APPLICATION OF ANALYTIC HIERARCHY PROCESS IN ATMOSPHERIC ICING CLIMATE FORECAST OF POWER NETWORK BASED ON MULTIPLEX CLIMATE FACTORS

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***Abstract**:* Atmospheric icing climate of power network was influenced by multiplex climate factors, such as sunspot, ocean temperature, subtropical highs, and atmospheric temperature and so on. Based on the fundamental principle of analytic hierarchy process (AHP), the hierarchical structure model for the atmospheric icing climate forecast of power network was established. With practical icing events happed in Hunan province of China as examples, multiplex climate factors for icing forecast are evaluated and calculated, the numerical priorities of climate factors are obtained.

1. INTRODUCTION

Atmospheric icing forecast of power network is a worldwide problem and has no exact theoretical guidance at the exploratory stage. Short-time-range atmospheric icing forecast research was carried out based on statistical analysis of meteorological data [1]. However, atmospheric icing climate forecast during long-time-range such as previous several months is required.

Atmospheric icing climate of power network was influenced by multiplex climate factors, such as sunspot, ocean temperature (El Nino and La Nino phenomenon), subtropical highs, and atmospheric temperature and so on. In order to synthesize the affects of multiplex climate factors, analytic hierarchy process (AHP) is one of simple and useful method. Based on the fundamental principle of AHP, the hierarchical structure model for icing of power network was established. A numerical weight or priority was obtained for each meteorological factor. The forecast result of atmospheric icing climate of power network can be derived by synthesizing the multiplex climate factors with their numerical priority.

2. RESULTS AND DISCUSSION

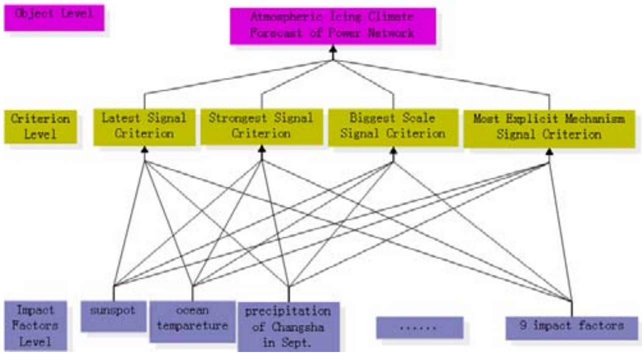

Figure. 1 Hierarchical Structure Model for Atmospheric Icing Forecast

According to the fundamental principle of AHP [2], a hierarchical structure model for atmospheric icing climate forecast of power network based on multiplex climate factors is studied and presented in Fig. 1. The numerical priorities of multiplex impact factors are obtained as shown Table I.

TABLE I. THE JUDGMENT MATRIX OF ICING FORECAST

Criterion Level	*Latest Sig. Crit.*	*Strongest Sig. Crit.*	*Biggest Scale Sig. Crit.*	*Most Explicit Mechanism Sig. Crit.*	***Priority***
sunspot	0.0556	0.0628	0.0773	0.0570	0.0623
ocean temparature	0.0556	0.0669	0.0891	0.0570	0.0658
intensity index of subtropics in summer	0.1113	0.0538	0.0590	0.1339	0.0837
area and ridge point of subtr. in August	0.1733	0.0581	0.0462	0.1339	0.0926
subtropical ridge in Feb. and June	0.0954	0.1503	0.2103	0.1339	0.1467
atomspheric circulation indices	0.0998	0.0619	0.0569	0.1169	0.0810
highest temperature of Changsha in Feb.	0.0883	0.1955	0.1703	0.0432	0.1368
precipitation of Changsha in Sept.	0.2389	0.1552	0.0764	0.1798	0.1623
subtr. ridge and ave.temperature of Changsha in Feb.	0.0818	0.1955	0.2146	0.1446	0.1688

3. CONCLUSION

In the impact factor level, the 3 most important climate factors of each impact factor related to atmospheric climate forecast are subtropical ridge and average temperature of Changsha in Feb., precipitation of Changsha in Sept., and subtropical ridge in Feb. and June, respectively.

4. REFERENCES

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[2] T. L. Satty, The Analtic Hierarchy Process. New Work， New York：McGraw-Hill, 1980.

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***Abstract*—Atmospheric icing climate of power network was influenced by multiplex climate factors, such as sunspot, ocean temperature (El Nino and La Nino phenomenon), subtropical highs, and atmospheric temperature and so on. Based on the fundamental principle of analytic hierarchy process (AHP), the hierarchical structure model for the atmospheric icing climate forecast of power network was established. With practical icing events happed in Hunan province of China as examples, multiplex climate factors for icing forecast are evaluated and calculated, the numerical priorities of climate factors are obtained.**

Keywords-atmospheric icing;climate forecast; AHP;

I. INTRODUCTION

Atmospheric icing forecast of power network is a worldwide problem and has no exact theoretical guidance at the exploratory stage [1]. Short-time-range atmospheric icing forecast research was carried out based on statistical analysis of meteorological data [2]. The analysis aims at establishing shape and statistical parameters of the transfer functions representing the correlations between hourly icing rate and the variations of the following meteorological variables: ambient temperature, hourly number of ice-rate meter signals, wind speed and direction, and freezing precipitation rate. Their purpose is to study and forecast atmospheric-icing loads on overhead power-line conductors during short-time-range such as previous several hours. However, atmospheric icing climate forecast during long-time-range such as previous several months is required.

Atmospheric icing climate of power network was influenced by multiplex climate factors, such as sunspot, ocean temperature (El Nino and La Nino phenomenon), subtropical highs, and atmospheric temperature and so on. In order to synthesize the affects of multiplex climate factors, analytic hierarchy process (AHP) is one of simple and useful method. Based on the fundamental principle of AHP, the hierarchical structure model for icing of power network was established. A numerical weight or priority was obtained for each meteorological factor. The forecast result of atmospheric icing climate of power network can be derived by synthesizing the multiplex climate factors with their numerical priority.

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II. PRINCIPLE OF ANALYTIC HIERARCHY PROESS

A. Analytic Hierarchy Proess

Based on mathematics and psychology, the AHP was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

The procedure for using the AHP can be summarized as: model the problem as a hierarchy containing the decision goal, the alternatives for reaching it, and the criteria for evaluating the alternatives; establish priorities among the elements of the hierarchy by making a series of judgments based on pairwise comparisons of the elements; synthesize these judgments to yield a set of overall priorities for the hierarchy; check the consistency of the judgments, come to a final decision based on the results of this process.

B. Hierarchical Structure Model

The first step in the Analytic Hierarchy Process is to model the problem as a hierarchy. In doing this, participants explore the aspects of the problem at levels from general to detailed, then express it in the multileveled way that the AHP requires. We use hierarchies to help us acquire detailed knowledge of complex reality: we structure the reality into its constituent parts, and these in turn into their own constituent parts, proceeding down the hierarchy as many levels as we care to. At each step, we focus on understanding a single component of the whole, temporarily disregarding the other components at this and all other levels. As we go through this process, we increase our global understanding of whatever complex reality we are studying.

C. Construct a set of pairwise comparison matrices

Establish priorities among the elements X={x_1, x_2, … , x_n} of the hierarchy by making a series of judgments based on pairwise comparisons of the elements. a_{ij} is the pairwise comparison between elements x_i and x_j , A is the pairwise comparison matrices.

$$A=(a_{ij})_{n\times n} \quad (1)$$

Table I exhibits the scale of the pairwise comparison with respect to the criterion or property with respect to which they are compared.

TABLE II. THE MOTHOD OF CONFIRMING COMPARSON SCALE

x_i/x_j	***Equal Importance***	***Moderate Import.***	***Strong Import.***	***Demonstrated Import.***	***Extreme Import.***
a_{ij}	1	3	5	7	9

D. Synthesize these judgments to yield a set of overall priorities for the hierarchy

Firstly, we should calculate the largest eigenvalue λ_{max} of judgments matrices $\boldsymbol{A}$. Then, according to

$$\boldsymbol{AW}= \lambda_{max}\boldsymbol{W} \quad (2),$$

where $\boldsymbol{W}$ is the feature vector corresponding to λ_{max}, the numerical priorities for the hierarchy are obtained from standardized $\boldsymbol{W}$.

E. Check the consistency of the judgments

The consistency index $\boldsymbol{C_I}$ of judgments matrices $\boldsymbol{A}$ is given by

$$\boldsymbol{C_I} = (\lambda_{max}-n) / (n-1) \quad (3).$$

The consistency rate $\boldsymbol{C_R}$=$\boldsymbol{C_I}$ /$\boldsymbol{R_I}$, where $\boldsymbol{R_I}$ is the randomicity index given by table II with respect to the order index n of judgment matrices of $\boldsymbol{A}$. When $\boldsymbol{C_R}<$ 0.10, the judgment matrices of $\boldsymbol{A}$ has satisfactory consistency.

TABLE III. THE VALUE OF R_I FOR RANDOMICITY INDEX

Order n	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***
R_I	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

III. APPLICATION OF AHP IN ATMOSPHERIC ICING CLIMATE FORECAST OF OF POWER NETWORK BASED ON MULTIPLEX CLIMATE FACTORS

A. Hierarchical Structure Model for Atmospheric Icing Climate Forecast of Power Network Based on Multiplex Climate Factors

According to the fundamental principle of AHP [3, 4], a hierarchical structure model for atmospheric icing climate forecast of power network based on multiplex climate factors is studied and presented in Fig. 1.

(1) Objective Level. The objective of this research is atmospheric icing climate forecast of power network.

(2) Criterion Level. This level includes four elements: latest signal criterion, strongest signal criterion, biggest scale signal criterion, most explicit mechanism signal criterion.

(3) Impact Factors Level. By studying the meteorological data from 97 weather observation stations during 59 years from 1951 to 2010 in Hunan of China, the main affect factors for atmospheric icing include: sunspot, ocean temperature, intensity index of subtropics in summer, area and ridge point of subtropics in August, subtropical ridge in February and June, atmospheric circulation indices, highest temperature of Changsha City in February, precipitation of Changsha City in September, subtropical ridge and average temperature of Changsha City in February.

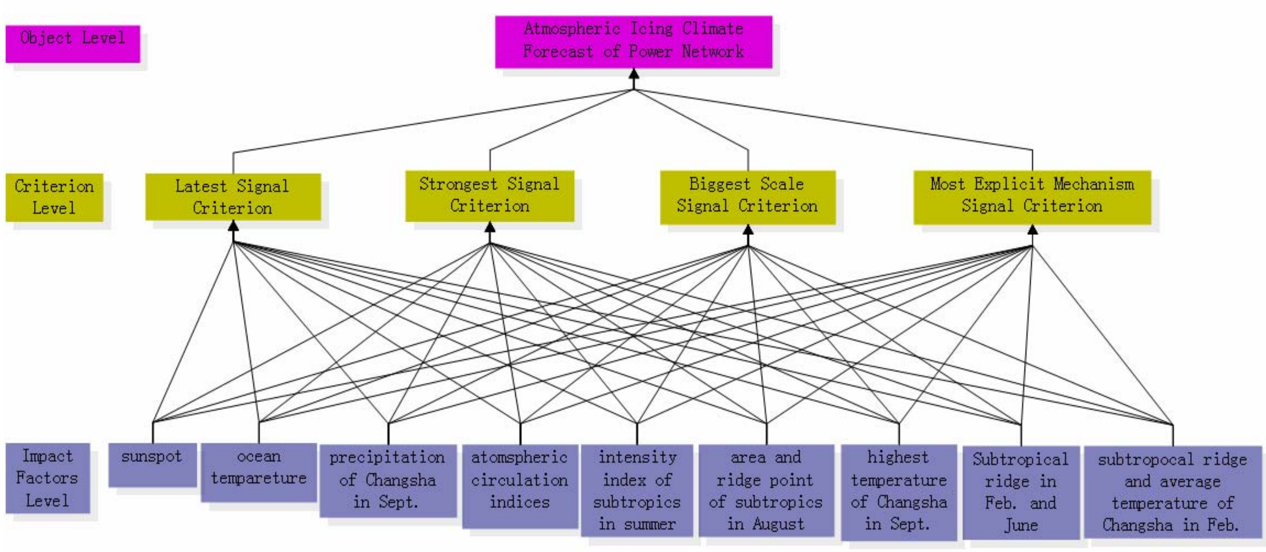

Figure 1. Hierarchical Structure Model for Atmospheric Icing Impact Factors

B. Analysis and Result

With practical icing events happed in Hunan province of China from 1951 to 2010 as examples, more than 17 impact factors were investigated for atmospheric icing climate forecast. The most correlative impact factors are the elements of impact factors level of hierarchical structure model as shown in Fig. 1.

For investigating the numerical weight or priority of the multiplex impact factors, according to the fundamental principle of AHP [3, 4], the judgment matrix of criterion-level for icing forecast goal is presented in Table III.

TABLE IV. THE JUDGMENT MATRIX OF CRITERION LEVEL

Icing Forecast Goal	*Latest Sig. Crit.*	*Strongest Sig. Crit.*	*Biggest Scale Sig. Crit.*	*Most Explicit Mechanism Sig. Crit.*	*Priority*
Latest Sig. Crit.	1	1/3	1	1/2	0.14
Strongest Sig. Crit.	1/3	1	3	2	0.46
Biggest Scale Sig. Crit.	1	3	1	1/2	0.14
Most Explicit Sig. Crit.	1/2	2	1/2	1	0.24

TABLE V. THE JUDGMENT MATRIX OF ICINGF

Criterion Level	*Latest Sig. Crit.*	*Strongest Sig. Crit.*	*Biggest Scale Sig. Crit.*	*Most Explicit Mechanism Sig. Crit.*	***Priority***
sunspot	0.0556	0.0628	0.0773	0.0570	0.0623
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According to Table III and (1) ~ (3), we can calculate that: λ_{max} = 4.0, $\boldsymbol{C_I}$ = 0, $\boldsymbol{R_I}$ = 0.9, $\boldsymbol{C_R}$ = 0. Therefore, the judgment matrix of criterion-level related to icing forecast goal has satisfactory consistency.

The judgment matrices multiplex impact factors related to criterion level are also investigated with satisfactory consistency ($\boldsymbol{C_R} < 0.1$).

According to the calculation result of judgment matrices of criterion-level and impact factors level, the numerical priorities of multiplex impact factors are obtained as shown Table IV.

The priorities of multiplex impact factors for atmospheric icing climate forecast of Hunan power network are obtained that: subtropical ridge and average temperature of Changsha City in February, precipitation of Changsha City in September, subtropical ridge in February and June, highest temperature of Changsha City in February, area and ridge point of subtropics in August, intensity index of subtropics in summer, atmospheric circulation indices, ocean temperature, sunspot.

IV. CONLUSION

According to the fundamental principle of analytic hierarchy process (AHP), the model of hierarchical structure of atmospheric icing climate forecast of Hunan power network based on multiplex climate factors is proposed, and the satisfactory consistency and accuracy are demonstrated by the calculated result of judgment matrices. The numerical priorities of the impact climate factors are obtained.

In the criterion level, the numerical priorities of each element related to atmospheric icing climate forecast are 0.14, 0.46, 0.14, and 0.24, respectively. Therefore, the most importance criterion of criterion level for atmospheric icing climate forecast is strongest signal of criterion. In the impact factor level, the 3 most important climate factors of each impact factor related to atmospheric climate forecast are subtropical ridge and average temperature of Changsha in Feb., precipitation of Changsha in Sept., and subtropical ridge in Feb. and June, respectively. The forecast result of atmospheric icing climate of power network can be derived by synthesizing the multiplex climate factors with their numerical priority.

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