

### **Anonymous Referee #3**

The manuscript applied support vector machines to setting up the critical rainfall line for debris flows. This topic is indubitably of interest to the readers of Natural Hazards and Earth System Sciences. The authors compiled the data carefully and got their results reasonably. I hope my following comments be useful to the authors:

#### **Major comments:**

1. This manuscript only describes the process of the model building, but lacks in-depth analysis of the results. In-depth analysis should be made to the 7 groups divided by the authors and to the differences among respective critical rainfall lines, particularly causes of the differences.

This study utilizes FCGA to cluster debris flow streams into different groups by considering their significant patterns. For establishing critical rainfall threshold, this study adopts support vector machine to calibrate critical rainfall threshold of each group. As the result, the main reason which effects critical rainfall threshold trends is the main significant patterns of each group in PAGE 7 LINE 2-7.

2. The manuscript should introduce some real cases for verification of the accuracy of the model generated by the authors.

Thank you for your reminding. We have added more references and also modified the paragraph in PAGE LINE.

The modified paragraph is as follows, *“When the streams with similar characteristics have clustered together, the critical rainfall line of debris flow could be set via SVM. SVM is a new machine learning approach proposed by Vapnic(1998) based on statistical learning theory and structural risk minimization (SVM). The advantage of SVM is that this theory raises the generalized ability of learning mechanisms according to minimize the risk and reduces the probability of overfitting problem under lack of data condition. Therefore, we can obtain the results with minimum error rates and without many training samples. Otherwise, SVM is an optimized algorithm which can be performed by a standard programming algorithm and obtained the global optima. The SVM has been widely applied in many disciplines to solve the problems of classification and regression in the field of hydrological engineering(Yu et al., 2011; Lin and Chen, 2011; Shen et al., 2011; Liang et al., 2012). This study intends to establish the critical rainfall line of debris flow via SVM.”* In PAGE 7 LINE 18-28.

3. In addition, the data process and establishment of the critical rainfall lines for debris flows seem in a logical mess.

This study is focused on the critical rainfall thresholds changed after 1999 921 earthquake in Taiwan, hence, this study collects this most effected four years data after earthquake to comprehend the variation of critical rainfall thresholds. However, there is not enough debris flow occurrence data of each debris flow streams. Therefore, this study utilizes FCGA to combine different debris flow streams which have the same significant patterns, and this procedure can also increase the accuracy of analysis results because the numbers of debris flow occurrence data have been raised. At last, this study adopts support vector machine to estimate the critical rainfall threshold of each group by their significant factors.

**Minor comments:**

1. Personally, I think that Figure 1 is meaningless and should be removed.  
We agree your advice, so Figure1 has been removed.
2. The author fails to explain the origin of rainfall data.  
We miss to describe the origin of data. In this new version, we have add origin of data, including rainfall, geological data and hydrological data source as “*geographical information from central geological survey MOEA, hydrological information from central weather bureau in Taiwan, historical data of damage from internet-based news*” in PAGE 3 LINE 18.
3. The research progress of the critical rainfall threshold is not summarized in Introduction.  
Thank you for your reminding. The original critical rainfall threshold has been established by Soil and Water Conservation Bureau (SWCB) in Taiwan, however, this study utilizes SVM to modify critical rainfall threshold by occurrence events and non-occurrence events dataset.
4. The blue dots in Figure 7 are not evident in the image and the figure should be redrawn following requirements.  
Thank you for your reminding, we have redrawn Figure 7.
5. Page 5959 Line 9-10“were considered” replacement “was considered”  
Thank you for your reminding, we have modified in PAGE 4 LINE 16.
6. The difference between streams with disaster and streams without disaster in the legend of Figure 2b is not obvious.  
Thank you for your reminding, we have redrawn Figure 1b.
7. Page 5959 Line 3: Nakamura et al. (2000) reference is missing.  
Thank you for your reminding, we have modified this missing.
8. I suggest authors to add references for Fig.4 and Fig.5 since they come from other articles.  
Thank you for your reminding, we have added two references about Fig. 4

and Fig. 5, but these two figures are drawn by ourselves.

*Liang W.J., Zhuang D.F., Jiang D., Pan J.J., Ren H.Y.: Assessment of debris flow hazards using a Bayesian Network, Geomorphology, 171–172, 94-100, 2012.*

*X. Yao, Tham L.G., Dai F.C.: Landslide susceptibility mapping based on Support Vector Machine: A case study on natural slopes of Hong Kong, China, Geomorphology, 101, 4, 572-582, 2008.*

9. Page 5963 Line 20: Authors should add “is” after “product” in the sentence of “This inner product generally made by a kernel function” .

Thank you for your reminding, we have modified in PAGE 3 LINE 20.

10. Figure 2 and Figure 3 are not clear and should be redrawn to improve resolutions.

Thank you for your reminding, we have improved the resolution of Figure 2 and Figure 3 in new version.

11. Please add more literatures and improve introduction for in-depth analyzing progress of the research of critical rainfall threshold.

Thank you for your reminding, we have added a series references as follows.

*Zhuang J.Q., Cui P., Wang G.H., Chen X.Q., Iqbal J., Guo X.J.: Rainfall thresholds for the occurrence of debris flows in the Jiangjia Gully, Yunnan Province, China, Engineering Geology, 195, 335-346, 2015.*

*Wan S., Lei T.C.: A knowledge-based decision support system to analyze the debris-flow problems at Chen-Yu-Lan River, Taiwan, Knowledge-Based Systems, 22, 8, 580-588, 2009.*

*Yuan L.F., Zhang Q.F., Li W.W., Zou L.J.: Debris Flow Hazard Assessment Based on Support Vector Machine, Geoscience and Remote Sensing Symposium, 2006. IGARSS 2006. IEEE International Conference, 4221-4224, 2006.*

*Bui D.T., Pradhan B., Lofman O., Revhang I.: Landslide Susceptibility Assessment in Vietnam Using Support Vector Machines, Decision Tree, and Naive Bayes Models, Mathematical Problems in Engineering, 2012, 1-26.*

*Zhou, W., and Tang, C.: Rainfall thresholds for debris flow initiation in the Wenchuan earthquake-stricken area, southwestern China, Landslides, 11, 5, 877-887, 2014.*

*Zhuang J.Q., Cui P., Wang G.H., Chen X.Q., Iqbal J., Guo X.J.: Rainfall thresholds for the occurrence of debris flows in the Jiangjia Gully, Yunnan Province, China, Engineering Geology, 195, 335-346, 2015.*