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Interpretation Procedure of Meteorological Radar Data for Propagation Application in Heavy Rain Region

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***Abstract*–Advanced satellite communication or modern wireless systems operate at high frequencies will suffer from deep signal fades caused by rain particularly in equatorial region. Meteorological radar operates by MET department is one of the valuable resources to provide the peculiarities of the local precipitation information oriented to the analysis of radio propagation impairments. In this paper, the processing methodology and the interpretation procedure of operational weather radar data are presented from the perspective of such application. The applicability of the processed meteorological radar data is preliminary assessed against Stratiform Convective-Synthetic Storm Technique (SC-SST) in terms of first order rain attenuation statistics. The radar data simulated statistic is found to agree well with the one obtained through SC-SST. This procedure can be useful as a reference methodology for the employment of operational meteorological radar particularly focus on the propagation applications.**

***Index Terms* —Diversity gain, Heavy rain region, Rain attenuation, Time diversity**

I. INTRODUCTION

Modern satellite communication systems operate at high frequencies will suffer from deep signal fades due to rain particularly in equatorial region. Besides temporal characteristics, complex satellite propagation channel models require also the knowledge of spatial variability of the precipitation. To this aim, ground weather radar is a power source in providing finest spatial information of the rainfall horizontal structure from the hydrometeor observation as compared to satellite and Space-borne radar. In fact, weather radar is capable to offer considerable quantities of information on the three-dimensional structure of the precipitation. However, in order to produce reliable radar data for such propagation application, the capability for elaborate filtering and data handling as well as efficient processing techniques of complex weather data are required.

In response to this need, this work describes the processing methodology and interpretation of large amounts of digitized reflectivity factor data for propagation applications. Section II briefly introduces the weather radar database used in this work. Afterwards, the procedure and processing flow of radar data is duly described in Section III. The processed database is preliminary validated in Section IV against the Synthetic Storm Technique, SC-SST [1] by assessing its validity in reproducing the firs-order rain attenuation statistics. Finally, Section V draws some conclusions.

II. THE WEATHER RADAR DATA

In this study, S-band weather radar managed by Malaysia Meteorological Department located at Kluang, Johor (latitude 2.02° N, longitude 103.3° E), Malaysia is employed. The database is extracted from January 2007 to December 2008 of continuous meteorological observation operation. The radar performing a volumetric scan (15 elevation angle :0.5°, 0.8°, 1.1°, 1.4°, 1.9°, 2.5°, 3.3°, 4.4°, 5.8°, 7.7°, 10.3°, 13.6°, 18.1°, 24.1° and 32.1°) at every 10 min with a complete azimuth scan which required 5 minutes of duration for a complete volumetric scan. The contiguous pulse volumes are sampled each 500m in range with a maximum radius of 250 km. [2].

III. METHODOLOGY OF RADAR DATA PROCESSING

In order to obtain an informative radar images with details digital value of radar reflectivity, the raw radar data that are encoded in the form of ASCII asynchronous format are first decoded into the matrix array. Each elevation angle consists of 360 arrays of data, each one corresponding to one azimuth angle, with 16 quantization levels of radar reflectivity Z. The radius of the observation area has been limited to 50 km to limit the averaging effect inherently performed by weather radars as a result of beam broadening.

After the decoding process, each volumetric scanned image consists of 15 elevation angles were subsequently remap to obtain pseudo CAPPI (Constant Altitude Plane Position Indicator) resulting from the composition of five elevation scans named 1.4°,1.9°,2.5°,3.3° and 4.4° at a constant plane of 1.5 km from ground as sketched in Fig.1. Each CAPPI image corresponding to the total scanned time of 1.5 minutes, in order to obtain the best spatial resolution with an almost instantaneous image of rain, while the radar data are kept at the constant height of 1.5 km above ground with aim to avoid

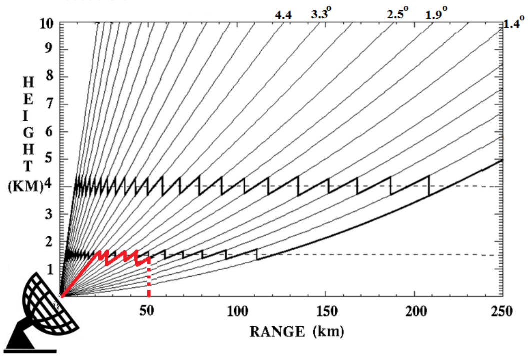

Fig. 1. Pseudo CAPPI radar image derived from a combination of 5 different elevations.

problematic data contaminated by ground clutter and the exclusion of melting layer. Next, CAPPI data originally in polar coordinate have been remapped into a Cartesian grid having a resolution of 500 ×500 m^2 [3]. Each image consists of 200 ×200 pixels.

The problematic images affected by ground clutter and blockage have been removed by means of static clutter map technique [4] which aim to identify the clutter and blockage by the estimation of percentage occurrences of ground rain.

Finally, the radar reflectivity Z (mm^6/mm^3) has been converted into rain rate R (mm/h) using the following relationship inferred from disdrometer measurement and the complementary cumulative distribution function CCDF of rain intensity was computed and compared with the one obtained from 20 years of long term measurements collected by the rain-gauge co-located with the radar [2].

$$Z = 300R^{1.4} \quad (1)$$

Fig.2 summarized the overall flow of the processing methodology as described above.

IV. Rain Attenuation Statistics

In order to demonstrate the validity of the processed radar database, the radar maps are then converted into attenuation maps experienced by an Earth-Space link pointing to the Syracuse 3A satellite (47° E: 25° elevation angle). Each rainfall intensity values R on the radar map pixels have been converted into the attenuation values A and numerically integrated according to the length of the radio link affected by rain. The CCDF of rain attenuation are computed and compared with the result produced by SC-SST [1] which employed one-minute integration time of rainfall rates as an input. The result illustrated in Fig.3 immediately proves the validity of such processing method which preserves local rainfall statistics for the prediction of rain attenuation in telecommunication design.

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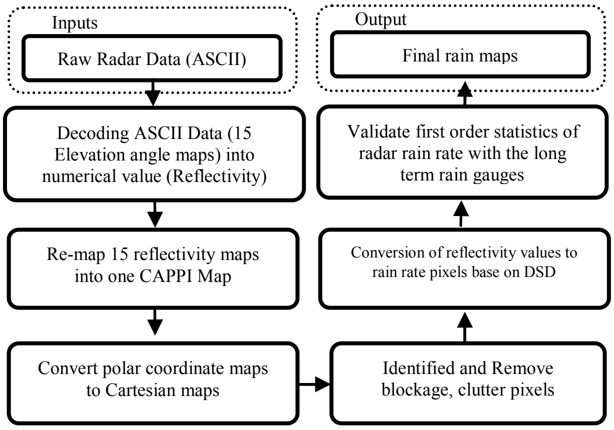

Fig. 2. Workflow of meteorological radar data processing

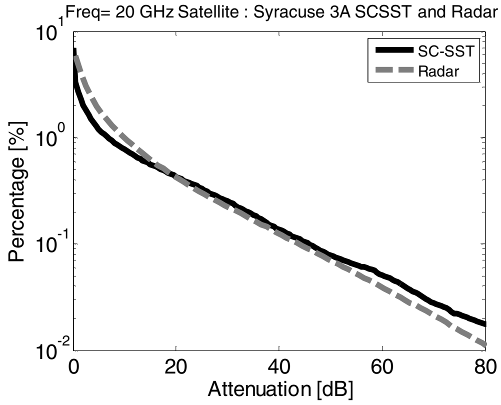

Fig. 3. CCDFs of rain attenuation at 20 GHz from the Syracuse-3A satellite (Elevation angle = 25°) : Predictions using the weather radar data and the SC-SST model[1].

V. Conclusion

This work presents the procedure of the meteorological radar data processing for the application of propagation in predicting the signal degradation due to precipitation. Preliminary test indicate that carefully processed radar data are capable to reproduce a pretty good agreement of first order statistics of rain attenuation with the one obtained by SC-SST model, which highlight the applicability of weather radar data pertaining to the propagation application.

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