QUALITY MANAGEMENT OF A EUROPEAN WIND PROFILER NETWORK (CWINDE)

Tim Oakley and Myles Turp
Met Office, Exeter, United Kingdom.
Tel +44 (0) 1392 885644 , Fax +44 (0) 1392 885681, Email tim.oakley@metoffice.com

Currently a network of 20 wind profiler systems in Europe (CWINDE) is providing continuous, real-time wind observations for operational use. This network is being supported under a programme sponsored by the National Met Services (EUMETNET) and the UK Met Office has been tasked in maintaining the hub and providing a quality management service. The network comprises of wind profiler systems of differing technical specification & measurement capabilities, which are operated for a variety of reasons ranging from research to aviation forecasting. In addition to the wind profilers the hub services have been extended to include wind observations from a number of the weather radar networks in Europe.

The Met Office has developed a suite of quality management software to enable the performance of the systems to be monitored in real-time and to allow feedback to the system operators and data users. This presentation will provide details on the quality management techniques being used to monitor the systems, the successes of CWINDE network and the challenges for the future.

Background

Operational networking of wind profilers in Europe started within the COST-76[1] Project and was successfully tested during two campaigns, CWINDE-97[2] and CWINDE-99. It was able to demonstrate that real-time networking of existing profiler installations was possible, even though these systems differed significantly in design & purpose and were operated by various research and operational institutions. After the COST-76 Action ended in March 2000 a proposal was made to continue the networking activities under the umbrella of EUMETNET[3], with a programme called WINPROF.

The main focus of WINPROF was to maintain the existing CWINDE network and to develop it further towards operations. Currently, there are 24 wind profiler systems able to provide wind data to CWINDE and countries like the United Kingdom and Germany are continuing to install further wind profiler radar systems as part of their operational upper air network. In addition, CWINDE is able to receive and process wind profile data from other systems, like the conventional Doppler weather radars using the VAD/VPP technique (60 sites) and sodars (2 sites). The wind profile data provided by CWINDE are nowadays mainly used by NWP. Major NWP centres in Europe, for example ECMWF, UK Met Office, Meteo France, Deutscher Wetterdienst and the HIRLAM group, are now using these data in their operational data assimilation.

Figure 1 provides a map of the current wind profiler systems contributing to CWINDE.

Annex A contains tables of the wind profiler & weather radar sites configured in CWINDE.

[1]COST - Cooperation On Science and Technology
[2]CWINDE - COST Wind Initiative for a Network Demonstration in Europe
Co-ordinated WIND profiler network in Europe (later definition)
[3]EUMETNET - Network of European Meteorological Services.

Other wind profiler networks are operated in the USA by NOAA-FSL (35 systems operating at 404 and 449~MHz, plus about 50 systems of so-called co-operative agencies) and in Japan by JMA (31 systems operating at 1357~MHz).

Figure 1: CWINDE Profiler Network (January 2005)

WINPROF & the CWINDE Network

On taking over the responsibility for the CWINDE network hub, the WINPROF program was tasked with 7 key objectives:

- To harmonise and improve the existing exchange of all wind profiler (National Met Services and Research institutions) and Weather radar wind data in Europe.
- To run and further develop a network hub for data processing and quality evaluation.
- To integrate new wind profiler and weather radar systems.
- To establish appropriate quality control procedures
- To define general quality standards and user requirements for operational use.
- To work on new/updated processing algorithms to improve data quality/availability.
- To provide expert support to members for wind profiler installations and operations.

Under COST76 the responsibility of managing and updating the CWINDE hub was tasked to the UK Met Office and this remained the case for the WINPROF project. A key objective for the hub is to provide a real-time processing and data-display service (the later via the Internet) for wind profiler and weather radar system in Europe. Providing a quality management service and feedback to the system operators is also an important task as this not only developed a better understanding of the relative quality of the wind data but also made operators aware when there were quality and/or data availability issues with their systems.

The hub processing and data displays are run on a dedicated workstation within the Met Office. Although the system is not classed as operational, it is housed within the main computer room of the Met Office and thus benefits from a number of services supported 24/7. Automated communication with the hub, from the observing site, is possible via the GTS (Global Telecommunication Service) or FTP. All products and archives are generated on the workstation automatically and currently the complete system requires approximately 0.3 of a person per year to support.

Figure 2 provides a schematic of the CWINDE processing hub.

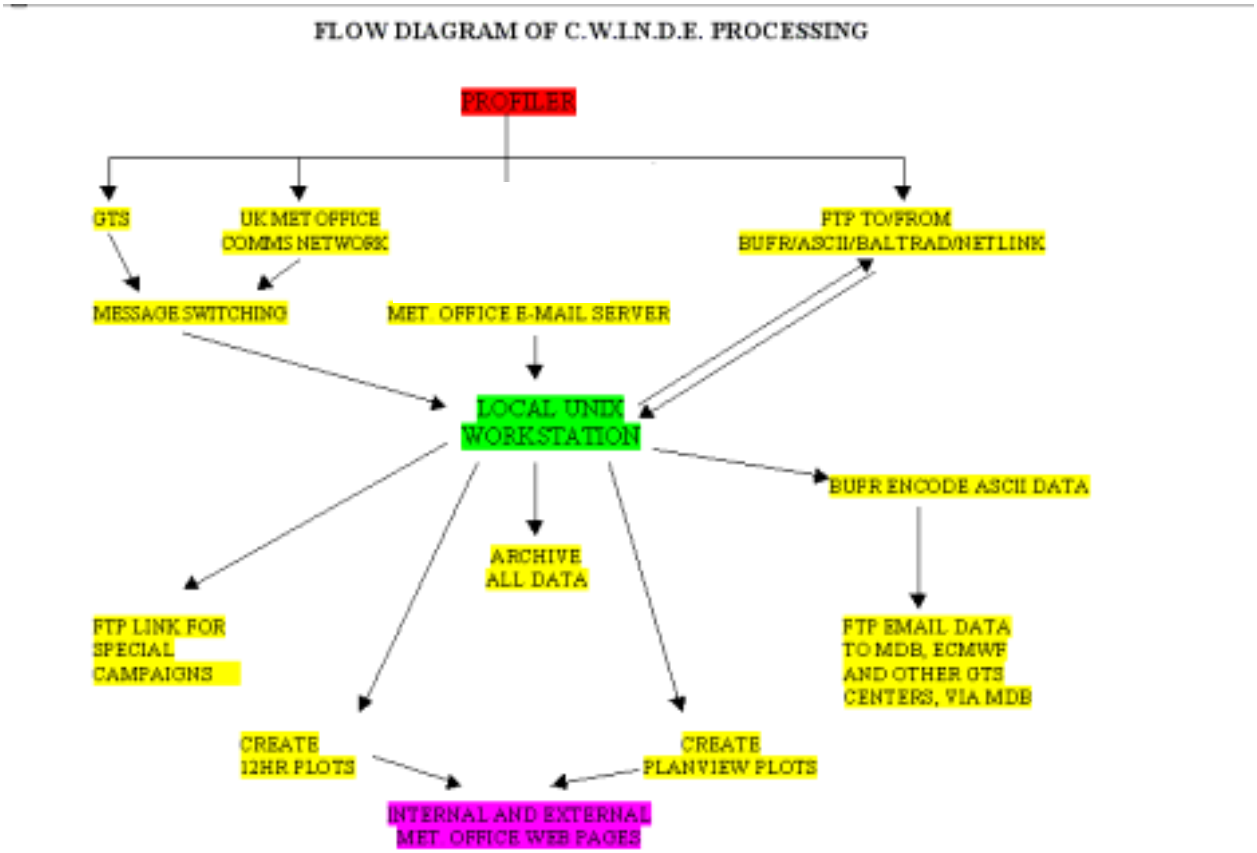

Figure 2: CWINDE Processing schematic (Jan 2005)

Since the automated processing was initiated in 1997, it has continued to run until the present day, with only a few outages due to hardware problems and the relocation of the Met Office from Bracknell to Exeter. The system is currently processing in excess of 7,500 messages each day. Figure 3 provides details of the percentage of data received in real-time for the wind profiler systems connected to CWINDE (2004). These statistics are produced regularly for the WINPROF program and are useful in classifying operational/non-operational systems on the basis of delivery of data.

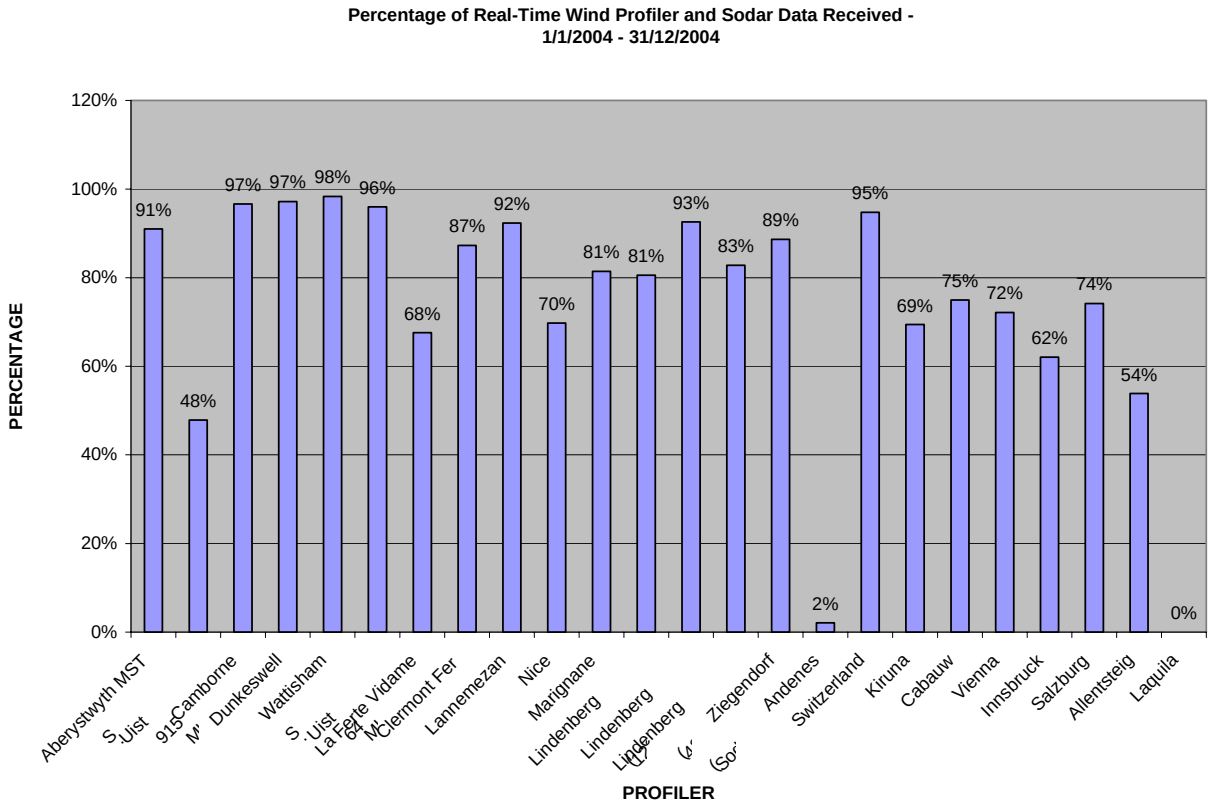

Figure 3: Data Availability from European wind profilers 2004.

Quality Management

CWINDE provides a comprehensive package of quality management products for the systems connected to the hub. These products vary for short term 'real-time' information (updated each hour), to longer term 'off-line' information (produced monthly or on request). The website address of CWINDE is:
http://www.metoffice.gov.uk/research/interproj/cwinde/index.html

A summary of the products available is as follows:

1. ***Real time data plots (See Figure 4)***

These plots are updated every 30 minutes and are made available on the CWINDE website. They provide an instant method of checking on the performance of the individual system both for data availability and quality. For forecasting they also provide access to the latest measurements of not only the wind data (wind barbs) but also the vertical velocity & signal to noise values. Many of the wind profiler and weather radar systems are completely automated and run unattended, thus these displays are a vital component on checking the current status. Figure 4 provides an example of the wind barb plot from Torino, Italy, the latest wind profiler to be added to CWINDE.

2. ***Plan view plots (See Figure 5)***

A composite data plot is generated every 3 hours showing data at selected height levels for all wind profiler and weather radar systems. The time frame for the plot is ±1.5 hours from the nominal time and wind data is displaced according to time and wind speed/direction. Radiosonde and aircraft data (if available) are included in these plots and these are also displaced according to the time and wind values. These displays provide a direct comparison of wind measurements with

other sites and observing systems. They are also useful to observe the horizontal wind fields over Europe and the distribution/density of the measurements

3. Weekly random variability/error plots (See Figure 6)

These plots are a quality evaluation product used to access the overall performance of the wind profiler systems. They calculate the random variability of the wind measurements and use these values combined with known structure functions to produce a random error estimate. Not only is this useful in accessing the current performance of a system but because the hardware from these radars tend to degrade over time, rather than completely fail, these plots from week to week (or longer) can detect changes in the systems performance. The example given in figure 5 is for the 64MHz wind profiler on South Uist. This system is working operationally and generally meets the 2ms^{-1} random error specification. In this case we observed some interference (clutter) from a wind-turbine 9-10km from the site which has slightly increased the random error estimate.

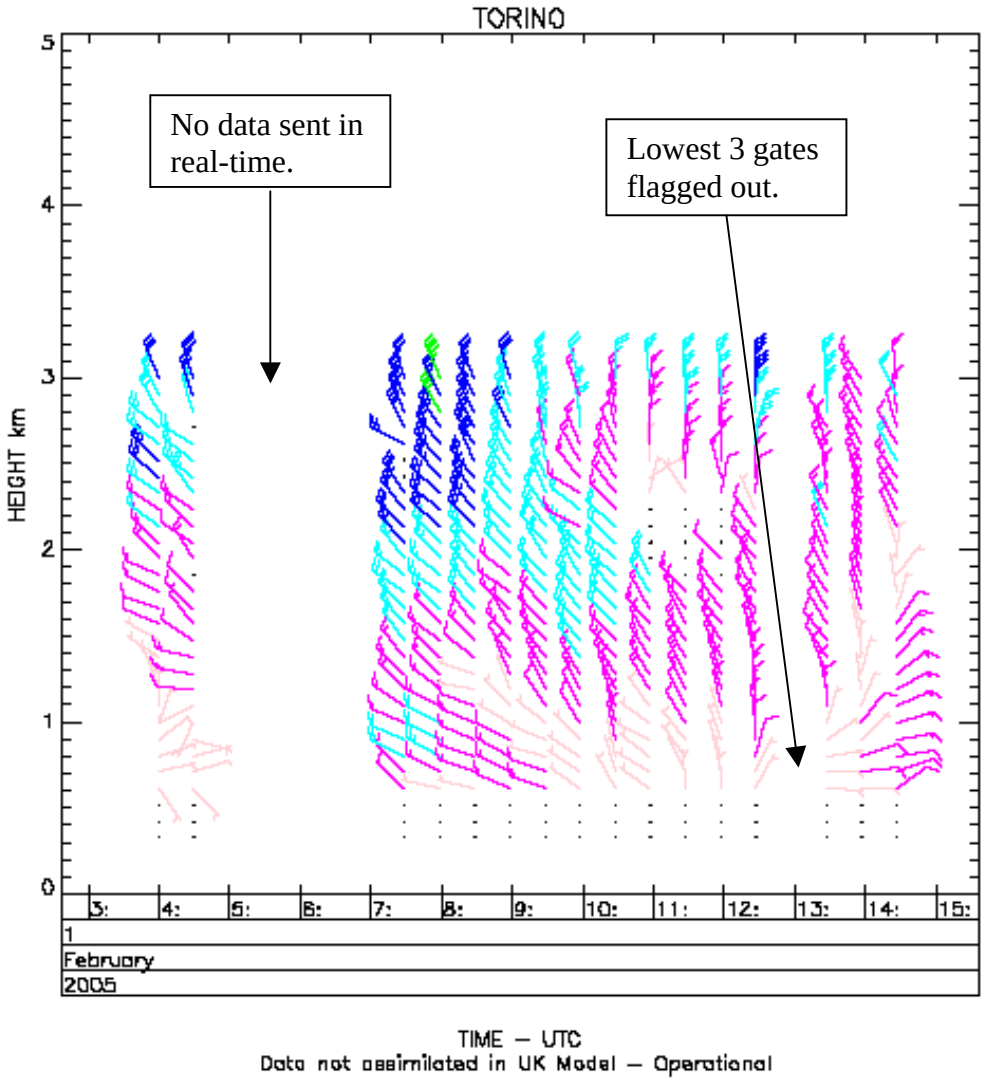

Figure 4: Real-time wind barb plot for Torino, Italy.

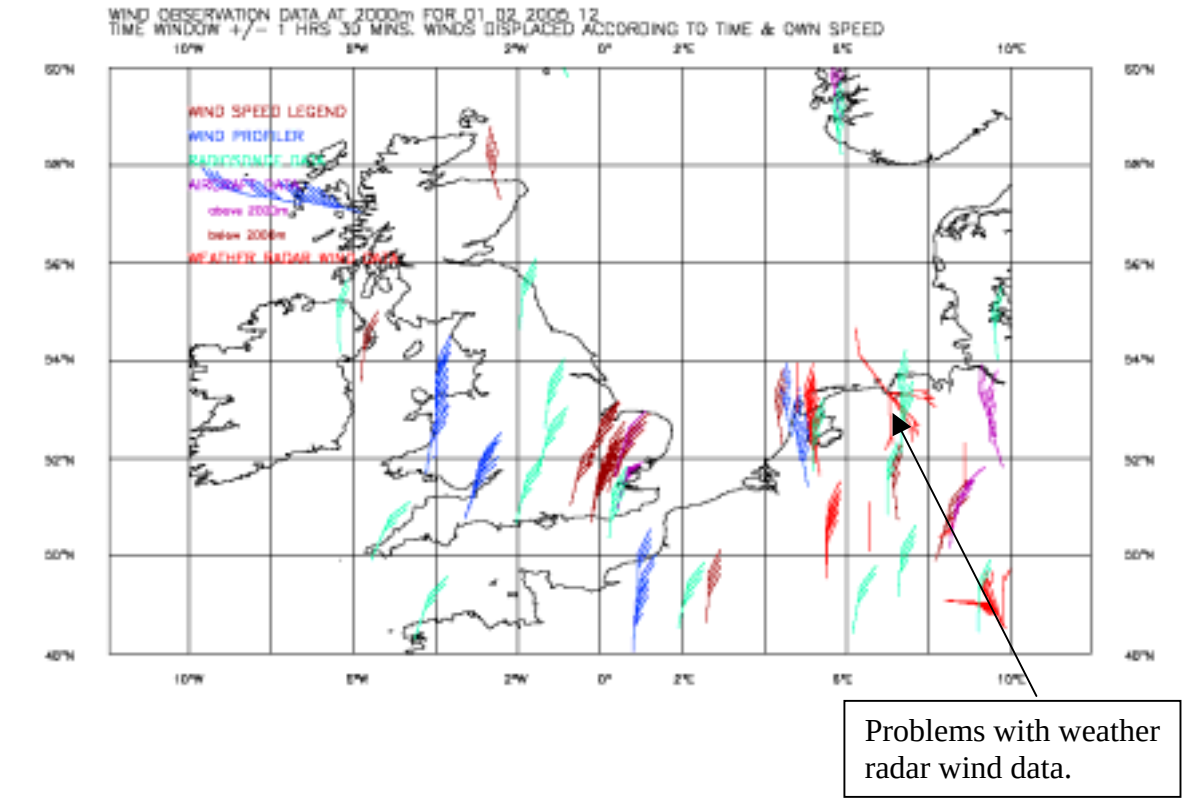

Figure 5: Example of plan view plot, UK area at 2km.

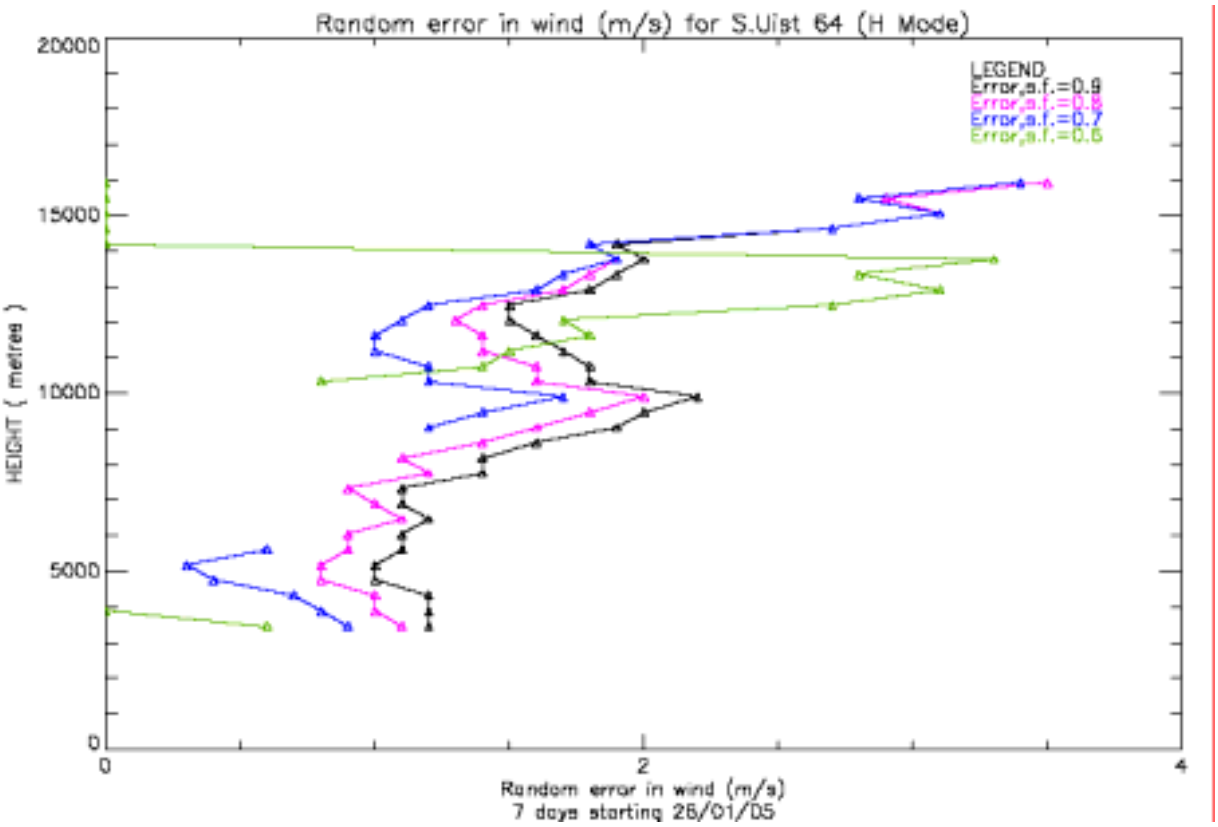

Figure 6: Random error plot for South Uist (26/01/05 – 02/02/05).

4. Monthly quality evaluation information.

The hub is responsible for producing and distributing a number of monthly quality evaluation products. These are either related to the real-time availability of wind data or the quality. Currently the wind data for the wind profiler systems are compared with the NWP background field of the Met Office, Meteo France and ECMWF, for the weather radar only a comparison with the Met Office models is available. Figure 7 provides an example of the monitoring statistics provided by Meteo France.

5. Archive data and Reprocessing.

A complete archive of the BUFR messages received by CWINDE is maintained by the hub. This allows data to be provided 'off-line' for case studies or impact assessments, it also allows a check of any data processed by the hub should there be any questions at a later date. It is also possible to reprocess the data to produce any of the real-time plots.

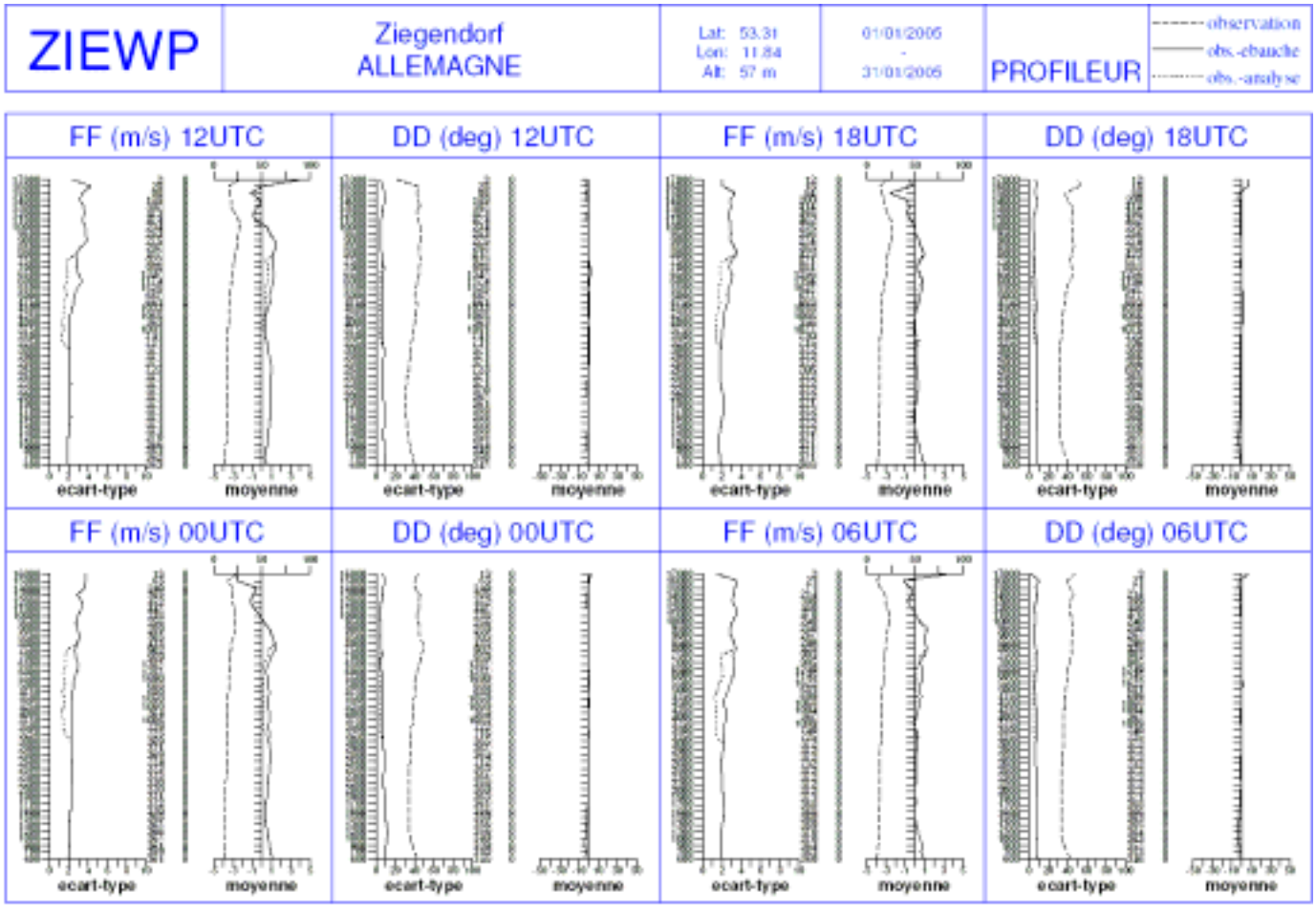

Figure 7: Monthly NMP statistics plot generated by Meteo France.

Conclusion and Future Plans

- CWINDE has been successful in providing a European wind profiler network hub for more than 5 years. It has been extended to include new wind profiler systems and wind data from the European weather radar network. It now has more than 80 sites providing routine data, with completely automated processing and requiring about a third of a man year to maintain.

- A number of the wind profiler and weather radar (UK only) sites are now being used operationally for NWP data assimilation. In February 13 of the 23 wind profiler sites and 20 of the 52 weather radar sites were being assimilated by the UK modellers.
- The 2 year WINPROF programme ended on 30th June 2004. A WINPROF-II programme has recently been approved and is expected to commence in the spring 2005. In the mean time the Met Office is continuing to maintain the hub under an extension contract with WINPROF. A key objective for WINPROF-II is the 'hand over' of the network to EUCOS (another EUMETNET program) which will take on the operational and quality management.

ANNEX A - WIND PROFILER & WEATHER RADAR LOCATIONS

PROFILER (Providing Data)	WMO NO.	LAT	LONG	HEIGHT
KIRUNA, SWEDEN	02043	67.88N	21.10E	295m
SOUTH UIST, UK	03023	57.21N	07.22W	4m
ABERYSTWYTH,UK	03501	52.42N	04.00W	50m
WATTISHAM,UK	03591	52.09N	00.96E	87m
CAMBORNE,UK	03807	50.13N	05.10W	88m
DUNKESWELL,UK	03840	50.90N	03.20W	253m
CABAUW,NETHERLANDS	06348	51.95N	04.88E	0m
PAYERNE,SWITZERLAND	06610	46.81N	06.95E	491m
ZURICH, SWITZERLAND	06670	47.48N	08.53E	425m
LA FERTE VIDAME, FRANCE	07112	48.61N	00.87E	245m
TOULOUSE, FRANCE	07115	43.37N	01.26E	158m
CLEMONT FERRAND, FRANCE	07453	45.71N	03.09E	660m
LANNEMEZAN, FRANCE	07626	43.13N	00.36E	600m
MARIGNANE, FRANCE	07650	43.43N	05.23E	7m
NICE, FRANCE	07690	43.66N	07.19E	4m
LINDENBERG, GERMANY	10394	52.17N	14.12E	70m
ZIEGENDORF, GERMANY	10266	53.30N	11.80E	57m
NORDHOLZ, GERMANY	10135	53.47N	08.40E	18m
VIENNA, AUSTRIA	11036	48.10N	16.60E	227m
INNSBRUCK, AUSTRIA	11120	47.16N	11.23E	614m
SALZBURG, AUSTRIA	11150	47.47N	13.00E	430m
BUDAPEST, HUNGARY	12843	47.43N	19.18E	139m
SZEGED, HUNGARY	12982	46.30N	20.10E	83m
TORINO, ITALY	16300	45.40N	07.40E	277m
LINDENBERG, GERMANY (SODAR)	10391	52.17N	14.12E	70m

PROFILER (Not Providing Data)	WMO NO.	LAT	LONG	HEIGHT
KARLSRUHE,GERMANY	10722	49.05N	08.26E	109m
ROME, ITALY	16239	41.83N	12.64E	121m
ALLENTSTEIG, AUSTRIA	11019	48.68N	15.37E	596m
L'AQUILA, ITALY	16228	42.40N	14.40E	980m
ANDENES,NORWAY	01012	69.28N	16.03E	0m

WEATHER RADAR	WMO NO.	LAT	LONG	HEIGHT
KIRUNA, SWEDEN	02032	67.70N	20.62E	646m
LULEA, SWEDEN	02092	65.55N	22.12E	35m
OSTERSUND, SWEDEN	02200	63.18N	14.44 E	465m
ORNSKOLDSVIK,SWEDEN	02262	63.63N	18.39E	522m
LEKSAND, SWEDEN	02430	60.72N	14.88E	458m
ARLANDA, SWEDEN	02451	59.65N	17.95E	75m
NORRKOPING, SWEDEN	02570	58.61N	16.12E	57m
HEMSE, SWEDEN	02588	57.24N	18.38E	56m
VARA, SWEDEN	02600	58.25N	12.81E	170m
ANGELHOLM, SWEDEN	02607	56.36N	12.85E	10m
KARLSKRONA, SWEDEN	02666	56.29N	15.60E	122m
LUOSTO, FINLAND	02836	67.13N	26.89E	534m
UTAJARVI, FINLAND	02870	64.76N	26.31E	118m
KUOPIO, FINLAND	02918	62.86N	27.38E	268m
KORPO, FINLAND	02933	60.13N	21.64E	61m
IKAALINEN, FINLAND	02941	61.77N	23.07E	154m
ANJALANKOSKI, FINLAND	02954	60.90N	27.11E	139m
VANTAA, FINLAND	02975	60.27N	24.87E	83m
SHANNON, IRELAND	03962	52.70N	08.93W	26m
DUBLIN, IRELAND	03969	53.43N	06.24W	100m
DEN HELDER, NETHERLANDS	06234	52.96N	04.79E	51m
DE BILT, NETHERLANDS	06260	52.10N	05.18E	44m
ZAVENTEM, BELGIUM	06451	50.90N	04.47E	73m
WIDEUMONT, BELGIUM	06477	49.92N	05.51E	592m
LA CORUNA , SPAIN	08007	43.17N	08.52W	621m
ASTURIAS, SPAIN	08019	43.46N	06.30W	933m
PALENCIA, SPAIN	08072	42.00N	04.60W	870m
VIZCAYA, SPAIN	08081	43.4N	02.84W	625m
BARCELONA, SPAIN	08179	41.41N	01.88E	664m
ZARAGOZA, SPAIN	08162	41.73N	00.56W	829m
MADRID, SPAIN	08228	40.18N	03.71W	717m
CECERES, SPAIN	08262	39.00N	06.00W	676m
VALENCIA, SPAIN	08289	39.00N	00.00W	234m
MURCIA, SPAIN	08364	38.00N	01.00W	1274m
SEVILLA, SPAIN	08386	37.00N	06.00W	530m
ALMERIA, SPAIN	08489	37.00N	03.00W	1173m
MALAGA, SPAIN	08475	37.00N	04.00W	495m

WEATHER RADAR	WMO NO.	LAT	LONG	HEIGHT
GRAN CANARIA, SPAIN	60028	26.00N	15.00W	1781m
LA CORUNA , SPAIN	08007	43.17N	08.52W	621m
HAMBURG, GERMANY	10147	53.62N	09.99E	46m
ROSTOCK, GERMANY	10169	54.17N	12.05E	36m
EMDEN, GERMANY	10204	53.34N	02.40E	58m
HANNOVER, GERMANY	10338	52.45N	09.69E	81m
UMMENDORF, GERMANY	10356	52.15N	11.17E	185m
BERLIN, GERMANY	10384	52.47N	13.38E	80m
ESSEN, GERMANY	10410	51.41N	06.97E	180m
FLETCHDORF, GERMANY	10434	51.33N	08.85E	550m
DRESDEN, GERMANY	10488	51.12N	13.77E	262m
NEUHAUS, GERMANY	10557	50.50N	11.14E	873m
NEUHEILENBACH, GERMANY	10605	50.11N	06.50E	585m
FRANKFURT, GERMANY	10637	50.05N	08.57E	146m
EISBERG, GERMANY	10780	49.54N	12.40E	799m
TUERKHEIM, GERMANY	10832	48.58N	09.78E	765m
MUNICH, GERMANY	10871	48.34N	11.61E	511m
FELDBERG, GERMANY	10908	47.87N	08.00E	1517m
VIENNA, AUSTRIA	11038	48.12N	16.57E	183m
SALZBURG, AUSTRIA	11052	48.06N	13.06E	581m
PATSCHERKOFEL, AUSTRIA	11126	47.21N	11.46E	2254m
ZIRBITZKOGEL, AUSTRIA	11164	47.07N	14.56E	2372m
BRIC DELLA CROCE, ITALY	16061	45.03N	07.73E	736m