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Met O (P) Turbulence and Diffusion Note No. 200

A collection of radiosonde ascents
showing gravity wave activity

by

A.M.Muscat

METEOROLOGICAL OFFICE.

~~Met. O. (P)~~ Turbulence and Diffusion Note No.200

A collection of radiosonde ascents showing gravity wave
activity.

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551.558

551.501.5

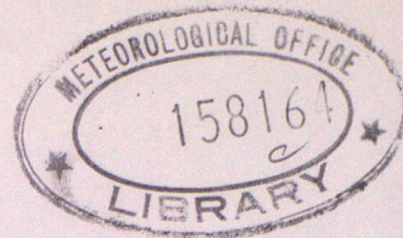
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Met O (P) Turbulence and Diffusion Note No. 200

**A collection of radiosonde ascents
showing gravity wave activity**

by

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24th April 1991

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(Atmospheric Processes)
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Note

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A collection of radiosonde ascents showing gravity wave activity.

1 Foreword

The following is a collection of radiosonde ascents showing gravity wave activity over various types of orography in the United Kingdom. It has been produced as a small reference on the occurrence of gravity waves and to show how useful that operational radiosonde data can be. The data contained here concerns ascents from four radiosonde stations in the United Kingdom, these being Aberporth (52.1N, 4.3W), Aughton (53.3N, 2.6W), Shanwell (56.3N, 2.5W) and Stornaway (58.1N, 6.2W). In addition, data was analysed from two field experiments carried out at Caersws (52.5N, 3.4W), a small village west of Newtown in mid-Wales, and at Loch Cluanie (57.2N, 5.1W) which is situated about 80 kilometres north of Fort William in Scotland. All six sites were chosen due to their close proximity to significant orography, this being a vital ingredient in the forcing of gravity waves.

Data were available, from each radiosonde ascent, indicating ascent rate, geopotential height, pressure, temperature, wind speed and wind direction at regular time intervals (typically every 2 seconds). Manipulation of this data allowed the trajectory of the radiosonde to be calculated and this was then plotted onto the orographic map corresponding to the release site.

It was also possible to compare the ascent rate at each time step with an average ascent rate at that time step; the average value being calculated by fitting a cubic equation to the ascent rate data. This comparison indicated whether a particular ascent rate was greater than or less than the ascent rate that would be expected at a particular height if there was no gravity wave influence. Less than the average suggested that the radiosonde was being slowed down. Conversely, greater than the average suggested that the radiosonde was being speeded up. On the trajectory plots contained here the colour blue indicates a vertical velocity which is less than the expected average at that height whilst the colour yellow indicates a vertical velocity which is greater than the expected average. Consequently the position of the gravity wave with respect to the orography may be seen.

For each of the trajectory plots there are four graphs showing how the ascent rate, temperature, wind speed and wind direction change with height during the ascent.

Broadly speaking, there are two types of gravity wave:

1). The trapped lee wave type, illustrated particularly well by the Loch Cluanie ascents of October 1990. In particular the 1053 GMT ascent on 12th October. Indeed, the Loch Cluanie cases are near perfect examples of the trapped lee wave phenomenon.

2). The vertically propagating stratospheric gravity wave of unusually large amplitude. These are well illustrated by a number of the Shanwell ascents, particularly the 1142 GMT ascent on the 19th December 1988 and the 1118 GMT ascent on the 14th January 1989.

One other height - ascent rate "signature" is apparent from the graphs. This consists of a significant "spike" in the ascent rate, the vertical velocity more than doubling from its nominal value. Good examples of this occur in the 2318 GMT ascent on 23rd January 1989 and the 1115 GMT ascent on 28th October 1989, both from Shanwell. The cause of this "spike" is not altogether clear but it is interesting to note that on both occasions the "spike" occurs at a height of approximately 12 km and coincides with a significant change in the wind direction and a local minimum in the temperature profile.

There is also a chart showing the synoptic situation at, or around, the time that the radiosonde was released.

Much of the data from 1989 onwards has been recorded by the MARK IV radiosonde which is now widely used at outstations. These outstations are intending to store 2 years worth of data on a continuous basis; data which is easily copied onto 3.5 inch computer disk and hence is easily available to all those who require it.

Contents

1 Loch Cluanie

Ascents from 8th October to 25th October 1990.

2 Shanwell

Ascents from 3rd April 1987 to 18th January 1991.

3 Stornaway

Ascents from 5th October to 26th October 1990.

4 Aughton

Ascents from 2nd September 1986 to 22nd December 1990.

5 Aberporth

One ascent on 6th October 1989.

6 Caersws

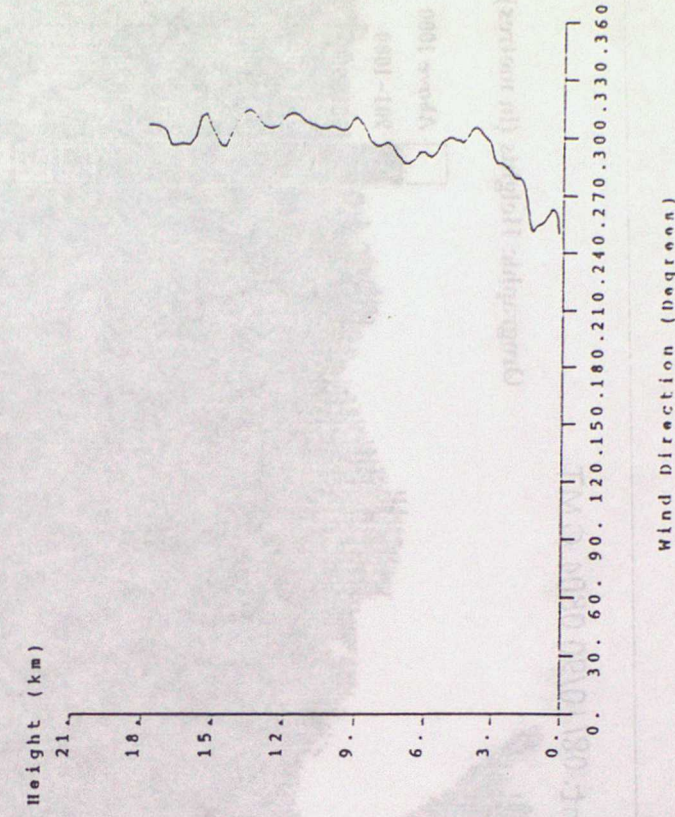
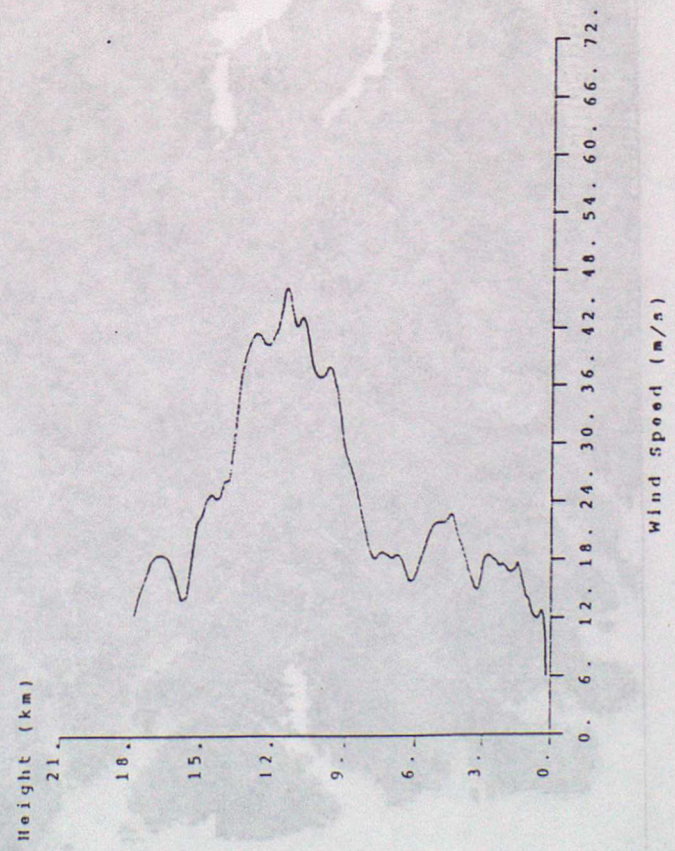
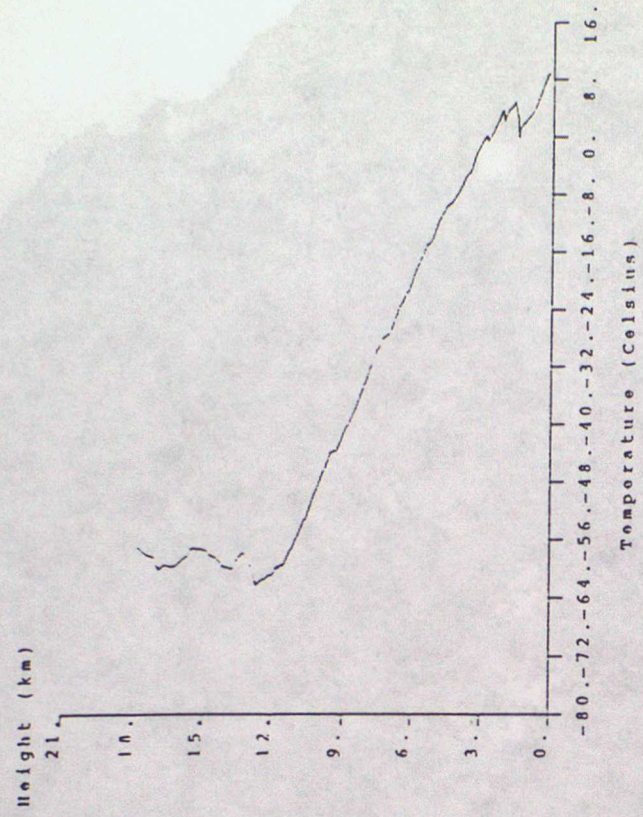
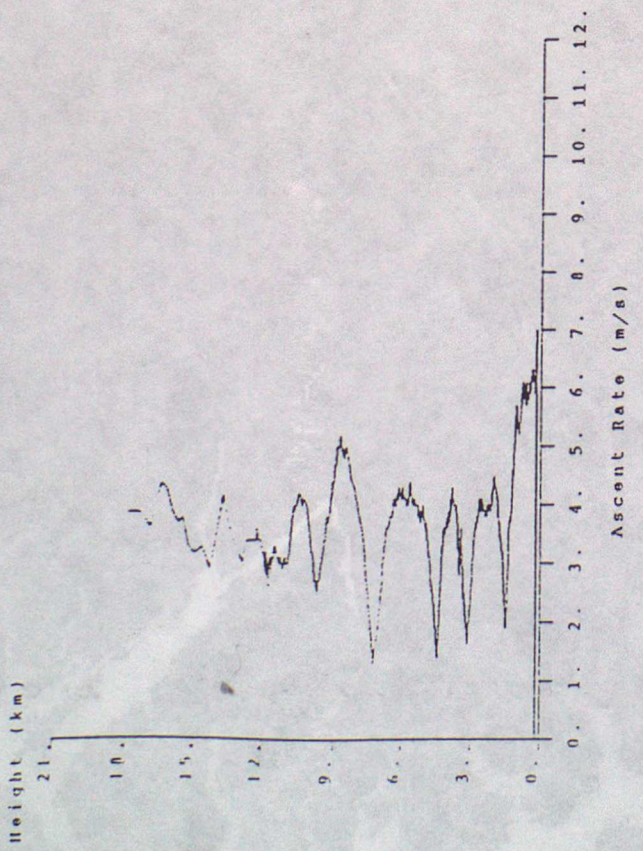
Ascents on 6th October and 20th October 1989.

Radioonde Asc: 08/10/90 0804 GMT

Orographic Heights (in metres)



Loch Cluanie Radiosonde Ascent 08/10/90 0804 GMT



Radioonde Ascend: 08/10/90 1143 GMT

Orographic Heights (in metres)

Above 1000
901 - 1000

801 - 900

701 - 800

601 - 700

501 - 600

401 - 500

301 - 400

201 - 300

101 - 200

0 - 100

Below sea level

Sea level (0)

Sea level (0)

Sea level (0)

Sea level (0)

Sea level (0)

Sea level (0)

Sea level (0)

Sea level (0)

Sea level (0)

Sea level (0)

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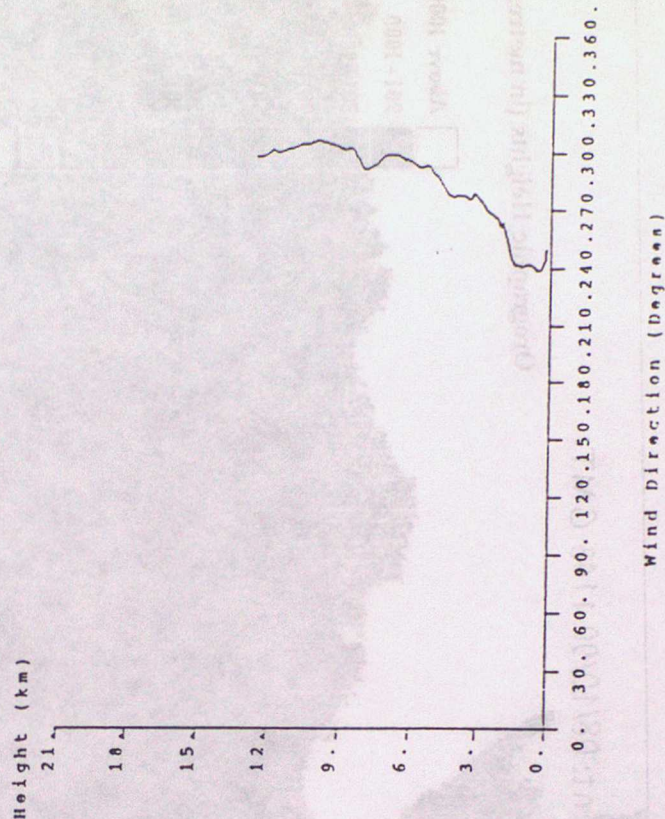
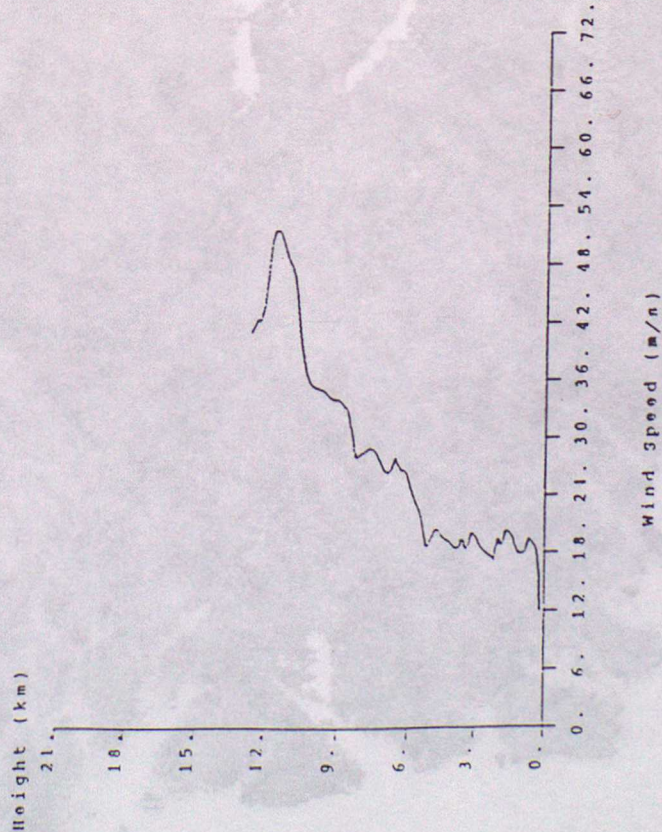
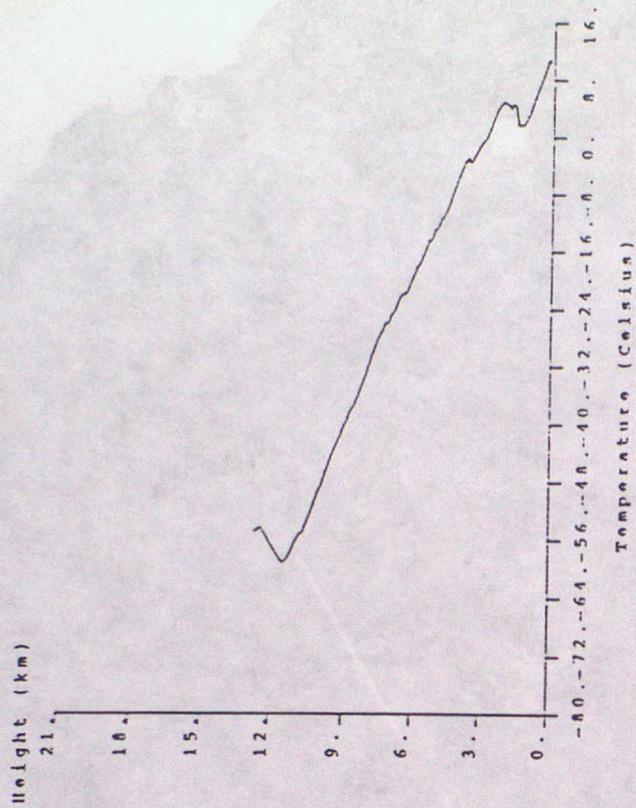
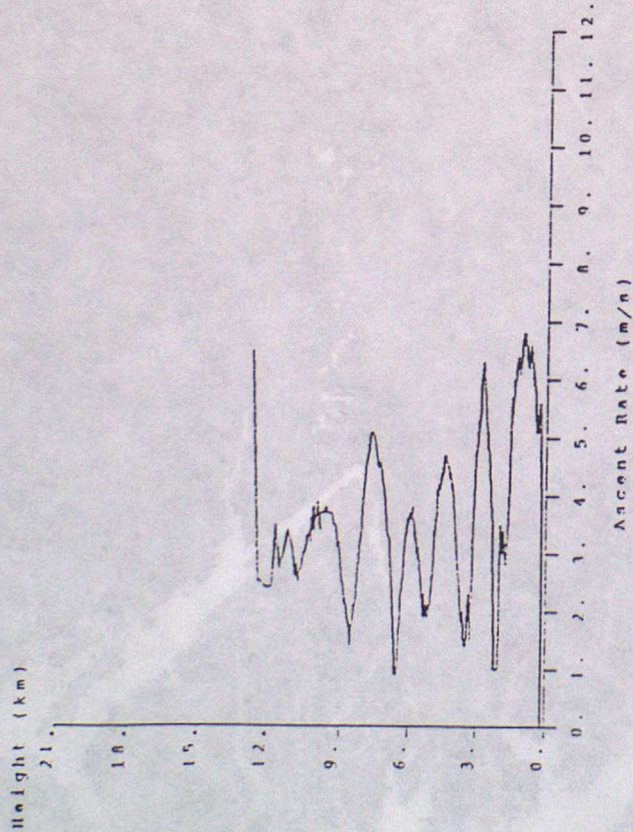
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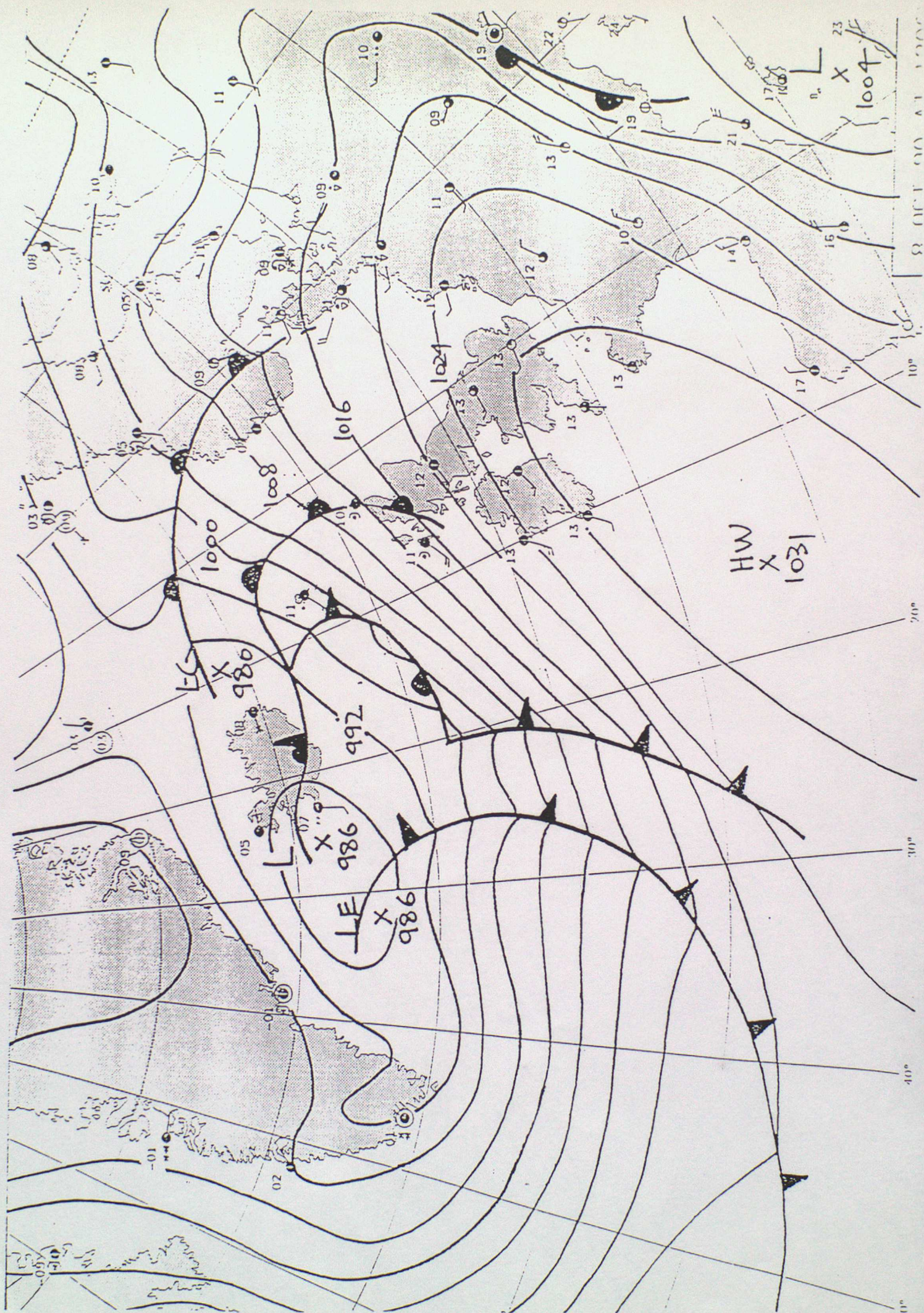
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Sea level (0)

Sea level (0)

Loch Cluanie Radiosonde Ascent 08/10/90 1143 GMT



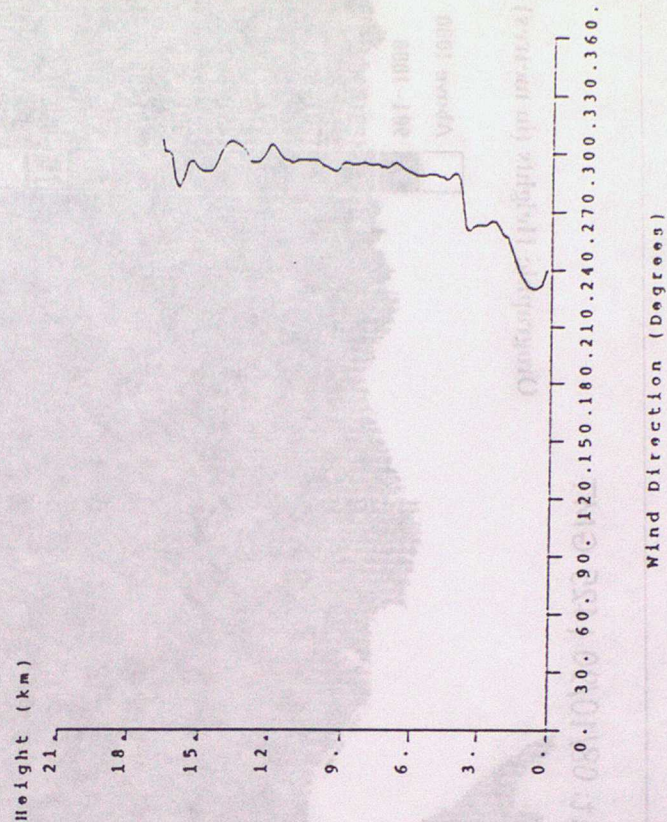
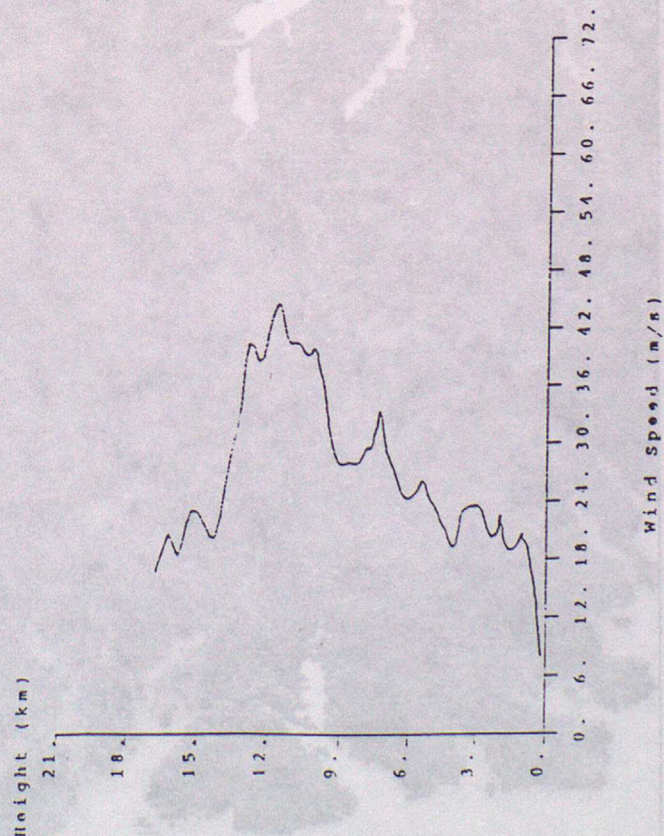
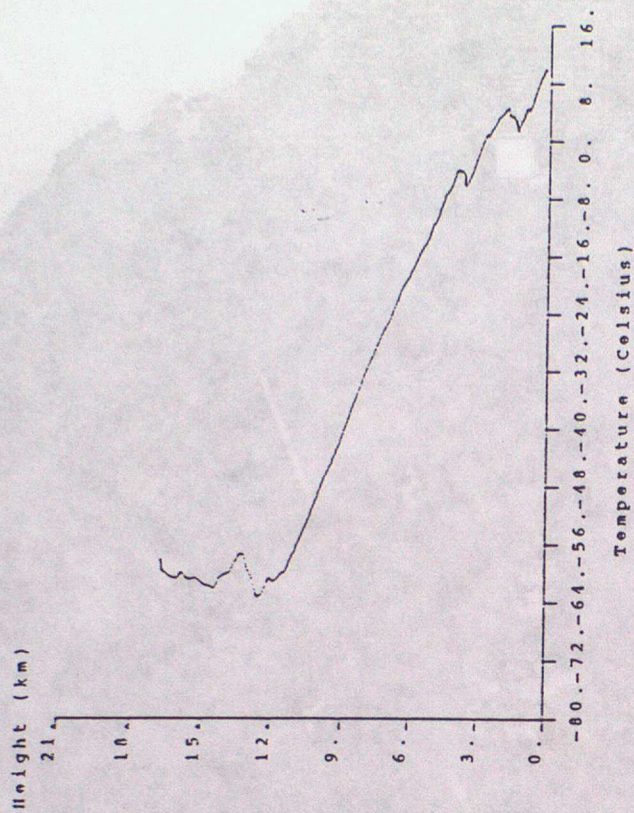
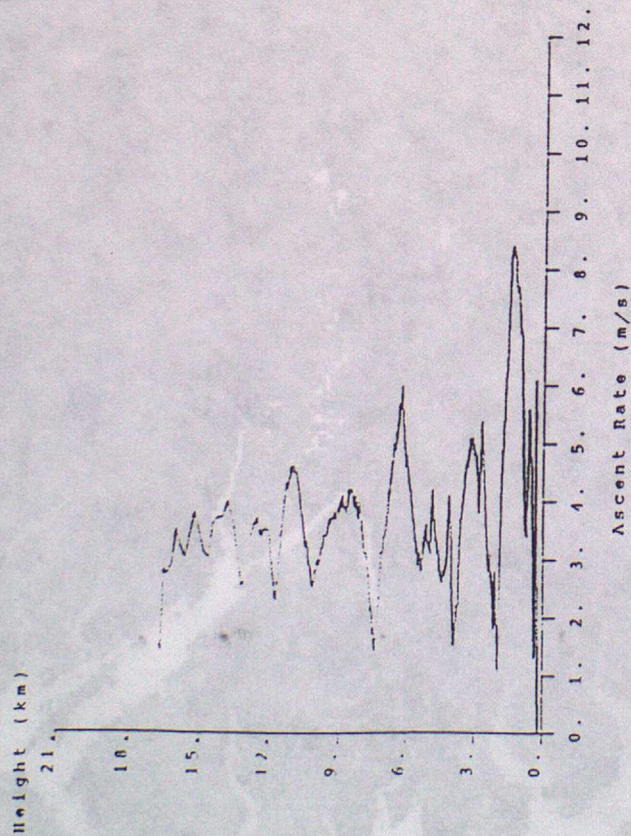


Radioonde Ascent: 08/10/90 1425 GMT

Orographic Heights (in metres)



Loch Cluanie Radiosonde Ascent 08/10/90 1425 GMT

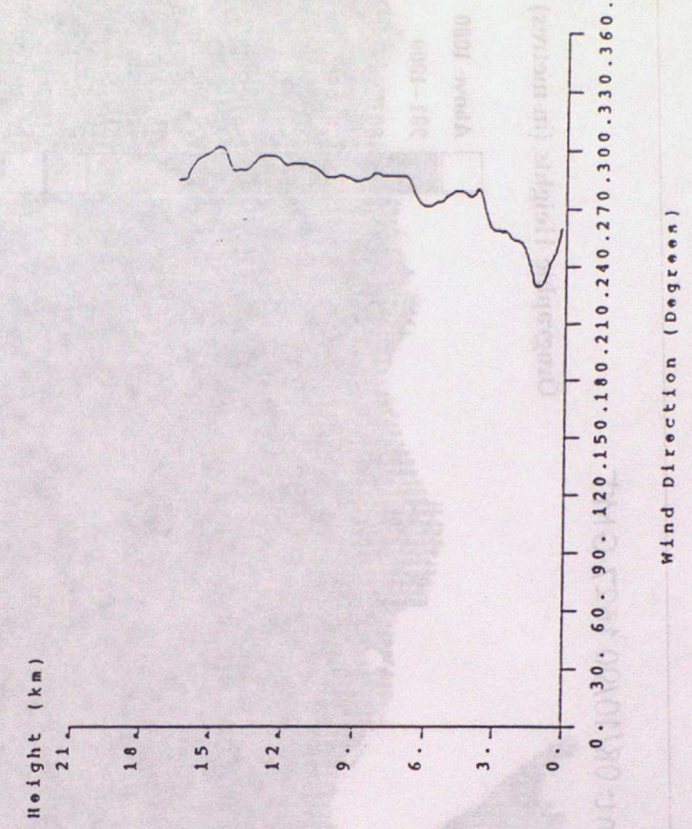
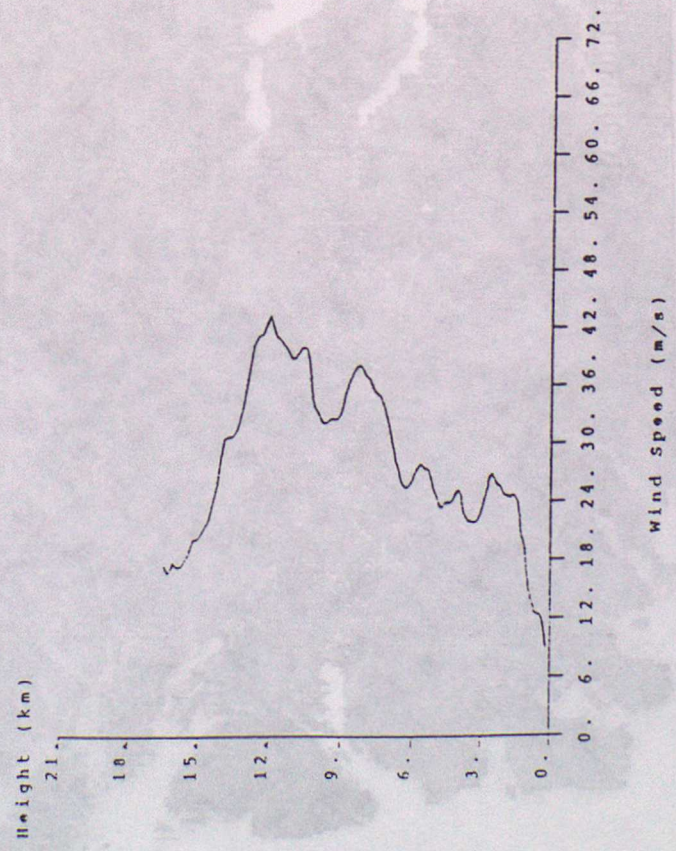
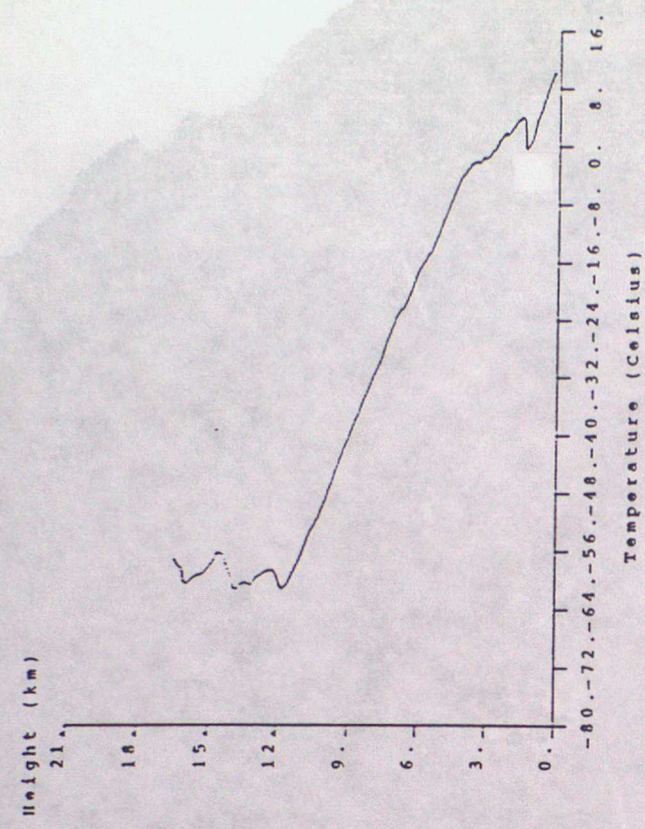
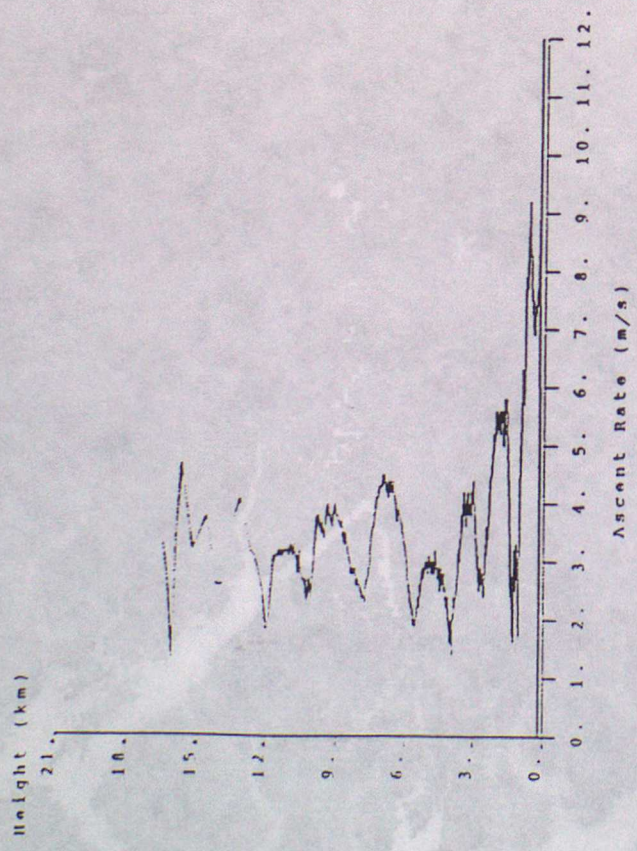


Radioonde Ascension t: 08/10/90 1627 GMT

Orographic Heights (in metres)



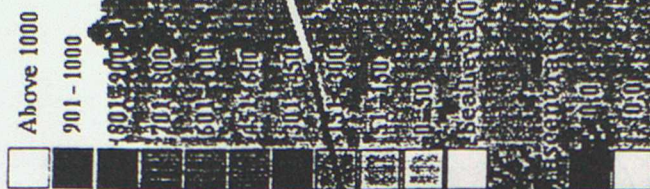
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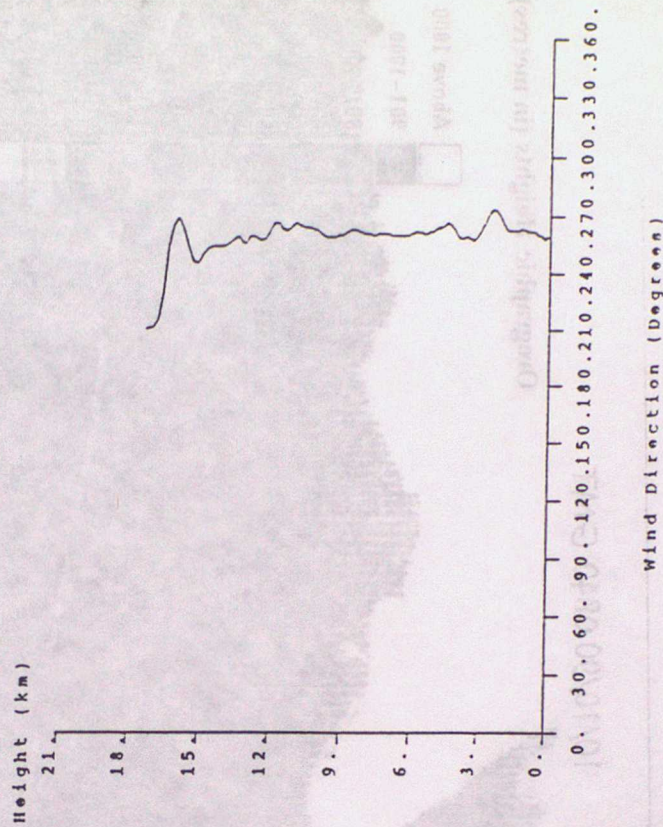
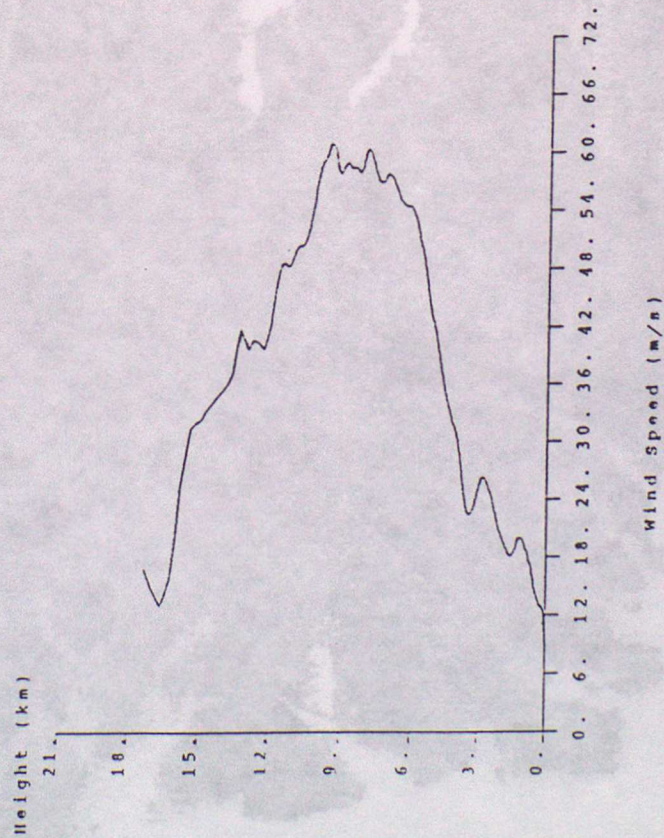
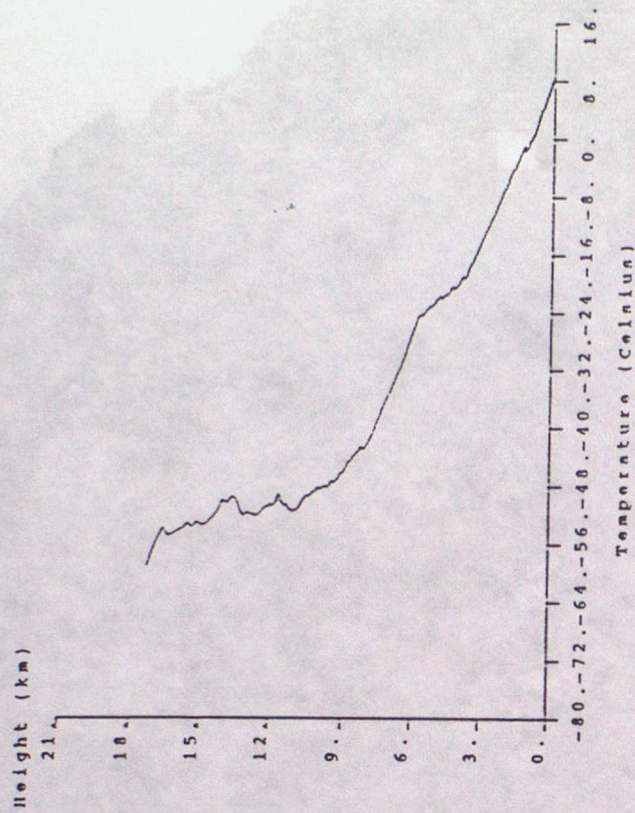
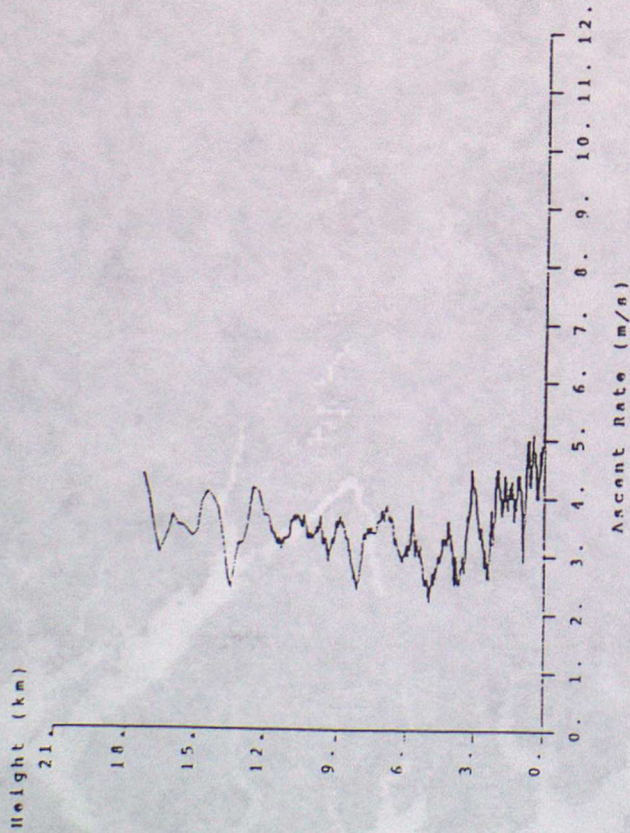
Radisonde Asc

10/10/90 0840 GMT

Orographic Heights (in metres)



Loch Cluanie Radiosonde Ascent 10/10/90 0840 GMT



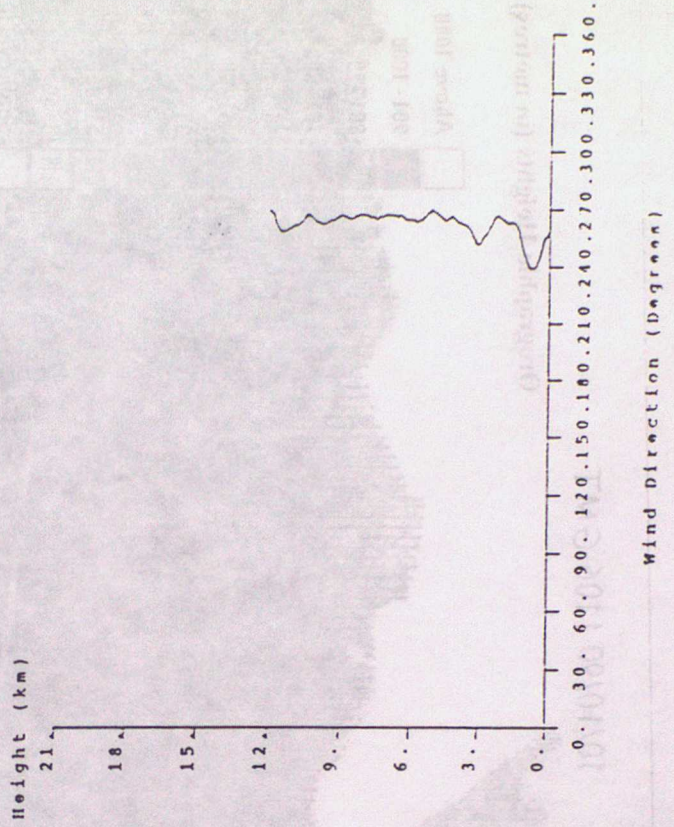
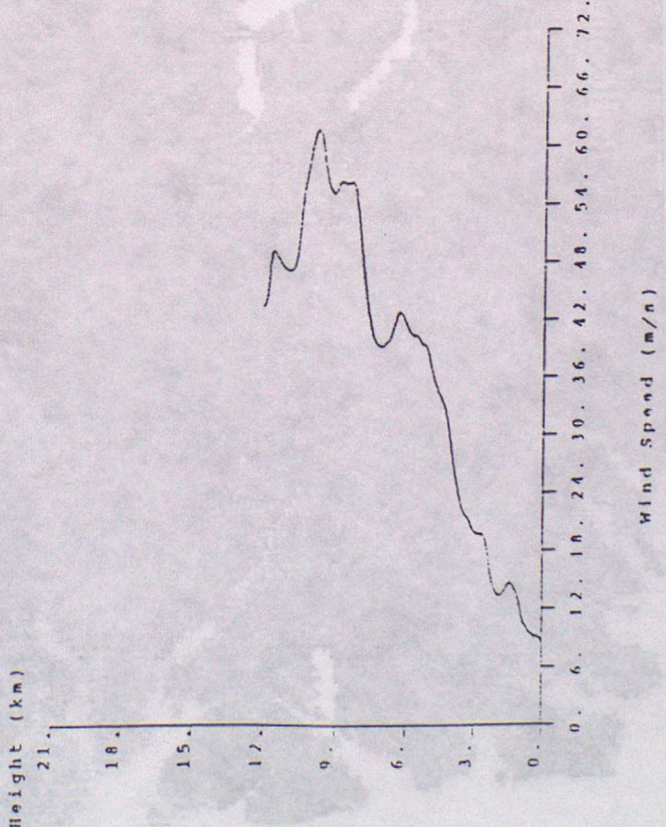
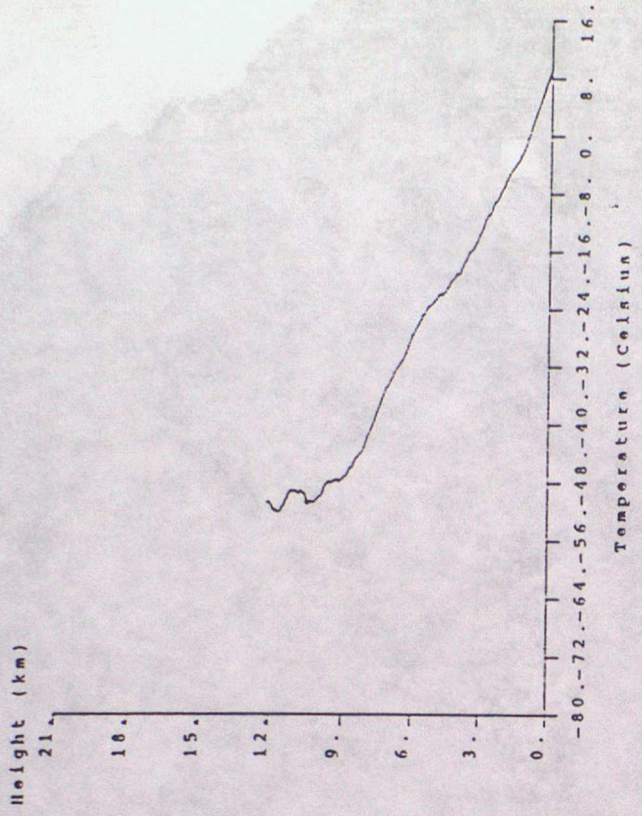
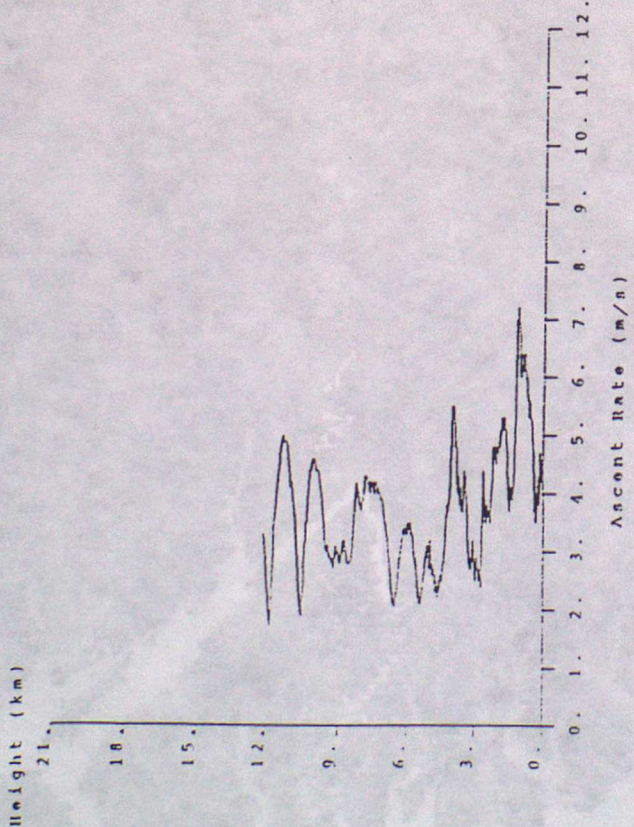
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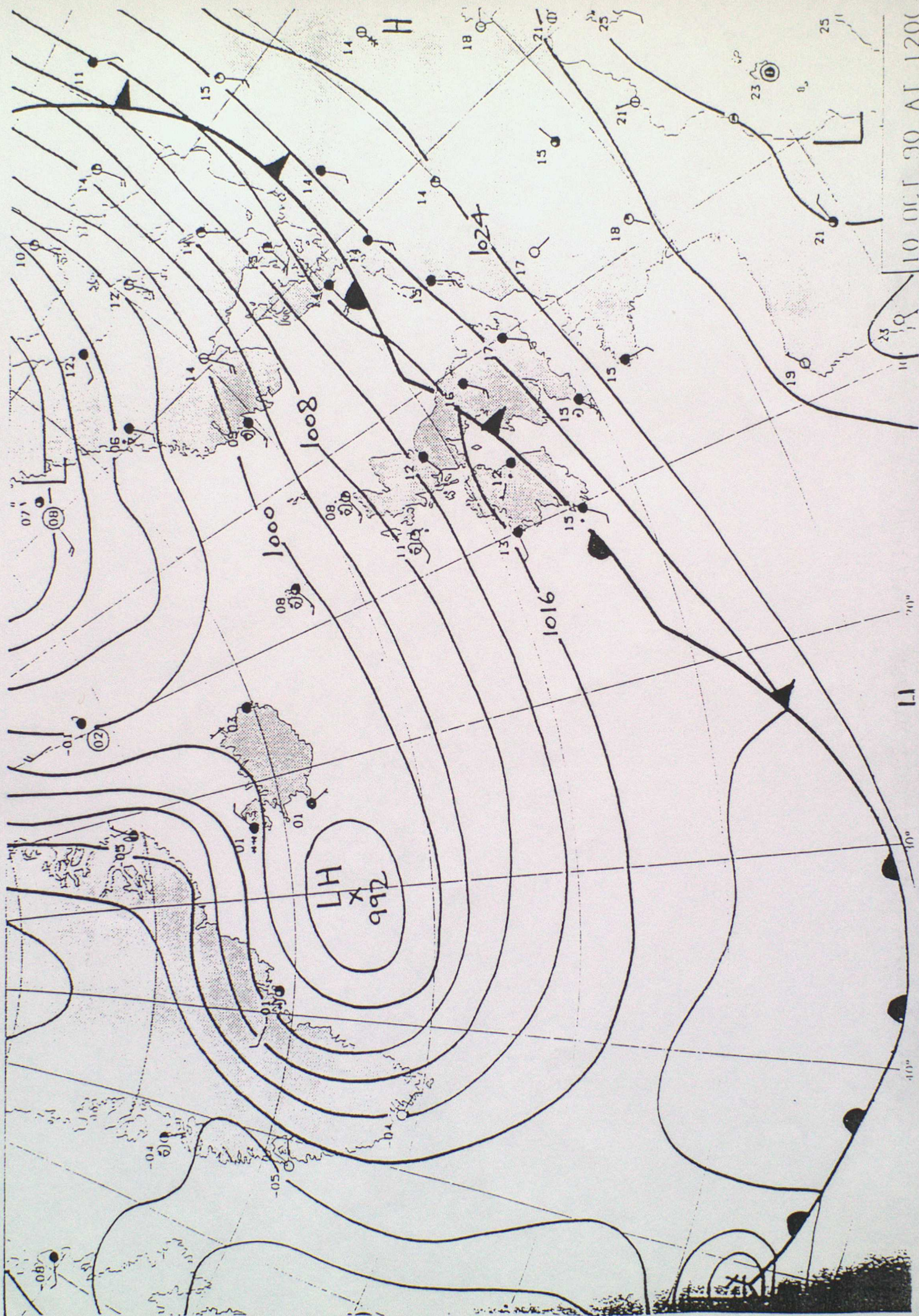
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Ornographic Heights (in metres)



Loch Cluanie Radiosonde Ascent 10/10/90 1106 GMT





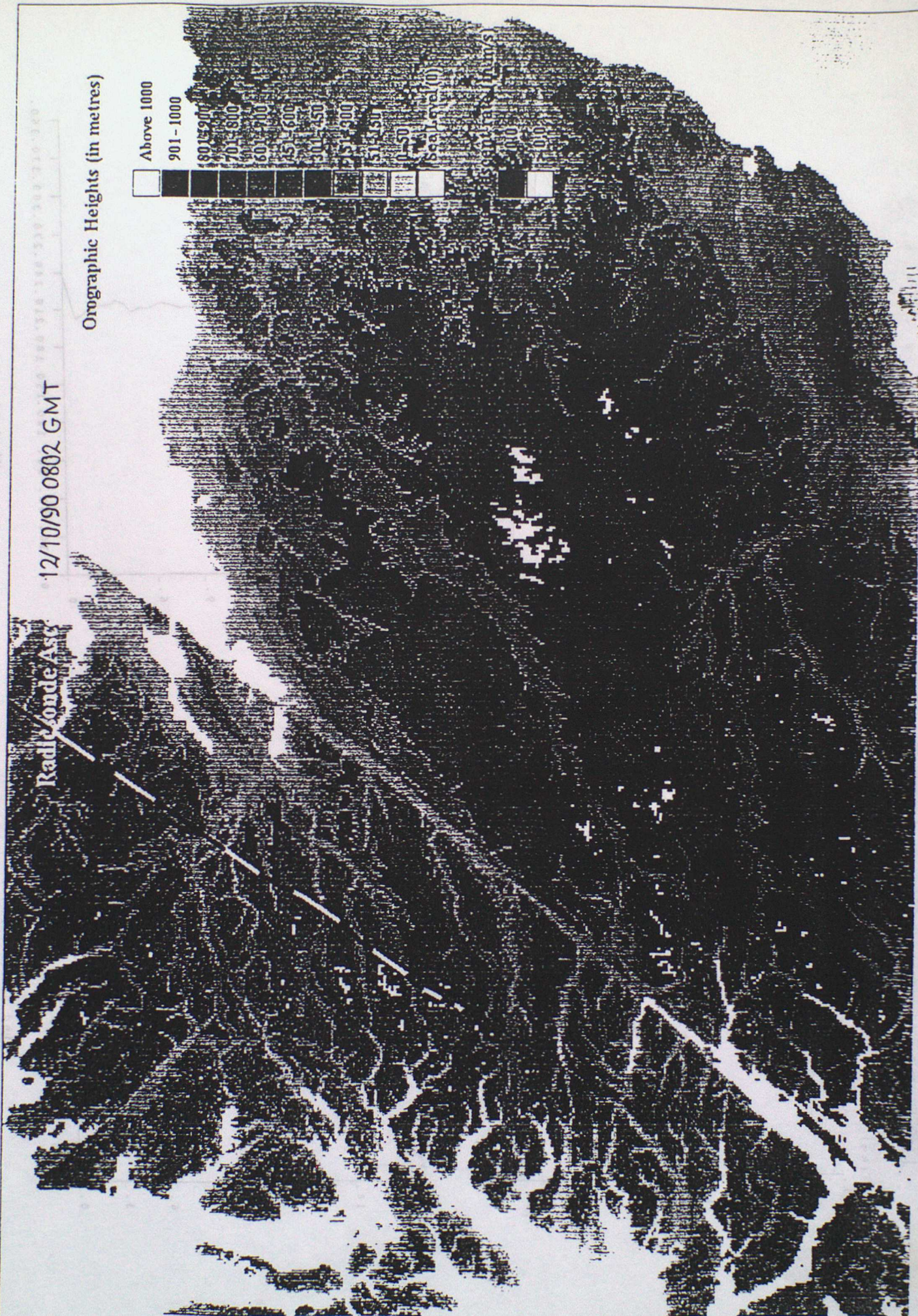
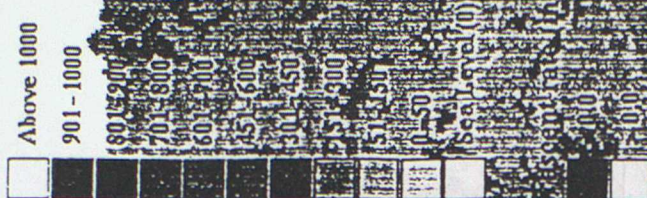
10 OCT 90 AT 1200

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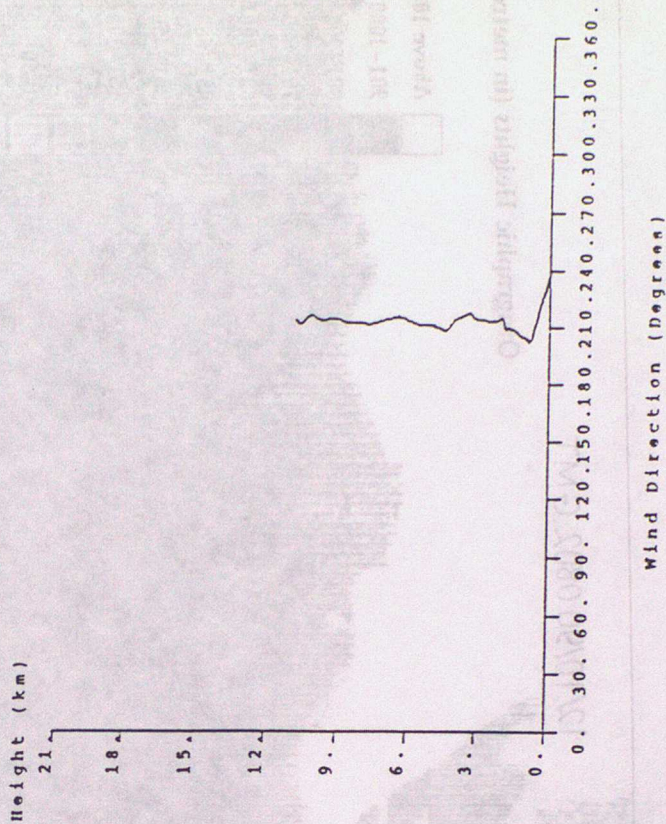
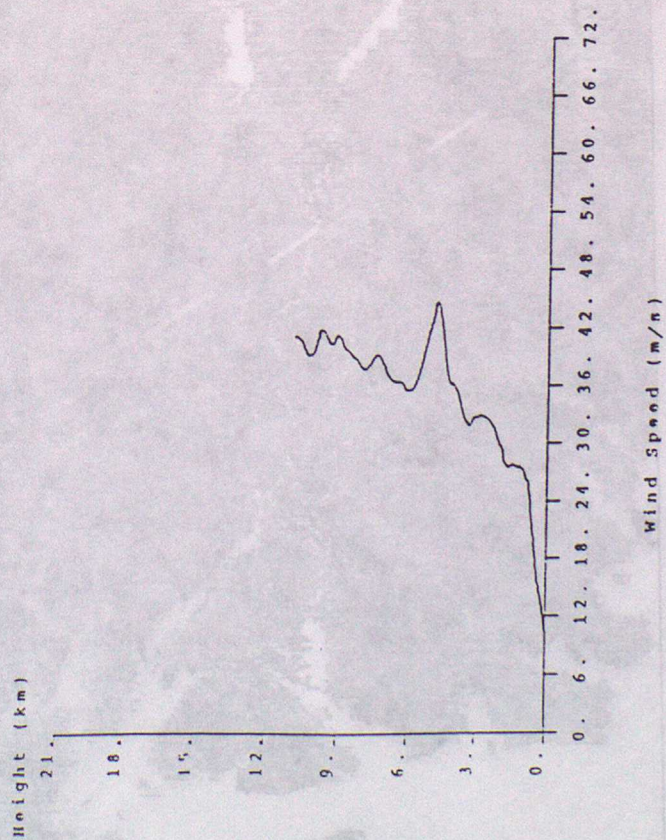
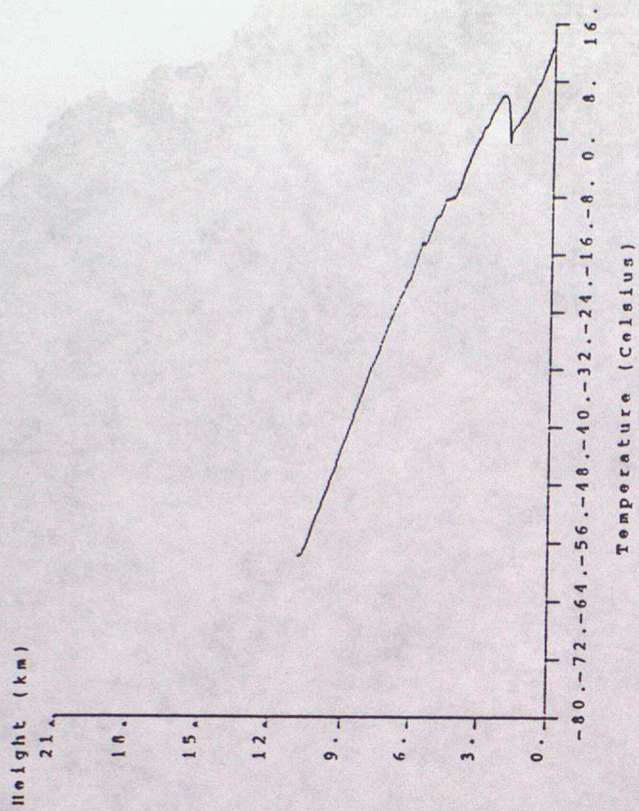
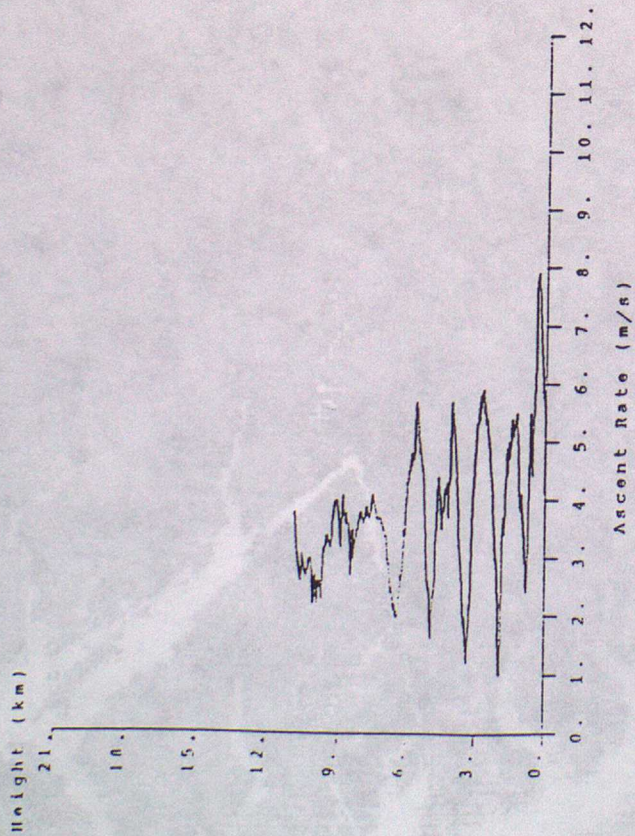
12/10/90 0802 GMT

Radle/onde Asc

Orographic Heights (in metres)

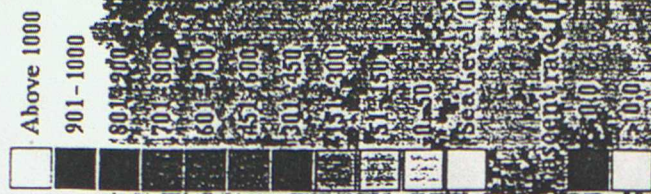


Loch Cluanie Radiosonde Ascent 12/10/90 0802 GMT

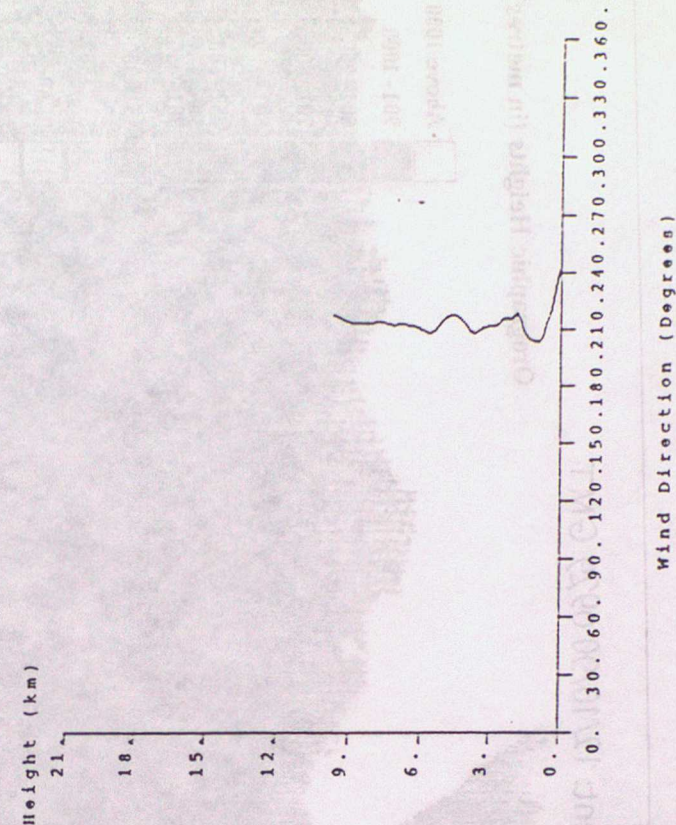
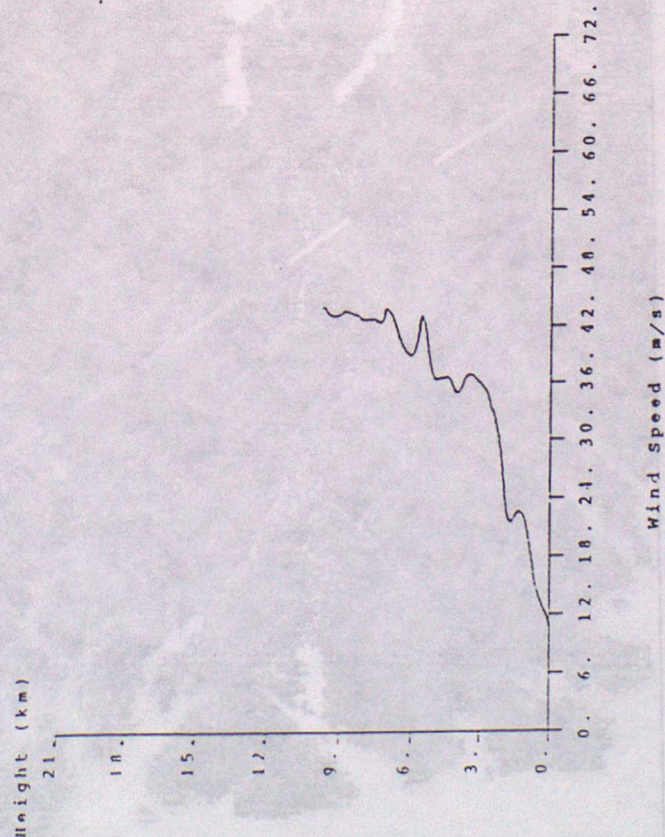
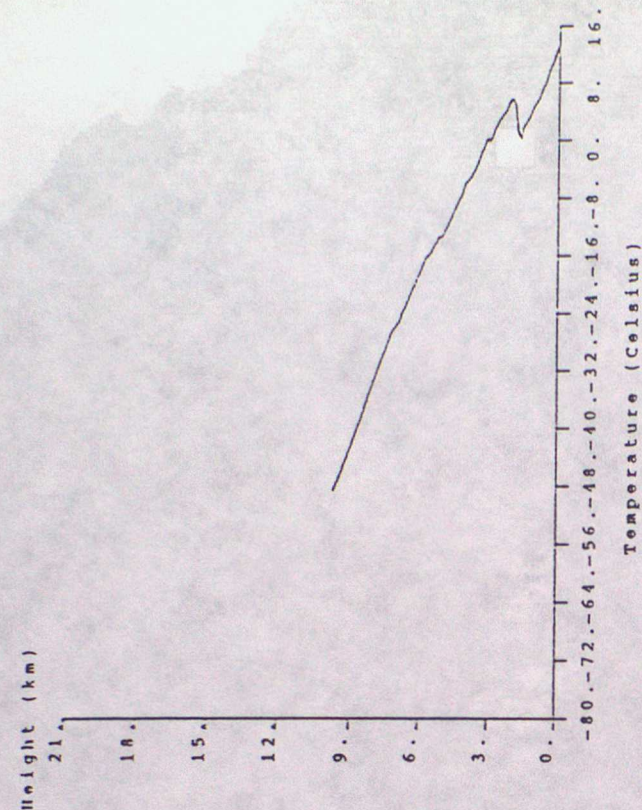
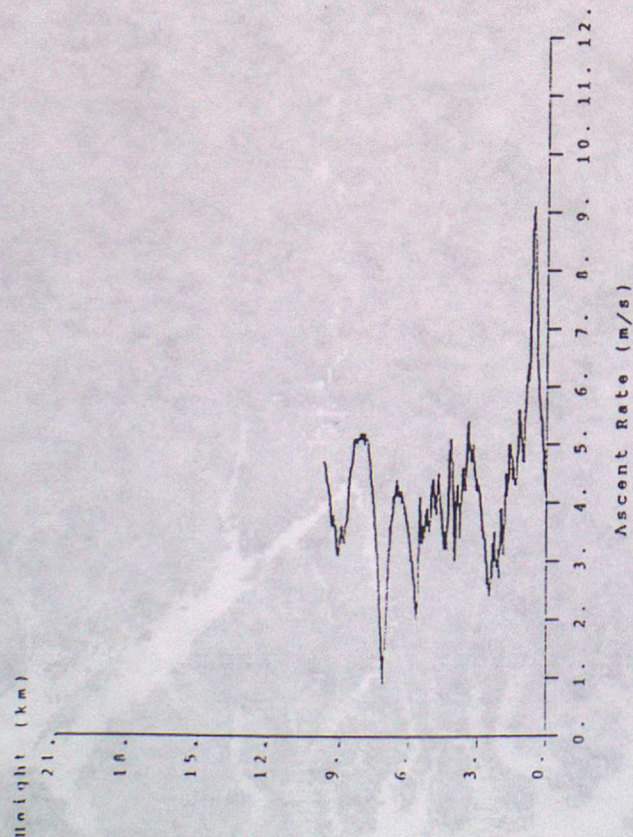


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Orographic Heights (in metres)

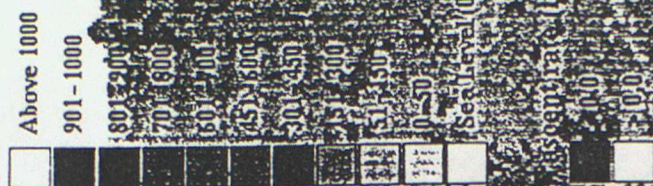


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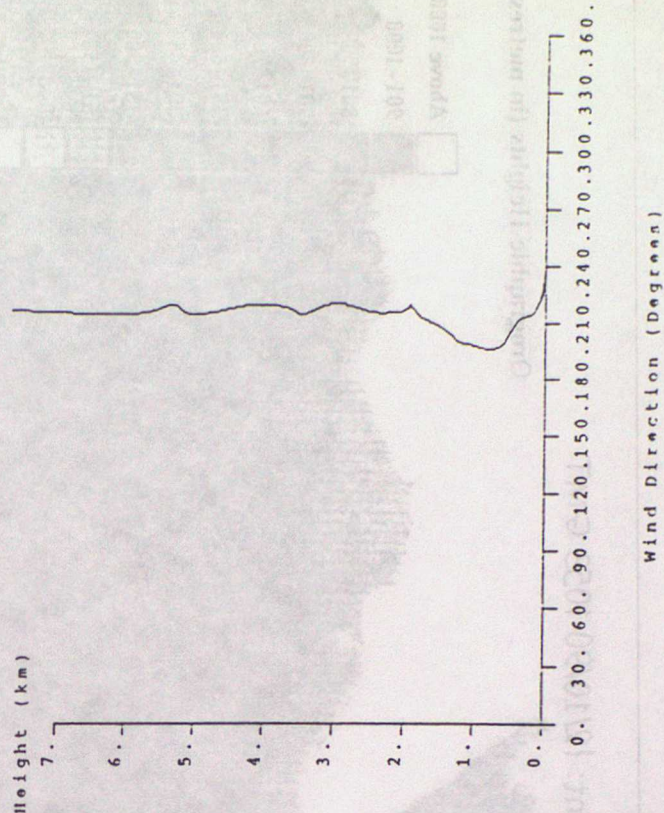
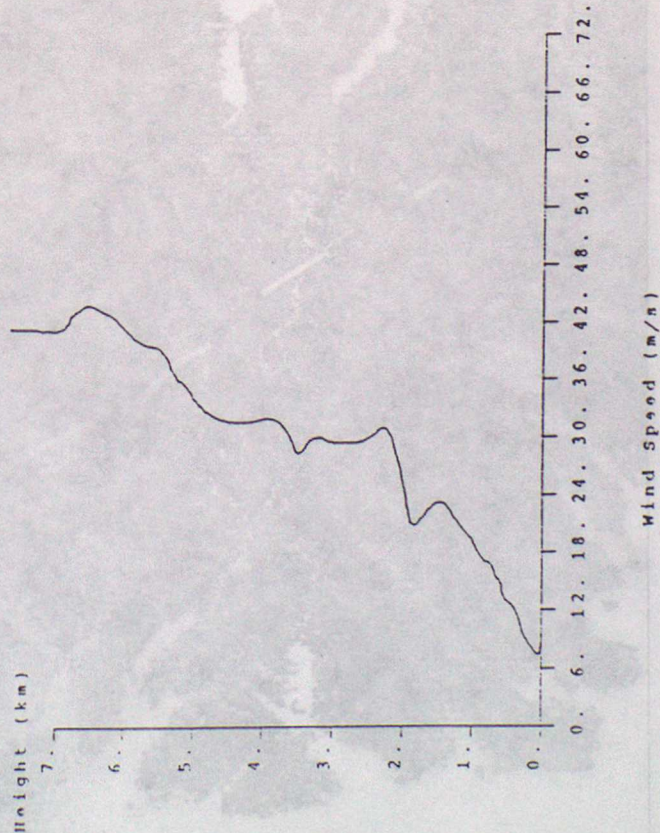
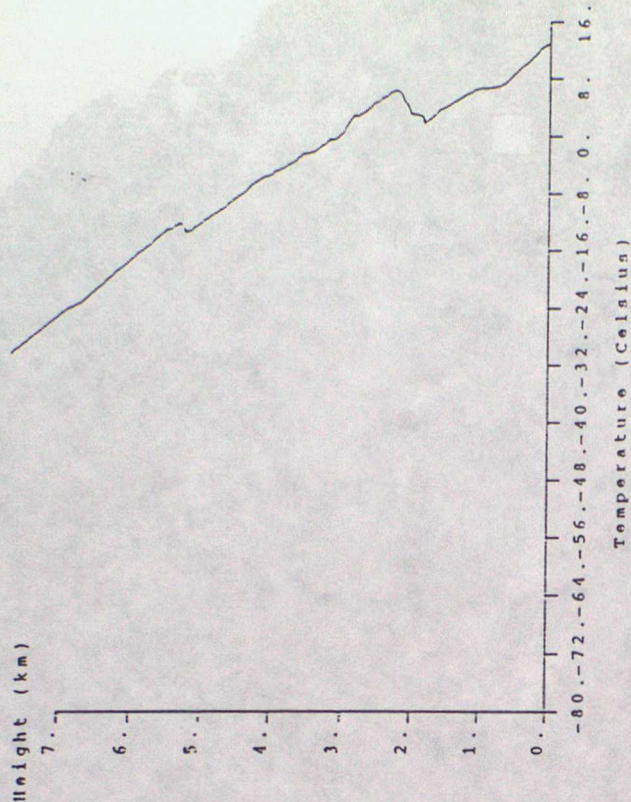
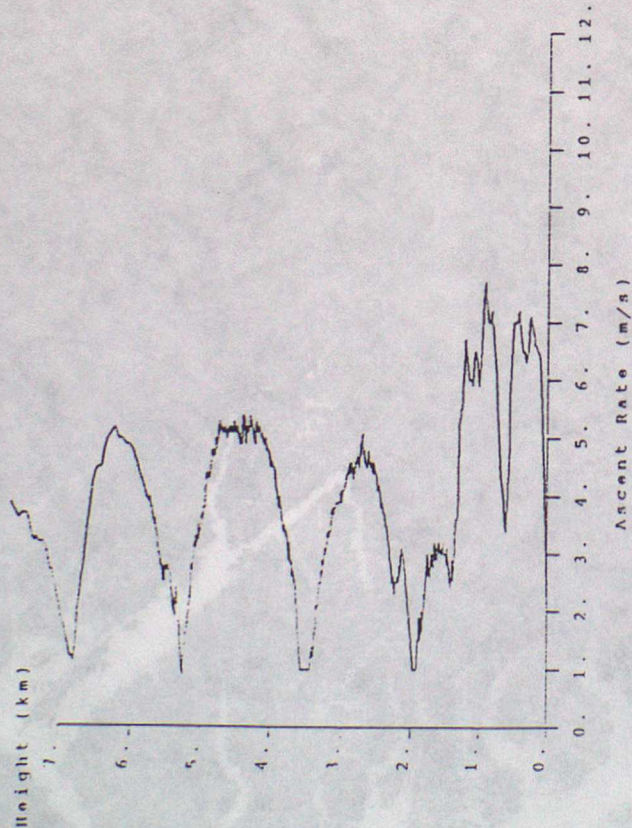


Radlasonde Asc nt: 12/10/90 1053 GMT

Ornographic Heights (in metres)



Loch Cluanie Radiosonde Ascent 12/10/90 1053 GMT





12 OCT 90 AT 1200

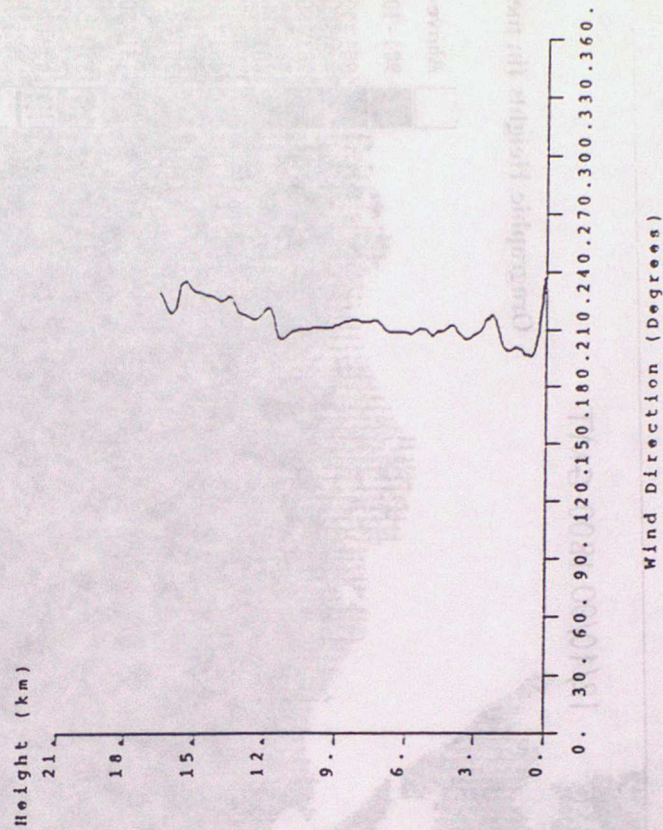
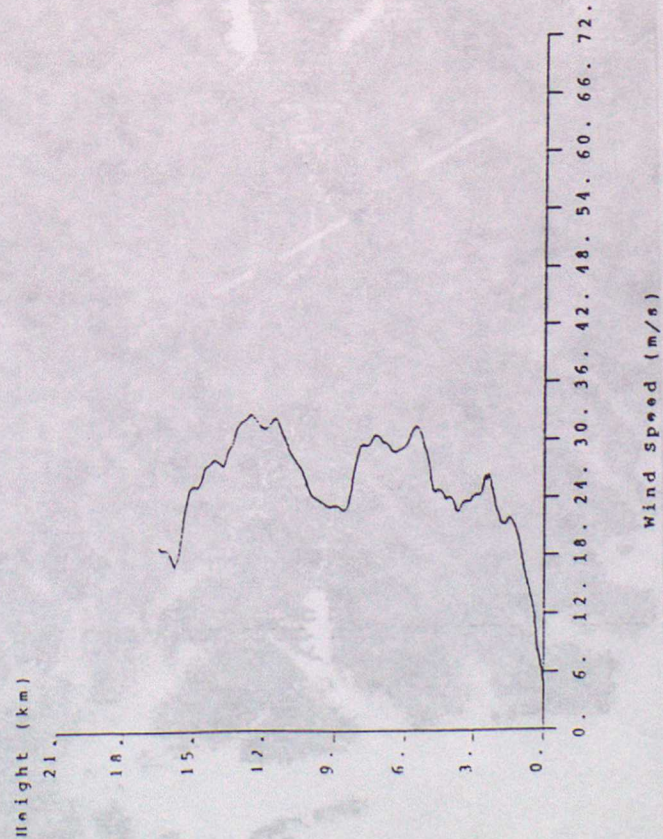
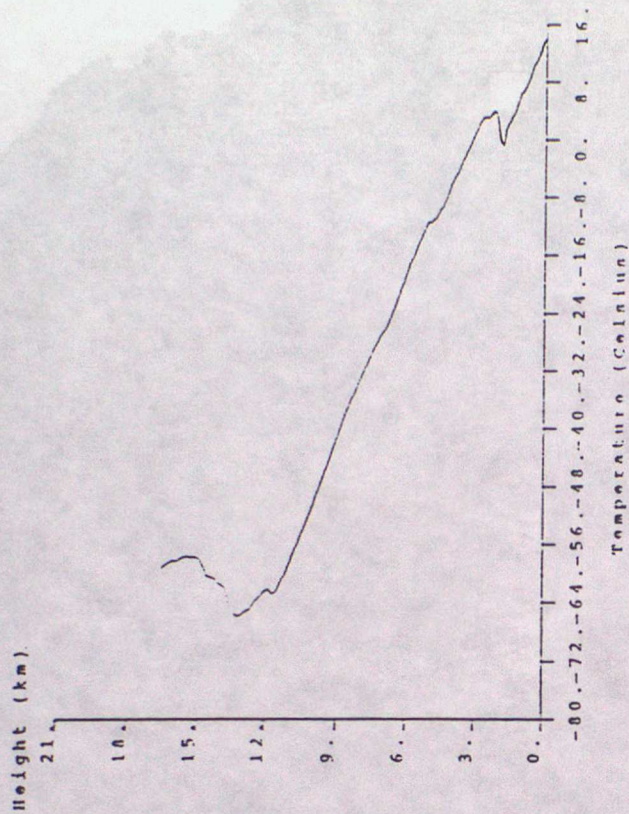
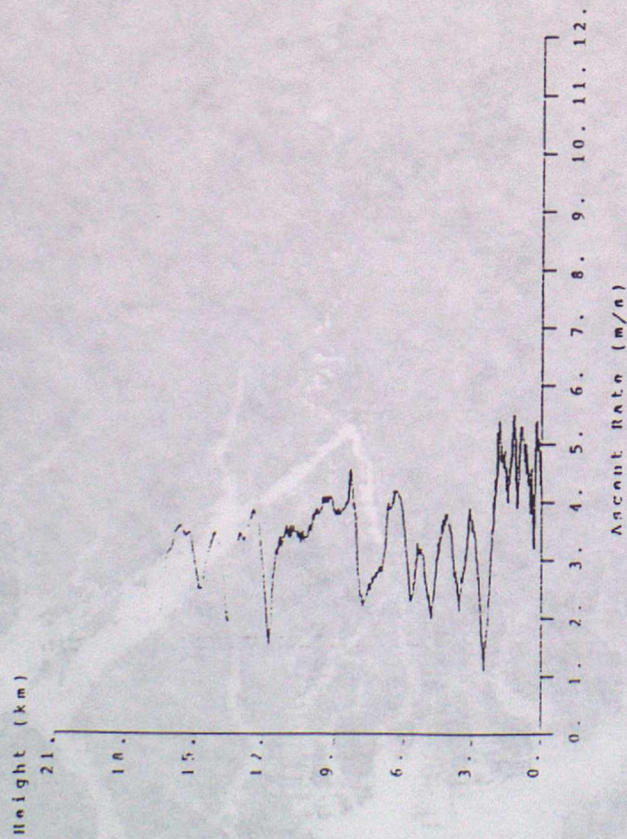
Radiosonde Asc

12/10/90 1800 GMT

Ornographic Heights (in metres)



Loch Cluanie Radiosonde Ascent 12/10/90 1800 GMT



Radlogonde Asc

25/10/90 1600 GMT

Orographic Heights (in metres)

Above 1000

901 - 1000

801 - 900

701 - 800

601 - 700

451 - 600

301 - 450

151 - 300

51 - 150

0 - 50

Sealevel (0)

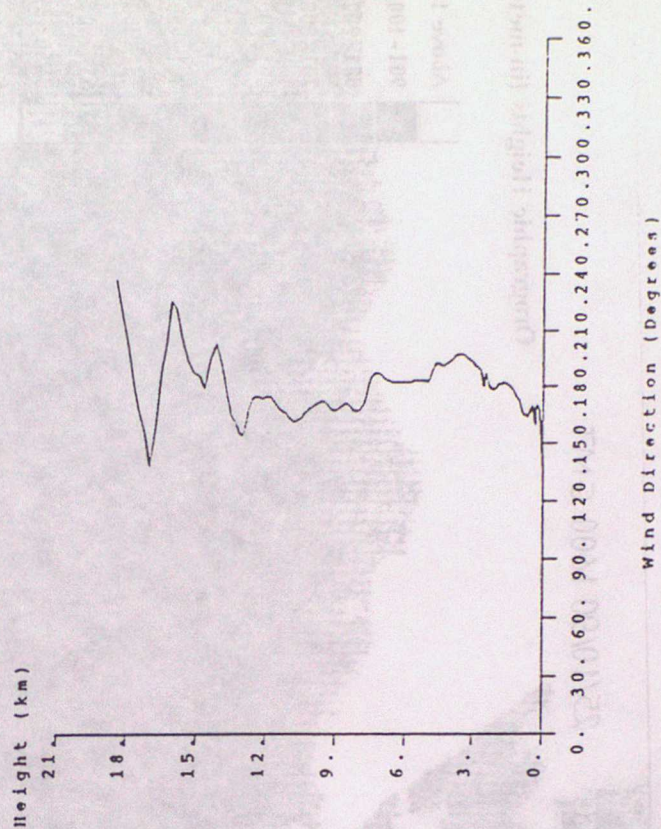
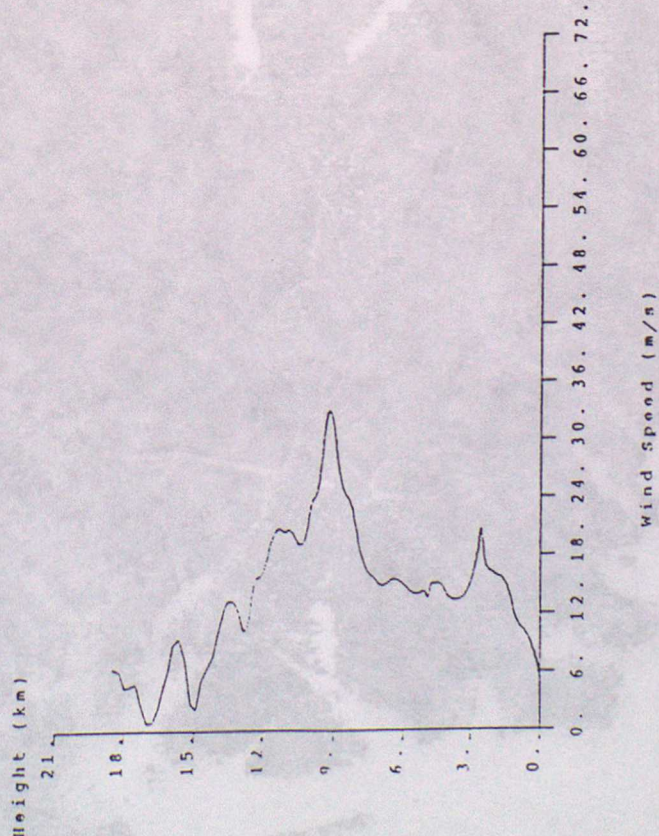
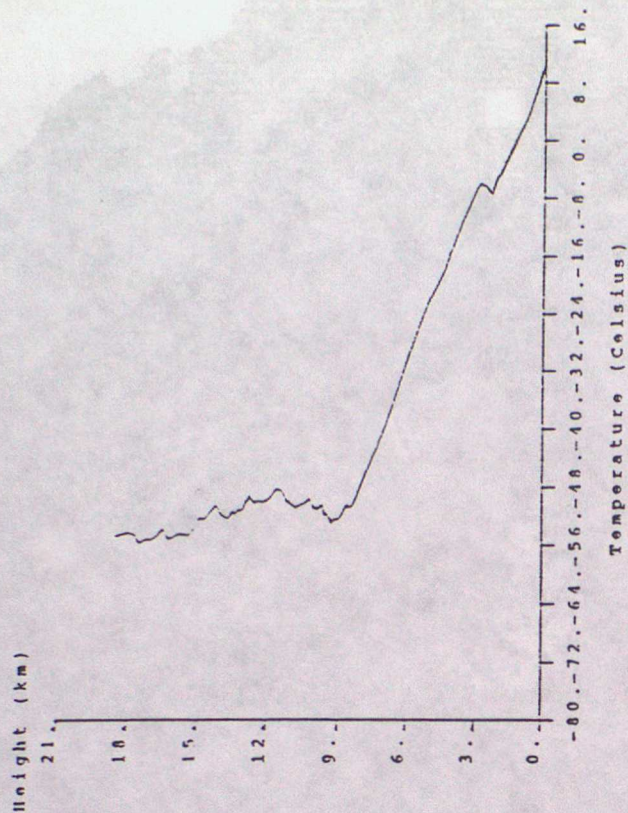
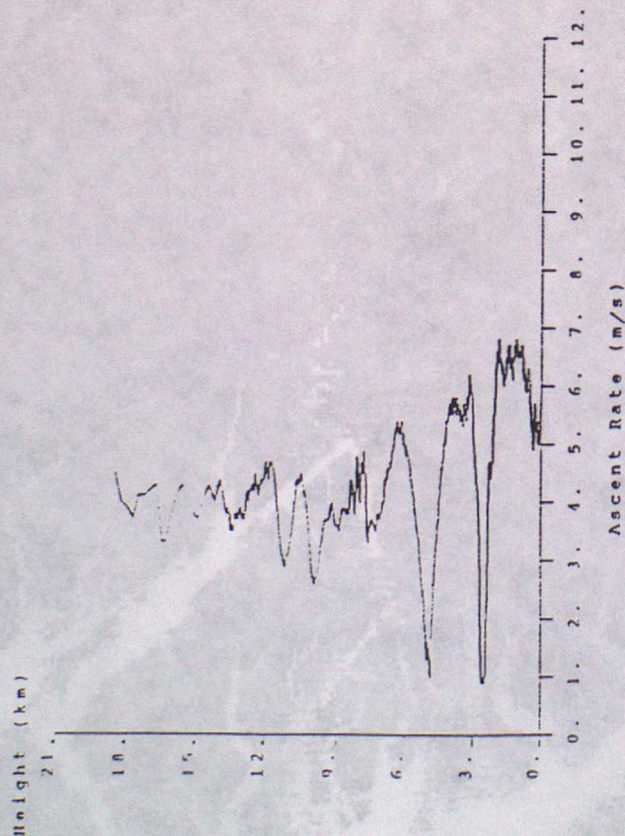
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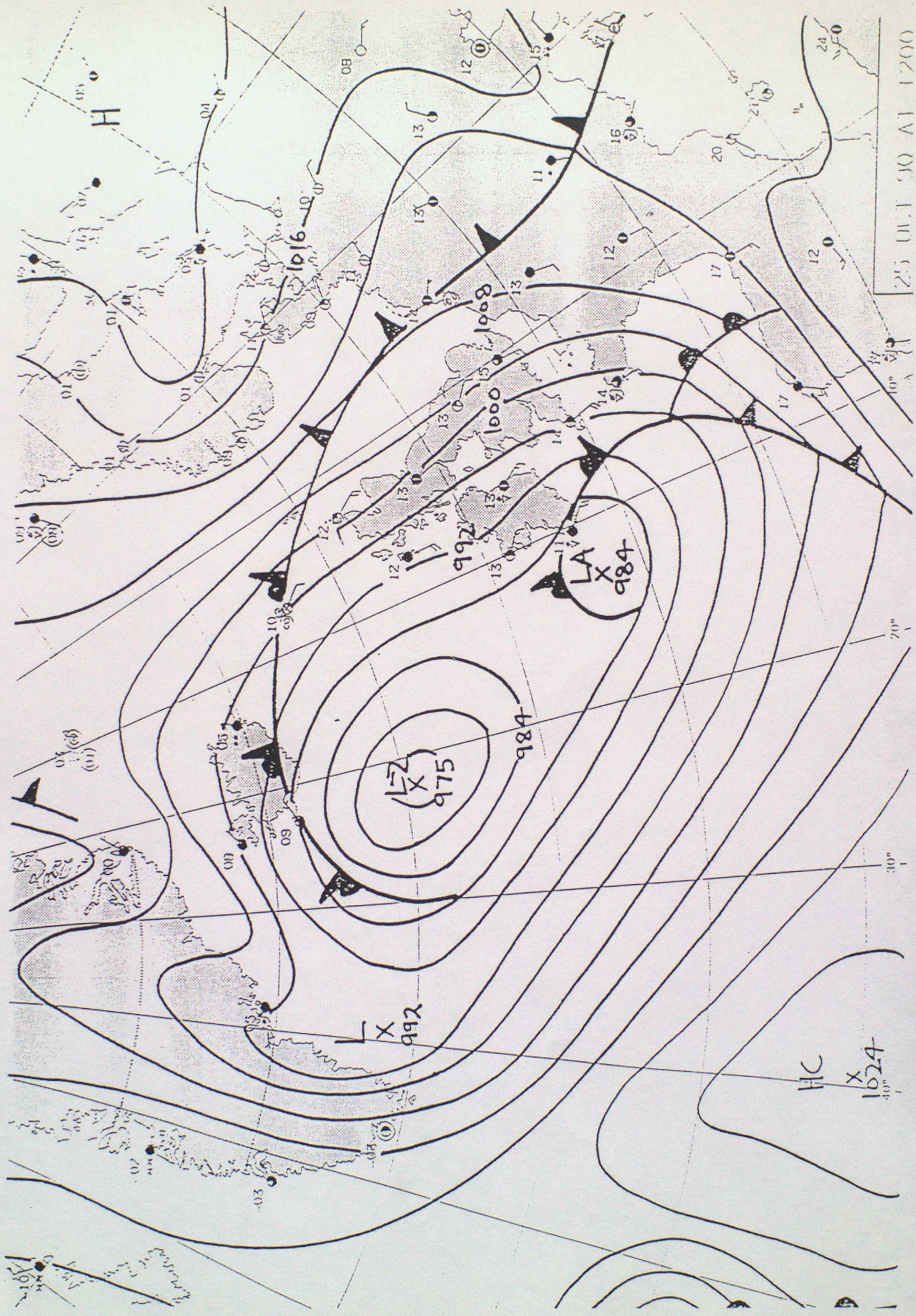
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Loch Cluanie Radiosonde Ascent 25/10/90 1600 GMT

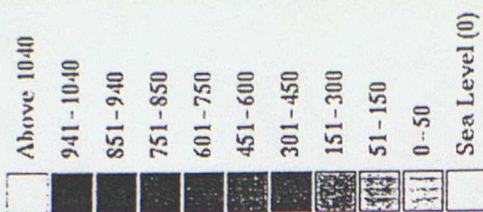




25 JUL 90 AT 1200

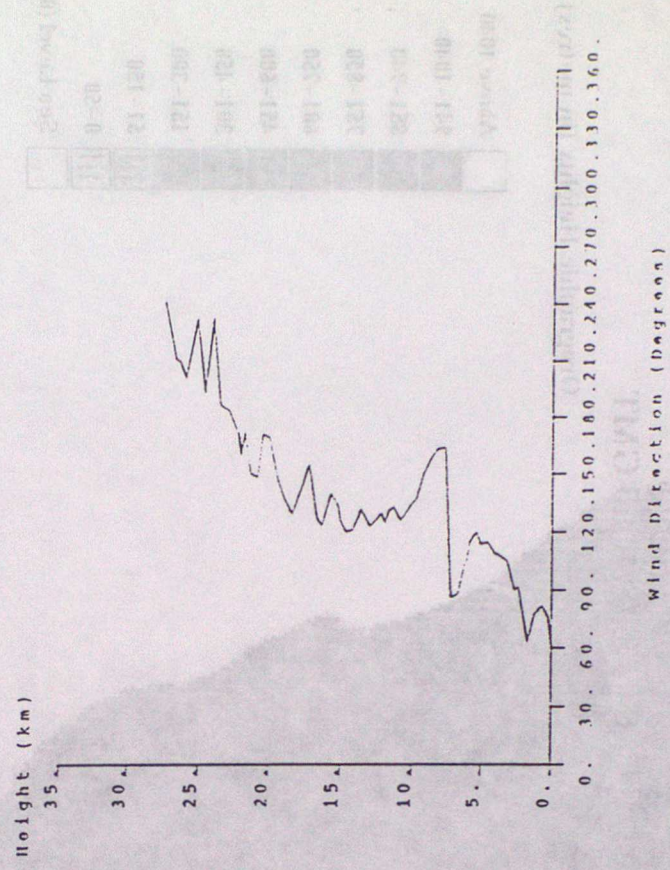
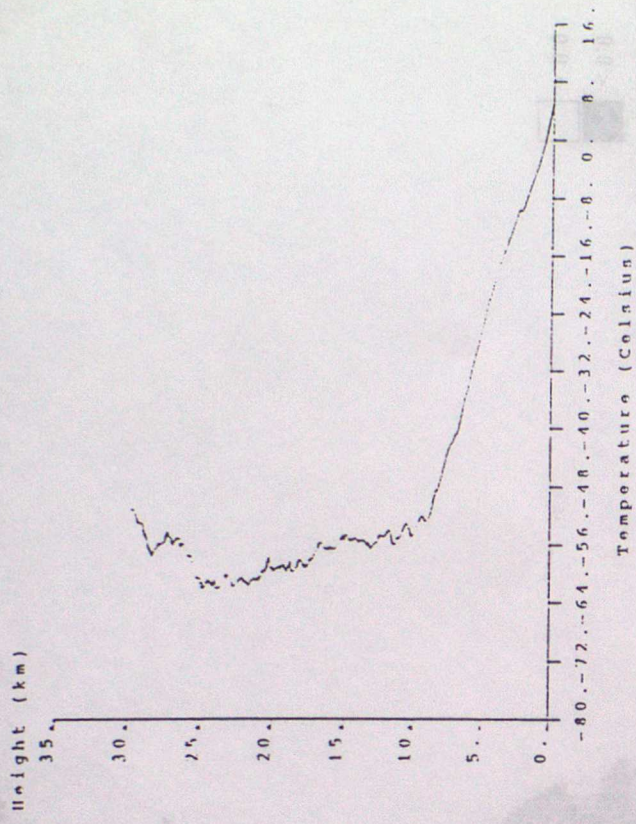
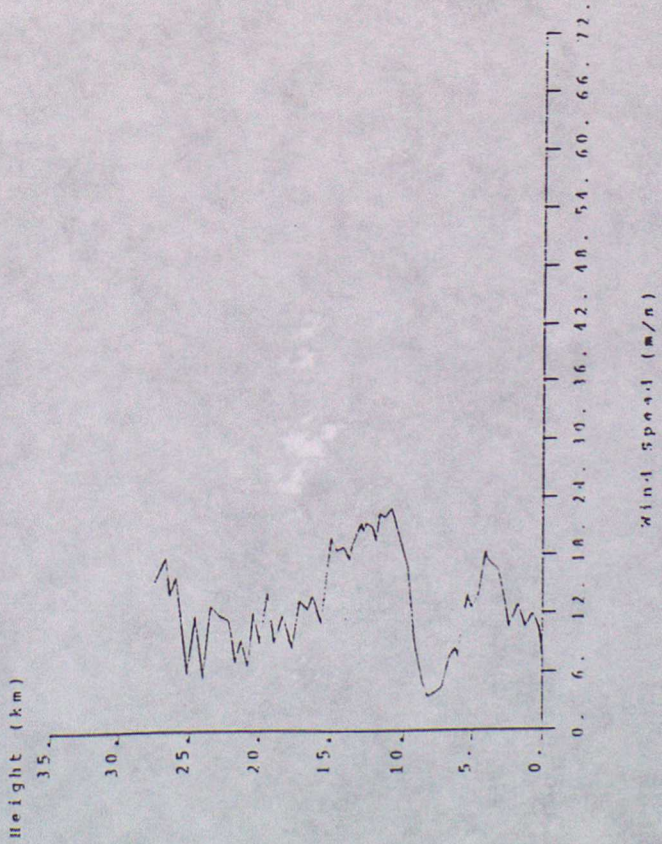
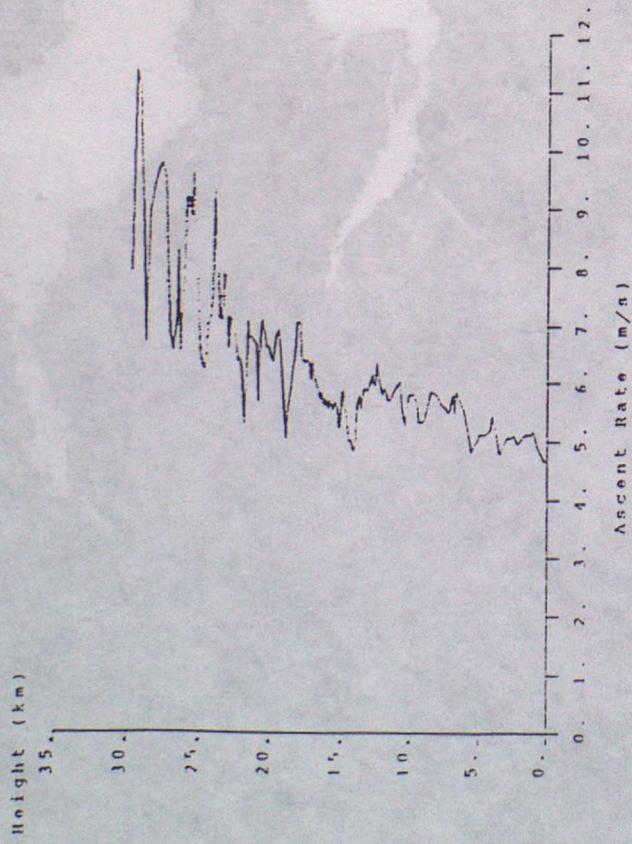
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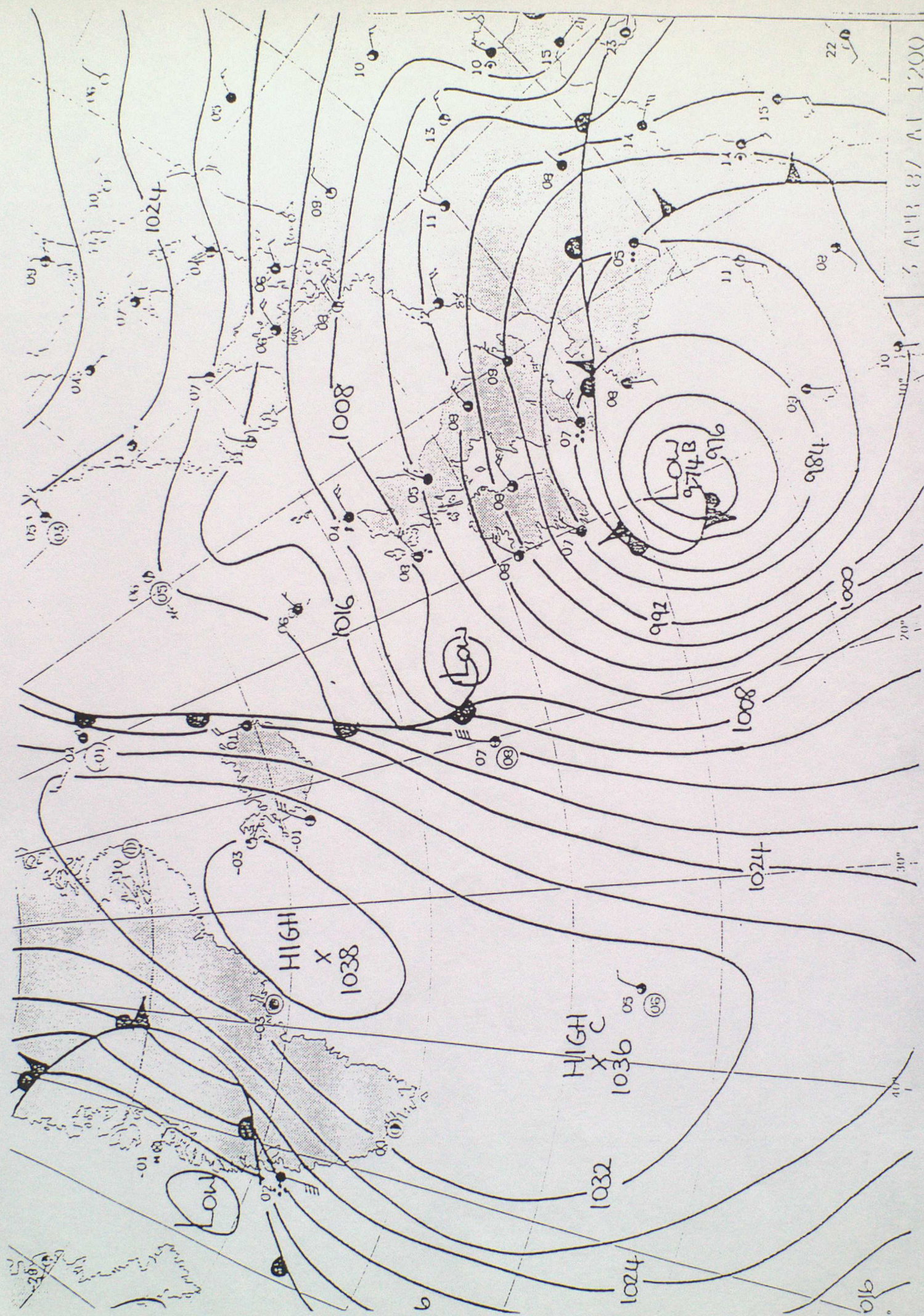
Orographic Heights (in metres)



Variance from mean ascent rate (in m/s)



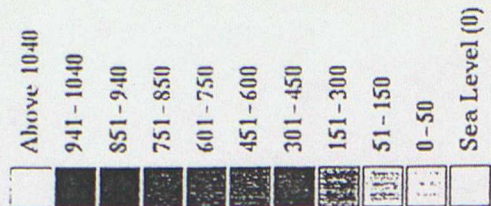




5 APR 87 AT 1200

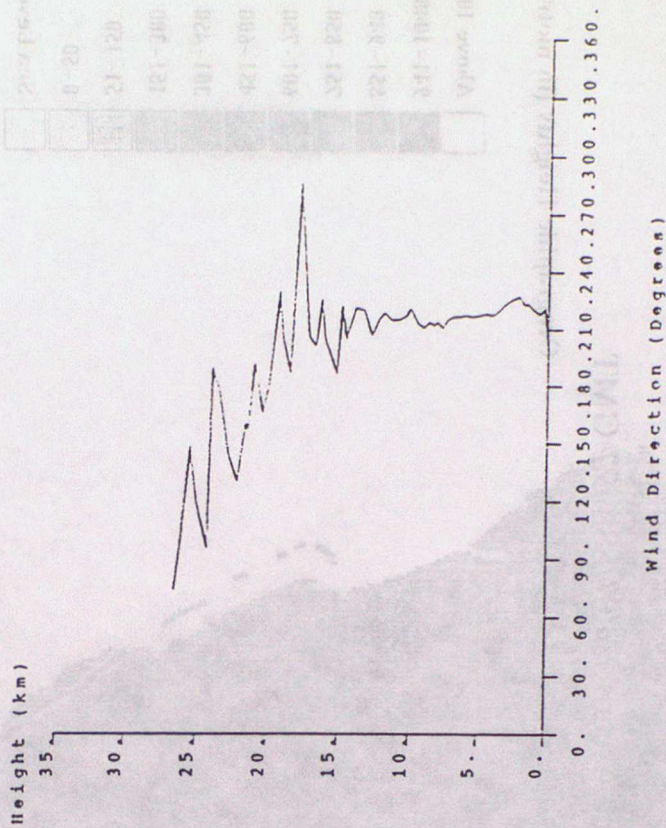
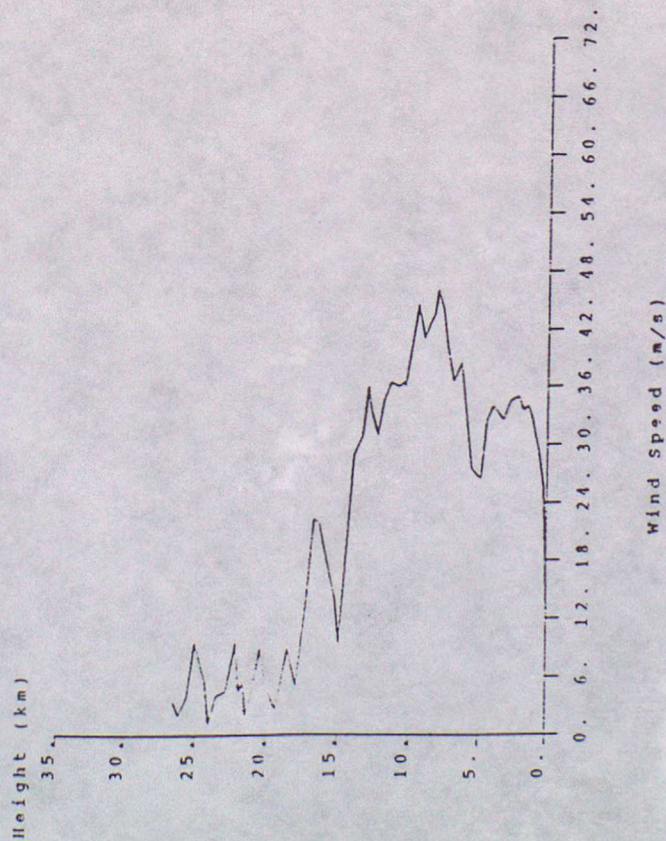
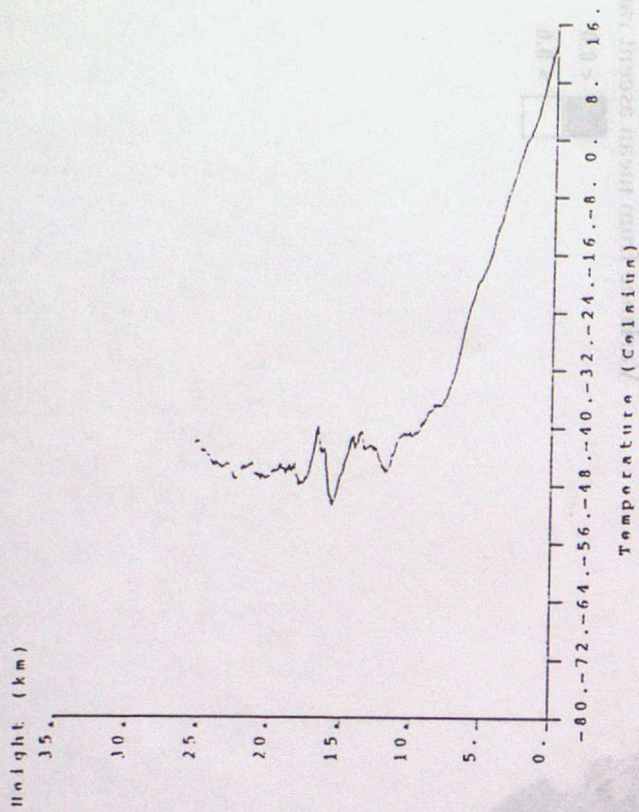
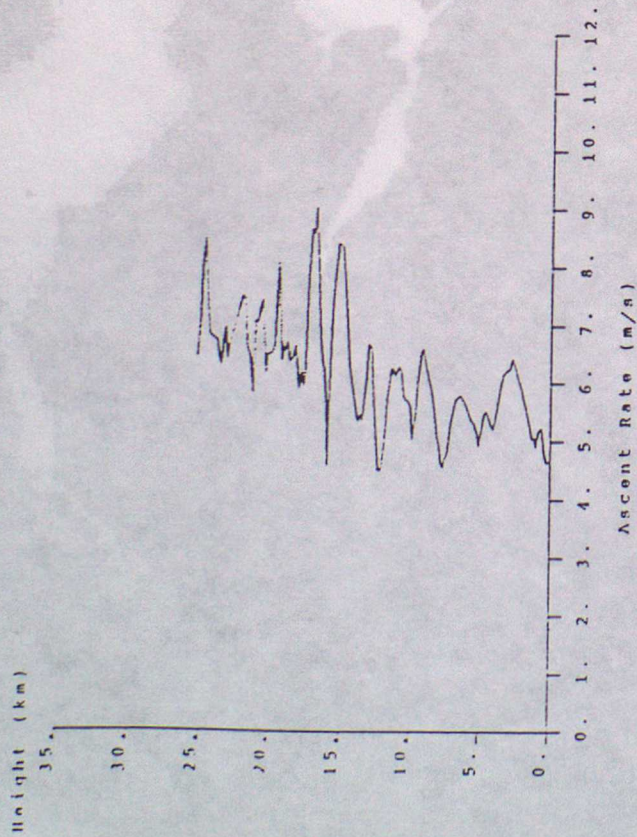
Radar made ascent 25/07/88 1127 GMT

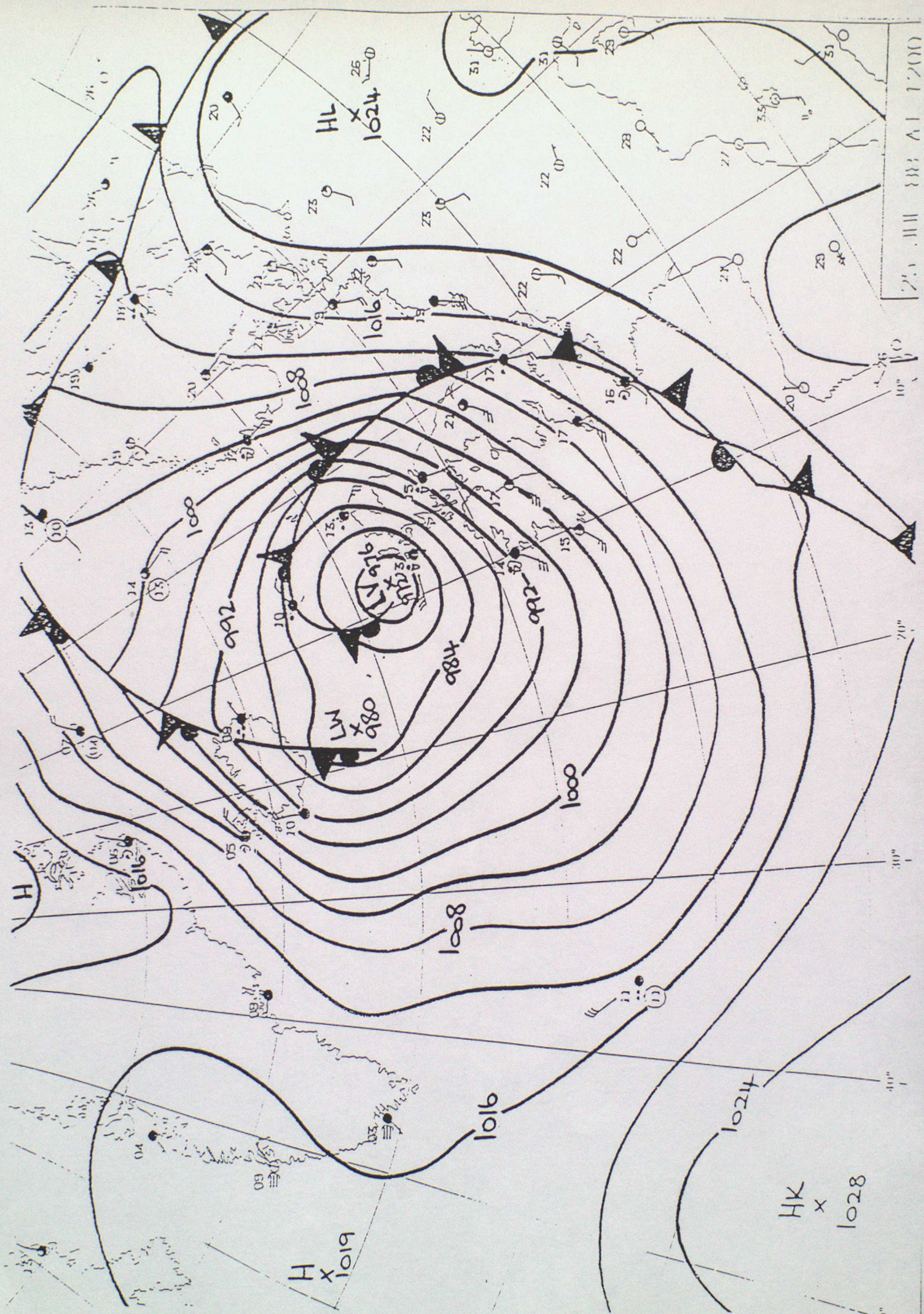
Orographic Heights (in metres)



Variance from mean ascent rate (in m/s)

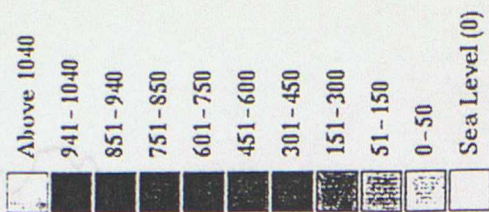




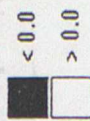


Orographic Ascent: 19/12/88 1142 GMT

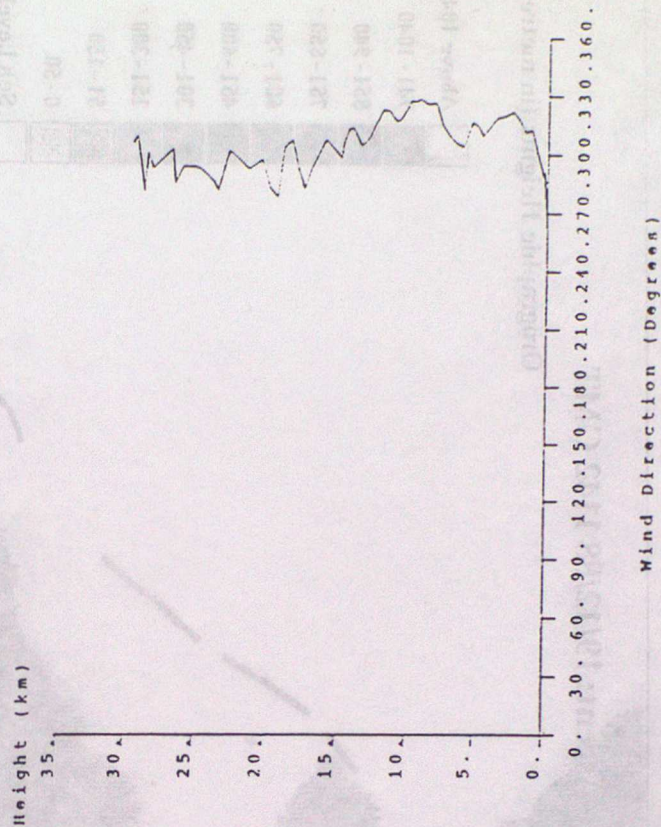
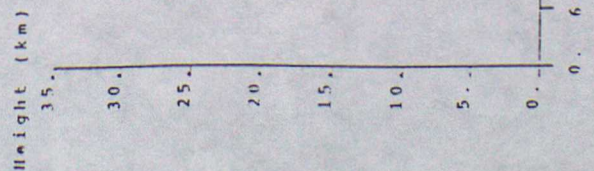
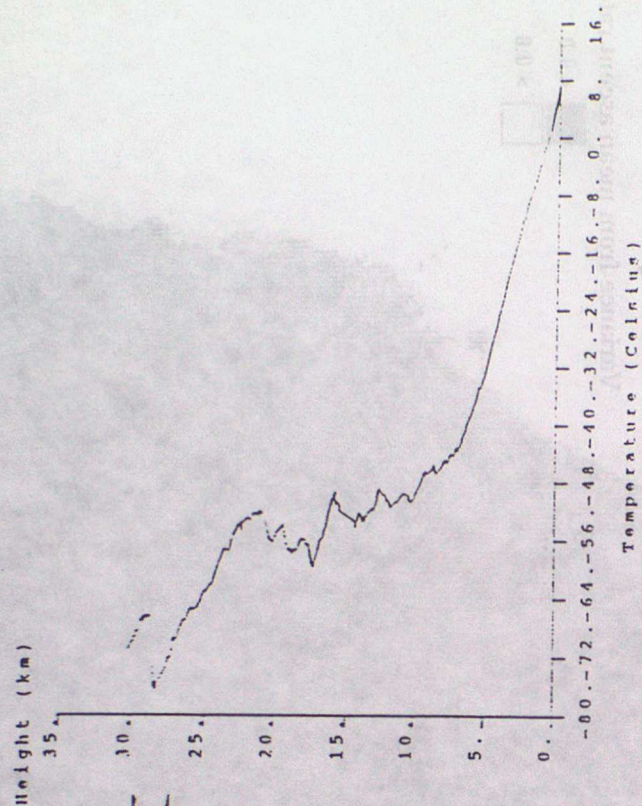
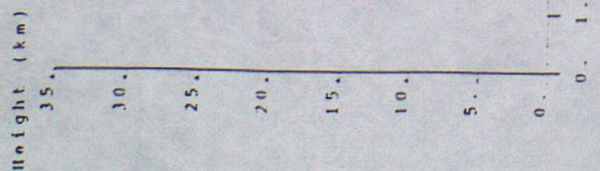
Orographic Heights (in metres)

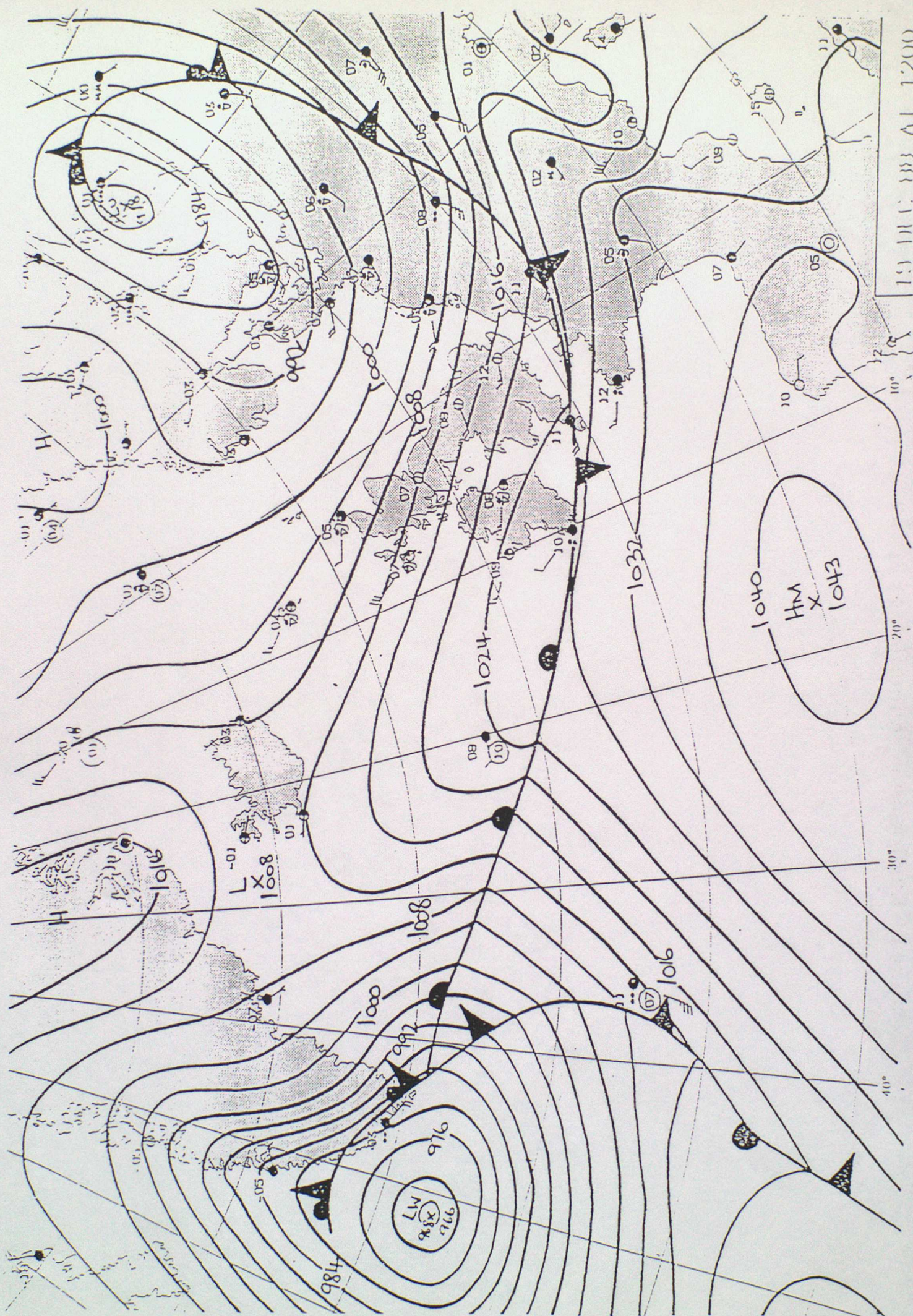


Variance from mean ascent rate (in m/s)



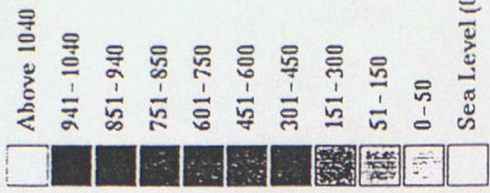
Shanwell Radiosonde Ascent 19/12/88 1142 GMT



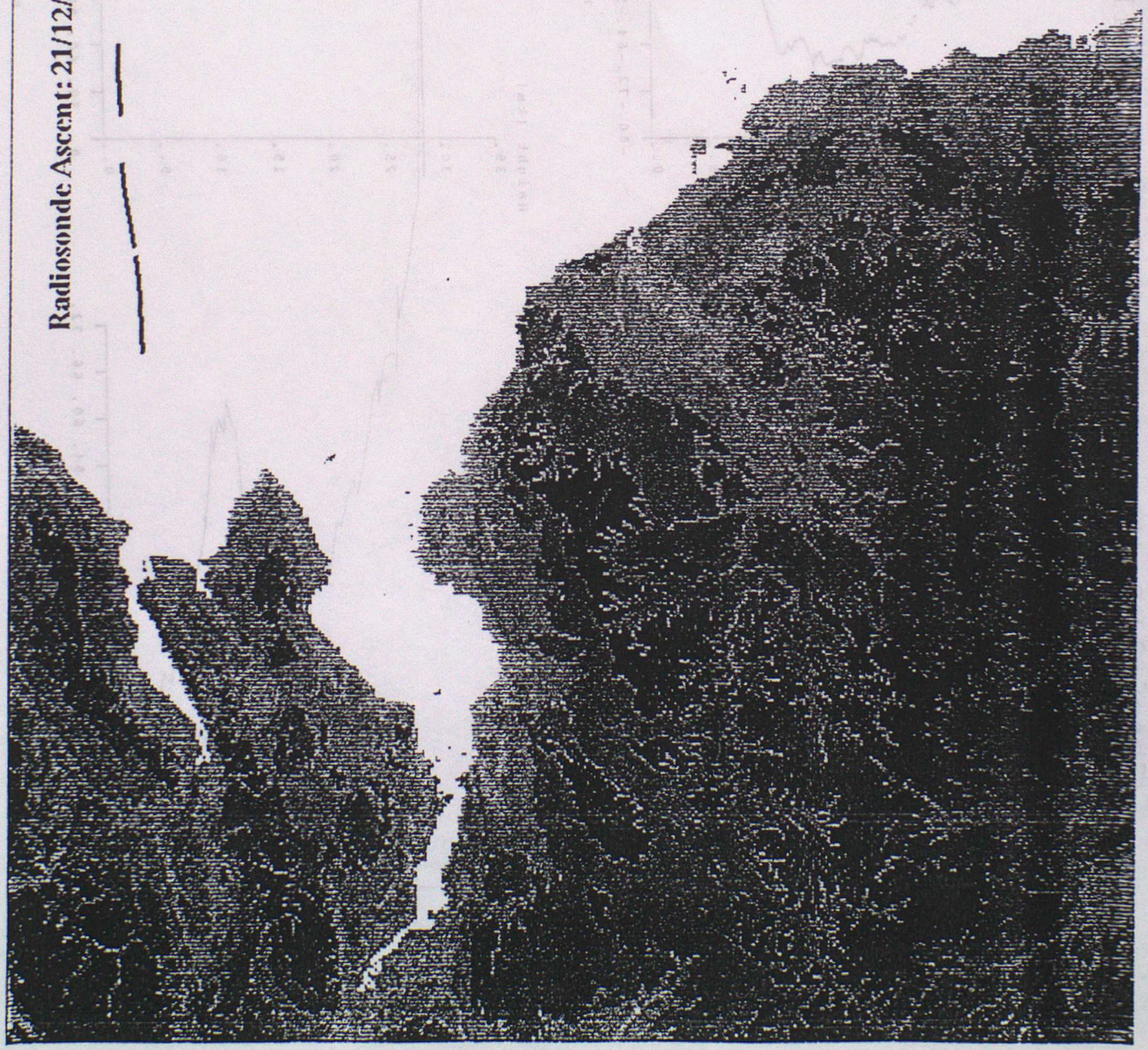
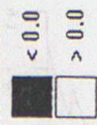


Radiosonde Ascent: 21/12/88 1115 GMT

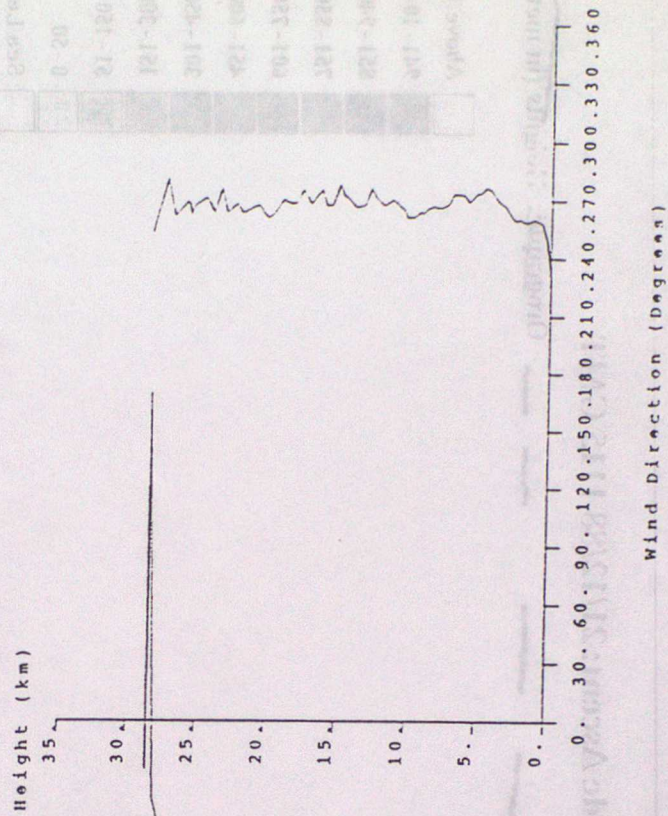
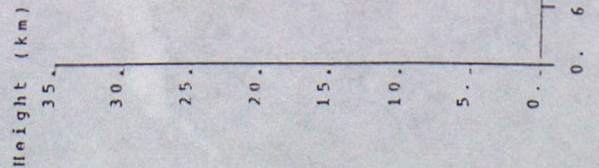
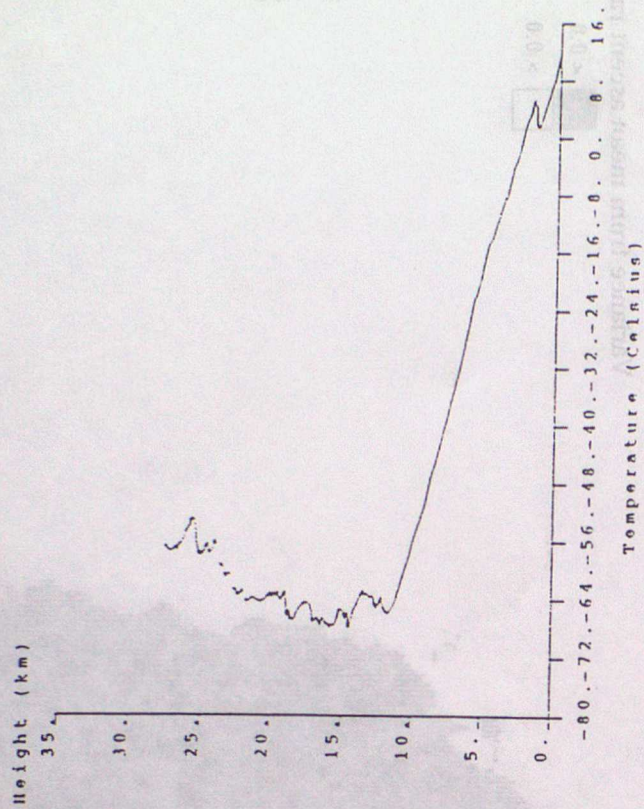
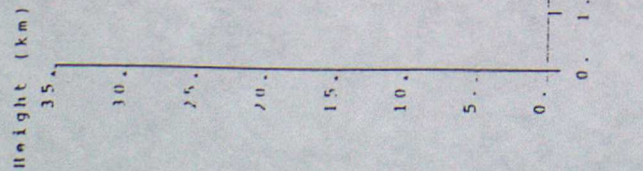
Orographic heights (in metres)

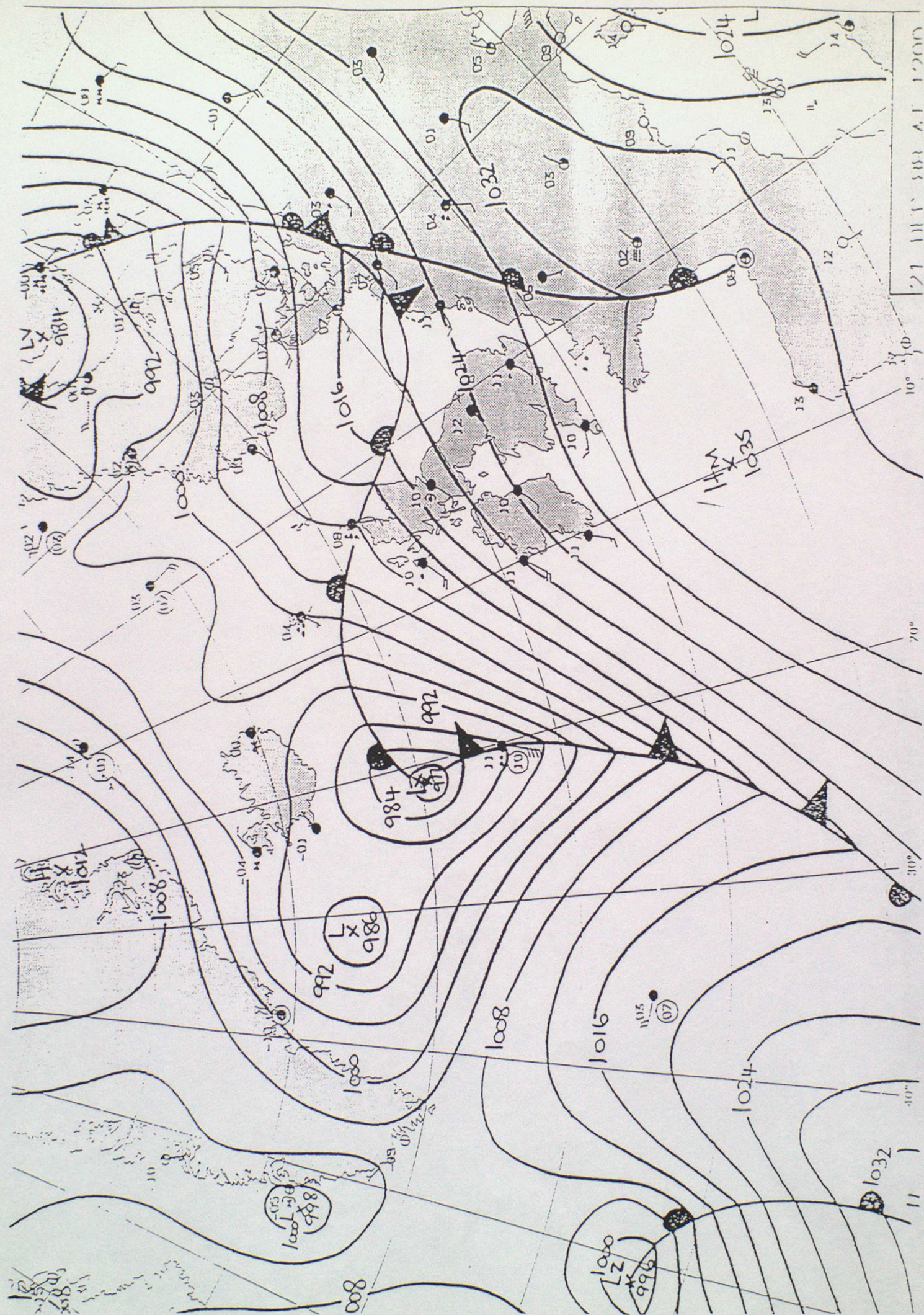


Variance from mean ascent rate (in m/s)



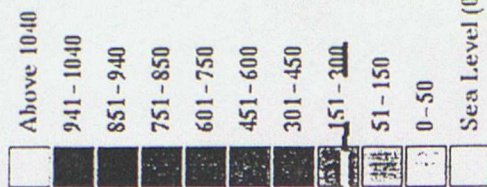
Shanwell Radiosonde Ascent 21/12/88 1115 GMT



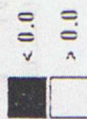


Trallier Creek Ascent 11/01/89 1134 GMT

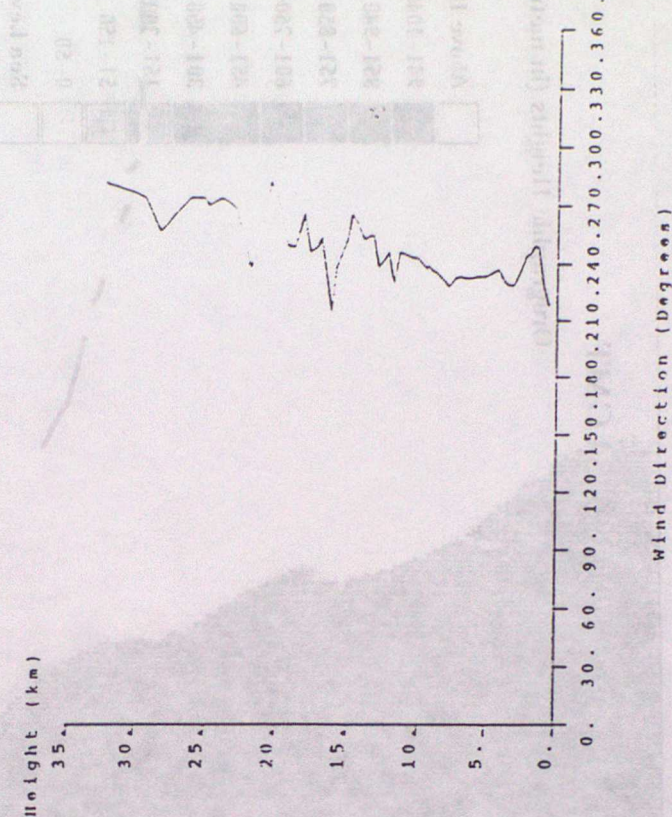
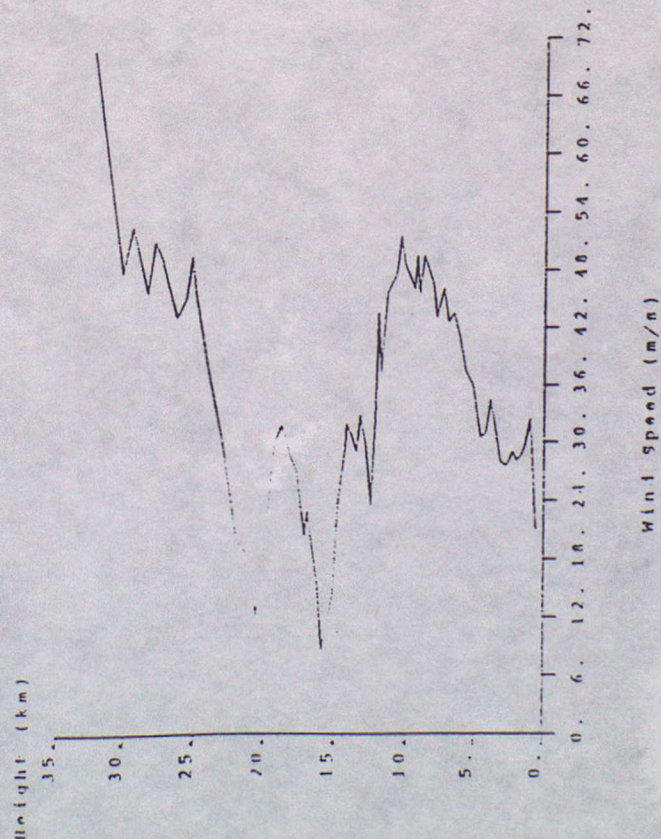
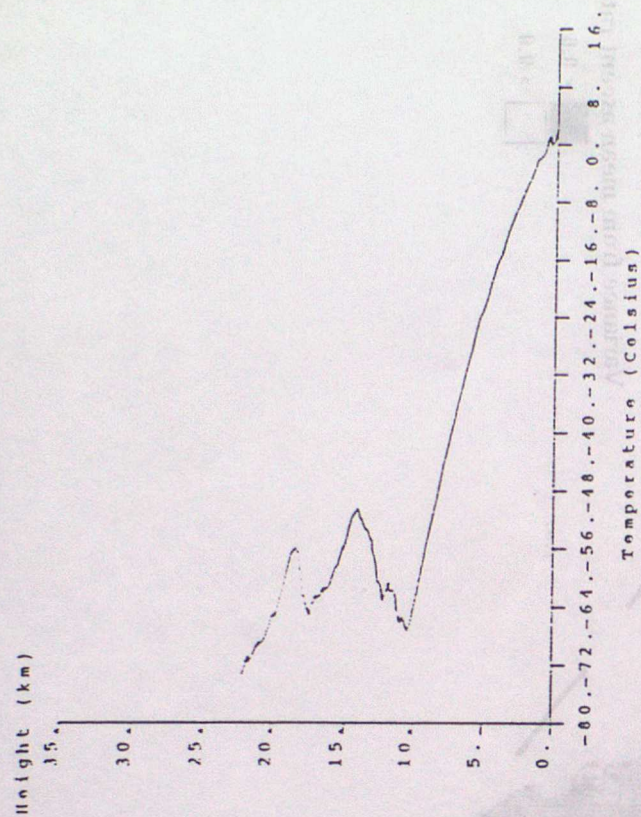
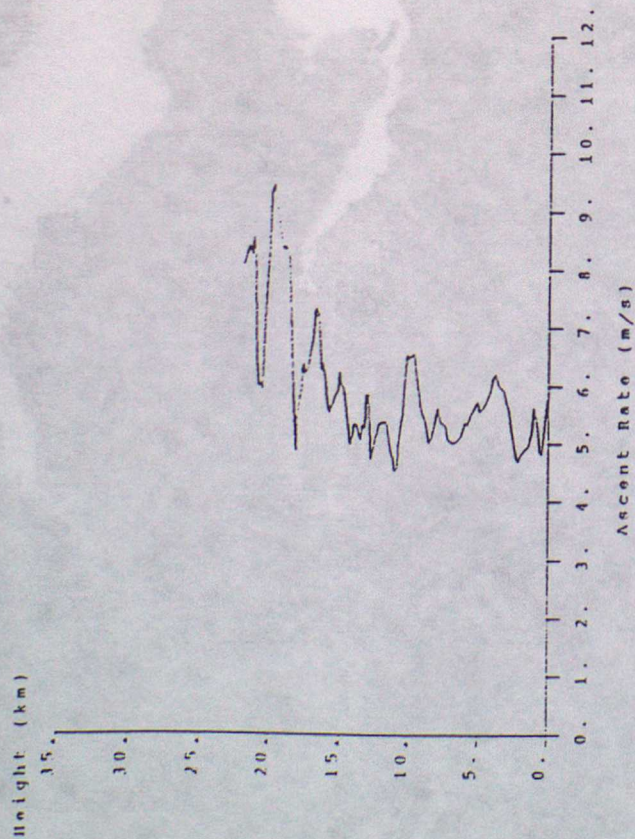
Orographic Heights (in metres)

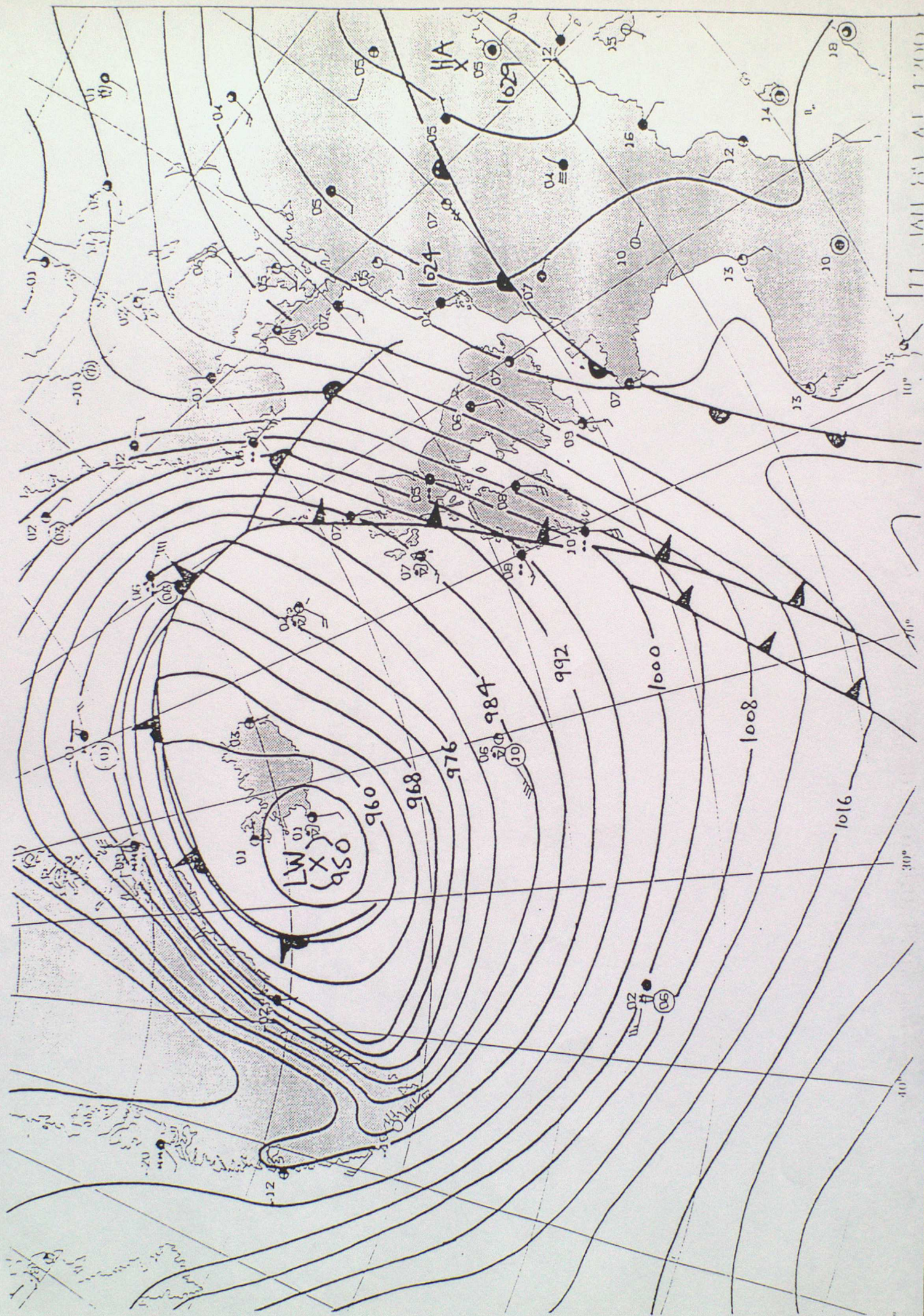


Variance from mean ascent rate (in m/s)



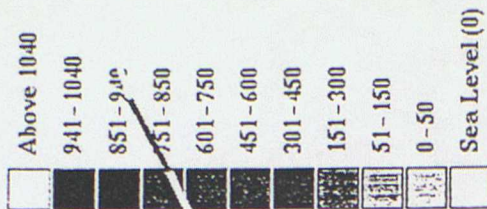
Shanwell Radiosonde Ascent 11/01/89 1134 GMT



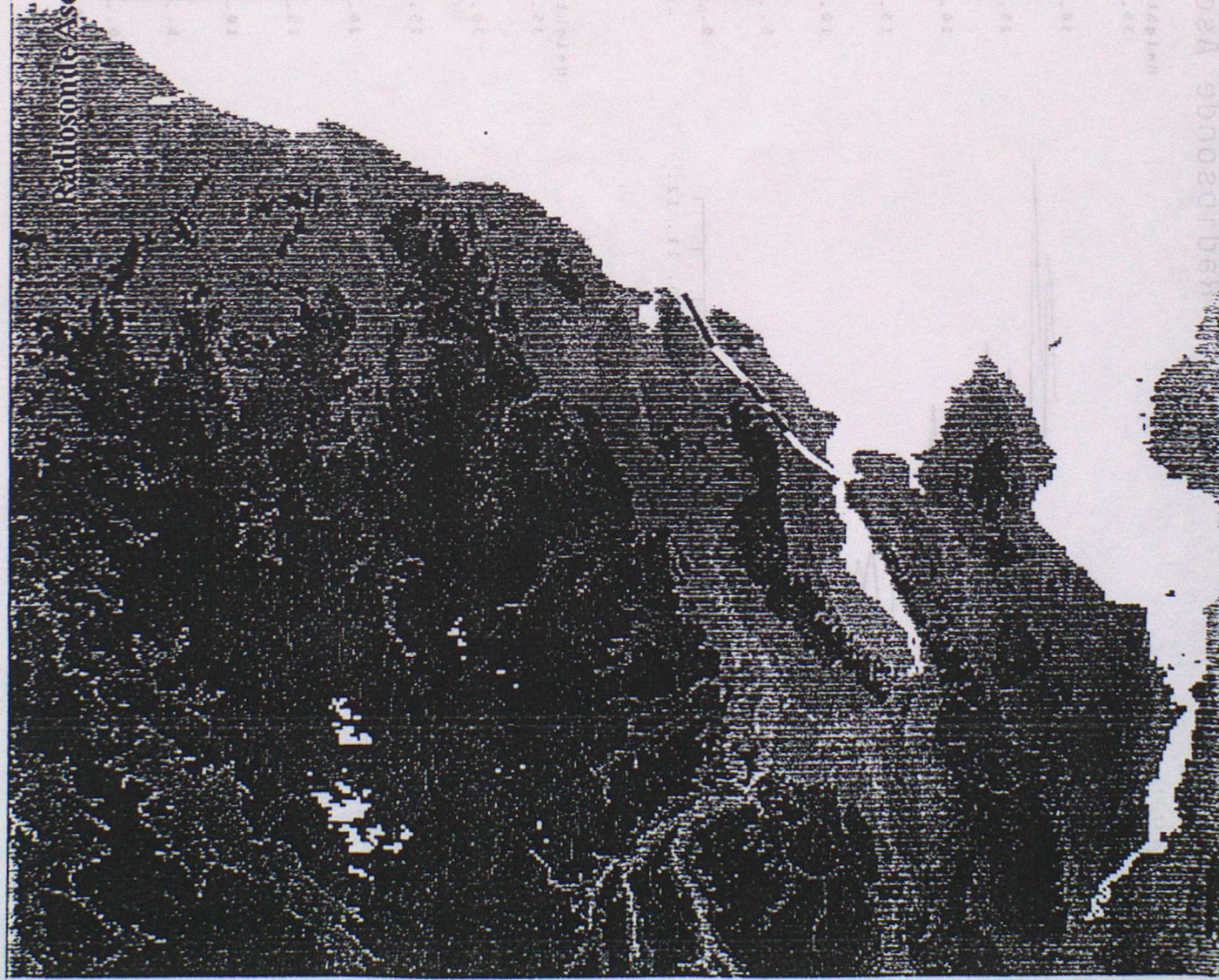
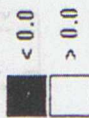


13/01/89 1137 GMT

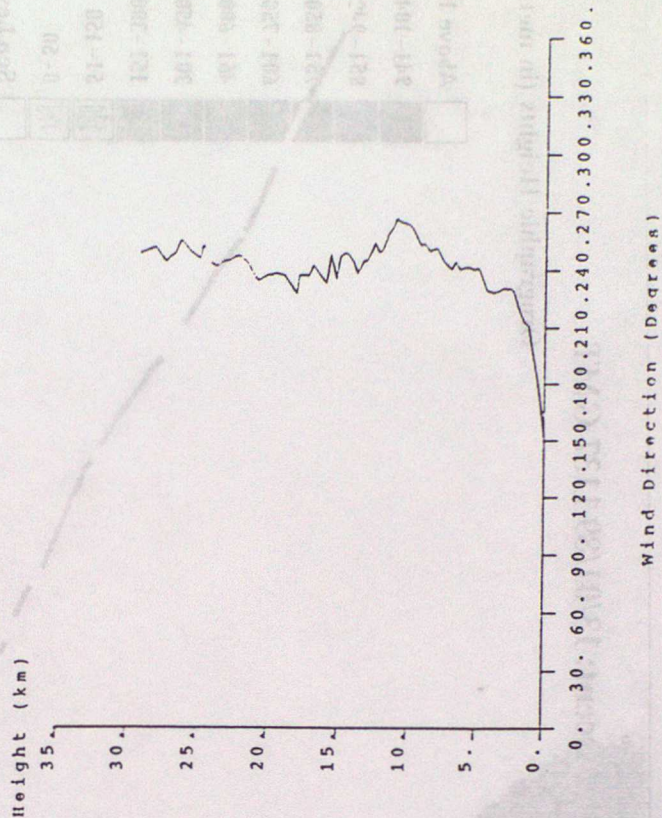
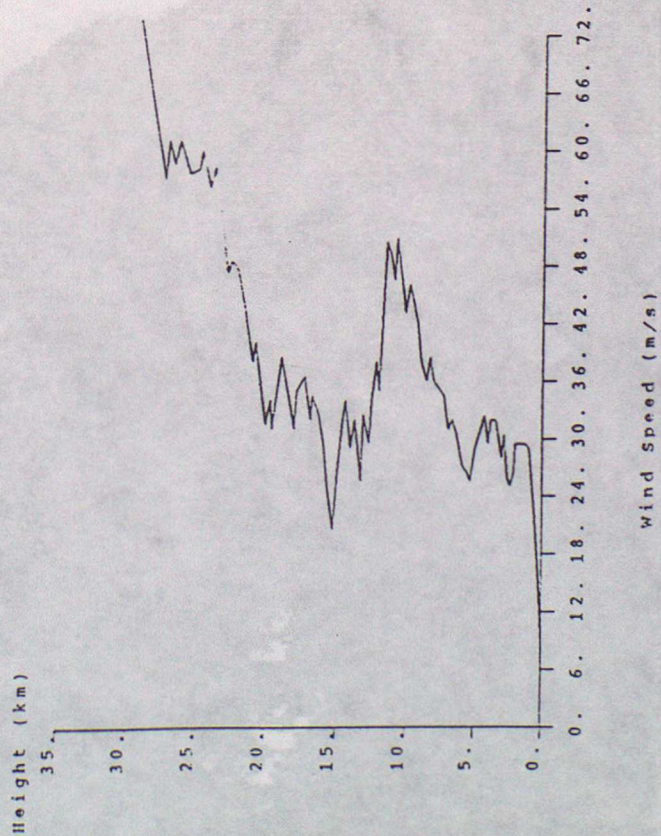
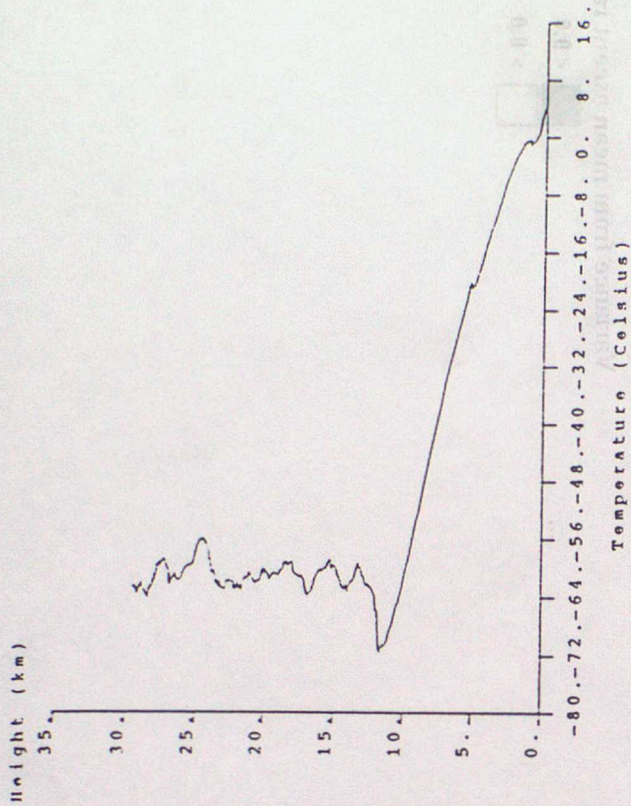
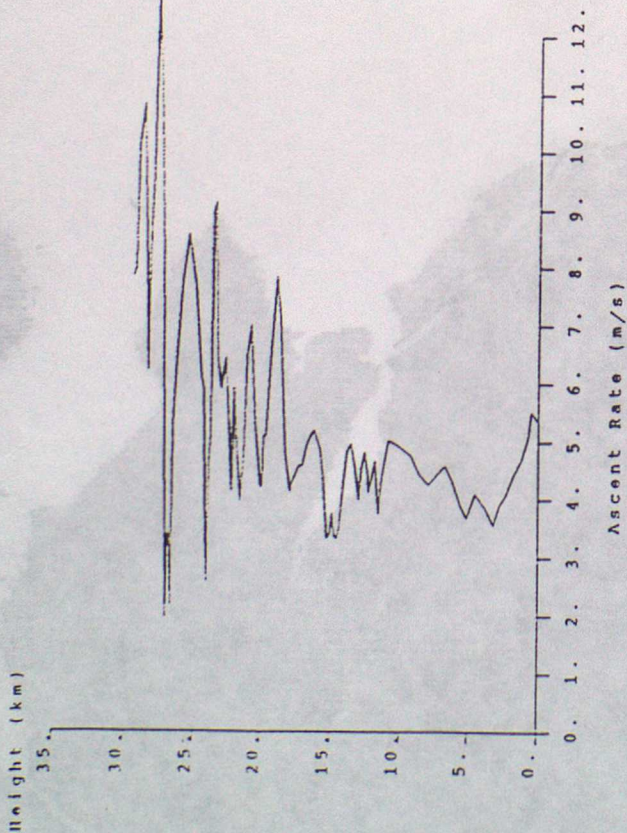
Orographic Heights (in metres)

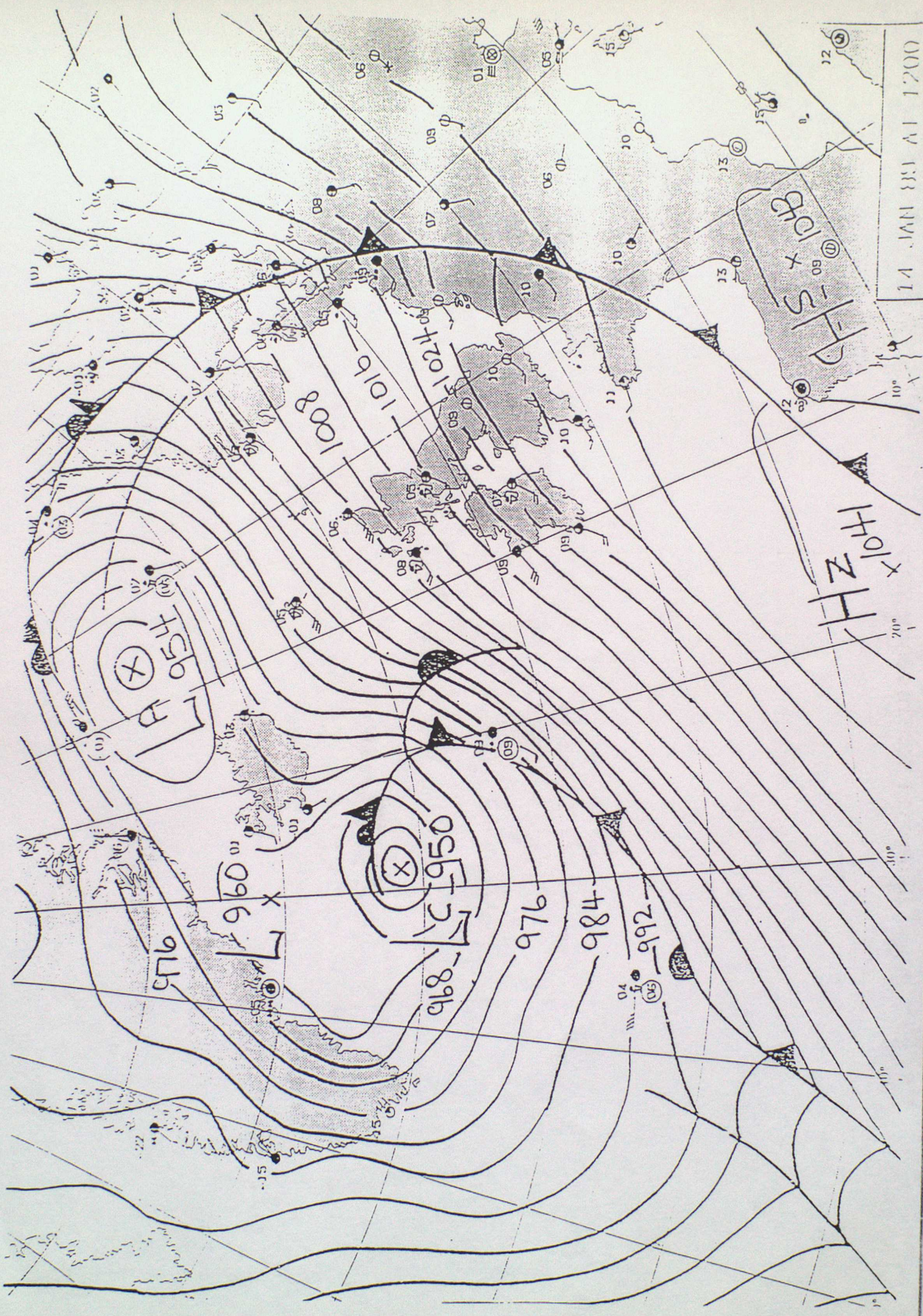


Variance from mean ascent rate (in m/s)



Shanwell Radiosonde Ascent 13/01/89 1137 GMT

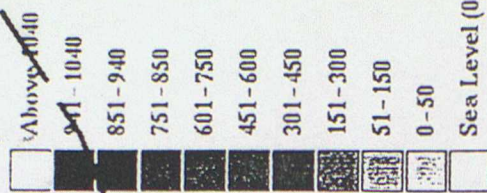




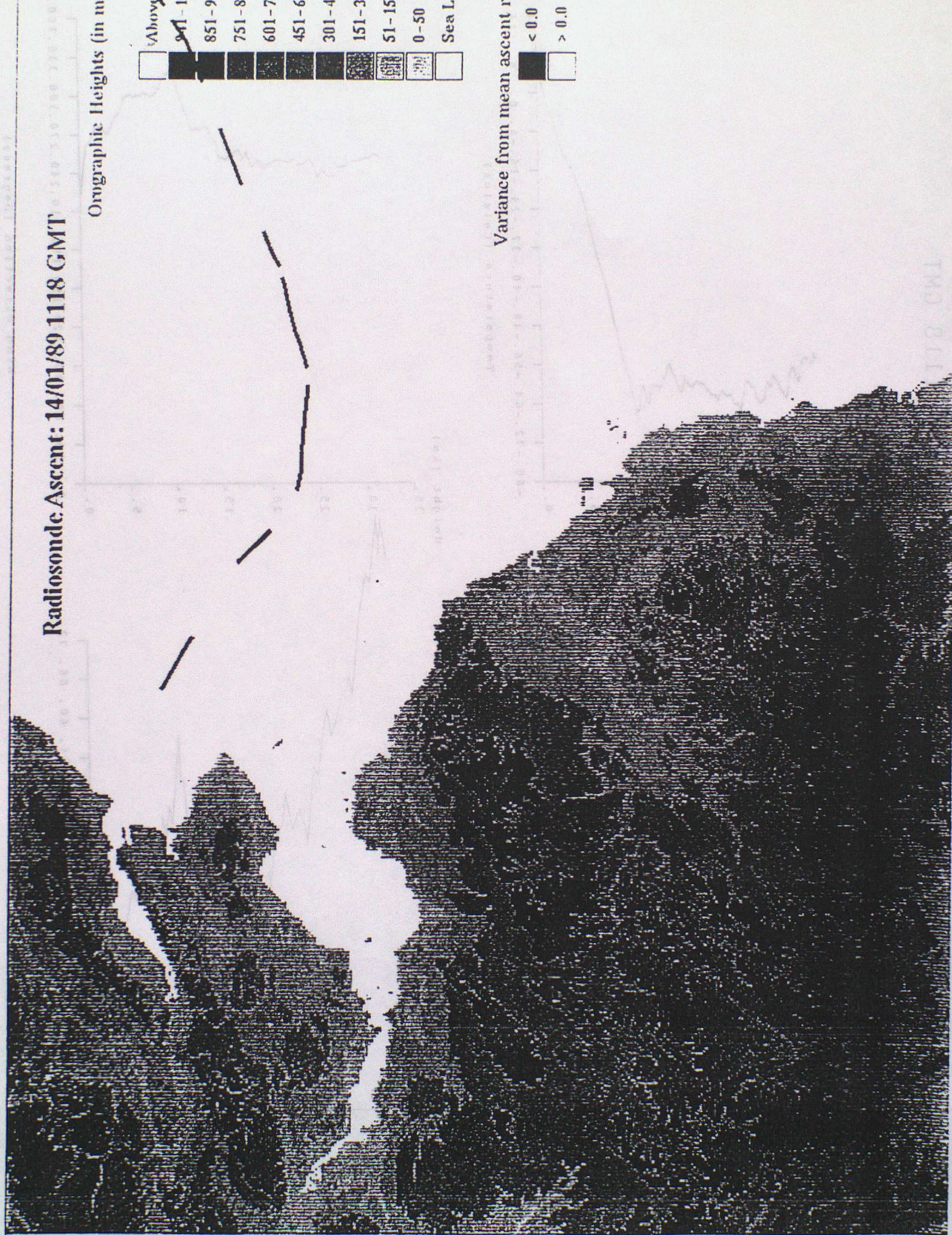
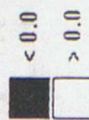
14 JAN 83 AT 1200

Radiosonde Ascent: 14/01/89 1118 GMT

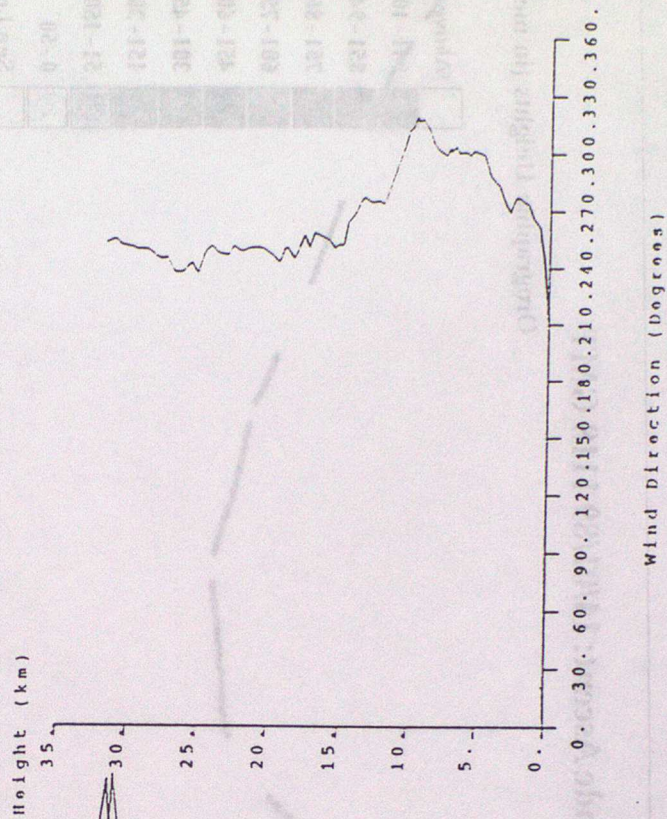
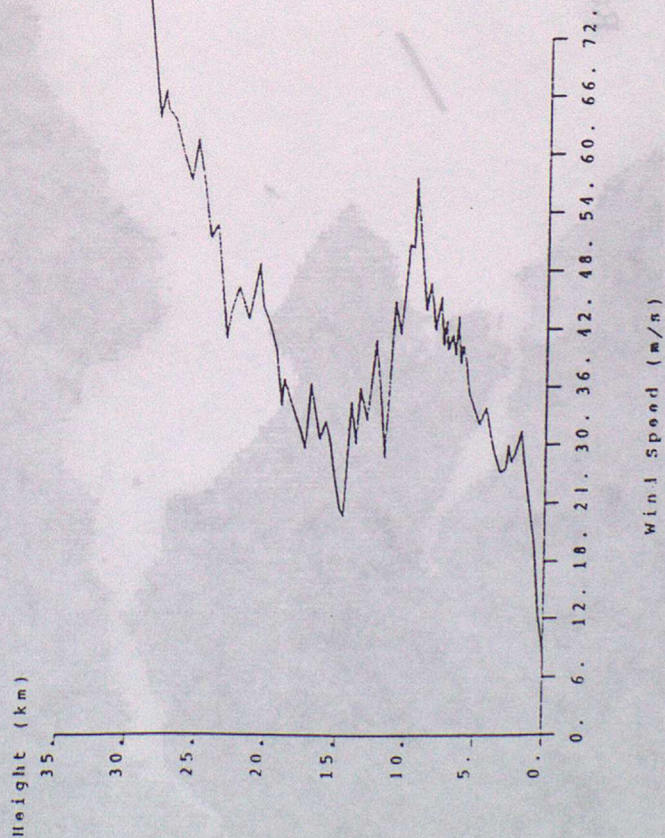
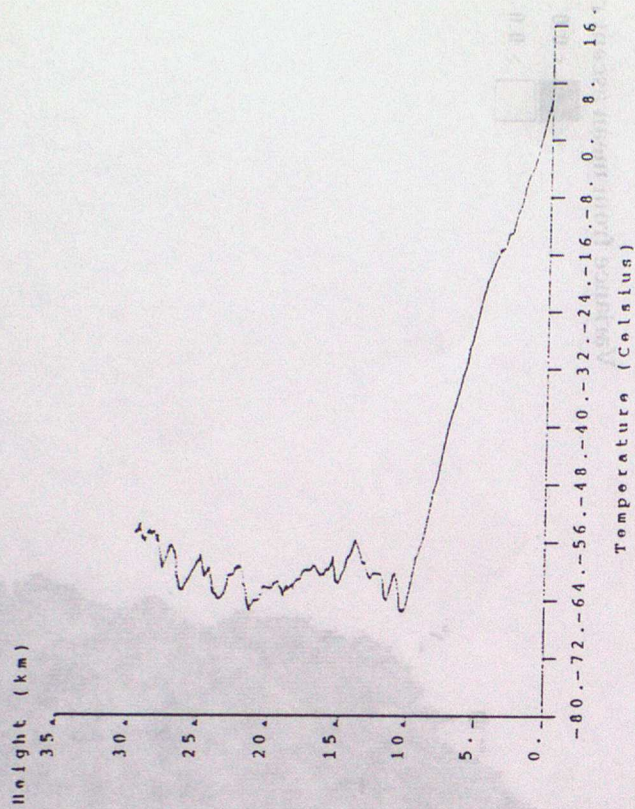
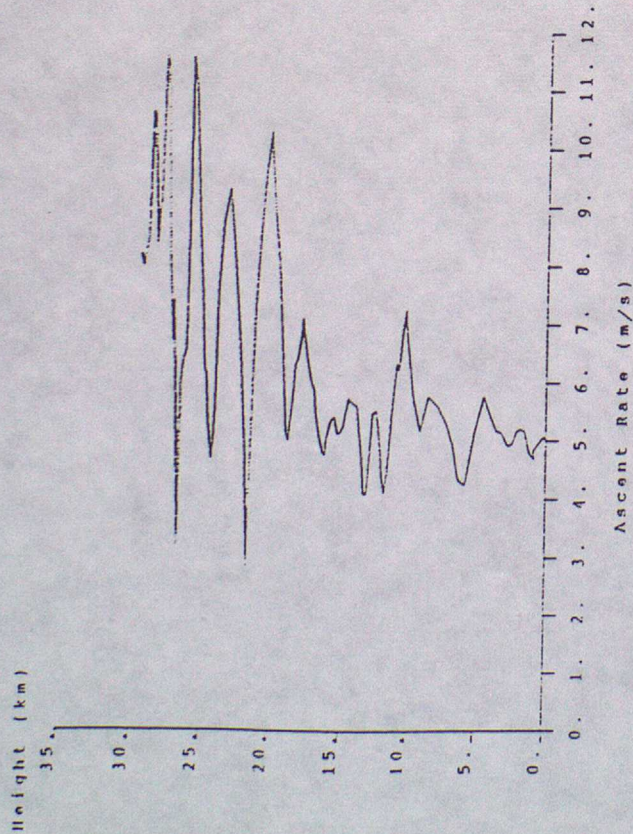
Ornographic Heights (in metres)



Variance from mean ascent rate (in m/s)



Shanwell Radiosonde Ascent 14/01/89 1118 GMT

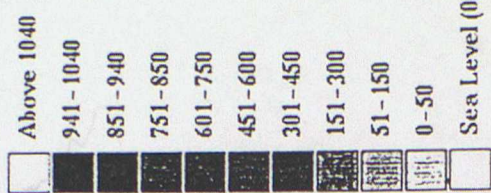




$\tau_A, \lambda_A, \beta_A, \gamma_A(\cdot)$

Radiosonde Ascent: 18/01/89 1119 GMT

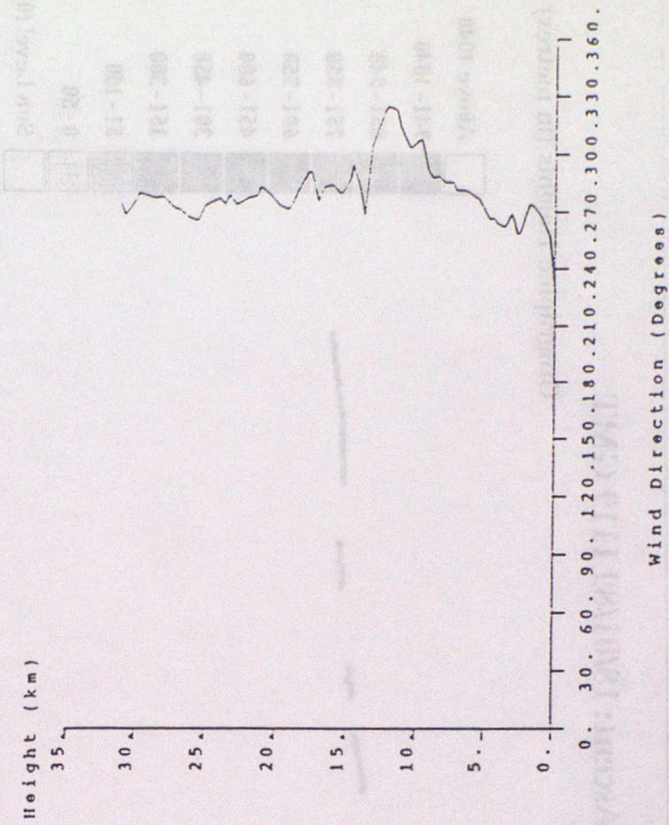
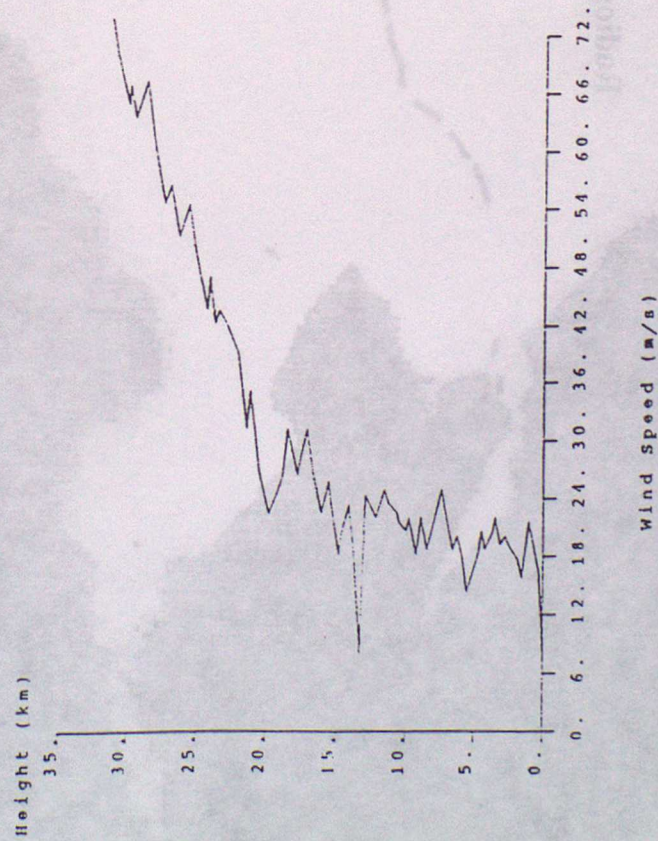
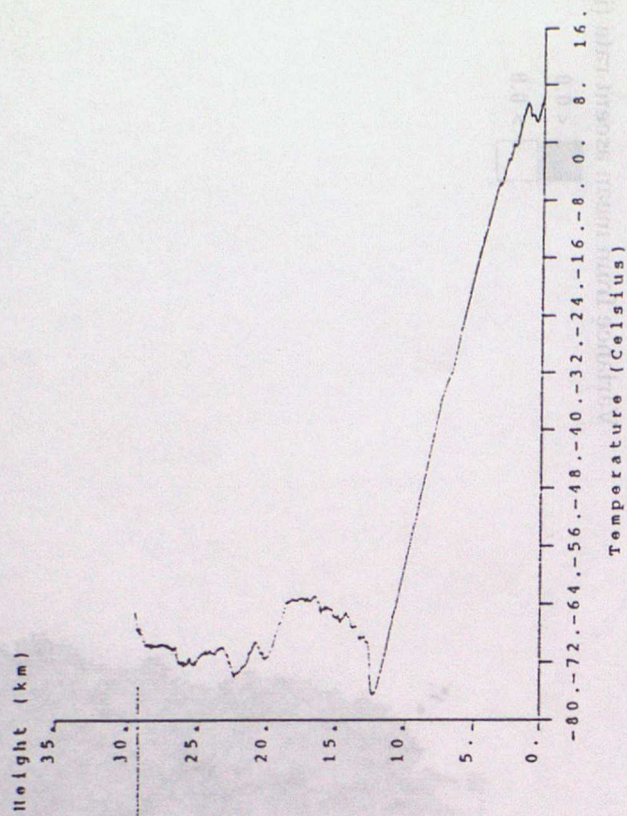
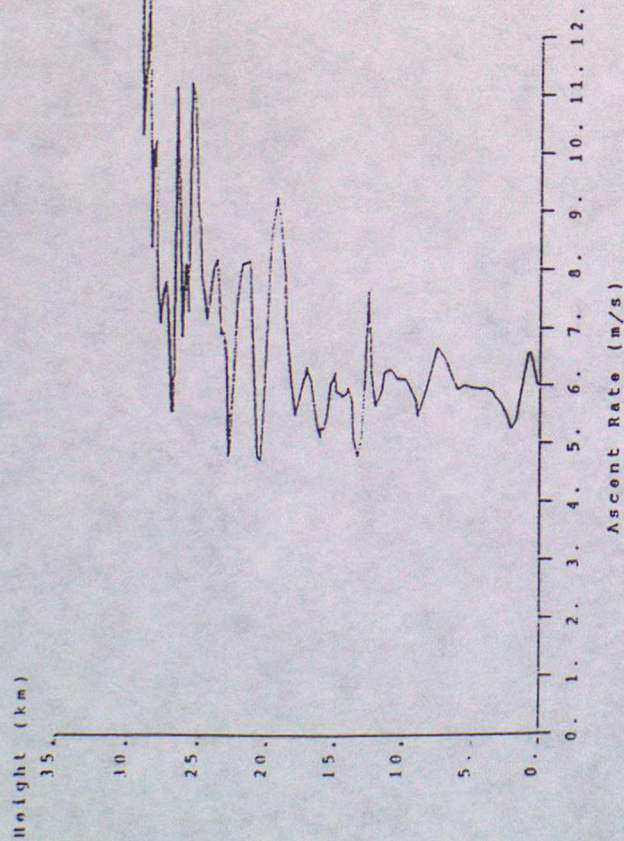
Orographic Heights (in metres)

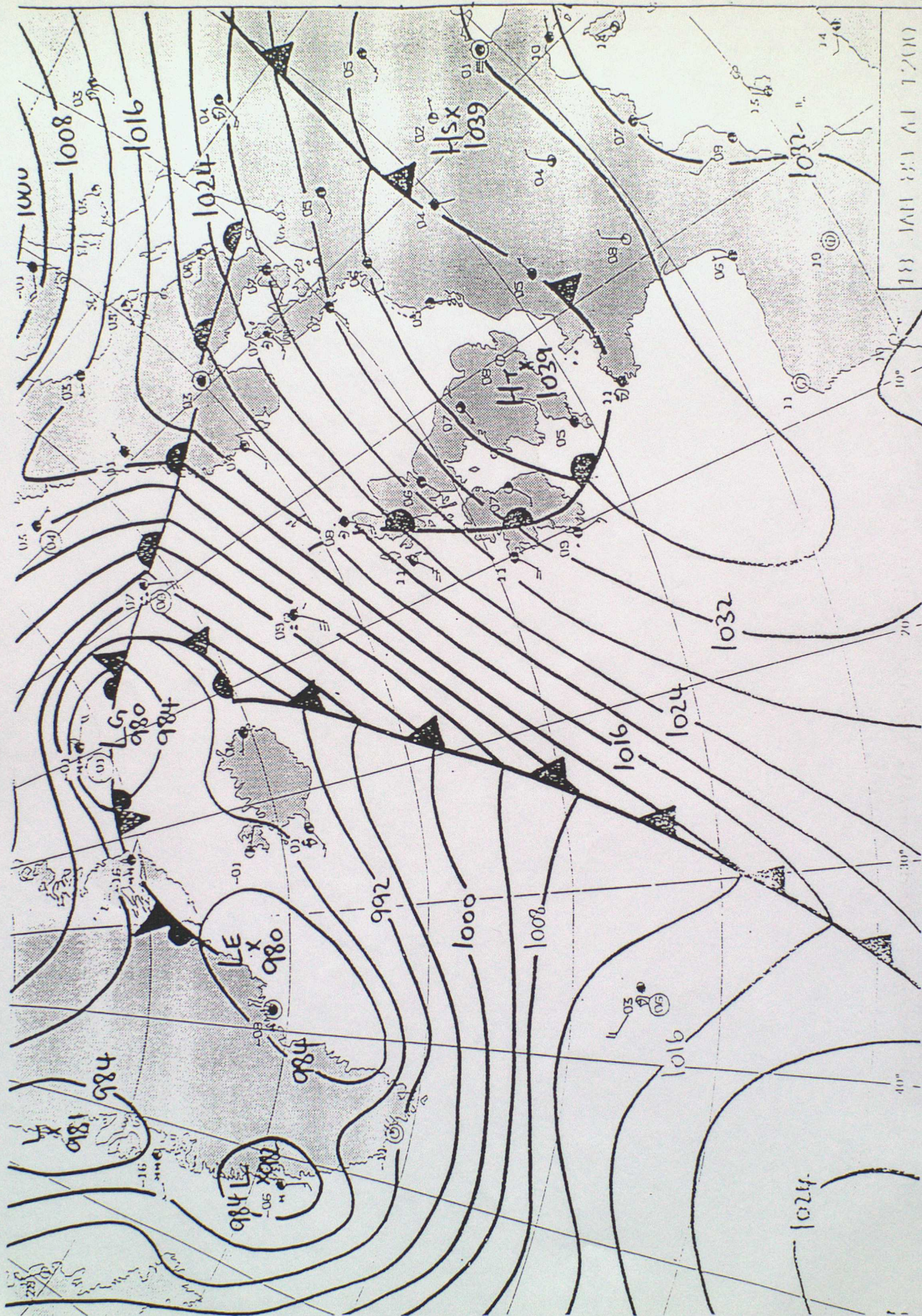


Variance from mean ascent rate (in m/s)



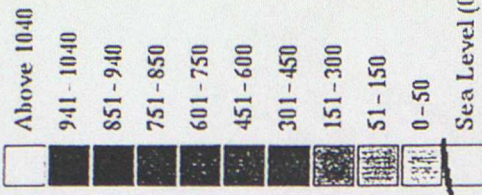
Shanwell Radiosonde Ascent 18/01/89 1119 GMT



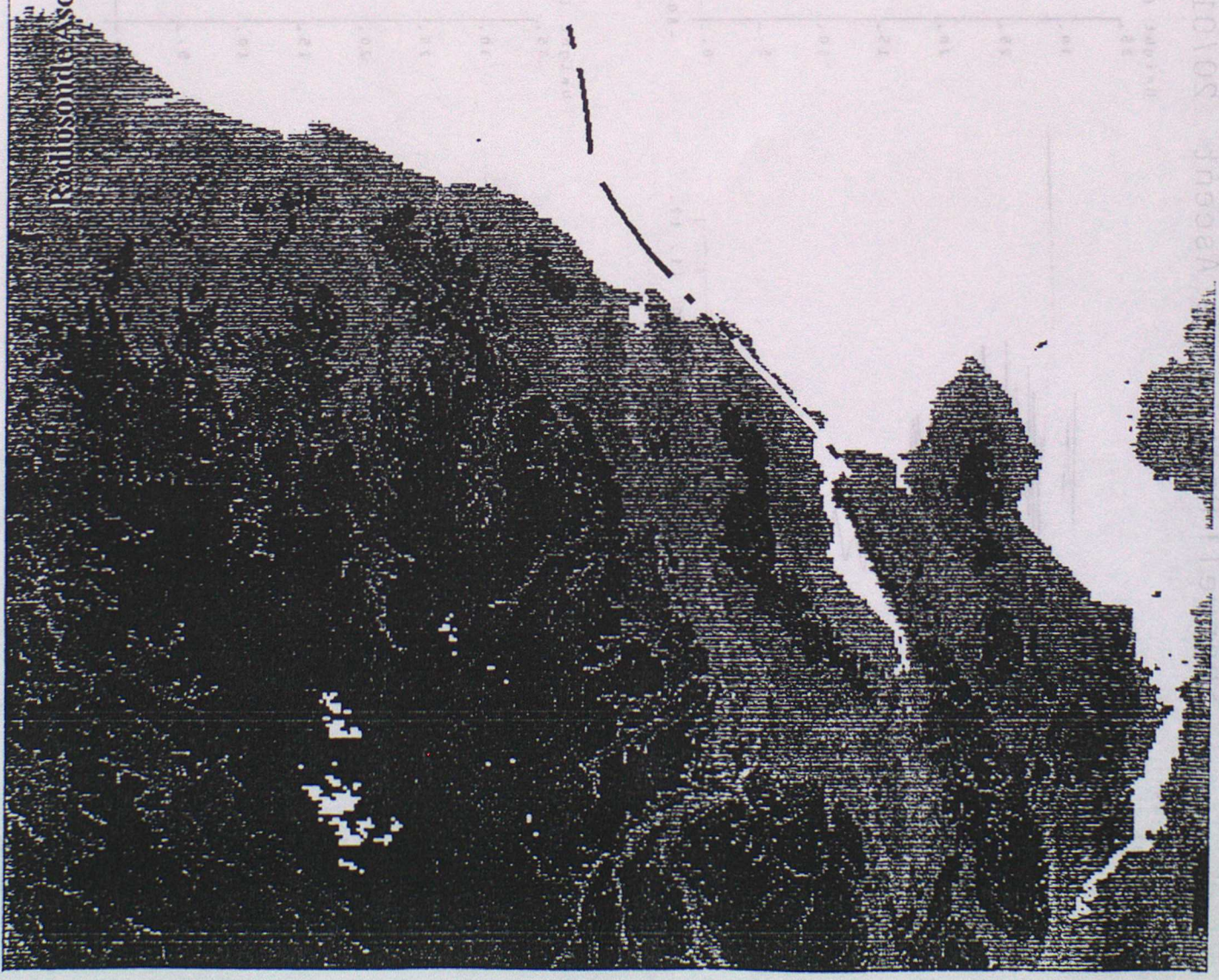
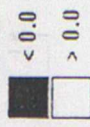


Radisonde Ascent: 20/01/89 1115 GMT

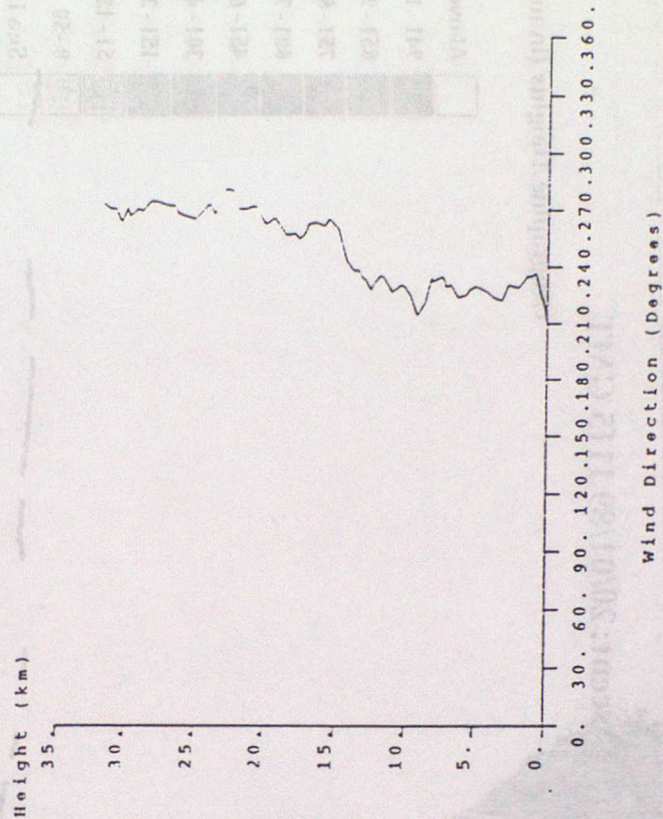
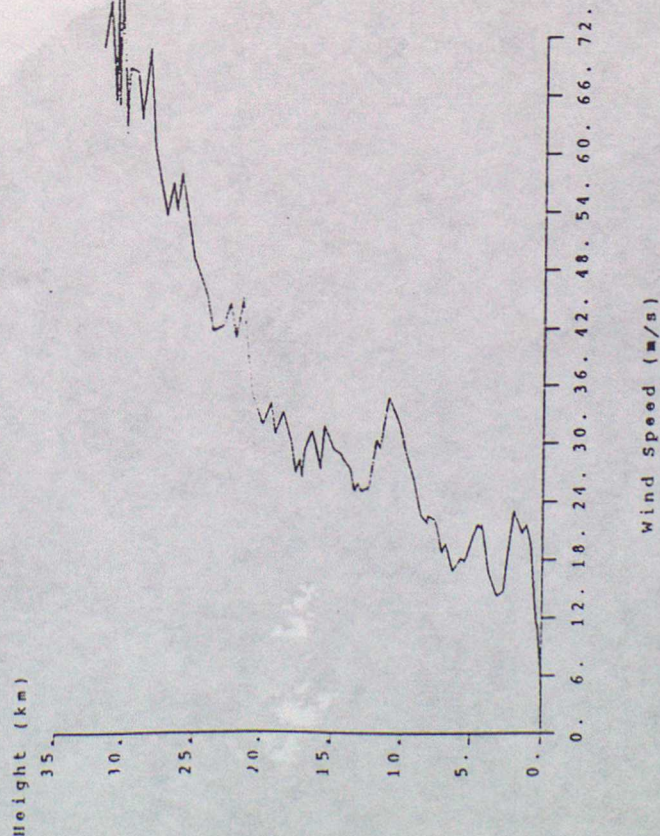
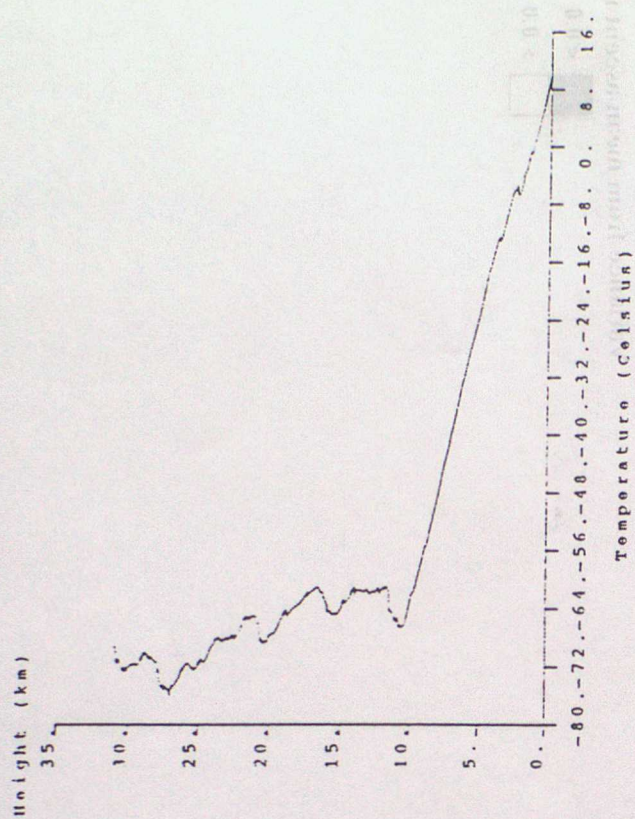
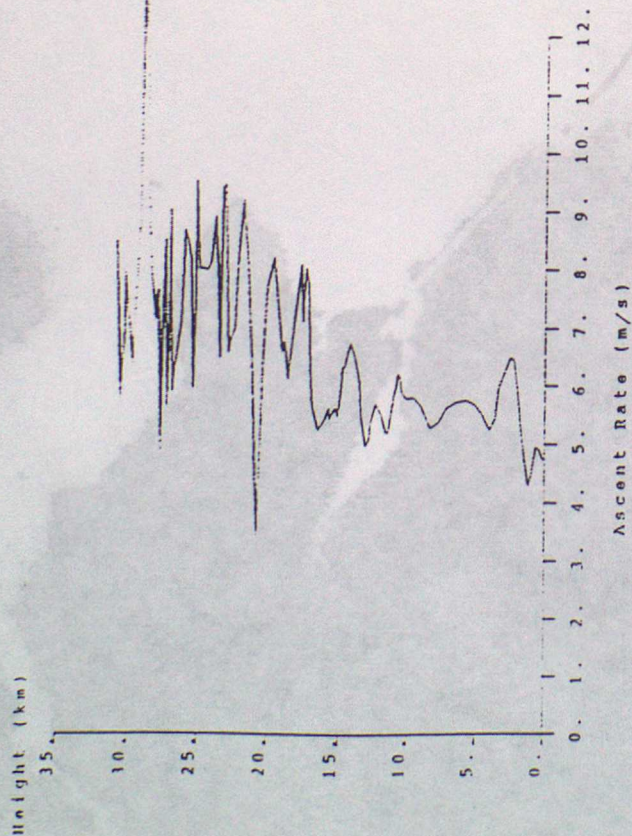
Orographic Heights (in metres)

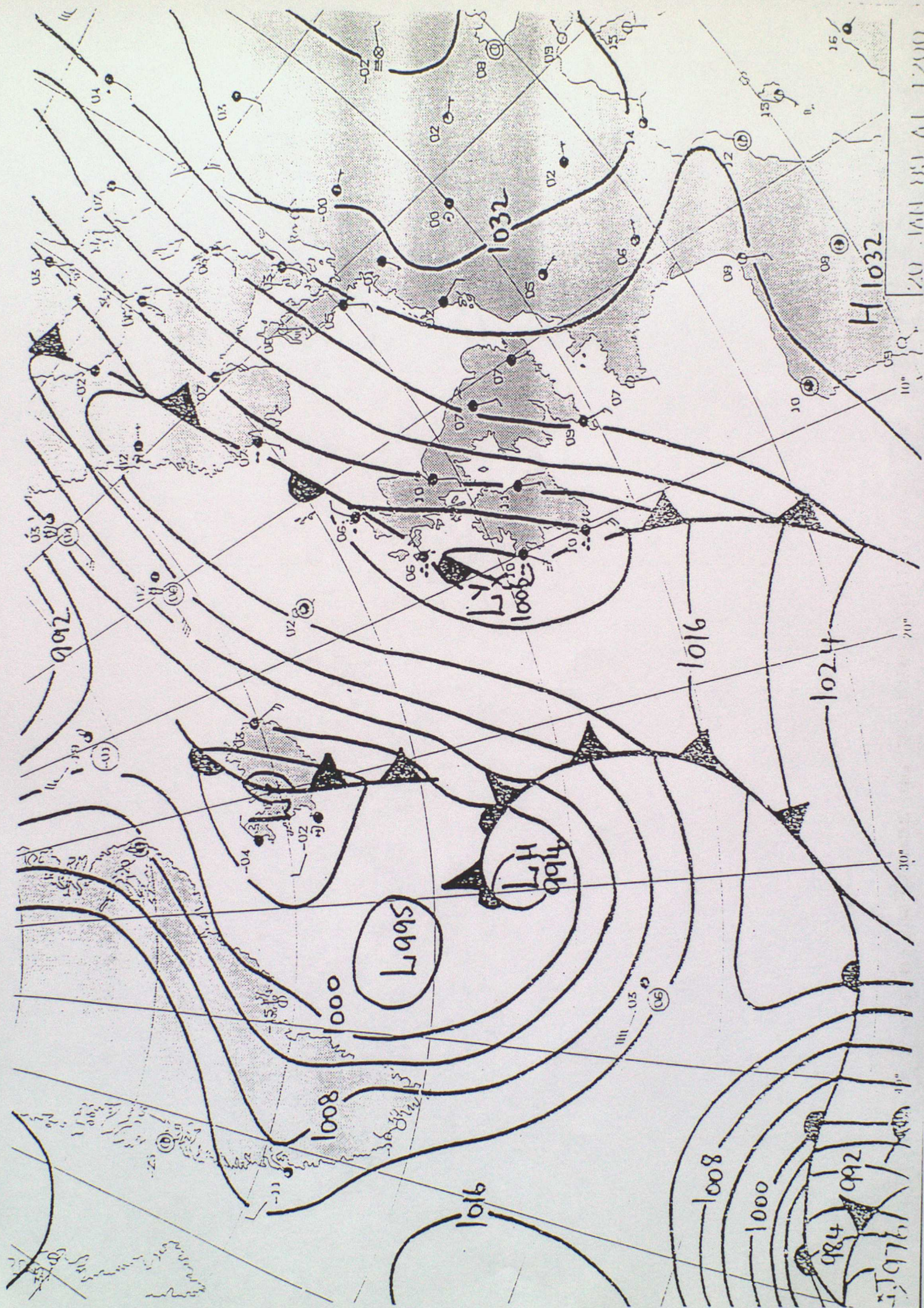


Variance from mean ascent rate (in m/s)



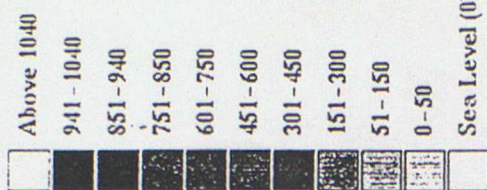
Shanwell Radiosonde Ascent 20/01/89 1115 GMT



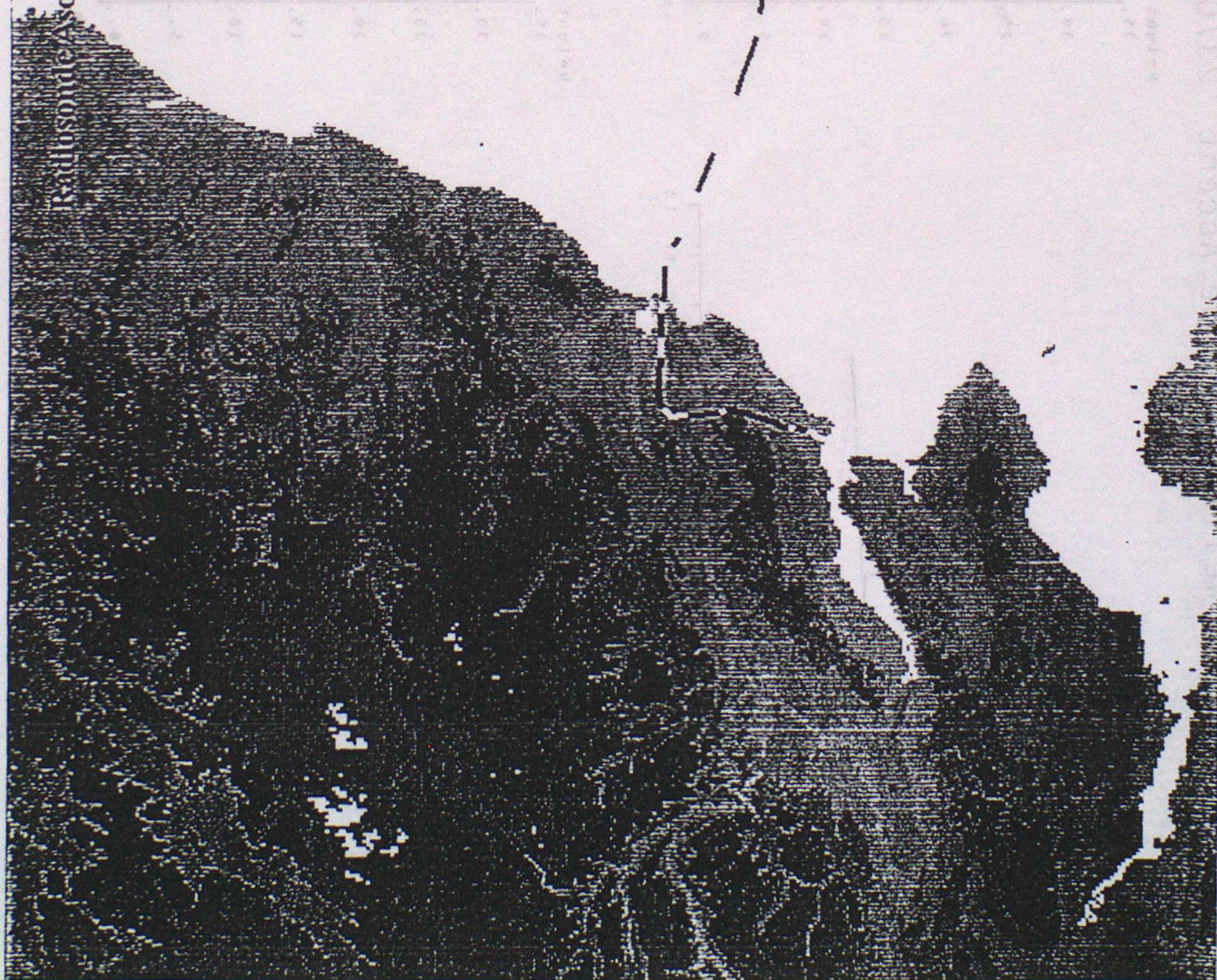
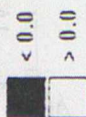


Radlosonde Ascent: 23/01/89 2318 GMT

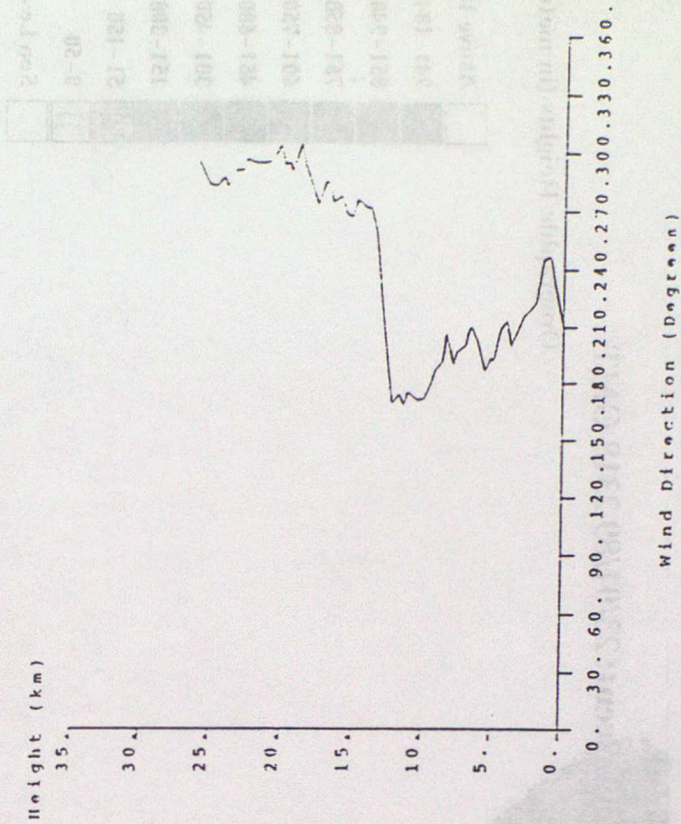
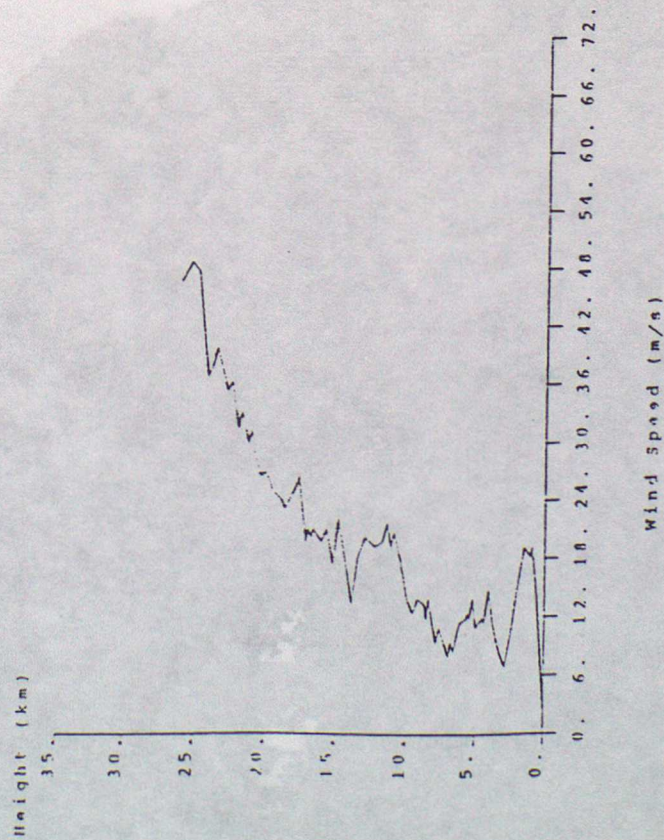
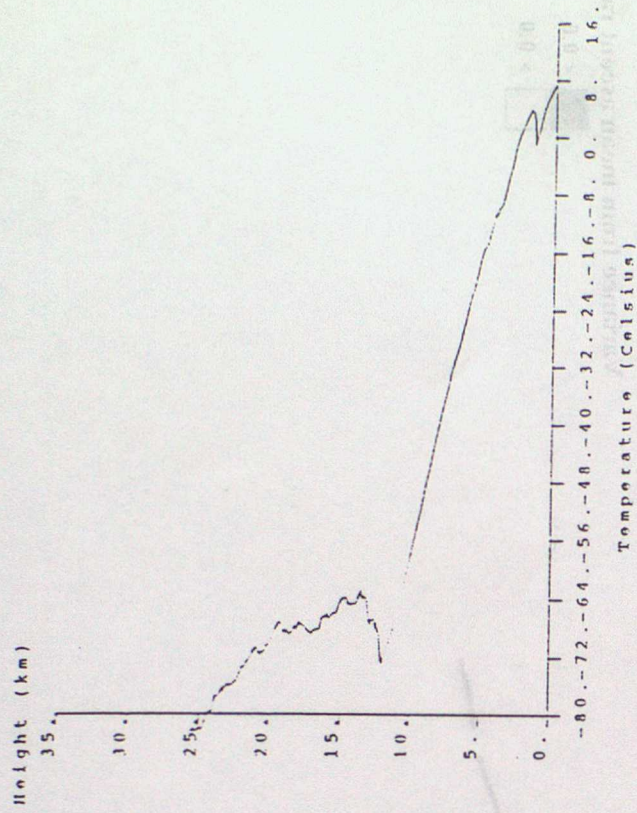
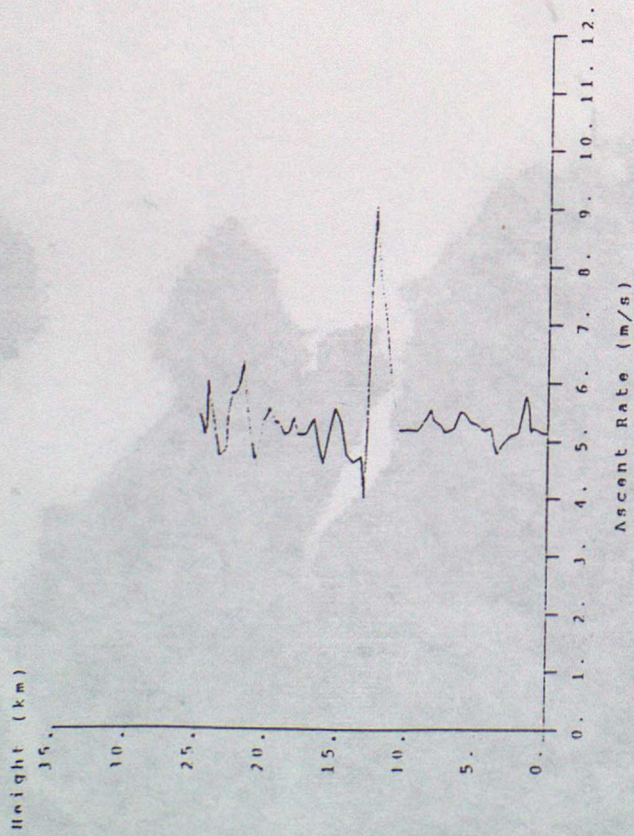
Orographic Heights (in metres)

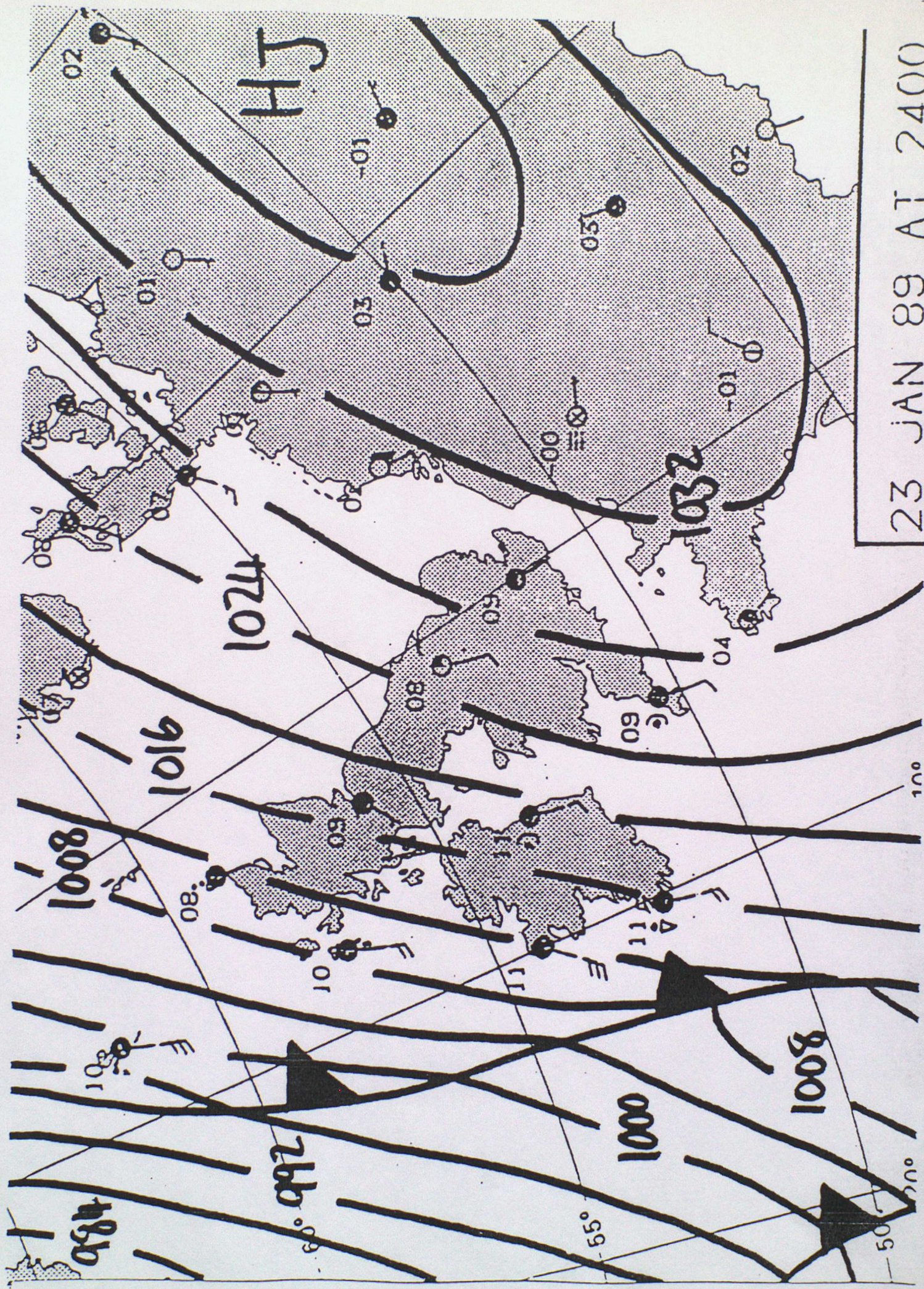


Variance from mean ascent rate (in m/s)



Shanwell Radiosonde Ascent 23/01/89 2318 GMT

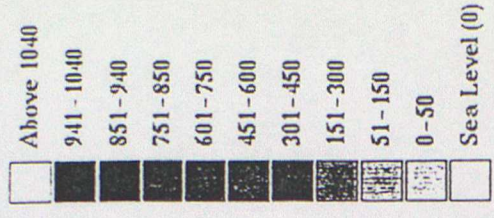




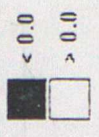
23 JAN 89 AT 2400



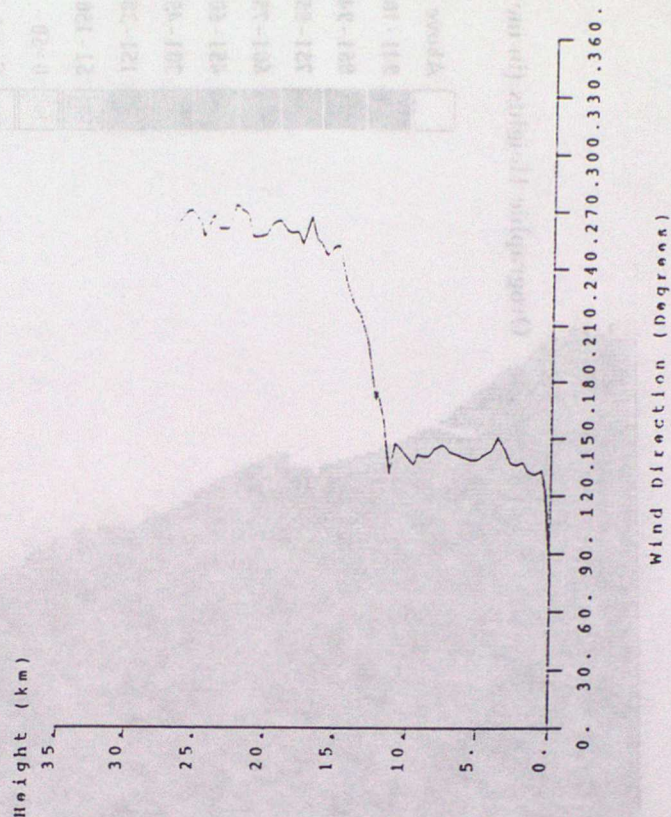
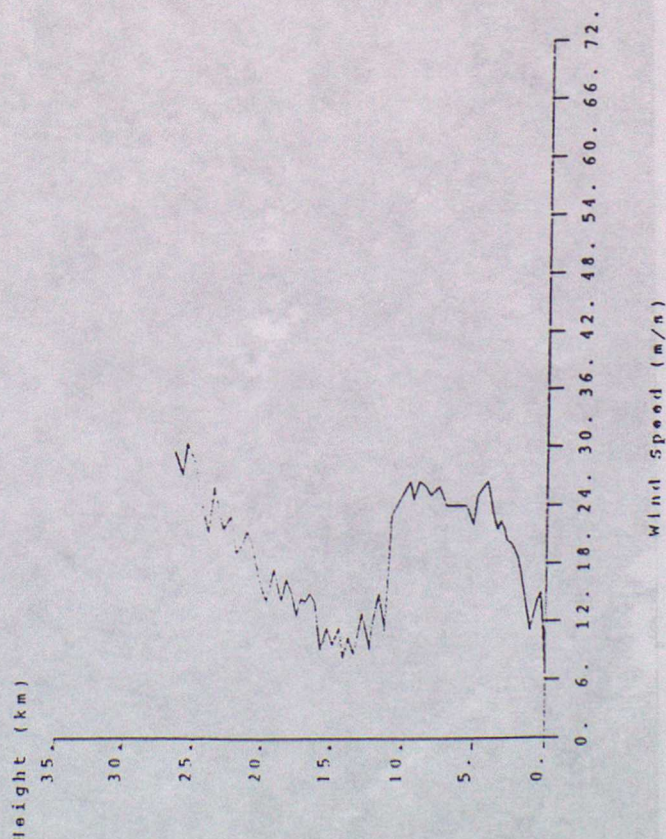
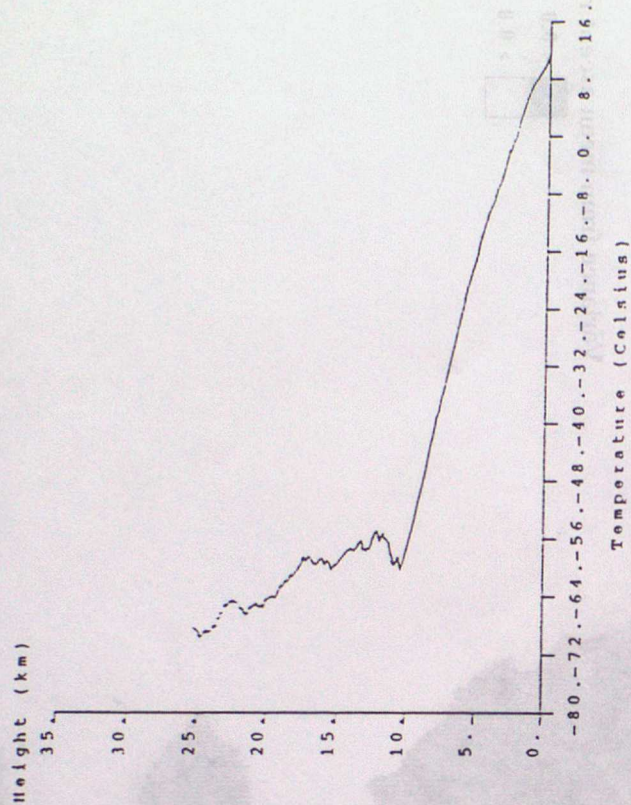
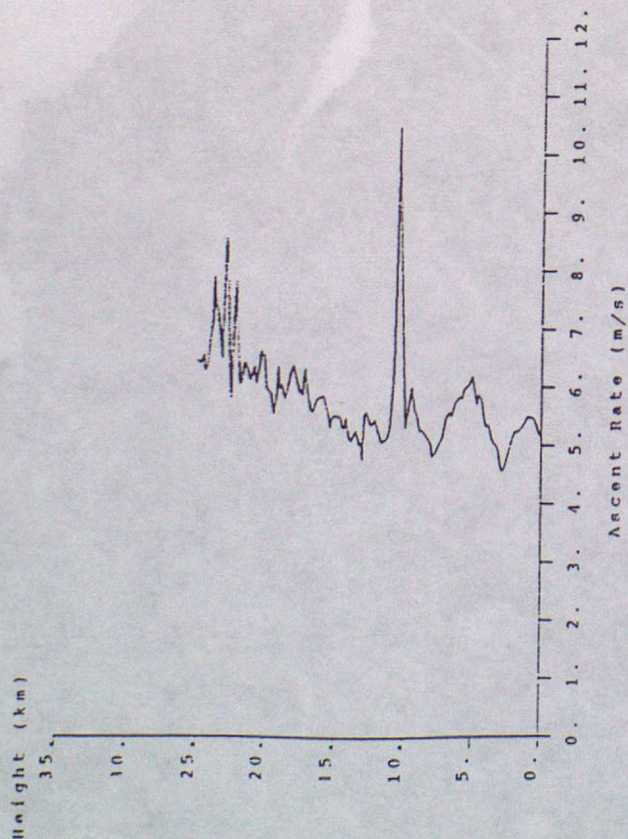
Orographic Heights (in metres)



Variance from mean ascent rate (in m/s)



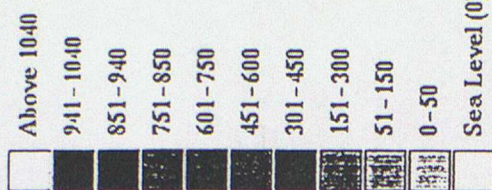
Shanwell Radiosonde Ascent 28/10/89 1115 GMT



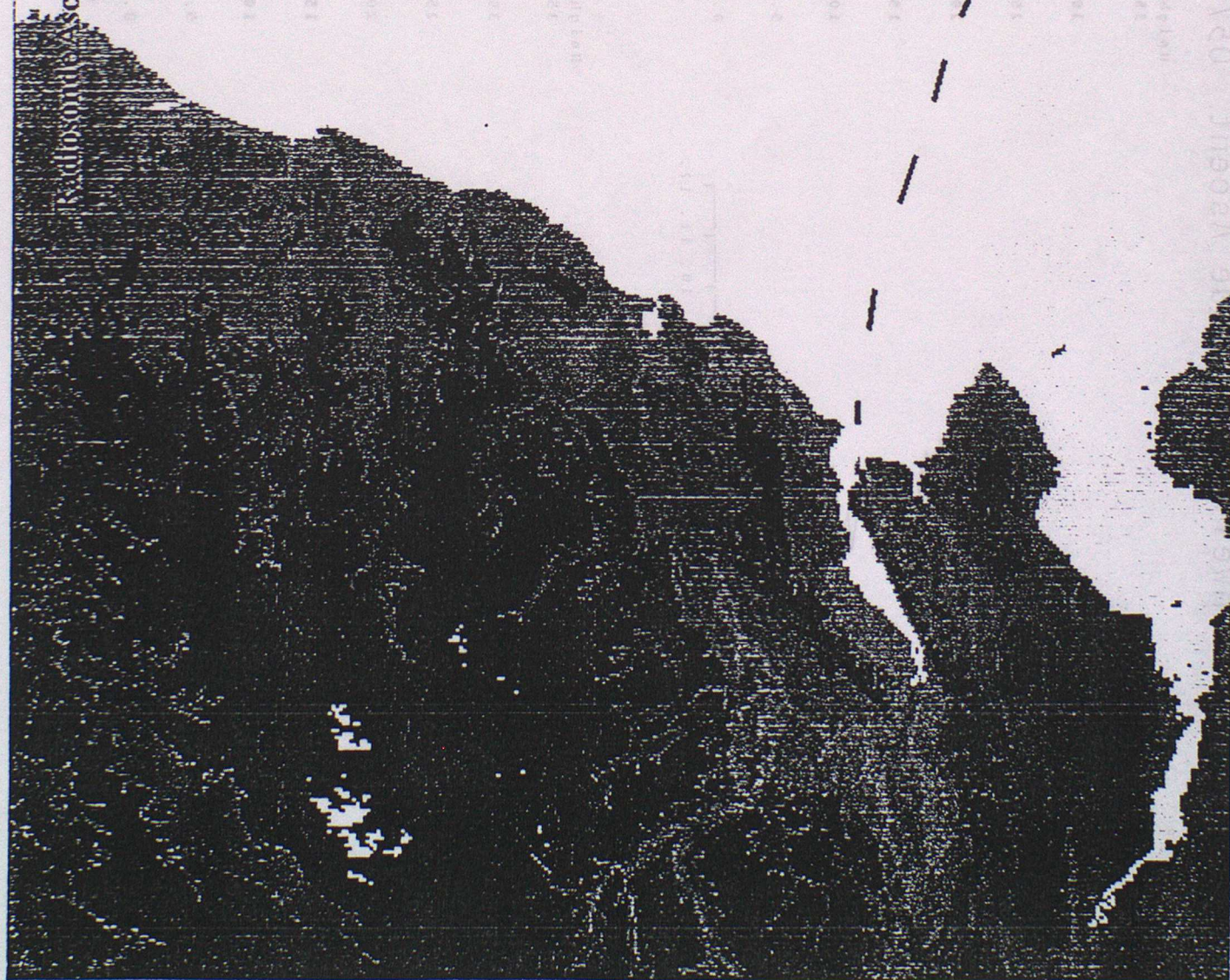
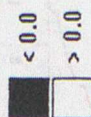


Radioonde Ascent: 05/10/90 1117 GMT

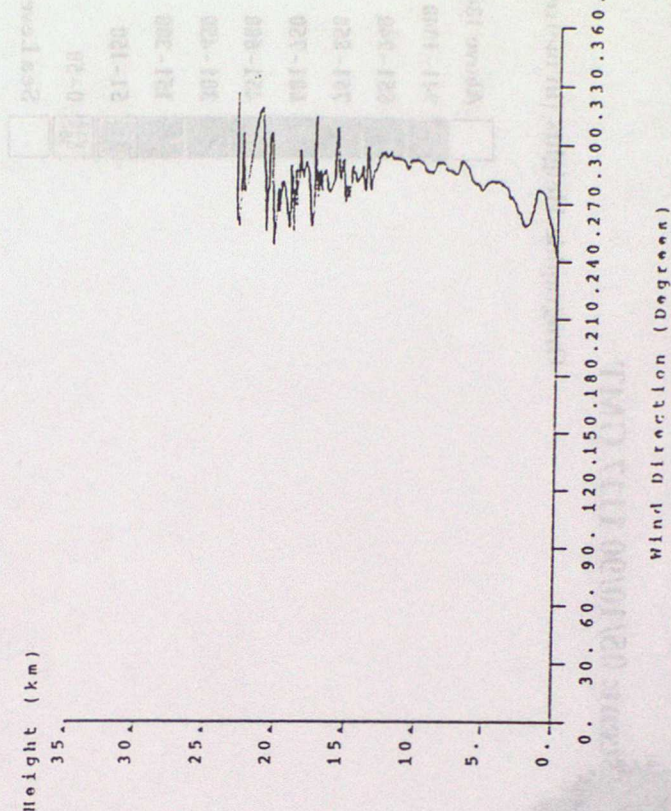
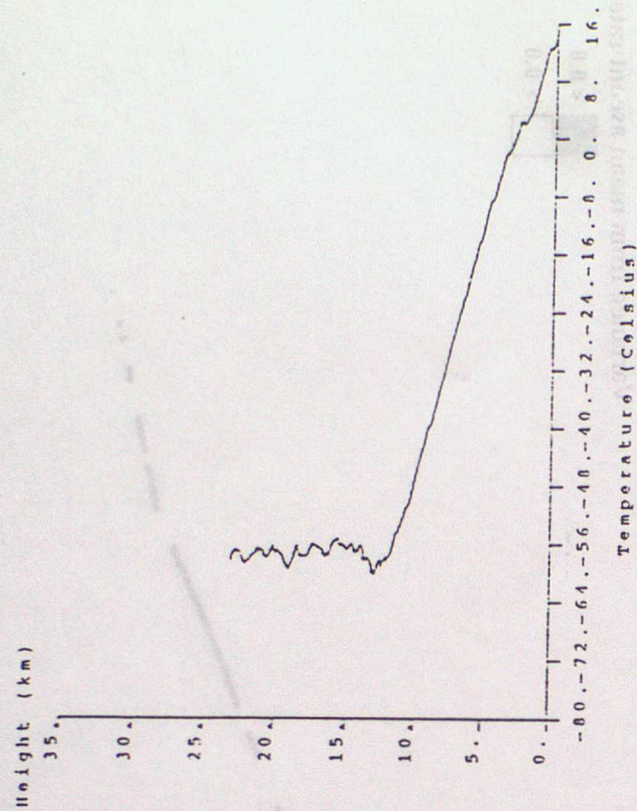
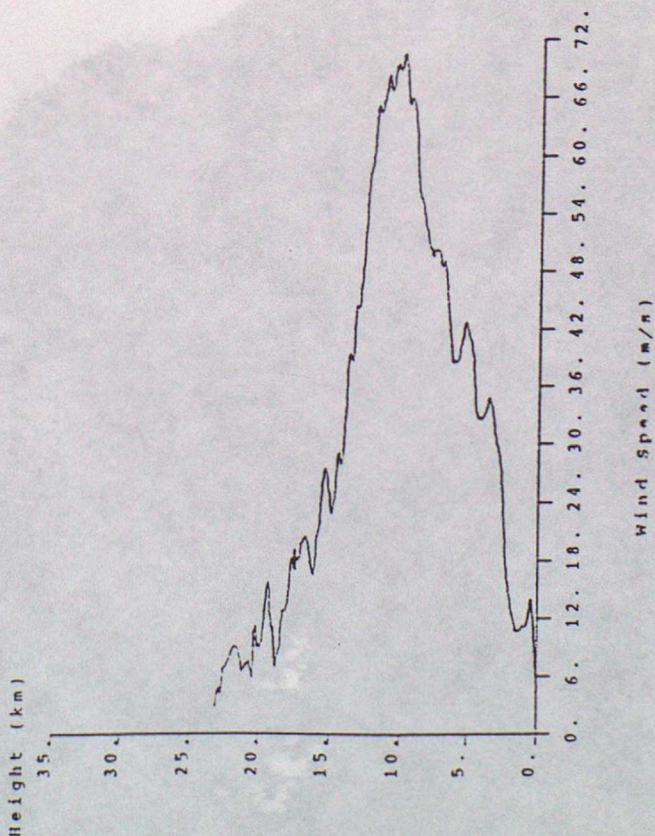
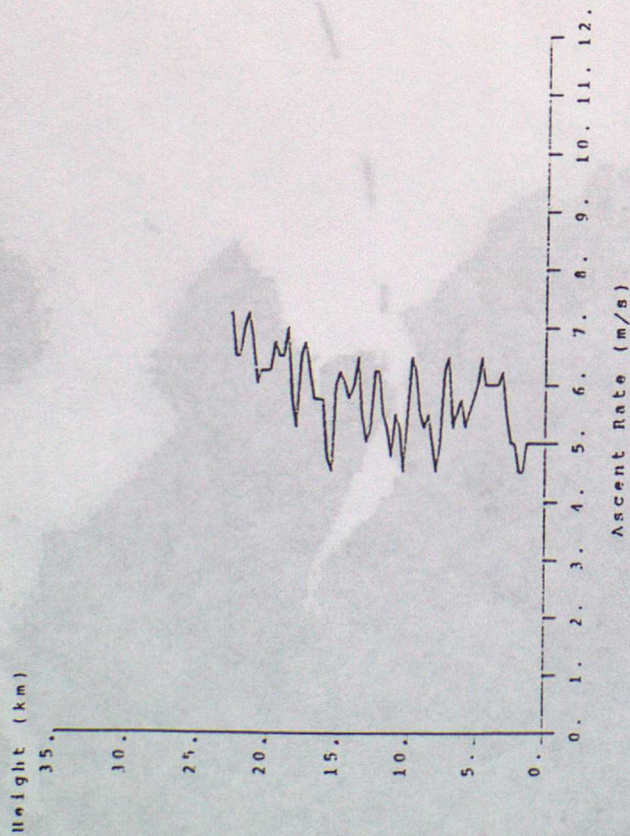
Orographic Heights (in metres)

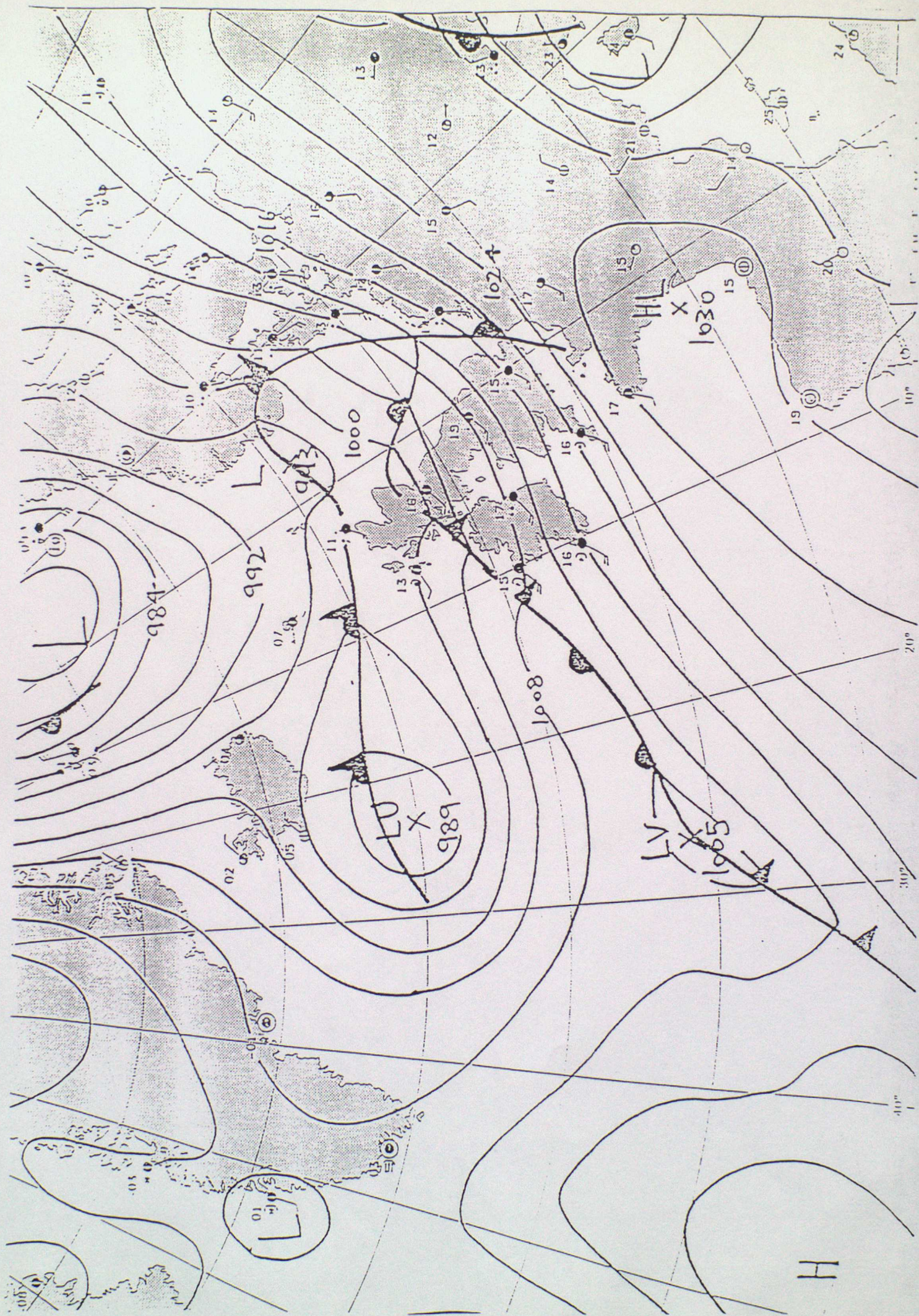


Variance from mean ascent rate (in m/s)



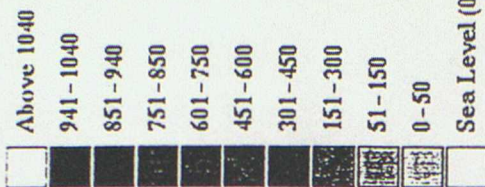
Shanwell Radiosonde Ascent 05/10/90 1117 GMT



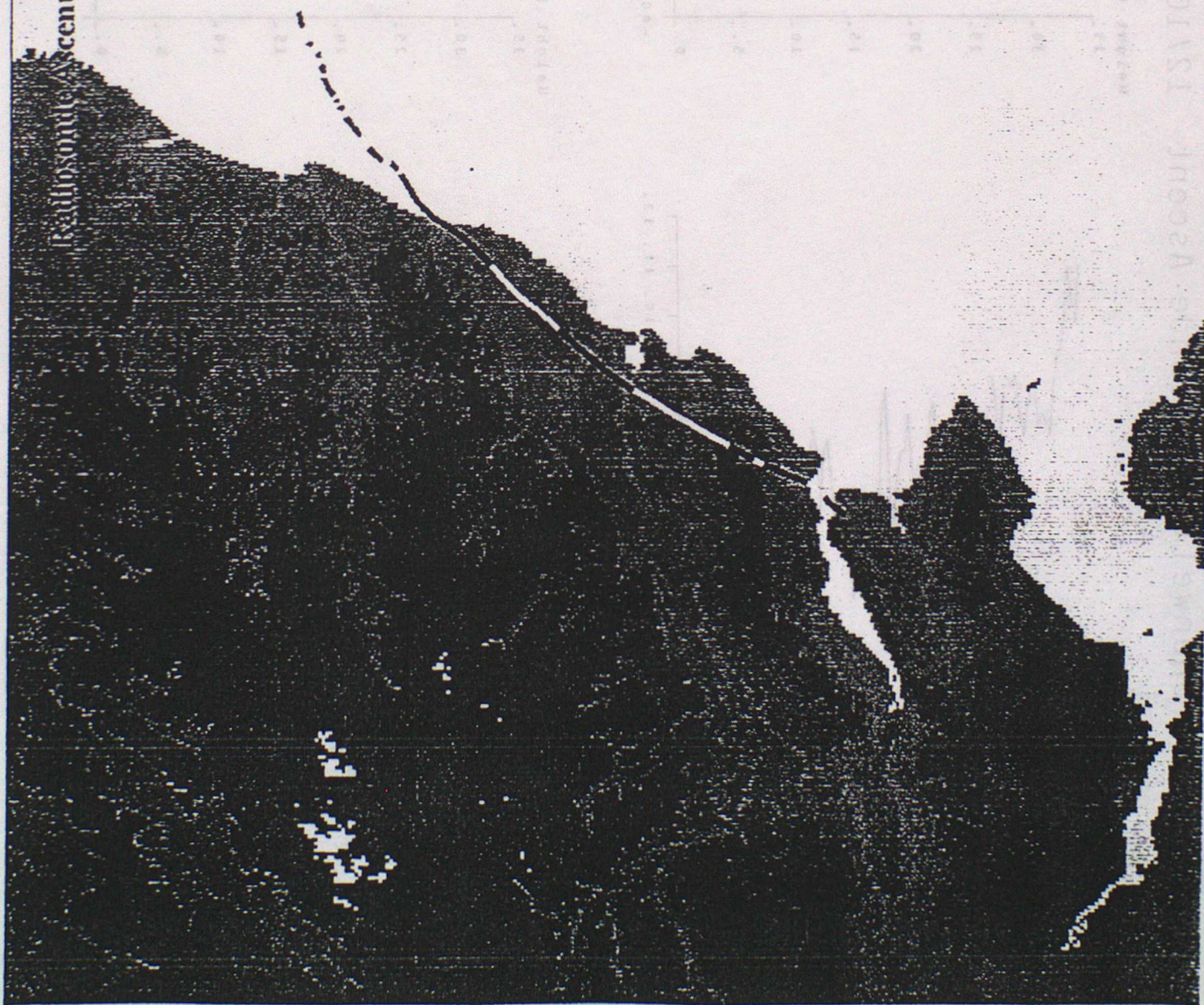


Radioonde Ascent: 12/10/90 1116 GMT

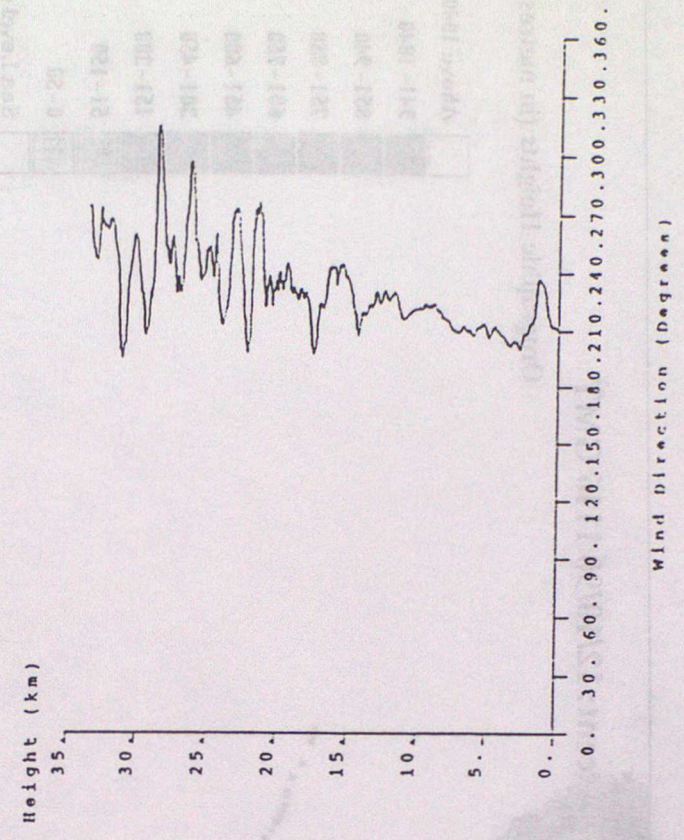
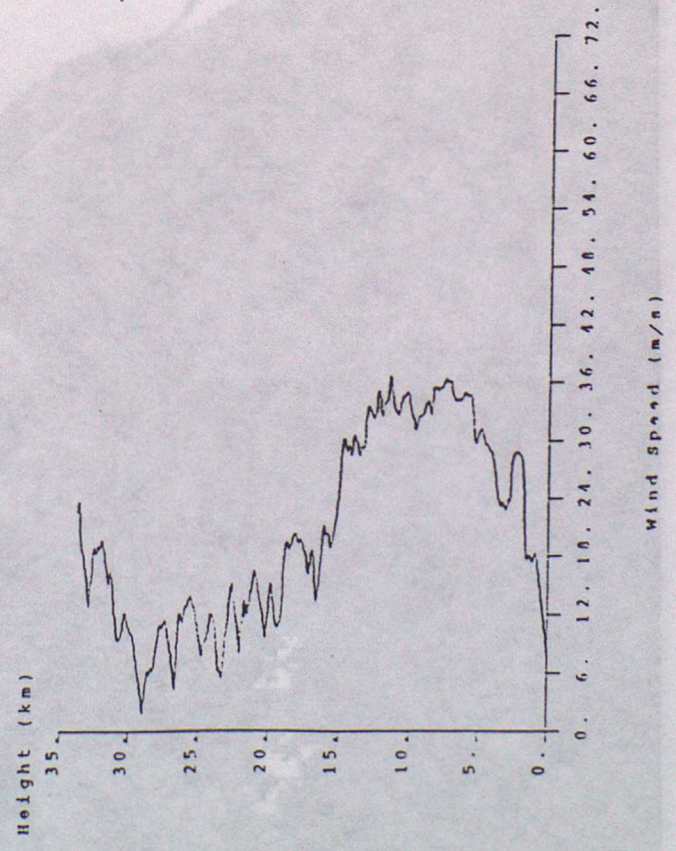
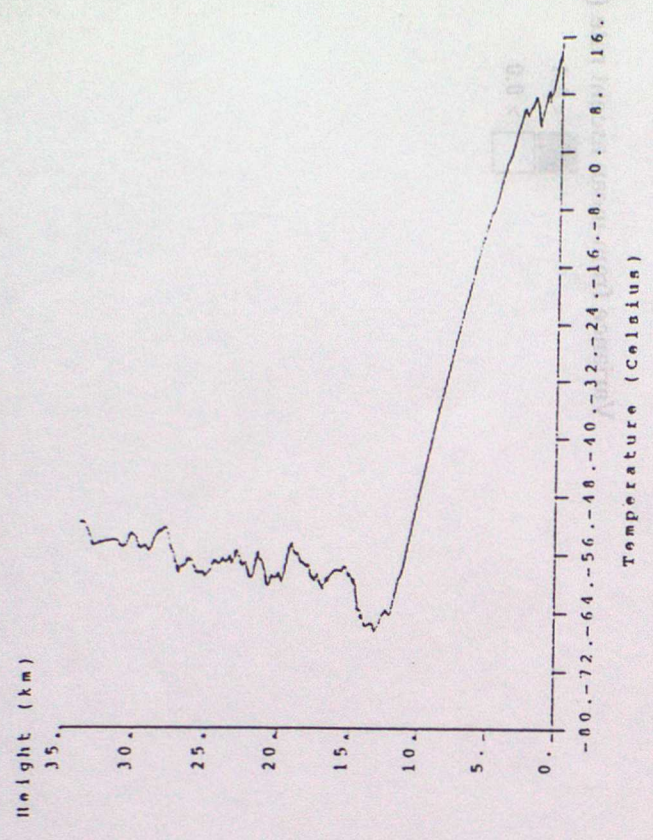
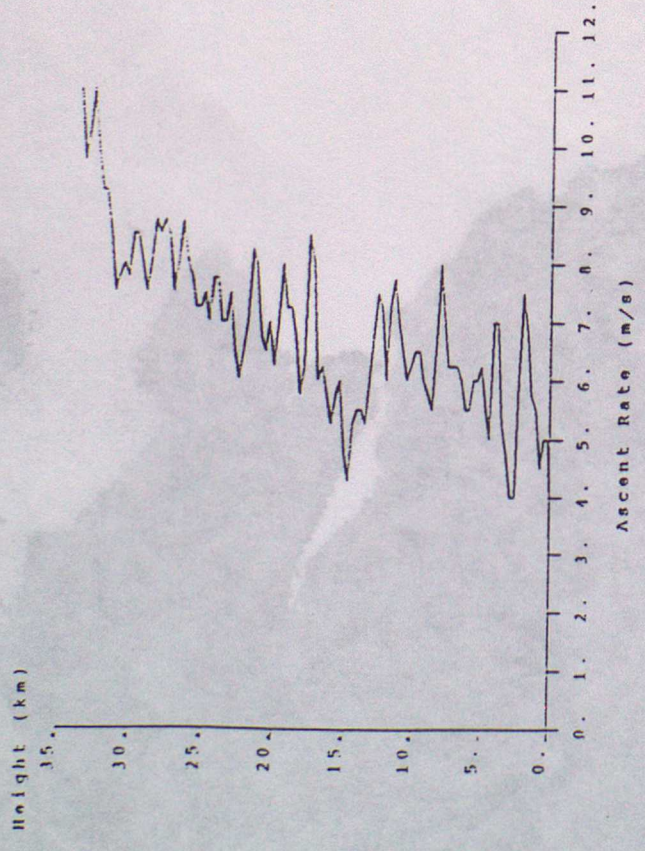
Orographic Heights (in metres)



Variance from mean ascent rate (in m/s)



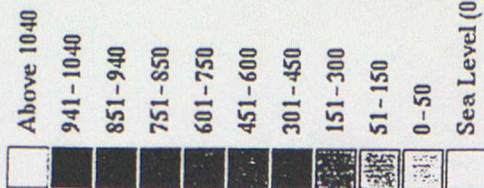
Shanwell Radiosonde Ascent 12/10/90 1116 GMT





Radioonde Ascent: 16/10/90 1116 GMT

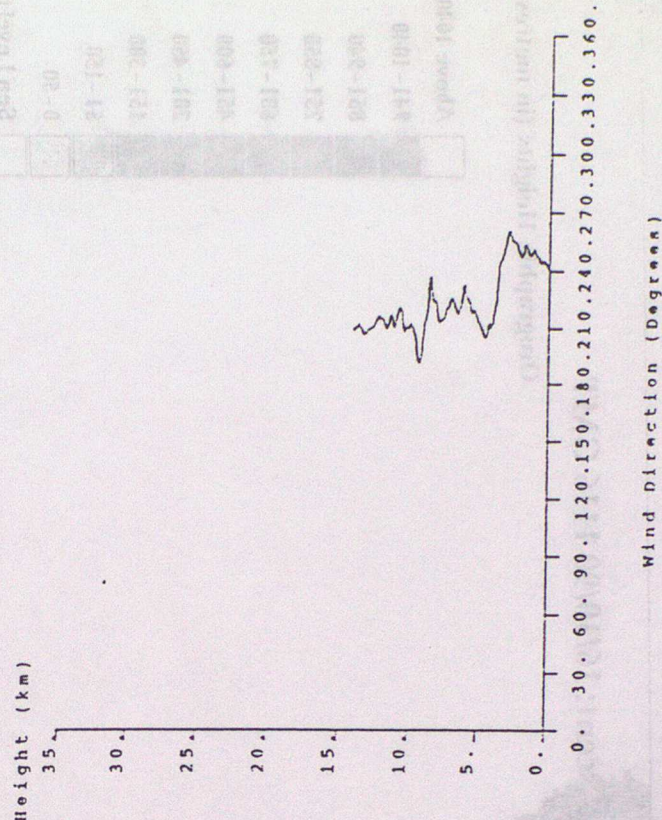
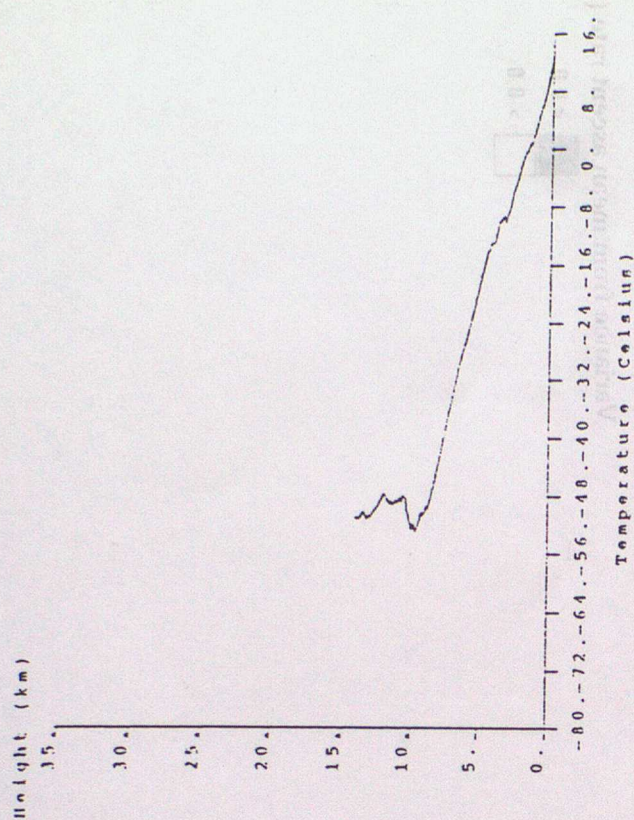
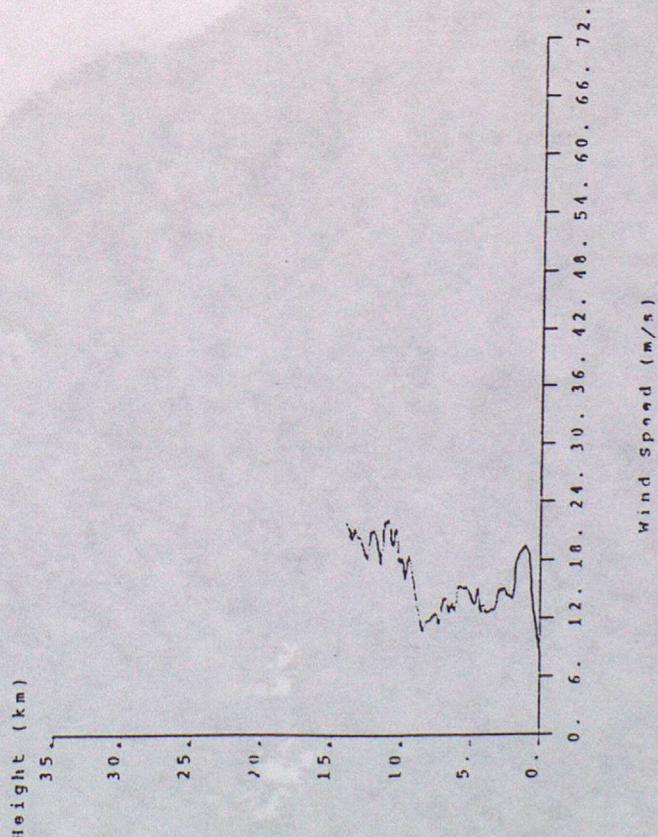
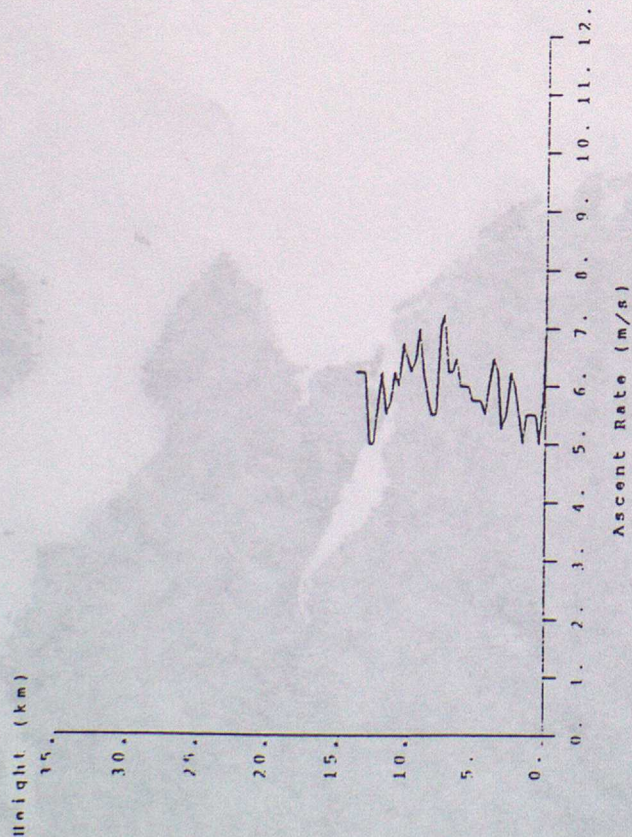
Orographic Heights (in metres)



Variance from mean ascent rate (in m/s)



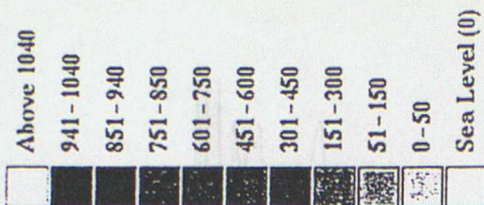
Shanwell Radiosonde Ascent 16/10/90 1116 GMT





Radio Route Ascent: 26/10/90 1116 GMT

Orographle Heights (in metres)

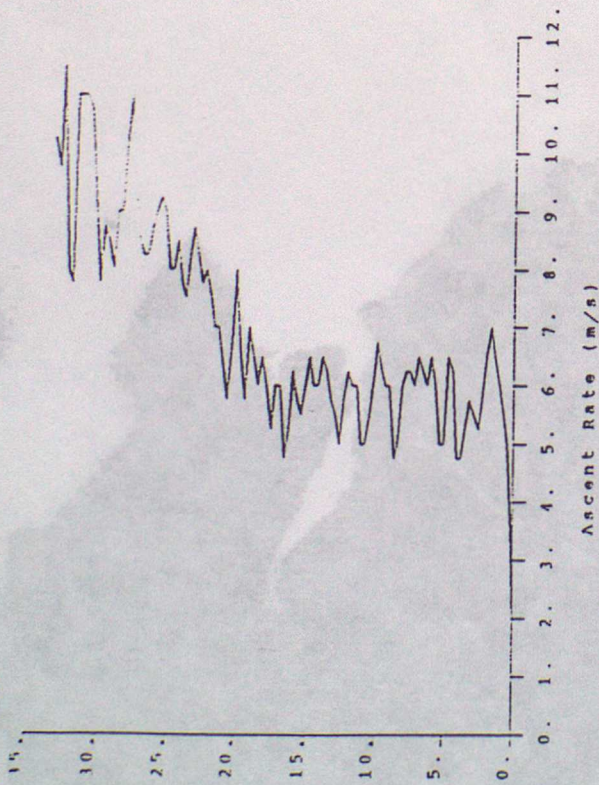


Variance from mean ascent rate (in m/s)

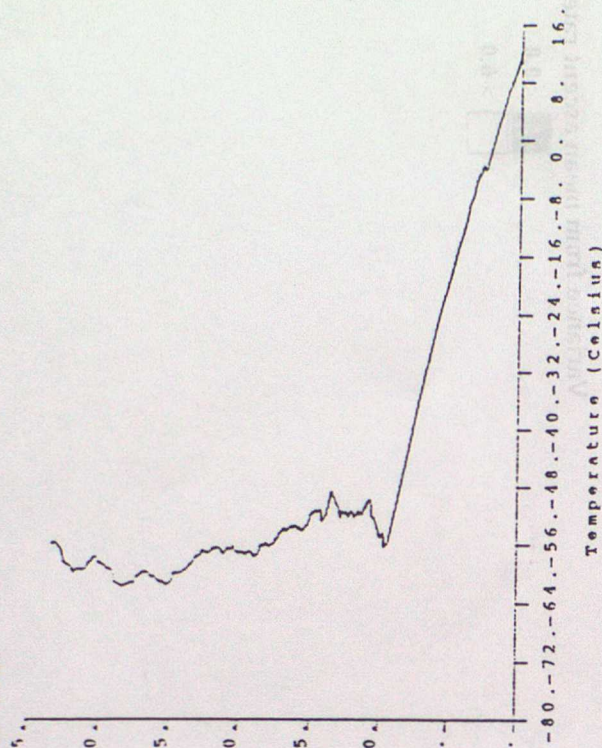


Shanwell Radiosonde Ascent 26/10/90 1116 GMT

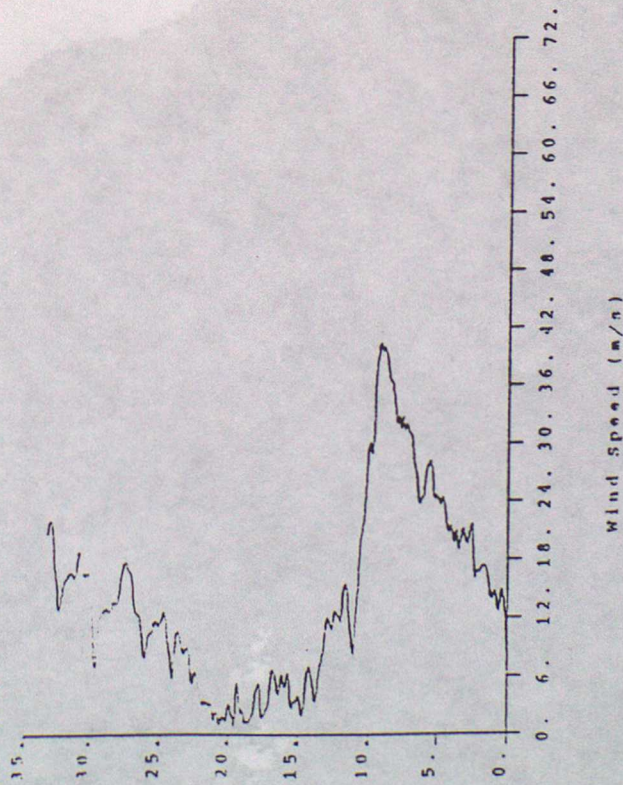
Height (km)



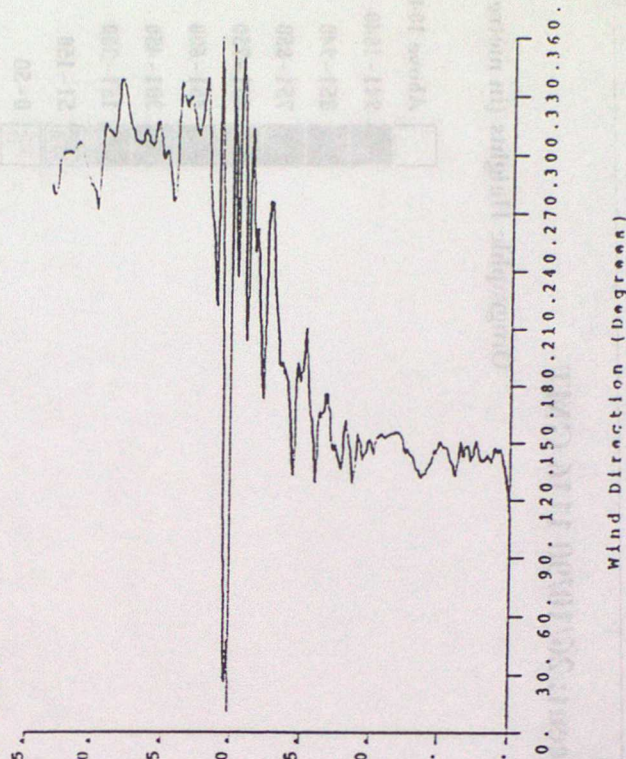
Height (km)

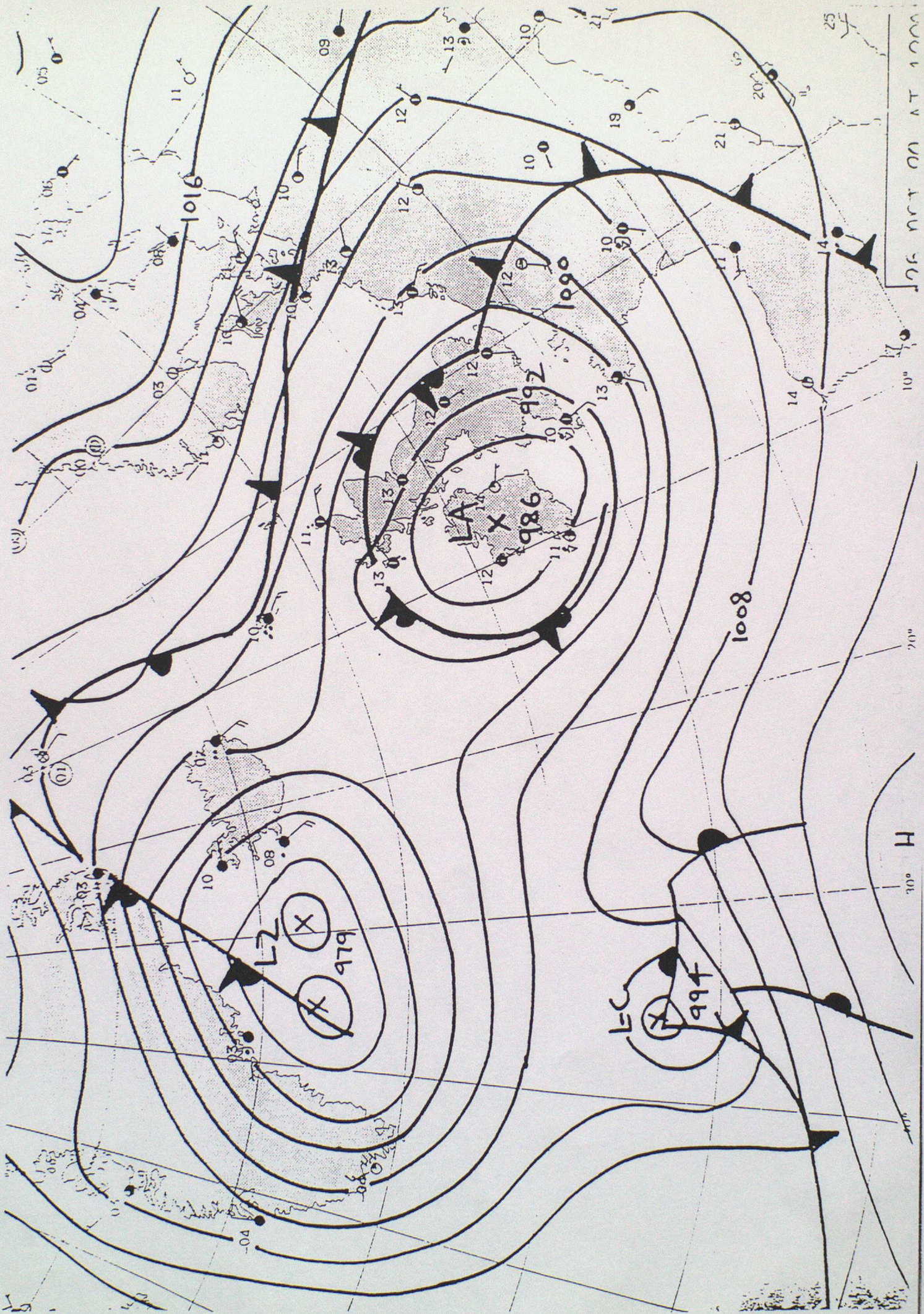


Height (km)



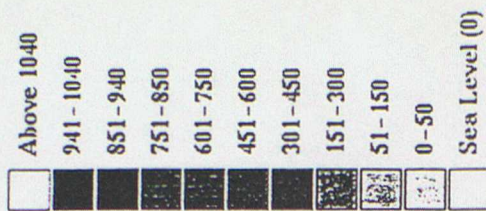
Height (km)



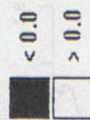


180101 1117 GMT

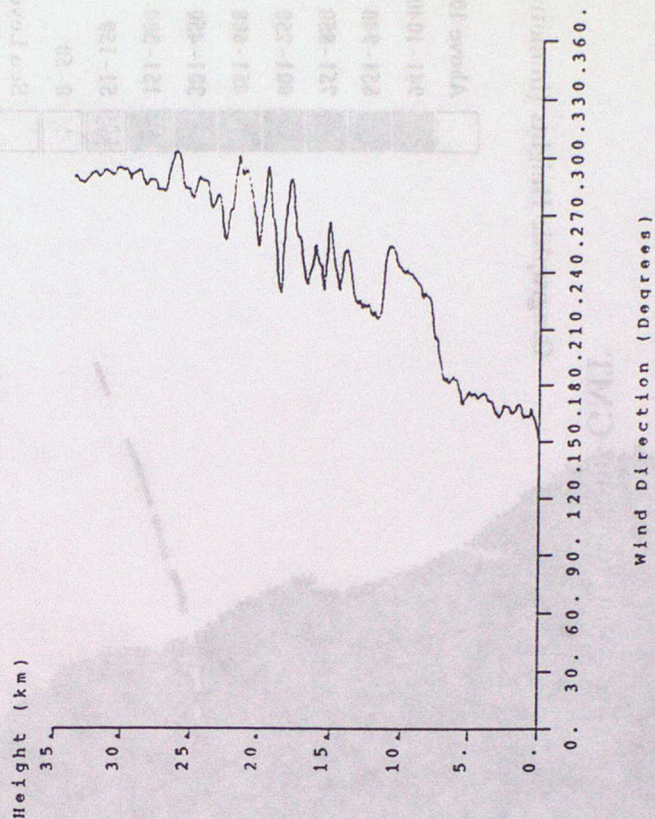
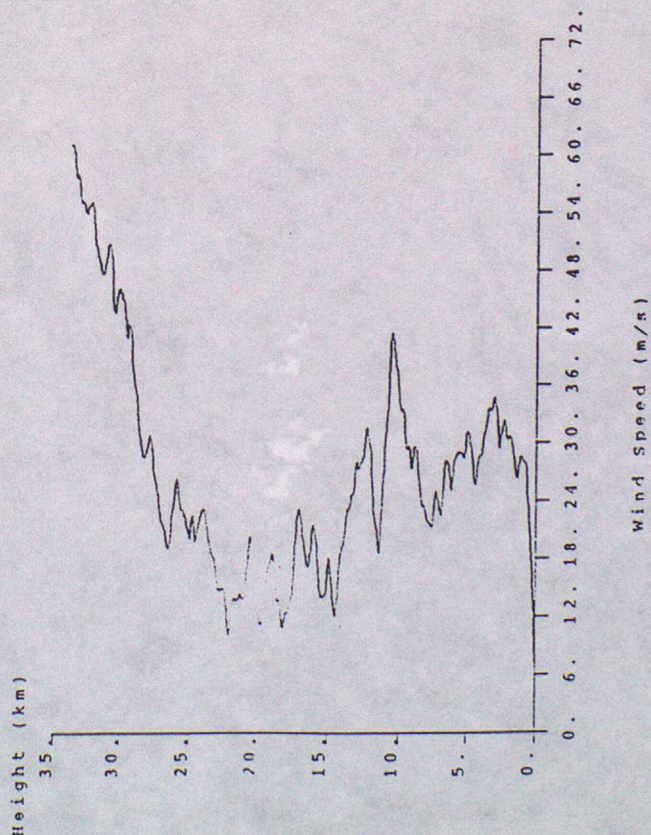
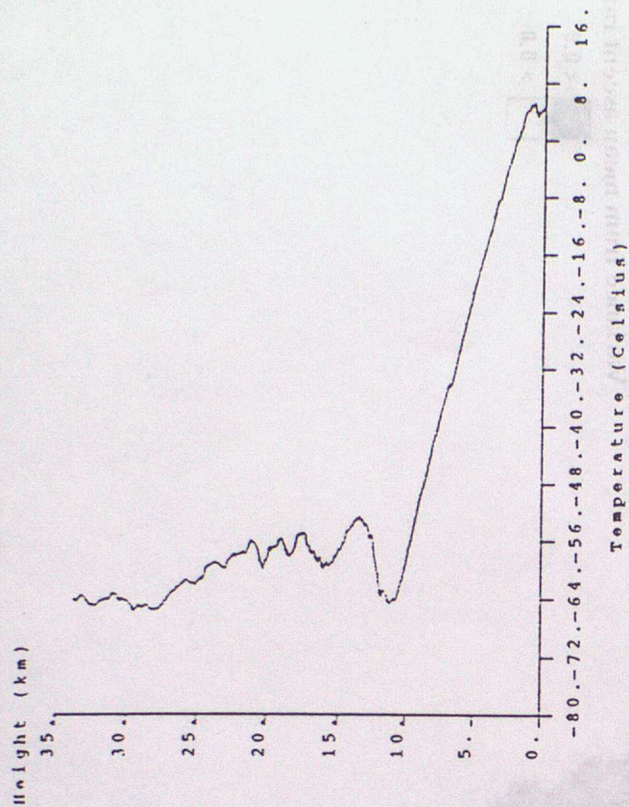
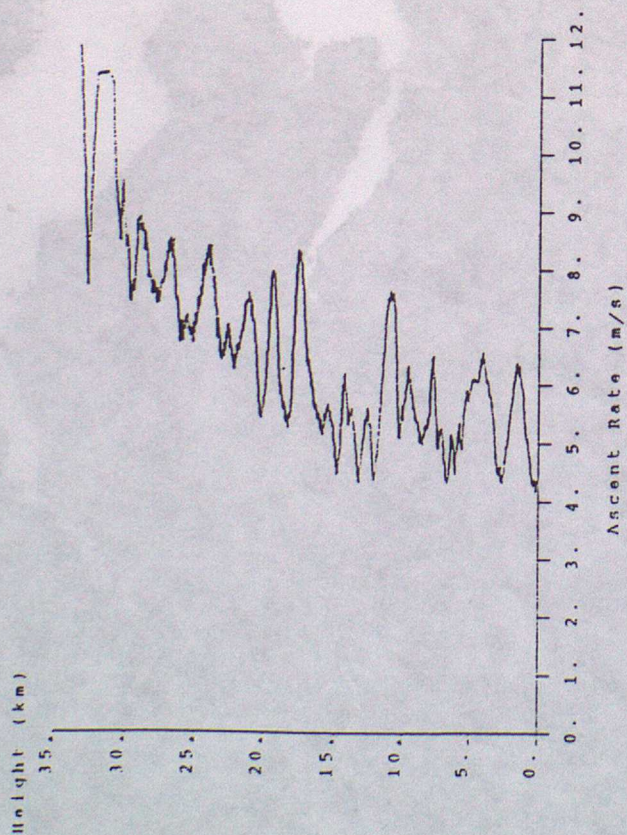
Orographic Heights (in metres)

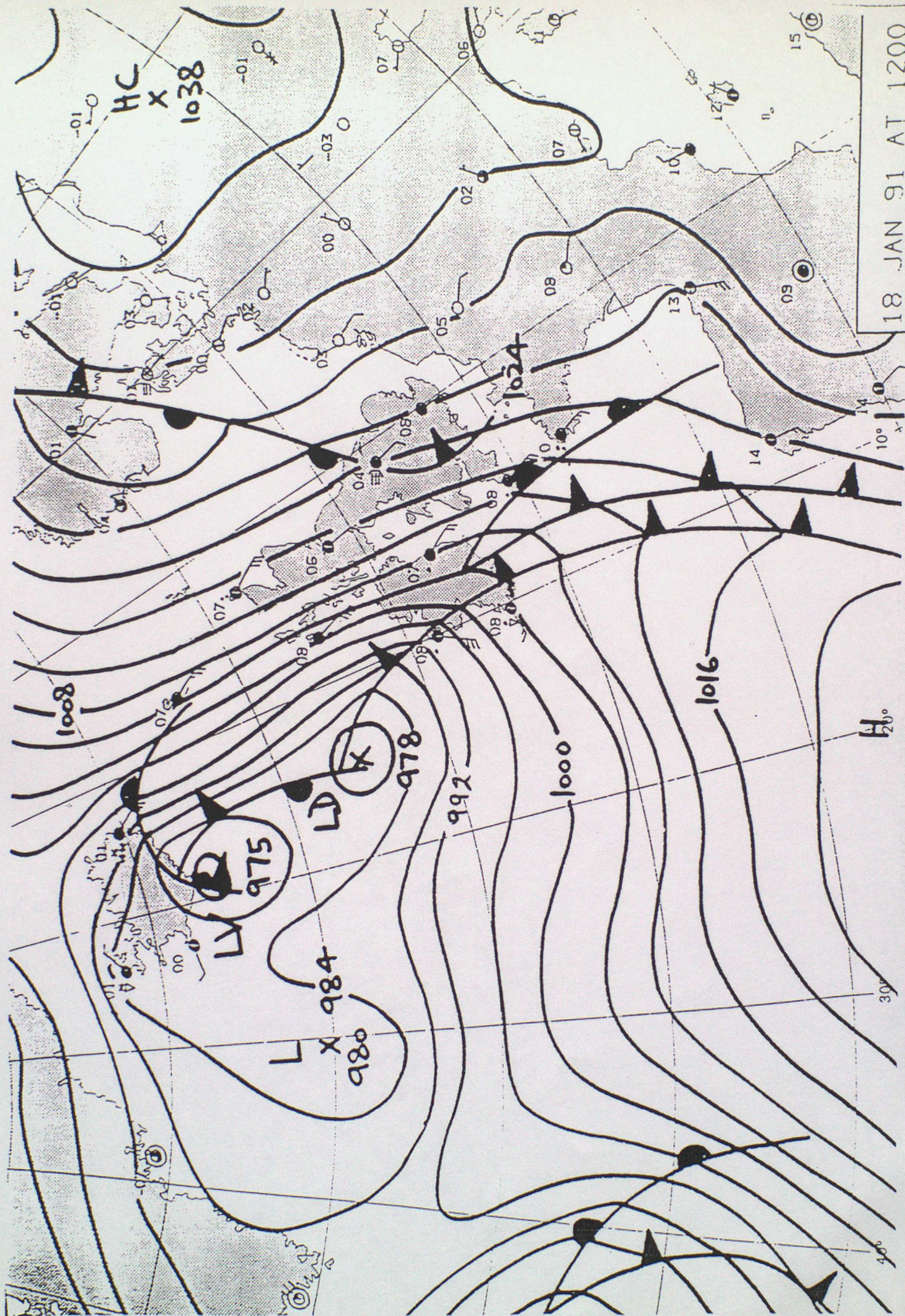


Variance from mean ascent rate (in m/s)



Shanwell Radiosonde Ascent 18/01/91 1117 GMT

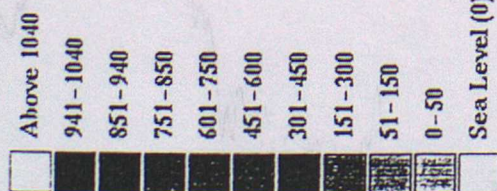




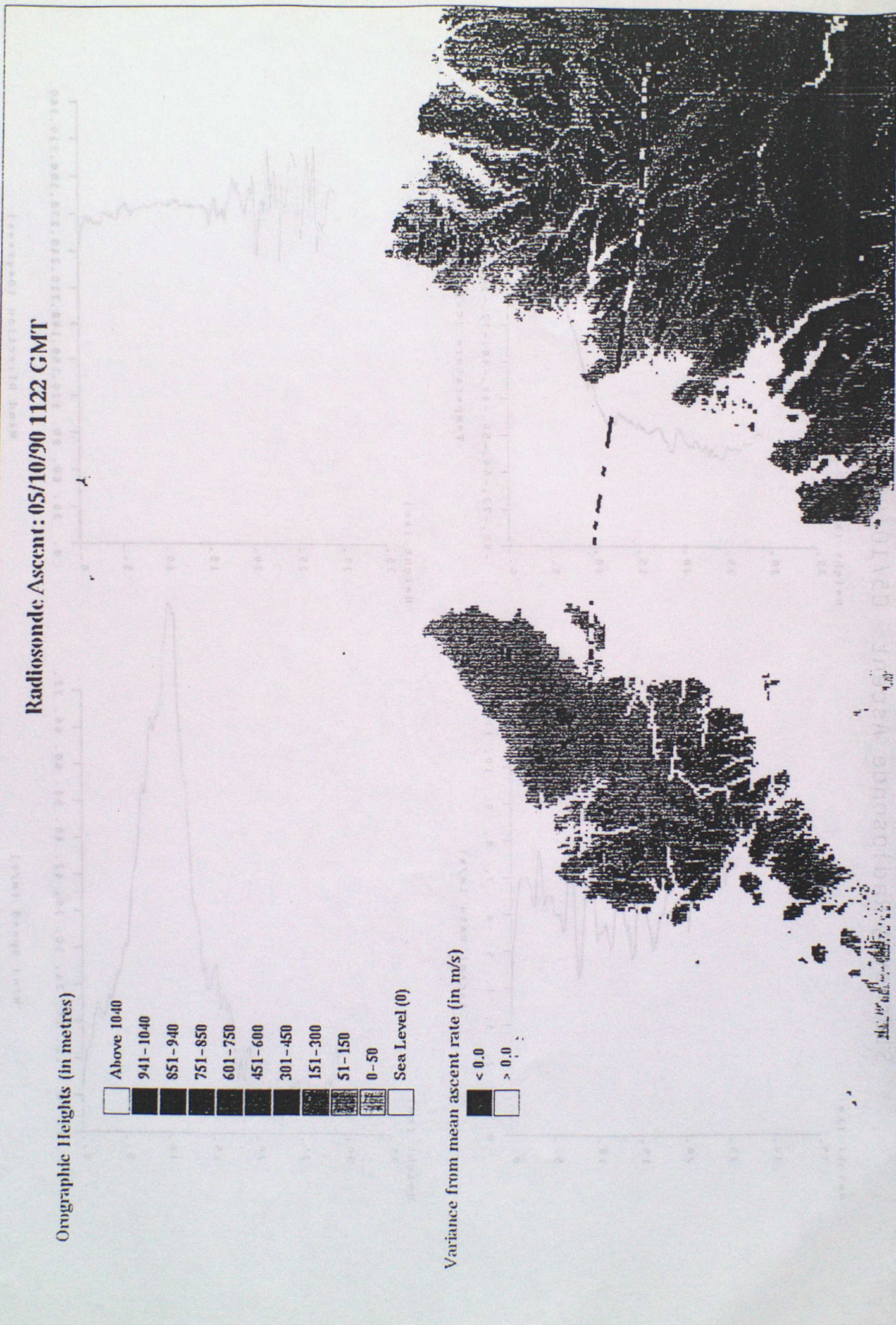
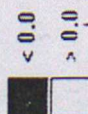
18 JAN 91 AT 1200

Radiosonde Ascent: 05/10/90 1122 GMT

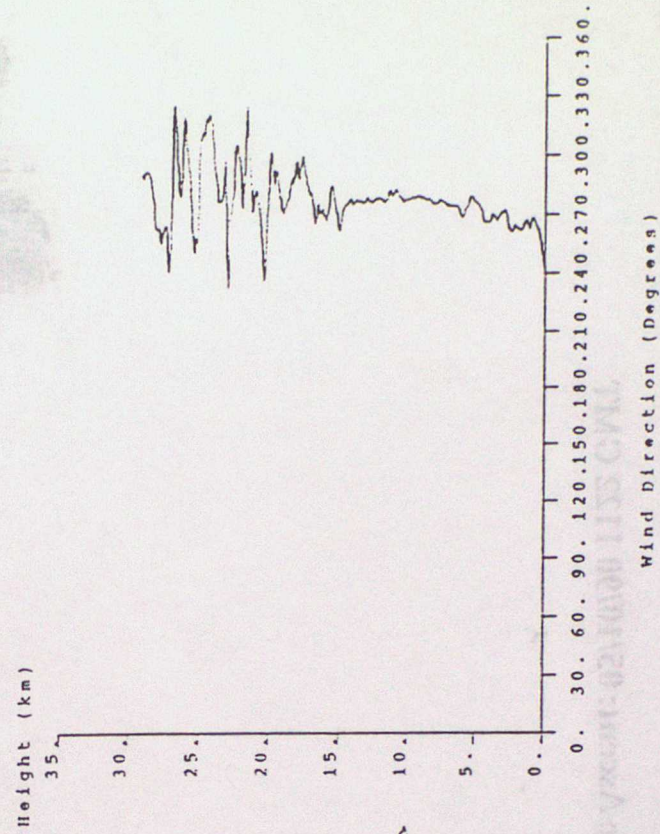
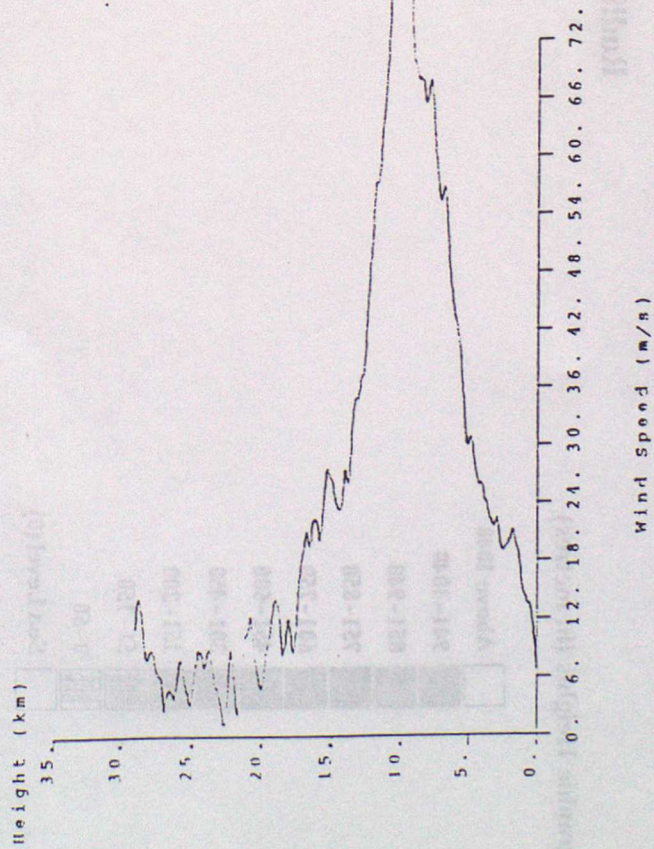
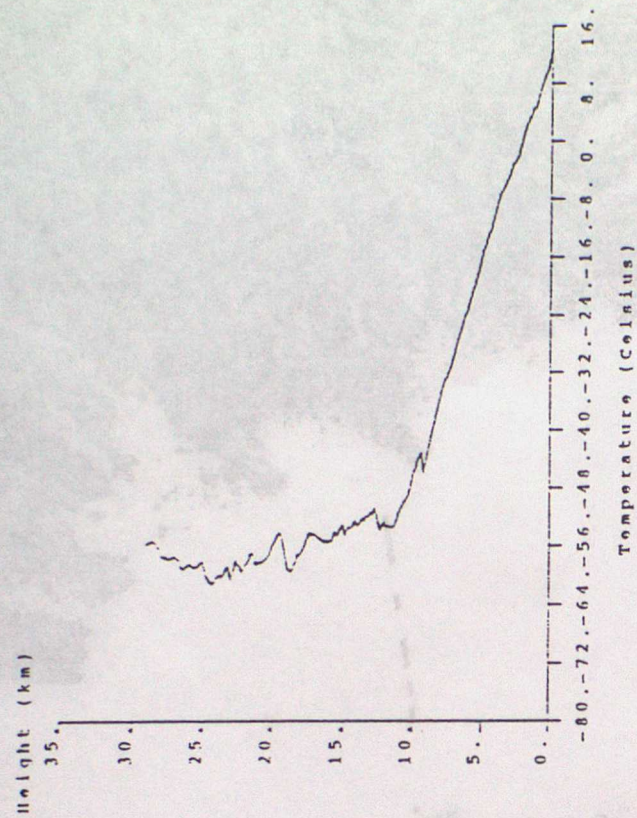
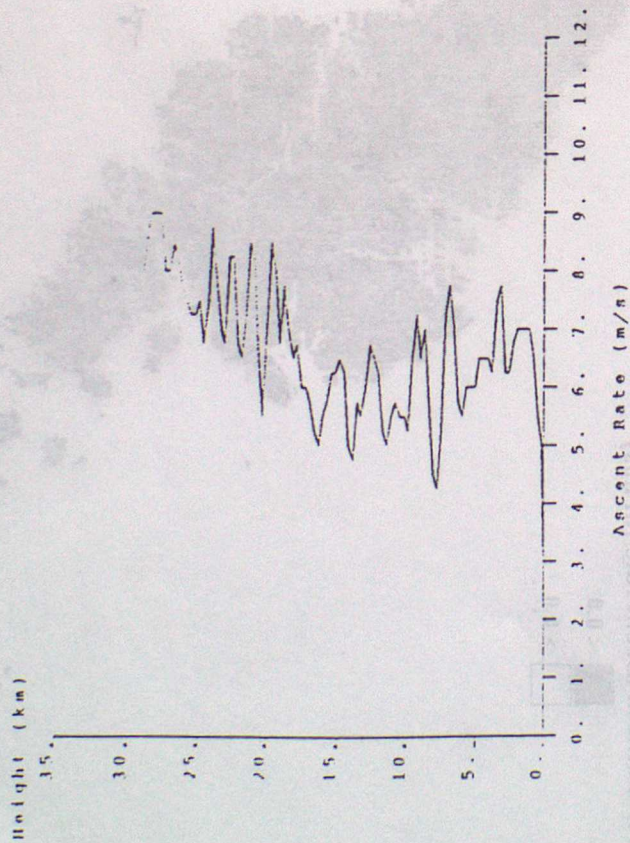
Orographic Heights (in metres)

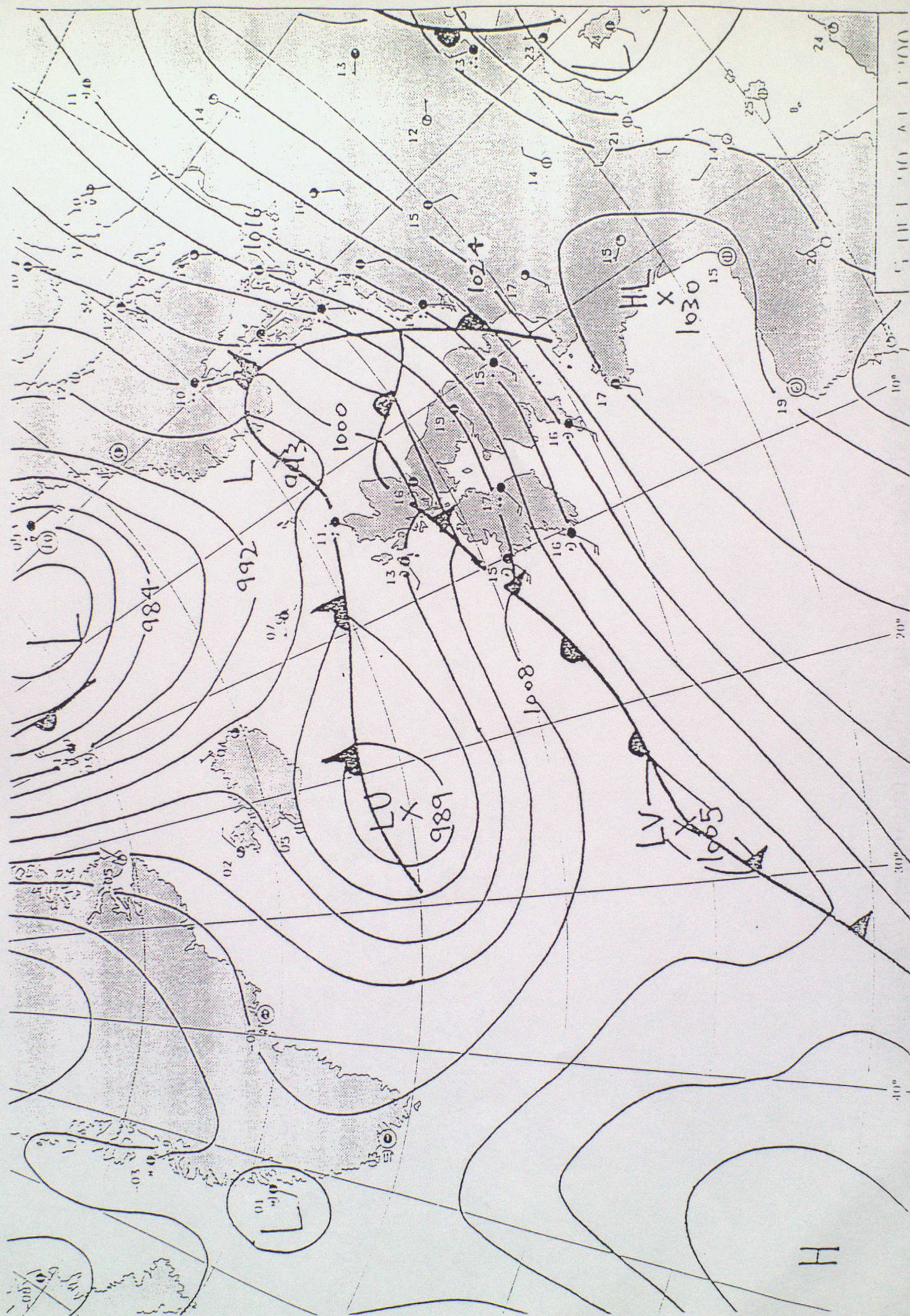


Variance from mean ascent rate (in m/s)



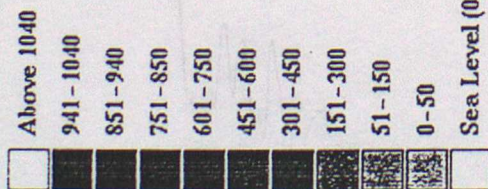
Stornaway Radiosonde Ascent 05/10/90 1122 GMT



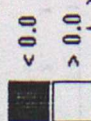


Radiosonde Ascent: 12/10/90 1120 GMT

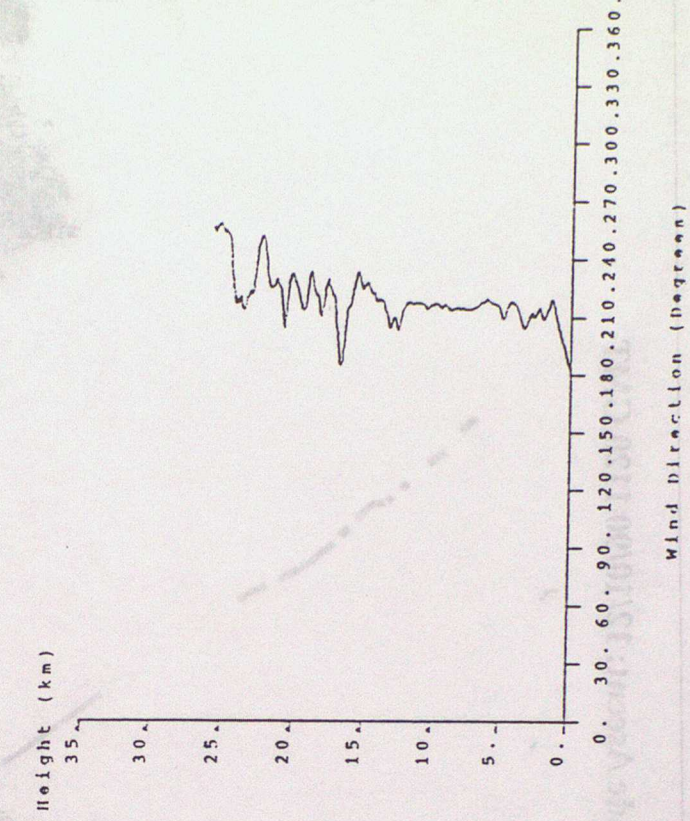
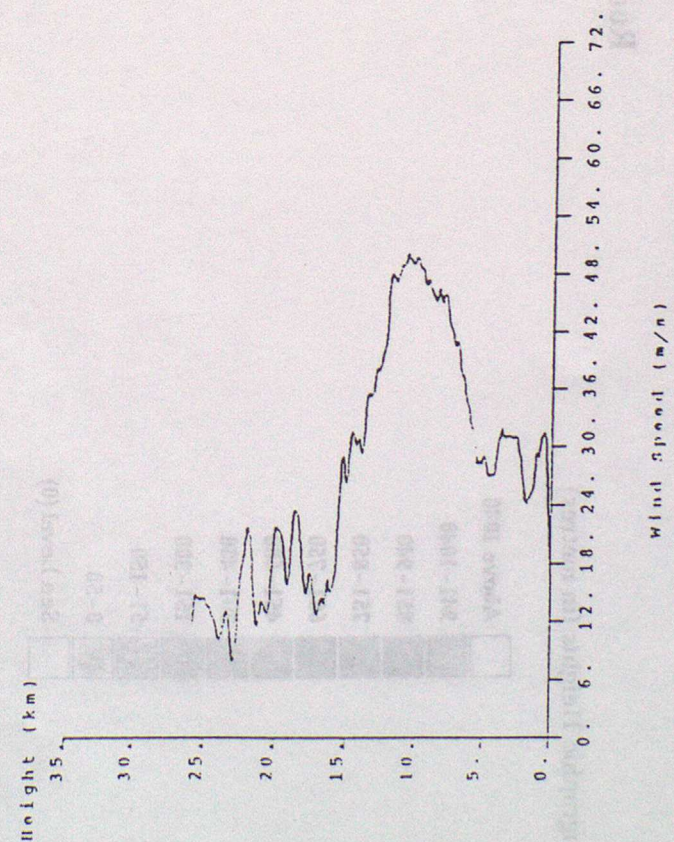
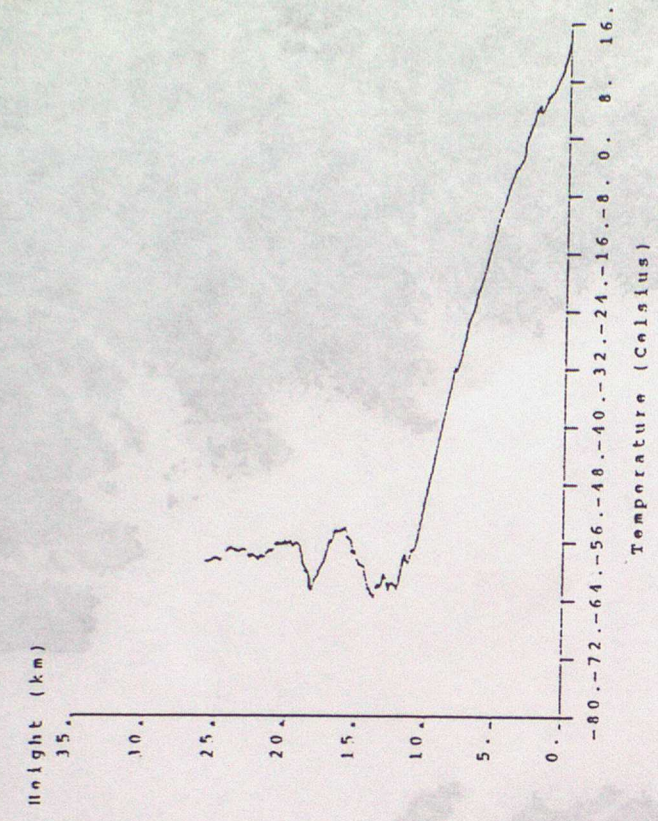
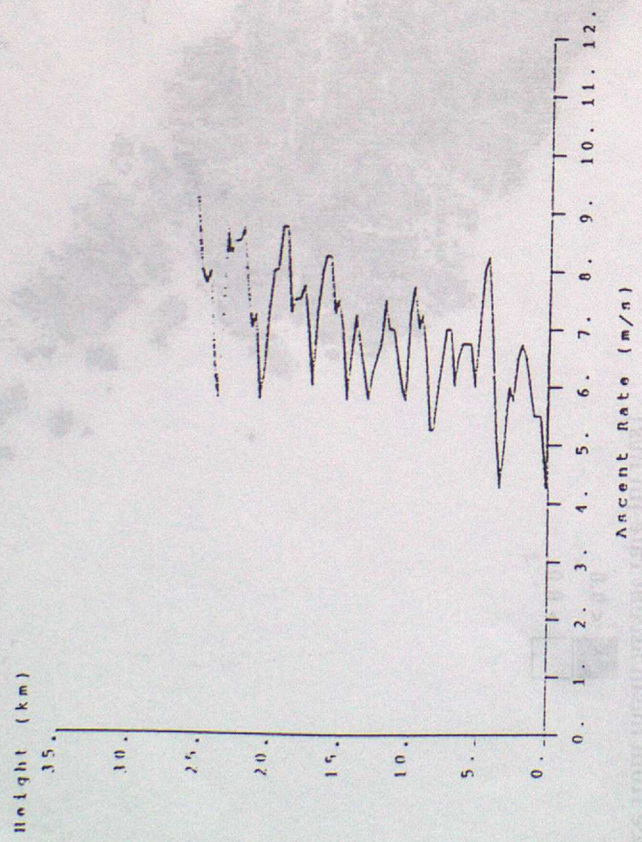
Orographic Heights (in metres)



Variance from mean ascent rate (in m/s)



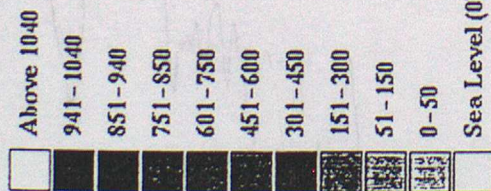
Stornaway Radiosonde Ascent 12/10/90 1120 GMT



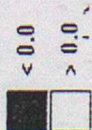


Radiosonde Ascent: 14/10/90 1122 GMT

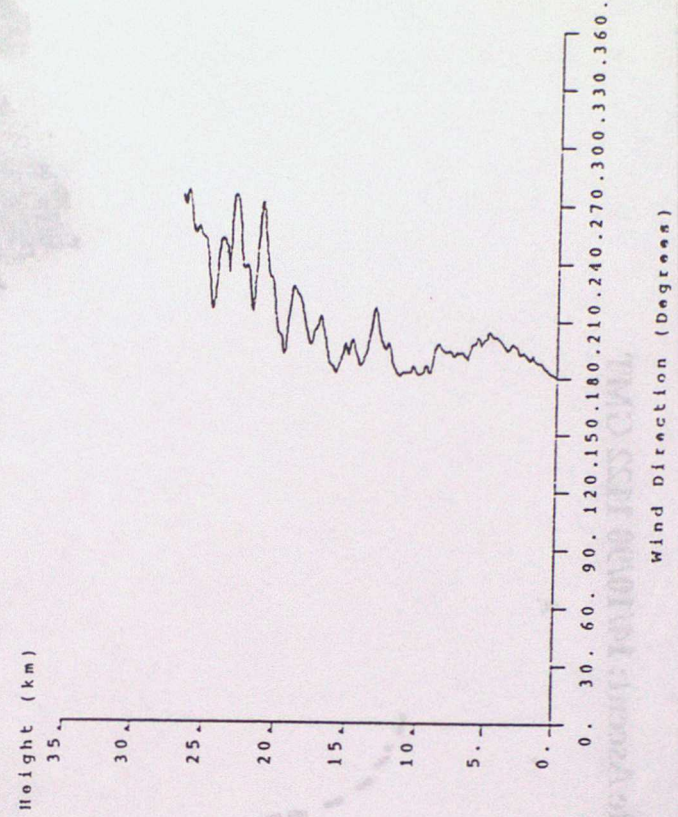
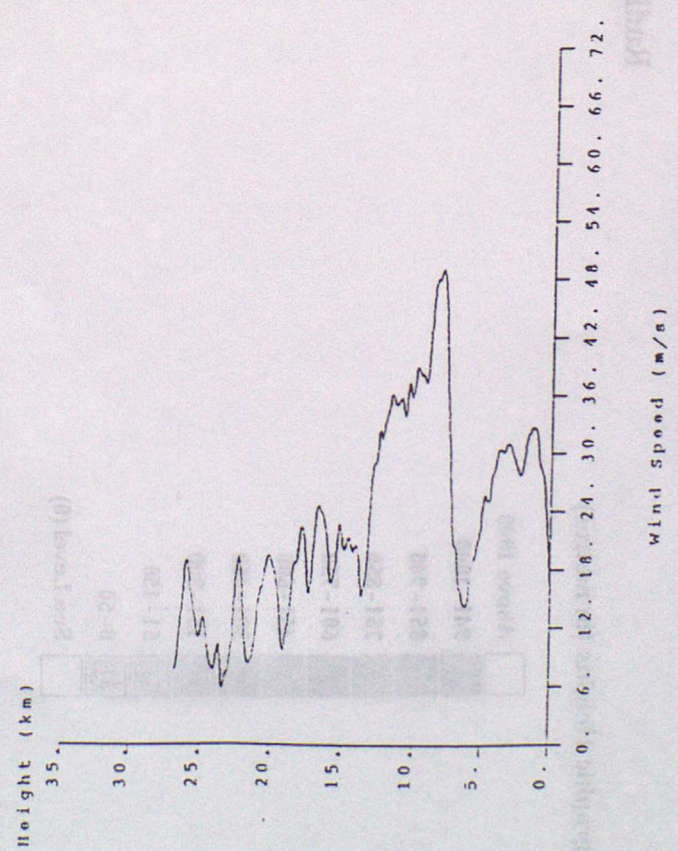
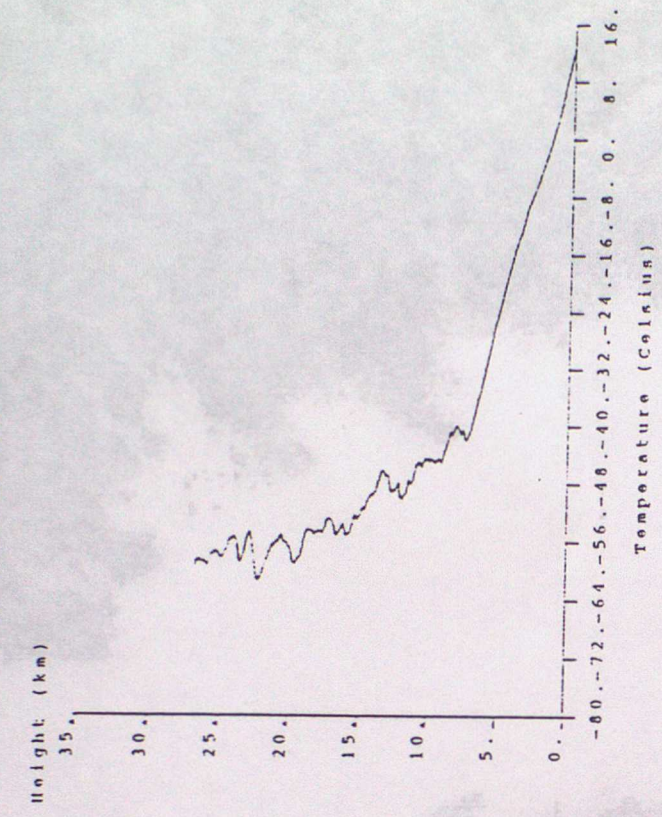
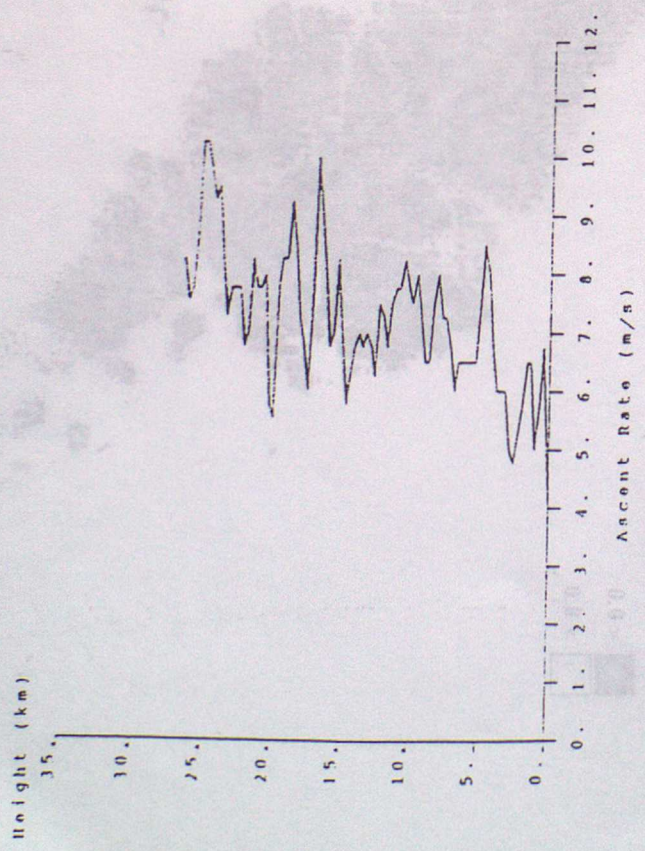
Orographic Heights (in metres)

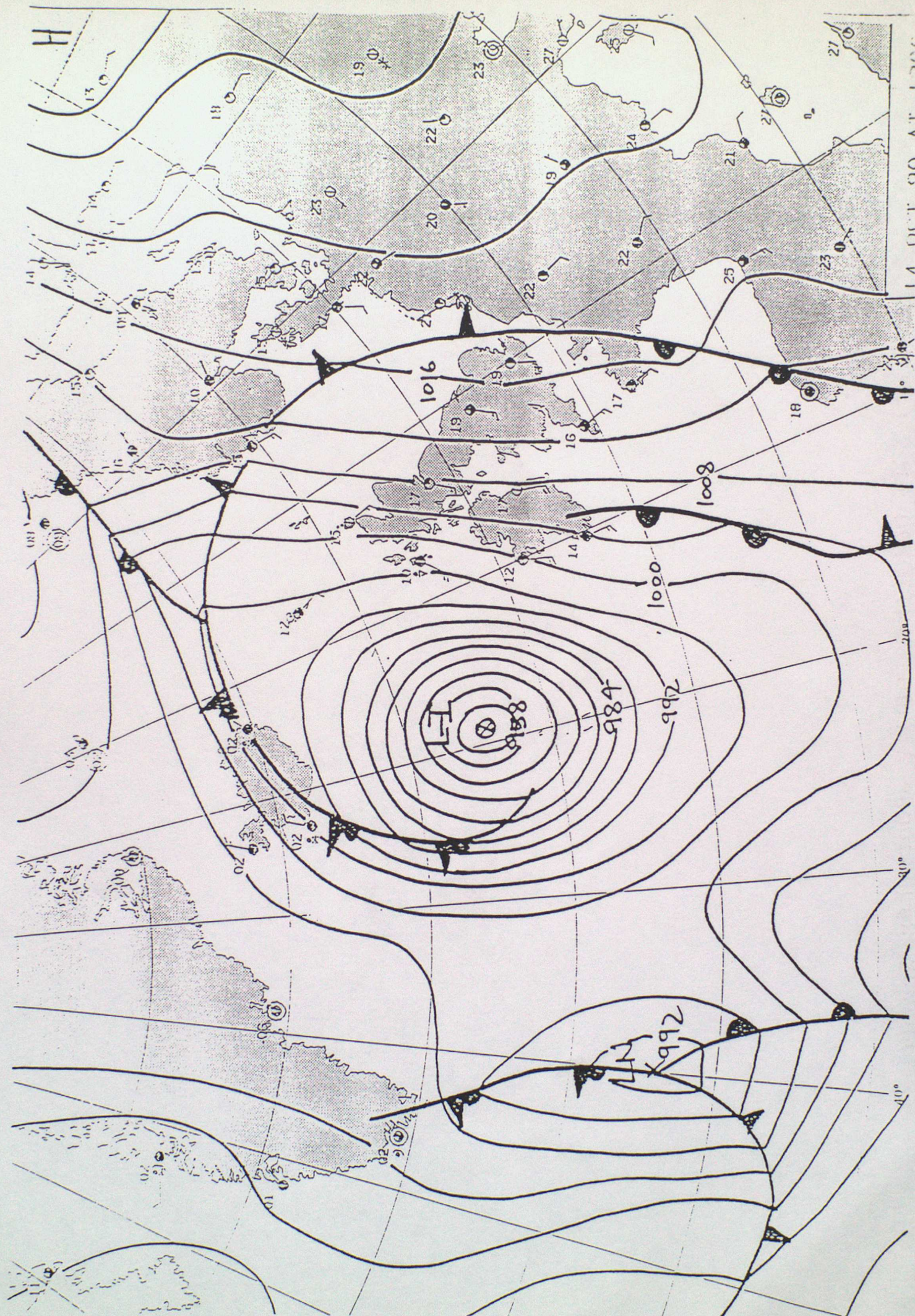


Variance from mean ascent rate (in m/s)



Stornaway Radiosonde Ascent 14/10/90 1122 GMT





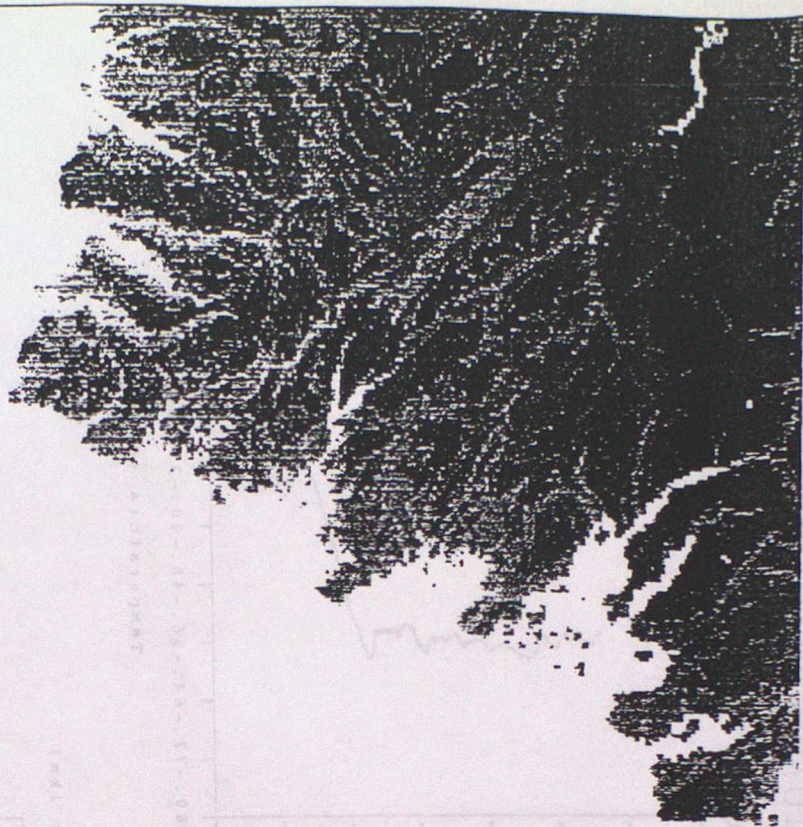
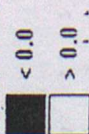
LA OUT CO AT 1300

Radiosonde Ascent: 20/10/90 1118 GMT

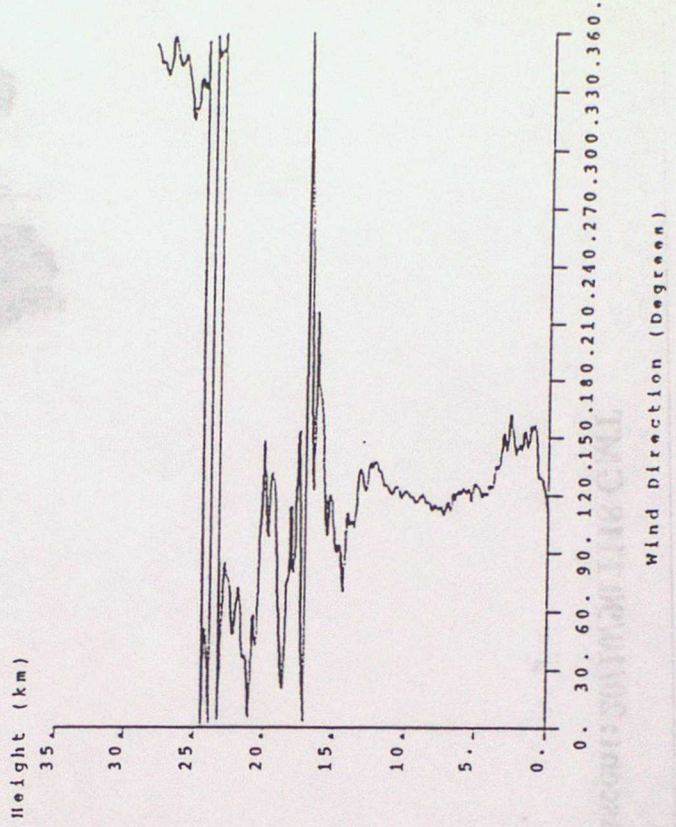
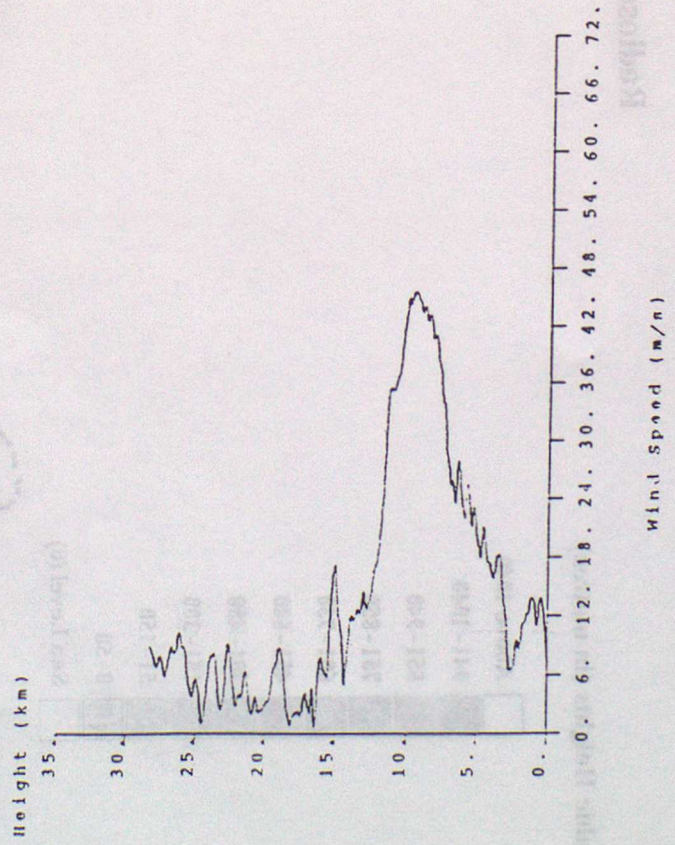
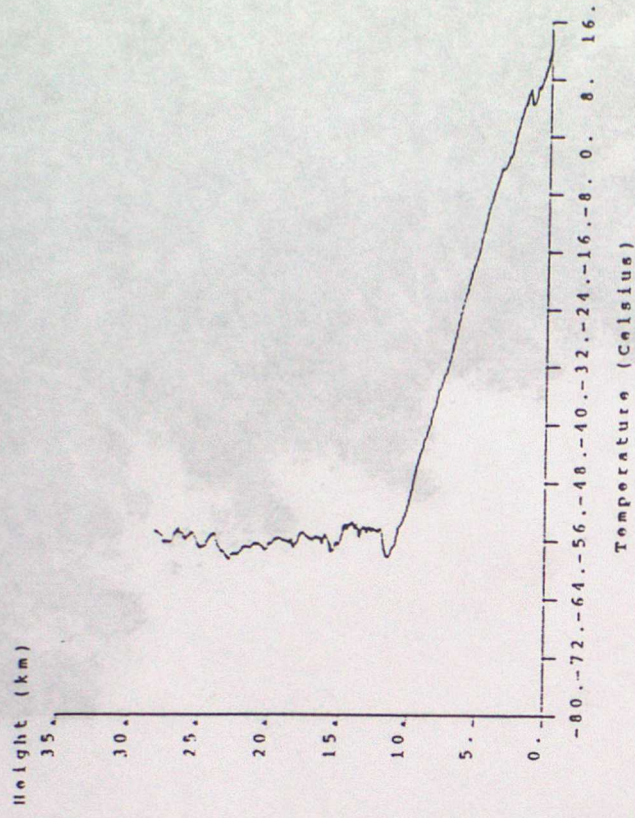
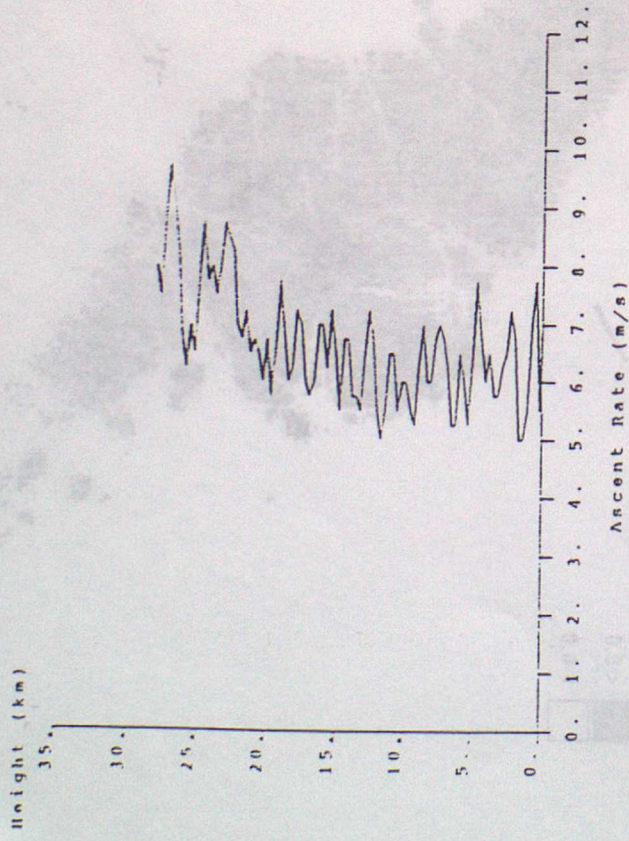
Orographic Heights (in metres)

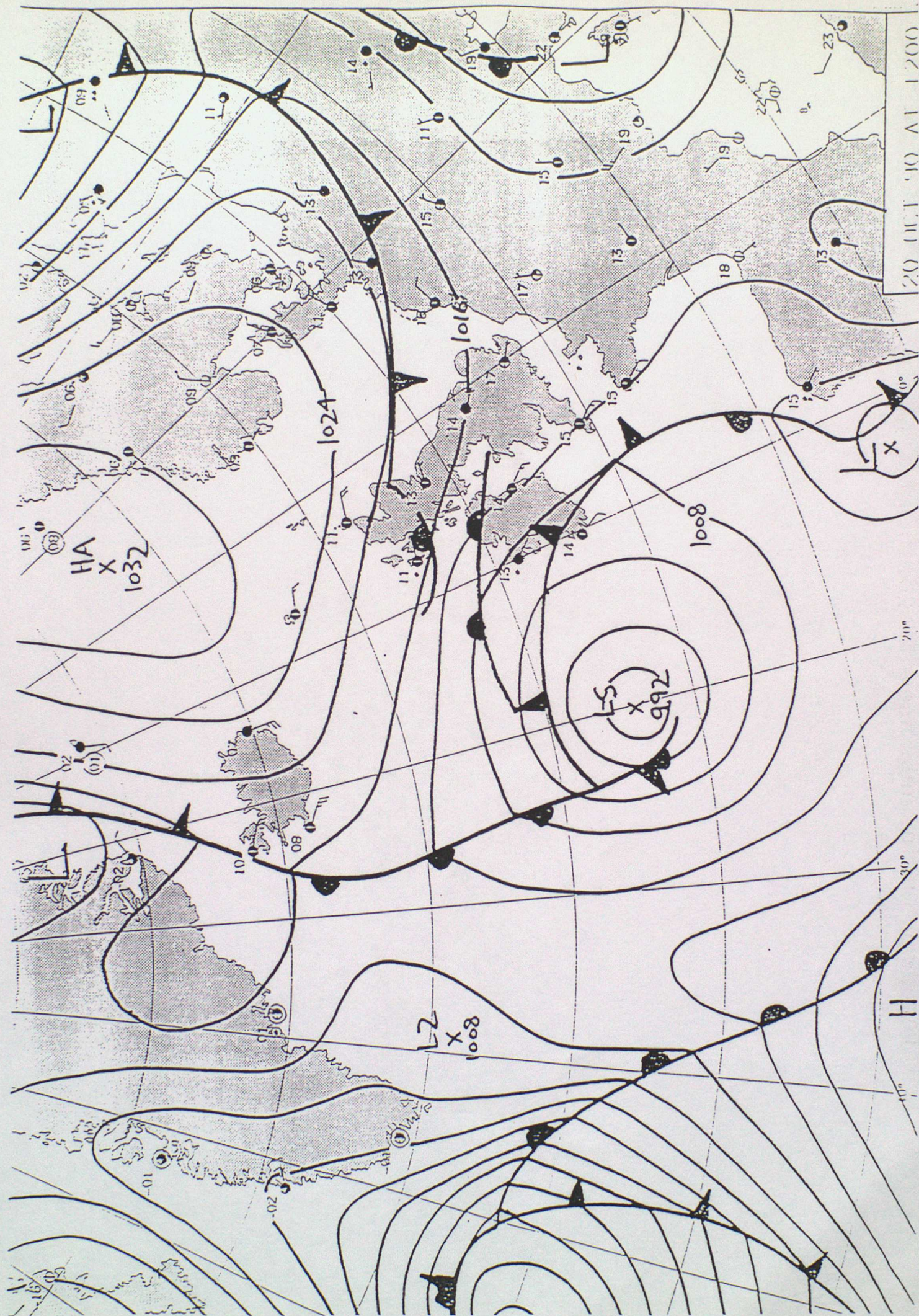


Variance from mean ascent rate (in m/s)



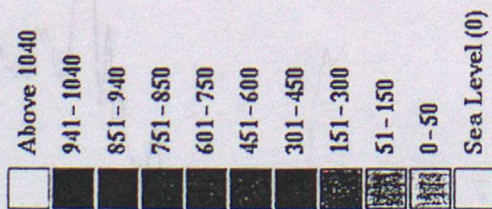
Stornaway Radiosonde Ascent 20/10/90 1118 GMT



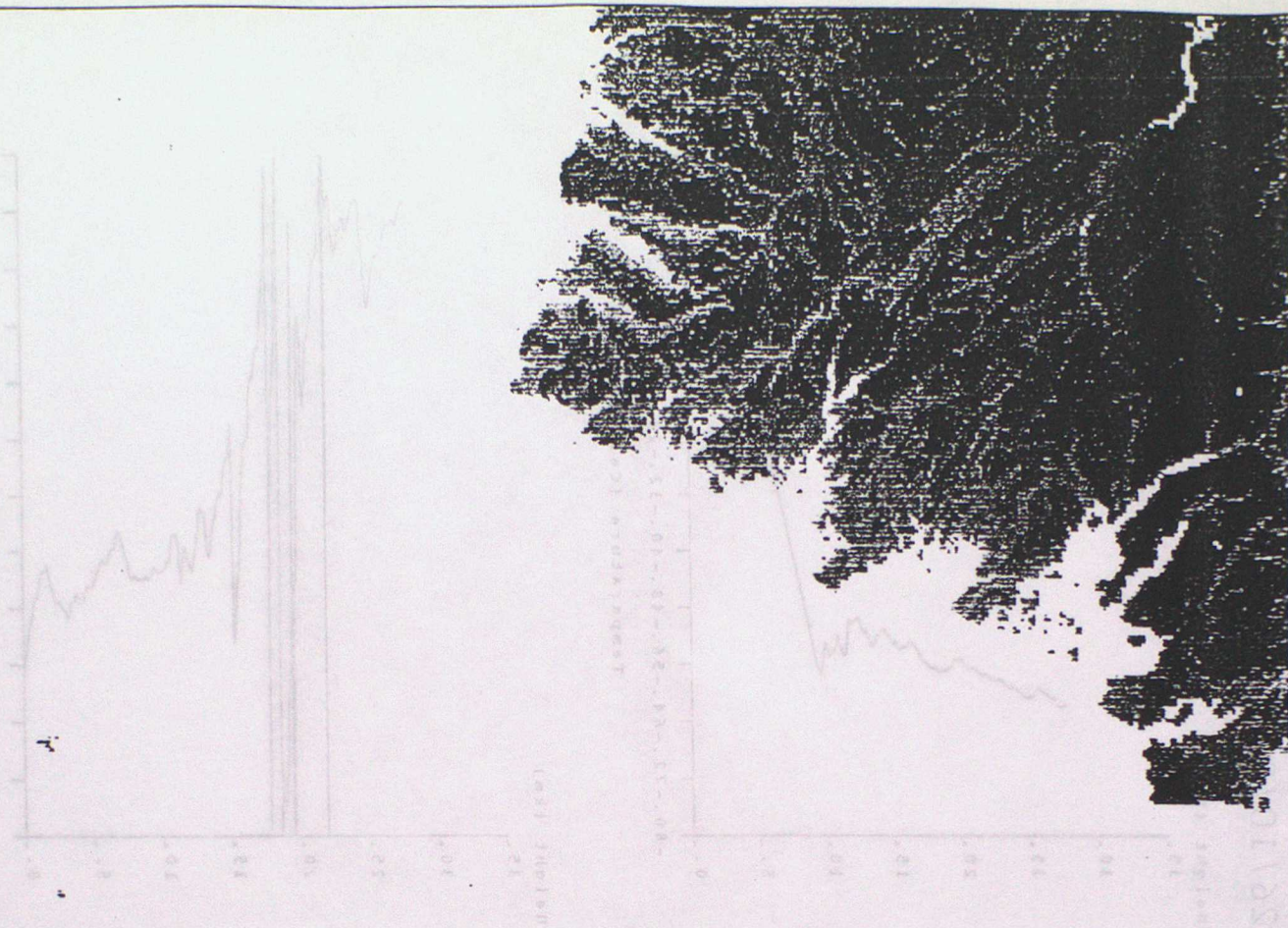
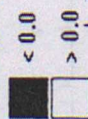


Radiosonde Ascent: 26/10/90 1115 GMT

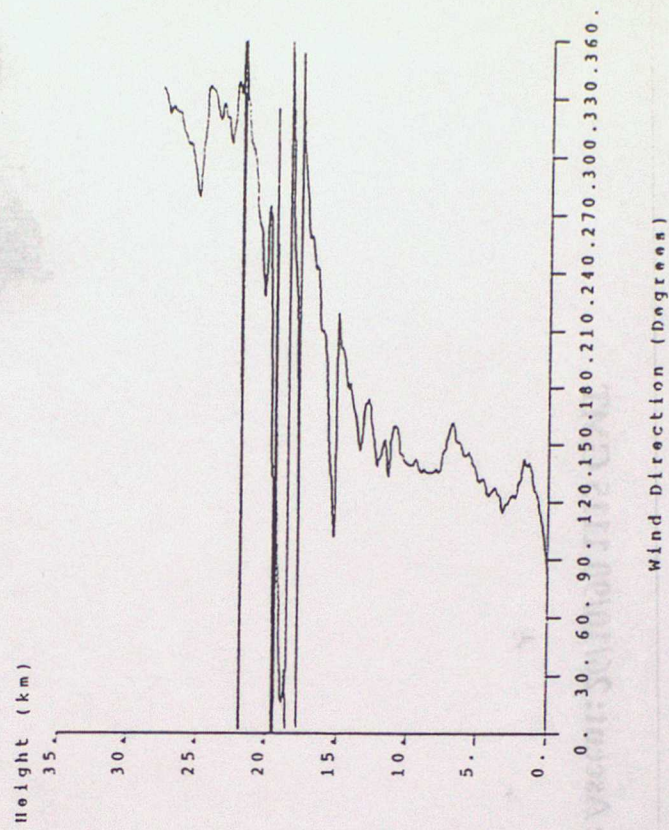
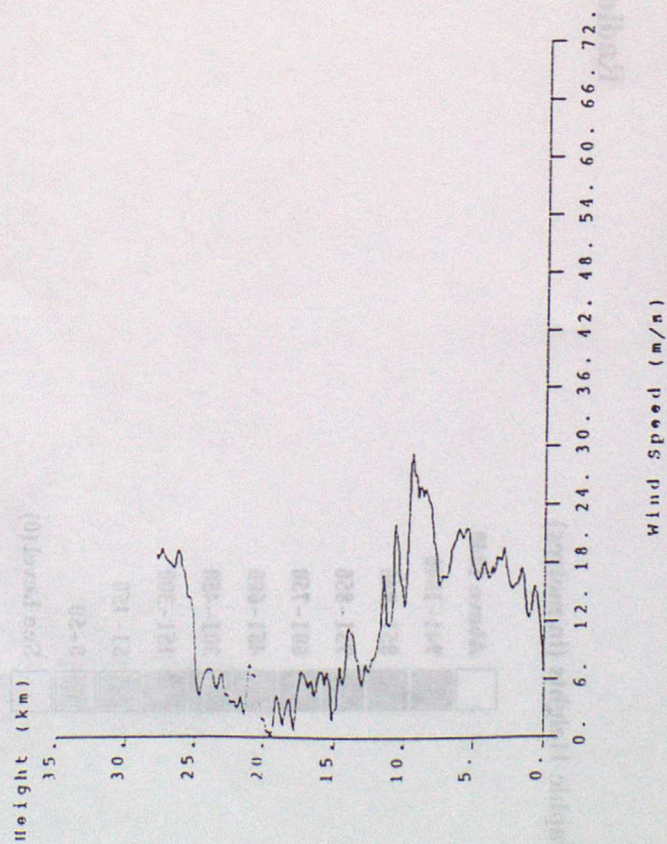
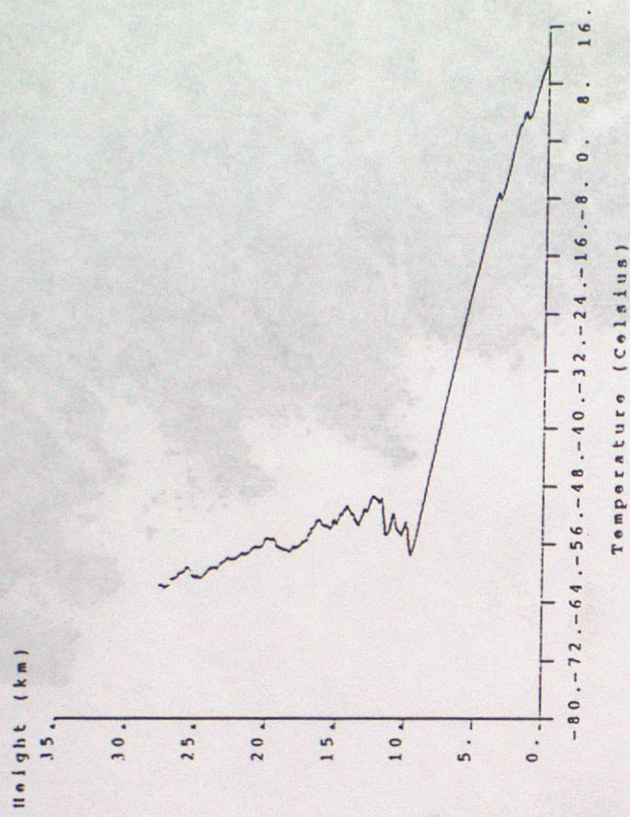
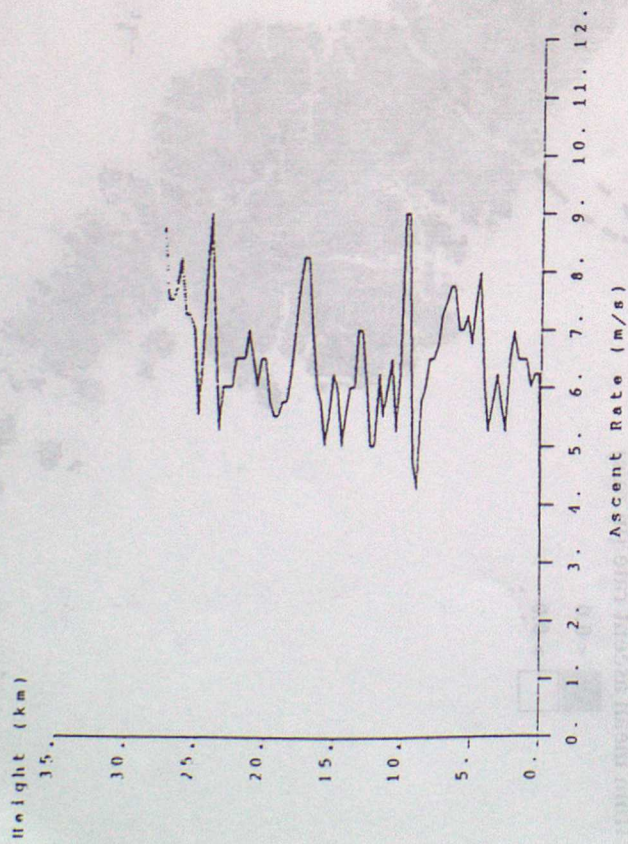
Orographic Heights (in metres)

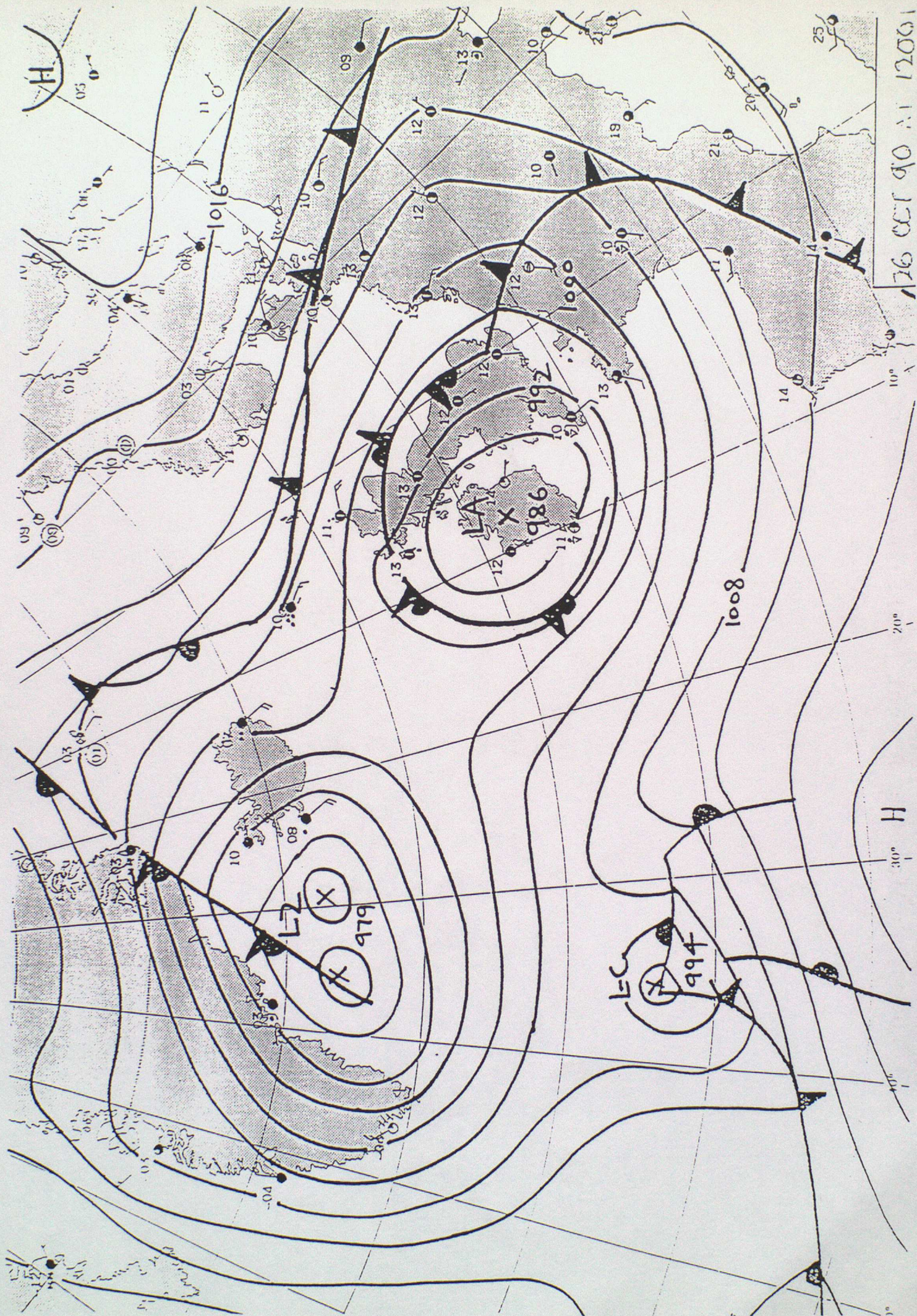


Variance from mean ascent rate (in m/s)



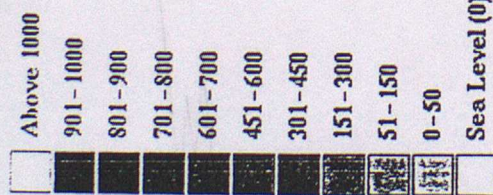
Stornaway Radiosonde Ascent 26/10/90 1115 GMT



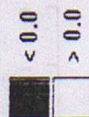


Radioonde Ascent: 02/09/86 1122 GMT

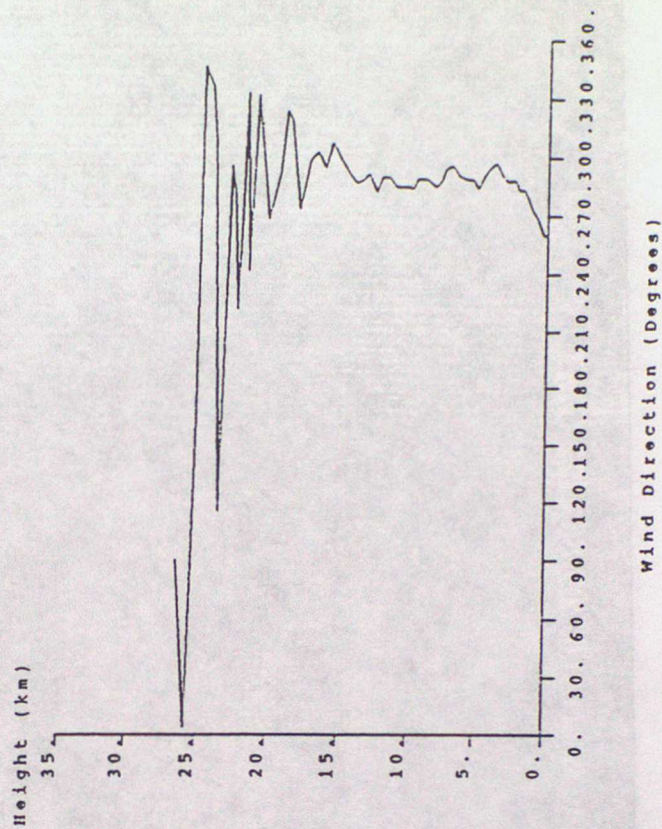
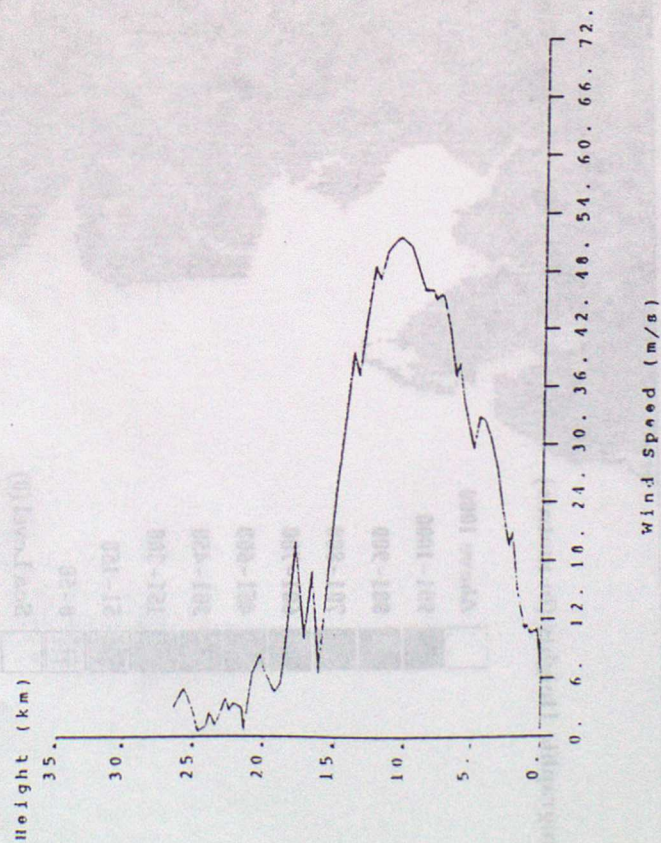
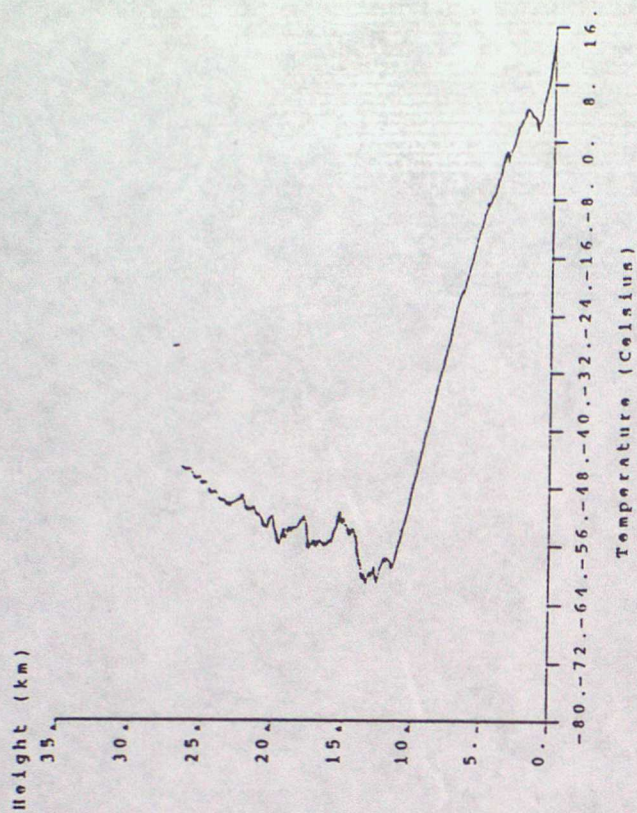
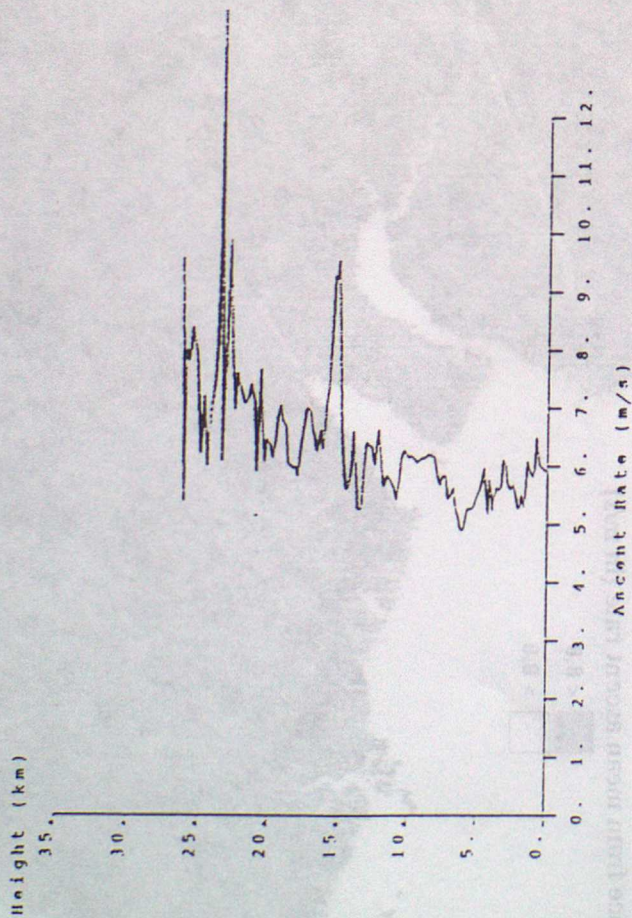
Orographite Heights (In metres)

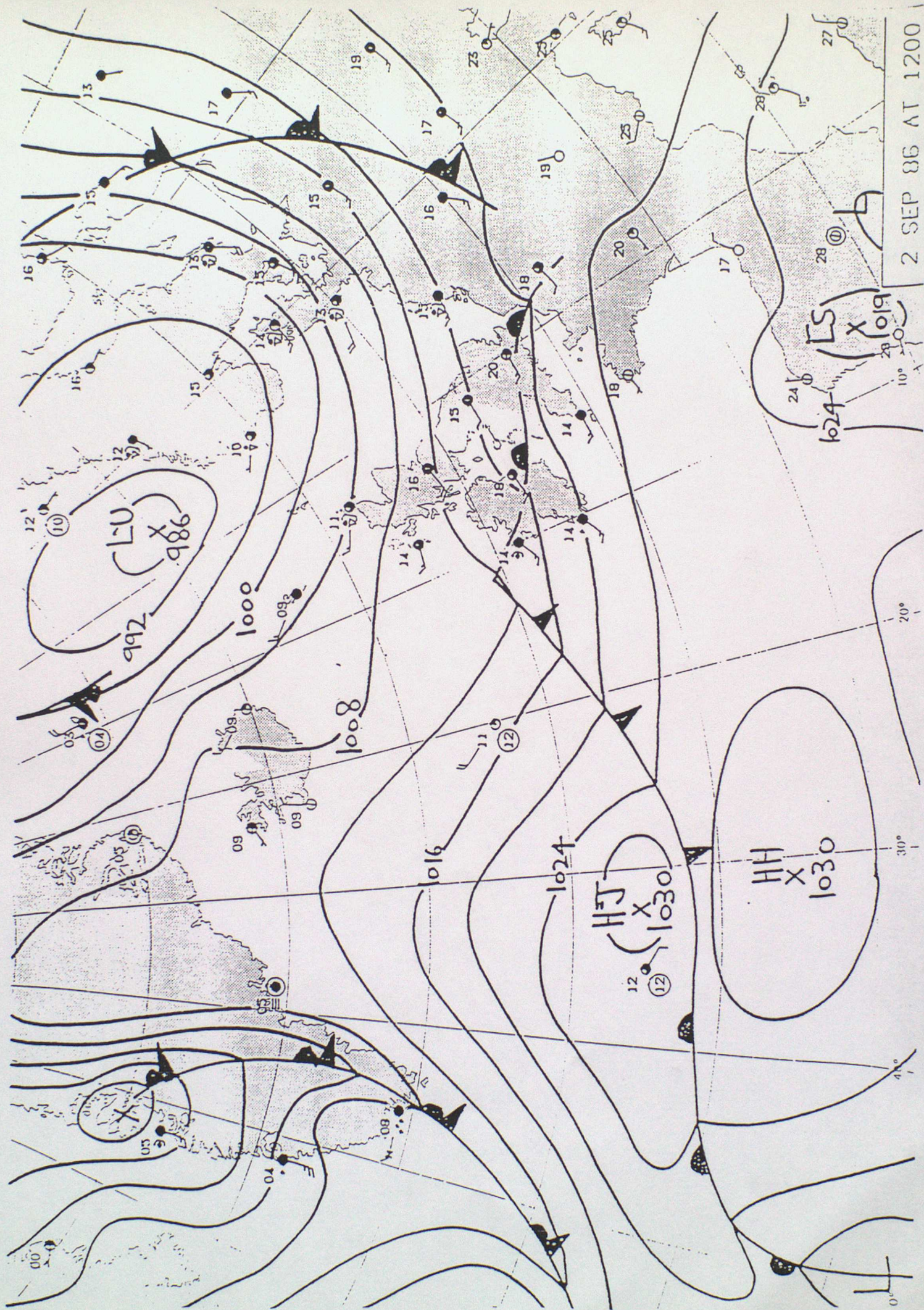


Variance from mean ascent rate (in m/s)



Aughton Radiosonde Ascent 02/09/86 1122 GMT





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Radiosonde Ascent: 03/04/87 1115 GMT

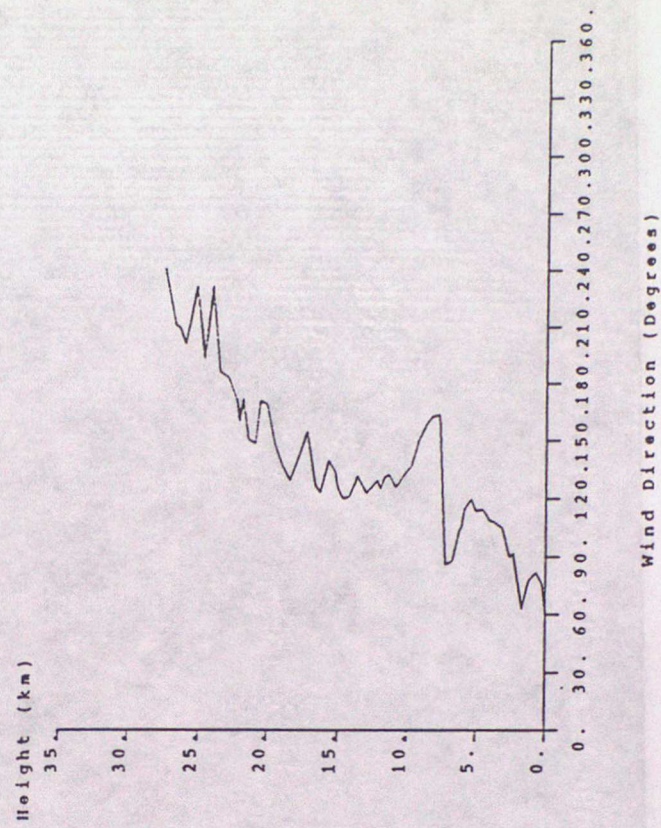
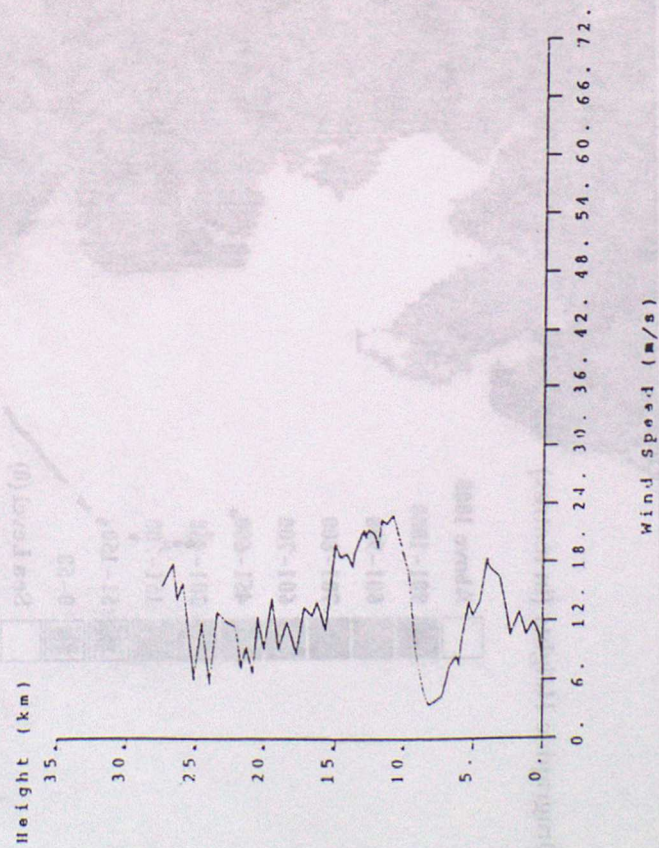
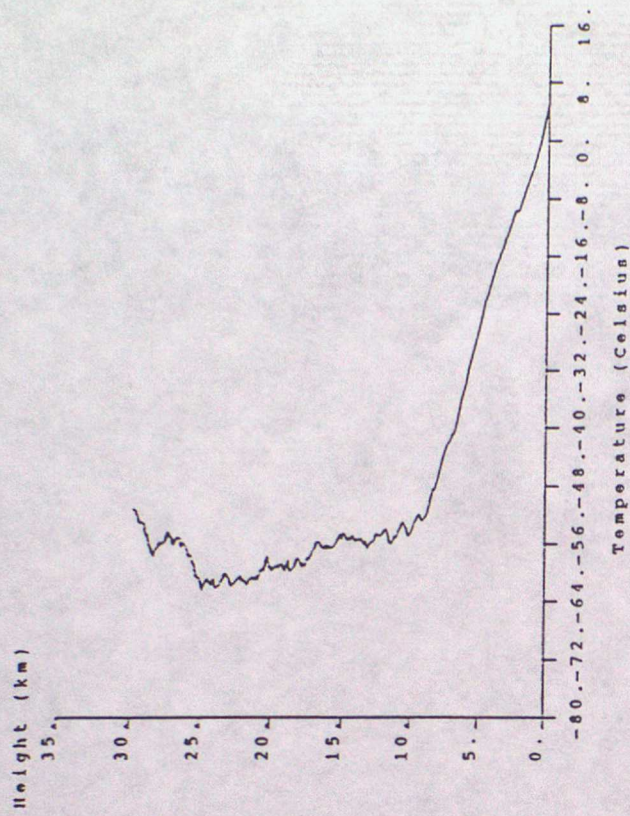
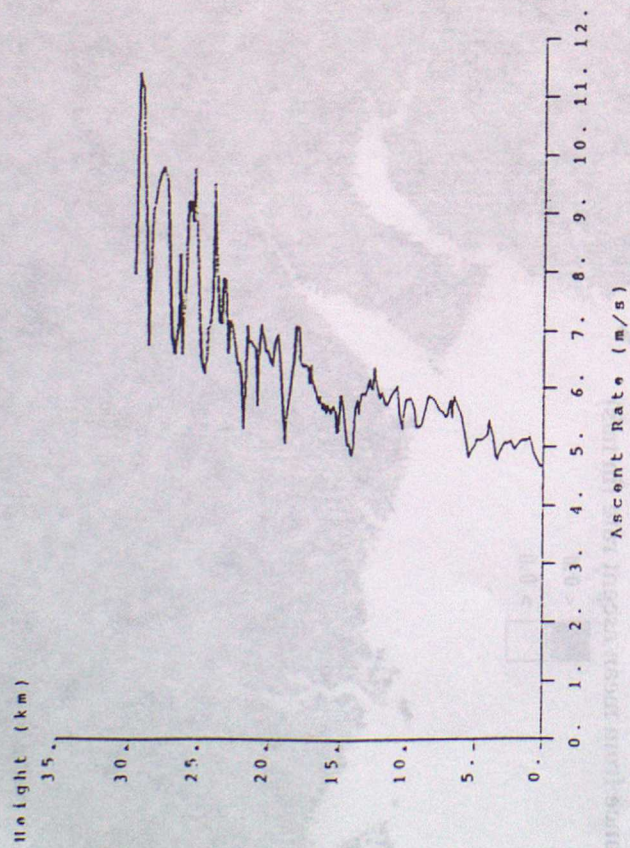
Orographic Heights (in metres)

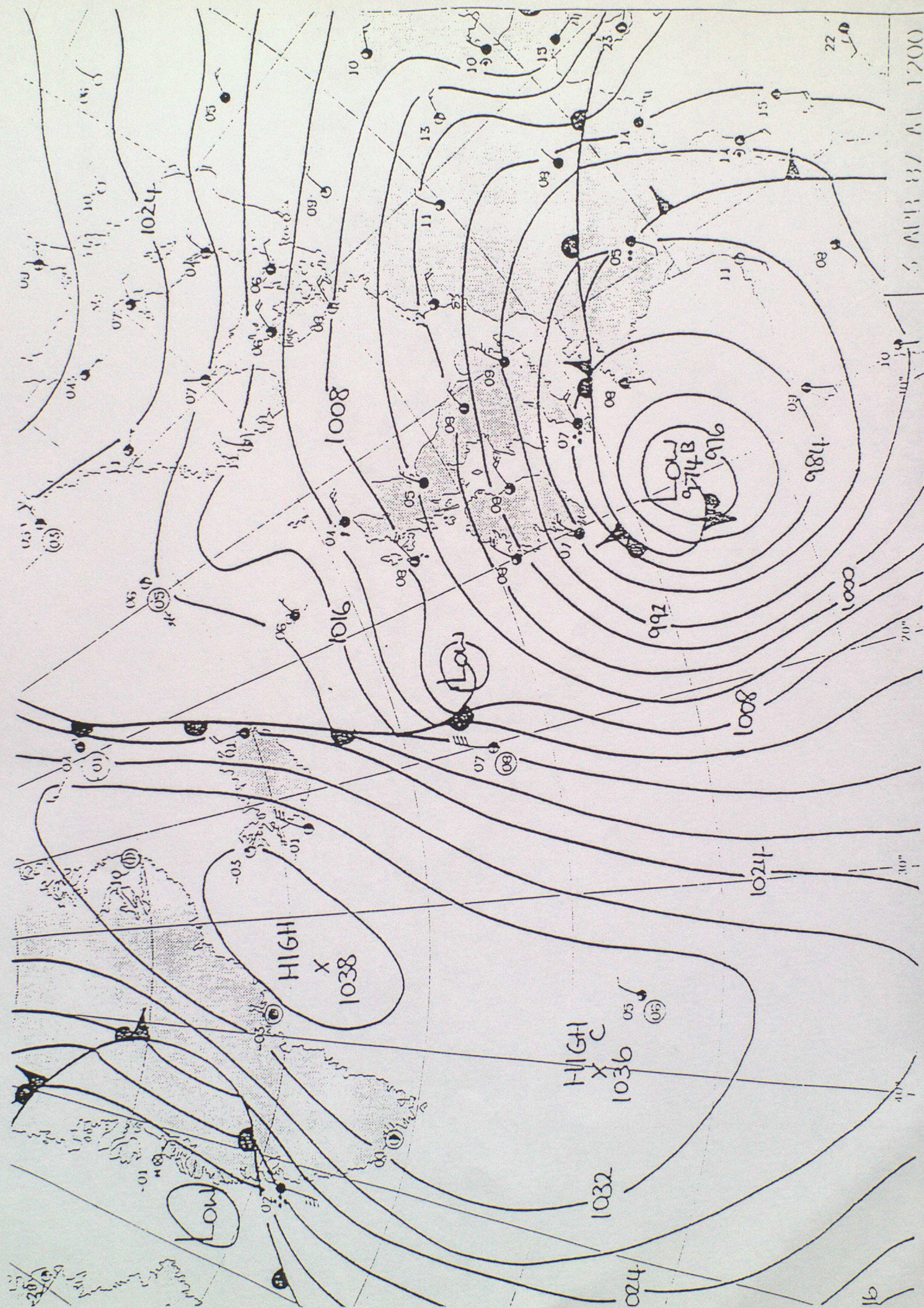


Variance from mean ascent rate (in m/s)



Aughton Radiosonde Ascent 03/04/87 1115 GMT



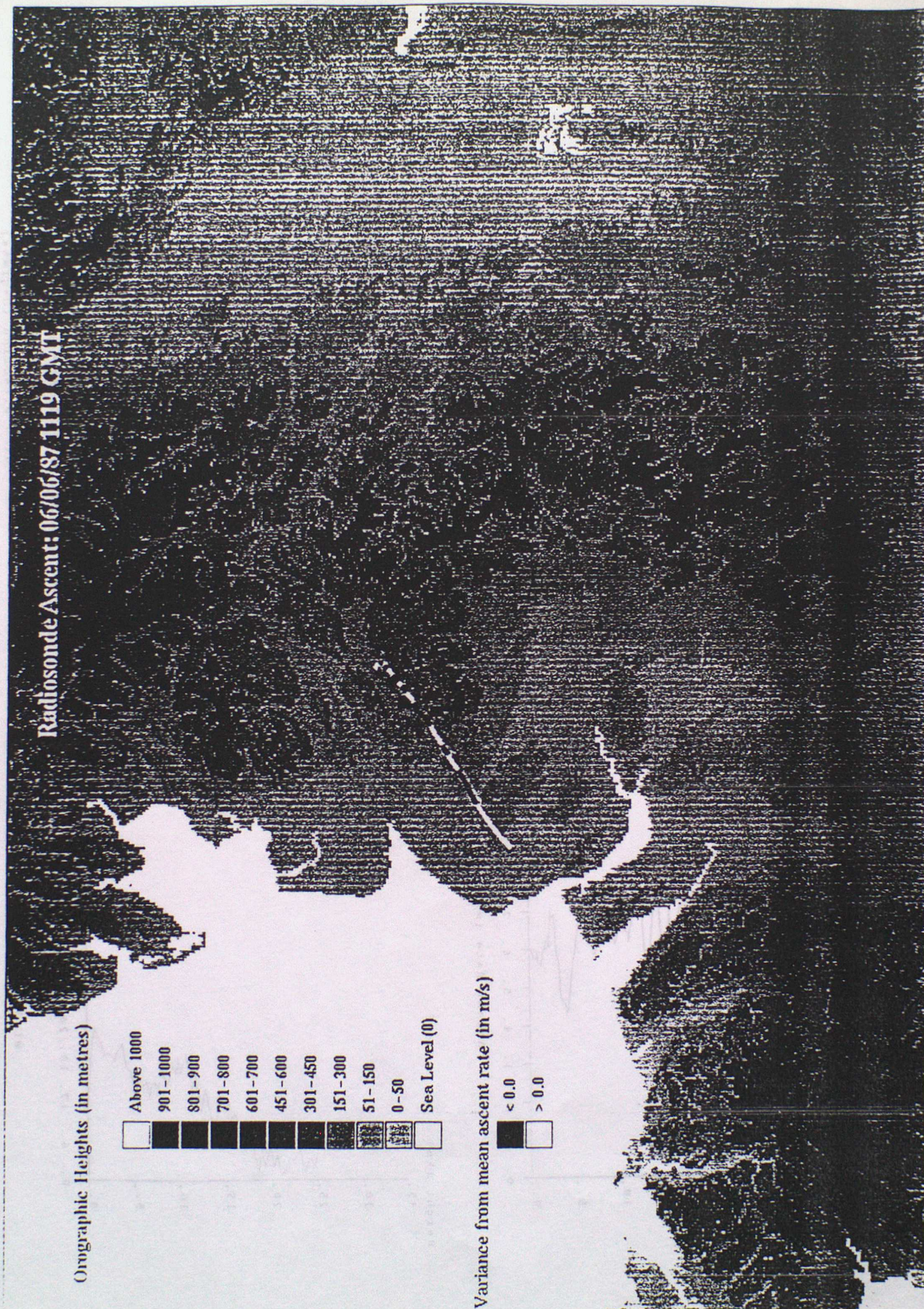
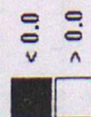


Radioonde Ascent: 06/06/87 1119 GMT

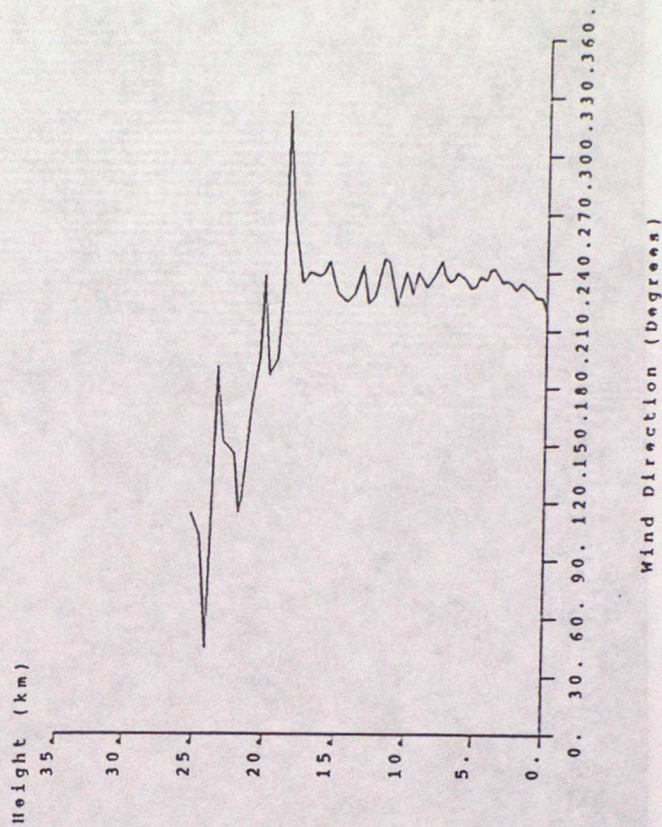
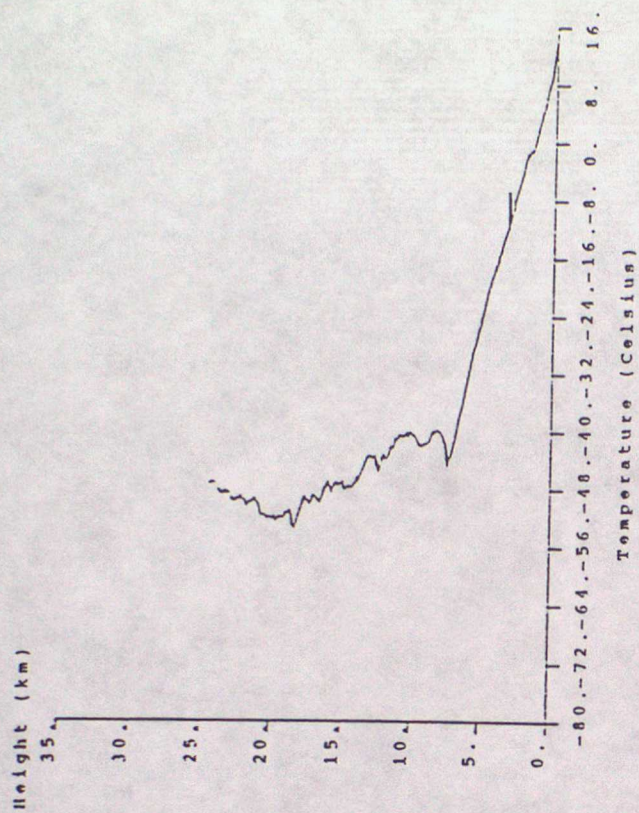
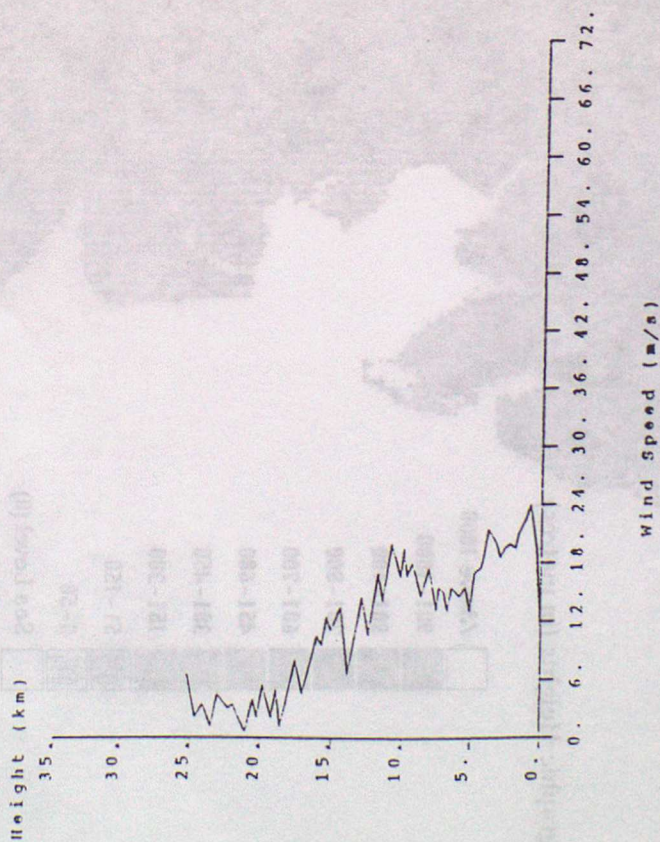
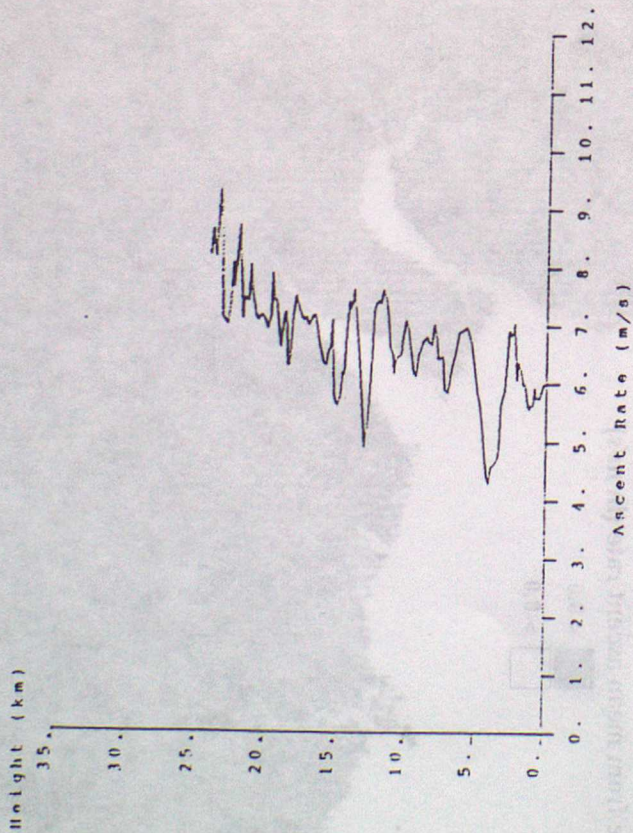
Orographic Heights (in metres)

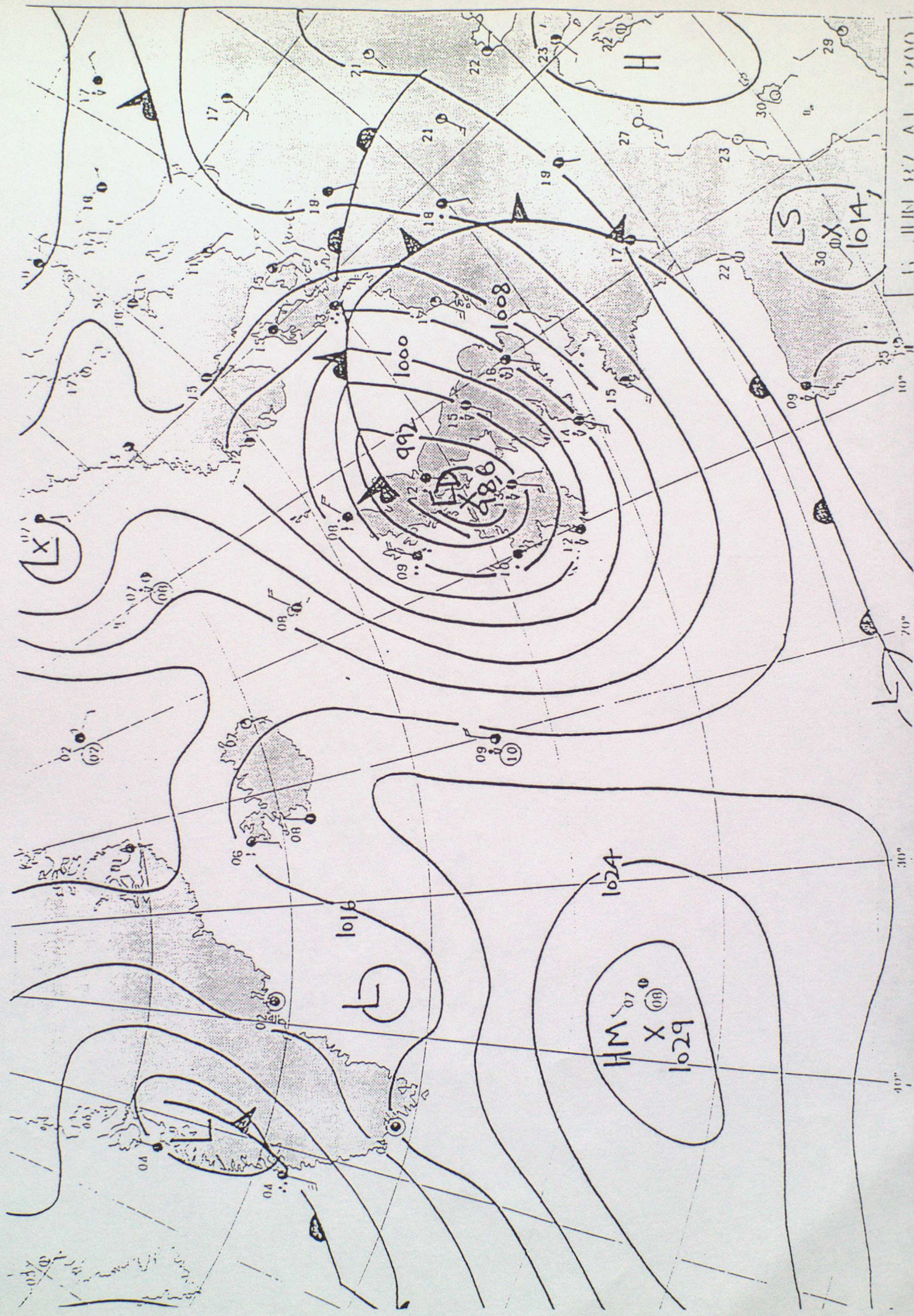


Variance from mean ascent rate (in m/s)



Aughton Radiosonde Ascent 06/06/87 1119 GMT





1111 127 AT 1200

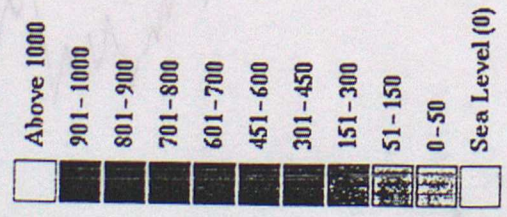
30°

40°

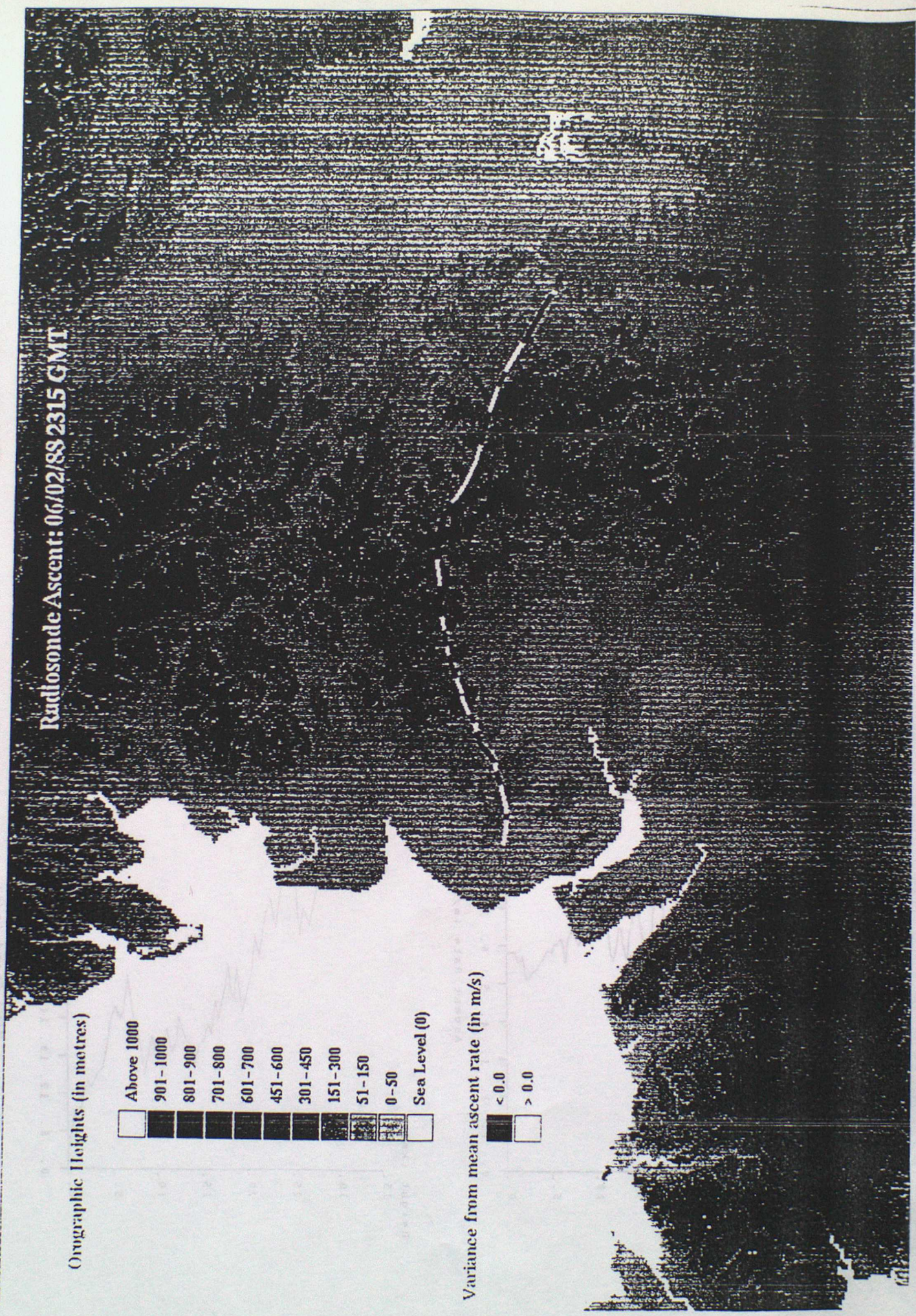
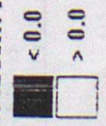
NOVA OBSERVATION (Dedicated)

Radioonde Ascent: 06/02/89 2315 GMT

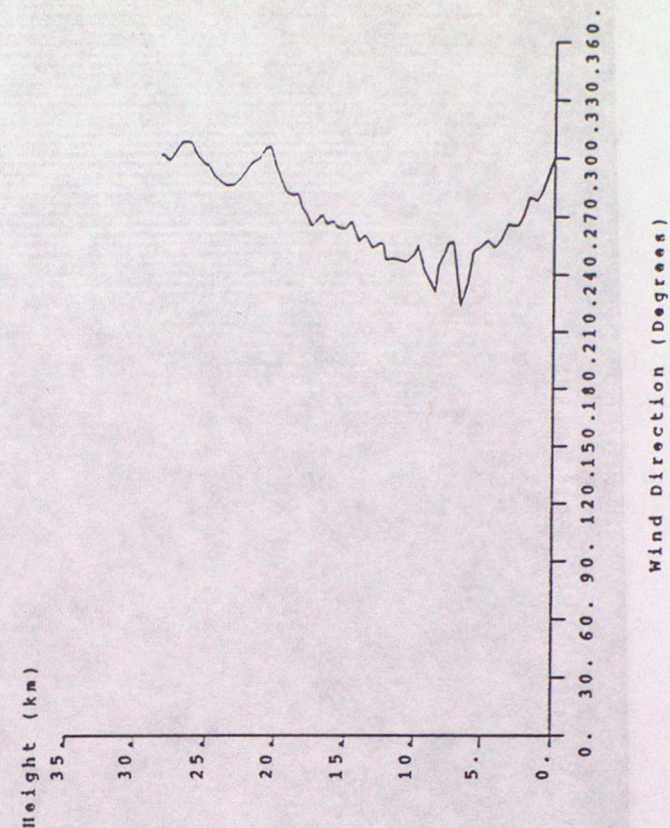
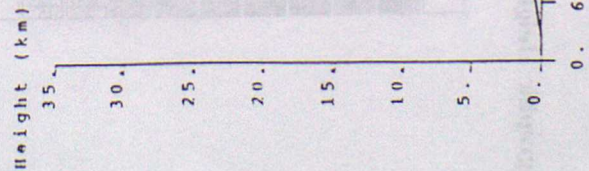
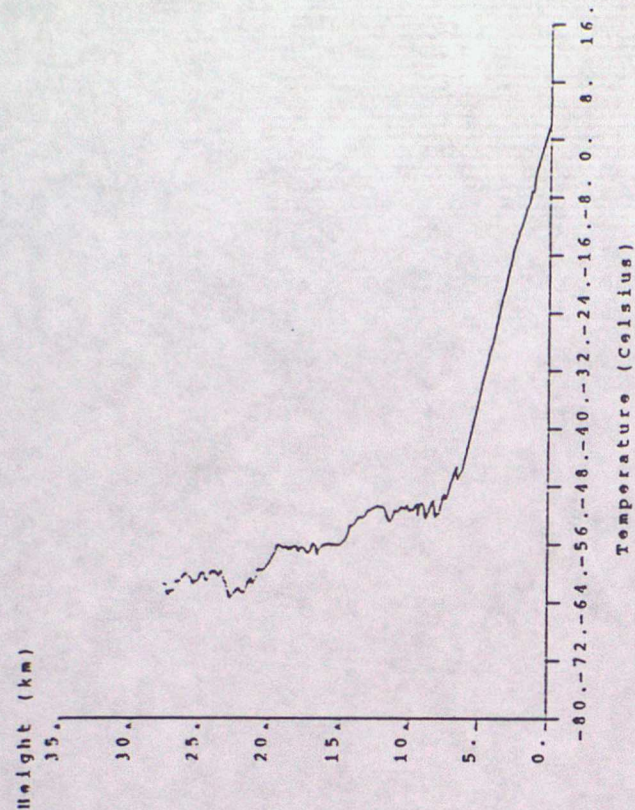
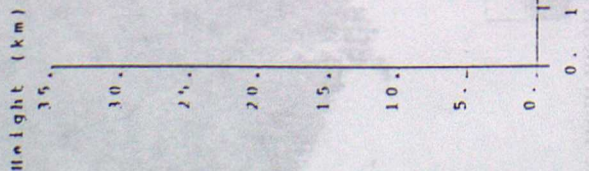
Orographic Heights (in metres)

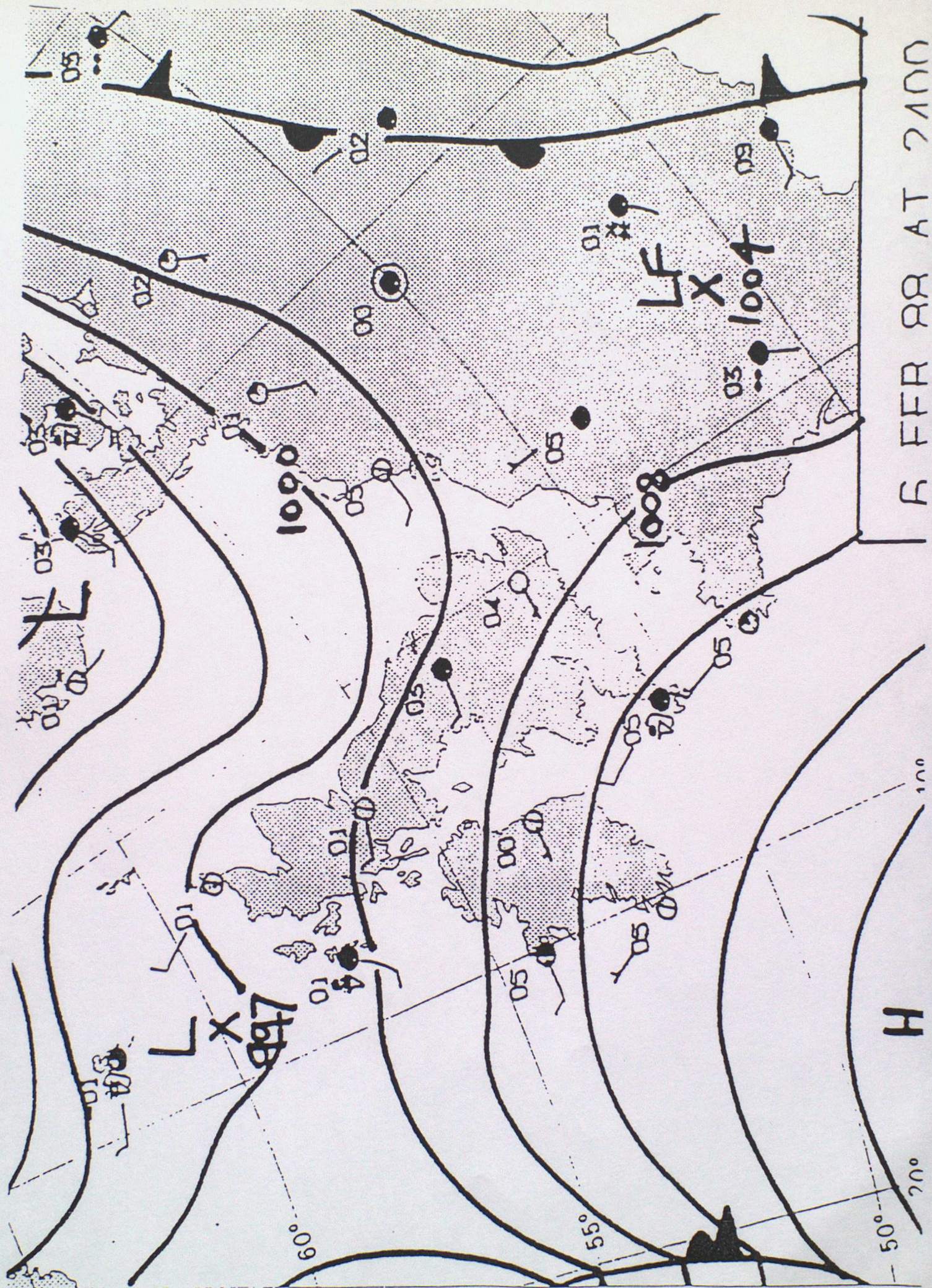


Variance from mean ascent rate (in m/s)



Aughton Radiosonde Ascent 06/02/88 2315 GMT

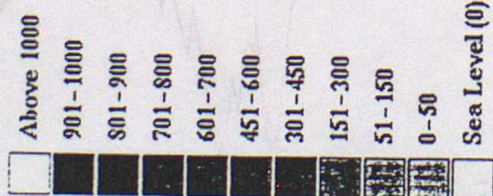




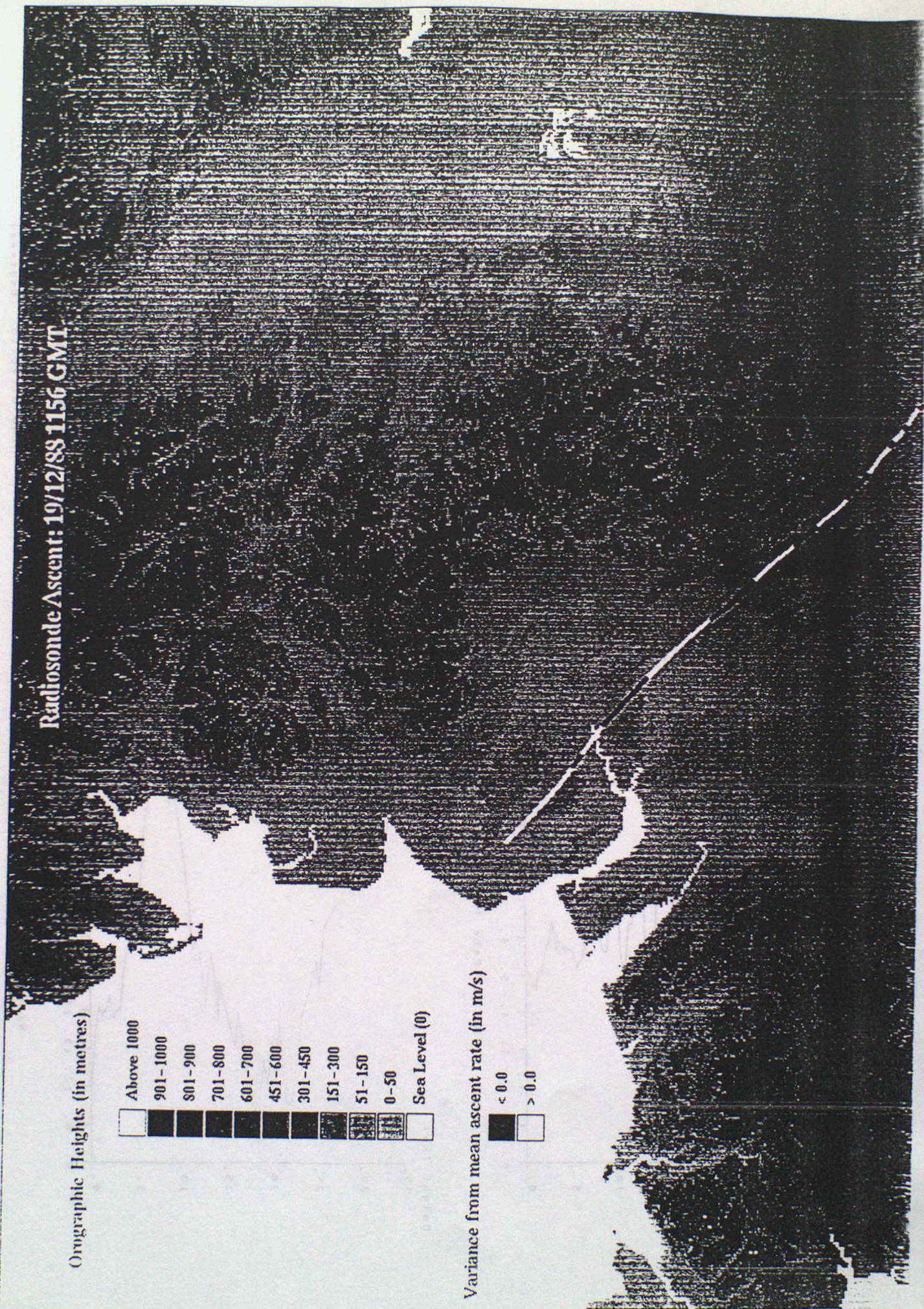
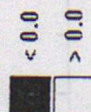
F FEB 88 AT 2100

Radiosonde Ascent: 19/12/88 1156 GMT

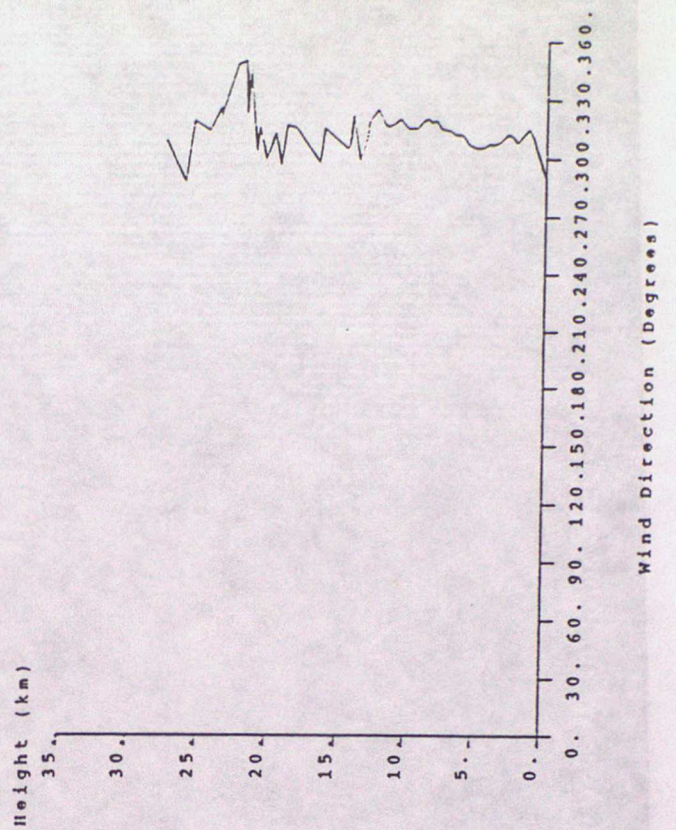
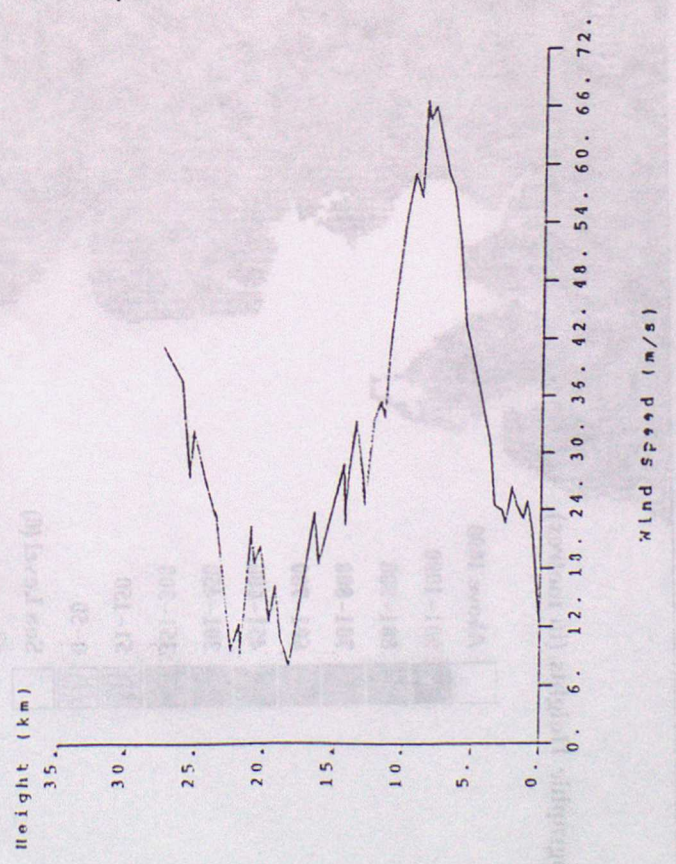
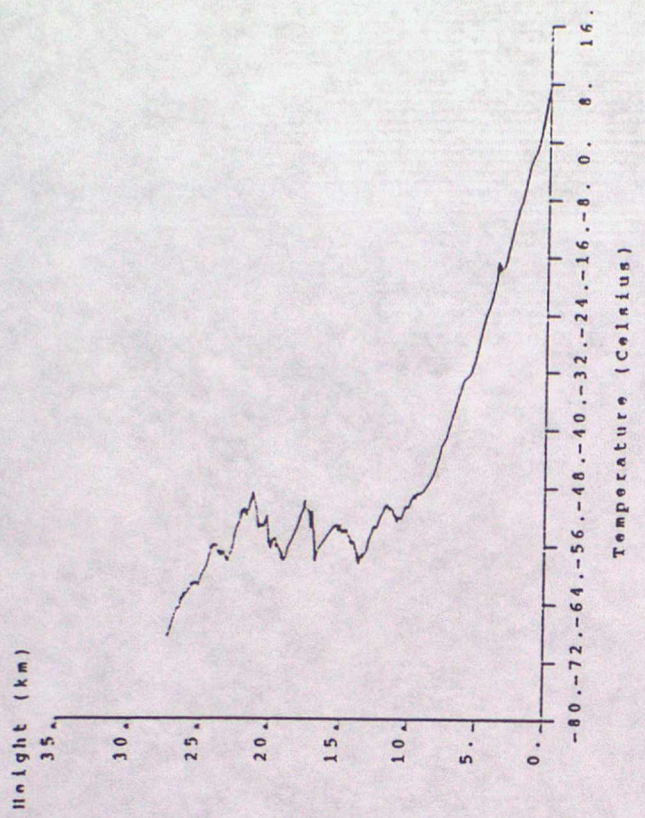
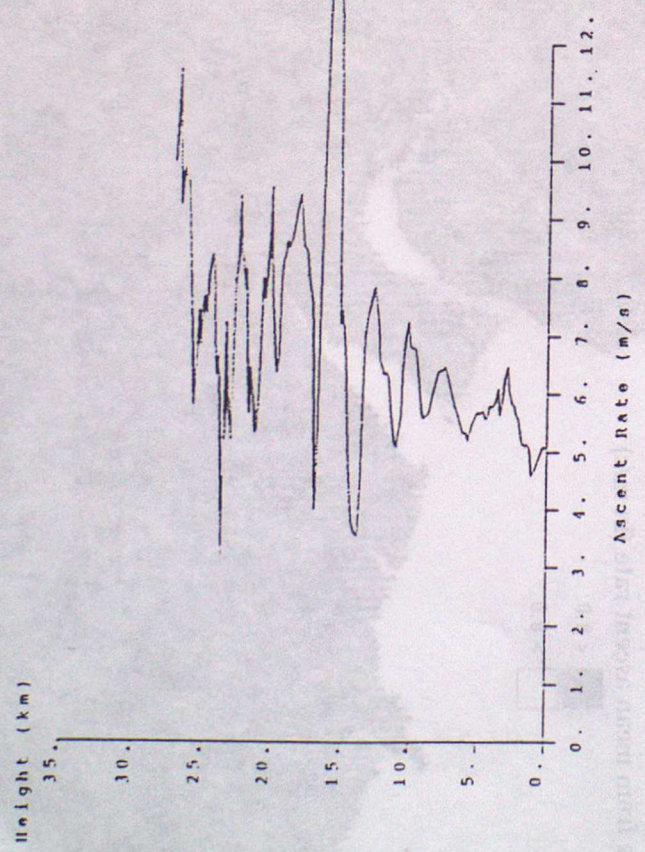
Orographic Heights (in metres)

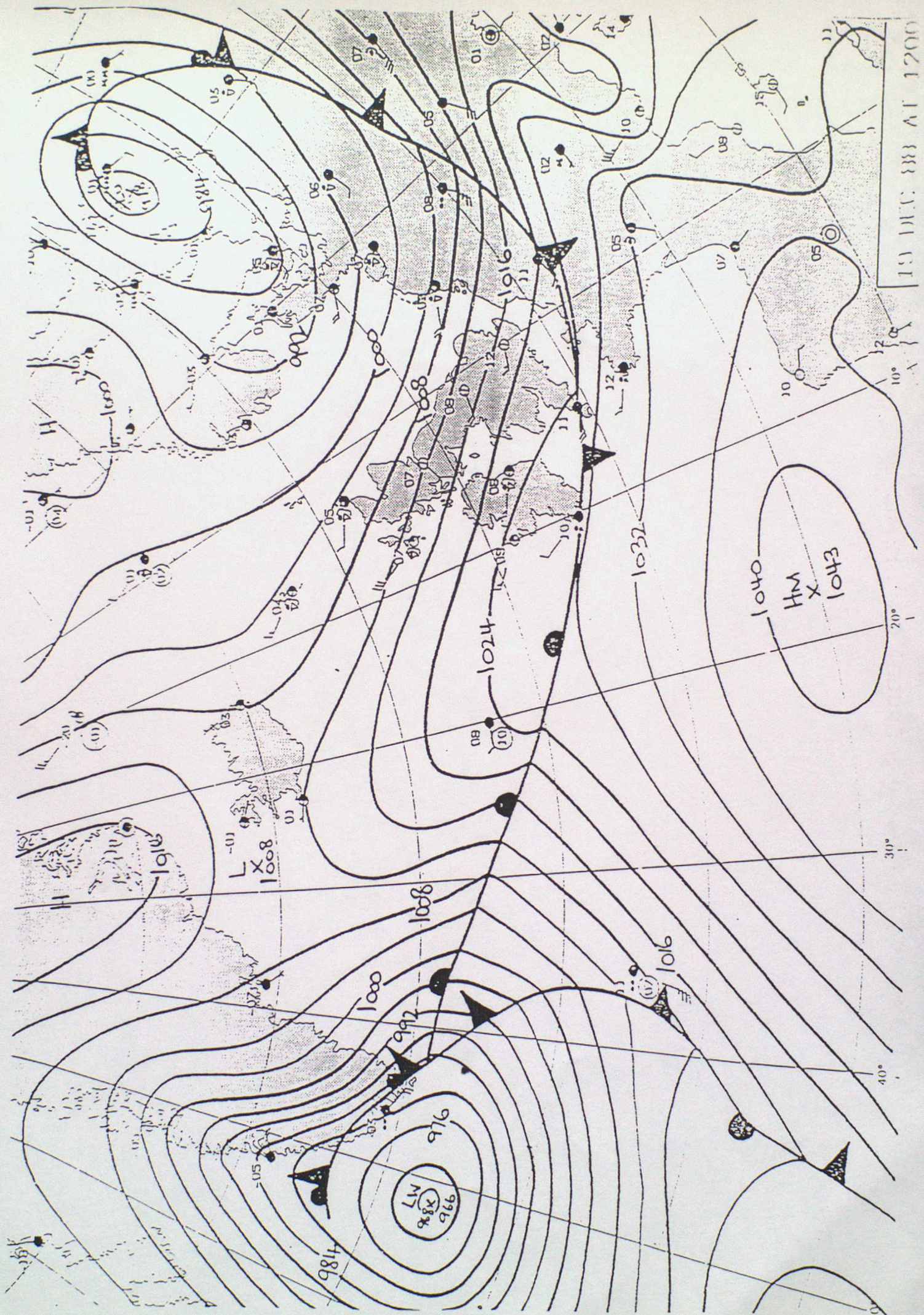


Variance from mean ascent rate (in m/s)



Aughton Radiosonde Ascent 19/12/88 1156 GMT

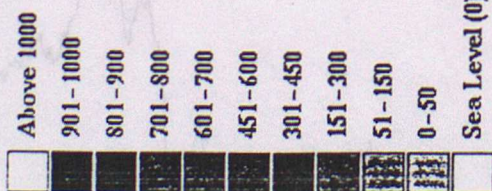




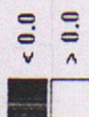
TO THE: 33 AF 1200

Radiosonde Ascent: 09/10/90 1132 GMT

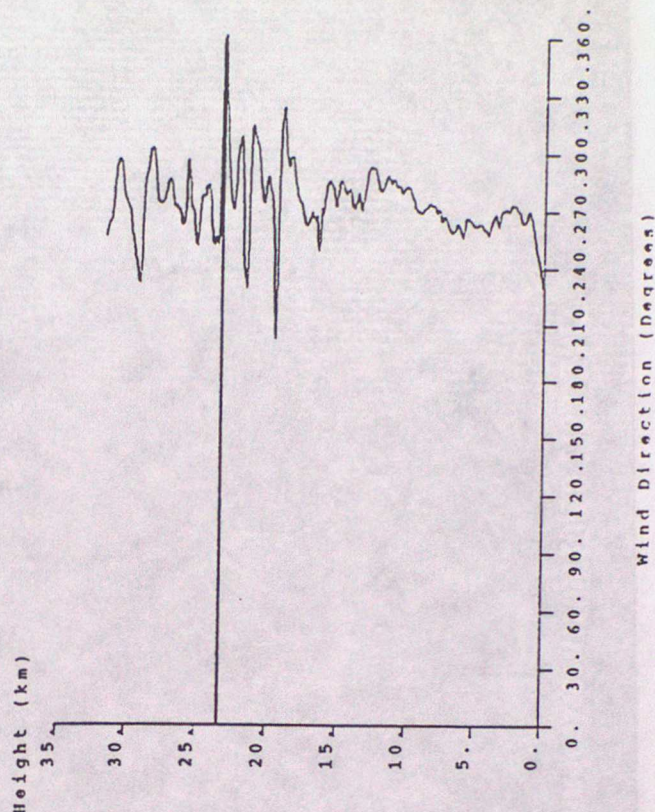
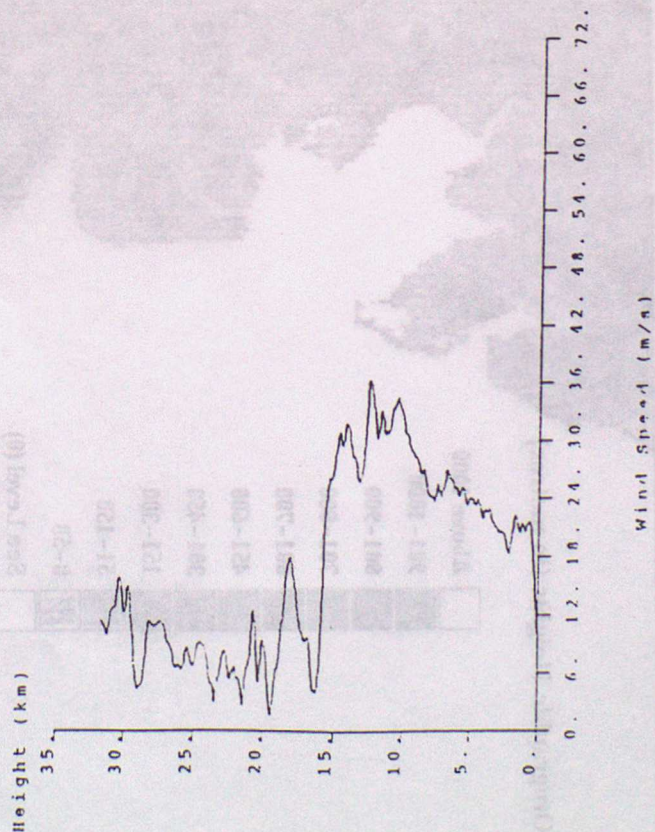
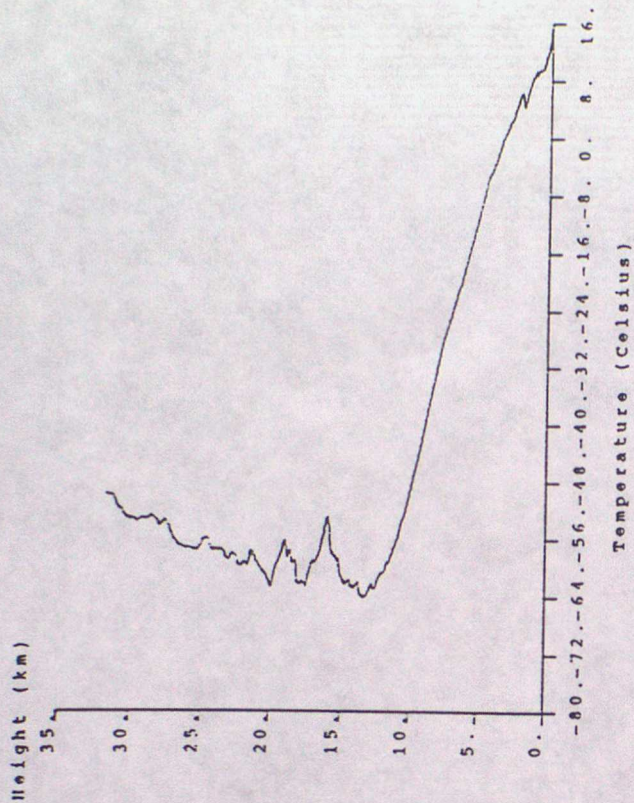
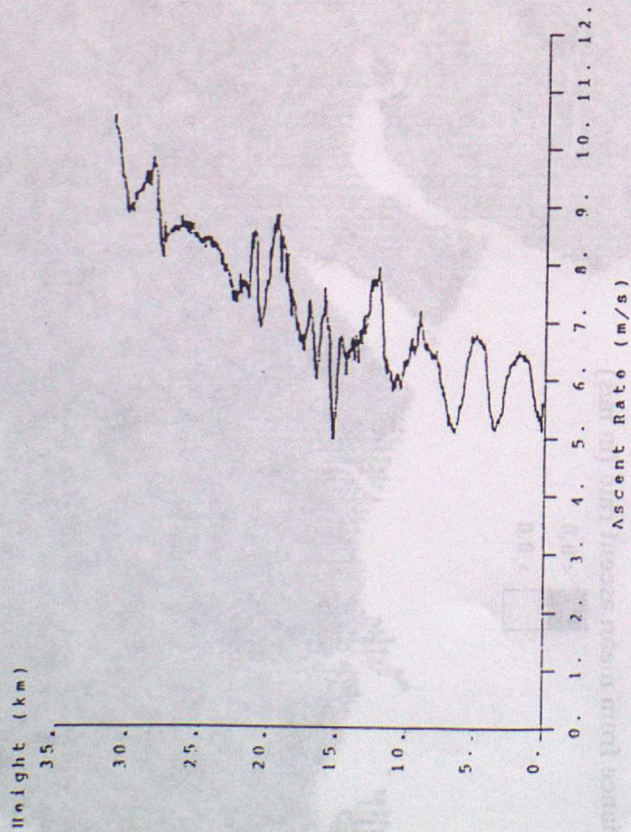
Orographic Heights (in metres)

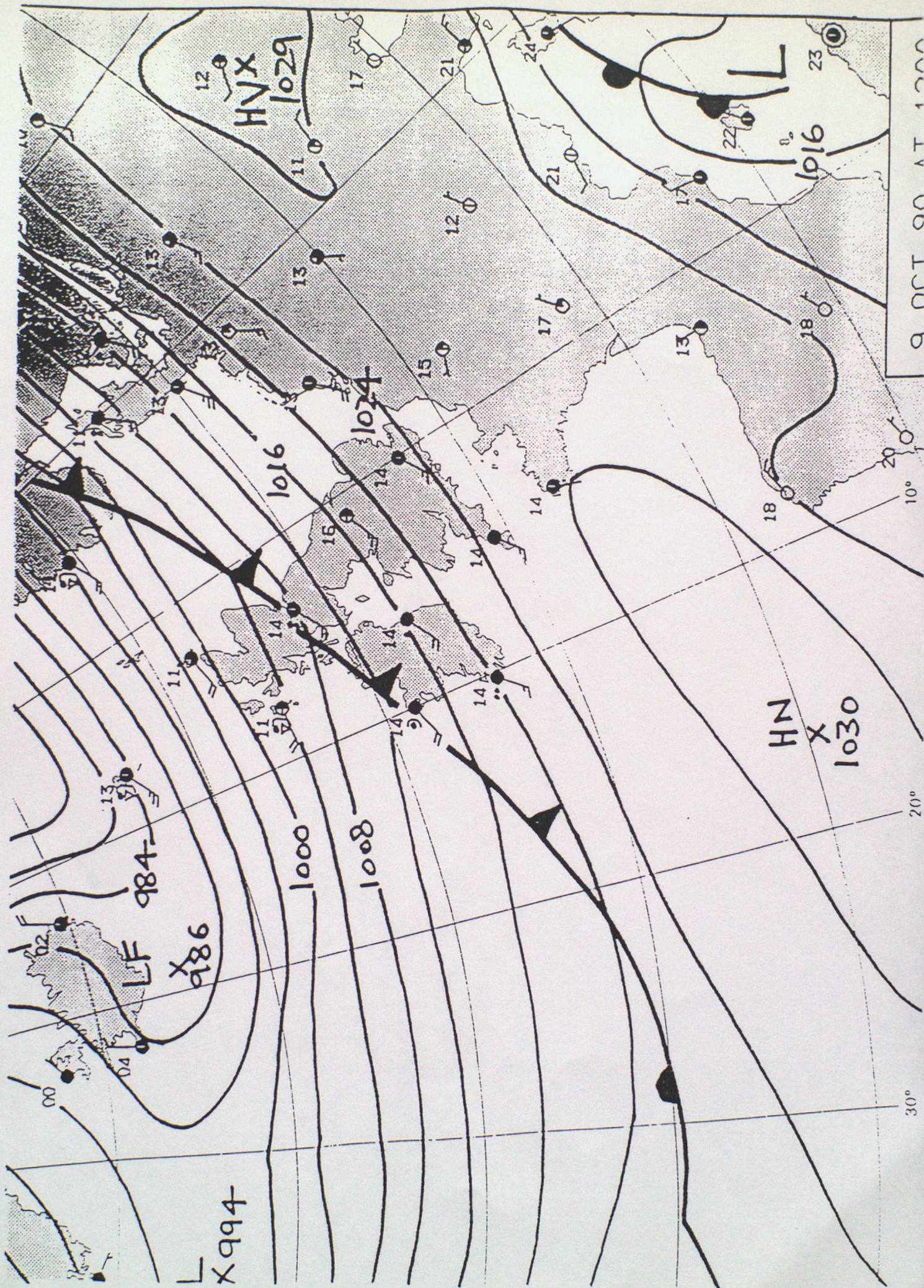


Variance from mean ascent rate (in m/s)



Aughton Radiosonde Ascent 09/10/90 1132 GMT



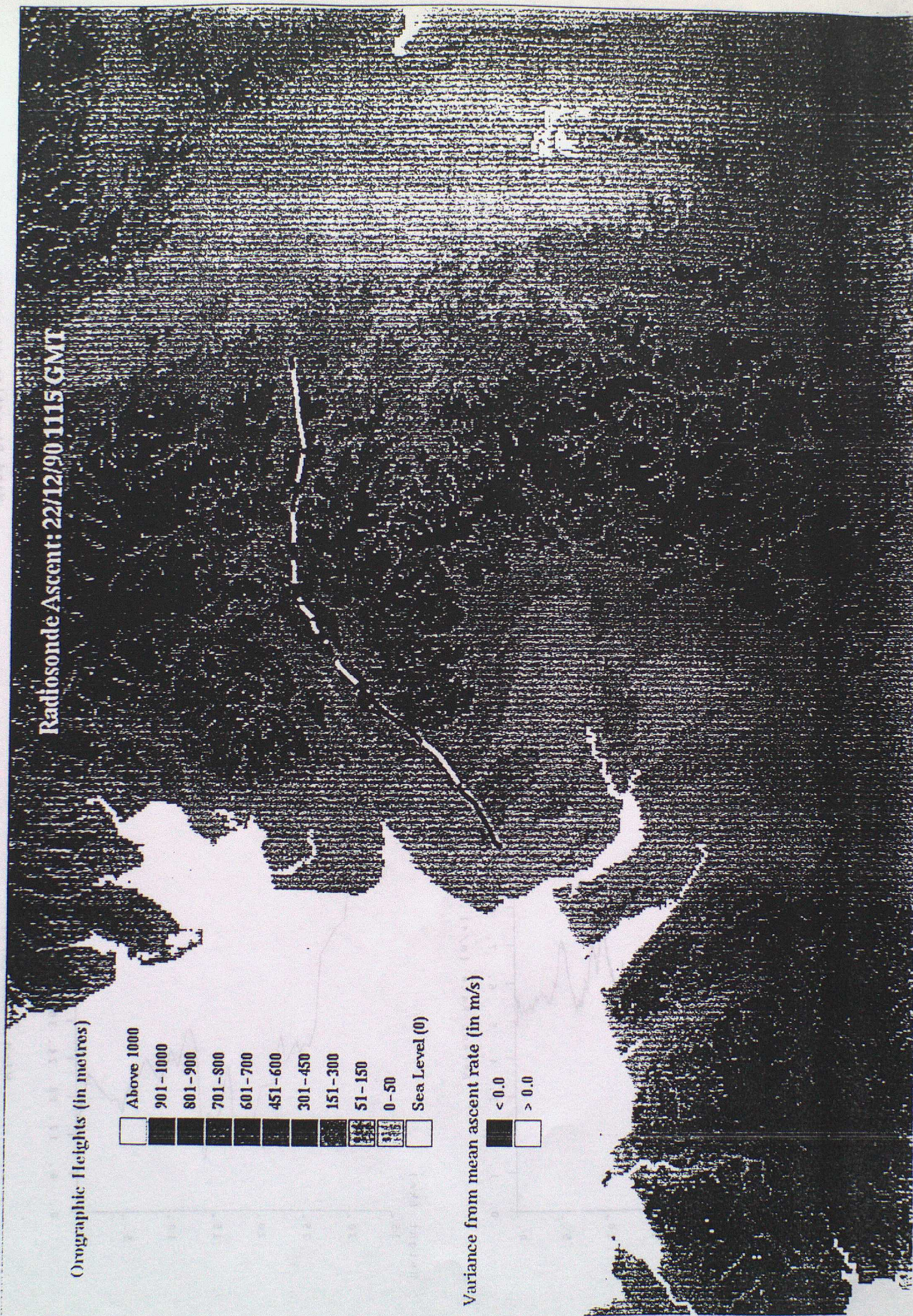
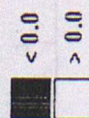


Radioonde Ascent: 22/12/90 1115 GMT

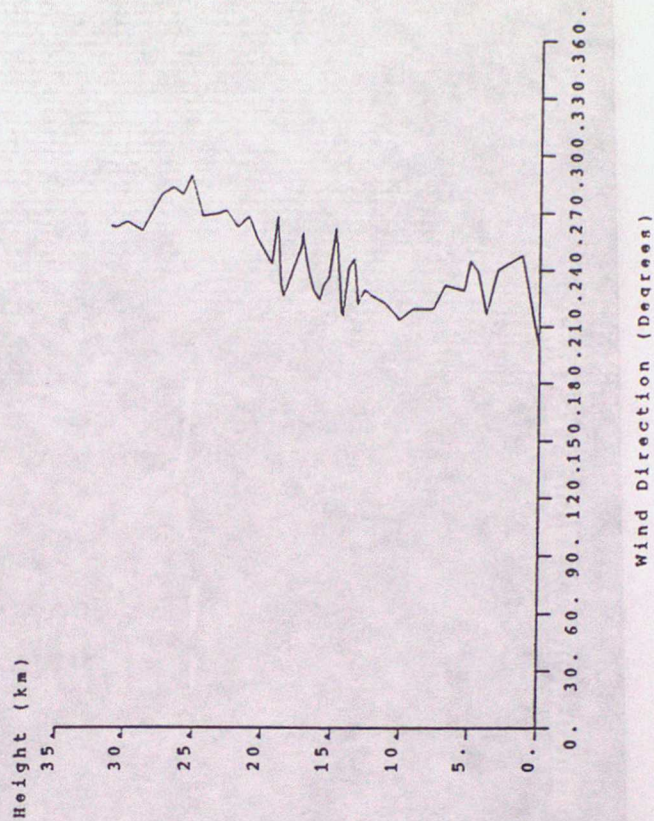
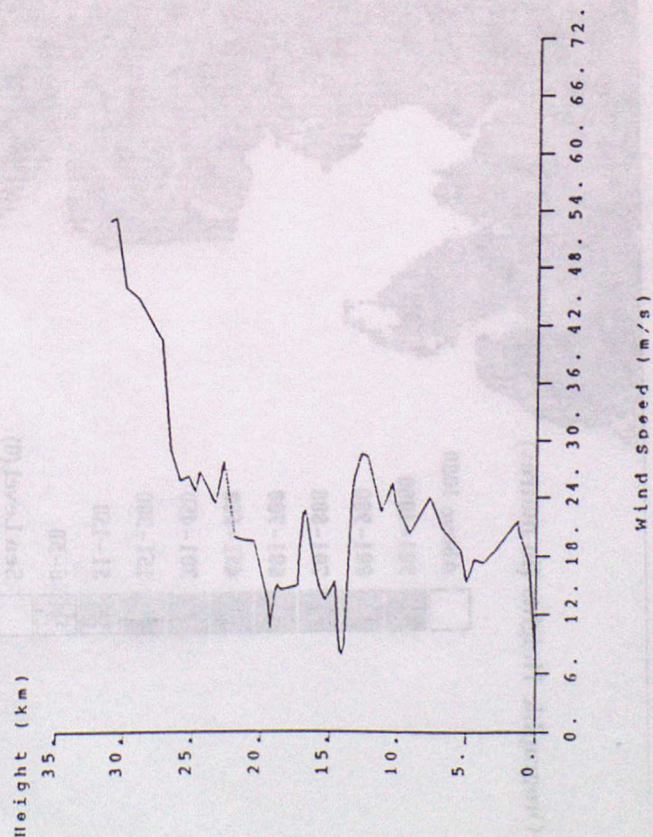
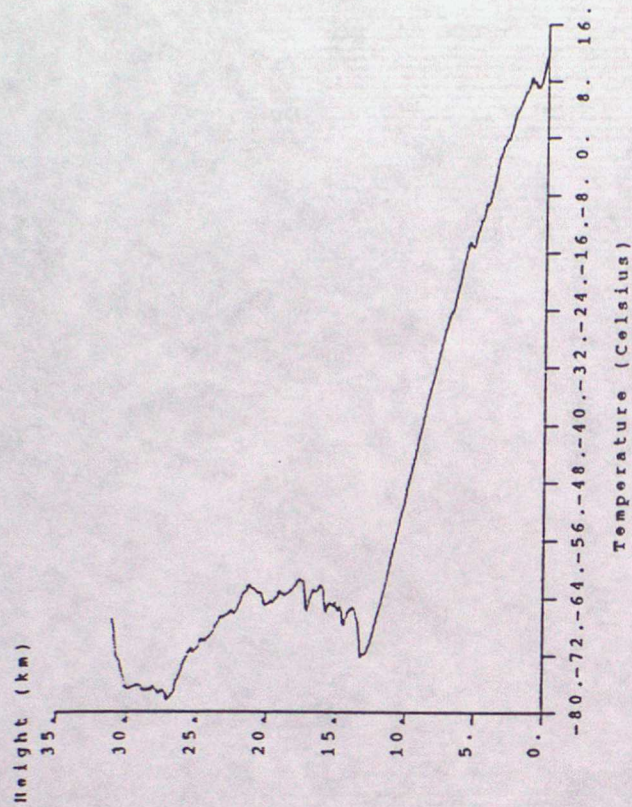
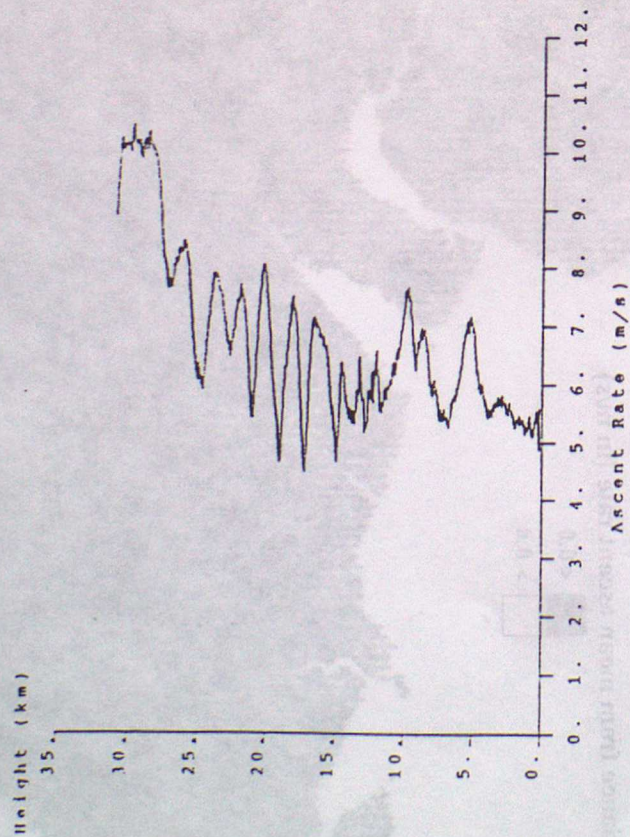
Orographic Heights (in metres)

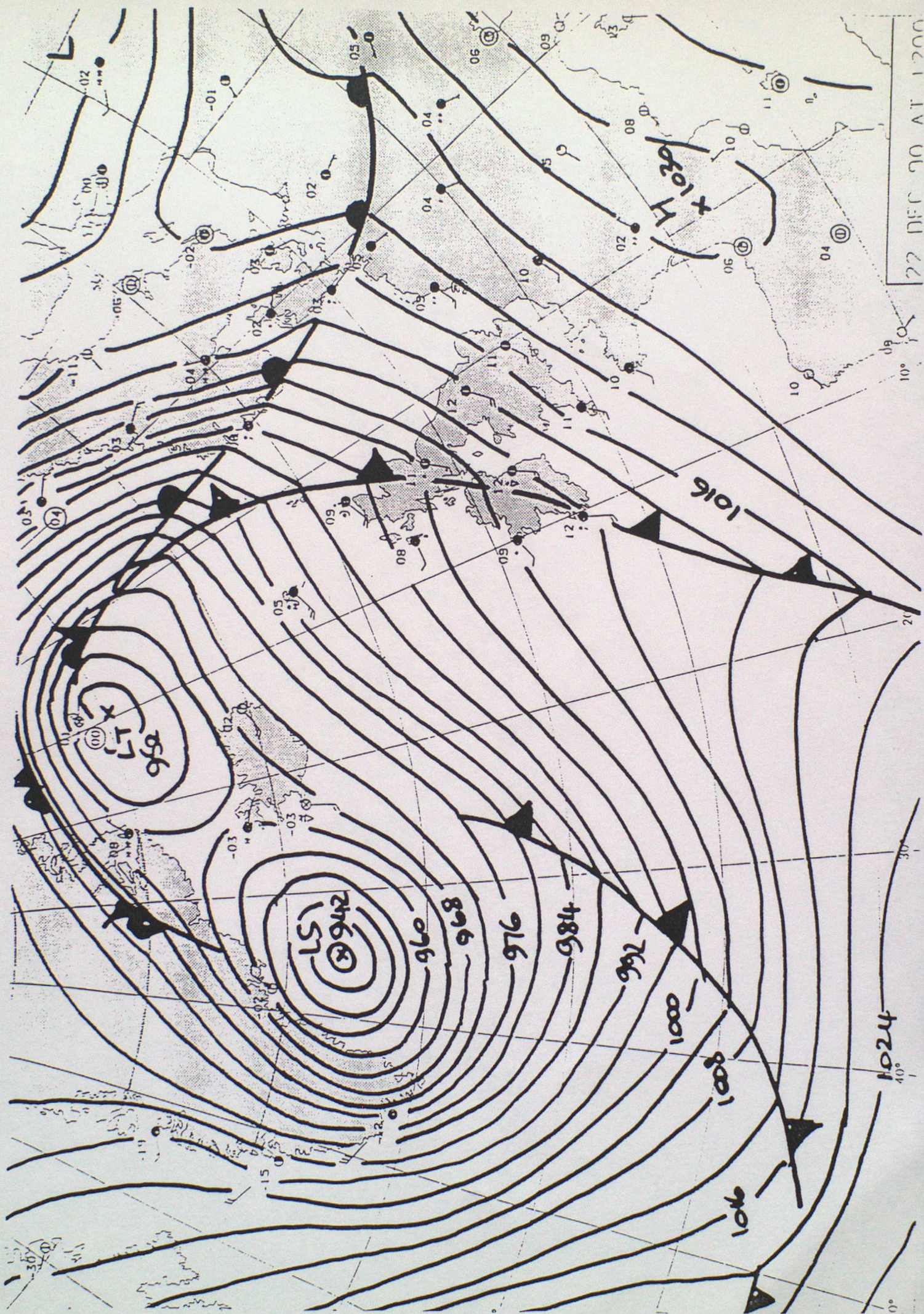


Variance from mean ascent rate (in m/s)



Aughton Radiosonde Ascent 22/12/90 1115 GMT

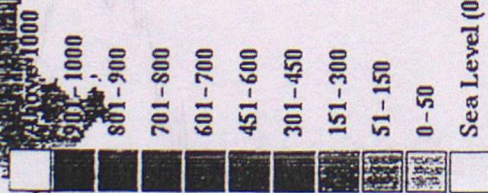




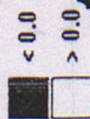
22 DEC 70 AT 1200

Radlosonde Ascent: 06/10/89 0557 GMT

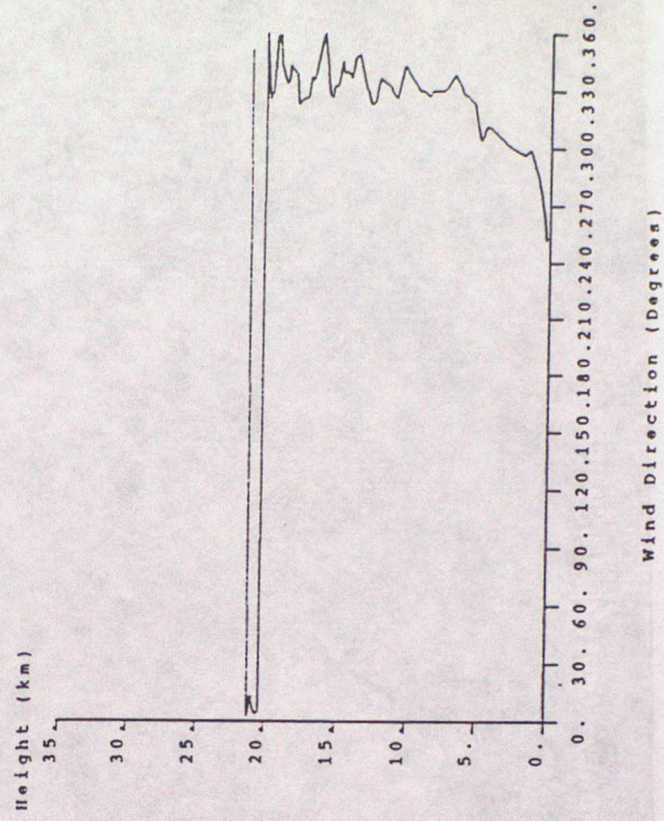
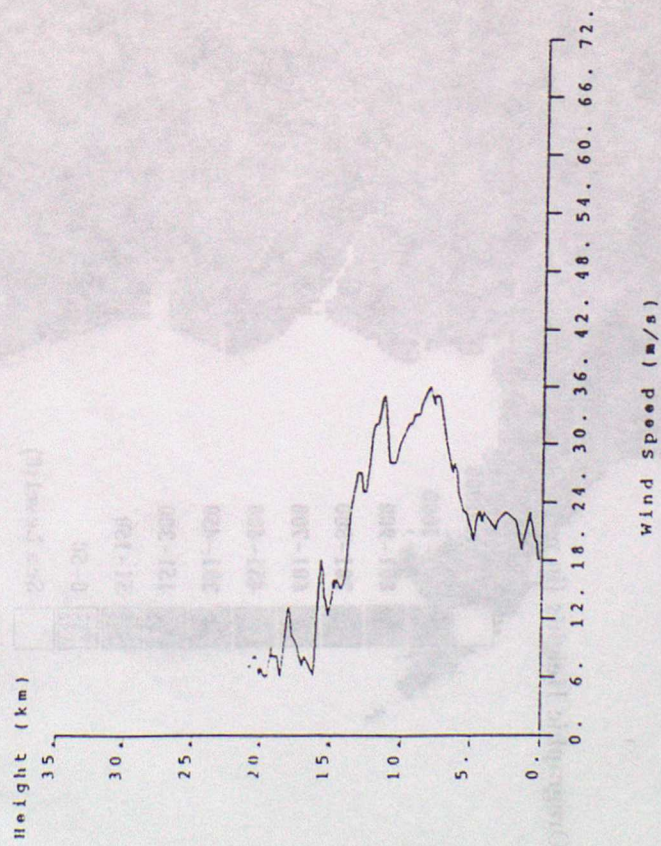
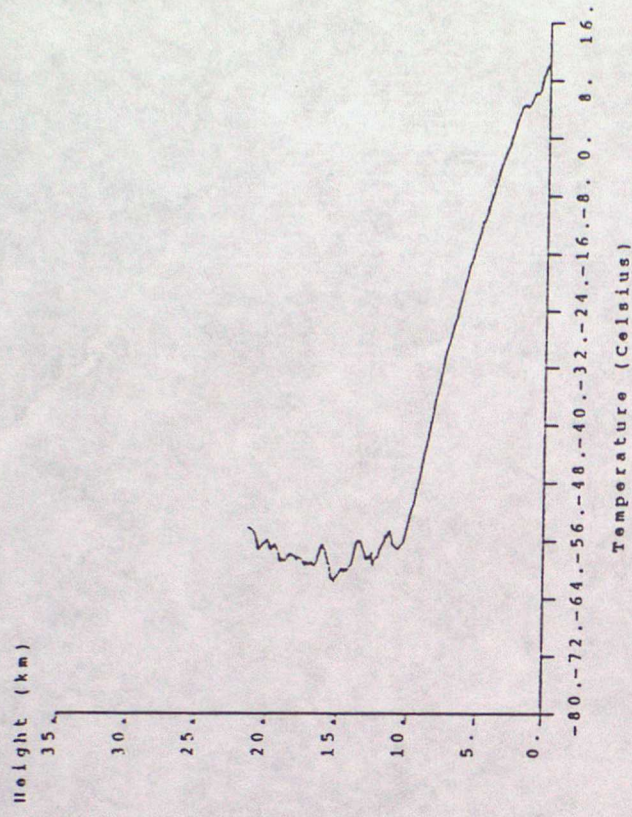
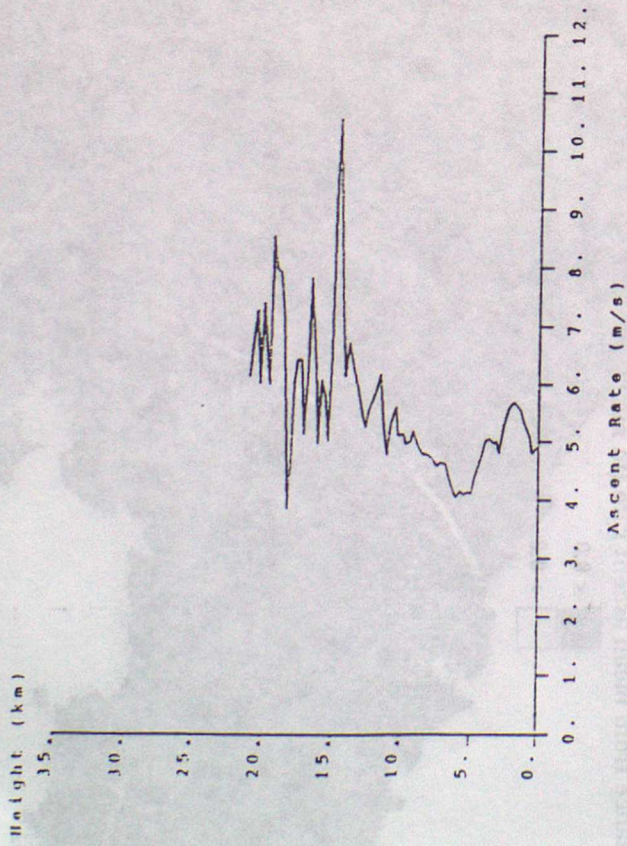
Orographic Heights (in m)

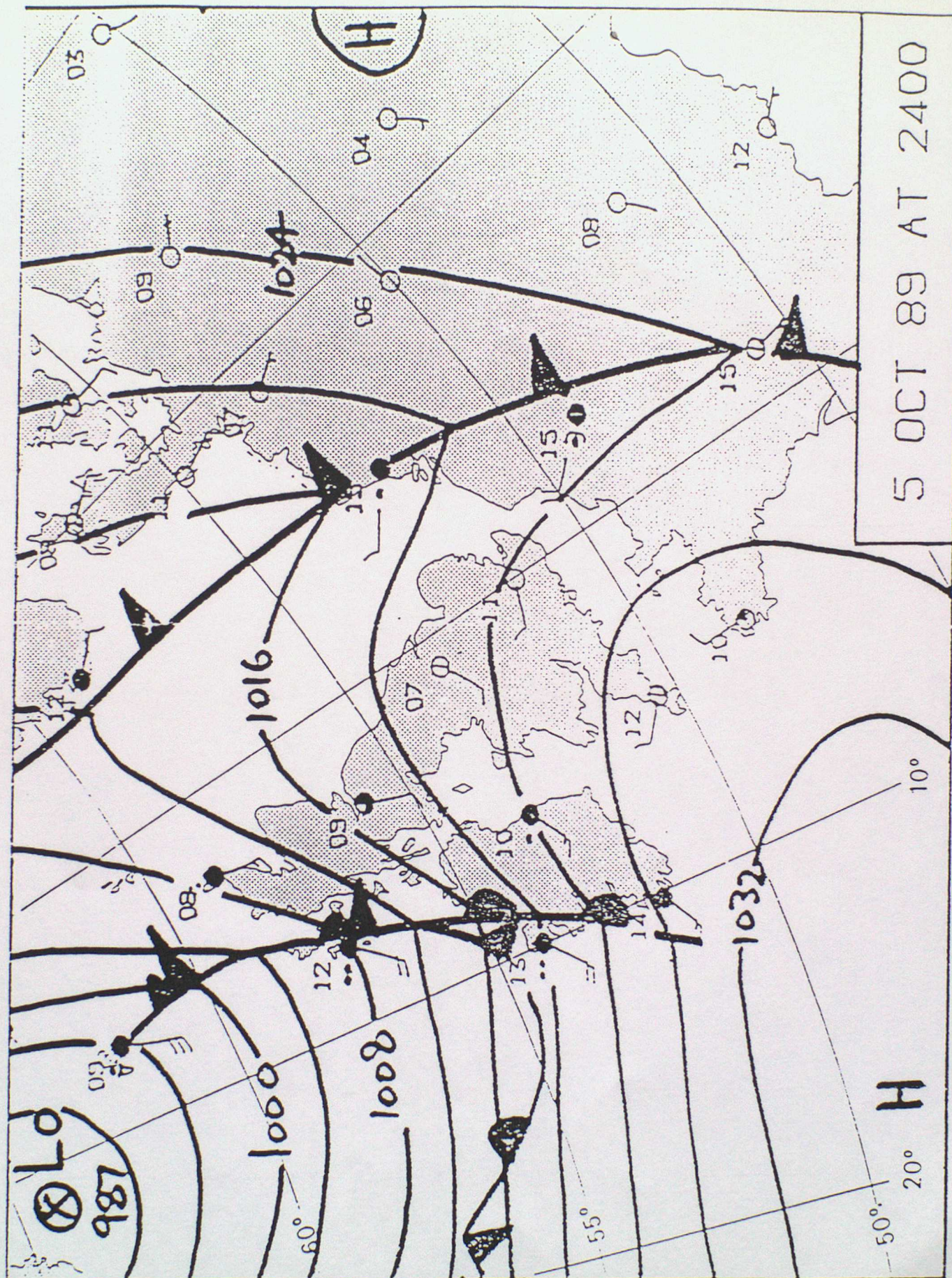


Variance from mean ascent rate (in m/s)



Aberporth Radiosonde Ascent 06/10/89 0557 GMT



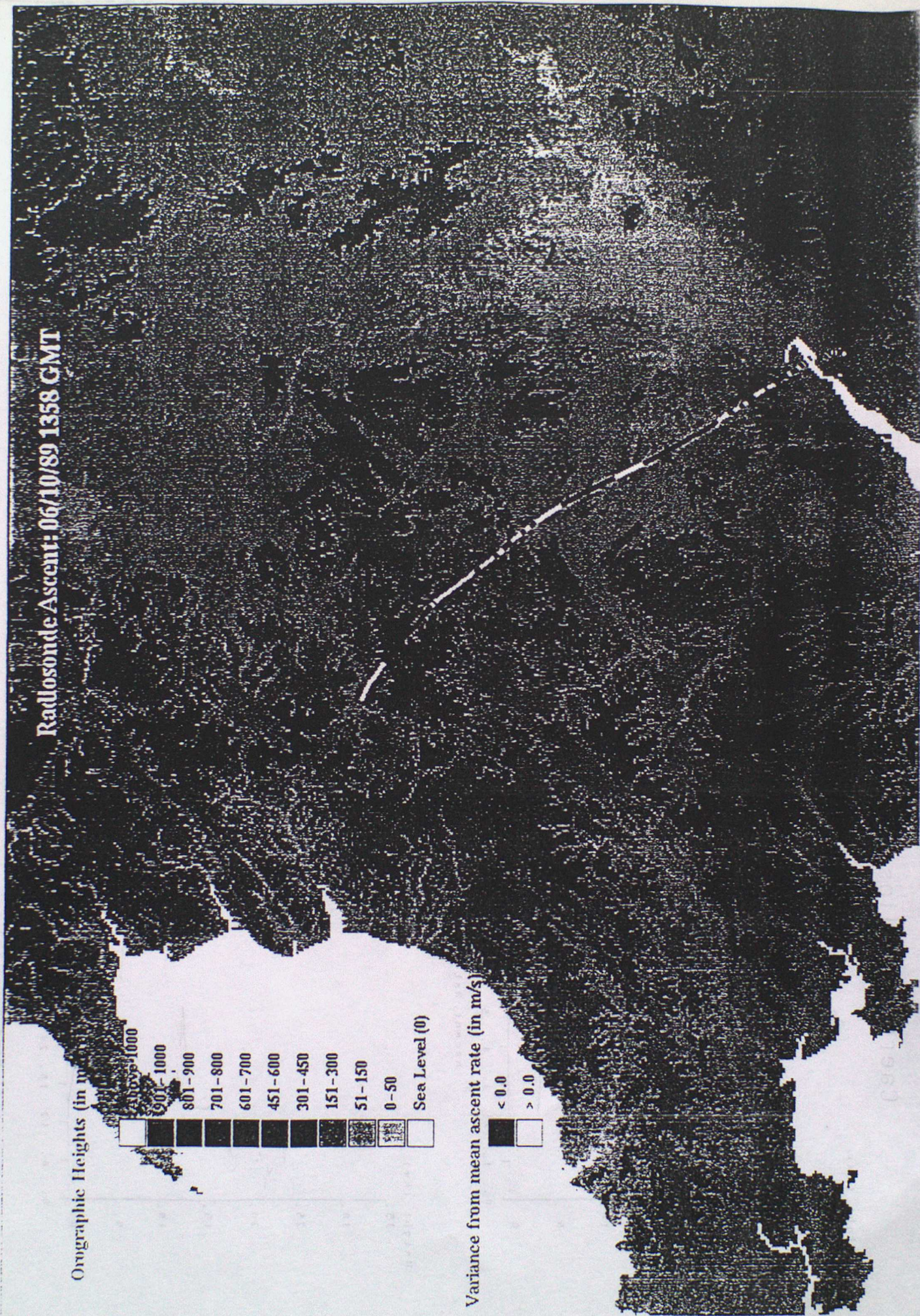
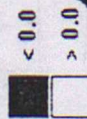


Radlosonde Ascent: 06/10/89 1358 GMT

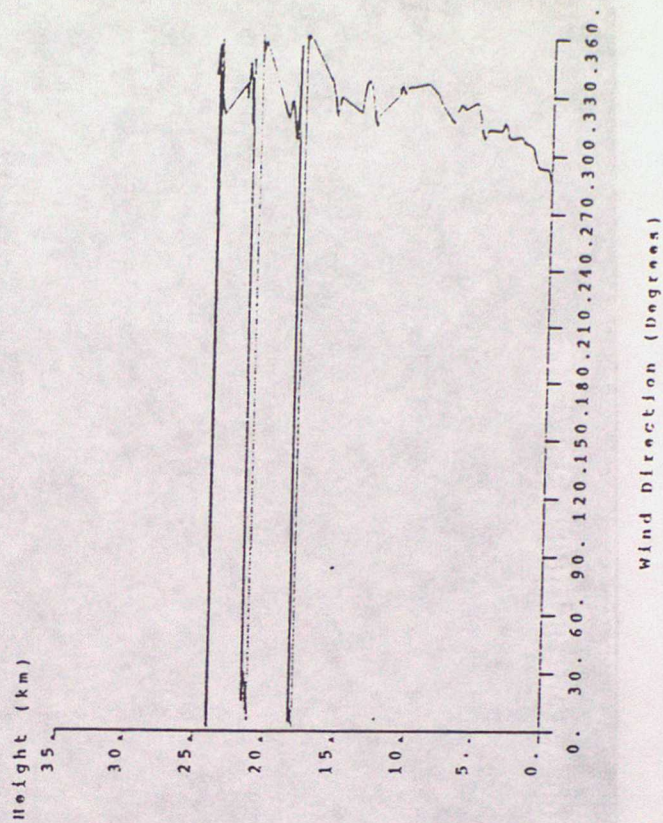
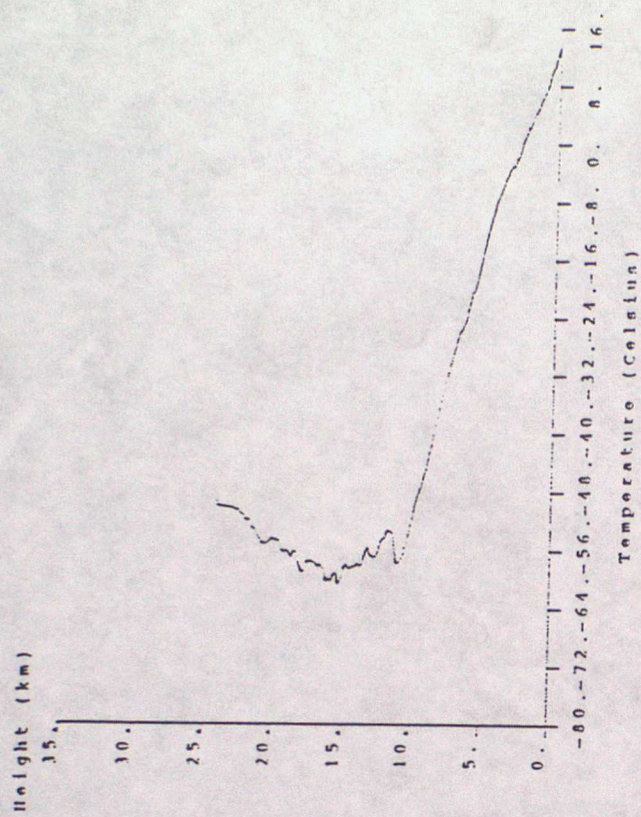
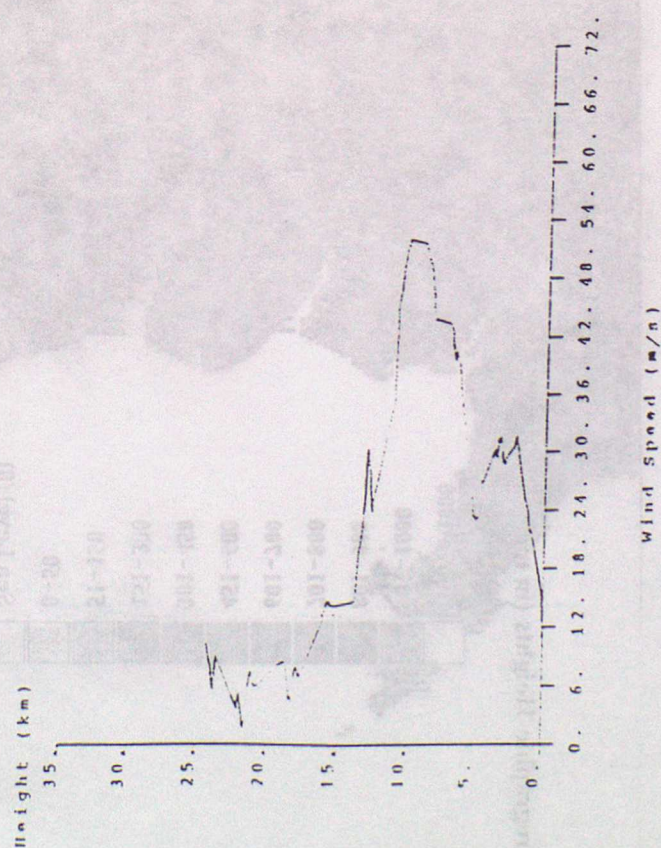
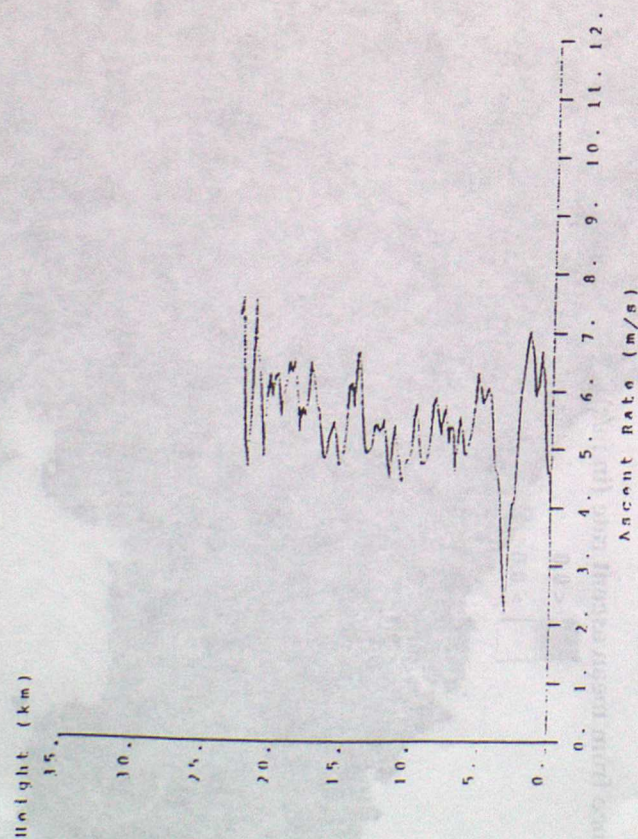
Orographic Heights (in m)

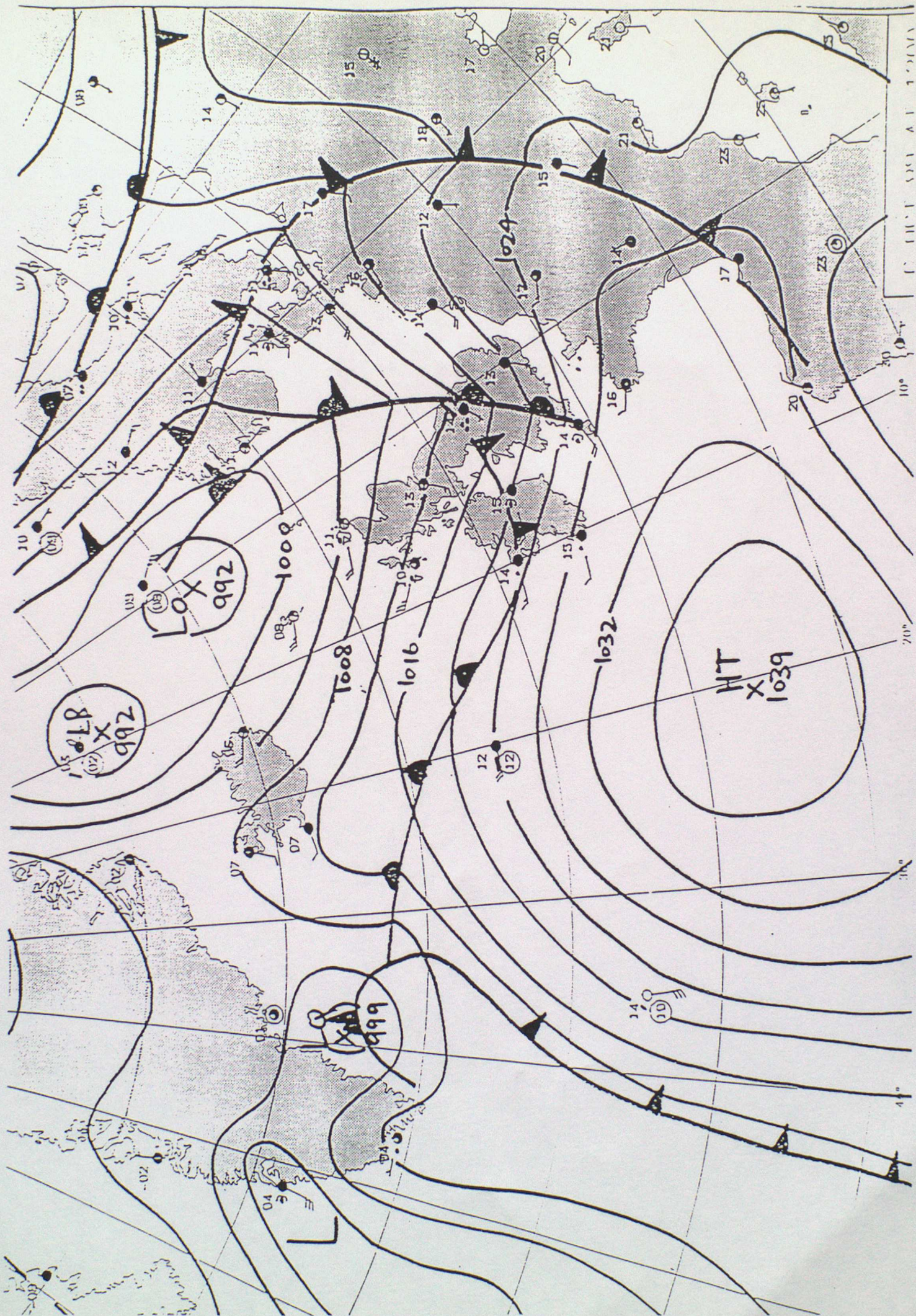


Variance from mean ascent rate (in m/s)

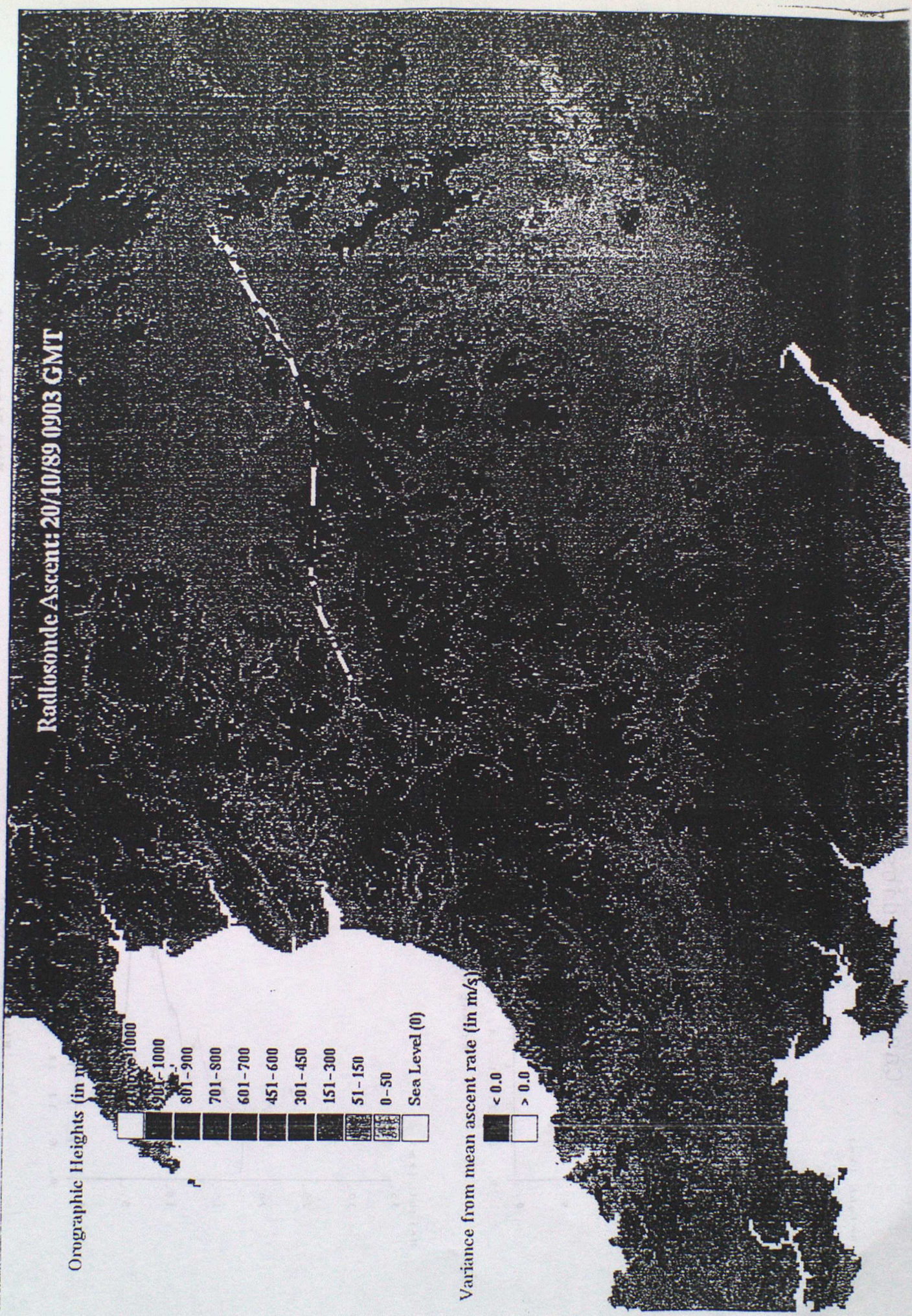
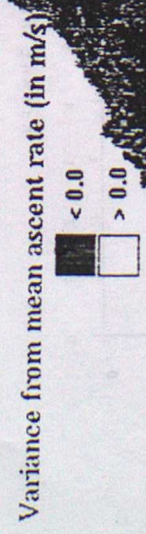
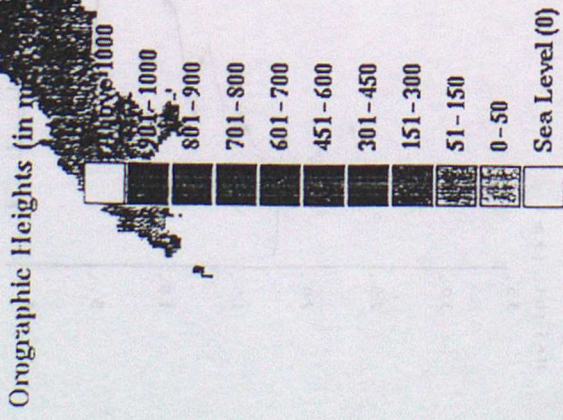


Caersws Radiosonde Ascent 06/10/89 1358 GMT

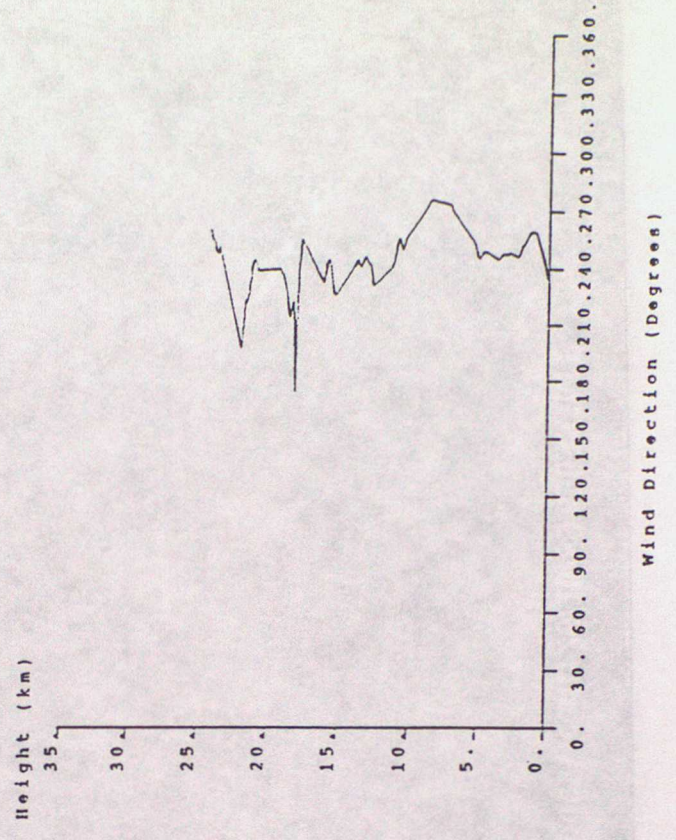
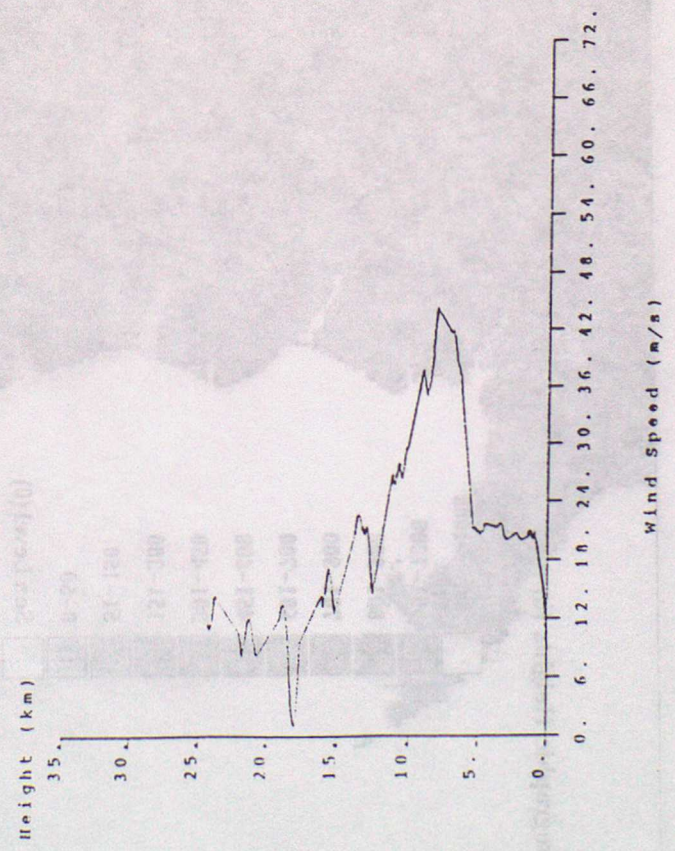
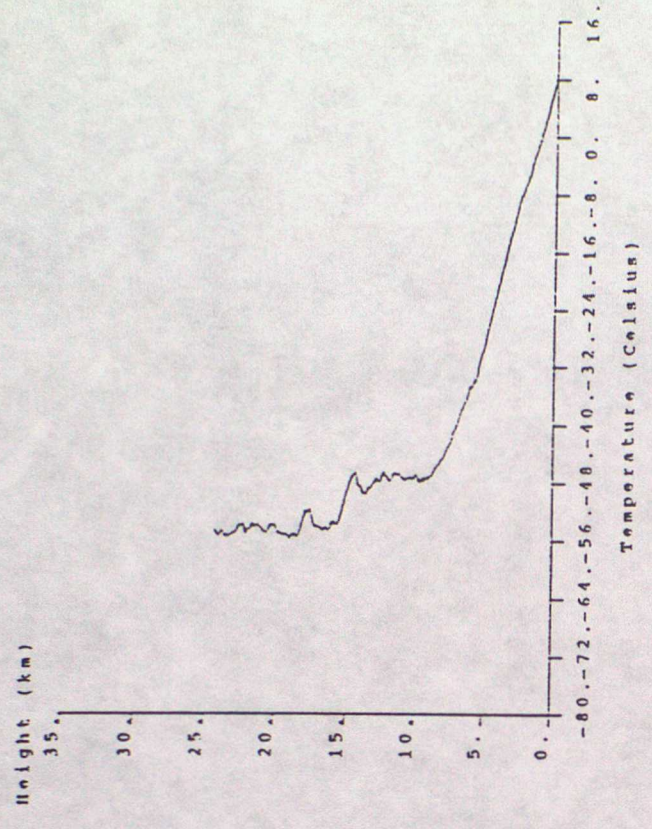
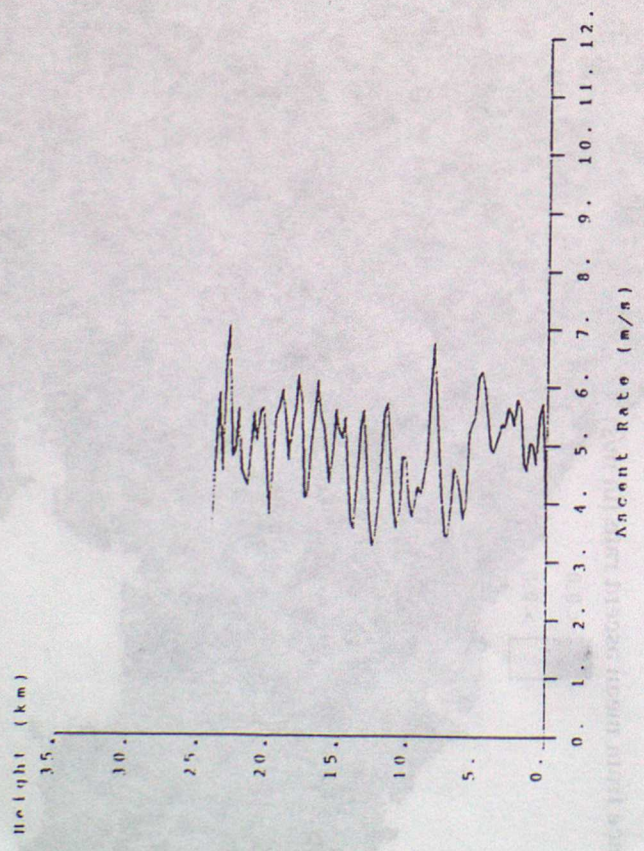


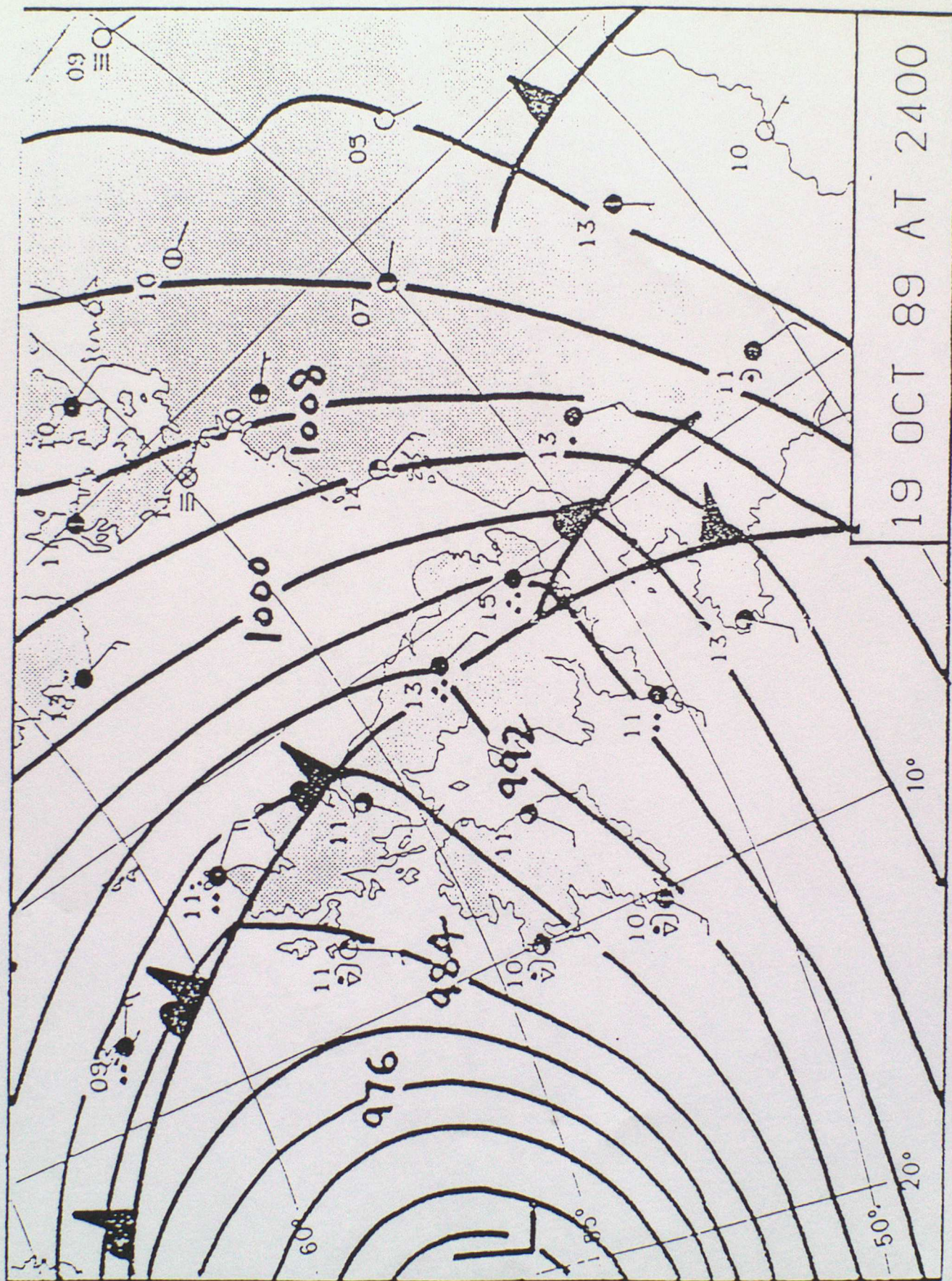


Radioonde Ascent: 20/10/89 0903 GMT



Caersws Radiosonde Ascent 20/10/89 0903 GMT



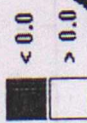


Radio-sonde Ascent: 20/10/89 2004 GMT

Orographic Heights (in m)



Variance from mean ascent rate (in m/s)



Caersws Radiosonde Ascent 20/10/89 2004 GMT

