DISCRIMINATE ANALYSIS FOR DUST STORM PREDICTION IN THE GOBI AND STEPPE REGIONS IN MONGOLIA

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Abstract. A discriminate analysis method for probability forecast of dust storms in Mongolia has been developed. The prediction method uses data recorded at 23 meteorological stations in the Gobi and steppe regions of Mongolia, including surface air pressure and geo-potential height at the 500-hPa level on grid points, and weather maps from 1975 to 1990.

Weather elements such as air temperature, pressure, geo-potential height etc, which influence the formation of dust storms, are prepared as predictors. To select the most informative/important predictors (variables), we used a mean correlation matrix of variables together with the Mahalonobis distance, and correlation coefficients between dust storms and predictors with an orthogonalization for removing correlated predictors. The most informative predictors for dust storm prediction are intensities of surface cyclones and migratory anticyclones, passage of cold fronts, the horizontal gradients of the surface air pressure in the cold frontal zone, cyclonic circulations from the ground surface up to the 500-hPa level, the geo-potential height at 500-hPa level and its temporal changes.

Selected predictors are used in discriminate analysis for formulating dust storm prediction equations. Sandstorm data have been classified into three classes, viz., strong, moderate and weak dust storms, depending on their intensities, durations and areas covered. Predictions of the probabilities of dust storm occurrence use the prediction equations for each class. The prediction is made from 12 hours to 36 hours.

Verification of the probability forecasts of dust storms is also shown. The accuracy of forecasts is 72.2–79.9% with the data used for developing equations (dependent variables), in contrast to 67.1–72.0% with unrelated data for deriving equations (independent variables).

Keywords: dust storms in Mongolia, dust storm prediction, discriminate analysis, predictor, predictand

1. Introduction

Dust storm prediction is one topic of the studies of dust and sand phenomena. Investigators throughout the world (First LAS/WMO ISSDS-1, 1998) use different kinds of prediction methods for dust and sand storms, including synoptic and statistical methods for predicting dust storm occurrences and convective dust/sand storms, an atmospheric for dust model containing modules for dust uptake, transport and deposition, and simulation of the atmospheric transport and deposition of dust.

In Mongolia, the main sectors of the economy depend directly on weather and natural conditions. For example, due to severe snow storms and dust storms on 17–20 April 1980 and 5–6 May 1993, between 9–16 people and 100–675 thousand head of livestock died and private houses, cattle pens, and telecommunication and electric lines were damaged. Many thousands of hectares of wheat and crops were...
laden under snowfalls on 25–26 September 1993 due to snowstorms and heavy snowfall (Jugder, 1999). Strong dust storms cause many adverse effects on nomadic livestock husbandry in the country. They can kill a great number of livestock and cause great economic losses in spring in Mongolia. Strong dust and sand storms can be considered as a natural disaster in Mongolia in relation to economic losses and their impact on soil erosion, sand movement, desertification and the ordinary activities of railway, road and air transportation.

In relation to social requirements on the reduction and prevention of natural disasters, and scientific and practical needs, some research work on the prediction of disaster phenomena such as strong dust and sand storms, can contribute to the reduction of economic losses in Mongolia.

The prediction of dust and sand storms also has great importance in providing users with good weather forecasts. Moreover, we need a statistical interpretation of some hydrodynamic model outputs with high accuracy to improve the weather forecasting quality, methodology and technology. For the methodology, statistical methods have been widely used for weather forecasting in the last few decades (Daniel et al., 1995; Perekhodtseva, 1977, 1985; Oganesyan, et al. 1986; Uspensky, 1990 and others).

For all of the above reasons, our goal is to develop a dust storm prediction method using statistical data and to apply it for issuing severe storm warnings and weather forecasts. Prior to this study, only the synoptic method was used for weather forecasting in Mongolia.

2. Data Used

The study is based on dust storm observations at 23 meteorological stations in the Gobi and eastern steppe areas in Mongolia from 1975 to 1990. The surface air pressure, geo-potential height at 500 hPa level and weather maps between 1975 and 1990 are also used. Surface air pressure and geo-potential height are prepared at 36 grid points with range of 5° along the latitude and 10° along the longitude within 35–60°N and 80–130°E at 00 Coordinated Universal Time (UTC) and 12 UTC. The grid points are shown in Figure 1.

Areas used for the dust storm prediction are the Gobi and eastern steppe regions in Mongolia (Figure 2) and forecast time is short range, as from 12 to 36 hours.

Predicting phenomena (predictand) are dust storms with different intensity. In total, about 20 variables (predictors) are used for the predicting dust storms, including central pressures of cyclones and anticyclones, enclosed isobars of pressure systems, atmospheric fronts in binary form, air temperature at 700 hPa level at 4 aerological stations (see Figure 2), surface pressure at 16 grid points, and geopotential heights at 500 hPa level at 16 grid points.

Synchronous data sets of the predictand and predictors are created for the dust storm prediction study. Dust storm occurrences included 233–273 cases in the Gobi area and around 80–112 cases in the eastern steppe area in Mongolia during the