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An Energy Structure Analysis of Spring Gale

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Abstract

This paper used NCEP analysis data and routine detect data to realize the gale weather in Nanjing, 4-10, 2011. It shows that the vertical shear formed by strong upper-level jet stream and low-level convergence deepened the convection; for the dry convection, CAPE can not show rightly, but it can be corrected by using other parameter and V-3θ chart, we can forecast the weather break ahead of time if we grasp the non-homogeneity of energy, ultralow temperature of atmosphere and discontinuous of wind.

Keyword: Gale, stability parameter, energy parameter, dynamic parameter, V-3θ

1. Introduction

Gale is one significant weather phenomena that usually occur in spring. For the gale caused by cold air there are several reasons, momentum transfer down and the temperature difference between upper and low air can indicate in forecasting [1], barometric gradient and cold advection may be the main reason to gale [2] Hailing weather with gale normally happens in the area surrounded by high value center of the screwing degree of lower position cyclone and the storage area of convective unstable energy at middle and lower altitude [3].

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2. Analysis of weather situation

There is a cold vortex near 120°E, 50-55°N in 500hPa on 08:00 April 9, vortex center is -40°C. From the cold eddy center to Lanzhou have a though and the trough was strengthening and southward, eddy center moved to 125°E, 50°N on 20:00. The cold eddy continued to strengthen till -42°C on 08:00, April10. The upper trough line has been to Nanjing. The whole system moves quickly, the intensity is not reduced. There is a central value of 1035hPa the cold high-pressure in the west of Lake Baikal at 08:00, April 9, and in the 127°E, 52°N there is a low pressure which central value was 997.5hPa, cool air center moves to the southwest of Lake Baikal at 20:00 and the intensity decreased slightly, till 08:00, April 10, the cold high pressure continue to strengthen and move south, and the front reached to Shandong, resulting in Shandong northerly winds, front segment arrives to Xuzhou at 14:00, caused winds at level 7, the front arrived in Nanjing at 20:00, Nanjing appear level 7-8 winds.

A strong westerly jet exist in the upper troposphere between 30°N to 35°N , with the use of NCEP reanalysis data we can see the strong wind position , jet axis at 33°N -35°N, the maximum wind speed reaches 90m/s. strong positive and negative vorticity exist near the jet axis at 850hPa. High-altitude wind convergence will increase low-level airflow away, play a role in ventilation, the bottom of the strong vertical wind shear environment as the top "suction" effect will continue to develop, is conducive to the maintenance of convection, development, provides a strong vertical circulation conditions for the development [4]. Strong westerly jet stream location and the role of jet power are inseparable in the windy weather.

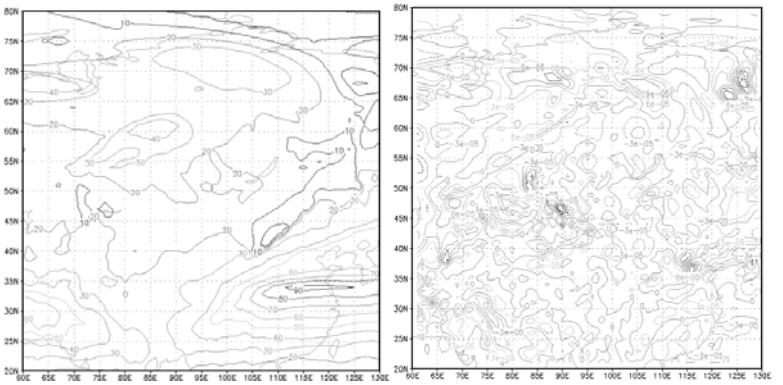

Fig. 1. (a) max wind speed on 200hPa，April 9; (b) 850hPa vorticity 08:00, April 10

3. Parameters and structural analysis of atmospheric convection

We often use a variety of convective parameters, and thermal stability, energy and power parameters to express the occurrence and the development environment of severe convective weather. The following is the relevant parameter in MICAPS system most commonly used in types of analysis

Table 1. The parameter of Nanjing station from 08:00, April 9 to 20:00, April

Nanjing	08:00 April 9	20:00 April 9	08:00 April 10	20:00 April 10
LI（℃）	13.02	10.09	11.19	2.99
KI（℃）	3	8	8	9

A（℃）	-17	-11	-12	-22
CAPE（J/kg）	0	0	0	13.9
CIN（J/kg）	0	0	0	202.5
V（knots）	14.5	24.8	25.8	23.4

3.1. Analysis of the stability index

Lift index is defined difference between the temperature when gas block lift from the modified lower (usually the ground or near ground level) up to reach condensation level by the dry adiabat and then along the wet adiabat up to 500hPa and the temperature of the environment at 500hPa [5]. When LI <0, the atmosphere is unstable, and the greater the negative absolute value is, the stronger the instability is; the contrary, that gas is stable. Seen from the table, LI values continue to decrease, indicating that a steady state of the atmosphere become weak instability.

K index, also known as air mass indicators, typically used for stations forecast under the conditions of in a single air mass, it can distinguish air mass of moisture, stability. K index value is greater, the atmosphere is warmer, water vapor more, more unstable stratification, from the table, although the increasing trend seen but not great, and a longer period of time before, Nanjing controlled by high pressure, it occurs with relatively dry air.

3.2. Energy index analysis

Convective available potential energy (CAPE) is heat variables that be able to quantitatively reflect the deep convection which is likely to occur. CAPE says that in the free convection height above, the gas block get energy from the positive buoyancy.

$$CAPE = g \int_{Z_{LFE}}^{Z_{EL}} \left(\frac{T_{vp} - T_{ve}}{T_{ve}} \right) dz \qquad (1)$$

T_v is virtual temperature, subscript e and p indicate environment and gas blocks physical quantity. Z_{LFE} and Z_{EL} indicate Lifting condensation level and balance height. And strong convection is a process associated with the wet deep convection, CAPE values from the table shows, only in the strong winds occur when there 13.9J/Kg, small CAPE value which is due to less water vapor in the air and it can not indicate convective weather, so the air humidity make CAPE have no indication in this windy weather.

3.3. Power-index analysis

Wind index is empirical index, but based on observations and numerical simulations. The index reaches its maximum before the wind, index and the actual wind speed values are in good agreement, which is due to the windy weather is dry convective weather, and where the humidity of the physical quantities only accounted for a relatively small part, so in this weather wind index for the convective weather play a good indication. Gale caused by the vast majority of dry thunderstorms produce in environment that the convective available potential energy is small but the vertical wind shear is large in the lower troposphere[6], a long time before windy weather, Nanjing controlled by high-pressure, air drying , resulting in dry convective weather, although the convective available potential energy does not

indicate this severe convective weather, we can not say that there is no potential convection, at this time the power-index can indicate better.

4. Structural analysis and V-3θ diagram

V-3θ diagram is the analysis tool which uses real existing data and information, the core problem is the vertical difference between the information constitutes a vortex motion, it can use a single-station data to reveal and enlarge non-continuous information. The main function is to reflect the troposphere tumble occur and maintain within inhomogeneous structure, and tumble disappearance within homogeneous structure [7].

This method differs from the traditional method is use non-rule information (feature level information) that usually lost or not included, and also centre the feature level information to reveal the weather changes in the flow direction of the roll. Tumble effect of the flow field was divided into existing and potential effects. Existing flow field tumble effect, is the occurrence and the maintenance period of rainy (especially the maintenance period) are; or vice versa, against tumble are in fine weather. Potential tumble effects, it is that along tumble (or against tumble) appear 24-36 hours before sunny (or rainy), the sunny (or rainy) will come to rainy (or sunny) weather [8].

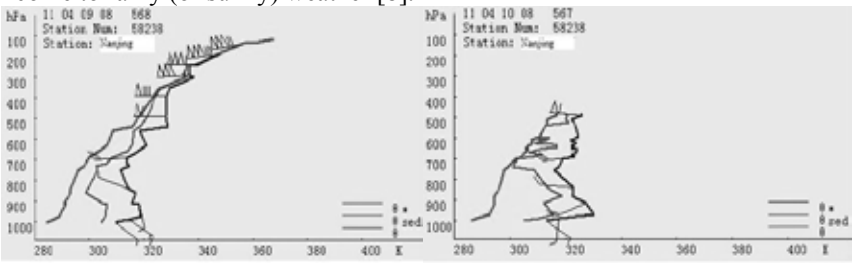

Fig. 2. (a) V-3θ of Nanjing station 08:00，April 9; (b) V-3θ of Nanjing station 08:00，April 10

The wind vector structure analysis(Fig.2.(a)) shows that upper is strong westerly wind, low-level is southeast wind, constitute the along tumble, while it just means good weather transform to bad weather; there is ultra-low temperature phenomenon over 150hPa, namely a sharp decrease in θ with the decline in p, θ-line distribution is very uneven, there are several layers left angle that means the atmosphere is very uneven in heat distribution which are essential condition of the disaster weather; in 950hPa-900hPa the three lines to the left make obtuse whit T-axis, indicating a very unstable energy in lower atmosphere. from the Fig.2.(b) we can see the atmosphere becomes more unstable, probably due to high-altitude wind speed becomes greater, resulting in high-altitude data loss, θ line almost perpendicular to T-axis in 900hPa-700hPa and there are various "break" in 650hPa-500hPa, indicating atmosphere has high energy and uneven distribution; near-surface θ^* and θ_{sed} have 10K disparity while high-level θ^* and θ_{sed} have around 20K, the formation of dry in low-level and wet in high-level is unstable structure, prone to convective weather.

5. Summary

The low pressure caused by the sustained high temperature in North China and Central Plains region before the gale and cold high pressure constitute a " south low and north high pressure " situation, the strong barometric gradient offer the power conditions for the fast-moving cold air, strong barometric gradient, high-altitude cold advection are main reasons to this weather.

The high-level jet stream over the gale region, and it transport the air converged come from low-level to form a strong vertical circulation patterns, so that convergence is more intense and strengthen the development of convection, have an important role in the formation of strong winds.

For dry or wet convective weather, the convective available potential energy sometimes can not well play a role in report, at this time we need to think over the specific weather conditions and other index, with the V-3θ diagram, seize the uneven distribution of energy, ultra-low temperature of atmosphere, wind vector is not continuous and along tumble structure to determine the weather turning point in advance.

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References

[1] Jianming Sun, Weifeng Chen. An analysis and forecasting for a gale caused by momentum under-transfer, Zhejiang Meteorological Science and Technology, 22, 1-4(2001).

[2] Yuezhi Ma, Xinhong Wang, Dong Ye, Jinping Zhang, Xiangyi Meng, Bing Wang, Jizhou Li. Analysis of Gale Weather Caused by Passing Cold Front in Spring, Meteorological and Environmental Sciences,33,41-47(2010).

[3] Chuanxin Zhen. Application of screwing degree of cyclone in the analysis of spring hailing weather with gale in Guangxi, Jouturnal Of Guangxi Meteorology, 01,17-19(2002)

[4] Haiyan Fei, Ming Wei. Numerical simulation of heavy rain and echo analysis,july,2007, Science and Technology Innovation Herald,13,147(2008)

[5] Li Lin, Rong Li, Xia Zhang, Huimin Feng, Hongxing Wang. Analysis of the Stability and Energy Parameters in a Short-time Rainstorm, Meteorological and Environmental Sciences,30,45-49(2007)

[6] Xaionong Miao. Analysis on Environmental Condition for Wind Gust in Beijing Area, Climatic and Environmental Research, 14,54-62(2009)

[7] Yubin Chen. the structure of V-3θ diagram and "7.29" Thunderstorm Analysis, Heilongjiang Meteorology 04,19-20(2002)

[8] Shouchen Oyang, Yigang Chen, Yi Lin. Digital information and forecasts, Meteorological Press, 133-134(2009)