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WIND AND TEMPERATURE PROFILES AT TERUEL POWER STATION NOVEMBER 1978

BY

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FOREWORD

This work has been sponsored by Ecopolsa, Sereland and was carried out at the end of November 1978. Meteorological data from Spain, site descriptions and maps were provided by Sereland. V. Lurud, NILU was responsible for radiosonde instrumentation and participated in the experiments in Teruel.

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WIND AND TEMPERATURE PROFILES AT TERUEL NOVEMBER 1978

1 INTRODUCTION

The Norwegian Institute for Air Research (NILU) has been asked by ECOPOLSA, Sereland in Madrid to study the vertical wind- and temperature profiles in the surroundings of the Teruel power station in Spain.

Data on the build up of unstable surface layers capped by upper inversions are important when estimating maximum impact at surface level as a result of emissions of air pollutants from high stacks.

The first part of this study was undertaken in November 1978. A second part has been suggested to be undertaken during May 1979.

This report presents the results of the first part of the study, and includes the data collected at the site and data from the climatological observations in Andorra.

2 SITE DESCRIPTIONS

The Teruel power plant site is located in the north eastern part of Spain near the village of Andorra in the province of Teruel (see map Figure 1).

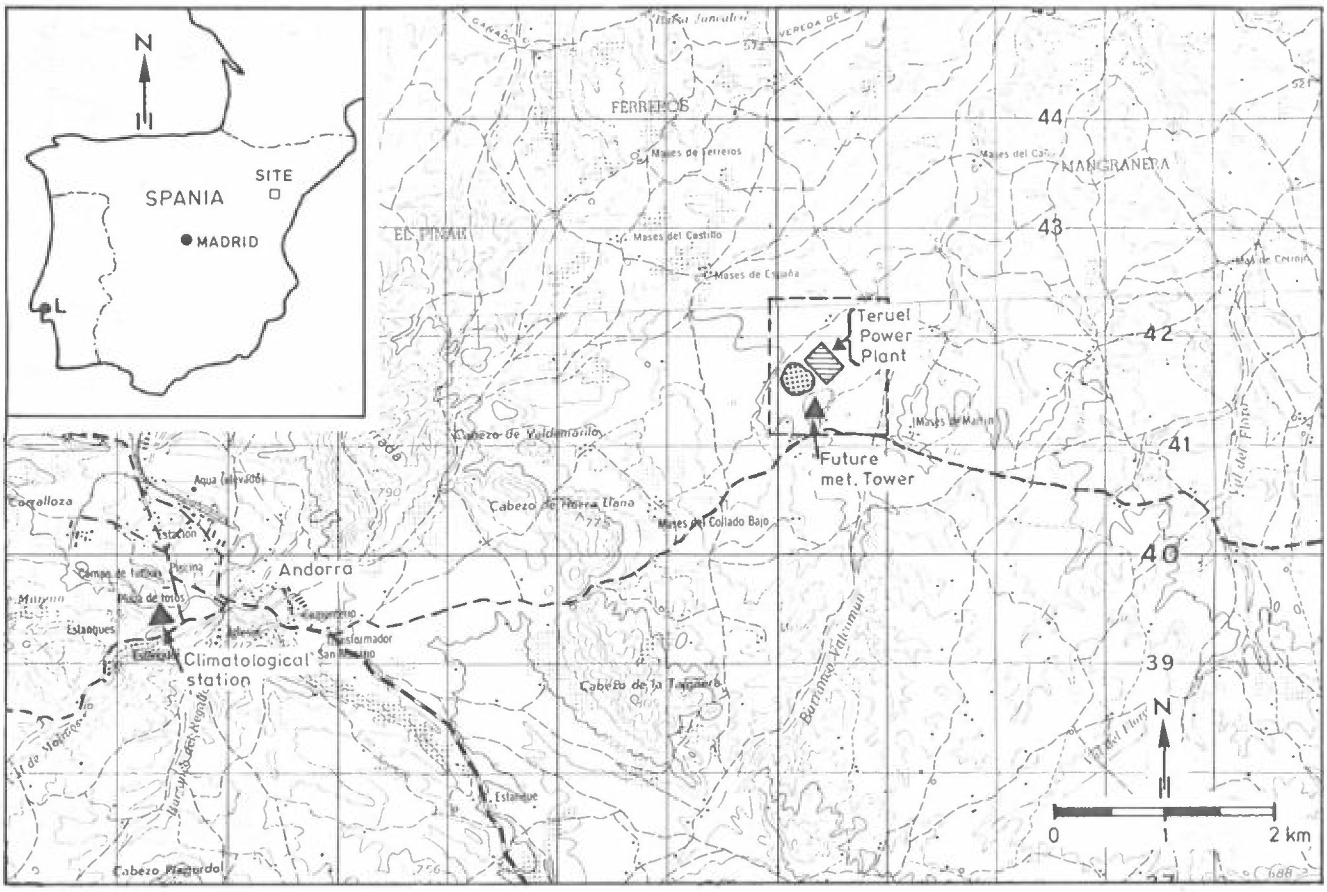


Figure 1: Location of the Teruel power plant.

The site is located about 600 m above sea level in a relatively homogeneous and desert-like area. The closest surroundings (within ∿ 5 km) are fairly flat. At further distances the areas are more hilly. Hill sides rise to almost 200 m above site level at distances of ∿ 6 km south of the site. Further south and south west the height of the mountains are about 1000-2000 m.

A map of the plant layout and the locations of the release points for radio sondes and pilot balloons are shown in Figure 2.

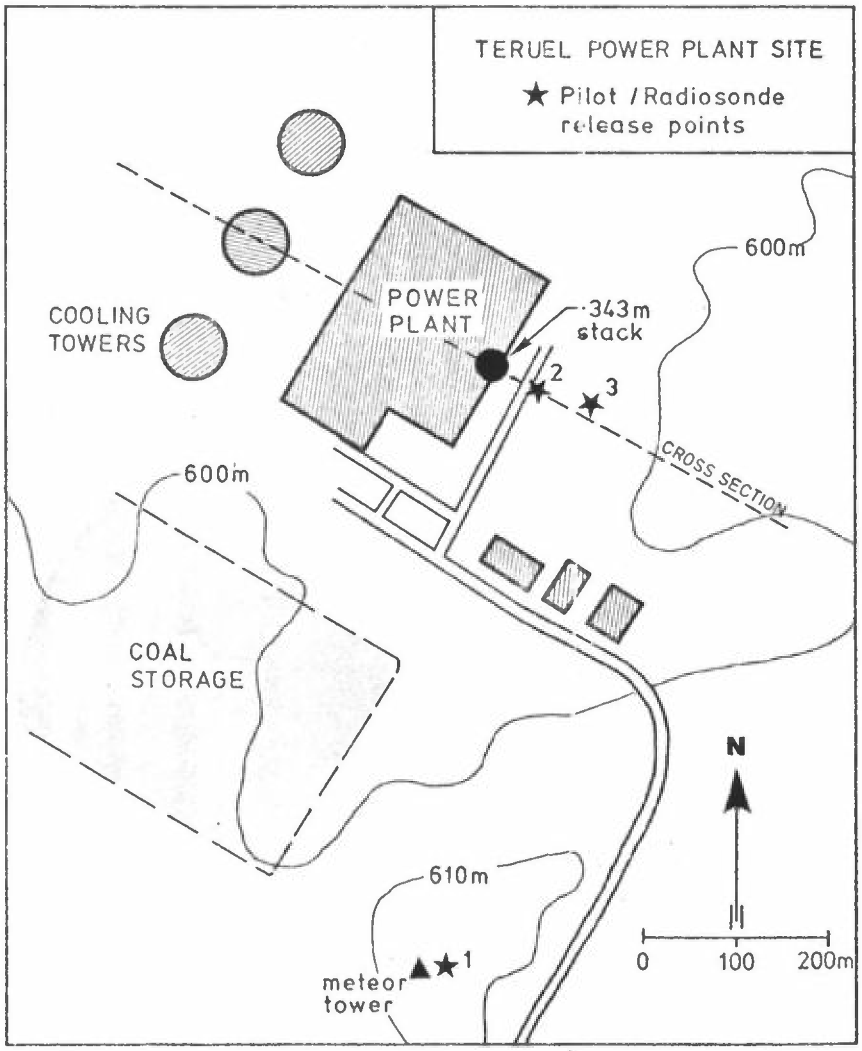


Figure 2: Power plant site layout and release points for balloons.

The height of the power plant structures are indicated in Figure 3 which shows a cross section through the plant. (See also Figure 2.)

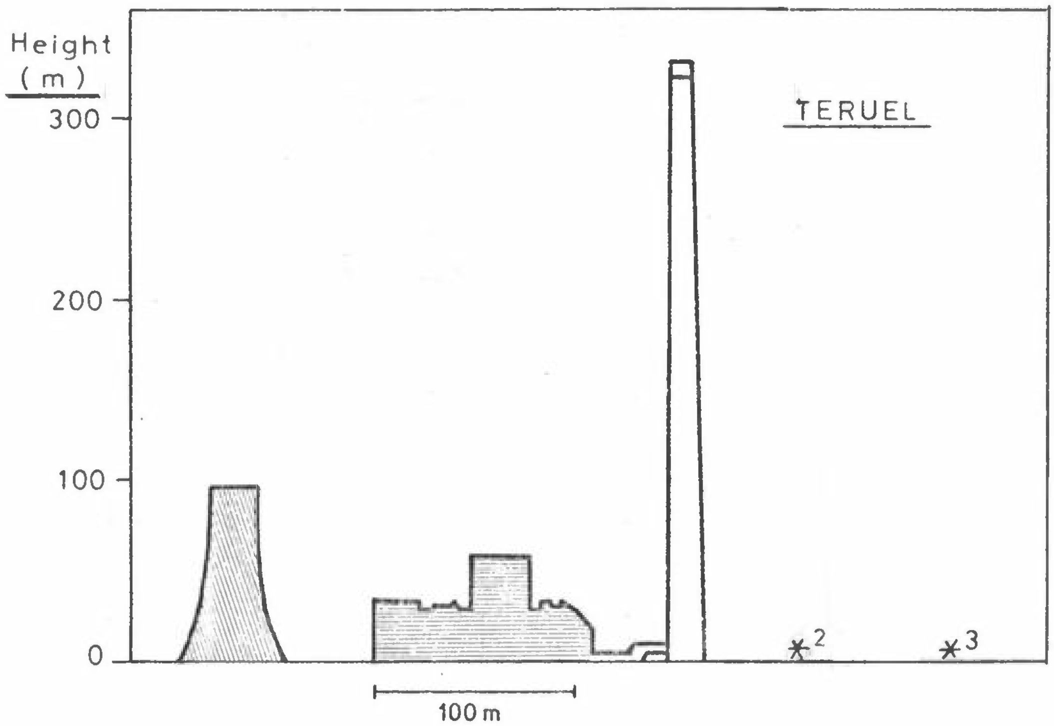


Figure 3: A cross section (NW-SE) of the power plant.

At the northwestern end of the site three natural draft cooling towers rise to about 100 m.

The height of the boiler buildings is about 60 m, and the power plant stack height is 343 m.

For balloon releases at point 2 and 3 south east of the stack, the first part of the balloon track might be influenced by the turbulence zone behind the buildings at winds from NW.

3 INSTRUMENTS

3.1 Radiosondes

Radiosondes, type Minisonde LARS 5100 (low altitude radio sonde) were used to measure temperature variations as a function of the height above the ground.

The temperature sensor was shielded to avoid direct sun radiation. The radio sonde weight is ∿ 75 g, and can be used as a wiresonde or as a free sonde. The wire-sonde sensor is also ventilated. The wire-sonde can however not be released when the wind speed is too high. The exact position of free sondes are determined as for pilot balloons with a theodolite and a distance meter.

3.2 Pilot balloons

Pilot balloons were used to determine the wind speed and wind direction as a function of height. The positions of the balloons were determined using a theodolite (for measuring azimut and elevation angles) and an optical distance meter. The distance can be determined with an accuracy of about ±10% within the range of 300 m to 1200 m. When the balloon is outside this range the assumption of a constant vertical balloon velocity is used to determine the exact position. Azimut, elevation and distance is usually recorded every 15 sec. A computer program calculates and prints the height, wind speed, wind direction and horizontal coordinates of the balloon position every 15 sec.

4 LARGE SCALE WEATHER CONDITIONS DURING THE TEST PERIOD

The large scale weather maps are presented in Appendix A, for the measuring period 28.-30.11.78. The weather conditions were strongly influenced by a deep low pressure system, moving slowly eastwards during the measuring period from the western coast of Italy to Yougoslavia. A high pressure area in the Atlantic, west of Spain was persistent during the period. This caused strong and cold winds from north and northwest over Teruel.

The upper winds (850 mb) were from the north on 28.11.78, turning slowly to wind from north west on the 29.11.78 and from west on the 30.11.78. The surface winds were mainly from west along the main Ebro valley, during the whole test period.

5 CONTINUOUS CLIMATOLOGICAL OBSERVATIONS AT ANDORRA

Climatological data have been collected by the Spanish weather service at Andorra, ∿ 5 km west south west of the site. Records of air temperature, wind speed and wind direction are presented in Figure 4.

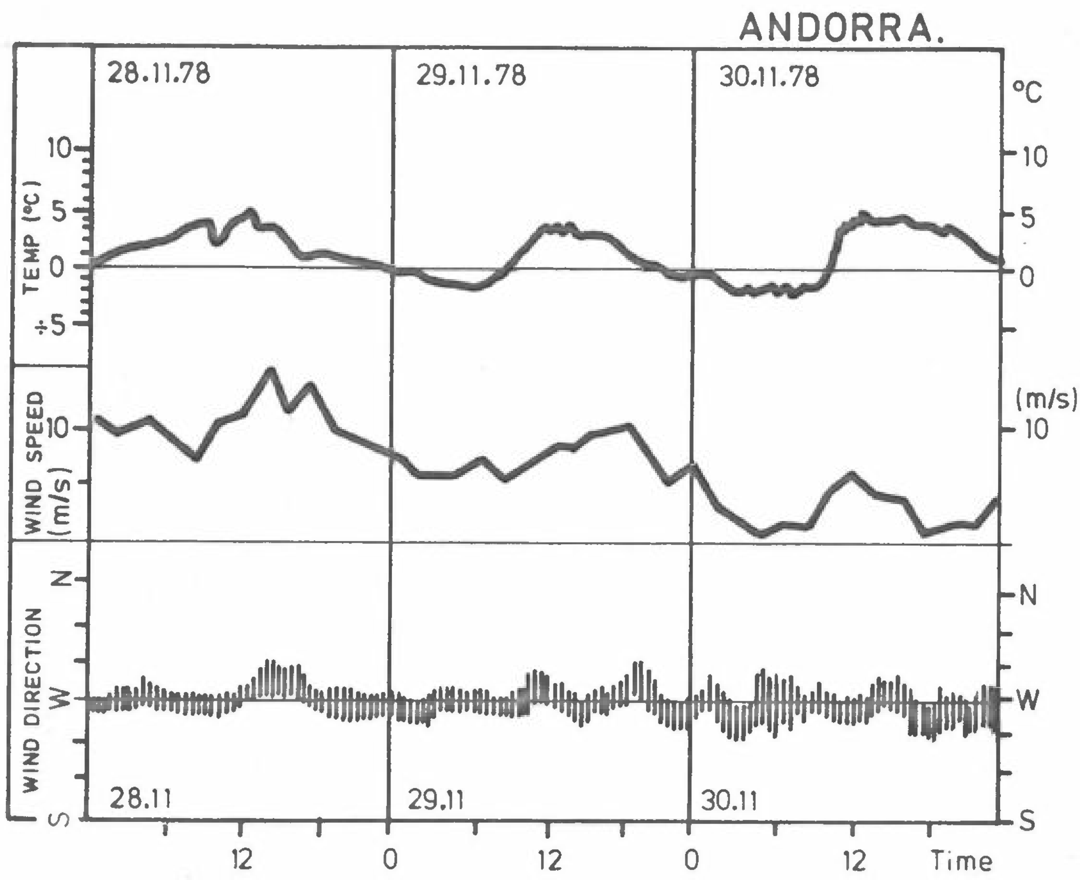


Figure 4: Continuous record of temperature (°C), wind speed (m/s) and wind direction from Andorra; 28.11.-30.11.1978.

As seen from Figure 4 the winds at Andorra were blowing steadily from around west all through the measuring period. The one hour average wind speeds were about 10 m/s varying up to 15 m/s on the 28.11., decreasing through the period to about 1-5 m/s on the 30.11.78. The air temperature varied from about -2^{O}C at night time to about 5^{O}C in the early afternoons.

Westerly winds are usually frequent during the Autumn season at Andorra, as shown from the wind rose in Figure 5.

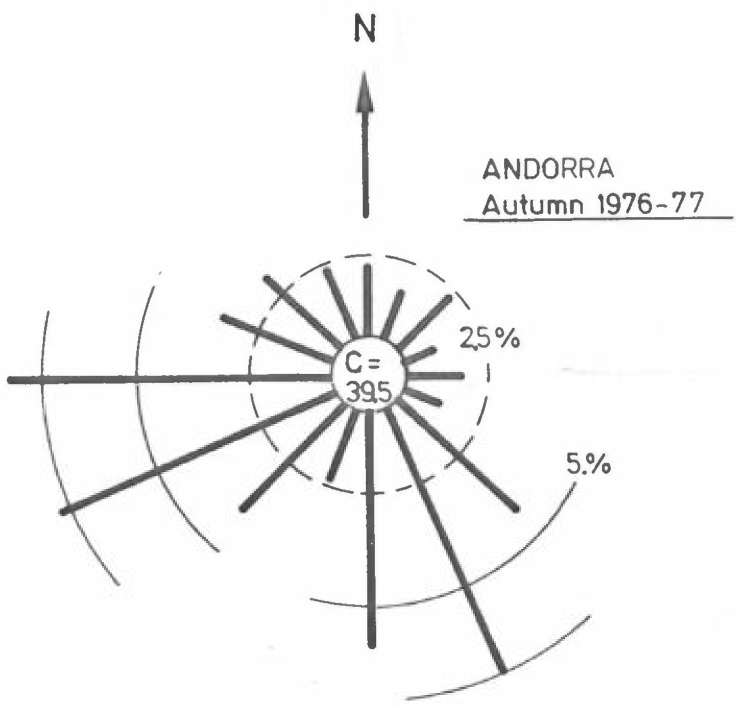


Figure 5: Wind frequency distribution (wind rose) from Andorra, Autumn 1976-77. (C = frequency of calms.)

The wind rose show that two prevailing wind directions occurs during the Autumn season: winds from west and south west occur in 15.6% of the time and winds from south and south east occur in 13.9% of the time.

6 WIND AND TEMPERATURE PROFILES

6.1 28. November 1978

Wind profiles were measured at release point 1 (Figure 2) at 10.35 hrs and 12.25 hrs, and at point 2 at 16.15 hrs. The variation of wind speed and wind direction with height above the ground is presented in Figure 6.

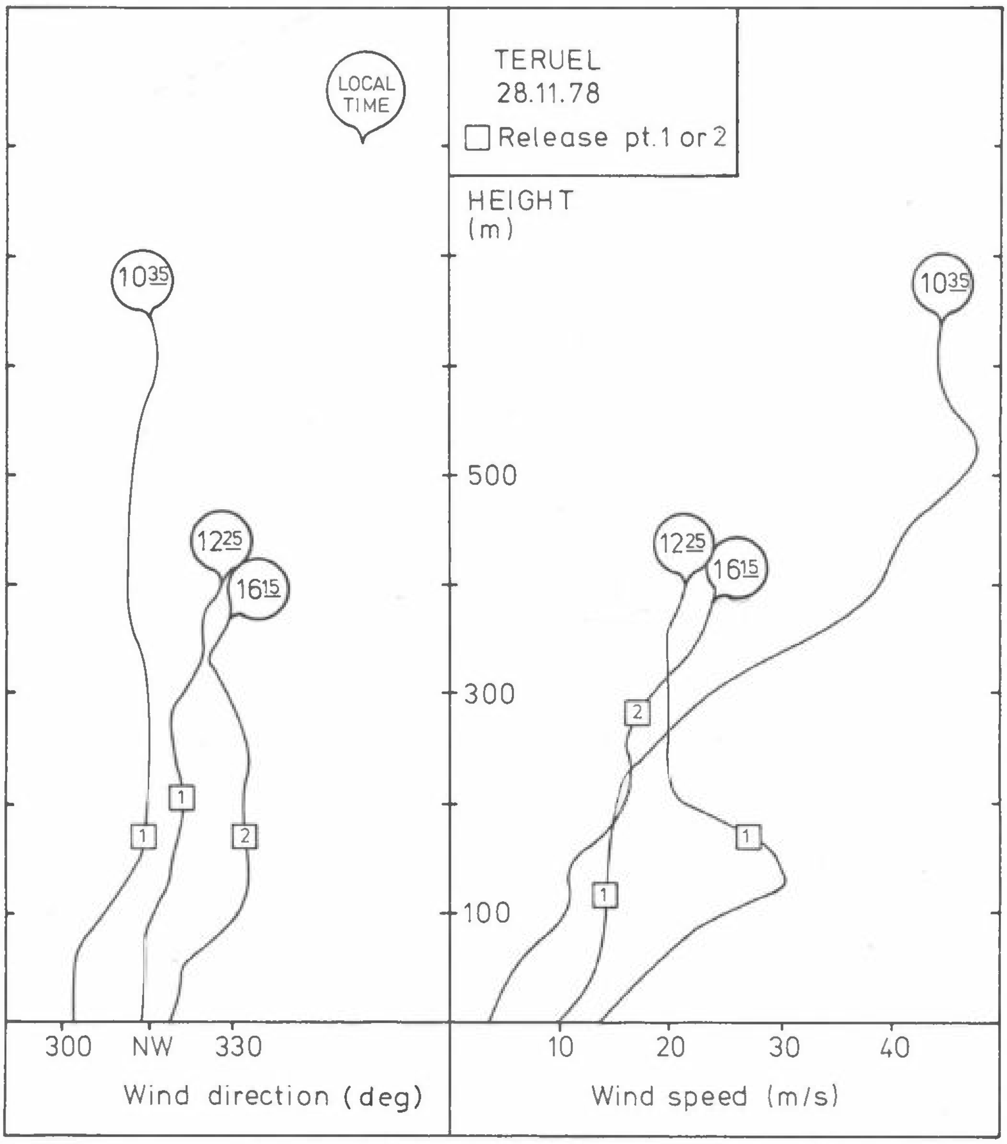


Figure 6: Wind speed and wind direction as a function of the height above the ground at Teruel, 28.11.78.

On the hill at release point 1, the wind at ground level was very gusty during the morning. At 10.35 hrs the wind speed was ∿ 10 m/s at the surface increasing to ∿ 30 m/s at the stack top level (∿ 350 m). The wind was blowing from WNW at the surface and from NW at the 300 m level.

At 12.25 hrs the wind speed at the surface had increased to ∿ 14 m/s increasing to a maximum of 30 m/s at 120 m above the surface. At 300 m the wind speed was 20 m/s. The wind direction was from NW slightly turning more northerly aloft.

In the afternoon, at 16.15 hrs, the measurements were taken from point 2 (Figure 2) behind the buildings at the power plant. The surface wind speed was ∿ 4 m/s increasing with height to 18 m/s at 300 m. As will be demonstrated from several of the ascents, the lower part of the wind profile was influenced by the turbulence zone in the wake behind the building mass (see Figure 3). The wind directions and the wind speed variation indicate that the wake zone had a height of approximately 100 m at 16.15 hrs.

The temperature profile was also measured from release point 2 at 16.35 hrs. Figure 7 show that this profile was very close to the dry adiabatic lapse rate (neutral conditions). The temperature at surface level was 4.4^{o}C decreasing to 1^{o}C at 300 m.

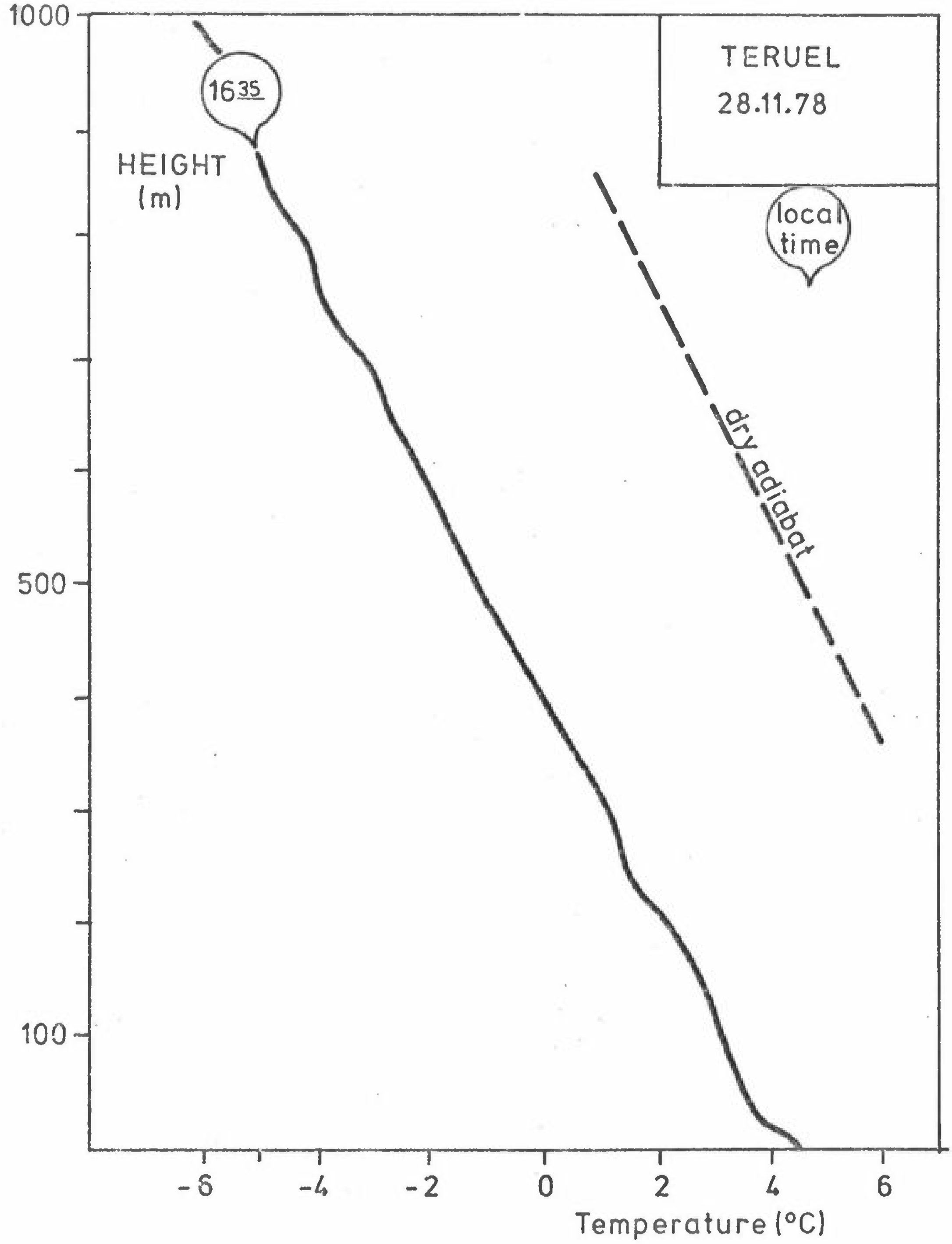


Figure 7: Temperature as a function of height above the ground at Teruel, 28.11.78. (Release point 2.)

6.2 <u>29. November 1978</u>

Wind profiles were taken on 29.11.78 at 10.15, 13.05, 13.20 and 15.35 hrs. All profiles were measured from release point 2. The wind variations with height are presented in Figure 8.

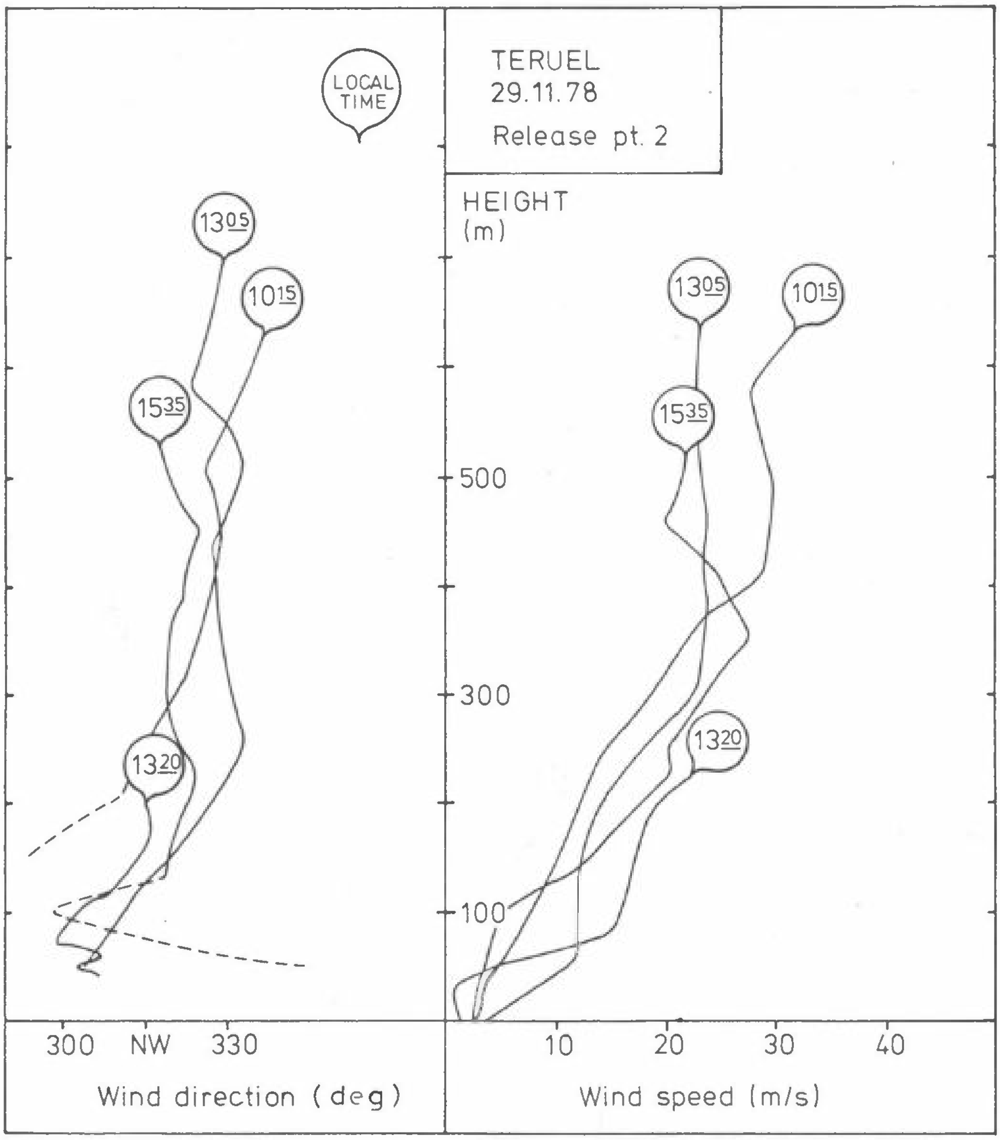


Figure 8: Wind speed and wind direction as a function of the height above the ground at Teruel, 29.11.78.

The surface wind speed varied between 1 and 4 m/s in the wake zone behind the plant, increasing to around 20 m/s at the 300 m level. At 500 m above the ground the wind speeds varied between 20 and 30 m/s.

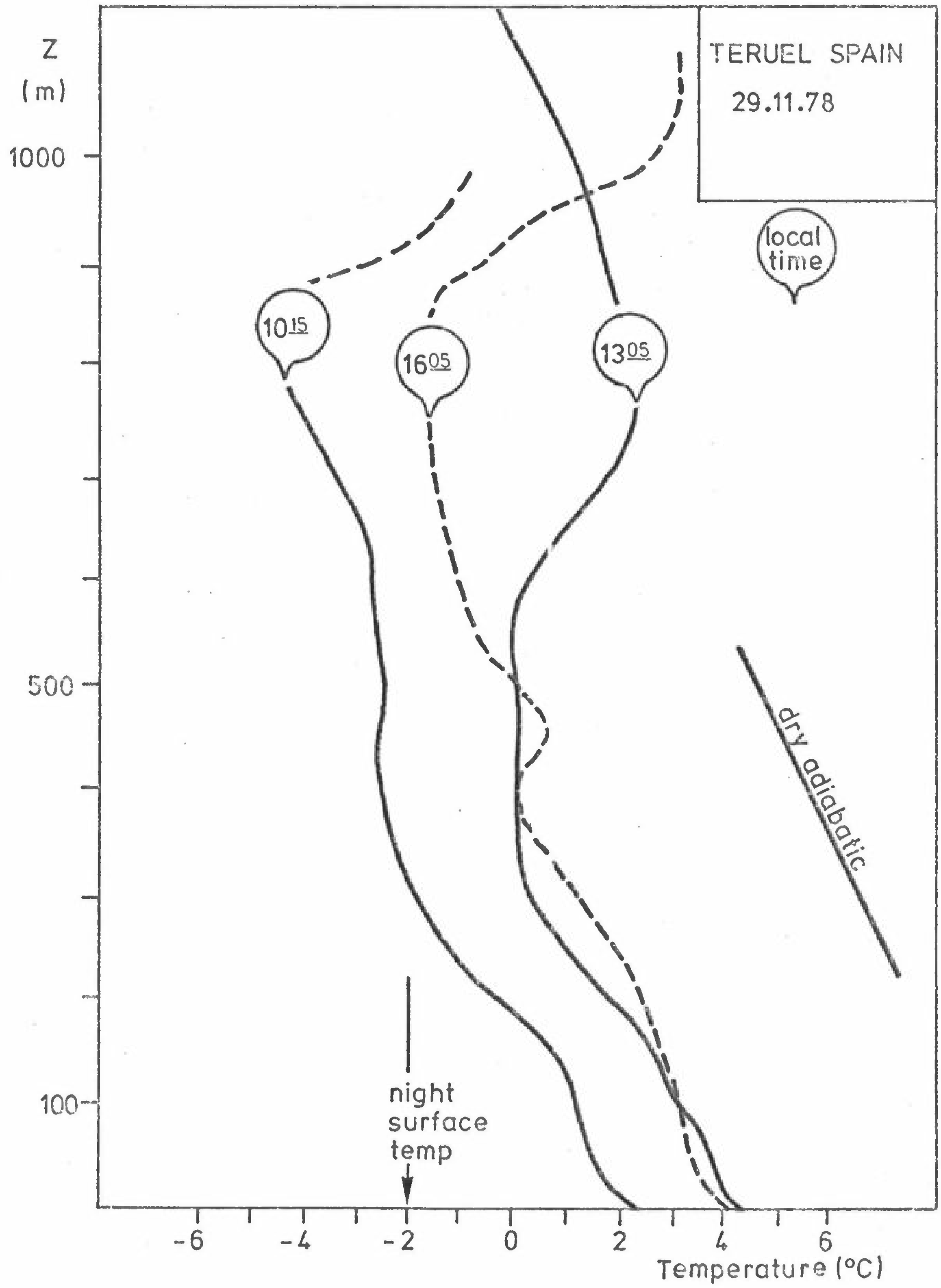


Figure 9: Temperature as a function of height above the ground at Teruel, 29.11.78. (Release point 2.)

The wind directions varied considerably around WNW between the surface and ∿ 200 m above the surface. At 400 m the wind direction was from around NNW during all ascents.

Temperature profiles were measured at 10.15, 13.05 and 16.05 hrs. The result of these measurements are presented in Figure 9.

The temperature profiles measured at daytime, indicate a heated surface causing an unstable stratification from the surface up to about 300 m, and a slightly stable layer above, reaching at least ∿ 800 m. Above 800 m the temperature profiles are more uncertain because of the high winds at these levels, bringing the radio sonde transmitter at least 6 km away from the receiver.

The night time surface temperature was about -2^{O}C as measured at Andorra (see Figure 4). This indicate that a surface inversion might have been present at night.

6.3 30. November 1978

Wind profiles, measured at 8.15, 10.00, 13.05 and 16.15 hrs on 30.11.78, are presented in Figure 10.

The wind speeds are all through the lowest 1000 m less than the day before. The relative variation with height look however, much the same. The wind speed at the surface varied from 1.5-3 m/s. At 300 m the wind speed was about 10 m/s at all profiles. Maximum wind speeds of 15-20 m/s were recorded at about 600 m.

The wind directions were in the morning hours from SW and W at the surface, with a component of wind from the mountains towards the Ebro river. At levels above 400 m the wind was from NW. In the afternoon the wind was from NW at all levels.

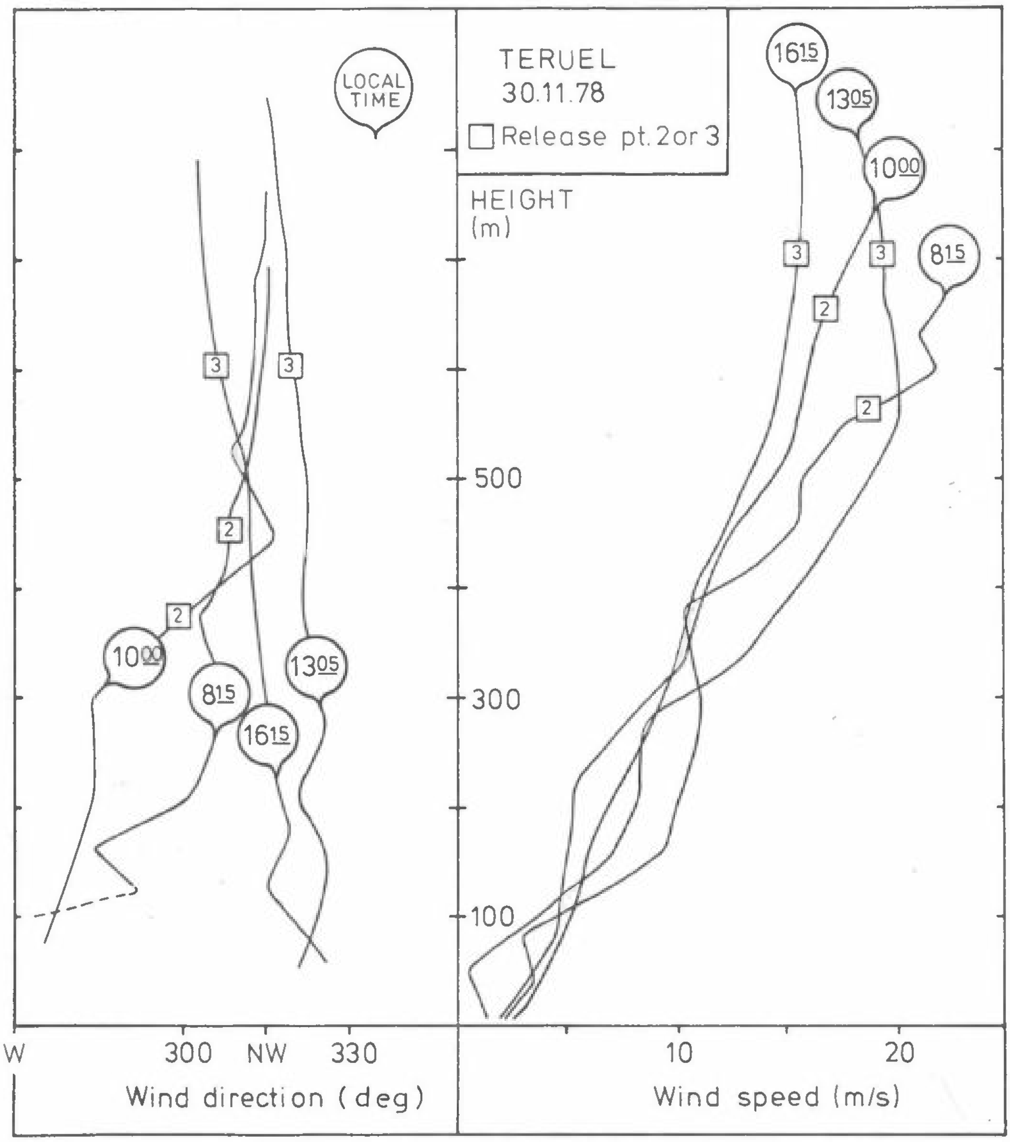


Figure 10: Wind speed and wind direction as a function of the height above the ground at Teruel, 30.11.78.

Temperature profiles were measured at the same hours as the wind data presented i Figure 10. The first profile at 08.15 was taken at sunrise and a surface based inversion was present. The surface temperature was -2°C increasing to +2°C at 200 m. The day time temperature variation with height show a slightly unstable surface layer up to ∿2-300 m, capped by more stable layers aloft.

7 CONCLUSIONS

Based upon the limited information presented in this report a few general conclusions might be drawn:

- The surface wind directions recorded during the measuring period are typical for the autumn and winter seasons at Teruel.

- The wind directions at Andorra seem to be somewhat more channelized from west to east than at the power plant site.

- During the measuring period the wind directions at Andorra were usually from west (W), while at the Teruel power plant site the winds were more from north west (NW), even at the surface. At the top of the stack level ($\sim$ 350 m) the wind was always turned to the right (clock wise) compared to the surface wind. The wind direction at this level was usually from NW or NNW.

- Measurements conducted from the wake zone behind the power plant buildings indicate that the influence zone reach up to about one hundred meters above the surface at this point. This also affects the ratio between the 350 m level wind speed and the 10 m level wind speed, which for the cases of measurements in the wake were at least 4.

- For measurements of wind profiles not influenced by building turbulence the wind speed ratio between 350 m and 10 m vary between 1.3 and 3.

- The temperature profiles indicate that surface based inversions might build up during the night time to a few hundred meters if the wind speed is low enough (less than $\sim$ 3 m/s).

- For the measurements conducted at the end of November, the day time unstable surface layer only reached up to about 2-300 m.

- Upper inversions were recorded on 29.11.78, but the data at these levels were uncertain at the high wind speeds present.

The build up of unstable surface based layers, capped by upper inversions (at levels above the stack top) are important for estimating maximum ground level impact of air pollutants emitted from high stacks. It is therefore important to carry out similar experiments as those reported here, during late spring or summer, when the unstable layer is expected to reach a higher level than in late fall (November).

These profile data including wind and temperatures are needed to specify input parameters in maximum impact estimates, for emissions from a high stack as the one in Teruel. The data can also be used to study the representativity of continuous measurements of meteorological parameters collected at typical levels near the surface.

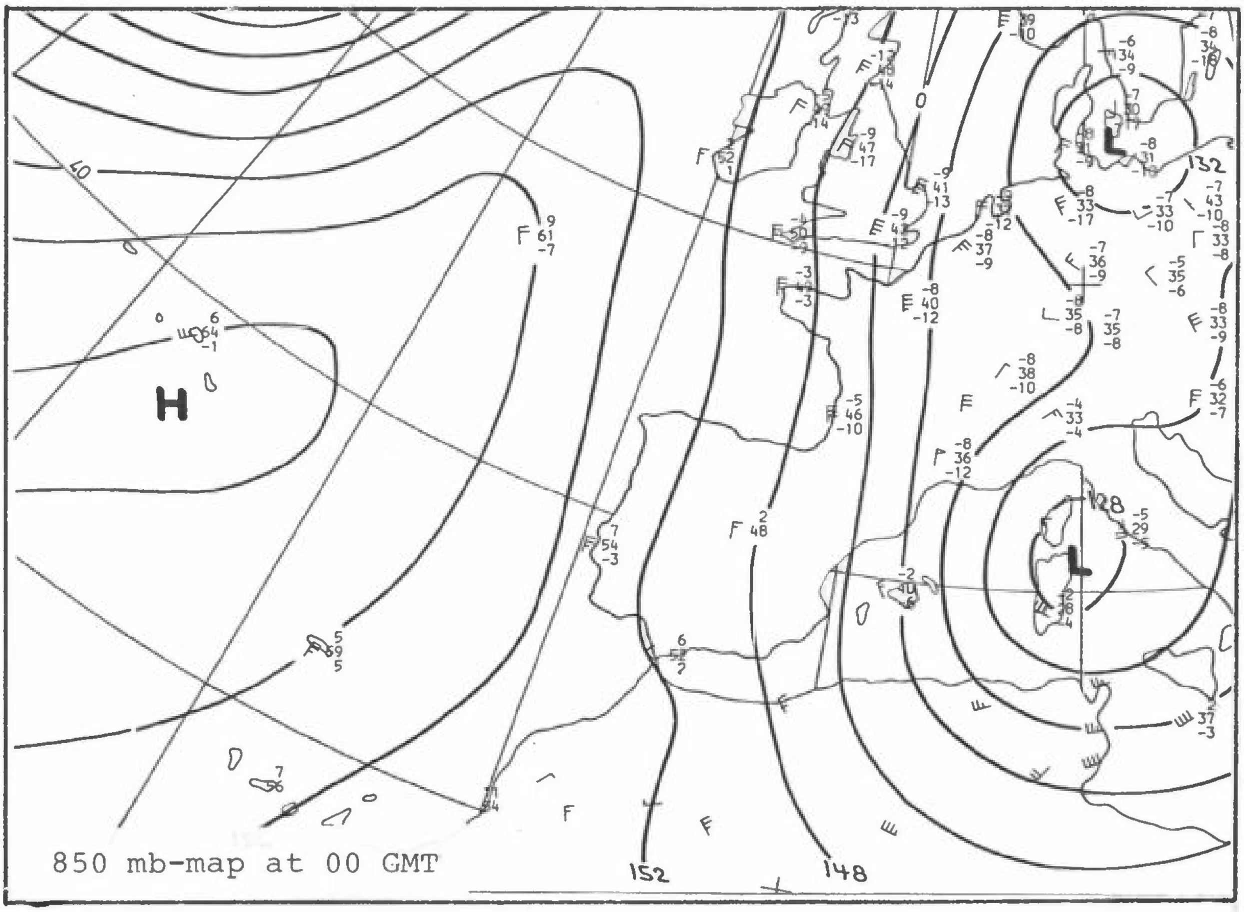
The wind profiles could further be used to correlate with geostrophic winds in order to estimate frequencies of different transport directions of the elevated plume.

Temperature profiles including information on mixing heights should be compared to simultaneous profile measurements from Zaragoza in order to enable a direct utilization of previous collected radiosonde data from Zaragoza.

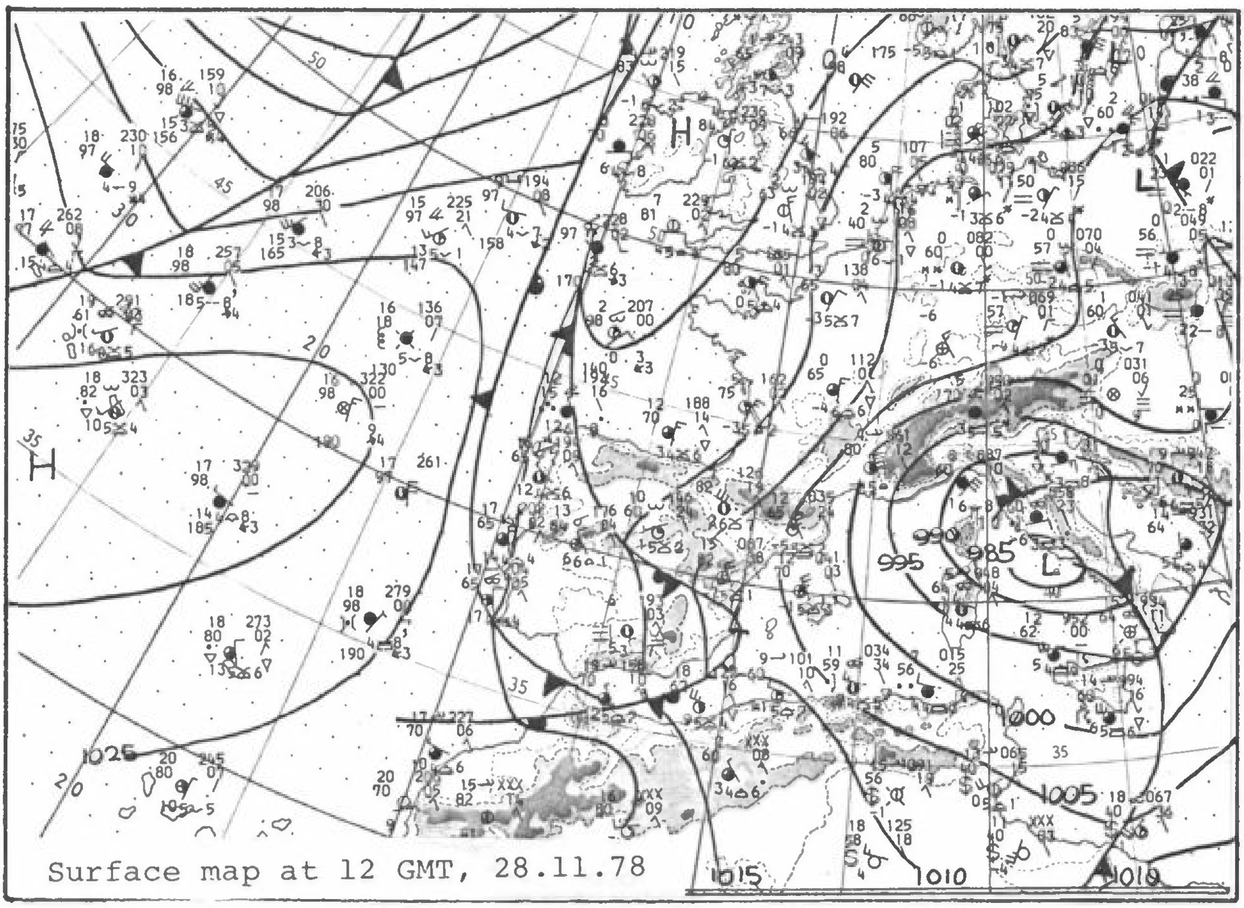
APPENDIX A

WEATHER MAPS 28.-30.11.78

28.11.1978

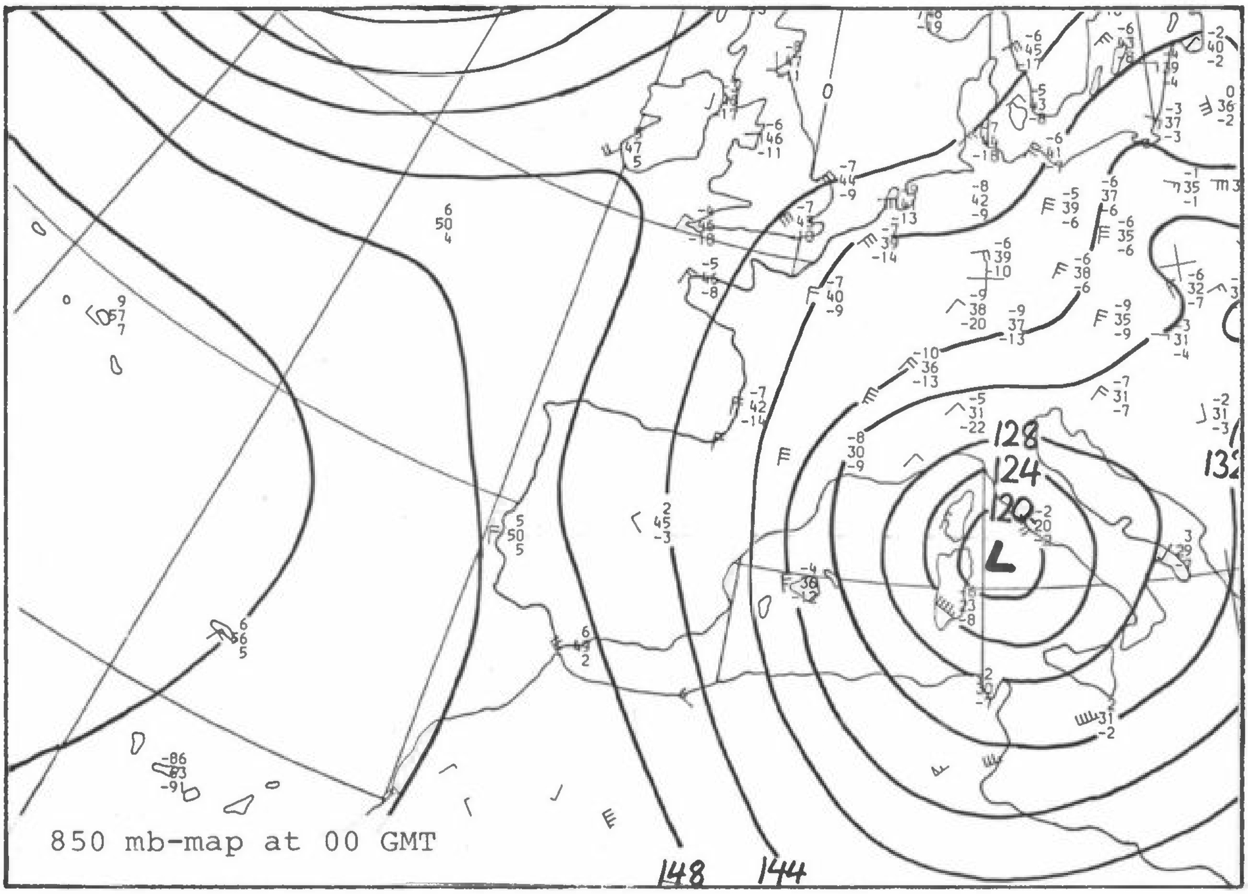


850 mb-map at 00 GMT

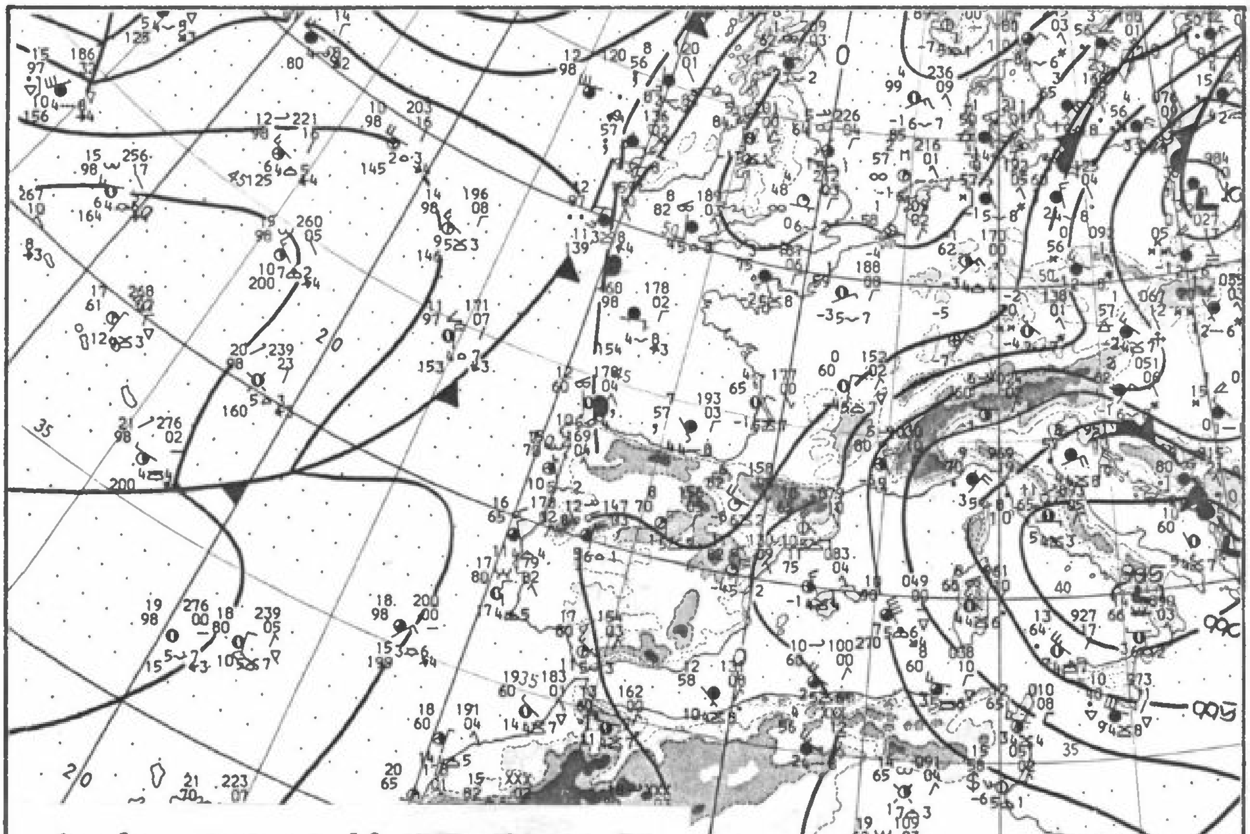


Surface map at 12 GMT, 28.11.78

29.11.1978

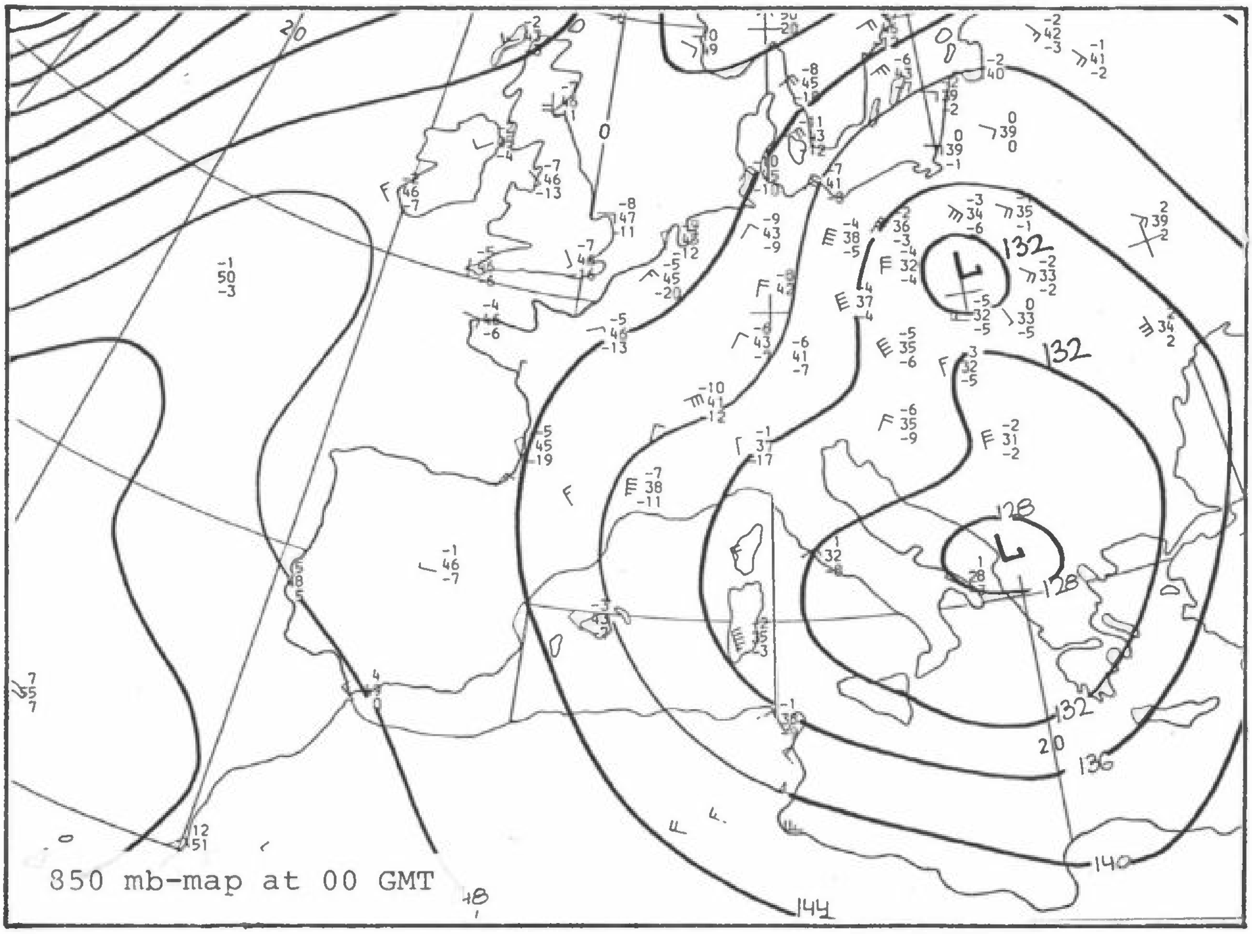


850 mb-map at 00 GMT

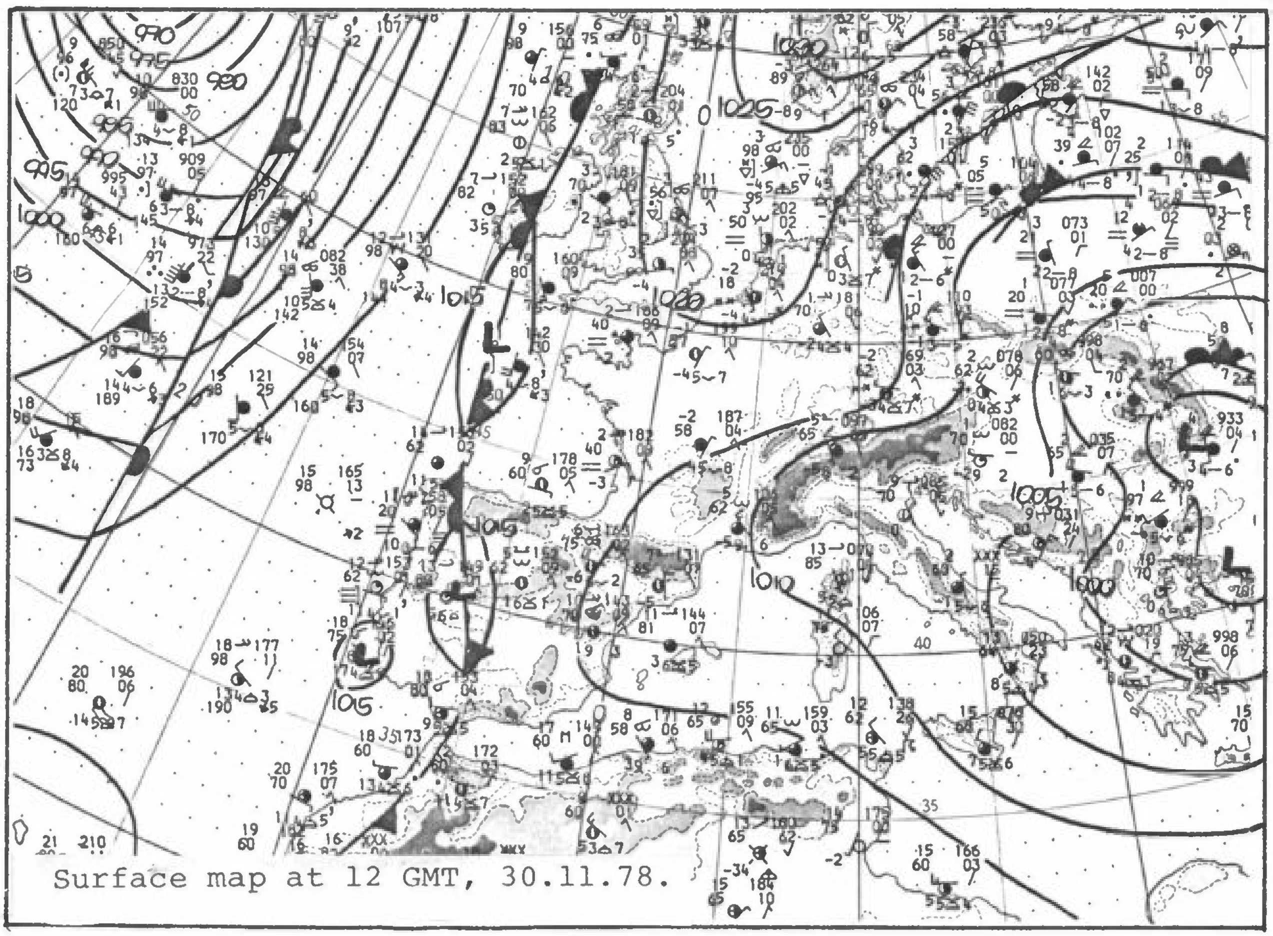


Surface map at 12 GMT, 29.11.78

30.11.1978



850 mb-map at 00 GMT



Surface map at 12 GMT, 30.11.78.

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OPPDRAGSGIVER Ecopolsa, Sereland, Spania		
3 STIKKORD (á maks.20 anslag) Vindprofiler	Temperaturprofiler	Varmekraftverk

REFERAT (maks. 300 anslag, 5-10 linjer)

Den vertikale variasjon av vind og temperatur ble målt med piloter og sonder ved byggestedet for varmekraftverket Teruel i det nordøstlige Spania. Resultatene av disse målingene er presentert sammen med klimatologiske data fra værstasjonen Andorra i provinsen Teruel.

TITTEL

ABSTRACT (max. 300 characters, 5-10 lines)

Pilot balloons and radiosondes were used to measure the vertical profiles of wind and temperature at the power plant site "Teruel" in north eastern Spain. The profiles are presented and discussed together with climatological data from Andorra in the province of Teruel.

**Kategorier: Åpen - kan bestilles fra NILU A
Må bestilles gjennom oppdragsgiver B
Kan ikke utleveres C