

Damage of Snowstorm Weather and Defensive Measures in Tongliao Area

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Abstract The annual average number of snowstorm days in Tongliao area is 1–3 d. Snowstorms mainly happen from October to next May, peaking from December to next March. The incidence is the highest between 12:00 and 15:00. The Mongolian low vortex is the main weather system that triggers snowstorms, and can be classified into three types: small trough development, horizontal trough becoming vertical, and low trough moving eastwards. Snowstorms pose a relatively serious threat to agricultural and animal husbandry production, transportation, power and communication in Tongliao. Especially in spring, snowstorm weather poses a greater threat to agriculture and animal husbandry in Tongliao. It is needed to pay attention to the impact of extreme weather and climate events such as snowstorms, strengthen research on the mechanisms of disaster-causing weather, enhance the early warning capability of disasters, and provide good service guarantees for low-temperature weather in winter.

Key words Snowstorm; Occurrence characteristics; Harm; Defensive measures

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Tongliao City is located in the east of Inner Mongolia Autonomous Region and in the heart of the Horqin Grassland. It belongs to a typical northern agricultural and pasturing interlaced zone, and has a mid-temperate arid and semi-arid continental monsoon climate. Due to the significant influence of the cold high pressure from Siberia and Mongolia as well as the southeast monsoon, this area has distinct four seasons. Spring is dry and windy, and summer is hot; autumn is short and cool, and winter is long and cold. Snowstorm weather occurs every winter, and it is a kind of disastrous weather accompanied by gales, snowfall and low temperatures. When wind speed exceeds 15.7 m/s (above force 7), it is accompanied by heavy snowfall (snowfall ≥ 8 mm), strong temperature drop (temperature drop ≥ 8.0 °C)^[1], and visibility drops to an extremely low level, the most destructive snowstorm disaster will be caused.

1 Characteristics of snowstorm weather in Tongliao area

1.1 Spatial and temporal distribution characteristics of snowstorms The number of snowstorm days in Tongliao area each year is 1–3 d. Among them, active mongolian cyclones and flat terrain on the grassland are conducive to the formation of gales, so snowstorm disasters happen frequently. The occurrence of snowstorm weather in Tongliao area has distinct spatial and temporal distribution characteristics^[2]. Snowstorms occur mainly from October to next May and most frequently from December to next March, during which the number of snowstorm days accounts for

approximately 70% of the annual number of snowstorm days, and the peaks appear usually in December and January. It is small in October and May. These spatial and temporal distribution features are mainly related to the variation in the strength of the Mongolian–Siberian high. During the southward movement of strong cold air, it meets the local moist air current to trigger the formation of heavy snowfall. Moreover, Tongliao area is higher in the west and lower in the east. The mountainous area in the northwest and the plain in the southeast form a natural wind channel to promote frequent occurrence of gale weather, which all provide favorable dynamic conditions for the formation of snowstorm weather.

The diurnal variation characteristics of snowstorms in Tongliao area are also quite significant, and the frequency of occurrence during the day is higher than that at night. From 08:00 to 15:00, the incidence of snowstorms gradually increases, reaching its peak between 12:00 and 15:00, and then shows a decreasing trend from hour to hour. From 22:00 to 02:00, the incidence of snowstorms is the lowest. The diurnal variation characteristics of snowstorms in Tongliao area are mainly related to the diurnal variation of solar radiation. The diurnal variation of solar radiation causes the surface atmospheric junction to change accordingly, thereby resulting in the diurnal variation of gales on the ground.

1.2 Weather systems affecting snowstorms The Mongolian low vortex is the main weather system that triggers snowstorms. A closed Mongolian cold vortex is formed at 500–700 hPa, and shows certain regularity during its movement. When it deepens strongly, it moves eastwards and southwards, and the center of the cold vortex drops by 2–3 contour lines. It is at 45°–50° N to the south, and gradually moves northeastwards after weakening. In this case, the Mongolian cold vortex will trigger a snowstorm. In reality, many cold vortexes do not reach the aforementioned lati-

tudes, so most cold air activities cannot cause snowstorm disasters. According to the weather systems of the Mongolian cold vortex, the main weather patterns affecting snowstorm weather can be classified into three types, including small trough development, horizontal trough becoming vertical, and low trough moving eastwards^[3].

2 Damage of snowstorm weather

When a snowstorm occurs, the activity of cold air is intense, and the weather change is usually completed within a few hours. Therefore, snowstorms are sudden and destructive. In 2018, a snowstorm hit the central and southern parts of Tongliao City. Instantaneous wind speed was over force 9, and visibility was less than 10 m, while temperature dropped by nearly 15 °C within 12 h. Such characteristics of the snowstorm made it difficult for people and livestock to respond quickly, causing serious losses. Although snowstorm weather mainly occurs from December to next March in winter, the frequency of snowstorm disasters is the highest from March to May in spring, accounting for more than 70% of the total frequency of snowstorm disasters. That is, from March to May when the number of snowstorm days accounts for only about 30%, the incidence of snowstorm disasters is over 70%. It can be seen that snowstorm disasters in Tongliao area occurs in winter and spring, but the impact is the most severe in spring. The damage caused is mainly shown in the following aspects.

2.1 Impact on animal husbandry Animal husbandry is one of the pillar industries in Tongliao. Snowstorms are one of the meteorological disasters that pose a significant threat to pastoral areas. Snowstorm weather is accompanied by gales, snowfall and a drop in temperature. When the grassland is covered with 15 cm of snow, it is impossible to graze. After the snow melts, temperature drops, and ice forms. Livestock not only cannot eat normally but are also prone to being scratched by the ice shell. Strong winds stir up snow on the ground to cause insufficient visibility, so that it is very easy for nomadic herdsman and livestock to lose their way, and traffic is severely blocked to affect transportation. In addition, strong winds can also collapse livestock sheds, causing the livestock to be scattered in flocks. Livestock consume a lot of energy in cold winter, while their energy generally declines in spring, and their ability to resist disasters weakens. After the weather warms up in spring, temperature is relatively high. If there is a snowstorm, the continuous drop in temperature and snowfall will lead to a large number of livestock being frozen to death or injured, causing a major disaster to the livestock industry.

2.2 Influence on agriculture During a snowstorm, a certain amount of snowfall can increase soil moisture, which is beneficial for winter crops and spring ploughing and sowing in the following year. Meanwhile, snow cover can alleviate the frost damage to winter crops. Low temperatures inhibit their vigorous growth and kill overwintering pests. However, prolonged low temperatures

may lead to frost damage, and especially after the ice and snow melt, continuous low temperatures can cause winter crops to be frozen. Strong winds and accumulated snow can damage and crush facility agricultural greenhouses. Excessive snow accumulation affects temperature and light inside greenhouses, so that fruits and vegetables in greenhouses are frozen, causing serious losses. Besides, accumulated snow can also break the branches of fruit trees, and long-term low temperatures can cause trees to be frozen. Snowstorms in spring are not conducive to spring plowing and sowing as well as the recovery and growth of winter crops.

2.3 Impact on other industries When low-temperature and snowstorm weather happens, power transmission lines, communication lines and other facilities are prone to ice formation and movement, which may cause tripping and circuit breaks to affect power supply and normal communication. Moreover, snowstorms can cause vehicles and residents to be trapped and carports to collapse. Roads are covered with snow, causing traffic to be disrupted or paralyzed.

2.4 Influence of a severe snowstorm disaster in Tongliao during November 5 – 10, 2011 From November 5 to 10, 2011, a severe snowstorm hit Tongliao. The weather affected eight counties and districts, and lasted for 5 d, with a total snowfall duration of more than 90 h. The maximum snowfall occurred in Horqin District, reaching 102.9 mm. The maximum snow depth was 68 cm, and appeared in Kulun Banner, exceeding the local maximum since 1951. From November 7 to 9, snowfall lasted for 46 h, with the snowfall exceeding 80 mm. From 08:00 on November 7 to 08:00 on November 8, the snowfall at five meteorological stations in Horqin Left Wing Middle Banner, Horqin Left Wing Back Banner, Horqin District, Kulun Banner and Qinglongshan exceeded the daily maximum of snowfall in previous years. The maximum wind speed at the Kulun Banner National Meteorological Observatory reached 20.8 m/s on November 8, breaking the historical maximum. As of 17:00 on November 11, the snowstorm disaster had affected 46 000 people, and the direct economic losses reached 663 million yuan. Besides, many expressways and airports were closed. Among them, one person and 973 livestock died due to the disaster, and 8 503 sheds were destroyed. In addition to economic losses, snowstorms often cause secondary disasters such as traffic paralysis and power outages, seriously affecting the normal life of people.

3 Defensive measures of snowstorms

In response to this regular natural disaster, Tongliao area has established a snowstorm disaster response system. Meteorological departments ensure the release of early warning information 72 h in advance through a modern monitoring network. Transportation departments formulate emergency plans to guarantee the smoothness of major roads under extreme weather conditions. In pastoral areas, the "settled rotational grazing" model is implemented, and

wintering greenhouses and grass reserve depots are built. These measures have to some extent reduced the losses caused by snowstorms, but in the face of the uncertainty of climate change and the increase of extreme weather events, the disaster resistance and reduction work in Tongliao area still has a long way to go.

3.1 Attaching importance to the impact of extreme weather and climate events such as blizzards With global warming, society and the public are very likely to neglect the prevention and response to extreme weather events. Therefore, it is necessary to attach importance to the impact of extreme weather events, and further improve the emergency response linkage mechanism among departments. Meteorological departments should conduct information sharing with other relevant departments to enhance the joint response capabilities of all departments and avoid and reduce the adverse effects and hazards of disastrous weather as much as possible.

3.2 Strengthening research on the mechanisms of disaster-causing weather and enhancing the capacity for the early warning of disasters Responding to climate change is a common issue faced by the world at present. Under the influence of global warming, extreme and disastrous weather occurs frequently in various places, and the intensity of the damage is increasing. Meteorological departments should continuously enhance the level of weather prediction and research and assessment of the impact of climate change, strengthen the tracking and analysis of extremely cold weather events in winter and spring, intensify research and analysis on attribution and disaster-causing mechanisms, and thereby improve the capacity for the forecasting and early warning of extreme weather as well as the early warning level of risks.

3.3 Continuing to provide good service guarantees for low-temperature weather in winter The possibility of a phased extreme cold wave weather event is relatively high at present, so it is needed to strengthen the prevention of adverse effects of low temperatures in winter and spring. Meanwhile, it is needed to conduct weather forecasts for agricultural and pastoral production, promptly convey weather forecasts and meteorological disaster warning information to farmers and herdsmen through various means, guide them to scientifically arrange agricultural and grazing activities,

establish cold-proof and warm sheds in pastoral areas, rationally utilize favorable weather to arrange activities such as the harvest of mature crops, livestock transfer, shearing, lambing, and mating. Besides, it is needed to develop professional meteorological service products for departments such as transportation, power, and communication, promptly release warning information on blizzard weather and road icing, and ensure service guarantees for power, travel, and communication.

4 Conclusion

Snowstorms are one of the common meteorological disasters in Tongliao area during winter and spring. The brought gales, snowfall and temperature drop can cause frost damage, low visibility, *etc.*, which pose a serious threat to agricultural and animal husbandry production, transportation, power and communication, *etc.* Especially the blizzard weather that occurs in spring poses a greater threat to the safe production of agriculture and animal husbandry in Tongliao area. When a blizzard extremely cold weather event occurs, local meteorological departments should promptly issue early warning information to provide decisions for the emergency organization of the government and relevant departments, and quickly activate the extreme weather emergency response, issue the order to activate the emergency response, and take preventive and protective measures. Meteorological departments should constantly improve the prediction and prediction level of meteorological disasters, strengthen the publicity of meteorological disaster prevention, raise the public's awareness of extreme weather, and minimize the losses caused by disasters to the greatest extent.

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