4th Calibration and Monitoring Workshop
United Kingdom, Exeter
8th to 10th November 2023

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

DWD

Enhancing Radar Network Reliability with Grafana Monitoring

Maximilian Schaper, Michael Frech, Cornelius Hald – *DWD, Observatorium Hohenpeissenberg*
Jan Petersen, David Michaelis, Benjamin Rohrdantz – *DWD, Hamburg Sasel*

Reliable radar networks are vital for meteorological data collection, emphasizing the significance of precise radar calibration. We are working to improve radar network reliability by leveraging Grafana's visualization capabilities, focusing on end-to-end radar calibration monitoring methods. Additionally, we analyze long time series trends and use Grafana's comprehensive and easily understandable visualizations to assess overall network performance. Automated alerts and the simple post-processing of stored monitoring data have become vital components of our efforts.

Fig. 1: Operational DWD weather radar network shown with a 150 km coverage radius
Geo data: ©SRTM – http://www.eea.europa.eu

Live overview of aggregated monitoring parameter

[Solar Power Offset]

station	PW04	PW08	Diff H/V
ASB	0.14 dB	0.12 dB	0.24 dB
BOO	0.39 dB	0.27 dB	0.30 dB
DRS	0.06 dB	0.06 dB	0.37 dB
EIS	0.37 dB	0.07 dB	0.12 dB
ESS	0.25 dB	0.29 dB	0.03 dB
FBG	1.23 dB	0.15 dB	0.42 dB
FLD	0.47 dB	0.18 dB	0.59 dB
HNR	0.58 dB	0.18 dB	0.30 dB
ISN	0.47 dB	0.23 dB	0.47 dB
MEM	0.49 dB	0.64 dB	0.21 dB
NEU	0.12 dB	0.20 dB	0.34 dB
NHB	0.42 dB	0.66 dB	0.31 dB
OFT	0.81 dB	0.38 dB	0.02 dB
PRO	0.37 dB	0.38 dB	0.35 dB
ROS	0.06 dB	0.01 dB	0.00 dB
TUR	1.00 dB	1.25 dB	0.24 dB
UMD	0.09 dB	0.10 dB	0.10 dB

[Pointing-Bias]

station	AZ_PW04	AZ_PW08	EL_PW04	EL_PW08
ASB	0.090°	0.023°	0.045°	0.014°
BOO	[illegible]	0.002°	0.033°	0.008°
DRS	0.042°	0.009°	0.006°	0.043°
EIS	[illegible]	0.012°	0.019°	0.008°
ESS	0.036°	0.041°	0.003°	0.036°
FBG	0.007°	0.012°	0.045°	0.019°
FLD	0.016°	0.018°	0.096°	0.055°
HNR	0.092°	0.062°	0.002°	0.016°
ISN	0.043°	0.022°	0.004°	0.003°
MEM	0.018°	0.026°	0.042°	0.022°
NEU	0.098°	0.025°	0.042°	0.016°
NHB	0.001°	0.001°	0.014°	0.036°
OFT	0.019°	0.023°	0.006°	0.008°
PRO	0.065°	0.021°	0.012°	0.043°
ROS	0.068°	0.052°	0.011°	0.021°
TUR	0.022°	0.013°	0.037°	0.038°
UMD	0.022°	0.007°	0.018°	0.017°

[ZDR-Offset]

station	Last ZDR-O
ASB	0.051 dB
BOO	0.038 dB
DRS	0.042 dB
EIS	0.079 dB
ESS	0.119 dB
FBG	0.031 dB
FLD	0.113 dB
HNR	0.077 dB
ISN	0.088 dB
MEM	0.033 dB
MHP	0.076 dB
NEU	0.042 dB
NHB	0.218 dB
OFT	0.016 dB
PRO	0.028 dB
ROS	0.086 dB
TUR	0.001 dB
UMD	0.095 dB

Fig. 2: Data quality overview showing aggregated parameter from the centralized data based monitoring. Tables from left to right contain: solar power offset to DRAO reference measurement, antenna pointing offset to calculated sun position and residual ZDR offset in birdbath (90deg) scan. On the right are the used color thresholds.

How to assess the validity and quality of the radar calibration?

Figure 2 displays the results of various methods for monitoring the calibration performance. These methods are considered 'end-to-end' because they provide valuable insights for analyzing the system's performance, spanning from the hardware state and signal processing in the radar software to the overall radar configuration including its calibration. Thereby, following the entire data path.
In addition to these methods, basic radar moments can be analyzed to provide further insights into overall radar network performance. Figure 3 illustrates such a deviation in the ISN radar data, where the PHIDP texture reaches a value of 61.2, significantly deviating from the network average of about 2 – due to a HW problem.

Fig. 3: PHIDP texture (standard deviation) as 7-day median for all sites. ISN 61.2 outlier - due to HW fault.

Grafana visualization options

Figures 2 and 3 allow our second-level support team to promptly detect real-time issues. However, they provide only a snapshot of the current radar network state. To capture trends that frequently uncover additional insights into radar hardware health and overall system stability, long time series displays are indispensable (Figure 4 to 6).

Long time series to detect trends within the DWD radar network

Fig. 4: Time series of corrected reflectivity, since May 2021, averaged over the entire radar sweeps and in time, for three radar sites (Feldberg, Isen und Memmingen). These three sites have a significant overlap in detection area.

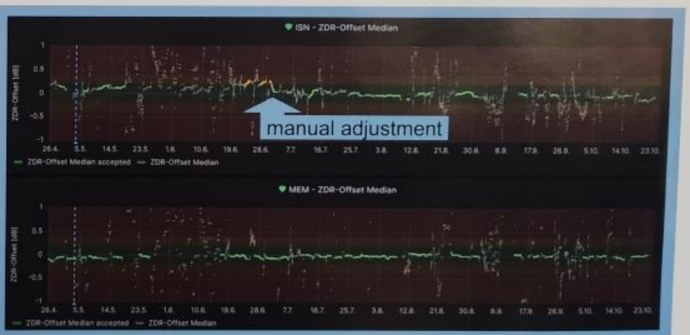

Fig. 5: Residual ZDR-offset for two sites (ISN, MEM) since April 2023 calculated from the birdbath (90deg) scan. Background color indicates the DWD data quality requirements. Colored points (green, orange) indicate sufficient amount of data points – grey points represent invalid data due to insufficient precipitation over the site.

Continuous monitoring and long term trends in radar performance

The seemingly simplest way to monitor network coherence is by comparing the averages of radar moments between different neighboring radar sites (Figure 4). However, the utilized aggregation method can greatly complicate the fault detection. Figure 5 displays our Grafana alerting system with ZDR-offset thresholds. An email notification is sent to our support team when predefined thresholds are reached. Finally, quality scores are calculated for all monitoring parameter to obtain a simple overview of the network performance and highlight potential issues (Figure 6).

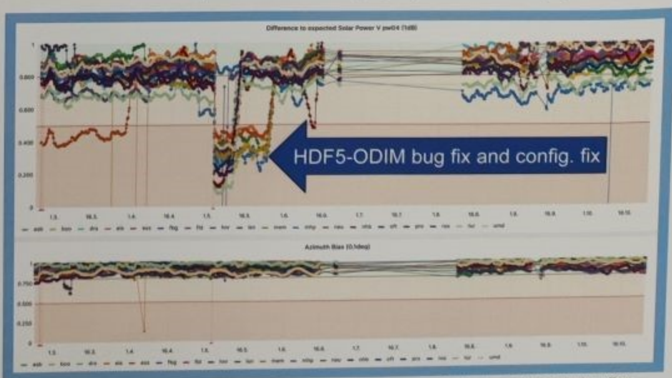

Fig. 6: Time series of quality index for all radar sites – showing solar power offset and azimuth positioning offset. The scale of 20% is 1dB and 0.1deg respectively. The data gap is due to an upcoming migration of the server.

Outlook

Improvements to our monitoring

In the near future, our objective is to enhance the efficiency and reliability of our radar network by further automating and centralizing critical aspects of our monitoring process. For example a daily update of the ZDR-offset is automatically carried out at our research site MHP, and has proven to be very reliable. Also additional monitoring server are setup for testing and as operational backup.

Our experiences with Grafana

Grafana has become out primary tool to visualize monitoring data, offering a comprehensive and straightforward view of the status of our DWD radar network. As we are still running an older version of InfluxDB, we do have some limitations on our post-processing capabilities. Our radar technicians particularly appreciate the flexibility of Grafana, but some dense data sets do impose a high loading time.

Deutscher Wetterdienst, Remote Sensing Application Development
Maximilian Schaper, maximilian.schaper@dwd.de