Impacts of Sagebrush Vegetation

in a Desert Climate on the Atmospheric Boundary Layer

B. Eng, M. Moody, and T. Morrison

Department of Mechanical Engineering
University of Utah

ME EN 7710 Final Project, 2017

Outline

1. Introduction
   - Motivation
   - MATERHORN Data
2. Analysis
   - Probability Distributions
   - Autocorrelation
   - Dissipation
   - Turbulence Spectra

Outline

1. Introduction
   - Motivation
   - MATERHORN Data
2. Analysis
   - Probability Distributions
   - Autocorrelation
   - Dissipation
   - Turbulence Spectra

Motivation

- Benefits of understanding turbulence
  - NWP
  - Industry
  - Aviation
- Modelling turbulence
  - Turbulence is random – difficult to model
  - More difficult around complex terrain & vegetation
  - Current methods inaccurate in some environments

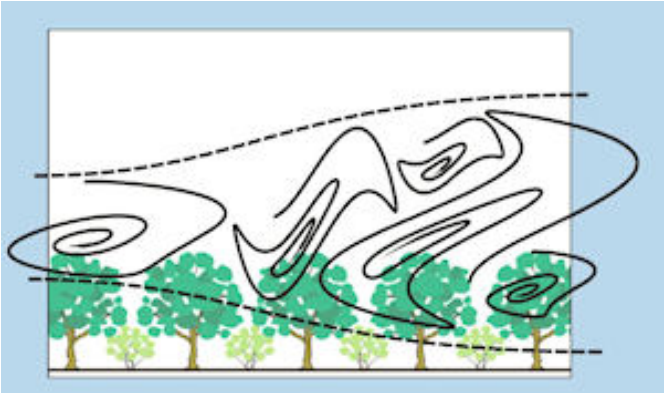


Image source: http://www.windlab.com/technology/turbulence

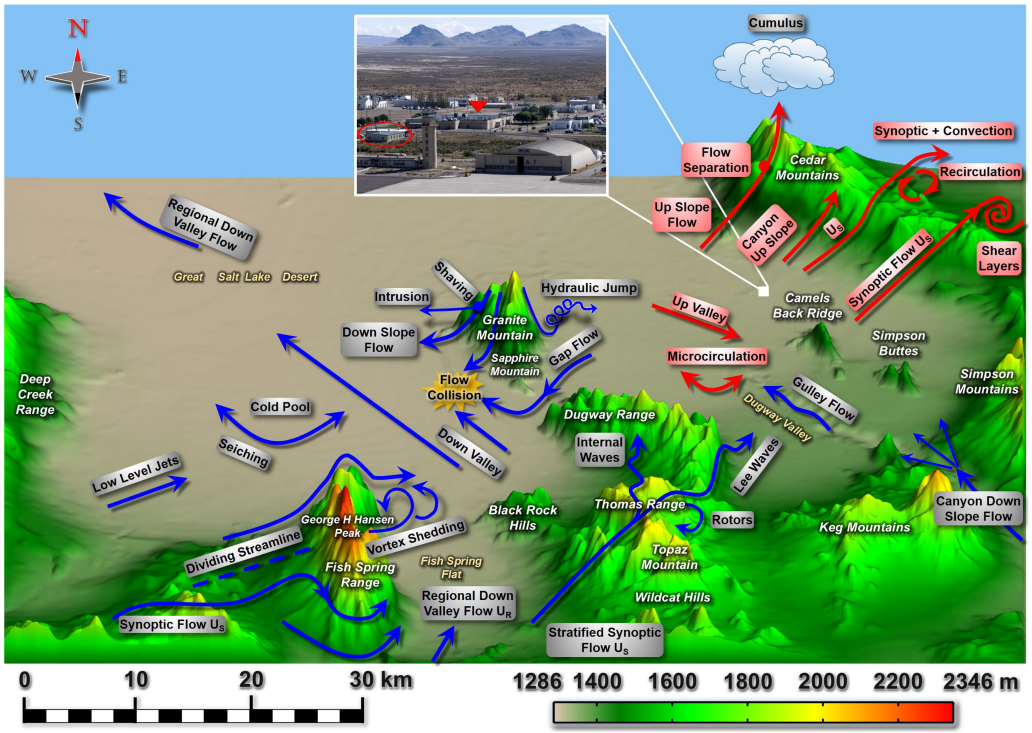
Outline

1. Introduction
   - Motivation
   - MATERHORN Data
2. Analysis
   - Probability Distributions
   - Autocorrelation
   - Dissipation
   - Turbulence Spectra

MATERHORN

Overview

- MATERHORN Goals:
  - Study limitations of current models in complex terrain
  - Improve prediction methods

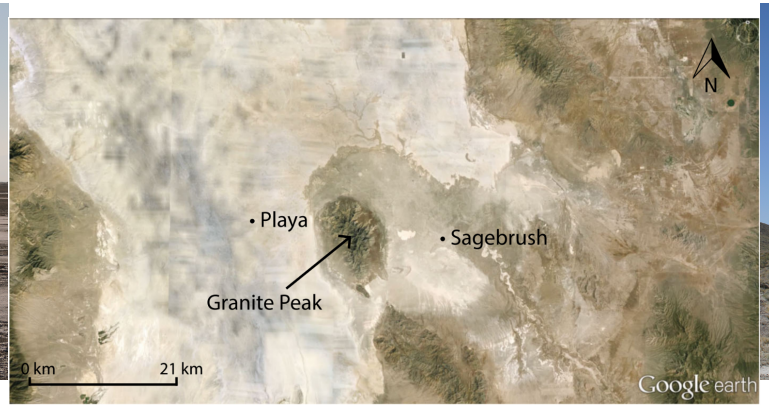


[?]

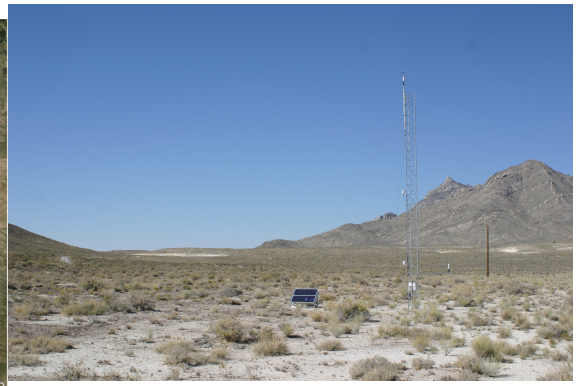
MATERHORN

Data

Playa



[?]

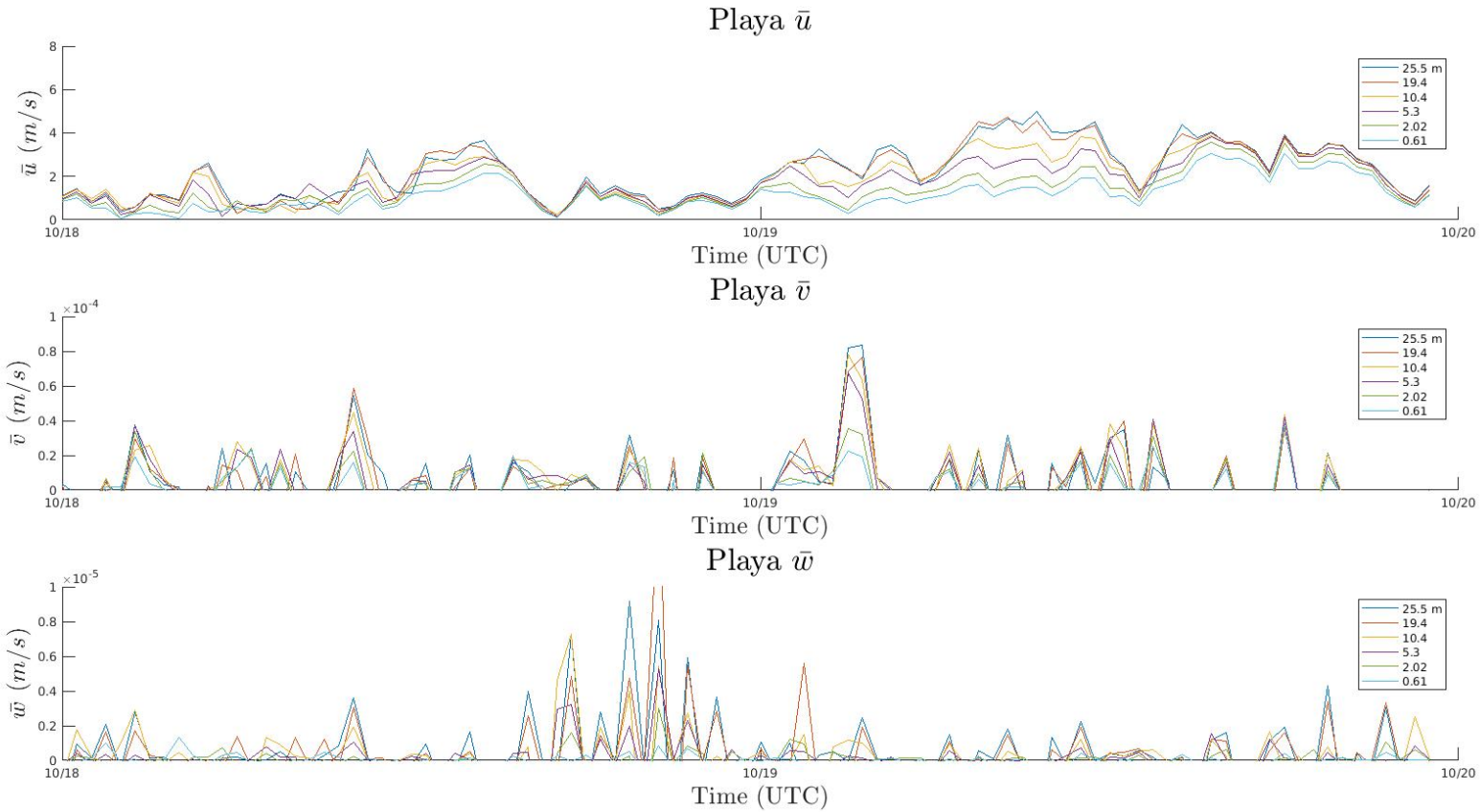


Sagebrush

MATERHORN

Data

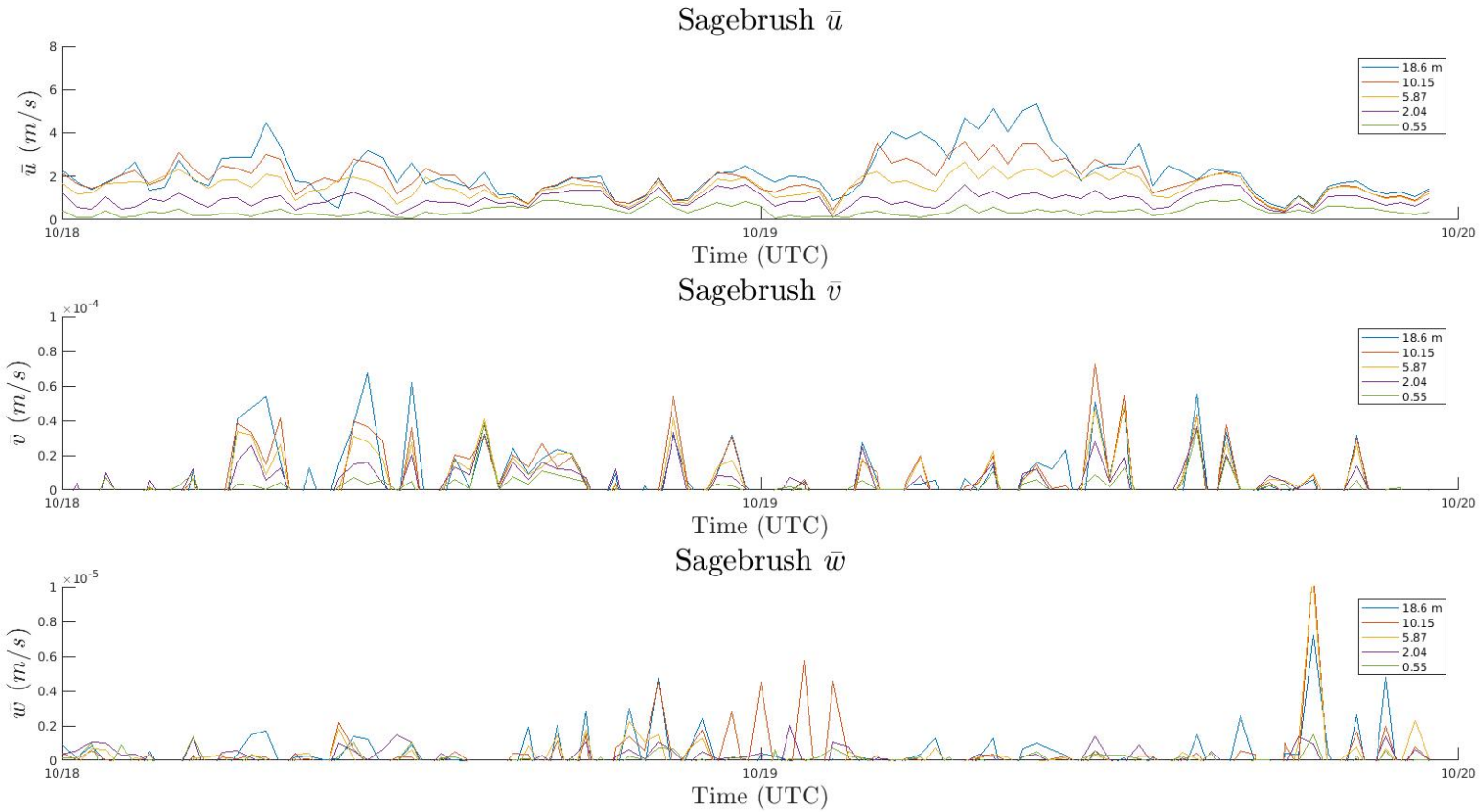
- Rotated Data



MATERHORN

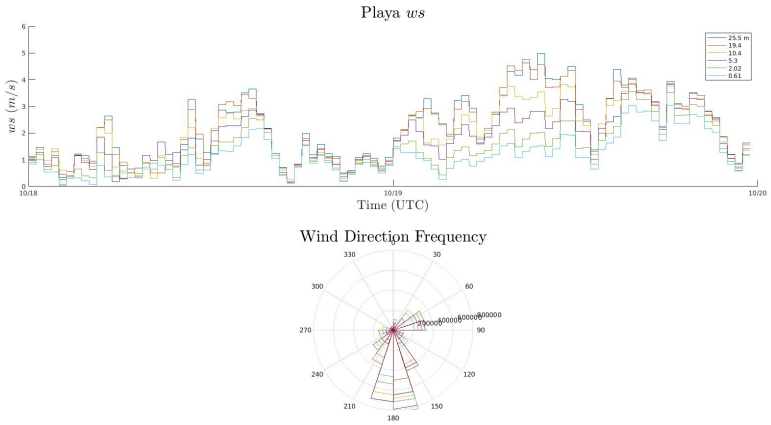
Data

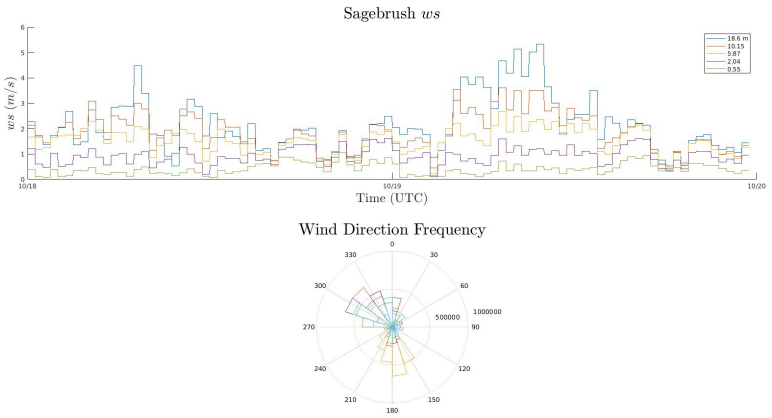
- Rotated Data



MATERHORN

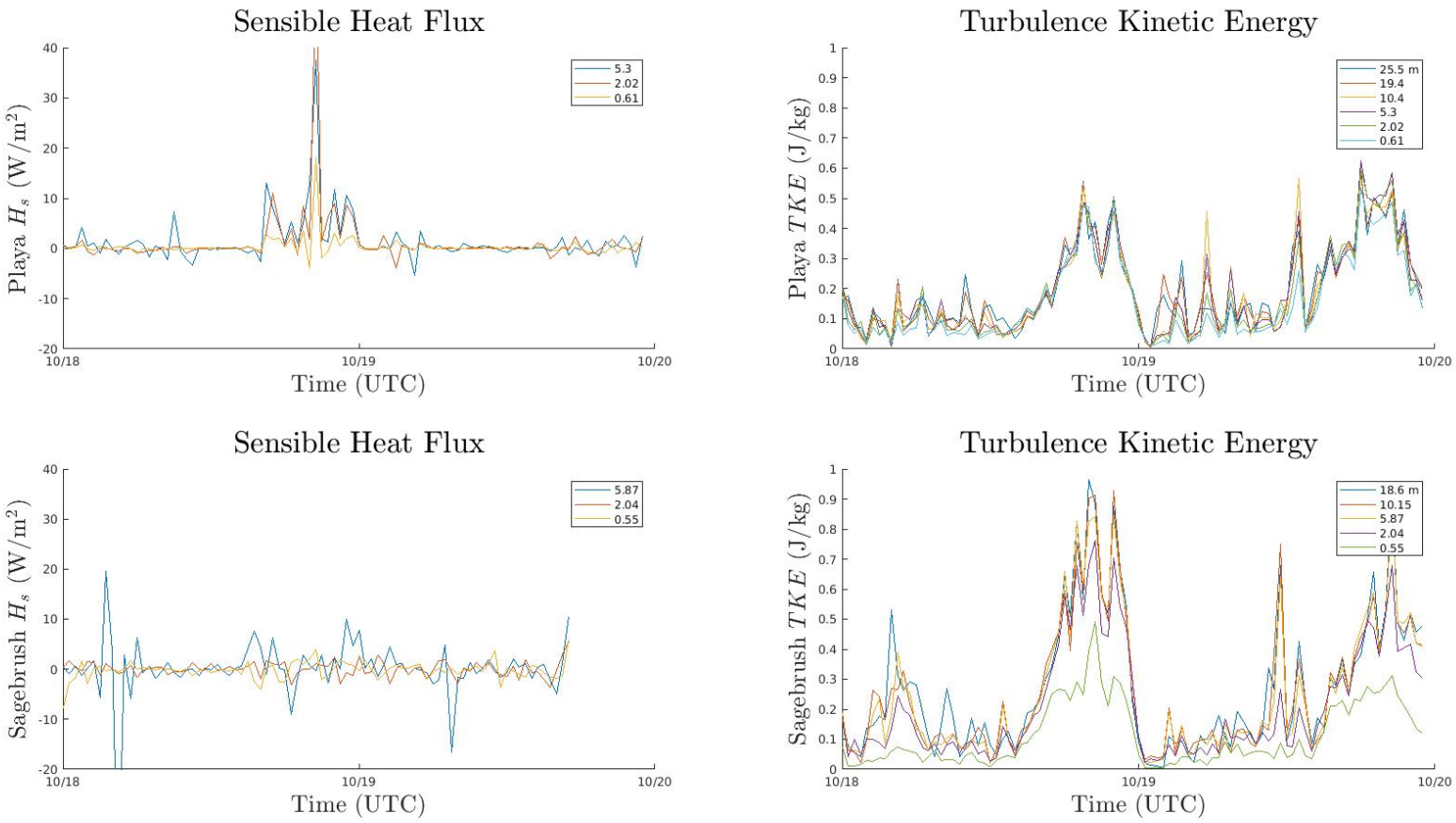
Data





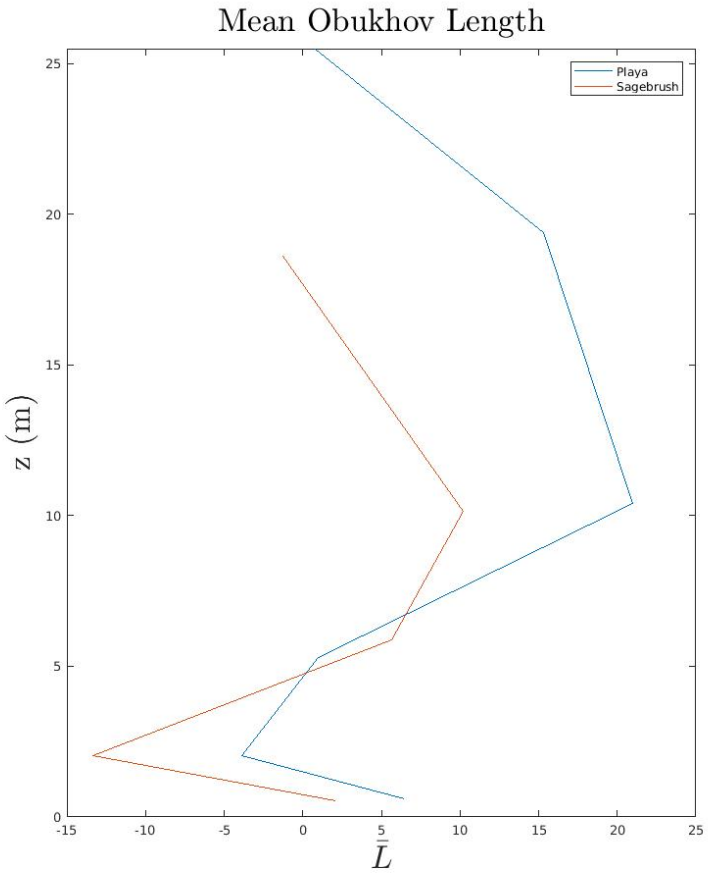
MATERHORN

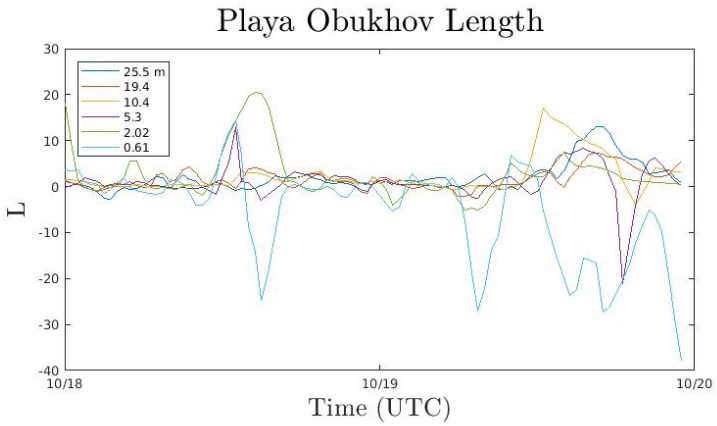
Analysis

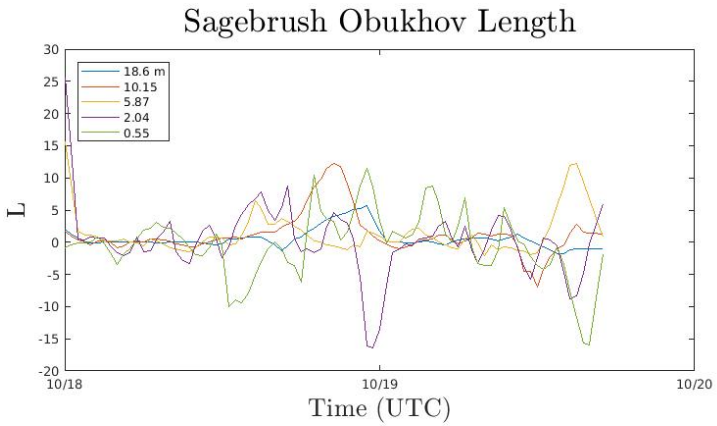


MATERHORN

Analysis







Outline

1 Introduction
- Motivation
- MATERHORN Data

2 Analysis
- Probability Distributions
- Autocorrelation
- Dissipation
- Turbulence Spectra

Probability Distribution

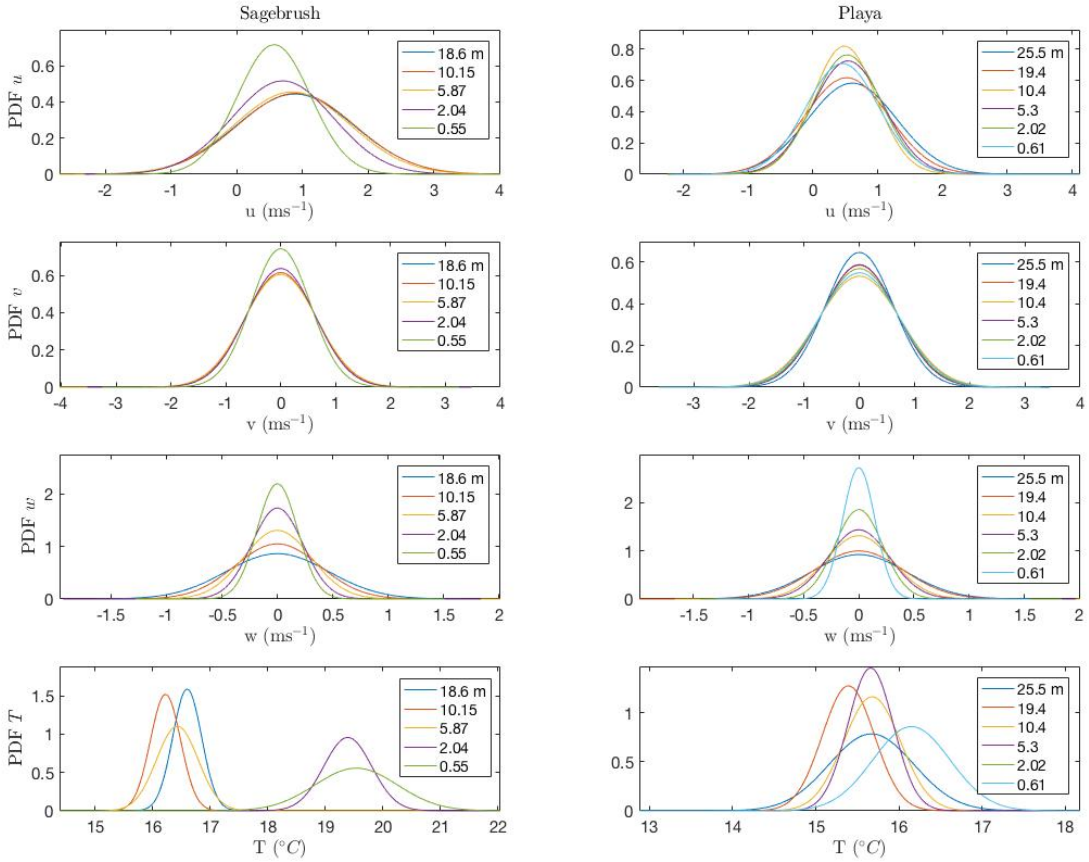


Figure: PDF for velocity and temperature for each height during period of interest, 3pm MST on October 19th, 2012

Turbulence and Temperature analysis

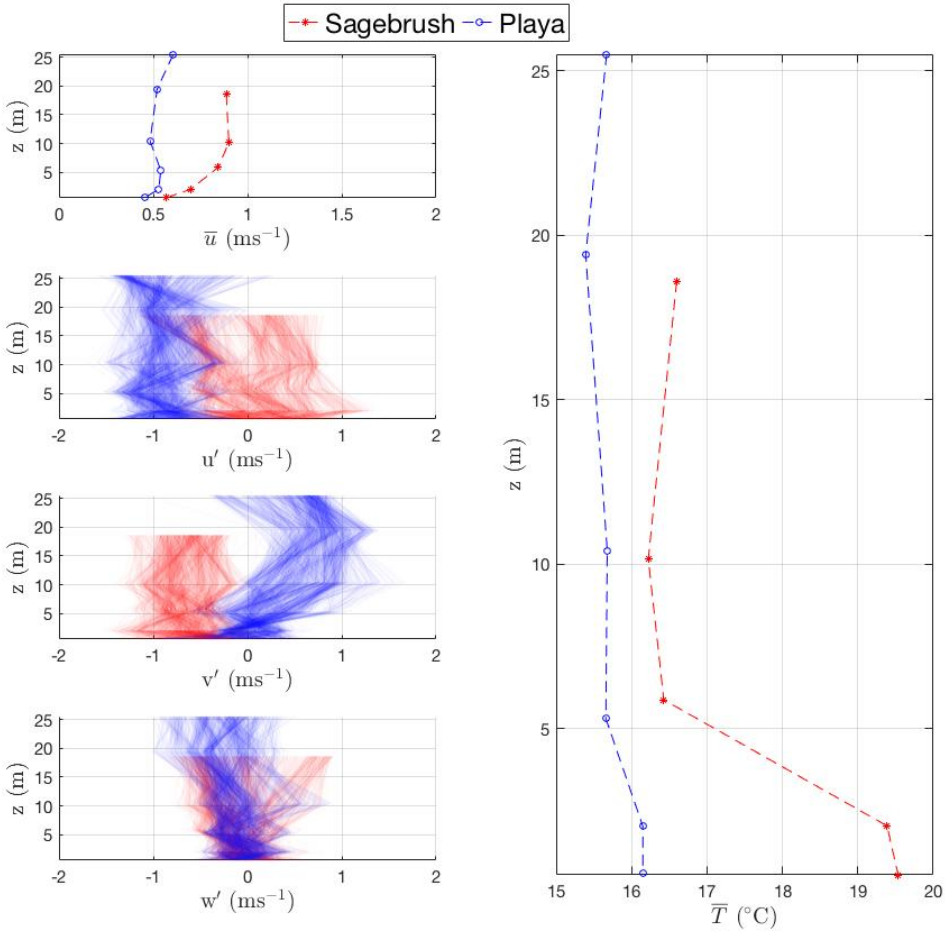


Figure: Sagebrush (red) and Playa (blue) mean velocity (top left), velocity fluctuations (left) and temperature (right) for each height during period of

Outline

1 Introduction
- Motivation
- MATERHORN Data

2 Analysis
- Probability Distributions
- Autocorrelation
- Dissipation
- Turbulence Spectra

Autocorrelation

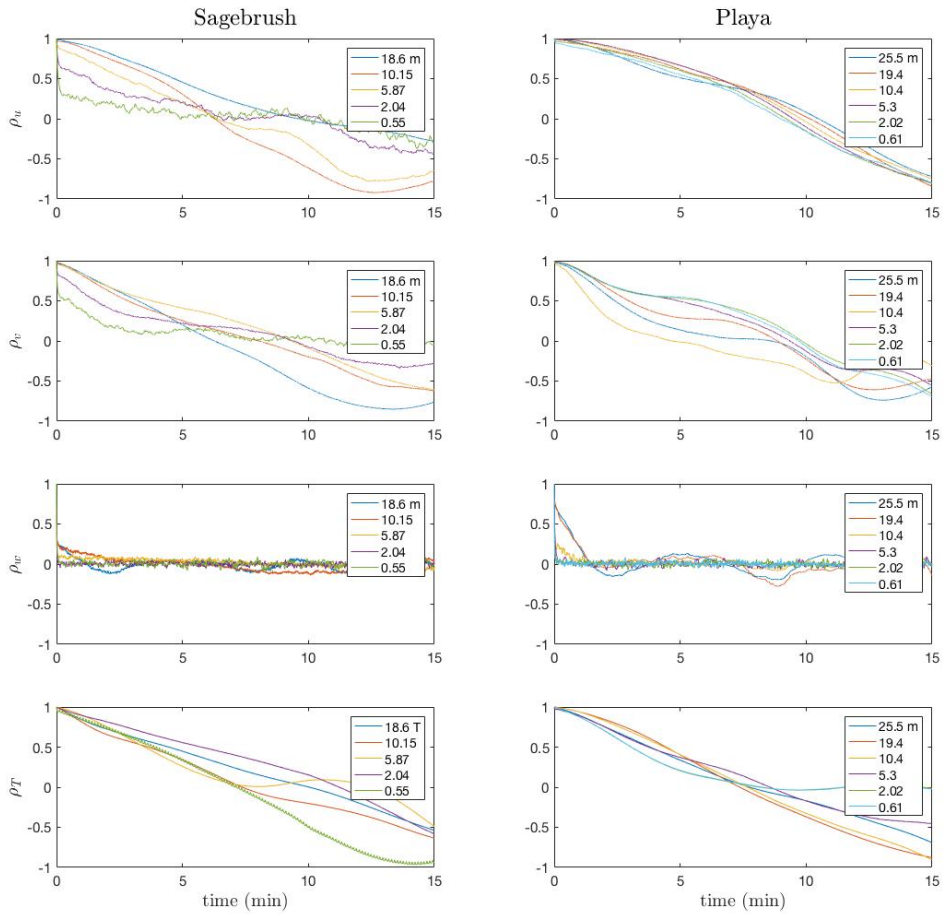


Figure: Autocorrelations for velocity and temperature for each height during period of interest, 3pm MST on October 19th, 2012

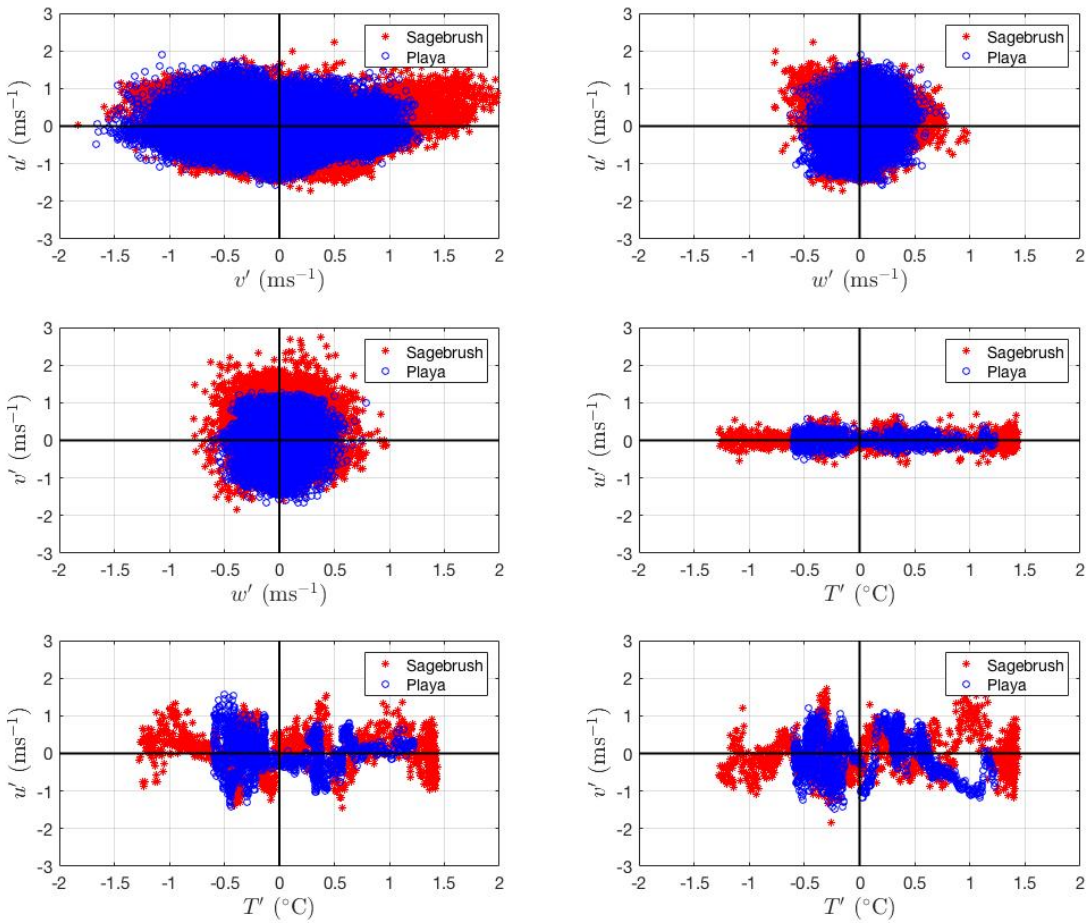


Figure: Correlations for momentum and heat flux for 0.5 m during period of interest, 3pm MST on October 19th, 2012

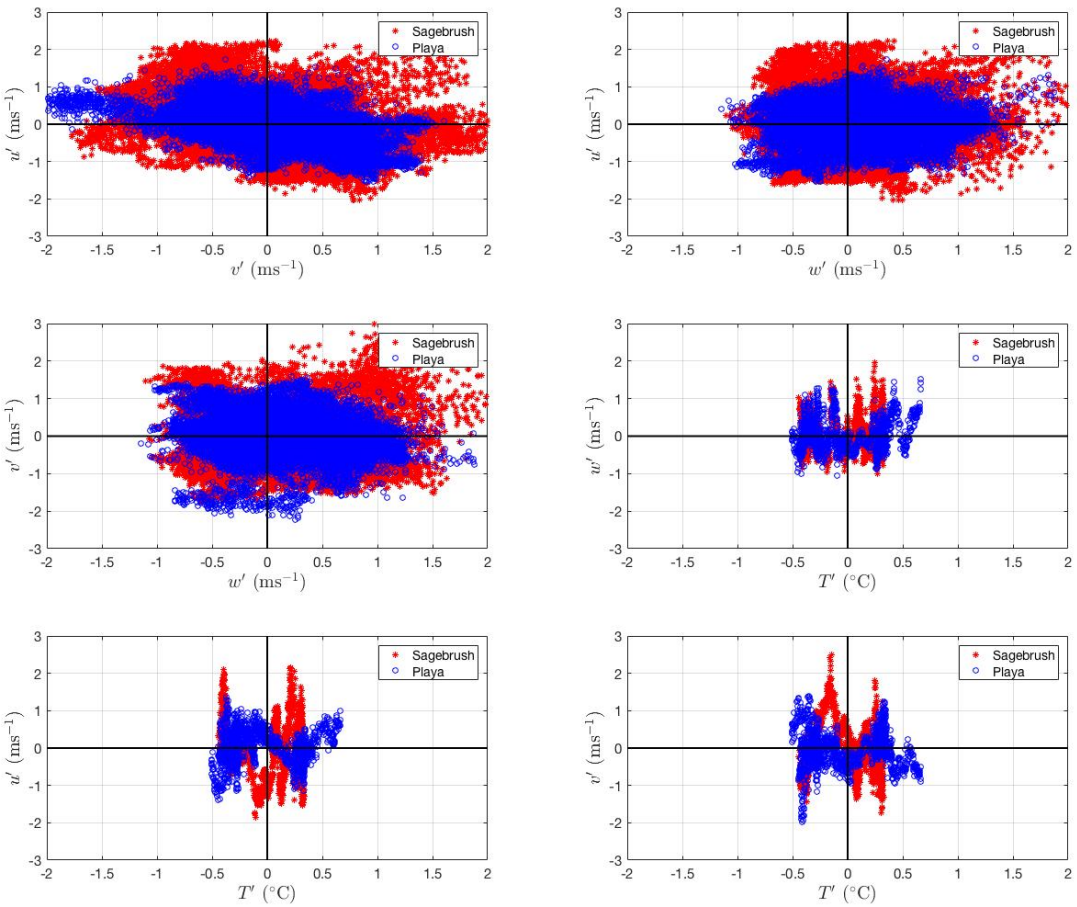


Figure: Correlations for momentum and heat flux for 20 m during period of interest, 3pm MST on October 19th, 2012

Outline

1 Introduction
- Motivation
- MATERHORN Data

2 Analysis
- Probability Distributions
- Autocorrelation
- Dissipation
- Turbulence Spectra

Dissipation

Dissipation rates calculated at 10 m tower height.

Dissipation Rate		
—	Playa	Sagebrush
6:00 am	0.0019	0.0035
6:30 am	0.0021	0.0011
7:00 am	0.0077	0.0055

Kolmogorov Length		
—	Playa	Sagebrush
6:00 am	1.52 mm	2.36
6:30 am	1.51	1.79
7:00 am	1.92	2.11

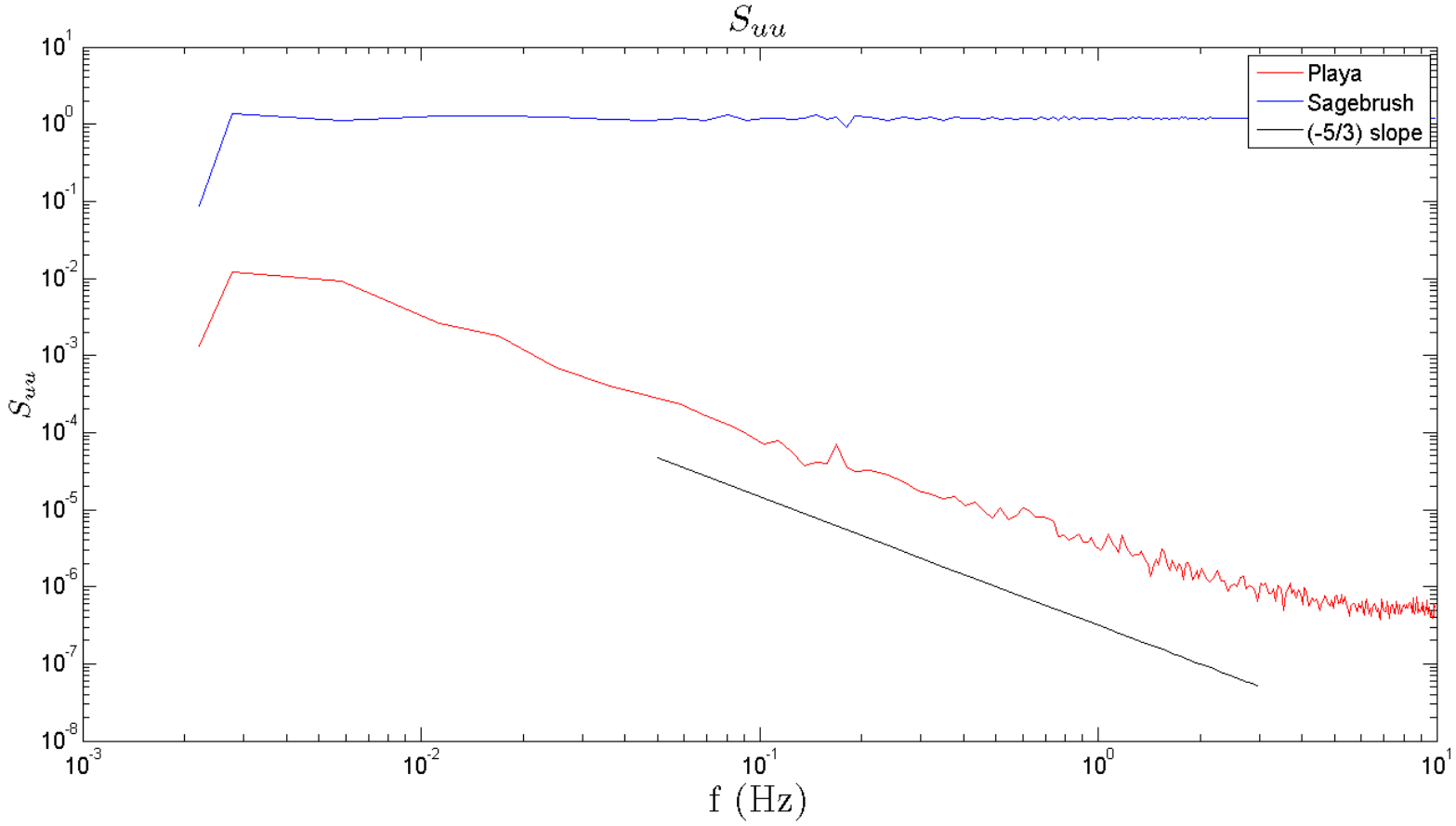
Outline

1 Introduction
- Motivation
- MATERHORN Data

2 Analysis
- Probability Distributions
- Autocorrelation
- Dissipation
- Turbulence Spectra

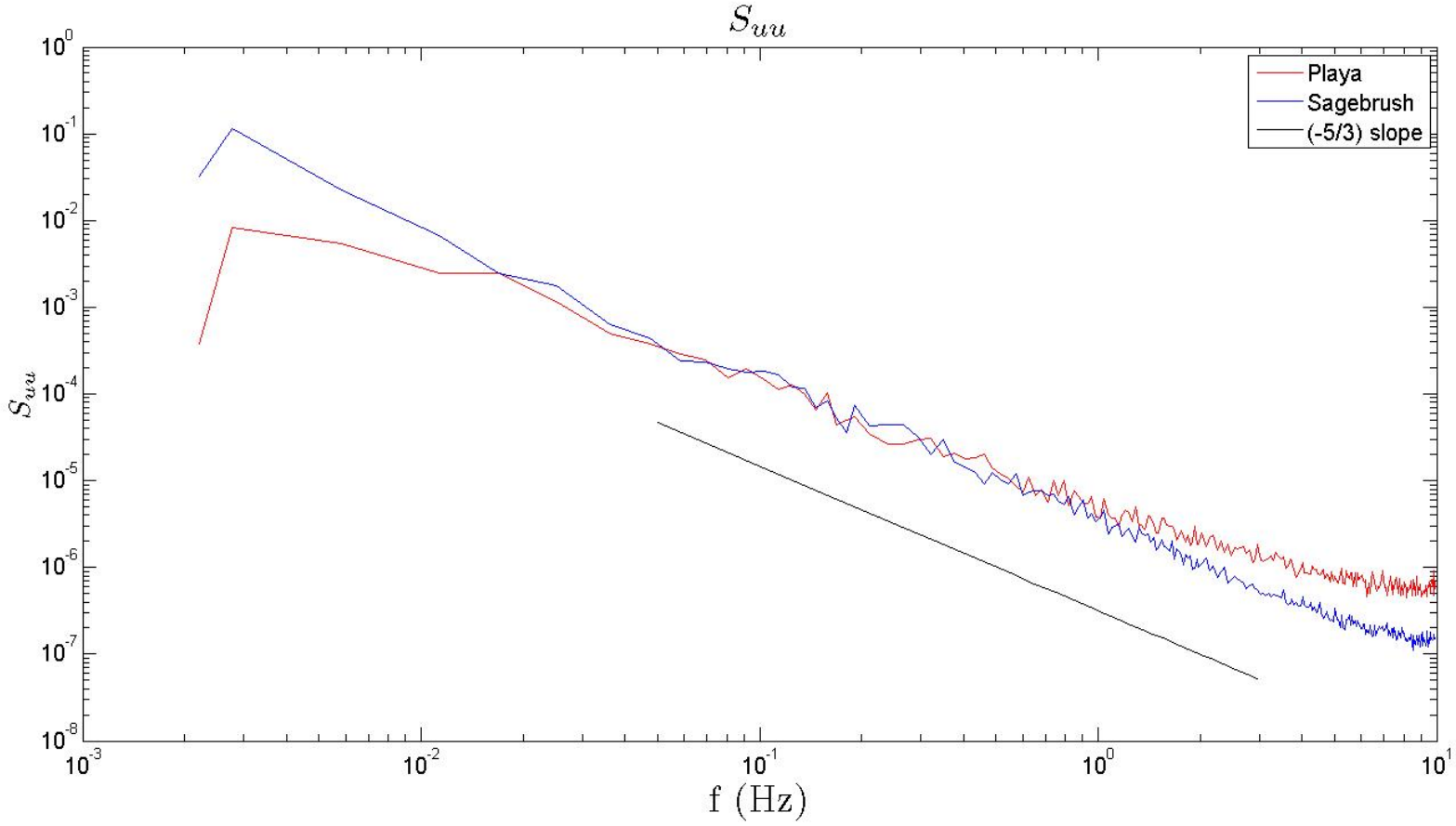
Turbulence Spectra 2 m

Turbulence Spectra at 2 m tower height.



Turbulence Spectra 10 m

Turbulence Spectra at 10 m tower height.



Turbulence Spectra

Differences in turbulence spectra and Kolmogorov lengths for tower heights at Sagebrush site.

- Kolmogorov Lengths
  - 2 m $\leftarrow$ Length Scale = 0.06 mm
  - 10 m $\leftarrow$ Length Scale = 2.11 mm
- Dissipation Rate
  - 2 m $\leftarrow$ Dissipation Rate $\approx$ 800
  - 10 m $\leftarrow$ Dissipation Rate = 0.0015
- Turbulence Cascade

Summary

Contrasting surface heterogeneities at the Playa and Sagebrush sites were examined by study of the flow near the surface. Noticeable differences from the study are:

- The Sagebrush site has increased dissipation, energy storage, and larger contribution of high frequency eddies as a result of the increased surface roughness.
- The Playa site demonstrated stronger autocorrelations along all heights.
- The impacts of the vegetation at the Sagebrush site diminish by 10 m.
- Outlook
  - A Multi-Resolution Decomposition should be performed to determine correct detrending time and to further understand dominate length scales.
  - Begin to include data which includes spatial information, such as thermal imagery, LEMs, soil moisture measurements.