Use of the NASA KSC 50-MHz ST Profiler for Operations Support to Spaceflight — Part II, Characterization of the Atmosphere

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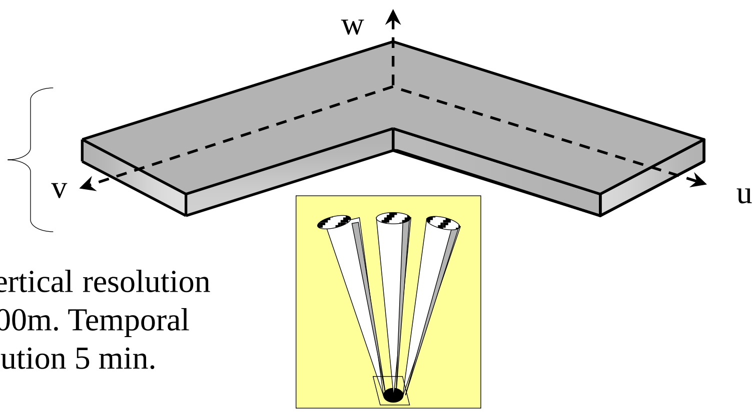
Overview

- Background
  - Determine spatial and temporal characteristics of wind which governs resolution requirements for launch wind measurements.
- Data set characteristics
- Probability distribution of wind changes in time
  - What temporal resolution is needed for launch wind measurements?
- Lifetime of mid-tropospheric features as a function of vertical scale
  - What spatial resolution is needed for launch wind measurements?

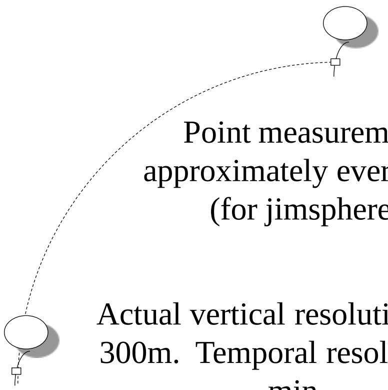
Background

Wind profiling technology is under consideration to supplement balloons (rawinsondes and jimspheres) for day of launch wind measurements

Gate spacing = 150 m



Actual vertical resolution 300 - 500m. Temporal resolution 5 min.



Point measurements approximately every 30 m (for jimspheres)

Actual vertical resolution 150 - 300m. Temporal resolution 60 min.

- Profilers provide substantially higher temporal resolution than balloons
- Balloons provide somewhat higher spatial resolution than profilers
- Is the temporal resolution of profilers required (in other words, is it worth the expense?)
- Is the spatial resolution of profilers adequate?

Data Set

Season:

29 September 1995 through 26 March 1996 - total of 117 days.

Florida winter season characterized by strong westerlies and subtropical jet.

Altitude:

Range Gates 28 through 100 corresponding to the range from 6211 m to 17011 m.

Eliminated known problems with ground clutter and lack of signal at the lowest and highest range gates, respectively.

Maintained altitudes of primary concern to vehicle launch community.

Sample Size:

For assessing the frequency of significant wind changes, over **25 000** wind profiles were accepted for analysis.

For assessing the vertical resolution, only days with over 100 consecutive “good” profiles were used. **93 days** met this criteria resulting in **23045** profiles.

Data QC Process

Quality control absolutely necessary for evaluating tail statistics.

1. Data excluded from analysis if QC logs (see Part I) indicated processing algorithm was affected by obvious sidelobe or other interference signal.
2. Entire profiles with excessive vertical velocities were eliminated (suspect precipitation contamination).
3. Wind estimates with excessive spectral widths were eliminated from the data set (suspect interference signal).
4. Small median test for height and time continuity. (Details in *Mon. Wea. Rev*., **123**, 2165-2180.)
5. Wind estimates with excessive vertical shear or insufficient SNR were eliminated from data set.
6. Manual examination of speed and direction contours for discrimination of natural features such as jet streaks from artifacts such as sidelobe signatures.

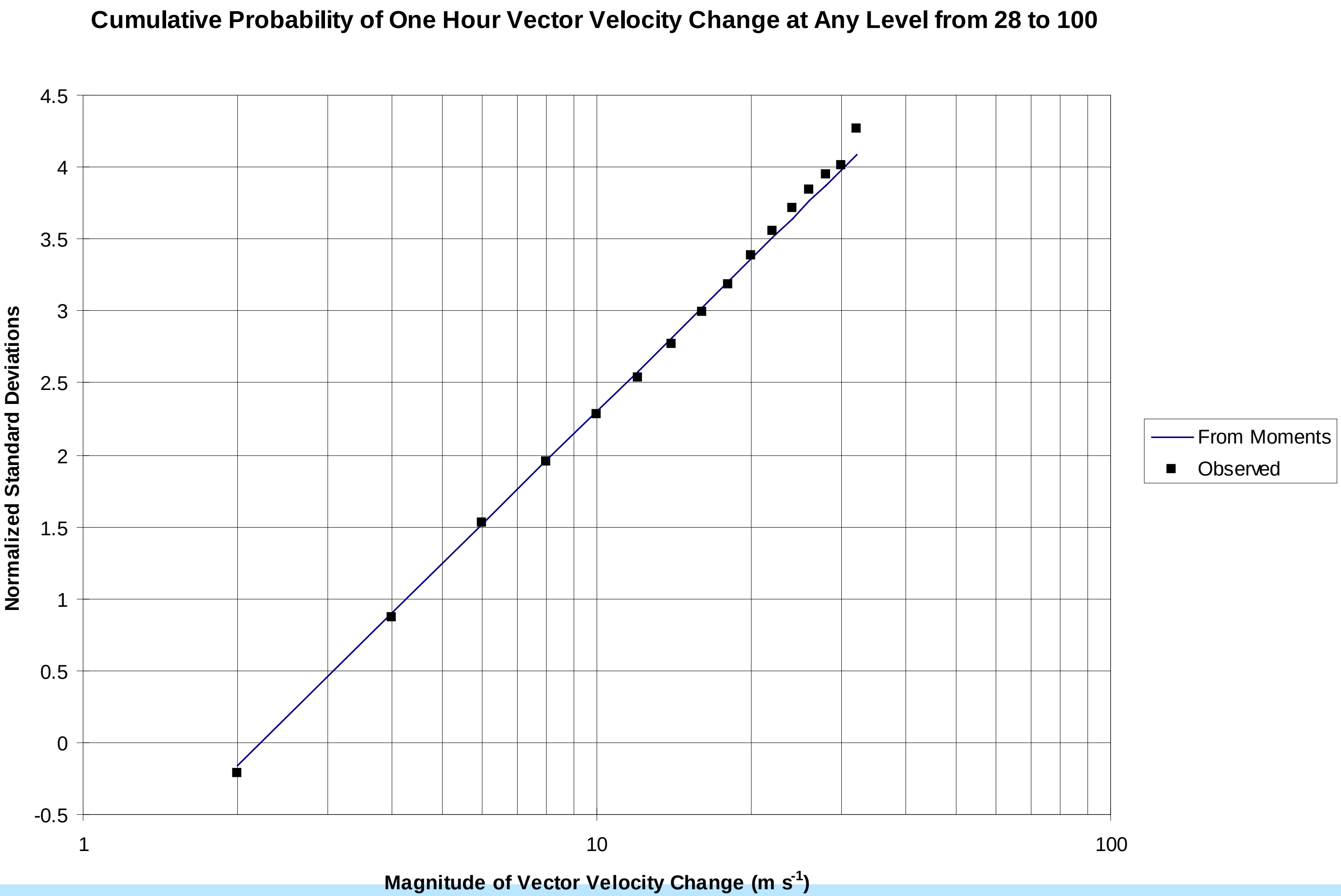
Probability Distribution of Wind Changes in Time

Methodology for determining wind change probability distribution

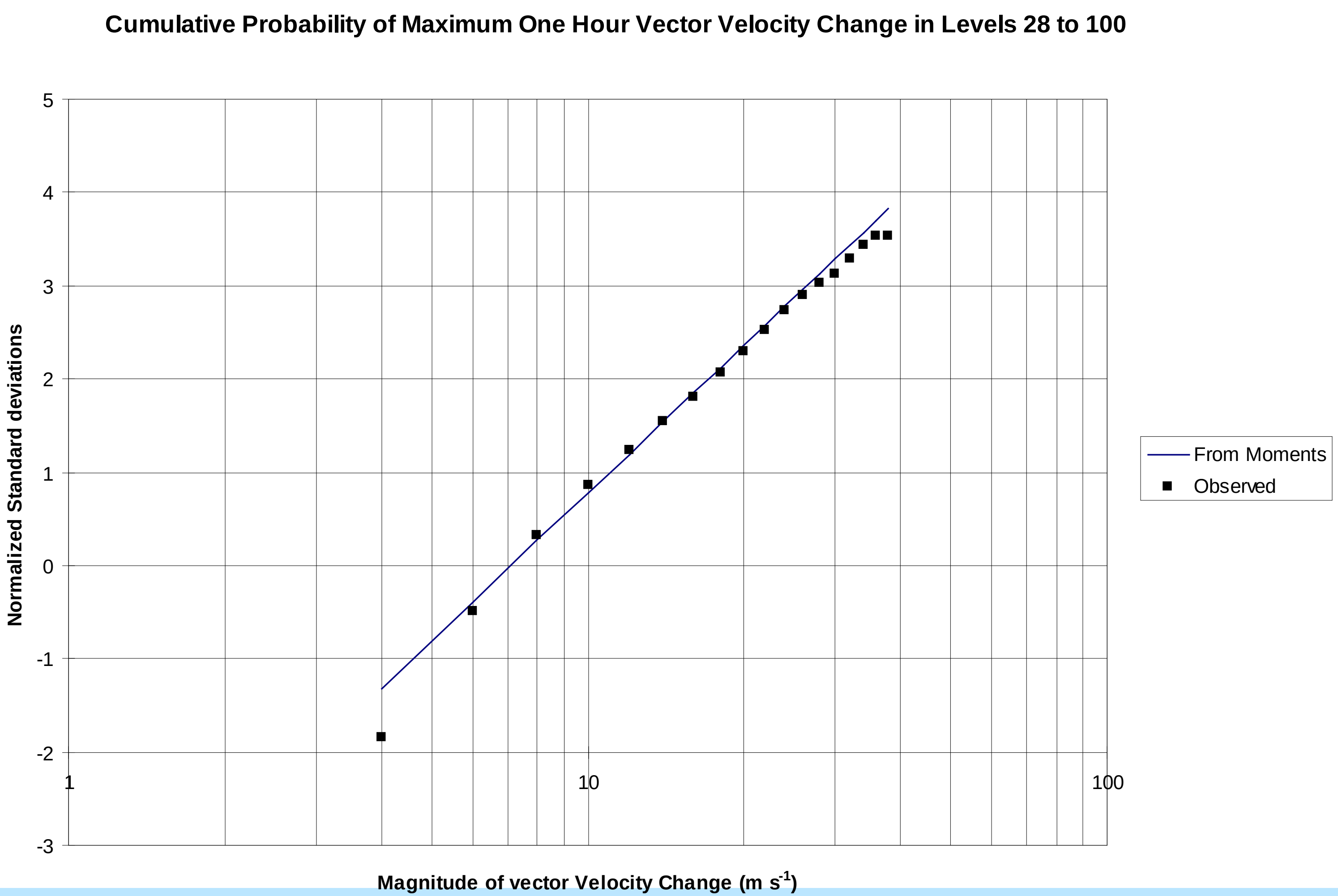
1. Computed composite statistical moments (mean, standard deviation, skewness, and kertosis) of the horizontal wind changes over .25, 1, 2, and 4 hours for entire data set.
2. Compared composite statistics to statistics computed for range gates 32 to 34 (6811 m to 7161 m) only to qualify vertical homogeneity.
3. Noted that data appeared to be lognormally distributed (versus Gaussian).
4. Computed statistical moments and solved for parameters μ and σ of the lognormal distribution based on the moment equation:

$M^n = \exp(n\mu + n^2\sigma^2/2)$ where M^n is the nth central moment.

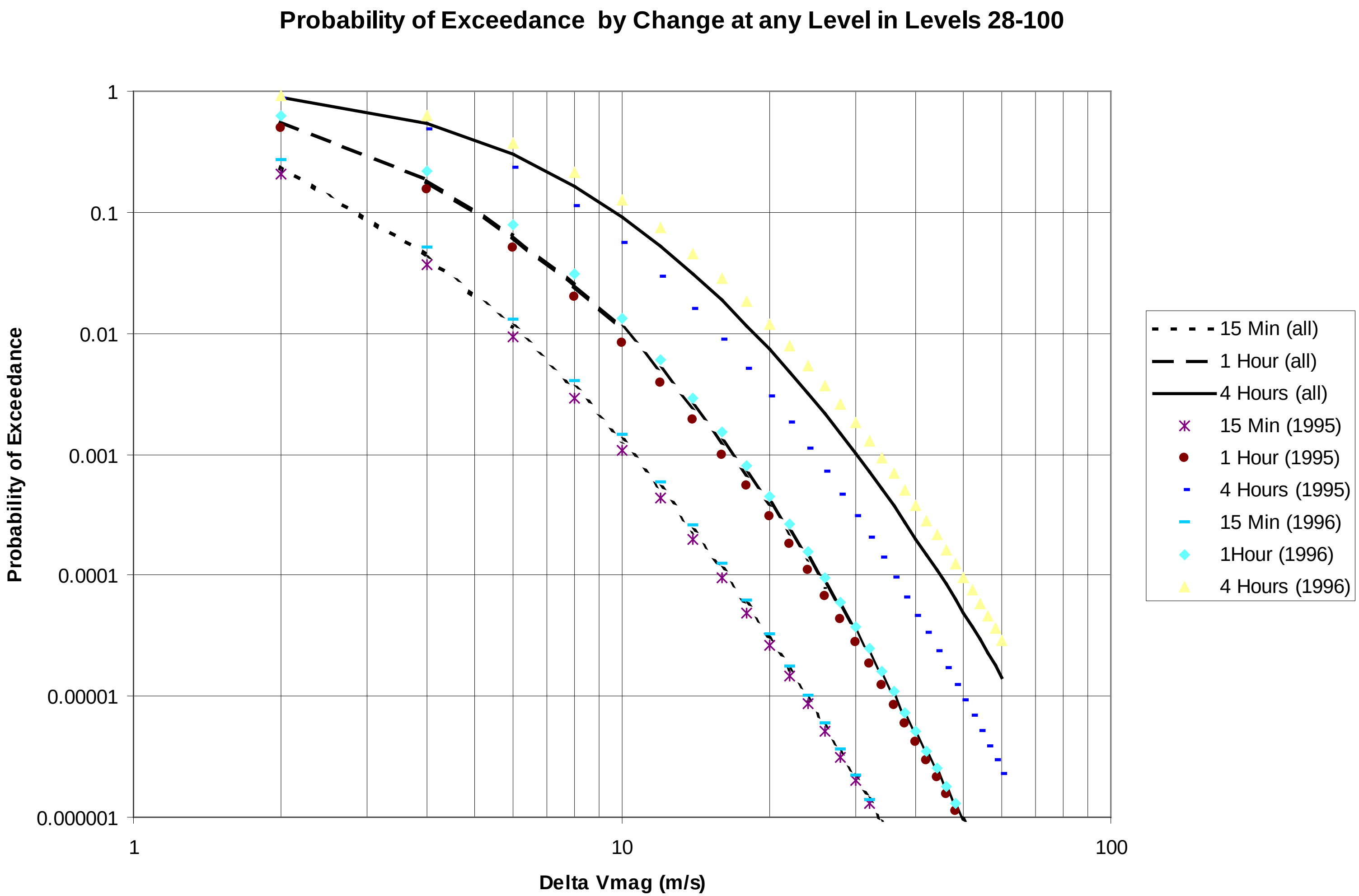
Probability Distribution of Wind Changes in Time



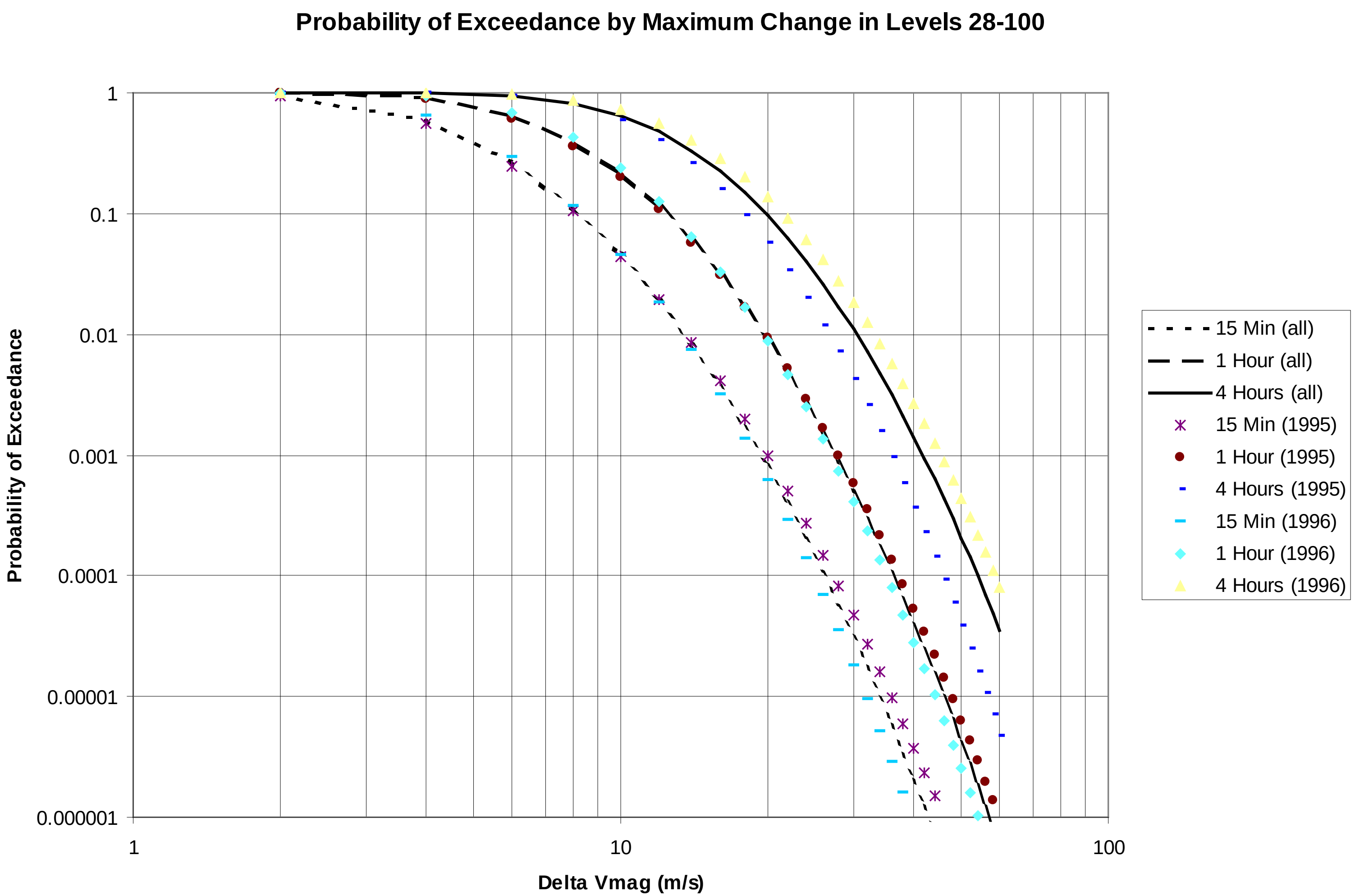
Probability Distribution of Wind Changes in Time



Probability Distribution of Wind Changes in Time



Probability Distribution of Wind Changes in Time



Probability Distribution of Wind Changes in Time

Consequences of Lognormal versus Gaussian distribution

Need graph here. I'm not sure of equation - before I go through the work to make one, I'd like your opinion.

Are we comparing the right things here. If assuming the logs are normally distributed, then we base probabilities on the sigma derived from the normal distribution of the logs.

If we are assuming the differences themselves are Gaussian, then should we compare the sigma computed from the differences themselves rather than from the logarithm's distribution?

Basic stat question, should the sample mean and standard deviation computed from the original differences be equal to the derived mean and standard derived from the sample mean and standard deviation of the logarithm of the differences? In other words, in eq's 6-8 of the rockets paper, what is S and how was it calculated? (Is it the differences sample std. Or is it the std of the log of the differences?)

Lifetime of Mid-Tropospheric Features as a Function of Vertical Scale - Analysis Methodology

- Coherence Analysis using wind profile pairs
- Reduced data range to gates 33-96 (6811 m to 16271 m)
- Vertical Fourier transforms of 64 gate records
  - Parzen (triangular) window
  - Detrend/Demean
  - Ensemble of 23 045 pairs separated by 5, 15, 30, 60 120 minutes
- Compute coherence squared
- Select threshold value of coherence squared to define lifetime of a feature (lifetime is defined the time lag beyond which the coherence squared falls below the threshold. (For this paper that value is 0.25 - incoherent and coherent parts have equal power spectra.)

Lifetime of Mid-Tropospheric Features as a Function of Vertical Scale

- Define λ_m as the vertical scale at which the effective lifetime (Coherence^2 = 0.25) is t_{min}
- Analysis yielded $\lambda_m = 127\ t_{min}^{0.537}$ or $t_{min} = 1.2\text{E-}4\ \lambda_m^{1.862}$

A plot here would be nice

Summary

1. Wind changes are lognormally distributed
2. Extreme events are much more frequent than with a Gaussian distribution.
3. The lifetime of mid-tropospheric features varies roughly as the square of the vertical scale.

Conclusions

1. Large wind changes over short time intervals occur frequently enough to justify the cost of using wind profilers to complement balloon measurements on day of launch.
2. The vertical resolution of profilers is adequate to measure features which survive from the time of measurement to the time of launch.