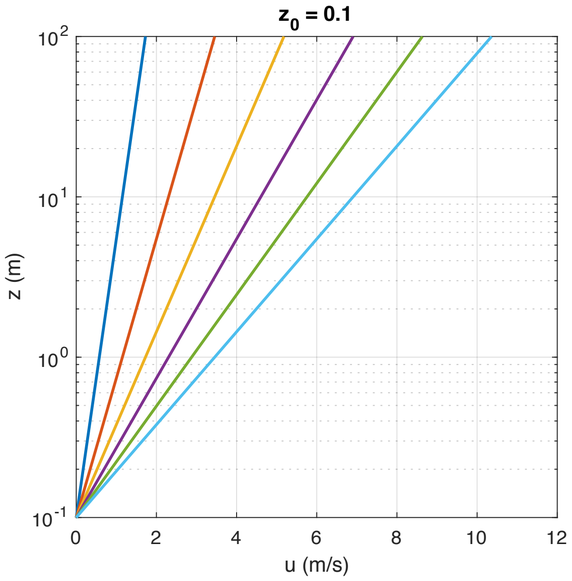
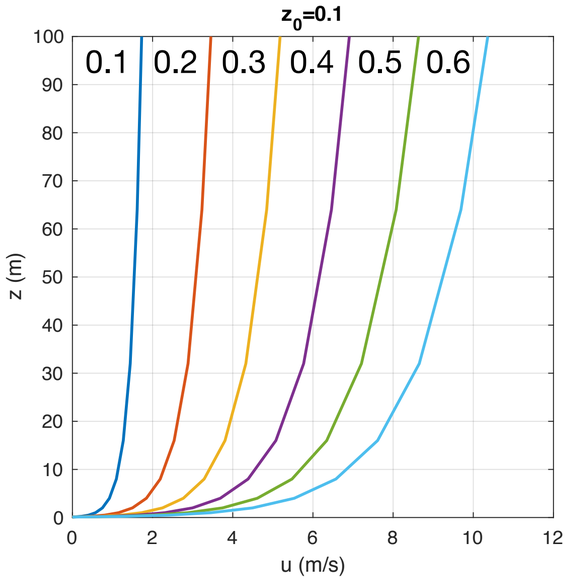
Surface layer wind profiles in neutral stratification

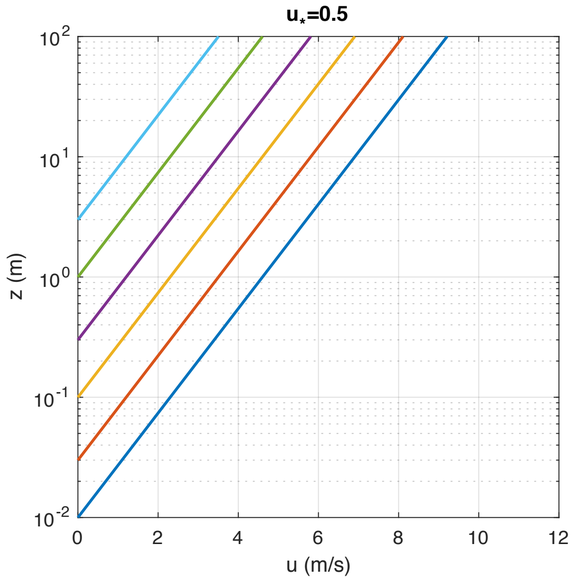
$$|\mathbf{V}| = \frac{u_*}{k} \log\left(\frac{z}{z_0}\right)$$

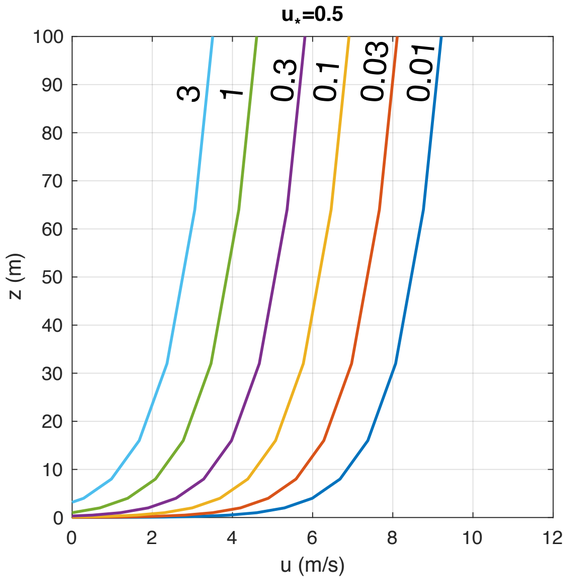
Vary friction velocity (m/s)





Vary roughness length (m)





$$\overline{u'w'} = -u_*^2 = -kzu_* \frac{d\mathbf{V}}{dz} = -ku_* \frac{d\mathbf{V}}{d\log z}$$

Atmospheric Sciences 5300
Surface Layer Wind Profiles

Find u_* and z_0 from the following wind profile measurements made during statically neutral conditions at sunset:

z (m)	$\bar{u}$ (m/s)
0.5	2.8
2	4.2
8	5.6
32	7.0

To calculate u_*, apply the log wind profile

$$u = u_*/k \log(z/z_0),$$

at any two heights z_1 and z_2 to obtain

$$u(z_2) - u(z_1) = u_*/k \log(z_2/z_1),$$

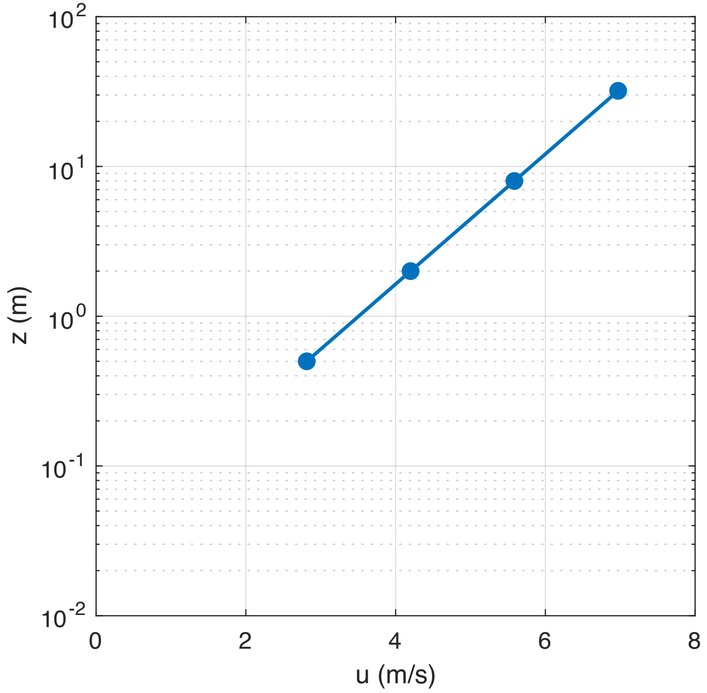
then solve for u_*:

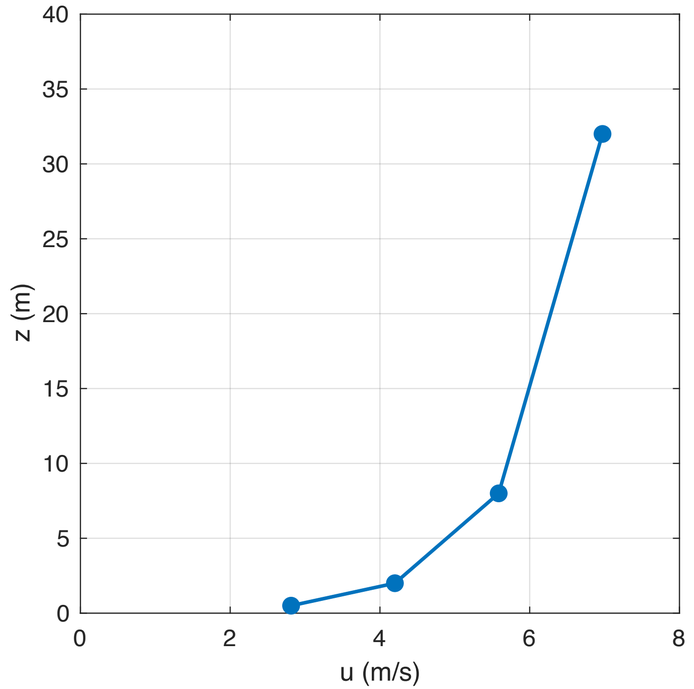
$$u_* = k\frac{u(z_2) - u(z_1)}{\log(z_2/z_1)}.$$

To calculate z_0, solve the log wind profile at any height z for z_0:

$$z_0 = z \exp(-ku(z)/u_*).$$

The graphical solution method is to plot the wind profile u versus $\log z$, then extrapolate the profile to $u = 0$. The height at which $u =$ is z_0.





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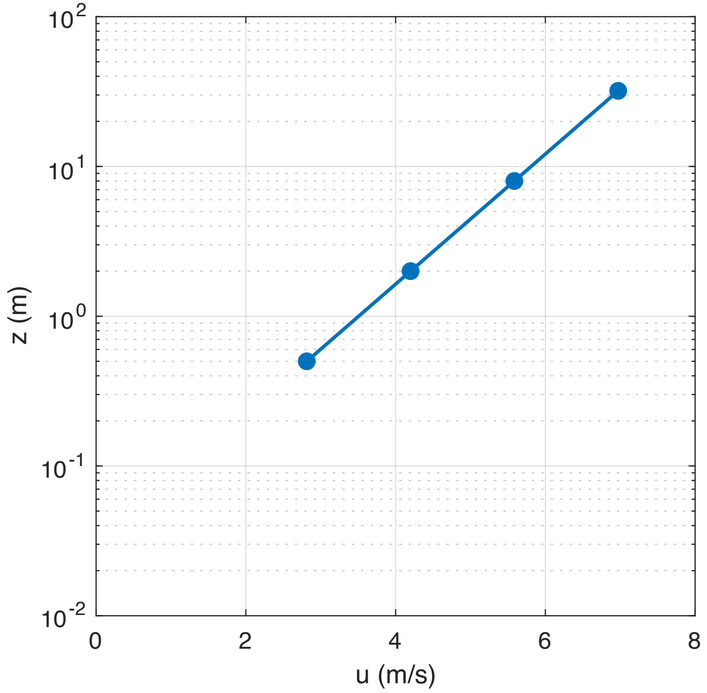
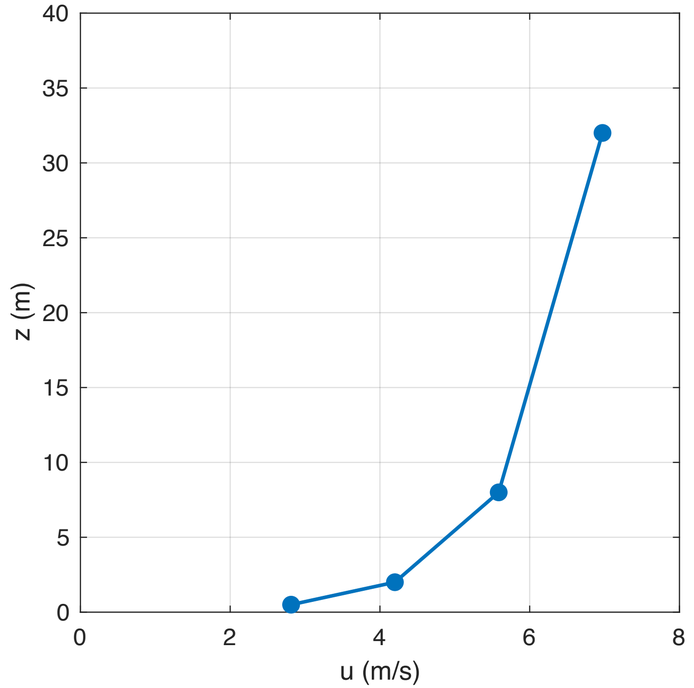
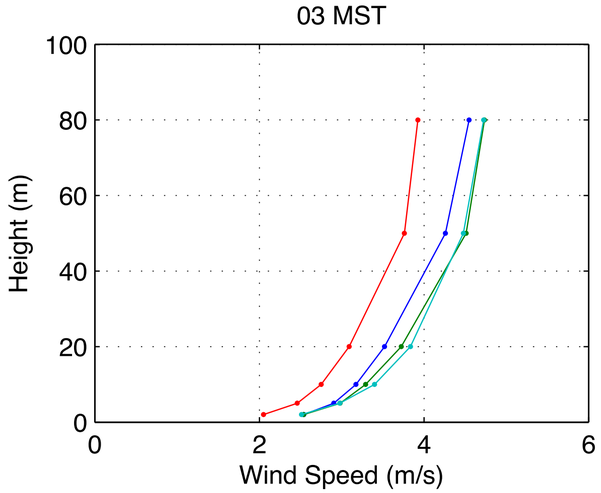
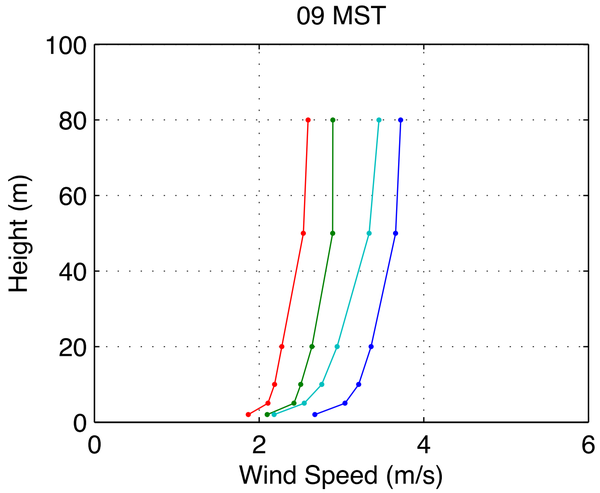
Answer:
$u_* = 0.4$ m/s, $z_0 = 0.03$ m.

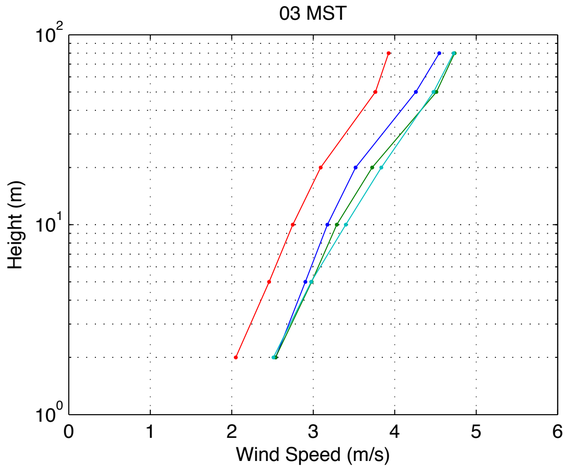


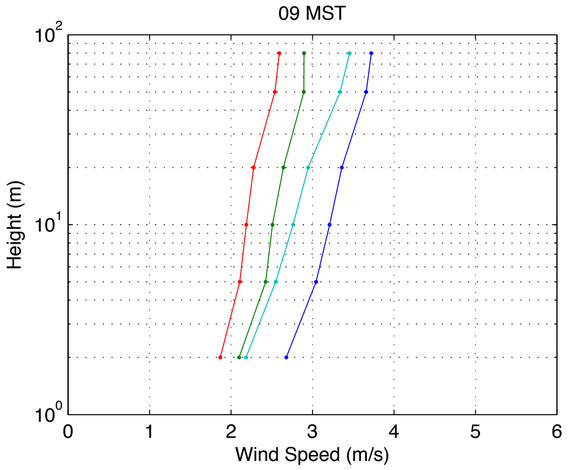


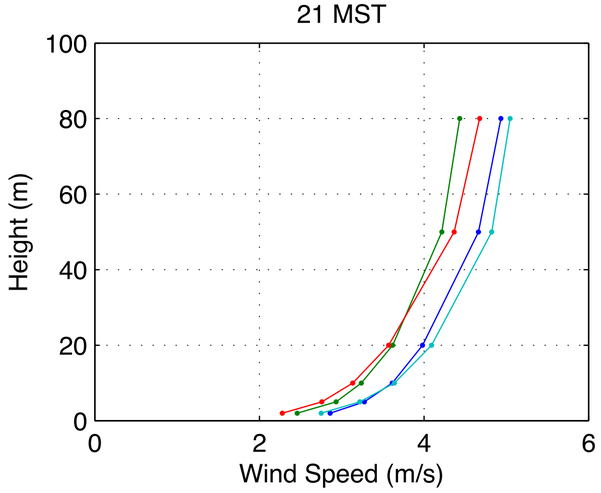
Boulder, Colorado, 82-m meteorological tower

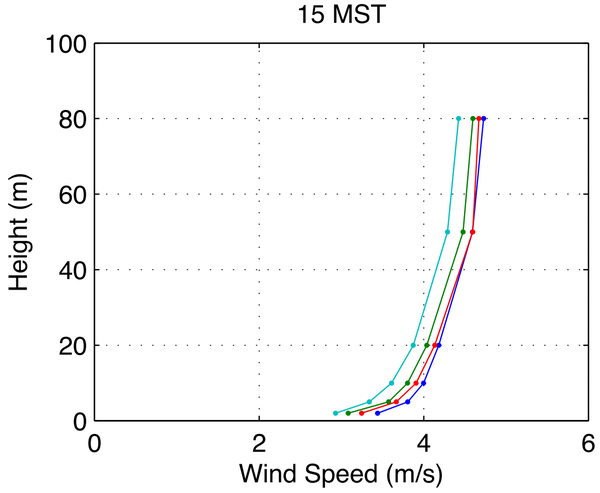

03 MST
Height (m)
Wind Speed (m/s)
0
20
40
60
80
100
0
2
4
6

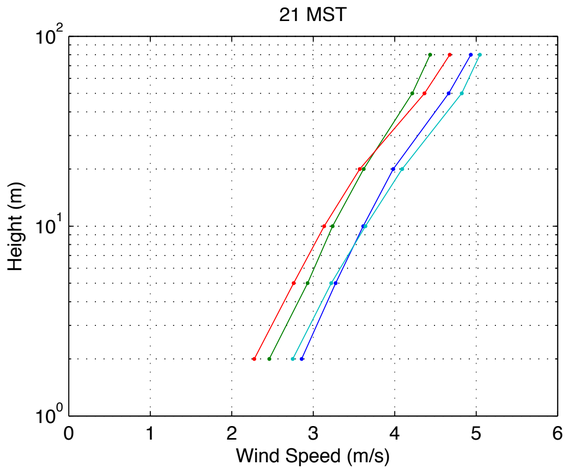

09 MST
Height (m)
Wind Speed (m/s)
0
20
40
60
80
100
0
2
4
6

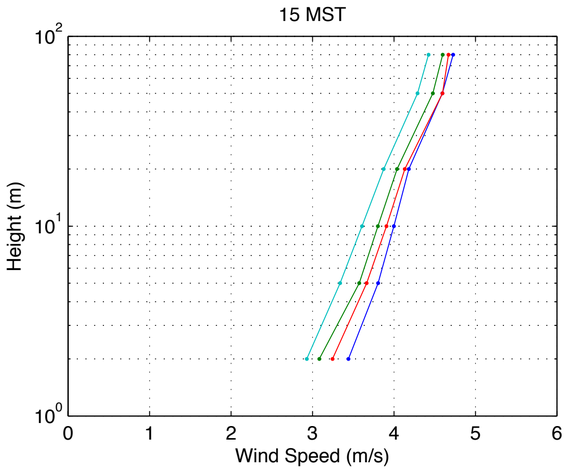

03 MST
Height (m)
Wind Speed (m/s)
10^0
10^1
10^2
0
1
2
3
4
5
6


09 MST
Height (m)
Wind Speed (m/s)
10^0
10^1
10^2
0
1
2
3
4
5
6


21 MST
Height (m)
Wind Speed (m/s)
0
20
40
60
80
100
0
2
4
6


15 MST
Height (m)
Wind Speed (m/s)
0
20
40
60
80
100
0
2
4
6


21 MST
Height (m)
Wind Speed (m/s)
10^0
10^1
10^2
0
1
2
3
4
5
6


15 MST
Height (m)
Wind Speed (m/s)
10^0
10^1
10^2
0
1
2
3
4
5
6