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used to monitor the impact of mixing native soil with MSS or yard waste (YW) mixed with MSS (YW +MSS) on: i) sweet potato yield and quality and ii) concentration of seven heavy metals (Cd, Cr, Mo, Cu, Zn, Pb, and Ni) in sweet potato plant parts (edible roots, leaves, stem, and feeder roots). Soil samples were collected and analyzed for total and extractable metals using two extraction procedures, concentrated nitric acid (to extract total metals from soil) as well as CaCl2 solution (to extract soluble metals in soil that are available to plants), respectively. Elemental analyses were performed using inductively coupled plasma mass spectrometry (ICP-MS). Overall, plant available metals were greater in soils amended with MSS compared to control plots. Concentration of Pb was greater in YW than MSS amendments. Total concentrations of Pb, Ni, and Cr were greater in plants grown in MSS+YW treatments compared to control plants. MSS+YW treatments increased sweet potato yield compared to plants grown in native soil. Concentration of heavy metals in MSS amended soil and in sweet potato roots were below their respective permissible limits. However, monitoring heavy metals in soil and edible plants should be regarded as a requirement for the safe use of soil amendments in agricultural fields. 14-20

Applications of Ferrocement in Strengthening of Unreinforced Masonry Columns
Abid A. Shah

Abstract*:* The load carrying capacity, ductility and serviceability of unreinforced masonry columns can substantially be improved if encased by ferrocement. The parameters such as cement mortar thickness, gage-wire spacing and bond at the interface of ferrocement and brick columns have effects on overall behavior. In the present experimental study, it was found that the first crack load and ultimate load of a ferrocement encased masonary column was increased by 119% and 121% respectively. Cracks developed in ferrocement-encased column were finer and well distributed as compared to plain specimen. However, premature failure is possible when bond at the interface of brick masonry column and ferrocement is poor. At higher reinforcement ratio, severe spalling and delamination is expected. 21-27

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Harmonizing Member State Water Policies to the EU Water Directive 2000/60/EU: The Case of Greece
Kallopi Kalampouka, George N. Zaimes, Dimitrios Emmanouloudis

Abstract*:* Water is a resource with increasing pressure due to the increase in its demand for many diverse uses. This is why the European Parliament and the EU Council enacted a directive-framework (2000/60/EU) for the protection of the inland surface, coastal and ground waters. The harmonization of the legislations to the provisions of this directive is very important due, on the one hand, to the desired results and aims of the directive, on the other hand, due to the kind of measures that member states are required to take in order to protect the environment and their citizens. This study determines the margin of evaluation that member states have, according to the directive and the jurisprudence of the Court in order to establish the most effective Standards of Quality for the Environment (SQE). 29-33

Wearable System Supporting Navigation of the Blind
Lukasz Kaminski, Andrzej Stepnowski, Jerzy Demkowicz

Abstract*:* Improving blind people comfort of life is a problem of great importance. Fortunately, new technolgies provide us with additional methods to improve everyday life of the blind and visually impaired. The paper presents experimental system made by researchers from Department of Geoinformatics of Gdansk University of Technology, which is capable of finding the route from the indicated source to chosen destination, using dedicated digital map and a set of various sensors. Subsequently, it supports the movement of the blind along the found 34-40

route. The user's position is obtained with the use of DGPS receiver. In order to further improve accuracy, particle filtering method is used. The system operates on a casual smartphone and communicates with the blind by the touch screen and by the voice messages generated by voice synthesizer.

Generating Transition Rules of Cellular Automata for Urban Growth Prediction
N. Laila Ab Ghani, Siti Z.Z. Abidin, M. Zamani Z. Abiden

Abstract*:* Urban growth prediction can be simulated using digital maps. The growth of a non-built area can be detected through the change of pixels in a temporal imagery data. A built area usually affects the growth of its surrounding area as similar to Cellular Automata theory. Cellular Automata (CA) is a system consists of grid cells where each one is in finite number of states. The basic components of CA are cells, states neighborhood and transition rules. This research is mainly about obtaining a set of transition rules that detect the pattern of urban growth based on digital maps. The datasets are in the form of satellite images of the study area, the district of Subang Jaya, one of the most rapid urban growth areas. It is difficult to specify equation-based transition rules due to complex geographical processes in the urban growth. Most of the available transition rules are defined statically. This research proposes a different approach using deterministic and pixel-based method by experimentally identifying the unique pattern of surrounding cells on every pixel in the map. Then, the unique patterns are used to generate the transition rules. The rules are implemented as a prototype engine and the accuracy of the rules are tested by comparing predicted results with the original satellite images. Due to the rapid urbanization process in Malaysia, it is important to have a system that has the ability to predict the future growth of an urban area. Excellent accuracy will lead to better monitoring system to cater future livings.

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Phase Field Theory Modeling of CH4/CO2 Gas Hydrates in Gravity Fields
M. Qasim, B. Kvamme, K. Baig

Abstract*:* Natural gas hydrates in reservoirs are thermodynamically unstable due to the interactions with surrounding fluids (aqueous, gas) and mineral surfaces. Depending on the local flow hydrate will dissociate as well as reform. If the dissociation rate is faster than the capacity of the surrounding fluids to dissolve the released gas, the gas will form bubbles. Depending on the rate of released gas and possible fracture patterns this may lead to venting of gas. The proper implementation of hydrodynamics will provide a deeper insight of the hydrate kinetics involved during dissociation and formation processes which involve hydrate former phase as smaller or larger bubbles or even continuous gas phase. In this work the phase field theory coupled with hydrodynamics model is implemented with variable density using the relative composition, phase field parameter and flow, which is an extension of our previous work which considers a constant density.

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Paper Title, Authors, Abstract (Issue 3, Volume 5, 2011)	Pages

Computational Seismic Algorithmic Comparison for Earthquake Prediction
Sajjad Mohsin, Faisal Azam

Abstract*:* Seismic data is generated in nature by the changes or movement of the earth crust. This data has evolutionary patterns. Since this data is based on time, a model can be formed to predict the future pattern. In this work we have focused on different statistical learning models to identify the potential seismic changes in the geography related to Pakistan. We used both deterministic and un-deterministic optimized algorithms to determine the future values. The results of different applied techniques show the possibility of future earthquakes in Pakistan region. This work also elaborates the comparative performance of statistical techniques for earthquake prediction. For this purpose, M8 and MSc algorithms have also been considered for critical overview.

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	of science points to rising dangers from the ongoing buildup of human-related greenhouse gases - produced mainly by the burning of fossil fuels and forests. What is climate changes, how do we know they are happening, and what can we expect from them? Certainly, the answer to these questions we must be known and understood. Another problem related to these climate changes and global warming is the increase of soil salinity. Beside this increase, current problems arising the agricultural development are appearing, as natural disasters, drinking water scarcity, less food production, infectious diseases and lower soil productivity. Conventional techniques used to control soil salination process - soil leaching or fertilization enhancing - contribute highly to soil and aquifers contamination; on the other hand, the use of salt tolerant plant species will be very useful to the plants, but it does not solve the problem of soil or groundwater contamination. Hence, the only way to control the salination process and to maintain the sustainability of landscape and agricultural fields is to combat the salination problems by environmentally safe and clean techniques. One of these techniques is the use of salt removing species. In order to study the climatical changes effects on the potential capacity to remove soil salts, two horticultural leaf species Tetragonia tetragonioides and Portulaca oleracea were planted. The total growth and the leaf mineral composition of these species were studied. According to the results of plant growth and leaf analysis, it was seen that Tetragonia tetragonioides are the best salt removing species; on the other hand Portulaca oleracea was the most tolerant species to soil and water salinity. It was shown that this technique to control salinity is a powerful and environmental clean tool to maintain the sustainability of the landscape and of the agricultural areas. As final remarks, it is concluded that in arid climates and global warming, the clean and environmental safe procedures to control salinity could be associated to the conventional techniques, combining environmental, economical and social aspects, contributing, therefore, to increase the sustainability of the environment and plant growth.	79-85
	C:N ratio of Sediments in a sewage fed Urban Lake *Durga Madhab Mahapatra, Chanakya H. N., Ramachandra T. V.* **Abstract***:* C:N ratio of lake sediments provide valuable information about the source and proportions of terrestrial, phytogenic and phycogenic carbon and nitrogen. This study has been carried out in Varthur lake which is receiving sewage since many decades apart from large scale land cover changes. C:N profile of the surficial sediment layer collected in the rainy and the dry seasons revealed higher C:N values[43] due to the accumulation of autochthonous organic material mostly at the deeper portions of the lake. This also highlights N limitation in the sludge either due to uptake by micro and macro-biota or rapid volatilization, denitrification and possible leaching in water. Organic Carbon was lower towards the inlets and higher near the deeper zones. This pattern of Organic C deposition was aided by gusty winds and high flow conditions together with impacts by the land use land cover changes in the watershed. Spatial variability of C:N in surficial sediments is significant compared to its seasonal variability. This communication provides an insight to the pattern in which nutrients are distributed in the sludge/sediment and its variation across seasons and space impacted by the biotic process accompanied by the hydrodynamic changes in the lake.	86-92
	Paper Title, Authors, Abstract (Issue 4, Volume 5, 2011)	**Pages**
	Developing a Nomograph for Estimating Erodibility Factor of Calcareous Soils in North West of Iran *A. R. Vaezi, H. A. Bahrami, S. H. R. Sadeghi, M. H. Mahdian* **Abstract***:* In the USLE model, the soil erodibility factor (K) is measured using the average rate of soil loss from the unit plot per the unit of rainfall erosivity factor. This factor can also be estimated by the USLE nomograph on the basis of some measurable soil properties. The USLE nomograph has been developed based on	

underground soil after the rainfall flow. The substantial parameters are from AMeDAS data and detected exactly river flows dates. They are compared with actual survey of the recorded dates to check its accuracy. To develop the simulation model, the System Dynamics was used. As a consequence, a connected rainfall model and river model was constructed as good result.

Modelling Seismic Activity using a Bayesian Non-Parametric Method
S. Hernandez, P. Sallis

Abstract*:* Machine learning consists of a set of computational tools for performing large multi-dimensional data set analysis where standard statistical tests are not easily implemented. Many parametric approaches for machine learning consist of model selection and at least a two-step process. Using these techniques the underlying structure of the observed data may not be fully realised. On the other hand, Bayesian non-parametric methods perform inference operations over an infinitely greater number of parameters and because the inherent model uncertainty is also incorporated in the single-step approach, this can lead to a more robust estimation of resulting values. This paper applies this approach to the modelling geophysical events, which is a challenging spatio-temporal problem domain. This paper contributes to the ongoing investigation of optimal methods for geophysical event modelling by introducing a numerical computation solution using a Bayesian unsupervised learning algorithm with earthquake magnitude and location data from Central Chile following a recent 8.8 magnitude earthquake that destroyed many buildings and other property. It is envisaged that this method could be applied to other major earthquakes and further work is gathering data for analysis in this regard. 126-130

Automatic Generation of Chinese Phonetic Initial Field in ArcGIS Map Database and its Application
Lianhe Yang, Shanshan Ji

Abstract*:* Based on the existed ArcGIS map database, the CPI field is generated automatically for all layers. An amending method is introduced based on phrase, which is used to amend the possible CPI errors caused by Chinese polyphones. As its application, CPI inquiry functionality is added to the original ArcGIS map and further extended into customary abbreviation inquiry functionality, which makes ArcGIS map inquiry efficient and humanized. 131-134

Production of Alkali Felspar and Nepheline at the Cerro Siete Cabezas Complex (Alto Paraguay): A Pilot Study
Francesco Comin-Chiaramonti, Luca Zanetti, Piero Comin-Chiaramonti

Abstract*:* A pilot study, relative to the feldsparsnepheline eco-sustainable exploitation, was planned in an economically depressed area from the Paraguyan Chaco, i.e. Alto Paraguay river, Cerro Siete Cabezas complex. The latter represents an alkaline complex made of prevailing syenitic rocks. A twenty years business plan may allow to a whole profit of about 304 U$ million dollars, and a final conversion to a touristic locality similar to that existing in the near brazilian side of the Paraguay river, i.e. Porto Murtinho town. Analogous industrial models may be applied to the many similar alkaline complexes in the South America platform. 135-141

Risks and Vulnerabilities of Future Satellitebased Tracking Systems
Miikka Ohisalo, Otto Tiuri, Tatu Urpila, Pasi Kamppi, Jyri Rajamaki

Abstract*:* This study finds out if in the future, some special risks and vulnerabilities concerning satellite-based tracking and navigation occur. The concept of risks plays an important role in future studies and in all future thinking. To find out possible future risks, future research methods such as scenarios and weak signal

LEMBAR PENGESAHAN

Judul	:	**A study modeling of 15 days cumulative rainfall at Purajaya Region, Bandar Lampung, Indoneisia**
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A study modeling of 15 days cumulative rainfall at Purajaya Region, Bandar Lampung, Indonesia

Ahmad Zakaria*

Abstract—Aim of this research is to study periodic modeling of 15 days cumulative rainfall time series. The study was undertaken using 25 years (1977–2001) data of Purajaya region. The series of the daily rainfall data assumed was trend free. The periodic component of 15 days cumulative rainfall time series could be represented by using 253 harmonic expressions. The stochastic component of the 15 days cumulative rainfall was using the 3rd order autoregressive model. Validation of generated 15 days cumulative rainfall series was done by comparing between the generated with the measured rainfall series. The correlation coefficient between the generated or synthetic rainfall series with the measured rainfall series with the number of the data *N* is equal to 512 days for 25 years was found to be 0.99996. Therefore, developed model could be used for future prediction of 15 days cumulative rainfall time series.

Index Terms - 15 days cumulative rainfall, fast Fourier transform, autoregressive model, least squares method.

I. Introduction

To design water consuming of irrigation, detailed information about the rainfall with respect to time is required. To provide long sequence record of rainfall data was very difficult, so sometime to extend the rainfall record, generating the synthetic rainfall record is necessary. Various methods have been used by Engineers and scientists to provide this information. Most the existing methods are either deterministic or probabilistic in nature [3] and [2]. While the former methods do not consider the random effects of various input parameter, the later method employ the concept of probability to the extent that the time based characteristics of rainfalls are ignored. With the ever increasing demand for accuracy of analyzing rainfall data, these methods are no longer sufficient.

The rainfalls are periodic and stochastic in nature, because they are affected by climatological parameter, i. e., periodic and stochastic climate variations are transferred to become periodic and stochastic components of rainfalls. Hence the rainfalls should be computed considering both the periodic and the stochastic parts of the process. Considering all other factors known or assumed that the rainfall is a function of the stochastic variation of the climate. Hence periodic and stochastic analysis of rainfall time series will provide a mathematical model that will account for the periodic and stochastic parts and will also reflect the variation of rainfalls.

During the past years, some researches that study the periodic and stochastic modeling have been published by [4] [5] [7] [8] [9] [10].

Aim of this research is to generate the sequences of 15 days cumulative rainfall time series for Purajaya station using fast Fourier transform and least squares methods. The model can be used to provide synthetic and reasonably rainfall data for planning the irrigation or water resource projects in the future.

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II. Materials and Methods

2.1. Study Area

The study area comes under the humid region of the sub-district of West Lampung, Profince of Lampung, Indonesia.

2.2. Collection of Rainfall Data

Daily rainfall data of Purajaya region was collected from Indonesian Meteorological, Climatological and Geophysical Agency, Profince of Lampung. Rainfall data for a period of 25 years (1977-2001) was used in the study.

The mathematical procedure adopted for formulation of a predictive model has been discussed as follows: The principal aim of the analysis was to obtain a reasonable model for estimating the generation process and its parameters by decomposing the original data series into its various components.

Generally a time series can be decomposed into a deterministic component, which could be formulated in manner that allowed exact prediction of its value, and a stochastic component, which is always present in the data and can not strictly be acounted for as it is made by random effects. The time series $X(t)$ was represented by a decomposition model of the additive type [5][7][8], as folows,

$$X(t) = T(t) + P(t) + S(t) \quad (1)$$

Where, $T(t)$ is the component of trend, $t = 1, 2, 3... N$. $P(t)$ is the periodic components, and $S(t)$ is the stochastic components.

In this research, the rainfall data is assumed to have no trend. So this equation can be presented as follows,

$$X(t) \approx P(t) + S(t) \tag{2}$$

(2) is an equation to obtain the representative periodic and stochastic models of 15 days cumulative rainfall series.

2.3. Spectral Method

Spectral method is one of the transformation method which generally used in applications. it can be presented as Fourier transform [6][8][9][10] as follows,

$$P(f_m) = \frac{\Delta t}{2\sqrt{\pi}} \sum_{n=-N/2}^{n=N/2} P(t) \cdot e^{\frac{-2.\pi.i}{M}.m.n} \tag{3}$$

Where $P(t)$ is a 15 days cumulative rainfall data series in time domain and $P(f_m)$ is a 15 days cumulative rainfall data series in frequency domain. The t is a series of time that present a length of the rainfall data to N, The f_m is a series of frequencies.

Based on the rainfall frequencies resulted using Equation (3), amplitudes as functions of the rainfall frequencies can be generated. The maximum amplitudes can be obtained from the amplitudes as significant amplitudes. The rainfall frequencies of significant amplitudes used to simulated synthetic rainfalls are assumed as significant rainfall frequencies. The significant rainfall frequencies resulted in this study is used to calculate the angular frequencies (ω_r) and obtain the periodic components of Equation (4) or (5).

2.4. Periodic Components

The periodic component $P(t)$ concerns an oscillating movement which is repetitive over a fixed interval of time (Kottegoda 1980). The existence of $P(t)$ was identified by the fourier transformation method. The oscillating shape verifies the presence of $P(t)$ with the seasonal period P, at the multiples of which peak of estimation can be made by a Fourier Analysis. The frequencies of the spectral method clearly showed the presence of the periodic variations indicating its detection. The periodic component $P(t)$ was expressed in Fourier series [4] as follows,

$$\hat{P}(t) = S_o + \sum_{r=1}^{r=k} A_r \sin(\omega_r.t) + \sum_{r=1}^{r=k} B_r \cos(\omega_r.t) \tag{4}$$

Equation (4) could be arranged to be Equation as follows,

$$\hat{P}(t) = \sum_{r=1}^{r=k+1} A_r \sin(\omega_r.t) + \sum_{r=1}^{r=k} B_r \cos(\omega_r.t) \tag{5}$$

Where $P(t)$ is the periodic component, $\hat{P}(t)$ is the periodic component of the model, $S_o = A_{k+1}$ is the mean of the rainfall time series ω_r is the angular frequency. A_r and B_r are the coefficients of Fourier components.

2.5. Stochastic Components

The stochastic component was constituted by various random effects, which could not be estimated exactly. A stochastic model in the form of autoregressive model was used for the presentation in the time series. This model was applied to the $S(t)$ which was treated as a random variable. Mathematically, an autoregressive model of order p can be written as:

$$S(t) = \varepsilon + \sum_{k=1}^{p} b_k.S(t-k) \tag{6}$$

Equation (6) may be arranged as,

$$S(t) = \varepsilon + b_1.S(t-1) + b_2.S(t-2) + ... + b_p.S(t-p) \tag{7}$$

Where, b_r is the parameter of the autoregressive model. ε is the constant of random numbers. $r = 1, 2, 3, 4,..., p$ is the order of stochastic components. To get the parameter of the autoregressive model and the constant of random number, least squares method can be applied.

2.6. Least Squares Method

2.6.1. Analysis of periodic components

In curve fitting, as an approximate solution of periodic components $P(t)$, to determine Function $\hat{P}(t)$ of Equation (4) and (5), a procedure widely used is least squares method. From Equation (5) we can calculate sum of squares [4] as follows,

$$\text{Sum of squares} = J = \sum_{t=1}^{t=m} \left\{P(t) - \hat{P}(t)\right\}^2 \tag{8}$$

Where J is depends on A_r B_r, and ω_r. A necessary condition for J be minimum is as follows,

$$\frac{\partial J}{\partial A_r} = \frac{\partial J}{\partial B_r} = 0 \quad \text{with } r = 1,2,3,4,5,...,k \tag{9}$$

Using the least squares method, we can find equations as follow,

a. mean of series,

$$S_o = A_{k+1} \tag{10}$$

b. amplitudes of significant harmonics,

$$C_r = \sqrt{A_r^2 + B_r^2} \tag{11}$$

c. phases of significant harmonics,

$$\varphi_r = \arctan\left(\frac{B_r}{A_r}\right) \tag{12}$$

Mean of 15 days cumulative rainfalls, amplitudes, and phases of significant harmonics can be substituted into an equation as follow,

$$\hat{P}(t) = S_o + \sum_{r=1}^{r=k} C_r.Cos\left(\omega_r.t - \varphi_r\right) \tag{13}$$

Equation (13) is harmonic model of the 15 days cumulative rainfall where can be found based on the 15 days cumulative rainfall data series of Purajaya.

2.6.2. Analysis of stochastic components

Based on the results of the simulations obtained from periodic rainfall models, stochastic components S (t) can be generated. The stochastic component is the difference between rainfall data series with calculated rainfall series obtained from periodic model. Stochastic series as a residual rainfall series, which can be presented as follows,

$$S(t) \approx X(t) - P(t) \tag{14}$$

(14) can be solved by using the same way with the way that used to get periodic rainfall series components. Following (8) and (9), stochastic models (7) can be arranged to be as follows,

$$\text{Sum squares of error} = J = \sum_{t=1}^{t=m} \left\{S(t) - \hat{S}(t)\right\}^2 \tag{15}$$

Where J is sum square of error. It depends on the Ɛ and b_r values, where the coefficients can only be minimum value if it satisfies the equation as follows,

$$\frac{\partial J}{\partial \varepsilon} = \frac{\partial J}{\partial b_r} = 0 \quad \text{with } r = 1, 2, 3, 4, 5, ..., p \tag{16}$$

In the next, by using (16) stochastic parameters ε and b_r of the residual rainfall data can be calculated.

III. Results and Discussion

For testing the statistical characteristics of daily rainfall series, 25 years data (1977-2001) of daily rainfall from station Purajaya was taken. The statistical characteristic of the annual mean and maximum rainfall of daily rainfall series were estimated. Figure 1 shows the daily rainfall time series.

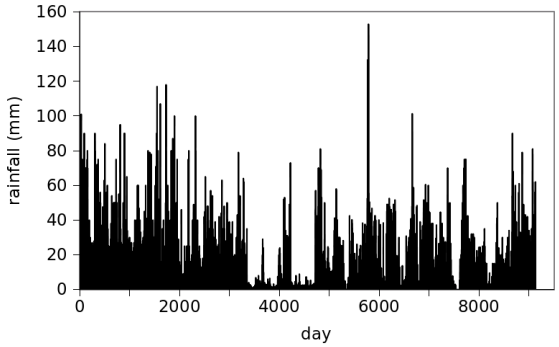

Figure 1. Daily rainfall time series for 25 years from Purnajaya station.

From Figure 1 is presented mean annual daily rainfall values vary from 2 mm in the year of 1986 to 12.5 mm in the year of 1977. Maximum annual daily rainfall values vary from 35 mm in the year of 1986 to 152.9 mm in the year of 1992. For annual cumulative daily rainfall indicate minimum value of 552.5 mm in the year of 1989 and maximum value of 4308.9 mm in the year of 1996 with mean annual cumulative daily rainfall value of 2553.5 mm. Based on daily rainfall time series, a series of 15 days cumulative rainfall was generated as presented in Figure 2,

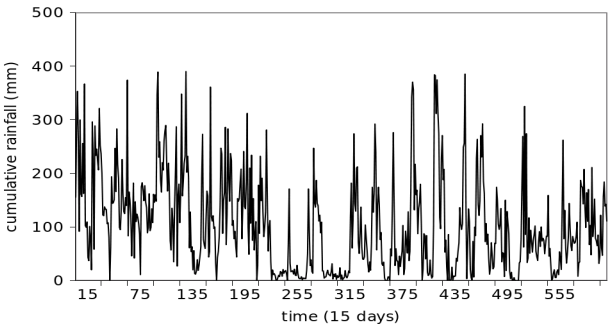

Figure 2. Variation of 15 days cumulative rainfall series for 25 years from Purajaya station.

A number of the daily rainfall series N is about 9131 days. From the daily rainfall series, a series of 15 days cumulative rainfall was generated. The length of the 15 days cumulative rainfall series is about 608 points. From the series, the statistical analysis of the 15 days cumulative rainfall series has been estimated. It was found that maximum value of 15 days cumulative rainfall annually were vary from 31.4 mm in the year of 1989 up to 390 mm in the year of 1982.

In order to running periodic model, periodogram of rainfall series should be generated before. A power of 2 must be used to enable using fast Fourier transformation method. For this case, a number of 512 data points was used to find the periodogram of periodic modeling. Result of the Fourier transformation is presented in Figure 3 as follows,

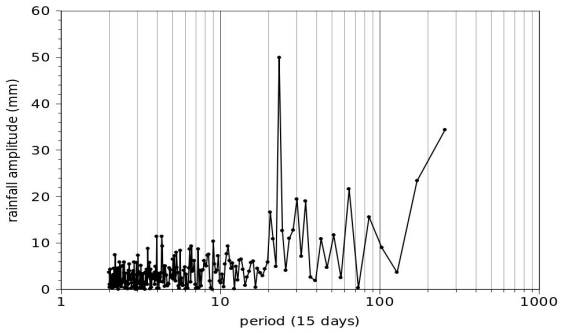

Figure 3. Variation periodogram of the 15 days cumulative rainfall for 25 years from Purajaya station.

From Figure 3 shown maximum amplitude of the 15 days cumulative rainfall is occurred at 52.1326 mm for period of 365.7149 days or nearly one year. It indicates that the annual component of periodicity is quite dominant compared with the others. The spectrum above is presented in the rainfall amplitudes as a function of periods.

To confirm the presence of periodic component in the 15 days cumulative rainfall series and to generate dominant rainfall frequencies, the Fourier transform method was applied. For modeling and generation the 253 dominant rainfall frequencies of the 15 days cumulative rainfall, 512 data points of rainfall data series were used. The generated frequencies were obtained by using an algorithm which proposed by [1] where the number of data N to be analyzed is a power of 2, i. e. $N = 2^k$. Based on the results, periodic modeling of the 15 days cumulative rainfall series, calculated and measured rainfalls are presented in Figure 4 and 5. The statistical parameters of 15 days cumulative rainfall are presented in Table 1 and Table 2.

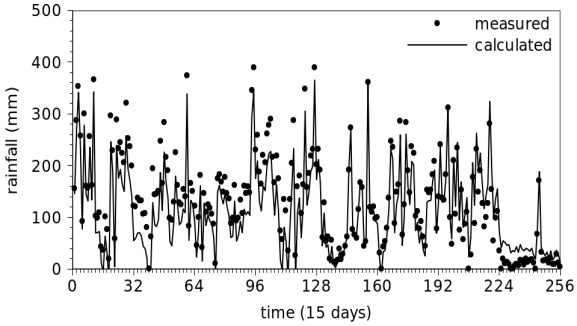

Figure 4. Variations of measured and calculated rainfall series for 25 years from Purajaya station using periodic model (1 ~ 256).

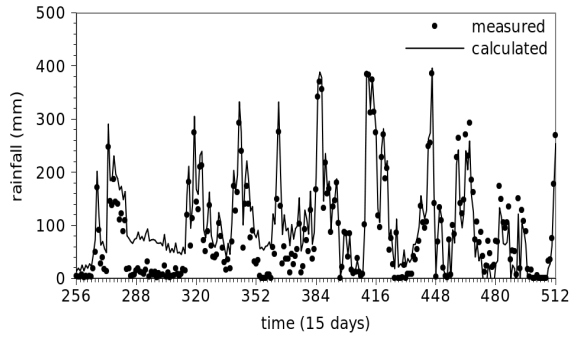

Figure 5. Variations of measured and calculated rainfall series for 25 years from Purajaya station using periodic model (256 ~ 512).

TABLE 1
10 MAXIMUM AMPLITUDES OF 253 PERIODIC COMPONENTS

No	Period (day)	Amplitude (mm)
1	365.7149	52.1326
2	3839.8635	23.5065
3	480.0000	22.5415
4	1279.9848	20.4015
5	548.5686	19.4426
6	960.0000	18.6756
7	320.0000	17.0262
8	511.9988	16.5882
9	384.0000	16.1898
10	1536.0109	15.8058

TABLE 2
STATISTICAL PARAMETERS OF PERIODIC RAINFALL DATA

Statistical parameters of cumulative rainfall series	***values***
Root Mean Squares (RMS)	30.53
Standard of Deviation (SD)	18.3401
Coefficient of Correlation (R)	0.9239

Coefficient of Variance	0.6006
Coefficient of Skewness (Cs)	0.2887
Coefficient of Curtosis (Cc)	2.0702

Based on the results of periodic modeling, the residual of cumulative rainfall was generated by using Equation (14) is presented in Figure 6 and Figure 7.

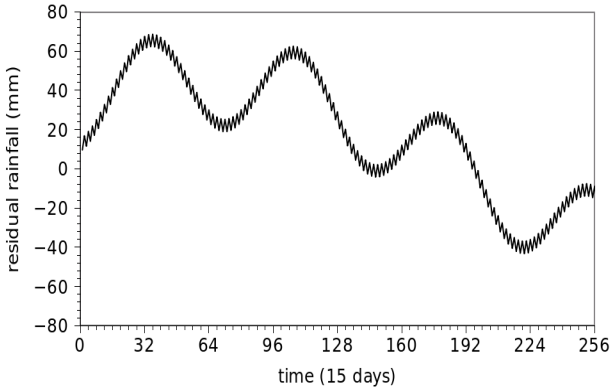

Figure 6. Residual variation of measured and calculated 15 days cumulative rainfall for Purajaya station (1 ~ 256).

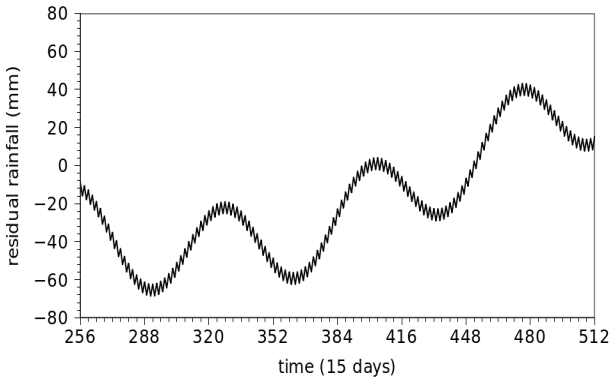

Figure 7. Residual variation of measured and calculated 15 days cumulative rainfall for Purajaya station (256 ~ 512).

TABLE 3
AUTOREGRESSIVE PARAMETERS FOR 3TH ORDER ACCURACIES

autoregressive parameters	***value***
ε	0
b_1	0.9562
b_2	0.9955
b_3	−0.9550

Autoregressive parameters presented in Table 3 results the best fit for the stochastic model of the residual rainfall. Based on the results, comparison between measured and calculated residual 15 days cumulative rainfall are presented in Figure 8 and Figure 9. These results show that the calculated results have good agreement with measured results.

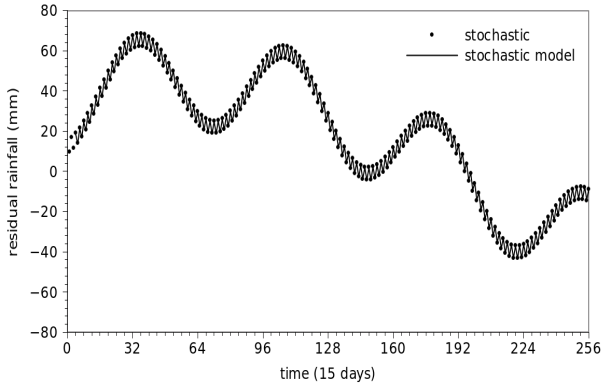

Figure 8. Variations of measured and calculated residual 15 days cumulative rainfall for Purajaya station (1 ~ 256).

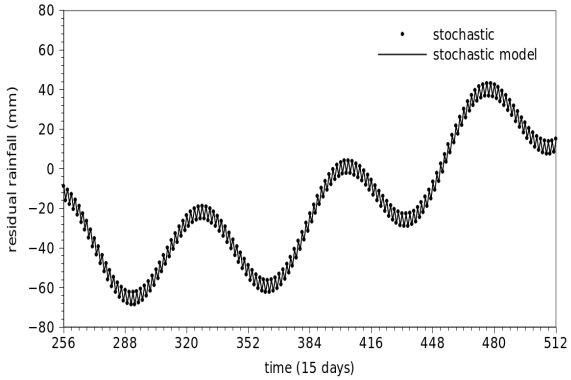

Figure 9. Variations of measured and calculated residual 15 days cumulative rainfall for Purajaya station (256 ~ 512).

A comparison between the measured 15 days cumulative rainfall and the calculated 15 days cumulative rainfall of the periodic and stochastic modeling as shown in Figure 10 and Figure 11 indicate that, the calculated 15 days cumulative rainfall of the periodic and stochastic models gives highly accurate results.

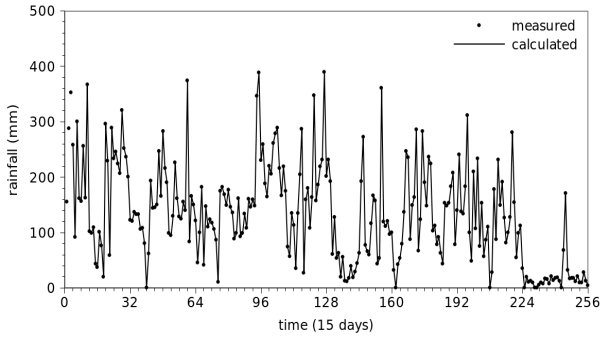

Figure 10. Variations of measured and calculated 15 days cumulative rainfall series for Purajaya station using periodic and stochastic model (0 ~ 256).

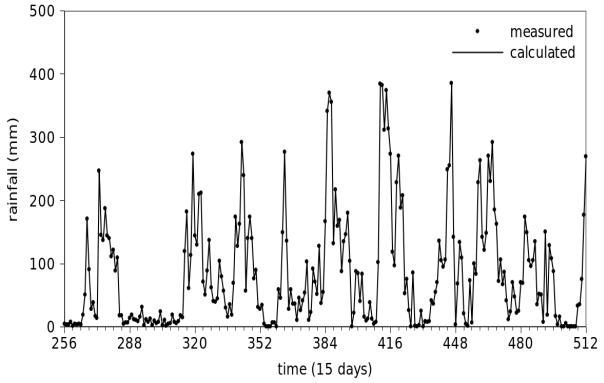

Figure 11. Variations of measured and calculated 15 days cumulative rainfall series for Purajaya station using periodic and stochastic model (256 ~ 512).

For modeling of the periodic rainfall provides the correlation coefficient *R* is 0.9239. For modeling of the stochastic rainfall is using 3rd orders autoregressive model gives the correlation coefficient *R* is 0.9997. For modeling of stochastic and periodic 15 days cumulative rainfall giving the correlation coefficient between the data and the model increases to be 0.99996. The coefficient correlation *R* is almost close to 1. This shows that the model of periodic and stochastic 15 days cumulative rainfall is almost close to the pattern of rainfall 15 days cumulative rainfall data. It indicates that the periodic and stochastic models can give more accurate and significant result.

Variation of the correlation coefficient of the stochastic model R(S), the correlation coefficient of the periodic and stochastic model R(P+S) and the error of the 15 days cumulative rainfall versus the orders of the autoregressive model can be seen in the Fig. 12.

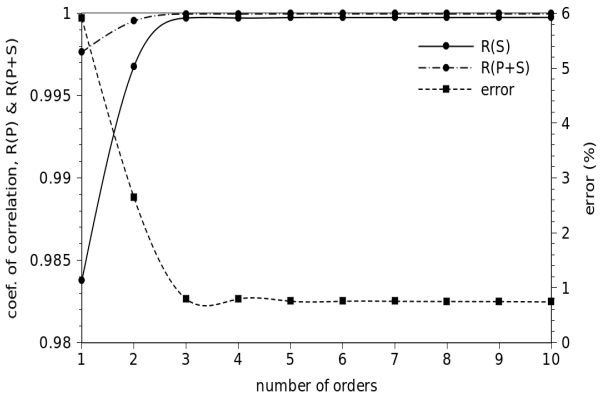

Figure 12. Variations of error, correlation coefficients of stochastic (S), periodic and stochastic (P+S) models for different stochastic orders.

Based on, the results presented in Fig. 12 shows that using the 3rd order autoregressive model can give better accuracy results than the 2nd order autoregressive model. For the accuracy of the 4th order up to the accuracy of the 10th order did not provide more significant results, if it is compared with the accuracy of the 3rd order autoregressive model. So in this research, the stochastic component is modeled using the 3rd order autoregressive model. The correlation coefficient *R* and the error (%) for modeling of the synthetic periodic rainfall give the correlation coefficient is equal to 0.9239 and the error is equal to 28%. For modeling the periodic and stochastic rainfalls provides the correlation coefficient is equal to 0.99996 and the error is equal to 0.79 %.

The 15 days cumulative rainfall modeling in this research can be compared to the synthetic rainfall modeling such as have been done by [5] and [7], where in the modeling they only use a few periodic and stochastic parameters. To model the synthetic rainfall, in his work, [5] using up to six harmonic components and with stochastic components using 3rd order autoregressive model. For [7], in the research, they use only three harmonic components with stochastic component for 1st order autoregressive model. In this research, more complex solution is conducted than previous researches. Even though by using 253 periodic components, the harmonic modeling of 15 days cumulative rainfall in this research is done easily. Because, by applying the fast Fourier transforms (FFT), the dominant rainfall frequencies of the 15 days cumulative rainfall can be generated quickly.

Behavior of the stochastic 15 days cumulative rainfall can be seen such as presented in Fig. 8 and Fig. 9. The stochastic components series is the difference between the 15 days cumulative rainfall data with the periodic model series. From the figures they present that the stochastic component fluctuates in value from - 68.6 mm up to 68.6 mm. The correlation coefficient of stochastic models with the accuracy of the 3rd order is equal to 0.9997, while the 1st order autoregressive model of the stochastic model is equal to 0.9838. The result is better when compared with the results presented by [7] which uses stochastic model for the accuracy

of the 1st order and give the coefficient correlation for stochastic model of 0.9001.

By using the 253 periodic components and 3rd order autoregressive model yield the simulation model of 15 days cumulative rainfall accurately, with a correlation coefficient is equal to 0.99996. The correlation coefficient presented in Fig. 12 is proof that periodic and stochastic models (P + S) of 15 days cumulative rainfall has a very good correlation and accurate results when compared with only using periodic model (P) that generates correlation coefficient of 0.9239. This result also looks much better when compared to the research done by [7], where the model only using the 3 periodic components with the 1st order accuracy of stochastic component with the correlation coefficient is 0.9961.

The results also better even though compared with the research for the daily rainfall series of 25 years rainfall data which have been done by [9], where by using the 253 harmonic components, average of the correlation coefficient of periodic model is about 0.9576. In [10] by using the 253 harmonic components and the 2nd order autoregressive model, average of the correlation coefficient of stochastic model is about 0.9989 and for the correlation coefficient of periodic and stochastic models is about 0.99993.

IV. Conclusion

The spectrum of the 15 days cumulative rainfall time series generated by using the FFT method is used to simulate the synthetic 15 days cumulative rainfall. By using the least squares method, the 15 days cumulative rainfall time series can be produced synthetic rainfall quickly. By using 253 periodic components and 3rd order stochastic components, the 15 days cumulative rainfall model from Purajaya station can be produced accurately with the correlation coefficient of 0.99996.

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