

## **About the Use of Anti-Hail Rockets "Loza-2" in the Work of Anti-Hail System in Kakheti (Georgia)**

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### **ABSTRACT**

*In the Kakheti region of Georgia in the work of anti-hail system anti-hail rockets "Loza-2" of the production of Bulgaria from September 2018 are used. Some results of the calculations of the optimum areas of cloud seeding by the crystallizing reagent for more than 80 points of action located on the protected territory in Kakheti are given. The characteristics of the anti-hail rockets "Loza-2" and "Trayal D 6-B" are compared.*

**Key Words:** Weather modification, anti-hail rockets.

### **Introduction**

In Georgia special attention is paid to the scientific and practical works on the fight with the hail [1-3]. Production work on the fight with the hail here was conducted in the period from 1967 through 1989 [2,3]. Taking into account importantly this problem [4] with the support of the government of Georgia, to the active operation of Scientific-Technical center "Delta", the collaborators of institute of geophysics and institute of hydrometeorology, the work of anti-hail service in Kakheti in the end of May 2015 was restored [5-7].

From the set of anti-hail items in 2015 year it was possible to acquire the anti-hail rockets SK-6 of the productions of Macedonia [2,6,8-10], which were used until August 2016. From September 2016 to August 2018 for dealing with the hail anti-hail rockets "Trayal D 6- B" of the production of Serbia were used [11,12]. From September 2018 to present anti-hail rockets "Loza-2" of the production of Bulgaria are used [13].

Some results of the calculations of the optimum areas of cloud seeding by the crystallizing reagent of anti-hail rockets "Loza-2" for more 80 points of action located on the protected territory in Kakheti are given below. The characteristics of the anti-hail rockets "Loza-2" and "Trayal D 6-B" are compared also.

### **Material and methods**

To protect the whole region of Kakheti (800 thousand hectares) in 2018-2019 more than 80 launching points were used. There is a rocket launching device, solar panel, grounding and security

systems installed on the launching site. The launching device carries 26 anti-hail rockets, aims to any given direction and fires [10]. The launchers at the heights from 205 to 1775 m above sea level placed [12].

The anti-hail rocket „Loza-2“ the production of Bulgaria (fig. 1) is an unguided, 55 mm rocket, which carries  $1.28 \cdot 10^{16}$  particles of silver iodide reagent and disperses it for 30 seconds [13]. Some parameters of anti-hail rocket „Loza-2“ is represented lower.



Fig. 1. Anti-hail Rockets „Loza-2“ (photo in real form and in the container for transport).

Anti-hail rocket „Loza-2“ technical parameters [13].

- Rocket quantity in launching device SD-26 or SD-52: 26-52 rockets
- Elevation: 55-80°
- Traverse: 360°
- Rocket diameter: 55 mm
- Rocket length: 876 mm
- Rocket weight: 3300 gram
- Initial speed of rocket: 70 m/sec
- Rocket maximum velocity: 600 m/sec
- Shoot maximum distance at sea level (elevation 55°): 7900 meter
- The maximum from sea level (elevation 80°): 5800 meter
- Mass of reagent: 400 gram
- The outlet of reagent from the rocket at a temperature -10°C –  $1.28 \cdot 10^{16}$  particles
- Reagent emission start: 7-10 sec
- Duration of the reagent emission: 30 sec
- Diameter of the dissipated reagent: 5 m

Data about concentration of reagent in the initial volume of the flight paths of different anti-hail rockets in table 1 are presented [2,8-10].

As follows from this table, the concentration of the reagent in the initial volume of the flight path of the “Loza-2” rocket is quite high and commensurate with such modern rocket as “Alazan-9”, “Alan-2”, “Ac”, “SK-6” [2,8-10].

Table 1

Concentration of reagent in the initial volume of the flight paths of different anti-hail rockets,  $m^{-3}$

| The initial radius of the route, m | Alazan-2M | Alazan-6 | Alazan-9 | Alan-2  | Ac      | SK-6    | Trayal D-6B | Loza-2   |
|------------------------------------|-----------|----------|----------|---------|---------|---------|-------------|----------|
| 2-2.5                              | 2.5E+10   | 4.2E+10  | 7.5E+10  | 6.6E+10 | 1.6E+11 | 1.1E+11 | 3.5E+10     | 1.19E+11 |

The calculations of the optimum areas of cloud seeding by the crystallizing reagent it was carried out taking into account level of the zero isotherm (and isotherm  $-6.0\text{ }^{\circ}\text{C}$ ) [14-16] and also heights of the arrangement of launchers.

### Results and discussion

The results of calculations on Fig. 2-6 and table 2 are presented.

As follows from fig. 2-6 and table 2 optimum areas of cloud seeding by the crystallizing reagent depend on the height of the arrangement of launchers and level of isotherm  $-6^{\circ}\text{C}$ . Distribution of the optimum areas of cloud seeding by reagent is unevenly. Basic reason for this - the insufficiently long courses of the rocket “Loza-2” (as and rocket “Trayal D-6B” [12]).

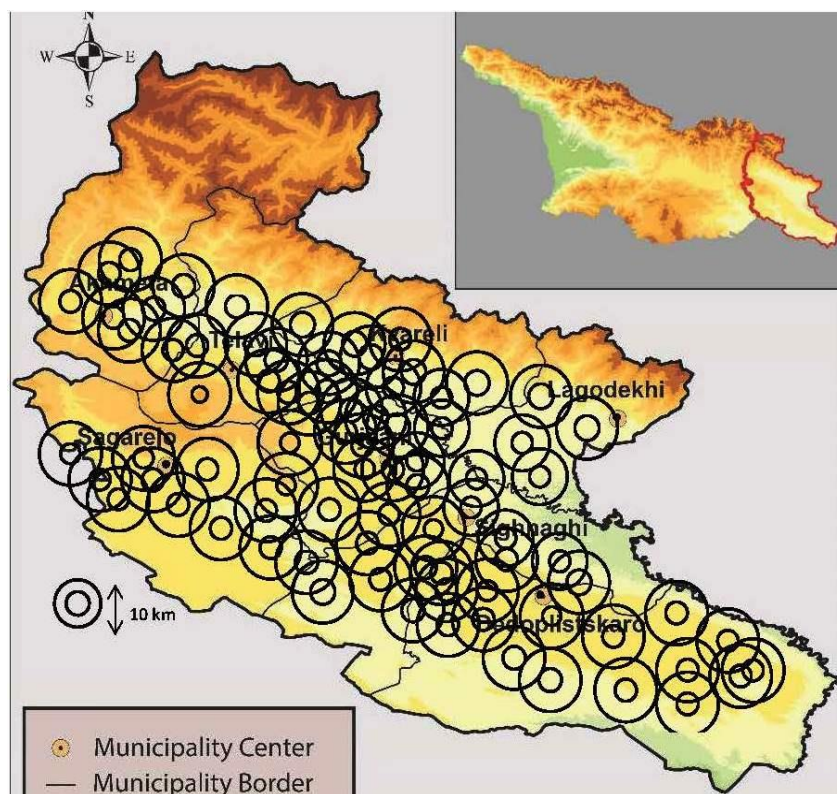


Fig. 2. Optimum areas of cloud seeding by the crystallizing reagent for the points of action by anti-hail rockets “Loza-2” in the protected territory in Kakheti. Height of the isotherm  $-6^{\circ}\text{C}$  = 3.6 km.

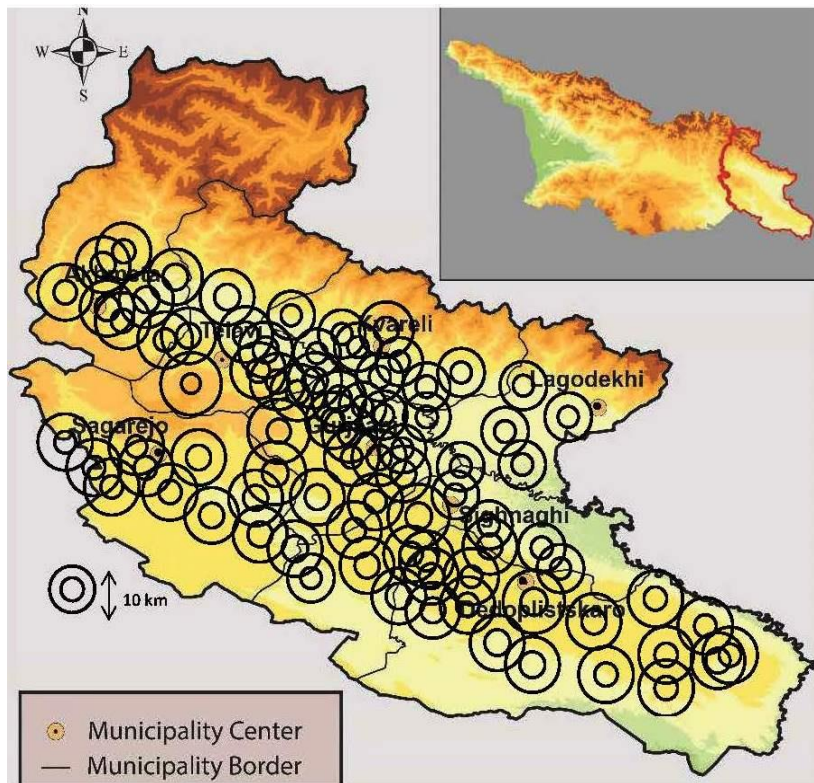


Fig. 3. Optimum areas of cloud seeding by the crystallizing reagent for the points of action by anti-hail rockets “Loza-2” in the protected territory in Kakheti. Height of the isotherm  $-6^{\circ}\text{C} = 4.4$  km.

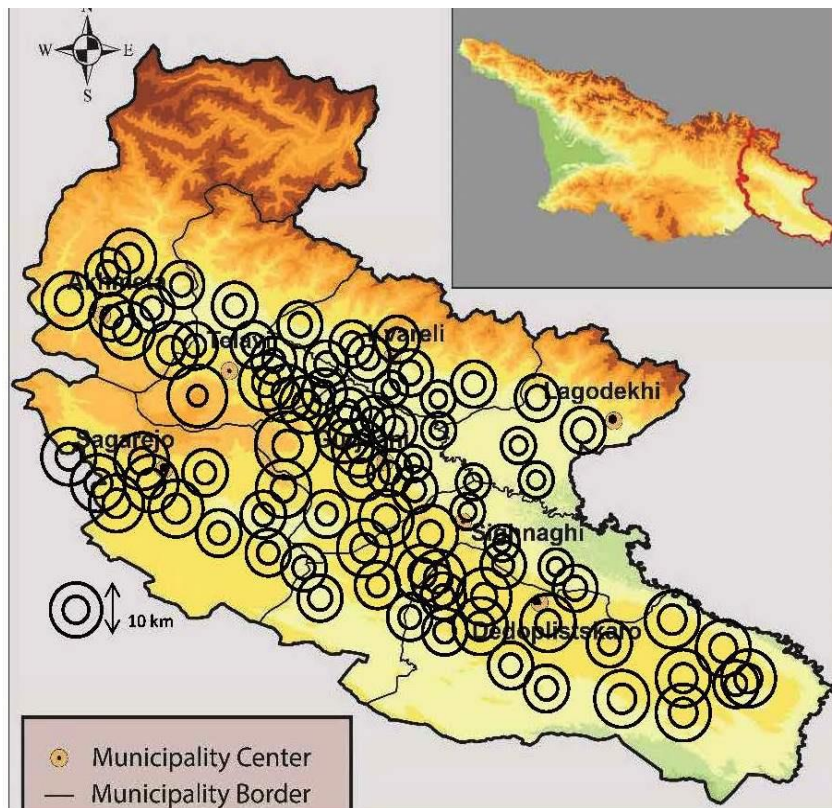


Fig. 4. Optimum areas of cloud seeding by the crystallizing reagent for the points of action by anti-hail rockets “Loza-2” in the protected territory in Kakheti. Height of the isotherm  $-6^{\circ}\text{C} = 5.2$  km.

Table 2

Comparison of the characteristics of cloud seeding by reagent from the rockets “Loza-2” and “Trayal D-6B”

X1 - beginning of the optimal seeding route, X2 - end of the seeding route, (X2-X1) - optimal length of the horizontal projection of the seeding route, S - optimal horizontal seeding area, the height of the point of action: 250-550 m a.s.l.

| H T(-6°C),<br>km | Loza-2 | Trayal<br>D-6B | Loza-2 | Trayal<br>D-6B | Loza-2         | Trayal<br>D-6B | Loza-2             | Trayal<br>D-6B     |
|------------------|--------|----------------|--------|----------------|----------------|----------------|--------------------|--------------------|
|                  | X1, km | X1, km         | X2, km | X2, km         | (X2-X1),<br>km | (X2-X1),<br>km | S, km <sup>2</sup> | S, km <sup>2</sup> |
| 3.2              | 2.1    | 2.7            | 6.6    | 6.3            | 4.5            | 3.6            | 123                | 101                |
| 3.6              | 2.4    | 2.7            | 6.4    | 6.1            | 4.0            | 3.4            | 113                | 93                 |
| 4.0              | 2.4    | 2.3            | 5.9    | 5.5            | 3.5            | 3.2            | 93                 | 78                 |
| 4.4              | 2.5    | 2.1            | 5.6    | 4.9            | 3.1            | 2.8            | 78                 | 62                 |
| 4.8              | 2.2    | 1.9            | 4.7    | 4.1            | 2.5            | 2.2            | 56                 | 42                 |
| 5.2              | 2.0    | 1.8            | 4.1    | 3.6            | 2.0            | 1.8            | 39                 | 32                 |
| 5.6              | 1.8    | 1.7            | 3.3    | 3.1            | 1.5            | 1.4            | 26                 | 22                 |
| 6.0              | 1.8    | 1.4            | 3.1    | 2.3            | 1.2            | 0.9            | 19                 | 11                 |

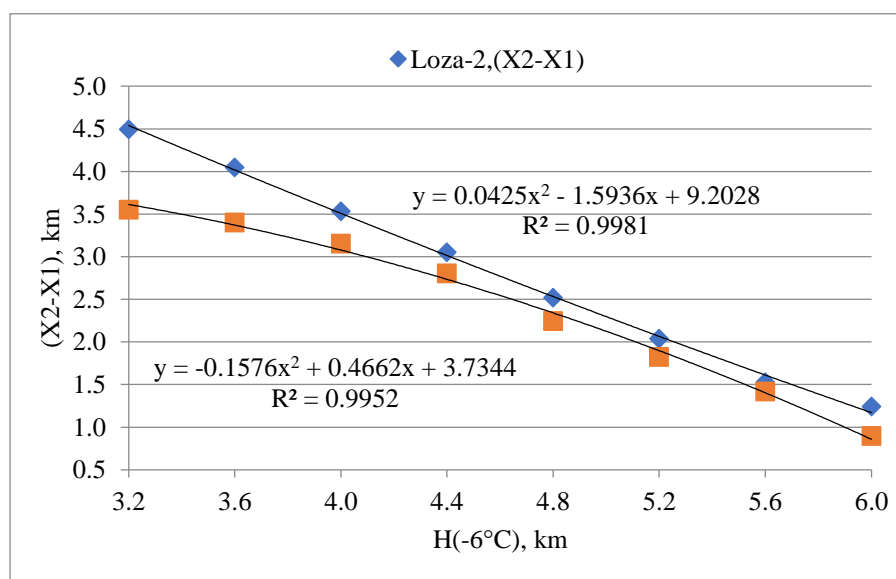


Fig. 5. Dependence of optimal length of the horizontal projection of the seeding route from the rockets “Loza-2” and “Trayal D-6B” from izotherm -6°C.

The height of the point of action: 250-550 m a.s.l.

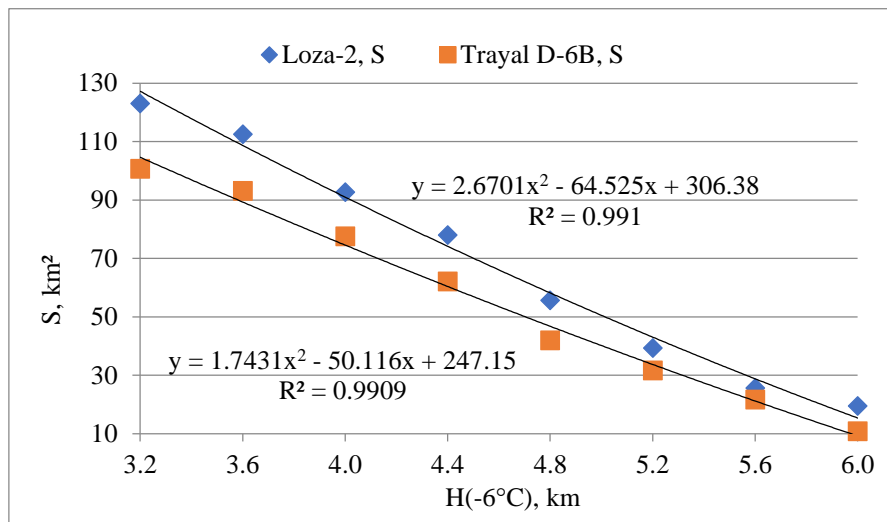


Fig. 6. Dependence of the optimal horizontal seeding area from the rockets “Loza-2” and “Trayal D-6B” from izoterm  $-6^{\circ}\text{C}$ . The height of the point of action: 250-550 m a.s.l.

In general, the characteristics of the rockets “Loza-2” are slightly better than “Trayal D-6B”. However, both types of the rockets are characterized by an insufficient length of the seeding path. The number of rockets „Loza-2“ as and "Trayal D 6- B" needed during one year estimated to be 5000-6000 units [12].

## Conclusions

In near future it is planned to improve means and methods of anti-hail protection in connection with local conditions and possibilities of obtaining the means of action and tracking of the hail clouds. The newly created distance automatic system of action on the clouds will be simultaneously improved, a question about the organization of own production of anti-hail rockets will be examined, etc. [16,17].

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## **კახეთის (საქართველო) სეტყვასაწინააღმდეგო სისტემის მუშაობაში “Loza-2” ტიპის სეტყვასაწინააღმდეგო რაკეტების გამოყენების შესახებ**

**ა.ამირანაშვილი, ვ.ჩიხლაძე, უ.ძოდუაშვილი, ი. საური, შ. თელია**

### **რეზიუმე**

2018 წლის სექტემბრიდან საქართველოში კახეთის რეგიონში სეტყვასაწინააღმდეგო სამსახურში გამოიყენება ბულგარეთის წარმოების “Loza-2” ტიპის სეტყვასაწინააღმდეგო რაკეტები. კახეთში დასაცავ ტერიტორიაზე განლაგებული ზემოქმედების 80-ზე მეტი პუნქტისთვის მაკრისტალიზებელი რეაგენტით ღრუბლების ჩათესვის ოპტიმალური ფართობების გათვლების ზოგიერთი შედეგია მოყვანილი. შედარებულია სეტყვის საწინააღმდეგო რაკეტების "Loza-2" -ის და Trayal D 6- B" -ს მახასიათებლები.

## **Об использовании противорадовых ракет “Loza-2” в работе противорадовой системы в Кахетии (Грузия)**

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И.П. Саури, Ш.О. Телия**

### **Резюме**

С сентября 2018 года в Кахетинском регионе Грузии в работе противорадовой системы используются противорадовые ракеты “Loza-2” производства Болгарии. Приводятся некоторые результаты расчетов оптимальных площадей засева облаков кристаллизующим реагентом для более чем 80 пунктов воздействия, расположенных на защищаемой территории в Кахетии. Проведено сравнение характеристик противорадовых ракет “Loza-2” и "Trayal D 6- B".