Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Weather Radar Calibration and Monitoring Workshop

BOOK OF ABSTRACT

18 – 20 October 2017, Offenbach, Headquarters of DWD

Table of Contents

Session 1: Introduction & Keynote

ZDR CALIBRATION AND MONITORING: NCAR'S S-POL EXPERIENCE

John Hubbert

NCAR

In this paper temporal Zdr (differential reflectivity) bias variations are investigated using the NCAR's S-band polarimetric radar (S-Pol) solar scan data collected over extended time periods. The measurements reveal a high linear correlation between the ambient temperature at the radar and the Zdr. Through the solar measurements and the ratio of crosspolar powers, the components of the radar that cause the variation of the Zdr bias are identified. It is shown that the thermal expansion of the antenna is the primary cause of the Zdr bias variation. The crosspolar power (CP) technique is used for calibration of Zdr for PECAN (Plains Elevated Convection at Night) data. A technique to mitigate the Zdr bias caused by temperature variations is given. The Zdr bias from the CP technique is compared to vertical pointing Zdr bias calculations and the uncertainty of the Zdr bias estimates are given. It is also shown how the CP technique can be applied to simultaneous H and V transmit radars.

Session 2: Poster session

THE LIST OF THE PREPARED POSTERS YOU FIND AT THE END OF THE DOCUMENT!

Session 3: Operational Monitoring System

OVERVIEW OF REALTIME MONITORING & CALIBRATION ON METEOSWISS WEATHER RADAR NETWORK

M. Boscacci

MeteoSwiss

A general overview of real-time monitoring and calibration on MeteoSwiss weather radar.
During the design of the 4th generation of the weather radar dedicated the necessary time to carefully describe the monitoring and calibration specifications, based on the operational problems arisen with the previous generation.
Some special MeteoSwiss implementation are presented, at different component level, like transmitter, receiver, antenna. All Swiss weather radar are installed on unmanned building , remote control and monitoring of the auxiliary equipment play also an import roles, information from UPS, air conditioning system, external weather sensors are also collected.
More than 350 variables are recorded up to 20 times per volume scan, archived since the beginning of the installation.
A brief list of monitoring measurements extracted during the processing of the radar data and the generation of the radar products is also presented.

MONITORING OF SYSTEM STABILITY AND DATA QUALITY AT OPERATIONAL S-BAND DUAL-POLARIZATION RADAR

Chang-Rok Oh, Jeong-Eun Lee, Sung-Hwa Jung, Chang-Hwan Park, Jong-Seong Kim, and Sun-Ki Lee

Korea Meteorological Administration

The quality of radar data is subjected to the stability of radar system including not only electric components but mechanical part. The performance of mechanical component usually influences the accuracy of the pointing of the radar antenna in azimuth and elevation. The mis-calibration in transmission and receiving chain and the poor signal processor lead to low quality of dual-polarimetric measurements. Although the monitoring of radar system is essential for weather radar operation, around-the-clock monitoring of radar system is still challengeable issue.
In this study, we examined the stability of radar hardware and data generation chain for the KMA operational S-band dual polarization radar. First, the pointing accuracy of the radar antenna was investigated by comparing the azimuth and elevation angle recorded at each ray in radar moment file to nominal angles defined by radar operator. The azimuthal difference between neighboring two rays was examined to ensure the stability of antenna rotation. As an integrity check for data generation chain, the number of valid radar fields, the number of elevation angles on volume file, and the number of rays on each sweep were checked. In order to analyze the effect of ground clutter filter, we compared the radial texture of reflectivity after applying ground clutter filter to raw radar reflectivity. The temporal variability between radial textures of unfiltered and filtered reflectivity was analyzed to check the stability of radar signal processor or ground clutter filter. Other issues related to ground clutter filter is the change in valid echo area of variables such as radial velocity and cross correlation coefficient after applying the filter. The rapid temporal variation of the valid echo area is related to use of dual pulse repetition frequency, pointing accuracy of antenna in elevation, and the performance of signal processing.
KEYWORDS
Dual-polarization radar, radar system stability, integrity check, data reliability, ground clutter filter
ACKNOWLEDGMENT
The research is supported by "Development and application of cross governmental dual-pol radar harmonization (WRC-2013-A-1)" project of the Weather Radar Center, Korea Meteorological Administration.

OVERVIEW OF THE UK WEATHER RADAR NETWORK CALIBRATION AND MONITORING

Caroline Bulpett, Timothy Darlington

Met Office

After recent upgrade of the Met Office radars hardware and software monitoring is changing; with improved efficiency and robustness of components calibration and maintenance is now carried out routinely at operational weather Radar sites every 6 months.
From an operational viewpoint we detail the process, including upgrades to the radar software "Cyclops", receiver calibration and provide a description of the routine engineering maintenance, e.g. oil change, transmitter checks etc.
The process used by the Met Office to monitor and progress incidents, and changes will be shown, including details of the the flow of information required to take a fault to resolution, and the main teams involved. From the first indication of an issue, via the automatic monitoring tool or visual

monitoring of the raw data, to the tool currently used to track any incidents and changes, keeping everything in one place helps to ensure communication and finally resolution by the field service or software engineers.
The current operational antenna pointing calibration technique making use of the the sun will be presented, and monitoring results shown.

Session 4: Calibration Methods and Sources (1): Sun, external Sensors, Ground clutter, Noise source

WEATHER RADAR MONITORING AND CALIBRATION OF DUAL-POLARIZATION RECEIVERS USING THE SUN AS A RADIO NOISE SOURCE

M. Gabella, M. Frech, M. Sartori, I. Holleman, M. Boscacci, A. Huuskonen, U. Germann

MeteoSwiss

The radio noise that comes from the Sun has been proved to be an effective reference for checking the quality of dual-polarization weather radar receivers and evaluating their calibration accuracy. Two complementary methodologies have been implemented and used so far: A) "High Sun-to-Noise ratio", dedicated observations obtained by pointing (and tracking) the antenna beam axis at the center of the solar disk (on-demand Sun-tracking); B) operational monitoring based on the analysis of solar signals in the polar volume radar reflectivity data produced during the operational weather scan program (automatic, daily Sun-check).
At the workshop in October we will present several examples, figures, results and statistical summary regarding both A) the on-demand Sun-tracking and B) the operational automatic, daily Sun-check. Regarding B) the focus will be on the slowly solar variation in 2014 as observed at C-band in Switzerland, the Netherlands, Finland and Germany (including relative and absolute calibration scores). Concerning A), we will present absolute calibration performances of the five C-band, dual-polarization radars belonging to the recently renewed weather radar network of the Swiss Confederation.
A) The idea of an on-demand Sun-tracking technique was discussed in the literature by Whiton et al. [1] 41 years ago. The idea was implemented in the late 70s and presented by Frush [2] in 1984. In 1989, Pratte and Ferraro [3] presented the first quantitative comparison between S-band single polarization radar-derived solar flux values and the accurate reference measurements acquired by the Dominion Radio Astrophysical Observatory (DRAO). In the 90s, using the above-cited semi-automated technique [3] a radar operator could perform the data acquisition phase of the calibration in twenty minutes. With modern fully digital receivers and radar signal processor, the acquisition time has been reduced by an order of magnitude. At MeteoSwiss for instance, we have implemented on each radar of the C-band weather radar network a Sun tracking procedure that lasts less than two minutes. If overall losses along the receiver path, bandwidth and antenna equivalent area are known, then one can transform the received power from the Sun into incident spectral irradiance, which is often called Solar flux and measured in W/(m2 Hz) [4]. Such radar estimates can be quantitatively evaluated in three ways: A) mutual agreement between radar Horizontal (H) and Vertical (V) polarization retrieved values; B) relative agreement between radar H (or V) and the DRAO reference; C) absolute agreement between radar H (or V) and DRAO [5]. Unfortunately, the radar has to be off-line during the tracking of the Sun and the technique is run manually by an operator. Very

recently, a fully automatic version of the method has been implemented on a dual-pol, fast 3D scanning, Doppler X-band radar on wheel [6].

B) For operational weather services, the Sun-tracking method has the disadvantage that the radar has to be off-line during the sun raster scans (typically three or five observations to derive one daily value). A valid alternative is the operational method (by Holleman, Huuskonen, et alia), which analyzes Sun signals acquired during operational scan and stored in polar volume data; for retrieving a daily value of solar spectral power, several tens of radar reflectivity values are fitted using the model described in [7]. Once that the 5 parameters are derived (for instance by means of the least squares method), the peak solar power that the radar would have received if the beam had hit the Sun center, can be estimated. Indeed, this is the "core" of the method; it deals with the convolution between the antenna radiation pattern and the solar disk (during operational scans, the antenna beam axis does normally not hit the center of the solar disk!) For this reason, the Sun-to-Noise ratio may be significantly worse than with Sun tracking (for each sun hit, it obviously depends on the angular distance between the antenna beam axis and the center of the solar disk). The method has been successfully implemented for determining and monitoring the electromagnetic antenna pointing [8], assessing the receiver stability [9] and monitoring the differential reflectivity offset [10] during several months of 2008, which is a period of quiet solar flux activity. The method proved to be successful also during the currently active Sun period: eleven C-band radar receivers analyzed in 2014 in Europe [11-13] were able to capture and describe the monthly variability of the Sun microwave signal. Recently, a further refinement of the method with focus on the monitoring of weather radar differential reflectivity bias has been developed and applied to several radars in Finland [14] and it is going to be applied also within the OPERA consortium.

REFERENCES

[1] Whiton, C.P.; Smith, P.; Harbuck, A.C. Calibration of weather radar systems using the Sun as a radio source. In Proceedings of the 17th Conference on Radar Meteorology, Seattle, WA, USA, 26–29 October 1976; pp. 60–65.

[2] Frush, C.L. Using the Sun as a calibration aid in multiple parameter meteorological radars. In Proceedings of the 22nd Conference on Radar Meteorology, Zurich, Switzerland, 10–13 September 1984; pp. 306–311.

[3] Pratte, J.F.; Ferraro, D.G. Automated solar gain calibration. In Proceedings of the 24th Conference on Radar Meteorology, Tallahassee, FL, USA, 27–31 March 1989; pp. 619–622.

[4] Gabella, M. Checking absolute calibration of vertical and horizontal polarization weather radar receivers using the Solar flux. J. Electrical Eng. 2015, 3, 163–169.

[5] Gabella, M.; Boscacci, M.; Sartori, M.; Germann, U. Calibration accuracy of the dual-polarization receivers of the C-band Swiss weather radar network. Atmosphere. 2016, 7, 76.

[6] Gabella, M.; Leuenberger A. Dual-Polarization Observations of Slowly Varying Solar Emissions from a mobile X-Band Radar, Sensors. 2017, 17, 15 pp.

[7] Holleman, I., and H. Beekhuis, 2004: Weather radar monitoring using the sun. Royal Netherlands Meteorological Institute (KNMI) Tech. Rep. TR-272, 40 pp.

[8] Huuskonen, A.; Holleman, I. Determining weather radar antenna pointing using signals detected from the Sun at low antenna elevations. J. Atmos. Ocean. Technol. 2007, 24, 476–483.

[9] Holleman, I.; Huuskonen, A.; Kurri, M.; Beekhuis, H. Operational monitoring of weather radar receiving chain using the Sun. J. Atmos. Ocean. Technol. 2010, 27, 159–166.

[10] Holleman, I.; Huuskonen, A.; Gill, R.; Tabary, P. Operational monitoring of radar differential reflectivity using the Sun. J. Atmos. Ocean. Technol. 2010, 27, 881–887.

[11] Gabella, M.; Huuskonen, A.; Sartori, M.; Holleman, I.; Boscacci, M. The solar slowly varying component as detected by dual-and single-polarization C-band weather radars in Europe, presented at the Electromagnetic Wave Propagation and Scattering in microwave Remote Sensing Symposium, Technische Universität Chemnitz, February 10-13, 2015. Submitted to Adv. in Meteor. in April 2017.

[12] Frech, M.; Hagen, M.; Mammen, T. Monitoring the absolute calibration of a polarimetric weather radar. J. Atmos. Ocean. Technol. 2017, 34, 599–615.

[13] Gabella, M.; Sartori, M.; Boscacci, M.; Germann, U. Vertical and horizontal polarization observations of slowly varying solar emissions from operational Swiss weather radars. Atmosphere. 2015, 6, 50–59.
[14] Huuskonen, A.; Kurri, M.; Holleman, I. Improved analysis of Solar signals for differential reflectivity monitoring. Atmos. Meas. Tech. 2016, 9, 3183–3192.

AUTOMATIC RECEIVER CALIBRATION MONITORING FOR THE UK WEATHER RADAR NETWORK

Timothy Darlington, Laura Sarson

Met Office

There exist many possible sources of calibration information which are routinely collected as part of a weather radar's operational activities. This work brings together these sources of information with the aim of determining an optimum estimate of the receiver gain, to convert from the measured voltages to the received power.

Sources of calibration used are the opportunistically measured solar flux, injected noise source power, and the known profile of atmospheric noise with elevation (tip curve), with the power injection carried out at engineering site visits acting as a background value. This work makes use of a particle filter to bring together the different measurements, accounting for their very different error characteristics. This approach gives the flexibility to include additional measurements as they become available, provides an error estimate on correction and is highly responsive to sudden changes in calibration value, an improvement over e.g. a moving average.

MONITORING RADAR CALIBRATION USING GROUND CLUTTER

Valery Melnikov, D. Zrnic, A. Free, R. Ice, R. Macemon

NOAA, National Severe Storm Laboratory

The WSR-88D radars feature hardware and a supporting program package to calibrate reflectivity (Z) and differential reflectivity (ZDR). To verify the ZDR calibration procedure, three methods are used on the radar network: measurements in light rain, in snow areas above the melting layer, and in areas of Bragg scatter. These methods have limitations, the strongest of which is the presence of appropriate weather conditions that limits continuous verification of ZDR calibration. Ground clutter is observed always that potentially can be used for radar calibration, if some stable parameters of clutter can be found.

Radar returns from ground clutter in a spectral interval -0.5 to +0.5 m/s are studied before applying ground clutter filters. The mean powers of these signals exhibit variations within ±1 dB and ZDR values are within ±0.1 dB, if the radar is in a good technical state. Examples of deviations from these intervals caused by radar hardware are demonstrated. A conclusion is made that these clutter signals can be used to monitor Z and ZDR calibrations. It is also shown that a wet radar radome decrease the mean clutter power. This decrease correlates with the rain rate on radar sites that can be used to estimate attenuation caused by wet radomes.

These variations weakly depend on temperature and the wind near the ground. Therefore these signals can be used for continuous monitoring of radar calibration. This approach does not use a dedicated ground clutter scan, the data are from the standard volume coverage patterns. This approach could be used to verify the calibration procedures in radars having built-in equipment (WSR-88Ds) and in radars without such equipment.

MONITORING RADAR CALIBRATION USING EXTERNAL SENSORS AND SOURCES

Michael Frech, Theo Mammen, Martin Hagen, Bertram Lange und Kay Desler

DWD

The absolute calibration and the differential reflectivity of a dualpolarization radar of the German Meteorological Service is continuously monitored using the operational birdbath scan, a co-located disdrometer measurements, a MRR, and solar power measurements extracted from the opertational scanning. For absolute calibration, the assumption is that a disdrometer measurement close to the surface can be related to the radar measurement at the first farfield rangebin. This is verified using a micro rain radar (MRR). The MRR data fills the gap between the measurement near the surface and the farfield range bin at 650 m. Differential reflectivity (ZDR) is monitored and calibrated once a day using birdbath scans . The performance and issues of this approach is illustrated with data from the DWD radar network from the last four years (starting in the beginning of 2014). We also illustrate how solar measurements can be used to monitor the ZDR calibration.

Session 5: Calibration Methods and Sources (2)

MET OFFICE REAL TIME ZDR AND PHIDP CALIBRATION

Donal Adams, Steven Best

Met Office

The Met Office is beginning to realise the benefits of upgrading its weather radars with polarimetric capability. One such benefit is the ability to use differential reflectivity (ZDR) and differential phase (FDP) information to develop better quantitative precipitation estimation (QPE) algorithms. In order to provide quantitatively useful data, these parameters must be well calibrated with the effects of system noise and variations removed adequately from the relevant signal from precipitation.
Described here are calibration and monitoring schemes which have been developed that are capable of correcting or tracking system variations. Real time calibration is performed on differential reflectivity (ZDR) and differential phase (FDP) variations, making use of vertically pointing ‘bird bath’ scans as an initial system offset, and then also accounting for temporal and azimuthal variations on a ray by ray basis.

CALIBRATION USING A HORN ANTENNA FOR DUAL-POLARIZATION DOPPLER WEATHER RADARS

Yusuke Kajiwara, Hiroshi Yamauchi, Hidehiro Okumura, Akihito Umehara

Japan Meteorological Agency

- In 2016, the Japan Meteorological Agency (JMA) began to operate C-band dual-polarization Doppler weather radars with solid-state power amplifiers at three international airports (Kansai, Tokyo and Narita).
- Dual-polarization Doppler weather radar operation involves reference to slight differences in magnitude and phase between received horizontal and vertical polarized waves. However, it is known that significant phase shift between transmitted polarized waves and low cross-polarization discrimination (XPD) cause a significant increase in the bias of differential reflectivity (Zdr) owing to cross-coupling between the two polarized waves.
- Accordingly, transmitted phase alignment was conducted by receiving radar waves with a standard horn antenna located in the far field so that shift was settled to within a few degrees. The use of dial-type variable phase shifters for individual polarized waves facilitated fine alignment.
- Simultaneously, XPD observation was conducted with transmission from the horn antenna and a signal generator (SG). The results showed XPD values of 35 dB for two radars, which is within the required performance specifications. XPD needs to be re-evaluated for the other radar because the value appears to have been reduced by mirror reflection.
- Fine measurement of transmission and receipt line loss (including radome loss) in the radar system was realized by using two-way communication between the radar antenna and the horn antenna.
- The presentation will also cover results of bird-bath scans and rain gauge comparisons and outline the calibrations methods used.

UAV-AIDED ABSOLUTE CALIBRATION OF WEATHER RADAR

Jiapeng Yin, Fred van der Zwan, Erik Oudejans, Christine Unal, Herman Russchenberg

Delft University of Technology

Weather radar is well recognized as one effective tool for obtaining the information of atmospheric phenomena, capable of both high spatial and temporal resolution. Radar calibration is one of the most important prerequisites for achieving accurate observations. Current calibration methods are either a metal sphere hanging underneath a tethered balloon or a trihedral corner reflector locating on the top of a tower or mast. However, there are some problems with these methods: (1) They are location bound. The calibrator should be placed in the far-field, which seems impossible for some radars locating on the top of high buildings or towers. (2) It is relatively costly for tower setup or helium balloon purchase. (3) It is not easy to repeat the calibration process for mobile radars, especially for some fieldwork campaigns in complex terrain. (4) For vertically pointing cloud radars, the current methods are impossible to calibrate them. Therefore we propose a portable, cost-effective and repeatable solution to replace the current calibration techniques. An industrial-grade UAV serves as our stable aerial platform carrying a metal sphere, flying over the radar illumination areas to complete the calibration process. To retrieve the position of the sphere, the real-time single-frequency Precise Point Positioning (PPP) type GNSS solution is developed. Both receiver, microcontroller, and antenna are mounted on an additional platform above the sphere. The radar constant is calculated in the range-Doppler domain, and only these data which metal sphere separates from the ground clutter and UAV are selected. The spectral-polarization features are studied to further verify the recognition of metal sphere. The S-band polarimetric Doppler weather radar Transportable Atmospheric Radar (TARA) is used in the calibration campaign. The preliminary results show the effectiveness of the proposed radar calibration technique.

TECHNIQUE FOR CALIBRATION OF POLARIMETRIC RADARS AT ATTENUATING FREQUENCY USING ZDR AND PHIDP

Ahoro ADACHI, Takahisa Kobayash and Hiroshi Yamauchi

Meteorological Research Institute

Polarimetric radars require an accurate method for absolute power calibration to achieve their full potential. A technique is described which uses a combination of Zdr and Phai-dp measurements in rain to calibrate the radar. This method is based on an autocalibration of Z introduced by Goddard et al. (1994). Because their autocalibration technique does not take the attenuation effect into account, it is valid for S-band but limited for C-band to use with weak rain when the attenuation effect is negligibly small. Following their studies, we expand the consistency relationship, which governs the autocalibration, to include attenuation correction procedures and develop an autocalibration technique for radars at attenuating frequency with heavy rainfall. This technique also considers excess attenuation due to rain on the radome, which means that the estimated calibration constant has azimuthal and temporal dependency with wet radome. This method is evaluated by comparing calibrated and attenuation corrected Z with disdrometer measurements.

Session 6: QC Algorithms and SW-Tools

POLARIMETRIC DATA QUALITY MONITORING WITH PYRAD

Jordi Figueras i Ventura, Andreas Leuenberger, Zaira Künsch, Jacopo Grazioli, Urs Germann

MeteoSwiss

Pyrad is an open source real-time data processing framework developed by MeteoSwiss. The framework is aimed at processing and visualizing data from individual Swiss weather radars both off-line and in real time. It is written in the Python language. The framework is version controlled and automatic documentation is generated based on doc-strings. It is capable of ingesting data from all the weather radars in Switzerland, namely the operational MeteoSwiss C-band rad4alp radar network, the MeteoSwiss X-band METEOR 50DX radar and the EPFL MXPol radar.
The signal processing and part of the data visualization is performed by a MeteoSwiss developed version of the Py-ART radar toolkit which contains enhanced features. MeteoSwiss regularly contributes back to the main Py-ART branch once a new functionality has been thoroughly tested and it is considered of interest for the broad weather radar community.
The processing flow is controlled by 3 simple configuration files. Multiple levels of processing can be performed. At each level new datasets (i.e. attenuation corrected reflectivity) are created which can

be stored in a file and/or used in the next processing level (for example, creating a rainfall rate dataset from the corrected reflectivity). Multiple products can be generated from each dataset (i.e PPI, RHI images, histograms, etc.). In the off-line mode, data from multiple radars can be ingested in order to obtain products such as the inter-comparison of reflectivity values at co-located range gates. Within Pyrad, all the standard data quality monitoring functionalities have been implemented and statistics are provided on a daily basis. The data can provide detailed information of the temporal and spatial variability of the polarimetric data. The quality of the antenna system is monitored using daily observations of the co-polar correlation coefficient in rain (with the 80% quantile expected to be above 0.99). The stability of the transmit-receive path is monitored by gathering statistics of the system differential phase offset in precipitation. The channel imbalances are controlled by observing the differential reflectivity in moderate rain (0.2 dB at 20-22 dBZ of reflectivity). The self-consistency of the polarimetric variables in rain is used to monitor the absolute calibration of the system. In the framework, there is also implemented an algorithm to inter-compare the reflectivity of two radars in precipitation which is very useful to homogenize a network. Furthermore, the methods first developed by Holleman and Huuskonen to monitor the radar performance using the sun are also implemented. For each monitored parameter, a set of user-configurable alarms are available so that when the parameters exceed a particular threshold the user is notified via email.
At the moment the software is used to operationally control the data quality of the METEOR 50DX. In the near future it will substitute the current rad4alp IDL-based data quality monitoring system. During the workshop details of the implementation as well as examples of output are going to be provided.

POST PROCESSING RADAR DATA QUALITY CONTROL AT DEUTSCHER WETTERDIENST (DWD)

Manuel Werner

DWD

Radar data quality control at DWD consists of two basic stages. The first stage, situated at the radar site, is represented by radar monitoring and calibration schemes performed directly on the radar PC and by the signal processor filters. The second stage is represented by the post processing quality control algorithms applied to the radar data gathered in DWD's central office.
In the second stage, dual-polarimetric algorithms and classical techniques are used to perform a quality control of horizontal reflectivity and radial velocity measurements, as well as the dual-pol measurements, primarily ZDR, PHIDP, and KDP. For each individual reflectivity and radial velocity measurement, separate quality flag products are produced, in which for each range bin a quality bit mask is encoded. Each bit refers to one phenomenon affecting the data quality at that range bin, like, for instance, spoke or ring artifacts, clutter, bright band or attenuation. Moreover, such quality products contain global quality flags marking quality issues affecting the whole data set. In addition, also corrected reflectivity, radial velocity, ZDR, PHIDP, and KDP measurements adjusted according to the priorly detected spurious parts are provided along with potential specific or differential propagation path attenuation biases.
The intention of this talk is twofold. Firstly, the structure and organization of the post processing data quality control component and how it is embedded into the radar data processing chain at DWD is highlighted. Secondly, some ideas are collected how the outcome of the second stage of quality control can be used to generate beneficial feedback for the monitoring of the radar system itself.

THE SWEDISH WEATHER RADAR NETWORK: CALIBRATION AND MONITORING

Günther Haase, Daniel Johnson

Swedish Meteorological and Hydrological Institute

The Swedish weather radar network (SWERAD) consists of twelve C-band Doppler weather radars and is jointly operated by the Swedish Meteorological and Hydrological Institute (SMHI) and the Swedish Armed Forces. Recently, five radars have been upgraded to dual-polarization capabilities, the remaining seven radars will be modernized by 2019.

Maintenance including transmitter and receiver calibrations is regularly performed by an external company. Antenna pointing accuracy (azimuth and elevation) is monitored in real-time by an algorithm implemented in the BALTRAD toolbox based on solar signals. Additionally, the maintenance staff runs occasionally a sun-tracking method provided by the commercial radar processing software.

For the upgraded radar sites the scan strategy has been changed considerably. The new scheme even includes bird-bath scans with an update cycle of 15 minutes for future ZDR offset calibration. Range dependent noise level and sensitivity monitoring software has been developed for radar acceptance purposes, but is now applied pre-operational.

Moreover we are monitoring radar system BITE information (e.g. azimuth and elevation drives, transmitter status, and receiver temperature), data communication, as well as local and central computer hardware and software (including BALTRAD) performance. Finally, the results are visualized on internal websites.

MONITORING OF CZECH WEATHER RADAR NETWORK

Hana Kyznarova

Czech Hydrometeorological Institute

Czech Hydrometeorological Institute (CHMI) operates Czech weather radar network CZRAD which consists of two weather radars Vaisala WRM 200. BITE (Built-In Test Equipment) output is available however it doesn't meet all the requirements for monitoring of radar systems in the CHMI.

The presentation describes a combination of several software tools that are used in CHMI for extended monitoring and automatic issuing of messages to interested groups of people. These tools include export of outputs of BITE units integrated into the radar system, CHMI programmed utilities for creating specific output, and using SNMP protocol and extensions of linux snmpd agent functionalities. It is possible to monitor values of all the parameters offered by BITE and their change in time (for example transmitter parameters and VSWR). It is possible to monitor also other equipment such as additional temperature sensors, servers on radar sites (availability, load, disk space, etc.) and network accessibility of radar sites. Icinga 2 software is used for unified collection, processing, sending messages, displaying and analysis of history of all the monitored parameters. Graphical output of Icinga 2 is available using a web browser.

Poster

P1. Central Asia Water Problems

Aygul Agayeva

Kocaeli

The collapse of the Soviet Union in 1991 meant that overnight the newly independent Central Asian Republics (CAR s) had to assume responsibility for the management and maintenance of a huge, poorly managed and maintained water distribution and irrigation system. Problems emerged almost immediately with a lack of funds virtually halting maintenance programmers. The decline of the system has been marked and it is likely that major failures will occur in the near future. Tension over access to water is also increasing and despite public assurance regarding regional cooperation over water resource allocation a number of recent incidents suggest this is more political rhetoric than reality. The situation is likely to deteriorate as government backed policies coupled with predicted population increases mean that water resources will become stressed and demand will far outstretch supply. This paper presents a brief review of past water-management strategies, outlines current problems and highlights the challenges which Central Asia's leaders face as they strive to develop a water management strategy to ensure the economic and social well-being of the region into the 21st century.

P2. Overview of calibration and monitoring techniques for JMA's operational C-band dual-polarization Doppler weather radars

Akihito Umehara, Tetsuji Koike, Yusuke Kajiwara, Hiroshi Yamauchi and Hidehiro Okumura

Japan Meteorological Agency

In 2016, the Japan Meteorological Agency (JMA) began to operate C-band dual-polarization Doppler weather radars with solid-state power amplifiers at three international airports (Kansai, Tokyo and Narita). In order to determine appropriate radar parameters (especially PhiDP and ZDR), the following calibrations/adjustments were conducted during their installation periods.

- Azimuth alignment using sun noise
- Range alignment using strong ground clutter
- Antenna pattern measurement, transmission phase adjustment, and absolute calibration of reflectivity using an external standard horn antenna
- Bias calibration for PhiDP and ZDR using bird-bath and RHI scan data

The following items have been monitored for quality control purposes since the start of operation:

- Transmitter power
- Changes in receiver gain and phase using pilot signals
- Variations in PhiDP and ZDR bias using bird-bath and RHI scan data
- Received power levels for major ground clutter echoes
- Noise level
- Chassis air temperature

To validate calibration, JMA also operates disdrometers within radar observation areas and has provisionally conducted inter-comparison.

The presentation will outline the calibration and monitoring methods used and show examples of practical application.

P3. Calibration of System Bias in ZH and ZDR of Yong-In S-band Dual-Polarization Radar in Korea

Jong-Seong Kim, Hae-Lim Kim, Chang-Rok Oh, Chang-Hwan Park, Sung-A Jung, Sung-Hwa Jung2, and Sun-Ki Lee

Korea Meteorological Administration

Radar measurements suffered from the mis-calibration of radar system, this error leads to significant uncertainty in radar-based quantitative precipitation estimation (QPE) as well as hydrometeor classification. Thus, absolute calibration of reflectivity (ZH) and differential reflectivity (ZDR) is essential for producing high quality weather radar data, particularly for rainfall measurement.

In this study, we analyzed long-term variability of calibration bias in ZH and ZDR measurements from S-band dual-polarization radar at Yong-In Testbed (YIT) to product stable and accurate system bias of radar. Two ZH biases were derived based on the self-consistency principle between ZH and specific differential phase (KDP) and the direct comparison with simulated ZH from drop size distribution (DSD) measurement of two-dimensional video disdrometer (2DVD), respectively. ZDR biases were calculated by using three approaches based on empirical relationship between ZH and ZDR, vertical pointing measurements, direct comparison with simulated ZDR from DSD.

We examined calibration bias of ZH and ZDR according to different calibration methods during the period from May 2015 to October 2016. As a result, mean values of ZH biases based on self-consistency principle and 2DVD measurements were -3.28 and -2.72 dB, respectively. Although, ZH-KDP self-consistency calibration method is stable, the number of data used for calculation differed according to rainfall cases. In addition, ZH calibration bias calculated from the 2DVD is affected by the precipitation system that passes over the 2DVD and shows more variability compared to ZH-KDP self-consistency method.

The mean values of ZDR biases by ZH-ZDR relationship, vertical pointing measurement, and simulated ZDR from DSD were -0.03 dB, -0.05, and -0.11 dB, respectively. ZH-ZDR relationship method shows the smallest bias value compared to other methods. For the use of vertical pointing measurements, ZDR bias can be calculated only when the rainfall system passes over the radar site and depends on the selection of rain regime under the melting layer. However, this method yields a stable bias during the precipitation passes over the radar site.

Temporal trend of ZH and ZDR biases are well matched with each other. However, the standard deviation of both ZH and ZDR biases obtained from 2DVD measurements were relatively larger than other methods (not shown), due to DSD variability in vertical, drop sorting, under-sampling problem of 2DVD measurements.

KEYWORDS

Dual-polarization radar, Two-dimensional video disdrometer, calibration bias, self-consistency, vertical pointing measurement

ACKNOWLEDGMENT

The research is supported by “Development and application of cross governmental dual-pol radar harmonization (WRC-2013-A-1)” project of the Weather Radar Center, Korea Meteorological Administration.

P4. Operational Use of status information: HW monitoring and data quality

Maurizio Sartori, M. Boscacci, M. Gabella, J. Figueras, L. Clementi, A. Leuenberger

Radar, Satellite e Nowcasting, MeteoSvizzera

A continuous radar monitoring is essential to guarantee the long term operation of a radar network, in terms of the total number of available volumes per unit time, but also from the point of view of the quality of the data of the volume itself.
In the Swiss weather radars, over 350 status parameters are recorded up to 20 times during each volume scan (5', 20 elevations, one value per elevation).They include RF parameters, current and voltage values, temperature and humidity values, as well as numerous control status parameters.
This information can be used for short term analysis and problem solving, as well as long term system behavior studies, which can be useful to identify hidden problems or system weaknesses. This type of errors may not affect data quality, but on the long term might have an impact on the overall performance of the system and, ultimately, on the number of volumes delivered to the end user. Other data sources can be used for this purpose as well: an unremarkable type of data which can be very useful for detailed analysis of this type is represented by the IQ metadata: they can be used to determine the precision of the sector blanking, but also to verify the performance of the slipring in case of trigger signal transmission issues.
To guarantee the overall quality of the data, the same approach is used, making sure to have long time records for data analysis, especially if the collected data are used operationally for radar calibration.
For example, in antenna mounted receiver systems, as in the Swiss weather radars, the analogue receiver chain (ARX), even though enclosed in a box, can be exposed to temperature changes which are larger than those typical for an air-conditioned control room. For this reason, a reference signal (noise source, with a very low power output variation over temperature, ca. 0.016dB/K) is injected every 5'directly into the LNA, in order to account for the performance changes of the ARX chain due to temperature variations. The same reference signal is also used to measure every 5' a portion of the receiver chain, from the TR-Limiters down to the LNA. In this case, especially the stability of the TR-Limiter can be monitored.

P5. Overview of the Czech Weather Radar Network

Petr Novak

Czech Hydrometeorological Instiute

The Czech weather radar network (CZRAD), operated by the Czech Hydrometeorological Institute (CHMI), covers entire area of the Czech Republic and vicinity using volume scan measurements of its two radars with 5 minute update rate up to 260 km range. The CZRAD data are used for severe weather and precipitation monitoring, nowcasting and warning by national civil and military weather services, operational hydrology, air traffic control and many other users including general public. In 2015, the CZRAD radars were completely replaced with new modern dual polarization Doppler weather radars Vaisala WRM-200. A dual polarization capability of the new radars enable improve quality of standard radar reflectivity data (better filtering of non-meteorological data and attenuation correction) and also enable measurements of new radar quantities that can be used for radar echo classification. On the other hand, polarimetric radars are more demanding for calibration and monitoring.

The presentation will give an overview of the CZRAD network. Main focus will be given on the radar systems monitoring and calibration.

P6. Weather radar monitoring in Austria

Rudolf Kaltenböck, Lukas Tüchler (ZAMG), Marco Happenhofer, Markus Kraft (Austro Control)

Austro Control

In the last three years, we tested within the project TUNDRA - a cooperation between Austro Control and ZAMG - different monitoring methods to monitor the Austrian weather radar system in order to increase and to guarantee the quality of the radar moments with special focus on dual polarization. These monitoring methods should set into an operational mode soon.
Ground clutter-analyses are used in monitoring calibration of reflectivity (Z) and differential reflectivity (ZDR), and in monitoring the pointing accuracy of the antenna. The receiving chain (Z, ZDR) and antenna pointing accuracy is monitored by using operational sun signals. The bird-bath-scan - which is performed every 15 minutes - is used to get the offset of the differential reflectivity. Radar-radar-intercomparisons give information about the calibration between the radars.
Comparisons of operational radar reflectivity with vertical pointing radar, disdrometer, rain gauges and polairzed QPE give closer insights in the data quality of new radars.
We will show our experiences and some results of the monitoring methods, applied on the Austrian radar data.

P7. Properties of radar-derived rainfall fields and object-oriented verification for short-term radar-rainfall forecasting

Ting He, Thomas Einfalt, Christian Reinhardt-Imjela, Achim Schulte

Bureau of Hydrology(Center of water Resources Information) Ministry of Water Resources of P.R.China

Estimating and nowcasting precipitation at high resolution are the main tasks in flood forecasting. The present work exploits a new method to identify and track rainfall fields with the aid of radar data and to estimate their properties. Extrapolating methods based on particle image velocimetry (PIV) are developed to improve the capability of short-term radar-rainfall forecasting. Two object-oriented verification methods are implemented for testing the qualities of exploited methods.

Results of applying the developed methods to the Essen Radar in the North Rhine Westphalia, western Germany demonstrate that the properties of identified rainfall fields were large and flat with underestimated precipitation and slightly deviated mass centers, and their properties presented characteristics of extreme value distributions. PIV-based extrapolating methods are verified by traditional verification method; however, they were unduly praised via the objective verification way. Constraints for the qualities of proposed methods are also revealed.

P8. Monitoring the Transmit Pulses of a Dual Polarimetric Weather Radar with an External Device

A. Leuenberger, M. Sartori, Z. Künsch, J. Figueras, J. Grazioli

Federal Office of Meteorology and Climatology MeteoSwiss

Monitoring the transmitter path of a weather radar is among the most challenging calibration issues, affected by significant uncertainties. Conventional built-in monitoring systems of the transmitted pulses do not usually include the complete transmit path, nor the characteristics of the antenna. Additionally, the absolute power level of the pulses cannot usually be referenced satisfactorily. Indirect calibration methods that use as a reference the rainfall rate measured by other instruments (rain gauges or disdrometers) give information about the quality of the full data chain, including transmit path, receive path, and data processing. In case a miscalibration becomes evident with such methods, it is not straightforward to understand which part of the system caused the problem.

In this work, we present an alternative approach to monitor the quality of the transmit path (and calibration) of a radar system through a pulse logger. A pulse logger is an external device that can be placed a few kilometers away from the location of a radar. It receives and records the pulses transmitted by the radar simultaneously in two channels: one for the horizontal, the other one for the vertical polarization. It is worth noting that, given the short distance between the radar and the pulse logger, the atmospheric attenuation is negligible in most weather conditions. The pulse logger mounts a horn antenna of very well-known characteristics, allowing in this way to measure the absolute power level and the frequency of each pulse for both polarizations with a good accuracy. The core of the pulse logger consists of a state-of-the-art software-defined radio device, that is relatively low cost. If the pulse logger is deployed in a sheltered location, also long term monitoring measurements become possible. In this context, the pulse logger has probably the potential to deliver valuable information about the variation of the one-way attenuation due to the wet radome, a well-known issue affecting weather radar measurements.

This poster summarizes the measurements conducted with an in-house developed pulse logger and a C-band weather radar belonging to MeteoSwiss. We will illustrate and describe measurements of power level, variations of the pulses, frequency, pulse width, and we will highlight the main advantages and limitations of this approach for the monitoring of the transmit path of a weather radar.

P9. Met Office weather radar data quality and acceptance testing

Donal Adams

Met Office

The Met Office is coming to the end of a major weather radar network renewal project of upgrading all of the United Kingdom's C-Band weather radars with Doppler and polarimetric capability. Here, the means of evaluating and monitoring numerous data quality and calibration parameters of the systems are outlined.

Each upgraded radar is equipped with either a refurbished or a new parabolic reflector, each antenna arrangement (reflector, horn, OMT and waveguide) is range tested in order to optimise the positioning of the feed-horn and provide assessments of relevant electrical properties; cross polar isolation and sidelobe levels, gain, beam squint, beam width, VSWR and OMT port to port isolation. This information is used to assess the suitability of the antenna for use in polarimetric weather

radars. Results are outlined comparing the measurements of the levels of inter channel cross polarisation of the antenna and measured linear depolarisation ratio (LDR) in rain.
Following an upgrade, a series of data quality and performance tests are also performed in order to judge the acceptability of the radar for single polarisation use, and also the quality of the polarimetric parameters and their suitability for use in new quantitative precipitation estimation (QPE) algorithms.

P10. RADAR CALIBRATION MONITORING AT THE SAWS USING THE SUN

Erik Becker, Hidde Leijnse

South African Weather Service

Over the past few years the South African Weather Service (SAWS) has invested a lot of time and money in improving their radar based applications. The SAWS radar network was upgraded with 10 new Gematronik Meteor 600S S-band radars (1 of which a dual polarized radar) during 2010-2012, bringing the network total to 14 radars. This has led to various projects and collaboration with international partners. One of these projects called Rain for Africa (R4A) is attempting to reach a number of smallholding farmers and supply them with improved Quantitative Precipitation Estimation (QPE) information. One of the deliverables of the project is to produce a high quality radar QPE product. Thus, the quality of radar data has become an important topic of discussion at the SAWS. Collaboration with international partners, like the Dutch Weather Service (KNMI) in the project, resulted in the implementation of various support software such as calibration monitoring software that analysis the signals detected by the radar as a result from solar interference. This allows for monitoring antenna alignment and radar performance. SCOUT radar processing software, developed by Hydro & Meteo in Germany has been implemented to handle Quality Control (QC) processes to filter none precipitating echoes from the radar data and the existing SAWS QPE algorithm was updated to include the latest techniques in precipitation estimation; such as making use of precipitation classification with dual Z-R relationships, and the use of Optical Flow vectors to smooth temporal biases within accumulations. Through the collaboration with KNMI the calibration monitoring algorithms has been running operationally at the SAWS since August 2014. It has already assisted in identifying as 21 degree offset in one of the radars antenna alignment within the network. Data from all 14 radars in the network are currently being analysed and more results will be presented during the conference.

P11. CALIBRATION OF TWIN SET OF POLARIMETRIC X-BAND RADARS IN BONN AND JÜLICH

Josephin Beer, Kai Mühlbauer

Meteorological Institute University of Bonn

The twin set of two polarimetric X-band radars are located in Bonn and Jülich (45 km distance). Both radars are operated for >7 years and deliver polarimetric information in a range of ~100 km. Scans are repeated in a 5 min schedule containing ~ 7 PPIs with elevations >1°, 1 RHI, and a Birdbath Scan.
The large overlapping domain, as well as the scan schedule give a good possibility for radar calibration. The calibration is exercised and tested for the self consistency method and the ZDR

calibration with the birdbath scan. Additionally a corner reflector as well as a co located active transmitter module will be mounted soon to track the transmitted and recieved power of the Bonner X-band radar system.

P12. Remote control system of identification of RLAN interferences Czech Weather Radar

Ondrej Fibich

Czech Hydrometeorological Institute

Czech weather radars operating in C band in 5600 - 5650 MHz are constantly disturbed by RLAN .These interferences negatively influence radar measurements. Exact identification of the source of interference is very problematic, because in the Czech republict are thousands of RLAN equipments transmitting in 5 GHz spectrum. That is the reason why in the CHMI we are using antenna of our weather radars for exact location and identification. During such a measurement we disconnect weather radar reciever and then connect a 5GHz RLAN reciever to the same spot. This procedure is very useful for Czech National Telecommunications Regulatory Authorities as a support for incident resolution and penalization in case of 5 GHz interference. We have carried out the standard procedure of interference measurement once per month since 2009 till now. Unfortunately a significant decrease of number of RLAN interferences wasn´t recorded. The progress was reached only when we shortened time between the measurements of RLAN interference to 14 days. At this point we decided to realize idea of remote measurement of RLAN interferences at the end of 2016. This demans permanent installation of RLAN receiver in the radar in the path of received signal. The most important criterium the installation was the least possible reduction of radar receiver sensitivity, the maximum increase of attenuation was 0,5 dB. We managed to keep this attenuation increase in the range bellow 0,5 dB. The other advantage is a shorter time without meteorological radar data. We are able to identificate one source of RLAN interference in a time shorter than 5 minutes. The last advantage is that we can carry out a measurement of RLAN interference at any time. The presentation will show the way of implementation and remote control system of identification of RLAN interferences.

P13. Radar calibration and monitoring methods at the Finnish Meteorological Institute

Asko Huuskonen, Mikko Kurri

FMI

The Finnish Meteorological Institute (FMI) is running a network of 10 dual-polarized weather radars. During the years FMI has developed several calibration and remote monitoring methods which are used operationally today.
Monitoring of the antenna pointing is based on using solar hits from operational scan data. Hits over a certain period of time, usually one day, are collected and analyzed together to get estimates of the antenna elevation and azimuth biases. Based on the solar hit analysis, the power level of the solar radiation received by the radar can be deduced. This information is used in monitoring the calibration levels of FMI radars. As the solar radiation is unpolarized, solar hit analysis can also be used for deriving the differential reflectivity bias of polarimetric weather radars.

The drawback of solar monitoring is, that it can only be used to monitor the receiver chain of the radar. In order to be able to monitor also the transmitter chain other methods have been developed. In radar pair comparison the radar reflectivity values in the same measurement volumes of nearby radars are analyzed. This method will give the relative calibration levels of the radars used in the analysis. For deriving the differential reflectivity biases of the polarimetric weather radars FMI uses automated zenith scans. A dedicated analysis system for deriving the differential reflectivity bias from the zenith measurements is also developed.