P13 Study on the formation and evolution of “6.3”damage wind

WANG Xiuming* YU xiaoding ZHOU Xiaogang

China Meteorological Administration Training Center , Beijing,100081, China

1. The damage wind event introduction

A widespread convective damage wind events occurred on 3 June 2009 in China, which cause great damage and casualty at Shangqiu（Henan province）, North of Anhui and Jiangsu province .It claimed 18 at Shangqiu (red circle at Fig1), and a few people died at the North part of Anhui. The observed maxinum damage wind speed is 31m/s, but it should be more that 31m/s infered from 0.5° doppler weather radar radial velocity. The synopical forcing is weak, the moisture is marginal at boundary, the vetical wind shear is weak. So it’s a challage in forecasting and reasearch. The quasi-linear mescoscale convective system show tipical bow echo shape, and the stronger storm clusters are high orgenized with mesocyclone and middle altitude radial velocity.This presentation discuss the structure evolution of the wind storm, the mesocale analysis, convetion initiation and the formation of damage wind gust.

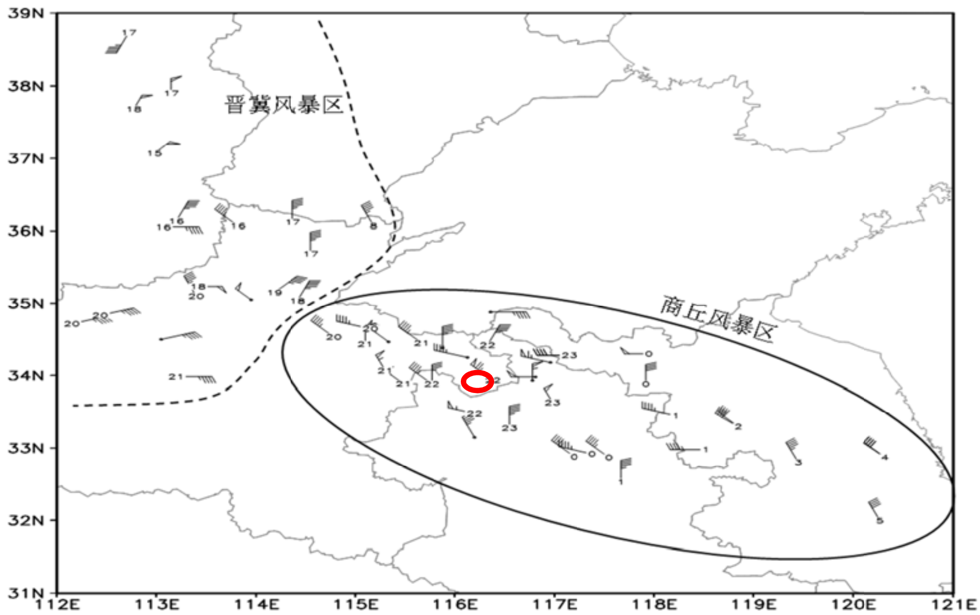


Fig.1 The distribution of surface damage wind on 3 June 2009, digital is time（LST）, full bar is 4m/s.

2. The evolution of the storm

The convective storm develop from superscell(Fig2) to bow echo squall line(Fig3), Severe convection last more than seven hours. The strom develop very quickly, convection initation at 18:00, and it evolute to supercell clusters in an hour. The supercell has deep and strong middle altitude radial convegence, that means the supercell storm can produce high wind at surface. In

*Corresponding Author Email address: wangxm@cma.gov.cn

supercell stage, the surface wind damage was driven by downdrafts incorporation of multi-supercell. The squalline come into being when two superceller clusters move in different direction (fig3,20:56).When the bow echo broken, Shangqiu severe wind disaster happened. The reason of long-lived Squall line are the incorporation of line-shape cumulus at the north part of squalline, The line cumulus was triggered by dryline（Fig2d, pinkle dot line donate the location of dry line ）and overlapped disturbances .

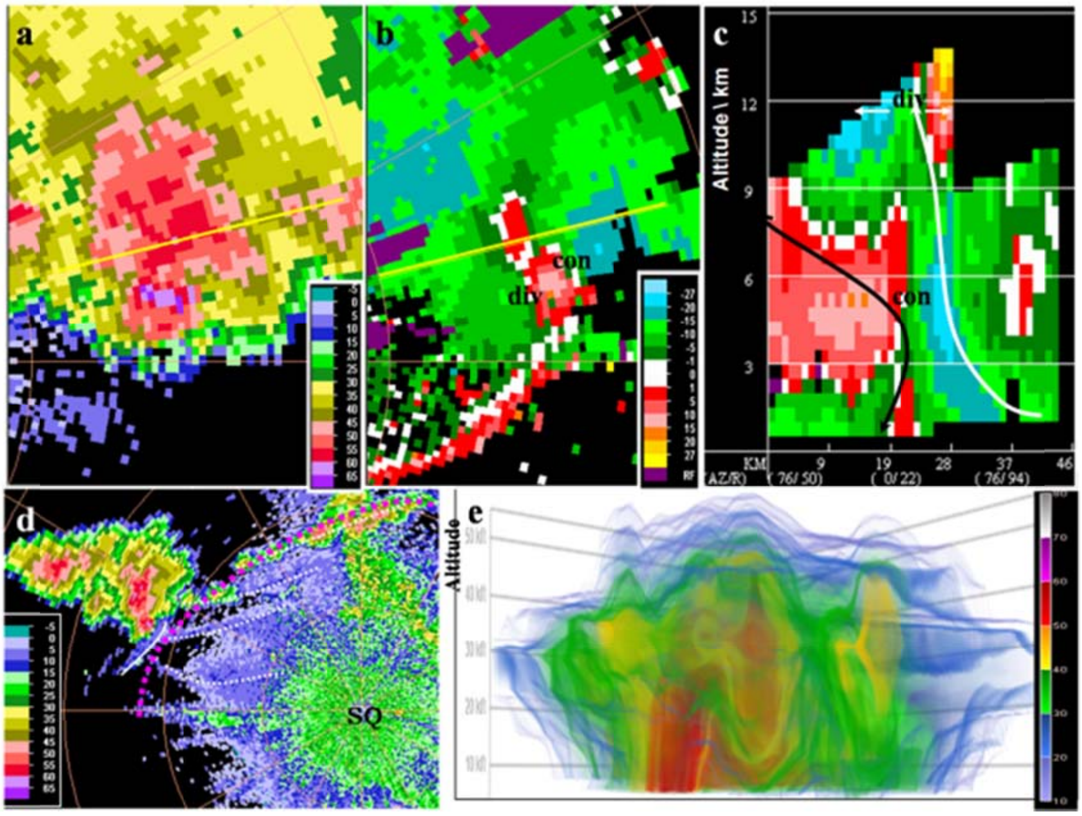


Fig2. Supercell structure observation at 19:13 on 3 June 2009, the 0.5°elevation Reflectivity (a), radial velocity (b) ,radial velocity cross section(c) along yellow line in Fig2b from Zhengzhou radar, white(black) solid line is updraft(downdraft), ‘con’ and ‘div’ donate convergence and divergence; 0.5°elevation Reflectivity and the location of surface dryline(purple dote line)(d) and 3D picture look from south-east(e)of Shangqiu radarFig3. 0.5 elevation bow echo reflectivity evolution on 3 June 2009, black arrow donate orientation of cell movement, blue dot sign location of Yongcheng (belong to Shangqiu).

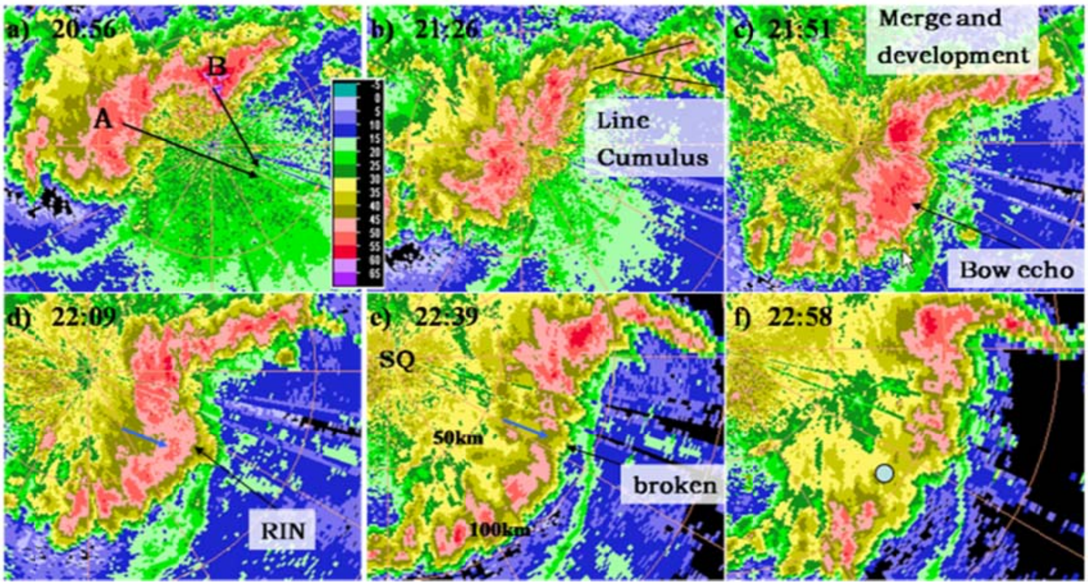
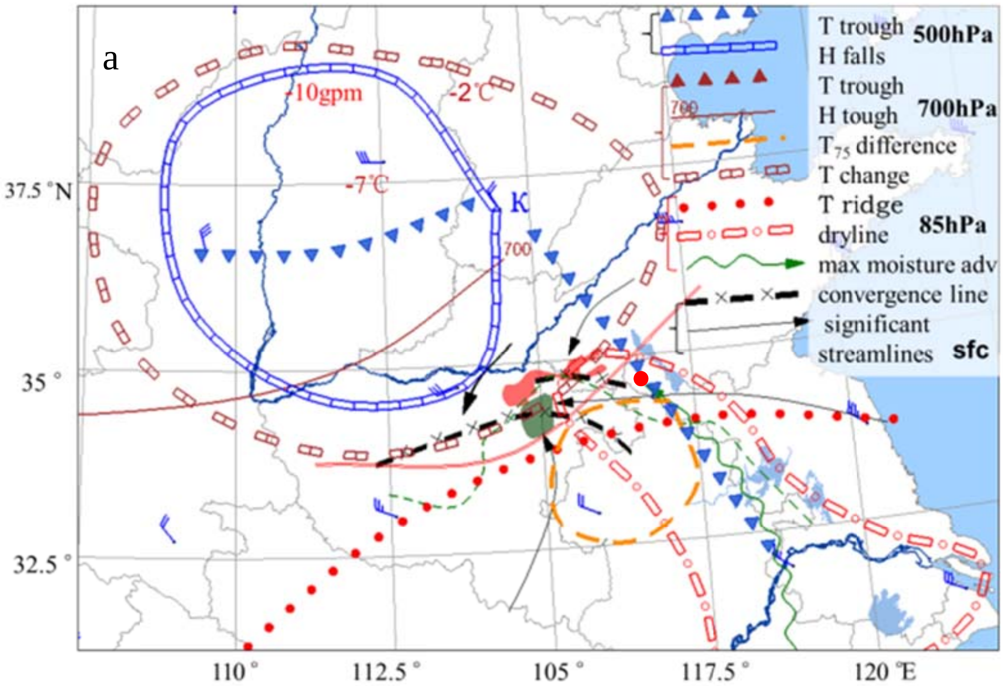


Fig3 0.5 elevation bow echo reflectivity evolution on 3 June 2009, black arrow donate orientation of cell movement, blue dot sign location of Yongcheng (belong to Shangqiu)

3. mesoscale analysis and sounding

Mesoscale analysis show that the storm enviroment are favorable for Derecho(Fig4a). The severe storm area is in front of the subsynoptic scale inverted tough and with weak cold advection at 700hPa,which corresponding to nagtive temperature change at 700hPa high fallen at 500hPa. The trough is not signifancant and not easy to detect, but it's very significant at satellite vapor image show as dark area. There's a temperature trough extend to north east part of Anhui, which overlap on temperature ridge on 850hPa,That means it's unstable. The convective potential energy(CAPE) is about 3000J/kg from the proximity sounding. There's a dryline and surface convergence line near storm, and Shangqiu is the place where 3 flow convergence. The Xuzhou(red dot in Fig4a) sounding pattern is like wet downburst sounding. The average mixing ratio at boundary is less than 12g/kg. The moiture is enough for thunderstorm but not abandent.



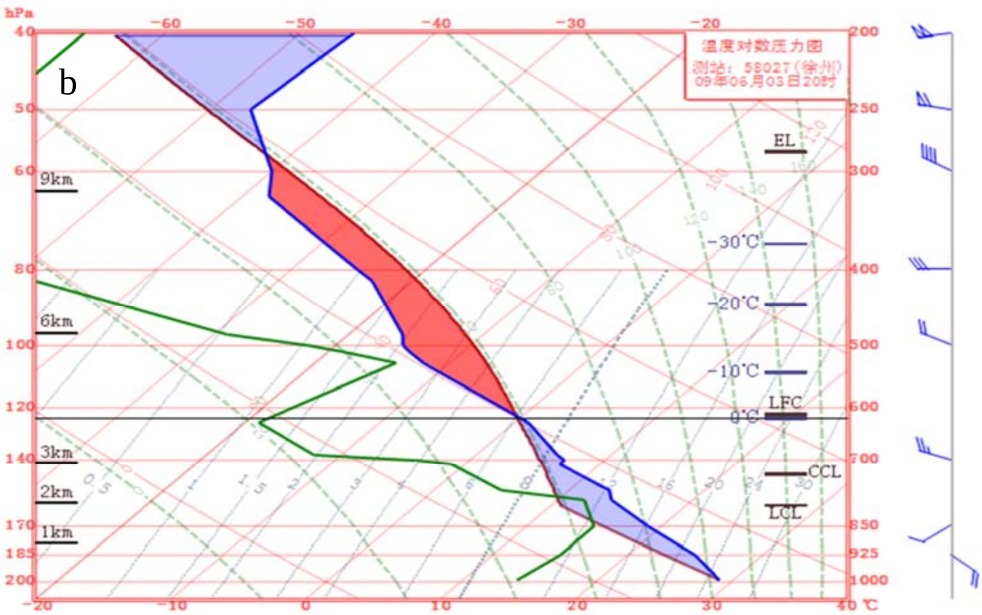


Fig4a. Mesoscale composite analysis chart at 20:00 on 3 Jun 2009(left), red shaded area is radar reflectivity more than 45 dBZ at 21:00, green shaded is surface dew point more than 22 ℃,green dash line is 20 ℃ contour of surface dew point, “K” donates cold centre at 500 hPa,blue wind barbs is wind at 500 hPa,full wind bar is 4m/s.

Fig4b Xuzhou sounding plotted on a Skew T-log p diagam at 2000lst 3Jun 2009(right)

4. The iniation of the severe storm

Shangqiu wind storm is not the quasi-linear MCS move from Shanxi high plain, but a new initation one(show as a red shaded area in Fig5 right). The Shanxi quasi-linear MCS move slow and decay after 18:00 LT. The new convetion is near Yangtser reiver, the distance between Shanxi quasi-linear MCS and new convection is nearly 80KM. As it's farer than usual so people doubt that the new storm is triggerd by the gust front of old linear storm. The narrow-band echo is not very clear, but the outflow boundary is signifanct in 0.5° elevation angle reflectivity. The strong NNE outflow wind is detected by 0.5° radial velocity and the aws. When the gust front move to the place where there's a dryline overlaped and the moisture is enough, new convection initation.

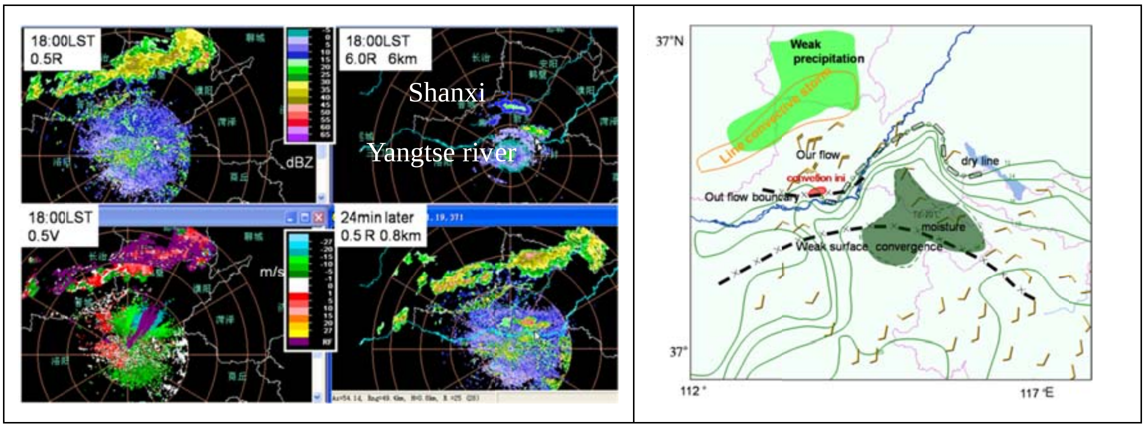


Fig.5 The radar observation of Zhengzhou Doppler weather radar(left) and Surface observation at 18:00 on 3 June 2009(right), green shade is the moisture pool (dew temperature more that 20 ℃), red shade is where storm initiation, black circle and pane donate surface dryline, blue line is Yellow River.

5. The formation of the damage wind

The damage winds of bow echo are driven by Strong downdraft divergence flow , strong cold pool outflow and evaporation of stratus hydrometeors. Estimate from radial velocity we can see that the effect of these three elements is almost equal. Incorporation of cold pool play an important role on Yongcheng damage wind

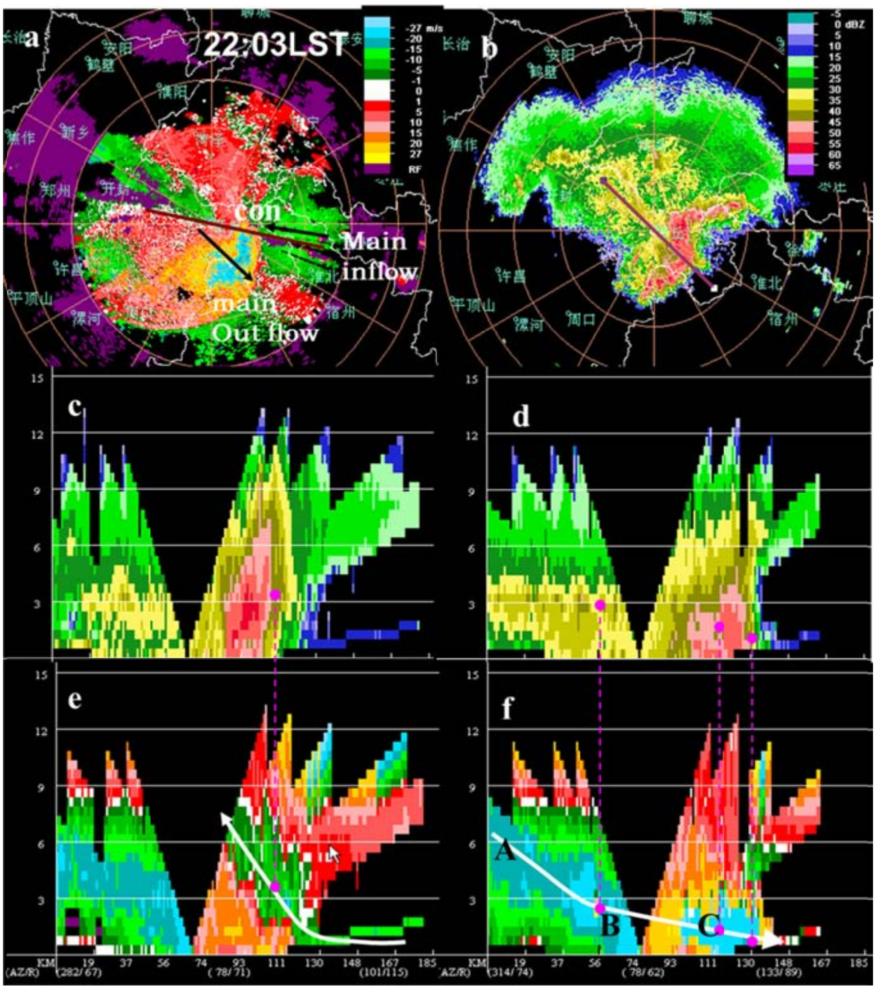
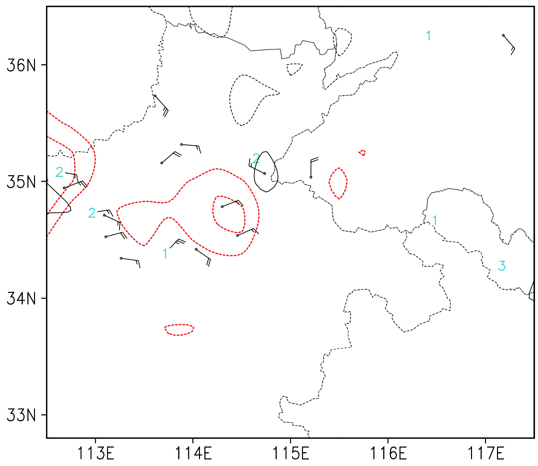
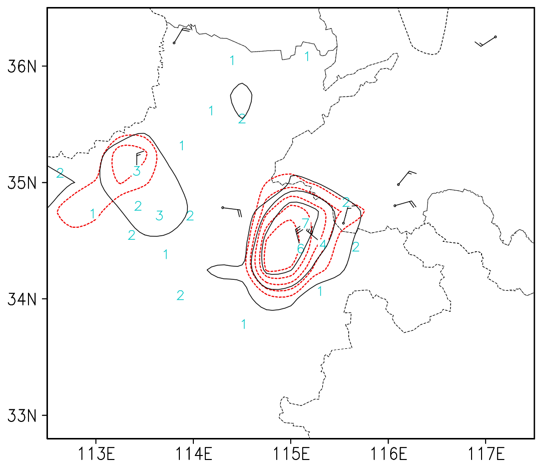


Fig6. Squall line structure at 22:03 on 3 June 2009, 0.5 elevation radial velocity(a) and 2.4 elevation reflectivity, cross section of reflectivity(c) and radial velocity(e) along purple line in Figa, cross section of reflectivity(d) and radial velocity(f) along purple line in Figb, white solide line are vertical movement, black arrow is main inflow and outflow.

a)



b)



c)

d)

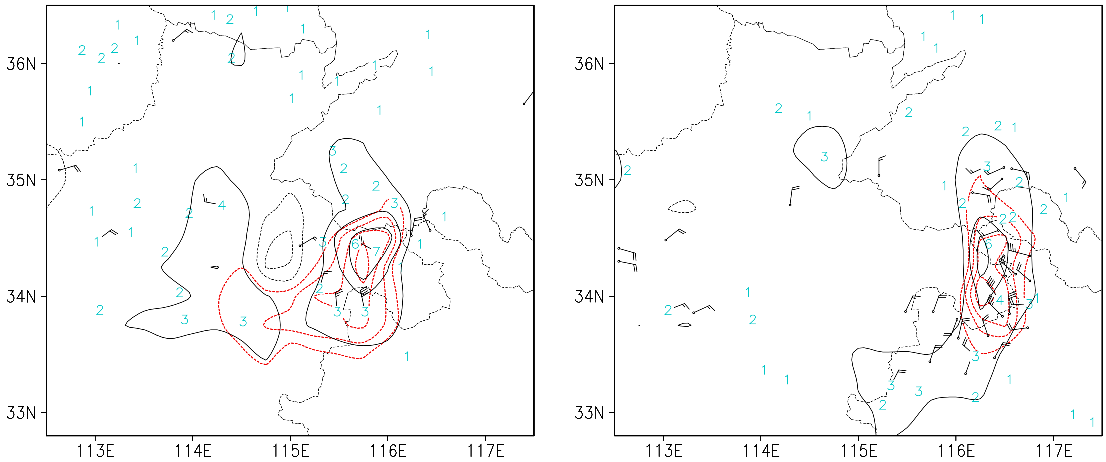


Fig7.surface observation at 20:00(a),21:00(b),22:00(c) and 23:00(d) on 3 June 2009, digital is one hour pressure increase，solid dark line contour at 2 hPa interval, red dash line is one hour temperature fall contour from 4 ℃at interval 2 ℃

6. Discuss

a. How can this severe bow echo squalline development at relatively low 0-6km vetical wind shear enviroment.
b. Moisture is a very important element for this event. In the morning, the PBL is relatively dry, the surface moisture pool is shallow, how to anticipate the low level moisrture evolution is a problem that need more discuss.

6. The reference

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