THE MICROPHYSICAL CHARACTERISTICS OF FOG IN THE RIME AND GLAZE

Wen Ji-fen1 Luo Ning2 Meng lei3
1: Guizhou Weather Modification Office, Guiyang, 550002, China
2: Guizhou Meteorological Bureau, Guiyang, 550002, China
3: Key Laboratory of Atmospheric Physics & Atmospheric Environment (LAPE), NUIST, Nanjing, 210044, China

1. INTRODUCTION

Because of different kinds of climate characteristics, the fluence of rime and glaze are very high in Guizhou, China. Rime and glaze are not only the winter scenery, but also the natural disaster. In order to prohibit the transmission line from the disaster and do some research on the microphysical characteristics of this kind of weather phenomenon. Through analyzing the data of microphysical characteristic of fog during the lasting of rime or glaze in the winter of 1990, 1991 in Guizhou province Lou Hill and Maluojing area. Based on the theory of fog, make clear that the relationship among the elements in the rime and glaze. We can find out that the fluent of the foggy evolution in the rime and glaze is less obvious than that in the fog. The relationship between the fluent and micro-physical characteristics of droplet spectrum is very tight.

Overhead wires ice accretion by glaze and rime ice is harmful to electric power, transportation, communication, industrial and agricultural production, conduct ice accretion is a common meteorological disaster in YUNGUI Plateau and other mountain areas. Each year the economical loss of GUIZHOU Province by this disaster is very great, the loss of 2008 year is greatest during 80 years.

According to (Person et al, 1988), the main factors affecting wire ice accretion are: liquid water content, distribution of droplet spectrum, wind direction velocity and temperature. Because of the transmission line being through very complex geographical environment, and the complexity of meteorological factors in different areas as well as their temporal and spatial difference, study of ice accretion is very difficult. Ice accretion observatory station have been established in CHINA and some developed countries, depended on the data aggrandized for long time, ice accretion diameter changed as the height above sea level was summarized. The studies above are significant to the selection of overhead conductor direction road, however, they only reflected the climatic characteristics of ice accretion, and did not involve the mechanism of icing formation. It is short of reality observation data. This paper is studying liquid water content and distribution of droplet spectrum during ice accretion.

2. INVESTIGATED DATA

In order to reveal the law and mechanism of wire ice accretion in GUIZHOU plateau, micro-characteristics of fog and cloud were observed while investigating and collecting the micro-meteorological and macro-meteorological conditions in heavy ice accretion areas. Accidents of wire ice accretion usually take place in heavy ice accretion areas. More fog is a typical climate characteristic of heavy ice accretion areas. Three heavy ice accretion areas of GUIZHOU Province were selected as field investigation areas in the project, they are MALUOQIN in the west LOUSHAN Mountain in north and YUNWU Mountain in the centre, and their heights above sea level are 2128, 1780 and 1659.
The typical characteristic includes ice accretion data and routine meteorological data: liquid water content, distribution of droplet spectrum, wind direction velocity, temperature and ice increasing.

3. THE MICROPHYSICAL CHARACTERISTICS OF FOG IN THE RIME AND GLAZE

Liquid water content and distribution of droplet spectrum during ice accretion are very important to research micro-physical characteristics of ice accretion.

3.1 CHARACTERISTICS OF DROPLET SPECTRUM

According to the cloud droplet spectrum data of west part and north part in GUOZHOU, the calculated value are show in table 1.

Table 1: Physical characteristics of supercooled cloud droplet spectrum

<table>
<thead>
<tr>
<th>parameter</th>
<th>west</th>
<th>north</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lee side</td>
<td>windwardside</td>
<td></td>
</tr>
<tr>
<td>Arithmetic mean diameter(μm)</td>
<td>range</td>
<td>4.3-13.3</td>
<td>3.7-7.0</td>
</tr>
<tr>
<td></td>
<td>average</td>
<td>7.0</td>
<td>6.1</td>
</tr>
<tr>
<td>Cobe root diameter(μm)</td>
<td>range</td>
<td>7.3-14.4</td>
<td>4-12.3</td>
</tr>
<tr>
<td></td>
<td>average</td>
<td>11.8</td>
<td>8.4</td>
</tr>
<tr>
<td>Peak diameter(μm)</td>
<td>4.0</td>
<td>4.3</td>
<td>4.2</td>
</tr>
<tr>
<td>The rate of peak concentration to total concentration</td>
<td>62%</td>
<td>73%</td>
<td>51%</td>
</tr>
<tr>
<td>Cloud droplet concentration/cm³</td>
<td>average</td>
<td>235</td>
<td>259</td>
</tr>
<tr>
<td>samples</td>
<td>16</td>
<td>21</td>
<td>13</td>
</tr>
</tbody>
</table>

The cloud droplet spectrums have slight difference in different years in the west of GUIZHOU Province. The characteristic values of cloud in the north and west have the same order.

The elementary characteristic of cloud droplet spectrum distribution is that the cloud droplet concentration is small, the characteristic diameter of droplet spectrum is relatively great, for example in 1991. The cloud droplet concentration is great, and the characteristic diameter of droplet spectrums is small. Most distribution of the cloud droplet spectrum is single peak type. Under most peak diameter, the greater the diameter, the greater the droplet concentration. Above the peak diameters, the greater the diameter, the smaller the droplet concentration. This rule meets the droplet spectrum formula of Khrgian–Mazin:

\[ n'(r)dr = cr^2 e^{-br} dr \]

<table>
<thead>
<tr>
<th>year</th>
<th>place</th>
<th>droplet spectrum formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>MALUOQIN</td>
<td>( n(d) = 7.28d^{-0.25} )</td>
</tr>
<tr>
<td>1989</td>
<td>MALUOQIN</td>
<td>( n(d) = 7.55d^{-0.25} )</td>
</tr>
<tr>
<td>1991</td>
<td>MALUOQIN</td>
<td>( n(d) = 5.38d^{-0.25} )</td>
</tr>
<tr>
<td>1990</td>
<td>LOUSHAN1</td>
<td>( n(d) = 6.8d^{-0.25} )</td>
</tr>
<tr>
<td>1990</td>
<td>LOUSHAN2</td>
<td>( n(d) = 7.45d^{-0.25} )</td>
</tr>
</tbody>
</table>

Where, \( n'(r) \) the droplet concentration as radius between \( r+dr \). \( c \) and \( b \) are constants. Different cloud droplet spectrum can be
distinguished with different \( c \) and \( b \). From the actual data of Table 1, the average droplet spectrum formula of glaze and rime ice per year in GUIZHOU Province can be obtained. Fog droplet spectrum shown in Fig. 1, cloud and fog droplet spectrum shown in Fig. 2.

According to calculating of reality observation data, the average formula of cloud and fog droplet spectrum is follow:

\[
    n(d) = 6.88d^2e^{-0.24d}
\]
3.2 THE BIG DROPLET CHARACTERISTIC -IC ITS CONTRIBUTION TO LIQUID WATER CONTENT(LWC)

Some experiments of collection efficiency show:collection efficiency has direct ratio with the radius of fluid particles (Makkonen et al,1987).The greater the droplet in cloud and fog, the higher the collision frequency with circular wires, the more the amount of wire ice accretion .Therefore the study of ice accretion especially concerns droplet spectrum width and big droplet .The minimum of median volume diameter caculated with actual cloud droplet data of GUIZHOU is 14 μm.The droplet above 14 μm is regarded as big droplet in cloud in this paper.Counting the rate of cloud droplet above 14 μm among total cloud droplet concentration, the rate is 15% in 1988, 6.3% in 1989, 12% in 1990, 18.6% in 1991. Statistics shows: the maximal diamter of cloud droplet is between 35 and 50 μm and the concentration only makes up about 1% of the total concentration. The total contribution of cloud droplet of the two areas in the West and the North to the liquid water content is showed in fig.3.

![Fig.3 Percentage of the contribution of different cloud-fog droplet size to LWC. Shade areas is the integration of cloud droplet about 14 μm to LWC.](image)

Fig.3 Percentage of the contribution of different cloud-fog droplet size to LWC. Shade areas is the integration of cloud droplet about 14 μm to LWC.

Fig.3 show that: the big droplet above 14 μm only makes up about 15% of total cloud droplet, but the contribution to liquid water content is up to 75% ~ 81%. Therefore, the studies of cloud droplet spectrum should emphasize mean cube root diameter and median volume diameter whose characteristic could represent big droplet and have the most contribution to liquid water content.

3.3 LIQUID WATER CONTENT(LWC)

Liquid water content is a key factor of studying ice accretion. 394 LWC data in several years are showed in the table 3:

In the West of GUIZHOU, the heights above sea level are the maximum, the average LWC is the minimal. The heights above sea level are minimal among the three areas, because of the very low temperature during observation, LWC is not very high. LWC is related not only with height above sea level of topography but also with the distribution of temperature. The actual average LWC in different scope in three areas of the West, North and Centre of GUIZHOU are showed in table 4.

A relationship of LWC and temperature is obtained: between 0 ℃ ~ -6 ℃, LWC tends to decrease as the temperature decreases, and in the same temperature scope, the higher the height above sea level, the lower the LWC, and vice versa. This phenomenon is mainly related with the environment, geographic position of three observatory spots and the height of cloud layer of winter stationary front in GUIZHOU-YUNNAN Plateau. Because the temperature scope was only between -4 ℃ ~ -6 ℃ during observation in the Central areas, the relationship of temperature and LWC can not be determined easily.

4. CONCLUSIONS

The study of liquid water content and droplet spectrum by observation data during ice accretion indicates the following:

a. The cloud-fog droplet concentration and average diameter characteristic observed in
The west and north of GUIZHOU Province in several years,don’t have obvious regional difference.Tdifferencce of each value should be the natural diffience of cloud-fog.The main Characteristics are: cloud-fog. Droplet average concenration is between 140 and 312 per cm³.Arithmetic mean diameter and cube root diameter of cloud-fog droplet are 7.4 and 13.2 respretively.The average rate of maximal concentration to total concentra tion is 62%.  

b. The cloud droplet concentration and droplet value meet the formula of Khrgian –Mazin:n (d)=cd²e−bd. After c,b were calcula ted with the actual cloud-fog droplet spec -trum formal is: n (d)=6.88d²e−0.24d. 

c. Summing up several years cloud-fog droplet spectrum data, the cloud-fog droplet concentration above 14 μm makes up 12.5% of the total cloud-fog droplet concen -tration, but its contribution to LWC is up to 78%. Since big droplet contributes greatly to LWC ,and collision efficiency with wire is high, the characteristic of big droplet is a great problem concerning ice accretion.

d. LWC of cloud-fog is between0.03 and 0.56 g/m³, the average is 0.20 g/m³. LWC is obviously related with temperature and height above sea level. Within 0 ℃ ~-6 ℃, LWC descends as temperature descends, the higher the Height above sea level, the less the average LWC.

REFERENCE
