372

Assessment of European wind profiler data, in an NWP context

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Abstract

Data from the European network of radar wind profilers have been assessed in the context of the global 4D-Var data assimilation system at ECMWF. The data received through the Global Telecommunications System comprises 17 stations in 8 countries. It was found that the reporting practices (frequency, vertical resolution and extent) as well as the data quality vary significantly between stations in the network. Time series from November 2000 to November 2001 show that the data quality in general has been very good with some exceptions, with several stations improving over time. An impact study was conducted using data from May 2001, assimilating only the eight profiler stations that had performed consistently well in that period. The results were sufficiently good to go ahead with pre-operational trials in January 2002, using data from twelve of the stations. Operational implementation followed three months thereafter.

1. Introduction

In recent years, the European research on stratospheric and tropospheric wind radars (Stenhagen *et al.* 1998; Kotroni *et al.* 1995) has in recent years been co-ordinated to form a more coherent operational network. This has been achieved through the COST-76 and CWINDE-99 projects. The current network consists of more than twenty stations in ten countries (Figure 1), with further expansion planned. In 2001 ECMWF received data in real-time from 17 of the stations: in Great Britain (5), Ireland (1), the Netherlands (1), Switzerland (1), France (3), Germany (2), Austria (3) and Italy (1). The real-time data have been monitored and compared against short-range forecasts and analyses, generated by ECMWF's global Numerical Weather Prediction (NWP) system. The quality of the observations has been assessed.

Figure 1 The European wind profiler network. The map is from the web site of the CWINDE-99 project, coordinated by the MetOffice.

We report a quality assessment of the real-time data from the European wind profiler network, through data monitoring within the ECMWF data assimilation system. Based on the monitoring results a subset of good data has been identified and used in a data impact study for May 2001. This study attempts to measure only the impact on analyses and short-range forecasts within the context of global NWP. The impact is measured in the presence of all other data routinely assimilated at ECMWF, at the resolution of the operational system: a forecast model at T511 (40 km) with analysis increments at T159 (120 km) horizontal resolution. The value of the profiler data in regional models for smaller-scale applications is outside the scope of this report.

The use of a data assimilation scheme for monitoring new observing systems is a well-established practice (Hollingsworth *et al.* 1986; Andersson and Bouttier 1999). Comparisons between observations and model data can quantify the frequency of gross errors and the magnitude of random and systematic errors. Such monitoring techniques have proved very powerful for the calibration and validation of satellite instruments (e.g. Stoffelen and Anderson 1994; Köpken 2001) and for the global monitoring of the radiosonde network (Strauss 1996).

Wind profilers are Doppler radars that derive wind information from the Doppler shift in echoes produced by turbulence in clear air. They operate at three frequencies (50, 400 and 1000 MHz) each corresponding to a vertical range (30, 16 and 5 km, respectively). In the absence of heavy rain, the profilers can sample winds almost continuously, with high vertical resolution. The collection, encoding (in BUFR) and distribution via the Global Telecommunication System (GTS) of the European profiler data is carried out within the CWINDE-99 project, co-ordinated by the Met Office (http://www.meto.gov.uk/sec5/CWINDED/cwinde99/cwinde99e.html).

The ECMWF data assimilation system is a 4D-Var scheme (Rabier *et al.* 2000). One of the strengths of 4D-Var is its ability to assimilate frequent data, as demonstrated by e.g. Järvinen *et al*. (1999). All available observations within a 12-hour period are used (Bouttier 2001a) in one global estimation problem. The observations are compared with a short-range forecast, on a half-hourly basis. The observation-minus-forecast differences are analysed to obtain a corrected model state (the analysis) which evolves during the 12-hour assimilation period in better agreement with the observations. Hourly data from the American wind-profiler network have been used in 4D-Var since July 1999 (Bouttier 2001b). The main aim of the current study is to establish which of the European profiler data are of consistently good quality, and are suitable for operational assimilation.

The 4D-Var scheme and the methods for quality control are briefly described in Section 2. Section 3 presents monitoring results, which formed the basis for a selection of consistently good data for use in the impact study, described in Section 4. Conclusions are drawn in Section 5.

2. The 4D-Var scheme

The monitoring (Section 3) of European wind profiler data and the impact study (Section 4) have been carried out in the context of ECMWF's operational 4D-Var data assimilation scheme (Rabier *et al*. 2000). The scheme uses a wide variety of meteorological observations (as outlined in Courtier *et al*. 1998) from both conventional and satellite instruments. Global data within a 12-hour period (the so-called assimilation window running from 03 to 15 UTC and from 15 to 03 the following day) are used for the assimilation (Bouttier 2001a).

2.1 Incremental formulation

The 4D-Var estimation problem is solved by minimising iteratively a cost function J with respect to the model state $\mathbf{x}$ at the time t_0 at the start of the assimilation window. In the *incremental* formulation (Courtier *et al.* 1994) the cost function is written in terms of increments $\delta\mathbf{x}$ with respect to the background-state $\mathbf{x}_b$ (a short-range forecast), i.e. $\delta\mathbf{x} = \mathbf{x} - \mathbf{x}_b$. The increments are propagated in time using a the tangent linear

$\mathbf{M} \equiv (\partial M / \partial \mathbf{x})\big|_{\mathbf{x}=\mathbf{x}_b}$ of the model M, and compared with the observations by means of the tangent linear $\mathbf{H}$ of the observation operators H:

$$J(\delta\mathbf{x}) = \delta\mathbf{x}^T \mathbf{B}^{-1} \delta\mathbf{x} + \sum_{i=1}^{N} (\mathbf{H}_i \mathbf{M}_i \delta\mathbf{x} - \mathbf{d}_i)^T \mathbf{R}^{-1} (\mathbf{H}_i \mathbf{M}_i \delta\mathbf{x} - \mathbf{d}_i)$$

where the summation is over N sub-divisions (or *time slots*) of the assimilation time window. The length of each time slot was one hour (i.e. $N = 13$) in the operational system before January 2002 when it was halved to 30 minutes ($N = 25$). We shall see that the shorter time slot coincidentally matches the reporting frequency of the majority of European profiler stations.

The vector $\mathbf{d}_i$ represents the innovations:

$$\mathbf{d}_i = \mathbf{y}_i - H_i x_b(t_i) = \mathbf{y}_i - H_i M_i x_b(t_0),$$

where $\mathbf{y}_i$ represents the observations. Note that the innovations are calculated using the non-linear observation operators, after propagating the model state to the time of the observations using the full non-linear forecast model (T511/L60). This ensures the highest possible accuracy for the calculation of the innovations which are the primary input to the assimilation. The performance of the model at the current resolution have been described by Untch *et al.* (1996; 1998), Miller (1999) and Teixeira (1999).

For efficiency reasons the increments $\delta\mathbf{x}$ are calculated at a lower resolution than that of the full model. The current forecast model is run at T511 spectral truncation (corresponding to a 40 km resolution) whereas the analysis increments $\delta\mathbf{x}$ are evaluated at T159 (120 km). The analyses $\mathbf{x}_a(t)$ at times $t = [0,6,12,18]$ UTC are formed by adding the increments to the background fields:

$$\mathbf{x}_a(t) = \mathbf{x}_b(t) + \delta\mathbf{x}(t).$$

2.2 Quality control

All data are quality controlled through comparison with the background (BgQC) and through variational quality control (VarQC) as described by Andersson and Järvinen (1999). In BgQC data are rejected if the departure from the background $d = y - Hx_b(t)$ exceeds a multiple α of its expectation, i.e. rejection occurres if $d > \alpha\sqrt{\sigma_b^2 + \sigma_o^2}$. Here σ_b is the background error standard deviation in terms of the observed quantity (Andersson *et al*. 2000) and σ_o is the assumed observation error. For profiling data α is set to 5.

In VarQC a probability of gross error is computed for each observation at each iteration of the variational minimisation, based on Bayesian probability theory. The weight of the observations is smoothly reduced with increased probability of gross error. Effectively VarQC rejects data that cannot be fitted by the analysis, often because of marked inconsistency with surrounding observations. See Andersson and Järvinen (1999) for further details. Rejection counts for the European profilers will be shown as a diagnostic, in the following sections.

3. Data monitoring results

European profiler data have been received and pre-processed at ECMWF in BUFR format, in real-time via the GTS, since the beginning of year 2000. The data have been processed by the data assimilation system, as if they were used but with zero weight, to enable monitoring and to prepare for subsequent operational use of the data. The data have been compared against short-range forecasts (the background information in data assimilation) and against 4D-Var analyses valid at the time of the observations. The resulting differences between the observations and their short-range forecast and analysis equivalents will be called OmF and OmA *departures*, respectively, in the following. This study is primarily concerned with the data received since November 2000. Two three-week periods has been studied in more detail: one in May 2001 and the other in January 2002. The data set comprises 17 stations, in 8 countries as detailed in Table 1. The vertical range of each station is also given in the table.

Station ID	*Latitude*	*Longitude*	*Name*	*Country*	*Elevation (m)*	*Vertical Range*
03500	52.42	-4.00	Aberystwyth	UK	50	BL/TROP
03501	52.42	-4.00	Aberystwyth	UK	50	TROP/LST
03591	52.07	0.58	Wattisham	UK	87	BL/TROP
03807	50.13	-5.10	Camborne	UK	88	BL/TROP
03840	50.87	-3.23	Dunkeswell	UK	253	BL/TROP
03969	53.43	-6.24	Dublin	IRL	100	TROP
06348	51.95	4.88	Cabauw	NL	0	BL
06601	-	-	Mobile system	CH	-	BL
07112	48.61	0.87	La Ferte Vidame	F	245	TROP/LST
07650	43.43	5.23	Marignane	F	7	BL/TROP
07690	43.66	7.19	Nice	F	4	BL/TROP
10391	52.17	14.12	Lindenberg	D	70	BL
10394	52.21	14.13	Lindenberg	D	107	BL/TROP/LST
11036	48.10	16.60	Vienna	A	227	BL
11120	47.16	11.23	Innsbruck	A	593	TROP
11150	47.47	13.00	Salzburg	A	430	BL
16228	42.40	13.40	L'Aquila	IT	1000	TROP

Table 1 List of Stations in the network of European wind profilers from which data were received in real-time at ECMWF, in the year 2001. The abbreviations for vertical range indicate: boundary layer (BL), mid-troposphere (TROP) and lower stratosphere (LST).

3.1 Time series

Data counts and statistics of OmF and OmA vector wind departures have been accumulated 6-hourly, for each station, for the period since November 2000. Time series of the statistics reveal that the quality of the data for some stations has varied over the year (Nov 2000 to Nov 2001). Not all stations have performed consistently well over the period. Two examples of such time series are shown in Figure 2. The station at Aberystwyth (top panel) has performed well throughout the year, at 500 (green) and 700 hPa (blue), Figure 2a. The time series for Dublin on the other hand (Figure 2b) shows some deterioration at 500 and 700 hPa towards the end of the period.

The time series also reveal that the frequency of reporting has changed markedly over time for some stations. The figures show that the data volumes from Aberystwyth (Figure 2a) increased 10-fold between January and August 2001, and that Dublin (Figure 2b) started its reporting in February 2001. The Swiss mobile station 06601 (not shown) started operations in July 2001 in place of 06610. The French stations 07650 and 07690 and the German boundary layer profiler at Lindenberg (10391) first started reporting in May 2001. Data volumes received from the 482 MHz profiler at Lindenberg (10394) are approximately 40% less in 2001 than they were in 2000.

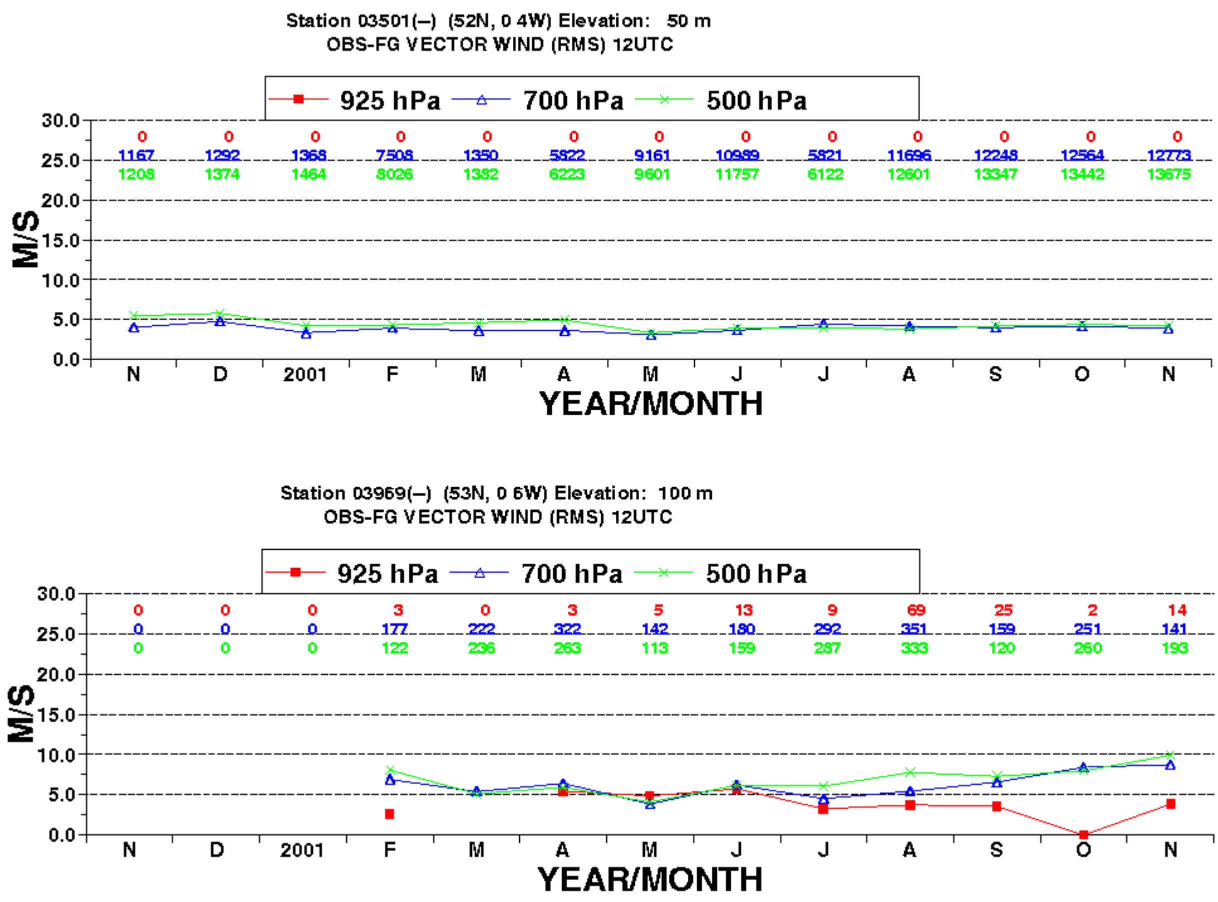

Figure 2 Time series of r.m.s. of observation minus background vector wind differences (m/s), accumulated monthly from November 2000 to November 2001, for data within three hours of 12 UTC. The top panel (a) shows Aberystwyth (03501) and the lower panel (b) shows station Dublin (03969). The statistics are shown for three vertical levels: 925 (red), 700 (blue) and 500 hPa (green). Data counts for each month and each level are also given.

3.2 Vertical range and frequency of reporting

The vertical range of the profilers differs from station to station due to the frequency at which the radar instrument operates. The vertical range of the received data for each station is indicated in Table 1. Five of the 17 stations are boundary layer profilers (BL), 12 reach the mid-troposphere (TROP) and three profilers (Aberystwyth, La Ferte Vidame and Lindenberg) reach the lower stratosphere (LST). Many stations report twice hourly, while Aberystwyth reports every 10 minutes. The data volumes received from each station in May 2001 are shown in Figure 3. We can see that the station 03501 (Aberystwyth) alone has produced 61% of the data. Only very small data volumes have been received from 03969, 07650, 07690 and 10391 in this period.

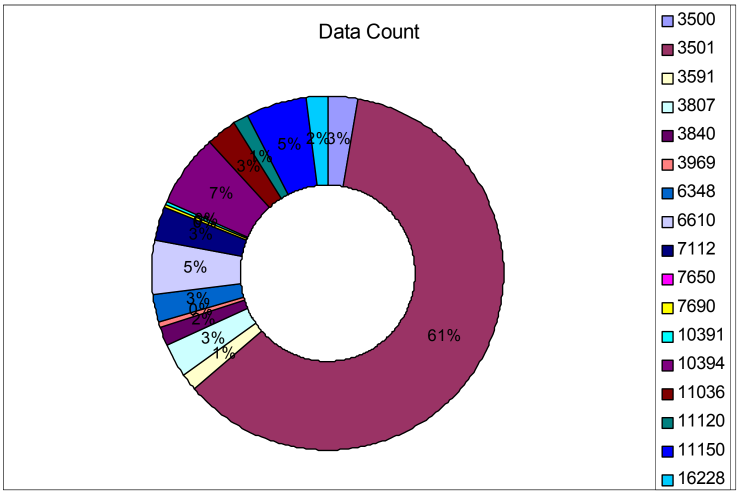

Figure 3 Data counts by station as received at ECMWF in the month of May 2001.

The irregular reporting practices and the difference in instrumentation make it less than straightforward to determine which of the data to use actively in the data assimilation system. As noted earlier the operational 4D-Var system has recently been enhanced to use time series of data on a 30-minute rather than hourly basis, which incidentally matches the reporting frequency of most European profilers. Any intermediate data from more frequent time series (such as Aberystwyth) are discarded as redundant.

3.3 Biases, random errors and gross errors

Vertical profiles of OmF (full lines) and OmA (dashed) departure statistics are shown in Figure 4, for the three stations with the largest vertical range (Aberystwyth, La Ferte Vidame and Lindenberg), for an assimilation that did not use the data. The figures show standard deviation (left) and bias (right) in terms of wind speed. The data appear generally of very good quality. The biases are practically zero, except a slow bias of 2 m/s for La Ferte Vidame between 700 and 300 hPa. The standard deviations are generally between 2 and 4 m/s, which compares well with similar statistics for European radiosondes (shown by Bouttier 2001b). The larger standard deviations for Aberystwyth (compared to the other two stations) is likely to be an indication of short-range forecast errors being generally larger in western coastal regions than in continental Europe. The large OmA standard deviations for Aberystwyth at 70 and 50 hPa (6-8 m/s) may however be an indication of larger observational errors at those higher elevations.

Gross errors are easily detectable by the run-time quality procedures (BgQC and VarQC as described above). The frequency of gross errors as detected by BgQC is given in Table 2, for May 2001 and January 2002. The results confirm that the data from most stations generally are of very good quality, with less than 1% of the data affected by gross errors. Data from stations in mountainous regions may be affected by intense local phenomena that are poorly resolved by the forecast model. This may have contributed to the higher figures for the Swiss station, for Vienna, Salzburg and L'Aquila. The table also confirms that the data quality for Dublin has deteriorated in recent months compared to earlier in 2001 (see also Figure 2b).

3.4 Proposed data usage

The proposed data usage in an operational context must be based on the past performance of each station. The situation is regularly followed up and decisions about data usage are in practice at ECMWF modified on a monthly basis. A prudent approach is required as biased or non-representative data can have a negative influence on analyses, if used. Only those stations that have consistently performed well over a substantial period of time can be accepted for operational use.

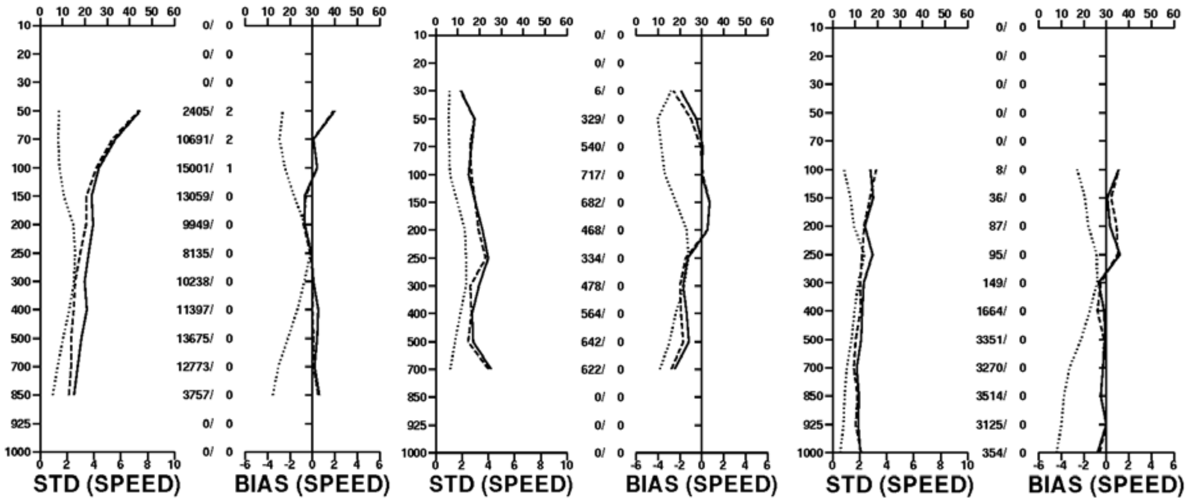

Figure 4 Standard deviation and bias of differences between observations and short-range forecasts (full lines) and analyses (dashed) for the three stations with largest vertical range: Aberystwyth-03501 (left), La Ferte Vidame-07112 (middle) and Lindenberg-10394 (right), for the data within 3 hours of 12 UTC, November 2001. Dotted lines indicate standard deviation and bias (m/s) of the analyzed wind speed, according to the scale at the top.

Station ID	*Name*	*May 2001*		*January 2002*	
		Usage	*Gross errors*	*Usage*	*Gross errors*
	Aberystwyth	<950	0.15	<950	0.48
03501	Aberystwyth	-	0.17	<950	0.42
03591	Wattisham	<950	0.26	<950	0.20
03807	Camborne	<950	0.34	<950	0.59
03840	Dunkeswell	<950	0.61	<950	0.54
03969	Dublin	<950	0.35	-	5.19
06348	Cabauw	<950	0.43	<950	0.81
06601/10	Mobile system	-	2.66	-	0.09
07112	La Ferte Vidame	-	1.61	<950	0.13
07650	Marignane	-	-	700-400	-
07690	Nice	-	2.97	700-400	0.19
10391	Lindenberg	-	-	<950	0.11
10394	Lindenberg	<950	1.21	<950	0.03
11036	Vienna	<950	3.40	<950	2.82
11120	Innsbruck	-	0.76	-	0.14
11150	Salzburg	-	2.42	-	18.98
16228	L'Aquila	-	8.44	-	5.35

Table 2 Proposed data usage in assimilation experiments and occurrence of gross errors (%) as identified by the BgQC checks, for data in May 2001 and January 2002.

Based on the statistics available mid-2001 eight stations were selected for use in the May-2001 impact study (see next section). Due to improvements in more recent statistics (Dec-2001) 12 of the stations could be used for the January-2002 experiments, see Table 2. The selection is primarily based on the time series of bias and standard deviation of OmF and OmA departures. Local orographic effects that are not well represented by the forecast model can deteriorate these statistics, especially in the lower parts of the atmosphere and for stations in mountainous regions. For the time being profiler data below 950 hPa will therefore not be assimilated (Bouttier 2001b).

4. The data impact study May 2001

A data impact study has been carried out for the period 1-31 May 2001, following the proposed data usage as outlined above. Data from eight stations were used on an hourly basis, above the 950 hPa level. In the case of multiple reports within the hour, data selection was carried out with preference given to the data closest to the forecast time. A 4D-Var experimental assimilation was run at full operational resolution (i.e. T511/T159) with 12-hourly cycling, with 10-day forecasts run from 12 UTC each day. The results were compared with a control run from which the experiment differed only in its use of European profiler data. The results have been evaluated in terms of OmF and OmA departure statistics, and in terms of short-range forecast performance. The amount of additional data is relatively small (about 1800 additional data per 12-hour cycle) and the profilers are located in a data dense area in Western Europe. We can therefore expect that the impact on analyses and forecasts will be fairly limited. The test period was considered too short for reliable assessment in the medium range and beyond. This was confirmed by a t-test on the significance of the forecast verification results.

4.1 Analysis impact

The analysis impact is limited to parts of central Europe, Great Britain, Ireland and the adjacent seas. In 4D-Var the shape and spatial extent of analysis increments are influenced by the dynamics and the flow in the surroundings. The influence of data taken at a time towards the end of the assimilation window will be seen upstream at earlier times. It is therefore not surprising that the largest analysis differences are seen in the sea areas around the Britain and Ireland. Figure 5 shows the RMS of vector wind analysis differences over 30 days of the experiment. Information from Aberystwyth, Dublin, Camborne and Cabauw for example has been extrapolated into areas with relatively fewer observations over the sea. The figure also shows that the data from Lindenberg have had a sizeable influence in its surroundings. Analysis differences otherwise tend to be smaller over continental Europe where the analysis in most cases, on these scales, is well determined by the information from conventional data sources.

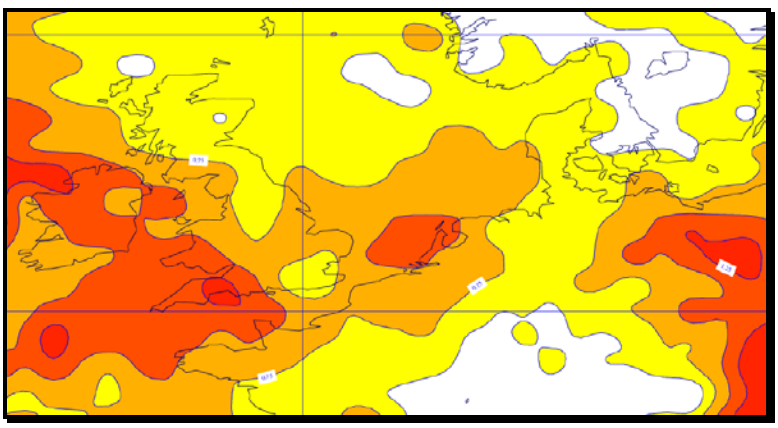

Figure 5 RMS of the vector wind analysis difference (m/s) at 850 hPa between the European profiler experiment and the control, 20010502-20010531, 12 UTC. Contour interval is 0.25 m/s with shading starting at 0.5 m/s.

Figure 6 shows an example of analysis differences between the experiment and the control, four days into the assimilation. There is a clear influence from the British profilers, Cabauw (the Netherlands) and Lindenberg (Germany), with differences extending into the English Channel and the Bay of Biscay. Temperature differences (top right) with a magnitude of about 0.5 K are the result of mass/wind coupling in the analysis. The vorticity and divergence differences (lower panels) show large amplitude at very small scales, which likely is a consequence of the high frequency of the used profiler time series. In a 4D-Var system, a time sequence of station data is equivalent to a string of data distributed along the upstream trajectory through the station (Daley 1992) – so high data frequency is largely equivalent to high data density. Also, the larger scales are likely to be accurately determined by the conventional data in this region.

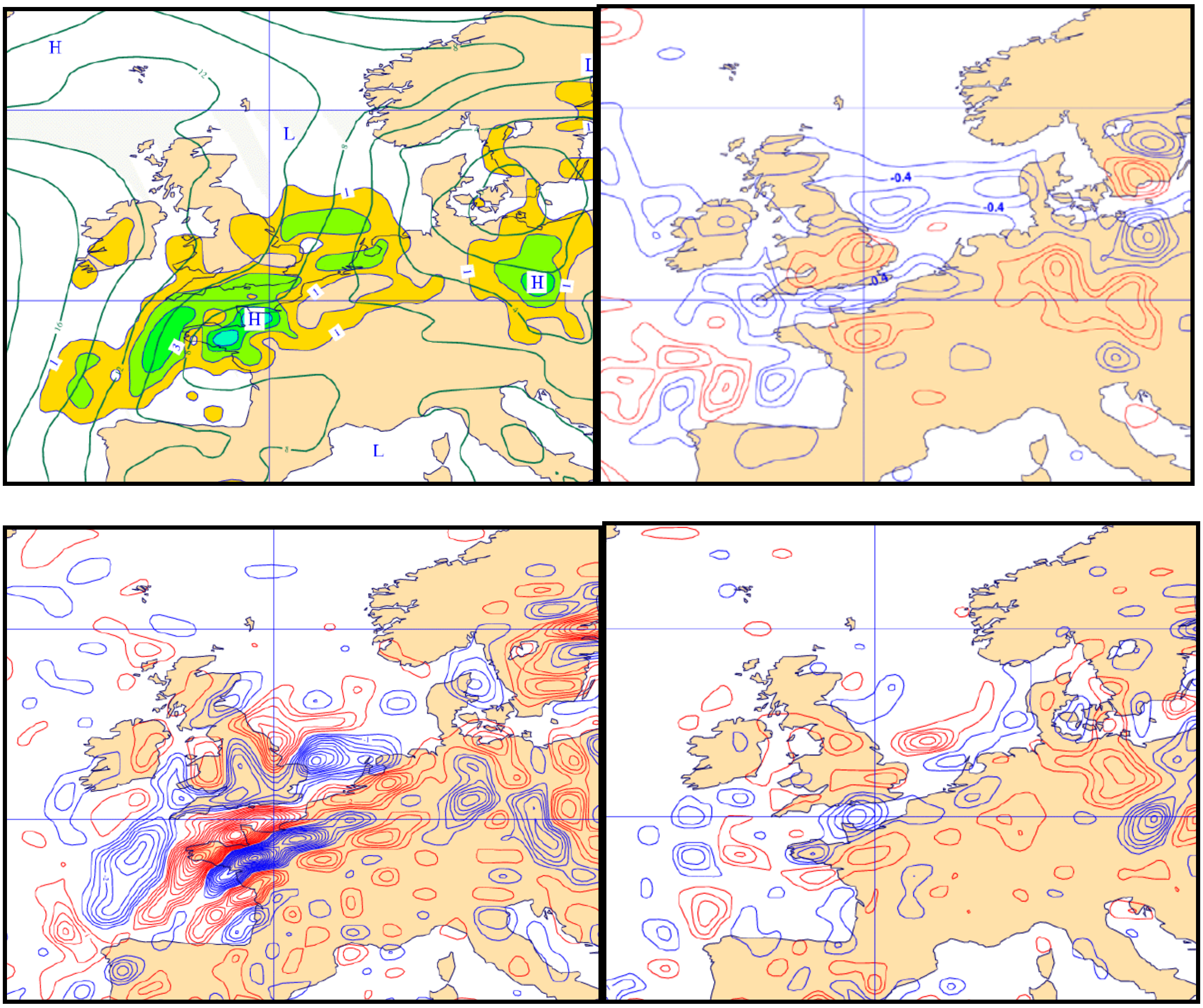

Figure 6 Analysis differences at 850 hPa between the European profiler experiment and its control, 20010504-00, i.e. four days into the assimilation. Top left: amplitude of vector wind difference, shading starts at 1 m/s with an interval of 1 m/s. The geopotential height of the 1000 hPa surface is contoured in green (interval is 2 deca metres). Top right: temperature (0.2 K), Lower left: vorticity ($0.5x10^{-5}$ s^{-1}). Lower right: divergence ($0.5x10^{-5}$ s^{-1}). Red contours for positive and blue for negative values.

Vertical profiles of departure statistics are shown in Figure 7 for the European profilers. For comparison we show in Figure 8 the corresponding plot for the American profilers. The departures for both networks are small and compare well with similar statistics for radiosondes (Bouttier 2001b). The European profilers have generally smaller departures than the American profilers, which is an indication of good data quality as well as accurate analyses and short-range forecasts in the European area. American profilers are not used below 700 hPa (Bouttier 2001b), whereas the European ones are used down to 950 hPa. The figures also show that the American network (~30 stations, at 50 MHz) provides a higher yield of data in the upper troposphere. Speed biases (right panels) for both networks are small. The gap between the OmF (full lines) and the OmA (dashed) curves indicate that the data have been 'drawn for', i.e. that they have had a substantial influence on the assimilation at observation points, at observation times. It could also be an indication that the profiler data generally are in agreement with other assimilated data in the vicinity. Assigned observation and background errors are both in the order of 2 m/s for the u and v wind components.

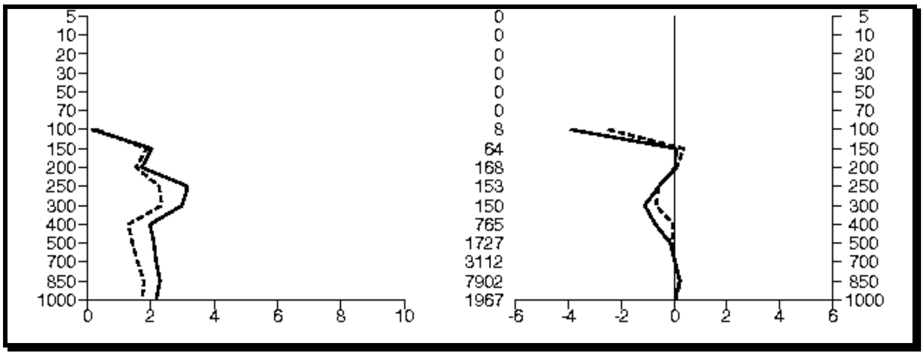

Figure 7 Wind speed (m/s) standard deviation (left) and bias (right) for all used European profiler data in the period 20010502-00 to 20010510-12 UTC. Full lines show OmF departures (observation minus short-range forecast) and dashed lines show OmA departures (observation minus analysis).

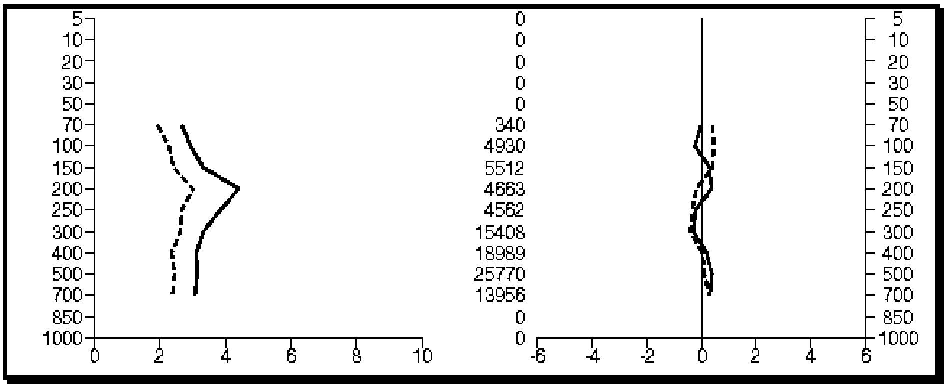

Figure 8 As Figure 7 for the American profiler network.

4.2 Forecast impact

The forecast impact in this 30-day experiment is significant only at short range. Maps of forecast impact show small random influences eventually spreading over the entire hemisphere. A t-test on the significance of the measured forecast impact in terms of RMS of forecast error has been performed. It shows significance only for the North Atlantic area. A map of the difference in +48 hour forecast error RMS (experiment minus control) is shown in Figure 9, for 1000 hPa geopotential. Green shading indicates lower errors in the experiment using European profiler data. We can see predominantly positive impact (lower errors) of the additional data in parts of the North Atlantic. This is confirmed by the scatter diagram (Figure 10) showing RMS of forecast error at day 3, for the North Atlantic area, in terms of 500 hPa vector wind. The t-test gives a significance of 98% to this result, although the magnitude of the impact is small. The small amplitude of the forecast impact is also apparent in Figure 9, in which the area integrated value for the European area (35°-75° N, 12.5° W-42.5° E) is just –0.26 metres.

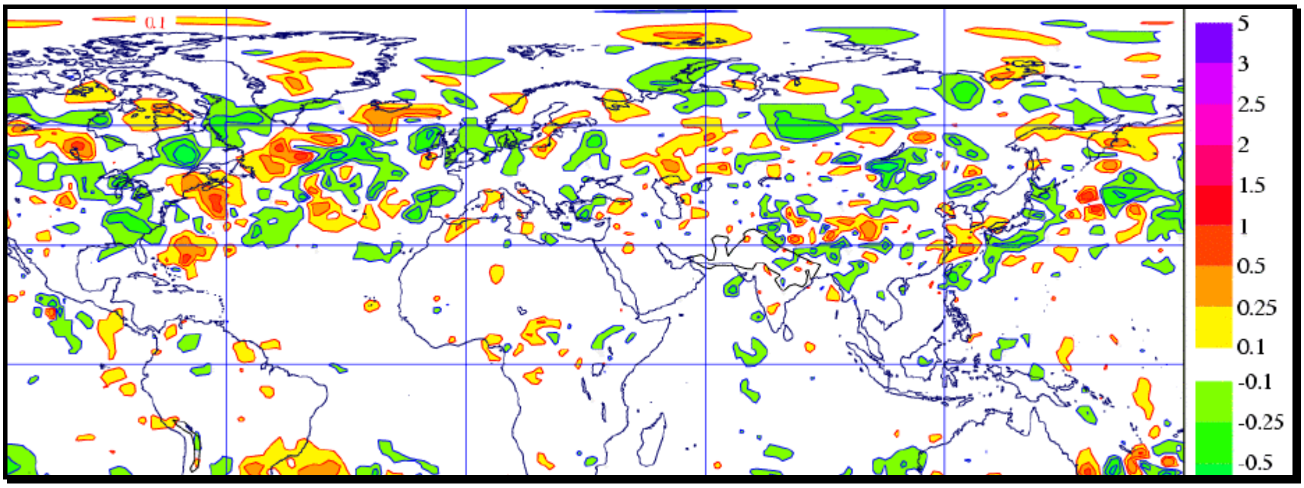

Figure 9 Difference in RMS of forecast error between the European profiler experiment and its control, for +48 hour forecasts of 1000 hPa geopotential (deca metres) in the period from 20010502 to 20010531, 12 UTC. Green (orange) shading, starting at -1.0 (+1.0) metre, indicate smaller (larger) errors in the experiment than in the control. Area integrated values are for Europe: -0.26 m, North Atlantic: -0.08 m and the Northern Hemisphere extra tropics: -0.23 m.

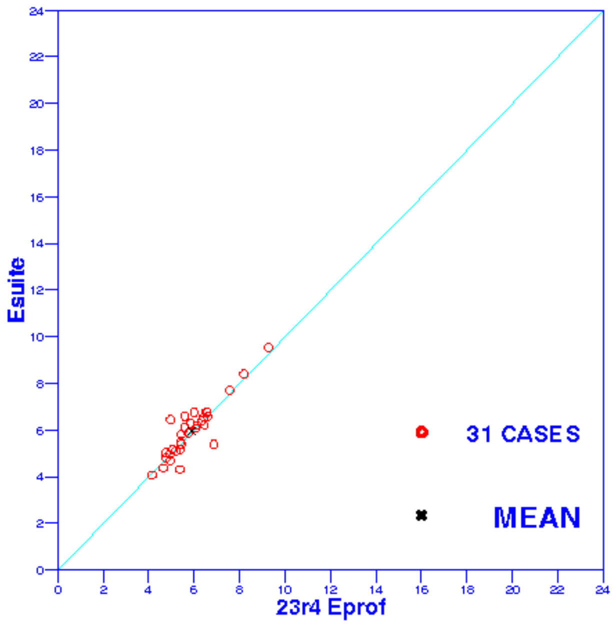

Figure 10 Scatter plot of RMS of +72 hour 500 hPa vector wind (m/s) forecast error for the North Atlantic area (25°-65°N, 10°-70°W) for the European profiler experiment (x-axis) and the control (y-axis). Each circle represents a forecast in the period from 20010501 to 20010531, 12 UTC. Circles above the diagonal indicate smaller error for the experiment with profiler data. The result is significant at the 98% level (t-test).

5. Discussion and Conclusions

Data from the European network of wind profiling radars have been assessed in the context of ECMWF's global 4D-Var data assimilation scheme. The data were found to be of generally good quality with some distinct improvements towards the end of 2001. The network is far from homogeneous as instrumentation, quality control procedures and reporting practices differ from station to station. Three of the stations reach the lower stratosphere, and five are exclusively for boundary layer profiling. The Swiss station is a mobile unit. The French stations are not in continuous operation – their resolution and height coverage change depending on local requirements such as aviation. Most operational stations report every 30 minutes with Aberystwyth reporting even more frequently at ten-minute intervals.

Eight of the network's stations were selected for use in an impact study in May 2001. The analysis and forecast impact was relatively small and confined to parts of Central Europe and the areas around the British Isles. A small but statistically significant positive forecast impact was found at day-3 for the North Atlantic verification area, based on a sample of 31 forecasts in May 2001. The results were considered sufficiently good to go ahead with pre-operational trials. Trials have started from 1 January 2002 in which European profiler time series are now used from twelve stations (see Table 2) on a half-hourly basis. Thinning to a minimum vertical separation of 5 hPa (or 5% of pressure above 100 hPa) has been introduced. Operational implementation followed in April 2002.

The resulting data usage (left) and data rejection frequency (right) for the twelve selected stations are shown in Figure 11, for a three-week period in January 2002. The figures highlight the inhomogeneity of the network in terms of both reporting practices and data accuracy. The most numerous data come from Aberystwyth (49% + 7%), Lindenberg (17%), Camborne (7%), Dunkeswell (5%) and La Ferte Vidame (5%). Gross errors are very infrequent (less than 1%) apart from Nice (4%), Vienna (3.5%) and Aberystwyth (2%). The data rejections at Aberystwyth are mostly at levels above 70 hPa, were it should not be ruled out that the model fields rather than the observations might be in error. The monitoring of European profiler data will continue, and their usage revised on a monthly basis. More recently data from the Japanese profiler network have also been received in real-time; these will also be monitored and considered for operational assimilation.

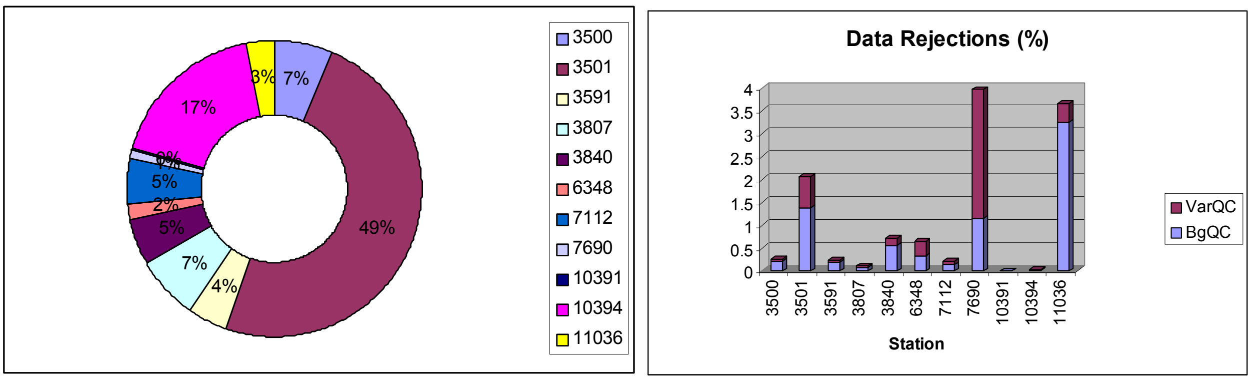

Figure 11 Data counts by station (left, % of total) and data rejections (right, in % for each station), for used data in the ongoing parallel trials, 20020101-20020120. A very small number of data have been used from stations 07690 (Nice) and the boundary layer profiler at Lindenberg (10391), in this period. See the main text for a description of BgQC and VarQC.

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