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## Postprint: Blizzard Risk Assessment in Inner Mongolia Pastoral Areas

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### Abstract

Snowstorm weather constitutes one of the most severely damaging meteorological disasters in the grassland pastoral areas of Inner Mongolia. To achieve a more precise understanding of the characteristics of snowstorm disaster weather, snowstorm events were classified by season into three types: late-autumn-to-early-spring snowstorms, midwinter snowstorms, and late-spring-to-early-summer wet-snow-cold-rain-type snowstorms. Through factor analysis and grey relational analysis of these three snowstorm types, it was revealed that all represent wind-snow-cold-wave disaster cluster weather phenomena; however, the primary influencing factors differ across seasons, resulting in varying degrees of disaster severity. Therefore, mastering the seasonal characteristics of snowstorm weather holds significant practical value for forecasters seeking to enhance their forecasting and early warning capabilities. This study attempted to evaluate snowstorm disaster grades using both the BP neural network method and Support Vector Machine (SVM). Comparative analysis against disaster grades assessed from actual disaster conditions demonstrated that the SVM method yielded superior evaluation performance compared to the BP neural network approach. Consequently, the development of snowstorm disaster early warning products based on numerical weather prediction outputs via the SVM method becomes viable, providing an objective reference framework for snowstorm disaster forecasting and early warning operations, thereby improving forecasting service effectiveness and reducing disaster losses.

### Full Text

## Preamble

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**Abstract:** Snowstorms occur annually in the central and eastern regions of Inner Mongolia, China, often causing serious harm. Therefore, it is necessary to improve forecasting, early warning, and service capabilities for such weather disasters to reduce disaster losses as much as possible. Because the hazard degree caused by snowstorms varies across seasons, this analysis must be conducted seasonally. Snowstorms are classified into three categories based on season: late autumn and early spring snowstorms, midwinter snowstorms, and the cold rain or wet snow type of snowstorm that occurs in late spring and early summer, all of which have been analyzed in this paper. Based on factor analysis and grey correlation degree analysis, it is found that snowstorms, regardless of type, occurring in different seasons are basically all hazardous weather events resulting from gale, snowfall, and cold wave, or a combination of these three factors. The leading factors differed across seasons, leading to different hazard degrees. Understanding the characteristics of snowstorms in various seasons will help weather forecasters in snowstorm prediction and early warning. The BP neural network method and SVM method were further used to evaluate snowstorm hazard levels using data from snowstorm events that have occurred in recent decades. Through comparing the effectiveness of the evaluation results, it showed that the computational efficiency of the SVM method was better and it makes early warning possible in snowstorm forecasting based on numerical forecast products.

**Keywords:** snowstorm; risk assessment; BP; SVM

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## ## 1. Introduction

Snowstorm disasters in Inner Mongolia exhibit distinct seasonal characteristics, with varying hazard mechanisms and impact patterns across different periods. The region's unique geographical location and climatic conditions make it particularly vulnerable to severe snowstorm events that can cause substantial economic losses and social disruption. Effective risk assessment requires seasonal classification and analysis of the underlying meteorological factors.

## ## 2. Data and Methods

### ### 2.1 Data Collection and Processing

The study utilized meteorological data from 193 snowstorm events occurring between 1980 and 2010 in central and eastern Inner Mongolia. The data included various meteorological factors such as wind speed, precipitation, temperature, and other relevant parameters. The snowstorm events were categorized into

three seasonal types for analysis: late autumn and early spring events, midwinter events, and late spring/early summer cold rain/wet snow events.

### ### 2.2 Methodological Framework

The research employed factor analysis and grey correlation analysis to identify the primary meteorological factors contributing to snowstorm hazards. Principal component analysis was conducted to reduce dimensionality and extract the most significant variables. The BP neural network and Support Vector Machine (SVM) methods were then applied to establish risk assessment models. The SVM model utilized a radial basis function kernel with parameters optimized through cross-validation.

## ## 3. Model Implementation

### ### 3.1 SVM Model Application

The SVM model was implemented using LIBSVM with the following optimized parameters:  $c = 1000$  and  $g = 0.0069$ . The model was trained on 70% of the historical snowstorm data and validated on the remaining 30%. The input variables included the principal components derived from factor analysis, representing the key meteorological factors. The output classified snowstorm hazard levels into five categories based on disaster loss data.

### ### 3.2 BP Neural Network Application

The BP neural network was constructed with a three-layer architecture: input layer, hidden layer, and output layer. The network parameters were set as:  $c = 1000$  and  $g = 0.0078$ . The same training and validation datasets were used for comparative analysis. The network utilized a backpropagation algorithm with adaptive learning rate to minimize error between predicted and actual hazard levels.

## ## 4. Results and Analysis

The comparative analysis demonstrated that both methods could effectively evaluate snowstorm hazard levels, but the SVM method exhibited superior computational efficiency and generalization capability. The SVM model achieved a correlation coefficient of 0.73 between predicted hazard grades and actual disaster losses, with the first three principal components explaining 72.5% of the total variance. The hazard assessment results for different seasonal snowstorm types showed that the leading factors varied: late autumn/early spring events were primarily driven by strong winds and rapid temperature drops, midwinter events by heavy snowfall accumulation, and late spring events by combined effects of precipitation and low temperatures.

The factor analysis revealed that the primary meteorological factors contributing to snowstorm hazards included 48-hour maximum wind speed, maximum snowfall intensity, minimum temperature, and their interactive effects. The grey correlation analysis further quantified the relative importance of these factors

across different seasons, providing a scientific basis for targeted early warning systems.

[Figure 1: see original paper]

[Figure 2: see original paper]

[Figure 3: see original paper]

The results indicate that machine learning methods, particularly SVM, offer significant potential for operational snowstorm risk assessment and early warning in Inner Mongolia, enabling more timely and accurate disaster prevention and mitigation efforts.

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## References

[The references section contains citations that were preserved in the original format and should be listed here according to the journal's citation style.]

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