EXPANSION OF TURKISH WEATHER RADAR NETWORK

Ismail TEMİR[1]

[1]*Turkish State Meteorological Service, Keçiören, Kalaba, Ankara,itemir@dmi.gov.tr*

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1. Introduction

Weather radar systems are one of the most important instruments for observing weather and early warning systems. Turkish State Meteorological Service (TSMS) has operated ten C-Band Doppler weather radars which were established in Ankara, Istanbul, Zonguldak, Balıkesir, and İzmir, Muğla, Antalya, Hatay, Samsun and Trabzon.

The first radar of TSMS was installed as C- Band with dual polarization capability in Ankara in 2001. It has upgraded analog receiver to digital receiver at the end of 2013. Then the network was formed by adding three C-Band single polarization weather radars in 2003. And the project for the installation of six (6) C- Band radars has finished in 2013. Four of them will have the dual polarization capability while two of them will have the single polarization capability. At the end of the year 2013, TSMS has decided to extended its radar network and added seven magnetron tube C-Band radars with dual polarization capability. At the end of 2016, TSMS is going to be completed its C- Band weather radar network with 17 weather radars.

TSMS also installed one dual polarization magnetron tube Mobile X- Band radar for aviation, research and testing purpose in 2013. According to results of evaluations, new X Band Radar Network for cities, airports and gaps in the C Band Radar Network is planned.

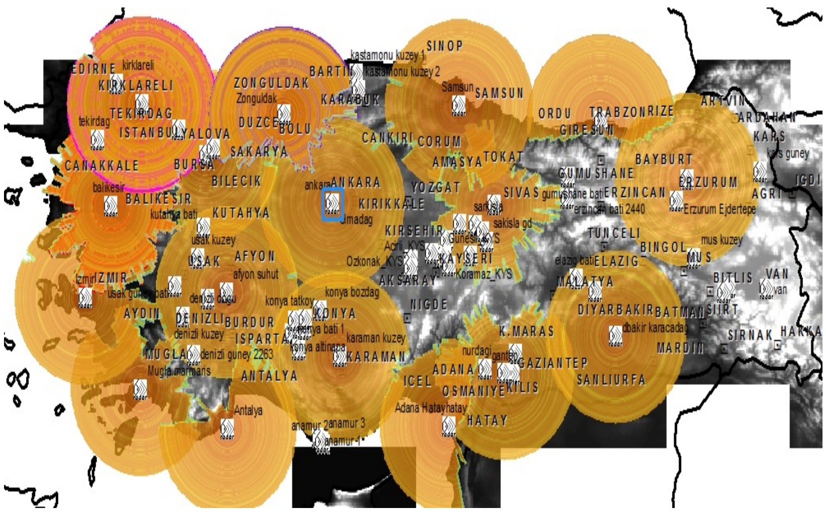
In this paper, new C Band Weather Radar Network of TSMS is going to be presented in details and future plans for other type of weather radars like X Band Radars is going to be mentioned.

2. The Abstract

All TSMS’s radars except Ankara Radar will be capable of performing of intensity and velocity calibration. Automatic multi point receiver calibration should be done by using the signal generator which is be mounted at each radar system. It will be possible to make the intensity check and to measure the phase noise by means of the maintenance software.

3. Expansion of Turkish Weather Radar Network

In last ten years, TSMS have lots of improvements on weather radar systems including different radar equipments as well as on radar network. Now TSMS operate ten C- Band Klystron tube weather radars and it will be 17 at the end of 2016. Turkish C- Band Weather Radar network have been completed at the end of 2016 . There are many types of improvements on our weather radar systems. These are mainly hardware, software, radar infrastructure and other improvements. I will briefly explain hardware improvements on weather radar system in this paper.



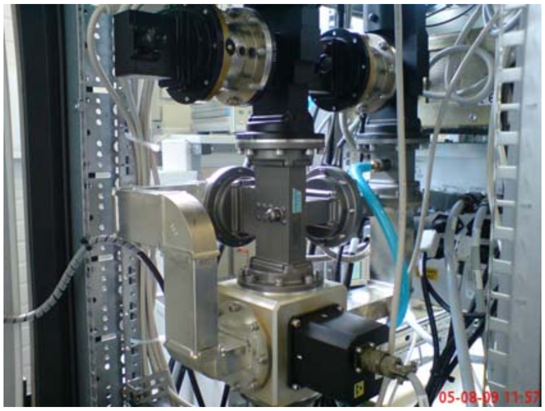
Pict. TSMS whole radar Network

3.1- Hardware Improvements:

3.1.a-) Dual Type: Switch or Simultaneous

TSMS's have ten C-Band Doppler weather radars with klystron tube, seven of them are dual polarization capability and TSMS will be installed seven C- Band Doppler weather radars with magnetron tube in 2016. In 2013, TSMS first radar which is name of Ankara Radar has upgraded switch type dual polarization mode to Simultaneous Transmitting and Receiving (STAR) mode. All of our radars have 5625 MHZ frequency and 250 kW peak power.

Simultaneous Transmitting and Receiving (STAR) mode shall be used (*Pict. 1*). Also only horizontal or only vertical or both horizontal and vertical polarization capability will be available. Although the transmitter’s peak power is 250kW at first, the transmitted power is sent half of the peak power (125kW) to atmosphere in STAR mode after RF signal passes from power splitter for simultaneous transmitting. Thus radar can receive RF signals reflected from targets in both horizontal and vertical channel. So in this type of dual polarization the transmitted peak power decreases half of power but much more information can be obtained from the targets in the atmosphere at the same time.



Pict. 1 Simultaneous Dual Polarization Channel

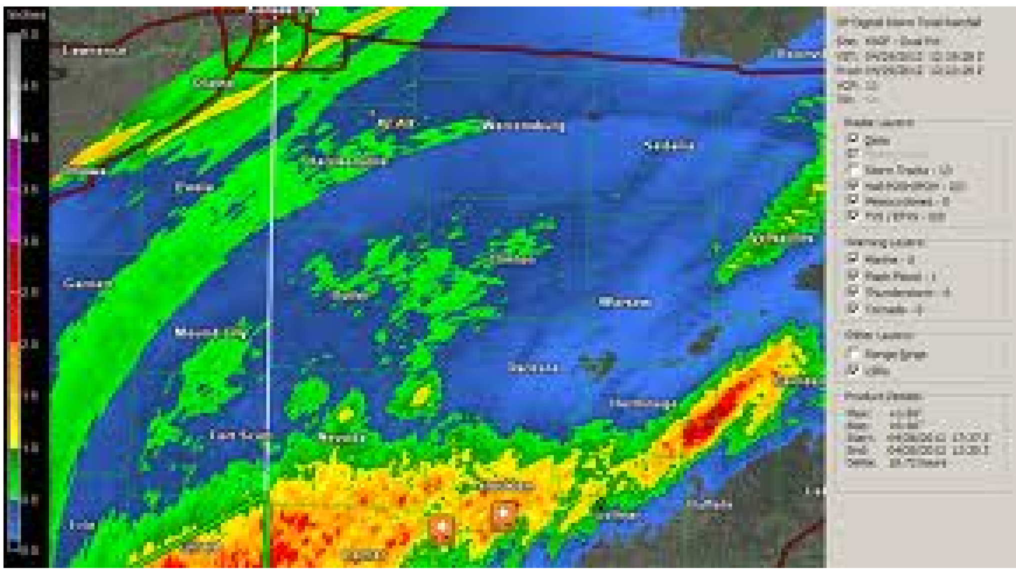
In TSMS’ 7 radar project both of them will have dual polarization capability with magnetron tube.

Pict.2 Weather Radar with magnetron tube

3.2- Software Improvements

3.2.a-) Dual Polarization Products

All TSMS's polarimetric radars will produce dual polarization products such as: Rainfall Accumulation product, Hydrometeor Classification Product, Precipitation Efficiency Rate Products. In these products Z- Reflectivity, Z_{DR}- Differential Reflectivity, KDP- Specific Differential Phase, LDR- Linear Depolarization Ratio, $Ø_{DP}$- Differential Phase Shift, ρ_{HV}- Polarimetric-Correlation Coefficient parameters have been used. These products shall be generated by using the hydrometeor classification algorithms based on Fuzzy Logic and/or Artificial Neural Network.



Pict 3. Rainfall Accumulation Product

3.2.b-) Receiver Calibration

In our first radar which was started operation in 2001, there is anolog receiver. But we changed analog receiver to digital receiver by improving new technologies in 2013. Also our three radars which were installed in 2003, we changed from analog to digital receivers by improving new technologies. Our six radar , receivers are digital and dynamic ranges are better than the other three radars. Also our new seven radar installation projects, receivers are also digital and dynamic range of news are better than the other ten radars.

All operational and still under installation radars have automatic multi-point receiver calibration tool in their maintenance software. Automatic signal generator (*Pict.4*) should be installed in the radar system for automatic multi-point calibration. The signals from noise level to saturation level are applied automatically by using signal generator for multi-point calibration. So a receiver response curve is plotted by calibration tool (*Fig. 1*) and calibration results are saved. Receiver calibration must be done at least in every 6 months periodical maintenance.

Pict. 4- Automatic Signal Generator mounted to the radar system

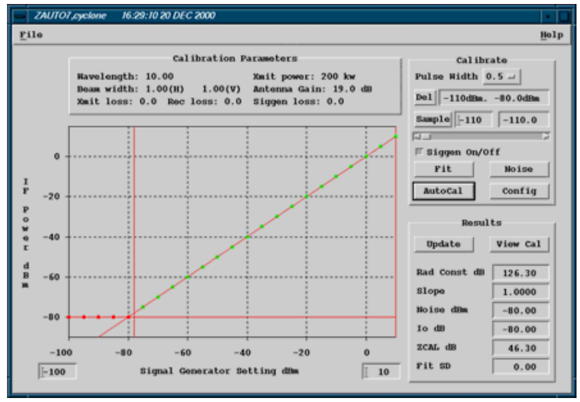


Fig. 1- Receiver Calibration Tool

3.2.c-) Sun Calibration

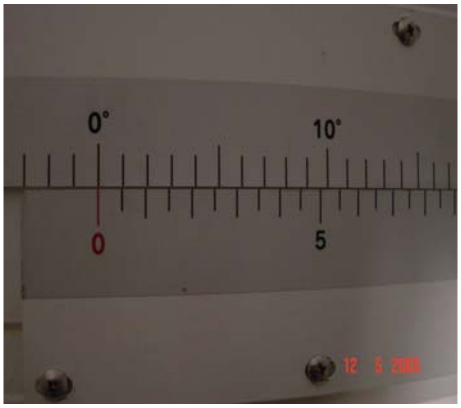
The sun may serve as an external radiation source for calibration of the radar systems. The sun's position can be calculated from any point on earth at any given time provided that accurate time and lat/lon information is known. This provides a convenient check for antenna pointing accuracy. The sun's power can also be useful technique for monitoring the calibration of the receive chain of the radar when used in conjunction with independent measurements of solar flux density.

In our first radar, sun calibration tool shows the position of the sun, correct time and longitude-latitude of the radar. We can compare and the actual antenna position according to the values from sun cal tool.

However in three radars sun calibration is done manually by using sun cal tool. If we get correct time and correct position of the sun then we do sun tracking. At the antenna any error occurs during sun tracking test (*Pict.5*), then we do some adjustment. First we do adjustments electrically (*Pict.6*) to make the error zero, the second stage may be needed by sliding the angle measuring bar mechanically (*Pict.7*). After these adjustments sun calibration is done again. If the errors don't exceed the given limit values, sun calibration becomes ok. Otherwise it is not ok.

Pict. 5- *Sun Calibration Tool*

Pict. 6- Electrically adjustment by using dip switch



Pict. 7- Mechanical adjustment by using antenna scale

In six radars and seven radar project there is automatic sun cal utility. The sun calibration is carried out automatically and angle errors during the calibration are ignored and corrected values for angles are stored automatically by using software. The sun cal utility can be run interactively from a command line and does not use a graphical interface. The sun cal utility outputs a BEAM product (*Fig.2*). The BEAM product will contain SNR (Signal to Noise Ratio) data with no thresholding and can be viewed on an IRIS system, but is not automatically inserted into an IRIS product dictionary. The BEAM product is then processed to produce a final calibration results file. The calibration results file produced contains lots of information derived from the calibration such as the time, location and the site name. Also there are radar calibration numbers such as the noise level and the receiver bandwidth.

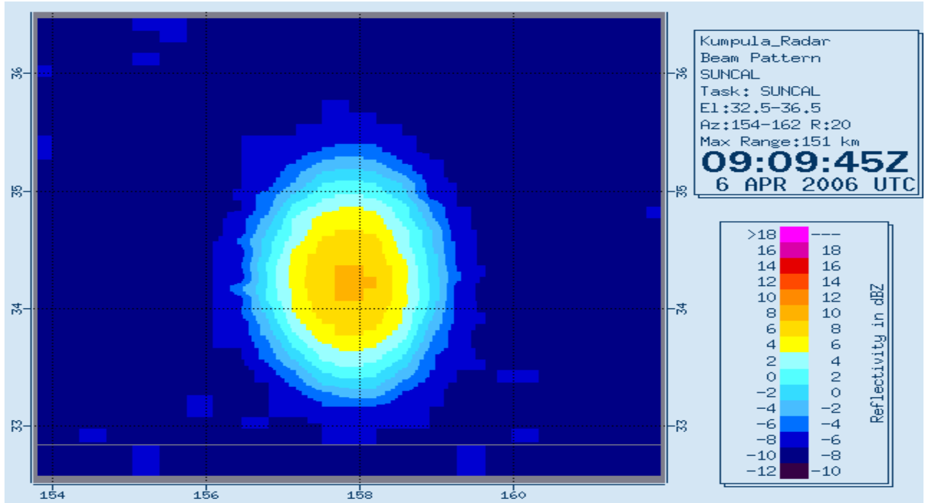
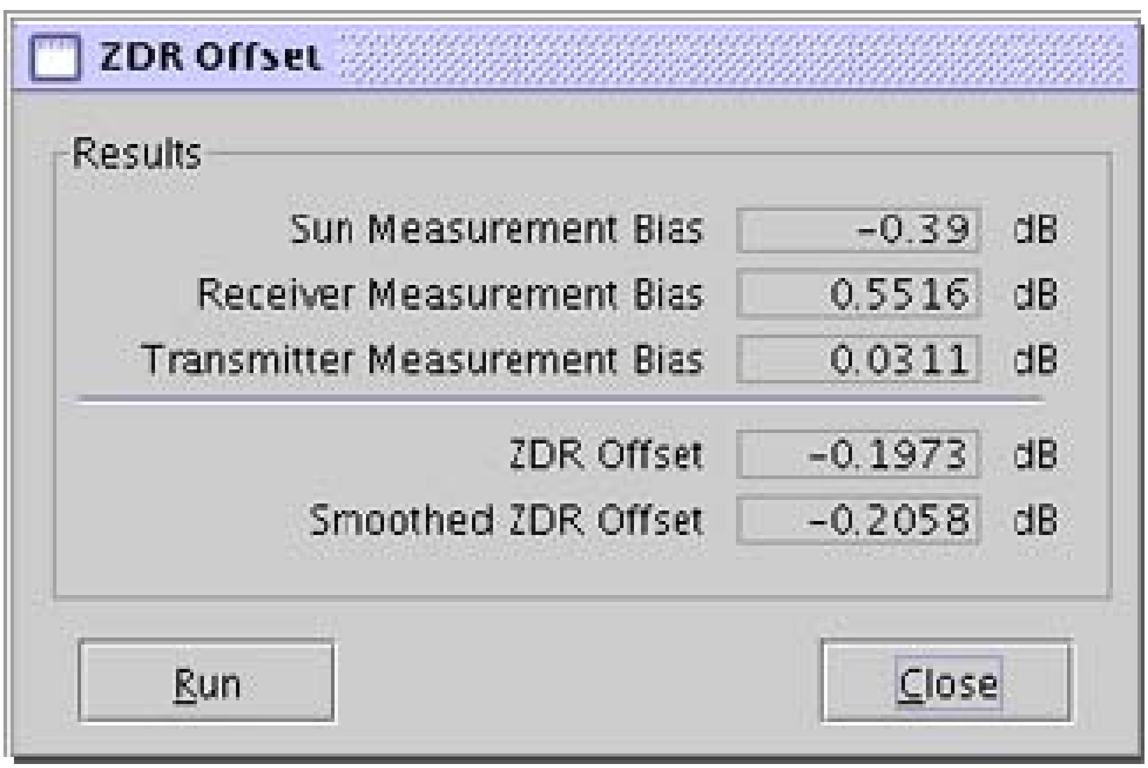


Fig. 2- BEAM Product from SUNCAL Utility showing sun

Also some methods shall be provided for the calibration of dual polarization. For example, ZDR calibration (*Pict.8*) shall be fulfilled and recorded by the values which are received after the antenna shall positioned upwards full vertical position and turned on horizontal position at least once per day.

Also radar system shall measure the sun energy daily and record the values for purpose of checking the data quality.



Pict.8 ZDR Calibration

3.3- Mobile X Band Radar

TSMS now operate one Mobile X Band Magnetron Radar (*Pict.9*) in Atatürk airport in İstanbul for checking echos, rain and the others between C band and Mobile radars. If testing period will be successful TSMS will have planning to fill to gap between C Band radars and the to fill the others airport for aviation purpose.

Pict.9 Mobile X-Band Radar with Magnetron tube

3.4- HF Radars

And finally TSMS have operating HF radars *(Pict.10*) used to determine wavelength and current direction of the water in two sides of the bosphorus.

Pict.10 HF Radars

4. Conclusion

TSMS has been planning to install new radars to be able to cover the whole country and trying to take into consideration the improvements of technology on weather radars at the end of 2016. Day by day technology is adding new features to the radar systems. Therefore TSMS would like to have these new technological improvements according to the necessities.

TSMS has been planning to expand its network to cover whole country by adding 7 C- Band and X-Band radars by considering the topography, coverage and the meteorological targets. In future, to cover the whole Country, 7 C-Band and 15 X-Band Weather Radars are proposed to be installed.

TSMS has been trying to improve its observation capability by establishing modern and well developed observing systems in order to provide the meteorological services and products to the users. Regional and international cooperation is one critical component to improve the capacity of the agency, and to increase the quality of the service. This is why TSMS is always open for any cooperation activity.

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