1 Historical development

After the first successful demonstration of clear-air wind measurements by Woodman and Guillen (1974) the potential capabilities of this technique for meteorological applications became suddenly apparent (Larsen and Röttger (1982)) and dedicated meteorological profiler systems were suggested (Hogg et.al. (1983)). It took not long until the installation of a small experimental wind profiler network in Colorado (Strauch et.al. (1984)). A brief historical overview of wind-profiling radars is given by van Zandt (2000).

The first truly operational network, called the Wind Profiler Demonstration Network (WPDN), was completed in May 1992, later it became known as the NOAA National Profiler Network Weber et.al. (1990), Barth et.al. (1994), NOAA Wind Profiler Assessment Report and U.S. Wind Profilers: A Review.

While the first systems used mostly operating frequencies in the VHF or lower UHF range, higher frequency (so-called boundary layer) profilers were also developed and later commercialized by a technology transfer to the private sector, see Ecklund et.al. (1988) and Carter et.al. (1995).

In Europe, a first demonstration of wind profiler networking was organized during the COST-76 action in early 1997 as the CWINDE (COST WIND initiative for a network demonstration in Europe)-97 project (Nash and Oakley (2001)). The acronym has meanwhile been rephrased as the Co-ordinated WIND profiler network in Europe, which is currently managed by the E-WINPROF Programme of EUMETNET. Right now, CWINDE is comprised of 26 systems in 9 countries. Most radars are Boundary layer profiler (915, 1280 or 1290 MHz), but there are also four full tropospheric 482 Mhz systems in Germany and five VHF systems (45 - 64 MHz) in France, the UK and Sweden. In Asia, the Japanese Meteorological Administration is operating a network of 31 L-band wind profilers (Ishihara et.al. (2006)), and the Korean Meteorological Administration has installed five L-band wind profiler since 2002 (Park and Lee (2002)).

2 Data use and impact

RWP's are widely used in operational meteorology and atmospheric research. Major meteorological field experiments make regular use of RWP, e.g. METCRAX (Whiteman et.al. (2008)), T-REX (Grubisic et.al. (2008)), NAME (Higgins et.al. (2006)), IHOP (Weckwerth et.al. (2004)), BAMEX (Davis et.al. (2004)), CASES (Poulos et.al. (2002)) or MCETEX (Keenan et.al. (2000)).

In a more operational setting, RWP measurements have been used either directly in subjective weather forecasting and case studies (Dunn (1986), Kitzmiller and McGovern (1990), Beckman (1990), Edwards et.al. (2002), Crook and Sun (2004), Bond et.al. (2006), Wagner et.al. (2008)), or automated in data assimilation for numerical weather prediction Smith and Benjamin (1993), Bouttier (2001), Andersson and Garcia-Mendez (2002), Benjamin et.al. (2004), St.James and Laroche (2005) and Ishihara et.al. (2006)

Their particular advantages are a high temporal resolution and the capability to provide unambiguous profiles independently of the used assimilation system, the latter being in contrast to most passive remote sensing systems. Furthermore, measurements can be made under almost all weather conditions.

Due to the potential of RWP's to provide high-resolution observations, they are especially well suited to describe the atmospheric state at the mesoscale (Browning (1989), Park and Zupanski (2003), Browning (2005)) where the current observation coverage is still quite incomplete in space, time and also state variables of the models, see e.g. Carbone et.al. (2009). It is very unlikely, that the models can always generate the correct mesoscale atmospheric state without proper initial data. The current experience with high-resolution models has shown that even a 12-24 hour deterministic prediction of some intense convective precipitation systems can drastically fail. For example, Gallus et.al. (2005) reported about an intense derecho event accompanied by a well-organized band of heavy rainfall that they were not able to simulate although a range of different models, different parameterizations and initial conditions was used.

While both the numerical models and the global observation system are constantly evolving, impact studies are regularly performed to assess the usefulness of RWP and other observations in various NWPM's. This task is quite challenging and the results depend on the number of observations available, their quality, the error specification as well as on the particular meteorological situation. For example, Amstrup (2008) has used DMI-HIRLAM to assess the impact of various terrestrial observing systems in 2005. While it was found that the impact from the very few wind profilers used is generally negligible, there was also a case identified where the assimilation of only three RWP in Alaska showed a very positive impact in an extreme weather situation near the Faeroe islands. Experiences gained with a high resolution (COSMO-2 model, grid spacing 2.2 km) by MeteoSwiss indicate that RWP data are especially beneficial for short range forecasts at smaller scales. It was found that the assimilation of three ground based remote sensing stations (equipped with a 1290 MHz low tropospheric wind profiler and microwave radiometer) substantially improved the quality of COSMO-2 forecasts (Calpini et.al. (2011)).

Apparently, the usefulness of RWP data is variable in time and, in specific meteorological situations, also in height. Cardinali (2009) has identified a situation where high wind variability on small spatial and temporal scales had an impact on the measurements of the North American RWP, which lead subsequently to a degradation of the forecast in the ECMWF model. This problem was associated with a rather large height and strong activity of the continental convective boundary layer at the profiler sites.

Benjamin et.al. (2010) have recently used the RUC model of NCEP to assess the short-range forecast impact of a number of data types, including RWP's.

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