ECMWF IFS Bias Analysis on Vortex Shear Line Rainstorm in Southern China in 2016-2017

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Introduction

Vortex shear line rainstorm in southern china as the most important precipitation system in CMA forecast operation often leads to thousands of sufferers and huge economic loss. Since ECMWF IFS resolution was updated to 9km in 2016, it was found that forecast rain band above 50mm per day brought by vortex shear line in southern china often lails north to the observation by tens of kilometers even in 36h forecast time, which troubled forecaster in rainstorm warning. In our work, precipitation forecast bias statistics and typical case synoptic verification were used to research possible reasons for the bias, for better application of ECMWF products.

Bias Statistics

24h accumulated precipitation in 36h forecast and CMA QPE products were used. Consistent rain bands above 50mm per day larger than 1000 grid-boxes were discerned and the objects information such as rain area, location and so on were obtained by MODE[1]. 29 cases with 15 cases made by warm shear while 14 by cold shear were found in 2016 and 2017.

In warm shear cases (zonal rain bands), 13 cases forecast precipitation centers were north to observations with maximum bias of 0.62° and average 0.325° . Forecast areas were averagely 0.4 times larger than observation.

While in cold shear cases (meridional rain bands), 11 cases forecast centers were north to observations with maximum bias of 1.31° and average 0.54° . Forecast areas were averagely 0.3 times larger than observation. Apparently, most of the cases were north to and larger than the observation.

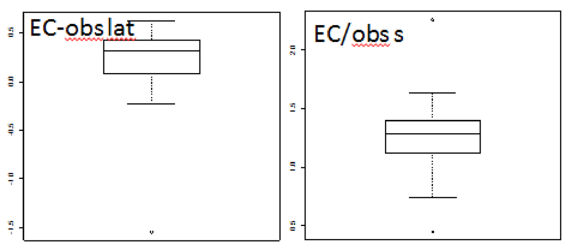

Figure1. Warm shear cases bias, latitude bias of rain bands center (left), area bias (right)

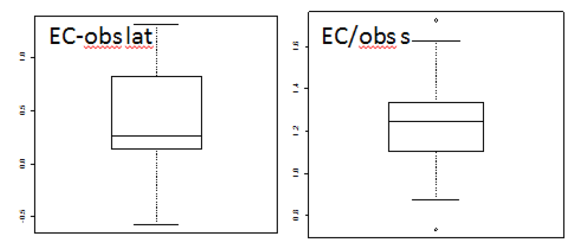

Figure2. Cold shear cases bias, lontitude bias of rain bands center (left), area bias (right)

Cases Analysis

Rainstorm on April 17th 2016 was chosen for the inclusion of both cold front precipitation and mesoscale convective precipitation in the warm sector ahead of the front. While rainstorm brought by warm shear with obvious location bias on Jun 24th 2017 was Mei-yu which was the most important precipitation type in China.

Analysis was conducted from the aspects of mesoscale convective system initiation, maintenance and propagation.

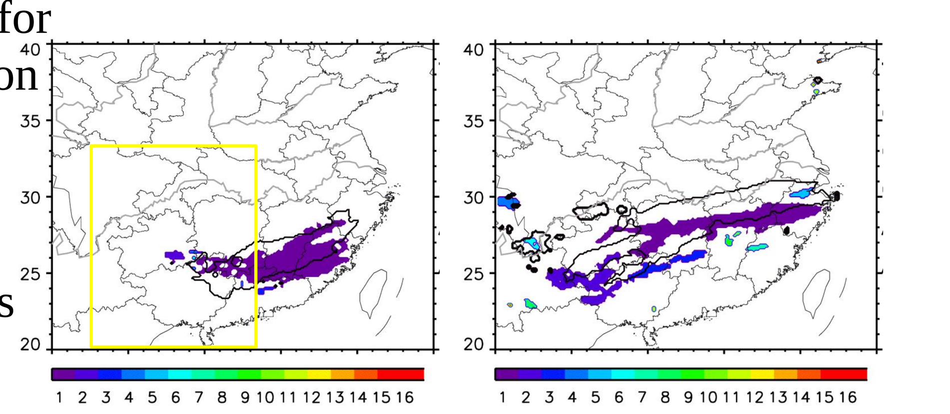

Figure3. 24h accumulated precipitation, shaded: observed rain bands above 50mm per day, contour: 36h forecast. cold shear case, 08:00 April 17th 2016 (left, local time). Warm shear case,08:00 Jun 25th 2017 (right).

1. Initiation

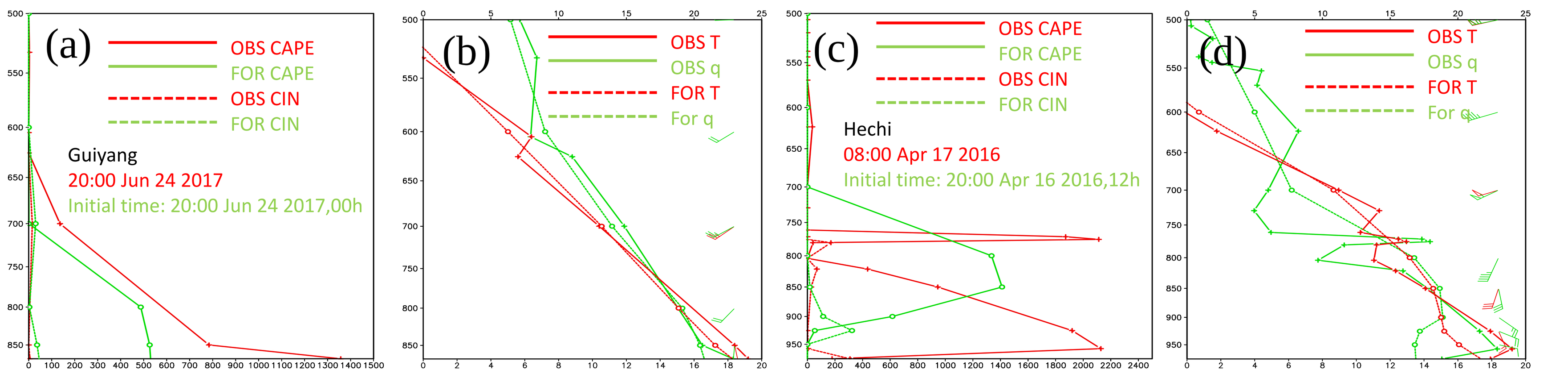

Figure4. Profile of CAPE and CIN(a,c), temperature and specific humidity(b,d)

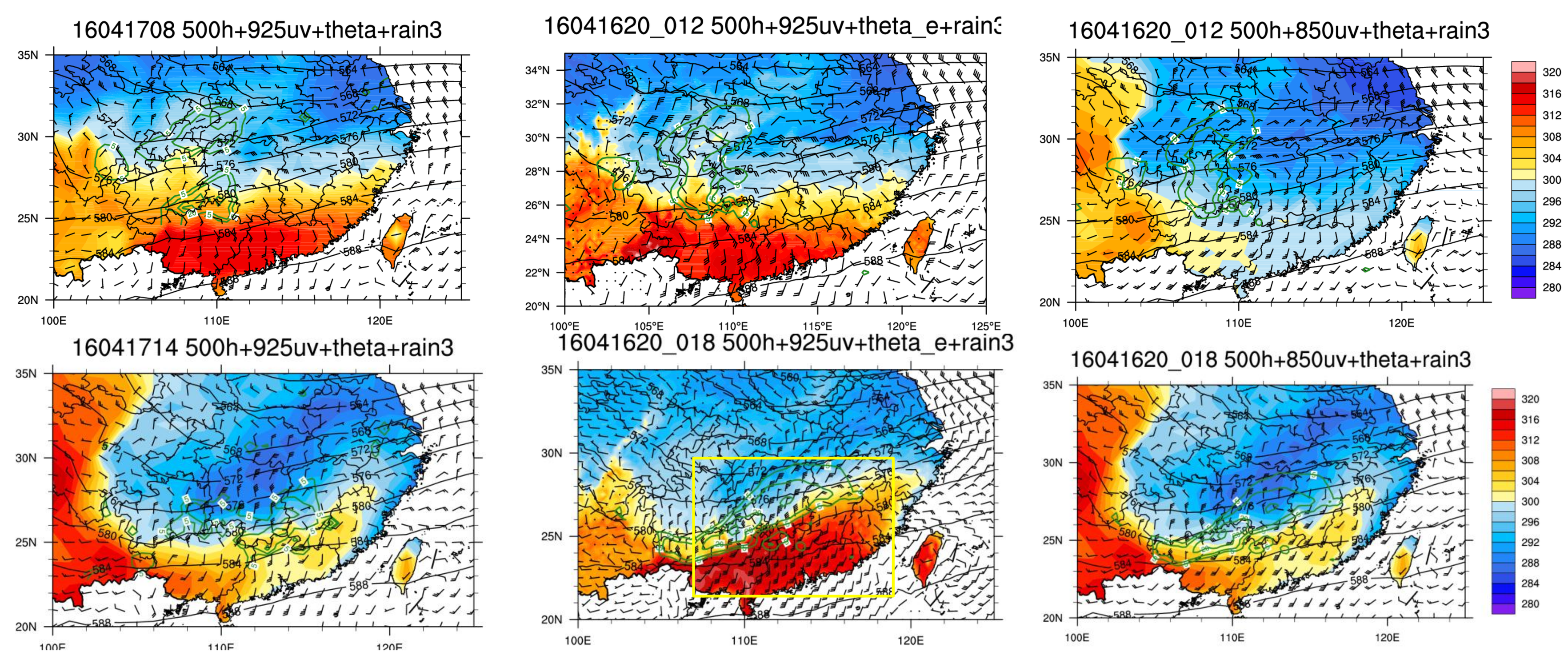

Figure5. 3h accumulated precipitation (green contour) NCEP analysis wind, geopotential height(left, local time, observation, see picture title) ECMWF IFS forecast (middle and right)

Temperature and moisture deficiency in low level troposphere especially in boundary layer gave rise to the CAPE deficiency in low level (Figure 4). Hence either stronger wind convergence or longer way of lift were needed to trigger convection, leading to the precipitation initiation location lying behind the observation (Figure 5,6)and started later[2]. At the same time , since convection parameterization (CP) was derived by grid scale convergence, common in operation , CAPE deficiency in low level could even make the model miss mesoscale convective precipitation in the warm sector ahead of the front . This problem often occurred in southwest part of China (rectangle in fig.2) in the outset of rainstorms.

2. Maintenance

Convection was weaker in the model on account of CAPE deficiency and CP that could not remove excessive CAPE and moisture. Then excessive grid-scale precipitation that could lead to mesoscale cyclogenesis and stronger vortex formed [3]. But in fact convective rain bands had already propagated south to the place where there was abundant moisture and energy, while the model tried to exhaust excessive CAPE and moisture and the vortex moved south slower or even stand still. Finally, forecast rain bands fell behind.

12h forecast vortex intensity was nearly consistent with analysis but became more and more stronger as forecast time increased.
The vortex developing stronger, low level wind were stronger in southern China.
At 36h forecast, larger area of cloud occurred near the shear line where was the strongest wind convergence.
But in analysis, the cloud system appeared south to the shear line and moved south.
Finally, rain bands were north to observation.
Additionally, simulated infrared radiation were effective in estimating convection strength.

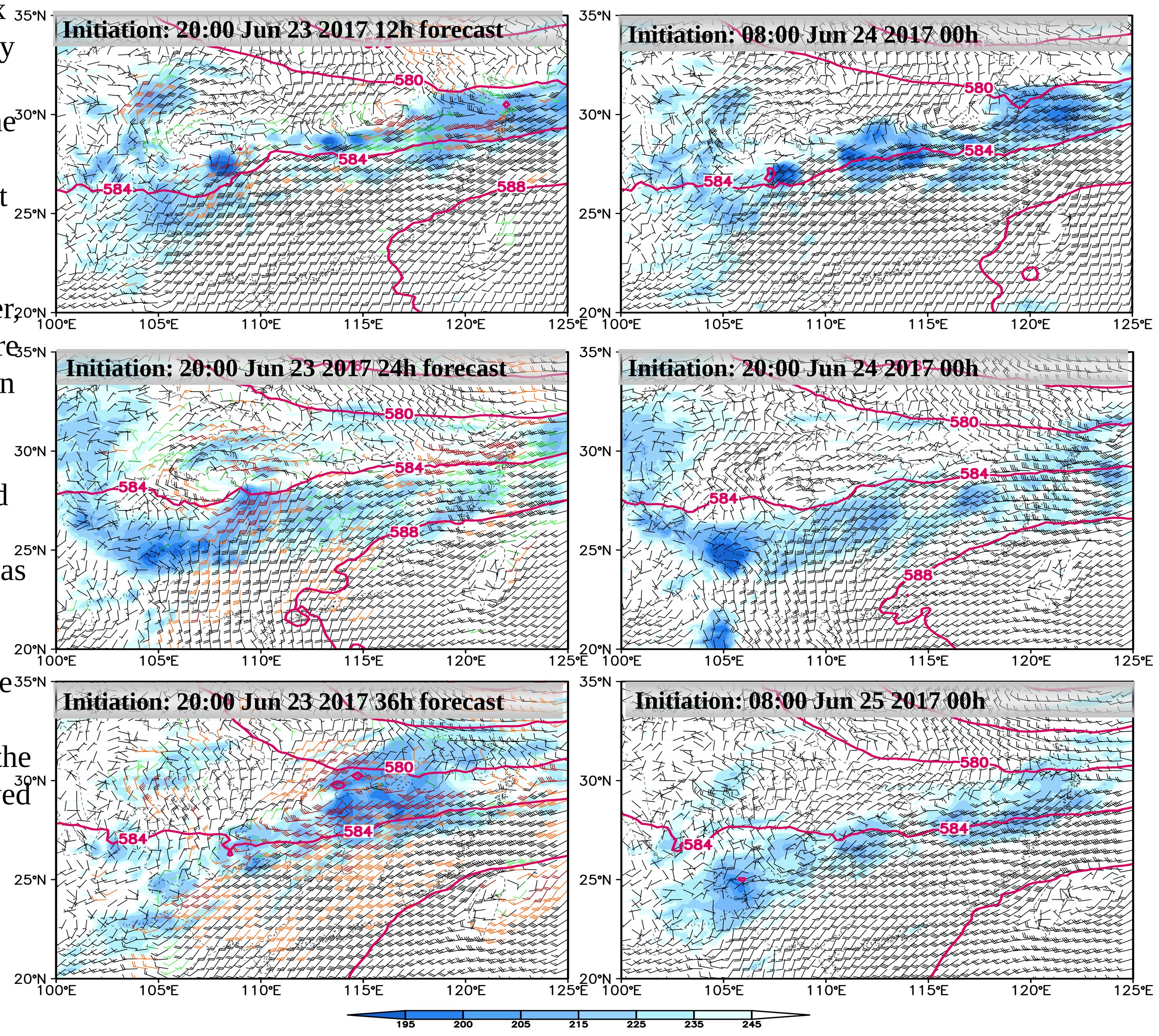

Figure6. Simulated infrared radiation (shaded), 850hPa wind (red:wind speed larger than analysis , green: wind speed less than analysis, light:2m/s,dark:4m/s) , 500hPa geopotential height

Forecast rain area above 60mm was smaller than observation and maximum rain was also smaller.
Since CAPE was exhausted, forecast rain brought by shear line near Yangtze river interrupted at 20:00 Jun 24, whereas observed rain bands moved south slowly.

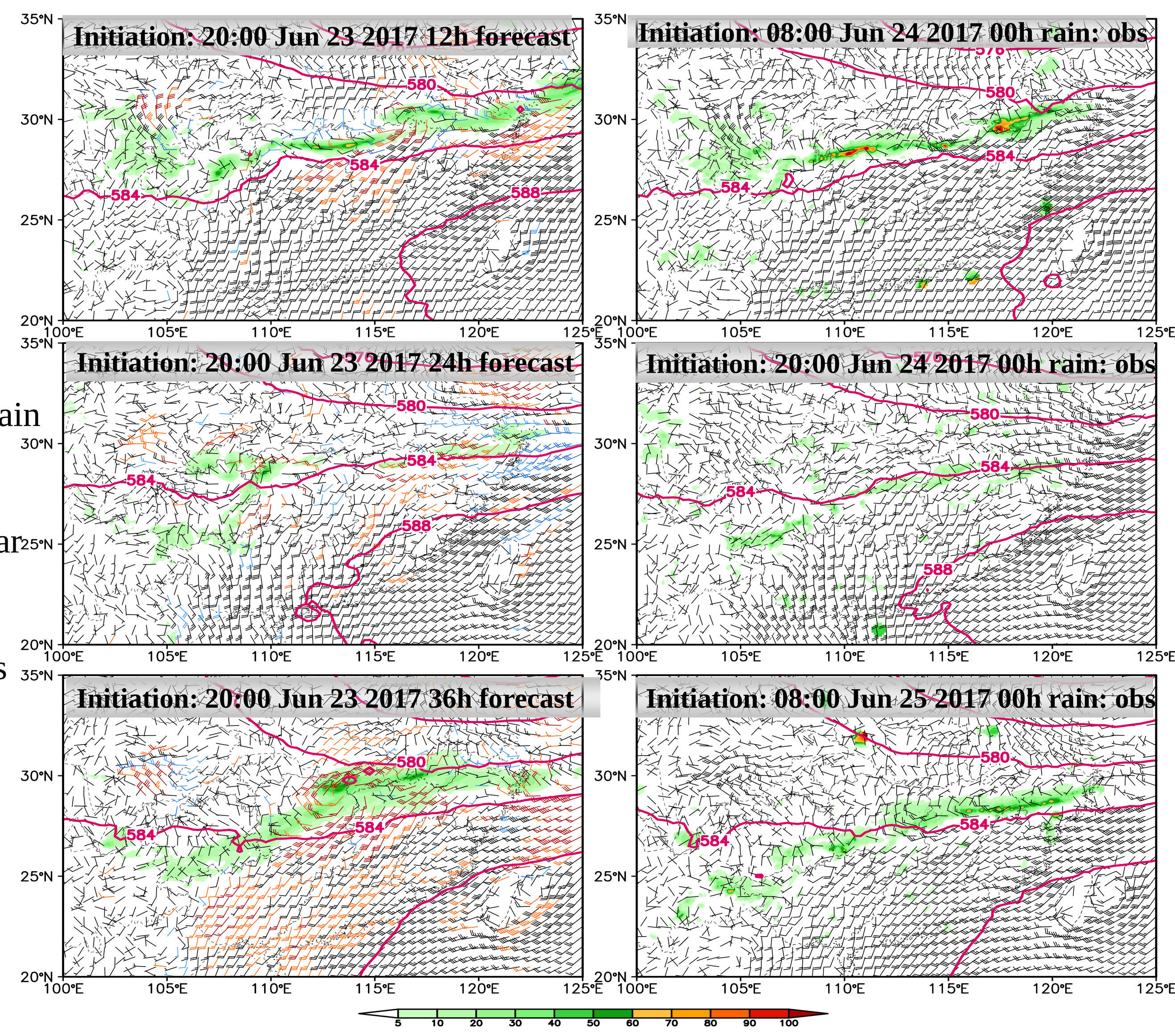

Figure7. 3h accumulated precipitation (shaded), 925hPa wind (red: wind speed larger than analysis , green: wind speed less than analysis, light:2m/s,dark:4m/s) , 500hPa geopotential height

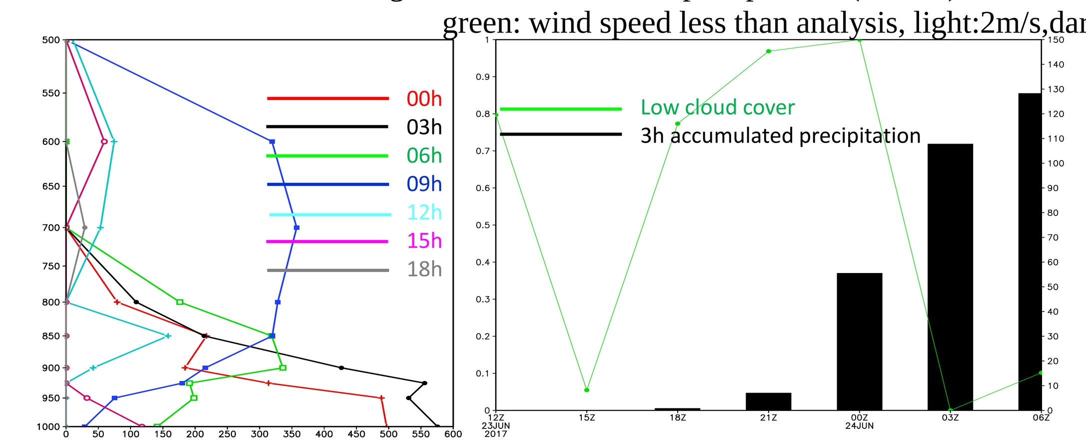

Figure8. Profile of forecast CAPE, low cloud cover and 3h accumulated precipitation. Initiation: 20:00 Jun 23 2017

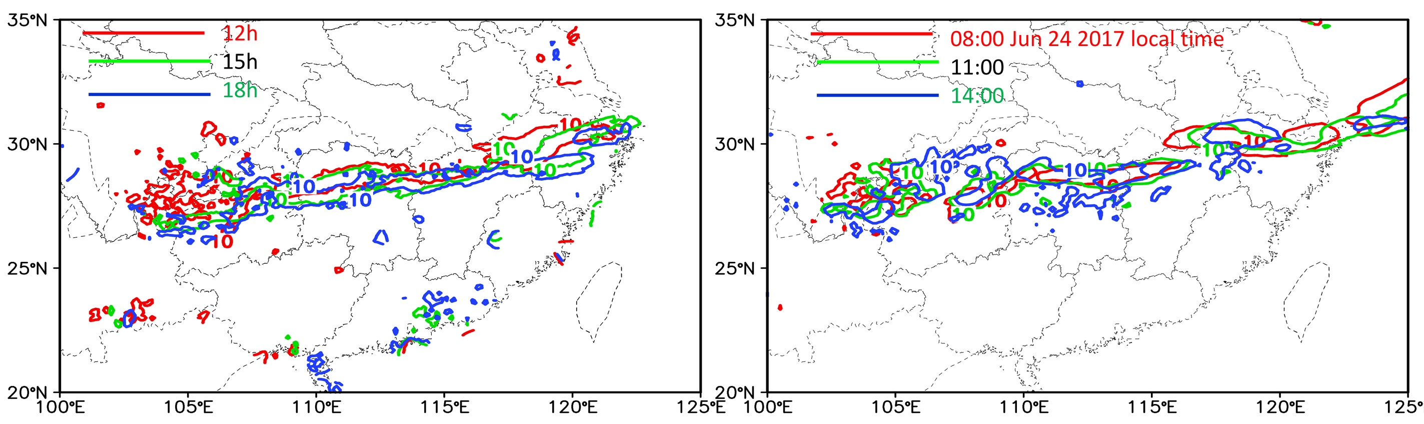

Figure9.Forecast (left) Initiation: 20:00 Jun 23 2017 and observation (right) 3h accumulated precipitation

3. Propagation

In forecast, mesoscale convective system structure was not clear on account of weak cold pool and downdraft, which could also make the precipitation system move slowly.

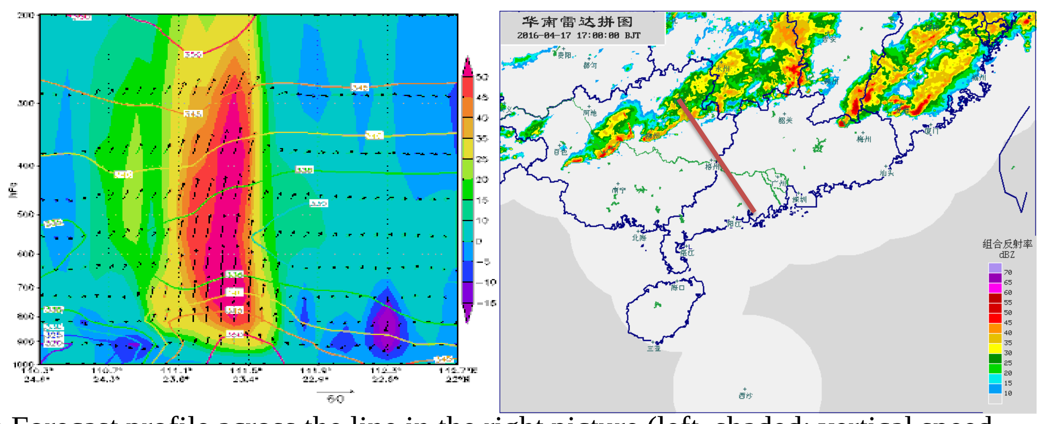

Figure10.17h Forecast profile across the line in the right picture (left, shaded: vertical speed , contour: potential pseudo-equivalent temperature , vector: wind),radar observation CR(right)

Conclusion

1.Estimate the convection strength and location by means of simulated infrared radiation product efficiently. If convection is possible, more consideration including mesoscale model product and observation analysis especially on sounding and the boundary layer humidity and temperature are needed. Furthermore, be aware of the fake mesoscale vortex result from excessive grid-scale precipitation. Modification of the location of rain area is needed.

2.More ECMWF products showing convection such as simulated radar echo are necessary, which could help the forecaster make rainstorm warning more efficiently.

References

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