Atmospheric Measurements with Kites and Miniaturized Sensors

Geoff Bland/NASA/GSFC (613)

Why?

Understanding Community Air Quality:
https://thrivingearthexchange.org/projects/

Eclipse Impacts on Local Winds:
https://solarsystem.nasa.gov/eclipses/future-eclipses/

Sponsored by the NASA Science Activation *AEROKATS and ROVER Education Network* (*AREN*/Henry/NNX16AB95A) and the GSFC *Aerovator* project (Bland, et al)

Atmospheric Measurements with Kites and Miniaturized Sensors

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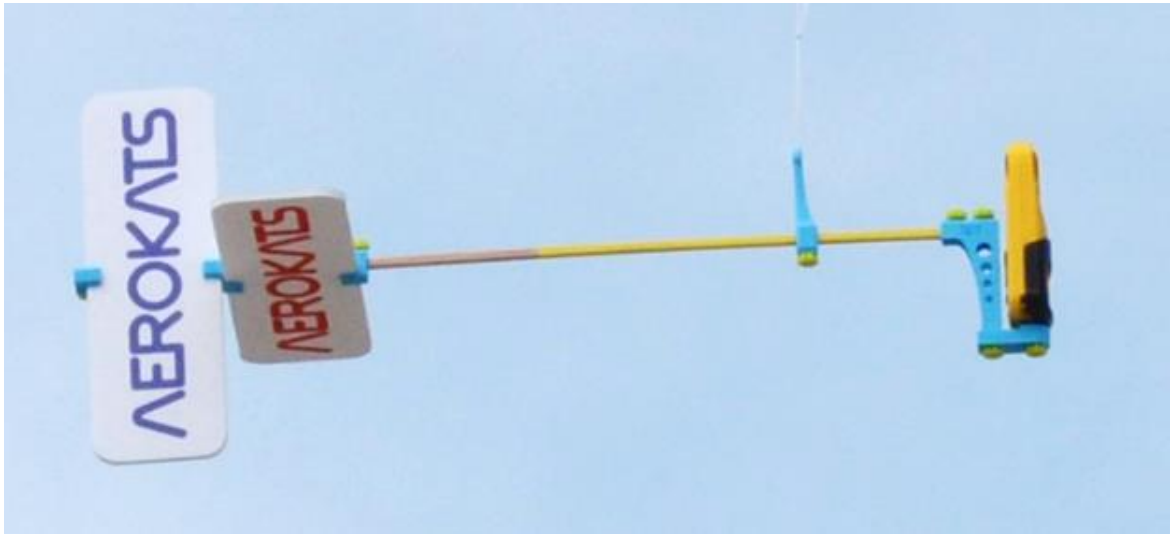
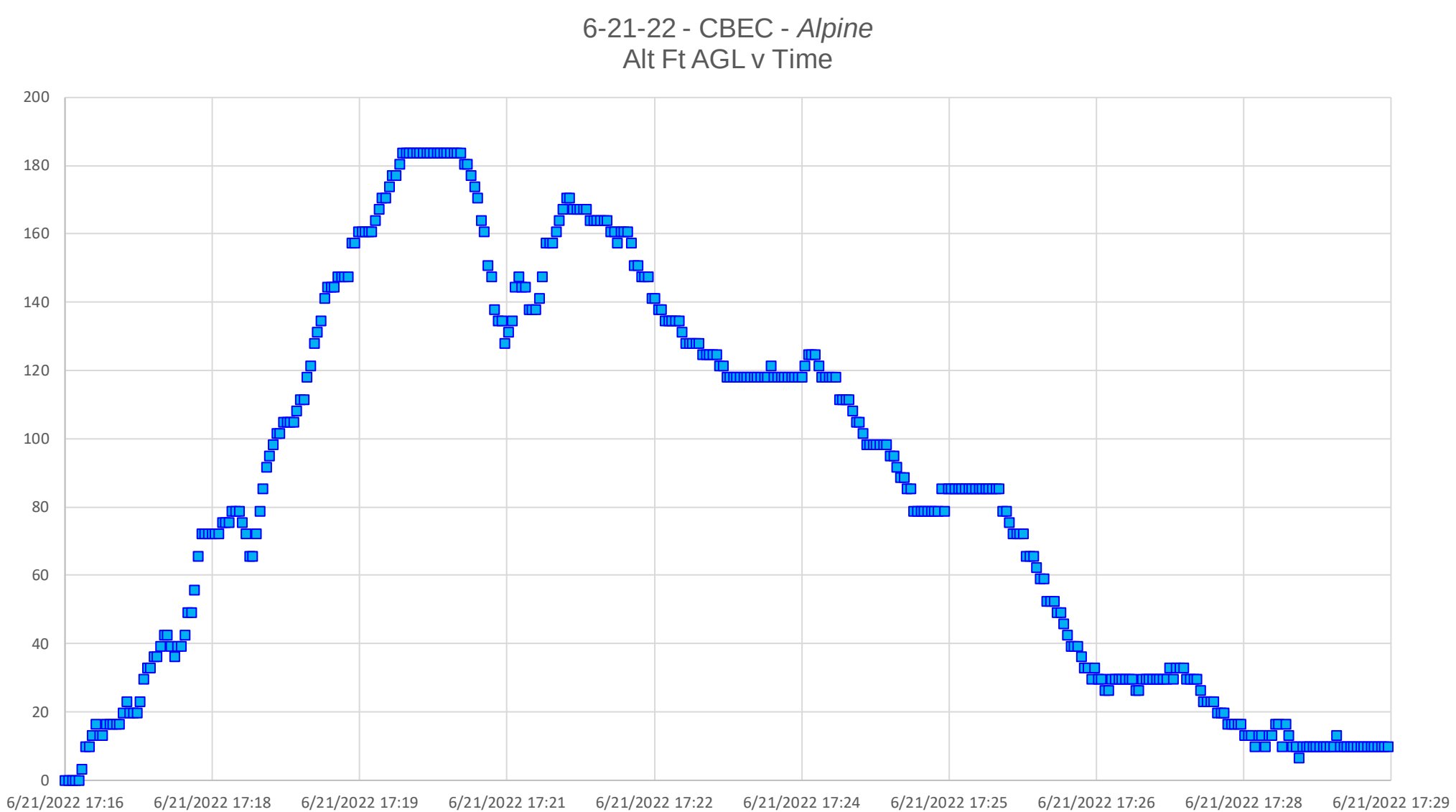
- Winds, Temperature, Humidity: *Profiler* "Aeropod*" with *Kestrel 5500 Weather Meter**
- Kite Performance
- Particulates (PM 2.5/10)
- Chemistry – Sulfur Dioxide

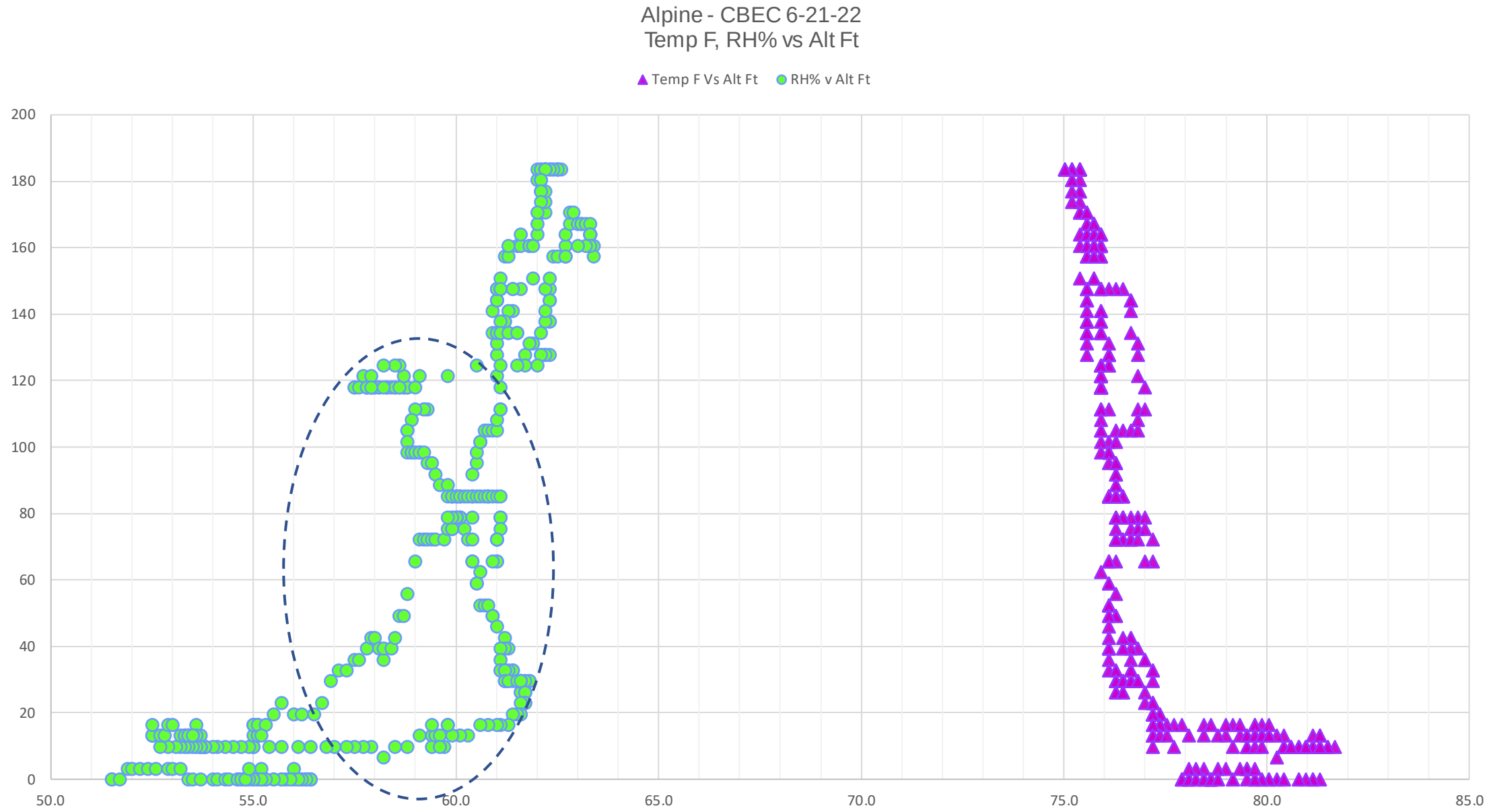


* US Patent # 8,196,853
** Dimensions: 5.0 x 1.8 x 1.1 in. / 12.7 x 4.5 x 2.8 cm
Weight: 3.6 Ounces / 102 Grams
https://kestrelmeters.com/products/kestrel-5500-weather-meter
2 second data rate typical... > 10,000 data points
Temperature, Humidity, Pressure, Wind Speed, Wind Direction

Low Wind – *Alpine*

Chesapeake Environmental Center (CBEC), MD: 6-21-22


6-21-22 - CBEC - *Alpine*
Alt Ft AGL v Time
200
180
160
140
120
100
80
60
40
20
0
6/21/2022 17:16
6/21/2022 17:18
6/21/2022 17:19
6/21/2022 17:21
6/21/2022 17:22
6/21/2022 17:24
6/21/2022 17:25
6/21/2022 17:26
6/21/2022 17:28
6/21/2022 17:29



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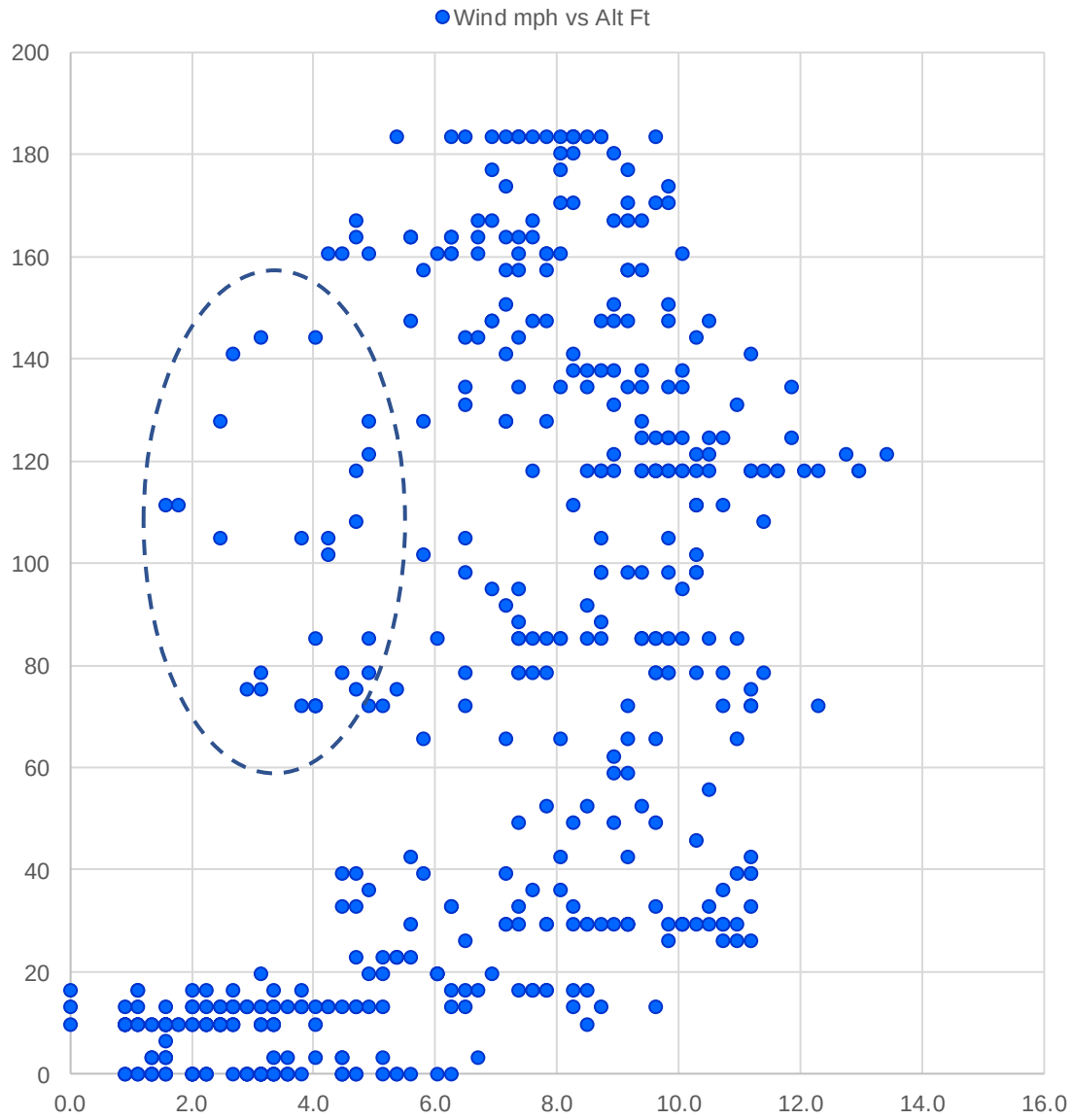
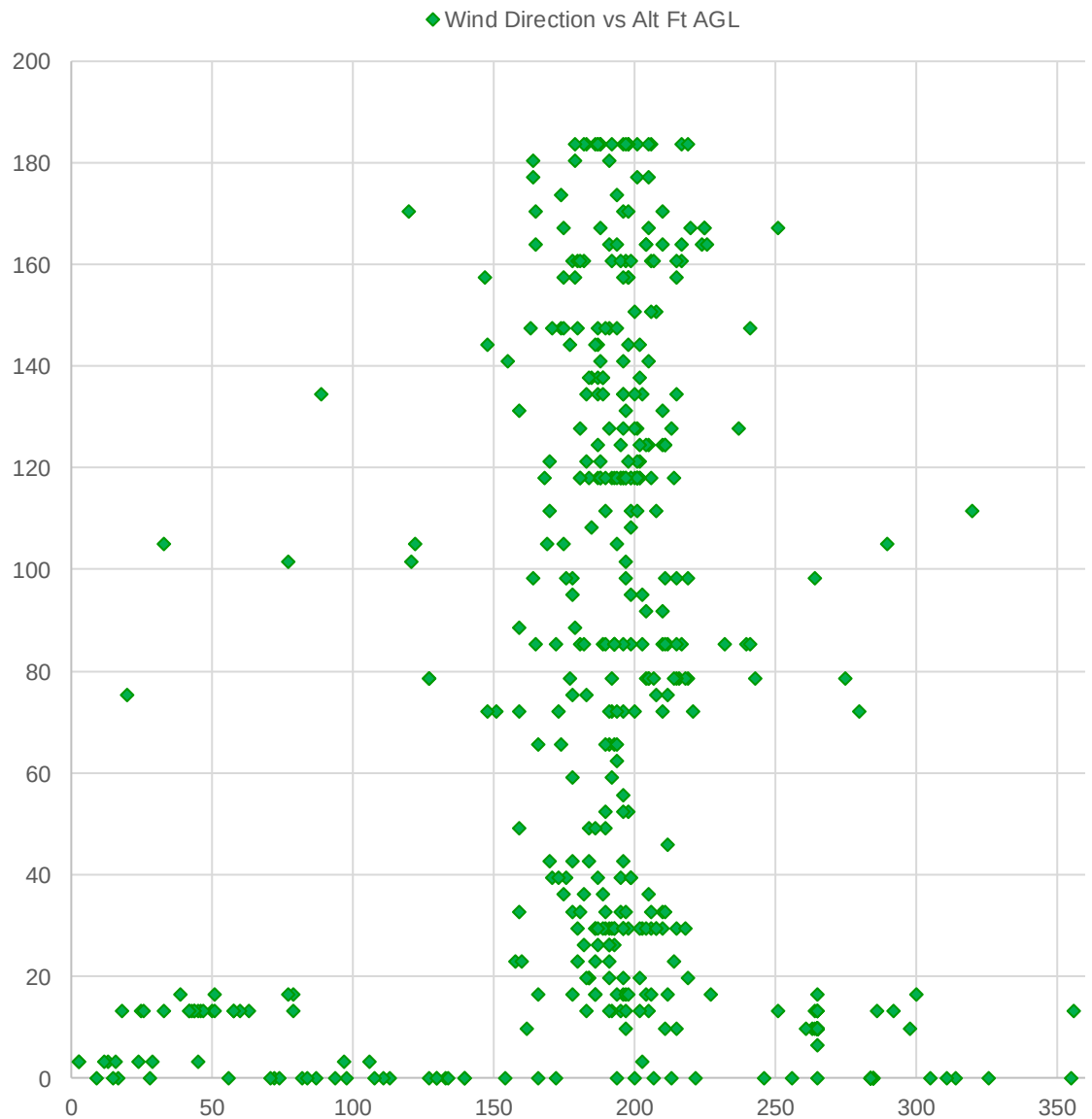
Alpine 6-21-22
Wind MPH F Vs Alt



Alpine 6-21-22
Wind Direction vs Alt Ft AGL



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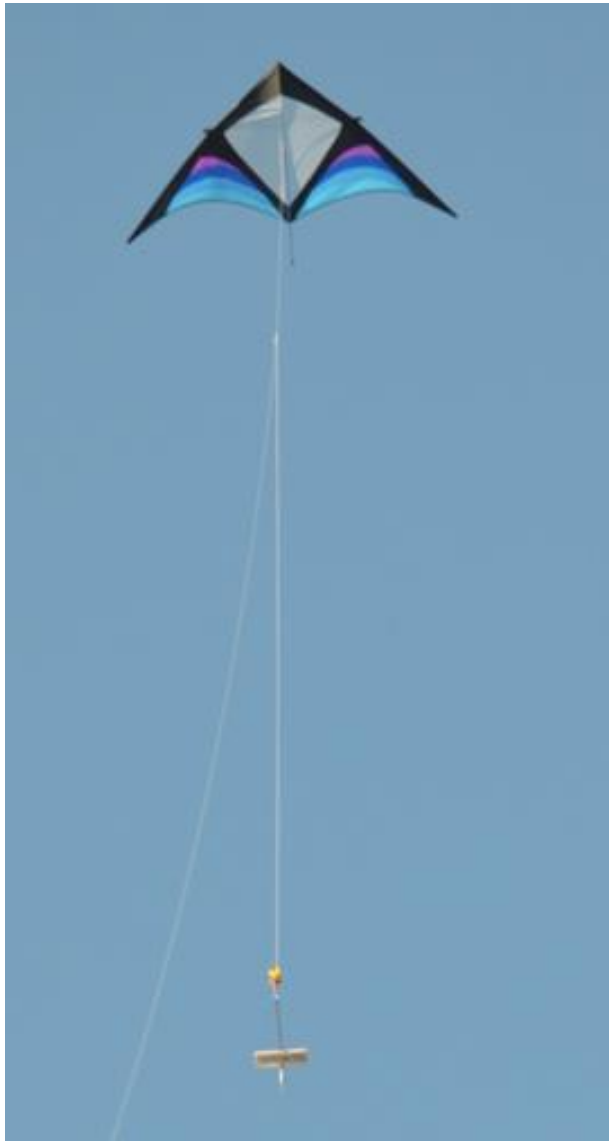
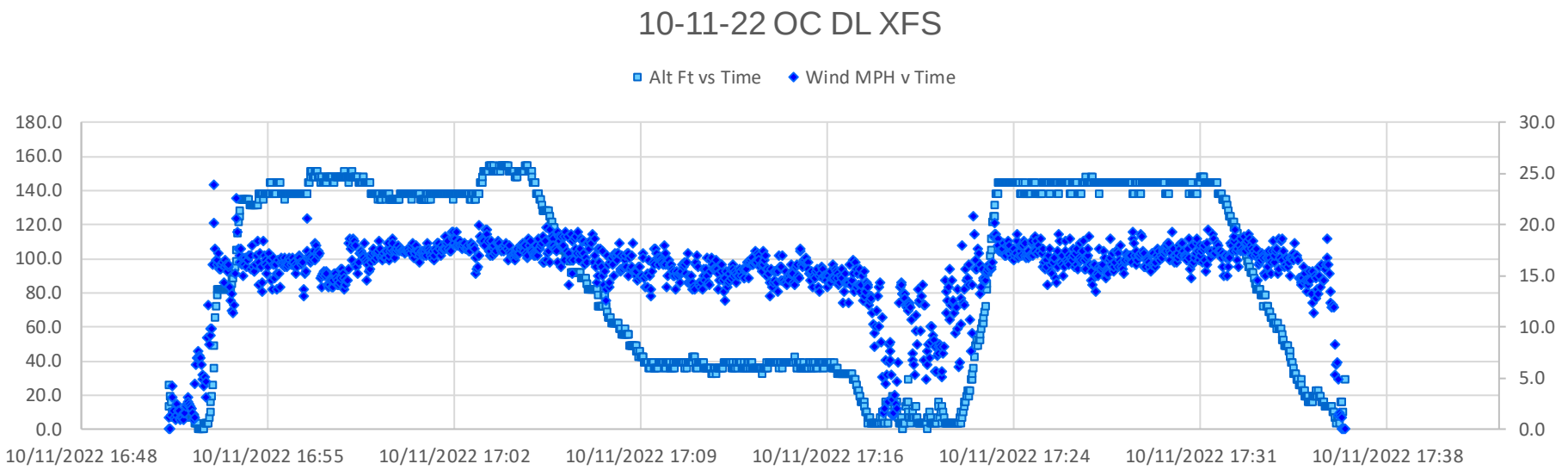
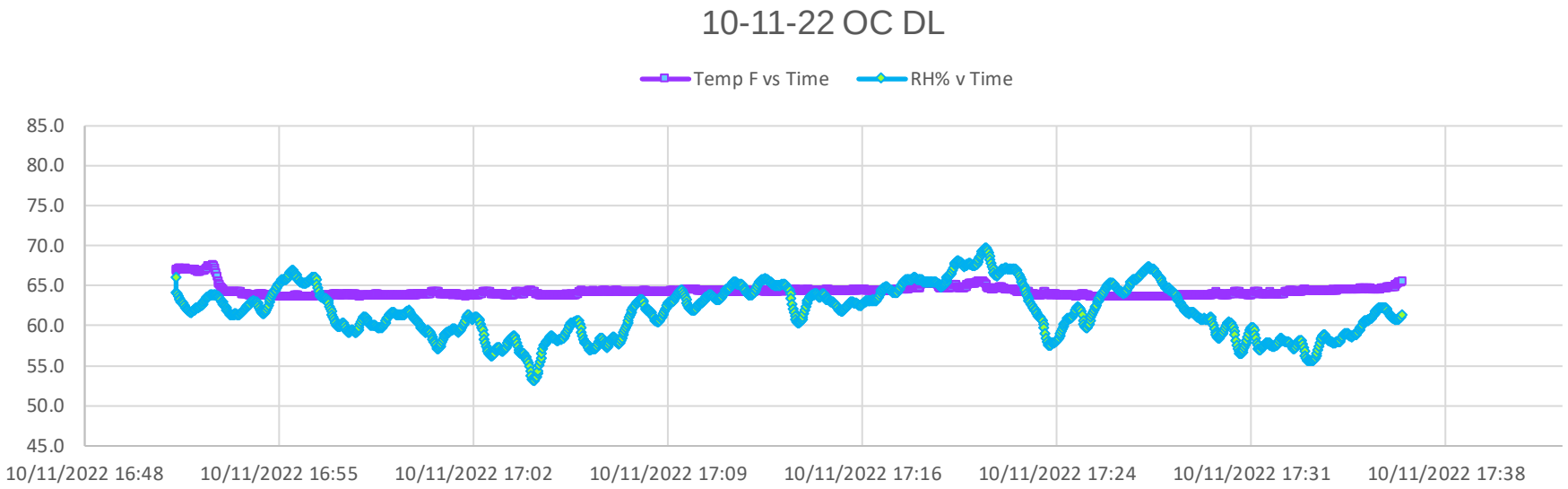
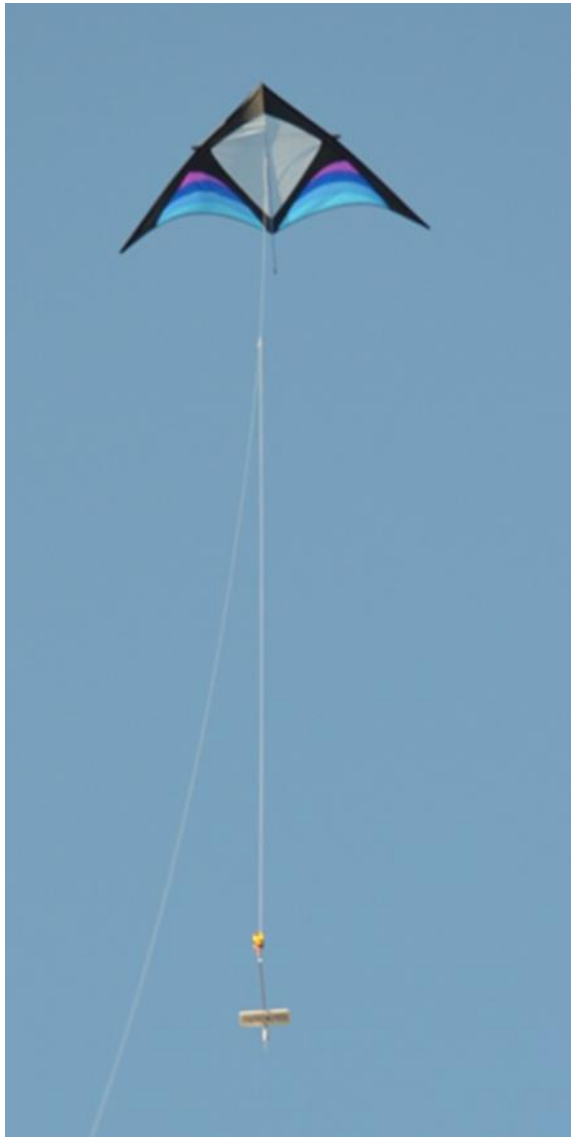
Coastal Breeze – DL *XFS*

Ocean City MD, 10-11-22









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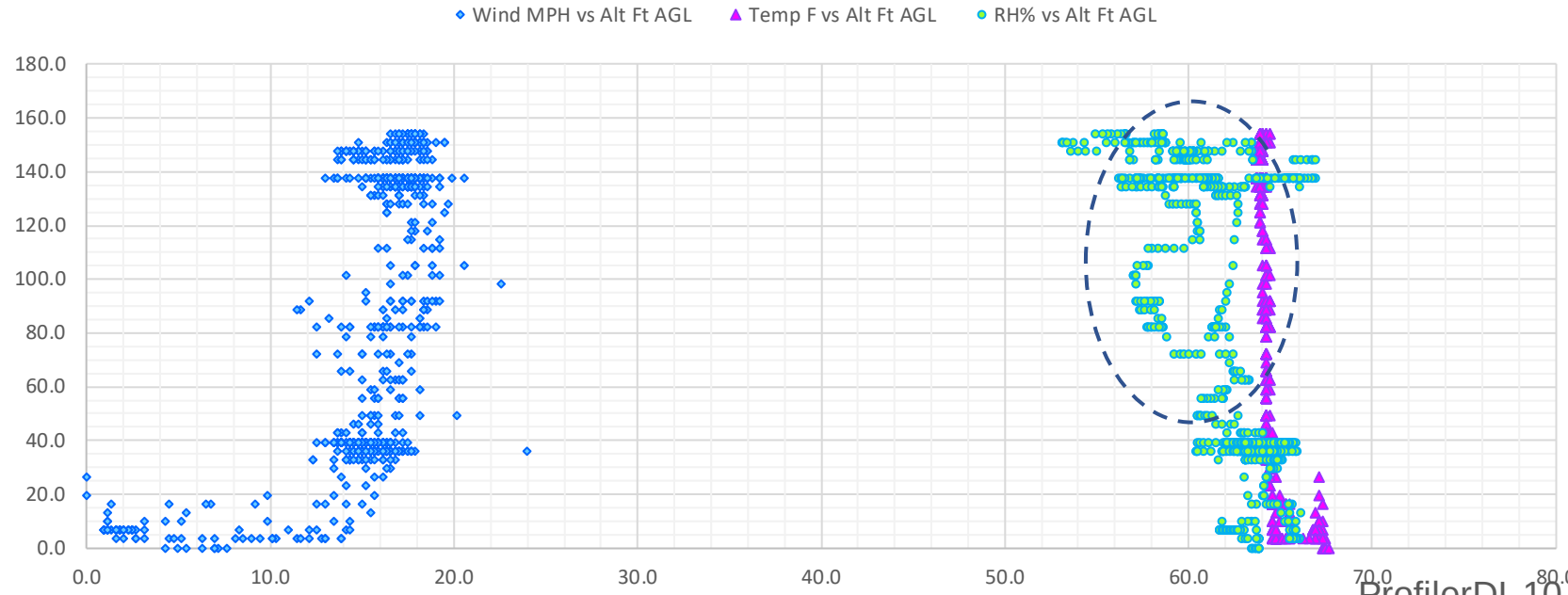
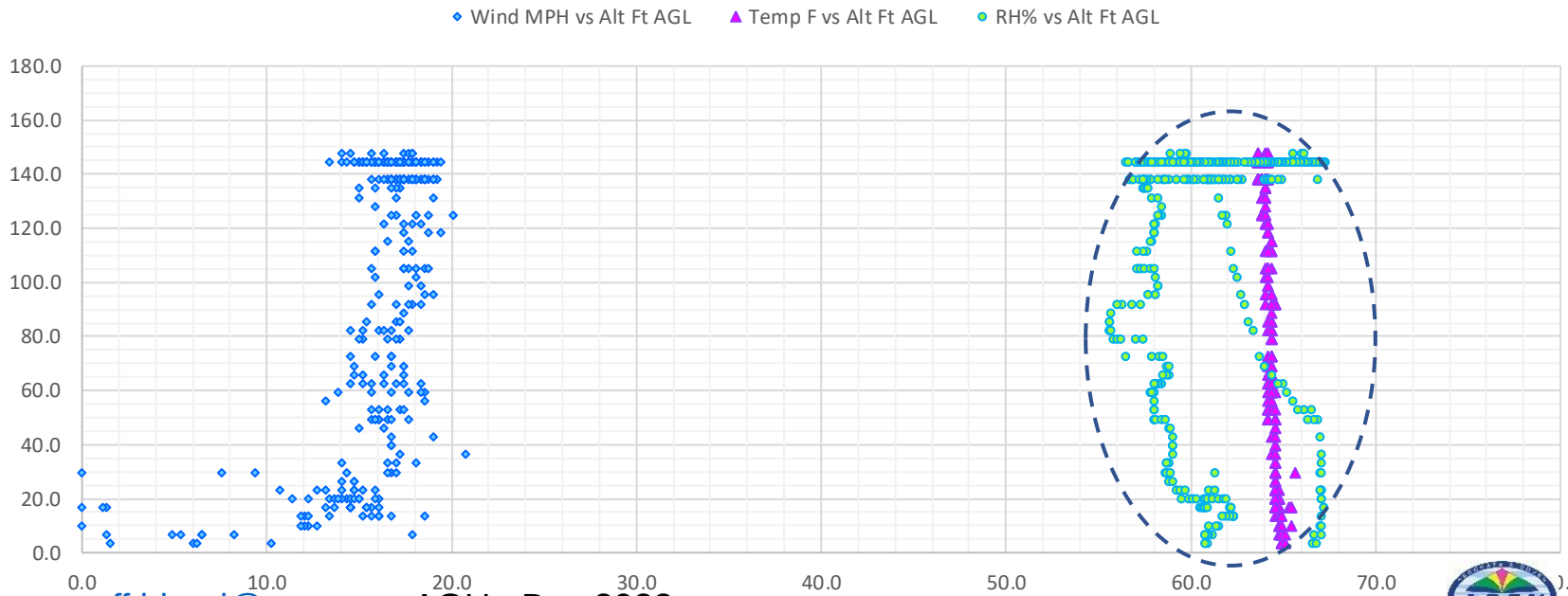
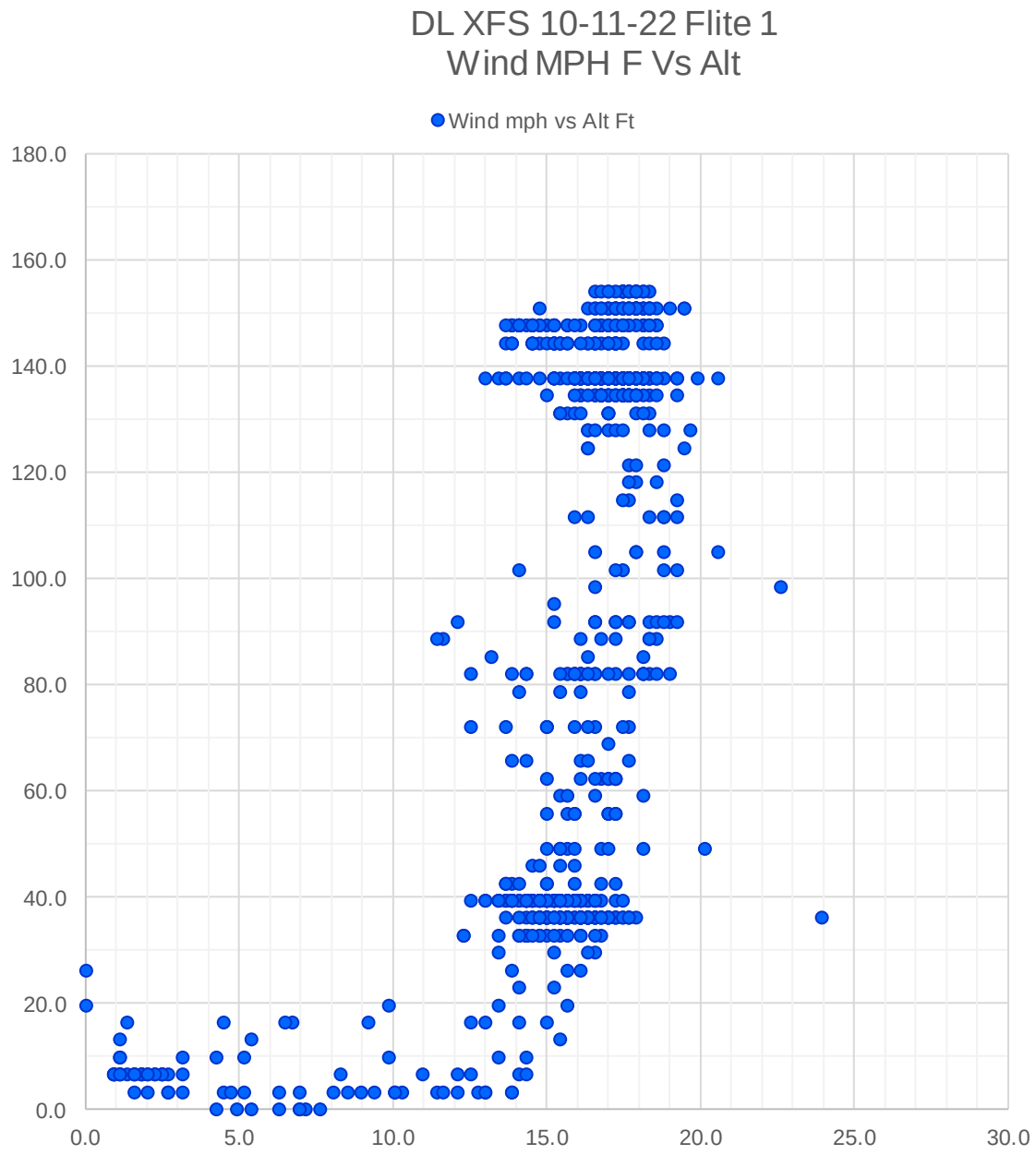
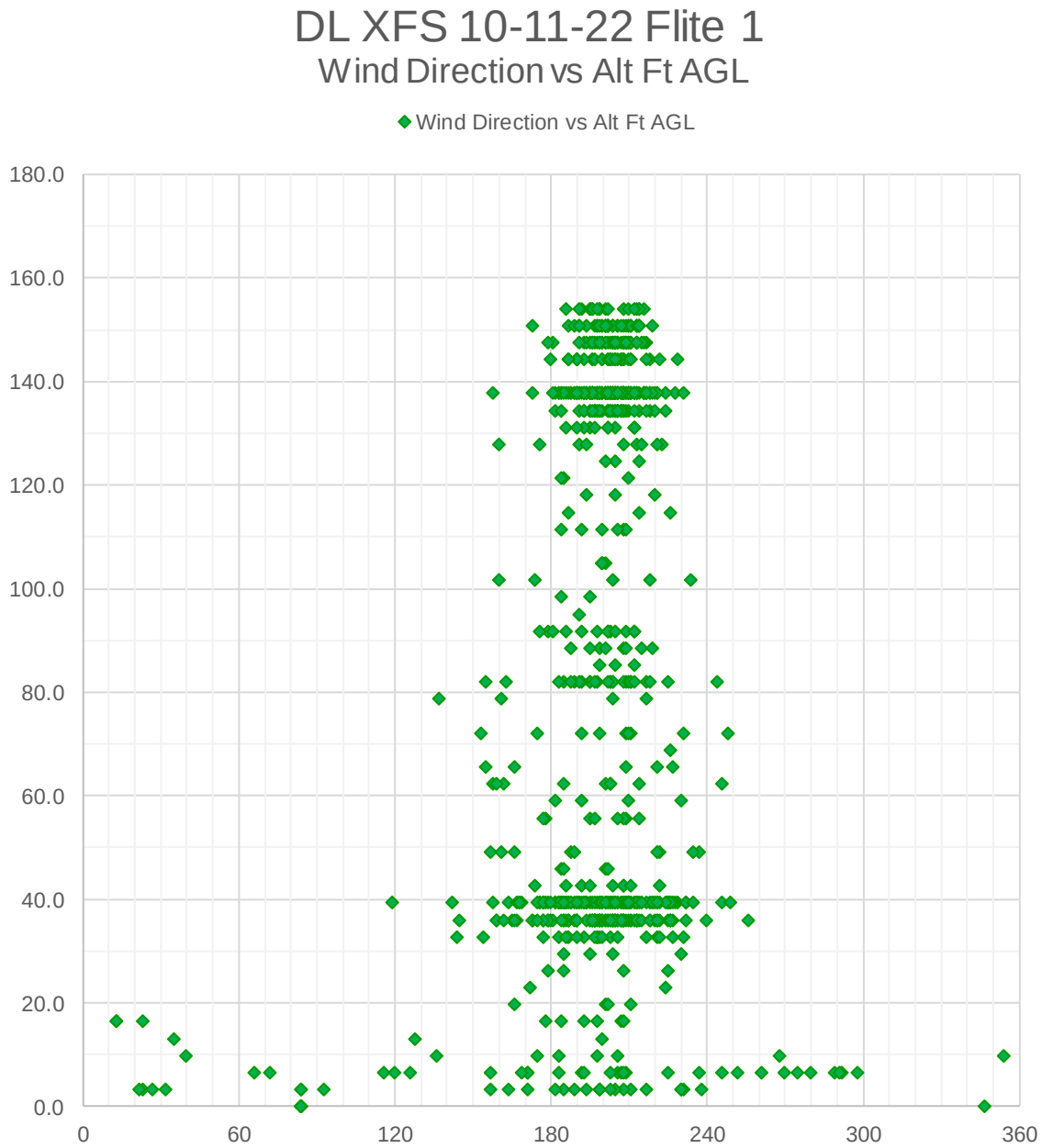
ProfilerDL 10-11-22 OC - Flite 1

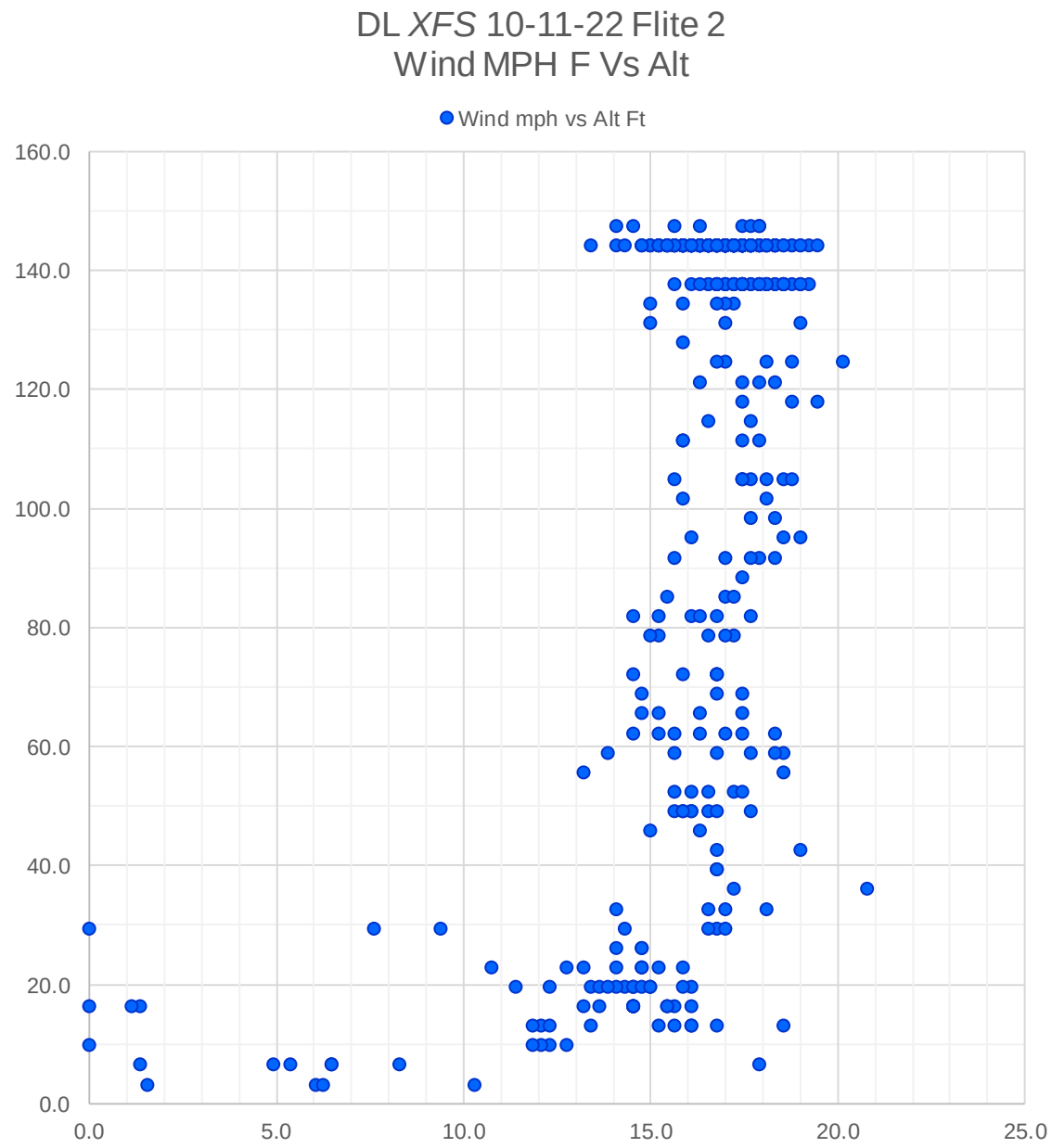


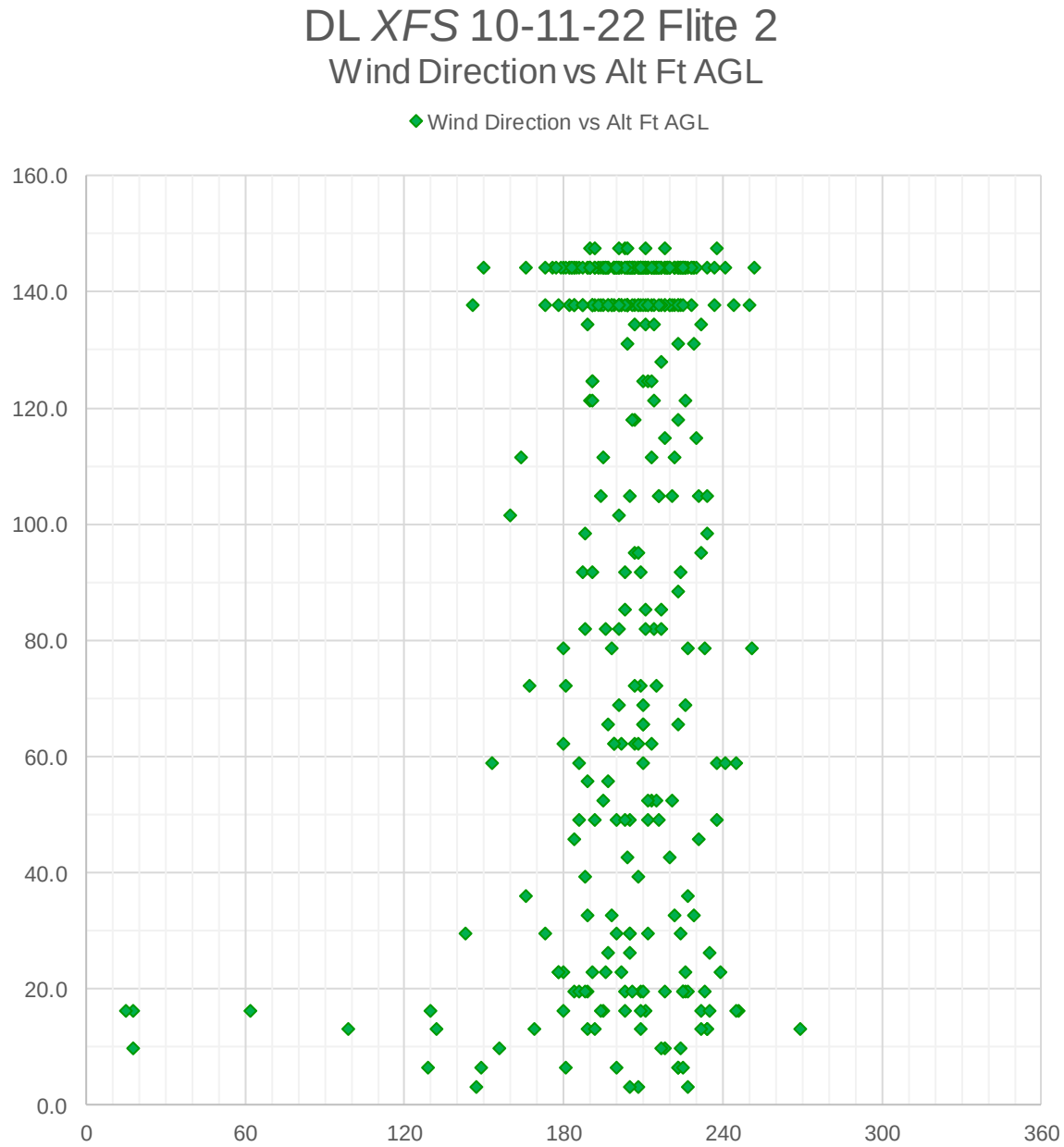
ProfilerDL 10-11-22 OC - Flite 2




DL XFS 10-11-22 Flite 1
Wind MPH F Vs Alt
Wind mph vs Alt Ft
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0

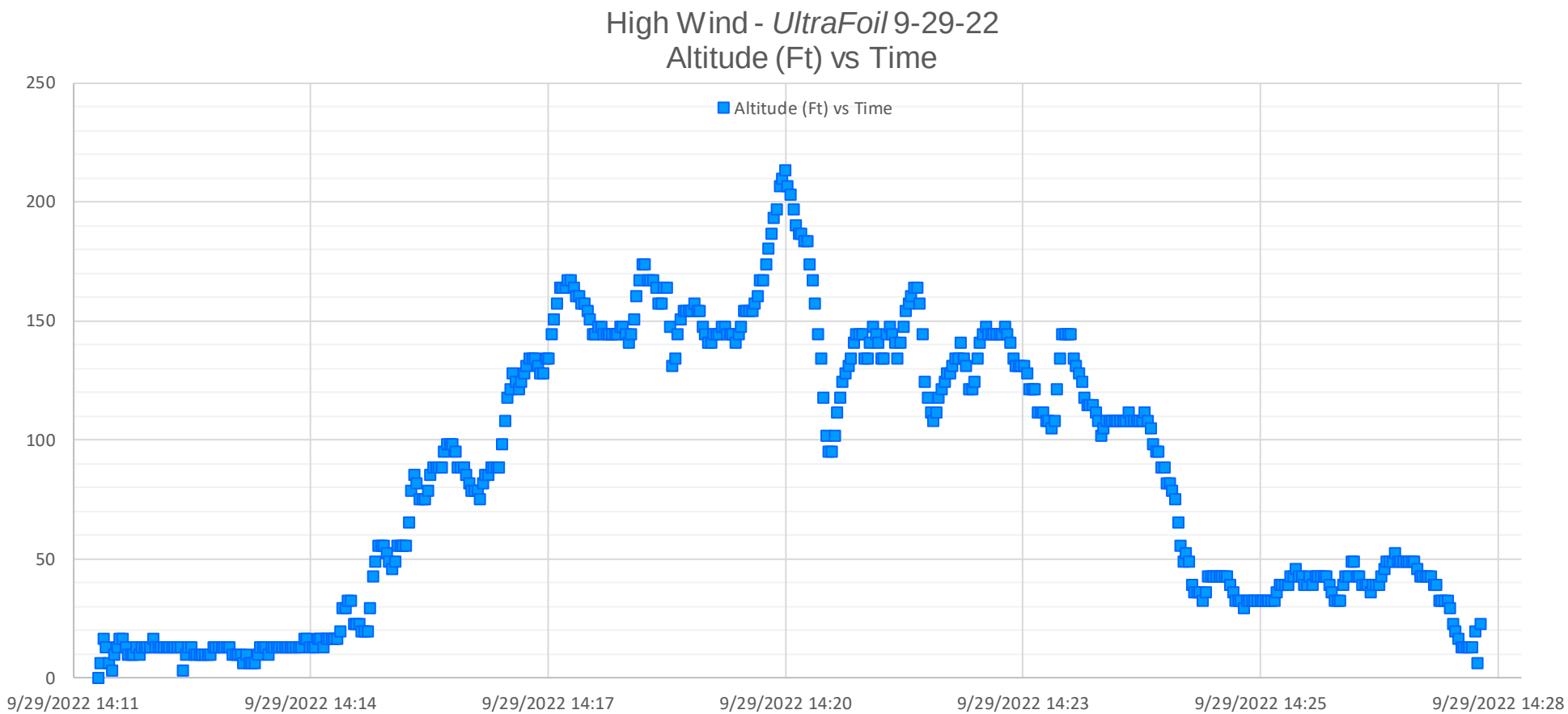

DL XFS 10-11-22 Flite 1
Wind Direction vs Alt Ft AGL
Wind Direction vs Alt Ft AGL
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
60
120
180
240
300
360

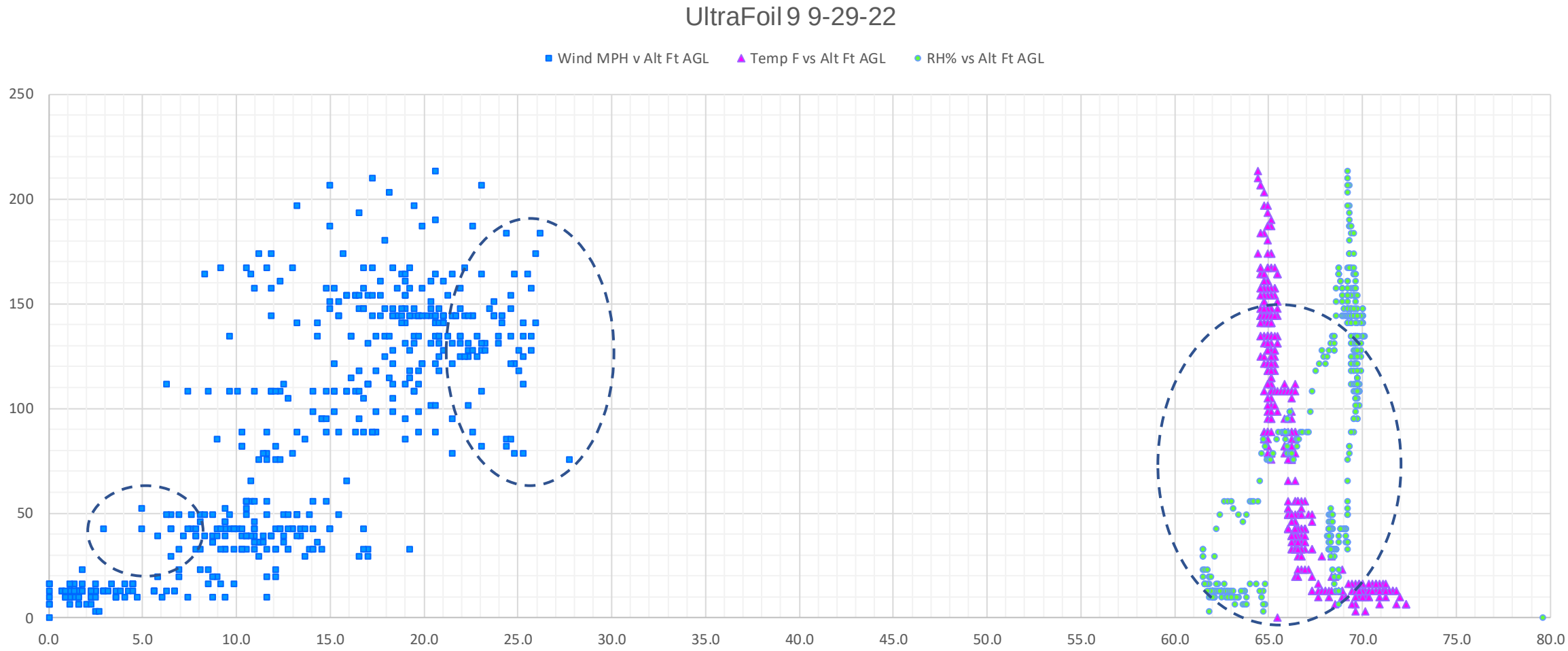

DL XFS 10-11-22 Flite 2
Wind MPH F Vs Alt
Wind mph vs Alt Ft
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0

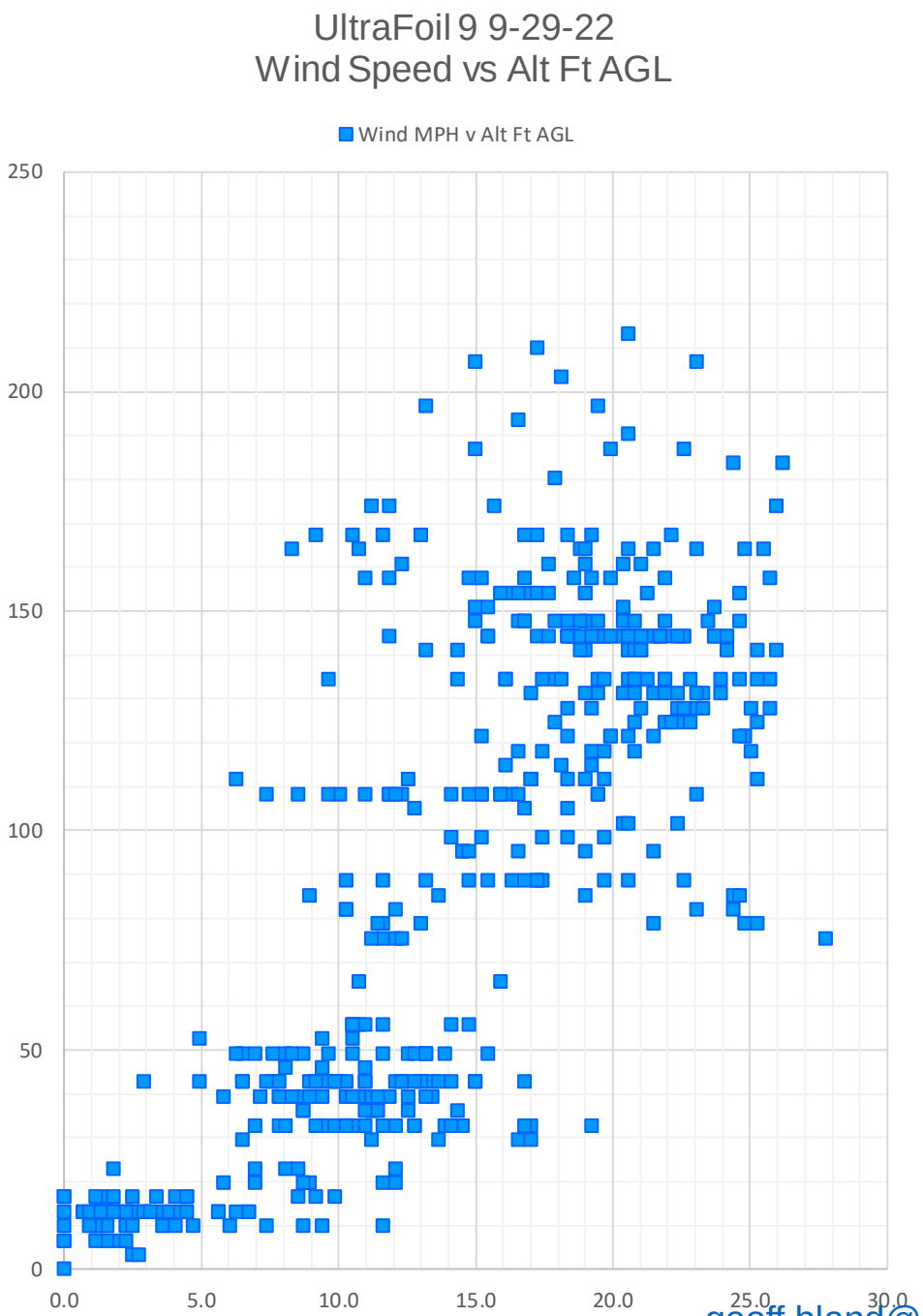

DL XFS 10-11-22 Flite 2
Wind Direction vs Alt Ft AGL
Wind Direction vs Alt Ft AGL
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
60
120
180
240
300
360

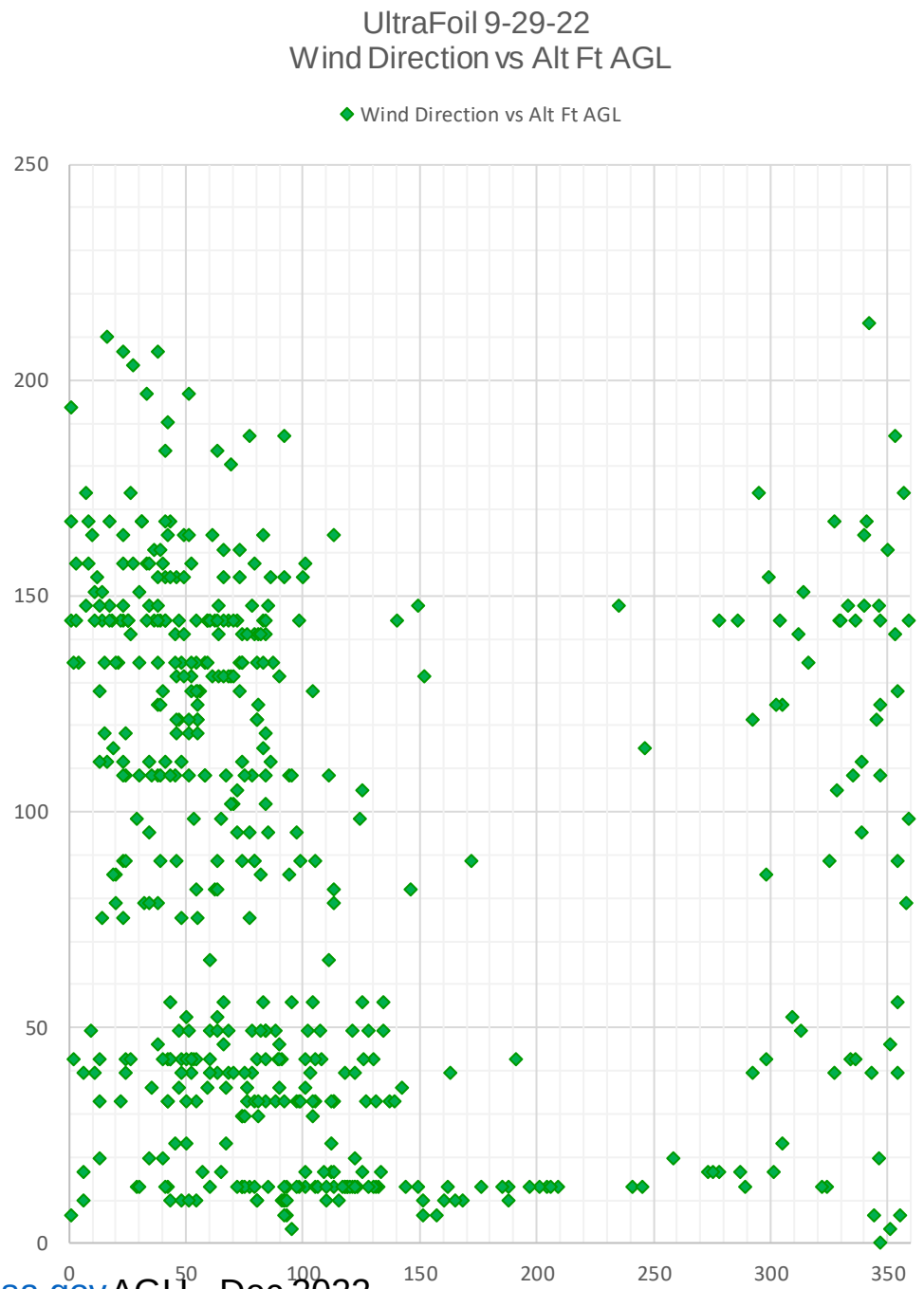
High Wind – *UltraFoil* 9

WindiWood 9-29-22


High Wind - *UltraFoil* 9-29-22
Altitude (Ft) vs Time
Altitude (Ft) vs Time
250
200
150
100
50
0
9/29/2022 14:11
9/29/2022 14:14
9/29/2022 14:17
9/29/2022 14:20
9/29/2022 14:23
9/29/2022 14:25
9/29/2022 14:28

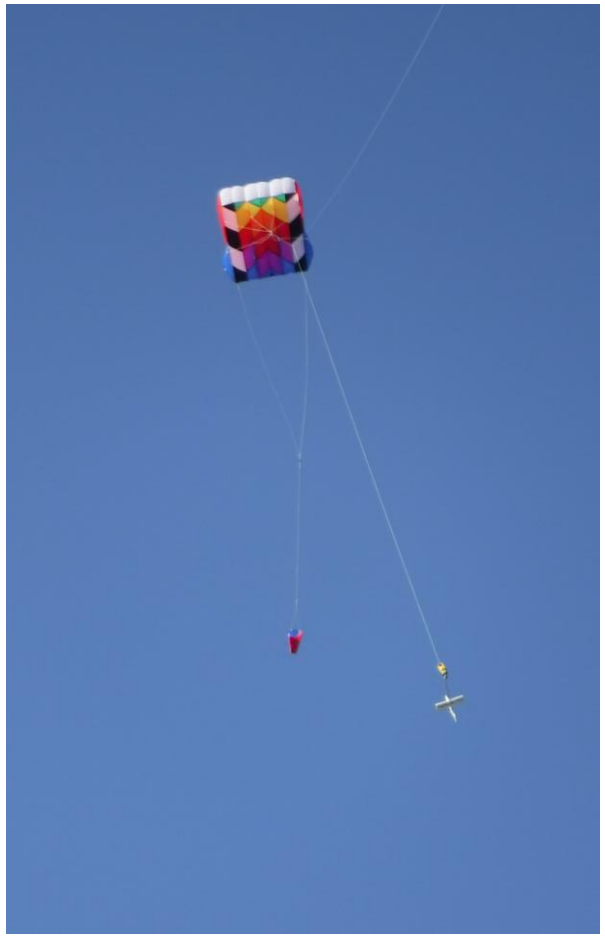
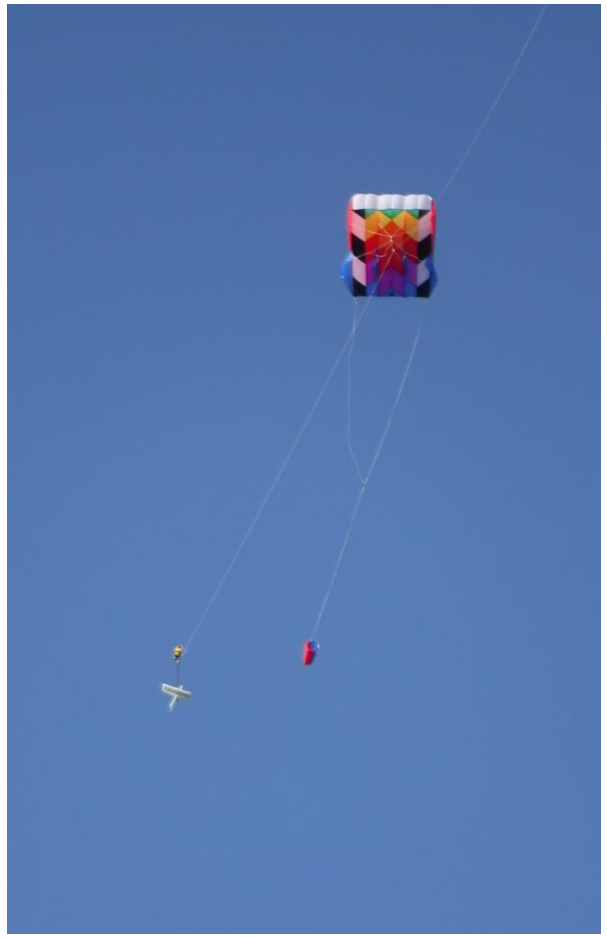
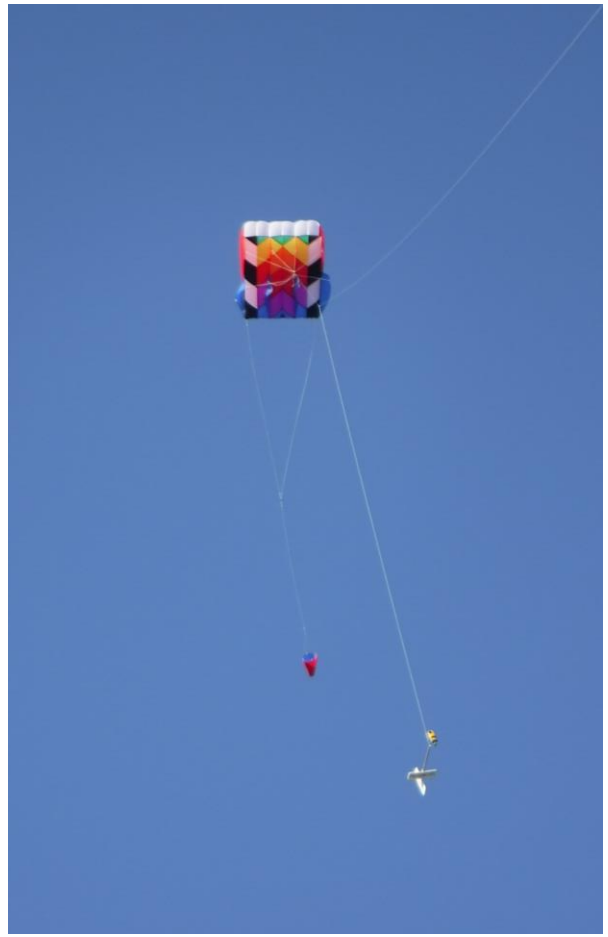

UltraFoil 9 9-29-22
Wind MPH v Alt Ft AGL
Temp F vs Alt Ft AGL
RH% vs Alt Ft AGL
250
200
150
100
50
0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
75.0
80.0

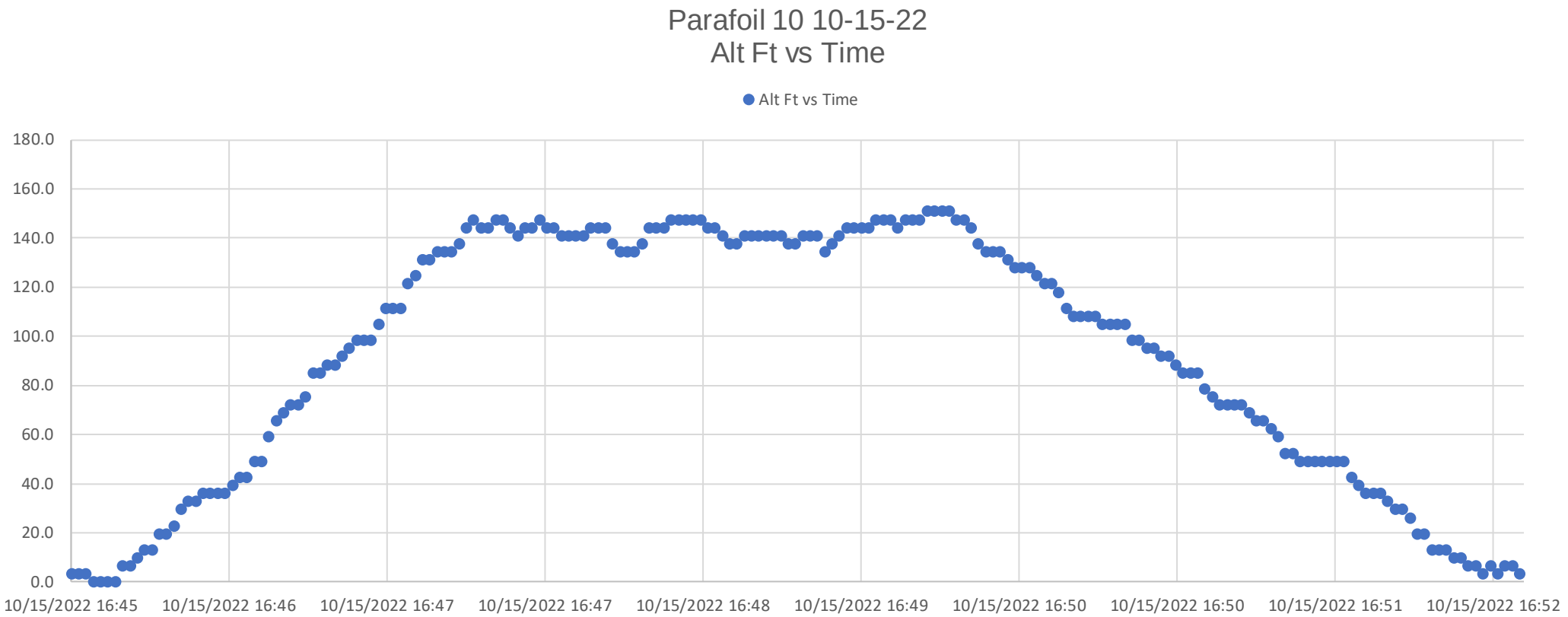

UltraFoil 9 9-29-22
Wind Speed vs Alt Ft AGL
Wind MPH v Alt Ft AGL
250
200
150
100
50
0
0.0
5.0
10.0
15.0
20.0
25.0
30.0

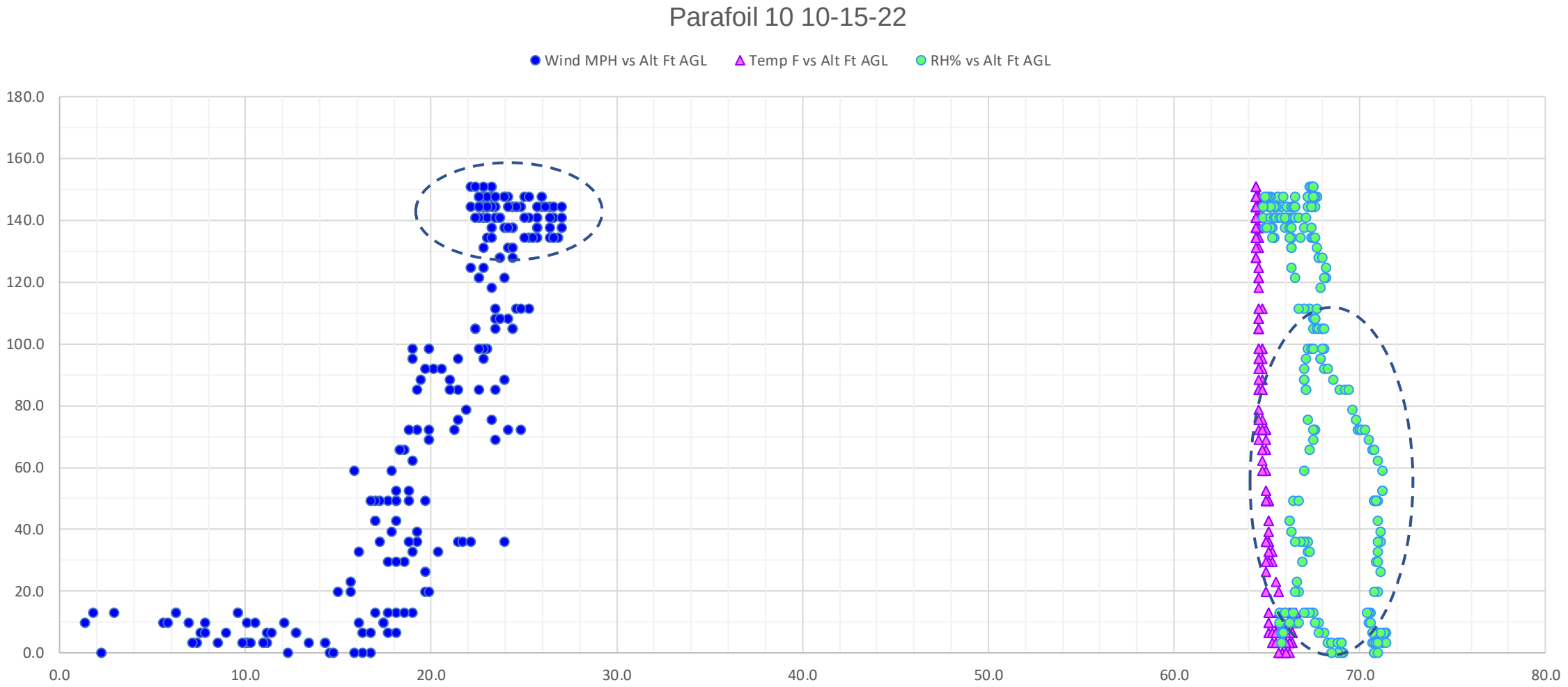

UltraFoil 9-29-22
Wind Direction vs Alt Ft AGL
Wind Direction vs Alt Ft AGL
250
200
150
100
50
0
0
50
100
150
200
250
300
350

High Wind – *Parfoil10*

Ocean City MD, 10-15-22


Parafoil 10 10-15-22
Alt Ft vs Time
Alt Ft vs Time
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
10/15/2022 16:45
10/15/2022 16:46
10/15/2022 16:47
10/15/2022 16:47
10/15/2022 16:48
10/15/2022 16:49
10/15/2022 16:50
10/15/2022 16:50
10/15/2022 16:51
10/15/2022 16:52



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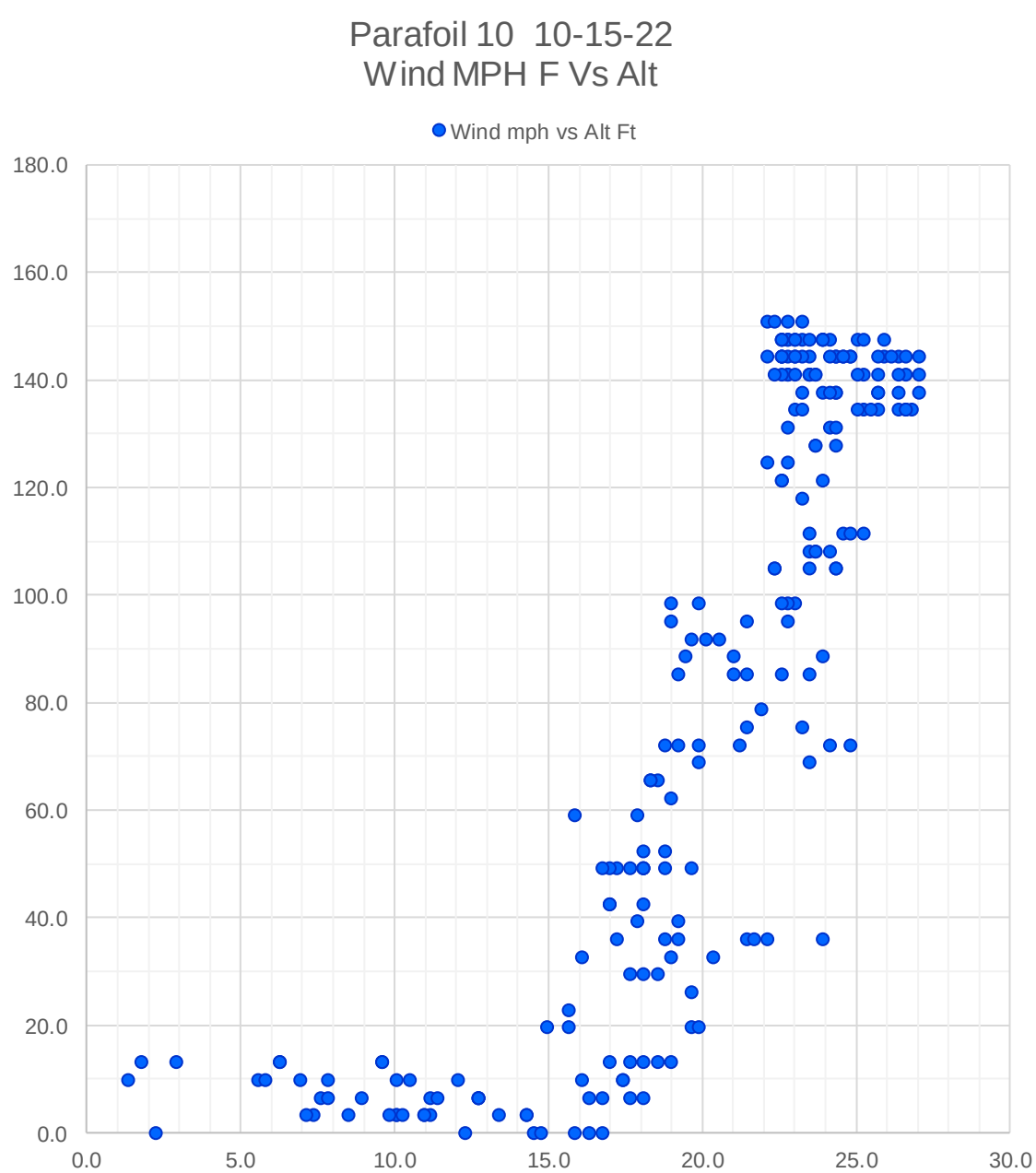
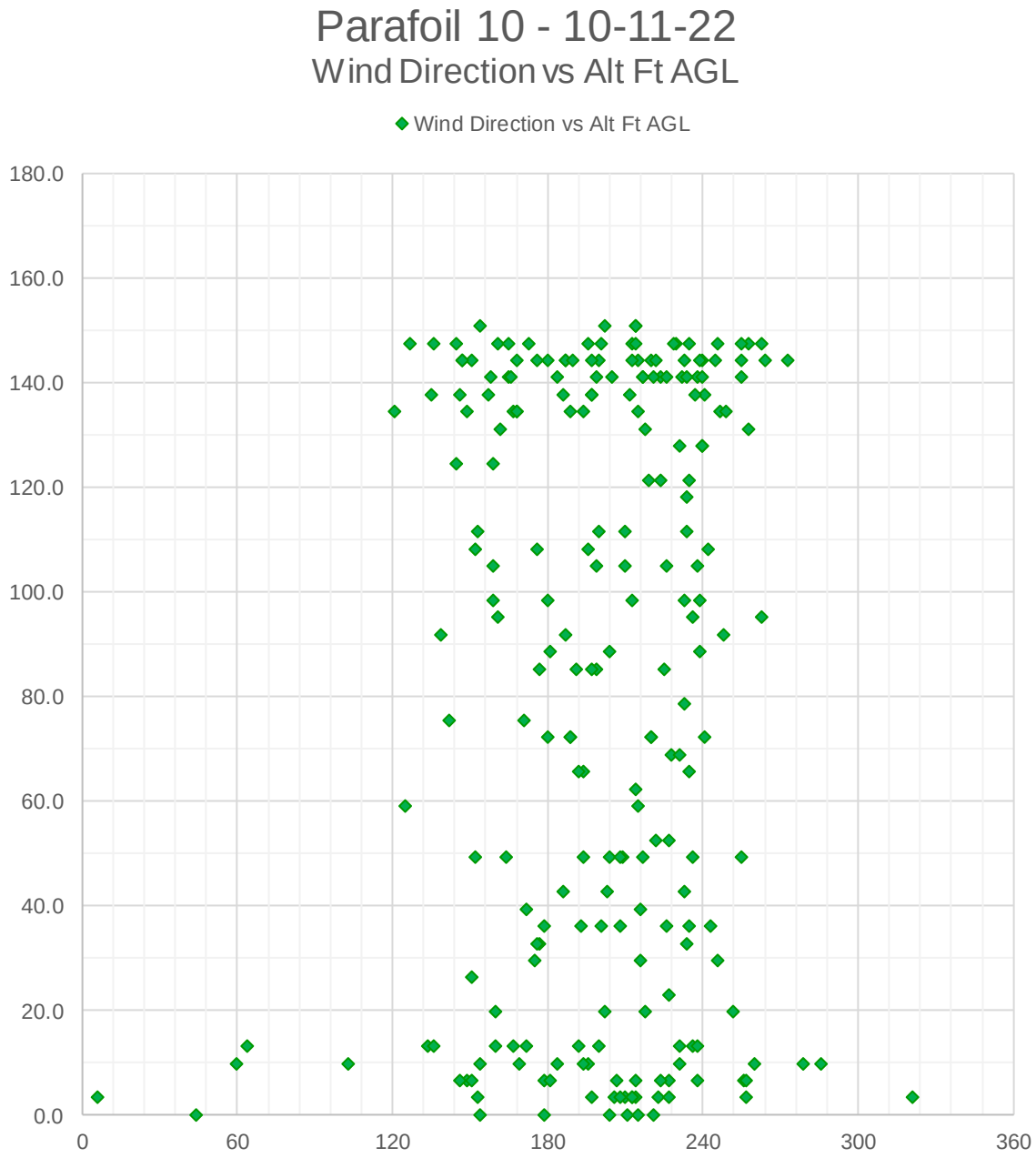
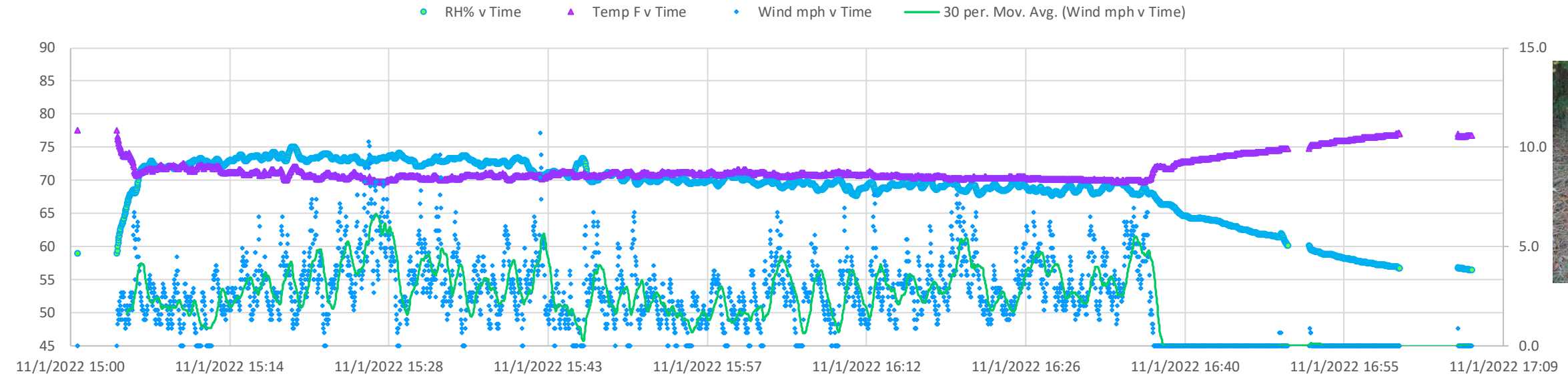
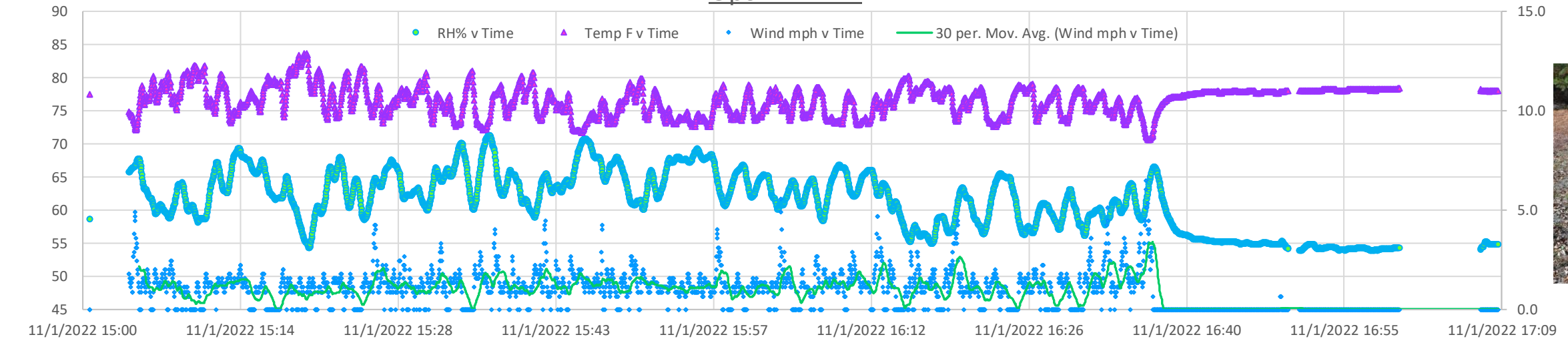

Parafoil 10 10-15-22
Wind MPH F Vs Alt
Wind mph vs Alt Ft
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0


Parafoil 10 - 10-11-22
Wind Direction vs Alt Ft AGL
Wind Direction vs Alt Ft AGL
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0
60
120
180
240
300
360

Shade 11-1-22



Open 11-1-22



possibly variable clouds?

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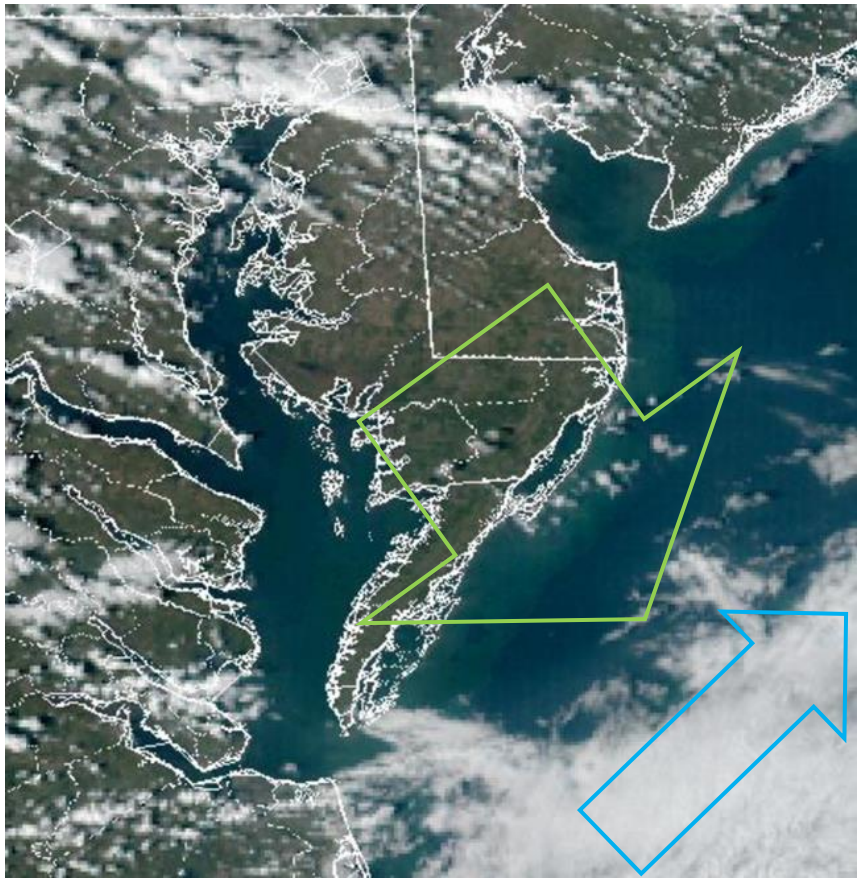
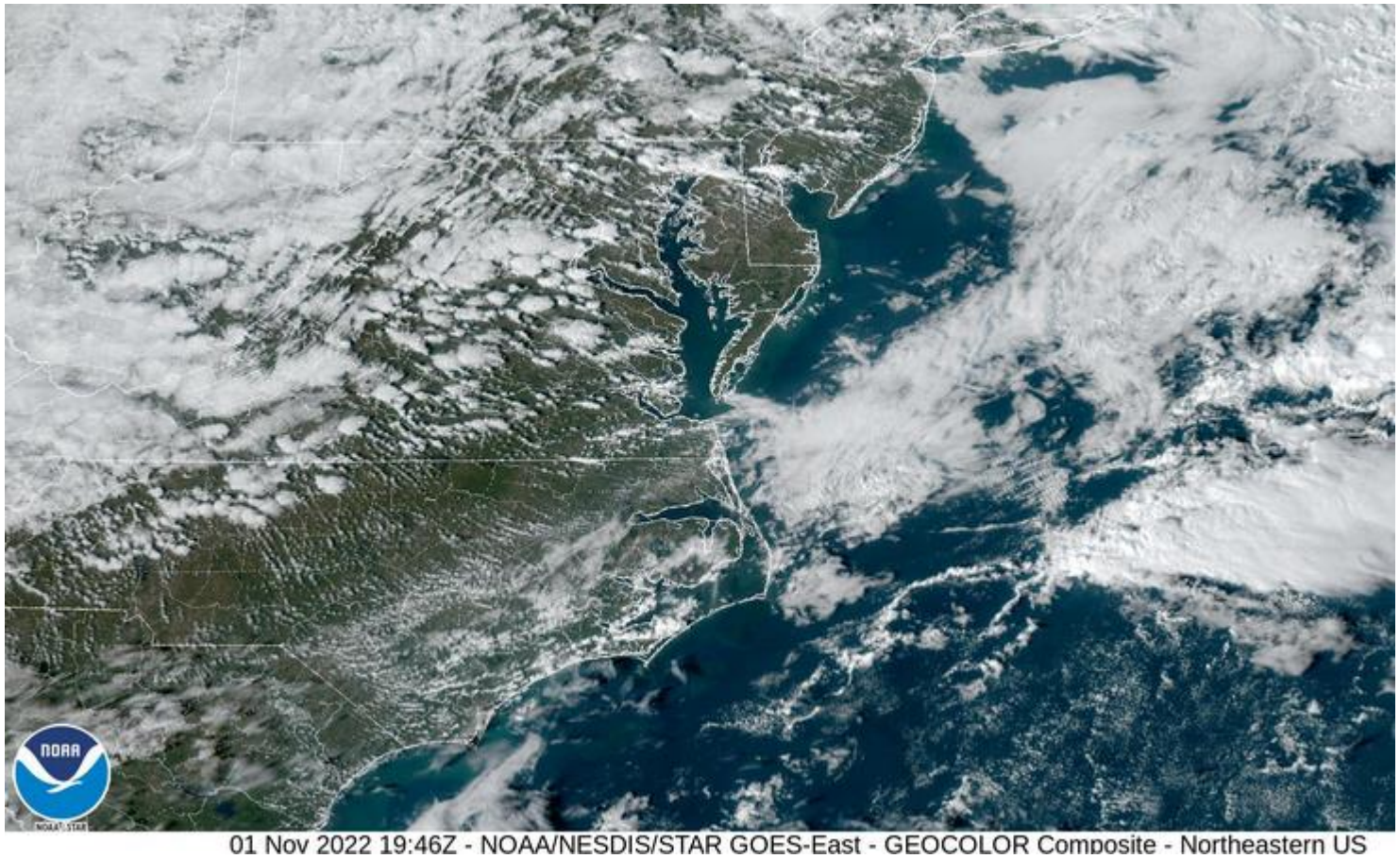
GOES East 19:46 Z 11-1-22





https://www.star.nesdis.noaa.gov/GOES/sector.php?sat=G16&sector=ne

Atmospheric Measurements with Kites and Miniaturized Sensors

- **Winds** – measurements from 5 to 25 mph have been demonstrated
- **Temperature** – appears to be reliable
- **Humidity** – challenging to address

Atmospheric Measurements with Kites and Miniaturized Sensors

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Recent work on kite-based instrumentation is intended to make routine distributed measurements practical. Several important developments have contributed to increasing confidence in an affordable path towards measurements of local-scale conditions. Of particular interest are vertical distributions of temperature, wind speed, wind direction and humidity, and reliable flight in a wide range of conditions from low/no wind to high wind/high turbulence are also a subject of study. Progress towards creating such systems for community-based environmental observations will be presented.