POLARIZATION SELECTIVE ANTENNAS FOR REFLECTED WAVE DEPOLARIZATION DETERMINATION

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Abstract

In this paper the approach to estimate dynamic processes in the atmosphere with help of polarimetry as well as multi-antenna polarimetric radar system is considered. The requirements to polarization selective antennas parameters are discussed.

Keywords: Radar polarimetry, polarization antennas, atmospheric dynamics.

1. INTRODUCTION

The coherent Doppler radar as well as conventional non-coherent radar both ground-based and airborne are widely used nowadays for obtaining information about dangerous atmospheric phenomena. Doppler weather radars have much better possibilities compare to conventional non-coherent weather radar that are still in use in many states including Ukraine. There were also some researches concerning possibilities of combined Doppler and Polarimetric Radars for meteorological purposes [1]. The researches show that Doppler-Poarimetric approach has better possibilities in contrast to both conventional and coherent weather Doppler Radars alone. In these researches the abilities of Doppler methods to obtain information about dynamics in the Atmosphere were combined with abilities of radar polarimetry that is sensitive to the shape of the radar signal reflectors. Generally the radar polarimetry is proposed for use when it is necessary to retrieve information about microstructure of atmospheric formation.

In [2, 3, 4] the possible use of polarimetry for determination of dangerous weather phenomena connected with wind is reviewed. In [5] is shown that the influence of wind phenomena including atmospheric turbulence on liquid hydrometeors leads to changing their shape and spatial orientation. As a result of it the electromagnetic waves reflected from hydrometeors change their polarization with respect to the sounding wave polarization. Therefore the value and character of changing polarization angle of reflected electromagnetic wave are the informative parameters that characterize the degree of phenomena influence on the hydrometeors.

Modern polarimetric radars can receive the reflected signals of main polarization and signals with polarization that is orthogonal to the main one. The signals with polarization that is orthogonal to the main polarization are often too low for successful use when polarimetric parameters calculation at accepted probability level for dangerous phenomena determination. Therefore the engineering problem of obtaining and estimating reflected waves energy with different polarizations still exists.

In [6] the system for studding polarization structure of signals scattered in Troposphere with more than two receiving antennas that are sensitive to polarization is shown. In [7] the possibility to develop system that have antenna with rearrangeable polarization in the limits of 90° is considered.

Taking into account the mentioned technical advances and possibility to use polarimetry for dangerous atmospheric phenomena determination including wind phenomena it is reasonable to consider possibility to develop systems with polarization selective antennas for enhancing the effectiveness of atmospheric phenomena determination as well as atmospheric processes study.

2. MULTI ANTENNA POLARIMETRIC SYSTEM

In [8] the approach that shows the possibility to use polarimetry for turbulence intensity estimate was proposed. In this approach the turbulence is considered as a source of the origin of temporal and spatial changes of polarization in reflected electromagnetic waves. Turbulence intensity quantitatively estimated when energy characteristics of reflected waves with main polarization as well as waves with changed polarization due to the influence of turbulence (let us to name it turbulent polarization) are estimated.

This approach is based on the transmitting into the atmosphere the sounding waveform with the fixed polarization and receiving reflected signals by the set of the antennas. Each antenna in the antenna set is adjusted to receive electromagnetic waves of certain polarization. Then measuring the power of the waves with different polarization is made and if necessary the polarimetric parameters are calculated. Device for this method realization is described in [9].

3. PARAMETERS OF POLARIZATION SELECTIVE ANTENNAS

It is known that the best receiving polarized waves is achieved when vectors of antenna polarization and electromagnetic wave polarization are coinciding. In case of turbulent atmosphere, vectors of electromagnetic field strength from different reflectors of radar signals do not coincide with initial polarization of sounding waveform. The effective values of these vectors provide the appearance of the antenna current and depend on the received wave polarization angels. It leads to the decreasing antenna current. In [10] this current variation is taken into account with help of the weight coefficients that define antenna pattern and depend upon the changing polarization of the wave reflected from hydrometeors.

According to [1], Figures 1-3 show the current variation in the receiving antennas that is set up to receive reflected electromagnetic waves with different polarization with respect to the polarization of sounding waveform.

In Fig. 1-3 the normalized value of antenna current relative to its maximum value is put along y axis. The angle of received wave depolarization is put along *x* axis.

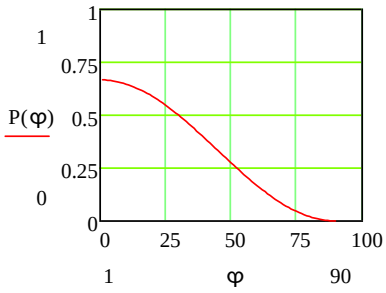

Fig. 1. Current variation in the receiving antenna coordinated to receive horizontally polarized electromagnetic waves

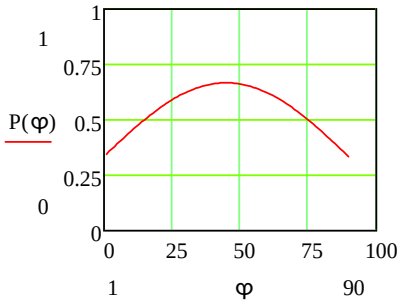

Fig. 2. Current variation in the receiving antenna coordinated to receive electromagnetic waves with polarization 45°

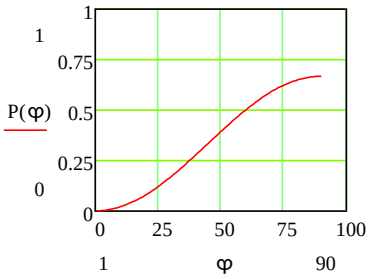

Fig. 3. Current variation in the receiving antenna coordinated to receive vertically polarized electromagnetic waves

From the Fig. 1-3 one can see that the decreasing received power (in dB) in any single antenna is accompanied with the increasing received power in the other antenna. It reflects the process of turbulent energy spend for hydrometeor deformation and as a result for appearance of depolarized signals.

It is known that the total power in the receiving antenna is the mixture of useful signal power and noise power. In general case the noise has the additive character. Taking into account this fact let us to model the level of useful signal power variation in the receiving antennas that is set up to receive reflected electromagnetic waves with different polarization relative to the polarization of the sounding waveform. The level of noise power is taken at 0,3 from the total received power (Fig. 4-6).

The angle of depolarization is put along x axis in Fig. 4-6. The normalized value of useful antenna current relative to its maximum value is put along y axis.

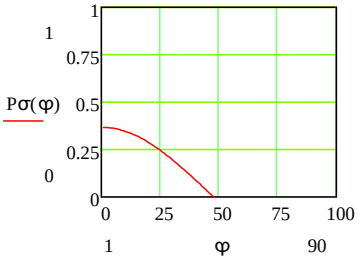

Fig. 4. Useful current variation in the receiving antenna coordinated to receive horizontally polarized electromagnetic waves

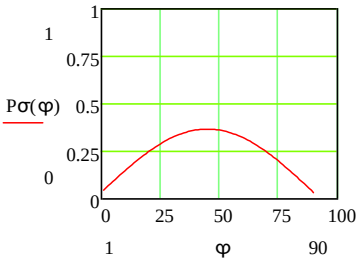

Fig. 5. Useful current variation in the receiving antenna coordinated to receive electromagnetic waves with depolarization 45°

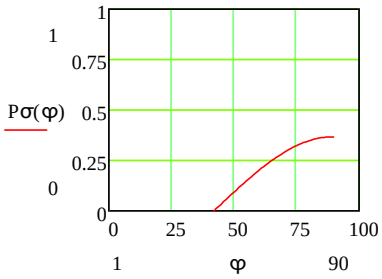

Fig. 6. Useful current variation in the receiving antenna coordinated to receive vertically polarized electromagnetic waves

From the comparison of figures 1 and 4 as well as figures 3 and 6 one can see that effective reception of depolarized waves is possible when angle of depolarization is less than 45 deg. From the figures 2 and 5 one can see that almost all power of the depolarized electromagnetic field can be received with the antenna coordinated to receive electromagnetic waves with depolarization 45°.

In real situation the most of the wind phenomena can cause the depolarization in the limits of about 15 degrees. Therefore in case of transferring into the atmosphere the horizontally polarized sounding waves the energy level of received depolarized waves in cross-polarized antenna will appear to be less than power of noise. The same situation takes place in antenna coordinated to receive horizontally polarized waves when transferring vertically polarized waveform toward the object under the study. This fact makes almost impossible further signal processing and parameter calculation. In the intermediate antenna to receive waves in the limits of deformation up to 45 degrees the informative signal still exists.

3. CONCLUSIONS

The radar system with antenna coordinated to receive reflected from weather formation waves with polarization that is different from sounding waveform polarization allows to obtain the significantly higher level of depolarized signal than in the antenna with orthogonal polarization with respect to the sounding wave polarization.

The better signal-to-noise ratio allows to make polarization parameter calculation for dangerous phenomena determination at higher probability level.

The further investigation concerning the polarimetric antennas specification should be made for successful implementation of presented approach. Antenna requirements should cover such points as polarization antenna pattern and polarization antenna beamwidth. Polarization antenna pattern implies the perception of signal energy depending on polarization angle. Polarization antenna beamwidth is characterized by the relative sensitivity of the antenna for the receiving signals with certain polarization in the given direction. In this case it is necessary to make clear that antenna should receive not only the electromagnetic waves with coordinated polarization but momentary spectrum of the signals of the same frequency with different polarization angles. We named it as polarization spectrum [4,5]. Therefore traditional antenna beamwidth should be corrected taking into account receiving waves of different polarization angles.

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