Research Scheme on Pre-assessment Theory and Method for Influences of Disastrous Meteorological Events

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Abstract
It has an important practical significance and is extremely urgent to make a research scheme on pre-assessment theory and method for influences of disastrous meteorological events, and the need for enhancing emergency management capability in the future is imperative. This paper develops a research scheme aiming at these objective need. First, this paper gives an integrated overview of the related literature about research status, as well as problems of current research. Then, it clarifies the research content and uses a graphical representation to show the technical routes in detail. Finally, it proposes the key scientific issues that need to be resolved.

Keywords
Research Scheme; Disastrous Meteorological Event; Pre-assessment Theory

Introduction
The risk pre-assessment of disastrous meteorological event has its own characteristics, as the meteorological disaster has the following characteristics: great variety, wide affected areas, high frequency, long duration, coexistence with other fatalities, serious secondary disasters and enormous economic loss.

Besides above features, disastrous meteorological events also have some characteristics of the unconventional emergencies as follows.

(1) Sudden: especially the meteorological disasters and the secondary disasters caused by local extreme weather events are difficult to forecast and warn accurately, so they occur very suddenly, and their influence often spreads widly and rapidly.

(2) Complexity: as numerous objects are involved in the disastrous meteorological event response, collecting and dealing with the information of multiple hazard-bearing bodies distributed in different geographical locations is needed; and the government, society and other departments are needed in the emergency response, they should participate collaboratively, dispatch existing resources reasonably and draft the response plans; all interrelated and coupled factors lead to the complexity of the response and decision-making for disastrous meteorological events;

(3) Timeliness: if interference and restraints to disastrous meteorological events were not implemented timely and effectively, serious and even disastrous consequence will occur consequentially; hence, carrying out emergency decision-making and implementing response plans are faced with heavy time pressures.

Although experts have conducted more research now on meteorological disaster risk management, but they has not yet developed a relatively complete theoretical system. Therefore, China urgently need to build the theory of pre-assessment for disastrous meteorological events. This study is designed to provide a complete solution to pre-assessment theory and method, and to point out specific research and some technical routes.

Research Status
Recently, pre-assessment theory and method for influences of disastrous meteorological events begin being taken into consideration seriously, which mainly focuses on single disaster. In the evaluation methods, existing researches mainly focus on delphi method and AHP method (Yongbo Tie, 2005; Chuanming Liu, 2006). Zhang Xing(2008) analyzed the features of meteorological disasters and their effect on the grain production. Li Chunhua (2009) estimated the loss amount of grain yield due to natural disaster using grey prediction model. Generally speaking, researches in meteorological disaster risk mainly concentrate on the static analysis of disaster risk, evaluation and

Currently, there are several problems existing in the pre-assessment of disastrous meteorological events according to overseas and domestic research status: firstly, most of the researches analyze hazard-bearing bodies separately, and lack awareness of the interaction mechanism between hazard-bearing bodies and meteorological disaster-formative factors; secondly, most of the researches focus on the risk assessment of a specific meteorological disaster; thirdly, when evaluating risks, the resilience of the hazard-bearing bodies is lack of consideration; finally, most of the awareness of the meteorological disaster risk assessment is the static risk. Especially, the spatiotemporal variability and the integration and coupling of several meteorological disaster-formative factors are less considered in disaster risk assessment.

Research Contents

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Spatial and Temporal Variation of Disastrous Weather Events

Disastrous meteorological events are results from comprehensive effects of complex interactions between meteorological disaster-formative factors and disaster-bearing bodies. With regard to disastrous meteorological events caused by accumulation and coupling of disaster-formative factors, we established meteorological data set with wide range and long-time scale through collecting meteorological data with high-quality provided by Chinese meteorological administration.
The correlations between meteorological disaster-formative factors and disastrous meteorological events should be first researched in this part. As various disastrous meteorological events are induced by several essential meteorological disaster-formative factors, including rain\snow, wind, temperature, etc., through generalizing and analyzing the numerous historical disastrous meteorological events data, the relational models between meteorological disaster-formative factors and disastrous meteorological events can be built.

Then, disastrous meteorological events evaluation criteria should be built. Through the research on relationship between meteorological disaster-formative factors accumulation, current forecast, historical level at the same period and disastrous meteorological events, the evaluating index system and the division method of prediction threshold and hazard level for disastrous meteorological events induced by meteorological disaster-formative factors can be developed.

Finally, spatiotemporal variety of disastrous meteorological events should be studied in this part. As a typical kind of spatiotemporal events, disastrous meteorological events have characteristics of spatiotemporal evaluation and distribution. On the basis of numerous historical disastrous meteorological events data, through data mining and analyzing, spatiotemporal distribution models can be built.

Classification for hazard-bearing bodies should be researched and its concept as well as the formalized expression for their relationships should be studied. The concrete research contents mainly include the followings: first, research on the concept model of the classification for meteorological hazard-bearing bodies based on ontology; second, research on the hierarchical levels of hazard-bearing bodies as well as their expression; third, establish integrative ontology model including disaster-formative factor, hazard-bearing body and hazard inducing environment. Establish the map concerns between disaster-formative factors (actions) and hazard-bearing bodies (properties). Meteorological disasters as well as their secondary and derived disasters always act in the ways of material, energy and information, thereby it leads to the harm on bodies and functions of hazard-bearing bodies. According to the classification of hazard-bearing bodies, the analysis and reasoning of the following problems can be realized: which hazard-bearing bodies will be influenced by several specific meteorological disaster-formative factors and which meteorological disaster-formative factors will act on a specific kind of hazard-bearing bodies. Construct information extracting algorithm for hazard-bearing bodies and expression models for anti-disaster ability.

Dynamic Risk Assessment Method of Meteorological Disasters

On the basis of acknowledging the spatial and temporal variation and unified modeling of multiple hazard-bearing bodies, we will built models for the spatial and temporal dynamic evolution process between disaster intensity and anti-disaster ability. One of the models is to study the risk's assessment and expression of a single hazard-bearing body. The other model is the dynamic risk zoning model of meteorological disasters

Single hazard-bearing body risk is defined as the extent of the damage of a specific hazard-bearing body under the action of meteorological disaster-formative factors (including the coupling of multiple disaster-formative factors), which can be thought of as the
gaming result between the disaster intensity of disaster-formative factors and the anti-hazard capacity of hazard-bearing bodies. Therefore, the risk of hazard-bearing bodies “α” under the action of disaster-formative factors can be expressed as \( R_{c,\alpha}(t) = F_c(s,t) \odot V_{\alpha}(s,t) \), where \( \odot \) represents the interactions between the disaster intensity and the anti-hazard capacity. The risk of hazard-bearing bodies under the action of multiple disaster-formative factors “∂” can be expressed as \( R_{\partial}(t) = R_{c,\alpha}(s,t) \odot R_{b,\alpha}(t) \), where \( \odot \) represents the superimposed influence that multiple disaster-formative factors act on hazard-bearing bodies α. In this part, \( \odot \) and \( \odot \) are emphatically studied. On the basis of the research on disaster-formative factors spatiotemporal distribution and the classification model for hazard-bearing bodies of meteorological disasters, dynamic risk assessment models with generality for a single hazard-bearing body can be built. On the basis of dynamic risk assessment for a single hazard-bearing body, regional risk can be calculated through accumulating the risk of a single hazard-bearing body in a specific region. Given the dynamic change of risk with time, regional dynamic risk can be calculated through accumulating the risk of hazard-bearing bodies in spatiotemporal domain. For instance, the dynamic risk of region A in the time interval \([t, t+T]\) can be expressed as \( R_{dT} = \int (A \times T) R_{c,\alpha}(s,t) ds \, dt \). In this part, the multidimensional and dynamic visualization of meteorological disaster risk based on GIS is going to be studied. Besides, research on the analysis for spatiotemporal varieties of risk is being developed.

**Meteorological Disaster Response and Decision-making Pre-assessment**

The essence of the emergencies are plans about response actions, which aim to minimize the risk, control disasters and reduce disaster loss through taking a series of actions, including tasks, powers used and measures. Through deducting the emergencies dynamically, evaluating the results, comparing and selecting the better ones of former emergency plans and adjusting and reevaluating the emergencies timely before taking actions, the decision-making can be more scientific, efficient, timely and reliable. The major research routes of this part mainly include the followings: dynamic deduction methods for emergency plans and assessment models for emergency plans, which mainly evaluate the results of the emergencies through considering multiple aspects comprehensively. Research on the decision scheme for meteorological disaster response includes a variety of solutions based on “prediction-response” and “scene-decision” models. Using the major research plan sublimation integration platform, we studies dynamic-response inference method aiming at meteorological disasters and builds a pre-evaluation model for the decision scheme for meteorological disaster which is based on dynamic response.

**The Key Scientific Issues**

This paper addresses the key scientific problems including the following four aspects:

**Multiple Hazard-bearing Bodies Generalized Expression Model**

Hazard-bearing bodies have different characteristics for their different property features, spatial scale, structure, etc. With regard to specific disasters and hazard-bearing bodies, patterns and effects of disasters vary from each other. Meteorological disaster hazard-bearing bodies have diversification. How to express the common characteristics of the destruction of disaster-formative factors for multiple hazard-bearing bodies and establish the hazard-bearing bodies classification model based on these common characteristics are two of the key problems that need to be solved. Through the systematic carding of the typical meteorological disaster hazard-bearing bodies, we will learn from the ontology modeling ideas, research the classification model of hazard-bearing bodies of meteorological disasters and the formal description of their relationships, and solve the problem of the information integration and expression of the multiple hazard-bearing bodies.

**The Spatiotemporal Patterns of Hazard-bearing Bodies Suffered by Disaster-formative Factors**

Meteorological disasters are reflections of the intrinsic links between the various disaster-formative factors and hazard-bearing bodies. To study the mechanism and laws essentially, a unified model to describe the inner mechanism of various meteorological disasters is urgently needed. The key point to solve the problem that how to summarize the common action ways among the various meteorological disasters and many hazard-bearing bodies and make a quantitative description is to establish a form of mathematical expression of the disasters structure based on the common action ways, which both reflects the common
features that the different disasters act on the hazard-bearing bodies, and reflects the difference of the mechanism that different disasters act on different hazard-bearing bodies. Through the concept of the element actions of the emergency and the meta-characteristics of hazard-bearing bodies, meteorological disaster system can be expressed by three parts, including disaster-formative factors, hazard-bearing bodies and element actions, which can be used to describe the spatiotemporal and dynamic interaction between the disaster-formative factors and the hazard-bearing bodies.

**Dynamic Risk Assessment Theory of Aisastrous Meteorological Events**

Meteorological disaster-formative factors and hazard-bearing bodies have multi-stage spatiotemporal variation, leading to differences of the spatiotemporal variation of the risk level in the various stages, including the birth, occurrence and development of meteorological disasters, which is comprehensive effects of the disaster intensity related to the disaster-formative factors and the resistance related to the hazard-bearing bodies in the spatiotemporal domain. Whether it is a single hazard-bearing body risk or a specific area integrated risk, it is a essential function of the property of the disaster-formative factor and the hazard-bearing body in spatiotemporal domain. How to create a pre-assessment model for single hazard-bearing body and regional hazard-bearing bodies is one of the key problems should be solved.

**Assessment Method for Emergency Plans Based on Dynamic Deduction**

Meteorological disasters have many unconventional characteristics, which determines that its response process is a complex, nonlinear feedback system. And these characteristics bring enormous challenges to the deduction and evaluation for meteorological disaster emergency plans. Base on pre-assessment model for disastrous meteorological events, we will integrate it and simulate emergency decision-making processes based on combining with “prediction-respond” and “scenario-respond”. On the basis of the dynamic deduction and the analysis of their results, the method for dealing with emergency plans assessment will be proposed.

**Conclusion**

Through systematic analysis, this paper proposes a research scheme on pre-assessment plan for disastrous meteorological events. This paper also designs and develops some specific technical routes of risk pre-assessment on disastrous meteorological events, and sums up four key scientific issues that need to be resolved. According to this scheme of risk pre-assessment on disastrous meteorological events, the research contents and the technical routes in detail are perspicuous. These researches’ results will contribute to enhancing the capacity of decision-makings among several meteorological administrations, reducing casualties, economic loss caused by these events, etc., and it has a significant impact on improving emergency management on disastrous meteorological events.

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