CALIBRATION STUDIES IN TURKISH WEATHER RADAR NETWORK FOR IMPROVING DATA QUALITY

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ABSTRACT

Turkish State Meteorological Service (TSMS) has ten(10) C-Band weather radars in its network after six new radars have been installed by new project between 2010 and 2012. In TSMS's weather radar network, there are five single polarization radars and five dual polarization radars. Basic periodical maintenance and calibration procedures have been applied for the radars. Periodical maintenance for those radars has been carried out monthly, 6 monthly and yearly by TSMS's engineers.

Maintenance and Calibrations are carried out for the transmitter, receiver and antenna for TSMS weather radars.

TRANSMITTER CALIBRATION:

Actual transmitted peak and average power should be measured by calibrated tools and checked with the settings of transmitted power value for reflectivity calibration. The correct values are applied to the transmitter settings. So the value of actual transmitted power is entered as the right value for calculation of reflectivity in the signal processor.

Also all transmitter equipments should show the correct standard values. During the periodical maintenance these values are checked. If these values does not show the standard values of the equipments, necessary corrective maintenance are carried out.

RECEIVER CALIBRATION:

Receiver response curve, receiver noise level and the phase noise are controlled during maintenance and intensity checking tests are carried out for the accuracy of the received signals.

Automatic multi-point receiver calibration is realized by using the signal generator which is mounted at each radar system. In figure-1, signals are applied automatically with radar software and filtered power is shown at vertical line. This radar maintenance software also shows receiver response curve.

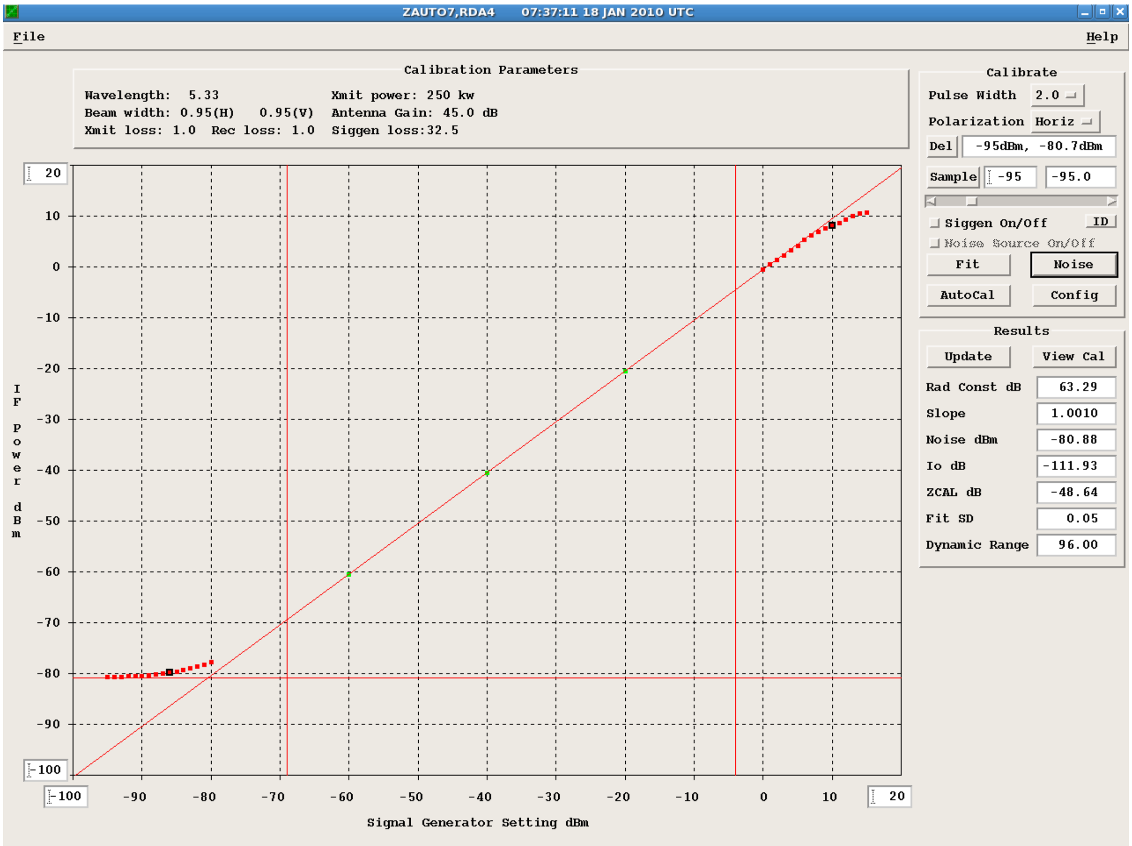

Figure-1. A multi-point receiver calibration and receiver response curve

It is possible to measure phase noise for new six(6) radars in TSMS radar network. Some radar tasks are executed for the calibration of the dual polarization products Zdr and Ldr in each volume scan. However for the other dual products, calibration methods are being searched.

Zdr Calibration and Zdr Offset Adjustment:

In the polarimetric (dual polarization) weather radars of TSMS, calibration of Differential Reflectivity (Zdr) product can be carried out automatically with a radar task schedule. When the radar detects the rain during its working, a Zdr task schedule starts automatically. Otherwise it does not start. The Zdr calibration requires moderate rain at the atmosphere. The rain returns need to be in order of 20-30 dBz. A melting layer higher than 2 km is suggested, but the specific characteristic of the radar should be considered.

During Zdr task schedule, a surveillance task starts but antenna goes to 90 degrees elevation and rotates several 360 degrees in azimuth direction for a couple of minutes. Also radar has no clutter filter and sets the thresholds to "all pass" during Zdr calibration task.

After Zdr task finished, radar software gives a printout of Zdr calibration results. These results give us Old Zdr Offset Value, New Zdr Offset Estimate Value, Number of Zdr data points used in the result, Observed Zdr width and Expected Zdr width.

Zdr Offset adjustment is done according to New Zdr Offset Estimate Value listed in the Zdr calibration task results. This value is entered into setup of the Radar Video Processor and exited with save. So, Zdr products can be corrected after Zdr Calibration task and Zdr Offset Adjustment.

Here is an example related to Zdr calibration issue and Zdr Offset Adjustment. We have a chance for correcting heavy rain attenuation effect by this procedure.

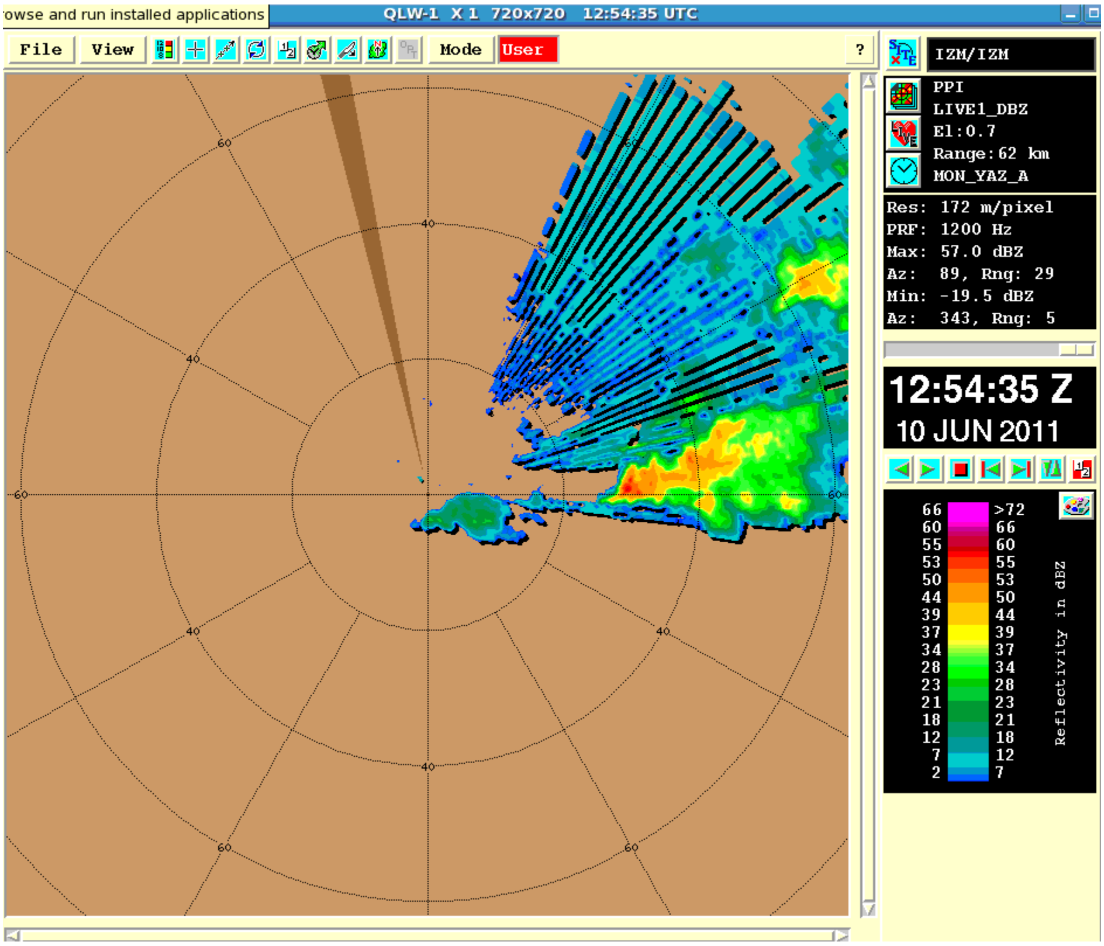

Figure-2. dBz product display showing Heavy Rain

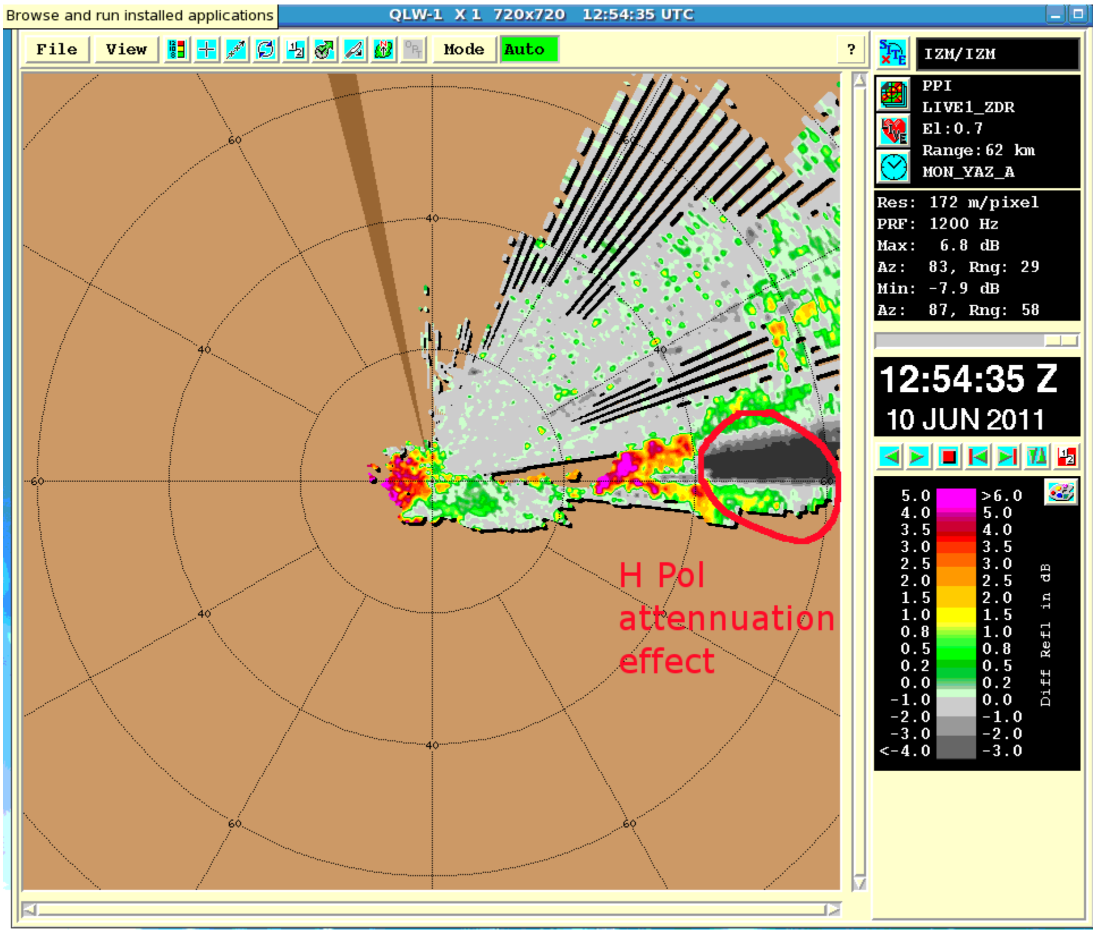

Figure-3. Heavy Rain Attenuation Effect

Figure-3 shows the same product as figure-2 (the second time around effects are also shown), but is displaying the ZDR data. Notice the negative ZDR in the area behind the area of heavy rain. The heavy rain in this area can be seen in the figure-2 dBZ product display.

The ZDR is negative in figure-3 because the horizontal channel is attenuated a lot more than the vertical channel as it travels through the heavy rain.

The extensive area of small negative ZDR for most of the upper right return seems to indicate that the ZDR offset for the radar may be a little low. In this case, a ZDR calibration should be performed and an adjustment of the ZDR offset should be adjusted to the correct level. After Zdr calibration task finished, radar generates a file of Zdr calibration result. From this result, New Zdr Offset Estimate Value is entered into the setup of radar. Zdr products are controlled and checked after Zdr Offset adjustment is finished.

ANTENNA CALIBRATION:

Manual Sun Calibration:

Sun calibration is done manually by sun tracking in four(4) radars in TSMS during periodical maintenance. Transmitter is off during sun calibration. This calibration is done two times as morning and before evening time. Sun calibration is carried out according to exact time and right azimuth and elevation positions of the antenna. The radar already knows that the antenna will be at which azimuth and elevation positions. The exact time is entered into setup of radar according to the greenwich mean time. Manual sun calibration is carried out at exact time and right position of antenna. Sun tracking tool is started by pressing a sun tracking button on the antenna utility window. The signal level is seen in the ascope utility of radar at the same time during antenna motion. The signal is at a maximum level when the antenna shows the sun exactly. Antenna is moved manually from software in azimuth and elevation separately in 0.1 degree. Signal level decreases when antenna is moved to the left and right in azimuth direction and moved to up and down of elevation direction. The error values for azimuth and elevation are determined when the signal level is decreased sufficiently. The average values of the azimuth errors are calculated for morning and the time before evening. Also the average values of the elevation errors are calculated for morning and the time before evening. The average errors for azimuth and elevation should not exceed 0.1 degree. If the average errors are exceeded 0.1 degree, some corrective maintenance are applied to the radar system.

Figure-4. Antenna Sun Calibration(Tracking) and signal level from sun in ascope

Figure-5. Software adjustment **Figure-6. Mechanical Adjustment**

In figure-4, antenna sun calibration(tracking) and signal level from sun is shown. In figure-5, error zeroing is realized by software of antenna utility. In figure-6, mechanical adjustments of errors are realized.

Automatic Sun Calibration:

Sun calibration is done automatically with a command by sun tracking for new six(6) radars in TSMS during periodical maintenance. Sun calibration is done by sun tracking with maintenance software by entering sun calibration command. Sun calibration product which is called as suncal product is produced after automatic sun calibration with command finished. A list of sun calibration results shows antenna scan and error values of sun calibration. If these errors exceed 0.1 degree, some error correction is done by entering the command.

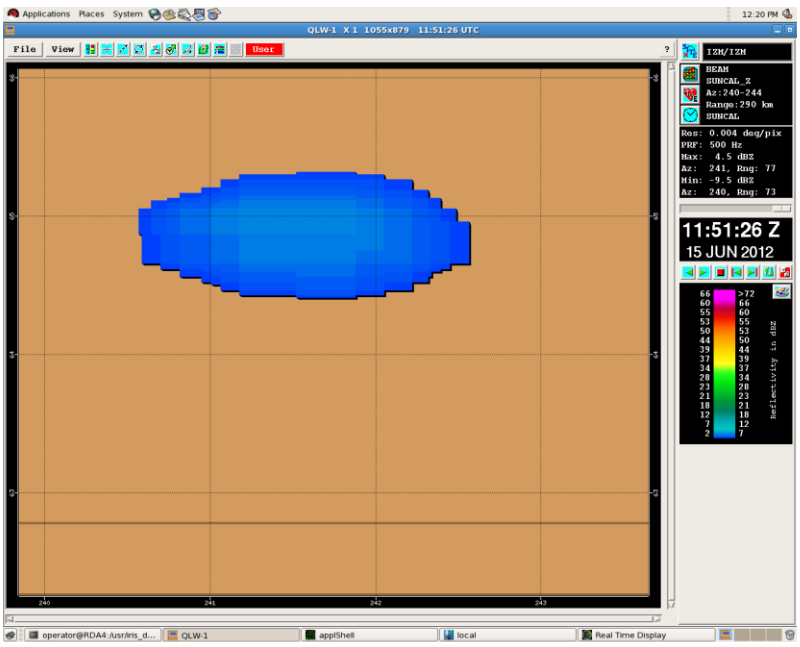

Figure-7. Sun Calibration Product with command

In the new 6(six) radars of TSMS, sun power also is being stored for calibration purposes. A sun calibration task schedule also works for every day. Radar generates results from the Cross Polarization Beam product in figure-8 including Sun Power, total power, Ldr measured and Ldr Offset values after sun calibration task finished.

```
results.fTargetWidthAz = 0.9536228828
results.fTargetWidthEl = 0.9711920172
results.fTargetPowerTotal = -69.00610544
results.fTargetPowerSun = -70.27117355
results.fTarget3dBArea = 0.697860557
# If 1, then continue processing.
results.bPositionsValid = 1
results.fAzError = 0.05029590662
results.fElError = 0.1524408573
# If 1, then the Az and El errors were within tolerance.
results.bAzElErrorsOK = 1

# Results from the Cross Pol BEAM product.
results.bXpolProcessed = 1
results.fXpol3dBArea = 0.697860557
# If 1, then offset was calculated.
results.bXpolLdrOffsetValid = 1
results.fXpolLdrMeasured = -0.1337247228
results.fXpolLdrOffset = 0.1962752772
# If 1, then the LDR offset error was within tolerance.
results.bXpolLdrOffsetOK = 1
```

Figure-8. Results from sun calibration task

Ldr Offset value is entered into setup of radar system. The sun power is stored in this file. The sun can be used a standard target. By knowing from the measurements of other parameters how much power the sun is emitting, we can get the gain of a radar antenna.

CONCLUSION:

TSMS's dual polarization radars are capable of performing transmitted peak power, receiver, sun tracking, intensity checking, Zdr and Ldr calibrations by means of the maintenance software. TSMS's single polarization radars are also capable of performing transmitted peak power, receiver, sun tracking calibrations and intensity checking. It is necessary to be able to make some other calibrations for the other dual polarization products for improving data quality. Accuracy of reflectivity and data quality of radar depends on those calibrations. The Ldr and Zdr Offset values should be entered into setup of radar automatically after every Ldr and Zdr Offset values were obtained with calibration tools. This issue and full path calibration are challenging issues in calibration of our network.

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