

HAIL SUPPRESSION IN CROATIA

Organization and operation

Hail suppression (HS) in Croatia

- First activity has begun around 1950., (with small rockets)
- Hydrometeorological Institute (HMI) was involved from 1967. in operational activity (forecast, warning and developing new methods)
- In 1970. the first radar centre was established for HS (Radar Centre on Psunj)
- In the 1988. passed the first law about HS
- In the 1990. HMI took over all jobs about HS
- In the 1994. HS introduced VORTEX groundgenerators
- From 1995. HS has been working combined : with rockets and groundgenerators



Basis for Hail suppression in Croatia

- The Motiv: Protection of lives and property
- Scientific basis: Microphysics and dynamics of clouds – weather modification
- Theoretical basis: hypothesis (...beneficial competition)
 - successfully – interaction of microphysical and dynamical processes – reduction of hailstone size, or fully melting during fall to the ground
 - seeding the area of new growth (area of weak updraft - BWER)
 - speeding up the natural processes of precipitation creation (premature rain stimulation)
- Legal basis
 - Hail suppression law, Instruction for operative activity and Instruction of technical conditions for hail suppression system
 - Other laws, Instructions, EU Normatives (transportation, storing and handling with explosive and flammable substances)

Last Law about HS

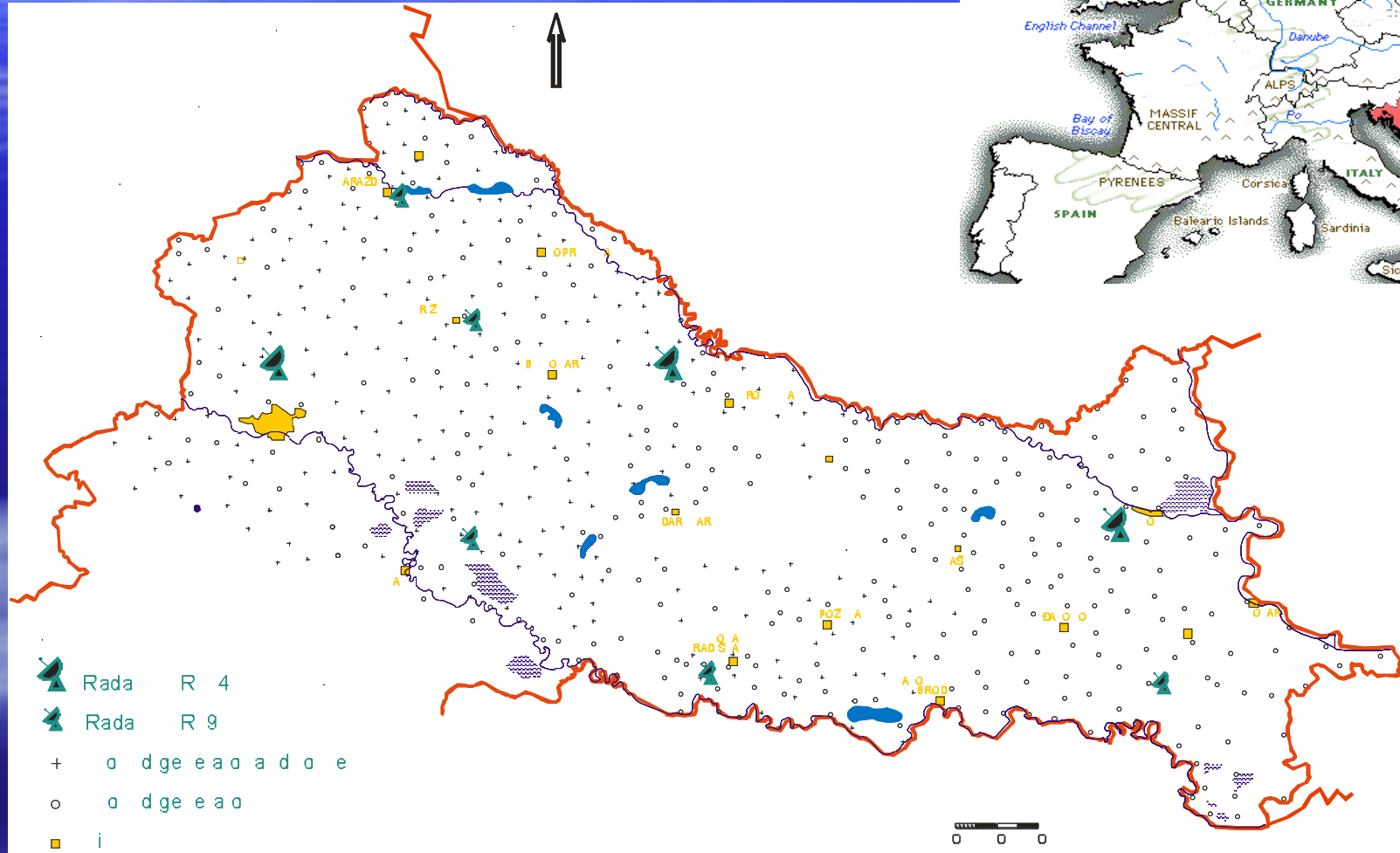
- MHS – is operational performer of HS
- Ministry of Agriculture – is supervisor of HS law implementation
- Funders of HS: Ministry of Agriculture
Ministry of Finance
Local government

Operative implementation of Hail suppression

- Combined system

- enable – continuously spatial and timely early intervention
- ground generators – prefrontal, and preconvective action
 - specialized forecasters
- rockets – for mature Cb systems

Hail protected area in continental part of Croatia



Subject of HS and working area

- 8 radar centers
- 8 radars (3 long range – WSR type, 5 small range – MER93 type)
- 83 employees
- Suppressed area: 26 800 km² (North Croatia)
- 590 Ground gen. stations – 365 Launching stations – 710 Hp stations
- 1300 temporary employees in HS season (May to September)
- Reserve of HS rockets yearly : about 5000 - 7000
 - average consumption for last 10 years (2005 – 2014) : around 3800
- Reserve of Aceton solution of Agl yearly : about 100.000 l
 - average consumption for last 10 years (2005 – 2014) : around 75000 l
- Annual Budget of HS : about 3.500.000 EUR





RC Gorice



Two types of rockets

Long range – 9 km

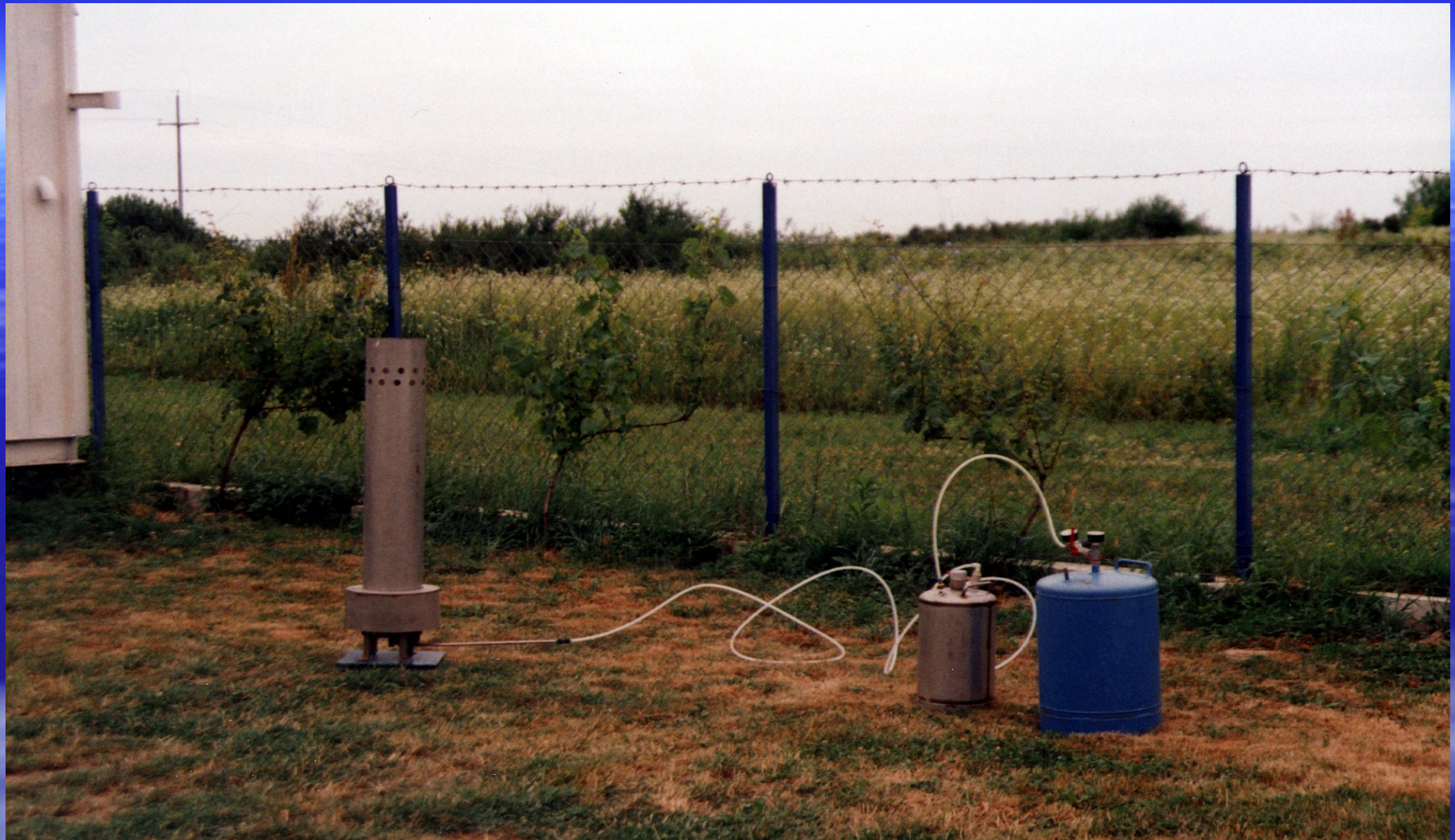
Middle range – 7 km

Minimal seeding of reagent 5×10^{11}
IN per meter of the trajectory

Different types of rockets



Different types of rocket launchers



Ground generator vortex type -- Minimal seeding of reagent 5×10^{13} IN per hour of work of generator

Fig. 1. Monthly distribution of hail occurrence in continental part of Croatia (1981-2005)

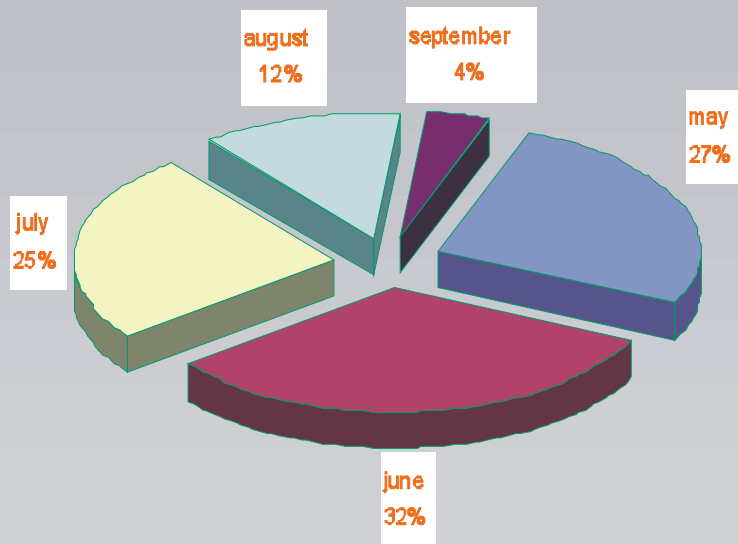
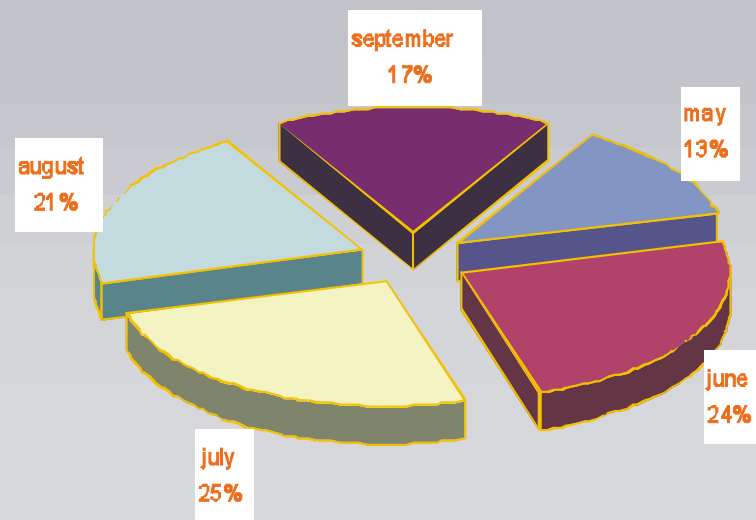
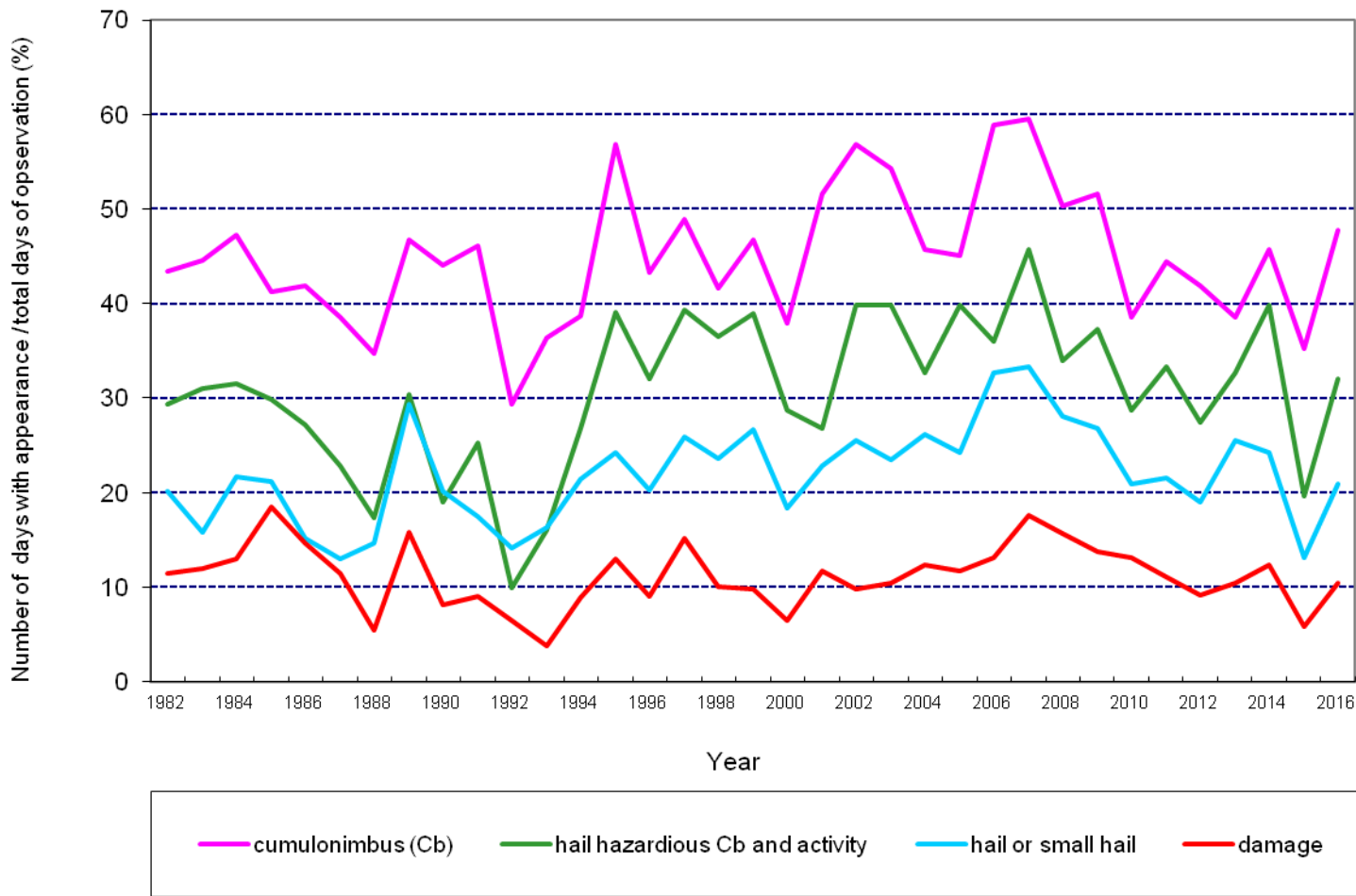
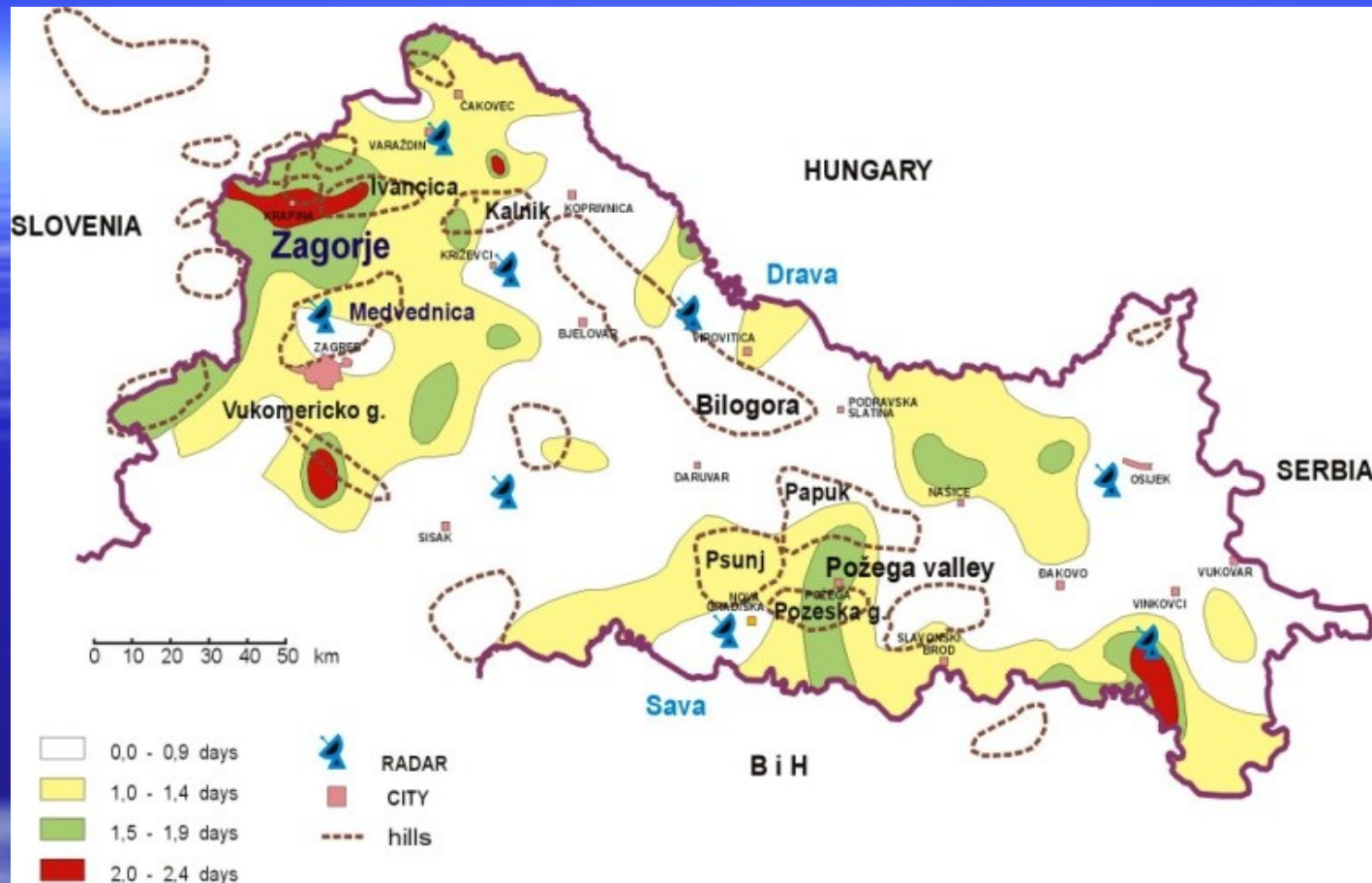


Fig. 2. Monthly distribution of hail occurrence and damage in continental part of Croatia (1981-2005)

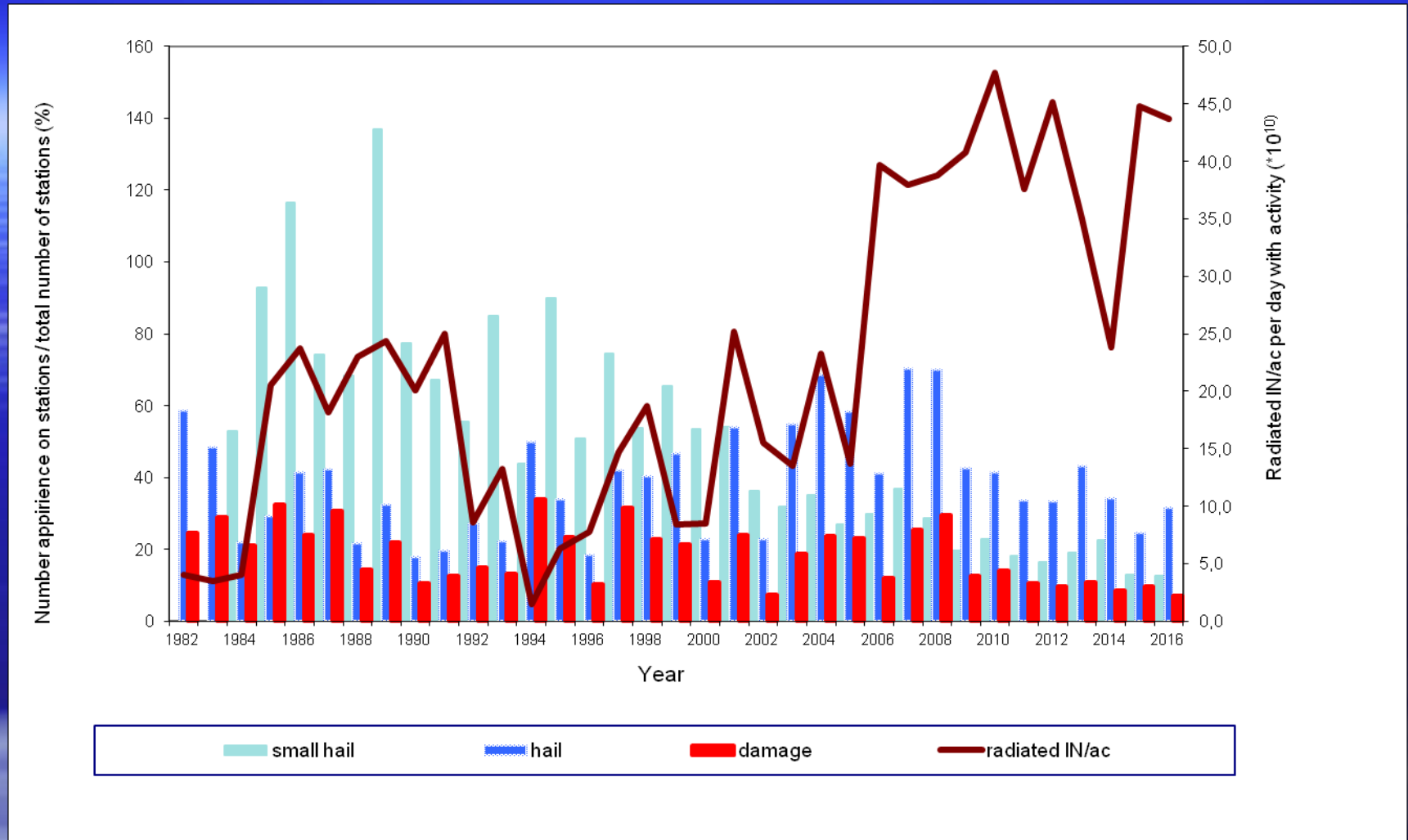




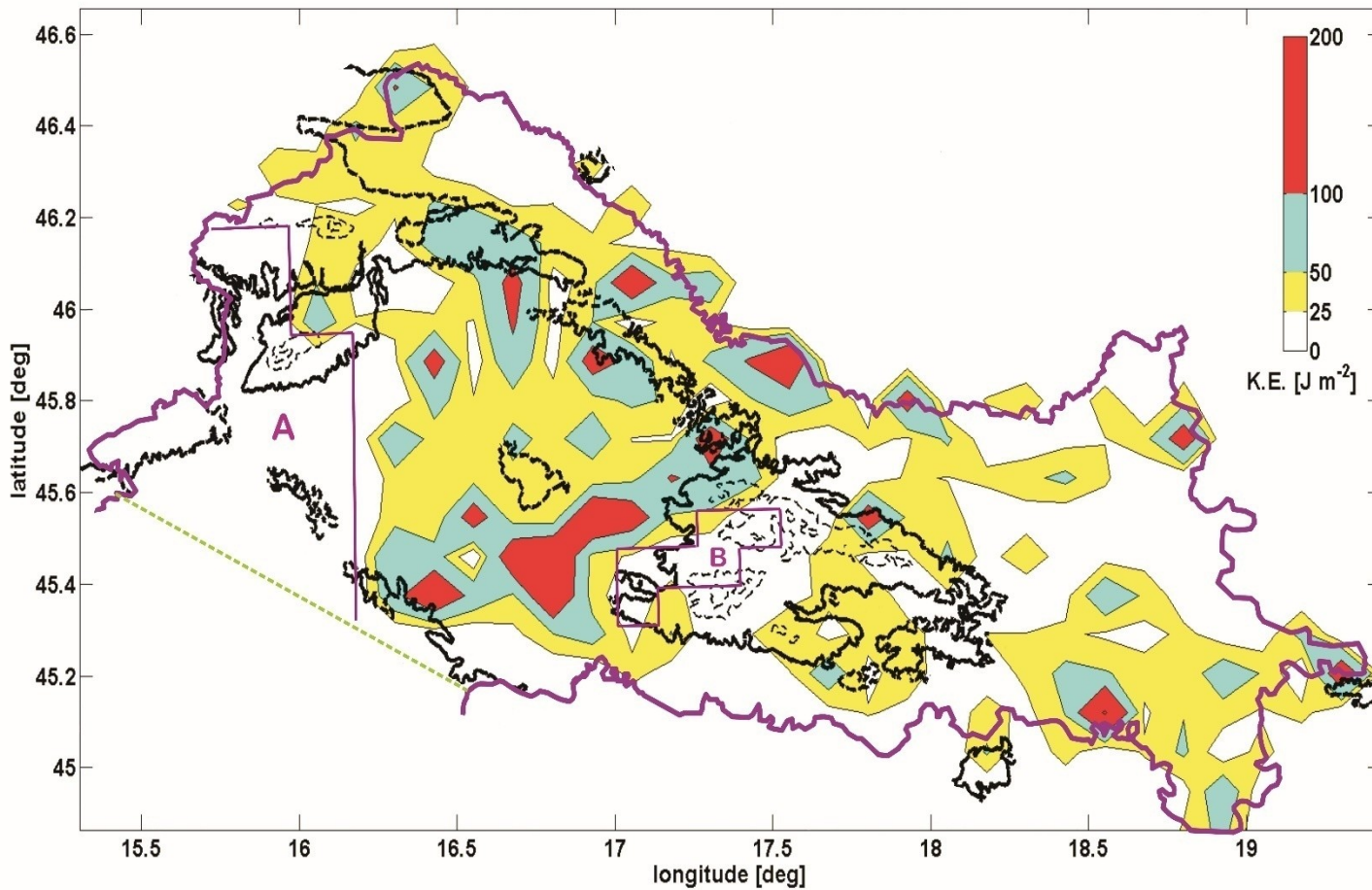
Relative frequency of the days with CB, hail hazardous CB, hail or small hail and damage appearance on the protected area in period 1982 - 2016



Spatial distribution of mean number of days with hail/season in continental part of Croatia (1981. – 2012.)

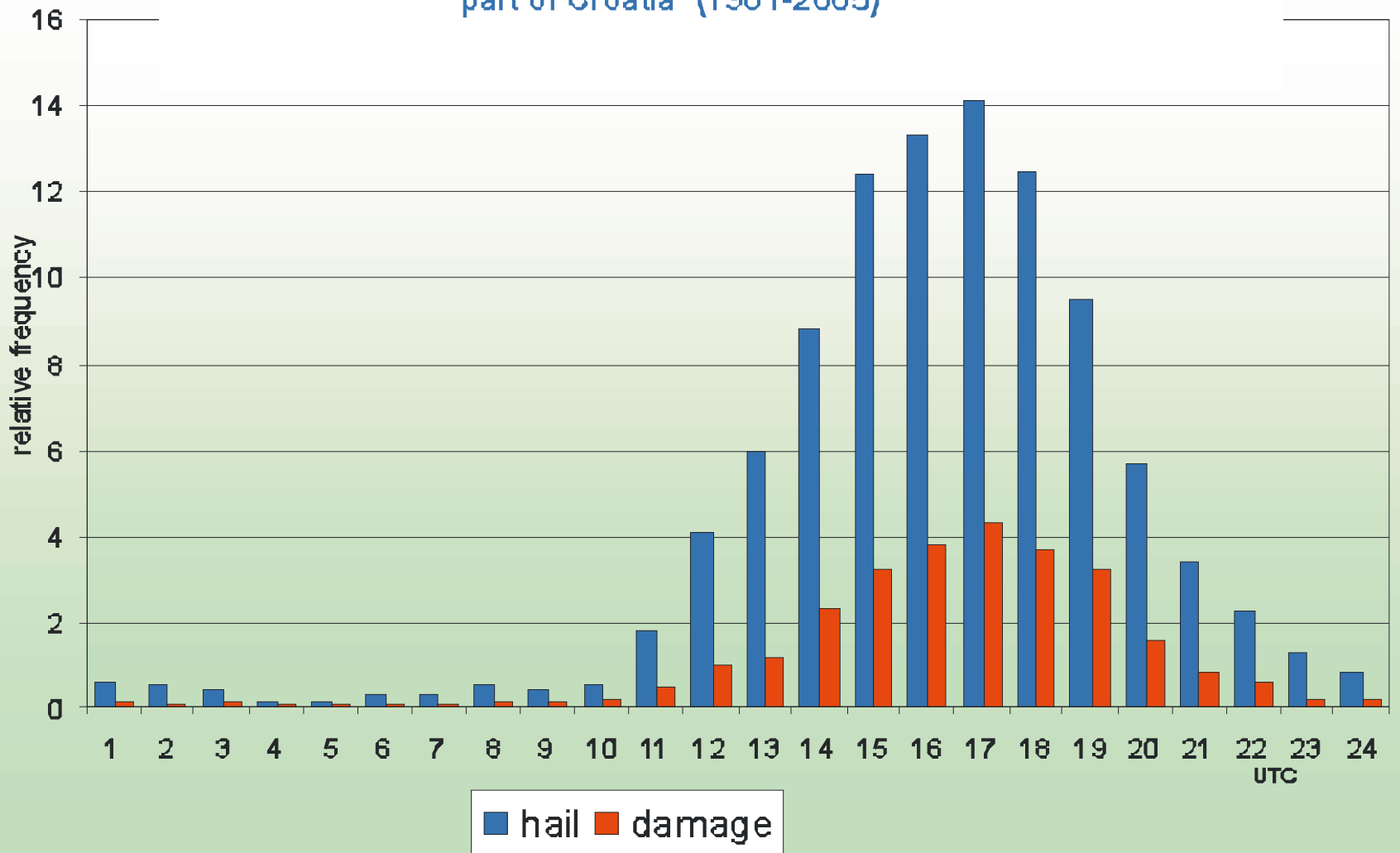


Relative frequency of small hail, hail, damage appearance on HS stations and quantities of seeded IN per acre of protected area in period 1982 - 2016

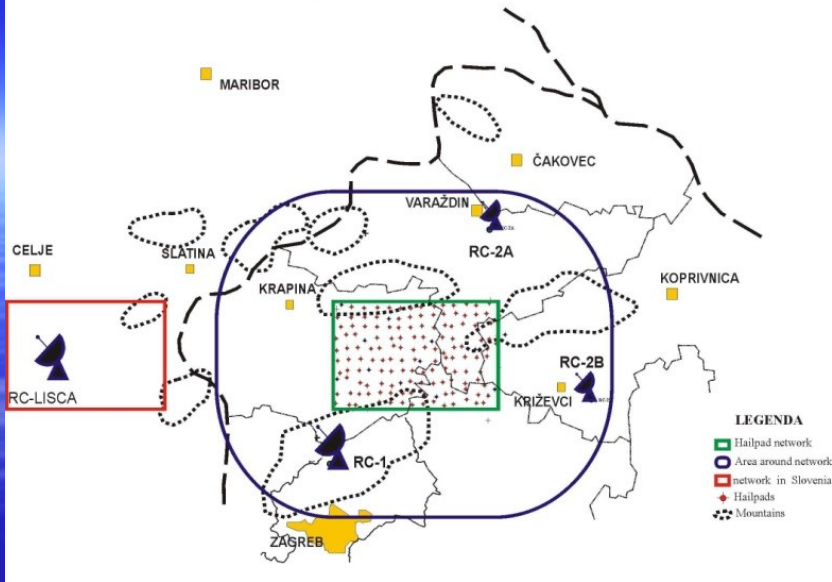


Spatial distribution of the mean kinetic energy in the continental part of Croatia in the period 2002.-2012. (colored contours). Black dashed lines denote orography, starting from 270 m (thick line) at the outer edge of certain mountain. Areas A and B are excluded from the analysis because of none homogenous set of data

Fig. 3. Hourly distribution of hail occurrence in continental part of Croatia (1981-2005)



HAILPAD NETWORK



The hailpad polygon (30 x 20 km) in the western part of the hail-protected territory of Croatia; n=150.



Hailpad

New ideas and new technology

Remote controlled ground generator



Remote controlled launching station



INVESTIGATION RESULTS AND CONCLUSIONS

Spatial analysis of mean number of days with hail shows two different areas. Western (hilly) part is area with the greatest number of days with hail (specially endangered area is Zagorje), between three greater mountains, with average more than two days per season.

East, flat area, has mostly minimum days with hail, and the values ranges from 0,1 to 0,9 days, except in areas with lower mountains.

Spatial distribution of hailfall duration shows mostly longer average duration of hailfall in front of the mountain concerning the Cb cells movement.

Thank you

