

# Sea Breeze Front and Convective Weather Events Detected by Doppler Weather Radar

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**Abstract.** Statistical analysis is performed on the relationship between Sea Breeze Front (SBF) of Bohai Bay and convective weather's formation and evolution, based on the Doppler weather radar and automatic weather station data during Jun. to Sep. in 2008 and 2009 respectively. The results show that the formation times of SBF are different, and the earliest time is 09:30 (Beijing Standard Time: BST), the latest is 16:00. The duration time of SBF is also different, and the longest is 6.5 hours, the shortest is just 1 hour. The general distance that SBF extends to the interior is 70-80 km. The results also show that: As small horizontal extent, the sole SBF generally cannot form the convective weather events; if the SBF collides with weak narrow band in a certain angle (30-90°), the convective weather events will form at the collision area; in addition, there will be stronger if thunderstorms exist.

**Keywords:** Sea Breeze Front, Convective weather events, Bohai Bay, Radar echo characteristics

## 1. Introduction

A series of progress has been made in the world that the application of radar data to study the trigger mechanism for the formation of thunderstorms by boundary layer convergence lines. Wilson<sup>[1-2]</sup> thought that the thunderstorm formation is related to boundary layer convergence lines, and the boundary layer convergence line monitoring and feature recognition is the key of thunderstorm formation, development and disappearance. If the vertical stratification of the atmosphere is conducive to the development of convection, boundary layer convergence lines in the two intersection collisions, usually, it will trigger the formation of thunderstorms; if the intersection of the boundary layer convergence lines already has a thunderstorm, the thunderstorm will develop rapidly. Kingsmill<sup>[3]</sup> expounded a thunderstorm weather evolution which is formed by the SBF and cold front collision. With the increase of the Doppler weather Radar, gratifying achievements has been made in China, especially in the observation of thunderstorms formation and the formation environmental conditions<sup>[4]</sup>. Applied the Doppler weather radar data, Yu Xiaoding<sup>[4]</sup> analyzed a downburst accompanied by a series of strong hail in Anhui province, and found that reflectivity factor nuclear declines from the middle troposphere before the downburst arrival, accompanying with the cloud base above the nucleus toward the reflectivity characteristics of the flow convergence, which has an important significance for nowcasting of thunderstorm and strong wind. Liu<sup>[5]</sup> gave a new method to identify the boundary layer convergence line through the Doppler weather radar. Many researches have been done about the formation environment of thunderstorm. The results suggested that at the point of thunderstorm formation, the characteristics of equivalent temperature profile decreases with height and then increases with height, with the minimum value appearing around 570 hPa. However, it's very limited for comprehensive study about the boundary layer convergence lines triggering the formation of thunderstorm evolution as well as the application of Doppler weather radar and automatic weather station<sup>[6-7]</sup>.

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Tianjin is located in the western Bohai Bay, easily influenced by the SBF. Yu<sup>[8]</sup> carried out 5 field observations about SBF of Bohai Bay, and suggested that Bohai Bay SBF has a triggering action to the thunderstorms, and the SBF only combines with westerly system that can cause the thunderstorm. Using the Doppler weather radar, Wang<sup>[9]</sup> analyzed typical SBFs in Bohai Bay, and found that in this area, thunderstorm event can be triggered by SBF. When under the suitable weather, the collision between SBF and weak narrow band at a certain angle can form thunderstorm events at the area of collision.

## 2. Data

The data analyzed in this paper are the Bohai Bay SBF cases from Jun. to Sep. in 2008 and 2009 respectively, and the thunderstorm cases triggered by SBF during 2002 and 2009 acquired from the new generation weather radar(CIN RAD WSR/98D) in Tianjin. Radar uses VCP21 model for low-elevation (0.5 ° or 1.5 °) of the basic reflectivity product information, and also select the same period of Automatic weather stations data.

## 3. The Basic characteristics of the radar echo of Bohai Bay SBF

SBF is a discontinuities surface caused by the land and sea temperature difference (LSTD) and belongs to a feature of the boundary layer convergence lines.

Bohai Bay SBF is generally formed in fine weather, and in the saddle-shaped field or under the control of pressure in the ground. It is easily to get by radar, with characteristics as below:

In the basic reflectivity products of low elevation angle (0.5 ° or 1.5 °), the Bohai Bay SBF shows the characteristic with weak strength, parallel with Bohai Bay and slow-moving narrow band echo. The echo intensity just maintains at 15-25 dBz, and the length is generally 100-300 kilometers. The movement speed is about 15 km /h, and moves slowly from the southeast to the northwest. The echo width changes with the season and the weather background. If the elevation angle is raised, the narrow band echo would weaken and vanish (As the SBF is boundary layer mesoscale weather system).

In general condition, it will judged as the Bohai Bay SBF if it satisfies the above characteristics.

## 4. Statistical characteristics of radar data of Bohai Bay SBF cases from June to September of 2008 and 2009

Using the Bohai Bay SBF weather data detected by the Doppler weather radar and corresponding automatic weather station data during June and September of 2008 and 2009, feathers of Bohai Bay SBF was statistical analyzed including duration time, frequency and the relationship about the formation of convective weather events. The results showed that there was 100 cases of SBF during June and September of 2008 and 2009 observed by the Doppler weather radar, in which there was 56 cases and 44 cases in 2008 and 2009.

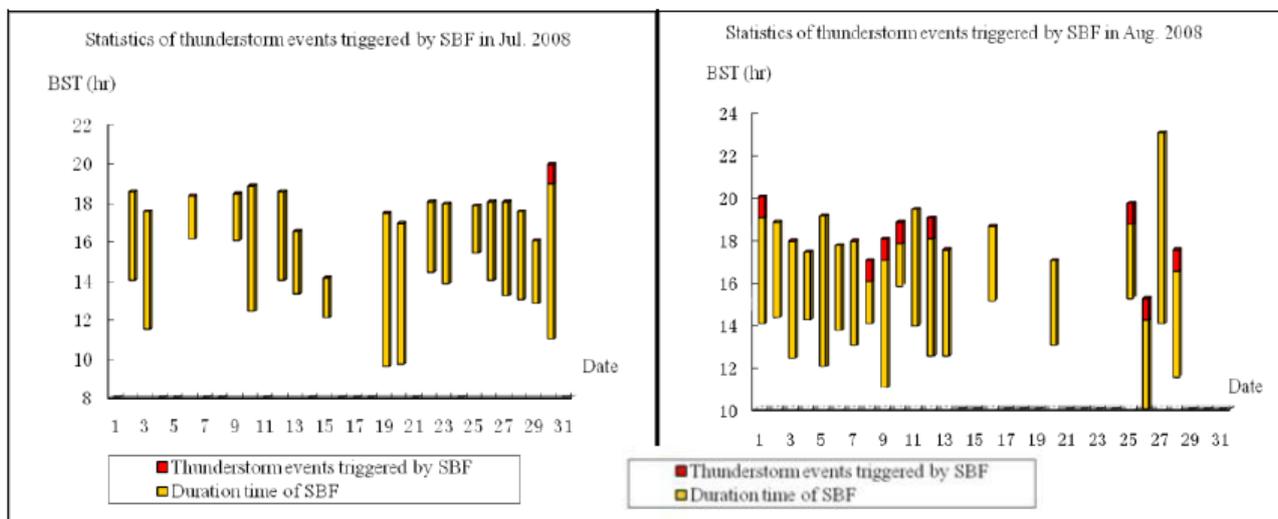


Fig. 1.A

Fig. 1.B

Fig. 1. Statistics of thunderstorm events triggered by SBF cases in Bohai Bay from July to Aug. in 2008

The occurrence time of observed SBF during June and September of 2008 are showed in Fig. 1.( 2009 omitted). From the monthly distribution, we can see that in the 100 cases there was 26, 35, 35, and 4 cases during June, July, August and September respectively, and accounts for 26%, 35%,35%, and 4% respectively, which indicated that midsummer is the SBF active season.

The formation times of SBF are different from the day to another, the earliest time is 09:30 (Beijing standard time), the latest was 16:00, and most of them are during 13:00-16:00. The SBF's duration time also has different length, the longest duration time is 6.5 hours, and the shortest is only 1 hour. The general distance that SBF extends to the interior is 70-80 km, and the farthest distance reaches 120 km, and the height is 1.5 km in general.

The SBF is the common mesoscale system in Tianjin coastal area, and also one of the trigger mechanisms of convective weather events (Fig. 1.). Among 56 cases in 2008, convective weather events appeared for 17 times, and also appeared 8 times in 2009, which suggested that the SBFs that trigger the convective weather events occupied 25% of all cases.

## 5. Bohai Bay SBFs and convective weather events

### 5.1. The sole SBF generally cannot form the convective weather events, can only change temperature, wind direction and other meteorological element characteristics

Case analysis on July 4, 2010: The Doppler weather radar completely monitored the Bohai Bay SBF variation process on July 4, 2010 (as shown in Fig. 2). In the 0.5 ° elevation angle basic reflection product, weak narrow band echo which parallel to the coastline was formed at 14:00, and the echo strength only was 15-20 dBz (Shown with the arrow in Fig. 2A);The echo slowly moved to the interior after formation, and the narrow band echo transfers to Ninghe to Beichen to Xiqing line at 16:30, with the echo strength maintains invariable at 15-20 dBz (Shown with the arrow in Fig. 2B). The narrow band width was no more than 10 km, and the length duration approximately 150 km, with the height at 1.5 km. Afterward, the SBF moved to Wuqing to Xiqing line, at 17:30, with the strength decreased to 5-10 dBz, and then the echo vanished gradually. There may be two reasons for the Bohai Bay SBF vanish: The SBF real weakens vanishing, and another is that the radar can not survey the low SBF as the height increased with the distance.

### 5.2. Convection weather events triggered by Bohai Bay SBF

Using the data of convective weather events triggered by Bohai Bay SBF during June and September of 2008 and 2009, and the data of evolution characteristics of SBF triggered convective weather events data during 2002 and 2007, the convective weather events characteristics are analyzed as below:

The SBF colliding with weak narrow band echo from the different direction, different collision led to different results. For example, if the weak narrow band echo comes from northeast and collides with

Bohai Bay SBF, there is generally convective weather events formed at the collision area, which is

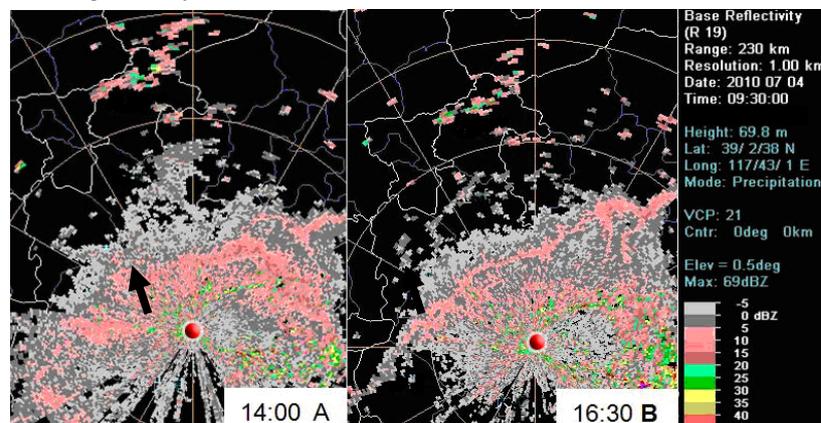


Fig. 2. 0.5° PPI basic reflectivity evolution on July 4,2010(50 km per ring)

consistent with Wilson's[2] studying. If the SBF collided with other weak narrow band echo in parallel direction, mostly examples indicated that there will be a convective weather events formation or

strengthening, and minority examples indicated that the weather doesn't change obviously, which possibly have a close relationship with the meso-scale weather background condition, and it need further study. If two or more SBFs collide with one after another, there will be generally no any convective weather events formation. This result has a very useful value for the convective weather events nowcasting.

## 6. Summary

6.1 There were 100 cases of SBF during June and September of 2008 and 2009 observed by the Doppler weather radar, in which there were 56 cases and 44 cases in 2008 and 2009, respectively. The formation times of SBF are different from the day to another, and the earliest time is 09:30 (BST), the latest is 16:00. The duration time of SBF also has different length, and the longest duration time is 6.5 hours, and the shortest is only 1 hour. The general distance that SBF extends to the interior is 70-80 km, and the farthest distance is about 120 km, with the height of 1.5 km in general.

6.2 Owing to small horizontal extent, generally, the sole SBF cannot form the convective weather events. However, if the SBF collides with weak cold front in a certain angle( $30-90^{\circ}$ ), the convective weather events will form at the collision point. If the SBF collides with other weak narrow band echo in parallel direction, most examples indicate that there will be a convective weather events formation or strengthening. If two or more SBFs collide with one after another, generally, there isn't any convective weather events formation. This result has a very useful value for the convective weather events nowcasting.

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