Assessment of the Principal Causes of Dust-Resultant Haze at IMPROVE Sites in the Western United States

Final report

Prepared for:

Western Regional Air Partnership

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EXECUTIVE SUMMARY

A total of 644 worst dust days, defined as 20% worst visibility days when the sum of extinction from coarse mass (CM) and (FS) was larger than any other component, were observed during the period 2001-2003. We provide a summary of the findings of the overall findings of the study. For detailed results Table 9 shows on a site by site basis the confidence levels with which each event type was identified as a primary source of the worst dust day. Table 10 enumerates every worst dust day for the sites considered in this study over the 2001 – 2003 period and provides an indication of the event type that was identified as the primary source of dust. Maps are also available for every worst dust day and should be consulted for additional detail.

Using the tools described in this report, it was found that:

(i) approximately 50% (318 cases) of worst dust days were attributable, with a moderate (***) to high (*****) degree of confidence, the following events/classes:

- Transcontinental transport from Asia: 48 cases (7.5%);
- Windblown dust (generated locally in the vicinity – nominally within 10 km - of the site): 125 cases (19.4%);
- Upwind transport (does not involve significant windblown dust from sources local to the site): 145 cases (22.5%);

(ii) Approximately 30% (190 cases) of the remaining days were attributed to the following events/classes with a low (*) to moderate (***) degree of confidence:

- Transcontinental transport from Asia: 7 cases (1.1%);
- Windblown dust: 76 cases (11.8%);
- Upwind transport: 107 cases (16.6%);

(iii) The remaining 21% of worst dust days (136 case) were not attributable to any events/classes using the tools employed in this study.

A number of temporal trends were also observed, both in terms of frequency of event occurrence and in terms of worst dust days resulting from undetermined sources. The impact of transcontinental transport from Asia was only observed during spring (100% of 48 cases). Windblown dust as a dust causing event was most important in spring (56.8% of 125 cases), while transport from upwind sources did not vary significantly by season except for a notable decrease in the winter months (spring: 35% of 145 cases, summer: 28%, fall: 31%, winter: 6%).

For states with more than 12 worst dust days during the 2001-2003 period, a large percentage of worst dust days was explained by one of the three event types with a moderate (***) to high (*****) degree of confidence for the sites in New Mexico (70% of 106 cases), Colorado (57% of 60 cases), Utah (56% of 41 cases), Nevada (56% of 16 cases), Wyoming (79% of 14 cases), Oregon (54% of 13 cases), and Idaho (69% of 13 cases). A comparatively smaller percentage was explained with the same degree of confidence for sites in Arizona (38% of 238 cases), California (38% of 73 cases), Texas (37% of 30 cases) and Montana (47% of 19 cases). For states with less than 12 worst dust days during the 2001-2003 period, events were associated with specific days with a moderate (***) to high (*****) degree of confidence for sites in South Dakota (78% of 9 cases), Alaska (40% od 5 cases), Washington (34% of 6 cases), and North Dakota (50% of 2 cases).

For the sites considered in this study, worst dust days exhibited a seasonal pattern, with the most frequent occurrences in summer (246 out of 644) and spring (241). The fall (115) and winter (43) were associated with significantly fewer worst dust days. Of the 644 total worst dust days, a total of 136 were a result of events/sources that could not be determined using the tools employed in this study. The greatest number of undetermined events occurred in the summer, corresponding to 79 cases (32% of summer worst dust days), followed by spring (23 cases, 10% of all spring worst dust days) and fall (22 cases, 19% of all fall worst dust days), and winter (12 cases, 28% of all winter worst dust days).

1. Introduction

1.1 Background

Dust is the principal component of haze on the 20% worst visibility days of the year ("worst days" hereafter) most frequently at Class I areas in the Western United States. The magnitude of the impact of dust on haze varies by region as well as by season due to source variations in spatial scale, time, location, and causes of emission. For example, paved and unpaved road dust emissions tend to follow the diurnal patterns associated with motor vehicle traffic, with some additional dependence on seasonal occurrences such as snow and agricultural activities. Windblown dust emissions generally occur over larger spatial scales and the magnitude of dust emissions during these events can eclipse the comparatively smaller, but more regular road dust emissions. On a transcontinental scale, enormous, regional dust storms can be transported across oceans and continents and impact the entire WRAP region.

Dust is defined as the sum of Fine Soil mass (FS) and Coarse Mass (CM) as measured by monitors in the IMPROVE network, which operates 24-hr filter samples on a one in three day basis. CM is the difference between PM_{10} and $PM_{2.5}$ fractions. FS is calculated from a linear equation based on the measured concentrations of five metals associated with mineral dust (Al, Si, Ca, Fe, and Ti). The aerosol visibility extinction resulting from suspended aerosols (i.e. does not include Rayleigh scattering) is quantified through the extinction coefficient, $\beta_{ext,aer}$, which is calculated from the equation:

$$\beta_{ext,aer} = 3 \cdot f(RH) \cdot [SO_4^{2-}] + 3 \cdot f(RH) \cdot [NO_3^-] + 4 \cdot [OMC] + 10 \cdot [LAC] + 1 \cdot [FS] + 0.6 \cdot [CM] \qquad \text{Eq. 1-1}$$

where the brackets indicate concentrations of sulfate (SO_4^{2-}), nitrate (NO_3^-), organic carbon (OMC), light absorbing carbon (LAC), fine soil (FS) and coarse mass (CM) in □g/m^3, respectively and they are inherently subject to both positive and negative sampling and analysis biases. For example, CM originating from sea spray, non-soil organic debris, or from wildfires would result in an overestimate of ambient airborne dust extinction caused by non-dust components.

2. Objectives and methodology

The principal aim of the study was to specifically identify the primary causes of dust measured in the WRAP region by:

1. developing a methodology for assigning worst days when dust constituted the largest contributor to aerosol visibility extinction (worst dust days, hereafter) at IMPROVE monitors within the WRAP domain to a set of source classes;
2. using the methodology to categorize worst dust days over the period 2001 – 2003.

The methodology employs several existing tools in novel ways including air mass backward trajectories, land use maps, and soil characteristics maps. In addition, two new methods have been developed as part of this work. The first is a metric for estimating the contribution of Asian dust to IMPROVE-measured dust on worst dust days. The second utilizes multivariate linear regression of measured dust concentrations vs. nominally local surface meteorological data. These tools were combined using a semi-quantitative approach to preliminarily determine the likely source of dust on a worst dust day at a given site. Due to limitation of the information and capabilities of the tools, the causes of some worst dust days were not determined with any confidence. Using 2001-2003 data from IMRPOVE (and some protocol) monitors in the WRAP regions, each worst dust day was associated with one of these events:

- Transcontinental transport of large scale events from Asia
- Windblown dust events
- Transport of windblown dust from sources upwind (i.e. not from immediate vicinity of site)
  - Further specification if windblown and upwind transport events appears to be regional in nature based on scale of meteorological phenomenon causing dust and number of sites affected
- Undetermined Events

This study focused on 71 sites from the IMPROVE network (and protocol sites) located in the WRAP domain. These sites were selected based on availability of data over the 2001 – 2003 period and the availability of a nearby surface meteorological station over the same period. Table 1 shows the 71 IMPROVE sites considered in this study, the surface meteorological sites used to represent conditions at each IMPROVE site, and distances and elevation differences between the two.

3. Elemental concentrations and ratios: The Asian Dust Score

The transport of airborne dust emitted from high wind events originating in China to the west coast of the US (about 7 – 10 days en route) has received considerable attention in recent years (Cheng et al., 2005; Park et al., 2005; Zhang et al., 2005; Darmenova et al., 2005). Large "Asian dust" events can contribute significantly to haze over large portions of the western US. These large Asian dust episodes are initiated by low pressure systems in the Gobi desert region of Mongolia and northwest China. Once elevated to the troposphere, Asian dust can move fast under zonal flow due to the jet stream. Under high pressure ridge conditions, large-scale exchange of dust from the troposphere to the boundary layer may occur resulting in elevated ground-level mineral aerosol concentrations.

Although it is difficult to quantitatively separate the influence of the Asian dust from dust that is generated on the North American continent or transported from other regions of the world (e.g. Africa), some chemical markers can help identify dust of Asian origin. Perry et al. [1997] and VanCuren and Cahill [2002] suggested that Al/Ca and K/Fe ratios are useful for identifying Asian and African dust. African dust is associated with Al/Ca ratios greater than 3.8, while those ratios for Asian dust are generally less than 2.6. The K/Fe ratio is consistently above 0.5 for Asian dust, while African dust exhibits lower values for this ratio.
Similar chemical markers have been adopted to help distinguish Asian dust from dust generated on the North American continent for this study. The large Asian dust storm on April 19, 1998 was used as a benchmark for establishing these markers. The dust plume from the 4/19/1998 storm crossed the Pacific Ocean, and subsided to the surface of the western United States around 4/29/1998.

For 17 of the WRAP IMPROVE monitoring sites, 4/29/1998 was a worst visibility day with mineral aerosol being responsible for the majority of the reconstructed extinction. Ratios of Al/Si, K/Fe, Al/Ca and CM/Dust (where Dust is the sum of fine soil, [FS], and coarse mass, [CM]), were quite different compared to average values (Table 2). Based on the chemical signature of the 4/19/1998 dust event, ratios of Al/Si, K/Fe, CM/Soil and Al/Ca were used to calculate an Asian Dust Score (ADS):

$$\mathrm{ADS} = \frac{1}{\prod\left(\mathrm{Z}_{\mathrm{score(X/Y)}} \cdot \left(\frac{\varepsilon\left(\mathrm{X}/\mathrm{Y}\right)_j}{\left(X/\mathrm{Y}\right)_j} \cdot 100\right)\right)} \qquad \text{Eq. 3-1}$$

where

$$Z_{score(X/Y)} = \frac{\left(\left(X/Y\right)_j - \left(X/Y\right)_{ref}\right)}{\sqrt{\left(\varepsilon\left(X/Y\right)_j^2 + \sigma\left(X/Y\right)_{ref}^2\right)}} \qquad \text{Eq. 3-2}$$

and

$$\varepsilon\left(X/Y\right)_j = \sqrt{\left(\frac{\varepsilon_X}{100}\right)^2 + \left(\frac{\varepsilon_Y}{100}\right)^2} \qquad \text{Eq. 3-3}$$

where $(X/Y)_j$ is the ratio of component X to component Y at a specific site-day j, $(X/Y)_{ref}$ is the reference ratio calculated from the 4/19/1998 dust event, $\sigma(X/Y)_{ref}$ is the standard deviation of the reference ratio, and $\varepsilon(X/Y)$ is the uncertainty of the $(X/Y)_j$ ratio, which is estimated by propagating the measurement uncertainties associated with the X and Y components.

For valid measurements of Al, Si, K, Fe and CM, ADS values are greater than zero, increase when ratios on sampling day j are closer to the reference ratios, and decrease with increasing measurement uncertainty. Thus the ADS does not provide a measure of how much of the IMPROVE sample collected for day j is comprised of Asian dust. Rather the ADS provides a measure of the confidence that measured ratios are close to the Asian dust ratios. With the caveat that even a high ADS value only provides a loose metric for assessing possible Asian dust influence that requires independent verification, based on experience gained in working with ADS ratios, the following approximate guidelines for interpreting the ADS are presented:

- ADS < 750 - small Asian dust signature; Asian influence not likely

- 750 < ADS < 1500, - moderate Asian dust signature; Asian influence should be considered
- ADS > 1500, - strong Asian dust signature; Asian influence is supported by chemical analysis but independent verification or corroborating additional evidence is required for greater confidence

4. Multivariate Linear Regression Analysis (MLRA): Local wind vs. measured dust

MLRA was applied to estimate the impact of local windblown dust by regressing measured dust concentrations against wind direction and speed. 1-hour wind direction (WD) and speed (WS) and precipitation (if available) data were obtained from meteorological sites located at or nearby each IMPROVE site represented in this analysis (See Table 1). In order to reduce the number of permutations of wind speed and direction and to utilize wind direction information in the regression, these met data were transformed into categorical bins (true=1, false=0) (Table 3, Table 4, and Table 5). Since dust mass concentrations were measured on 24-h integrated samples, for each day, the daily sum for each category was calculated. The database was screened using precipitation data when available. In general: (a) A day was removed from the MLRA if precipitation occurred during the sample day for more than 10 hours or on the day prior to the sample day or; (b) Only the last twelve hours (from 12:00 pm to 12:00 am) of a day was removed if precipitation occurred after 12:00 pm.

The concept of multivariate linear regression analysis presumes the ability to predict the value of a dependent variable (y_m) based on the values of n- independent variables (x_i, $i=1,\ldots,n$). The results from MLRA can provide information on the existence of a correlation between dependent and independent variables, an estimate of the accuracy of predicting the dependent variable by using a linear combination of the independent variables, and an estimate of the variation in the dependent variable that can be explained by variations in the independent variables. The equation that describes the multivariate linear regression between measured dust mass on a given sample day at a given site and wind speed and direction characteristics on that sample day is:

$$y_m = y_p + \varepsilon = b_1 \cdot x_1 + b_2 \cdot x_2 + ... + b_k \cdot x_k + a + \varepsilon \qquad \text{(Eq. 4-1)}$$

where:

y_m is the measured dust mass concentration;

y_p is the dust concentration estimated by a linear combination of independent variables that describe the wind conditions;

$b_1, b_2, ..., b_k$ are the regression coefficients of the independent variables;

$x_1, x_2, ..., x_k$ are the values of independent variables that describe the wind conditions;

a is the intercept which corresponds to y_p when $x_1, x_2, ..., x_k$ are equal to 0 and;

ε is the residual error - the difference between the y_m and y_p

x_1 , x_2 , …x_k in this analysis correspond to the daily sum of the number of occurrences of 1-hour averaged wind conditions in specific wind speed/direction bins as outlined in Tables 3, 4, and 5. In order to minimize the number of independent variables used in the MLRA, wind conditions corresponding to hourly average speeds less than 14 mph (corresponding to G_1, G_5, G_9, and G_{13} in Table 5) were not included in the analysis. Omission of these low wind speeds was justified on the basis that windblown dust emissions require moderate to high wind speeds. This omission reduces the number of dependent variables from 16 to 12 and greatly reduces the noise in the regressions. The coefficients b_1, b_2,….b_k and a were obtained using the Least-Squares method for the best fit to the data. For each site, the MLRA was run twice, once using the wind direction bins corresponding to column A in Table 4 and once using the bins corresponding to column B.

In order to ascertain the importance of individual independent variables to the overall regression results, variable screening methods (VSM), including stepwise (both forward and backward) procedures, were employed to objectively determine which variables were significant using 0.15 significance level *t*-value criteria. Therefore, the local windblown dust for day *j*, LWD_j, was calculated as follows

$$LWD_j = b_1 G_{1,j} + b_2 G_{2,j} + ... + b_k G_{k,j} \qquad \text{Eq. 4-2}$$

where b_1, b_2, ….b_k are equal to the regression coefficients of $G_{1,j}$, $G_{2,j}$, ,,,,,, $G_{k,j}$ when the variable is significant for a specific site and zero when the variable is not significant. The error associated with the estimated LWD_j was provided by:

$$E_j = e_1 G_{1,j} + e_2 G_{2,j} + ... + e_k G_{k,j} \qquad \text{Eq. 4-3}$$

where e_1, e_2, ….e_k are the standard errors of the regression coefficients when the variable is significant for a specific site and zero when the variable is not significant. Note that the intercept α was not included in Eq. 3-2 since it represents a "background" dust concentration and not windblown dust derived from the vicinity of the site.

LWD was calculated for all site-days when meteorological data were available. However, LWD values associated with high levels of uncertainty (i.e. $LWD_j - 2 \cdot E_j \leq 0$) were replaced with zero, signifying low confidence in any dust mass concentrations on day *j* estimated from wind conditions. This resulted in meaningful MLRA results for 42 of the 71 sites considered in the analysis. Polar diagrams of standardized regression coefficients and scatter plots of estimated LWD vs. total measured dust for all IMPROVE sample days (including non-worst dust days) for those 42 sites are presented in Figures 1 through 42 (See below for an explanation of polar and scatter plots). Note that the choice of wind direction bins (A vs. B in Table 3) affects the quality of the regression results – though for most of the sites, the difference between choosing A or B is quite small. Whichever choice provided the better fit was used to calculate final values of LWD for a given site and the polar and scatter plots in Figures 1 – 42 represent that choice.

4.1 Description of polar and scatter plots

Although the "absolute" regression coefficients (b_1, b_2, ….b_k in Eq 3-2) were used to estimate the LWD for each site day (where data are available and the regression yields meaningful results), they provide no information on the relative importance of each variable in terms of the contribution to the estimated LWD value. That is, for example, though a specific set of wind conditions may be statistically well-correlated with measured dust concentrations, the occurrence of those conditions may be so infrequent that on the whole, those conditions represent only a negligible contribution to LWD. To better represent the importance of specific wind conditions to the estimated LWD, the independent (G_1, G_2, …G_k) were transformed to a z-score,, with mean of zero and standard deviation of 1. A separate MLRA was completed using these normalized variables and resulting in a set of standardized regression coefficients (β_1, β_2,......, β_n). Whereas the absolute regression coefficients are more useful for estimating the value of LWD for a given site-day, the standardized coefficients provide more insight into the relative importance of specific wind conditions with respect to LWD for all days in the regression. For this reason, this latter set of coefficients was used to construct the polar plots in Figures 1 – 42. Table 6 shows the values of the absolute regression coefficients for each of the 42 sites.

Figures 1 – 42 also show scatter plots of LWD values (screened using the $LWD_j - 2 \cdot E_j \leq 0$ criteria) vs the total measured dust for each IMPROVE site when both IMPROVE aerosol and surface meteorological data were available. IMPROVE data were the measured dust was in the lowest 5th percentile for the year are not included in the figures. Worst dust days are indicated by red triangles. The dashed line in the figures represents where points with a 1:1 correspondence would be located. Moderate-to-high contributions of LWD are represented by data-points located above (upper-left) and near the 1:1 line, while comparatively low contributions of estimated LWD to measured dust are indicated by data-points that lie close to the y-axis. Data-points that are located below the 1:1 line correspond to site days when estimates of LWD exceed the total measured dust (i.e. LWD is overestimated by the regression model.) Two specific example cases are discussed below.

Example 1, Badlands National Park, SD (BADL): The polar plot indicates that three statistically significant variables (wind conditions), namely, WD3WS2-B, WD2WS3-B and WD1WS3-B (where the direction bins in column B of Table 3 were used). According to the plot, the first variable, WD3WS2-B, was the most important contributor (β > 0.35) to the estimated LWD. The vast majority of the IMPROVE sample days at BADL are located above the 1:1 line. Considering the scatter plot for BADL, for most of non-worst dust days, LWD was accounted for most of the measured dust concentrations as illustrated by the proximity of the blue points to the 1:1 line. For worst dust days, the contribution of local windblown dust accounted for 20 - 50% of measured dust concentrations.

Example 2, Bosque del Apache, NM (BOAP): The polar plot for BOAP shows two statistically significant variables, namely, WD2WS3-A and WD3WS3-A. WD2WS3-A, appeared to be the more important contributor (β > 0.35) compared to WD3WS3-A. For both non-worst dust days and worst dust days, data-points are on or near the 1:1 line indicating that local windblown dust was the major source of dust.

5. Air masses backward trajectories

Back trajectories going back in time for 2 days were generated for all sites considered in this analysis every 3 hours using the NOAA HYSPLIT trajectory model (Draxler and Hess, 1997) and Eta Data Assimilation System (EDAS) meteorological fields as inputs. For sites in Hawaii and Alaska, hemispheric FNL meteorological fields were used as inputs instead of EDAS. Starting heights for all sites were 500 m above ground level. Back trajectories were useful for two reasons. First, they provided an approximate path for the air mass measured at the site, thereby providing information on potential dust sources that may have been encountered along the way. Second, they provided information on approximate wind speeds along the path of travel. In order to facilitate comparison with the results of the MLRA discussed above, wind speeds calculated from back trajectories were grouped into three categories: (a) Trajectory speed < 14 miles/hour; (b) 14 < Trajectory speed < 20 miles/hour and; (c) Trajectory speed > 20 miles/hour. The utility of these categories in accomplishing the overall goals of this study are discussed in a later section.

6. Land use

The National Land Cover Characterization 2001 (NLCD, 2001) database, covering all 50 states and Puerto Rico, was obtained from the USGS. The database provides a 30 m by 30 m delineation of land use using 19 categories (See Table 7). For the purposes of the present analysis, the 19 categories were further distilled into three major categories:

1. Human-influenced: Land use groups 21, 22, 23, 32, 33, 81, 82, 83, 84 and 85
2. Forests and wetlands: Land use groups 11, 12, 41, 42, 43 and 61
3. Grasslands and shrub lands: Land use groups 31, 51 and 71

Category 1 was intended to represent areas that have been influenced by human activity. This category includes residential/commercial areas, mines and quarries, and agricultural activities. Category 2 includes areas that are forested and therefore very unlikely to be significant sources of windblown dust. Category 3 includes grasslands and shrublands.

Depending on the geographic region being considered, grasslands, especially during long dry periods, could be potential sources of windblown dust. Shrublands are mostly prevalent in the desert southwest and can represent significant source areas for windblown dust.

7. Soil properties – Wind Erosion Group

Windblown dust emission is a complex process that is dependent to varying extents on wind conditions, vegetation (or other) cover, and soil properties. The USGS has mapped the soil characteristics of the United States and based on textural properties has estimated the rates of water and wind erosion that certain areas are likely to experience. For this study, the Wind Erosion Group (WEG) index provided by USGS was utilized to provide a screening level assessment of which parts of the WRAP region – or areas upwind – are potentially large contributors to measured dust concentration through the wind erosion process. The WEG number ranges from 1 to 8, with 1 representing the most erodible soil types and 8 representing the least erodible soil types. WEG data for 48 US states were downloaded from USGS Water Resources (Table 8). While WEG data can be helpful, it is important to keep in mind that the WEG index only provides an approximate categorization of soil types with respect to their erodibility under a specific set of conditions. The presence or absence of vegetative cover, a surface crust, or mitigating topography can greatly influence actual wind erosion and dust emission rates. Thus, in order to make use of the information provided by the USGS soil database, it is important to combine the WEG with information on land use.

The WEG index (spanning the range 1 – 8) was reduced to three categories. The first encompassing WEG numbers from 1-3 corresponds to soil textures that are likely to result in high dust emissions. The second category corresponds to soil textures with intermediate inherent wind erodibility (4-6). The third category corresponds to soil textures least likely to be subject to wind erodibility (6-8). Using this revised wind erodibility measure, the three categories were spatially combined with the three land use categories (human-influenced, forest and wetlands, and shrub and grasslands) to yield a total of 9 possible combinations. The resultant WEG/Landuse data base was used as the background for all GIS analyses.

8. Integration into ArcGIS – Data analysis

For this study, the tools discussed previously including MLRA, Asian dust score, back trajectories, and soil and land use databases served as input information for the primary tool used in completing this analysis, a geographic information system (GIS) rendering of all the separate components. Viewed in unison, these tools provided the means for heuristic and semi-quantitative analysis of the causes of dust-resultant haze on the worst dust days at sites within the WRAP.

For every worst dust at each of the 71 sites considered over the 2001-2003 period, a map was generated containing the following components (when data were available):

1. An indicator of the Asian dust score at that site
2. An indicator of the ratio of LWD to measured dust
3. Three back trajectories (with trajectory points coded for wind speed) corresponding to start times of 8:00 AM, 2:00 PM, and 8:00 PM (Central Standard time for all sites)

For sample days where there were multiple sites experiencing worst dust days, data for all of those sites was displayed on the same map.

Since this analysis is inherently non-quantitative, an event type was associated with every worst dust days with a specification of the level of confidence in the association. The event types were: Asian dust event, windblown dust event, transport of dust from upwind of the site, and “undetermined” event. The undetermined event signifies that insufficient information was available to determine the primary cause of the worst dust day. Windblown events were further associated with a gauge of the scale of the event.

The degree of confidence in an event specification for a given worst dust day was specified using five “+” signs. For worst dust days where the event type was identified with a high degree of confidence, five “+” signs were assigned to that event type. For days when the confidence in the event was lower, fewer “+” signs were assigned to the suspected event that caused the dust and the remainder (total of five) were assigned to the “undetermined” event category. On days where there was insufficient evidence for even a low confidence guess, all five “+” signs were placed in the “undetermined” event category. The criteria shown in Table 9 were used as guidelines for determining the best category and level of confidence for each worst dust day and not as a rigid decision tree. In some cases, experience gained through the process of reviewing the 644 worst dust days provided better direction than the actual numbers (e.g. Asian dust score) associated with the worst dust day at a given site. An effort was made to keep those “professional” judgments to a minimum. Figure 43 shows the legend of ths layers used to develop the maps. An example of a map is illustrated at Figure 44.

9. Example Case studies

9.1 April 16, 2001 (20010416)

On April 16, 2001, 29 sites were classified as worst dust days. For 22 sites, the Asian Dust Score was higher that 1500, indicating a strong Asian signature. Satellite and Naval Research Laboratory model results corroborated a large Asian dust plume engulfing a large portion of the West coast. Thus, the worst dust days for those 22 sites were surmised to be caused by an Asian dust event with a confidence level of +++++.

Though the LWD factor for Bliss State Park constituted 5.7% of the total measured dust, that site provided a very high Asian Dust Score (624741) combined with the large number of surrounding sites affected by Asian dust with high confidence. Therefore, according to the criteria in Table 9, the worst dust day at Bliss State Park was associated with the Asian Dust event with a confidence level of +++. Similar reasoning was used to assign Lava Beds (LABE), Ike’s Backbone (IKBA), Mesa Verde (MEVE), and Brooklyn Lake (BRLA) to an Asian dust event with confidence level of +++. These sites illustrate cases were professional judgment was used. Though Asian Dust Scores were less than 1500, the clear eveidence of strong Asian Dust influence over the western US combined with lack of substantial evidence that another event (e.g. windblown dust) resulted in exceptions to the guidelines shown in Table 9.

Salt Creek (SACR) showed only a moderate Asian Dust Score, but a LWD to total dust ratio >0.5. In addition, back trajectories indicate high winds near SACR over fairly erodible terrain. Thus, the worst dust day at SACR was associated with windblown dust (confidence +++++). Since it is the only site in the area with windblown dust effects, the event was not deemed to be of regional scale. At Guadalupe Mountains, (GUMO), surface meteorological data indicated that winds at the site were not of sufficient force to cause windblown dust to an appreciable degree (LWD = 0). Back trajectories indicated that high winds were possible over portions of Mexico. However, those high winds had occurred more than 24 hours prior to the worst dust day at GUMO and soil erodibility information for Mexico was not available for this study. Therefore, GUMO was completely undetermined for this worst dust day (i.e. undetermined +++++).

9.2 September 10, 2001 (20010910)

On September 10, 2001, 5 sites located in Arizona were classified as worst dust days. For all sites, the ADS was low (or not calculated), suggesting a negligible contribution of transported Asian dust. Local windblown dust was only estimated (by MLRA) in SAGU (LWD=60.7%). SAGU was associated with windblown dust with a confidence of +++++ but the event was not deemed regional. Trajectory analysis for all sites indicated moderate-to-high speed trajectories over areas with moderate-high erodibility in southeast Arizona, south New Mexico and east/southeast Texas. IKBA and SIAN were associated with upwind transport with a confidence level of +++ (more than 8 hours spent at high wind). CHIR was also associated with upwind transport but at a confidence level of + (more than 3 hours spent over erodibile land). SYCA likely also experienced upwind transport (based on confidence level +++ at IKBA and SIAN), but the absence of surface met data did not allow for exclusion of windblown dust. Therefore, SYCA was associated with upwind transport at a confidence level of +.

9.3 July 06, 2001 (20010706)

On July 06, 2001, 4 sites were classified as worst dust days. At Colombia River Gorge (CORI) the LWD to Total measured dust ratio was 40.5%. However, back trajectories did not show sustained high winds over moderately (or highly) erodible terrain. Thus, CORI was assigned to a windblown event at a confidence level of +. At Bandalier (BAND) the LWD to total measured dust ratio was ~ 6% and trajectories showed some high winds over moderately erodible terrain. BAND was associated with windblown event with a confidence of +. The information available for Nearby San Pedro (SAPE) And Gila (GICL) did not provide any indication of the event that may have caused a worst dust day there (undetermined +++++).

9.4 April 03, 2003 (20030403)

Great Sand Dunes (GRSA), Weminuche Wilderness (WEMI), and Rocky Mountain (ROMO) had worst dust days on April 03, 2003. Back trajectories for all three sites showed high winds over erodible land upwind of the sites. At GRSA, and WEMI, the LWD to total measured dust ratios were > 0.25 and > 1 respectively. At ROMO, no LWD was estimated for the wind conditions there. Based on these observations, GRSA was associated with windblown dust (confidence +++++), WEMI was associated with windblown dust (confidence +++), and ROMO was associated with transport from upwind (confidence +++). For all three sites, the event was flagged as a regional scale event since the same general flow pattern caused all three sites to have worst dust days.

10. References

Cheng, TT, Lu, DR, Wang, GC, Xu, YF. Chemical characteristics of Asian dust aerosol from Hunshan Dake sandland in Northern China. Atmospheric Environment, 2005. 2903-2911

Darmenova, K, Sokolik, IN, Darmenov, A. Characterization of east Asian dust outbreaks in the spring of 2001 using ground-based and satellite data. Journal of Geophysical Research, 2005 D02204

Draxler, R.R. and G.D. Hess, 1997, Description of the Hysplit_4 modeling system, NOAA Tech Memo ERL ARL-224, Dec, 24p

Park, SU, Chang, LS, Lee, EH. Direct radiative forcing due to aerosols in East Asia during a Hwangsa(Asian dust) event observed on 19-23 March 2002 in Korea. Atmospheric Environment, 2005, 2593-2606

Perry KD, Cahill TA, Eldred RA, Dutcher DD, Gill T, 1997, Long-range transport of North African dust to the eastern United States Journal of Geophysical Research 102 (D10): 11225-11238

VanCuren RA, Cahill TA Title: Asian aerosols in North America: Frequency and concentration of fine dust. Journal of Geophysical Research 107 (D24): Art. No. 4804 DEC 28 2002

Zhang, RJ, Arimoto, R, An, JL, Yabuki, S, Sun, JH. Ground observations of a strong dust storm in Beijing in March 2002. Journal of Geophysical Research, 2005, D18S06

Table 1: **Locations of 71 IMPROVE sites and associated meteorological sites from RAWS, ISH, CASTNET, AZDEQ and NPS networks. Sites with statistically significant (at a *p*-level < 0.15) are shaded**

Site Name	State	Site ID	Lat.	Lon.	Elev.	Meteorological site[a]	Network[b]	Lat.	Lon.	Elev.	Dist. (in km)	Elev. Diff. (in m)
Agua Tibia	CA	AGTI	33.464	116.971	507	Oak Grove	RAWS	33.393	116.795	839	18	332
Badlands Nat. Park	SD	BADL	43.744	101.941	736	24024-726516	ISH	44.050	101.600	673	43	-63
Bandelier Nat. Monument	NM	BAND	35.780	106.266	1987	Tower	RAWS	35.833	106.333	1981	8	-6
Big Bend Nat. Park	TX	BIBE	29.303	103.178	1075	Big Bend NP	CASTNET	29.302	103.177	1052	0	-23
Bliss State Park (TRPA)	CA	BLIS	38.976	120.102	2116	93230-725847	ISH	38.900	120.000	1909	12	207
Bosque del Apache	NM	BOAP	33.870	106.852	1383	Bosque	RAWS	33.800	106.883	1372	8	-11
Brooklyn Lake	WY	BRLA	41.366	106.242	3196	Centennial	CASTNET	41.364	106.240	3178	0	18
Bryce Canyon Nat. Park	UT	BRCA	37.618	112.174	2477	23159-724756	ISH	37.700	112.150	2312	9	-164
Canyonlands Nat. Park	UT	CANY	38.459	109.821	1799	Canyonlands NP	CASTNET	38.458	109.821	1814	0	15
Chiricahua Nat.Monument	AZ	CHIR	32.009	109.389	1570	Chiricahua NM	CASTNET	32.009	109.389	1570	0	0
Columbia River Gorge	WA	CORI	45.668	121.023	201	24219-726988	ISH	45.617	121.150	73	11	-128
Craters of the Moon NM	ID	CRMO	43.461	113.555	1817	CRMO-VC	NPS	43.460	113.562	1815	0	0
Death Valley Nat. Park	CA	DEVA	36.511	116.847	125	Death Valley NM	CASTNET	36.509	116.848	125	0	0
Denali National Park	AK	DENA	63.723	148.968	658	Denali NP	CASTNET	63.726	148.963	661	0	3
Dome Lands Wilderness	CA	DOME	35.728	118.138	925	Kernville	RAWS	35.755	118.417	829	21	-68
Gila Wilderness	NM	GICL	33.220	108.235	1776	Gila Center	RAWS	33.223	108.240	1707	0	-69
Glacier Nat. Park	MT	GLAC	48.510	113.997	979	Glacier NP	CASTNET	48.510	113.996	976	0	-3
Great Basin National Park	NV	GRBA	39.005	114.216	2068	Great Basin NP	CASTNET	39.005	114.216	2060	0	-8
Great Sand Dunes Nat.Park	CO	GRSA	37.725	105.519	2504	Bighorn	RAWS	37.200	106.201	2540	83	36
Guadalupe Mountains Nat.Park	TX	GUMO	31.833	104.809	1674	23055-722620	ISH	31.833	104.817	1663	0	0
Hance Camp at Grand Canyon	AZ	GRCA	35.973	111.984	2267	Tusayan	RAWS	35.990	112.120	2041	12	-226
Hawaii Volcanoes Nat.Park	HI	HAVO	19.431	155.258	1204	Hawaii Volcanoes	CASTNET	19.420	155.240	1199	2	-5
Hillside	AZ	HILL	34.429	112.963	1510	Stanton	RAWS	34.167	112.733	1097	35	-413
Hoover Wilderness	CA	HOOV	38.089	119.176	2566	Brawley Peak	RAWS	38.261	118.880	2463	32	-103
Ike's Backbone	AZ	IKBA	34.340	111.682	1303	Ike’s Backbone	AZDEQ	34.560	111.683	1280	0	0
Joshua Tree	CA	JOSH	34.069	116.389	1228	Joshua Tree NM	CASTNET	34.071	116.391	1244	0	16
Kalmiopsis Wilderness	OR	KALM	42.552	124.059	90	Agness	RAWS	42.330	124.220	46	27	-44
Lassen Volcanic Nat.Park	CA	LAVO	40.540	121.578	1755	Lassen Volcanic NP	CASTNET	40.540	121.576	1756	0	1

Lava Beds	CA	LABE	41.712	121.507	1469	Indian Well	RAWS	41.742	121.538	1454	4	-15
Lostwood Wilderness	ND	LOST	48.642	102.402	692	94011-727675	ISH	48.417	101.350	497	81	-195
Medicine Lake Wilderness	MT	MELA	48.487	104.476	605	Crosby	RAWS	48.968	104.200	650	56	45
Mesa Verde Nat. Park	CO	MEVE	37.198	108.491	2177	Mesa Verde NP	CASTNET	37.198	108.490	2165	0	-12
Monture	MT	MONT	47.122	113.154	1293	GRER	RAWS	47.183	113.447	1291	23	-2
Mount Baldy Wilderness	AZ	BALD	34.058	109.441	2513	GRER-AZDEQ	RAWS	34.070	109.433	2513	2	0
Mount Hood Wildernes	OR	MOHO	45.289	121.784	1341	Red Box	RAWS	45.280	121.921	991	10	-35
Mount Rainier Nat.Park	WA	MORA	46.758	122.123	427	Mount Rainier NP	CASTNET	46.758	122.122	421	0	-6
North Absaroka Wilderness	WY	NOAB	44.745	109.382	2480	Rattle Snake Mtn	RAWS	44.574	109.261	2568	21	88
Pasayten Wilderness	WA	PASA	48.388	119.928	1634	Washington Pass	RAWS	48.525	120.647	1720	55	86
Phoenix	AZ	PHOE	33.504	112.096	338	Phoenix	AZDEQ	33.504	112.096	33	0	0
Pinnacles Nat. Monument	CA	PINN	36.485	121.156	317	Pinnacles NM	CASTNET	36.485	121.156	335	0	18
Point Reyes Nat. Seashore	CA	PORE	38.120	122.912	85	Barnaby	RAWS	38.280	122.702	247	25	162
Puget Sound	WA	PUSO	47.570	122.312	80	24234-727935	ISH	47.533	122.300	6	4	-74
Queen Valley	AZ	QUVA	33.294	111.286	658	23104-722786	ISH	33.300	111.667	412	35	-246
Rocky Mountain Nat.Park	CO	ROMO	40.278	105.546	2755	Rocky Mtn NP	CASTNET	40.278	105.546	2804	0	49
Saguaro Nat. Park East	AZ	SAGU	32.174	110.737	933	SAGU	NPS	32.174	110.736		0	0
Saguaro Nat. Park West	AZ	SAWE	32.249	111.218	718	TUMO	AZDEQ	32.250	111.220	718	0	0
Salt Creek Wilderness	NM	SACR	33.460	104.404	1077	Eight Mile Draw	RAWS	33.651	104.322	1127	22	50
San Gabriel Wilderness	CA	SAGA	34.297	118.028	1791	93136-722890	ISH	34.233	118.067	1741	7	-50
San Gorgonio Wilderness	CA	SAGO	34.192	116.901	1705	Converse	RAWS	34.194	116.913	1712	1	7
San Pedro Parks Wilderness	NM	SAPE	36.017	106.845	2919	Quemazon Canyon	RAWS	35.926	106.384	2978	42	59
Sawtooth National Forest	ID	SAWT	44.171	114.928	1980	04112-726824	ISH	44.167	114.933	1980	0	0
Sequoia National Park	CA	SEQU	36.489	118.829	535	SEKI-AS	NPS	36.489	118.826	535	0	0
Sierra Ancha	AZ	SIAN	34.091	110.942	1595	Sierra Ancha	AZDEQ	34.150	110.930	1559	7	-36
Simeonof Wilderness	AK	SIME	55.326	160.506	57	99999-703165	ISH	55.317	160.517	7	1	-50
Snoqualamie Pass,	WA	SNPA	47.420	121.428	1160	24237-727815	ISH	47.283	121.333	1206	16	464
Spokane Res.	WA	SPOK	47.904	117.861	548	99999-727854	ISH	47.967	117.417	672	33	124
Starkey	OR	STAR	45.225	118.513	1258	J. Ridge	RAWS	45.114	118.404	1579	14	321
Sycamore Canyon	AZ	SYCA	35.141	111.969	2039	Sycamore Canyon	AZDEQ	35.130	111.970	2126	0	0
Theodore Roosevelt Nat. Park	ND	THRO	46.895	103.378	853	Theodore Roosevelt	CASTNET	46.895	103.378	850	0	-3
Three Sisters Wilderness	OR	THIS	44.291	122.043	885	Pebble	RAWS	44.233	121.983	1085	8	200
Tonto Nat.Monument	AZ	TONT	33.649	111.109	786	Roosevelt	RAWS	33.655	111.133	664	2	-122
Trapper Creek	AK	TRCR	62.315	150.316	155	26528-702510	ISH	62.317	150.100	105.2	11	-498

Trinity	CA	TRIN	40.786	122.805	1007	Lowden	RAWS	40.689	122.831	951	11	-56
UL Bend Wilderness	MT	ULBE	47.582	108.720	893	Armellscr	RAWS	47.587	108.869	867	11	-26
Weminuche Wilderness	CO	WEMI	37.659	107.800	2765	99999-724627	ISH	37.950	107.900	2769	33	-4
White Mountain Wilderness	NM	WHIT	33.470	105.523	2050	99999-722683	ISH	33.467	105.533	2076	1	26
White River Nat.Forest	CO	WHRI	39.152	106.820	3418	Taylor Park	RAWS	38.908	106.602	3256	32	-162
Wind Cave	SD	WICA	43.558	103.484	1300	Custer	RAWS	43.750	103.633	1585	24	285
Yellowstone Nat. Park 2	WY	YELL	44.565	110.400	2425	Yellowstone NP	CASTNET	44.560	110.401	2400	0	-25
Yosemite Nat. Park	CA	YOSE	37.713	119.704	1615	Yosemite NP	CASTNET	37.713	119.706	1605	0	-10
Zion Nat. Park	UT	ZION	37.459	113.224	1545	93129-724755	ISH	37.700	113.100	1702	28	158

[a] Meteorological site names are specific to the network. See footnote (b)

[b] Networks: (1) AZDEQ: operated by the Arizona Department of Environmental Quality. Site name is a four letter mnemonic; (2) CASTNET: operated by the U.S. E.P.A.. Sites are normally collocated with IMPROVE sites; (3) ISH: Integrated surface hourly data from Airports. ISH data are archived at the National Climate data center and site name corresponds to WBAN number –USAF number (4) NPS: operated by the National Park Service and normally collocated with IMPROVE sites; (5) RAWS) Remote Automated Weather Stations are operated primarily by U.S. Forest Service. Data are obtained from National Climate data center.

Table 2: Typical values of elemental diagnostic ratios of atmospheric aerosol for long-range transport of Asian dust and years 2001 and 2002

Period		Elemental ratios					
		Al/Ca	Al/Si	Ca/Si	Fe/Si	K/Fe	CM/Soil
Year 2001		1.4	0.31	0.22	0.27	0.67	7.10
Year 2002		1.7	0.43	0.25	0.25	0.72	16.02
April 29, 1998	Mean	2.1	0.52	0.25	0.29	0.59	2.11
	St. dev.	0.3	0.06	0.03	0.04	0.07	0.94

<u>Table 3:</u> Wind direction bins (A and B)

	A	B
WD1	0^{o} - 90^{o}	$< 45^{o}$ or $> 315^{o}$
WD2	90^{o} - 180^{o}	45^{o} - 135^{o}
WD3	180^{o} - 270^{o}	135^{o} - 225^{o}
WD4	270^{o} - 359^{o}	225^{o} - 315^{o}

<u>Table 4:</u> Wind speed bins

WS1	< 14 mph
WS2	14 – 20 mph
WS3	20 – 26 mph
WS4	> 26 mph

<u>Table 5:</u> Combination of categorical wind direction and wind speed groups (same for A or B)

	WS1	WS2	WS3	WS4
WD1	G1	G2	G3	G4
WD2	G5	G6	G7	G8
WD3	G9	G10	G11	G12
WD4	G13	G14	G15	G16

Table 6: Regression coefficients (± st.error) of multilinear regression of measured dust concentrations vs. wind speed by quadrant.

Site Name	WD1			WD2			WD3			WD4		
	WS2	WS3	WS4	WS2	WS3	WS4	WS2	WS3	WS4	WS2	WS3	WS4
Badlands Nat. Park		0.438 ± 0.438			2.272 ± 0.694		1.590 ± 0.177					
Bandelier Nat. Monument				10.395 ± 2.197			6.919 ± 2.641		6.919 ± 2.641	0.959 ± 0.241		14.576 ± 3.453
Big Bend Nat. Park	9.854 ± 1.840							11.368 ± 3.597		1.565 ± 0.396		
Bliss State Park (TRPA)							0.231 ± 0.091		0.824 ± 0.500	5.172 ± 1.716		
Bosque del Apache					39.278 ± 8.138			7.924 ± 1.060				
Bryce Canyon Nat. Park							0.480 ± 0.146		4.359 ± 0.331			
Canyonlands Nat. Park	1.266 ± 0.648						2.836 ± 0.395	1.992 ± 0.922		1.718 ± 0.584		
Chiricahua Nat.Monument				3.318 ± 0.779			0.863 ± 0.554	8.596 ± 2.328				
Columbia River Gorge	3.934 ± 0.415			1.352 ± 0.554							0.523 ± 0.306	1.647 ± 1.003
Craters of the Moon NM				6.573 ± 1.213			0.159 ± 0.077	0.335 ± 0.126				
Death Valley Nat. Park			3.169 ± 1.052			3.673 ± 1.590	1.005 ± 0.195		0.762 ± 0.355	9.606 ± 1.245		
Gila Wilderness	4.818 ± 3.202						1.279 ± 0.366					
Great Sand Dunes Nat.Park								5.013 ± 1.082			1.878 ± 0.503	3.591 ± 1.784
Guadalupe Mountains Nat.Park			0.779 ± 0.349						1.027 ± 0.341			0.833 ± 0.286
Hillside						7.360 ± 2.483	0.737 ± 0.223		13.158 ± 3.048			
Hoover Wilderness			4.389 ± 1.224									
Ike's Backbone							1.187 ± 0.385					
Joshua Tree				23.497 ± 2.113								
Kalmiopsis Wilderness	0.605 ± 0.262											
Lava Beds								1.246 ± 0.408				
Lostwood Wilderness								0.873 ± 0.200				
Medicine Lake Wilderness				0.537 ± 0.228				0.527 ± 0.352	1.607 ± 0.526			
Mesa Verde Nat. Park							5.197 ± 0.499			15.501 ± 1.765		
Mount Baldy Wilderness							0.410 ± 0.129		8.776 ± 4.105			
Pasayten Wilderness										1.875 ± 0.465		
Puget Sound										2.685 ± 1.099		
Queen Valley							1.458 ± 0.597	3.486 ± 1.929		1.557 ± 1.056		
Saguaro Nat. Park East		6.013 ± 3.982		1.830 ± 0.699					8.045 ± 4.804	1.391 ± 0.828		
Saguaro Nat. Park West				1.451 ± 0.589			1.789 ± 0.829	11.716 ± 3.515				
Salt Creek Wilderness			12.235 ± 2.504	1.061 ± 0.467			2.032 ± 0.676	2.621 ± 0.995	14.896 ± 1.541			
San Pedro Parks Wilderness				2.650 ± 0.314				12.262 ± 3.645				
Sawtooth National Forest							0.973 ± 0.276					
Sierra Ancha	11.002 ± 7.416			2.517 ± 1.027			1.511 ± 0.708					
Simeonof Wilderness			0.237 ± 0.121						0.383 ± 0.172		0.500 ± 0.168	
Spokane Res.				3.236 ± 1.725	19.664 ± 10.855			3.79 ± 1.052				
Theodore Roosevelt Nat. Park				0.359 ± 0.193	1.632 ± 0.591			0.529 ± 0.176				3.372 ± 1.577
Tonto Nat.Monument				8.735 ± 2.931								
UL Bend Wilderness					8.411 ± 5.349			3.502 ± 0.945		0.387 ± 0.264		
Weminuche Wilderness				0.479 ± 0.291			1.871 ± 0.238	1.814 ± 0.737				
White Mountain Wilderness				1.222 ± 0.413			0.550 ± 0.246		2.910 ± 0.333			
White River Nat.Forest							1.962 ± 0.286					
Zion Nat. Park					2.866 ± 1.700				2.962 ± 0.365		29.405 ± 5.214	

Table 7: Descriptions of National land Cover Dataset (NLCD) classification[a]

Code	Description
11. Open Water	All areas of open water, generally with less than 25% cover of vegetation/land cover.
12. Perennial Ice/Snow	All areas characterized by year-long surface cover of ice and/or snow.
21. Low Intensity Residential	Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80% of the cover. Vegetation may account for 20 to 70% of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.
22. High Intensity Residential	Includes highly developed areas where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20% of the cover. Constructed materials account for 80 to100% of the cover.
23.Commercial/Industrial /Transportation	Includes infrastructure (e.g. roads, railroads, etc.) and all highly developed areas not classified as High Intensity Residential.
31. Bare Rock/Sand/Clay	Perennially barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, beaches, and other accumulations of earthen material.
32. Quarries/Strip Mines/Gravel Pits	Areas of extractive mining activities with significant surface expression.
33. Transitional	Areas of sparse vegetative cover (less than 25% of cover) that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.).
41. Deciduous Forest	Areas dominated by trees where 75% or more of the tree species shed foliage simultaneously in response to seasonal change.
42. Evergreen Forest	Areas dominated by trees where 75% or more of the tree species `maintain their leaves all year. Canopy is never without green foliage.
43. Mixed Forest	Areas dominated by trees where neither deciduous nor evergreen species represent more than 75% of the cover present.
51. Shrubland	Areas dominated by shrubs; shrub canopy accounts for 25-100% of the cover. Shrub cover is generally greater than 25% when tree cover is less than 25%. Shrub cover may be less than 25% in cases when the cover of other life forms (e.g. herbaceous or tree) is less than 25% and shrubs cover exceeds the cover of the other life forms.
61. Orchards/Vineyards /Other	Orchards, vineyards, and other areas planted or maintained for the production of fruits, nuts, berries, or ornamentals.
71. Grasslands /Herbaceous	Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25%, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.
81. Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.
82. Row Crops	Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.

83. Small Grains	Areas used for the production of graminoid crops such as wheat, barley, oats, and rice.
84. Fallow	Areas used for the production of crops that do not exhibit visable vegetation as a result of being tilled in a management practice that incorporates prescribed alternation between cropping and tillage.
85. Urban/Recreational Grasses	Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.
91. Woody Wetlands	Areas where forest or shrubland vegetation accounts for 25-100% of the cover and the soil or substrate is periodically saturated with or covered with water.
92. Emergent Herbaceous Wetlands	Areas where perennial herbaceous vegetation accounts for 75-100% of the cover and the soil or substrate is periodically saturated with or covered with water.

[a] Land cover class definitions were obtained from http://landcover.usgs.gov/classes.asp

Table 8: Description of soil properties for Wind Erosion Group values[a]

WEG	Description
1	Very fine sand, fine sand, sand or coarse sand
2	Loamy very fine sand, loamy fine sand, loamy sand, loamy coarse sand; very fine sandy loam and silt loam with 5% or less clay and 25% or less very fine sand; and sapric soil materials except folists.
3	Very fine sandy loam, fine sandy loam, sandy loam, coarse sandy loam, and noncalcareous silt loam that has 20% to 50% very fine sand and 5 to 12% clay
4	Clay, silty clay, noncalcareous clay loam that has more than 35% clay, and noncalcareous silty clay loam that has more than 35% clay. All of these do not have sesquic, parasesquic, ferritic, ferruginous, or kaolinitic mineralogy (high iron oxide content). Calcareous loam, calcareous silt loam, calcareous silt, calcareous sandy clay, calcareous sandy clay loam, calcareous clay loam and calcareous silty clay loam.
5	Noncalcareous loam that has less than 20% clay; noncalcareous silt loam with 12 to 20% clay; noncalcareous sandy clay loam; noncalcareous sandy clay; and hemic materials.
6	Noncalcareous loam and silt loam that have more than 20%clay; noncalcareous clay loam and noncalcareous silty clay loam that has less than 35% clay; silt loam that has parasesquic, ferritic, or kaolinitic mineralogy (high iron oxide content)
7	Noncalcareous silt; noncalcareous silty clay, noncalcareous silty clay loam, and noncalcareous clay that have sesquic, parasesquic, ferritic, ferruginous, or kaolinitic mineralogy (high content of iron oxide) and are Oxisols or Ultisols; and fibric material
8	Soils not susceptible to wind erosion due to rock and pararock fragments at the surface and/or wetness; and folists

[a] Definitions of Wind Erosion Group were obtained from http://soils.usda.gov/technical/handbook/contents/part618p7.html#ex16

Table 9: The criteria used to determine the category and level of confidence for each worst dust day

Event/ Confidence Level	Educated guess (+)	Somewhat confident (+++)	Very Confident (++++)
1. Asian Dust	Case 1: Asian Dust Score Available for site {Asian Dust score > 1500 at multiple sites} OR {(Asian dust score >1500 at one site) AND (back trajectories suggest air mass originated over Pacific Ocean)} Case 2: Asian Dust Score not available for site {(Asian dust scores at multiple sites surrounding the site of interest >1500) AND (back trajectories suggest air mass originated over Pacific Ocean)}	Case 1: Asian dust score available for site {(Asian Dust Score > 1500 at multiple sites) AND (back trajectories suggest air mass originated over Pacific Ocean)} Case 2: Asian Dust Score not available for site {(Asian dust is primary event causing dust at multiple sites surrounding the site of interest with a confidence of +++++)	Case 1: Asian dust score available for site {(Asian Dust Score > 1500 at multiple sites AND (back trajectories suggest air mass originated over Pacific Ocean) AND (satellite or models indicate large scale transport of dust from Asia)}
2. Windblown Dust	Case 1: Meteorological data available and MLRA showed significant relationship between high wind conditions and dust measured {(LWD to total measured dust ratio	Case 1: Meteorological data available and MLRA showed significant relationship between high wind conditions and dust measured {(LWD to Total measured dust ratio	Case 1: Meteorological data available and MLRA showed significant relationship between high wind conditions and dust measured {(LWD to total measured dust ratio

	>0) AND (Back trajectories show high wind speed (>20 mph) at or near the site over terrain with moderate or greater wind erodibility)} Case 2: Meteorological data not available for day of interest but MLRA showed significant relationship between high wind conditions and dust measured at site of interest {(Back trajectories show high wind speed (>20 mph) at the site over terrain with moderate or greater wind erodibility) AND (Worst dust days at one or more sites near the site of interest are caused by windblown emission with confidence of “+++” or higher)}	>0.25) AND (back trajectories show high (>20 mph) wind speed at or near the site over terrain with moderate or greater wind erodibility)} Case 2: Meteorological data not available for day of interest but MLRA showed significant relationship between high wind conditions and dust measured at site of interest {(Back trajectories show high wind speed (>20 mph) at the site over terrain with moderate or greater wind erodibility) AND (Worst dust days at one or more sites near the site of interest are caused by windblown emission with confidence of “+++++” or higher)}	> 0.5) AND (back trajectories show high (>20 mph) wind speed at or near the site over terrain with moderate or greater wind erodibility)}
3. Transport from windblown dust sources upwind	Case 1: Meteorological data available AND No evidence of local windblown dust (LWD=o or not calculated) (back trajectory for site shows up to three hours of high winds (>20 mph)	Case 1: Meteorological data available AND No evidence of local windblown dust (LWD=o or not calculated) (back trajectory for site shows up to 8 hours of high winds (>20 mph)	Case 1: Meteorological data available AND No evidence of local windblown dust (LWD=o or not calculated) (back trajectory for site shows up to 15 hours of high winds (>20 mph)

	over terrain with moderate or greater wind erodibility within one day of transport of the site)} OR (back trajectories for multiple sites shows up to 3 hours of high winds (>20 mph) over terrain with moderate or greater wind erodibility within one day of transport of the site)}	over terrain with moderate or greater wind erodibility within one day of transport of the site)} OR (back trajectories for multiple sites shows up to 3 hours of high winds (>20 mph) over terrain with moderate or greater wind erodibility within one day of transport of the site)}	over terrain with moderate or greater wind erodibility within one day of transport of the site)}
	Case 2: Meteorological data not available for day of interest but MLRA showed significant relationship between high wind conditions and dust measured at site of interest {(back trajectory for site shows up to three hours of high winds (>20 mph) over terrain with moderate or greater wind erodibility within one day of transport of the site) but absence of high winds over the site itself}	Case 2: Meteorological data not available for day of interest but MLRA showed significant relationship between high wind conditions and dust measured at site of interest {(back trajectory for site shows up to eight hours of high winds (>20 mph) over terrain with moderate or greater wind erodibility within one day of transport of the site) but absence of high winds over the site itself}	Case 2: Meteorological data not available for day of interest but MLRA showed significant relationship between high wind conditions and dust measured at site of interest {(back trajectory for site shows up to 15 hours of high winds (>20 mph) over terrain with moderate or greater wind erodibility within one day of transport of the site) but absence of high winds over the site itself}
2-3a. Windblown Dust: Regional Event	{(Same as for 2 or 3.) AND {(back trajectories for multiple sites indicate a common regional flow pattern)}	{(Same as for 2 or 3.) AND {(back trajectories for multiple sites indicate a common regional flow pattern)}	{(Same as for 2 or 3.) AND {(back trajectories for multiple sites indicate a common regional flow pattern)}

Table 10: Event types that were identified as the primary dust sources for every worst dust day for the 71 IMPROVE and protocal sites over the 2001-2003 period. The number of "*" indicated the degree of confidence R1 and R2 are indicators of regional-scale effects (for details see Table 9)

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
03/14/2001	3	Spring	2001	UT	Canyonlands National Park		*****			
04/10/2001	4	Spring	2001	TX	Big Bend National Park		*****			R1
04/10/2001	4	Spring	2001	CO	Great Sand Dunes National Monument		*****			R1
04/10/2001	4	Spring	2001	NM	Salt Creek Wilderness		*****			R1
04/13/2001	4	Spring	2001	CA	Bliss State Park (TRPA)				*****	
04/13/2001	4	Spring	2001	CO	Great Sand Dunes National Monument				*****	
04/13/2001	4	Spring	2001	CO	White River National Forest				*****	
04/16/2001	4	Spring	2001	CA	Agua Tibia	*****				
04/16/2001	4	Spring	2001	NM	Bandelier National Monument	*****				
04/16/2001	4	Spring	2001	CA	Bliss State Park (TRPA)	*****				
04/16/2001	4	Spring	2001	WY	Brooklyn Lake	***			**	
04/16/2001	4	Spring	2001	UT	Bryce Canyon National Park	*****				
04/16/2001	4	Spring	2001	UT	Canyonlands National Park	*****				
04/16/2001	4	Spring	2001	ID	Craters of the Moon NM(US DOE)	*****				
04/16/2001	4	Spring	2001	CA	Death Valley National Park	*****				
04/16/2001	4	Spring	2001	CA	Dome Lands Wilderness	*****				
04/16/2001	4	Spring	2001	NV	Great Basin National Park	***			**	
04/16/2001	4	Spring	2001	CO	Great Sand Dunes National Monument	*****				
04/16/2001	4	Spring	2001	TX	Guadalupe Mountains National Park				*****	
04/16/2001	4	Spring	2001	AZ	Ike's Backbone	***			**	
04/16/2001	4	Spring	2001	CA	Joshua Tree	*****				
04/16/2001	4	Spring	2001	CA	Lassen Volcanic National Park	*****				
04/16/2001	4	Spring	2001	CA	Lava Beds	*****				
04/16/2001	4	Spring	2001	CO	Mesa Verde National Park	***			**	
04/16/2001	4	Spring	2001	OR	Mount Hood Wildernes	*****				
04/16/2001	4	Spring	2001	WA	Pasayten Wilderness	*****				
04/16/2001	4	Spring	2001	NM	Salt Creek Wilderness		*****			
04/16/2001	4	Spring	2001	NM	San Pedro Parks Wilderness	*****				
04/16/2001	4	Spring	2001	ID	Sawtooth National Forest	*****				
04/16/2001	4	Spring	2001	AZ	Sierra Ancha	*****				
04/16/2001	4	Spring	2001	CA	Trinity	*****				
04/16/2001	4	Spring	2001	CO	Weminuche Wilderness	*****				
04/16/2001	4	Spring	2001	CO	White River National Forest	*****				
04/16/2001	4	Spring	2001	WY	Yellowstone National Park 2	*****				
04/16/2001	4	Spring	2001	CA	Yosemite National Park	*****				
04/16/2001	4	Spring	2001	UT	Zion National Park	***			**	
04/19/2001	4	Spring	2001	AK	Denali National Park				*****	
04/19/2001	4	Spring	2001	NV	Great Basin National Park	*****				
04/19/2001	4	Spring	2001	CO	Great Sand Dunes National Monument	*****				
04/19/2001	4	Spring	2001	AZ	Ike's Backbone				*****	

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
04/19/2001	4	Spring	2001	CO	Mesa Verde National Park	*****				
04/19/2001	4	Spring	2001	AZ	Saguaro National Park East	*****				
04/19/2001	4	Spring	2001	NM	San Pedro Parks Wilderness		*****			
04/19/2001	4	Spring	2001	SD	Wind Cave	*****				
04/19/2001	4	Spring	2001	UT	Zion National Park	*****				
04/22/2001	4	Spring	2001	AK	Denali National Park	*****				
04/22/2001	4	Spring	2001	TX	Guadalupe Mountains National Park		*		****	R1
04/22/2001	4	Spring	2001	NM	Salt Creek Wilderness		*****			R1
04/25/2001	4	Spring	2001	AZ	Chiricahua National Monument			*	****	R1
04/25/2001	4	Spring	2001		Gila Wilderness			***	**	R1
04/25/2001	4	Spring	2001	CO	White River National Forest				*****	
05/01/2001	5	Spring	2001	NM	Bandelier National Monument		*****			R1
05/01/2001	5	Spring	2001	UT	Canyonlands National Park	*****				
05/01/2001	5	Spring	2001	CA	Death Valley National Park		***		**	
05/01/2001	5	Spring	2001	CO	Great Sand Dunes National Monument			*	****	
05/01/2001	5	Spring	2001	CO	Mesa Verde National Park	*			****	
05/01/2001	5	Spring	2001	OR	Mount Baldy Wilderness	*****				
05/01/2001	5	Spring	2001	AZ	Queen Valley	***			**	
05/01/2001	5	Spring	2001	NM	San Pedro Parks Wilderness		*****			R1
05/01/2001	5	Spring	2001	CO	Weminuche Wilderness		*****			R1
05/01/2001	5	Spring	2001	UT	Zion National Park	*****				
05/07/2001	5	Spring	2001	AZ	Hillside			***	**	R1
05/07/2001	5	Spring	2001	MT	Medicine Lake Wilderness			*	****	
05/07/2001	5	Spring	2001	AZ	Sycamore Canyon				*****	R1
05/07/2001	5	Spring	2001	MT	UL Bend Wilderness	***			**	
05/07/2001	5	Spring	2001	UT	Zion National Park	***			**	
05/10/2001	5	Spring	2001	AZ	Chiricahua National Monument	*			****	
05/10/2001	5	Spring	2001	ID	Craters of the Moon NM(US DOE)	***			**	R1
05/10/2001	5	Spring	2001	NV	Great Basin National Park	*			****	
05/10/2001	5	Spring	2001	WY	North Absaroka Wilderness	*****				R1
05/10/2001	5	Spring	2001	AZ	Sierra Ancha	*****				
05/10/2001	5	Spring	2001	WY	Yellowstone National Park 2	*****				R1
05/10/2001	5	Spring	2001	UT	Zion National Park	*****				
05/13/2001	5	Spring	2001	ID	Craters of the Moon NM(US DOE)				*****	
05/13/2001	5	Spring	2001	CO	Rocky Mountain National Park	*			****	
05/16/2001	5	Spring	2001	CA	Death Valley National Park		***		**	
05/16/2001	5	Spring	2001	MT	UL Bend Wilderness		*****			
05/19/2001	5	Spring	2001	TX	Guadalupe Mountains National Park	*			****	
05/25/2001	5	Spring	2001	AZ	Hillside				*****	
05/25/2001	5	Spring	2001	CO	Rocky Mountain National Park			***	**	

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
05/25/2001	5	Spring	2001	AZ	Sycamore Canyon				*****	
05/28/2001	5	Spring	2001	CA	Death Valley National Park		***		**	
05/28/2001	5	Spring	2001	NV	Great Basin National Park				*****	
05/31/2001	5	Spring	2001	TX	Guadalupe Mountains National Park			*	****	
05/31/2001	5	Spring	2001	AZ	Saguaro National Park East				*****	
05/31/2001	5	Spring	2001	AZ	Tonto National Monument				*****	
06/03/2001	6	Summer	2001	TX	Guadalupe Mountains National Park		***		**	
06/03/2001	6	Summer	2001	AZ	Hance Camp at Grand Canyon NP			*	****	R1
06/03/2001	6	Summer	2001	AZ	Hillside		***		**	R1
06/06/2001	6	Summer	2001	CA	Death Valley National Park			***	**	
06/06/2001	6	Summer	2001	AZ	Hillside				*****	
06/06/2001	6	Summer	2001	AZ	Ike's Backbone				*****	
06/06/2001	6	Summer	2001	AZ	Sycamore Canyon				*****	
06/06/2001	6	Summer	2001	UT	Zion National Park				*****	
06/09/2001	6	Summer	2001	AZ	Chiricahua National Monument				*****	
06/09/2001	6	Summer	2001	AZ	Sierra Ancha				*****	
06/09/2001	6	Summer	2001	AZ	Sycamore Canyon				*****	
06/12/2001	6	Summer	2001	UT	Bryce Canyon National Park		***		**	R1
06/12/2001	6	Summer	2001	AZ	Chiricahua National Monument			*	****	
06/12/2001	6	Summer	2001	CO	Mesa Verde National Park		*****			R2
06/12/2001	6	Summer	2001	CO	Weminuche Wilderness		***		**	R2
06/12/2001	6	Summer	2001	UT	Zion National Park		*****			R1
06/15/2001	6	Summer	2001	AZ	Sycamore Canyon				*****	
06/18/2001	6	Summer	2001	NV	Great Basin National Park				*****	
06/18/2001	6	Summer	2001	CA	Point Reyes National Seashore				*****	
06/18/2001	6	Summer	2001	AZ	Saguaro National Park East				*****	
06/18/2001	6	Summer	2001	AZ	Sycamore Canyon				*****	
06/21/2001	6	Summer	2001	NM	Bosque del Apache			*	****	
06/21/2001	6	Summer	2001	CA	Death Valley National Park				*****	
06/21/2001	6	Summer	2001	AZ	Ike's Backbone				*****	R1
06/21/2001	6	Summer	2001	CO	Mesa Verde National Park				*****	
06/21/2001	6	Summer	2001	NM	Salt Creek Wilderness			***	**	
06/21/2001	6	Summer	2001	AZ	Sierra Ancha				*****	R1
06/21/2001	6	Summer	2001	AZ	Sycamore Canyon			***	**	R1
06/24/2001	6	Summer	2001	ID	Craters of the Moon NM(US DOE)		***		**	R1
06/24/2001	6	Summer	2001	TX	Guadalupe Mountains National Park				*****	
06/24/2001	6	Summer	2001	ID	Sawtooth National Forest		*****			R1
06/24/2001	6	Summer	2001	AZ	Sycamore Canyon				*****	
06/24/2001	6	Summer	2001	WY	Yellowstone National Park 2		***		**	
06/27/2001	6	Summer	2001	TX	Big Bend National Park			*	****	

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
06/27/2001	6	Summer	2001	AZ	Sycamore Canyon				*****	
06/30/2001	6	Summer	2001	AZ	Sycamore Canyon				*****	
07/06/2001	7	Summer	2001	NM	Bandelier National Monument		*		****	R1
07/06/2001	7	Summer	2001	WA	Columbia River Gorge		*		****	
07/06/2001	7	Summer	2001		Gila Wilderness				*****	R1
07/06/2001	7	Summer	2001	NM	San Pedro Parks Wilderness				*****	R1
07/09/2001	7	Summer	2001	NM	Bosque del Apache			*	****	
07/09/2001	7	Summer	2001	TX	Guadalupe Mountains National Park		*		****	
07/15/2001	7	Summer	2001	TX	Guadalupe Mountains National Park			*	****	
07/18/2001	7	Summer	2001	AZ	Sycamore Canyon				*****	
07/21/2001	7	Summer	2001	AZ	Sycamore Canyon				*****	
07/24/2001	7	Summer	2001	WA	Columbia River Gorge		***		**	
07/24/2001	7	Summer	2001	MT	Monture				*****	
07/24/2001	7	Summer	2001	AZ	Tonto National Monument				*****	
07/27/2001	7	Summer	2001	MT	Monture			*	****	
08/11/2001	8	Summer	2001	CA	San Gorgonio Wilderness				*****	
08/17/2001	8	Summer	2001	CA	Agua Tibia				*****	
08/17/2001	8	Summer	2001	CA	Death Valley National Park		***		**	
08/17/2001	8	Summer	2001	CA	Joshua Tree		***		**	
08/17/2001	8	Summer	2001	CA	San Gorgonio Wilderness				*****	
08/17/2001	8	Summer	2001	UT	Zion National Park				*****	
08/23/2001	8	Summer	2001	NV	Great Basin National Park	*			****	
08/26/2001	8	Summer	2001	AZ	Chiricahua National Monument			*	****	
08/29/2001	8	Summer	2001	CA	Dome Lands Wilderness				*****	
08/29/2001	8	Summer	2001	MT	Monture				*****	
09/01/2001	9	Fall	2001	AZ	Sycamore Canyon				*****	
09/04/2001	9	Fall	2001	TX	Guadalupe Mountains National Park			***	**	
09/04/2001	9	Fall	2001	MT	Medicine Lake Wilderness			***	**	
09/04/2001	9	Fall	2001	MT	Monture			*	****	
09/07/2001	9	Fall	2001	CA	Dome Lands Wilderness				*****	
09/07/2001	9	Fall	2001	NV	Great Basin National Park			***	**	R2
09/07/2001	9	Fall	2001	TX	Guadalupe Mountains National Park		*****			
09/07/2001	9	Fall	2001	AZ	Ike's Backbone			*	****	R1
09/07/2001	9	Fall	2001	AZ	Sierra Ancha			*	****	R1
09/07/2001	9	Fall	2001	OR	Starkey				*****	
09/07/2001	9	Fall	2001	AZ	Sycamore Canyon			***	**	R2
09/07/2001	9	Fall	2001	AZ	Tonto National Monument			*	****	R1
09/10/2001	9	Fall	2001	AZ	Chiricahua National Monument			***	**	R1
09/10/2001	9	Fall	2001	AZ	Ike's Backbone			***	**	R1
09/10/2001	9	Fall	2001	AZ	Saguaro National Park East		***		**	R1

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
09/10/2001	9	Fall	2001	AZ	Sierra Ancha			***	**	R1
09/10/2001	9	Fall	2001	AZ	Sycamore Canyon			***	**	R1
09/13/2001	9	Fall	2001	CA	Dome Lands Wilderness				*****	
09/25/2001	9	Fall	2001	ID	Craters of the Moon NM(US DOE)		***		**	
09/25/2001	9	Fall	2001	NV	Great Basin National Park		***		**	
09/25/2001	9	Fall	2001	WA	Pasayten Wilderness			*	****	
09/25/2001	9	Fall	2001	NM	Salt Creek Wilderness			*	****	
09/25/2001	9	Fall	2001	CA	Sequoia National Park			*	****	
09/28/2001	9	Fall	2001	SD	Badlands National Park			***	**	
09/28/2001	9	Fall	2001	CA	Dome Lands Wilderness				*****	
09/28/2001	9	Fall	2001	CO	Great Sand Dunes National Monument				*****	
09/28/2001	9	Fall	2001	AZ	Phoenix				*****	
10/01/2001	10	Fall	2001	CA	Death Valley National Park			***	**	
10/01/2001	10	Fall	2001	CA	Joshua Tree			***	**	
10/04/2001	10	Fall	2001	CA	Dome Lands Wilderness				*****	
10/04/2001	10	Fall	2001	OR	Mount Hood Wildernes			*	****	
10/07/2001	10	Fall	2001	MT	UL Bend Wilderness			***	**	
10/07/2001	10	Fall	2001	WY	Yellowstone National Park 2		***		**	
10/16/2001	10	Fall	2001	NM	Bosque del Apache			***	**	R1
10/16/2001	10	Fall	2001	AZ	Chiricahua National Monument			*****		R1
10/16/2001	10	Fall	2001	AZ	Ike's Backbone			*****		R1
10/16/2001	10	Fall	2001	AZ	Mount Baldy Wilderness			***	**	R1
10/16/2001	10	Fall	2001	AZ	Phoenix			*****		R1
10/16/2001	10	Fall	2001	AZ	Queen Valley			*****		R1
10/16/2001	10	Fall	2001	AZ	Saguaro National Park East			***	**	R1
10/16/2001	10	Fall	2001	AZ	Sierra Ancha			*****		R1
10/16/2001	10	Fall	2001	AZ	Tonto National Monument			*****		R1
10/19/2001	10	Fall	2001	AZ	Phoenix			*	****	R1
10/19/2001	10	Fall	2001	AZ	Queen Valley			*	****	R1
10/19/2001	10	Fall	2001	AZ	Saguaro National Park East				*****	
10/19/2001	10	Fall	2001	AK	Trapper Creek			*	****	
10/25/2001	10	Fall	2001	AZ	Phoenix			*	****	
10/25/2001	10	Fall	2001	AZ	Queen Valley			*	****	
10/28/2001	10	Fall	2001	AZ	Tonto National Monument			***	**	
10/31/2001	10	Fall	2001	AZ	Phoenix		***		**	
11/09/2001	11	Fall	2001	AZ	Chiricahua National Monument			*****		R1
11/09/2001	11	Fall	2001	AZ	Queen Valley			*****		R1
11/09/2001	11	Fall	2001	AZ	Saguaro National Park East			*****		R1
11/09/2001	11	Fall	2001	AZ	Saguaro National Park West (AZDEQ)			***	**	R1
11/09/2001	11	Fall	2001	AZ	Tonto National Monument			*****		R1

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
11/24/2001	11	Fall	2001	TX	Big Bend National Park			***	**	
12/21/2001	12	Winter	2001	AZ	Chiricahua National Monument		***		**	
12/21/2001	12	Winter	2001	NM	Salt Creek Wilderness		*****			
01/23/2002	1	Winter	2002	AZ	Chiricahua National Monument			*	****	
01/23/2002	1	Winter	2002	AZ	Queen Valley			***	**	
02/04/2002	2	Winter	2002	CO	Great Sand Dunes National Monument			*	****	
02/10/2002	2	Winter	2002	AZ	Chiricahua National Monument			*****		
02/22/2002	2	Winter	2002	AZ	Phoenix				*****	
02/22/2002	2	Winter	2002	MT	UL Bend Wilderness		*****			
02/25/2002	2	Winter	2002	NV	Great Basin National Park				*****	
02/25/2002	2	Winter	2002	NM	Salt Creek Wilderness			*****		
02/28/2002	2	Winter	2002	NV	Great Basin National Park			***	**	
02/28/2002	2	Winter	2002	CA	Hoover Wilderness				*****	
02/28/2002	2	Winter	2002	AZ	Saguaro National Park East				*****	R2
02/28/2002	2	Winter	2002	AZ	Saguaro National Park West (AZDEQ)				*****	R2
03/12/2002	3	Spring	2002	TX	Big Bend National Park			*	****	
03/15/2002	3	Spring	2002	AZ	Chiricahua National Monument		*		****	R1
03/15/2002	3	Spring	2002		Gila Wilderness		*		****	R1
03/15/2002	3	Spring	2002	TX	Guadalupe Mountains National Park			*	****	R1
03/15/2002	3	Spring	2002	NM	White Mountain Wilderness		***		**	R1
03/21/2002	3	Spring	2002	NM	Bosque del Apache				*****	
03/24/2002	3	Spring	2002	TX	Guadalupe Mountains National Park		***		**	R1
03/24/2002	3	Spring	2002	NM	Salt Creek Wilderness		*****		.	R1
03/27/2002	3	Spring	2002	AZ	Mount Baldy Wilderness				*****	
03/27/2002	3	Spring	2002	AK	Simeonof Wilderness	*****				
03/30/2002	3	Spring	2002	TX	Big Bend National Park		*****			
03/30/2002	3	Spring	2002	UT	Zion National Park			*****		
04/02/2002	4	Spring	2002	TX	Big Bend National Park		***		**	R1
04/02/2002	4	Spring	2002	TX	Guadalupe Mountains National Park		*		****	R1
04/02/2002	4	Spring	2002	NM	Salt Creek Wilderness		*****			R2
04/02/2002	4	Spring	2002	NM	White Mountain Wilderness		*		****	R2
04/17/2002	4	Spring	2002	UT	Bryce Canyon National Park		*****			R1
04/17/2002	4	Spring	2002	UT	Canyonlands National Park		*****			R1
04/17/2002	4	Spring	2002	CO	Great Sand Dunes National Monument			***	**	R1
04/17/2002	4	Spring	2002	CO	Mesa Verde National Park			***	**	R1
04/17/2002	4	Spring	2002	CO	Weminuche Wilderness		*****			R1
04/17/2002	4	Spring	2002	CO	White River National Forest		*****			R1
04/17/2002	4	Spring	2002	UT	Zion National Park			*****		R1
04/20/2002	4	Spring	2002	NM	Bandelier National Monument		*****			R1
04/20/2002	4	Spring	2002	CO	Great Sand Dunes National Monument		***		**	R1

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
04/20/2002	4	Spring	2002	NM	Salt Creek Wilderness		*****			R1
04/23/2002	4	Spring	2002	WY	North Absaroka Wilderness	***			**	R1
04/23/2002	4	Spring	2002	ND	Theodore Roosevelt				*****	
04/23/2002	4	Spring	2002	WY	Yellowstone National Park 2	***			**	R1
04/26/2002	4	Spring	2002	NM	Bandelier National Monument		***		**	R1
04/26/2002	4	Spring	2002	NM	Bosque del Apache		*****			R1
04/26/2002	4	Spring	2002	AZ	Chiricahua National Monument		*****			R1
04/26/2002	4	Spring	2002		Gila Wilderness		***		**	R1
04/26/2002	4	Spring	2002	CO	Mesa Verde National Park			***	**	R1
04/26/2002	4	Spring	2002	AZ	Queen Valley		***		**	R1
04/26/2002	4	Spring	2002	AZ	Saguaro National Park West (AZDEQ)		*****			R1
04/26/2002	4	Spring	2002	NM	San Pedro Parks Wilderness			***	**	R1
04/26/2002	4	Spring	2002	CO	Weminuche Wilderness			*	****	R1
04/26/2002	4	Spring	2002	NM	White Mountain Wilderness		*		****	R1
05/02/2002	5	Spring	2002	TX	Guadalupe Mountains National Park		*		****	
05/05/2002	5	Spring	2002	NM	Salt Creek Wilderness		*****			
05/05/2002	5	Spring	2002	CO	White River National Forest		*		****	
05/05/2002	5	Spring	2002	WY	Yellowstone National Park 2		*		****	
05/08/2002	5	Spring	2002	NM	Bandelier National Monument		*		****	R1
05/08/2002	5	Spring	2002	UT	Bryce Canyon National Park		*		****	R1
05/08/2002	5	Spring	2002	UT	Canyonlands National Park		*****			R1
05/08/2002	5	Spring	2002	CA	Death Valley National Park		***		**	
05/08/2002	5	Spring	2002	CO	Great Sand Dunes National Monument		***		**	R3
05/08/2002	5	Spring	2002	AZ	Hance Camp at Grand Canyon NP			*	****	
05/08/2002	5	Spring	2002	AZ	Hillside				*****	R3
05/08/2002	5	Spring	2002	CA	Hoover Wilderness				*****	
05/08/2002	5	Spring	2002	CA	Joshua Tree				*****	
05/08/2002	5	Spring	2002	CO	Mesa Verde National Park			*	****	R2
05/08/2002	5	Spring	2002	NM	San Pedro Parks Wilderness			***	**	R1
05/08/2002	5	Spring	2002	CO	Weminuche Wilderness		*		****	R2
05/11/2002	5	Spring	2002	CA	Death Valley National Park		*****			
05/11/2002	5	Spring	2002	CO	Great Sand Dunes National Monument		*****			R1
05/11/2002	5	Spring	2002	TX	Guadalupe Mountains National Park		*****			R2
05/11/2002	5	Spring	2002	AZ	Hance Camp at Grand Canyon NP		*		****	R3
05/11/2002	5	Spring	2002	AZ	Hillside		*		****	R3
05/11/2002	5	Spring	2002	AZ	Ike's Backbone		*		****	R3
05/11/2002	5	Spring	2002	CO	Mesa Verde National Park			***	**	R1
05/11/2002	5	Spring	2002	NM	Salt Creek Wilderness		*****			R2
05/11/2002	5	Spring	2002	AZ	Tonto National Monument			***	**	R3
05/11/2002	5	Spring	2002	CO	Weminuche Wilderness		*****			R1

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
05/11/2002	5	Spring	2002	CO	White River National Forest		*		****	R1
05/14/2002	5	Spring	2002	NM	Bandelier National Monument			*****		R1
05/14/2002	5	Spring	2002	NM	Bosque del Apache			***	**	R1
05/14/2002	5	Spring	2002	AZ	Chiricahua National Monument			*****		R1
05/14/2002	5	Spring	2002		Gila Wilderness			*****		R1
05/14/2002	5	Spring	2002	CO	Great Sand Dunes National Monument			***	**	R1
05/14/2002	5	Spring	2002	AZ	Ike's Backbone			*****		R1
05/14/2002	5	Spring	2002	AZ	Mount Baldy Wilderness			*****		R1
05/14/2002	5	Spring	2002	AZ	Queen Valley			*****		R1
05/14/2002	5	Spring	2002	AZ	Saguaro National Park East			***	**	R1
05/14/2002	5	Spring	2002	AZ	Saguaro National Park West (AZDEQ)			***	**	R1
05/14/2002	5	Spring	2002	NM	San Pedro Parks Wilderness			***	**	R1
05/14/2002	5	Spring	2002	AZ	Sierra Ancha			*****		R1
05/14/2002	5	Spring	2002	AZ	Tonto National Monument		***		**	R1
05/14/2002	5	Spring	2002	CO	Weminuche Wilderness		***		**	R1
05/17/2002	5	Spring	2002	NM	Bosque del Apache			***	**	R1
05/17/2002	5	Spring	2002	CA	Death Valley National Park		*		****	
05/17/2002	5	Spring	2002	CA	Dome Lands Wilderness			*	****	
05/17/2002	5	Spring	2002	CO	Great Sand Dunes National Monument			*	****	
05/17/2002	5	Spring	2002	TX	Guadalupe Mountains National Park			***	**	R1
05/17/2002	5	Spring	2002	AZ	Sycamore Canyon				*****	
05/20/2002	5	Spring	2002	UT	Canyonlands National Park		*****			R1
05/20/2002	5	Spring	2002	CA	Death Valley National Park		***		**	R1
05/20/2002	5	Spring	2002	MT	Glacier National Park			*	****	
05/20/2002	5	Spring	2002	NV	Great Basin National Park		***		**	R1
05/20/2002	5	Spring	2002	ND	Theodore Roosevelt			***	**	
05/20/2002	5	Spring	2002	UT	Zion National Park		*****			R1
05/23/2002	5	Spring	2002	CO	Great Sand Dunes National Monument		*****			
05/23/2002	5	Spring	2002	NM	Salt Creek Wilderness		*		****	
05/26/2002	5	Spring	2002	TX	Guadalupe Mountains National Park				*****	
05/26/2002	5	Spring	2002	NM	White Mountain Wilderness		*		****	
05/29/2002	5	Spring	2002	CO	Great Sand Dunes National Monument		*		****	
06/01/2002	6	Summer	2002	UT	Canyonlands National Park		*		****	R2
06/01/2002	6	Summer	2002	CO	Great Sand Dunes National Monument		*		****	R1
06/01/2002	6	Summer	2002	AZ	Ike's Backbone				*****	R2
06/01/2002	6	Summer	2002	MT	Medicine Lake Wilderness		*		****	
06/01/2002	6	Summer	2002	CO	Mesa Verde National Park		***		**	R1
06/01/2002	6	Summer	2002	CO	Weminuche Wilderness		***		**	R1
06/01/2002	6	Summer	2002	CO	White River National Forest				*****	R1
06/01/2002	6	Summer	2002	UT	Zion National Park		***		**	R2

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
06/04/2002	6	Summer	2002	AZ	Hillside				*****	
06/04/2002	6	Summer	2002	NM	Salt Creek Wilderness		***		**	
06/07/2002	6	Summer	2002	NM	Bandelier National Monument		*		****	R1
06/07/2002	6	Summer	2002	NM	Bosque del Apache				*****	R2
06/07/2002	6	Summer	2002	AZ	Chiricahua National Monument				*****	R2
06/07/2002	6	Summer	2002		Gila Wilderness				*****	R2
06/07/2002	6	Summer	2002	AZ	Hance Camp at Grand Canyon NP		*		****	R3
06/07/2002	6	Summer	2002	AZ	Ike's Backbone			*	****	R3
06/07/2002	6	Summer	2002	WY	North Absaroka Wilderness			*	****	
06/07/2002	6	Summer	2002	AZ	Queen Valley			*	****	R3
06/07/2002	6	Summer	2002	AZ	Saguaro National Park East		*		****	R3
06/07/2002	6	Summer	2002	AZ	Saguaro National Park West (AZDEQ)				*****	R3
06/07/2002	6	Summer	2002	NM	San Pedro Parks Wilderness				*****	R1
06/10/2002	6	Summer	2002	WY	Brooklyn Lake			***	**	
06/10/2002	6	Summer	2002	TX	Guadalupe Mountains National Park			*	****	
06/10/2002	6	Summer	2002	AZ	Hance Camp at Grand Canyon NP				*****	
06/10/2002	6	Summer	2002	CO	Rocky Mountain National Park			*	*****	R1
06/10/2002	6	Summer	2002	CO	Weminuche Wilderness		***		**	R3
06/10/2002	6	Summer	2002	CO	White River National Forest		***		**	R3
06/13/2002	6	Summer	2002	AZ	Chiricahua National Monument			*	****	
06/13/2002	6	Summer	2002	CA	Dome Lands Wilderness				*****	
06/13/2002	6	Summer	2002	CO	Great Sand Dunes National Monument		*		****	
06/13/2002	6	Summer	2002	TX	Guadalupe Mountains National Park			*	****	R1
06/13/2002	6	Summer	2002	CA	Lassen Volcanic National Park		*		****	
06/13/2002	6	Summer	2002	AZ	Saguaro National Park East				*****	
06/13/2002	6	Summer	2002	NM	Salt Creek Wilderness		***		**	R1
06/13/2002	6	Summer	2002	AZ	Sycamore Canyon				*****	
06/16/2002	6	Summer	2002	NM	Bandelier National Monument			***	**	
06/16/2002	6	Summer	2002	TX	Big Bend National Park		*****			
06/16/2002	6	Summer	2002	NM	Bosque del Apache			***	**	
06/16/2002	6	Summer	2002	AZ	Chiricahua National Monument			*	****	
06/16/2002	6	Summer	2002	CO	Great Sand Dunes National Monument			*	****	
06/16/2002	6	Summer	2002	TX	Guadalupe Mountains National Park		*		****	
06/16/2002	6	Summer	2002	CA	Lassen Volcanic National Park				*****	
06/16/2002	6	Summer	2002	NM	White Mountain Wilderness			***	**	
06/19/2002	6	Summer	2002	WY	Brooklyn Lake			***	**	
06/19/2002	6	Summer	2002	CA	Death Valley National Park		*		****	
06/19/2002	6	Summer	2002	CO	Great Sand Dunes National Monument				*****	
06/19/2002	6	Summer	2002	TX	Guadalupe Mountains National Park			*	****	
06/19/2002	6	Summer	2002	AZ	Hillside		*		****	

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
06/19/2002	6	Summer	2002	AZ	Sycamore Canyon				*****	
06/22/2002	6	Summer	2002	NM	Bosque del Apache			***	**	R1
06/22/2002	6	Summer	2002	CA	Death Valley National Park			***	**	
06/22/2002	6	Summer	2002	CO	Great Sand Dunes National Monument			***	**	R1
06/22/2002	6	Summer	2002	TX	Guadalupe Mountains National Park		*		****	R1
06/22/2002	6	Summer	2002	AZ	Sycamore Canyon				*****	
06/25/2002	6	Summer	2002	TX	Guadalupe Mountains National Park			*	****	
06/25/2002	6	Summer	2002	AZ	Sycamore Canyon				*****	
06/28/2002	6	Summer	2002	SD	Badlands National Park		*****			
06/28/2002	6	Summer	2002	AZ	Chiricahua National Monument				*****	
06/28/2002	6	Summer	2002	CA	Death Valley National Park			*	****	
06/28/2002	6	Summer	2002	AZ	Sycamore Canyon				*****	
07/01/2002	7	Summer	2002	SD	Badlands National Park		*		****	
07/01/2002	7	Summer	2002	CA	Death Valley National Park		*		****	
07/01/2002	7	Summer	2002	AZ	Queen Valley			*	****	R1
07/01/2002	7	Summer	2002	AZ	Sycamore Canyon				*****	R1
07/01/2002	7	Summer	2002	AZ	Tonto National Monument			*	****	R1
07/04/2002	7	Summer	2002	SD	Badlands National Park			***	**	
07/04/2002	7	Summer	2002	UT	Canyonlands National Park				*****	
07/04/2002	7	Summer	2002	AZ	Chiricahua National Monument			*	****	
07/04/2002	7	Summer	2002	CA	Lassen Volcanic National Park				*****	
07/07/2002	7	Summer	2002	AZ	Chiricahua National Monument			*	****	
07/07/2002	7	Summer	2002	AZ	Sycamore Canyon				*****	
07/10/2002	7	Summer	2002	UT	Bryce Canyon National Park			*	****	
07/10/2002	7	Summer	2002	UT	Canyonlands National Park			*	****	
07/10/2002	7	Summer	2002	AZ	Saguaro National Park East			***	**	R1
07/10/2002	7	Summer	2002	AZ	Saguaro National Park West (AZDEQ)			*	****	R1
07/10/2002	7	Summer	2002	CA	Sequoia National Park	*			****	
07/10/2002	7	Summer	2002	UT	Zion National Park			*	****	
07/13/2002	7	Summer	2002	CA	Death Valley National Park		*		****	
07/13/2002	7	Summer	2002	AZ	Hance Camp at Grand Canyon NP			*	****	R1
07/13/2002	7	Summer	2002	AZ	Hillside			*	****	R1
07/13/2002	7	Summer	2002	CA	Lassen Volcanic National Park				*****	
07/13/2002	7	Summer	2002	AZ	Saguaro National Park West (AZDEQ)				*****	R1
07/13/2002	7	Summer	2002	AZ	Sycamore Canyon			*	****	R1
07/13/2002	7	Summer	2002	UT	Zion National Park			*	****	
07/22/2002	7	Summer	2002	UT	Canyonlands National Park		***		**	
07/22/2002	7	Summer	2002	AZ	Hillside		*		****	
07/22/2002	7	Summer	2002	MT	Monture		*		****	
07/25/2002	7	Summer	2002	AZ	Queen Valley			*	****	

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
07/28/2002	7	Summer	2002	AZ	Hance Camp at Grand Canyon NP				*****	
07/31/2002	7	Summer	2002	SD	Badlands National Park			***	**	
07/31/2002	7	Summer	2002	AZ	Hance Camp at Grand Canyon NP			*	****	R1
07/31/2002	7	Summer	2002	AZ	Ike's Backbone			*	****	R1
07/31/2002	7	Summer	2002	CA	Joshua Tree				*****	
07/31/2002	7	Summer	2002	MT	Monture			*	****	
07/31/2002	7	Summer	2002	AZ	Sierra Ancha			*	****	R1
07/31/2002	7	Summer	2002	AZ	Sycamore Canyon			*	****	R1
07/31/2002	7	Summer	2002	AZ	Tonto National Monument			*	****	R1
07/31/2002	7	Summer	2002	UT	Zion National Park			*	****	R1
08/06/2002	8	Summer	2002	CA	Bliss State Park (TRPA)		*		****	
08/09/2002	8	Summer	2002	NV	Great Basin National Park				*****	
08/09/2002	8	Summer	2002	CO	Mesa Verde National Park				*****	
08/12/2002	8	Summer	2002	AZ	Ike's Backbone				*****	
08/12/2002	8	Summer	2002	CO	Mesa Verde National Park			*	****	
08/12/2002	8	Summer	2002	OR	Mount Hood Wildernes			*	****	
08/15/2002	8	Summer	2002	CO	Great Sand Dunes National Monument			*	****	R2
08/15/2002	8	Summer	2002	AZ	Hillside		*****			R1
08/15/2002	8	Summer	2002	CO	Mesa Verde National Park			*	****	R2
08/15/2002	8	Summer	2002	CO	Rocky Mountain National Park			*	****	R2
08/15/2002	8	Summer	2002	AZ	Saguaro National Park West (AZDEQ)				*****	R1
08/15/2002	8	Summer	2002	NM	Salt Creek Wilderness			***	**	
08/18/2002	8	Summer	2002	CO	Mesa Verde National Park				*****	
08/18/2002	8	Summer	2002	MT	Monture				*****	
08/21/2002	8	Summer	2002	UT	Bryce Canyon National Park		*		****	R1
08/21/2002	8	Summer	2002	UT	Canyonlands National Park			*****		R1
08/21/2002	8	Summer	2002	UT	Zion National Park			***	**	R1
08/27/2002	8	Summer	2002	CA	Death Valley National Park			*****		
08/27/2002	8	Summer	2002	CO	Great Sand Dunes National Monument		*		****	
08/27/2002	8	Summer	2002	AZ	Saguaro National Park West (AZDEQ)				*****	
08/30/2002	8	Summer	2002	CA	Death Valley National Park		*		****	
09/02/2002	9	Fall	2002	AZ	Hillside				*****	
09/05/2002	9	Fall	2002	WY	North Absaroka Wilderness		*		****	
09/05/2002	9	Fall	2002	AZ	Queen Valley			*	****	
09/17/2002	9	Fall	2002	CA	Dome Lands Wilderness				*****	
09/17/2002	9	Fall	2002	AZ	Hillside		***		**	R1
09/17/2002	9	Fall	2002	AZ	Ike's Backbone			*	****	R1
09/17/2002	9	Fall	2002	CO	Mesa Verde National Park		*****			R1
09/17/2002	9	Fall	2002	AZ	Queen Valley		***		**	R1
09/17/2002	9	Fall	2002	AZ	Tonto National Monument			***	**	R1

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
09/17/2002	9	Fall	2002	CO	Weminuche Wilderness			*	****	R1
09/20/2002	9	Fall	2002	AZ	Sycamore Canyon			*	****	
09/23/2002	9	Fall	2002	CA	Trinity				*****	
09/26/2002	9	Fall	2002	WY	Brooklyn Lake			***	**	
09/26/2002	9	Fall	2002	CO	Mesa Verde National Park			***	**	
09/26/2002	9	Fall	2002	AZ	Saguaro National Park West (AZDEQ)				*****	
10/02/2002	10	Fall	2002	AZ	Hillside		*		****	
10/02/2002	10	Fall	2002	AZ	Ike's Backbone		*		****	R1
10/02/2002	10	Fall	2002	AZ	Saguaro National Park West (AZDEQ)		*		****	R1
10/02/2002	10	Fall	2002	CA	San Gabriel Wilderness			***	**	
10/11/2002	10	Fall	2002	ID	Craters of the Moon NM(US DOE)		*		****	
10/11/2002	10	Fall	2002	NV	Great Basin National Park			***	**	
10/14/2002	10	Fall	2002	AZ	Chiricahua National Monument		*		****	R1
10/14/2002	10	Fall	2002	AZ	Hillside		*		****	
10/14/2002	10	Fall	2002	AZ	Saguaro National Park East		*		****	R1
10/14/2002	10	Fall	2002	AZ	Saguaro National Park West (AZDEQ)		*		****	R1
10/23/2002	10	Fall	2002	AZ	Saguaro National Park West (AZDEQ)				*****	
10/29/2002	10	Fall	2002	OR	Three Sisters Wilderness			***	**	
11/04/2002	11	Fall	2002	AZ	Saguaro National Park East				*****	
11/07/2002	11	Fall	2002	OR	Starkey			*****		
11/19/2002	11	Fall	2002	AZ	Saguaro National Park East			*	****	
11/19/2002	11	Fall	2002	AZ	Saguaro National Park West (AZDEQ)			*	****	
11/22/2002	11	Fall	2002	AZ	Sycamore Canyon				*****	
11/25/2002	11	Fall	2002	CA	Agua Tibia			*****		
11/25/2002	11	Fall	2002	AZ	Phoenix				*****	
11/25/2002	11	Fall	2002	AZ	Queen Valley			*	****	
11/25/2002	11	Fall	2002	AZ	Saguaro National Park East				*****	
11/25/2002	11	Fall	2002	AZ	Saguaro National Park West (AZDEQ)				*****	
12/16/2002	12	Winter	2002	AZ	Ike's Backbone				*****	R1
12/16/2002	12	Winter	2002	CO	Mesa Verde National Park			*	****	
12/16/2002	12	Winter	2002	AZ	Saguaro National Park East				*****	R1
12/16/2002	12	Winter	2002	CA	San Gabriel Wilderness				*****	
12/16/2002	12	Winter	2002	AZ	Tonto National Monument				*****	R1
12/19/2002	12	Winter	2002	CA	San Gabriel Wilderness				*****	
01/06/2003	1	Winter	2003	AZ	Chiricahua National Monument		*****			R1
01/06/2003	1	Winter	2003	AZ	Phoenix				*****	R1
01/06/2003	1	Winter	2003	AZ	Tonto National Monument		*		****	R1
01/30/2003	1	Winter	2003	AZ	Phoenix			***	**	R1
01/30/2003	1	Winter	2003	AZ	Saguaro National Park West (AZDEQ)			***	**	R1
02/02/2003	2	Winter	2003	NM	Bandelier National Monument		*****			R1

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
02/02/2003	2	Winter	2003	NM	Bosque del Apache		***		**	R1
02/02/2003	2	Winter	2003	AZ	Chiricahua National Monument		*****			R1
02/02/2003	2	Winter	2003	CA	Death Valley National Park		*****			
02/02/2003	2	Winter	2003	CO	Great Sand Dunes National Monument		*****			R1
02/02/2003	2	Winter	2003	CO	Mesa Verde National Park		*****			R1
02/02/2003	2	Winter	2003	AZ	Mount Baldy Wilderness		*****			R1
02/02/2003	2	Winter	2003	NM	Salt Creek Wilderness		***		**	R1
02/02/2003	2	Winter	2003	NM	San Pedro Parks Wilderness		*****			R1
02/02/2003	2	Winter	2003	NM	White Mountain Wilderness		***		**	R1
03/13/2003	3	Spring	2003	OR	Starkey		*****			
03/28/2003	3	Spring	2003	AZ	Saguaro National Park West (AZDEQ)			*****		
04/03/2003	4	Spring	2003	CO	Great Sand Dunes National Monument		*****			R1
04/03/2003	4	Spring	2003	CO	Rocky Mountain National Park			*****		R1
04/03/2003	4	Spring	2003	CO	Weminuche Wilderness		***		**	R1
04/12/2003	4	Spring	2003	ID	Craters of the Moon NM(US DOE)		*****			R1
04/12/2003	4	Spring	2003	NV	Great Basin National Park		***		**	R1
04/15/2003	4	Spring	2003	SD	Badlands National Park		*		****	
04/15/2003	4	Spring	2003	NM	Bosque del Apache		*****			R1
04/15/2003	4	Spring	2003	CO	Mesa Verde National Park		***		**	R1
04/15/2003	4	Spring	2003	NM	White Mountain Wilderness		*****			R1
05/03/2003	5	Spring	2003	CO	Great Sand Dunes National Monument		***		**	R1
05/03/2003	5	Spring	2003	CO	Weminuche Wilderness		*****			R1
05/03/2003	5	Spring	2003	CO	White River National Forest		***		**	R1
05/09/2003	5	Spring	2003	NM	Bosque del Apache		*****			R1
05/09/2003	5	Spring	2003	CO	Great Sand Dunes National Monument		*****			R1
05/09/2003	5	Spring	2003	CO	Mesa Verde National Park		*****			R1
05/09/2003	5	Spring	2003	NM	San Pedro Parks Wilderness		*****			R1
05/09/2003	5	Spring	2003	AZ	Sycamore Canyon			***	**	R1
05/09/2003	5	Spring	2003	CO	Weminuche Wilderness		*****			R1
05/15/2003	5	Spring	2003	NM	Bandelier National Monument		*****			R1
05/15/2003	5	Spring	2003	NM	Bosque del Apache		*****			R1
05/15/2003	5	Spring	2003	AZ	Chiricahua National Monument		*		****	R2
05/15/2003	5	Spring	2003	AZ	Hillside			***	**	R3
05/15/2003	5	Spring	2003	CO	Mesa Verde National Park		*		****	R1
05/15/2003	5	Spring	2003	AZ	Mount Baldy Wilderness		*		****	R2
05/15/2003	5	Spring	2003	AZ	Phoenix			***	**	R2
05/15/2003	5	Spring	2003	AZ	Queen Valley			***	**	R2
05/15/2003	5	Spring	2003	AZ	Saguaro National Park East			***	**	R2
05/15/2003	5	Spring	2003	AZ	Saguaro National Park West (AZDEQ)			***	**	R2
05/15/2003	5	Spring	2003	NM	Salt Creek Wilderness		*****			

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
05/15/2003	5	Spring	2003	NM	San Pedro Parks Wilderness			*****		R1
05/15/2003	5	Spring	2003	AZ	Sierra Ancha			***	**	R2
05/15/2003	5	Spring	2003	AZ	Sycamore Canyon			***	**	R3
05/15/2003	5	Spring	2003	AZ	Tonto National Monument			***	**	R2
05/15/2003	5	Spring	2003	NM	White Mountain Wilderness		***		**	R1
05/18/2003	5	Spring	2003	CO	Great Sand Dunes National Monument		*****			
05/21/2003	5	Spring	2003	NM	Bandelier National Monument			***	**	R1
05/21/2003	5	Spring	2003	AZ	Chiricahua National Monument			***	**	R1
05/21/2003	5	Spring	2003	AZ	Hillside			***	**	R1
05/21/2003	5	Spring	2003	AZ	Ike's Backbone			***	**	R1
05/21/2003	5	Spring	2003	AZ	Queen Valley			***	**	R1
05/21/2003	5	Spring	2003	AZ	Saguaro National Park East			***	**	R1
05/21/2003	5	Spring	2003	AZ	Saguaro National Park West (AZDEQ)		*		****	R1
05/21/2003	5	Spring	2003	NM	Salt Creek Wilderness			***	**	R1
05/21/2003	5	Spring	2003	NM	San Pedro Parks Wilderness			***	**	R1
05/21/2003	5	Spring	2003	AZ	Sierra Ancha			***	**	R1
05/24/2003	5	Spring	2003	UT	Bryce Canyon National Park				*****	
05/24/2003	5	Spring	2003	UT	Canyonlands National Park			*	****	
05/24/2003	5	Spring	2003	NV	Great Basin National Park			*	****	
05/24/2003	5	Spring	2003	CO	Mesa Verde National Park			*	****	
05/24/2003	5	Spring	2003	NM	Salt Creek Wilderness		*		****	
05/24/2003	5	Spring	2003	AZ	Sycamore Canyon			*	****	
05/24/2003	5	Spring	2003	UT	Zion National Park			*	****	
05/30/2003	5	Spring	2003	ID	Craters of the Moon NM(US DOE)		***		**	
05/30/2003	5	Spring	2003	MT	Glacier National Park			*****		
05/30/2003	5	Spring	2003	AZ	Hance Camp at Grand Canyon NP			***	**	
05/30/2003	5	Spring	2003	AZ	Sierra Ancha			*	****	
06/02/2003	6	Summer	2003	NM	Salt Creek Wilderness		*		****	
06/05/2003	6	Summer	2003	CO	Mesa Verde National Park			*****		
06/05/2003	6	Summer	2003	NM	Salt Creek Wilderness		*		****	
06/14/2003	6	Summer	2003	AZ	Sycamore Canyon			*	****	
06/17/2003	6	Summer	2003	SD	Badlands National Park			***	**	
06/17/2003	6	Summer	2003	UT	Canyonlands National Park			*	****	
06/17/2003	6	Summer	2003	AZ	Chiricahua National Monument			***	**	
06/17/2003	6	Summer	2003	AZ	Ike's Backbone			*	****	R1
06/17/2003	6	Summer	2003	AZ	Queen Valley			*	****	R1
06/17/2003	6	Summer	2003	AZ	Saguaro National Park East		*		****	R1
06/17/2003	6	Summer	2003	AZ	Saguaro National Park West (AZDEQ)			*	****	R1
06/17/2003	6	Summer	2003	AZ	Sierra Ancha			***	**	R1
06/17/2003	6	Summer	2003	AZ	Tonto National Monument		*		****	R1

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
06/20/2003	6	Summer	2003	CA	Dome Lands Wilderness			*	****	
06/20/2003	6	Summer	2003	CO	Mesa Verde National Park		*		****	
07/08/2003	7	Summer	2003	MT	Glacier National Park			*****		
07/08/2003	7	Summer	2003	NV	Great Basin National Park			*****		
07/08/2003	7	Summer	2003	CO	Rocky Mountain National Park			*****		
07/08/2003	7	Summer	2003	AZ	Saguaro National Park West (AZDEQ)			***	**	
07/11/2003	7	Summer	2003	AZ	Chiricahua National Monument			***	**	
07/11/2003	7	Summer	2003	AZ	Saguaro National Park East			***	**	R1
07/11/2003	7	Summer	2003	AZ	Saguaro National Park West (AZDEQ)		***		**	R1
07/11/2003	7	Summer	2003	OR	Starkey				*****	
07/14/2003	7	Summer	2003	AZ	Ike's Backbone				*****	R1
07/14/2003	7	Summer	2003	AZ	Queen Valley				*****	R1
07/14/2003	7	Summer	2003	CO	Rocky Mountain National Park			*****		
07/14/2003	7	Summer	2003	AZ	Saguaro National Park East		*		****	R1
07/14/2003	7	Summer	2003	AZ	Saguaro National Park West (AZDEQ)			*	****	R1
07/14/2003	7	Summer	2003	AZ	Tonto National Monument			*	****	R1
07/17/2003	7	Summer	2003	AZ	Chiricahua National Monument			*****		R1
07/17/2003	7	Summer	2003	CA	Death Valley National Park		*		****	
07/17/2003	7	Summer	2003	AZ	Hillside			***	**	R2
07/17/2003	7	Summer	2003	CA	Hoover Wilderness		*		****	
07/17/2003	7	Summer	2003	AZ	Queen Valley			*****		R1
07/17/2003	7	Summer	2003	AZ	Saguaro National Park East		*		****	R1
07/17/2003	7	Summer	2003	AZ	Saguaro National Park West (AZDEQ)		*		****	R1
07/17/2003	7	Summer	2003	OR	Starkey			*	****	
07/17/2003	7	Summer	2003	AZ	Tonto National Monument			*****		R1
07/20/2003	7	Summer	2003	NM	Bosque del Apache			***	**	
07/20/2003	7	Summer	2003	CO	Great Sand Dunes National Monument				*****	
07/20/2003	7	Summer	2003	AZ	Queen Valley			*	****	R1
07/20/2003	7	Summer	2003	AZ	Saguaro National Park West (AZDEQ)			*	****	R1
07/23/2003	7	Summer	2003	SD	Badlands National Park		***		**	
07/23/2003	7	Summer	2003	CA	Hoover Wilderness		*		****	
07/23/2003	7	Summer	2003	CO	Mesa Verde National Park			*****		
07/23/2003	7	Summer	2003	OR	Starkey			***	**	
07/23/2003	7	Summer	2003	AZ	Tonto National Monument				*****	
07/26/2003	7	Summer	2003	UT	Canyonlands National Park			*	****	
07/26/2003	7	Summer	2003	AZ	Hillside			*****		R1
07/26/2003	7	Summer	2003	AZ	Tonto National Monument			*	****	R1
07/29/2003	7	Summer	2003		Gila Wilderness			***	**	
07/29/2003	7	Summer	2003	CA	Hoover Wilderness			*	****	
07/29/2003	7	Summer	2003	OR	Starkey				*****	

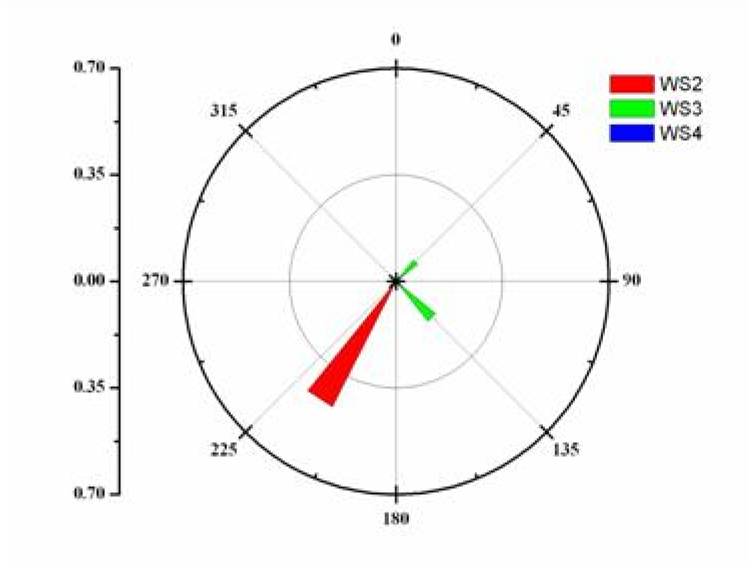
Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
08/01/2003	8	Summer	2003	OR	Starkey			***	**	
08/01/2003	8	Summer	2003	MT	UL Bend Wilderness			*****		
08/07/2003	8	Summer	2003	CO	Great Sand Dunes National Monument				*****	
08/07/2003	8	Summer	2003	CO	Mesa Verde National Park				*****	
08/10/2003	8	Summer	2003	CO	Great Sand Dunes National Monument				*****	
08/10/2003	8	Summer	2003	AZ	Sycamore Canyon				*****	
08/13/2003	8	Summer	2003	UT	Bryce Canyon National Park			*	****	
08/13/2003	8	Summer	2003	UT	Canyonlands National Park				*****	
08/13/2003	8	Summer	2003	AZ	Queen Valley				*****	
08/16/2003	8	Summer	2003	ID	Craters of the Moon NM(US DOE)		*		****	
08/16/2003	8	Summer	2003	CA	Death Valley National Park		***		****	
08/16/2003	8	Summer	2003	WA	Spokane Res.			*	****	
08/19/2003	8	Summer	2003	CA	Death Valley National Park		***		**	
08/19/2003	8	Summer	2003	CA	Joshua Tree			*	****	
08/22/2003	8	Summer	2003	CA	Hoover Wilderness				*****	
09/09/2003	9	Fall	2003	AZ	Saguaro National Park West (AZDEQ)			*****		
09/15/2003	9	Fall	2003	UT	Bryce Canyon National Park		***		**	
09/15/2003	9	Fall	2003	AZ	Chiricahua National Monument			***	**	
09/21/2003	9	Fall	2003	AZ	Hance Camp at Grand Canyon NP				*****	
09/24/2003	9	Fall	2003	AZ	Ike's Backbone			***	**	R1
09/24/2003	9	Fall	2003	AZ	Mount Baldy Wilderness			***	**	R1
09/24/2003	9	Fall	2003	AZ	Sycamore Canyon			*	****	
09/24/2003	9	Fall	2003	AZ	Tonto National Monument			***	**	R1
09/27/2003	9	Fall	2003	AZ	Sycamore Canyon			*	****	
09/30/2003	9	Fall	2003	ID	Craters of the Moon NM(US DOE)			***	**	
10/03/2003	10	Fall	2003	ID	Craters of the Moon NM(US DOE)				*****	
10/03/2003	10	Fall	2003	WA	Spokane Res.			*	****	
10/03/2003	10	Fall	2003	MT	UL Bend Wilderness			***	**	
10/12/2003	10	Fall	2003	CA	Dome Lands Wilderness				*****	
10/18/2003	10	Fall	2003	AK	Trapper Creek		*		****	
10/30/2003	10	Fall	2003	CA	Death Valley National Park		*		****	
10/30/2003	10	Fall	2003	CA	Dome Lands Wilderness		*		****	
10/30/2003	10	Fall	2003	CA	Hoover Wilderness		*****			
10/30/2003	10	Fall	2003	CO	Mesa Verde National Park		*****			
10/30/2003	10	Fall	2003	OR	Three Sisters Wilderness			***	**	
11/02/2003	11	Fall	2003	AZ	Queen Valley			*	****	
11/02/2003	11	Fall	2003	AZ	Saguaro National Park West (AZDEQ)			***	**	
12/02/2003	12	Winter	2003	AZ	Saguaro National Park East				*****	
12/05/2003	12	Winter	2003	NM	Bandelier National Monument			***	**	
12/05/2003	12	Winter	2003	AZ	Chiricahua National Monument		*		****	R1

Date	Month	Season	Year	State	Site name	Asian dust	Windblown dust	Upwind Transport Only	Undetermined	Regional Event
12/05/2003	12	Winter	2003	AZ	Queen Valley			***	**	R1
12/05/2003	12	Winter	2003	AZ	Saguaro National Park West (AZDEQ)			***	**	R1
12/05/2003	12	Winter	2003	NM	White Mountain Wilderness			***	**	
12/26/2003	12	Winter	2003	NM	White Mountain Wilderness		*****			

Figure 1

Badlands National Park, SD (BADL)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

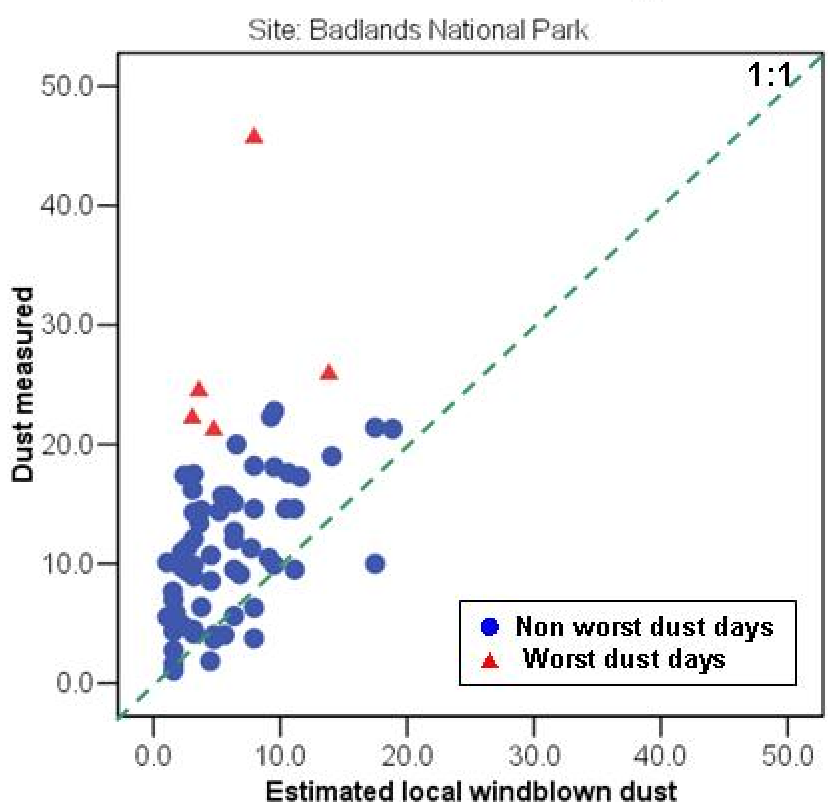
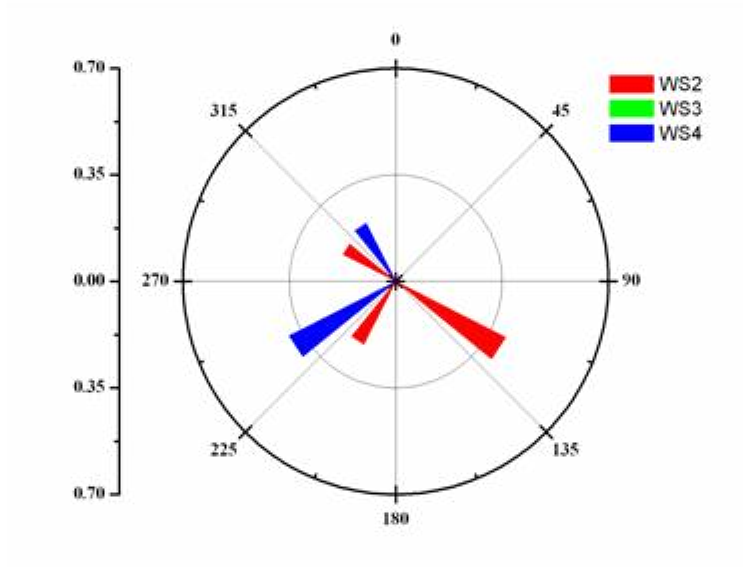


Figure 2

Bandelier National Monument, NM (BAND)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

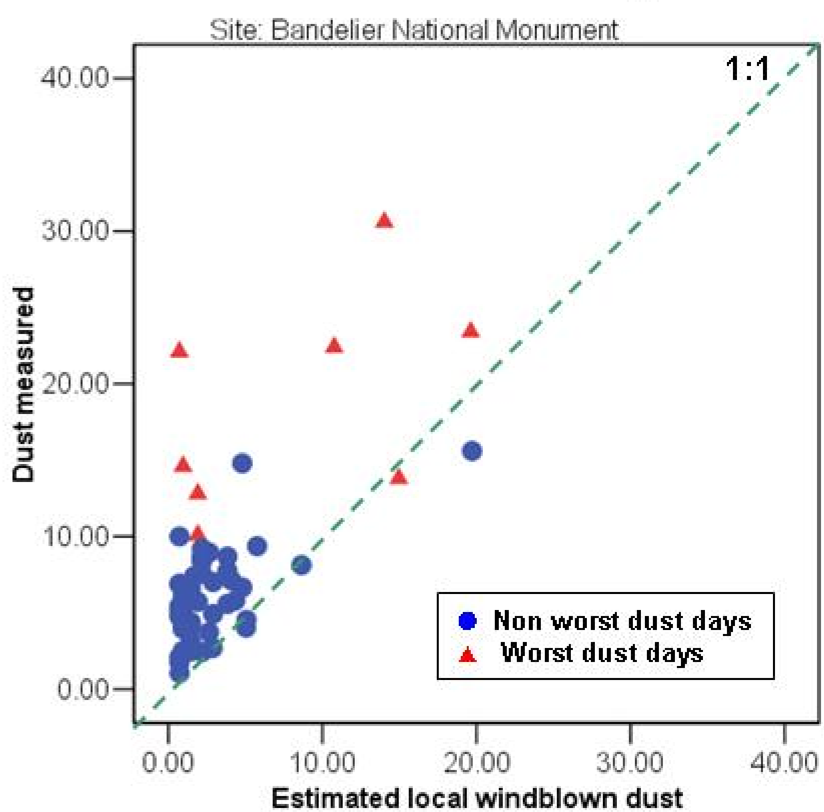
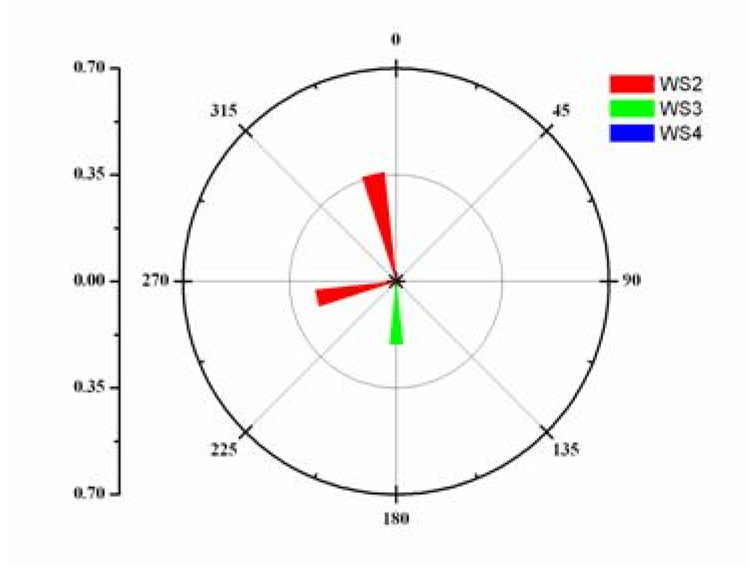


Figure 3

Big Bend National Park, TX (BIBE)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

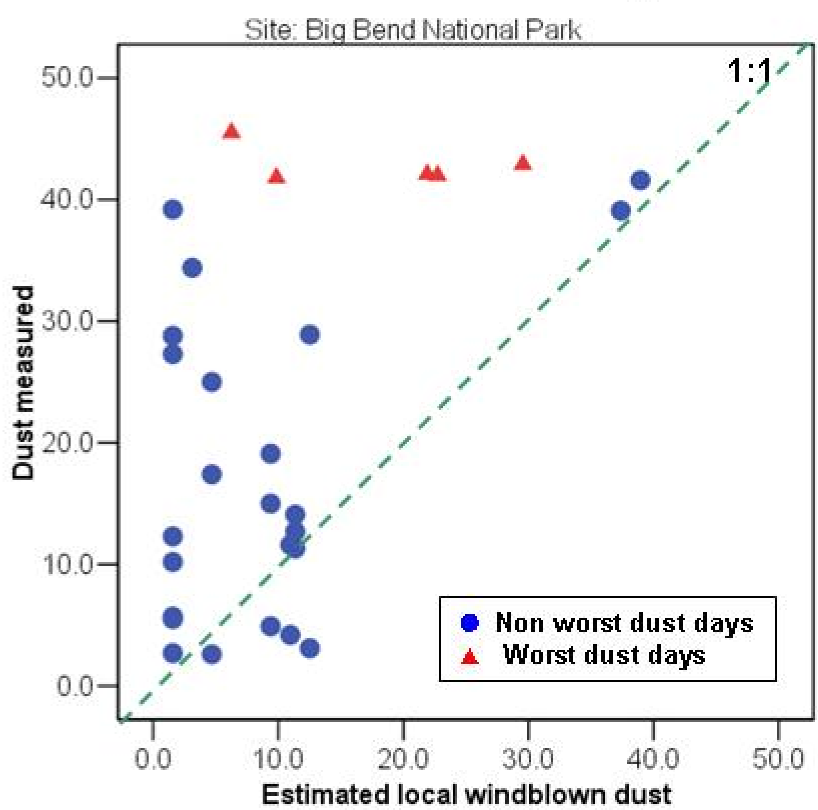
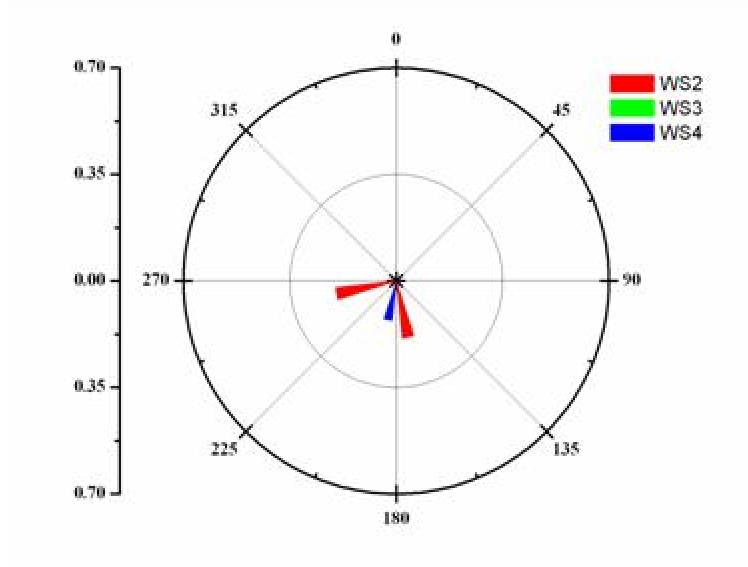


Figure 4

Bliss National Park, CA (BLIS)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

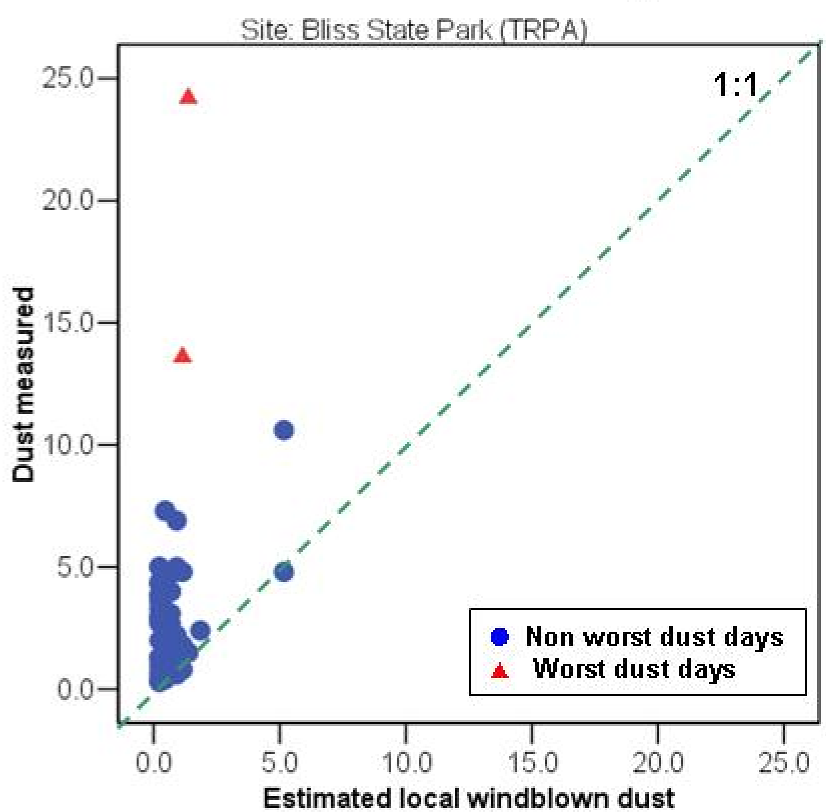
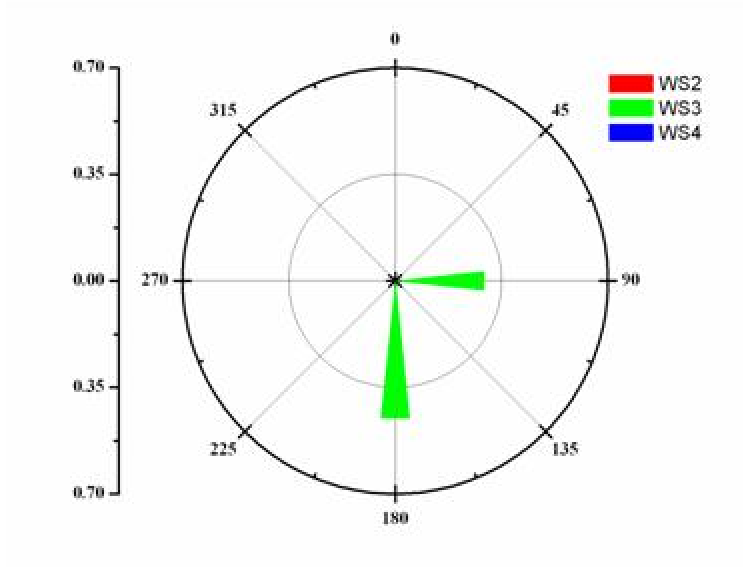


Figure 5

Bosque del Apache, NM (BOAP)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

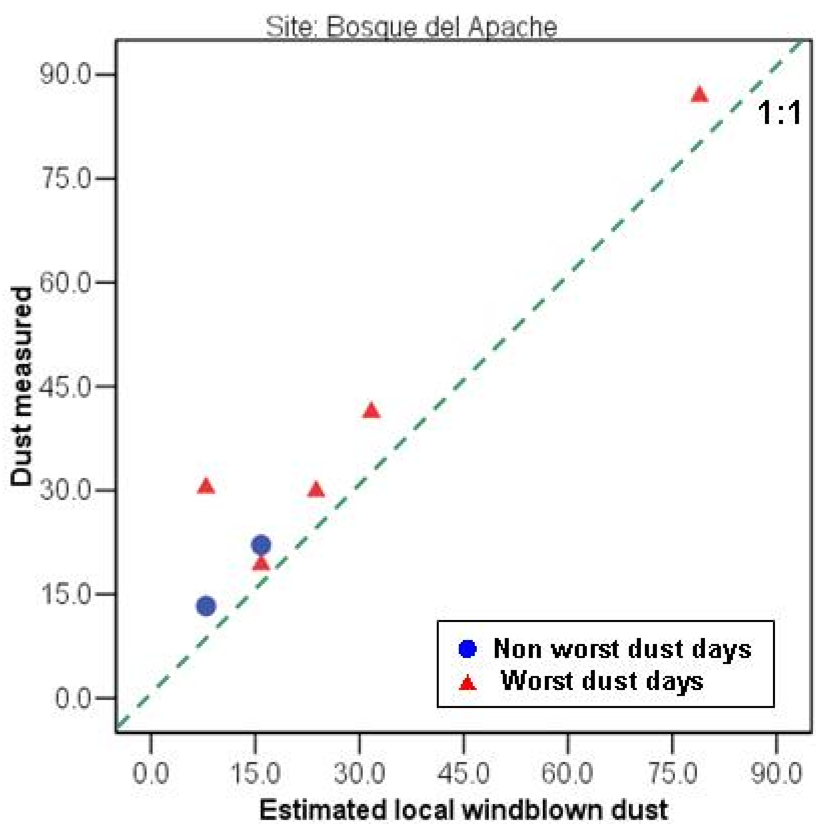
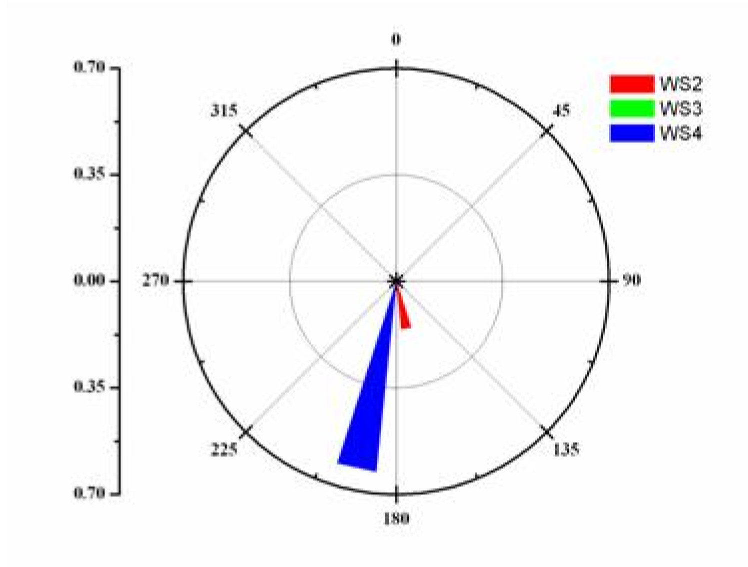


Figure 6

Bryce Canyon National Park, UT (BRCA)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

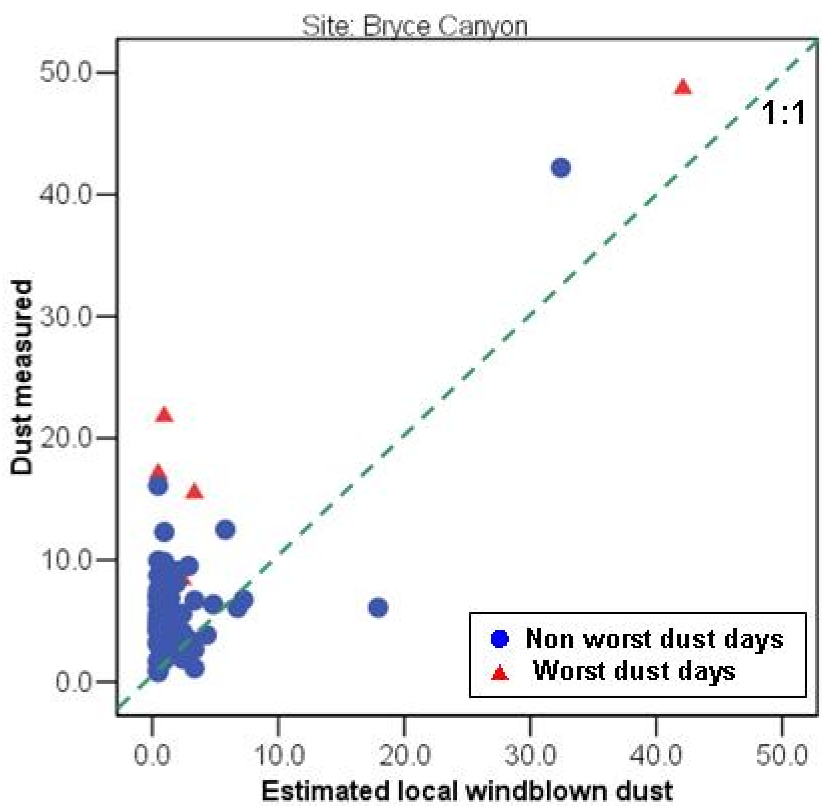
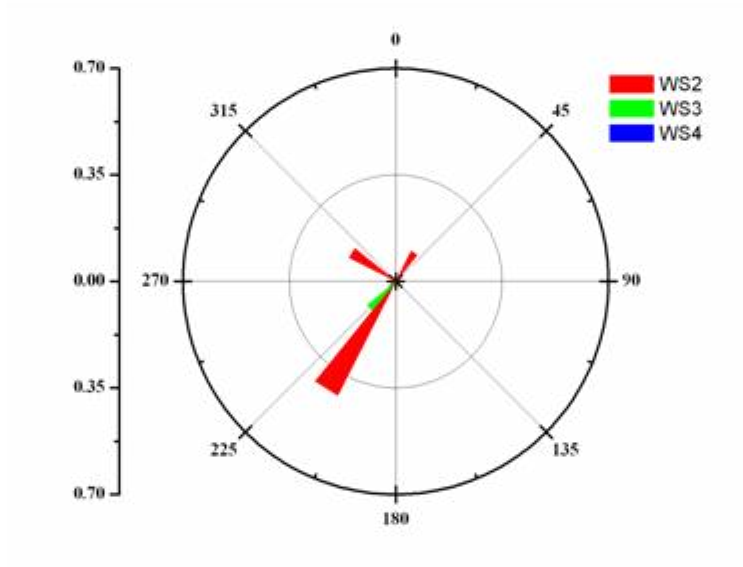


Figure 7

Canyonlands National Park, UT (CANY)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

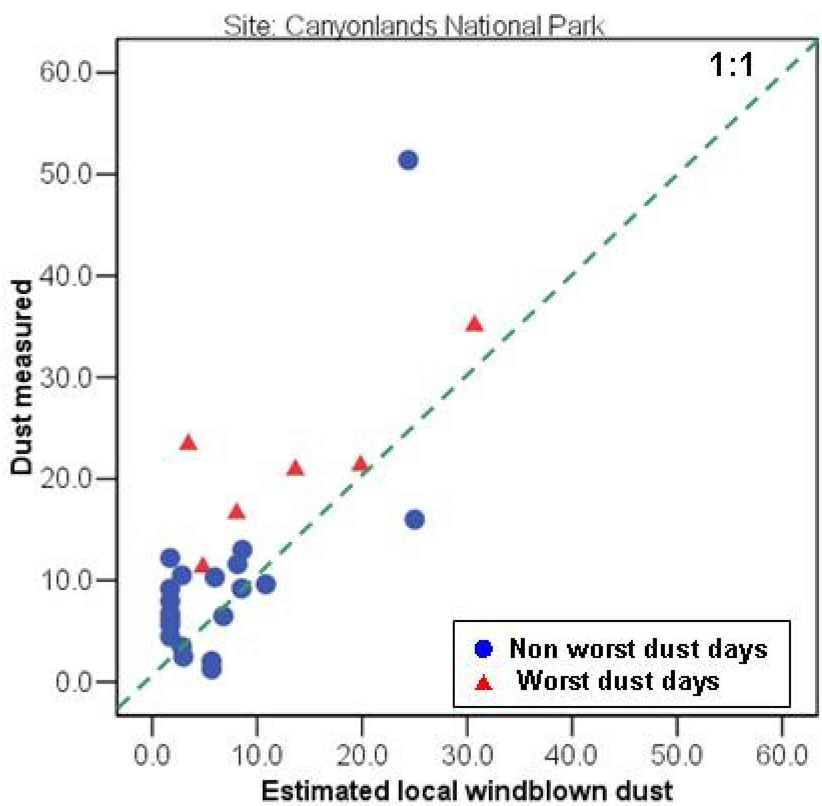
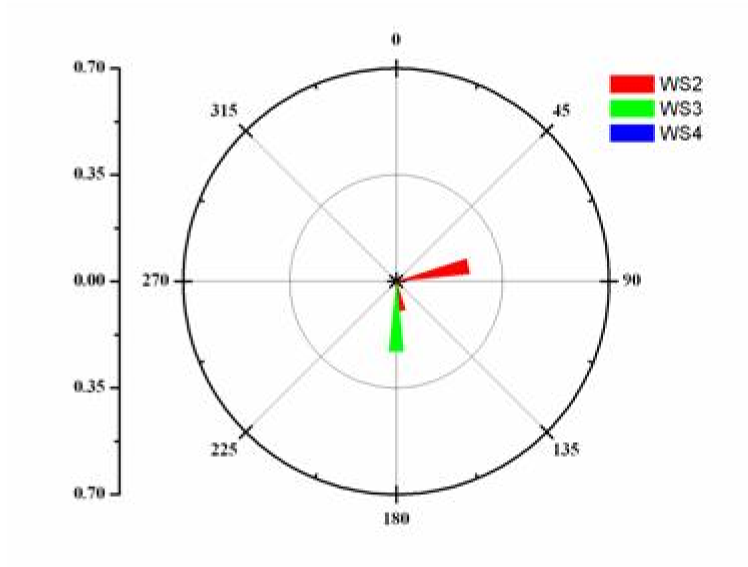


Figure 8

<u>Chiricahua National Monumnet, AZ (CHIR)</u>

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

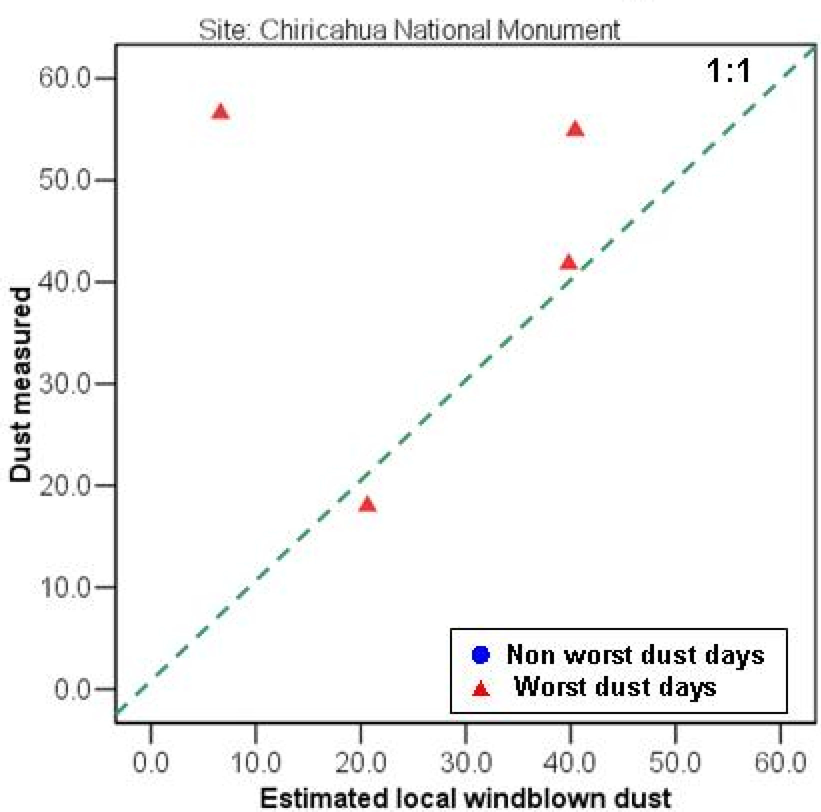
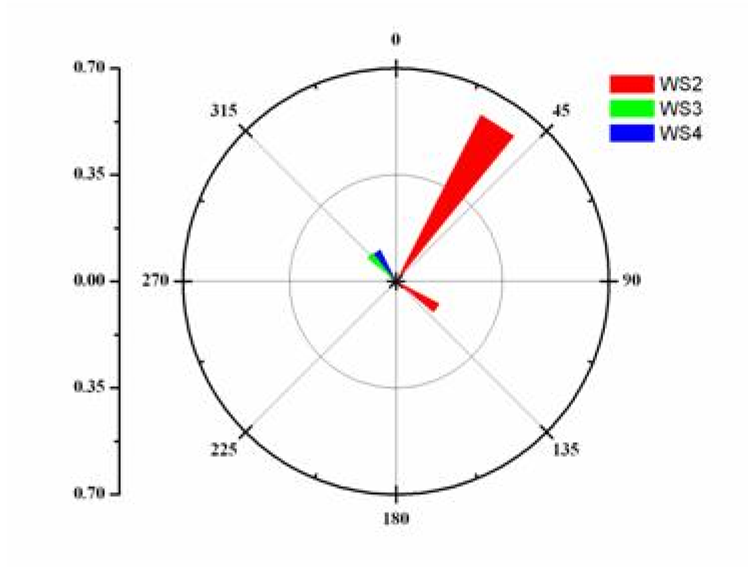


Figure 9

<u>Columbia River Gorce, WA, SD (CORI)</u>

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

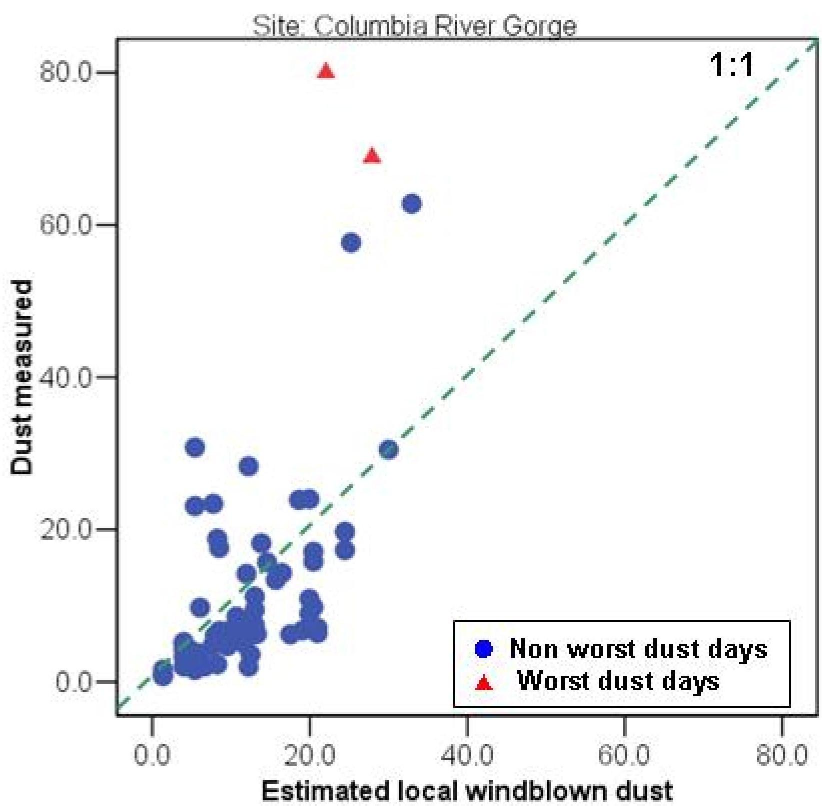
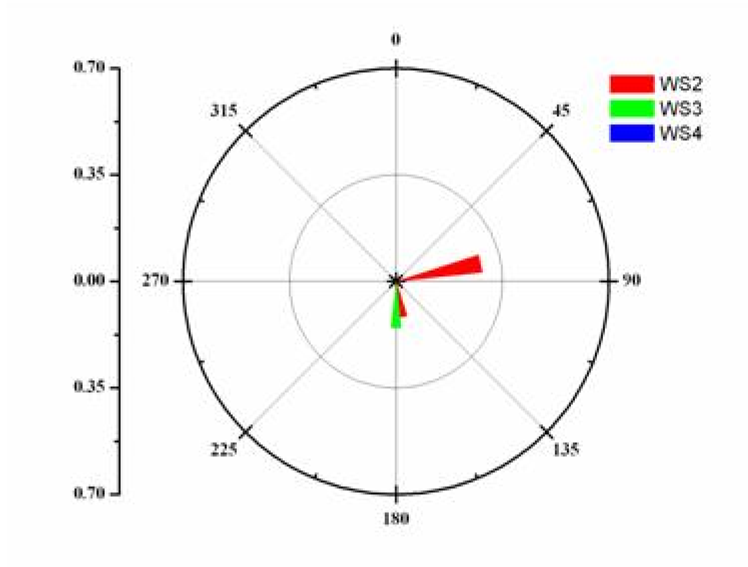


Figure 10

Craters of the Moon, ID (CRMO)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

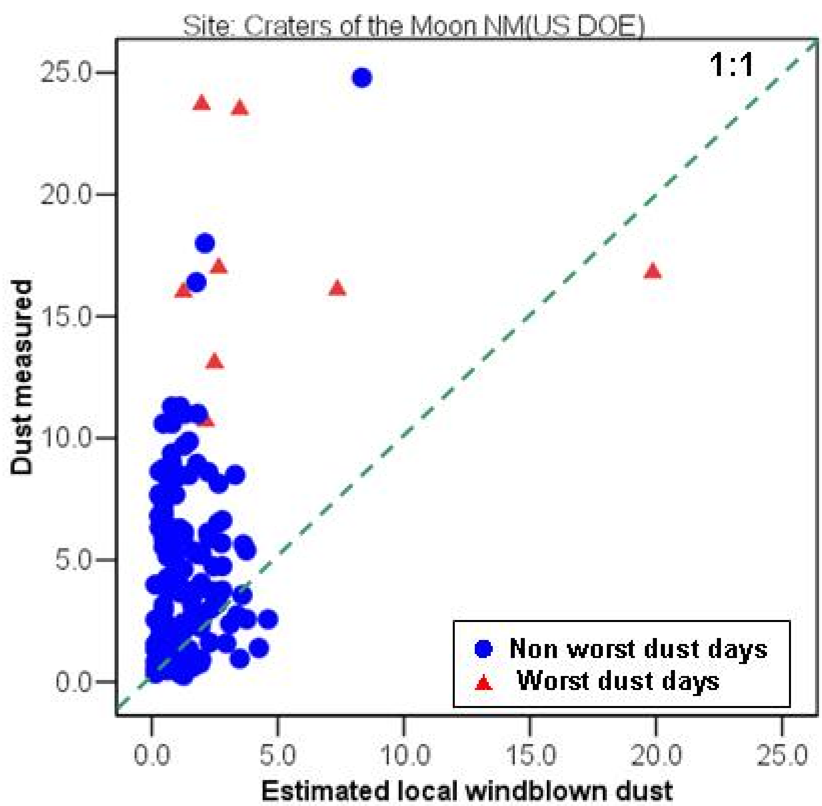
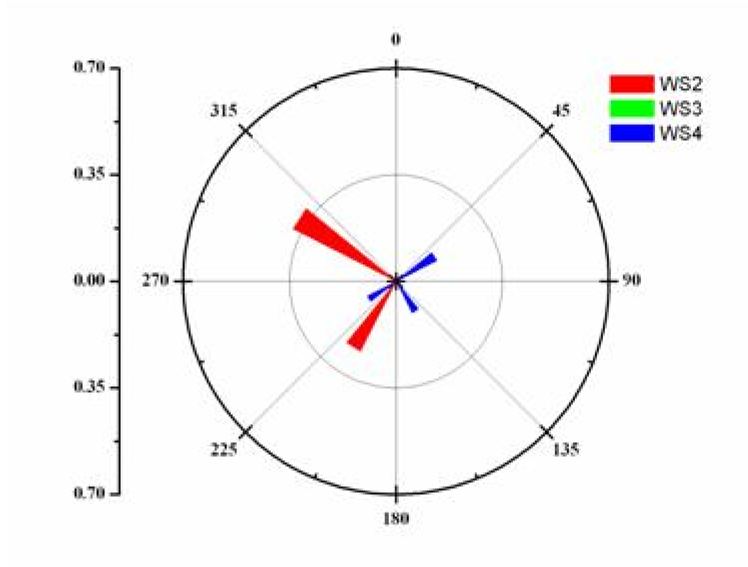


Figure 11

Death Valley National Park, CA (DEVA)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

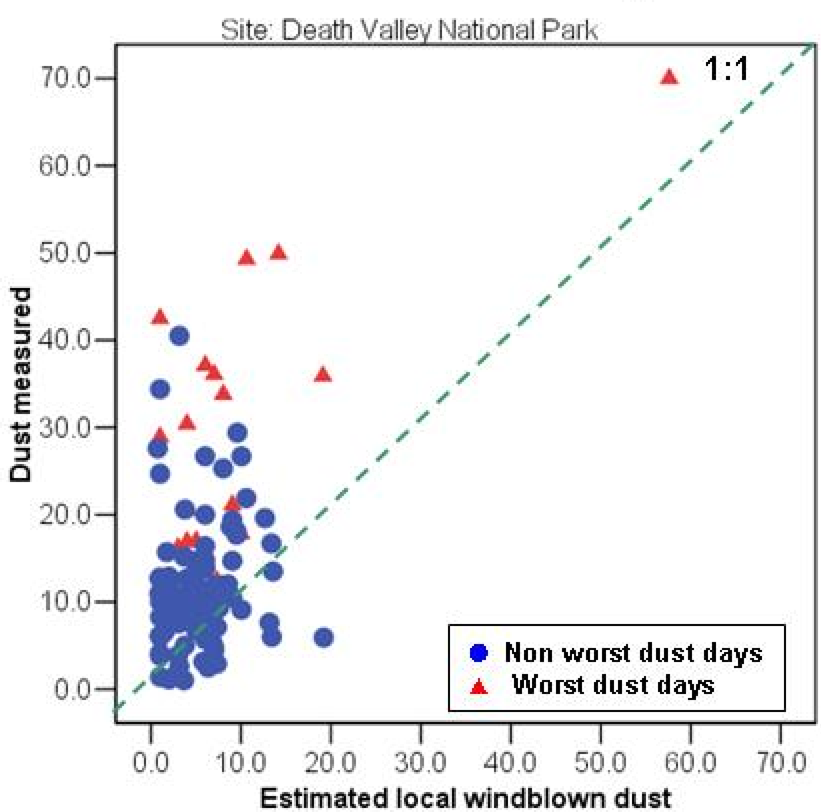
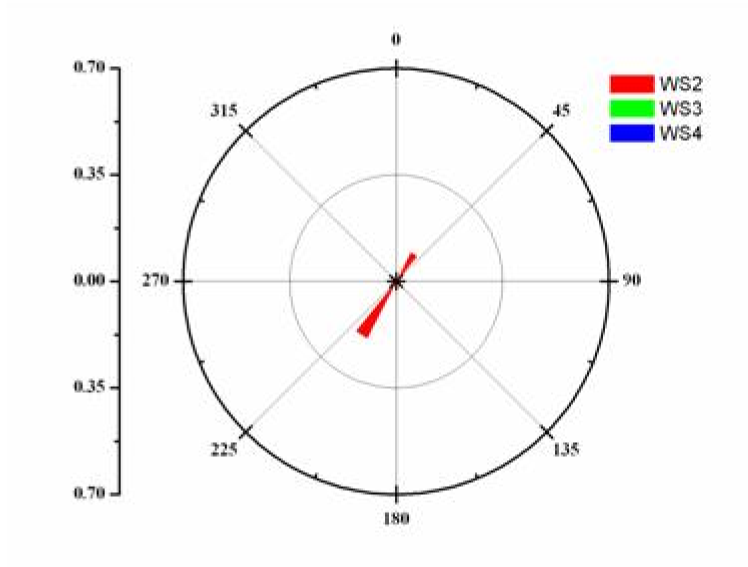


Figure 12

Gila Wilderness, NM (GICL)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

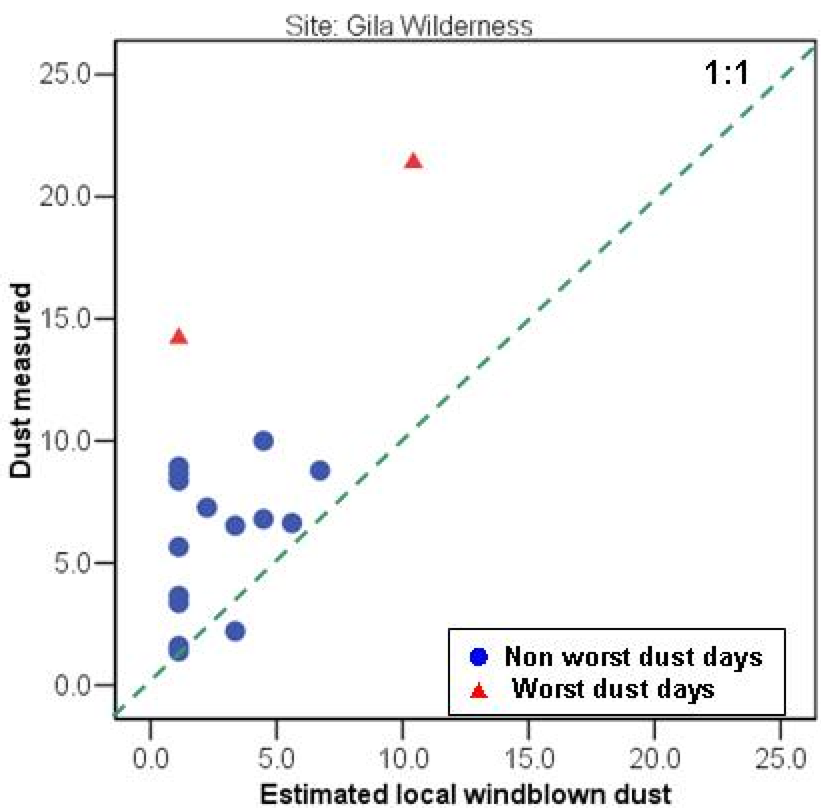
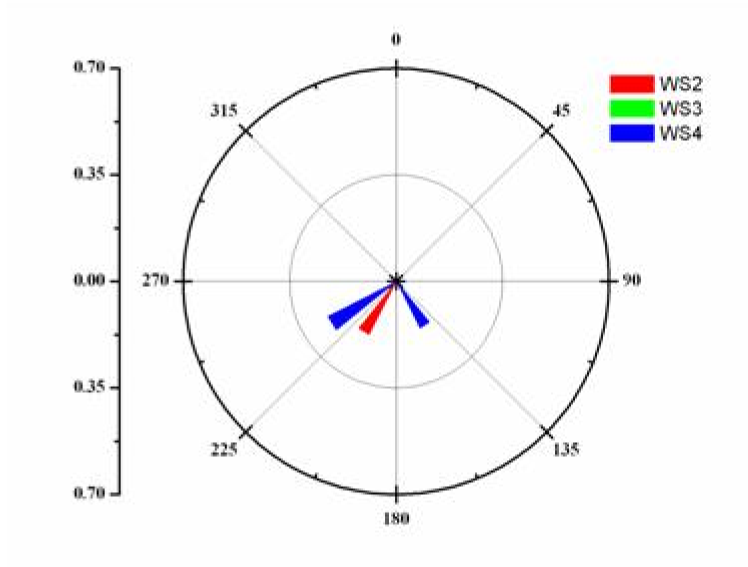


Figure 13

<u>Hillside, AZ (HILL)</u>

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

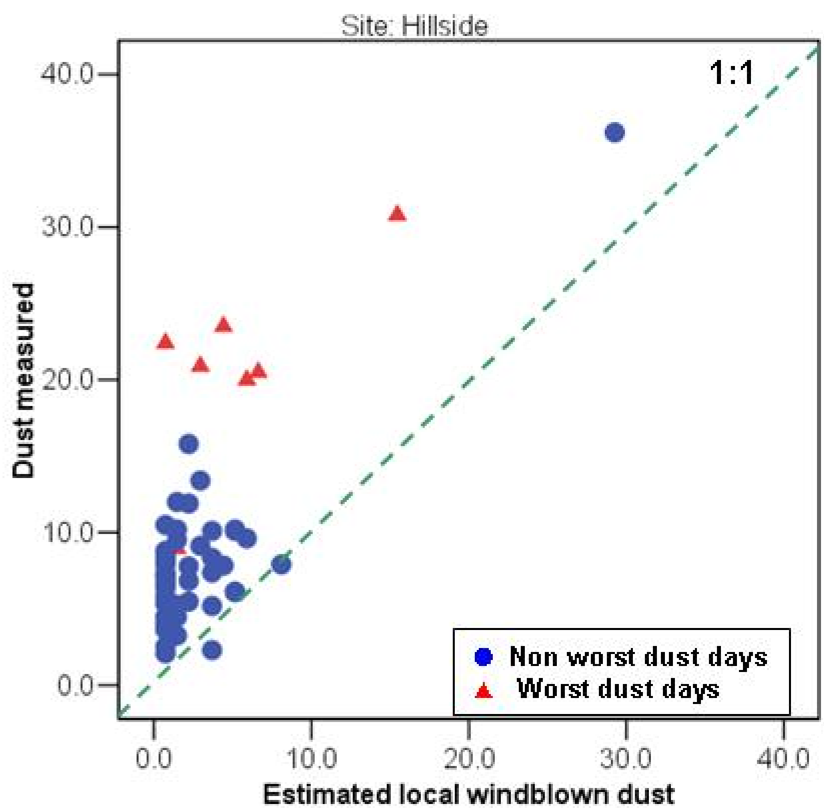
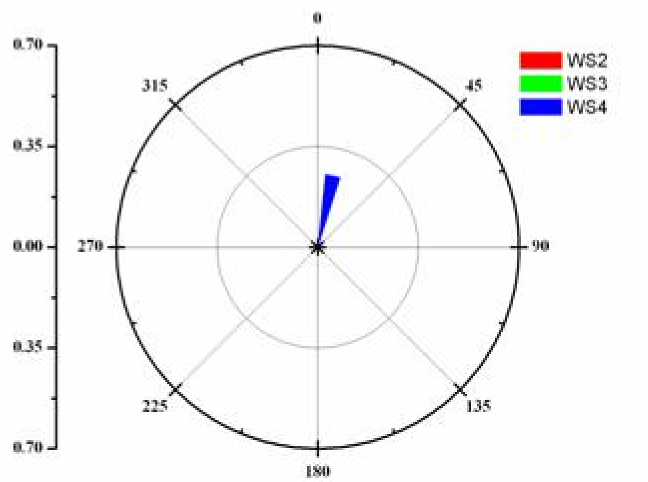


Figure 14

Hoover Wilderness, CA (HOOV)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

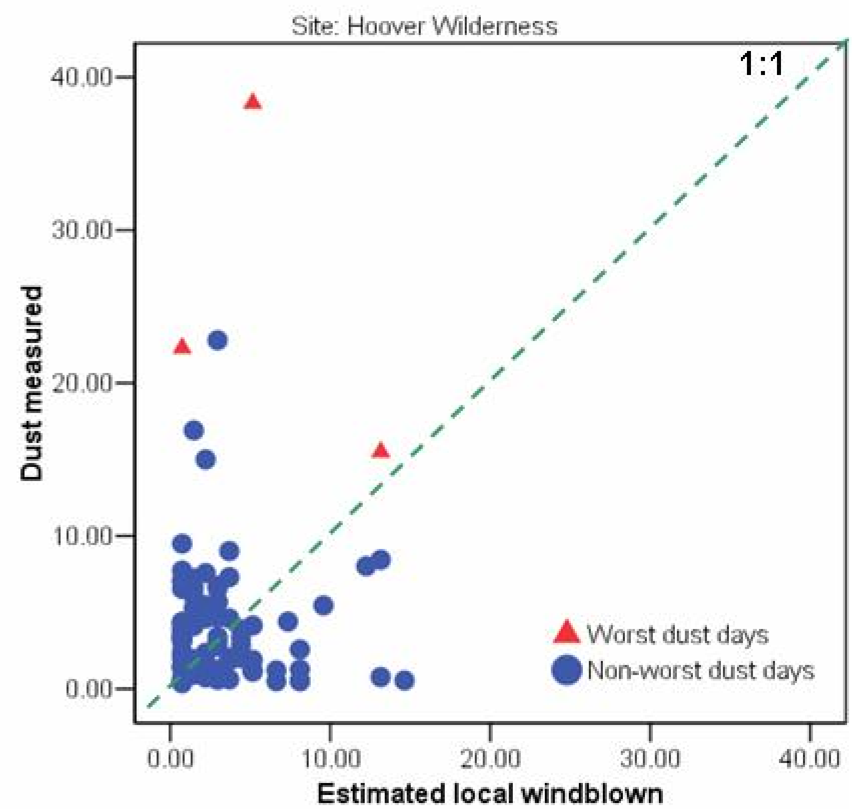
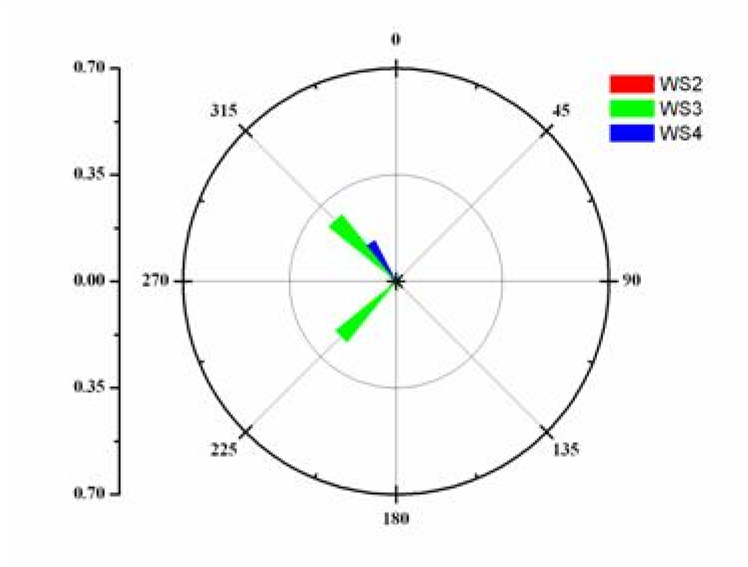


Figure 15

<u>Great Sand Dunes National Monument, CO (GRSA)</u>

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

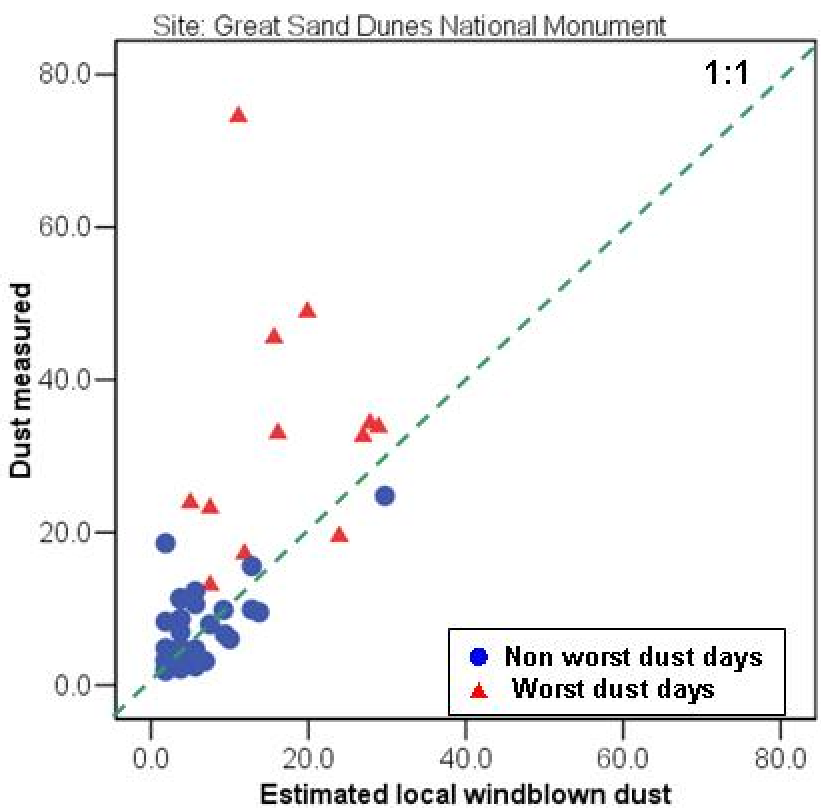
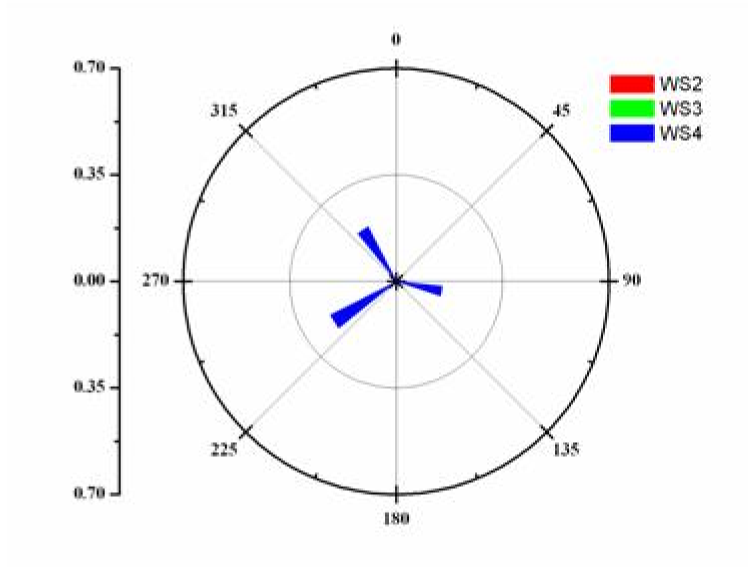


Figure 16

Guadalupe Mountains National Park, TX (GUMO)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

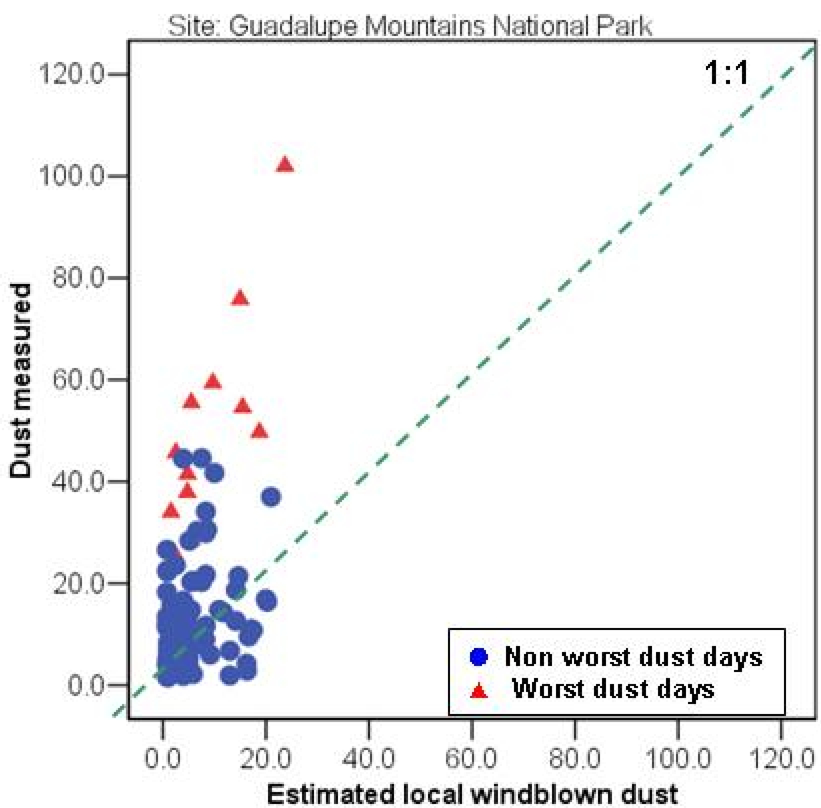
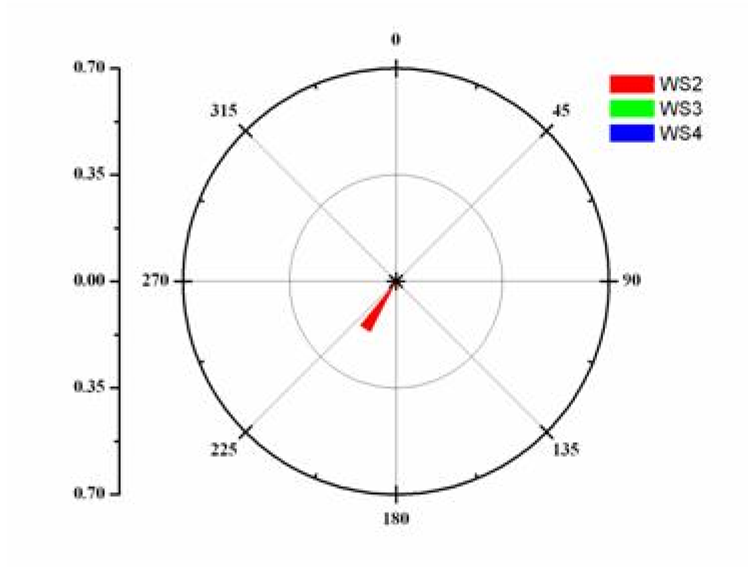


Figure 17

<u>Ike's Backbone, AZ (IKBA)</u>

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

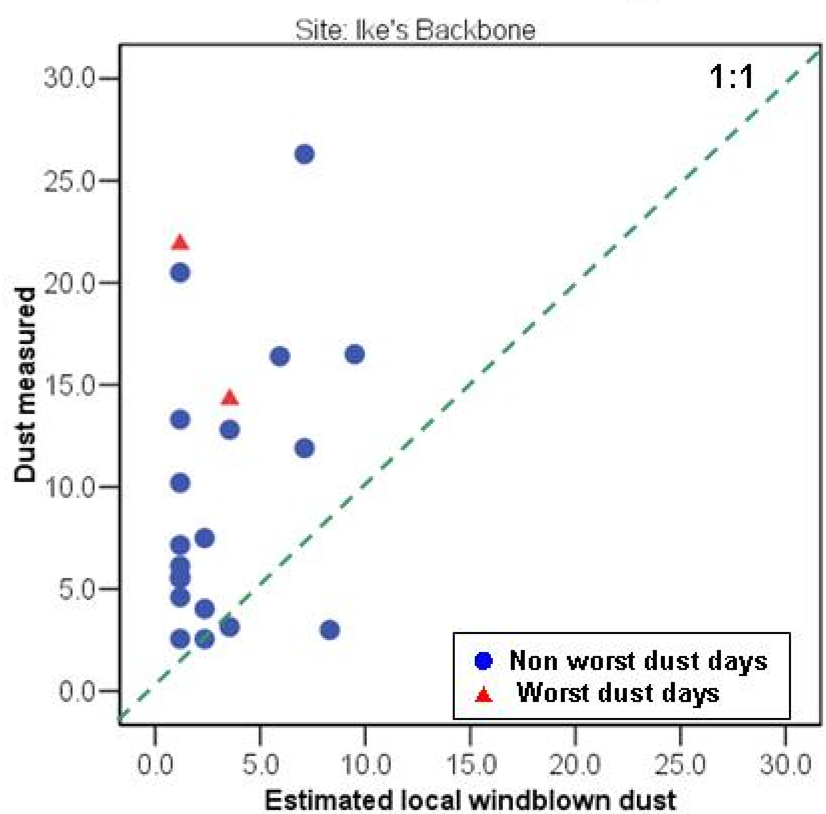
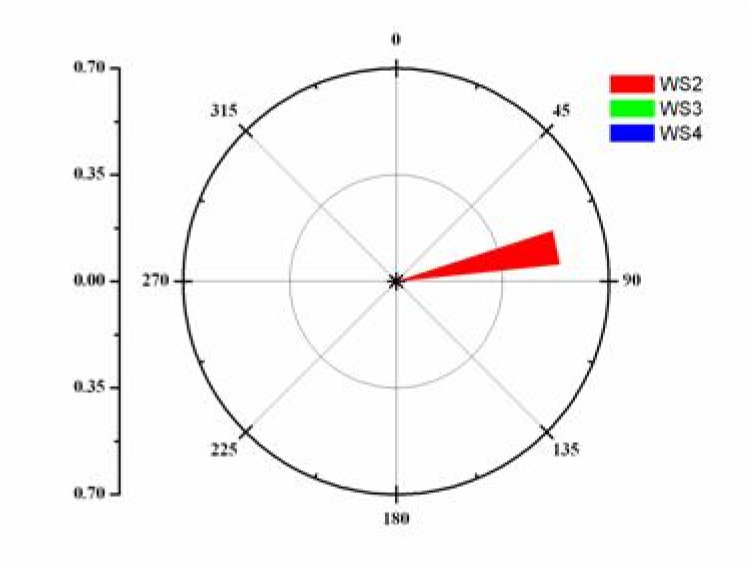


Figure 18

Joshua Tree, CA (JOSH)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

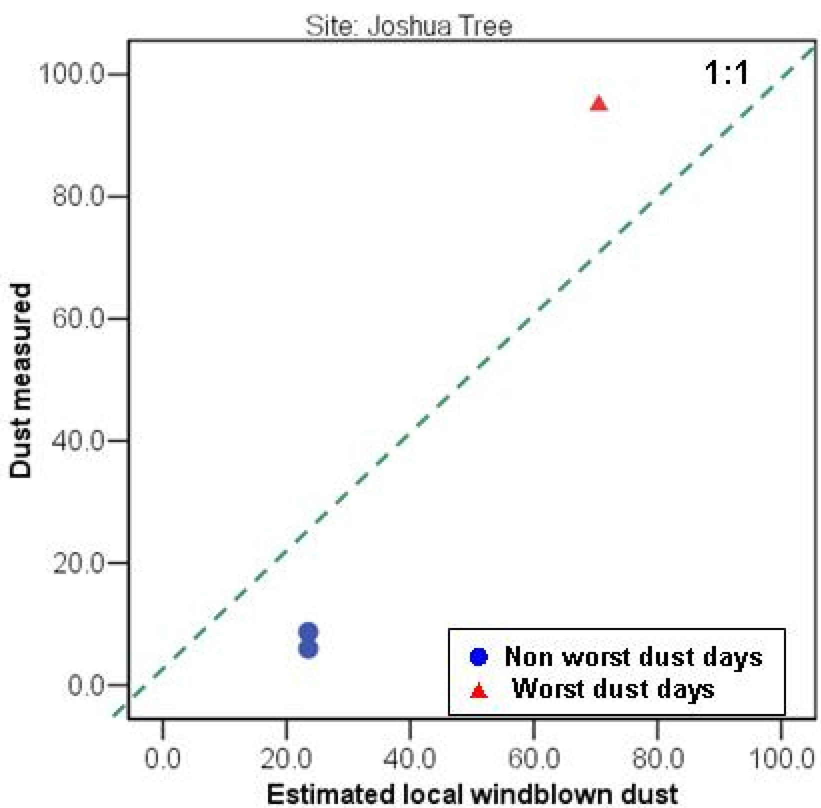
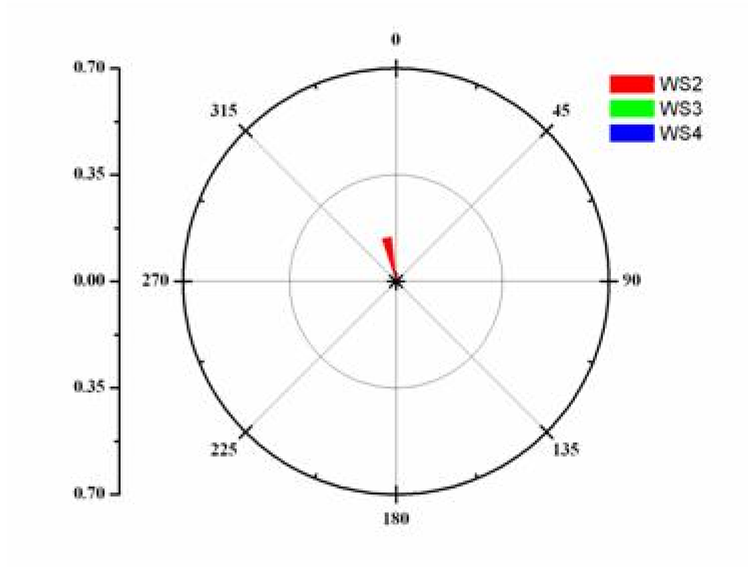


Figure 19

Kaliompsis Wilderness, OR (KALM)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

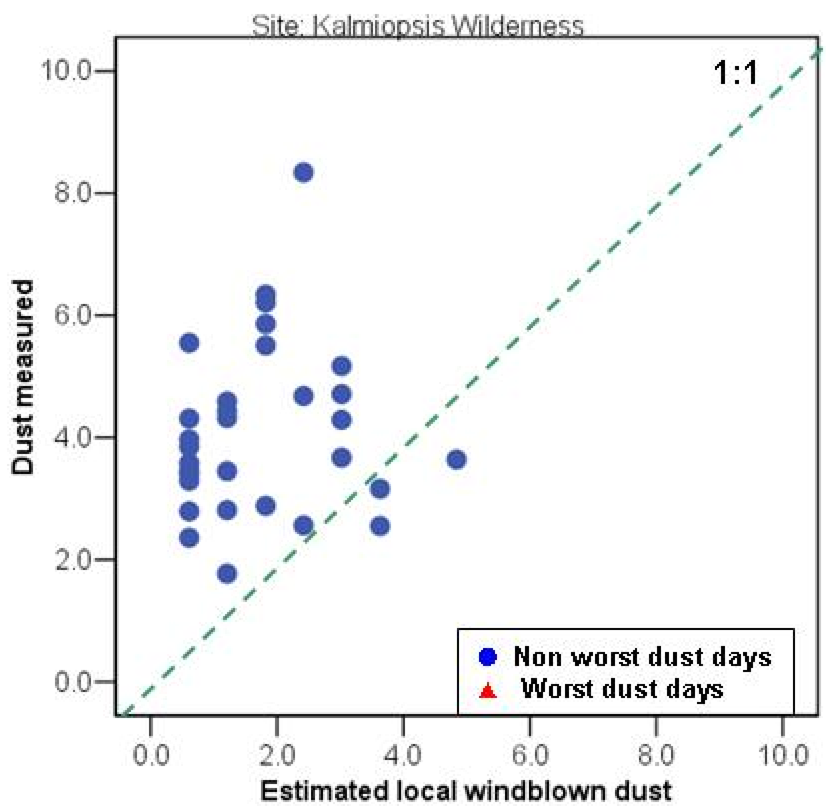
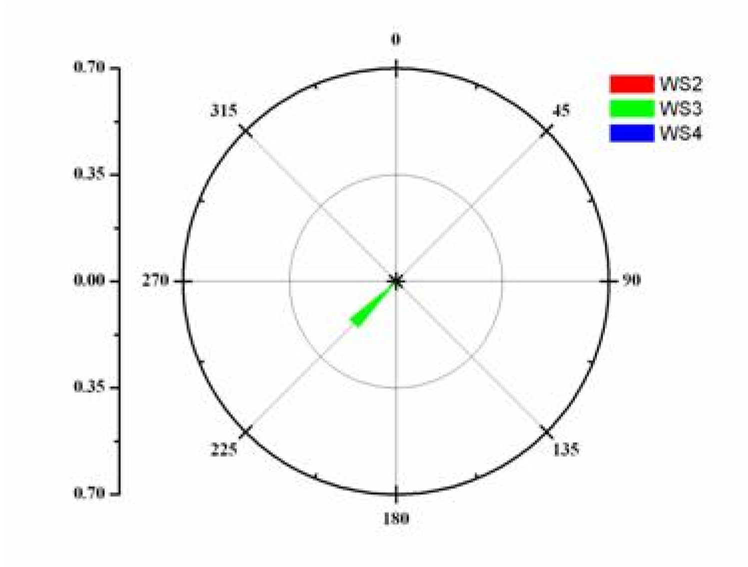


Figure 20

Lava Beds National Park, CA (LABE)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

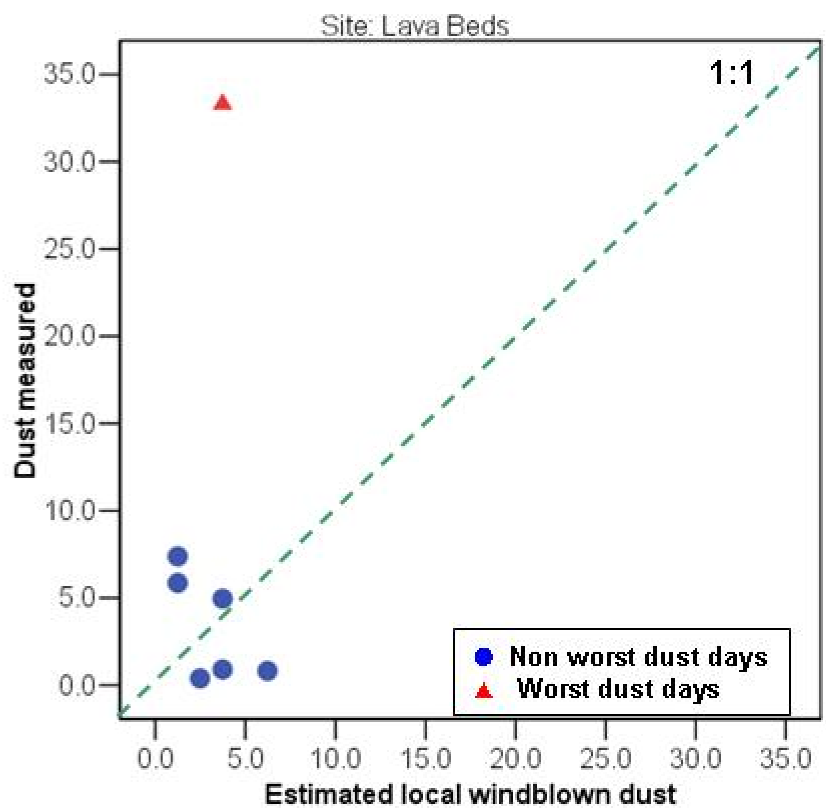
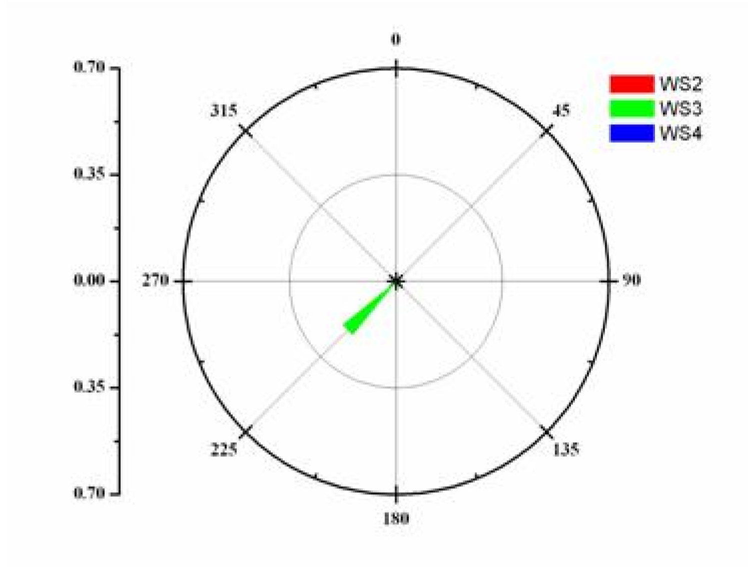


Figure 21

Lostwood Wiilderness, ND (LOST)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

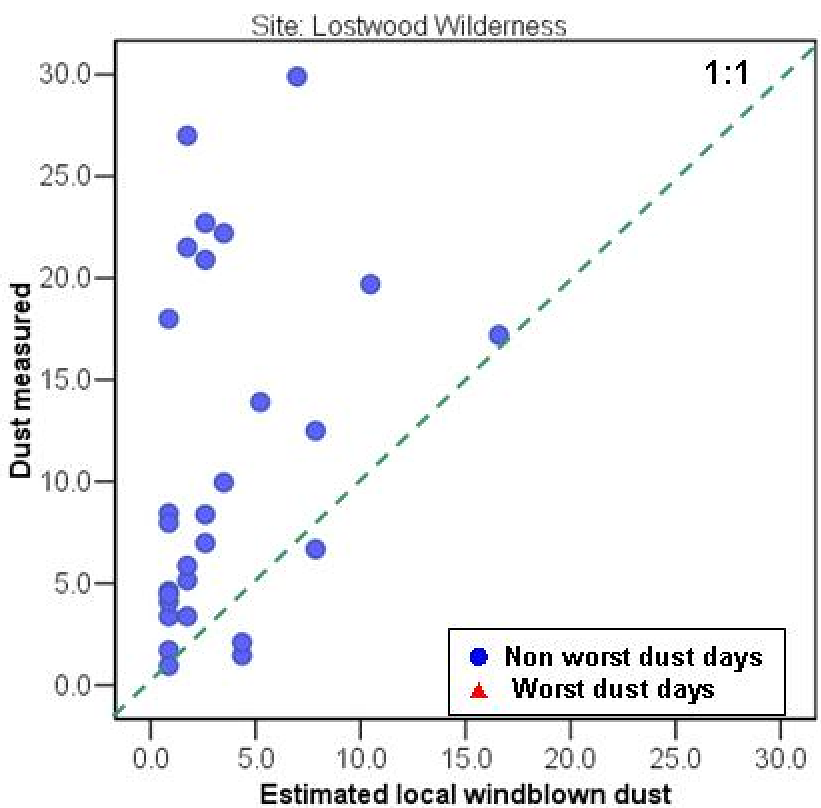
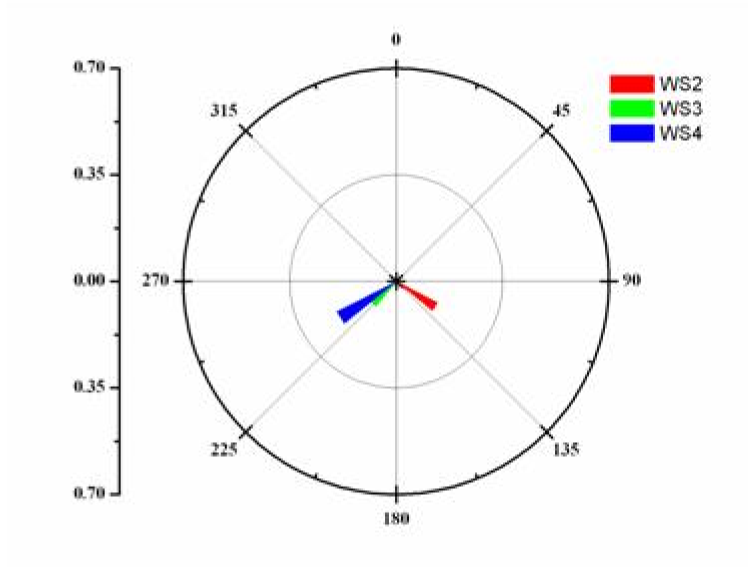


Figure 22

Medicine Lake Wilderness, MT (MELA)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

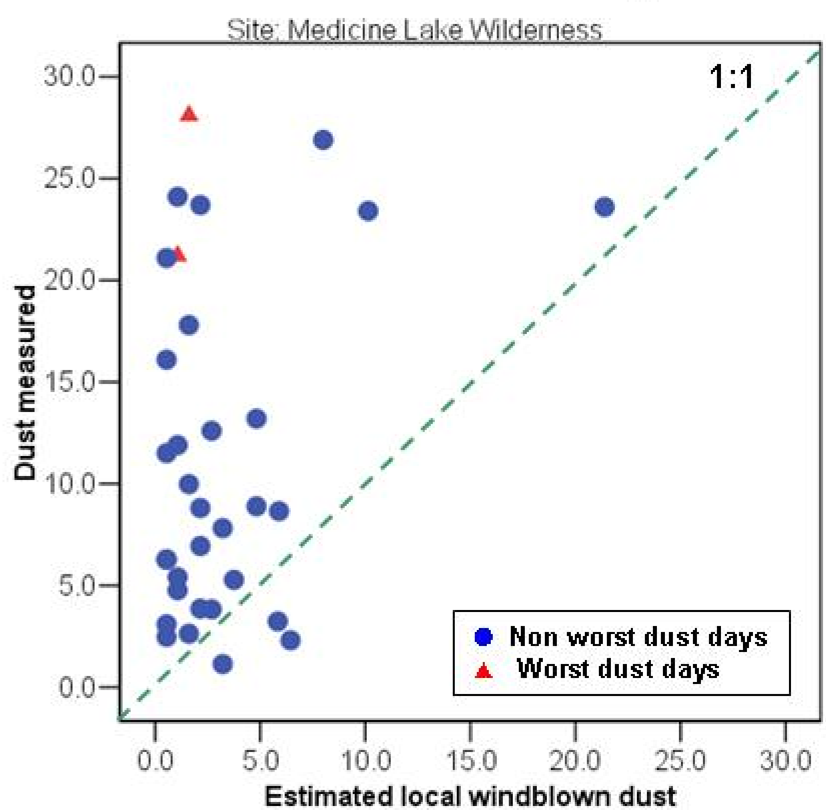
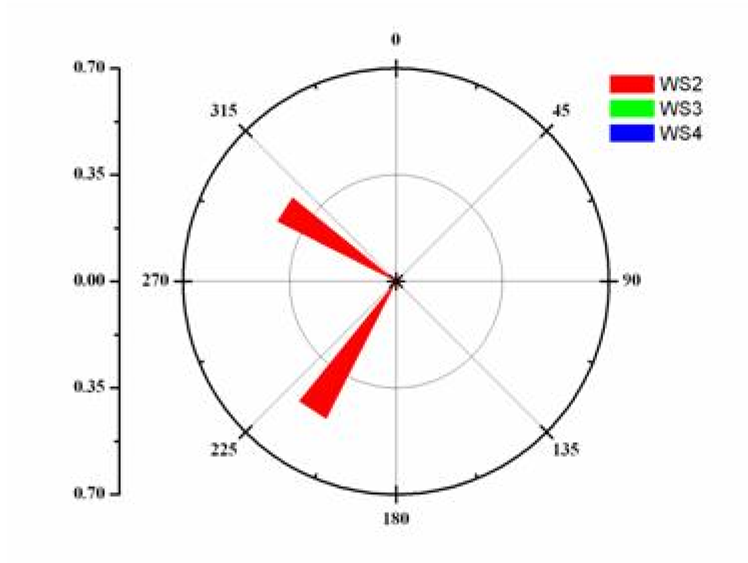


Figure 23

Mesa Verde National Park, NM (MEVE)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

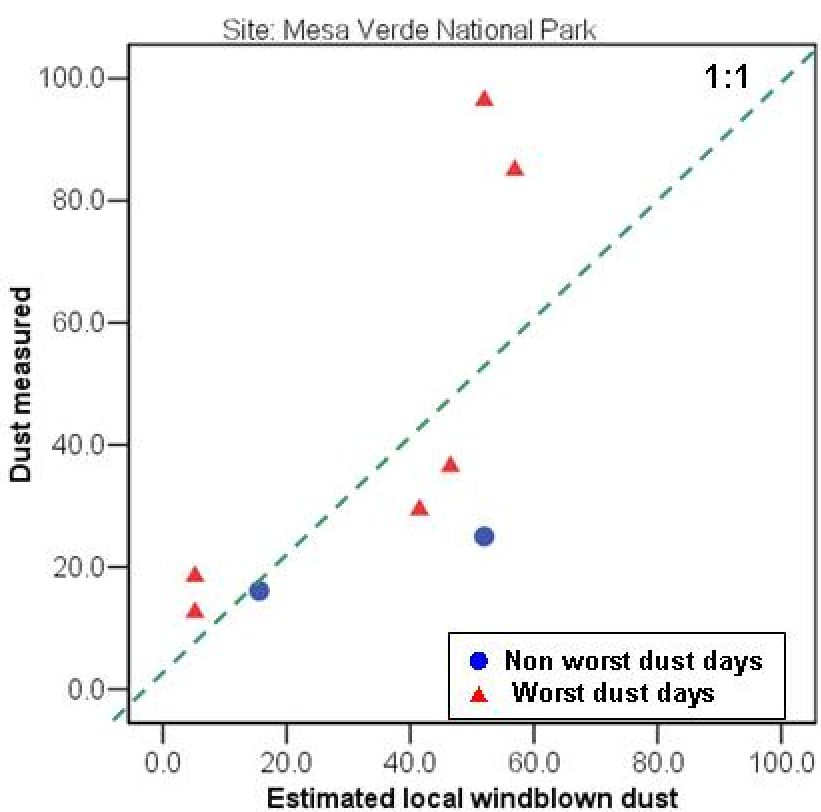
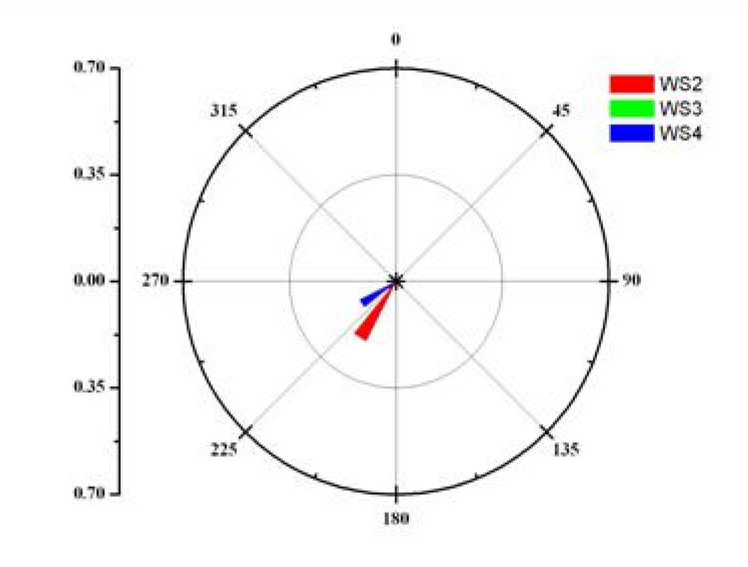


Figure 24

Mount Baldy Wilderness, AZ (BALD)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

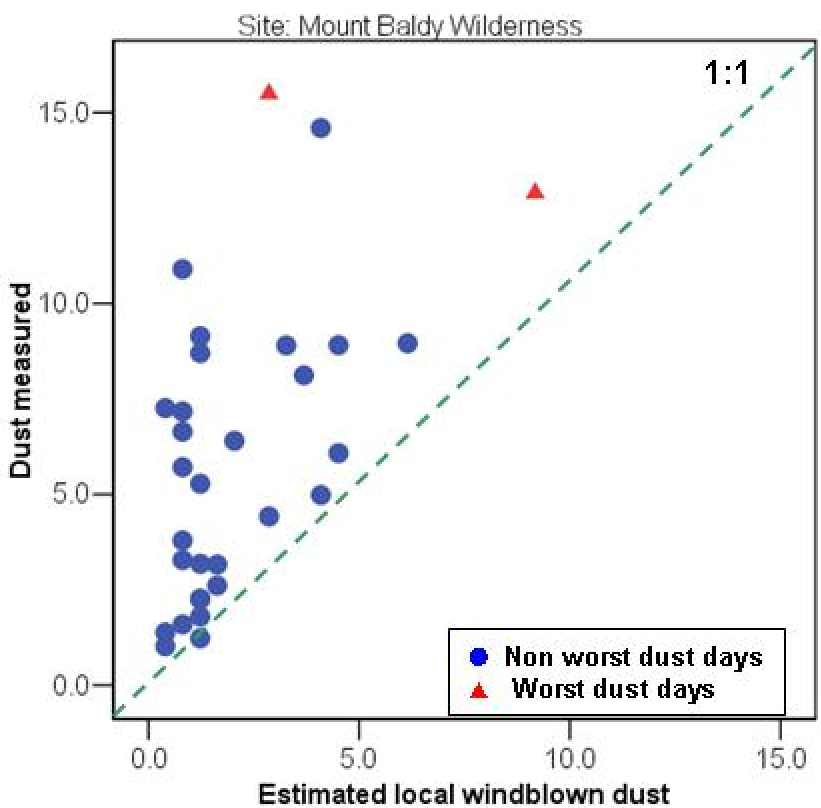
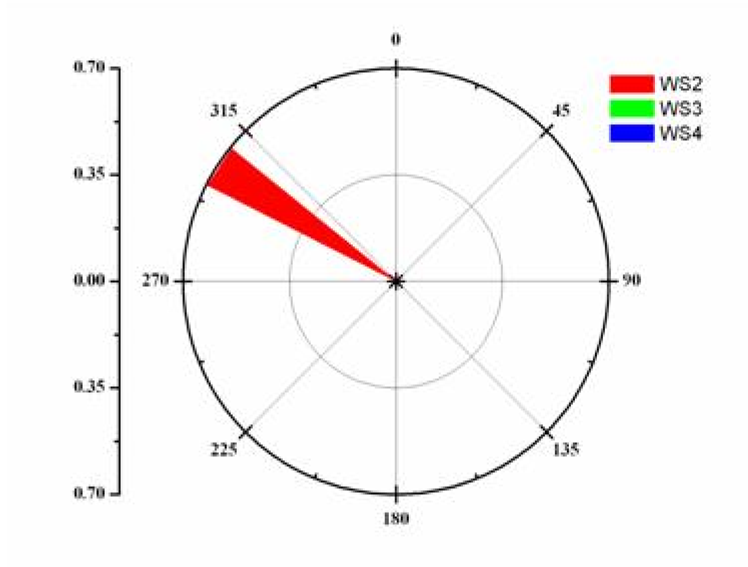


Figure 25

Pasayten Wilderness, AZ (PASA)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

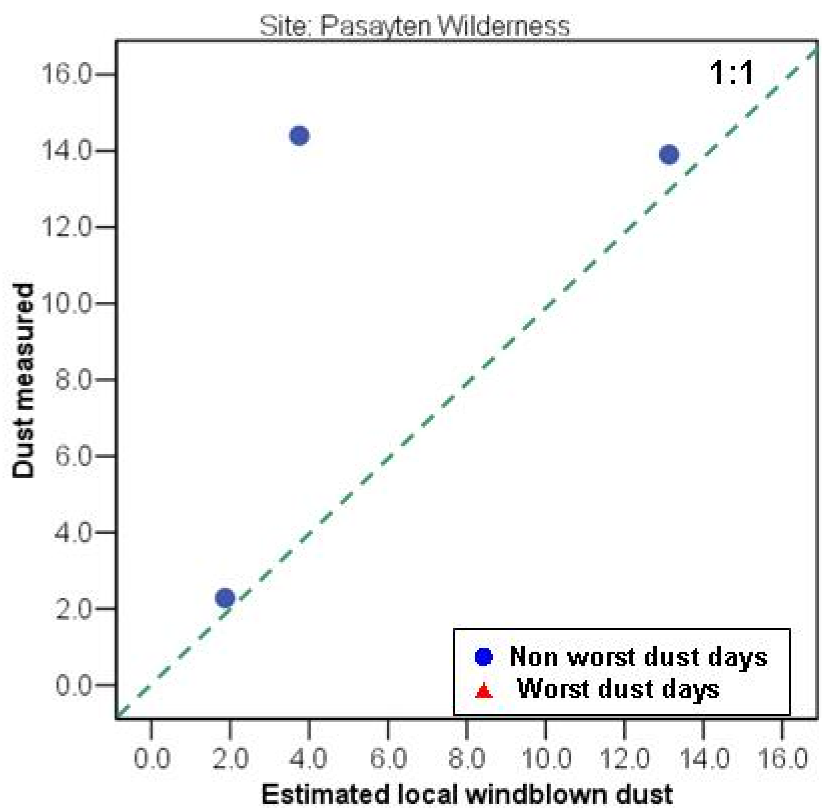
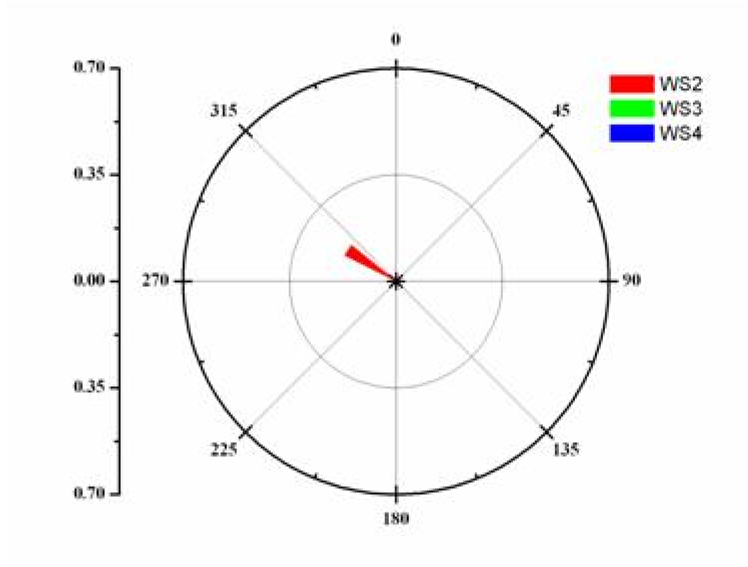


Figure 26

Puget Sound, WA (PUSO)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

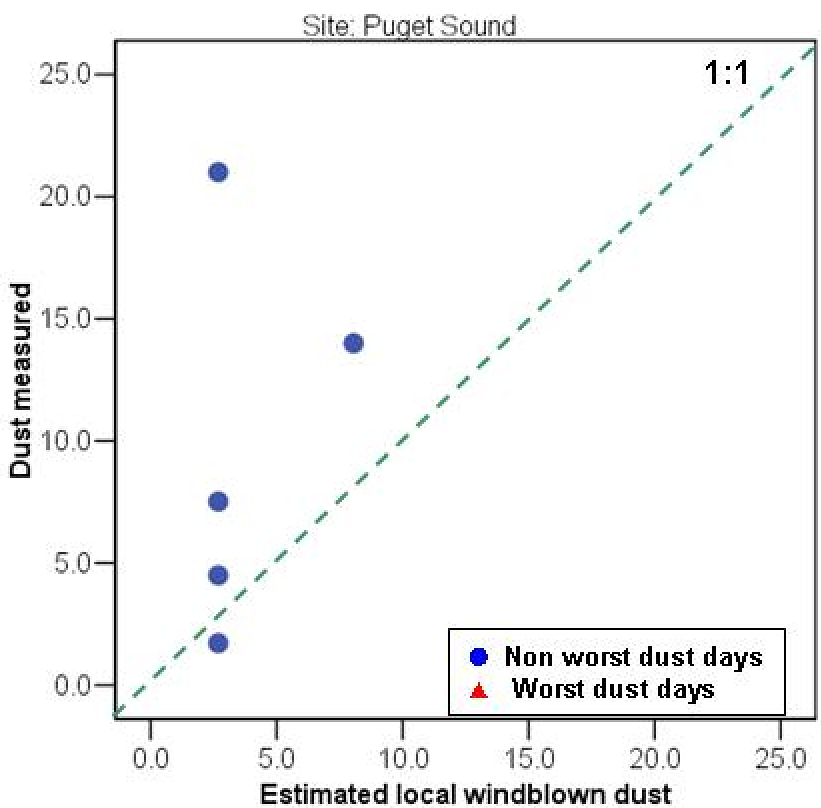
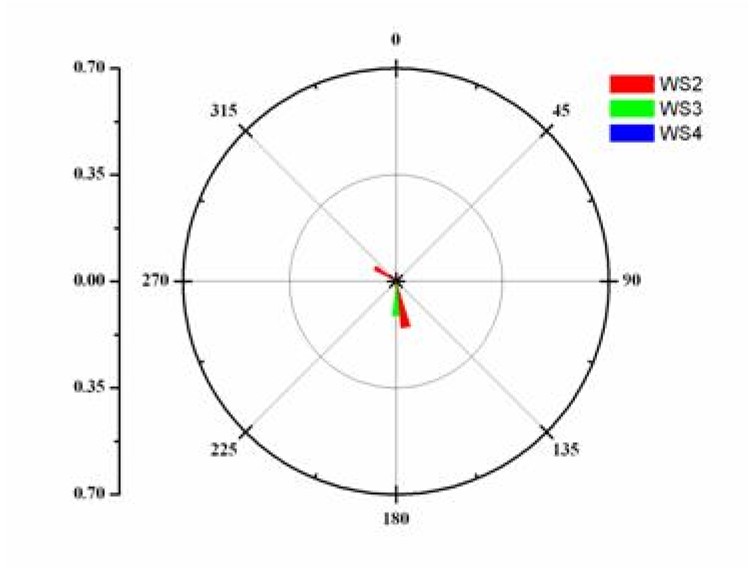


Figure 27

Queen Valley National Park, AZ (QUVA)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

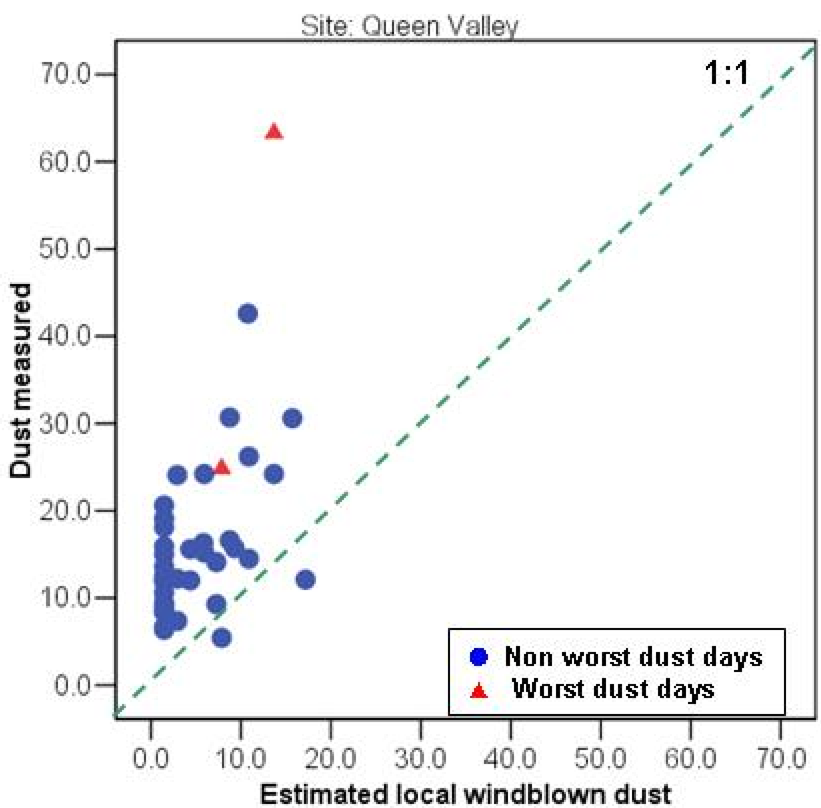
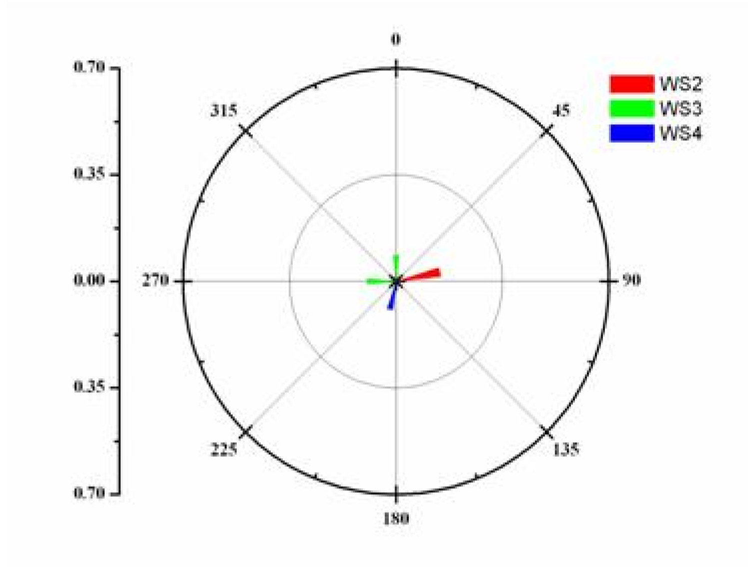


Figure 28

Saguaro National Park, AZ (SAGU)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

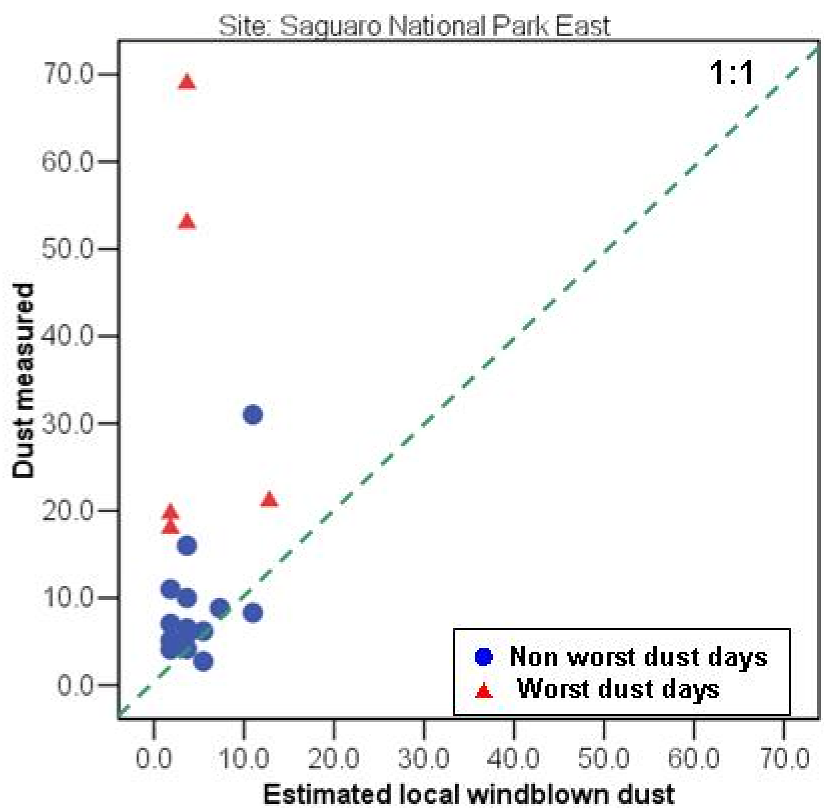
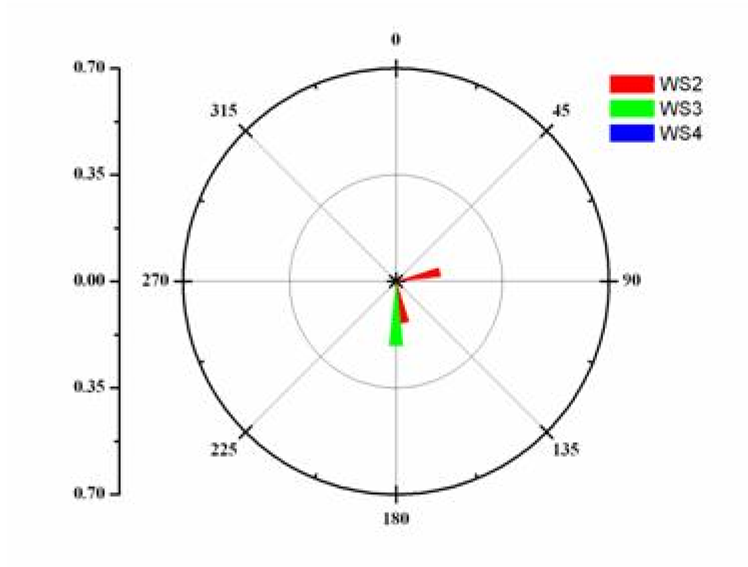


Figure 29

Saguaro National Park West, AZ (SAWE)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

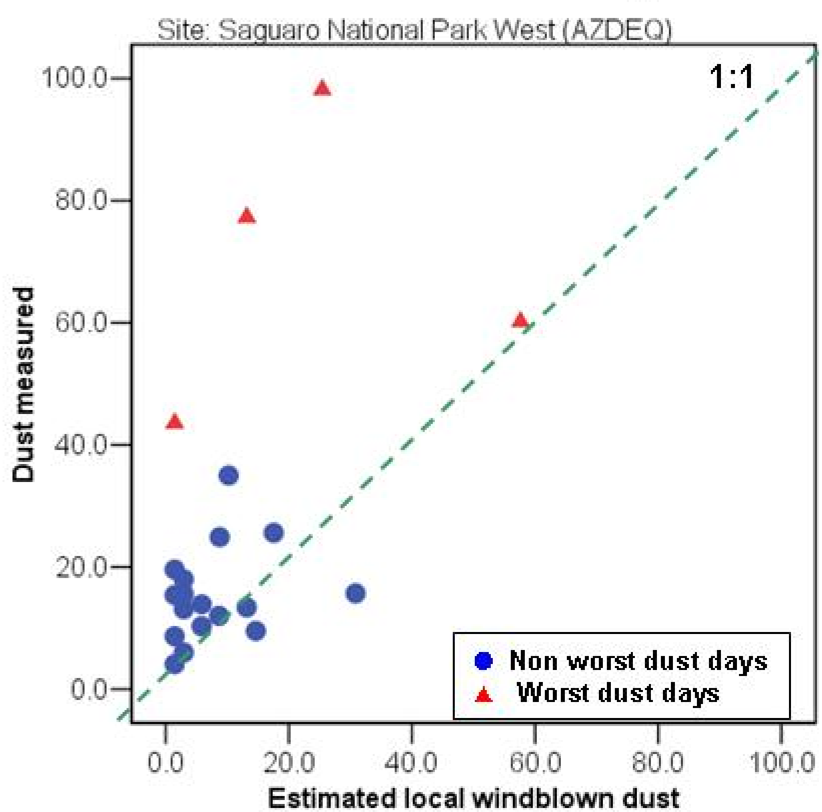
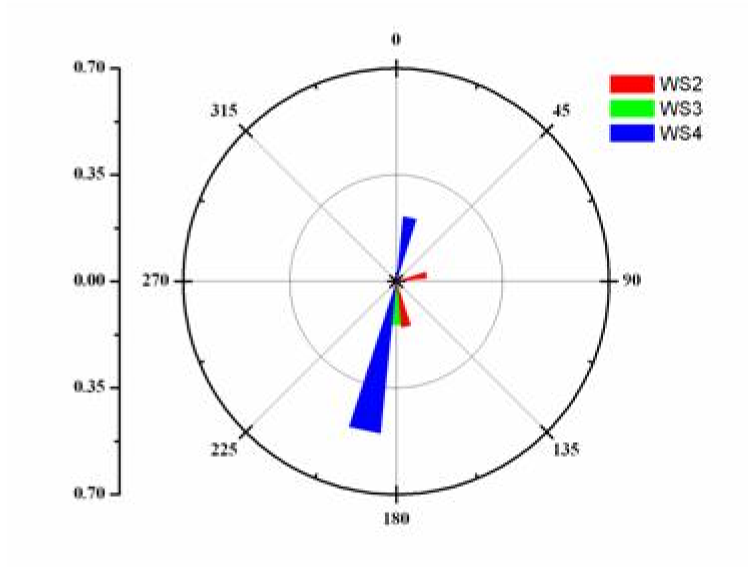


Figure 30

Salt Creek Wilderness, NM (SACR)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

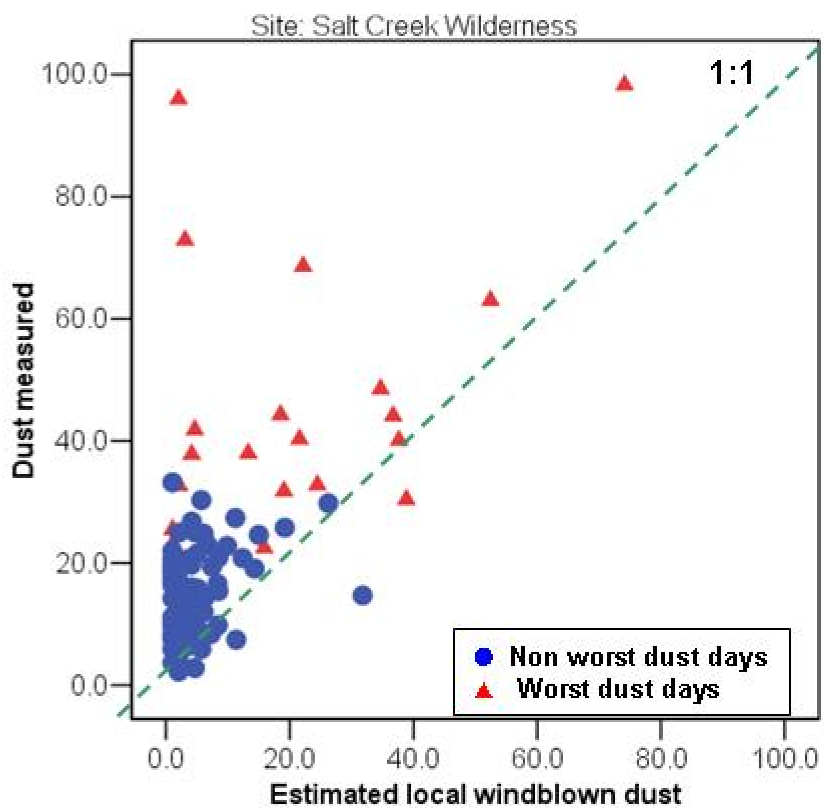
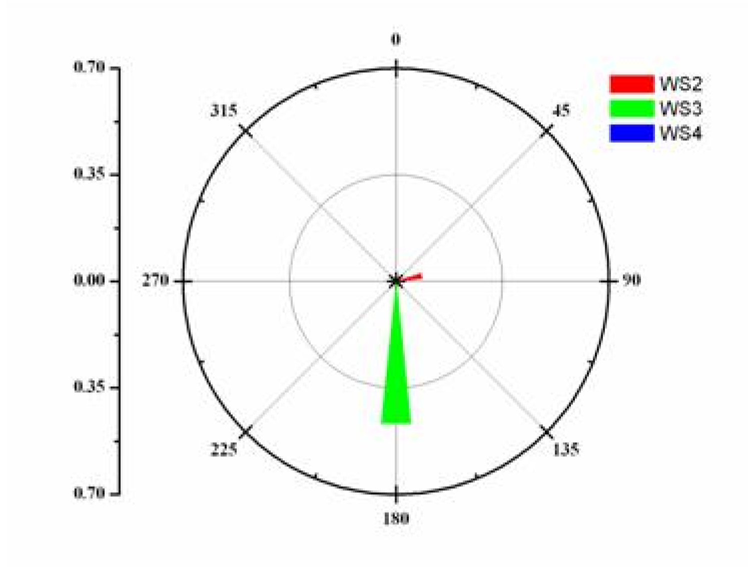


Figure 31

San Pedro Parks Wilderness, NM (SAPE)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

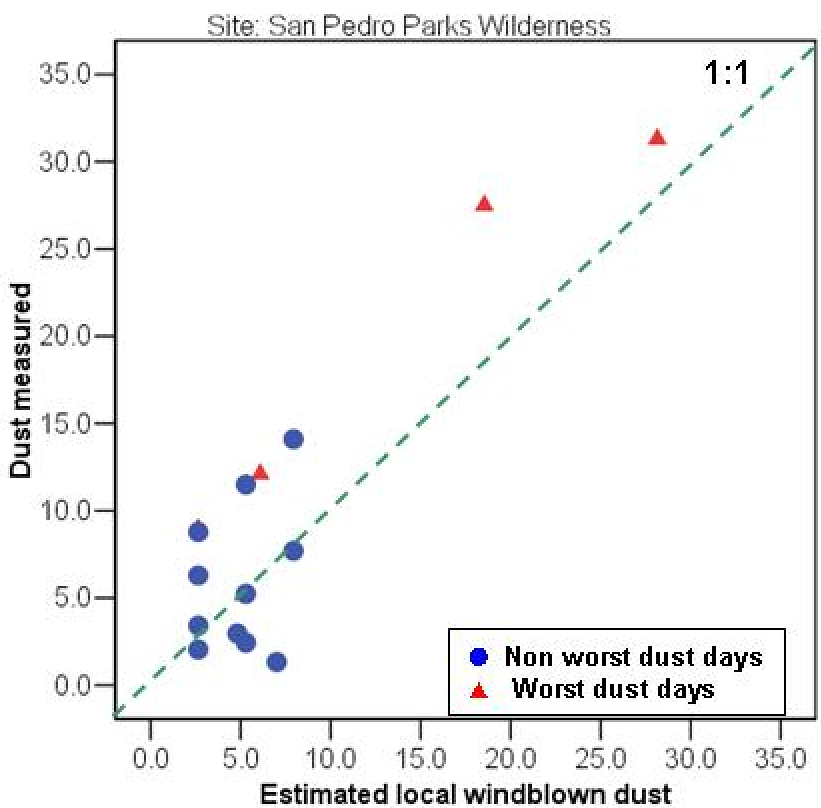
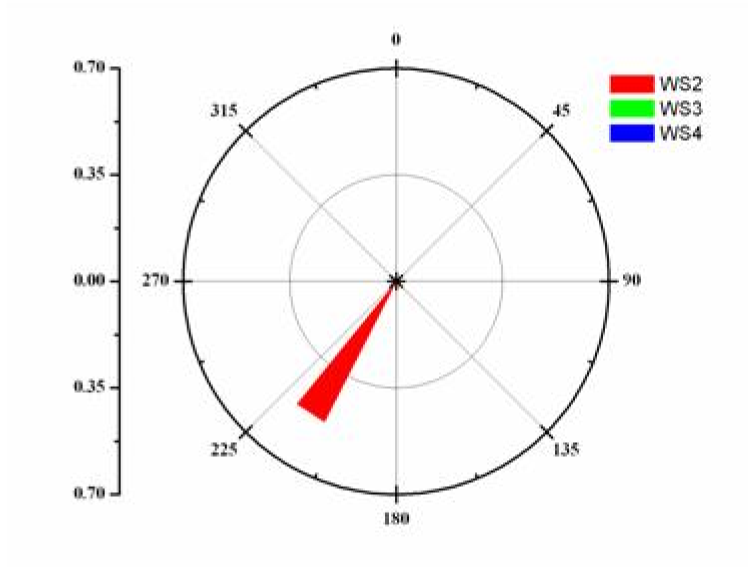


Figure 32

Sawtooth National Forest, ID (SAWT)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

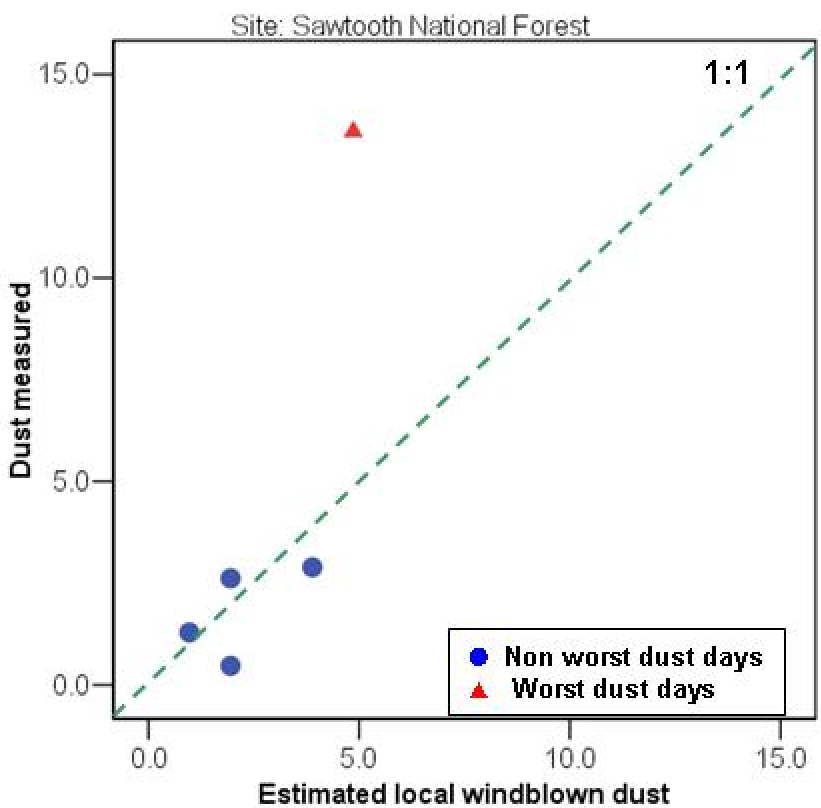
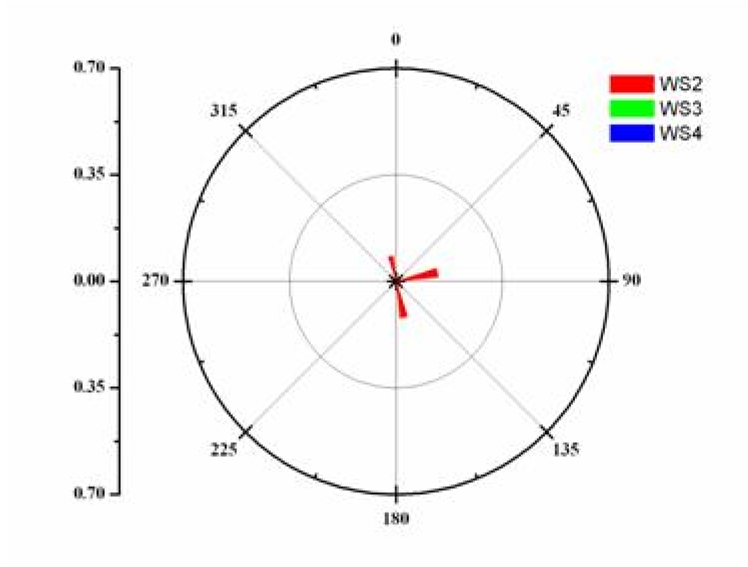


Figure 33

Sierra Ancha, AZ (SIAN)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

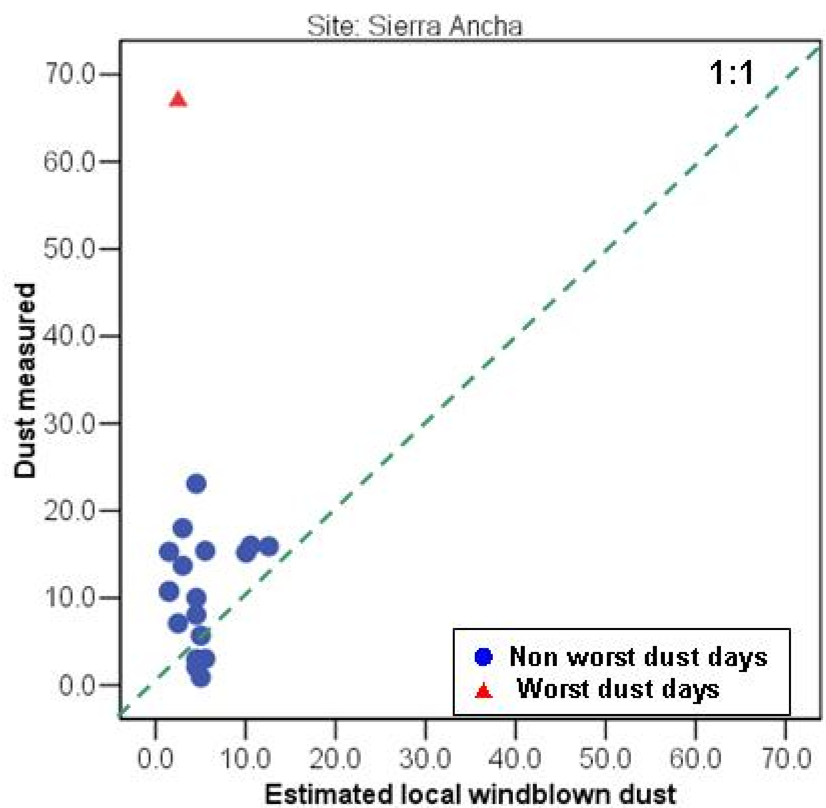
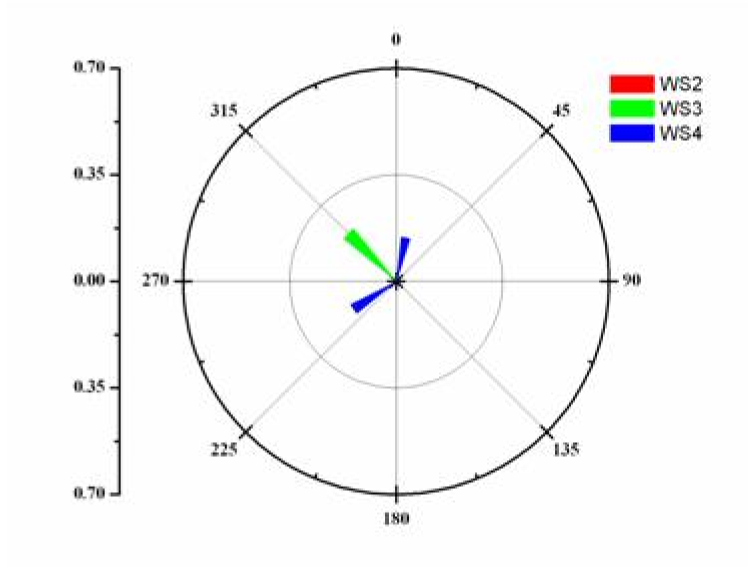


Figure 34

<u>Simeonof Wilderness, AK (SIME)</u>

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

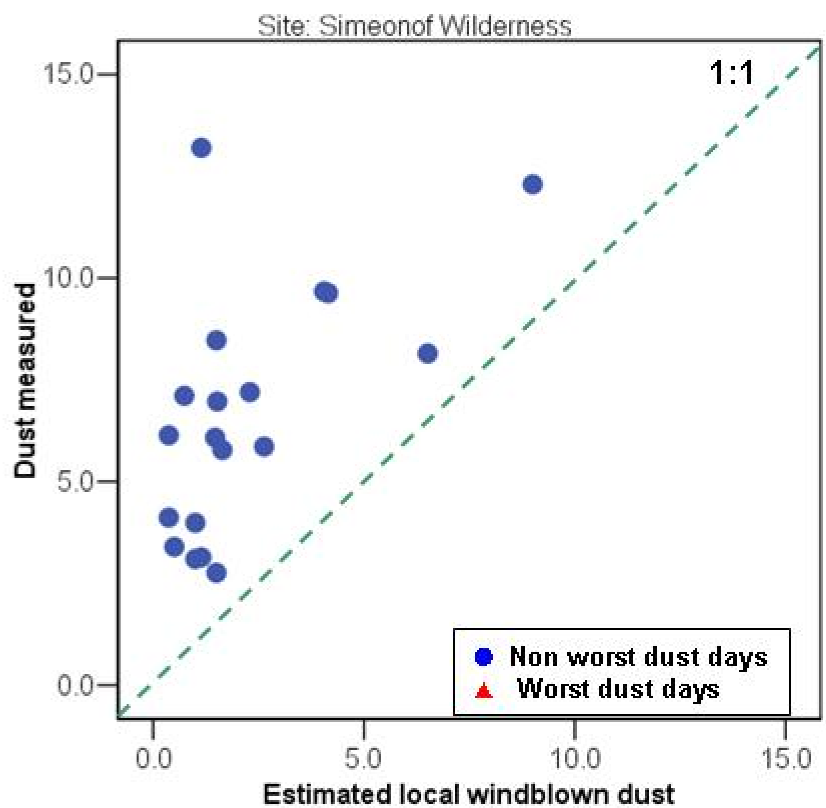
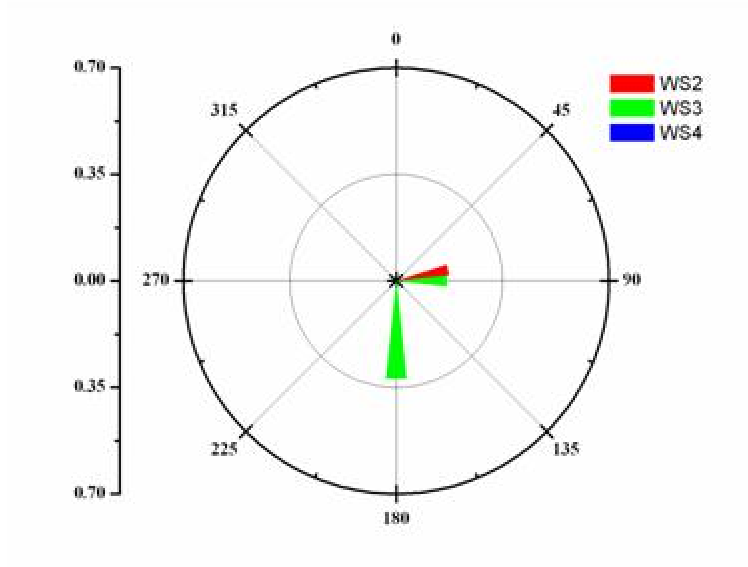


Figure 35

Spokane Res. WA (SPOK)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

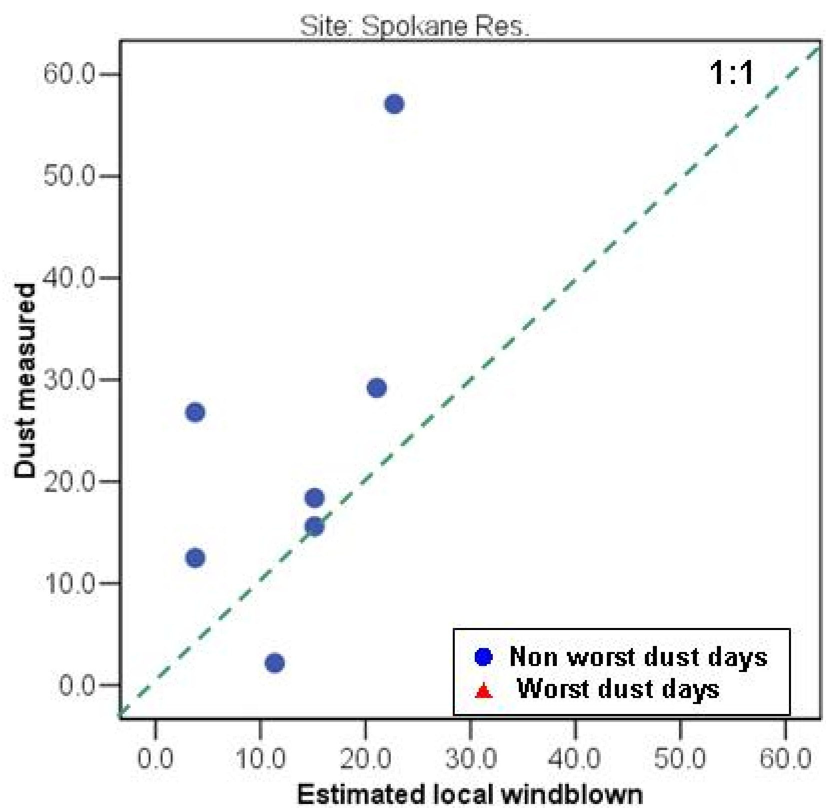
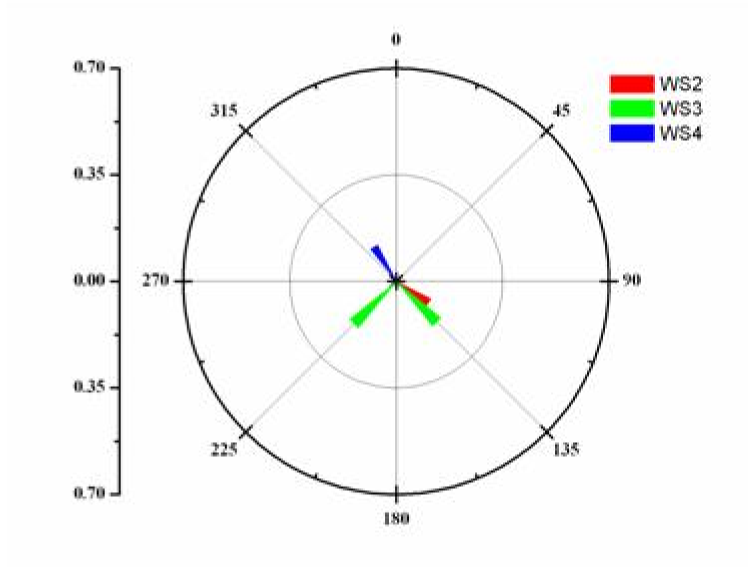


Figure 36 **Theodore Roosevelt National Park, ND (THRO)**

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

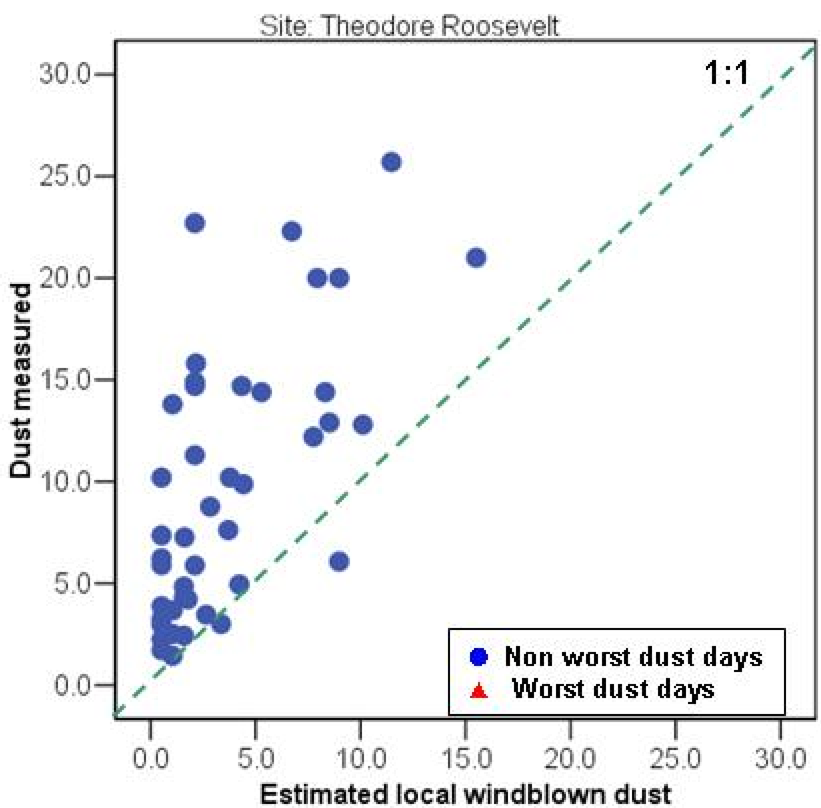
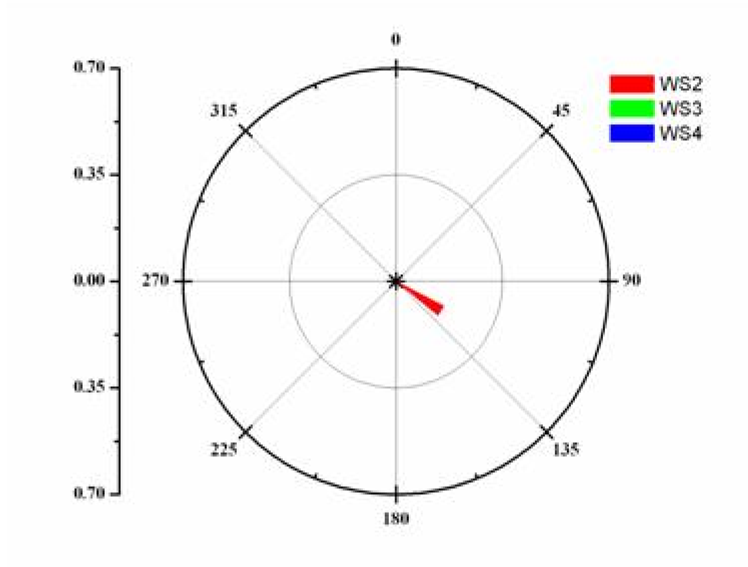


Figure 37

Tonto National Monument, AZ (TONT)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

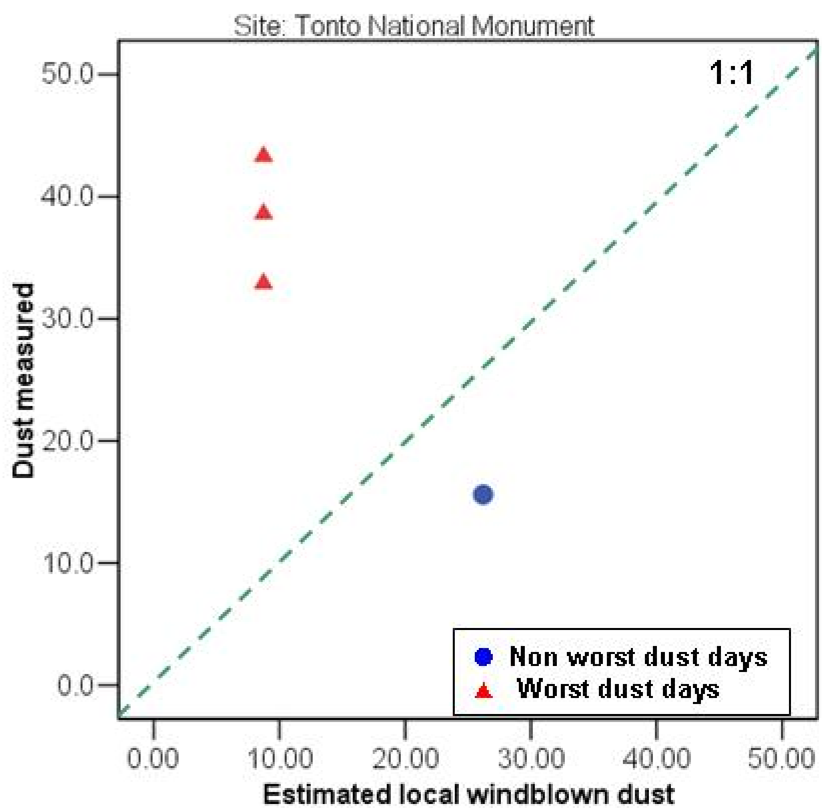
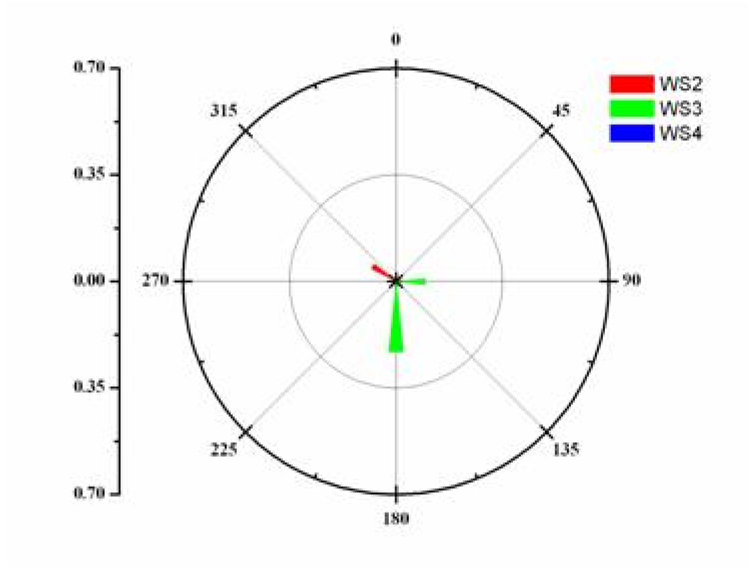


Figure 38

UL Bend Wilderness, MT (ULBE)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

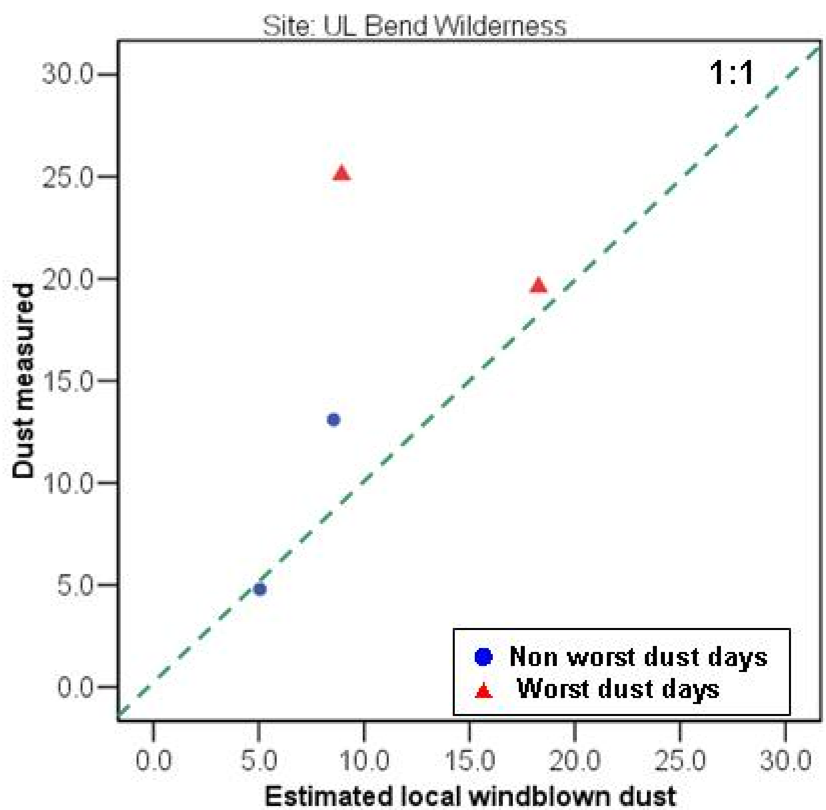
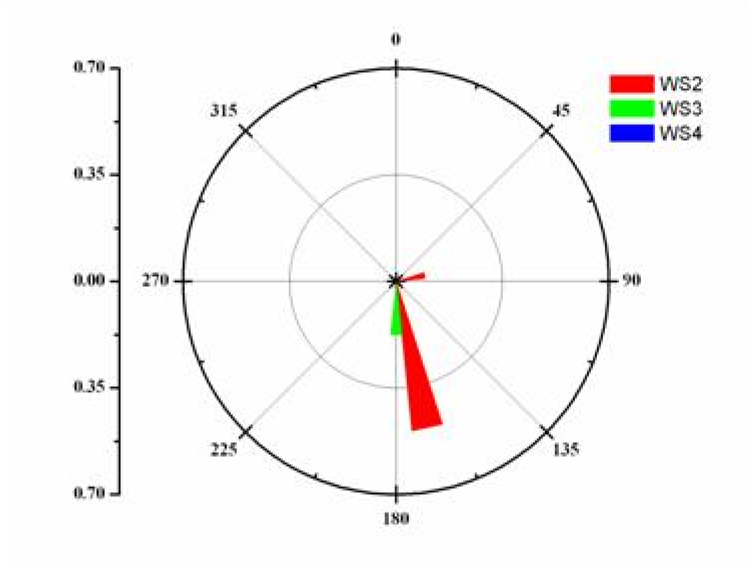


Figure 39

Weminuche Wilderness, CO (WEMI)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

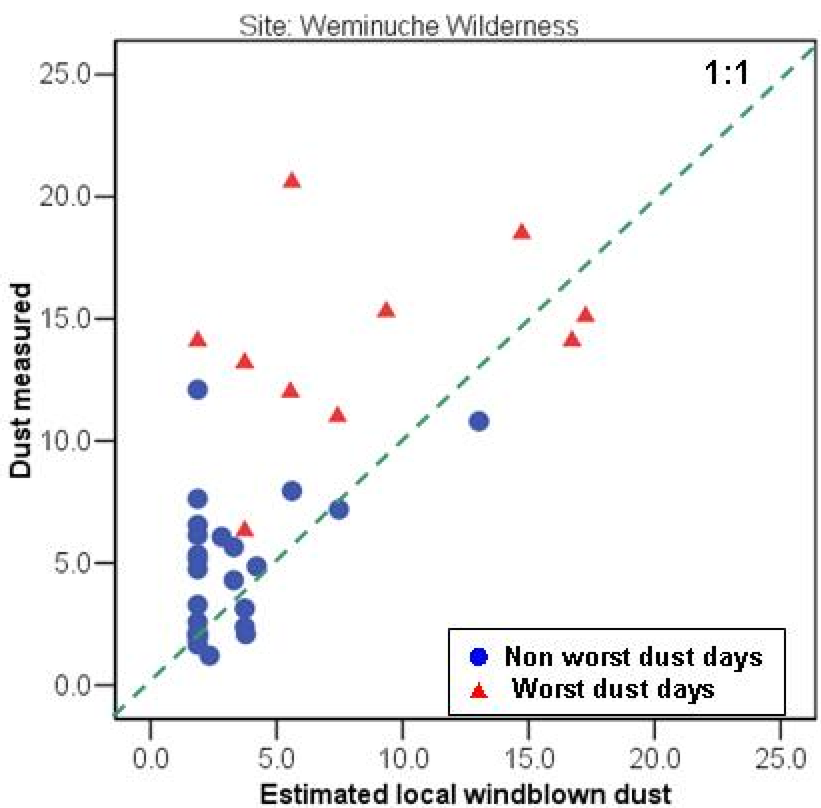
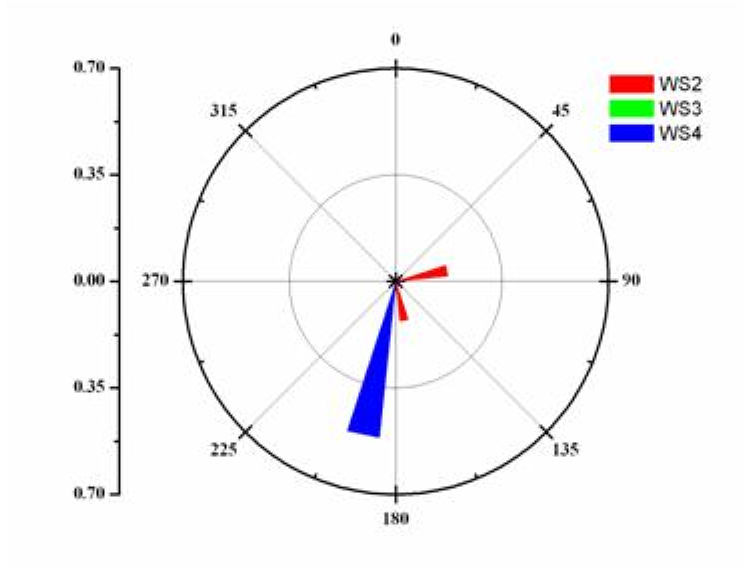


Figure 40

White Mountains Wilderness, NM (WHIT)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

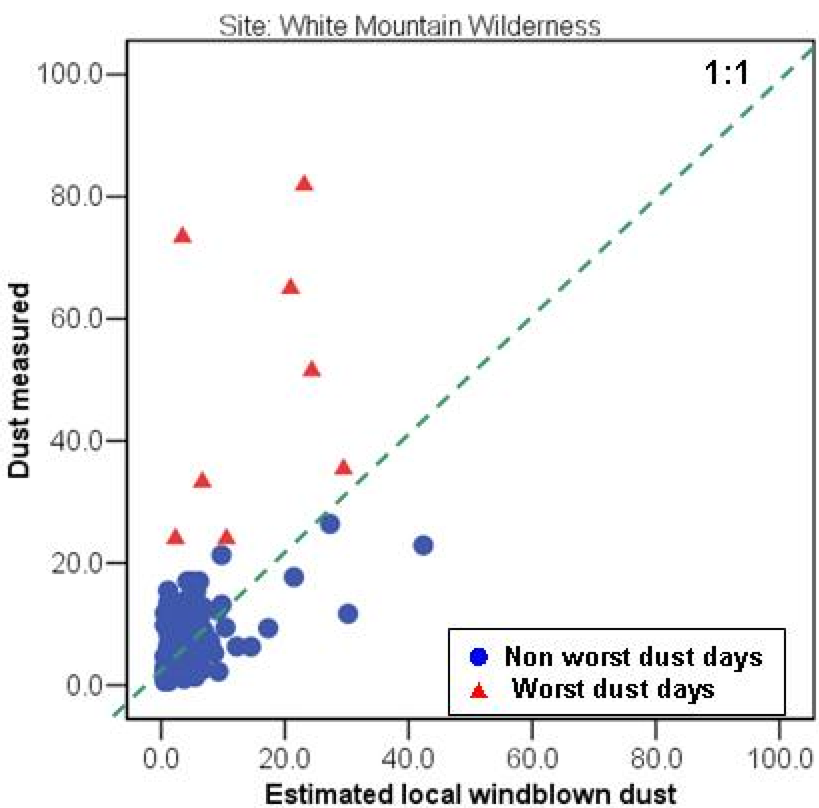
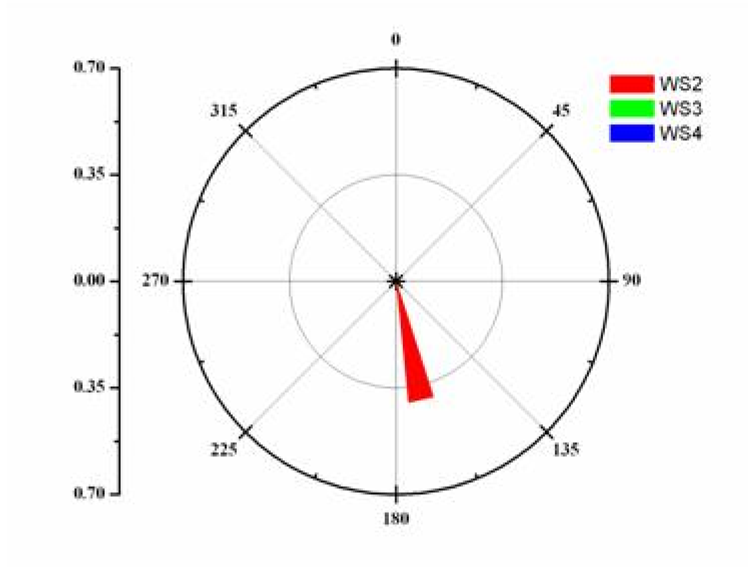


Figure 41

White River National Forest, CO (WHRI)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

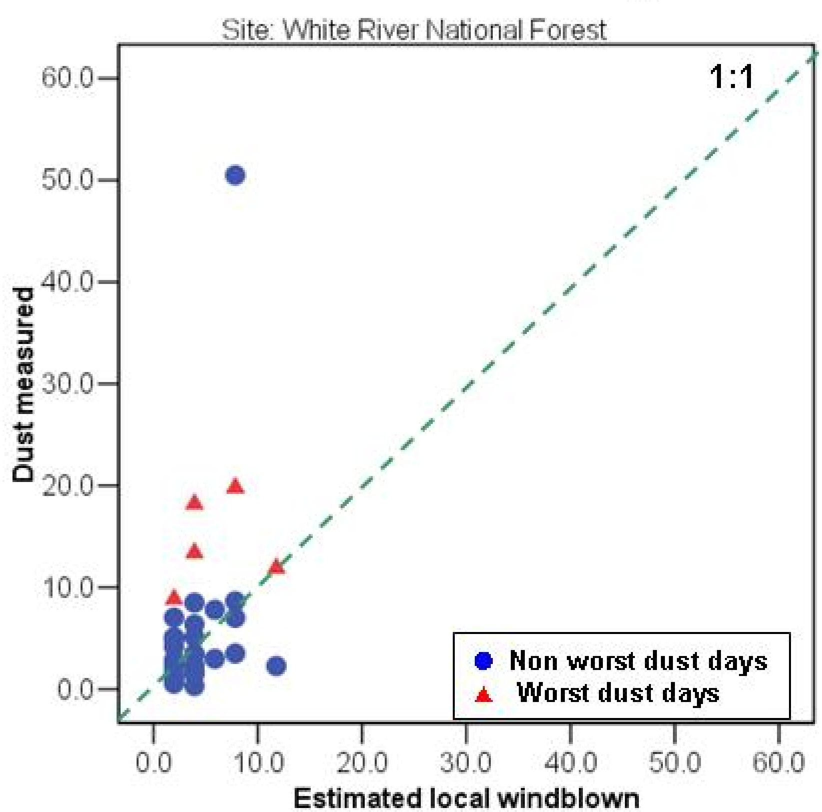
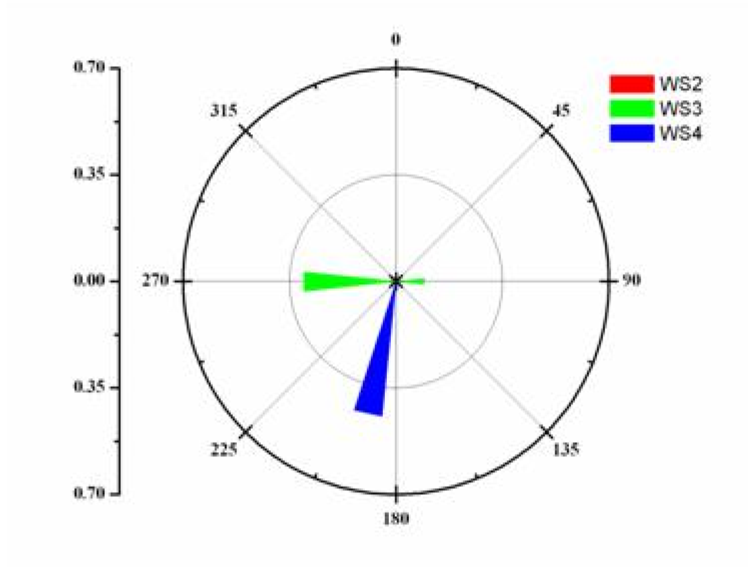


Figure 42

Zion National Park, UT (ZION)

Standardized regression coefficients (measured dust vs. wind speed by quadrant)



Measured dust vs. predicted local windblown dust for IMPROVE sample days when data were available and significant

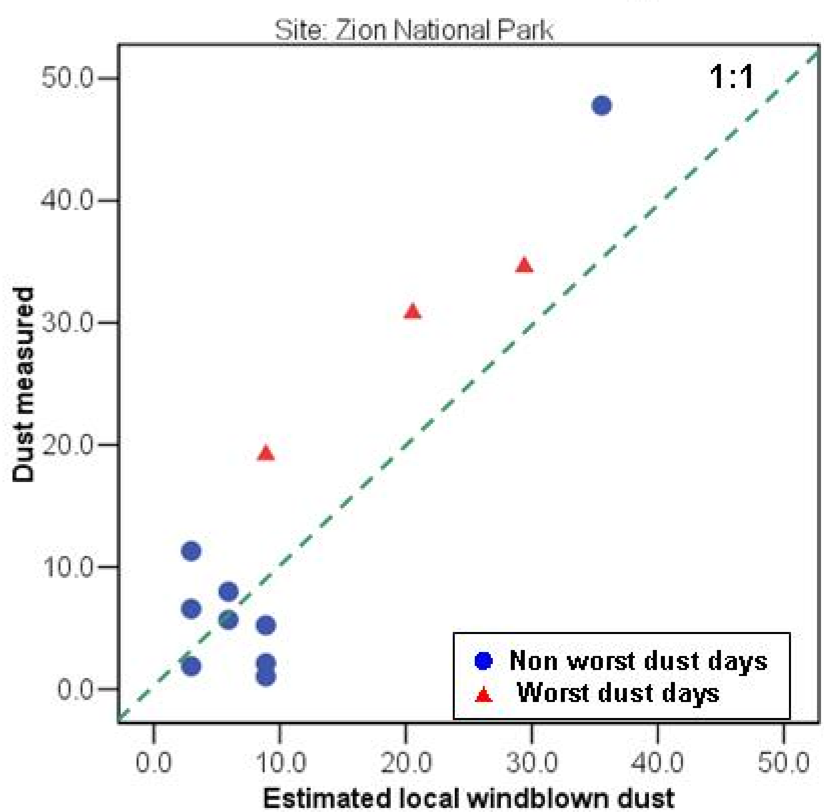


Figure 43: Legends for GIS maps

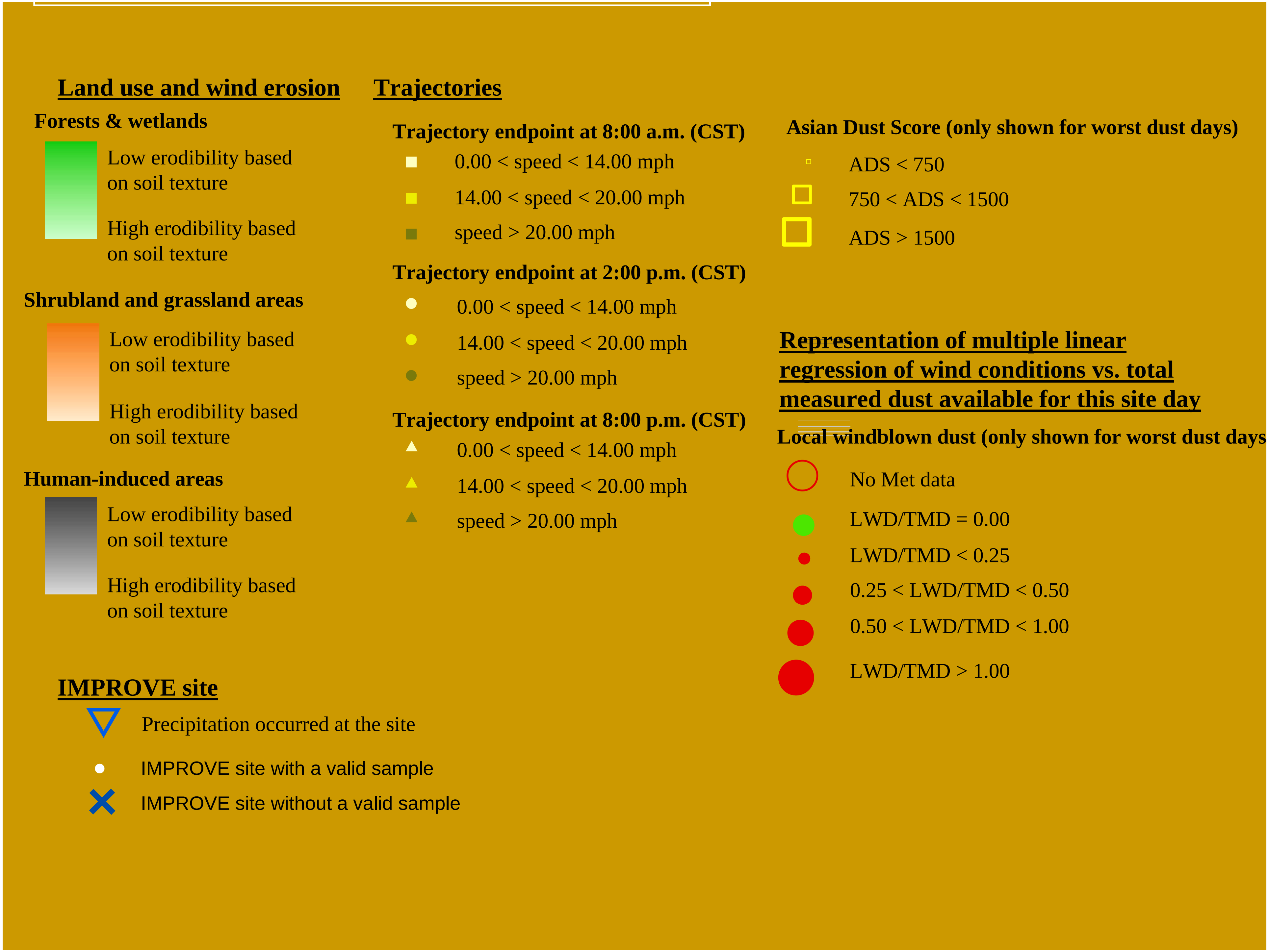


Figure 44. Description of the conclusion obtained from GIS maps