# Fulcrum3D Sodar Technical Note
## Data version 3.6.1 addresses wind speed bias at low heights

### Overview

Fulcrum3D Sodar wind speed and direction data is currently calculated in FlightDECK using data version v3.6.1 which was implemented in August 2019.

A bias that can lead to an overestimate in wind shear was discovered in data version v3.5.1 during the IEC classification process. v3.6.1 incorporates a correction to shear at lower heights only.


### Physics behind bias and applied correction

The Fulcrum3D Sodar measures wind speed over a volume in space. For example, the 40m range bin is a volume extending from 35m to 45m. The strength of the signal recorded by the Sodar exhibits spherical spreading in line with the inverse-square law ($1/height^2$) which is the main cause of reduced availability at higher heights.

Based on this, the Sodar receives a stronger signal from the base of the range bin than it does from the top. While the center of the sampling volume from the signals' time of flight is 40m (from 35m to 45m) for the above example, the weighted average of the signal strength from the sampling volume corresponds to a measurement taken below 40m, assume 38m for the purposes of this example.

This resulting bias leads to the wind speed reported for 40m to be incorrect, as it is only valid at 38m. This height mismatch causes wind speeds to be reduced (assuming a normal shear profile) and therefore results in a systematic over estimation of the shear exponent.

The 1/height$^2$ nature of the bias means that the effect reduces with height. However, the acoustic scattering from the atmosphere is not necessarily constant with height and can have non-linear profiles. The weighted center of the range bin can therefore sometimes be exactly at the center as calculated by the time of flight.

The correction implemented in data version 3.6.1 looks at the signal strength of adjacent range bins and, applying the known operating physics, calculates the actual height of the measured wind speed. It then interpolates this back to the intended/reported measurement height for each 10-min period in isolation and only uses the adjacent range bins. Under v3.6.1, the wind speed initially measured at 38m in the example above will now be correctly calculated and reported as the wind speed at 40m.

Note that this correction is not applied at and above 100m. Data availability and filtering is unchanged between v3.5.1 and v3.6.1, which means v3.6.1 and v3.5.1 are identical for 100m and above at all sites.

## Example comparison between v3.5.1 and v3.6.1

The table below shows an example comparison between the old v3.5.1 and new v3.6.1 at a site where a client flagged an overestimate in shear measurements:

*Table 1: Example comparison between v3.5.1 and v3.6.1*

| Height [m] | v3.5.1 [m/s] | v3.6.1 [m/s] | Ratio of 3.6.1/3.5.1 |
|---|---|---|---|
| 50 | 5.019 | 5.0975 | 1.01564 |
| 60 | 5.528 | 5.567 | 1.00705 |
| 70 | 5.85 | 5.882 | 1.00547 |
| 80 | 6.129 | 6.136 | 1.00114 |
| 90 | 6.16 | 6.164 | 1.00065 |
| 100 | 6.139 | 6.139 | 1.00000 |

Reported numbers above are average wind speeds over several months. At this site, the effect on wind speeds is 0.7% at 60m to 0% at 100m and above, however the effect on the shear exponent calculated from the 60m to 100m bins can be on the order of 10%.

Note that the bias depends on the site shear AND turbulence profiles. The typical correction at 60m is <0.5% but some sites will have zero change in their data, while others may have >0.5%.

## Comparing v3.5.1 and v3.6.1 for FlightDECK users

All users can log into FlightDECK and download the old data (v3.5.1) and new data with the bias correction applied (v3.6.1). This allows users to do a direct comparison and revisit historic analysis with the new data version. Analyses using wind speed measurements at 100m and above will be unchanged.