Flux Tower Data Quality Analysis

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Motivation

- North American Monsoon (NAM)
  - Seasonal large scale reversal of atmospheric circulation
  - Occurs during the summer months due to a large temperature gradient between the ocean surface and the continent
  - Characterized by a pronounced increase in precipitation lasting from July to mid/late September
  - Centered over northwestern Mexico, but it is also observable in Arizona, New Mexico, southern Colorado and southern Utah

NAM – Key Features

• Shading: mean (July-September 1979-1995) precipitation in millimeters

• Arrows: lower-tropospheric (925-hPa) vector wind (m s^{-1})

• Contours: upper-tropospheric (200-hPa) circulation pattern

• The position of the upper-tropospheric monsoon anticyclone is indicated by “A”.

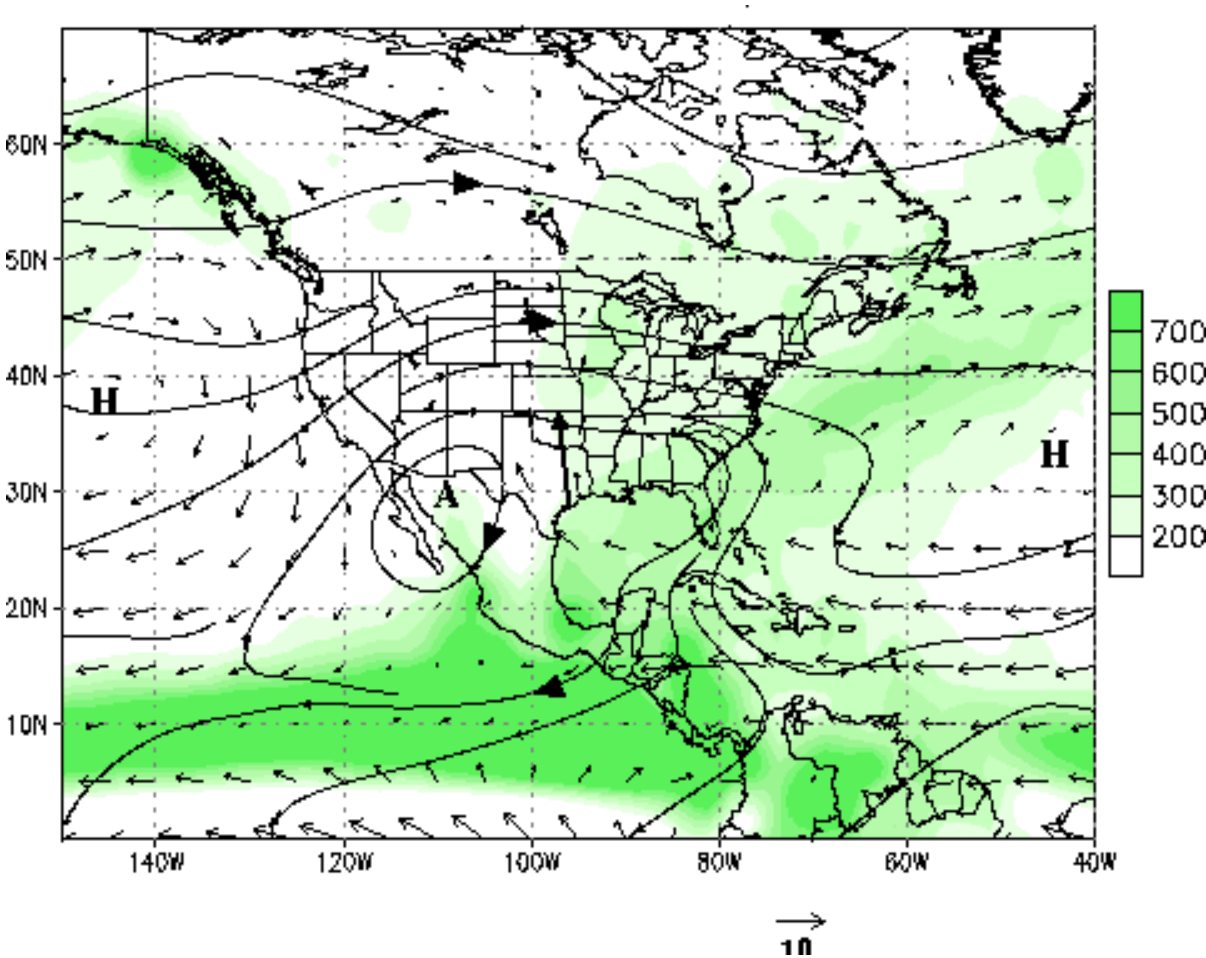


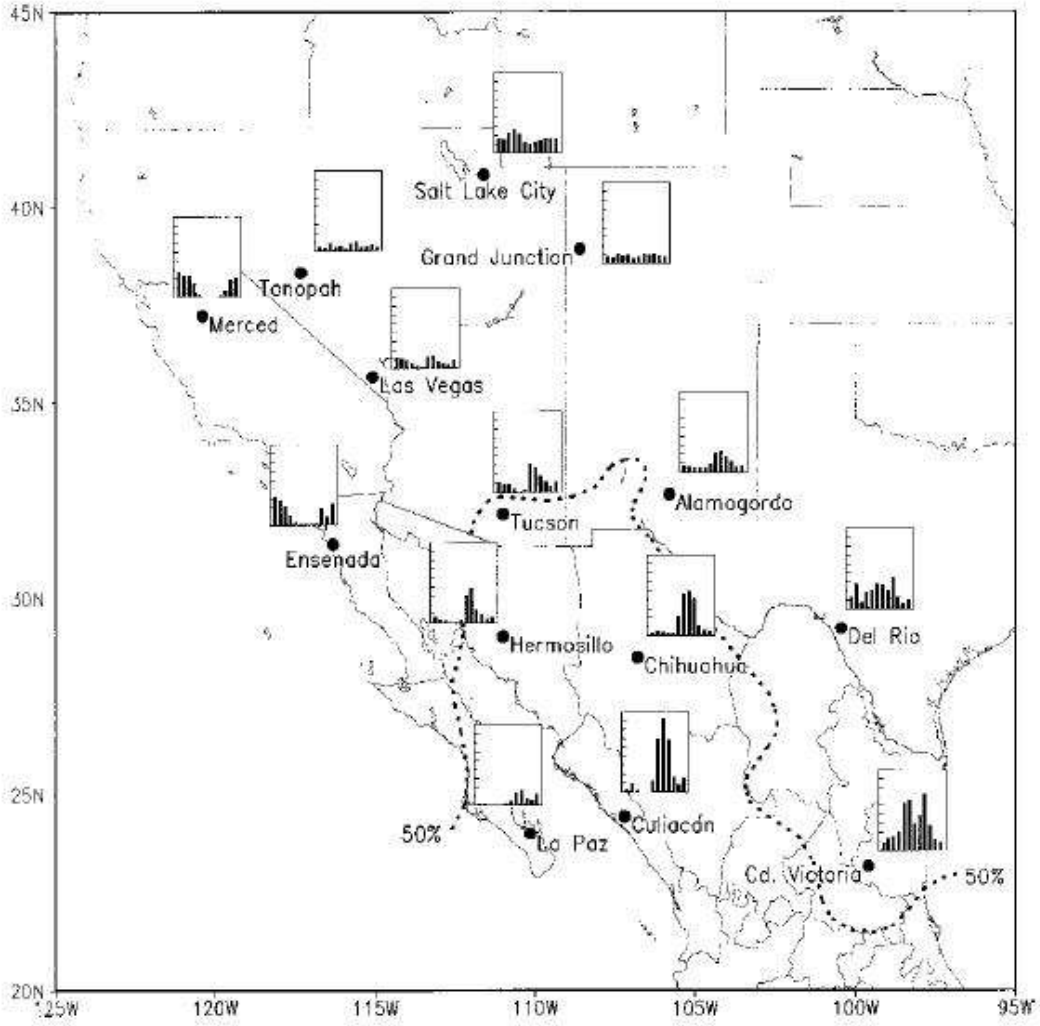
Figure from: http://www.cpc.noaa.gov

2. NAM – precipitation distribution

- Northwestern Mexico shows the strongest monsoon signal, which diminishes through Arizona and New Mexico

- Northeastern Mexico and Texas are not directly influenced by the monsoon – display early summer – late fall precipitation peaks

- West coast shows a typically Mediterranean precipitation distribution – dry summers, wet winters



Seasonal distribution of precipitation across southwestern North America

Figure from Adams and Comrie, 1997

Land atmosphere coupling in the NAM region

- Do the soil conditions affect precipitation?
  - Soil moisture
  - Albedo
- If yes, how?
  - Positive soil moisture-precipitation mechanism
  - Negative soil moisture-precipitation mechanism
  - Or something completely different?

Data

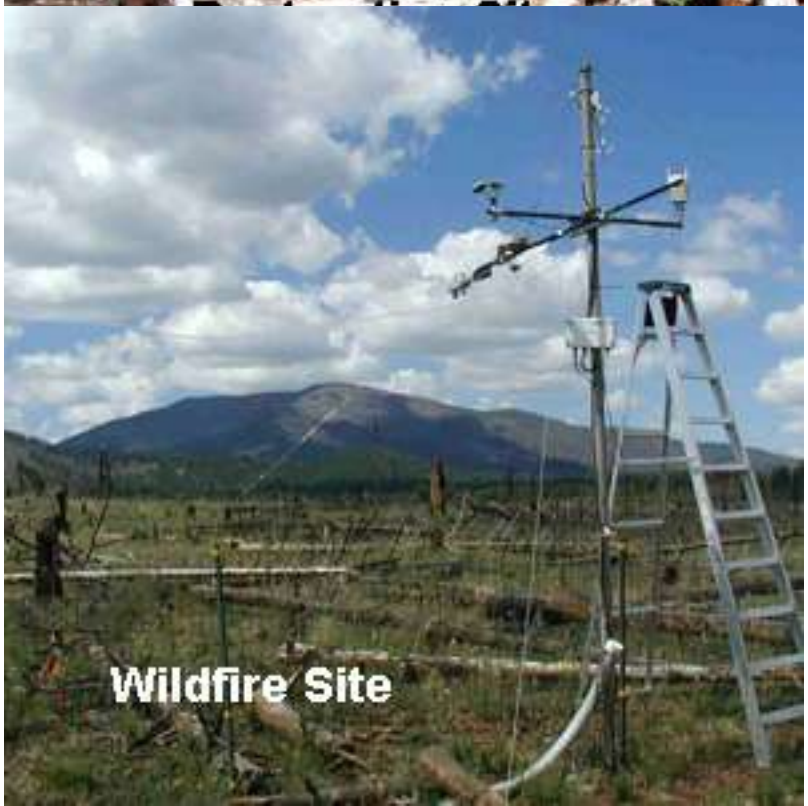
- 4 AmeriFlux towers in Arizona
  - Audubon Research Ranch (Lat 31.59, Lon -110.50)
  - Flagstaff Managed Forest (Lat 35.14, Lon -111.72)
  - Flagstaff Unmanaged Forest (Lat 35.08, Lon -111.76)
  - Flagstaff Wildfire (Lat 35.44, Lon -111.77)

- Data type – Level 2
  - Data received from individual sites are reviewed and incorporated into a network-wide AmeriFlux database. The review process includes checks for consistent units, naming conventions, and reporting intervals and reformatting is often necessary to maintain consistency within the larger network-wide database.

Measured/computed quantities

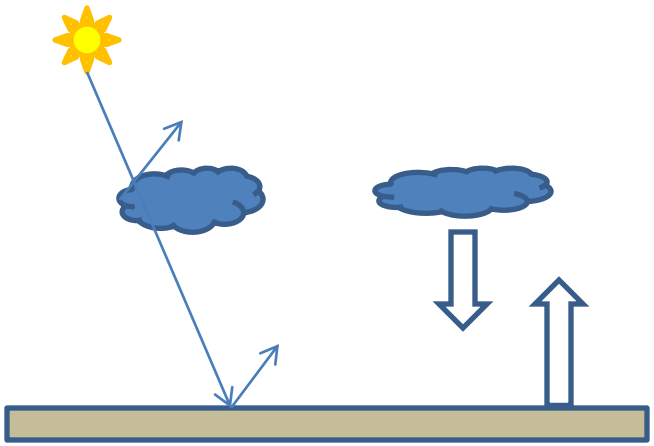
- U*
- T_{air}
- Wind speed and direction
- Latent heat
- Sensible heat
- Ground flux
- Soil temperature (2 depths)
- CO_2 flux
- Precipitation
- Relative humidity
- Pressure
- Soil water content (2 depths)
- Net radiation
- Longwave radiation(↑,↓)
- Shortwave radiation(↑,↓)
- Canopy storage of latent and sensible heat

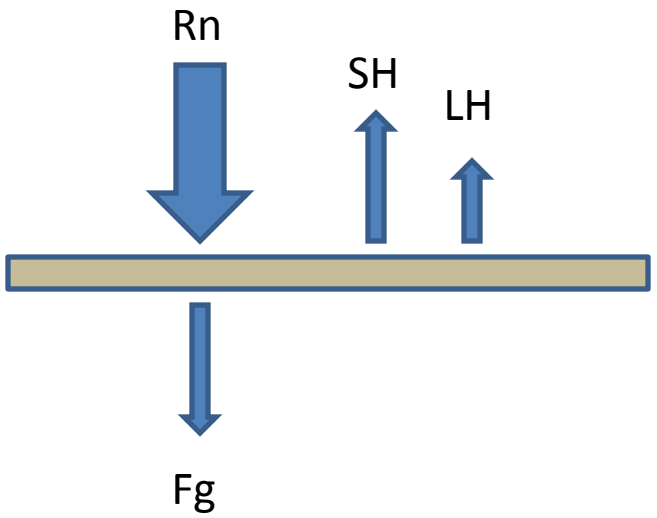

Control Site


Wildfire Site

Data Quality Check – Energy Budget

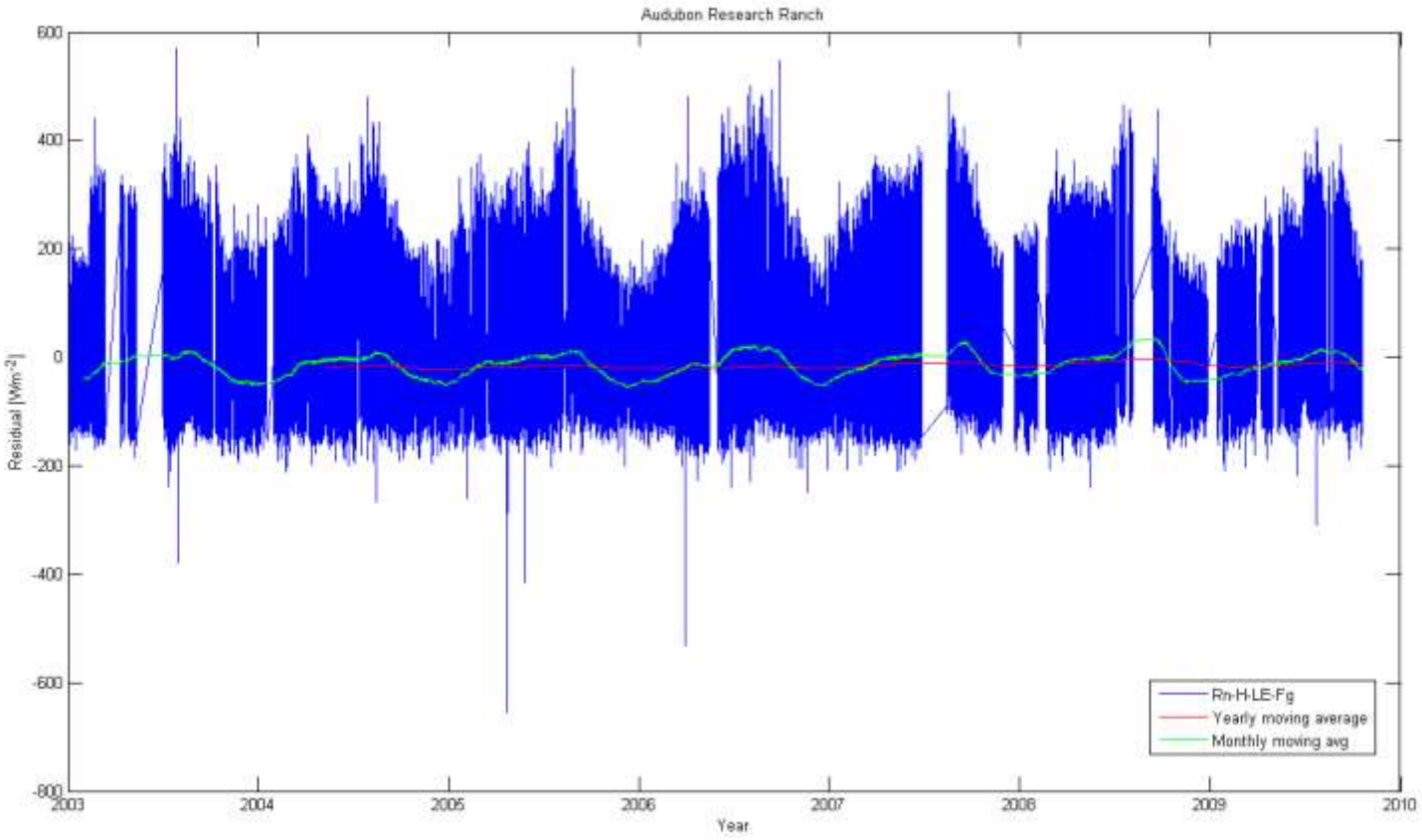
- $Rn = S(1 - a) + LW\downarrow - LW\uparrow$
- $Rn - SH - LH - Fg = 0$



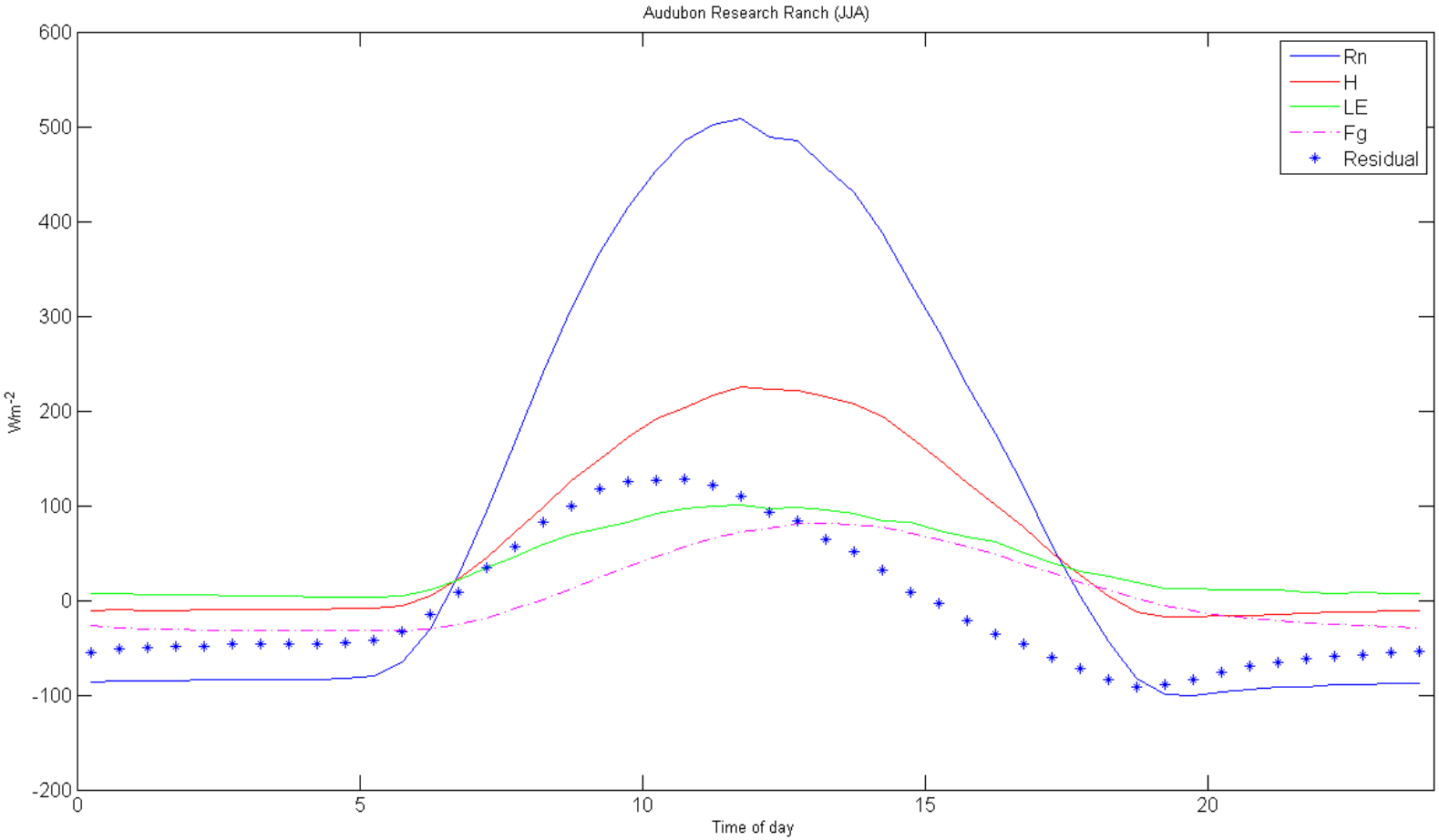


Energy Budget - residual

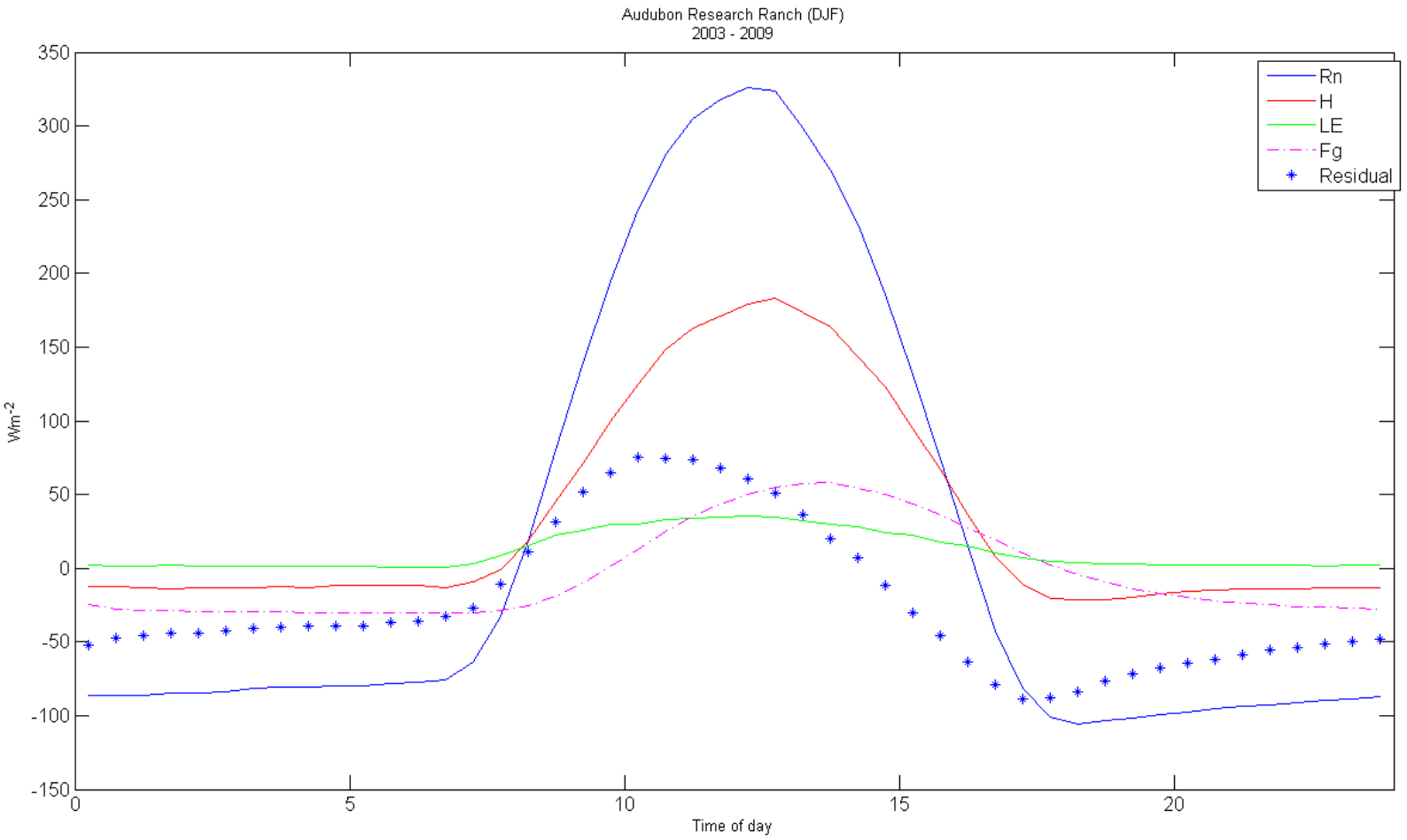
Audubon Research Ranch



Diurnal Cycle (JJA)

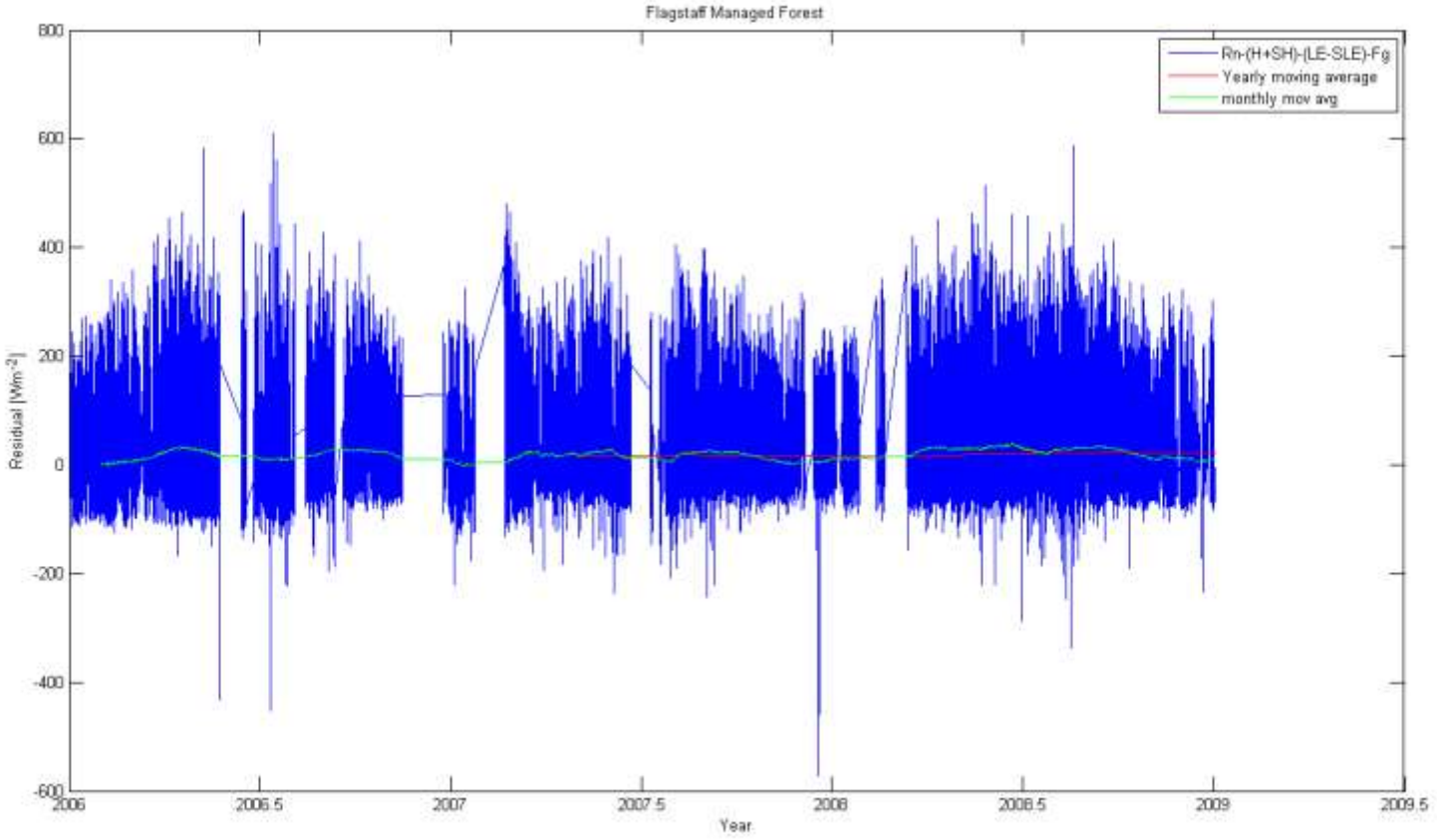


Diurnal Cycle (DJF)

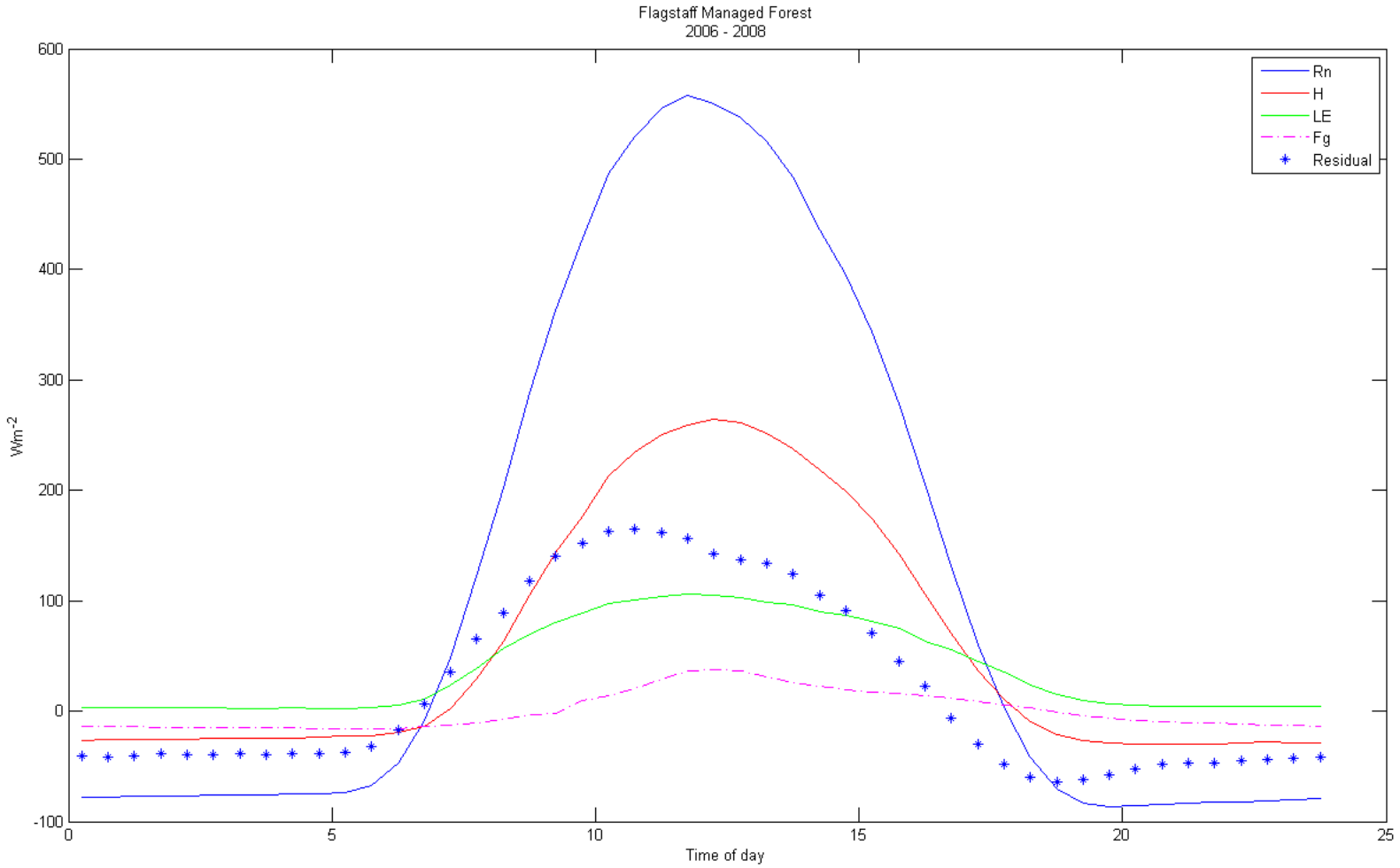


Energy Budget – residual (continued)

Flagstaff Managed Forest

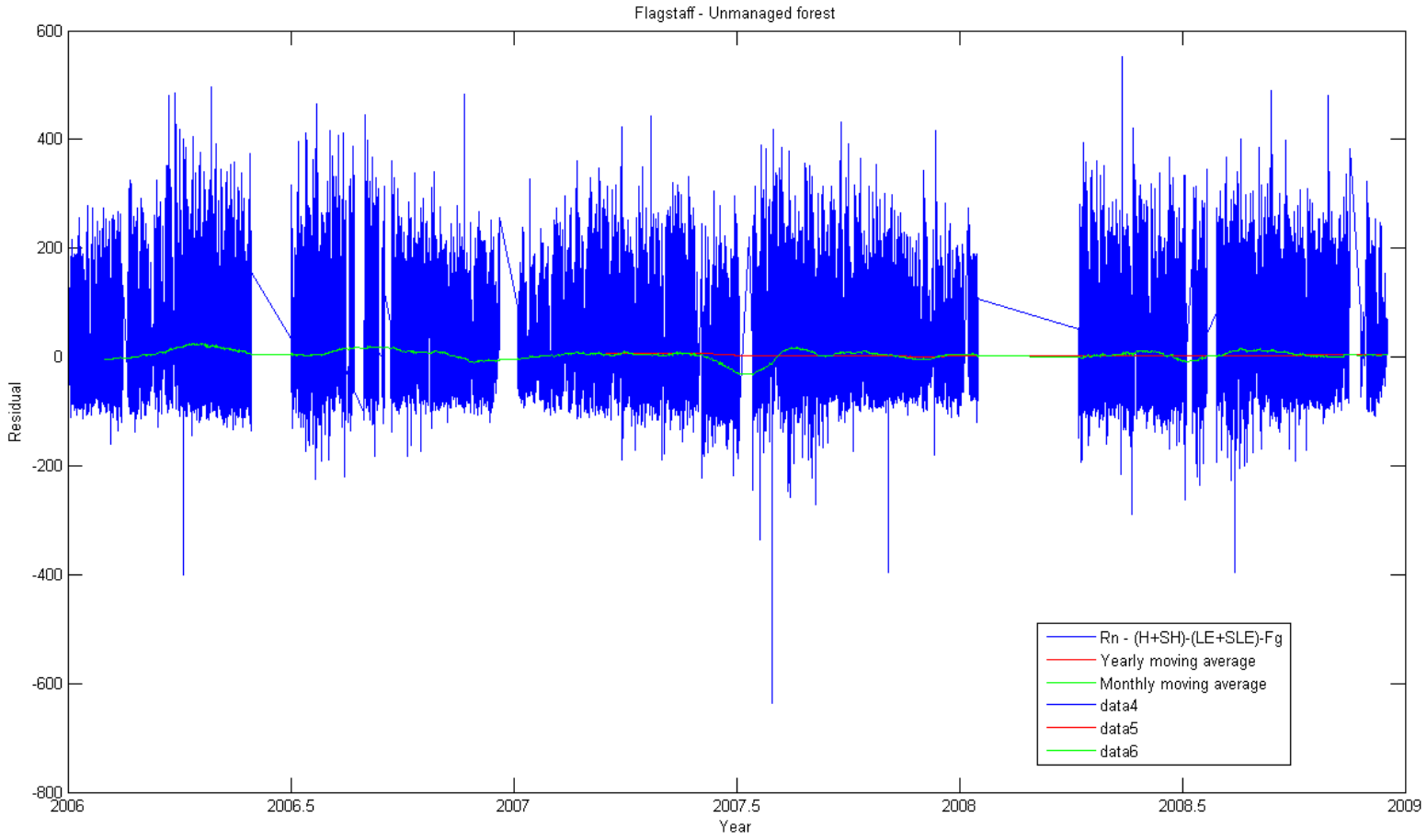


Flagstaff Managed Forest
Diurnal Cycle (yearly)

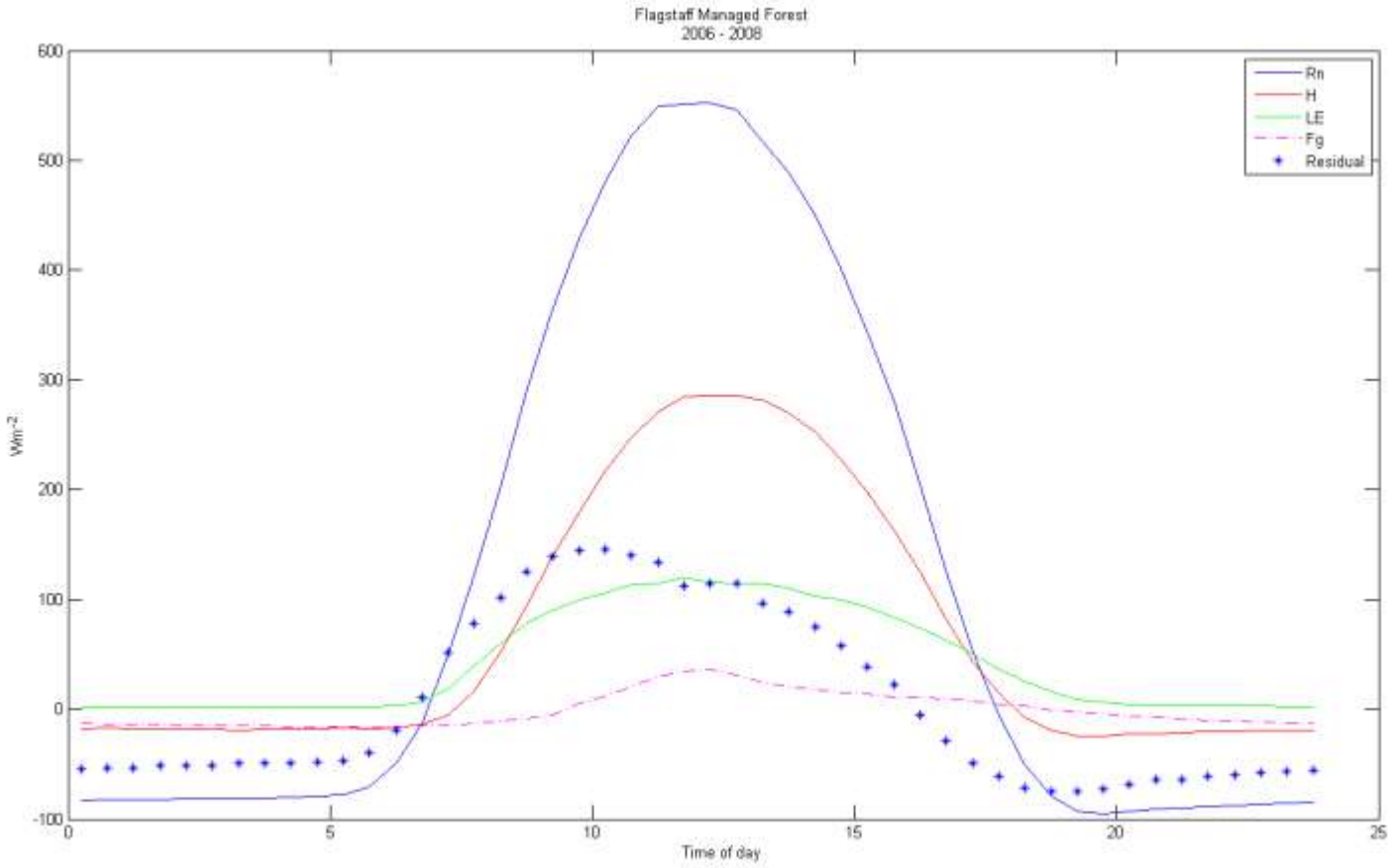


Energy Budget – residual (continued)

Flagstaff Unmanaged Forest

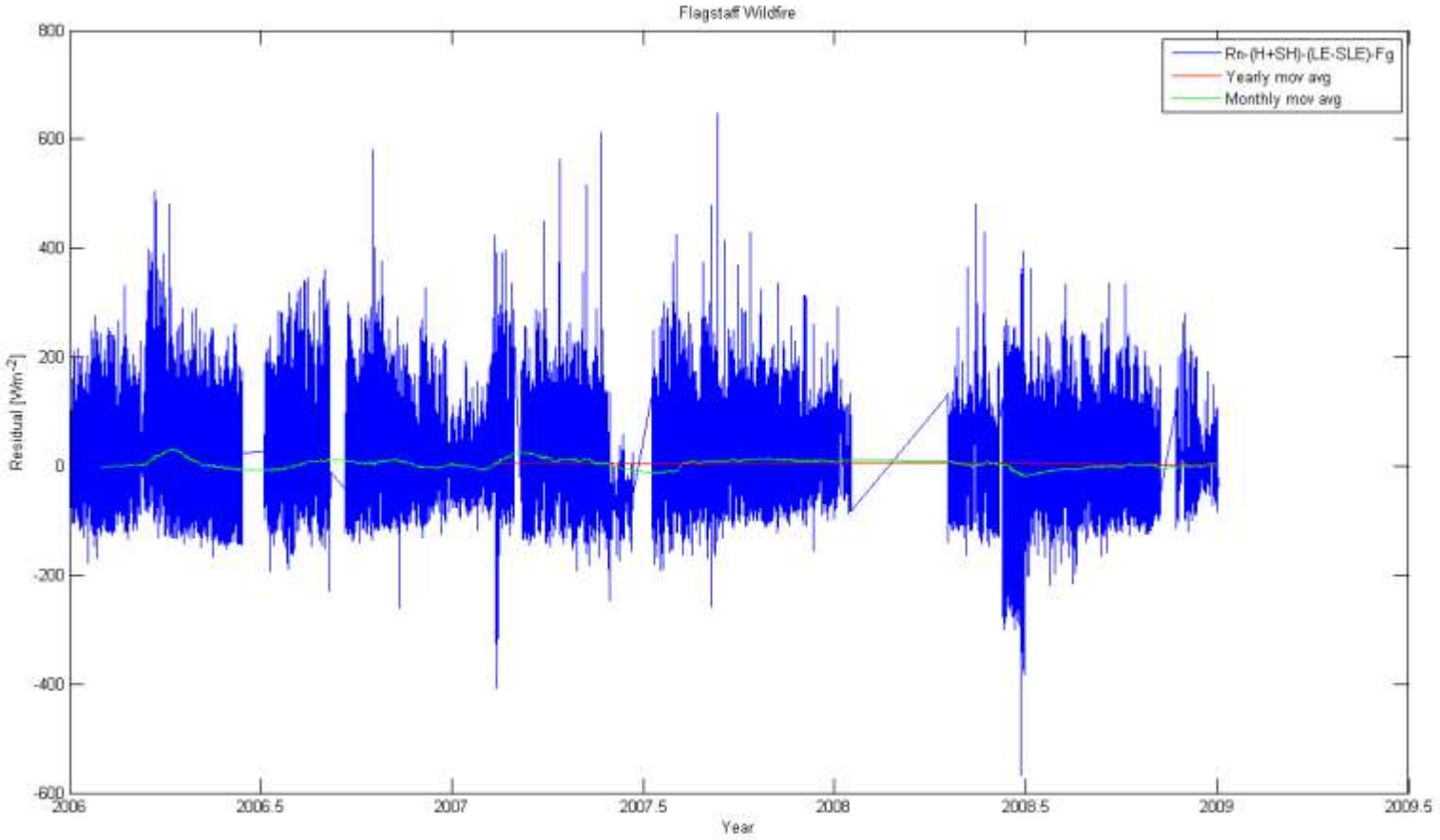


Flagstaff Unmanaged Forest
2006 - 2008

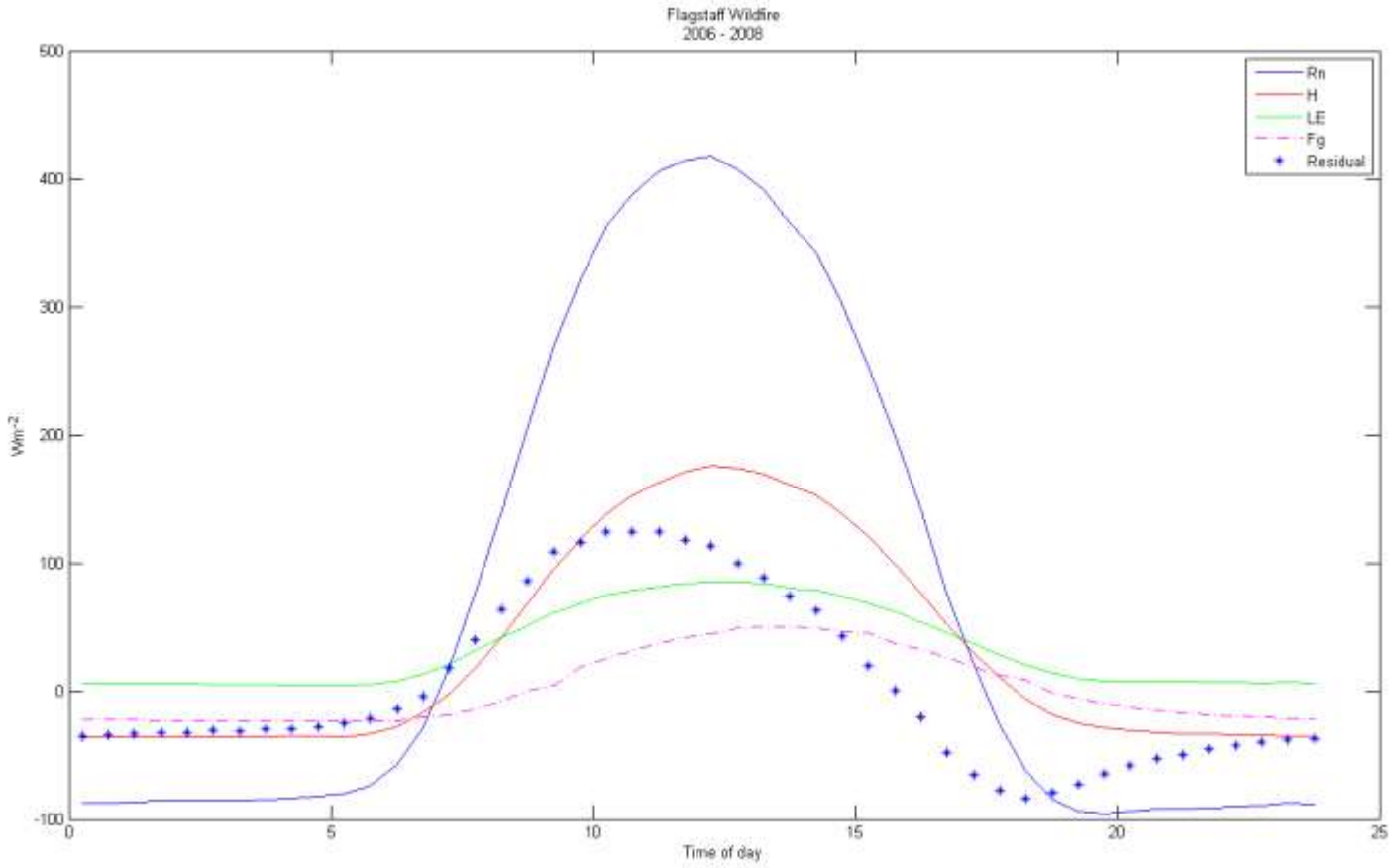


Energy Budget – residual (continued)

Flagstaff Wildfire



Flagstaff Wildfire
2006 - 2008



Energy Budget - summary

	Mean Residual [Wm^{-2}]
Flagstaff Unmanaged Forest	18.99
Flagstaff Managed Forest	4.42
Flagstaff Wildfire	4.02
Audubon Grasslands	-15.22

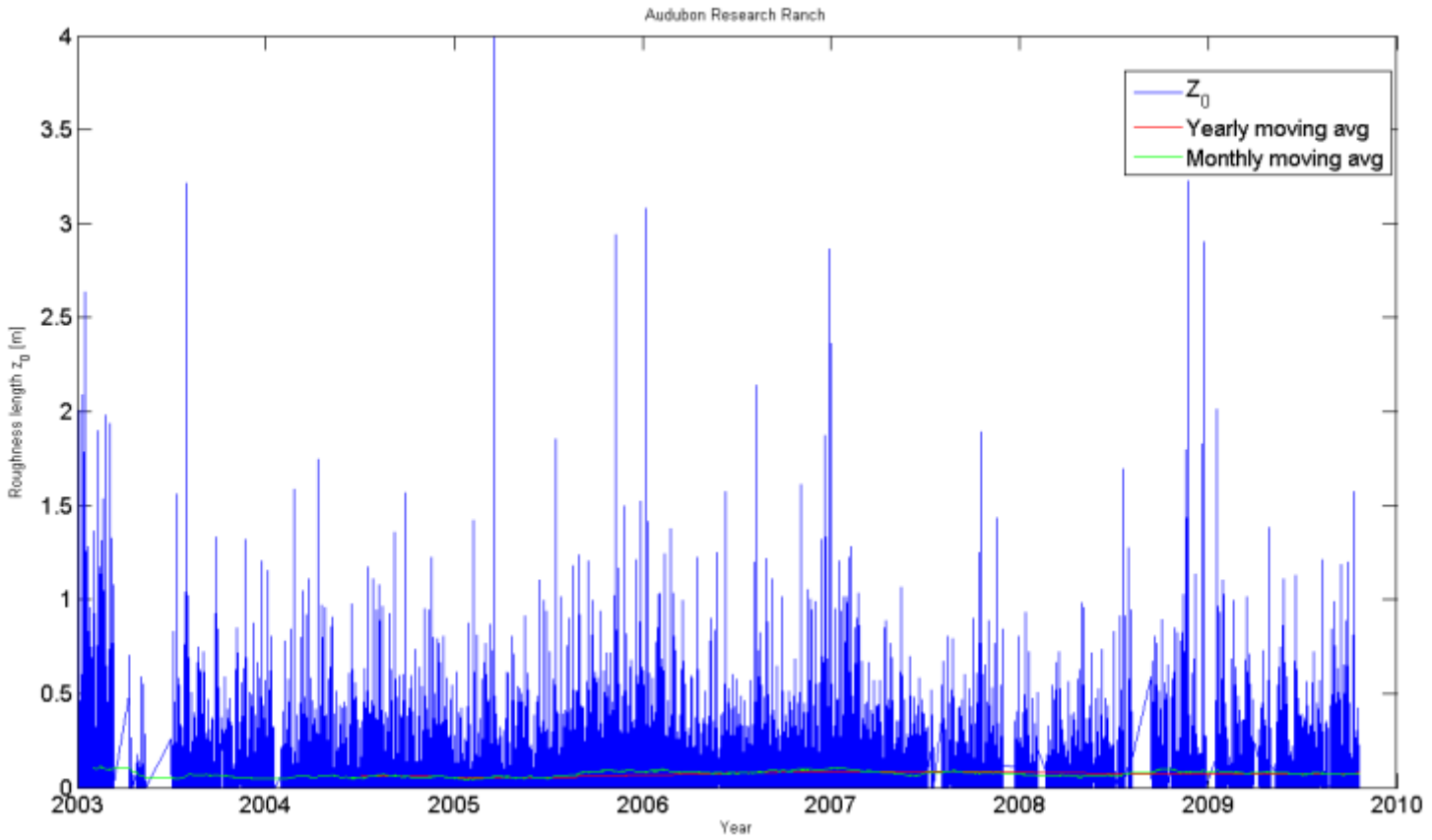
Consistency with the Log law theory

$$u(z) = \frac{u^*}{K} \ln\left(\frac{z}{z_0}\right)$$

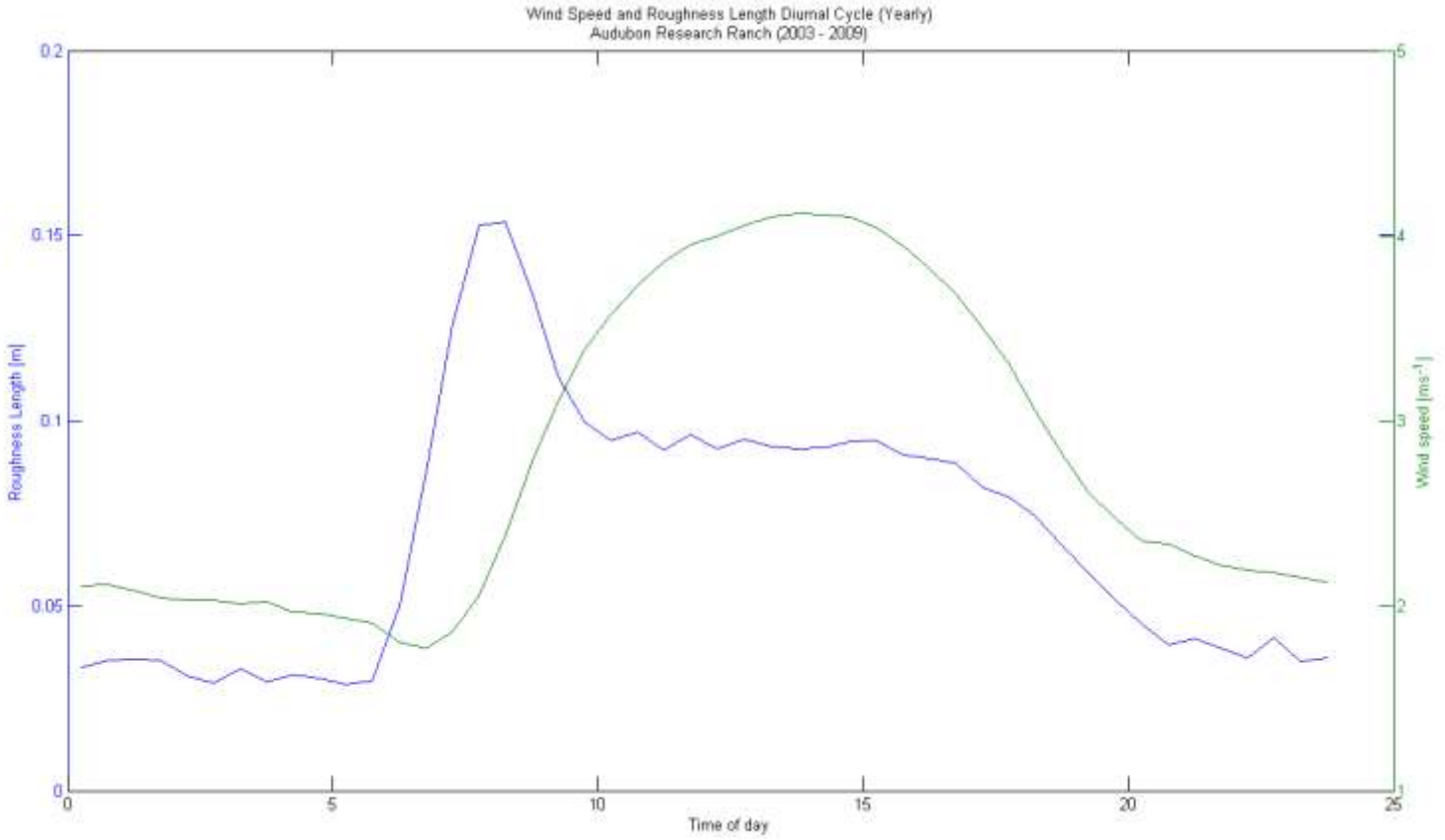
- U* = friction velocity
- K = Von Karman constant (=0.4)
- z_0 = roughness length

Consistency with the Log law theory - results

Audubon Research Ranch

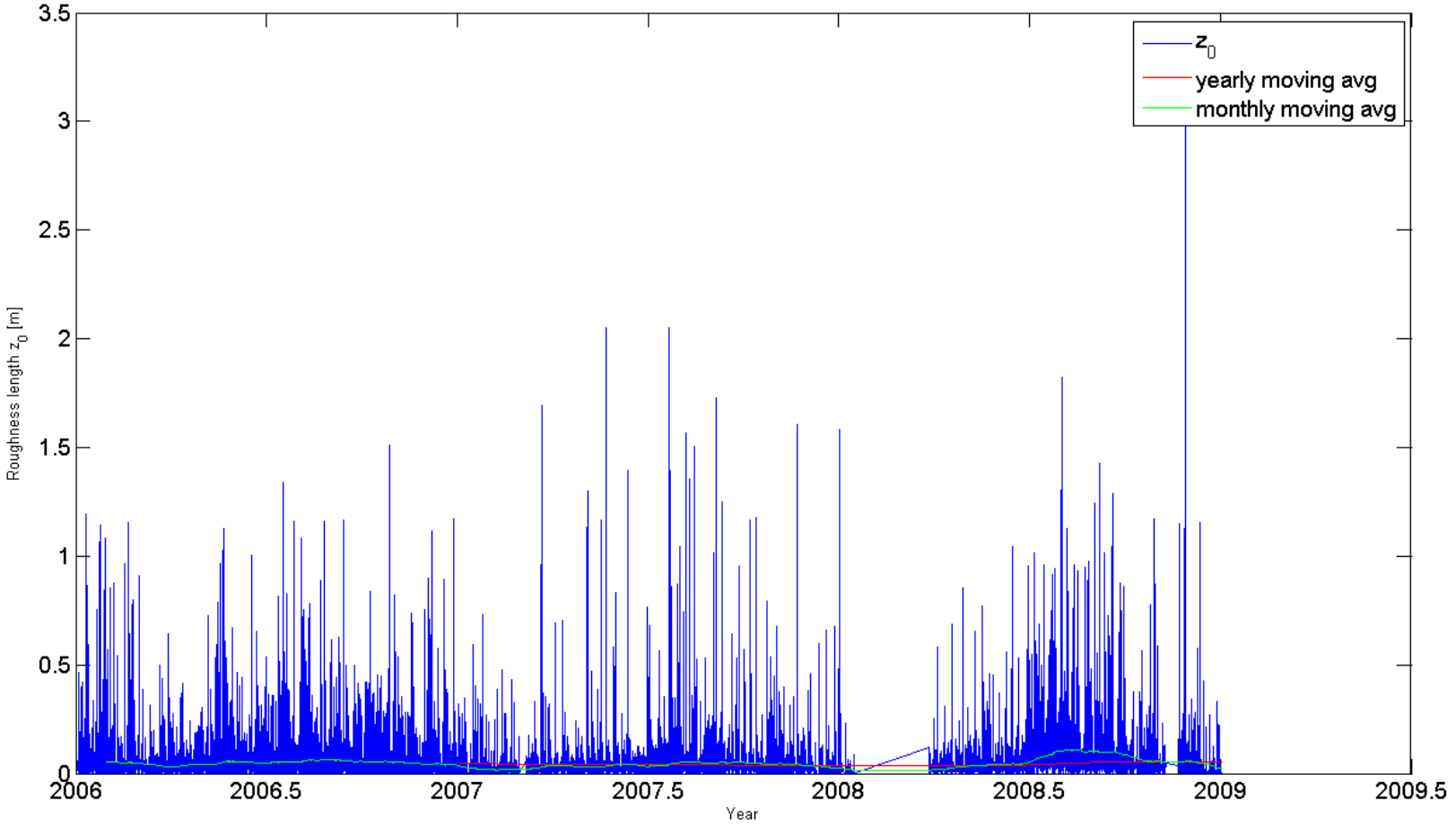


Diurnal Cycle of Wind Speed and Roughness Length
Audubon Research Ranch

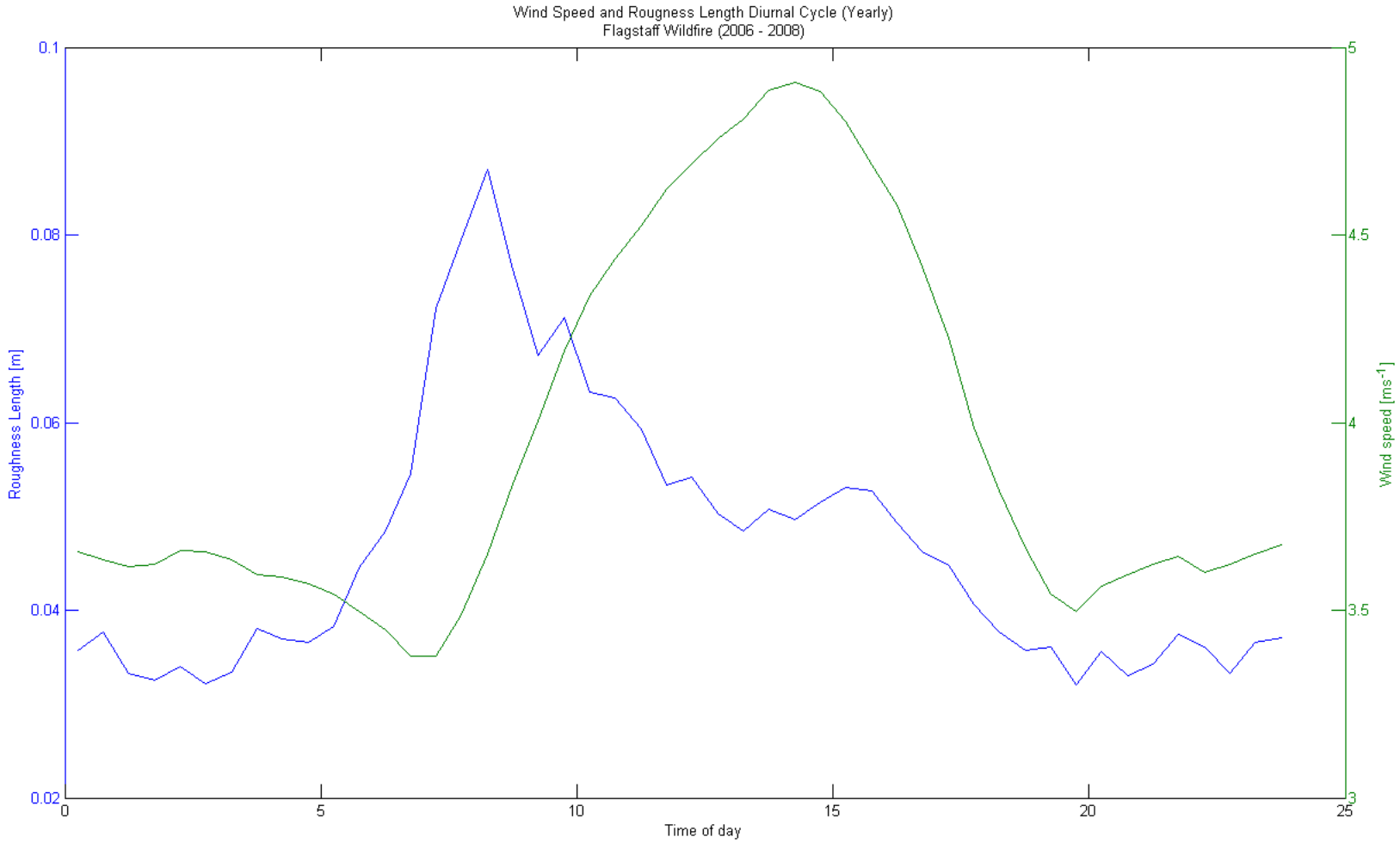


Consistency with the Log law theory - results

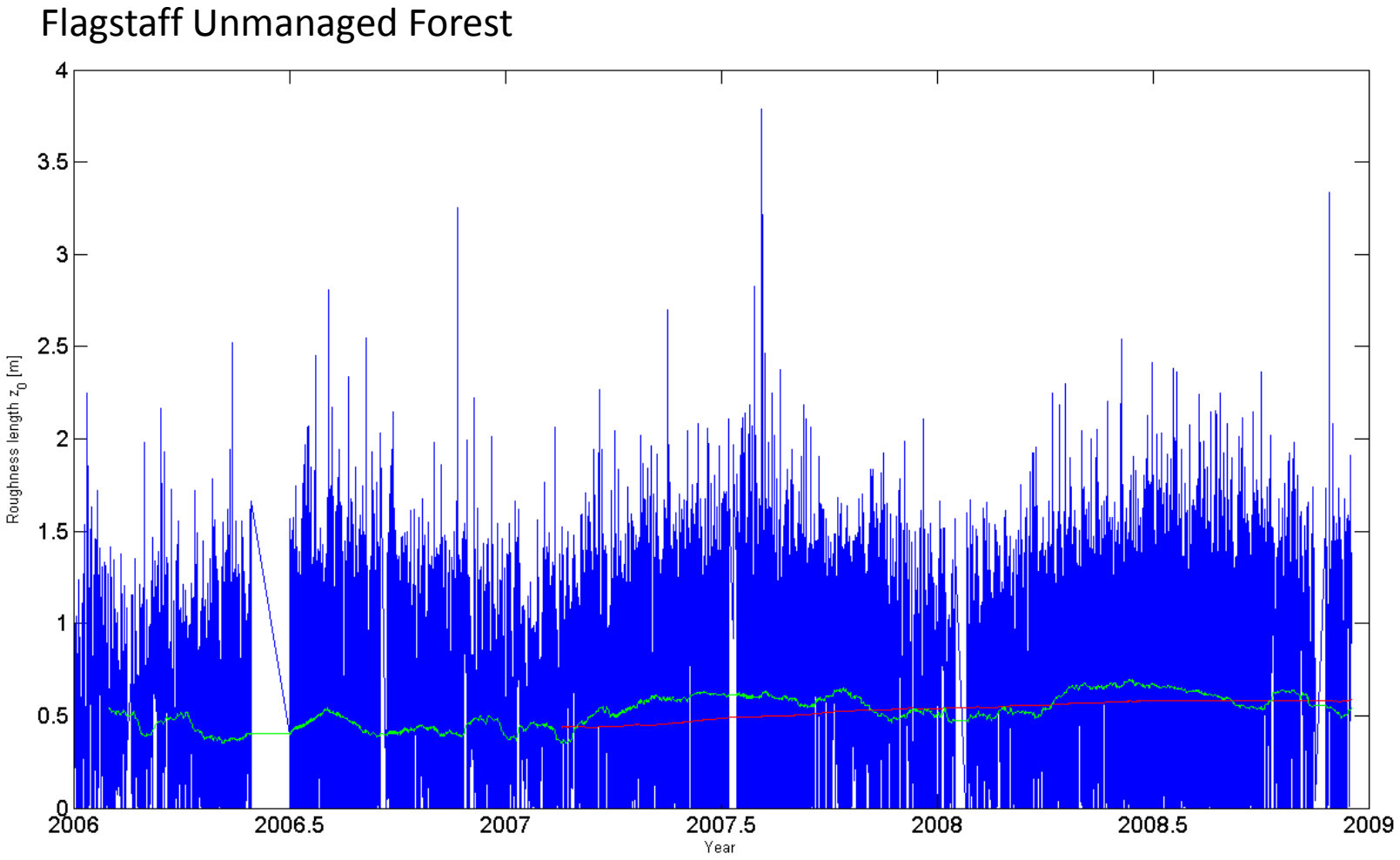
Flagstaff Wildfire



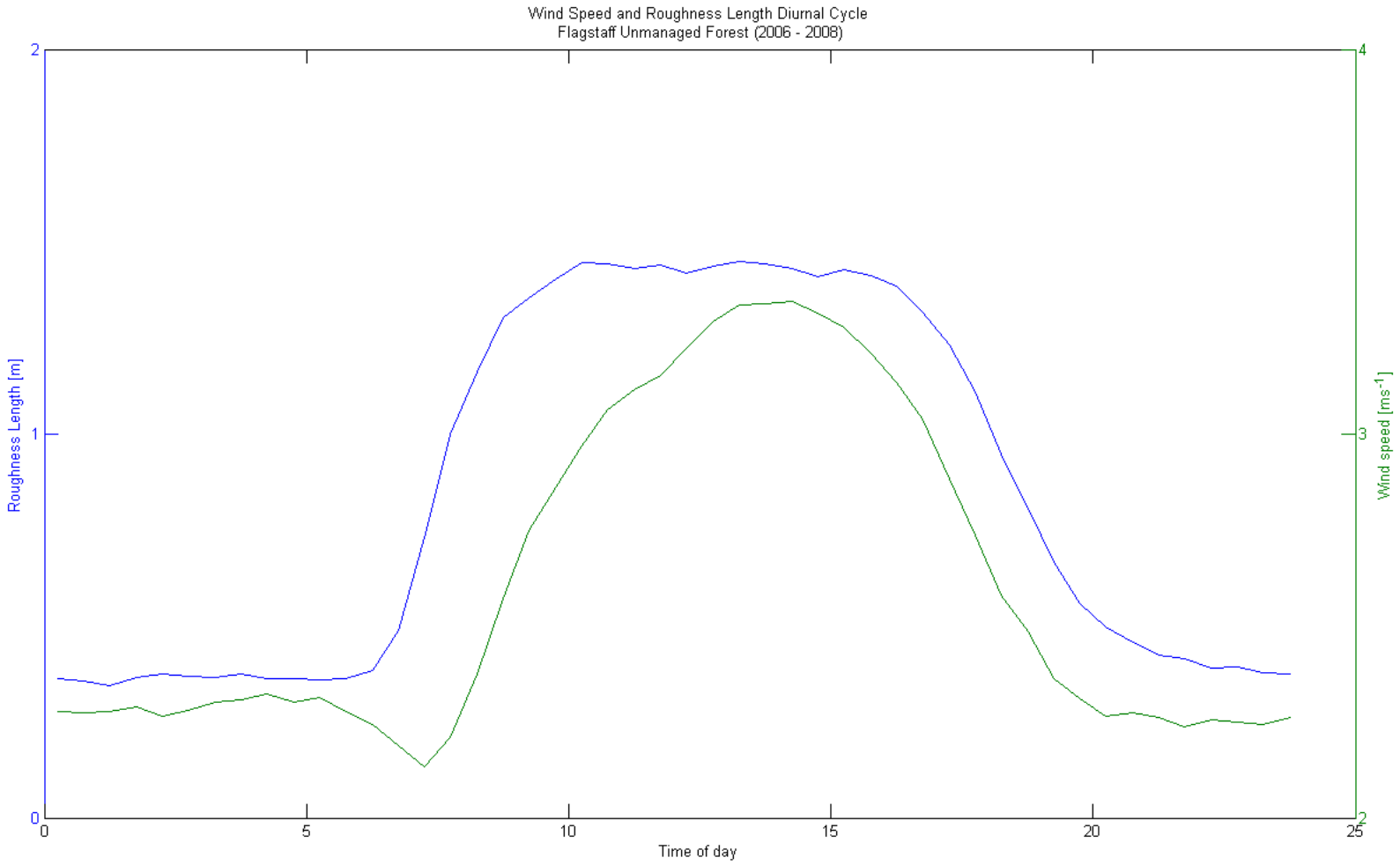
Flagstaff Wildfire
Diurnal Cycle of Wind Speed and Roughness Length



Consistency with the Log law theory - results

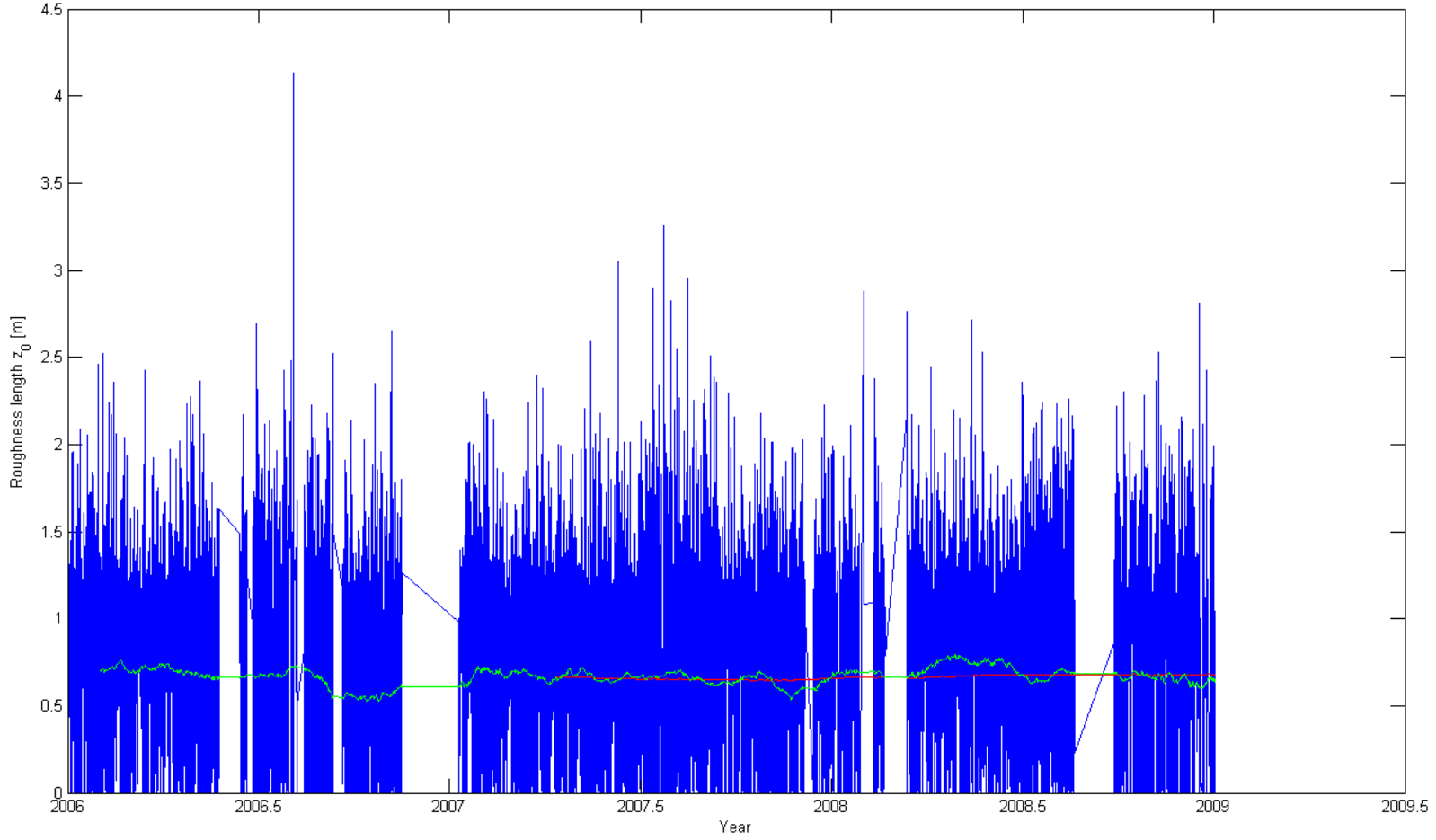


Flagstaff Unmanaged Forest
Diurnal Cycle of Wind Speed and Roughness Length

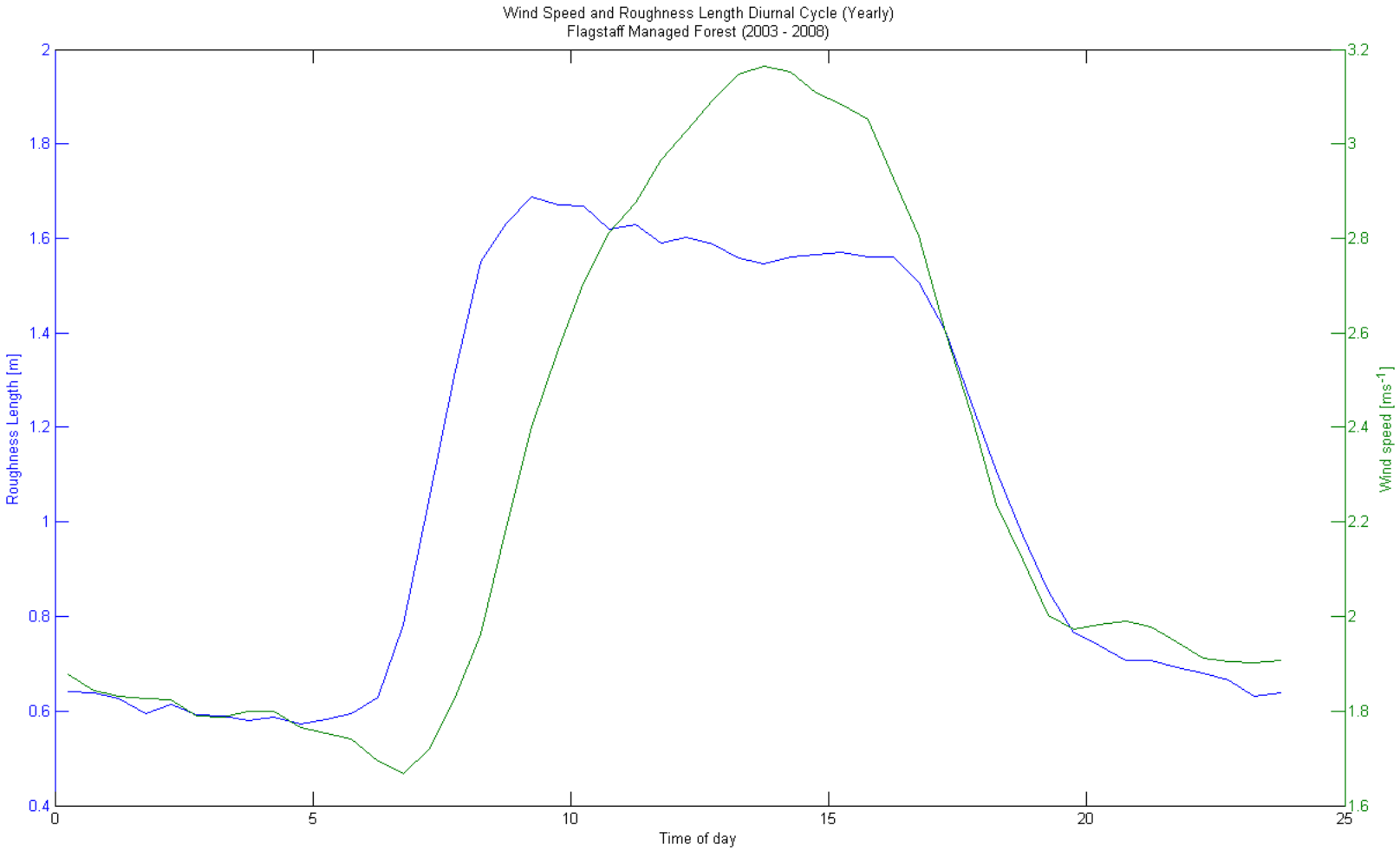


Consistency with the Log law theory - results

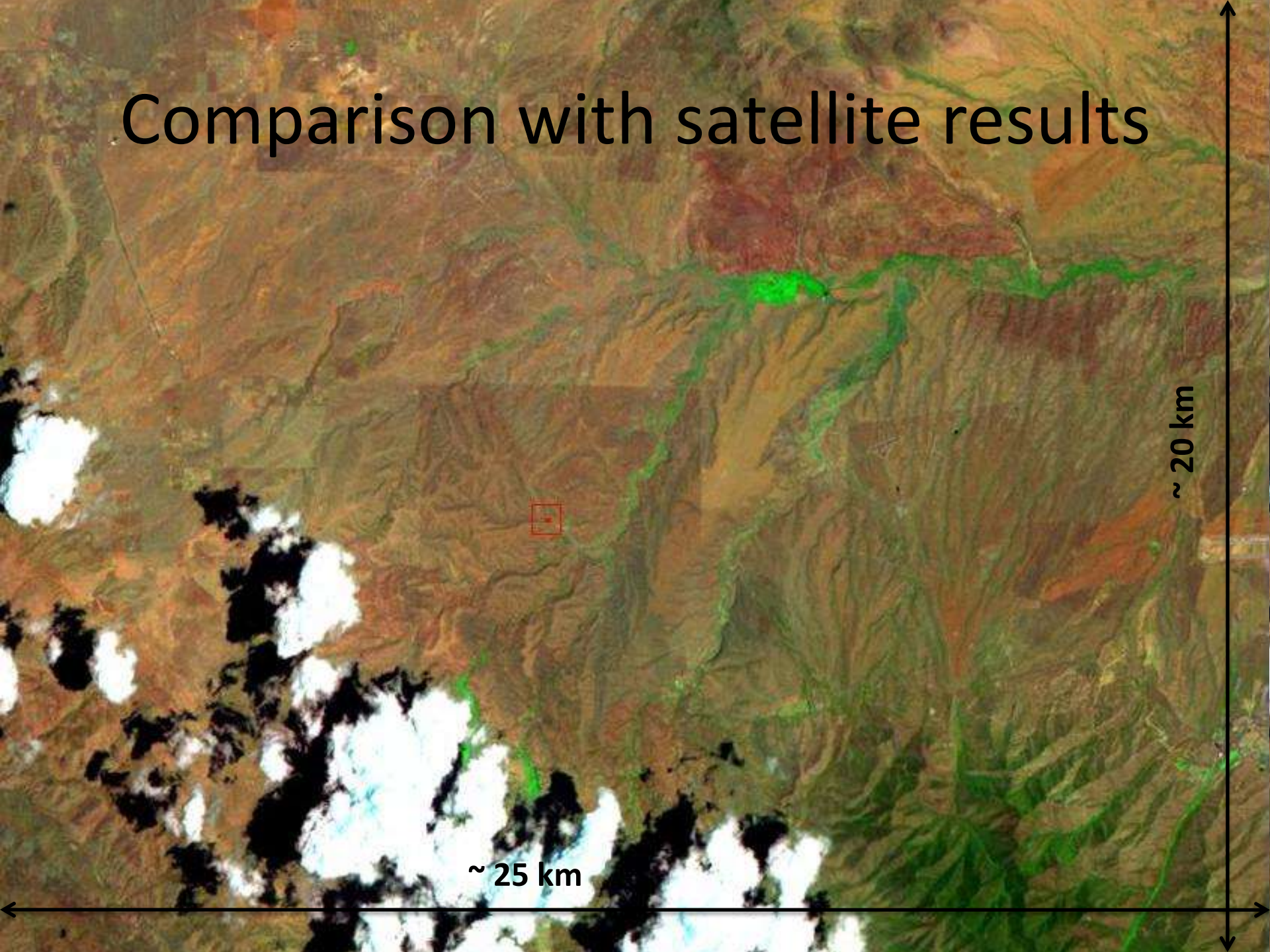
Flagstaff Managed Forest



Flagstaff Managed Forest
Diurnal Cycle of Winds Speed and Roughness Length



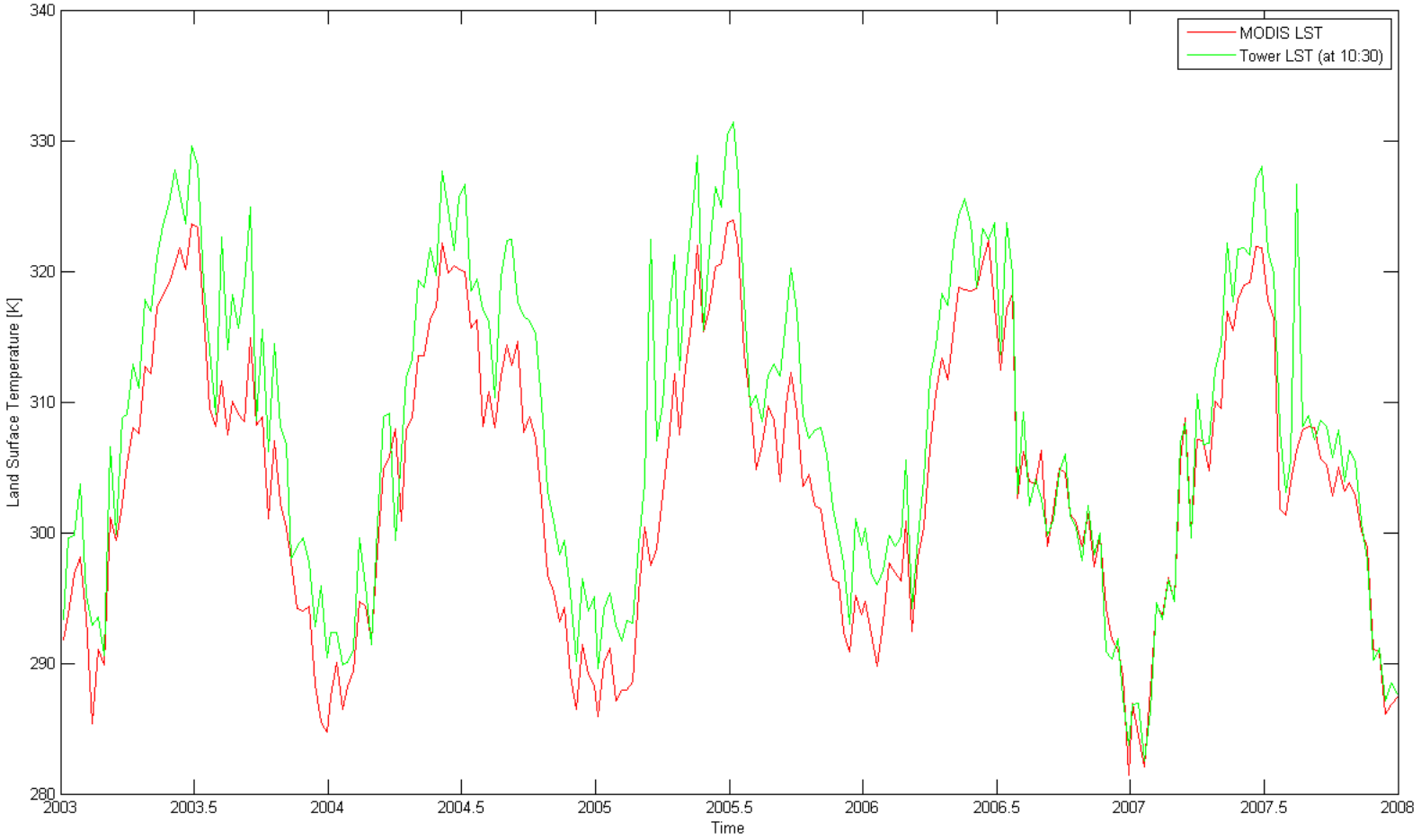
Comparison with satellite results



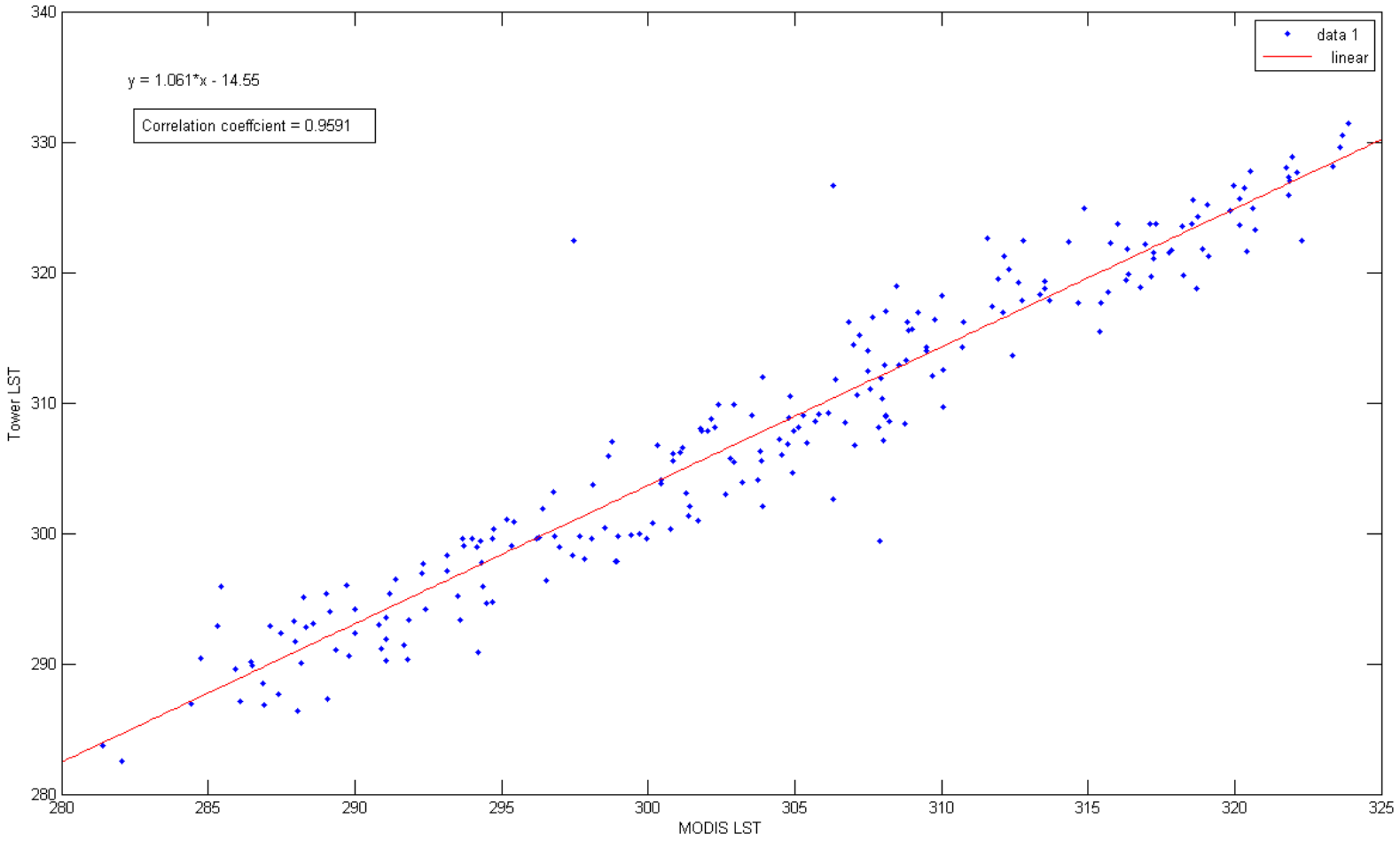
Land Surface Temperature and Albedo

- MODIS
  - LST
    - 8-day composite
    - 1km resolution
  - Albedo
    - Black Sky Albedo
    - Shortwave (350nm – 700 nm)
    - 8-day composite
    - 500m resolution

LST

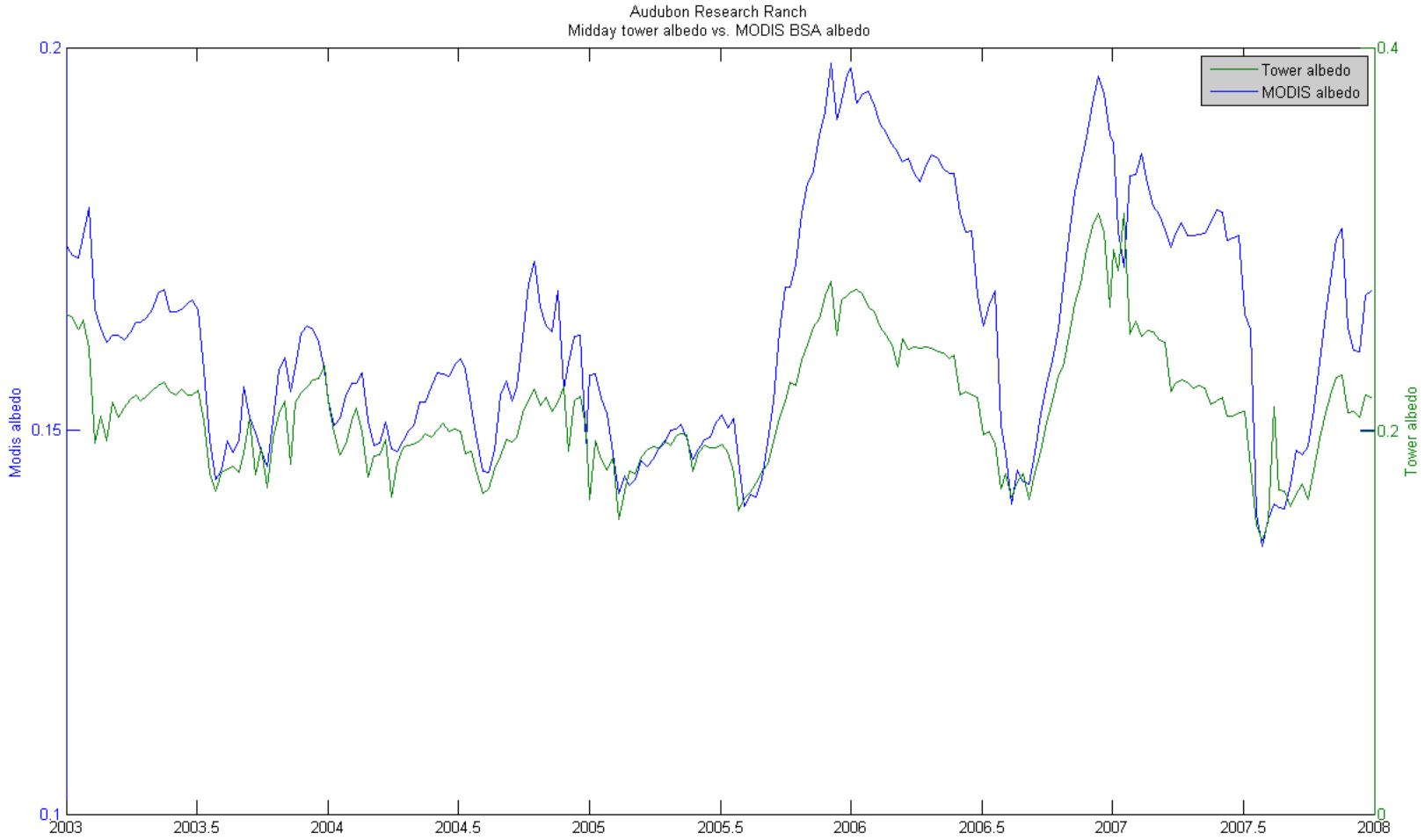

MODIS LST
Tower LST (at 10:30)
Land Surface Temperature [K]
Time
340
330
320
310
300
290
280
2003
2003.5
2004
2004.5
2005
2005.5
2006
2006.5
2007
2007.5
2008

MODIS LST and Tower LST Scatter Plot

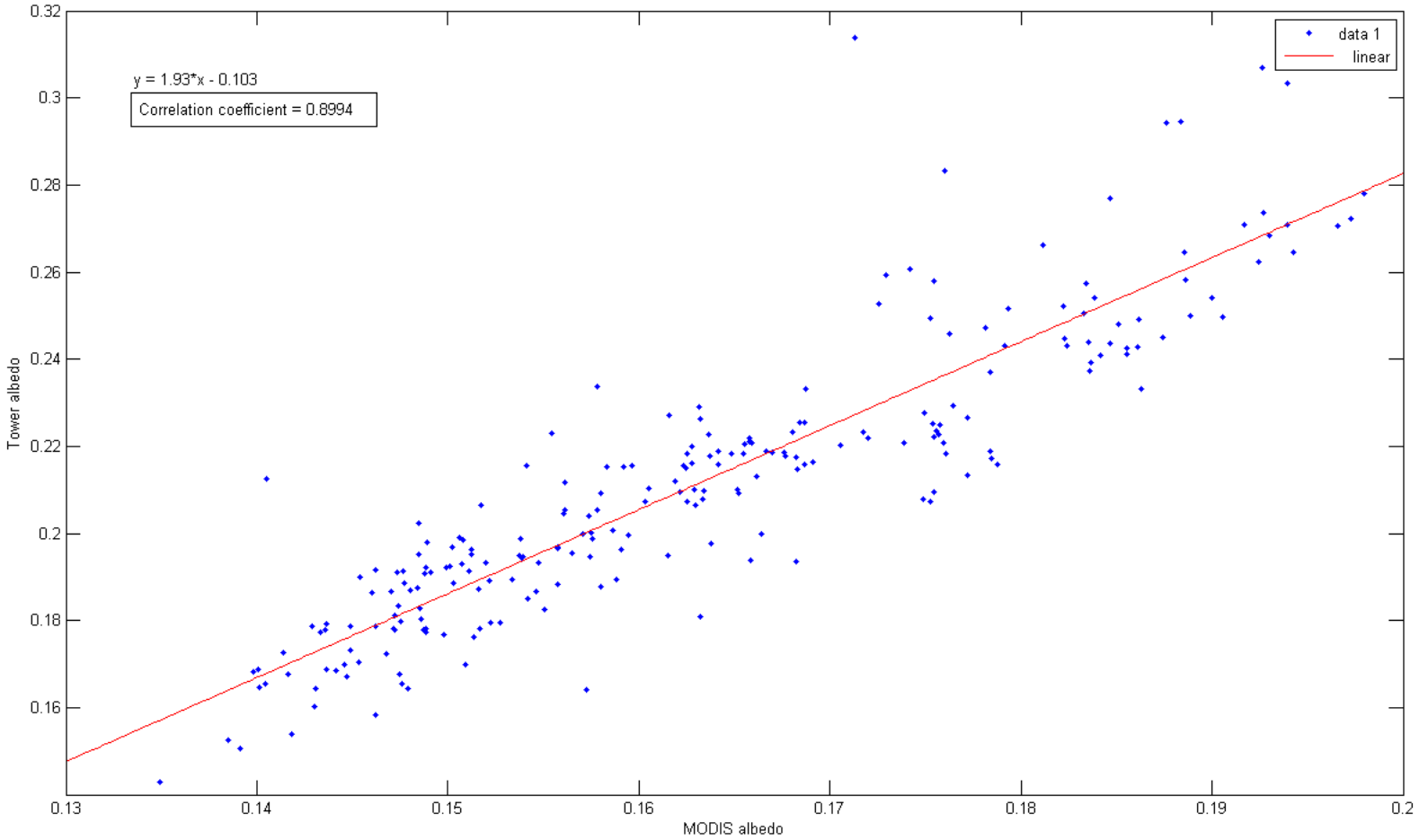


Albedo

MODIS BS albedo and tower albedo
Audubon Research Ranch Area



MODIS albedo and tower albedo scatter plot

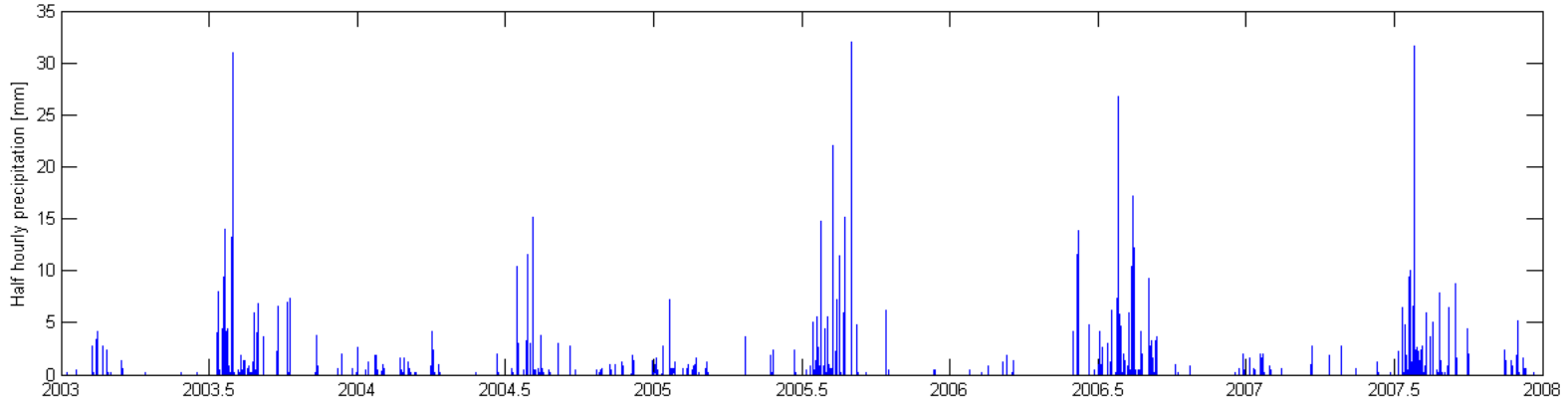


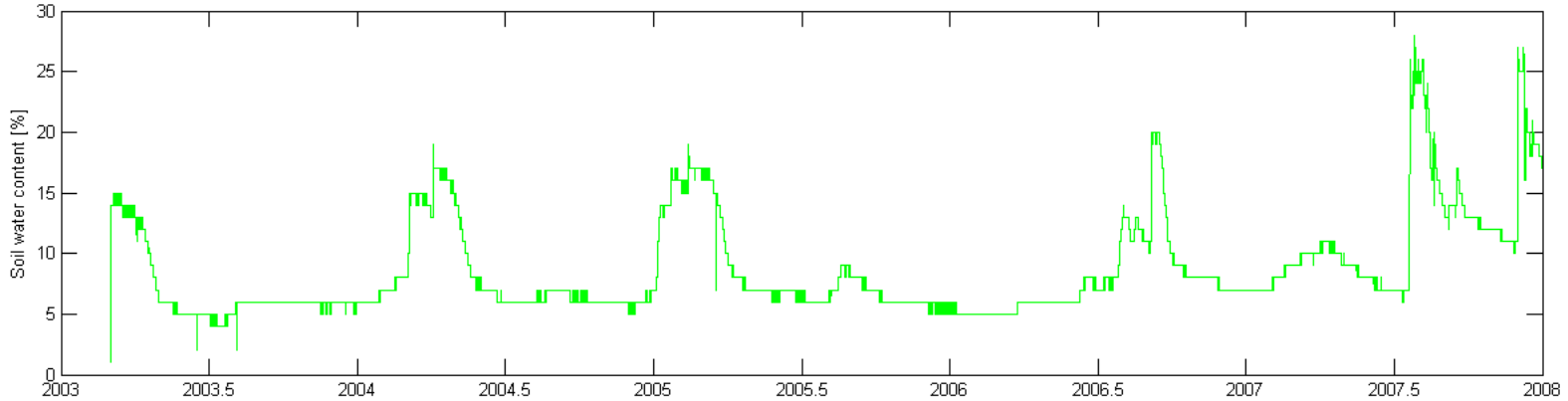
Consistency within measured variables

- Precipitation and soil moisture
  - Precipitation
    - Precipitation measured by tipping bucket method
    - 30min intervals
  - Soil moisture
    - Neutron attenuation method
    - 30 min intervals
  - Expect to see increase in soil moisture after a precipitation event

Measurements

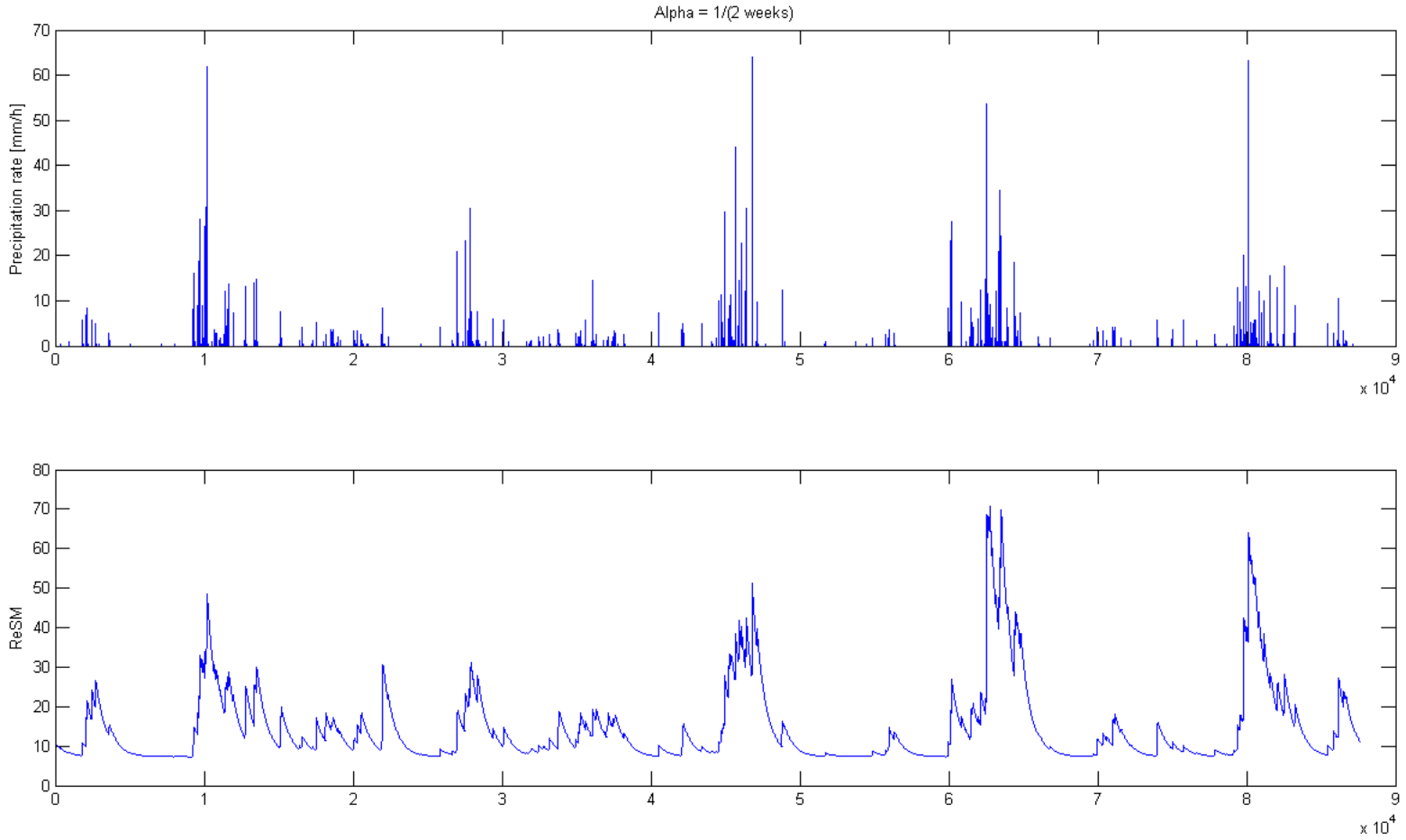
Audubon Research Ranch



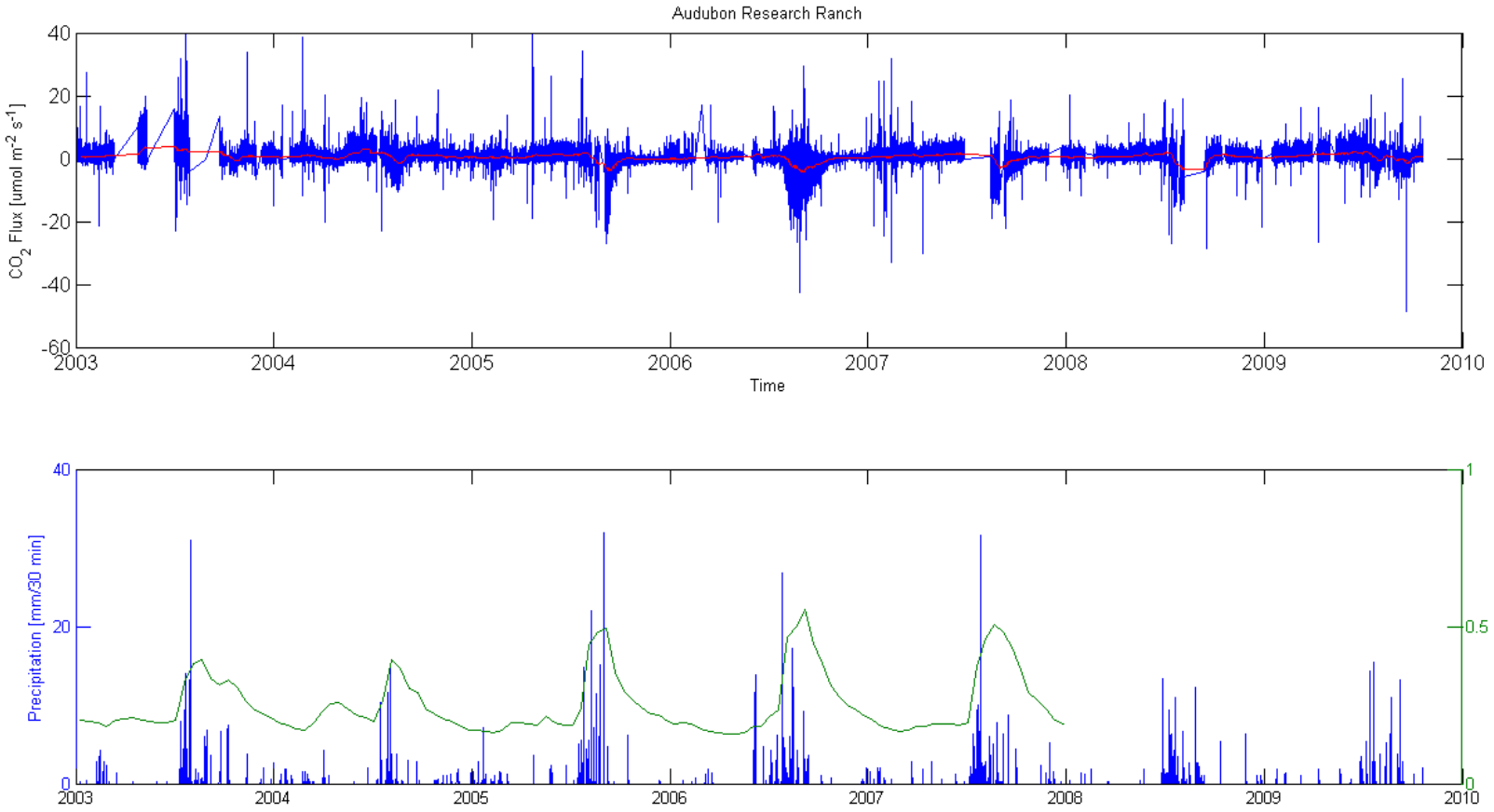


Modeled soil moisture

Audubon research Ranch



Audubon Research Ranch
CO_2 Flux, Precipitation and NDVI



Conclusions

Energy Flux

- Energy flux measurements show substantial errors in high frequency measurements
- Averaged values of error are very small
- Consistent with satellite data!

Log law

- Roughness length varies rapidly – sort of expected because log law invalid at night
- However, averaged roughness length shows no variations
- Diurnal cycle shows constant z_0 during daytime

Conclusions

- **Precipitation and soil moisture**
  - Soil moisture not well correlated with precipitation
  - Measured soil moisture not correlated with modeled soil moisture
    - Model too simple (P-E)
    - Soil moisture data not good

Thank You! ☺