MET O 11 TECHNICAL NOTE NO 181

3 OCTOBER 83, A CASE STUDY AND MATTERS ARISING THEREFROM.

by

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1. Introduction

This case study was brought to our attention by senior forecasters in CFO who felt that the model had produced a 'spurious' area of rain and moved it 'unrealistically' fast across UK. The model prediction was examined and compared with reality; a discussion follows in section 2. However some undesirable aspects of the assimilation suite were identified and these are presented in section 3.

2. Case Study

1. One initial criticism of the model in this case was the apparent 'urealistically' fast movement of the peak rainfall accumulation area.

However, by considering the movement of the rainfall (rate) area, the speed of movement was found to be 40-50 kts. This was consistent with the 700 mb winds over UK (Aughton 51, Crawley 38, Camborne 43). See Fig 1.

2. Satellite pictures showed a wave at about 48°N 13°W at 2100Z (Meteosat) and by midnight, this was analysed as a single wave or ripple at 49°N 11°W with very little evidence of further waves to the SW. However, the pictures 0530-0600Z (NOAA , Meteosat) suggest that a wave was crossing UK but that another more defined feature was developing near 45°N 18°W.

3. From a close study of UK surface charts, it seemed likely that indeed a very shallow wave on the front had run into the Bristol Channel by 0100Z, subsequently continuing E and decaying. It was followed by another very shallow ripple running up the Bristol Channel before 0400Z and away E off the Norfolk coast by 0900Z. The scale of these features was small and not clearly defined, pressure falls being only between 0.5 to 1.0 mb/3 hr.

4. Rainfall accumulations associated with the waves/ripples produced up to 10mm in the 6hr period 00-06Z over SW England, S Midlands and S Wales. The model was slow and out of position (too far NW) with its rain and too extensive with the rain area. By 0600Z rates of 1mm hr^{-1} were predicted over an area with a width of over 100 miles which is greatly overdone.

By 1200Z, the actual ripples were gone from the UK Chart, 06-12Z accumulations coming from orographic rain in the SW, the ripple in the E and warm sector slight rain and drizzle elsewhere. The model on the other hand had a much larger area of high accumulations suggesting the passage of a considerably more developed wave. At 1200Z the model rainfall was over the N. Sea, just clearing the Lincs/S Yorks coast. This is still too far North but with a fairly accurate timing: the main error is in the intensity of the development and therefore precipitation. See Fig 2/3.

5. This over development is consistent with the large vertical velocities developed within the model, again over an erroneously large area. This simply confirms that the model has made too much of the system. The 1000-500 mb model thickness patterns also show up the movement of the model wave, consistent with its own rainfall production, favouring the cold front rather than the warm. See Fig 4.

Interestingly, the model thickness pattern shows another (shallower) wave over the UK at 18Z with substantiating precipitation over Wales and W England. This feature is also erroneous with no evidence of any such feature in reality. This suggests that while the model may (correctly) develop waves in a baroclinic zone, they are not necessarily the same features as are occurring in reality.

6. The next feature in reality was a major wave pushing NNE just off the W Irish coast, (the feature at 45°N 10°W at 0600Z). This brought rain into SW Ireland as the warm front pushed North, peak accumulations occurring in the latter part of the period 12-18Z. Large accumulations were also recorded 18-00Z (as the wave tip continued NE) over Ireland and SW Scotland.

In this period, the model produced

i) spurious convective rain over Ireland 12-18Z (up to 6mm) and

ii) no dynamic rain returning into Ireland, the model "front" having remained S of St George's channel.

iii) The incoming wave was slow so that 18-00Z rainfall accumulated largely over the sea SSW of Ireland, with SW Scotland virtually dry.

The periods 00-06Z, 06-12Z continued to compound the timing error by putting 'wet on dry'.

Summary

In a situation where waves are evident on a front, extreme caution should be shown when using model output. Furthermore, when small scale ripples and waves are forming (in a very moist zone), the model is as likely as not to develop a realistic looking wave in the wrong place: thus with large rainfall accumulations involved, the scale of the error is large. These comments apply not only in the period T+18 to T+36 but also (to a lesser extent) to T+0 to T+18.

The scale of some wave features is too small to be correctly represented by the model since the initial analysis of such a feature is on a 150km grid. The net result may be in an error of scale of a developing wave, as in this case, despite a reduction to a 75km grid at the forecast stage.

3. Matters arising from this case study

1. It was noted that there were apparent errors in the Brest and Camborne profiles. Brest showed a marked superadiabat and cold region at low levels while Camborne had a similar superadiabat at medium levels. The 1000-850 mb thicknesses suggested Brest was too cold while Camborne was too warm. It was felt that the inclusion of recognisably erroneous data may have forced in an erroneous wave structure, particularly when considering also the 1000-500 mb thickness pattern near Brest. However, a rerun of the FM model with these two ascents removed from the assimilation produced an

"identical" erroneous wave development. This suggests that most of the information regarding the wave was held in the 18Z field for the start of the 00Z assimilation.

Further investigation revealed that while the superadiabat at Brest had been flagged as erroneous by the SDB, similar problems at Camborne were not flagged.

2. Other model profiles were also compared and some marked inconsistencies were found, mainly in the humidity profiles. It was felt that a detailed investigation of the quality control of the data should be carried out in order to clarify just where these differences were getting into the model. Consequently, T-Ø profiles were plotted from

i) the original SDB data, noting any flagged values,

ii) the version of the ascent being offered to the coarse mesh assimilation, also noting Mode 1/2 flags.

iii) the final FM profile (from the Met O 9 FM archive).

What was found was that for an ascent with a marked change from a dry zone to a moist one, or vice versa, apparently perfectly acceptable humidity data was being flagged at the Mode 1 check stage (with the background field). It was therefore felt helpful to run a sequence of computer jobs to produce profiles and fields for the background field ie. the six hour forecast from the 18Z assimilation field. The vertical profiles were quite revealing.

It became quite apparent that the background field had dry and moist areas in different places from the new data, and consequently, the new data was flagged at Mode 1. The nature of the quality control algorithm is such that these flagged data are not included in the Mode 2 checks, where values for one point are compard with neighbouring values. Thus, as happened in this case, if two neighbouring observations agree with each other but disagree with the background field, then neither is included in the Mode 2 check for the other. Consequently, they may both fail the Mode 2 check and be rejected, despite being good, corroborative data.

In one particular case, 600 mb data for Hemsby and Crawley were flagged as too high an HMR, $\simeq$ 4.0, when compared with a background value of $\simeq$ 1.5. De Bilt was also flagged at Mode 1 as being too dry compared with a moist background. This left Uccle as a comparison within the search radius for Crawley. Despite the value being high - corroborating the Crawley value - Crawley failed Mode 2 and was rejected. It seems intuitively odd that data may be rejected on the basis of comparison with data so far away when it agrees well with its nearest neighbour. In this case, the comparison was across a frontal zone making such comparisons meaningless. See Fig 5.

Similar problems were noted with a marked dry zone at lower levels over the continent. The net result on the model profiles was that the humidity traces owed more to an erroneous background than they did to new data, with some very marked deficiencies. Dry zones were moved to different levels; frontal cloud layers were dried out or removed. See Fig 6.

3. Another problem was found involving isolated ship observations. The OWS 'Romeo' ascent showed clear evidence of medium cloud layers above 800 mb, indicating the presence of a frontal zone. However, the background fields above 700 mb had the main frontal zone of high HMR values well to the SE of Romeo. Consequently, some good data was again flagged, and even that which was accepted had an undesired effect. The assimilation process produced a fit to the single observation over only a part of the length of the frontal zone, contours simply bulging out to include the new data. The main axis of the frontal zone remained in the same incorrect position with an erroneous broadening of the zone itself. See Fig 5.

4. The final area of concern was that of temperature corrections to radio-sonde data before it goes into the model. Historically, each radio-sonde station has a correction to be applied to the 100 mb height value so that sensible 100 mb charts may be drawn. A consistent temperature correction is included in the data extraction routine before

the data goes into the assimilation, and is applied over the whole depth of the ascent. The present values have been in use since 1981 and reflect the variability of different radio sonde types, national practices etc. Brest was one of the stations having a negative correction requiring a cooling of about 1°C over the ascent. It was noted that the 1000-500 mb thickness contours dipped south to fit the Brest data suggesting that the layer was too cold, perhaps due to the correction that was intended to improve heights above the tropopause.

More seriously, it was found that while temperature values were corrected, dew point values were not corrected. Consequently, humidity values were altered depending on the sign of the height correction; a negative correction resulted in a cooling of temperature value and hence a moistening. While this is of little consequence at medium or high cloud levels, it is important in the boundary layer where low-level moisture flow may be quite critical. (The initiation of convection is such a process). Examples of super saturation were noted in the lowest layers, a direct result of the temperature correction.

4. Conclusions

1. These findings raise doubts concerning the present quality control procedure with respect to HMR. One way of improving the problem would be to analyse relative humidity instead of HMR. Relative humidity is constrained by a lower and upper bound in all seasons, at all levels whereas HMR has a much greater variability dependent on season and level. Hence it would seem a simpler matter to quality control RH data rather than HMR.

2. Whichever humidity variable was to be used, the Mode 1 check should be relaxed, or removed so that only obvious 'rubbish' values are discarded and all other data accepted for the Mode 2 check. It may be necessary to allow increased variability at this stage to prevent good data being rejected or perhaps all data passing the initial screening should simply be used. This

would cut down the time spent in quality controlling humidity data to a minimum and avoid the expense of complex algorithms that still discard valid data.

3. The concept of moving whole frontal zones etc is difficult without an interactive intervention system. This is almost impossible to implement with the present assimilation scheme. However, a change to RH as the analysed moisture variable would make the insertion of bogus values considerably easier since forecasters have a much better feel for RH than for HMR in relation to cloud observations, fronts etc.

Since we are concerned primarily with rainfall forecasts over the UK and surrounding area, it may be worth considering a human quality control of RH so that frontal zones which are apparently incorrectly positioned may be moved in toto. This would avoid the effect of isolated ship observations leading to only local changes in a frontal zone, leaving the broader scale error untouched. However, it is felt that there may be little advantage in altering humidity fields without altering the associated temperature and wind fields to move the dynamic system. Clearly this is an immensely complex task, such that it may be necessary to accept errors of this kind rather than run the risk of making matters worse by subtely deficient bogussing.

4. With regard to corrections made to radio-sonde data, Hawson and Caton stressed the importance of regular reassessment of correction values. They suggested the need for an annual review and a constant monitoring of changes in equipment, observing practices etc on an international basis. If this monitoring is not carried out, we run the risk of degrading the quality of data rather than improving it. More seriously however, if temperatures are to be corrected, then dew point temperatures should also be corrected before HMR values (or RH) are calculated. This would avoid the alteration of humidity values, particularly at low levels.

25 November 1983

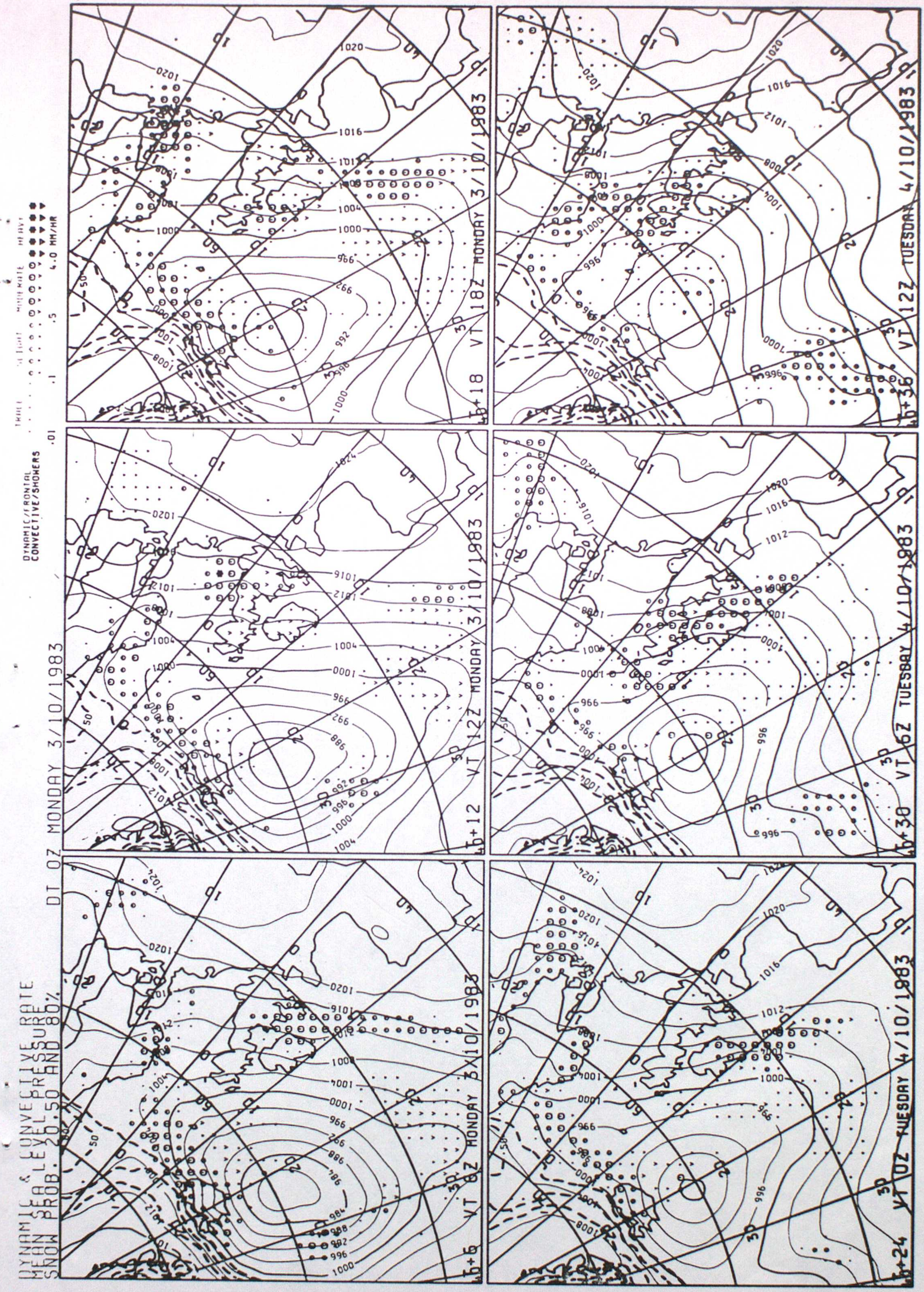
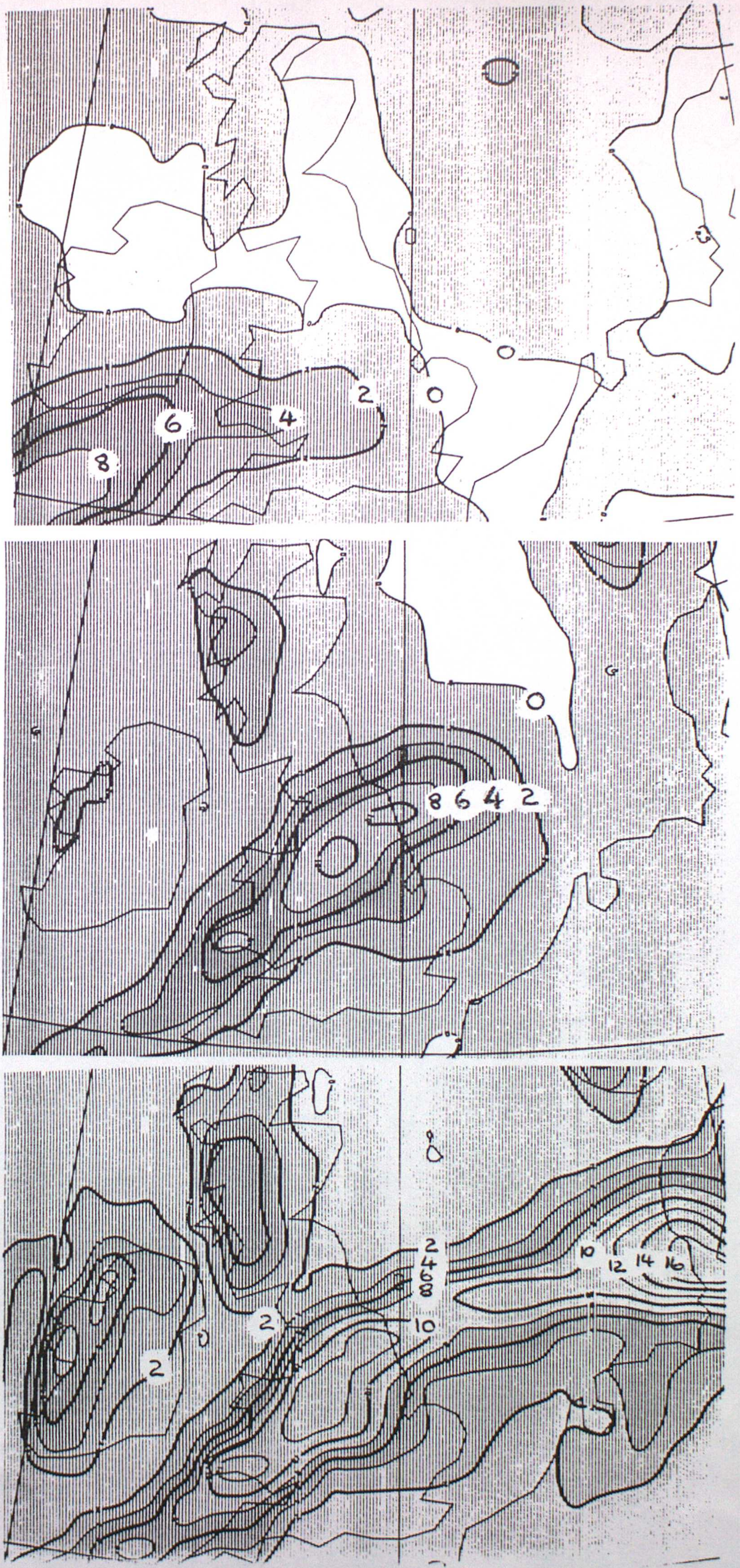


FIG 1. Operational output showing rainfall rates . Note rain area associated with wave.

FIG 2. Model predicted rainfall accumulations.



(a) 00 - 06Z

(b) 06 - 12Z

(c) 12 - 18Z

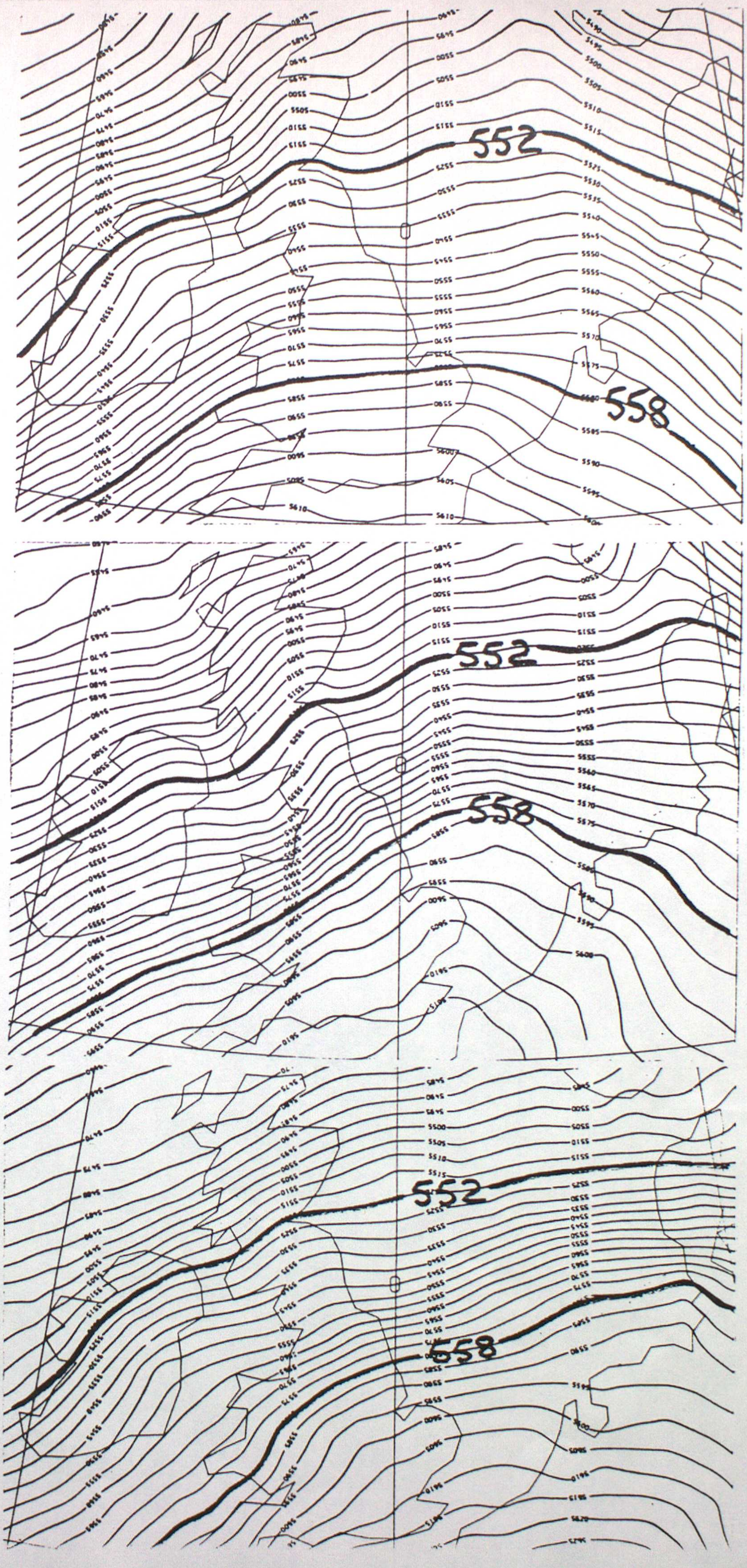
FIG 3. Actual rainfall accumulations.
(Dark shaded areas $\geqslant$ 10mm)

(a) 00 - 06Z

(b) 06 - 12Z

(c) 12 - 18Z

FIG 4. Model predicted thickness(1000-500mb) patterns.



(a) 06Z

(b) 12Z

(c) 18Z

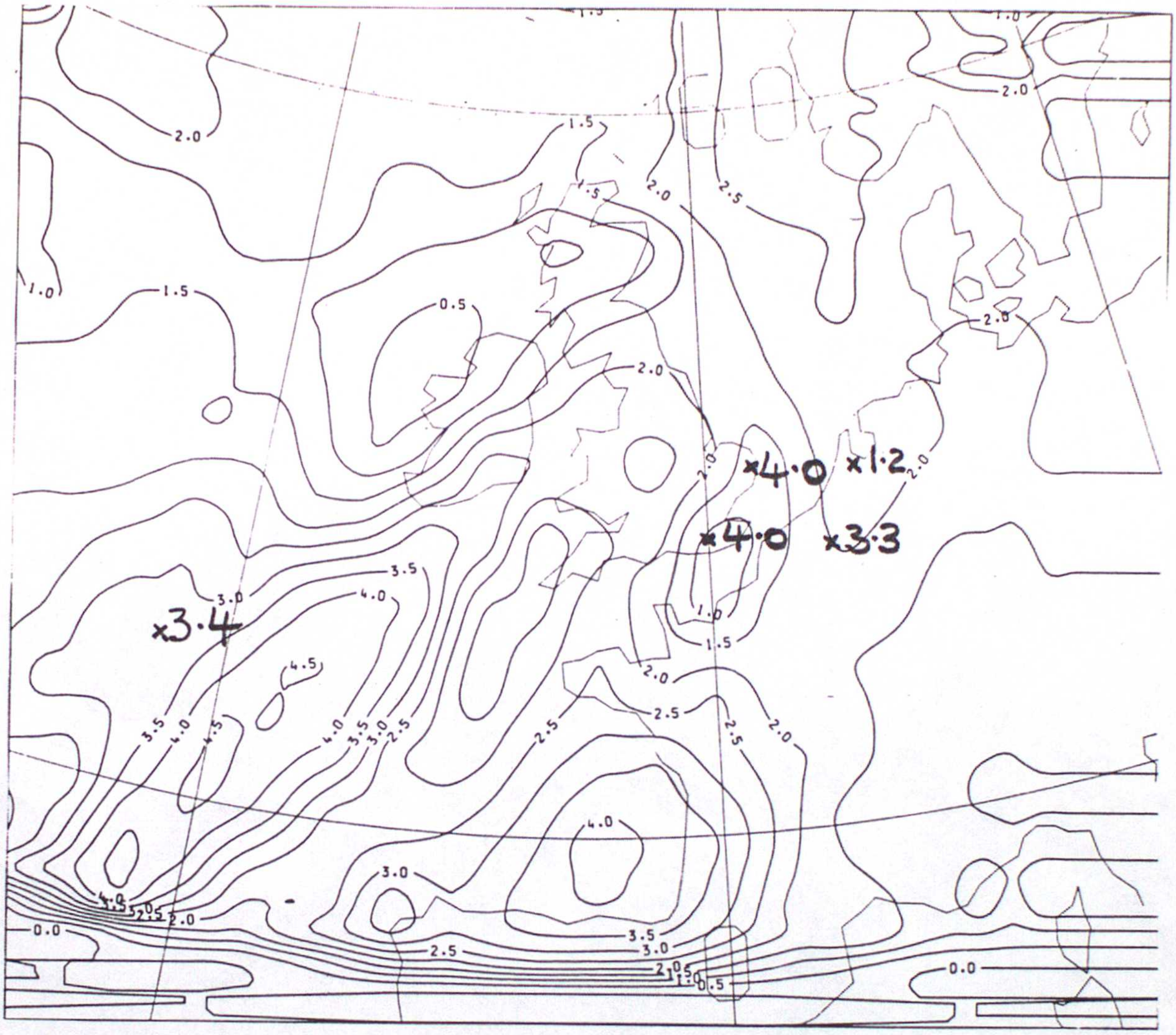


FIG 5. 600mb HMR field for 00Z 3 OCT 83, Fine Mesh initial data. Large figures are actual data for upper air stations Hemsby, Crawley, Uccle, De Bilt and 'Romeo'.

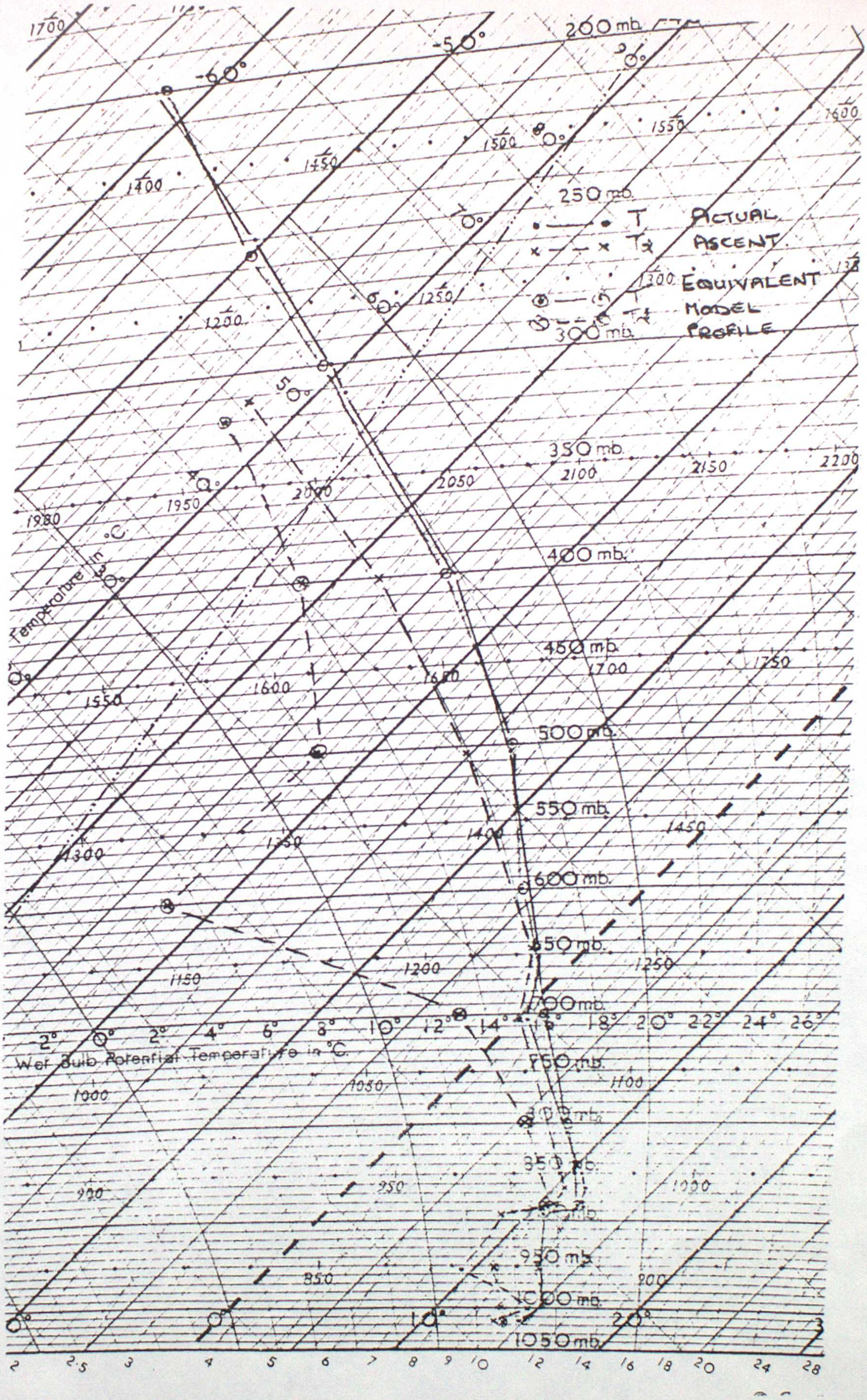


FIG 6. Comparison of actual with model profile for Hemsby, at OOZ on 3 OCT 83, showing erroneous dry zone in model profile due to rejection of good data.