

# Electric Field Polarity Asymmetry in the Occurrence of Thunderstorm Ground Enhancements during the End of Storm Oscillation (EOSO)

## Radar diagnosis of the thundercloud electron accelerator

H. Mkrtchyan<sup>1</sup>, E. Williams<sup>2</sup>, A. Chilingarian<sup>1,3</sup>, S. Hovakimyan<sup>4</sup>, D. Aslanyan<sup>1</sup>

<sup>1</sup> Yerevan Physics Institute,

<sup>2</sup> Massachusetts Institute of Technology,

<sup>3</sup> Russian Space Research Institute,

<sup>4</sup> Ministry of Emergency Situations of Armenia

# Overview

- Stations
- Instrumentations and Radar characteristics
- Thunderstorm activity over Aragats.
- Introduction to TGEs
- What are EOSO?
- TGEs registered during negative and positive fields.  
Difference between them.
- CAPPIs measurements and Examples of events with  
RADAR data: May 30

# Instrumentations

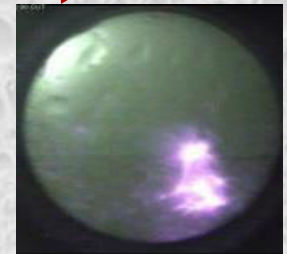
**Boltek EFM-100 for Electric field**



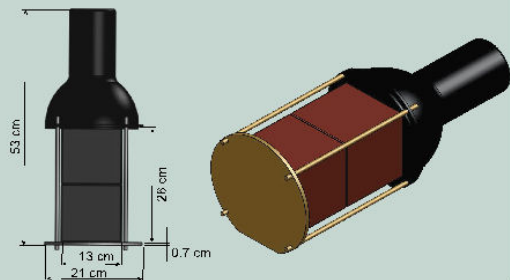
**Vantage Pro Weather station**



All sky camera

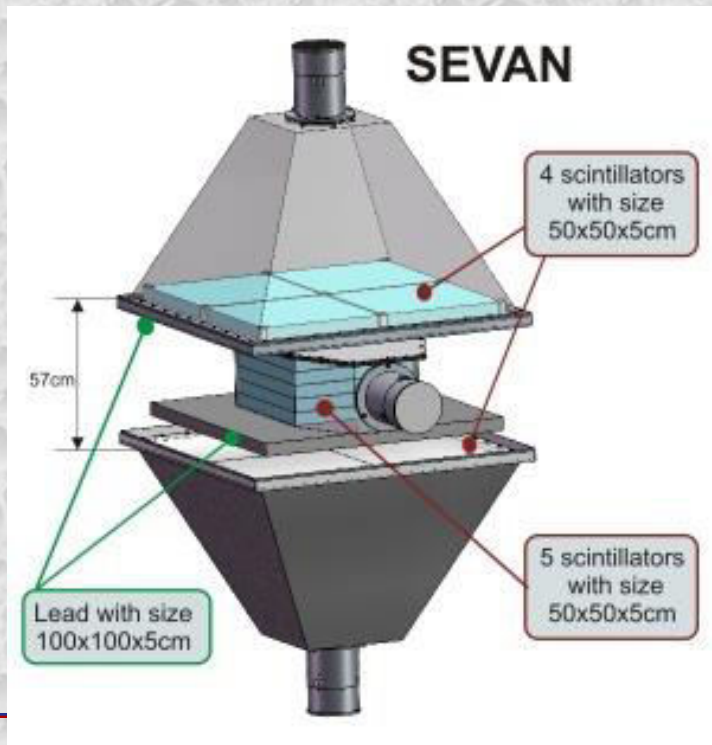


## Nal Detector



0.26 MeV to 7 MeV

## Particle detectors



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Example of 3&1 cm plastic scintillator detectors for particle registration

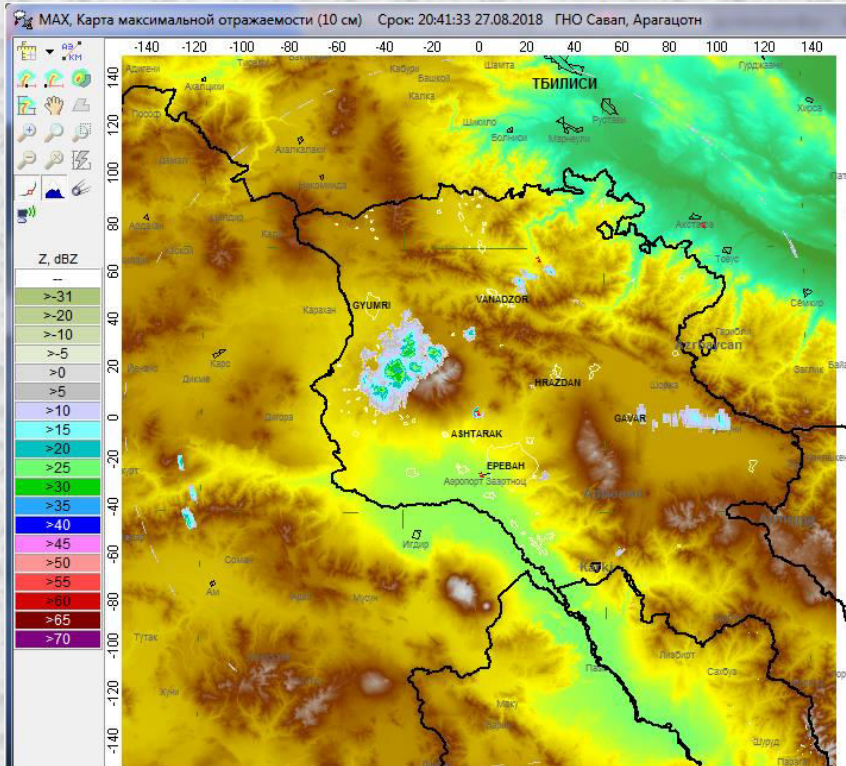


- Aragats (3 EFM-100, 3200 m. asl)**
- Nor Amberd (2000 m asl)**
- Yerevan (1000 m asl)**
- Sevan (1900 m asl)**
- RADAR (1634 m asl)**

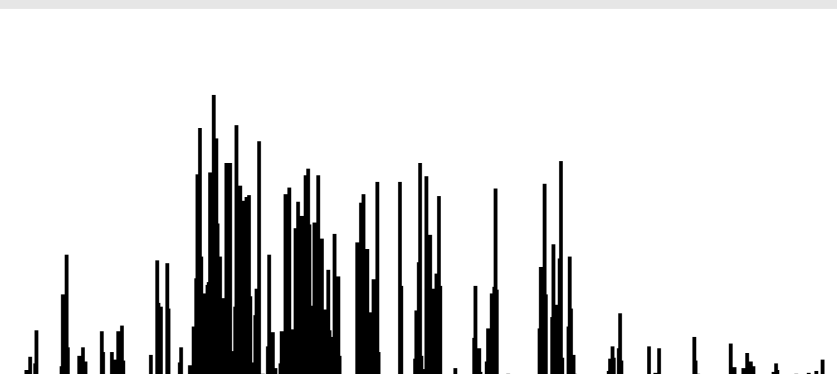
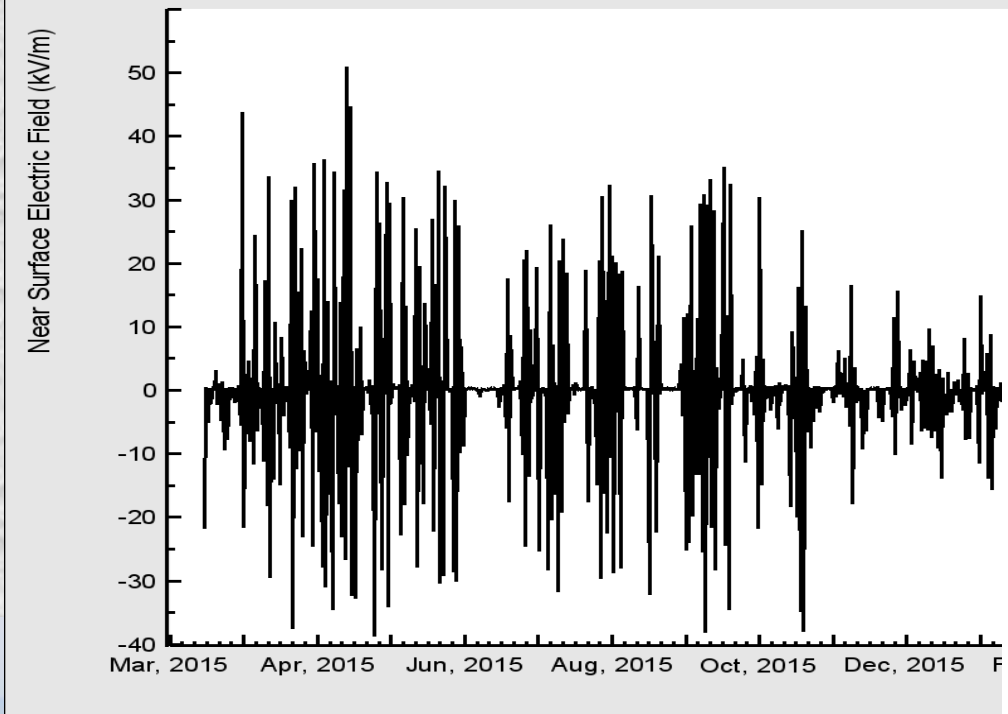


# ARMENIAN GEOPHYSICAL NETWORK

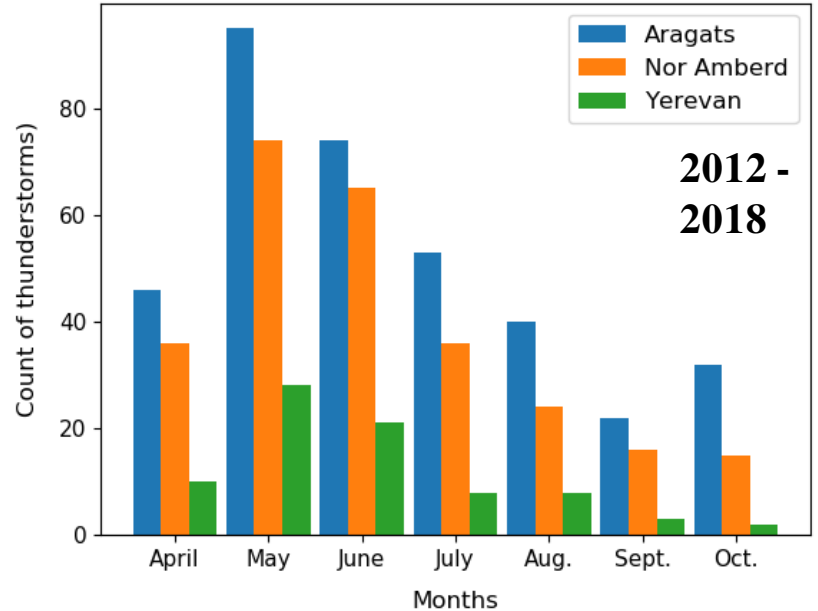
# Radar characteristics



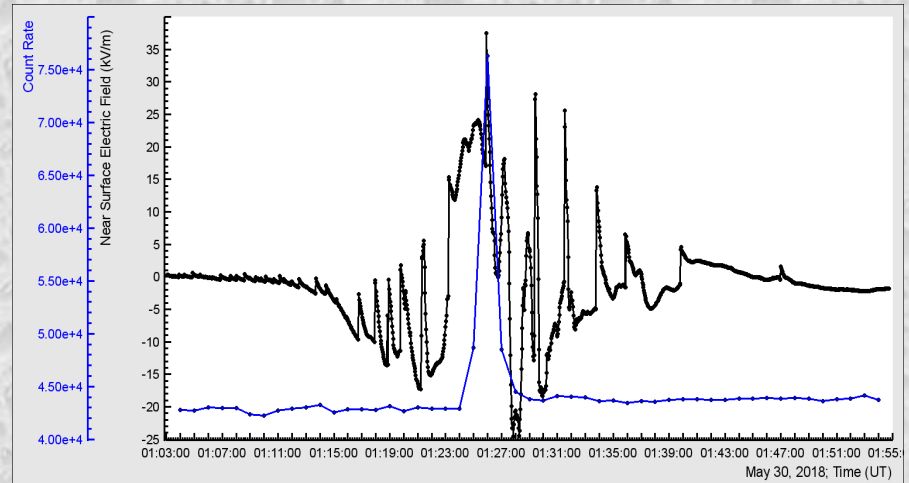
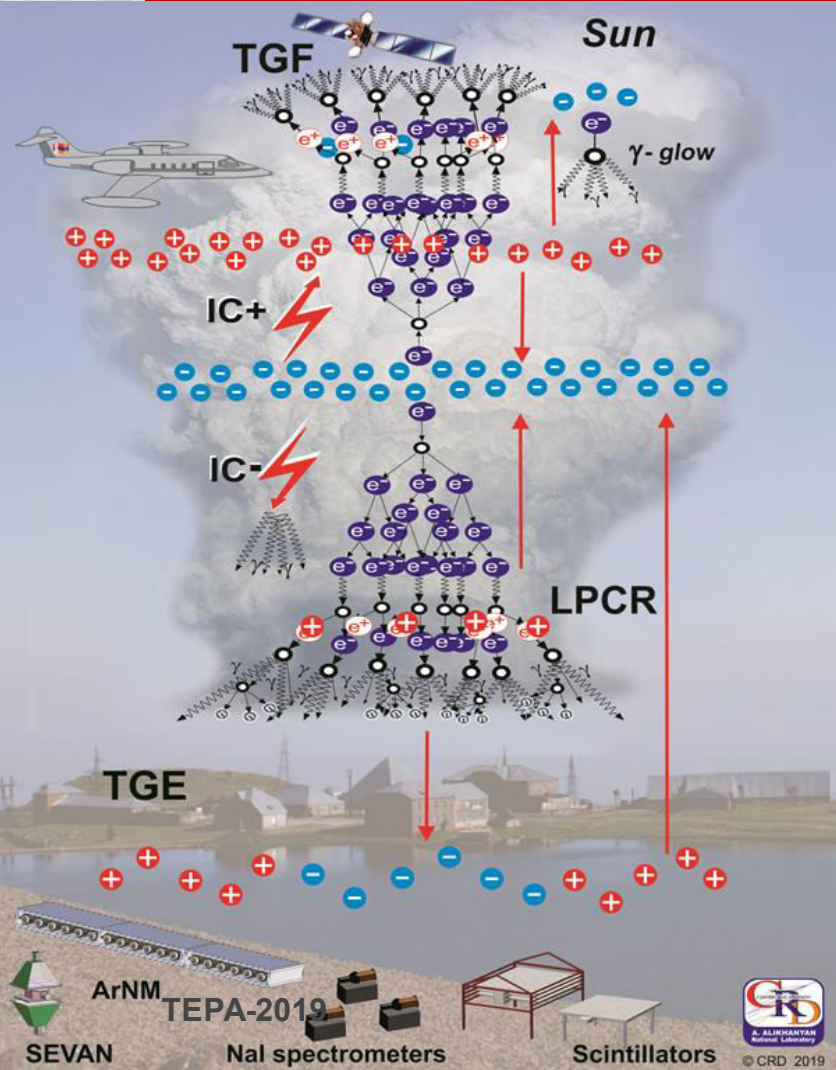
- Spatial resolution
  - by longitudinal 500m (+-10 m) & 1000m(+/-20 m)
  - by azimuth - 1.0 degree;
  - by angle - from 0 to 85 degree (with 18 angles).
- The range of the system: 200 km or 400 km (operator's choice).
- Cloud processing height: 0 to 20 km.
- it determines the direction and speed of movement of cloud systems and selected convective cells.
- Angel count per rotation is varied from 18 to 36. Accuracy for vertical angle is +/-0.1. Duration of the review cycle is 3 minutes 20 seconds.
- The speed of rotation of the antenna is 5-6 rotation /minutes.



Thunderstorm monthly activity

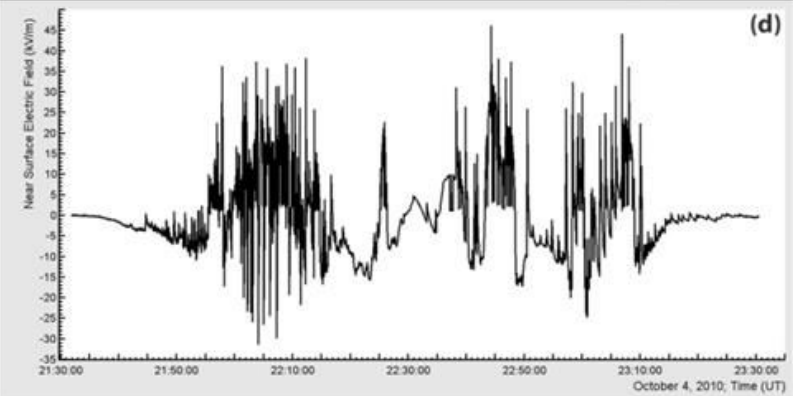
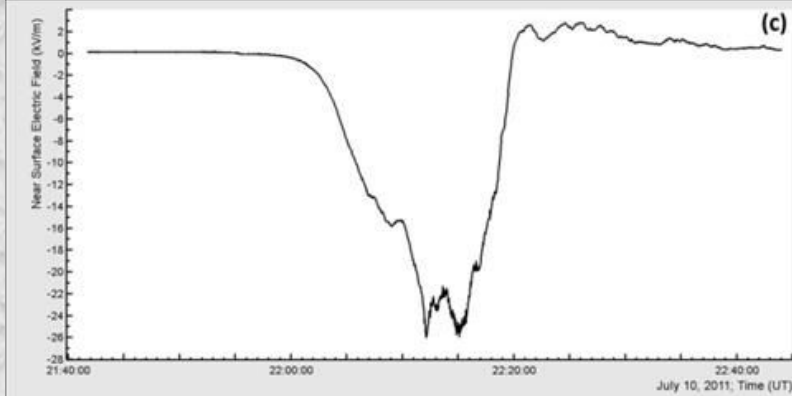
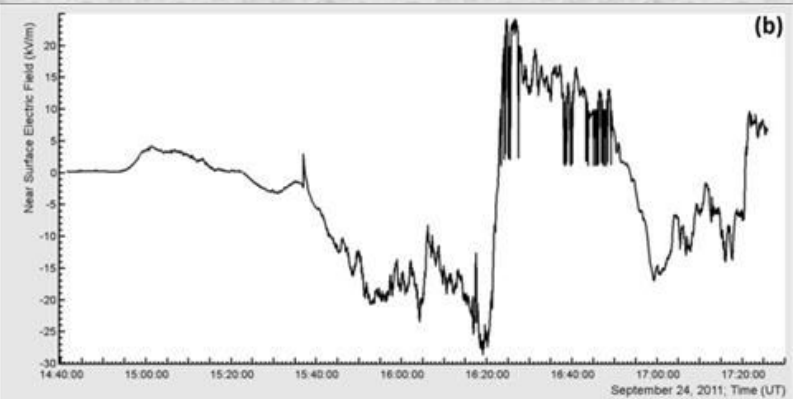
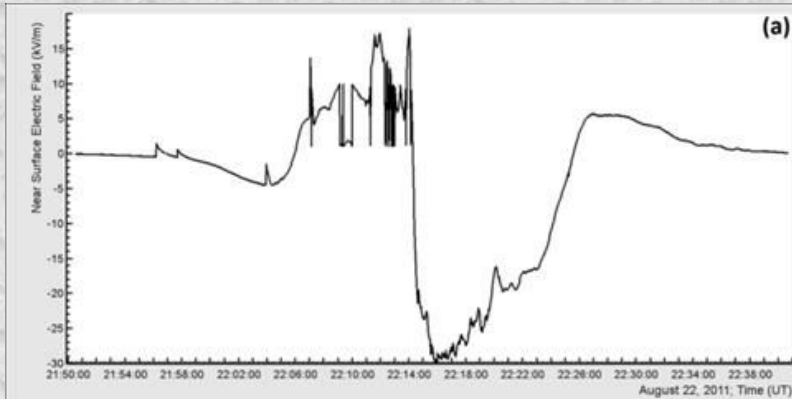


# The initiation model of Thunderstorm Ground Enhancement (TGEs)

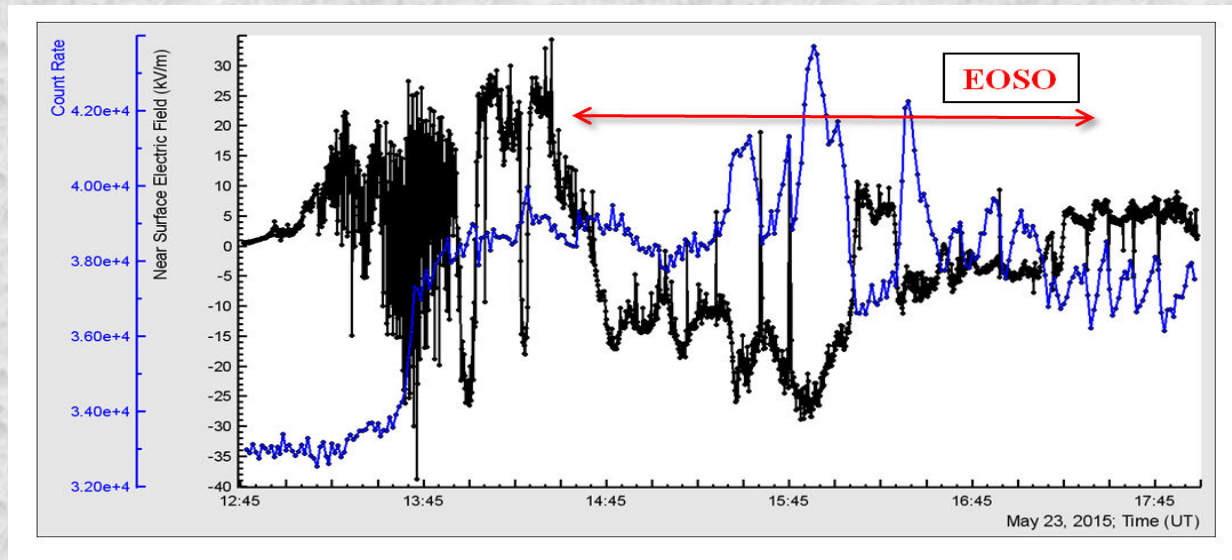




# Thunderstorms Ground Enhancements



# End-of-storm oscillation (or EOSO)



The EOSO describes the behavior of the electric field (E) at the ground beneath decaying thunderstorms involving several polarity changes over a period of 30–75 min.

2015-2018 ~300 TGEs

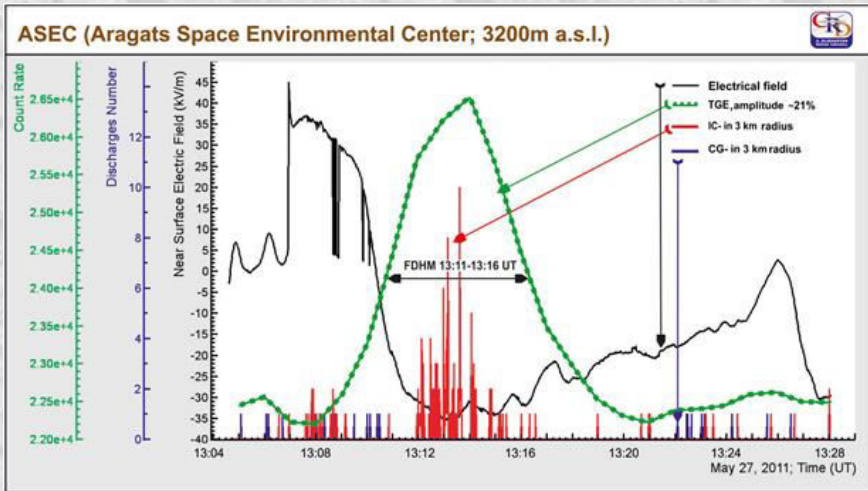
With 42 EOSO events

What about Field Excursions Associated with Precipitation ?

# Thunderstorms Ground Enhancements

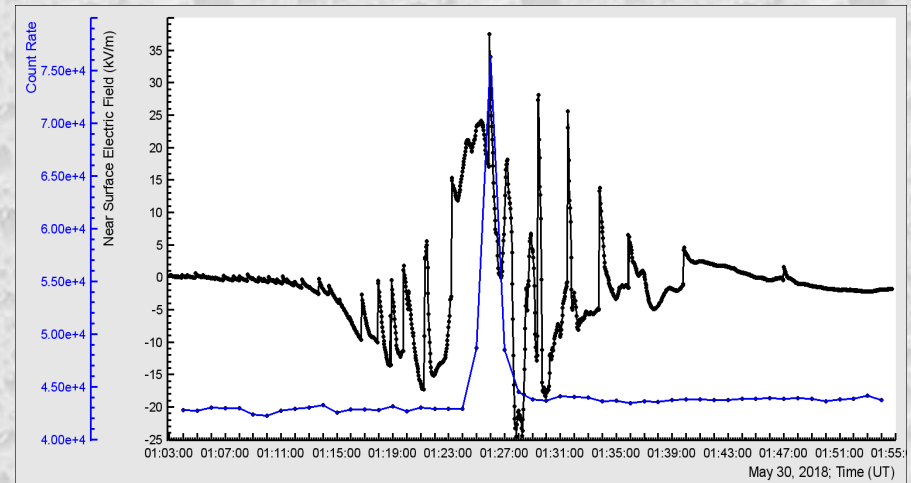
## During negative field

(a negative field is dominant – charge overhead)



## During positive field

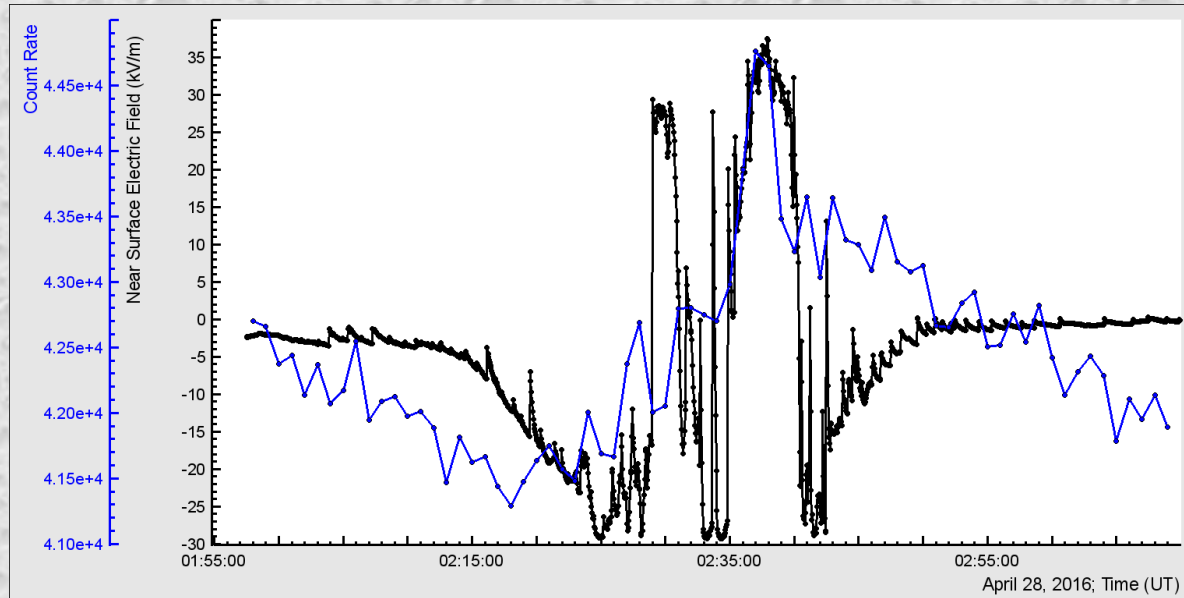
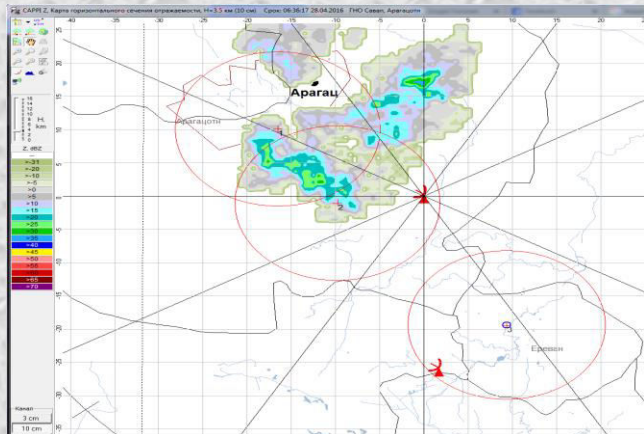
(a positive field is dominant + charge overhead)



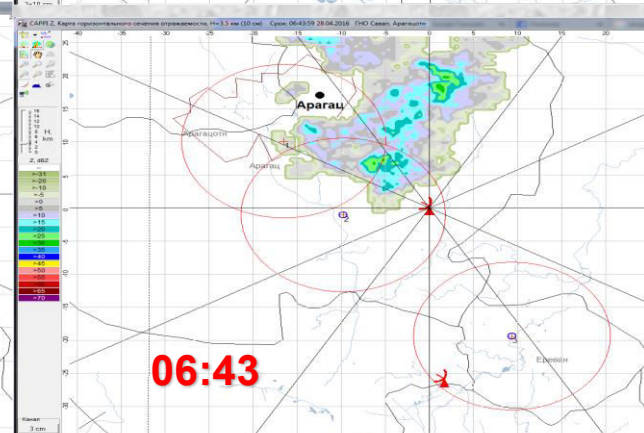
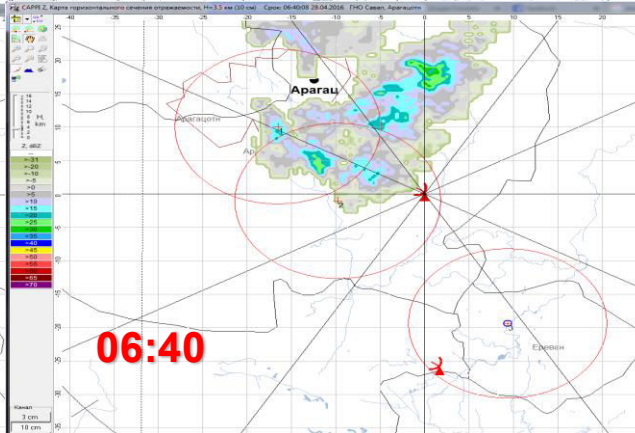
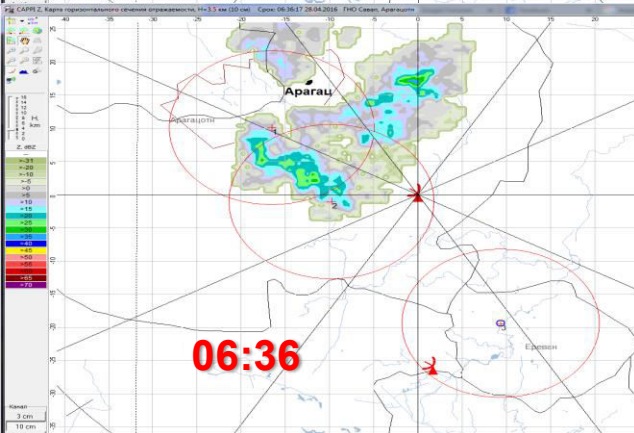
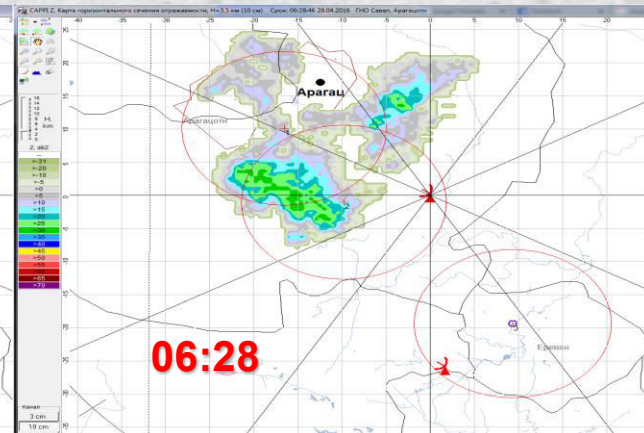
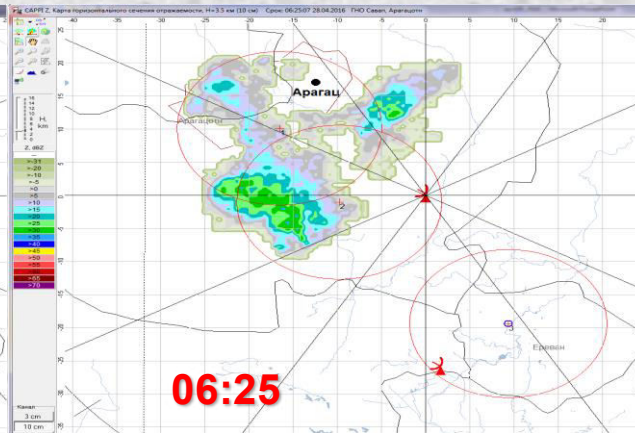
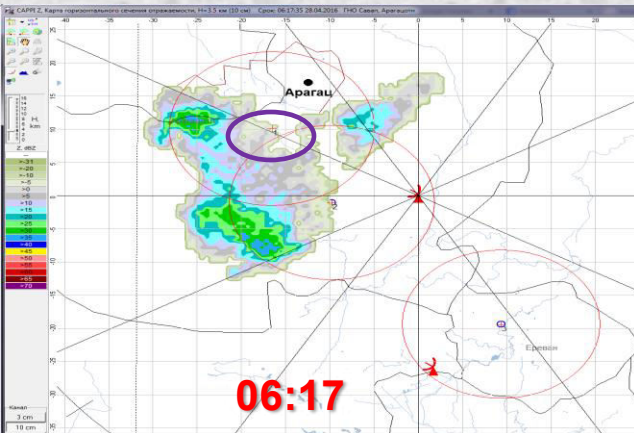
**12 TGEs events out from 60 were  
analyzed during negative field**

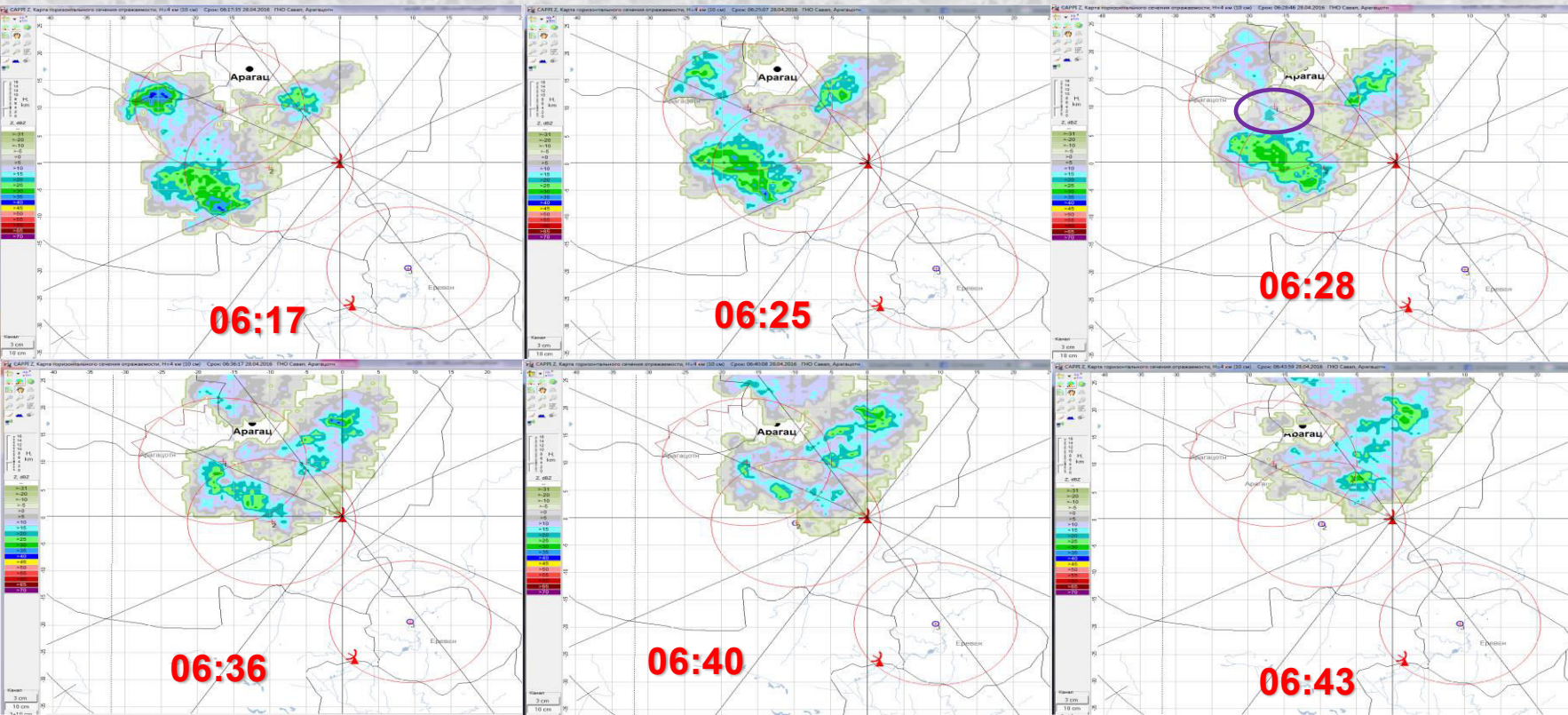
**10 TGEs events out from 40 were  
analyzed during positive field**

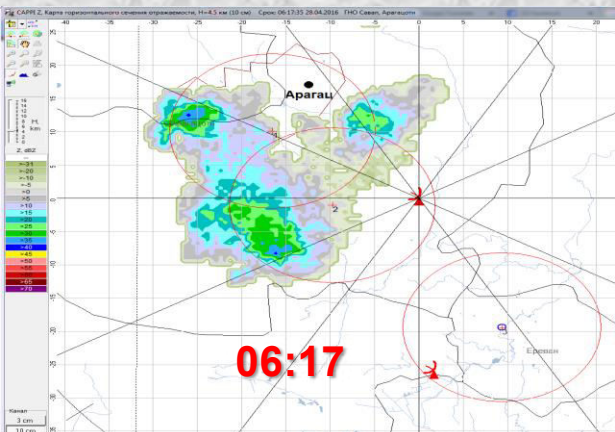
# Example on April 28 2016: positive case



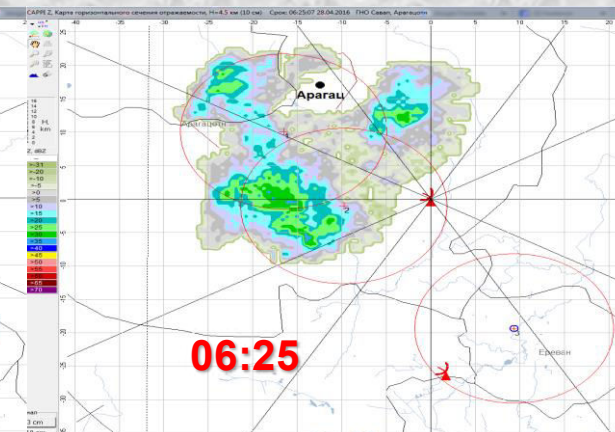
# 3.5 km, Constant altitude plan position indicator (CAPPI)



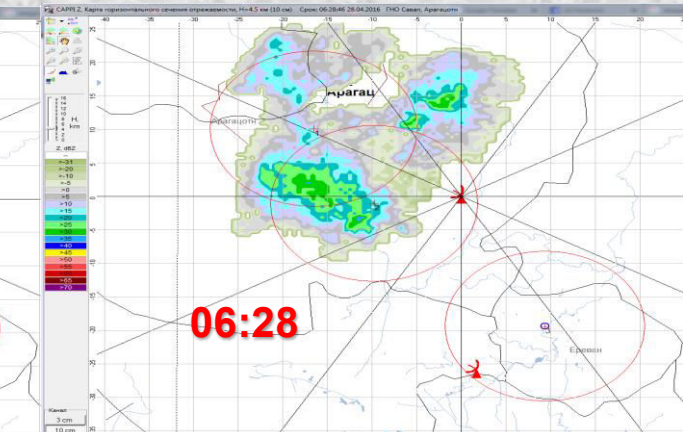




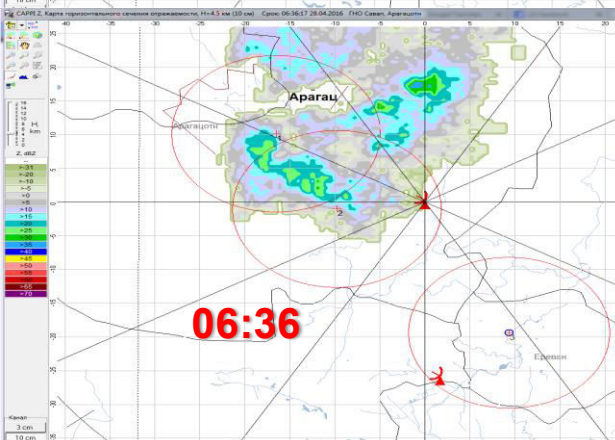
**06:17**



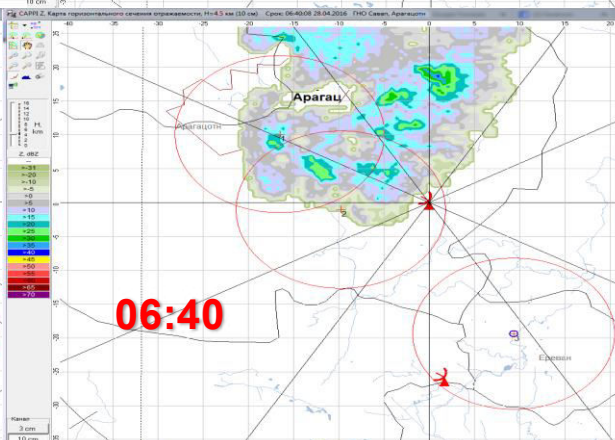
**06:25**



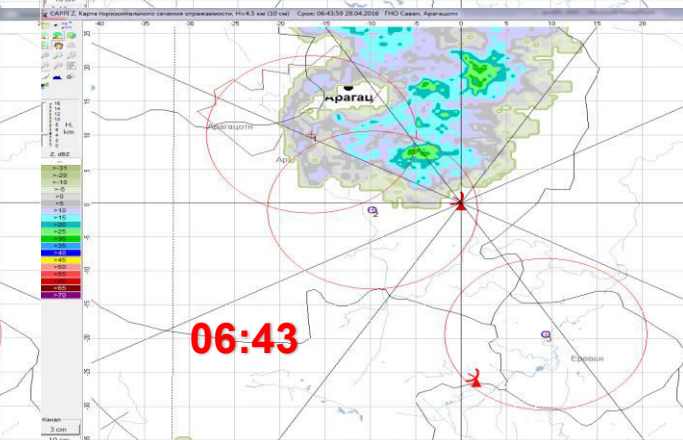
**06:28**



**06:36**

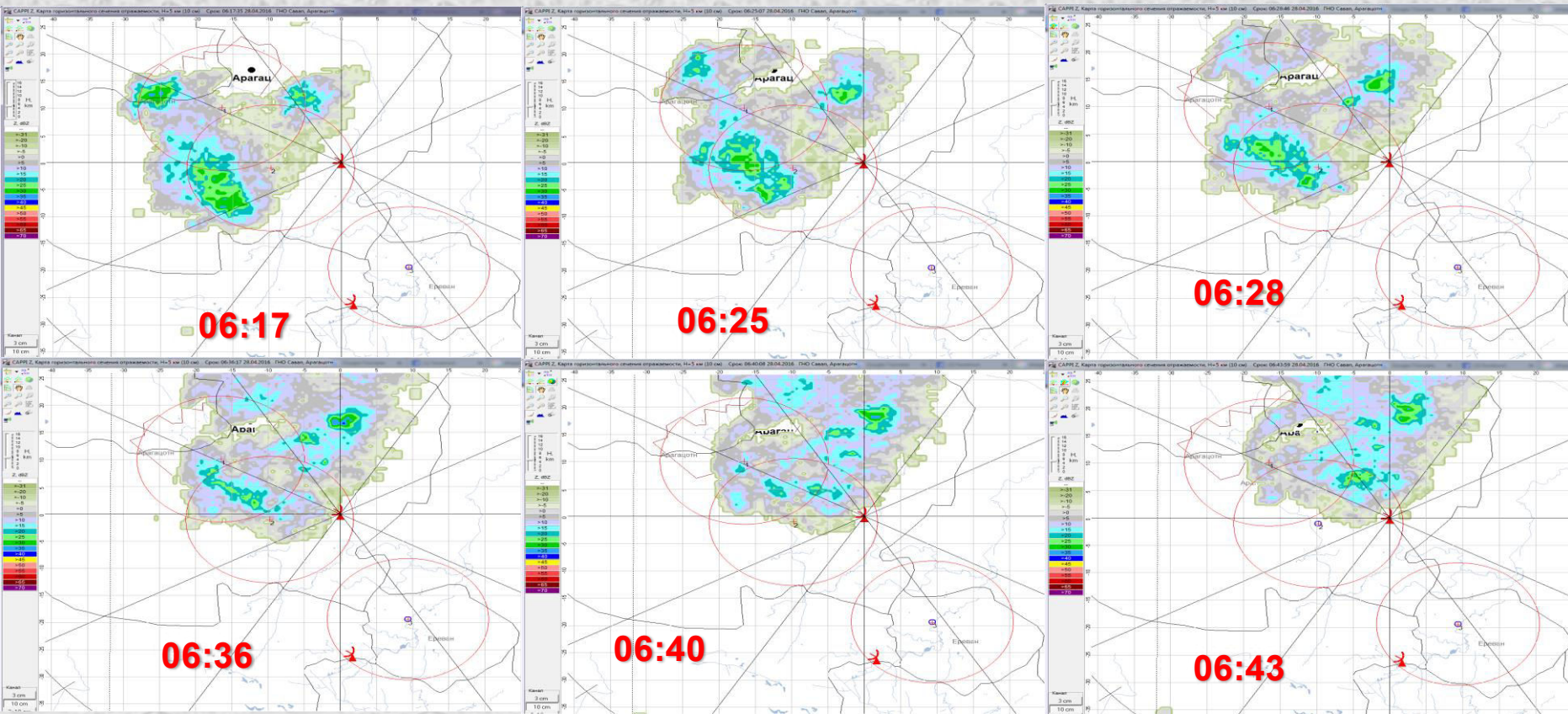


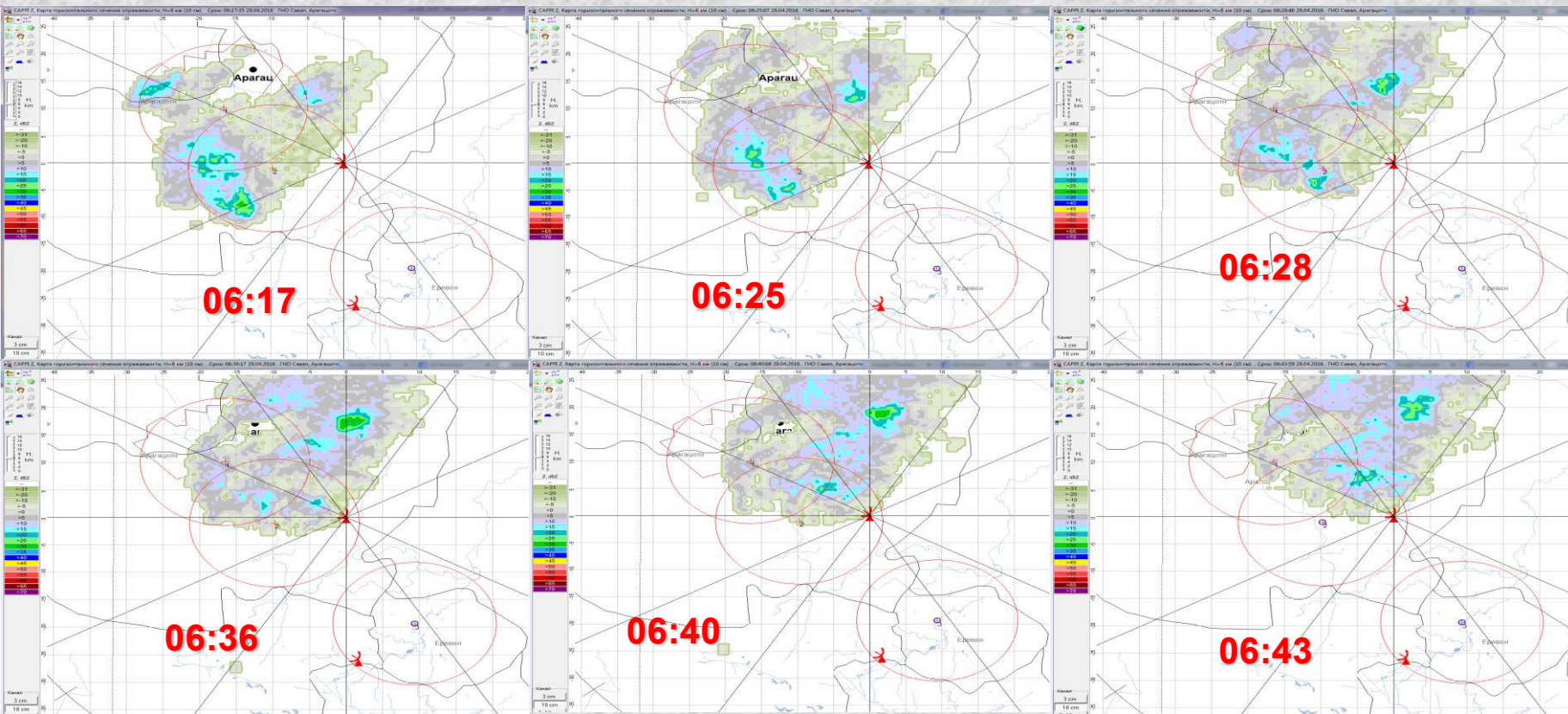
**06:40**



**06:43**

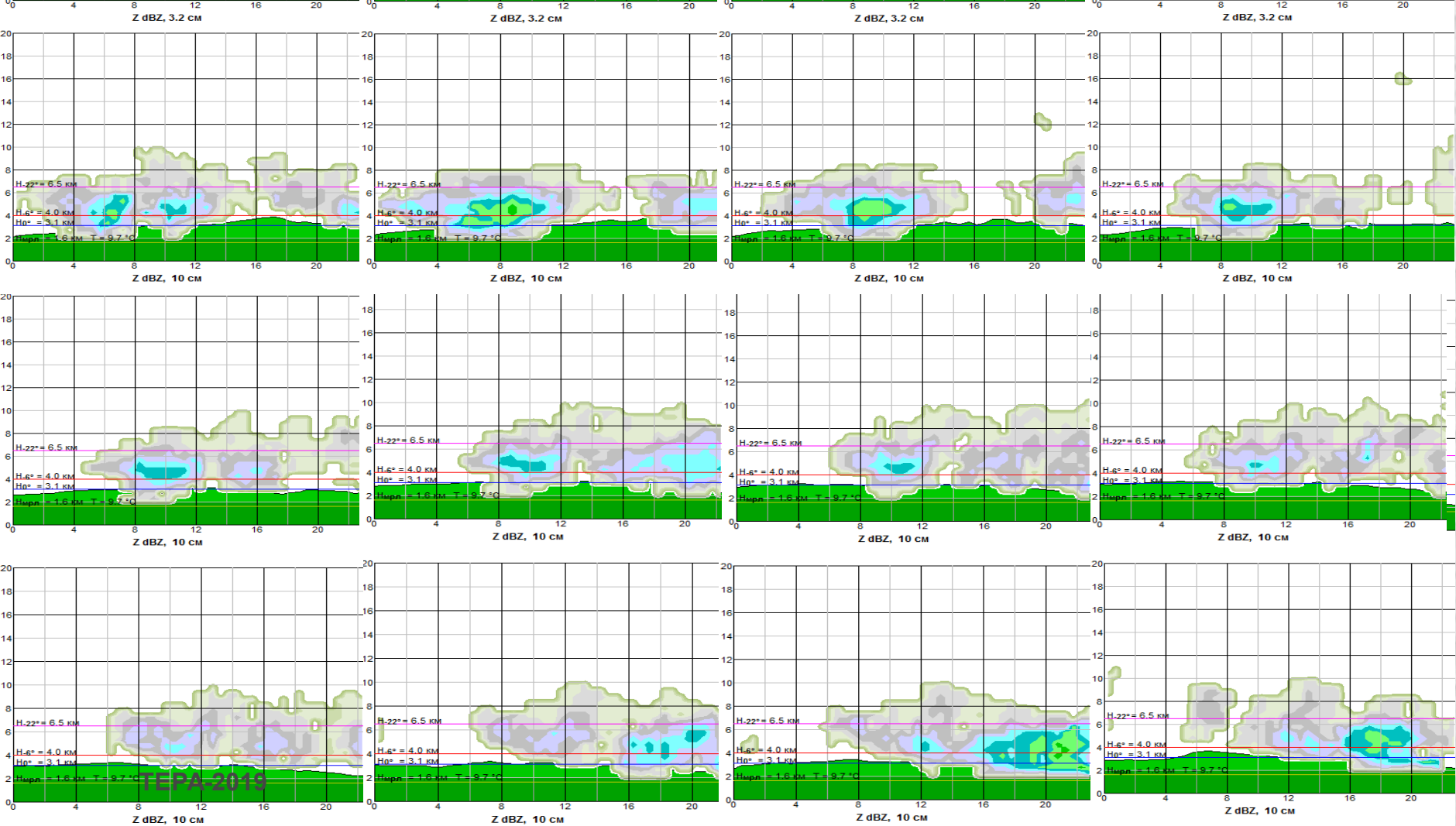




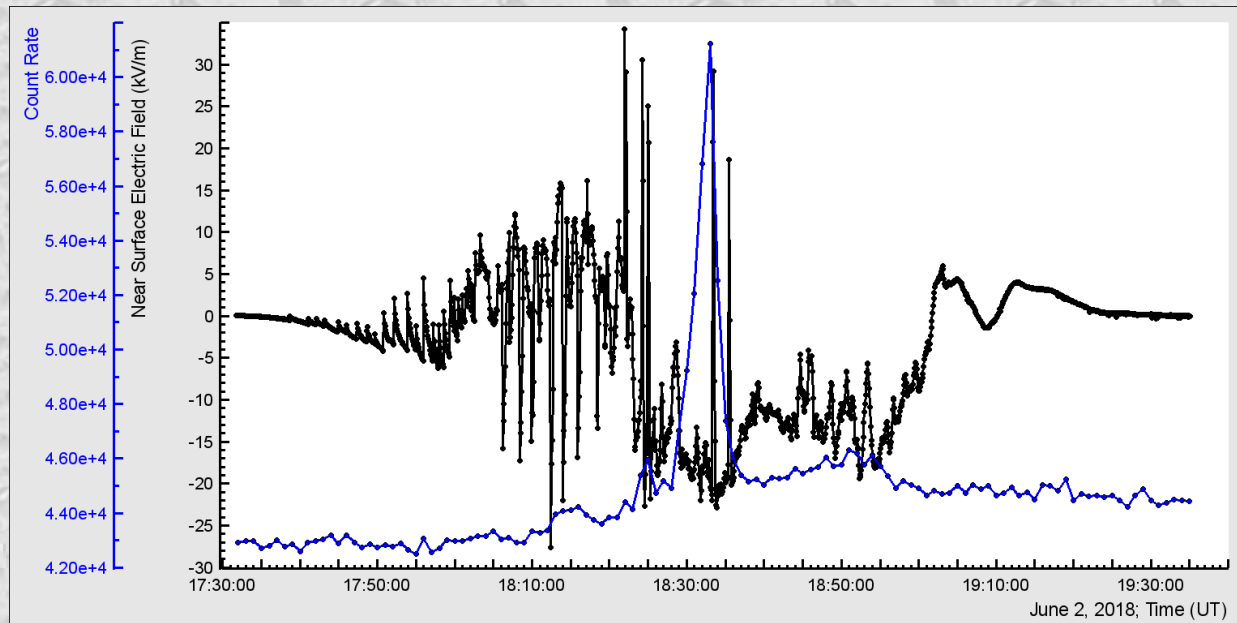
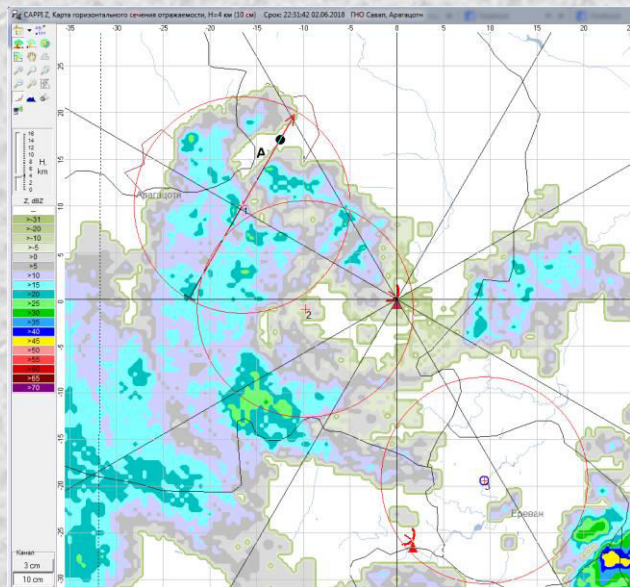


Station is at ~11.5 km of horizontal  
scale

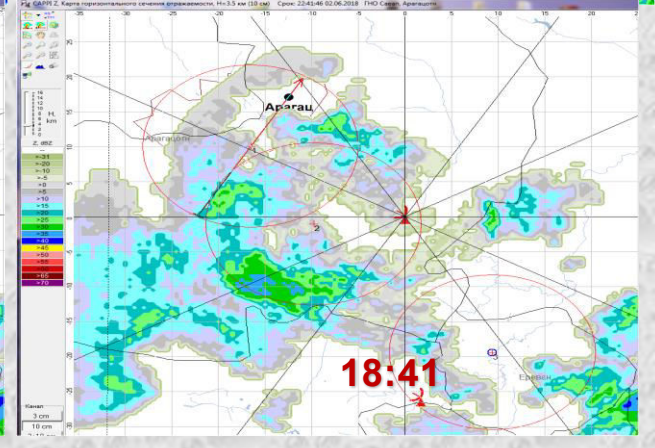
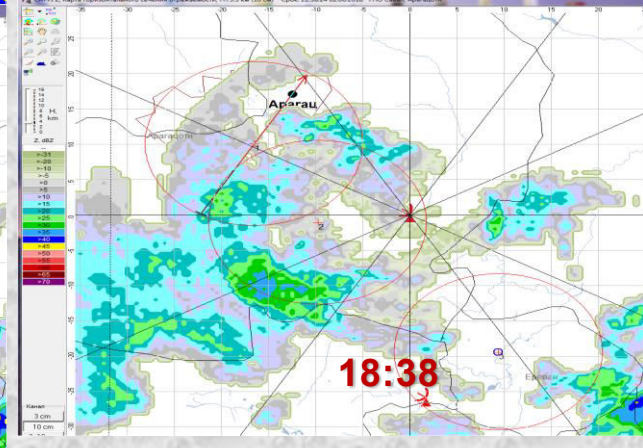
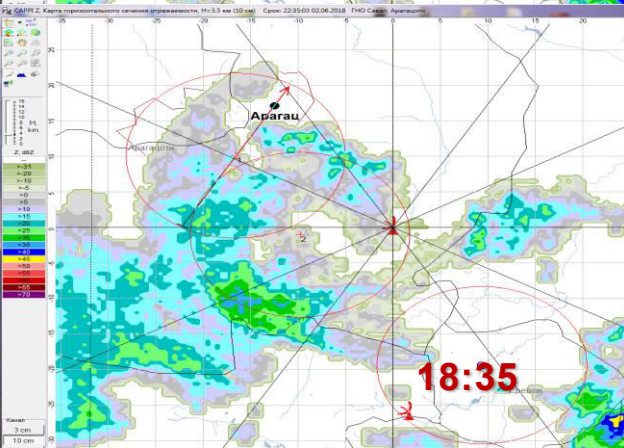
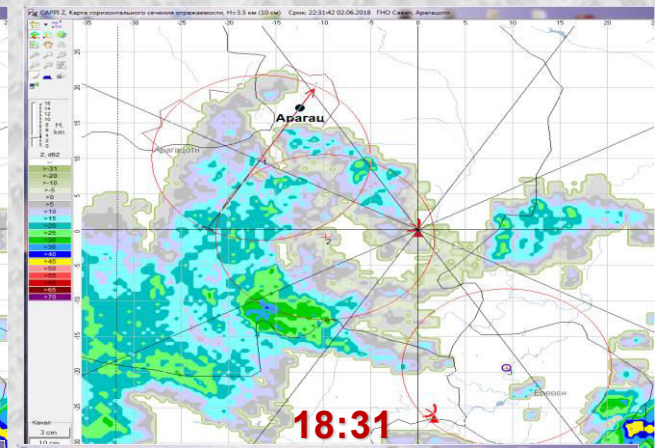
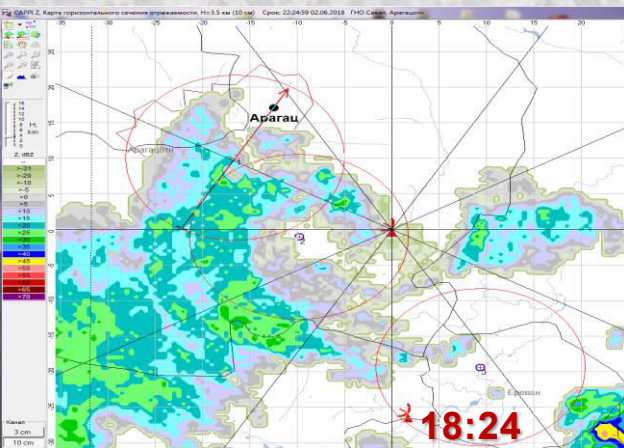
below the vertical cut of the figures  
are starting from 0 ° to 330° by step  
of 30 °



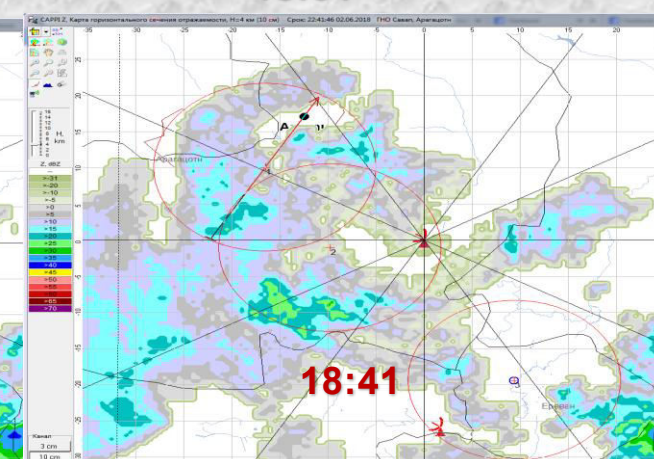
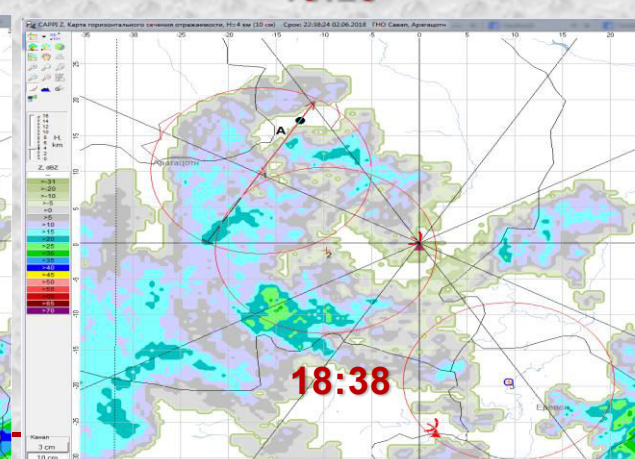
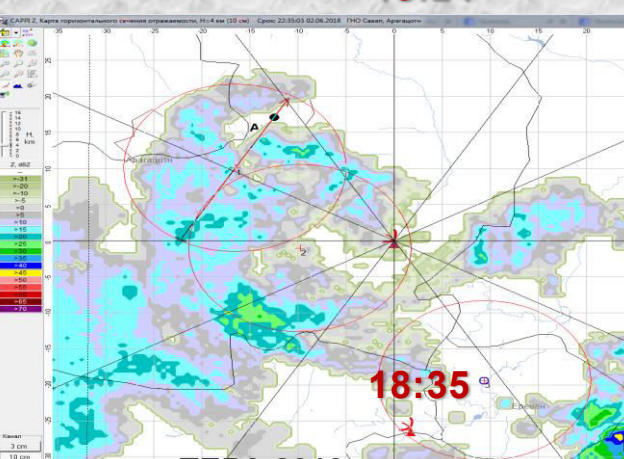
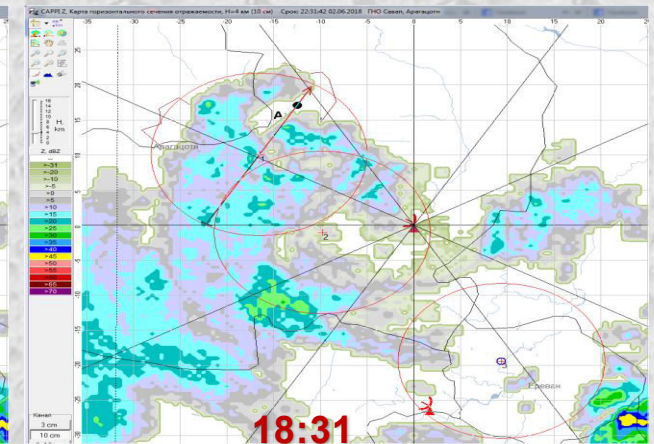
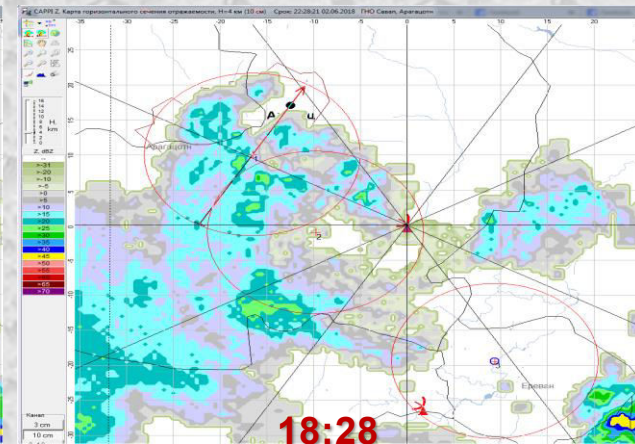
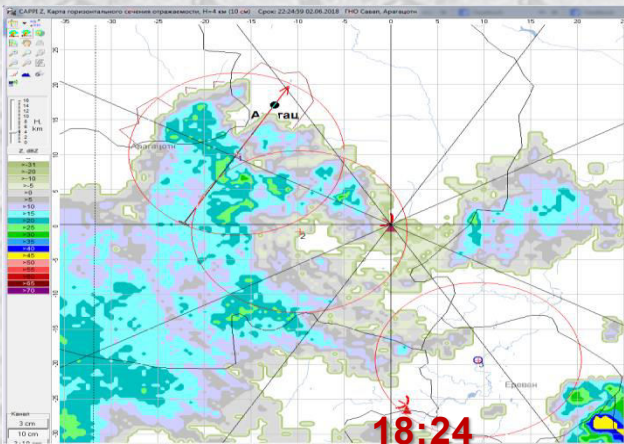
# Example on June 2 2018: negative case



# 3.5 km, Constant altitude plan position indicator (CAPP)

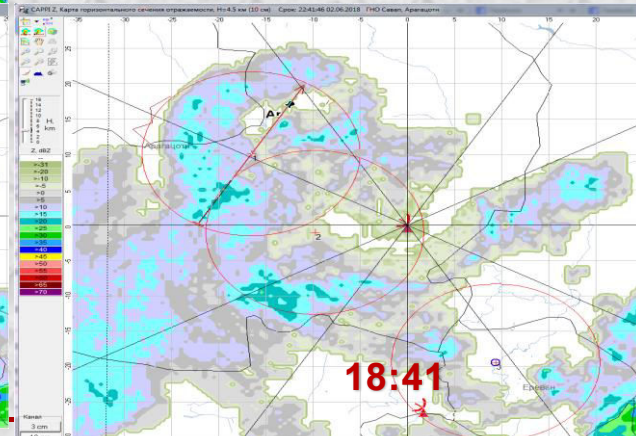
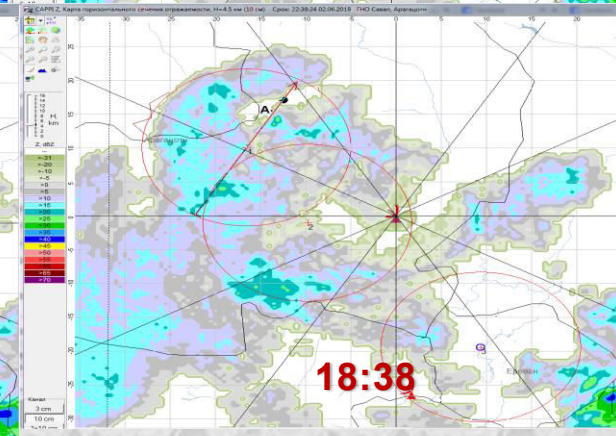
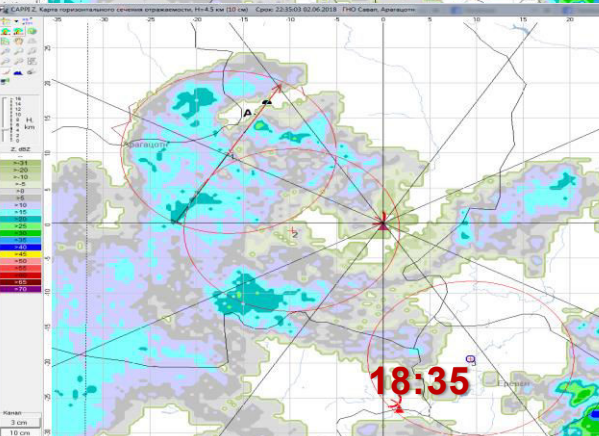
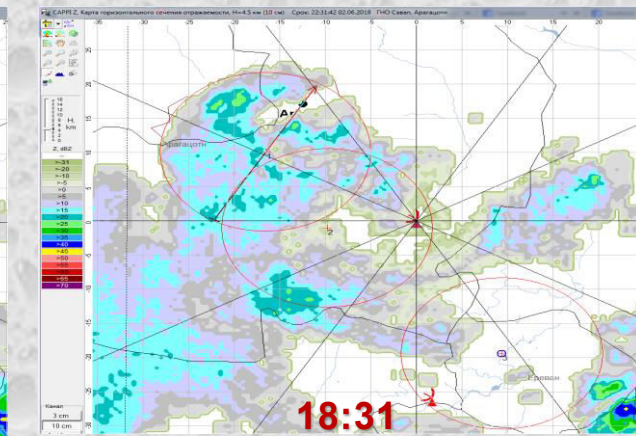
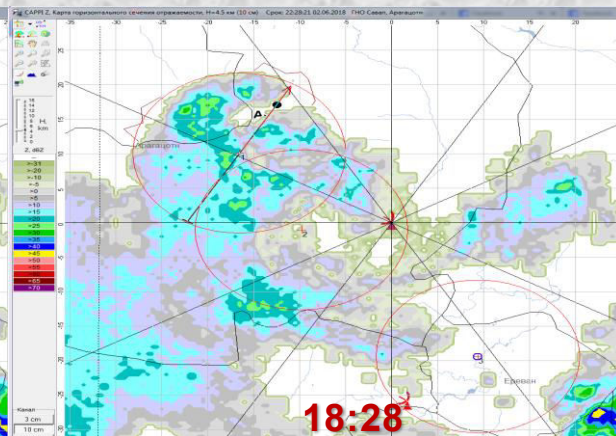
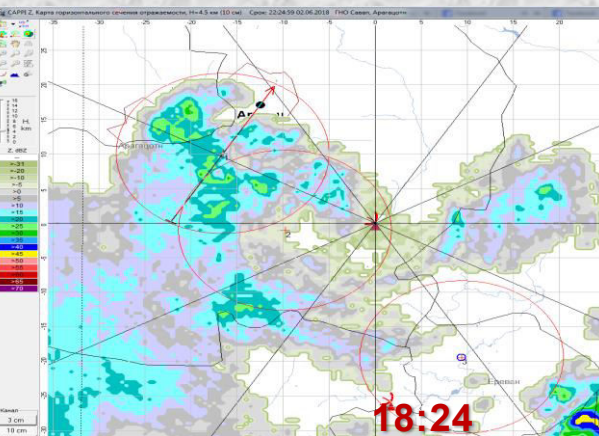


# 4 km

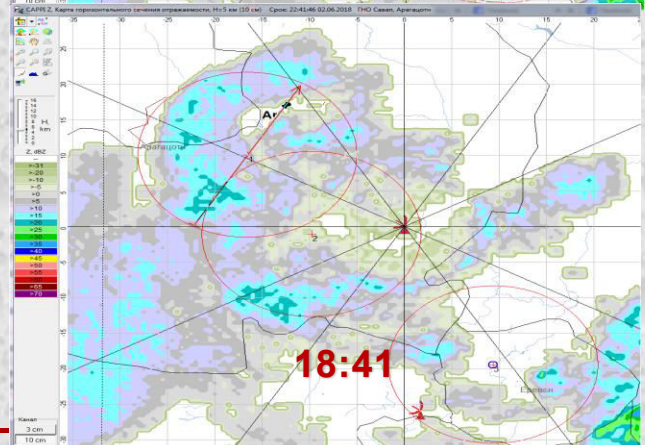
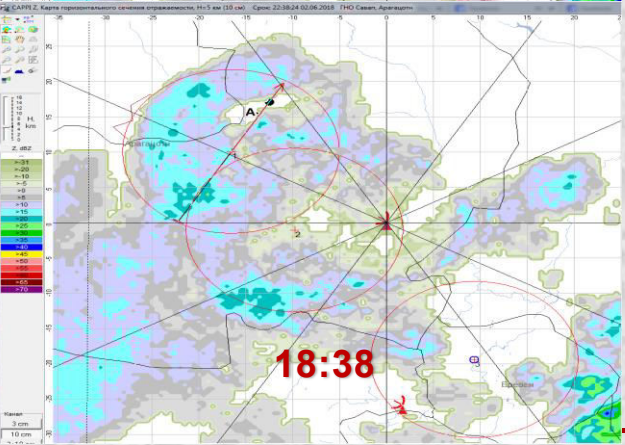
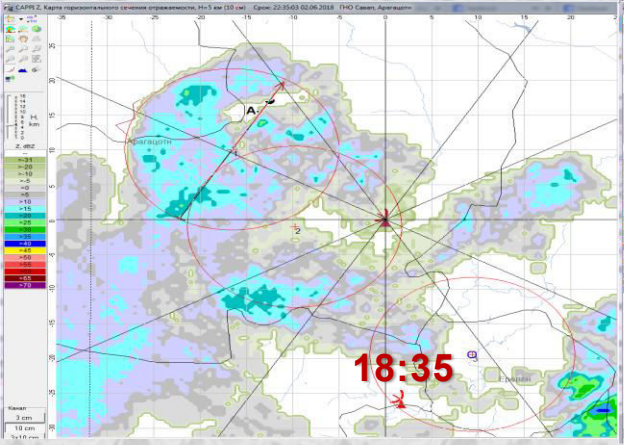
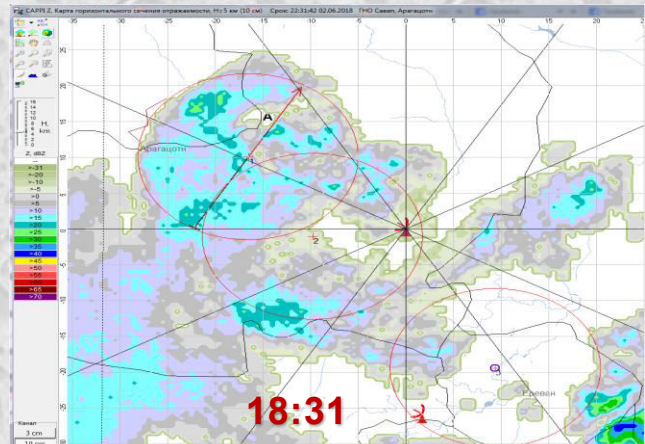
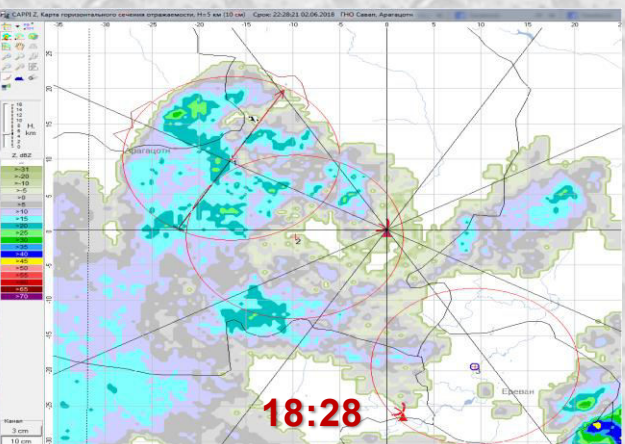
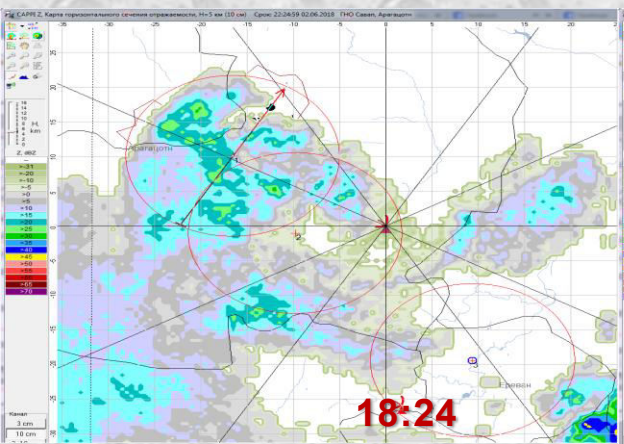


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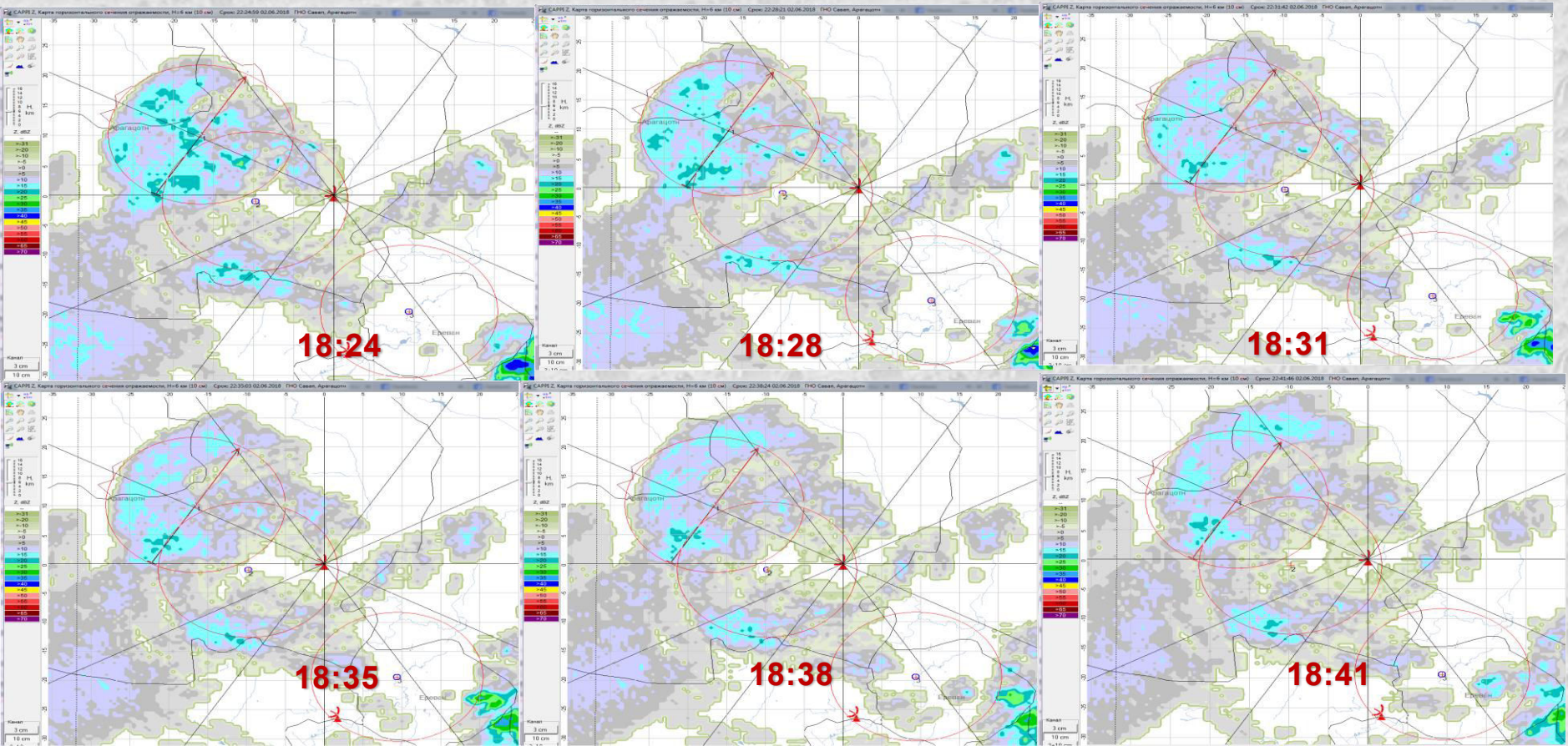
# 4.5 km





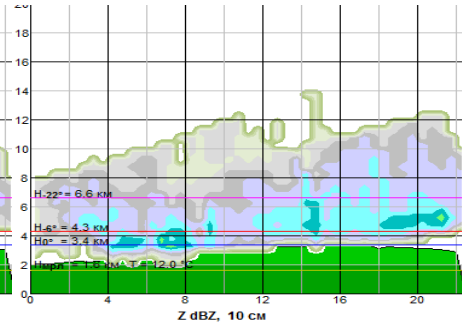
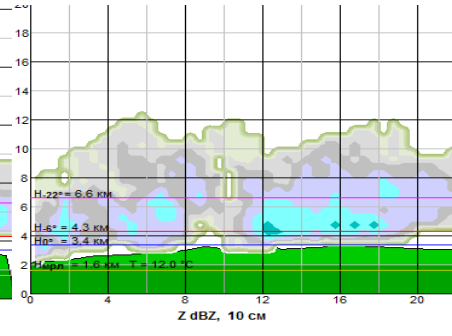
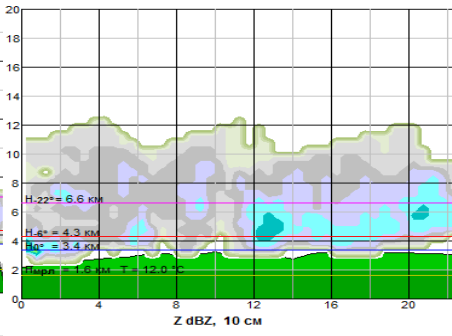
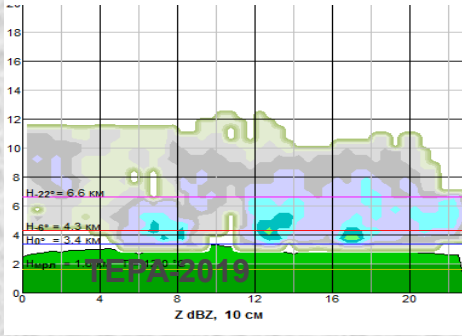
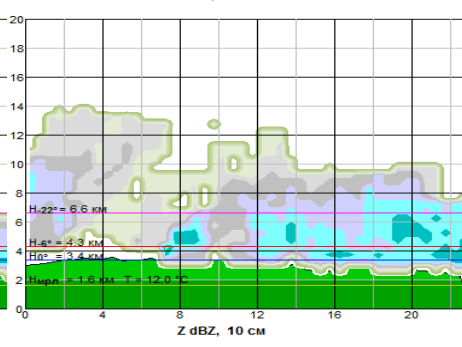
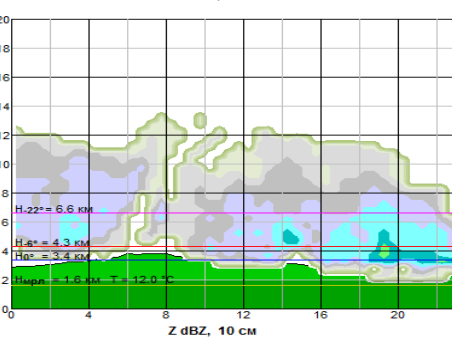
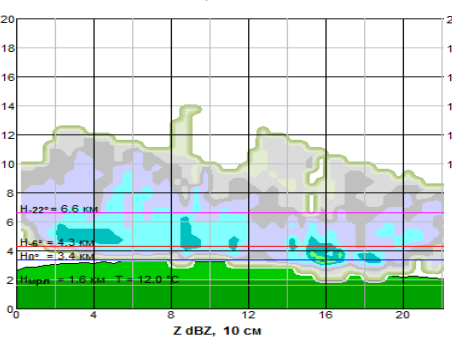
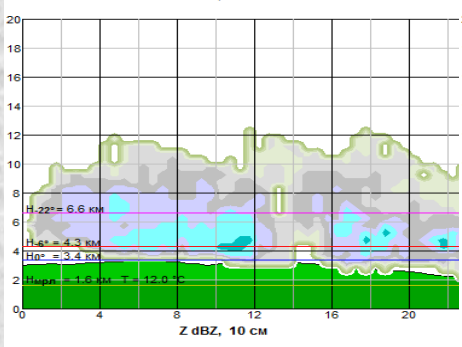
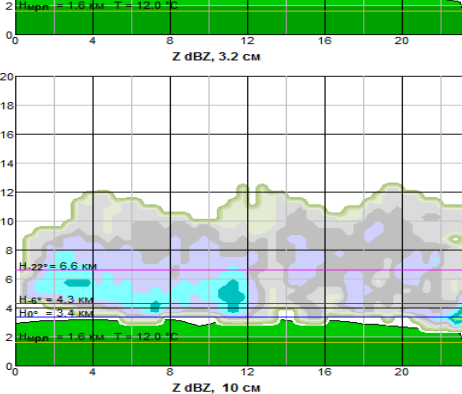
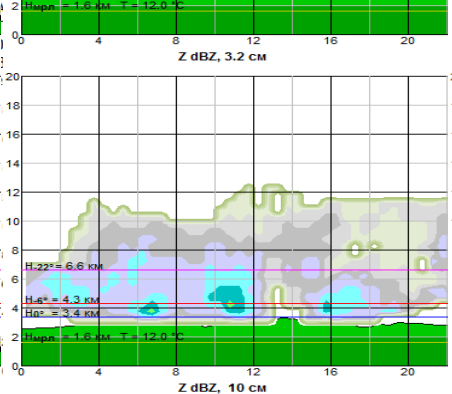
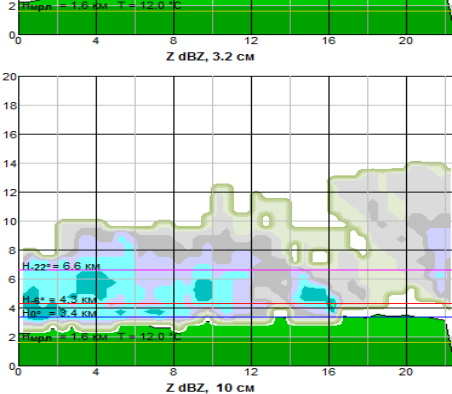
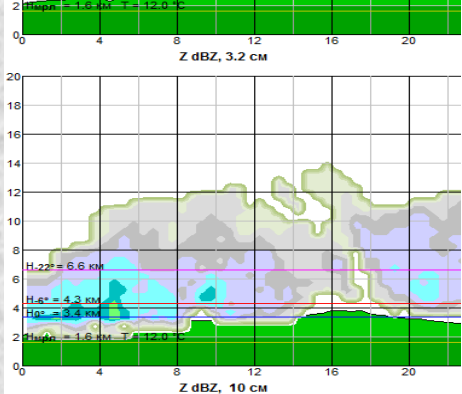


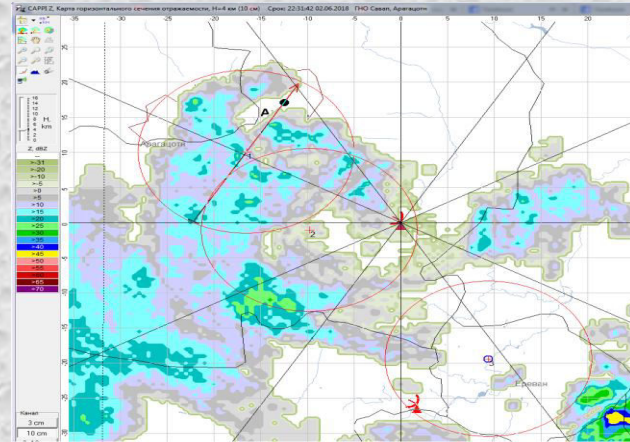
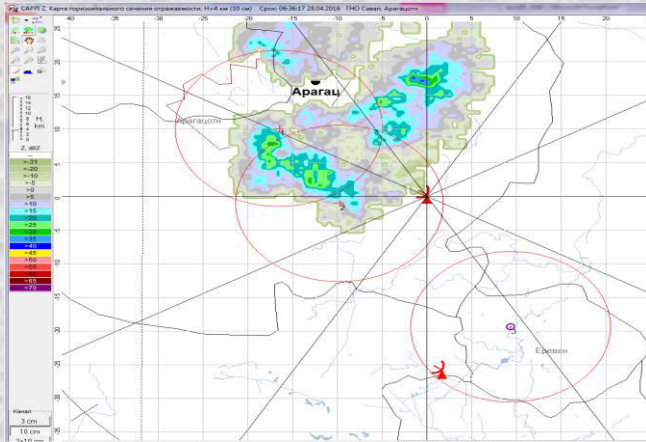
# 6 km



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At 22:31:41 LT  
Station is at ~11.5 km of horizontal  
scale  
below the vertical cut of the figures  
are starting from 0 ° to 330° by step  
of 30 °





**positive case**

**negative case**

Date	CAPPis at 4 km (dBZ)	Electric field (kV/m)	TGEs (sigmas)
<b>Positive Cases</b>			
April 28. 2016 06:36	10	20	21.38
June 10 2016 12:11	5	15	5.8
June 15 2015 22:30	10	17	12.41
May 4 2016 19:03	10	10	37.31
May 11 2015 10:45	15	25	23
May 26 2017 20:49	15	25	7.8
May 30 2018 05:26	10	35	140
<b>Negative cases</b>			
June 2 2018 18:31	25	-23	84.15
May 14 2017 19:13	25	-35	20.69
May 23 2016 15:35	15	-7	29.5
May 23 2016 11:14	15	-20	16

# Summary

- “Radiate” thunderclouds are full of enhanced fluxes of electrons, gamma rays and neutrons.
- Graupel particles have essential role for acceleration of electrons to runaway with the negative charge available within storm.
- Clouds for TGEs with positive field are more isolated than negative ones.
- The prevalence of TGEs in the presence of negative charge overhead is far more common than the positive counterpart during the EOSO.
- The largest magnitudes of electric field generally occur during the EOSO when lightning is relatively infrequent or completely absent.



*Thank you*