About The WakeWatch Wind Profiler – With Examples

This memo provides a description of the results obtained by the wind profiler, with examples. Figure 1 is used to describe all of the individual graphics. The graphics are numbered from top Left (1x1) to the bottom right (6x4).

Strong Wind

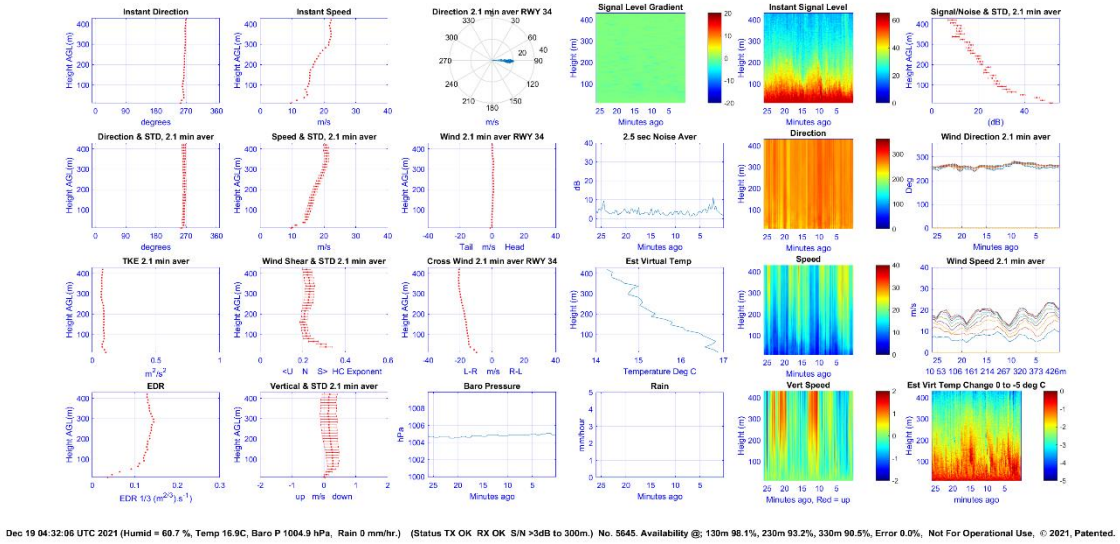

Figure 1. Strong wind in a neutral atmosphere with a small amount of convective activity. See below for a detailed description of each of the 24 graphics.

There are 6 graphics across and 4 down so that each graphic can be addressed by the across position and down position (1-6 x 1-4).
Graphic 1x1 of Fig. 1 (top Left) shows a single measurement (updated every 15.75 seconds) of the wind direction to a height of 420m.
Graphic 1x2 shows a single measurement (updated every 15.75 seconds) of the wind speed to a height of 420m.
Graphic 1x3 shows the 2.1 minute average (8 measurements) of the wind direction to a height of 420m but in a vector form so that the arrow shows the direction in which the wind is going.
Graphic 1x4 shows the vertical gradient of the signal level and is used to show the location of temperature inversion layers with the strength of the inversion layer shown by the colour bar on the right. The green indicates that there are no inversion layers present. The graphic shows the last 25 minutes of measurements.

Graphic 1x5 shows the structure of the atmosphere to a height of 420m. The signal level is indicated by the colour bar on the right. This graphic shows the signal backscattered from

turbulence cells generated by small changes in the temperature of the atmosphere and can thus indicate the height of inversion layers as well as convective activity. The graphic shows the last 25 minutes of measurements.
Graphic 1x6 shows the signal-to-noise (S/N) ratio to a height of 420m averaged over 8 measurements (2.1 minutes) as well as the standard deviation of these measurements.
Graphic 2x1 shows the wind direction averaged over 2.1 minutes and the associated standard deviation. Note the small standard deviation achieved to 420m in a neutral atmosphere achieved through the use of a small vertical beam offset of 7 degrees.
Graphic 2x2 shows the wind speed averaged over 2.1 minutes and the associated standard deviation. Note the small standard deviation achieved to 420m in a neutral atmosphere.
Graphic 2x3 shows the head wind/tail wind components of the wind to a height of 420m for a 34 runway utilisation. For the strong Westerly wind there is only a very small cross wind component.
Graphic 2x4 shows the point measured running noise averaged over 2.5 seconds for the last 25 minutes which is used to calculate the S/N ratio of the received signal shown in 1x6.
Graphic 2x5 shows the wind direction for the last 25 minutes to a height of 420m. The colour bar on the right shows the colours for directions between 0 and 360 degrees.
Graphic 2x6 shows the wind direction for the last 25 minutes at of heights of 10m, 53m, 106m, 214m, 267m, 320m, 373m and 426m.
Graphic 3x1 shows the Turbulent-Kinetic-Energy (TKE) of the atmosphere to a height of 420m. TKE is the mean kinetic energy per unit mass associated with eddies in turbulent flow and indicates the amount of turbulent energy is extracted from mean wind flow.
Graphic 3x2 shows the level of wind shear up to 420m. Wind shear is the change in wind speed with height in the atmosphere and can be represented by the Hellmann power law to estimate the atmospheric stability at various heights as shown here where the stability is represented by "U" for unstable, "N" for neutral and "S" for stable. In this case the atmosphere is slightly stable near the ground going to neutral above about 100m.
Graphic 3x3 shows the cross wind to a height of 420m for a runway 34 operation.
Graphic 3x4 shows the estimated virtual temperature to a height of 400m. This measurement is achieved by finding the difference between the received signal level (1x6) and a standard signal level for a neutral atmosphere. The differences are then scaled to a neutral lapse rate of 6 deg. C/1000m. The temperature estimate is then achieved by adding in the ground temperature. This is especially useful for finding the heights and strengths of temperature inversions.
Graphic 3x5 shows the wind speed for the last 25 minutes to a height of 420m. The colour bar on the right shows the colours for speeds between 0 and 40m/s.
Graphic 3x6 shows the wind speed for the last 25 minutes at of heights of 10m, 53m, 106m, 214m, 267m, 320m, 373m and 426m.
Graphic 4x1 shows the Eddy-Dissipation-Rate (EDR) up to 420m. The EDR represents the amount of small scale turbulence in the atmosphere and is important is assessing the potential for long lived wake vortices to be present, it is the parameter used to determine the amount of energy lost by the viscous forces in the turbulent flow.
Graphic 4x2 shows the vertical wind speed and its standard deviation and is particularly useful for determining the amount of vertical wind arising from convective plumes that can cause wind shear on hotter days.
Graphic 4x3 shows the barometric pressure for the last 25 minutes which is a useful addition to understanding the current state of the atmosphere.

Graphic 4x4 shows the rain rate for the last 25 minutes.
Graphic 4x5 shows the vertical wind to a height of 420m speed for the last 25 minutes, the colour bar displays the vertical wind speed between -2 and +2 m/s. There are two periods when the vertical wind is driven by upwards convection, the first period at between 10 and 13 minutes ago while the second period of between 18 and 23 minutes ago. Each of these periods corresponds to decreases in the wind speed (3x5) and increases in the return signal level with height (1x5).
Graphic 4x6 shows the vertical temperature gradient without the ground temperature for the last 25 minutes for vertical temperature changes between 0 and -5 degrees.

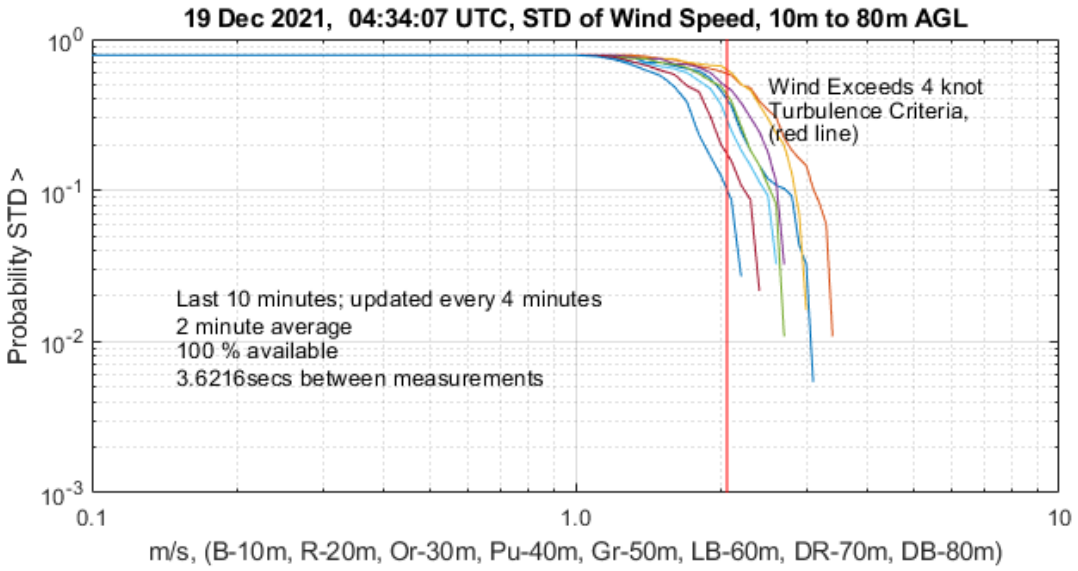

Figure 1a. Wind shear between 10m and 80m for the strong wind in a neutral atmosphere shown in Figure 1. The red vertical line shows the probability that the 4 knot vertical turbulence criteria (as set out in Guideline B) will be exceeded for the same time period as shown in Figure 1 above. The 4 knot shear criteria has up to 6 times higher probability of being exceeded between 10m and 60m than above 70m showing how critical it is that shear be measured close to the ground here aircraft are most vulnerable. The wind shear during this Westerly wind event was probably due to a box forest that is 320m to the West of the measurement location.

Wind Storm

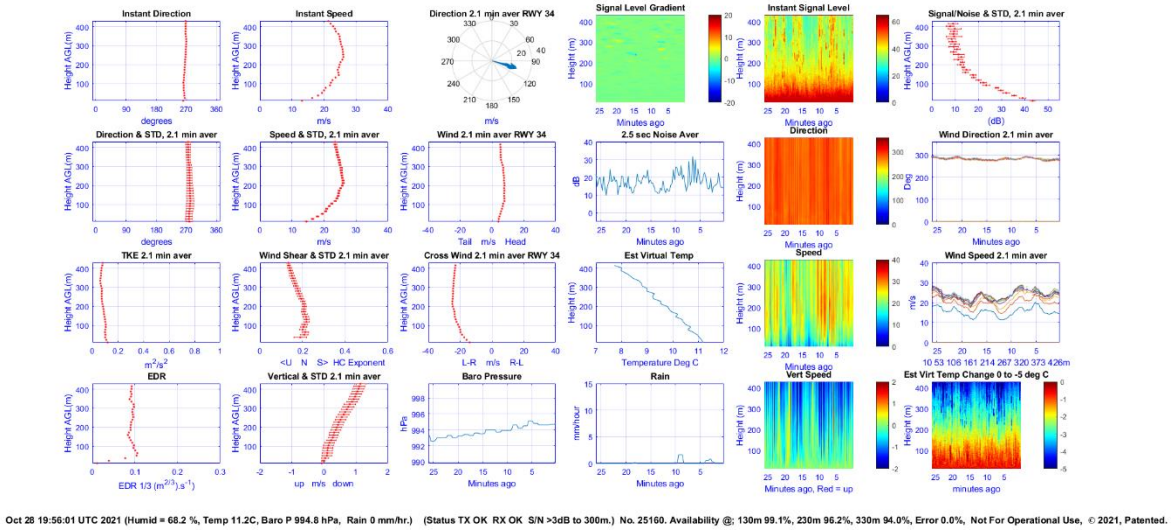

Figure 2. Wind storm in a neutral to unstable atmosphere. The ground wind speed is 14m/s while the wind at 200m is 25m/s and shows the presence of a low level jet peaking at 200m (2x2).

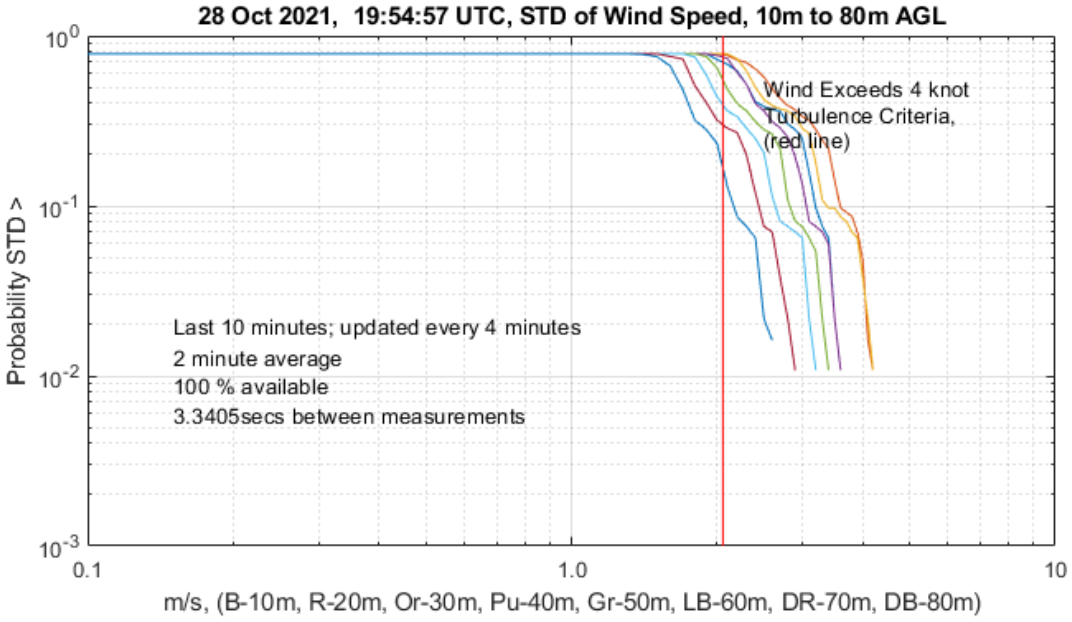

Figure 2a. Wind shear between 10m and 80m for the wind storm in a neutral to unstable atmosphere shown in Figure 2. The red vertical line shows the probability that the 4 knot vertical turbulence criteria (as set out in Guideline B) will be exceeded for the same time period as shown in Figure 2 above. The 4 knot shear criteria has an 80% chance of being exceeded between 10m and 30m while the probability of being exceeded at 80m is 20% once again showing how important it is to measure the wind shear close to the ground. The wind shear during this Westerly wind event was probably due to a box forest that is 320m to the West of the

measurement location and shows how far wind shear can travel downwind from terrain or building objects.

Low Level Jet

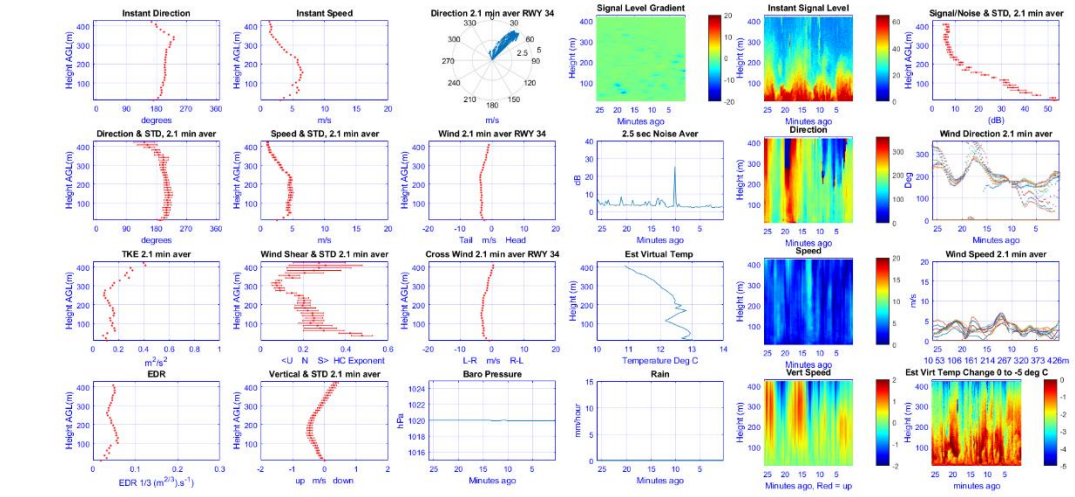

Figure 3. Low level jet below 200m in an atmosphere varying from stable near the ground to unstable above 250m. The evolution of the low level jet can be seen in (1x5) where the dramatic speed decrease above 250m is evident from about 10 minutes ago.

Convection

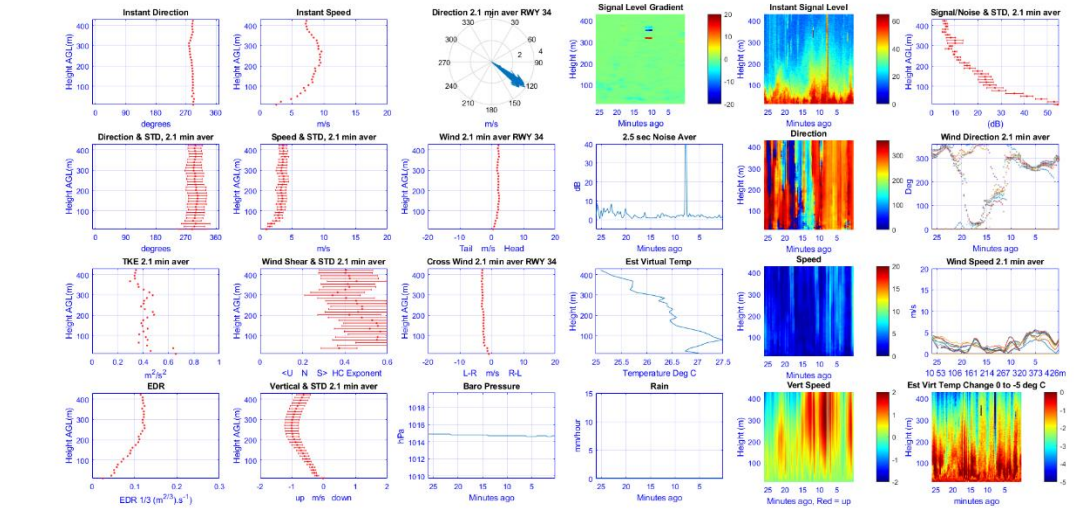

Figure 4. A strong convective event is evident in (4x5) where the vertical wind speed is up to 2m/s between 5 and 14 minutes ago. The increase in vertical signal level with height is also evident in (1x5) at the same time.

Gust Front

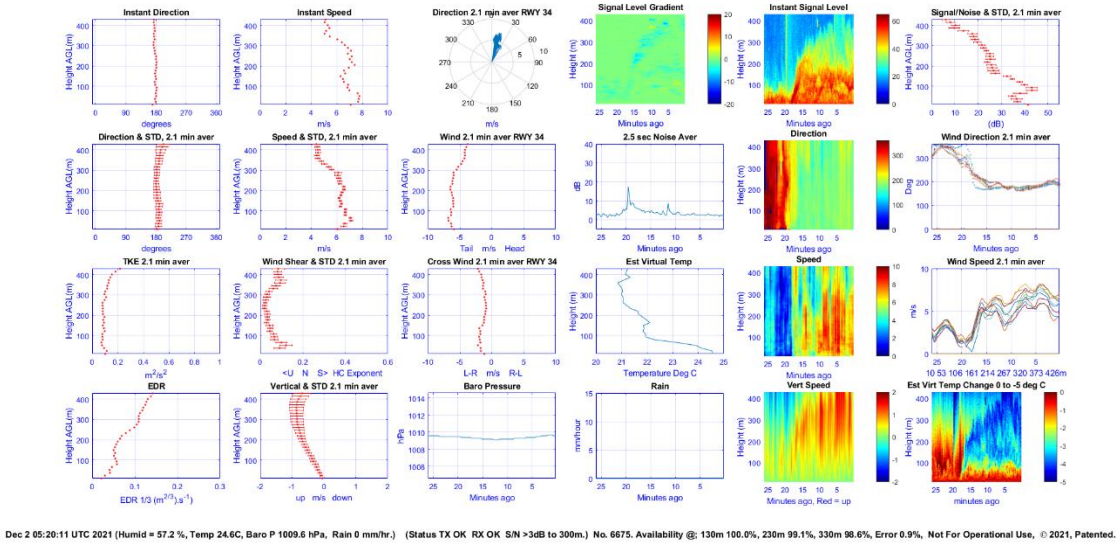

Figure 5. A gust front with change in wind direction and an increase in the wind speed after the front passes is evident (1x5), (2x5), (3x5) and an increase in the vertical wind speed (4x5).

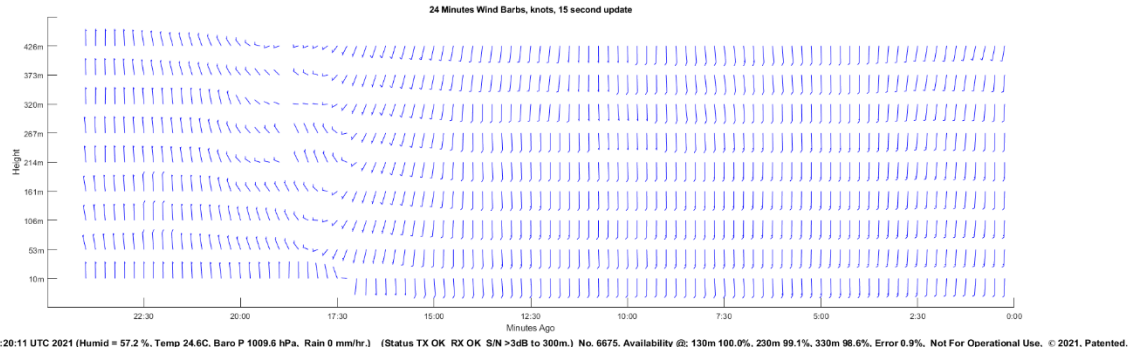

Figure 5a. A gust front with change in wind direction and an increase in the wind speed after the front passes is evident in this wind barb diagram and is for the same time period as that of Figure 5. The evolution of the wind speed and direction with height is also evident.

Rain

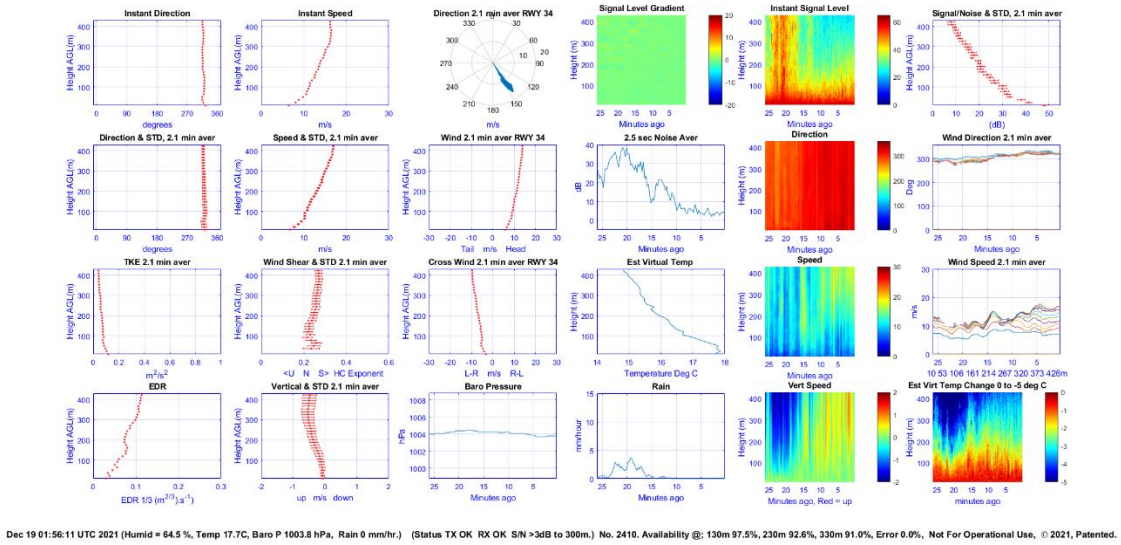

Figure 6. A rain event occurred between 15 and 25 minutes ago (4x4) with a peak rain rate of about 2.5mm/hr. The increase in noise associated with the rain is also evident. During the rain event the vertical range of the system is reduced to about 106m as is evident in (3x6).

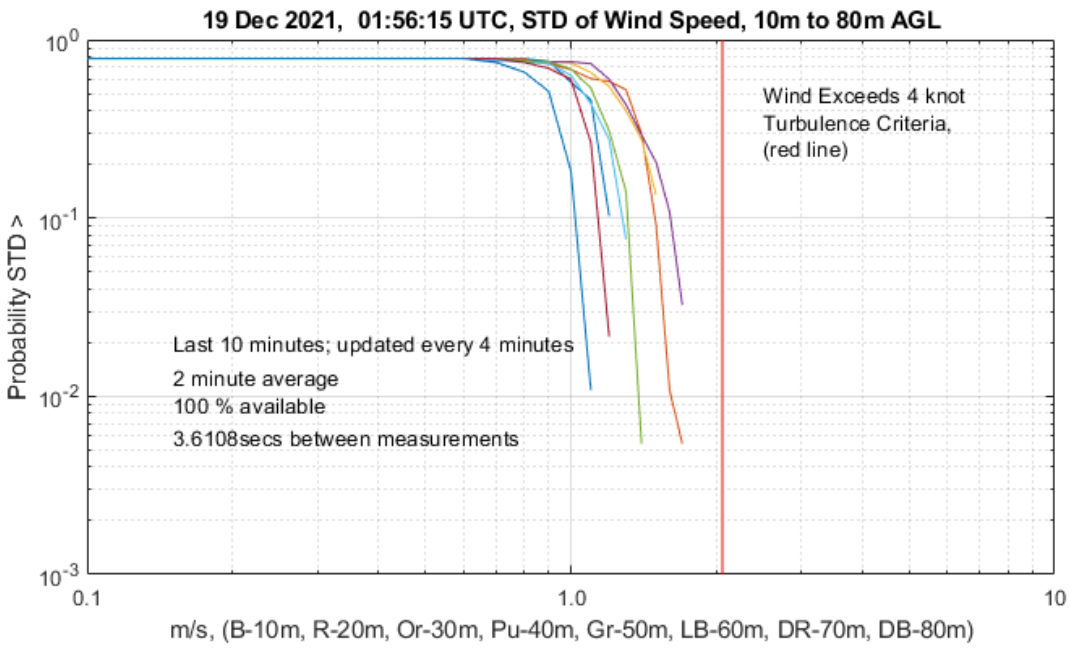

Figure 6a. After the rain event up to 10 minutes ago the wind speed increased (3x6) and the atmosphere was neutral (3x2). During this time the probability that the turbulence exceeded the 4 knot limit was low. This result is to be compared with that of Figure 1 and 1a where for a Westerly wind of similar speed to that shown in Figure 6, the 4 knot criteria is exceeded due to a brush forest about 300m to the West. For the wind shear result above, the wind direction was around 315 degrees and was not obstructed by any forest or terrain objects thus the much lower turbulence is measured when the wind is from 315 degrees.

Inversion Layers

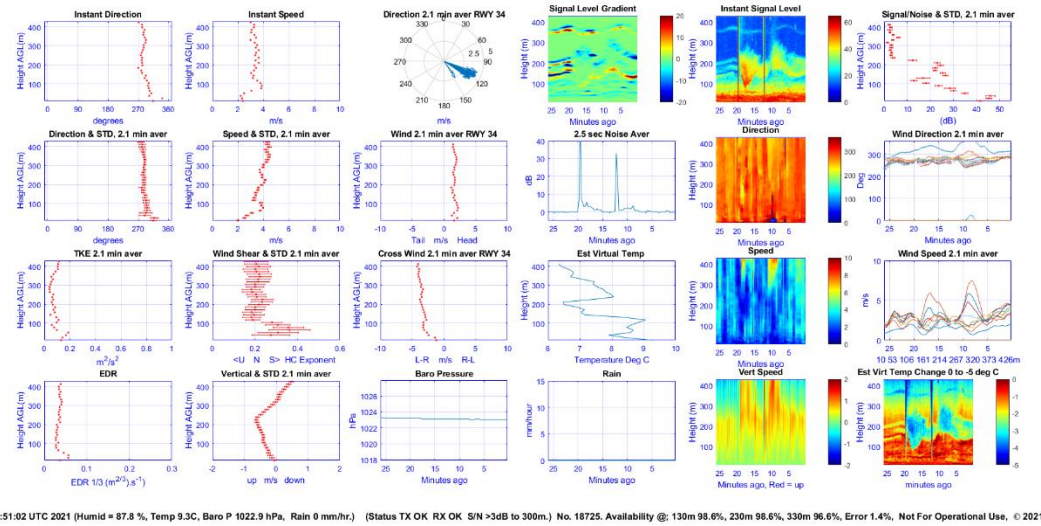

Figure 7. Temperature inversion layers are readily evident in (1x4) where an increase in temperature gradient is shown in blue and a decrease in temperature gradient is shown in red. This is most evident at 0 time on the right of (1x4), these points is shown in the estimated virtual temperature profile in (3x4). At around 19 minutes ago an A330 departs at a height of around 200m (1x4) and the wake vortex traverses the wind profiler which takes about 5 minutes. This serves to show how long wake vortices last above inversion layers and the substantial disturbance of the atmosphere from the wake vortex.

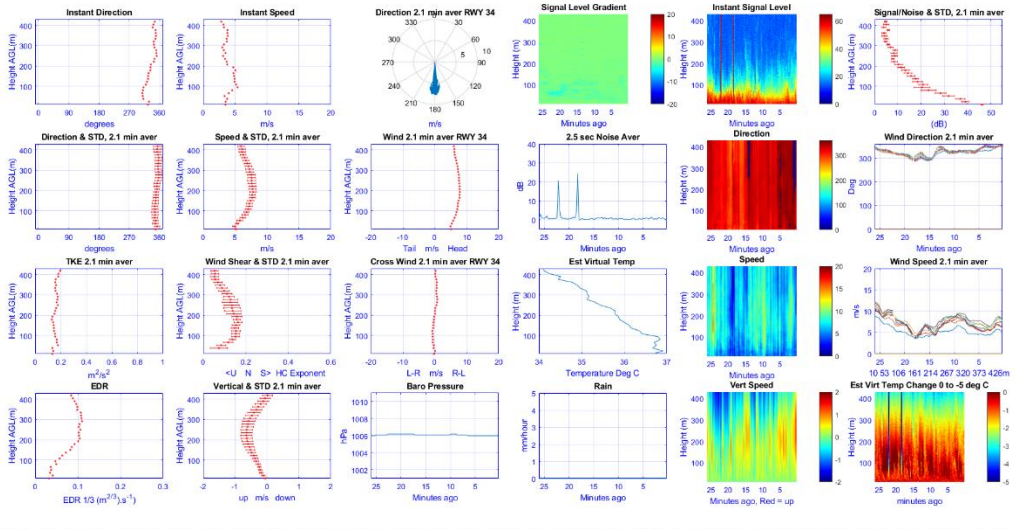

Figure 8. Operation of the wind profiler in a low humidity of 15% where the attenuation of the acoustic signal close to its maximum.

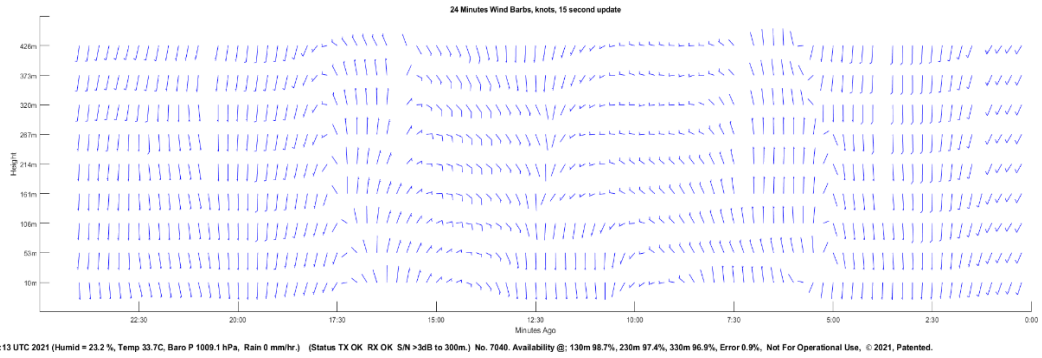

Figure 9. Wind barb diagram showing the wind vectors for speed and direction at 9 heights between 10m and 426m. In this light and variable wind the evolution of the winds to 426m are very evident and consistent to a height of 426m. There is no averaging used in this measurement and the updates occur every 15 seconds and serves to show the quality of the measurements and it system capability in low humidity.