EXPERIMENTAL CAMPAIGN FOR THE ENVIRONMENTAL IMPACT EVALUATION OF SOSTANJ THERMAL POWER PLANT

PROGRESS REPORT

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DSR/CRTN

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ABSTRACT

During spring 1991, ENEL/DSR/CRTN Milan, CISE-"Tecnologie Innovative" Milan and Institut "Jozef Stefan" Ljubljana performed an experimental campaign around the Sostanj thermal power plant in the Republic of Slovenia.

The aim of this project was to investigate environmental impact due to the pollutants emitted by the power plant.

The data measured by a local network of fixed stations, mobile laboratories, Doppler SODAR and DIAL, from March 15th to April 5th 1991, have been stored in an appropriate database to validate advanced models for pollutant transport and diffusion over complex terrain.

1. INTRODUCTION

The impact of fossil fired power plants on air quality is one of the major concern of State and Local authorities and of the scientific community, especially when the plant is located in highly populated or protected areas and/or uses low-quality fuel.

Current researches are focused both on emission reduction and on the development of instruments and methods for monitoring and forecasting the fate of pollutants in the environment.

In 1990, ENEL/CRTN-Milan, CISE-Milan and Institut "Jozef Stefan"-Ljubljana started a cooperation for R&D activities in the field of environmental monitoring and control.

In this frame, during spring 1991, ENEL/CRTN, CISE and IJS, performed an experimental campaign in the area surrounding the Sostanj Thermal Power Plant (TPP), in the northern region of Slovenia, 60 km from Ljubljana.

The main goal of the campaign was to perform a field test of an integrated system, based on:

- conventional chemical and meteorological network;
- two mobile laboratories to measure meteo-chemical ground level variables;
- advanced remote sensing devices: a Doppler SODAR to measure vertical wind profile and a Differential LIDAR to measure SO_2 concentration in air.

During the campaign, all the data coming from the different instruments in field (together with the main plant data: electrical load, emissions and so on), have been concentrated (on and off line) in a mobile intelligent node (MIN). Using the real time gathered data it has been possible to perform:

- a real-time assessment of reliability of chemical and meteorological data, comparison and intercalibration of different instruments;
- a global analysis of the meteorological situation both at ground level and at different altitudes;
- a real-time and off-line test of different diffusion models.

All the data have been stored on floppy disks in order to provide a database available for further processing and research. The database compiled by this unique monitoring network (available on request) provides very interesting opportunities for studies of pollutant transport in complex terrain.

The following sections of this report describe the Sostanj area, the measuring devices, included a brief description of the data validation methodology, and the synoptic meteorological conditions during the campaign. Furthermore, all the collected data and the database structure are shown.

2. DESCRIPTION OF SOSTANJ AREA

Slovenia lies at the junction of the Alps, the Panonian basin, the Dinar mountain chain and the Mediterranean basin (see fig. 1). The climate varies from submediterranean in the coastal area to central-european continental in the north-eastern part. Geotectonically, Slovenia is at the crossroad of the Alps and the Dinar mountains, which results in a very dynamic landscape.

The area of investigation (see fig. 2) lies in the Saleska valley, which is situated in the north-eastern part of Slovenia. The central part of the Saleska valley (also called "the Velenje basin") is the plain north to the river Paka, with an average altitude of three hundred meters above sea level. During the Pliocene geohistorical period, sinking occurred north of the thermal fault line Topolsica - Sostanj - Dobrna. The depression was filled by a lake and persisted there for a relatively long period of time.

In the lake sediment there are abundant supplies of lignite, which are exploited by the Velenje coal mine. The lake sediment gave the basin its morphological characteristics, forming low hills that never exceed a relative height of one hundred to one hundred forty meters. These long chains of hills are positioned concentrically around the lowest part of the plain. They are characterized by levelled peaks and gentle slopes, engraved into the Pliocene plate by numerous streams. The resulting river network shows an extremely beautiful concentric arrangement.

Streams and rivers flow from all sides towards the lengthwise axis of the basin, where they are gathered by the river Paka. The lower plateaus are quite wet, and are often flooded: this justifies the great presence of meadows in the area. The higher plateaus are drier and are used for fields. The hilly landscape surrounding the basin is mostly overgrown with wide coniferous forests. In the west, there are the Smrekovsko highlands, with peaks over one thousand five hundred meters high. The northern border of the basin is the midmountainous continuation of the Karavanke mountains, with altitudes from six hundred to one thousand meters. The southern and eastern borders are more dynamic as they consist of Triade lime and dolomite shaped into numerous blunt and sharp mountains. In fig. 3 are shown 2D and 3D numerical topography of the Velenje basin.

Economically, the Saleska valley is characterized by the lignite mine in Velenje. The coal supplies are abundant, as some layers are over one hundred meters thick. The only problems are the great depth and tectonic parcelling. The coal mine has caused the decay of some old settlements that were located above the coal findings. Because the lignite layers are so thick, the cavities that are left underground after the excavation of the coal are not fully filled this causes the ground to sink. For this reason caverns form on the surface and landslides occur on the hills. Water flooded the larger depressions and caverns between Skale and Velenje and formed permanent lakes where bathing areas and sporting facilities have been built.

The main source of SO_2 pollution in the Saleska valley is the Sostanj Thermal Power Plant, where greater part of the Velenje coal is used, since it is not suitable for sale and for use in individual burning sites because of its low caloric value. This coal also has a high level of sulphur that greatly pollutes the basin in the form of SO_2 and chimney gases emitted by the thermal power plant.

Desulphurisation facilities are not yet fully finished. Due to the unfavourable climatic conditions (thermal inversion in the basin), very high concentrations of SO_2 occur especially during the winter and in the north-eastern part of the basin. One of the consequences is the chlorosis and necrosis of the needles of the conifers that grow on the nearby hills. Apart from this, the chemical composition of the soil changes and is one of the reasons for the die-out of the forests in the region. The high concentrations of SO_2 are harmful to the health of the inhabitants of the area, the greater part of whom are concentrated in two larger towns: Sostanj and Velenje.

Sostanj has approximately 3000 inhabitants, and Velenje about 24000. About 9000 people live in the villages around. With the goal of an early discovery of SO_2 pollution and of taking appropriate measurements, an ecological network (see fig. 2) consisting of six fixed automatic measuring stations (the performance of which is integrated by a mobile unit that has been located 17 Km NNE far from Sostanj during the experimental campaign) has been positioned in the surroundings of the thermal power plant. The gathered data allow to understand the local climatic situations and thus enable at least a partial management of the pollution.

3. INSTRUMENTS AND METHODS

In this section the technical description of the different measuring systems and data validation methodology are reported.

3.1. The Ecological Information System of Sostanj TPP

Sostanj thermal power plant represents the most harmful SO_2 source in Slovenia. A computerized monitoring system has been built around it in order to monitor emissions, ground level concentrations of the main pollutants, operational parameters of the power plant and meteorological and hydrological parameters.
The system can be used to determine critical conditions in which power reduction, desulphurisation or better quality of coal could reduce pollution levels.

Design criteria

The system represents a complex local network of computerized measuring, communication, and data-processing equipment (Lesjak et al., 1989). It performs the following tasks:

- measurements of ground level concentrations and meteorological data at representative remote points in the surroundings of the TPP;

- measurements of emissions released by the TPP through stacks;
- measurements of some significant operational parameters of the TPP;
- hydrological measurements of the cooling water;
- data transmission between remote measuring points and central data processing equipment;
- the generation of data bases, reports, diagrams and messages on the central data processing equipment;
- export of data to the plant computer, to external mainframes and to terminals of external data consumers;
- data quality controls;
- controls of system performance.

In order to achieve these goals, the monitoring system consists of:

- a network of six fixed stations, located on representative points around the TPP (see fig. 2),
- a mobile station, mounted in a caravan trailer,
- a mobile emission station, mounted in a van,
- a fixed emission station that also measures some significant operational parameters of the TPP,
- a hydrological station (physically joined the emission station),
- two communication preprocessors,
- a doubled central computer.

Fixed and mobile stations for air quality measurements

Each station (see fig. 4) consists of a low-power CMOS microcomputer-controlled automatic measuring equipment with an autonomous power supply and sensors for wind, air temperature, and relative humidity. Every station has an SO_2 monitor and possibilities to connect NO_x, O_3 and CO monitors (see fig. 5).

Two stations have a full set of monitors. In addition, the Sostanj station measures precipitation, radioactivity, air pressure, solar radiation, and noise pollution. Once a day an automatic calibration is performed for the ecological monitors. Data are transmitted through a fixed telephone line to the communication preprocessor by each station.

The mobile station is functionally identical to the fixed stations except for that it has a PC instead of a non-intelligent terminal. The PC allows for local data-processing and storage when the station is operating as a stand-alone system. The mobile station is equipped with an autodialing modem and can transfer data to the centre through a switched telephone network. When connected this way, the system treats it as a supplementary station.

Emission station

This station measures the emission concentrations and the significant operational parameters of the TPP:

- the emissions of SO_2, O_2, dust, NO_x,
- the temperature of chimney gases,

- the power of the generators,
- the power of the heating stations.

It is located inside the TPP and is connected to the communication preprocessor through a 20 mA current loop. The station has its own local terminal and printer.

Hydrological station

The hydrological station (see fig. 6) is physically a part of the emission station and communicates with the central equipment through the same transmission channel. Logically, the hydrological station measures hydrological data of the river Paka which is used as a supply for cooling water. The station measures water level, pH, turbidity, flow, water temperature and air temperature.

Mobile emission station

The mobile emission station is functionally identical to one block section of the stationary emission station with the possibility of measuring SO_2, NO_x, CO, O_2, dust, the temperature of chimney gases and operational parameters. The data gathered are processed on the built-in PC and can be send to the central computer.

Communication preprocessors

Specialized communication preprocessor has been chosen for the following reasons:

- a large number of communication channels;
- a single standard RS232 connection is needed between the pre-processor and the central computer;
- the communication preprocessor can switch lines, control modems, and handle multiple simultaneous protocols independently of the central computers;
- the preprocessor can maintain its own database (a subdivision of the general database in the central computers) and thus regularly transfer data to the external users.

Being an essential part of the system, the preprocessors are doubled; each is connected to one of the two central computers.

Central computers

The central data processing equipment is based on two PC-AT compatible computers protocol. Both ATs are interconnected with a RS 232 link and control each other: they work in parallel and give the diagnosis of the system operational state.

Data processing

All the data are processed on two levels: first locally at the station and further on the central computers (Mlakar et al., 1990).

At the air quality stations, the sampling rate is 1 second for wind, 10 seconds for the majority of parameters and 5 minutes for precipitation. The local concentration of data makes from this large amount of data a much smaller set of significant derived data suitable for storage and

transmission. Data-processing is repeated every half-hour and every 24 hours (computing of daily values).
Data concentration consists of the first level of data control and the computing of average, extremes, times of their occurrence and standard deviation.
At the emission stations, standardized procedures are applied to obtain:

- emission concentrations in damp chimney gases under normal conditions and at the actual concentrations of O_2,
- emission concentrations in damp chimney gases under normal conditions and at the reference concentration of O_2,
- emission concentrations in dry chimney gases under normal conditions and at the reference concentration of O_2.

These concentrations are used for computing the absolute emissions.
On the central computers, the second level of control is performed, and the database, reports, some graphical presentations and data tables are made.

Data control

A two level data quality control is applied: first as an integral part of the data-processing at the measuring stations and after as a part of the data -processing on the central computers. The control at the measuring stations consists of two separate parts; the first one includes controls within each parameter:

- the data should lie inside the physically acceptable boundaries
- the relation (max $\geq$ avg $\geq$ min) should be true;
- the relations [(max - avg) < C] and [(avg - min) < C] should be true (extremes are close enough to the mean value);
- the relation [(max-min) > D] should be true (the measured value is not constant).

All these controls are binary coded within one status byte.
The second control is common for all parameters and shows the measurement conditions:

- the status of the door (indicates entering the measuring unit);
- the status of the thermostats (the measuring equipment works at room temperature);
- the status of the fire alarm indicator;
- the status of the air flow (for the aspirated temperature sensor);
- the air temperature inside the station;
- the reference voltage for the temperature sensors.

These controls are written into a special control file.
No data are rejected at the station control level. Only a byte with the firstly mentioned controls is appended to each parameter file and aspecial file with the other mentioned controls is written. All these data is then transmitted to the central unit.
The central unit appends two additional bytes to the control byte of each parameter. Two bytes make another 16 binary controls possible.

These controls are divided into two groups: the first eleven to check within the parameter and the last five for the measurement conditions connected with the parameter.

The controls are:

- the data should be inside the logically acceptable boundaries;
- the data should be inside the extremes allowed for the current month;
- the relation (min $\leq$ avg $\leq$ max) should be true;
- if max = avg or min = avg, then the standard deviation should lie inside fixed boundaries;
- the difference between average and extreme values should be inside the boundaries determined with the standard deviation;
- the ratio between the vector and scalar wind average value should be inside the constant interval;
- the wind direction should lie inside the constant interval;
- the data should lie inside the monitor measuring range;
- the calibration zero voltage should lie inside the boundaries determined with the preset zero voltage;
- the test concentration voltage should lie inside boundaries determined with the preset span voltage;
- if the monitor is in calibration mode or manually set to zero or test concentration, error status is set;
- if the station is being serviced, error status is set;

- if the supply voltage is out of limits, error status is set;
- if the mean air temperature inside the station is out of limits, error status is set;
- if some special conditions are not true (aspiration and proper reference voltage for air temperature, air flow for ecological monitors, water flow for water temperature ...), error status is set.

In the future, additional data quality controls are going to be implemented in the central unit in order to control the correlations of the data from adjacent measuring intervals and relations between the data of different parameters inside the same measuring interval.

Ecological monitors and sensors

- SO_2 Monitor Labs UV fluorescence analyzer model 8850S;
- NO-NO_x-NO_2 Monitor Labs chemiluminescent analyzer model 8840;
- O_3 Monitor Labs selective UV-photometric analyzer model 8810;
- CO Monitor Labs infra-red light absorption analyzer model 8830;
- CO_2 Monitor Labs model ZRC-1.

Calibration: Monitor Labs Audit Calibrator model 8580.

Meteorological sensors

- 10 meter mast,
- wind speed and direction cup/vane sensor,
- aspirated thermolinear thermistor temperature sensor,
- hair hygrometer,
- Kipp & Zonen CM5/6 solarimeter,
- tipping-bucket rain and snow gauge,
- gamma monitor

3.2. CISE Mobile Laboratory

The main components of CISE mobile station (see fig. 7) are:

- IVECO 65-12 truck: power 85 CV (63 kW), total weight 6.7 tons, with limited-slip differential;
- container (with hydraulic loading pistons), for the housing of measuring equipment (see following description);
- electric generator (10 kW power).

Measuring equipment (see fig. 8) consists of:

Chemical sensors

- SO_2 UV fluorescence analyzer HORIBA APSA350E,
- NO_x-NO-NO_2 chemiluminescence analyzer HORIBA APNA350E,

- CO IR analyzer HORIBA APMA350E,
- O_3 UV analyzer HORIBA APOA350E,
- calibration device MONITOR LABS 8550 (with permeation tubes for SO_2 and NO_2, O_3 generator, dilution and GPT channels),
- data acquisition system, based on COMPAQ 286 Personal Computer, with field interface board, for signal sampling every 10 seconds, and a SW package for first level statistical analysis and data validation and control;

Meteorological sensors

- 10 meter mast,
- wind speed and direction cup/vane sensor,
- Pt100 air temperature sensors at 2 levels (2 and 10 m),
- conducimetric relative humidity sensor,
- black&white pyranometer sensor,
- rain gauge,
- dedicated data logger (based on HITACHI 6303-R CPU and 256 Kb memory), capable of analog/digital signal acquisition at about 0.4 Hz frequency and a SW package for first level statistical analysis and data validation and control.

During the campaign, the Mobile Station was connected to the MIN through a radio transmission system.

All the data were processed in two steps: the first one locally, on-line, and the other one off-line.

On-line test rejects out-of-range data and incomplete data set.

Off-line test allows:

- data correction, according to analyzer calibration results,
- standard statistical data analysis and correlation checks between chemical and meteorological data.

3.3. ENEL 3-D Monostatic Doppler SODAR

The Doppler SODAR system is an instrument to measure vertical wind field up to 1000 meters height.

The physical principle is based on the analysis of the returned echo of an acoustic pulse transmitted by a directional antenna pointed towards the sky. Within a fraction of second after the brief sound speed is transmitted, the same antenna begins to receive the returning echo. Since the air crossed by the sound pulse is in turbulent motion, a shift is produced in the Doppler frequency of the echo received by each antenna. These frequency variations are a direct function of the speed of the air mass crossed by the sound wave. By repeating these operations along three different axes, the three components of wind direction can be obtained.

The 3-D Doppler SODAR, used during this campaign, was a commercial device manufactured by Multimicro-TIM (Elisei et al., 1986). The system, in a monostatic configuration, is mounted on a truck (see fig. 9) and utilizes three antennas with paraboloids of 1.2 m diameter: of the three beams one points vertically, the other two points obliquely, at an angle of about 20° to the vertical, and azimuths 90° apart. The system is capable of simultaneously radiating bursts of tones different for each antenna and of receiving the echoes generated by each tone with anappropriate choice for the filters, independently as well as collectively by each antenna. The following table shows its main features:

SOUNDING FREQUENCIES	1750, 2000, 2250 Hz (each from one of the 3 antennas at the same time)
PULSE POWER	150 W
PULSE LENGTH	100 ms (typical)
PULSE REPETITION RATE	6 s (typical)
INTEGRATION TIME	30 min (typical)
ACCURACY	0.3 m/s (speed) 5° (direction)

The scientific literature reports that SODAR accuracy is better than 0.3 m/s for wind speed and 5° for wind direction (Gland, 1980; Kaimal et al., 1984).

During the campaign, SODAR was connected by radio to the MIN.

3.4. ENEL UV-DIAL system

The UV-DIAL system utilizes a doubled dye laser pumped by the second harmonic of a Nd-YAG laser with 20 Hz repetition rate. The emission at λ_{on} (maximum absorption wavelength for SO_2) and λ_{off} (minimum absorption wavelength for SO_2) is changed shot by shot by means of a device that inserts a prism in the dye laser oscillator cavity; in this way, the laser beam is deflected on the grating of the laser cavity that selects the wavelength.

The laser beam is coaxially transmitted by means of steering optics to the telescope. This can rotate over a solid angle of 2π with a precision of 0.1° in zenith and 0.25° in azimuth. The optical signal is detected by a photomultiplier, whose gain is modulated in time with a quadratic law. In this way, the dynamic of the DIAL signal is greatly reduced with improvement of precision in A/D conversion. The digitized signals are then transmitted to a DEC VAXStation GPX/II.

Through the electronic control and timing system, the computer is able to make fully automatic measurements. It is possible to program telescope rotation, laser firing, wavelengths change and other functions. The software permits measurements over a fan of directions, with real-time data processing. The results, that are SO_2 concentrations as a function of distance, are stored on hard disk and subsequently can be recalled to get concentration maps using a printer-plotter. The following tables summarize the system specifications.

TRANSMITTER

LASER SYSTEM	Nd-YAG pumped dye laser
ENERGY OUTPUT	300 mJ (at 530 nm) 10 mJ (at 300 nm) 10 mJ (at 490 nm) 30 mJ (at 720 nm)
LASER BANDWIDTH	0.1 cm^{-1}
REPETITION RATE	20 Hz
PULSE DURATION	10 ns

RECEIVER

TELESCOPE AREA	0.25 m^2
OPTICS EFFICIENCY	20% (SO_2)
FIELD OF VIEW	1 mrad
DETECTOR	Photomultiplier PHILIPS XP-2050Q
DETECTOR SPECIFICATIONS	20% quantum efficiency
TRANSIENT RECORDER	SONY TEKTRONIX 390 AD (10 bit 10 MHz)

PERFORMANCES

RANGE	up to 3 Km
LOWER DETECTABLE VALUE	50 ppb (SO_2)
SPATIAL RESOLUTION	15 to 200 m
TELESCOPE ANGLE RESOLUTION	0.1° in zenith 0.25° in azimuth

The system, installed on a truck (see fig. 10) and equipped with a power generator of 50 kVA, is provided with remote control of laser beam alignment. Also a TV camera is mounted on the telescope for eye safety and pointing control.

The total time taken for the measurement in one direction, including

telescope movement, is about 10-30 seconds; the set-up time for the whole system is around 2 hours.
During the 6th EEC Campaign on Remote Sensing at Fos-Berre in 1983 (Capitini et al., 1984; Marzorati et al., 1984) an intercalibration was performed on June 3rd and 4th among the DIAL systems taking part in the campaign, i.e. NPL (UK), Lund (Sweden), CEA/EERM (France) and ENEL (Italy), on the hill overlooking Martigues. This test has showed the good reliability of the DIAL apparatus performance.

3.5. ENEL Mobile Intelligent Node (MIN)

The Mobile Intelligent Node (MIN) is a truck-mounted system (see fig. 11) for data acquisition and processing, making use of Remote Sensing Control (RSC) Software implemented on a DEC MicroVAX 3400 computer (FPU, 12 Mbytes RAM, ETHERNET Controller, 400 Mbytes RF71 Hard Disk, TK70 Streamer Tape, 8 Full-Modem RS232 Asyncronous Lines). The RSC Software (Tinarelli et al., 1991) is designed to handle and integrate meteorological and pollution data coming from different sources, taking full advantage from DEC/VMS operating system real-time and multiprogramming capability.
During the Sostanj campaign, the MIN was connected to a Doppler SODAR (§ 3.3) and CISE mobile laboratory (§ 3.2) by means of a radio communication system operating at 44.900 MHz. The radio communication system is able to connect up to 6 remote locations within 10 Km

distance from the MIN, that controls data transmission and diagnostic. Using the KERMIT protocol, the DEC MicroVAX 3400 was able to receive data coming from Sostanj monitoring network (§ 3.1). The experimental layout of Sostanj campaign is shown in figure 12.
The synoptical graph (see fig. 13) displays the site geographical map and the time (day, hour and minutes) of the last message received in real-time by every station. With the help of a mouse and by pointing to a particular site on the map, it was possible to obtain detailed information about data coming from the site itself. As an example, the thermal-power station data provided by RSC are displayed below the graphic.
Every 30 minutes the MIN was able to receive the raw data, store them into a database useful for graphical and statistical real time management and to activate different mathematical models:

* APC-2 (Morselli et al., 1991):
  gaussian diffusion model to carry out SO_2 ground level concentration maps and stochastic models to forecast the half-hour and daily average SO_2 ground level concentration at the six stations of the network.

* ICARO (Morselli et al., 1991):
  package to reproduce the three-dimensional wind fields on complex terrain. It contains different mathematical models to define a non-divergent wind field, using anemometer and Doppler SODAR measurements.

* LAMBDA (Brusasca et al., 1991):

(LAgrangian Model for Buoyant Dispersion in the Atmosphere): a Montecarlo particle model for simulating pollution dispersion in a three-dimensional domain.

4. CAMPAIGN DESCRIPTION

4.1. General Overview

The selection of the time period for the campaign has depended mainly upon the climatic conditions in the area of the Sostanj basin. Measurements performed over the period of several years have shown that the highest levels of pollution occur during wintertime. The power plant works to the highest capacity in the winter and therefore emits a large amount of SO_2 and other pollutants.

Furthermore temperature inversion and stable conditions are frequent in winter; in such conditions, the dilution of emitted pollutants is minimum. Sostanj TPP is located in the low part of the Velenje district, and, in spite of the height of the stacks, the plumes easily impact the surrounding elevated hills.

As a result, the SO_2 ground concentrations can exceed the allowed limits by several times.

Although the winter would be the best period to perform the campaign, the snow - very frequent in this season - would have made difficult for the mobile laboratories to reach the appropriate locations, on the hills surrounding Sostanj and to transport and install, near TPP, LIDAR, SODAR and MIN. For these reasons, early spring has been chosen for the campaign; it should be noted that, during this period, typical winter conditions have often occurred, as can be seen from figure 7.

The data gathering started on March 15^{th} and finished on April 5^{th} 1991. The location of mobile laboratories are shown in fig. 2; in particular CISE laboratory has been located in Zavodnje from March 15^{th} to 25^{th} near a IJS station to intercalibrate the chemical and meteorological instruments; then it has been set in Hrust, till up the end of the campaign, with the goal to verify the "overcrossing" of the plume besides Zavodnje pass.

4.2. Synoptic Condition

This brief description of the meteorological situation is based on the analysis of the surface, 850 hPa and 700 hPa synoptic charts (pressure and wind field) from the Europäischer Wetterbericht (Offenbach), the ECMWF (Reading) and on the local data measured during the campaign.

The period has been characterized by at least three different synoptic conditions, which determined various phenomena, such as precipitation (mostly snow), which are frequent during seasonal change.

During the first days of the campaign (March 15^{th}-19^{th}) the main pressure structure observed on the area consisted on a weak gradient, with no significant circulation (see fig 14). This configuration has generally determined stable weather condition, except for weak rainfall on March 18^{th} (caused by warm front advection).

During the following days (March 20^{th}-23^{rd}) the pressure field took a light curvature accompanied by a weak W-NW anticyclonic motion. This new dynamic structure (see fig. 15), conditioned by low pressure on the Scandinavian peninsula, determined cloudy sky and low temperatures on the site.

A strong worsening of the meteorological conditions was observed between March 23^{rd} and 24^{th}. The passing of the warm sector of a front, slowed down by the Azore's anticyclone, created high clouds (altocumulus and altostratus) and weak precipitation on the area. The winds, whose intensity was moderate to strong, had a main WSW component.

During March 25^{th} the convergence of the southern warm air with the northern cold air (fig. 16) determined a very strong worsening on the meteorological conditions till up March 28^{th}. These conditions started a low pressure regime at 850 hPa, with low to moderate winds, and unstable weather on the ground with a strong temperature decrease and intense precipitations (even snow).

From March 29^{th} to April 1^{st} weather conditions on the area were gradually getting better. Fresh air, coming from N-NE, brought in the lower atmosphere good weather condition.

Clouds, due to wind rotation from NE to E, crossed over the site, without causing rainfall.

During the last days of the campaign, the weather was conditioned by western winds from the Atlantic ocean (see fig. 17), which gradually rotated from W to SW. So the ground temperature rose and the moisture brought in by the warm sector of a front, created increasing cloudiness and unstable weather conditions.

5. DATA REPORTS

In the present section some significant chemical and meteorological data collected by the entire system are reported in a graphical form. Such presentation allows a first draft about the air pollution trend connected with the evolution of the meteorological condition during the campaign.

5.1. Thermal Power Plant SO_2 Emission Rate

Figure 18 shows the SO_2 emission rate (tons per hour) relative to the three stacks of the plant against the Julian day. In the legenda are reported:

MAX	= measured maximum value
NPT	= total number of data
NPV	= number of good data
MOY	= average value
SIG	= standard deviation
MIN	= measured minimum value.

The graphs represent the contribution of the plant blocks, in particular, the first one shows the gases outcoming from the three blocks (Q1+Q2+Q3), connected to stack 1.

The following table summarizes the emission parameters of the three different stacks at maximum load.

Blocks	Power (MW)	Stack	Height (m)	Diam. (m)	Emission rate (ton/h)	Stack exit speed (m/s)	Plume Temp. (°C)
Q1	30	1	100	6.5	1300	6.2	170
Q2	30						
Q3	75						
Q4	275	2	150	6.34	2700	13.2	180
Q5	345	3	230	6.20	3300	13.8	200

5.2. Meteorological Data

To allow a quick discrimination between good and bad weather conditions, the total solar radiation (Watt/m^2) and the rain (mm) against the Julian day, measured at Sostanj fixed station are represented in figs. 19 a-b.

The legenda is the same like in 5.1. A "false" threshold (due to instrumental noise) in solar radiation is present near the zero value.

5.3. Wind Roses

In figs. 20-21 the wind roses of all fixed and mobile stations and the lowest level of SODAR (50 m) are plotted on the contour level map. The two maps represent the diurnal and nocturnal statistical wind flux of the entire period.
In the centre of each wind roses the percentage (‰, per thousand) of calm situations (wind < .5 m/s) is shown; the length of rays is related to the frequency of the different wind classes and the width represents the wind class.
It can be noticed that the main components of the wind are along and across the axis of the valley, with a significant rotation, observed on some stations, due to complex terrain.
During the day it can be observed a strong SE component in all the stations, except for Graska Gora and IJS mobile station, where there is no sensible difference between the diurnal and nocturnal regime.
During the night it can be observed a high percentage of calm wind.
At last, the data measured at Topolsica station (B) haven't to be considered significant (too high calm wind percentage) because the station is closed from three sides by hill slopes.

5.4. SODAR Data

The Doppler SODAR, located close to the DIAL system (see fig. 2), was continuously in operation from March 15th to April 5th, 1991. In this period, it gave vertical profiles of wind field (horizontal wind speed and direction, standard deviation of wind direction, vertical wind speed, standard deviation of vertical wind speed, echo intensity and its standard deviation) on 30-min averaging time. The vertical profiles were obtained with a spatial resolution of about 50 m, starting from 50 m minimum height.

The cumulative frequency distribution of the maximum height attained by the SODAR sounding, during the above defined period, is shown in figure 22. It can be seen that the average maximum height was in 50% of cases more than 600 m and that in 90% of cases the height of about 450 m gave measurements.

The evolution of the horizontal wind speed during the period of the campaign are represented in figs. 23 a-v (only on 1-hour basis).

5.5. SO_2 Data

In the figs. 24-34 (a,b) the two days trend of SO_2 ($\mu g/m^3$) against hours for all stations are represented (four per page). The meaning of the legenda is the same of par. 5.1.

In particular, the maximum values (more than 800 $\mu g/m^3$, Slovenian alarm threshold) have been measured in Veliki Vrh during March 17^{th} and 24^{th}, in Sostanj during March 23^{rd} and in Topolsica and Sostanj in April 2^{nd}.

5.6. DIAL Measurements

During this campaign, the DIAL system was located at a distance of about 1100 meters in direction N from Sostanj power plant (see fig. 2); vertical and horizontal scans in various directions and at different elevation angles were performed to measure plumes pattern and SO_2 concentration (every single measurement is obtained by averaging 200 laser shots with a spatial resolution of 15 meters).
Tables 1 a,b reports the list of DIAL measurements performed during the campaign; each measurement is identified by:

- file name;
- date;
- measurement start;
- measurement stop;
- type;
- elevation angles;
- azimuth;
- zenith.

As an example in figure 35 it is represented the plume vertical section and its horizontal dimension obtained on April 2nd, 1991 from 18:38 to 19:28, while in figures 36, 37 and 38 the measurements performed at 18:49, 19:09 and 19:28 respectively in direction 185°N, 200°N and 215°N are shown.

Table 1a - List of DIAL measurements

FILE NAME	DATE	START	STOP	TYPE	AZIMUTH	ZENITH
SOS91001	18/3/91	10:22:32	10:27:32	Azimuthal	170 - 210°N	25°
SOS91003	18/3/91	11:10:38	11:15:32	Azimuthal	170 - 220°N	15°
SOS91004	18/3/91	11:28:33	11:33:26	Zenithal	185°N	10° - 45°
SOS91005	18/3/91	10:40:07	10:49:58	Zenithal	200°N	10° - 50°
SOS91007	18/3/91	12:48:24	12:53:31	Zenithal	230°N	10° - 50°
SOS91008	18/3/91	14:59:49	15:03:57	Zenithal	230°N	10° - 34°
SOS91009	18/3/91	15:24:31	15:28:06	Zenithal	210°N	10° - 34°
SOS91010	18/3/91	15:38:12	15:43:12	Zenithal	220°N	10° - 40°
SOS91011	18/3/91	15:54:33	15:59:27	Zenithal	220°N	10° - 40°
SOS91012	18/3/91	17:14:12	17:18:34	Azimuthal	173 - 200°N	15°
SOS91013	18/3/91	17:29:20	17:35:45	Zenithal	185°N	10° - 40.5°
SOS91014	18/3/91	17:49:27	17:59:16	Zenithal	170°N	20° - 70°
SOS91015	18/3/91	18:05:58	18:10:51	Zenithal	210°N	10° - 50°
SOS91016	19/3/91	10:57:37	11:04:36	Azimuthal	175 - 195°N	15°
SOS91017	19/3/91	11:14:33	11:19:32	Azimuthal	165 - 195°N	20°
SOS91018	19/3/91	11:32:51	11:37:45	Azimuthal	170 - 200°N	25°
SOS91020	19/3/91	15:29:05	15:38:54	Zenithal	235°N	50° - 130°
SOS91021	19/3/91	15:51:59	15:56:32	Zenithal	235°N	30° - 75°
SOS91023	19/3/91	17:10:49	17:17:11	Zenithal	240°N	10° - 36°
SOS91024	19/3/91	17:30:02	17:34:56	Zenithal	250°N	15° - 40°
SOS91025	20/3/91	8:55:01	9:02:55	Zenithal	102°N	50° - 130°
SOS91026	20/3/91	9:20:14	9:31:53	Zenithal	120°N	35° - 155°
SOS91027	20/3/91	10:23:21	10:27:06	Azimuthal	188 - 198°N	15°
SOS91030	20/3/91	12:19:44	12:28:26	Zenithal	245°N	15° - 100°
SOS91031	20/3/91	13:32:36	13:40:36	Zenithal	120°N	60° - 140°
SOS91033	20/3/91	16:23:52	16:29:06	Zenithal	198°N	15° - 35°
SOS91034	20/3/91	17:22:47	17:39:20	Zenithal	198°N	40° - 90°
SOS91036	21/3/91	9:41:36	9:55:50	Zenithal	110°N	25° - 160°
SOS91037	21/3/91	11:11:18	11:24:33	Zenithal	110°N	25° - 160°
SOS91040	21/3/91	13:37:11	13:41:20	Azimuthal	137 - 177°N	20°
SOS91042	21/3/91	15:17:12	15:25:02	Zenithal	120°N	15° - 95°
SOS91044	21/3/91	16:19:41	16:29:22	Zenithal	170°N	15° - 72°
SOS91045	21/3/91	16:46:51	16:59:25	Zenithal	160°N	15° - 90°

Table 1b - List of DIAL measurements

FILE NAME	DATE	START	STOP	TYPE	AZIMUTH	ZENITH
SOS91046	21/3/91	17:13:08	17:23:29	Zenithal	140°N	15° - 78°
SOS91047	21/3/91	17:34:31	17:46:56	Zenithal	100°N	15° - 90°
SOS91048	22/3/91	10:06:34	10:23:41	Zenithal	234°N	29.8° - 149.8°
SOS91050	22/3/91	14:17:50	14:31:16	Zenithal	175°N	15° - 150°
SOS91051	22/3/91	15:11:14	15:24:49	Zenithal	160°N	15° - 150°
SOS91052	22/3/91	16:27:13	16:34:08	Zenithal	182°N	15° - 85°
SOS91053	25/3/91	11:51:04	12:04:50	Zenithal	175°N	20° - 160°
SOS91054	28/3/91	14:20:39	14:29:30	Azimuthal	135 - 225°N	25°
SOS91055	28/3/91	16:46:34	16:51:39	Azimuthal	173 - 203°N	20°
SOS91056	1/4/91	13:55:06	14:05:08	Zenithal	185°N	10° - 50°
SOS91A57	1/4/91	14:23:42	14:33:43	Zenithal	200°N	5° - 25°
SOS91B57	1/4/91	14:23:42	14:33:43	Zenithal	200°N	25° - 55°
SOS91058	1/4/91	14:45:25	14:55:38	Zenithal	215°N	5° - 53°
SOS91059	1/4/91	15:15:11	15:25:04	Zenithal	185°N	10° - 40°
SOS91060	1/4/91	15:33:49	15:43:52	Zenithal	200°N	5° - 40°
SOS91061	1/4/91	15:52:53	16:03:06	Zenithal	215°N	11° - 65°
SOS91062	2/4/91	13:06:28	13:17:10	Zenithal	185°N	34° - 50°
SOS91063	2/4/91	13:30:58	13:41:25	Zenithal	200°N	5° - 59°
SOS91064	2/4/91	14:13:09	14:28:40	Zenithal	215°N	5° - 77°
SOS91065	2/4/91	14:46:28	14:56:35	Zenithal	185°N	10° - 50°
SOS91066	2/4/91	15:06:20	15:16:21	Zenithal	200°N	5° - 75°
SOS91067	2/4/91	15:23:17	15:33:30	Zenithal	215°N	5° - 65°
SOS91068	2/4/91	17:38:00	17:47:50	Zenithal	185°N	10° - 30°
SOS91069	2/4/91	17:58:11	18:08:16	Zenithal	200°N	5° - 35°
SOS91070	2/4/91	18:19:36	18:29:27	Zenithal	215°N	5° - 55°
SOS91071	2/4/91	18:38:23	18:48:40	Zenithal	185°N	10° - 30°
SOS91072	2/4/91	18:59:09	19:08:55	Zenithal	200°N	5° - 45°
SOS91073	2/4/91	19:18:13	19:27:55	Zenithal	215°N	5° - 55°
SOS91074	4/4/91	17:57:40	18:08:32	Zenithal	90°N	10° - 98°
SOS91075	4/4/91	18:19:24	18:29:16	Zenithal	90°N	20° - 70°
SOS91076	4/4/91	18:37:29	18:47:14	Zenithal	90°N	20° - 90°
SOS91077	4/4/91	18:57:50	18:09:47	Zenithal	90°N	20° - 50°
SOS91078	4/4/91	19:21:07	19:32:09	Zenithal	90°N	10° - 50°

6. FINAL REMARKS

The aims of the campaign can be divided into two groups:
on-line evaluations: the real-time acquisition of all collected data allowed:

* to "follow up" the falling back at the ground of air pollutants (through the monitoring network data) and to understand the dynamic of the phenomena with simulation models;
* to monitor the final plume rise;
* to measure the wind at the final plume rise, in order to identify the fixed monitoring station at ground mostly representative for the plume direction, in different meteorological situations;
* to compare the mobile laboratory data with those of the fixed monitoring stations in order to identify the reliability of different instruments and calibration methods.

off-line evaluations and data processing is in progress; the researchers' attention is mainly focused on the following points:

* comparison between the plume rise detected by DIAL and predicted by the LAMBDA particle model;
* statistical model evaluation between different diffusion models, in order to forecast ground level concentration at the network stations.

* simulation of particular cases (long distance dispersion, high concentration at ground level and chemical transformations) by mesoscale transport and diffusion models, using all the campaign data, as well as large scale data (i.e. wind, pressure and temperature synoptic fields coming from Reading's European Centre for Medium range Weather Forecast).

The work performed so far has confirmed the reliability of the new remote sensing instruments and the importance of the collected information.

It also appears that, if the remote sensing equipment (Doppler SODAR, DIAL) and the advanced mathematical models are used together with existing power plant air pollution monitoring networks, a considerable improvement in the interpretation of the data can be obtained, ensuring the use of more rational criteria for power plant management under "critical" conditions.

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LIST OF FIGURES

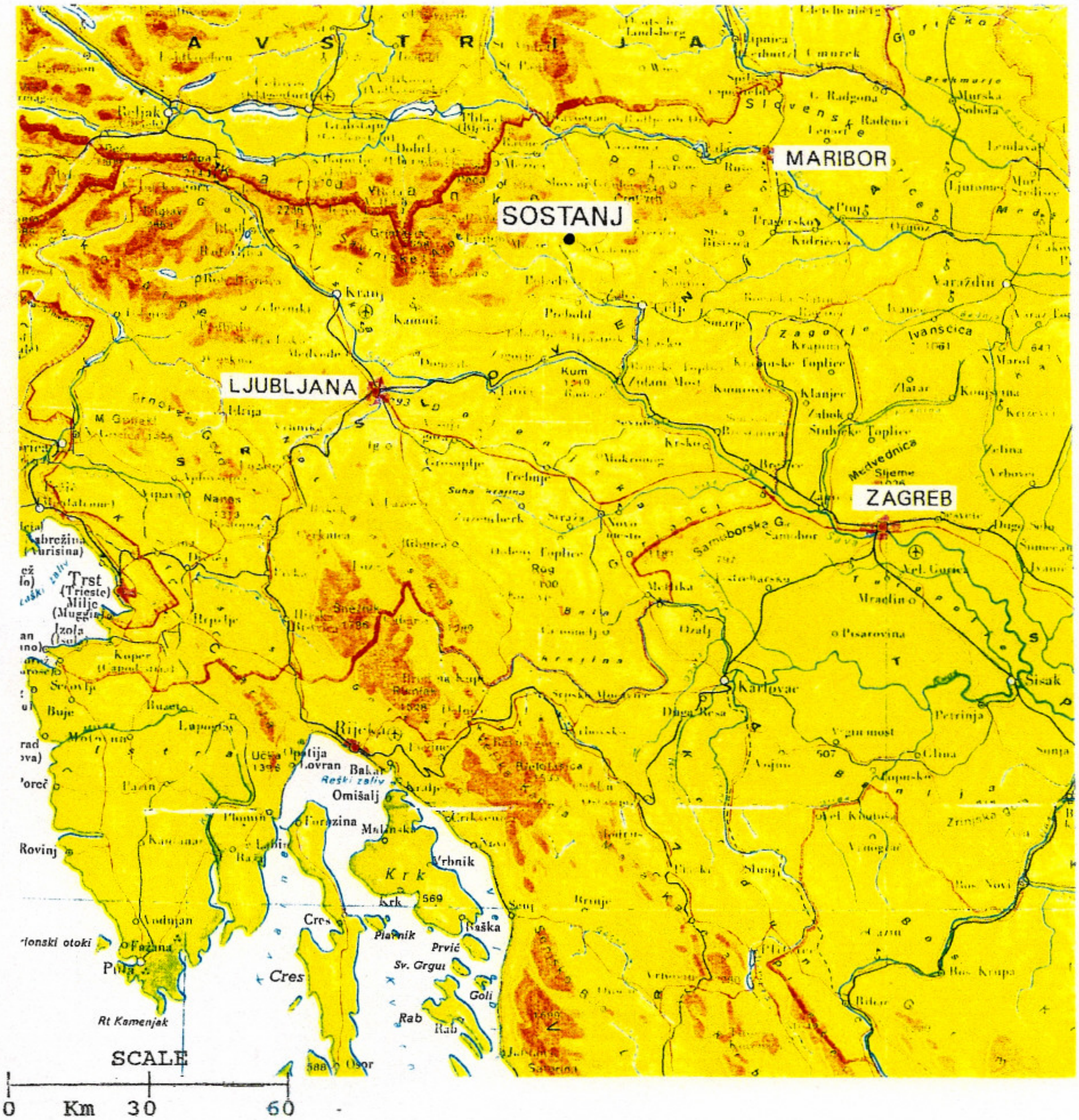


Figure 1 - SLOVENIA REGION

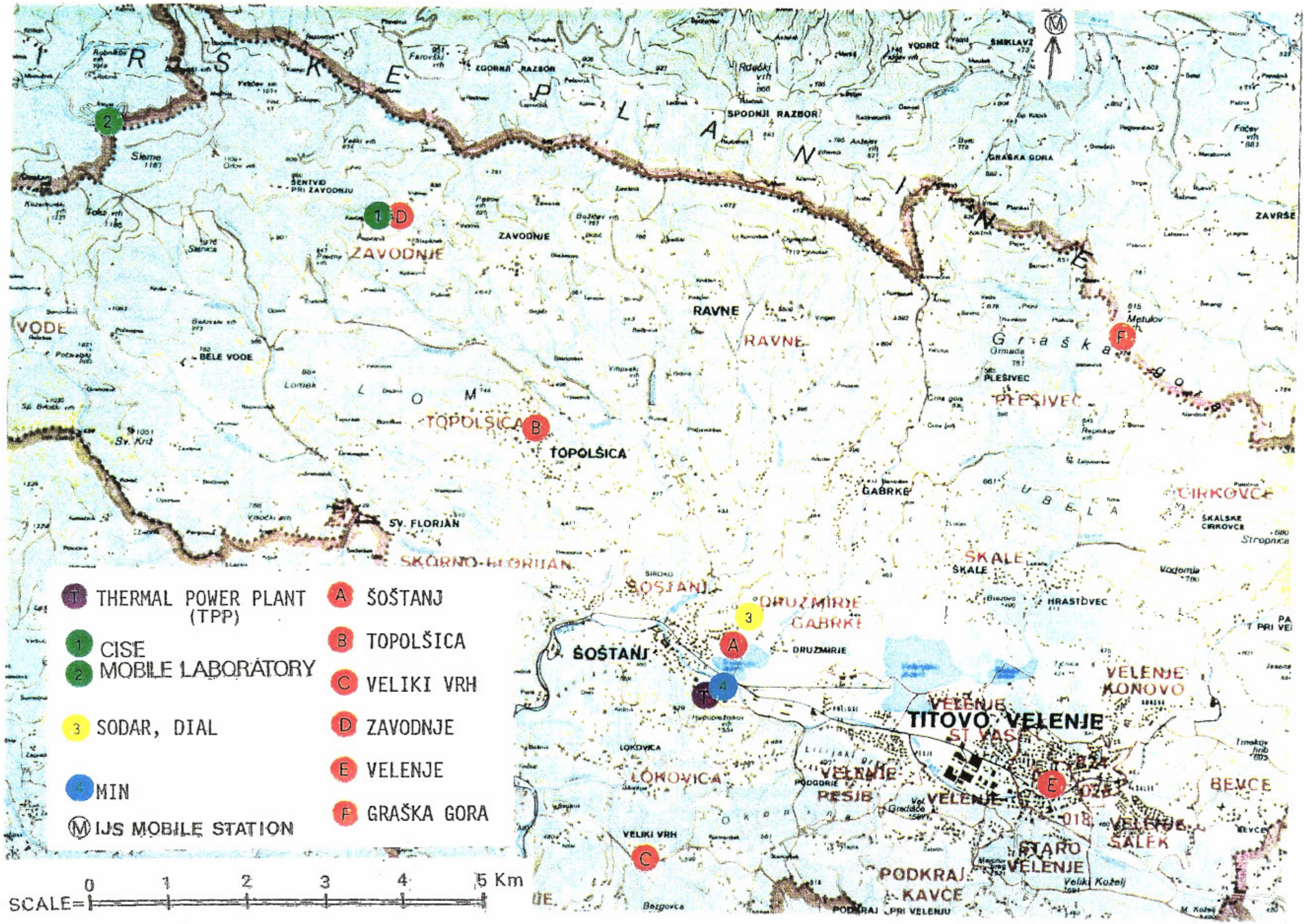


Figure 2 - VELENJE DISTRICT

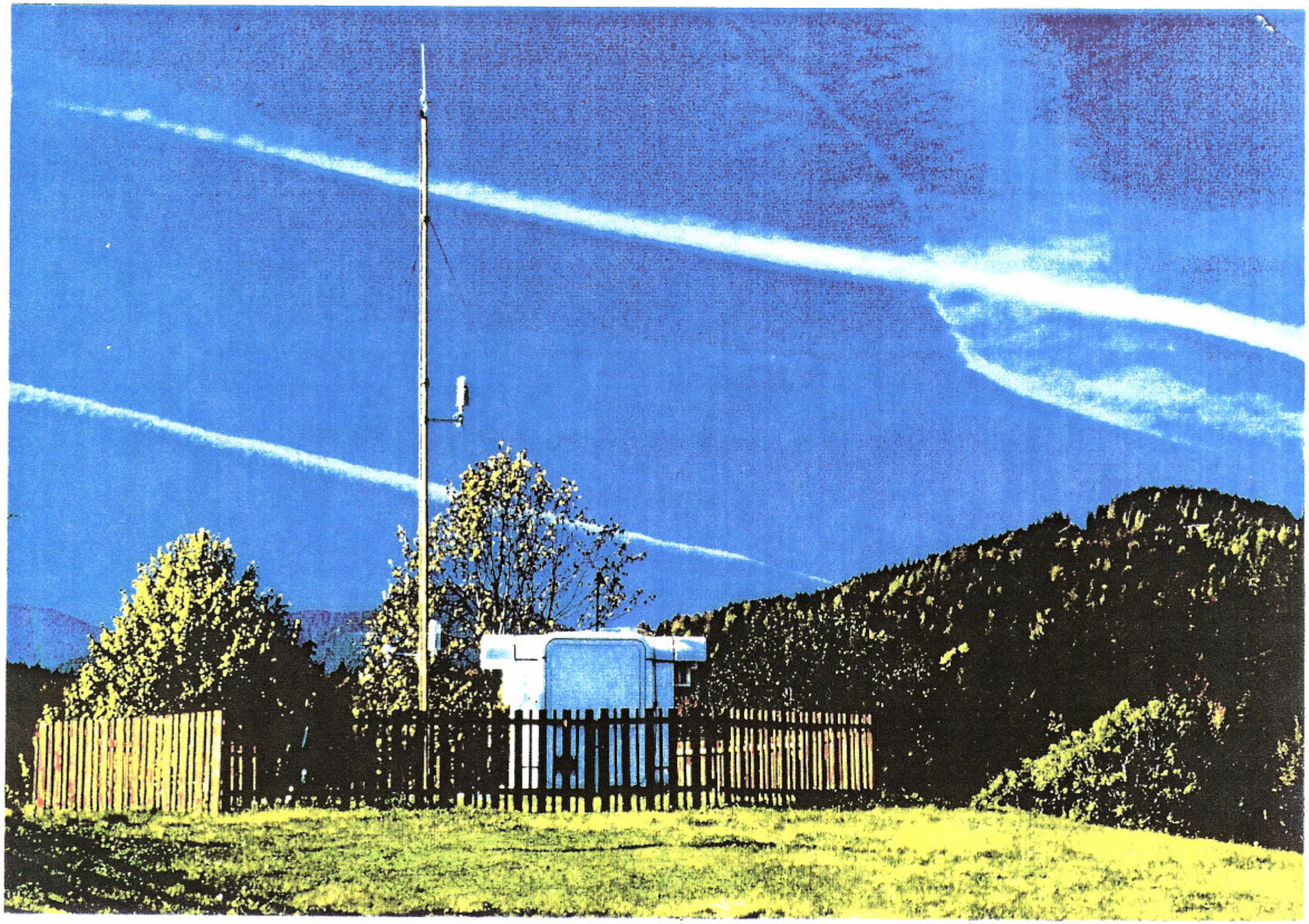


Figure 4 - Zavodnje monitoring station (IJS)

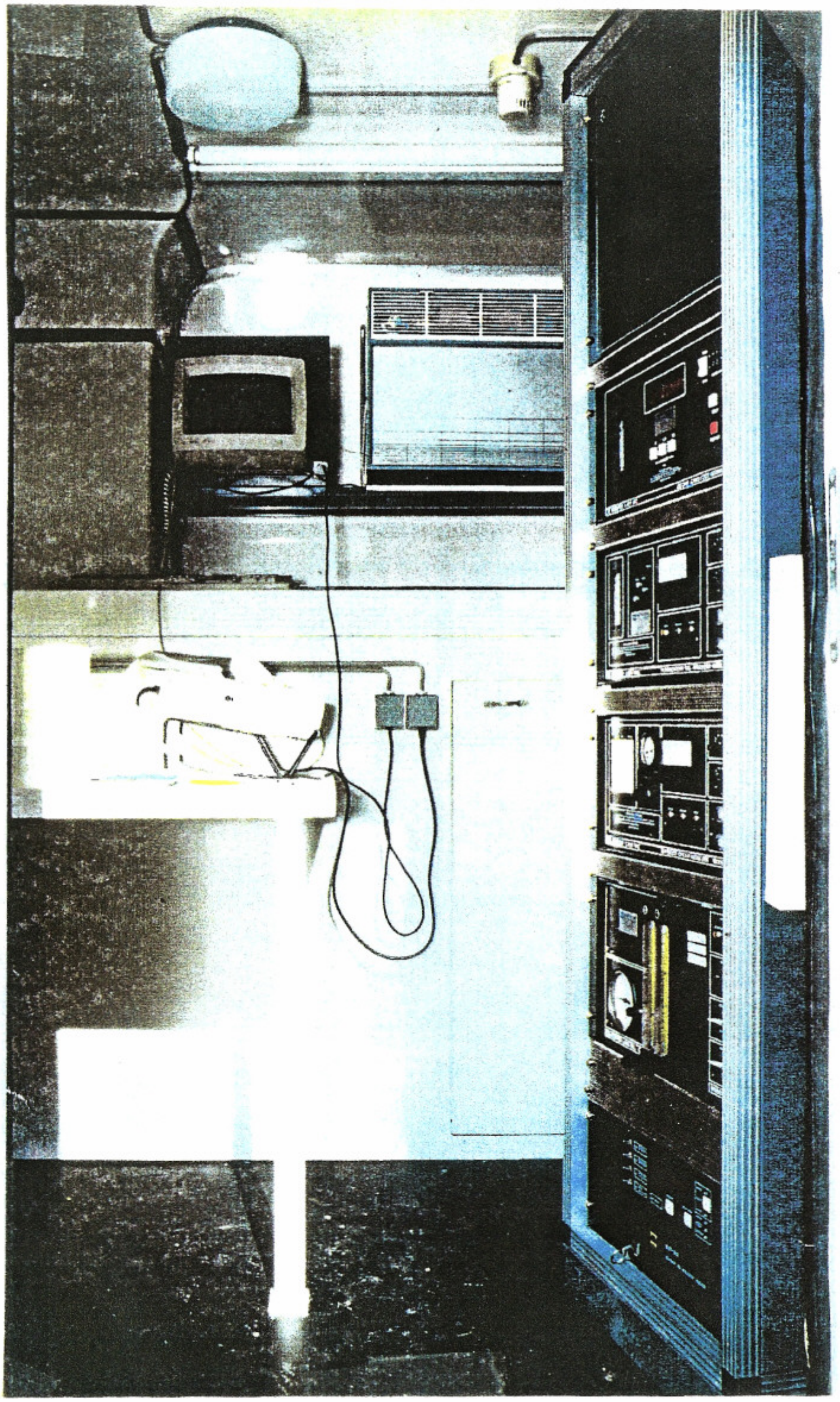


Figure 5 - Instrumental apparatus of a typical IJS station

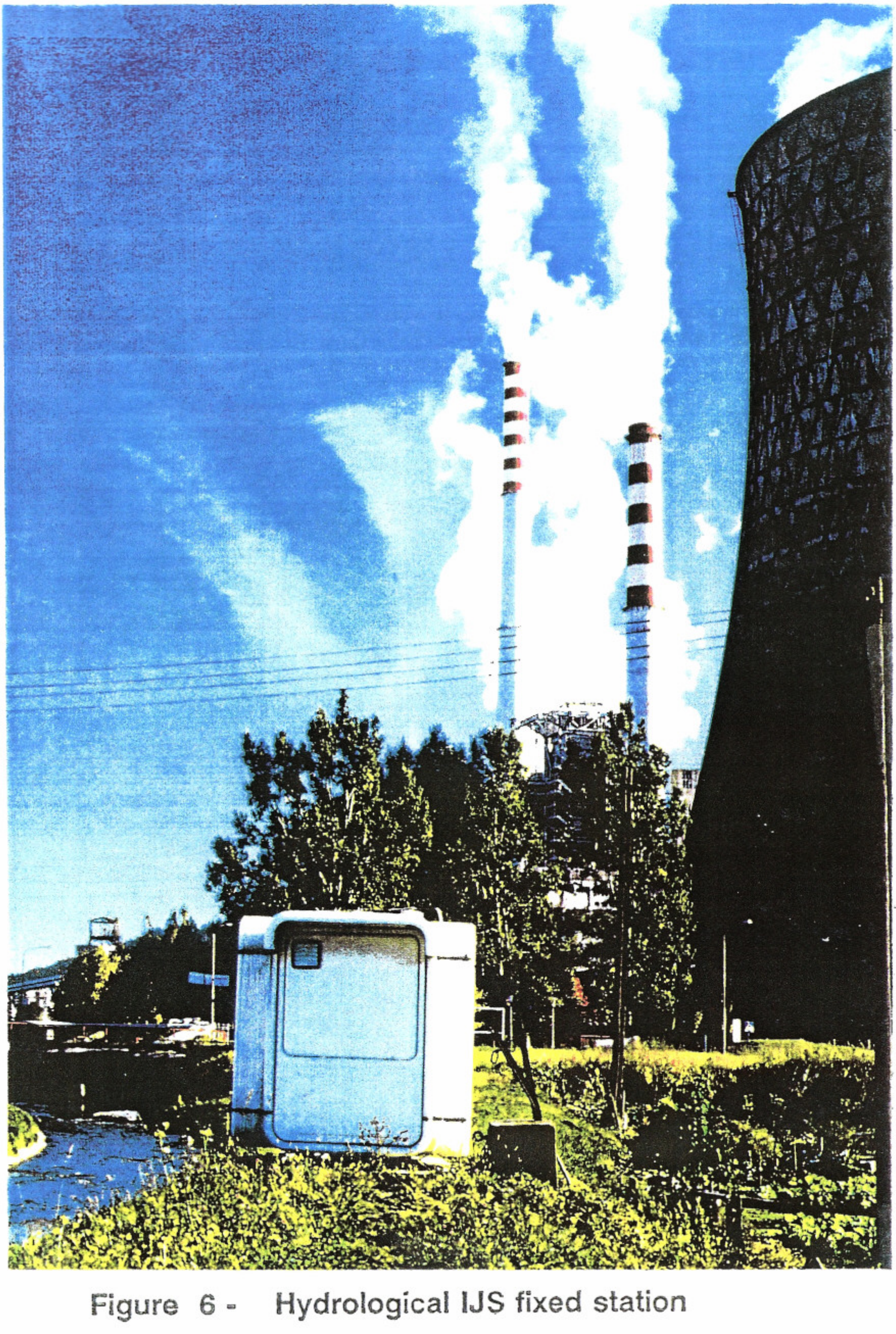


Figure 6 - Hydrological IJS fixed station

Figure 7 - CISE mobile laboratory in Hrust

Figure 8 - Instrumental apparatus of CISE laboratory

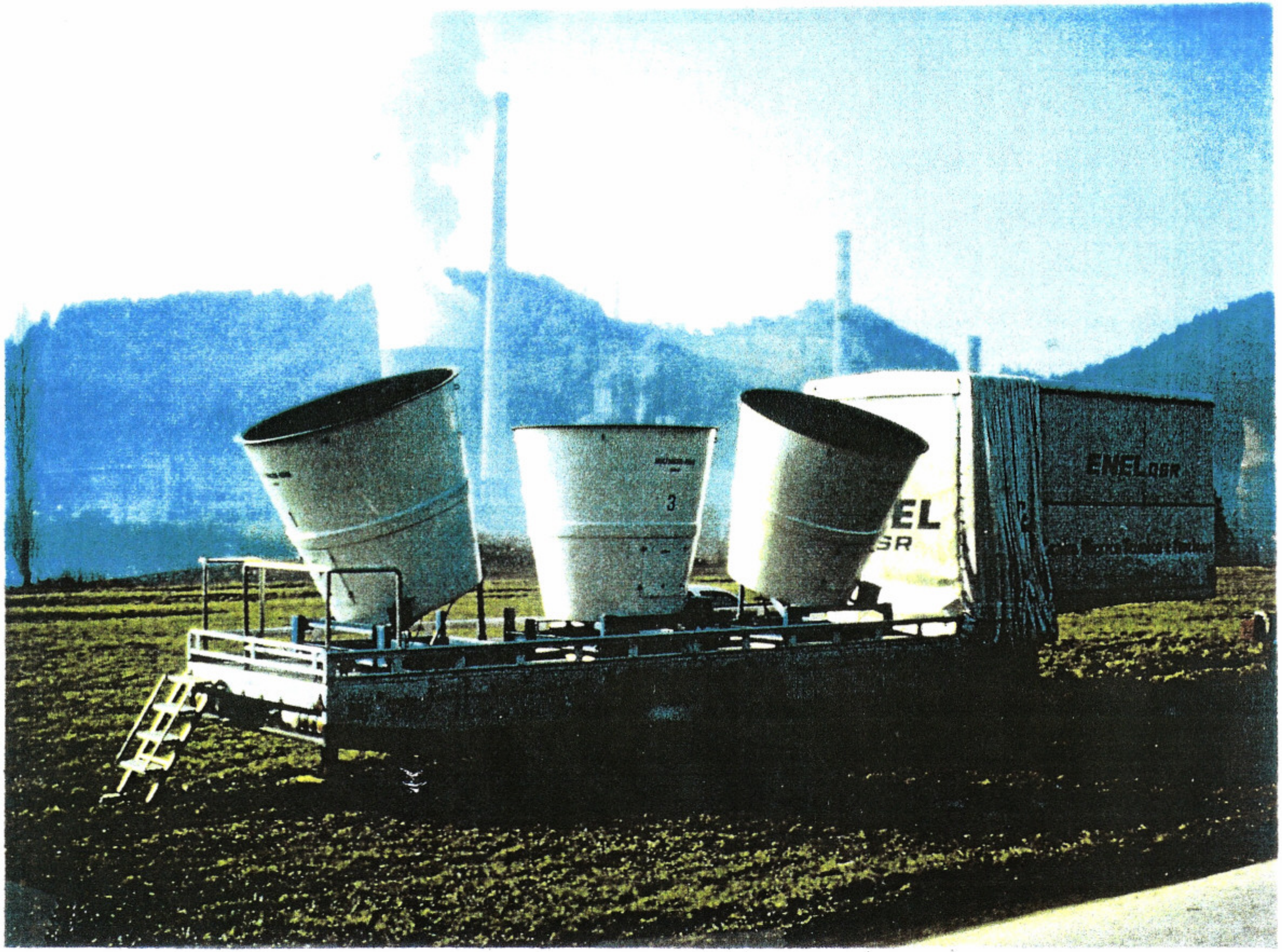


Figure 9 - ENEL/CRTN Doppler SODAR system

Figure 10 - ENEL/CRTN DIAL

Figure 11 - ENEL/CRTN Mobile Intelligent Node

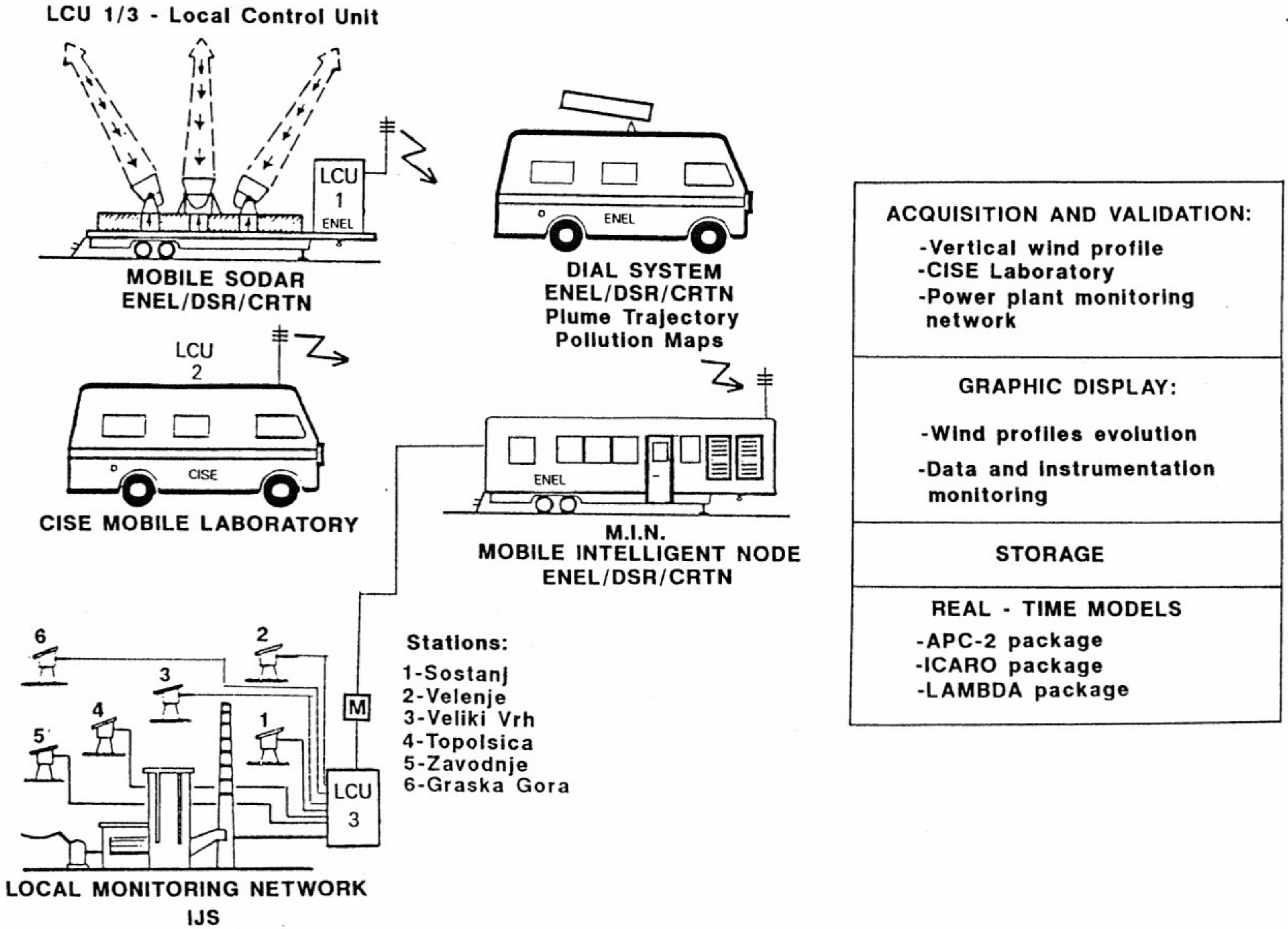
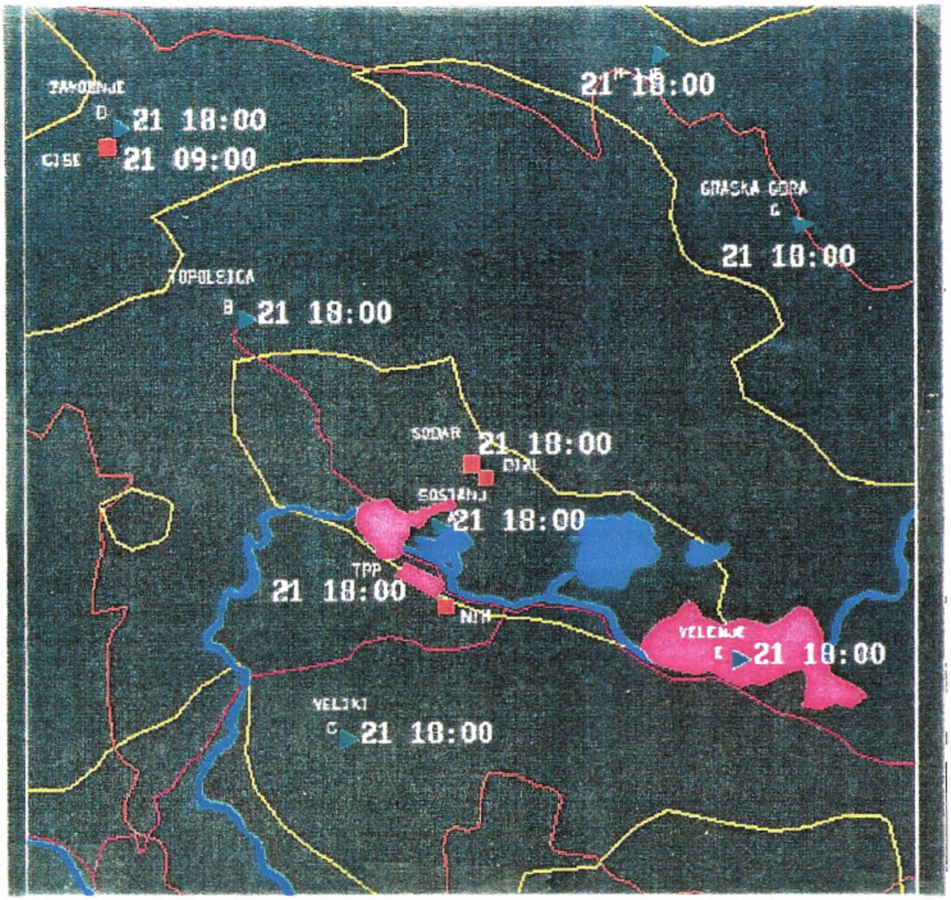


Figure 12 - Experimental layout of Sostanj campaign



STATION X POWER PLANT

Last message time 91/03/21 18:00

Block	Power (MW)	Emission (T/h)	Rate (MMm^3/s)
1	-	0.00	0.00
2	-	-	-
3	43.0	1.54	0.25
4	-	-	-
5	227.0	5.49	1.09

Block	Temperature (°C)	SO2 conc	Dust emiss (T/h)
123	170	6784.0	-
4	-	-	-
5	193.0	6055.0	.11

```
type --------->    1  2  3   4     5  6  7  8  Z for exit
for stations       A, B, C, D+CISE, E, F, M, X
```

Figure 13 - Example of real time synoptical map in the MIN (to control the state of the remote data acquisition)

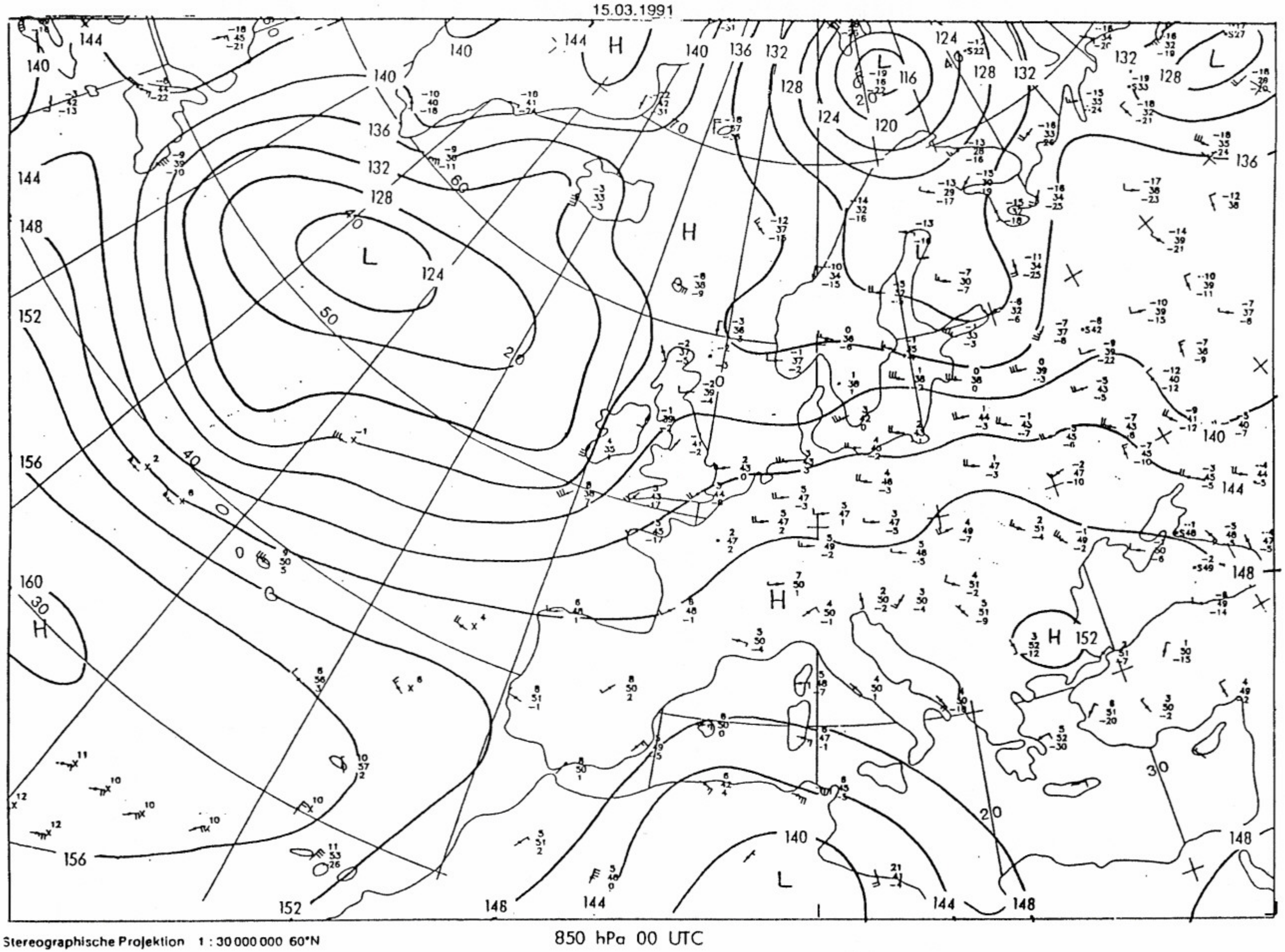
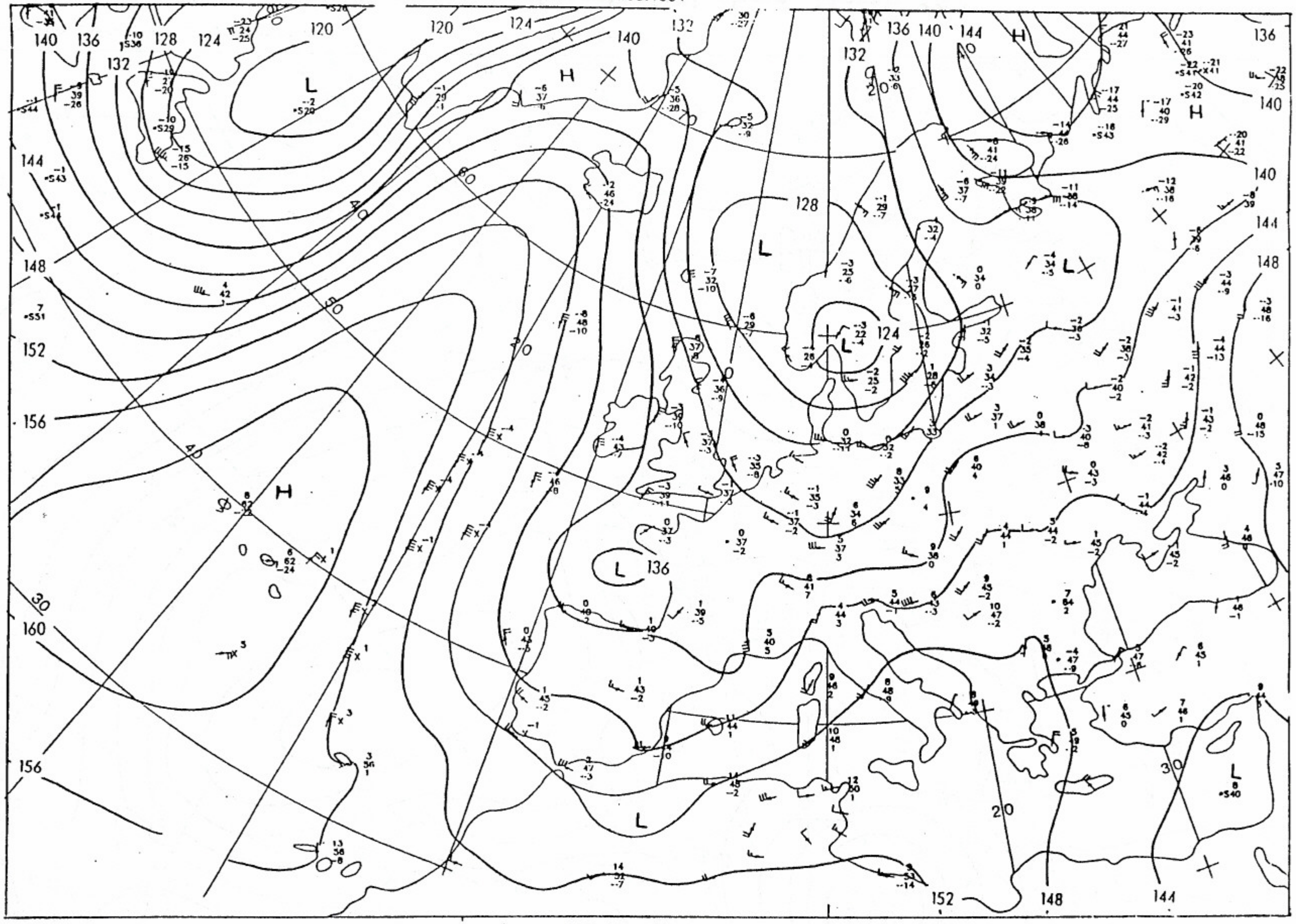


Figure 14 - Synoptic meteorological chart, March 15th, 1991 (from the Europäischer Wetterbericht, Offenbach)

22.03.1991



Stereographische Projektion 1 : 30 000 000 60°N

850 hPa 00 UTC

Figure 15 - Synoptic meteorological chart, March 22nd, 1991 (from the Europäischer Wetterbericht, Offenbach)

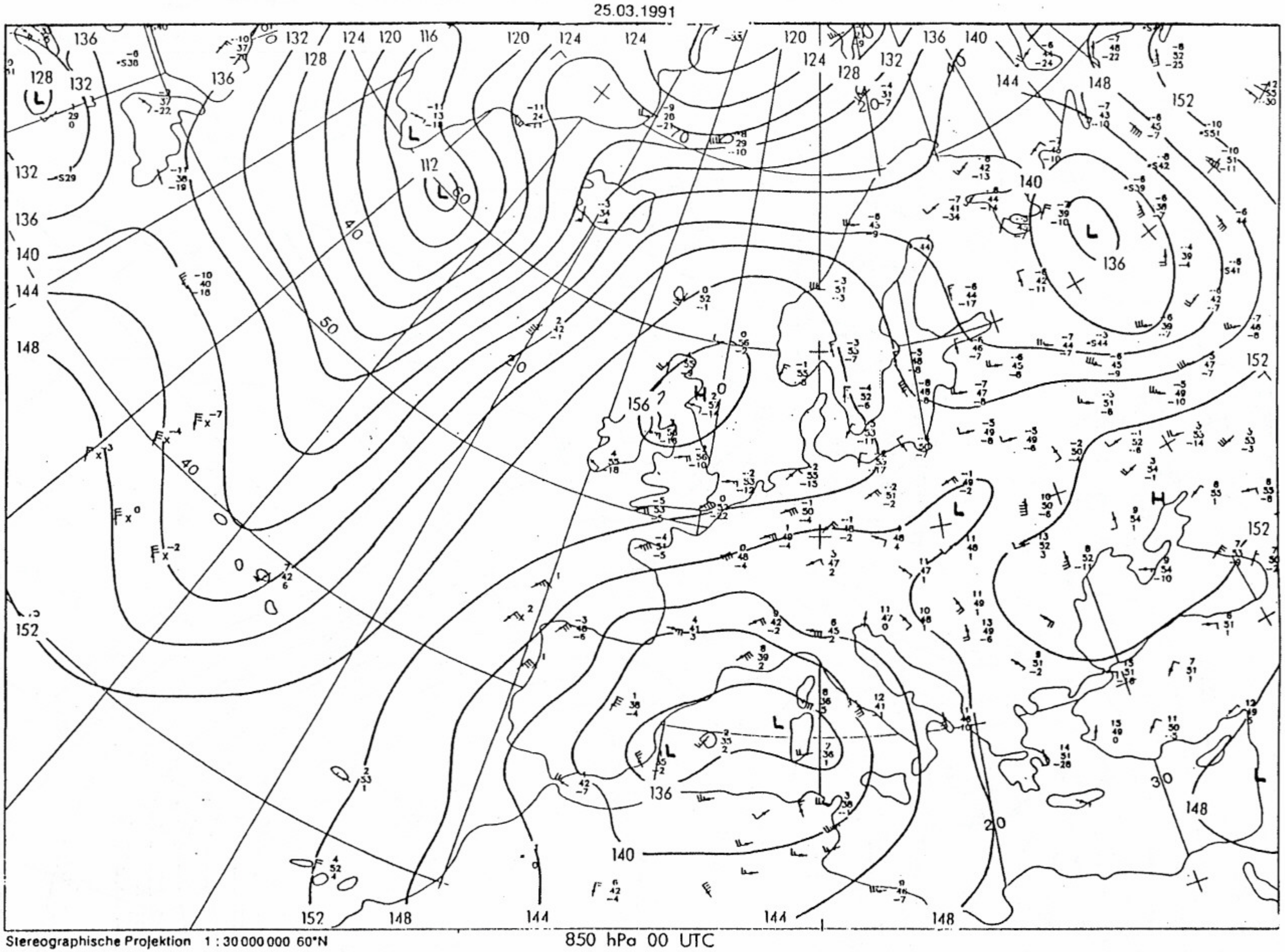


Figure 16 - Synoptic meteorological chart, March 25th, 1991 (from the Europäischer Wetterbericht, Offenbach)

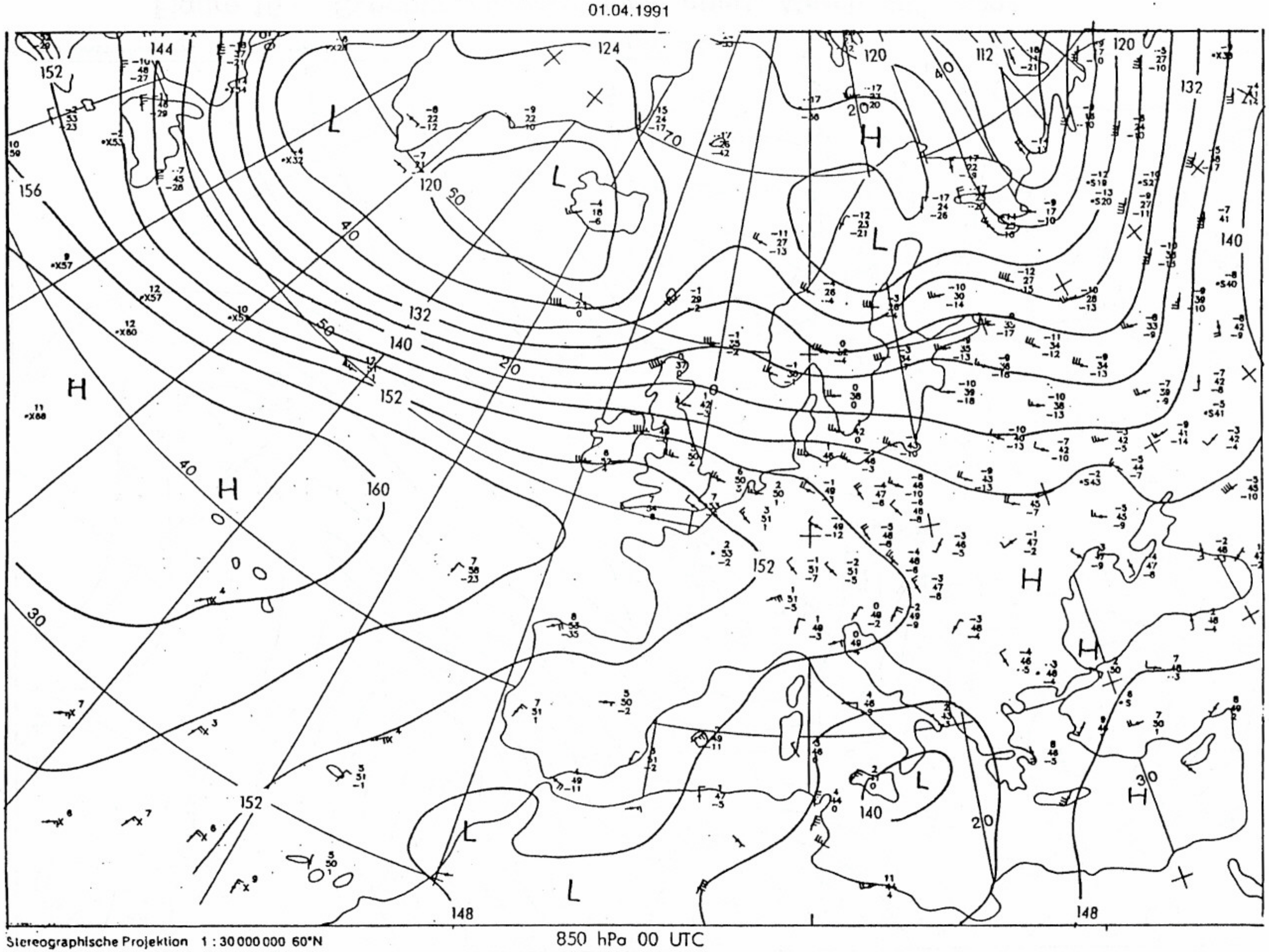


Figure 17 - Synoptic meteorological chart, April 1st, 1991 (from the Europäischer Wetterbericht, Offenbach)

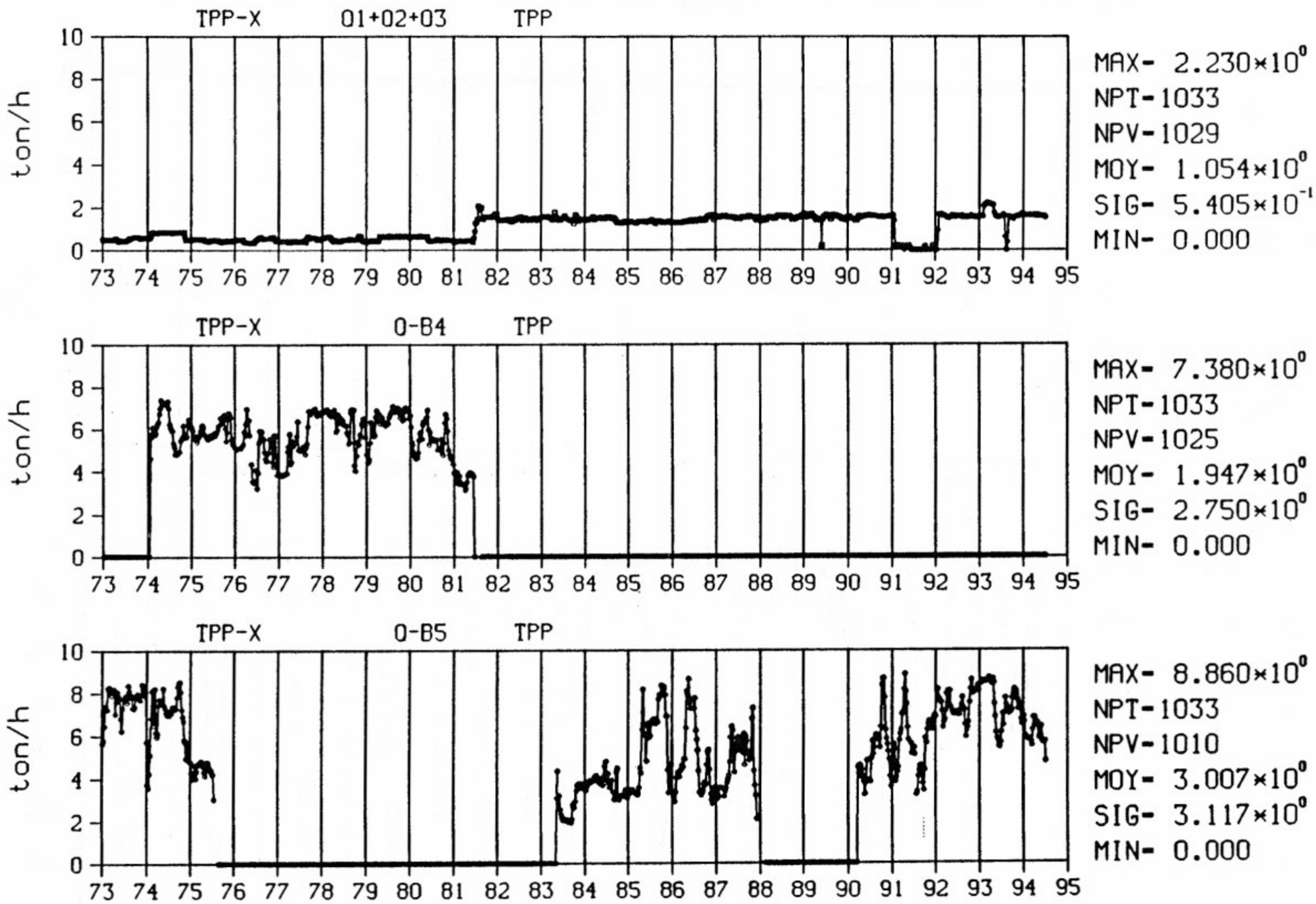


Figure 18 - **Thermal power plant SO_2 emission rate (ton/h) vs the Julian day, since March 15th, 00:00 to April 5th, 1991, 12:00**

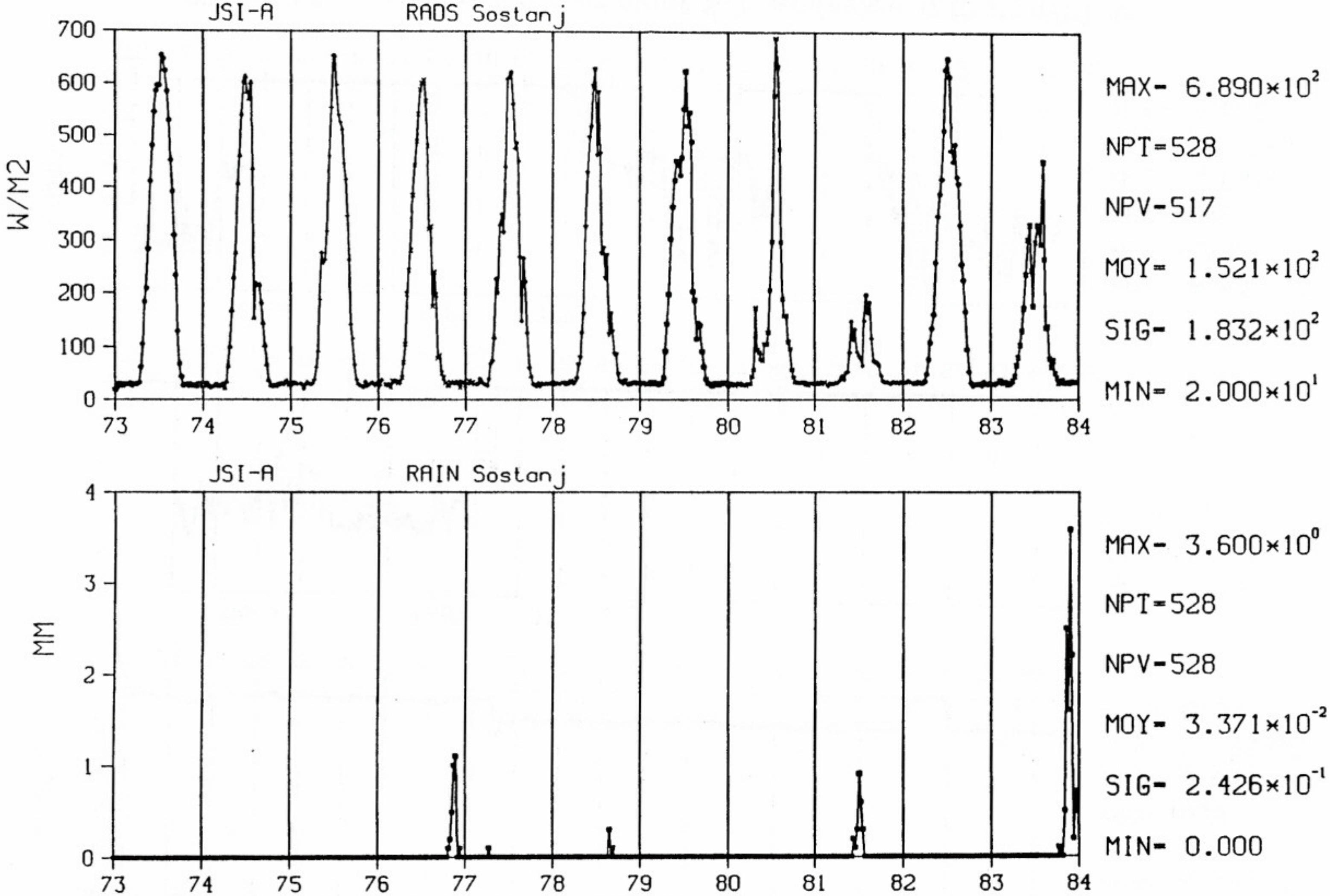


Figure 19a - Solar radiation (Watt/m^2) and rain (mm) vs the Julian day, during the first part of the campaign (since March 15th, 00:00 to March 25th, 1991 23:30)

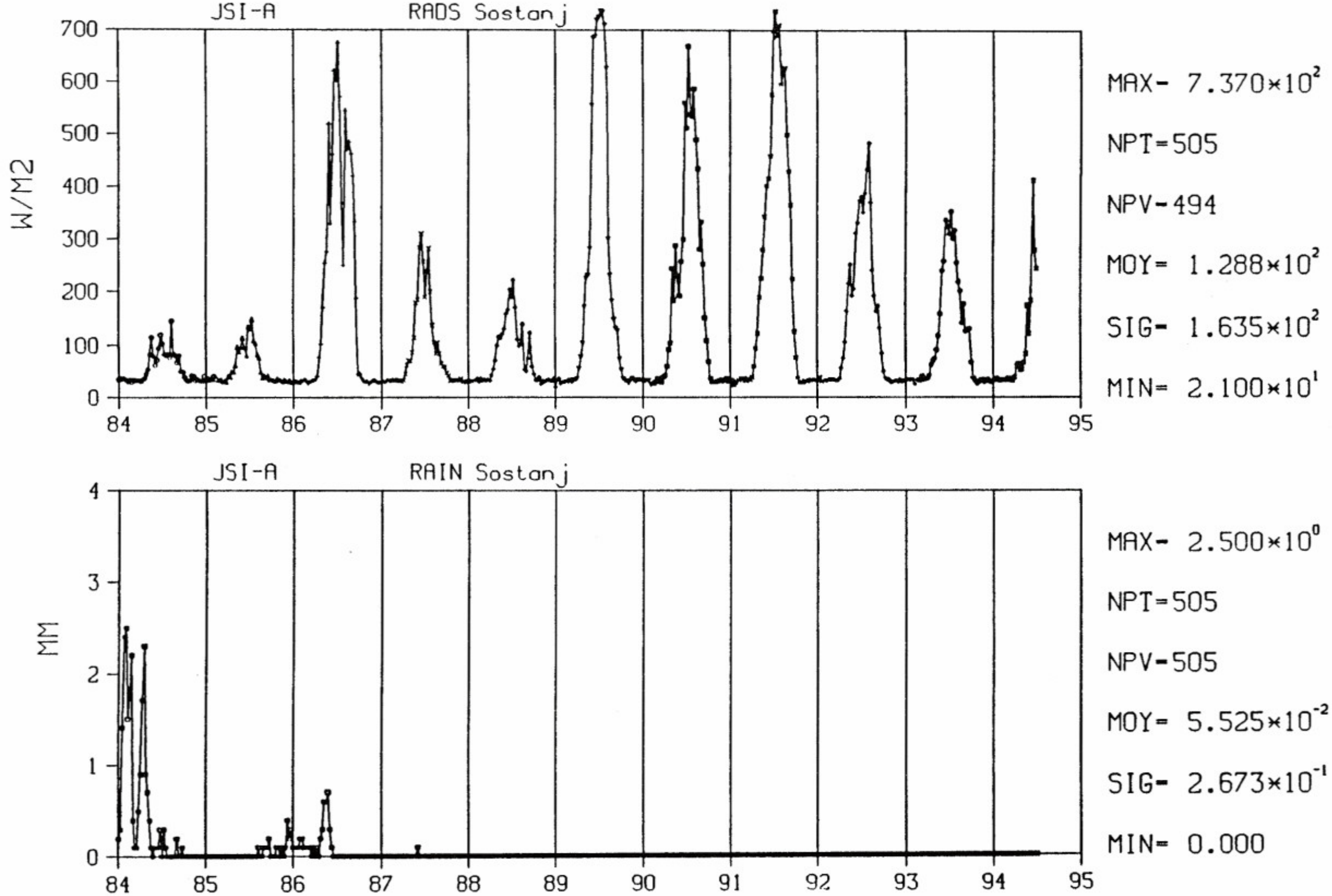


Figure 19b - Solar radiation (Watt/m^2) and rain (mm) vs the Julian day, during the second part of the campaign (since March 26th, 00:00 to April 5th, 1991, 12:00)

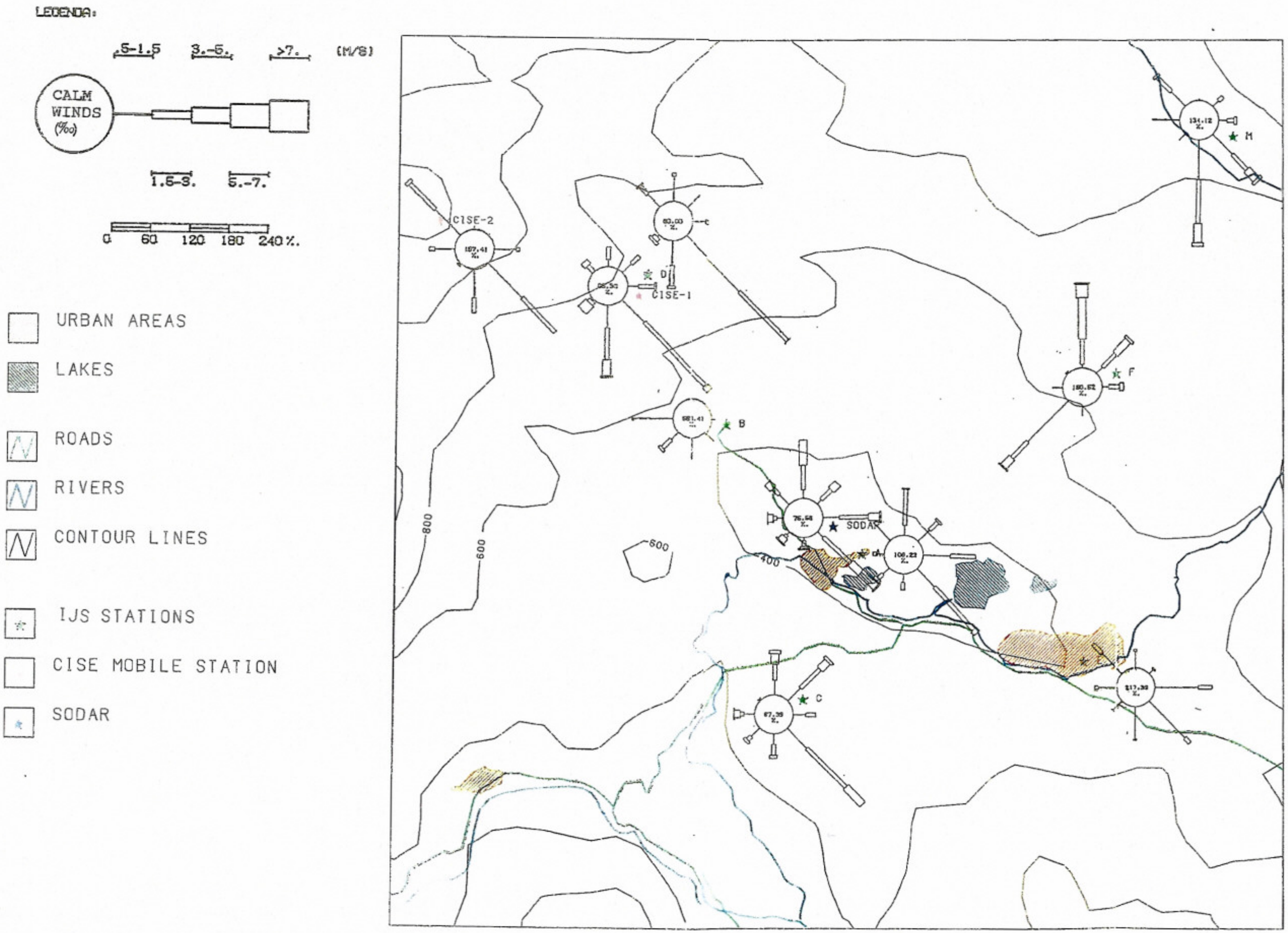


Figure 20 - Diurnal wind roses at the different stations

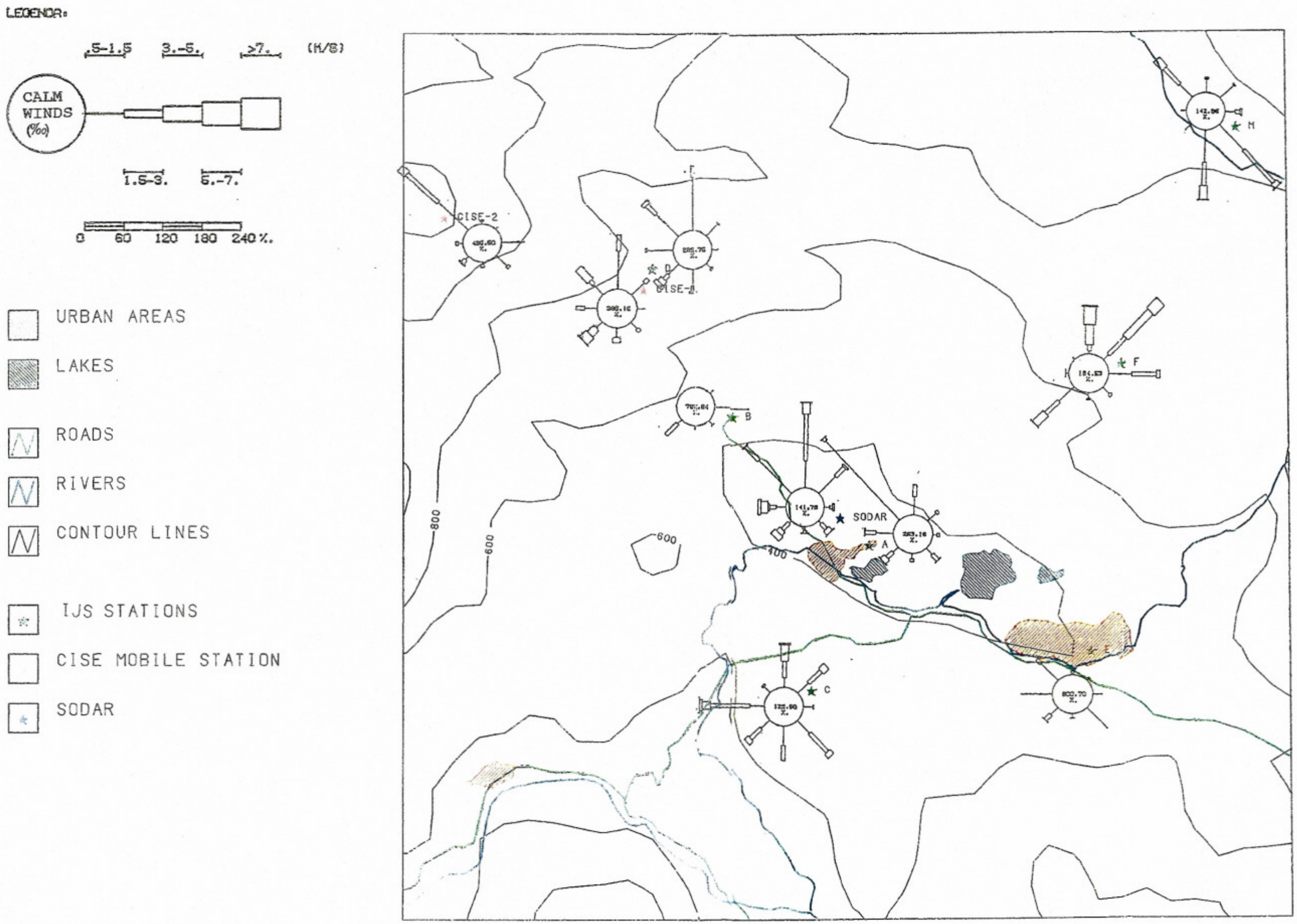


Figure 21 - Nocturnal wind roses at the different stations

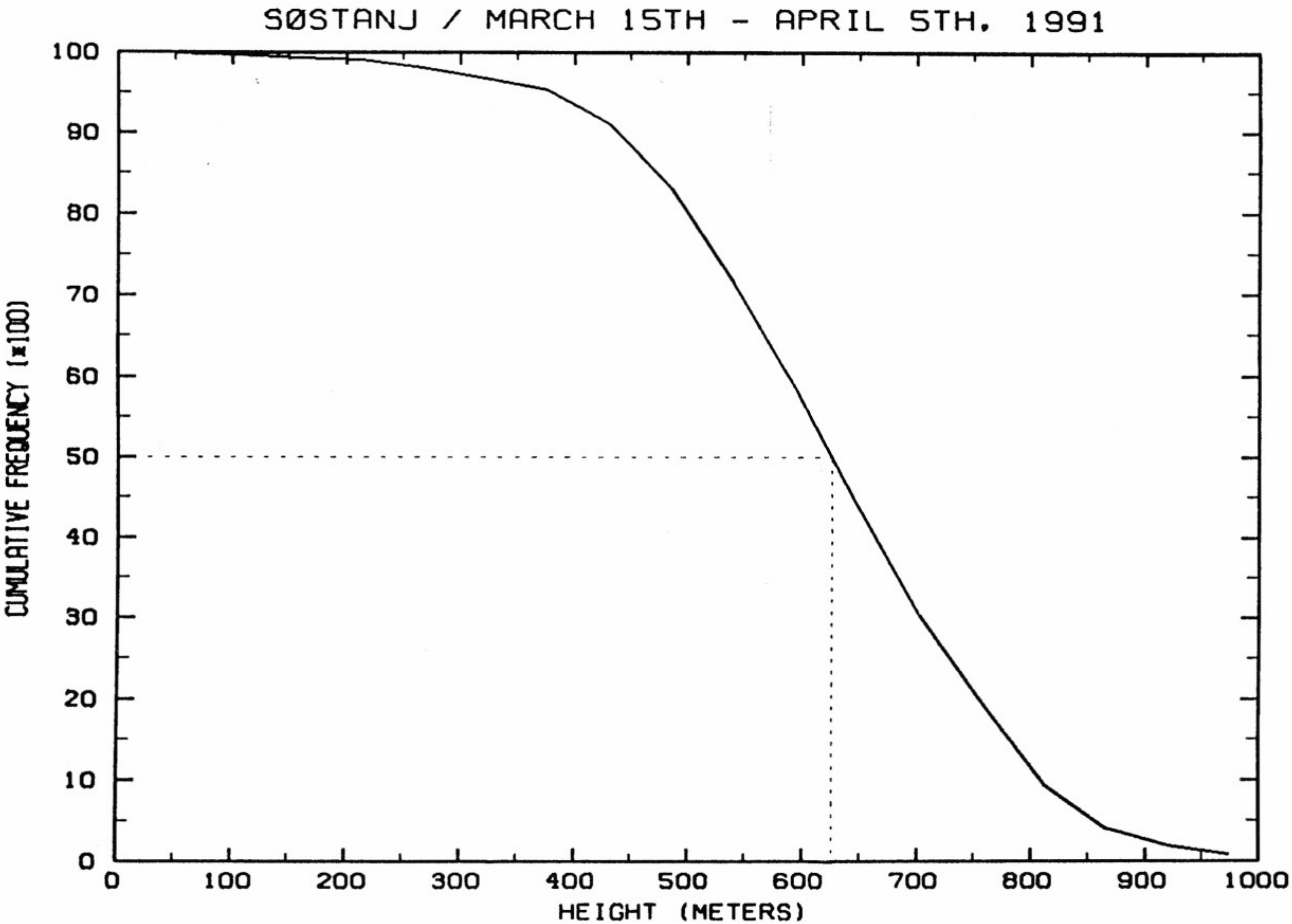


Figure 22 - **Cumulative frequency distribution of SODAR data vs sampling height**

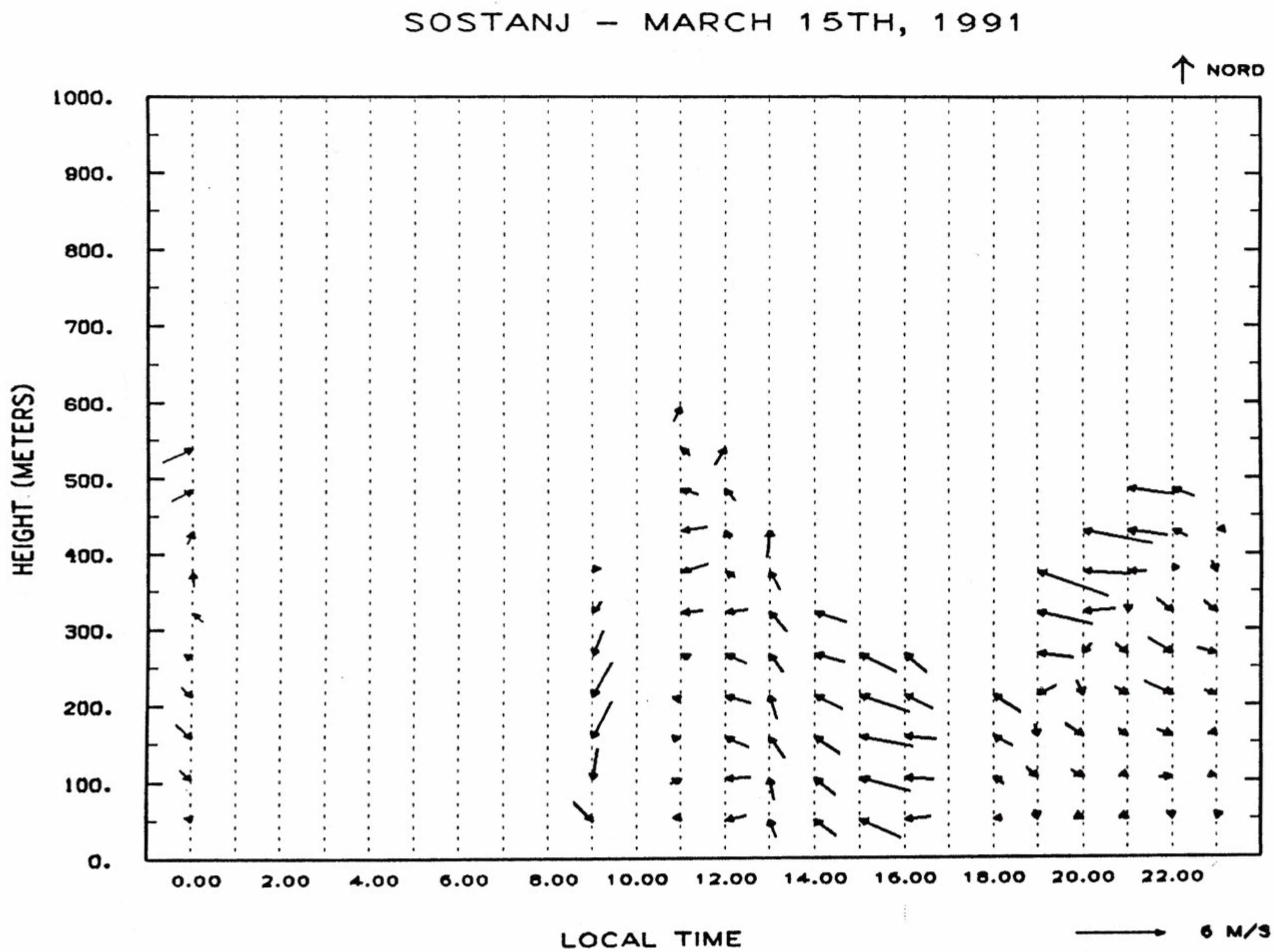


Figure 23a - Daily SODAR horizontal wind profile

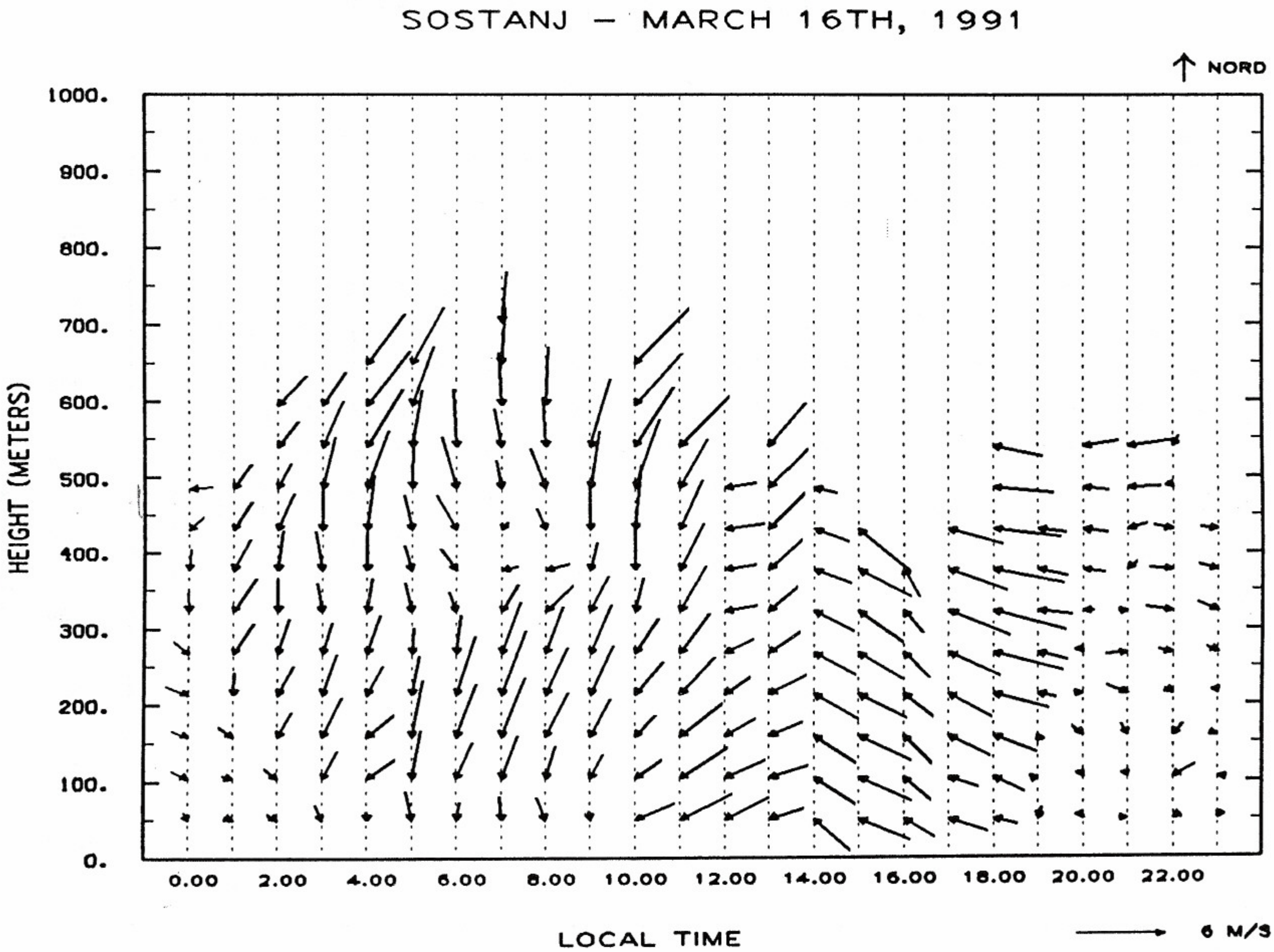
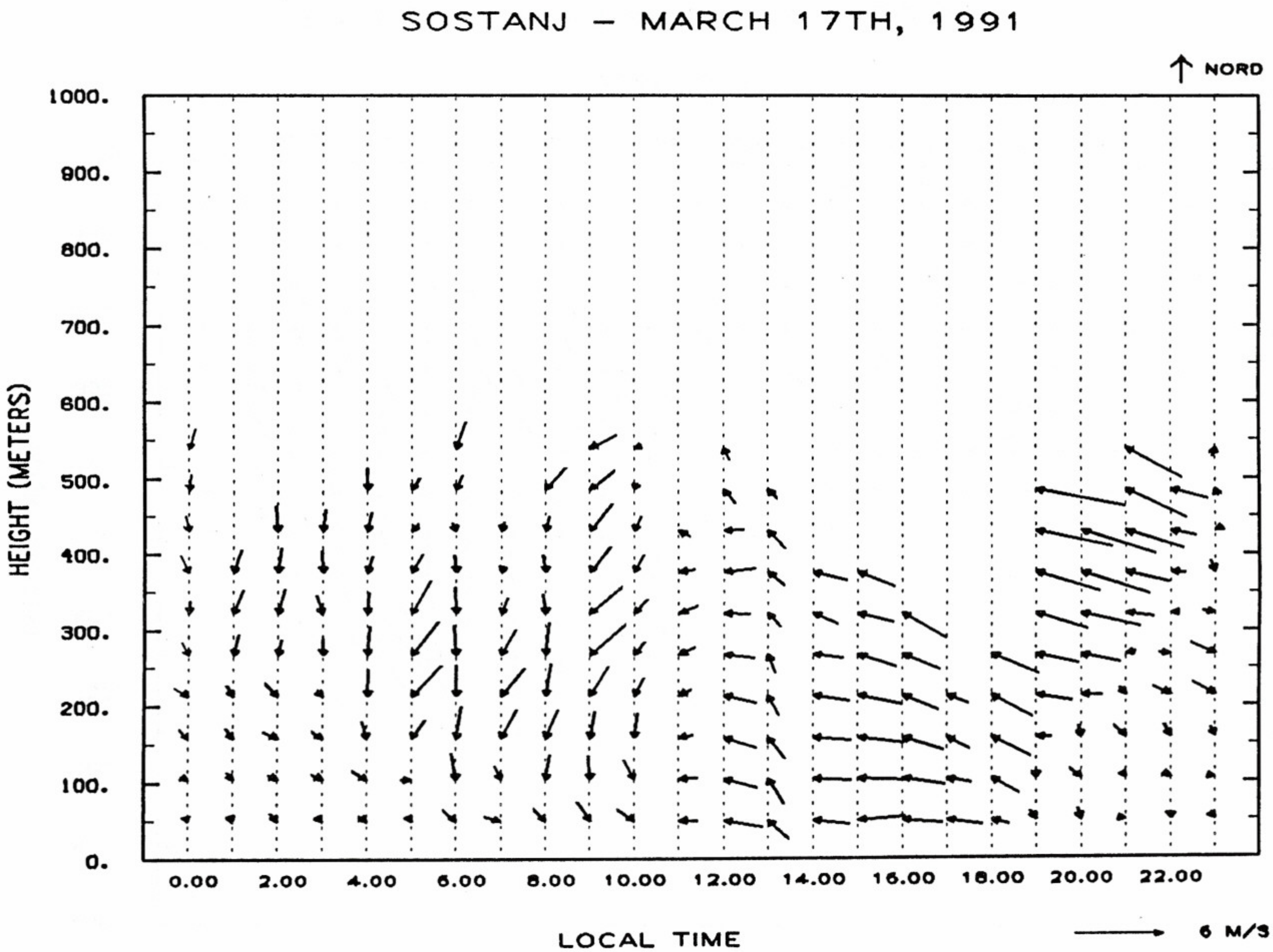


Figure 23b - Daily SODAR horizontal wind profile



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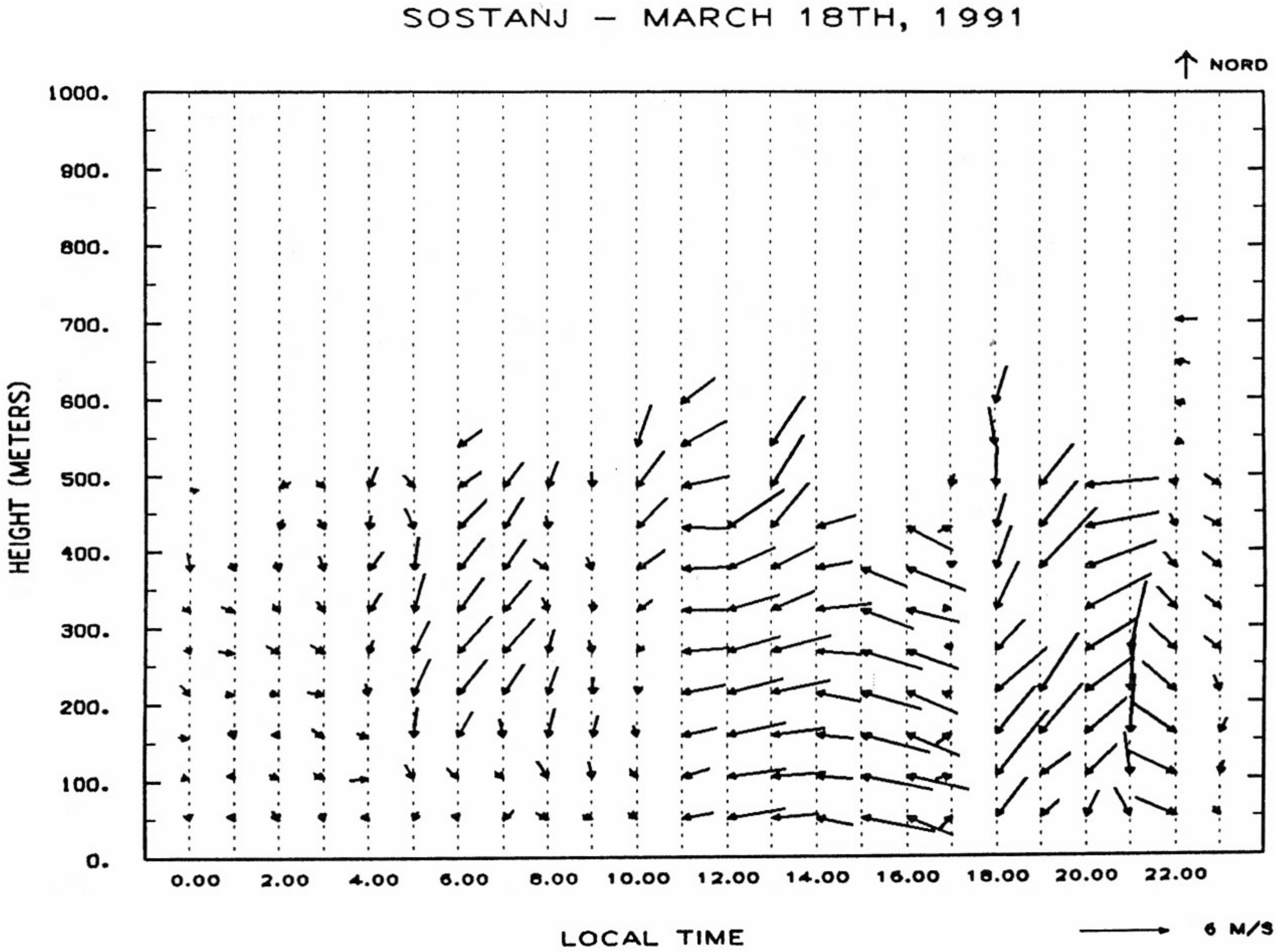

Figure 23d - Daily SODAR horizontal wind profile

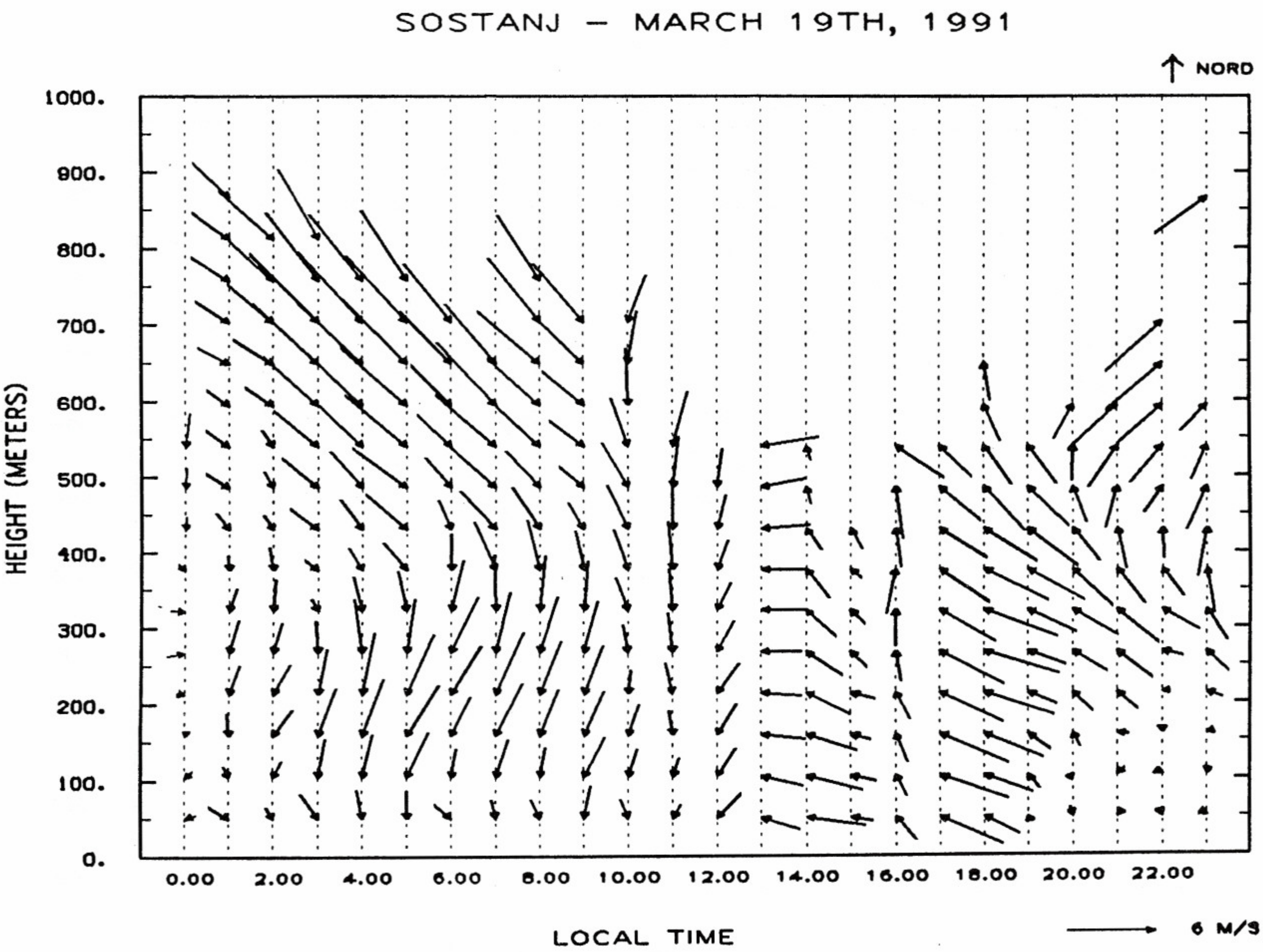

Figure 23e - Daily SODAR horizontal wind profile

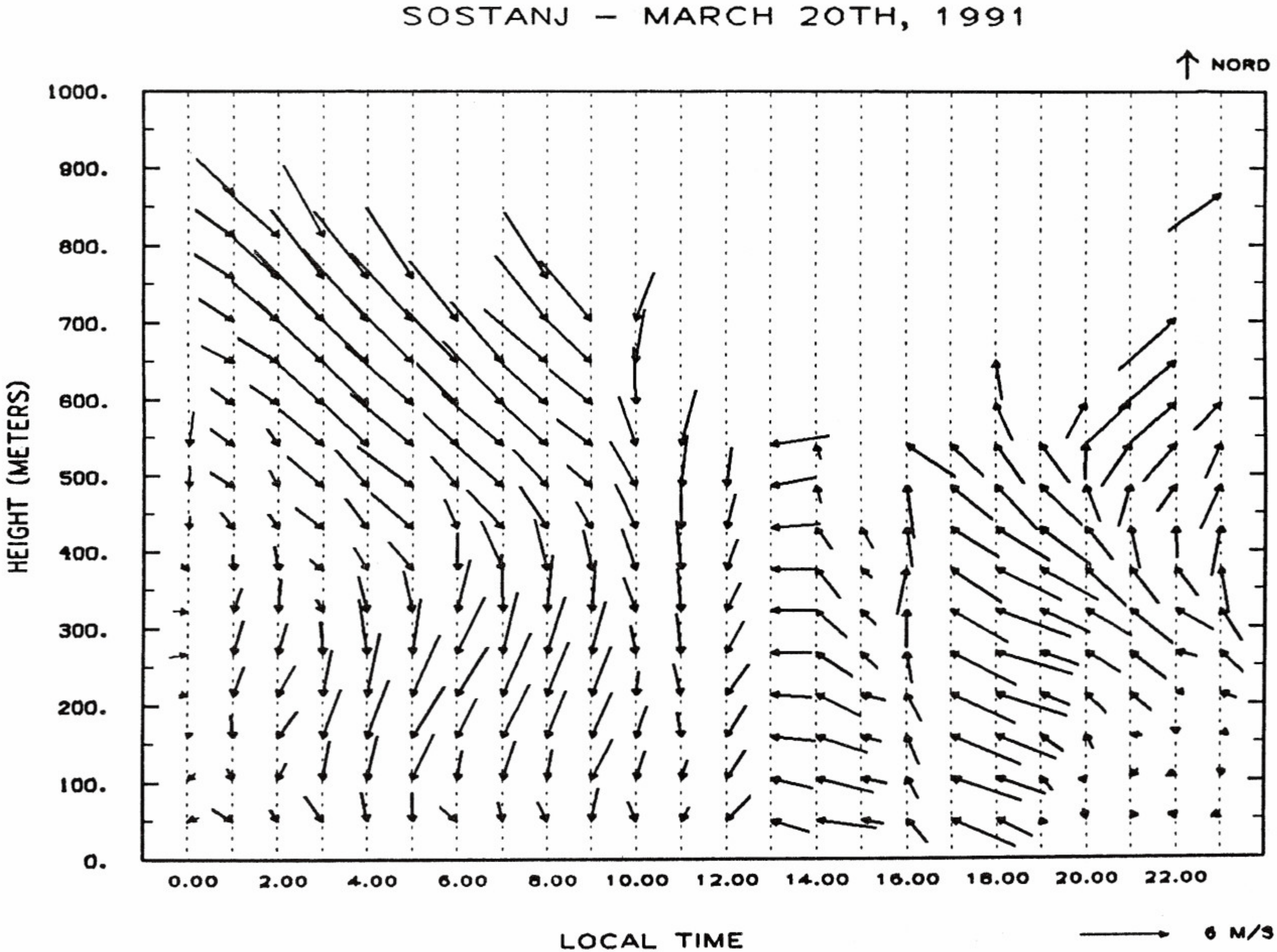

Figure 23f - Daily SODAR horizontal wind profile

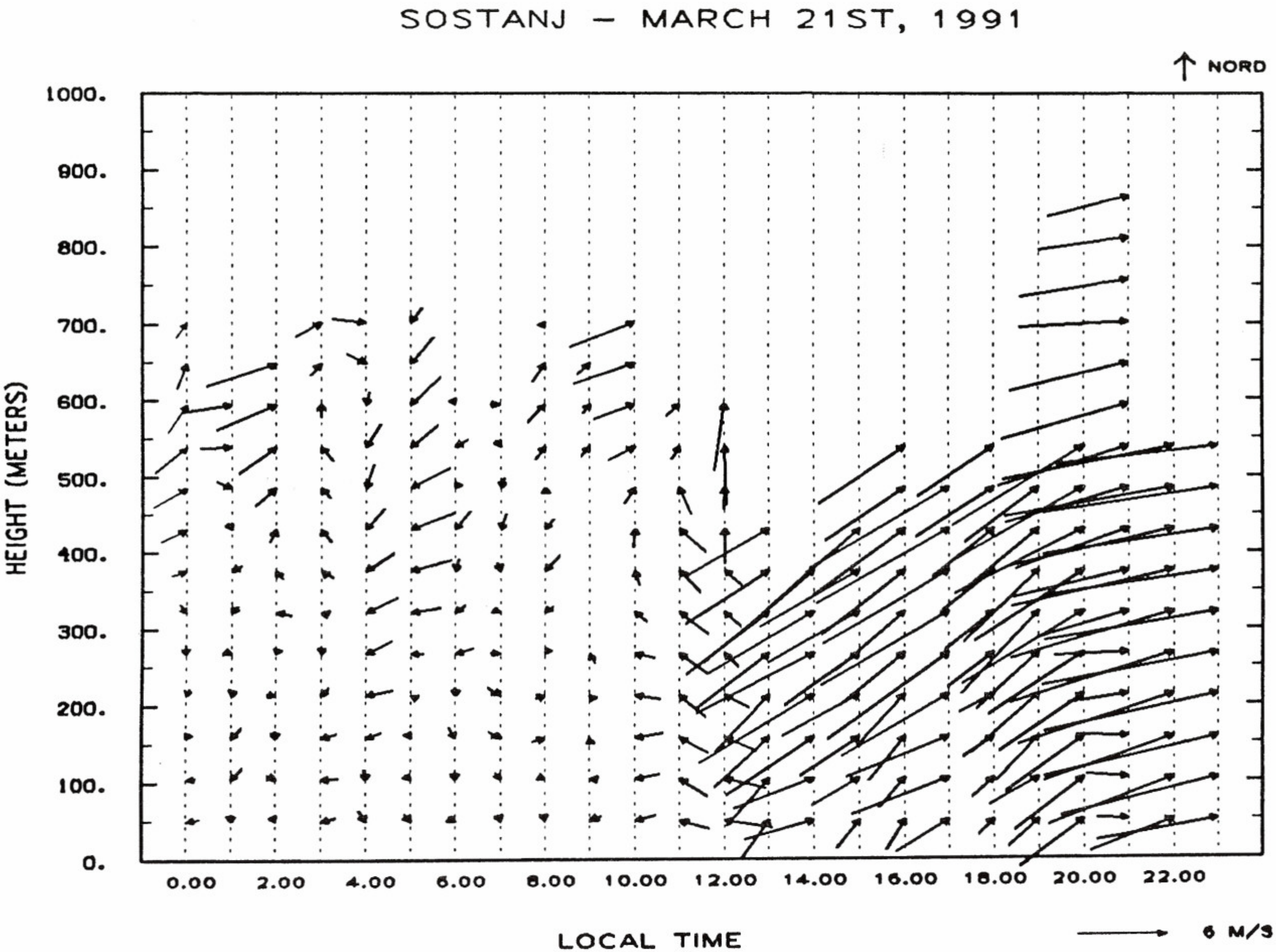

Figure 23g - Daily SODAR horizontal wind profile

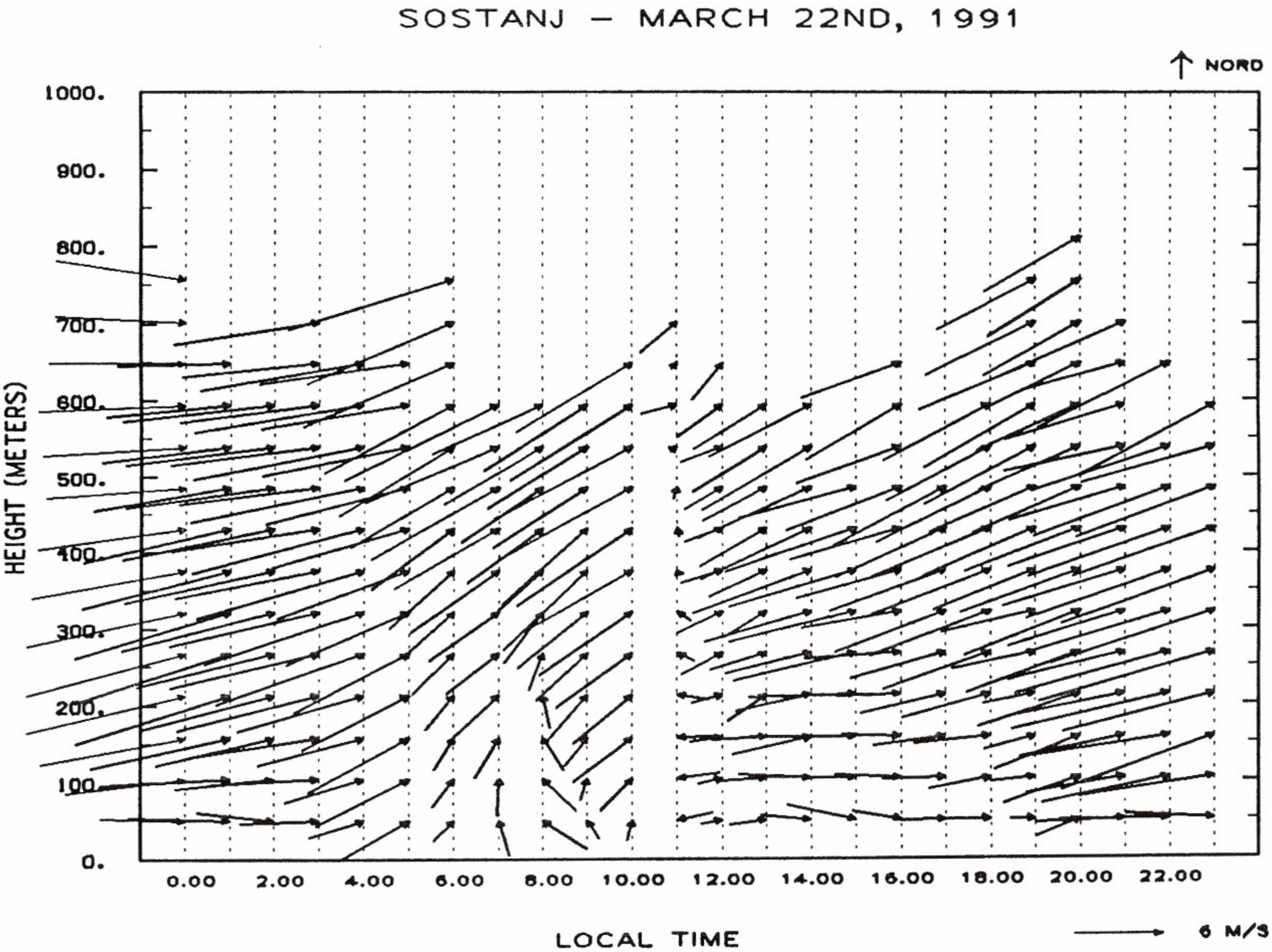

Figure 23h - Daily SODAR horizontal wind profile

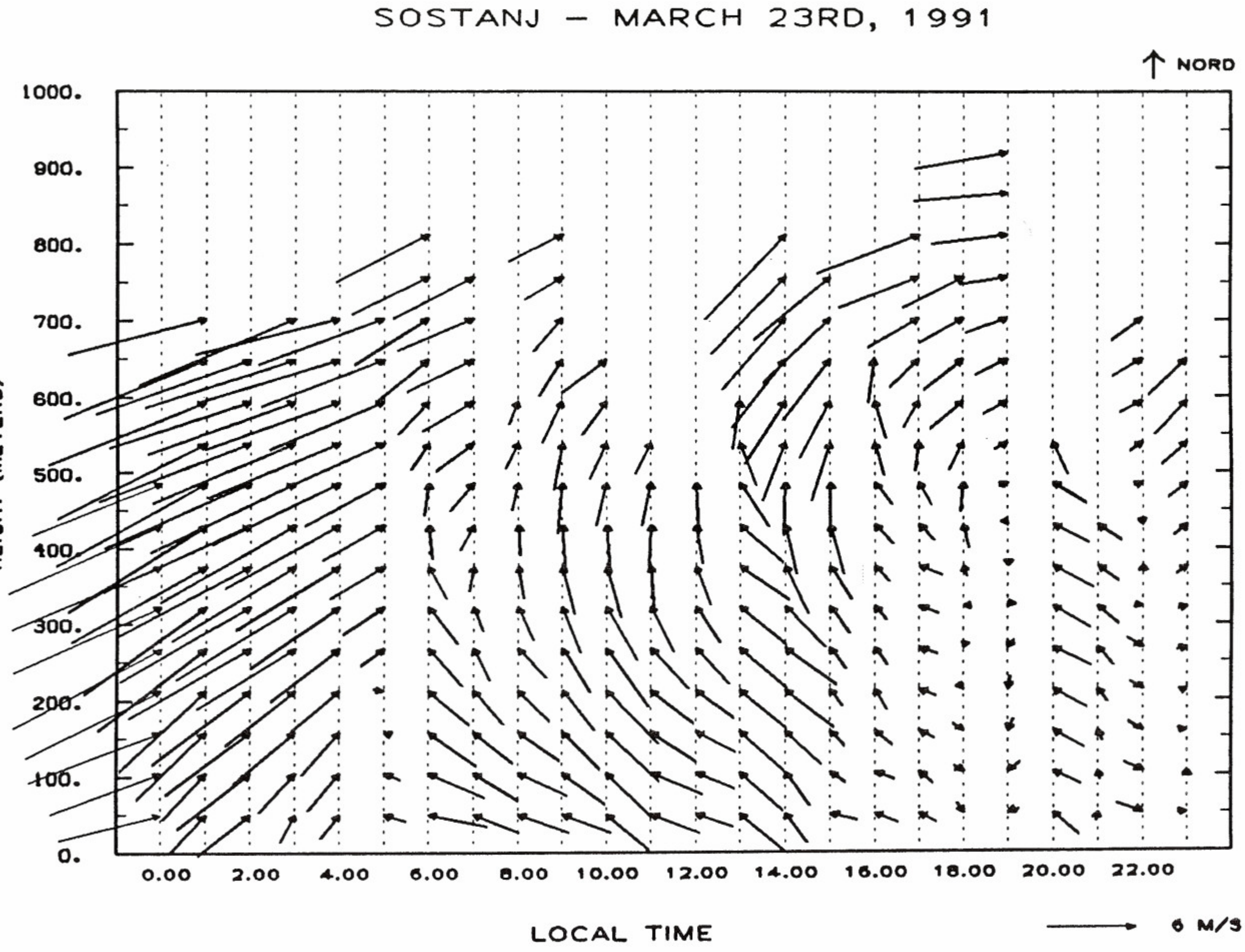

Figure 23i - Daily SODAR horizontal wind profile

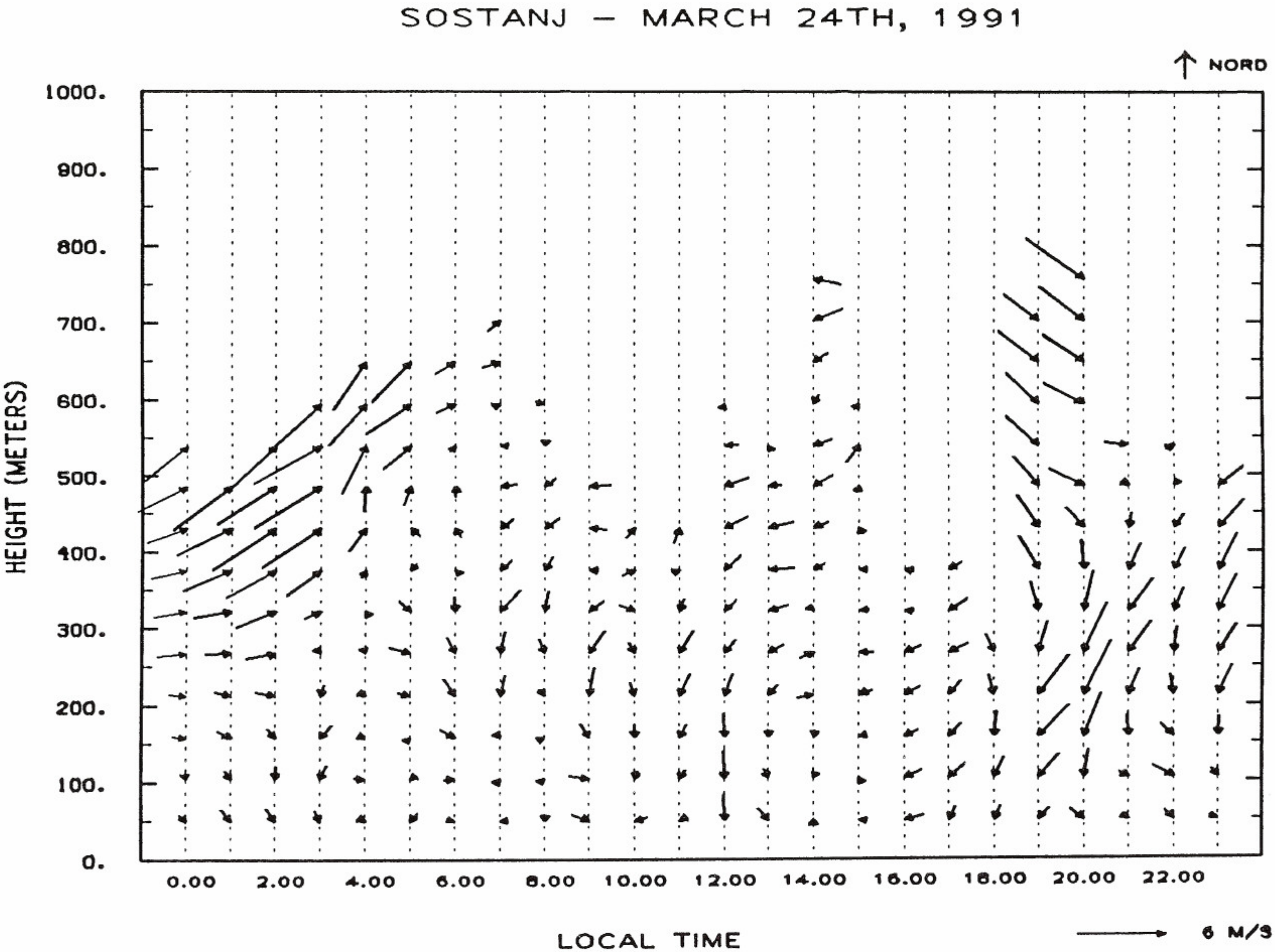

Figure 23j - Daily SODAR horizontal wind profile

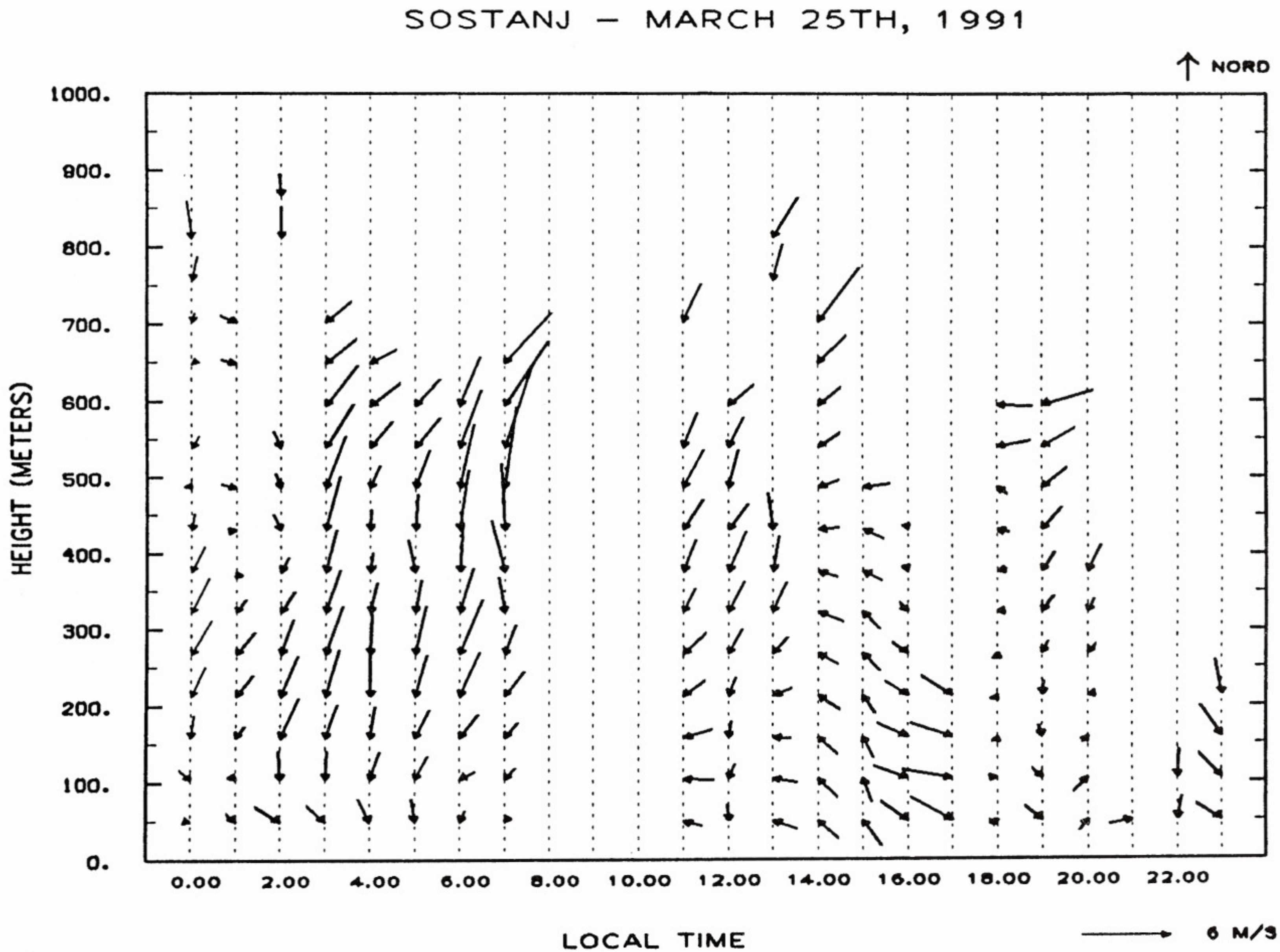

Figure 23k - Daily SODAR horizontal wind profile

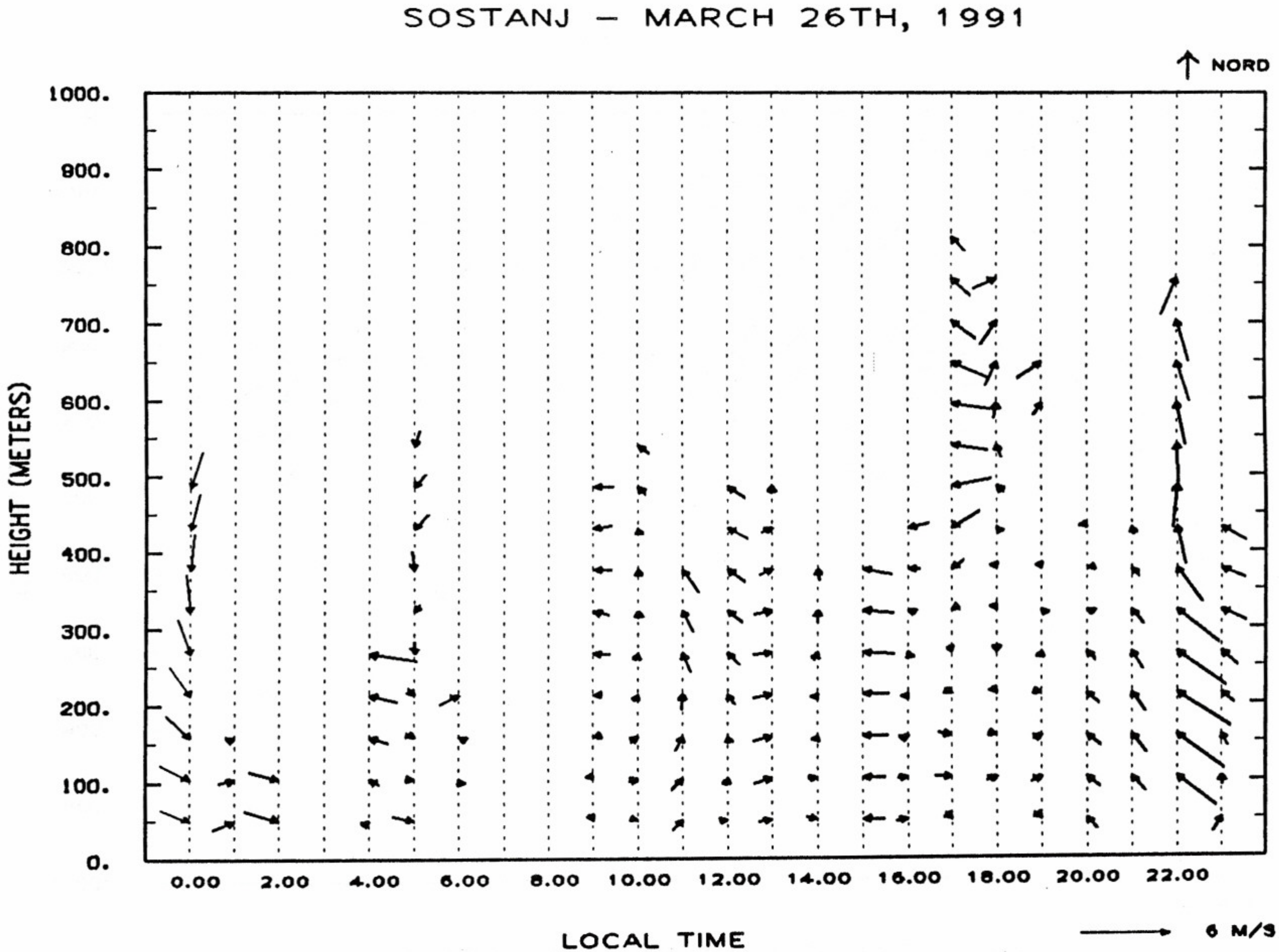

Figure 23l - Daily SODAR horizontal wind profile

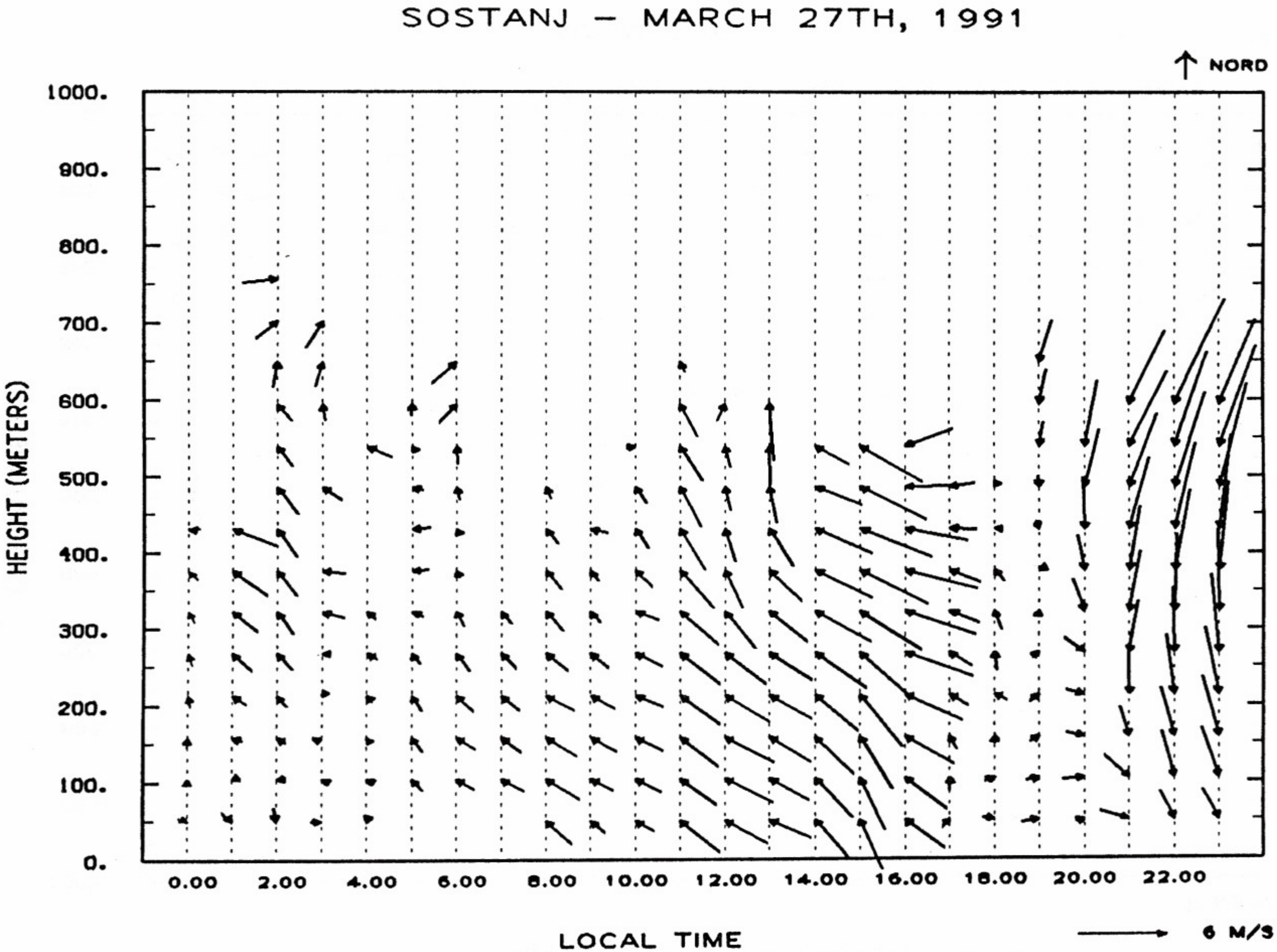

Figure 23m - Daily SODAR horizontal wind profile

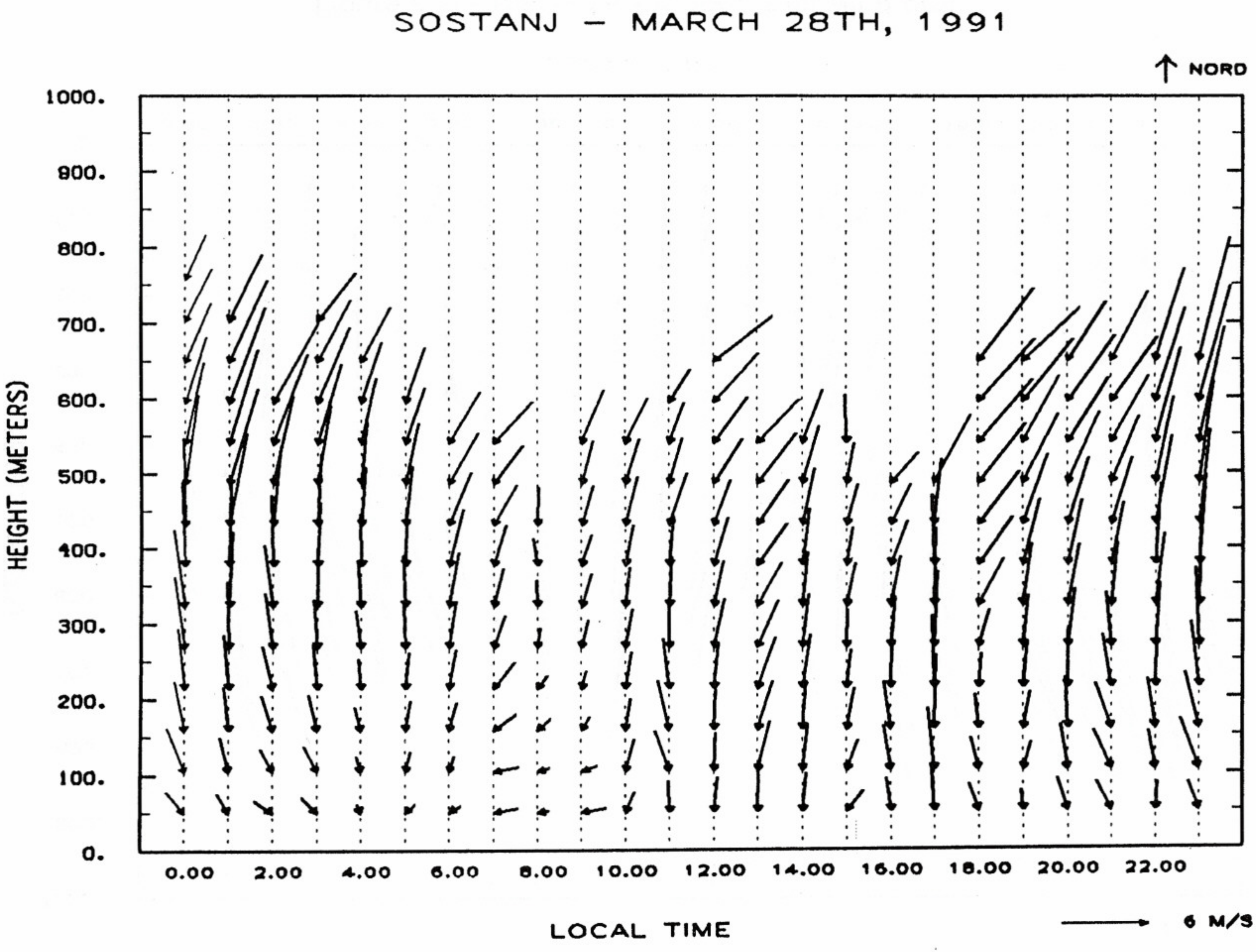

Figure 23n - Daily SODAR horizontal wind profile

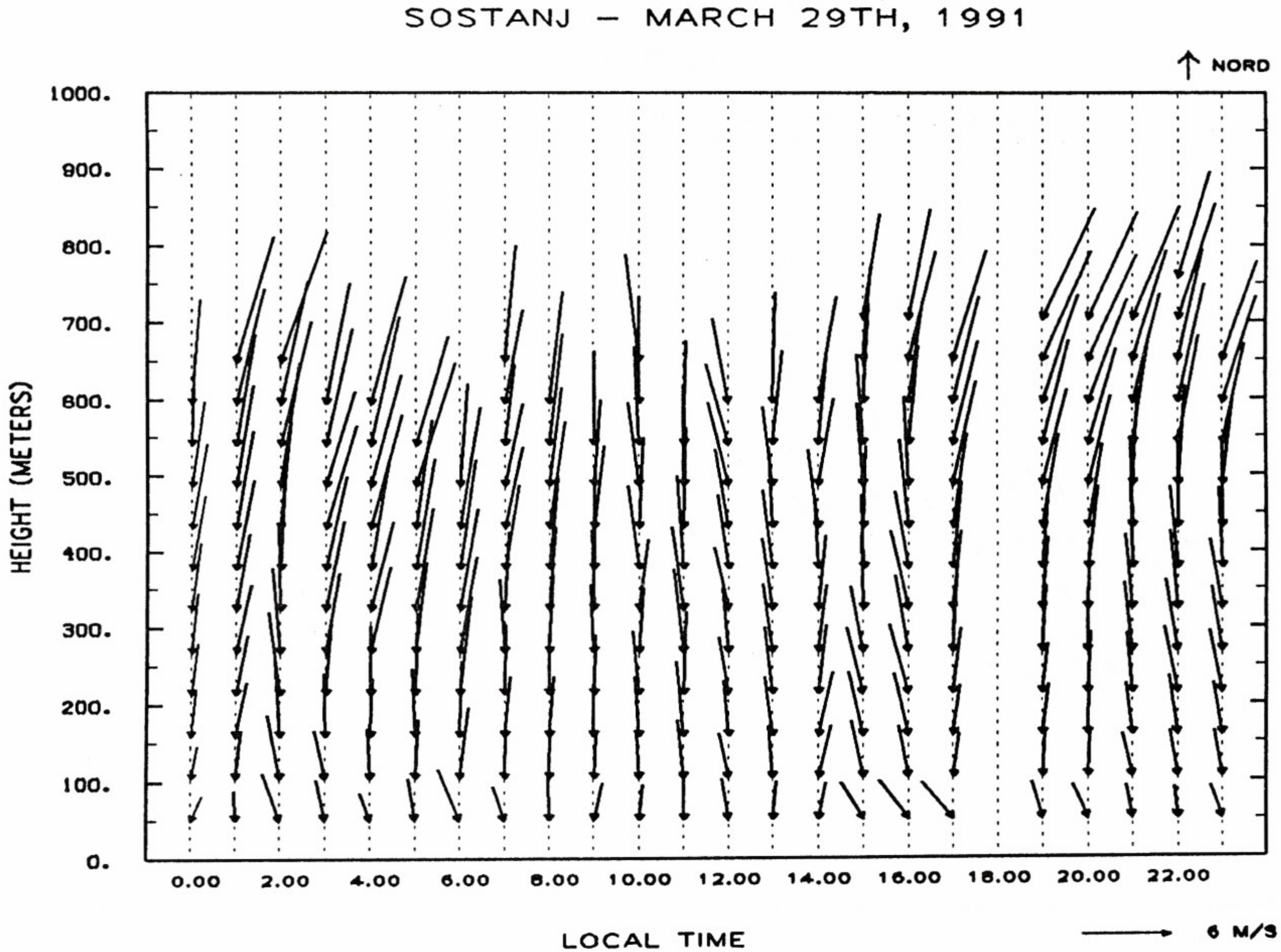

Figure 23o - Daily SODAR horizontal wind profile

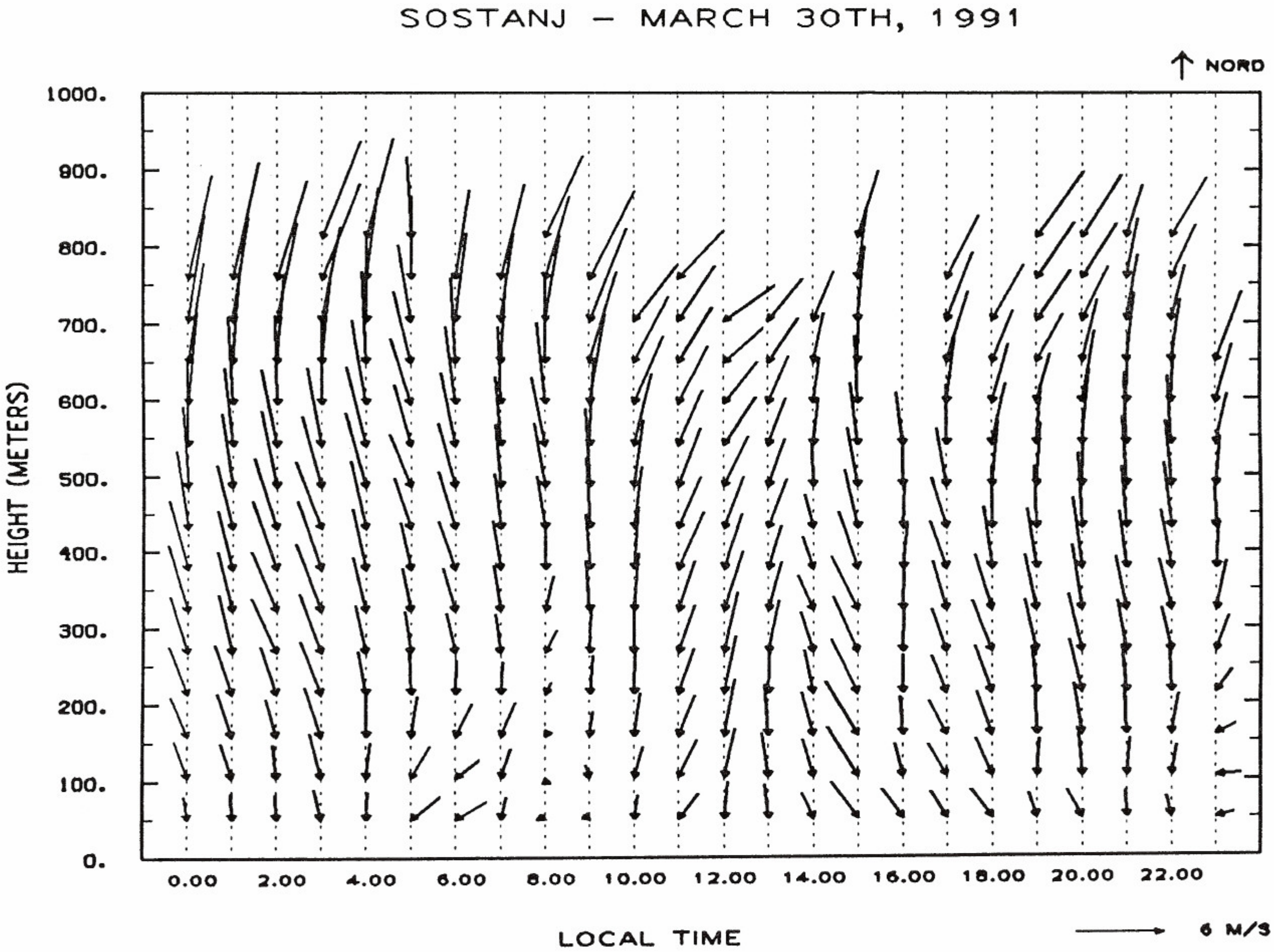

Figure 23p - Daily SODAR horizontal wind profile

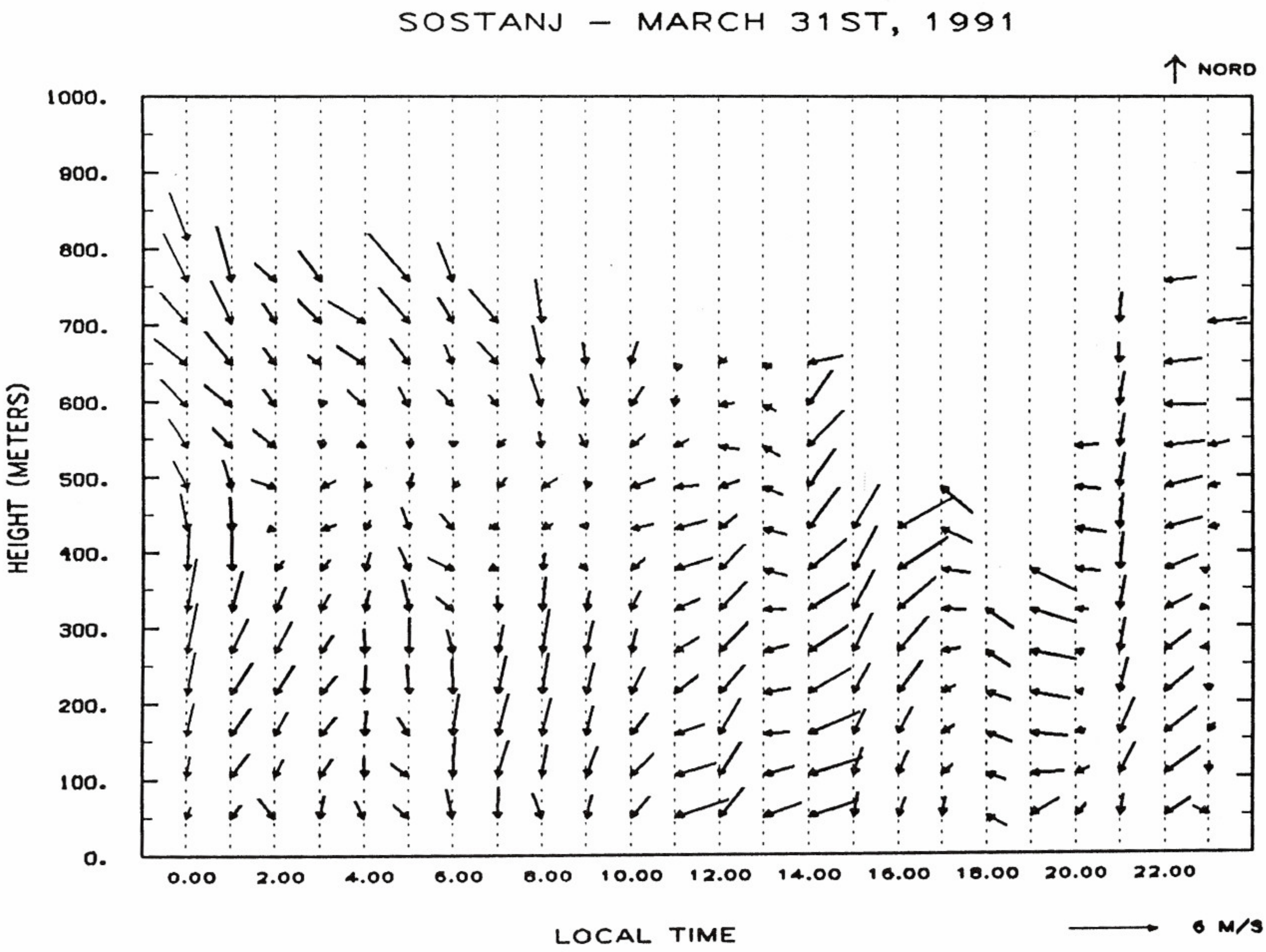

Figure 23q - Daily SODAR horizontal wind profile

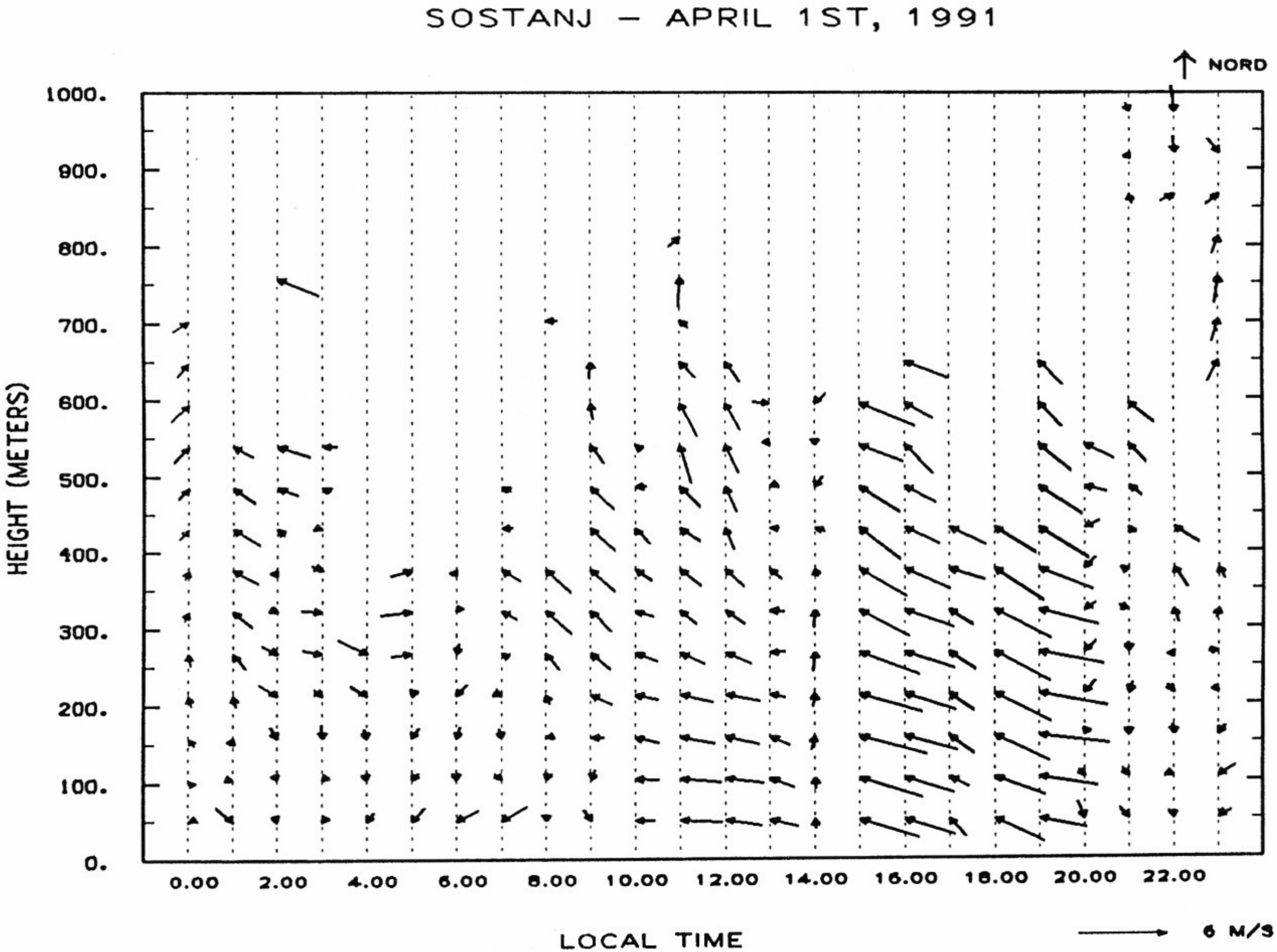

Figure 23r - Daily SODAR horizontal wind profile

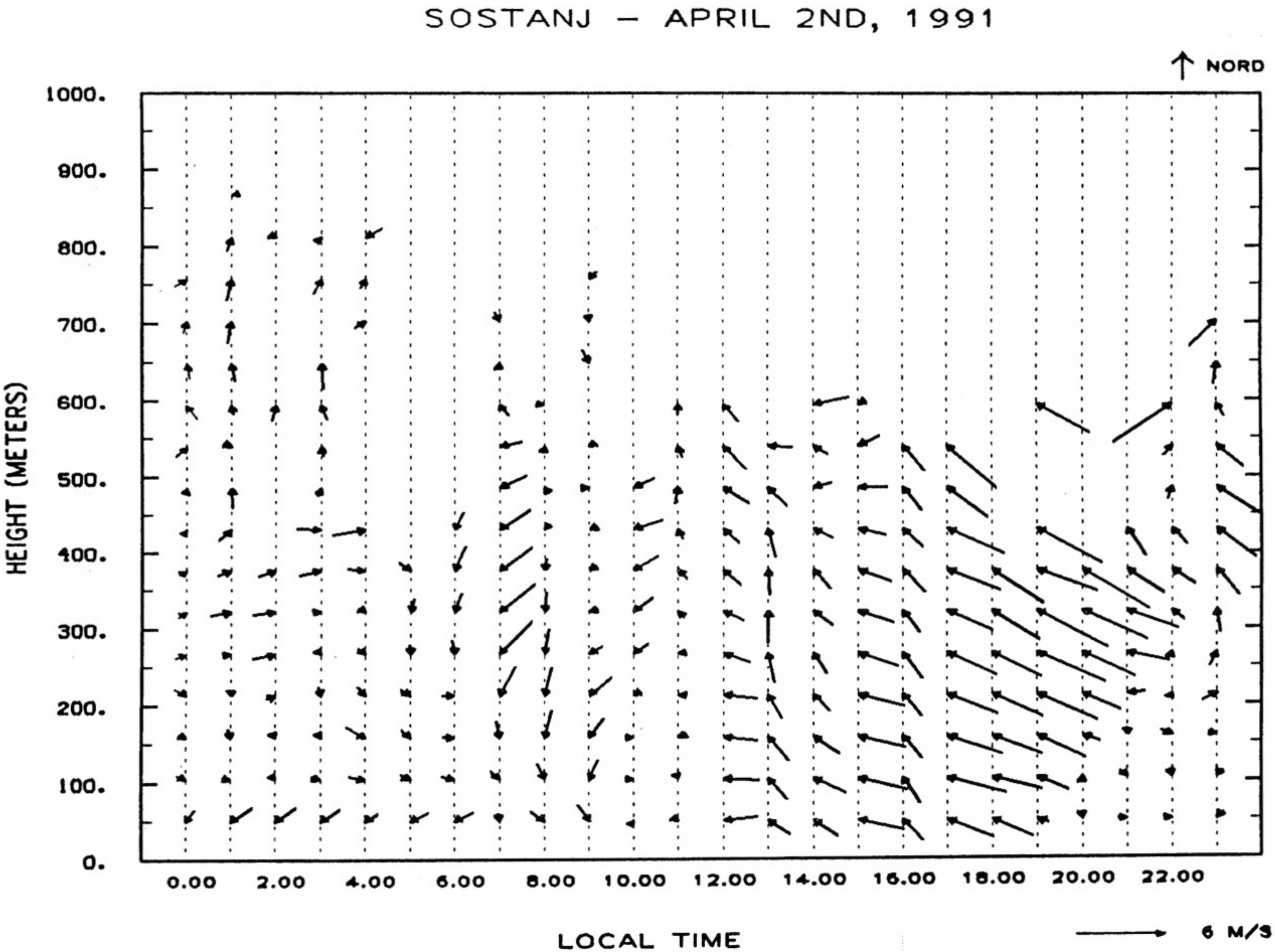

Figure 23s - Daily SODAR horizontal wind profile

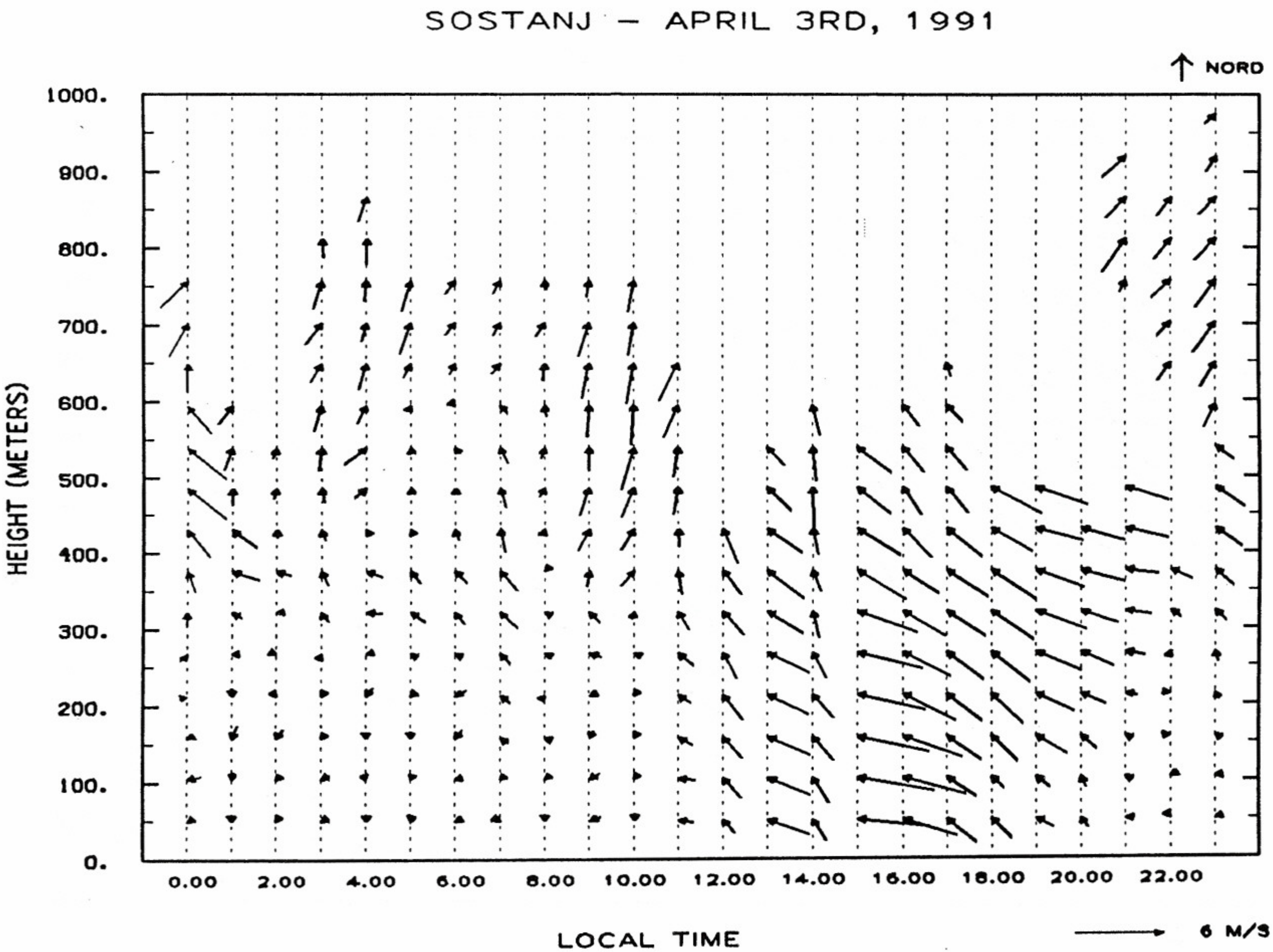

Figure 23t - Daily SODAR horizontal wind profile

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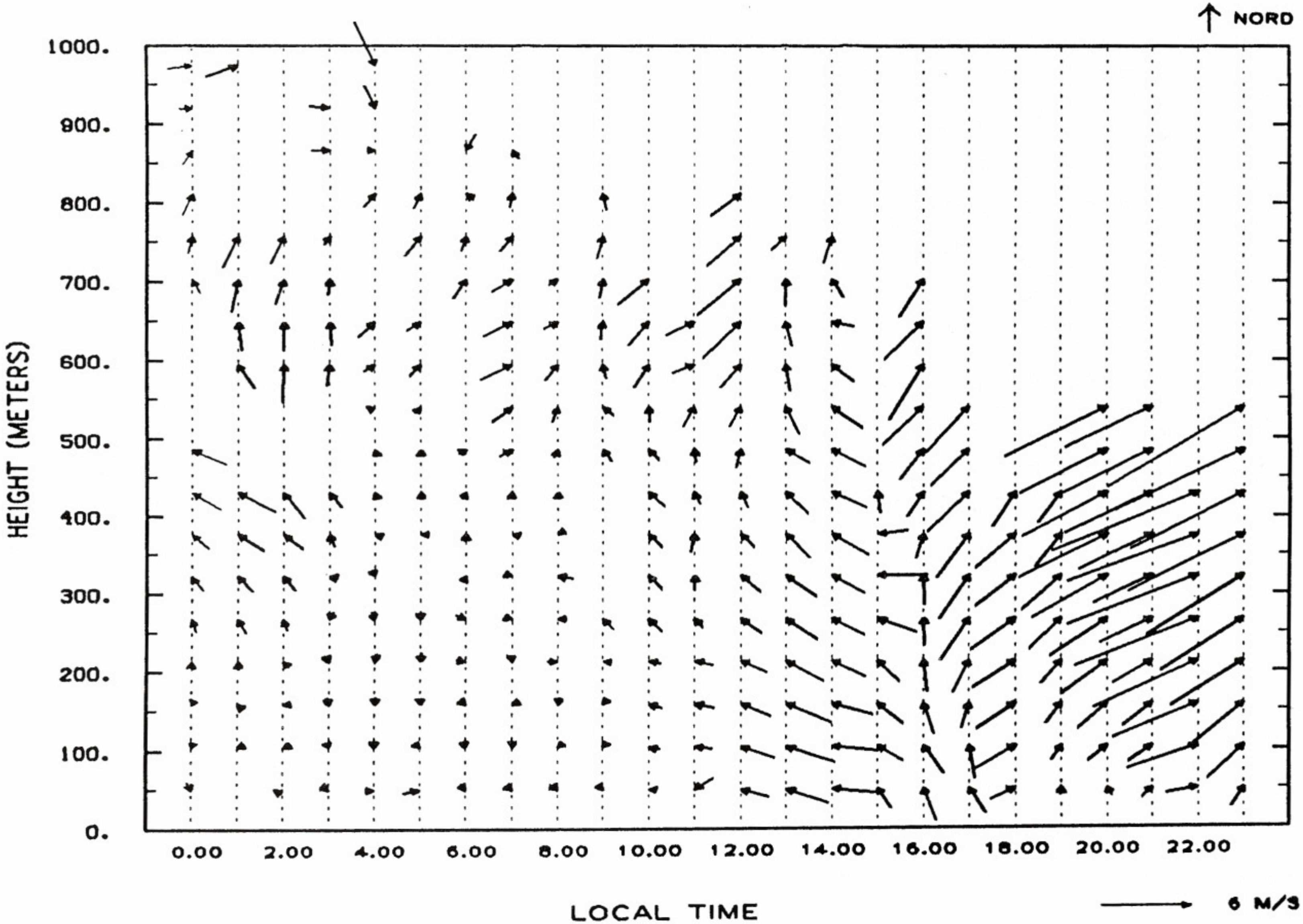

Figure 23u - Daily SODAR horizontal wind profile

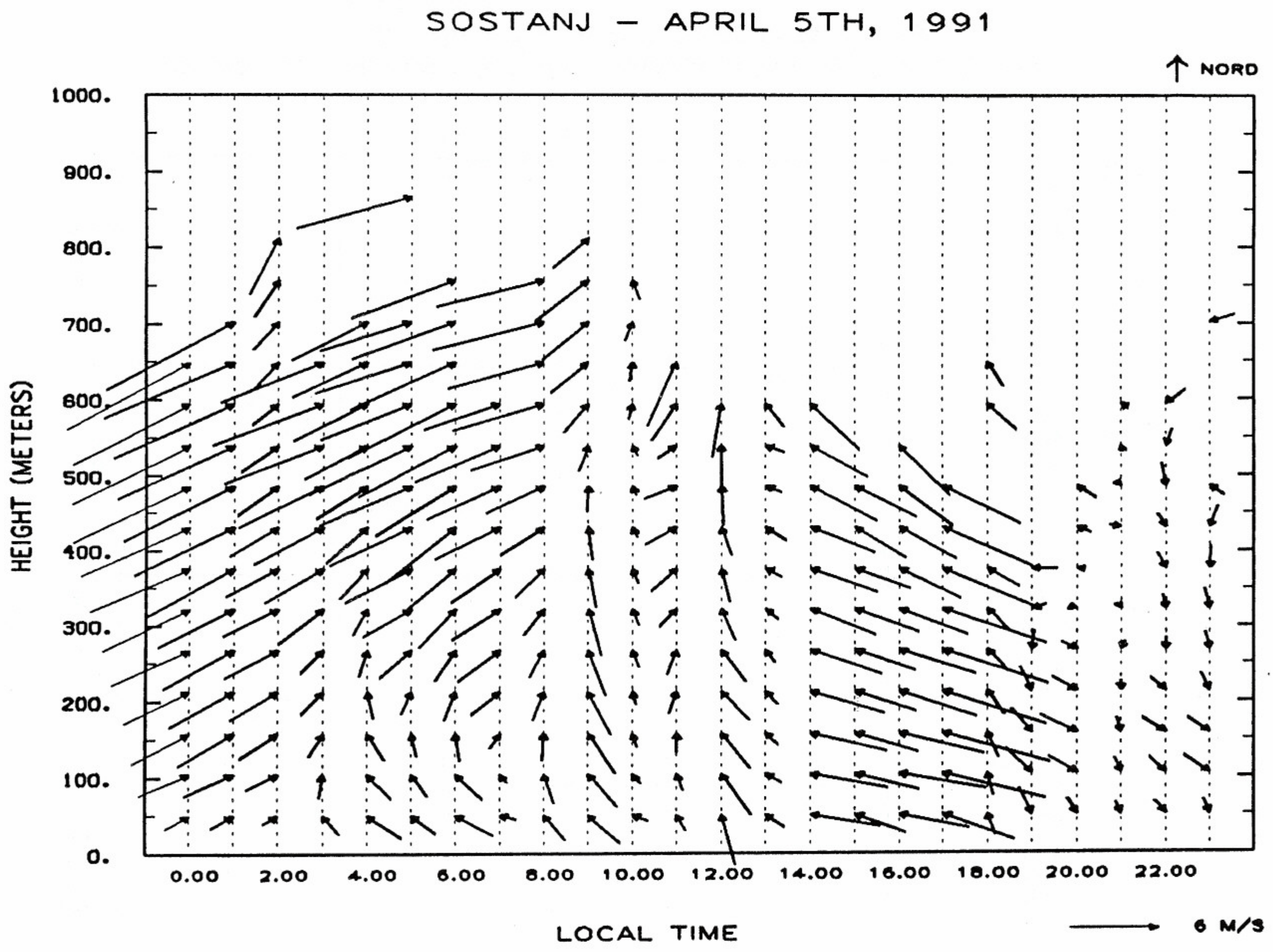

Figure 23v - Daily SODAR horizontal wind profile

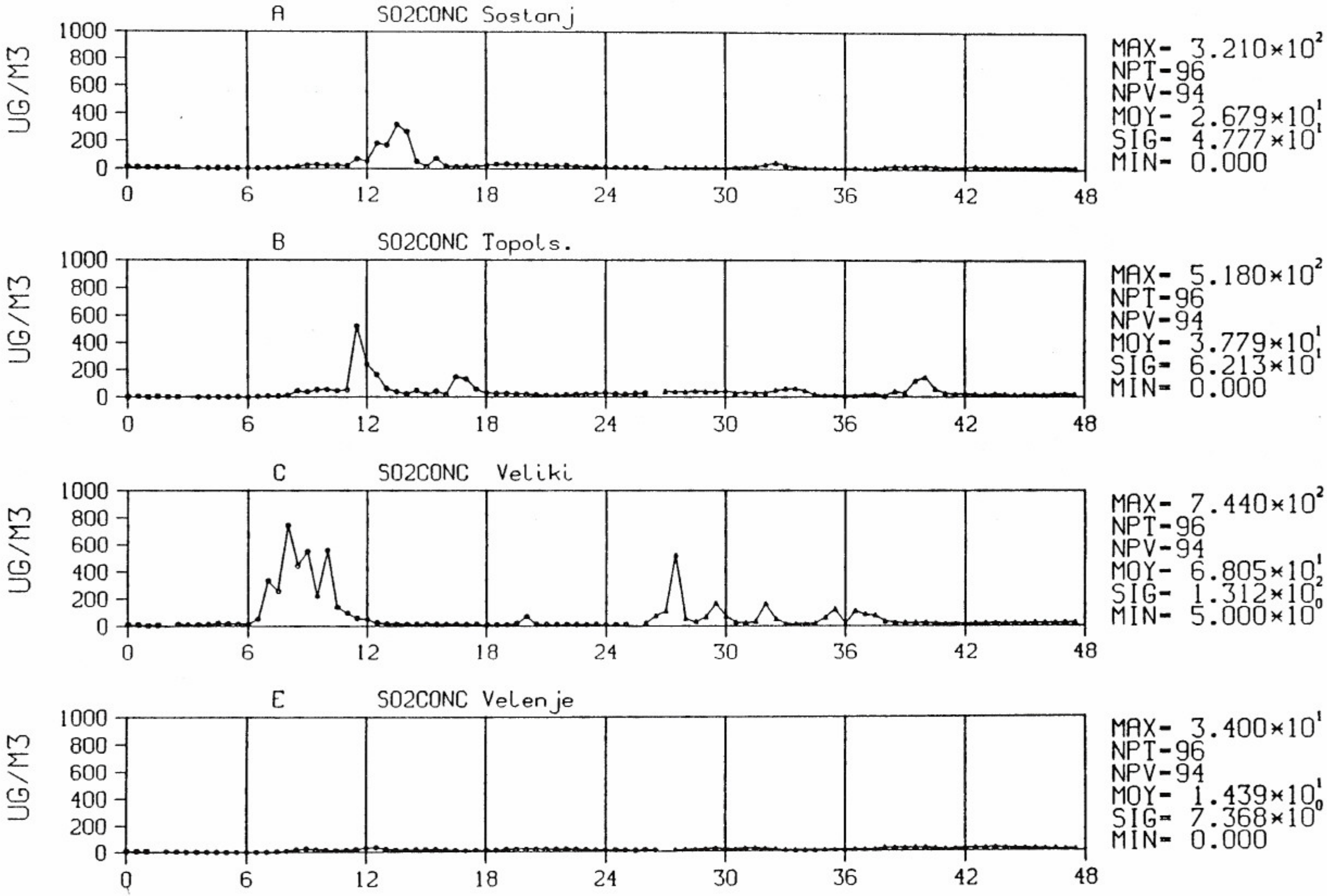

Figure 24a - **48 hours SO_2 data measured in A, B, C and E stations, since March 15th, 00:00 to March 16th, 1991, 23:30**

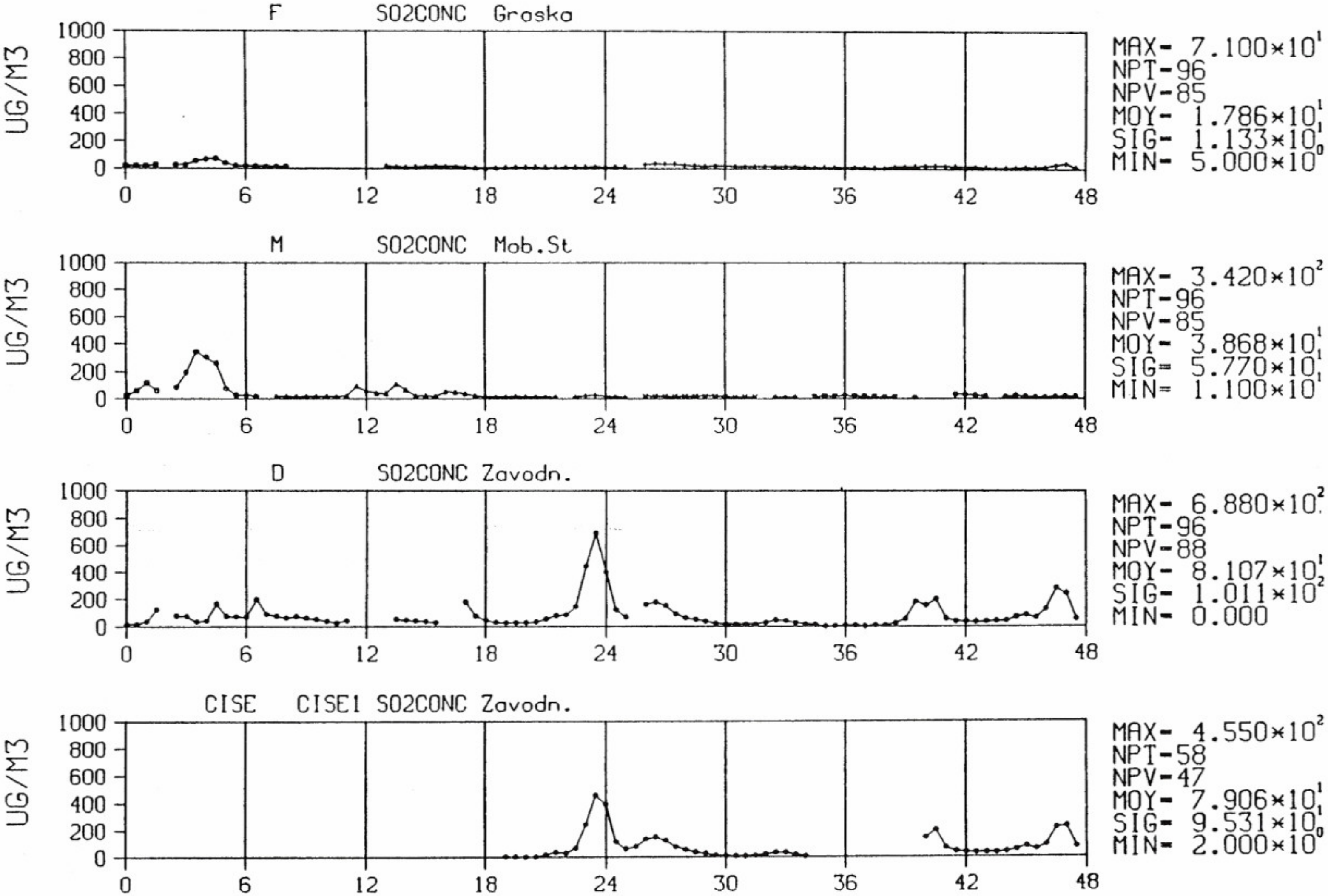

Figure 24b - 48 hours SO_2 data measured in F, M, D and CISE-1 (Zavodnje) stations, since March 15th, 00:00 to March 16th, 1991, 23:30

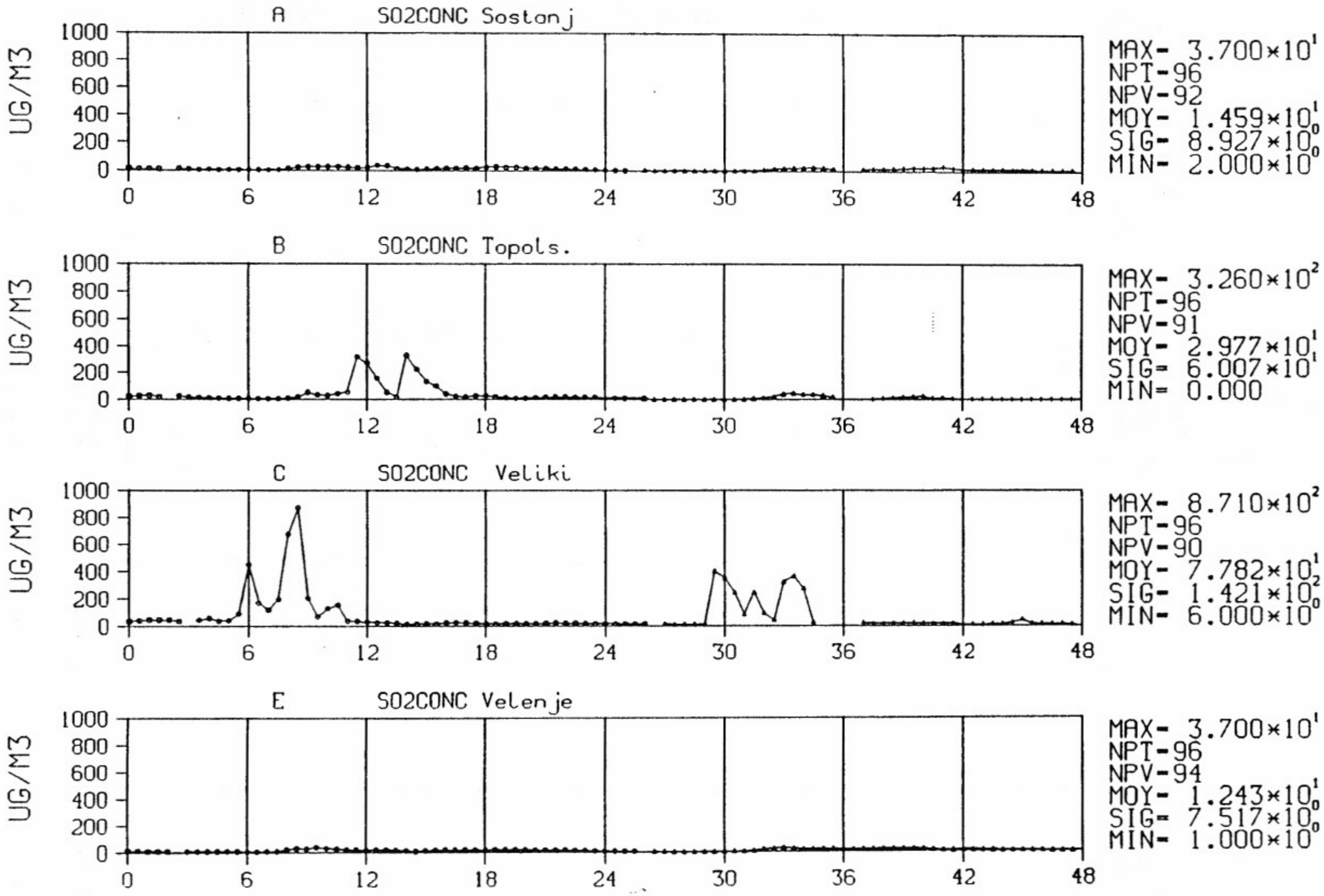

Figure 25a - 48 hours SO_2 data measured in A, B, C and E stations, since March 17th, 00:00 to March 18th, 1991, 23:30

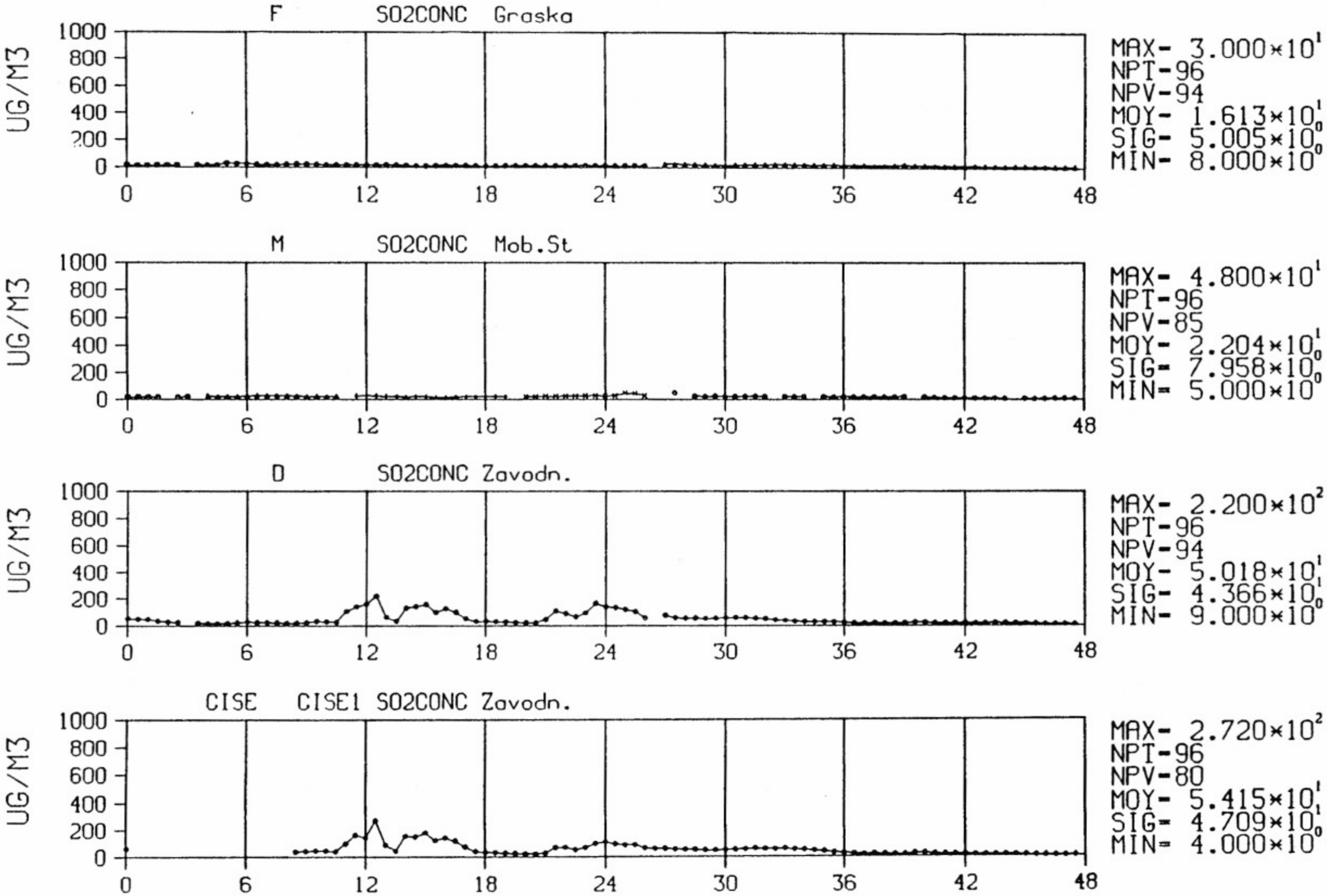

Figure 25b - 48 hours SO_2 data measured in F, M, D and CISE-1 (Zavodnje) stations, since March 17th, 00:00 to March 18th, 1991, 23:30

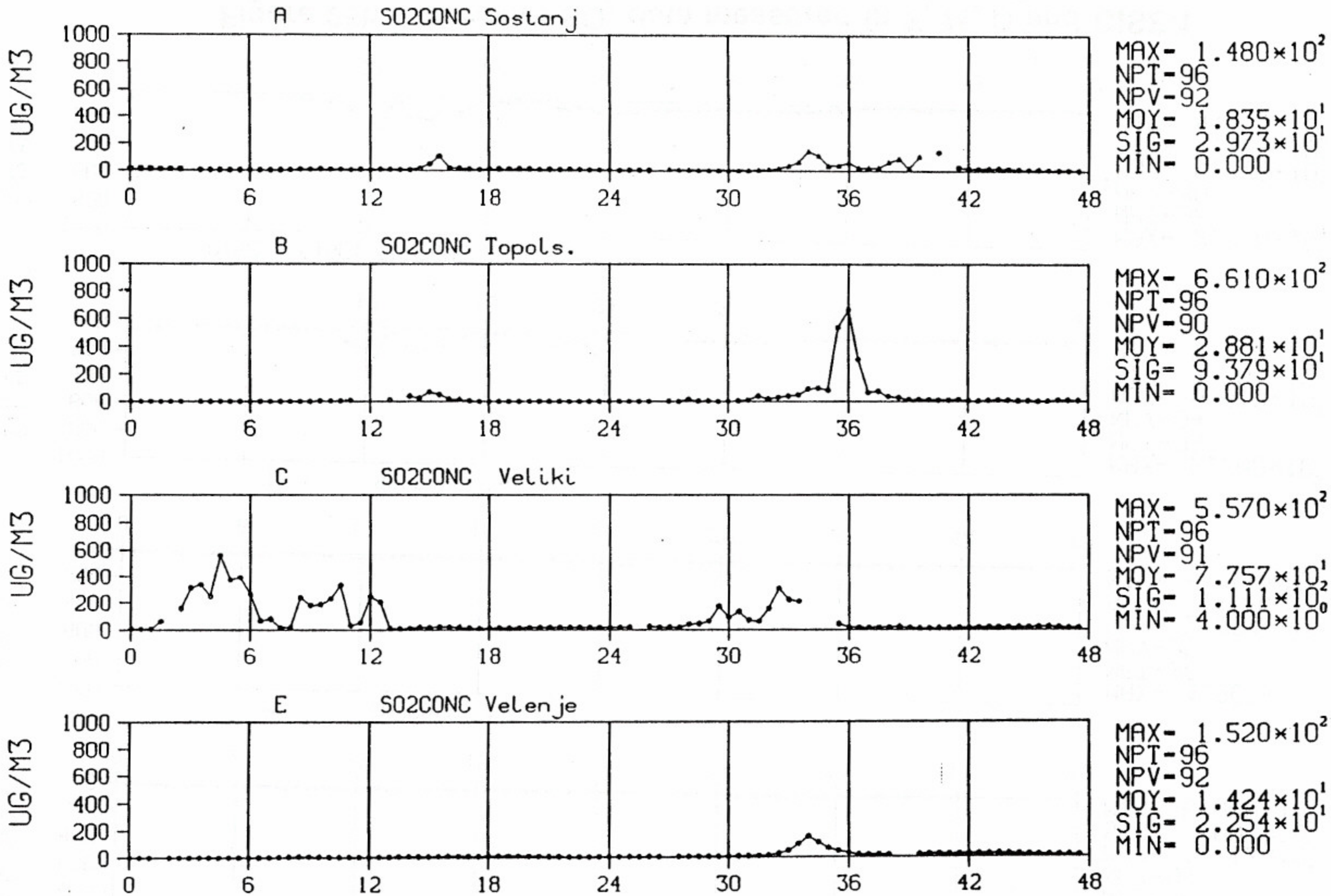

Figure 26a - 48 hours SO_2 data measured in A, B, C and E stations, since March 19th, 00:00 to March 20th, 1991, 23:30

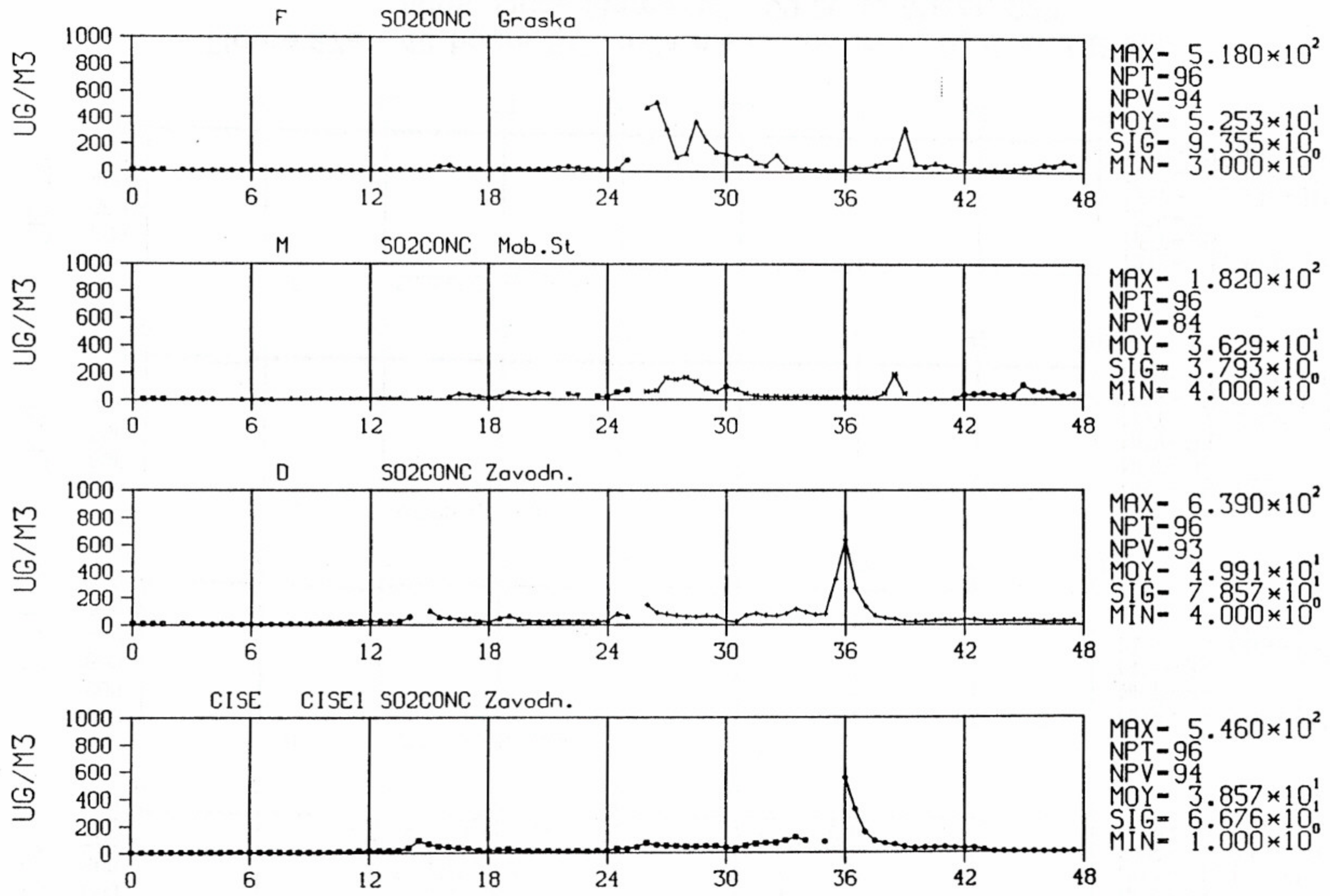

Figure 26b - 48 hours SO_2 data measured in F, M, D and CISE-1 (Zavodnje) stations, since March 19th, 00:00 to March 20th, 1991, 23:30

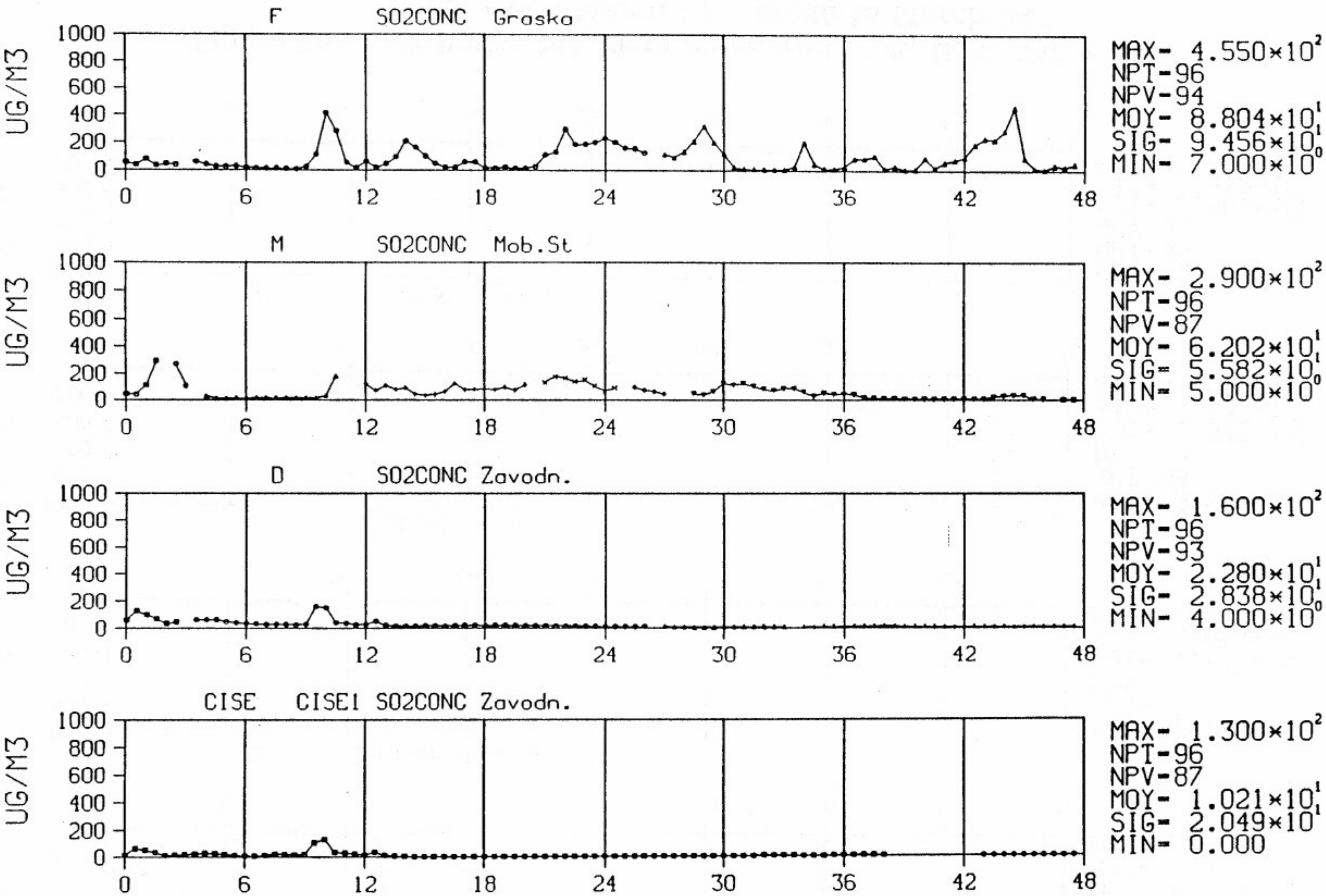

Figure 27b - 48 hours SO_2 data measured in F, M, D and CISE-1 (Zavodnje) stations, since March 21st, 00:00 to March 22nd, 1991, 23:30

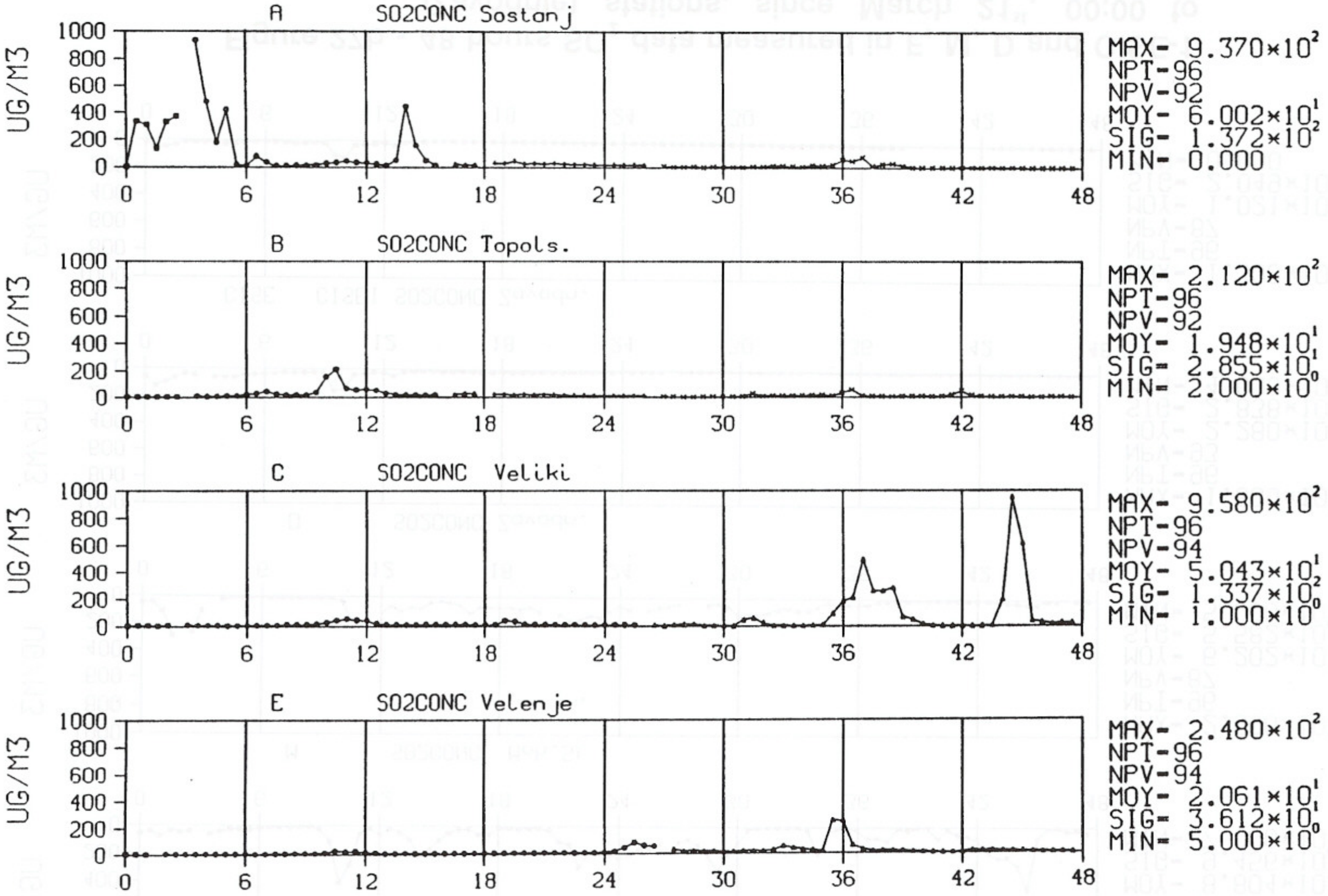

Figure 28a - 48 hours SO_2 data measured in A, B, C and E stations, since March 23rd, 00:00 to March 24th, 1991, 23:30

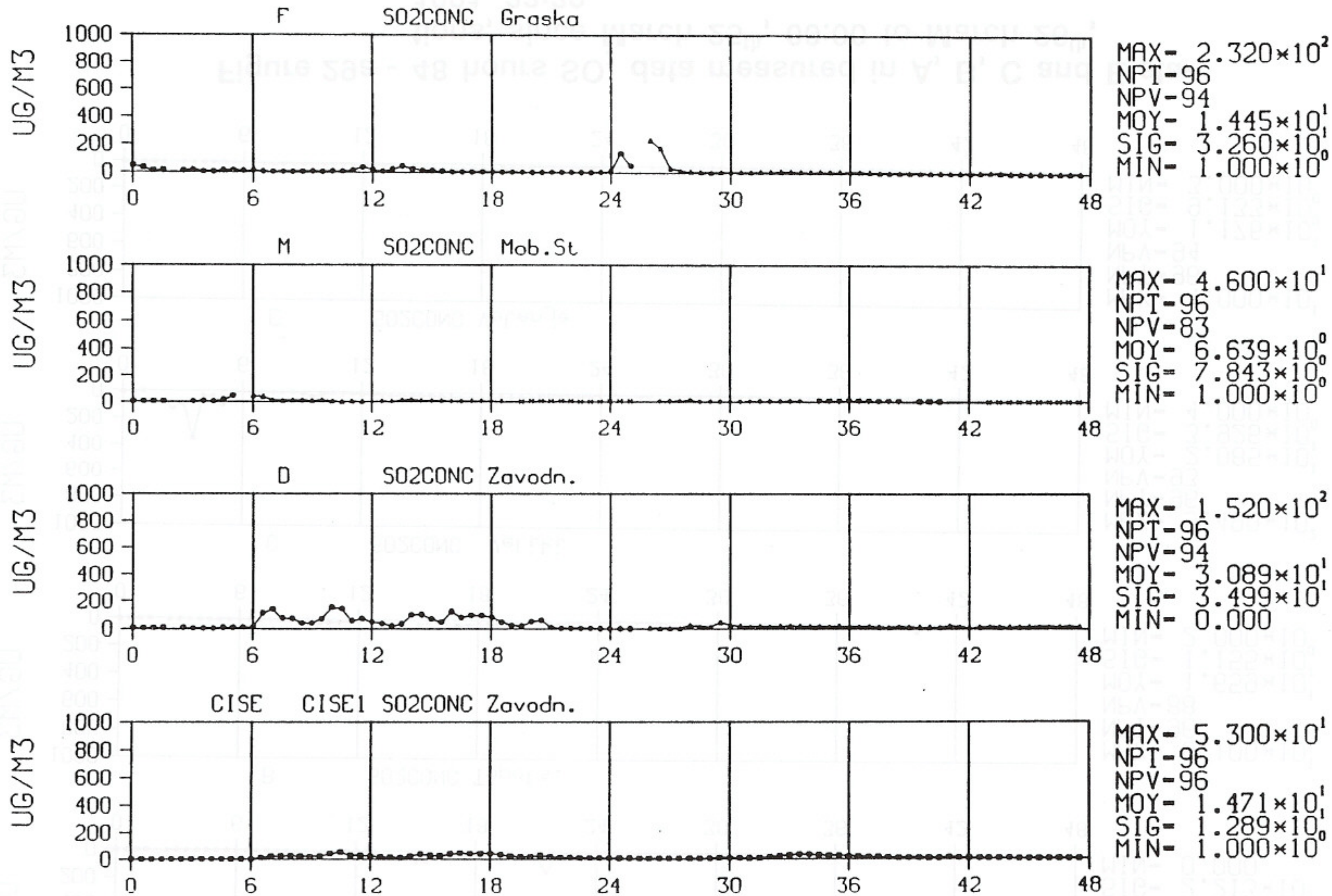

Figure 28b - 48 hours SO_2 data measured in F, M, D and CISE-1 (Zavodnje) stations, since March 23rd, 00:00 to March 24th, 1991, 23:30

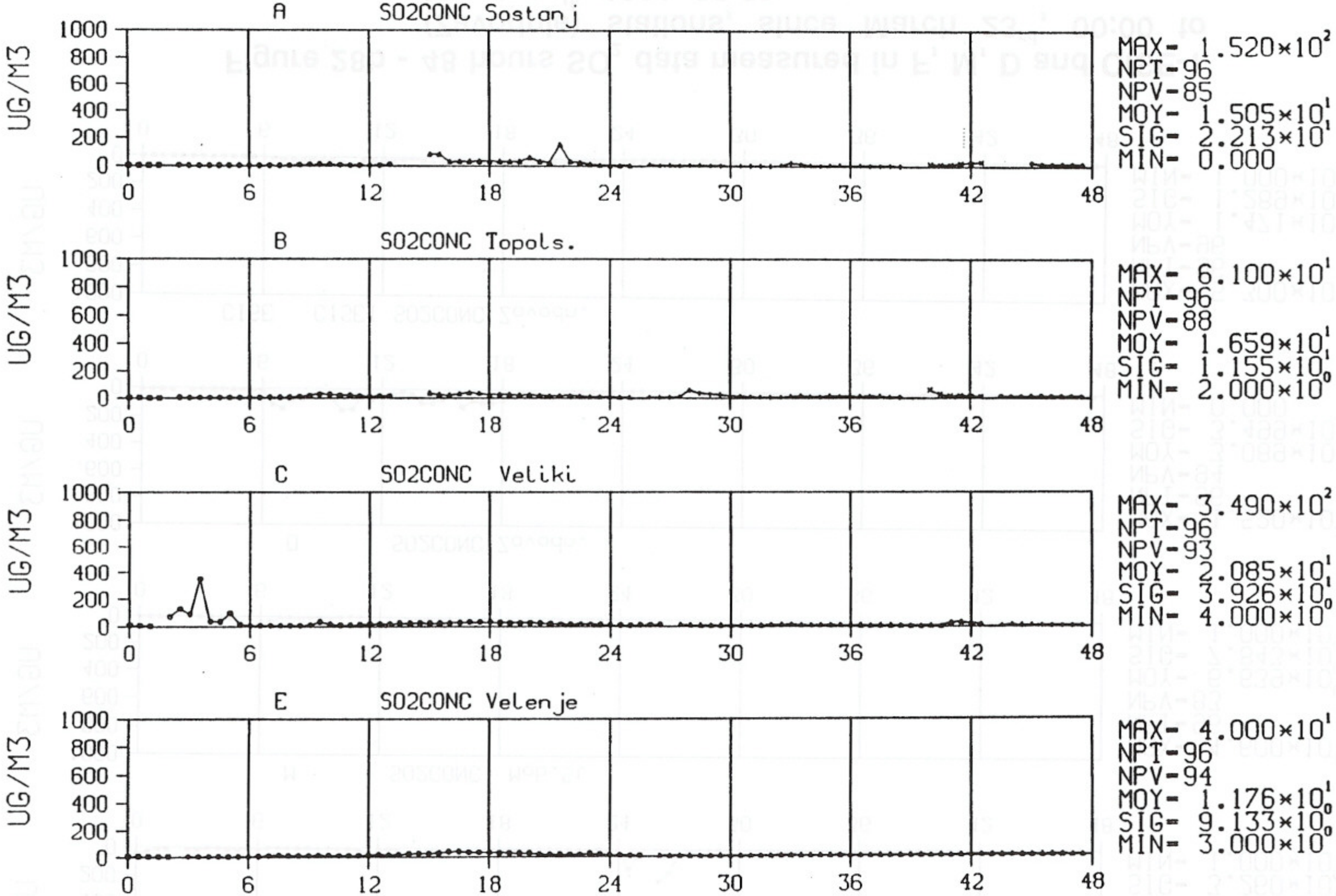

Figure 29a - 48 hours SO_2 data measured in A, B, C and E stations, since March 25th, 00:00 to March 26th, 1991, 23:30

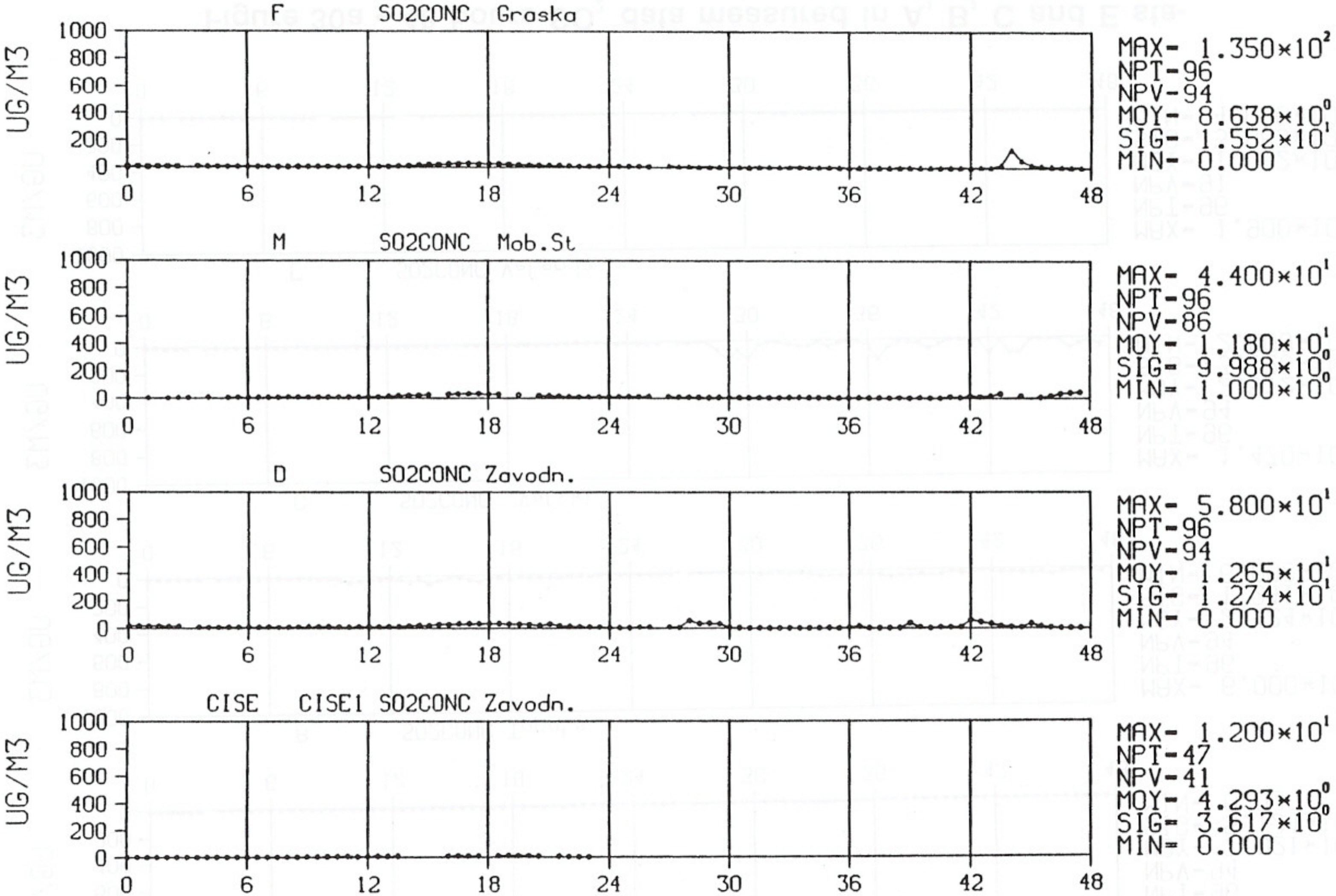

Figure 29b - 48 hours SO_2 data measured in F, M, D and CISE-1 (Zavodnje) stations, since March 25th, 00:00 to March 26th, 1991, 23:30

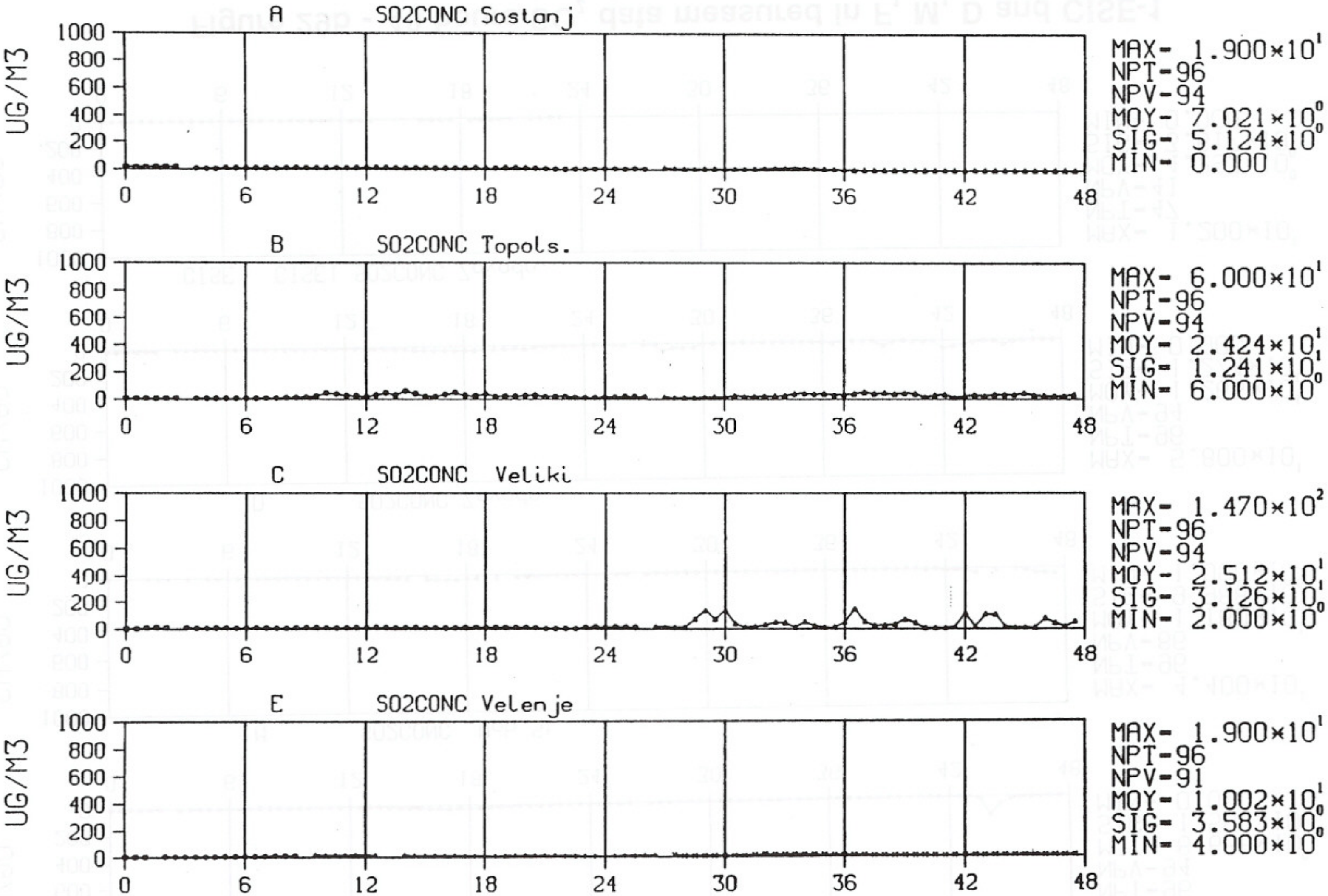

Figure 30a - 48 hours SO_2 data measured in A, B, C and E stations, since March 27th, 00:00 to March 28th, 1991, 23:30

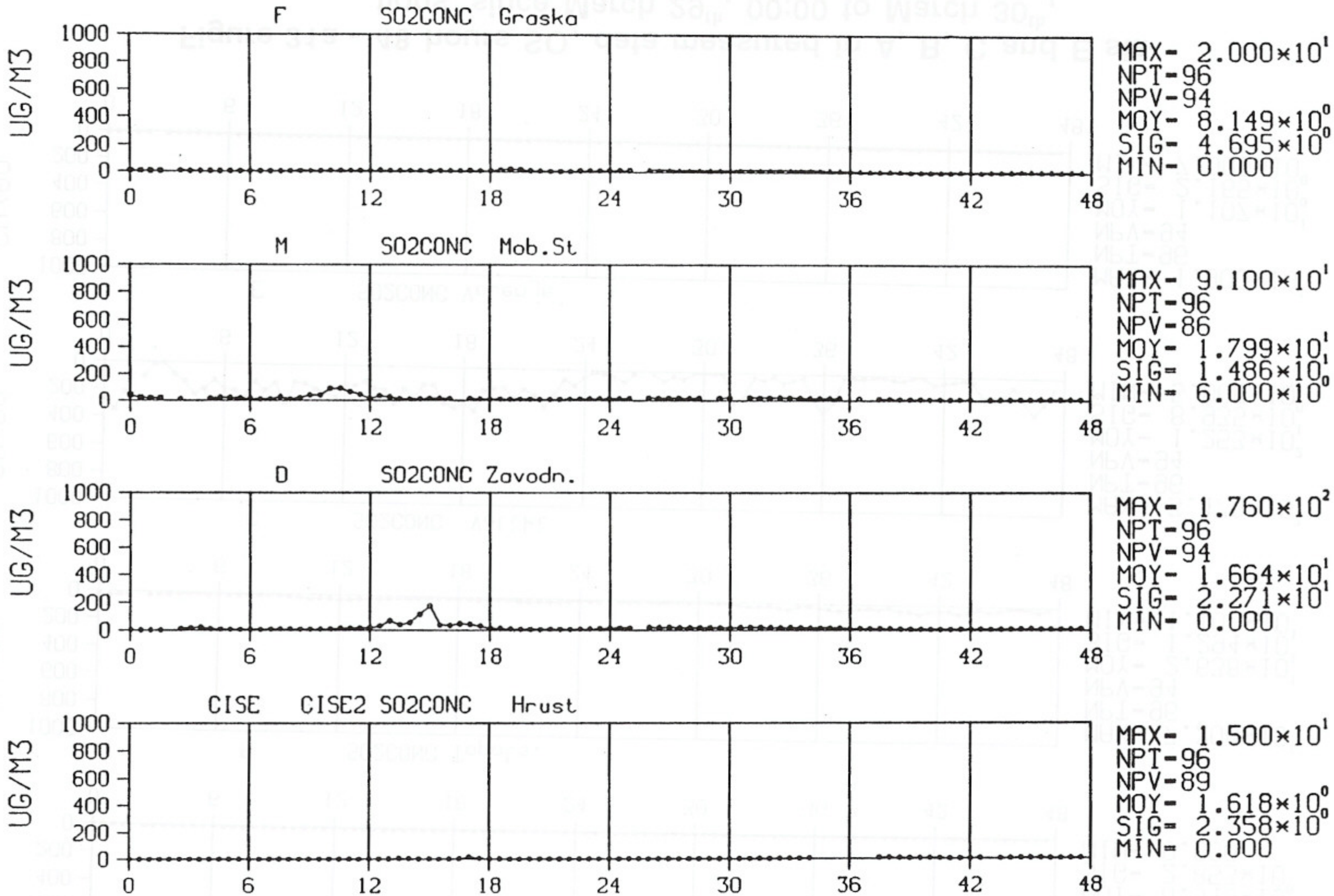

Figure 30b - 48 hours SO_2 data measured in F, M, D and CISE-2 (Hrust) stations, since March 27th, 00:00 to March 28th, 1991, 23:30

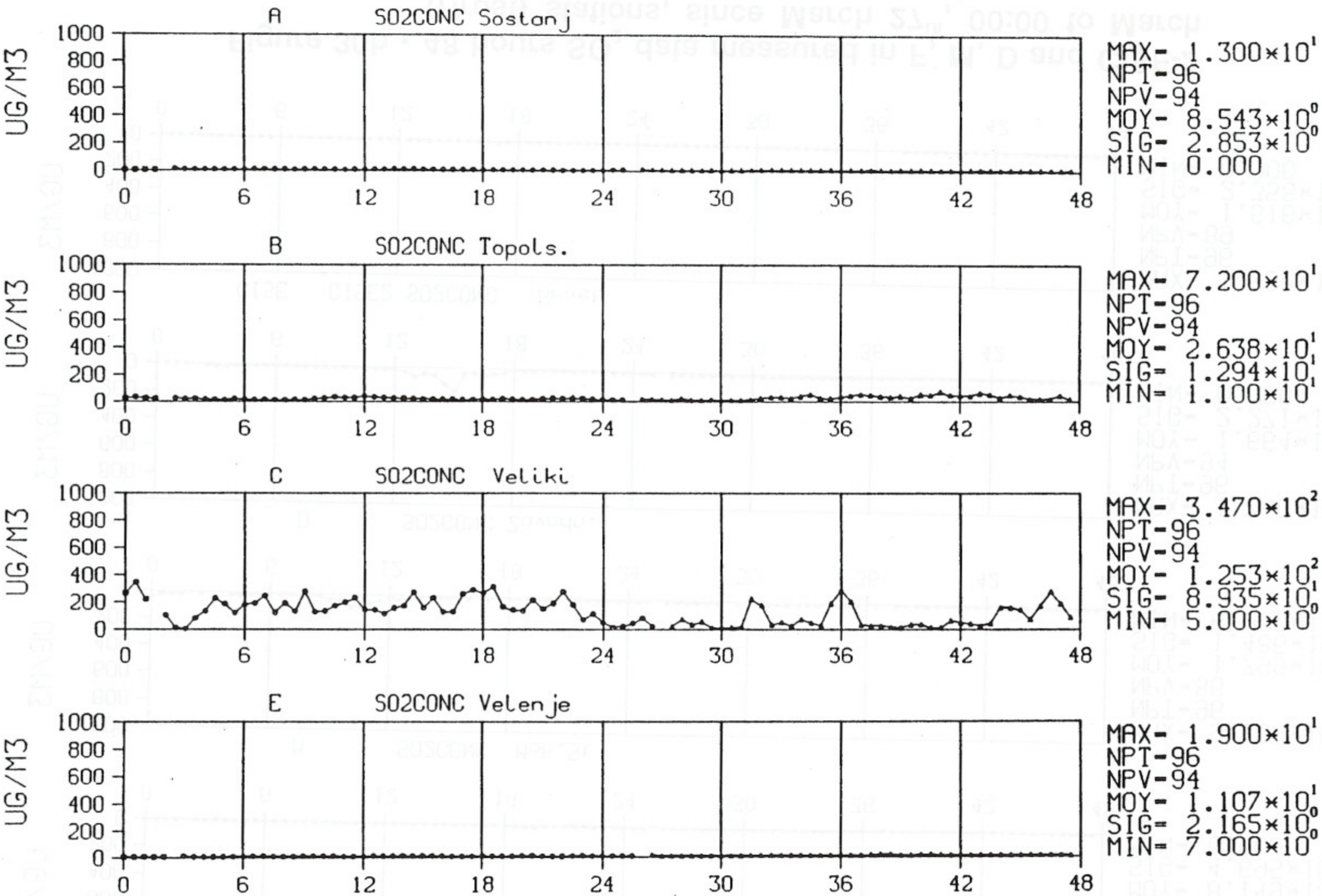

Figure 31a - 48 hours SO_2 data measured in A, B, C and E stations, since March 29th, 00:00 to March 30th, 1991, 23:30

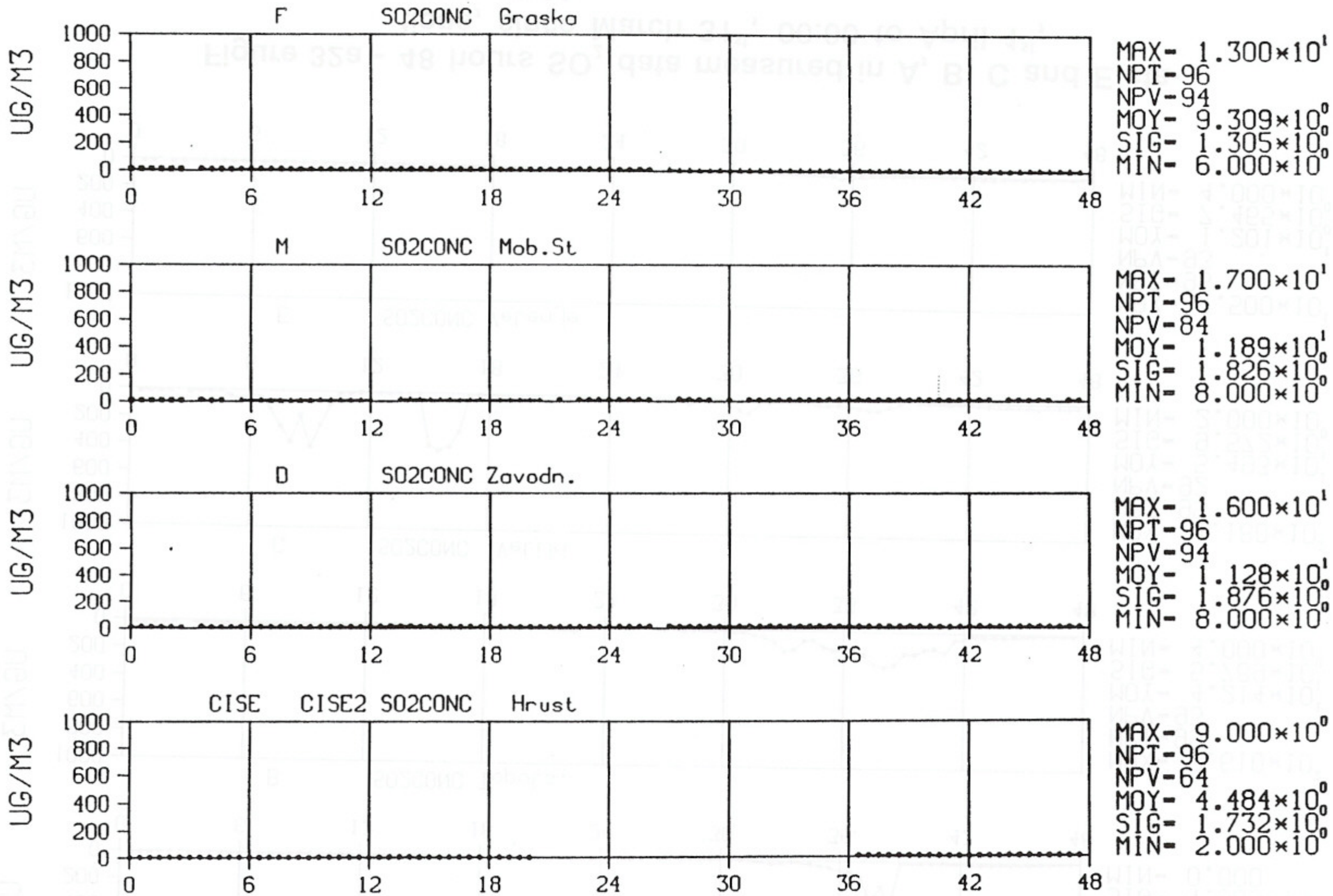

Figure 31b - 48 hours SO_2 data measured in F, M, D and CISE-2 (Hrust) stations, since March 29th, 00:00 to March 30th, 1991, 23:30

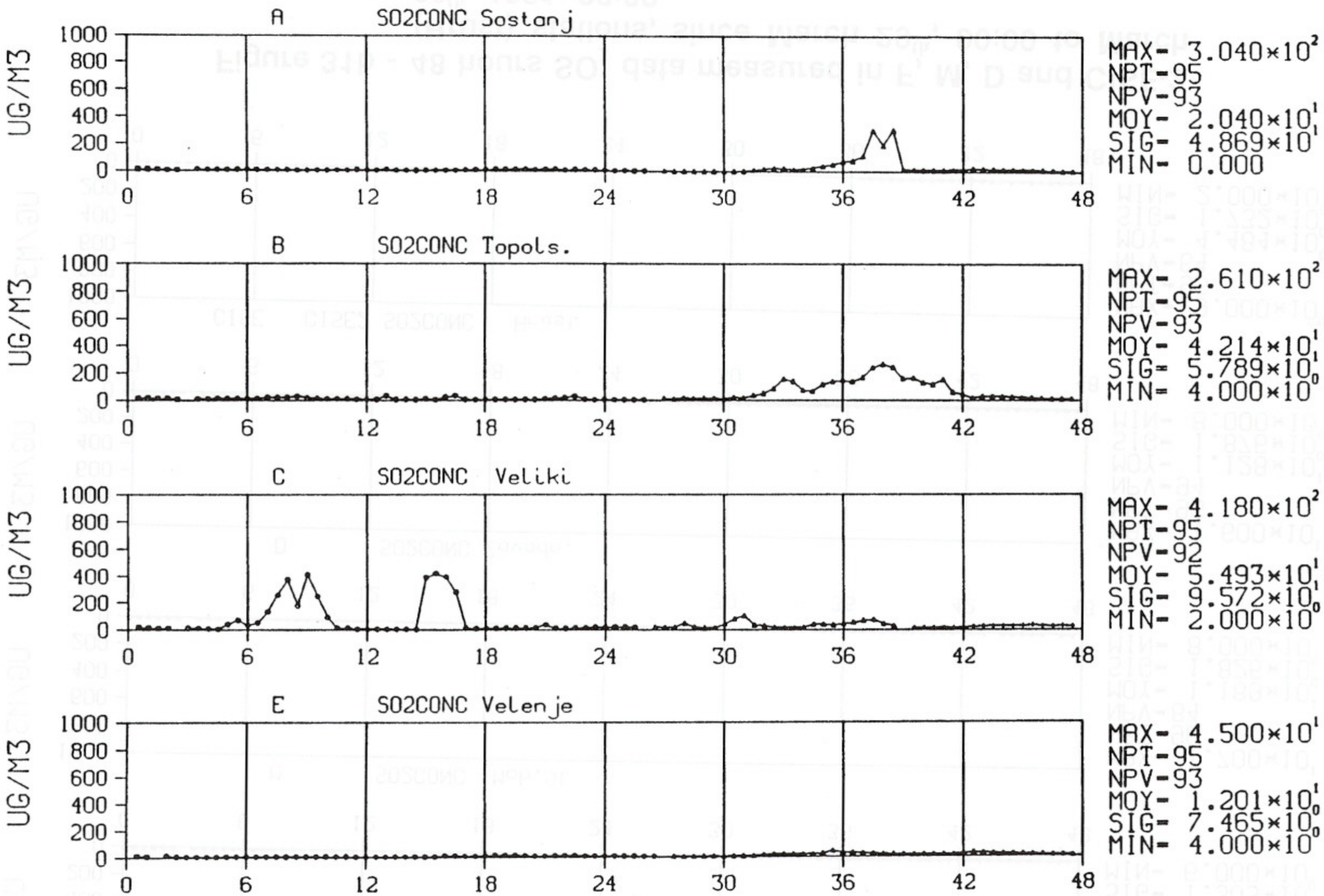

Figure 32a - 48 hours SO_2 data measured in A, B, C and E stations, since March 31st, 00:00 to April 1st, 1991, 23:30

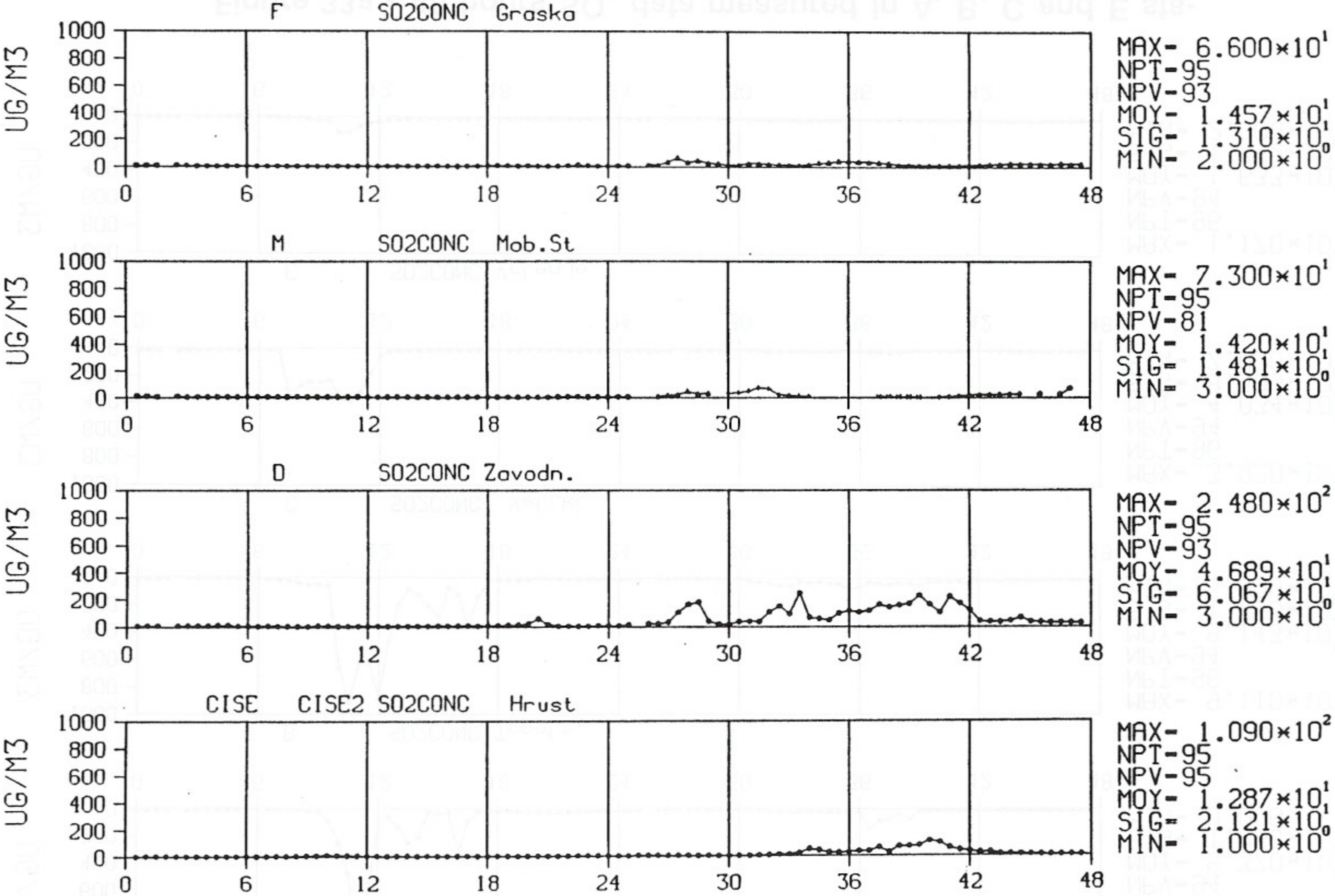

Figure 32b - 48 hours SO_2 data measured in F, M, D and CISE-2 (Hrust) stations, since March 31st, 00:00 to April 1st, 1991, 23:30

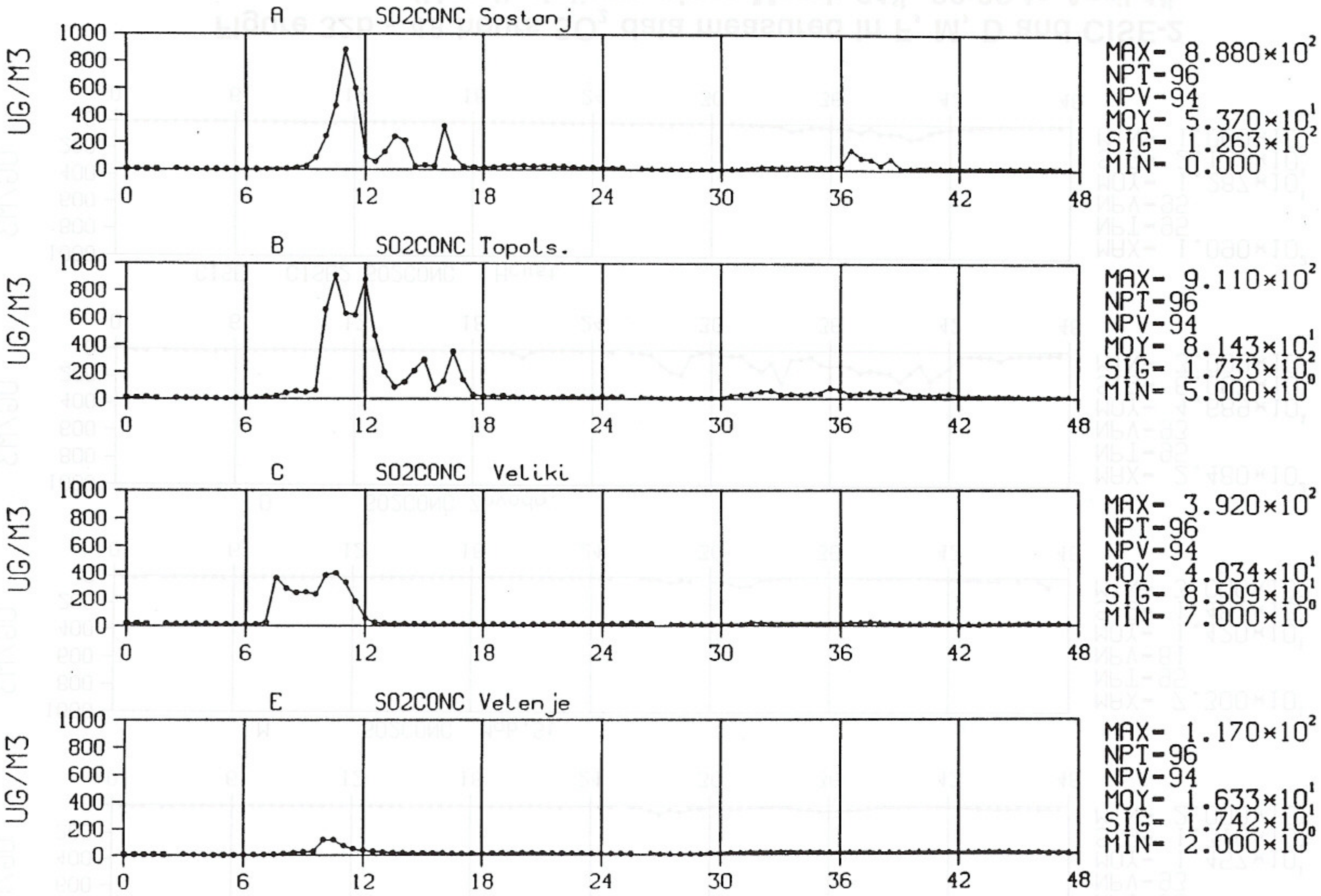

Figure 33a - 48 hours SO_2 data measured in A, B, C and E stations, since April 2nd, 00:00 to April 3rd, 1991, 23:30

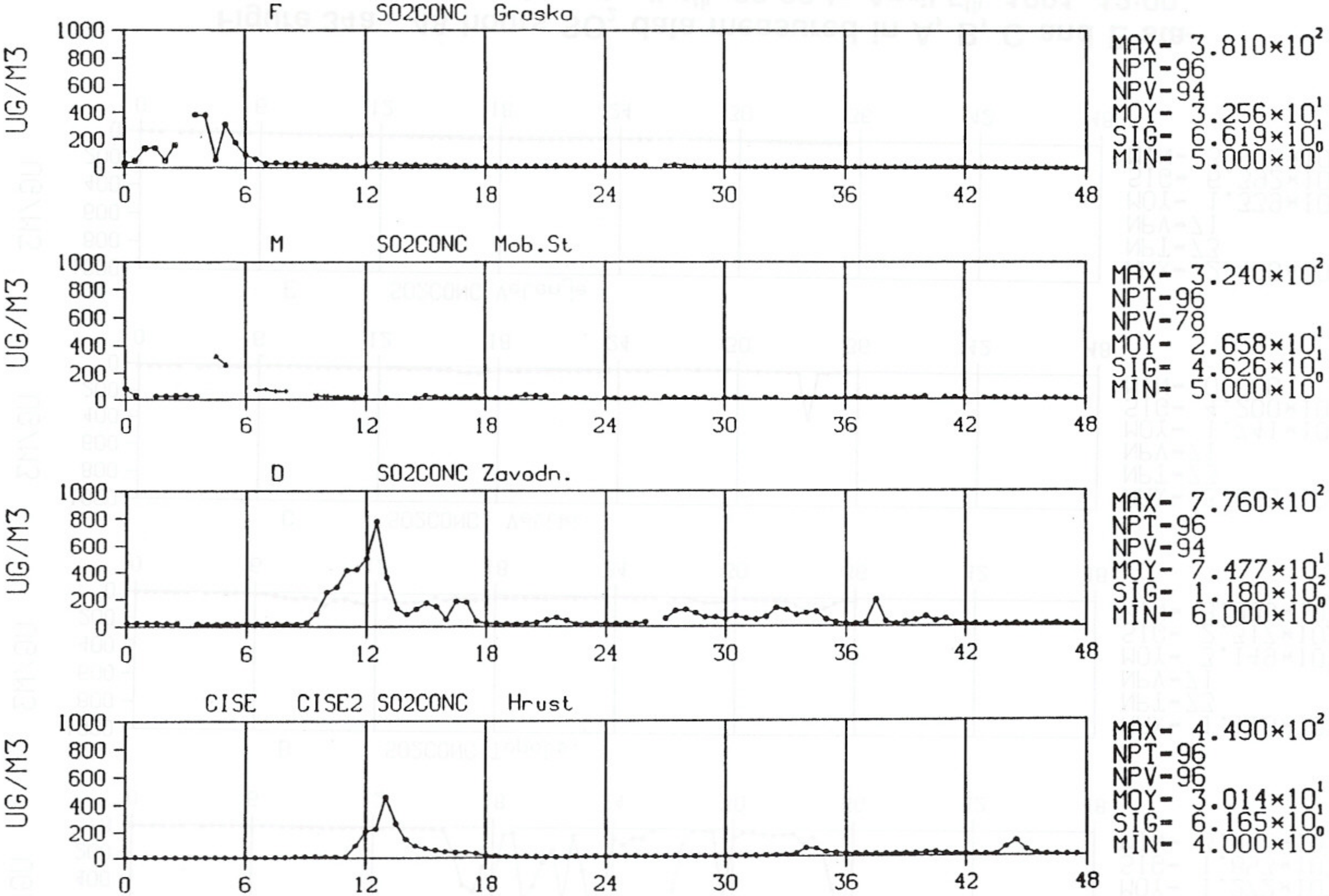

Figure 33b - 48 hours SO_2 data measured in F, M, D and CISE-2 (Hrust) stations, since April 2nd, 00:00 to April 3rd, 1991, 23:30

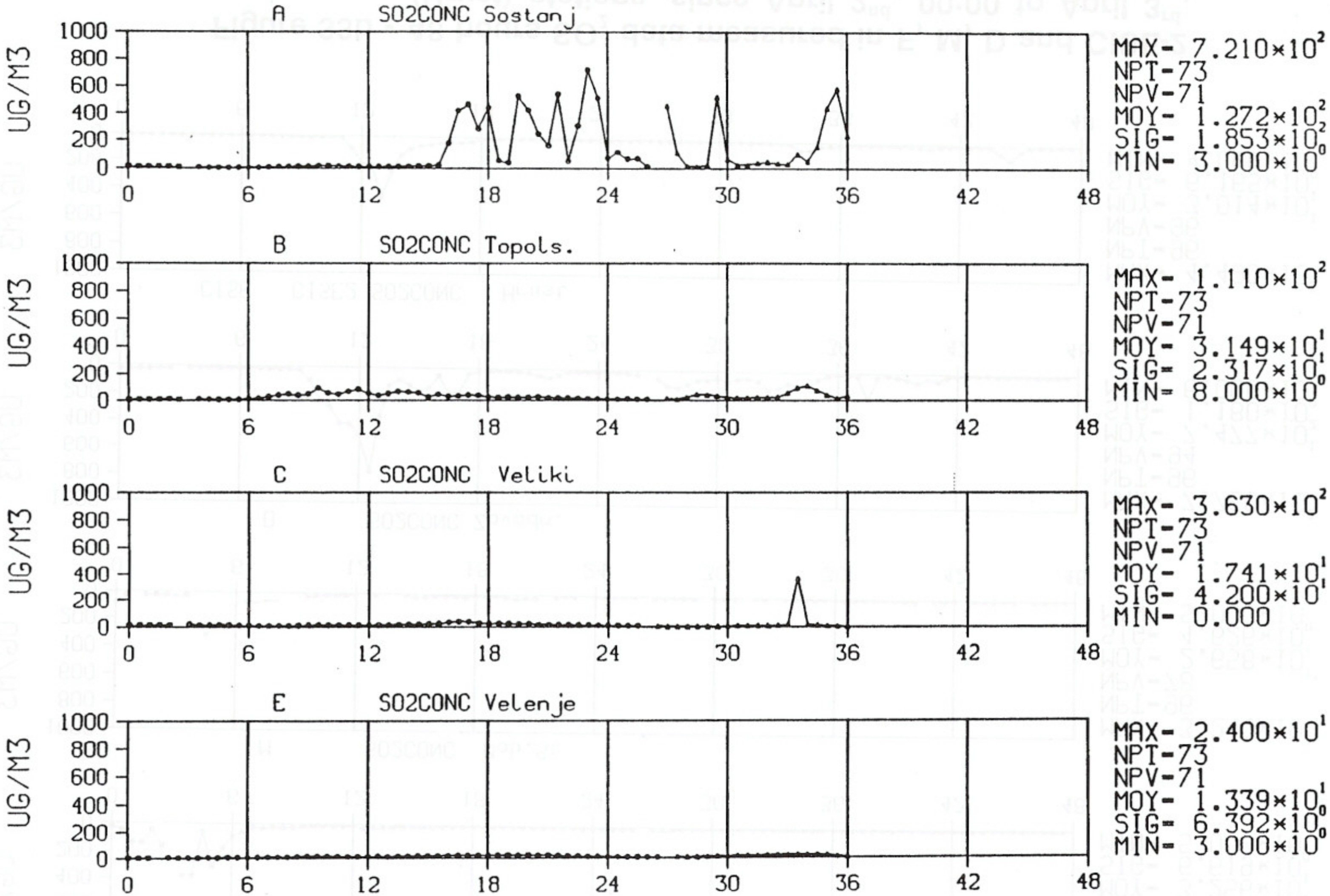

Figure 34a - 48 hours SO_2 data measured in A, B, C and E stations, since April 4th, 00:00 to April 5th, 1991, 12:00

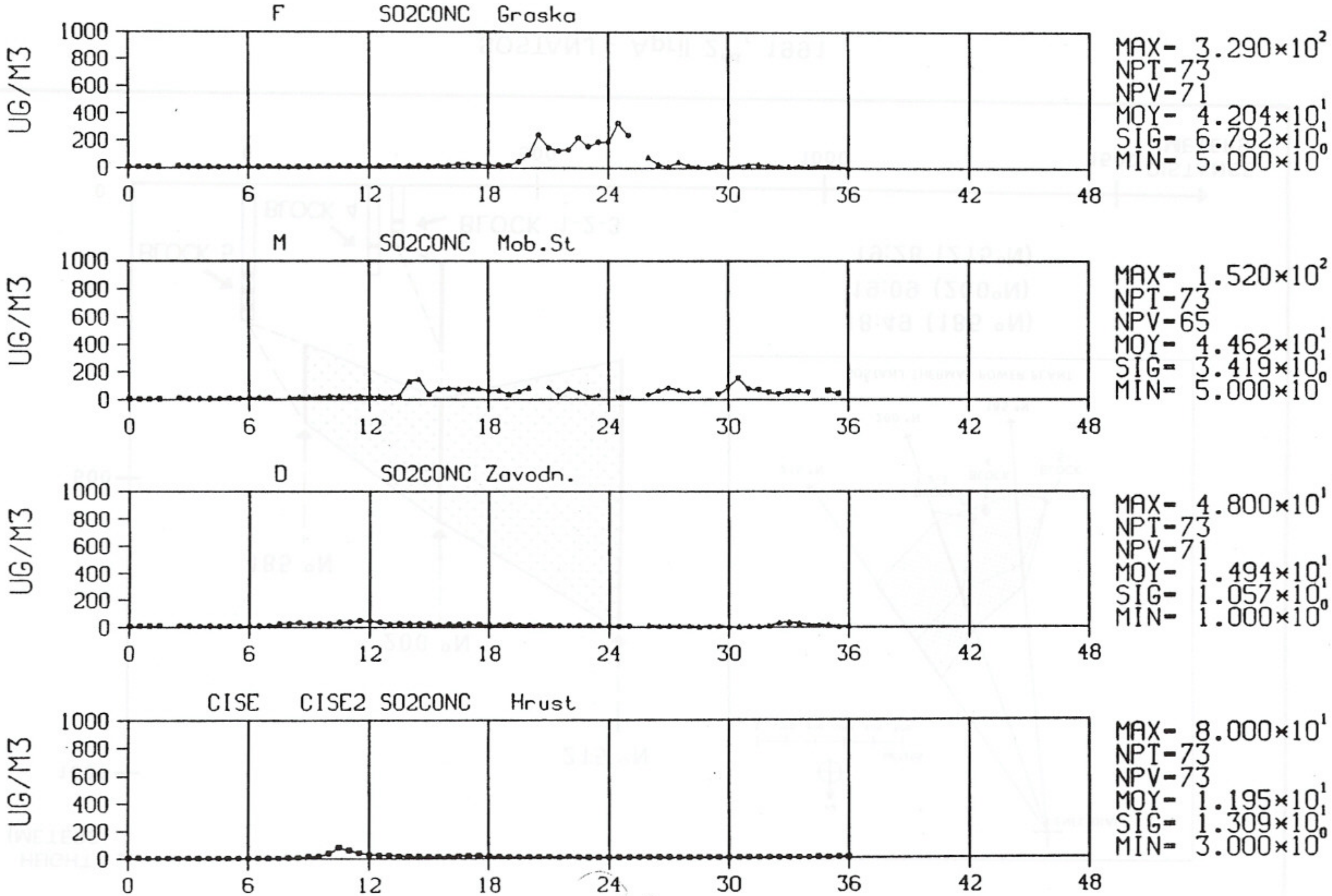

Figure 34b - 48 hours SO_2 data measured in F, M, D and CISE-2 (Hrust) stations, since April 4th, 00:00 to April 5th, 1991, 12:00

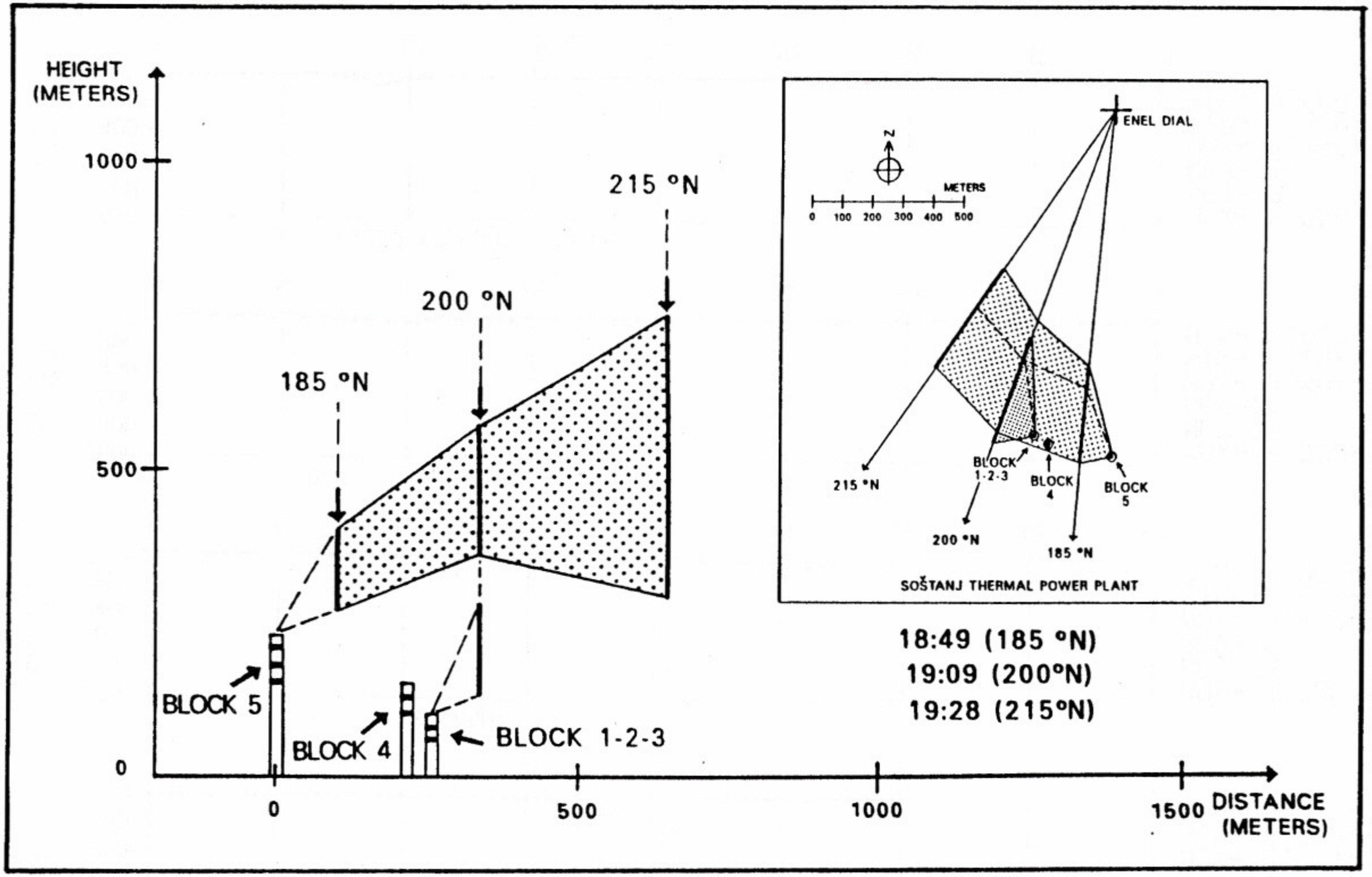

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Figure 35 - Plumes section derived from DIAL measurements

DATA FILE : SOS91071
ACQ. START: 02/04/91 18:38:23 STOP: 02/04/91 18:48:40
CONCENT. RANGE: 0.00 to 1.96 SCALE: PPM - SCAN TYPE: ZENITHAL
AZIMUTH: 185 °N - ELEVATION ANGLES: 10°- 30°

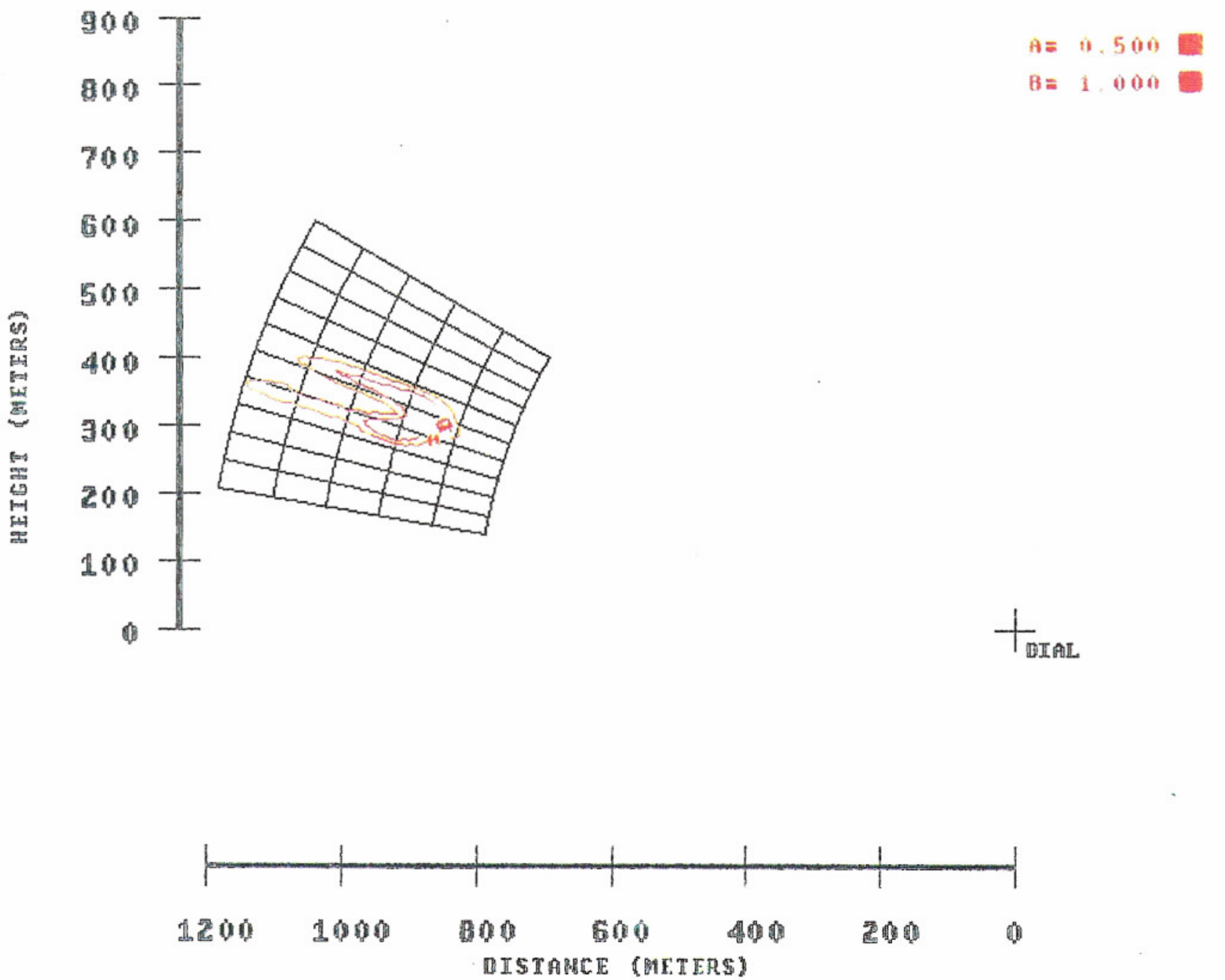

Figure 36 - Example of SO_2 concentration map obtained with DIAL

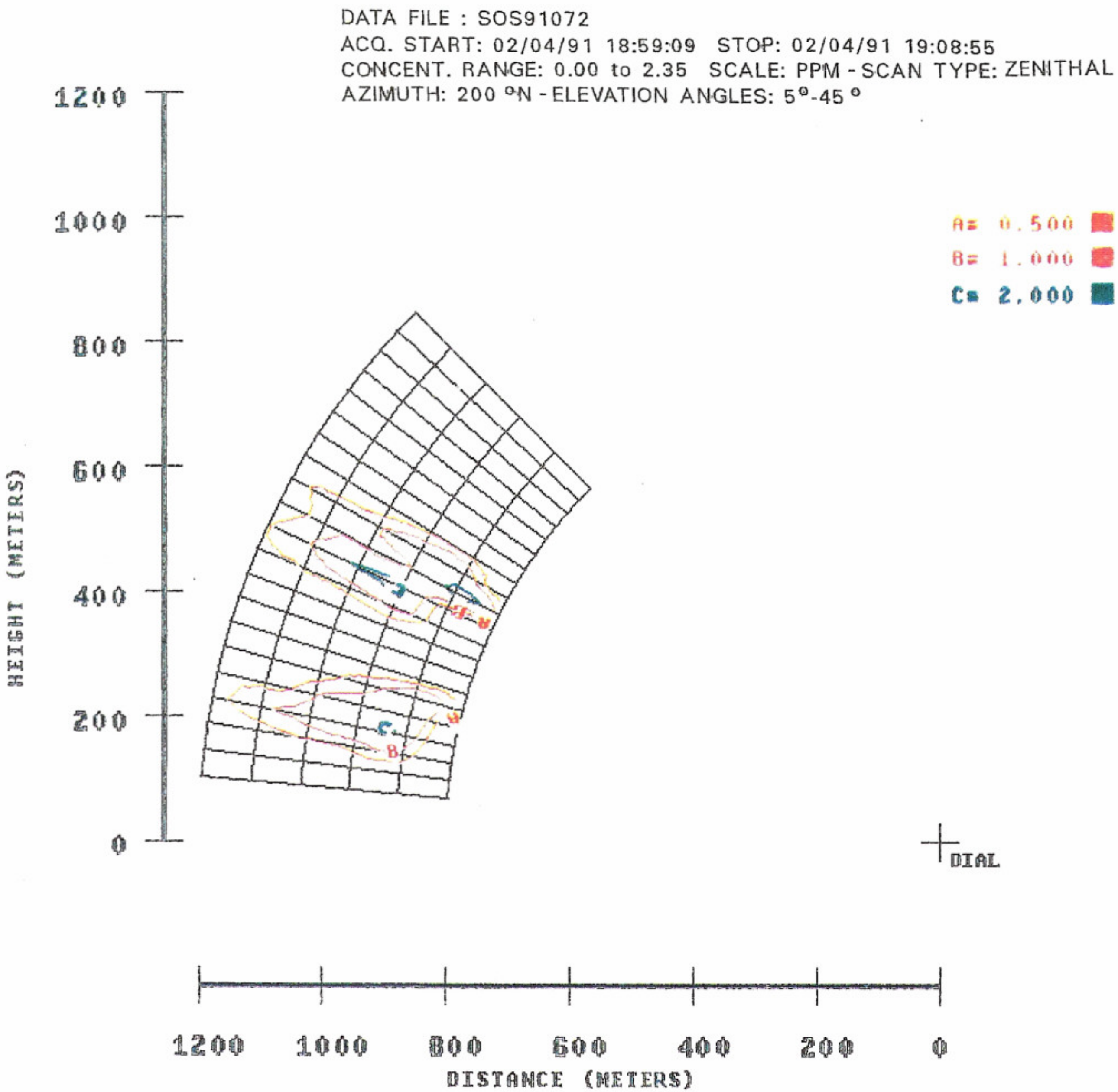

Figure 37 - Example of SO_2 concentration map obtained with DIAL

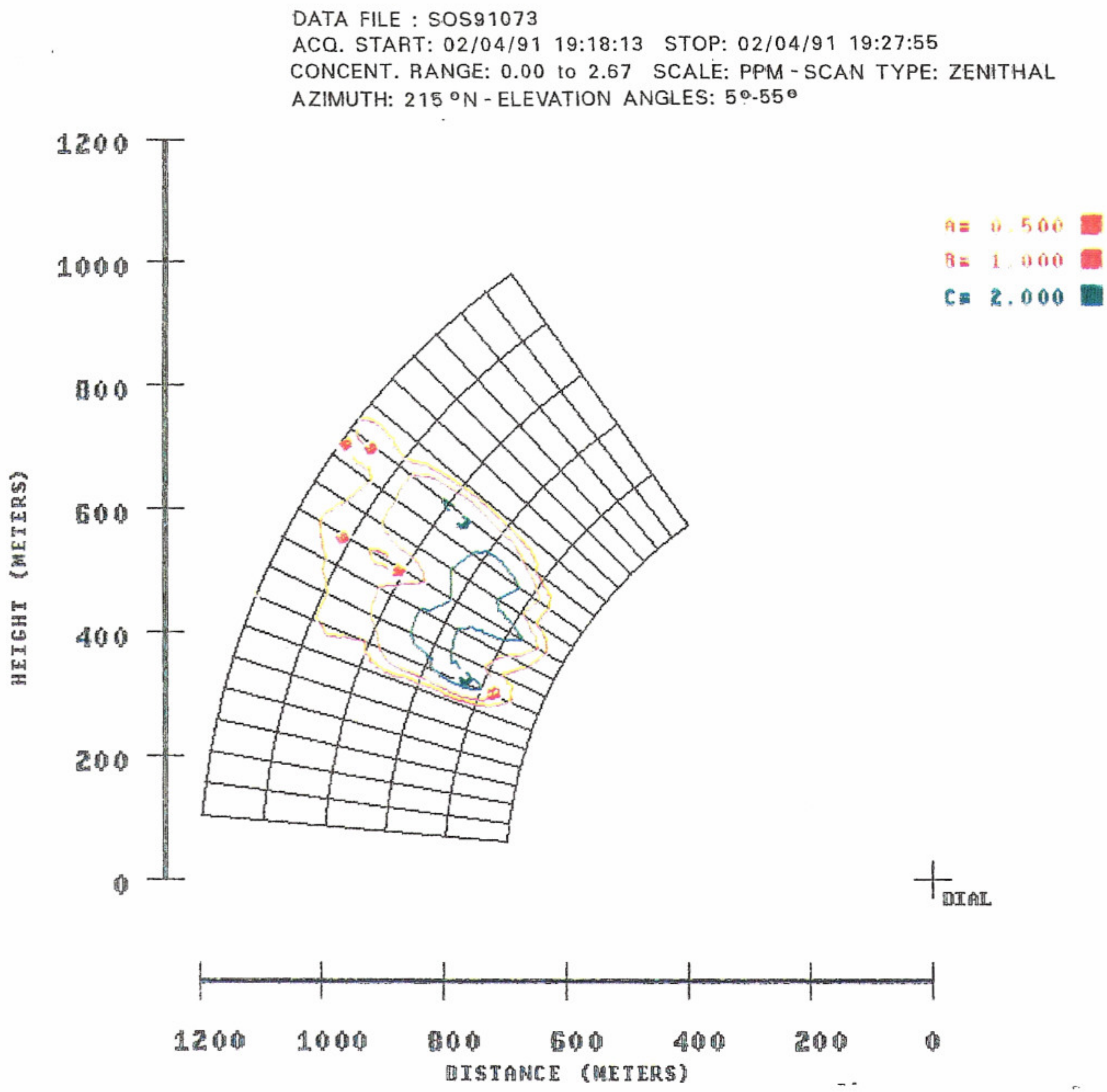

Figure 38 - Example of SO_2 concentration map obtained with DIAL

APPENDIX

DATA FORMAT OF THE FLOPPY DISKS

DATA FORMAT OF THE FLOPPY DISKS

The whole data set of the experimental campaign has been organized in an ADSO database (a package developed by EDF-France and distributed by ARIA-Technologies, Colombes, France), which consists of 14 ASCII-files:

*	**IJS-A.dat**	: air quality-fixed station
*	**IJS-B.dat**	: "
*	**IJS-C.dat**	: "
*	**IJS-D.dat**	: "
*	**IJS-E.dat**	: "
*	**IJS-F.dat**	: "
*	**IJS-M.dat**	: air quality-mobile station
*	**CISE-1.dat**	: "
*	**CISE-2.dat**	: "
*	**EMIS.dat**	: emission data
*	**SODAR.dat**	: Sodar data
*	**TOPOG.dat**	: topography (30x30 Km grid)

The first record of these files contains:

- station name
- station number
- x-y coordinates expressed in Km based on TOPOG file

After this identification record we can find the data consisting of half hourly averaged value of the measured parameters; the first line of each data block is organized in 8 fixed fields:

- Julian day	(J)
- station number	(S)
- day	(D)
- month	(M)
- year	(Y)
- hour	(H)
- minutes	(m)
- seconds	(s)

stored according to the following format:

(blank)JJJJSSSS(blank)DDMMYYHHmmss

The remaining lines of each data block contain the measured data.

The following table shows the station corresponding to each data file, it also gives their identification number, their site and their coordinates:

station number	file	X (km)	Y (km)	site
1	IJS-A	15.800	15.100	Sostanj
2	IJS-B	13.100	18.000	Topolsica
3	IJS-C	14.500	12.100	Veliki
4	IJS-D	11.300	20.700	Zavodnje
5	IJS-E	20.000	13.200	Velenje
6	IJS-F	20.900	19.300	Graska Gora
7	IJS-M	22.100	32.000	Mobile
9	CISE-1	11.300	20.700	Zavodnje
10	CISE-2	7.200	22.400	Hrust
11	EMIS	15.450	14.600	TPP
201	SODAR	16.700	15.900	Sostanj

The measured variables and their format for each file are described in the following pages.

* Files IJS-A...M.dat

Each data block of these files consists of two lines, the first one containing the chemical data, the second one containing the meteorological data.

Data formats and variables order are shown in the following table:

n°	DATA	FIELD FORMAT
1	SO_2 concentration ($\mu g/m^3$)	XXXXX.XX
2	NO_x concentration ($\mu g/m^3$)	XXXXX.XX
3	NO concentration ($\mu g/m^3$)	XXXXX.XX
4	O_3 concentration ($\mu g/m^3$)	XXXXX.XX
5	air temperature (°C)	XXXXX.XX
6	relative humidity (%)	XXXXX.XX
7	solar radiation (Watt/m^2)	XXXXX.XX
8	rain (mm)	XXXXX.XX
9	wind velocity (m/s)	XXXXX.XX
10	wind direction (deg)	XXXXX.XX
	MISSING DATA = -999.00	

* Files CISE-1/2.dat

Each data block of these files consists of two lines, the first one containing the chemical data, the second one containing the meteorological data.

Data formats and variables order are shown in the following table:

n°	DATA	FIELD FORMAT
1	SO_2 concentration ($\mu g/m^3$)	XXXXX.XX
2	NO_x concentration ($\mu g/m^3$)	XXXXX.XX
3	NO concentration ($\mu g/m^3$)	XXXXX.XX
4	CO concentration ($\mu g/m^3$)	XXXXX.XX
5	O_3 concentration ($\mu g/m^3$)	XXXXX.XX
6	air temperature (°C) at 2m	XXXXX.XX
7	air temperature (°C) at 10m	XXXXX.XX
8	relative humidity (%)	XXXXX.XX
9	pressure (mbar)	XXXXX.XX
10	solar radiation (Watt/m^2)	XXXXX.XX
11	rain (mm)	XXXXX.XX
12	wind velocity (m/s)	XXXXX.XX
13	wind direction (deg)	XXXXX.XX
14	standard dev. of wind dir.	XXXXX.XX
	MISSING DATA = -999.00	

* file EMIS.dat

In this file the x,y coordinates are referred to the stack number 2. Each data block of this file consists of the variables illustrated in the following table. These data are divided in two lines: 10 quantities on the first one and 8 on the second one.

n°	DATA	FIELD FORMAT
1	power block 1 (MW)	XXXXX.XX
2	power block 2 (MW)	XXXXX.XX
3	power block 3 (MW)	XXXXX.XX
4	temperature block 1-2-3 (°C)	XXXXX.XX
5	SO_2 emission rate block 1 (ton/h)	XXXXX.XX
6	SO_2 emission rate block 2 (ton/h)	XXXXX.XX
7	SO_2 emission rate block 3 (ton/h)	XXXXX.XX
8	stack gases volume block 1 (Mm^3/h)	XXXXX.XX
9	stack gases volume block 2 (Mm^3/h)	XXXXX.XX
10	stack gases volume block 3 (Mm^3/h)	XXXXX.XX
11	power block 4 (MW)	XXXXX.XX
12	temperature block 4 (°C)	XXXXX.XX
13	SO_2 emission rate block 4 (ton/h)	XXXXX.XX
14	stack gases volume block 4 (Mm^3/h)	XXXXX.XX
15	power block 5 (MW)	XXXXX.XX
16	temperature block 5 (°C)	XXXXX.XX
17	SO_2 emission rate block 5 (ton/h)	XXXXX.XX
18	stack gases volume block 5 (Mm^3/h)	XXXXX.XX
	MISSING DATA = -999.00	

* File SODAR.dat

Each data block of this file consists of 18 lines containing measured data for each vertical level.

Data formats and variables order of each line are showed in the following table:

n°	DATA	FIELD FORMAT
1	height (m)	XXXXX.XX
2	horizontal wind velocity (m/s)	XXXXX.XX
3	horizontal wind direction (deg)	XXXXX.XX
4	standard dev. of horiz. wind dir. (deg)	XXXXX.XX
5	vertical wind velocity (cm/s)	XXXXX.XX
6	standard dev. of vertic. wind vel. (cm/s)	XXXXX.XX
	MISSING DATA = -999.00	

* File TOPOG.dat

The topography file is organized differently than the data files:

* the first record consists of:
  - the number of the grid points in X and Y (61x61);
  - the grid step (0.5 Km);

* the second record contains:
  - UTM zone of the origin;
  - (X,Y) UTM coordinates of the origin, corresponding to the South-West corner of the grid.

* the remaining records are organized as a matrix (61,61) containing the elevation (metres) above the sea level of a 30x30 Km region that includes the Sostanj environmental network. Rows are stored from N to S and columns are stored from W to E. Each row consists of a block of 8 lines.

The topography matrix is followed by some records containing the coordinates of the three stacks and the measuring stations, stored as shown below:

- station site name;
- X, Y coordinate (Km);
- Z (metres).