Recollection

A Brief of Cold Spell Warning Actions of the National Meteorological Center of China Meteorological Administration

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The "Outline for High-Quality Development of Meteorology (2022–2035)" was published by the State Council of the People's Republic of China in April 2022 (*1*). This publication highlights the essential role of meteorological disaster warnings, particularly cold spell warnings, in preventing and mitigating disasters. The outline also sets forth stricter expectations for enhancing the overall capacity of society in terms of meteorological disaster preparedness and response.

The characteristics of a cold spell are characterized by significant drops in temperature and a wide-ranging impact that can lead to serious disasters (*2*–*3*). Cold spells may be accompanied by or trigger intense cooling, gales, rain, snow, ice, etc. These events not only result in considerable losses in the national economy, particularly in agriculture, forestry, and animal husbandry production, but also pose significant impacts and hazards to the lives and health of the public.

The history of meteorological disaster warning actions in China can be traced back to 1951 when the China Meteorological Administration (CMA) first began implementing such actions. However, it was in June 2007 that the well-known modern meteorological disaster warning system was established through the issuance of the "Measures for the Issuance and Dissemination of Meteorological Disaster Warning Signals" (*4*), which regulated the issuance and dissemination of warning signals for 13 types of meteorological disasters by meteorological departments at all levels. In the same year, the National Meteorological Center established the mechanism for issuing weather warnings for meteorological disasters, including cold spell warnings. The latest version of the "Measures for Issuance of Meteorological Disaster Early Warnings of the National Meteorological Center" (*5*) was revised and issued by the CMA in March 2023. This updated version optimizes the types of disaster warnings, expanding it to 14 categories, improves the warning responsibilities authorized by the CMA, and implements normalized actional standards for cold spell warnings. Additionally, it provides national-level defense guidelines for meteorological disasters.

EXPERIENCES AND ACHIEVEMENTS

Technical Research And Development

Building upon the advanced integrated three-dimensional meteorological observation system encompassing land, sea, air, and space, and grounded in a firm understanding of meteorological principles and the dynamics of standard weather models, meteorological agencies have honed forecasting and warning services for cold spells over many decades (*6*–*7*). The advent of increased automation and the perpetual evolution of technologies, such as numerical modeling and AI, have revolutionized cold spell warnings, transitioning from manual observations and synoptic chart analysis to automated data acquisition and sophisticated numerical weather prediction techniques. Consequently, scientific and technological advancements have become the cornerstone for enhancing the precision of forecasting and warning systems for cold spells and other extreme weather events.

Service Actions

Analysis and prediction of weather forecasts. The National Meteorological Center diligently monitors, analyzes, and predicts cold spells in advance, specifically focusing on the movement of cold air and examining the underlying atmospheric circulation patterns and their future changes. This enables forecasts of cold spells with an extended lead time of more than 10 days.

Meteorological forecasters use a comprehensive analysis of integrated data from ground, air, and satellite observations, as well as numerical models, to predict the cold spell's timing, intensity variations, and

affected areas. They also assess whether future weather conditions such as low temperatures, rain, and snow will meet the criteria for issuing cold spell warnings. Additionally, forecasters evaluate the potential economic and social impacts and risks associated with the cold spell. (*8*)

Expert consultation for joint decision-making. As the forecast time approaches, the predictability and accuracy of cold spell disaster weather forecasting also improve. Prior to the official release of a cold spell warning (usually more than three days in advance), the National Meteorological Center (NMC) convenes experts from provincial meteorological departments for a daily morning national consultation. During this session, the experts study the upcoming cold spell process and collectively decide on the subsequent progressive warnings and follow-up service strategies.

Disaster warning production and dissemination. In accordance with the Measures for Issuance and Dissemination of Meteorological Disaster Warnings of the National Meteorological Center, cold spell warnings are typically issued by the NMC 24 hours in advance. These warnings undergo review, issuance, and rechecking by the relevant departments. Additionally, the CMA collaborates with other relevant departments to establish an early warning information release mechanism for emergencies, ensuring the timely dissemination of information to the public. The issued warning information is continuously monitored and evaluated throughout the cold spell and will be updated or lifted as appropriate based on the actual situation.

The NMC classifies the cold spell early warning standard into three grades (blue, yellow, and orange), which align with the national standard for cold spell intensity levels (cold spell, extreme cold spell, and super cold spell). However, the specific details of provincial cold spell warnings may vary, such as the warning level, issuing standards, and regional coverage. The NMC issues a national-level warning that applies to the entire country and is required when a cold spell impacts more than four provincial-level administrative divisions (PLADs). On the other hand, PLAD's Meteorological Bureau issues warnings based on the specific conditions and service requirements of each PLAD. The release standards may vary to account for the PLAD's unique climatic characteristics and disaster prevention needs. Some PLADs still maintain four cold spell warning levels (blue, yellow, orange, and red). Despite the differences in warning levels and methods, the primary objective remains the same — to inform the public in advance and enable them to take precautionary measures to minimize the impact of cold spells.

Intersectoral Joint Emergency Response. Given the potentially severe impacts of cold spell events, meteorological agencies, in conjunction with emergency management departments, are diligently enhancing the integration of meteorological warning systems and emergency response activation criteria. Additionally, meteorological departments and government bodies at various levels are collaboratively developing and refining a suite of mechanisms, including rapid decision-making and dispatch, sector-specific emergency responses, and public engagement strategies. With meteorological forecasts serving as a vanguard, these initiatives aim to advance disaster prevention and reduction efforts, thereby significantly improving our overall capacity to defend against and manage meteorological disasters with precision and effectiveness.

Follow-up assessment and services. Meteorological departments establish and enhance comprehensive review systems to address cold spells and other weather-related disasters. This system encompasses meteorological forecast and warning technology service inspection, standardized assessment of the warning information release process, and evaluation of disaster reduction efforts and socio-economic benefits. The insights gained from these reviews directly contribute to the enhancement of weather warning services and associated operational systems. Simultaneously, meteorological departments prioritize the improvement of public awareness regarding meteorological warnings. This involves strengthening education and trainings for emergency response personnel and refining the mechanism for disseminating meteorological warnings.

Overall Situation

Early warning business layouts have been gradually improved. National and provincial levels have established early warning actions focused on meteorological disasters, including early warnings and warning signals. Furthermore, a "progressive forecasting, progressive warning, and follow-up services" system has been developed, allowing for extended-release of outlooks for critical weather processes, forecasts for critical weather processes within 3–7 days, and information on disaster weather warnings and decision-making services 1–2 days in advance. Additionally, short-range prediction products and warning signals are released in a timely manner,

achieving the desired effect of early notification and early warning.

Increasing public coverage of early warning information. The China Meteorological Administration has coordinated the establishment of a national platform for releasing early warning information on emergencies. Initially, a service system called "one vertical and four horizontal" has been formed to facilitate the real-time sharing of platforms and information between meteorological departments at various levels and warning issuing agencies and government emergency management departments. Currently, early warning information, including cold spell warnings, can be released in real time through multiple channels such as radio, television, and the Internet. As of 2021, the public coverage rate has reached 96.9%.

Establishment of the emergency response mechanism. These mechanisms have been crucial in dealing with meteorological disasters. Local meteorological departments have been actively advocating for the establishment and enhancement of meteorological early warning and emergency response linkage mechanisms among local governments and relevant departments. Currently, a total of 25 PLADs have the capability to make informed decisions regarding the initiation of an emergency response based on meteorological disaster warnings. Additionally, 26 PLADs have developed specific standards for implementing measures such as school closures or business suspensions to different extents. Some PLADs have even implemented rapid emergency response linkage mechanisms that automatically trigger school closures once a defined level of warning is reached.

CHALLENGES

The cold spell weather will have significant and extensive impacts on both the general public and industries. China's economy and society are currently in a phase of high-quality development. With the increasing sensitivity of the social system to meteorological impacts, there is a growing demand for accurate forecasting and effective prevention of major risks, including meteorological disasters (*9*–*10*).

While China has developed a relatively comprehensive operational system for predicting and issuing early warnings for cold spells, there are still several challenges ahead in achieving high-quality development. Improving forecast accuracy involves strengthening the ability to provide more precise forecasts for the intensity, region, and impact of extreme strong cold spells and super cold spells. Enhancing service quality and efficiency requires continuous innovation and exploration of the "soft power" of modern meteorological early warning capabilities. The social benefits of cold spell forecasting and early warning, particularly their impacts on human health, need further exploration. Additionally, there is a need to address the lack of unified emergency response coordination between meteorological departments and local government departments at all levels. To achieve this, there is a need for an improved, legally binding, multi-departmental emergency response mechanism led by cold spell early warning.

PROSPECTS

Continuously Improving the Accuracy of Cold Spell Disaster Weather Prediction Models

Enhancing the accuracy and timeliness of cold spell forecasting is crucial for effectively preventing and mitigating meteorological disasters, as well as ensuring the safety and security of individuals and their properties. In order to achieve this, it is essential to continuously improve the forecasting capability of cold spell disaster weather. Given the current information revolution, there is a need to enhance the application of intelligent and digital technologies, deepen our understanding of the mechanisms and patterns of cold spell weather, and strengthen our ability to forecast such weather accurately. This will serve as the foundation for establishing a robust first line of defense against meteorological disasters.

Continuously Maximizing the Effectiveness of Cold Spell Forecasting and Alert Systems

It is important to recognize the advantages of cold spell forecasting and warning in various sectors such as agriculture, transportation, energy, and high-risk groups. To cater to the specific needs of these sectors and groups, it is crucial to enhance collaboration between industries and social sectors. This includes conducting objective and quantitative risk assessment and zoning for the potential impacts of cold spells. Furthermore, targeted risk forecasting and service strategies should be researched and implemented to fully utilize the benefits of meteorology in preventing

harm.

Continuously Improving the Timeliness and Efficacy of Government-Led Disaster Prevention and Response Mechanisms

Efforts must be made to enhance the effectiveness of the early warning system and strengthen government-led disaster prevention and mitigation mechanisms. Meteorological agencies and governmental bodies at all levels should strive to enhance the emergency management system, taking a proactive role in guiding and coordinating efforts. By prioritizing early warning as a proactive measure, it is essential to organize scientifically and efficiently the defense against cold spells during disaster emergencies, ensuring the safety of the public and minimizing socio-economic losses.

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