BTD-300

Standalone (thunderstorm) Lightning Detectors

White Paper

# Standalone (thunderstorm) Lightning Detectors

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## *Biral BTD-300 vs. Vaisala TSS928*

- **TSS928** uses radio signals produced by lightning cloud-to-ground return strokes at multiple frequencies to estimate distance. Signals suspected to be from intra-cloud lightning are counted, but no range or direction is attributed and the sensor has a lower detection efficiency for these flashes compared to cloud-to-ground. Since radio signals are subject to interference, the TSS928 uses an additional optical flash detector to reduce false alarms by checking that both radio and optical signals are registered at the same time, indicative of lightning. Vaisala set the maximum range limit to 30 nautical miles (56 km) due to both the limit of optical flash detection and high uncertainty in their range estimation beyond this distance.

- **Biral BTD-300 (and 350)** thunderstorm detectors do not use radio signals to detect and range lightning. Instead, they detect changes in the atmospheric electrostatic field below 50 Hz which is used to estimate flash distance, given assumptions about the lightning height and charge neutralisation. Total charge neutralised by the flash is a more consistent parameter than, for example, radio signal amplitude, so variability in this assumed value is small compared to the distance-dependent change of signal amplitude, especially for lightning a few 10s of km away. Whilst the natural variability of total charge neutralisation and height are the main sources of flash distance uncertainty for the BTD, this uncertainty is within the size of a typical small thunderstorm cell, so the technique is entirely appropriate for locating areas of thunderstorm activity surrounding a site.

### False alarms:

Unlike radio signals, electrostatic changes below 50 Hz are not greatly affected by interference, so false alarms are naturally very low and do not therefore require additional techniques such as optical coincidence detection that the TSS928 has to use. In addition, the BTD's electrostatic detection and ranging technique produces excellent flash detection efficiency for all types of lightning, not just cloud-to-ground. This is because it is not limited by the high variability in radio signal amplitude and frequency observed between different flash types. Where flash direction is required, the optional BTD direction finding module, which is a multi-antenna radio receiver, is integrated into the sensor. This radio module exploits the ability of radio waves to indicate flash direction, whilst not being a source of false alarms since only the electrostatic signals are used for indicating a flash has occurred.

### Detection ranges:

Like the TSS928, the default maximum lightning warning range of the BTD's is 30 nautical miles (56 km), as required for FAA compliancy. However, the improved confidence in range estimation gained from using electrostatic signals combined with an integrated model accounting for the effects of the ionosphere allows improved distance accuracy beyond 56 km, permitting the user to increase the maximum warning range to 45 nautical miles (83 km). Whilst flash detection efficiency is reduced beyond the 56 km default range, it is still sufficient to locate the presence of an active thunderstorm, thereby providing an extended early warning of an approaching storm compared to the TSS928.

## Sensitivity:

The BTD-300 has been installed in a number of locations where its data can be directly compared to the local lightning network. These include the highly regarded LINET network as well as the Italian Airforce network LAMPINET. Data from these comparisons has been reviewed and analysed both by Biral and by independent meteorological organisations. Whilst the comparisons uphold the BTD's accuracy claims for both the range and direction of the lightning flashes, it also demonstrates the high sensitivity of its measurement system. In all network data comparisons to date, the BTD's detect at least as many flashes as the network, and for some comparisons the BTD reports more than twice as many lightning flashes within a 20km radius than the network. This is due to the BTD's ability to detect the much weaker intra-cloud lightning which is too weak for many lightning networks to detect. As these intra-cloud lightning events are often pre-cursors to cloud-to-ground lightning, the BTD is once again able to give an advanced warning of the threat of vicinity cloud-to-ground lightning before it has developed, providing a lead time which in many cases exceeds that of network detection.

## Overhead thunderstorm warnings:

An important feature of the BTD detectors is their ability to warn of potential overhead thunderstorm activity before the first lightning flash. Such a feature is essential for early warning of thunderstorms that develop in the immediate vicinity of the site. These overhead storms do not produce the distant lightning needed to track the incoming storm using a lightning-only detector like the TSS928. This pre-flash warning is achieved by sampling the charge on individual hydrometeors (raindrops, snowflakes, etc.) and corona ions present at the site using the electrostatic antennae of the BTD.

The need for pre-flash warning is recognised by other thunderstorm warning systems, which require separate sensors such as electric field mills to be installed in addition to lightning detectors like the TSS928. Electric field mills are designed for assessing local field strength and can therefore also indicate developing thunder clouds overhead. However, unlike the BTD, their need for moving parts can produce maintenance and reliability issues.

## Comprehensively tested:

Biral has thoroughly analysed the performance of the BTD detectors, comparing them to class leading lightning network systems and other independent methods of lightning and electric field detection since the BTD technology was developed in 2012.

The BTD technique and comparisons underpinning the sensor specifications have been published in peer-reviewed scientific journals and as part of WMO technical conference proceedings. All of which support the claims around the BTD's inherent sensitivity and accuracy in both detection and location of lightning flashes.

## Published Peer-Reviewed and Conference Papers:


Bennett, A.J. and Vergari, S., 2018. Comparison of electrostatic, radio and human observation techniques for thunderstorm warning at the WMO field intercomparison site in Vigna di Valle–Italy. *TECO 2018 WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation,* O**2**(12), 8-11 October, Amsterdam, The Netherlands.

Bennett, A. J., 2018. Warning of imminent lightning using single-site meteorological observations. *Weather,* **73**(6), pp.187-193. doi: 10.1002/wea.2782.

Bennett, A. J., 2013. Identification and ranging of lightning flashes using co-located antennas of different geometry. *Measurement Science and Technology,* **24**, 125801.



***About the Author***

*Dr Bennett is the Meteorological Products Manager for Biral, UK. He has a PhD in Atmospheric Electricity and over 10 years' experience in research and development of lighting detection systems, including working at the UK Met Office and being a visiting Research Fellow at the University of Bath. He has written over 30 papers in atmospheric electricity, published in peer-reviewed international journals.*






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