안정된 위성방송서비스를 위한 강우강도 예측에 관한 연구

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Studies on Rainfall Rate Forecasting for Reliable Satellite Broadcasting Service

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Abstract

In the satellite system design, the processes from the initial design to launch take about 5 years and the broadcasting satellite lifetime goes over 15 years. Furthermore, global warming phenomenon causes rainfall rate increasing more and more in some regions on the earth. Consequently, at the stage of the satellite link design, we need to consider the future rain attenuation over 20 years. In this paper, we investigated two time-series system models for forecasting to consider the future rainfall rate for the satellite broadcasting service. We found that rainfall rate of the future 30 years is increasing continuously.

Key words: rainfall rate, forecasting, satellite broadcasting service

1. Introduction

Rain attenuation is a very important factor for the reliable Ku/Ka band satellite broadcasting service, and there have been many researches to solve the rain attenuation problem due to heavy rain. The rain attenuation is estimated by using the rainfall rate exceeded 0.01% of the year[1], and the global warming phenomenon causes rainfall rate to increase gradually in some regions on the earth. In the satellite link design, we need to consider the whole period of the satellite broadcasting service. If the rainfall rate is changing continuously, we need to forecast the future rainfall rate to estimate the future rain attenuation. The satellite broadcasting service begins around 5 years later from the satellite system design stage, and the broadcasting satellite lifetime is about 15 years [2]. Therefore we need to consider the rainfall rate of 20 years from the beginning of the design for the reliable satellite broadcasting service, and we need to forecast the future rainfall rate longer than 20 tears.

We used AR (Autoregressive) and ARIMA (Autoregressive Integrated Moving Average) models to forecast the rainfall rate based on the rainfall rate data measured in Seoul from 1961 to 2012.

2. Forecasting models

In general, there are three forecasting methods: Time-series method, Casual method and Judgmental method [3,4]. We employed the time-series forecasting method because it is based on analysis of historical data, and we are trying to forecast the future rainfall rate using the past rainfall rate data. Time-series analysis provides some tools to select the model which can be used to forecast future events. In this paper, two models of forecasting are presented; Autoregressive model (AR) and Autoregressive Integrated Moving Average model (ARIMA).

2.1. AR

Many observed time-series are highly correlated in time, and this suggests that past observations might predict current observations. The process models the conditional mean of y_t as a function of past observations, $y_{t-1}, y_{t-2}, \ldots y_{t-p}$. An AR process that depends on p past observations is called an AR model of degree p, denoted by AR(p).

The AR model is defined as follows:

$$y_t = c + a_1 y_{t-1} + \cdots + a_n y_{t-p} + e(t) \quad (1)$$

where y_t is the output at time t, c is a constant, p is the number of poles of the system, $y_{t-1}, y_{t-2},\ldots,y_{t-p}$ are the previous outputs on which the current output depends, $e(t)$ is white-noise disturbance, and $a_1, \ldots, a_p$ parameters can be calculated by using Yule-Walker equations [5].

2.2. ARIMA

The ARIMA model is combining AR and Moving Average (MA) models. A linear time series model for the response process y_t and innovations ε_t is a expressed as

$$y_t = c + \phi_1 y_{t-1} + \cdots + \phi_P y_{t-P} + \varepsilon_t + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q} \quad (2)$$

The coefficients of autoregressive polynomials ϕ_P correspond to AR at the degree of the polynomials, p. Similarly, the coefficients of polynomials θ_q correspond to MA at the degree of the polynomials, q.

3. Results and Discussion

Through Figures 1-2, each rainfall rate data is a moving average of 10 years, and it is observed that the forecasted rainfall rates continues to grow over time.

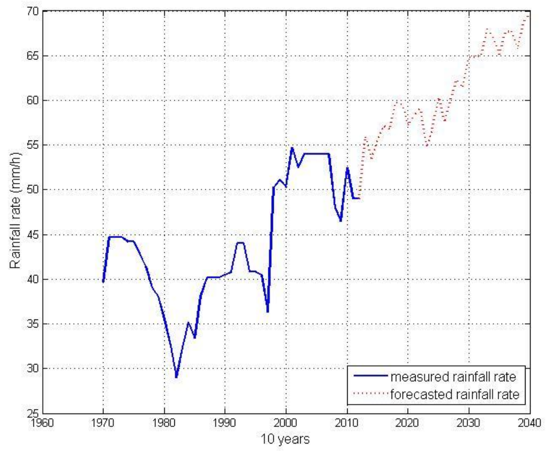

Figure 1. Forecasting for rainfall rate exceeded 0.01% of ten years using AR model.

The ARIMA model contains not only parts for AR and MA models, but also the extra part for their differences. The extra part allows the model to deal with long term variation better than the AR model. Consequently, the ARIMA model shows better results than the AR model.

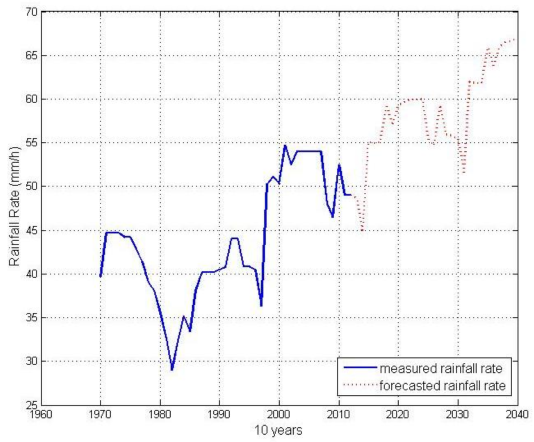

Figure 2. Forecasting for rainfall rate exceeded 0.01% of ten years using AR model.

4. Conclusion

This paper presents the rainfall rate forecasting for satellite link analysis using the measured data for 30 years. They include Autoregressive model (AR) and Autoregressive Integrated Moving Average model (ARIMA). Rainfall rates are measured at exceeded 0.01% of the time of ten years. The ARIMA model gives the best result for forecasting rainfall rate exceeded 0.01% of the time of ten years. It can be concluded that rain attenuation for the future 30 years increases when they are forecasted based on the past measured data because of the growing trend of forecasted rainfall rate in the future.

5. References

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