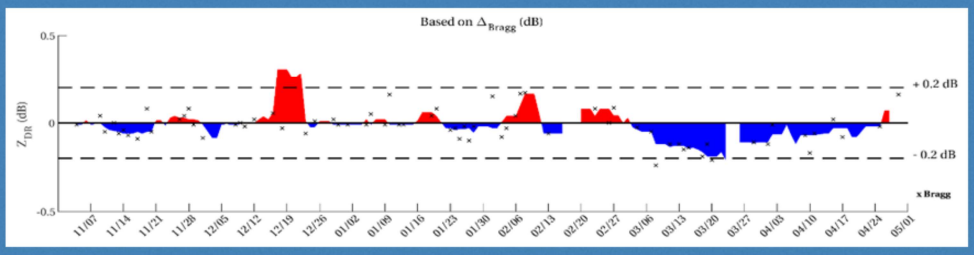
This presentation is designed to promote a discussion on ZDR bias between the WFO electronics staff and meteorologists.

Goals

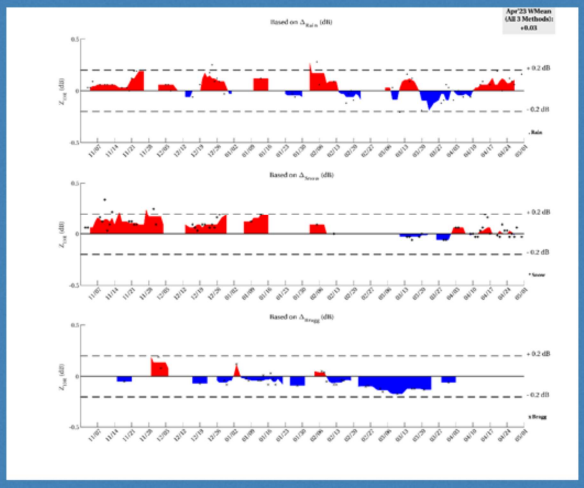
- What are "shade charts"? What is ZDR Bias?
- How to resolve ZDR bias: Challenges with calibration procedures (EHB), test equipment tolerances
- What does this mean to forecasters and technicians?



The goals of this presentation include a short description of "shade charts" and ZDR bias. We'll talk about some challenges identified by the maintenance community in resolving ZDR bias including calibration procedures and test equipment tolerances. We'll also describe what the ZDR bias means to forecasters and technicians, as well as the impacts to the data.

What are "Shade Charts"?

- 3 methods of returns to estimate ZDR bias
  - Rain
  - Snow
  - Bragg (non-weather)
- Average of estimates is used to calculate the overall 30-day weighted mean ZDR bias for a given WSR-88D
- Charts produced bi-monthly and provided to agency focal points once a month for distribution to field sites



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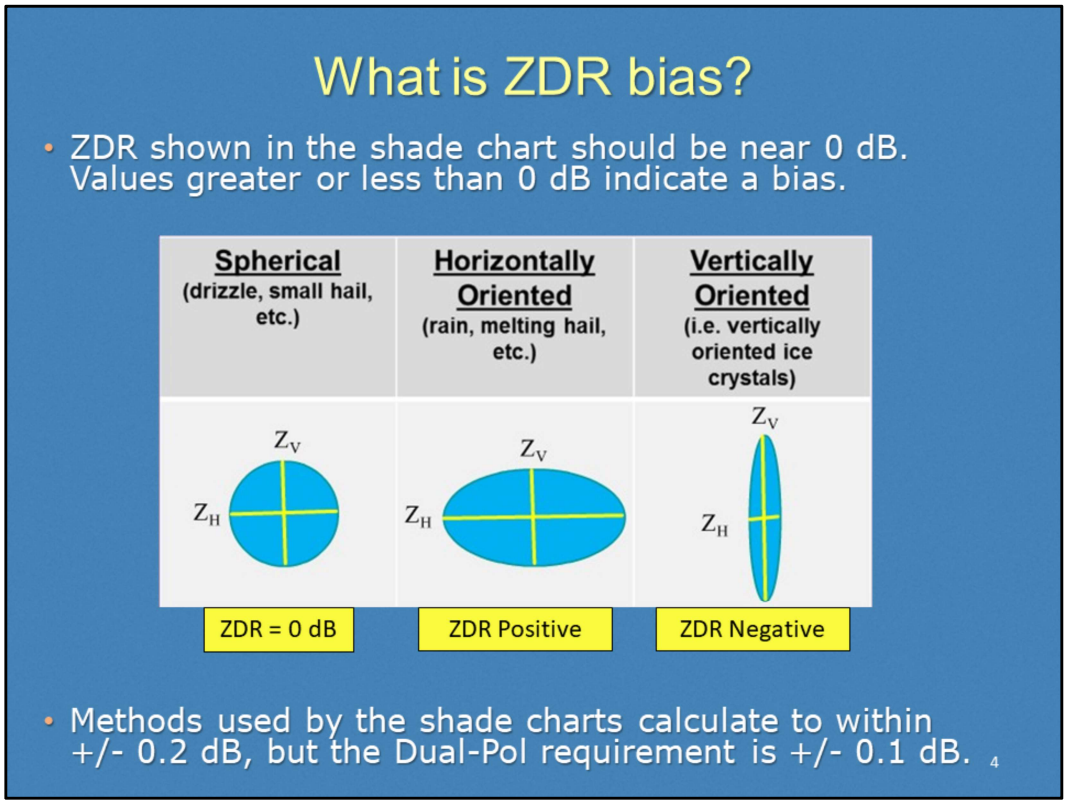
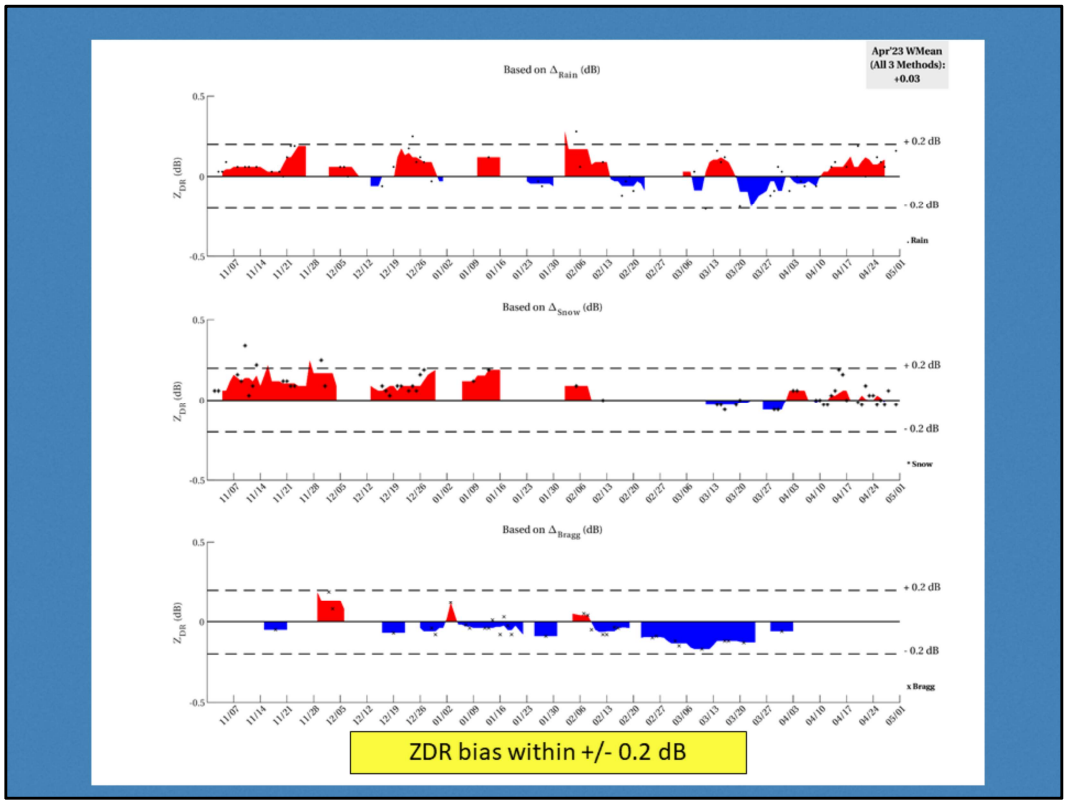
The shade charts are visual representations of the ZDR bias using 3 methods: 2 weather methods (i.e., light rain and snow) and 1 non-weather method called Bragg scatter. The ZDR bias that is reported each month is a weighted mean of these three estimates. We produce shade charts twice a month and provide them monthly to agency focal points for distribution to field sites.

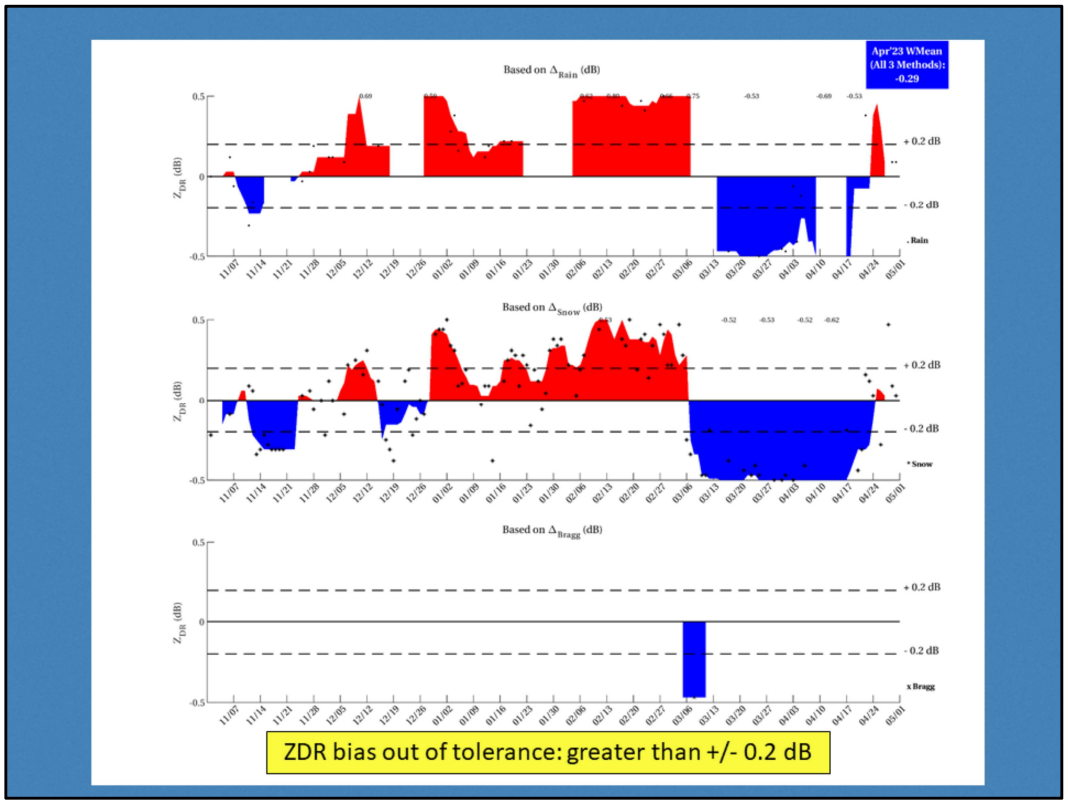


The 3 methods used by the shade charts use criteria to analyze ZDR in areas where research has shown the value should be zero. In those specific regions, any non-zero value of ZDR indicates a bias.

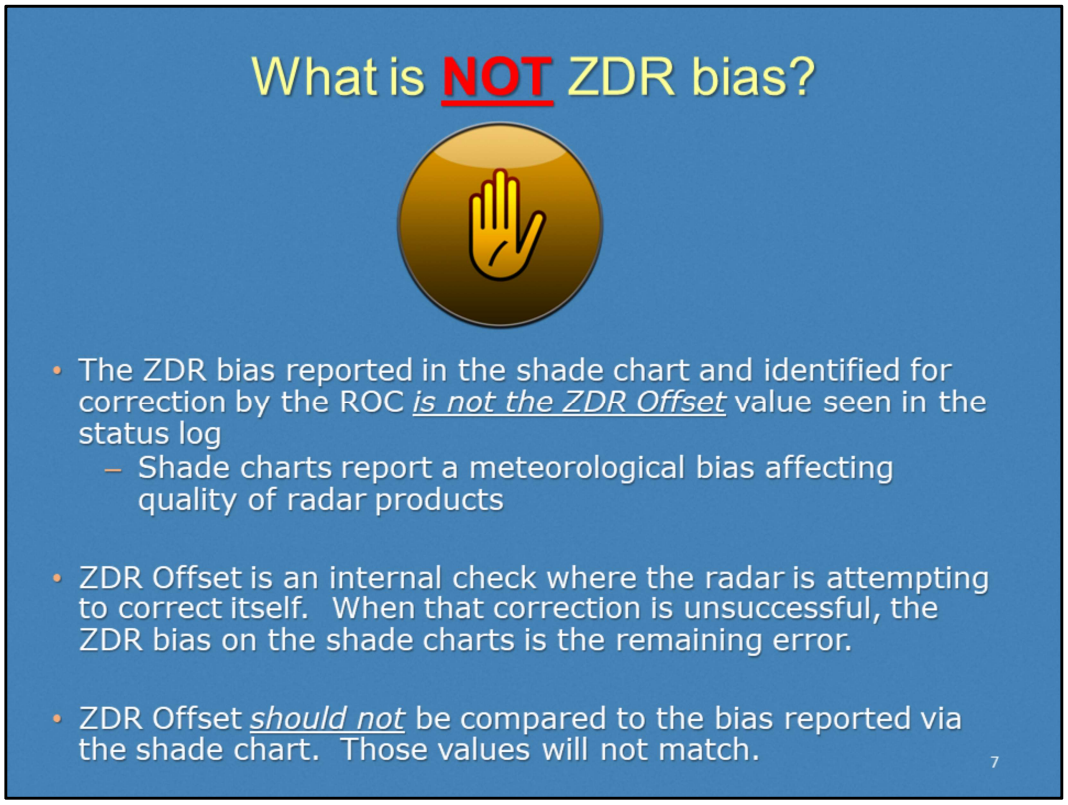
Although the Dual-Pol requirement is a ZDR bias within +/- 0.1 dB--and algorithms are designed for this requirement--about the best accuracy that can be provided by the shade charts at this time is +/- 0.2 dB. So, we consider any radar with a bias greater than +/- 0.2 dB to be out-of-tolerance, but any bias greater than +/- 0.1 dB will impact the algorithm output.



Here is an example of a shade chart showing a radar with a ZDR bias within the +/- 0.2 dB tolerance. Note the measurements from the 3 estimates are generally within the dashed +/- 0.2 dB lines.



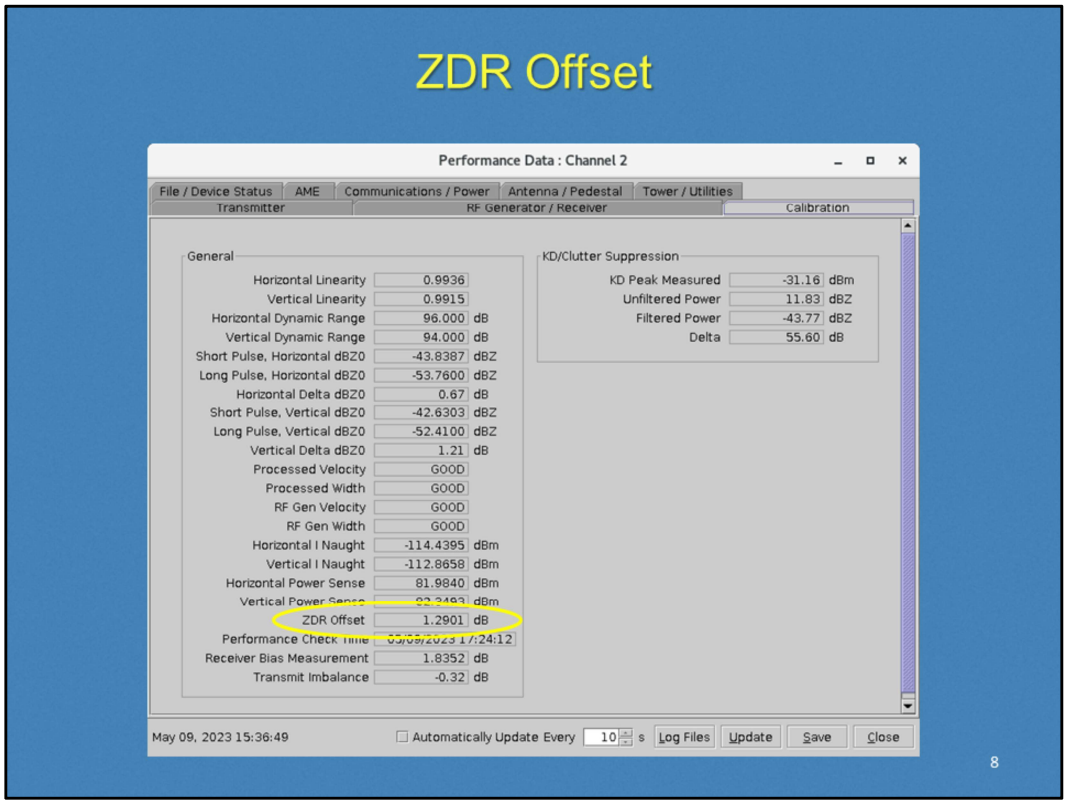
This shade chart is from a site that was out-of-tolerance from November through mid-April and appears to have come back into tolerance in the last few days of the month. In this situation, we will continue to monitor to see if the bias drifts back out-of-tolerance.



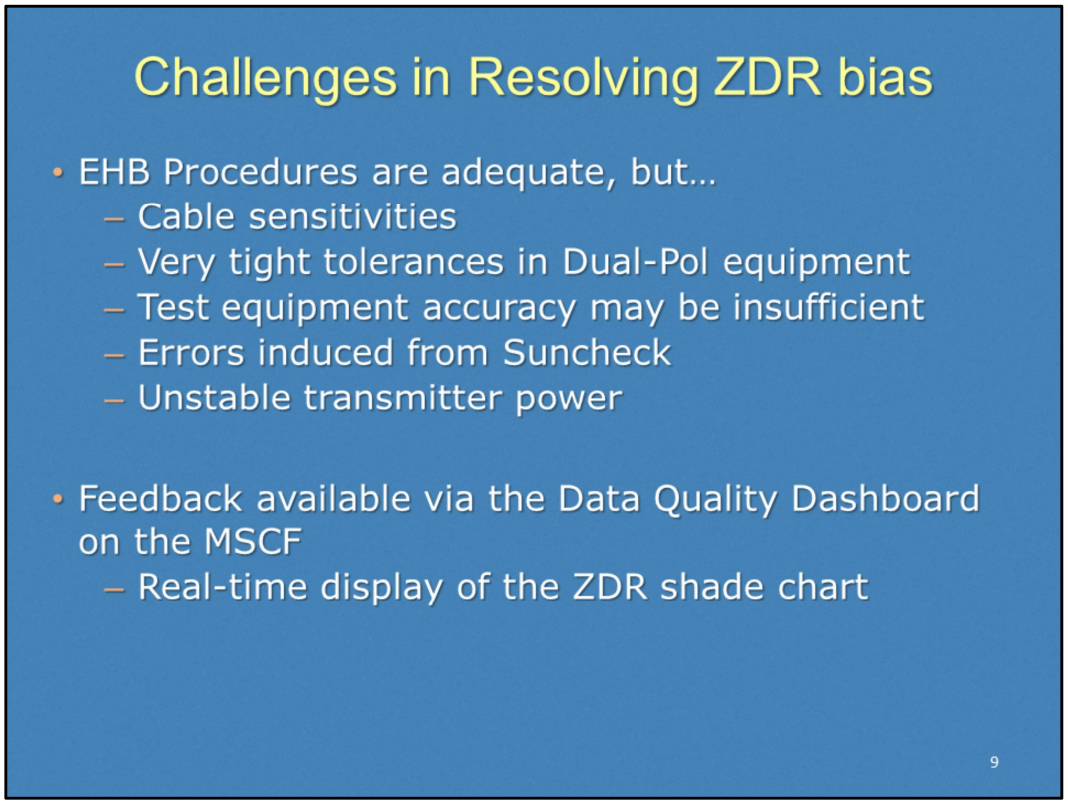
What is not ZDR bias? This is an important point for the maintenance community. The ZDR bias reported by the shade charts and distributed monthly IS NOT the same as the ZDR Offset reported in the status log. Those values will not match. The values have very different meanings.

ZDR Offset is the radar's internal correction for ZDR. The value may have a wide range, depending on how much the system believes it needs to correct itself. When this correction is unsuccessful, the remaining error is the ZDR bias reported by the shade charts. In other words, the ZDR bias is the error of ZDR Offset. In a perfect world, ZDR Offset would always provide a proper internal correction and the ZDR bias would be zero.

What is critical for both the forecasters and technicians to understand is if your radar has a ZDR bias, as reported by the shade charts, the ZDR data produced by the radar is in error and the algorithm performance will be degraded. Even though the ZDR data can still be interpreted by forecasters based on maximum and minimum values, the algorithm impacts have far-reaching effects. These will be discussed a bit later.



ZDR Offset, shown here, is the total adjustment applied by the system. This is the combination of the Transmit Bias (TXB), Receiver Bias (RXB), and Sun Measurement Bias (SMB). ZDR Offset fluctuates, as it should, when a calibration is performed at the end of each volume scan, performance check, and offline calibration.



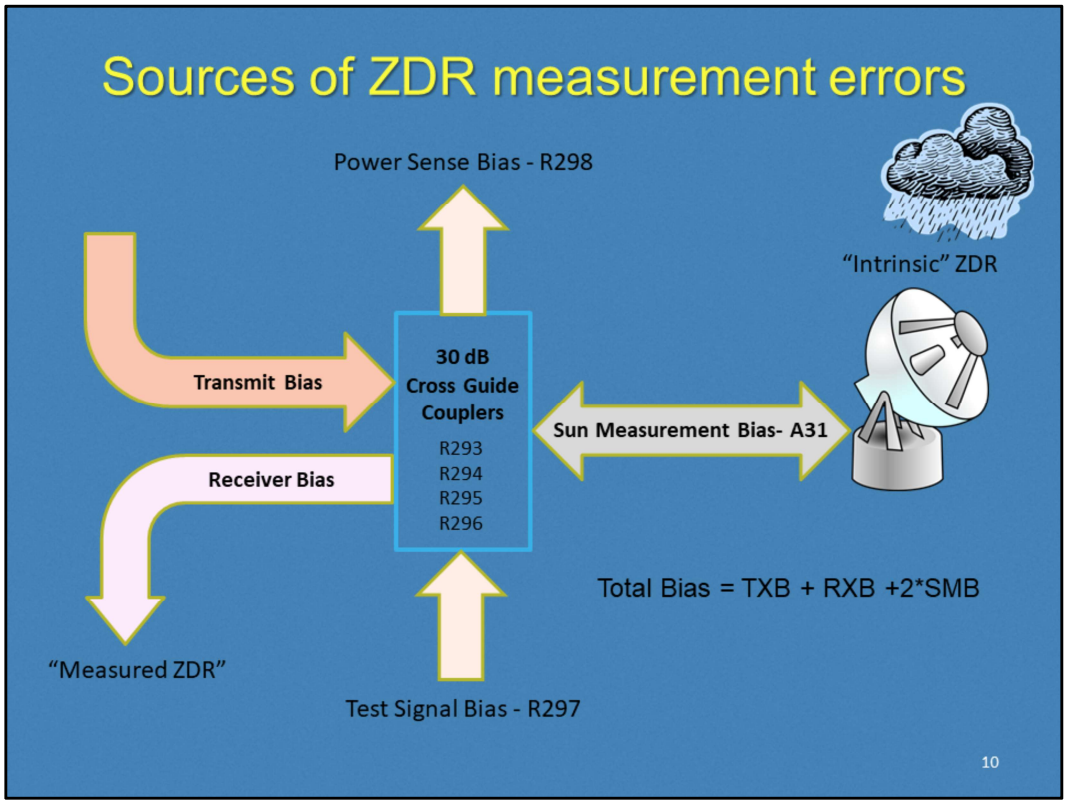
We have heard from technicians in the field about the challenges and frustrations of resolving ZDR bias. It is a sometimes difficult process that is different from our expectations before Dual-Pol.

The maintenance procedures for correcting ZDR bias are accurate, but there are several factors that can impact the success of those procedures. The cables on the Dual-Pol equipment are very sensitive. Minor movement in the cables can cause an error in the system. The Dual-Pol equipment requires tighter tolerances than ever required before. The test equipment, which is the same equipment we've been using for the last 20 years, also requires a high degree of accuracy.

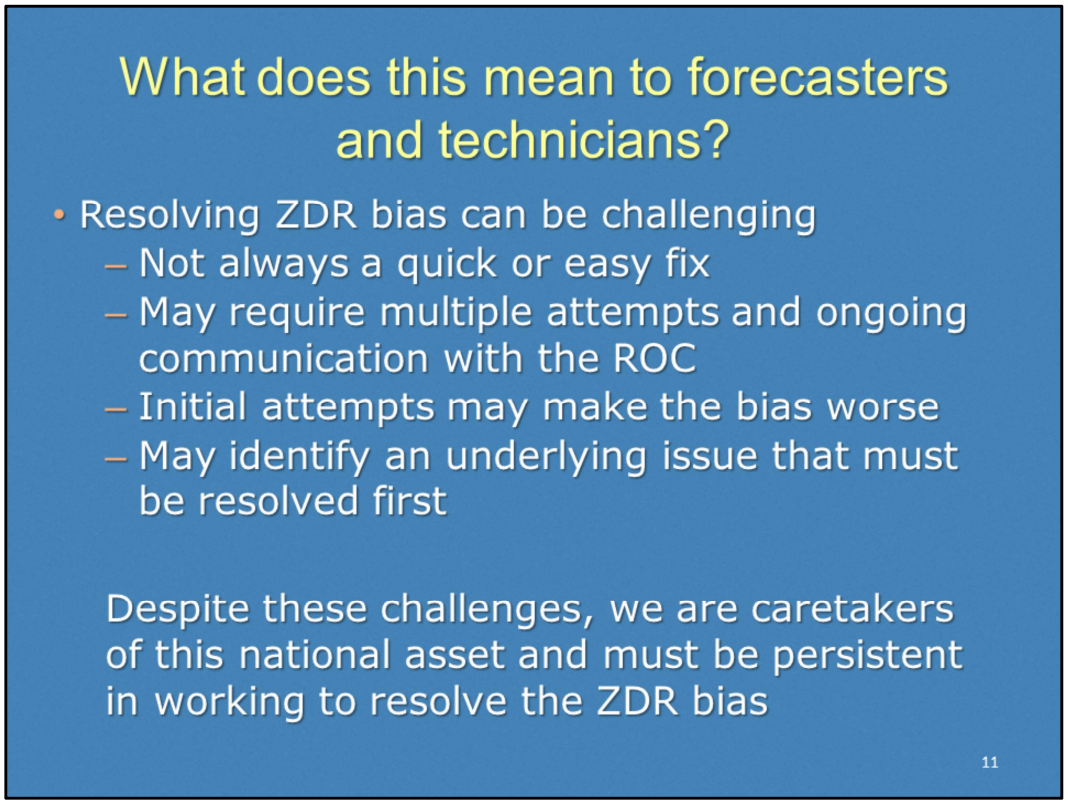
Errors can be induced from running (or not running) Suncheck. It is not uncommon for a radar to develop a ZDR bias because a system calibration was performed, but Suncheck was not run.

Additionally, the transmitter power must be stable before conducting any ZDR calibration procedures.

Field technicians have asked us for instant feedback so they can see if the bias improved following related maintenance. We implemented a real-time display of shade chart data on the MSCF, called the Data Quality Dashboard (DQD). The DQD can be found in the RPG Applications Sub-Menu.



This chart shows the three measurement paths for measuring ZDR Offset: The Transmit Bias, the Receiver Bias, and the Sun Measurement Bias.

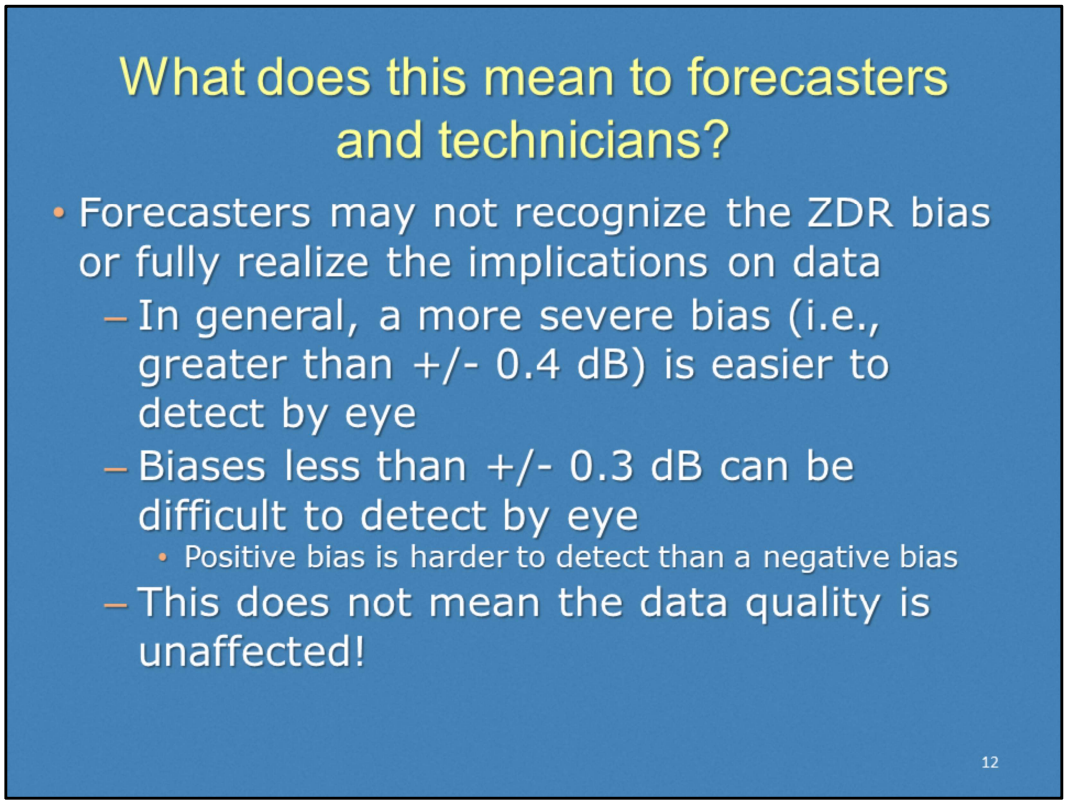


So what does all of this mean to the forecasters and technicians?

Identifying and resolving ZDR bias is not an issue that can be addressed only on the operations floor or only in the maintenance shop. It requires everyone working together.

Resolving ZDR bias is challenging and is not always an easy fix. It may be frustrating for the MIC, SOO, ESA, technicians, and forecasters as you go through the process, perhaps over several months, of addressing the bias. It is possible that initial attempts may make the bias worse. In some cases, an underlying issue was brought to light that must first be resolved before the bias can be corrected.

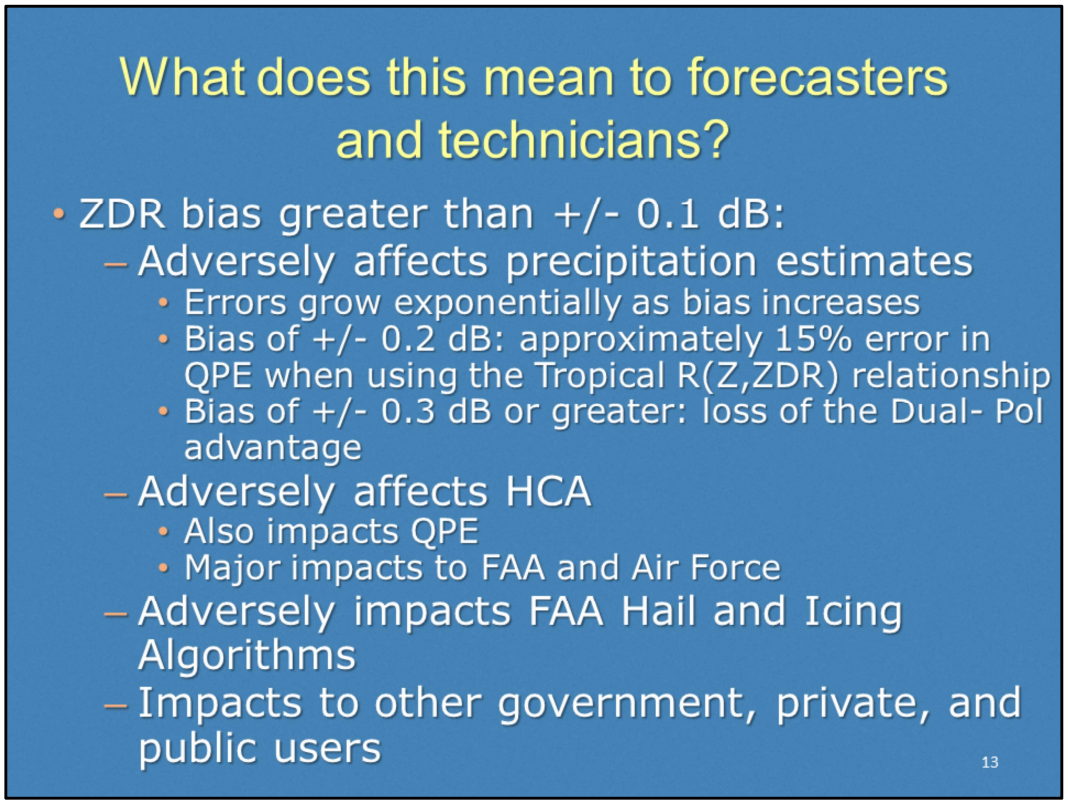
However, despite these challenges and frustrations, the WSR-88D is a national asset. We are charged as caretakers of this system and we must be persistent in resolving any ZDR bias.



There can be some confusion within the WFO because the forecasters may feel the ZDR data is accurate while the ROC is indicating a bias, so the technician is receiving conflicting information.

It is important to remember that the human eye is really only good at identifying a bias once the bias has become quite severe, +/- 0.4 dB or greater. Even then, the eye can detect a bias, but the exact value is difficult to discern. Because of AWIPS color curves, it tends to be easier for forecasters to notice a ZDR bias when it is negative, as opposed to a positive bias. For the human eye to correctly identify a bias, though, one must use the Level II ZDR data in areas meeting specific criteria (i.e., reflectivity values, distance from radar, outside of clutter, etc.). The ZDR product in AWIPS is Level III, not Level II, and not suitable for identifying ZDR bias. The ROC is investigating adding a raw (i.e., Level II) ZDR product to the RPG which would then be sent to AWIPS, similar to the raw CC and PHI products currently available.

As we mentioned earlier, forecasters can still use biased ZDR data to detect relative maximums and minimums; however, algorithm performance will be degraded.

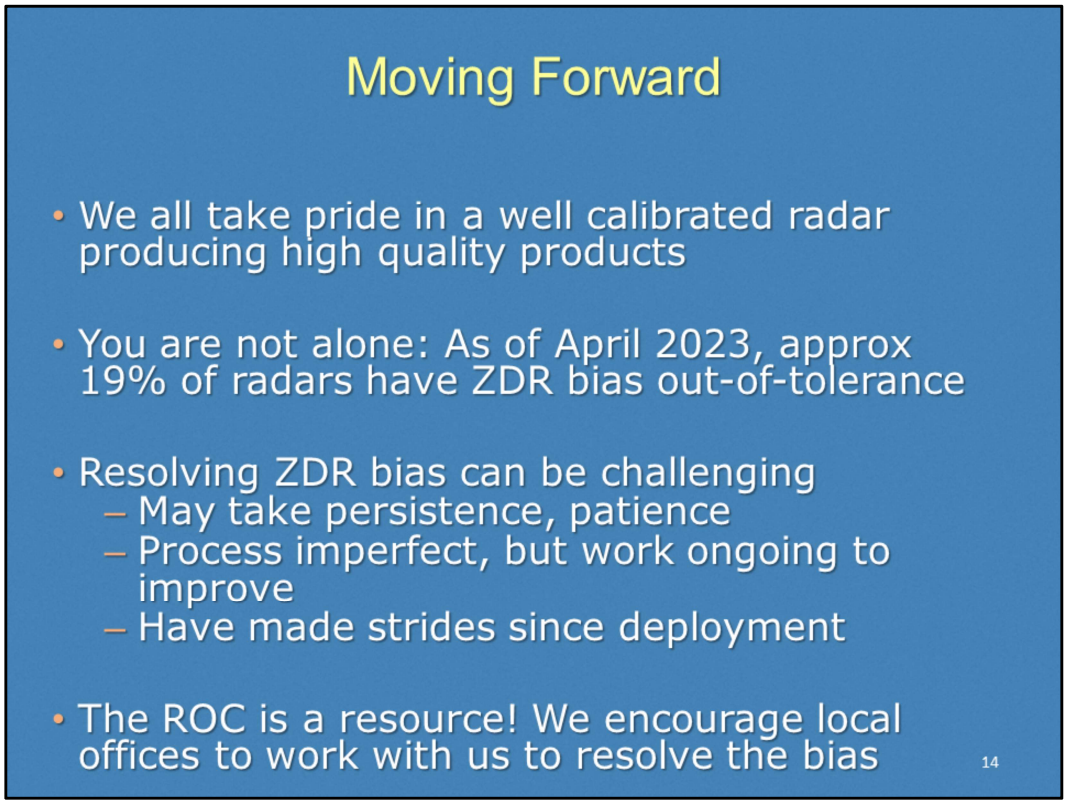


What are the impacts of a ZDR bias on data quality?

Any bias greater than +/- 0.1 dB adversely affects precipitation estimates and those errors grow exponentially as the bias increases. All other impacts being equal, with a bias of +/- 0.3 dB or greater, the advantage of Dual-Polarization in precipitation estimates has been lost and there is no discernable difference between QPE and Legacy PPS.

ZDR bias also adversely impacts the performance of HCA, which is another contributing factor in QPE. Additionally, the FAA and Air Force are primary users of HCA, and ZDR bias directly impacts their ability to use those products.

For example, ZDR bias causes adverse impacts on the FAA's Hail and Icing algorithms and affects all downstream users of these products, including other government agencies and the private sector and media.



Although the process may be challenging and frustrating at times, we all take pride in what we do and want what is best for the mission. If you are going through the process of addressing ZDR bias, you are not alone. As of April 2023, approximately 19% of the fleet is out-of-tolerance in terms of the +/- 0.2 dB range. We have, however, made significant progress in reducing the number of sites severely out-of-tolerance (+/- 0.5 dB, which is currently just 2% of the network).

Patience and persistence are needed during this process. We are actively working, alongside field sites, to improve the process and feedback. Your suggestions, questions, and concerns are always welcome.

We are more than willing to help. Please do not hesitate to call the Hotline for assistance or support.

We would be happy to take any questions by email or phone.