ICE NUCLEI MEASUREMENTS IN ITALY

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1. OPERATIVE AREAS

In Italy, SO.R.E.M. carries out experimental campaigns for anti-hail defense for various Official Bodies (Regions and Provinces) in various Official Bodies (Regions and Provinces) in several areas of Northern Italy.

The interested area amounts in total to more than 10^6 ha = 10,000 km^2, subdivided in 9 operative areas, the sizes of which range from 35,000 to 390,000 ha.

Three of these areas are contiguous; really, they make up one large surface of 520,000 ha = 5,200 km^2 (picture 1).

2. TECHNIQUE OF INTERVENTION

The technique applied by SO.R.E.M. is a combined one. In each main operative area, a 24 hour Meteorological Centre guides the operations; it is equipped with X-band radar, calibrated for the purpose. There are two types of intervention: preventive (H24) with stationary and mobile ground-generators, and immediate (H-J) by airplanes. A decision about preventive intervention is based mainly on the elaboration of synoptic and local meteorological data; a decision for airplane use is based on radar observations, on the basis of the value of echo reflectivity in the operative area, as well as in a peripheral strip.

3. MEASURES OF ICE-NUCLEI CONCENTRATION

Considering the basic role performed by the ground generators, either stationary or mobile, a considerable effort has been devoted to the development of cold chambers for the monitoring of the ways of diffusion of artificial nuclei, as well as for the concentration of natural ones.

Where this is allowed by the orographic characteristics of the operative areas, automatic stations have been established on the mountains equipped with automatic analyzers, belonging to the "Puy de Dome" type, carrying out 24 measures per day.

In cooperation with French specialists (particularly with Professor Admirat), measurements with airplanes were strongly promoted.

4. THE CFM/AVIO 12

For some years, a kind of cold chamber working with eutectic fluid

was employed. It was ground cooled, then airborne exploiting the thermic inertia and the insulation. Since 1974, however, a kind of cooled chamber is being used with a refrigerating unit powered by the airplane electrical equipment. This has a measurement volume of 2 liters, cooled by an automatic refrigerating circuit (picture 2).

The measurement chamber is checked with a thermistor thermometer; the equipment is completed by an electric aspirator and humidifier, both powered by the airplane electrical net. This cold chamber, the endurance is only conditioned by the airplane's autonomy.

5. THE AIRPLANES

The airplanes used in the measurements are both single (150 HP: P66) and twin (400 HP: P/68).

With the former type, the practical achievable altitude during the measurements is about 12,000 feet; the twin type has a practical ceiling of 21,000 feet.

Practically, however, there is no interest in measurements above 5-6000 feet.

Particular care has been taken in securing the pure air-inlet to the cold chamber, preventing any pollution due to engine exhaust gas.

6. RESULTS OF MEASUREMENTS

Several measurements were carried out both inside and outside the operative areas, without interventions, to determine the values of the concentration of natural ice-nuclei. Considering the maximal envelope-curves, the results are as follows:

	Temperature °C		
	-10	-15	-21
Concentration n/l	1.7	5.5	15.0

(See Fig. 3)

During the years from 1971 to 1973, on the analogy of what was made in the ground measurement stations, measures at the temperature of -21°C were carried out.

Starting from 1974, also on the basis of Professor Admirat's suggestions, measures have been consistently carried out at temperature of -15°C.

Although the measurable concentration is lower at -15°C the natural level sharply decreases; therefore, it is easier to observe the effects of

the diffusion of artificial nuclei.

The following table reports the results of 51 measures carried out at -15°C in 1974; the distribution is shown as "multiples of the natural background", which, as previously said, at this temperature will surely be lower than 5.5 n/l.

As can be observed, the highest frequencies occur for background multiples ranging from 10 to 30 times. It is to be noted that the last class (40 times and beyond) includes values as high as 150 times the natural background (Fig. 4).

	CLASSES OF NATURAL BACKGROUND MULTIPLES						Total
	≤ 1	1/10	10/20	20/30	30/40	>40	
Frequency %	2	45	25	16	6	6	100
Cumulative frequency	100	98	53	28	12	6	

(See Fig. 4)

7. SOME RESULTS OF THE "STATIONARY" MEASUREMENT STATIONS

As above said, these automatic stations operate around-the-clock. Therefore, they are particularly suited to point out the variations of the ice-nuclei concentration during the day; since 1973, in Vicenza operative area, a station is located on the northern border of the district, at an altitude of about 2,500 feet (Fig. 5).

This station has allowed a good evaluation of the characteristics of diffusion of nuclei produced by ground-generators (about 40 stationary and 4 mobile on a surface of about 2,000 km^2).

Also, the existence of huge phenomena of "persistence" (whose nature, causes and modalities are still to be explained) is confirmed and represents an interesting field of investigation (Fig. 6 and following ones).

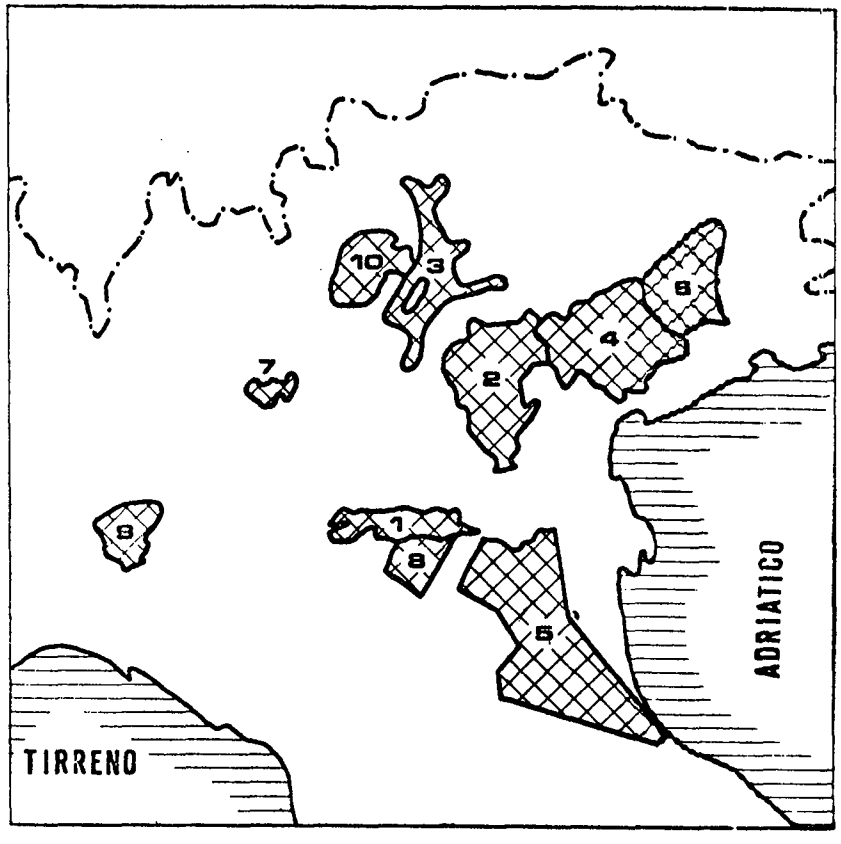

Fig. 1 - Operative areas of the experimental anti-hail campaigns SO.R.E.M. 1975 in Italy: 1) Bassa Mantovana; 2) Prov. di Vicenza; 3) Prov. di Trento; 4) Prov. di Treviso; 5) Prov. di Bologna, Ferrara, Forlì, Ravenna; 6) Prov. di Pordenone; 7) Prov. di Brescia; 8) Prov. di Modena; 9) Prov. di Pavia; 10) Bacino Sarca-Chiese (rain stimulation).

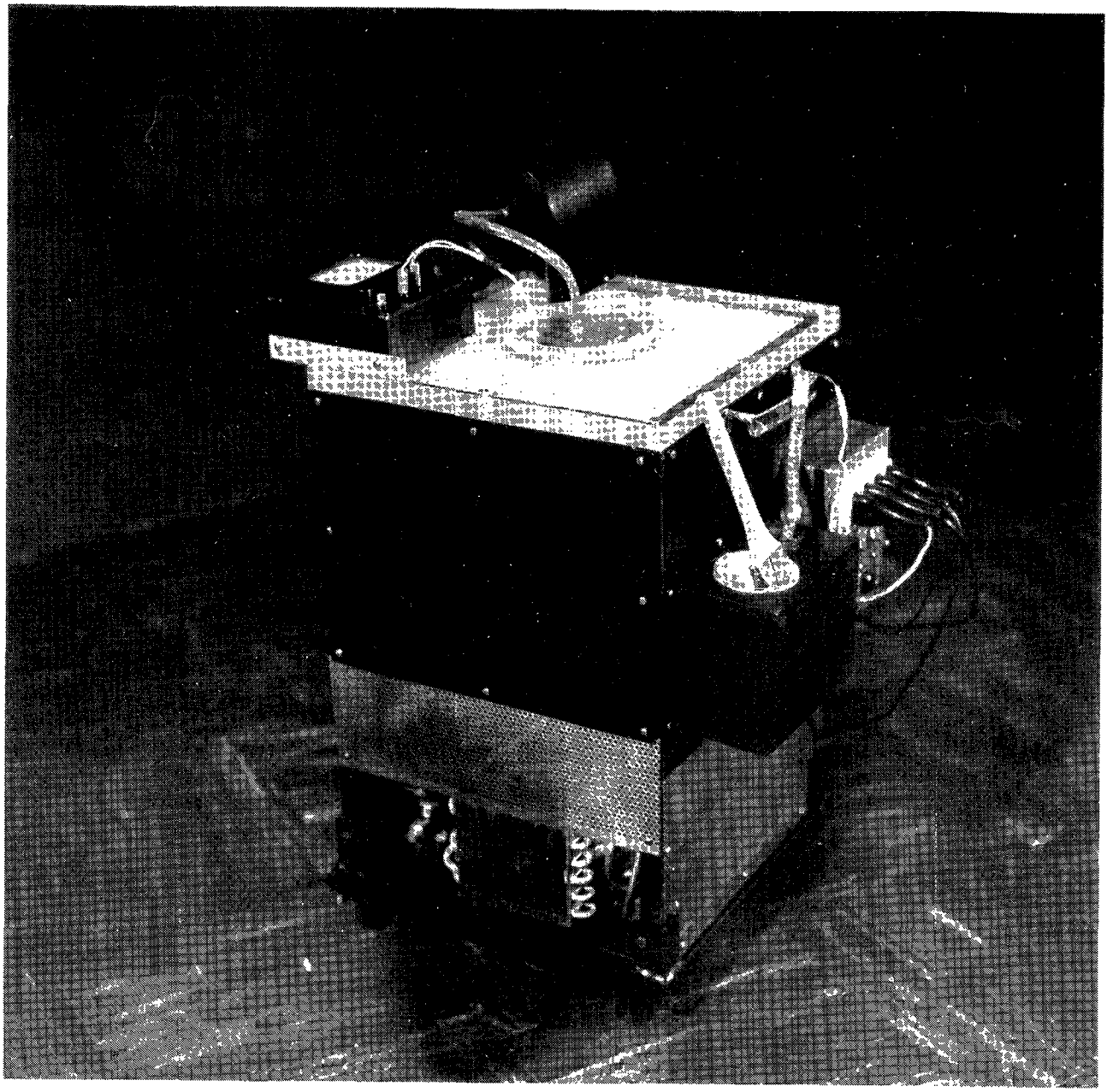

Fig. 2 - Airborne cold-box type CFM/AVIO 12; supplied by the aircraft power system 12 Volt.

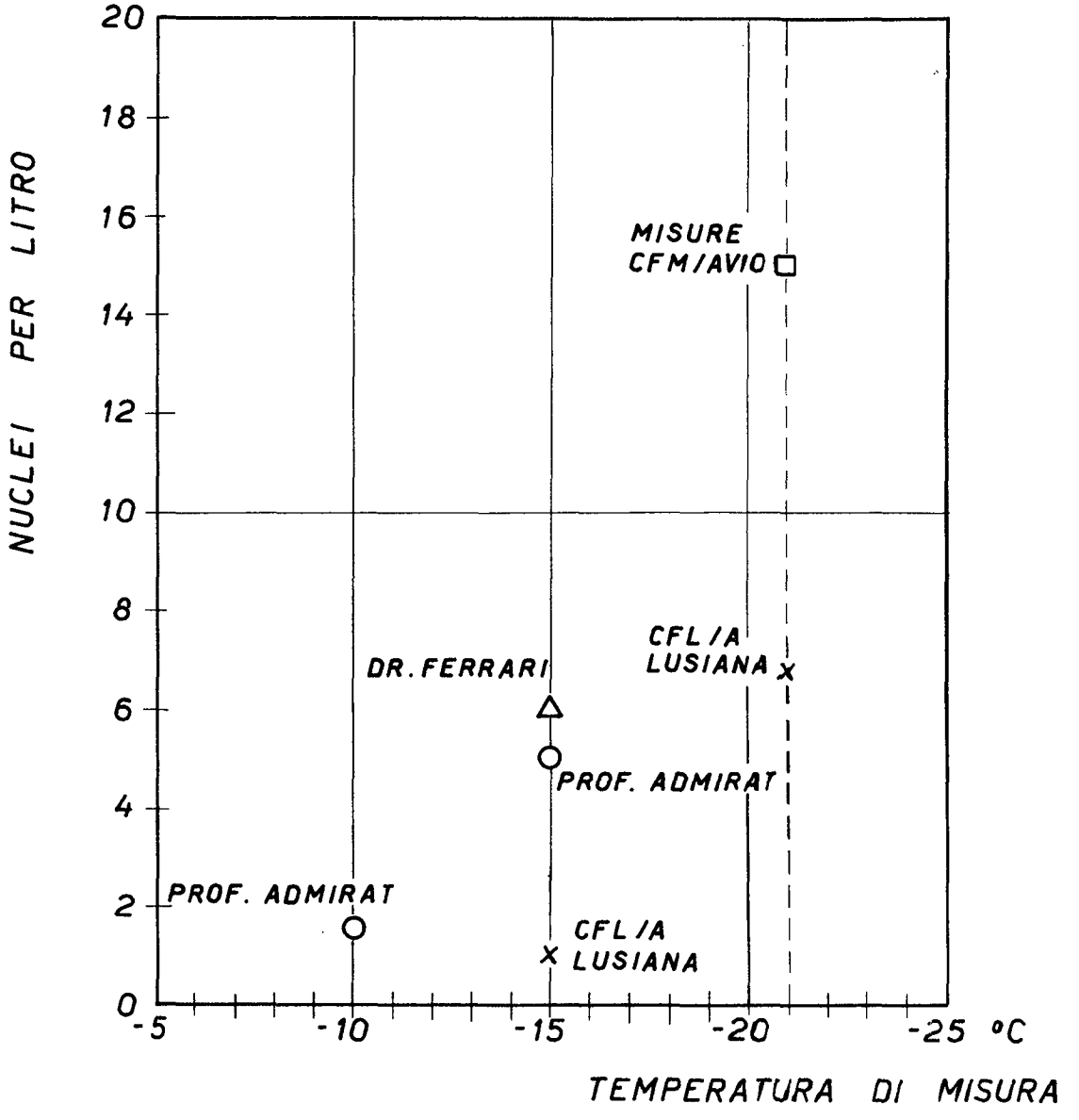

Fig. 3 - Relationship between the temperature in the cold-box and the ice-nuclei concentration

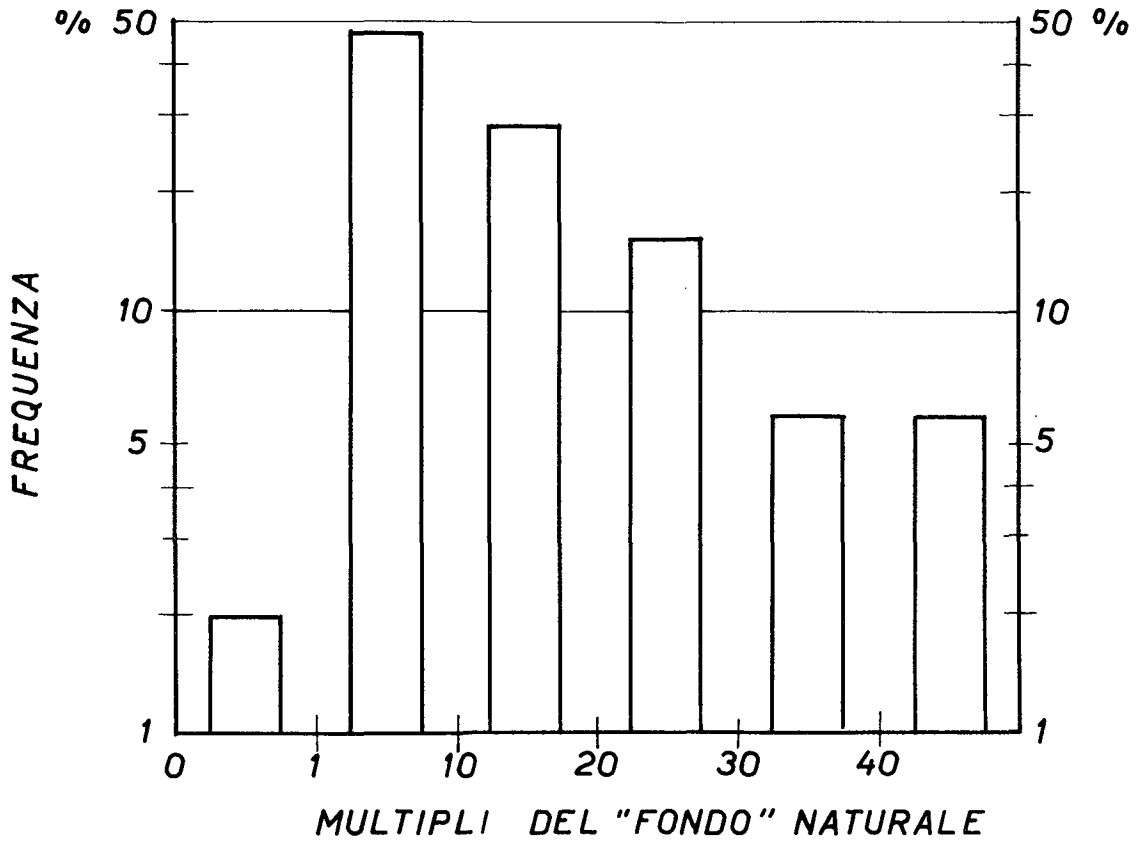

Fig. 4 - Frequency of the ice-nuclei measurements subdivided in classes of the natural background multiples

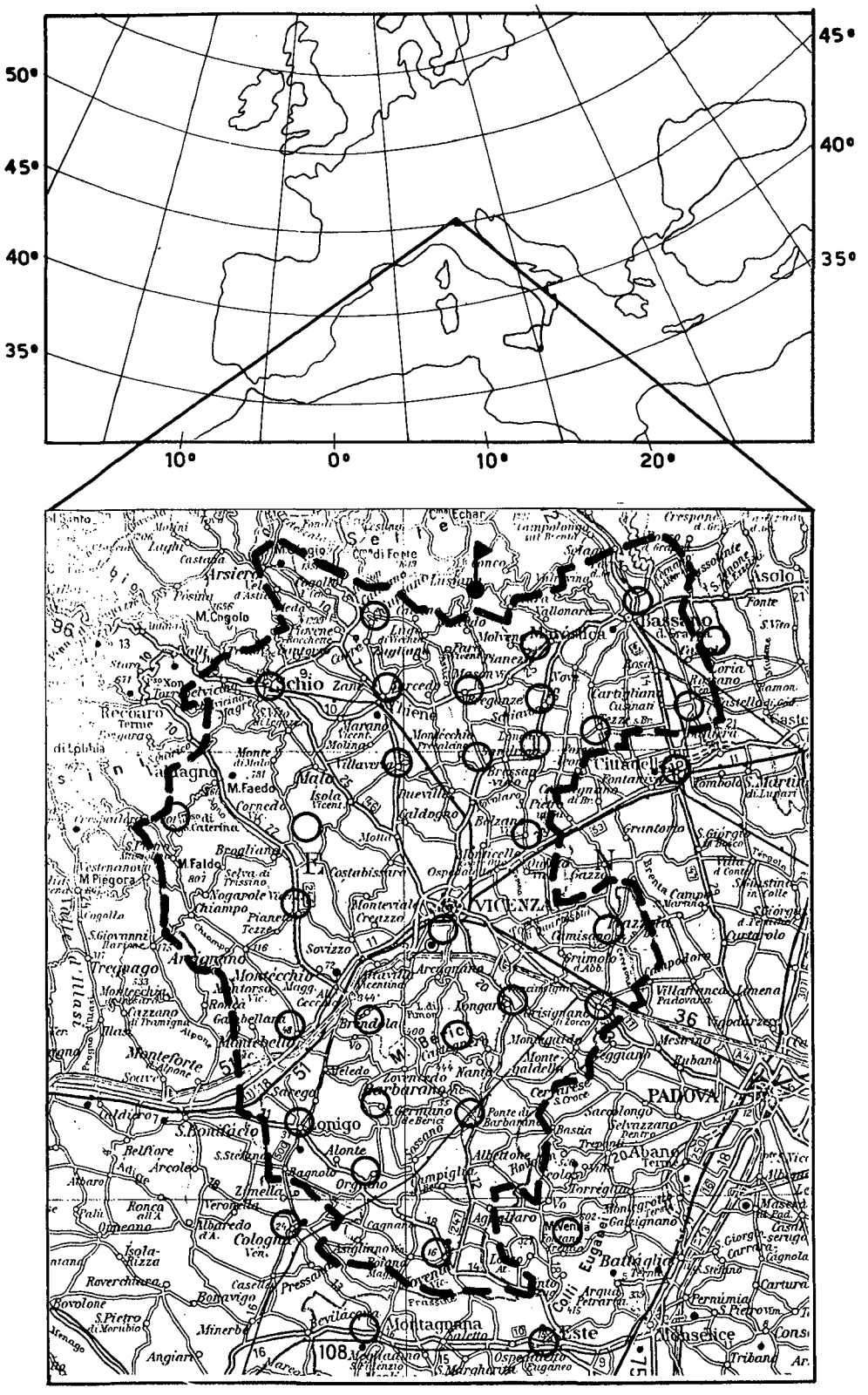

Fig. 5 - Experimental area anti-hail Vicenza

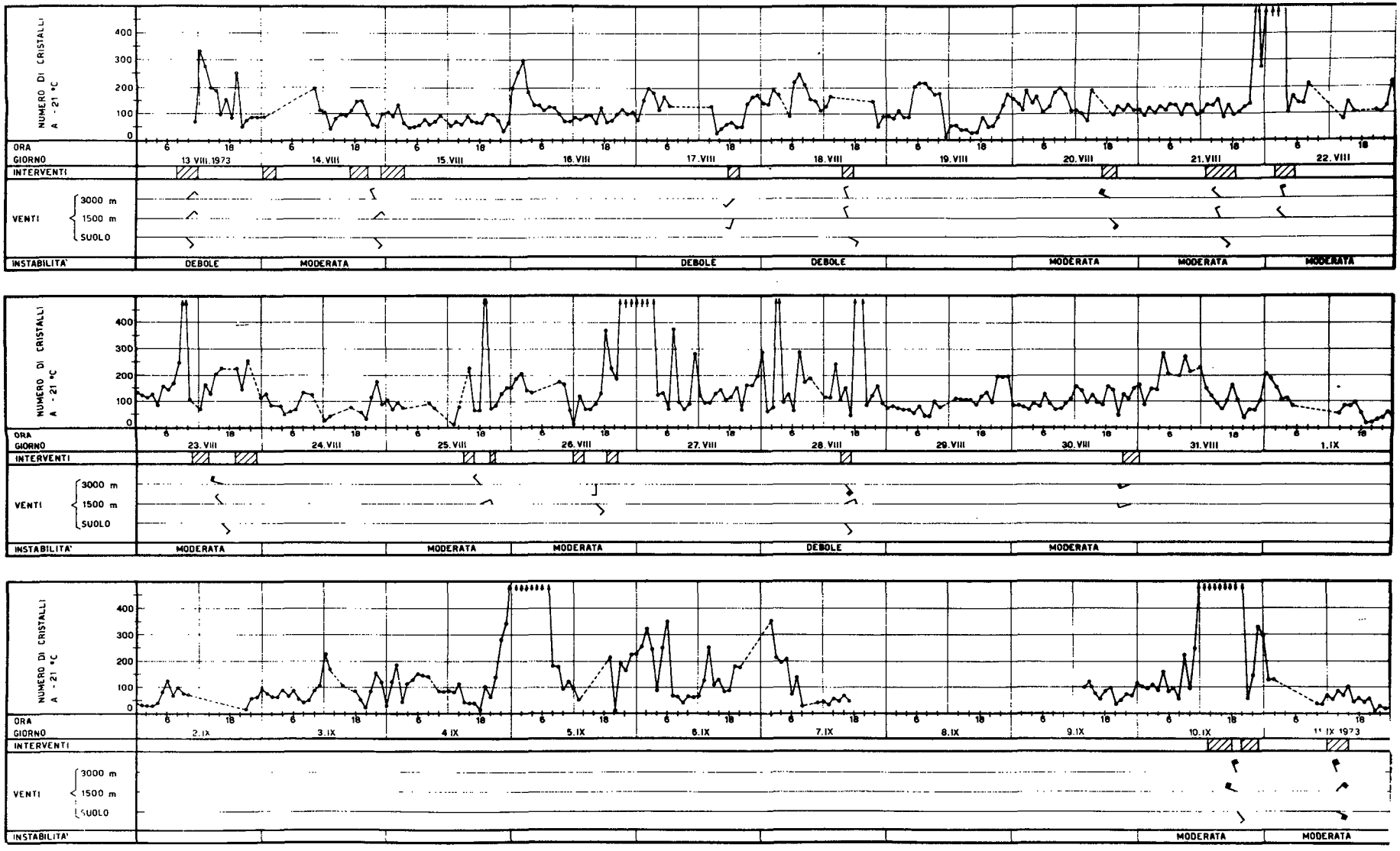
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Fig. 6

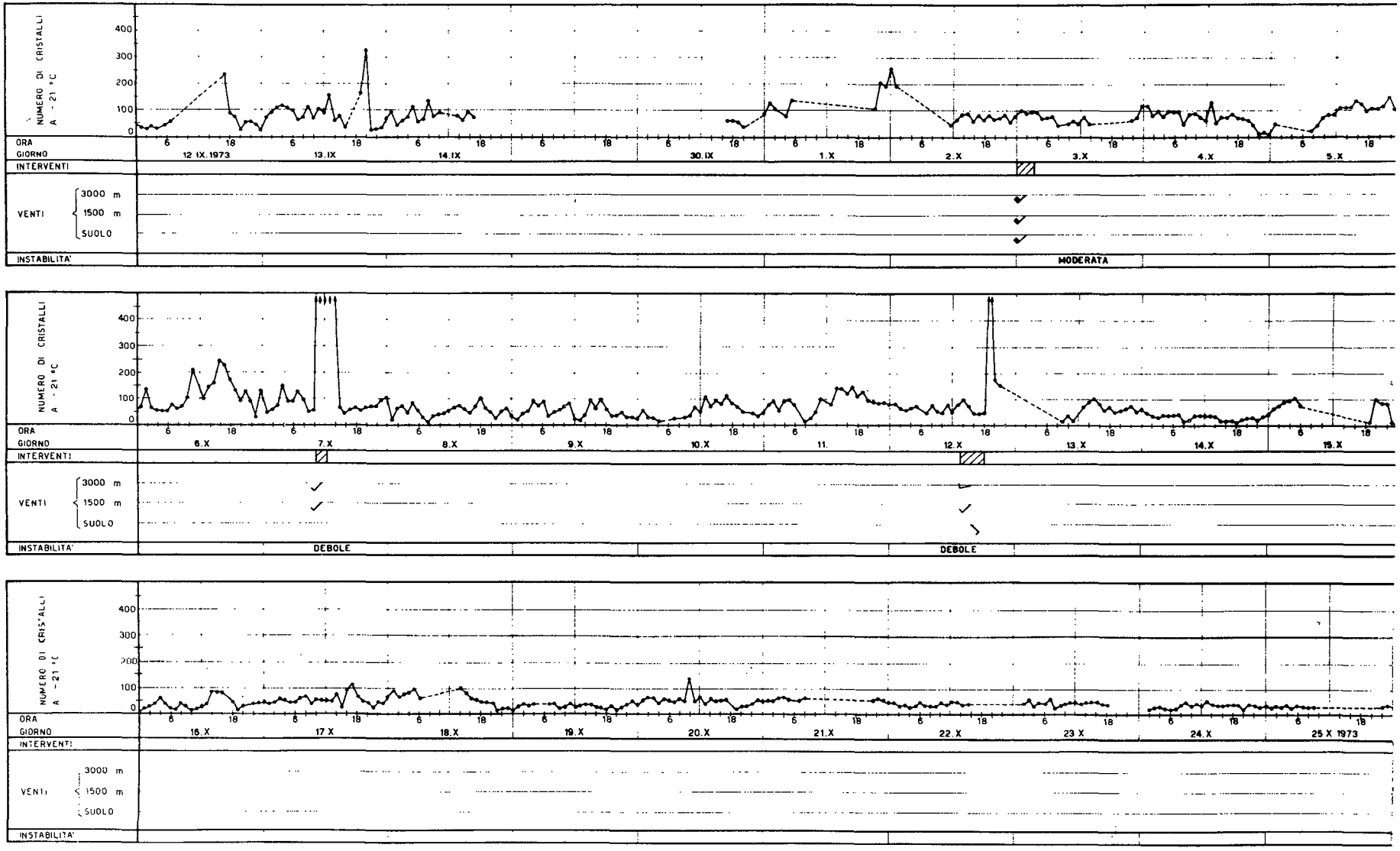
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Fig. 7

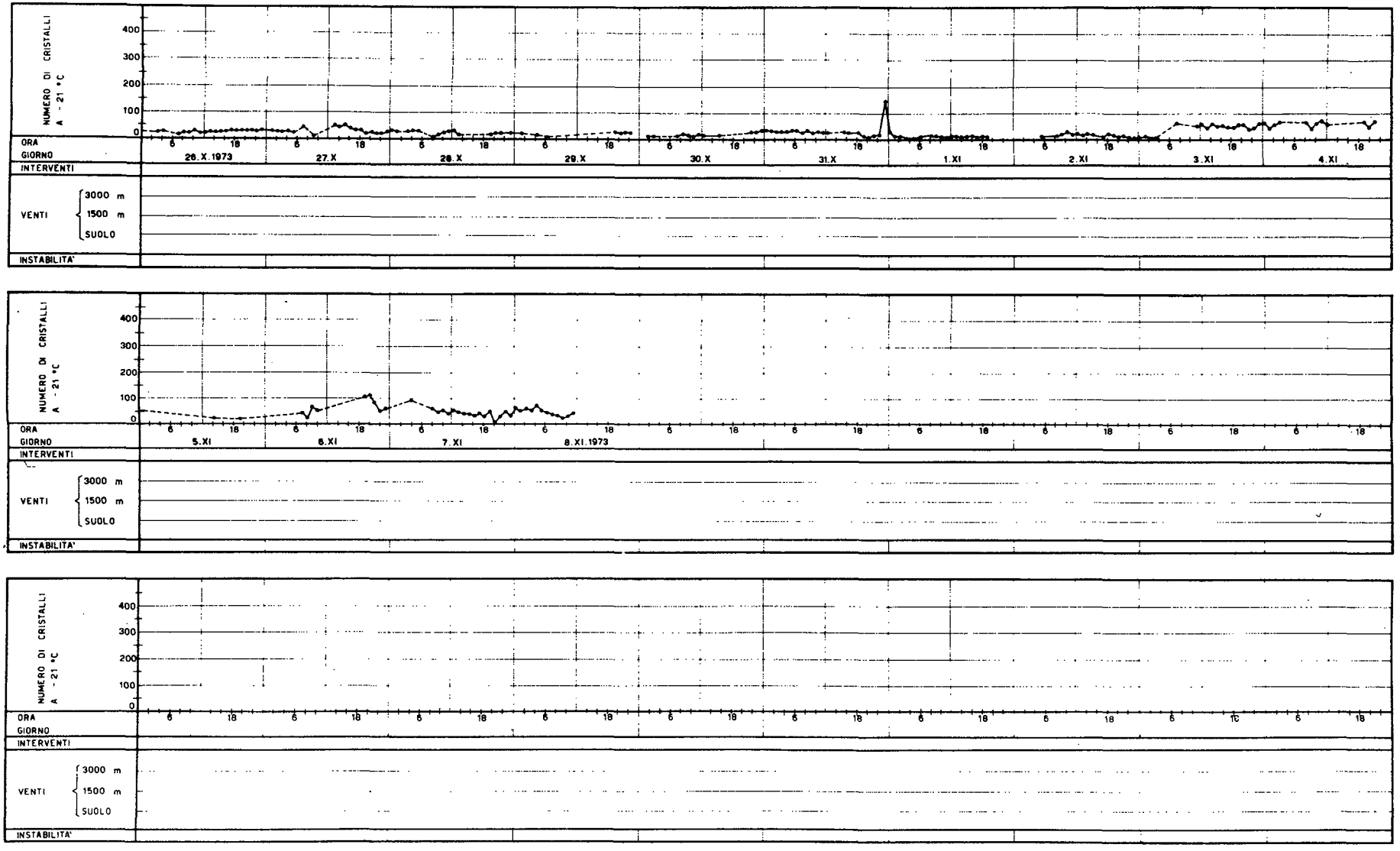
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Fig. 8

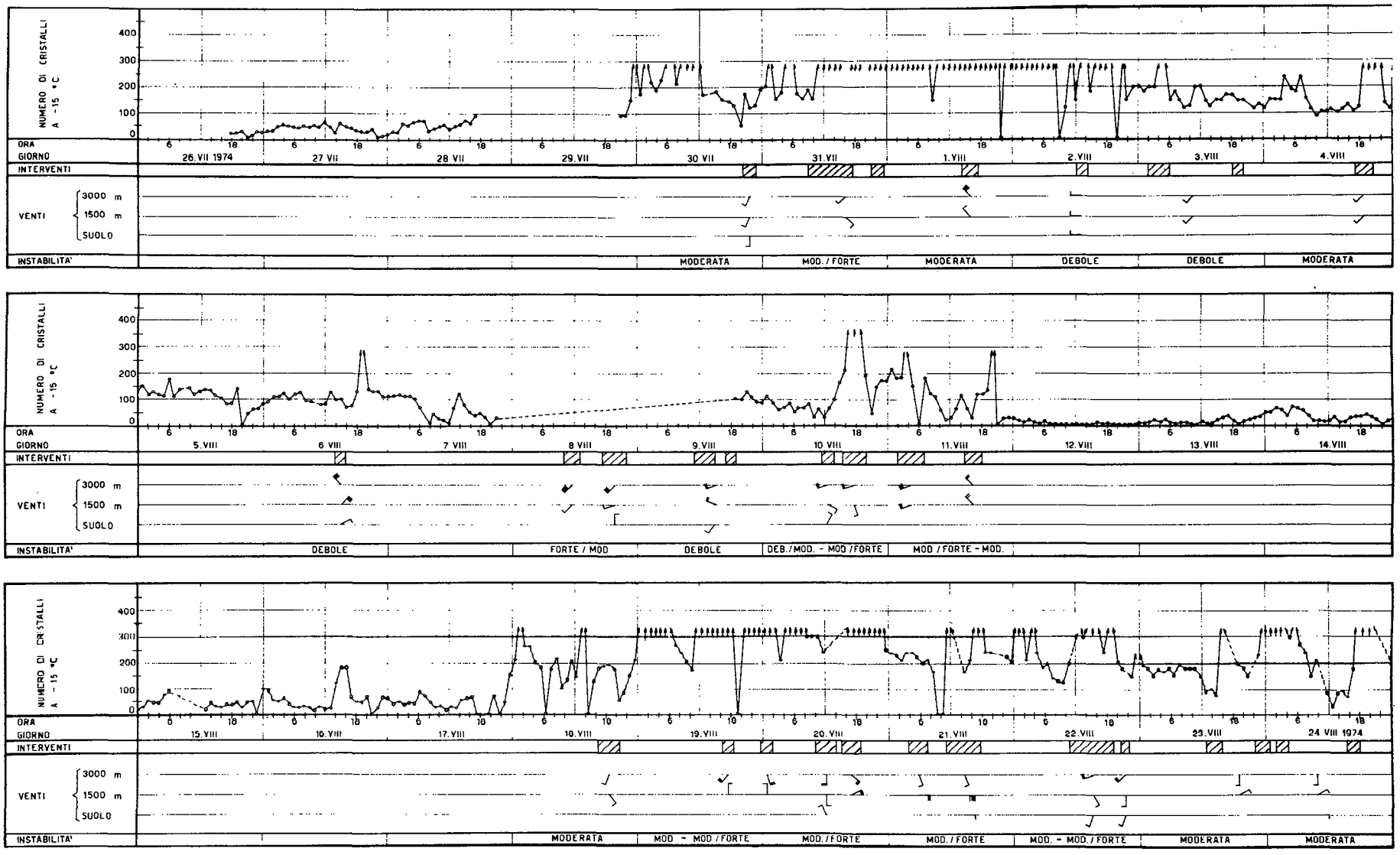
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Fig. 9

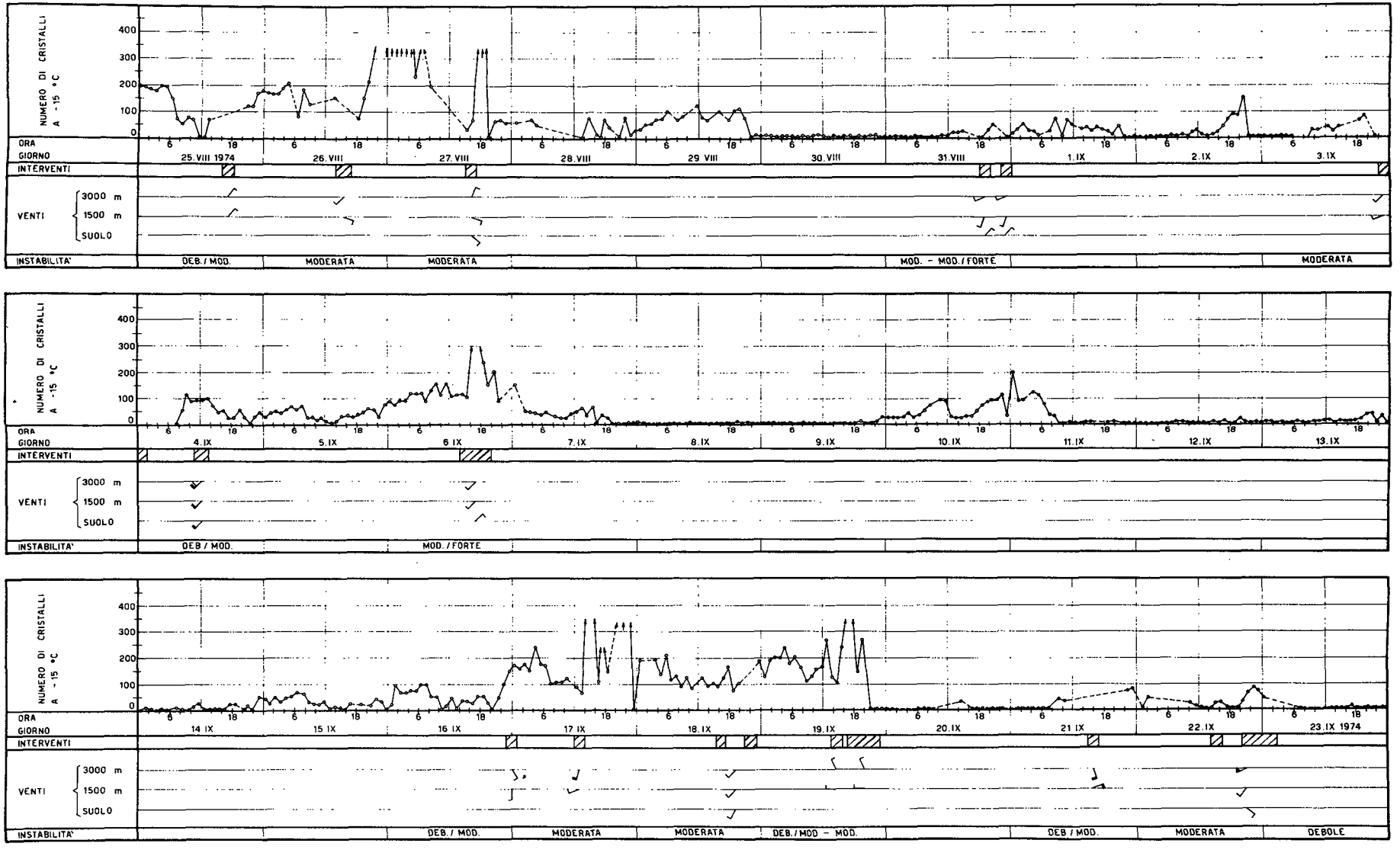
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Fig. 10

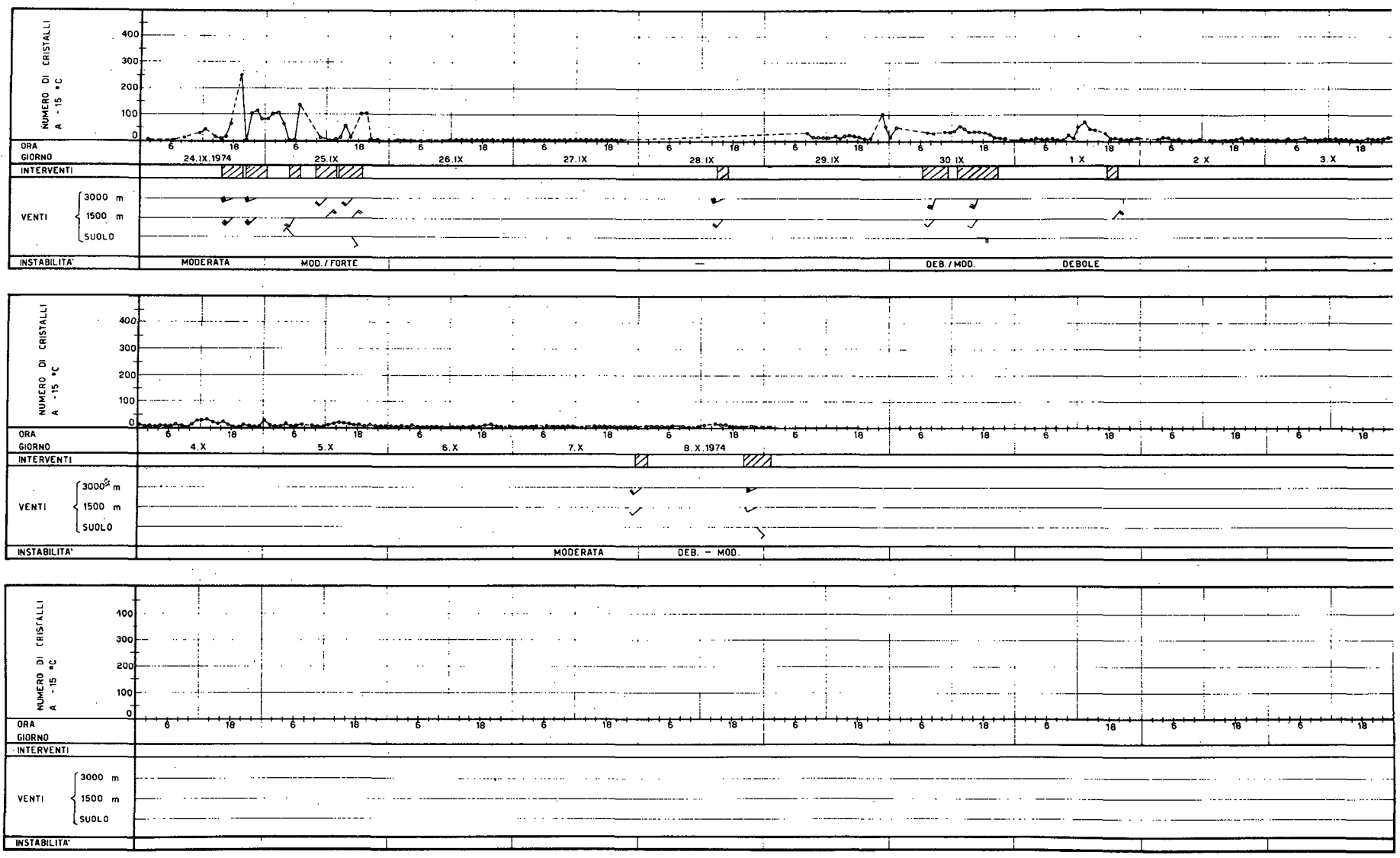
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Fig. 11