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On Ramsey Minimal Graphs for a 3-Matching Versus a Path on Five Vertices

Kristiana Wijaya, Edy Tri Baskoro, Asep Iqbal Taufik, Denny Riama Silaban

Let G, H, and F be simple graphs. The notation F ⟶ (G, H) means that any red-blue coloring of all edges of F contains a red copy of G or a blue copy of H. The graph F satisfying this property is called a Ramsey (G, H)-graph. A Ramsey (G, H)-graph is called minimal if for each edge e ∈ E(F), there exists...

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Ramsey Graphs for a Star on Three Vertices Versus a Cycle

Maya Nabila, Edy Tri Baskoro, Hilda Assiyatun

Let G, A, and B be simple graphs. The notation G → (A, B) means that for any red-blue coloring of the edges of G, there is a red copy of A or a blue copy of B in G. A graph G is called a Ramsey graph for (A, B) if G → (A, B). Additionally, if the graph G satisfies that G − e ↛ (A, B), for any e ∈ E(G),...

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On Ramsey (mK_2, P_4)-Minimal Graphs

Asep Iqbal Taufik, Denny Riama Silaban, Kristiana Wijaya

Let F, G, and H be simple graphs. The notation F → (G, H) means that any red-blue coloring of all edges of F will contain either a red copy of G or a blue copy of H. Graph F is a Ramsey (G, H)-minimal if F → (G, H) but for each $e \in$ E(F), $(F - e) \nrightarrow$ (G, H). The set $\mathscr{R}$(G, H) consists of all Ramsey (G,...

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Spectrum of Unicyclic Graph

Budi Rahadjeng, Dwi Nur Yunianti, Raden Sulaiman, Agung Lukito

Let G be a simple graph with n vertices and let A(G) be the (0, 1)-adjacency matrix of G. The characteristic polynomial of the graph G with respect to the adjacency matrix A(G), denoted by χ(G, λ) is a determinant of (λI − A(G)), where I is the identity matrix. Suppose that λ1 ≥ λ2 ≥ ⋯ ≥ λn are the adjacency...

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Distinguishing Number of the Generalized Theta Graph

Andi Pujo Rahadi, Edy Tri Baskoro, Suhadi Wido Saputro

A generalized theta graph is a graph constructed from two distinct vertices by joining them with l (>=3) internally disjoint paths of lengths greater than one. The distinguishing number D(G) of a graph G is the least integer d such that G has a vertex labelling with d labels that is preserved only...

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Edge Magic Total Labeling of (*n, t*)-Kites

Inne Singgih

An edge magic total (EMT) labeling of a graph G = (V, E) is a bijection from the set of vertices and edges to a set of numbers defined by λ: V ∪ E → {1,2, ..., |V| + |E|} with the property that for every xy ∈ E, the weight of xy equals to a constant k, that is, λ(x) + λ(y) + λ(xy) = k for some integer...

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Further Result of *H*-Supermagic Labeling for Comb Product of Graphs

Ganesha Lapenangga P., Aryanto, Meksianis Z. Ndii

Let G = (V, E) and H = (V', E') be a connected graph. H-magic labeling of graph G is a bijective function f: V(G) ∪ E(G) → {1,2, ..., |V(G)| + |E(G)|} such that for

every subgraph H'of G isomorphic to H, ∑v ∈ V(H') f(v) + ∑e ∈ E(H') f(e) = k
Moreover, it is H-supermagic labeling if f(V) = {1,2 ,..., |V|}....

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Labelling of Generalized Friendship, Windmill, and Torch Graphs with a Condition at Distance Two

Ikhsanul Halikin, Hafif Komarullah

A graph labelling with a condition at distance two was first introduced by Griggs and Robert. This labelling is also known as L(2,1)-labelling. Let G = (V, E) be a non-multiple graph, undirected, and connected. An L(2,1)-labelling on a graph is defined as a mapping from the vertex set V(G) to the set...

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On the Minimum Span of Cone, Tadpole, and Barbell Graphs

Hafif Komarullah, Ikhsanul Halikin, Kiswara Agung Santoso

Let G be a simple and connected graph with p vertices and q edges. An L(2,1)-labelling on the graph G is a function f: V(G) → {0,1, ..., k} such that every two vertices with a distance one receive labels that differ by at least two, and every two vertices at distance two receive labels that differ by at...

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L(2,1) Labeling of Lollipop and Pendulum Graphs

Kusbudiono, Irham Af'idatul Umam, Ikhsanul Halikin, Mohamat Fatekurohman

One of the topics in graph labeling is L(2,1) labeling which is an extension of graph labeling. Definition of L(2,1) labeling is a function that maps the set of vertices in the graph to non-negative integers such that every two vertices u, v that have a distance one must have a label with a difference...

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Magic and Antimagic Decomposition of Amalgamation of Cycles

Sigit Pancahayani, Annisa Rahmita Soemarsono, Dieky Adzkiya, Musyarofah

Consider G = (V, E) as a finite, simple, connected graph with vertex set V and edge set E. G is said to be a decomposable graph if there exists a collection of subgraphs of G, say $\mathscr{H}$ = {Hi|1 ≤ i ≤n} such that for every i ≠ j, Hi is isomorphic to Hj, ∪ i=1n Hi = G and should satisfy that E(Hi) ∩ E(Hj)...

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A Minimum Coprime Number *for Amalgamation of Wheel*

Hafif Komarullah, Slamin, Kristiana Wijaya

Let G be a simple graph of order n. A coprime labeling of a graph G is a vertex labeling of G with distinct positive integers from the set {1, 2, ..., k} for some k ≥ n such that any adjacent labels are relatively prime. The minimum value of k for which G has a coprime labelling, denoted as $\mathfrak{pr}$(G), is...

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Rainbow Connection Number of Shackle Graphs

M. Ali Hasan, Risma Yulina Wulandari, A.N.M. Salman

Let G be a simple, finite and connected graph. For a natural number k, we define an edge coloring c: E(G) → {1,2,..., k} where two adjacent edges can be colored the same. A u – v path (a path connecting two vertices u and v in V(G)) is called a rainbow path if no two edges of path receive the same color....

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Local Antimagic Vertex Coloring of Corona Product Graphs $P_n \circ P_k$

Setiawan, Kiki Ariyanti Sugeng

Let G = (V, E) be a graph with vertex set V and edge set E. A bijection map f : E → {1,2, ..., |E|} is called a local antimagic labeling if, for any two adjacent vertices u and v, they have different vertex sums, i.e. w(u) ≠ w(v), where the vertex sum w(u) = Σe ∈ E(u) f(e), and E(u) is the set of edges...

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Local Antimagic Vertex Coloring of Gear Graph

Masdaria Natalina Br Silitonga, Kiki Ariyanti Sugeng

Let G = (V, E) be a graph that consist of a vertex set V and an edge set E. The local antimagic labeling f of a graph G with edge-set E is a bijection map from E to {1, 2, ..., |E|} such that w(u) ≠ w(v), where w(u) = ∑e ∈ E(u) f(e) and E(u) is the set of edges incident to u. In this labeling, every vertex...

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Implementations of Dijkstra Algorithm for Searching the Shortest Route of Ojek Online and a Fuzzy Inference System for Setting the Fare Based on Distance and Difficulty of Terrain (Case Study: in Semarang City, Indonesia)

Vani Natali Christie Sebayang, Isnaini Rosyida

Ojek Online is a motorcycle taxi that is usually used by people that need a short time for traveling. It is one of the easiest forms of transportation, but there are some obstacles in hilly areas such as Semarang City. The fare produced by online motorcycle taxis is sometimes not in accordance with the...

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Mohamad Hasan

During the deposition process, many factors play a role in the dynamics of the system including materials' characteristics and media onto which the materials dropped. The stick-slip model has been applied to simulate the depositions of polydisperse granular materials. As the size of the materials varied,...

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Natanael Karjanto

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Agustina Pradjaningsih, Fatmawati, Herry Suprajitno

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Generalization of Chaos Game on Polygon

Kosala D. Purnomo

The original chaos game has been applied to the triangular attractor points. With the rules for selecting attractor points randomly, the points generated in large iterations will form like a Sierpinski triangle. Several studies have developed it on the attractor points of quadrilaterals, pentagons, and...

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High Order Three-Steps Newton Raphson-like Schemes for Solving Nonlinear Equation Systems

Rizki Multazamil Fatahillah, M Ziaul Arif, Rusli Hidayat, Kusbudiono, Ikhsanul Halikin

This study proposes several new 3-steps schemes based on the Newton-Raphson method for solving non-linear equation systems. The proposed schemes are analysed and formulated based on the Newton-Raphson method and the Newton-cotes open form numerical integration method. In general, the schemes can be considered...

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Symmetry Functions with Respect to Any Point in R^n and Their Properties

Firdaus Ubaidillah

A function f : R → R is said to be an odd function if f(−x) = −f(x) for every x in R. The graph of an odd function is symmetric with respect to the origin, that is the point (0,0). The aims of this paper are to generalize odd functions on Rn and introduce symmetry functions with respect to any point...

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Root Water Uptake Process for Different Types of Soil in Unsteady Infiltration from Periodic Trapezoidal Channels

Millatuz Zahroh, Imam Solekhudin

This study involves a non-linear partial differential equation known as Richard's Equation. An unsteady infiltration from trapezoidal periodic irrigation channel with root-water uptake is considered as the problem. To solve the problem, A set of transformations, Kirchhoff transformation, dimensionless...

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Alvida Mustika Rukmi, Wildan Zakky, M. Lutfhi Shahab

In 2020, the world is facing a Covid-19 virus pandemic. The fields of epidemiology and networks are needed in dealing with its spread. Individual (contact) tracing is an important control measure in the spread of infectious diseases. The network of contacts describes the potential pathways for the spread...

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Kusno, Abduh Riski

Modeling industrial objects needs the formulas of curves and surfaces to construct a precise shape of real goods and simulate some process of form creations. For this reason, the study of the equations of curves and surfaces for objects modeling is essential for resulting in a required shape and feature...

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Hanging Rotera Modeling by Joining Deformation Result of Space Geometry Objects

Een Ubaningrum, Bagus Juliyanto, Ahmad Kamsyakawuni, Firdaus Ubaidillah

The hanging rotera is a small lamp covered by a glass lid with a light source from a burning candle or LED (Light Emitting Diode) candle and hung on a support pole that is hooked to the rotera connector. The purpose of this paper are to obtain a models of the various and symmetrical components of the...

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SHINY OFFICE-R: A Web-based Data Mining Tool for Exploring and Visualizing Company Profiles

I Made Tirta, Mohamad Fatekurahman, Khairul Anam, Bayu Taruna Widjaja Putra

The profile of institutions or companies are often measured internally, nationally and internationally using several indicators that may be changed over time. We develop SHINY OFFICE-R a Web-GUI (Graphical User Interface) using R software to explore and visualize data on institution performance/ profile....

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Preeclampsia (PE) often described as new-onset hypertension and proteinuria during the third trimester of pregnancy. PE, is one of the most feared complications of pregnancy because it can progress rapidly to serious complications, including death of both mother and fetus. It is important to get a better...

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Dinagusti Sianturi, Alvida Rukmi

The COVID-19 pandemic has impact in every sector of life. Studies of the impact of the COVID-19 pandemic on stock trading are also being develo[
in Indonesia regarding to the number of industries affected by the pandemic. This research aims to provide information about the results of the correlation...

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Muhammad Hafidh Effendy, Dian Anggraeni, Yuliani Setia Dewi, Alfian Futuhul Hadi

Banks are financial institutions whose activities are to collect funds from the public in the form of deposits (saving deposit, demand deposit, and time deposit) and distribute them to the public in the form of credit or other forms. Deposits are an alternative for customers because the interest offered...

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Case Study: Three Popular Online News Sites in Indonesia

Ferry Wiranto, I Made Tirta

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Statistical Downscaling Technique Using Response Based Unit Segmentation-Partial Least Square (REBUS-PLS) for Monthly Rainfall Forecasting

Izdihar Salsabila, Alfian Futuhul Hadi, I Made Tirta, Yuliani Setia Dewi, Firdaus Ubaidillah, Dian Anggraeni

One of the newest forecasting techniques today is the Statistical Downscaling (SDs) technique. The SDs technique is a procedure for inferring high-resolution information from low-resolution variables. Forecasting rainfall using the SDs technique is to build a function that can predict the value of a...

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Nur Kamilah Sa'diyah, Ani Budi Astuti, Maria Bernadetha T. Mitakda

Poisson regression is one of the model to explain the functional relationship between response variable in the form of count and predictor variable. An important assumption in Poisson Regression analysis is equidispersion. In certain cases, where response variable consists of too many zeros, causing...

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Multiple Discriminant Analysis Altman Z-Score, Multiple Discriminant Analysis Stepwise and K-Means Cluster for Classification of Financial Distress Status in Manufacturing Companies Listed on the Indonesia Stock Exchange in 2019

Hazrina Ishmah, Solimun, Maria Bernadetha Theresia Mitakda

This study uses the MDA (Multiple Discriminant Analysis) Altman Z-Score to predict the status of financial distress in manufacturing companies listed on the Indonesia Stock Exchange in 2019. MDA Stepwise model is used to prove that the variables used in the MDA Altman Z-Score method are the best variables...

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Naive Bayes Classifier (NBC) for Forecasting Rainfall in Banyuwangi District Using Projection Pursuit Regression (PPR) Method

Ana Ulul Azmi, Alfian Futuhul Hadi, Yuliani Setia Dewi, I Made Tirta, Firdaus Ubaidillah, Dian Anggraeni

Rainfall is one of the climates that has a big influence on life, such as aviation, plantations, and agriculture. Remote areas like Banyuwangi Regency are most likely to lack information on weather and climate data. Rainfall information in the future is also very decisive for the community in carrying...

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Rufina Indriani, Erma Oktania Permatasari

One of the main problems in Papua Province is poverty, because the Poverty Depth Index (P1) in Papua Province is greater than other province, which was 7.17 in 2019. This value is bigger than the Poverty Depth Index in Indonesia which was only 1.55. This study will analyse the factors that affect the...

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Projection Pursuit Regression on Statistical Downscaling Using Artificial Neural Network and Support Vector Regression for Rainfall Forecasting in Jember

Chandrika Desyana Putri, Ema Fahma Farikha, Alfian Futuhul Hadi, Yuliani Setia Dewi, I Made Tirta, Firdaus Ubaidillah, Dian Anggraeni

Information about rainfall is very necessary for the country of Indonesia which bears the title of an agricultural country. This is because the agricultural sector is very vulnerable to climate change, where rainfall is one indicator of climate change-related to crops. Therefore, an accurate rainfall...

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Ummi Masrurotul Jannah, Mohamat Fatekurohman

Weather forecasting is one of the important factors in everyday life, because it can affect the activities carried out by the community. Weather forecasting refers to a series of activities carried out to produce a set of information about weather conditions. One method that can be used to model these...

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Anjeli Lutfiani, Bety Hayat Susanti

Modification Detection Code (MDC) as an unkeyed hash function is designed to provide data integrity. Manipulation Detection Codes (MDC-2) is one of double-length (2n-bit) hash-values that requires 2 block cipher operations per block of hash input where the output size of the hash function is twice the...

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Primary Key Encryption Using Hill Cipher Chain (Case Study: STIE Mandala PMB Site)

Muhamat Abdul Rohim, Kiswara Agung Santoso, Alfian Futuhul Hadi

The condition of the world experiencing the COVID-19 pandemic has resulted in some daily activities limited by health protocols. The Indonesian government's policy in the academic field has forced STIE Mandala Jember, as one of the private universities, to implement online-based new student admissions....

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A Modification of ECDSA to Avoid the Rho Method Attack

Amira Zahra, Kiki Ariyanti Sugeng

Elliptic Curve Digital Signature Algorithm (ECDSA) is a digital signature algorithm that utilizes an elliptic curve. ECDSA consists of three steps, w are key generation, signature generation, and verification algorithm. ECDSA is used on Bitcoin transactions to generate the user's public key, private...

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Kiswara Agung Santoso, Maulidyah Lailatun Najah, Moh. Hasan

Image is a digital media that is easy to change, so it is susceptible to being used for crime. Image changes may be affected by the unstable internet during transmission or deliberate manipulation of images for specific purposes. Hence, we need a tool to determine the authenticity of the image. One strategy...

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Pattern Recognition of Batik Madura Using Backpropagation Algorithm

Abduh Riski, Ega Bandawa Winata, Ahmad Kamsyakawuni

Since October 2, 2009, UNESCO has acknowledged batik as one of Indonesia's intellectual properties. Throughout the archipelago, distinct and diverse batik motifs have emerged and been produced with the passage of time; Madura batik is one of them. The Backpropagation Algorithm is used to recognize Madura...

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Kiswara Agung Santoso, Muhammad Bagus Kurniawan, Ahmad Kamsyakawuni, Abduh Riski

Optimization problems have become interesting problems to discuss, including the knapsack problem. There are many types and variations of knapsack problems. In this paper, the authors introduce a new hybrid metaheuristic algorithm to solve the modified bounded knapsack problem with multiple constraints...

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Statistical Downscaling Technique Using Response Based Unit Segmentation-Partial Least Square (REBUS-PLS) for Monthly Rainfall Forecasting

Izdihar Salsabila[1], Alfian Futuhul Hadi[1,*], I Made Tirta[1], Yuliani Setia Dewi[1], Firdaus Ubaidillah[2], Dian Anggraeni[1]

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ABSTRACT
One of the newest forecasting techniques today is the Statistical Downscaling (SDs) technique. The SDs technique is a procedure for inferring high-resolution information from low-resolution variables. Forecasting rainfall using the SDs technique is to build a function that can predict the value of a response variable using predictor variables, for example, the variables in the Global Circular Model (GCM). In this study, forecasting will be carried out using the Partial Least Square (PLS) model and compared with the PLS model that has been time segmented namely the REBUS-PLS model. We use four latent variables consisting of three exogenous latent variables and one endogenous latent variable. The exogenous variable ξ_1 is precipitation, ξ_2 is air pressure, and ξ_3 is temperature, while the endogenous variable is monthly rainfall. The measurement model is a functional rule that describes the mathematical relationship between exogenous latent variables ξ_1, ξ_2, and ξ_3 with their corresponding manifests. After obtaining the structural model and measurement model, then parameter estimation is carried out. The PLS model obtained was then tested for the goodness of the model with several indicators, namely R^2, mean redundancy, and Goodness of Fit. The values obtained are 70.05%, 49.098%, and 76.11%. There are 4 segmentations which are segment 1 (33 months), segment 2 (29 months), segment 3 (50 months), and segment 4 (32 months). The validity and reliability tests were carried out again in each segment. Furthermore, the goodness of the model is also tested on each local model. The R-square values generated in segment 1, segment 2, segment 3, and segment 4 are 97.13%, 97.52%, 85.05%, and 91.38%. Overall, the PLS model has a smaller RMSE than the REBUS-PLS model at 25 observation stations. Meanwhile, at the other 52 observation stations, the accuracy of the REBUS-PLS model is better than the PLS model.

Keywords: *General Circulation Model (GCM), Statistical Downscaling (SDs), Partial Least Square (PLS), Response Based Unit Segmentation-Partial Least Square (REBUS-PLS).*

1. INTRODUCTION

Rainfall is one of the climate components that is often used as a reference, especially in agriculture. The erratic condition of rainfall fluctuation in recent years has caused agricultural planning to be suboptimal. Rainfall is a meteorological element with high variability in space and time scales, making it the most difficult to predict. Rainfall has the potential for both profitable and detrimental agriculture [1]. One area that has the potential to continue to develop its agricultural sector is Jember Regency. So far, the agricultural sector is a sector that has a reasonably significant role (leading sector) for the economy of Jember Regency. The latest data released by the Jember Regency Government show that around 41.73% of the total added value created in the economy of Jember Regency comes from the agricultural sector [2]. For that, we need a support system for agricultural activities in Jember Regency, one of which is the availability of information on current and future rainfall. This relates to the fact that cropping pattern planning will need to pay attention to the amount of rainfall in the future.

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One of the most recent forecasting techniques is the statistical downscaling (SDs) technique. The SDs technique is a procedure for inferring high-resolution information from low-resolution variables. Forecasting rainfall using the SDs technique is to build a function that can predict the value of a response variable, namely rainfall using predictor variables, namely the variables in the global circular model (GCM). The Partial Least Square (PLS) model has been widely used in forecasting rainfall using statistical downscaling techniques. So far, the PLS model has been widely used in forecasting rainfall using statistical downscaling techniques. One of them is a study conducted by Estiningtyas and Wigena in 2011 [3]. The study compared the Principal Component Regression (PCR) and PLS models for forecasting rainfall under El Nino, La Nina, and normal conditions. Kurniawan states that REBUS-PLS can be done after the PLS-PM analysis finds characteristics in the quality of structural models that are not sufficiently representative, such as R^2 and Goodness of Fit (GoF) which indicate heterogeneity is not observed in the data [4]. Pratiwi, et al stated that the REBUS-PLS model was able to detect heterogeneity in the SEM-PLS model with the value of R^2 in each segment formed (local model) greater than the value of R^2 in the global model, which indicates that the local model is better than the global model [5].

In this research, forecasting will be carried out using the pls model and compared with the pls model which has been time segmented, hereinafter referred to as the rebus-pls model.

2. MATERIAL AND METHOD

2.1. Study Region

The research located was in Jember Regency. Jember Regency is one of the Regency in East Java that has an astronomical location with $113°\,16'\,28''$ E to $114°\,3'\,42''$ E longitude and $7°\,59'6''$ S to $8°\,33'56''$ S latitude. Jember Regency has an area of 3,293.34 km2 with a topographical character of fertile canyon plains in the middle and south and surrounded by mountains that extend the western and eastern borders [6]. Global Circular Model (GCM) data in this research was obtained from: http://climexp.knmi.nl/selectfield_cmip5.cgi. The area's boundaries used in this study are the latitude range of -21.25 to 3.75 and the longitude range of 101.25 to 126.25.

2.2. Data Description

In this study, two data were used, Global Circular Model (GCM) as explanatory variable and monthly rainfall data in Kabupaten Jember from January 2005 to December 2017 as the response. Monthly rainfall data in Jember Regency was obtained from 77 observation station points, each with coordinates longitude and latitude. The GCM data used are the precipitation variable (pr) in mm, air temperature (tas) in K units, and sea surface pressure (psl) in Pa units, from January 2005 to December 2017. In general, there are four latent variables. The variables used in this study are rainfall variables, precipitation variables, air temperature variables, and sea level pressure variables. The rainfall variable is composed of 77 manifest variables, each with historical rainfall data at each observation station. Meanwhile, the variables of precipitation, air temperature, and sea level pressure are each composed of 100 manifest variables, so that in total there are 377 manifest variables used in this study.

2.3. Method

2.3.1. Partial Least Square

SD modeling generally uses poorly conditioned covariates (large dimensions and has high correlation/multicollinearity). The model in this study is Partial Least Square (PLS) which can handle large-dimensional and multicollinearity problems. The first stage in the PLS model is to get a concept-based and structural model. The structural model is a design of the relationship between latent variables. We have used four latent variables consisting of three exogenous latent variables ξ and one endogenous latent variable η. The exogenous variable ξ_1 is precipitation, ξ_2 is air pressure, and ξ_3 is temperature, while the endogenous variable is monthly rainfall. The structural model of the four variables is first compiled in the form of a path matrix below:

$$A = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 \end{bmatrix}$$

If the matrix A is described in the form of a path, then the path is obtained as shown in Figure 1 below:

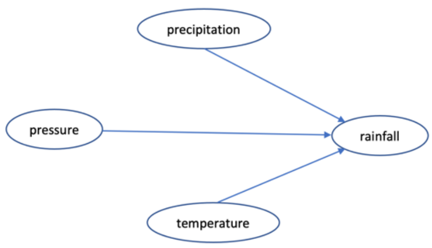

Figure 1 The Structural model trajectory.

Next, the structural model construction is carried out, so that it is obtained

$$\eta_i = [\xi_{1i} \quad \xi_{2i} \quad \xi_{3i}] \begin{bmatrix} \gamma_1 \\ \gamma_2 \\ \gamma_3 \end{bmatrix} + b \qquad (1)$$

The next step is to design a measurement model. The design of the measurement model is the process of determining the type of indicator of each latent variable. The equation below is a functional rule that describes the mathematical relationship between exogenous latent variables ξ_1 , ξ_2 , and ξ_3 with their corresponding manifestations, namely precipitation (pr), air pressure (psi), and temperature (tas). The measurement model is obtained as equation bellow:

$$\begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \end{bmatrix} = \begin{bmatrix} \lambda_{pr11} & \cdots & \lambda_{pr1010} & 0 & 0 & \cdots & \cdots & \cdots & 0 \\ 0 & \cdots & 0 & \lambda_{psl11} & \cdots & \lambda_{psl1010} & 0 & \cdots & 0 \\ 0 & 0 & \cdots & \cdots & \cdots & 0 & \lambda_{tas11} & \cdots & \lambda_{tas1010} \end{bmatrix} \begin{bmatrix} pr_{11} \\ \vdots \\ pr_{1010} \\ psl_{11} \\ \vdots \\ psl_{1010} \\ tas_{11} \\ \vdots \\ tas_{1010} \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \end{bmatrix} \tag{2}$$

The next step is to determine the measurement model for each manifest Y. Manifest γ_1, γ_2, and so on are the rainfall variables at the first, second, and so on observation stations up to the 77th station. This equation will be the final stage of the calculation of the rainfall forecasting at 77 observation stations. Here is the measurement model of measurement for Y

$$\begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_{77} \end{bmatrix} = \eta \begin{bmatrix} \lambda_{Y1} \\ \lambda_{Y2} \\ \vdots \\ \lambda_{Y77} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_{77} \end{bmatrix} \tag{3}$$

Next is the selection of the GCM variable output. One of the stages in PLS modeling is validity and reliability testing. A validity test is a test on each manifest whether it is feasible or not to be used as an explanation for the latent variables that it composes. The indicator of validity testing is to look at the loading on each manifest. The manifests included in the analysis are manifest with loading greater than 0.6. Meanwhile, the reliability test was carried out with the Cronbach Alpha indicator. The variable is explanatory that is consistent if the Cronbach Alpha value in each latent variable exceeds 0.5.

$$\begin{pmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \end{pmatrix} = \begin{bmatrix} \lambda_{pr12} & \cdots & \lambda_{pr109} & 0 & 0 & \cdots & \cdots & \cdots & 0 \\ 0 & \cdots & 0 & \lambda_{psl11} & \cdots & \lambda_{psl109} & 0 & \cdots & 0 \\ 0 & 0 & \cdots & \cdots & \cdots & 0 & \lambda_{tas11} & \cdots & \lambda_{tas108} \end{bmatrix} \begin{bmatrix} pr_{12} \\ \vdots \\ pr_{109} \\ psl_{11} \\ \vdots \\ psl_{109} \\ tas_{11} \\ \vdots \\ tas_{108} \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \end{bmatrix} \tag{4}$$

If the initial data used consists of 377 variables with 100 precipitation variables, 100 air pressure variables, 100 temperature variables, and 77 rainfall variables, then after testing the validity and reliability tests, the data is reduced to 298 variables with 75 precipitation variables, 81 air pressure variables, 65 temperature variables, and 77 rainfall variables. So that the measurement model is rearranged into a new measurement model as in the equation (4).

The parameter estimation results in the PLS inner model are as follows

Table 1. Inner model parameter estimation

Coefficient	Estimation	Std.	p-value
Intercept	0.000	0.044	1.000
ξ_1	0.438	0.106	0.000
ξ_2	-0.903	0.102	0.000
ξ_3	0.352	0.090	0.000

Based on the parameter estimation results, the PLS structural model for forecasting monthly rainfall in Jember Regency is as follows

$$\begin{bmatrix} \eta_1 \\ \eta_2 \\ \vdots \\ \eta_n \end{bmatrix} = \begin{bmatrix} 1 & \xi_{11} & \xi_{21} & \xi_{31} \\ 1 & \xi_{12} & \xi_{22} & \xi_{32} \\ \vdots & \vdots & \vdots & \vdots \\ 1 & \xi_{1n} & \xi_{2n} & \xi_{3n} \end{bmatrix} \begin{bmatrix} 2{,}496 \times 10^{-15} \\ 0{,}4383 \\ -0{,}9039 \\ 0{,}3506 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{bmatrix} \tag{5}$$

The structural model of rainfall forecasting using the PLS model is then tested using several test indicators to see how good the PLS model is in forecasting monthly rainfall. The test indicators used are the R-square value (R^2), the average redundancy, and the Goodness of Fit (GoF). The results of model testing on each indicator are as follows:

Table 2. Model goodness indicator

Variable	Type	R^2	*Mean*	GoF
ξ_1	Exogenous	0.000	0.000	0.761
ξ_2	Exogenous	0.000	0.000	
ξ_3	Exogenous	0.000	0.000	
η	Endogenous	0.701	0.491	

The model that is considered to have good quality is the model with GoF > 70%. The PLS model produced in this study has a GoF value of 76.11%.

2.3.2. Response Based Unit Segmentations (REBUS) on the PLS Model

The main purpose of implementing Response Based Unit Segmentations (REBUS) is to obtain several models in each of which the model can explain the diversity better than the PLS model. The initial stage in REBUS is choosing the number of segmentations. The number of segmentation in REBUS-PLS so far has been done using cluster analysis. The number of segmentation generated determines the number of local models formed in REBUS-PLS. The selection of the number of segmentation in this study uses the rainfall classification segmentation by Schmidt-Ferguson, which is as many as four segments. The results of segmentation on the resulting rainfall data are as shown in Table 3.

Table 3. Data segmentation results

No	Segment 1	Segment 2	Segment 3	Segment 4
1	Mar-05	Feb-05	Jan-05	Des-05
2	Jul-05	Apr-05	May-05	Mar-06
3	Aug-05	May-06	Jun-05	Des-07
4	Oct-05	Sep-06	Sep-05	Mar-08
5	Jan-06	Dec-06	Nov-05	Oct-08
6	Feb-06	Mar-07	Jun-06	Nov-08
7	Apr-06	Apr-07	Jul-06	Des-08
8	Feb-07	Jun-07	Aug-06	Apr-10
9	Feb-08	Nov-07	Oct-06	May-10
10	Jul-08	Jan-08	Nov-07	Jul-10

Table 4. Cronbach Alpha value in each segment

Segments	Latent Variable	Cronbach Alpha
Segment 1	Precipitation	0.997
	Air pressure	0.998
	Temperature	0.997
Segment 2	Precipitation	0.997
	Air pressure	0.998
	Temperature	0.997
Segment 3	Precipitation	0.997
	Air pressure	0.998
	Temperature	0.996
Segment 4	Precipitation	0.996
	Air pressure	0.998
	Temperature	0.994

Table 5. Parameter estimation value in each segment

Seg-ment	Coeffi-cient	Esti-mation	Std. Error	p-value
Seg-ment 1	Intercept	0.000	0.030	1.000
	ξ_1	0.366	0.070	0.000
	ξ_2	-0.805	0.068	0.005
	ξ_3	0.550	0.062	0.000
Seg-ment 2	Intercept	0.000	0.029	1.000
	ξ_1	0.321	0.070	0.000
	ξ_2	-0.654	0.057	0.000
	ξ_3	0.701	0.055	0.000
Segment 3	Intercept	0.000	0.051	1.000
	ξ_1	0.228	0.119	0.000
	ξ_2	-0.762	0.120	0.000
	ξ_3	0.397	0.112	0.000
Segment 4	Intercept	0.000	0.064	1.000
	ξ_1	0.349	0.132	0.015
	ξ_2	-0.109	0.159	0.000
	ξ_3	0.201	0.132	0.014

The Cronbach Alpha value based on Table 4 is quite large, exceeding 90%. This indicates that the segmentation division has been going well. Parameter estimation in the local model for each class can be seen in the following Table 5.

REBUS-PLS modeling requires retesting the validity and reliability of the data. It aims to see the consistency of latent and manifest variables in smaller data sizes. In the validity test, the loading value on the manifest of each segment is >0.6 or it can be said that the entire manifest value is eligible. The results of reliability test values are as shown in Table 4.

Based on the table, all exogenous latent variables have a significant effect on endogenous latent variables. Just as in the global model, the local model generated in each segment is tested for the goodness of the model. The results of model testing in each segment are as shown in Table 6.

Table 6. The goodness of the model on each segment

Segments	Variable	R^2	*Mean*	GoF
Segment 1	ξ_1	0.000	0.000	0.878
	ξ_2	0.000	0.000	
	ξ_3	0.000	0.000	
	η	0.972	0.616	
Segment 2	ξ_1	0.000	0.000	0.864
	ξ_2	0.000	0.000	
	ξ_3	0.000	0.000	
	η	0.975	0.556	
Segment 3	ξ_1	0.000	0.000	0.828
	ξ_2	0.000	0.000	
	ξ_3	0.000	0.000	
	η	0.850	0.703	
Segment 4	ξ_1	0.000	0.000	0.845
	ξ_2	0.000	0.000	
	ξ_3	0.000	0.000	
	η	0.912	0.620	

The average redundancy in each segment is 61.58%, 55.60%, 70.29%, and 61.97%. This indicates that the ability of exogenous variables to explain endogenous diversity in the PLS model in each segment is better than the global PLS model, which only has an average redundancy of 49.098%.

3. MODEL DEVELOPMENT

The PLS structural model for forecasting monthly rainfall in Jember Regency is as follows

$$\begin{bmatrix}\eta_1\\ \eta_2\\ \vdots\\ \eta_n\end{bmatrix} = \begin{bmatrix}1 & \xi_{11} & \xi_{21} & \xi_{31}\\ 1 & \xi_{12} & \xi_{22} & \xi_{32}\\ \vdots & \vdots & \vdots & \vdots\\ 1 & \xi_{1n} & \xi_{2n} & \xi_{3n}\end{bmatrix}\begin{bmatrix}2{,}496\times 10^{-15}\\ 0{,}4383\\ -0{,}9039\\ 0{,}3506\end{bmatrix} + \begin{bmatrix}\varepsilon_1\\ \varepsilon_2\\ \vdots\\ \varepsilon_n\end{bmatrix} \quad (6)$$

The PLS model is generally divided into two parts, the inner model using the structural model and the outer model using the measurement model. The resulting PLS model can be used for forecast rainfall with GCM output data input of 221 variables according to the selected coordinates with 75 precipitation variables, 81 air pressure variables, and 65 temperature variables.

4. RESULT AND DISCUSSION

Previously, it was found that the local REBUS-PLS model in each segment could explain the diversity better than the global PLS model. Meanwhile, in forecasting rainfall, a model that is considered good is a model that can produce accurate forecasts. For this reason, forecasting is carried out on testing data as the final stage to test the ability of the PLS and REBUS-PLS models in forecasting monthly rainfall in the Jember Regency.

Table 7. Rainfall forecast results at 4 rainfall stations

Period	Puger			Cumedak		
	Actual	PLS	REBUS-PLS	Actual	PLS	REBUS-PLS
Jan17	262	227.48	202.41	546	519.24	474 91
Feb17	264	150.86	168.49	482	462.74	565.02
Mar17	184	127.23	146.49	492	481.22	578.14
Apr17	186	59.10	115.68	173	332.20	429.34
May17	72	64,81	68,73	94	181.77	211.91
Jun17	0	0.79	2,11	71	76.79	131,99
Jul17	7	52.04	8.45	0	55.19	26.37
Aug17	0	99.73	3.01	9	187.36	4.36
Sep17	2	15,27	16,53	97	148,22	63.04
Oct17	71	46.46	25.61	137	298.30	231.15
Nov17	255	62,44	53.65	335	414.89	415.79
Dec17	265	199.21	161.87	363	503.50	420.29
Error	-	85.41	77.73	-	102.61	101.18

Period	Lojejer			DAM.Klatakan		
	Actual	PLS	REBUS-PLS	Actual	PLS	REBUS-PLS
Jan17	221	269.37	238.24	490	454.52	439.29
Feb17	167	181,04	194.49	448	351.42	435,50
Mar17	138	139.54	170.69	413	346 81	464.19
Apr17	181	49.58	120.43	119	264.67	301.77
May17	41	84,09	84,92	108	87,65	130,22
Jun17	9	12,21	14.01	148	62.78	96.47
Jul17	2	78.24	12.76	46	112.11	122.22
Aug17	5	115,40	5,99	10	137,51	22.84
Sep17	3	8.32	12.79	48	98.31	47.03
Oct17	38	46.84	24.32	188	215.71	158.57
Nov17	236	67,23	64.84	417	349.06	327.21
Dec17	190	233.74	198.34	196	520.93	457.18
Error	-	76.47	55.98	-	78.01	82.06

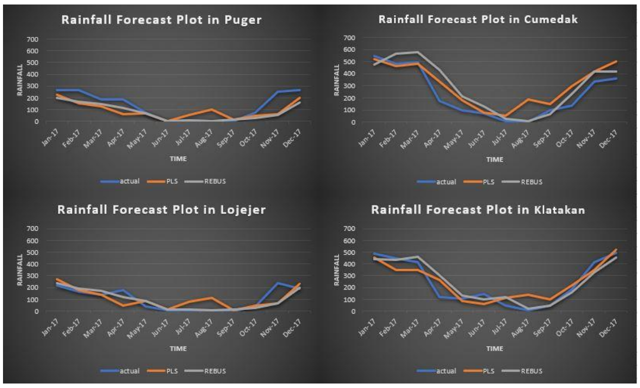

Figure 2 Rainfall forecast plot at 4 observation stations.

Rainfall plots at 4 observation stations are shown in Figure 2. If the RMSE values in both models at 77 observation stations are averaged, then the average RMSE value is 82.19 for the PLS model and 73.54 for the REBUS-PLS model. The PLS model has a smaller RMSE than the REBUS-PLS model at 25 observation stations. Meanwhile, at the other 52 observation stations, the accuracy of the REBUS-PLS model is better than that of the PLS model.

5. CONCLUSION

The rainfall forecasting model using the REBUS-PLS model can overcome the problem of diversity that is not well explained in the PLS model. Overall, the REBUS-PLS model has a better forecasting accuracy than the PLS model. The REBUS-PLS model has a smaller RMSE value than the PLS model at 52 observation stations. The PLS model produces a smaller RMSE compared to the REBUS-PLS model only at 25 observation stations.

REFERENCES

[1] B. Lakitan, Pengaruh Curah Hujan bagi Tanaman (in Indonesian), Universitas Indonesia, 2009.

[2] Bappeda Jawa Timur, Potensi Kabupaten dan Kota (in Indonesian), 2013, . http://bappeda.jatimprov.go.id/bappeda/wp-content/uploads/potensi-kab-kota-2013/kab-jember-2013.

[3] A. H. Wigena Regresi Kuadrat Terkecil Parsial Multi Respon untuk Statistical Downscaling (Multi Response Partial Least Square for Statistical Downscaling), Forum Statistika dan Komputasi, vol. 16, no. 2, pp. 12-15, Bogor, 2011.

[4] A. Kurniawan, Analisis Structural Equation Modeling Dengan Response-Based Units Segmentation Partial Least Square (Rebus-Pls) (in Indonesian), Thesis, Universitas Jember, 2018.

[5] F. S. Pratiwi, Sudarno, and S. Agus, Penerapan Response Based Unit Segmentation In Partial Least Square (Rebus-Pls) Untuk Analisis Dan Pengelompokan Wilayah (in Indonesian), Jurnal Gaussian, vol. 9, no. 3, pp. 364 – 375, 2020.

[6] R. Wilby, and T. Wigley, Downscaling General Circulation Model Output: A Review of Method ana Limitations, Progress in Physical Geography, vol. 4, pp. 530-548, 1997.