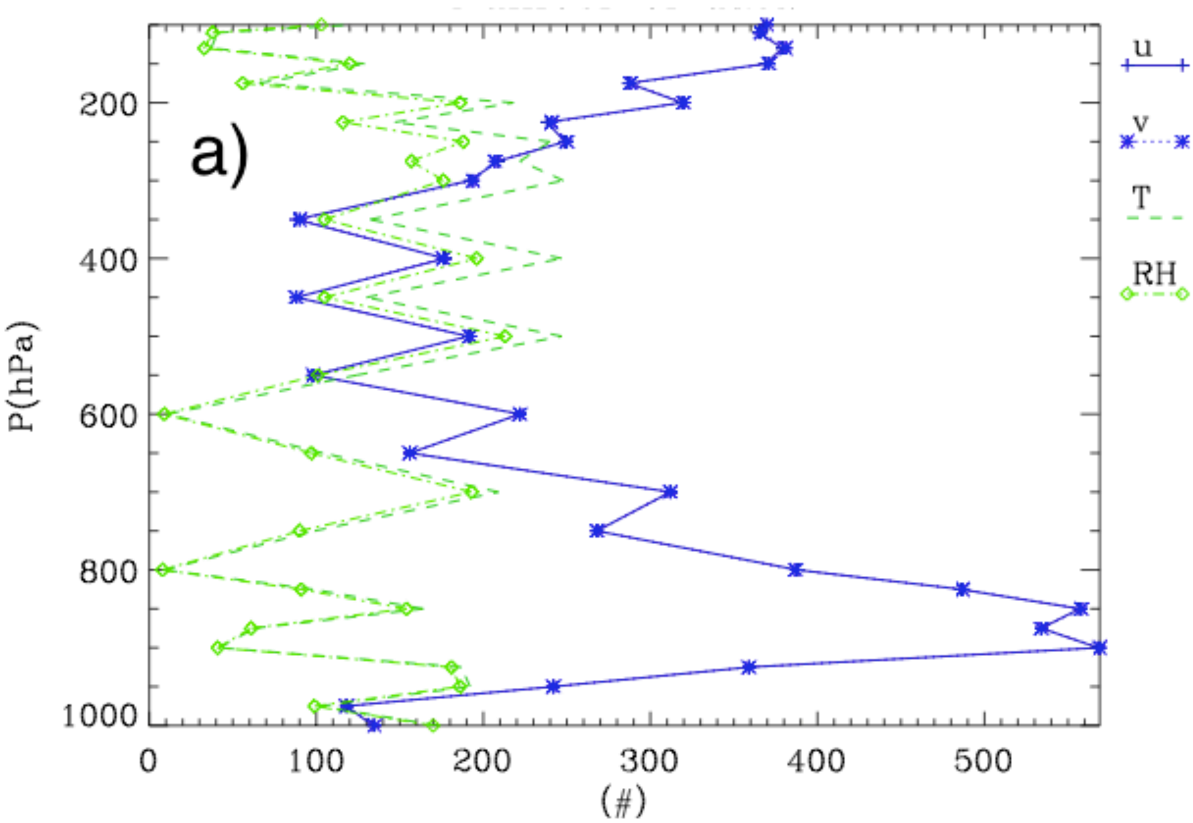
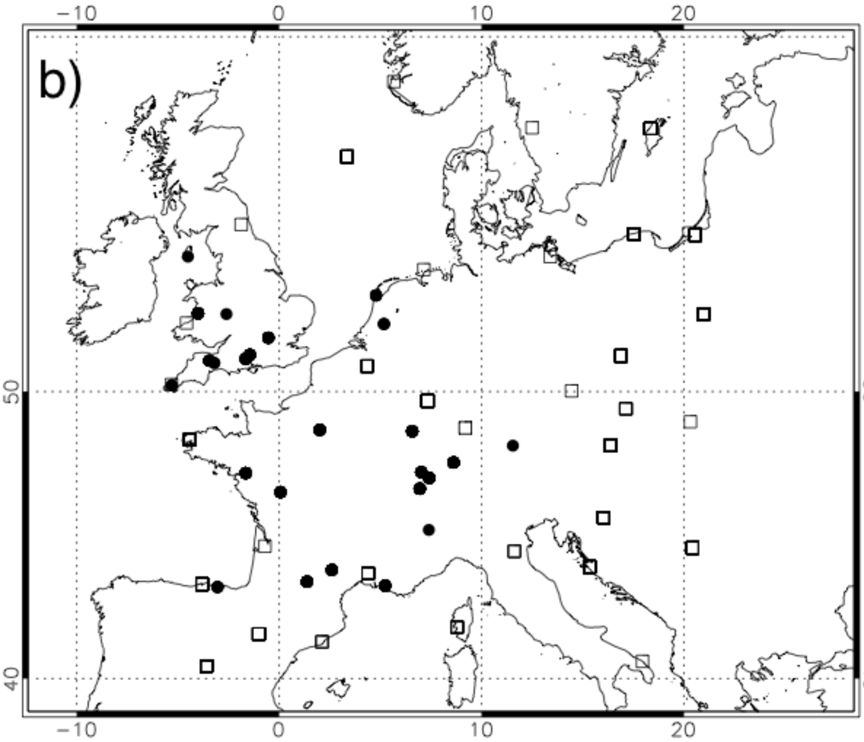
General comment

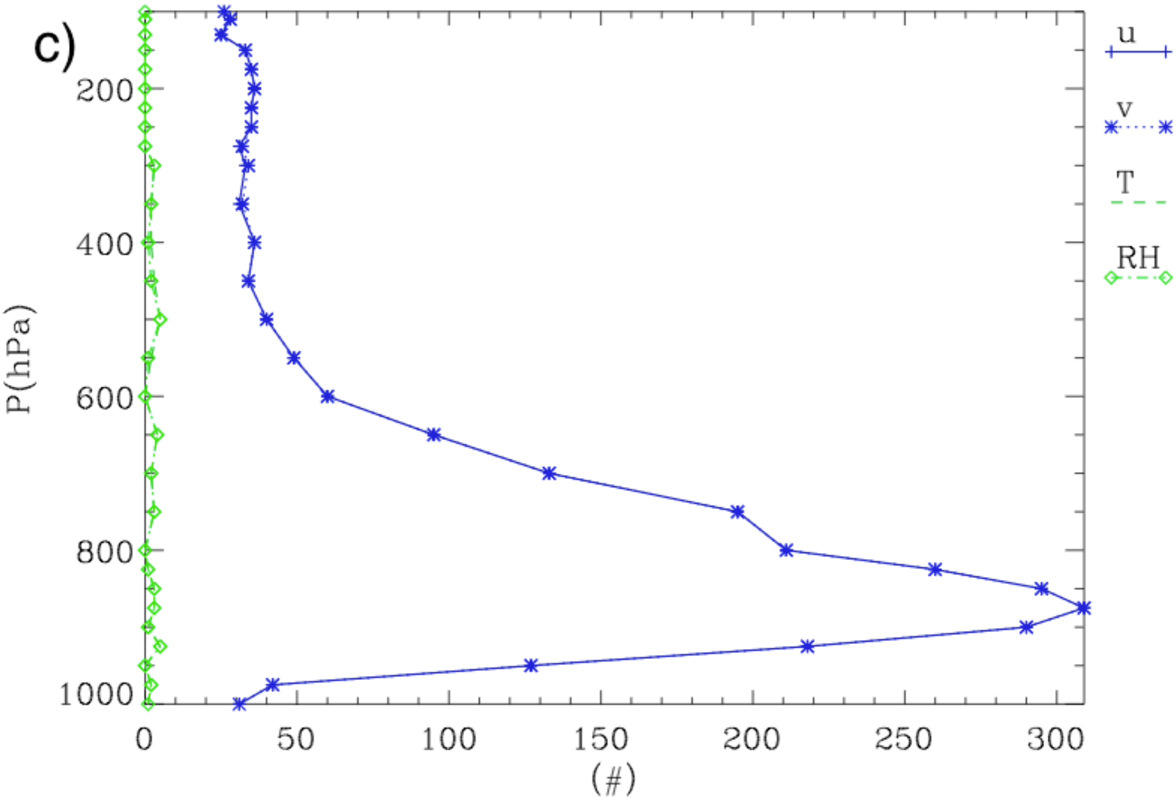
"This paper presents a newly developed 3D-VAR system for RAMS model. An application to assimilation of wind profiler data is presented. The topic is relevant by both theoretical and observative point of view, but to better fit the scope of the ATM journal the author should add a section to present the measurements and the wind profiler.
I noticed that several paragraphs are self citations of a previous paper (Federico, S., 2013) where the preliminary results of the 2D version is presented; this is strongly discouraged.
I believe that an accurate review for a newly developed assimilation technique for wind profiler should be performed by a journal dedicated to this subject before accepting for publication in ATM. I would suggest to send the paper for a further review to a developer of assimilation techniques - I will be glad to suggest some name by private communication to the editor."

Considering the general comment about a deeper discussion on the observing systems used in this work (i.e. radiosoundings and wind profilers) I will change the paper in the following ways.

Two new figures will be added to show the position of the radiosoundings and wind profilers used in this work. In the revised version of the paper, the Figure 6 will be a four panel figure where the positions of the observing systems will be shown at analysis and forecasting times. The new Figure 6 is the following:




b)
−10
0
10
20
50
40


c)
P(hPa)
200
400
600
800
1000
0
50
100
150
200
250
300
(#)
u
v
T
RH

a)

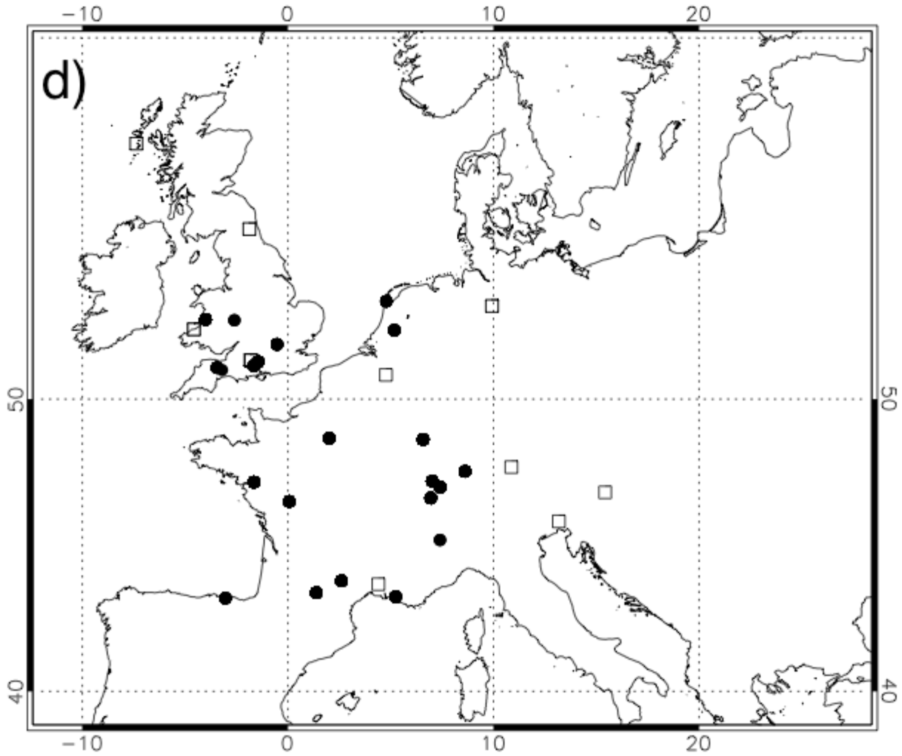


Figure 6: a) The number of data available at the analysis time (12 UTC) accumulated for the whole period and over the whole domain. *T* is for temperature, *RH* is for relative humidity, *u* and *v* are for the zonal and meridional wind components, respectively. The number of data for the wind components (*u, v*) is the same for all levels; b) positions of the radiosoundings (open squares) and radar wind profilers (filled circles) at 12 UTC considering the whole period. Not all radiosoundings and radar wind profilers are reporting data at a specific analysis time; c) as in a) for 13 UTC; d) positions of the radiosoundings (open squares) and radar wind profilers (filled circles) at forecasting times (13, 14 and 15 UTC). Not all radiosoundings and radar wind profilers are reporting data at a specific forecasting time.

Moreover a new table (Table 3) will be added to the paper to better support the discussion about observations:

TABLE 3: Number of available data at analysis and forecasting times accumulated over the whole period and over the whole domain. *u* is for zonal velocity, *v* is for meridional velocity, *T* is for temperature, and *RH* is for relative humidity.

TIME	Radiosoundings				Wind profilers	
	Soundings number	*u,v*	*T*	*RH*	Soundings number	*u,v*
12 UTC	458	5978	4019	3486	405	2678
13 UTC	5	57	/	/	407	2763
14 UTC	8	73	/	/	407	2744

15 UTC	9	90	/	/	413	2802

Finally, an appendix (Appendix A, reported at the end of this author comment) will be added to shortly describe the observing systems used in this work.
In doing the figures, however, I noticed that Figure 6a of the discussion paper had a wrong cut-off of the data after 21 days. This resulted in less data number displayed in the old Figure 6a, compared to the new one. This change, however, does not affect the discussion that was made in the paper (sections 3 and 4) about Figure 6a.

Considering the problem of the self citations of Federico (2013), in the revised version of the paper there will be two self citations to this paper (five in the old version). One in the introduction to highlight the improvement compared to the previous version of the variational data assimilation scheme shown in Federico (2013), and the other in a footnote, when discussing the option to run the analysis system using a regular latitude-longitude grid.

Specific comments:
1) pag 3584 from line 2 to the end of the page: The author describes the main features of the data assimilation system into the introduction, I would strongly suggest to move this part into section 2 and leave only a brief description.

The description of the data assimilation system in the introduction will be shortened in the revised version of the paper. In particular I will write:
"The analysis system uses the incremental formulation of the cost-function (Courtier et al., 1994), ensuring that the analysis imbalance is kept at minimum as the first guess, to which the increments are added, is already balanced because it comes from the output of a numerical model. Moreover, a control variable transform is used to make the minimization of the cost-function practicable."
However, because the main features of the data assimilation system were already included in section 2, I will leave the section 2 unchanged, at least for this comment.

2) A section dedicated to the European wind profiler network, with a figure showing their location would help the reader to understand the results. Moreover, a description of the instruments is necessary.

Both of these issues will be considered in the revised version of the paper, by adding two new figures (namely Figures 6b and 6d), one table (Table 3) and the Appendix A. Nevertheless, it is important to highlight that not all the observational systems displayed in Figures 6b and 6d are reporting data for a particular analysis/forecasting time. This is clarified in the caption of the new Figure 6.

3) Section 3 is dedicated to the experiment set up, but it is not clearly explained where/which are the observations over the domain and which of them are used for the assimilation and/or the verification. This should be stated clearly (figure 4 is not clear).

In addition to the discussion for the point 2), the Figure 4 will be changed to show the position of the observational systems, whose data were used for the analysis. Moreover, I will use the zonal velocity at 850 hPa because there are more measurements at this level from both wind profilers and radiosoundings, compared to the 500 hPa surface, that was used in the discussion paper. The new Figure 4 will be:

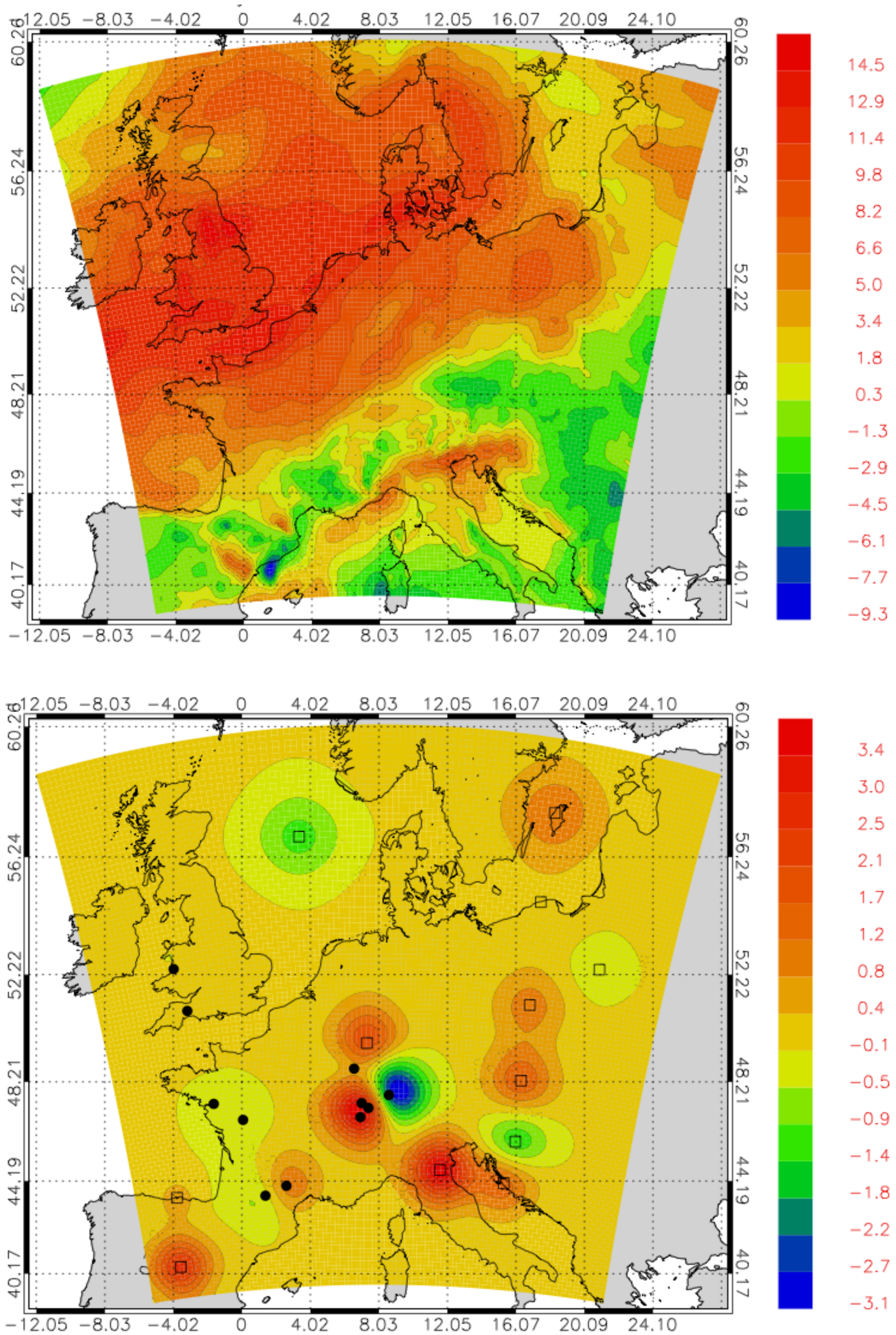


Figure 4: a) Background of the zonal wind component (m/s) at 850 hPa at 12 UTC on 01 July 2012; b) analysis increments (m/s) at the same time and level of a). The positions of the radiosoundings (open squares) and of the wind profilers (filled circles) used in the analysis are shown. The figure shows the horizontal domain used in this paper.

Figure 4b, in particular, shows how the interaction among several observations impacts the analysis increments, as over Central Europe; it also shows the effects of isolated observations on the analysed field, as over the Gotland Island and North Sea. It is worth noticing that not all the observing systems shown in Figure 4b give a contribution to the zonal velocity analysis at 850 hPa. For example, the wind profilers over Wales and England report measures for middle-upper troposphere (above 600 hPa) and do not give a contribution to the analysis at 850 hPa because the lengthscale of the vertical background error correlation is 2500 m for both wind components.

APPENDIX A

In this paper measurements from two observing systems are used: radiosondes and wind profilers. These instruments are shortly reviewed in this Appendix.

Radiosondes

The radiosonde is a balloon-borne device that measures, *in situ*, the vertical profile of meteorological variables and transmits the data to a ground-based receiving station.
Vertical profiles of temperature, humidity, and pressure are given as the balloon ascends from the land or ocean surface to heights up to about 30 km. The profile of these meteorological variables is called an upper-air sounding that is known as a radiosonde observation or RAOB.
The radiosonde is carried aloft by a balloon, which is made by natural rubber (latex) or synthetic rubber (neoprene). Operational radiosonde systems typically use balloons that weight from 0.3 to 1.2 kg, filled to ensure an ascent rate of 300 m/min. The meteorological measurements are made at intervals that vary from 1 to 6 s, depending on the radiosonde type.
Sensors used for pressure, humidity and temperature observations are often of the capacitance type. Changes in pressure, temperature and humidity result in changes in the capacitance of each sensor, which is converted to a frequency signal. Frequencies are converted to physical measurements by factory calibration measurements. Wind speed and direction are determined by observing the drift of the balloon and high quality tracking information is necessary for obtaining high quality wind measurements. Nowadays Global Positioning System (GPS) is becoming into widespread usage, because of the high accuracy and of the global coverage. A GPS receiver inside the radiosonde measures directly the drift velocity of the balloon and hence the wind.
Countries launching operational radiosondes are members of the World Meteorological Organization's World Weather Watch program. They launch radiosondes at 00 and 12 UTC (actually the launches occur 45 minutes before these observing times) and are contemporary worldwide to provide a synoptic description of the atmosphere. Countries of the World Weather Watch program freely share their sounding data with each other. After an operational upper-air sounding is completed, a standard data message (TEMP) is prepared and made available to all nations using the Global Telecommunications System.
There are two main applications of radiosounding observations: to analyze and describe current weather patterns, and to provide inputs to short- and medium-range weather forecasting models.

More information about radiosondes is provided by the World Meteorological Organization (WMO, 1996).

Wind profilers

The radar wind profiler is a remotely observing equipment using pulsed electromagnetic radiation to measure the winds in the atmosphere, both in the horizontal plane and in the vertical direction. The principle of working is the following: an electromagnetic wave is sent to the atmosphere and a small fraction of its energy is scattered in all directions, including that of the receiving antenna. The returned energy is amplified and discriminated in range by sampling it with delays of fixed intervals, which are built in the data processing system. In such way, the radar receives scattered energy from discrete altitudes, referred as range gates.

In the troposphere and the stratosphere the backscattered energy is produced by small-scale fluctuations of the refractive index, which are in turn produced by small-scale fluctuations in atmospheric density. These small-scale fluctuations are produced by the turbulence and move with the bulk motion of the medium in which they are embedded. The radar is most sensitive to the scattering by turbulent eddies whose spatial scale is half of the lengthscale of the electromagnetic radiation emitted by the radar (Table A1).

The Doppler frequency shift of the backscattered energy is determined and it is used to calculate the velocity of the air toward or away from the radar, along the direction of the emitted beam as a function of the height.

A typical configuration of the radar wind profiler is that of an antenna, which is both the transmitter and the receiver, emitting electromagnetic pulses in five directions: one is the vertical and the other four, tilted off the vertical, are orthogonal to one another. The vertical beam is used to retrieve the vertical velocity, while the combination of all the beams is used to determine the horizontal wind components.

Finally, Table A1 shows the main characteristics of the radar wind profilers, including those of the European wind profiler network, used for wind profiling in the troposphere/low stratosphere. More information about wind profilers can be found in Clifford et al. (1994).

Table A1: Characteristics of the radar wind profilers

Frequency (MHZ)	Antenna size (m^2)	Power peak (kW)	Range (km)	Resolution (m)	Name and description
50	10.000	250	2-20	150-1000	VHF wind profiler. Wind profiler used for sampling the troposphere and lower stratosphere.
400	120	40	0.2-14	250	UHF wind profiler. Wind profilers used for sampling the troposphere.
1000	5	0.5	0.1-5	60-100	Boundary layer wind profiler. Used to sample

					the lower troposphere.