51 NEW COMPREHENSIVE PHYSICAL INDEX BASED ON INGREDIENTS -BASED METHODOLOGY AND ITS APPLICATION IN FORCASTING HEAVY RAINFALLS

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1 Introduction

Heavy rainfall often leads to floods and related disasters, and it is also one of the difficulties for weather forecast. Some studies found that the key of precipitation forcast is processing and data mining strong signal form the various early physical quantities. Physical factors process analysis replaced the experience forcast in U.S. Bureau of the strong local storm to forcast and warn the strong rainfall, the level of forcast and warning the strong rainfall is greatly improved[1]. However, in China, in the actual work applied research and basic research for severe convective weather forecast are not seriously enough, especial data processing of causing precipitation of the relevant physical field and using physical quantities to forcast the strong rainfall, has not been fully carried out together.

2 Construction Principle of Physical Index

2.1 Thermal Instability

A new paremeter describing the static stability is obtained, namely θ_{se} flux divergence of the difference $\Gamma = \frac{\partial}{\partial p}(-\nabla_h \bullet (\theta_{se}\vec{V}))$, thermodynamic instability parameter Γ reflect the systems configuration of different levels and quantitatively described static stability.

2.2 Dynamic Instability

the relative helicity has practical significance for development and maintain of storm.

2.3 Moisture and Uplift Conditions

Research indicates that there are close relationship between atmospheric precipitation water PW and local precipitatio during the heavy rainfall the evolution of water vapor has obvious characteristics, moisture accumulated to a certain extent and then consumption[2].

2.4 THP Index Construction

These conditions are necessary conditions for heavy rainfall occurrence, the atmospheric system is complexity, and there is many nonlinear interactions between the various physical conditions. When a real heavy precipitation occurs, not all of the indicatiors are relatively extremes, in fact, when the combination of index is maximum, higher probability of precipitation occurrence, such as, some heavy rainfall can occur in weak dynamic instability and strong thermal instability situation, some is in opposite condition. The main reason is these physical fields can make up for each other. Based on the above analysis, several thermodynamics, dynamics and moisture factors are combined to constructe a new comprehensive physical index THP(Temperature, Helicity and Precipitable Water).

$$THP = \Gamma \bullet H \bullet PW = \frac{\frac{\partial}{\partial p}(-\nabla \bullet (\theta_{se}\vec{V})) + \left|\frac{\partial}{\partial p}(-\nabla \bullet (\theta_{se}\vec{V}))\right|}{2} \bullet \frac{H + |H|}{2} \bullet PW$$

Avoiding the multiplying result of the negativeΓ and negative H appears positive, the average of the absolute value of Γ(H) and the value ofΓ(H) is caculated. When theΓand H are negative, its averages are 0, the THP index not only reflect the real thermodynamics, dynamics and moisture situation, but also integrated the signals of conducive occurrence of heavy rainfall.

3 Application Cases

There was a heavy rainfall in north and center of Henan province and west of Shandong province on Aug 17th,2009. The THP index is then diagnosed and tested through two heavy precipitation processes in Henan province and Beijing

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in China by using NCEP/NCAR reanalysis data and ground observational data.The THP index not only reflects the thermodynamics, dynamics and moisture situation, but also integrated the main three factors of conducive occurrences of heavy rainfall. The THP index amplified strong signals, attenuated weak signals, and enhanced forecasting stability by calculated the intersection between the three physical factors. the forecasting performance and stability of the new index THP which based on Ingredients-based Methodology, is better than the method of using single physical parameter (θ_{se} flux divergence, relative horizontal helicity and PW) in forecasting analysis.

Compared with some conventional physical indexes (K index, Quasi-geostrophic Q vector divergence, moisture vertical helicity), the high value distribution of THP is great consistent with precipitation areas in the following six hours.

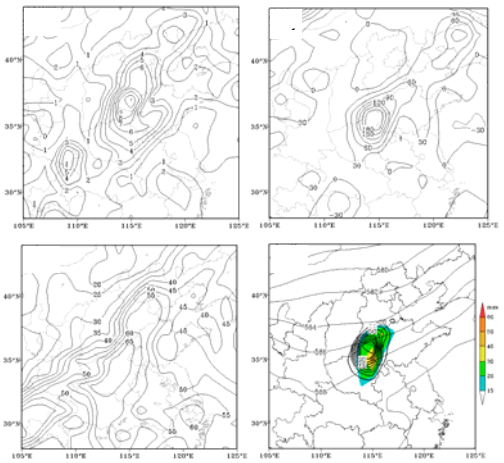

Fig.1 The difference of θ_{se} flux divergence (a, units: $10^{-5}Ks^{-1}hPa^{-1}$), the storm relative helicity (b, units: $m^2 \cdot s^{-2}$) , the precipitable water vapor (c, units: $kg \cdot m^{-2}$), and THP index (d, units: $10^{-2}K \cdot m \cdot s^{-1}$) with the locations of heavy rainfall (shaded) at 00:00 UTC, 17 August 2009

The precipitation phase lag behind THP phase variation, the variation of THP indicates the beginning and ending time of a heavy rainfall. Besides, the THP index is also some significance of precipitation intensity forecast which occurs in the pre-trough pattern. Therefore, the THP index can be used in the objective probability forecast and enrich the model results as a statistical post-processing of model output for heavy rainfall forecast.

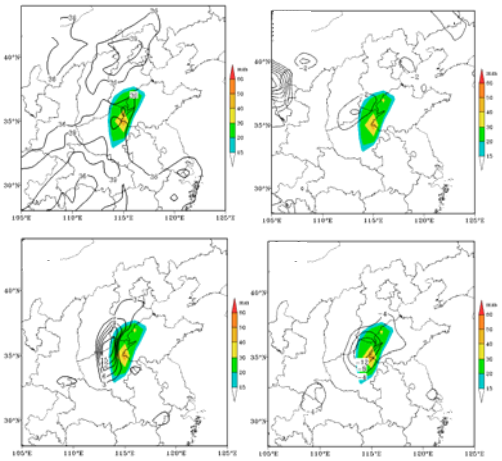

Fig.2 The K index (a, units: ℃), the 850hPa negative values in divergence of quasi- geostrophic Q-vector (b, units: $m^2 \cdot s^{-2}$), the positive values in vertical helicity of water vapor(c, $10^{-3}kg^{-1} \cdot m^3 \cdot Pa^2 \cdot s^{-2}$), and divergence of moisture flux from surface to 200hPa (d, units: 10^{-3} $K \cdot m \cdot s^{-1}$) at 00:00 UTC 17 August 2009, and shaded areas show the locations of heavy rainfall in the following 6 hours

4 Conclusion

Based on the philosophy of Ingredients-based Methodology and combined with the advantage of Pattern-recognition Method, a new physical index THP is established, it amplified strong signals, attenuated weak signals, and enhanced forecasting stability.The high value distribution of THP is great consistent with precipitation areas in the following six hours. The precipitation phase lag behind THP phase variation, the variation of THP indicates the beginning and ending time of a heavy rainfall, the THP index is also some significance of precipitation intensity forecast which occurs in the pre-trough pattern.

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