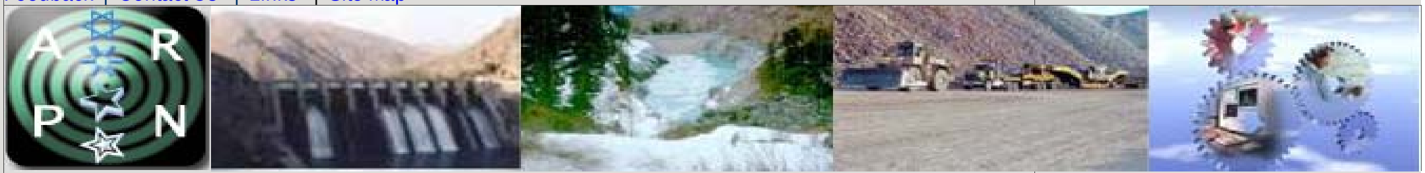

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ARPN Journal of Engineering and Applied Sciences June 2011 | Vol. 6 No. 6

Title: A numerical approach for the spread of gonorrhea in homosexuals

Author (s): R. Rama Kishore and N. Ch. Pattabhiramacharyulu

Abstract: This paper presents a simple mathematical model of gonorrhea in homosexual population. This model is characterized by a pair of non-linear first order ordinary differential equations reflecting the growth rates of promiscuous and infectives in a homosexual population and here cured infectives are separated from the main stream for further investigation. Numerical examples are given to explain the effect of cure rate and infective rate on the spread and control of the disease, and also estimated for lower cure rates.

Full Text

Title: Z-source inverter with a new space vector PWM algorithm for high voltage gain

Author (s): U. Shajith Ali and V. Kamaraj

Abstract: This paper presents a methodology to apply a novel space vector pulse width modulation control for three phase Z-source inverter. The space vector modulation for the conventional voltage source inverter is modified so that the additional shoot-through states are inserted within the zero states. So zero voltage time period is diminished for generating a shoot-through time, and active states are unchanged. The shoot-through states are evenly distributed to each phase within zero state. The shoot-through time is used for controlling the dc link voltage boost and hence the output voltage boost of the inverter. This new method provides a high voltage gain at higher modulation index. The proposed algorithm is verified with simulation and experiment. MatLab/Simulink is used for simulating the complete circuit with RL load. The frequency spectra of the output voltage and current are explored.

Full Text

Title: Optimisation of engine operating parameters for eucalyptus oil mixed diesel fueled DI diesel engine using Taguchi method

Author (s): Tamilvendhan D., Ilangovan V. and Karthikeyan R.

Abstract: The present investigation used Eucalyptus oil, distilled oil from leaf of eucalyptus as an alternate fuel for diesel fuel. Generally, Eucalyptus oil possesses low cetane number which is not sufficient to operate existing diesel engine. However, this could be admissible along with diesel fuel in the form of blends. Keeping this in mind experiments have been conducted using blends of Eucalyptus oil and diesel fuel to study its replace ability, performance and emission behaviour. As the investigation involves three parameters such as blend proportion, injection timing and injection pressure, a simultaneous optimisation method called Taguchi was used in the work. This method requires fewer numbers of trials for fixing optimum levels. This is the primary advantage of this method. As per this method nine trials were experimented and its results were used for optimisation. In addition, an ANOVA was also performed for the parameters to evaluate its percentage contribution over the desired output. The results of the taguchi experiment showed that the 40Eu blend (40% Eucalyptus oil and 60% diesel) performed better at 29°BTDC injection timing and at 180 bar injection pressure than other blends and had a capacity to cold start the engine. Using the optimum levels, a full range experiment was also conducted using 40Eu blend to compare its performance and emission behaviour with standard diesel operation. The results of the full range experiment showed that the 40Eu blend offered approximately 2.5% higher brake thermal efficiency than diesel baseline operation without much worsening the exhaust emission.

Full Text

Title: Stochastic characteristics of daily rainfall at Purajaya region

Author (s): Ahmad Zakaria

Abstract: Aim of this research is to study stochastic characteristics of daily rainfall 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 components of daily rainfall series were represented by using 253 harmonic expressions and stochastic components of daily rainfall series were presented using second order autoregressive parameters. Validation of generated daily rainfall series was done by comparing between generated with measured daily rainfall series. For periodic modeling, mean of the correlation coefficient between generated and measured daily rainfall series with the number of the data N is equal to 512 days for 25 years was found to be 0,9576. For periodic and stochastic modeling, mean of the correlation coefficient was found to be 0.9999. Therefore, developed periodic and stochastic model could be used for future prediction of daily rainfall time series.

Full Text

Title: Effects analysis of additional thermal protection for retrofitted buildings

Author (s): Ioan Sârbu and Călin Sebarchievici

Abstract: One of main research direction on the construction field is the reduction of the energy consumption, which supposes materials, technology and conception of buildings with lower specific energy need on one hand and equipment with high performances on the other hand. Proper thermal rehabilitation of a building will lead to a significant reduction of heating energy demand offering a higher degree of comfort, and better condition for hygiene. At the same time the environment is less polluted. The energy saving depends on the initial building characteristics and the thermal rehabilitation level on one hand, and on the proper adjustment and control of the heating system on the other hand. In this paper is analyzed the main effects of building thermal rehabilitation, with implications upon heating energy consumption and upon comfort of the occupants. Thus, it is developed a computational model of optimum additional insulation thickness, taking into account the investment cost to improve thermal resistance of building envelope and operational costs as heating energy consumption.

Full Text

Title: Kinetic sorption study of phenol onto activated carbon derived from fluted pumpkin stem waste (*Telfairia occidentalis* hook F.)

Author (s): O. A. Ekpete and M. Horsfall Jnr

Abstract: Fluted activated carbon obtained from fluted pumpkin stem waste can be harnessed as a useful adsorbent for the removal of phenol from aqueous solution. The contact time data was modeled using pseudo, first - order, pseudo second order, Elovich, intra-particle and liquid - film diffusion. The kinetic data favoured pseudo second-order with regression value of 0.950. Thermodynamic parameters ΔH^o, ΔS^o, and ΔG^o of the adsorption of phenol onto fluted activated carbon were negative which revealed exothermic nature of the sorption process, strong bond formation between the adsorbent and adsorb ate molecules and the spontaneous nature of the adsorption with a high preference for phenol.

Full Text

Title: A 10 kW combined hybrid (wind and solar photovoltaic) energy systems for isolated generating system

Author (s): M. Muralikrishna and V. Lakshminarayana

Abstract: There is a potentially vast world market for stand-alone power sources. In rural districts of the developing world, the energy consumption per capita is very low and basic energy needs are for water pumping, electricity supplies to small hospitals, lighting, cooling and telecommunications. Often the cost of connection to the grid in remote locations cannot be justified. Photovoltaic and wind power can meet these needs, but either source alone provides an intermittent supply and energy storage is needed to deliver a reliable supply. However, these two sources are complementary since sunny days are usually calm and strong winds are often accompanied by cloud and may occur at night. A combined plant therefore has higher availability than either individual source and so needs less storage capacity. A stand-alone electrical supply system is described which combines the output of wind a solar Photovoltaic generating systems. The experimental system comprise wind and solar collectors, each of 5 KW rating, with a lead-acid battery for storage and a 10 KW PWM inverter for the final output. The wind turbine generator is a 200 rpm, direct drive, Permanent-magnet, axial-flux machine based on the 'Torus' configuration. Its three-phase output is rectified to form a variable-voltage dc link. The power converter uses two dc-dc converters connected in series, each with a bypass diode which conducts continuously when the corresponding source is not available. For all load demands the levelised energy cost for PV-wind hybrid system is always lower than that of standalone solar PV or wind

system. The PV wind hybrid option is techno-economically viable for rural electrification.

Full Text

Title: Performance of voltage source multilevel inverter - fed induction motor drive using Simulink

Author (s): Neelashetty Kashappa and Ramesh Reddy K.

Abstract: This paper deals with performance of voltage source multilevel inverter-fed induction motor drive. A Voltage source inverter (VSI) is compared with multilevel inverter. A conventional Voltage Source Inverter-fed induction motor drive is modeled and simulated using Matlab/ Simulink and the results are presented. Multilevel inverter employing Selective Harmonic Elimination (SHE) method is also simulated and the corresponding results are presented. The FFT spectrum for the outputs is analyzed to study the reduction in harmonics.

Full Text

Title: Investigation on start-up characteristics of cryogenic heat pipes

Author (s): M. Senthil Kumar and A. Senthil Kumar

Abstract: Heat pipe is a device which transfers heat from one location to another with a small temperature gradient. Application includes use of cryogenic heat pipe in cooling infrared sensors, laser systems, cryocoolers, thermal control large superconducting magnets and tumor surgery. This paper deals with transient behavior of cryogenic heat pipes with wire mesh and axial grooved wick using nitrogen and oxygen as working fluid. A special liquid nitrogen cryostat has been designed and developed for evaluating the transient behavior of heat pipes at 77 K when the condenser portion is connected to the cold sink externally. In this study, the start-up characteristic of heat pipes is experimentally investigated.

Full Text

Title: Effect of wetting and drying on the geotechnical properties of lime - fly ash stabilized collapsible residual sand

Author (s): F. N. Okonta and E. Govender

Abstract: Berea Red Sands underlying most of the Kwazulu Natal midlands and coastal plain is a very recent unconsolidated, weakly cemented red to brown, collapsible sands. The effect of wetting and drying cycles on the UCS and CBR of compacted and cured samples of stabilized Berea Sands was investigated. Different sample mix were prepared with 4% and 8% Lime and 0%, 6% 12% and 18% Fly Ash, and tested after 4, 8 and 12 cycles of wetting and drying. Changes in mass of the stabilized sands were measured to facilitate the interpretation of changes in strength properties. The result showed reduction in UCS and CBR with increase in the number of wetting and drying cycles that is dependent on the amount of Lime and Fly Ash and the ratio of Lime to Fly Ash. For Given amount Fly Ash, samples stabilized with 8% Lime are more durable than samples stabilized with 4% Lime. Also durability increases with increase in Fly Ash content, for samples stabilized with 4% Lime to a maximum UCS associated with 12% Fly Ash, excess quantities of Fly Ash results in decreased durability. For samples stabilized with 8% Lime, increase in Fly Ash quantities results in an increase in durability for up to 18% Fly Ash used in this research. The process of wetting and drying results in general reduction in the mass of the test samples, and the percentage reduction in mass decreases with increase in quantities of Fly Ash. In the long term, defined by 12 cycles of wetting and drying, only the 8% lime and 18% fly ash material have adequate CBR under the operative drainage conditions to sustain the stresses applied by traffic loadings.

Full Text

Title: Impact of embedding renewable distributed generation on voltage profile of distribution system: A case study

Author (s): Akash T. Davda, M. D. Desai and B. R. Parekh

Abstract: Present scenario of Power system operation is contingency-constrained, and often associated with voltage limit violation problems. In this paper, the low voltage problems in an existing 2.2 MVA conventional electricity distribution network of a particular area of Gujarat State, India, have been identified and solved by injecting Renewable Distributed Generation at appropriate locations. The results of the simulations carried out using distribution system software were analyzed with respect to voltage at different nodes thereby identifying low voltage areas which were again studied by injecting RDGs at different locations and the results were analyzed. The final analysis revealed that there was no low voltage problem at any node on the network. It has been concluded that looking to serious environmental problems like pollution, greenhouse gas emissions, and long and over loaded lines attached to conventional electric power generation, transmission and distribution Networks, the injection of Renewable Distributed Generation can give a solution to low voltage problems. Reduction in losses and increased reserve capacity of the distribution network are the added advantages.

Full Text

Title: Studies on tribological properties of ZnO filled polymer nano composites

Author (s): Naga Raju B., Ramji K. and Prasad V. S. R. K.

Abstract: The tribological behavior of polyester filled with ZnO nano particles was studied. For this study, ZnO nano particles were synthesized and size was found to be 34nm. The synthesized ZnO nano particles organically functionalized with γ-aminopropyltriethoxysilane (APS). The functionalized ZnO nano particles are mixed with polyester resin through ultra sonication for getting uniform dispersion. The wear samples were prepared by mixing 1wt%, 2wt%, 4wt% and 6wt% ZnO nano particles with polyester resin. The wear properties are studied by using pin-on-disc apparatus. The 1% ZnO nano polyester composite has excellent wear properties when compared to pure polyester. The characteristics of ZnO nano polyester composite is also studied by using Scanning Electron Microscopy (SEM). Filling of nano ZnO particles in polyester changed the microstructure of polyester and prevented the destruction of polyester banded structure during the friction process which might be one of the anti-wear mechanisms of nano ZnO. The improved and best tribo-performance of the composite can be attributed due to particular mechanical properties of nano particles.

Full Text

Title: Mechanics of deformation during open die forging of sintered preform: comparative study by equilibrium and upper bound methods

Author (s): Parveen Kumar, R. K. Ranjan and Rajive Kumar

Abstract: The paper reports on an investigation into the various aspects of open die forging of metal powder preforms, which have been compacted and sintered from atomized metal powder. An attempt has been made for the determination of the relative average die pressure developed for given geometries of the disc during the open die forging of sintered metal powder preform by using an upper bound and equilibrium method approach as different frictional stresses are assumed on top and bottom interfaces. The deformation characteristics of metal powder preform has been demonstrated by applying an appropriate interfacial friction law and yield criteria. The results so obtained are discussed critically to illustrate the interaction of various process parameters involved and are presented graphically.

Full Text

Title: Production and characterization of micro and nano AL_2O_3 particle-reinforced LM25 aluminium alloy composites

Author (s): S. M. Suresh, Debadutta Mishra, A. Srinivasan, R. M. Arunachalam and R. Sasikumar

Abstract: LM25 aluminum alloy metal matrix composites (MMCs) reinforced with weight fractions of micro and nano Al_2O_3 particles up to10 wt.% were produced by stir casting. The composites thus produced were characterized for their mechanical properties such as hardness and tensile strength as well as for the dispersion of the micro and nano Al_2O_3 particles. The results reveal that stir casting could be an economical route for the production of nano composites. Nano particle reinforced MMCs exhibit better hardness and strength when compared to micro particles reinforced composites. Scanning electron microscopic observations of the microstructures revealed that the dispersion of the micron size particles where more uniform while nano particles led to agglomeration of the particles.

Full Text

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STOCHASTIC CHARACTERISTICS OF DAILY RAINFALL AT PURAJAYA REGION

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ABSTRACT

Aim of this research is to study stochastic characteristics of daily rainfall 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 components of daily rainfall series were represented by using 253 harmonic expressions and stochastic components of daily rainfall series were presented using second order autoregressive parameters. Validation of generated daily rainfall series was done by comparing between generated with measured daily rainfall series. For periodic modeling, mean of the correlation coefficient between generated and measured daily rainfall series with the number of the data N is equal to 512 days for 25 years was found to be 0,9576. For periodic and stochastic modeling, mean of the correlation coefficient was found to be 0.9999. Therefore, developed periodic and stochastic model could be used for future prediction of daily rainfall time series.

Keyword: daily rainfall, fast fourier transform, fourier analysis, autoregressive model, least squares method.

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, Kotegoda, (1980) and Yevjevich (1972). 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 rainfall. Hence the rainfall 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 series will provide a mathematical model that will account for the periodic and stochastic parts and will also reflect the daily variation of rainfall.

During the past years, some researches that study the periodic and stochastic modeling have been published by Zakaria (1998), Rizalihadi (2002), Bhakar (2006), Zakaria (2008). Rizalihadi (2002) and Bhakar (2006) studied periodic and stochastic modeling for monthly rainfall series, but Zakaria (2008) have studied for daily rainfall series.

Aim of this research is to study stochastic characteristics of daily rainfall series in Purajaya using fast Fourier transform, Fourier analysis, autoregressive model and method of least squares. The model can be used to provide synthetic and reasonably rainfall data for planning the irrigation or water resource projects in the future.

MATERIALS AND METHODS

Study area

The study area comes under the humid region of the subdistrict of West Lampung, Profince of Lampung, Indonesia.

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 or periodic 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, as folows: (Rizalihadi, 2002; Bhakar, 2006; dan Zakaria, 2008),

$$X_{(t)} = T_{(t)} + P_{(t)} + S_{(t)} \qquad (1)$$

Where

$T_{(t)}$ = trend component
$P_{(t)}$ = periodic component

$S_{(t)}$ = stocastic component
t = 1,2,3,...,N
N = number of observation points

The trend component describes the long smooth movement of the variable lasting over the span of observations, ignoring the short term fluctuations. A hypothesis of no trend was made. So the equation can be presented as an equation as follows:

$$X_{(t)} \approx P_{(t)} + S_{(t)} \quad (2)$$

Equation (2) is as a approximation equation to model a periodic and stochastic modeling of daily rainfall.

Spectral method

Spectral method is one of the transformation method which widely used in many applications. it can be presented as Fourier transform as follows, (Zakaria, 2003; Zakaria, 2008):

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

Where P (t_n) is a daily rainfall data series in time domain and P (f_m) is a daily rainfall data series in frequency domain. Where the P (f_m) is used in Equation (4) and (5) as an angular frequency (ω_r). The t_n 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 rainfalls frequencies of significant amplitudes have been used to simulated synthetic daily rainfalls were assumed as significant rainfall frequencies. The significant rainfall frequencies resulted in this study was used to calculate the angular frequencies and obtain the periodic components of Equation (4) or (5).

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 $P(f_m)$ was identified by the fourier transformation method. The oscillating shape verifies the presence of $P(f_m)$, with the seasonal period, 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 as follows (Zakaria, 1998):

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

Equation (4) could be arranged to be Equation (5) as follows,

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

Where

$\hat{P}(t)$ = model of periodic component
$S_o = A_{K+1}$ = mean of daily rainfall (mm)
ω_r = angular frequencies (rad)
t = time (day)
A_r, B_r = Fourier coefficients
k = number of significant harmonics

Stochastic components

The stochastic component was constituted by various random effects, which could not be estimated exactly. In the case of rainfall series from Purajaya region. A stochastic model in the form of autoregressive model was used for the presentation in the time series. This model was applied to the $\hat{S}(t)$ which was treated as a random variable. The deterministic components were removed and the residual was stationary in nature. Mathematically, an autoregressive model of order p can be written as follows:

$$\hat{S}_t = \varepsilon + \sum_{j=1}^{j=k} b_j .S_{t-j} \quad (6)$$

Equation (6) can be presented as follows:

$$\hat{S}_t = \varepsilon + b_1 .S_{t-1} + b_2 .S_{t-2} + ... + b_k .S_{t-k} \quad (7)$$

Where

b_k = autoregressive model parameters
ε = independent random number
j = 1, 2, 3, 4, ..., k
k = number of stochastic order

To generate a number of model parameters and independent random number of the stochastic model, method of least squares was applied.

METHOD OF LEAST SQUARES

Determination of periodic parameters

In curve fitting, as an approximate solution of periodic components P (t), to determine Function $\hat{P}(t)$ of Equation (5), a procedure widely used is method of least squares. From Equation (5) we can calculate sum of squares (Zakaria, 1998) as follows:

Sum of squares =

$$J = \sum_{t=1}^{t=m} \left\{ P(t) - \hat{P}(t) \right\}^2 \quad (8)$$

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

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

Using method of least squares, we can find equations as follow:

a) mean of daily rainfall,

$$S_o = A_{k+1} \quad (10)$$

b) amplitude of significant harmonic,

$$C_r = \sqrt{A_r^2 + B_r^2} \quad (11)$$

c) phase of significant harmonic,

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

Mean of daily rainfall, amplitudes, and phases of significant harmonics can be substituted into an equation as follows:

$$\hat{P}(t) = S_o + \sum_{r=1}^{r=k} C_r.Cos(\omega_t.t - \varphi_r) \quad (13)$$

Equation (13) is a harmonic model of daily rainfall where can be found based on daily rainfall series of Purajaya.

Estimation of autoregressive parameters

Using Equation (2) we can find stochastic component of daily rainfall as follows:

$$S_{(t)} \approx X_{(t)} - \hat{P}_{(t)} \quad (14)$$

Following Equation (8), using Equation (14) and Equation (7) we can calculate sum of squares as follows:

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

Where J depends on ε and b_k. A necessary condition for J to be minimum is

$$\frac{\partial J}{\partial} = \frac{\partial J}{\partial b_k} = 0 \text{ with } k = 1,2,3,4,5,...,p \quad (16)$$

Using method of least squares, we can find independent random number ε and autoregressive model parameters b_k.

RESULTS AND DISCUSSIONS

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.

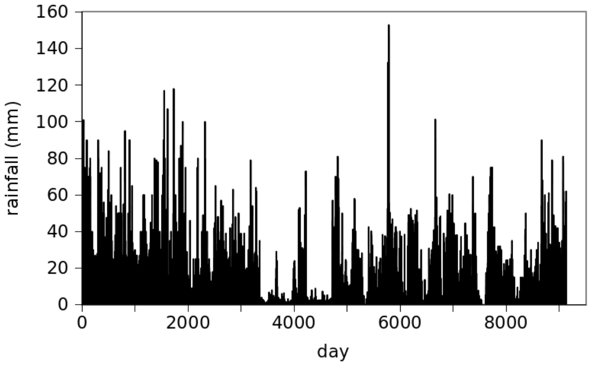

Figure-1. Variation of daily rainfall series for 25 years from Purajaya station.

Based on the analysis, mean annual daily rainfall values vary from 2.00 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 1986 to 152.9 mm in the year of 1992. The variation may be attributed towards the natural changes in yearly climate. Annual cumulative rainfall of Purajaya indicates minimum 552.5 mm in the year of 1989 and maximum 4308.9 mm in the year of 1996 with mean annual cumulative rainfall 2553.5 mm.

Figure-1 presented the 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.

Spectrum of daily rainfall time series can be generated using fast Fourier transform method. For 25 years daily rainfall data, result of the Fourier transformation is presented in Figure-2 as follows:

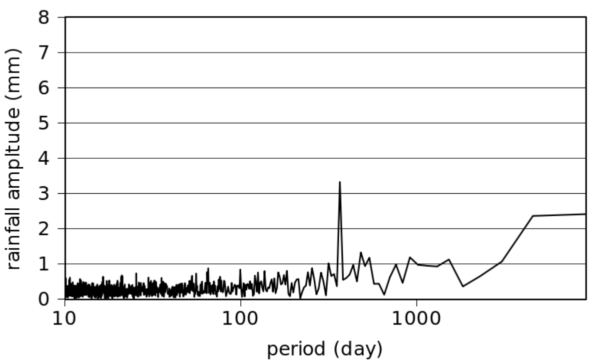

Figure-2. Variation of daily rainfall period series for 25 years from Purajaya station.

Figure-2 shows that the maximum amplitude of daily rainfall is occurred at 3.3255 mm for period of 365.2 days or 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. Spectrum of daily rainfall data presented in Figure-2 was generated by using the FFT toolbox of the Matlab software.

To confirm the presence of periodic component in daily rainfall series, the Fourier transform method was applied to generate dominant rainfall frequencies. For one year daily rainfall data, 512 days of rainfall data series were used to get the dominant rainfall frequencies. The generated frequencies were obtained using an algorithm which proposed by Cooley and Tukey (1965) where the number of data N to be analyzed is a power of 2, i.e., N = 2 k. Based on the results, spectrum of one year daily rainfall, calculated and measured daily rainfalls for the year of 1977 are presented in Figures 3 and 4 as follows:

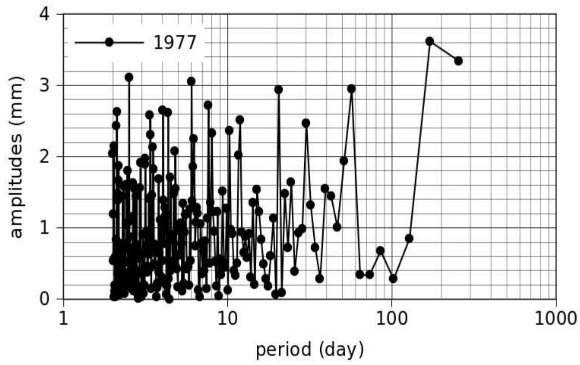

Figure-3. Variation of daily rainfall periods in the year of 1977.

Figure-3 presents periods of daily rainfall for the year of 1977, using a number of data, N equal to 512. The data is started at 1st of January for every year. The Figure presents the daily rainfall amplitudes as a function of the daily rainfall periods. The daily rainfall amplitudes vary highly. It indicates that the values of rainfall periodicities also vary highly.

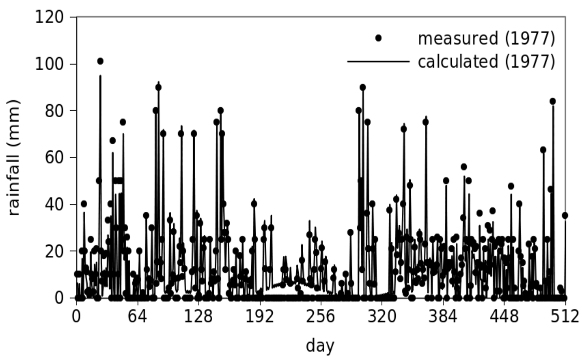

Figure-4. Variation of measured and predicted daily rainfall in the year of 1977. (P)

Figure-4 presents periodic modeling and measured daily rainfall series in the year of 1977 for a number of the data, N is equal to 512. The 253 significant periods were generated from the spectrum of daily rainfall. The significant frequencies of calculated daily rainfall series presented here were found using the rainfall periods of daily rainfall series presented in the Figures-3. Calculated daily rainfall series presented here are predicted values of the best fitting model. Because of measured daily rainfall series highly varies in time, so calculated daily rainfall time series significantly varies in time.

Using Equation (14), stochastic components of daily rainfalls at Purajaya region have been calculated. Stochastic components of daily rainfall in the year of 1977 is presented in Figure-5 as follows:

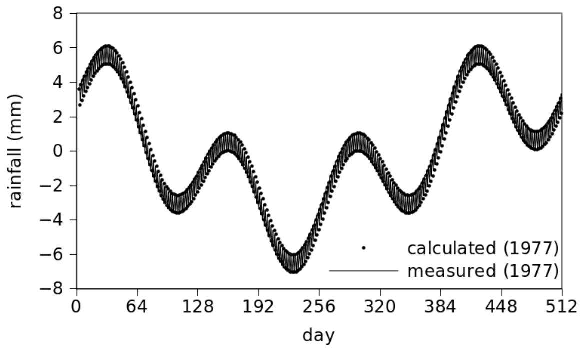

Figure-5. Stochastic components of calculated and measured rainfall in the year of 1977.

Based on an analysis of stochastic components of daily rainfall in the year of 1977 resulted in Figure-5, a periodic and stochastic modeling of daily rainfall for year of 1977 is found such as presented in Figure-6.

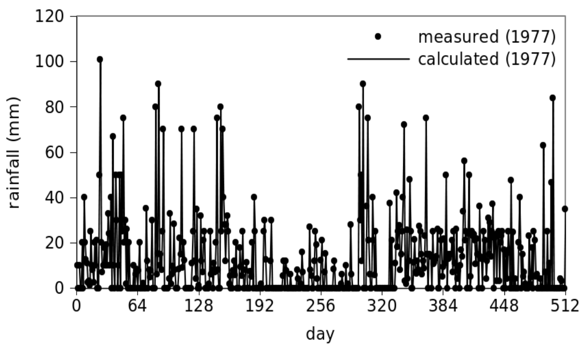

Figure-6. Variation of measured and predicted daily rainfall in the year of 1977.(P+S)

For stochastic components of daily rainfall from the years of 1977 to 2000 are presented in Figure-7 to Figure-29.

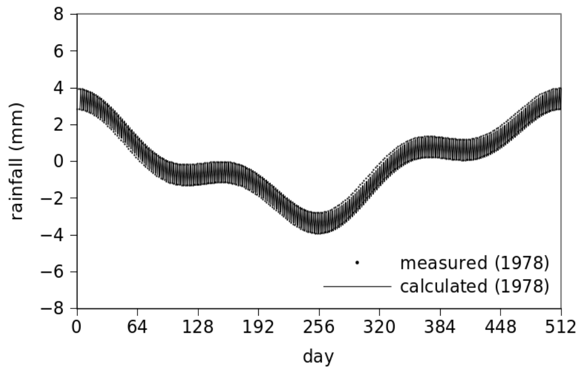

Figure-7. Stochastic components of measured and calculated rainfall in the year of 1978.

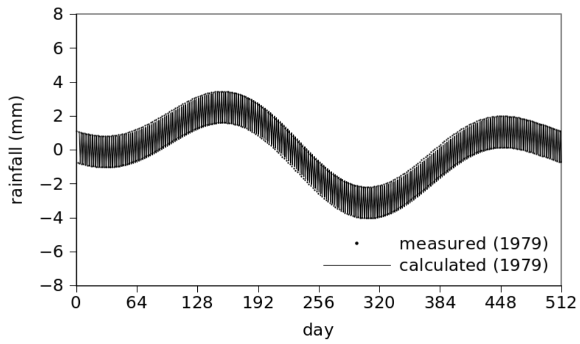

Figure-8. Stochastic components of daily rainfall in the year of 1979.

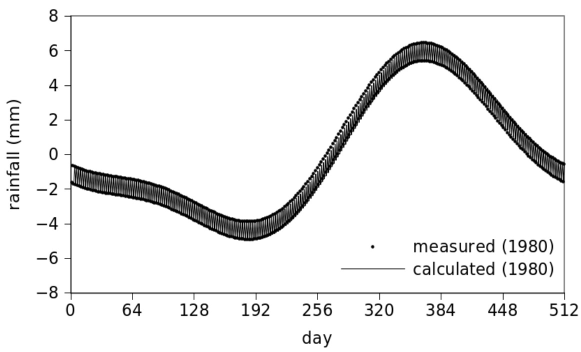

Figure-9. Stochastic components of measured and calculated rainfall in the year of 1980.

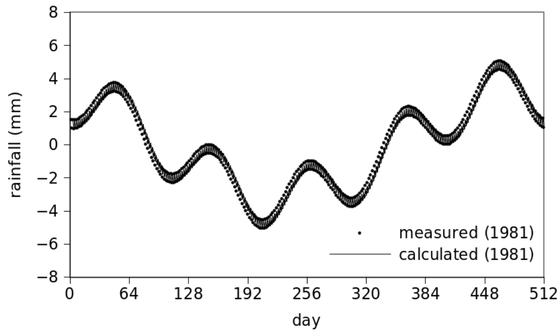

Figure 10. Stochastic components of measured and calculated rainfall in the year of 1981.

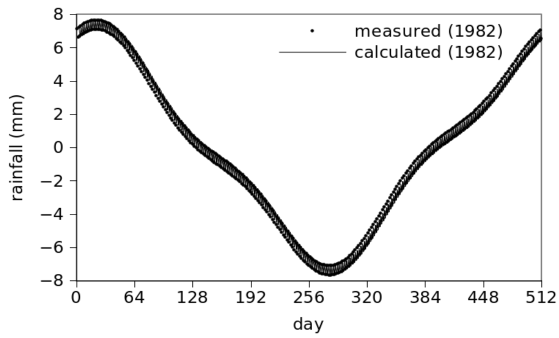

Figure-11. Stochastic components of measured and calculated rainfall in the year of 1982.

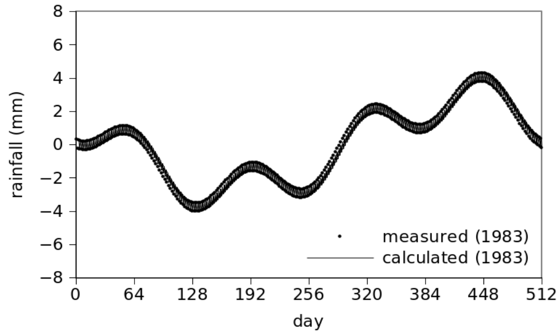

Figure-12. Stochastic components of measured and calculated rainfall in the year of 1983.

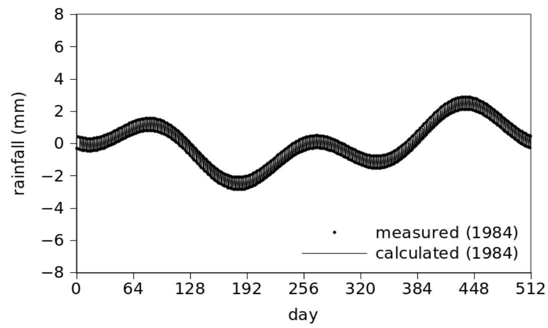

Figure 13. Stochastic components of measured and calculated rainfall in the year of 1984.

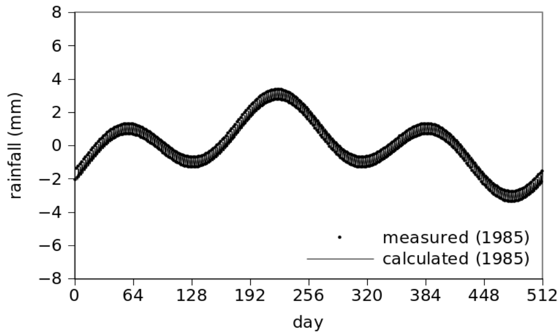

Figure-14. Stochastic components of measured and calculated rainfall in the year of 1985.

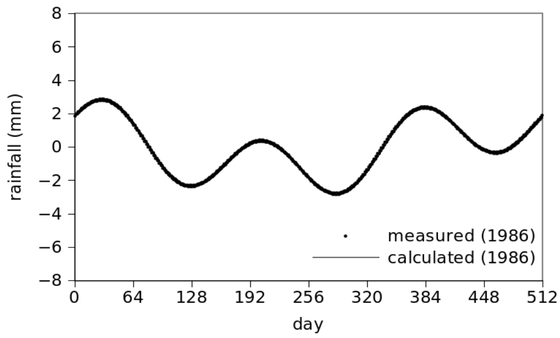

Figure-15. Stochastic components of measured and calculated rainfall in the year of 1986.

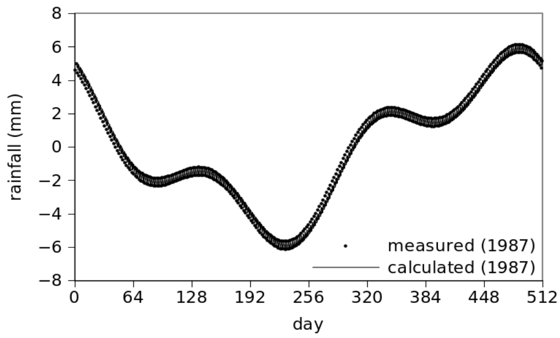

Figure-16. Stochastic components of measured and calculated rainfall in the year of 1987.

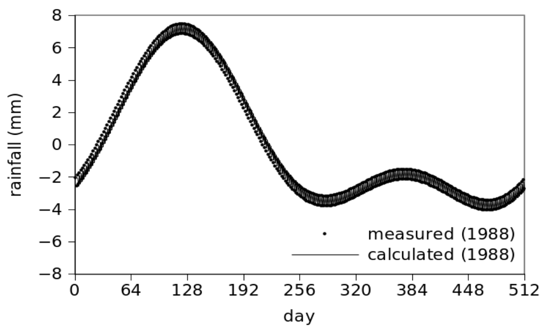

Figure-17. Stochastic components of measured and calculated rainfall in the year of 1988.

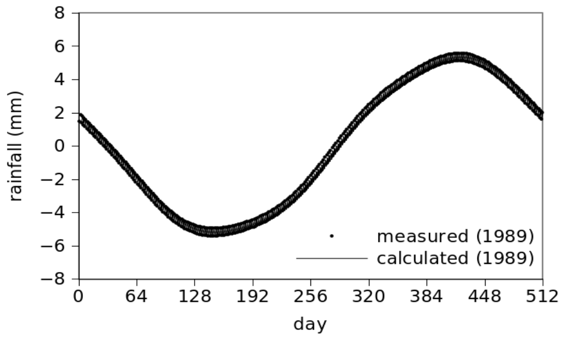

Figure-18. Stochastic components of measured and calculated rainfall in the year of 1989.

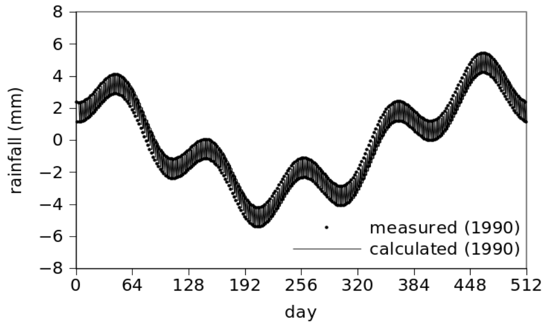

Figure-19. Stochastic components of measured and calculated rainfall in the year of 1990.

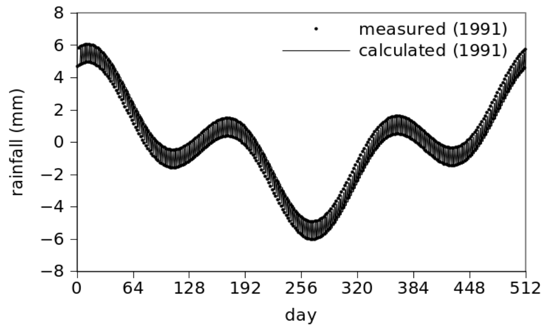

Figure-20. Stochastic components of measured and calculated rainfall in the year of 1991.

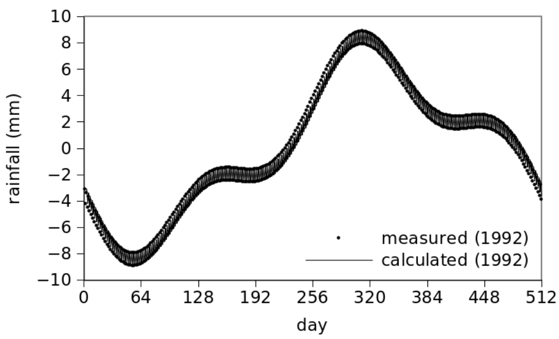

Figure-21. Stochastic components of measured and calculated rainfall in the year of 1992.

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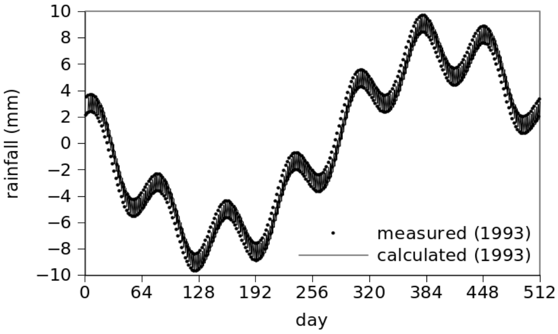

Figure-22. Stochastic components of measured and calculated rainfall in the year of 1993.

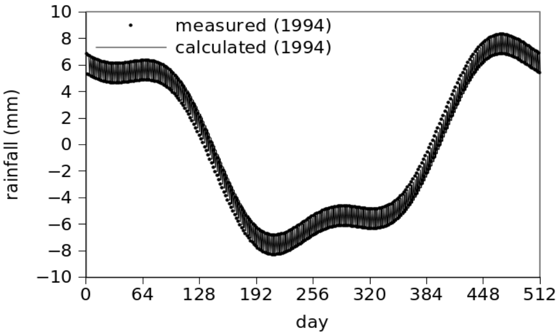

Figure-23. Stochastic components of measured and calculated rainfall in the year of 1994.

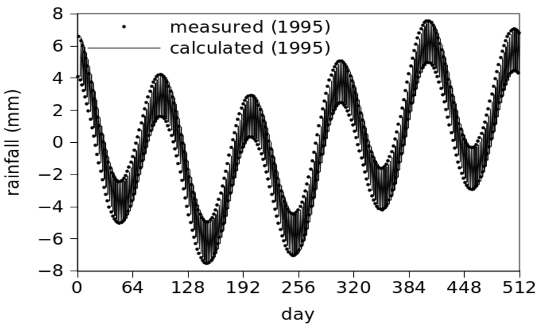

Figure-24. Stochastic components of measured and calculated rainfall in the year of 1995.

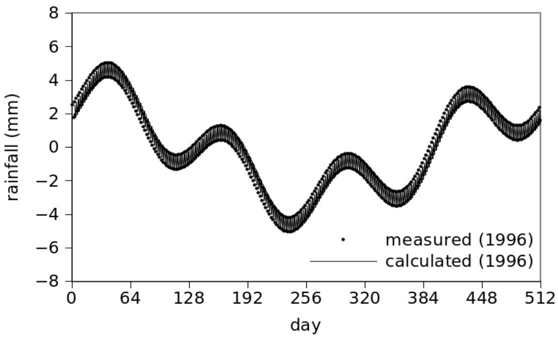

Figure-25. Stochastic components of measured and calculated rainfall in the year of 1996.

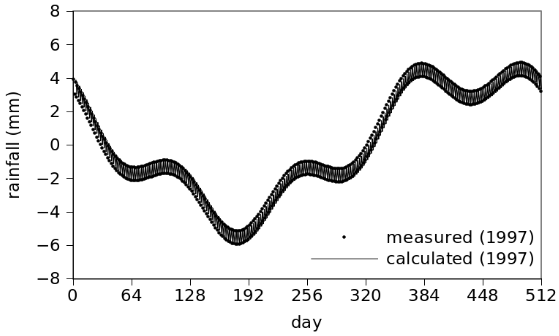

Figure-26. Stochastic components of measured and calculated rainfall in the year of 1997.

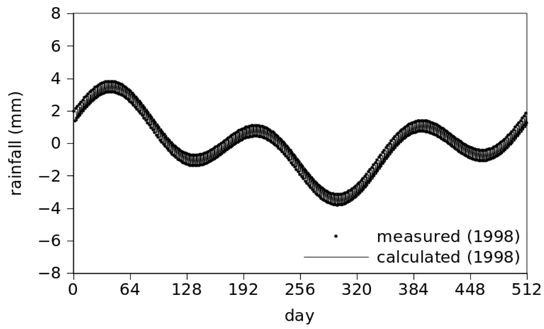

Figure-27. Stochastic components of measured and calculated rainfall in the year of 1998.

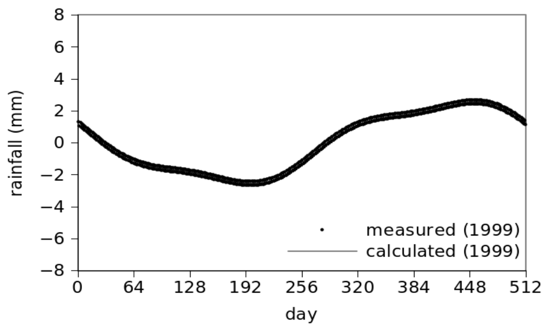

Figure-28. Stochastic components of measured and calculated rainfall in the year of 1999.

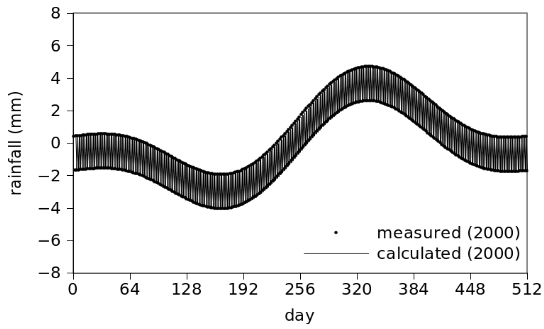

Figure-29. Stochastic components of measured and calculated rainfall in the year of 2000.

Stochastic components of measured and calculated daily rainfall presented from Figure-7 to Figure-29 show that the shapes of the stochastic components of measured and calculated daily rainfall quite vary for every year. It is indicated that the stochastic characteristics of daily rainfall series significantly vary yearly.

Independent random number (ε) and second order (b_1 and b_2) autoregressive model parameters of the periodic modeling of daily rainfall for 25 years at Purajaya region are presented in Figure-30 as follows:

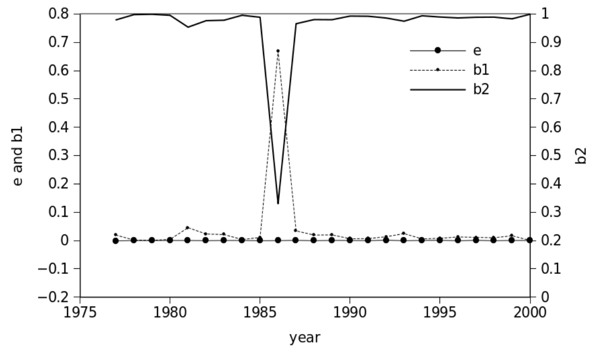

Figure-30. Variation of independent random number (ε) and autoregressive model parameters (b_1, b_2) for 25 years at Purajaya region.

Figure-30 indicates that the parameters of periodic modeling relatively is not quite varies yearly.

A coefficient of correlation R is as the best fitting parameter to measure level of correlation between calculated and measured daily rainfall series data. From the results as presented in Figure-31, it indicates that the coefficients of correlation are varying for every year.

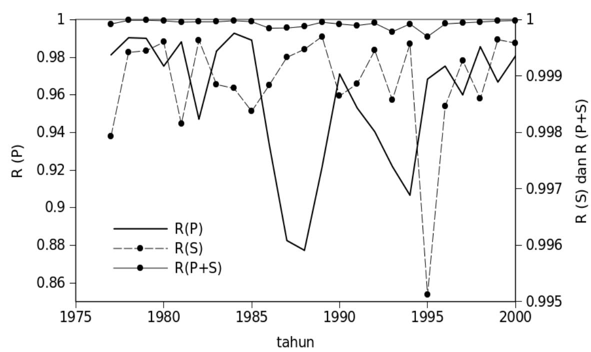

Figure-31. Correlation coefficients of the periodic R (P) stochastic R (S) and periodic + stochastic R (P+S) models.

For the periodic modeling of daily rainfall series, the R values vary from 0.8773 in the year of 1988 up to 0.9928 in the year of 1984 with the mean of correlation coefficient to be 0.9576. The stochastic modeling presents that the R values vary from 0.9951 in the year of 1995 up to 0.9997 in the year of 1989 with the mean of correlation coefficient to be 0.9989. For the periodic and stochastic modeling, the R values vary from 0.9997 in the year of 1995 up to 0.99999 in the year of 1979 with the mean of correlation coefficient to be 0.99993. The periodic modeling indicated that at the years, 1987 and 1988 occurred highly variation of the climate. Also the years before 1985 have least variation of the climate if it is compared with the years after 1985.

CONCLUSIONS

By using fast Fourier transform, autoregressive model, Fourier analysis and method of least squares, calculated daily rainfall series can be produced synthetic rainfall series significantly. Spectrum of daily rainfall series generated by using Fast Fourier Transform can be used to simulated synthetic daily rainfall series accurately.

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