



Monitoring Dust along the Denali Park Road

Summary Report 2007–2009

Natural Resource Data Series NPS/DENA/NRDS—2014/692



ON THE COVER

Visitor Transportation Bus traveling along the Denali Park Road
Photograph courtesy of Denali National Park and Preserve

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Abstract

This report summarizes information collected during 2008 and 2009 on off-road dust migration at five sites along the Denali Park Road. The study was designed to quantitatively determine the amount of dust deposited along the park road and to assess the contribution of different environmental, physical, and management-controlled factors on dust production and migration. Key results include:

- Daily dust deposition was greatest at sites closer to the road in both 2008 and 2009.
- The Sanctuary site (mile 23.6) had the highest dust production levels, followed by the Mile 51, Toklat (mile 55.5), and Teklanika (mile 29.5) sites. The paved Mile 11 control site had the lowest dust production levels in both 2008 and 2009.
- There was a substantial decrease in dust deposition 5 meters from the road at the Teklanika site following application of CaCl_2 on July 2th, 2008.
- Based on 2008 data, the distance from the park road, elevation in relation to the park road, precipitation (rain), amount of traffic, and the two-way interaction of elevation from road and traffic volume were all significant in explaining the log of dust measured in grams per square meter per day ($F(5,185)=84.91$, $P<0.05$, $N=185$, $R^2=0.77$).

In the event that traffic levels along the park road are changed (increased or decreased) the baseline data presented in this report can be compared to data collected after the change is implemented to determine the impact of changed traffic levels on dust production.

Acknowledgments

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Introduction

In 2006, Denali National Park and Preserve (Denali) managers initiated the Road Capacity Study (RCS), a comprehensive study designed to identify levels of traffic that could be accommodated on the park road (i.e., carrying capacity) while protecting park resources and visitor experience. The RCS included a number of concurrent studies to assess the effects of changes in traffic volumes and patterns on the biological, physical, and social resources associated with the Denali Park Road (Phillips et al. 2010). The dust monitoring study presented in this report was among the studies included under the RCS. Since traffic can influence dust generation, any proposed change in traffic should be evaluated to determine how the change may influence the amount of dust generated and if the change has the potential to impact the surrounding vegetation, wildlife or visibility.

According to the Environmental Protection Agency (EPA), dust generated by vehicles moving over unpaved roads is the highest single source of fugitive dust emission categories (Pace 2005). Fugitive dust from unpaved roads can disperse long distances and can impact air quality and visibility (Grand Canyon Commission 1996). Dust also settles near the source (5–100 m from source) resulting in significant and lasting impacts to areas surrounding unpaved roads. The effects of dust deposition adjacent to unpaved roads in Alaska are significant and well documented (Everett 1979, Webber et al. 1979, Walker and Werbe 1980, Auerbach et al. 1997, Myers-Smith 2006, Walker and Everett 1987).

Dust fallout from unpaved roads in Alaska results in higher soil pH, lower soil moisture, altered snowpack, deeper active-layer thaw, and lower vegetation species richness in the corridor along the road (Auerbach et al. 1997). The main direct effect of road dust on vegetation results from smothering and a change in soil chemistry (Webber et al. 1979, Walker and Werbe 1980). In general, vegetation near the roadside exhibits lower species diversity (Auerbach et al. 1997), less cover and biomass of Sphagnum moss (Walker and Everett 1987, Myers-Smith et al. 2006), near absence of lichens (Walker and Everett 1987, Myers-Smith 2006), increased cover of graminoids (Auerbach et al. 1997), higher biomass of deciduous shrubs and sedges (Myers-Smith et al. 2006), and lower abundance of evergreen shrubs (Auerbach et al. 1997). These effects have been recorded at dust loads ranging from 30 to 708 g/m² (avg.=189 g/m²; Sagwon and Toolik sites; Everett 1979, Walker and Everett 1987).

Deciduous plants may be increasing in biomass along unpaved roadways in response to deep or protective snowbanks next to a road which provide insulation and extra moisture during spring melt (Webber et al. 1979, Klinger et al. 1983). Additionally deciduous plants may adapt to dust cover on leaf surfaces and increase productivity by producing larger leaves; the low shrub *Salix lanata richardsonii* grows in nonacidic soil and is particularly adaptable to road side conditions (Webber et al. 1979, Werbe 1980). Conversely, evergreen plants may experience more negative impacts from dust because they retain dust covered leaves for more than one year; the accumulated dust can clog plant stomata and increase absorption of infrared radiation (Eller 1977).

Significant amounts of dust are produced by traffic along the 92-mile Denali National Park Road during dry summer periods. Past studies estimated that a one-meter-wide section of the park road

could generate 0.5 pounds of dust accumulation in areas adjacent to the road in one day (Karle 1997). The impacts of dust production along the park road include reduced visibility, detrimental health effects, and increased maintenance costs due to the loss of surface material in addition to the changes in the pH of soils adjacent to the road and subsequent changes in the vegetative cover (Furbish 1997).

Environmental and physical factors, road maintenance, and the volume and speed of vehicles can affect the amount of roadside dust deposition. Environmental factors include elevation in relation to the surface of the roadbed, precipitation, roadside vegetation cover, and prevailing wind direction, speed, and turbulence. Physical and road maintenance factors include the composition of the road surface, frequency of grading operations, and the application of palliatives (e.g., calcium chloride). The size, speed, and volume of traffic also affect deposition rates.

Although the Environmental Assessment for Dust Abatement Activities on the Denali Park Road (NPS 1999) specifies a monitoring plan to track the long-term effects of calcium chloride on park resources, particularly vegetation, soils, and water, there currently is no formal monitoring of the level of dust deposition along the road. This study provides a quantitative estimate of roadside dust deposition along the park road and will assist in identifying potential impacts to the roadside resources not currently monitored in any other way.

This report summarizes information, collected between 2008 and 2009, on the production of dust at four sites along the unpaved (gravel) portion of the park road and one site along the paved section of the road, which served as a control. The study was designed to quantitatively determine the amount of dust deposited along the park road and to assess the contribution of different environmental, physical, and management-controlled factors on dust production. In the event that traffic levels along the park road are changed (increased or decreased) the baseline data presented in this report can be compared to data collected after the change is implemented to determine the impact of changed traffic levels on dust production.

Methods

Study Area

Denali is located in interior Alaska between Anchorage and Fairbanks. Most visitors to Denali access the park's 2.4 million hectares via the 92-mile road that connects George Parks Highway to the former mining community of Kantishna. The Denali Park Road follows a 1 to 10 km wide valley between the Alaska Range to the south and the foothills to the north commonly referred to as the Outer Range. Habitat along the road includes boreal forests dominated by spruce (*Picea* spp.), scrub shrub dominated by birch (*Betula* spp.) and willow (*Salix* spp.), and high-elevation tundra characterized by *Dryas* spp. or graminoids and sedges (*Carex* spp. and *Eriophorum* spp.) The climate in Denali is subarctic. Summers are short and cool with average minimum and maximum temperatures of 0°C and 24°C, respectively (Western Regional Climate Center 2007). Annual precipitation averages 38 cm with over half occurring during the summer months. Snow cover is generally present from October through early May. Daylight varies during the year from more than 20 hours in June to four hours in December.

Site Selection

Five test sites along the park road were chosen, using input of road crew foremen and including sites in areas used by previous dust monitoring studies (Karle 1997, 1999, Marshall 1997). The easternmost site was at mile 10.4, on the paved portion of the road. The remaining four sites were on the unpaved portion of the road between mile 23.6 (Sanctuary Hill) and mile 55.5 (west of Toklat) (Figure 1). The sites include areas of the road treated with the dust palliative CaCl₂ (calcium chloride) and areas that do not receive the treatment. The sites (from east to west) are as follows:

- Site 1: Mile 11 (mile 10.4) Control site located along paved portion of the road.
- Site 2: Sanctuary (Sanctuary Hill, mile 23.6) Previous application of CaCl₂ in 2004, 2005, 2007. No future applications of CaCl₂.
- Site 3: Tek (Teklanika forest, west of campground, mile 29.5) Previous application of CaCl₂ in 2005, 2006. Applications of CaCl₂ in 2008.
- Site 4: Mile 51 (mile 51.2) No previous application of CaCl₂. No future applications of CaCl₂.
- Site 5: Toklat (West of Toklat Road Camp, mile 55.5) Previous application of CaCl₂ in 2005. Applications of CaCl₂ in 2008.

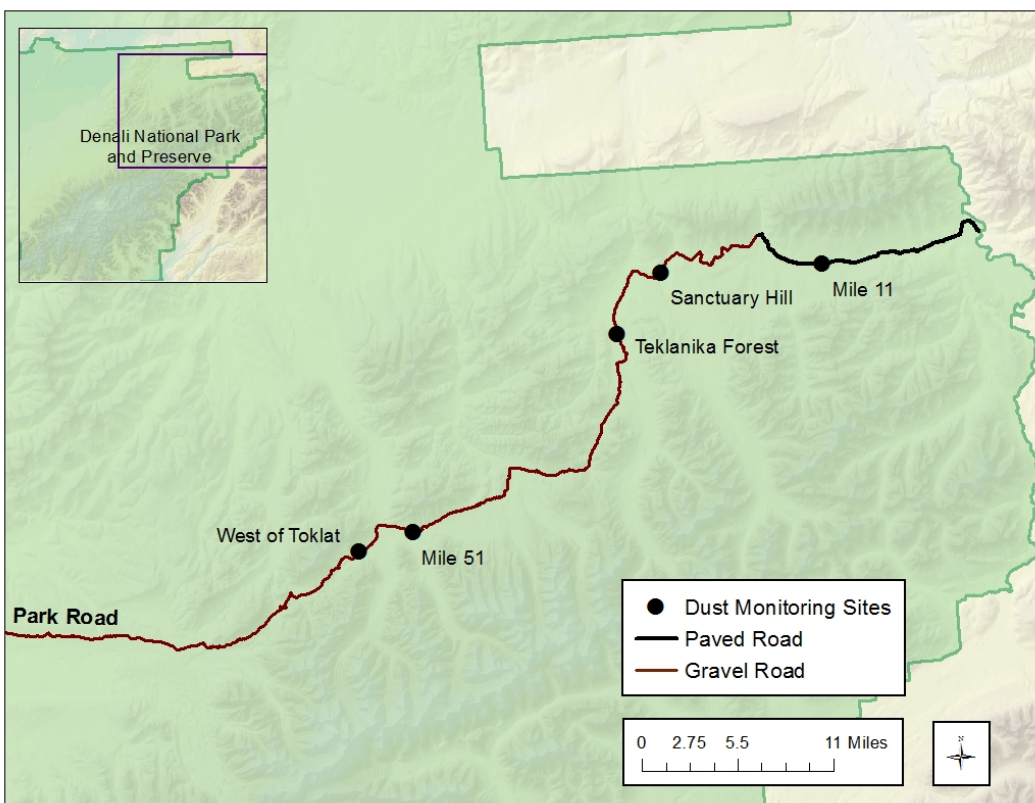


Figure 1. Location of dust monitoring sites along the Denali Park Road, Denali National Park and Preserve, AK.

Sampling

Accumulated dust was collected at the five sites following protocols of previous dust monitoring studies along the Denali Park Road (Karle 1997, 1999, Marshall 1997). At each site, we established two parallel transects, 20 meters apart, perpendicular to the road. The sampling design was repeated on both sides of the road (four transects total per site). Each transect consisted of three dust collection bins placed at 5, 25 and 50 meters from the edge of the road bed (12 samples per site per sampling period). Dust was collected in 5-liter plastic containers (20.5 cm diameter, 17.8 cm deep, surface collection area 330.1 cm²) secured to metal fence posts driven into the ground. The collection buckets and metal posts were painted green to be less conspicuous. Containers were mounted at a height of one meter from the ground or at the height of surrounding vegetation, depending on which was higher. We filled the buckets half full with distilled water at the beginning of the sampling period and monitored the buckets to prevent them from overflowing due to precipitation or evaporation. Dust that landed in the collection bins was trapped and settled to the bottom.

In 2007, we conducted a pilot study, collecting dust for a period of two weeks during July and August. The pilot study enabled us to perfect our sampling and processing techniques; however, these data were not included in the analysis presented in this report. For this monitoring report, we collected dust for a period of two weeks during June, July and August in 2008 and 2009 (Table 1).

Table 1. Dates of dust sample periods for 2007 through 2009 in Denali National Park and Preserve, AK, USA.

	June	July	August
2007		3 to 17	6 to 20
2008	4 to 18	2 to 16	6 to 20
2009	3 to 17	1 to 15	5 to 19

Sample collection occurred on the last day of each sample period. We decanted off most of the water in the container without disturbing the dust that was settled in the bottom. A small amount of water was retained in the container and was swirled around to resuspend the dust. We poured the slurry into a labeled Nalgene bottle, rinsed the container with distilled water and poured all rinses into the bottle to capture any remaining sediments.

Dust Processing

The 2008 and 2009 samples were sent for final processing (drying and removal of organic sediments) to the University of Alaska, Fairbanks-Palmer Research Center (533 E. Fireweed, Palmer, AK 99645). Results from the lab were given as grams of inorganic dust per sample.

Physical Factors

Surface Composition

Surface materials for the gravel portion of the Denali Park Road come from two major sources in the park. The first 15 miles of the park are paved with asphalt. The Teklanika (Tek) Pit provides the majority of the surfacing materials for the road from the Savage Check Station (mile 15) to Sable Pass (mile 39). The Tek Pit is located on an alluvial deposit and provides shale-like materials with high content of fine particles $>20\mu\text{m}$ (silt and clay). As a result, the materials bind well on the road surface; however, fine particles are more likely to remain suspended as dust and travel greater distances from the road. Road bed materials for the area west of Sable Pass come largely from the Toklat River flood plain where most fine particles get washed downstream by the river. As a result, the Toklat River material has a lower overall content of fine material. Surface type for each site was defined as either paved, alluvial or riverbed depending on the location of the site and the predominant type of material used on the road surface at the site.

Topography

The elevations of sample buckets, in relation to the road bed surface, were measured using level-transit surveying equipment. Elevation was recorded as the difference (in meters) of bucket height from the height of the road bed surface (Appendix A). This value was used as a surrogate for roadside elevation in relation to the road at the sampling locations.

Environmental Factors

Precipitation and Wind Direction

We measured precipitation at each site by attaching a rain gauge to one of the metal posts. We recorded the accumulated precipitation at the end of each two-week sample period, and emptied the

rain gauge for the next sample period. Local weather data, including wind speed and direction, were obtained from the Toklat Road Camp weather station and recorded for each sample period.

Vegetative Cover

Each sites' predominant vegetative cover was determined from the land cover map of Denali National Park and Preserve (Table 2).

Table 2. Predominant vegetation cover type for dust monitoring sites in Denali National Park and Preserve, AK, USA.

Site	Vegetation Cover Type
Mile 11	Closed Low Shrub Birch
Sanctuary	Stunted Spruce
Teklanika	Dense Open Spruce
Mile 51	Low Shrub Birch-Ericaceous Willow, Low- Shrub Sedge
Toklat	Low Shrub Birch-Ericaceous Willow, Low Shrub-Sedge

Management Factors

Calcium Chloride (CaCl₂) Application

CaCl₂ is applied as chloride brine on sections of the park road to reduce the creation of dust (dust palliative). Road maintenance staff were responsible for recording the date, start and end mile of application (using handheld GPS units), and concentration of suppressant applied (in pounds per square yard) for every application of dust suppressant. Most of the data on CaCl₂ application was collected from 2002 through 2009, although some data were available from 1995 through 1997 that covered application between mile 21.25 and mile 28.5 (Appendix B). CaCl₂ was applied to the Teklanika site on July 7th 2009. The application was between the June and July sampling periods allowing us to evaluate the effect of the palliative application on dust deposition levels at the Teklanika site before and after the application. To compare the dust deposition before and after palliative application, we used data from the five-meter sampling buckets only, assuming the effect to be greatest at the closest sampling locations.

For modeling the influence of palliative application on dust deposition rates, we used the CaCl₂ application rate that occurred during or immediately prior to the sampling period. Because application of CaCl₂ might inhibit dust migration for longer than the initial application period, we examined potential effects of application of CaCl₂ during the two monitoring periods following the time of initial application. For example, the application of two doses of CaCl₂ at a concentration of 0.29 lbs/yd² during the 2009 June sampling period on the road adjacent to the Tek site were counted as 0.58 lbs/yd² of CaCl₂ application for the June and July monitoring periods for the Tek site.

Traffic Volumes

Traffic volumes were obtained from traffic counters installed at several locations along the park road. We used data from three traffic interval counters (Sprite™ , Diamond Traffic, Oakridge, OR)

installed in the roadbed of the park road (Phillips et al. 2012). The counters collected data on the number and direction of travel of vehicles every hour of the day during the summer season (generally early May to mid-September). We tabulated the total number of vehicle trips (east and west bound) during the sampling period from the traffic counter nearest to the collection site (Table 3) as a measure of traffic volume for calculating dust deposition ($\text{g/m}^2/\text{vehicle}$) and for use as a covariate in multiple regression analysis.

Table 3. Traffic counter data used for each dust site.

Site	Traffic Counter Name, Location
Mile 11	Savage, mile 15
Sanctuary	Tek28, mile 28
Teklanika	Tek28, mile 28
Mile 51	Toklat, mile 52.5
Toklat	Toklat, mile 52.5

Data Analysis

We display the amount of dust deposition per day ($\text{g/m}^2/\text{day}$), expressed as the average of the four 5-meter sampling locations, for each site in 2008 and 2009 for illustrative purposes. Additionally, we evaluated the dust levels before and after the application of dust palliative which occurred between two sampling periods during the summer of 2008. CaCl_2 was applied to the Teklanika site on July 7th, between the June and July sampling periods, providing the opportunity to examine the effect of palliative application on dust production levels. We averaged the dust deposition from the four 5-m sites at each location and examined the trend in dust deposition before and after palliative application. Since there are only four samples (at the 5-m sites) we did not feel that a statistical test of significance would be valid between the two sampling periods and the results are presented for illustrative purposes only.

Previous studies (Karle 1997) in Denali showed a negative linear log-log relationship between the amount of dust deposition and the distance from the road. We evaluated the relationship between distance from the road and dust deposition using linear regression on the log-transformed variables of dust deposition ($\text{g/m}^2/\text{day}$) and distance from the road (m).

We used the R statistical programming package (R Version 2.15.2012-10-21, www.r-project.org, accessed 7/1/2012) to conduct all statistical analyses. Because previous studies in Denali found a log-log relationship between dust mass and distance from road, we chose to use only the dust deposition measurements at the 5-m sample locations to model the relationship between dust deposition and traffic levels along the park road. We modeled dust deposition in relation to elevation from the road, precipitation during the sampling period, surface type, CaCl_2 application and the total traffic volume during the sampling period. We did not use vegetation type as a predictor variable in our models because vegetation was affected by surface type, and because road clearing near the edges of the road

effectively removes most vegetation, up to and beyond 5 meters from the road edge. We used the `glmulti` function in R (Calcagno 2013) to create the most inclusive generalized linear model including main effects only and the subset of all nested models with no interaction or higher order terms. Data from the control site (Mile 11) were omitted from the model in order to model dust deposition only along the gravel stretch of the road. We used the Akaike information criterion corrected for small sample sizes (AICc) to select the best model because this criterion is recommended when the sample size (n) is small with respect to the number of parameters (k) estimated (Hurvich and Tsai 1989). We performed model averaging on top ranked models (models with ΔAIC values less than 2) using the `coef.glmulti` function in package `glmulti`. This function calculates the natural average of the parameter estimates among a set of candidate models and computes unconditional variance (Buckland, Burnham, and Augustin 1997, Burnham and Anderson 2002).

Results

Precipitation and Wind Data

Precipitation, measured in mm of rain per day, ranged from 0 to 5.64 mm/day, with an average of 2.05 ± 1.29 mm/day for all monitoring sites and periods (Table 4). Wind speed and direction data from the Toklat weather station during the 2008 and 2009 sampling periods is available in Appendix C.

Table 4. Precipitation in mm per day from dust monitoring site rain gauges.

		Mile 11	Tek	Sanctuary	Mile 51	Toklat
Sampling Period	2008					
	June	0.43	2.07	2.64	1.21	2.64
	July	0.75	1.14	3.21	1.39	2.29
	August	NA	3.79	5.64	3.57	3.93
	2009					
	June	0.00	1.00	0.57	2.64	1.79
	July	0.79	1.43	1.14	2.36	NA
	August	1.86	1.50	2.29	3.36	NA

Traffic Volumes

The average daily number of vehicle passes for the four gravel road sites varied from 228 to 160 vehicle passes daily (Table 5).

Table 5. Average number of vehicle passes per day by site from traffic counters.

Average Vehicle Passes per Day		
	Sites	Sanctuary and Teklanika
Sampling Period	2008	Mile 51 and Toklat
	June	187
	July	228
	August	215
	2009	
	June	192
	July	204
	August	192

Dust Collection Data

Superficially, it appears that the dust levels at Teklanika site were the lowest of the unpaved portion sites, and the Mile 11 control site had the lowest levels of dust in both 2008 and 2009. Dust deposition levels and the variance in dust deposition levels appear highest at the Sanctuary site (mile 23.6) in both years, while dust levels at Mile.51 and Toklat were similar (Figure 2).

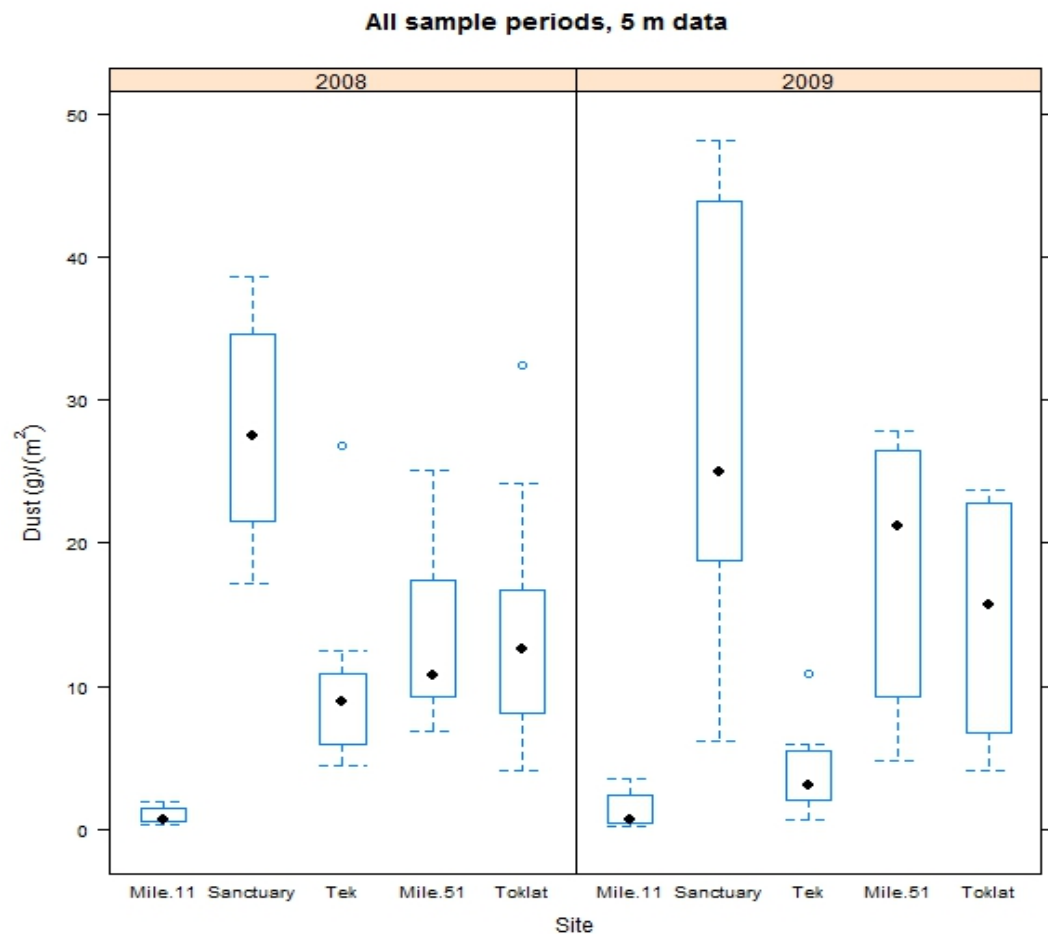


Figure 2. Dust (grams/m²) for samples collected 5 meters from the road during 2008 and 2009. Mile 11 served as a control and the remainder were monitoring sites.

CaCl₂ was applied to the Teklanika site on July 2th, 2008 at the beginning of the July sampling period. Although we did not conduct a statistical test on the results, there appeared to be a substantial decrease in dust collected in the sample bucket located 5 meters from the road between the June and July sample period and while August showed a slight increase from July, the dust deposition was still substantially lower than in June (Figure 3).

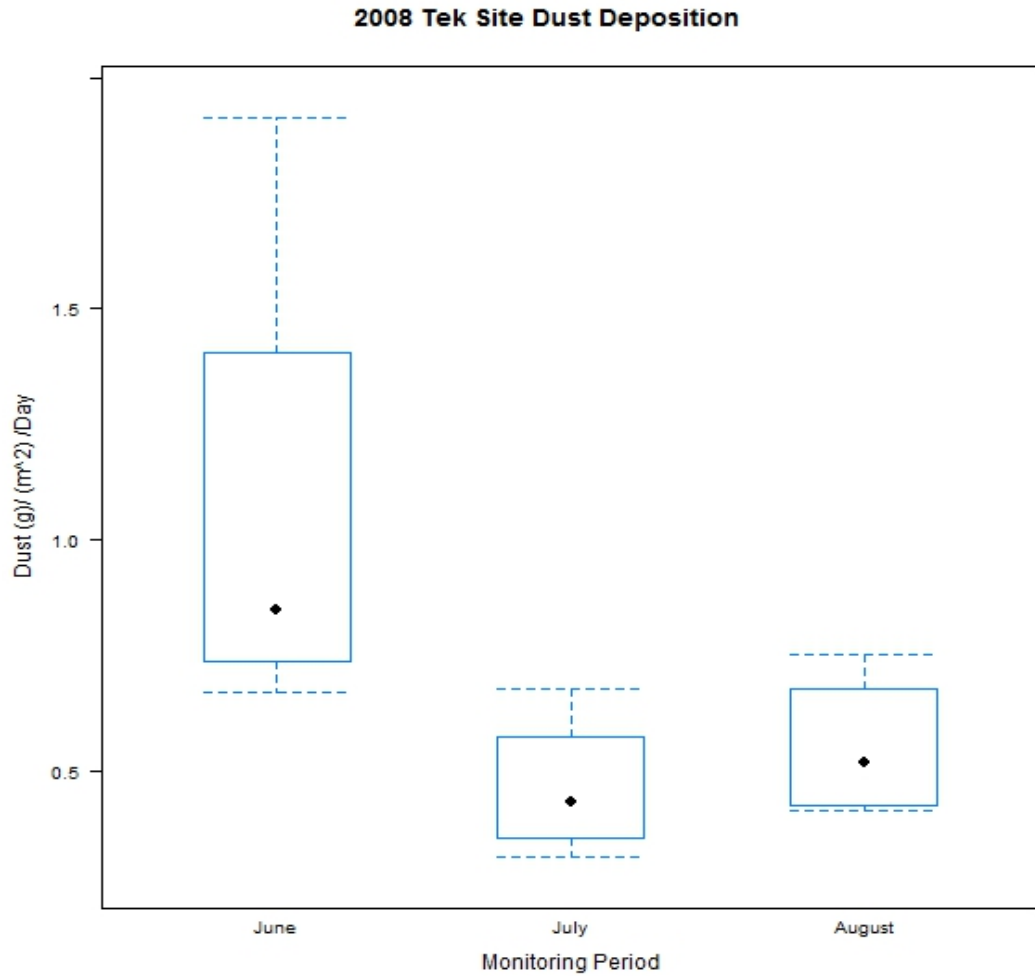


Figure 3. 2008 dust production levels before and after CaCl_2 (calcium chloride) application at the Teklanika site.

Data Analysis

As predicted, we found a log-log relationship between dust mass and distance from road at all sites, with dust deposition greatest near the road (Figure 4, Figure 5). The R^2 values for the linear regression relationships ranged from 0.62 to 0.68.

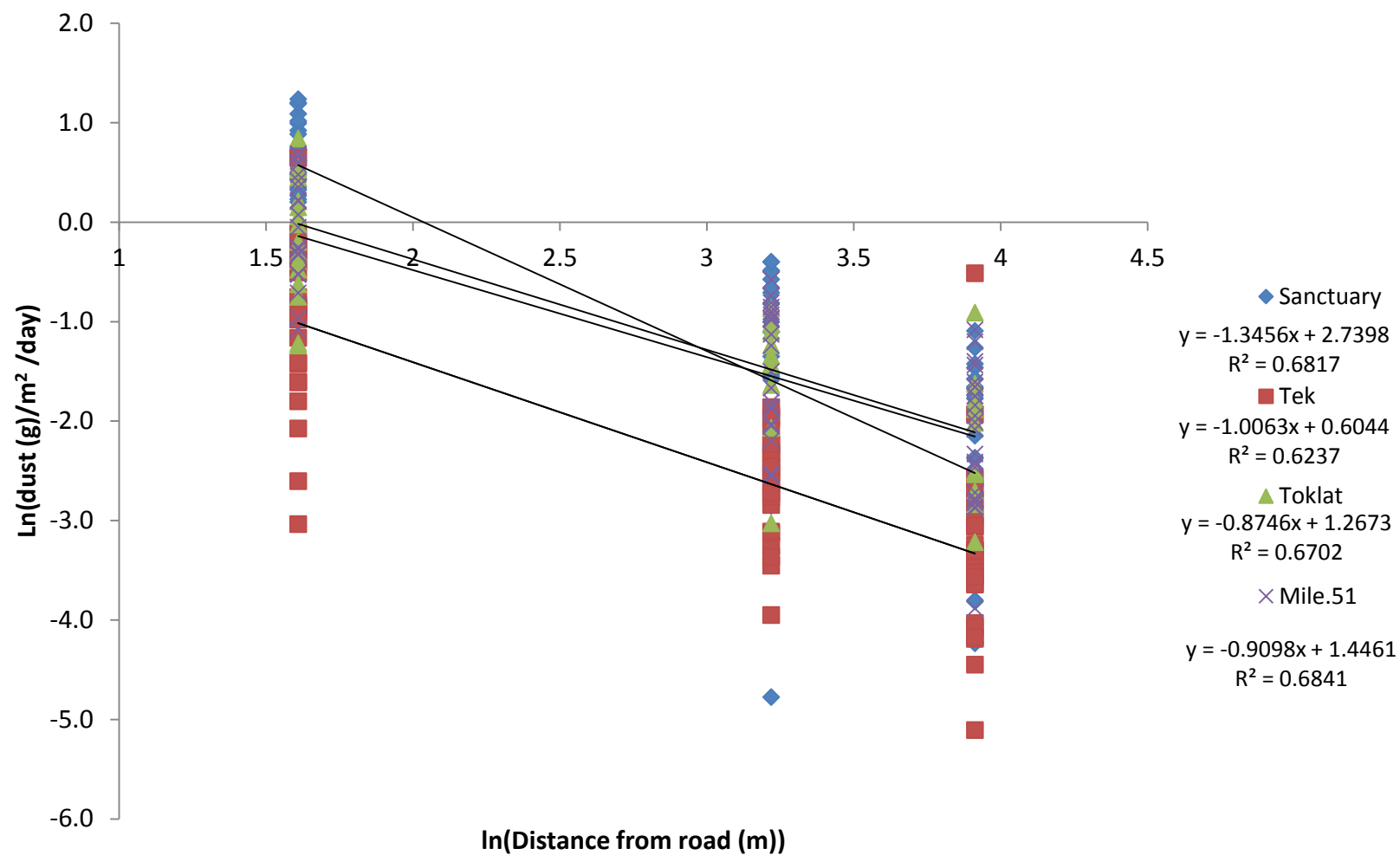


Figure 4. Relation of dust (grams/m²/day) to distance from the Park Road (m) for all dust monitoring sites in 2008 and 2009 in Denali National Park and Preserve, AK, USA.

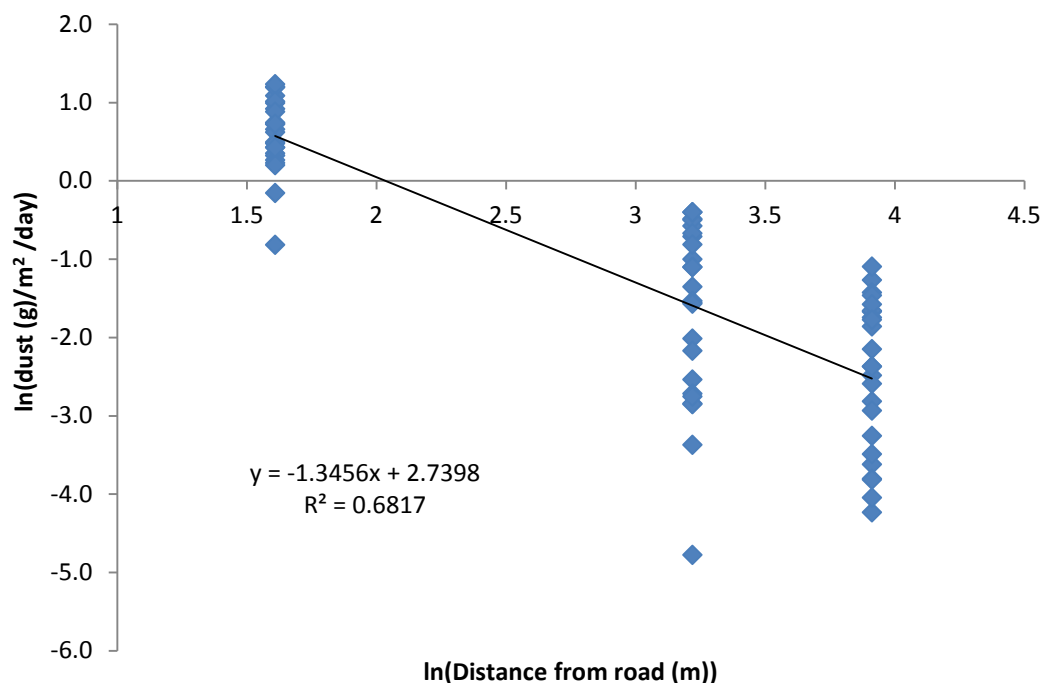


Figure 5. Sanctuary dust monitoring site relationship of dust (grams/m²/day) to distance from road (m).

Dust Model

The best model included the covariates surface type, elevation, and palliative application, and all models that included these covariates performed substantially better than the other models ($\text{dAICc} > 11.27$). Adding additional covariates resulted in increased value of AICc, suggesting that these factors had relatively little effect on dust deposition rates (Table 4). Based on the sign of the model-averaged parameter estimates, our data suggest that elevation and alluvial surface type were positively related to deposition rates, whereas palliative application had a negative effect (Table 5).

Table 6. Candidate model set and model selection criteria evaluating parameters potentially affecting dust deposition along the Denali Park Road, Denali National Park and Preserve, Alaska, USA.

Model	AICc	Δ AICc	AICc Weight	Cumulative Weight
surface ¹ + elev ² + CaCl ³	157.53	0.00	0.54	0.54
surface + elev + CaCl ₂ + trafficperday ⁴	159.49	1.97	0.20	0.74
surface + elev + CaCl ₂ + rain.mm.day ⁵	159.67	2.14	0.18	0.92
surface + elev + CaCl ₂ + rain.mm.day + trafficperday	161.39	3.86	0.08	1.00
surface + CaCl ₂	172.66	15.13	0.00	1.00
surface + CaCl ₂ + rain.mm.day	174.72	17.19	0.00	1.00
surface + CaCl ₂ + trafficperday	174.78	17.26	0.00	1.00
elev + CaCl ₂ + trafficperday	175.78	18.25	0.00	1.00
elev + CaCl ₂ + rain.mm.day + trafficperday	175.93	18.41	0.00	1.00
surface + CaCl ₂ + rain.mm.day + trafficperday	176.71	19.18	0.00	1.00
CaCl ₂ + trafficperday	180.81	23.28	0.00	1.00
CaCl ₂ + rain.mm.day + trafficperday	181.37	23.84	0.00	1.00
elev + trafficperday	209.56	52.03	0.00	1.00
surface + elev + rain.mm.day	210.45	52.92	0.00	1.00
elev + rain.mm.day + trafficperday	210.58	53.06	0.00	1.00
surface + elev	210.79	53.26	0.00	1.00
surface + elev + rain.mm.day + trafficperday	212.70	55.17	0.00	1.00
surface + elev + trafficperday	212.92	55.39	0.00	1.00
trafficperday	215.13	57.60	0.00	1.00
rain.mm.day + trafficperday	215.71	58.18	0.00	1.00
surface	216.80	59.28	0.00	1.00
surface + rain.mm.day	216.88	59.35	0.00	1.00
surface + trafficperday	218.96	61.43	0.00	1.00
surface + rain.mm.day + trafficperday	219.02	61.49	0.00	1.00
elev + CaCl ₂ + rain.mm.day	230.82	73.29	0.00	1.00
elev + rain.mm.day	230.97	73.44	0.00	1.00
CaCl ₂ + rain.mm.day	234.65	77.12	0.00	1.00
rain.mm.day	235.10	77.57	0.00	1.00
elev	301.13	143.60	0.00	1.00
elev + CaCl ₂	302.29	144.76	0.00	1.00
-1	309.58	152.06	0.00	1.00
CaCl ₂	310.74	153.22	0.00	1.00

^a Surface type: alluvial or not (riverbed)

^b Elevation of the bucket above or below the roadbed

^c Palliative application prior to or during sampling period

^d Total traffic averaged over the sampling period

^e Averaged daily precipitation over the sampling period

Table 7. Model averaged parameter estimates for variables predicting dust deposition along the Denali Park Road, Denali National Park, AK, USA.

Parameter	Estimate	Unconditional variance
rain.mm.day	-0.0071	0.0004
trafficperday	0.0009	0.0000
elev	0.1858	0.0019
surface:alluvial*	1.6432	0.2032
surface:riverbed*	0.7637	0.1495
CaCl ₂	-3.2431	0.1456

* Parameter estimate is compared to the control portion of the road with a paved surface.

Discussion

In accordance with previous studies, our data suggest that distance from the road has a strong effect on the level of road dust. The relationship between dust deposition rates and distance from the road was very similar for all sites. This implies that the dust deposition at further distances from the road can be extrapolated by a log-log relationship from the dust deposition measurements at 5 meters from the park road. This strong relationship supports using measurements of dust deposition at 5 meter distances from the road for the purposes of modeling impacts of physical, environmental and management variables on dust deposition rates. Furthermore, we suggest that future monitoring of dust deposition focus on dust deposition rates near the road.

Previous studies documented the effectiveness of CaCl_2 as a dust palliative on the park road (National Park Service 1999). The substantial decrease in deposition during 2008 at the Tek site following application of CaCl_2 supports the earlier findings. Because of the small sample size, we did not conduct a test for significance. However, the dust model provides a quantitative estimate of the efficacy of CaCl_2 as a dust abatement measure on road segments maintained with material from different sources (Tek versus Toklat) that experience different environmental factors and traffic conditions. However, not all applications of CaCl_2 were completely recorded. Some records of CaCl_2 application provided by the road maintenance staff were missing date of application or the start and end mileage (Appendix B), leading us to conclude that the current method of recording palliative application could be improved. Palliative applications should be rigorously recorded and checked for accuracy in future years, particularly if the information will be used for modeling and to ensure accuracy for compliance with the dust abatement environmental assessment (National Park Service 1999).

Our model illustrated the influence of physical, environmental and management related variables on the rates of dust deposition off road. As expected, palliative application is negatively related to dust deposition levels, with the magnitude of the impact from palliative application notably greater than that of other parameters (as noted from parameter estimates and model selection, Table 7). The physical site characteristics of elevation and surface type are included in the top models, indicating their utility in predicting dust deposition rates. Alluvial and riverbed surface type were positively associated with dust deposition rates as compared with the paved sections of road. The sites with road material taken from alluvial surfaces were associated with greater rates of dust deposition than occurred at sites constructed with riverbed materials, which consist of less fines to be suspended and migrate off road.

Elevation is positively associated with dust deposition, indicating that dust buckets above the elevation of the road have greater dust deposition than those below the grade of the road. This is somewhat counterintuitive, as we would expect dust buckets at lower elevations to collect suspended dust from all heights above the bucket and those buckets placed lower in relation to the road would have a greater amount of suspended dust to collect. However, wind strength and direction are also assumed to be driving factors in the spatial migration of road dust. Data for wind speed and direction were obtained from a weather station located at Toklat. Due to the highly variable and local nature of

these conditions, it is unlikely that these parameters would be relevant to sites not in the immediate vicinity and thus wind parameters were not modeled directly because of their variability but may interact with elevation.

Daily traffic levels and precipitation were included in the second and third ranked models, but the magnitude of the effects were small (0.0009 unit of increase in dust deposition per unit increase in daily traffic level, -0.0071 unit of decrease in dust deposition per unit of increase in rain [in mm/day]). Although the impact from one unit of increase in traffic is small, note that there was not much variation in the traffic since the traffic levels from Teklanika and Sanctuary as well as the Mile 51 and Toklat sites were derived from the same traffic counters (Table 3). As the purpose of the model is to evaluate impacts from changes in traffic levels, we believe it is valid to present parameter estimates from this covariate in the model. Similarly, we expect that an increase in the variability of precipitation has the potential to influence dust deposition rates significantly and that precipitation and traffic covariates should be included in this and future models to analyze the impact of traffic on dust deposition rates for the purpose of the Before-After Control Impact study.

The detrimental effects of dust deposition on roadside vegetation have been recorded at dust loads ranging from 30 to 708 g/m² (avg.=189 g/m²; Sagwon and Toolik sites; Everett 1979, Walker and Everett 1987). Dust deposition rates along the Denali Park Road during a two-week period can reach almost 30 g/m² (Figure 2). Thus annual deposition rates can exceed the threshold beyond which vegetation effects can be seen. Although dust mitigation through dust palliative application reduces traffic generated dust, the impacts of management actions such as increased traffic levels will need to be addressed to reduce unnecessary impacts to roadside vegetation.

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Appendix A. Elevation of dust collection containers in relation to surface of road bed.

Site name	North/South	East/West	Distance (m)	Elevation (m)
Mile.11	N	E	5	0.02
Mile.11	N	E	25	1.60
Mile.11	N	E	50	2.68
Mile.11	N	W	5	0.15
Mile.11	N	W	25	0.95
Mile.11	N	W	50	0.95
Mile.11	S	E	5	-1.08
Mile.11	S	E	25	-2.08
Mile.11	S	E	50	-3.35
Mile.11	S	W	5	-0.65
Mile.11	S	W	25	-1.33
Mile.11	S	W	50	-3.16
Sanctuary	N	E	5	1.08
Sanctuary	N	E	25	7.90
Sanctuary	N	E	50	17.39
Sanctuary	N	W	5	2.68
Sanctuary	N	W	25	10.82
Sanctuary	N	W	50	21.44
Sanctuary	S	E	5	-2.82
Sanctuary	S	E	25	-6.90
Sanctuary	S	E	50	-9.15
Sanctuary	S	W	5	-1.59
Sanctuary	S	W	25	-4.99
Sanctuary	S	W	50	-9.05
Tek	N	E	5	0.09
Tek	N	E	25	-1.99
Tek	N	E	50	-2.13
Tek	N	W	5	0.66
Tek	N	W	25	2.60
Tek	N	W	50	-1.16
Tek	S	E	5	-0.55
Tek	S	E	25	0.55
Tek	S	E	50	2.23
Tek	S	W	5	-0.06
Tek	S	W	25	-0.09
Tek	S	W	50	-2.40
Mile.51	N	E	5	2.76
Mile.51	N	E	25	7.24
Mile.51	N	E	50	9.31
Mile.51	N	W	5	1.84
Mile.51	N	W	25	5.63
Mile.51	N	W	50	8.26
Mile.51	S	E	5	0.65
Mile.51	S	E	25	-1.88

Appendix A. Elevation of dust collection containers in relation to surface of road bed (continued).

Site name	North/South	East/West	Distance (m)	Elevation (m)
Mile.51	S	E	50	-3.46
Mile.51	S	W	5	-0.35
Mile.51	S	W	25	-3.96
Mile.51	S	W	50	-4.76
Toklat	N	E	5	1.52
Toklat	N	E	25	4.65
Toklat	N	E	50	8.59
Toklat	N	W	5	1.54
Toklat	N	W	25	4.14
Toklat	N	W	50	9.45
Toklat	S	E	5	-0.37
Toklat	S	W	5	-1.11

Appendix B. Dates and rates of calcium chloride (CaCl₂) applications.

Date of Application	Mile Start	Mile Finish	Rate of Application (lbs/yd ²)	Site
1995	26.50	28.00	1.30	
1996	21.25	22.70	1.30	
1996	22.85	23.50	1.30	
1996	27.25	28.00	0.75	
1996	28.00	28.50	1.30	
1997	21.50	23.10	0.75	
1997	14.50	15.00	0.75	
7/8/2002	53.43	53.19	0.57	
7/8/2002	53.52	53.43	0.57	
7/8/2002	54.01	53.54	0.57	
6/3/2003	14.94	16.89	0.97	
6/5/2003	17.94	18.93	0.65	
6/11/2003	25.22	26.77	0.68	
6/13/2003	3.95	4.07	1.30	
7/2/2003	21.80	22.81	0.68	
7/8/2003	18.93	19.97	0.68	
7/8/2003	19.97	20.97	0.68	
7/9/2003	20.97	21.98	0.68	
7/9/2003	27.26	28.27	0.68	
7/9/2003	28.27	29.27	0.68	
6/17/2004	3.92	4.08	1.00	
6/18/2004	34.26	37.41	2.93	
7/5/2004	76.13	72.16	0.42	
7/6/2004	81.04	81.00	0.36	
7/6/2004	81.51	81.22	0.36	
7/6/2004	81.95	81.83	0.36	
7/6/2004	84.44	82.09	0.36	
7/6/2004	85.29	84.50	0.36	
7/7/2004	76.78	76.57	0.58	
7/7/2004	78.12	77.73	0.58	
7/7/2004	78.69	78.20	0.58	
7/7/2004	80.19	78.75	0.58	
7/7/2004	86.70	86.59	0.58	
7/7/2004	90.68	90.57	0.58	
7/7/2004	91.46	91.38	0.58	
8/3/2004	16.89	22.12	0.32	
8/5/2004	22.12	22.73	0.68	
8/5/2004	22.73	24.88	0.51	Sanctuary
8/6/2004	16.89	22.12	0.32	
8/6/2004	22.12	20.47	0.68	
8/10/2004	25.93	28.53	0.40	
8/11/2004	29.76	31.29	0.68	
6/16/2005	16.91	14.98	0.70	
6/16/2005	26.43	25.47	0.70	

Appendix B. Dates and rates of calcium chloride (CaCl₂) applications (continued).

Date of Application	Mile Start	Mile Finish	Rate of Application (lbs/yd ²)	Site
6/17/2005	31.30	30.39	0.70	
6/17/2005	31.36	34.10	0.70	
6/22/2005	29.00	29.32	0.70	
6/24/2005	22.91	23.52	0.57	
6/24/2005	23.52	24.16	0.57	Sanctuary
6/24/2005	25.60	24.16	0.70	
6/24/2005	28.56	30.34	0.70	Tek
7/19/2005	19.15	21.21	0.70	
7/22/2005	25.50	26.43	0.70	
7/22/2005	30.39	31.30	0.70	
7/22/2005	34.14	37.40	0.70	
8/10/2005	52.36	54.10	0.27	
8/11/2005	55.20	56.01	0.37	Toklat
8/11/2005	59.32	60.77	0.37	
8/11/2005	62.05	62.17	0.37	
8/11/2005	62.99	63.47	0.37	
8/19/2005	62.05	62.17	0.26	
8/19/2005	69.64	70.33	0.26	
8/22/2005	52.36	54.10	0.30	
8/22/2005	52.36	54.10	0.45	
8/22/2005	53.88	55.22	0.30	
8/22/2005	70.33	72.27	0.45	
6/8/2006	24.08	28.13	0.25	
6/8/2006	28.12	25.88	0.25	
6/13/2006	24.19	26.15	0.50	
6/13/2006	26.31	24.35	0.50	
7/26/2006	14.91	16.95	0.50	
7/26/2006	16.95	14.91	0.50	
7/28/2006	19.06	21.13	0.50	
7/28/2006	21.13	19.06	0.50	
8/2/2006	19.05	17.15	0.50	
8/2/2006	19.05	17.15	0.50	
8/2/2006	31.21	30.11	0.25	
8/2/2006	31.31	34.05	0.25	
8/3/2006	30.29	28.08	0.50	Tek
8/3/2006	30.29	28.08	0.50	Tek
8/4/2006	21.09	23.49	0.50	
8/4/2006	23.49	21.09	0.50	
5/18/2007	30.32	34.04	0.44	
5/24/2007	25.84	28.27	0.36	
5/24/2007	28.27	25.84	0.36	
6/8/2007	14.93	17.70	0.45	
6/8/2007	15.94	14.93	0.45	
6/13/2007	17.74	18.76	0.45	
6/13/2007	18.76	15.94	0.45	
6/19/2007	22.52	22.74	0.36	

Appendix B. Dates and rates of calcium chloride (CaCl₂) applications (continued).

Date of Application	Mile Start	Mile Finish	Rate of Application (lbs/yd ²)	Site
6/19/2007	22.74	22.52	0.36	
6/19/2007	24.05	25.84	0.36	
6/19/2007	25.84	24.05	0.36	
6/20/2007	20.51	22.52	0.34	
6/20/2007	22.52	22.74	0.34	
6/20/2007	22.52	20.51	0.34	
6/20/2007	22.74	22.52	0.36	
6/20/2007	24.05	25.84	0.36	
6/20/2007	25.84	24.05	0.36	
6/21/2007	18.76	20.51	0.36	
6/21/2007	20.51	22.52	0.34	
6/21/2007	20.51	18.76	0.36	
6/21/2007	22.52	20.51	0.34	
6/21/2007	22.74	23.44	0.36	
6/21/2007	23.44	22.74	0.36	
6/26/2007	29.70	30.00	0.30	
6/26/2007	29.70	29.80	0.30	
6/26/2007	30.94	31.23	0.30	
6/26/2007	31.23	30.94	0.30	
6/26/2007	34.04	31.29	0.30	
6/27/2007	31.29	34.04	0.16	
6/27/2007	34.04	31.29	0.16	
6/27/2007	34.04	33.04	0.08	
6/28/2007	16.90	18.83	0.34	
6/28/2007	18.88	16.90	0.34	
6/29/2007	18.88	20.84	0.34	
6/29/2007	20.84	18.88	0.34	
8/1/2007	22.73	24.88	0.40	Sanctuary
6/5/2008	41.43	33.23	0.30	
6/6/2008	33.23	41.43	0.36	
6/27/2008	25.43	27.54	0.28	
6/27/2008	27.54	25.43	0.28	
7/2/2008	30.04	27.52	0.27	Tek
7/2/2008	30.04	27.52	0.27	Tek
7/3/2008	25.59	24.06	0.34	
7/3/2008	23.37	22.79	0.34	
7/3/2008	22.79	23.37	0.34	
7/3/2008	24.06	25.59	0.34	
7/9/2008	21.17	22.73	0.45	
7/9/2008	22.73	21.17	0.45	
7/15/2008	17.00	14.95	0.43	
7/15/2008	14.95	16.84	0.43	
7/15/2008	31.22	30.94	0.44	
7/15/2008	30.91	30.13	0.44	
7/15/2008	30.05	29.93	0.44	
7/15/2008	29.93	30.05	0.44	

Appendix B. Dates and rates of calcium chloride (CaCl₂) applications (continued).

Date of Application	Mile Start	Mile Finish	Rate of Application (lbs/yd ²)	Site
7/15/2008	30.13	30.91	0.44	
7/15/2008	30.94	31.22	0.44	
7/16/2008	19.66	17.67	0.43	
7/16/2008	17.67	19.66	0.43	
7/16/2008	41.43	34.09	0.29	
7/16/2008	34.09	41.43	0.29	
7/17/2008	17.00	17.67	0.40	
7/17/2008	21.17	19.66	0.40	
7/17/2008	25.59	24.06	0.43	
7/17/2008	23.37	22.79	0.43	
2008	63.30	63.30	0.33	
2008	49.88	50.88	0.33	
2008	56.41	56.67	0.33	
2008	60.79	60.79	0.33	
2008	47.68	47.36	0.33	
2008	47.68	49.88	0.33	
2008	59.22	60.48	0.33	
2008	54.85	56.41	0.33	Toklat
2008	52.94	52.33	0.33	
2008	53.89	54.19	0.33	
2008	65.62	64.38	0.33	
2008	64.38	63.34	0.33	
2008	54.19	54.85	0.33	
2008	53.49	53.89	0.33	
2008	53.49	52.94	0.40	
2008	0.00	0.00	0.67	
2008	61.50	62.16	0.33	
6/3/2009	29.94	27.71	0.29	Tek
6/3/2009	27.71	29.94	0.29	Tek
6/4/2009	27.71	25.69	0.34	
6/4/2009	25.69	27.71	0.34	
6/4/2009	30.05	31.13	0.68	
6/4/2009	31.13	30.05	0.68	
6/5/2009	16.84	14.82	0.43	
6/5/2009	14.82	16.84	0.43	
6/5/2009	29.94	27.71	0.29	Tek
6/5/2009	27.71	29.94	0.29	Tek
6/9/2009	25.37	24.03	0.43	
6/9/2009	23.34	22.70	0.43	
6/9/2009	18.83	16.84	0.41	
6/9/2009	16.84	18.83	0.41	
6/9/2009	25.69	27.71	0.40	
6/9/2009	27.71	25.69	0.40	
6/10/2009	18.83	20.83	0.43	
6/10/2009	18.83	20.83	0.43	

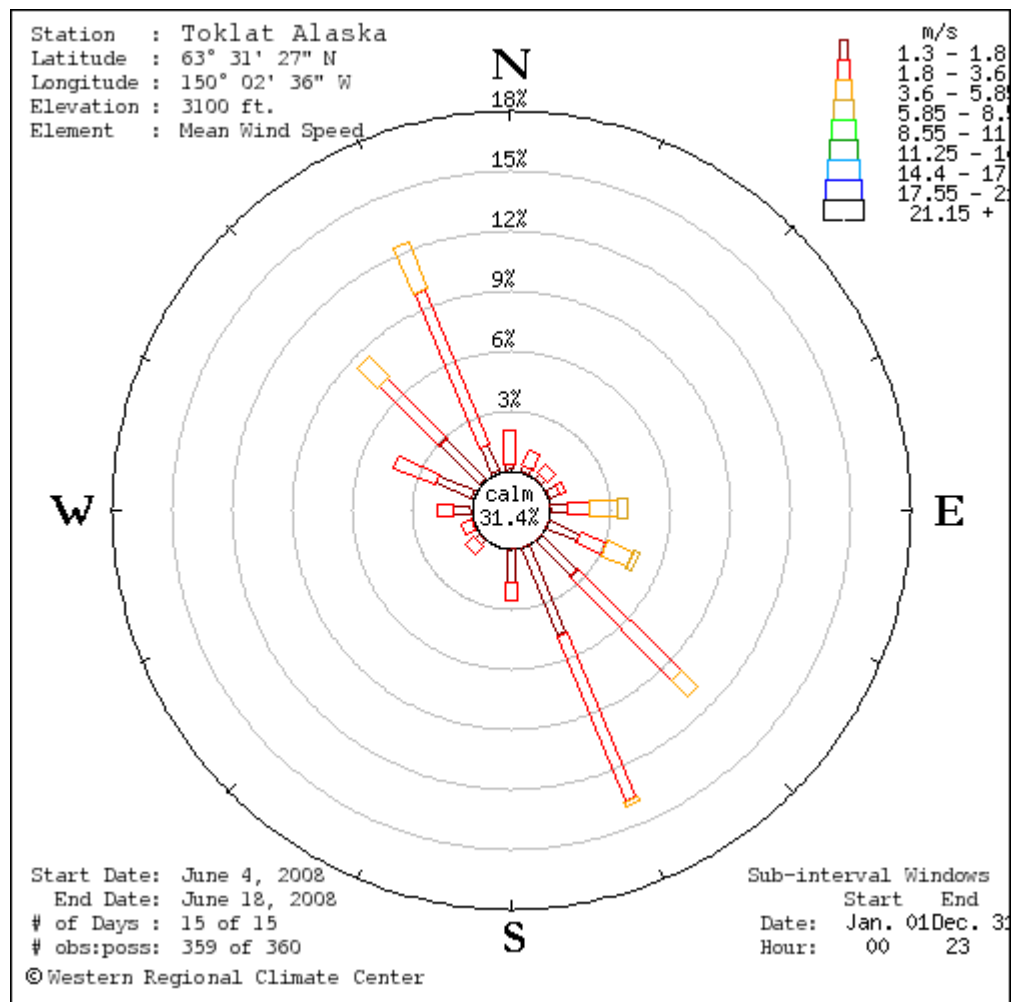
Appendix B. Dates and rates of calcium chloride (CaCl₂) applications (continued).

Date of Application	Mile Start	Mile Finish	Rate of Application (lbs/yd ²)	Site
6/10/2009	18.83	16.84	0.43	Tek
6/10/2009	16.84	18.83	0.43	
6/11/2009	31.19	33.95	0.46	
6/11/2009	33.95	31.19	0.46	
6/11/2009	20.83	22.67	0.41	
6/11/2009	22.67	20.83	0.41	
6/12/2009	33.95	37.35	0.45	
6/12/2009	37.35	33.95	0.45	
6/12/2009	16.84	14.82	0.43	
6/12/2009	14.82	16.84	0.43	
7/30/2009	14.82	16.81	0.38	
7/30/2009	20.81	22.02	0.38	
7/30/2009	22.48	22.67	0.38	
8/6/2009	22.74	27.68	0.35	
7/21/2009	91.91	92.44	0.67	
7/21/2009	91.28	91.50	0.67	
7/21/2009	90.58	90.40	0.67	
7/22/2009	87.40	87.08	0.67	
7/22/2009	86.46	86.26	0.67	
7/22/2009	84.75	84.28	0.67	
7/22/2009	83.85	84.17	0.67	
7/29/2009	71.84	70.81	0.67	
7/30/2009	70.57	68.66	0.67	
8/3/2009	52.54	51.91	0.67	
8/3/2009	53.24	52.54	0.67	
8/3/2009		53.57	0.67	
8/3/2009	53.57	54.19	0.67	
8/4/2009	50.74	49.47	0.67	
8/5/2009	49.48	48.20	0.67	
8/5/2009	48.20	47.67	0.67	

Appendix C. Toklat Weather Station Data June-August for 2008 and 2009.

June 4-18 2008

Toklat Alaska



Toklat Alaska - Wind Frequency Table (percentage)

Latitude : 63° 31' 27" N
 Longitude : 150° 02' 36" W
 Elevation : 3100 ft.
 Element :

Start Date : June 4, 2008
 End Date : June 18, 2008
 # of Days : 15 of 15
 # obs : poss : 359 of 360

Sub Interval Windows
 Start End
 Date Jan. 01 Dec. 31
 Hour 00 23

(Greater than or equal to initial interval value and Less than ending interval value.)

Range (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
1.3 - 1.8	0.3	0.3	0.3	0.6	0.8	1.7	2.5	4.7	1.7	0.0	0.3	0.0	0.8	1.9	2.8	1.4	20.1
1.8 - 3.6	1.7	0.8	0.6	0.3	1.1	1.4	7.2	8.9	0.8	0.0	0.6	0.6	0.8	2.2	4.2	8.4	39.6
3.6 - 5.85	0.0	0.0	0.0	0.0	1.4	1.4	1.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.4	2.5	8.1
5.85 - 8.55	0.0	0.0	0.0	0.0	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
8.55 - 11.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.25 - 14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.4 - 17.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.55 - 21.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21.15 -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total(%)	1.9	1.1	0.8	0.8	3.9	4.7	10.9	13.9	2.5	0.0	0.8	0.6	1.7	4.2	8.4	12.3	68.5
Calm (<1.3)																	31.4
Ave Speed	3.3	2.5	2.1	1.7	3.5	3.2	2.4	2.1	2.5	6.8	2.7	3.4	1.9	2.0	2.5	2.8	1.7

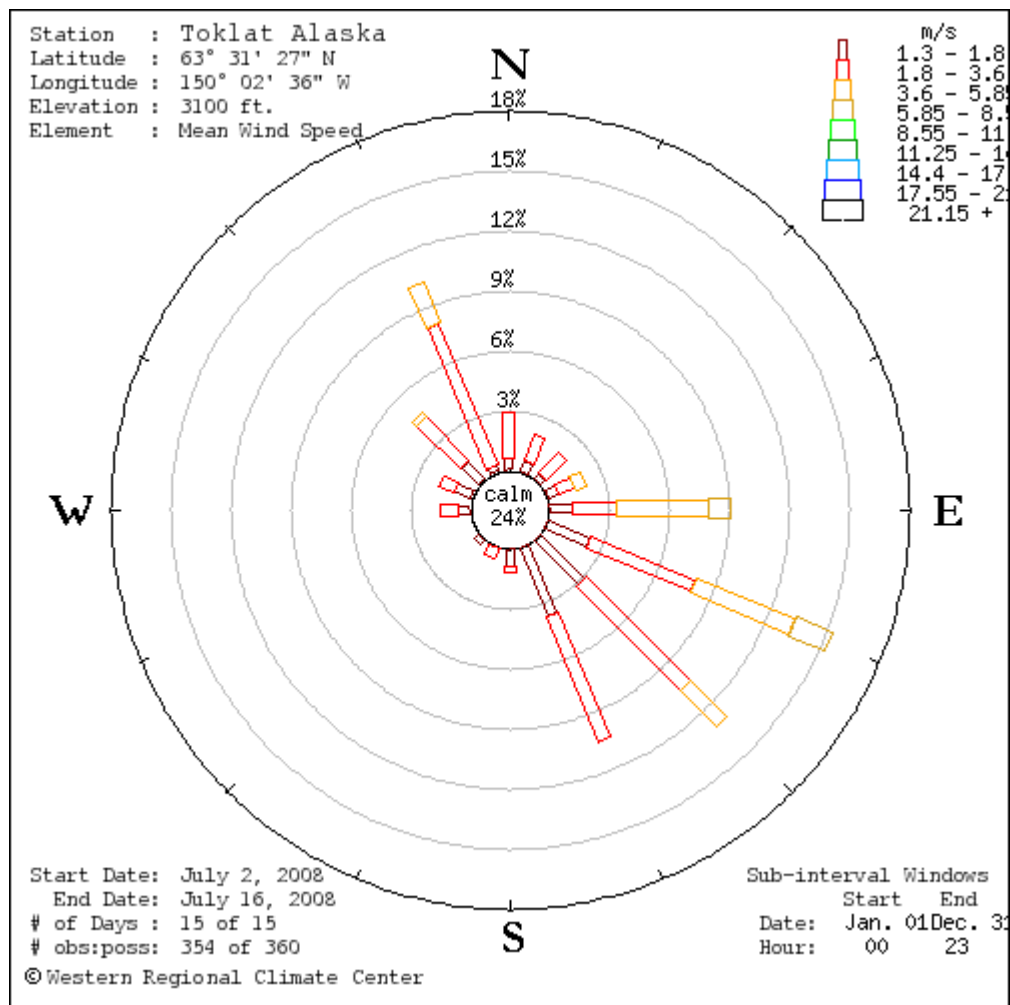
Toklat Alaska - Hourly Wind Statistics Table

Latitude : 63° 31' 27" N	Start Date : June 4, 2008	Sub Interval Windows
Longitude : 150° 02' 36" W	End Date : June 18, 2008	Start End
Elevation : 3100 ft.	# of Days : 15 of 15	Date Jan. 01 Dec. 31
Element :	# obs : poss : 359 of 360	Hour 00 23

Time - Time of Day (L.S.T.)
Speed - Average (Scalar) Speed in m/s
U-Vel - East-West Velocity, Positive to East
V-Vel - North-South Velocity, Positive to North
Res Spd - Vector Average (resultant) Speed in m/s
Res Dir - Vector Average (resultant) Direction
Dir Con - Directional Constancy (Res Spd/Speed)
Num Spd - Number of Wind Speed Observations
Num Dir - Number of Wind Direction Observations

Time	Speed	U-Vel	V-Vel	Res Spd	Res Dir	Dir Con	Num Spd	Num Dir
0	1.1	-0.1	0.6	0.6	167	0.523	15	15
1	0.9	-0.1	0.5	0.5	173	0.618	15	15
2	1.1	-0.1	0.6	0.6	174	0.538	15	15
3	1.1	-0.3	0.8	0.9	161	0.765	15	15
4	1.0	-0.2	0.8	0.8	164	0.805	15	15
5	1.2	-0.4	1.0	1.1	160	0.904	15	15
6	1.1	-0.3	0.8	0.9	162	0.825	15	15
7	1.0	-0.5	0.7	0.8	147	0.831	15	15
8	1.1	-0.5	0.3	0.5	119	0.492	15	15
9	1.3	-1.0	0.2	1.0	104	0.742	15	15
10	1.7	-0.5	-0.1	0.6	76	0.323	15	15
11	2.0	-0.7	-0.2	0.7	75	0.357	15	15
12	2.0	-0.4	-0.4	0.6	43	0.281	15	15
13	2.5	-0.4	-0.5	0.7	35	0.268	15	15
14	2.7	-0.2	-0.4	0.4	26	0.163	15	15
15	2.6	0.1	-0.4	0.5	344	0.180	15	15
16	2.6	-0.3	-0.7	0.8	24	0.311	15	15
17	2.6	-0.3	-0.6	0.6	26	0.243	15	15
18	2.4	-0.1	-0.8	0.8	10	0.347	15	15
19	2.4	0.5	-0.3	0.6	298	0.240	15	15
20	2.4	0.3	-0.9	0.9	338	0.390	15	15
21	2.1	0.5	-0.6	0.8	323	0.371	15	15
22	1.7	0.4	-0.2	0.4	294	0.255	14	14
23	1.2	-0.0	0.1	0.1	171	0.086	15	15
ALL	1.7	-0.2	0.0	0.2	94	0.105	359	359

July 2-16 2008
Toklat Alaska



Toklat Alaska - Wind Frequency Table (percentage)

Latitude : 63° 31' 27" N	Start Date : July 2, 2008	Sub Interval Windows
Longitude : 150° 02' 36" W	End Date : July 16, 2008	Start End
Elevation : 3100 ft.	# of Days : 15 of 15	Date Jan. 01 Dec. 31
Element :	# obs : poss : 354 of 360	Hour 00 23

(Greater than or equal to initial interval value and Less than ending interval value.)

Range (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
1.3 - 1.8	0.6	0.6	0.3	0.6	1.1	2.3	3.1	3.7	0.8	0.0	0.3	0.0	0.6	0.8	1.1	0.3	16.1
1.8 - 3.6	2.3	1.4	1.4	0.8	2.3	5.6	7.3	6.8	0.3	0.6	0.0	0.0	0.8	0.8	3.1	7.6	41.2
3.6 - 5.85	0.0	0.0	0.0	0.6	4.5	5.4	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.3	15.5
5.85 - 8.55	0.0	0.0	0.0	0.0	1.1	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1
8.55 - 11.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.25 - 14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.4 - 17.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.55 - 21.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21.15 -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total(%)	2.8	2.0	1.7	2.0	9.0	15.3	13.0	10.5	1.1	0.6	0.3	0.0	1.4	1.7	4.5	10.2	76.0
Calm (<1.3)																	24.0
Ave Speed	2.2	2.1	2.3	3.3	3.9	3.5	2.7	2.2	3.3	3.2	1.8	0.9	2.2	2.0	2.3	2.9	2.2

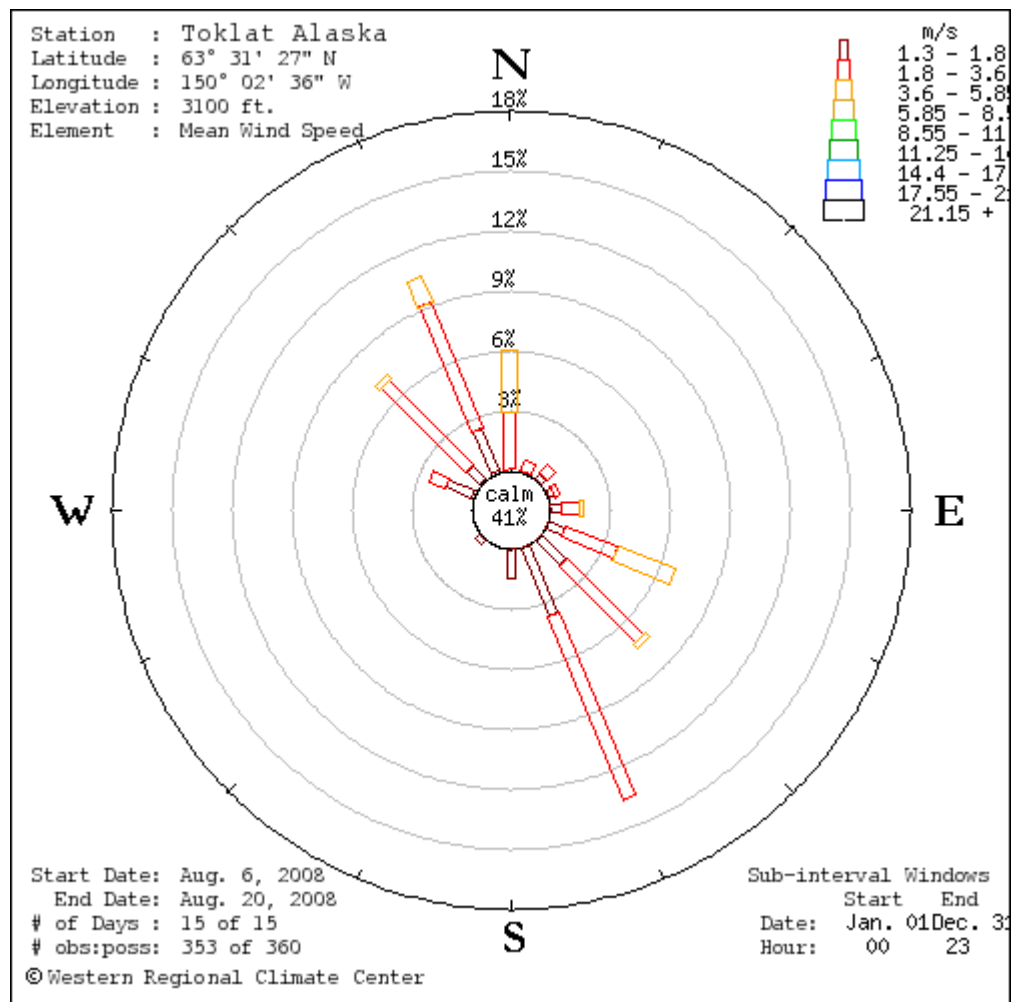
Toklat Alaska - Hourly Wind Statistics Table

Latitude : 63° 31' 27" N	Start Date : July 2, 2008	Sub Interval Windows
Longitude : 150° 02' 36" W	End Date : July 16, 2008	Start End
Elevation : 3100 ft.	# of Days : 15 of 15	Date Jan. 01 Dec. 31
Element :	# obs : poss : 354 of 360	Hour 00 23

Time - Time of Day (L.S.T.)
Speed - Average (Scalar) Speed in m/s
U-Vel - East-West Velocity, Positive to East
V-Vel - North-South Velocity, Positive to North
Res Spd - Vector Average (resultant) Speed in m/s
Res Dir - Vector Average (resultant) Direction
Dir Con - Directional Constancy (Res Spd/Speed)
Num Spd - Number of Wind Speed Observations
Num Dir - Number of Wind Direction Observations

Time	Speed	U-Vel	V-Vel	Res Spd	Res Dir	Dir Con	Num Spd	Num Dir
0	1.9	-1.0	0.8	1.3	129	0.658	15	15
1	1.7	-1.0	0.7	1.2	127	0.725	15	15
2	1.5	-0.8	1.1	1.4	142	0.893	15	15
3	1.7	-0.9	1.4	1.7	146	0.987	15	14
4	1.4	-0.8	1.1	1.3	146	0.955	15	15
5	1.5	-0.8	0.9	1.2	139	0.818	15	15
6	1.6	-0.9	0.9	1.3	133	0.823	15	15
7	1.3	-0.8	0.6	1.0	126	0.770	15	15
8	1.3	-0.9	0.2	0.9	105	0.746	15	15
9	1.3	-0.9	-0.1	0.9	83	0.670	15	15
10	1.7	-0.7	-0.4	0.9	60	0.489	15	15
11	2.2	-0.8	-0.6	1.0	50	0.450	14	14
12	2.5	-0.8	-0.8	1.1	47	0.438	15	15
13	2.5	-0.5	-0.9	1.0	28	0.391	15	15
14	2.9	-1.1	-0.7	1.3	60	0.465	15	15
15	3.0	-1.7	0.0	1.7	91	0.562	14	14
16	3.3	-1.5	0.1	1.5	95	0.465	14	14
17	2.9	-1.3	-0.3	1.4	76	0.471	15	15
18	2.9	-1.5	-0.4	1.6	74	0.548	15	15
19	2.9	-1.0	-0.1	1.0	84	0.338	15	15
20	2.9	-1.1	-0.1	1.1	84	0.390	15	15
21	2.8	-1.2	0.2	1.2	100	0.435	13	13
22	2.5	-1.4	0.2	1.4	98	0.559	15	15
23	2.5	-1.3	0.6	1.4	116	0.568	15	15
ALL	2.2	-1.0	0.2	1.0	100	0.478	355	354

Aug 6-20 2008
Toklat Alaska



Toklat Alaska - Wind Frequency Table (percentage)

Latitude : 63° 31' 27" N	Start Date : Aug. 6, 2008	Sub Interval Windows
Longitude : 150° 02' 36" W	End Date : Aug. 20, 2008	Start End
Elevation : 3100 ft.	# of Days : 15 of 15	Date Jan. 01 Dec. 31
Element :	# obs : poss : 353 of 360	Hour 00 23

(Greater than or equal to initial interval value and Less than ending interval value.)

Range (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
1.3 - 1.8	0.0	0.0	0.3	0.3	0.6	0.8	1.7	3.7	1.4	0.0	0.3	0.0	0.0	1.4	0.8	2.3	13.6
1.8 - 3.6	2.8	0.6	0.6	0.3	0.8	2.8	5.4	9.9	0.0	0.0	0.0	0.0	0.0	0.8	5.9	6.8	36.8
3.6 - 5.85	3.1	0.0	0.0	0.0	0.3	3.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.4	8.5
5.85 - 8.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.55 - 11.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.25 - 14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.4 - 17.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.55 - 21.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21.15 -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total(%)	5.9	0.6	0.8	0.6	1.7	6.8	7.4	13.6	1.4	0.0	0.3	0.0	0.0	2.3	7.1	10.5	58.9
Calm (<1.3)																	41.0
Ave Speed	3.4	2.5	2.9	3.4	2.8	3.2	2.3	2.2	3.9	5.0	4.5	1.8	4.5	2.3	2.5	2.5	1.6

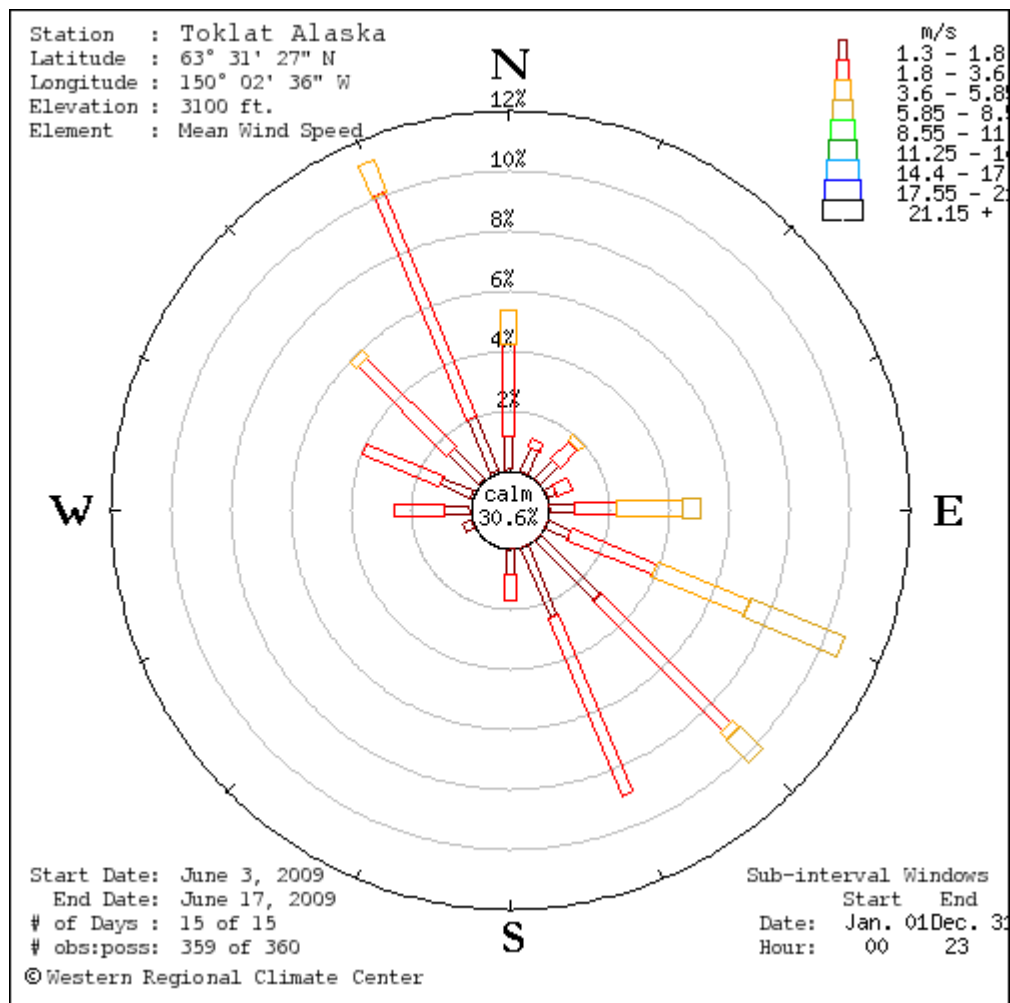
Toklat Alaska - Hourly Wind Statistics Table

Latitude : 63° 31' 27" N	Start Date : Aug. 6, 2008	Sub Interval Windows
Longitude : 150° 02' 36" W	End Date : Aug. 20, 2008	Start End
Elevation : 3100 ft.	# of Days : 15 of 15	Date Jan. 01 Dec. 31
Element :	# obs : poss : 353 of 360	Hour 00 23

Time - Time of Day (L.S.T.)
Speed - Average (Scalar) Speed in m/s
U-Vel - East-West Velocity, Positive to East
V-Vel - North-South Velocity, Positive to North
Res Spd - Vector Average (resultant) Speed in m/s
Res Dir - Vector Average (resultant) Direction
Dir Con - Directional Constancy (Res Spd/Speed)
Num Spd - Number of Wind Speed Observations
Num Dir - Number of Wind Direction Observations

Time	Speed	U-Vel	V-Vel	Res Spd	Res Dir	Dir Con	Num Spd	Num Dir
0	0.8	0.1	0.3	0.3	207	0.370	15	15
1	0.8	-0.1	0.6	0.6	166	0.783	15	15
2	1.0	-0.3	0.8	0.8	161	0.816	15	15
3	1.4	-0.5	1.1	1.2	154	0.893	15	15
4	1.4	-0.5	1.0	1.1	156	0.811	15	15
5	1.4	-0.5	1.0	1.1	154	0.735	14	14
6	1.2	-0.4	1.0	1.1	160	0.896	13	13
7	1.2	-0.4	1.1	1.2	159	0.950	15	15
8	1.0	-0.2	0.7	0.8	162	0.745	15	15
9	1.0	-0.6	0.5	0.8	128	0.803	15	15
10	1.2	-0.6	0.1	0.6	98	0.535	14	14
11	1.6	-0.4	-0.4	0.6	42	0.341	15	14
12	1.7	-0.4	-0.2	0.5	58	0.270	14	14
13	2.1	-0.5	-0.5	0.7	46	0.355	15	15
14	2.3	-0.1	-0.7	0.7	6	0.287	15	15
15	2.4	-0.4	-0.8	0.9	24	0.377	15	15
16	2.7	-0.4	-1.1	1.2	19	0.431	15	15
17	2.8	-0.3	-1.5	1.5	10	0.543	15	15
18	2.4	0.6	-1.6	1.7	338	0.700	14	14
19	2.3	0.1	-1.2	1.2	357	0.512	15	15
20	2.3	0.0	-1.3	1.3	359	0.561	15	15
21	1.5	0.3	-0.4	0.5	319	0.324	15	15
22	1.1	0.1	-0.1	0.1	311	0.122	15	15
23	0.7	0.1	0.2	0.2	217	0.353	15	15
ALL	1.6	-0.2	-0.1	0.2	75	0.139	354	353

June 3-17 2009
Toklat Alaska



Toklat Alaska - Wind Frequency Table (percentage)

Latitude : 63° 31' 27" N	Start Date : June 3, 2009	Sub Interval Windows
Longitude : 150° 02' 36" W	End Date : June 17, 2009	Start End
Elevation : 3100 ft.	# of Days : 15 of 15	Date Jan. 01 Dec. 31
Element :	# obs : poss : 359 of 360	Hour 00 23

(Greater than or equal to initial interval value and Less than ending interval value.)

Range (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
1.3 - 1.8	1.1	0.8	0.8	0.3	0.8	0.8	2.8	2.5	0.8	0.0	0.0	0.3	0.8	1.1	1.4	1.9	16.4
1.8 - 3.6	3.1	0.3	0.8	0.6	1.4	3.1	6.1	6.4	0.8	0.0	0.0	0.0	1.7	2.8	4.2	8.1	39.3
3.6 - 5.85	1.1	0.0	0.3	0.0	2.2	3.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.1	8.6
5.85 - 8.55	0.0	0.0	0.0	0.0	0.6	3.3	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0
8.55 - 11.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.25 - 14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.4 - 17.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.55 - 21.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21.15 -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total(%)	5.3	1.1	1.9	0.8	5.0	10.6	10.3	8.9	1.7	0.0	0.0	0.3	2.5	3.9	5.8	11.1	69.4
Calm (<1.3)																	30.6
Ave Speed	2.8	2.2	2.4	4.4	3.7	4.4	2.6	2.2	3.1	3.2	2.2	4.5	2.1	2.1	2.2	2.6	2.0

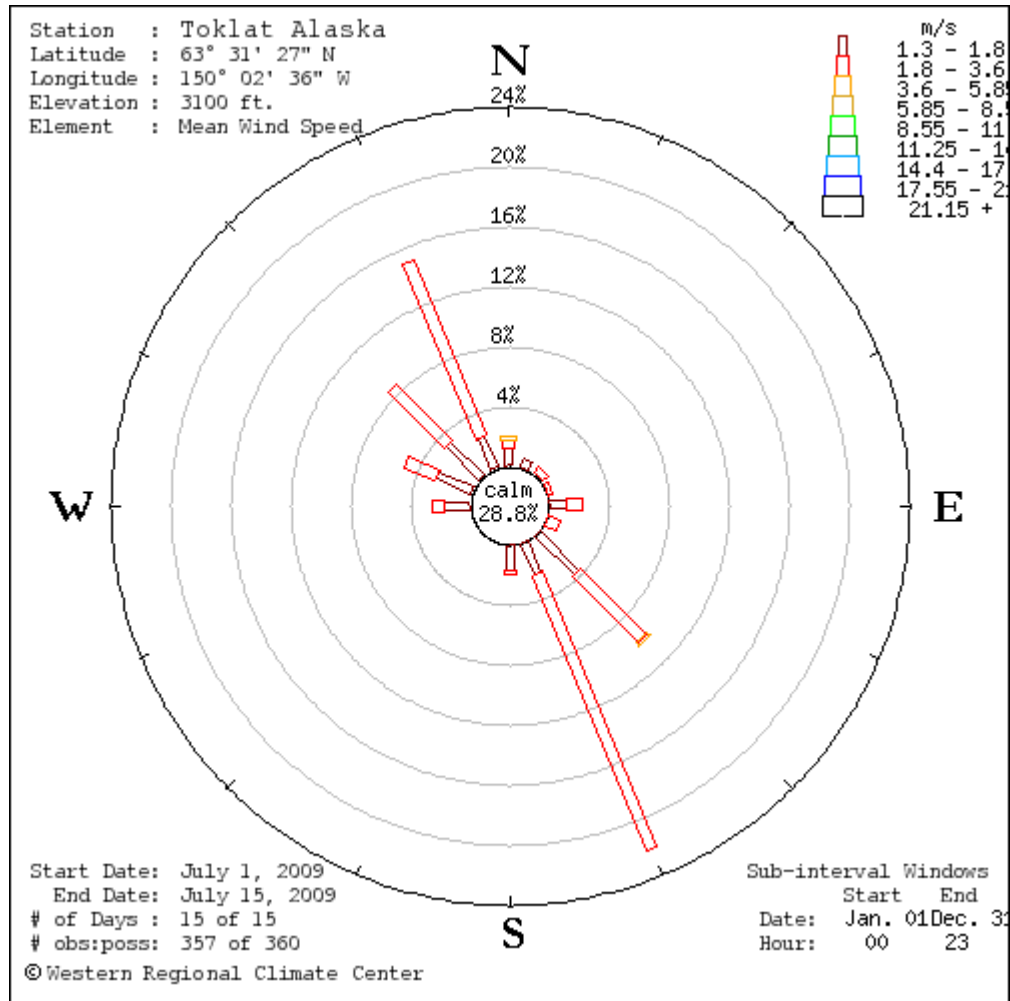
Toklat Alaska - Hourly Wind Statistics Table

Latitude : 63° 31' 27" N Start Date : June 3, 2009 Sub Interval Windows
Longitude : 150° 02' 36" W End Date : June 17, 2009 Start End
Elevation : 3100 ft. # of Days : 15 of 15 Date Jan. 01 Dec. 31
Element : # obs : poss : 359 of 360 Hour 00 23

Time - Time of Day (L.S.T.)
Speed - Average (Scalar) Speed in m/s
U-Vel - East-West Velocity, Positive to East
V-Vel - North-South Velocity, Positive to North
Res Spd - Vector Average (resultant) Speed in m/s
Res Dir - Vector Average (resultant) Direction
Dir Con - Directional Constancy (Res Spd/Speed)
Num Spd - Number of Wind Speed Observations
Num Dir - Number of Wind Direction Observations

Time	Speed	U-Vel	V-Vel	Res Spd	Res Dir	Dir Con	Num Spd	Num Dir
0	1.4	-0.4	0.5	0.6	137	0.441	14	14
1	1.2	-0.5	0.6	0.8	136	0.676	15	15
2	1.6	-0.8	0.8	1.1	136	0.698	15	15
3	1.7	-1.1	1.1	1.5	135	0.866	15	15
4	1.7	-0.9	1.1	1.4	143	0.823	15	15
5	1.6	-0.8	1.1	1.4	144	0.866	15	15
6	1.9	-1.0	0.9	1.4	134	0.727	15	15
7	1.8	-0.9	0.4	1.0	113	0.556	15	15
8	1.6	-1.2	0.4	1.3	108	0.795	15	15
9	1.5	-1.0	-0.1	1.0	83	0.665	15	15
10	1.5	-0.6	-0.4	0.7	53	0.485	15	15
11	2.1	-0.7	-0.7	0.9	45	0.453	15	15
12	2.4	-0.9	-0.6	1.1	55	0.451	15	15
13	2.3	-0.4	-0.9	1.0	25	0.431	15	15
14	2.2	-0.4	-0.7	0.8	32	0.366	15	15
15	2.3	-0.4	-0.7	0.8	26	0.359	15	15
16	2.4	-0.2	-0.9	0.9	15	0.385	15	15
17	2.7	-0.2	-0.5	0.5	22	0.197	15	15
18	2.9	-0.5	-0.9	1.0	31	0.342	15	15
19	2.6	-0.3	-0.2	0.3	52	0.123	15	15
20	2.8	-0.5	-0.1	0.5	75	0.179	15	15
21	2.4	-0.7	-0.2	0.7	73	0.297	15	15
22	1.9	-0.3	-0.3	0.4	54	0.232	15	15
23	1.7	-0.2	0.0	0.2	94	0.148	15	15
ALL	2.0	-0.6	-0.0	0.6	89	0.310	359	359

July 1-15 Toklat Alaska



Toklat Alaska - Wind Frequency Table (percentage)

Latitude : 63° 31' 27" N	Start Date : July 1, 2009	Sub Interval Windows	
Longitude : 150° 02' 36" W	End Date : July 15, 2009	Start	End
Elevation : 3100 ft.	# of Days : 15 of 15	Date	Jan. 01 Dec. 31
Element :	# obs : poss : 357 of 360	Hour	00 23

(Greater than or equal to initial interval value and Less than ending interval value.)

Range (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
1.3 - 1.8	1.1	0.6	0.0	0.0	1.1	0.0	3.6	2.2	1.7	0.0	0.0	0.0	1.7	2.5	3.1	2.2	19.9
1.8 - 3.6	0.6	0.0	0.6	0.3	1.1	0.8	6.2	19.9	0.3	0.0	0.0	0.0	0.8	2.2	5.3	12.6	50.7
3.6 - 5.85	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
5.85 - 8.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.55 - 11.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.25 - 14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.4 - 17.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.55 - 21.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21.15 -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total(%)	2.0	0.6	0.6	0.3	2.2	0.8	10.1	22.1	2.0	0.0	0.0	0.0	2.5	4.8	8.4	14.8	71.1
Calm (<1.3)																	28.8
Ave Speed	2.8	2.3	2.2	8.1	2.5	3.9	2.1	2.2	1.7	3.1	3.2	3.6	2.4	1.9	2.1	2.4	1.6

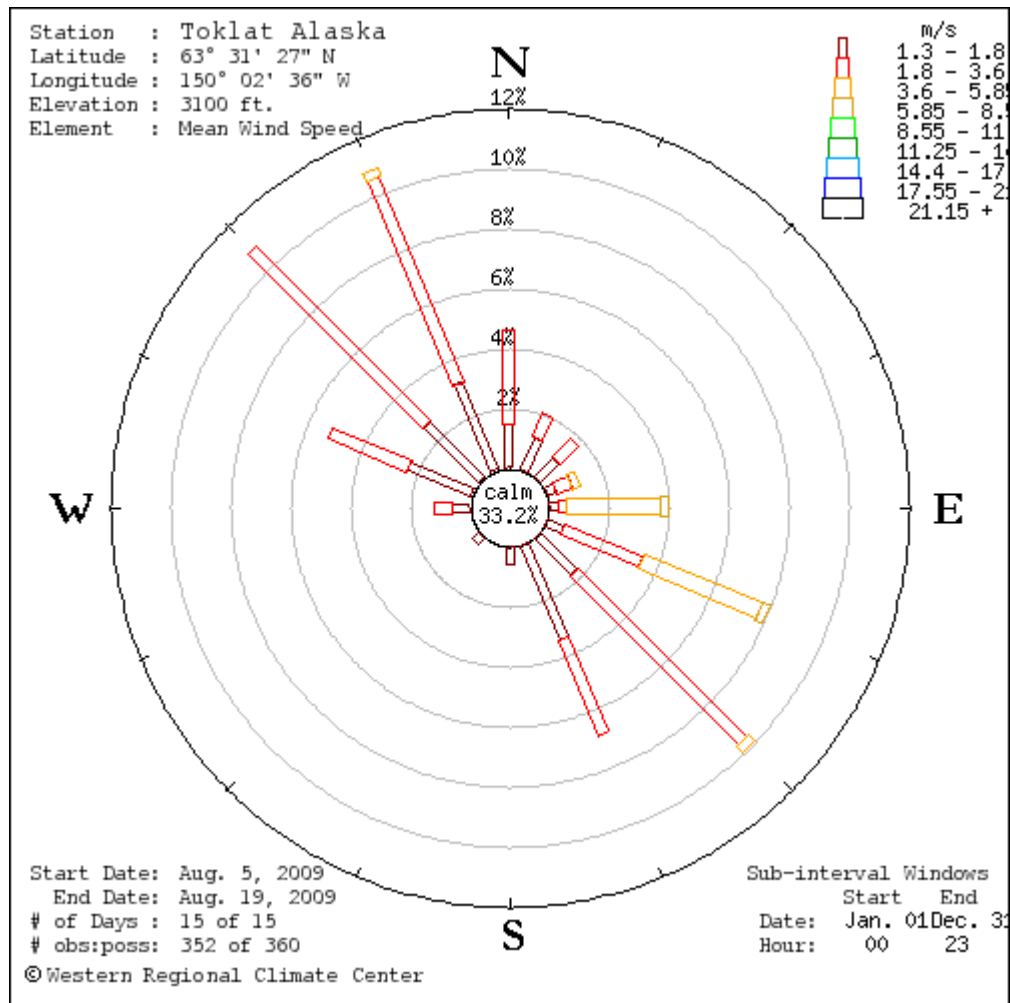
Toklat Alaska - Hourly Wind Statistics Table

Latitude : 63° 31' 27" N	Start Date : July 1, 2009	Sub Interval Windows
Longitude : 150° 02' 36" W	End Date : July 15, 2009	Start End
Elevation : 3100 ft.	# of Days : 15 of 15	Date Jan. 01 Dec. 31
Element :	# obs : poss : 357 of 360	Hour 00 23

Time - Time of Day (L.S.T.)
Speed - Average (Scalar) Speed in m/s
U-Vel - East-West Velocity, Positive to East
V-Vel - North-South Velocity, Positive to North
Res Spd - Vector Average (resultant) Speed in m/s
Res Dir - Vector Average (resultant) Direction
Dir Con - Directional Constancy (Res Spd/Speed)
Num Spd - Number of Wind Speed Observations
Num Dir - Number of Wind Direction Observations

Time	Speed	U-Vel	V-Vel	Res Spd	Res Dir	Dir Con	Num Spd	Num Dir
0	1.1	-0.4	0.9	0.9	157	0.867	15	15
1	1.7	-0.6	1.5	1.6	157	0.975	15	15
2	1.8	-0.6	1.4	1.6	159	0.861	15	15
3	1.9	-0.7	1.6	1.7	157	0.930	15	15
4	2.0	-0.8	1.6	1.8	155	0.901	15	15
5	1.9	-0.8	1.7	1.9	155	0.977	15	15
6	1.9	-0.9	1.5	1.7	149	0.929	15	15
7	1.9	-0.8	1.6	1.8	154	0.946	15	15
8	1.9	-0.8	1.3	1.6	148	0.842	15	15
9	1.3	-0.8	0.6	1.0	128	0.748	14	14
10	0.7	-0.3	0.1	0.3	108	0.409	15	15
11	1.0	0.1	-0.7	0.7	348	0.684	15	15
12	1.4	0.1	-0.9	0.9	353	0.640	15	15
13	1.5	0.4	-1.1	1.2	339	0.798	13	13
14	1.7	0.3	-1.1	1.2	344	0.662	15	15
15	1.9	0.4	-1.1	1.2	340	0.617	15	15
16	1.9	0.4	-1.1	1.2	339	0.635	15	15
17	2.3	0.7	-1.3	1.5	332	0.645	15	15
18	1.9	0.6	-1.0	1.2	328	0.631	15	15
19	2.1	0.7	-1.4	1.5	332	0.721	15	15
20	2.0	1.0	-1.1	1.5	317	0.736	15	15
21	1.7	0.9	-0.6	1.1	306	0.674	15	15
22	1.1	0.6	-0.2	0.7	290	0.604	15	15
23	0.8	0.2	0.3	0.4	217	0.475	15	15
ALL	1.6	-0.0	0.1	0.1	165	0.065	357	357

August Sampling Period Toklat Alaska



Toklat Alaska - Wind Frequency Table (percentage)

Latitude : 63° 31' 27" N	Start Date : Aug. 5, 2009	Sub Interval Windows
Longitude : 150° 02' 36" W	End Date : Aug. 19, 2009	Start End
Elevation : 3100 ft.	# of Days : 15 of 15	Date Jan. 01 Dec. 31
Element :	# obs : poss : 352 of 360	Hour 00 23

(Greater than or equal to initial interval value and Less than ending interval value.)

Range (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
1.3 - 1.8	1.4	1.1	0.9	0.3	0.3	0.6	1.7	3.4	0.6	0.0	0.3	0.0	0.6	2.3	2.6	3.1	19.0
1.8 - 3.6	3.1	0.9	0.9	0.6	0.3	2.8	8.0	3.4	0.0	0.0	0.0	0.0	0.6	2.8	8.2	7.4	38.9
3.6 - 5.85	0.0	0.0	0.0	0.3	3.1	4.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	8.2
5.85 - 8.55	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
8.55 - 11.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.25 - 14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.4 - 17.55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.55 - 21.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21.15 -	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total(%)	4.5	2.0	1.7	1.1	4.0	8.0	9.9	6.8	0.6	0.0	0.3	0.0	1.1	5.1	10.8	10.8	66.8
Calm (<1.3)																	33.2
Ave Speed	2.4	1.7	1.8	2.9	4.4	3.6	2.1	1.9	5.9	4.1	5.4	0.9	2.8	2.2	2.3	2.2	1.7

Toklat Alaska - Hourly Wind Statistics Table

Latitude : 63° 31' 27" N Start Date : Aug. 5, 2009 Sub Interval Windows
 Longitude : 150° 02' 36" W End Date : Aug. 19, 2009 Start End
 Elevation : 3100 ft. # of Days : 15 of 15 Date Jan. 01 Dec. 31
 Element : # obs : poss : 352 of 360 Hour 00 23

Time - Time of Day (L.S.T.)
 Speed - Average (Scalar) Speed in m/s
 U-Vel - East-West Velocity, Positive to East
 V-Vel - North-South Velocity, Positive to North
 Res Spd - Vector Average (resultant) Speed in m/s
 Res Dir - Vector Average (resultant) Direction
 Dir Con - Directional Constancy (Res Spd/Speed)
 Num Spd - Number of Wind Speed Observations
 Num Dir - Number of Wind Direction Observations

Time	Speed	U-Vel	V-Vel	Res Spd	Res Dir	Dir Con	Num Spd	Num Dir
0	1.0	-0.2	0.5	0.5	155	0.508	15	15
1	1.3	-0.5	0.7	0.9	142	0.687	15	15
2	1.5	-0.8	0.8	1.1	135	0.704	14	14
3	1.5	-0.8	0.7	1.1	128	0.716	14	14
4	1.5	-0.8	0.8	1.1	136	0.766	15	15
5	1.4	-0.8	0.8	1.1	134	0.802	15	15
6	1.0	-0.6	0.7	0.9	138	0.899	15	15
7	1.0	-0.2	0.4	0.4	153	0.433	15	15
8	1.3	0.1	0.1	0.2	214	0.136	14	14
9	1.7	-0.3	-0.1	0.3	75	0.153	14	14
10	1.7	-0.0	-0.6	0.6	1	0.358	14	14
11	1.9	-0.1	-0.9	0.9	7	0.463	15	15
12	1.6	-0.4	-0.7	0.8	26	0.514	15	15
13	1.8	-0.1	-0.9	0.9	4	0.508	15	15
14	2.2	-0.3	-0.9	1.0	16	0.439	15	15
15	2.6	0.0	-1.0	1.0	359	0.382	15	15
16	2.6	-0.2	-1.0	1.0	10	0.367	15	15
17	2.3	0.0	-0.7	0.7	359	0.318	15	15
18	2.3	0.1	-1.1	1.1	354	0.489	15	15
19	2.3	0.2	-0.9	0.9	345	0.389	14	14
20	2.1	-0.4	-0.8	0.8	27	0.397	15	15
21	1.8	-0.6	-0.2	0.7	71	0.363	14	14
22	1.2	0.0	-0.0	0.0	326	0.012	14	14
23	1.0	-0.0	0.4	0.4	175	0.411	15	15
ALL	1.7	-0.3	-0.2	0.3	59	0.189	352	352

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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National Park Service
U.S. Department of the Interior



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