Study on characteristics of atmospheric layer's temperature change in the sleet weather process in 2008

Wan Xiecheng, Liu Tiantian, Liao Chunhua, Xiao Sheng
Meteorological Service Center, Hunan Meteorological Bureau, Changsha, China

Abstract: Based on ground and upper-air data of Chenzhou, analyzed the temperature various characteristics of surface layer, boundary layer, the troposphere and the stratosphere in the process of Sleet weather from Jan. 11 to Feb.3 in 2008, the results are as follows: (1) This long period of sleet weather is caused by three cold air activities. (2) From the ground floor to the top border layer ,it basically remains a powerful and stable inversion layer, coming into being a heavy warm cover, This is the most basic conditions of the long-term maintenance of sleet weather.(3) From the boundary layer to the free air base, namely from 850hPa to 700hPa, there has a inversion layer too. But the inversion layer is divided and unsteady, sometimes strong and sometimes weak, which is weaker than the boundary layer as a whole. The temperature lamination has past four stages of changes, the first stage is from a normal temperature lamination to a divided inversion layer; the second stage is a long-term maintenance of normal temperature lamination; afterwards returning to the first stage of the state; Last appearing a long time and strong inversion layer. The four stages and its changes is important in the development and maintenance of sleet weather. (4) The temperature varies slightly in the middle troposphere. It shows that the cold air activities are no continuity in space and time, which is below and above the middle troposphere. The cold air invades in different time from the lower and upper layer respectively. (5) Contrast to the middle troposphere, the temperature change greater in the upper troposphere. There are three obvious cold air activities. The temperature rising process is fairly suddenly, it appears a feature of the impulsive warming. It is different from the stratosphere impulsive warming, the impulsive warming during this sleet weather process happens in the upper troposphere. (6) The characteristic of temperature variation in the top Troposphere is steady between two stools and significant in the middle. So it plays a role in the maintenance of sleet weather. (7) In the later period of this sleet weather process, the temperature variation is noticeable in the stratosphere, and unfolds abrupt warm and cold in the characteristic, but the warming scope is smaller in the stratosphere than in the upper troposphere. (8) Towards the end of this sleet weather process, the temperature declines sharply in the middle troposphere, but not in the other layers. This shows that temperature drop in 500hPa has much significance for forecasting a long time weather process.

Keywords: sleet; boundary layer; troposphere

Ying Xiao
Climate Center

Ⅰ. INTRODUCTION

From mid January of 2008 to mid February, a wide range and long period of rain, snow, freezing weather event had occurred in south china, which did much harm, especially with sleet. There used to have lots of work on sleet research.Minghui Zhu[1] analyzed on change regulation of sleet for 50 years in Nanyue Mountain. By studing on sleet in Huangshan Mountain, Youxun Wu[2] summarized the relationship between winter air temperatures with occurrence of sleet. Xiuping Jiang[3] who studied the sleet change regulation of a county, analyzed the distribution of sleet strength and the variation of Ice Covering thickness in different height. But these researches didn't disclose the sleet cause so far, which is not enough to provide a scientific evidence for forecast sleet. Based on surface and upper-air data of Chenzhou, this paper analyzed the temperature various characteristics of surface layer, boundary layer, the troposphere and the stratosphere in a process of Sleet weather, expecting to reveal some new facts.

Ⅱ. TEMPERATURE VARIOUS CHARACTERISTICS OF SURFACE LAYER

The daily evolution of ChenZhou surface temperature in the sleetweather process is shown in Fig. 1. From Jan 11 to Feb 3, the temperatures which have changed little after experienced a transient sharp decline on about January 11th. The temperature have been maintaining 0℃ on nearly 20 days. From Fig. 1, we can see there have a strong cold air southward from the North China influence ChenZhou on

January 11th, which is the first cold air activity to cause this long time sleet weather, and also is the most powerful, so that it make this area's temperature decrease 10℃ in 24 hours.

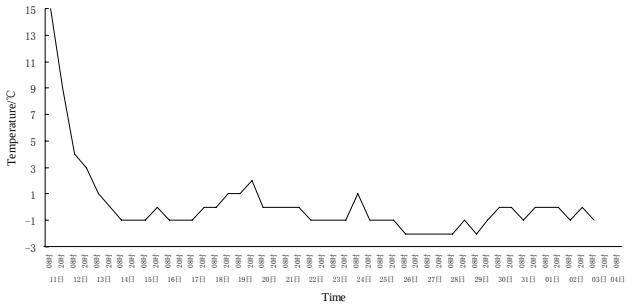

Fig. 1 The evolution of Chenzhou surface temperature

From Fig. 2, we can see there have three cold air activities which influence ChenZhou every ten day at this long period of sleet weather, respectively on January 11th, 20th, 30th or about. In addition to the first time, the other two cold air activities are very weak, only in the air pressure to reflect, and is weaker each time. The first cold air activity make the temperature drop from 23℃ to 0℃ or so, the last two make temperature maintain about 0℃, that is definitely not dispensable to keep the Sleet weather.

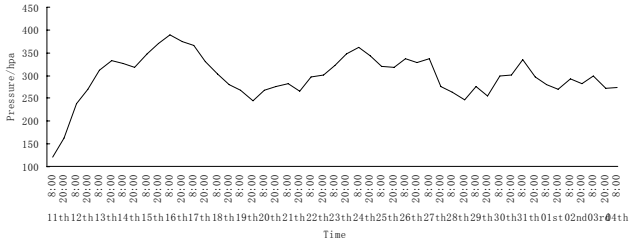

Fig. 2 The evolution of Chenzhou pressure

Ⅲ. FEATURES OF TEMPERATURE IN BOUNDARY LAYER

From Fig.3, we can see there also have three cold air activities at 850hPa. Compared with the ground, the first cold air activity is the same stronger, the other two are more significance. It shows the frontal zone in boundary layer is noticeable. For a better comparing, the evolution of temperature on ground, at 850hPa and 700hPa are made in Fig.4 and Fig.5. Fig.4 shows that the fluctuation of temperature is more obvious at 850hPa at the beginning of sleet weather, namely from 8am on 13 Jan to 8am on 16 Jan. The temperature at 850hPa is sometimes lower and sometimes higher than on ground. At 8am on 13 Jan, the temperature at 850hPa is 5℃ lower, after 12 hours, it is 3℃ higher, and it is 5℃ lower 48 hours later. Beacause the surface temperature has been maintaining 0℃ at that time, the inversion layer is divided and unsteady, sometimes strong and sometimes weak from ground to 1500m upper air. From 20pm on 16 Jan to 20pm on 29 Jan, the temperature at 1500m has been higher than the surface temperature. That is, always maintain a clear inversion layer. This time is also the periods of sleet weather's strengthening and maintaining. In 13 days 24 times, the temperature at 850hPa is 4.8℃ higher than surface temperature averagely, the most is 9℃ higher. This big figure shows that the inversion layer is not only for a long time and its strength is very strong. This is just as a powerful and warmer cover over Hunan.

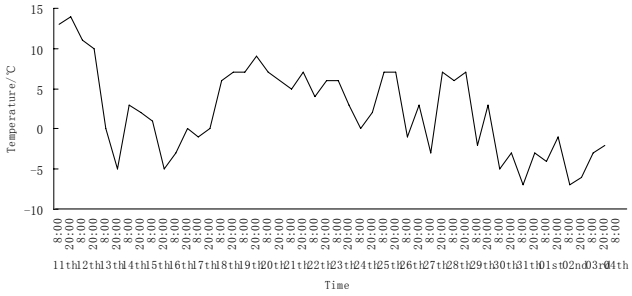

Fig 3. The variation of temperature at 850hPa in Chenzhou

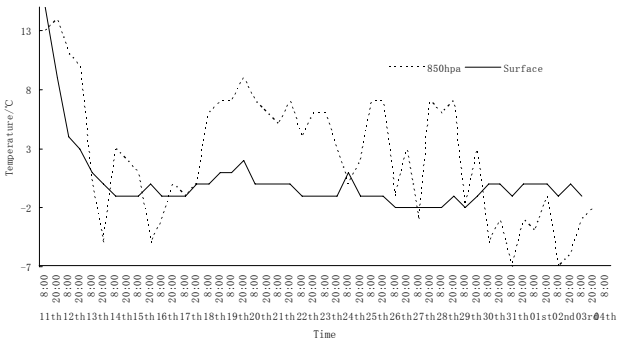

Fig.4 Comparing temperature at 850hPa with surface temperature

Fig.5 shows that the temperature at 850hPa is higher than at 700hPa before 8am on 13 Jan, temperature lamination is normal, from 20pm on 13 Jan to 20pm on 17

Jan, the normal temperature lamination is broken, a unsteady inversion layer is appeared. Compared with temperature at 850hPa, the temperature at 700hPa is 5℃ higher at 20pm on 13 Jan and at 20pm on 15 Jan, but is 4℃ lower at 8am on 14 Jan. The variation of temperature lamination is intense and speedy. The temperature at 850 hPa has been higher than at 7000hPa from 20pm on 17 Jan to 20pm on 23 Jan, it is normal temperature lamination. From 20pm on 23 Jan to 20pm on 29 Jan, a obviously unsteady inversion layer is appeared again, which is alternate existence and vanishing, and sometimes strong and sometimes weak. From 8am on 30 Jan to 20pm on 3 Feb, the temperature at 700hPa is much higher than at 850hPa, it shows a strong inversion layer is appeared. The most is 9℃ higher, so a higher level warm cover come into being.

From the analysis presented above, we will find the temperature lamination has past four stages of changes to keep a long time sleet weather process from the boundary layer to the free air base, the first stage is from a normal temperature lamination to a divided and unsteady inversion layer; the second stage is a long-term maintenance of normal temperature lamination; afterwards returning to the first stage of the state; Last appearing a long time and strong inversion layer. The four stages and its changes is important in the development and maintenance of sleet weather.

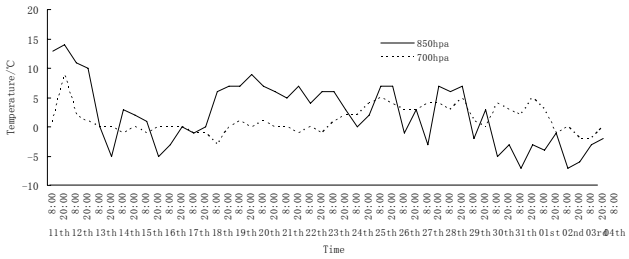

Fig.5 Comparing temperature at 850hPa with temperature at 7000hPa

Ⅳ. CHARACTERS OF TEMPERATURE IN MID-TROPOSPHERE

During the long-time process of high-strength glaze, temperature variations in mid-troposphere were smaller than that in boundary layer. Only at the beginning of glaze, it showed that cold air inserted. The decreasing temperature were 3℃ and 6℃, on 13 Jan at 8 am and 17 Jan at 8am, respectively. Temperature change has been always comparatively stable thereafter. Until the glaze was almost at the end that was on 2 Feb at 8am, temperature significantly reduced only. It indicated that there existed relatively strong cold air. But this activity of cold air did not reflect in other layers. So it means that it is an invasion of cold air from mid-troposphere (fig 6).

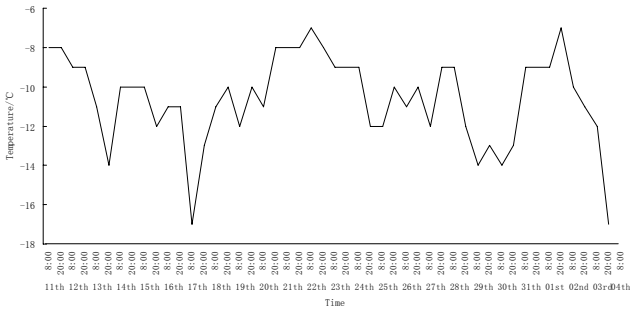

Fig 6. The evolution of temperature at 500hPa in Chenzhou

Ⅴ. THE EVOLUTION OF TEMPERATURE IN UPPER TROPOSPHERE

The temperature variation in upper troposphere is more obvious than that in mid-troposphere. Fig 7 showed the daily evolution of temperature at 300hPa level during glaze process. From the figure, we can see that there are three processes of more obvious cold are activities in the studied time frame. The first was from 8pm on 13 Jan to 8am on 17 Jan. During this process, temperature dropped from -30℃ to -41℃. The temperature drop was 11℃, during these 5 days. It means that daily cooling was 2.2℃. Before the arrival of the cold air, the temperature increased form -42℃ at 8am on 10 Jan to -30℃ at 8am on 13 Jan, 4℃ daily. Heating-up time was longer and extent of rise was greater during this process. The second was from 8am on 19 Jan to 8am on 26 Jan, the temperature decreasing form -33℃ to -39℃. The temperature drop was 6℃, 0.86℃ daily. Before the process, there was only 24-hour heating-up time ,but the increase was 8℃. The third was from 8pm on 26 Jan to 8pm on 29 Jan, the temperature decreasing form -29℃ to -38℃. The temperature drop was 9℃, 3℃ daily. Before the process, there was only 12-hour heating-up time, the temperature increasing form -39℃ to -29℃. This was fulminated warming in upper troposphere. Compared figs 7

with fig 2, the three processes at 300hPa level were not synchronized. It means that the cold airs inserted form surface or upper troposphere respectively.

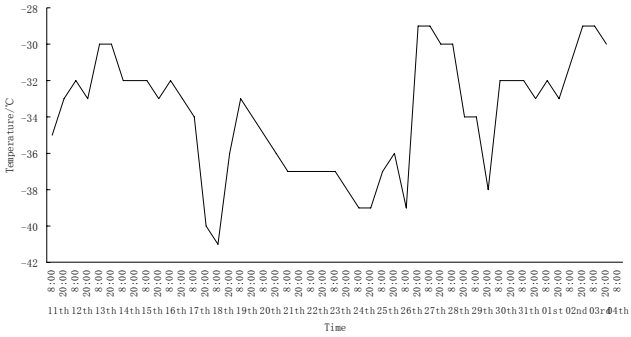

Fig 7. The evolution of temperature at 300hPa in Chenzhou.

Ⅵ. THE CHARACTERISTICS OF TEMPERATURE VARIATION IN THE TROPOPAUSE

The height of 250hPa level was at about tropopause. By analyzing the temperature in the tropopause, the variation was very stable during the process in the glaze during the early and late. It showed that there was not obvious cold air. The temperature maintained -39℃ or -40℃, form 8am on 11 Jan to 8pm on 17 Jan. Form 8am on 28 Jan to the end, the temperature was about -40℃. But there was a weak cold air invasion at this level, the temperature decreasing form -41℃ at 8am on 18 Jan to -48℃ at 8am on 25 Jan. The drop was 7 ℃, and the process maintained 7 days. After the process, there was 2-day heating-time. This cold air was synchronized with the second at 300hPa level. But the first and the third at 300hPa did not investigate. So was heating-up processes during those. It means that the temperature variation in the tropopause was different form other levels during long-time glaze.

Fig 8. The evolution of temperature at 250hPa in Chenzhou

Ⅶ. THE TEMPERATURE VARIATION IN THE STRATOSPHERE

Fig 9 was the evolution of daily temperature at 100hPa in Chenzhou. Different form troposphere, the temperature variation form 8am on 11 Jan to 8am on 25 Jan was smooth, meaning that there was no cold air activities. But there was obvious variation, decreasing form -70℃ to -83℃, form 8am on 25 Jan to the end. The drop was 13℃ during 2 half days. After that, the temperature increased form -83℃ at 8pm on 27 Jan to -73℃ at 8pm on 29 Jan. After that, the variation appeared again, but not obviously. This showed that the temperature variation was severe, more frequent and stronger cold air existed in the late of glaze.

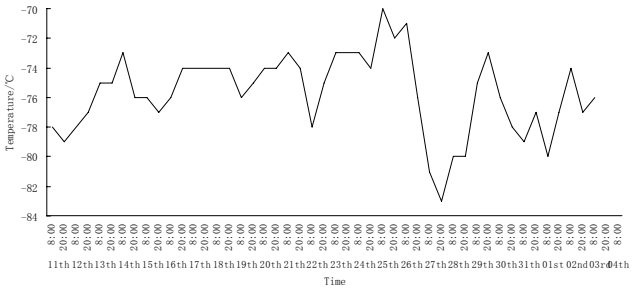

Fig 9. The evolution of temperature at 100hPa in Chenzhou

Ⅷ. CONCLUSION

(1) This long period of sleet weather is caused by three cold air activities.

(2) From the ground floor to the top border layer, it basically remains a powerful and stable inversion layer, coming into being a heavy warm cover, this is the most basic conditions of the long-term maintenance of sleet weather.

(3) From the boundary layer to the free air base, namely from 850hPa to 700hPa, there has a inversion layer too. But the inversion layer is divided and unsteady, sometimes strong and sometimes weak, which is weaker than the boundary layer as a whole. The temperature lamination has past four stages of changes, the first stage is from a normal temperature lamination to a divided inversion layer; the second

stage is a long-term maintenance of normal temperature lamination; afterwards returning to the first stage of the state; Last appearing a long time and strong inversion layer. The four stages and its changes are important in the development and maintenance of sleet weather.

(4) The temperature varies slightly in the middle troposphere. It shows that the cold air activities is no continuity in space and time, which is below and above the middle troposphere. The cold air invades in different time from the lower and upper layer respectively.

(5) Contrast to the middle troposphere, the temperature change greater in the upper troposphere. There are three obvious cold air activities. The temperature rising process is fairly suddenly, it appears a feature of the impulsive warming. It is different from the stratosphere impulsive warming, the impulsive warming during this sleet weather process happens in the upper troposphere.

(6) The characteristic of temperature variation in the top Troposphere is steady between two stools and significant in the middle. So it plays a role in the maintenance of sleet weather.

(7) In the later period of this sleet weather process, the temperature variation is noticeable in the stratosphere, and unfolds abrupt warm and cold in the characteristic, but the warming scope is smaller in the stratosphere than in the upper troposphere.

(8) Towards the end of this sleet weather process, the temperature declines sharply in the middle troposphere, but not in the other layers. This shows that temperature drop in 500hPa has much significance for forecasting a long time weather process.

REFERENCES

[1] Minghui Zhu, Qi Wang, Tiantian Liu, Chunhua Liao, Wei Yu, Xiaochun Deng, “Analysis of Glaze in Nanyue Mountain”, Meteorological Science and Technology. China. Beijing, vol. 34(4), pp. 436–440, Aug 2006.

[2] Youxun Wu, Jianwu Chen, Baogui Yang, Bing Zhang, Bin Jiang, Wei Xu, Jinbao Wang, “Type of the Winter Air Temperature in Huangshan Mountain and Its Climatic Analysis of Snow Claze and Rime ”, Acta Meteorologica Sinica. China. Beijing, vol.58(3), pp. 376–384, Jun 2000.

[3] Xiuping Jiang, “Analysis of Sleet Variation Rule in Xiuwen”,Guizhou Meteorology. China. Guizhou, pp. 33–34, 2001