

Lightning warning options for the SuperWASP observatories

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Below is a brief summary of the most common lightning detection and warning systems, including their mode of function and relevant application to the protection of the North and South SuperWASP observatories.

During periods of fair weather a potential difference of 200 to 500 kV exists between the Earth's surface and ionosphere which, according to current theories, can only be sustained by the electrical current transfer from between one to two thousand typical thunderstorms at any one time around the world.

This high number of electrical storms poses a great risk to astronomical observatories which is heightened by the nature of their construction and their high altitude. It seems only sensible to employ some form of early warning system which, on the onset of such a storm, would allow the observatory to shut-down and power-down minimising the chances of damage from a strike.

The robotic (and hence unsupervised) nature of the SuperWASP observatories requires that such a detection system must be able to automatically assess the lightning threat and interface with the observatory control systems to close the roof and power-down the observatory if there is a strike risk within a pre-defined safety zone. The enclosure is protected by a 'Farrell Engineering' lightning protection system which safely conducts electricity to the ground after a strike.

It should be noted at this point that most lightning detection systems can only provide a warning after a strike has taken place within the system's detection range. There can be no warning if the first strike is directly above. The SuperWASP observatories are equipped with a weather station, however, which may be able to detect weather features indicative of an electrical storm and shut-down the observatory in advance of a strike.

From my web research I have found two suitable possibilities available for providing strike protection for the SuperWASP observatories which I will discuss further in this document.

- i) Strike warnings from a commercial lightning detection network available by subscription.
- ii) Strike warnings from a lightning detector mounted on the observatory itself.

Commercial Lightning Detection Networks

Automatic systems to detect 'Cloud to Ground' strikes were developed in the 1970s and are now common in America, Europe and Australia. Such networks consist of several receiving antennae separated by a few hundred kilometres which use a variety of techniques to detect strikes including magnetic direction finders, time of arrival techniques, and VHF interferometry.

A number of European countries (excluding the UK) have joined together to form a Europe-wide detection network known as 'Euclid' (European Cooperation for Lightning Detection)¹. This uses the American Global Atmospheric Inc. (Tucson, AZ) system capable of detecting 95% of strikes to an accuracy of 500m.

The MET Office use an in-house designed system called the VLF Arrival-Time Difference (ATD) system which can detect and locate lightning at very long range but with reduced detection efficiency.

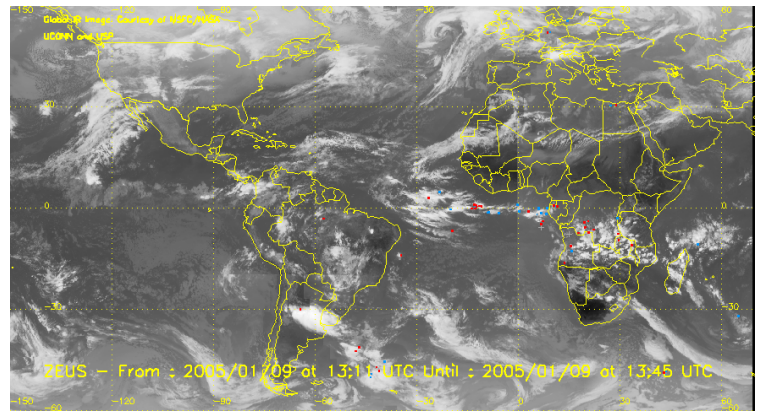
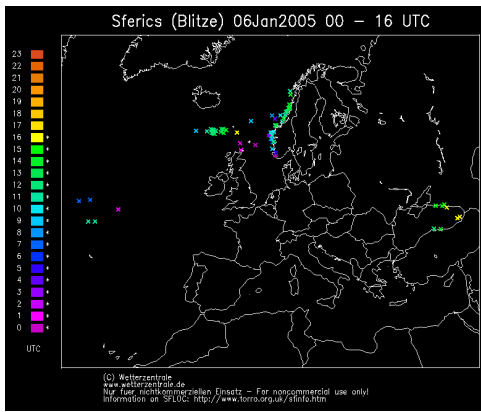
It is also possible to monitor Lightning Strikes from space by looking for optical flashes, although this information is normally used for long-term meteorological studies rather than short-term lightning warnings. Examples include NASA's Optical Transient Detector and the Lightning Imaging Sensor, deployed on the Tropical Rainfall Measuring Mission.

Despite the immense lightning detection coverage in Europe and America I have been unable to find any commercial companies offering specific lightning warnings that cover either the Canary islands or southern Africa regions. There are two organisations, however, that provide a regularly updated free online map which details strikes in these areas.

The first is at <http://www.wetterzentrale.de/pics/Rsfloc.html> (shown in fig. 1) and shows lightning strikes across central Europe but also covers the northern tip of Africa including the Canary Islands. The map is only updated every one hour and has quite poor spatial resolution. The lack of coverage south of the Canary Islands may limit its usefulness.

The second is at <http://www.zeus.iag.usp.br/> (shown in fig. 2) and uses data from the Zeus long range lightning monitoring network which covers Europe, Africa and the Pacific Ocean. The Zeus network is relatively new (completed in 2003) and is the only network covering the African/Pacific region. The following extract detailing the network is taken from their website:

¹ www.euclid.org



Figures 1: <http://www.wetterzentrale.de/pics/Rsfloc.html> (left) and 2: <http://www.zeus.iag.usp.br/> (right)

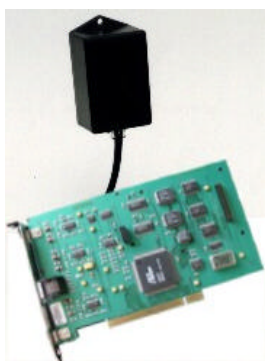
ZEUS - REAL TIME LONG RANGE LIGHTNING MONITORING NETWORK

Funded by the National Science Foundation (Water Cycle Program), with joint support by the Hellenic General Secretariat for Research and Development, we have deployed and operating an experimental long-range lightning detection system (Zeus) in Africa and Europe. The system, built by Resolution Displays, Inc., consists of a network of ten Very Low Frequency (7-15 kHz) radio receivers (named "sferics") spread over the European and African continents. Sferics is the radio noise emitted by lightning over a broad region of the electromagnetic spectrum, which in the VLF band can propagate over thousands of kilometres in the earth-ionosphere wave-guide. The European receivers are situated in Birmingham (UK), Roskilde (Denmark), Iasi (Romania), Larnaka (Cyprus), and Evora (Portugal), and the African receivers are in Addis Ababa (Ethiopia), Dar es Salaam (Tanzania), Bethlehem (South Africa), Osun state (Nigeria), and Dakar (Senegal). The European and African network deployments were completed in the summers of 2001 and 2003, respectively. Since then lightning activity occurring over a large part of the globe is being continuously monitored at varying spatial accuracy (e.g. 10-20 km within and >50 km outside the network periphery) and high temporal (1 msec) resolution. This unprecedented dataset on convection presents a unique opportunity to advance water cycle research in the most active regions of earth (Africa, Amazon and ITCZ). The availability of continuous information on lightning activity over such an extensive area would further support real-time applications in hydrology/water resources (improve high-frequency satellite rainfall estimation), meteorology (improve quantitative forecasting of convective storms through continuous lightning data assimilation), and aviation safety (predict regions of strong vertical motion in a cloud that an aircraft should avoid).

I have, so far, not been able to find any additional/detailed information on the Zeus network other than this map. As the project is designed primarily for climatic research such information may not be available. A simple program could be written to monitor this online map and give warnings if any lightning strikes occur within a certain radius of the observatories but the positional accuracy would be very poor and temporally only accurate to plus or minus half an hour (as the map is refreshed). This would be an extremely cheap option, however, providing a rough lightning warning that may warrant further consideration and investigation.

Lightning detection sensors

The second lightning warning option would be to use one of many lightning detection/warning sensors available to buy at varying costs. These typically consist of a lightning detection sensor that can be located in a suitable position (away from electrical equipment) and an electronic control box some of which interface directly with a computer and provide a wealth of information on local lightning activity. The main models are briefly detailed below:



Boltek of Buffalo, USA (www.boltek.com) claim to be the world leaders in affordable thunderstorm tracking technology (!?) and provide several systems for detecting strikes. Their "Storm tracker" device (pictured left) consists of a small antenna box, which can be attached in almost any location, which connects to a PCI interface card (its slightly more expensive brother is an external device that connects via USB). The system features a direction finding antenna which can detect the direction of strikes at a range of 300 miles (measuring in the 100-700kHz range) and integrated electronics that measure the intensity of the radio signals allowing the distance to be determined. Included software allows detected lightning strikes to be displayed on a map of the local region and suitable alerts set-up.

The system seems very complete and well supported with a variety of third party software available. It is available for \$499 (or £499 from UK websites!).

Note the software only supports MS Windows.

Boltek also offer early warning sensors which monitor static electric fields and can warn of atmospheric conditions preceding a strike. Boltek recommend, however, that this system is not designed as a lightning warning system and should only be used for scientific study.

There is also a valuable online forum for customers to discuss all matters related to the installation, operation and maintenance of the system.



Vaisala are a well established weather product company and produce a large range of both national scale and professional lightning warning equipment. They are responsible for the US National Lightning Detection Network (NLDN). Their 'Thunderstorm System TSS928' detailed at <http://www.vaisala.com/page.asp?Section=47466> provides a sophisticated system for accurate strike warnings similar to the Boltek system. It comprises of an antenna and control electronics which are mounted onto a short tripod (or can be pole mounted) which interface directly with included software via a serial connection. The system has a maximum range of 30 nautical miles and classifies strikes into 3 distance bands 0-10, 10-20, 20-30 miles and eight compass directions: N, NE, E, SE etc. Detection efficiency is claimed at 90% within 10 miles, 99% with 2 discharges and 100% with 3 discharges – they also claim that this is the most precise stand-alone lightning detector available in the world. In addition to VLF signals the antenna is able to measure magnetic and optical lightning emissions to reduce false alarms. The unit can integrate with a control relay for activating/deactivating external devices such as alarms, power supplies etc. Optionally, electric field mills can be attached which monitor electric static potential providing early warnings (although the effectiveness of this is unknown).

The data output (in serial ASCII format) is highly flexible and has been designed to interface with a variety of communication systems including weather stations using METAR observations(?).

The included software contains all the expected features but again is only available for MS Windows. This is not likely to pose a significant problem, however, as the data format and transmission appears well documented.

The price is not listed but I suspect it will be significantly higher than the Boltek system. I have yet to hear back from Vaisala on this matter.



The 'FMLA-1000' (shown left) is sold by www.weathershop.com and represents a more basic system - only detecting the presence of lightning within a 25 mile radius (no positional or range information). Output is via a flashing LED and a loud siren with an optional relay unit for activating external devices. There is little information on its detection method and sensitivity although it can be assumed it operates in the same manner as all the other systems in its class by detecting VLF radio. The basic system is available for \$249 plus another \$89 for the relay. (A little expensive for such limited functionality).



'EWS-PRO Lightning Detection & Early Warning System' is available from <http://www.ambientweather.com/>. This is a professional lightning detection system contained in a portable handheld box and again gives no direction and only limited range information. It is available from \$799. As this is a portable device (not ideally suited to the observatories) I will not go into any further detail.



The 'SkyScan Lightning Detector' available for £149 from http://www.ukweathershop.co.uk/acatalog/skyscan_sub.html is a basic wall-mounted device that detects VLF radio frequencies. The unit gives warnings of strikes within 40 miles in the divisions of 0-3, 3-8, 8-20, 20-40 miles but gives no direction information. Warnings are given in the form of flashing LEDs and audible alarms. Again this device is claimed to be one of the most accurate available and in common use at baseball stadiums, golf courses etc. Normally battery powered, an optional mains power supply is available.

Although no doubt there are countless other systems available to buy (including a surprising number of pocket sized personal detectors) these 5 are the most well documented and well advertised on the internet. They range in scale from the simple to the highly complex and I would suspect this would be reflected in their accuracy and performance.

Without doubt the Vaisala system represents the most professional and complete system but as a cost compromise the Boltek system provides equivalent features although not perhaps quite as accurately. Both systems could provide adequate warning and protection for the observatories and could be configured to interface with the observatory control systems. Both systems could also be set-up with a web interface (relevant software for the Boltek system is already available) allowing lightning data to be accessed by interested parties (other local observatories) or by consortium members from home. The data could also be incorporated into the ING weather station.

I should point out, for completeness, that there is a third option available – building our own warning system; Detecting the VLF radio signals from nearby strikes is not difficult and <http://www.techlib.com/electronics/lightning.html> (as well as many other sites) provide a variety of circuit diagrams and instructions to build a homemade detector. Although such a system would likely be effective it would be crude and would lack many of the useful features exhibited by the more sophisticated commercial systems such as range and direction finding capabilities.