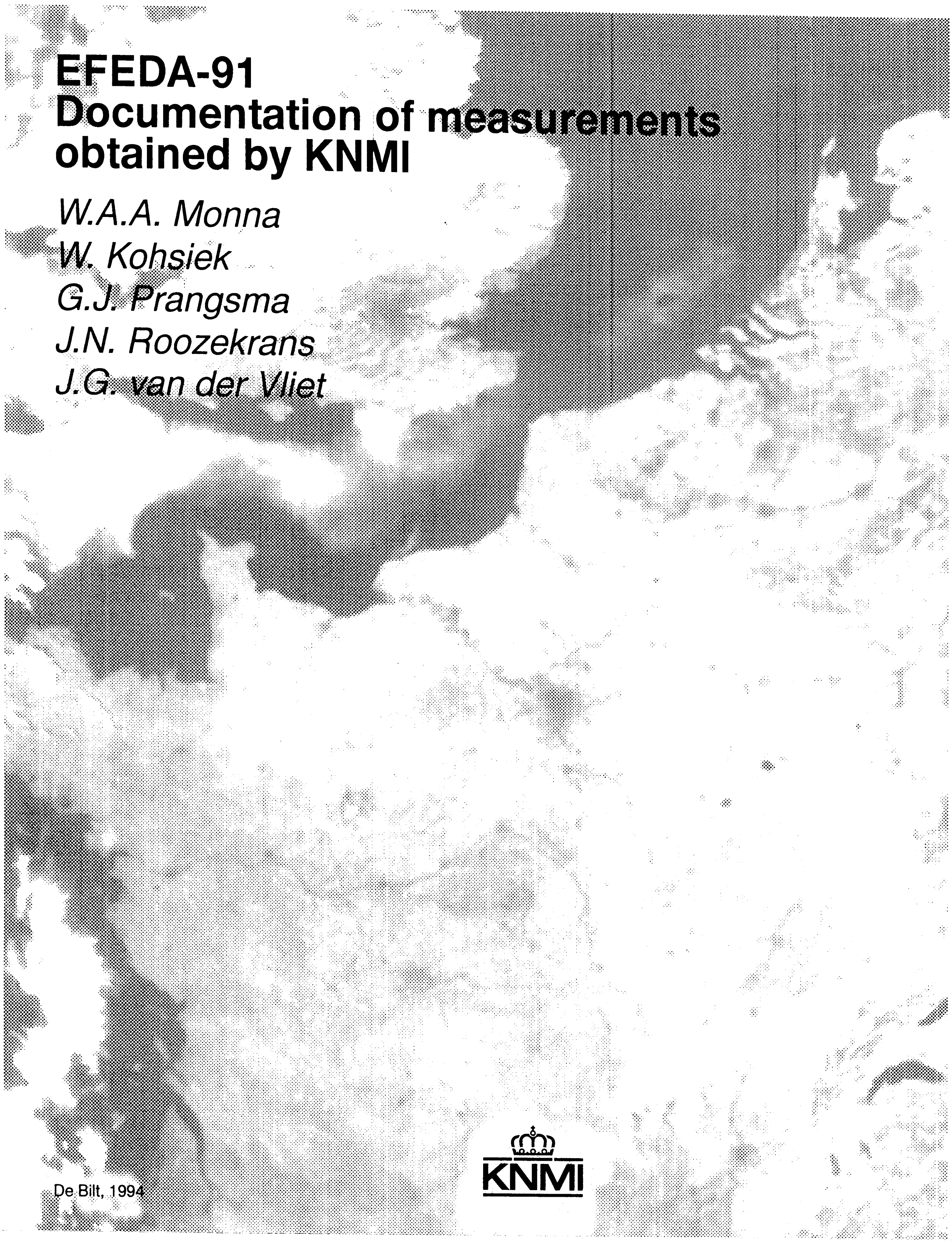
Technical report
TR-171

Ministerie van Verkeer en Waterstaat

Koninklijk Nederlands
Meteorologisch Instituut



EFEDA-91
Documentation of measurements obtained by KNMI

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De Bilt, 1994

KNMI

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1. INTRODUCTION

In June 1991 the EFEDA pilot experiment was carried out in the semi-arid region Castilla-La Mancha in Spain. The acronym stands for ECHIVAL Field Experiment in Desertification-threatened Areas. It was the first major action within the European International Project on Climatic and Hydrological Interactions between the Vegetation, the Atmosphere and the Landsurface (ECHIVAL), a component of the EPOCH programme.

The main objectives were:
- Development and verification of area averaged parameterizations of the exchange processes between surface, vegetation and atmosphere in semi-arid regions, with emphasis on drying conditions.
- Comparison of in-situ and Remote Sensing measurements to verify and improve RS-algorithms.

An extensive description of the experiment, and of preliminary results is given by Bolle et al. (1993).

The experiment had a truly international character: about 150 scientists from eight countries, representing more than 30 research groups, were involved. From the Netherlands there were contributions from the Agricultural University of Wageningen (LUW) (two Departments), the University of Amsterdam (UvA), the Free University of Amsterdam (VU) and the Winand Staring Centre. The Royal Netherlands Meteorological Institute (KNMI) participated as a subcontractor of the Department of Meteorology of the LUW.

KNMI participated in EFEDA because the objectives are closely related to one of the aims of the KNMI TEBEX research programme: development and verification of parameterizations of soil-vegetation-atmosphere interactions in Global Climate Models. Moreover, an experimental remote sensing technique could be tested. Our contribution consisted of:
- measurements of the wind profile up to 500 m height with a Doppler Sodar;
- measurements of the area averaged heat flux with a scintillometer;
- creation of a database with NOAA/AVHRR observations;
- creation of a TOVS database.

After a quality check of the measurements, a database was produced, which was made available to the participants in the autumn of 1991. In this report the KNMI contribution to EFEDA-91 is documented.

2. MEASURING LOCATION

KNMI participated at the Tomelloso site (39°10' N, 3°01' W), one of the three sites that were investigated. The equipment was installed at 7.5 km ESE of the village of Tomelloso, close to the farm Casa de Don Diego (fig. 1). At the same location the micrometeorological stations of the majority of the groups from the Netherlands were situated.

The measuring site was located in a flat "Meseta" landscape, at an altitude of 690 m ASL. To the south, the land slowly rises, forming small hilly ridges reaching 800 m at a distance of about 7 km. The soil is very dry and contains many stones. The water table is about 55 m below the surface, the land is not irrigated. The land is mainly covered with vineyards (± 80%) and cereals (± 10%). Apart from some olive groves, the remaining parcels are barren land. The vines are typical for La Mancha, covering circles with a diameter of about 1.5 m, and reaching a height of 1 m. The distance between the vines is about 2.5 m.

The Doppler Sodar and the scintillometer-receiver were installed on a barren parcel with grass and thistles, about 500 m SW of Casa de Don Diego (figures 3 and 4). The scintillometer transmitter was intalled at Casa de las Carascas. The surrounding parcels were used as vineyard (south and west), or used for growing barley. A map of the location is given in figure 2.

During the measuring period the land dried up significantly. The grass changed from rather green to dry brown. The barley was harvested during the mearuring period. The vines, still finding water, changed from showing first shoots to nearly fully grown.

3. MEASUREMENTS

Doppler Sodar and scintillometer measurements were carried out from 1 June 1991, 13.30 UTC to 29 June 1991, 14.00 UTC. The instruments were installed and put into operation by Kohsiek, Monna, and Van der Vliet. The positions are shown in figure 2. During the first days of the experiment students from the LUW were trained to carry out the maintenance of the equipment, to check the quality of the measurements and to control data storage procedures. In the period 4 to 28 June the instruments were fully controlled by the LUW group. During the whole experiment a logbook was kept.

No mains connection being available, the Doppler Sodar, the scintillometer receiver and the data loggers were powered by a generator. Every fourth day the generator had to be serviced, which caused a break in the measurements. For the scintillometer transmitter a 12 V battery was used, which from time to time had to be replaced by a loaded spare.

NOAA/AVHRR-data and TOVS-data were extracted from the data that are operationally received at KNMI in De Bilt.

3.1 Doppler Sodar

The KNMI Doppler Sodar is a mono-static Remtech system with three parabolic antennas with a diameter of 1.2 m (Beljaars, 1985). The off-zenith angle of the two oblique antennas was 18 degrees. The software used was Remtech programme ANCHOR 1. Each measuring cycle consisted of 3 pulses, one pulse per antenna. The system parameters were: dual frequency mode, 1600 ± 15 Hz; pulse length 150 ms; peak power 200 W; pulse interval 4.5 s; averaging time 20 min. Range gates were set at 25 m intervals, ranging from 50-525 m above ground level. The distance to sound reflecting obstacles like the houses of Casa de Don Diego and some barns was so large (about 500 m) that no fixed echoes disturbed the measurements. The noise of the generator at about 200 m, and even of the LUW generator somewhat further away, could be heard, but did not affect Sodar operation.

System electronics was housed in a small wheeled container, placed 66 m north of the antenna. Every 20 min the system computer produced mean values of the horizontal windspeed, and mean values and standard deviation of wind direction, vertical wind and echo strength. A printout enabled a continuous check on system performance. For later use, the data were automatically stored on floppy discs, using an external PC.

Usually the system functioned properly. However, the frequency stability of the AC mains generator was insufficient for the time keeping of the system clock. Regularly a time consuming synchronisation procedure was necessary, causing some loss of data.

3.2 Scintillometer

A scintillometer was installed with its transmitter located at the farmhouses Las Carrascas and its receiver at the location of the KNMI Doppler Sodar, near Casa de Don Diego. In this way, the path ran almost completely over vineyards, and closely past the site where the Agricultural University of Wageningen, and others performed micro-meteorological measurements. The path lenght was 875 m. The scintillometer is of the 15 cm aperture, 0.94 μm type as described by Kohsiek (1987). A dual receiver system was used. With the pair of receivers, the wind speed across the optical path can be measured. Most of the time only one receiver served for the measurement of C_n^2. Both receivers, and the transmitter were mounted on guyed light weight tripods, 3.27 m above the local surface. The terrain under the optical path is not flat, however, and an effective height had to be calculated. In this calculation the weighing function of the scintillometer has to be taken into account, together with the height profile of the terrain. The latter was only crudely assessed from pictures, after completion of the experiment. A value of 4.00 m ± 0.40 m resulted for the effective height. From the observed values of C_n^2, the sensible heat flux can be calculated (Kohsiek, 1982; Hill, 1992). Although provisions were taken to measure the windspeed perpendicular to the optical path by means of the covariance of the two receiver signals, it is felt that the quality of these observations is not high enough to include them in the database. Time and tools were lacking to make the necessary adjustments of the electronic processing unit.

The logarithmic C_n^2 output and the crosswind output were sampled with a Campbell 21 X datalogger. Samples (in mV) were taken every second, and every 10 minutes the average values and their standard deviations were put in memory. Afterwards, C_n^2 was calculated with

$$C_n^2 = F\,10^{\log C_n^2/1000 + 1.151(s\,d\,C_n^2/1000)^2} \quad (10^{-14}\,m^{-2/3})$$

Here, the second term in the exponent takes account of the non commutative behaviour of the log operation and the averaging operation; s d C_n^2 is the standard deviation of C_n^2. The factor F accounts for post calibration of the instrument; it is 0.981 till 3 June, 10:20 UTC and 1.16 thereafter. Bad data were recognised from entries in the log sheets, and from recordings on a chard recorder, and removed. As noted before, the cross wind observations are regarded as suspicious. The accuracy of the C_n^2 values is 5%.

3.3 AVHRR data

Earth surface data can be obtained via the polar orbiting NOAA-satellites. One of the main sensors on board the operational meteorological NOAA-satellites is the Advanced Very High Resolution Radiometer (AVHRR). This radiometer measures radiation in five different wavelength bands (red, near-infrared and 3x thermal infrared) with a spatial resolution of about 1 x 1 km. Two satellites (NOAA-10 and 11) were in operation during the EFEDA campaign providing roughly 4 image-datasets per day (± 3.00, 8.00, 14.30 and 19.00 hours UTC).
KNMI operates a groundstation for real-time reception of NOAA-AVHRR data of the whole of Europe (thus including the EFEDA study area). During the EFEDA campaign AVHRR-imagedata of southeast Spain have been received, processed and archived at KNMI.
Processing of the raw AVHRR-data included the following steps:
- calibration of the 5 AVHRR channel-data,
- exact navigation of the data,
- detection of cloud-contaminated pixels in the image,
- calculation of surface parameters: land surface temperature (LST), surface albedo (ALB) and vegetation index (NDVI),
- map projection of the images in a polar stereographic projection.

The methodology of the processing is described in Roozekrans and Prangsma (1988).

3.4 TOVS data

The NOAA operational meteorological satellites carry a number of instruments observing the state of the atmosphere (and earth surface). Among these the High-resolution InfraRed Sounder (HIRS) and Microwave Sounding Unit (MSU) sense the radiation emitted by the earth's surface and the atmosphere in a number of wavelength channels, thus providing a tool to assess the temperature and humidity structure of the atmosphere. The instrument readings in binary form are embedded in the High Resolution Picture Transmission (HRPT) data stream, continuously broadcast by the satellite and available for local data reception. KNMI runs a HRPT receiving station for its own operational tasks and has therefore easy access to -among others- the TIROS Operational Vertical Sounder (TOVS) data which consist of the HIRS and MSU data streams. Data extraction and retrieval software is available at KNMI to interpret these TOVS data. A full description of the capabilities of the TOVS instruments can be found in the technical reports issued by NOAA and its subsidary bodies. See e.g. Werbowetzki (1981) and Planet (1988). During the EFEDA campaign TOVS data have been archived for most of the period for the satellites NOAA-10 and NOAA-11.

4. DATABASE

After the experiment the quality of the data was carefully checked, and finally four individual databases were produced for the four types of measurements. Time is UTC. The procedures and the contents are described hereafter.

4.1 Doppler Sodar

Based on the printout, a manual quality-check was preformed on the data as stored on the floppy discs. For some periods data and time information had to be corrected. Some 20 min averages that were based on measurements lasting less than 20 min were skipped. Then the data were transformed into the final database, which is available on floppy disc (in ASCII). The database contains a file description (fig. 5), and a calendar showing the periods for which data are available (fig. 6). An example of 20 min averages is given in figure 7.

4.2 Scintillometer

From the 10 minute values of C_n^2, half hour values were calculated by averaging. If more than one 10 minute block was missing, the whole half hour block was set missing. The 25 kbyte datafile is named EFEDA30G.PRN. Its format reads:

(..., '(1x, i3, 1x, i4, 1x, f 10,4)') idag, igmt, cn2

where idag is the day number (June 1 = 152, June 2 = 153, etc.), igmt the time (GMT=UTC) on which the data block ends (e.g., 1130 refers to data from 11.00 till 11.30). and cn2 the value of C_n^2 in 10^{-14} $m^{-2/3}$.

The data file starts on day 152 (June 1) at 16.30 UTC and ends on day 180 (June 29) at 09.30 UTC. It is not contiguous in time, but shows a gap from day 162, 11.00 UTC till day 166, 12.00 UTC (due to an error in handling the data logger). Including this gap, during 75% of the time meaningful registrations were obtained. The data is available on floppy disk.

4.3 AVHRR data

The database generated for the EFEDA-project contains AVHRR-data of a large number of NOAA-passes in the period 1 - 30 June 1991. Data of 71 passes (out of a maximum of 120) are received and processed. The rather low percentage of acquisition (59%) is due to technical problems with the KNMI groundstation during the EFEDA campaign. Just before the campaign a new system (hardware and software) was installed. An overview of the available passes is given in table 1.
The following image-files are archived for the night and evening NOAA-passes:

- calibrated channel 3 until 5 data (not cloudcleared),
- land surface temperature (cloudcleared).

For the morning and afternoon passes (with significant solar radiation):

- calibrated channel 1 until 5 data (not cloudcleared),
- land surface temperature (cloudcleared),
- surface albedo (cloudcleared),
- vegetation index (not cloudcleared).

All images are polar stereographical projected covering the same area between 40° 42' and 36° 30' north and between 4° 30' west and 1° 30' east (all images can be superimposed on each other). Every pixel in an image represents an area of 1 x 1 km at the surface. An image contains 480 lines and 512 pixels per line. A pixel-value is stored in 8 bits. Including a one line header one image contains 246272 bytes of data. The complete AVHRR-dataset for the EFEDA campaign contains 404 image-files and thus 99.5 Mb of data.

The image-files are written in a binary format developed by KNMI and can be displayed on a MS-DOS PC screen with the NOAAPC-software package of KNMI.

4.4 TOVS data

The database contains the extracts of the HRPT station data as they are locally received at KNMI. Directly after the the antenna the signal has been split into records/frames. This TIP-data stream has been stored on TK50 tapes, along with relevant information for the orbital description for later processing. Due to a change-over to new hardware for the TOVS-processing and a new operating system these files will be transferred to the general KNMI archive in the near future, from where full reprocessing into calibrated and earth-located radiance data (level 1-B) or derived products is a simple, though time-consuming procedure. The data are stored in the raw form, usually called "level 0 data", and can be made available after reprocessing according to the latest procedures by KNMI. For the days 9 and 10 June, no data have been received. An overview of the available orbits is given in table 2.

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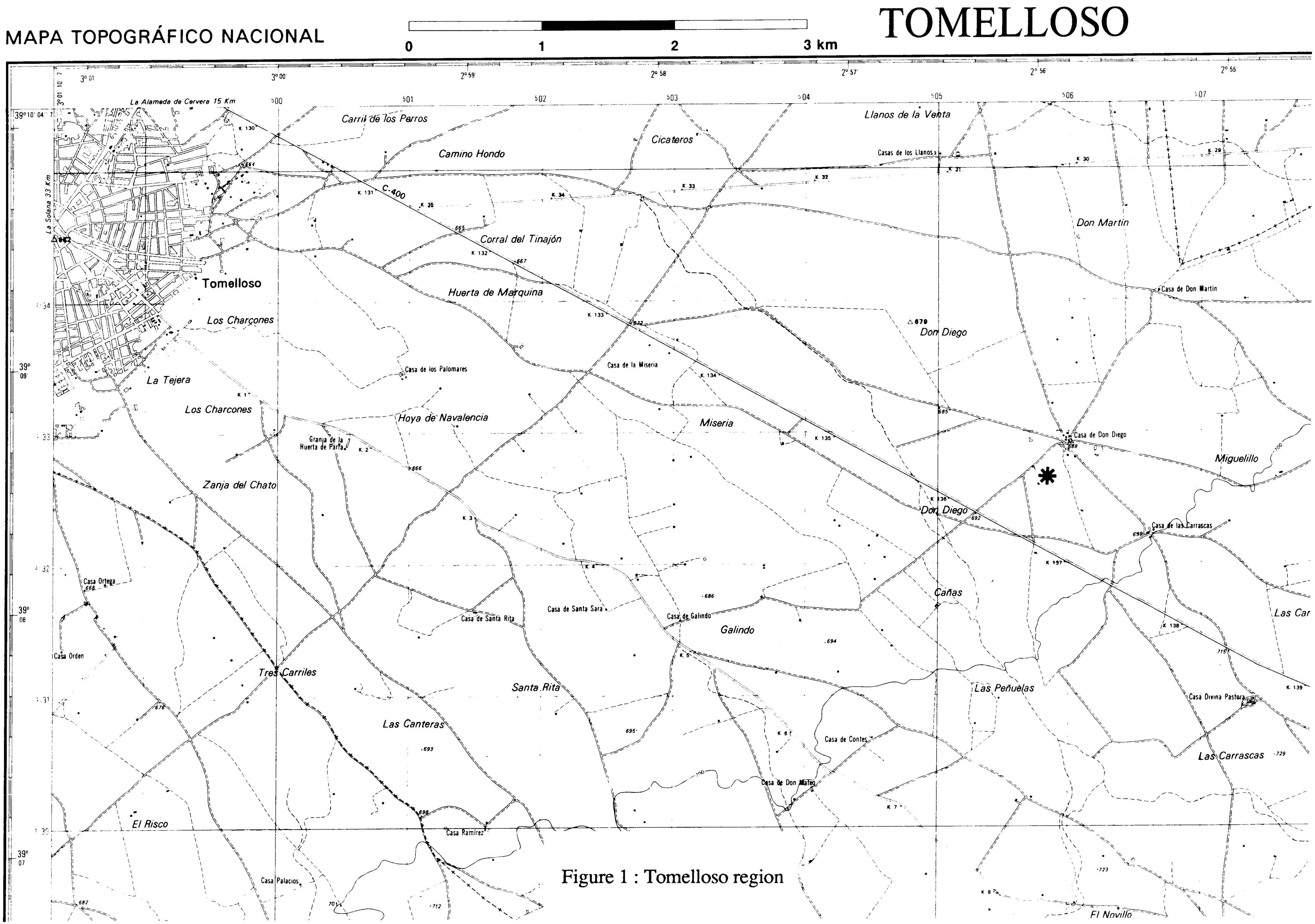

Figure 1 : Tomelloso region

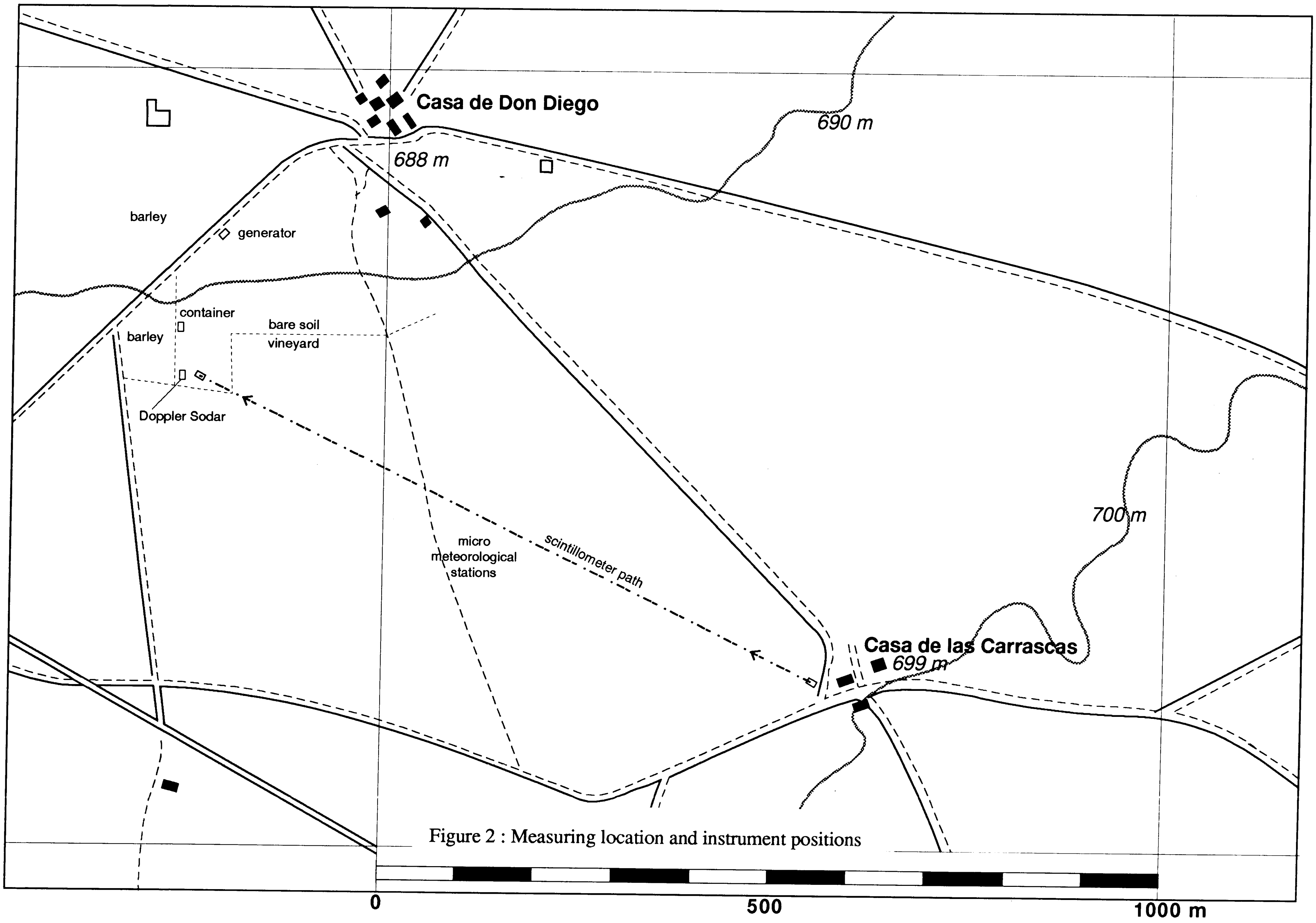

Figure 2 : Measuring location and instrument positions

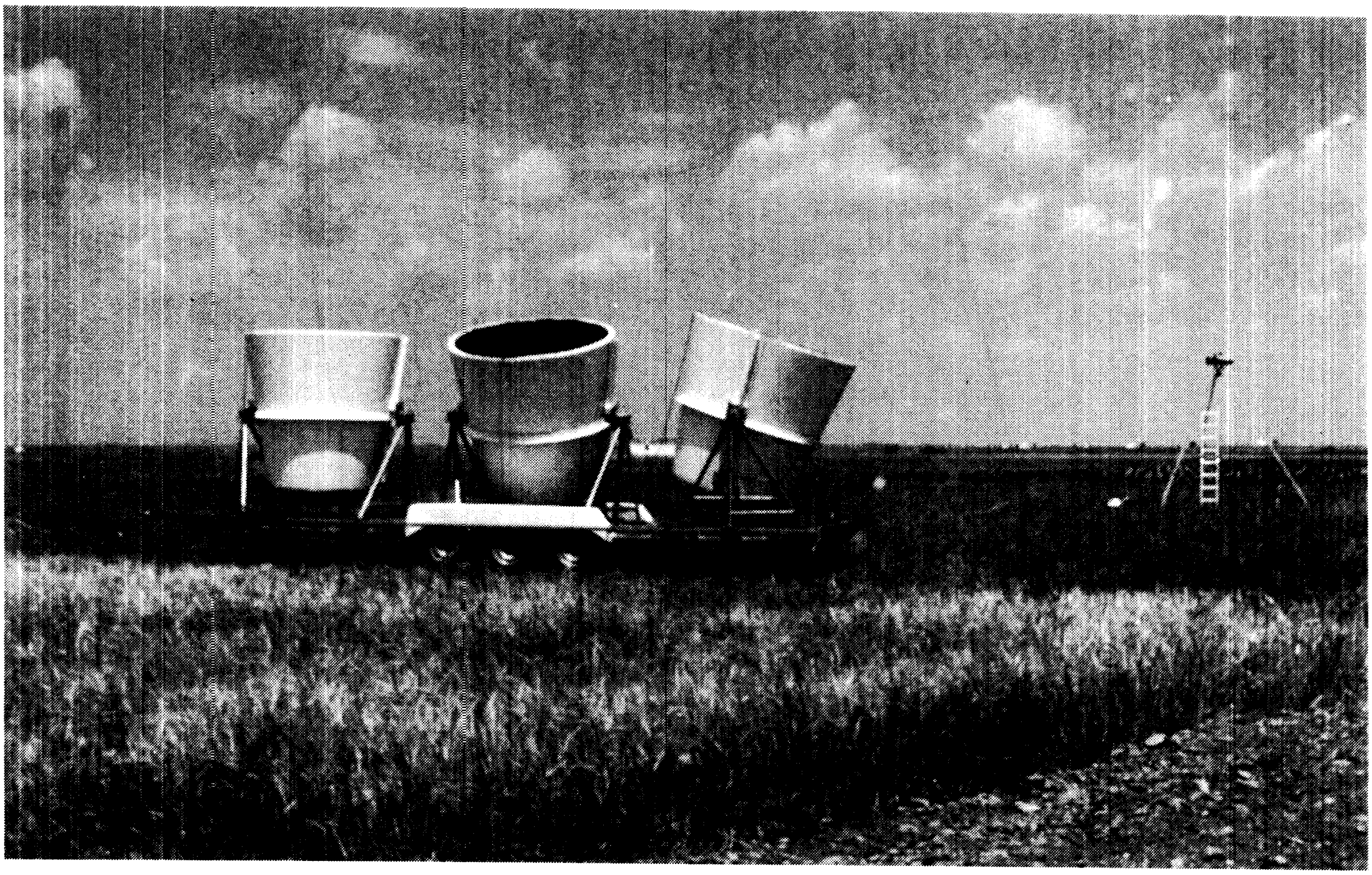

Figure 3 : Doppler Sodar and scintillometer receiver

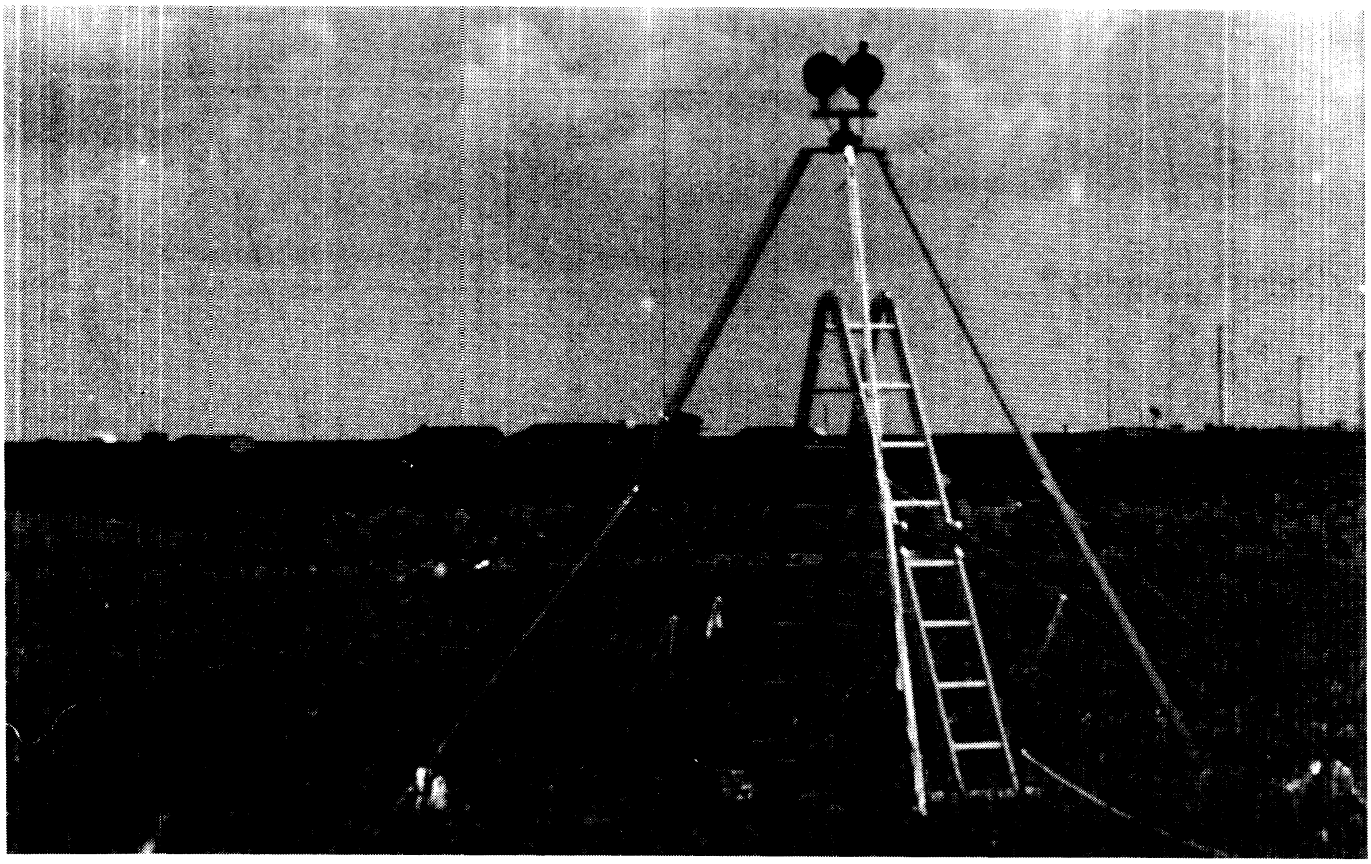

Figure 4 : Scintillometer receiver

Doppler-EFEDA

This file contains the Doppler Sodar measurements carried out in Spain by KNMI, the Netherlands, during "EFEDA 1991".
The Doppler Sodar is a three dimensional mono-static Remtech system. No facsimile recording is available. The double frequency measuring program ANCHOR1 has been used, the one that has been verified at Cabauw (the Netherlands) by comparing the results with tower measurements (Beljaars, A.C.M., 1985: Verification of Doppler-Sodar measurements. KNMI Scientific Report 85-2).

The measuring range went up to 500 m height, depending on atmospheric conditions. The lowest level is 50 m.

Emission pulse length is 150 ms.

Because a generator was used for the electric power the registration time has an accuracy in time of about 5 min.

Period: 1 June 1991, 13.40 UTC - 29 June 1991, 14.00 UTC.

The KNMI station was located about 7.5 km ESE of the centre of Tomellose, Castilla - La Mancha, Spain in the surroundings of Casa de Don Diego. The altitude is about 690 m.

Description of the dataset:

```
DATE   = DDMMYY
TIME   = HHMM, end of the  20 min integration period
Z      = height (m)
ECHO   = echo intensity vertical antenna
         -9999 means: no echo measured
S-ECHO = standard deviation echo intensity
         blank means: equipment not in operation
SPEED  = horizontal windspeed (0,1 m/s)
DIR    = winddirection (deg)
S-DIR  = standard deviation winddirection (deg)
W      = vertical windspeed (0,01 m/s)
S-W    = standard deviation vertical windspeed (0,01m/s)
```

Calendar:

For every day a detailed survey is made of the availability of the 20 min data. When the measurements are available "." is noted, when they are not available "**" is noted.

The KNMI contribution to EFEDA 1991 is described in detail in the KNMI report:

"EFEDA-91, Documentation of measurements obtained by KNMI" by W.A.A. Monna, W. Kohsiek, G.J. Prangsma, J.N. Roozenkrans and J.G. van der Vliet.

Figure 5 : Doppler Sodar data file description

DOPPLERSODAR - JUNE 1991

NO OBSERVATION = **

TIME | DATE

TIME	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
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1500	.	.	**	.	.	.	.	.	.	.	.	.	.	.	.	**	.	.	.	.	.	.	.	.	.	.	.	.	**	**
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1740	**	.	.	.	**	.	.	.	.	.	.	.	.	.	.	**	.	.	.	.	.	.	.	.	.	.	.	.	**	**
1800	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	.	.	.	.	.	.	.	.	.	.	.	**	**
1820	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	.	.	.	.	.	.	.	.	.	.	.	**	**
1840	.	.	.	.	.	.	.	.	**	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
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1920	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
1940	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
2000	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
2020	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
2040	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
2100	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
2120	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
2140	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
2200	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
2220	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
2240	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
2300	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
2320	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
2340	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**
2400	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**	.	**	.	.	.	.	.	.	.	.	.	.	**	**

Figure 6 : Doppler Sodar data calender

DATE = 010691 TIME = 1400

Z	ECHO	S-ECHO	SPEED	DIR	S-DIR	W	S-W
525	-9999	-9999					
500	-9999	-9999					
475	-9999	-9999					
450	-9999	-9999					
425	-9999	-9999	64	137	-9999	-9999	-9999
400	-9999	-9999	79	131	-9999	-9999	-9999
375	51	-9999	45	134	-9999	-11	-9999
350	45	14	63	112	-9999	-30	67
325	52	13	56	123	-9999	-17	46
300	50	22	45	114	10	-36	61
275	55	29	50	109	16	-22	53
250	55	15	55	126	4	-23	56
225	49	4	39	111	13	-24	50
200	61	24	41	110	12	-15	53
175	54	18	40	102	19	-26	41
150	56	22	40	107	13	-20	55
125	64	23	41	101	16	-15	35
100	83	50	39	100	13	-20	43
75	121	67	42	100	13	-3	39
50	177	85	36	84	14	7	35

Figure 7 : Example of Doppler Sodar measurements

Table 1

Overpass times (hours UTC) of available AVHRR data

Date	NOAA10	NOAA11
03-Jun-1991	7, 18	14
04-Jun-1991	7, 18	3, 14
05-Jun-1991	-	2, 14
06-Jun-1991	7, 19	2, 14
07-Jun-1991	7, 18	13
08-Jun-1991	-	-
09-Jun-1991	-	-
10-Jun-1991	-	-
11-Jun-1991	19	14
12-Jun-1991	7, 18	3
13-Jun-1991	-	14
14-Jun-1991	8	14
15-Jun-1991	7	2, 14
16-Jun-1991	7, 18	13
17-Jun-1991	18	3, 13
18-Jun-1991	8	3, 13
19-Jun-1991	7, 19	3
20-Jun-1991	7, 18	14
21-Jun-1991	18	14
22-Jun-1991	8, 18	2, 14
23-Jun-1991	8, 19	2, 14
24-Jun-1991	7, 18	2, 14
25-Jun-1991	7, 18	13
26-Jun-1991	18	3, 13
27-Jun-1991	8	3
28-Jun-1991	7, 19	14
29-Jun-1991	7, 18	14
30-Jun-1991		3
01-Jul-1991	8	

Table 2

Orbit numbers of available TOVS data

Date	Tapes	NOAA10	NOAA11
03-Jun-1991	EFEDA 04-juni	24457	--------
04-Jun-1991	EFEDA 04-juni	24473	--------
		24477/79	13867/69
05-Jun-1991	EFEDA 05-juni	24485	13875/77
		--------	13881/83
06-Jun-1991	EFEDA 06-juni	24500/01	--------
		24506/07	13895/98
07-Jun-1991	EFEDA 07-juni	24514/15	13903/06
		24521/22	13910/11
08-Jun-1991	EFEDA 12-juni	--------	13918
09-Jun-1991	------------	--------	--------
10-Jun-1991	------------	--------	--------
11-Jun-1991	EFEDA 11-juni	24576/78	13954/67/68
12-Jun-1991	EFEDA 12-juni	24584/87	13974/76
	(+ volume II)[1]	24591/93	13980/82
13-Jun-1991	EFEDA 13-juni	24599/24600	--------
		--------	13996
14-Jun-1991	EFEDA 14-juni	24613/15	14002/04
	(+ volume II)	24620/21	14008/11
15-Jun-1991	EFEDA 15-juni	24628/29	14016/19
		24634/35	14023/25
16-Jun-1991	EFEDA 16-juni	24641/42	14030/32
17-Jun-1991	EFEDA 17-juni	24656/58	--------
		24662/64	14052/53
18-Jun-1991	EFEDA 18-juni	24670/72	14059/61
	(+ volume II)	24676/78	14065/67
19-Jun-1991	EFEDA 19-juni	24685/86	14073/75
		24690/92	14080/81
20-Jun-1991	EFEDA 20-juni	24698/24700	14087/89
	(+ volume II)	24704/07	14093/95
21-Jun-1991	EFEDA 21-juni	24712/15	14101/03
		24719/21	14108/09
22-Jun-1991	EFEDA 22-juni	24727/29	14115/17
		24733/35	14121/23
23-Jun-1991	EFEDA 23-juni	24742/43	14129/32
		24748/49	14136/38
24-Jun-1991	EFEDA 24-juni	24756/57	14143/46
		24761/64	14150/51
25-Jun-1991	EFEDA 25-juni	24769/72	14158/59
	(+ volume II)	24776/78	14164/66
26-Jun-1991	EFEDA 26-juni	24784/86	14172/73
		24791/92	14178/80
27-Jun-1991	EFEDA 27-juni	24798/24800	14186/88
	(+ volume II)	24804/06	14192/94
28-Jun-1991	EFEDA 28-juni	24812/14	14200/02
		24818/20	14207/08
29-Jun-1991	EFEDA 29-juni	24826/29	14214/16
	(+ volume II)	24833/35	14220/22
30-Jun-1991	EFEDA 30-Juni	24841/42	14228/30
		--------	14234/36

1: (+ volume II) means: some of the orbits present on second tape