Introduction of FY-4 Developing Convection Product

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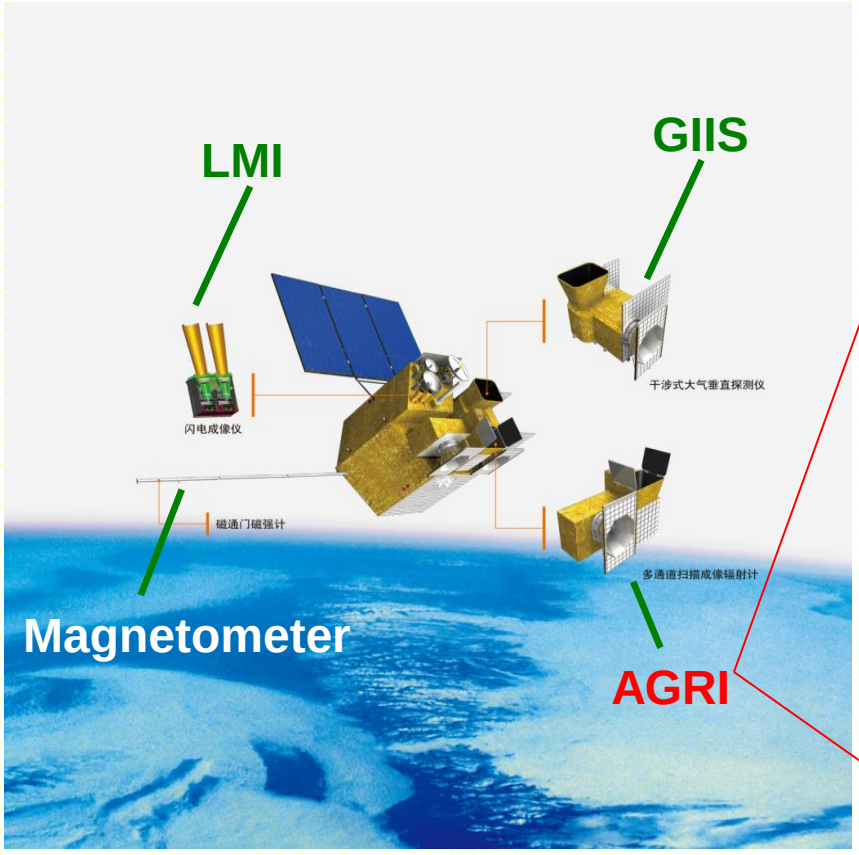
FY-4A satellite(R&D)

Instruments:

1. GIIRS: Geo. Interferometric Infrared Sounder
2. AGRI: Advanced Geosynchronous Radiation Imager
3. LMI: Lightning Mapping Imager
4. SEP: Space Environment Package



In September 2016,FY-4A will complete industry department and ready to launch

Channel	Band (*μm*)	Spatial Resolution (Km)	Application
Visible & Near-Infrared	0.45～0.49	1	Aerosol
	0.55～0.75	0.5～1	Fog,Clound
	0.75～0.90	1	Vegetation
Short-wave Infrared	1.36～1.39	2	Cirrus
	1.58～1.64	2	Cloud,Snow
	2.1～2.35	2～4	Cirrus,Aerosol
Mid-wave Infrared	3.5～4.0(high)	2	Fire
	3.5～4.0(low)	4	Land surface
Water Vapor	5.8～6.7	4	WV
	6.9～7.3	4	WV
Long-wave Infrared	8.0～9.0	4	WV,Clound
	10.3～11.3	4	SST
	11.5～12.5	4	SST
	13.2～13.8	4	Clound,WV

FY-4A Products

Baseline Products of imager(AGRI) & LMI

No .	Products	No.	Products
1	Cloud Mask	13	Downward Shortwave Radiation: Surface
2	Cloud Type	14	Derived Motion Winds
3	Cloud Top Temperature	15	Lightning Detection
4	Cloud Top Pressure	16	Rainfall Rate/QPE
5	Cloud Optical Depth	17	Developing Convection
6	Cloud Liquid Water	18	Tropopause Folding Turbulence Prediction
7	Cloud Particle Size Distribution	19	Sea Surface Temperature (skin)
8	Aerosol Detection	20	Fire/Hot Spot Characterization
9	Aerosol Optical Depth	21	Land Surface (Skin) Temperature
10	Downward Longwave Radiation: Surface	22	Land Surface Emissivity
11	Upward Longwave Radiation: TOA	23	Snow Cover
12	Upward Longwave Radiation: Surface		

Baseline Products of sounder(GIIRS)

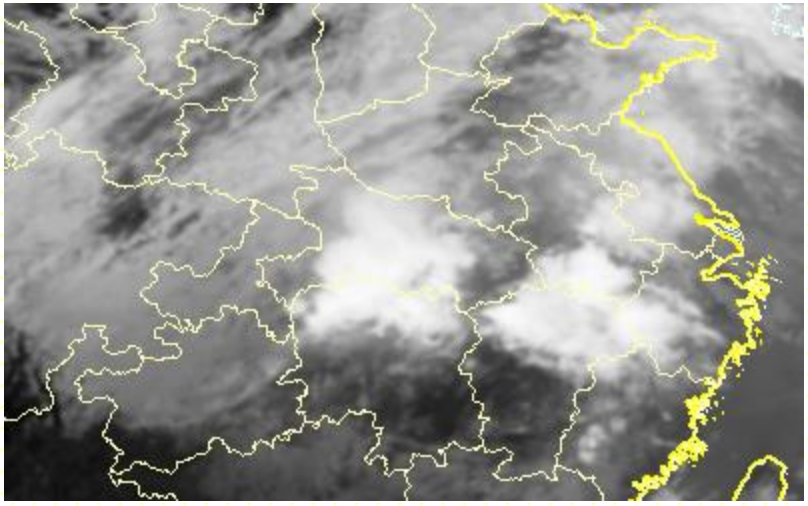
No .	Products
24	Atmospheric Temperature, Humidity and Ozone Profiles (Clear)
25	Atmospheric Temperature and Humidity Profiles (Cloudy)

Baseline Products of SEP

No .	Products
26	Distribution of High Energy Particle
27	Intensity of Magnetic Field
28	Effects of Spatial Environment

FY-4 Developing Convection Product

The developing product uses a multi spectral thresholding technique, which tracks convective clouds with cloud top temperature keeping cooling, and monitor their spectral characteristics. If it's cloud top cooling rate(CTC) threshold is exceeded, then the pixels within the cloud object are flagged for developing convection（DC）. The DC product concerning not only convective initiation but also vigorous deep convective clouds and cloud systems.



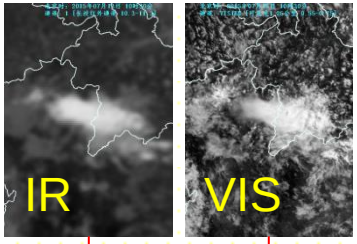
Name	satellite	Geographic Coverage	Vertical Resolution	Horizontal Resolution	Output	Measurements Accuracy	RefreshTime	Temporal Coverage Qualifiers
Developing Convection	FY-4A	North east Asia	N/A	4km	binary，Yes/No，CTC levels	70% Probability of Correct Detection	6/15min	Day and Night

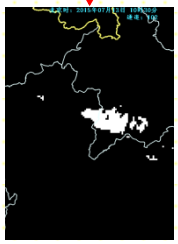
FY-4 Developing Convection Algorithm

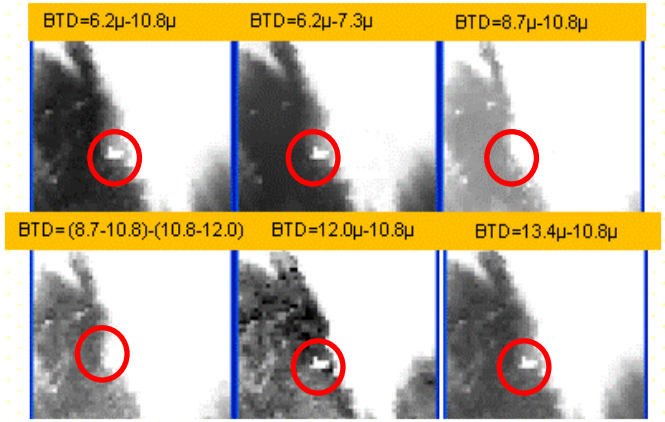
1.Convective targets Identification

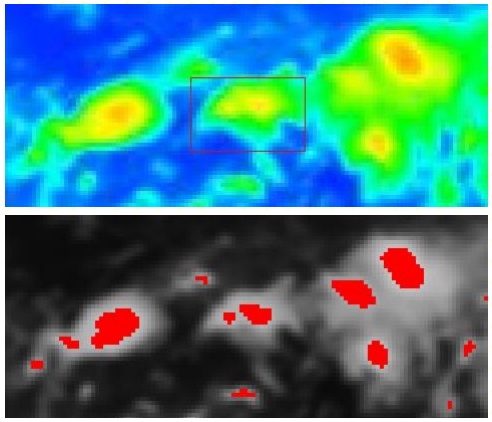
2.Multi Targets Trace

3.Cloud Top Cooling rate







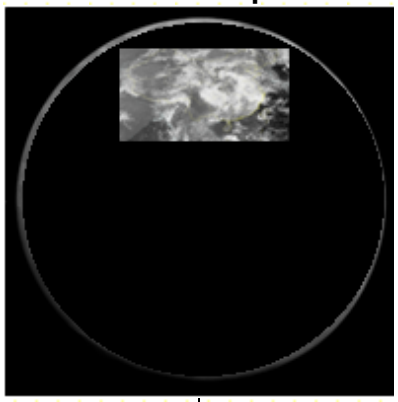


- IR and VIS thresholds
- Multi channel tests
- Water shed method

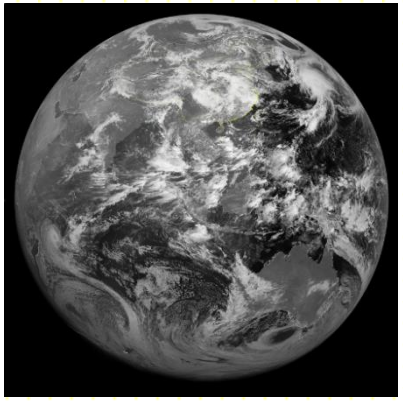
Multi Targets Trace

FY-4A observation mode

The Regional obs
<6 minutes temporal resolution

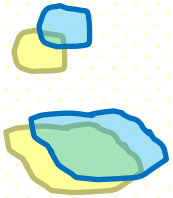


Full disc obs
15 minutes temporal resolution

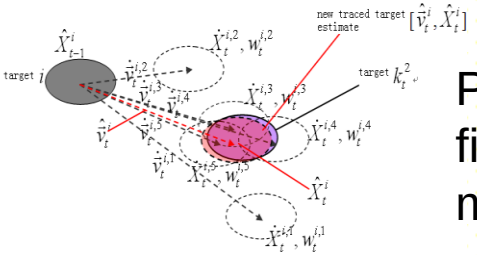


Pyramid Lucas Kanade
optical flow method

Automatic
tracing
method

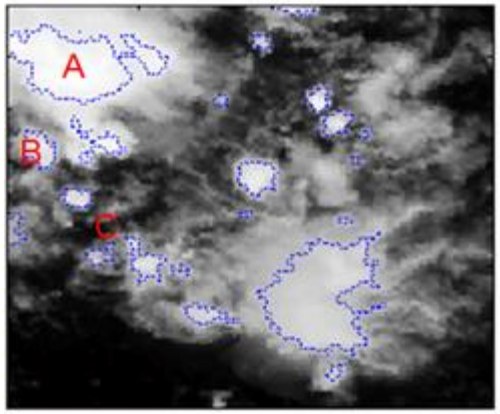


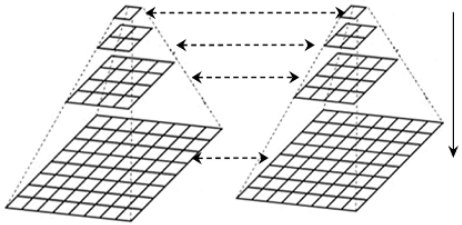
Overlap
method

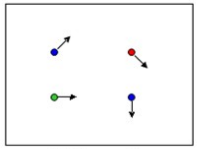


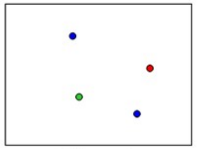
Partial
filter
method

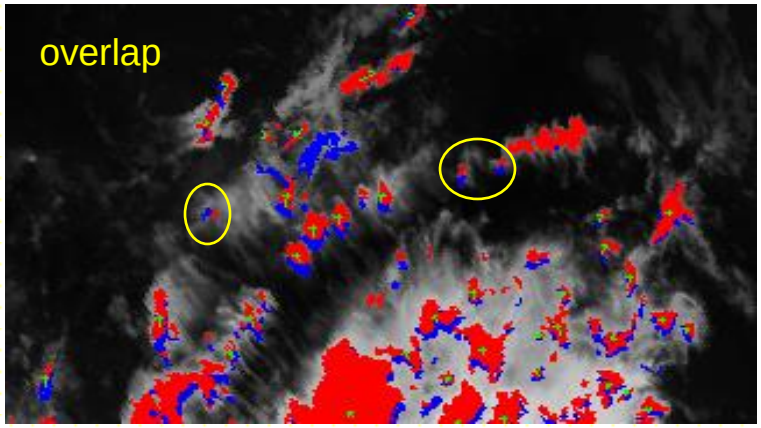
Why use Pyramid_Lucas Kanade optical flow method?






T-1

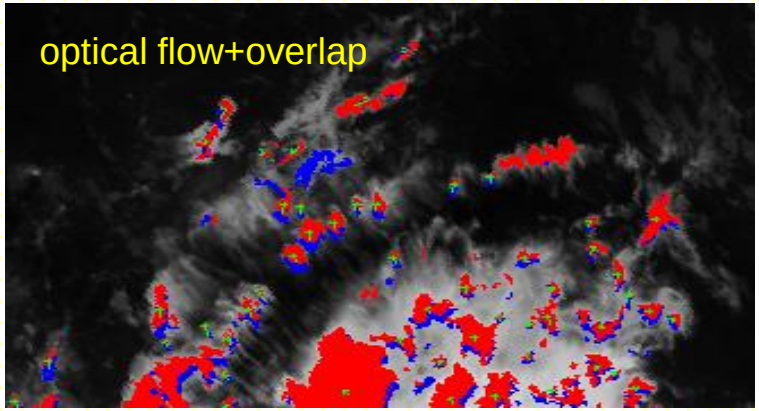

T0



Blue for previous time

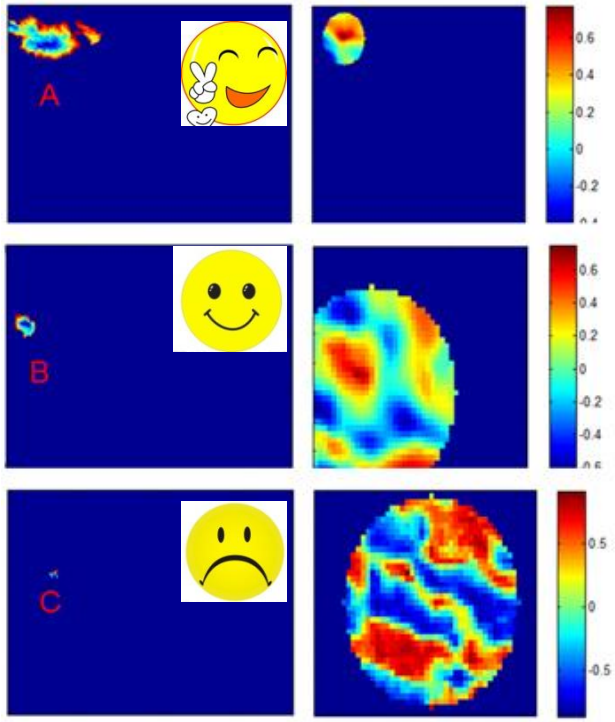
Red for current time

Green bar for velocity estimated



The optical flow method can increase correct percentage of tracing .

correlation coefficient



The smaller target has higher possibility of false trace results.

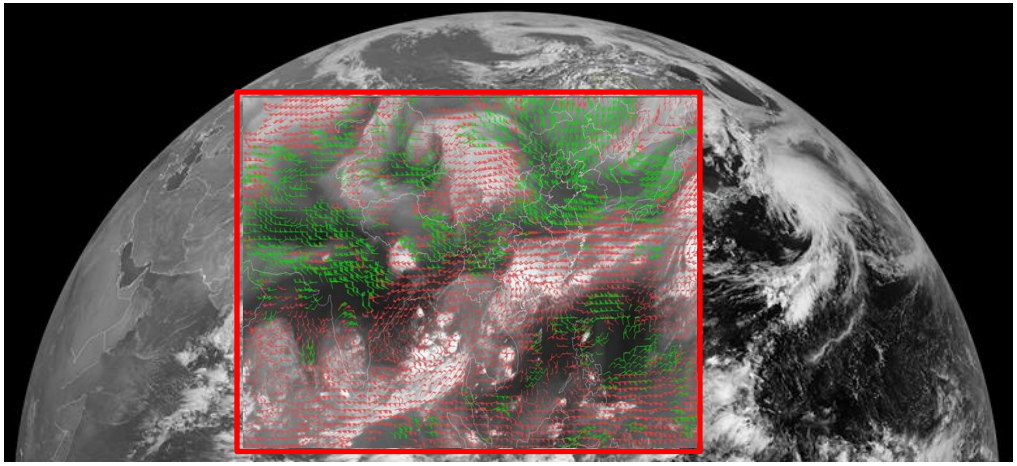
How fast a convective cloud cluster moved?

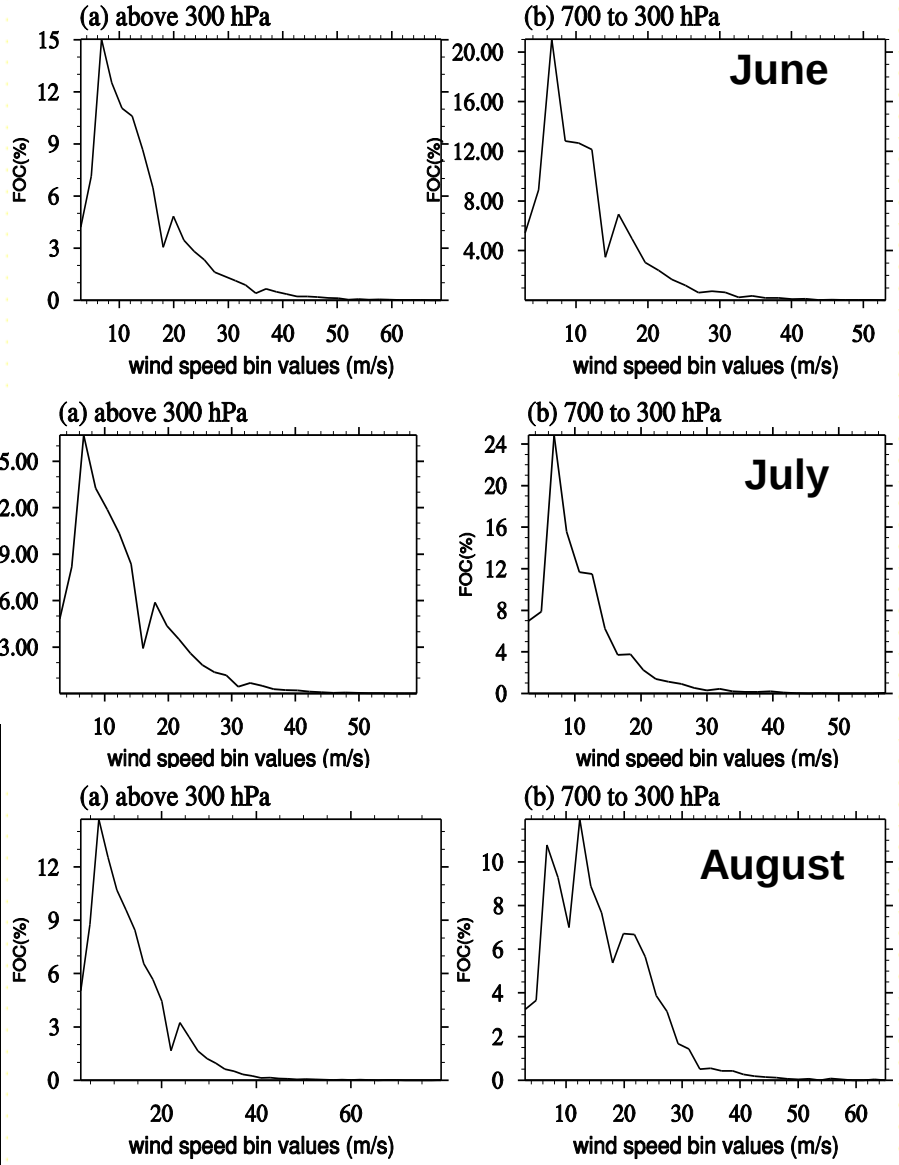
Probability distribution functions(PDF) of Atmospheric Motion Vectors (AMV) associated with convections over the East Asia in summer of 2012

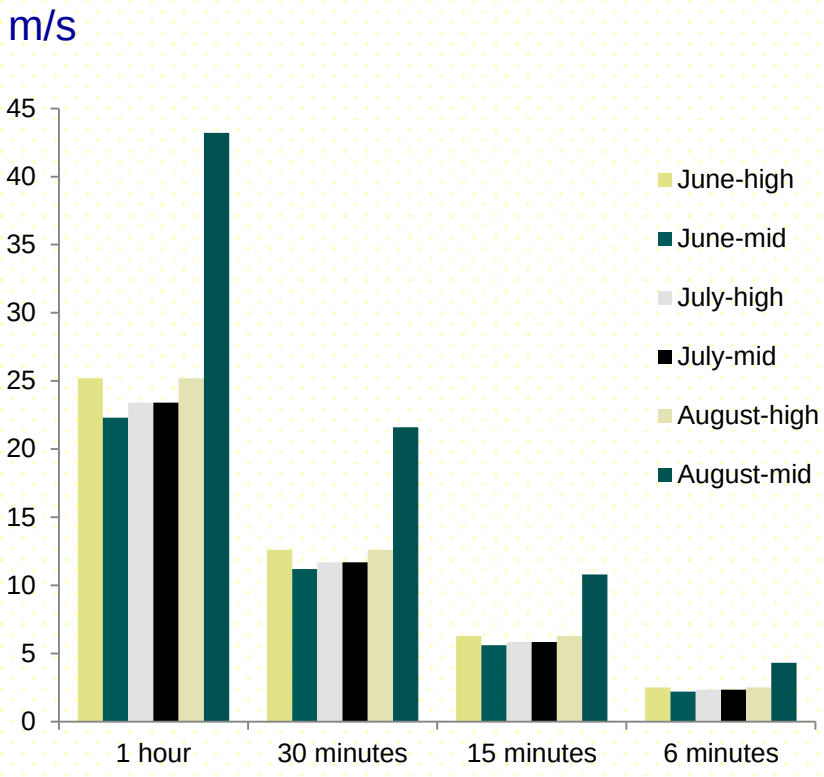
	Total pixels	Pixels in low level	Pixels in mid level	Pixels in high level
June	230673	0	8347	33454
July	247846	0	4416	41401
August	241138	0	4915	36450

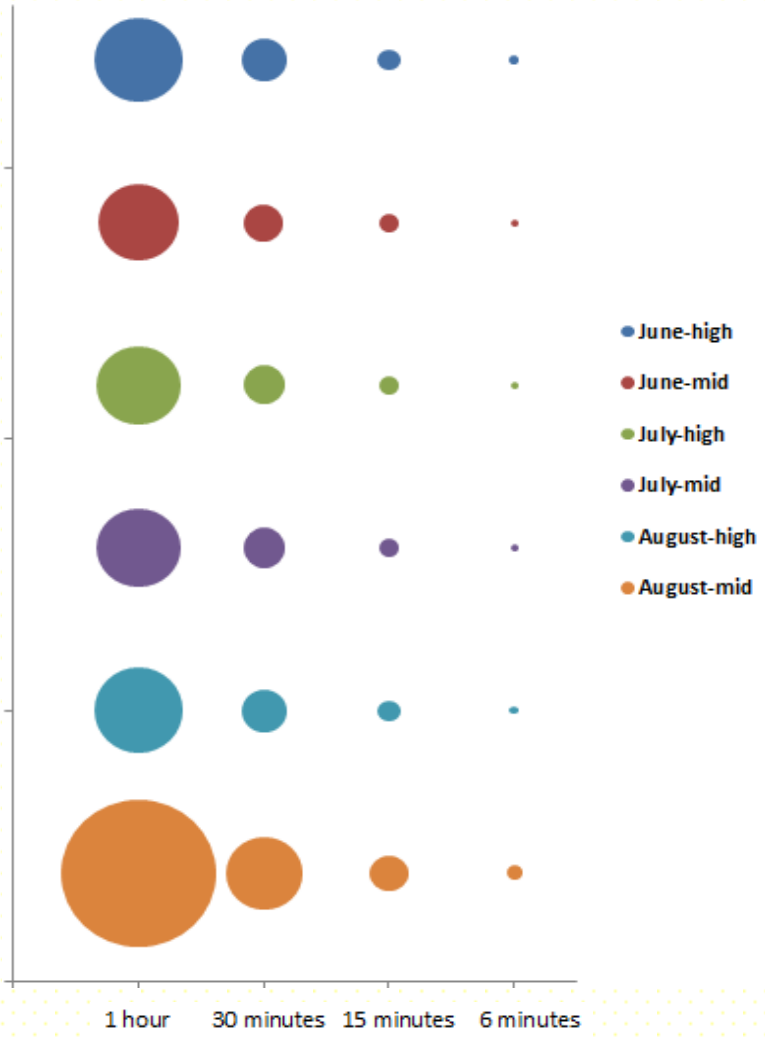
Data: IR1 AMV of FY-2E (2012)

Convections: IR1 TBB ≦ 235K









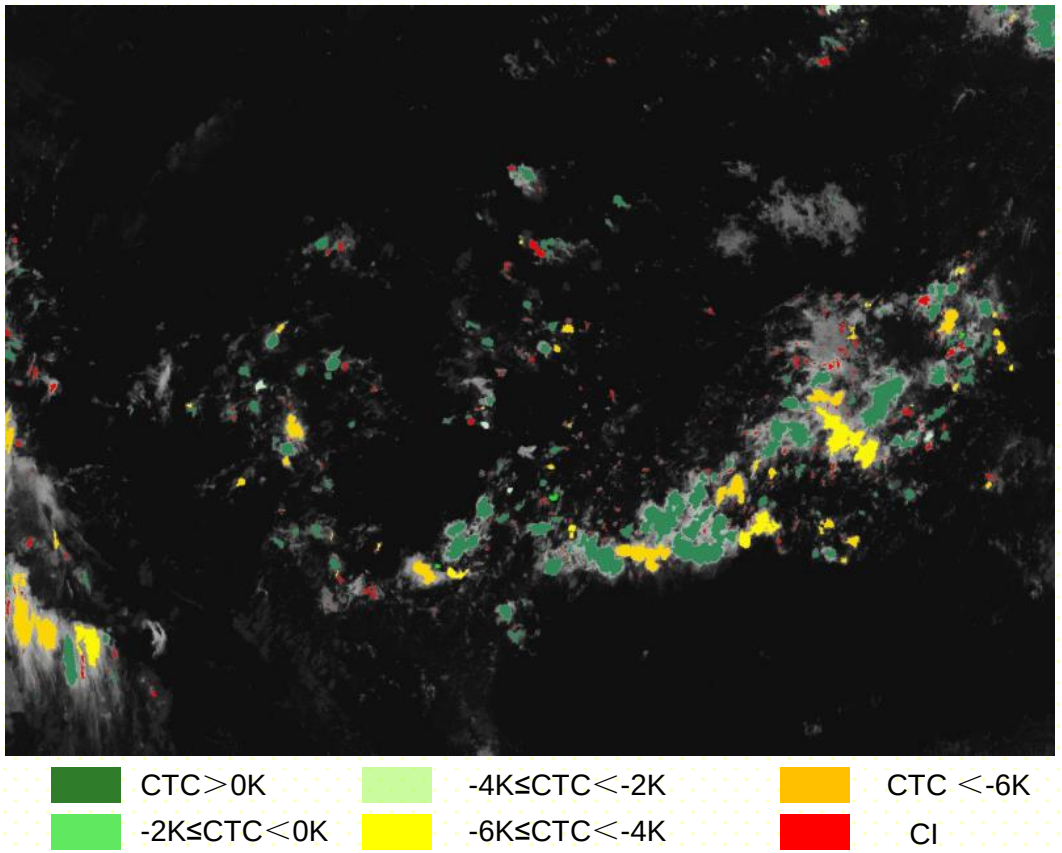
By analysis the high probability of velocity for AMV associated with summer convections, we know the largest BOX are for tracking the convective targets in different clouds for different time intervals.

Test by Using Himawari-8 AHI Data

Bands for Himawari-8 AHI

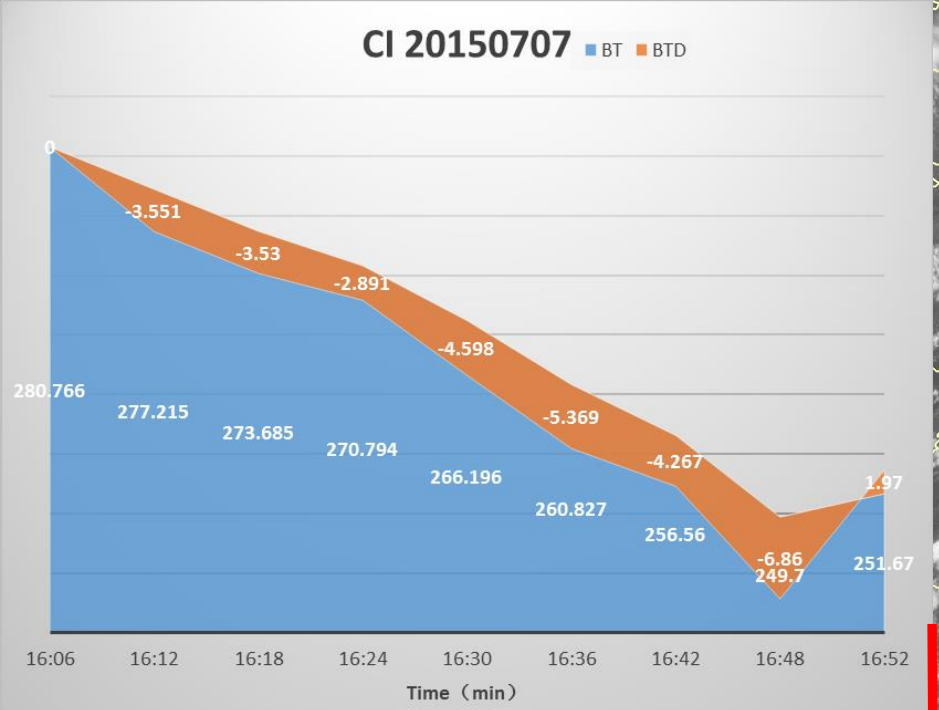
Spectral Band	Wavelength [μm]	Spatial Resolution/ Quantization
1	0.47	1 km/11 bit
2	0.51	1 km/11 bit
3	0.64	0.5 km/11 bit
4	0.86	1 km/11 bit
5	1.6	2 km/11 bit
6	2.3	2 km/11 bit
7	3.9	2 km/14 bit
8	6.2	2 km/11 bit
9	6.9	2 km/11 bit
10	7.3	2 km/12 bit
11	8.6	2 km/12 bit
12	9.6	2 km/12 bit
13	10.4	2 km/12 bit
14	11.2	2 km/12 bit
15	12.4	2 km/12 bit
16	13.3 (CO_2)	2 km/11 bit

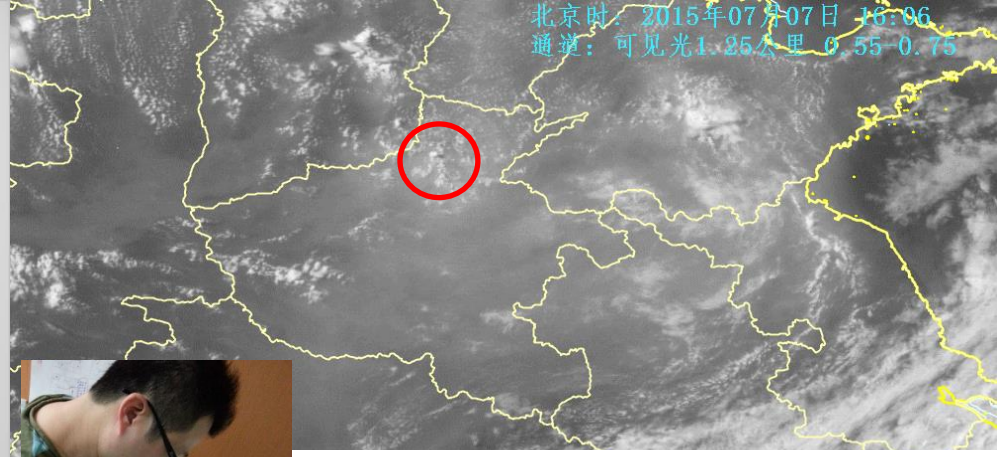
10min

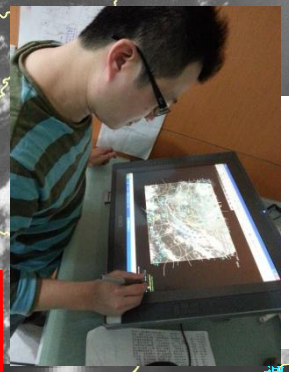


Summary

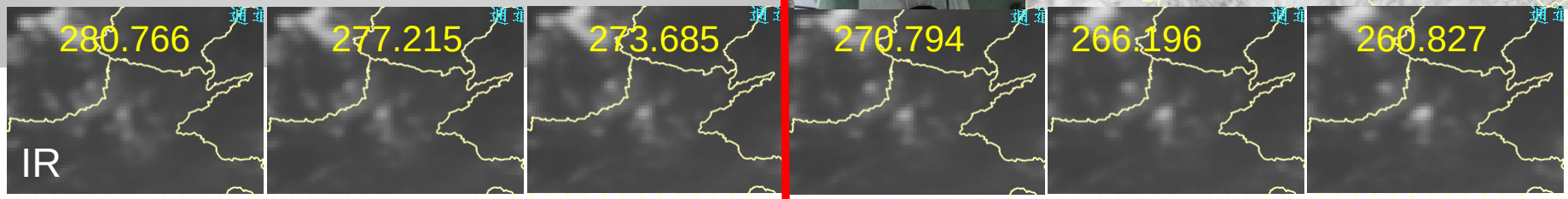
- The DC product algorithm of FY-4A is tested by use the Himawari-8 AHI data to reduce risk in the development, and it is now in engineering coding status. All readiness in septemper 2016.
- The FY-4A DC product will provide including convective initiation and vigorous deep convective clouds and cloud systems in the north east Asia area, with 6 minutes or 15 minutes refresh time depending on different observation mode.
- Since the FY-4A DC product is a new application for nowcasting, it will be updated in 2017 according to user feedback.

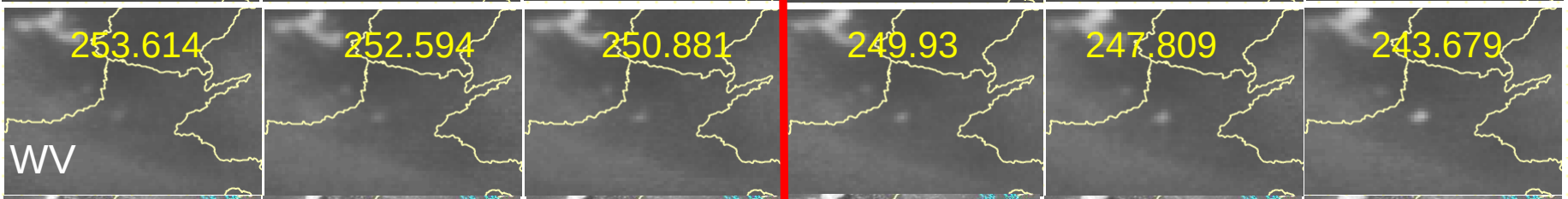


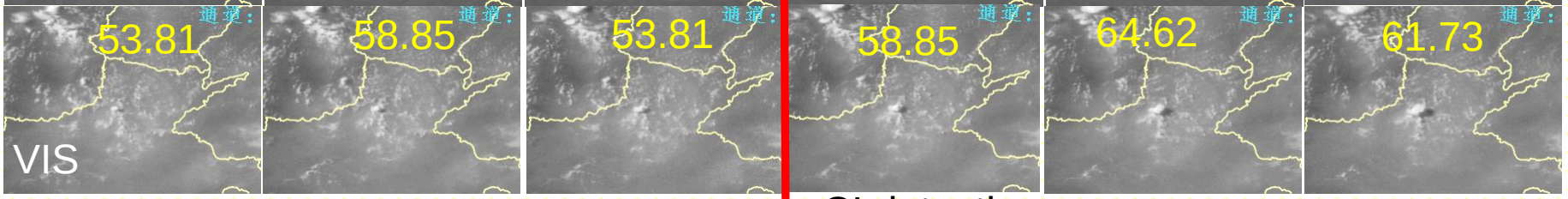




Could you tell me more earlier, when the potential disaster produced convection initiates?





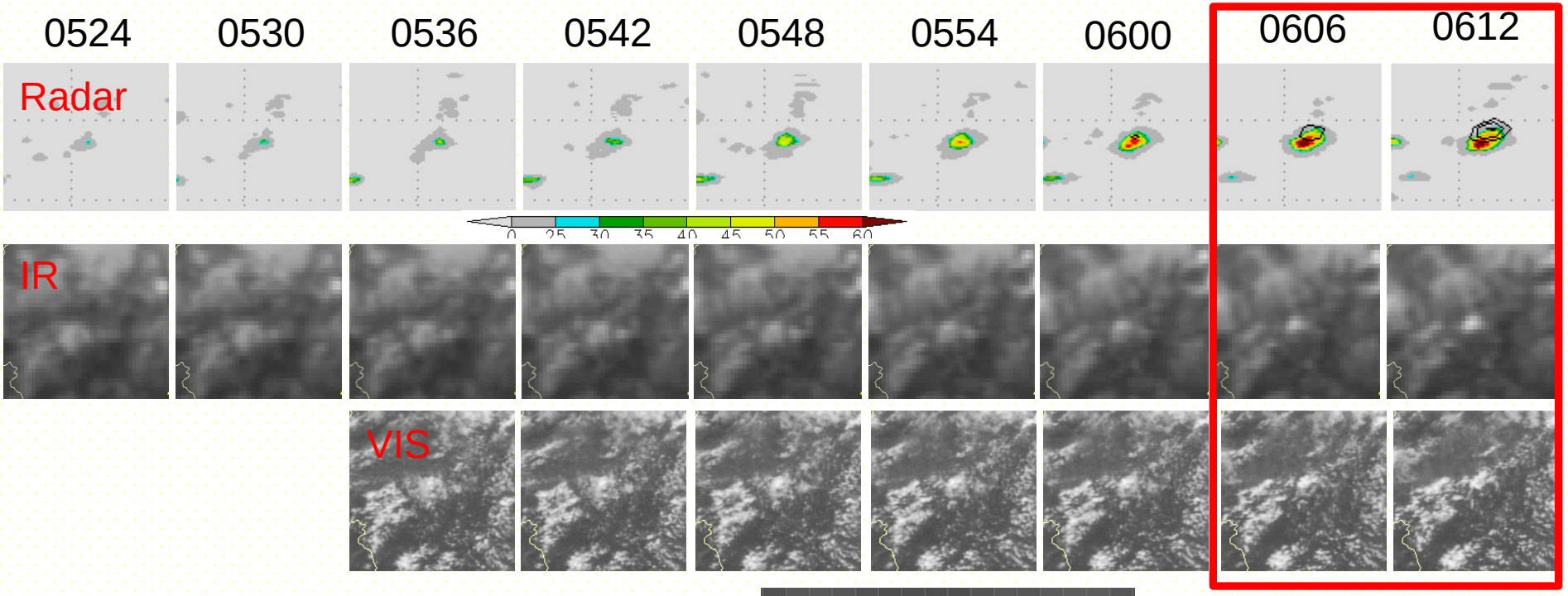


CI detecting

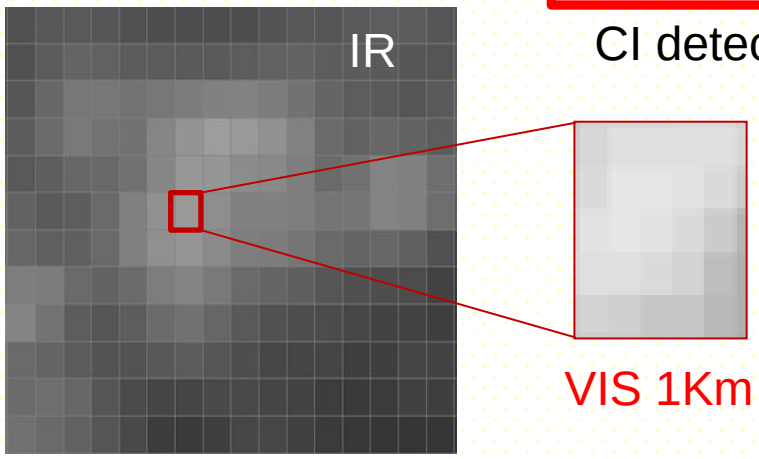
Consider VIS and IR resolution

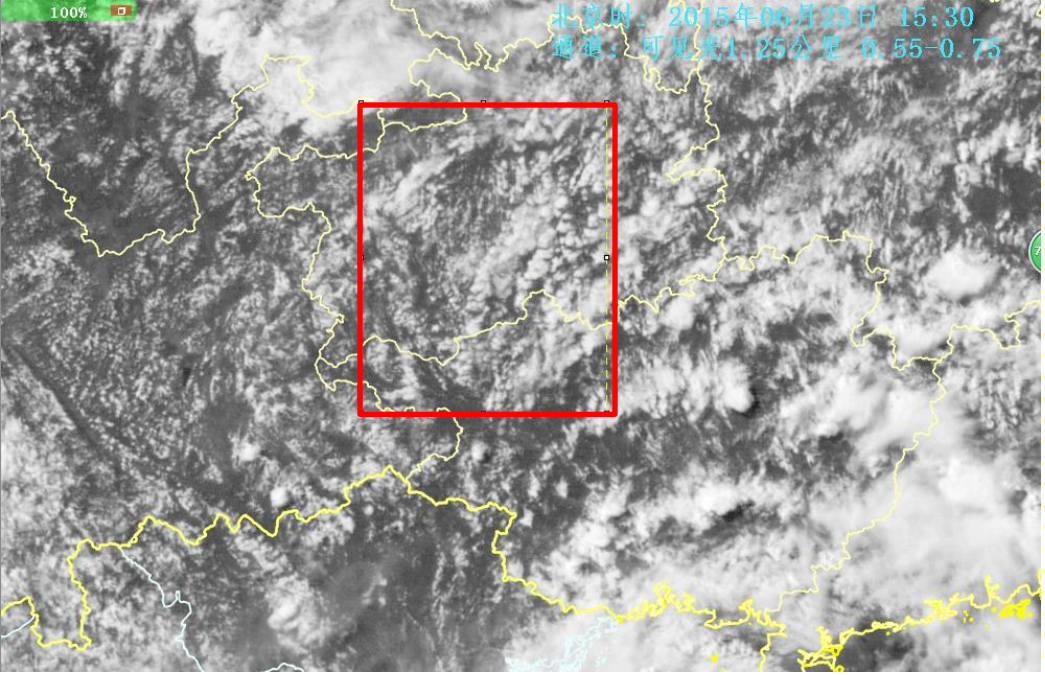
- For example, FY-2 geosynchronous satellite IR channel have ~5km spatial resolution，hence sometimes very small convective initiative cloud is showed as sub-pixel（ie 1km）signal.
- While VIS channel almost has higher resolution then IR, and these kind of high spatial resolution VIS data source become more and more, i.e. 500m 0.64μm for FY-4A. How to use the data is important but also a challenge.
- Nowcasting need early information for this smaller targets.

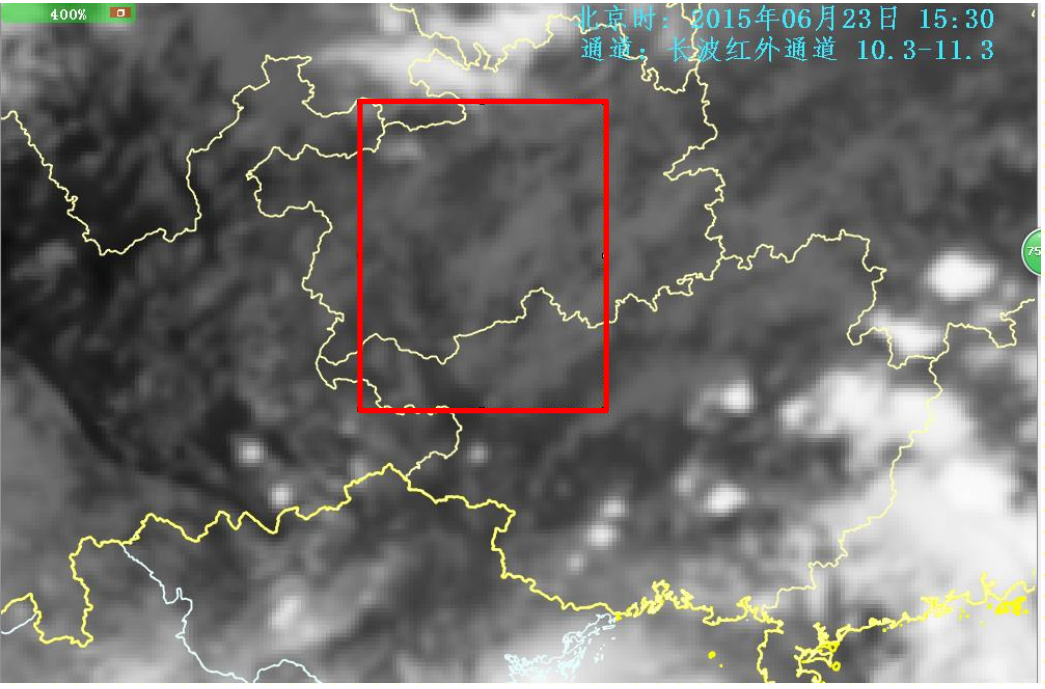
Can high spatial resolution VIS reflectance bring more leading time for CI detecting?



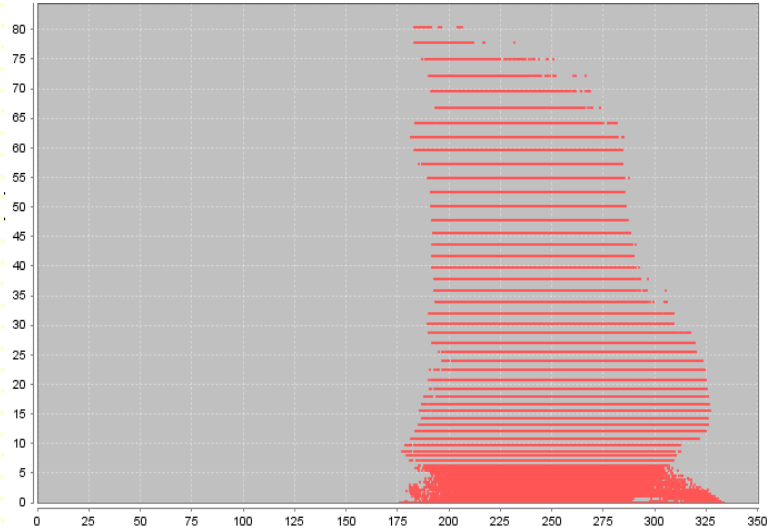
- When an CI cloud is too small to fill the whole IR pixel, it is warmer then expect to be detected by CI algorithm.
- Notice that high spatial resolution VIS can provide detail structure by reflectance variation.







Can we construct higher resolution BT to benefit CI detection?
If IR BT has close relationship with VIS reflection?

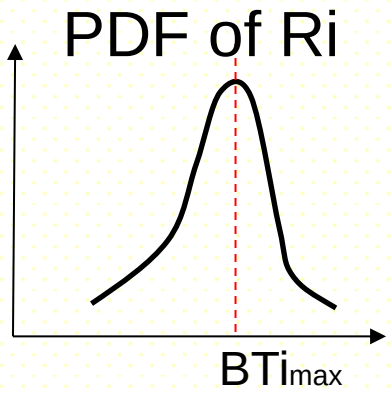


Usually each 5KM VIS reflection value(Ri) corresponds for many IR BT value(BTi), so the relationship between VIS reflection and IR BT seems uncertainty.

Hypotheses

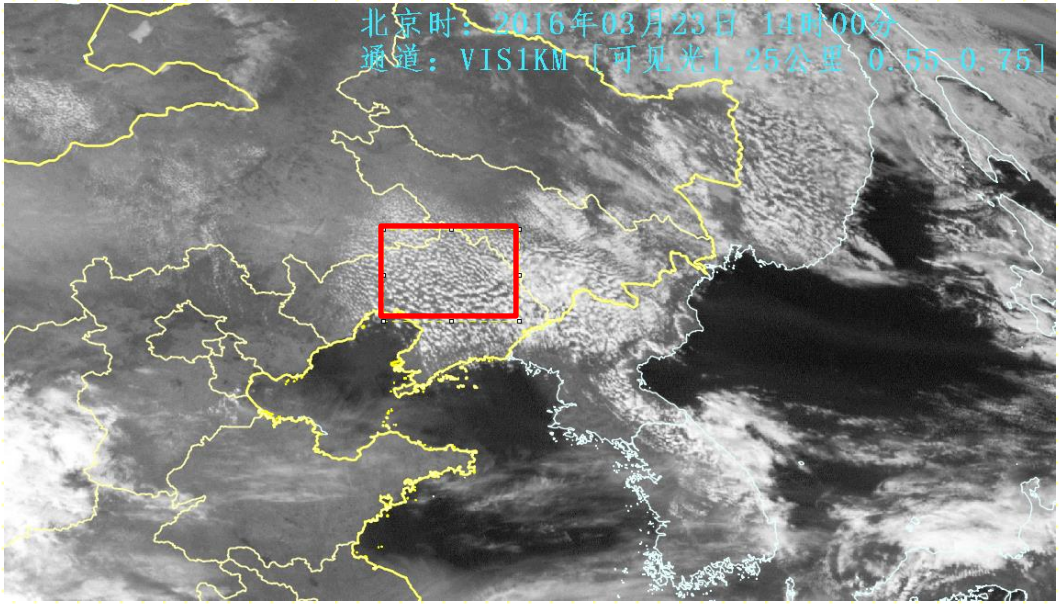
1. In a area and its vicinity, the cumuli grow with similar physical processes.
2. The hydrometeors in growing cumuli are also with similar components.

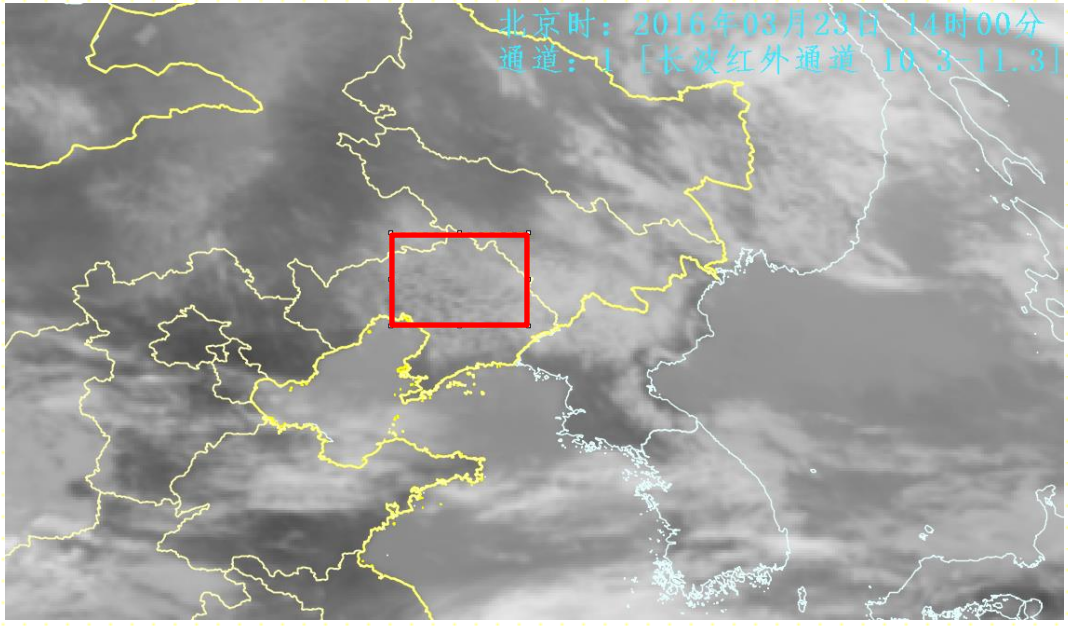
Then in the initiative growing stage, its VIS reflectance would has some kind of relationship with its IR BT.

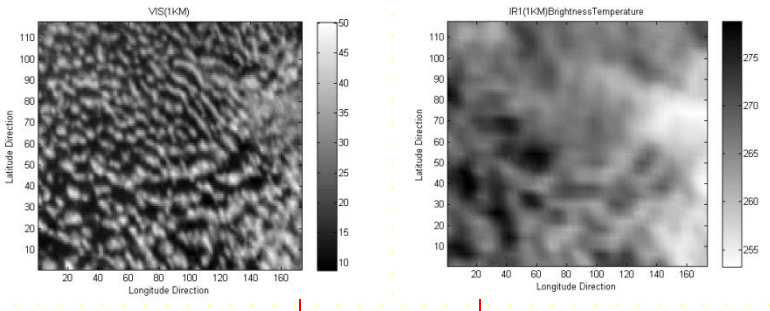


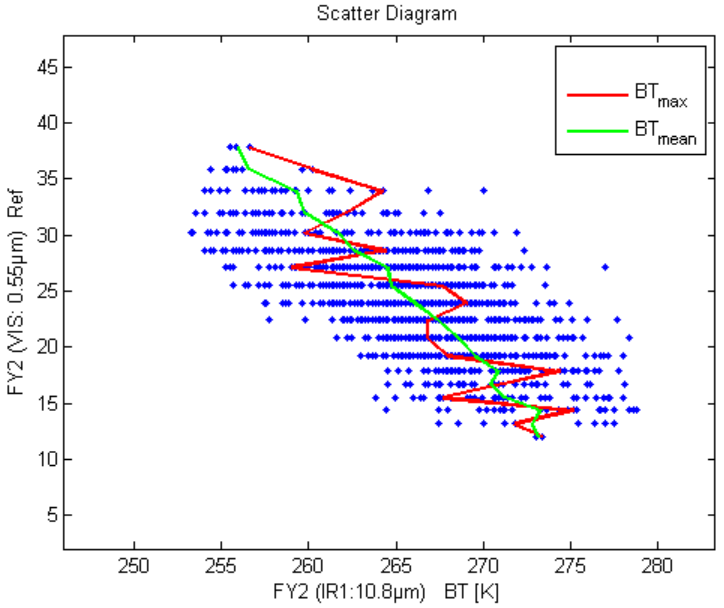
Ri=BTimax

By analysis the probability distribution function(PDF), let the PDF maxima of VIS reflectance equals to which IR BT counterpart, for example, we would get the one to one relationship bwtween VIS reflectance and IR BT.









Well organized shallow convections implied those hypotheses of stable environment situations that support similar physical process and hydrometeor components. We can find well tendency of BT decrease with reflectance increase.

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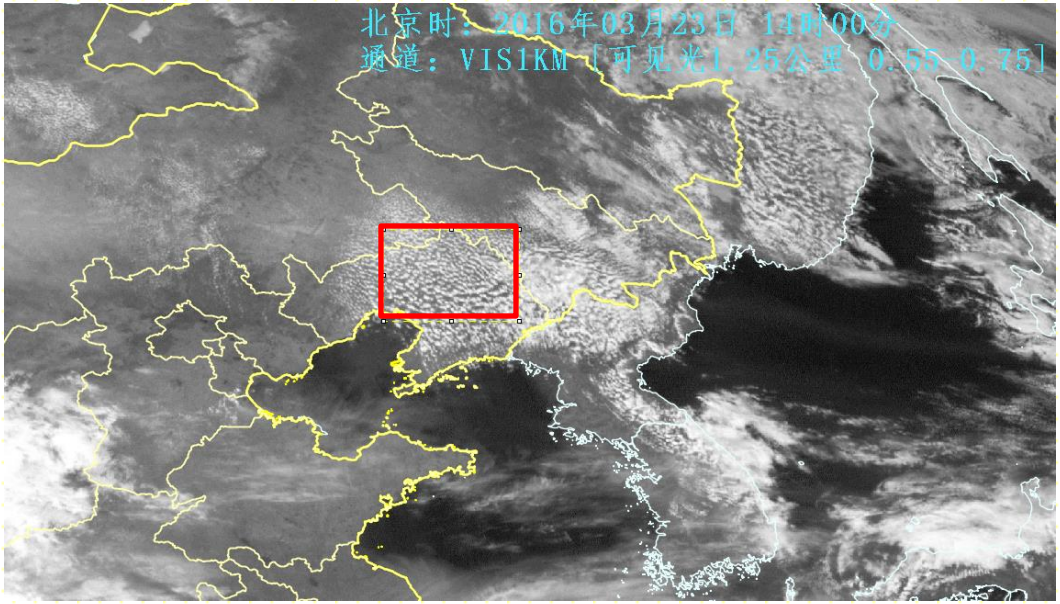
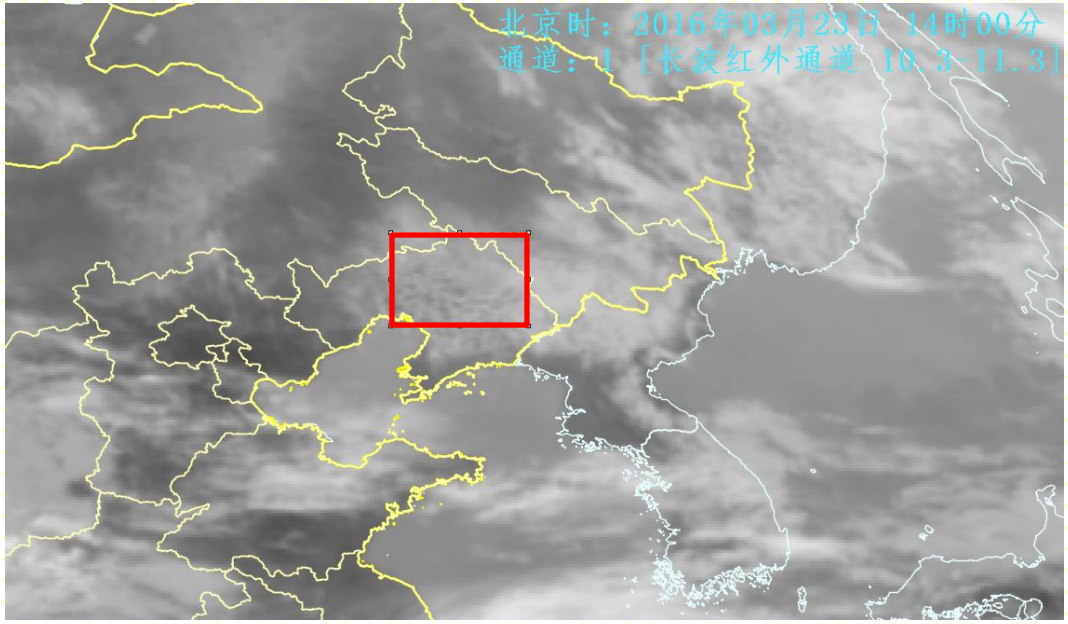

北京时：2016年03月23日 14时00分
通道：VIS1KM［可见光1.25公里 0.55-0.75］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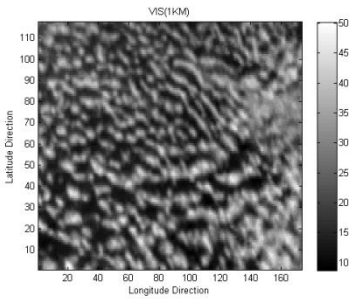
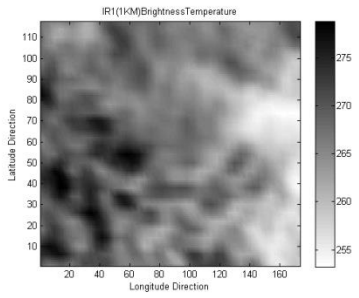
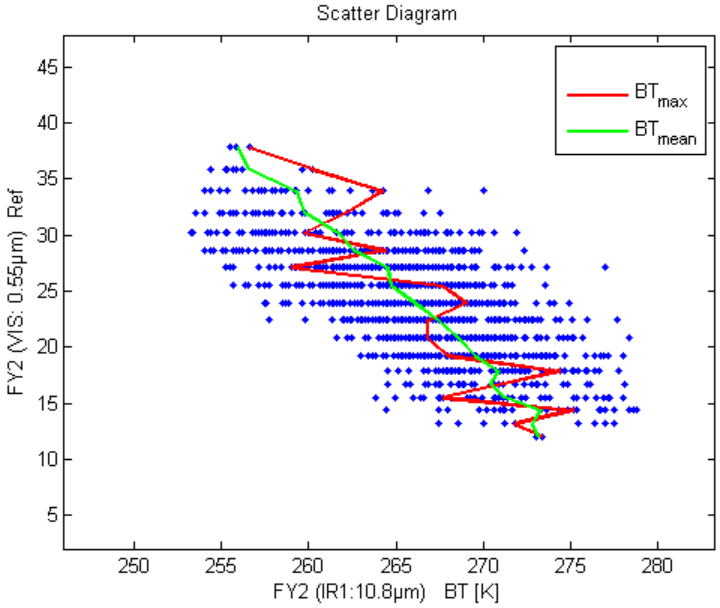
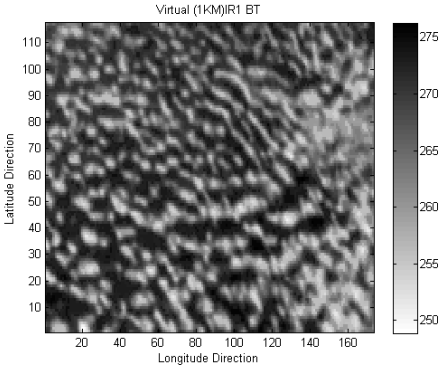
通道：1［长波红外通道 10.3-11.3］

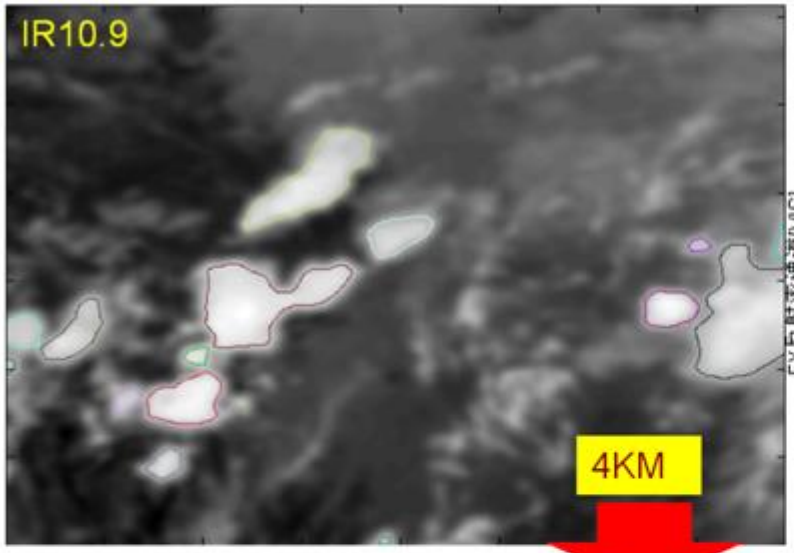

VIS(1KM)
Latitude Direction
Longitude Direction

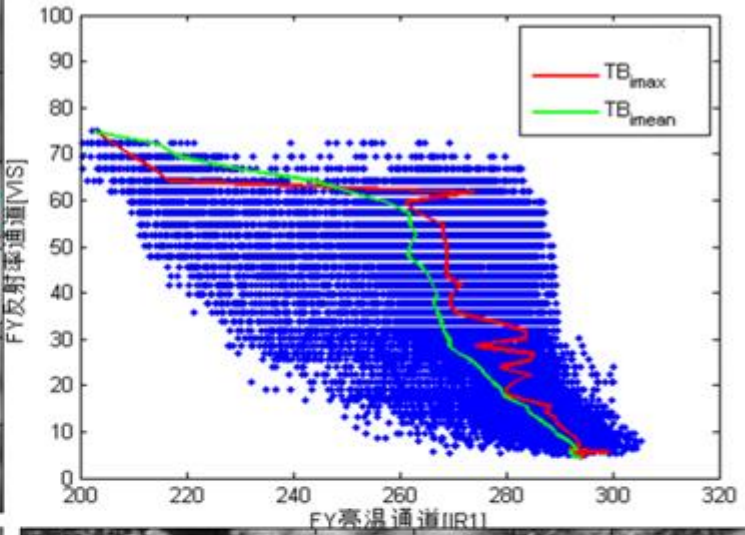

IR1(1KM)BrightnessTemperature
Latitude Direction
Longitude Direction


Scatter Diagram
BTmax
BTmean
FY2 (VIS: 0.55μm) Ref
FY2 (IR1:10.8μm) BT [K]


Virtual (1KM)IR1 BT
Latitude Direction
Longitude Direction

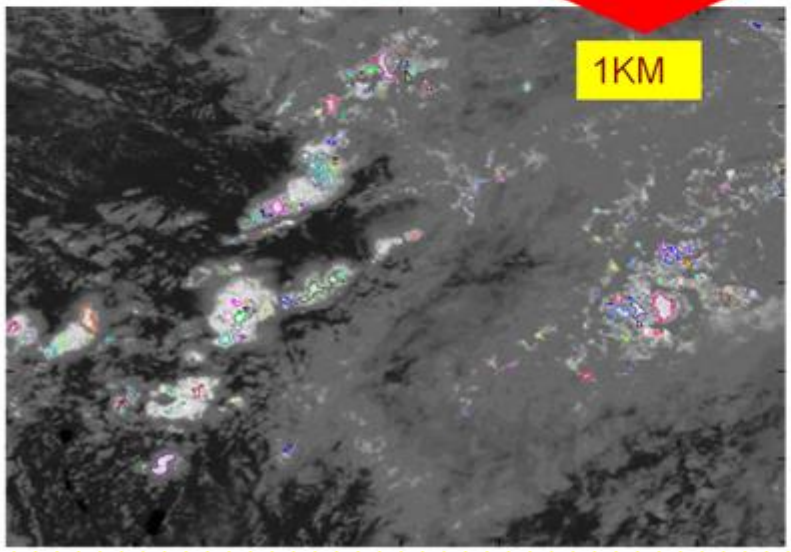
Another case

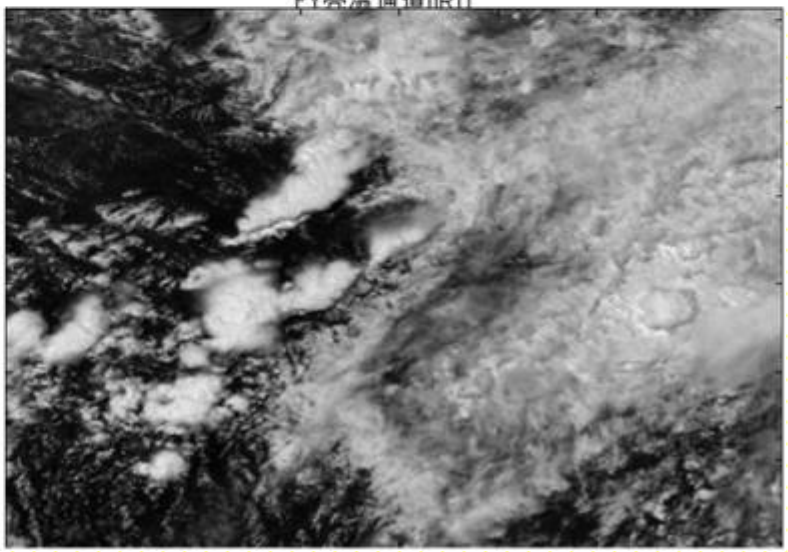


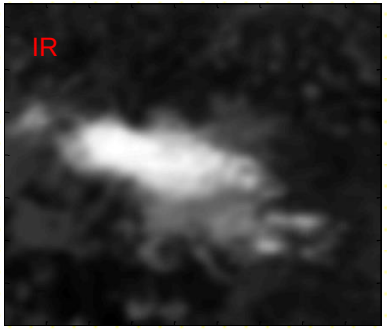


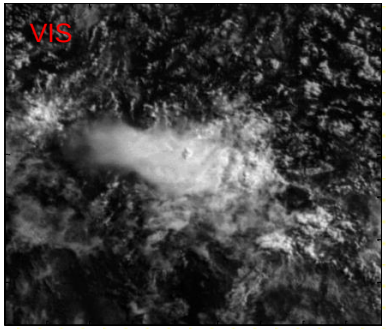
4KM

1KM

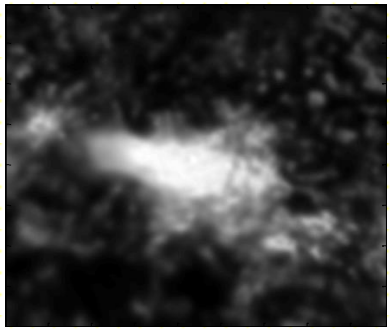




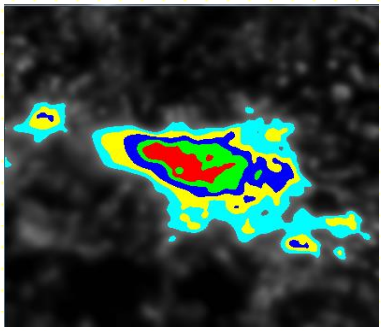




Virtual IR



BT of Virtual IR



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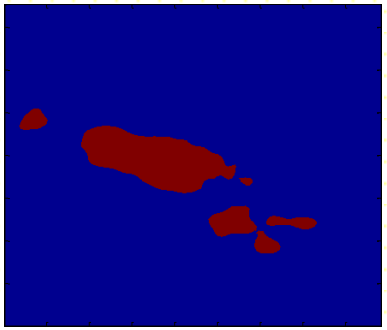
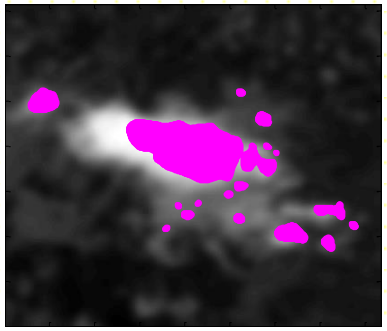
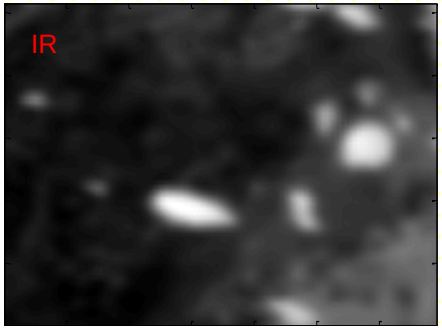
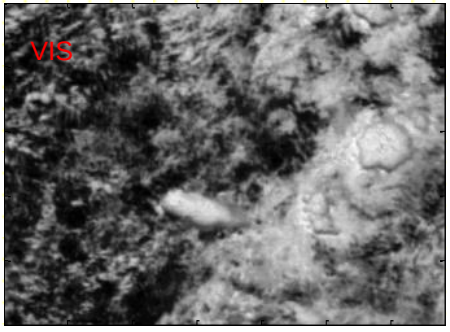
Without VIR



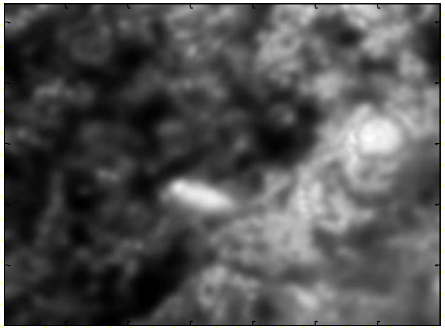
With VIR



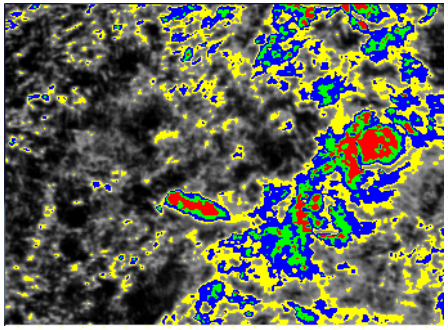




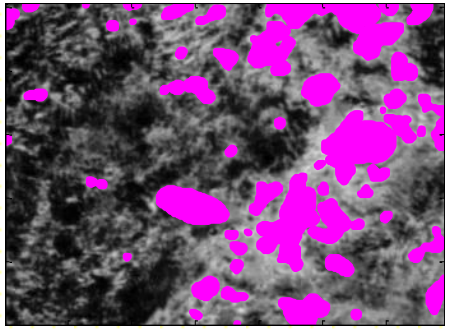
Virtual IR



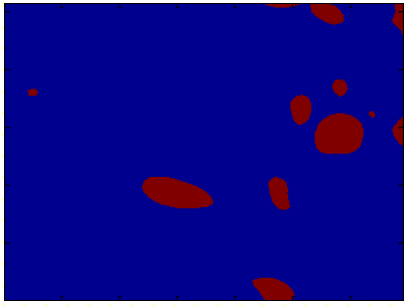
BT of Virtual IR



With VIR

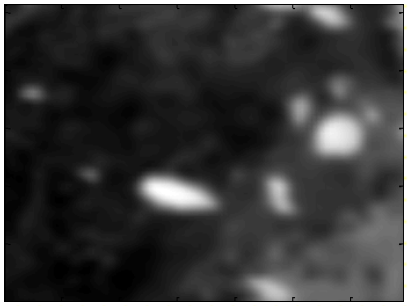


Conclusion: VIR BT can use for very small convective objects identification, so we have more leading time for CI detection.

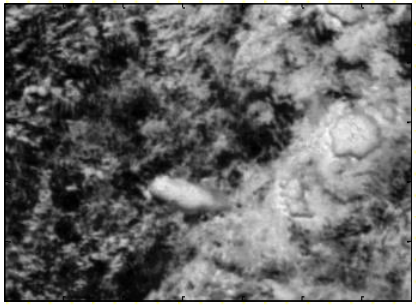


Without VIR

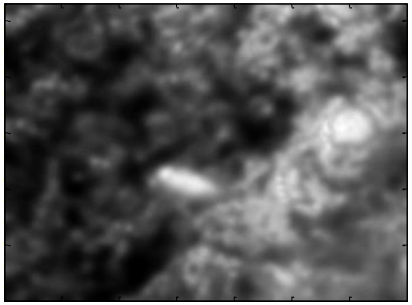
5km IR

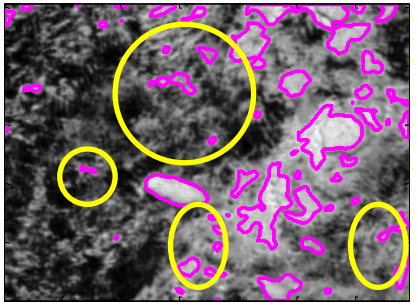


1km VIS

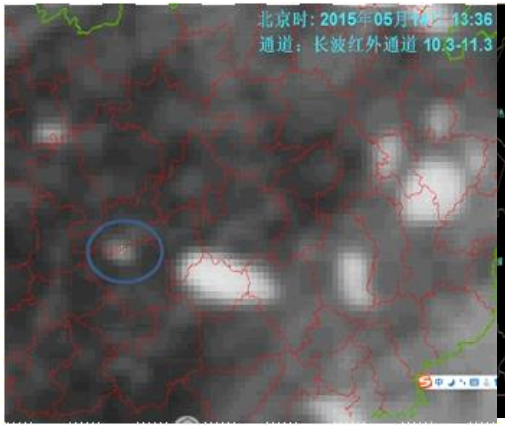


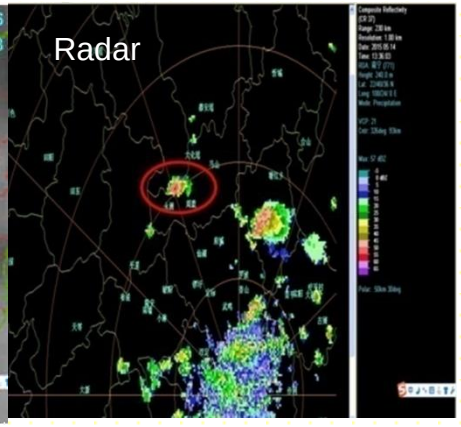
1km Virtual IR





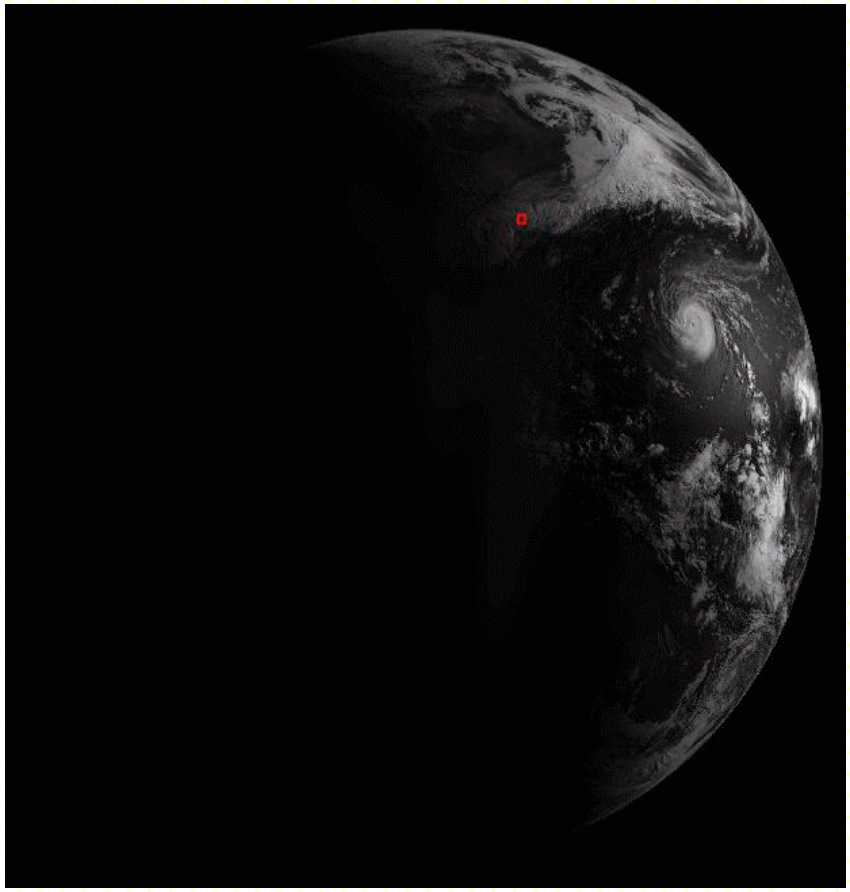
With VIR

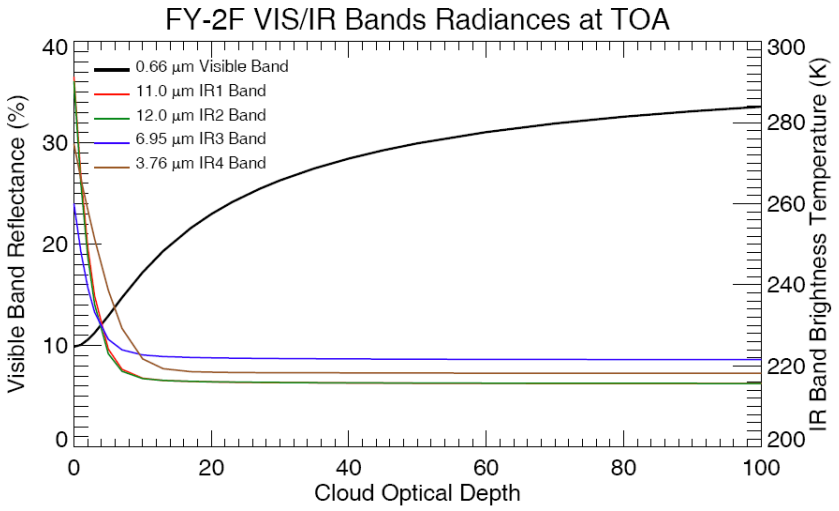


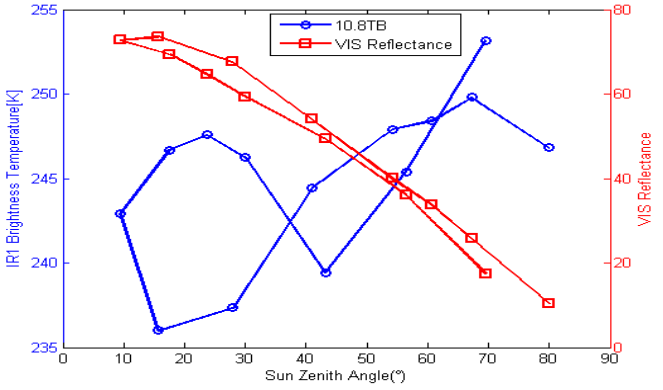


Need more analysis for VIR reconstruction

- Use MODIS, FY-3,Himawari-8 data
- Solar zenith angle factor, Bidirectional Reflectance Distribution Function(BRDF) correction
- Use the SBDART model (Santa Barbara DISTORT Atmospheric Radiative Transfer Model) to analysis the effects of COD(cloud optical depth)







Future plan

- In 2017 after FY-4A launch and becoming application, the GIIRS and LMI products will use to improve the convection detection, and to reduce false alarm by introduce atmospheric temperature and humidity information.
- New techniques keep tests to promote application, for example, use Kalman filter algorithm to extrapolate convection cloud systems moving.

Thanks for your attention!