There can be no doubt that high-quality wind observations of RWP are beneficial for NWPM. The challenge of operational networks is then to provide this high quality data on a 24/7 basis. A necessary prerequisite for a positive impact of RWP's is that the instruments are able to provide such high-quality measurements in an operational, fully automated fashion. This seemingly trivial requirement requires a constant endeavor in the operational practice. In the following, a few important practical aspects of the operational use of RWP are discussed.

1 Frequency management

The high sensitivity of the RWP's make them vulnerable to any external radio-frequency interference of sufficient strength that is in-band. Frequency management is therefore an essential issue for operational networks. As more and more technical applications are using electromagnetic waves, the frequency spectrum has become a scarce resource. Effective management of allocated frequency bands is paramount to maintaining and enhancing the quality of radar wind profilers and therefore an important task.

Wind profiler frequency allocations were on the agenda of the World Radiocommunication Conference 1997 (WRC-97), where the resolutions COM5-5, and Footnotes S5.162A and S.5.291A were accepted. In these documents, RWP frequency allocations are assigned for the bands 50 MHz, 400 MHz and 1000 MHz, depending on the ITU Region. Since then, the allocations have been constantly under pressure from other intended usage of these bands. For example, the European Radio Navigation Satellite Service GALILEO is going to use an L-band frequency range assigned to boundary-layer wind profilers. Compatibility studies (ECC-Report 90) were therefore necessary to ensure the best possible protection.

The sharing of profiler frequency bands with other services is obviously inescapable, but coexistence is often possible. Of advantage is here the nearly vertical direction of the profiler beams, which naturally enhances the protection against horizontally propagating waves. The 482 MHz RWP in Germany are operated in a frequency band that is primarily assigned to digital terrestrial television broadcasting (DVB-T) in UHF channel 22. With the exception of short-lived tropospheric ducting events, when TV signals can propagate over long distances up to 1000 km or more, the emissions of TV stations are no issue for the three 482 MHz wind profilers at Ziegendorf, Bayreuth and Lindenberg. However, RWP signal processing and quality control procedures needs to be developed further to eliminate all spurious data in such cases.

A convincing, but rather extreme example is the RFI that is constantly observed with the 482 MHz RWP at Nordholz, Germany. This profiler operates at a distance of only 30 km away from a powerful (10 kW ERP) DVB-T transmitter as a result of a frequency management mistake. Although the television signal is always clearly detectable in the Doppler spectrum, see Fig. as an example, the valid profiler data have a good quality and are routinely assimilated by ECMWF. However, the vertical data availability of this system is inevitably reduced due to the RFI.

2 System setup: Sampling and processing

Wind profilers were developed for research and it is therefore no surprise, that sampling and processing can be set-up in a variable way. After the first commercial radars were available, most research users were asking for further enhancements in flexibility. This has, among other things, lead to the development of modular and highly configurable RWP operating software.

However, this extensive flexibility, which is most welcomed by developers and researchers, can be quite intimidating and dangerous in an operational setting, where users usually only want a fully-automatic 'turn-key' meteorological instrument for mean wind profiling. Depending on the particular system, there is a great potential for suboptimal settings of both the profiler sampling and processing, which can easily lead to bad data quality. To avoid potential pitfalls, some basic knowledge about signal processing issues is essential.

In terms of the sampling settings (pulse repetition frequency, time increment in the I/Q raw data) it is of utmost importance to make sure that range and frequency aliasing effects, see e.g. Gaffard et.al. (2008), Gangoiti et.al. (2002), Miller et.al. (1994), are ruled out, because they can lead to large errors. Also important is a sufficient number of beam cycles to assure the validity of the DBS assumptions.

In some systems, also the chain of signal processing algorithms can be fully configured. That is, the user not only can make a selection for several parameters of an algorithm (and thereby determining important parameters like the dwell length, the time that is used to estimate a Doppler spectrum), but different processing algorithms can be daisy-chained in various ways. This option has clear advantages for addressing site-specific clutter issues, but deriving a good set-up is no trivial exercise. Sophisticated algorithms should only be used after they were properly tested and validated. As a rule of thumb, the simplest possible processing should be preferred over complex and widely 'tunable' algorithms.

3 Maintenance

RWP are complex technical instruments and regular maintenance is necessary to guarantee a high level of data quality. While the systems are typically specified to operate over a time period of 10-20 years without major technical upgrades, the MTBF of several system components is much less and both preventive and corrective maintenance becomes a clear necessity. A comprehensive discussion of various aspects of RWP maintenance can be found in Dibbern et.al. (2001).

Of particular importance is the preventive maintenance of systems components that can degrade or partly fail unnoticeable, but with consequences for the data quality. A prominent candidate is the usually employed phased array antenna. As an outdoor element, the antenna is exposed to humidity, precipitation and radiation and it needs to withstand temperature changes over 50 K during the course of the year. On the other hand, the failure of single antennas in a phased array is quite difficult to detect. Although the overall array performance degrades, this typically remains hidden due to the high variability of the atmospheric scattering processes.

RWP Maintenance in CWINDE

4 Data handling

The RWP measurements are disseminated using the BUFR format which is defined by WMO. A special BUFR code table for wind profiler has been defined in COST-76, and is used in the European CWINDE network. After several years of application, it appears to be necessary to clarify some of the definitions used. For example, the meaning of the descriptor 0 025 001 ('range-gate length') is not very well defined and therefore used in different ways (either as 3 dB range resolution determined by the pulse width or as the vertical difference between adjacent range gates). It would be useful to further harmonize the BUFR format, so that data from all operational RWP are encoded in the same way.

Besides the final wind profile data, RWP's generate and save a number of raw data during different stages of the processing. This includes the time series of the demodulated receiver voltage, the Doppler spectra and the estimated moments. For diagnostic purposes it is useful to archive some of these data. For the DWD 482 MHz RWP, the time series data are temporarily saved at the site for about a week, to allow detailed investigations if this becomes necessary (e.g. for failure investigation). All spectral and moments data are transferred once a day to the Observatory Lindenberg, where they are archived. This way, the essential raw- and metadata remain available for later analysis.

To transfer larger files through the network, a DWD software called Automatic File Distributor (AFD) is used. The AFD provides a framework for very flexible, non-stop, log and debug-able delivery of an arbitrary amount of files to multiple recipients as expressed in Uniform Resource Locators (URL). AFD is made available by DWD under a GNU-GPL license.

5 Siting

The operating site of a windprofiler has to be chosen carefully. The site should have electric power supply, data transmission infrastructure and should be accessible by car for maintenance. Further, a good choice of the site can help to reduce problems due to clutter, electromagnetic interference, corrosion and lightning damage. More information and recommendations on these issues can be found in Chapter 6 of WMO Instruments and Observing Methods Report No. 79.

Back to Radar wind profiler