12.12 STATISTICAL ANALYSIS ON SEVERE CONVECTIVE WEATHER COMBINING SATELLITE, CONVENTIONAL OBSERVATION AND NCEP DATA

Zhu Yaping*, Cheng Zhoujie, Liu Jianwen, Li Yaodong

Institute of Aviation Meteorology

1. Introduction

Severe convective weathers (SCW) in southeast China occur in wide spectra of time- and space scales associated with strong winds and heavy rain. The hazards related to thunderstorms in summer bring on the heavy flood and cost many tens of millions of dollars annually in lost time. There have been many researches focused on the SCW using conventional sounding data, satellite images and model data. Synoptic, dynamic and thermodynamic characteristics that support severe convective conditions and describe the development processes of SCW have been examined in numerous studies even though there are many difficulties and uncertainties in monitoring and forecasting SCW (Moncrieff and Miller, 1976; Weisman and Klemp, 1982; Adler et al., 1985; Porcu et al., 1999; Li et al., 2004; Cohen et al., 2007). Some parameters are presented to depict the temperature and moist conditions of convective air parcel and the atmospheric instability indices are proposed to indicate the favourable conditions for convective development (Showalter, 1953; Colby, 1984; Woodall, 1990; Doswell and Rasmussen, 1994; Williams and Renno, 1993; Georgiev, 2003).

The objective of this work is to explore a new way that combines three sources data which include surface conventional data, GOES-9 images and NCEP data, and to give a statistical analysis on dynamic, thermodynamic, and environmental parameters correlation with severe weather during the summer season in southeast China. The key one is try to find the correlation with satellite parameters from surface and NCEP data.

2. Data and parameters

The present work uses a combination of three different data sources: three hourly surface conventional observations, hourly GOES-9 satellite images, six hourly NCEP grid data. Thus the combining data are obtained four times daily (00, 06, 12, 18UTC). After synoptic stations correlating with severe weather from three hourly conventional observations are selected, the nearly simultaneous satellite pixels, and NCEP grid data are matched in longitude and latitude. The severe weather reports include synoptic codes 17-19, 89-99 which are from weather region 57 in southeast China from June to August 2004. In order to highlight the features of SCW the parameters of clear sky are selected and calculated. This study define 'clear day' is that weather codes are 0-3 and there are no any altitude clouds in the surface reports.

Some dynamic, thermodynamic, and environmental parameters are selected and calculated from three sources data which can depict development and evolution of severe convective weather. The parameter from the surface sounding reports is depression of the dew point which describes the temperature and moisture conditions in the surface air mass. The characteristics based on satellite pixels include the brightness temperatures (or reflections) of five channels and the brightness temperature differences between the infrared channels (IR1-IR2, IR1-WV, IR1-NIR, WV-NIR) from GOES-9. All these satellite information are from the top of convective clouds correlating with severe weather and have the ability to improve the analysis and prediction the development of deep convective clouds. The features

* Zhu Yaping, Institute of Aviation Meteorology, 11 Anningzhuang Road, Beijing 100085 China, e-mail: creamyap@126.com.

selected and calculated from NCEP grid data include a thermodynamic parameterθ_{se} which is considered as a conservative characteristic of the energy transformation in the atmosphere, three instability indices CAPE, CIN, SI, RSH, which reveal the potential instability of convective environments and have been identified as being suitable for destabilisation and development of convective storms.

In fact, 548 features were derived from three sources data including not only parameters presented above but also some other parameters and the primary analysis have proven that not all characteristics are representative in depicting SCW. This study focuses on the selected features with more clear representation.

3. Statistical analysis

After matching in temporal and spatial from three sources data at four times, 366 SCW cases are selected, which comprise 264 thunderstorms with rain and 102 thunderstorms, that is mean that SCW of Region 57 in southeast China are composed by thunderstorms almost with heavy rain, the other type of convective weathers occur rarely. The subset of four times include 65, 109, 124, 68 cases separately, which indicate the thunderstorms have more possible occurrences at afternoon or dusk.

All parameters above are analyzed by the way of drawing scatter figures. In order to find the correlations of these features, the x-axis and y-axis in scatter diagrams are different from each other, and then every two parameters from different sources data are demonstrated in figures. By examining the distribution of scatters at four times, the dynamic, thermodynamic, and environmental characteristics are discussed, and the key question is try to find the correlation between satellite parameters and surface observations or NCEP data.

Firstly, the characteristics based on GOES-9 satellite pixels show that brightness temperatures (TB) and TB differences between 6.7 and 10.7μm are more representing than other parameters in describing thunderstorms, but not all the thunderstorms have low TB and small TB differences. In general the convective clouds related to SCW in satellite images are considered to have very low TB and close TB differences, because the cloud tops are composed of ice particles overlapping cirrus plumes, and the cloud tops of the high, thick, cold clouds (such as convective storms) are always at of above the tropopause or possibly extending into the lower stratosphere (Mecikalski and bedka, 2006). The scatter diagrams combing satellite pixels and surface observations and NCEP grid data give interesting distributions different from the common issues about thunderstorms.

Figure 1 shows the results of combination of the depression of the dew point from surface reports and IR1-WV based on satellite pixels can discriminate the severe convective clouds and clear sky in the two-dimensional characteristic scatter figures. The depression of dew point can depict the saturation of the low level troposphere near surface and the thunderstorms with rain have very low T-Td because the humidity of air are very large. From the figure we find that the distributions of thunderstorms (plum dots) at 00UTC have more differences with those of clear sky (green dots).

Figure 2 gives the results of θ_{se} at 850hPa from NCEP grid data and the IR1 TB of GOES-9 data. The θ_{se} at 850hPa is selected because this parameter can describe a conservative characteristic of the energy transformation in the low level atmosphere. The parameter becomes particularly important in convective situations involving large moisture supplies. From the distribution of dots in y axis we find that the θ_{se} at 850hPa are almost above 340K, the high low-level values correspond to areas of high moisture and/or temperature and therefore represent favoured regions for convective development.

Figure 3-6 describe the distributions of instability indices CAPE, CIN, SI, RSH and IR1-WV TB differences. All these indices are applied to reveal the potential instability of convective environments. CAPE is effectively the positive buoyancy of an air parcel and is an indicator of atmospheric instability. From the distribution of dots we see that the values of CAPE change from very low to high that mean SCW can develop in an area of relatively low CAPE values, any value greater than 0 J/kg indicates instability and the possibility of thunderstorms. Combing IR1-WV TB differences the two subsets of dots in the diagrams can be identified. On the other hand CIN is the amount of energy required to overcome the negatively buoyant energy the environment exerts on an air parcel. Typically, an area with a high convection inihibition number is considered stable and has very little likelihood of developing a thunderstorm. Conceptually, it is the opposite of CAPE. In figure 4 the CIN values of thunderstorms are very small and near to zero especially at 00, 06, 12UTC that mean the atmosphere environments are very unstable and they are favorable to occur thunderstorms. The SI (Showalter Index) is an index used to assess 850hPa parcel stability. The negative SI indicates that atmosphere is unstable which convection can occur. The more negative the SI the more unstable the troposphere and the more buoyant the acceleration will be for rising parcels of air from the upper layer. In Figure 5 the SI values of thunderstorms are low to 5 and most of those are less than 0. The two subsets of dots are more clearly at 00UTC, while the SI values of clear sky are almost positive. RSH is a measure of the potential for convective updraft rotation in thunderstorms, and the high helicity is of help to maintain the energy of convection cell at the mature stage of storm, and lead to a long life cycle of convective cell. In figure 6 the RSH values are almost greater than 0, changing from 0 to several hundreds that mean the environments are unstable.

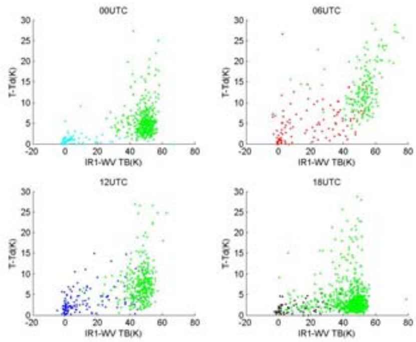

Fig. 1 The scatter diagram of T-Td and IR1-WV

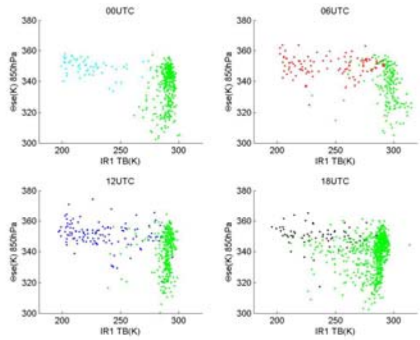

Fig. 2 The scatter diagram ofθse at 850hPa and IR1-WV

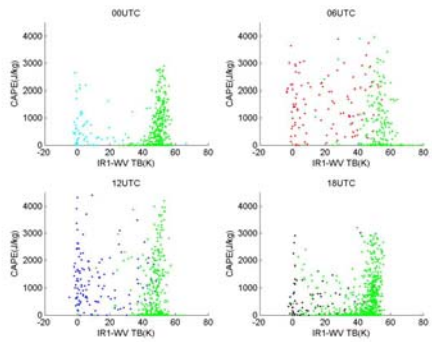

Fig. 3 The scatter diagram of CAPE and IR1-WV

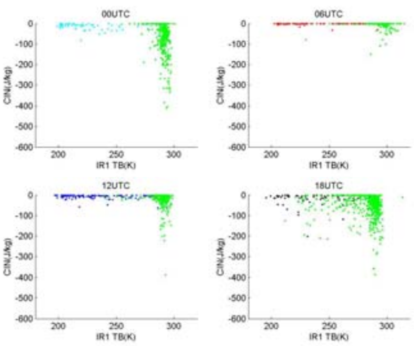

Fig. 4 The scatter diagram of CIN and IR1-WV

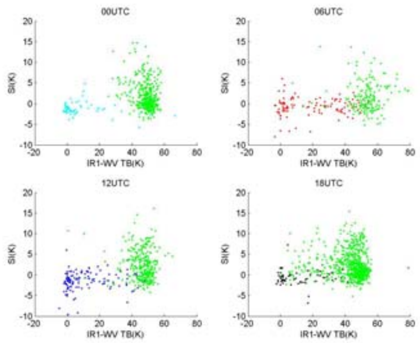

Fig. 5 The scatter diagram of SI and IR1-WV

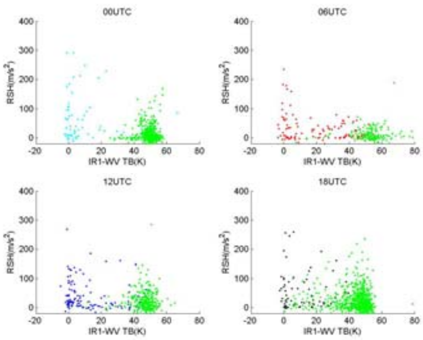

Fig. 6 The scatter diagram of RSH and IR1-WV

All the analyzed parameters above are just start of studies on SCW combining different sources data at diverse point of view. In the future work some additional parameters that depict quantitatively the evolution of convective clouds based on satellite images will be calculated, and the development process of SCW will be taken into consideration and the further analyses will be done combining genesis, maturity and decay phases of convective clouds related to SCW. Additionally, future work will include addition of more abundant sources data which include microwave remote sensing observations and radar data to further investigate the dynamic, thermodynamic, and environmental characteristics of SCW. Lastly the model products will be added and the interactional analyses will be done between SCW and background environments.

4. Conclusions

Some dynamic, thermodynamic, and environmental parameters are selected and calculated from surface observations, GOES-9 satellite pixels and NCEP grid data. The results show that combination with the depression of the dew point from surface reports and IR1-WV based on satellite pixels can discriminate the severe convective clouds and clear sky in the two-dimensional characteristic scatter figures. The high value of θ_{se} at low level correspond to areas of high moisture representing favoured regions for convective development. Instability indices depict the thermodynamic and dynamic characteristics a conditionally unstable atmosphere or increasing the conditional instability of large quantities of air in the unstable environment, these parameters combing satellite data could be applied to identify thunderstorms from clear sky. In fact, the characteristics from satellite images just describe the deep convective clouds whose tops penetrate to high level, it is hard to monitor and predict the initiation of severe convective weather correlating with small scale structure only using satellite remote sensing. At the different development processes of storms, especially in the period of initiation or for small scale cells, more effective methods combing other ways or parameters are proposed and the quantity criteria combing surface observations, satellite data and environment data are studied in the future work.

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