ANALYSIS OF THE MICROPHYSICAL STRUCTURES OF ULTRA HEAVY FOG AROUND NANJING IN THE 2006 WINTER
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1. INTRODUCTION
Fog is a phenomenon of the vapor condensation among atmosphere, and composed of droplet or ice crystal which suspend near the ground surface. In the earlier of 20th century, Taylor had conducted the radiation fog measurement with scientific method. During 25-27 December, 2006, heavy fog occurred in Nanjing and its suburbs, which resulted in the degradation of visibility badly, and had a profound effect on human activity and the environment. In this study, fog occurred under the uniform field governed by three high pressures with distribution from southwest to northeast, moving towards the east direction during 23-27 December. In surface chart, this heavy fog developed under the allocation of the middle-high latitude’s high pressure and the low latitude’s low pressure with the influence of southwest air current. Under these mechanisms, the fog is lifted in the lower layer, which is benefit to the warm and moist air current from southwest, supplied and concentrated in Nanjing.

During 27-31 December, 1996, Nanjing encountered a fog sustained for 5 days, Li analyzed the characteristics of microphysical structure and the major factors which influenced the structure, and their relationship with macro developments. In their studies, fogs generally formed by radiation cooling with large variation of microphysical structure within short time. With atmospheric sounding equipment [Vaisala, produced by Finland], the results from sounding data including temperature, relative humidity (RH), wind speed and specific humidity along with the IR visibility detector have shown that the fog of 25-27 December, 2006 is a typical advection fog.

2. DATA AND ANALYSIS
The data used in this paper were from SPP-FM100 fog droplet spectrometer, Vaisala’s wiresonde and robot weather station data in Nanjing, China during 25-27 December, 2006.

The SPP-FM100 fog droplet spectrometer is an optical detector manufactured by DMT. Based on Mie scatter theory, it accounts the fog droplet number during 2-50µm with different bin width through the light intensity when particles pass by its chamber, then we can get particle number concentration ($N_c$), mean diameter ($D_m$) and liquid water content ($L_w$) of each bin from the raw number data. The sample interval is 50ns, and the data output interval is 1s. The sample plane height was around 1m. In this paper, we pick up data during 25-26 to analyze the microphysical structure and the factors.

With synthesized analyses of sounding data and the synoptic background, advection process (or dynamic process) is the controlling factor for the fog development and dissipation. In the upper air, warm and moist air current with systematic descending movement arouse intensive descending thermodynamics, simultaneously, the continuous warm southwest air current...
supplies Nanjing with abundant water vapor, which makes this fog urge and develop. Moreover, the fog dissipation under the strength of cold air current and it’s moving towards south. On the other hand, radiation balance will be changed along with fog formation and development.

Figure 1 gives the two days’ fog top altitude evolution. Based on the evolution, we have this fog process partitioned into the following parts: 1) formation and development stage S1(BT00:00-07:00, 25); 2) maintenance stage S2(BT07:00, 25-20:45, 26), in this stage, it includes three sub-processes: I .the descending period p₁ with large amplitude (BT07:00-22:45,25), II .the explosive development period p₂(BT22:45, 25-00:00,26) and III. the stable oscillating period p₃ (BT00:00-20:45,26); 3) the dissipation stage S3(BT20:45, 26-14:14, 27). According to the analysis of sounding data, in the sub-stage I , due to the effects of the solar short-wave radiation warming, the warm air and the descending thermodynamics together, the fog top altitude descends to 188m from 625m in the end of this stage in the next sub-stage, the radiation cooling is contribute to the fog explosive growth; in the sub-stage III, fog top ascends as the temperature rising and the RH falling, while descends as temperature falling and RH rising, the intensity of warm and moist air current controls the emergence and amplitude of this oscillation process, while the short and long radiation controls the trends.

3. RESULTS

3.1 Characteristics of micro-structure parameters

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Table 1 gives the mean values of parameters in different stages. The data in the table has been averaged over the whole period of each stage. Here, we just consider these parameters including Nₐ, Lₜ, Dₗ, and the maximum diameter Dₘₐₓ. In this section, we just discuss these parameters’ characters in the different stage, then, we will look for the relationships with each other and the factors which influence the changes of parameters.

As discussed above, advection process is the major mechanism for the fog formation and development, at the beginning of formation, the surface temperature do not drop enough for aerosol nucleation, so the Nₐ appears lower, but the abundant water vapor supplied by warm air current contributes to the integration of LWC. In S2, as fog top descending, descending thermodynamics limits the condensation growth of droplets, so Dₗ descends as Nₐ increases; then the long-wave radiation cooling of fog and surface, which makes aerosol nucleation effect become more important, and improve the condensation and coagulation processes, so at p₂ period, Dₘ increases simultaneously with Nₐ, because the explosive growth needs more water vapor, Lₜ decreases in this period; in
the $p_3$, due to the effect of thermodynamics and dynamics balancing with each other and the fog body is lifted to the upper air, so the particles observed near surface decreases. In the dissipation stage, the development of cold air current makes the condensation and coagulation processes strengthened, drizzle particles is formed and drop with gravitational force.

**Table 1** The microphysical structure of fog stages

<table>
<thead>
<tr>
<th>Stages</th>
<th>$N_c$ cm$^{-3}$</th>
<th>$L_w$ g·m$^{-3}$</th>
<th>$D_m$ µm</th>
<th>$D_{max}$ µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>220.91</td>
<td>0.14</td>
<td>6.70</td>
<td>39.60</td>
</tr>
<tr>
<td>$p_1$</td>
<td>383.80</td>
<td>0.08</td>
<td>6.11</td>
<td>45.00</td>
</tr>
<tr>
<td>S2</td>
<td>661.24</td>
<td>0.11</td>
<td>7.33</td>
<td>50.00</td>
</tr>
<tr>
<td>$p_2$</td>
<td>135.00</td>
<td>0.05</td>
<td>4.99</td>
<td>35.86</td>
</tr>
<tr>
<td>S3</td>
<td>374.55</td>
<td>0.20</td>
<td>4.10</td>
<td>30.53</td>
</tr>
</tbody>
</table>

Moreover, the result is very different from the results of Li’s observational data in Nanjing, 1996, as the major factor for that fog development is the radiation cooling effect.

3.2 Relationship Between $N_c$ and $L_w$

Figure 2 gives a good insight that there has a good correlation between $N_c$ and $L_w$. Data in figure 2 has been averaged by every 10 min. There exists obvious oscillation both in $N_c$ and $L_w$ with almost same frequency. Except for the explosive growth stage, in the other two stages, the oscillation between $N_c$ and $L_w$ shows a strong positive correlation.

![Fig. 2: The time-scale evolution of liquid water content with the variation of number concentration in fog droplet](image)

(thick solid line: $L_w$; thin solid line: $N_c$)

3.3 Fog Droplet Spectrum

Figure 3 gives the typical fog droplet spectra averaged by every 5 min in the different stages. The distribution of fog droplet spectrum is a most important factor that affects the thermodynamics and dynamics of fog development.

In the stage of formation and development, surface temperature descending and the effect of warm air current are benefit to the aerosol nucleation and growth, so in this figure, we can see from BT00:05 to BT02:25, the spectrum is lifted and broadened, the maximum diameter detected also broadens from 10 µm to 41 µm.

Due to the descending thermodynamics, in the $p_1$ period, the number of small droplet increases rapidly; in the explosive growth period, long-wave radiation cooling is benefit to the aerosol nucleation and the development of condensation and coagulation processes, so each bin’s particles grow enough (spectrum labeled with 22:55/25). In the oscillating period, droplet spectrum repeats between being broadened (lifted) and narrowed (descended) by the effect of balance between thermodynamics and dynamics.

In dissipation stage, the effect of nucleation makes small droplet grow fast with $10^3$ magnitudes, with the drizzle formation and water vapor exhaustion, small and large particle all decrease rapidly.
4. CONCLUSIONS AND DISCUSSION

In this study, by using atmospheric sounding data and fog droplet spectrum data, we discuss the mechanisms for the fog development and dissipation, and the factors influence microphysical parameters. Advection process is the major factor for the fog development; and there exists apparent oscillation both in $N_c$ and $L_w$, the balance between thermodynamics and dynamics make fog droplet spectrum more complex.

In this presentation, all parameters are expressed by average number. Next we will put our research on the multi-scale dependent distribution and the dispersion effect.

5. BIBLIOGRAPHY


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