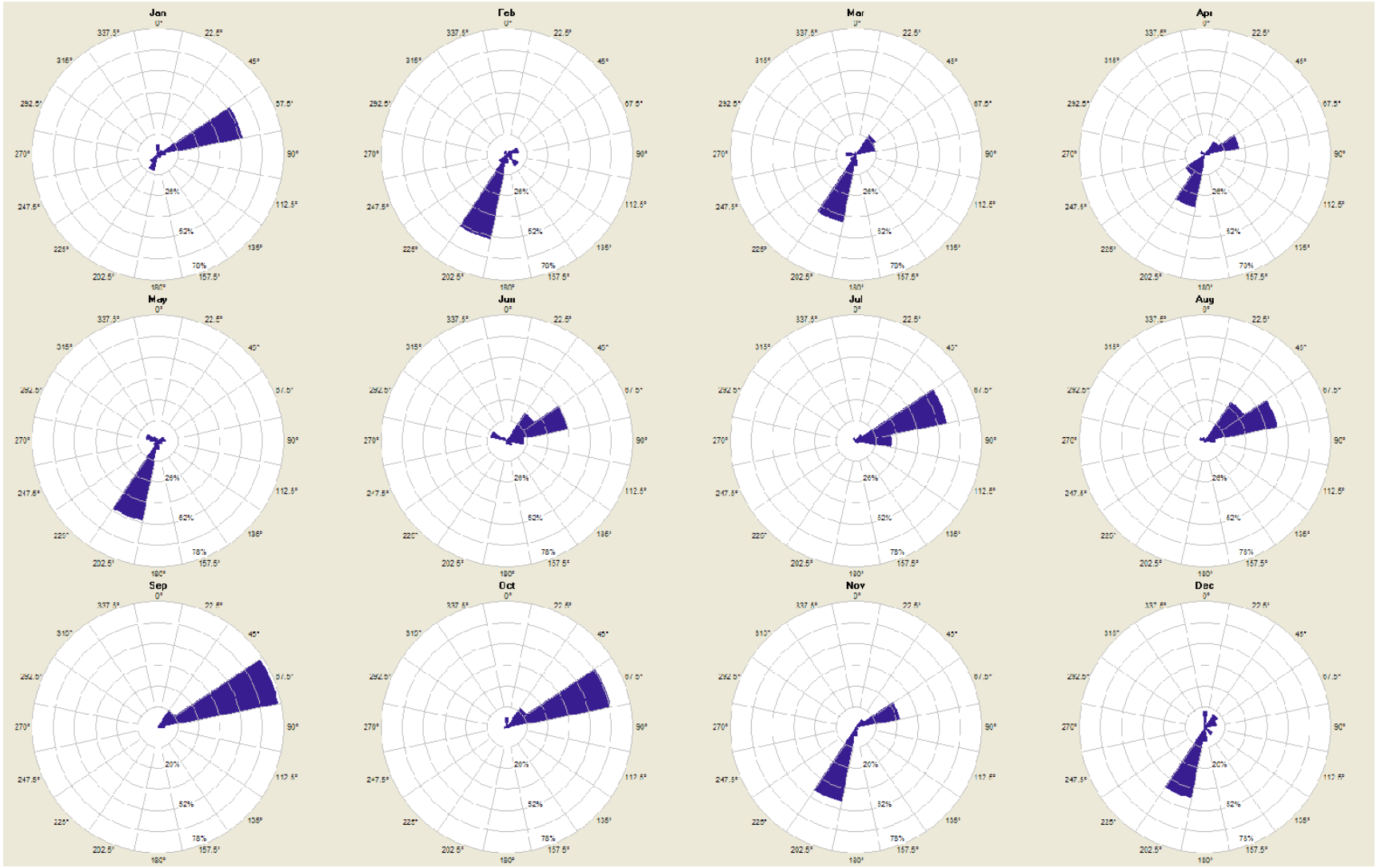


Figure 9B: Energy by direction (monthly)

Turbulence Intensity

Figure 10A shows the representative and mean turbulence intensities (TI) as a function of wind speed (@ 26m AGL). Turbulence intensity is akin to gustiness. The winds at this site are very turbulent. This could be due to the local & regional topography or by ground clutter near the monitoring site. For wind turbines high turbulence is unfortunate. High turbulence reduces wind turbine energy production and increases wear and tear (and thus operations and maintenance costs)

Figure 10B shows the turbulence by direction (again at 26m AGL). Comparison of Figure 10B with Figures 8A and 8B reveals that the winds from the predominant directions are the most turbulent winds.

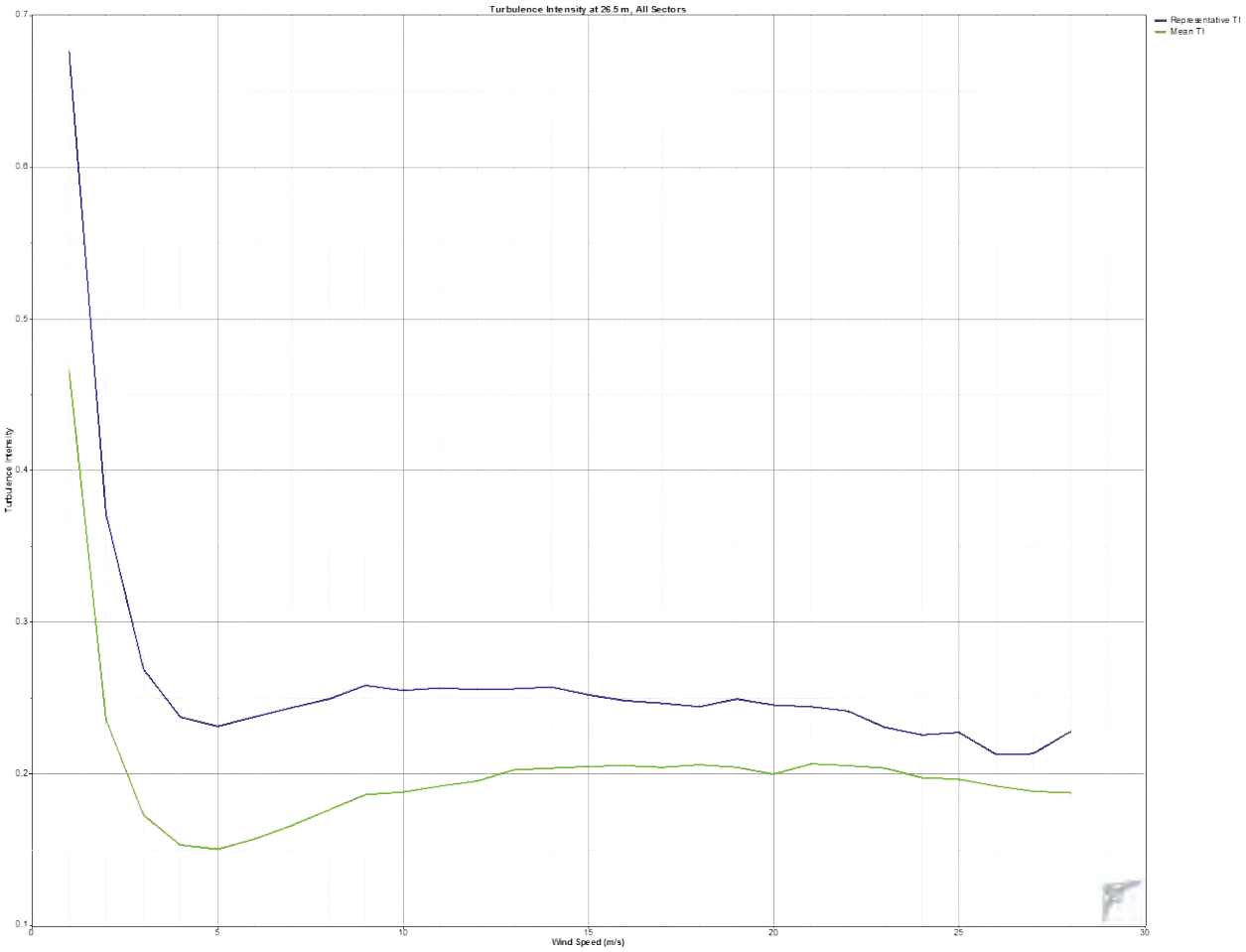


Figure 10A: Representative and Mean Turbulence Intensity versus Wind Speed – 26m

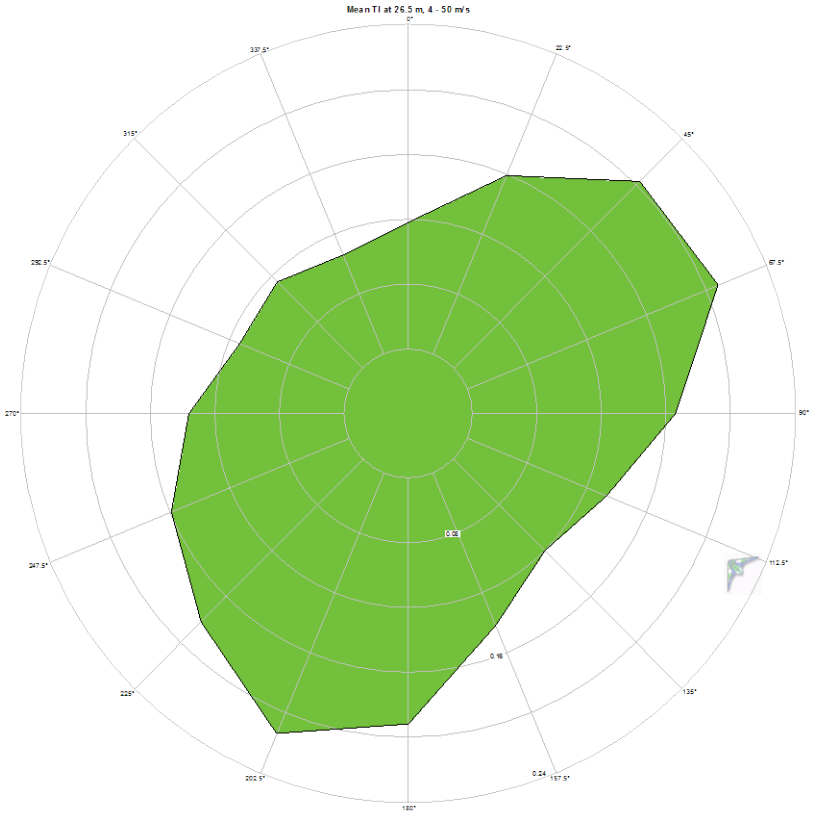


Figure 10B: Mean Turbulence Intensity versus direction (Wind speeds < 4 m/s filtered out)

Wind Shear

Figures 11A and 11B show two wind shear profiles for the site. The wind shear profile shows how the average wind speed changes with height. Each figure shows two profiles, one using the power law (commonly used in North America), the other profile uses the log law (commonly used in Europe). The profile in Figure 11A is the best fit profile using the data from all three heights. This profile has a very high shear factor (alpha) of 0.44. Figure 11B shows the best fit profiles using just the 19m and 26m heights. This profile has a much lower shear factor of 0.13. This issue is important because it bears on the wind resource as one goes above 26m AGL. The measured wind resource at 19 and 26 meters is usable, but not great. Using a shear factor of 0.44 gives an estimated 50m average wind speed of 8.1 m/s, a truly fantastic resource. Using the lower shear factor of 0.13 gives an estimated 50m average wind speed of 6.8 m/s, a much smaller wind resource. **Most likely 0.13 more closely matches the shear factor above 26m AGL and more accurately predicts the wind resource at heights greater than 26m AGL.** Typical shear values range from 0.1 to 0.3. The value of 0.44 for the shear between 11m and 19m is probably caused caused by ground clutter (trees) around the tower.

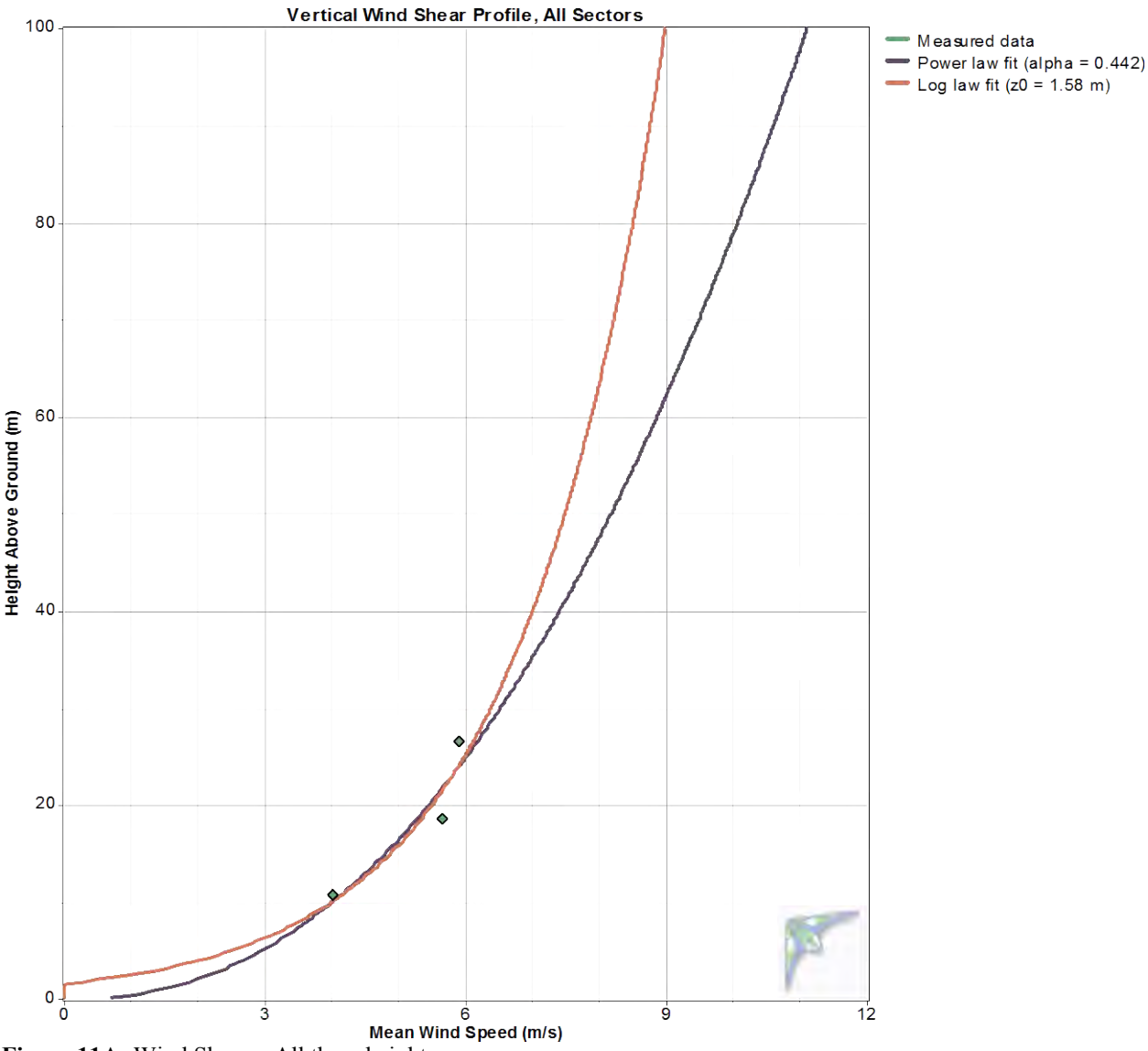


Figure 11A: Wind Shear – All three heights

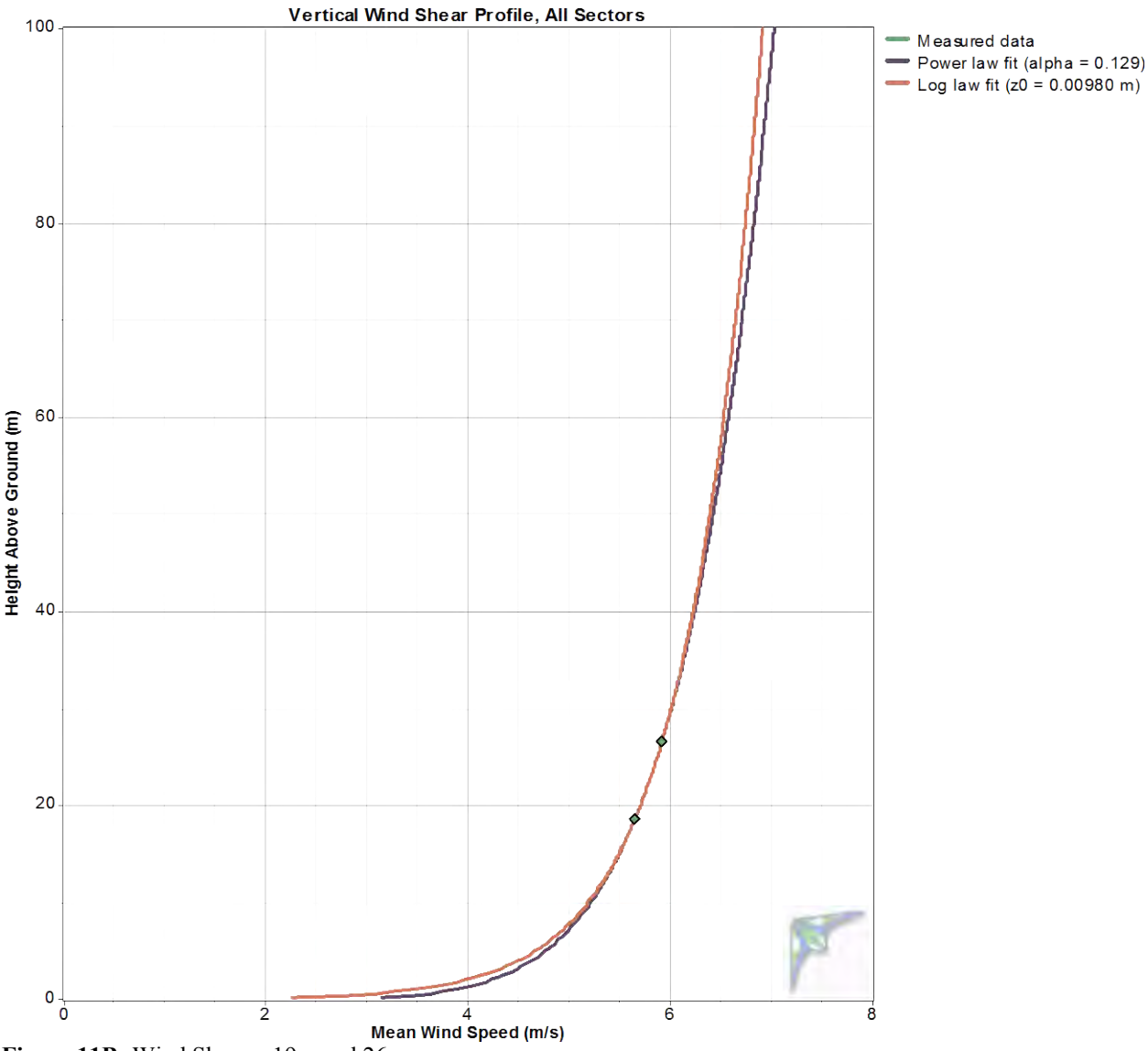


Figure 11B: Wind Shear – 19m and 26m

Frequency of Speed and Percent of Power by Speed

Figure 12 shows the annual frequency distribution of wind speed and power density at 26m AGL. The line labeled PCTs shows the fraction of time that the wind falls within the specified bin. The line labeled PCTp shows the fraction of total annual energy contributed by winds of the indicated wind speed bin. On an annual basis, while over half of the time the wind speed is between 1 m/s and 6 m/s (61%), over half of the wind energy is from winds with wind speeds from 7 to 15 m/s (55%). (See Appendix B).

The best fit weibull distribution parameters for the measured data are k = 1.5 and c = 6.6. The k value indicates how widely the winds are distributed. The weibull k is a bit on the low side because the winds at this site are heavily influenced by terrain and because the winds are often storm driven.

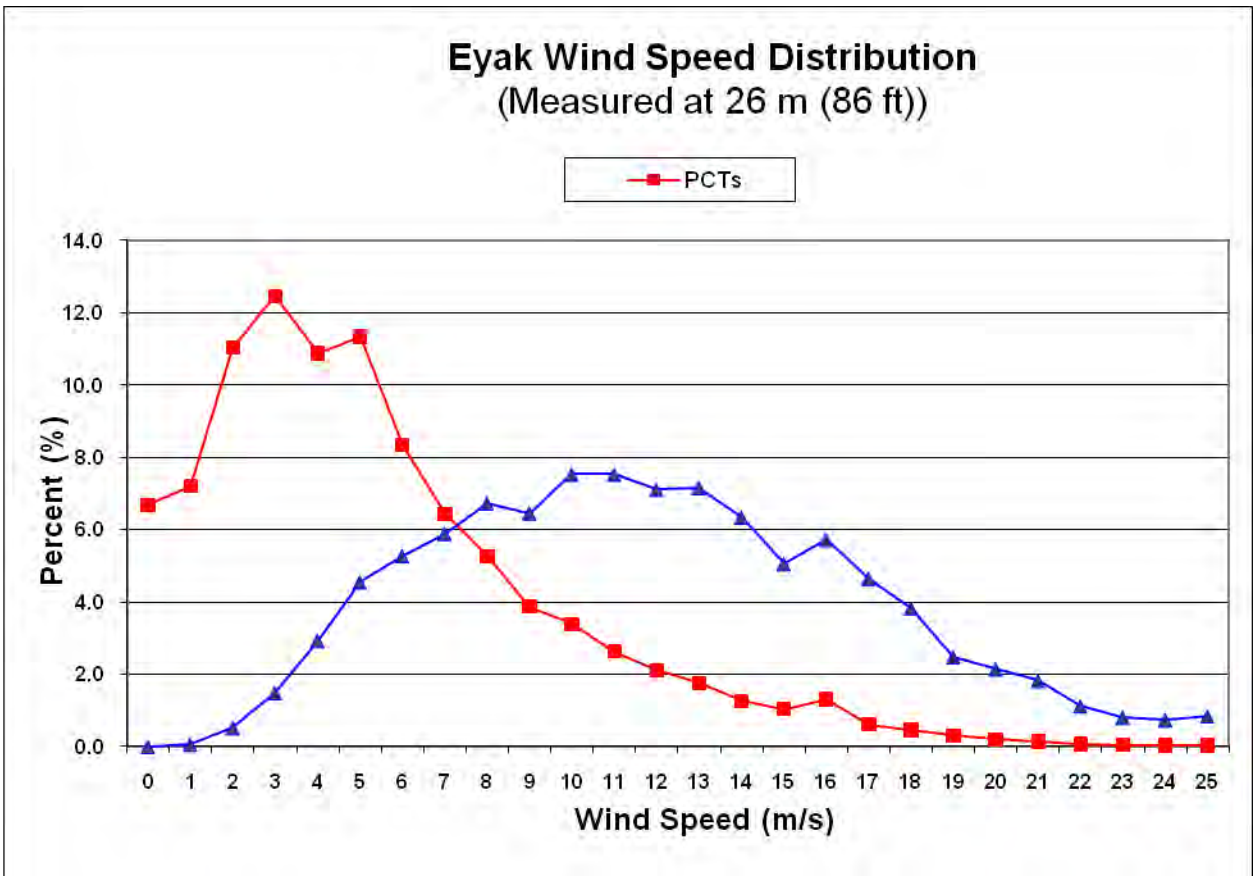


Figure 12: Annual wind and wind energy distribution.

Comparison of anemometer data with long term average data
An important consideration is the closeness with which the measured data reflects the long-term (multi-year) average wind resource. In other words, does the monitoring period data reflect a good year, a bad year or an average year? To answer this question long term data from a nearby reference site, Environmental Buoy 46060, was examined. For this site the multi year average wind speed was compared to the wind speed during the monitoring period. The results are given in the table below.

Figure 13 shows the monitoring period average wind speed compared to the long-term mean wind speed at the reference site. Note that reference site data was not available for 2009. Thus this analysis is limited to the monitoring period through December 2008. For the environmental buoy, the monitoring period data average wind speed is slightly greater than the long term average wind speed. Not much more can be said at this point. The correlation between the wind resource at the monitoring location and the reference site is unknown. All that can be said is that there is evidence that the winds during the first half of the monitoring period don't appear to be too far from the long term average.

	Lat	Long	Monitoring Period (Thru Dec 2008)	Long Term	Ratio
Valdez, AK	61.12	146.33	1.77	1.91	0.93
Environmental Buoy 46060	60.60	146.68	5.84	5.66	1.03
Monitoring Site	60.47	145.95			

Figure 13: Long term versus monitoring period wind data for reference stations.

Appendix A: Wind Data in Tabular Form

Table A1: Monthly average and annual average wind power density and wind speed. (26m AGL)

Month	Wind Speed (monitoring site) (m/s)	Wind Power (monitoring site) (W/m^2)
Jan	6.3	431
Feb	6.5	470
Mar	6.8	477
Apr	5.2	203
May	5.5	218
Jun	4.4	116
Jul	4.7	182
Aug	4.0	112
Sep	7.1	474
Oct	5.9	364
Nov	8.2	714
Dec	6.2	396
Average	5.9	346

Table A2: Average annual daily wind profile.

Hour	Wind Speed (m/s)	Wind Power (W/m^2)
1	5.7	333
2	5.8	314
3	5.7	316
4	5.7	321
5	5.8	321
6	5.7	313
7	5.7	323
8	5.7	324
9	5.7	328
10	5.7	330
11	5.8	331
12	5.9	351
13	6.0	359
14	6.0	369
15	6.2	372
16	6.3	382
17	6.3	389
18	6.2	379
19	6.2	369
20	5.9	347
21	5.9	346
22	5.8	330
23	5.8	340
24	5.8	340

Table A3: Frequency and Energy by direction.

	F%	%Pwr
Calm	6.7	
22.5	1.5	0.7
45	4.3	14.6
67.5	7.7	26.9
90	3.3	3.4
112.5	2.3	2.6
135	2.3	3.1
157.5	2.1	2.0
180	1.5	2.8
202.5	4.7	31.5
225	0.7	0.6
247.5	0.5	0.7
270	1.0	1.4
292.5	2.8	2.9
315	2.2	1.3
337.5	2.0	1.6
360	3.0	4.1

Table A4: Annual wind and wind energy distribution.

Wind Speed (m/s)	PCTs	PCTp
0	6.7	0.0
1	7.2	0.1
2	11.0	0.5
3	12.5	1.5
4	10.9	2.9
5	11.3	4.6
6	8.3	5.3
7	6.4	5.9
8	5.3	6.7
9	3.9	6.5
10	3.4	7.5
11	2.6	7.5
12	2.1	7.1
13	1.8	7.2
14	1.3	6.3
15	1.0	5.1
16	1.3	5.7
17	0.6	4.7
18	0.5	3.8
19	0.3	2.5
20	0.2	2.2
21	0.1	1.8
22	0.1	1.1
23	0.0	0.8
24	0.0	0.7
25	0.0	0.9

Interpretation of the Wind Data Charts

Introduction

This appendix is a guide to interpreting the wind data charts included in the report. Included are background information and an explanation of the meaning of the data in each chart.

The annual results given in the charts in this appendix will differ somewhat from the results given in the charts in the main body of the report. This is due to differences in how the data is processed. This is best described by using an example. Let us assume that 15 months of data was collected from a site, with the monitoring period running from 1 January 2003 to 31 March 2004. The annual average numbers given in the appendix simply provide the average of all the data collected. However this double counts the months of January, February & March. If these months tend to be windier than the rest of the year, then the wind resource will be over estimated.

The proper procedure is to average together the data from the double counted months before averaging the data to create annual averages. This is what has been done for the charts in the main body of the report.

The reason the software does not do this is that it was really designed to process multiyear data. If 9.5 years of data are processed, having 10 Januarys and 9 Julys creates negligible error. However, with only a little over a year of data, the double counted months can cause noticeable error.

Power Density versus Wind Speed

Wind turbines convert the kinetic energy of moving air into useful mechanical or electrical energy. The power of a column of moving air is given by the equation below.

$$P = 0.5\rho A v^3 \qquad \text{(Equation B - 1)}$$

Where

P	=	power in a column of air (watts)
ρ	=	density of air (kg/m^3) (Roughly ~ 1 kg/m^3)
A	=	cross sectional area of the column of air (m^2)
v	=	velocity of the air (m/s)

Thus the power a wind turbine can extract from the wind is proportional to the cross sectional area of the rotor, the density of the air, and the cube of the wind velocity. At a given location the air density typically doesn't change by more than 10%. Therefore the big variable is the wind speed. Annual average wind turbine production is very sensitive to the annual average wind speed.

A wind turbine cannot extract all the energy from the air stream moving past it. A wind turbine's extraction efficiency typically varies with wind speed. In their range of maximum conversion efficiency most of today's wind turbines extract about 40% - 50 % of the wind's energy.

Power density is simply the power divided by the cross sectional area. Power density is given in units of watts per meter squared. ($watts/m^2$)

$$\text{Power Density} = 0.5\rho v^3 \qquad \text{(Equation B - 2)}$$

The cubic dependence of wind power density upon velocity underscores the importance of accurately characterizing the wind at a given location. A small uncertainty in wind speed translates to a large uncertainty in wind turbine power production. For example a 5% uncertainty in wind speed leads to a 15% uncertainty in power output. The cubic relationship also makes it more difficult to predict the long-term performance of a wind turbine. More information is needed than simply the average wind speed. For example, imagine a location where the wind speed is a constant five meters per second. The average power density of a column of air with a 1m^2 cross section is then 0.5 * 1.0 kg/m^3 * 1.0 m^2 * 5 $(m/s)^3$ = 62.5 watts. Over a year the total energy of that column would be 547.5 kWh (this is found by multiplying the average power density by the number of hours in a year, then dividing by 1000 to convert to kilowatts). Now imagine a location where half the time the wind speed is 3 m/s and the other

half the time the wind speed is 7 m/s. The average wind speed is still 5 m/s but the average power density is now $0.5*1.0*1.0*(3^3 + 7^3)/2 = 92.5$ watts. This leads to an annual energy of 810 kWh.

Power density is listed in many of the graphs below because power density gives a better indication of wind turbine production than does wind speed alone. As can be seen from the graph titled "Speed and Power by Month," power density correlates to wind speed, but doesn't follow wind speed exactly.

Wind Speeds/Wind Directions
These first plots simply show the wind speed and direction for the monitoring period. Good data is shown with a solid line. Bad data is shown with a dotted line.

Speed and Power by Month
This graph gives the average wind speed and average power density for each month. This shows how the wind resource is distributed throughout the year.

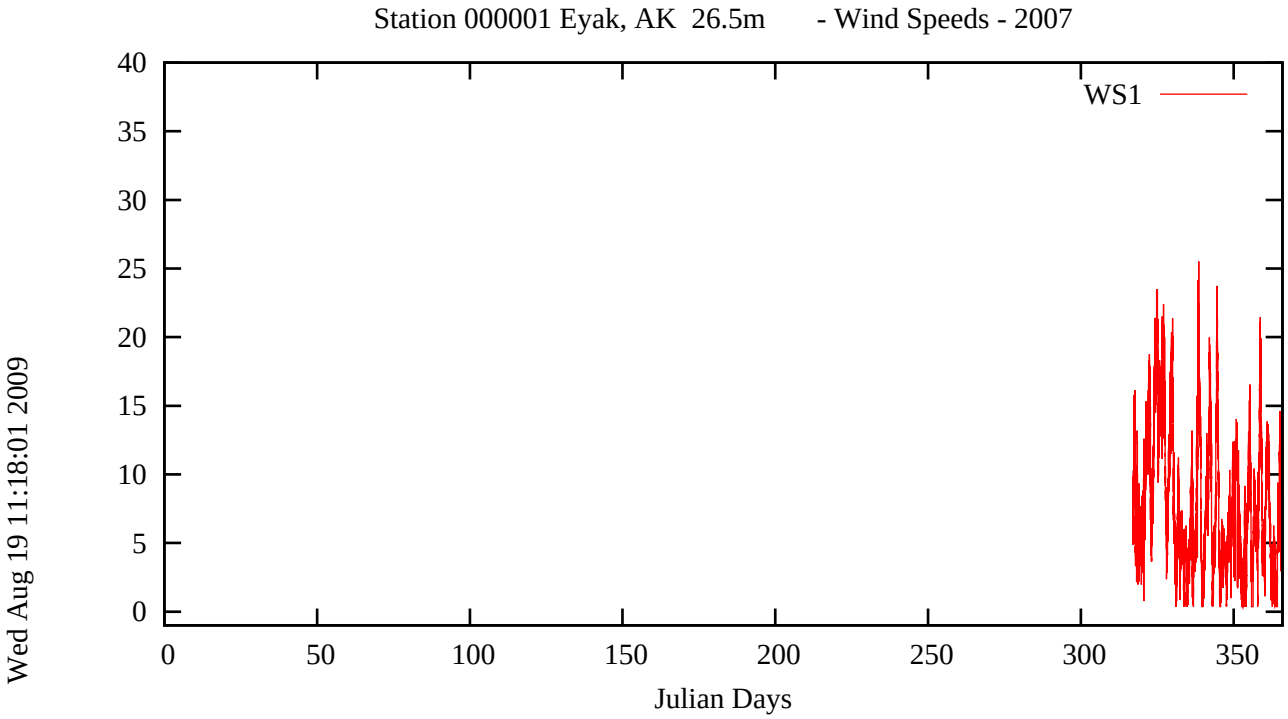
Observations by Month
This graph shows the number of observations for each month. The greater the number of observations, the greater the probability the data is close to the long-term average resource.

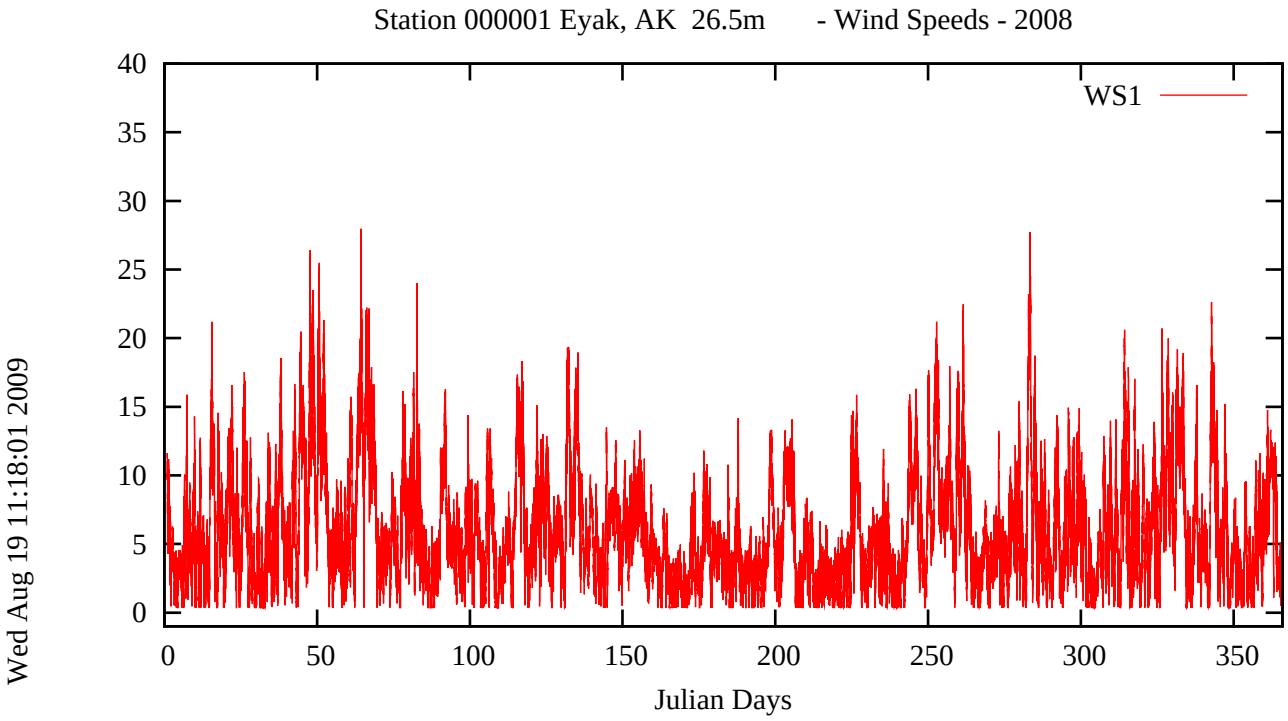
Speed and Power by Hour
The top graph shows how the wind speeds and power densities are distributed by time of day over the whole year. The other 12 graphs show the same thing for each month. On top of each graph is an average wind speed and power density for the period in question.

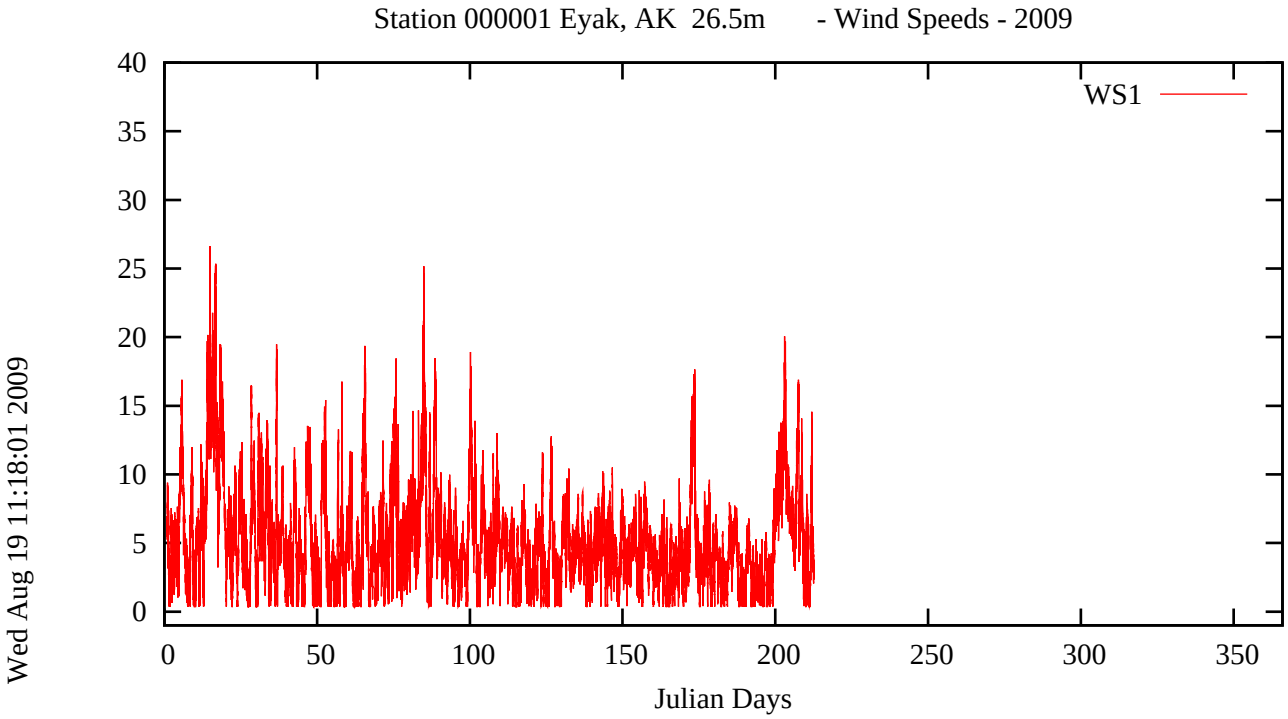
Frequency and Speed by Direction
These graphs show how the winds are distributed by direction. The solid line shows the fraction of time that the wind comes from a particular direction. The dotted line shows the average wind speed of the winds coming from a particular direction. Above each graph the fraction of time that the wind is calm (below 1.0 m/s) is given. These graphs indicate the directions from which the strongest winds come. Special care should be taken to ensure the wind turbines have good exposure to winds from these directions.

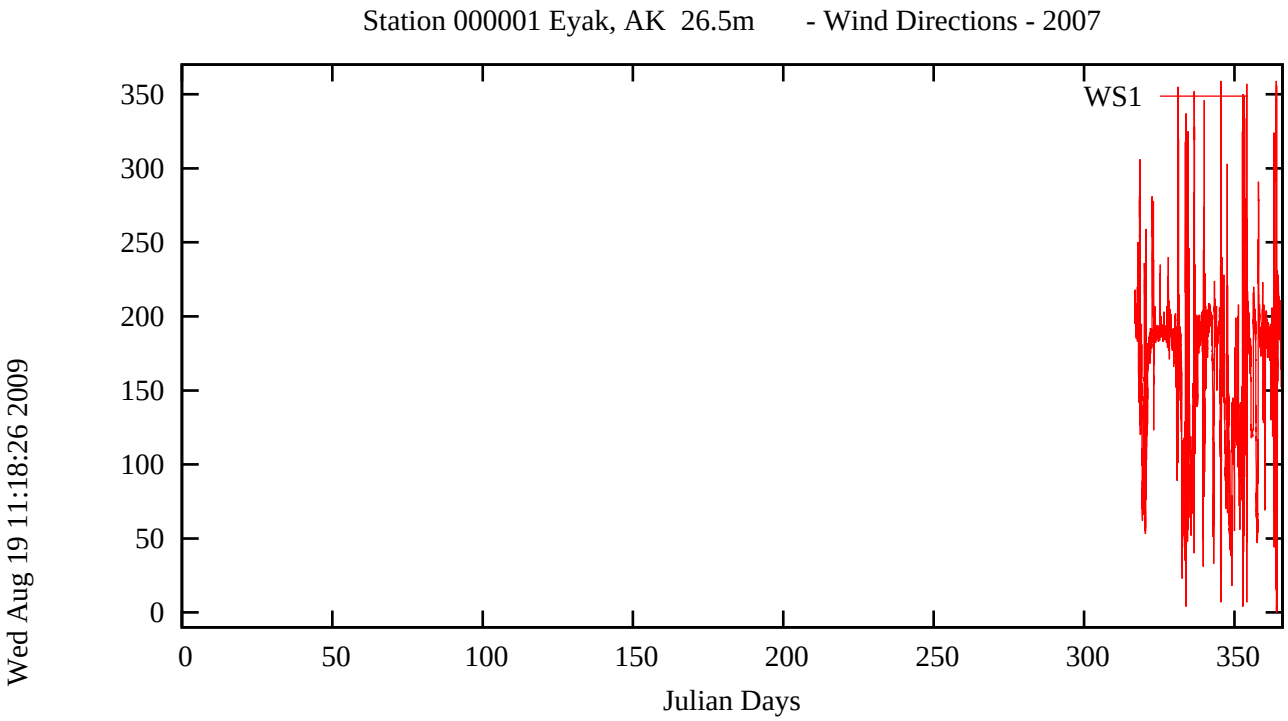
Frequency of Speed and Percent of Power by Speed
These graphs show the distribution of wind speeds and power densities. The solid line indicates the fraction of time that the wind has a particular velocity. The solid line indicates the fraction of the total wind power contributed by winds at each wind speed.

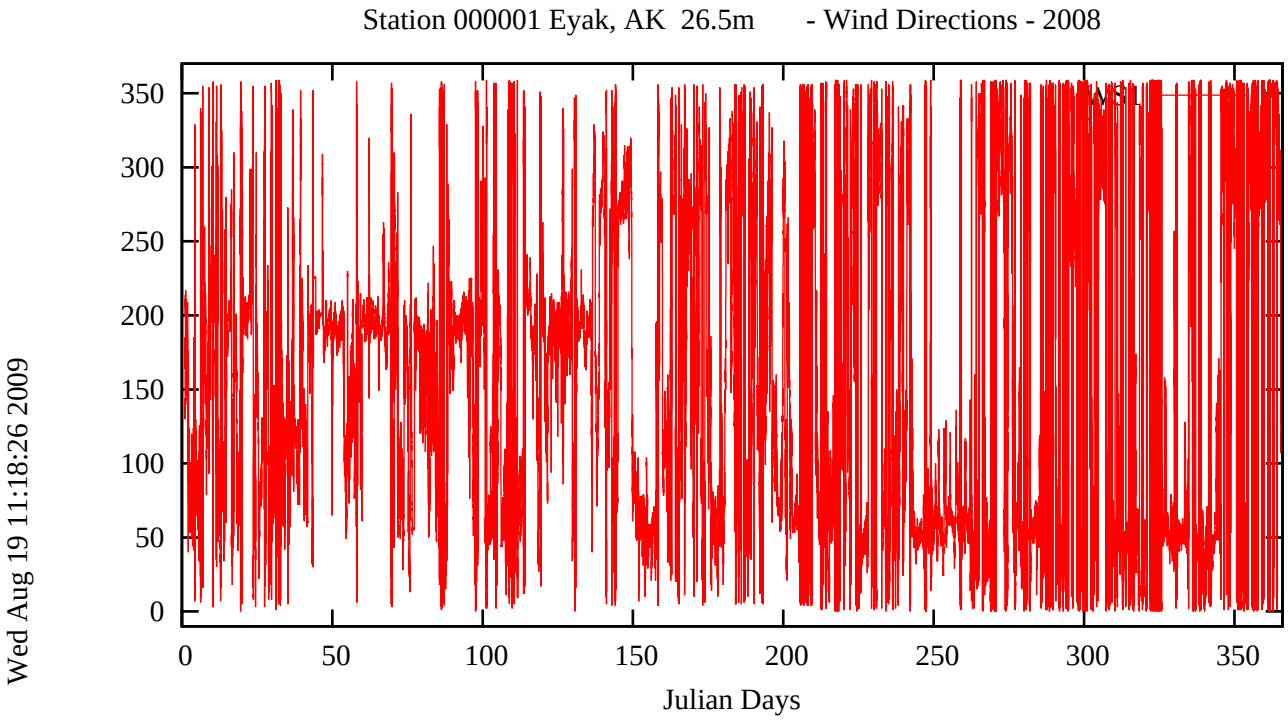
Appendix C: Wind Data Graphs
NREL Software Package

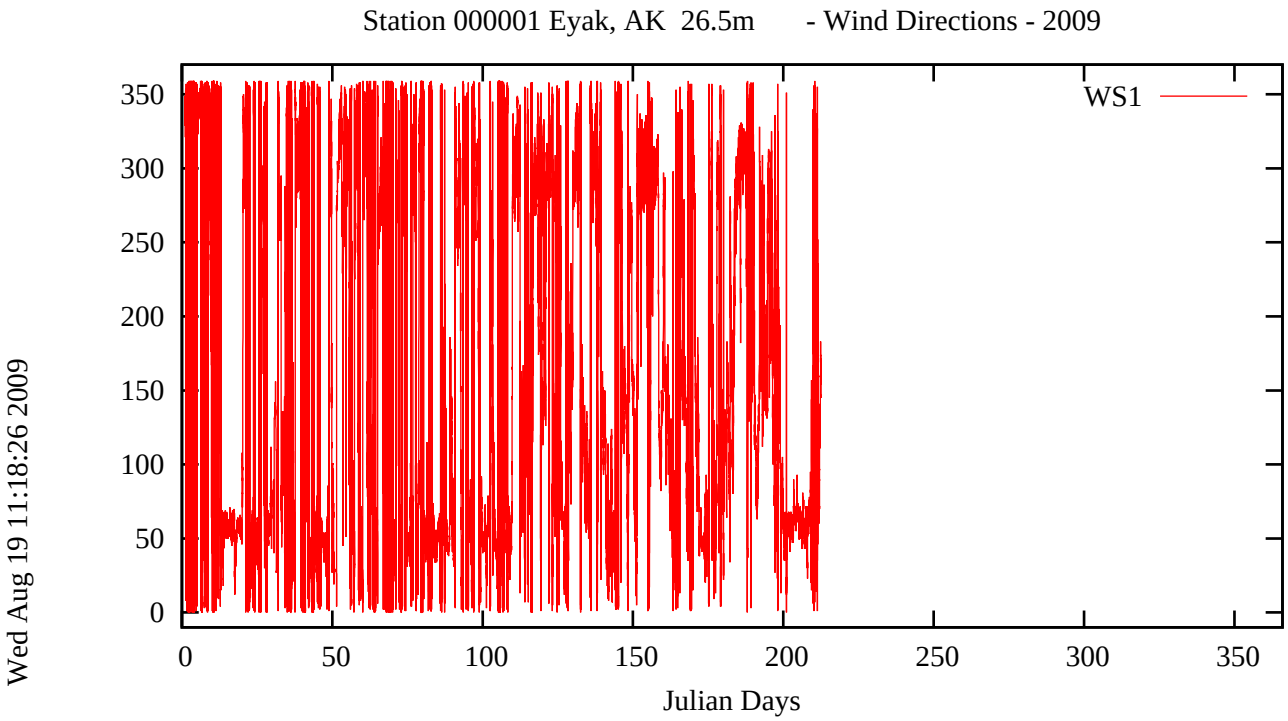

Station 000001 Eyak, AK 26.5m - Wind Speeds - 2007
WS1
Wed Aug 19 11:18:01 2009
Julian Days
0
5
10
15
20
25
30
35
40
0
50
100
150
200
250
300
350

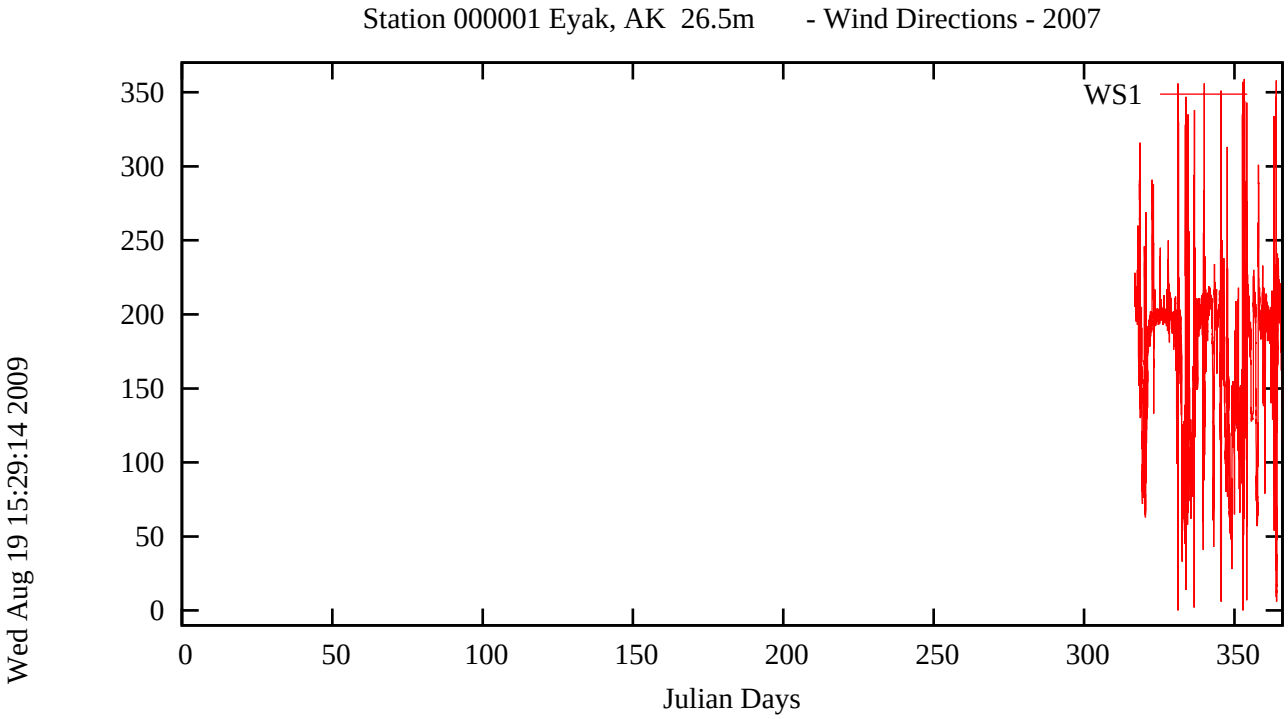

Station 000001 Eyak, AK 26.5m - Wind Speeds - 2008
WS1
Wed Aug 19 11:18:01 2009
Julian Days
0
5
10
15
20
25
30
35
40
0
50
100
150
200
250
300
350

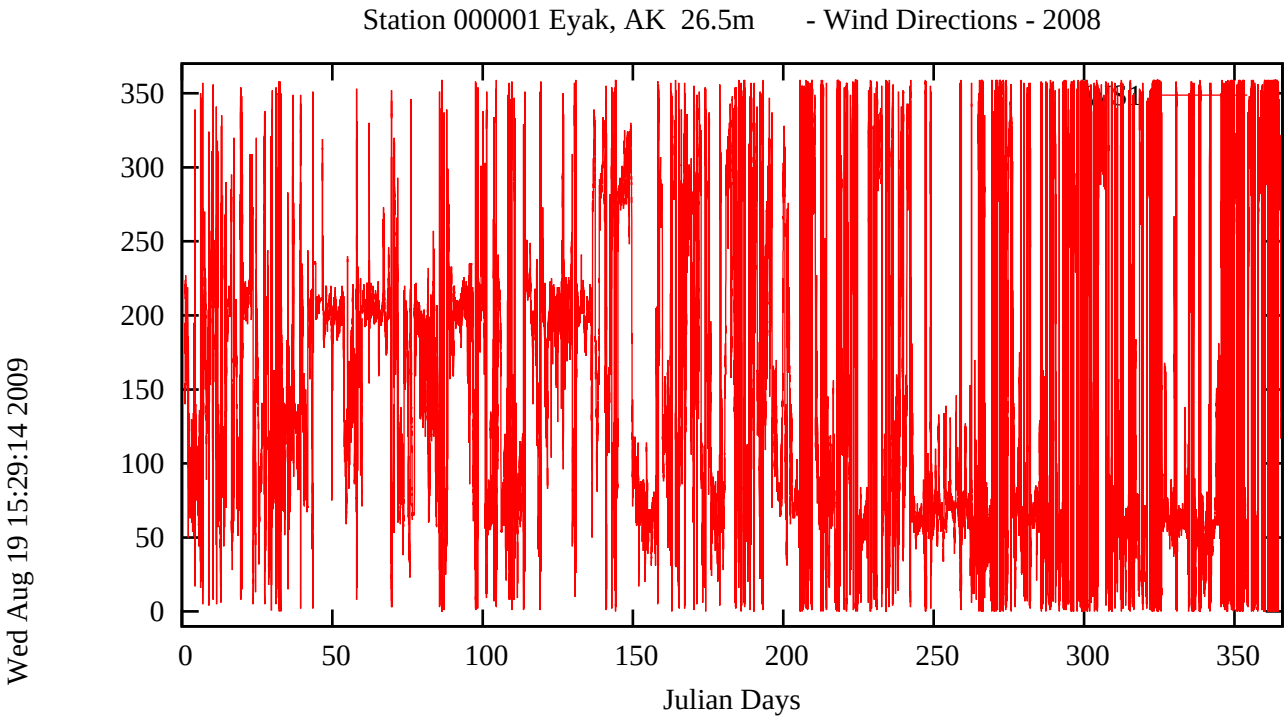

Station 000001 Eyak, AK 26.5m - Wind Speeds - 2009
WS1
Wed Aug 19 11:18:01 2009
Julian Days
0
5
10
15
20
25
30
35
40
0
50
100
150
200
250
300
350

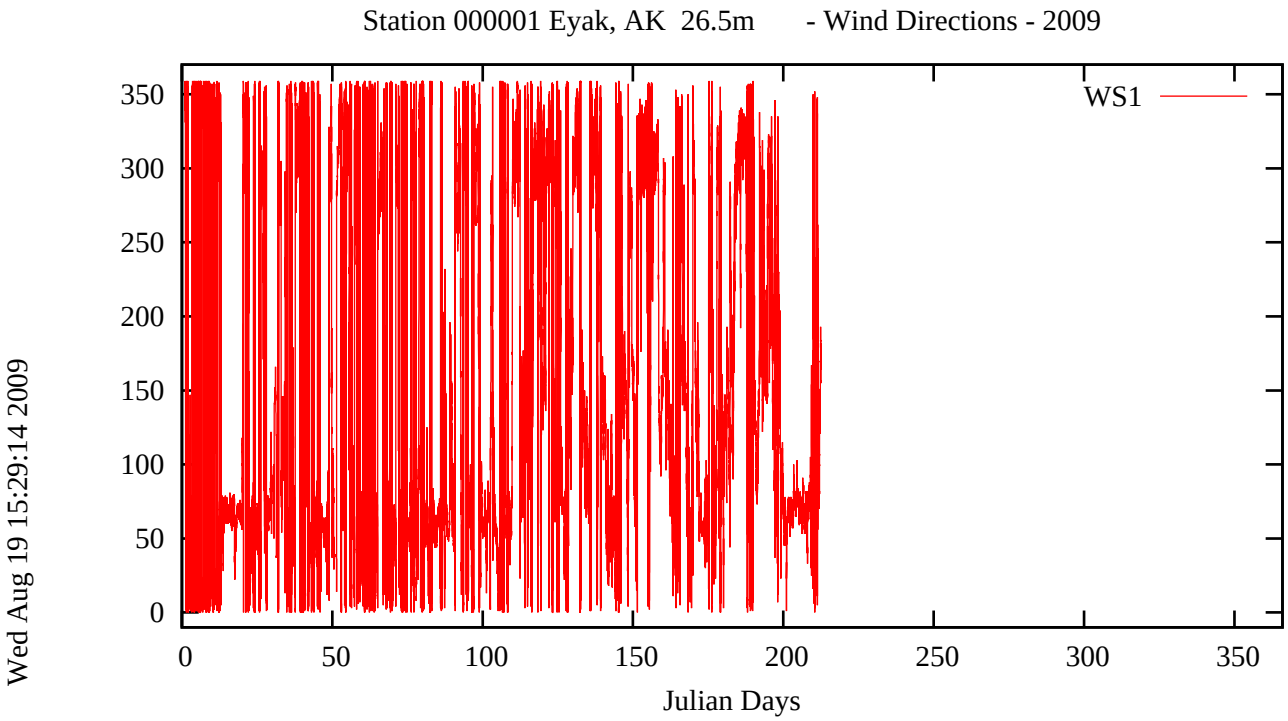

Station 000001 Eyak, AK 26.5m - Wind Directions - 2007
WS1
Wed Aug 19 11:18:26 2009
Julian Days
0
50
100
150
200
250
300
350


Station 000001 Eyak, AK 26.5m - Wind Directions - 2008
WS1
Wed Aug 19 11:18:26 2009
Julian Days
0
50
100
150
200
250
300
350


Station 000001 Eyak, AK 26.5m - Wind Directions - 2009
WS1
Wed Aug 19 11:18:26 2009
Julian Days
0
50
100
150
200
250
300
350

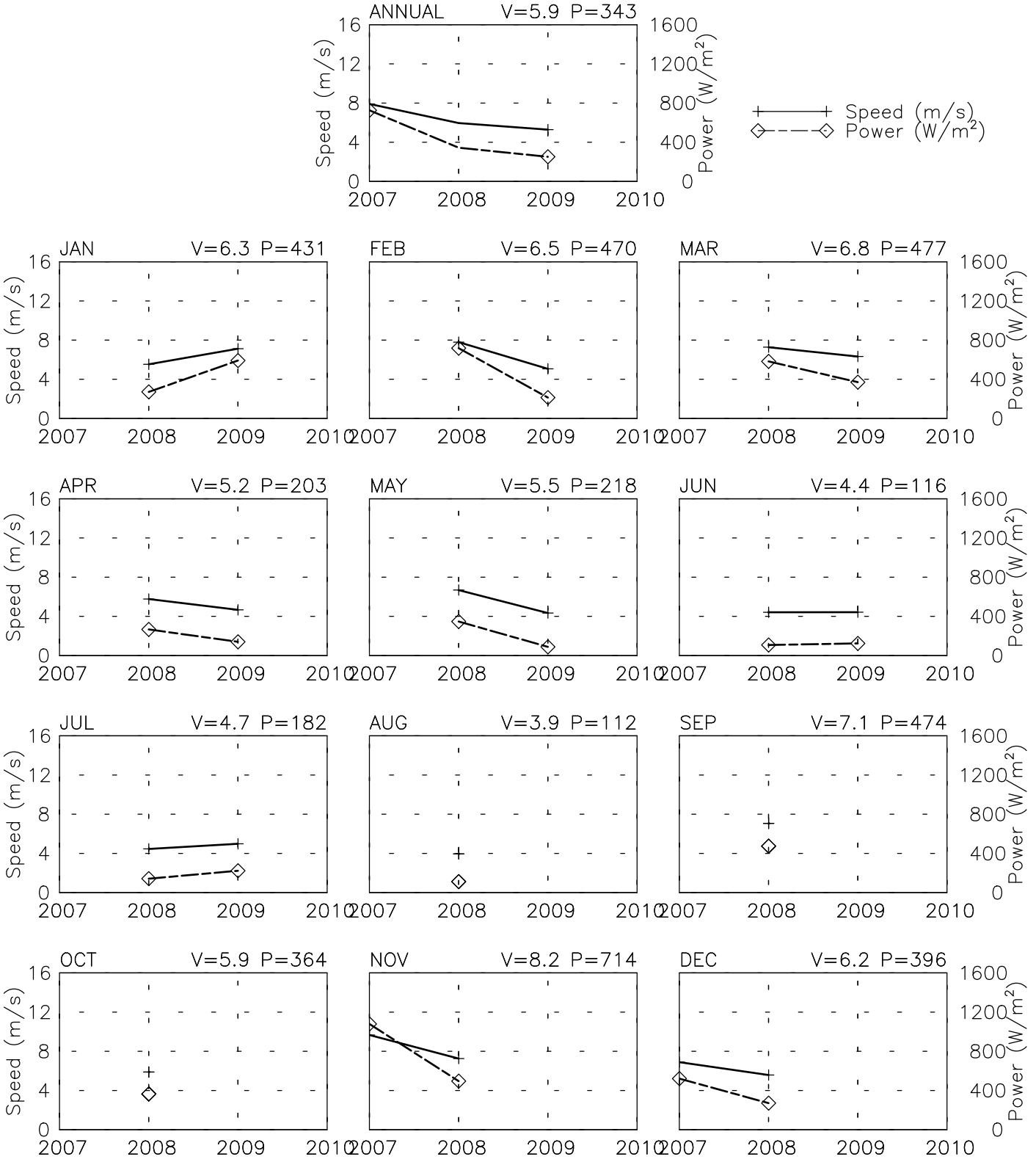

Station 000001 Eyak, AK 26.5m - Wind Directions - 2007
WS1
350
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
Julian Days
Wed Aug 19 15:29:14 2009


Station 000001 Eyak, AK 26.5m - Wind Directions - 2008
WS1
350
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
Julian Days
Wed Aug 19 15:29:14 2009


Station 000001 Eyak, AK 26.5m - Wind Directions - 2009
WS1
Wed Aug 19 15:29:14 2009
Julian Days
0
50
100
150
200
250
300
350

SPEED AND POWER BY YEAR

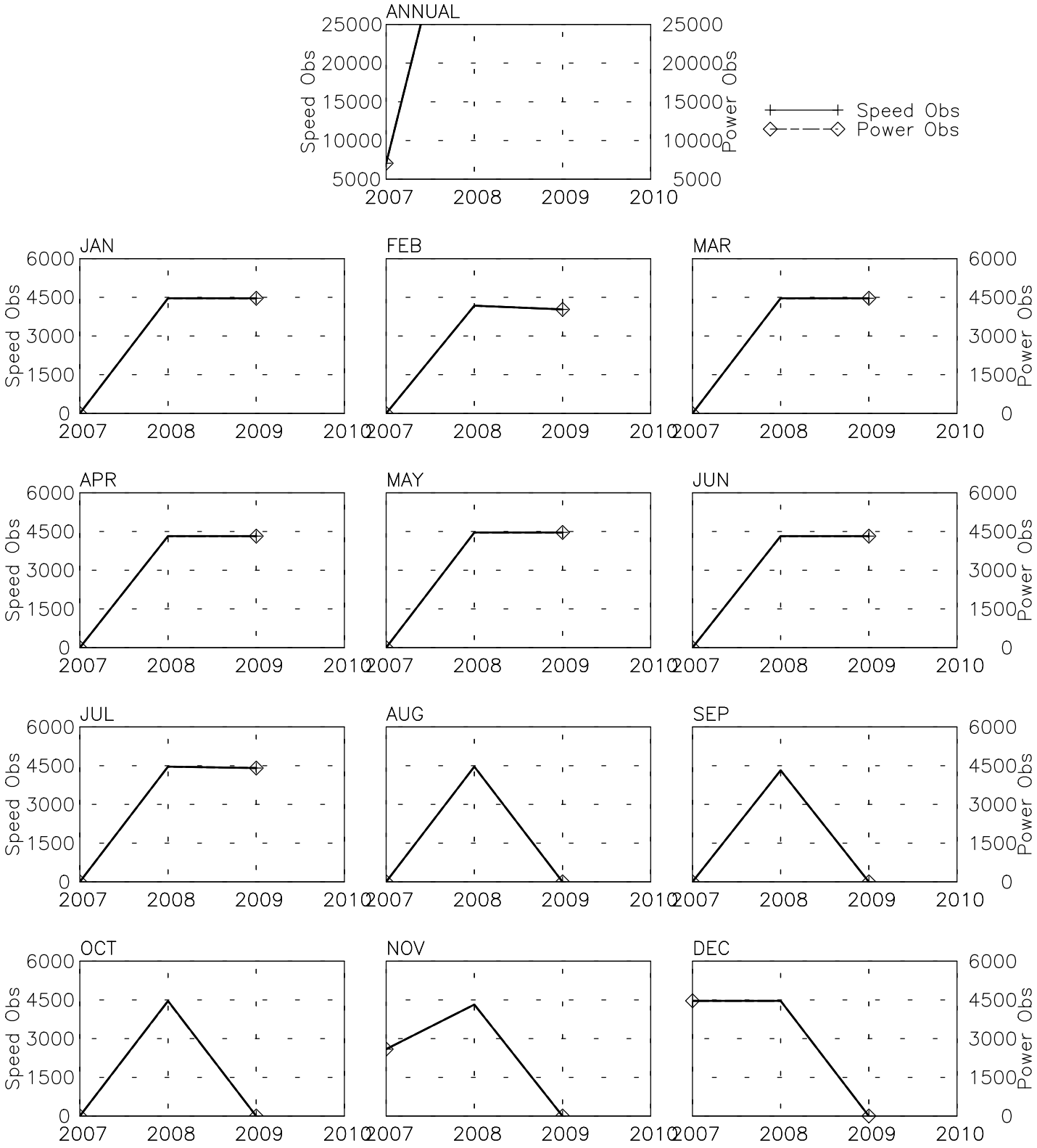
Eyak, AK 26.5m – 000001
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:33:53 2009

OBSERVATIONS BY YEAR

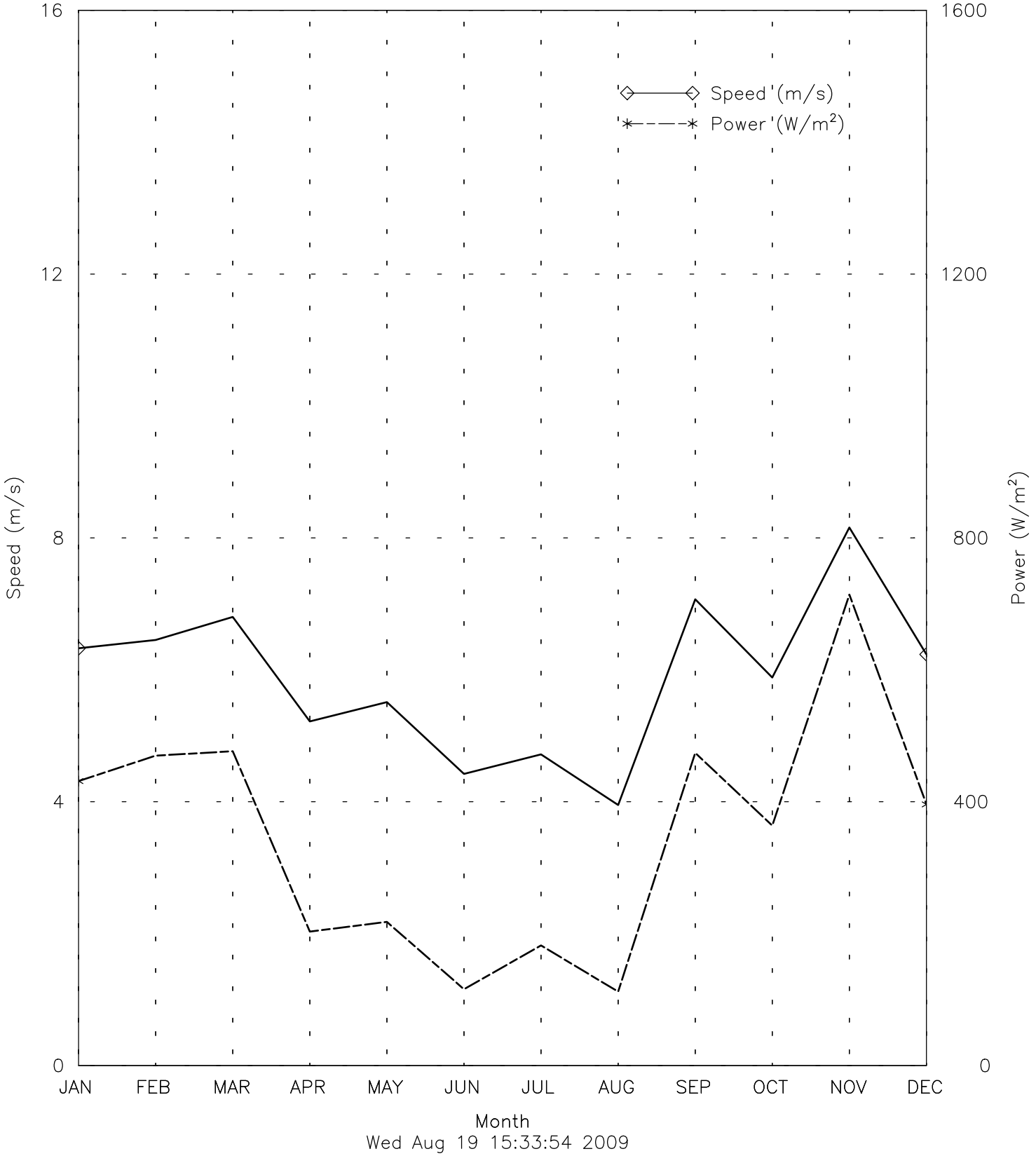
Eyak, AK 26.5m – 000001
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:33:53 2009

SPEED AND POWER BY MONTH

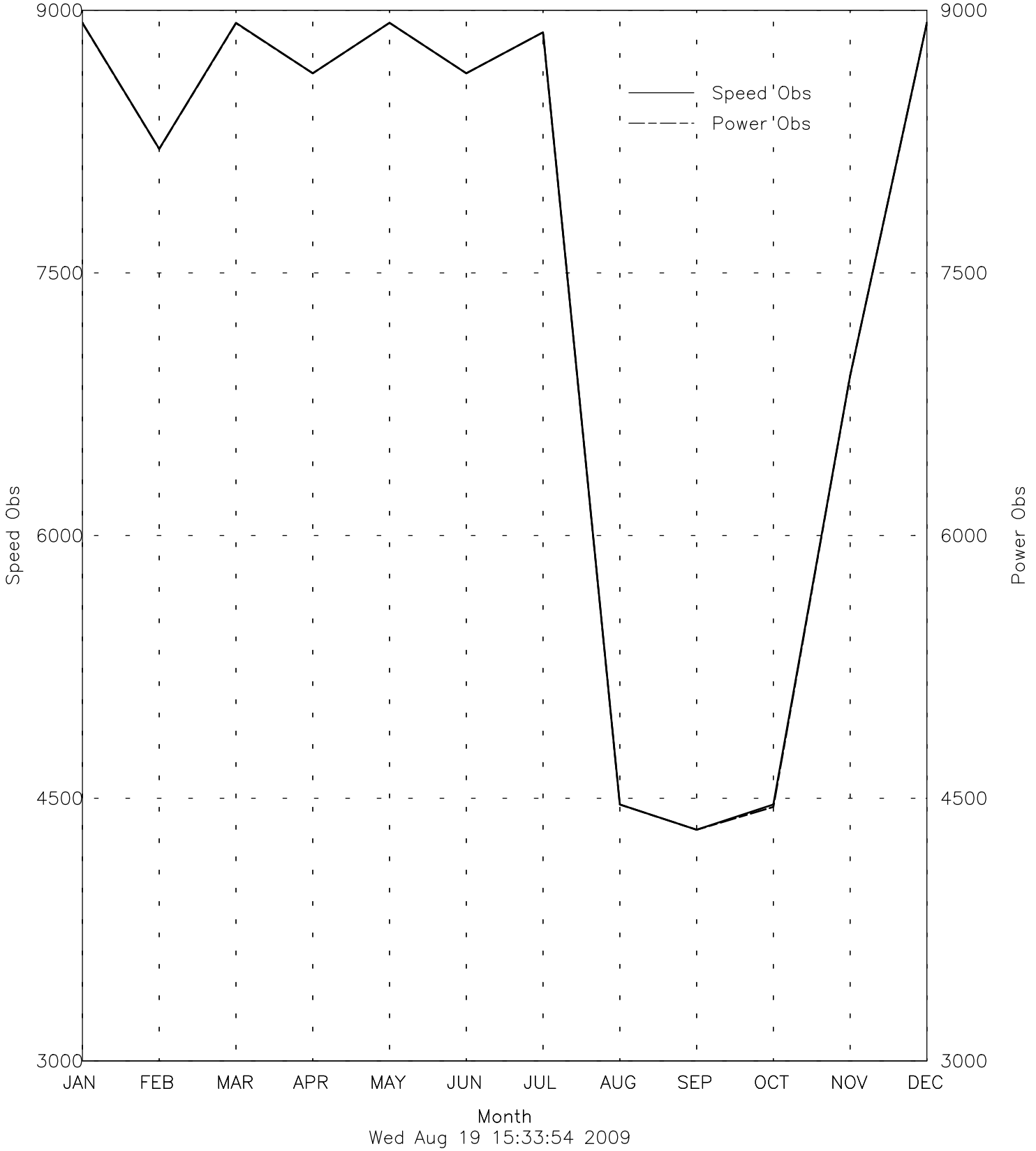
Eyak, AK 26.5m – 000001
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:33:54 2009

OBSERVATIONS BY MONTH

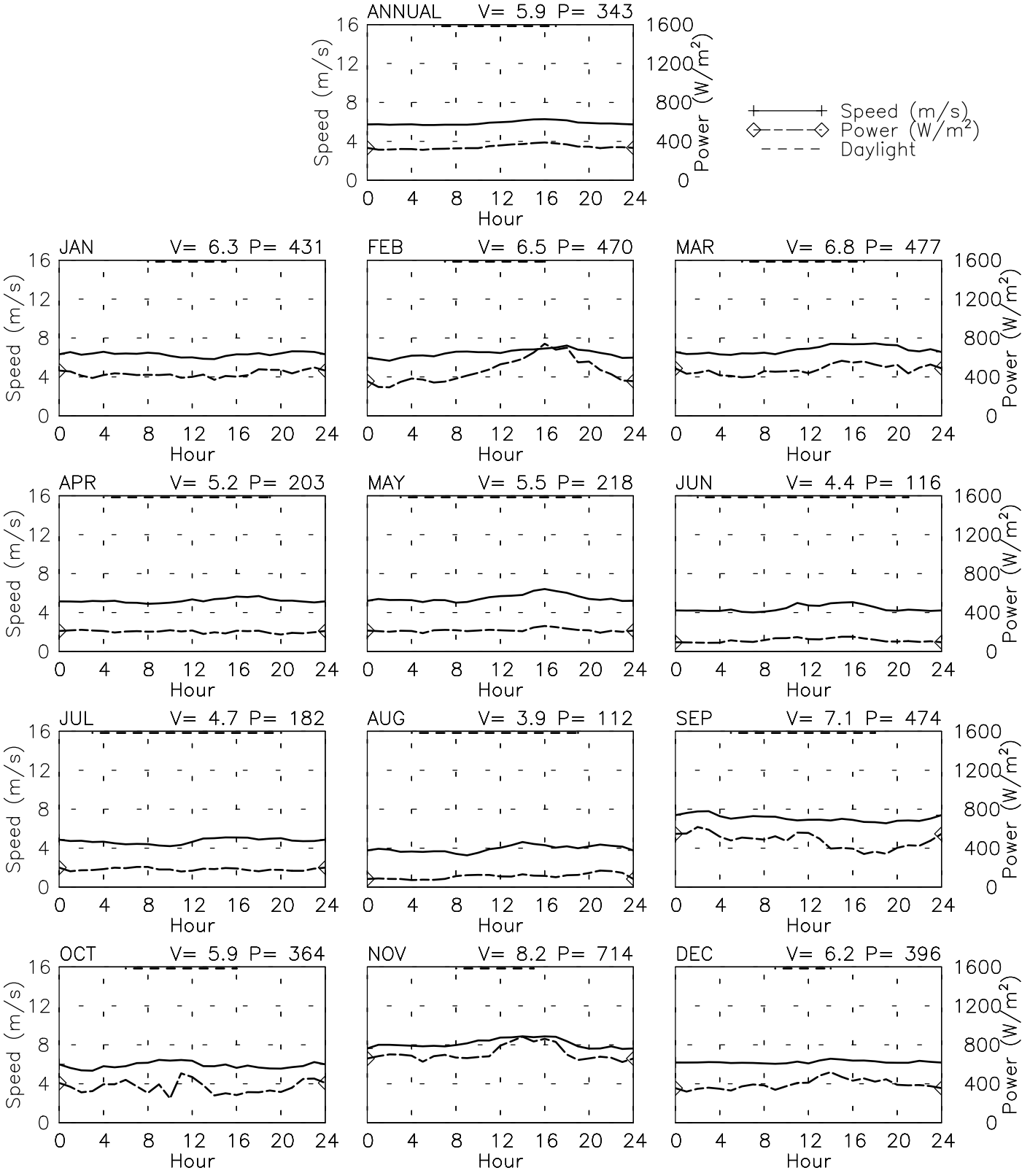
Eyak, AK 26.5m – 000001
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:33:54 2009

SPEED AND POWER BY HOUR

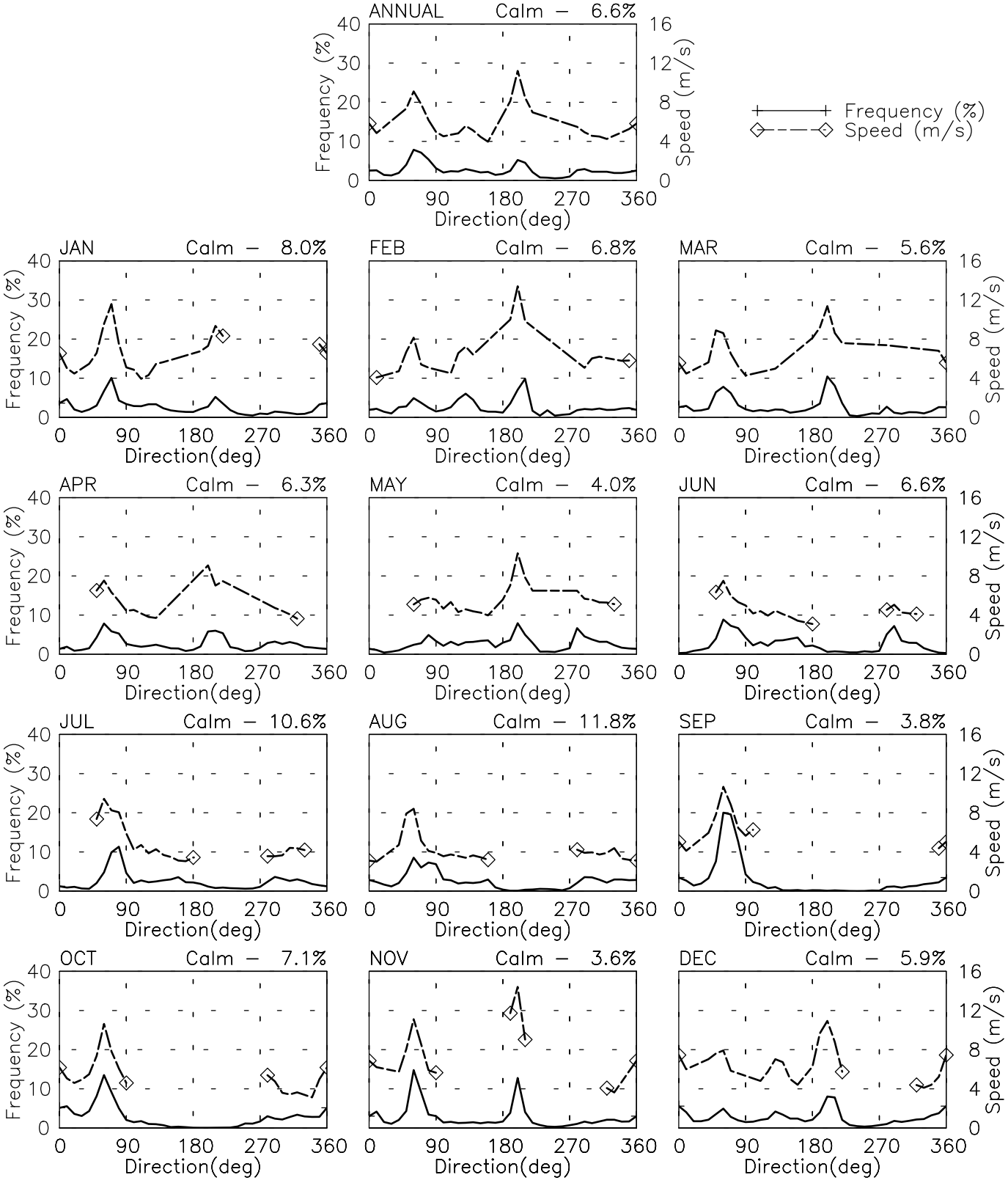
Eyak, AK 26.5m – 000001
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=−10
11/07–07/09



Wed Aug 19 15:33:54 2009

FREQUENCY AND SPEED BY DIRECTION

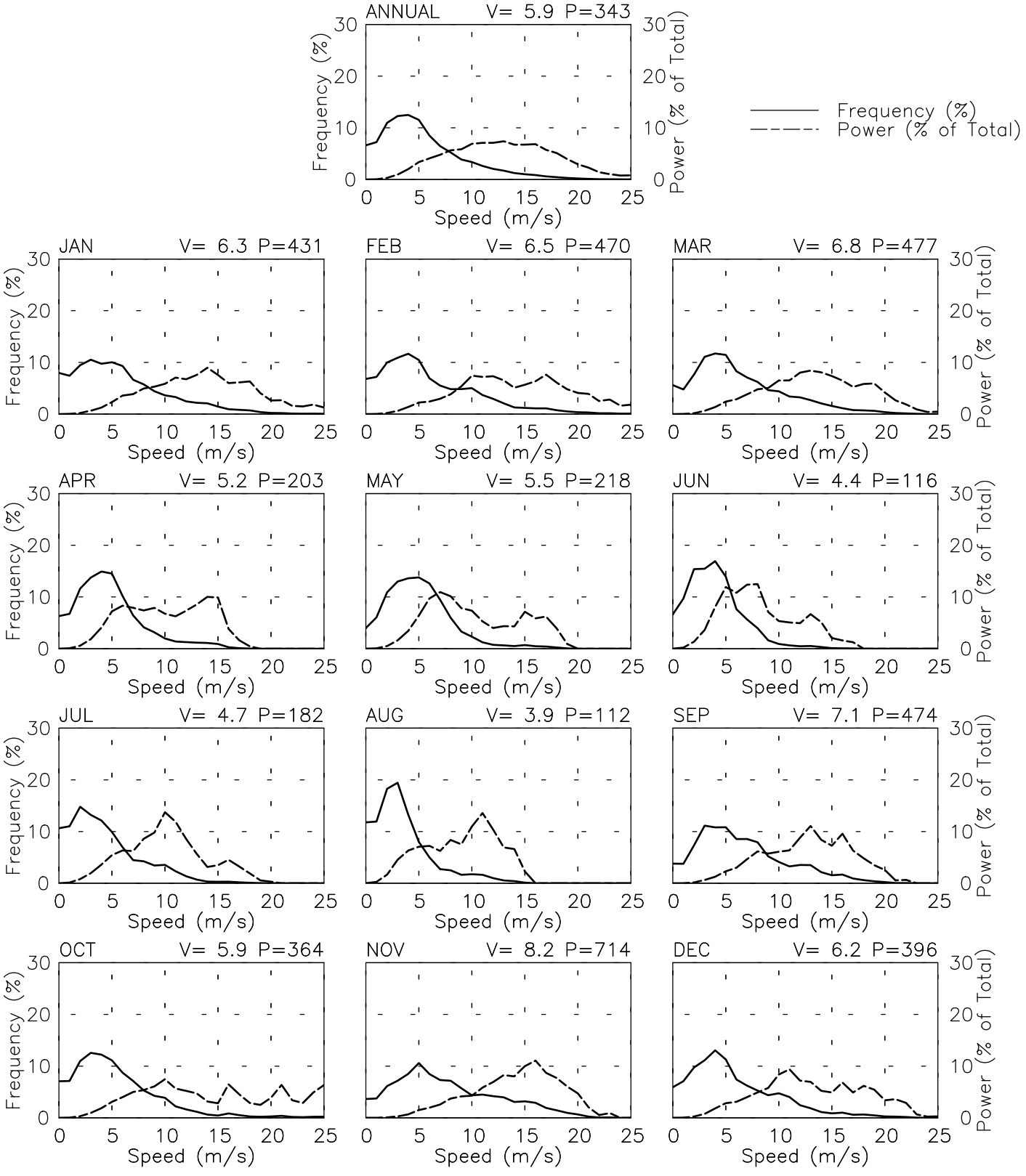
Eyak, AK 26.5m – 000001
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:33:55 2009

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

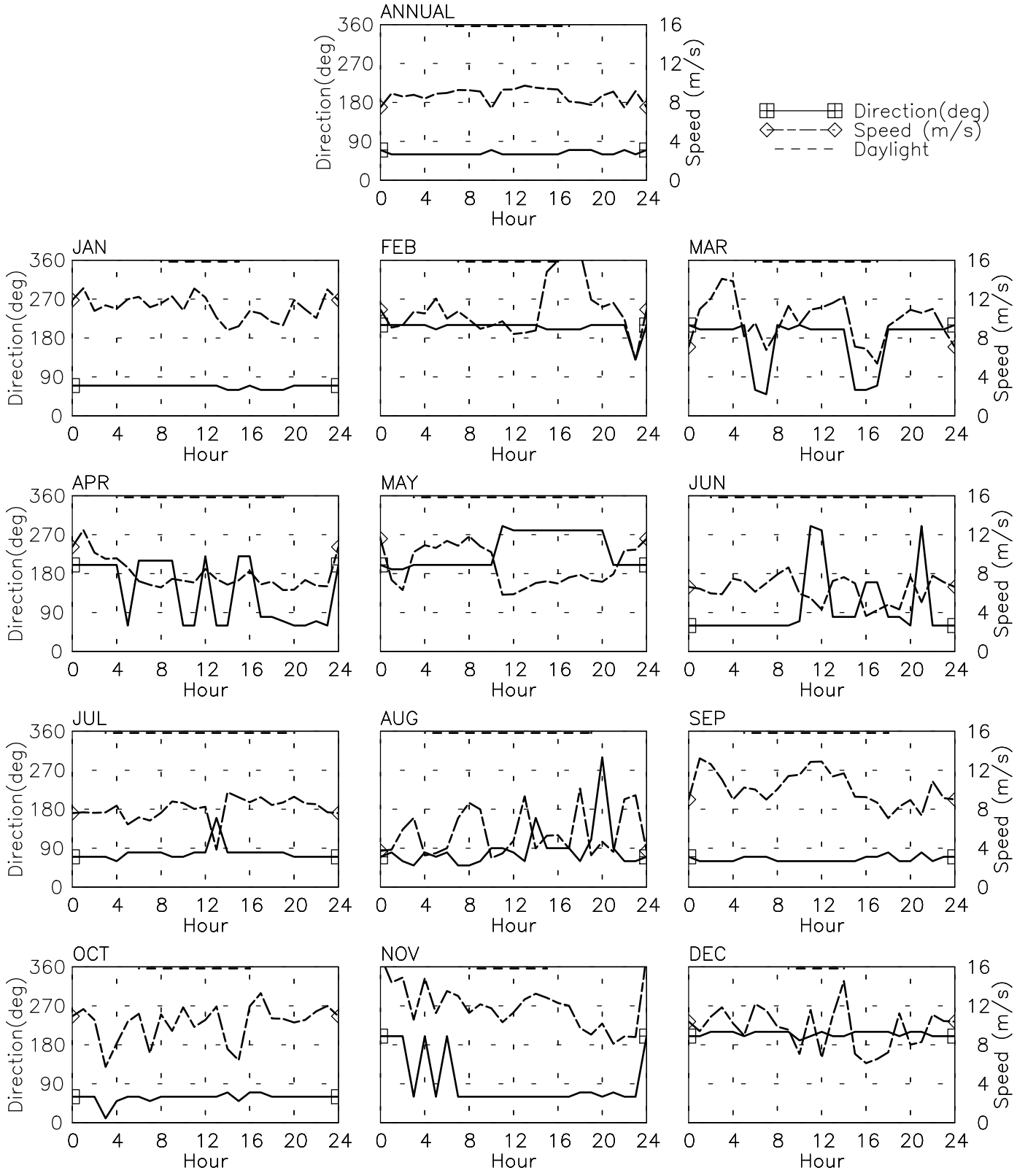
Eyak, AK 26.5m – 000001
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



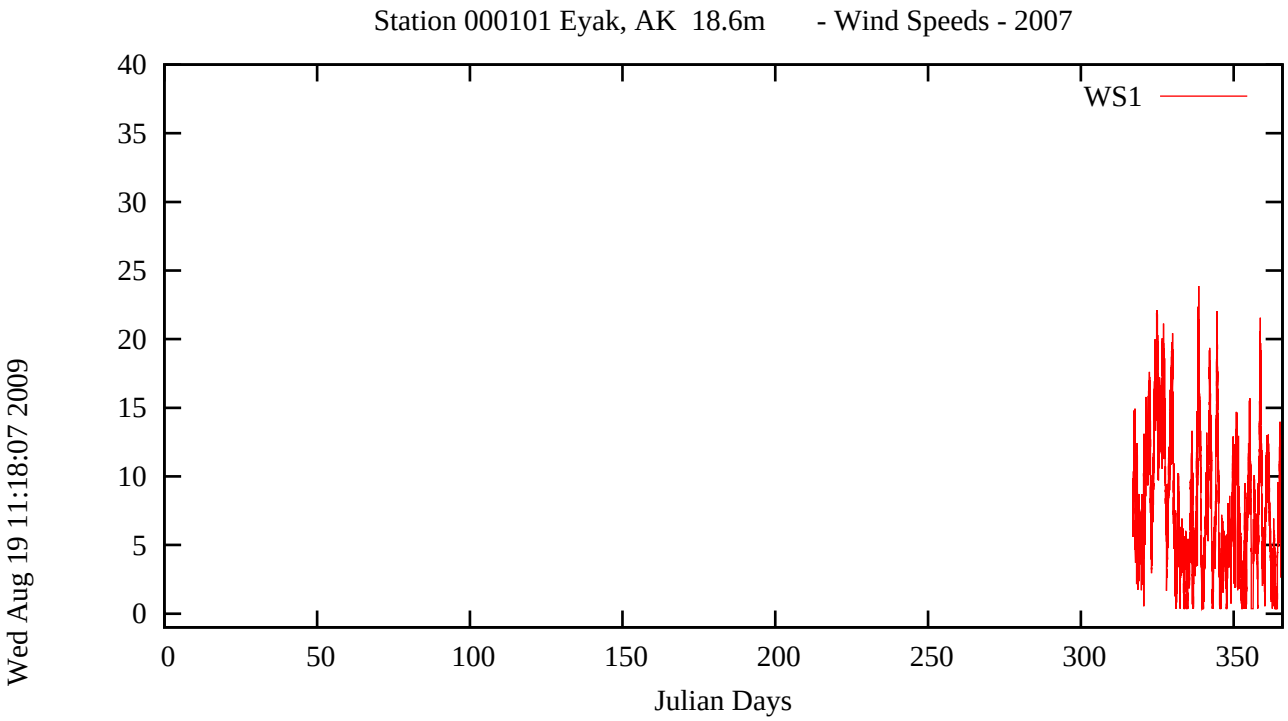
Wed Aug 19 15:33:55 2009

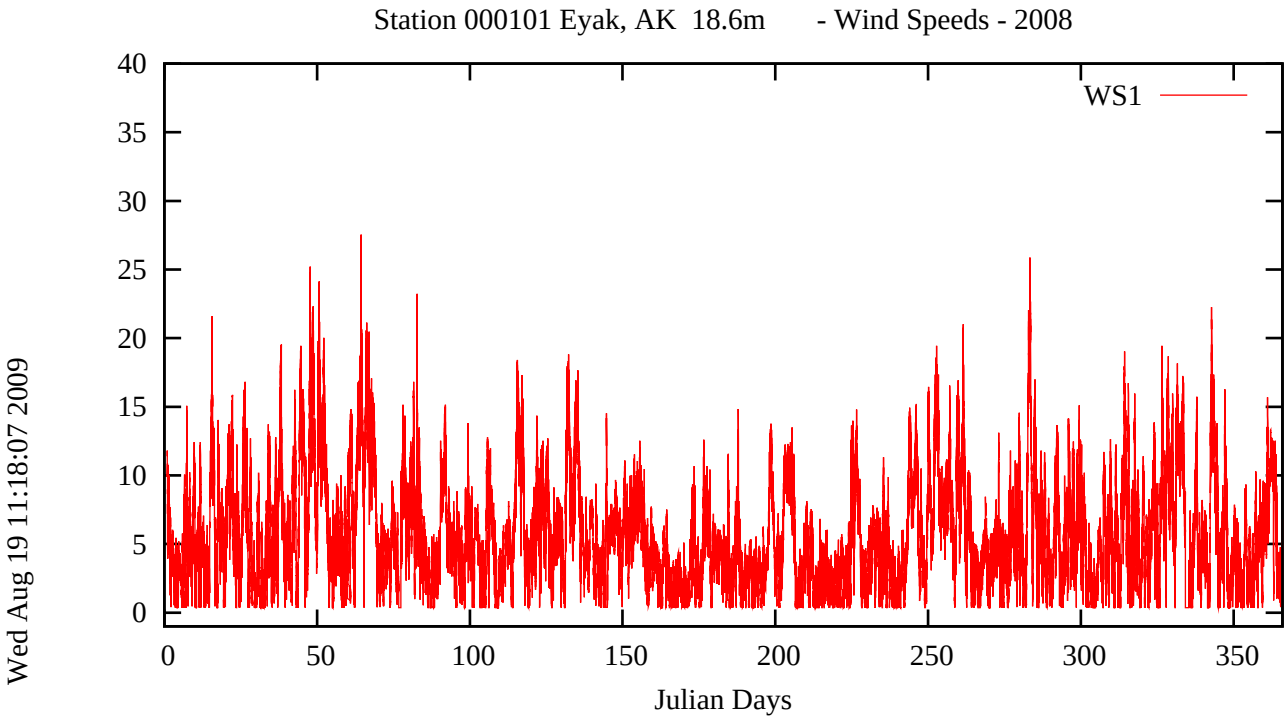
PREVAILING DIRECTION & SPEED BY HOUR

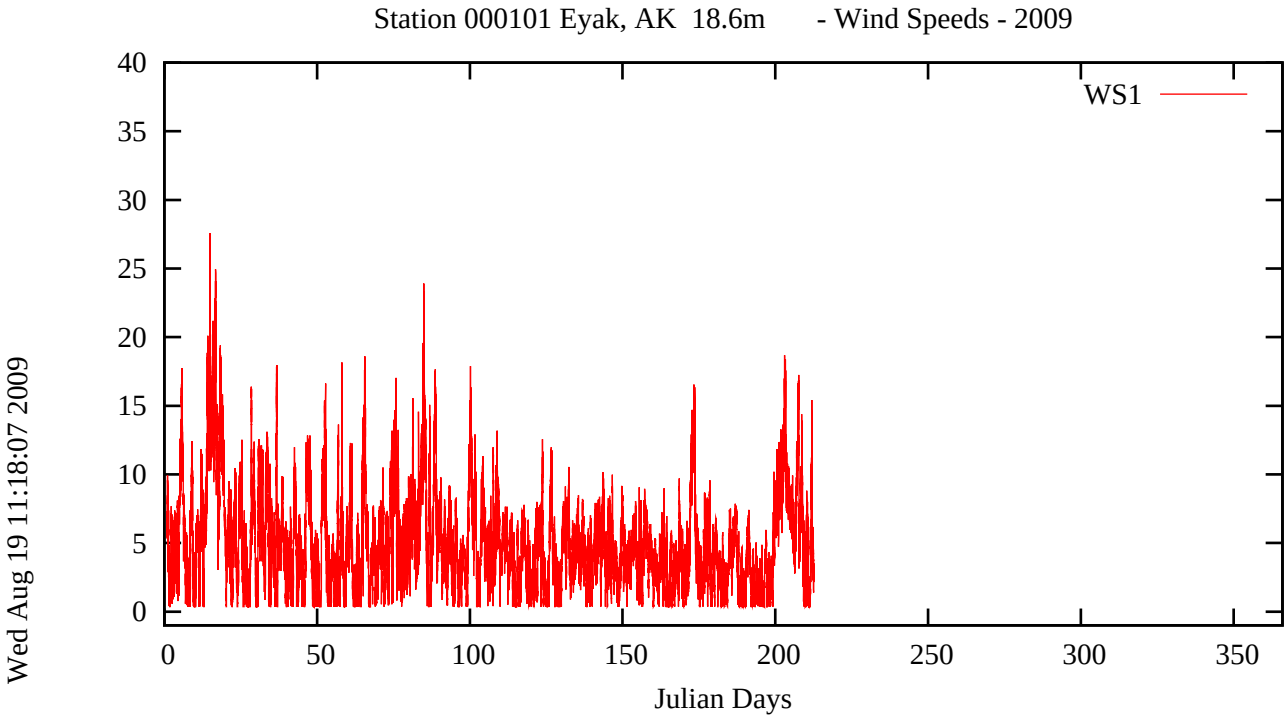
Eyak, AK 26.5m – 000001
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:33:56 2009

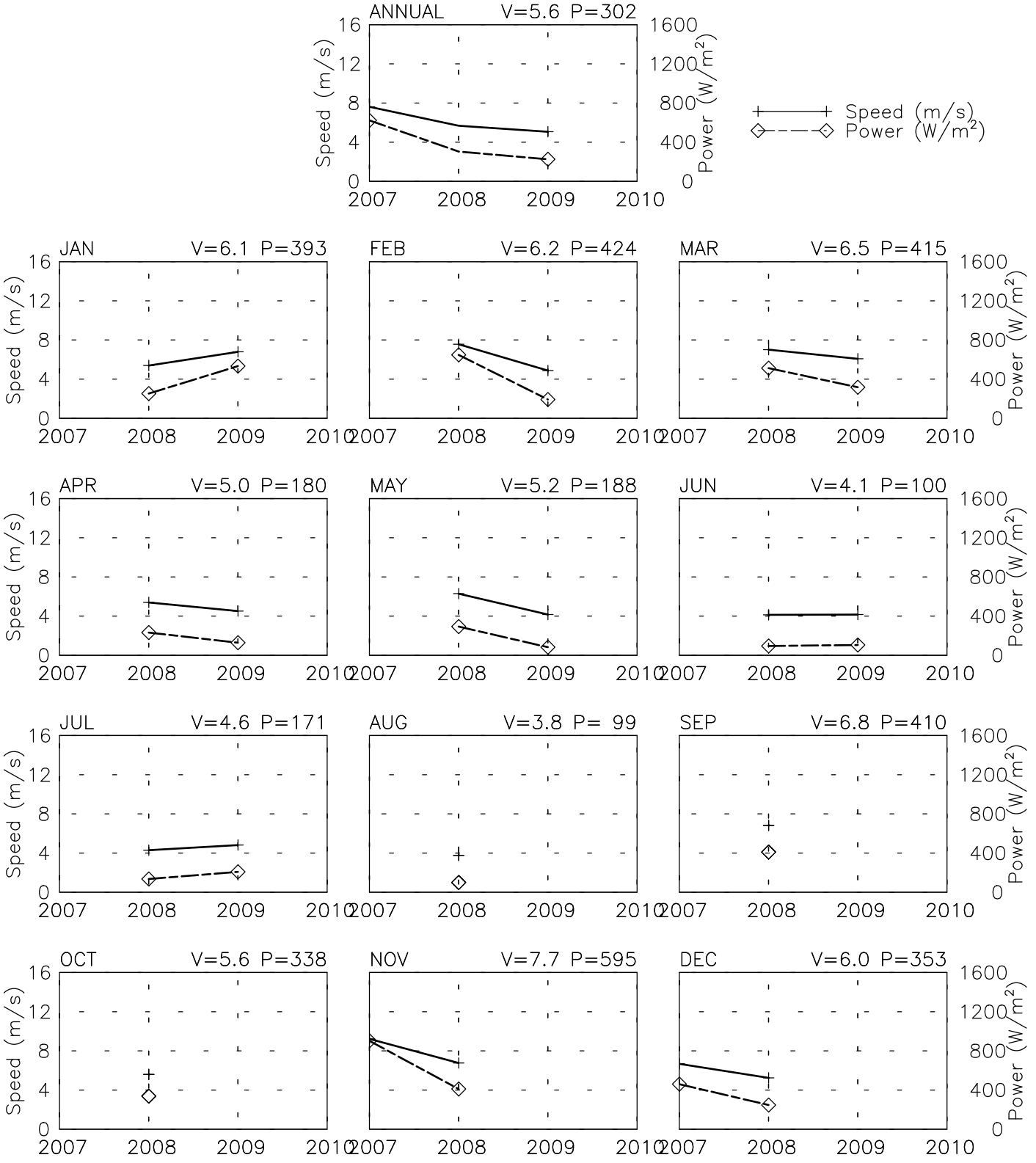

Station 000101 Eyak, AK 18.6m - Wind Speeds - 2007
WS1
Wed Aug 19 11:18:07 2009
Julian Days
0
5
10
15
20
25
30
35
40
0
50
100
150
200
250
300
350


Station 000101 Eyak, AK 18.6m - Wind Speeds - 2008
WS1
Wed Aug 19 11:18:07 2009
Julian Days
0
5
10
15
20
25
30
35
40
0
50
100
150
200
250
300
350


Station 000101 Eyak, AK 18.6m - Wind Speeds - 2009
WS1
Wed Aug 19 11:18:07 2009
Julian Days
0
5
10
15
20
25
30
35
40
0
50
100
150
200
250
300
350

SPEED AND POWER BY YEAR

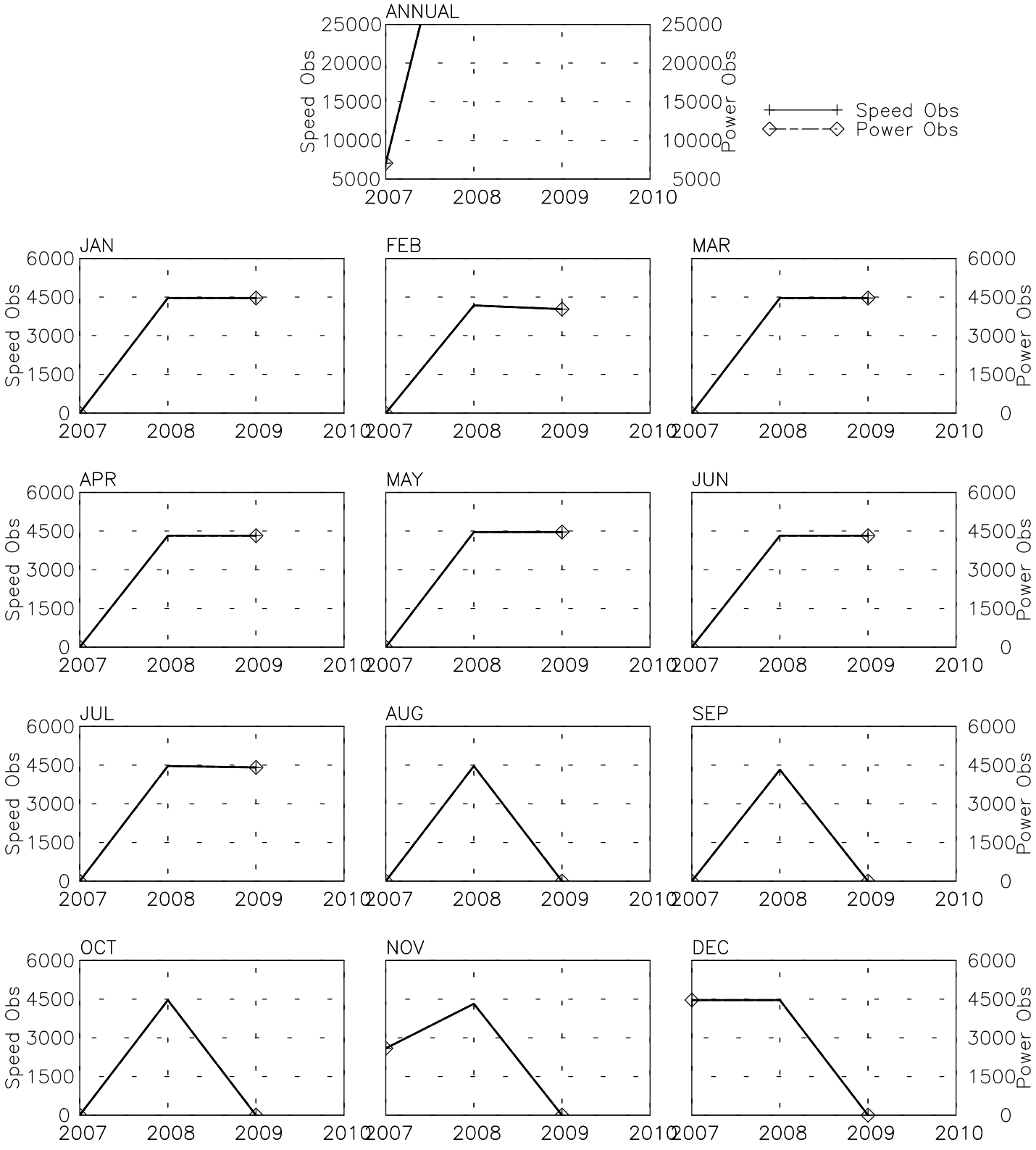
Eyak, AK 18.6m – 000101
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:33:57 2009

OBSERVATIONS BY YEAR

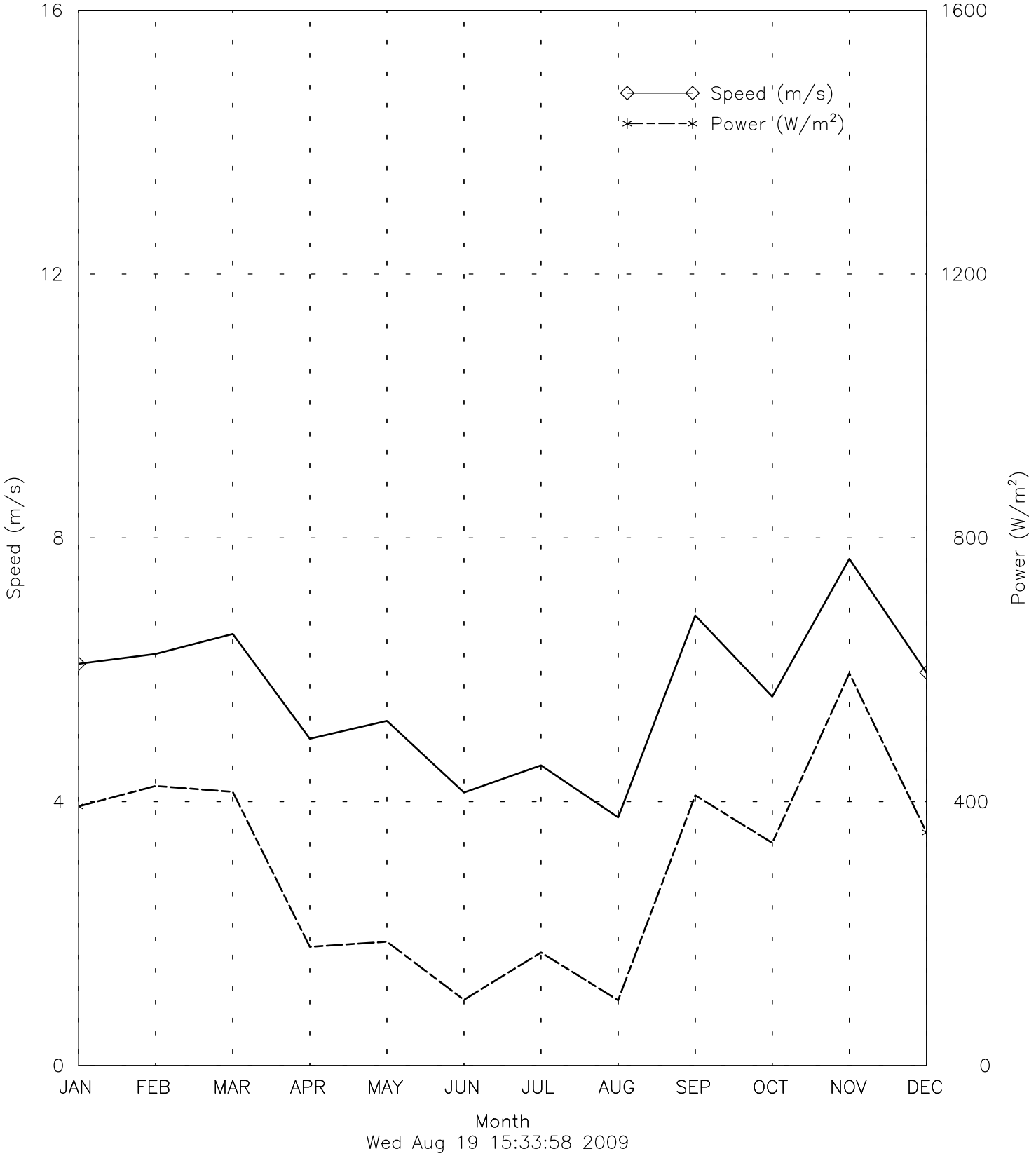
Eyak, AK 18.6m – 000101
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:33:57 2009

SPEED AND POWER BY MONTH

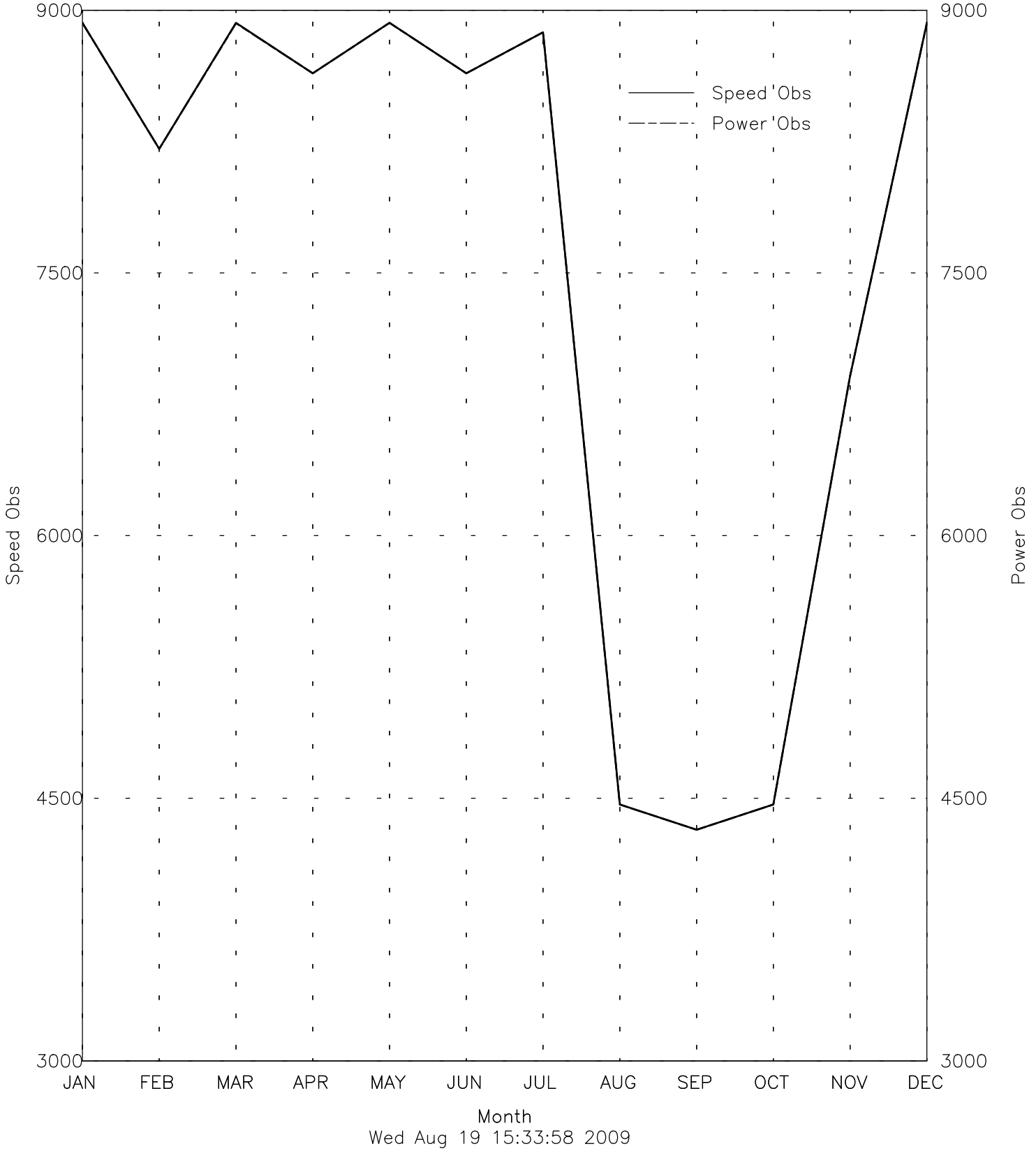
Eyak, AK 18.6m – 000101
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:33:58 2009

OBSERVATIONS BY MONTH

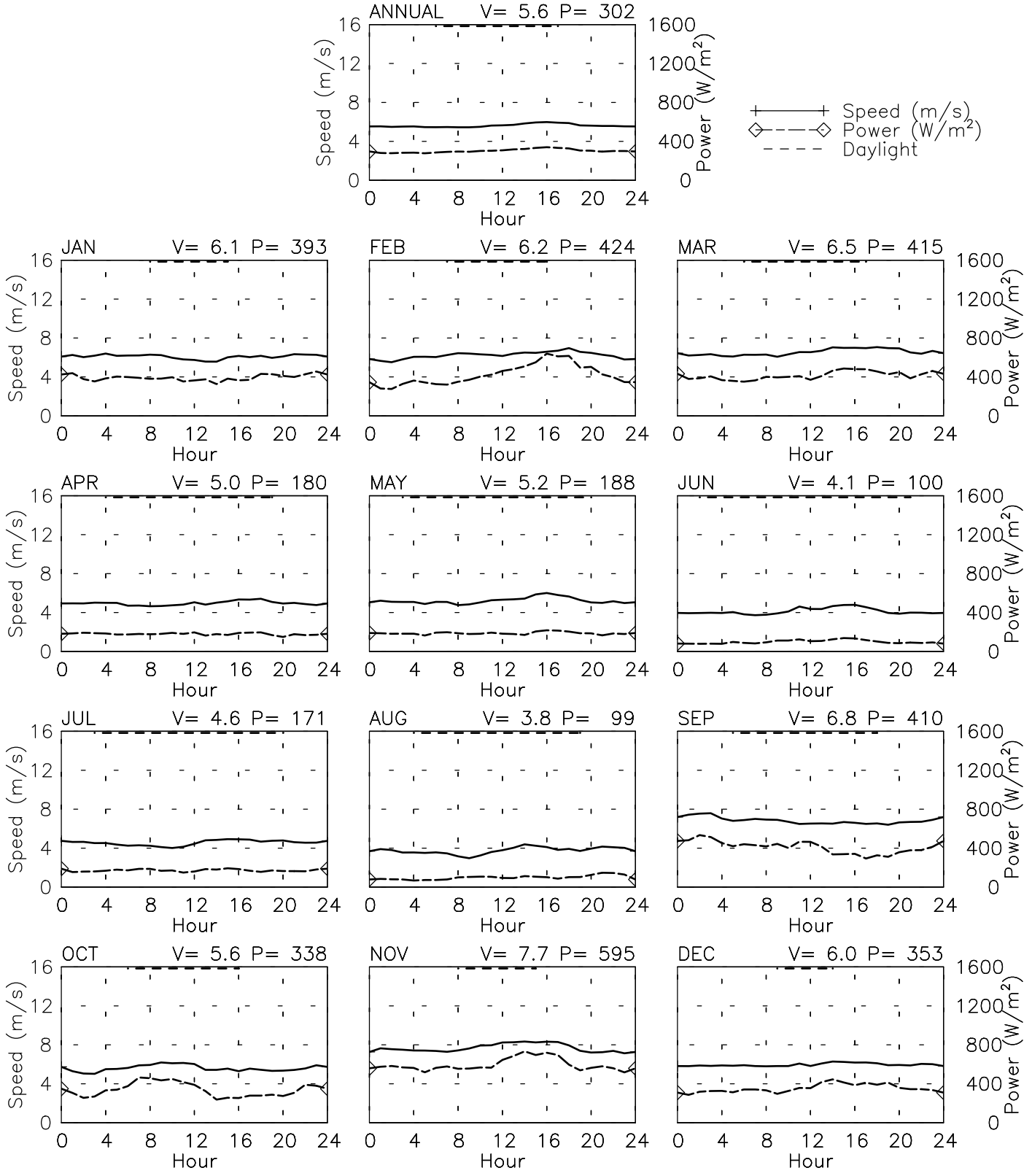
Eyak, AK 18.6m – 000101
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:33:58 2009

SPEED AND POWER BY HOUR

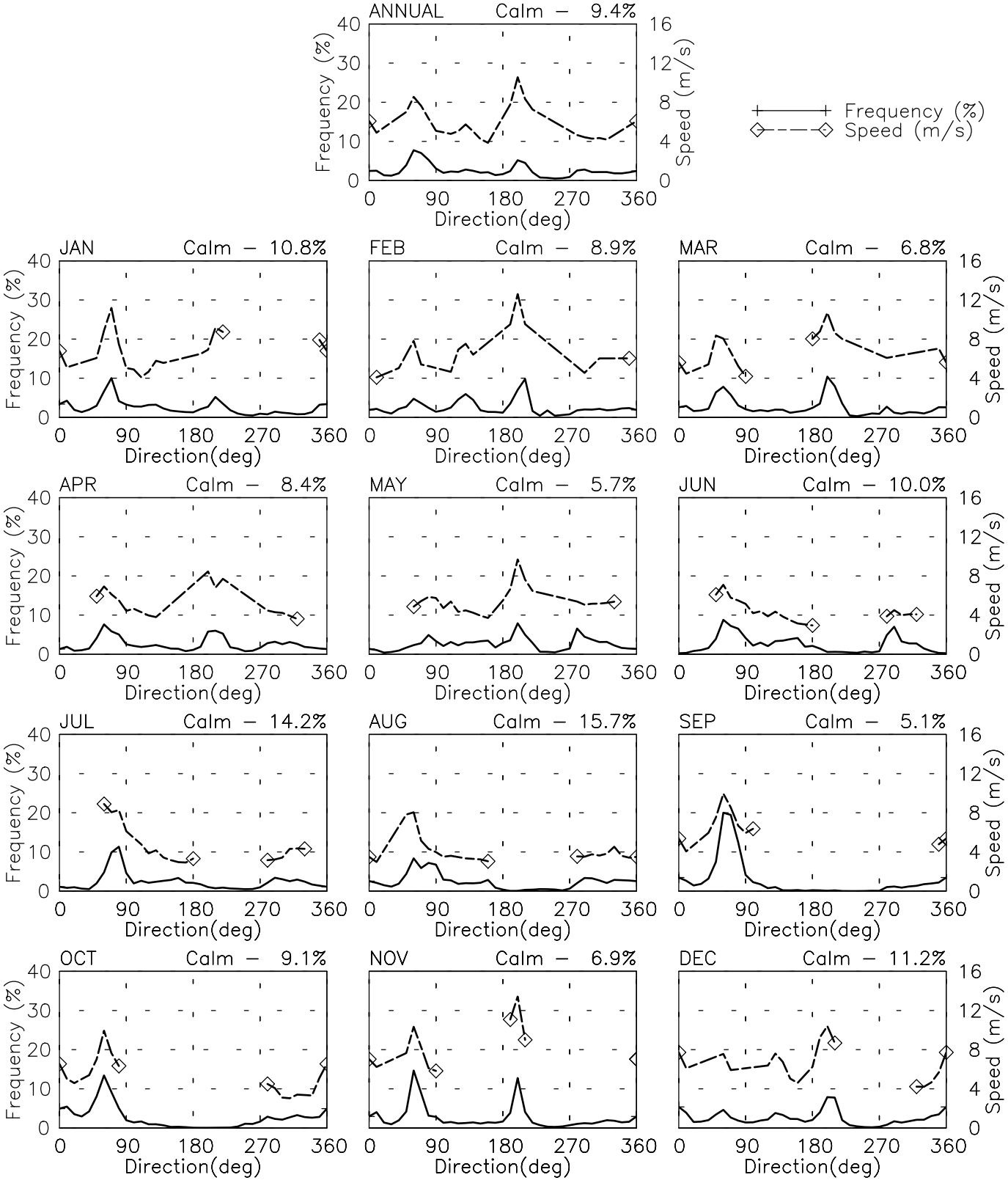
Eyak, AK 18.6m – 000101
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:33:58 2009

FREQUENCY AND SPEED BY DIRECTION

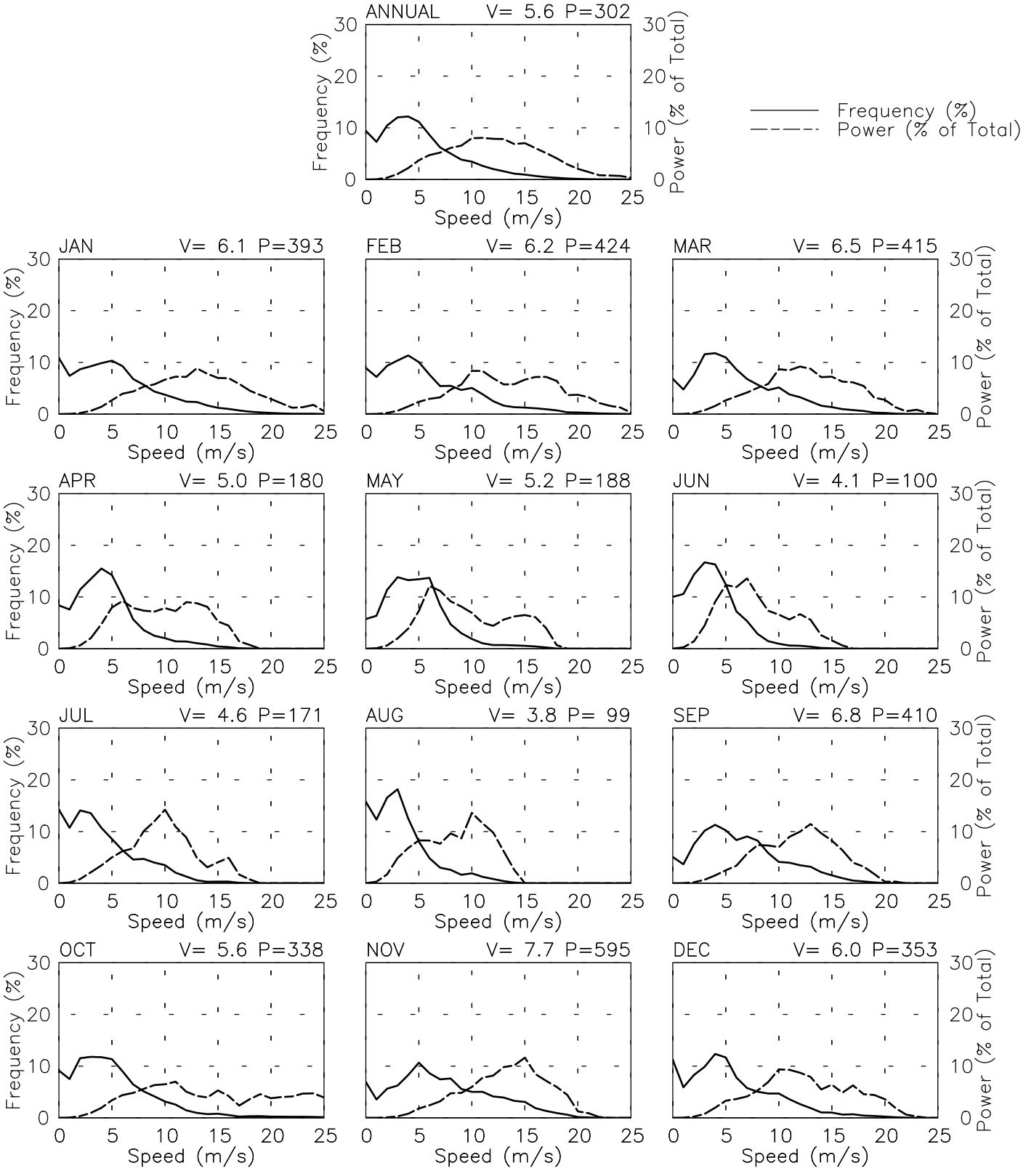
Eyak, AK 18.6m – 000101
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:33:58 2009

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

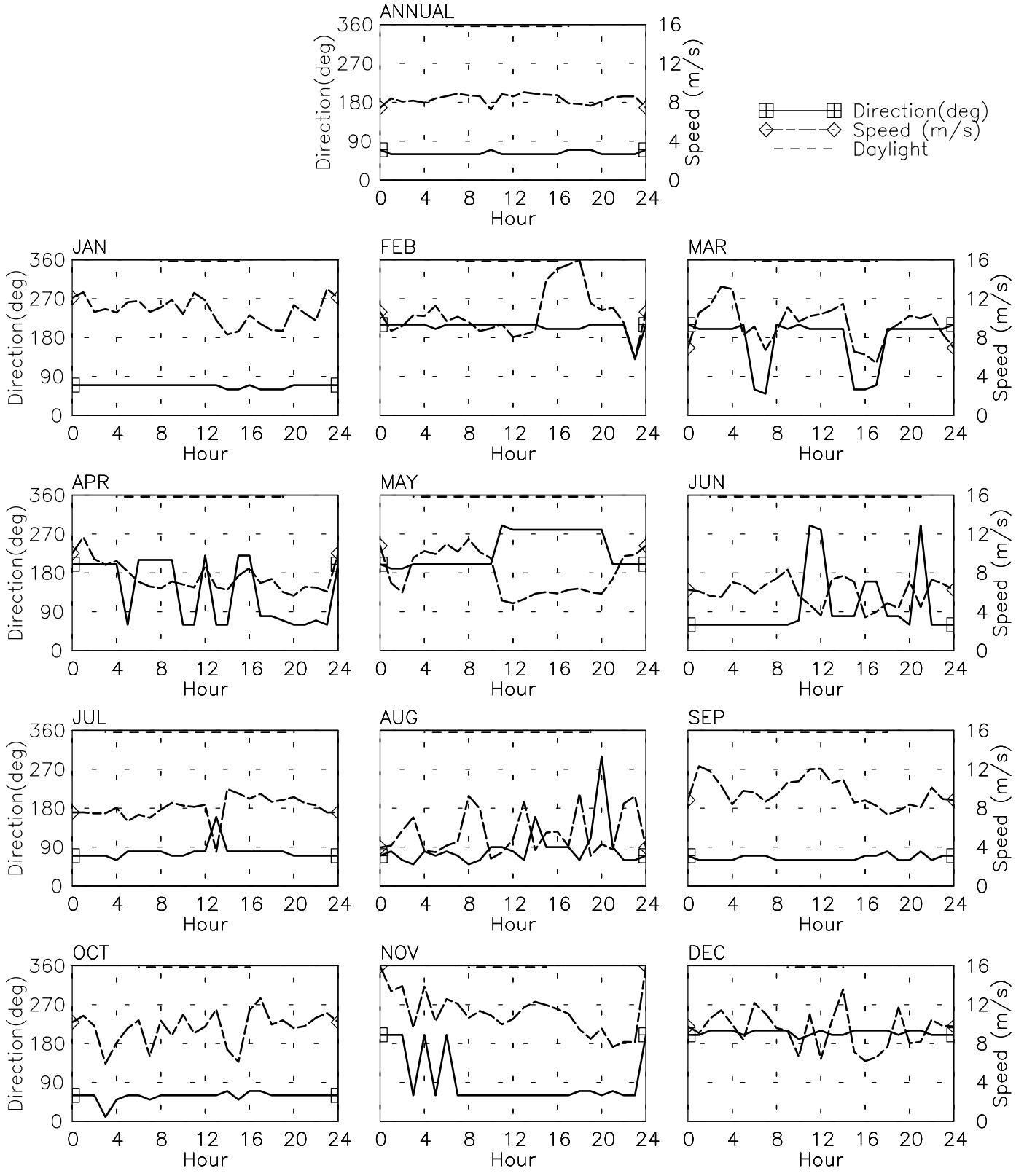
Eyak, AK 18.6m – 000101
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



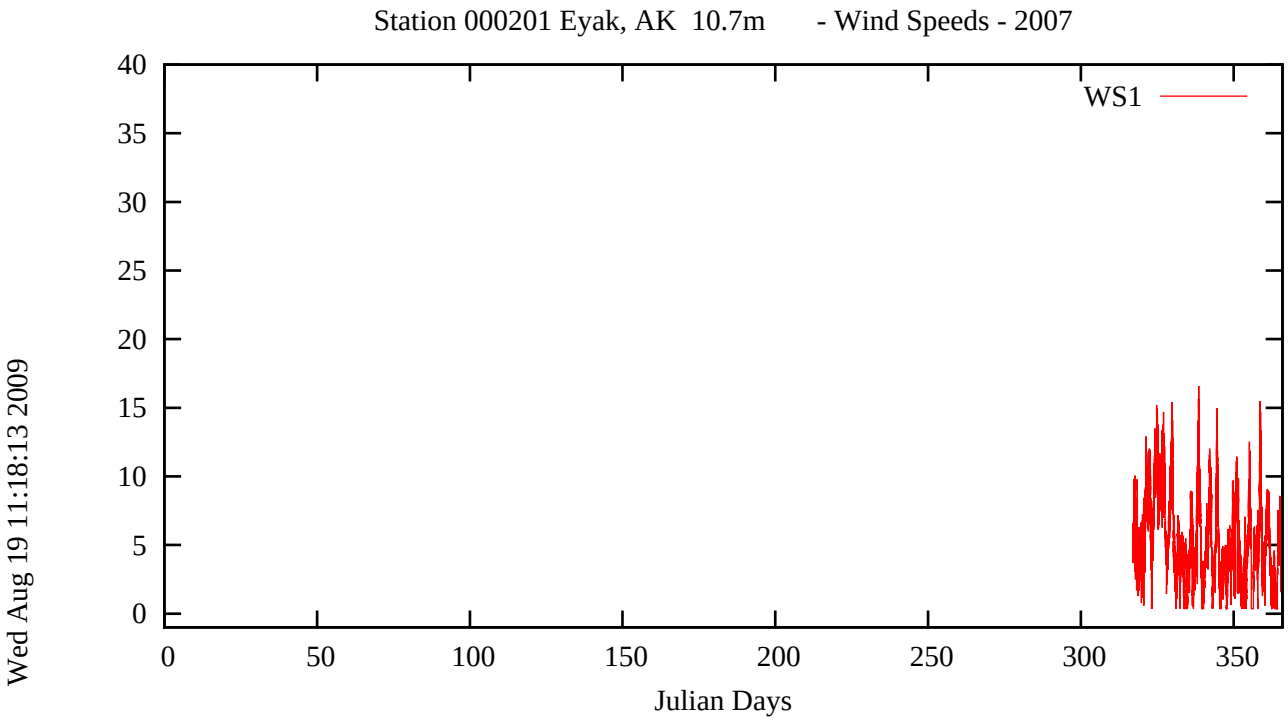
Wed Aug 19 15:33:59 2009

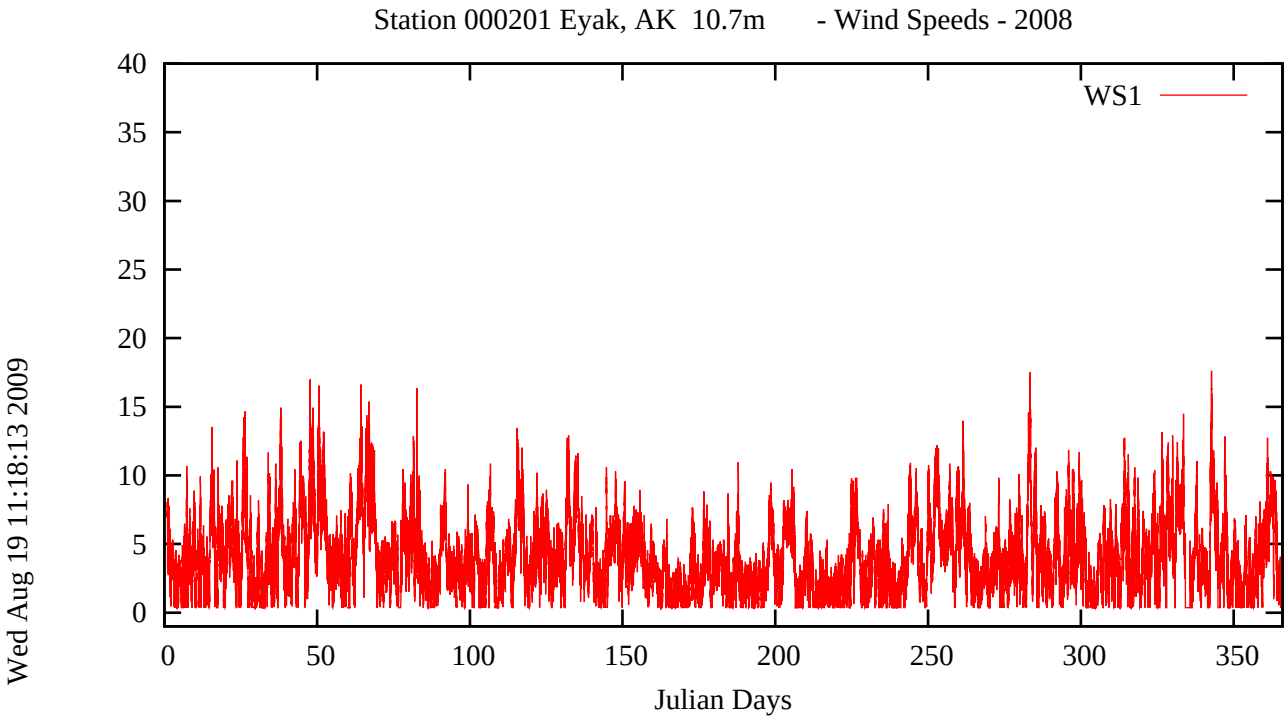
PREVAILING DIRECTION & SPEED BY HOUR

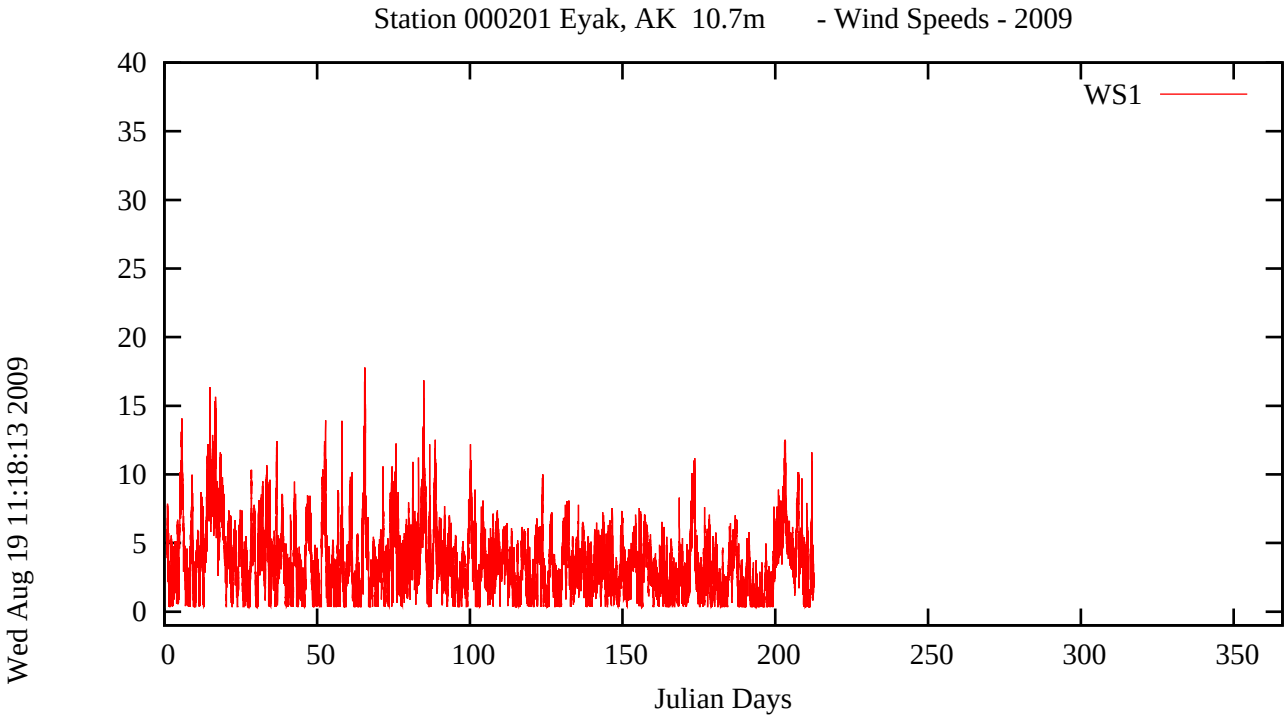
Eyak, AK 18.6m – 000101
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:33:59 2009

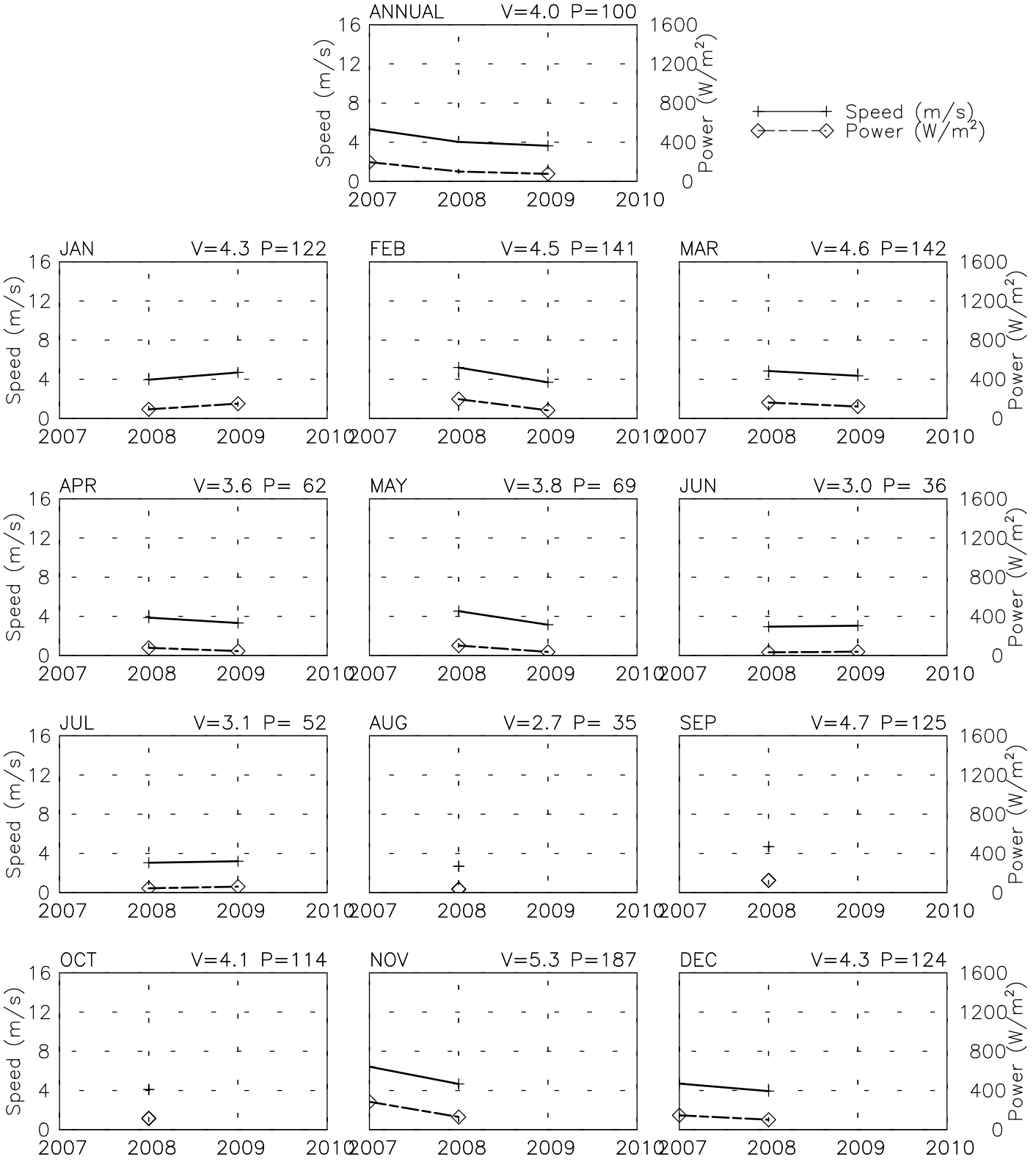

Station 000201 Eyak, AK 10.7m - Wind Speeds - 2007
WS1
Wed Aug 19 11:18:13 2009
Julian Days
0
5
10
15
20
25
30
35
40
0
50
100
150
200
250
300
350


Station 000201 Eyak, AK 10.7m - Wind Speeds - 2008
WS1
Wed Aug 19 11:18:13 2009
Julian Days
0
5
10
15
20
25
30
35
40
0
50
100
150
200
250
300
350


Station 000201 Eyak, AK 10.7m - Wind Speeds - 2009
WS1
Wed Aug 19 11:18:13 2009
Julian Days
0
5
10
15
20
25
30
35
40
0
50
100
150
200
250
300
350

SPEED AND POWER BY YEAR

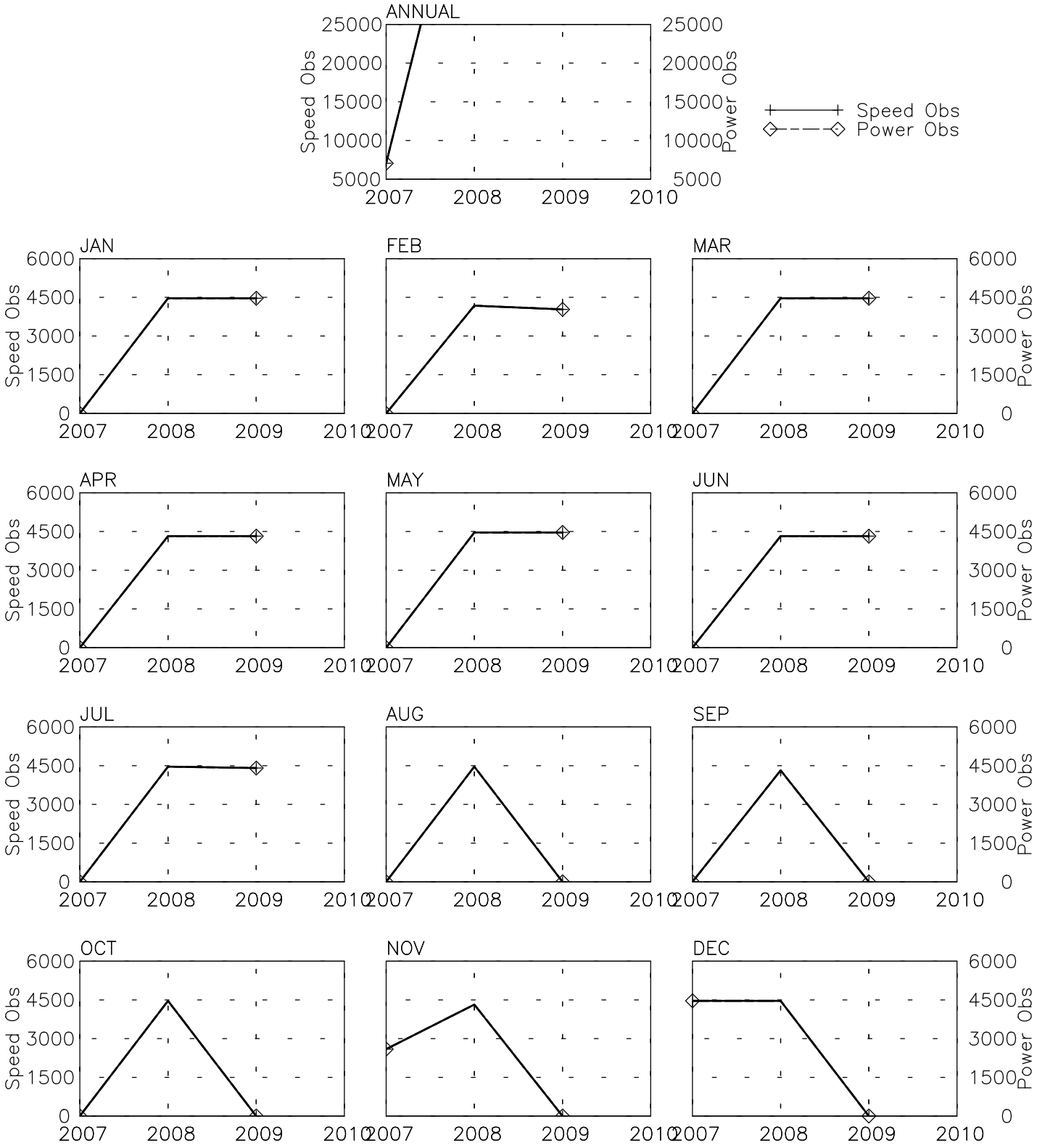
Eyak, AK 10.7m – 000201
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:34:00 2009

OBSERVATIONS BY YEAR

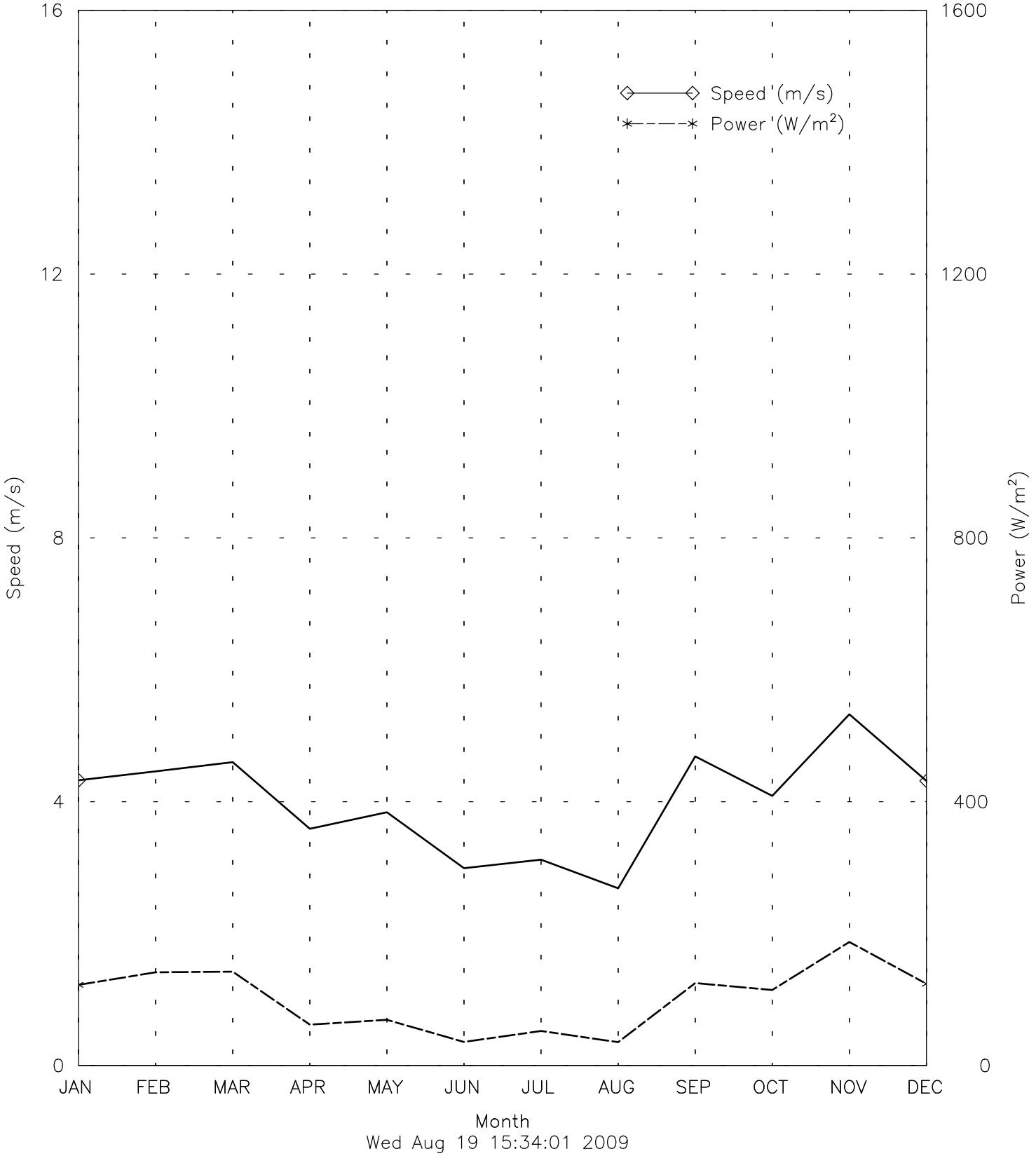
Eyak, AK 10.7m – 000201
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:34:01 2009

SPEED AND POWER BY MONTH

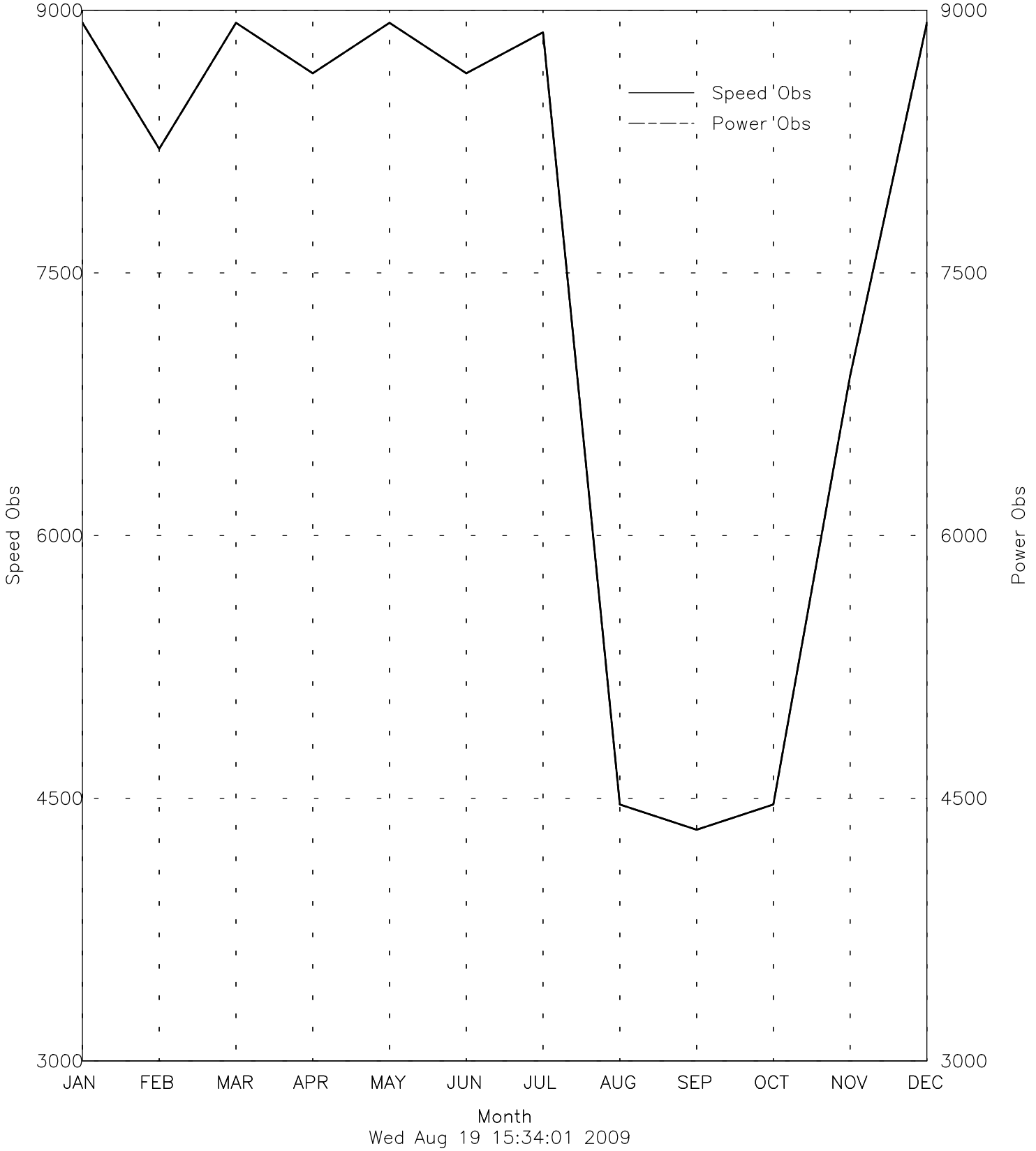
Eyak, AK 10.7m – 000201
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:34:01 2009

OBSERVATIONS BY MONTH

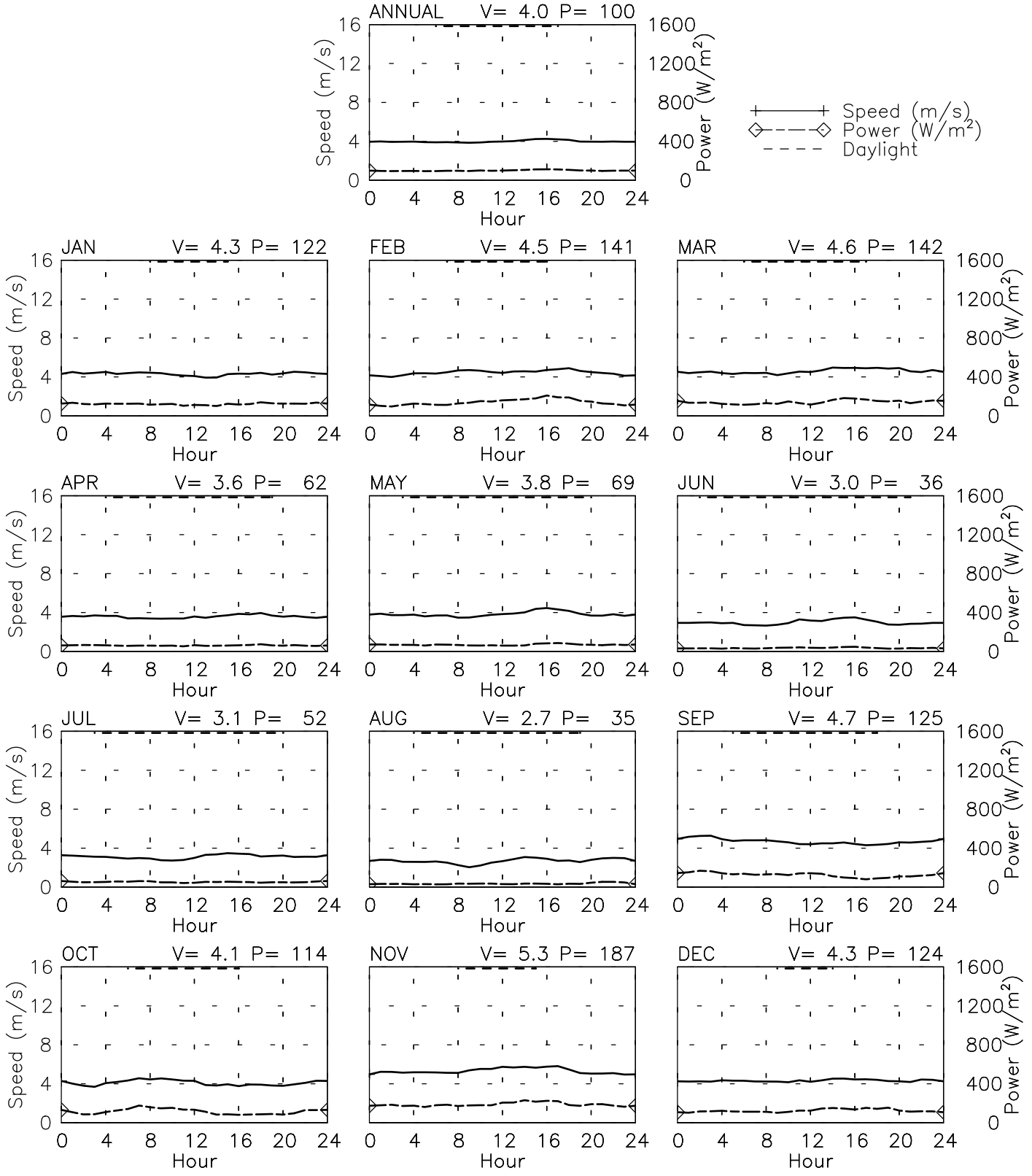
Eyak, AK 10.7m – 000201
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:34:01 2009

SPEED AND POWER BY HOUR

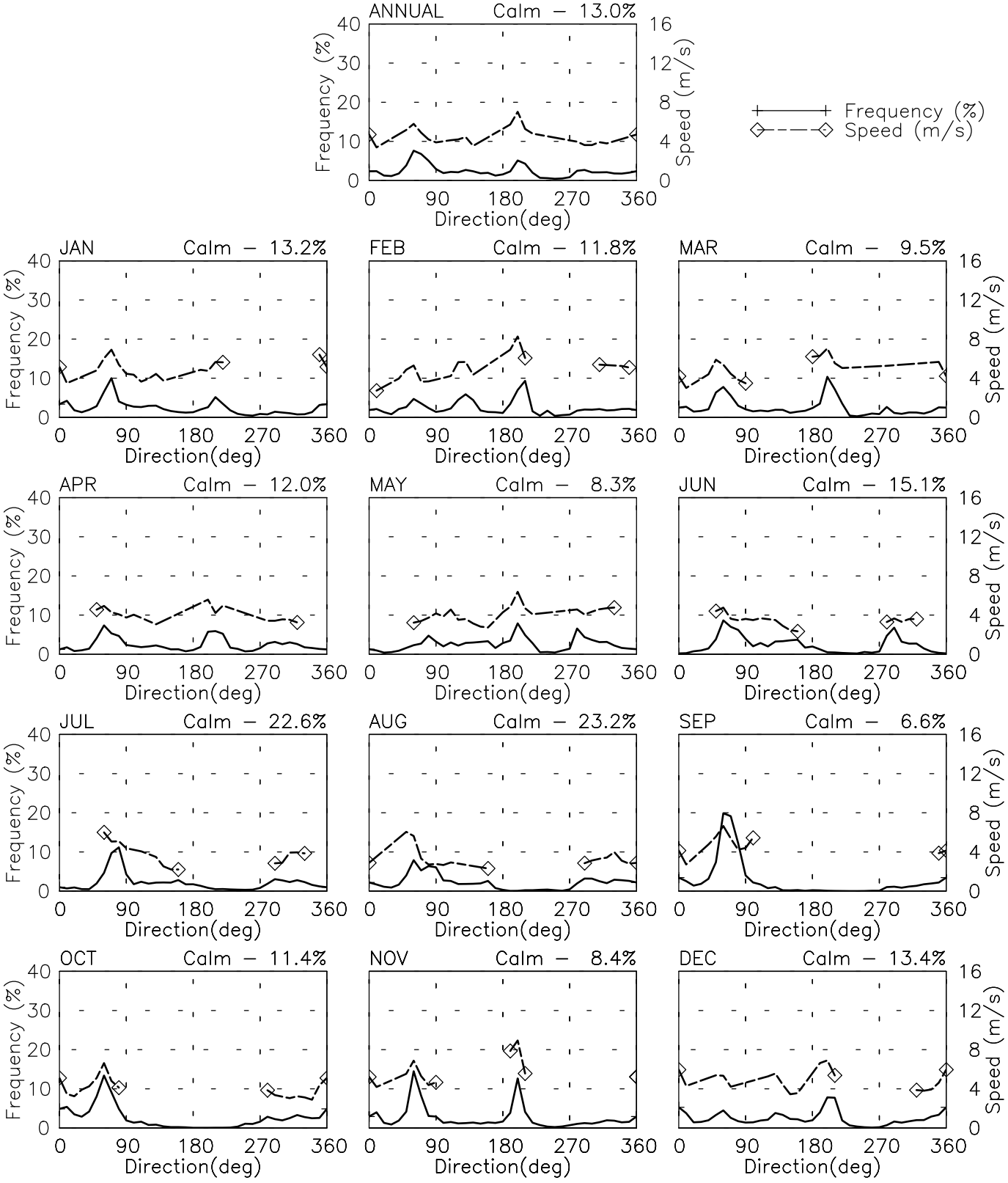
Eyak, AK 10.7m – 000201
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=−10
11/07–07/09



Wed Aug 19 15:34:01 2009

FREQUENCY AND SPEED BY DIRECTION

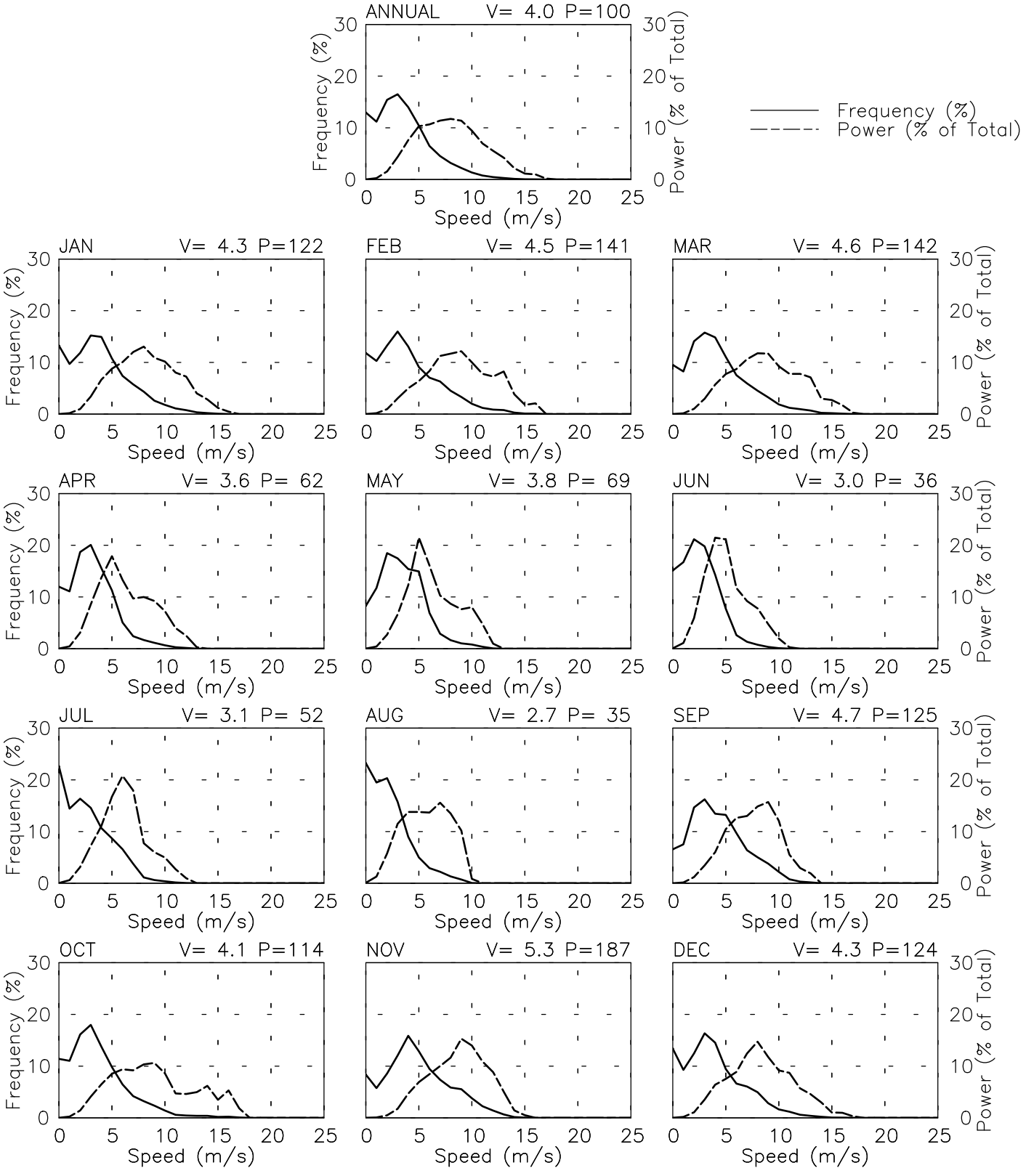
Eyak, AK 10.7m – 000201
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:34:02 2009

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

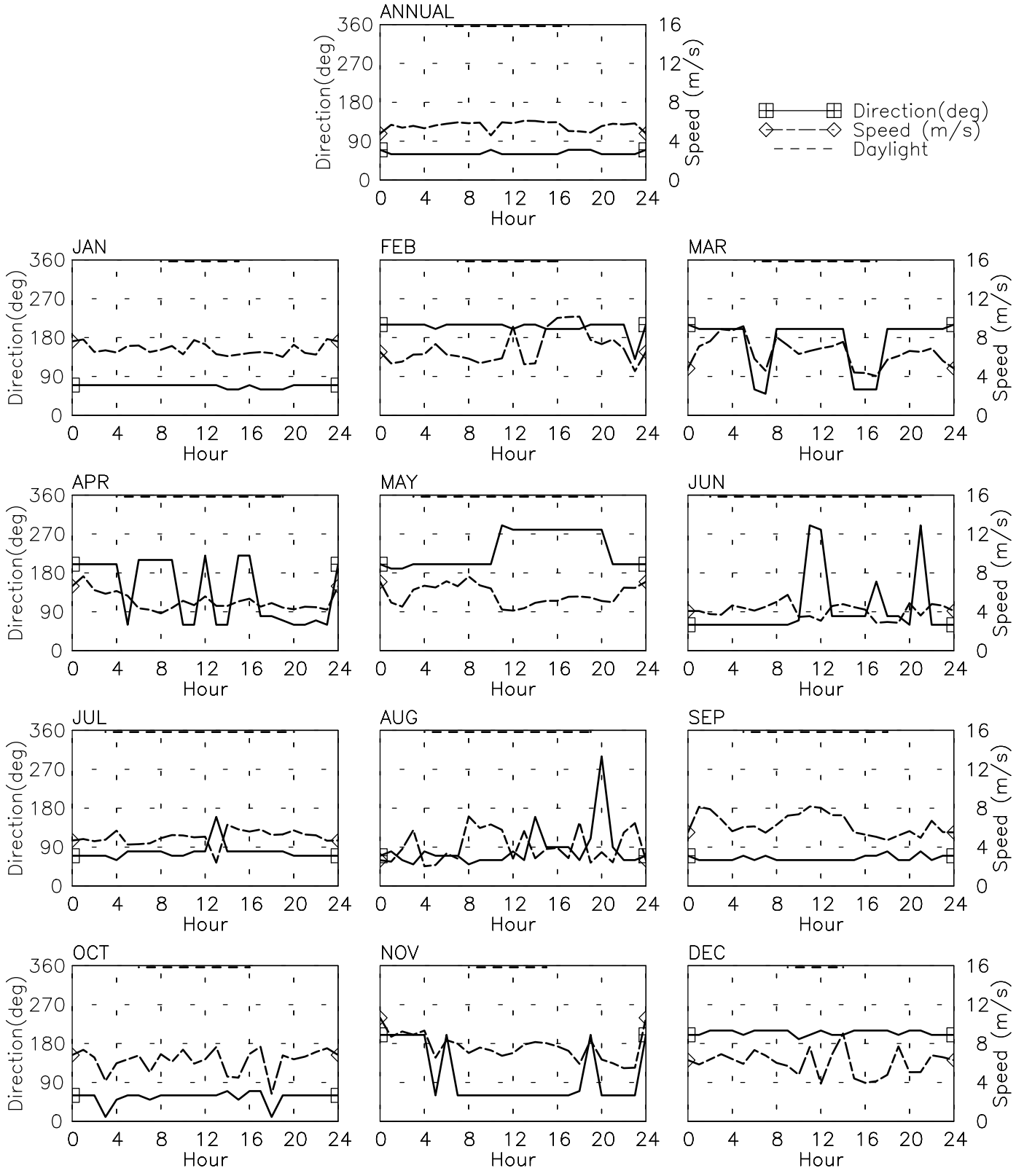
Eyak, AK 10.7m – 000201
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:34:03 2009

PREVAILING DIRECTION & SPEED BY HOUR

Eyak, AK 10.7m – 000201
60° 28' N 145° 57' W – Elev 122m LST=GMT+99 hours *NT=–10
11/07–07/09



Wed Aug 19 15:34:03 2009

Appendix D: Wind Data Graphs
WindPro

Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

Printed/Page
8/18/2009 4:44 PM / 1
Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027
Calculated:
8/18/2009 4:44 PM/

Meteo data report, height: 26.5 m

Name of meteo object: MET tower

Data from: 11/13/2007 12:00 AM Data to: 7/31/2009 2:50 PM Observations: 90234 Observations per day: 144 Recovery rate: 100%

day	11/07	12/07	01/08	02/08	03/08	04/08	05/08	06/08	07/08	08/08	09/08	10/08	11/08	12/08	01/09	02/09	03/09	04/09	05/09	06/09	07/09	08/09
1		144	144	(107)	144	144	144	144	144	(109)	144	(122)	144	144	(140)	144	144	144	(139)	144	144	
2		(143)	144	144	144	144	144	144	144	(143)	144	144	144	(135)	144	144	144	144	144	144	144	
3		144	144	144	144	144	144	144	144	144	144	(135)	(142)	144	144	(140)	(118)	144	(143)	144	144	
4		144	(137)	144	144	144	144	144	(121)	144	144	144	144	144	144	144	144	144	(142)	144	144	
5		(135)	(138)	144	144	144	144	144	(142)	144	(134)	144	144	144	144	(143)	(142)	144	144	144	144	
6		(143)	(142)	144	(142)	144	(138)	144	144	(139)	(139)	144	144	144	144	144	144	(136)	144	144	144	
7		144	144	144	144	144	144	144	144	(129)	144	144	144	(137)	144	144	144	144	144	144	144	
8		144	144	144	144	144	144	144	144	144	144	144	(142)	144	(143)	(141)	(121)	(136)	144	144	144	
9		(143)	144	144	144	144	(141)	144	(137)	(134)	144	(141)	(142)	144	(133)	(137)	144	(141)	144	144	144	
10		144	(131)	144	144	144	144	144	144	(141)	144	144	144	144	(121)	(141)	(143)	144	144	144	144	
11		(133)	(142)	144	144	(141)	(133)	(135)	(134)	(142)	144	144	144	144	(143)	(143)	144	144	144	144	144	
12		144	(143)	(143)	144	144	144	144	144	(142)	144	144	(134)	144	(142)	(140)	144	(121)	144	144	144	
13	144	144	(142)	144	144	(141)	144	(139)	(142)	144	144	(140)	144	144	144	144	(140)	(133)	144	144	144	
14	144	144	(139)	144	144	(143)	144	(141)	144	144	144	144	144	(133)	144	(141)	144	144	144	144	144	
15	144	144	144	144	144	144	144	(132)	144	144	(142)	(142)	(138)	144	144	144	144	144	144	144	144	
16	144	144	144	144	144	(143)	144	(141)	144	(129)	144	144	144	(143)	144	144	144	144	144	144	144	
17	144	144	(134)	144	144	144	144	144	144	(136)	144	144	(143)	144	144	(133)	144	144	144	144	144	
18	144	(133)	144	144	(88)	(130)	144	(143)	144	(140)	144	144	(143)	(138)	144	(138)	144	144	144	144	144	
19	144	(133)	(140)	144	144	(115)	144	(142)	144	144	144	144	144	144	144	(142)	144	144	144	144	144	
20	144	144	144	144	144	144	144	(133)	144	(143)	144	144	144	144	(143)	(114)	144	144	144	144	144	
21	144	(131)	144	144	144	144	144	144	144	144	(136)	(137)	(137)	(136)	144	144	144	144	144	144	144	
22	144	(85)	144	144	144	144	144	144	144	144	(143)	144	144	(143)	(138)	144	144	144	144	144	144	
23	144	(142)	(125)	144	144	144	144	144	144	144	(125)	144	144	144	(139)	(139)	144	144	144	144	144	
24	144	144	(139)	(143)	144	(137)	144	(121)	144	(140)	(137)	144	144	144	(142)	(140)	144	(128)	144	144	144	
25	144	144	144	144	144	144	(143)	144	(137)	144	144	144	144	144	144	(141)	144	(113)	144	144	144	
26	144	144	144	144	144	144	144	144	(139)	(131)	(136)	144	144	144	144	144	144	(141)	144	144	144	
27	(141)	144	(135)	(141)	(133)	144	144	(141)	(134)	(123)	(127)	144	144	144	(114)	(133)	(134)	144	144	144	144	
28	144	(143)	144	144	(110)	144	144	(134)	(134)	(137)	144	(142)	144	144	(142)	(132)	(142)	144	144	144	144	
29	(137)	(142)	(125)	144	(133)	(138)	144	144	144	(132)	144	(133)	144	144	(141)		144	144	144	144	144	
30	(138)	(130)	(142)		144	144	144	144	(142)	(137)	144	(132)	(134)	144	(118)		144	(139)	144	144	144	
31		144	(127)		144		144		(140)	144		(122)		144	144		144		144		(90)	
%	(99)	(97)	(97)	(99)	(97)	(99)	(100)	(98)	(98)	(96)	(98)	(98)	(99)	(99)	(97)	(97)	(98)	(98)	(100)	100	(99)	(0)

Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

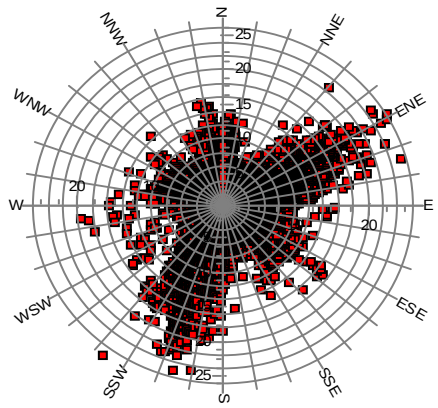
Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

Printed/Page
8/18/2009 4:44 PM / 2
Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027

Calculated:
8/18/2009 4:44 PM/

Meteo data report, height: 26.5 m

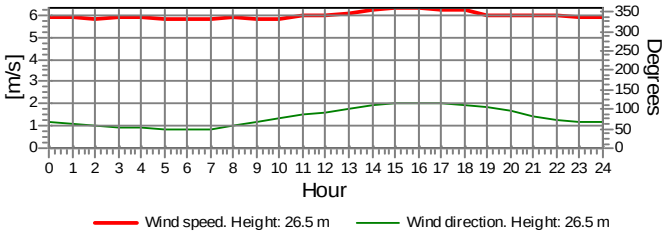
Name of meteo object: MET tower

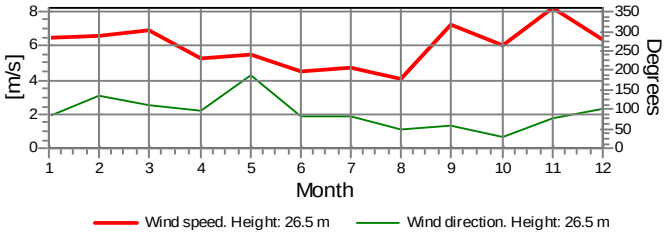


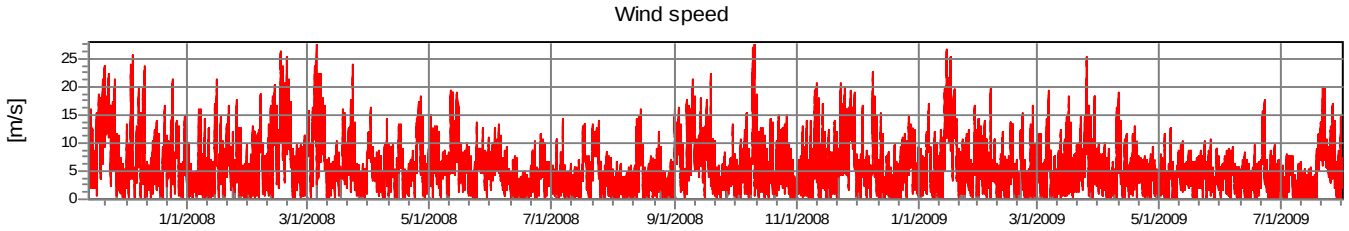
Wind speed [m/s]

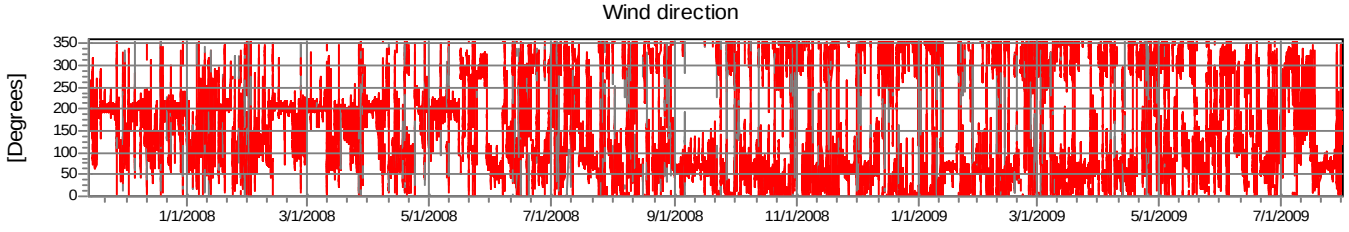
Monthly mean values of wind speed in m/s

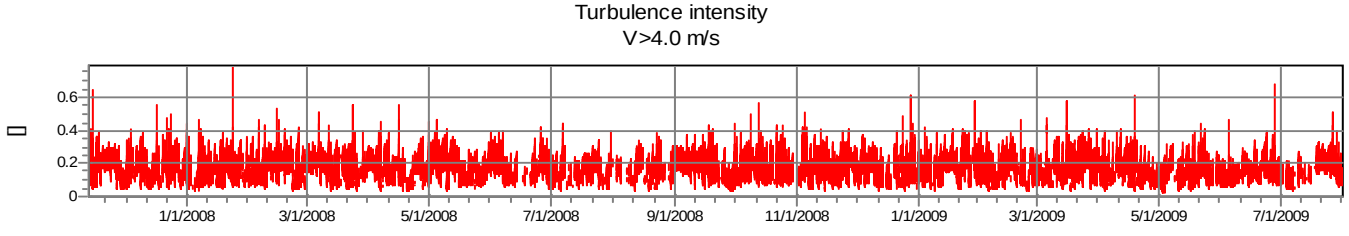
Month	2007	2008	2009	mean	mean of months
Jan		5.7	7.3	6.5	6.5
Feb		7.9	5.2	6.6	6.5
Mar		7.5	6.4	6.9	6.9
Apr		5.8	4.8	5.3	5.3
May		6.7	4.3	5.5	5.5
Jun		4.5	4.4	4.5	4.5
Jul		4.5	5.0	4.8	4.8
Aug		4.1		4.1	4.1
Sep		7.2		7.2	7.2
Oct		6.0		6.0	6.0
Nov	9.7	7.3		8.2	8.5
Dec	7.1	5.6		6.4	6.4
mean, all data	8.1	6.1	5.4	6.0	
mean of months	8.4	6.1	5.3		6.0











Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027

Calculated:
8/18/2009 4:44 PM/

Meteo data report, height: 26.5 m

Name of meteo object: MET tower

Frequency

Wind speed m/s	Sum	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.00 - 0.49	1,491	97	98	107	107	84	87	77	69	74	76	87	108	120	92	114	94
0.50 - 1.49	5,846	374	326	362	474	433	394	365	373	314	307	323	302	361	393	385	360
1.50 - 2.49	8,128	598	423	447	621	594	639	540	598	445	356	402	269	391	610	580	615
2.50 - 3.49	10,723	846	593	596	910	1,043	746	739	873	584	404	251	183	364	792	928	871
3.50 - 4.49	11,593	924	605	704	1,091	1,157	876	900	996	505	491	255	111	427	945	855	751
4.50 - 5.49	10,747	682	520	739	1,340	1,091	713	886	691	422	620	384	104	403	821	831	500
5.50 - 6.49	9,192	526	373	736	1,550	1,029	529	704	346	291	691	351	84	280	701	628	373
6.50 - 7.49	6,632	381	131	725	1,288	653	259	392	190	266	580	307	38	256	580	368	218
7.50 - 8.49	5,195	314	45	647	1,334	435	185	259	88	196	626	262	32	145	424	124	79
8.50 - 9.49	4,140	274	16	479	1,215	231	114	232	34	157	755	196	31	105	185	43	73
9.50 - 10.49	3,198	304	5	364	955	137	85	211	21	122	626	129	30	63	63	10	73
10.50 - 11.49	2,759	257	3	273	851	93	65	132	11	146	641	105	24	42	29	27	60
11.50 - 12.49	2,137	116	2	210	644	96	49	82	22	128	578	93	21	32	16	16	32
12.50 - 13.49	1,643	44	1	181	532	47	23	30	19	104	562	51	7	23	4	1	14
13.50 - 14.49	1,302	34	0	169	429	34	8	21	13	63	443	48	8	19	5	1	7
14.50 - 15.49	1,098	11	0	103	379	18	3	12	5	53	432	50	2	16	3	1	10
15.50 - 16.49	809	5	0	74	269	15	5	12	3	26	342	41	5	10	0	0	2
16.50 - 17.49	674	1	0	50	235	9	3	24	0	17	296	26	2	10	0	0	1
17.50 - 18.49	473	0	0	31	150	3	0	6	0	23	239	15	2	4	0	0	0
18.50 - 19.49	355	0	0	14	108	1	0	6	0	21	192	4	1	8	0	0	0
19.50 - 20.49	214	0	0	7	57	3	0	0	0	16	116	5	0	10	0	0	0
20.50 - 21.49	138	0	0	9	35	0	0	0	0	4	83	6	0	1	0	0	0
21.50 - 22.49	103	0	0	4	33	0	0	0	0	7	57	1	0	1	0	0	0
22.50 - 23.49	43	0	0	1	15	0	0	0	0	0	27	0	0	0	0	0	0
23.50 - 24.49	34	0	0	1	17	0	0	0	0	0	15	1	0	0	0	0	0
24.50 - 25.49	27	0	0	1	16	0	0	0	0	2	7	1	0	0	0	0	0
25.50 - 26.49	15	0	0	0	11	0	0	0	0	0	4	0	0	0	0	0	0
26.50 - 27.49	10	0	0	0	9	0	0	0	0	0	0	1	0	0	0	0	0
27.50 - 28.49	4	0	0	1	2	0	0	0	0	0	0	1	0	0	0	0	0
Sum	88,723	5,788	3,141	7,035	14,677	7,206	4,783	5,630	4,352	3,986	9,566	3,396	1,364	3,091	5,663	4,912	4,133

Turbulence

Wind speed	Sum	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.00 - 0.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.50 - 1.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.50 - 2.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.50 - 3.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3.50 - 4.49	0.151	0.111	0.167	0.189	0.200	0.165	0.129	0.129	0.149	0.161	0.209	0.194	0.167	0.166	0.122	0.118	0.100
4.50 - 5.49	0.150	0.106	0.152	0.196	0.197	0.160	0.122	0.115	0.144	0.167	0.204	0.182	0.171	0.143	0.118	0.116	0.102
5.50 - 6.49	0.157	0.112	0.157	0.196	0.199	0.165	0.134	0.113	0.139	0.186	0.213	0.181	0.166	0.135	0.114	0.116	0.093
6.50 - 7.49	0.166	0.121	0.166	0.202	0.210	0.167	0.146	0.115	0.139	0.200	0.211	0.180	0.163	0.126	0.115	0.112	0.102
7.50 - 8.49	0.176	0.123	0.200	0.203	0.210	0.173	0.147	0.126	0.133	0.196	0.215	0.179	0.141	0.121	0.104	0.113	0.127
8.50 - 9.49	0.186	0.134	0.186	0.214	0.213	0.177	0.139	0.126	0.134	0.201	0.216	0.178	0.159	0.117	0.100	0.119	0.141
9.50 - 10.49	0.188	0.130	0.145	0.211	0.214	0.174	0.147	0.127	0.114	0.209	0.216	0.181	0.144	0.122	0.098	0.132	0.136
10.50 - 11.49	0.192	0.129	0.086	0.209	0.215	0.172	0.143	0.124	0.100	0.211	0.219	0.186	0.149	0.126	0.105	0.117	0.137
11.50 - 12.49	0.195	0.134	0.101	0.210	0.215	0.163	0.138	0.120	0.103	0.214	0.216	0.187	0.143	0.115	0.113	0.110	0.126
12.50 - 13.49	0.203	0.135	0.110	0.209	0.213	0.159	0.133	0.118	0.107	0.216	0.216	0.187	0.139	0.123	0.098	0.121	0.147
13.50 - 14.49	0.204	0.127		0.214	0.215	0.145	0.138	0.116	0.101	0.210	0.217	0.183	0.148	0.128	0.088	0.097	0.128
14.50 - 15.49	0.205	0.123		0.209	0.211	0.152	0.144	0.115	0.121	0.205	0.215	0.180	0.124	0.135	0.088	0.085	0.123
15.50 - 16.49	0.204	0.113		0.210	0.213	0.150	0.150	0.154	0.122	0.195	0.211	0.175	0.123	0.151			0.110
16.50 - 17.49	0.205	0.122		0.211	0.208	0.148	0.125	0.139		0.203	0.214	0.181	0.142	0.158			0.069
17.50 - 18.49	0.206			0.205	0.208	0.154		0.129		0.203	0.211	0.181	0.169	0.133			
18.50 - 19.49	0.204			0.213	0.195	0.172		0.100		0.215	0.215	0.170	0.131	0.114			
19.50 - 20.49	0.198			0.200	0.197	0.170				0.205	0.209	0.171		0.085			
20.50 - 21.49	0.209			0.225	0.212					0.179	0.212	0.168		0.073			
21.50 - 22.49	0.204			0.204	0.201					0.187	0.210	0.154		0.075			
22.50 - 23.49	0.203			0.249	0.199						0.203						
23.50 - 24.49	0.199			0.184	0.195						0.206	0.184					
24.50 - 25.49	0.195			0.208	0.192					0.194	0.200	0.202					
25.50 - 26.49	0.189				0.189						0.191						
26.50 - 27.49	0.188				0.192							0.158					
27.50 - 28.49	0.188			0.222	0.192							0.149					
Sum	0.171	0.118	0.159	0.203	0.208	0.166	0.133	0.119	0.141	0.191	0.214	0.182	0.160	0.136	0.114	0.116	0.106

Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

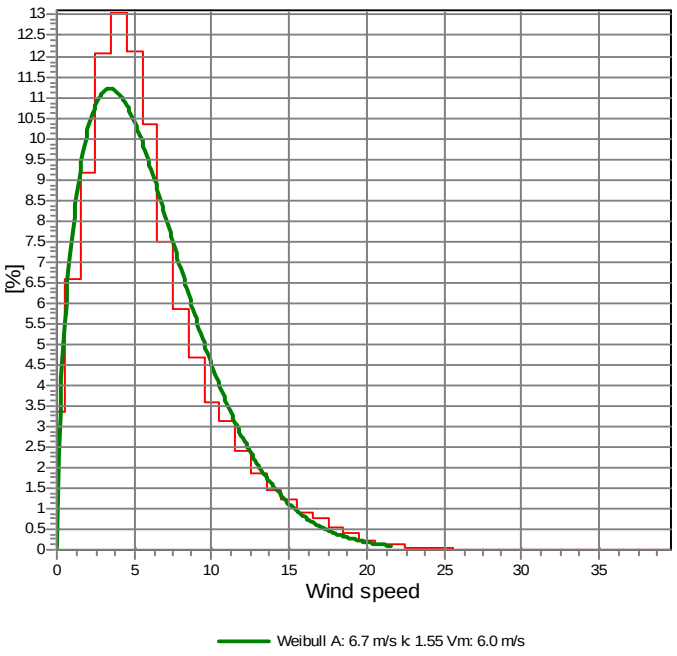
Printed/Page
8/18/2009 4:44 PM / 4
Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027

Calculated:
8/18/2009 4:44 PM/

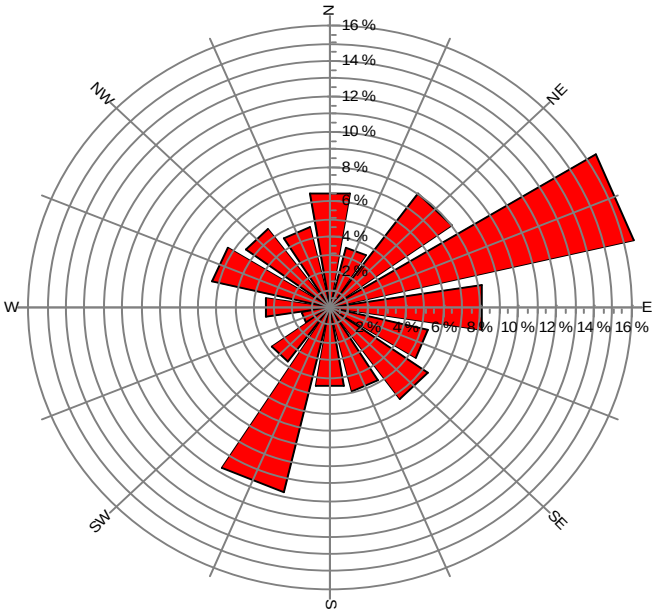
Meteo data report, height: 26.5 m

Name of meteo object: MET tower

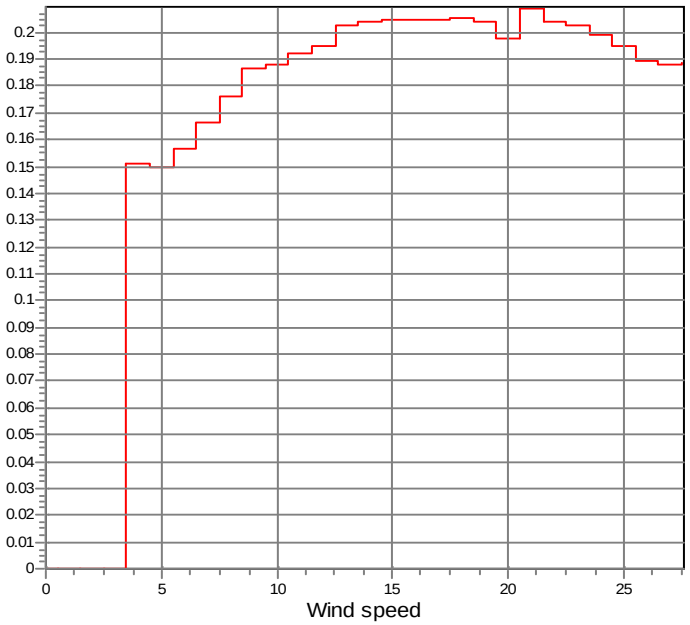
Frequency



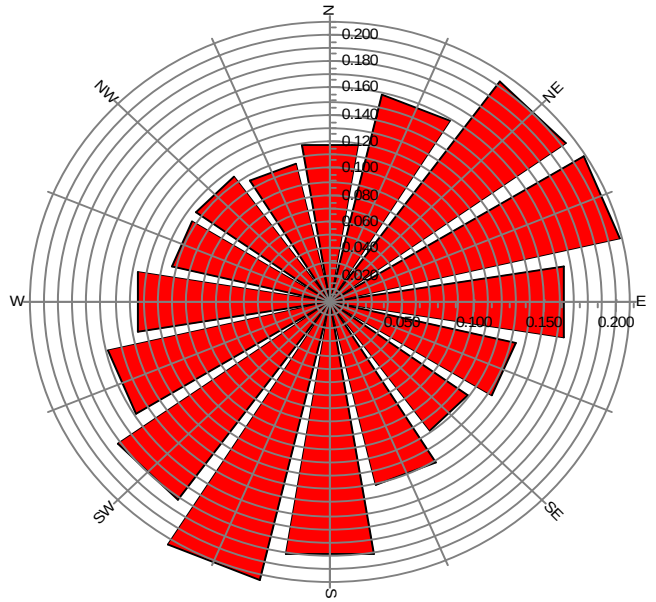
Frequency



Turbulence
V>4.0 m/s



Turbulence
V>4.0 m/s



Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

Printed/Page
8/18/2009 4:44 PM / 5
Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027

Calculated:
8/18/2009 4:44 PM/

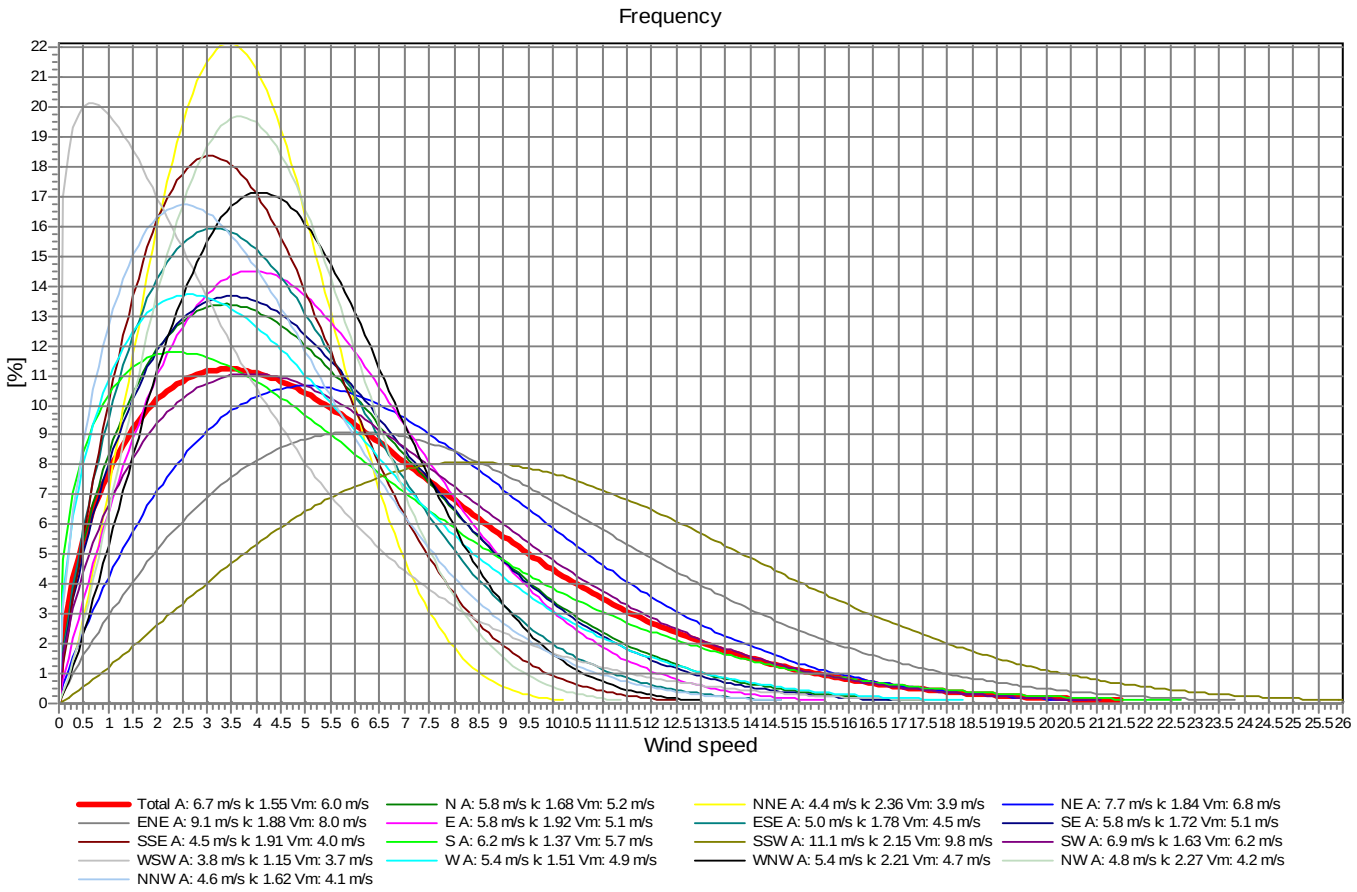
Meteo data report, height: 26.5 m

Name of meteo object: MET tower

Weibull Data

k-parameter correction: 0.0080/m

Sector	A- parameter [m/s]	Mean wind speed [m/s]	k- parameter	Frequency	Frequency [%]	Wind shear
0-N	5.80	5.18	1.677	6.52	6.5	0.00
1-NNE	4.36	3.86	2.358	3.54	3.5	0.00
2-NE	7.66	6.81	1.844	7.93	7.9	0.00
3-ENE	9.06	8.04	1.883	16.54	16.5	0.00
4-E	5.77	5.12	1.923	8.12	8.1	0.00
5-ESE	5.02	4.47	1.777	5.39	5.4	0.00
6-SE	5.76	5.14	1.725	6.35	6.3	0.00
7-SSE	4.54	4.02	1.908	4.91	4.9	0.00
8-S	6.23	5.70	1.366	4.49	4.5	0.00
9-SSW	11.12	9.85	2.147	10.78	10.8	0.00
10-SW	6.93	6.21	1.631	3.83	3.8	0.00
11-WSW	3.84	3.65	1.152	1.54	1.5	0.00
12-W	5.45	4.91	1.507	3.48	3.5	0.00
13-WNW	5.36	4.75	2.209	6.38	6.4	0.00
14-NW	4.76	4.22	2.268	5.54	5.5	0.00
15-NNW	4.58	4.10	1.622	4.66	4.7	0.00
mean	6.71	6.03	1.547	100.00	100.0	0.00



Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

Printed/Page
8/18/2009 4:50 PM / 1
Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027
Calculated:
8/18/2009 4:50 PM/

Meteo data report, height: 18.6 m

Name of meteo object: MET tower

Data from: 11/13/2007 12:00 AM Data to: 7/31/2009 2:50 PM Observations: 90234 Observations per day: 144 Recovery rate: 100%

day	11/07	12/07	01/08	02/08	03/08	04/08	05/08	06/08	07/08	08/08	09/08	10/08	11/08	12/08	01/09	02/09	03/09	04/09	05/09	06/09	07/09	08/09
1		144	144	(96)	144	144	144	144	144	(98)	144	(115)	144	(84)	(141)	144	144	144	(138)	144	144	
2		(141)	144	144	144	144	(143)	144	144	(140)	144	144	144	(94)	144	144	(140)	144	144	144	144	
3		144	(142)	144	144	144	144	144	144	(138)	144	(129)	(139)	144	144	(139)	(119)	144	(142)	144	144	
4		144	(123)	(143)	144	144	144	144	(117)	(143)	144	144	144	144	144	144	(142)	(143)	(141)	144	144	
5		(130)	(134)	144	144	(140)	144	144	(142)	144	(133)	144	144	(140)	144	(137)	(138)	144	144	144	144	
6		(138)	(139)	144	(141)	144	(137)	144	(143)	(128)	(134)	144	(140)	144	144	(143)	144	(109)	144	144	144	
7		144	(141)	144	144	144	144	144	(143)	(128)	144	144	(141)	(122)	(143)	144	(142)	144	144	144	144	
8		144	144	144	144	(139)	144	144	(139)	(143)	144	(140)	(132)	(143)	(143)	(141)	(106)	(137)	144	144	144	
9		(137)	144	144	144	144	(142)	144	(135)	(130)	144	(140)	(142)	144	(132)	(135)	144	(135)	144	144	144	
10		144	(111)	144	144	144	144	(143)	(142)	(133)	144	144	144	(139)	(121)	(136)	(143)	144	144	144	144	
11		(125)	(136)	144	144	(139)	(129)	(112)	(124)	(143)	144	144	144	(104)	(142)	(142)	144	144	144	144	144	
12		144	(142)	(141)	144	144	144	(139)	144	(139)	144	(142)	(128)	(143)	(139)	(138)	144	(106)	144	144	144	
13	144	(139)	(142)	144	144	(126)	144	(134)	(140)	144	144	(134)	144	144	(143)	144	(140)	(132)	144	144	144	
14	144	144	(138)	144	(141)	(142)	144	(132)	(143)	144	144	144	144	(101)	144	(140)	144	144	144	144	144	
15	144	144	144	(143)	144	(138)	144	(109)	144	144	(141)	(138)	(136)	(141)	144	144	144	144	144	144	144	
16	144	144	144	144	144	(119)	144	(136)	144	(125)	144	144	(143)	(140)	144	144	144	144	144	144	144	
17	144	144	(130)	144	(107)	144	144	(143)	144	(132)	144	(142)	(138)	(142)	144	(126)	144	144	144	144	144	
18	144	(133)	144	144	(81)	(125)	144	(142)	144	(126)	144	144	(137)	(130)	144	(128)	(143)	144	144	144	144	
19	144	(136)	(139)	144	144	(110)	144	(137)	144	144	144	144	144	(138)	144	(127)	144	(143)	144	144	144	
20	144	(141)	144	144	144	144	144	(128)	(142)	(139)	144	(142)	(142)	(141)	(141)	(90)	144	144	144	144	144	
21	144	(112)	144	144	144	144	144	144	144	144	(131)	(132)	(114)	(129)	144	144	144	144	144	144	144	
22	144	(78)	144	(143)	144	144	(143)	(142)	144	144	(143)	144	144	(137)	(135)	(143)	144	144	144	144	144	
23	144	(139)	(131)	144	144	144	(141)	144	144	(141)	(126)	144	(143)	(129)	(122)	(136)	144	144	144	144	144	
24	144	144	(137)	(140)	144	(138)	(135)	(118)	144	(135)	(135)	144	144	(135)	(137)	(142)	144	(124)	144	144	144	
25	144	144	144	144	144	144	(140)	144	(130)	144	144	144	144	144	(105)	(140)	144	(107)	144	144	144	
26	144	144	144	144	144	144	144	144	(128)	(123)	(130)	144	(135)	144	(130)	(143)	144	(141)	144	144	144	
27	(135)	144	(140)	(139)	(126)	144	144	(138)	(134)	(110)	(124)	144	144	144	(100)	(131)	(128)	144	144	144	144	
28	(143)	(143)	144	144	(107)	144	144	(130)	(133)	(132)	144	(142)	144	144	(140)	(131)	(141)	144	144	144	144	
29	(135)	(112)	(123)	144	(127)	(126)	144	144	144	(127)	144	(128)	144	144	(139)		144	144	144	144	144	
30	(130)	(104)	(135)		144	144	144	144	(138)	(131)	144	(124)	(40)	144	(108)		144	(136)	144	144	144	
31		144	(120)		144		144		(131)	144		(106)		144	144		144		144		(90)	
%	(99)	(94)	(96)	(98)	(96)	(97)	(99)	(96)	(97)	(94)	(98)	(96)	(95)	(93)	(95)	(95)	(98)	(96)	(100)	100	(99)	(0)

Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

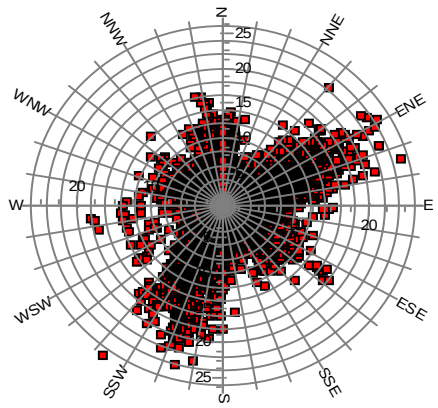
Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

Printed/Page
8/18/2009 4:50 PM / 2
Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027

Calculated:
8/18/2009 4:50 PM/

Meteo data report, height: 18.6 m

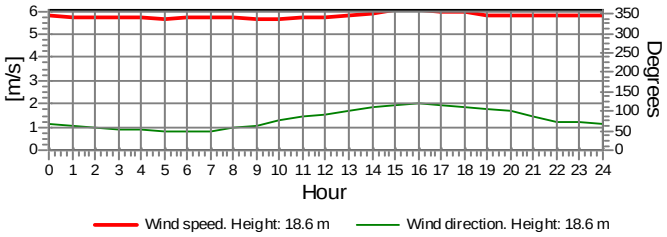
Name of meteo object: MET tower

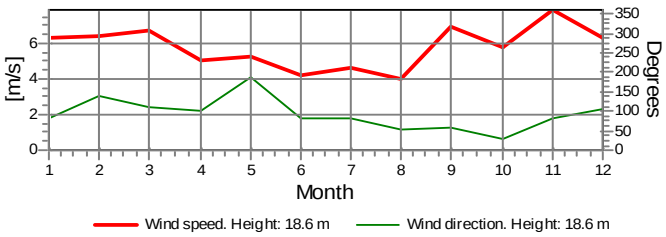


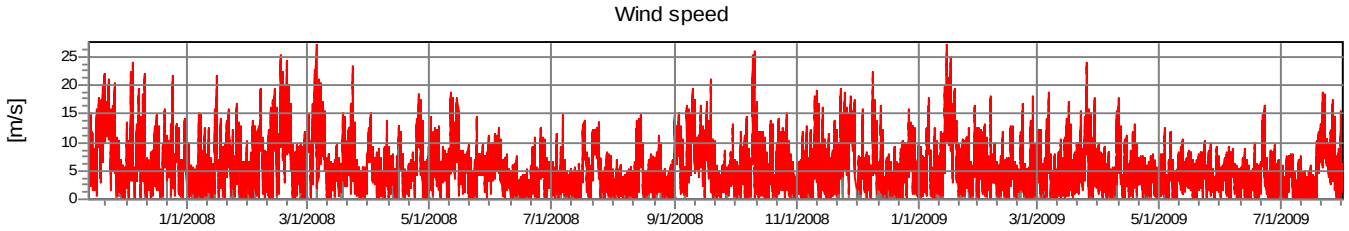
Wind speed [m/s]

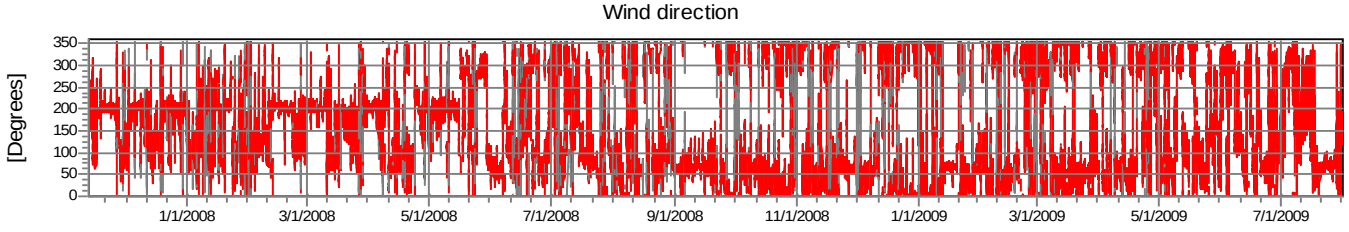
Monthly mean values of wind speed in m/s

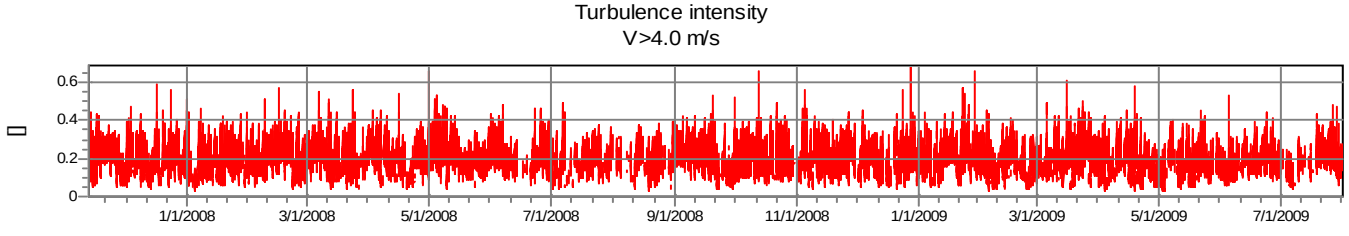
Month	2007	2008	2009	mean	mean of months
Jan		5.6	7.1	6.4	6.4
Feb		7.7	5.1	6.4	6.4
Mar		7.3	6.2	6.7	6.7
Apr		5.6	4.7	5.1	5.1
May		6.3	4.2	5.3	5.3
Jun		4.3	4.2	4.2	4.2
Jul		4.4	4.8	4.6	4.6
Aug		4.0		4.0	4.0
Sep		7.0		7.0	7.0
Oct		5.8		5.8	5.8
Nov	9.3	7.1		7.9	8.2
Dec	7.1	5.6		6.3	6.3
mean, all data	7.9	5.9	5.2	5.8	
mean of months	8.2	5.9	5.2		5.8











Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027

Calculated:
8/18/2009 4:50 PM/

Meteo data report, height: 18.6 m

Name of meteo object: MET tower

Frequency

Wind speed m/s	Sum	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.00 - 0.49	2,203	150	126	141	144	123	148	123	124	110	112	104	144	203	163	155	133
0.50 - 1.49	6,235	394	333	384	444	466	410	373	415	339	313	355	319	440	473	404	373
1.50 - 2.49	7,925	496	412	459	601	549	566	543	658	463	364	345	238	393	692	616	530
2.50 - 3.49	10,410	731	532	597	911	986	684	755	869	561	399	220	170	444	936	894	721
3.50 - 4.49	11,138	842	540	708	1,157	1,084	789	839	942	483	527	245	98	445	939	801	699
4.50 - 5.49	10,420	695	500	751	1,462	1,022	723	798	579	395	621	326	85	344	812	810	497
5.50 - 6.49	9,266	558	387	809	1,535	972	543	690	317	292	693	351	70	289	769	603	388
6.50 - 7.49	6,593	408	143	695	1,380	663	294	406	184	246	598	318	30	165	470	322	271
7.50 - 8.49	4,983	354	46	559	1,340	428	177	286	81	187	722	243	41	100	204	95	120
8.50 - 9.49	4,004	269	13	459	1,193	298	120	231	38	160	774	213	22	54	57	38	65
9.50 - 10.49	3,223	284	8	343	964	168	80	195	20	134	679	166	31	29	27	14	81
10.50 - 11.49	2,804	255	3	242	836	107	70	131	34	151	700	122	27	29	8	32	57
11.50 - 12.49	2,117	126	2	196	644	83	50	64	15	120	625	96	20	23	10	5	38
12.50 - 13.49	1,549	52	1	191	469	74	28	39	6	91	484	58	9	21	0	0	26
13.50 - 14.49	1,265	32	0	129	424	40	12	14	4	61	478	49	4	9	0	1	8
14.50 - 15.49	947	16	0	88	322	17	4	13	2	29	403	37	4	5	0	1	6
15.50 - 16.49	697	7	0	50	226	14	2	13	1	31	293	43	4	5	0	0	8
16.50 - 17.49	525	1	0	30	159	6	3	16	0	19	250	33	2	5	0	0	1
17.50 - 18.49	372	1	0	15	98	1	2	14	0	27	186	15	2	10	0	0	1
18.50 - 19.49	217	0	0	7	58	3	0	4	0	10	124	4	0	7	0	0	0
19.50 - 20.49	155	0	0	7	53	1	0	1	0	9	78	5	0	1	0	0	0
20.50 - 21.49	70	0	0	3	18	0	0	0	0	6	40	3	0	0	0	0	0
21.50 - 22.49	54	0	0	3	16	0	0	0	0	2	31	2	0	0	0	0	0
22.50 - 23.49	31	0	0	1	20	0	0	0	0	1	8	1	0	0	0	0	0
23.50 - 24.49	22	0	0	0	14	0	0	0	0	1	7	0	0	0	0	0	0
24.50 - 25.49	17	0	0	1	12	0	0	0	0	0	3	1	0	0	0	0	0
25.50 - 26.49	3	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
26.50 - 27.49	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
27.50 - 28.49	2	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Sum	87,248	5,671	3,046	6,868	14,504	7,105	4,705	5,548	4,289	3,928	9,512	3,357	1,320	3,021	5,560	4,791	4,023

Turbulence

Wind speed	Sum	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.00 - 0.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.50 - 1.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.50 - 2.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.50 - 3.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3.50 - 4.49	0.184	0.151	0.191	0.223	0.224	0.185	0.157	0.165	0.199	0.205	0.240	0.235	0.209	0.190	0.168	0.138	0.121
4.50 - 5.49	0.180	0.141	0.184	0.221	0.226	0.182	0.145	0.151	0.186	0.208	0.234	0.205	0.195	0.185	0.161	0.135	0.120
5.50 - 6.49	0.186	0.148	0.175	0.226	0.234	0.188	0.146	0.148	0.180	0.219	0.236	0.194	0.196	0.178	0.166	0.133	0.109
6.50 - 7.49	0.196	0.158	0.188	0.232	0.240	0.193	0.156	0.154	0.171	0.228	0.237	0.199	0.186	0.174	0.159	0.129	0.110
7.50 - 8.49	0.212	0.170	0.206	0.236	0.246	0.198	0.165	0.164	0.174	0.220	0.244	0.203	0.171	0.168	0.154	0.137	0.131
8.50 - 9.49	0.219	0.179	0.193	0.241	0.243	0.193	0.160	0.169	0.163	0.228	0.247	0.193	0.158	0.156	0.154	0.145	0.161
9.50 - 10.49	0.221	0.178	0.178	0.234	0.243	0.197	0.161	0.170	0.187	0.236	0.250	0.200	0.160	0.161	0.157	0.156	0.167
10.50 - 11.49	0.224	0.179	0.098	0.242	0.243	0.199	0.165	0.167	0.170	0.241	0.248	0.213	0.152	0.149	0.167	0.147	0.164
11.50 - 12.49	0.230	0.178	0.106	0.235	0.244	0.193	0.155	0.165	0.162	0.252	0.251	0.220	0.155	0.154	0.147	0.148	0.164
12.50 - 13.49	0.231	0.179	0.128	0.237	0.244	0.182	0.154	0.155	0.149	0.241	0.249	0.208	0.162	0.156			0.159
13.50 - 14.49	0.237	0.176		0.240	0.244	0.177	0.165	0.151	0.173	0.239	0.248	0.228	0.148	0.173		0.140	0.169
14.50 - 15.49	0.237	0.176		0.239	0.244	0.183	0.153	0.152	0.188	0.232	0.245	0.219	0.144	0.183		0.105	0.172
15.50 - 16.49	0.234	0.156		0.237	0.242	0.178	0.164	0.159	0.146	0.223	0.246	0.210	0.131	0.183			0.154
16.50 - 17.49	0.237	0.156		0.239	0.240	0.204	0.177	0.184		0.234	0.248	0.203	0.178	0.144			0.097
17.50 - 18.49	0.232	0.166		0.249	0.226	0.191	0.150	0.181		0.254	0.247	0.198	0.152	0.110			0.113
18.50 - 19.49	0.231			0.233	0.230	0.217		0.173		0.237	0.241	0.208		0.115			
19.50 - 20.49	0.237			0.247	0.237	0.198		0.172		0.237	0.242	0.200		0.096			
20.50 - 21.49	0.233			0.242	0.222					0.218	0.243	0.198					
21.50 - 22.49	0.232			0.229	0.229					0.200	0.237	0.205					
22.50 - 23.49	0.236			0.247	0.232					0.255	0.243	0.233					
23.50 - 24.49	0.222				0.223					0.207	0.223						
24.50 - 25.49	0.226			0.255	0.218						0.236	0.257					
25.50 - 26.49	0.210				0.210												
26.50 - 27.49	0.226											0.226					
27.50 - 28.49	0.191				0.178							0.205					
Sum	0.202	0.160	0.184	0.231	0.238	0.189	0.152	0.157	0.185	0.224	0.244	0.205	0.182	0.177	0.162	0.135	0.124

Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

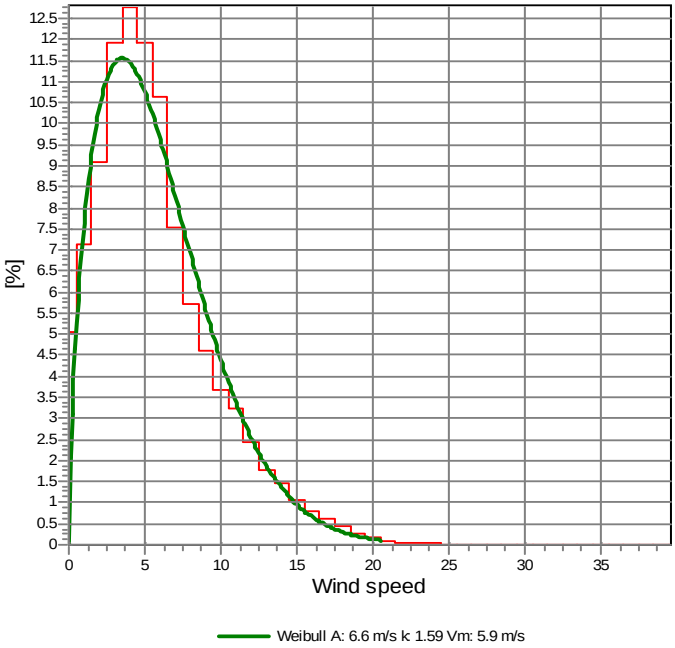
Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027

Calculated:
8/18/2009 4:50 PM/

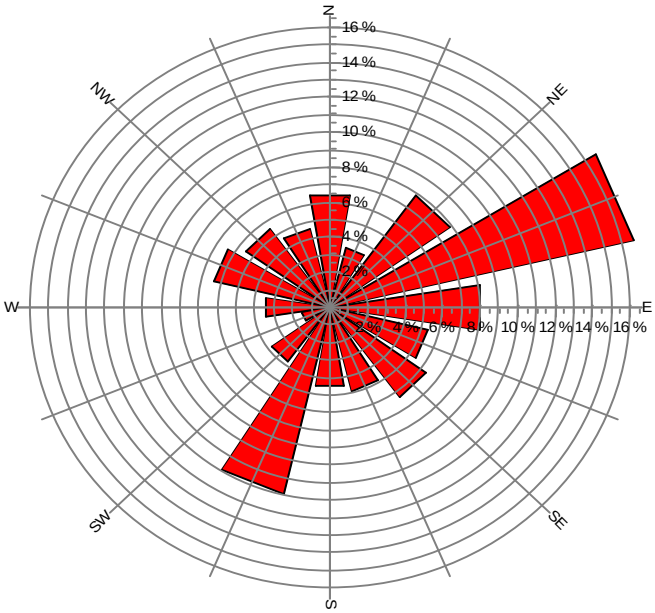
Meteo data report, height: 18.6 m

Name of meteo object: MET tower

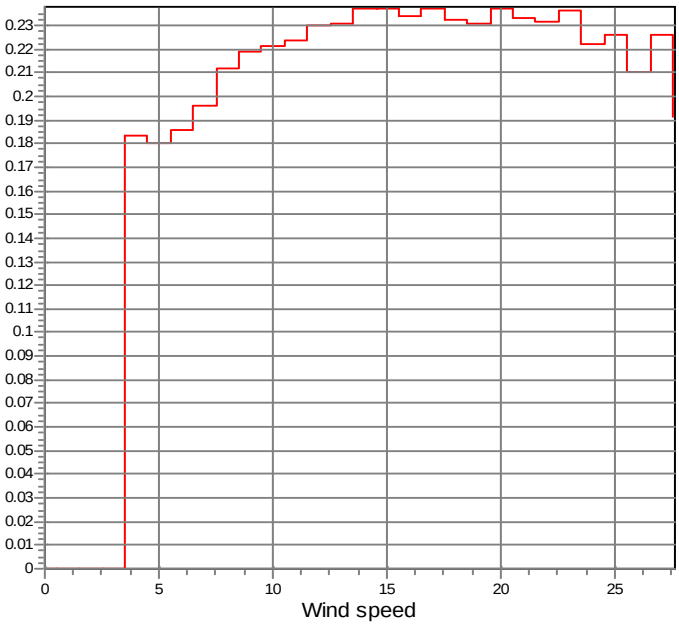
Frequency



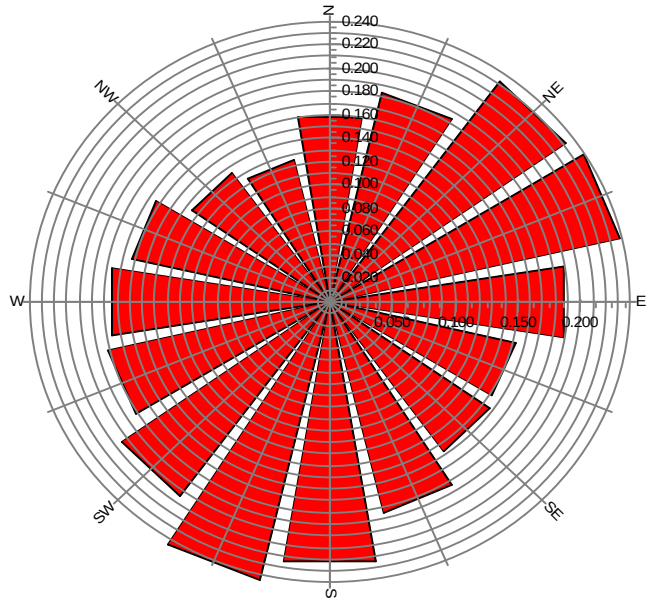
Frequency



Turbulence
V>4.0 m/s



Turbulence
V>4.0 m/s



Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

Printed/Page
8/18/2009 4:50 PM / 5
Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027

Calculated:
8/18/2009 4:50 PM/

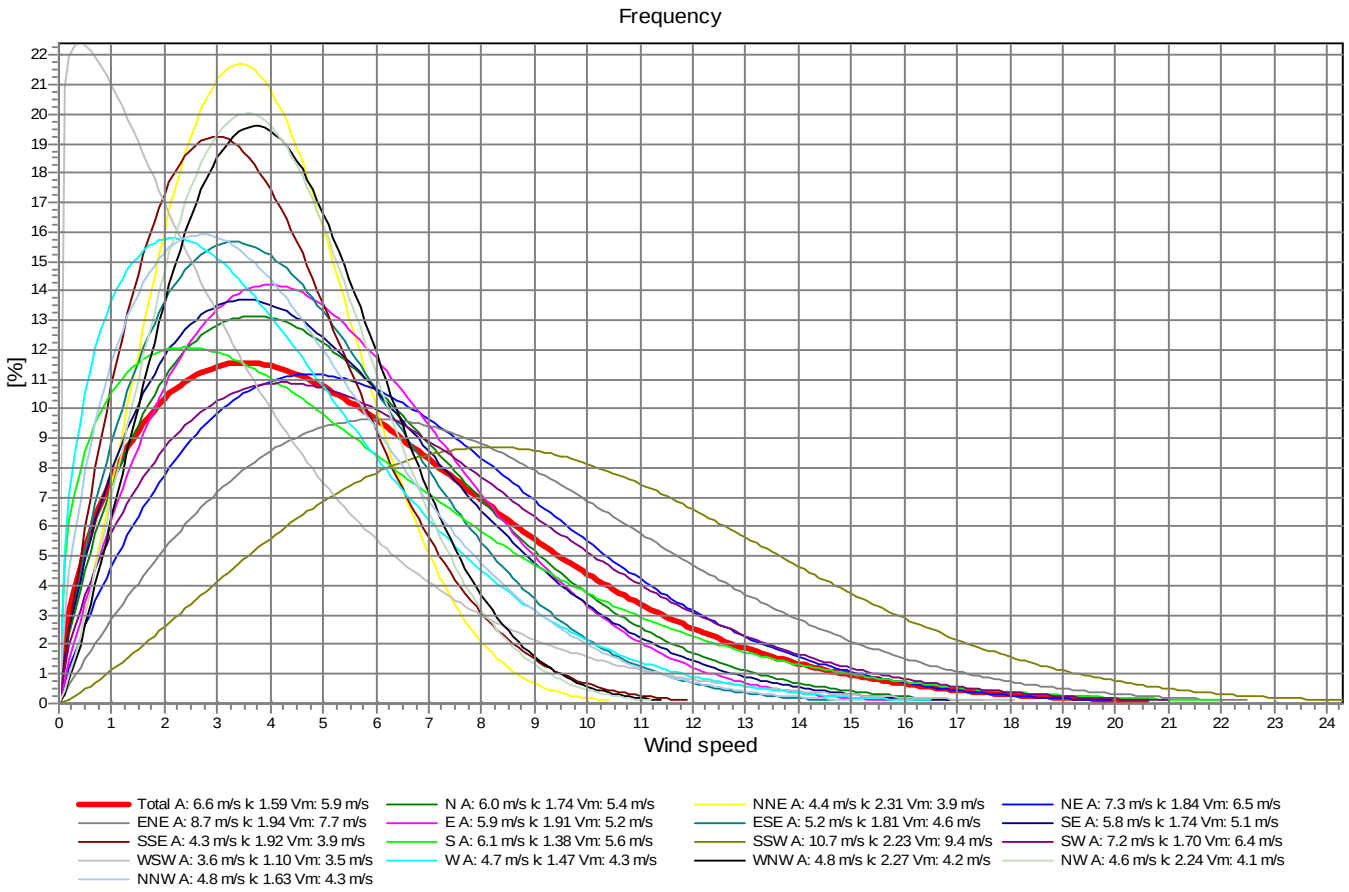
Meteo data report, height: 18.6 m

Name of meteo object: MET tower

Weibull Data

k-parameter correction: 0.0080/m

Sector	A- parameter [m/s]	Mean wind speed [m/s]	k- parameter	Frequency	Frequency [%]	Wind shear
0-N	6.01	5.36	1.741	6.50	6.5	0.00
1-NNE	4.38	3.88	2.313	3.49	3.5	0.00
2-NE	7.29	6.48	1.839	7.87	7.9	0.00
3-ENE	8.73	7.74	1.943	16.62	16.6	0.00
4-E	5.87	5.21	1.914	8.14	8.1	0.00
5-ESE	5.16	4.58	1.811	5.39	5.4	0.00
6-SE	5.77	5.14	1.737	6.36	6.4	0.00
7-SSE	4.34	3.85	1.920	4.92	4.9	0.00
8-S	6.08	5.55	1.378	4.50	4.5	0.00
9-SSW	10.65	9.44	2.235	10.90	10.9	0.00
10-SW	7.17	6.40	1.696	3.85	3.8	0.00
11-WSW	3.61	3.49	1.098	1.51	1.5	0.00
12-W	4.70	4.25	1.468	3.46	3.5	0.00
13-WNW	4.79	4.24	2.275	6.37	6.4	0.00
14-NW	4.64	4.11	2.241	5.49	5.5	0.00
15-NNW	4.83	4.32	1.633	4.61	4.6	0.00
mean	6.56	5.89	1.586	100.00	100.0	0.00



Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

Printed/Page
8/18/2009 4:52 PM / 1
Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027

Calculated:
8/18/2009 4:52 PM/

Meteo data report, height: 10.7 m

Name of meteo object: MET tower

Data from: 11/13/2007 12:00 AM Data to: 7/31/2009 2:50 PM Observations: 90234 Observations per day: 144 Recovery rate: 100%

day	11/07	12/07	01/08	02/08	03/08	04/08	05/08	06/08	07/08	08/08	09/08	10/08	11/08	12/08	01/09	02/09	03/09	04/09	05/09	06/09	07/09	08/09
1		144	144	(80)	(82)	144	144	144	144	(102)	144	(118)	144	(34)	(140)	144	144	144	(138)	144	(120)	
2		(141)	144	144	144	144	(143)	144	(141)	(139)	144	144	144	(122)	144	144	(143)	144	(143)	144	(133)	
3		144	(141)	144	144	144	144	144	(142)	(142)	144	(129)	(141)	144	144	(140)	(110)	144	(139)	144	(137)	
4		144	(119)	(142)	144	144	144	144	(105)	(143)	144	144	144	144	144	144	(134)	(140)	(134)	144	144	
5		(129)	(130)	144	144	(141)	144	144	(139)	(143)	(133)	144	144	(139)	144	(137)	(132)	(140)	(123)	(129)	144	
6		(139)	(132)	(142)	144	144	(133)	144	(143)	(128)	(134)	144	(141)	144	144	144	144	(100)	144	144	144	
7		144	(143)	144	144	144	144	144	(143)	(119)	144	144	(142)	(137)	(143)	144	(141)	(143)	(141)	144	(122)	
8		144	144	(143)	144	(141)	144	144	(135)	(141)	144	(139)	(135)	(143)	(143)	(141)	(106)	(124)	144	144	(100)	
9		(143)	(141)	144	144	144	(142)	144	(131)	(129)	144	(141)	(140)	144	(133)	(136)	144	(136)	(138)	(137)	(110)	
10		144	(123)	144	144	(141)	144	(143)	(132)	(132)	144	144	144	(138)	(125)	(139)	(141)	144	(143)	144	144	
11		(125)	(136)	144	144	(131)	(128)	(118)	(116)	(142)	144	144	144	(76)	144	(141)	144	(142)	144	(142)	(87)	
12		144	(142)	144	144	(132)	144	144	(142)	(137)	144	144	(124)	(143)	(139)	(133)	144	(92)	(141)	(141)	(83)	
13	144	(141)	(140)	144	144	(74)	144	(131)	(137)	144	144	(137)	144	144	144	144	(137)	(135)	(140)	(127)	(126)	
14	144	144	(134)	144	(143)	(142)	144	(129)	(136)	144	144	144	144	(104)	144	(126)	(142)	144	144	(132)	(134)	
15	144	144	144	(143)	144	144	144	(101)	144	144	(140)	(140)	(135)	(142)	144	144	144	144	144	(142)	(84)	
16	144	144	144	144	144	(120)	144	(133)	144	(119)	144	144	144	(143)	144	144	144	144	144	(141)	(122)	
17	144	144	(139)	144	(101)	144	144	(143)	144	(122)	144	(142)	(143)	(136)	144	(137)	144	(143)	144	(141)	(127)	
18	144	(134)	144	144	(87)	(125)	144	(139)	144	(131)	144	144	(140)	(122)	144	(134)	(142)	144	(126)	(140)	(138)	
19	(135)	(136)	(140)	144	144	(105)	144	(136)	144	144	144	144	144	(129)	144	(130)	144	144	(138)	144	144	
20	144	(141)	144	144	144	144	144	(125)	(141)	(136)	144	(143)	(140)	(138)	(141)	(89)	144	144	(142)	144	144	
21	144	(112)	144	144	144	144	144	144	144	(143)	(132)	(137)	(130)	(133)	144	144	144	144	144	144	144	
22	144	(74)	144	144	144	144	(139)	(142)	144	(141)	(143)	144	144	(123)	(138)	144	144	144	(142)	144	144	
23	144	(143)	(129)	144	144	144	(139)	144	144	(141)	(126)	144	(114)	(143)	(121)	(130)	144	144	144	144	144	
24	144	144	(134)	(143)	144	(137)	(133)	(118)	144	(129)	(134)	144	(122)	(139)	(142)	(137)	144	(121)	(141)	(137)	144	
25	144	144	(143)	144	(143)	144	(140)	144	(122)	(142)	144	144	144	(143)	(105)	(138)	144	(114)	(132)	(141)	144	
26	144	144	144	144	144	144	144	144	(119)	(113)	(136)	144	(136)	144	(129)	(141)	144	(138)	144	(142)	144	
27	(137)	144	(135)	(139)	(115)	144	144	(139)	(131)	(100)	(126)	144	144	144	(116)	(130)	(129)	144	144	(136)	144	
28	144	(143)	144	144	(104)	144	144	(129)	(132)	(130)	144	(136)	144	144	(143)	(126)	(139)	144	(137)	(125)	(135)	
29	(134)	(135)	(118)	(107)	(128)	(125)	(143)	144	144	(127)	144	(112)	144	144	(140)		144	144	144	(143)	(138)	
30	(135)	(120)	(140)		144	144	144	144	(139)	(122)	(143)	(112)	(38)	144	(121)		144	(135)	144	(138)	(117)	
31		144	(98)		144		144		(130)	144		(88)		(143)	144		144		144		(90)	
%	(99)	(95)	(95)	(97)	(94)	(95)	(99)	(96)	(95)	(92)	(98)	(96)	(94)	(92)	(96)	(95)	(97)	(95)	(98)	(97)	(89)	(0)

Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

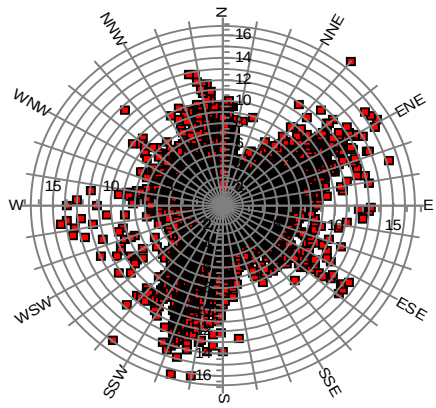
Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

Printed/Page
8/18/2009 4:52 PM / 2
Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027

Calculated:
8/18/2009 4:52 PM/

Meteo data report, height: 10.7 m

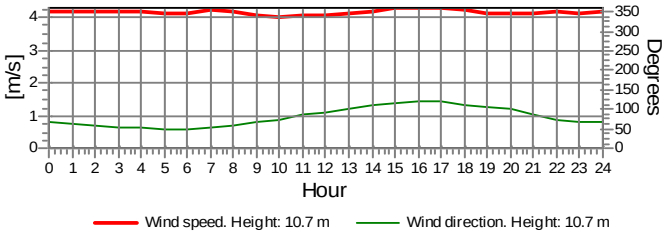
Name of meteo object: MET tower

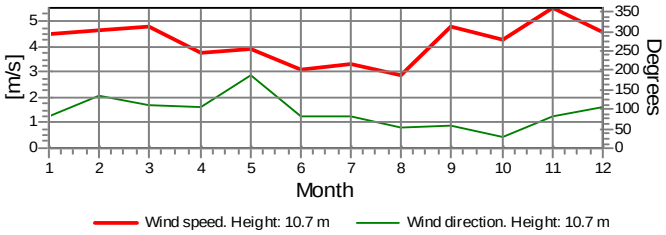


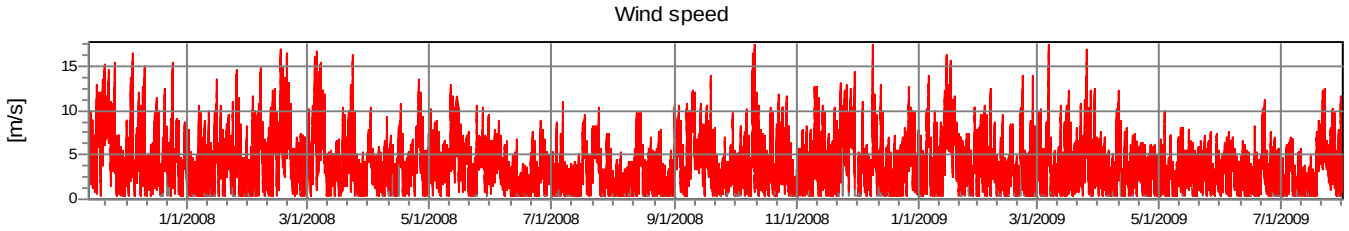
Wind speed [m/s]

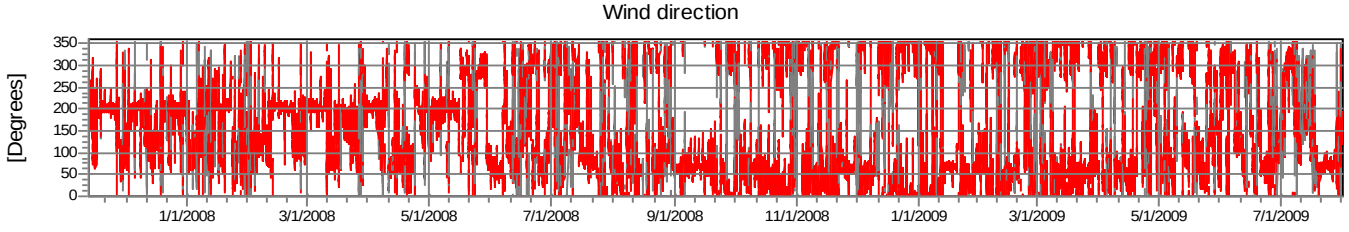
Monthly mean values of wind speed in m/s

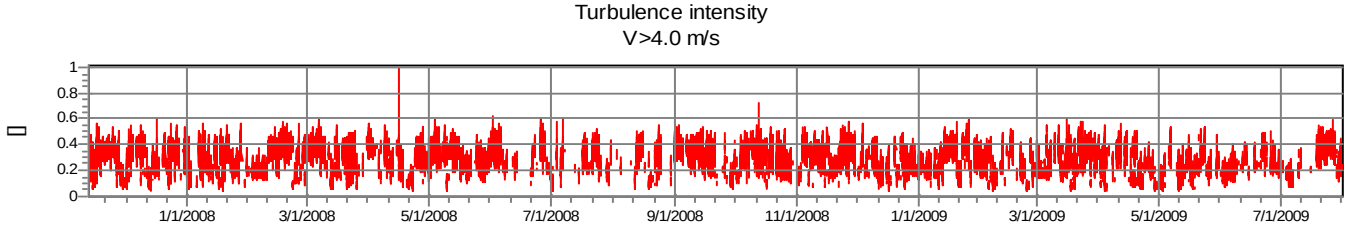
Month	2007	2008	2009	mean	mean of months
Jan		4.1	4.9	4.5	4.5
Feb		5.3	3.9	4.6	4.6
Mar		5.1	4.5	4.8	4.8
Apr		4.0	3.5	3.8	3.8
May		4.6	3.2	3.9	3.9
Jun		3.1	3.1	3.1	3.1
Jul		3.2	3.5	3.3	3.3
Aug		2.9		2.9	2.9
Sep		4.8		4.8	4.8
Oct		4.3		4.3	4.3
Nov	6.5	4.9		5.5	5.7
Dec	4.9	4.2		4.6	4.6
mean, all data	5.5	4.2	3.8	4.2	
mean of months	5.7	4.2	3.8		4.2











Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027

Calculated:
8/18/2009 4:52 PM/

Meteo data report, height: 10.7 m

Name of meteo object: MET tower

Frequency

Wind speed m/s	Sum	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.00 - 0.49	2,567	192	164	169	190	179	182	153	186	147	131	141	131	179	130	150	143
0.50 - 1.49	9,619	638	615	526	823	823	643	685	822	550	495	496	365	420	682	514	522
1.50 - 2.49	11,566	830	672	692	1,308	1,086	671	843	1,074	564	626	372	210	413	890	688	627
2.50 - 3.49	15,293	1,160	749	945	2,116	1,384	826	1,176	1,149	672	964	464	142	534	1,221	954	837
3.50 - 4.49	14,173	839	547	1,155	2,293	1,358	896	1,015	582	506	1,006	518	101	502	1,143	1,028	684
4.50 - 5.49	10,807	565	197	996	2,130	1,029	646	680	241	354	1,066	430	66	312	886	739	470
5.50 - 6.49	7,649	422	57	814	1,811	594	302	361	117	257	1,183	324	39	188	403	451	326
6.50 - 7.49	4,776	312	24	547	1,266	278	185	259	40	200	987	226	36	88	91	130	107
7.50 - 8.49	3,469	312	5	364	904	136	117	165	25	203	853	114	35	79	21	42	94
8.50 - 9.49	2,458	226	2	275	596	63	90	65	5	181	691	68	32	57	5	25	77
9.50 - 10.49	1,558	74	3	177	412	26	57	33	2	95	501	51	31	31	3	17	45
10.50 - 11.49	986	35	1	92	241	26	36	22	4	52	378	52	11	13	0	1	22
11.50 - 12.49	538	15	0	40	121	27	9	19	1	37	223	19	6	14	0	0	7
12.50 - 13.49	323	4	0	17	50	11	5	16	0	34	150	9	4	14	0	1	8
13.50 - 14.49	177	2	0	7	34	8	3	14	0	16	66	2	6	15	0	1	3
14.50 - 15.49	83	0	0	6	27	0	1	1	0	9	25	1	1	12	0	0	0
15.50 - 16.49	32	0	0	3	12	0	0	0	0	4	11	1	0	1	0	0	0
16.50 - 17.49	18	0	0	2	7	0	0	0	0	1	4	1	1	2	0	0	0
17.50 - 18.49	3	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0
Sum	86,095	5,626	3,036	6,828	14,342	7,028	4,669	5,507	4,248	3,882	9,360	3,289	1,217	2,875	5,475	4,741	3,972

Turbulence

Wind speed	Sum	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.00 - 0.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.50 - 1.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.50 - 2.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.50 - 3.49	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3.50 - 4.49	0.273	0.208	0.246	0.319	0.374	0.282	0.191	0.219	0.243	0.285	0.383	0.333	0.284	0.252	0.236	0.165	0.137
4.50 - 5.49	0.280	0.200	0.253	0.325	0.376	0.269	0.184	0.212	0.238	0.294	0.384	0.323	0.256	0.249	0.237	0.161	0.127
5.50 - 6.49	0.295	0.214	0.265	0.323	0.370	0.281	0.207	0.216	0.247	0.292	0.381	0.323	0.236	0.238	0.216	0.154	0.128
6.50 - 7.49	0.311	0.211	0.253	0.324	0.367	0.288	0.211	0.215	0.244	0.293	0.376	0.326	0.216	0.228	0.214	0.157	0.161
7.50 - 8.49	0.316	0.209	0.233	0.327	0.368	0.293	0.201	0.205	0.231	0.321	0.375	0.324	0.228	0.219	0.232	0.178	0.180
8.50 - 9.49	0.314	0.204	0.171	0.327	0.363	0.254	0.193	0.197	0.217	0.325	0.367	0.335	0.205	0.212	0.254	0.181	0.178
9.50 - 10.49	0.317	0.197	0.157	0.320	0.357	0.247	0.195	0.194	0.220	0.315	0.359	0.331	0.206	0.208	0.201	0.176	0.172
10.50 - 11.49	0.321	0.192	0.157	0.325	0.351	0.239	0.192	0.191	0.212	0.312	0.357	0.313	0.217	0.219		0.164	0.168
11.50 - 12.49	0.314	0.188		0.328	0.339	0.217	0.177	0.192	0.215	0.305	0.351	0.302	0.189	0.213			0.189
12.50 - 13.49	0.310	0.176		0.320	0.344	0.197	0.189	0.202		0.306	0.345	0.306	0.203	0.226		0.156	0.160
13.50 - 14.49	0.290	0.172		0.316	0.342	0.180	0.176	0.194		0.314	0.337	0.325	0.198	0.187		0.136	0.132
14.50 - 15.49	0.304			0.294	0.333		0.192	0.180		0.290	0.340	0.357	0.198	0.202			
15.50 - 16.49	0.318			0.276	0.327					0.296	0.331	0.321		0.266			
16.50 - 17.49	0.305			0.308	0.329					0.317	0.329	0.339	0.168	0.214			
17.50 - 18.49	0.262			0.279	0.293									0.214			
Sum	0.294	0.207	0.250	0.323	0.369	0.276	0.194	0.213	0.241	0.301	0.373	0.326	0.234	0.238	0.231	0.161	0.140

Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

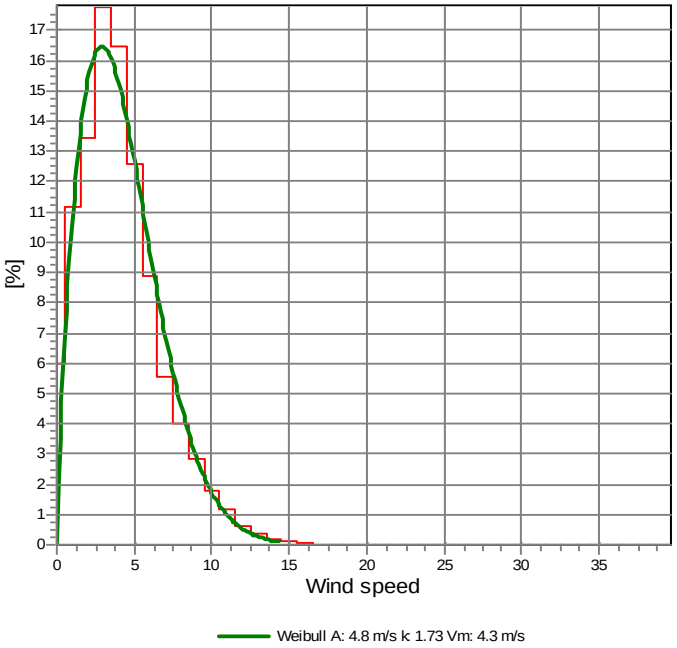
Printed/Page
8/18/2009 4:52 PM / 4
Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027

Calculated:
8/18/2009 4:52 PM/

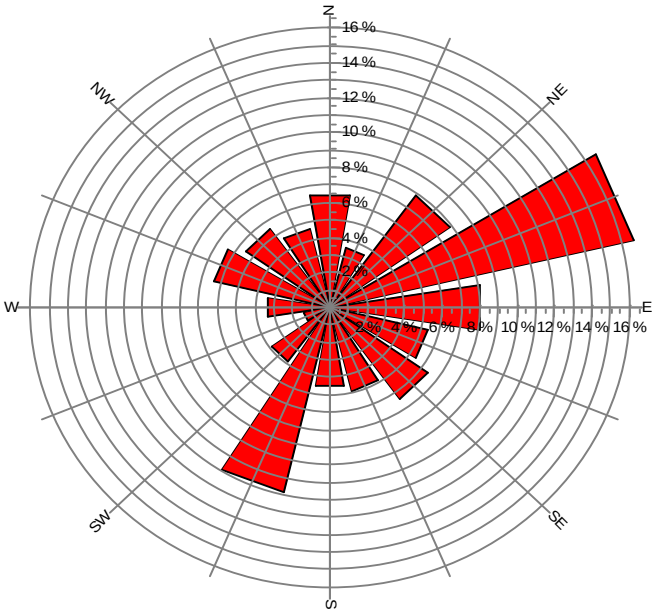
Meteo data report, height: 10.7 m

Name of meteo object: MET tower

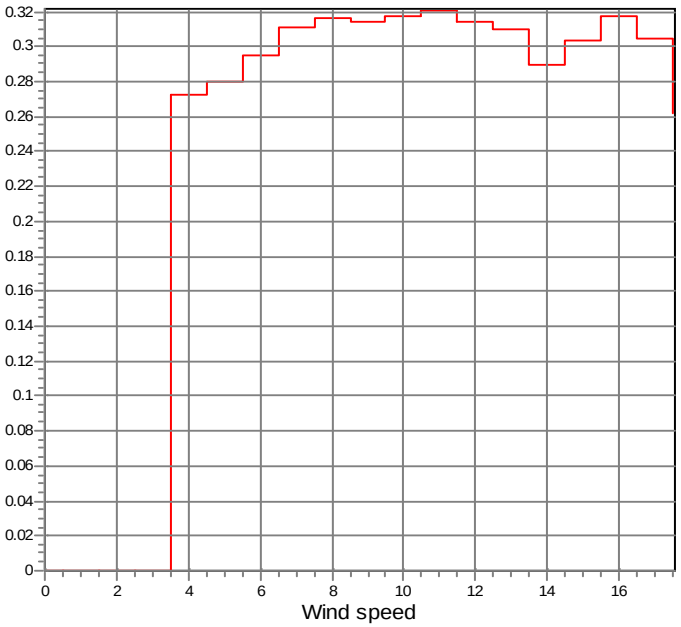
Frequency



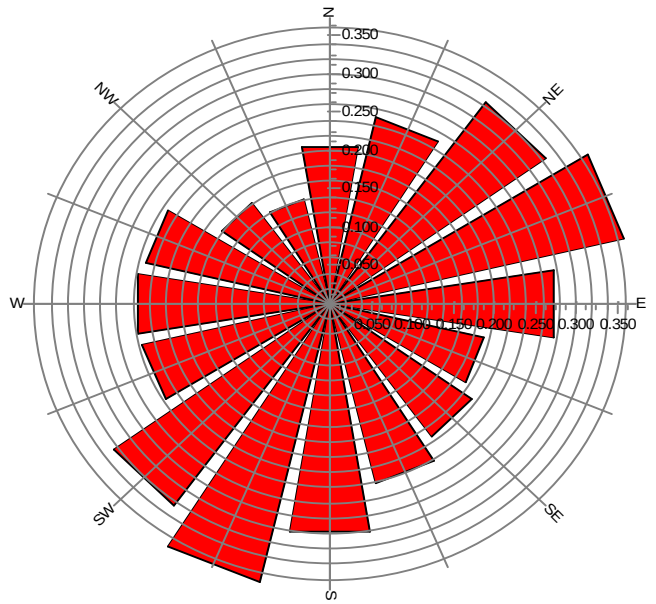
Frequency



Turbulence
V>4.0 m/s



Turbulence
V>4.0 m/s



Project:
Eyak

Clark Pearson
Scott Madison
Capital Projects Coordinator
Native Village of Eyak

Description:
Data from file(s)
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 071113.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080516.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 080730.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081001.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 081217.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090212.csv
Y:\5000\IS\shared\Anemometer_Loan_Programs\Tall Tower Loans\Eyak - AK\Wind data\Eyak 0001 090504.csv

Printed/Page
8/18/2009 4:52 PM / 5
Licensed user:
National Renewable Energy Laboratory
1617 Cole Blvd. (MS3811)
US-GOLDEN, CO 80401
+1 303-384-7027

Calculated:
8/18/2009 4:52 PM/

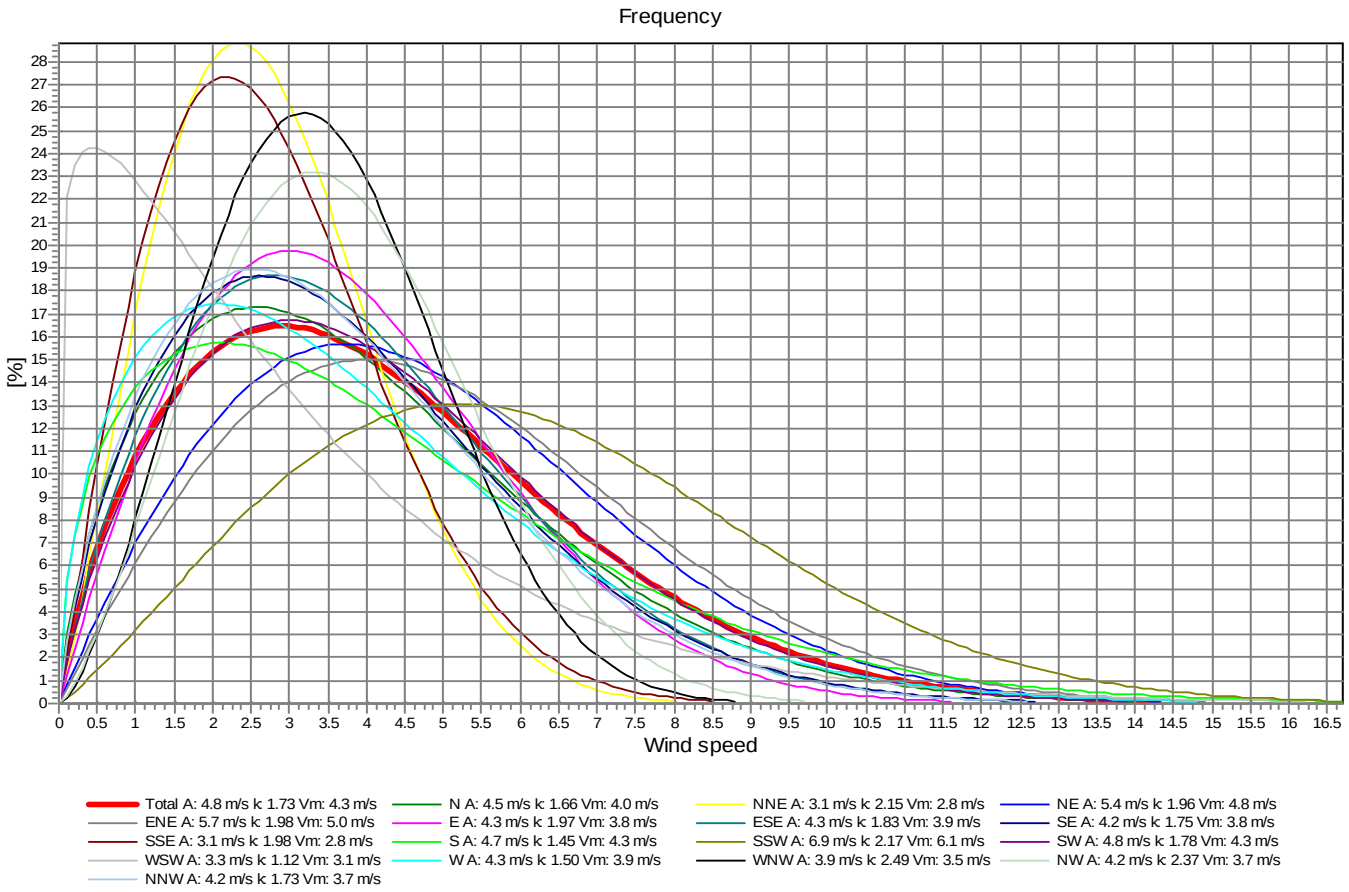
Meteo data report, height: 10.7 m

Name of meteo object: MET tower

Weibull Data

k-parameter correction: 0.0080/m

Sector	A- parameter [m/s]	Mean wind speed [m/s]	k- parameter	Frequency	Frequency [%]	Wind shear
0-N	4.47	4.00	1.663	6.53	6.5	0.00
1-NNE	3.12	2.77	2.147	3.53	3.5	0.00
2-NE	5.39	4.78	1.956	7.93	7.9	0.00
3-ENE	5.68	5.03	1.981	16.66	16.7	0.00
4-E	4.30	3.81	1.967	8.16	8.2	0.00
5-ESE	4.34	3.86	1.828	5.42	5.4	0.00
6-SE	4.25	3.78	1.749	6.40	6.4	0.00
7-SSE	3.11	2.76	1.979	4.93	4.9	0.00
8-S	4.70	4.26	1.452	4.51	4.5	0.00
9-SSW	6.92	6.13	2.169	10.87	10.9	0.00
10-SW	4.78	4.25	1.777	3.82	3.8	0.00
11-WSW	3.26	3.13	1.120	1.41	1.4	0.00
12-W	4.27	3.86	1.504	3.34	3.3	0.00
13-WNW	3.91	3.47	2.491	6.36	6.4	0.00
14-NW	4.18	3.70	2.374	5.51	5.5	0.00
15-NNW	4.17	3.71	1.734	4.61	4.6	0.00
mean	4.78	4.26	1.730	100.00	100.0	0.00



Appendix C. Avian study at Camp Hill

SPRING 2011 MIGRATtON WATCH AT WHITSHED, ALASKA

By Pete Mickelson, Bx 325, Cordova, AK 99574

Migrant birds crossing the northeast-southwest oriented ridge (labeled Camp 387 by US Geological Survey) at Whitshed were counted from April 14 to May 24, 2011 by Pete Mickelson for the Native Village of Eyak {NVE). NVE is evaluating a wind generator site {WGS) on the ridge and is concerned about bird traffic in the area.

Counts were conducted for 3-hour periods, generally from 6 am to 9 am and from 5 pm to 8 pm four days per week. A few counts began as early as 5 am for morning watches and as early as 2 pm for afternoon watches. Birds moving west comprised the majority of those tallied, although some reverse migrants {snow geese and white-fronted geese) were noted as were glaucous-winged gulls moving to and from feeding grounds in Orea Inlet. Also noted were bald eagles traveling over {sometimes even circling) the ridge. The counts included: date, time seen, species, number, direction flying, elevation, and distance north or south from the WGS. Weather conditions, ceiling, and tide stage were noted.

The center line for distance north or south was the brass cap labeled "Camp" on the ridge. Counts were made from that site, a triangular blind {3x3x3x4' high) 30 m to the west, and from a low ridge approximately 400m to the east. The majority of birds moved from east to west and were counted traveling in a corridor from 500 m north to 9 km south (primarily dark geese including whitefronts and Canada) although gulls beyond 200 m of the WGS were not tallied. All records in the field were recorded on waterproof notebooks and then data were transferred to data forms for summarization.

A total of 781 observations were tallied during 42 3-hour periods. A flock of geese or a single gull would constitute an observation. A total of 17,767 individual from 8 waterfowl, 1 crane, 5 raptor and 7 other species {great blue herons, shorebirds, and passerines) were counted. Of the 781 observations, 203 (26%) were waterfowl, 20 {3%) were cranes, 94 {12%) were raptors, and 464 {59%) were other species primarily (95%} gulls.

Canada geese were the most common waterfowl observed (8797 birds or 50% of all birds observed), followed by white-fronted geese (2828 or 13%), and snow geese. Most waterfowl passed well south (greater than 400m) of the WGS. For the raptors, most observations were of bald eagles, primarily local adult birds crossing over the ridge, generally well south of the WGS. Of the birds in the other category, all shorebirds passed well outside of a 200 m corridor centered at the WGS as did the vast majority of glaucous-winged gulls. Some gulls did pass within the 200 m corridor during light southeast (1-12 mph) breezes, probably due to updrafts along the southeastern face of the ridge.

The summary for movements to the south of the WGS reveal 115 of 781 observations within 50 m and 160 within 100 m of the WGS (all 160 were less than 100 mover the ridge top). Only 58 observations of 781 were within 50 m and 99 were within 100m to the north of the WGS. Thus, 22% of the observations were within a 100m corridor and 33% within a 200m corridor centered at the WGS. The majority of these narrow corridor observations (100m and 200m wide) were of gulls (57%).

The vast majority of migrants passed from April 20 to May 9, 2011. These were mostly Canada geese moving through well to the south (beyond 400m) of the WGS. First migrants were trumpeter swans (April 6) and most swans traveled wen south of the WGS. One flock of 70 sandhill cranes crossed directly over the WGS at 10m altitude during light rain. No other flocks of large birds (except for a few gull groups and single bald eagles-local birds) crossed so close and low. Of the passerines, most were single birds flitting from tree cover to shrub cover just 2m or Jess above ground.

I did notice a tendency for snow geese and probably cranes to veer off course, away from adult bald eagles perched on a ridge top tree. Eagle decoys might serve to alter the course of some migrant flocks to avoid the WGS. Also, there is a semi-active eagle nest in a tree at the 40 m elevation about 410 m south of the WGS. No bird was noted on the nest until 12 days after the count began and was not seen on the nest after the 6th of May. Perhaps low food availability caused abandonment of the nest as human activity was not a factor.

Bald eagles did circle along the ridge, mostly to the southeast of the ridge although sometimes within 40 m of the WGS, usually 60 m or more away though, same for glaucous-winged gulls, mostly during periods of southeast light breezes. Since the eagles and gulls are local birds, I presume they would become accommodated to avoiding an active wind generator at the site.

Generally, all birds were counted flying over the ridge, with probabJy some gulls missed due to their white undersides blending with an overcast sky. Also some passerines darting around from tree cover to shrubs were missed, and those migrating a night obviously were missed. No marbled murrelets were seen or heard even during the very early morning hours of 18 May when I camped out at the WGS. Early morning counts probably should be made in July when the birds are returning to feed chicks. I have heard murrelets calling when at my home during July and very early August in the past.

Counts during the peak of migratjon probably should be made more often than 4 times per week. For example, during the last week of April while not officially counting, I heard 19 flocks from 6:45 to 8:15 am, a very high number. Geese seemed to move through in greatest numbers just after a storm, and less so just before a storm.

During the peak of migration, a wind generator might be shut down for perhaps a week, 10 days or 20 days.