D14 FIU Site Characterization Supporting Data

PREPARED BY	ORGANIZATION	DATE
H Luo/H Loescher/E Ayres	FIU	09/22/2010

APPROVALS (Name)	ORGANIZATION	APPROVAL DATE
Hank Loescher	FIU	10/04/2011

RELEASED BY (Name)	ORGANIZATION	RELEASE DATE
Anne Balsley	CCB Administrator/DCS	10/07/2011

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1 DESCRIPTION

1.1 Purpose

Data collected, analyzed and described here are used to inform the site design activities for NEON project Teams: EHS (permitting), FCC, ENG and FSU. This report was made based on actual site visits to the 3 NEON sites in Domain 14. This document presents all the supporting data for FIU site characterization at Santa Rita and Jornada. We were not permitted access to the Phoenix/CAP LTER site during the FIU site characterization trip. Potential alternative sites were being sought in the Phoenix area.

1.2 Scope

FIU site characterization data and analysis results presented in this document are for two D14 tower locations: Santa Rita site (Advanced) and Jornada site (Relocatable 1). Issues and concerns for each site that need further review are also addressed in this document according to our best knowledge. No FIU site characterization was conducted at NEON CAP LTER candidate site due to permit issues, thus, no results are available for this site in this report.
Disclaimer, accuracy of our latitude and longitude points are subject to the tolerances of our GPS measurement system i.e., ~ ±3 m.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

AD[01]	NEON.DOC.011008 _ FIU Tower Design Science Requirements
AD[02]	NEON.DOC.011000 _ FIU Technical and Operation Requirements
AD[03]	
AD[04]	NEON.DOC.011029 _ FIU Precipitation Collector Site Design Requirements

2.2 Reference Documents

RD[01]	NEON.DOC.000008 NEON Acronym List
RD[02]	NEON.DOC.000243 NEON Glossary of Terms
RD[03]	
RD[04]	

2.3 Acronyms

2.4 Verb Convention

"Shall" is used whenever a specification expresses a provision that is binding. The verbs "should" and "may" express non-mandatory provisions. "Will" is used to express a declaration of purpose on the part of the design activity.

3 SANTA RITA EXPERIMENTAL RANGE (SRER) ADVANCED TOWER SITE

3.1 Site description

NEON candidate tower location at this site is located within property of Santa Rita Experimental Range (Figure 1), University of Arizona. The Santa Rita Experimental Range has served as an important outdoor laboratory for more than a century for researchers investigating sustainable grazing practices. The Santa Rita Experimental Range's 50,000 acres south of Tucson have served as an important outdoor laboratory for more than a century for researchers investigating sustainable grazing practices. The range, which butts up against the Santa Rita mountain range about 30 miles south of Tucson, receives from less than 11 inches of annual rainfall at lower elevations to up to 18 inches at higher elevations, mostly during a brief summer season when most vegetation growth occurs. The summer rains normally begin in late June or early July. (Info source: http://uanews.org/node/29773).

A flux tower (31.9083°, -110.8395°) has been setup at the Santa Rita Experimental Range over Creosote bush (info source: http://public.ornl.gov/ameriflux/Site_Info/siteInfo.cfm?KEYID=us.sr_creosote.01), which is located about 30 miles south of Tucson in southeastern Arizona. This Santa Rita Creosote (SRC) tower is ~ 400 m away from NEON candidate tower location. The SRER is bounded at its southern and eastern borders by the Santa Rita Mountains. Soil at the SRC tower site is sandy loam (~ 65% sand, ~ 24% silt, ~ 11% clay, averaged overall depths) with no caliche layer, to at least 1 m. Long term records from the SRER archives (http://ag.arizona.edu/SRER/ data.html) suggest that the SRC flux station area receives average annual precipitation of 330 mm, half occurring in July through September with monsoon rains and the other half occurring from December through February with winter and spring rains. Unique long-term measurements at the SRC tower site include continuous measurements of soil moisture at multiple depths in multiple profiles all down to 1 m. Additionally, three digital "game" cameras, on a time-lapse setting, are monitoring the daily phonological activity of the *Larrea*, such as green up and flowering, within footprint of the flux tower. (Info source: http://www.fluxnet.ornl.gov/fluxnet/FluxLetter_Vol2_No4.pdf).

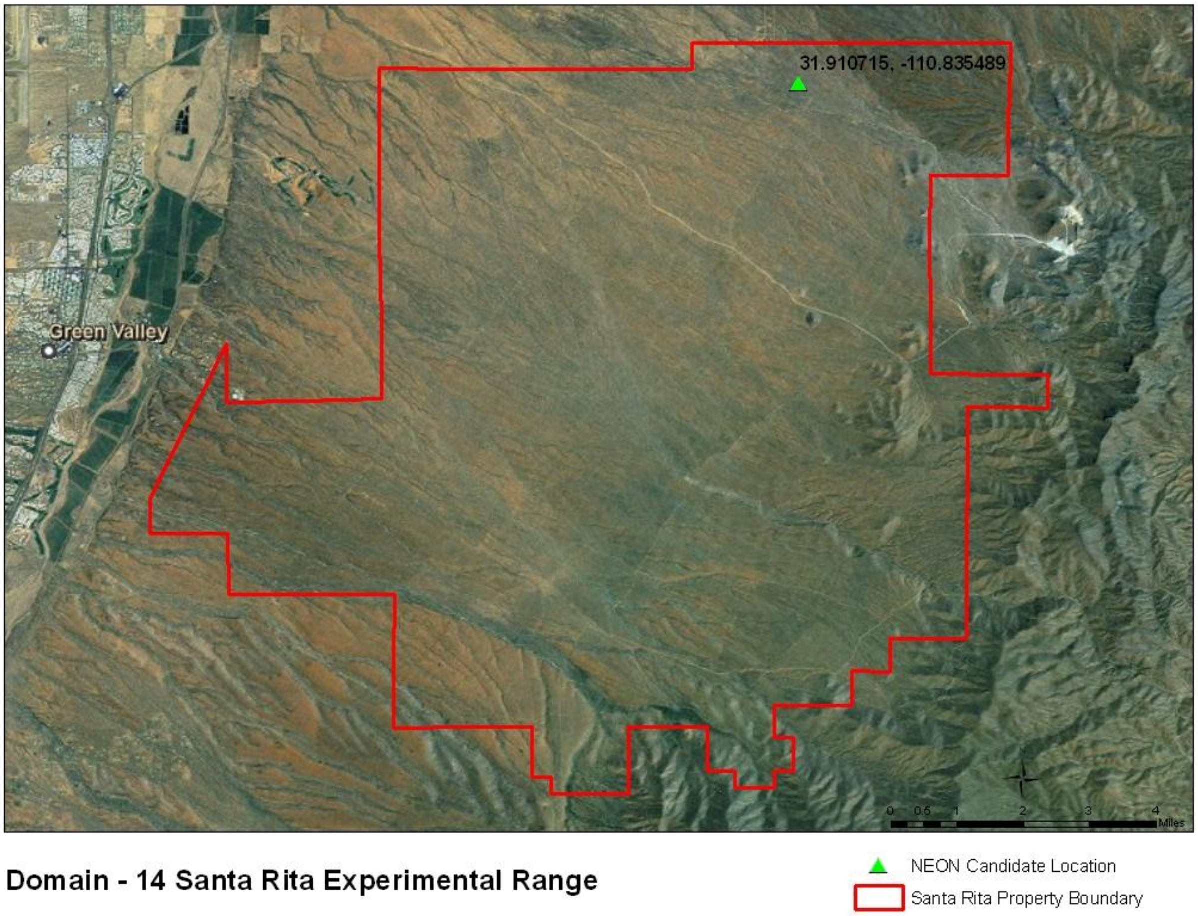


Figure 1. Boundary map for SRER and candidate tower location.

3.2 Ecosystem

Vegetation and land cover information at surrounding region are presented below:

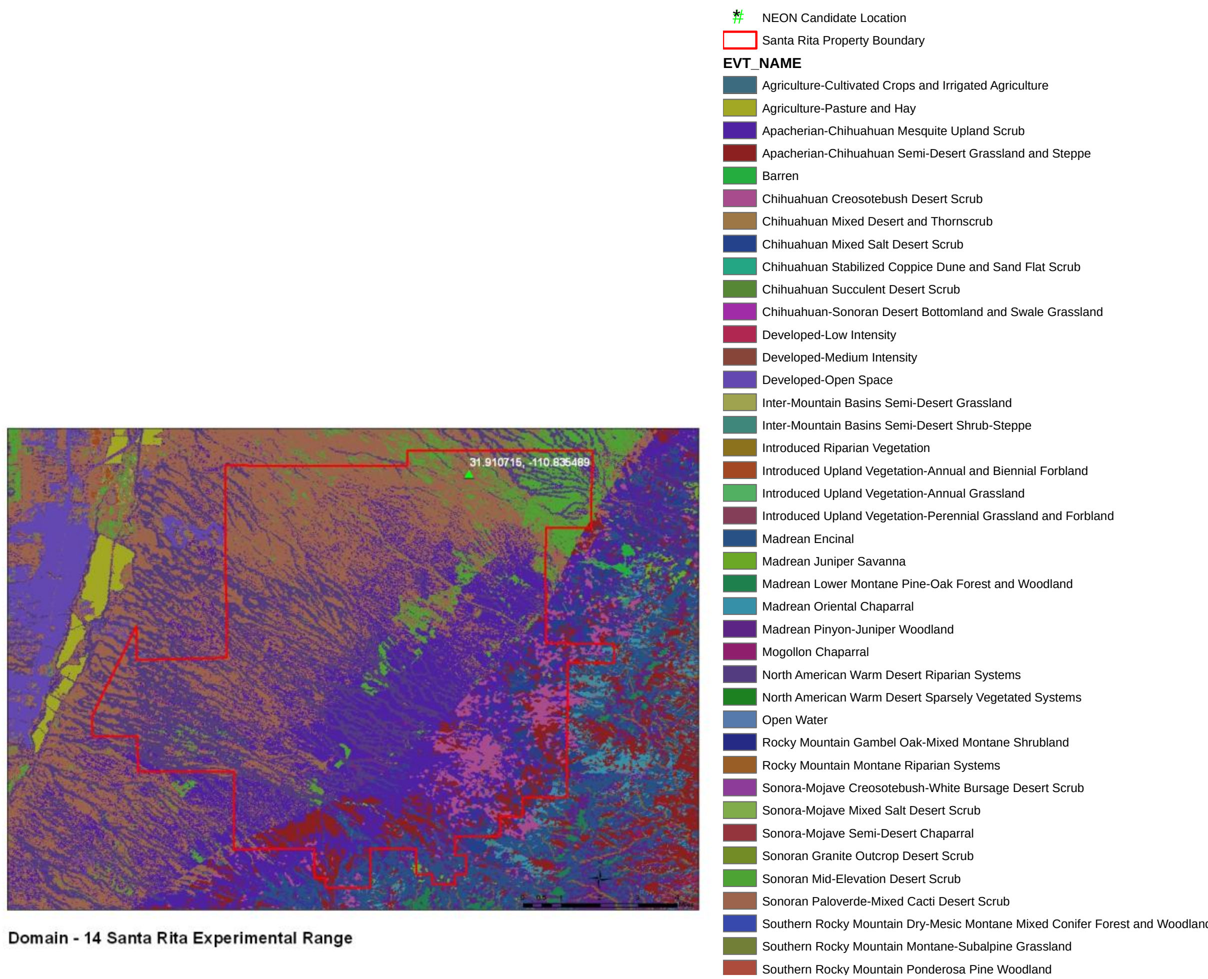


Figure 2. Vegetative cover map of Santa Rita and surrounding areas (information is from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm).

Table 1. Percent Land cover type at Santa Rita (information is from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm)

Vegetation Type	Area (km^2)	Percentage
Agriculture-Cultivated Crops and Irrigated Agriculture	0.016	0.01
Madrean Encinal	3.950	1.84
Madrean Pinyon-Juniper Woodland	1.066	0.50
Chihuahuan Creosotebush Desert Scrub	8.463	3.94
Chihuahuan Mixed Salt Desert Scrub	4.625	2.15
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	0.091	0.04
Sonora-Mojave Mixed Salt Desert Scrub	0.074	0.03
Sonoran Mid-Elevation Desert Scrub	12.128	5.64
Apacherian-Chihuahuan Mesquite Upland Scrub	64.058	29.79
Madrean Oriental Chaparral	0.330	0.15
Mogollon Chaparral	0.425	0.20

Sonoran Paloverde-Mixed Cacti Desert Scrub	66.543	30.95
Madrean Juniper Savanna	0.152	0.07
Apacherian-Chihuahuan Semi-Desert Grassland and Steppe	11.156	5.19
Inter-Mountain Basins Semi-Desert Shrub-Steppe	0.093	0.04
North American Warm Desert Riparian Systems	41.821	19.45
Rocky Mountain Montane Riparian Systems	0.002	0.00
Introduced Riparian Vegetation	0.040	0.02
Total Area Sq Km	215.031	100

Since at least 1904, Creosote bush (*Larrea*) has been the dominant species near the very northern boundary of the SRER. Total canopy cover at the SRC tower site is 24% (14% *Larrea* and the other 10% a combination of annual grasses, annual herbaceous species, and cacti). Soil crusts are also prevalent throughout the site. The height of the average *Larrea* is 1.7 m, with an average of 24 stems about 10 mm in diameter. Thus, *Larrea* at the SRC tower site are larger than many encountered in the southwestern United States. Additionally, insect galls – potentially an indication of plants with minimal water stress – are common on the *Larrea* at this site (Info source: http://www.fluxnet.ornl.gov/fluxnet/FluxLetter_Vol2_No4.pdf).

The USDA ARS SRC AmeriFlux tower site is just ~ 400 m away from NEON candidate tower site. Above ecosystem description is also apply to NEON site. The representative ecosystem that NEON design is focused around for this core site is Creosote bush. Canopy height is ~1.5 to 2.5 m around tower site with lowest branches at ground level. Prickly pear cactus form upper understory with height ~ 1.0 m. Barrel cactus and other annuals form the lower understory with height 0.3 – 0.5 m.

Figure 3 Creosote bush is the dominant vegetation type at SRER site

Table 2. Ecosystem and site attributes for SRER tower site.

Ecosystem attributes	Measure and units

Mean canopy height	2 m
Surface roughness[a]	0.4 m
Zero place displacement height[a]	1.5 m
Structural elements	Open shrubland, uniform
Time zone	Mountain time
Magnetic declination	10° 26' E changing by 0° 6' W/year

Note, [a] From field observation.

3.3 Soils

3.3.1 Soil description

Soil data and soil maps (Figure 4 Table 3) below for Santa Rita tower site were collected from 2.4 km^2 NRCS soil maps(http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm), which centered at the tower location, to determine the dominant soil types in the larger tower foot print. This was done to assure that the soil array is in the dominant (or in the co-dominant) soil type present in the tower footprint.

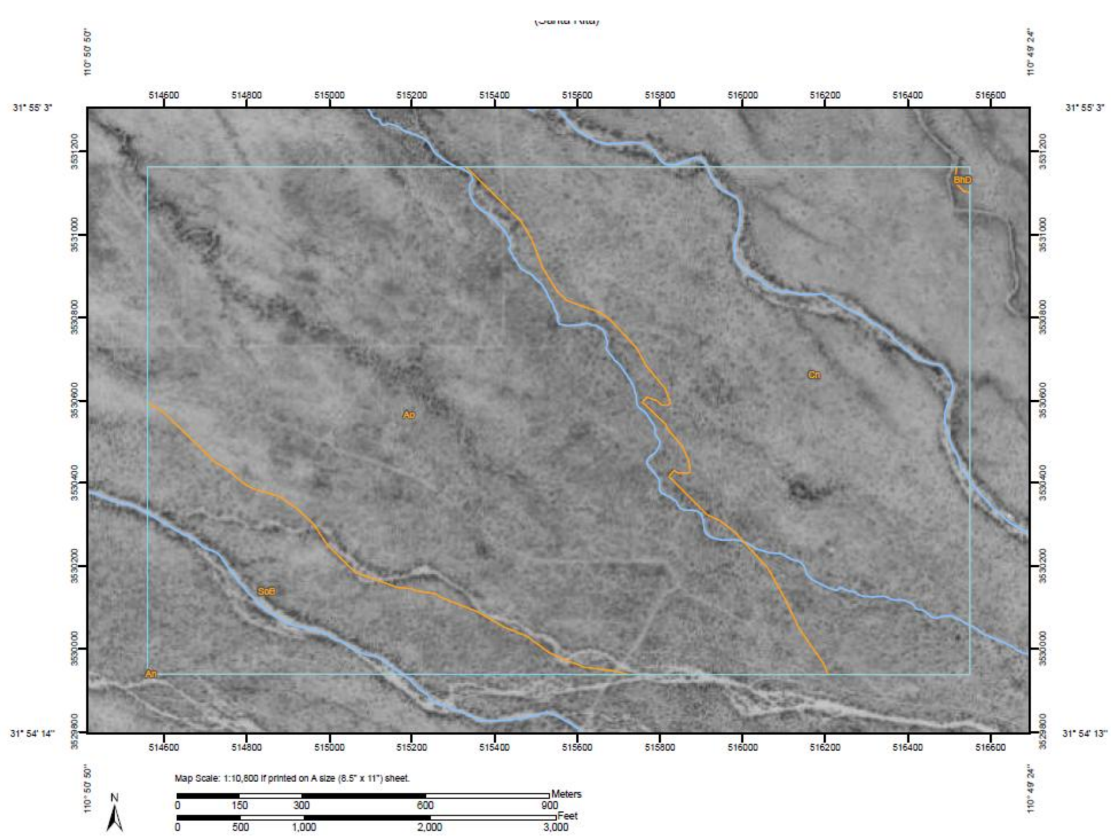


Figure 4. 2.4 km^2 soil map for Santa Rita forest NEON advanced tower site, center at tower location.

Map Unit Description The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit. A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils. Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called non-contrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soil types or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas. An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a soil series. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. Soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into soil phases. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series. Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups. A complex consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example. An association is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example. An undifferentiated group is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example. Some surveys include miscellaneous areas. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example. Additional information about the map units described in this report is available in other soil reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the soil reports define some of the properties included in the map unit descriptions.

Table 3. Soil Series and percentage of soil series within 2.4 km^2 centered on the tower. Area Object Interest (AOI) is the mapping unit from NRCS.

Santa Cruz and Parts of Cochise and Pima Counties, Arizona (AZ667)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
An	Anthony soils	0.0	0.0%
Ao	Anthony soils, very gravelly variants	297.8	49.5%
BhD	Bernardino-Hathaway association, rolling	0.4	0.1%
Cn	Cave gravelly sandy loam	226.6	37.6%
SoB	Sonoita gravelly sandy loam, 1 to 8 percent slopes	77.3	12.8%
Totals for Area of Interest		**602.3**	**100.0%**

Santa Cruz and Parts of Cochise and Pima Counties, Arizona - Ao—Anthony soils, very gravelly variants: Map Unit Setting Elevation: 3,000 to 3,600 feet Mean annual precipitation: 11 to 12 inches Mean annual air temperature: 64 degrees F Frost-free period: 200 to 250 days **Map Unit Composition** Anthony and similar soils: 0 percent Anthony and similar soils: 0 percent **Description of Anthony Setting** Landform: Alluvial fans Landform position (two-dimensional): Summit Landform position (three-dimensional): Tread Down-slope shape: Linear Across-slope shape: Linear Parent material: Recent gravelly alluvium derived from granite and/ or recent gravelly alluvium derived from limestone **Properties and qualities** Slope: 1 to 5 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr) Depth to water table: More than 80 inches Frequency of flooding: Occasional Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Available water capacity: Low (about 5.9 inches) **Interpretive groups** Land capability (nonirrigated): 6s Ecological site: Sandy Loam 12-16" p.z. Deep (R041XC318AZ) **Typical profile** 0 to 16 inches: Fine sandy loam 16 to 60 inches: Very gravelly fine sandy loam **Description of Anthony Setting** Landform: Alluvial fans Landform position (two-dimensional): Summit Landform position (three-dimensional): Tread Down-slope shape: Linear Across-slope shape: Linear Parent material: Recent gravelly alluvium derived from granite and/ or recent gravelly alluvium derived from limestone **Properties and qualities** Slope: 1 to 5 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr) Depth to water table: More than 80 inches Frequency of flooding: Occasional Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Available water capacity: Low (about 5.9 inches) **Interpretive groups** Land capability (nonirrigated): 6s Ecological site: Sandy Loam 12-16" p.z. Deep

(R041XC318AZ) **Typical profile** 0 to 2 inches: Gravelly sandy loam 2 to 16 inches: Fine sandy loam 16 to 60 inches: Very gravelly fine sandy loam

Santa Cruz and Parts of Cochise and Pima Counties, Arizona - An—Anthony soils: Map Unit Setting Elevation: 2,900 to 3,800 feet Mean annual precipitation: 11 to 12 inches Mean annual air temperature: 64 degrees F Frost-free period: 200 to 250 days **Map Unit Composition** Anthony and similar soils: 80 percent **Description of Anthony Setting** Landform: Alluvial fans, flood plains Landform position (two-dimensional): Summit Landform position (three-dimensional): Tread, dip Down-slope shape: Linear Across-slope shape: Linear Parent material: Mixed stratified alluvium **Properties and qualities** Slope: 1 to 3 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr) Depth to water table: More than 80 inches Frequency of flooding: Rare Frequency of ponding: None Calcium carbonate, maximum content: 6 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Available water capacity: Moderate (about 7.6 inches) **Interpretive groups** Land capability (nonirrigated): 6s Ecological site: Sandy Loam 12-16" p.z. Deep (R041XC318AZ) **Typical profile** 0 to 22 inches: Sandy loam 22 to 36 inches: Gravelly sandy loam 36 to 47 inches: Loam 47 to 60 inches: Sandy loam

Santa Cruz and Parts of Cochise and Pima Counties, Arizona - BhD—Bernardino-Hathaway association, rolling: Map Unit Setting Elevation: 3,600 to 5,400 feet Mean annual precipitation: 14 to 20 inches Mean annual air temperature: 55 to 63 degrees F Frost-free period: 160 to 220 days **Map Unit Composition** Bernardino and similar soils: 55 percent Hathaway and similar soils: 25 percent **Description of Bernardino Setting** Landform: Plains, fans Landform position (two-dimensional): Summit Landform position (three-dimensional): Tread Down-slope shape: Convex Across-slope shape: Convex Parent material: Old alluvium derived from igneous rock and/or old alluvium derived from tuff and/or old alluvium derived from limestone **Properties and qualities** Slope: 2 to 15 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 10 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: Moderate (about 7.5 inches) **Interpretive groups** Land capability (nonirrigated): 6e Ecological site: Clay Loam Upland 12-16" p.z. (R041XC305AZ) **Typical profile** 0 to 9 inches: Gravelly clay loam 9 to 15 inches: Gravelly clay 15 to 60 inches: Gravelly sandy loam **Description of Hathaway Setting** Landform: Fans, plains Landform position (two-dimensional): Summit Landform position (three-dimensional): Tread Down-slope shape: Convex Across-slope shape: Convex Parent material: Gravelly old alluvium derived from igneous and sedimentary rock **Properties and qualities** Slope: 2 to 30 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 15 percent Maximum salinity: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/ cm) Available water capacity: Moderate (about 6.2 inches) **Interpretive groups** Land capability (nonirrigated): 6e Ecological site: Limy Slopes 12-16" p.z. (R041XC308AZ) **Typical profile** 0 to 5 inches: Gravelly sandy loam 5 to 10 inches: Gravelly sandy clay loam 10 to 20 inches: Gravelly sandy loam 20 to 39 inches: Very gravelly sandy loam 39 to 60 inches: Sandy loam

Santa Cruz and Parts of Cochise and Pima Counties, Arizona - Cn—Cave gravelly sandy loam: Map Unit Setting Elevation: 3,200 to 3,800 feet Mean annual precipitation: 11 to 12 inches Mean annual air temperature: 64 degrees F Frost-free period: 240 to 270 days **Map Unit Composition** Cave and similar soils: 95 percent **Description of Cave Setting** Landform: Alluvial fans Landform position (two-dimensional): Summit Landform position (three-dimensional): Tread Down-slope shape: Convex Across-slope shape: Convex Parent material: Gravelly old alluvium derived from igneous rock and/ or gravelly old alluvium derived from granite and/or gravelly old alluvium derived from limestone **Properties and qualities** Slope: 0 to 5 percent Depth to restrictive feature: 4 to 20 inches to petrocalcic Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 25 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Sodium adsorption ratio, maximum: 30.0 Available water capacity: Very low (about 0.7 inches) **Interpretive groups** Land capability (nonirrigated): 7s Ecological site: Limy Upland 12-16" p.z. (R041XC309AZ) **Typical profile** 0 to 7 inches: Gravelly sandy loam 7 to 18 inches: Cemented material 18 to 60 inches: Very gravelly sandy loam

Santa Cruz and Parts of Cochise and Pima Counties, Arizona - SoB—Sonoita gravelly sandy loam, 1 to 8 percent slopes: Map Unit Setting Elevation: 3,800 to 5,000 feet Mean annual precipitation: 10 to 14 inches Mean annual air temperature: 59 to 64 degrees F Frost-free period: 200 to 265 days Map Unit Composition Sonoita and similar soils: 85 percent **Description of Sonoita Setting** Landform: Terraces, alluvial fans Landform position (two-dimensional): Summit Landform position (three-dimensional): Tread Down-slope shape: Convex Across-slope shape: Convex Parent material: Old alluvium derived from igneous rock and/or old alluvium derived from granite **Properties and qualities** Slope: 1 to 8 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 5 percent Available water capacity: Moderate (about 7.2 inches) **Interpretive groups** Land capability (nonirrigated): 6e Ecological site: Sandy Loam Upland 12-16" p.z. (R041XC319AZ) **Typical profile** 0 to 4 inches: Gravelly sandy loam 4 to 26 inches: Gravelly sandy loam 26 to 60 inches: Gravelly sandy loam

3.3.2 Soil semi-variogram description

The goal of this aspect of the site characterization is to determine the minimum distance between the soil plots in the soil array such that data farther apart can be considered spatially independent. The collected field data will be used to produce semivariograms, which is a geostatistical technique to characterize spatial autocorrelation between mapped samples of a quantitative variable (*e.g.*, soil property data in our case). In an empirical semivariogram, the average of the squared differences of a response variable is computed for all pairs of points within specified distance intervals (lag classes). The output is presented graphically as a plot of the average semi-variance versus distance class (Figure 5). For the theoretical variogram models considered here, the semivariance will converge on the total variance at distances for which values are no longer spatially auto-correlated (this is referred to as the range, Figure 5).

For the theoretical variograms considered here, three parameters estimated from the data are used to fit a semivariogram model to the empirical semivariogram. This model is then assumed to quantitatively represent the correlation as a function of distance (Figure 5), the range, the sill (the sill is the asymptotic value of semi-variance at the range), and the nugget (which describes sampling error or variation at distances below those separating the closest pairs of samples). The range, sill and nugget are estimated from theoretical models that are fitted to the empirical variograms using non-linear least squares methods.

The variogram analysis will be used, to determine the spatial scales at which we can consider soil measurements spatially independent. This characterization will directly inform the minimum distance between *i*) soil plots within each soil array, *ii*) the soil profile measurements, *iii*) EP plots, and *iv*) the microbial sampling locations. These data will directly inform NEON construction and site design activities.

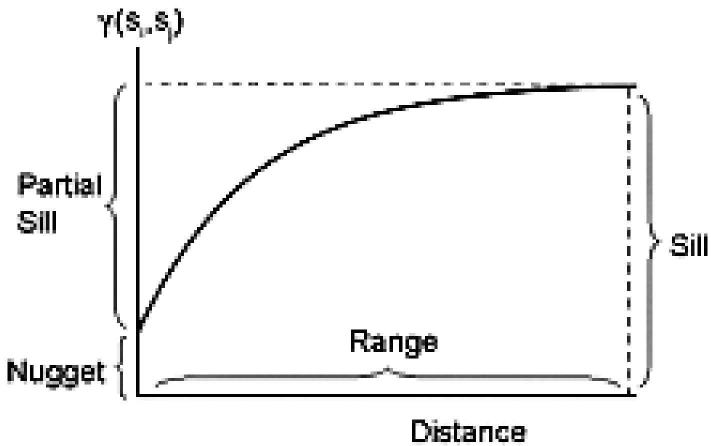


Figure 5. Example semivariogram, depicting range, sill, and nugget.

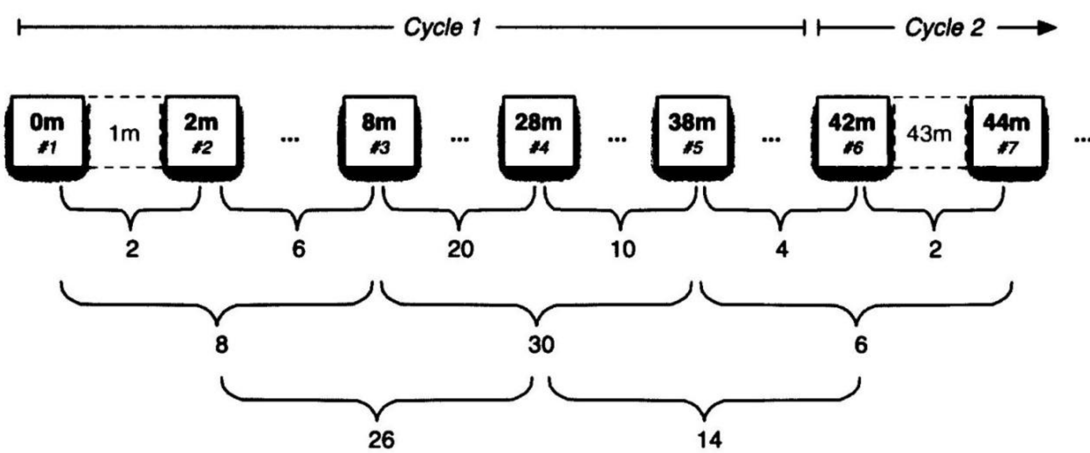


Figure 6. Spatially cyclic sampling design for the measurements of soil temperature and soil water content.

Field measurements of soil temperature (0-12 cm) and moisture (0-15 cm) were taken on 25 August 2010 at the Santa Rita site. The sampling points followed the spatially cyclic sampling design by Bond-Lamberty et al. (2006) (Figure6). Soil temperature and moisture measurements were collected along three transects (200 m, 84 m, and 84 m) located in the expected airshed at Santa Rita. Details of how the airshed was determined are provided below. Soil temperature was measured with platinum resistance temperature sensors (RTD 810, Omega Engineering Inc., Stamford CT) and soil moisture was measured with time domain diaelectric sensors (CS616, Campbell Scientific Inc., Logan UT).

As well as measuring soil temperature and moisture at each sample point in Figure6, measurements were also taken 30 cm in front and behind the sampling point along the axis of the transect. For example, at the 2 m sampling point, soil temperature and moisture was measured at 1.7 m, 2 m, and 2.3 m; this data is referred to as mobile data, since the measurements were taken at many different locations. In addition, soil temperature and moisture were continuously recorded at a single fixed location (stationary data) throughout the sampling time to correct for changes in temperature and moisture throughout the day.

Data collected were used for geospatial analyses of variograms in the R statistical computing language with the geoR package to test for spatial autocorrelation (Trangmar *et al.* 1986; Webster & Oliver 1989; Goovaerts 1997; Riberiro & Diggle 2001) and estimate the distance necessary for independence among soil plots in the soil array. To correct for changes in temperature and moisture over the sampling period, the stationary data was subtracted from the mobile data. In many instances a time of day trend was still apparent in the data even after subtracting the stationary data from the mobile data. This time of day trend was corrected for by fitting a linear regression and using the residuals for the semivariogram analysis. Soil temperature and moisture data, R code, graphs, and R output can be found at: P:\FIU\FIU_Site_Characterization\DXX\YYYYYYY_Characterization\Soil Measurements\Soil Data Analysis (where XX = domain number and YYYYYYY = site name).

3.3.3 Results and interpretation

3.3.3.1 Soil Temperature

Soil temperature data residuals, after accounting for changes in temperature in the stationary data and any remaining time of day trend, were used for the semivariogram analysis (Figure 7). Exploratory data analysis plots show that there was no distinct patterning of the residuals (Figure 8, left graphs) and directional semivariograms do not show anisotropy (Figure 8, center graph). An isotropic empirical semivariogram was produced and a spherical model was fitted using Cressie weights (Figure 8, right graph). The model indicates a distance of effective independence of 10 m for soil temperature.

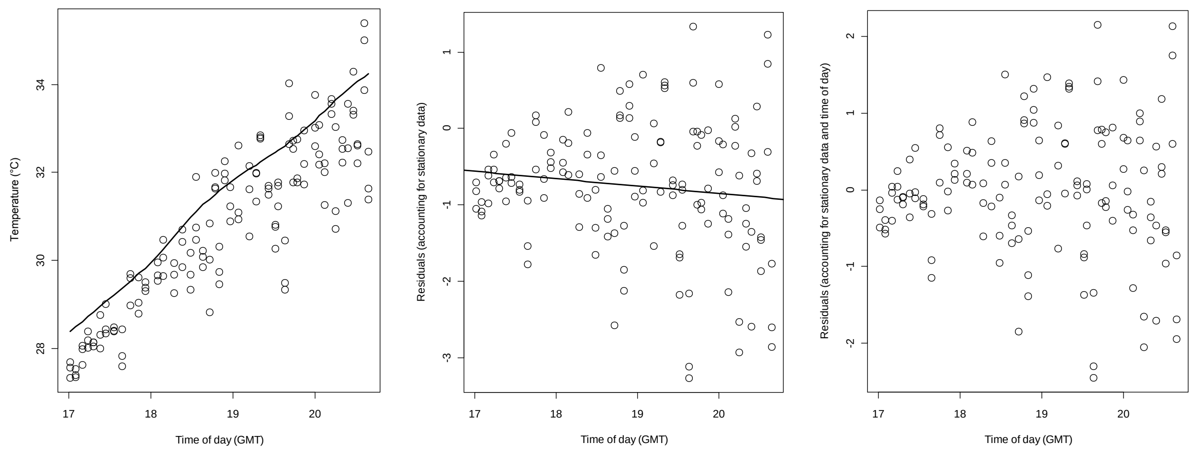


Figure 7. Left graph: mobile (circles) and stationary (line) soil temperature data. Center graph: temperature data after correcting for changes in temperature in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual temperature data after correcting for changes temperature in the stationary data and the time of day regression. Data in the right graph were used for the semivariogram analysis.

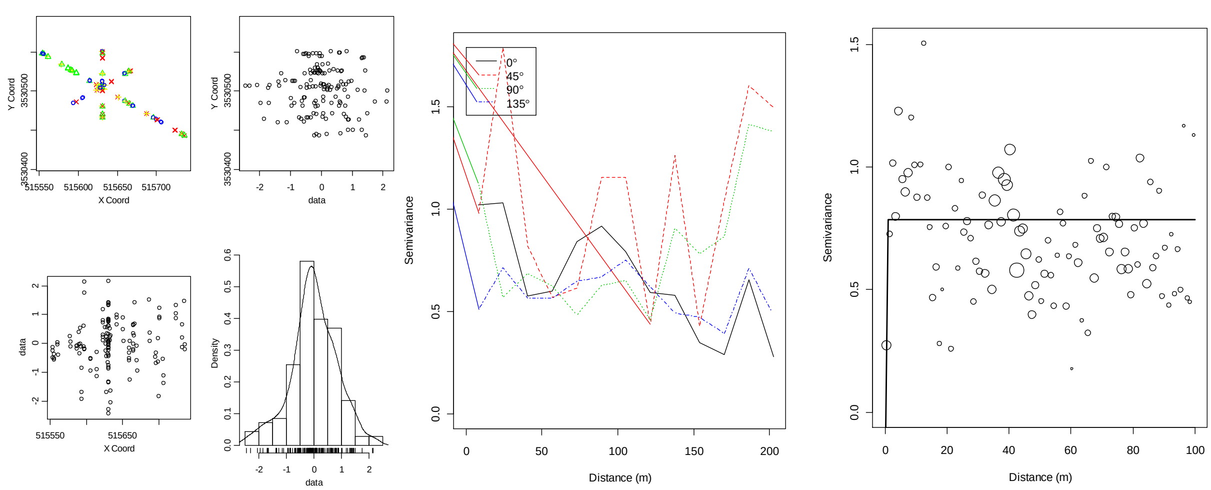


Figure 8. Left graphs: exploratory data analysis plots for residuals of temperature. Center graph: directional semivariograms for residuals of temperature. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of temperature.

3.3.3.2 Soil water content

Soil water content data residuals, after accounting for changes in water content in the stationary data and any remaining time of day trend, were used for the semivariogram analysis (Figure 9). Exploratory data analysis plots show that there was no distinct patterning of the residuals (Figure 10, left graph) and directional semivariograms do not show anisotropy (Figure 10, center graph). An isotropic empirical semivariogram was produced and a spherical model was fitted using Cressie weights (Figure 10, right graph). The model indicates a distance of effective independence of 17 m for soil water content.

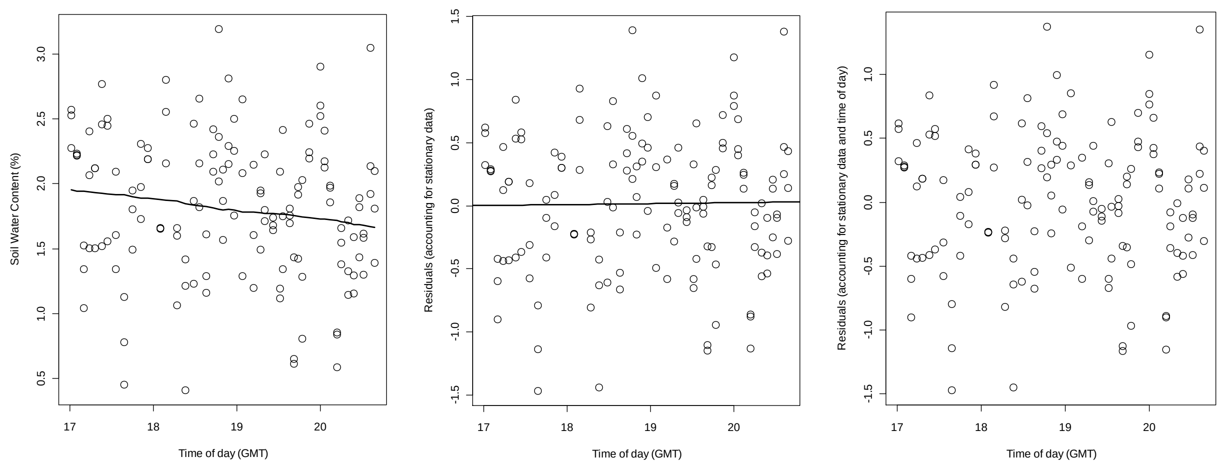


Figure 9. Left graph: mobile (circles) and stationary (line) soil water content data. Center graph: water content data after correcting for changes in water content in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual water content data after correcting for changes water content in the stationary data and the time of day regression. Data in the right graph were used for the semivariogram analysis.

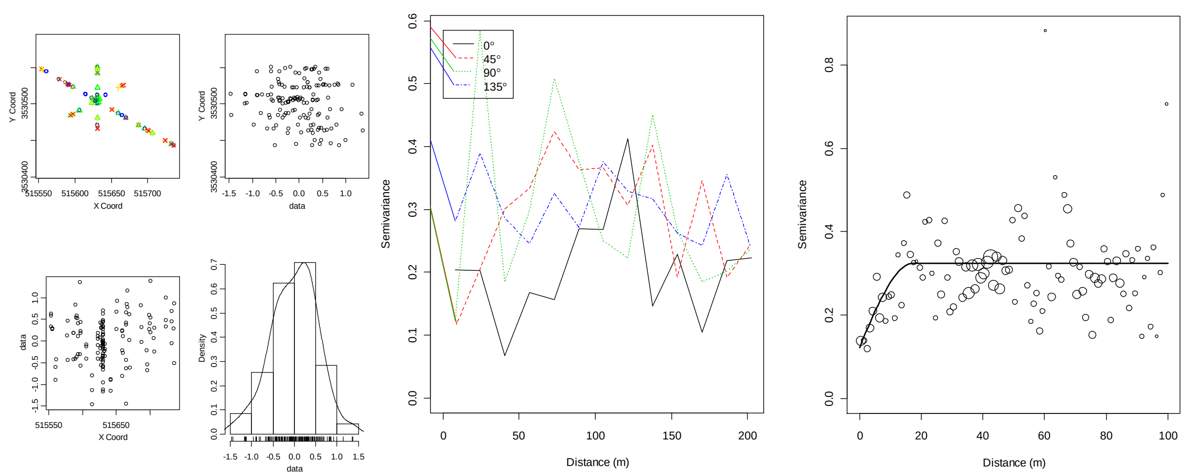


Figure 10. Left graphs: exploratory data analysis plots for residuals of soil water content. Center graph: directional semivariograms for residuals of water content. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of water content.

3.3.3.3 Soil array layout and soil pit location

The minimum distance allowable between soil plots is 25 m to ensure a degree of spatial independence in non-measured soil parameters (i.e., other than temperature and water content) and the maximum distance allowable between soil plots is 40 m due to cost constraints. The estimated distance of effective independence was 10 m for soil temperature and 17 m for soil moisture. Based on these results and the site design guidelines the soil plots at Santa Rita shall be placed 25 m apart. The soil array shall follow the linear soil array design (Soil Array Pattern B) with the soil plots being 5 m x 5 m. The direction of the soil array shall be 120° from the soil plot nearest the tower (i.e., first soil plot). The location of the first soil plot will be approximately 31.91082°, -110.83543°. The exact location of each soil plot will be chosen by an FIU team member during site construction to avoid placing a soil plot at an unrepresentative location (e.g., rock outcrop, drainage channel, large tree, etc). The FIU soil pit for characterizing soil horizon depths, collecting soil for site-specific sensor calibration, and collecting soil for the FIU soil archive will be located at 31.90863, -110.83781 (primary location); or 31.90830, -110.83736 (alternate location 1 if primary location is unsuitable); or 31.90804, -110.83694 (alternate location 2 if primary location is unsuitable). A summary of the soil information is shown in Table 4 and site layout can be seen in Figure 11.

Dominant soil series at the site: Anthony soils, very gravelly variants. The taxonomy of this soil is shown below:
Order: Entisols
Suborder: Fluvents
Great group: Torrifluvents
Subgroup: Typic Torrifluvents
Family: Coarse-loamy, mixed, superactive, calcareous, thermic Typic Torrifluvents
Series: Anthony soils, very gravelly variants

Table 4. Summary of soil array and soil pit information at Santa Rita.
0° represents true north and accounts for declination.

Soil plot dimensions	5 m x 5 m
Soil array pattern	B
Distance between soil plots: x	25 m
Distance from tower to closest soil plot: y	16 m
Latitude and longitude of 1st soil plot OR direction from tower	31.91065°, -110.83533°
Direction of soil array	120°
Latitude and longitude of FIU soil pit 1	31.90863, -110.83781 (primary location)
Latitude and longitude of FIU soil pit 2	31.90830, -110.83736 (alternate 1)
Latitude and longitude of FIU soil pit 3	31.90804, -110.83694 (alternate 2)
Dominant soil type	Anthony soils, very gravelly variants
Expected soil depth	>2 m
Depth to water table	>2 m

Expected depth of soil horizons	**Expected measurement depths***
0-0.05 m (Gravelly sandy loam)	0.03 m

0.05-0.41 m (Fine sandy loam)	0.23 m
0.41-1.52 m (Very gravelly fine sandy loam)	0.97 m

*Actual soil measurement depths will be determined based on measured soil horizon depths at the NEON FIU soil pit and may differ substantially from those shown here.

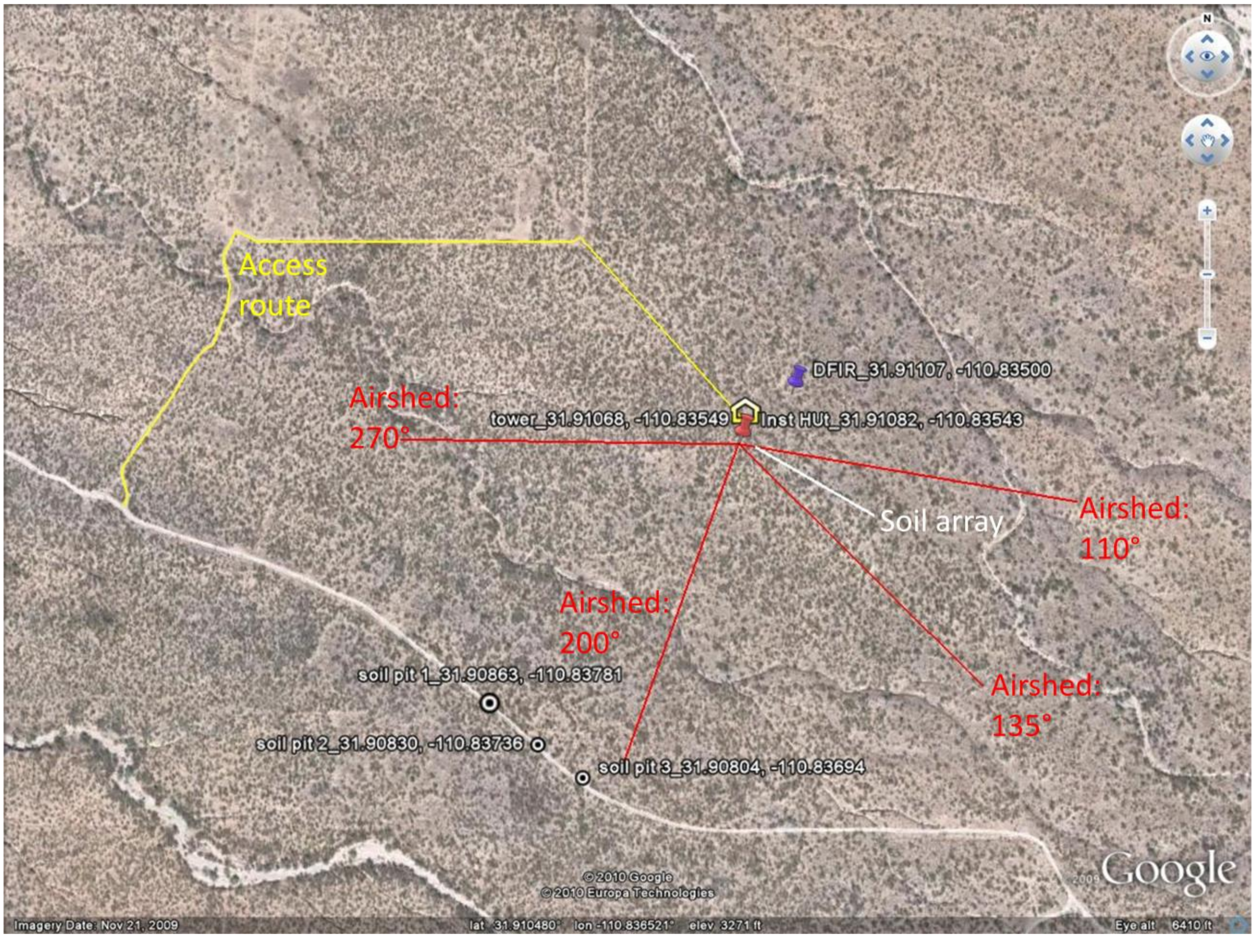


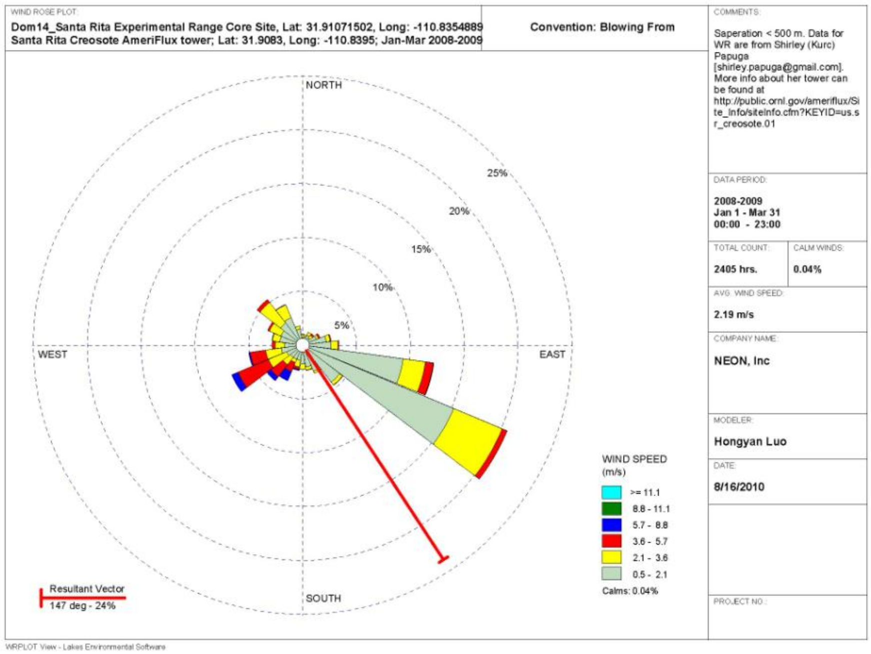
Figure 11. Site layout at Santa Rita showing soil array and location of the FIU soil pit.

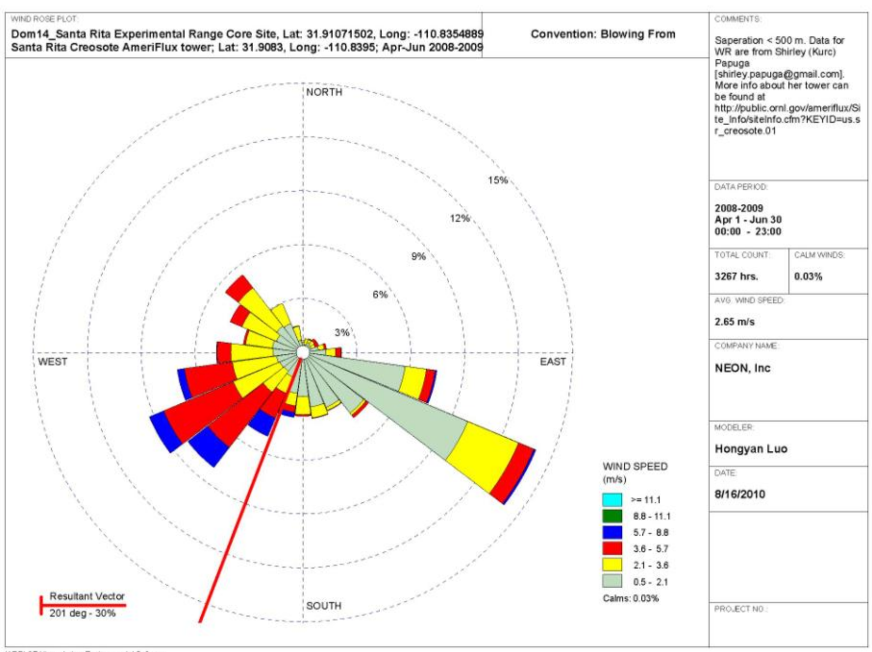
3.4 Airshed

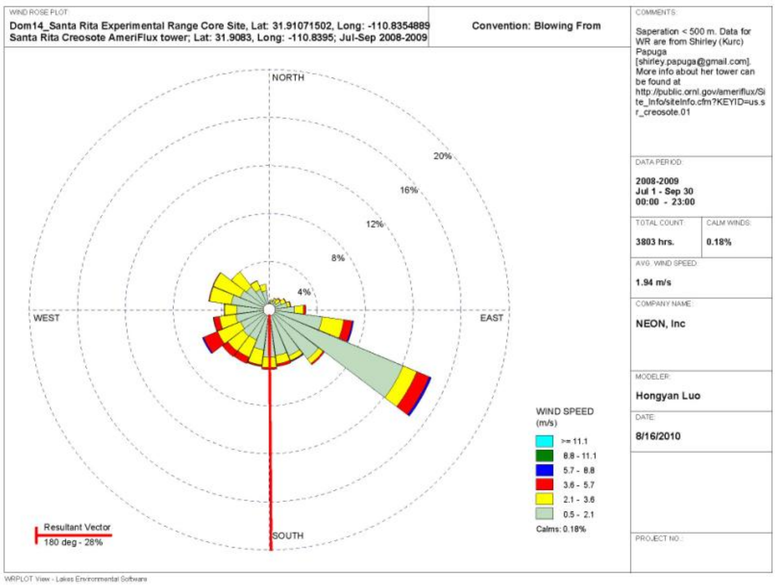
3.4.1 Seasonal windroses

Wind roses analytically determine and graphically represent the frequencies of wind direction and wind speed over a given timeseries, Figure 12. The weather data used to generate the following wind roses are from Santa Rita Creosote AmeriFlux tower site at 31.9083°, -110.8395°, which is ~460 m from NEON tower site. The orientation of the wind rose follows that of a compass (assume declination applied). When we describe the wind directions it should be noted that they are the cardinal direction that wind blows from. The directions of the rose with the longest spoke show wind directions with the largest frequency. These wind roses are subdivided into as 24 cardinal directions.

3.4.2 Results (graphs for wind roses)







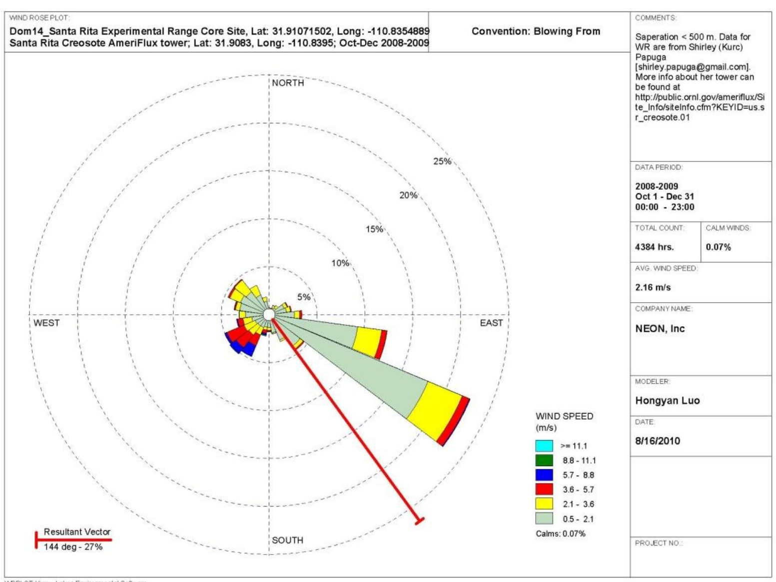


Figure 12. Windroses from the Santa Rita Core site.
Data used here are hourly data from 2008 to 2009. Data was collected and obtained from Santa Rita Creosote AmeriFlux tower site at 31.9083°, -110.8395°. It is assumed that the wind data was corrected for declination. Panels are (from top to bottom), Jan-Mar, Apr-Jun, Jul-Sept, and Oct-Dec.

3.4.3 Resultant vectors

Table 5. The resultant wind vectors from Santa Rita Core site using hourly data from 2008 to 2009.

Quarterly (seasonal) timeperiod	Resultant vector	% duration
January to March	147°	24
April to June	201°	30
July to September	180°	28
October to December	144°	27
Annual	168°	na.

3.4.4 Expected environmental controls on source area

Two types of models were commonly used to determine the shape and extent of the source area under different and contrasting atmospheric stability classes. An inverted plume dispersion model with modeled cross wind solutions were used for convective conditions (Horst and Weil 1994). For strongly stable conditions, and Lagrangian solution was used (Kormann and Meixner 2001). The source area models where bounded by the expected conditions depict the extreme conditions. Convective conditions typically have strong vertical mixing between the ecosystem and atmosphere (surface layer). Stable conditions typically have long source area and associated waveforms. Convective turbulence is often characterized by short mixing scales (scalar) and moderate daytime wind speeds, *e.g.,* 1-4 m s^{-2}. Higher wind speeds, like those experienced over the Rockies, are often the product of mechanical turbulence with long waveforms. Because thermal stratification is very efficient in suppressing vertical mixing, stable conditions also have typically very long waveforms.

As a general rule, shorter and less structurally complex ecosystems have good vertical mixing during all atmospheric stabilities. Taller and more structurally complex ecosystems have well mixed upper canopies during the daytime, and can be decoupled below the canopy under neutral and stable conditions (e.g., Harvard Forest, Bartlett Experimental Forest, and Burlington Conservation Area). The type of turbulence (mechanical verse convective) and the physical attributes of the ecosystem control the degree of mixing, and the length and size of the source area.

Here, we used a web-based footprint model to determine the footprint area under various conditions (model info: http://www.geos.ed.ac.uk/abs/research/micromet/EdiTools/). Winds used to run the model and generate following model results are extracted from the wind roses. Vegetation information, temperature and energy information were either from the RFI document, previous site visit report, available data files or best estimated from experienced expert. Measurement height was determined from the Tower Height Info document provided by ENG group, then verify according to the real ecosystem structure after FIU site characterization at site. Runs 1-3 and 4-6 represents the expected conditions for summer and winter conditions, respectively, with maximum and mean windspeeds (daytime convective) and nighttime (stable atmospheres) conditions. The wind vector for each run was estimated from wind roses and is placed as a centerline in the site map included in the graphics. The width of the footprint was also estimated using the length between the isopleth of 80% cumulative flux and center line to calculate the angle from centerline. This information, along with distance of the cumulative flux isopleths and wind direction, will define the source area for the flux measurements on the top of the tower.

Table 6. Expected environmental controls to parameterize the source area model, and associated results from SRER advanced site.

Parameters	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Run 6**	
Approximate season	summer			winter			Units
	Day (max WS)	Day (mean WS)	Night	Day (max WS)	Day (mean WS)	night	qualitative
Atmospheric stability	Convective	convective	Stable	Convective	convective	Stable	qualitative
Measurement height	6	6	6	6	6	6	m
Canopy Height	3	3	3	3	3	3	m
Canopy area density	1.8	1.8	1.8	1.8	1.8	1.8	m
Boundary layer depth	4000	4000	2800	2800	2800	1100	m
Expected sensible heat flux	600	600	-150	275	275	-75	W m^{-2}
Air Temperature	35	35	24	23	23	15	°C
Max. windspeed	8.8	2.5	3.0	5.7	2.7	3.0	m s^{-1}
Resultant wind vector	120	120	240	120	120	240	degrees
Results							
(z-d)/L	-0.01	-0.29	0.25	-0.02	-0.15	0.08	m
d	2.20	2.20	2.20	2.20	2.20	2.20	m
Sigma v	3.30	2.50	1.80	2.30	1.80	1.80	m^2 s^{-2}
Z0	0.18	0.18	0.18	0.18	0.18	0.18	m
u*	1.20	0.44	0.29	0.78	0.42	0.35	m s^{-1}
Distance source area begins	0	0	0	0	0	0	m
Distance of 90% cumulative flux	300	180	800	300	200	500	m
Distance of 80% cumulative flux	200	100	400	200	120	250	m
Distance of 70% cumulative flux	100	50	250	120	80	200	m
Peak contribution	25	15	25	25	15	25	m

3.4.5 Results (source area graphs)

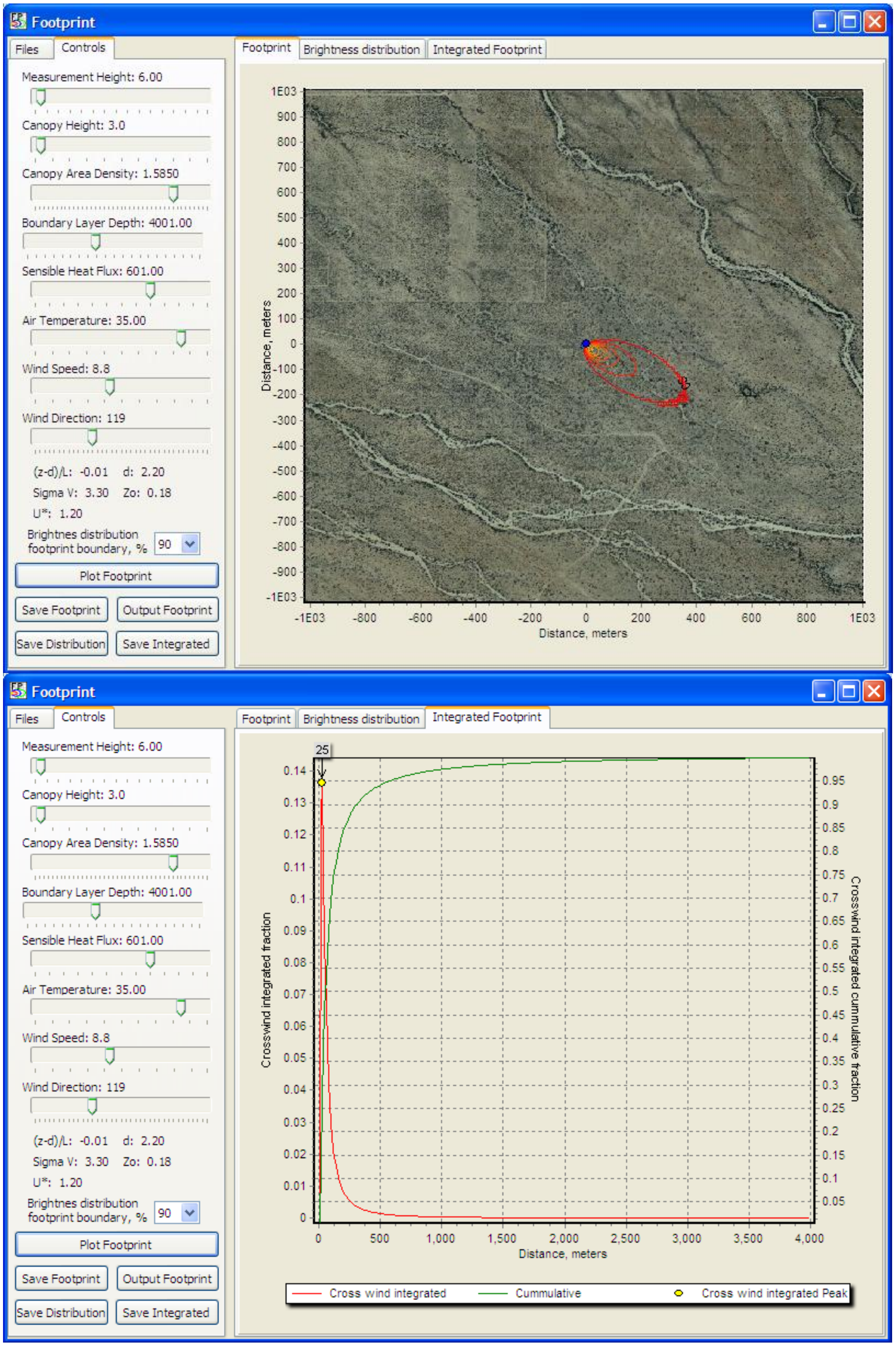


Figure 13. SRER Forest summer daytime (convective) footprint output with max wind speed.

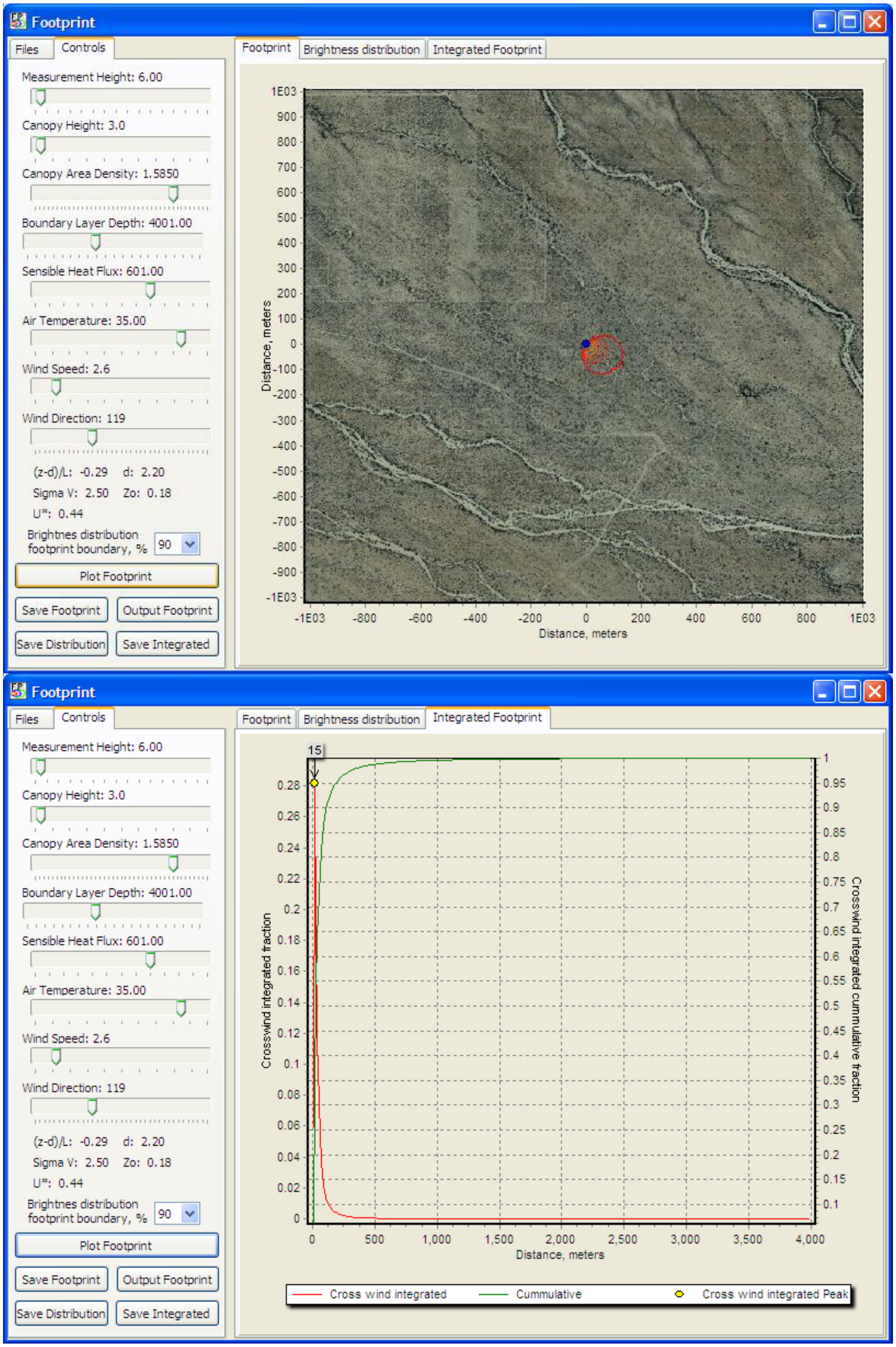


Figure 14. SRER summer daytime (convective) footprint output with mean wind speed.

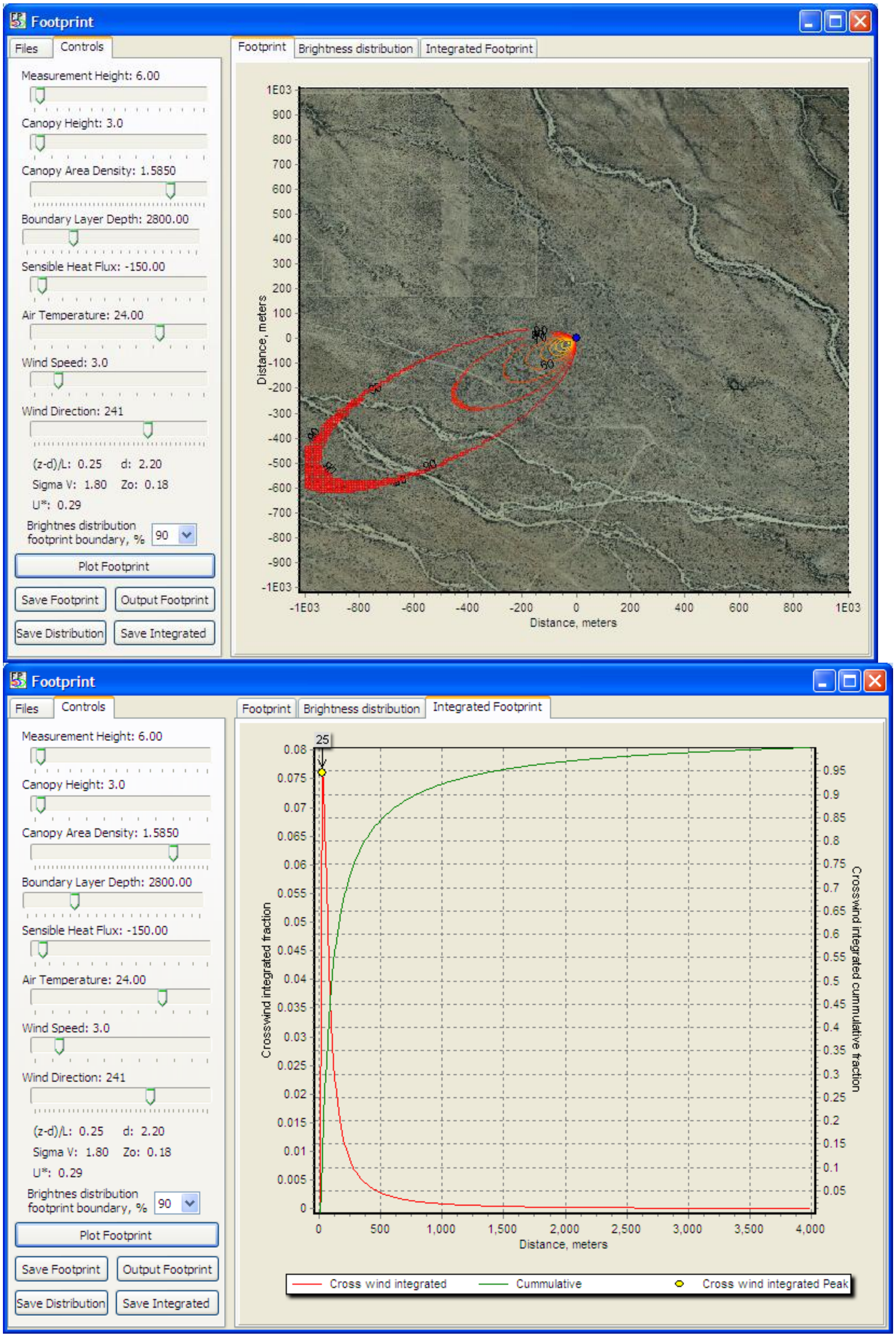


Figure 15. SRER summer nighttime (stable) footprint output with mean wind speed.

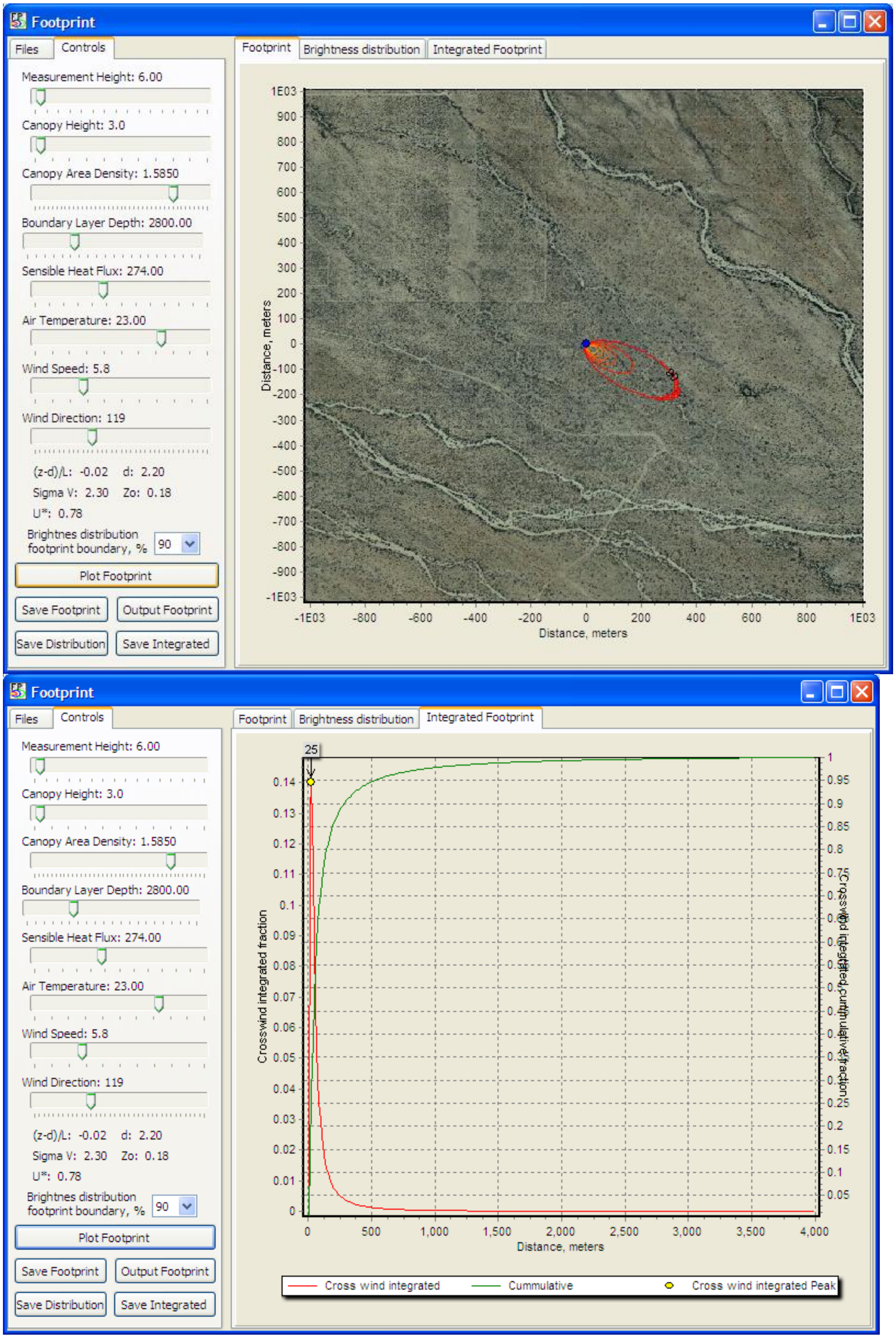


Figure 16. SRER winter daytime (convective) footprint output with max wind speed.

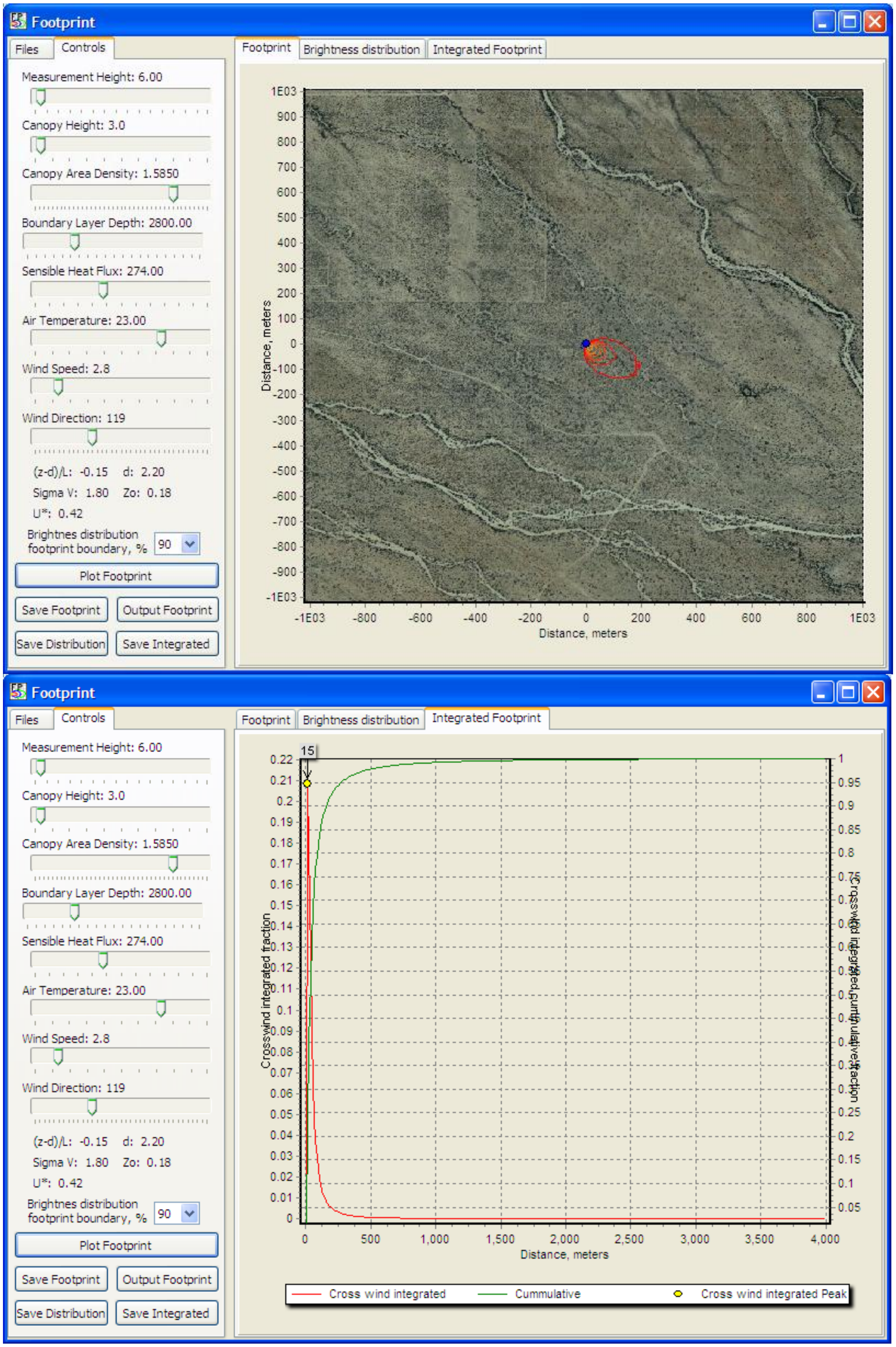


Figure 17. SRER winter daytime (convective) footprint output with mean wind speed.

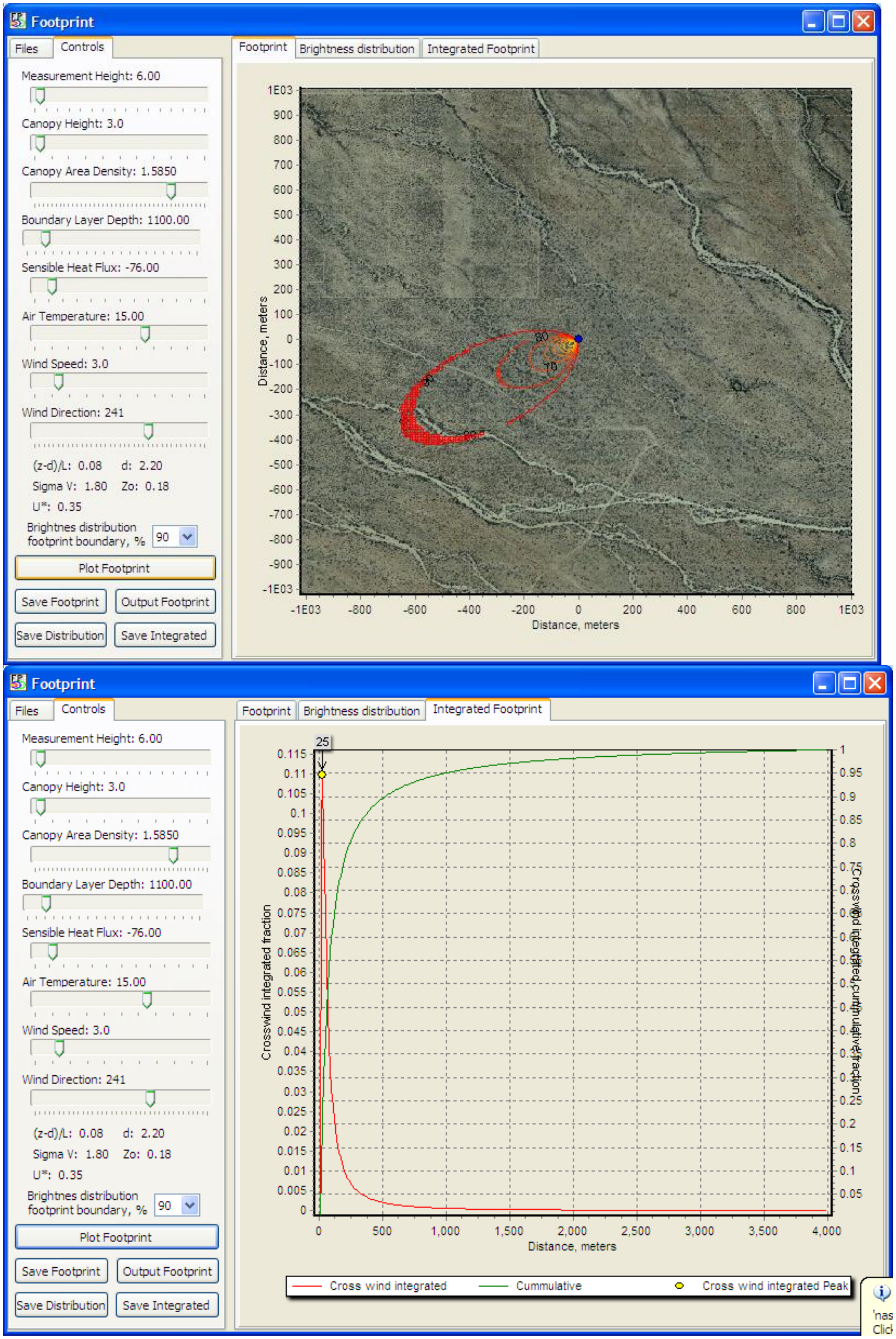


Figure 18. SRER winter nighttime (stable) footprint output with mean wind speed.

3.4.6 Site design and tower attributes

According to wind roses, the prevailing wind direction comes from 110° to 135° (major airshed, clockwise from 110°) and from 200° to 270° (secondary airshed, clockwise from 200°) throughout the year. Tower should be placed to a location to best catch the signals from the airshed of the ecosystem in interest, which is Creosote open shrubland here. To avoid the errors induced from the conversion from the northing and easting coordinates to decimal degrees, we found the tower location marker (a pile of rocks) and verfied the GPS reading. The coordinates change from 31.91071502, -110.8354889 to 31.91068, -110.83549. Therefore, the tower location is 31.91068, -110.83549.

Eddy covariance, sonic wind and air temperature **boom arms** orientation toward the SW will be best to capture signals from all major wind directions. **Radiation boom arms** should always be facing south to avoid any shadowing effects from the tower structure. An **instrument hut** should be outside the prevailing wind airshed to avoid disturbance in the measurements of wind and should be positioned to have the longer side parallel to frequent wind direction to minimize the wind effects on instrument huts and to minimize the disturbances of wind regime by instrument hut, and in this case, instrument hut should be positioned on the southeast side of tower and have the longer side parallel to SE-NW direction. Because this is an open shrubland, short statue ecosystem, the distance between the tower and the instrument hut is ~ 20 m. Therefore, we require the placement of instrument hut at 31.91082°, -110.83543°.

Canopy height is ~1.5 to 2.5 m around tower site with lowest branches at ground level. Prickly pear cactus form upper understory with height ~ 1.0 m. Barrel cactus and other annuals form the lower understory with height 0.3 – 0.5 m. We require 4 **measurement layers** on the tower with top measurement height at 8 m, and rest layers are 4 m, 1.8 m, and 0.25 m, respectively, to best characterize the fluxes on the tower top and environmental conditions in profile.

DFIR (Double Fenced International Reference) will be used for bulk precipitation collection. Coordinates are 31.91107, -110.83500, which is ~65 m on north east to tower and outside the major and secondary airshed. **Wet deposition collector** will collocate at the top of the tower. See AD 04 for further information and requirements for bulk precipitation collection and wet deposition collection.

The site layout is summarized in the table below. Assume the projected area of the tower is square. **Anemometer/temperature boom arm direction** is ***from*** the tower ***toward*** the prevailing wind direction or designated orientation. **Instrument hut orientation vector** is parallel to the long side of the instrument hut. **Instrument hut distance z** is the distance from the center of tower projection to the center of the instrument hut projection on the ground. The numbering of the **measurement levels** is that the lowest is level one, and each subsequent increase in height is numbered sequentially.

Table 7. Site design and tower attributes for SRER Advanced site.

0° is true north with declination accounted for. Color of Instrument hut exterior shall be tan to best match the surrounding environment.

Attribute	lat	long	degree	meters	notes
Airshed area			110° to		Clockwise from first

			135° (major), 200° to 270° (secondary)		angle
Tower location	31.91068°	-110.83549°	--	--	same site, new coordinates
Instrument hut	31.91082°	-110.83543°			
Instrument hut orientation vector	--	--	120° - 300°		
Instrument hut distance z	--	--	--	18	
Anemometer/Temperature boom orientation	--	--	200°	--	
DFIR	31.91107°	-110.83500°			
Height of the measurement levels					
Level 1				0.25	m.a.g.l.
Level 2				1.8	m.a.g.l.
Level 3				4.0	m.a.g.l.
Level 4				8.0	m.a.g.l.
Tower Height				8.0	m.a.g.l.

See AD 03 for technical requirement to determine the boom height for the bottom most measurement level.

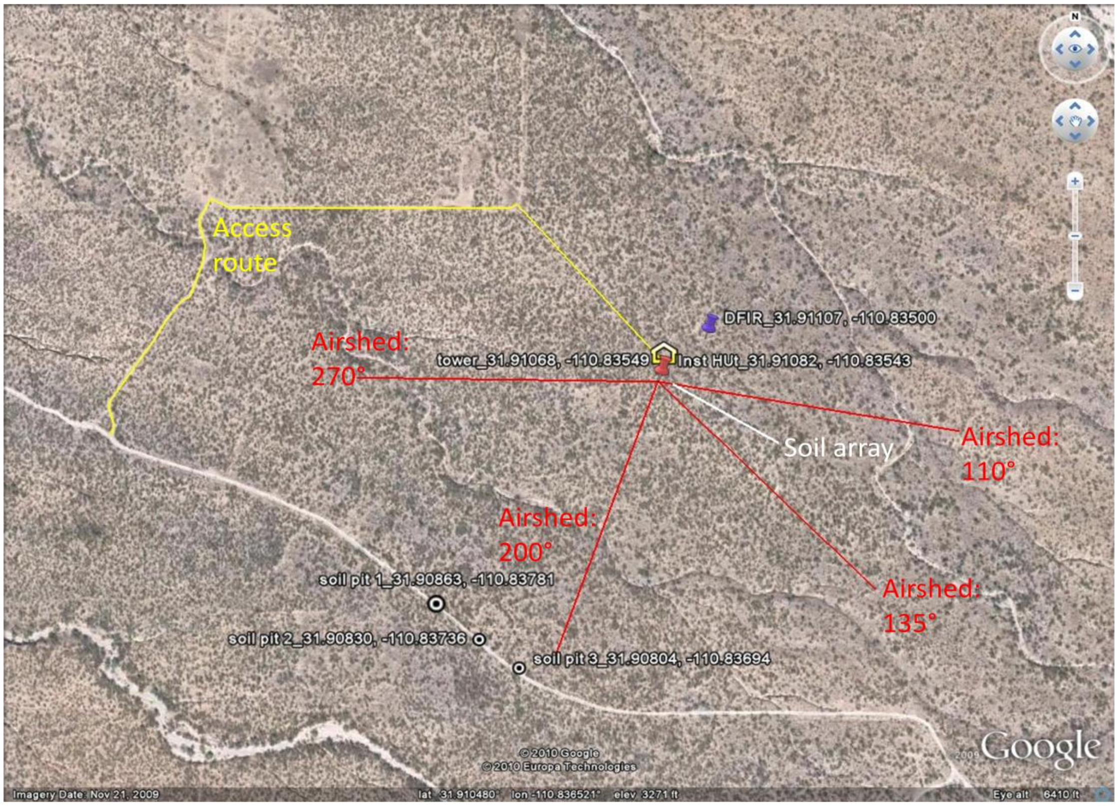


Figure 19. Site layout for Santa Rita tower site.

i) Tower location is presented (red pin), ii) red lines indicate the airshed boundaries. Vectors from 110^{o} to 135^{o} (major airshed, clockwise from 110^{o}) and from 200^{o} to 270^{o} (secondary airshed, clockwise from 200^{o}) are the airshed areas that would have quality wind data without causing flow distortions, respectively. iii) Yellow line is the suggested access road to instrument hut. iv) Purple pin is the DFIR location.

Boardwalks. Ultimately, the decision to use a boardwalk will be, in part, based on owner's preferences. There are strong science requirements that minimize site disturbance to the surrounding area, which will be difficult to manage over a 30-y period. Traffic control is key to minimizing the site disturbance. Confining foot traffic to boardwalks minimizes site impact; this is particularly true in places where wear caused by foot traffic becomes noticeable and grows. For example, in places with snow part of the year, worn footpaths tend to have low places that collect water, or places where the snow pack becomes uneven causing personnel to walk farther and farther around the sides of the original path, causing the path to grow in width. This is a very common phenomenon. Here, FIU assumes that all conduits will be either buried, or placed inside the boardwalk such that it does not extend beyond the 36" (0.914 m). wide footprint. The boardwalk to access the tower is not on any side that has a boom.

Specific Boardwalks at this site:

- All walkways in this Location shall be gravel, same width as standard boardwalk. This is because boardwalks cause enhanced risk to technicians because they create safe haven for rattlesnakes.
- Gravel walkway is from the access dirt road to instrument hut, pending landowner decision
- Gravel walkway from the instrument hut to the tower to intersect on north face of the tower
- Gravel walkway to soil array.
- No Gravel walkway from the soil array Gravel walkway to the individual soil plots

- Gravel walkway needed at DFIR site

The relative locations between tower, instrument hut and boardwalk can be found in the Figure below:

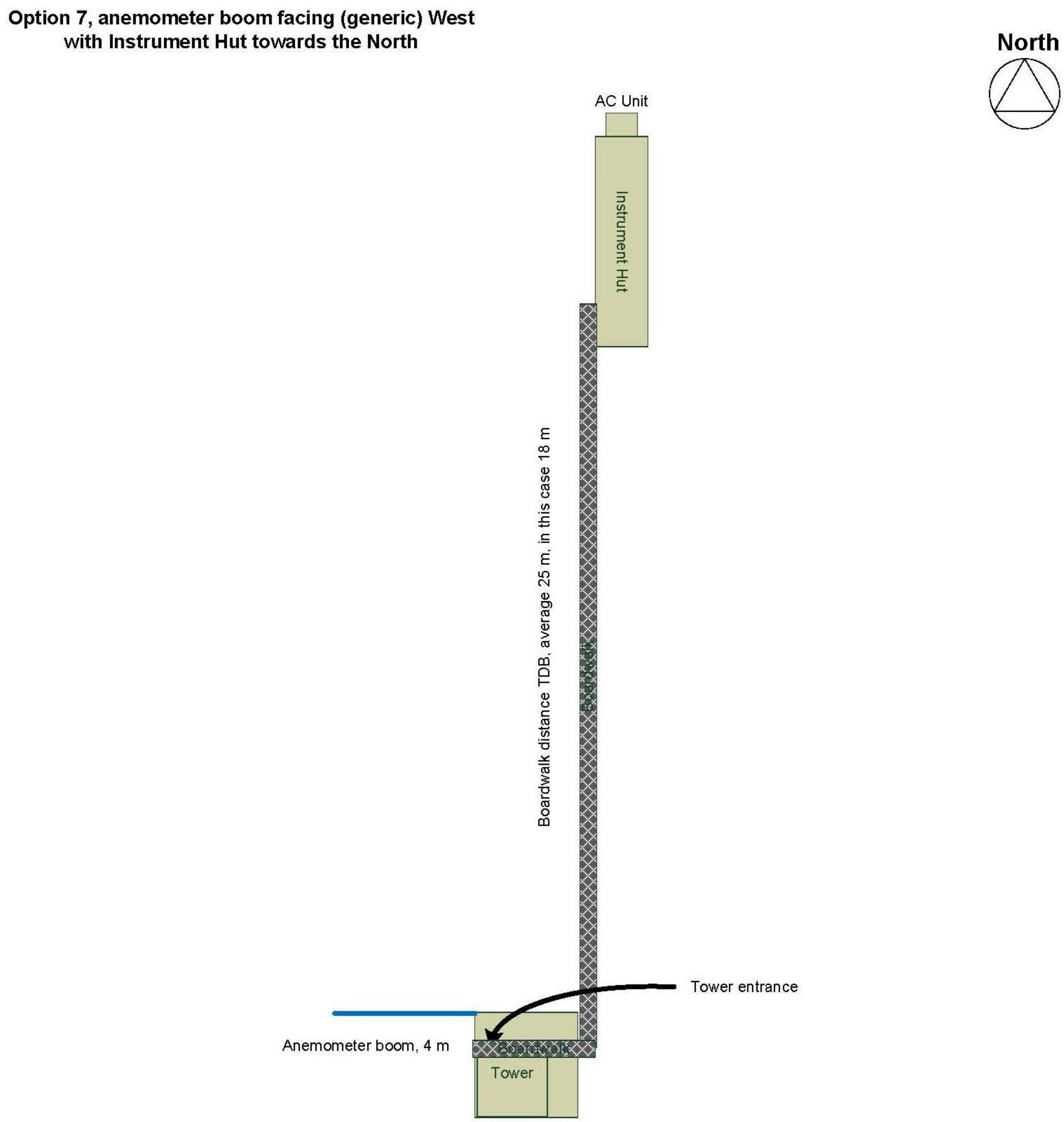


Figure 20 Generic diagram to demonstration the relationship between tower and instrument hut when boom facing west and instrument hut on the North towards the tower.

This is a generic diagram. The actual layout of boardwalk (or path if no boardwalk required) and instrument hut position will be the joint responsibility of FCC and FIU. At this site, the boom angle will be 200 degrees, instrument hut will be on the northeast towards the tower, the distance between instrument hut and tower is ~18 m. The instrument hut vector will be SE-NW (120° - 300°, longwise).

3.4.7 Information for ecosystem productivity plots

The tower at Santa Rita Advanced site has been positioned to optimize the collection of the air/wind signals both temporally and spatially over the desired ecosystem (Creosote shrubland). Tower airshed areas are from 110º to 135º (major airshed, clockwise from 110º) and from 200º to 270º (secondary airshed, clockwise from 200º) throughout the year, and 90% signals for flux measurements are in a distance of 500 m from tower, and 80% within 400 m. We suggest FSU Ecosystem Productivity plots be placed within the boundaries of 110º to 135º (major airshed, clockwise from 110º) and 200º to 270º (secondary airshed, clockwise from 200º) from tower.

3.5 Issues and attentions

Santa Rita core site was originally chosen by Drs. H. Loescher and M. Keller with the strong support of the Domain scientists. To avoid the errors induced from the conversion from the northing and easting coordinates to decimal degrees, FIU team found the tower location marker (a pile of rocks) and retook the GPS reading. The coordinates change from 31.91071502, -110.8354889 to 31.91068, -110.83549.

An existing AmeriFlux tower located on the SE from NEON tower site is ~460 m away, which is outside 80% flux fetch area of NEON tower, thus not a concern. Rodents chewing wires is common at this site. All cables and wires need good protection. There are no regulations about boardwalk at this site, preference is gravel walkway. Local contacts worry that boardwalk may provide shady spots for rattle snakes, thus may induce more risks for field crew, and suggest no boardwalk at this site, or if boardwalk is applied here, it should be on ground level. Dirt road around the tower site can be accessed by public. Vandalism, security and shooting targets are concerns if tower and instrument hut can be seen from road. Access road should be gated and locked.

A comb with dense teeth was suggested by local contacts as the best safety tool to pull out the fragile cactus spines.

4 JORNADA, RELOCATEABLE TOWER 1

4.1 Site description

NEON candidate Relocatable site is located inside the property of Jornada Experimental Range operated by the USDA Agricultural Research Service (Figure 21). The study site is located in the northern Chihuahuan Desert, approximately 25 km northeast of Las Cruces, New Mexico, USA (+32.5 N, -106.8 W, elevation 1188 m). Annual precipitation is 24 cm and maximum temperatures average 13 °C in January and 36 °C in June (info source: http://en.wikipedia.org/wiki/Jornada_Basin_LTER). The Jornada Basin Long Term Ecological Research program is also located inside this range. It is in collaboration with the USDA ARS Jornada Experimental Range, studies the causes and consequences of desertification: the broad scale expansion of woody plants into grasslands that results in more "desert like" conditions. Jornada LTER is interested in spatial and temporal variation in desertification dynamics, and how historic legacies, the geomorphic template, transport vectors (wind, water, animals), and environmental drivers (climate, land use, disturbance) interact with the patch structure of the vegetation to determine past, present, and future ecosystem dynamics across scales (info source: http://jornada-www.nmsu.edu/). The Jornada Basin Long Term Ecological Research Program (JRN LTER) has been investigating desertification processes since 1982. Significant progress has been made in understanding the causes and consequences of desertification, although key questions remain unresolved, including (1) How to integrate diverse observations about flora, fauna, soils, hydrology, climate, and human populations across spatial and temporal scales to improve our ability to understand current and historic patterns and dynamics? (2) How do processes interact across a range of scales and under different conditions to drive desertification dynamics and constrain the conservation of biological resources? (3) How can the use knowledge of desertification dynamics to more effectively promote the conservation of biological resources and the recovery of grasslands? This integration is the focus of current LTER studies (info source: http://en.wikipedia.org/wiki/Jornada_Basin_LTER). Jornada LTER's research outcomes can provide very helpful initial information to NEON's study.

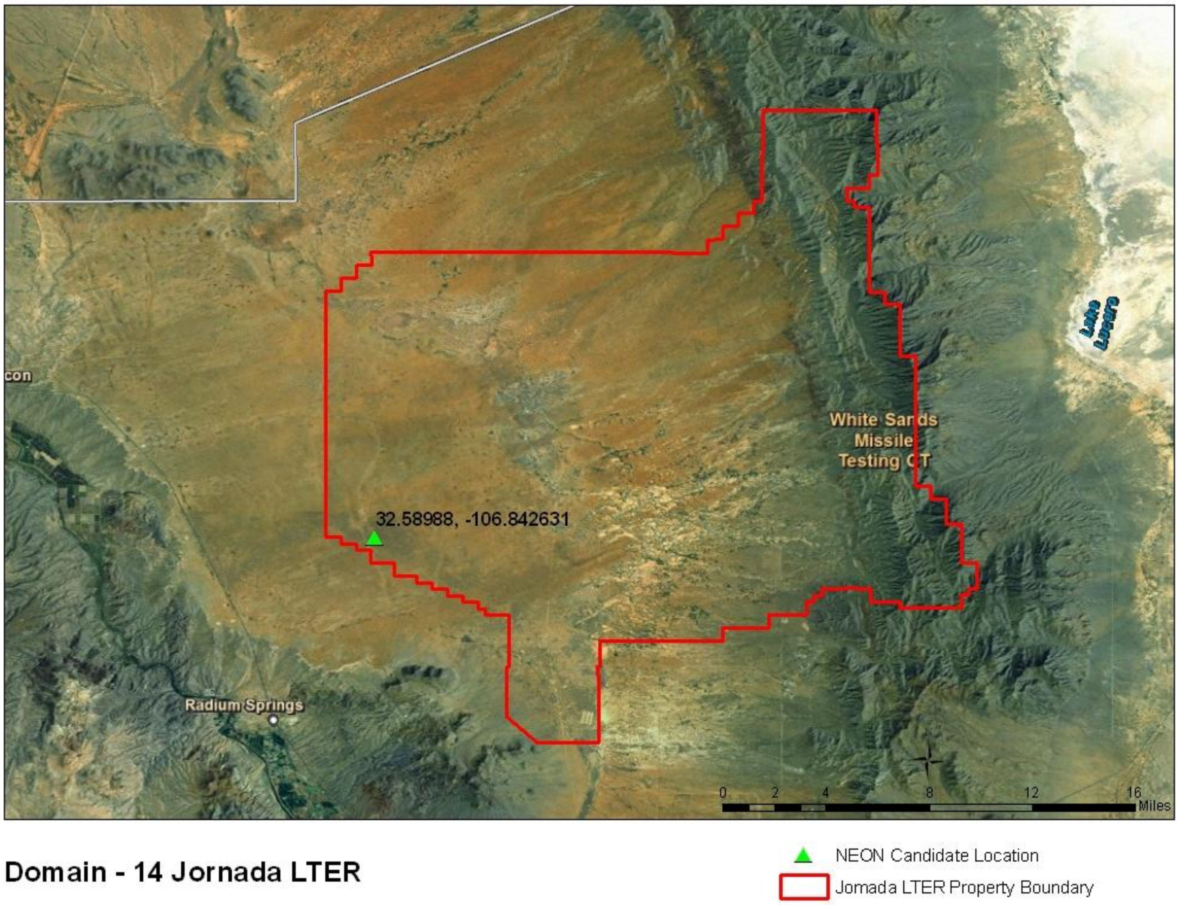


Figure 21. Jornada boundary map and NEON candidate tower location.

4.2 Ecosystem

Throughout southern New Mexico where the Jornada research site is located, large areas upland areas that were formerly dominated by perennial grasses, including black grama (*Bouteloua eriopoda*) and mesa dropseed (*Sporobolus flexuosus*), have been replaced by desert shrubland species, in particular creosotebush (*Larrea tridentata*) and honey mesquite (*Prosopis glandulosa*). Historical accounts of the region report significant changes in vegetation starting in the late 1800s coincident with the expansion of livestock grazing (Smith 1899, Wooton 1908). By 1912, the changes were sufficiently dramatic that area scientists and private land owners convinced the U.S. government to set aside Public Domain Lands for the Jornada Range Reserve for the purpose of scientific investigation on shrub invasion and subsequent loss of forage grasses. Much of this early research focused on quantifying utilization levels for forage species, developing livestock production strategies to deal with drought, and developing methods for shrub control and grass recovery. Exclosures were constructed and long-term plots were established throughout the range to monitor the continued expansion of shrubs across the landscape. Over the decades, numerous trials of various remediation approaches were put into place, from manual and mechanical shrub removal to herbicide application to construction of terraces or other means of redirecting surface flow of runoff (info source: http://en.wikipedia.org/wiki/Jornada_Basin_LTER).

More vegetation and land cover information in this region are presented below:

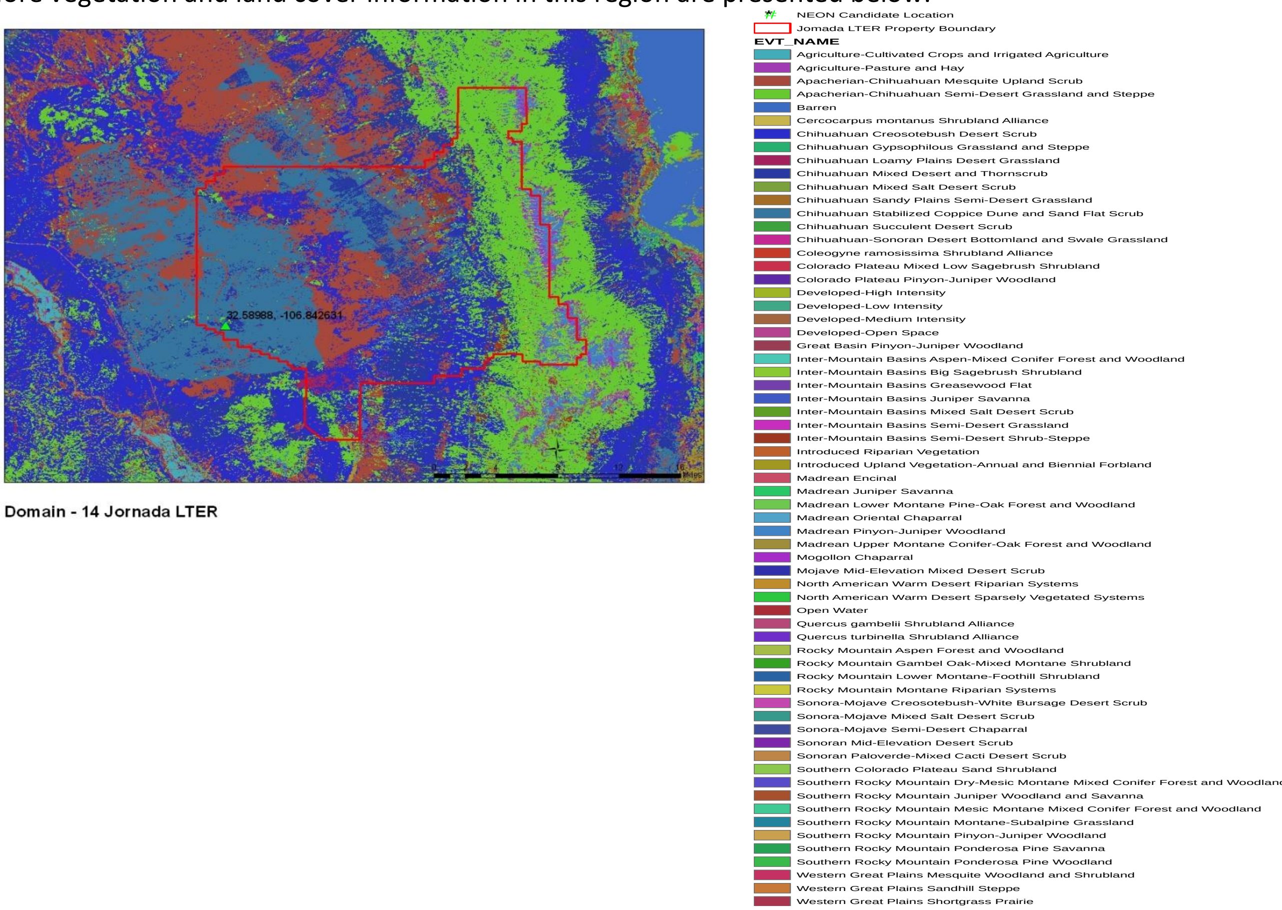


Figure 22. Vegetative cover map of Jornada and surrounding areas
(information is from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm)

Table 8. Land cover information at Jornada site
(information is from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm).

Vegetation Type	Area (km^2)	Percentage
Open Water	0.00	0.00
Barren	7.25	0.93
Agriculture-Cultivated Crops and Irrigated Agriculture	0.17	0.02
North American Warm Desert Sparsely Vegetated Systems	0.68	0.09
Madrean Encinal	0.17	0.02
Madrean Lower Montane Pine-Oak Forest and Woodland	0.02	0.00
Madrean Pinyon-Juniper Woodland	15.56	1.99
Southern Rocky Mountain Pinyon-Juniper Woodland	0.16	0.02
Chihuahuan Creosotebush Desert Scrub	127.55	16.34
Chihuahuan Mixed Salt Desert Scrub	3.95	0.51
Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub	184.72	23.66

Chihuahuan Succulent Desert Scrub	0.01	0.00
Inter-Mountain Basins Big Sagebrush Shrubland	0.18	0.02
Apacherian-Chihuahuan Mesquite Upland Scrub	139.37	17.85
Chihuahuan Mixed Desert and Thornscrub	106.67	13.66
Mogollon Chaparral	9.79	1.25
Rocky Mountain Gambel Oak-Mixed Montane Shrubland	0.00	0.00
Madrean Juniper Savanna	0.06	0.01
Apacherian-Chihuahuan Semi-Desert Grassland and Steppe	158.33	20.28
Chihuahuan Gypsophilous Grassland and Steppe	0.04	0.01
Inter-Mountain Basins Semi-Desert Shrub-Steppe	10.51	1.35
Chihuahuan Sandy Plains Semi-Desert Grassland	0.05	0.01
Inter-Mountain Basins Semi-Desert Grassland	0.69	0.09
Southern Rocky Mountain Montane-Subalpine Grassland	0.01	0.00
North American Warm Desert Riparian Systems	0.44	0.06
Rocky Mountain Montane Riparian Systems	2.97	0.38
Introduced Riparian Vegetation	0.14	0.02
Introduced Upland Vegetation-Annual and Biennial Forbland	0.07	0.01
Chihuahuan Loamy Plains Desert Grassland	10.96	1.40
Chihuahuan-Sonoran Desert Bottomland and Swale Grassland	0.23	0.03
Total Area Sq Km	**780.76**	**100**

The representative ecosystem around NEON site is desert grassland. Dominant plants are Black grama grass (mean height ~ 40 cm), mixed with Mesquite shrub (mean height ~ 1.3 m) and Yucca (mean height ~ 2 m. Although grass is the dominant ecosystem type at this site, Yucca and Mesquite shrub have large influence on the surface roughness with regarding to aerodynamics at this site. Therefore, yucca canopy height will be used when design the tower at this site.

Table 9. Ecosystem and site attributes for Jornada Relocatable site.

Ecosystem attributes	Measure and units
Grass Mean canopy height	0.4 m
Grass Surface roughness[a]	0.06 m
Grass Zero place displacement height[a]	0.2 m
Yucca Mean canopy height[b]	2.0 m
Structural elements	Desert grassland, open, homogenous
Time zone	Mountain time
Magnetic declination	9° 7' E changing by 0° 6' W/year

Note,

[a] From field survey.

[b] Although grass is the dominant ecosystem type at this site, Yaccu and Mesquite shrub have large influence on the surface roughness with regarding to aerodynamics at this site. Therefore, yucca canopy height will be used when design the tower at this site.

Figure 23 Desert grassland is the dominant ecosystem at Jornada Relocatable site

4.3 Soils

4.3.1 Description of soils

Soil data and soil maps (Figure 24 Table 10) below for Jornada tower site were collected from 2.6 km^2 NRCS soil maps (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm) to determine the dominant soil types in the larger tower foot print. This was done to assure that the soil array is in the dominant (or in the co-dominant) soil type present in the tower footprint.

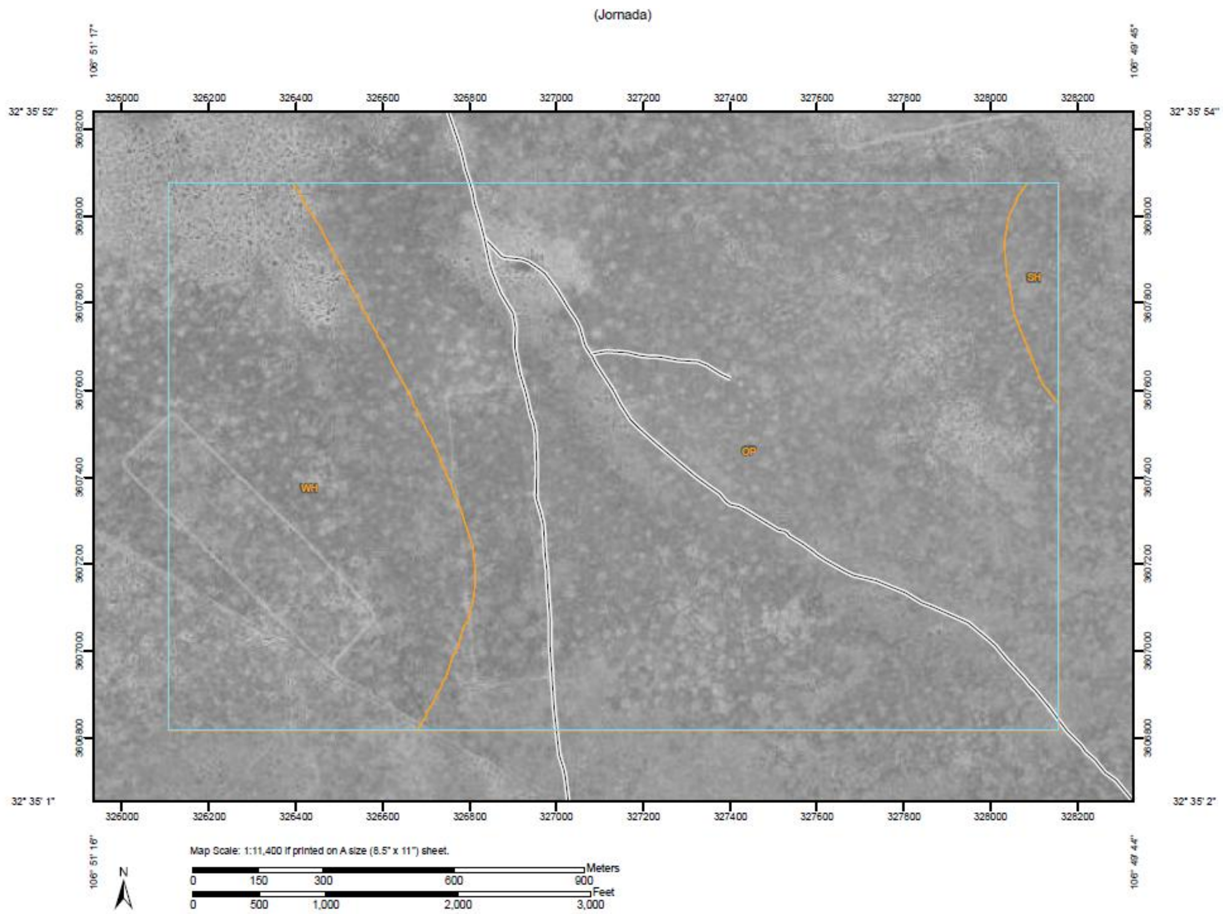


Figure 24 2.6 km^2 soil map for Jornada relocatable site.

Soil Map Units Description:

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit. The map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called non-contrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.
Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. Soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.
A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.
An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.
An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.
Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example. Additional information about the map units described in this report is available in other soil reports, which give properties of the soils and the limitations, capabilities,

and potentials for many uses. Also, the narratives that accompany the soil reports define some of the properties included in the map unit descriptions.

Table 10. Soil series and percentage of soil series within 2.6 km^2 centered on the tower, Jornada relocatable site.

Dona Ana County Area, New Mexico (NM690)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
OP	Onite-Pajarito association	451.7	70.8%
SH	Simona-Harrisburg association	11.3	1.8%
WH	Wink-Harrisburg association	174.8	27.4%
Totals for Area of Interest		**637.7**	**100.0%**

Dona Ana County Area, New Mexico - OP—Onite-Pajarito association: Map Unit Setting Elevation: 4,000 to 5,000 feet Mean annual precipitation: 8 to 10 inches Mean annual air temperature: 60 to 64 degrees F Frost-free period: 190 to 230 days **Map Unit Composition** Onite and similar soils: 40 percent Pajarito and similar soils: 30 percent Pintura and similar soils: 15 percent **Description of Onite Setting** Landform: Basin floors Landform position (three-dimensional): Talf Down-slope shape: Linear Across-slope shape: Linear Parent material: Igneous derived coarse-loamy alluvium **Properties and qualities** Slope: 1 to 5 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 40 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Sodium adsorption ratio, maximum: 1.0 Available water capacity: Low (about 5.8 inches) **Interpretive groups** Land capability (nonirrigated): 7c Ecological site: Sandy (R042XB012NM) **Typical profile** 0 to 5 inches: Loamy sand 5 to 18 inches: Sandy loam 18 to 60 inches: Loamy sand **Description of Pajarito Setting** Landform: Dunes on basin floors Landform position (three-dimensional): Rise Down-slope shape: Linear, convex Across-slope shape: Linear, convex Parent material: Mixed coarse-loamy alluvium **Properties and qualities** Slope: 0 to 5 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 5 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Sodium adsorption ratio, maximum: 1.0 Available water capacity: Moderate (about 8.4 inches) **Interpretive groups** Land capability classification (irrigated): 2e Land capability (nonirrigated): 7e Ecological site: Sandy (R042XB012NM) **Typical profile** 0 to 8 inches: Fine sandy loam 8 to 25 inches: Fine sandy loam 25 to 60 inches: Fine sandy loam **Description of Pintura Setting** Landform: Shrub-coppice dunes on basin floors Landform position (three-dimensional): Rise Down-slope shape: Convex, linear Across-slope shape: Convex, linear Parent material: Sandstone derived eolian sands **Properties and qualities** Slope: 0 to 5 percent Depth to restrictive feature: More than 80 inches Drainage class: Somewhat excessively drained Capacity of the most limiting layer to transmit water (Ksat): High to very high (6.00 to 20.00 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Sodium adsorption ratio, maximum: 1.0 Available water capacity: Low (about 4.1 inches) **Interpretive groups** Land capability (nonirrigated): 7e Ecological site: Deep Sand (R042XB011NM) **Typical profile** 0 to 8 inches: Fine sand 8 to 60 inches: Fine sand

Dona Ana County Area, New Mexico - SH—Simona-Harrisburg association: Map Unit Setting Elevation: 4,000 to 5,000 feet Mean annual precipitation: 8 to 10 inches Mean annual air temperature: 60 to 64 degrees F Frost-free period: 190 to 230 days **Map Unit Composition** Simona and similar soils: 50 percent Harrisburg and similar soils: 25 percent **Description of Simona Setting** Landform: Fan piedmonts Landform position (three-dimensional): Rise Down-slope shape: Linear Across-slope shape: Convex Parent material: Calcareous sandy alluvium **Properties and qualities** Slope: 1 to 5 percent Depth to restrictive feature: 7 to 20 inches to petrocalcic Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.01 to 0.06 in/hr) Depth to water table: More than 80 inches frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 95 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Sodium adsorption ratio, maximum: 1.0 Available water capacity: Very low (about 1.4 inches) **Interpretive groups** Land capability (nonirrigated): 7e Ecological site: Shallow Sandy (R042XB015NM) **Typical profile** 0 to 2 inches: Sandy loam 2 to 12 inches: Sandy loam 12 to 60 inches: Indurated **Description of Harrisburg Setting** Landform: Fan piedmonts Landform position (three-dimensional): Rise Down-slope shape: Linear Across-slope shape: Convex Parent material: Mixed coarse-loamy alluvium **Properties and qualities** Slope: 1 to 10 percent Depth to restrictive feature: 20 to 40 inches to petrocalcic Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.01 to 0.06 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 95 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Sodium adsorption ratio, maximum: 1.0 Available water capacity: Low (about 3.0 inches) **Interpretive groups** Land capability (nonirrigated): 7e Ecological site: Sandy (R042XB012NM) **Typical profile** 0 to 8 inches: Loamy sand 8 to 24 inches: Sandy loam 24 to 60 inches: Indurated

Dona Ana County Area, New Mexico - WH—Wink-Harrisburg association: Map Unit Setting Elevation: 4,000 to 5,000 feet Mean annual precipitation: 8 to 10 inches Mean annual air temperature: 60 to 64 degrees F Frost-free period: 190 to 230 days **Map Unit Composition** Wink and similar soils: 35 percent Harrisburg and similar soils: 25 percent **Description of Wink Setting** Landform: Swales on fan piedmonts Landform position (three-dimensional): Dip Down-slope shape: Concave, convex Across-slope shape: Concave, convex Parent material: Mixed calcareous coarse-loamy alluvium **Properties and qualities** Slope: 1 to 3 percent Depth to restrictive feature: More than 80 inches Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 40 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Sodium adsorption ratio, maximum: 1.0 Available water capacity: Moderate (about 6.7 inches) **Interpretive groups** Land capability (nonirrigated): 7e Ecological site: Sandy (R042XB012NM) **Typical profile** 0 to 2 inches: Fine sandy loam 2 to 26 inches: Fine sandy loam 26 to 60 inches: Sandy loam **Description of Harrisburg Setting** Landform: Fan piedmonts, ridges Landform position (three-dimensional): Rise Down-slope shape: Convex Across-slope shape: Convex Parent material: Mixed coarse-loamy alluvium **Properties and qualities** Slope: 1 to 5 percent Depth to restrictive feature: 20 to 40 inches to petrocalcic Drainage class: Well drained Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.01 to 0.06 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Calcium carbonate, maximum content: 5 percent Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm) Sodium adsorption ratio, maximum: 1.0 Available water capacity: Low (about 3.0 inches) **Interpretive groups** Land capability (nonirrigated): 7e Ecological site: Sandy (R042XB012NM) **Typical profile** 0 to 4 inches: Loamy fine sand 4 to 24 inches: Fine sandy loam 24 to 60 inches: Indurated

4.3.2 Soil semi-variogram description

The goal of this aspect of the site characterization is to determine the minimum distance between the soil plots in the soil array such that data farther apart can be considered spatially independent. The collected field data will be used to produce semivariograms, which is a geostatistical technique to characterize spatial autocorrelation between mapped samples of a quantitative variable (*e.g.*, soil property data in our case). In an empirical semivariogram, the average of the squared differences of a response variable is computed for all pairs of points within specified distance intervals (lag classes). The output is presented graphically as a plot of the average semi-variance versus distance class (Figure 25). For the theoretical variogram models considered here, the semivariance will converge on the total variance at distances for which values are no longer spatially auto-correlated (this is referred to as the range, Figure 25).

For the theoretical variograms considered here, three parameters estimated from the data are used to fit a semivariogram model to the empirical semivariogram. This model is then assumed to quantitatively represent the correlation as a function of distance (Figure 25), the range, the sill (the sill is the asymptotic value of semi-variance at the range), and the nugget (which describes sampling error or variation at distances below those separating the closest pairs of samples). The range, sill and nugget are estimated from theoretical models that are fitted to the empirical variograms using non-linear least squares methods.

The variogram analysis will be used, to determine the spatial scales at which we can consider soil measurements spatially independent. This characterization will directly inform the minimum distance between *i*) soil plots within each soil array, *ii*) the soil profile measurements, *iii*) EP plots, and *iv*) the microbial sampling locations. These data will directly inform NEON construction and site design activities.

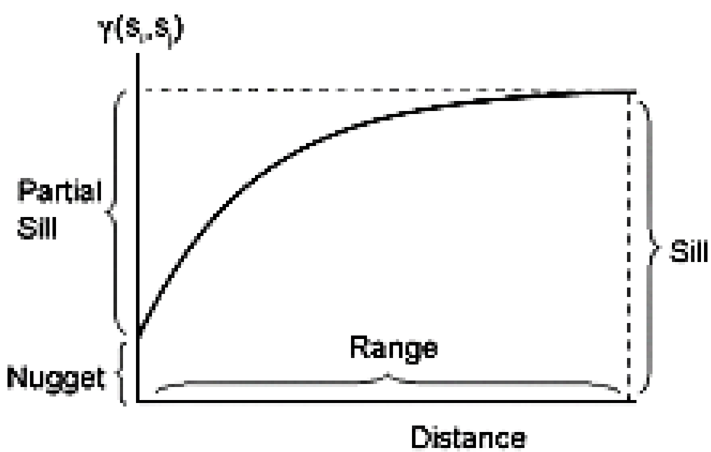


Figure 25. Example semivariogram, depicting range, sill, and nugget.

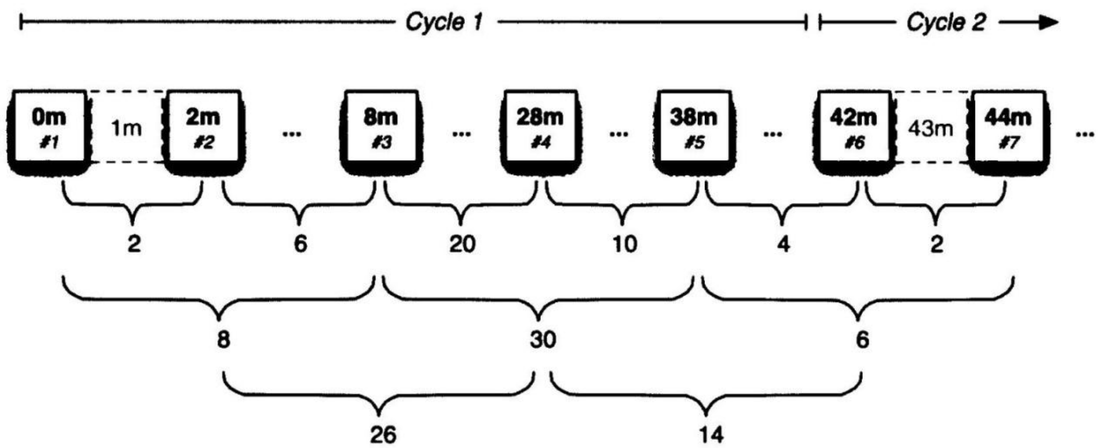


Figure 26. Spatially cyclic sampling design for the measurements of soil temperature and soil water content.

Field measurements of soil temperature (0-12 cm) and moisture (0-15 cm) were taken on 23 August 2010 at the Jornada site. The sampling points followed the spatially cyclic sampling design by Bond-Lamberty et al. (2006) (Figure 26). Soil temperature and moisture measurements were collected along three transects (210 m, 84 m, and 84 m) located in the expected airshed at Jornada. Details of how the airshed was determined are provided below. Soil temperature was measured with platinum resistance temperature sensors (RTD 810, Omega Engineering Inc., Stamford CT) and soil moisture was measured with time domain diaelectric sensors (CS616, Campbell Scientific Inc., Logan UT).

As well as measuring soil temperature and moisture at each sample point in Figure26, measurements were also taken 30 cm in front and behind the sampling point along the axis of the transect. For example, at the 2 m sampling point, soil temperature and moisture was measured at 1.7 m, 2 m, and 2.3 m; this data is referred to as mobile data, since the measurements were taken at many different locations. In addition, soil temperature and moisture were continuously recorded at a single fixed location (stationary data) throughout the sampling time to correct for changes in temperature and moisture throughout the day.

Data collected were used for geospatial analyses of variograms in the R statistical computing language with the geoR package to test for spatial autocorrelation (Trangmar *et al.* 1986; Webster & Oliver 1989; Goovaerts 1997; Riberiro & Diggle 2001) and estimate the distance necessary for independence among soil plots in the soil array. To correct for changes in temperature and moisture over the sampling period, the stationary data was subtracted from the mobile data. In many instances a time of day trend was still apparent in the data even after subtracting the stationary data from the mobile data. This time of day trend was corrected for by fitting a linear regression and using the residuals for the semivariogram analysis. Soil temperature and moisture data, R code, graphs, and R output can be found at: P:\FIU\FIU_Site_Characterization\DXX\YYYYYYY_Characterization\Soil Measurements\Soil Data Analysis (where XX = domain number and YYYYYYY = site name).

4.3.3 Results and interpretation

4.3.3.1 Soil Temperature

Soil temperature data residuals, after accounting for changes in temperature in the stationary data and any remaining time of day trend, were used for the semivariogram analysis (Figure 27). Exploratory data analysis plots show that there was no distinct patterning of the residuals (Figure 28, left graphs) and directional semivariograms do not show anisotropy (Figure 28, center graph). An isotropic empirical semivariogram was produced and a spherical model was fitted using Cressie weights (Figure 28, right graph). The model indicates a distance of effective independence of 46 m for soil temperature.

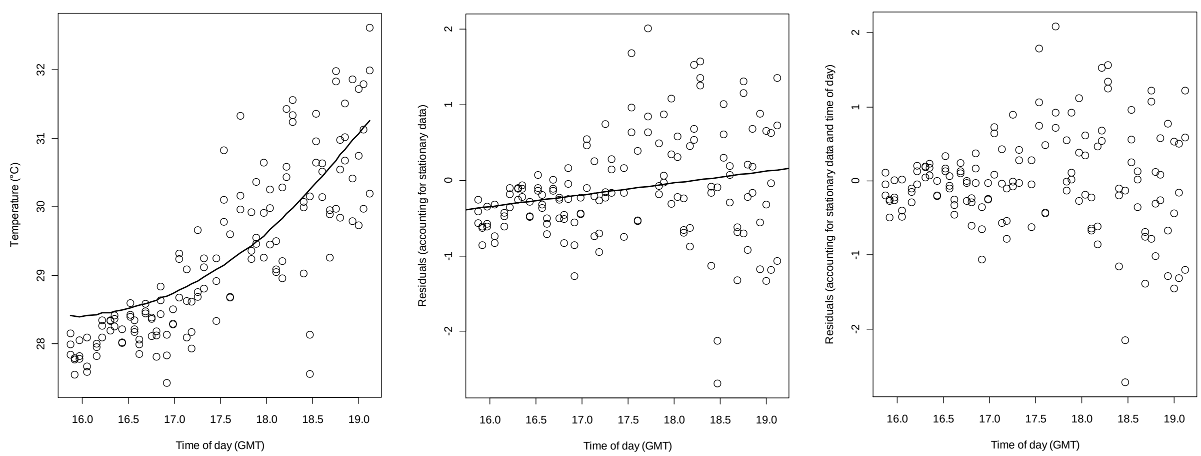


Figure 27. Left graph: mobile (circles) and stationary (line) soil temperature data. Center graph: temperature data after correcting for changes in temperature in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual temperature data after correcting for changes temperature in the stationary data and the time of day regression. Data in the right graph were used for the semivariogram analysis.

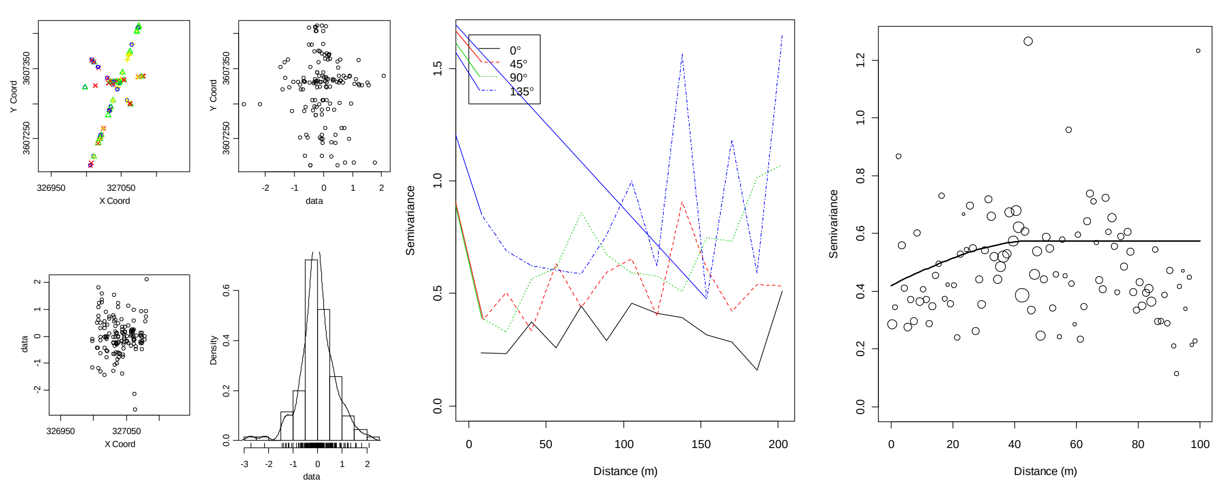


Figure 28. Left graphs: exploratory data analysis plots for residuals of temperature. Center graph: directional semivariograms for residuals of temperature. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of temperature.

4.3.3.2 Soil water content

Soil water content data residuals, after accounting for changes in water content in the stationary data and any remaining time of day trend, were used for the semivariogram analysis (Figure 29). Exploratory data analysis plots show that there was no distinct patterning of the residuals (Figure 30, left graph) and directional semivariograms do not show anisotropy (Figure 30, center graph). An isotropic empirical semivariogram was produced and a spherical model was fitted using Cressie weights (Figure 30, right graph). The model indicates a distance of effective independence of 8911 m for soil water content.

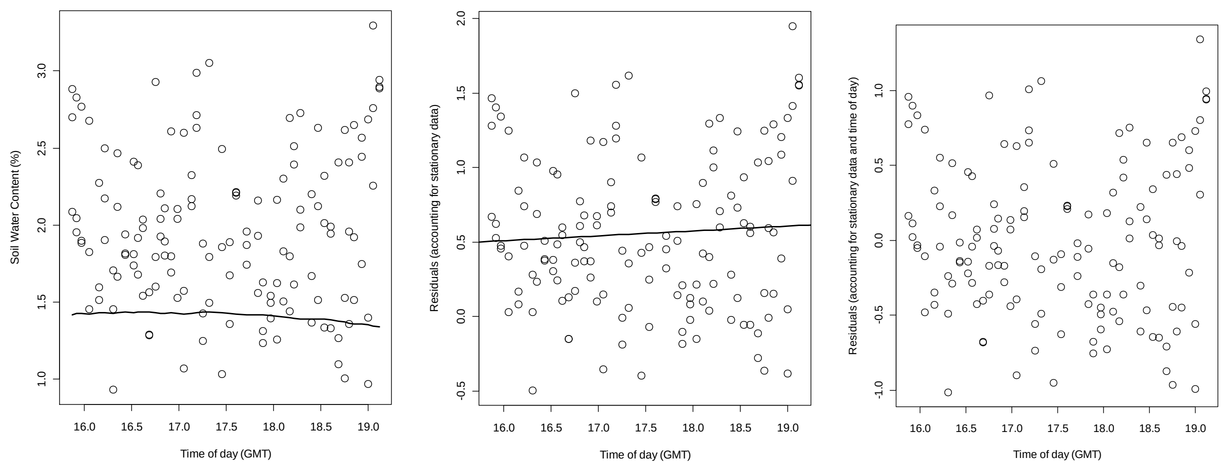


Figure 29. Left graph: mobile (circles) and stationary (line) soil water content data. Center graph: water content data after correcting for changes in water content in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual water content data after correcting for changes water content in the stationary data and the time of day regression. Data in the right graph were used for the semivariogram analysis.

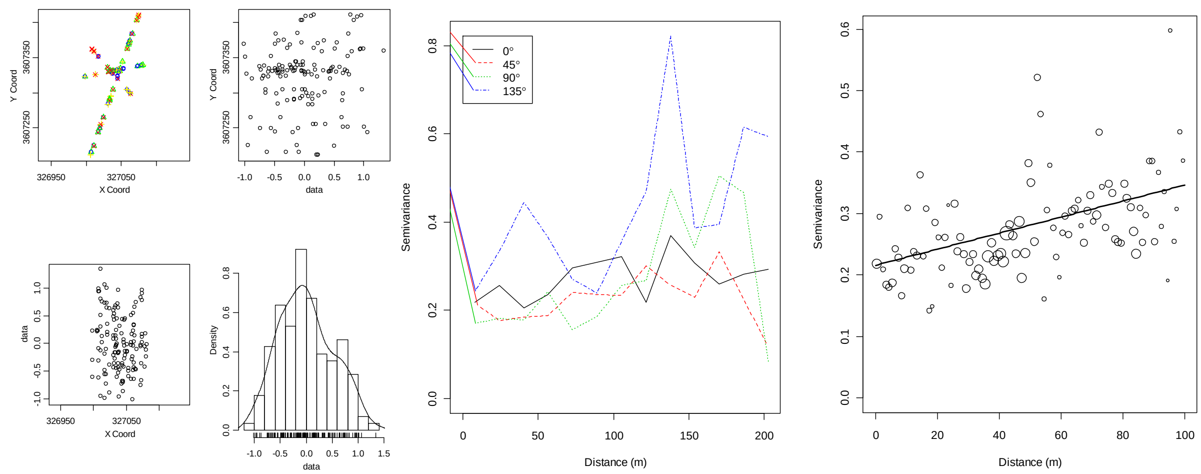


Figure 30. Left graphs: exploratory data analysis plots for residuals of soil water content. Center graph: directional semivariograms for residuals of water content. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of water content.

4.3.3.3 Soil array layout and soil pit location

The minimum distance allowable between soil plots is 25 m to ensure a degree of spatial independence in non-measured soil parameters (i.e., other than temperature and water content) and the maximum distance allowable between soil plots is 40 m due to cost constraints. The estimated distance of effective independence was 46 m for soil temperature and 8911 m for soil moisture. Based on these results and the site design guidelines the soil plots at Jornada shall be placed 40 m apart. The soil array shall follow the linear soil array design (Soil Array Pattern B) with the soil plots being 5 m x 5 m. The direction of the soil array shall be 200° from the soil plot nearest the tower (i.e., first soil plot). The location of the first soil plot will be approximately 32.59057, -106.84261. The exact location of each soil plot will be chosen by an FIU team member during site construction to avoid placing a soil plot at an unrepresentative location (e.g., rock outcrop, drainage channel, large tree, etc). The FIU soil pit for characterizing soil horizon depths, collecting soil for site-specific sensor calibration, and collecting soil for the FIU soil archive will be located at 32.59052, -106.84377 (primary location); or 32.59013, -106.84372 (alternate location 1 if primary location is unsuitable); or 32.58973, -106.84362 (alternate location 2 if primary location is unsuitable). A summary of the soil information is shown in Table 11 and site layout can be seen in Figure 31.

Dominant soil series at the site: Onite-Pajarito association. The taxonomy of this soil is shown below:
Order: Aridisols
Suborder: Argids-Cambids
Great group: Calciargids-Haplocambids
Subgroup: Typic Calciargids-Typic Haplocambids
Family: Coarse-loamy, mixed, superactive, thermic Typic Calciargids-Coarse-loamy, mixed, superactive, thermic Typic Haplocambids
Series: Onite-Pajarito association

Table 11. Summary of soil array and soil pit information at Jornada.
0° represents true north and accounts for declination.

Soil plot dimensions	5 m x 5 m
Soil array pattern	B
Distance between soil plots: x	40 m
Distance from tower to closest soil plot: y	14 m
Latitude and longitude of 1st soil plot OR direction from tower	32.59057, -106.84261
Direction of soil array	200°
Latitude and longitude of FIU soil pit 1	32.59052, -106.84377 (primary location)
Latitude and longitude of FIU soil pit 2	32.59013, -106.84372 (alternate 1)
Latitude and longitude of FIU soil pit 3	32.58973, -106.84362 (alternate 2)
Dominant soil type	Onite-Pajarito association
Expected soil depth	>2 m
Depth to water table	>2 m

Expected depth of soil horizons	Expected measurement depths*
0-0.13 m (Loamy sand)	0.07 m
0.13-0.46 m (Sandy loam)	0.30 m
0.46-1.52 m (Loamy sand)	0.99 m

*Actual soil measurement depths will be determined based on measured soil horizon depths at the NEON FIU soil pit and may differ substantially from those shown here.

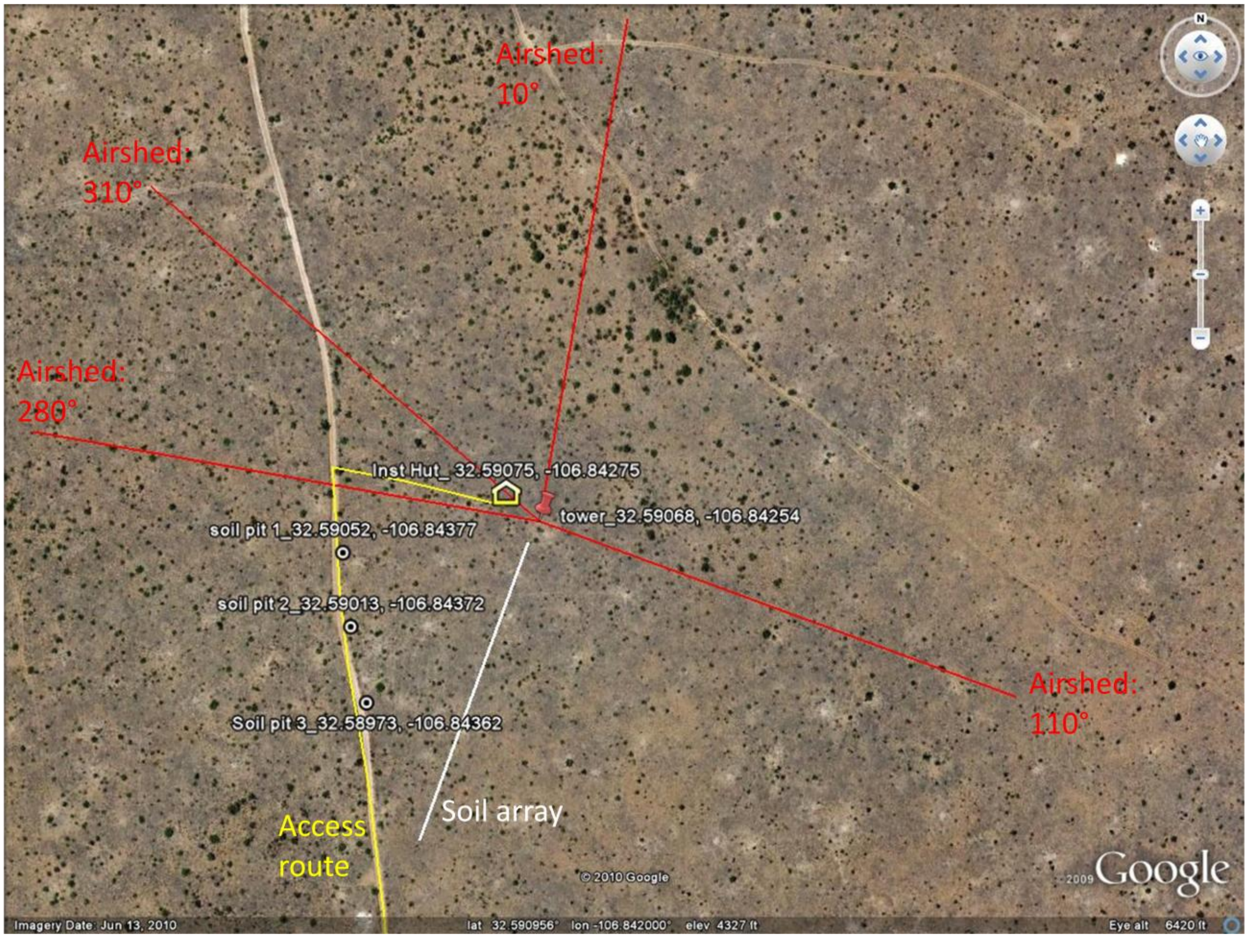


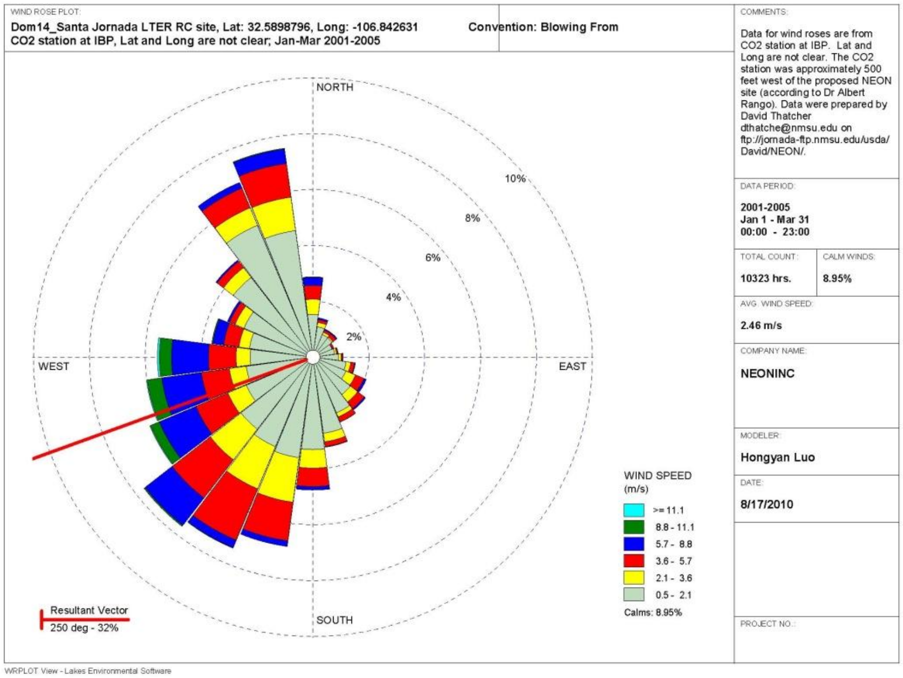
Figure 31. Site layout at Jornada relocatable site showing soil array and location of the FIU soil pit.

4.4 Airshed

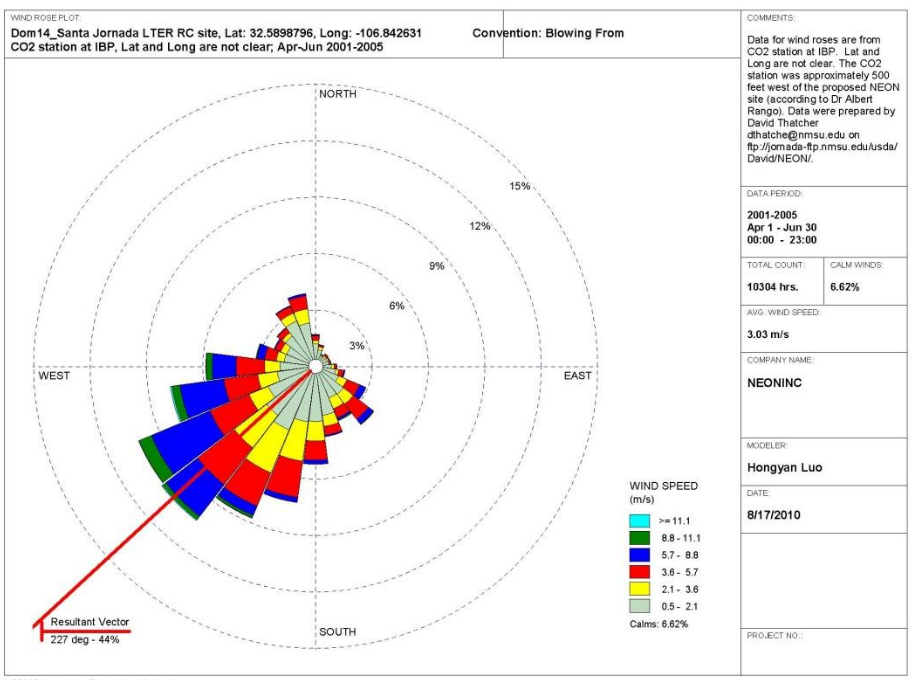
4.4.1 Seasonal windroses

Wind roses analytically determine and graphically represent the frequencies of wind direction and wind speed over a given timeseries, Figure 32. The weather data used to generate the following wind roses are from IBP CO_2 station, which is <500 m on the west to NEON tower site. The orientation of the wind rose follows that of a compass (assume declination applied). When we describe the wind directions it should be noted that they are the cardinal direction that wind blows from. The directions of the rose with the longest spoke show wind directions with the largest frequency. These wind roses are subdivided into as 24 cardinal directions.

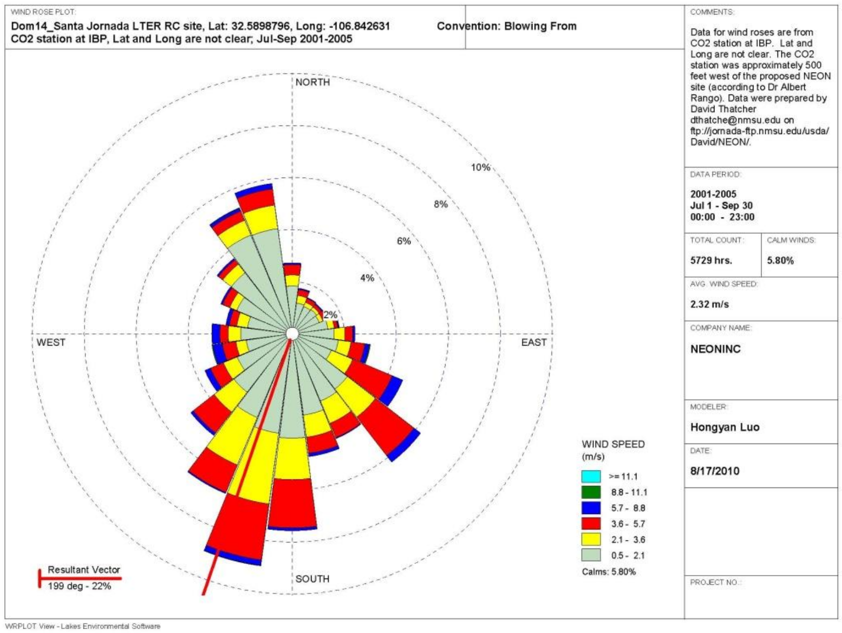
4.4.2 Results (graphs for wind roses)



WIND ROSE PLOT:
Dom14_Santa Jornada LTER RC site, Lat: 32.5898796, Long: -106.842631
CO2 station at IBP, Lat and Long are not clear; Jan-Mar 2001-2005
Convention: Blowing From
NORTH
SOUTH
WEST
EAST
2%
4%
6%
8%
10%
WIND SPEED (m/s)
>= 11.1
8.8 - 11.1
5.7 - 8.8
3.6 - 5.7
2.1 - 3.6
0.5 - 2.1
Calms: 8.95%
Resultant Vector
250 deg - 32%
COMMENTS:
Data for wind roses are from CO2 station at IBP. Lat and Long are not clear. The CO2 station was approximately 500 feet west of the proposed NEON site (according to Dr Albert Rango). Data were prepared by David Thatcher dthatche@nmsu.edu on ftp://jornada-ftp.nmsu.edu/usda/David/NEON/.
DATA PERIOD:
2001-2005
Jan 1 - Mar 31
00:00 - 23:00
TOTAL COUNT:
10323 hrs.
CALM WINDS:
8.95%
AVG. WIND SPEED:
2.46 m/s
COMPANY NAME:
NEONINC
MODELER:
Hongyan Luo
DATE:
8/17/2010
PROJECT NO.:
WRPLOT View - Lakes Environmental Software



WIND ROSE PLOT:
Dom14_Santa Jornada LTER RC site, Lat: 32.5898796, Long: -106.842631
CO2 station at IBP, Lat and Long are not clear; Apr-Jun 2001-2005
Convention: Blowing From
NORTH
SOUTH
WEST
EAST
3%
6%
9%
12%
15%
WIND SPEED (m/s)
>= 11.1
8.8 - 11.1
5.7 - 8.8
3.6 - 5.7
2.1 - 3.6
0.5 - 2.1
Calms: 6.62%
Resultant Vector
227 deg - 44%
COMMENTS:
Data for wind roses are from CO2 station at IBP. Lat and Long are not clear. The CO2 station was approximately 500 feet west of the proposed NEON site (according to Dr Albert Rango). Data were prepared by David Thatcher dthatche@nmsu.edu on ftp://jornada-ftp.nmsu.edu/usda/David/NEON/.
DATA PERIOD:
2001-2005
Apr 1 - Jun 30
00:00 - 23:00
TOTAL COUNT:
10304 hrs.
CALM WINDS:
6.62%
AVG. WIND SPEED:
3.03 m/s
COMPANY NAME:
NEONINC
MODELER:
Hongyan Luo
DATE:
8/17/2010
PROJECT NO.:
WRPLOT View - Lakes Environmental Software



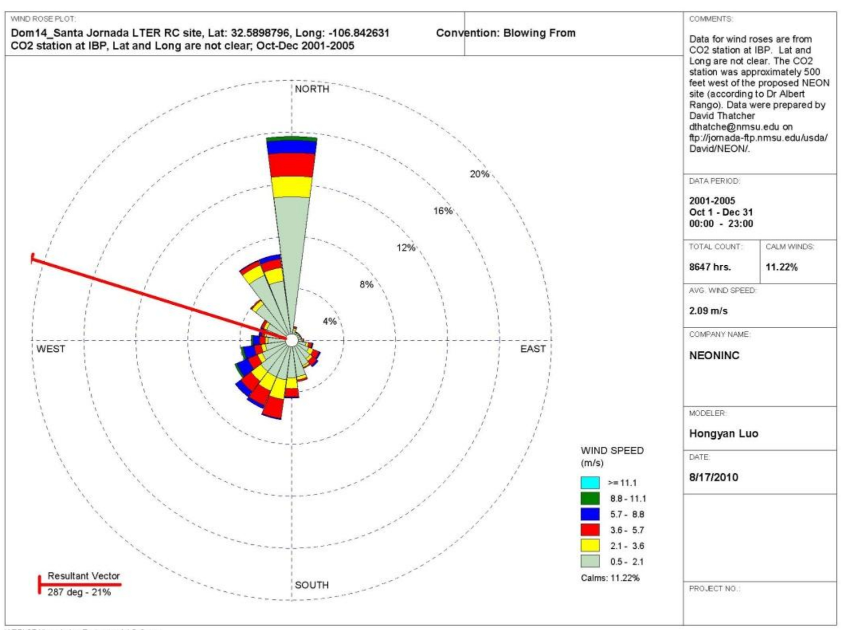


Figure 32. Windroses for Jornada relocatable site.

Data used here are hourly data from 2001 to 2005. Data were provided by Dr Albert Rango and David Thatcher. It is assumed that the wind data was corrected for declination. Panels (from Top to bottom), are from Jan-Mar, Apr-Jun, Jul-Sept, and Oct-Dec.

4.4.3 Resultant vectors

Table 12. The resultant wind vectors from Jarnada relocatable site using hourly data from 2001 to 2005.

Quarterly (seasonal) timeperiod	Resultant vector	% duration
January to March	250°	32
April to June	227°	44
July to September	199°	22
October to December	287°	21
Annual mean	240.75°	na.

4.4.4 Expected environmental controls on source area

Two types of models were commonly used to determine the shape and extent of the source area under different and contrasting atmospheric stability classes. An inverted plume dispersion model with modeled cross wind solutions were used for convective conditions (Horst and Weil 1994). For strongly stable conditions, and Lagrangian solution was used (Kormann and Meixner 2001). The source area models where bounded by the expected conditions depict the extreme conditions. Convective conditions typically have strong vertical mixing between the ecosystem and atmosphere (surface layer). Stable conditions typically have long source area and associated waveforms. Convective turbulence is often characterized by short mixing scales (scalar) and moderate daytime wind speeds, *e.g.,* 1-4 m s^{-2}. Higher wind speeds, like those experienced over the Rockies, are often the product of mechanical turbulence with long waveforms. Because thermal stratification is very efficient in suppressing vertical mixing, stable conditions also have typically very long waveforms.

As a general rule, shorter and less structurally complex ecosystems have good vertical mixing during all atmospheric stabilities. Taller and more structurally complex ecosystems have well mixed upper canopies during the daytime, and can be decoupled below the canopy under neutral and stable conditions (e.g., Harvard Forest, Bartlett Experimental Forest, and Burlington Conservation Area). The type of turbulence (mechanical verse convective) and the physical attributes of the ecosystem control the degree of mixing, and the length and size of the source area.

Here, we used a web-based footprint model to determine the footprint area under various conditions (model info: http://www.geos.ed.ac.uk/abs/research/micromet/EdiTools/). Winds used to run the model and generate following model results are extracted from the wind roses. Vegetation information, temperature and energy information were either from the RFI document, previous site visit report, available data files or best estimated from experienced expert. Measurement height was determined from the Tower Height Info document provided by ENG group, then verify according to the real ecosystem structure after FIU site characterization at site. Runs 1-3 and 4-6 represents the expected conditions for summer and winter conditions, respectively, with maximum and mean windspeeds (daytime convective) and nighttime (stable atmospheres) conditions. The wind vector for each run was estimated from wind roses and is placed as a centerline in the site map included in the graphics. The width of the footprint was also estimated using the length between the isopleth of 80% cumulative flux and center line to calculate the angle from centerline. This information, along with distance of the cumulative flux isopleths and wind direction, will define the source area for the flux measurements on the top of the tower.

Table 13. Expected environmental controls to parameterize the source area model, and associated results from Jornada Relocatable tower site.

Parameters	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Run 6**	
Approximate season	summer			winter			Units
	Day (max WS)	Day (mean WS)	Night	Day (max WS)	Day (mean WS)	night	qualitative
Atmospheric stability	Convective	convective	Stable	Convective	convective	Stable	qualitative
Measurement height	6	6	6	6	6	6	m
Canopy Height	2	2	2	2	2	2	m
Canopy area density	1.6	1.6	1.6	1.6	1.6	1.6	m
Boundary layer depth	4000	4000	2800	2800	2800	1100	m
Expected sensible heat flux	600	600	-150	275	275	-75	W m^{-2}
Air Temperature	35	35	24	23	23	15	°C
Max. windspeed	8.5	2.5	1.8	8.5	3.0	2.6	m s^{-1}
Resultant wind vector	195	195	345	225	225	345	degrees
Results							
(z-d)/L	-0.03	-0.51	3.00	-0.02	-0.24	0.77	m
d	1.40	1.40	1.40	1.40	1.40	1.40	m
Sigma v	3.10	2.50	1.60	2.50	1.80	1.70	m^2 s^{-2}
Z0	0.12	0.12	0.12	0.12	0.12	0.12	m
u*	0.98	0.39	0.04	0.97	0.39	0.17	m s^{-1}
Distance source area begins	0	0	220	0	0	20	m
Distance of 90% cumulative flux	400	180	3100	450	220	1500	m
Distance of 80% cumulative flux	300	120	2500	250	170	800	m
Distance of 70% cumulative flux	200	80	2050	180	100	500	m
Peak contribution	35	15	645	35	25	75	m

4.4.5 Results (source area graphs)

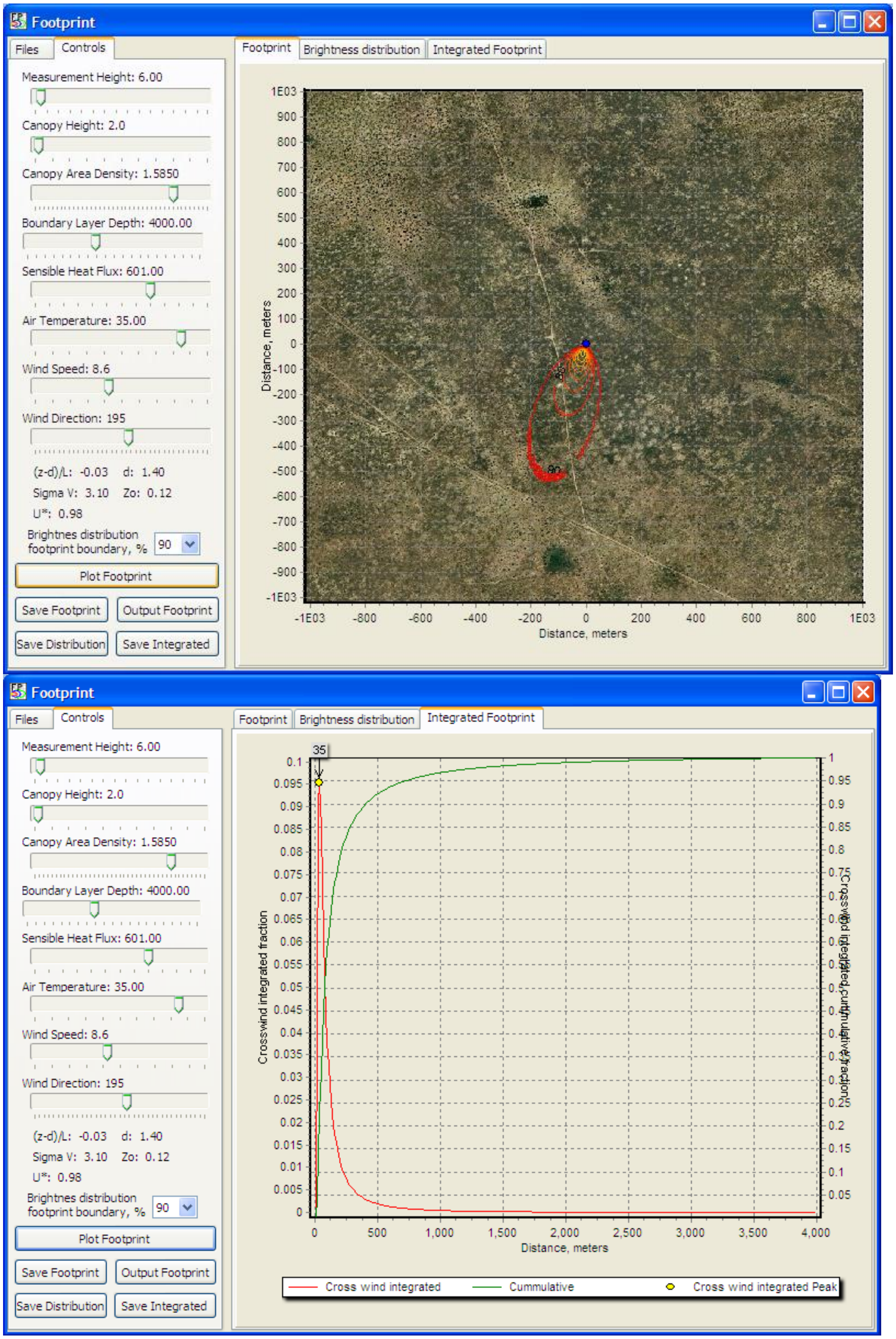


Figure 33. Jornada summer daytime (convective) footprint output with max wind speed.

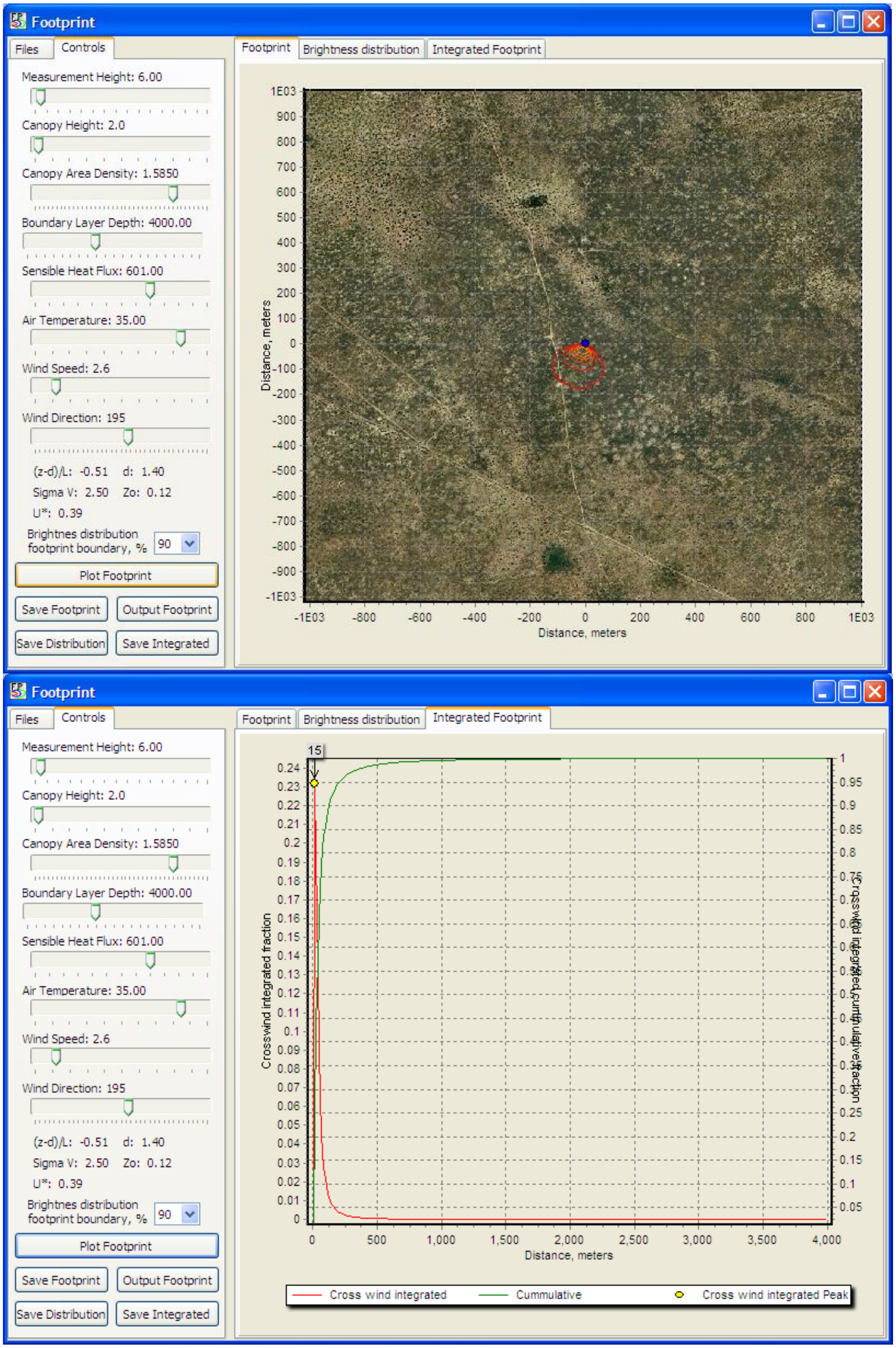


Figure 34. Jornada summer daytime (convective) footprint output with mean wind speed.

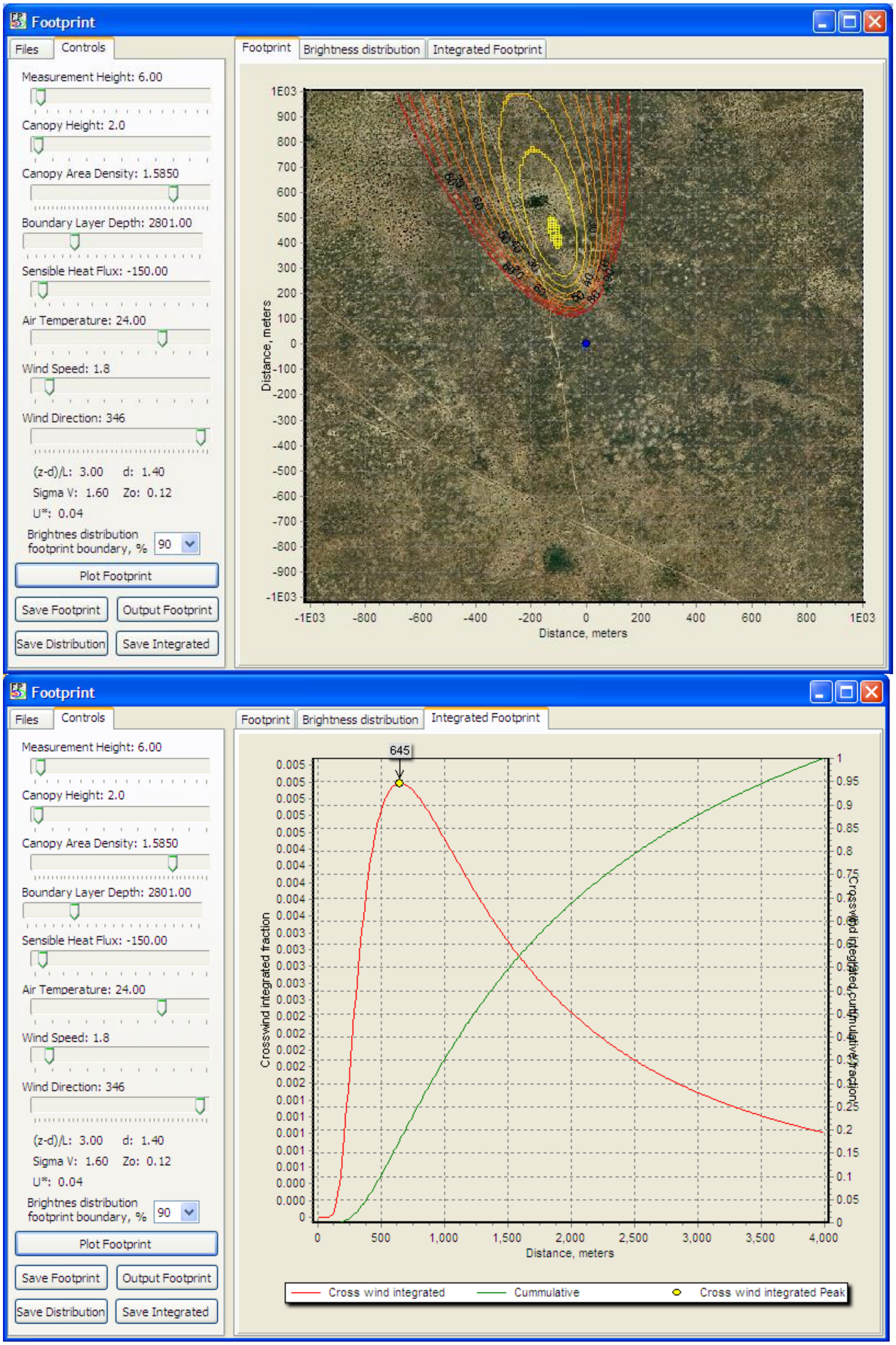


Figure 35. Jornada summer nighttime (stable) footprint output with mean wind speed.

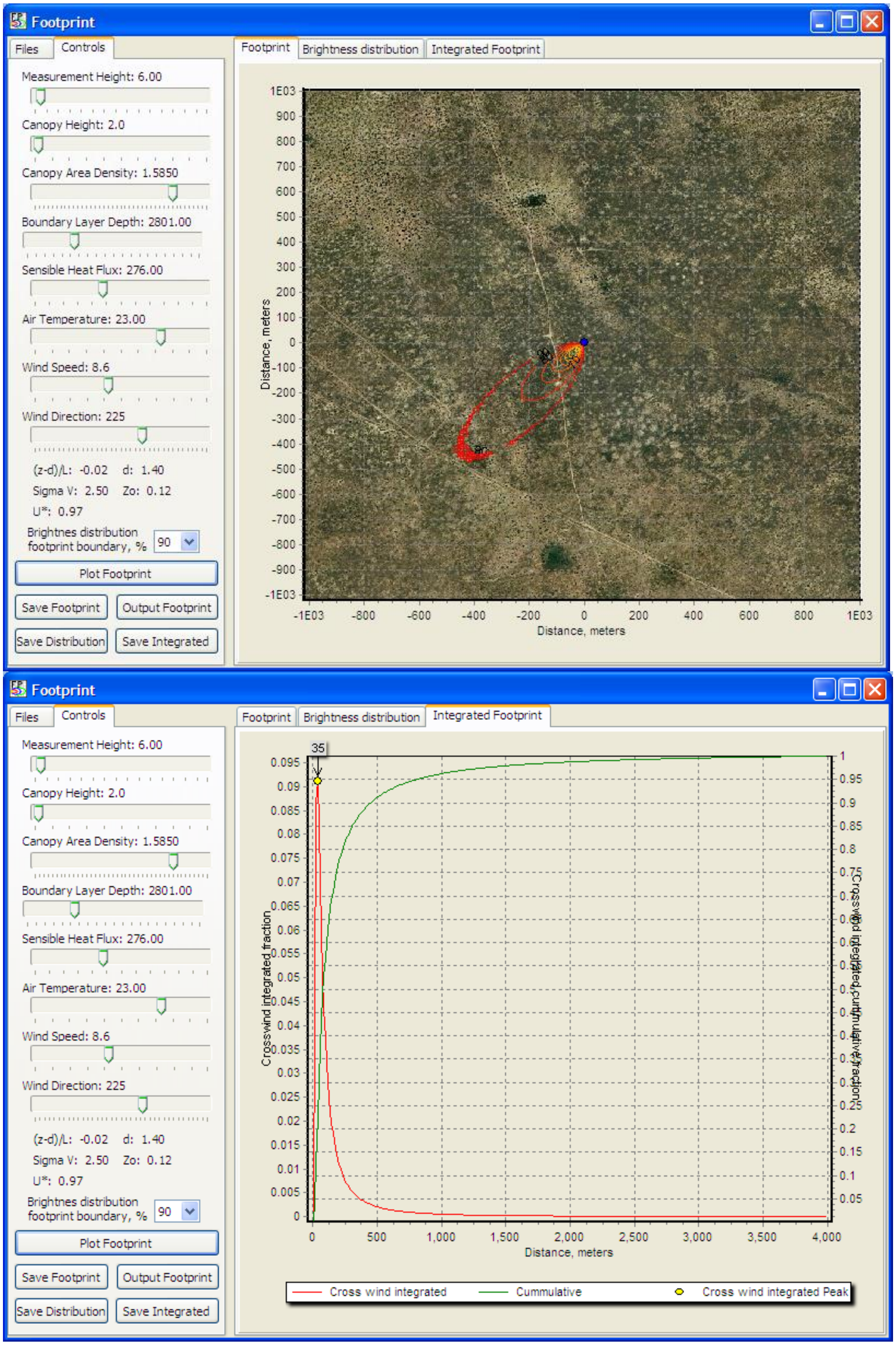


Figure 36. Jornada winter daytime (convective) footprint output with max wind speed.

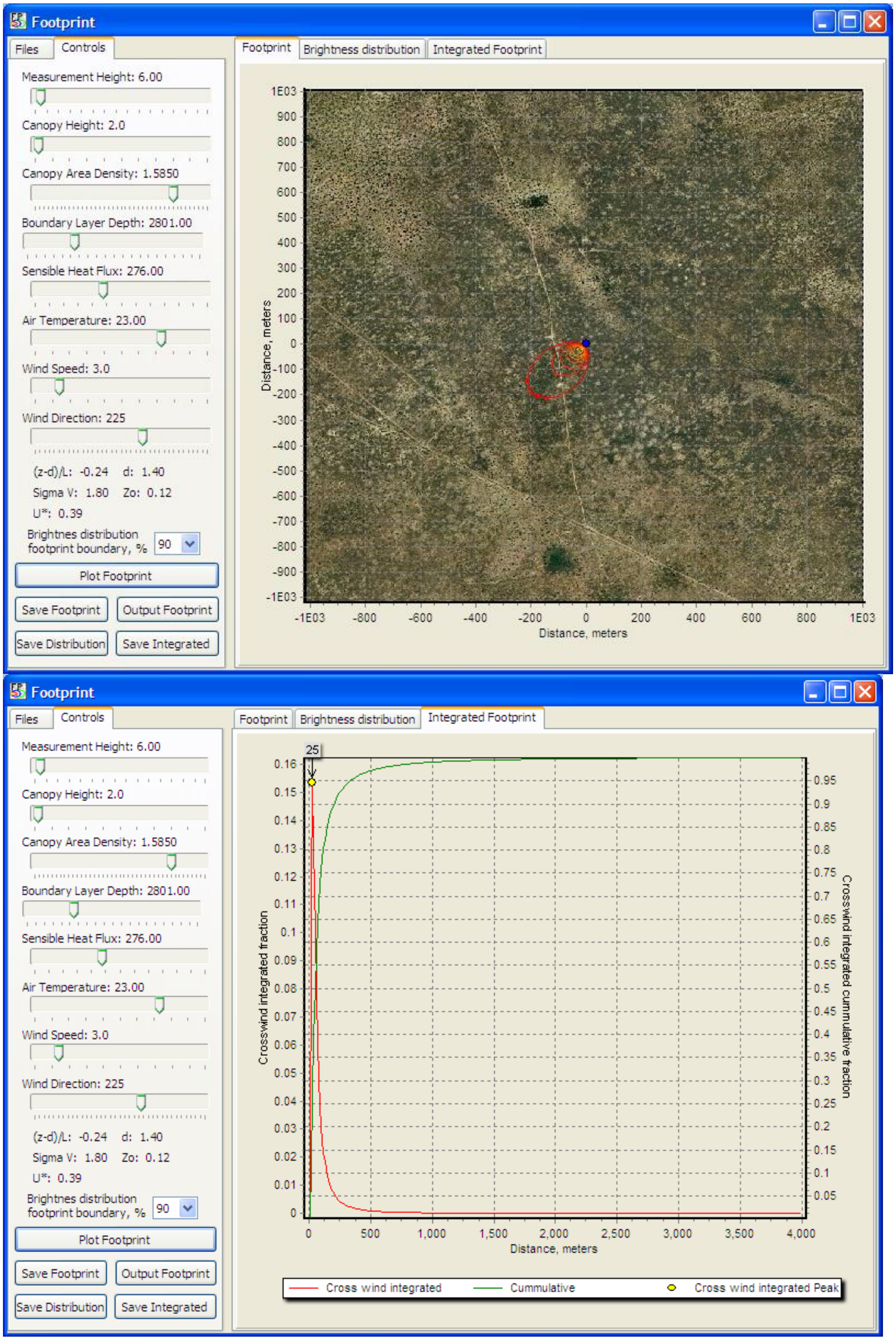


Figure 37. Jornada winter daytime (convective) footprint output with mean wind speed.

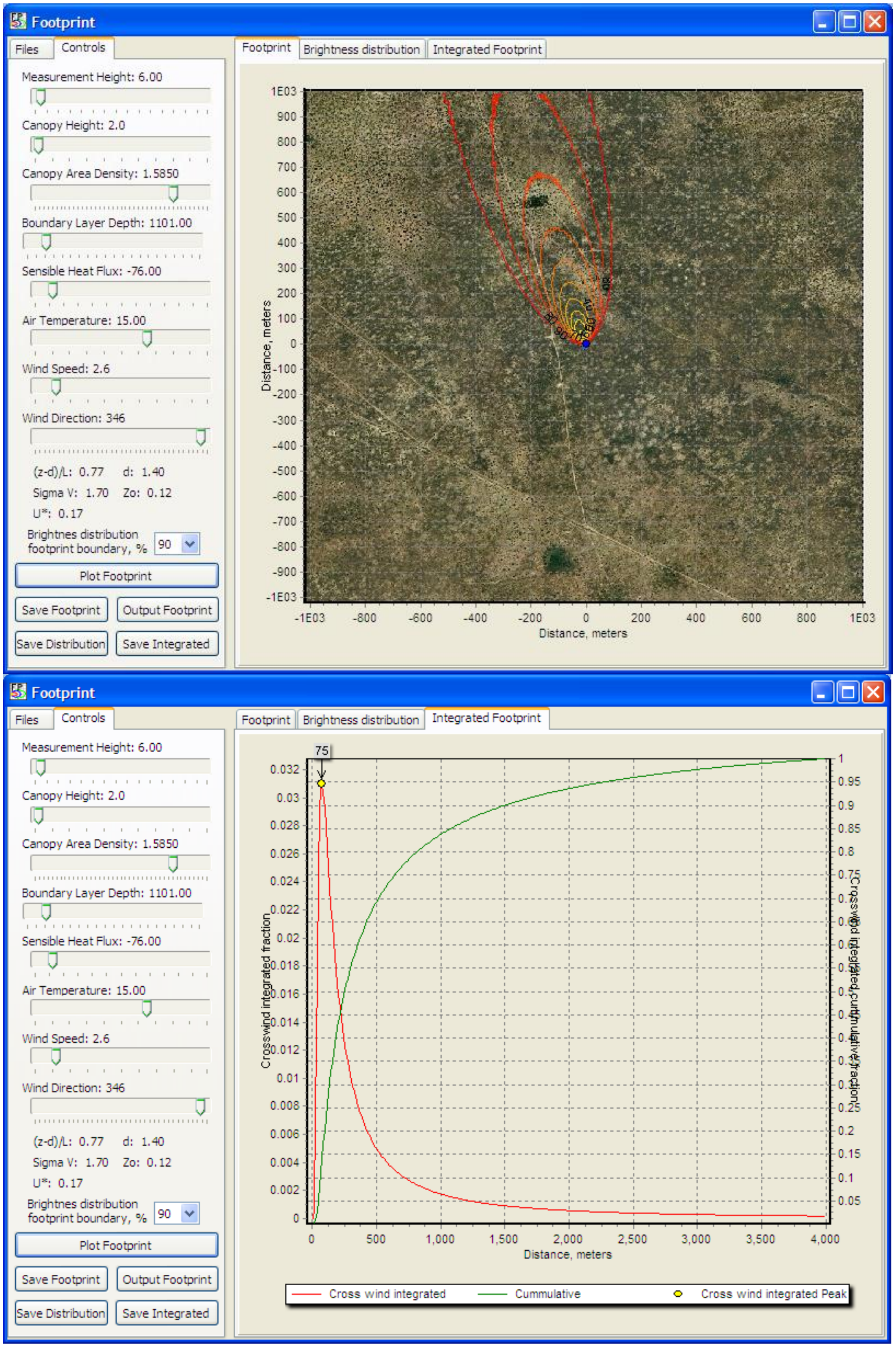


Figure 38. Jornada winter nighttime (stable) footprint output with mean wind speed.

4.4.6 Site design and tower attributes

According to wind roses, the prevailing wind direction blows from 110° to 280° (major airshed, clockwise from 110°) and from 310° to 10° (clockwise from 310°) throughout the year. Tower should be placed to a location to best catch the signals from the airshed of the ecosystem in interest, which is desert grassland ecosystem. The original tower site was 32.58988°, -106.842631°. After FIU site characterization, the **tower location** was microsited to 32.59068, -106.84254 to give longer and adequate flux fetch area on the same side of the access dirt road.

Eddy covariance, sonic wind and air temperature **boom arms** orientation toward the southwest will be best to capture signals from all major wind directions. **Radiation boom arms** should always be facing south to avoid any shadowing effects from the tower structure. An **instrument hut** should be outside the prevailing wind airshed to avoid disturbance in the measurements of wind and should be positioned to have the longer side parallel to frequent wind direction to minimize the wind effects on instrument huts and to minimize the disturbances of wind regime by instrument hut, and in this case, instrument hut should be positioned on the southeast side of tower and have the longer side parallel to NE-SW direction. Because this is a short grassland ecosystem, the distance between the tower and the instrument hut determined to be ~ 20 m at this site. Therefore, we require the placement of instrument hut at 32.59075°, -106.84275°.

At this site, dominant plants are Black grama grass (mean height ~ 40 cm), mixed with Mesquite shrub (mean height ~ 1.3 m) and Yucca (mean height ~ 2 m). Although grass is the dominant ecosystem type at this site, Yaccu and Mesquite shrub have large influence on the surface roughness with regarding to aerodynamics at this site. Therefore, yucca canopy height will be used when design the tower at this site. We require 4 **measurement layers** on the tower with top measurement height at 8 m, and rest layers are 4 m, 1.3 m and 0.2 m, respectively, to best characterize the fluxes on the tower top and environmental conditions in profile.

Secondary **precipitation collector** for bulk precipitation collection will be located the top of tower at this site. No **Wet deposition collector** will be deployed at this site. See AD 04 for further information and requirements for bulk precipitation collection and wet deposition collection.

The site layout is summarized in the table below. Assume the projected area of the tower is square. **Anemometer/temperature boom arm direction** is ***from*** the tower ***toward*** the prevailing wind direction or designated orientation. **Instrument hut orientation vector** is parallel to the long side of the instrument hut. **Instrument hut distance z** is the distance from the center of tower projection to the center of the instrument hut projection on the ground. The numbering of the **measurement levels** is that the lowest is level one, and each subsequent increase in height is numbered sequentially.

Table 14. Site design and tower attributes for Jornada site

0° is true north with declination accounted for. Color of Instrument hut exterior shall be tan to best match the surrounding environment.

Attribute	lat	long	degree	meters	notes
Airshed			110^o to 280^o (major) and 310^o to 10^o		Clockwise from first angle
Tower location	32.59068,	-106.84254	--	--	Same site, new coordinates
Instrument hut	32.59075,	-106.84275			
Instrument hut orientation vector	--	--	40^o-220^o		
Instrument hut distance z	--	--	--	20	
Anemometer/Temperature boom orientation	--	--	220°	--	
Height of the measurement levels					
Level 1				0.2	m.a.g.l.
Level 2				1.3	m.a.g.l.
Level 3				4.0	m.a.g.l.
Level 4				8.0	m.a.g.l.
Tower Height				8.0	m.a.g.l.

See AD 03 for technical requirement to determine the boom height for the bottom most measurement level.

Figure below shows the proposed tower location, instrument hut location, airshed area and access road.

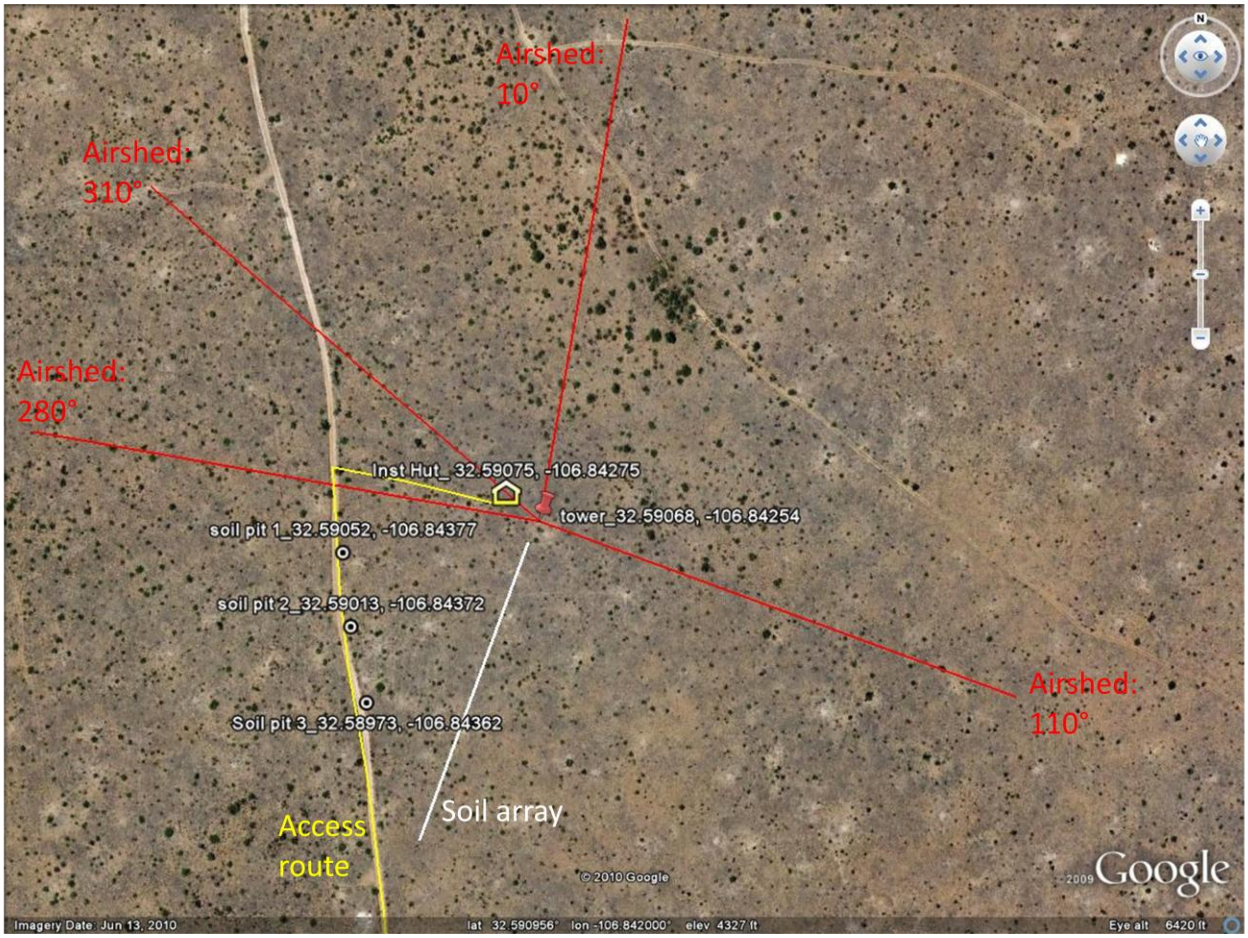


Figure 39. Site layout for Jornada Relocatable site.

i) new tower location is presented (red pin), ii) red lines indicate the airshed boundaries. Vectors 110° to 280° (clockwise from 110°, major airshed) and from 310° to 10° (clockwise from 310°, secondary airshed) that would have quality wind data without causing flow distortions, respectively. iii) Yellow line is the suggested access road to instrument hut.

Boardwalks. Ultimately, the decision to use a boardwalk will be, in part, based on owner's preferences. There are strong science requirements that minimize site disturbance to the surrounding area, which will be difficult to manage over a 30-y period. Traffic control is key to minimizing the site disturbance. Confining foot traffic to boardwalks minimizes site impact; this is particularly true in places where wear caused by foot traffic becomes noticeable and grows. For example, in places with snow part of the year, worn footpaths tend to have low places that collect water, or places where the snow pack becomes uneven causing personnel to walk farther and farther around the sides of the original path, causing the path to grow in width. This is a very common phenomenon. Here FIU assumes that all conduits will be either buried, or placed inside the boardwalk such that it does not extend beyond the 36' wide footprint. While the final design is not yet known, there are some general criteria that can be outlined. We assume that the boardwalk width is 36" (0.914 m). Material is not known, but must be fire proof, and in some locations the site is seasonally flooded and inundated with water. Boardwalks may also provide a scratching structure for grazing animals that in turn, would wear and unduly impact the site. Site by site evaluations must be done.

Specific boardwalks at the Jornada site

- All walkways in this Location shall be gravel, same width as standard boardwalk. This is because boardwalks cause enhanced risk to technicians because they create safe haven for rattlesnakes.
- Gravel walkway is from the access dirt road to instrument hut, pending landowner decision
- Gravel walkway from the instrument hut to the tower to intersect on north face of the tower
- Gravel walkway to soil array.
- No Gravel walkway from the soil array Gravel walkway to the individual soil plots

The relative locations between tower, instrument hut and boardwalk can be found in the diagram below:

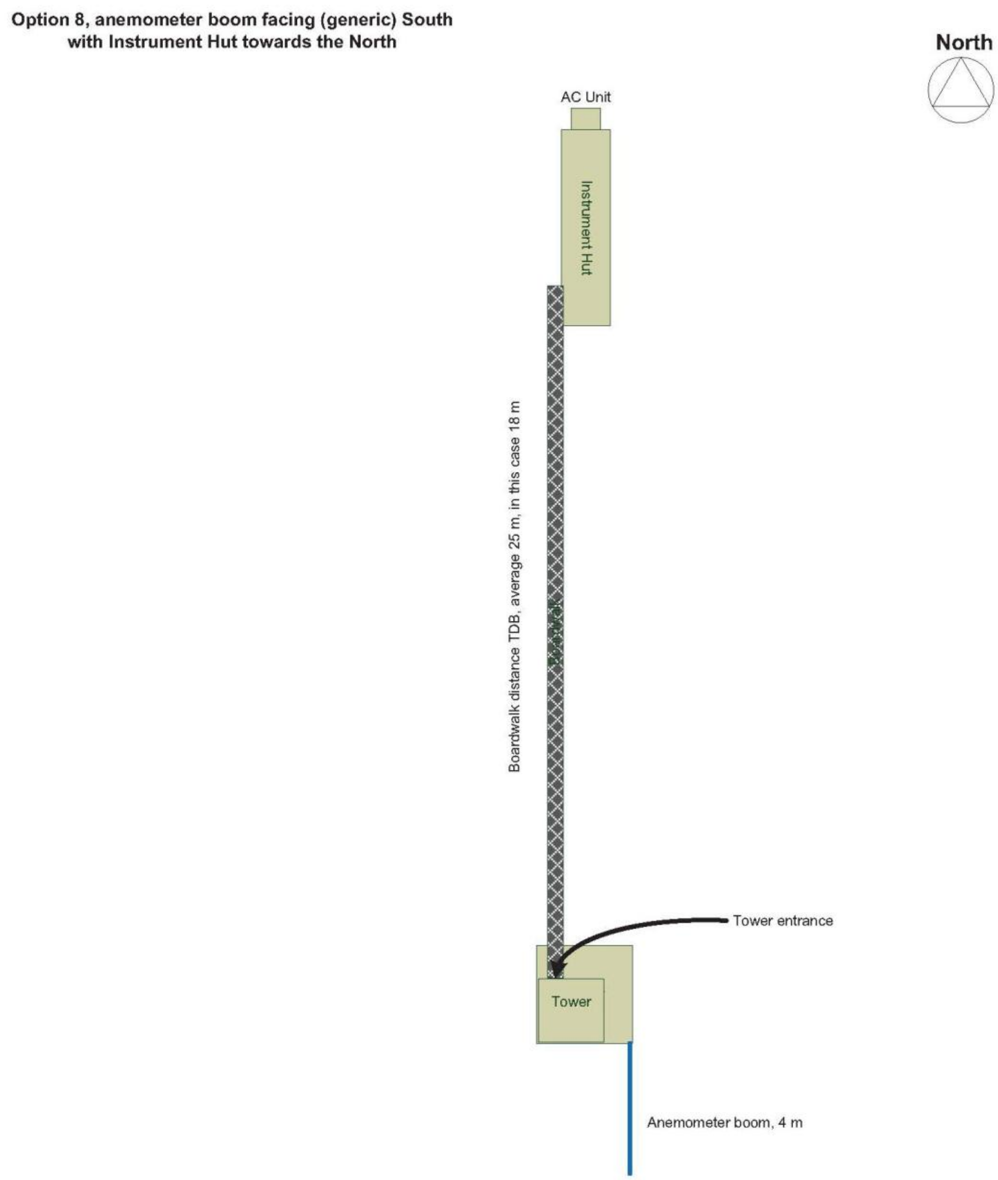


Figure 40. Generic diagram to demonstration the relationship between tower and instrument hut when boom facing south and instrument hut on the north towards the tower.

This is just a generic diagram. The actual design of boardwalk (or path if no boardwalk required) and instrument hut position will be the responsibility of FCC following FIU's guidelines. At this site, the boom angle will be 220 degrees. Instrument hut will be on the northwest towards the tower, boardwalk or walking path needs a dogleg to access tower on north. The distance between instrument hut and tower is ~20 m. The instrument hut vector will be NE-SW (40º-220º).

4.4.7 Information for ecosystem productivity plots

The tower at this site has been positioned to optimize the collection of the air/wind signals both temporally and spatially over the desired ecosystem (hardwood forest). Airshed at this site is from 110º to 280º (clockwise from 110º, major airshed) and from 310º to 10º (clockwise from 310º, secondary airshed), and 90% signals for flux measurements are within a distance of 500 m from tower during daytime, and 80% within 250 m. We suggest FSU Ecosystem Productivity plots to be placed within the major airshed boundaries of 110º to 280º (clockwise from 110º) and 310º to 10º (clockwise from 310º) from tower.

4.5 Issues and attentions

The candidate tower location on EHS' list was 32.58988°, -106.842631°. Based on local contact Dr A. Rango's suggestion and FIU site visit, the tower location was microsited to 32.59068, -106.84254 to give longer and adequate flux fetch area on the same side of the access dirt road. No preference and regulations about boardwalks. NEON can determine to have it or not. But rattle snakes concerns would be similar to Santa Rita site. Power is far away. We assume it will be FCC's responsibility to solve the power problem.

5 CAP LTER, RELOCATEABLE TOWER 2

No FIU site characterization activities were conducted at this site due to permit issues, thus no results can be report for this site.

6 REFERENCES:

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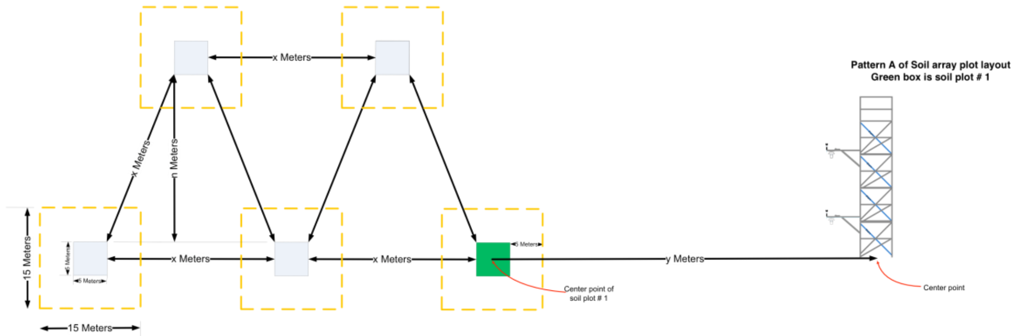
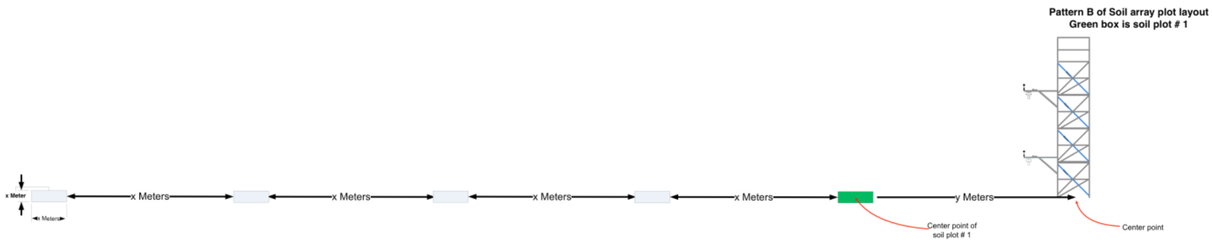
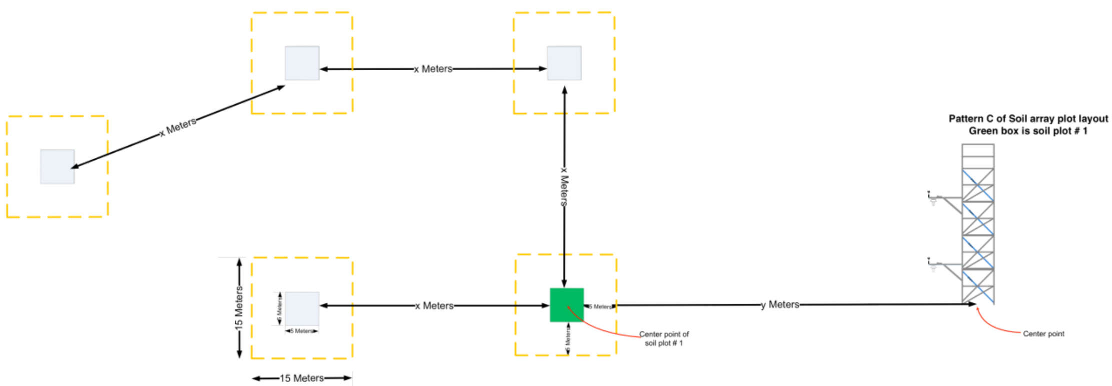
7 APPENDIX A. OPTIONAL SOIL ARRAY PATTERNS.







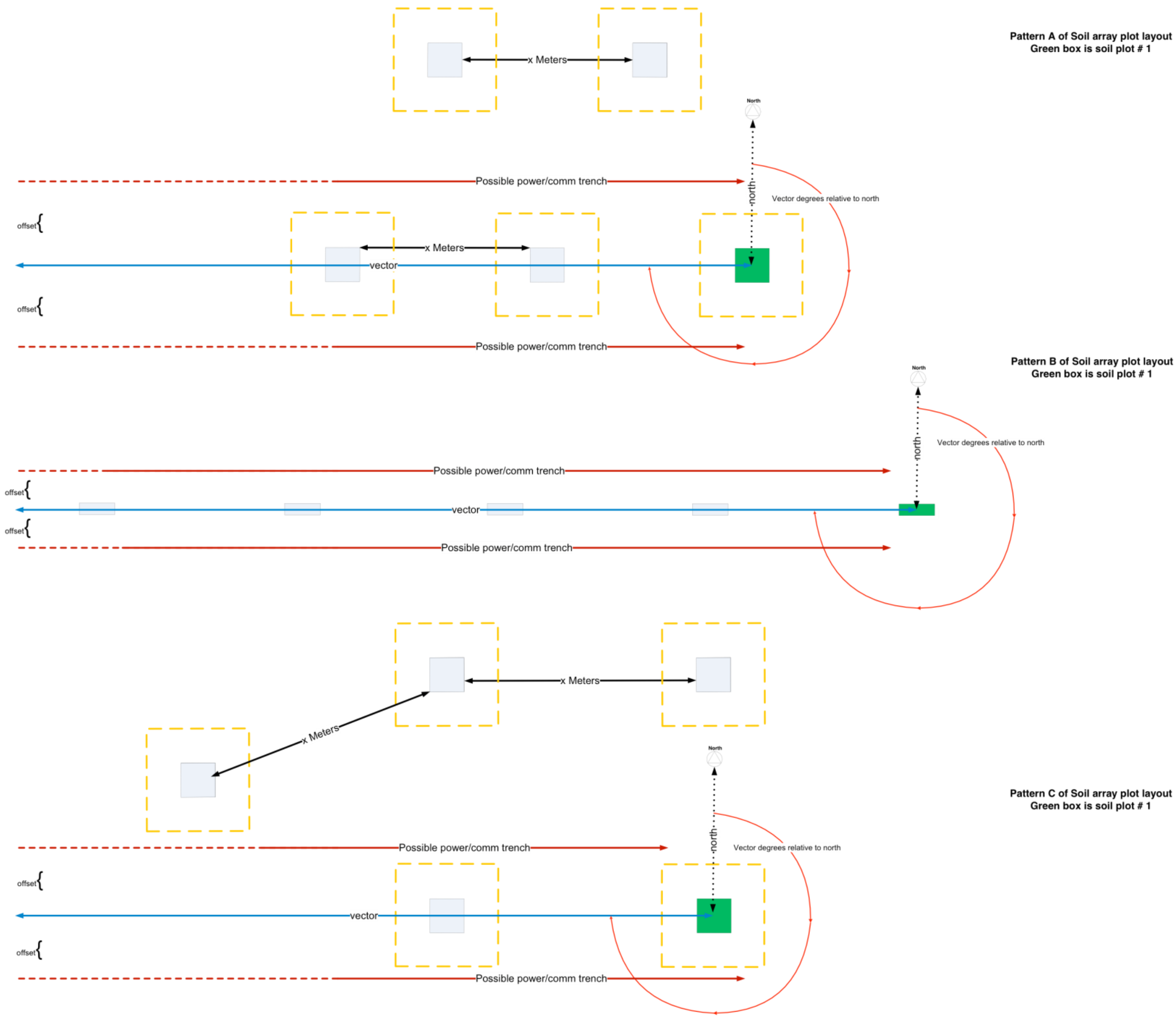


Figure A1. Conceptual diagram of Soil Array Patterns

Outlines the orientation for the soil array and instrument hut from the center point of the tower. The x, y, z distances are i) the distance between soil plots, ii) distance between the tower centerpoint and the closest edge of soil plot, and iii) the distance between the tower centerpoint and the closest edge of the instrument hut, respectively. The yellow outline around each soil plot is the 5 m perimeter keep out zone.