Advising Growers on Conditions for Sugarcane Burning in Cauca Valley (Colombia) Using Data Obtained From an Automated Weather Network

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Abstract

The application of meteorological and climatological information obtained through the Colombian sugarcane industry's automated weather network is discussed. A primary concern is to minimize the number of cases when the ash and smoke from sugarcane burning causes annoyances to the residents of population centers of the Cauca Valley in Colombia. The most important topics related to this agricultural practice that are presented include: the technology, the different types of information required, the climatological and statistical data on the wind's behavior, the procedures to obtain all this information, and the steps to apply it.

Introduction

For the last 30 years, since the Colombian sugar industry began the practice of burning the sugarcane prior to harvesting, the "sweet" sector of the Colombian economy has been facing an environmental and social problem. The burning of the cane harvest results in pieces of ash being dispersed and transported in the air by the wind and then falling to the ground, causing annoyances to the residents of the population centers in the Cauca Valley (Figure 1). Wind-blown smoke further complicated this problem in population centers.

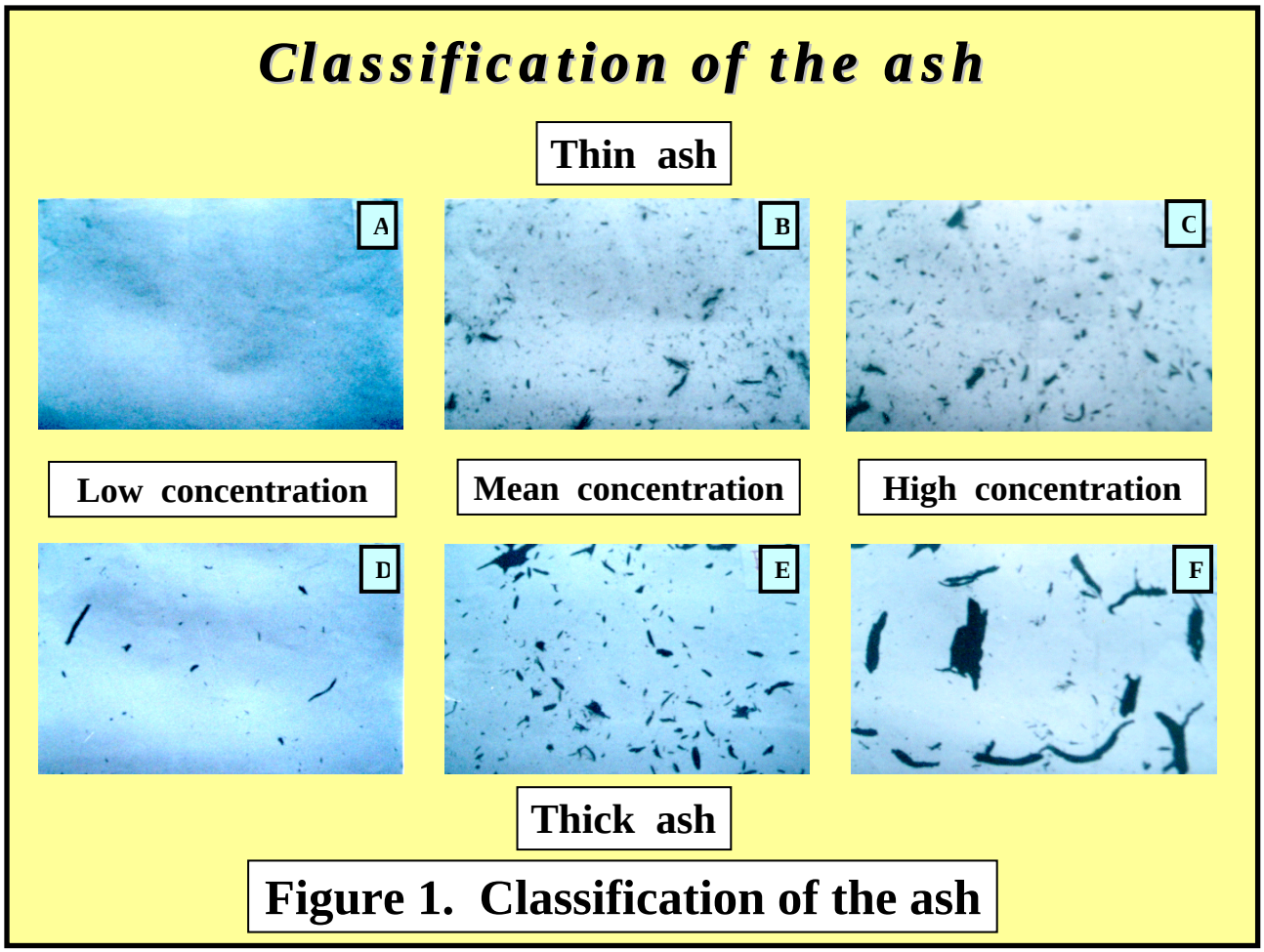

Figure 1. Wind-blown smoke in the Cauca Valley.

In view of the need to solve this problem, the Colombian sugar industry, located in the Valley of the Cauca River, acquired and installed an Automated Weather Network (AWN), which the Colombian Sugarcane Research Centre (CENICAÑA) has operated and administered since September 1993. At present there are 28 weather stations. The most immediate objective of this network, aside from the usual meteorological observations in the short-, intermediate-, and long-term, is to use the system as a technological tool to minimize the negative effect of the ash fallout in the population centers located in the area of influence of the sugarcane crop.

In order to accomplish that goal, CENICAÑA designed a set of procedures for managing the cane burning, based on using different kinds of information: geographical, climatological and meteorological. CENICAÑA has implemented several training events on such procedures for sugar mill employees. These procedures have been called "Meteorological monitoring of sugarcane burning."

Meteorological Monitoring of Sugarcane Burning

This monitoring consists of programming steps and carrying out the burning of the sugarcane in accordance with the appropriate atmospheric conditions, both climate and weather. Thus, if either climate or weather conditions are not conducive for burning, appropriate adjustments are made and the decision to burn is delayed.

This should be obvious, considering that practically everything involved in a burn is found or occurs in the atmosphere: the crop, the ignition, the combustion, the appearance of by-products of this last process (pieces of ash, smoke, some gases, and particulate matter), the rising into the air and later dispersion, transportation, and suspension or fallout of such products. Consequently, these conditions are the primary determinants of the form, size, quantity and other properties, as well as, the behavior and course that the generated products take during or after the burning.

The main objective of the meteorological monitoring of the sugarcane burn is to minimize, whenever possible, the number of events in which the ash fallout occurs on urban centers and other protected areas, to prevent annoyances for the residents of these centers as well as complaints to the environmental authorities.

Pilot Project for Management of Sugarcane Burning

In order to learn from experience and to improve everything related to the meteorological monitoring of sugarcane burning, CENICAÑA and the Colombian Sugarcane Growers Association (ASOCAÑA) entered into an agreement with the Regional Development Corporation for the Cauca Valley (CVC). The agreement was to implement a pilot project for managing the sugarcane burns by the mills in the area of Palmira, Rozo, and the regional International Airport, using information supplied by the stations of the Colombian sugar industry's AWN.

This pilot project began in July of 1996 under the supervision of a "burns inspector," contracted by the sugar industry. After four months, the information collected to date was analyzed. Two studies were conducted. First, the total number of controlled sugarcane burns was analyzed. These were programmed and carried out in the pilot project zone during that period, using the meteorological monitoring scheme (1,094 events). In the second study, the total number of sugarcane fires was reviewed. These were accidental burns and thus not programmed or controlled meteorologically, which occurred in the same area during the same period (124 events). The number of times that the controlled burns produced ash fallout in the urban areas of Palmira, Rozo, or on the grounds of the regional International Airport (54 events), and the number of times that fires or "accidental burns" produced the same effect (16 events) were also compared (Figure 2).

Event	(%)
Burnings	5
Fires	13
Re-burmings	3

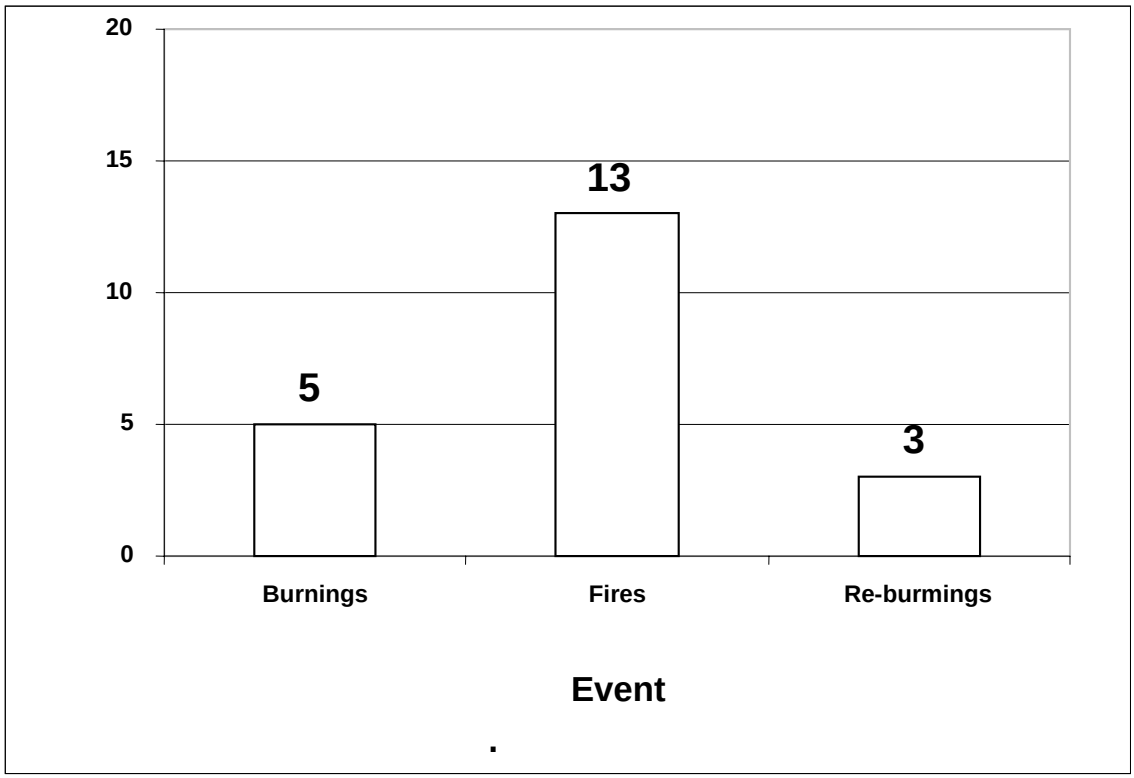

Figure 2. Percent of annoyances generated by different events.

This figure shows that of all the controlled sugarcane burns that occurred in the pilot project area during those 4 months, ashes fell in zones to be protected in only 5 percent of the cases, while in the case of fires or accidental burns (uncontrolled), the same effect was produced in 13 percent of the cases. The percentage of annoyances caused due to ash fallout originating in controlled burns constituted less than 40 percent of the annoyances caused by fires or accidental burns (uncontrolled).

There was a significant decrease in the number of annoyances caused by controlled sugarcane burns as compared to the number caused by accidental fires or uncontrolled burns. This decrease of more than 60 percent is evidently related to the use of climatological and meteorological information for programming and carrying out the burns.

In order to carry out the meteorological monitoring, three factors are required: 1) properly trained technicians, who must have good knowledge of the surrounding areas, as well as the matter of burning; 2) an adequate technology that responds to specific technical requirements; and, 3) geographical, climatological, and meteorological information.

Technology

The appropriate technology for meteorological monitoring is provided by the AWN of the Colombian sugar industry. The AWN operates in the flatlands of the Cauca River Valley in southwestern Colombia. It covers an area of about 400,000 hectares, of which some 200,000 are planted to sugarcane. The AWN began operating in September 1993. Initially, there were 12 meteorological stations, 2 radio frequency-repeating stations, and 1 base station, located at CENICAÑA. There have been four expansions. Since November 2001, there are 29 meteorological stations, each of which has a given area of influence (Figures 3 and 4).

Figure 3. Automated weather station.

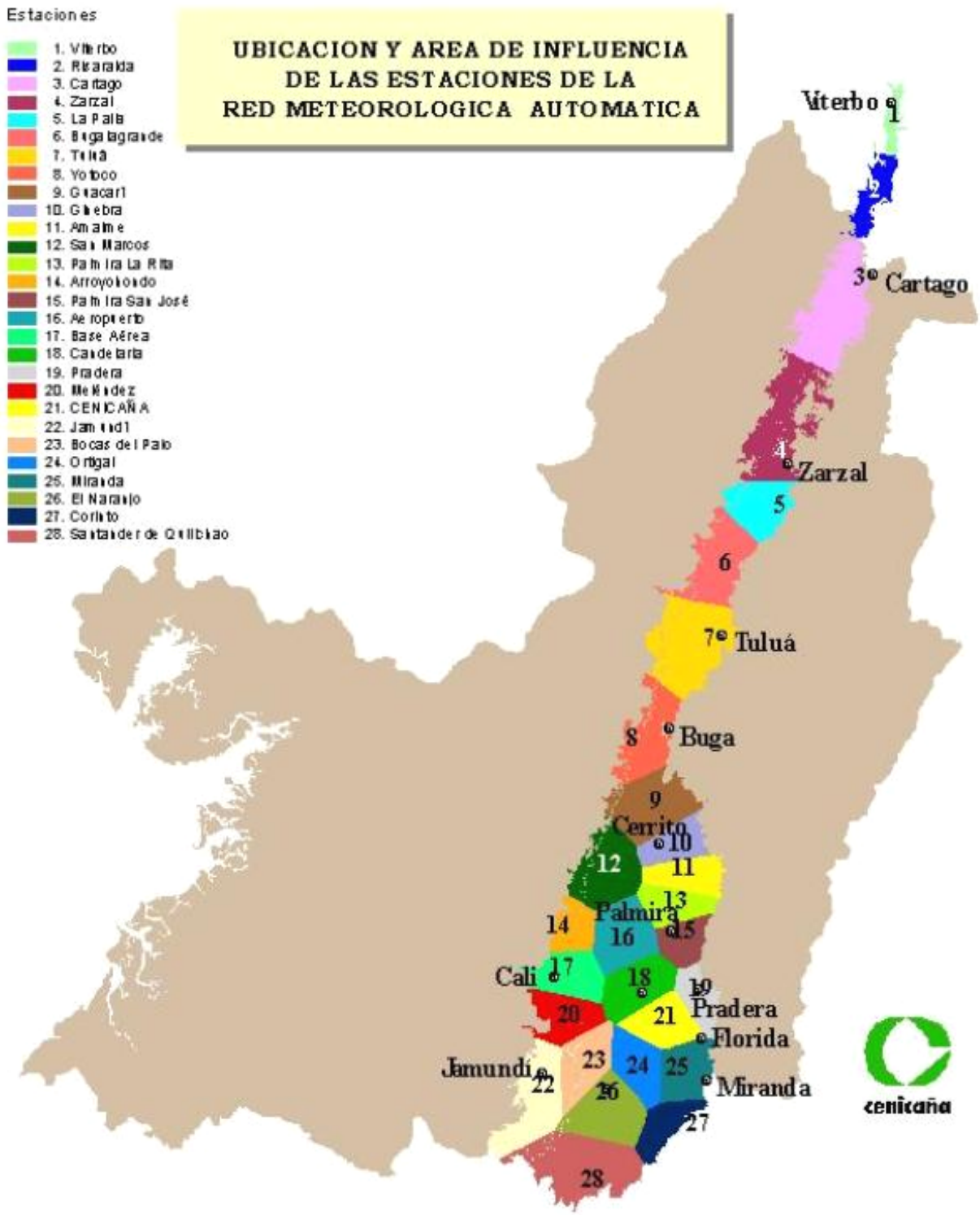

Figure 4. Map of the 29 automated weather stations in Cauca Valley.

CENICAÑA administers, operates, and maintains the AWN on behalf of the Colombian sugar industry. In addition, it provides technical support on the use of this technology and on the management and interpretation of the information that is supplied. The owners of the AWN are the sugar mills in the region, which, together with the cane growers, constitute the principal users of the data generated by the Network. In addition to these users, the information is widely used, generally through bilateral agreements, by universities, governmental entities, and individuals as well.

The AWN is cutting-edge technology, which in comparison to conventional networks has remarkable advantages. For example, the AWN has the very high frequency and precision of the measurements, and is easy to install, operate, and maintain. AWN is highly resistant to harsh weather and universally compatible with many instruments and equipment. Nevertheless, the most outstanding advantage of this technology for the Colombian sugar industry lies in the fact that data in real time (instantaneous) can be obtained and used through the system of telemetry and radio communications, which is a requisite of the technology to be used to carry out the meteorological monitoring of the burnings.

All the meteorological stations of the AWN measure the following atmospheric variables**:** temperatures of the air (minimum, mean, maximum); fluctuation of the temperature; relative moisture; rainfall; solar radiation; wind direction and speed; maximum winds or gusts; and, variability of wind direction. For each of these variables records are generated hourly and daily. Sunshine is also recorded at four stations with automated electronic sensors.

It is worth highlighting the Network's capacity for the permanent measurement and recording of the two atmospheric variables, wind and solar radiation, on an hourly and daily basis by all the AWN stations, given that these data are rarely recorded in the region or in the country, as well as in many parts of the world.

Given their configuration, programming and operation, all the AWN stations have the capacity to supply at any time, via radio, instantaneous meteorological data for any atmospheric variable. Naturally, these are raw data that have not been processed or verified, having been obtained directly from the meteorological stations.

Geographical Information

The geographical information used for this monitoring can be found in a wide range of maps and plans, which are available to the mills and cane plantations. This information is practically invariable unless new lands are put under cane production or are withdrawn from this activity. These documents show the location where the cane plantations and mill lots, cities and population centers, airports and main roads, as well as the weather stations of the sugar industry's AWN. For purposes of the meteorological monitoring of the sugarcane burns, what most matters is the *relative location* between plantations or lots, population centers, airports and roads, and weather stations.

The geographical information is basically used for two purposes: 1) to determine from which meteorological station(s) the data should be obtained for monitoring sugarcane burns in a given plantation, lot, or group of lots; and, 2) to determine the "favorable" ("permitted"), "unfavorable" ("forbidden"), and "risky" ("requiring precautions") wind directions for each plantation, lot, or group of lots with respect to the possibility of ash fallout or the presence of smoke in population centers, airports, and roads, if a burning is to be done in those places.

Climatological information

The climatological information can be found by consulting the database of the automated weather network or in different publications and studies of a climatological type. This information, which is primarily statistical in nature, contains the trends or patterns of behavior for the different atmospheric variables in the long term for each of the areas of

influence of the weather stations in the network and is represented by means of climatic variables. Given their nature, these data vary only slightly on a time scale of at least tens or even hundreds of years.

In the meteorological monitoring of sugarcane burning, basically the climatological data on the behavior of the winds are used, which can be obtained in the Detailed Study of the Wind in the Cauca Valley, which CENICAÑA has been carrying out and maintaining up to date. Thus, for the area of influence of each station of the sugar industry's AWN, data can be obtained on the most and least frequent wind directions for every hour of the day ("prevalent winds"), average wind speed hour by hour during the day, maximum periods and the variability of the wind direction, how these same three parameters behave under different wind directions, as well as the compass card or wind rose (percent distribution of the occurrence of the different wind directions in the long term).

The climatological information, in particular that of the wind, is used to program the burns of the cane crop, seeking to adjust the trends in different zones in order to carry out the burns effectively (without having to change the decision to do so) and without affecting the protected areas with ash fallout.

Detailed Study of the Winds for Cauca Valley

To ensure that the monitoring of the sugarcane burning is an effective tool in the task of minimizing the social and environmental impact, it is necessary to know the specifics of the wind's behavior in each site susceptible to burning as well as in the surrounding zone. Such knowledge includes the long-term trends of wind direction and speed (climatic information), as well as its variation in real time (meteorological information). Only then can the principal objective of such monitoring be achieved.

The main objective of this study was to determine the climatic regime of the wind; that is, the long-term trends and other details of wind behavior in the sugarcane-growing area of influence. Another general objective of this research was to supply the Colombian sugar industry with data, information, and analyses on the behavior of the wind, which, when applied to the management of the cane crop, can improve its productivity, profitability, and competitiveness

In this research, for each of the 28 weather stations involved, the following products, that constitute climatological information, were obtained**:**

- Most and least frequent winds for each hour of the day;
- Compass Card (Wind Rose) for each hour of the day (Figure 5);
- Periods of 6 and 3 continuous hours of greatest and least occurrence of the different wind directions during the day;
- Hourly frequency of incidence of each of the wind directions (16) (Figure 6);
- Distribution by hours of the mean wind speed, the maximum wind speed (gusts), and the mean variability of wind direction;
- Distribution by directions of the mean wind speed, the maximum wind speed (gusts) and the mean variability of wind direction; and,
- Overall Compass Card (Wind Rose) for the entire period analyzed (Figure 7).

CENICAÑA AUTOMATED WEATHER NETWORK OF THE COLOMBIAN SUGAR INDUSTRY	DETAILED STUDY OF THE WIND FOR THE CAUCA VALLEY - COLOMBIA	
	STATION : RISARALDA	LATITUD : 04° 54' 43" N LONGITUD : 75° 54' 07" W
	PERIOD : SEP/93 - ABR/97	ALTITUD : 900 m s n m

LESS FREQUENT WINDS					MORE FREQUENT WINDS				
HOUR	BLOWING FROM	FREQ. (%)	MEAN DIRECTION	TURN	HOUR	BLOWING FROM	FREQ. (%)	MEAN DIRECTION	TURN
00 - 01	SW - NW	14	W	1	00 - 01	NNW - ENE	63	NNE	1
01 - 02	SW - NW	12	W		01 - 02	NNW - ENE	67	NNE	
02 - 03	SW - NW	14	W		02 - 03	NNW - ENE	66	NNE	
03 - 04	SW - NW	14	W		03 - 04	NNW - ENE	66	NNE	
04 - 05	SW - NW	14	W		04 - 05	NNW - ENE	65	NNE	
05 - 06	SW - NW	11	W		05 - 06	NNW - ENE	69	NNE	
06 - 07	SW - NW	12	W		06 - 07	NNW - ENE	66	NNE	
07 - 08	SW - NW	6	W		07 - 08	N - E	70	NE	2
08 - 09	SW - NW	6	W		08 - 09	NNE - ESE	62	ENE	3
09 - 10	WSW - NNW	6	WNW	2	09 - 10	E - S	51	SE	4
10 - 11	WSW - NNW	7	WNW		10 - 11	ESE - SSW	62	SSE	5
11 - 12	WSW - NNW	7	WNW		11 - 12	ESE - SSW	63	SSE	
12 - 13	WSW - NNW	7	WNW		12 - 13	ESE - SSW	66	SSE	
13 - 14	WSW - NNW	9	WNW		13 - 14	ESE - SSW	64	SSE	
14 - 15	WSW - NNW	10	WNW		14 - 15	ESE - SSW	64	SSE	
15 - 16	WSW - NNW	13	WNW		15 - 16	SE - SW	56	S	6
16 - 17	WSW - NNW	20	WNW		16 - 17	SE - SW	46	S	
17 - 18	ENE - SSE	15	ESE	3	17 - 18	NW - NE	53	N	7
18 - 19	ENE - SSE	13	ESE		18 - 19	NW - NE	64	N	
19 - 20	ENE - SSE	14	ESE		19 - 20	NW - NE	63	N	
20 - 21	ENE - SSE	12	ESE		20 - 21	NW - NE	58	N	
21 - 22	ENE - SSE	15	ESE		21 - 22	NW - NE	58	N	
22 - 23	SW - NW	20	W	1	22 - 23	NNW - ENE	56	NNE	1
23 - 00	SW - NW	14	W		23 - 00	NNW - ENE	63	NNE	

Table 1. Detailed study of the wind for the Cauca Valley – Colombia.

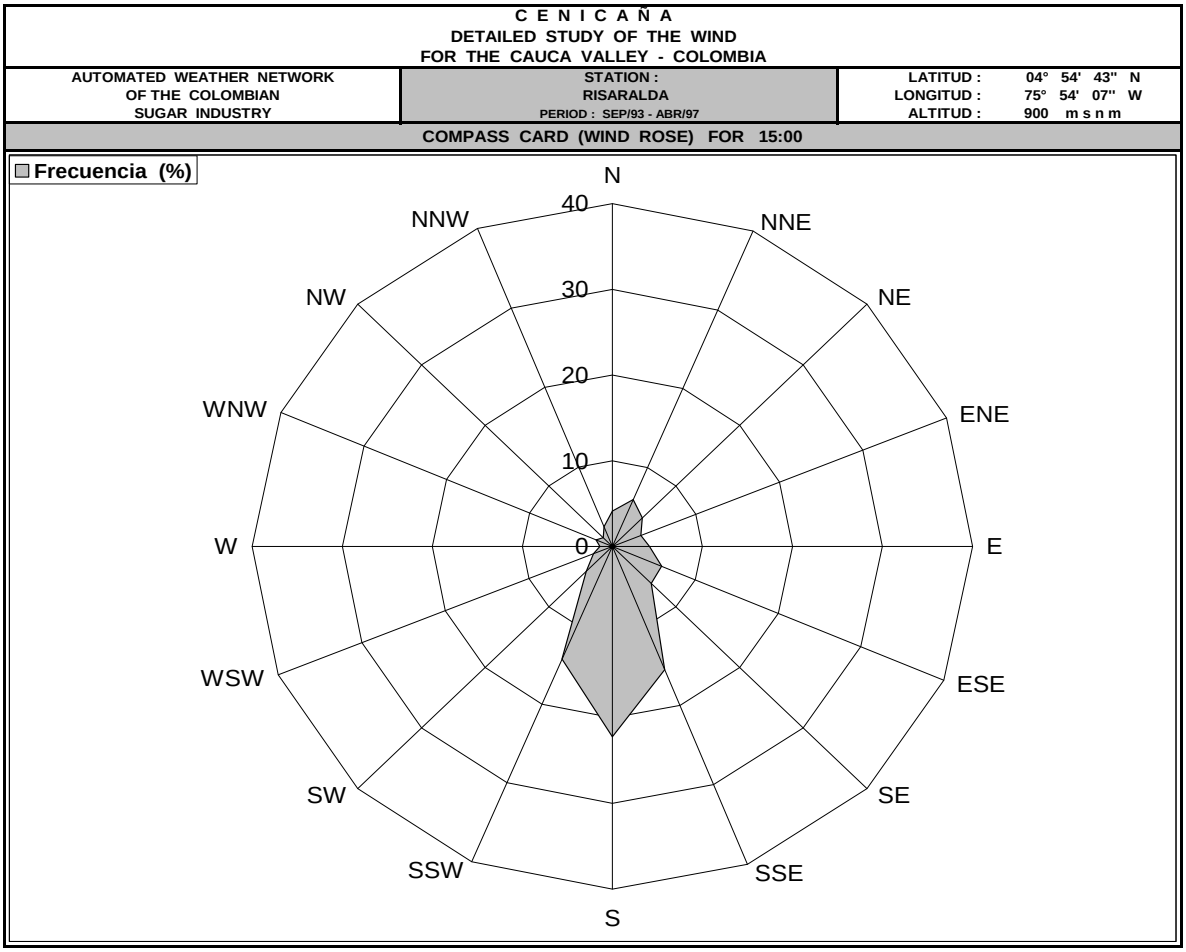

Figure 5. CENICAÑA – Automated weather network.

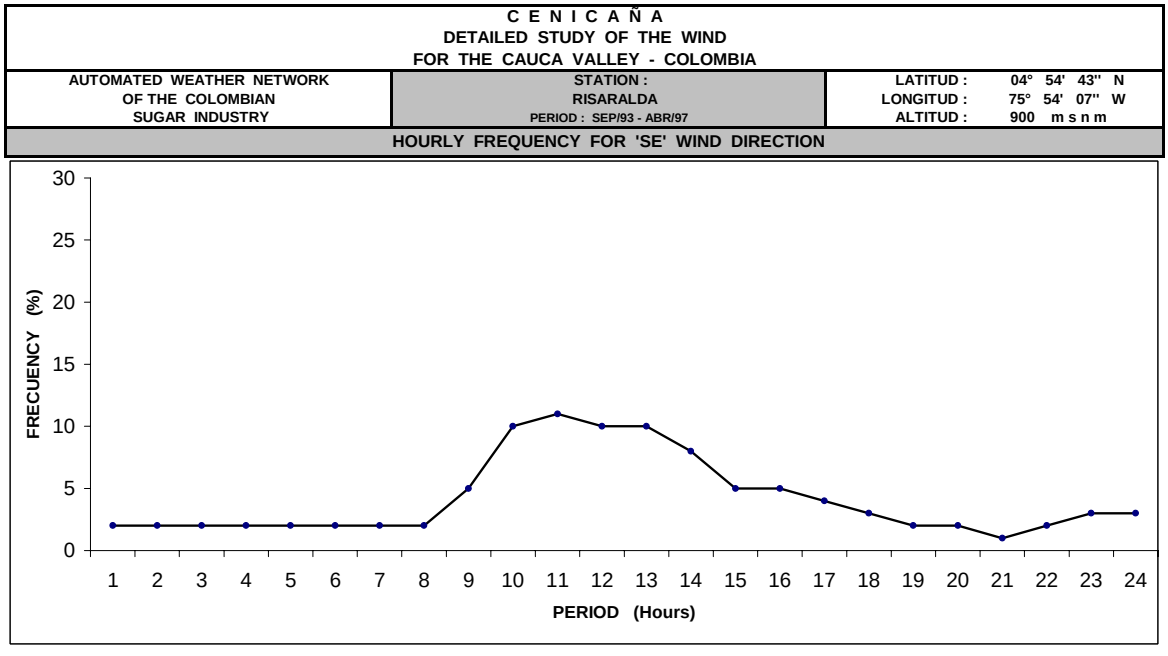

Figure 6. Hourly frequency for SE wind direction.

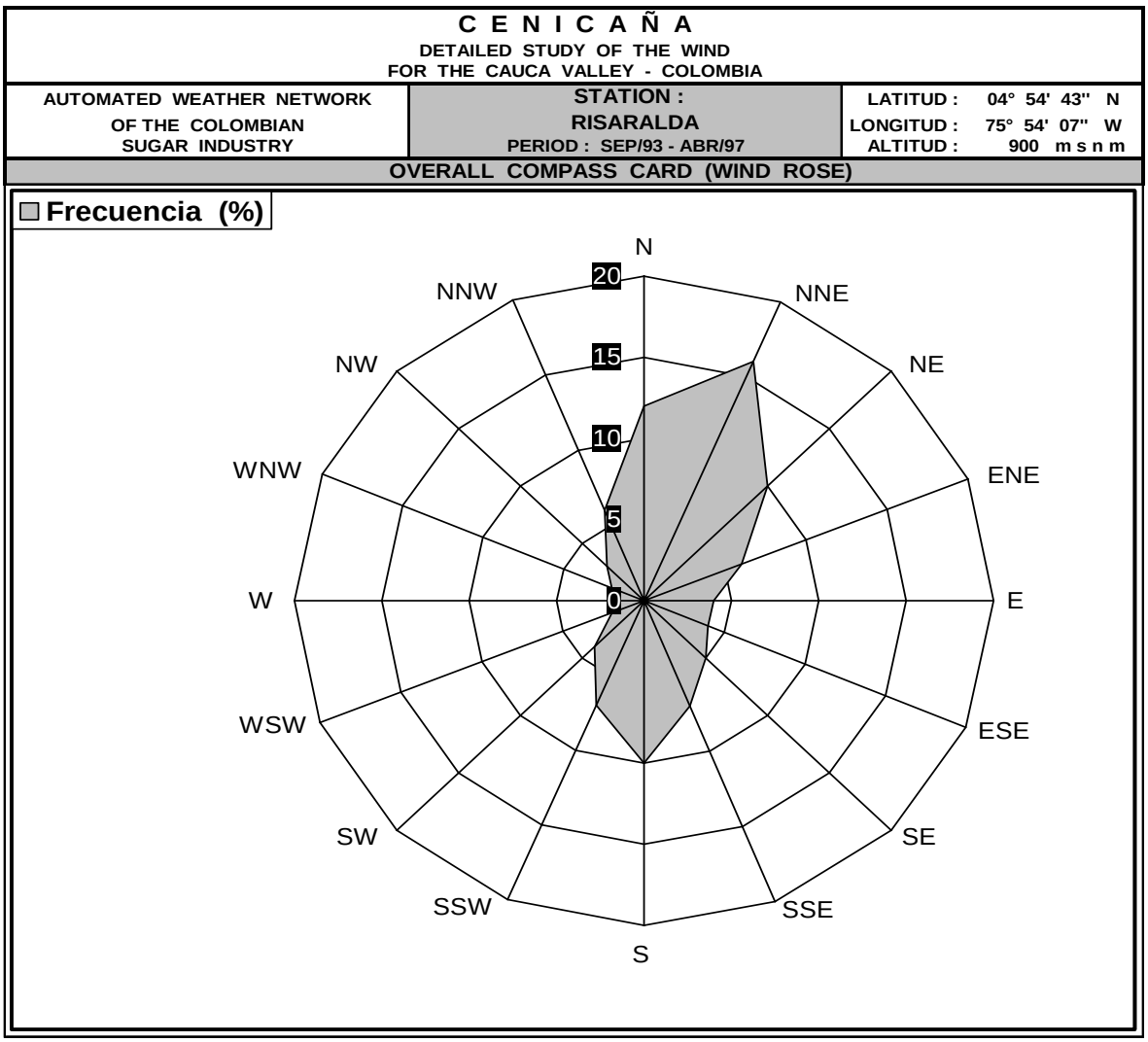

Figure 7. Overall compass card (wind rose).

Meteorological Information

Meteorological information can be obtained by three different routes: 1) by consulting in the database of the automated weather network hourly and/or daily data; 2) through "direct" communication with the weather station(s) via radio in order to find out the current atmospheric conditions in the zone where the burning is going to be done; and, 3) by measuring, with the help of portable sensors, the wind's direction, speed, gustiness, and variability directly at the burning site.

All of the means provide the meteorological information in real time. Given the nature of this information, there is great variability as the data are practically instantaneous.

Conclusion

The application of meteorological information for monitoring sugarcane burns makes it possible to decide whether to burn or not, depending upon whether the prevailing conditions in the place at the time foreseen for the burning so permit, without affecting the areas that are to be protected from ash fallout or smoke presence.

Glossary

Protected areas or *areas to be protected* are zones where ash fallout or the presence of smoke coming from the sugarcane burning is to be prevented. These areas are primarily cities and population centers in general, airports, and main intercity highways.

Restricted areas are those zones where the burns are permitted, but there are some conditions or restrictions (about time, for instance) on carrying out a burn.

Prohibited areas or *areas of no burning* are the zones where legal provisions explicitly prohibit burning. These are essentially the zones adjacent to urban perimeters, the most important being the airports and the intercity highways.

A *favorable or permitted wind direction* is one in which burning can be done at a particular site with only a slight probability of ash fallout in a given area that is to be protected precisely against this event.

An *unfavorable or prohibited wind direction* is one in which, if the cane is burned in a certain place, there is a high probability of affecting a protected area with ash fallout.

A *risky wind direction or a direction requiring precautions is a direction* in which, at first glance, there may appear to be no major risk of causing ash fallout in a protected zone, but due to normal changes (not sudden and abrupt) in the direction of the wind, ash fallout could occur.

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