D11 FIU SITE CHARACTERIZATION SUPPORTING DATA

PREPARED BY	ORGANIZATION	DATE
E Ayres/ H Luo/ H Loescher	FIU	01/07/2011

APPROVALS (Name)	ORGANIZATION	APPROVAL DATE
Dave Tazik	SCI	11/06/2014
Hanne Buur	PSE	12/03/2014

RELEASED BY (Name)	ORGANIZATION	RELEASE DATE
Judy Salazar	CM	12/05/2014

See Configuration Management System for approval history.

Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	1/21/2011	NEON.FIU.000286.CRE_D11 FIU Site Characterization Reports	INITIAL RELEASE
B	09/26/2011	ECO-00279	Update to new document number's/template throughout document.
C	12/05/2014	ECO-02388	Delete Northcutt site (soft site), and replace it with Witchita Mountain Wildlife Refuge.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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 visit to the 3 NEON sites in Domain 11. This document presents all the supporting data for FIU site characterization at D11.

1.2 Scope

FIU site characterization data and analysis results presented in this document are for the three D11 tower locations: LBJ National Grassland (Advanced), Northcutt site (Relocatable 1; originally planned for the University of Oklahoma Biological Station), and Klemme Range Research Station site (Relocatable 2). Issues and concerns for each site that need further review are also addressed in this document according to our best knowledge.

Disclaimer: all latitude and longitude points are subject to the tolerances of our measurement system, i.e., GPS.

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 LBJ NATIONAL GRASSLAND (UNDERC, ADVANCED TOWER SITE)

3.1 Site description

The LBJ National Grassland (Figure 1) forms part of the Caddo-LBJ National Grasslands that are managed by the US Forest Service. The LBJ National Grassland (>20,250 acres) is located ~75 miles northwest of Dallas and is used for habitat for wildlife, cattle grazing, and recreation (including hunting, camping, horse riding, and hiking). Due to extremely erosive soils, vehicle travel on both the LBJ and Caddo is restricted to designated Forest Service system and gravel-surfaced roads. (Source: http://www.fs.fed.us/r8/texas/recreation/caddo_lbj/caddo-lbj_gen_info.shtml)

The original location of the tower at this site was 33.39924722, -97.56842222. However, during the site characterization the NEON tower was microsited to 33.40123, -97.57000 (~265 m from the original location) to avoid edge effects at the forest-grassland interface.

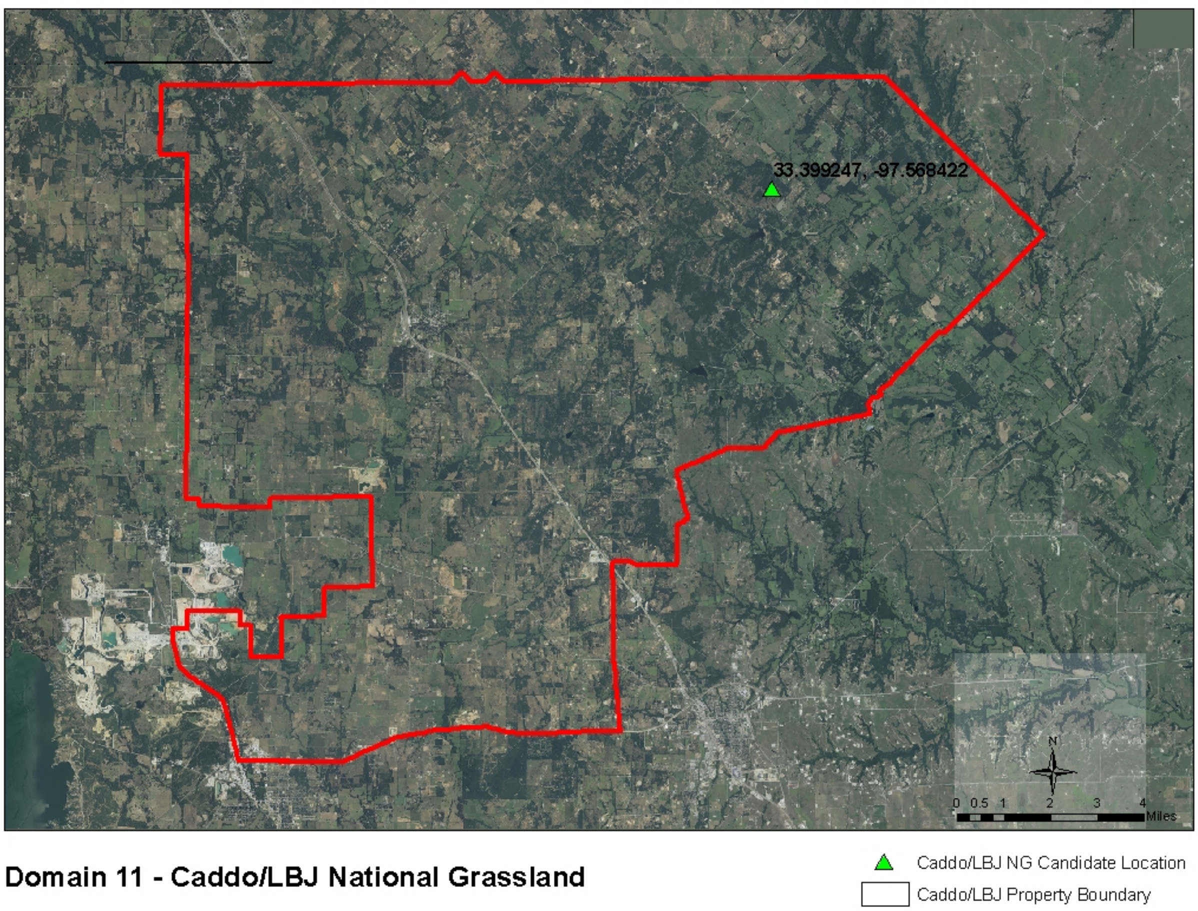
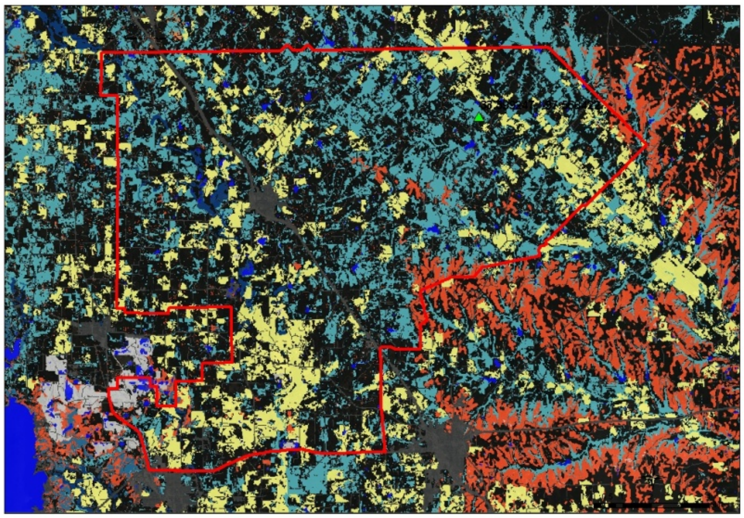


Figure 1. NEON candidate site tower location and boundary map. Coordinates represent the initial (old) tower site prior to micrositing.

3.2 Ecosystem

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



Domain 11 - Caddo/LBJ National Grassland

Figure 2. Vegetative cover map of LBJ National Grassland tower site and surrounding areas (information is from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm).

Table 1. Percent Land cover type at LBJ National Grassland Advance site (information is from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm)

Vegetation Type	Area	Percent
No Data	228.954	49.01637
Agriculture-Cultivated Crops and Irrigated Agriculture	18.51421	3.963674
Agriculture-Pasture and Hay	57.1466	12.23441
Barren	2.800552	0.599565
Central Interior and Appalachian Riparian Systems	0.006845	0.001465
Central Mixedgrass Prairie	0.001476	0.000316
Crosstimbers Oak Forest and Woodland	101.1903	21.66366
Developed-High Intensity	0.140372	0.030052
Developed-Low Intensity	7.061599	1.511805
Developed-Medium Intensity	1.59744	0.341993
Developed-Open Space	28.90075	6.187312
East-Central Texas Plains Post Oak Savanna and Woodland	0.001872	0.000401
Edwards Plateau Limestone Savanna and Woodland	0.715979	0.153283
Edwards Plateau Limestone Shrubland	0.063228	0.013536

Open Water	4.39696	0.941337
Recently Logged-Herb and Grass Cover	8.139152	1.742497
Recently Logged-Shrub Cover	1.073552	0.229835
Southeastern Great Plains Tallgrass Prairie	0.1898	0.040634
West Gulf Coastal Plain Seepage Swamp and Baygall	0.080538	0.017242
Western Great Plains Depressional Wetland Systems	0.000576	0.000123
Western Great Plains Floodplain Systems	5.963813	1.276782
Western Great Plains Mesquite Woodland and Shrubland	0.157425	0.033703
Total Area sq km	467.0971	100

The LBJ National Grassland has fairly flat terrain and consists of a mosaic of crosstimbers (oak-dominated) forest and grasslands. The ecosystem in the vicinity of the tower (including the airshed) is oak-dominated forest with a dense understory of vines with large thorns and other deciduous trees, which made walking around the site challenging (Figure 3). Note, poison ivy and ticks can be present. Besides oak, other tree species at the site include cedars and junipers (< 4 ha^{-1}). Around the edges of the forest there were several small ponds, which may have been ephemeral. The site is (managed) burned every 3-5 years. Cattle sometimes graze this area, but it is unlikely that they enter the forest due to the dense understory (except following a fire when the understory is more open).

The forest canopy was relatively open, but the dense understory means that only 30-40% of the light is transmitted to the forest floor. The forest floor had a ~2 cm thick litter layer and some coarse woody debris. Natural mortality and recruitment appears to be operating in the forest resulting in an un-even age structure. Trees with a stem diameter of > 10 cm at breast height had a density of ~200 stems ha^{-1}. Mean canopy height was 12-13.5 m. Understory is diverse with mean canopy height ~ 4 m.

Figure 3. The oak dominated forest has a very dense understory of prickly vines at the LBJ Advanced site

Table 2. Ecosystem and site attributes for LBJ Advanced tower site.

Ecosystem attributes	Measure and units
Mean canopy height	13 m
Surface roughness[a]	2 m
Zero place displacement height[a]	10 m
Structural elements	Open deciduous forest, diverse, dense and prickly understory
Time zone	central time zone
Magnetic declination	4° 35' E changing by 0° 7' W/year

Note, [a] From field observation.

3.3 Soils

3.3.1 Soil description

Soil data and soil maps below for the LBJ Advanced tower site were collected from 2.2 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.

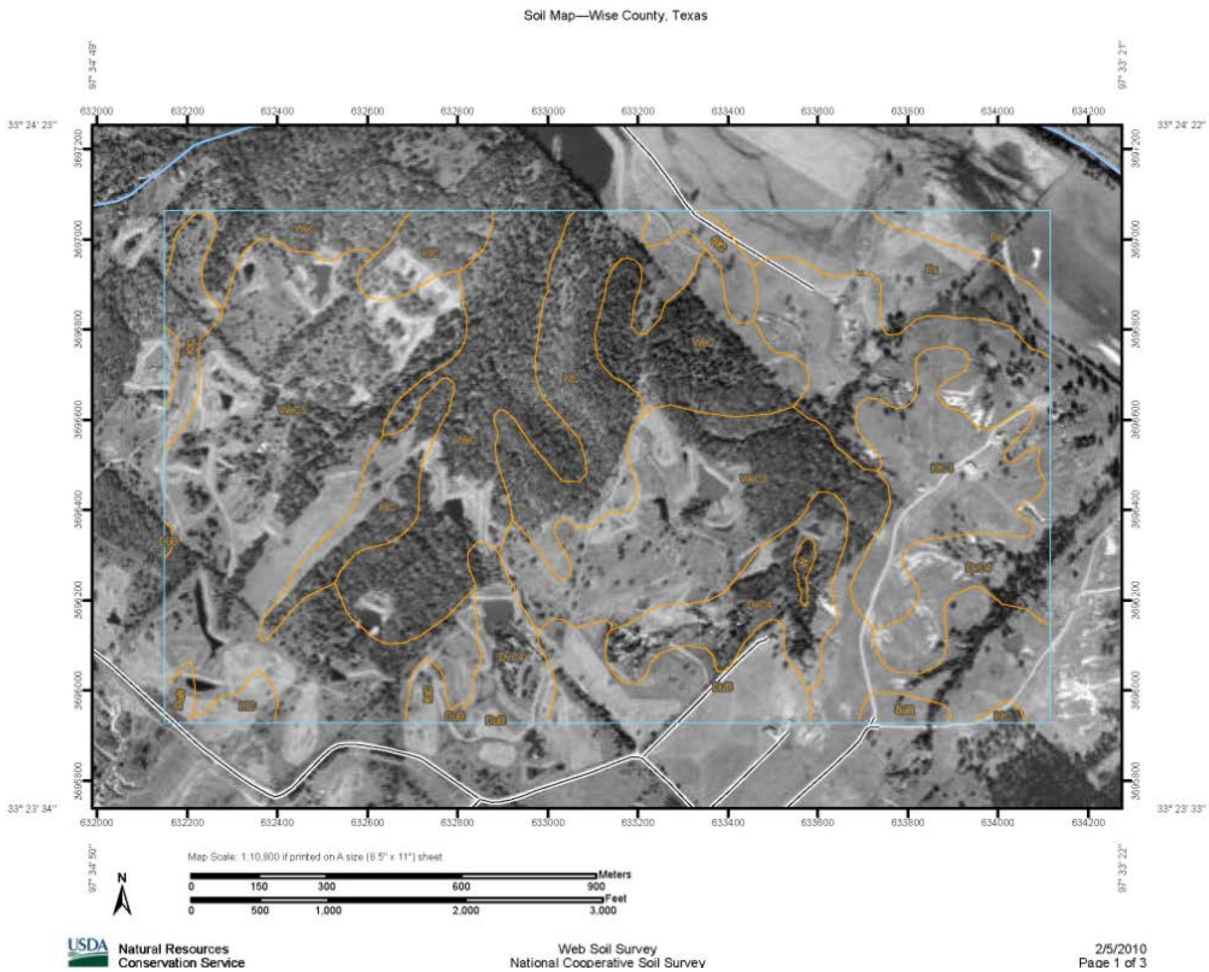


Figure 4. Soil map for the LBJ NEON advanced tower site.

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, are 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 2.2 km^2.
Area Object Interest (AOI) is the mapping unit from NRCS.

Wise County, Texas (TX497)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Ba	Balsora silt loam, occasionally flooded	9.0	1.6%
DuB	Duffau fine sandy loam, 1 to 3 percent slopes	26.1	4.7%
DvC4	Duffau-Gullied land complex, 3 to 8 percent slopes	89.5	16.2%
KtC	Keeter very fine sandy loam, 1 to 6 percent slopes	76.3	13.8%
KtC3	Keeter very fine sandy loam, 2 to 6 percent slopes, ero ded	31.3	5.7%
Ps	Pulexas very fine sandy loam, occasionally flooded	25.3	4.6%
SdB	Selden loamy fine sand, 1 to 3 percent slopes	2.7	0.5%
SfC	Silawa fine sandy loam, 3 to 8 percent slopes	5.8	1.1%
W	Water	0.9	0.2%
WeC	Weatherford-Duffau complex, 3 to 8 percent slopes	88.5	16.0%
WeC3	Weatherford-Duffau complex, 3 to 8 percent slopes, erod ed	195.9	35.5%
Totals for Area of Interest		**551.4**	**100.0%**

Wise County, Texas: Ba—Balsora silt loam, occasionally flooded. Map Unit Setting *Elevation:* 700 to 1,000 feet *Mean annual precipitation:* 28 to 32 inches *Mean annual air temperature:* 63 to 66 degrees F *Frost-free period:* 215 to 225 days **Map Unit Composition** *Balsora and similar soils:* 100 percent **Description of Balsora Setting** *Landform:* Flood plains *Landform position (three-dimensional):* Tread *Down-slope shape:* Linear *Across-slope shape:* Linear *Parent material:* Loamy alluvium **Properties and qualities** *Slope:* 0 to 1 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:* Occasional *Frequency of ponding:* None *Calcium carbonate, maximum content:* 5 percent *Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm) *Available water capacity:* Moderate (about 9.0 inches) **Interpretive groups** *Land capability (nonirrigated):* 2w *Ecological site:* Loamy Bottomland 29-33" PZ (R084BY170TX) **Typical profile** *0 to 6 inches:* Silt loam *6 to 62 inches:* Stratified very fine sandy loam to silty clay loam

Wise County, Texas: DuB—Duffau fine sandy loam, 1 to 3 percent slopes. Map Unit Setting *Elevation:* 800 to 1,400 feet *Mean annual precipitation:* 28 to 35 inches *Mean annual air temperature:* 64 to 66 degrees F *Frost-free period:* 230 to 250 days **Map Unit Composition** *Duffau and similar soils:* 100 percent **Description of Duffau Setting** *Landform:* Ridges *Landform position (two-dimensional):* Backslope *Down-slope shape:* Convex *Across-slope shape:* Convex *Parent material:* Loamy residuum weathered from limestone and shale **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:* None *Frequency of ponding:* None *Calcium carbonate, maximum content:* 5 percent *Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm) *Available water capacity:* High (about 9.2 inches) **Interpretive groups** *Land capability (nonirrigated):* 2e *Ecological site:* Sandy Loam 29-33" PZ (R084BY174TX) **Typical profile** *0 to 12 inches:* Fine sandy loam *12 to 61 inches:* Sandy clay loam *61 to 80 inches:* Fine sandy loam

Wise County, Texas: DvC4—Duffau-Gullied land complex, 3 to 8 percent slopes. Map Unit Setting *Elevation:* 10 to 6,000 feet *Mean annual precipitation:* 10 to 46 inches *Mean annual air temperature:* 57 to 73 degrees F *Frost-free period:* 220 to 320 days **Map Unit Composition** *Duffau and similar soils:* 70 percent *Gullied land:* 30 percent **Description of Duffau Setting** *Landform:* Ridges *Landform position (two-dimensional):* Backslope *Down-slope shape:* Convex *Across-slope shape:* Convex *Parent material:* Loamy residuum weathered from limestone and shale **Properties and qualities** *Slope:* 3 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):* 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:* 5 percent *Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm) *Available water capacity:* High (about 9.1 inches) **Interpretive groups** *Land capability (nonirrigated):* 4e *Ecological site:* Sandy Loam 29-33" PZ (R084BY174TX) **Typical profile** *0 to 8 inches:* Very fine sandy loam *8 to 48 inches:* Sandy clay loam *48 to 80 inches:* Sandy clay loam **Description of Gullied Land Setting** *Microfeatures of landform position:* Gullies **Interpretive groups** *Land capability (nonirrigated):* 7e **Typical profile** *0 to 80 inches:* Variable

Wise County, Texas: KtC—Keeter very fine sandy loam, 1 to 6 percent slopes. Map Unit Setting *Elevation:* 1,000 to 1,100 feet *Mean annual precipitation:* 26 to 33 inches *Mean annual air temperature:* 63 to 64 degrees F *Frost-free period:* 230 to 240 days **Map Unit Composition** *Keeter and similar soils:* 100 percent **Description of Keeter Setting** *Landform:* Ridges *Landform position (two-dimensional):* Backslope *Down-slope shape:* Linear *Across-slope shape:* Convex *Parent material:* Sandy and loamy alluvium **Properties and qualities** *Slope:* 1 to 6 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 (0.20 to 0.57 in/hr) *Depth to water table:* More than 80 inches *Frequency of flooding:* None *Frequency of ponding:* None *Calcium carbonate, maximum content:* 3 percent *Available water capacity:* Moderate (about 8.2 inches) **Interpretive groups** *Land capability (nonirrigated):* 4e *Ecological site:* Tight Sandy Loam 29-33" PZ (R084BY175TX) **Typical profile** *0 to 7 inches:* Very fine sandy loam *7 to 15 inches:* Clay loam *15 to 33 inches:* Clay loam *33 to 72 inches:* Very fine sandy loam

Wise County, Texas: KtC3—Keeter very fine sandy loam, 2 to 6 percent slopes, eroded. Map Unit Setting *Elevation:* 1,000 to 1,100 feet *Mean annual precipitation:* 26 to 33 inches *Mean annual air temperature:* 63 to 64 degrees F *Frost-free period:* 230 to 240 days **Map Unit Composition** *Keeter, eroded, and similar soils:* 100 percent **Description of Keeter, Eroded Setting** *Landform:* Ridges *Landform position (two-dimensional):* Backslope *Down-slope shape:* Linear *Across-slope shape:* Convex *Parent material:* Sandy and loamy alluvium **Properties and qualities** *Slope:* 2 to 6 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 (0.20 to 0.57 in/hr) *Depth to water table:* More than 80 inches *Frequency of flooding:* None *Frequency of ponding:* None *Calcium carbonate, maximum content:* 3 percent *Available water capacity:* Moderate (about 8.2 inches) **Interpretive groups** *Land capability (nonirrigated):* 4e *Ecological site:* Tight Sandy Loam 29-33" PZ (R084BY175TX) **Typical profile** *0 to 3 inches:* Very fine sandy loam *3 to 18 inches:* Sandy clay *18 to 38 inches:* Sandy clay loam *38 to 72 inches:* Very fine sandy loam

Wise County, Texas: Ps—Pulexas very fine sandy loam, occasionally flooded. Map Unit Setting *Elevation:* 650 to 800 feet *Mean annual precipitation:* 28 to 38 inches *Mean annual air temperature:* 64 to 70 degrees F *Frost-free period:* 230 to 240 days **Map Unit Composition** *Pulexas and similar soils:* 100

percent **Description of Pulexas Setting** *Landform:* Flood plains *Down-slope shape:* Linear *Across-slope shape:* Linear *Parent material:* Loamy alluvium **Properties and qualities** *Slope:* 0 to 1 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:* Occasional *Frequency of ponding:* None *Calcium carbonate, maximum content:* 5 percent *Available water capacity:* Moderate (about 7.9 inches) **Interpretive groups** *Land capability (nonirrigated):* 2w *Ecological site:* Loamy Bottomland 29-33" PZ (R084BY170TX) **Typical profile** *0 to 7 inches:* Very fine sandy loam *7 to 72 inches:* Loam

Wise County, Texas: SdB—Selden loamy fine sand, 1 to 3 percent slopes. Map Unit Setting *Elevation:* 400 to 1,100 feet *Mean annual precipitation:* 24 to 35 inches *Mean annual air temperature:* 63 to 68 degrees F *Frost-free period:* 230 to 240 days **Map Unit Composition** *Selden and similar soils:* 100 percent **Description of Selden Setting** *Landform:* Ridges *Landform position (two-dimensional):* Backslope *Down-slope shape:* Linear *Across-slope shape:* Convex, concave *Parent material:* Loamy alluvium **Properties and qualities** *Slope:* 1 to 3 percent *Depth to restrictive feature:* More than 80 inches *Drainage class:* Moderately well drained *Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.57 in/hr) *Depth to water table:* More than 80 inches *Frequency of flooding:* None *Frequency of ponding:* None *Available water capacity:* Moderate (about 7.9 inches) **Interpretive groups** *Land capability (nonirrigated):* 3e *Ecological site:* Loamy Sand 29-33" PZ (R084BY171TX) **Typical profile** *0 to 13 inches:* Loamy fine sand *13 to 70 inches:* Sandy clay loam

Wise County, Texas: SfC—Silawa fine sandy loam, 3 to 8 percent slopes. Map Unit Setting *Elevation:* 350 to 800 feet *Mean annual precipitation:* 30 to 42 inches *Mean annual air temperature:* 63 to 70 degrees F *Frost-free period:* 220 to 270 days **Map Unit Composition** *Silawa and similar soils:* 100 percent **Description of Silawa Setting** *Landform:* Stream terraces *Landform position (three-dimensional):* Riser *Down-slope shape:* Convex *Across-slope shape:* Convex *Parent material:* Sandy alluvium **Properties and qualities** *Slope:* 3 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):* 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 *Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm) *Available water capacity:* Moderate (about 8.3 inches) **Interpretive groups** *Land capability (nonirrigated):* 4e *Ecological site:* Sandy Loam 29-33" PZ (R084BY174TX) **Typical profile** *0 to 12 inches:* Fine sandy loam *12 to 46 inches:* Sandy clay loam *46 to 59 inches:* Fine sandy loam *59 to 80 inches:* Fine sandy loam

Wise County, Texas: W—Water. Map Unit Setting *Mean annual precipitation:* 28 to 36 inches *Mean annual air temperature:* 64 to 68 degrees F *Frost-free period:* 210 to 240 days **Map Unit Composition** *Water:* 100 percent

Wise County, Texas: WeC—Weatherford-Duffau complex, 3 to 8 percent slopes. Map Unit Setting *Elevation:* 600 to 1,400 feet *Mean annual precipitation:* 28 to 38 inches *Mean annual air temperature:* 64 to 66 degrees F *Frost-free period:* 210 to 250 days **Map Unit Composition** *Weatherford and similar soils:* 50 percent *Duffau and similar soils:* 40 percent *Minor components:* 10 percent **Description of Weatherford Setting** *Landform:* Ridges *Landform position (two-dimensional):* Shoulder *Down-slope shape:* Linear *Across-slope shape:* Convex *Parent material:* Loamy residuum weathered from sandstone **Properties and qualities** *Slope:* 3 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):* 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 *Available water capacity:* Moderate (about 8.0 inches) **Interpretive groups** *Land capability (nonirrigated):* 4e *Ecological site:* Sandy Loam 29-33" PZ (R084BY174TX) **Typical profile** *0 to 11 inches:* Very fine sandy loam *11 to 25 inches:* Sandy clay loam *25 to 47 inches:* Sandy clay loam *47 to 80 inches:* Fine sandy loam **Description of Duffau Setting** *Landform:* Ridges *Landform position (two-dimensional):* Backslope *Down-slope shape:* Convex *Across-slope shape:* Convex *Parent material:* Loamy residuum weathered from limestone and Shale **Properties and qualities** *Slope:* 3 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):* 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 *Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm) *Available water capacity:* High (about 9.4 inches) **Interpretive groups** *Land capability (nonirrigated):* 4e *Ecological site:* Sandy Loam 29-33" PZ (R084BY174TX) **Typical profile** *0 to 16 inches:* Very fine sandy loam *16 to 80 inches:* Sandy clay loam **Minor Components Unnamed, minor components** *Percent of map unit:* 10 percent

Wise County, Texas: WeC3—Weatherford-Duffau complex, 3 to 8 percent slopes, eroded. Map Unit Setting *Elevation:* 600 to 1,400 feet *Mean annual precipitation:* 28 to 38 inches *Mean annual air temperature:* 64 to 66 degrees F *Frost-free period:* 210 to 250 days **Map Unit Composition** *Weatherford and similar soils:* 50 percent *Duffau and similar soils:* 40 percent *Minor components:* 10 percent **Description of Weatherford Setting** *Landform:* Ridges *Landform position (two-dimensional):* Shoulder *Down-slope shape:* Linear *Across-slope shape:* Convex *Parent material:* Loamy residuum weathered from sandstone **Properties and qualities** *Slope:* 3 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):* 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 *Available water capacity:* Moderate (about 7.6 inches) **Interpretive groups** *Land capability (nonirrigated):* 4e *Ecological site:* Sandy Loam 29-33" PZ (R084BY174TX) **Typical profile** *0 to 8 inches:* Fine sandy loam *8 to 20 inches:* Sandy clay loam *20 to 41 inches:* Sandy clay loam *41 to 60 inches:* Fine sandy loam **Description of Duffau Setting** *Landform:* Ridges *Landform position (two-dimensional):* Backslope *Down-slope shape:* Convex *Across-slope shape:* Convex *Parent material:* Loamy residuum weathered from limestone and shale **Properties and qualities** *Slope:* 3 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):* 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:* 5 percent *Maximum salinity:* Nonsaline (0.0 to 2.0 mmhos/cm) *Available water capacity:* High (about 9.3 inches) **Interpretive groups** *Land capability (nonirrigated):* 4e *Ecological site:* Sandy Loam 29-33" PZ (R084BY174TX) **Typical profile** *0 to 10 inches:* Fine sandy loam *10 to 64 inches:* Sandy clay loam *64 to 80 inches:* Sandy clay loam **Minor Components Unnamed, minor components** *Percent of map unit:* 10 percent

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.

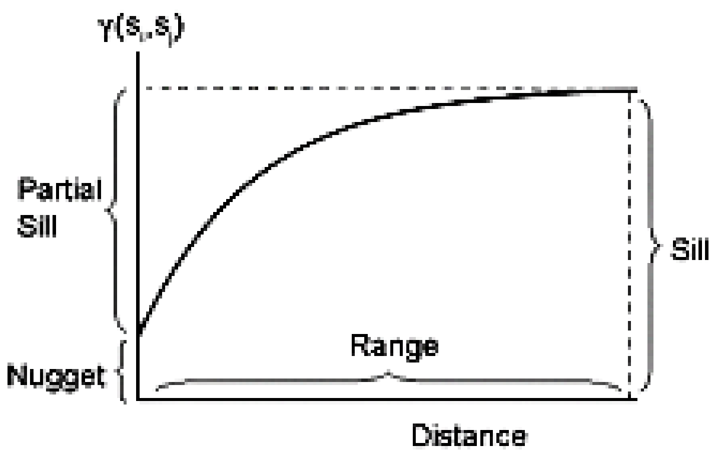


Figure 5. Example semivariogram, depicting range, sill, and nugget.

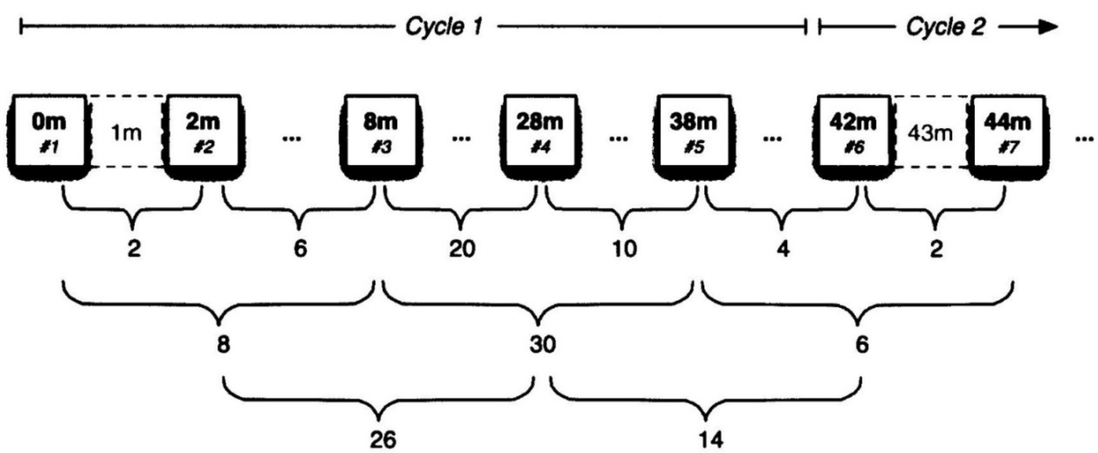


Figure 6. Spatially cyclic sampling design for the measurements of soil temperature and soil water content.

Field measurements of soil temperature (0-12 cm) and moisture (0-15 cm) were taken on 28 September 2010 at the LBJ site. The sampling points followed the spatially cyclic sampling design by Bond-Lamberty et al. (2006) (Figure 6). Soil temperature and moisture measurements were collected along three transects (168 m, 84 m, and 84 m) located in the expected airshed at LBJ. 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 Figure 6, 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 graph) 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 9 m for soil temperature.

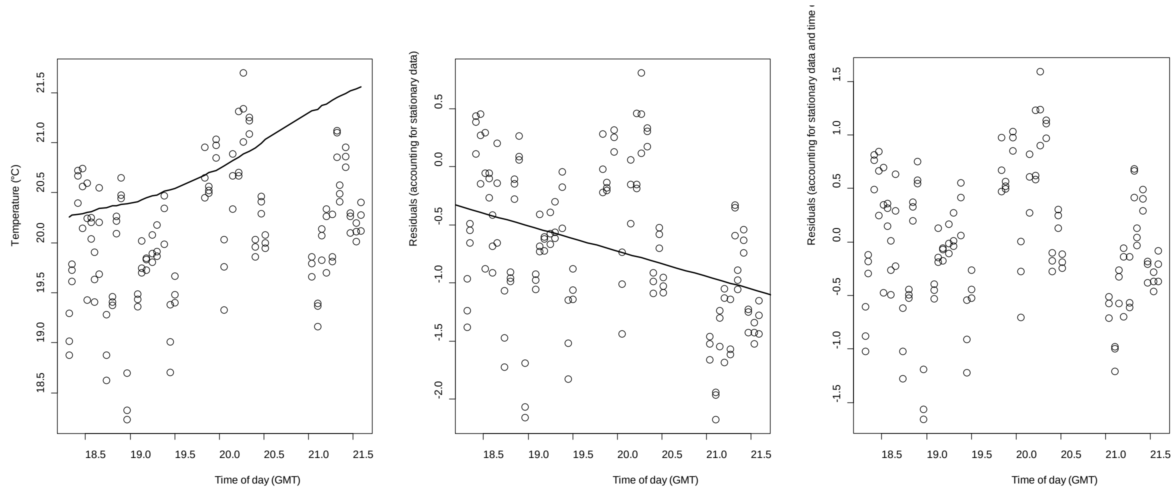


Figure 7. Left graph: mobile (circles) and stationary (line) soil temperature data. Center graph: temperature data after correcting for changes in temperature in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual temperature data after correcting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

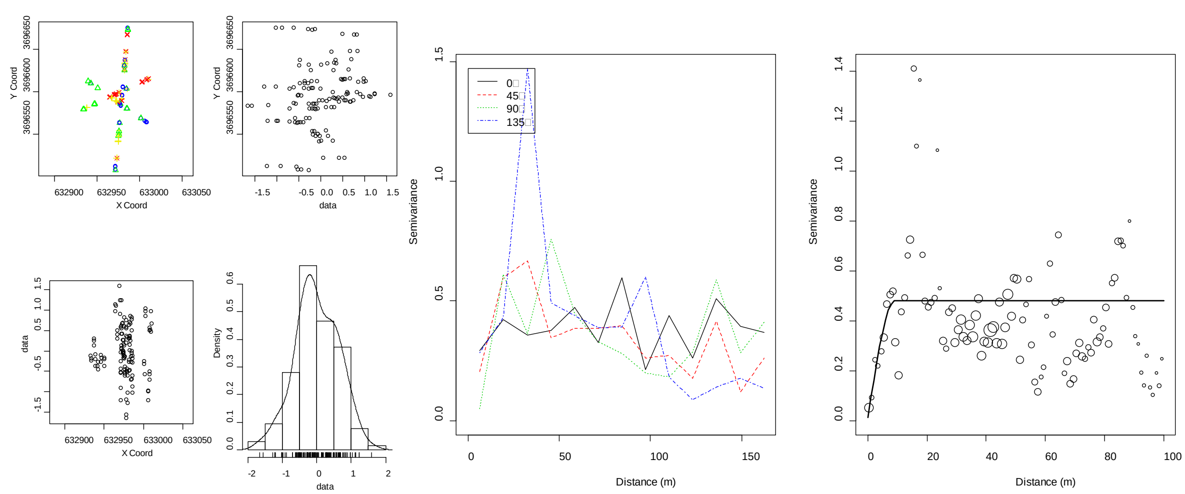


Figure 8. Left graphs: exploratory data analysis plots for residuals of temperature. Center graph: directional semivariograms for residuals of temperature. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of temperature.

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 3 m for soil water content.

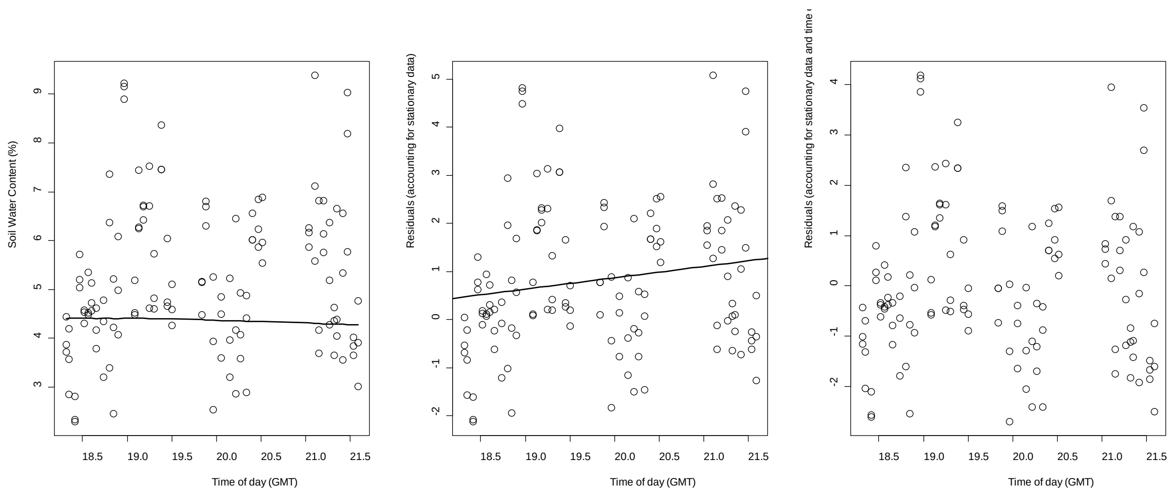


Figure 9. Left graph: mobile (circles) and stationary (line) soil water content data. Center graph: water content data after correcting for changes in water content in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual water content data after correcting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

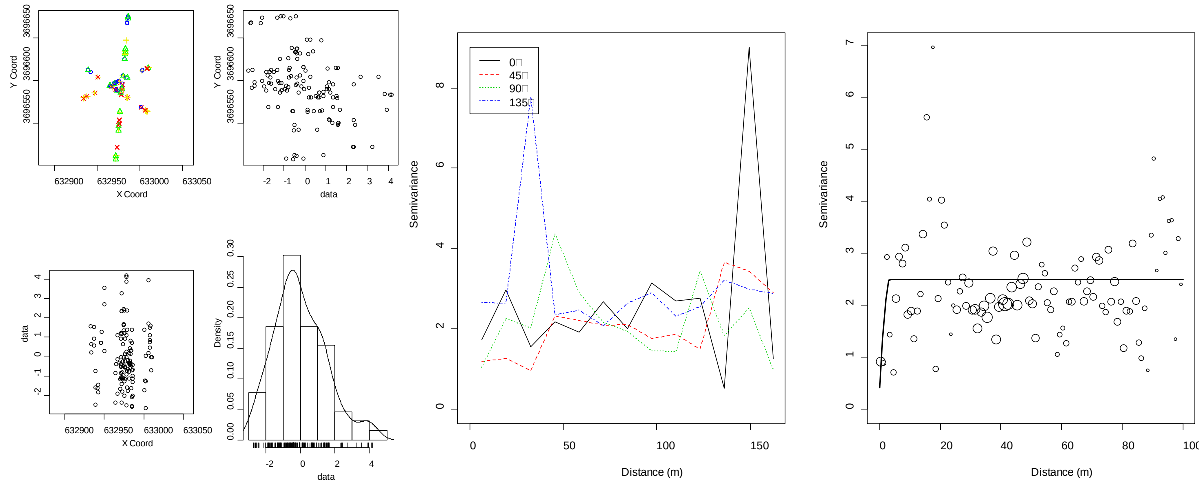


Figure 10. Left graphs: exploratory data analysis plots for residuals of soil water content. Center graph: directional semivariograms for residuals of water content. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of water content.

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 9 m for soil temperature and 3 m for soil moisture. Based on these results and the site design guidelines the soil plots at LBJ 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 165° from the soil plot nearest the tower (i.e., first soil plot). The location of the first soil plot will be approximately 33.401049°, -97.570000°. 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 33.401412, -97.567275 (primary location); or 33.401359, -97.566734 (alternate location 1 if primary location is unsuitable); or 33.401339, -97.566176 (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: Weatherford-Duffau complex, 3 to 8 percent slopes. The taxonomy of this soil is shown below:
Order: Alfisols
Suborder: Ustalfs
Great group: Haplustalfs- Paleustalfs
Subgroup: Ultic Haplustalfs- Udic Paleustalfs
Family: Fine-loamy, siliceous, active, thermic Ultic Haplustalfs- Fine-loamy, siliceous, active, thermic Udic Paleustalfs
Series: Weatherford-Duffau complex, 3 to 8 percent slopes

Table 4. Summary of soil array and soil pit information at LBJ. 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	20 m
Latitude and longitude of 1st soil plot OR direction from tower	33.401049°, -97.570000°
Direction of soil array	165°
Latitude and longitude of FIU soil pit 1	33.401412, -97.567275 (primary location)
Latitude and longitude of FIU soil pit 2	33.401359, -97.566734 (alternate 1)
Latitude and longitude of FIU soil pit 3	33.401339, -97.566176 (alternate 2)
Dominant soil type	Weatherford-Duffau complex, 3 to 8 percent slopes
Expected soil depth	>2 m
Depth to water table	>2 m

Expected depth of soil horizons	**Expected measurement depths**[*]
0-0.28 m (Very fine sandy loam)	0.14 m[a]
0.28-0.64 m (Sandy clay loam)	0.46 m[a]
0.64-1.19 m (Sandy clay loam)	0.92 m[a]
1.19-2 m (Fine sandy loam)	1.60 m
	2.00 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.
[a]Soil CO_2 probes

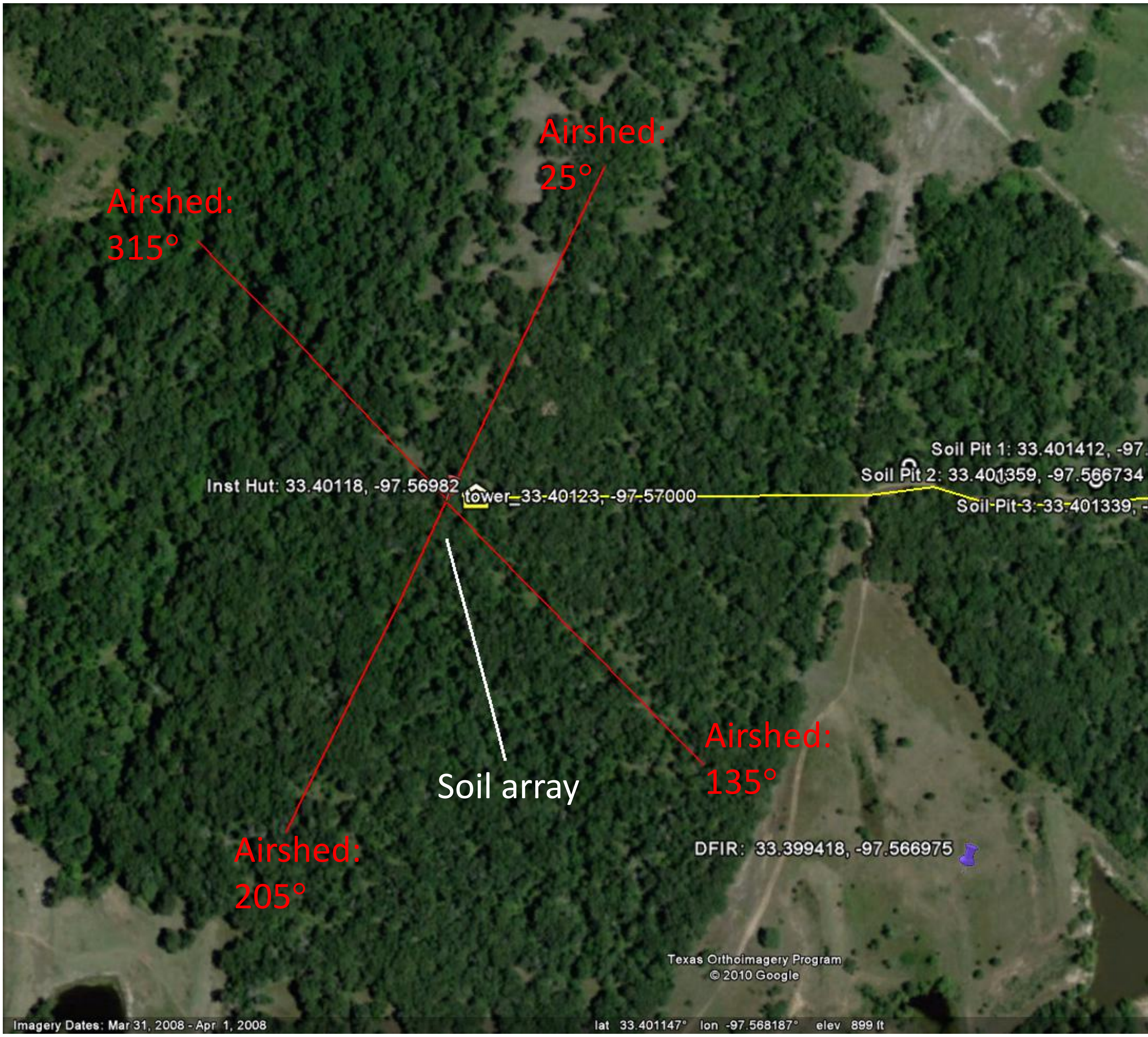


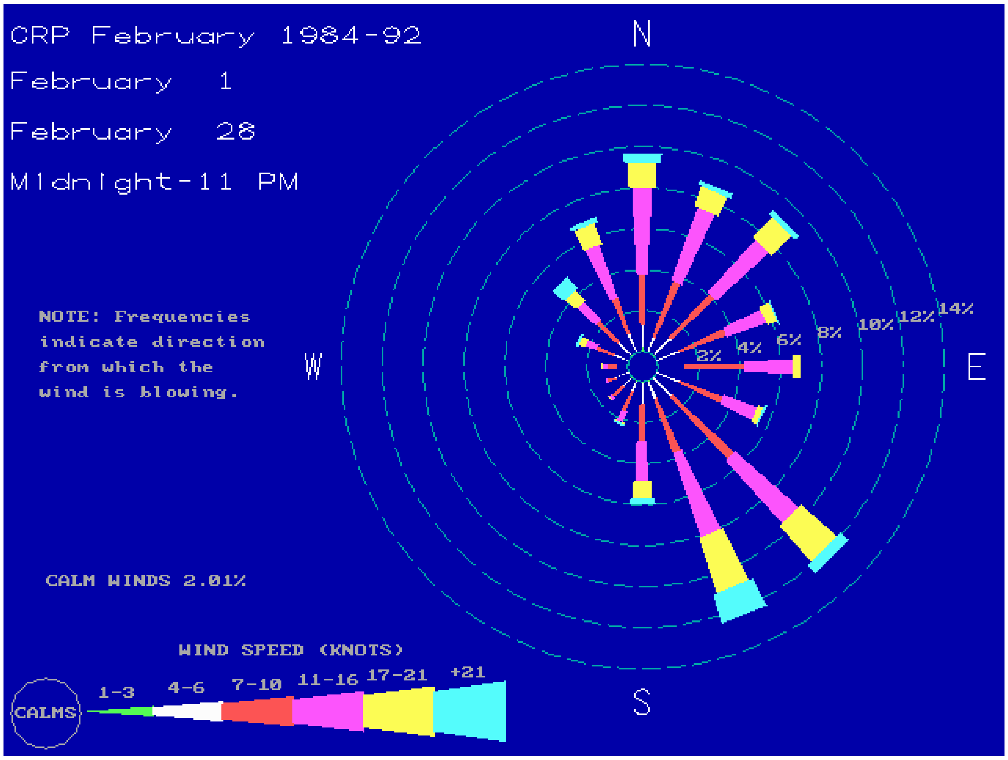
Figure 11. Site layout at LBJ showing soil array and location of the FIU soil pit.

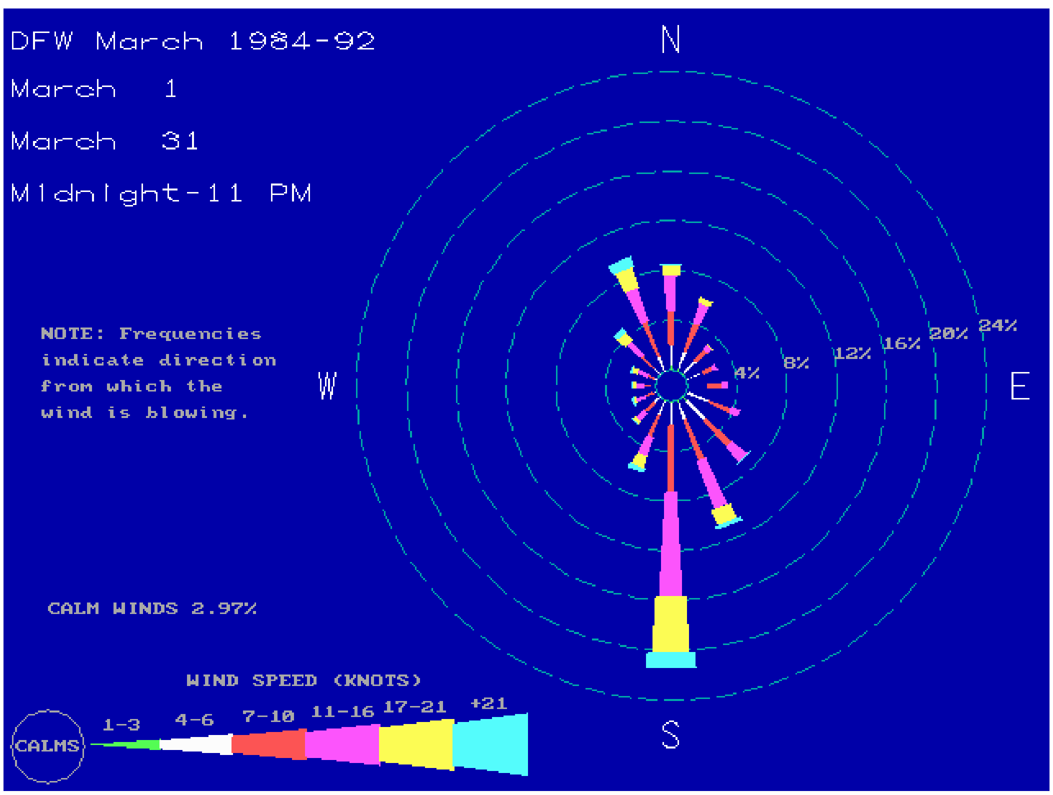
3.4 Airshed

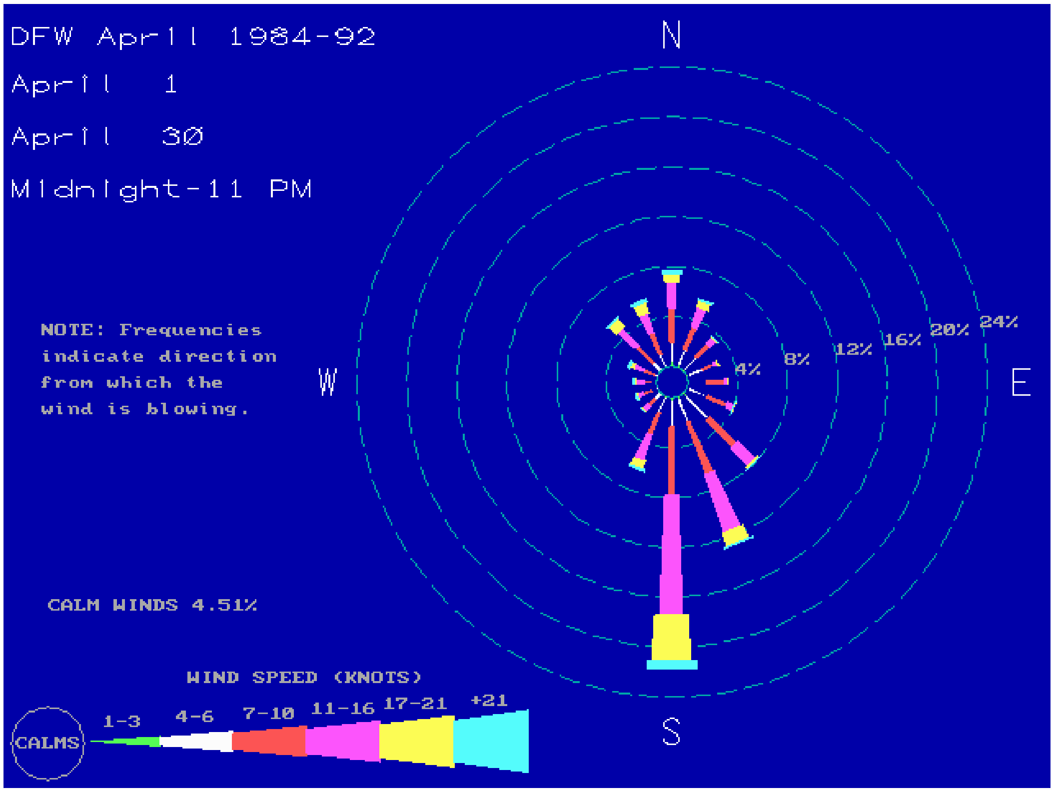
3.4.1 Seasonal windroses

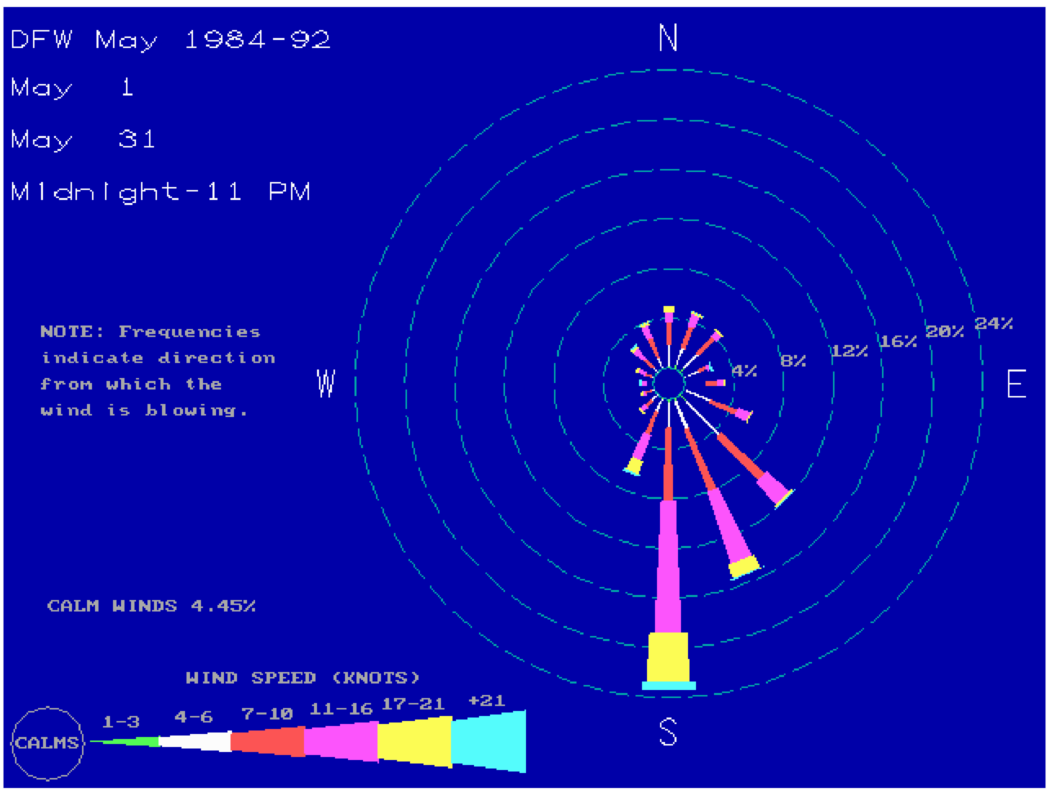
Wind roses analytically determine and graphically represent the frequencies of wind direction and wind speed over a given timeseries. This LBJ core site is between Wichita Falls and Dallas/Fort Worth. No weather data is available at site. The country is flat. We assume the wind pattern at LBJ site will be similar to Wichita Falls and/or Dallas/Fort Worth. The weather data and wind roses from both Wichita Falls (SFS station) and Dallas/Fort Worth (DFW station) are similar, which demonstrate prevailing wind direction from north and south direction, sometime slightly from southeast depending on season. Wind roses showed below are for DFW station (info source: http://www.tceq.state.tx.us/compliance/monitoring/air/monops/windroses.html). Coordinates for the weather station is unclear. The orientation of the windrose 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 16 cardinal directions in this case.

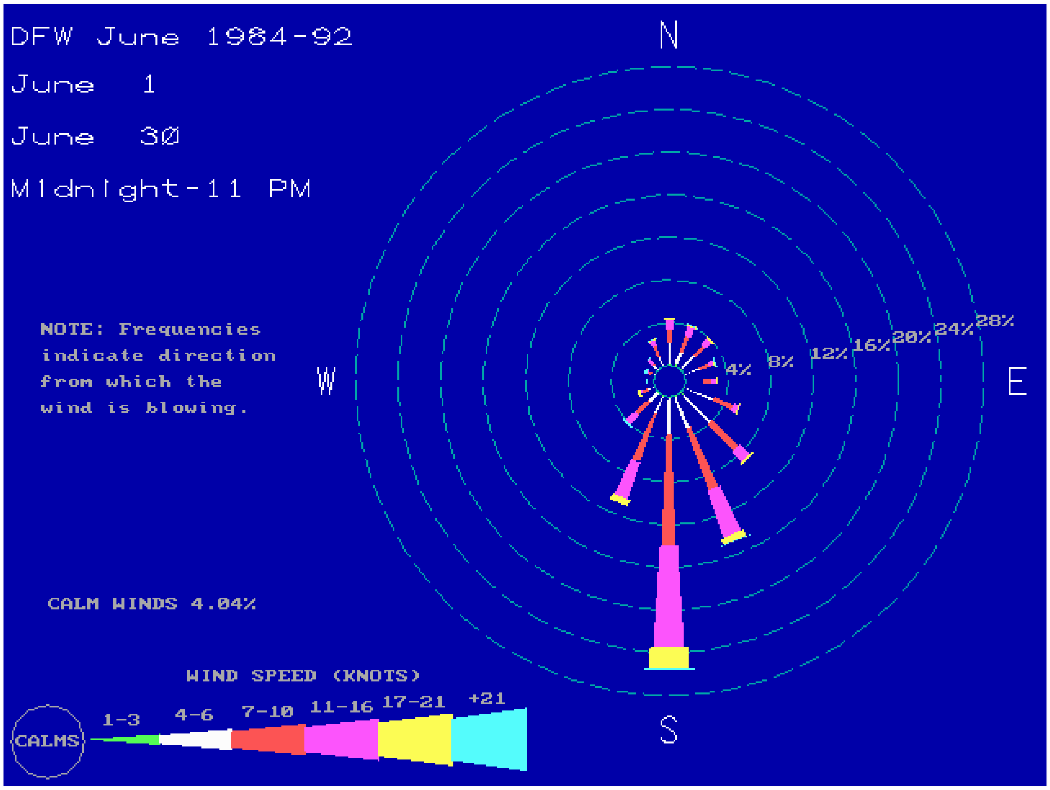
3.4.2 Results (graphs for wind roses)

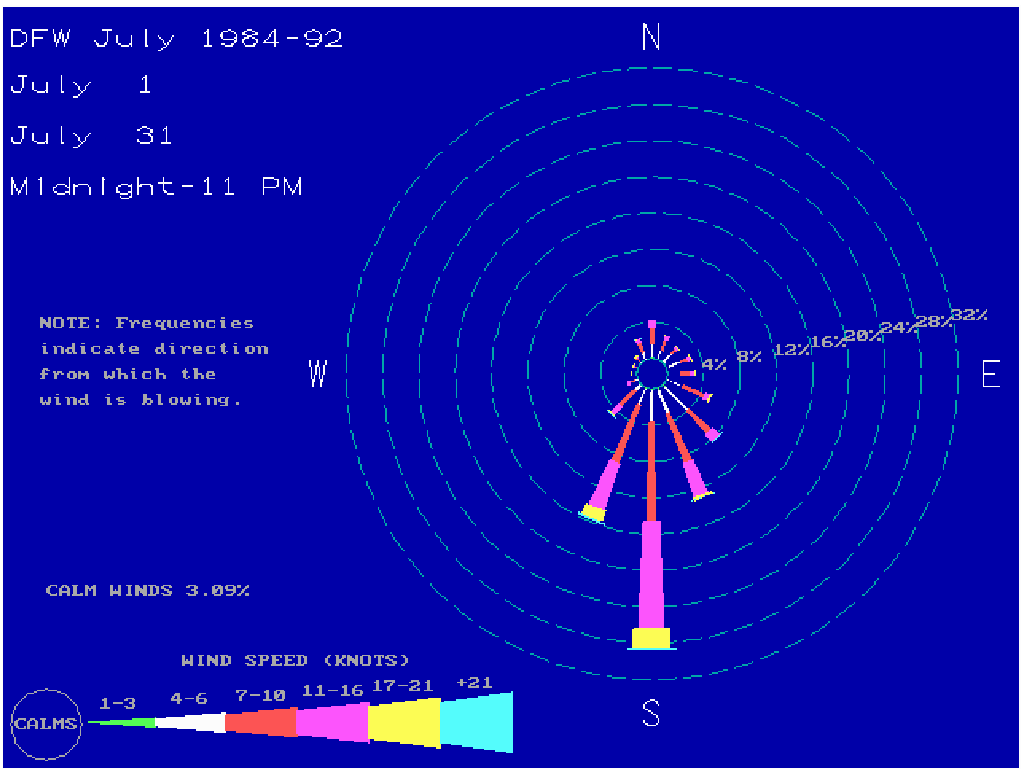

CRP February 1984-92
February 1
February 28
Midnight-11 PM
NOTE: Frequencies indicate direction from which the wind is blowing.
CALM WINDS 2.01%
WIND SPEED (KNOTS)
CALMS
1-3
4-6
7-10
11-16
17-21
+21
N
S
E
W
2%
4%
6%
8%
10%
12%
14%

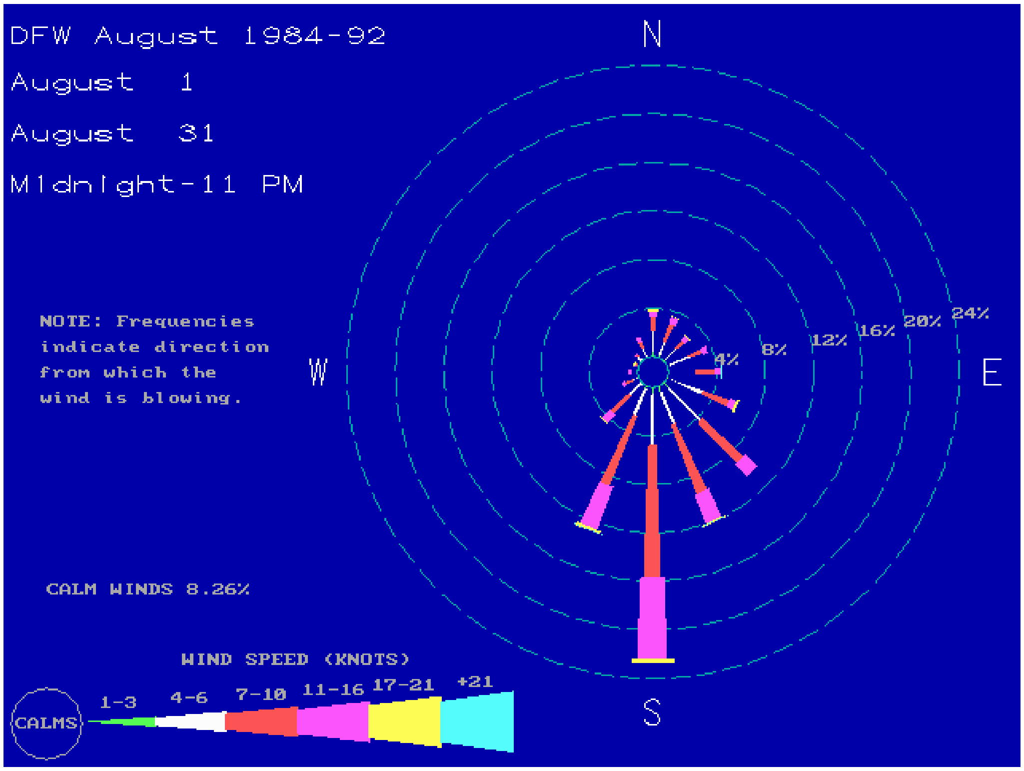

DFW March 1984-92
March 1
March 31
Midnight-11 PM
NOTE: Frequencies indicate direction from which the wind is blowing.
CALM WINDS 2.97%
WIND SPEED (KNOTS)
CALMS
1-3
4-6
7-10
11-16
17-21
+21
N
S
E
W
4%
8%
12%
16%
20%
24%

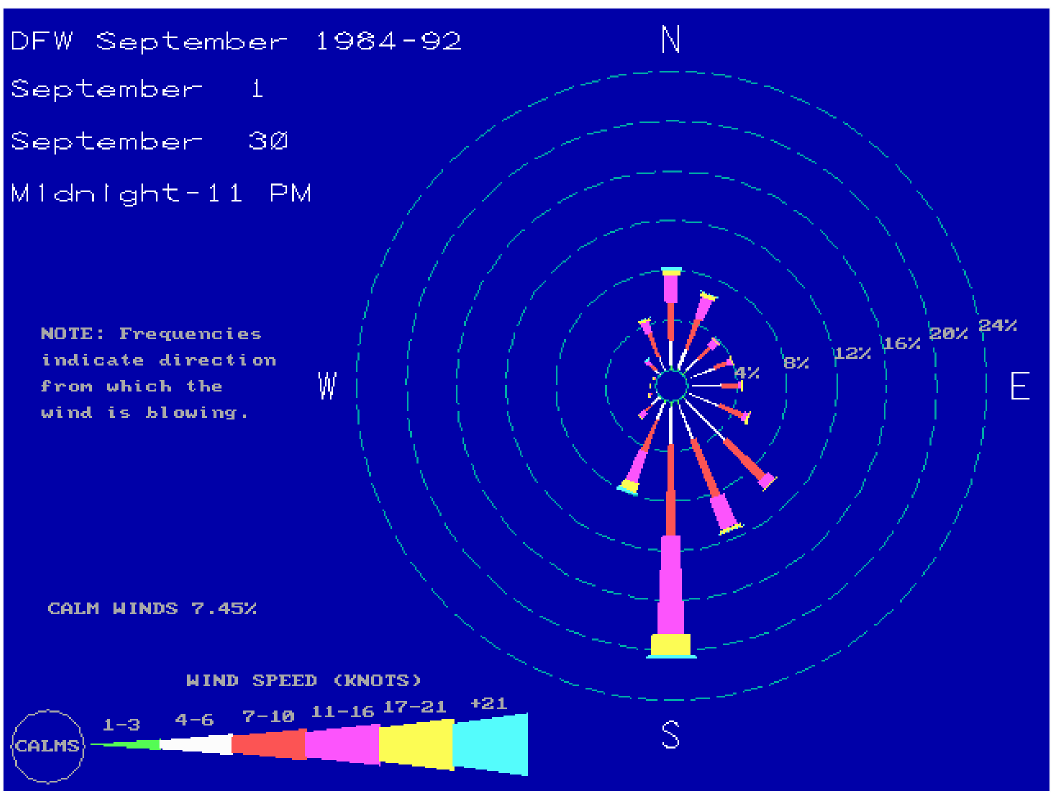

DFW April 1984-92
April 1
April 30
Midnight-11 PM
NOTE: Frequencies indicate direction from which the wind is blowing.
CALM WINDS 4.51%
WIND SPEED (KNOTS)
CALMS
1-3
4-6
7-10
11-16
17-21
+21
N
S
E
W
4%
8%
12%
16%
20%
24%

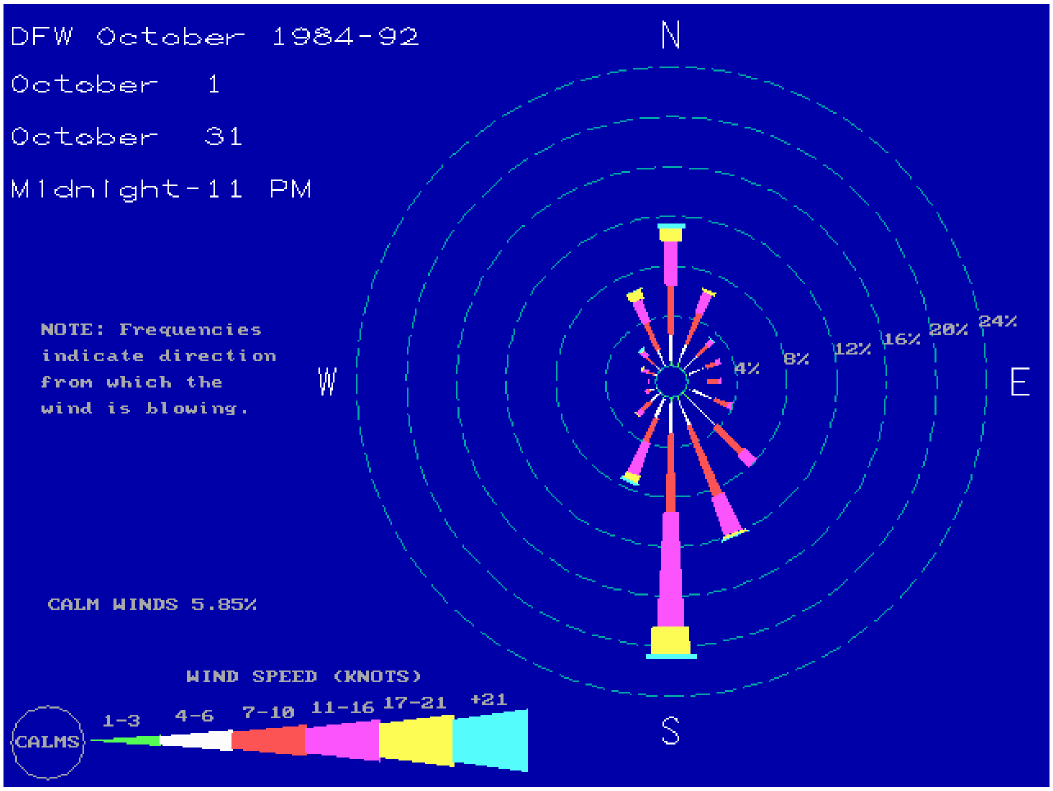

DFW May 1984-92
May 1
May 31
Midnight-11 PM
NOTE: Frequencies indicate direction from which the wind is blowing.
CALM WINDS 4.45%
WIND SPEED (KNOTS)
CALMS
1-3
4-6
7-10
11-16
17-21
+21
N
S
E
W
4%
8%
12%
16%
20%
24%

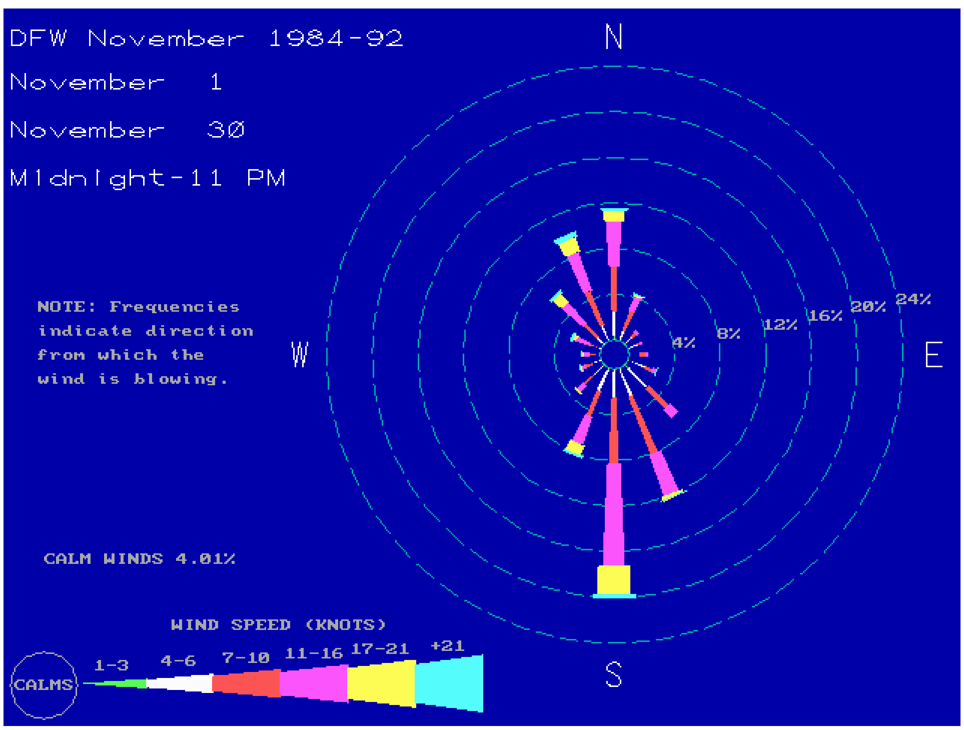

DFW June 1984-92
June 1
June 30
Midnight-11 PM
N
NOTE: Frequencies indicate direction from which the wind is blowing.
W
4%
8%
12%
16%
20%
24%
28%
E
CALM WINDS 4.04%
WIND SPEED (KNOTS)
CALMS
1-3
4-6
7-10
11-16
17-21
+21
S


DFW July 1984-92
July 1
July 31
Midnight-11 PM
N
NOTE: Frequencies indicate direction from which the wind is blowing.
W
4%
8%
12%
16%
20%
24%
28%
32%
E
CALM WINDS 3.09%
WIND SPEED (KNOTS)
CALMS
1-3
4-6
7-10
11-16
17-21
+21
S


DFW August 1984-92
August 1
August 31
Midnight-11 PM
NOTE: Frequencies indicate direction from which the wind is blowing.
CALM WINDS 8.26%
WIND SPEED (KNOTS)
CALMS
1-3
4-6
7-10
11-16
17-21
+21
N
S
E
W
4%
8%
12%
16%
20%
24%


DFW September 1984-92
September 1
September 30
Midnight-11 PM
NOTE: Frequencies indicate direction from which the wind is blowing.
CALM WINDS 7.45%
WIND SPEED (KNOTS)
CALMS
1-3
4-6
7-10
11-16
17-21
+21
N
S
E
W
4%
8%
12%
16%
20%
24%


DFW October 1984-92
October 1
October 31
Midnight-11 PM
NOTE: Frequencies indicate direction from which the wind is blowing.
CALM WINDS 5.85%
N
S
E
W
4%
8%
12%
16%
20%
24%
WIND SPEED (KNOTS)
CALMS
1-3
4-6
7-10
11-16
17-21
+21


DFW November 1984-92
November 1
November 30
Midnight-11 PM
NOTE: Frequencies indicate direction from which the wind is blowing.
CALM WINDS 4.01%
N
S
E
W
4%
8%
12%
16%
20%
24%
WIND SPEED (KNOTS)
CALMS
1-3
4-6
7-10
11-16
17-21
+21

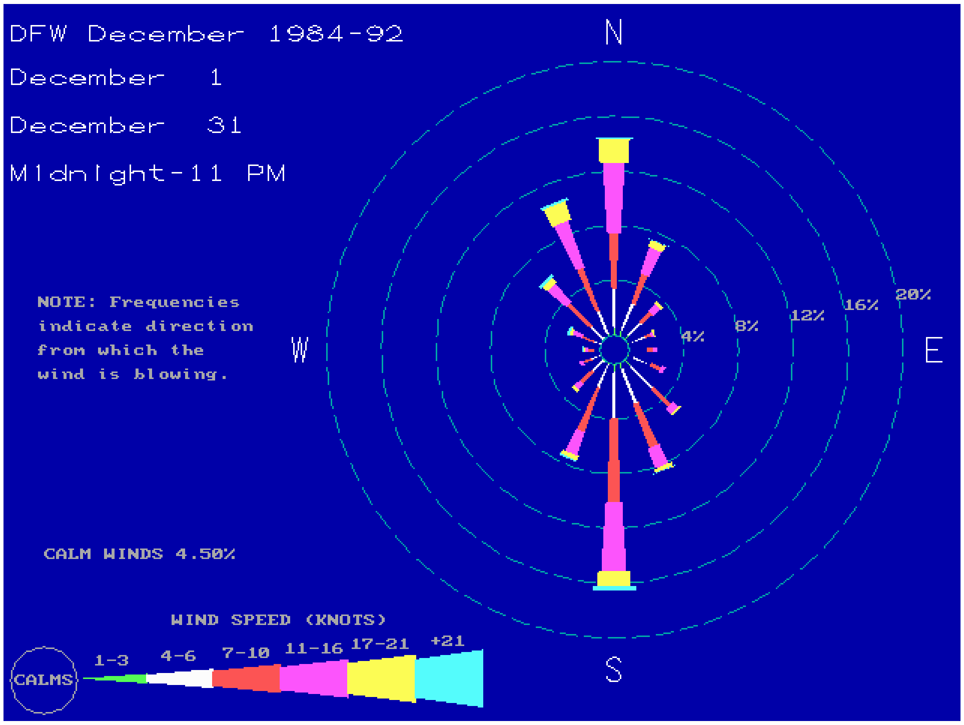


Figure 12. Windroses for LBJ Advanced tower site
Data used here are hourly from 1984-1992 from DFW weather station (http://www.tceq.state.tx.us/compliance/monitoring/air/monops/windroses.html). It is assumed that the wind data was corrected for declination. Panels are (from top to bottom) January to December.

3.4.3 Resultant vectors

Not available.

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. 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 5. Expected environmental controls to parameterize the source area model, and associated results from LBJ 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	22	22	22	22	22	22	m
Canopy Height	13	13	13	13	13	13	m
Canopy area density	4.0	4.0	4.0	2.5	2.5	2.5	m
Boundary layer depth	3500	3500	1700	1500	1500	800	m
Expected sensible heat flux	400	400	100	250	250	30	W m^{-2}
Air Temperature	33	33	24	15	15	9	°C
Max. windspeed	12	6.6	4.6	11	6.4	4.4	m s^{-1}
Resultant wind vector	180	180	180	180	180	360	degrees
			Results				
(z-d)/L	-0.01	-0.06	-0.05	-0.01	-0.04	-0.02	m
d	11.00	11.00	11.00	10.00	10	10.00	m
Sigma v	3.70	2.70	1.60	3.30	2.20	1.30	$m^2 s^{-2}$
Z0	0.51	0.51	0.51	0.64	0.64	0.64	m
u*	1.60	0.91	0.63	1.50	0.92	0.62	m s^{-1}
Distance source area begins	0	0	0	0	0	0	m
Distance of 90% cumulative flux	800	600	650	850	700	800	m
Distance of 80% cumulative flux	450	400	400	450	400	450	m

Distance of 70% cumulative flux	350	250	250	300	200	300	m
Peak contribution	65	55	65	65	55	65	m

3.4.5 Results (source area graphs)

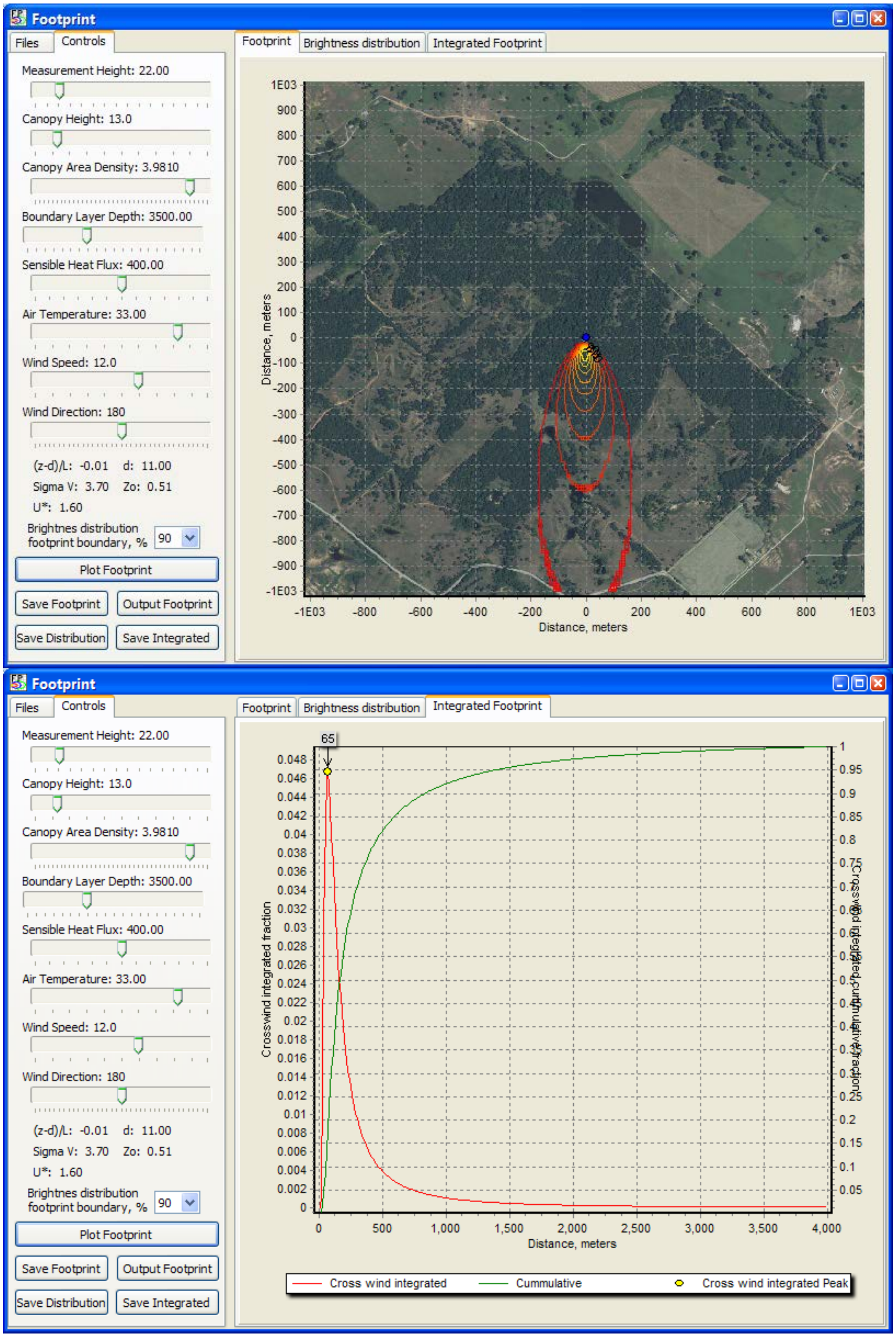


Figure 13. summer, daytime, max wind speed

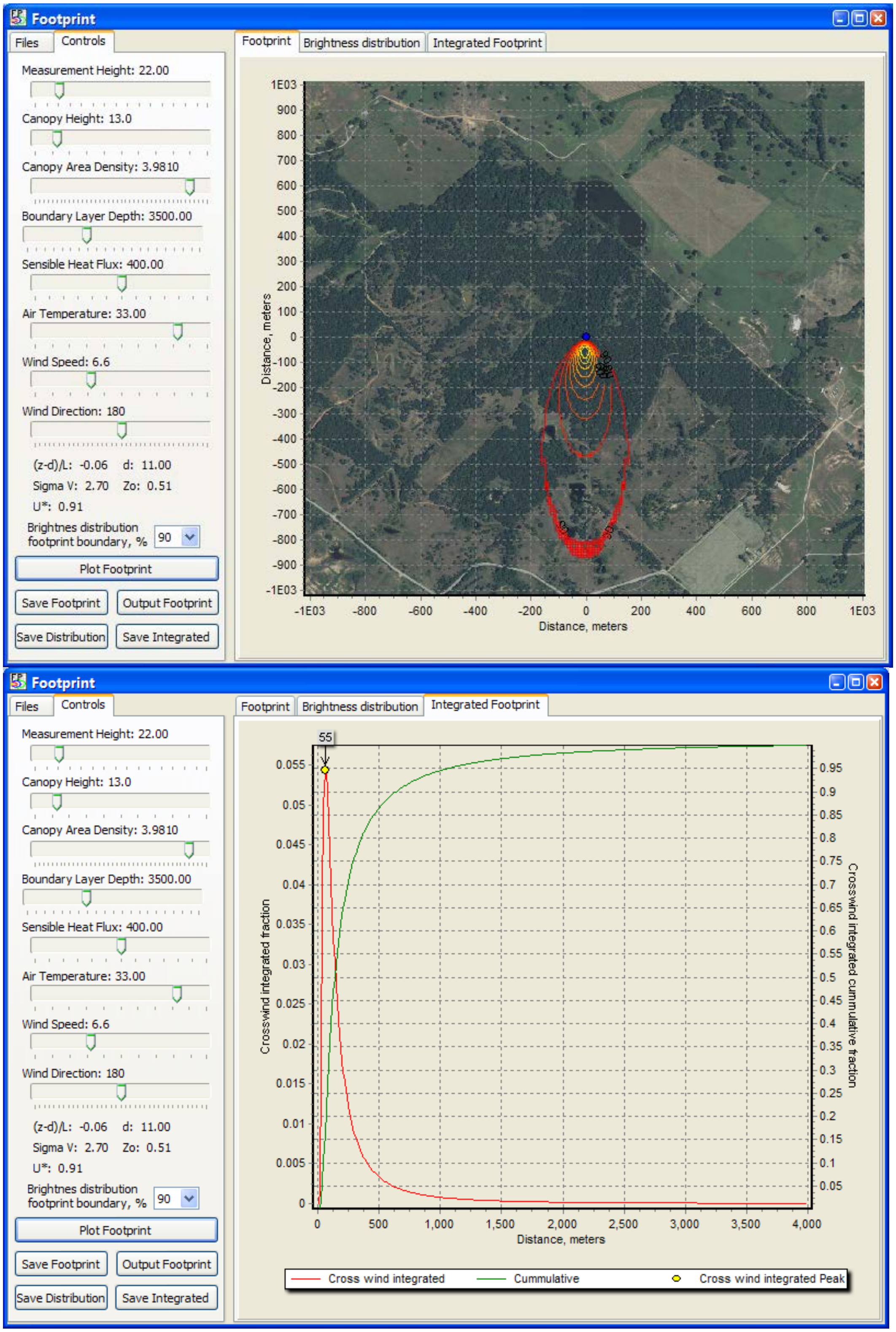


Figure 14. summer, daytime, mean wind speed

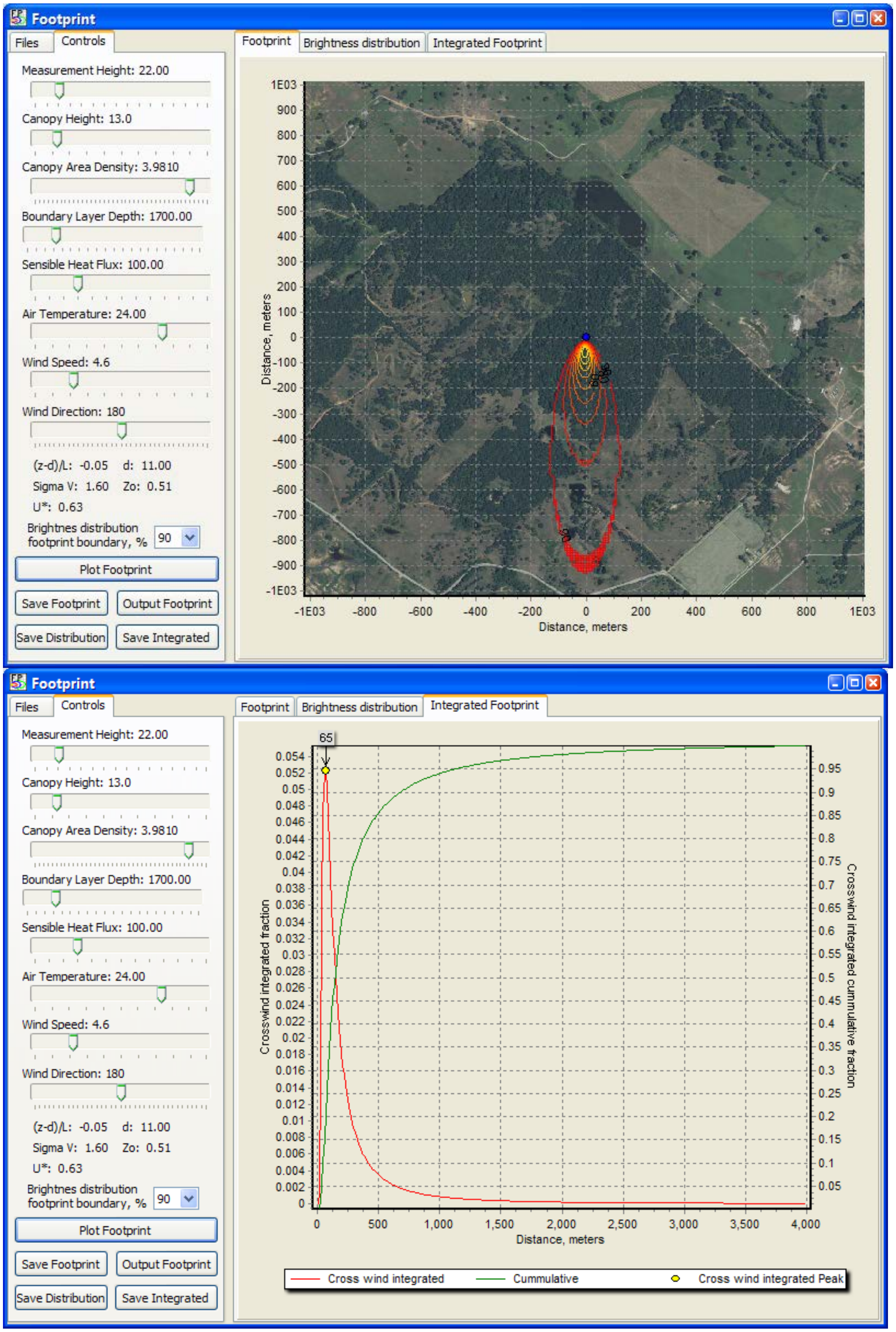


Figure 15. summer, nighttime, mean wind speed

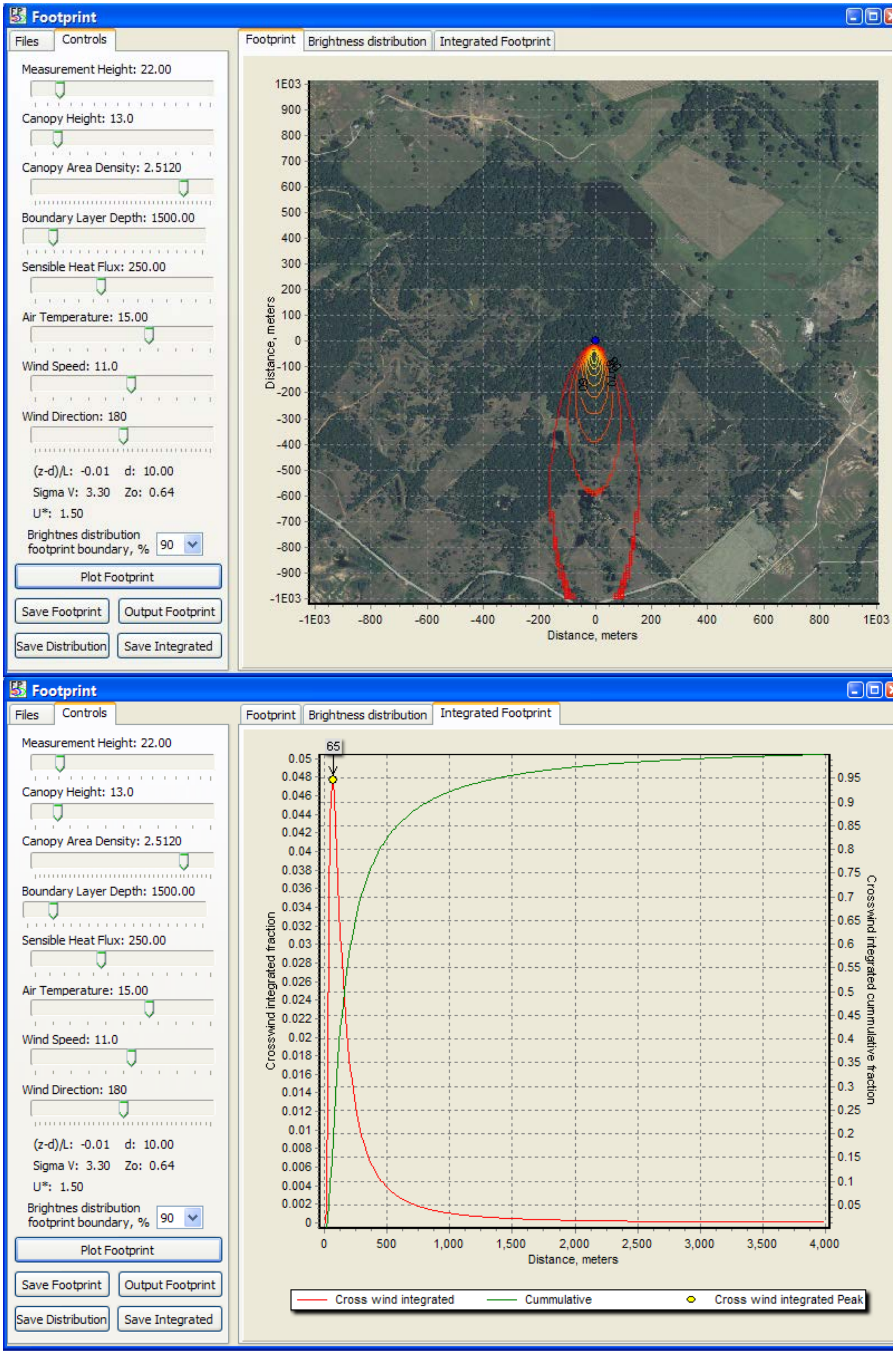


Figure 16. winter, daytime, max wind speed

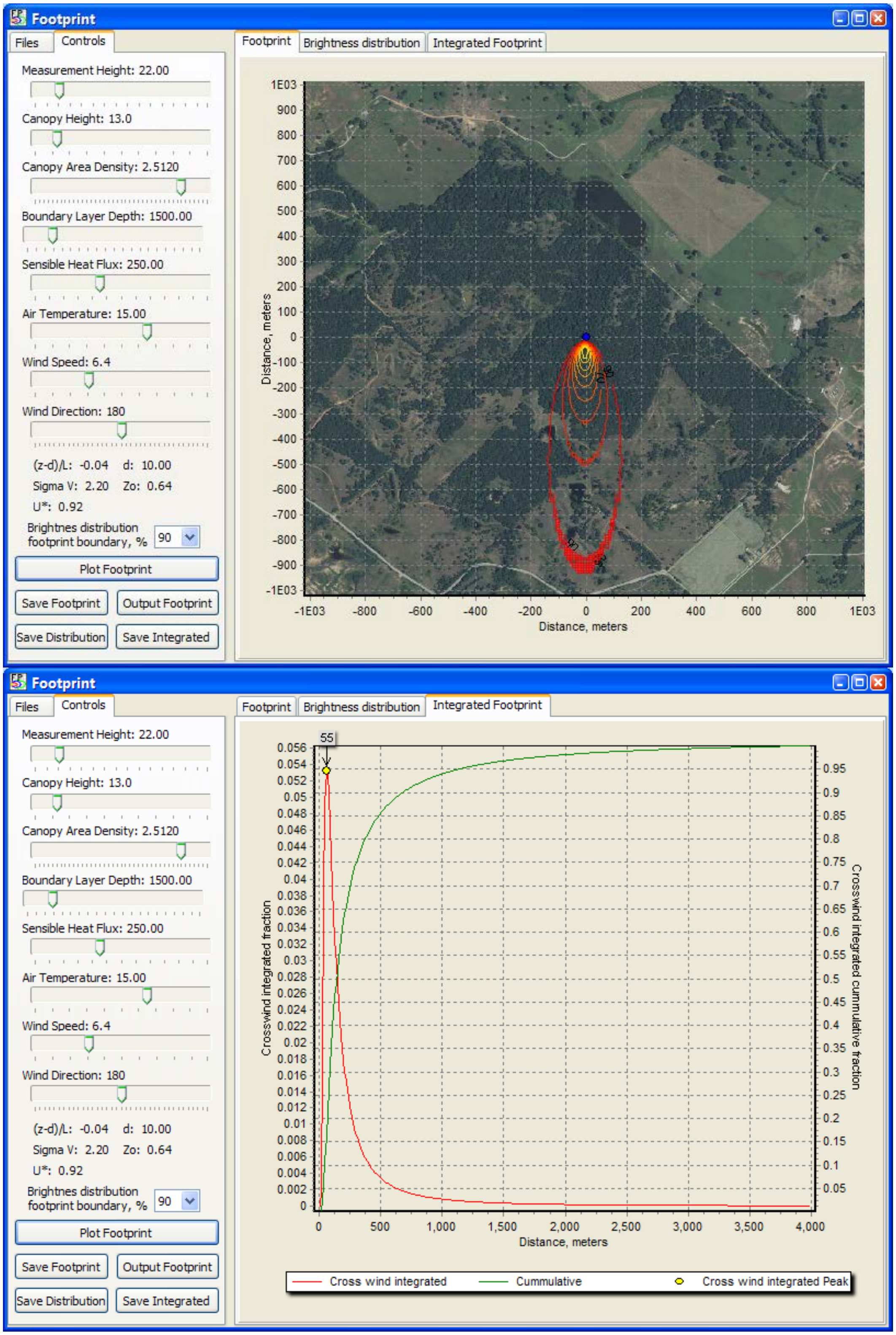


Figure 17. Winter daytime, mean wind speed

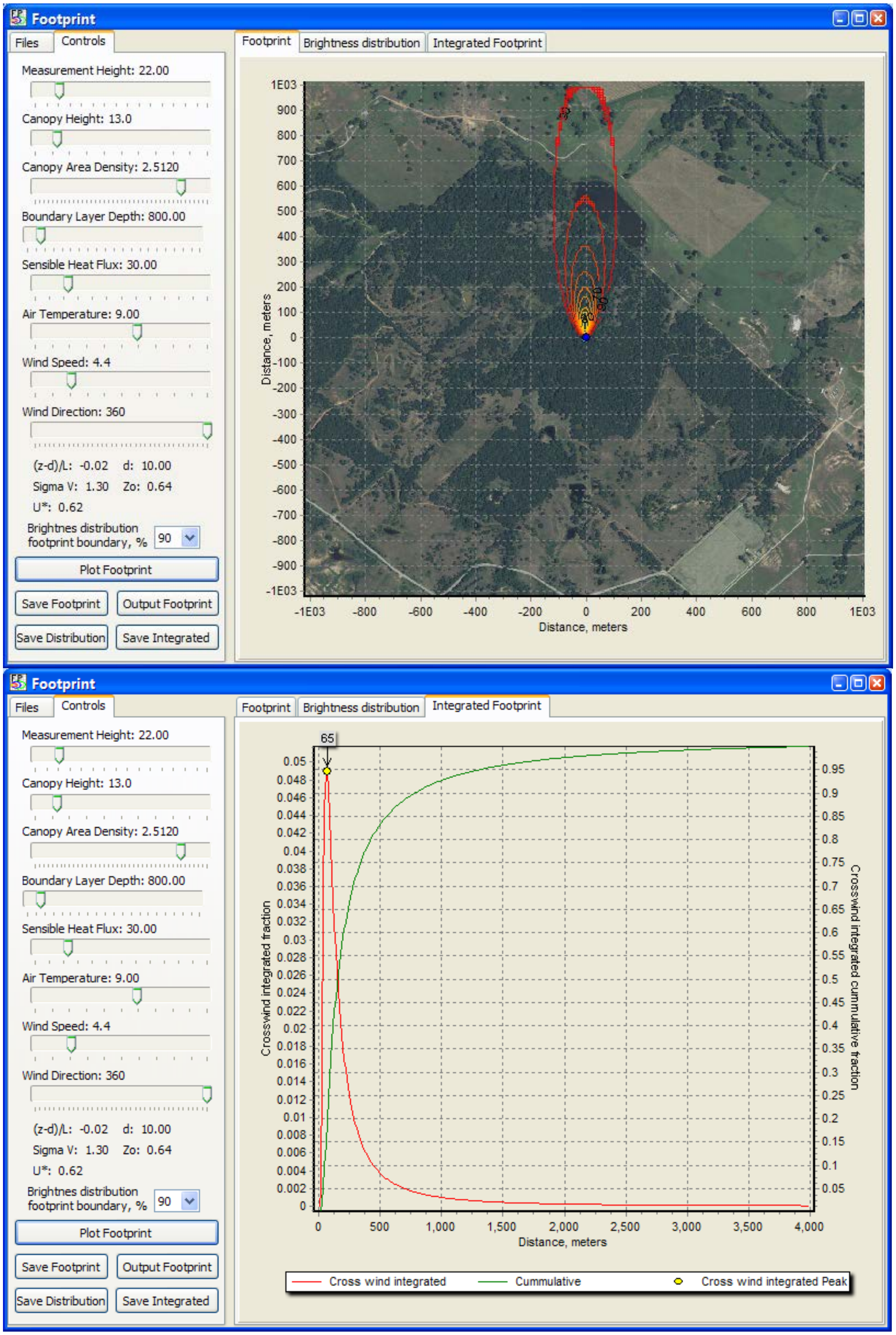


Figure 18. winter, nighttime, mean wind speed

3.4.6 Site design and tower attributes

According to wind roses, the prevailing wind direction blows from south (135^{o} to 205^{o}, clockwise from 135^{o}, **major airshed**) and north (315^{o} to 25^{o}, clockwise from 315^{o}, **secondary airshed**), which is fairly consistent throughout the whole year. Tower should be placed to a location to best catch the signals from the airshed of the ecosystem in interest, which is oak dominated forest. The candidate tower site was at 33.39924722°, -97.56842222°. After site visit, we microsited the tower location for ~265 m into the oak dominated forest at 33.40123°, -97.57000° to avoid edge effects at the forest-grassland interface. The new **tower location** is at 33.40123°, -97.57000°.

Eddy covariance, sonic wind and air temperature **boom arms** orientation toward the west will be best to capture signals from all 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 east side of tower and have the longer side parallel to S-N direction. The location of instrument hut is at 33.40118°, -97.56982°.

The oak-dominated forest canopy was relatively open, but the dense understory means that only 30-40% of the light is transmitted to the forest floor. The forest floor had a ~2 cm thick litter layer and some coarse woody debris. Natural mortality and recruitment appears to be operating in the forest resulting in an un-even age structure. Mean canopy height was ~13 m. Understory is diverse with mean canopy height ~ 4 m. We require 6 **measurement layers** on the tower with top measurement height at 22 m, and remaining levels are 16 m, 10m, 4 m and 0.3 m, respectively, to best characterize the fluxes on the tower top and environmental conditions in profile.

DFIR location is at 33.399418, -97.566975, which is ~350 m southeast toward tower. **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 6. Site design and tower attributes for LBJ Advanced site.

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

Attribute	lat	long	degree	meters	notes
Airshed area			135^{o} to 205^{o} (major), 315°		Clockwise from first

			to 25° (secondary)		angle
Tower location	33.40123°,	-97.57000°.	--	--	new site
Instrument hut	33.40118°,	-97.56982°.			
Instrument hut orientation vector	--	--	360° - 180°		
Instrument hut distance z	--	--	--	17	
Anemometer/Temperature boom orientation	--	--	270°	--	
DFIR	33.399418,	-97.566975			
Height of the measurement levels					
Level 1				0.3	m.a.g.l.
Level 2				4.0	m.a.g.l.
Level 3				10.0	m.a.g.l.
Level 4				16.0	m.a.g.l.
Level 5				22.0	m.a.g.l.
Tower Height				22.0	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, DFIR, airshed area and access road.

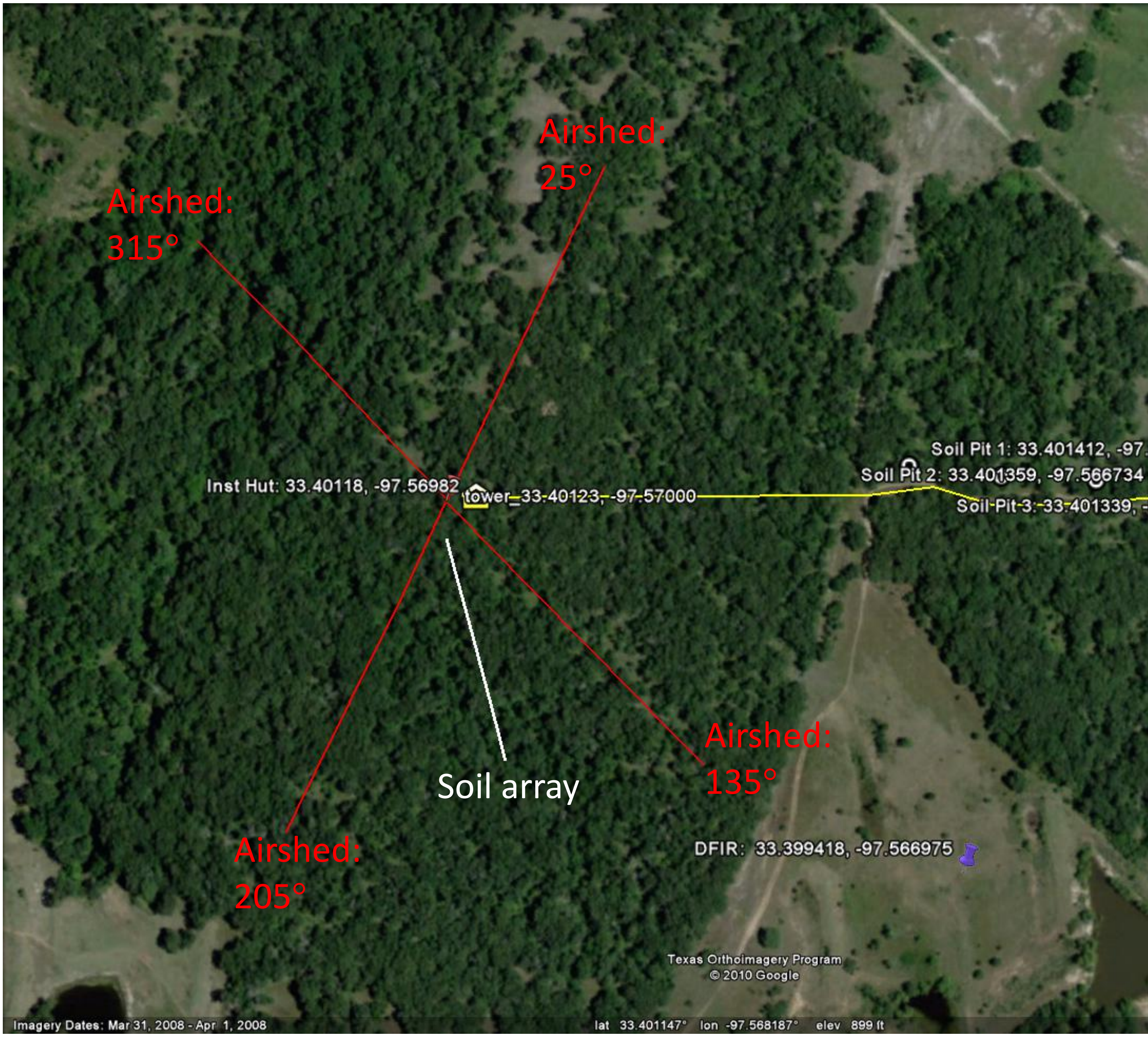


Figure 19. Site layout for LBJ Advanced tower site.
i) Tower location is presented (red pin), ii) red lines indicate the airshed boundaries. Vectors 135° to 205° (clockwise from 135°, major airshed) and 315° to 25° (clockwise from 315°, secondary airshed) are the airshed areas that would have quality wind data without causing flow distortions, respectively. iii) Yellow line is the suggested access road to instrument hut. iv) Purple pin is 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). The boardwalk to access the tower is not on any side that has a boom.
Specific Boardwalks at LBJ Advance site:

- Gravel path from the path to instrument hut, pending landowner decision
- Boardwalk from the instrument hut to the tower to intersect on north face of the tower
- Boardwalk to the soil array
- No boardwalk from the soil array boardwalk to the individual soil plots
- No boardwalk needed to DFIR site

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

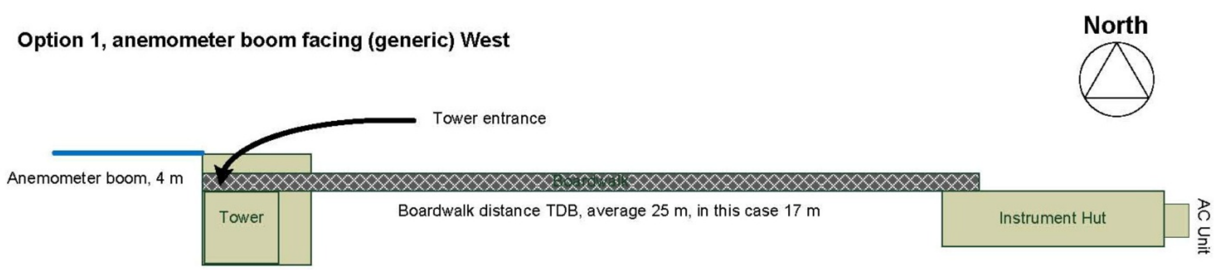


Figure 20. Generic diagram to demonstration the relationship between tower and instrument hut when boom facing west and instrument hut on the east towards the tower.

This is just 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 LBJ Advanced site, the boom angle will be 270 degrees, instrument hut will be on the east towards the tower, the distance between instrument hut and tower is ~17 m. The instrument hut vector will be S-N (180^{o}-360^{o}, longwise).

3.4.7 Information for ecosystem productivity plots

The tower at LBJ Advanced site has been positioned to optimize the collection of the air/wind signals both temporally and spatially over the desired ecosystem (oak dominated forest). Major airshed area at this site are from 135° to 205° (clockwise from 135^{o}, major airshed) and 315° to 25° (clockwise from 315^{o}, secondary airshed), and 90% signals for flux measurements are within a distance of 850 m from tower, and 80% within 450 m. We suggest FSU Ecosystem Productivity plots are placed within the major airshed boundaries of 135° to 205° (clockwise from 135^{o}) from tower.

3.5 Issues and attentions

The dense understory of vines with large thorns makes walking around the site very slow (even with a machete). Since the site is burned every ~3-5 years, it would probably make construction easier if NEON requests that the Forest Service burn this site immediately prior to construction. Fire resistant materials shall be used in construction. Controlling the vines and understory just to gain access to the tower, instrument hut and soil array will be challenging during Field Operations, and should be planned for.

The site is sometimes leased for grazing of cattle. Given the density of vines at the site, cattle are unlikely to go near the tower or soil array except following a fire (i.e. when there is little understory). Protection of sensors on the lower level on the tower may be needed. Individual guards may also be needed to protect sensors in the soil plots.

The pathways throughout the site are used by the public (including riding horses). The nearest pathway to the tower location is >200 m away; therefore, people and horses are not expected to commonly be encountered near the tower location, but may be encountered on pathways between the road and the tower.

The roads are prone to erosion, which may influence access by vehicles used in construction and operations.

Access and power could come from north or east of the tower pending landowner (and neighboring landowner) decision. However, this would require access to land owned by the neigbouring landowner.

The access on the current design is from east of the tower, which USFS personnel said would likely be acceptable to the neigbouring landowner. If the neighboring landowner does not agree to NEON access, the access route and power could came from the south, but this route would be approximately twice as long.

4 WITCHITA MOUNTAIN WILDLIFE REFUGE, RELOCATEABLE TOWER 1

4.1 Site description

The Wichita Mountains Wildlife Refuge (WMWR) was established to protect wildlife species that were in grave danger of extinction, and to restore species that had been eliminated from the area. Bison were reintroduced, along with elk and wild turkey. More recent reintroductions include the prairie dog, the river otter, and burrowing owls.

Established in 1901, Wichita Mountains Wildlife Refuge is one of more than 556 refuges throughout the United States managed by the U.S. Fish and Wildlife Service. The 59,020 acre refuge hosts a rare piece of the past - a remnant mixed grass prairie, an island where the natural grasslands escaped destruction because the rocks underfoot defeated the plow. The refuge provides habitat for large native grazing animals such as American bison, Rocky Mountain elk, and white-tailed deer. Texas longhorn cattle also share the refuge rangelands as a cultural and historical legacy species. More than 50 mammal, 240 bird, 64 reptile and amphibian, 36 fish, and 806 plant species thrive on this important refuge. (Info source: http://www.fws.gov/refuge/Wichita_Mountains/about.html).

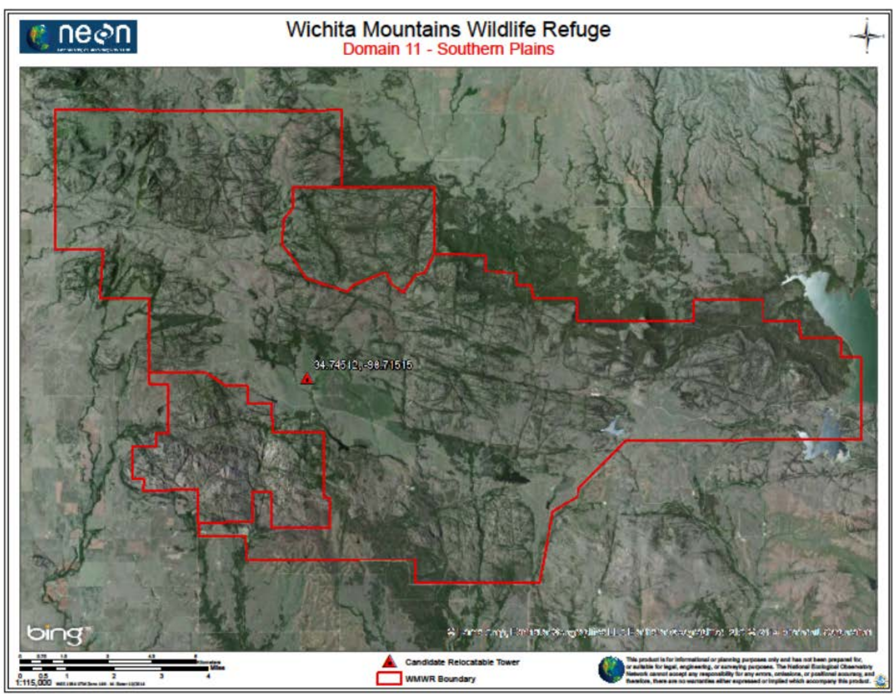


Figure 21. WMWR candidate tower location. Red line indicates property boundary of WMWR.
The canidate tower location is ~1.5 km on the north of the WMWR HQ office, and less than 600 m away from the power supply at WMWR corrals, where the Texas longhorn Auction and the American Bison Auction will be held annually on the third Thursday of September. The terrain is relatively flat with very gentle relief. The ecosystem is grassland and very uniform within the tower airsheds.

4.2 Ecosystem

Vegetation and land cover around tower site and surrounding area are presented below:

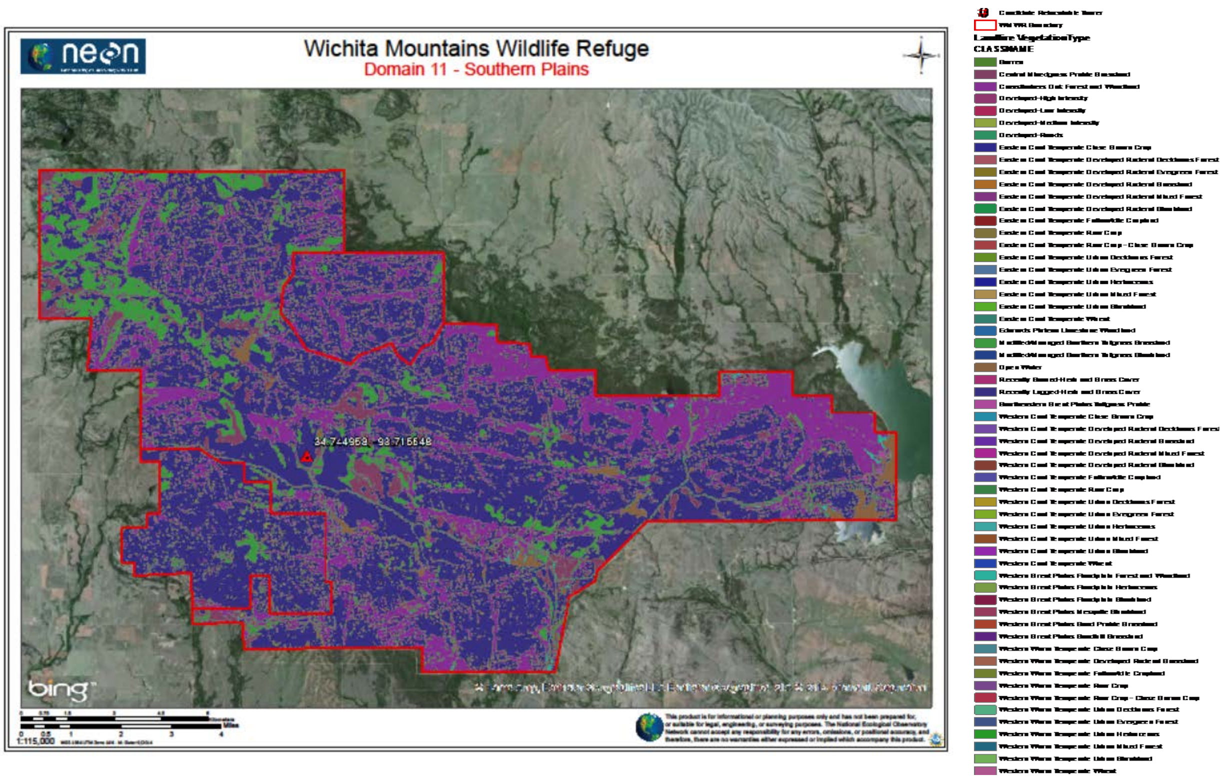


Figure 22. Vegetative cover map of the WMWR relocatable site and surrounding areas (from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm)

Note that the candidate tower location has been microsited to 34.74512, -98.71515.

Table 7. Percent Land cover information at the WMWR relocatable site (from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm)

Veg_Type	**Veg_Height**	**Area_KM2**	**Percentage (%)**
Barren	Barren	0.0117	0.0048
Central Mixedgrass Prairie Grassland	Herb Height 0 to 0.5 meters	8.6001	3.5624
Central Mixedgrass Prairie Grassland	Herb Height 0.5 to 1.0 meters	0.0117	0.0048
Crosstimbers Oak Forest and Woodland	Forest Height 0 to 5 meters	22.9658	9.5131
Crosstimbers Oak Forest and Woodland	Forest Height 10 to 25 meters	15.2407	6.3132
Crosstimbers Oak Forest and Woodland	Forest Height 5 to 10 meters	18.6663	7.7321
Developed-High Intensity	Developed - High Intensity	0.0117	0.0048
Developed-Low Intensity	Developed - Low Intensity	0.0243	0.0101
Developed-Medium Intensity	Developed - Medium Intensity	0.0315	0.0130
Developed-Roads	Developed-Roads	1.5419	0.6387
Eastern Cool Temperate Close Grown Crop	Herb Height 0 to 0.5 meters	0.2154	0.0892
Eastern Cool Temperate Close Grown Crop	Herb Height 0.5 to 1.0 meters	0.0054	0.0022
Eastern Cool Temperate Developed Ruderal Deciduous Forest	Forest Height 0 to 5 meters	0.0009	0.0004
Eastern Cool Temperate Developed Ruderal Deciduous Forest	Forest Height 5 to 10 meters	0.0018	0.0007

Eastern Cool Temperate Developed Ruderal Evergreen Forest	Forest Height 0 to 5 meters	0.0018	0.0007
Eastern Cool Temperate Developed Ruderal Grassland	Herb Height 0 to 0.5 meters	0.0675	0.0280
Eastern Cool Temperate Developed Ruderal Mixed Forest	Forest Height 0 to 5 meters	0.0045	0.0019
Eastern Cool Temperate Developed Ruderal Mixed Forest	Forest Height 5 to 10 meters	0.0036	0.0015
Eastern Cool Temperate Developed Ruderal Shrubland	Shrub Height 1.0 to 3.0 meters	0.0081	0.0034
Eastern Cool Temperate Fallow/Idle Cropland	Herb Height 0 to 0.5 meters	0.3932	0.1629
Eastern Cool Temperate Fallow/Idle Cropland	Herb Height 0.5 to 1.0 meters	0.0198	0.0082
Eastern Cool Temperate Row Crop	NASS-Row Crop	0.4182	0.1732
Eastern Cool Temperate Row Crop - Close Grown Crop	NASS-Row Crop-Close Grown Crop	0.0172	0.0071
Eastern Cool Temperate Urban Deciduous Forest	Developed-Upland Deciduous Forest	0.0498	0.0206
Eastern Cool Temperate Urban Evergreen Forest	Developed-Upland Evergreen Forest	0.0198	0.0082
Eastern Cool Temperate Urban Herbaceous	Developed-Upland Herbaceous	0.5899	0.2444
Eastern Cool Temperate Urban Mixed Forest	Developed-Upland Mixed Forest	0.0108	0.0045
Eastern Cool Temperate Urban Shrubland	Developed-Upland Shrubland	0.1258	0.0521
Eastern Cool Temperate Wheat	Herb Height 0 to 0.5 meters	0.3257	0.1349
Eastern Cool Temperate Wheat	Herb Height 0.5 to 1.0 meters	0.0418	0.0173
Edwards Plateau Limestone Woodland	Forest Height 5 to 10 meters	0.0036	0.0015
Modified/Managed Southern Tallgrass Grassland	Herb Height 0 to 0.5 meters	19.9690	8.2718
Modified/Managed Southern Tallgrass Grassland	Herb Height 0.5 to 1.0 meters	0.1337	0.0554
Modified/Managed Southern Tallgrass Shrubland	Shrub Height 1.0 to 3.0 meters	0.0153	0.0063
Open Water	Open Water	2.9380	1.2170
Recently Burned-Herb and Grass Cover	Herb Height 0 to 0.5 meters	0.3676	0.1523
Recently Logged-Herb and Grass Cover	Herb Height 0 to 0.5 meters	128.5722	53.2585
Recently Logged-Herb and Grass Cover	Herb Height 0.5 to 1.0 meters	1.9241	0.7970
Southeastern Great Plains Tallgrass Prairie	Herb Height 0 to 0.5 meters	0.2825	0.1170
Western Cool Temperate Close Grown Crop	Herb Height 0 to 0.5 meters	0.0434	0.0180
Western Cool Temperate Developed Ruderal Deciduous Forest	Forest Height 5 to 10 meters	0.0018	0.0007
Western Cool Temperate Developed Ruderal Grassland	Herb Height 0 to 0.5 meters	0.1061	0.0439
Western Cool Temperate Developed Ruderal Mixed Forest	Forest Height 5 to 10 meters	0.0009	0.0004
Western Cool Temperate Developed Ruderal Shrubland	Shrub Height 1.0 to 3.0 meters	0.0018	0.0007
Western Cool Temperate Fallow/Idle Cropland	Herb Height 0 to 0.5 meters	0.0143	0.0059
Western Cool Temperate Row Crop	NASS-Row Crop	0.0018	0.0007
Western Cool Temperate Urban Deciduous Forest	Developed-Upland Deciduous Forest	0.0010	0.0004
Western Cool Temperate Urban Evergreen Forest	Developed-Upland Evergreen Forest	0.0010	0.0004
Western Cool Temperate Urban Herbaceous	Developed-Upland Herbaceous	0.0959	0.0397
Western Cool Temperate Urban Shrubland	Developed-Upland Shrubland	0.0057	0.0024
Western Cool Temperate Wheat	Herb Height 0 to 0.5 meters	0.0406	0.0168
Western Cool Temperate Wheat	Herb Height 0.5 to 1.0 meters	0.0018	0.0007
Western Great Plains Floodplain Forest and Woodland	Forest Height 0 to 5 meters	0.0396	0.0164
Western Great Plains Floodplain Forest and Woodland	Forest Height 10 to 25 meters	0.3064	0.1269

Western Great Plains Floodplain Forest and Woodland	Forest Height 5 to 10 meters	0.2960	0.1226
Western Great Plains Floodplain Herbaceous	Herb Height 0 to 0.5 meters	0.2782	0.1152
Western Great Plains Floodplain Herbaceous	Herb Height 0.5 to 1.0 meters	0.0045	0.0019
Western Great Plains Floodplain Shrubland	Shrub Height > 3.0 meters	0.0171	0.0071
Western Great Plains Floodplain Shrubland	Shrub Height 0 to 0.5 meters	0.0226	0.0094
Western Great Plains Floodplain Shrubland	Shrub Height 1.0 to 3.0 meters	0.0097	0.0040
Western Great Plains Mesquite Shrubland	Shrub Height > 3.0 meters	0.2220	0.0920
Western Great Plains Mesquite Shrubland	Shrub Height 0.5 to 1.0 meter	0.0054	0.0022
Western Great Plains Mesquite Shrubland	Shrub Height 1.0 to 3.0 meters	1.1564	0.4790
Western Great Plains Sand Prairie Grassland	Herb Height 0 to 0.5 meters	0.2687	0.1113
Western Great Plains Sandhill Grassland	Herb Height 0 to 0.5 meters	14.5616	6.0319
Western Great Plains Sandhill Grassland	Herb Height 0.5 to 1.0 meters	0.0297	0.0123
Western Warm Temperate Close Grown Crop	Herb Height 0 to 0.5 meters	0.0290	0.0120
Western Warm Temperate Developed Ruderal Grassland	Herb Height 0 to 0.5 meters	0.0351	0.0145
Western Warm Temperate Fallow/Idle Cropland	Herb Height 0 to 0.5 meters	0.0401	0.0166
Western Warm Temperate Row Crop	NASS-Row Crop	0.0090	0.0037
Western Warm Temperate Row Crop - Close Grown Crop	NASS-Row Crop-Close Grown Crop	0.0009	0.0004
Western Warm Temperate Urban Deciduous Forest	Developed-Upland Deciduous Forest	0.0500	0.0207
Western Warm Temperate Urban Evergreen Forest	Developed-Upland Evergreen Forest	0.0072	0.0030
Western Warm Temperate Urban Herbaceous	Developed-Upland Herbaceous	0.0252	0.0104
Western Warm Temperate Urban Mixed Forest	Developed-Upland Mixed Forest	0.0081	0.0034
Western Warm Temperate Urban Shrubland	Developed-Upland Shrubland	0.0253	0.0105
Western Warm Temperate Wheat	Herb Height 0 to 0.5 meters	0.0132	0.0055
Western Warm Temperate Wheat	Herb Height 0.5 to 1.0 meters	0.0018	0.0007
TOTAL		**241.4116**	**100.0000**

The ecosystem at the tower site is grassland. It is grazed by bison, elk, steers, etc. The average canopy height varies with seasons and can reach 0.8 m at the end of the growing season. The vegetation is dominated by grasses (species unknown), and dotted with few small short shrubs (generally lower than the grass by the end of growing season in Fall).

Table 8. Ecosystem and site attributes for the WMWR Relocatable site.

Ecosystem attributes	**Measure and units**
Mean canopy height at construction	0.8 m
Surface roughness at construction	0.35 m
Zero place displacement height at construction	0.45 m
Structural elements	Grassland, homogeneous
Time zone	Central time zone
Magnetic declination	4.73° E changing by 0.13° W per year

Figure 23. Grassland is the dominant ecosystem type at the WMWR Relocatable site

4.3 Soils

4.3.1 Description of soils

Soil data and soil maps below for the WMWR tower site were collected from 4.1 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.

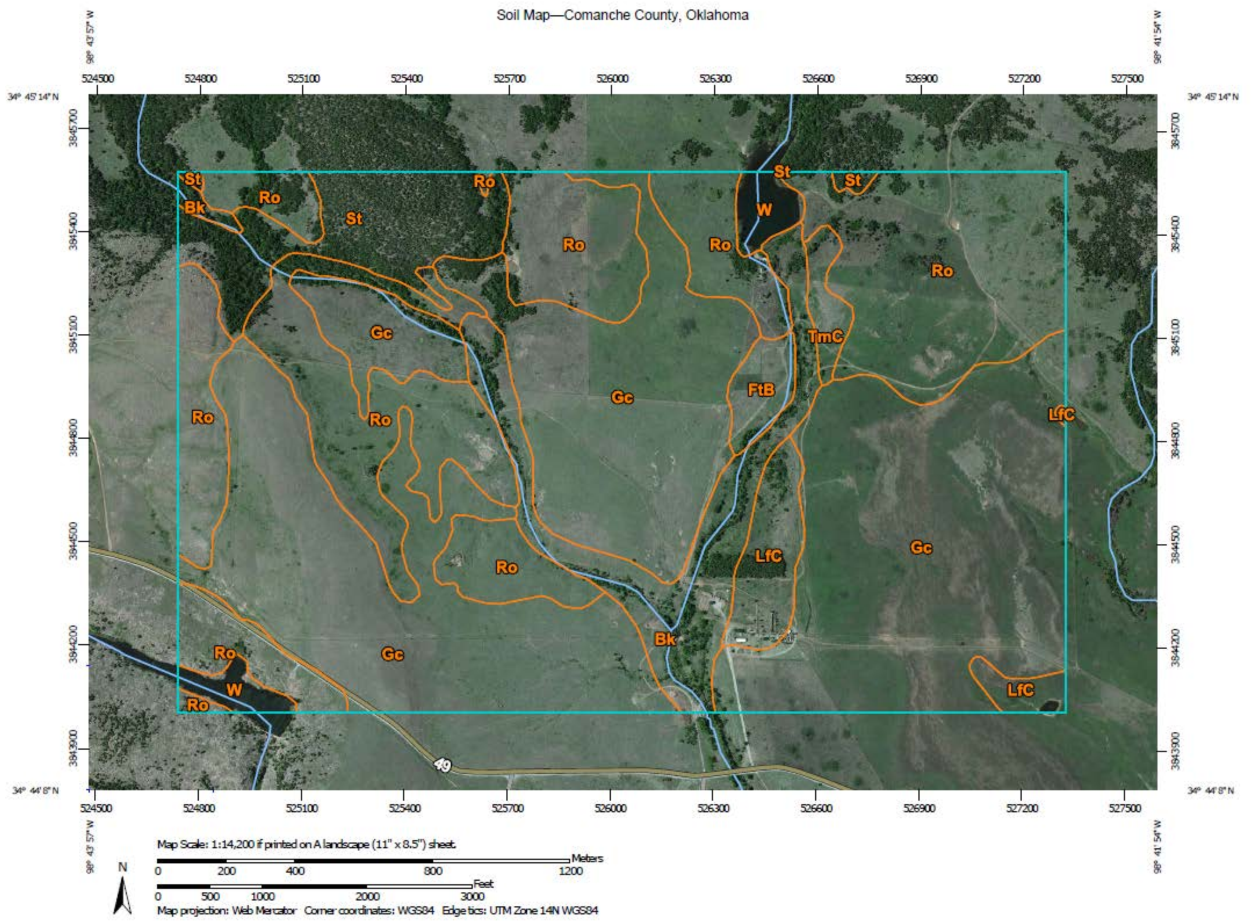


Figure 24. Soil map of the WMWR Relocatable site and surrounding areas.

Soil Map Units Description: The map units delineated on the detailed soil maps in a soil survey represents 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, 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, are 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 9. Soil series and percentage of soil series within 4.1 km^2 at the WMWR site

Comanche County, Oklahoma (OK031)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
Bk	Vernon-Clairemont complex, 0 to 12 percent slopes	69.5	6.9%
FtB	Foard and Tillman soils, 1 to 3 percent slopes	11.5	1.1%
Gc	Brico-Rock outcrop complex, 5 to 40 percent slopes	505.9	50.1%
LfC	Lawton-Foard complex, 3 to 5 percent slopes	29.3	2.9%
Ro	Rock outcrop-Brico complex, 3 to 20 percent slopes	309.6	30.7%
St	Brico soils and Rock outcrop, 15 to 50 percent slopes	58.1	5.8%
TmC	Tillman clay loam, 3 to 5 percent slopes	8.9	0.9%
W	Water	16.3	1.6%
Totals for Area of Interest		**1,009.0**	**100.0%**

Comanche County, Oklahoma Gc—Brico-Rock outcrop complex, 5 to 40 percent slopes Map Unit Setting National map unit symbol: dtpb Elevation: 500 to 2,200 feet Mean annual precipitation: 22 to 48 inches Mean annual air temperature: 57 to 64 degrees F Frost-free period: 190 to 240 days Farmland classification: Not prime farmland **Map Unit Composition** Brico and similar soils: 50 percent Rock outcrop: 45 percent Minor components: 5 percent Estimates are based on observations, descriptions, and transects of the mapunit. **Description of Brico Setting** Landform: Mountain slopes Landform position (three-dimensional): Mountainflank Down-slope shape: Convex Across-slope shape: Convex Parent material: Clayey colluvium derived from granite **Typical profile** A - 0 to 11 inches: very cobbly loam Bt - 11 to 40 inches: very cobbly clay loam BC - 40 to 80 inches: extremely cobbly clay loam **Properties and qualities** Slope: 5 to 20 percent Depth to restrictive feature: More than 80 inches Natural drainage class: Well drained Runoff class: High Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Available water storage in profile: Low (about 5.6 inches) **Interpretive groups** Land capability classification (irrigated): None specified Land capability classification (nonirrigated): 6e Hydrologic Soil Group: C Ecological site: Boulder ridge savannah pe 38-48 (R082BY004OK) Other vegetative classification: Unnamed (G082BY165OK) **Description of Rock Outcrop Setting** Landform: Mountain slopes Landform position (three-dimensional): Mountainflank Down-slope shape: Convex Across-slope shape: Convex Parent material: Granite **Typical profile** R - 0 to 24 inches: bedrock **Properties and qualities** Slope: 5 to 40 percent Depth to restrictive feature: 0 inches to lithic bedrock Runoff class: Very high Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr) Available water storage in profile: Very low (about 0.0 inches) **Interpretive groups** Land capability classification (irrigated): None specified Land capability classification (nonirrigated): 8s Hydrologic Soil Group: D Other vegetative classification: Unnamed (G082BY999OK) **Minor Components Lawton** Percent of map unit: 5 percent Landform: Mountain slopes Landform position (three-dimensional): Mountainbase Down-slope shape: Convex Across-slope shape: Convex Ecological site: Loamy prairie pe 38-48 (R082BY056OK) Other vegetative classification: Unnamed (G082BY017OK)

Comanche County, Oklahoma FtB—Foard and Tillman soils, 1 to 3 percent slopes Map Unit Setting National map unit symbol: dtp9 Elevation: 900 to 3,000 feet Mean annual precipitation: 17 to 30 inches Mean annual air temperature: 37 to 68 degrees F Frost-free period: 185 to 230 days Farmland classification: Not prime farmland **Map Unit Composition** Foard and similar soils: 60 percent Tillman and similar soils: 30 percent Minor components: 10 percent Estimates are based on observations, descriptions, and transects of the mapunit. **Description of Foard Setting** Landform: Paleoterraces on pediments Landform position (three-dimensional): Tread Down-slope shape: Linear Across-slope shape: Convex Parent material: Granitic clayey alluvium over shale and siltstone **Typical profile** A - 0 to 9 inches: silt loam Bt - 9 to 22 inches: clay Btk - 22 to 48 inches: clay BCk - 48 to 56 inches: clay C - 56 to 80 inches: clay **Properties and qualities** Slope: 1 to 3 percent Depth to restrictive feature: More than 80 inches Natural drainage class: Moderately well drained Runoff class: Very high Capacity of the most limiting layer to transmit water (Ksat): 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 in profile: 10 percent Salinity, maximum in profile: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm) Sodium adsorption ratio, maximum in profile: 25.0 Available water storage in profile: Moderate (about 8.4 inches) **Interpretive groups** Land capability classification (irrigated): 3e Land capability classification (nonirrigated): 4s Hydrologic Soil Group: D Ecological site: Clay loam 23-30" pz (R078CY096TX) Other vegetative classification: Unnamed (G078CY016OK) **Description of Tillman Setting** Landform: Paleoterraces on pediments Landform position (three-dimensional): Tread Down-slope shape: Linear Across-slope shape: Linear Parent material: Calcareous clayey and loamy alluvium derived from claystone **Typical profile** A - 0 to 6 inches: silty clay loam BA - 6 to 13 inches: clay loam Bt - 13 to 24 inches: silty clay Btk - 24 to 40 inches: silty clay BCk - 40 to 50 inches: silty clay C - 50 to 80 inches: clay **Properties and qualities** Slope: 1 to 3 percent Depth to restrictive feature: More than 80 inches Natural drainage class: Well drained Runoff class: High 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 in profile: 35 percent Gypsum, maximum in profile: 2 percent Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 8.0 mmhos/cm) Sodium adsorption ratio, maximum in profile: 12.0 Available water storage in profile: Moderate (about 7.0 inches) Interpretive groups Land capability classification (irrigated): 2e Land capability classification (nonirrigated): 2e Hydrologic Soil Group: D Ecological site: Clay loam 23-30" pz (R078CY096TX) Other vegetative classification: Unnamed (G078CY015OK) **Minor Components Vernon** Percent of map unit: 4 percent Landform: Hillslopes on hills Landform position (two-dimensional): Shoulder Down-slope shape: Convex Across-slope shape: Convex Ecological site: Clay prairie (north) (R078CY065OK) **Stamford** Percent of map unit: 3 percent Landform: Flats Landform position (three-dimensional): Tread Down-slope shape: Convex Across-slope shape: Convex Ecological site: Clay loam 23-30" pz (R078CY096TX) Other vegetative classification: Unnamed (G078CY015OK) **Hinkle** Percent of map unit: 3 percent Landform: Paleoterraces Landform position (three-dimensional): Tread Down-slope shape: Convex Across-slope shape: Linear Ecological site: Slickspot (R078CY091OK) Other vegetative classification: Unnamed (G078CY999OK)

Comanche County, Oklahoma Bk—Vernon-Clairemont complex, 0 to 12 percent slopes Map Unit Setting National map unit symbol: dtnx Elevation: 700 to 2,500 feet Mean annual precipitation: 20 to 40 inches Mean annual air temperature: 57 to 66 degrees F Frost-free period: 190 to 240 days Farmland classification: Not prime farmland **Map Unit Composition** Vernon and similar soils: 50 percent Clairemont and similar soils: 22 percent Minor components: 28 percent Estimates are based on observations, descriptions, and transects of the mapunit. **Description of Vernon Setting** Landform: Hillslopes on hills Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Convex Parent material: Calcareous clayey residuum weathered from claystone **Typical profile** A - 0 to 4 inches: clay Bk - 4 to 17 inches: clay Cd - 17 to 50 inches: bedrock Cr - 50 to 80 inches: bedrock **Properties and qualities** Slope: 5 to 12 percent Depth to restrictive feature: 17 to 40 inches to densic bedrock; 40 to 60 inches to paralithic bedrock Natural drainage class: Well drained Runoff class: Very high Capacity of the most limiting layer to transmit water (Ksat): 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 in profile: 30 percent Gypsum, maximum in profile: 2 percent Salinity, maximum in profile: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm) Sodium adsorption ratio, maximum in profile: 4.0 Available water storage in profile: Very low (about 2.2 inches) **Interpretive groups** Land capability classification (irrigated): None specified Land capability classification (nonirrigated): 6e Hydrologic Soil Group: D Ecological site: Shallow clay 23-30" pz (R078CY112TX) **Description of Clairemont Setting** Landform: Flood plains Down-slope shape: Linear Across-slope shape: Linear Parent material: Calcareous silty alluvium **Typical profile** A - 0 to 18 inches: silt loam C - 18 to 80 inches: silty clay loam **Properties and qualities** Slope: 0 to 1 percent Depth to restrictive feature: More than 80 inches Natural drainage class: Well drained Runoff class: Negligible 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: Frequent Frequency of ponding: None Calcium carbonate, maximum in profile: 10 percent Gypsum, maximum in profile: 2 percent Sodium adsorption ratio, maximum in profile: 4.0 Available water storage in profile: High (about 11.4 inches) **Interpretive groups** Land capability classification (irrigated): None specified Land capability classification (nonirrigated): 5w Hydrologic Soil Group: B Ecological site: Loamy bottomland 23-31" pz (R078CY103TX) Other vegetative classification: Unnamed (G078CY043OK) **Minor Components Ashport** Percent of map unit: 8 percent Landform: Flood plains Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy bottomland (R080AY050OK) Other vegetative classification: Unnamed (G080AY017OK) Knoco Percent of map unit: 8 percent Landform: Hillslopes on hills Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Convex Ecological site: Very shallow clay 23-31" pz (R078CY114TX) Other vegetative classification: Unnamed (G078CY282OK) **Rock outcrop** Percent of map unit: 7 percent Landform: Hillslopes on hills Down-slope shape: Convex Across-slope shape: Convex Other vegetative classification: Unnamed (G078CY999OK) **Wheatwood** Percent of map unit: 5 percent Landform: Flood plains Down-slope shape: Linear Across-slope shape: Linear Ecological site: Loamy bottomland 23-31" pz (R078CY103TX) Other vegetative classification: Unnamed (G078CY042OK

Comanche County, Oklahoma LfC—Lawton-Foard complex, 3 to 5 percent slopes Map Unit Setting National map unit symbol: dtpp Elevation: 900 to 2,250 feet Mean annual precipitation: 22 to 32 inches Mean annual air temperature: 57 to 65 degrees F Frost-free period: 185 to 230 days Farmland classification: All areas are prime farmland **Map Unit Composition** Lawton and similar soils: 60 percent Foard and similar soils: 30 percent Minor components: 10 percent Estimates are based on observations, descriptions, and transects of the mapunit. **Description of Lawton Setting** Landform: Paleoterraces Landform position (three-dimensional): Riser Down-slope shape: Convex Across-slope shape: Convex Parent material: Granitic outwash and loamy alluvium **Typical profile** A - 0 to 11 inches: loam BA - 11 to 18 inches: clay loam Bt - 18 to 47 inches: clay loam BC - 47 to 80 inches: sandy clay loam **Properties and qualities** Slope: 3 to 5 percent Depth to restrictive feature: More than 80 inches Natural drainage class: Well drained Runoff class: Medium Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr) Depth to water table: More than 80 inches Frequency of flooding:

None Frequency of ponding: None Available water storage in profile: High (about 10.2 inches) **Interpretive groups** Land capability classification (irrigated): None specified Land capability classification (nonirrigated): 3e Hydrologic Soil Group: C Ecological site: Loamy prairie pe 38-48 (R082BY056OK) Other vegetative classification: Unnamed (G082BY017OK) **Description of Foard Setting** Landform: Paleoterraces on pediments Landform position (three-dimensional): Riser Down-slope shape: Linear Across-slope shape: Convex Parent material: Granitic clayey alluvium over shale and siltstone **Typical profile** A - 0 to 9 inches: silt loam Bt - 9 to 22 inches: clay Btk - 22 to 48 inches: clay BCk - 48 to 56 inches: clay C - 56 to 80 inches: clay **Properties and qualities** Slope: 3 to 5 percent Depth to restrictive feature: More than 80 inches Natural drainage class: Moderately well drained Runoff class: Very high Capacity of the most limiting layer to transmit water (Ksat): 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 in profile: 10 percent Salinity, maximum in profile: Nonsaline to slightly saline (2.0 to 8.0 mmhos/cm) Sodium adsorption ratio, maximum in profile: 25.0 Available water storage in profile: Moderate (about 8.4 inches) **Interpretive groups** Land capability classification (irrigated): 3e Land capability classification (nonirrigated): 4s Hydrologic Soil Group: D Ecological site: Clay loam 23-30" pz (R078CY096TX) Other vegetative classification: Unnamed (G078CY016OK) **Minor Components Tillman** Percent of map unit: 4 percent Landform: Paleoterraces on pediments Landform position (three-dimensional): Riser Down-slope shape: Convex Across-slope shape: Convex Ecological site: Clay loam 23-30" pz (R078CY096TX) Other vegetative classification: Unnamed (G078CY016OK) **Rock outcrop** Percent of map unit: 3 percent Landform: Hillslopes on hills Down-slope shape: Convex Across-slope shape: Convex Other vegetative classification: Unnamed (G082BY999OK) **Hinkle** Percent of map unit: 3 percent Landform: Paleoterraces Landform position (three-dimensional): Tread Down-slope shape: Convex Across-slope shape: Linear Ecological site: Slickspot (R078CY091OK) Other vegetative classification: Unnamed (G078CY999OK)

Comanche County, Oklahoma Ro—Rock outcrop-Brico complex, 3 to 20 percent slopes Map Unit Setting National map unit symbol: dtpz Elevation: 500 to 2,200 feet Mean annual precipitation: 22 to 48 inches Mean annual air temperature: 57 to 64 degrees F Frost-free period: 185 to 240 days Farmland classification: Not prime farmland **Map Unit Composition** Rock outcrop: 70 percent Brico and similar soils: 20 percent Minor components: 10 percent Estimates are based on observations, descriptions, and transects of the mapunit. **Description of Rock Outcrop Setting** Landform: Mountain slopes Landform position (three-dimensional): Mountainflank Down-slope shape: Convex Across-slope shape: Convex Parent material: Granite **Typical profile** R - 0 to 24 inches: bedrock **Properties and qualities** Slope: 3 to 20 percent Depth to restrictive feature: 0 inches to lithic bedrock Runoff class: Very high Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr) Available water storage in profile: Very low (about 0.0 inches) **Interpretive groups** Land capability classification (irrigated): None specified Land capability classification (nonirrigated): 8s Hydrologic Soil Group: D Other vegetative classification: Unnamed (G082BY999OK) **Description of Brico Setting** Landform: Mountain slopes Landform position (three-dimensional): Mountainflank Down-slope shape: Convex Across-slope shape: Convex Parent material: Clayey colluvium derived from granite **Typical profile** A - 0 to 11 inches: cobbly loam Bt - 11 to 40 inches: very cobbly clay loam BC - 40 to 80 inches: very cobbly clay loam **Properties and qualities** Slope: 3 to 20 percent Depth to restrictive feature: More than 80 inches Natural drainage class: Well drained Runoff class: High Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Available water storage in profile: Moderate (about 6.2 inches) **Interpretive groups** Land capability classification (irrigated): None specified Land capability classification (nonirrigated): 6e Hydrologic Soil Group: C Ecological site: Boulder ridge savannah pe 38-48 (R082BY004OK) Other vegetative classification: Unnamed (G082BY166OK) **Minor Components Lawton** Percent of map unit: 5 percent Landform: Mountain slopes Landform position (three-dimensional): Mountainbase Down-slope shape: Convex Across-slope shape: Convex Ecological site: Loamy prairie pe 38-48 (R082BY056OK) Other vegetative classification: Unnamed (G082BY017OK) **Foard** Percent of map unit: 5 percent Landform: Paleoterraces on pediments Landform position (three-dimensional): Riser Down-slope shape: Linear Across-slope shape: Convex Ecological site: Clay loam 23-30" pz (R078CY096TX) Other vegetative classification: Unnamed (G078CY016OK)

Comanche County, Oklahoma St—Brico soils and Rock outcrop, 15 to 50 percent slopes Map Unit Setting National map unit symbol: dtq2 Elevation: 500 to 2,200 feet Mean annual precipitation: 22 to 48 inches Mean annual air temperature: 57 to 64 degrees F Frost-free period: 185 to 240 days Farmland classification: Not prime farmland **Map Unit Composition** Brico and similar soils: 50 percent Rock outcrop: 40 percent Minor components: 10 percent Estimates are based on observations, descriptions, and transects of the mapunit. **Description of Brico Setting** Landform: Mountain slopes Landform position (three-dimensional): Mountainflank Down-slope shape: Convex Across-slope shape: Convex Parent material: Clayey colluvium derived from granite **Typical profile** A - 0 to 11 inches: very cobbly loam Bt - 11 to 40 inches: very cobbly clay loam BC - 40 to 80 inches: very cobbly clay loam **Properties and qualities** Slope: 15 to 20 percent Depth to restrictive feature: More than 80 inches Natural drainage class: Well drained Runoff class: High Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr) Depth to water table: More than 80 inches Frequency of flooding: None Frequency of ponding: None Available water storage in profile: Low (about 5.6 inches) **Interpretive groups** Land capability classification (irrigated): None specified Land capability classification (nonirrigated): 6e Hydrologic Soil Group: C Ecological site: Boulder ridge savannah pe 38-48 (R082BY004OK) Other vegetative classification: Unnamed (G082BY165OK) **Description of Rock Outcrop Setting** Landform: Mountain slopes Landform position (three-dimensional): Mountainflank Down-slope shape: Convex Across-slope shape: Convex Parent material: Granite **Typical profile** R - 0 to 24 inches: bedrock Properties and qualities Slope: 15 to 50 percent Depth to restrictive feature: 0 inches to lithic bedrock Runoff class: Very high Capacity of the most limiting layer to transmit water (Ksat): Low to moderately low (0.00 to 0.06 in/hr) Available water storage in profile: Very low (about 0.0 inches) **Interpretive groups** Land capability classification (irrigated): None specified Land capability classification (nonirrigated): 8s Hydrologic Soil Group: D Other vegetative classification: Unnamed (G082BY999OK) **Minor Components Foard** Percent of map unit: 5 percent Landform: Paleoterraces on pediments Landform position (three-dimensional): Riser Down-slope shape: Linear Across-slope shape: Convex Ecological site: Clay loam 23-30" pz (R078CY096TX) Other vegetative classification: Unnamed (G078CY016OK) **Lawton** Percent of map unit: 5 percent Landform: Mountain slopes Landform position (three-dimensional): Mountainbase Down-slope shape: Convex Across-slope shape: Convex Ecological site: Loamy prairie pe 38-48 (R082BY056OK) Other vegetative classification: Unnamed (G082BY017OK)

Comanche County, Oklahoma TmC—Tillman clay loam, 3 to 5 percent slopes Map Unit Setting National map unit symbol: dtq4 Elevation: 1,000 to 2,500 feet Mean annual precipitation: 20 to 32 inches Mean annual air temperature: 57 to 66 degrees F Frost-free period: 185 to 240 days Farmland classification: All areas are prime farmland **Map Unit Composition** Tillman and similar soils: 80 percent Minor components: 20 percent Estimates are based on observations, descriptions, and transects of the mapunit. **Description of Tillman Setting** Landform: Paleoterraces on pediments Landform position (three-dimensional): Riser Down-slope shape: Convex Across-slope shape: Convex Parent material:

Calcareous clayey and loamy alluvium derived from claystone **Typical profile** A - 0 to 6 inches: clay loam BA - 6 to 13 inches: clay loam Bt - 13 to 24 inches: silty clay Btk - 24 to 40 inches: silty clay BCk - 40 to 50 inches: silty clay C - 50 to 80 inches: clay **Properties and qualities** Slope: 3 to 5 percent Depth to restrictive feature: More than 80 inches Natural drainage class: Well drained Runoff class: High 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 in profile: 35 percent Gypsum, maximum in profile: 2 percent Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 8.0 mmhos/cm) Sodium adsorption ratio, maximum in profile: 12.0 Available water storage in profile: Moderate (about 7.0 inches) **Interpretive groups** Land capability classification (irrigated): None specified Land capability classification (nonirrigated): 3e Hydrologic Soil Group: D Ecological site: Clay loam 23-30" pz (R078CY096TX) Other vegetative classification: Unnamed (G078CY015OK) **Minor Components Foard** Percent of map unit: 7 percent Landform: Paleoterraces on pediments Landform position (three-dimensional): Riser Down-slope shape: Linear Across-slope shape: Convex Ecological site: Clay loam 23-30" pz (R078CY096TX) Other vegetative classification: Unnamed (G078CY016OK) **Lawton** Percent of map unit: 7 percent Landform: Paleoterraces Landform position (three-dimensional): Riser Down-slope shape: Convex Across-slope shape: Convex Ecological site: Loamy prairie pe 38-48 (R082BY056OK) Other vegetative classification: Unnamed (G082BY017OK) **Vernon** Percent of map unit: 6 percent Landform: Hillslopes on hills Landform position (two-dimensional): Backslope Down-slope shape: Convex Across-slope shape: Convex Ecological site: Shallow clay 23-30" pz (R078CY112TX)

Comanche County, Oklahoma W—Water Map Unit Setting National map unit symbol: dtqc Elevation: 250 to 4,000 feet Mean annual precipitation: 22 to 48 inches Mean annual air temperature: 57 to 64 degrees F Frost-free period: 190 to 240 days Farmland classification: Not prime farmland **Map Unit Composition** Water: 100 percent Estimates are based on observations, descriptions, and transects of the mapunit. **Description of Water Setting** Landform: Valleys **Typical profile** W - 0 to 80 inches: water **Interpretive groups** Land capability classification (irrigated): None specified Land capability classification (nonirrigated): 8 Other vegetative classification: Unnamed (G078CY999OK)

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 3). 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 3).

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 3), 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.

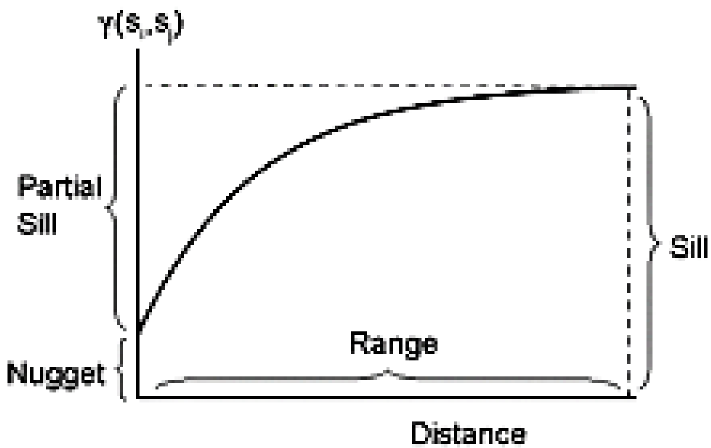


Figure 25. Example semivariogram, depicting range, sill, and nugget.

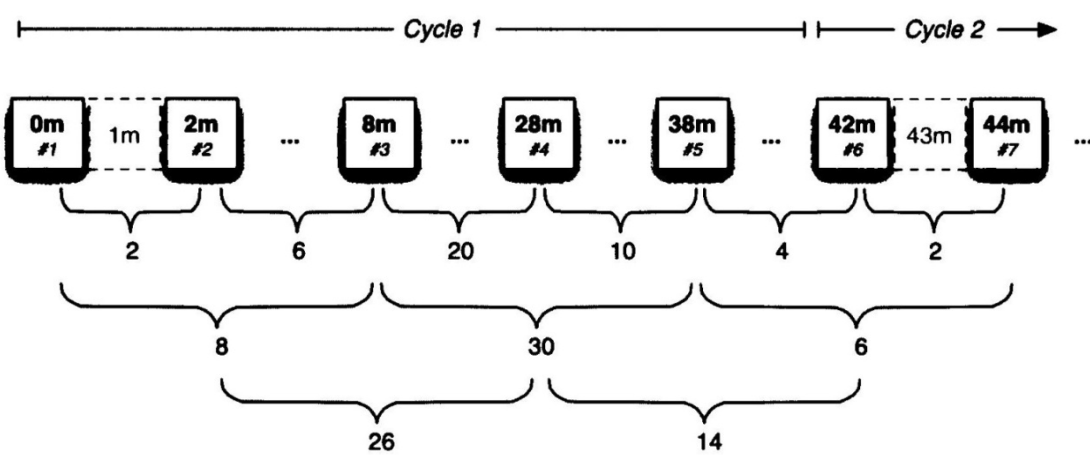


Figure 26. Spatially cyclic sampling design for the measurements of soil temperature and soil water content.

Field measurements of soil temperature (0-12 cm) and moisture (0-15 cm) were taken on 23 Sept 2014 at the WMWR 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 WMWR. 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 Figure 26, 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 graph) 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 11 m for soil temperature.

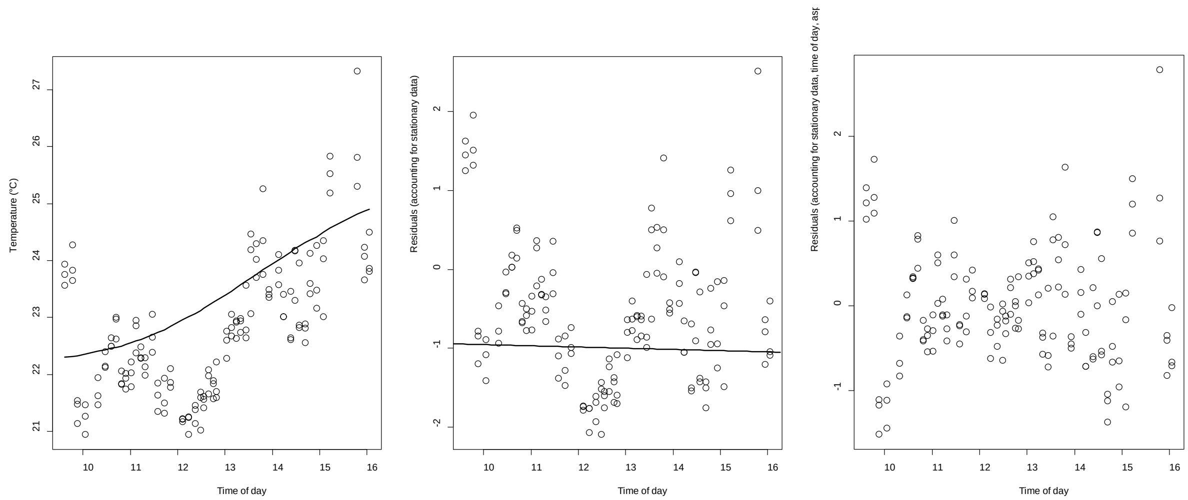


Figure 27. Left graph: mobile (circles) and stationary (line) soil temperature data. Center graph: temperature data after correcting for changes in temperature in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual temperature data after correcting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

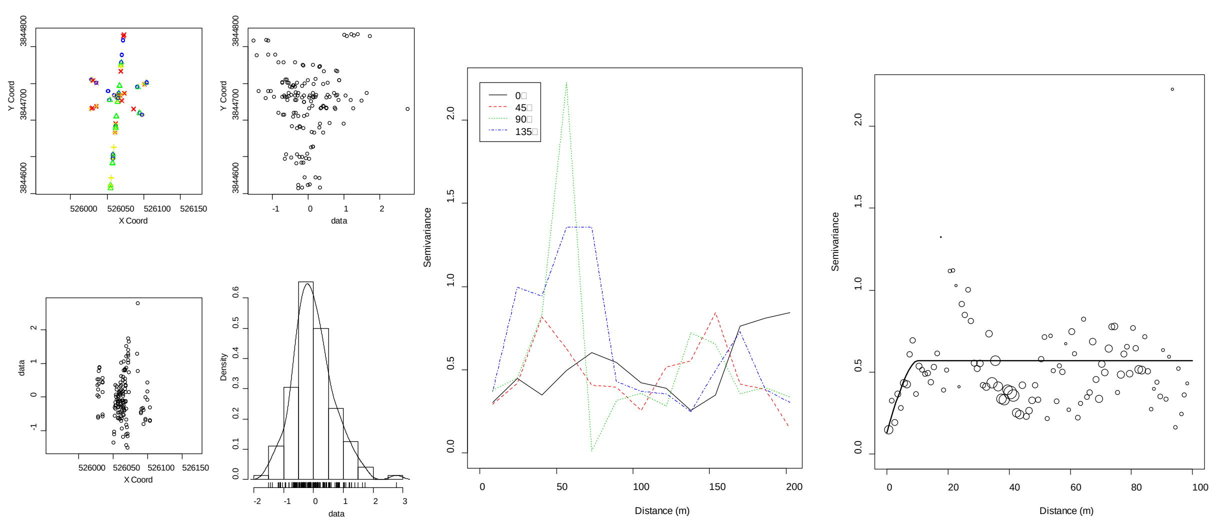


Figure 28. Left graphs: exploratory data analysis plots for residuals of temperature. Center graph: directional semivariograms for residuals of temperature. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of temperature.

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 2 m for soil water content.

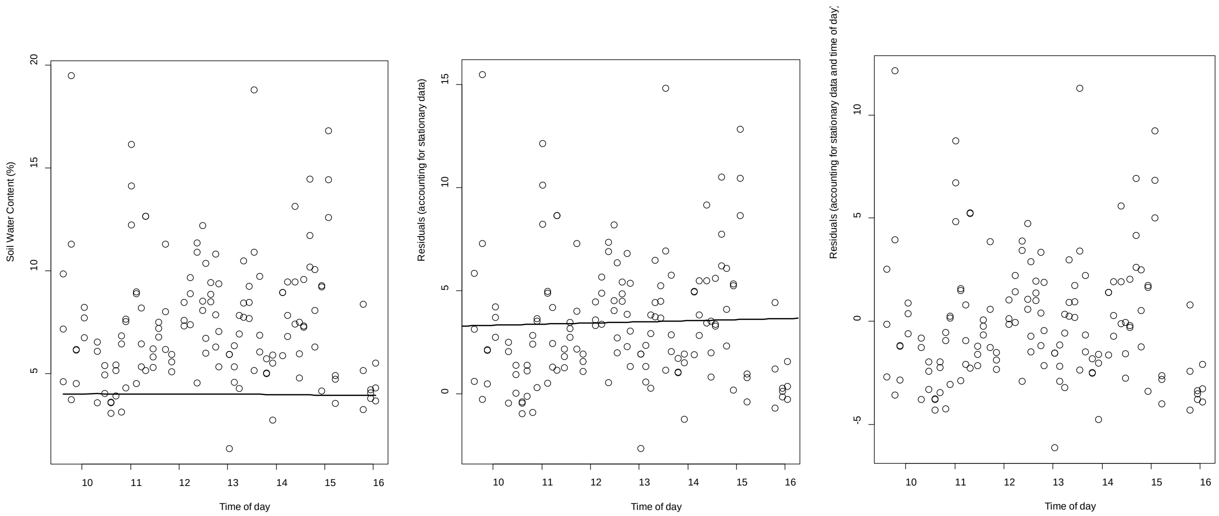


Figure 29. Left graph: mobile (circles) and stationary (line) soil water content data. Center graph: water content data after correcting for changes in water content in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual water content data after correcting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

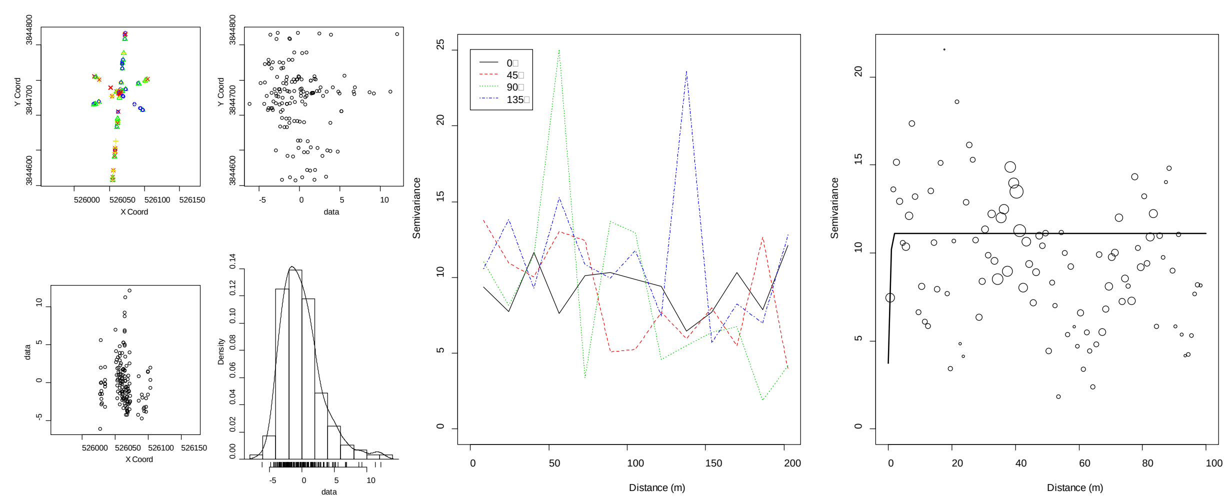


Figure 30. Left graphs: exploratory data analysis plots for residuals of soil water content. Center graph: directional semivariograms for residuals of water content. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of water content.

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 11 m for soil temperature and 2 m for soil moisture. Based on these results and the site design guidelines the soil plots at WMWR 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 180° from the soil plot nearest the tower (i.e., first soil plot). The location of the first soil plot will be 34.744706°, -98.715134°. The exact location of each soil plot may be microsited 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 34.745889, -98.713520° (primary location); or 34.745756, -98.713843 (alternate location 1 if primary location is unsuitable); or 34.745884, -98.715736 (alternate location 2 if primary location is unsuitable). A summary of the soil information is shown in Table 10 and site layout can be seen in Figure 31.

Dominant soil series at the site: Brico-Rock outcrop complex, 5 to 40 percent slopes. The taxonomy of this soil is shown below:
Order: Mollisols
Suborder: Ustolls
Great group: Argiustolls
Subgroup: Typic Argiustolls
Family: Clayey-skeletal, mixed, active, thermic Typic Argiustolls
Series: Brico-Rock outcrop complex, 5 to 40 percent slopes

Table 10. Summary of soil array and soil pit information at WMWR. 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	46 m
Latitude and longitude of 1st soil plot OR direction from tower	34.744706°, -98.715134°
Direction of soil array	180°
Latitude and longitude of FIU soil pit 1	34.745889, -98.713520 (primary location)
Latitude and longitude of FIU soil pit 2	34.745756, -98.713843 (alternate 1)
Latitude and longitude of FIU soil pit 3	34.745884, -98.715736 (alternate 2)
Dominant soil type	Brico-Rock outcrop complex, 5 to 40 percent slopes
Expected soil depth	>2 m
Depth to water table	>2 m

Expected depth of soil horizons	Expected measurement depths*
0-0.28 m (very cobbly loam)	0.14 m
0.28-1.02 m (very cobbly clay loam)	0.65 m

1.02-2 m (extremely cobbly clay loam)	1.51 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.

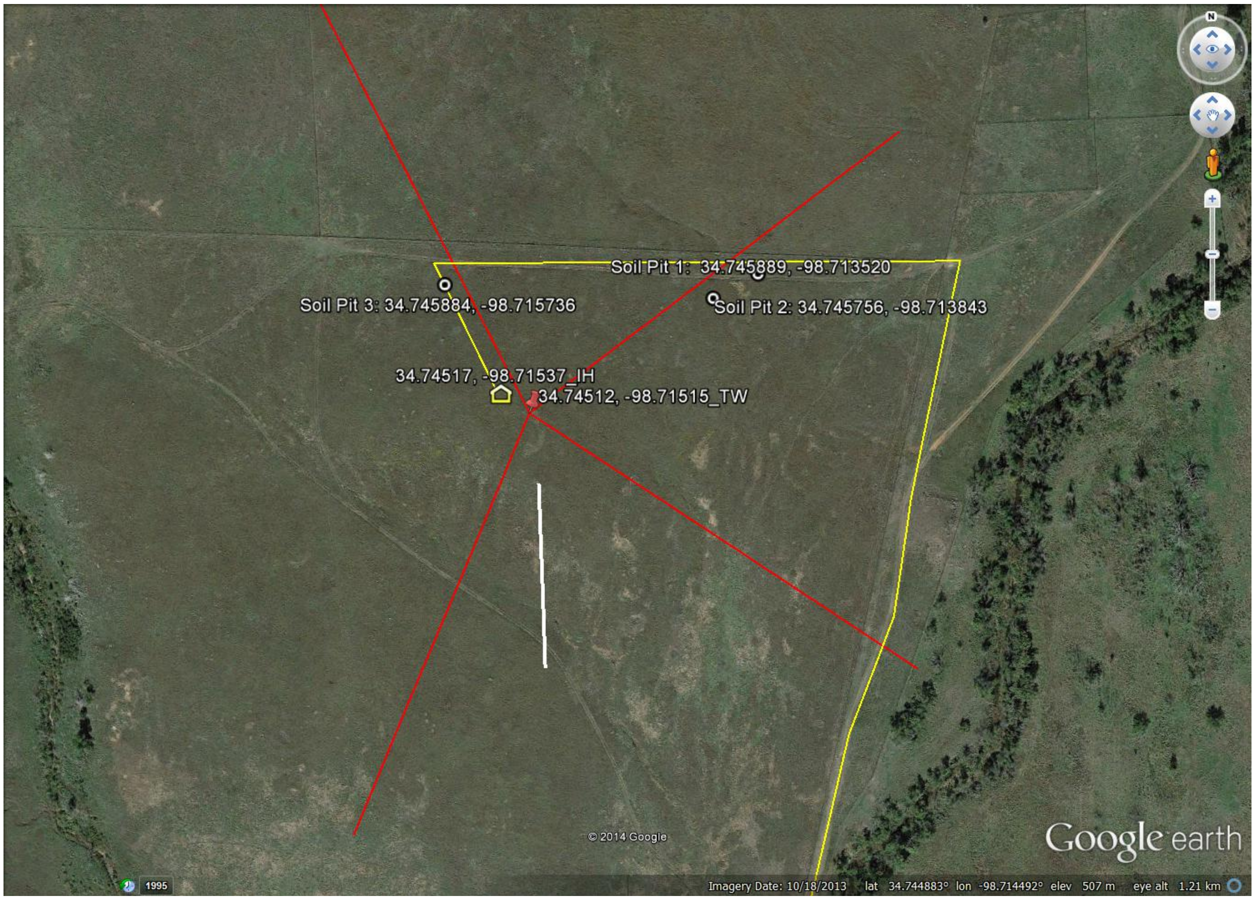


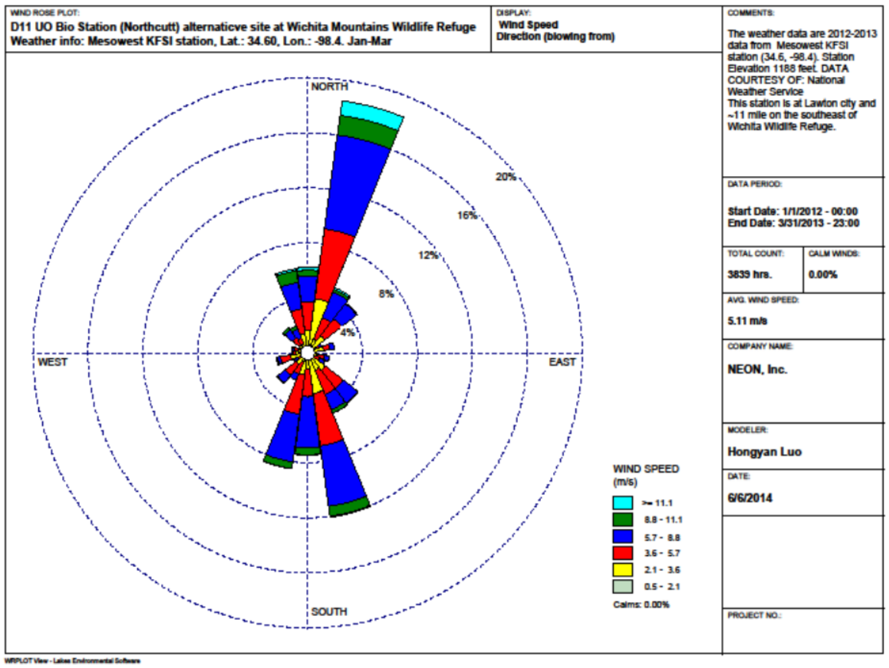
Figure 31. Site layout at WMWR showing soil array and location of the FIU soil pit.

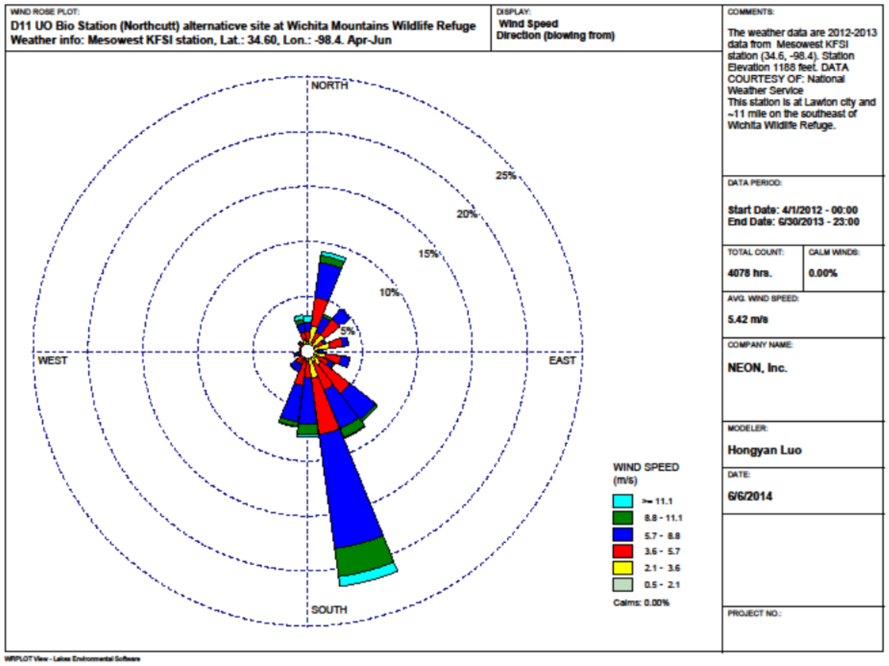
4.4 Airshed

4.4.1 Seasonal windroses

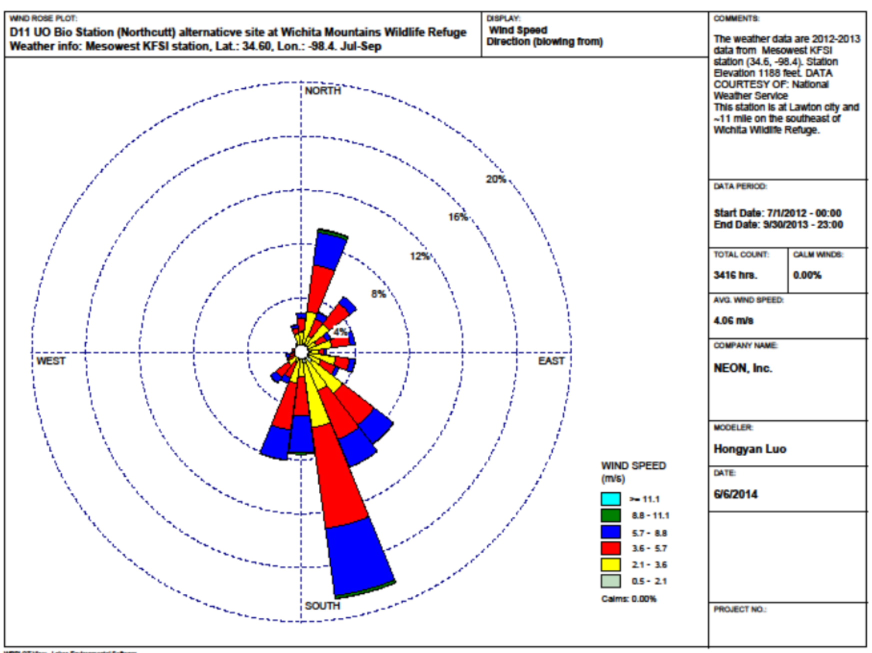
Wind roses analytically determine and graphically represent the frequencies of wind direction and wind speed over a given timeseries. Data used here are 2012-2013 data from Mesowest KFSI station (34.60, -98.4), which is ~11 miles on the southeast of the tower location. The wind roses from Mesowest KHBR station (34.98944, -99.05250, ~33 miles on the northwest of tower) and from KCHK station (35.09611, -97.96611, ~41 miles northeast of the tower) also display the similar wind patterns with major airshed from 125 to 205 degrees (clockwise) and secondary airshed from 335 to 55 degrees (clockwise). 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:
D11 UO Bio Station (Northcutt) alternaticve site at Wichita Mountains Wildlife Refuge
Weather info: Mesowest KFSI station, Lat.: 34.60, Lon.: -98.4. Apr-Jun
DISPLAY:
Wind Speed
Direction (blowing from)
COMMENTS:
The weather data are 2012-2013 data from Mesowest KFSI station (34.6, -98.4). Station Elevation 1188 feet. DATA COURTESY OF: National Weather Service
This station is at Lawton city and ~11 mile on the southeast of Wichita Wildlife Refuge.
DATA PERIOD:
Start Date: 4/1/2012 - 00:00
End Date: 6/30/2013 - 23:00
TOTAL COUNT:
4078 hrs.
CALM WINDS:
0.00%
AVG. WIND SPEED:
5.42 m/s
COMPANY NAME:
NEON, Inc.
MODELER:
Hongyan Luo
DATE:
6/6/2014
PROJECT NO.:
NORTH
SOUTH
WEST
EAST
5%
10%
15%
20%
25%
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: 0.00%
WRPLOT View - Lakes Environmental Software



WIND ROSE PLOT:
D11 UO Bio Station (Northcutt) alternaticve site at Wichita Mountains Wildlife Refuge
Weather info: Mesowest KFSI station, Lat.: 34.60, Lon.: -98.4. Jul-Sep
DISPLAY:
Wind Speed
Direction (blowing from)
COMMENTS:
The weather data are 2012-2013 data from Mesowest KFSI station (34.6, -98.4). Station Elevation 1188 feet. DATA COURTESY OF: National Weather Service
This station is at Lawton city and ~11 mile on the southeast of Wichita Wildlife Refuge.
DATA PERIOD:
Start Date: 7/1/2012 - 00:00
End Date: 9/30/2013 - 23:00
TOTAL COUNT:
3416 hrs.
CALM WINDS:
0.00%
AVG. WIND SPEED:
4.06 m/s
COMPANY NAME:
NEON, Inc.
MODELER:
Hongyan Luo
DATE:
6/6/2014
PROJECT NO.:
NORTH
SOUTH
WEST
EAST
4%
8%
12%
16%
20%
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: 0.00%
WRPLOT View - Lakes Environmental Software

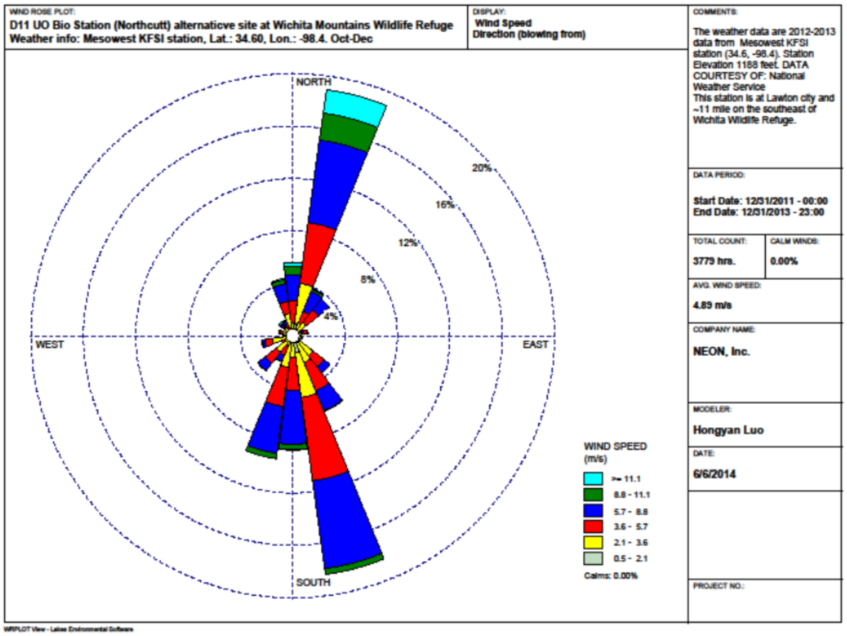


Figure 32. Windroses for Witchita relocatable site.
Data used here are 2012-2013 data from Mesowest KFSI station (34.60, -98.4). It is assumed that the wind data was corrected for declination. Panels are (from top to bottom) Jan-Mar, Apr-Jun, Jul-Sept, and Oct-Dec.

4.4.3 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.

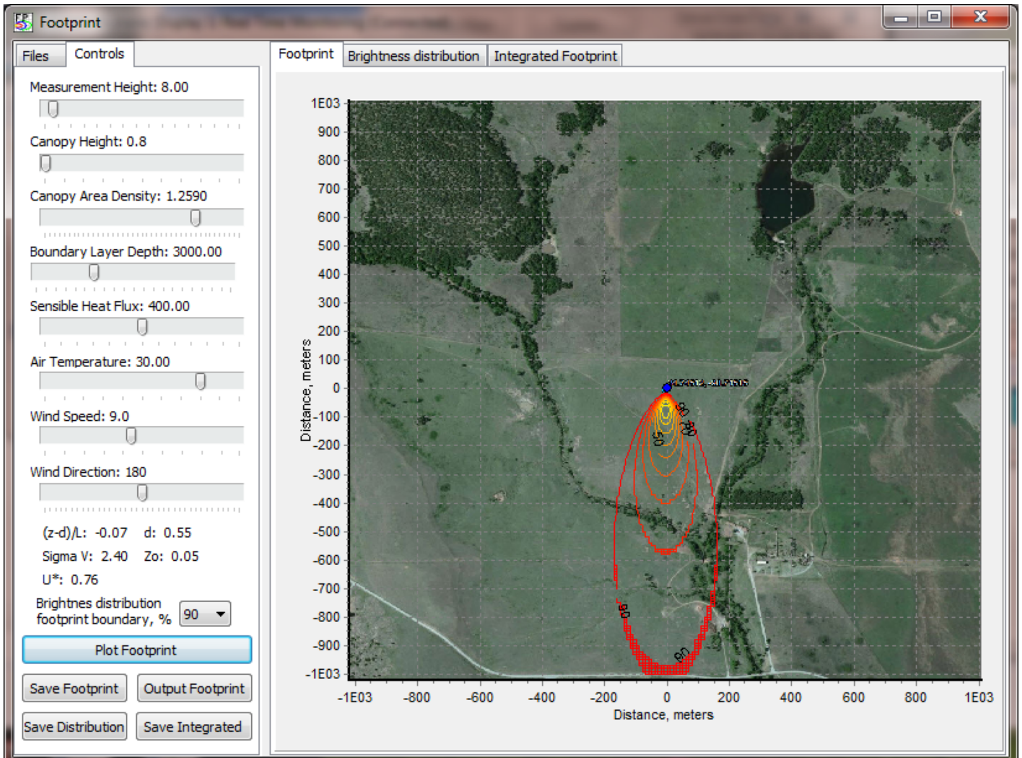
Here, we use a web-based footprint model to determine the footprint area under various conditions (model info: http://www.geos.ed.ac.uk/abs/research/micromet/EdiTools/). Winds used to run the model and generate following model results are extracted from the wind roses. Vegetation information, temperature 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 represent 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 11. Expected environmental controls to parameterize the source area model based on the wind roses for KFSI, KHBR and KCHK , and associated results for WMWR 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	8	8	8	8	8	8	m
Canopy Height	0.8	0.8	0.8	0.8	0.8	0.8	m
Canopy area density	1.2	1.2	1.2	1.2	1.2	1.2	m
Boundary layer depth	3000	3000	1500	1100	1100	700	m
Expected sensible heat flux	400	400	100	190	190	10	W m^{-2}
Air Temperature	30	30	22	14	14	5	°C
Max. windspeed	9.0	4.8	11.6	11	4.2	5.4	m s^{-1}
Resultant wind vector	180	180	15	180	180	15	degrees
			Results				
(z-d)/L	-0.07	-0.35	-0.01	-0.02	-0.28	-0.01	m
d	0.55	0.55	0.55	0.55	0.55	0.55	m
Sigma v	2.40	2.10	2.10	2.10	1.30	0.94	m^2 s^{-2}
Z0	0.05	0.05	0.05	0.05	0.05	0.05	m
u*	0.76	0.45	0.95	0.91	0.39	0.44	m s^{-1}
Distance source area begins	0	0	0	0	0	0	m
Distance of 90% cumulative flux	750	450	1000	980	500	1000	m
Distance of 80% cumulative flux	480	270	550	510	300	550	m
Distance of 70% cumulative flux	300	200	400	400	200	400	m

Peak contribution	75	55	75	85	65	75	m

4.4.4 Results (source area graphs)



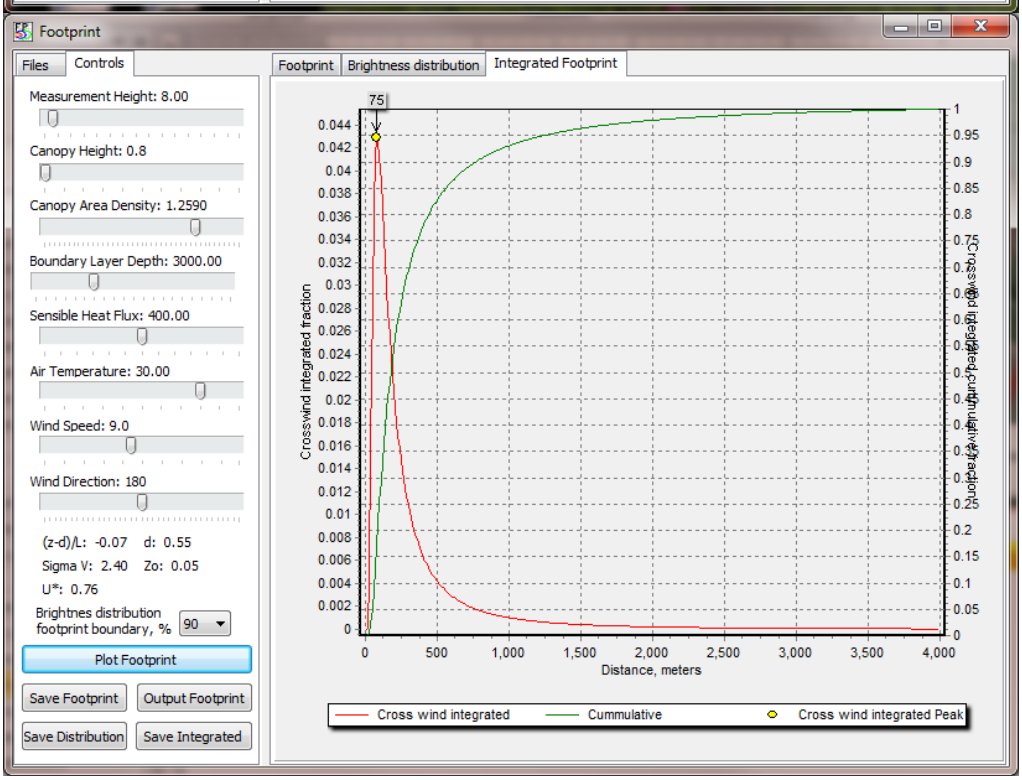


Figure 33. WMWR Relocatable site summer daytime (convective) footprint output with max wind speed

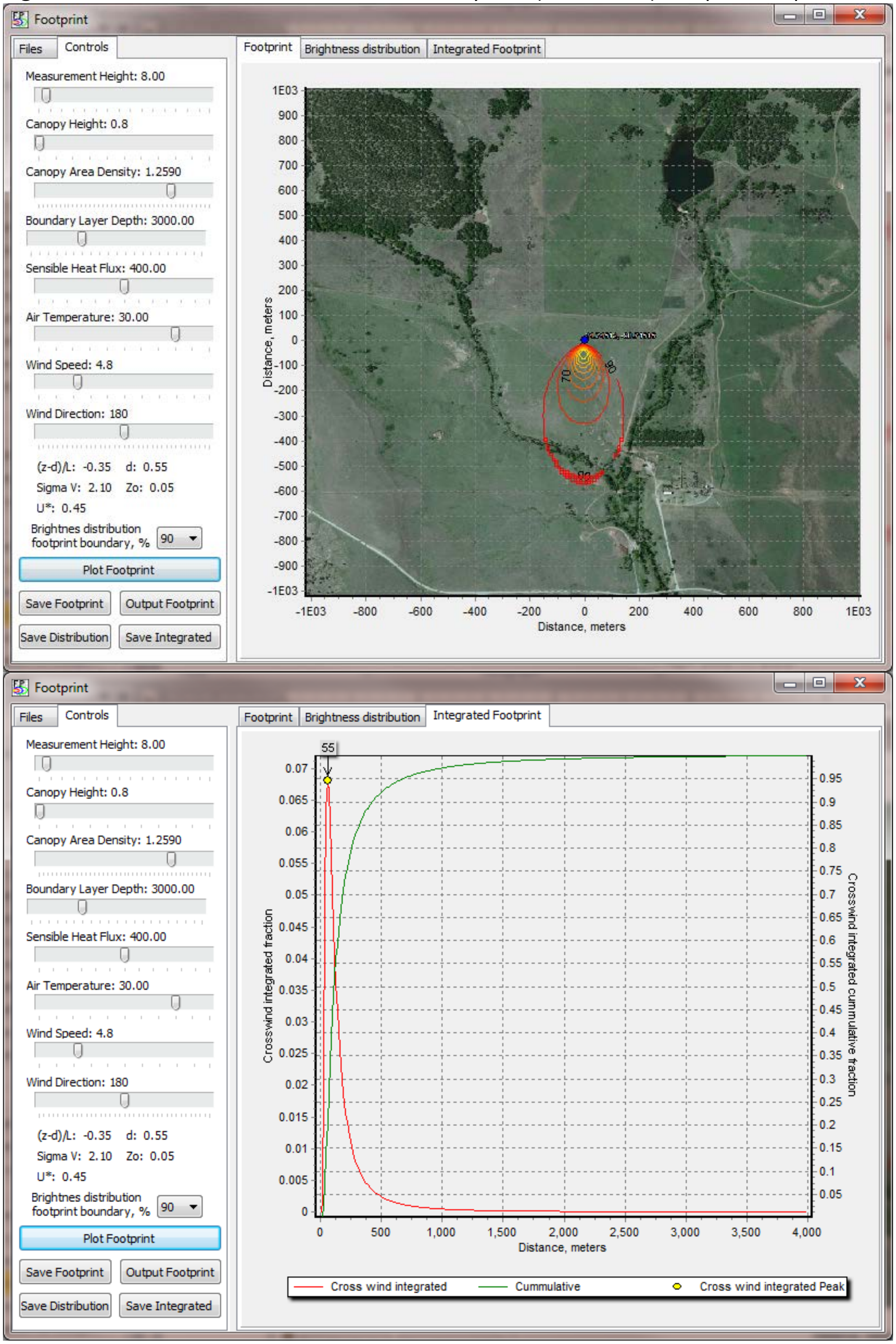
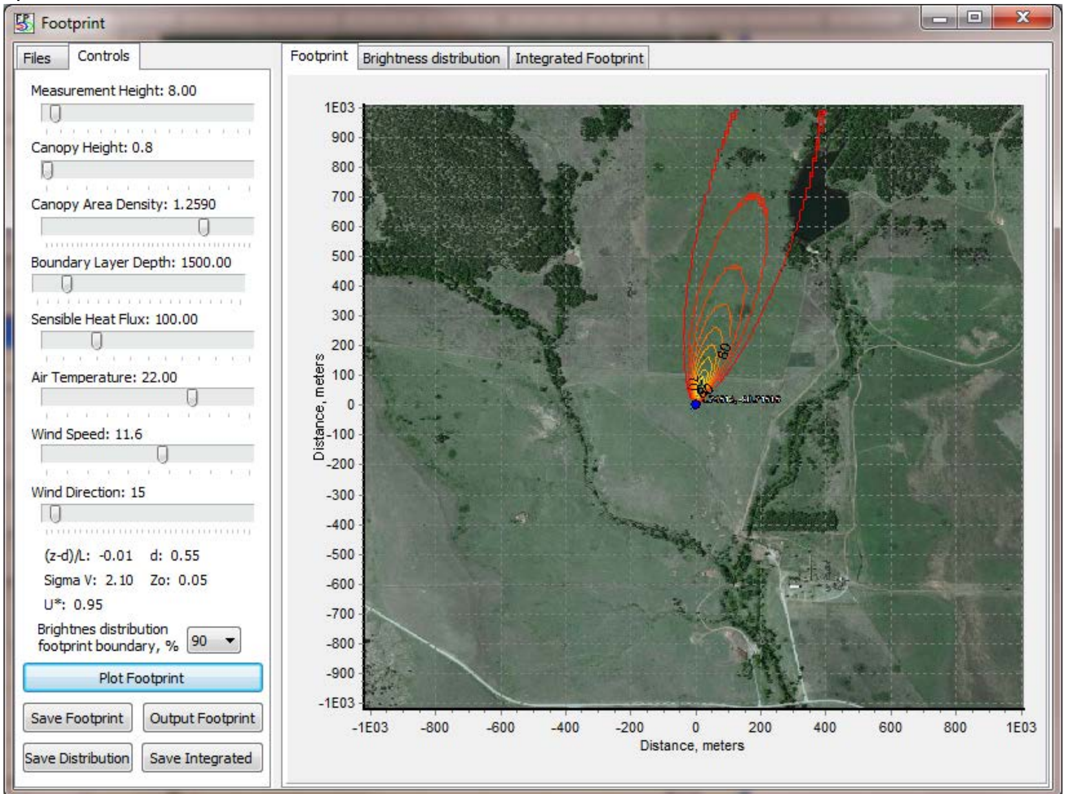


Figure 34. WMWR Relocatable site summer daytime (convective) footprint output with mean wind speed



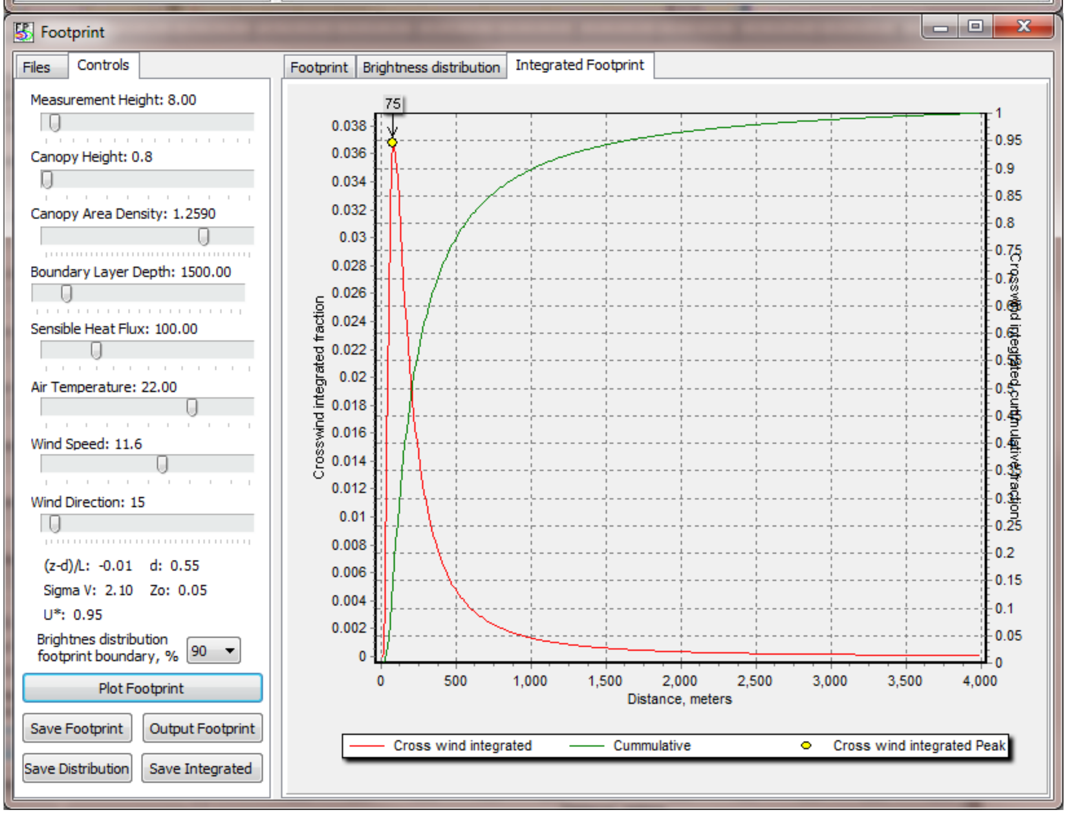
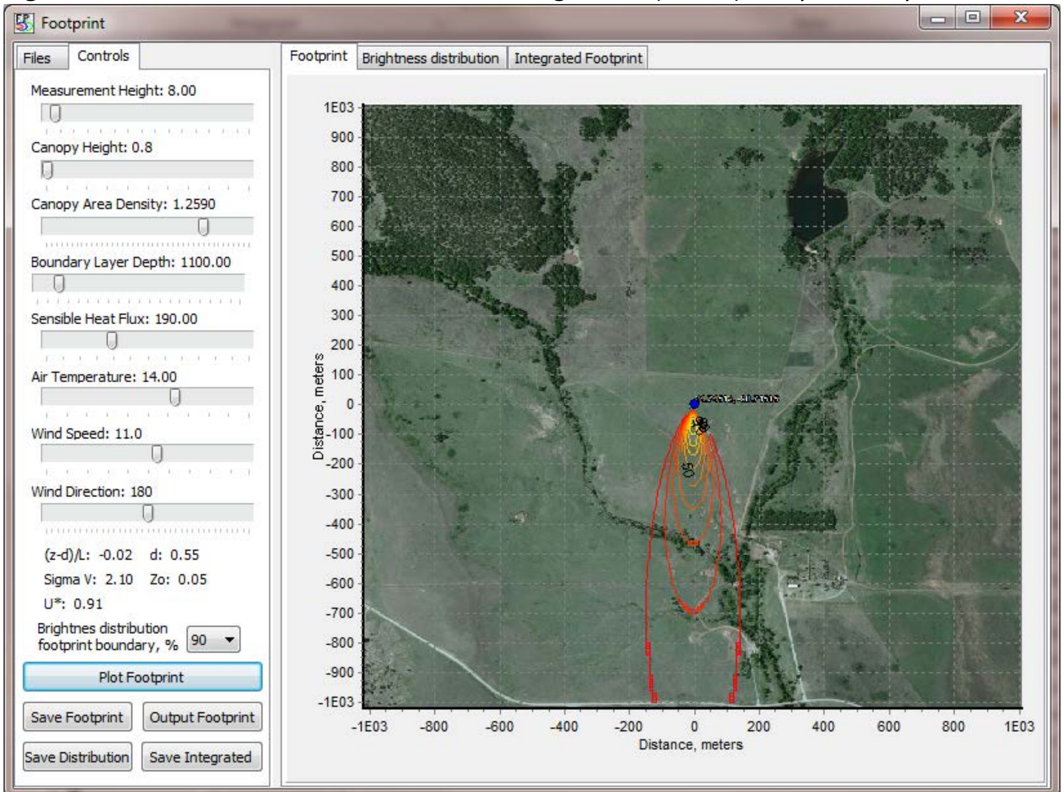


Figure 35. WMWR Relocatable site summer nighttime (stable) footprint output with mean wind speed



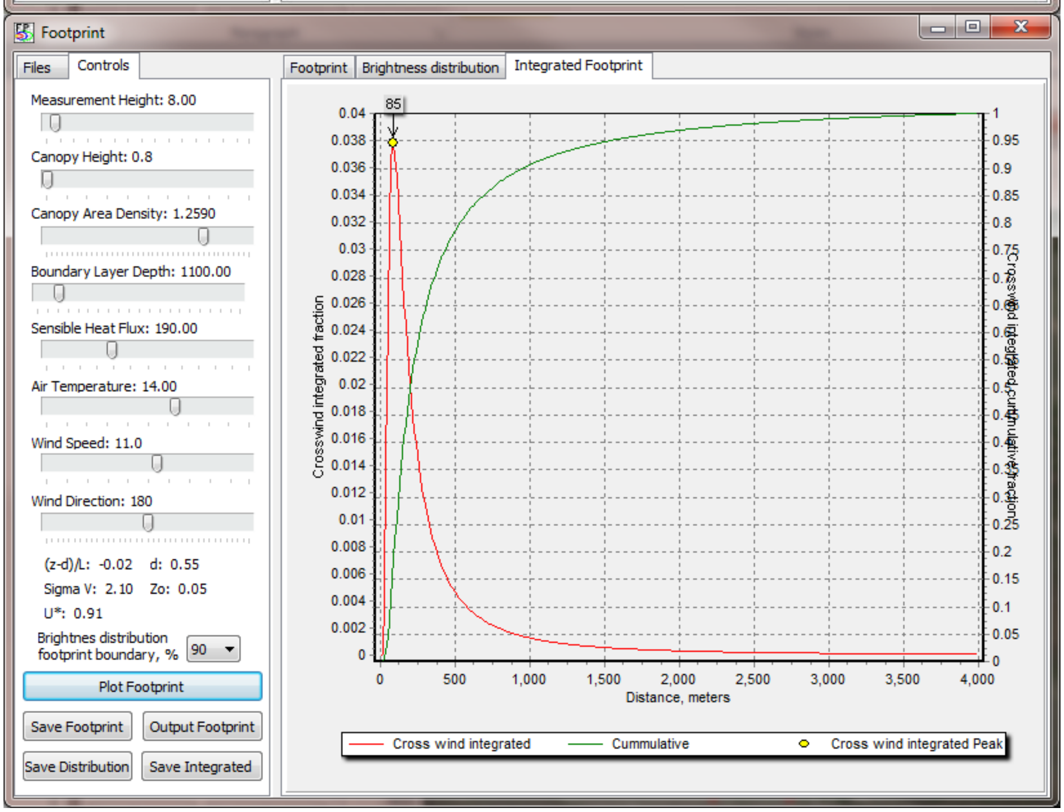


Figure 36. WMWR Relocatable site winter daytime (convective) footprint output with max wind speed

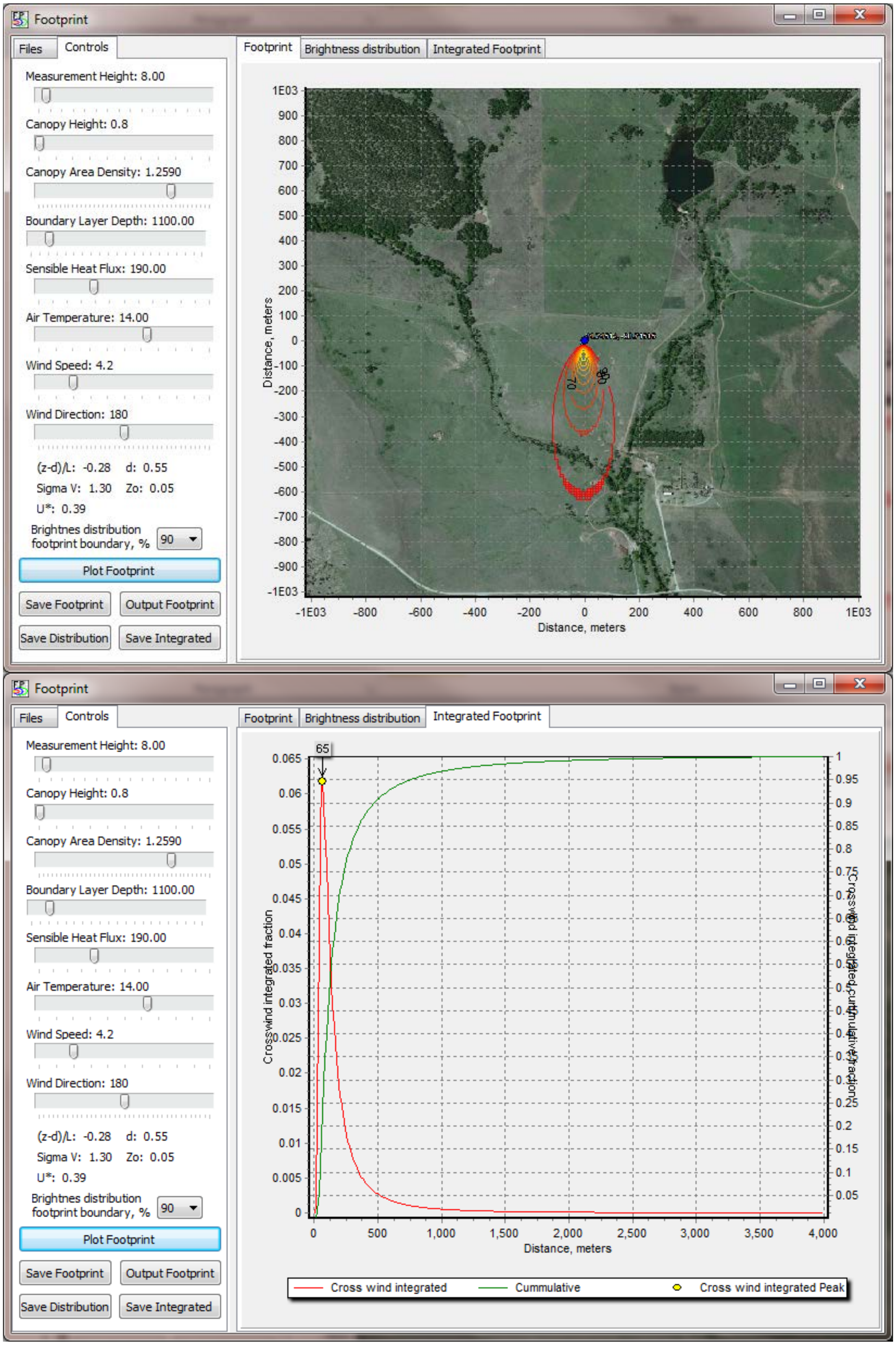


Figure 37. WMWR Relocatable site winter daytime (convective) footprint output with mean wind speed

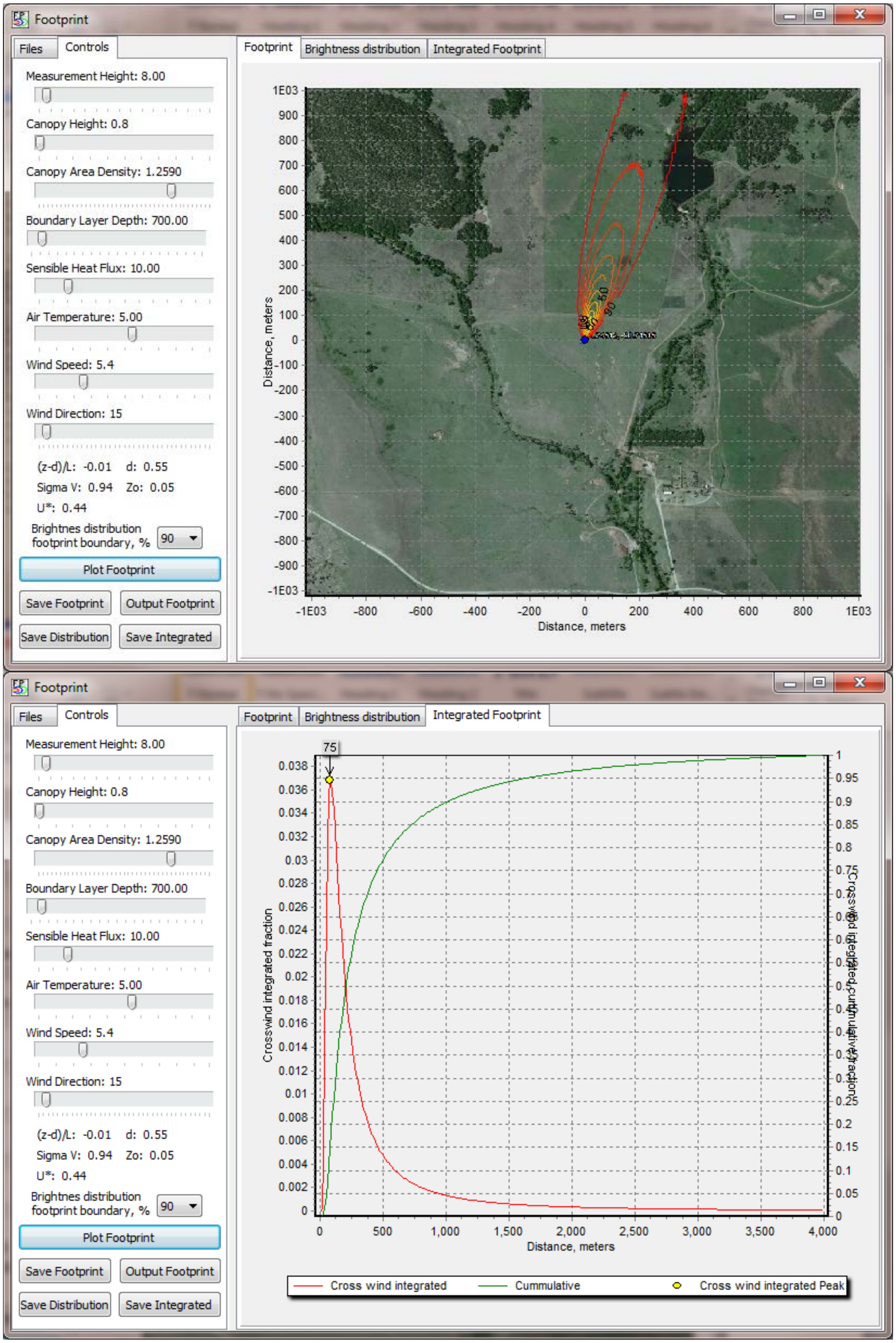


Figure 38. WMWR Relocatable site winter nighttime (stable) footprint output with mean wind speed

4.4.5 Site design and tower attributes

According to wind roses, prevailing wind blows from south (125° to 225°, clockwise from 125°, major airshed) and from north (335° to 55°, clockwise from 335°, secondary airshed). **Tower** should be placed to a location to best catch the signals from the airshed of the ecosystem in interest. After FIU site characterization, we determined the tower location to be at 34.74512, -98.71515 to meet the NEON science requirements best.

Eddy covariance, sonic wind and air temperature **boom arms** orientation toward the east 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 west toward tower and have the longer side parallel to N-S direction. Therefore, we decide the placement of instrument hut at 34.74517, -98.71537. The distance between the tower and the instrument hut is ~ 20 m.

The ecosystem at the tower site is grassland. It is grazed by bison, elk, steers, etc. The average canopy height varies with seasons and can reach 0.8 m at the end of the growing season. The vegetation is dominated by grasses (species unknown), and dotted with few small short shrubs (generally lower than the grass by the end of growing season in Fall). We require 4 **measurement layers** on the tower with top measurement height at 8 m, and remaining levels are at 4 m, 1.5 m (ideally we want this measurement level at average canopy height of 0.8 m. However, due to the NEON tower design, the lowest possible location is likely to be 1.5 m.) and 0.3 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. **Wet deposition collector** will be collocated at the tower top. 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 12. Site design and tower attributes for WMWR Relocatable site

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

Attribute	lat	long	degree	meters	notes
Airshed			125° 205° (major) and		Clockwise from first

			335^o to 55^o (secondary)		angle.
Tower location	34.74512,	-98.71515	--	--	new site
Instrument hut	34.74517	-98.71537			
Instrument hut orientation vector	--	--	180^o-360^o		
Instrument hut distance z	--	--	--	20	
Anemometer/Temperature boom orientation	--	--	90°	--	
Height of the measurement levels					
Level 1				0.3	m.a.g.l.
Level 2				1.5	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.

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

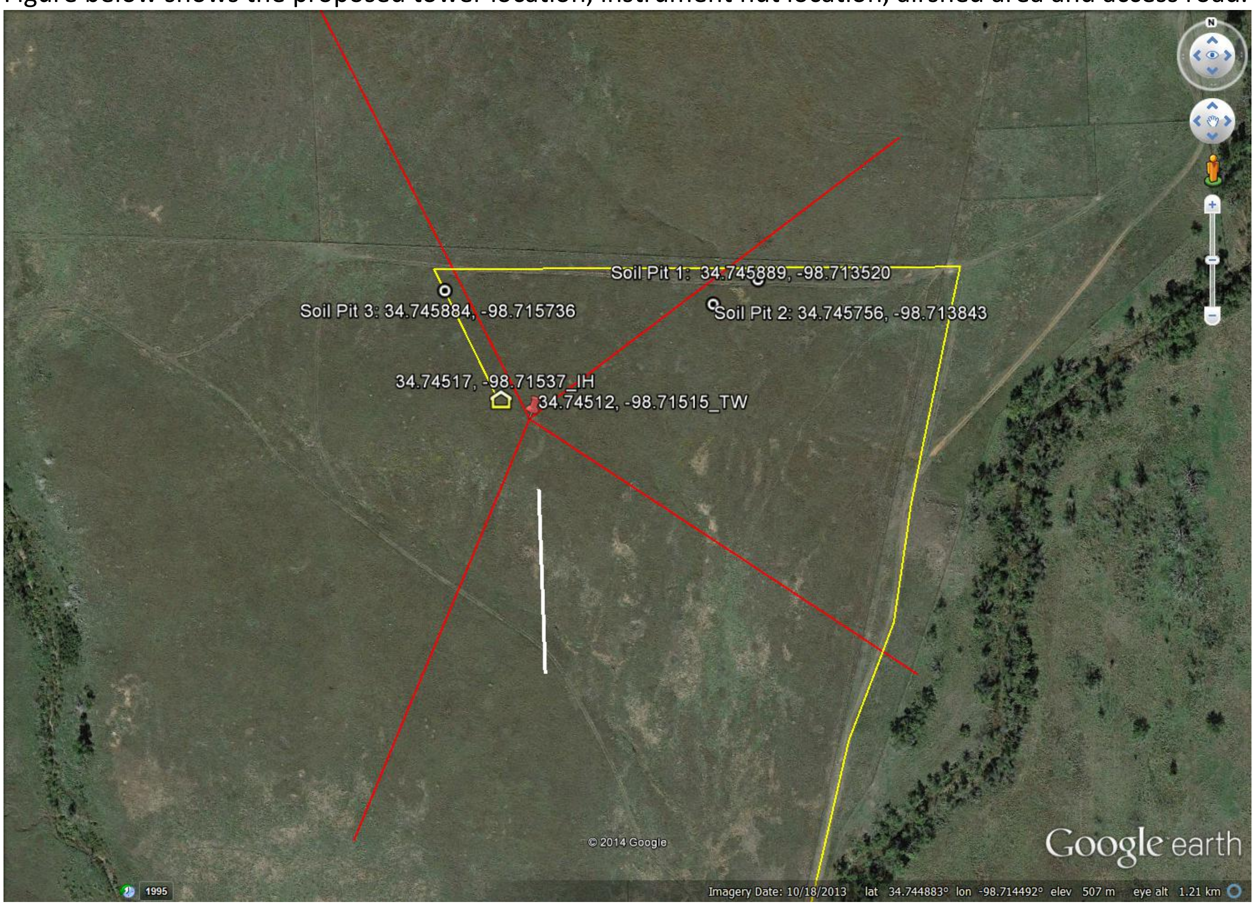


Figure 39. Site layout for Wichita Relocatable site.

i) tower location is presented (red pin), ii) red lines indicate the airshed boundaries. Vectors from 125° to 205° (clockwise from 125°, major airshed) and from 335° to 55° (clockwise from 335°, secondary airshed) are areas that would have quality wind data without causing flow distortions, respectively. iii) Yellow line is the suggested access way 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 this site:

- Improve path from the access dirt road to instrument hut, pending landowner decision
- Boardwalk from the instrument hut to the tower, pending landowner decision
- Improve path to soil array
- No boardwalk from soil array boardwalk to individual soil plots.

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

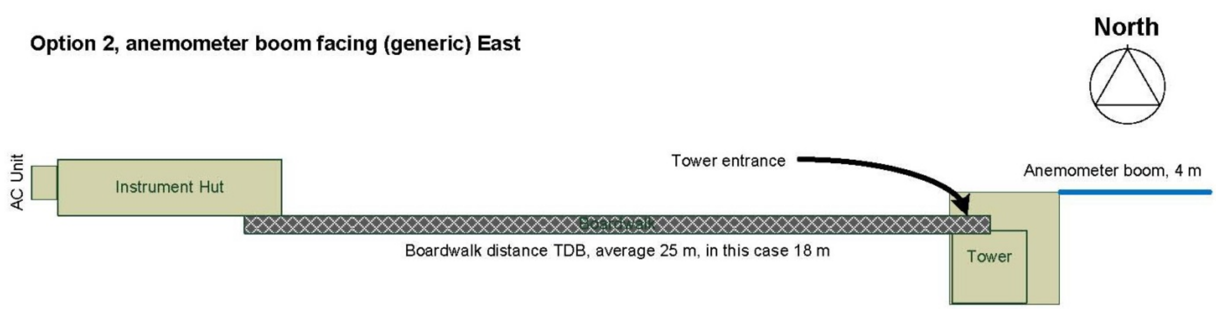


Figure 40. Generic diagram to demonstration the relationship between tower and instrument hut when boom facing east and instrument hut on the west towards the tower.

This is just a generic diagram when boom facing east and instrument hut on the western side of the tower. The actual design of boardwalk (or path if no boardwalk required) and instrument hut position will be joint responsibility of FCC and FIU.

4.4.6 Information for ecosystem productivity plots

The tower has been positioned to optimize the collection of the air/wind signals both temporally and spatially over the desired ecosystem (grassland). Prevailing winds blow from south (125^o to 205^o, clockwise from 125^o, major airshed) and from north (335^o to 55^o, clockwise from 335^o, secondary airshed). We expect that 90% signals for flux measurements are within a distance of 500 m from tower during daytime convective conditions, and 80% within 300 m. We suggest FSU Ecosystem Productivity plots are placed within the boundaries of 125^o to 205^o (major, clockwise from 125°) from tower.

4.5 Issues and attentions

This area is grazed and separated by many wire fences and gates for management purpose. The Kiowa lake on the NE of the candidate tower location is one of the major drinking water sources for bisons and other animals when creeks are dry out. Any facilities that NEON adds should not block the pathway for the animals to access this water source. NEON should follow the instructions from WMWR to close/open the gates as needed to accomadate WMWR management activities.

There are about 150 bisons in the WMWR. When the DNA tracking work is conducted annualy around September to October, WMWR staffs use temptation agent (they call it bison candy) to allure the bisons to this area for the convenience of sampling. For this reason, bison may approach people when they see vehicles and people around. But we were told they normally do not attack people unless they feel threatened.

The ecosystem at the tower site is grassland. It is grazed by bison, elk, steers, etc., but this is not expected to adversely affect NEON science at the site. Protection of sensors on the lower level on the tower and soil plots may be needed. Moreover, the standard cattle fence used at other NEON sites may not be sufficient to exclude bison.

5 KLEMME RANGE RESEARCH STATION, RELOCATEABLE TOWER 2

5.1 Site description

The Marvin Klemme Range Research Station is run by Oklahoma State University. The original tower location was 35.4072833, -99.0594972. However, the tower was moved ~370 m north (35.41059, -99.05879) to ensure that only one land-use type dominated the primary tower airshed. The new location was still close to the access road and it was closer to the location where the power line ends on the road.

The station consists of 1,560 acres and is located 10 miles south and 5 miles west of Clinton, Oklahoma. The station is located slightly south of the north/south midpoint of the Rolling Red Plains Resource Area. The Rolling Red Plains extends from south of the Red River to north of the Oklahoma/Kansas border consisting of approximately 9.4 million acres, which occupies a significant portion of Western Oklahoma excluding the Oklahoma Panhandle. (Source: http://www.oaes.okstate.edu/field-and-research-service-unit/marvin-klemme-range-research-station-1).

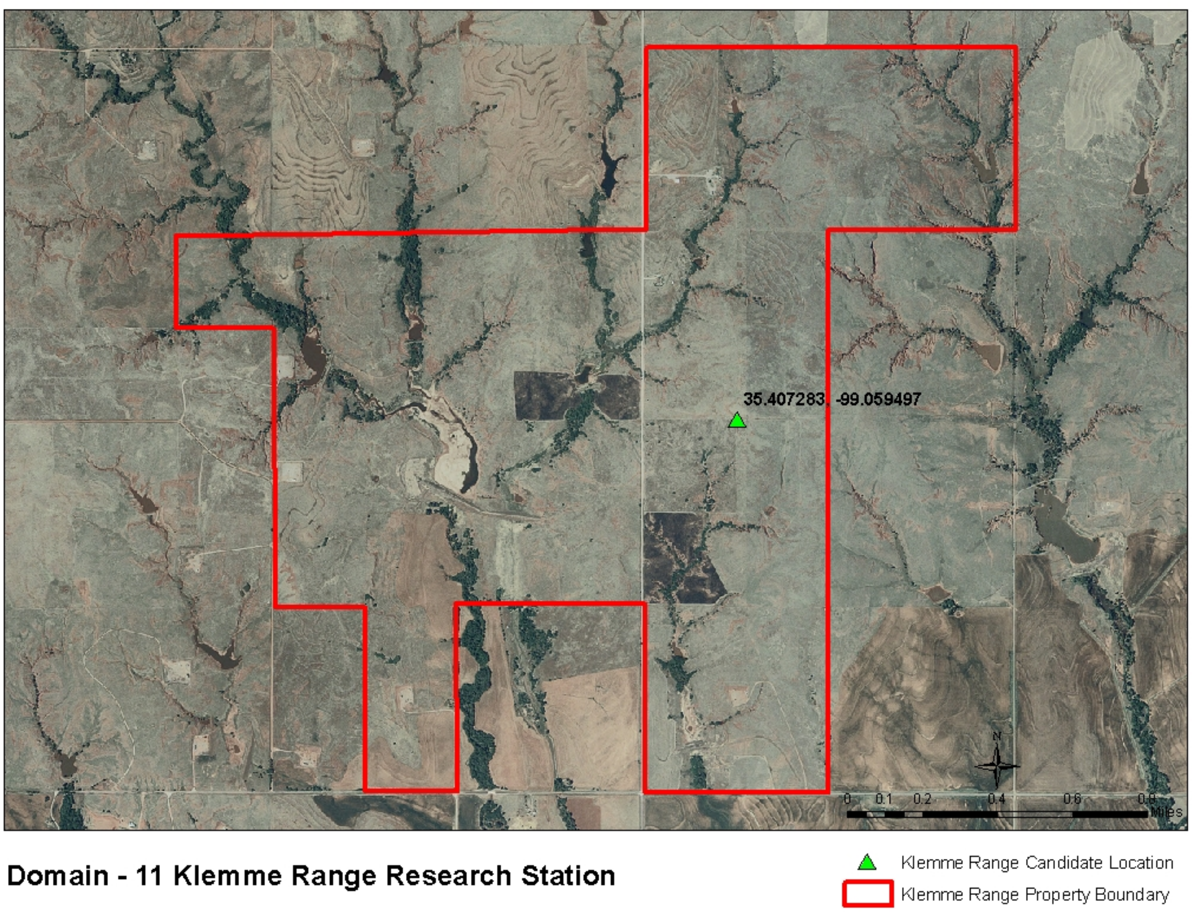
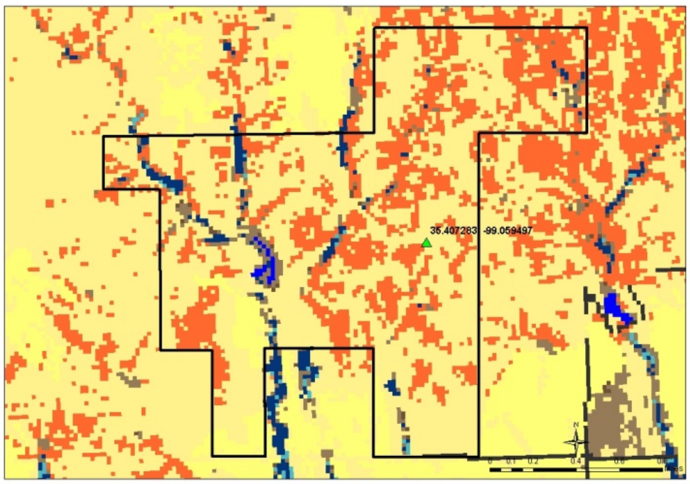


Figure 41. Property boundary of the Klemme site and original candidate tower location.
Note that the tower was micro-sited since this graph was made, actual tower location indicated below.

5.2 Ecosystem

Vegetation type and land cover information at this relocatable site are presented below:



Domain - 11 Klemme Range Research Station

Figure 42. Vegetative cover map of the Klemme relocatable site and surrounding areas (from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm), note that the tower was micro-sited since this graph was made, actual tower location indicated below.

Table 13. Percent Land cover information at the Klemme relocatable site (from USGS, http://landfire.cr.usgs.gov/viewer/viewer.htm)

Vegetation Type	Area	Perc entage
Agriculture-Cultivated Crops and Irrigated Agriculture	0.251061	4.043035646
Central Mixedgrass Prairie	3.865265	62.2454966
Crosstimbers Oak Forest and Woodland	0.013176	0.21218946
Developed-Open Space	0.0099	0.159427741
Introduced Upland Vegetation-Perennial Grassland and Forbland	1.721116	27.7165359
Open Water	0.0174	0.280214276
Western Great Plains Depressional Wetland Systems	0.0009	0.014493431
Western Great Plains Floodplain Systems	0.133832	2.15520263
Western Great Plains Mesquite Woodland and Shrubland	0.174338	2.807500097
Western Great Plains Sandhill Steppe	0.022722	0.365904218
Total Area sq km	6.20971	100

The ecosystem at the tower site was a shortgrass grassland with flat terrain. The management applied to the field containing the tower was moderate to light grazing and no controlled burns. The field ~400 m to the southwest was ungrazed and unburned, the field ~400 m to the southeast was grazed and burned every 4 years, and the field to the east was grazed and had an unknown burning regime.

Chesapeake Energy may install an oil well ~350 m southeast or southwest of the tower location. Oil wells were common throughout the region and there was noticeable ongoing oil well development during the site visit. Installation of the oil well is not expected to adversely affect NEON science at this site and may present interesting research opportunities.

Shortgrasses and forbs accounted for ~80% of ground cover at the site, while ~10% was tallgrass, and ~10% was bare ground. The mean canopy height of the grassland is ~ 0.5 m during FIU site characterization, but expected to reach ~1 m by the end of growing season. Tallgrass can reach ~ 1.5 m. There were deeply incised drainage channels throughout the area. There was little water in the channels during the site visit, but the banks appeared highly eroded, suggesting that they flow rapidly after a rainstorm. Trees exist only in and around the drainage channels. The soil was rocky, especially below ~10-15 cm.

This is a rolling upland prairie site consisting of a Cordell soil series. The site is predominately a shallow, somewhat excessively drained, moderately permeable soil that weathered form a hard siltstone under a cover of mid and short grasses. These soils are on hilltops, hillsides, and in swales and canyons on uplands with slopes from 1-15%. The average annual precipitation is 30.70 inches with an average summer high temperature of 93.6° and average winter low temperature of 26.1°. (Source: http://www.oaes.okstate.edu/field-and-research-service-unit/marvin-klemme-range-research-station-1).

Figure 43. Ecosystem and surrounding environment at the Klemme relocatable site.

Table 14. Ecosystem and site attributes for Klemme Relocatable site.

Ecosystem attributes	Measure and units
Mean canopy height	1.0 m
Surface roughness [a]	0.13 m
Zero place displacement height [a]	0.75 m
Structural elements	Shortgrass, uniform
Time zone	Central time zone
Magnetic declination	5° 29' E changing by 0° 7' W/year

Note, [a] From field survey.

5.3 Soils

5.3.1 Description of soils

Soil data and soil maps below for the Klemme tower site were collected from 2.1 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.

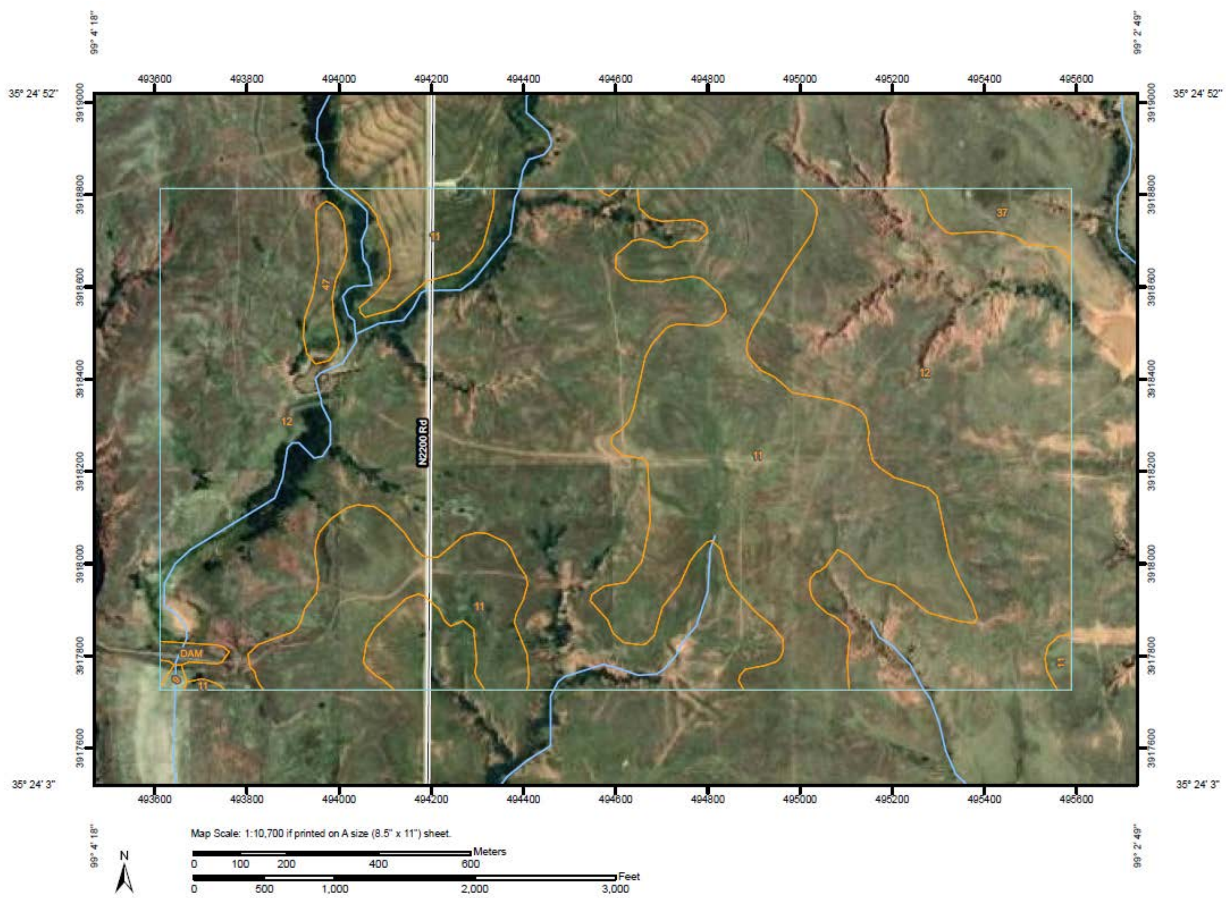


Figure 44. Soil map of the Klemme site and surrounding areas.

Soil Map Units Description: The map units delineated on the detailed soil maps in a soil survey represents 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, 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. T he 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, are 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 15. Soil series and percentage of soil series within 2.1 km^2 at the Klemme site

Washita County, Oklahoma (OK149)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
9	Clairemont silt loam, 0 to 1 percent slopes, occasionally flooded	0.5	0.1%
11	Cordell silty clay loam, 3 to 5 percent slopes	147.8	27.9%
12	Cordell-Rock outcrop complex, 2 to 15 percent slopes	368.0	69.3%
37	Quinlan-Obaro complex, 5 to 12 percent slopes	8.1	1.5%
47	St. Paul silt loam, 1 to 3 percent slopes	4.8	0.9%
DAM	Large dam	1.5	0.3%
Totals for Area of Interest		**530.8**	**100.0%**

Washita County, Oklahoma: 9—Clairemont silt loam, 0 to 1 percent slopes, occasionally flooded. Map Unit Setting *Elevation:* 700 to 2,250 feet *Mean annual precipitation:* 20 to 40 inches *Mean annual air temperature:* 57 to 65 degrees F *Frost-free period:* 185 to 240 days **Map Unit Composition** *Clairemont and similar soils:* 90 percent *Minor components:* 10 percent **Description of Clairemont Setting** *Landform:* Flood plains *Down-slope shape:* Linear *Across-slope shape:* Linear *Parent material:* Calcareous silty alluvium **Properties and qualities** *Slope:* 0 to 1 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:* 10 percent *Gypsum, maximum content:* 2 percent *Sodium adsorption ratio, maximum:* 4.0 *Available water capacity:* High (about 11.4 inches) **Interpretive groups** *Land capability (nonirrigated):* 3e *Ecological site:* Loamy Bottomland 23-31" PZ (R078CY103TX) **Typical profile** *0 to 9 inches:* Silt loam *9 to 80 inches:* Silt loam **Minor Components Westola** *Percent of map unit:* 5 percent *Landform:* Flood plains *Down-slope shape:* Linear *Across-slope shape:* Linear *Ecological site:* Loamy Bottomland 23-31" PZ (R078CY103TX) **Port** *Percent of map unit:* 5 percent *Landform:* Flood plains *Down-slope shape:* Linear *Across-slope shape:* Linear *Ecological site:* Loamy Bottomland 23-31" PZ (R078CY103TX)

Washita County, Oklahoma: 11—Cordell silty clay loam, 3 to 5 percent slopes. Map Unit Setting *Elevation:* 1,000 to 2,500 feet *Mean annual precipitation:* 20 to 32 inches *Mean annual air temperature:*

57 to 64 degrees F *Frost-free period:* 185 to 230 days **Map Unit Composition** *Cordell and similar soils:* 85 percent *Minor components:* 15 percent **Description of Cordell Setting** *Landform:* Hillslopes on hills *Landform position (two-dimensional):* Backslope *Down-slope shape:* Convex *Across-slope shape:* Convex *Parent material:* Loamy residuum weathered from calcareous siltstone **Properties and qualities** *Slope:* 3 to 5 percent *Depth to restrictive feature:* 10 to 20 inches to lithic bedrock *Drainage class:* Somewhat excessively drained *Capacity of the most limiting layer to transmit water (Ksat):* 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:* 5 percent *Available water capacity:* Very low (about 2.4 inches) **Interpretive groups** *Land capability (nonirrigated):* 4s *Ecological site:* Red Shale PE 32-44 (R078CY067OK) **Typical profile** *0 to 6 inches:* Silty clay loam *6 to 10 inches:* Silty clay loam *10 to 14 inches:* Very gravelly silty clay loam *14 to 17 inches:* Bedrock **Minor Components Quinlan** *Percent of map unit:* 10 percent *Landform:* Hillslopes on hills *Landform position (two-dimensional):* Backslope *Down-slope shape:* Convex *Across-slope shape:* Convex *Ecological site:* Shallow Prairie (South) PE 32-44 (R078CY084OK) **Carey** *Percent of map unit:* 5 percent *Landform:* Hillslopes on hills *Landform position (two-dimensional):* Backslope *Down-slope shape:* Convex *Across-slope shape:* Convex *Ecological site:* Loamy Prairie PE 32-44 (R078CY056OK)

Washita County, Oklahoma: 12—Cordell-Rock outcrop complex, 2 to 15 percent slopes. Map Unit Setting *Elevation:* 500 to 2,200 feet *Mean annual precipitation:* 22 to 48 inches *Mean annual air temperature:* 57 to 64 degrees F *Frost-free period:* 185 to 240 days **Map Unit Composition** *Cordell and similar soils:* 65 percent *Rock outcrop:* 35 percent **Description of Cordell Setting** *Landform:* Hillslopes on hills *Landform position (two-dimensional):* Backslope *Down-slope shape:* Convex *Across-slope shape:* Convex *Parent material:* Loamy residuum weathered from calcareous siltstone **Properties and qualities** *Slope:* 8 to 15 percent *Depth to restrictive feature:* 10 to 20 inches to lithic bedrock *Drainage class:* Somewhat excessively drained *Capacity of the most limiting layer to transmit water (Ksat):* 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:* 5 percent *Available water capacity:* Very low (about 2.4 inches) **Interpretive groups** *Land capability (nonirrigated):* 6e *Ecological site:* Red Shale PE 32-44 (R078CY067OK) **Typical profile** *0 to 6 inches:* Silty clay loam *6 to 10 inches:* Silty clay loam *10 to 14 inches:* Very gravelly silty clay loam *14 to 17 inches:* Bedrock **Description of Rock Outcrop Setting** *Landform:* Hillslopes on hills *Down-slope shape:* Convex *Across-slope shape:* Convex **Properties and qualities** *Slope:* 2 to 15 percent *Depth to restrictive feature:* 0 inches to lithic bedrock *Capacity of the most limiting layer to transmit water (Ksat):* Low to moderately low (0.00 to 0.06 in/hr) *Available water capacity:* Very low (about 0.0 inches) **Interpretive groups** *Land capability (nonirrigated):* 8s **Typical profile** *0 to 60 inches:* Bedrock

Washita County, Oklahoma: DAM—Large dam. Map Unit Setting *Elevation:* 1,000 to 2,000 feet *Mean annual precipitation:* 22 to 28 inches *Mean annual air temperature:* 59 to 64 degrees F *Frost-free period:* 200 to 230 days **Map Unit Composition** *Dam:* 100 percent **Description of Dam Setting** *Down-slope shape:* Linear *Across-slope shape:* Linear *Parent material:* Mine spoil or earthy fill **Interpretive groups** *Land capability (nonirrigated):* 8 **Typical profile** *0 to 80 inches:* Variable

Washita County, Oklahoma: 37—Quinlan-Obaro complex, 5 to 12 percent slopes. Map Unit Setting *Elevation:* 500 to 3,000 feet *Mean annual precipitation:* 20 to 48 inches *Mean annual air temperature:* 57 to 64 degrees F *Frost-free period:* 185 to 240 days **Map Unit Composition** *Quinlan and similar soils:* 55 percent *Obaro and similar soils:* 30 percent *Minor components:* 15 percent **Description of Quinlan**

Setting *Landform:* Hillslopes on hills *Landform position (two-dimensional):* Backslope *Down-slope shape:* Convex *Across-slope shape:* Convex *Parent material:* Loamy residuum weathered from calcareous sandstone **Properties and qualities** *Slope:* 5 to 12 percent *Depth to restrictive feature:* 10 to 20 inches to paralithic bedrock *Drainage class:* Well drained *Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.60 in/hr) *Depth to water table:* More than 80 inches *Frequency of flooding:* None *Frequency of ponding:* None *Calcium carbonate, maximum content:* 15 percent *Gypsum, maximum content:* 2 percent *Available water capacity:* Very low (about 2.8 inches) **Interpretive groups** *Land capability (nonirrigated):* 6e *Ecological site:* Shallow Prairie (South) PE 32-44 (R078CY084OK) **Typical profile** *0 to 6 inches:* Loam *6 to 17 inches:* Loam *17 to 20 inches:* Bedrock **Description of Obaro Setting** *Landform:* Hillslopes on hills *Landform position (two-dimensional):* Backslope *Down-slope shape:* Convex *Across-slope shape:* Convex *Parent material:* Calcareous residuum weathered from sandstone and siltstone **Properties and qualities** *Slope:* 5 to 12 percent *Depth to restrictive feature:* 20 to 40 inches to paralithic bedrock *Drainage class:* Well drained *Capacity of the most limiting layer to transmit water (Ksat):* Moderately high to high (0.20 to 2.00 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 (0.0 to 2.0 mmhos/cm) *Available water capacity:* Low (about 5.6 inches) **Interpretive groups** *Land capability (nonirrigated):* 6e *Ecological site:* Loamy Prairie PE 32-44 (R078CY056OK) **Typical profile** *0 to 33 inches:* Silty clay loam *33 to 37 inches:* Bedrock **Minor Components Carey** *Percent of map unit:* 7 percent *Landform:* Hillslopes on hills *Landform position (two-dimensional):* Backslope *Down-slope shape:* Convex *Across-slope shape:* Convex *Ecological site:* Loamy Prairie PE 32-44 (R078CY056OK) **Rock outcrop** *Percent of map unit:* 5 percent *Landform:* Hillslopes on hills *Down-slope shape:* Convex *Across-slope shape:* Convex **Cordell** *Percent of map unit:* 3 percent *Landform:* Hillslopes on hills *Landform position (two-dimensional):* Backslope *Down-slope shape:* Convex *Across-slope shape:* Convex *Ecological site:* Red Shale PE 32-44 (R078CY067OK)

Washita County, Oklahoma: 47—St. Paul silt loam, 1 to 3 percent slopes. Map Unit Setting *Elevation:* 750 to 2,750 feet *Mean annual precipitation:* 18 to 38 inches *Mean annual air temperature:* 57 to 66 degrees F *Frost-free period:* 185 to 240 days **Map Unit Composition** *St. paul and similar soils:* 80 percent *Minor components:* 20 percent **Description of St. Paul Setting** *Landform:* Paleoterraces *Landform position (three-dimensional):* Tread *Down-slope shape:* Convex *Across-slope shape:* Linear *Parent material:* Silty alluvium and/or calcareous residuum weathered from sandstone and siltstone **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 (0.20 to 0.60 in/hr) *Depth to water table:* More than 80 inches *Frequency of flooding:* None *Frequency of ponding:* None *Calcium carbonate, maximum content:* 10 percent *Available water capacity:* High (about 11.4 inches) **Interpretive groups** *Land capability (nonirrigated):* 2e *Ecological site:* Loamy Prairie PE 32-44 (R078CY056OK) **Typical profile** *0 to 8 inches:* Silt loam *8 to 13 inches:* Silty clay loam *13 to 50 inches:* Silty clay loam *50 to 60 inches:* Silt loam **Minor Components Abilene** *Percent of map unit:* 5 percent *Landform:* Paleoterraces *Landform position (three-dimensional):* Tread *Down-slope shape:* Concave *Across-slope shape:* Concave *Ecological site:* Clay Loam 23-30" PZ (R078CY096TX) **Carey** *Percent of map unit:* 5 percent *Landform:* Hillslopes on hills *Landform position (two-dimensional):* Shoulder *Down-slope shape:* Convex *Across-slope shape:* Convex *Ecological site:* Loamy Prairie PE 32-44 (R078CY056OK) **Pond creek** *Percent of map unit:* 5 percent *Landform:* Flats on paleoterraces *Landform position (three-dimensional):* Tread *Down-slope shape:* Linear *Across-slope shape:* Linear *Ecological site:* Sandy Prairie PE 44-64 (R080AY073OK) **Cornick** *Percent of map unit:* 4 percent *Landform:* Hillslopes on hills *Landform position (two-dimensional):* Shoulder *Down-slope shape:* Convex *Across-slope shape:* Convex *Ecological* *site:* Gyp 23-30 PZ (R078CY038OK) **Roscoe** *Percent of map unit:* 1 percent *Landform:* Terraces on pediments *Landform position (three-dimensional):* Tread *Down-slope shape:* Concave *Across-slope shape:* Concave *Ecological site:* Depressional Upland PE 32-44 (R078CY098OK)

5.3.2 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 51). 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 51).

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 51), 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.

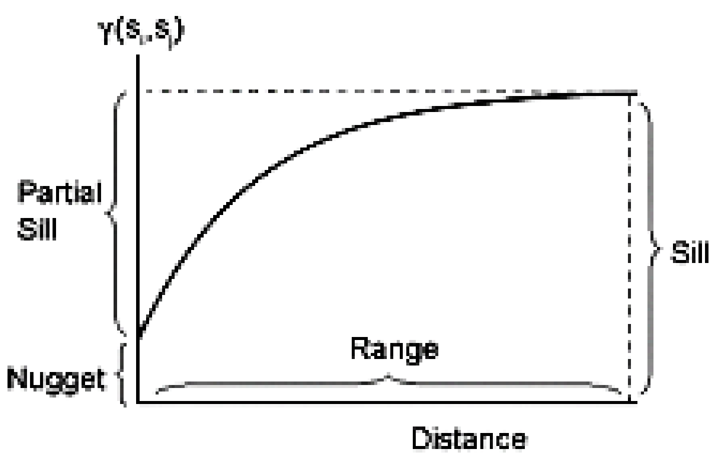


Figure 45. Example semivariogram, depicting range, sill, and nugget.

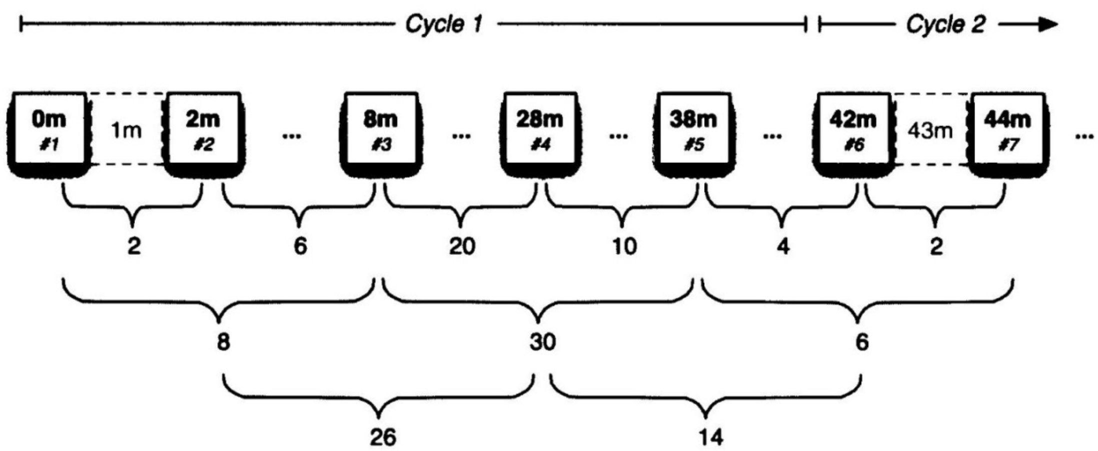


Figure 46. Spatially cyclic sampling design for the measurements of soil temperature and soil water content.

Field measurements of soil temperature (0-12 cm) and moisture (0-15 cm) were taken on 30 April 2010 at the Klemme site. The sampling points followed the spatially cyclic sampling design by Bond-Lamberty et al. (2006) (Figure 46). Soil temperature and moisture measurements were collected along three transects (210 m, 84 m, and 84 m) located in the expected airshed at Klemme. 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 Figure 46, 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).

5.3.3 Results and interpretation

5.3.3.1 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 53). Exploratory data analysis plots show that there was no distinct patterning of the residuals (Figure 54, left graph) and directional semivariograms do not show anisotropy (Figure 54, center graph). An isotropic empirical semivariogram was produced and a spherical model was fitted using Cressie weights (Figure 54, right graph). The model indicates a distance of effective independence of 22 m for soil temperature.

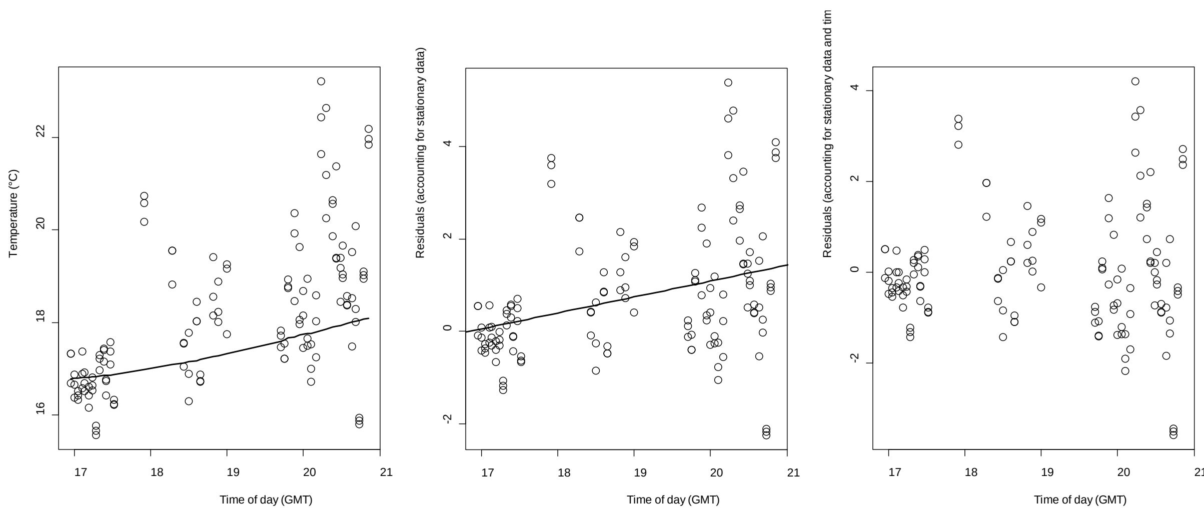


Figure 47. Left graph: mobile (circles) and stationary (line) soil temperature data. Center graph: temperature data after correcting for changes in temperature in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual temperature data after correcting for changes temperature in the stationary data and the time of day regression. Data in the right graph were used for the semivariogram analysis.

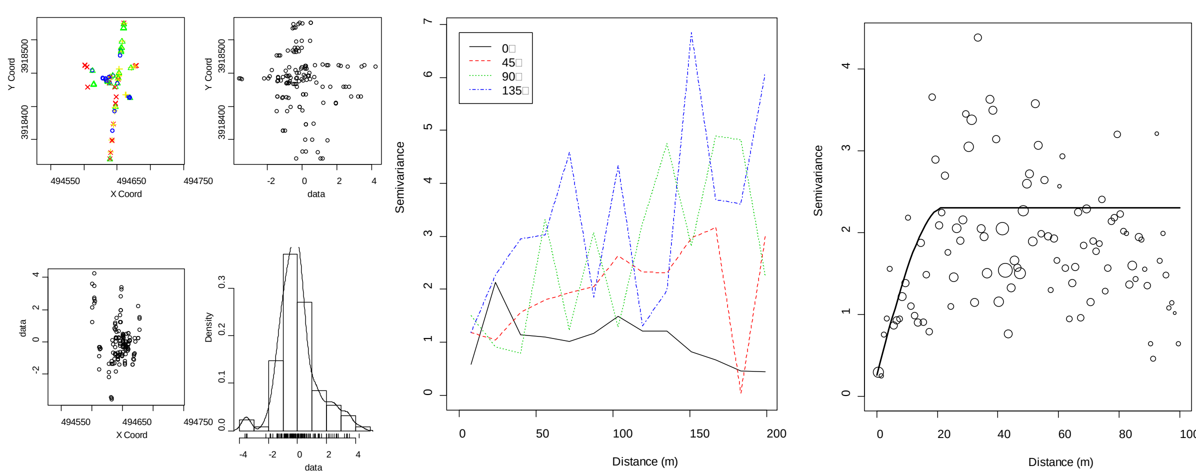


Figure 48. Left graphs: exploratory data analysis plots for residuals of temperature. Center graph: directional semivariograms for residuals of temperature. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of temperature.

5.3.3.2 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 55). Exploratory data analysis plots show that there was no distinct patterning of the residuals (Figure 56, left graph) and directional semivariograms do not show anisotropy (Figure 56, center graph). An isotropic empirical semivariogram was produced and a spherical model was fitted using Cressie weights (Figure 56, right graph). The model indicates a distance of effective independence of 72 m for soil water content.

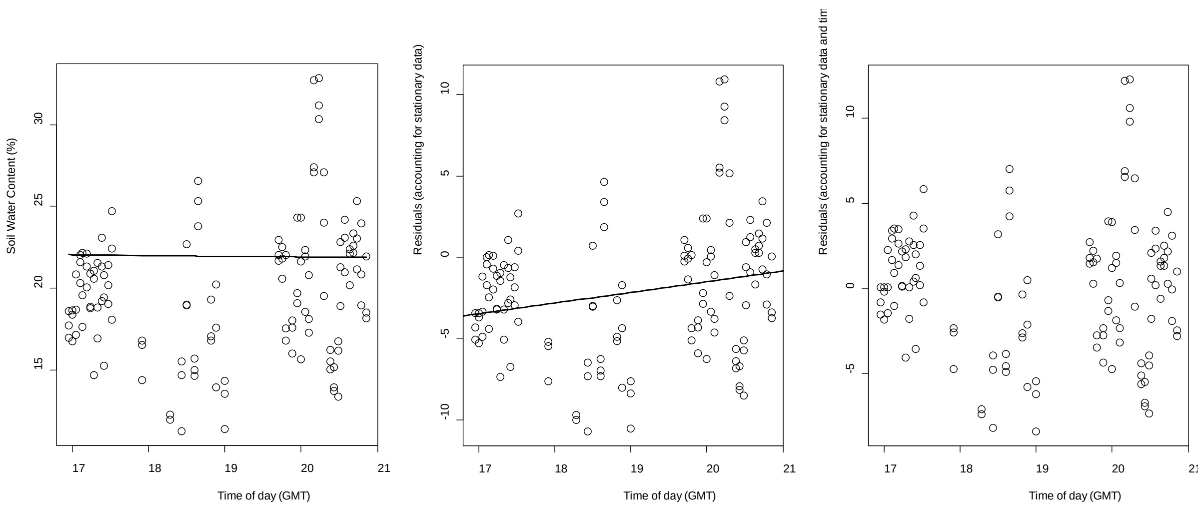


Figure 49. Left graph: mobile (circles) and stationary (line) soil water content data. Center graph: water content data after correcting for changes in water content in the stationary data (circles) and a linear regression based on time of day (line). Right graph: residual water content data after correcting 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.

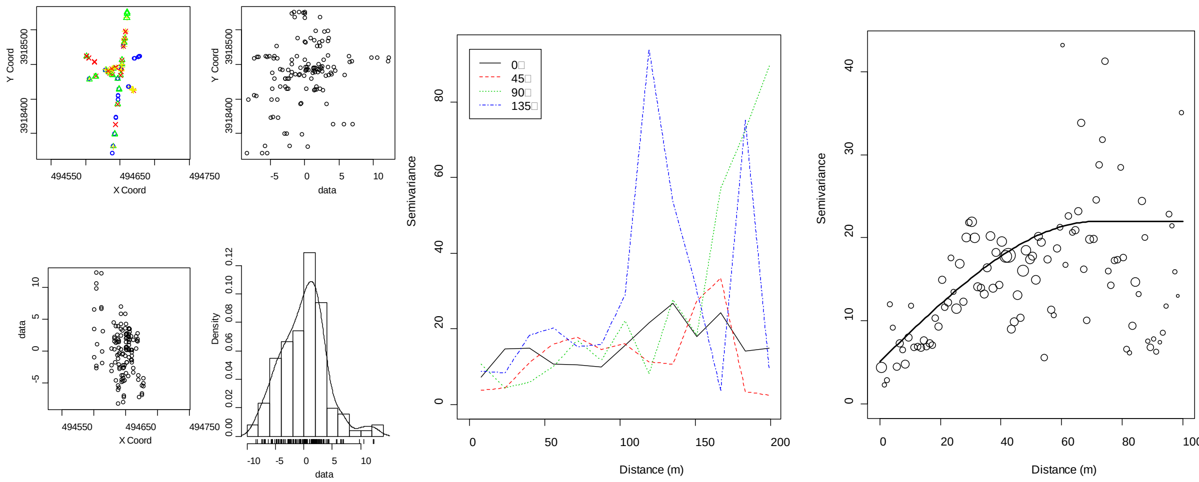


Figure 50. Left graphs: exploratory data analysis plots for residuals of soil water content. Center graph: directional semivariograms for residuals of water content. Right graph: empirical semivariogram (circles) and model (line) fit to residuals of water content.

5.3.3.3 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 22 m for soil temperature and 72 m for soil moisture. Based on these results and the site design guidelines the soil plots at Klemme 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 165° from the soil plot nearest the tower (i.e., first soil plot). The location of the first soil plot will be approximately 35.41040, -99.05875. 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 35.410596, -99.060444 (primary location); or 35.410259, -99.060845 (alternate location 1 if primary location is unsuitable); or 35.409968, -99.061308 (alternate location 2 if primary location is unsuitable). A summary of the soil information is shown in Table 18 and site layout can be seen in Figure 57.

Dominant soil series at the site: Cordell silty clay loam, 3 to 5 percent slopes-Cordell-Rock outcrop complex, 2 to 15 percent slopes. The taxonomy of this soil is shown below:
Order: Inceptisols
Suborder: Ustepts
Great group: Haplustepts
Subgroup: Lithic Haplustepts
Family: Loamy, mixed, active, thermic Lithic Haplustepts
Series: Cordell silty clay loam, 3 to 5 percent slopes-Cordell-Rock outcrop complex, 2 to 15 percent slopes

Table 16. Summary of soil array and soil pit information at Klemme. 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	21 m
Latitude and longitude of 1st soil plot OR direction from tower	35.41040, -99.05875
Direction of soil array	165°
Latitude and longitude of FIU soil pit 1	35.410596, -99.060444 (primary location)
Latitude and longitude of FIU soil pit 2	35.410259, -99.060845 (alternate 1)
Latitude and longitude of FIU soil pit 3	35.409968, -99.061308 (alternate 2)
Dominant soil type	Cordell silty clay loam, 3 to 5 percent slopes-Cordell-Rock outcrop complex, 2 to 15 percent slopes
Expected soil depth	0.25-0.51 m
Depth to water table	>2 m

Expected depth of soil horizons	**Expected measurement depths***
0-0.15 m (Silty clay loam)	0.08 m[a]
0.15-0.25 m (Silty clay loam)	0.20 m[a]
0.25-0.36 m (Very gravelly silty clay loam)	0.31 m[a]
0.36-0.43 m (Bedrock)	

*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.
[a]Soil CO_2 probes

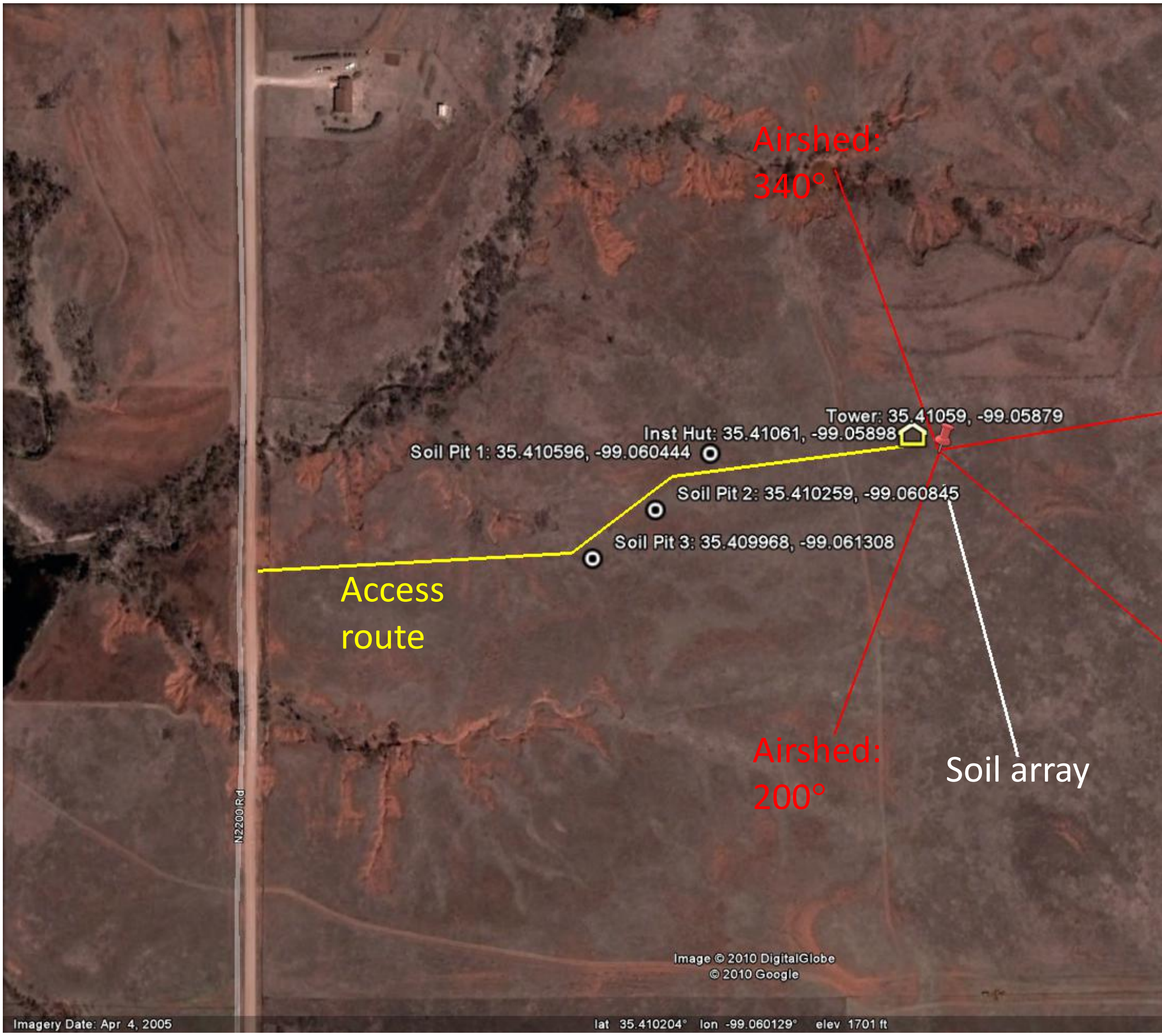


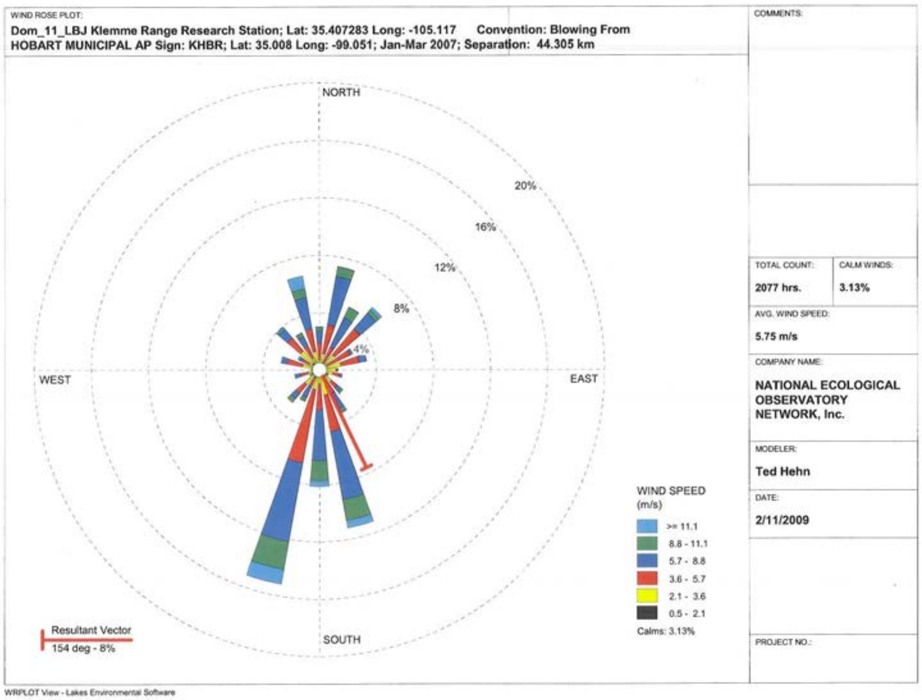
Figure 51. Site layout at Klemme showing soil array and location of the FIU soil pit.

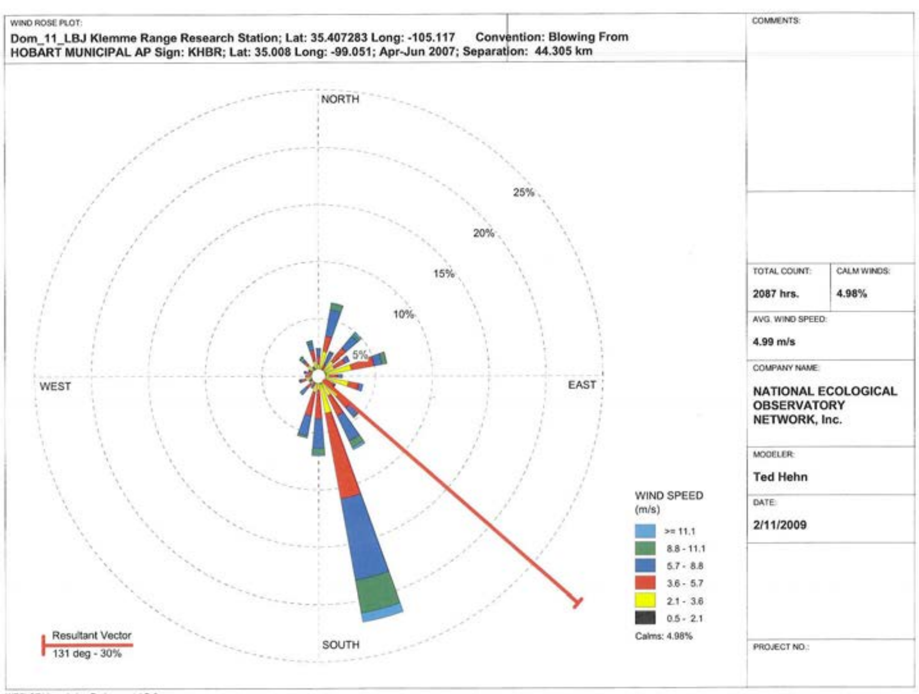
5.4 Airshed

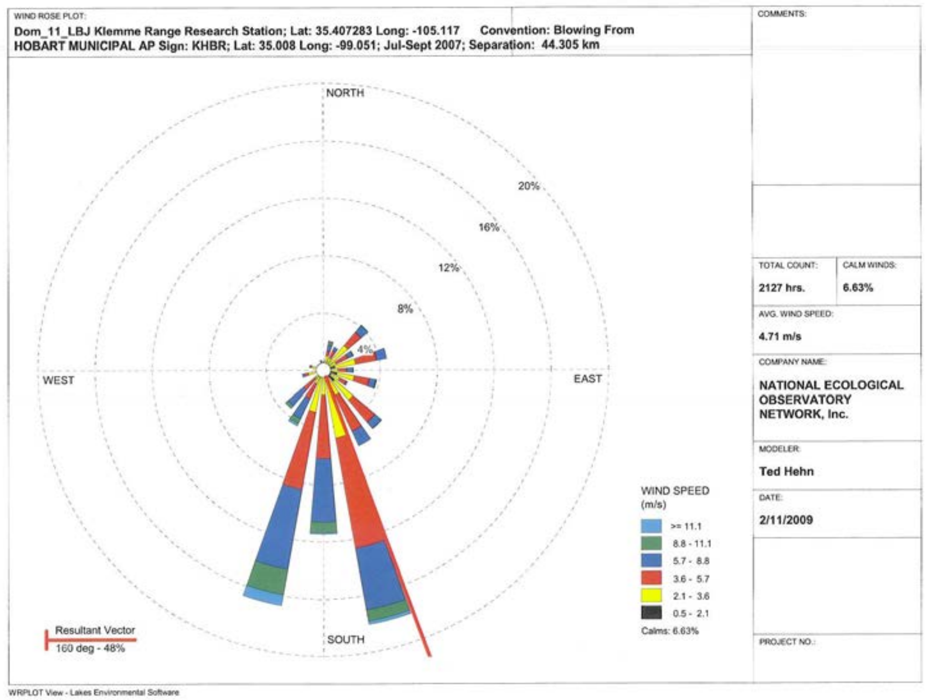
5.4.1 Seasonal windroses

Wind roses analytically determine and graphically represent the frequencies of wind direction and wind speed over a given timeseries. The weather data used to generate the following wind roses are from Hobart Municipal airport (35.008, -99.051), which is ~45 km from tower site. Terrain is flat in this region. We assume that the wind patterns at Hobart Municipal airport are similar to the ones at our 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.

5.4.2 Results (graphs for wind roses)







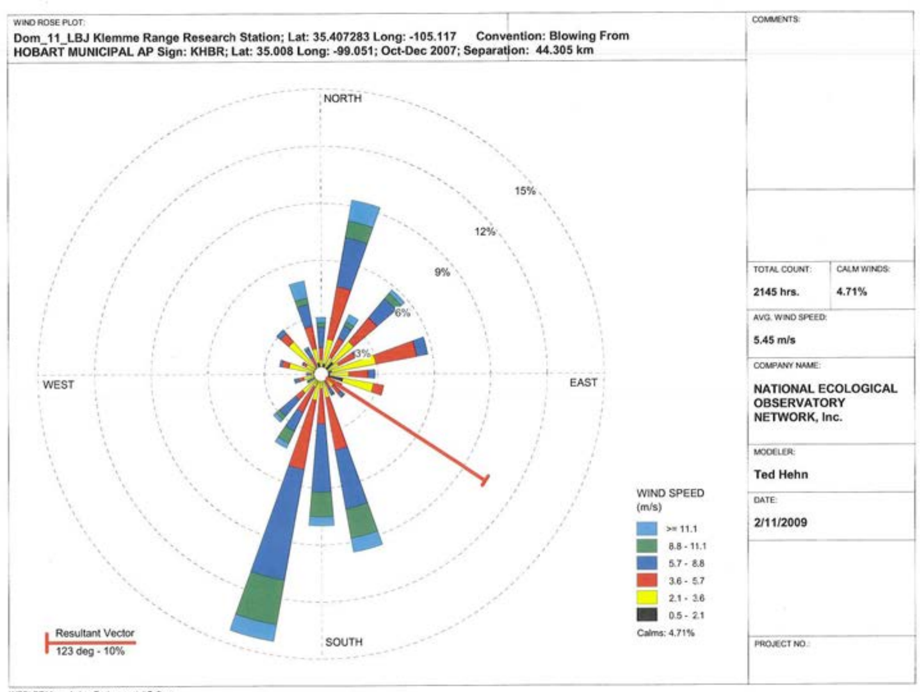


Figure 52. Windroses from Klemme Relocatable site.

Data used here are 2007 data from Hobart Municipal airport (35.008, -99.051), which is ~45 km from tower site. Terrain is flat in this region. We assume that the wind patterns at Hobart Municipal airport are similar to the ones at our site. 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.

5.4.3 Resultant vectors

Table 17. The resultant wind vectors from Klemme using hourly data in 2007.

Quarterly (seasonal) timeperiod	Resultant vector	% duration
January to March	154°	8
April to June	131°	30
July to September	160°	48
October to December	123°	10
Annual mean	142°	na.

5.4.4 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 use 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 represent 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 18. Expected environmental controls to parameterize the source area model and associated results from Klemme 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	1.4	1.4	1.4	1.4	1.4	1.4	m
Canopy area density	0.8	0.8	0.8	0.3	0.3	0.3	m
Boundary layer depth	3500	3500	1700	1100	1100	600	m
Expected sensible heat flux	450	450	110	190	190	10	$W\ m^{-2}$
Air Temperature	34	34	24	12	15	5	°C
Max. windspeed	13	6.4	3.6	13	7.2	4.6	$m\ s^{-1}$
Resultant wind vector	180	180	180	180	180	15	degrees
Results							
(z-d)/L	-0.01	-0.07	-0.09	0.00	-0.03	-0.01	m
d	0.88	0.88	0.88	0.73	0.73	0.73	m
Sigma v	3.40	2.50	1.30	2.90	1.90	1.00	$m^2\ s^{-2}$
Z0	0.11	0.11	0.11	0.11	0.11	0.11	m
u*	1.40	0.71	0.41	1.40	0.76	0.48	$m\ s^{-1}$
Distance source area begins	0	0	0	0	0	0	m
Distance of 90% cumulative flux	550	400	350	550	500	550	m
Distance of 80% cumulative flux	300	250	220	350	300	350	m
Distance of 70% cumulative flux	200	150	150	200	180	200	m
Peak contribution	35	35	35	45	45	45	m

5.4.5 Results (source area graphs)

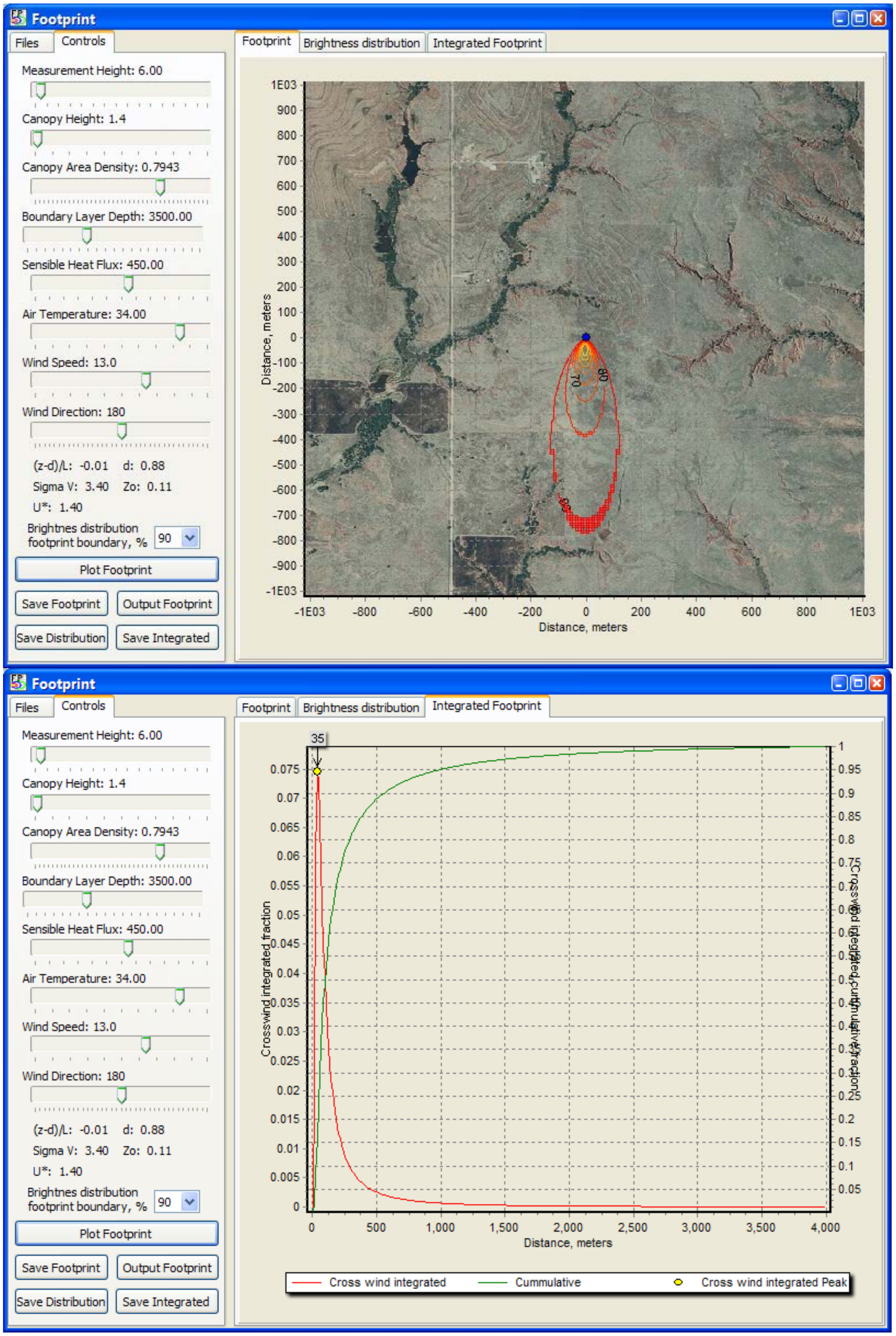


Figure 53. Klemme Relocatable site summer daytime (convective) footprint output with max wind speed

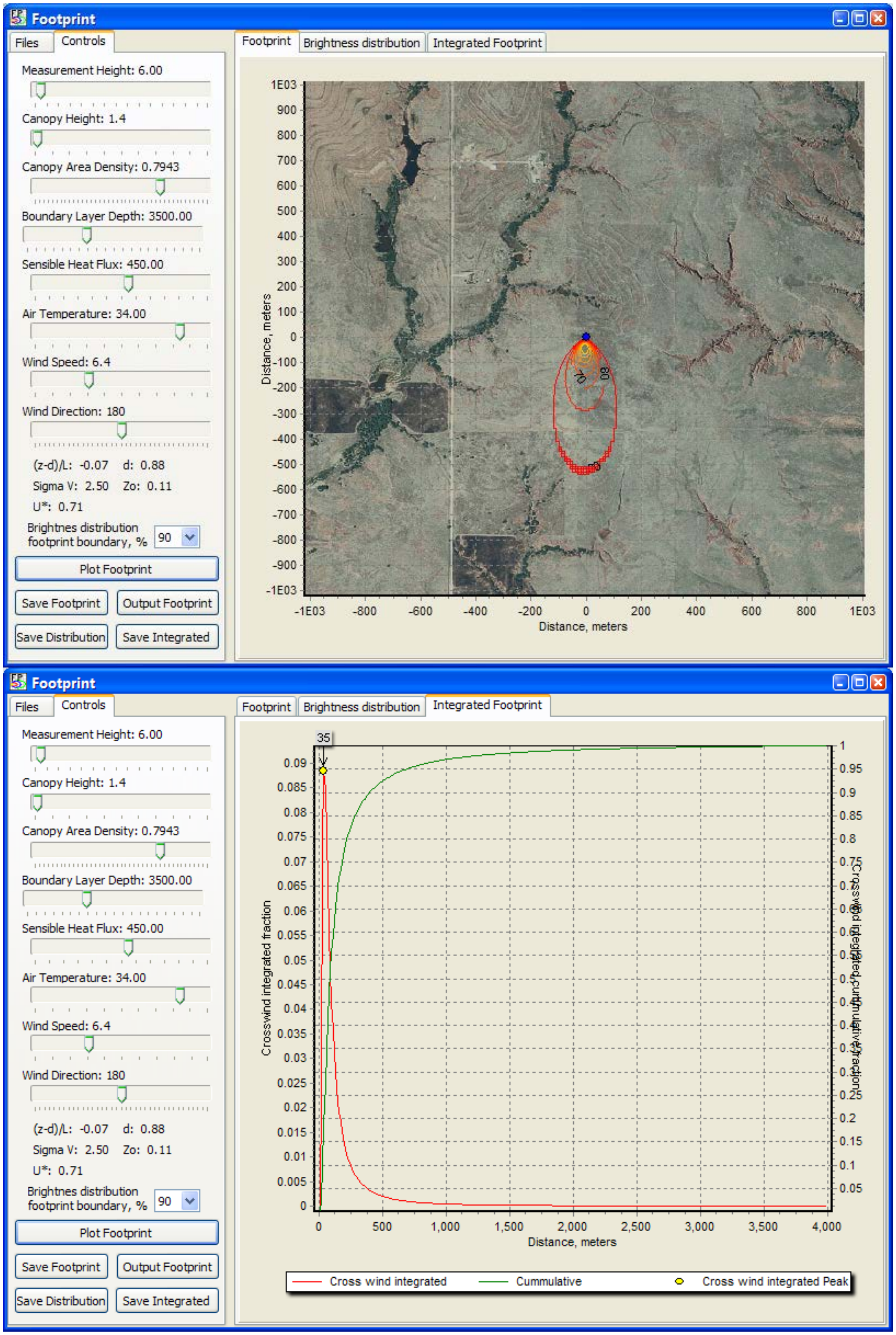


Figure 54. Klemme Relocatable site summer daytime (convective) footprint output with mean wind speed

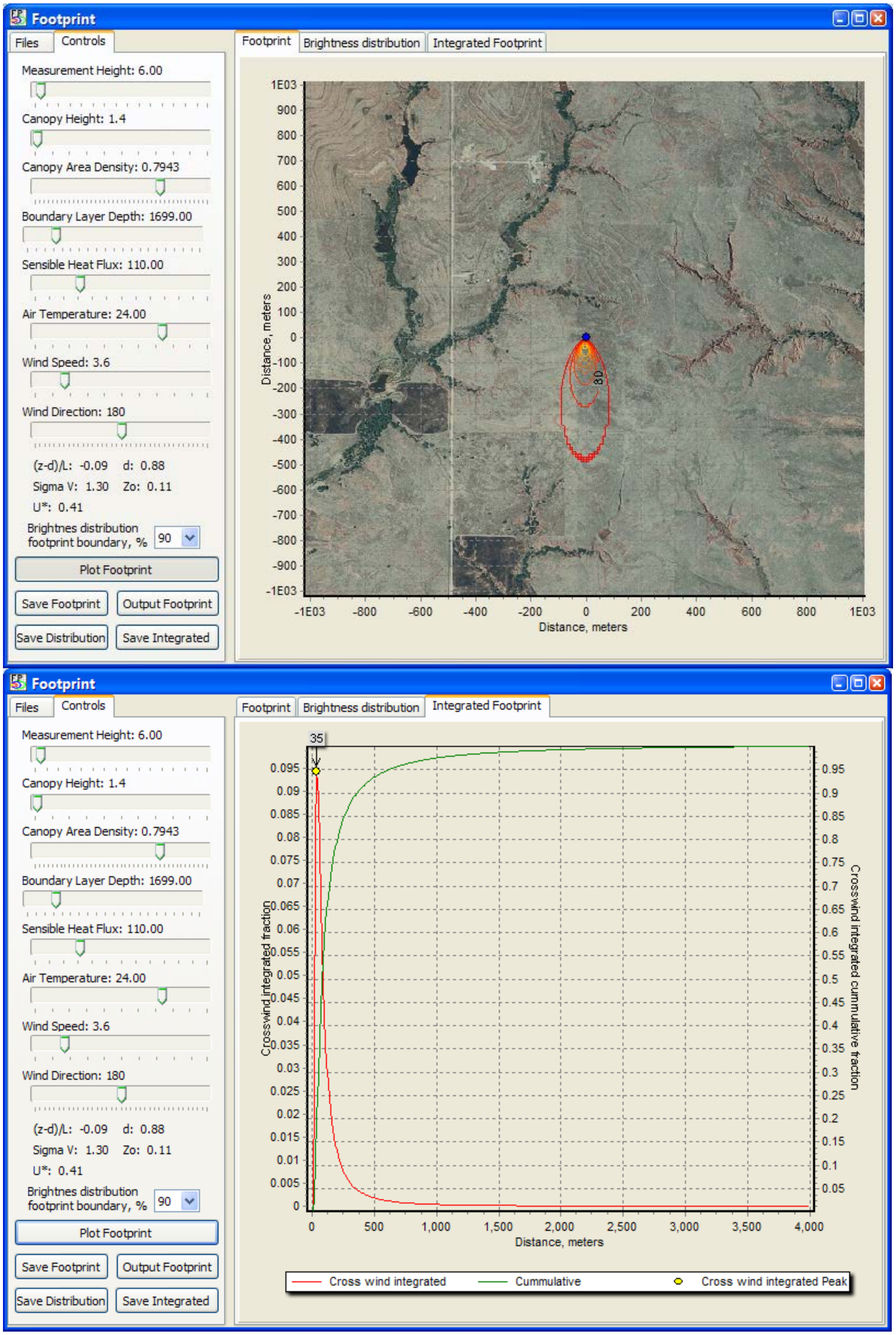


Figure 55. Klemme Relocatable site summer nighttime (stable) footprint output with mean wind speed.

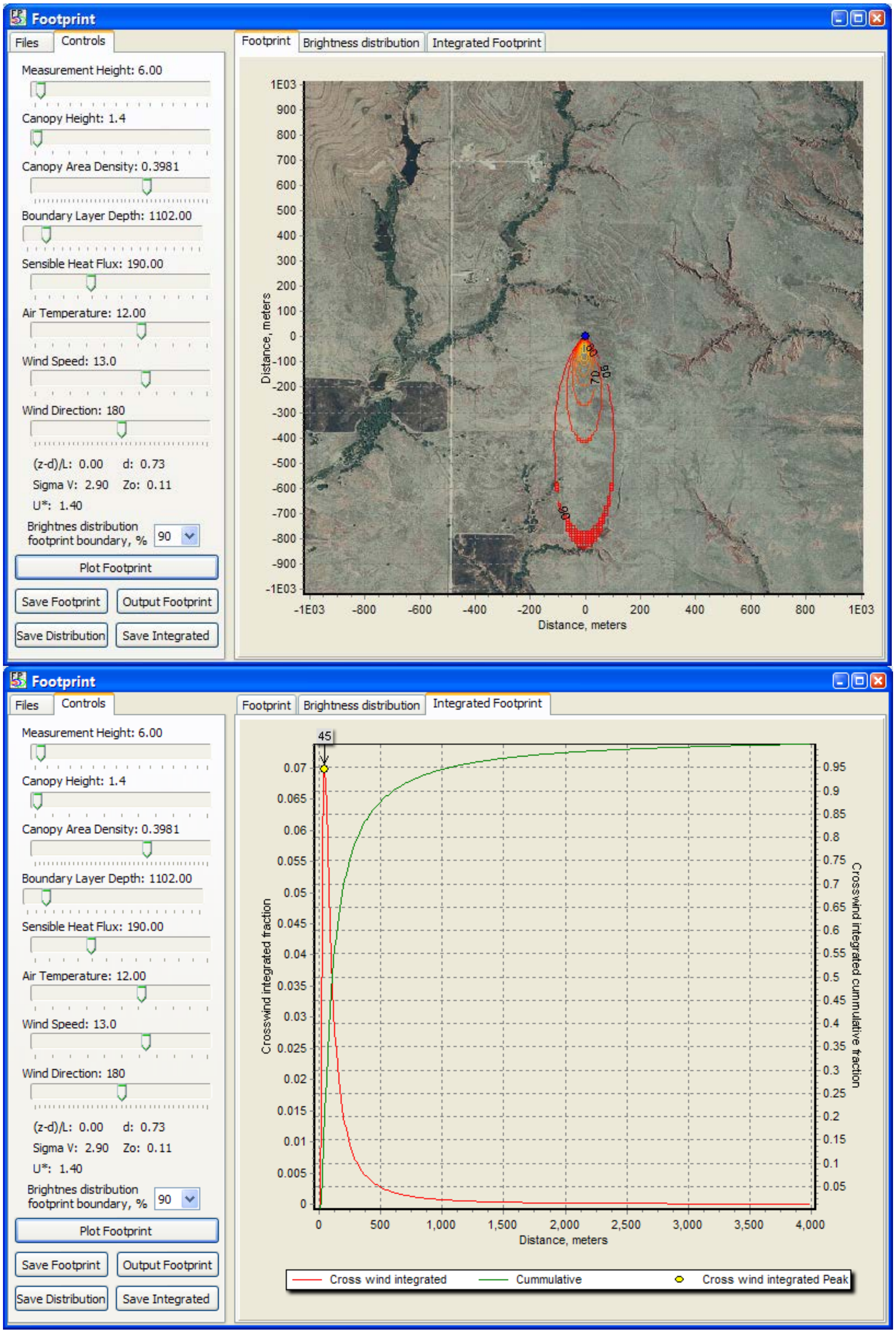


Figure 56. Klemme Relocatable site winter daytime (convective) footprint output with max wind speed

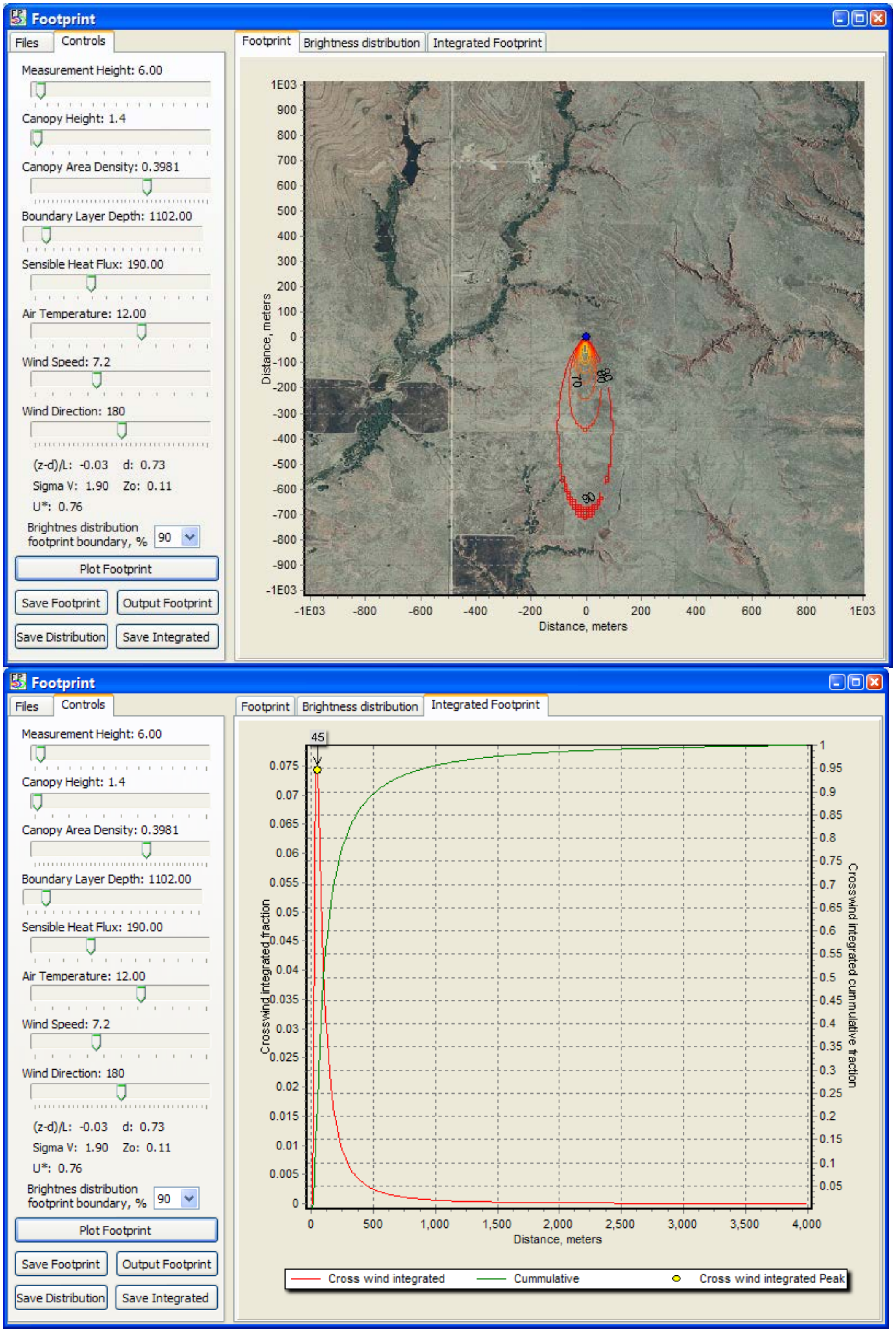


Figure 57. Klemme Relocatable site winter daytime (convective) footprint output with mean wind speed.

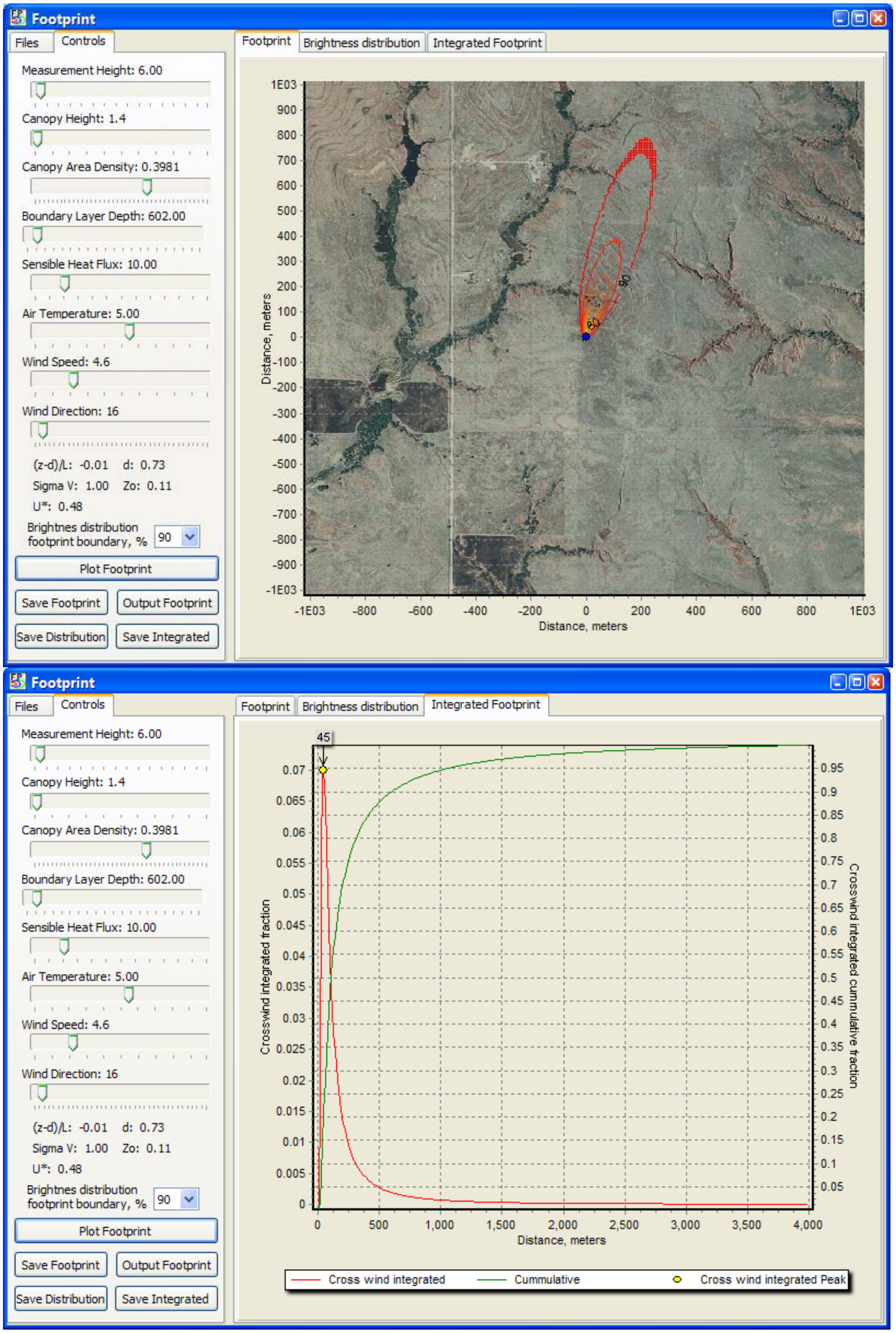


Figure 58. Klemme Relocatable site winter nighttime (stable) footprint output with mean wind speed.

5.4.6 Site design and tower attributes

According to wind roses, prevailing wind blows between south (130° to 200°, clockwise from 130°, major airshed) and NNE (340° to 80°, clockwise from 340°, secondary airshed). **Tower** should be placed to a location to best catch the signals from the airshed of the ecosystem in interest, which is short grassland at this site. The original tower location was 35.4072833, -99.0594972. However, the tower was moved ~370 m north (35.41059, -99.05879) to ensure that only one land-use type dominated the primary tower airshed. The new location was still close to the access road and it was closer to the location where the power line ends on the road. New tower location is 35.41059, -99.05879.

Eddy covariance, sonic wind and air temperature **boom arms** orientation toward the east 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 west toward tower and have the longer side parallel to N-S direction. Therefore, we decide the placement of instrument hut at 35.41061, -99.05898.

The ecosystem around tower site and in the major tower airshed is short grassland and forbs. The mean canopy height of the grassland is ~ 0.5 m during FIU site characterization, but expects reach ~1 m by the end of growing season. Tallgrass can reach ~ 1.5 m. We require 4 **measurement layers** on the tower with top measurement height at 6 m, and the remaining levels are 4 m, 2 m and 0.3 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. W**et deposition collector** will be collocated 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 19. Site design and tower attributes for Klemme Relocatable site

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

Attribute	lat	long	degree	meters	notes
Airshed area			130° to 200° (major) and 340° to 80° (secondary)		Clockwise from first angle

			airshed).		
Tower location	35.41059,	-99.05879	--	--	new site
Instrument hut	35.41061,	-99.05898			
Instrument hut orientation vector	--	--	360° - 180°		
Instrument hut distance z	--	--	--	18	
Anemometer/Temperature boom orientation	--	--	90°	--	
Height of the measurement levels					
Level 1				0.3	m.a.g.l.
Level 2				2.0	m.a.g.l.
Level 3				4.0	m.a.g.l.
Level 4				6.0	m.a.g.l.
Tower Height				6.0	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.

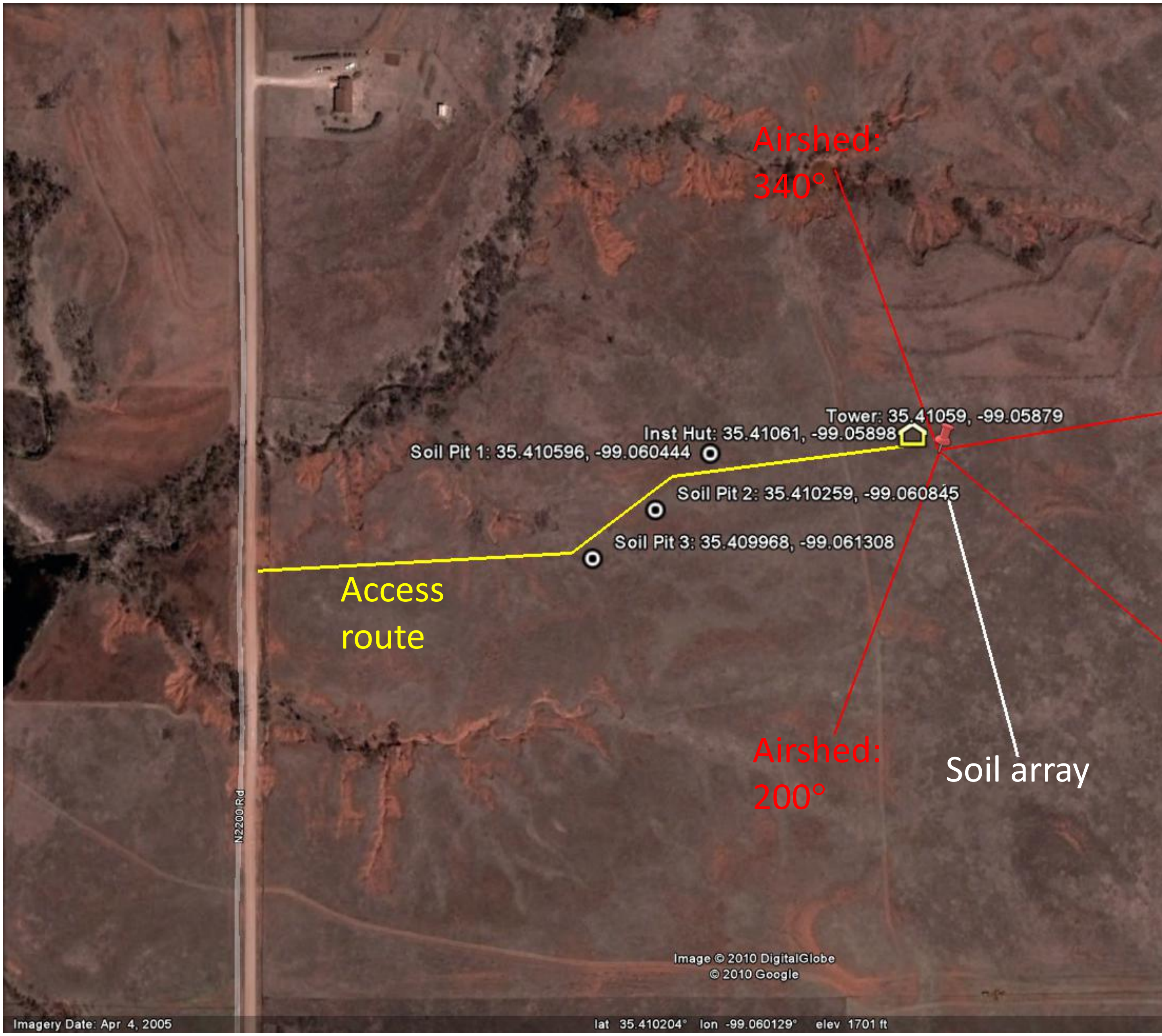


Figure 59. Site layout for Klemme Relocatable site.
i) new tower location is presented (red pin), ii) red lines indicate the airshed boundaries. Vectors 130° to 200° (clockwise from 130°, major airshed) and 340° to 80° (clockwise from 340°, secondary airshed) would have quality wind data without causing 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 Klemme Relocatable site

- Gravel path from the access road to instrument hut, pending landowner decision
- Boardwalk from the instrument hut to the tower to intersect on north face of the tower
- Gravel path to the soil array
- No gravel path or boardwalk to individual soil plots

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

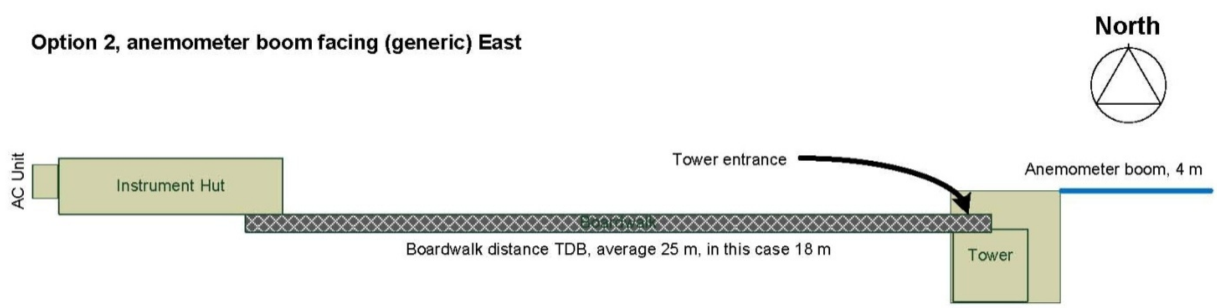


Figure 60. Generic diagram to demonstration the relationship between tower and instrument hut when boom facing east and instrument hut on the west towards the tower.

This is just 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 Klemme Relocatable site, the boom angle will be 90^o, instrument hut will be on the west towards the tower, the distance between instrument hut and tower is ~18 m. The instrument hut vector will be N-S (360^o-180^o, longwise).

5.4.7 Information for ecosystem productivity plots

The tower at Klemme relocatable site has been positioned to optimize the collection of the air/wind signals both temporally and spatially over the desired ecosystem (shortgrass and forbs). Prevailing wind blows from south (130^o to 200^o, clockwise from 130^o, major airshed) and NNE (340^o to 80^o, clockwise from 340^o, secondary airshed). 90% signals for flux measurements during daytime are within a distance of 550 m from tower, and 80% within 350 m. We suggest FSU Ecosystem Productivity plots are placed within the boundaries of 130^o to 200^o (major, clockwise from 130°) from tower.

5.5 Issues and attentions

An oil well may be built approximately 350 m southeast or southwest of the tower site, which is close to the 80% isopleth of the expected flux source area. Oil wells are common in this region, therefore, the development is not expected to detrimentally affect science at this site and may present interesting opportunities to study the impact of oil well development on the ecology of this ecosystem.

This is an actively grazed site (light to moderate grazing intensity). Protection of sensors on the lower level on the tower may be needed. Individual guards may also be needed to protect sensors in the soil plots.

Burning is not a management strategy in the field where the tower is located, but some of the nearby adjacent fields are burnt (every ~4 years). Fire resistant materials are suggested for construction in case a burn spreads to the tower location.

Access to the instrument hut would ideally come from the west, rather than from the south, to avoid travelling through the primary airshed and to reduce the length of the access route and power/communications lines. However, this would require the landowner agreeing to a new gate and dirt road.

6 REFERENCES:

Bond-Lamberty B., Brown K.M., Goranson C. & Gower S.T. (2006). Spatial dynamics of soil moisture and temperature in a black spruce boreal chronosequence. *Canadian Journal of Forest Research-Revue Canadienne De Recherche Forestiere*, 36, 2794-2802

Ehleringer et al (1992). Red Butte Canyon Research Natural Area: History, Flora, Geology, Climate, and Ecology. Great Basin Naturalist, 2,95-121.

Goovaerts P. (1997). *Geostatistics for Natural Resource Evaluation*. Oxford University Press, Oxford.

Horst, TW, Weil, JC, 1992. Footprint estimation for scalar flux measurements in the atmospheric surface layer. *Boundary Layer Meteorology* **59**, 279-296.

Horst, TW, Weil, JC, 1994a. How far is far enough?: The fetch requirements for micrometeorological measurement of surface fluxes. *J. Atmospheric Oceanic Technology*, **11**, 1019-1025.

Horst, TW, Weil, JC, 1994b. Corrigenda: How far is far enough?: The fetch requirements for micrometeorological measurement of surface fluxes. *J. Atmospheric Oceanic Technology*, **12**, 447.

Horst, TW, 2001. Comments on: Footprint analysis: a closed analytical solution based on height-dependent profiles of wind speed and eddy viscosity. *Boundary Layer Meteorology* **101**, 435-447.

Kormann R, Meixner, FX, 2001. An analytic footprint model for neutral stratification, *Bound.-Layer Meteorol.* **99.**

Riberiro J.R. & Diggle P.J. (2001). geoR: A package for geostastical analysis. R-NEWS, 1, ISSN 1609-3631

Trangmar B.B., Yost R.S. & Uehara G. (1986). Application of geostatistics to spatial studies of soil properties. *Advances in Agronomy*, 45-94

Webster R. & Oliver M.A. (1989). Optimal interpolation and isarthmic mapping of soil properties: VI Disjuctive kriging and mapping the conditional probability. *Journal of Soil Science*, 40, 497-512