The new Standard VDI 3786-20 for radar measurement of precipitation

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(Dated: 18 July 2014)

1 Introduction

Standard VDI 3786-20 “Environmental meteorology – Ground-based remote sensing of precipitation – Weather radar” covers aspects of metrology, system design, radar calibration, quantitative precipitation measurement, data quality assurance, short-term precipitation forecasting (nowcasting) and applications and requirements in water management.

Weather radar measurements are not a substitute for the conventional methods described in Standard VDI 3786-7; indeed, where higher accuracy is required in terms of quantitative precipitation estimation (e.g. for flood warning systems), they may need to be supported by conventional measurements.

These issues are available for the first time as consensus-based document. The document has been produced in German and English language and has passed final checks to become the official German Standard in the second half of 2014. Standard VDI 3786-20 is a first and important step in the international harmonization of quantitative precipitation measurement using weather radar. This paper discusses the scope of Standard VDI 3786-20 and shows the potential usage of radar data in typical applications in water management.

2 The scope of Standard VDI 3786-20

Standard VDI 3786-20 describes sounding of the atmosphere using ground-based weather radar systems at wavelengths between 3 cm and 10 cm. These systems are suitable for area-wide detection of precipitation and other targets up to an altitude of several 1000 m above ground.

The main application described in Standard VDI 3786-20 is quantitative precipitation measurement. Area-wide detection of precipitation areas opens a series of important applications. One popular qualitative application is the real-time display of precipitation areas, and the distribution of these displays e.g. on various Internet portals accessible to the general public. Many professional users, such as e.g. DWD (German Weather Service), in the fields of water management and in agriculture, utilise the data obtained by the radar network sometimes by supplementary special radar stations, to detect the precipitation distribution. For such users the quantitative precipitation estimation is of great importance. For this reason, Standard VDI 3786-20 covers not only measurement techniques per se but also the procedures used in the preparation of the data for various applications.

Standard VDI 3786-20 does not discuss, meteorological process studies and air quality. It does not describe radars on moving platforms (aircraft, ships) nor does it deal with weather forecasting methods used in combination with numerical weather models.

3 Applications in water management

In water management, precipitation is the most sensitive input variable (VDI 3786-20, 2014); however, the relevant target variable for the design and operation of water management systems is the runoff resulting from precipitation and catchment area characteristics.

Radar data supplement the selective recording of precipitation using precipitation gauges, by providing spatial precipitation distribution across the whole area (VDI 3786-20, 2014). Both measurement methods have their own specific advantages, such that normally a combination of both leads to the best mapping of the spatial and temporal precipitation distribution (WMO, 2008). The quality of the two methods can be judged, inter alia, by using them as the input in hydrological models and comparing the resulting modelled runoff with the measured runoff.

Tables 1 and 2 show examples of radar data applications in water management. The examples are divided into online and offline applications. The minimum and optimum requirements for these applications can be found in Standard VDI 3786-20.

Table 1: Possible online applications of radar precipitation data (VDI 3786-20, 2014)

Application	*Description*
RTC of sewer systems	In real-time control (RTC) of sewers, the use of free storage capacity in the sewage network can be optimised by controlling the runoff. A small gain of reaction time is already achieved through the radar precipitation measurement, since the precipitation is measured at an altitude and therefore before it reaches the ground and enters the sewage network. A further and sometimes significantly greater gain of reaction time can be achieved by nowcasting with the help of radar data (cell tracking)
Control of Sewage treatment plants	In rainy weather, increased inflow into the treatment plant may occur over several hours, necessitating a temporary increase in its capacity. This requires precipitation forecasting that predicts exceedance of critical thresholds well in advance. The necessary forecasting horizon depends on the type of procedures implemented at the treatment plant and the structure (flow times) in the sewage network. As in RTC of sewers, here too radar data can improve the quality and lead time of the required precipitation forecasting.
Flood warning services	Precipitation products and nowcasts can be used either as input variables for hydrological or sewage network models. Information about the exceedance of critical precipitation levels and the resulting runoffs, is beneficial for many services.
Reservoir management	Radar data in combination with numerical weather forecasting models, support the management of reservoirs and similar technical systems for managing water quantities in situations of both low- and high-water. Due to the large catchment areas, there is sufficient response times for decision-making in system control.
Flood control	Radar precipitation image products provide important and area-wide qualitative information that aids in assessing the flooding situation. Quantitative radar data can be integrated into large scale hydrological models, thus forming an important component of flood prediction; and subsequent operational flood control actions such as flood warnings, the control of retention basins and reservoirs or of dike defences. By linking them with numerical weather forecasting models, it is also possible to forecast outflow rates over time beyond nowcasting timeframes.

Table 2: Possible offline applications of radar precipitation data (VDI 3786-20, 2014)

Application	*Description*
Precipitation climatology	Long-term accumulations (days, months, years) of radar precipitation measurements allow analysis of special regional features of the precipitation distribution, e.g. those due to orographic effects, urban impact, preferred storm paths and windward-leeward effects. On this basis, it is possible e.g. to optimise measurement station networks or identify high-risk regions (e.g. those having a high risk of heavy precipitation).
Event documentation and analysis	Radar data offer a better understanding of extreme and damaging precipitation events. They make it possible, for example, to establish whether a structure failed due to technical or operational defects, or whether the event exceeded the design limit. The consequences of inundated areas by water courses, too, can be classified more effectively in this way (with implications for questions of liability/insurance cover).

4 Outlook

Standard VDI 3786-20 will be the initial document for an upcoming ISO standard working group to be formed in 2014.

5 Commission on Air Pollution Prevention of VDI and DIN – Standards Committee KRdL

Acting on its own responsibility and in cooperation with the public authorities concerned, scientists and industry, KRdL ascertains the state of scientific and technological progress and lays this down in Standards. The Standards are prepared in over 170 committees and working groups with about 1,200 specialists from the industrial, scientific and administrative fields, are adopted in legislation and are incorporated in the activities of the executive.

The Technical Rules describe the state of the art in science and technology in the Federal Republic of Germany and serve as a decision-making aid in the preparatory stages of legislation and application of legal regulations and ordinances. KRdL's working results are also considered as the common German point of view in the establishment of standards on the European level by CEN (European Committee for Standardization) and on the international level by ISO (International Organization for Standardization).

KRdL is divided in four technical subdivisions. Subdivision II "Environmental Meteorology" writes Standards on meteorological measurements; dispersion of pollutants in the atmosphere; emissions from accidental releases; micro- and meso-scale wind field models; interaction between the atmosphere and surfaces; applied climatology; air pollution maps; human-biometeorological evaluation of climate and air hygiene; transfer of meteorological data.

Acknowledgement

We wish to express our gratitude to all honorary contributors to Standard VDI 3786-20. Notably, these are Jens Didszun, Uwe Ehret, Frank Gekat, Martin Hagen, Kai Mühlbauer, Gerhard Peters, Markus Quirmbach, Marc Scheibel, Adrian Treis, Hans-Reinhard Verworn and Elmar Weigl. We thank VDI for the release of the guideline for the preparation of this paper.

References

VDI 3786 Part 7 (2010). Environmental meteorology - Meteorological measurements - Precipitation. Berlin, Beuth Verlag

VDI 3786 Part 20 (2014). Environmental meteorology – Ground-based remote sensing of precipitation – Weather radar. Berlin, Beuth Verlag

World Meteorological Organization (2008). Guide to Meteorological Instruments and Methods of Observation. WMO No. 8, Seventh Edition, Part II Observing Systems, Chapter 9 Radar Measurements