Using self-organizing map to develop a probabilistic flood early warning system based on radar echo

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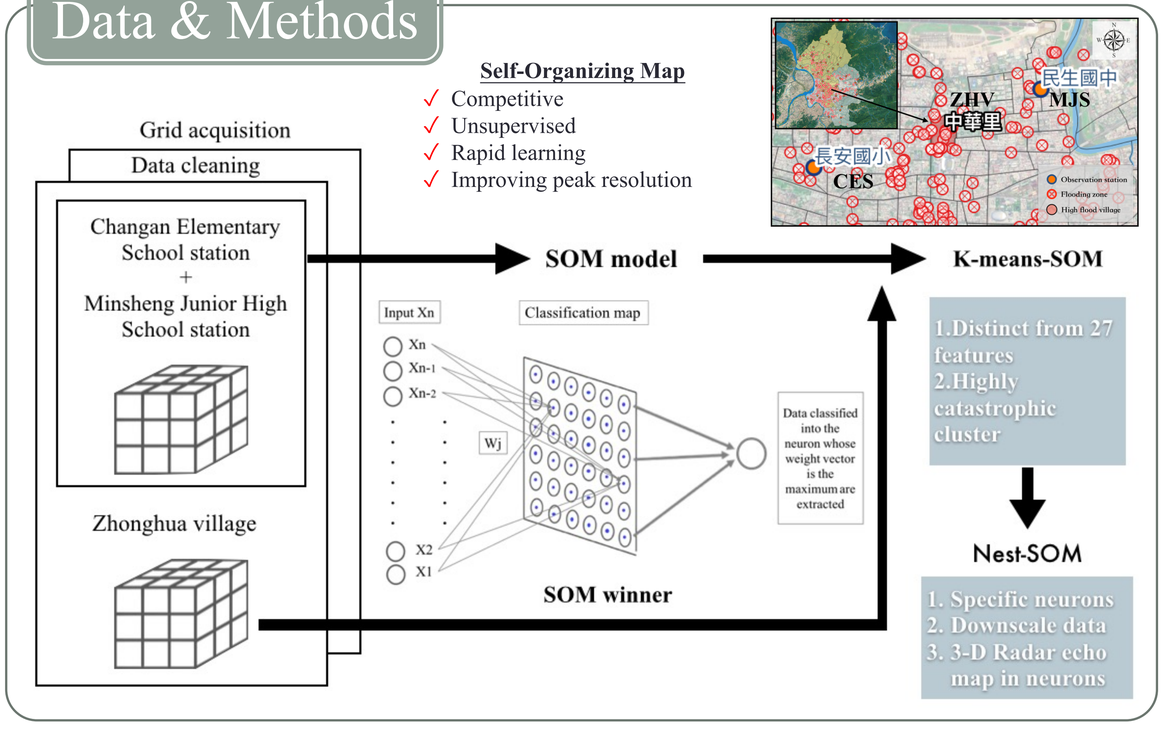
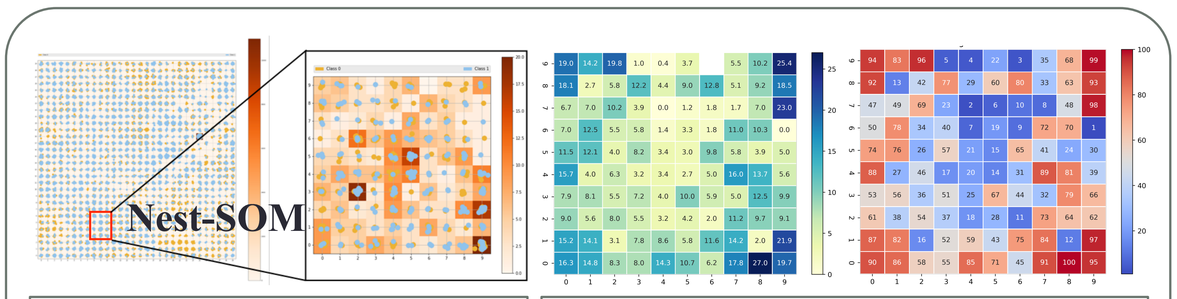
Abstract

The frequency and intensity of hazardous weather events have increased year by year under climate change. For flood early warning, radar echo is adopted to improve the spatial resolution of early warning system, and an un-supervised neural network is applied to develop a probabilistic flood early warning system (PFEWS) for village scale in this study. To develop the PFEWS, this research collected real-time radar echo maps and historical rainfall data in the flood-prone area of Taipei City, Zhonghua village in Songshan District, from 2014 to 2018. Then the study used a neural network (Self-organizing map, SOM) to establish the relationship between the three-dimensional space radar echo data of the study area and the actual rainfall observations. Additionally, the probabilistic rainfall range could be carried out in each topological map. The PFEWS based on SOM and radar echo could provide a probabilistic flood warning message with enhanced spatial resolution for CERTs to adopt preventive measures.

Data & Methods





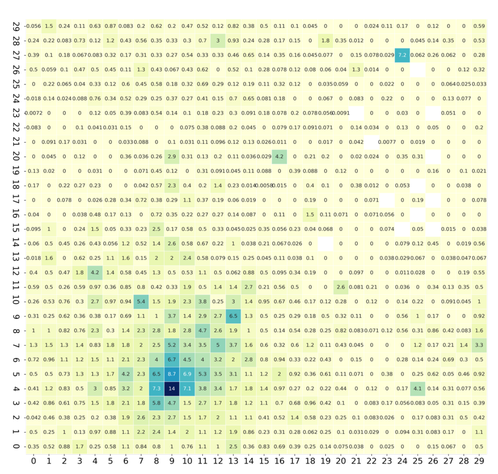
SOM(30X30) downscaled data to Nest-SOM(10X10)

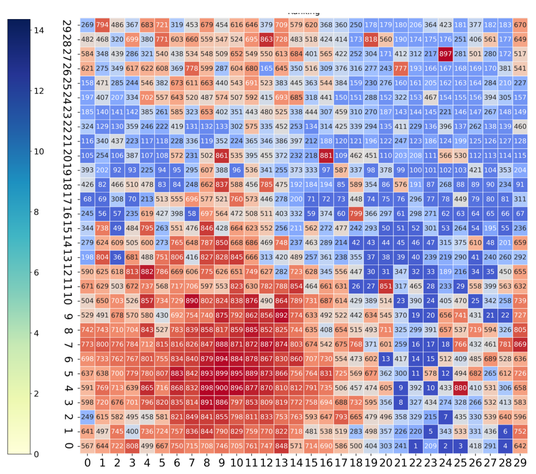
Average rainfall and ranking them in each neuron of Nest-SOM

Build a real-time probabilistic radar echo-flood warning model

- Use Nest-SOM to receive a more detailed classification
- Time series of spatial-temporal radar echo patterns
- Winner neurons of a track on the topological map
- Changes of flood probabilities in real-time
- Provide the frequency of precipitation
- Rank all the average rainfall of the neurons in the SOM
- K-means analysis inspect the performance of 27 features

Results &Discussion



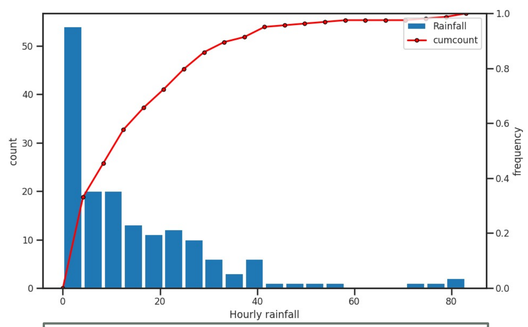


The corresponding average hourly rainfall(left) vs. Ranking average rainfall from No.1 to No.900(right)

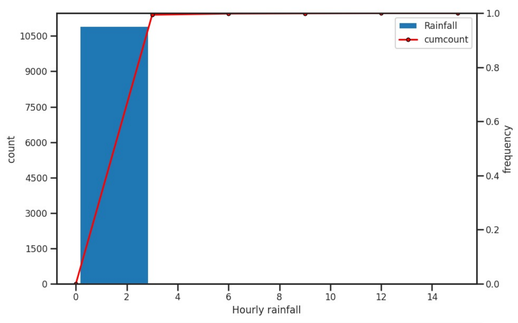
-Maximum rainfall of the neuron (4, 9) is 14.362 mm

-Largest number of data were classified into neuron (18, 24) and its average rainfall is 0.053 mm/hr

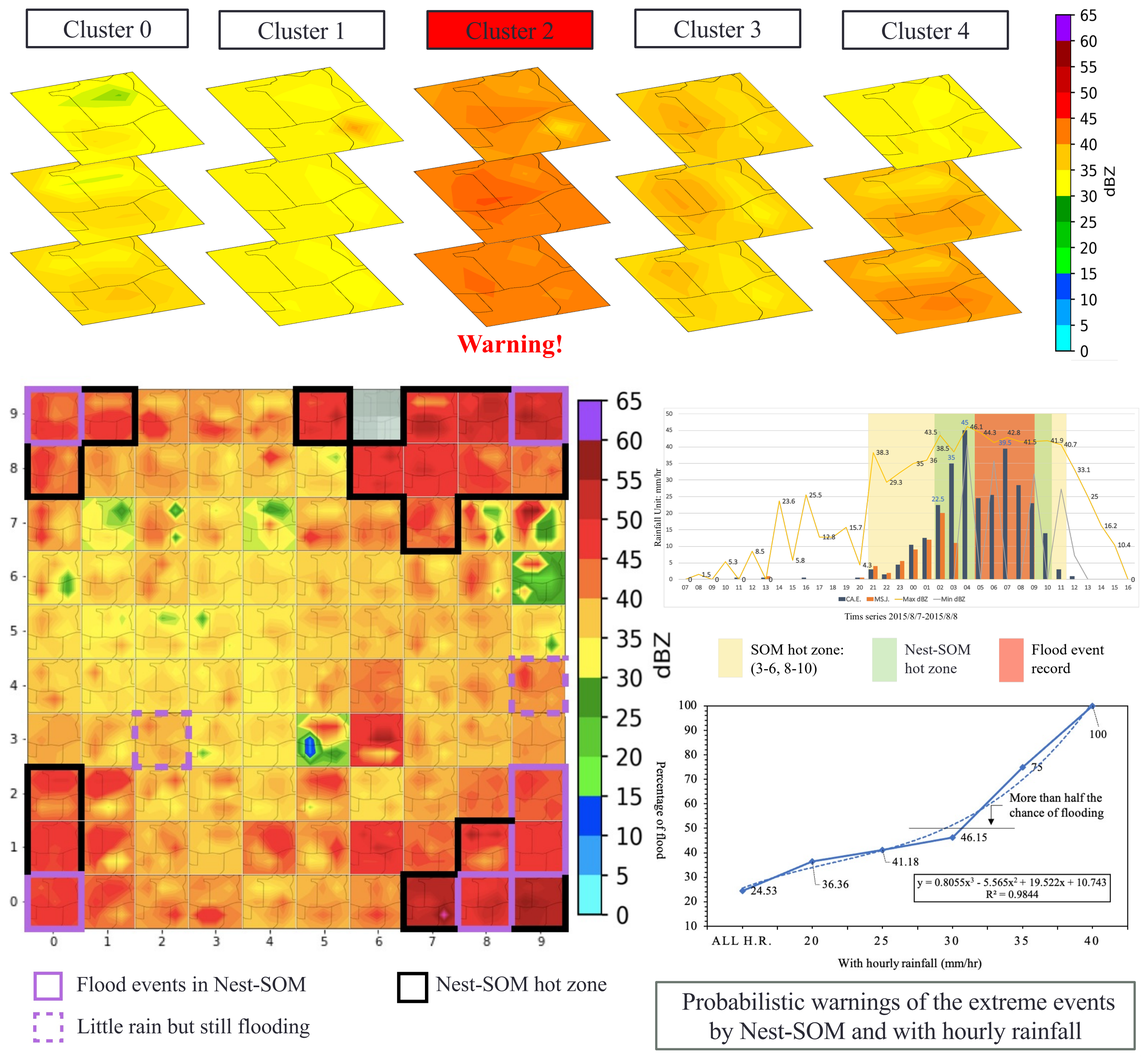
- The frequency of precipitation as the bar charts right below -



Neuron (4, 9) – Highest hourly rainfall



Neuron (18, 24) – Largest number of data



Probabilistic warnings of the extreme events by Nest-SOM and with hourly rainfall

Conclusion

- The difference between the existing and the proposed SOM-based models is the pre-analysis process of three-dimensional space radar echo data. The proposed model is established on the basis of SOM via analyzing historical data to extract data with specific properties, which can provide helpful information for flood forecasts.
- The extracted data and the raw observed events are used to construct SOM for improving the long lead time forecasting. The result confirms that incorporating data with specific properties from SOM topological map certainly improves real-time forecasting performance.
- Development of a probabilistic flood early warning system. The performance of the proposed model for extreme events is highlighted to estimate the applicability of the proposed model. The result shows study areas early warning before the occurrence of warning and flooding disasters, the rainfall characteristics of different grid features, and the corresponding rainfall range and rainfall frequency.