The new Met Office ATDNET lightning detection system

J. Nash, N.C. Atkinson, E. Hibbett, G. Callaghan , P.L. Taylor, P. Odams, D. Jenkins, S. Keogh, C. Gaffard and E. Walker
Met Office, Exeter, UK

1. Introduction

The Arrival Time Difference (ATD) Thunderstorm detection system is a low-cost innovation that has grown out of a requirement placed on the Met Office to locate thunderstorms for general weather prediction [public safety], the national Electricity supply Grid and Defense operations . The outputs find many applications, for instance, to verify occasions of very intense rainfall detected by the weather radar network.

The first ATD system started operation in 1986 and system upgrades in the late 1990s facilitated increased automation. From early 2000, the system has operated autonomously with occasional intervention, under the supervision of a network manager normal working hours and by network and Engineering staff at other times. This system is fully supported by the Met Office and does not rely on any external manufacturer to sustain operations.

The ATD system works by detecting the vertical component of the electromagnetic field generated by a lightning discharge at a narrow band frequency in the range 10 to 14 kHz. Strong electromagnetic emissions at these frequencies are caused by rapid neutralisation of charge in the lowest few hundred meters of cloud to ground (C-G) strokes. Atmospheric attenuation at these frequencies is very low and the electromagnetic discharge (SFERIC) can propagate over thousands of kilometers along the earth-atmosphere wave guide. ATDNET outstations, Fourier analyze the SFERIC wave and the waves from different outstations are correlated in the central processor to produce the time difference used for flash location. 3 pairs of time differences are required to obtain a location, but it is preferable to have at least 4 if possible, to guard against error in one of the individual time differences and solve ambiguity location.

The ATD system is not very sensitive to cloud to cloud strokes especially at long range from the sensors, since it primarily senses SFERICS polarized in the vertical.
Details of the system are presented in Keogh et al (2006) with some ideas about extending the system for global coverage. Detection characteristics of the existing ATDNET were first presented in Nash et al (2005). The existing system has used several New Outstation [NOS] to maintain and improve its operations since 2004, so the Met Office is quite confident about the stability of operation of the NOS sensing systems, including software.

However, a completely new ATDNET system will become operational in December 2006, using a larger number of NOS than possible previously. A new flash location processors feeds locations into a Logical Data Store and then into a Product Generation System. This system structure was dictated by the Met Office Policy for processing data from new observing systems giving much more flexibility in product

generation than exists with the current system. This paper illustrates some of the test results obtained with the system in recent months as it moves towards operational implementation.

2. Operational locations for new ATDNET system

The outstation sensor, see Fig. 2.1, is of similar design to the current system, but it has been found that the frequency of observation may have to be changed from 10 kHz to 13.6 kHz , because in the Indian Ocean there are sporadic transmissions at 10 kHz which prevent the use of 10 kHz for operations. Efforts will be made to register 13.6 kHz with ITU as an operational frequency for lightning detection, since this frequency seems to be clear at all the proposed ATDNET NOS locations.

Fig. 2.1 ATD whip antenna used for observations at 10 kHz or 13.6 kHz
[frequency can be changed using software]

The new outstation software has been upgraded in the last year but remains similar in function to that reported in earlier papers, Fig. 2.2 shows one example of the outstation processing electronic which consists of a couple of proprietary programmable processing boards mounted within a PC.

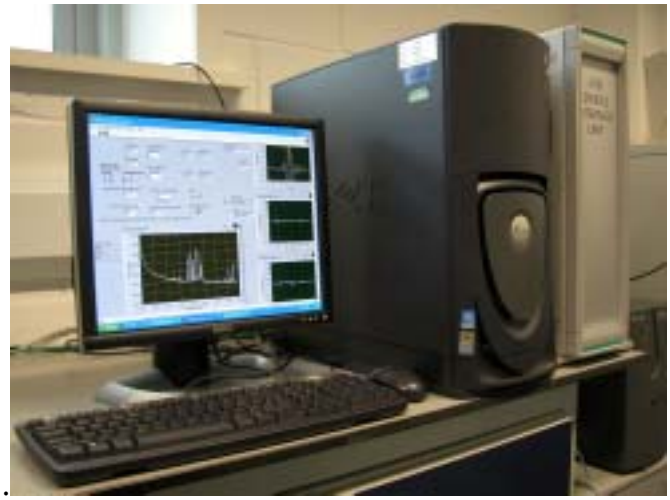


Fig. 2.2 New Outstation [NOS] allows increased throughput of detected SFERICS of at least 100, 000 flashes per hour, with usual rates normally in the range 10,000 to 60,000 depending on the time of day in Europe.

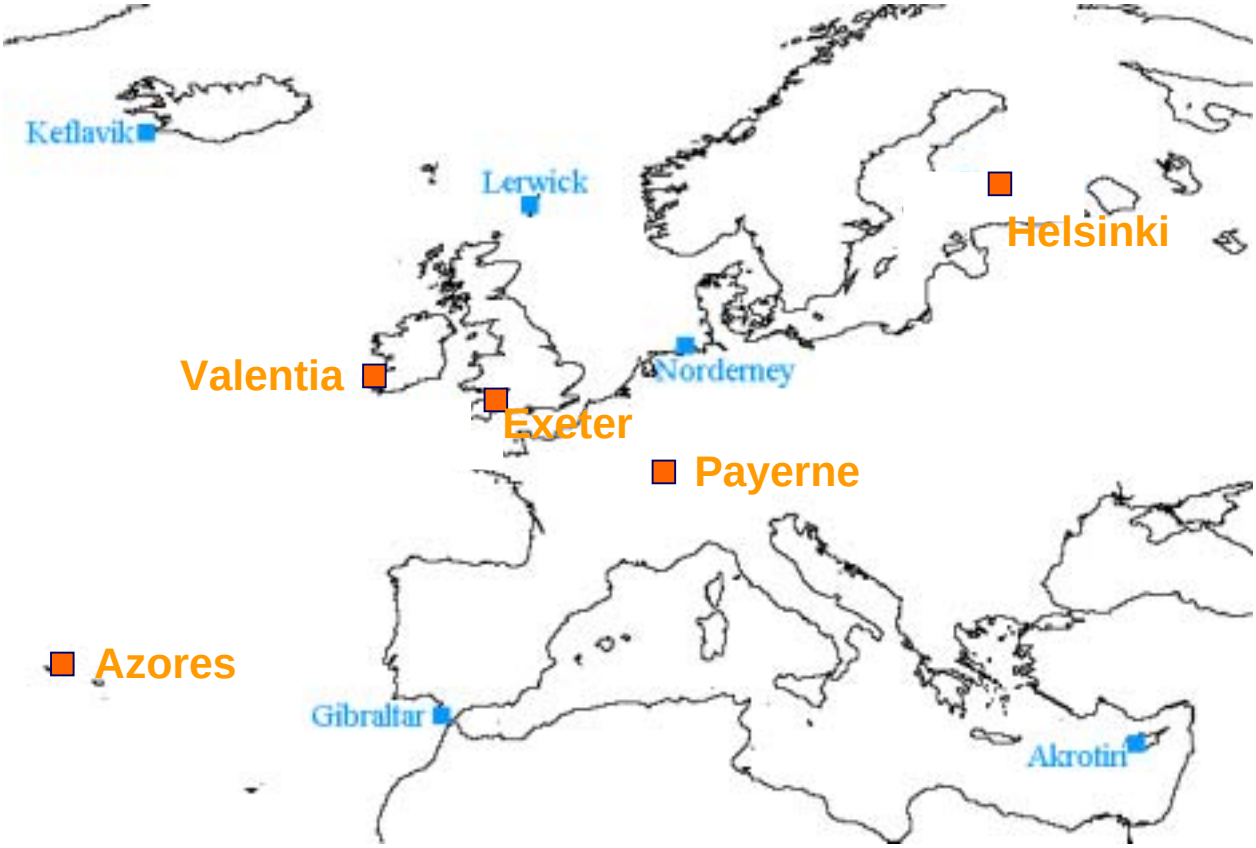
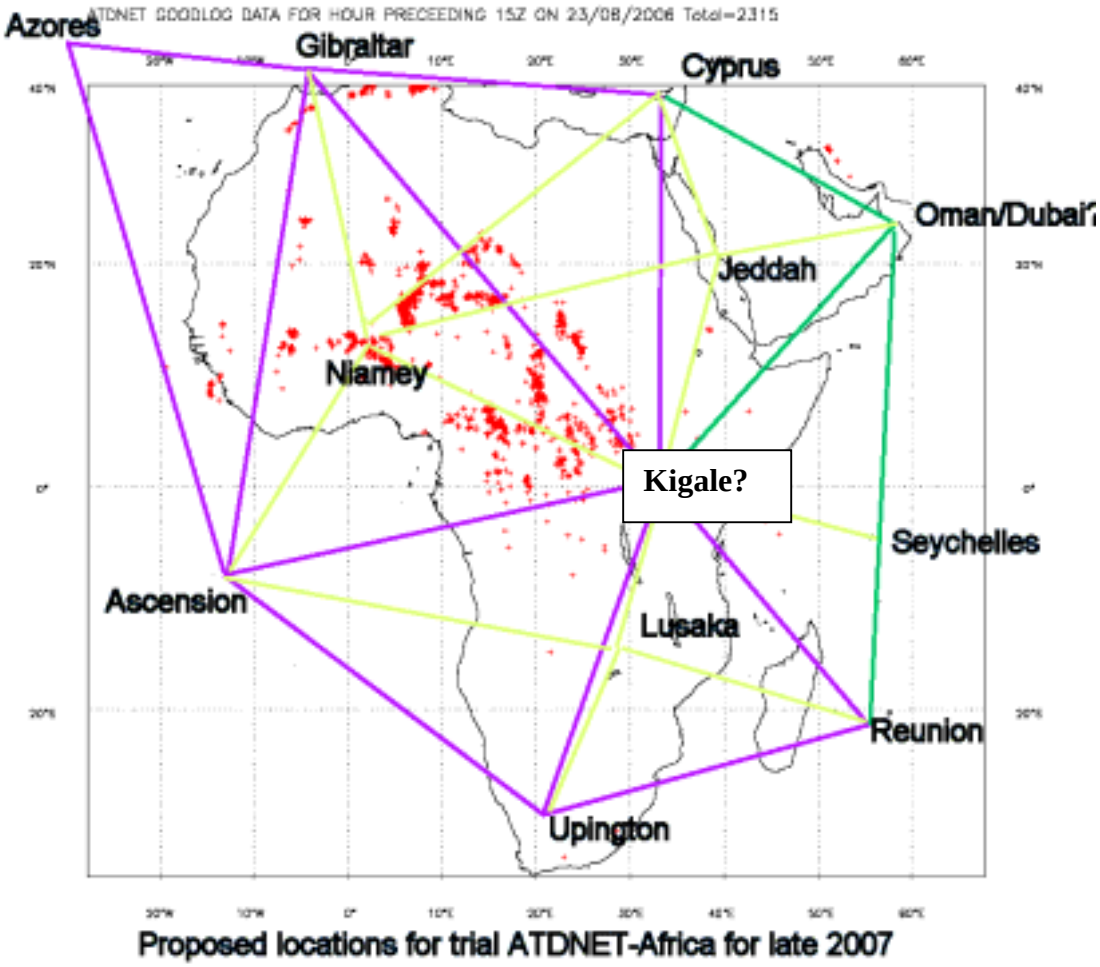


Fig. 2.3 Expected location of NOS outstations within Europe by mid-2007, in blue are the existing NOS, in orange the one to be installed in the foreseen future. In each case a memorandum of understanding will have been generated so that each country benefits from the operation of the system

More NOS outstations will be deployed compared to the current system, see Fig. 2.3, with the new NOS installed in Ireland by December 2006 and the stations in the Azores and Payerne shortly afterwards. The station currently at Korpoo in Finland also needs to be moved, probably to Helsinki to improve detection capability in the north east. In order to minimize communication costs the current links to Keflavik, Nordeney and Finland will be changed to Internet type communications, reducing communication costs by an order of magnitude.

It is planned that ATDNET will be expanded to cover Africa and Arabia with higher detection efficiency during 2007/8. In this case, a proposal for additional outstations necessary to provide a relatively high detection efficiency across this area at all times is shown in Fig. 2.4. The NOS at Reunion has been established and is now transmitting data back to the UK on a VPN line [Virtual Private Network]. The observations at Reunion are set at 13.6 kHz and it is expected that the whole ATDNET system will be changed to this frequency shortly after operations start. Transmission of data over the line from La Reunion was not easy to achieved but the experience gained indicates that it will be possible to utilize these very much cheaper communications, and it is expected that the annual communication costs associated with the networks in Fig. 2.3 and Fig. 2.4 will be at least half those of the existing ATD system



Proposed locations for trial ATDNET-Africa for late 2007

Fig. 2.4 Possible location of ATDNET outstations for good coverage of Africa., superimposed on thunderstorms detected with new ATDNET using European stations only in August 2006. Purple lines indicate the stations that are expected to be established first and the green and yellow lines join to potential sites that have not yet been approached.

In extending across Africa, memoranda of understanding will be sought with each country, in a similar fashion to Europe, with the Met Office providing the sensing system and the host country being willing to help with occasional activities if the NOS operation has a problem. Access to data for all countries in Africa is expected to be provided, but the precise details of the process has not yet been decided.

The new flash location processor is much faster than the existing system and the locations are ready for dissemination within two minutes of being sampled, thus providing a much better service for all potential customers.

3. Examples from recent testing of ATDNET

The number of flashes located per month by the existing ATD system has been monitored since 2002 and the results are compared with the number located by ATDNET since June 2006, with ATDNET operating with a maximum of six stations, see Fig. 2.5. In the middle of the summer the new ATDNET system was detecting twice as many locations as the current system, with the increased throughput allowing up to 30,00 flashes per hour to be reported in the middle of the day and at night, but with almost as many locations failing the current quality control checks.

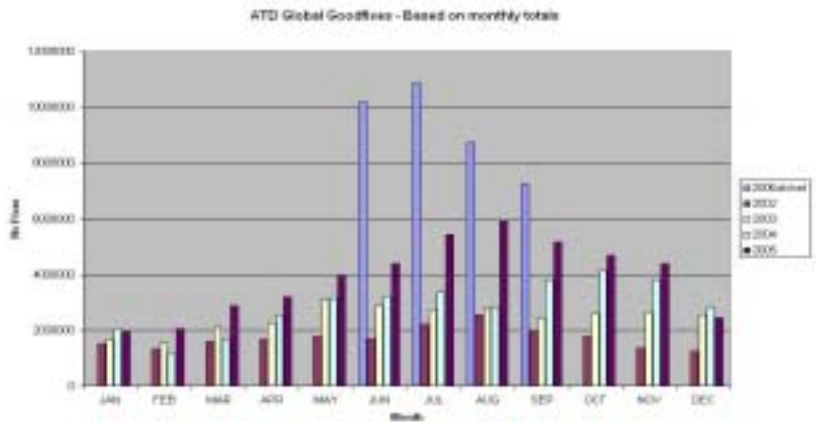


Fig. 3.1 Monthly totals of flashes located by ATD and ATDNET [darker blue]

Thus, there is still work to perform to optimize the quality control procedures , particularly at night where too many locations are being rejected . Once these

problems are resolved the new ATDNET will report at least 30 to 50 per cent more locations than those shown in Fig. 3.1 with detection efficiency better than 90 per cent in some areas. With the proposed extensions to the network the number of locations should increase even further in the next two years.

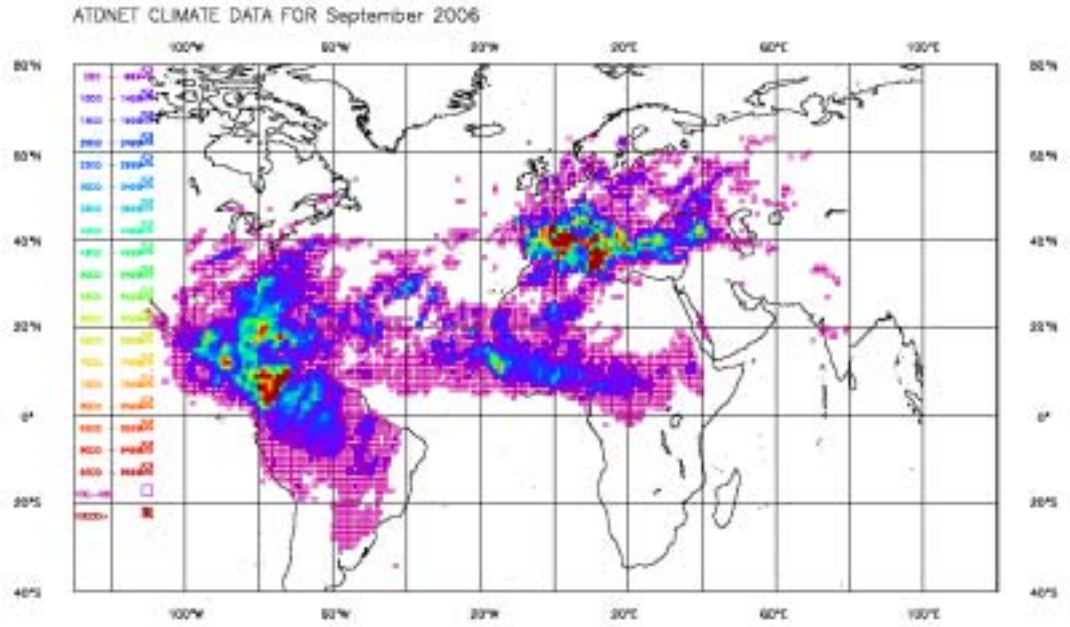


Fig. 3.2 (a) Climatology of ATDNET flash locations , September 2006, showing the large number of flashes located in the Caribbean and Central America, west Africa, and the Mediterranean.

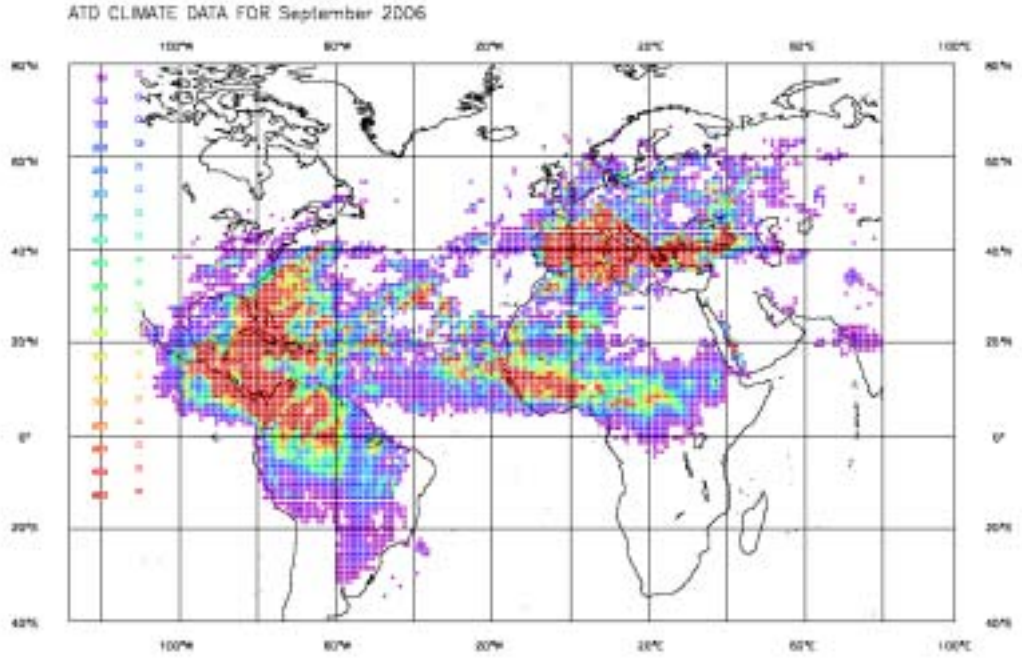


Fig. 3.2 (b) Climatology of existing ATD, note that the red colours on this plot correspond to the boundary between the dark blue and purple colours in Fig. 3.2(a)

The coverage of lightning locations obtained in September 2006 is shown in Fig. 3.2(a) for new ATDNET and Fig. 3.2(b) for current ATD. The region of coverage is similar, but the new system currently misses more storms in Arabia, because of problems with the new communications to the outstations at Cyprus and Gibraltar. Here conflict with forecast data being sent to the stations on current Met Office links limited the amount of ATDNET data reaching Exeter. This is now being rectified by changing the communication links and once this is done, the main remaining weakness in the new ATDNET configuration should be removed. This should have occurred by the end of November 2006.

Fig. 3.3 (a) ATDNET flash locations for the Mediterranean and Arabia displayed on Upper Air Team workstation having competed processing by the flash location processor and storage in the Logical Data Store.

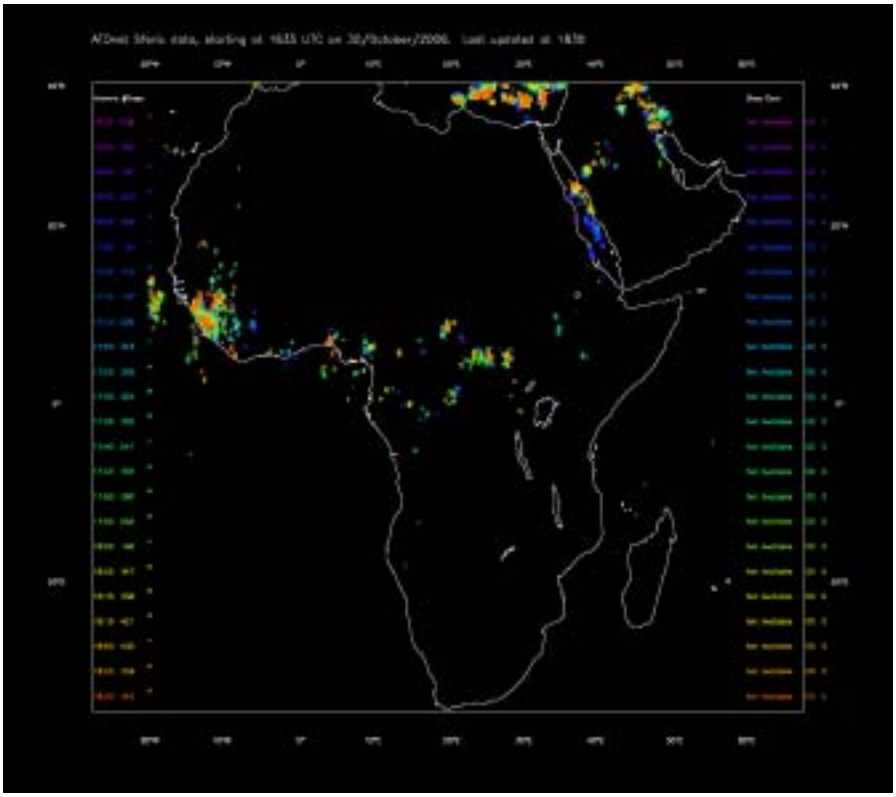


Fig. 3.3 (b) ATDNET flash locations for Africa displayed on Upper Air Team workstation having competed processing by the flash location processor and storage in the Logical Data Store.

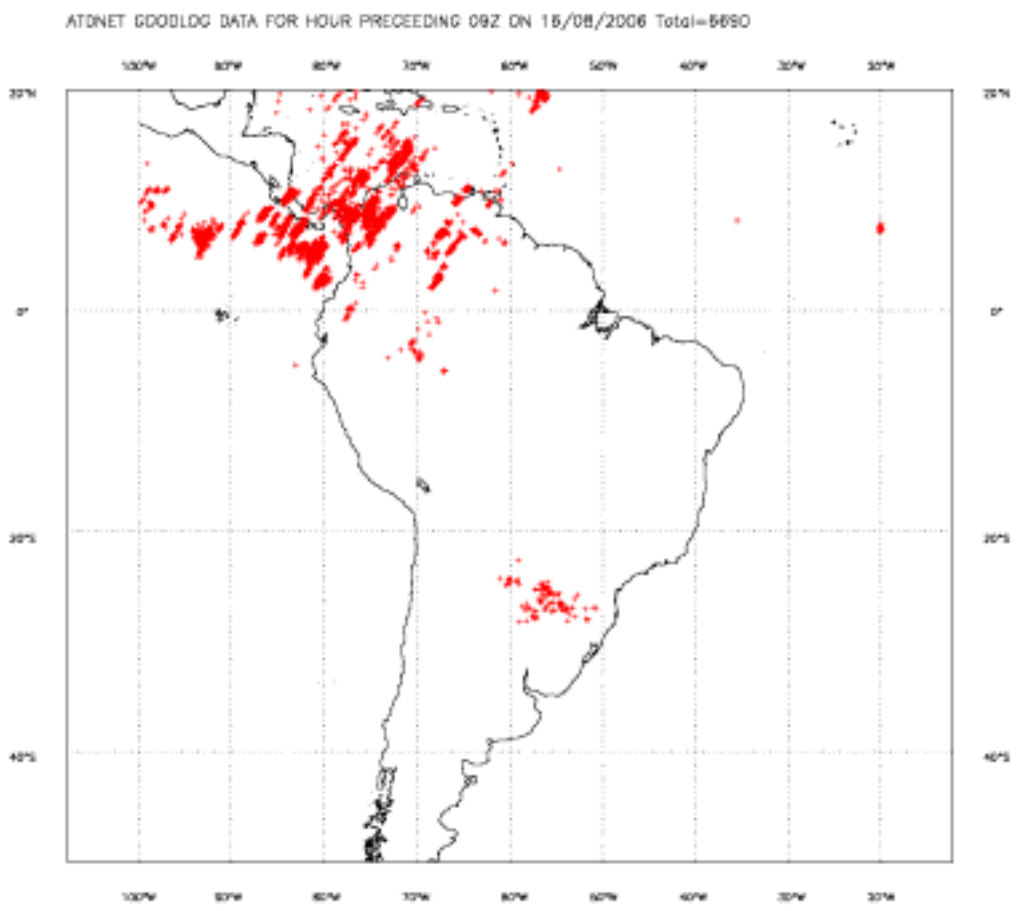


Fig. 3.4 (a) ATDNET locations for South America on 16 August 2006

Fig. 3.4(b) Lightning locations from the Brazilian Rindat system for a similar time to the ATDNET observations in Fig. 3.4(a)

4. Plans for the future

The Met Office is in the process of planning dissemination of the ATDNET products to a much wider range of countries than is currently possible. This will be managed under projects to be initiated in 2007. Countries interested in extending the ATDNET system by collaboration with the UK or those interested in receiving the products in future are requested to contact the Met Office so that their requirements can be taken into account in planning for the future.

Fig. 4.1 show an example of where ATD locations have been superimposed on a Meteosat MSG cloud image , as an example of what could be delivered in future.

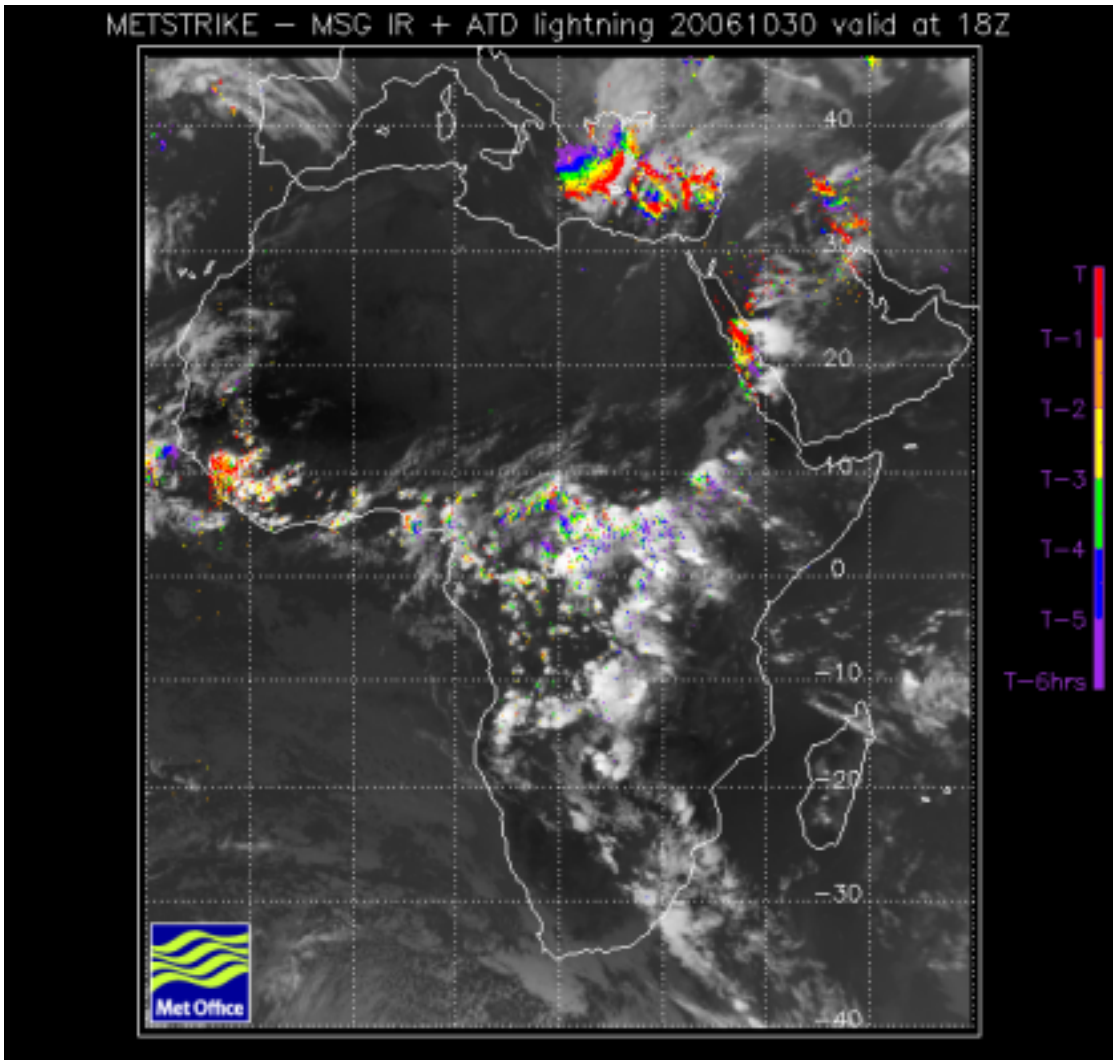


Fig. 4.1 Current ATD superimposed on Meteosat MSG cloud picture – a possible product for supply to Africa with ATDNET in future. Here the latest observations are in red and the observations 6 hours earlier are in purple.

REFERENCES:

1. J. Nash et. al, Progress in Introducing New Technology sites for the Met Office long range lightning detection system, Paper 2.9 WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation (TECO-2005), Instruments and Observing Methods Report No. 82, WMO/TD-No. 1265

2. S. Keogh, E. Hibbett, J. Nash and J. Eyre, The Met Office Arrival Time Difference (ATD) system for thunderstorm detection and lightning location. Met Office, Numerical Weather Prediction : Forecasting Research Technical Report No. 488, e-mail:nwp_publications@metoffice.gov.uk