

THUNDERSTORM IDENTIFICATION, TRACKING AND NOWCASTING USING LIGHTNING DATA

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OUTLINE

- ◎ **1. Research background**
- ◎ **2. Thunderstorm identification, tracking and nowcasting**
 - 2.1 Thunderstorm Identification
 - 2.2 Thunderstorm Tracking
 - 2.3 Thunderstorm Nowcasting
- ◎ **3. Future work**



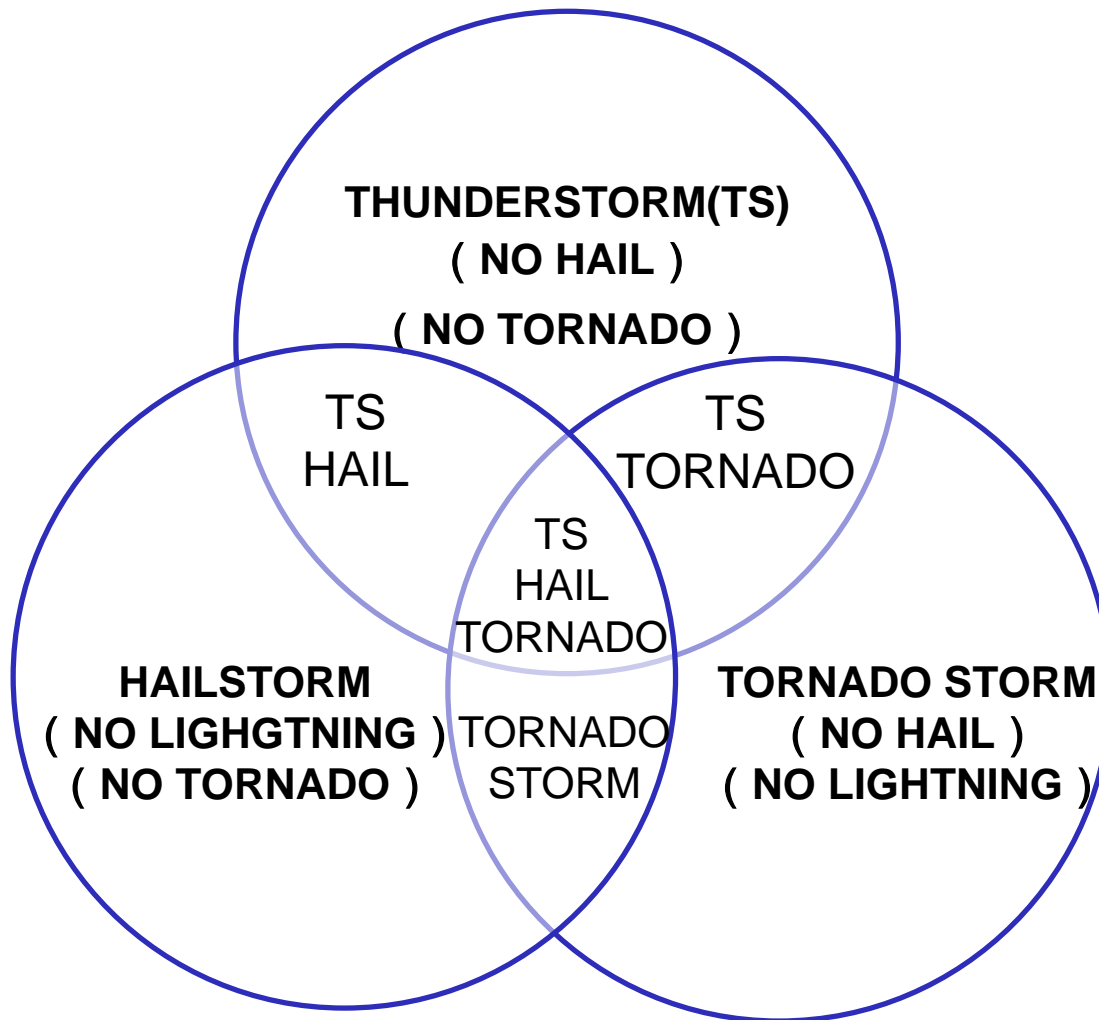
WHAT IS A THUNDERSTORM ?



A **thunderstorm** is a type of storm characterized by the presence of **lightning** and **thunder**. Thunderstorms occur in association with a type of cloud known as a cumulonimbus, usually accompanied by **strong winds**, **heavy rain** and **hail**.

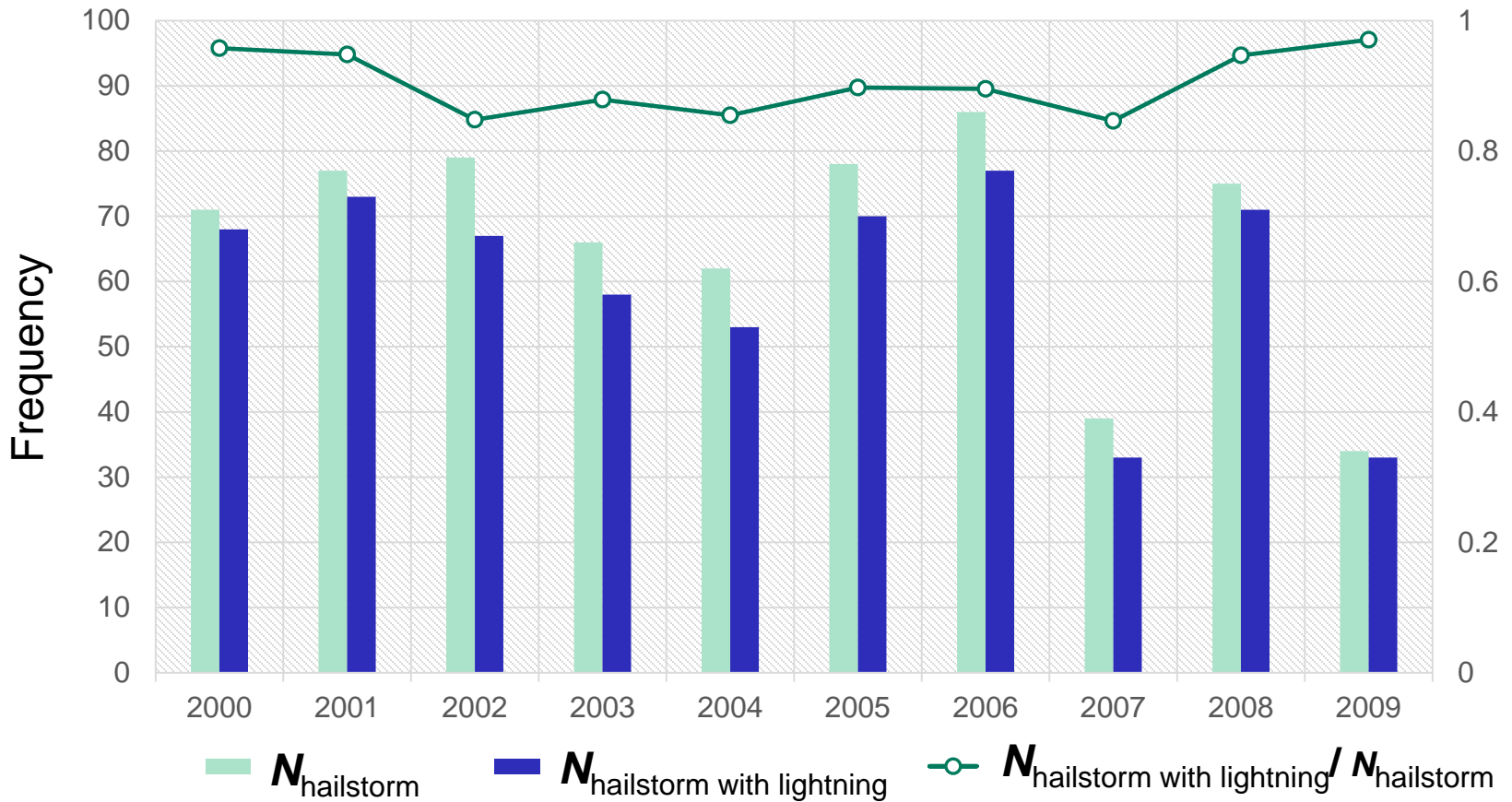
Rakov V A, Uman M A. Lightning: physics and effects, 2003.





Charles A. Doswell, *Severe Convection storms*, 2001





*The manual weather observation data shows lightning appeared in **90.4%** hailstorms in North China from 2000 to 2009.*



Why we use lightning data?

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• O



2. Thunderstorm identification, tracking and nowcasting

◎ Input

- The national Cloud-Ground lightning location data of China

◎ Output

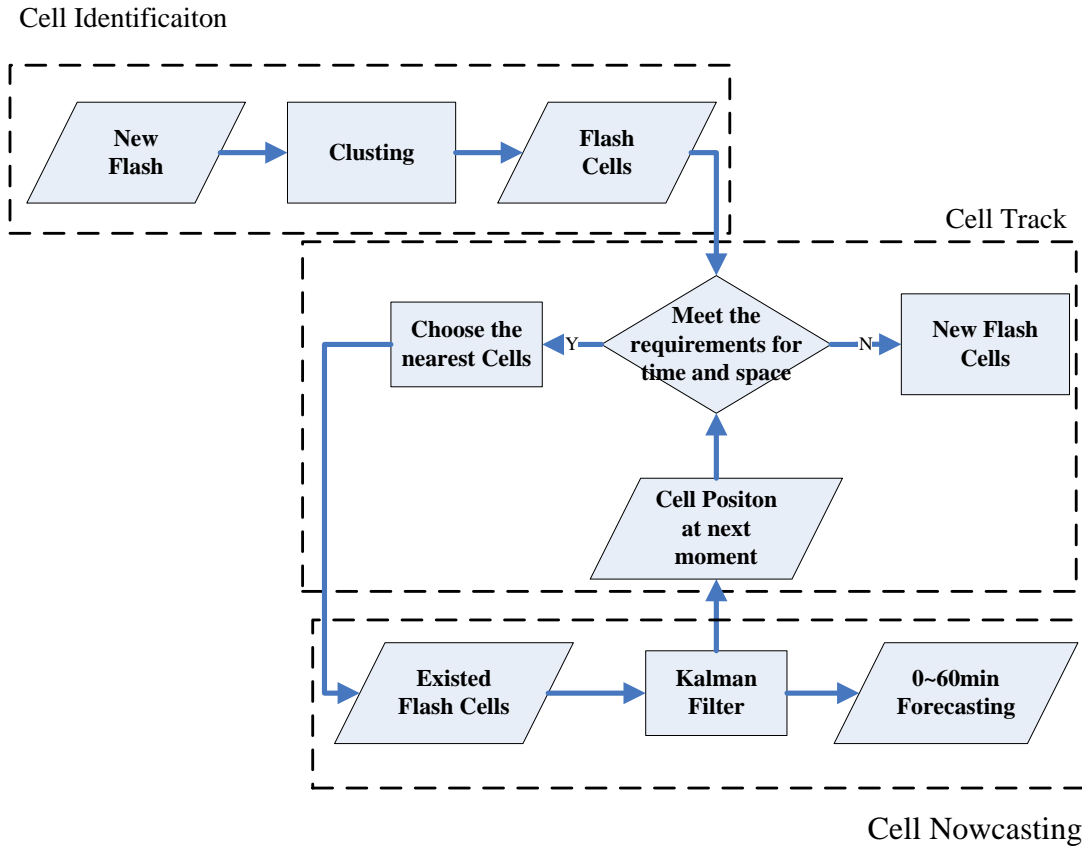
- the identified and tracked thunderstorm, including **speed**, **area**, **direction** and **distance**, etc.
- nowcasting result in 60min

◎ Running Parameter

- Runtime: Every 10min
- The data was in the 7th MICAPS data format

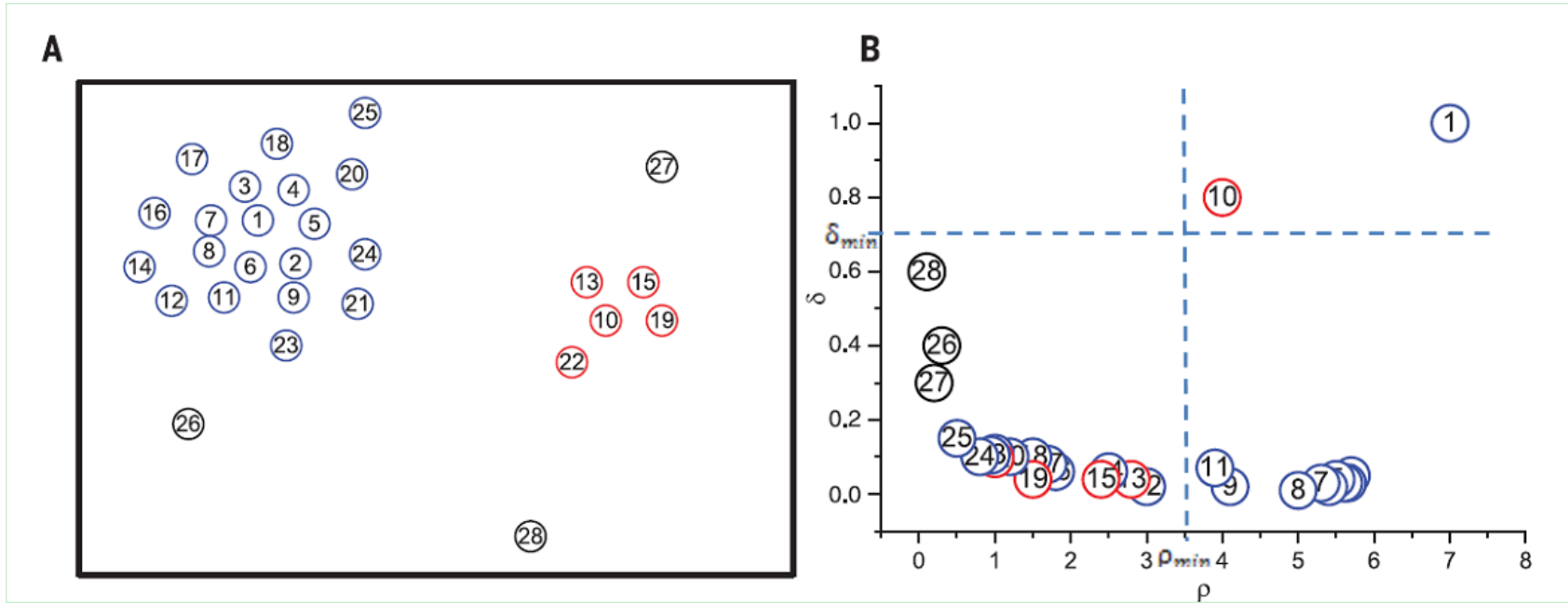


2. Thunderstorm identification, tracking and nowcasting



- Cell identification: Clustering
- Tracking and Nowcasting: Kalman Filter

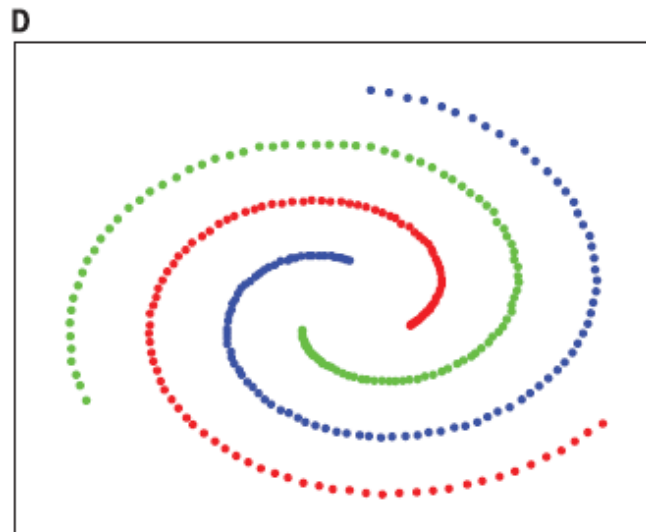
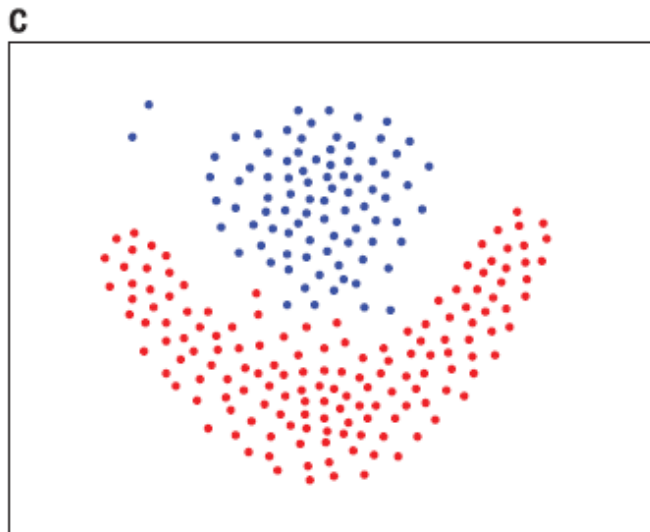
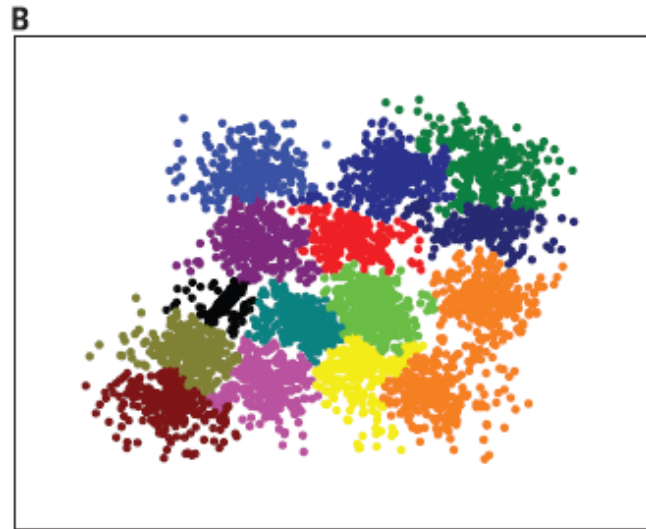
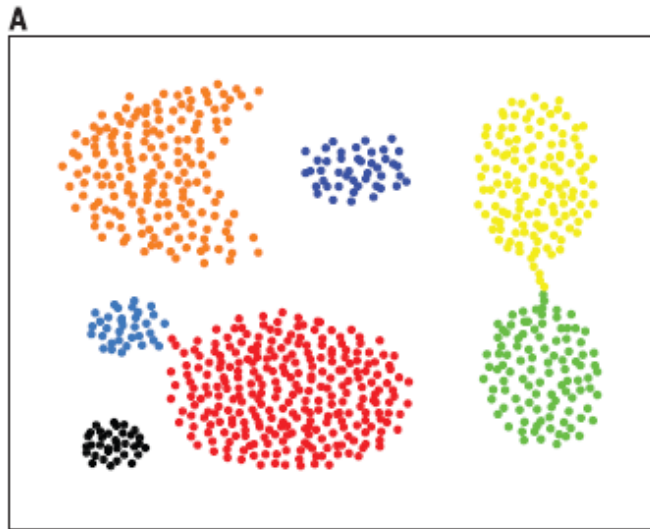
2.1 Flash Cell Identification



Clustering by fast search and find of density ,
 Alex Rodriguez , 2014 , Science

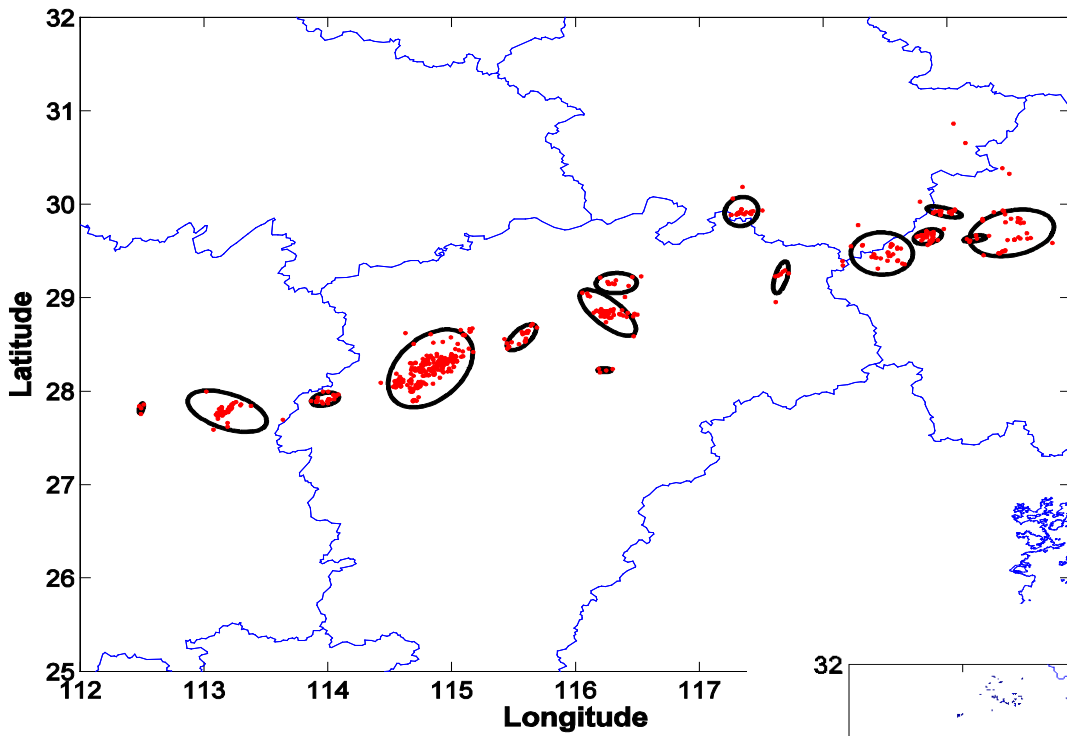
- 1. Flash Density $\rho_i = \sum_j \chi(d_{ij} - d_c)$ $\chi(x) = \begin{cases} 1, x < 0 \\ 0, x \geq 0 \end{cases}$
- 2. Minimum distance between the flash i and other point with higher density $\delta_i = \min_{j: \rho_j > \rho_i} (d_{ij})$

2.1 Flash Cell Identification

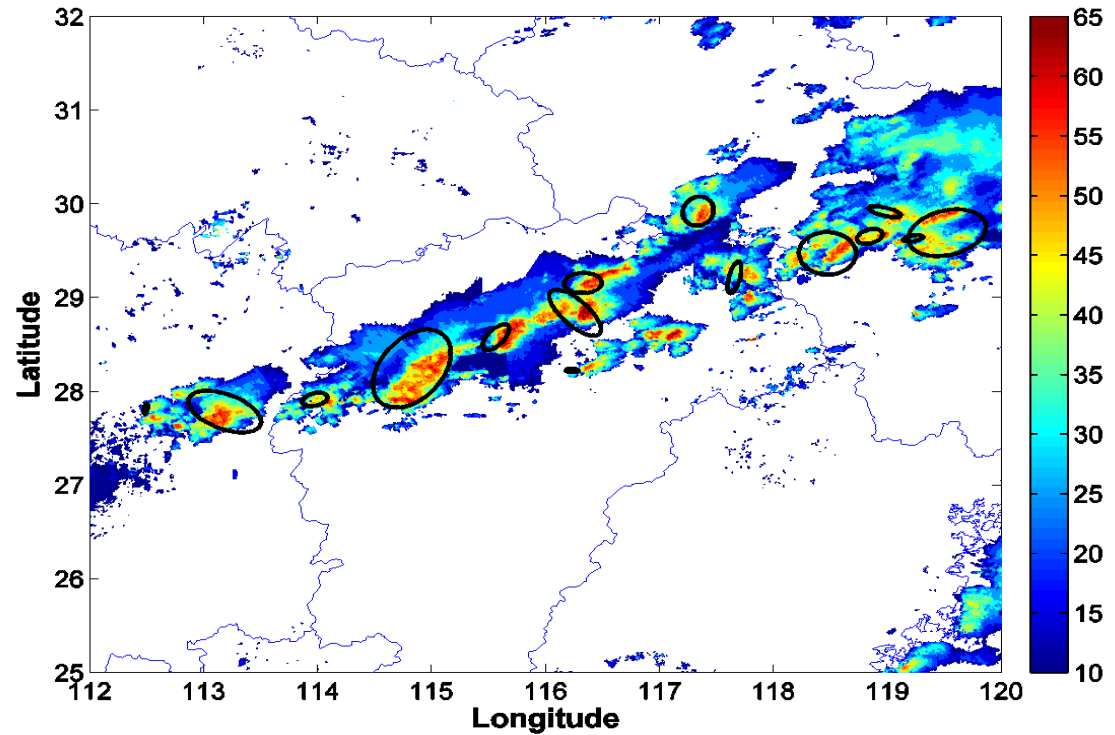


Clustering demos

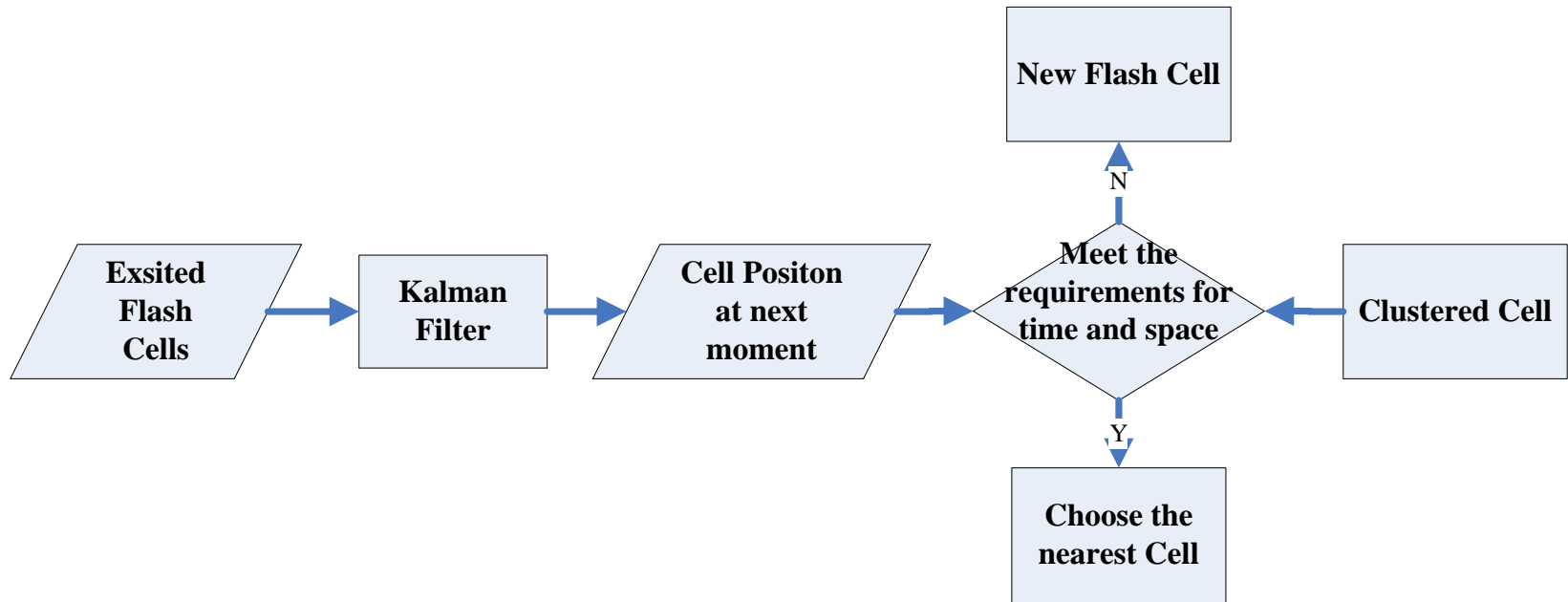




The Clustering example of flash cells in south China



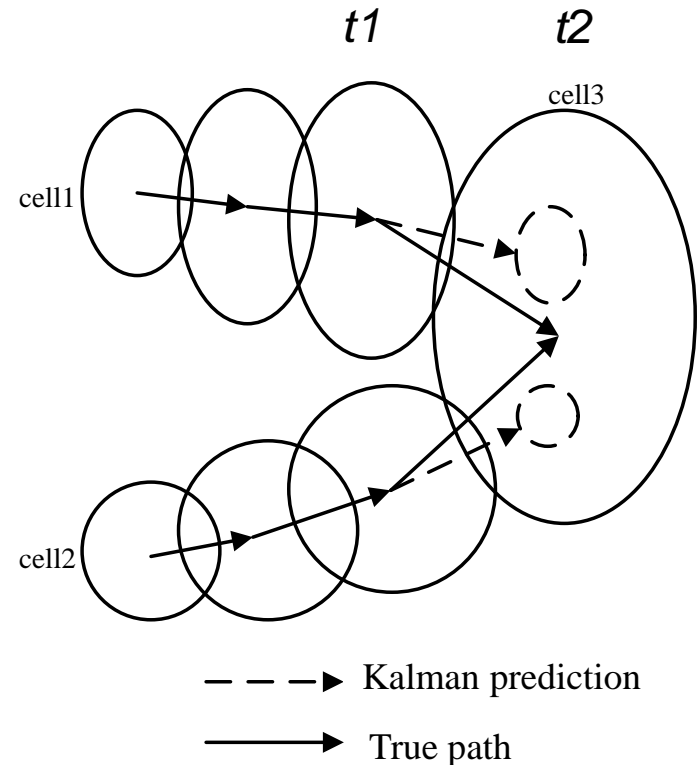
2.2 Cell Tracking



2.2 Cell Tracking

Cell merging

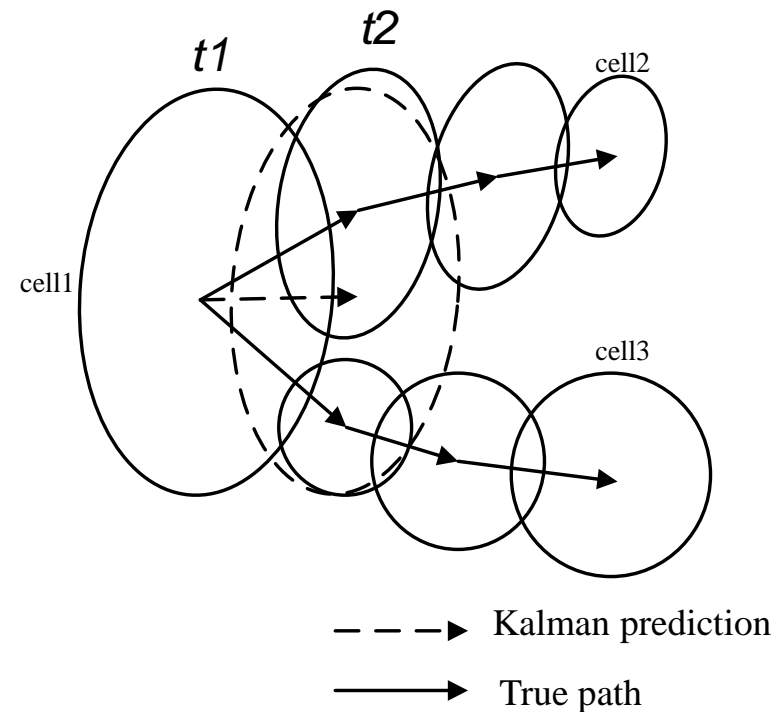
- if cell3 was the only cell was monitored in t_2
- the forecasting cell1 and cell2 were in the area of cell3 in t_2
- The time and space distance between before-merging cell and after-merging cell was in the limited value
- Then the cell3 was the merging cell of cell1 and cell2



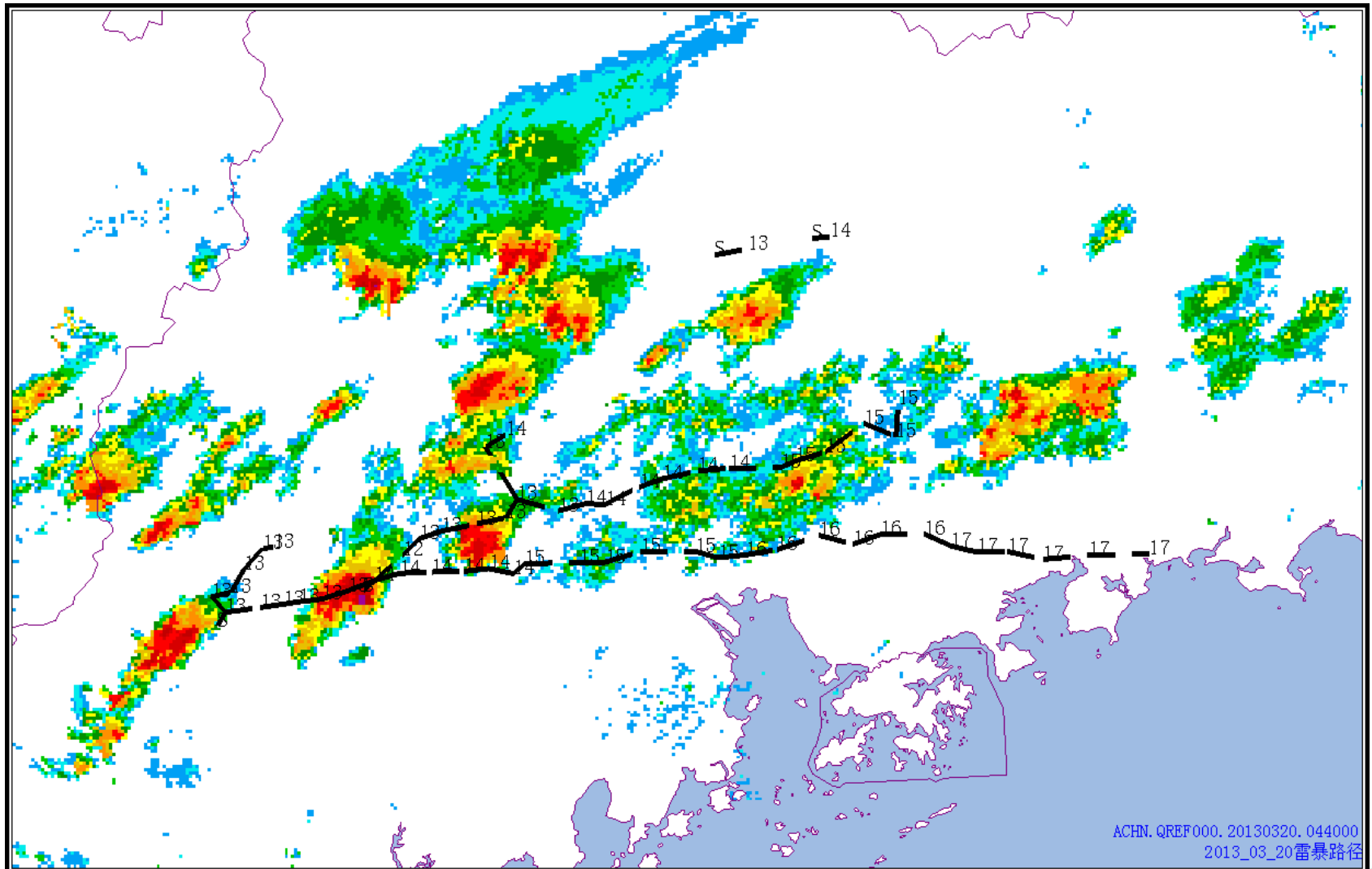
2.2 Cell Tracking

Cell split

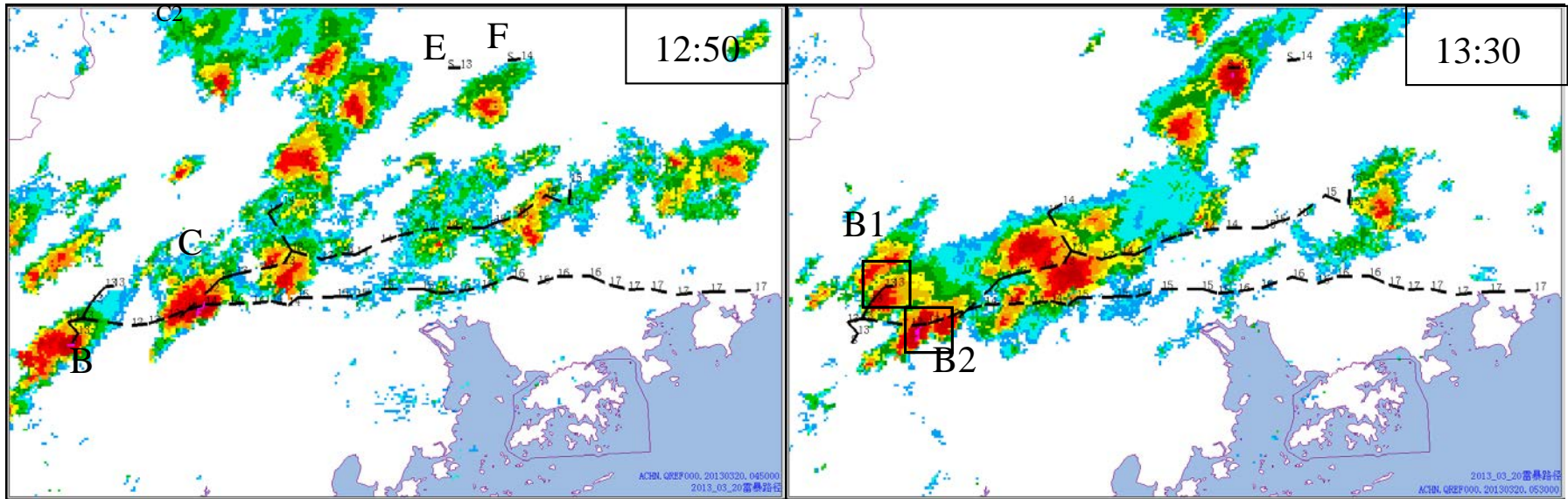
- *If the center of cell2 and cell3 in the forecasting area of cell1*
- *The time and space distance between before-merging cell and after-merging cell was in the limited value*
- *Then the cell2 and cell3 were the splits of cell1*



Thunderstorms on 20 March, 2013

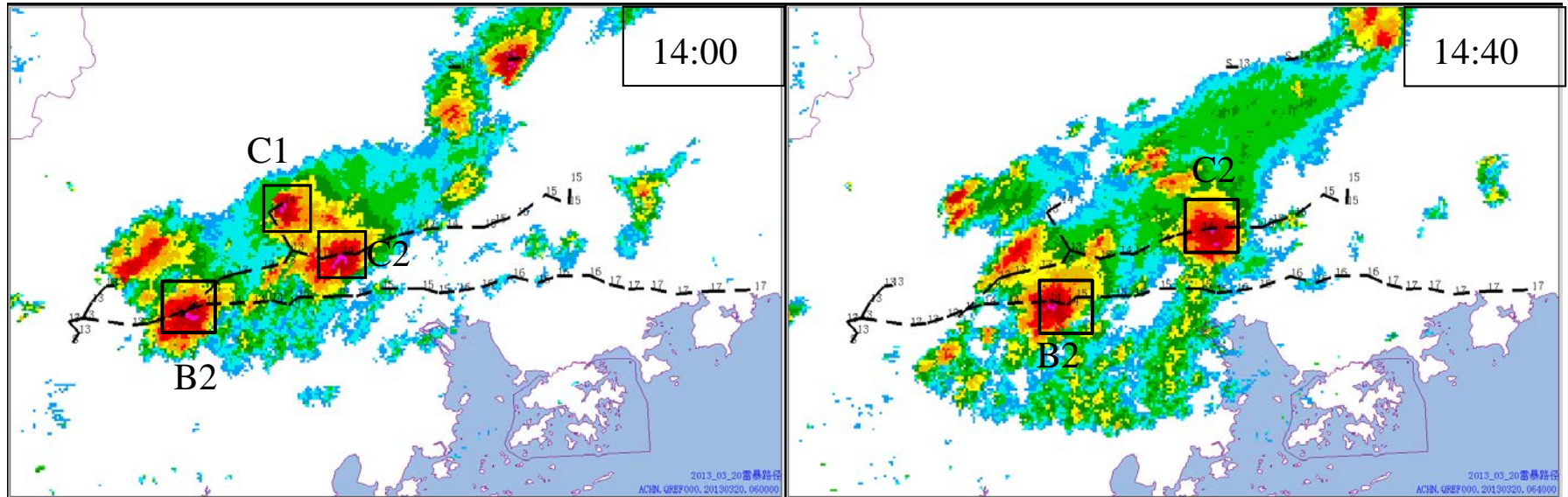


Thunderstorms on 20 March, 2013



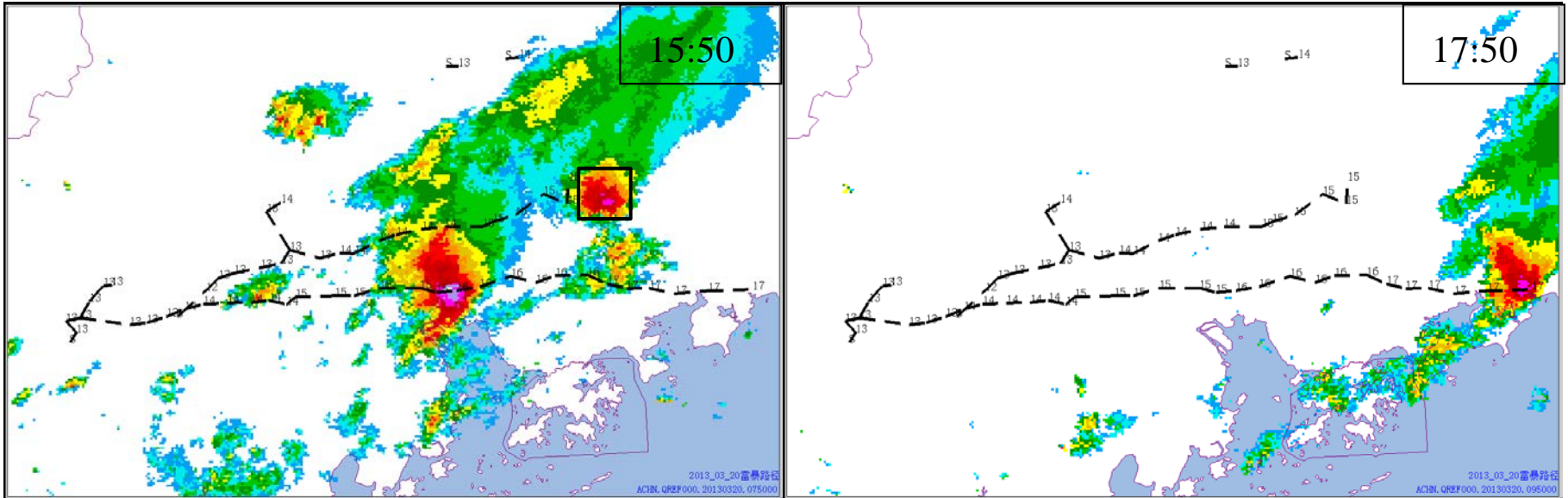
- ① **12:50**
 - ① *The radar echoes show the storm cell B and C had generated*
 - ① *Storms with low reflectivity and small area*
- ① **13:30**
 - ① *Cell B splited to two smaller cells, B1 and B2*
 - ① *Cell C is about to split immediately*

Thunderstorms on 20 March, 2013



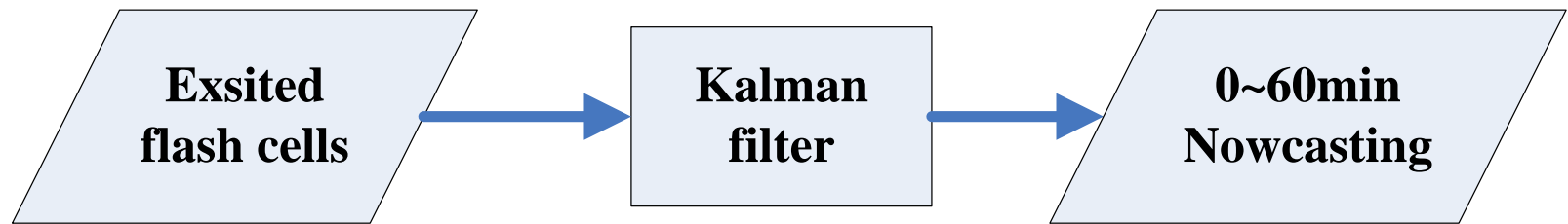
- **14:00**
 - *The subcell B1 disappeared*
 - *The subcell B2, as the main subcell, moved east*
 - *Cell C splits into subcell C1 and C2*
- **14:40**
 - *Subcell B2 and C2 moved east.*

Thunderstorms on 20 March, 2013



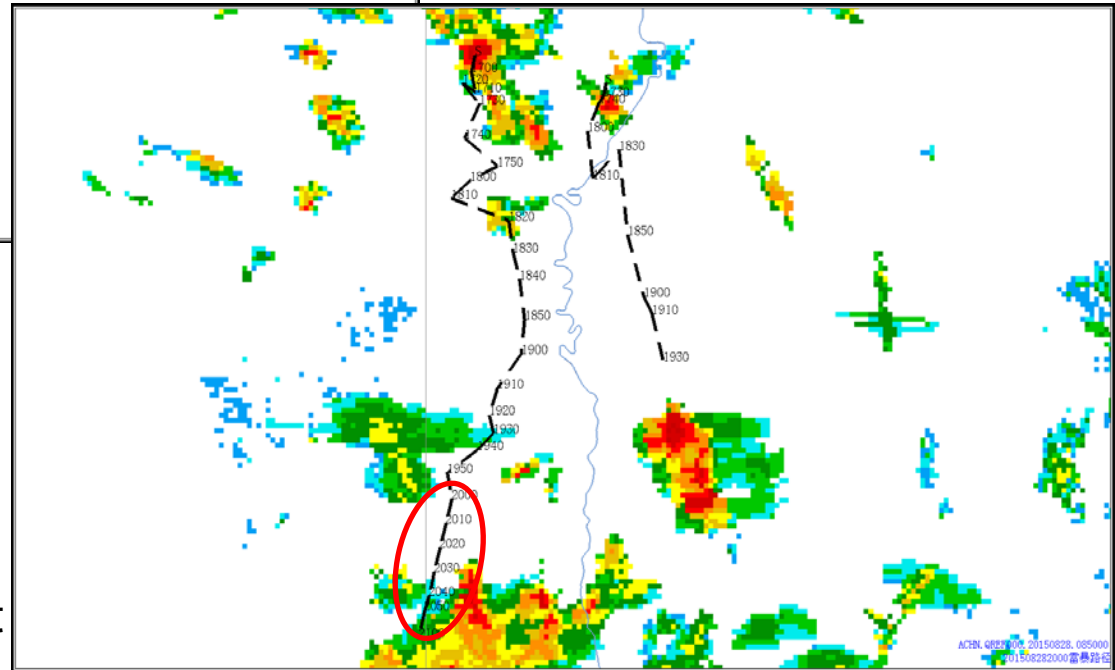
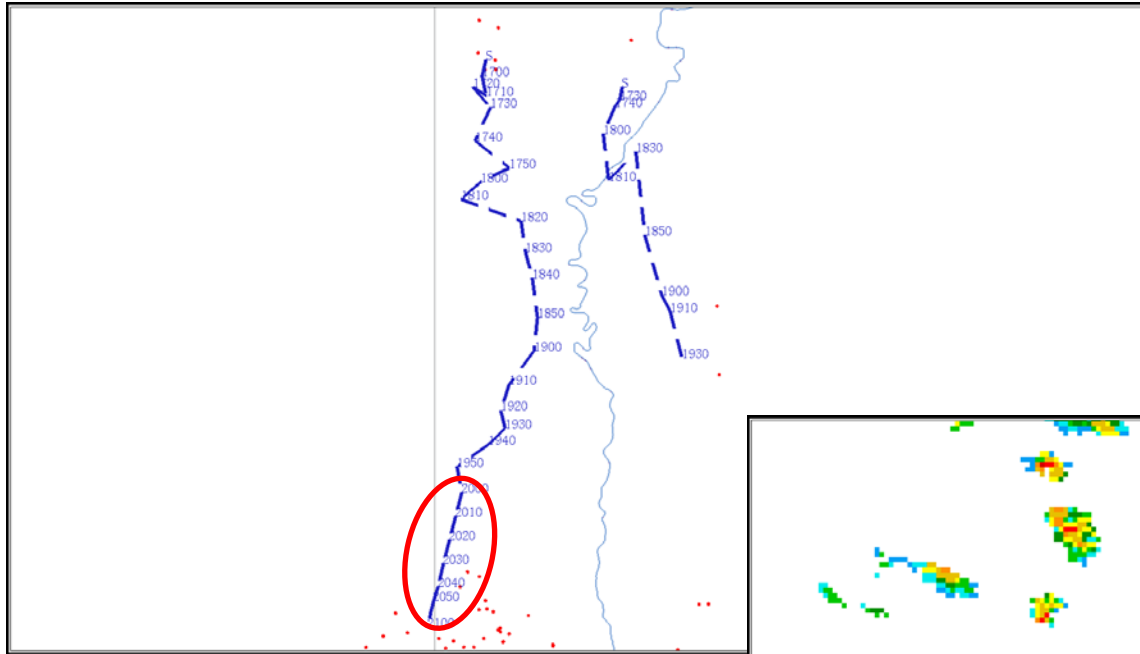
- ◎ **14:40~17:50 :**
 - ◎ *Cell B2 and C2 moving east and disappeared*
 - ◎ *The flash cell disappeared before the storms obviously, meaning the lightning could be a significant parameter to forecast the dissipation of convective storms.*

2.3 Flash Cell Nowcasting



Linear Extrapolation

2.3 Flash Cell Nowcasting



28 Aug, 2015

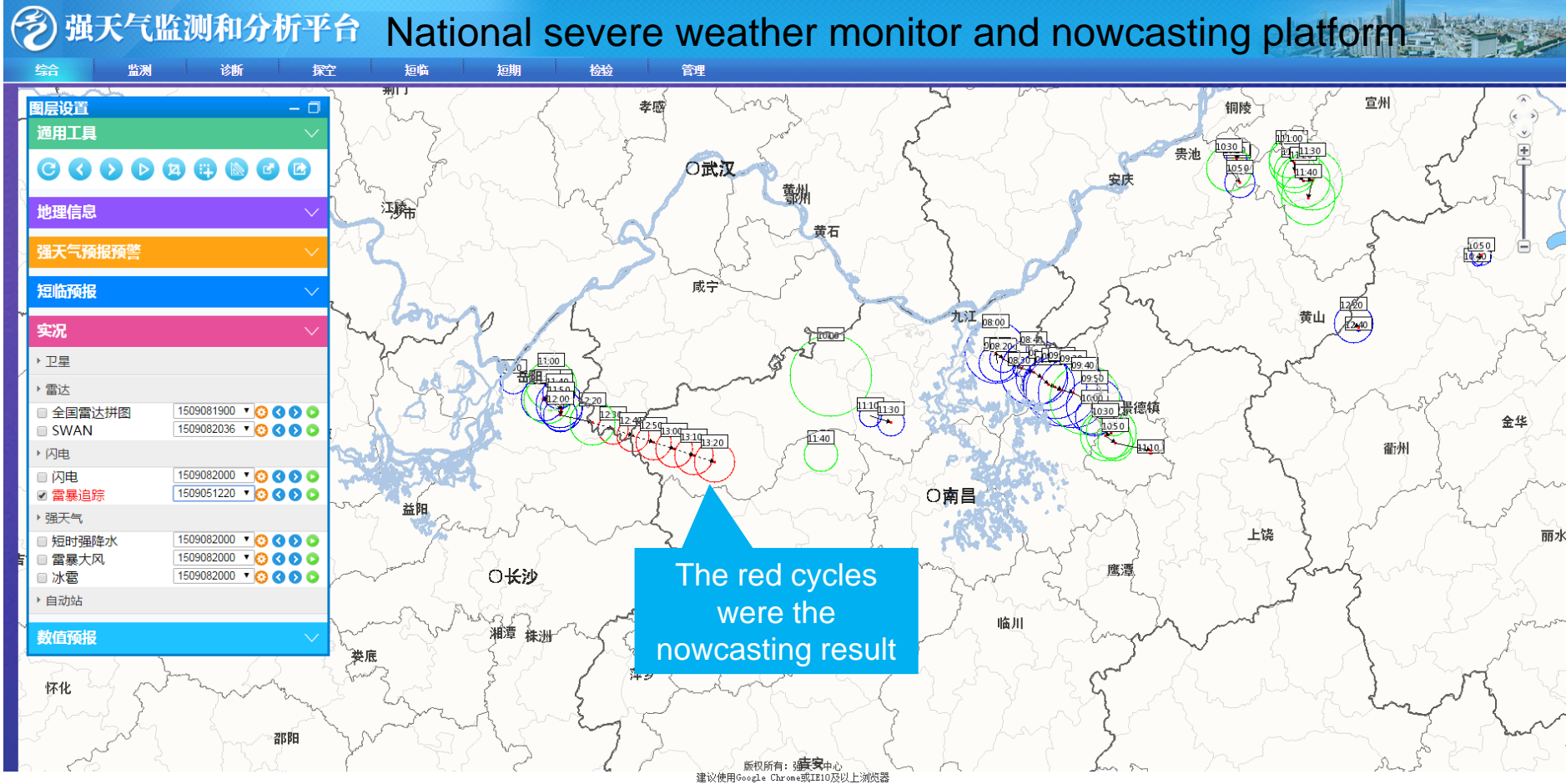
The thunderstorm path in the ellipse was the nowcasting result

2.3 Flash Cell Nowcasting

The Evaluation of nowcasting in 60 minutes

	Forecast Lead Time	POD	FAR	CSI
20150719	10min	0.70	0.44	0.45
	30min	0.64	0.54	0.37
	60min	0.19	0.75	0.18
20150820	10min	0.73	0.43	0.42
	30min	0.59	0.51	0.33
	60min	0.28	0.58	0.23
TITAN ^[1]	12min	0.64	0.40	0.45
	30min	0.42	0.62	0.25

The application in weather forecast daily work



3. Future work

- *The algorithm can not forecast the generation and extinguish of thunderstorm.*
- *Flashes disappeared in the dissipative stage of storms, which would be an indicator in predicting the end of convective systems.*
- *The lightning variation characteristics related to different types of severe weather, such as hail, gust and heavy rain. Study the relationship of them, severe weather could be forecasted by this algorithm.*



THANKS !

