Wake Measurement Examples and the Effect of Inversion layers

Introduction.

This series of graphics show various behaviours of wake vortices in different atmospheres. The effect of inversion layers on wake vortex lifetimes is illustrated. The effect of an inversion layer on the aircraft wake vortices is clear as shown here. However, managing the transitions from an unstable atmosphere where the wake lifetimes are quite short, through a neutral atmosphere where the wake lifetimes are longer, to a stable atmosphere where the probability of inversion layers and the longest wake lifetimes occur will always be a challenge. There is thus a clear need for real time wind and atmosphere profiles together with wake measurements to ensure the continuous safety of weather dependent operations.

Shown below, each set of data has two components, the wake vortex measurement and the associated met conditions up to 420m. The wake measurements show a colourised vertical velocity gradient with red having the highest velocity gradient. The wake colourisations have a linear scale (volts) and consistently show very high signal-to-noise ratios. The aircraft are overhead when there is a strong red vertical bar which affects the measurements for about 10 seconds, after that the vortices became evident to the right of the vertical red bar. A detailed explanation of the meteorological data is given in "About the Wake Watch Wind Profiler" on the reports page.

Departure Wake Vortices.

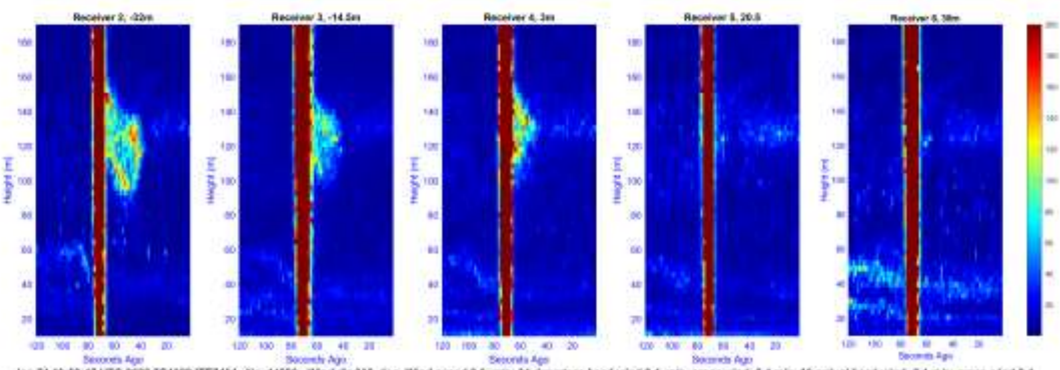

Figure 1a. B463 departure wake, within the inversion layer at around 120m, higher turbulence holds the wake lifetime to around 40 seconds with light and variable winds. Figure 1b shows the associated met data.

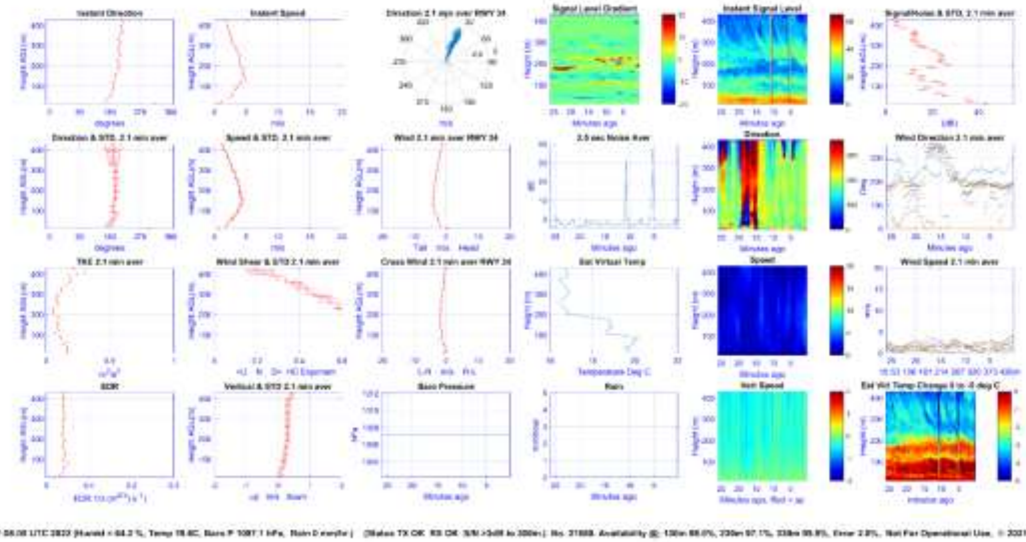

Figure 1b. B463 departure, within the inversion layer, the inversion layers are readily evident in graphic row 1, 5 across. The departing aircraft can be seen as the vertical line at around 10 minutes ago where the turbulence is higher at 120m.

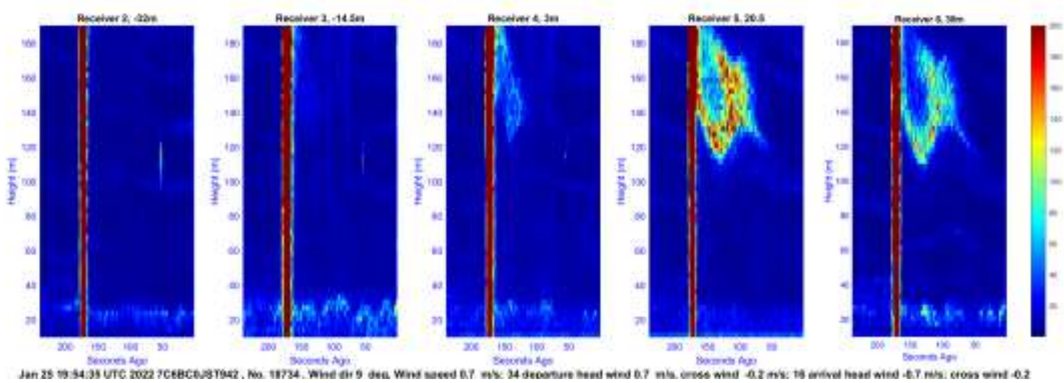

Figure 2a. B788 departure, within the inversion layer. The turbulence seems to be similar to that shown in Figure 1b so the heavier aircraft is most likely responsible for the increase in the wake lifetime to around 100 seconds. Figure 2b shows the associated met data.

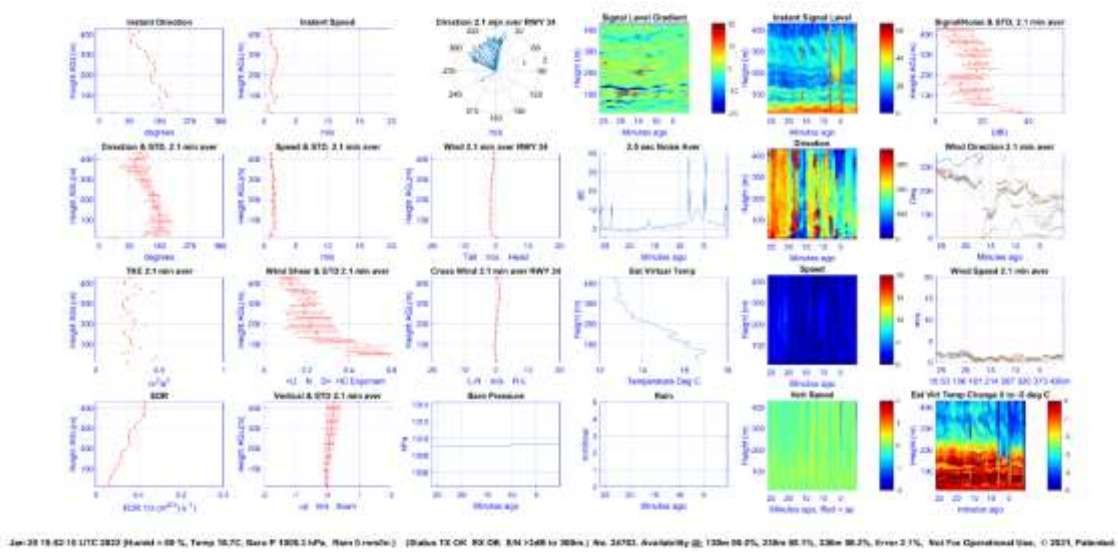

Figure 2b. B788 departure, within the inversion layer, the inversion layers are readily evident in graphic row 1, 5 across. Several inversion layers are evident. The departing aircraft can be seen as the vertical line at around 8 minutes ago, the resulting wake vortex is also evident. The interaction of the vortex with the inversion layer is evident in graphic row 4, 6 across.

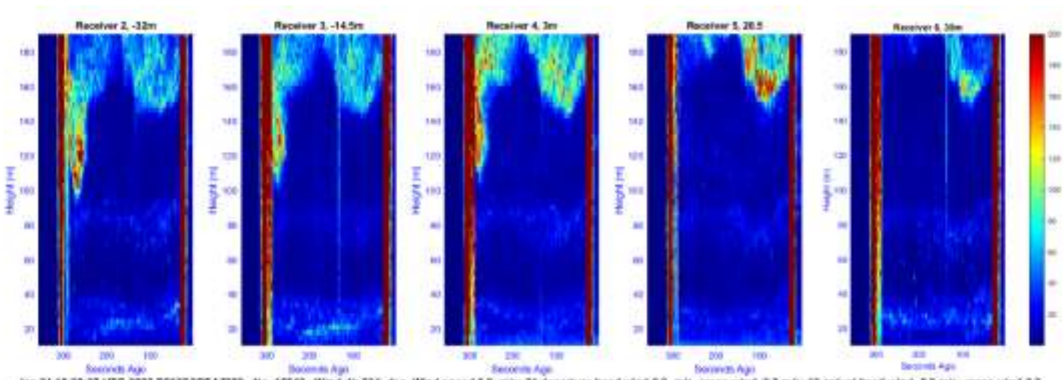

Figure 3a. B463 departure, above the inversion layer, lower turbulence increases the wake lifetime to around 160 seconds. Figure 3b shows the associated met data. The time in the annotation is for a later A321 aircraft.

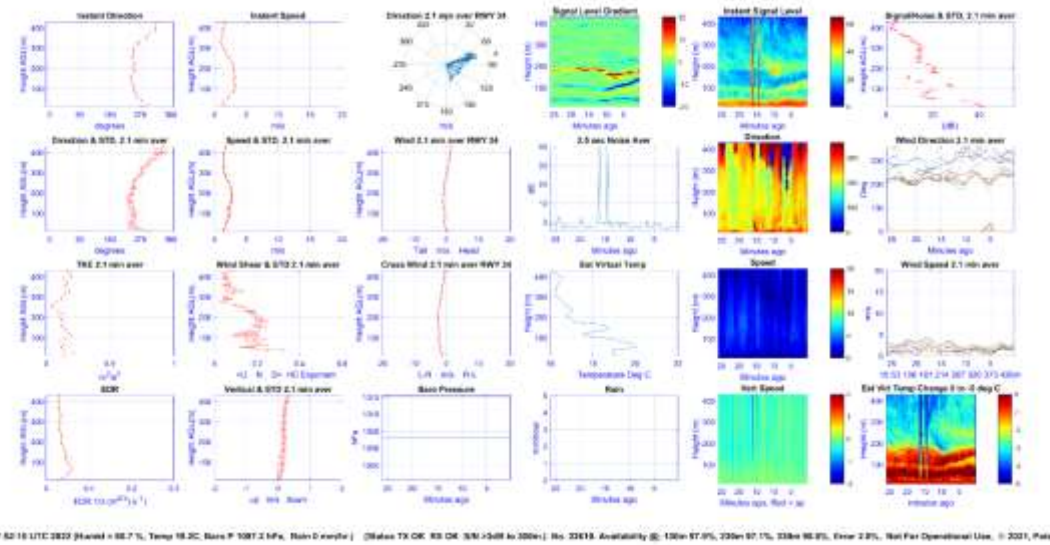

Figure 3b. B463 departure, within the inversion layer, higher turbulence holds the wake lifetime to around 40 seconds. The strength of the inversion layer gradients is shown in row 1, 4 across, with red showing the top of the inversion layer above which the temperature decreases and blue showing the bottoms of the inversion layers where the temperature increases. Multiple inversion layers are present. The scale of the temperature changes between 0 and -5 degrees C is shown in row 4, 6 across.

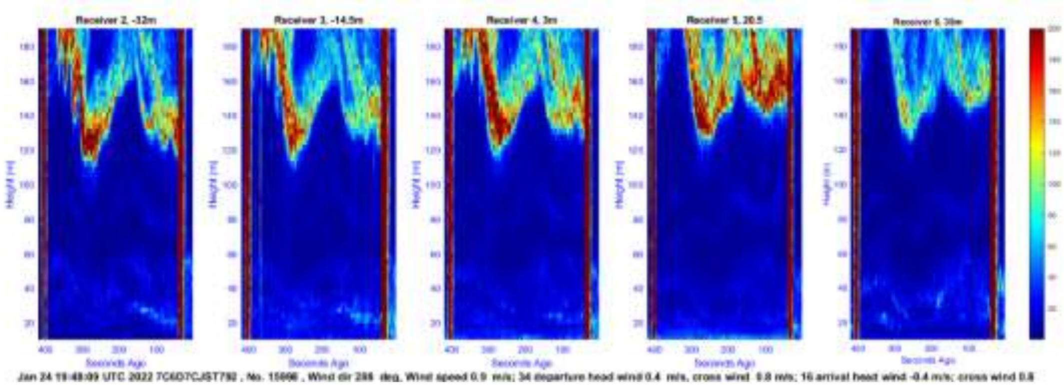

Figure 4a. B738 departure, above the inversion layer, lower turbulence increases the wake lifetime to around 6 minutes. Figure 4b shows the associated met data. The time in the annotation is for a later A321 aircraft.

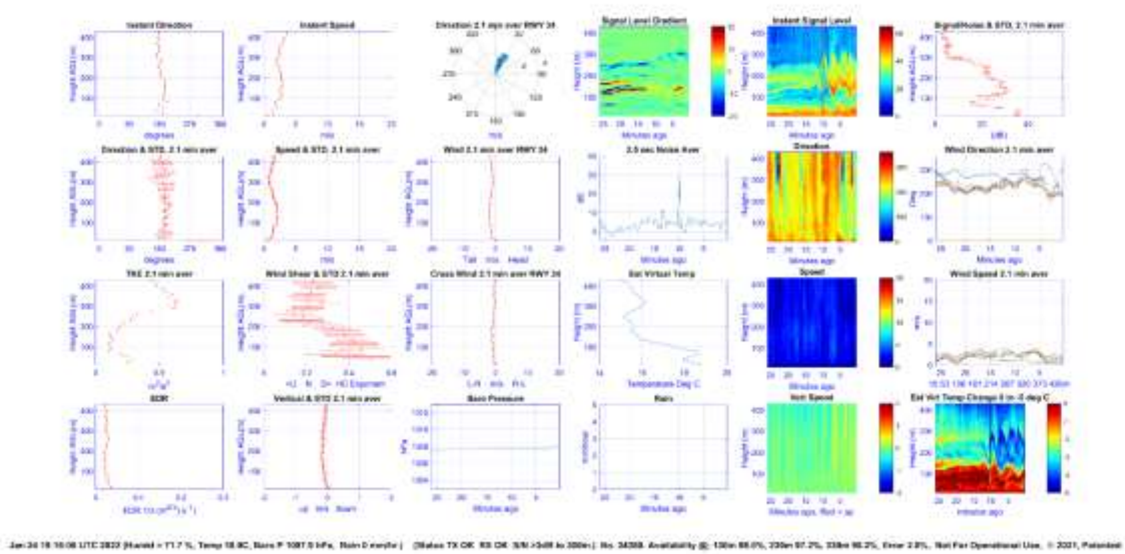

Figure 4b. B738 departure, above the inversion layer, much lower turbulence increases the wake lifetime to around 6 minutes. The strength of the inversion layer gradients is shown in row 1, 4 across, with red showing the top of the inversion layer above which the temperature decreases and blue showing the bottoms of the inversion layers where the temperature increases. Multiple inversion layers are present. The scale of the temperature changes between 0 and -5 degrees C is shown in row 4, 6 across. The interaction between the wake vortex and the inversion layer from which the wake vortex rebounds twice, is clearly evident. The inversion layer eventually reforms after about 15 minutes (not shown here).

Arrival Wake Vortices.

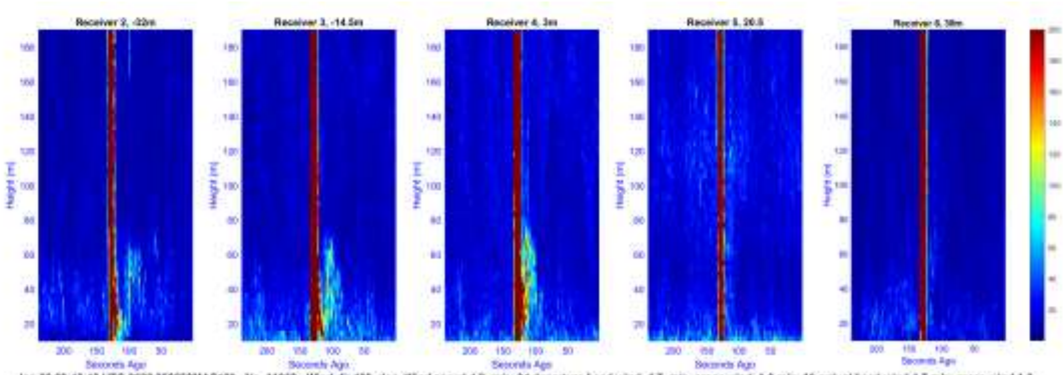

Figure 5a. A333 arrival in higher headwinds of 4.7m/s at a height of 60m with no inversion layer, higher turbulence holds the wake lifetime to around 40 seconds. Figure 5b shows the associated met data. The left (port) vortex rebounds. The wind is from right (starboard) to left (port).

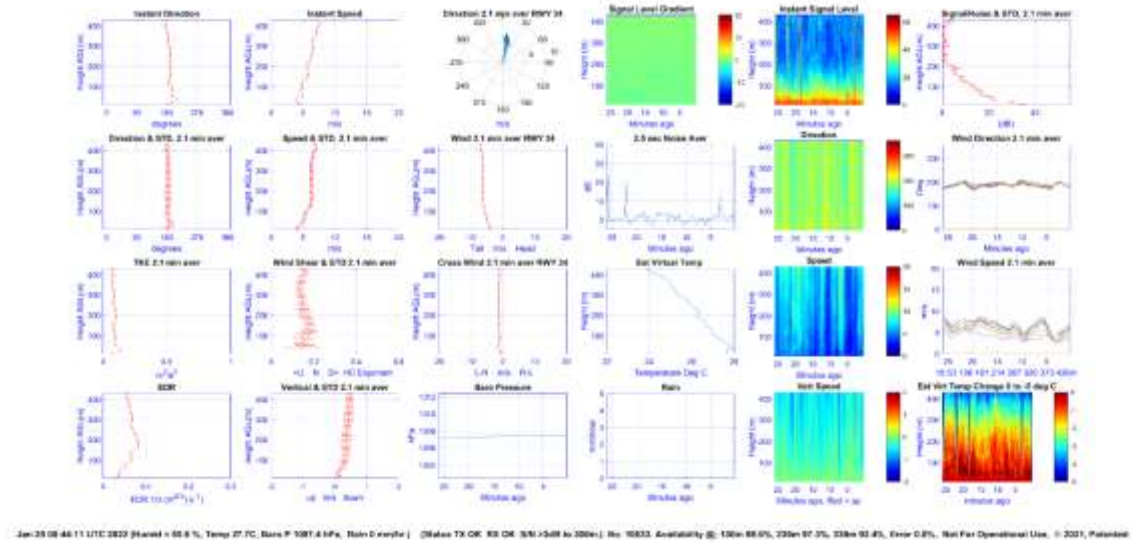

Figure 5b. A333 arrival, with no inversion layers evident, higher turbulence holds the wake lifetime to around 40 seconds. The wind is from 180 degrees and is a headwind for this 16 arrival. The graphic 2 down, 3 across, shows a tail wind but that is for a 34 arrival.

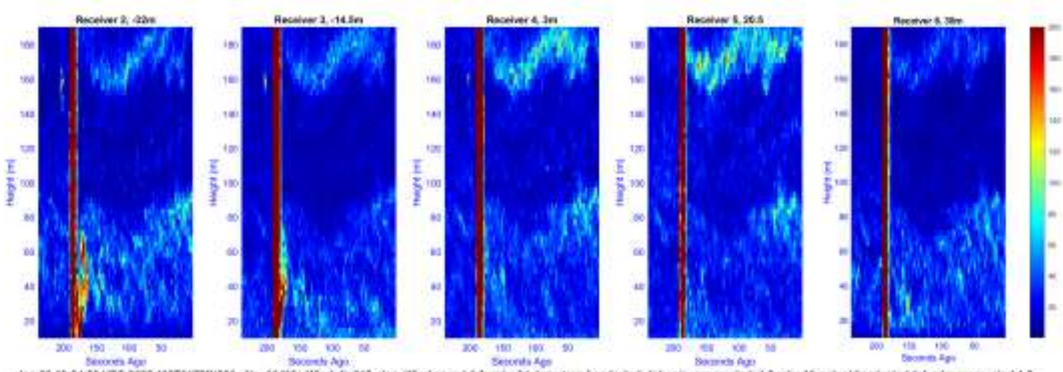

Figure 6a. B763 arrival, below an inversion layer, higher turbulence below the inversion layer holds the wake lifetime to around 30 seconds. Figure 6b shows the associated met data.

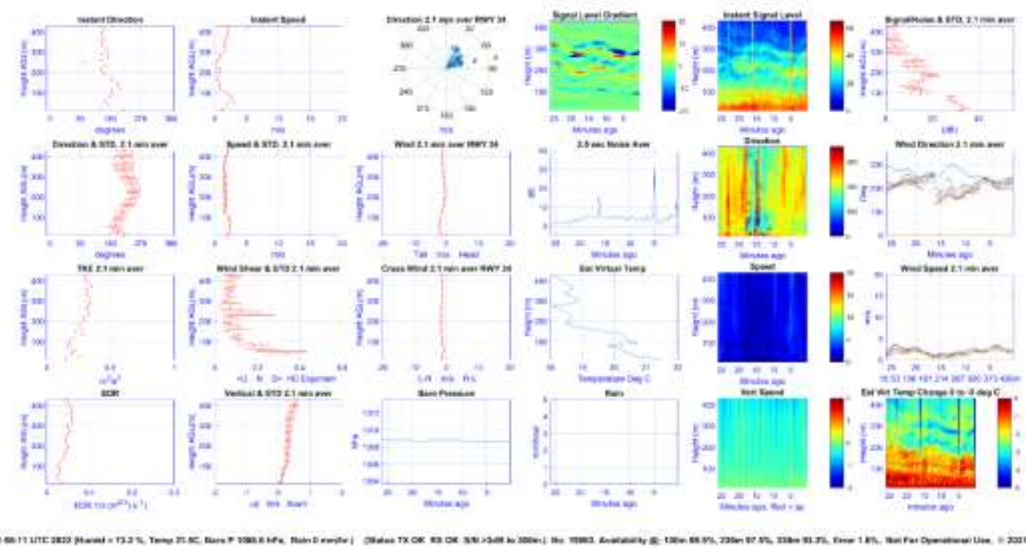

Figure 6b. B763 arrival below the inversion layer, higher turbulence holds the wake lifetime to around 30 seconds. The strong inversion layer top is around 300m with a weaker inversion layer at around 100m.