



Short-range Forecasting Research

Short Range Forecasting Division

Technical Report No.15

The verification of mesoscale model forecasts of
liquid water content using helicopter reports over
the north sea during winter 1991

by

M. Ahmed, R.W. Lunnon and R.J. Graham

May 1992

Meteorological Office
London Road
Bracknell
Berkshire
RG12 2SZ
United Kingdom

Short-Range Forecasting Research Division

Technical Report No. 15

THE VERIFICATION OF MESOSCALE MODEL FORECASTS OF LIQUID WATER CONTENT
USING HELICOPTER REPORTS OVER THE NORTH SEA DURING WINTER 1991

by

M Ahmed, R W Lunnon and R J Graham

May 1992

Short-Range Forecasting Research Division
Meteorological Office
London Road
Bracknell
Berkshire RG12 2SZ
ENGLAND

N.B. This paper has not been published. Permission to quote from it must be obtained from the above Met Office division

THE VERIFICATION OF MESOSCALE MODEL FORECASTS OF LIQUID WATER CONTENT USING HELICOPTER REPORTS OVER THE NORTH SEA DURING WINTER 1991

Previous work on this subject was written up in Lunnon (1990) and Lunnon (1991). The latter is a slightly extended version of the former: however the former contains the details of the observations used in the assessment. But for all practical purposes it can be considered that either paper contains the necessary historical background to understand the present work, which should be regarded as an update containing only the results from the winter 1991.

It will be recalled that during winter 1991 there were several days (4 successful ones) during which appropriately instrumented helicopters were asked to report LWC and temperature at regular intervals during flights. This report describes the use of these observations to verify forecasts made by the mesoscale model.

A specific question to be resolved is: on what vertical and horizontal scale does the mesoscale model have useful skill? If two adjacent gridpoints in the North Sea have LWCs of 0.2 and 0.6 gm^{-3} there is no reason to believe that icing is more likely in the latter than the former. Similar arguments apply in the vertical. The scales used in the product disseminated during the past winter (see Lunnon 1991) were dictated by an existing spot-wind chart, but there is no fundamental reason to stick to this in the future. There is also a fundamental difficulty in verifying forecasts stemming from the small number of verifying observations. The best day had 64 helicopter reports: however the forecast issued each day comprised information at 4 times, 6 levels and 16 boxes, so the number of 4-D boxes with more than one observation in will be very small.

Therefore it was proposed to verify the forecasts in a way in which both observations and basic model data are aggregated into boxes of various sizes. For each horizontal and vertical scale, both the observed and forecast LWC for each box were categorised by fairly coarse increments of both mean and maximum LWC, in fact into intervals of 0.2 g/kg. Intervals of 0.2 g/kg were chosen because the helicopters are certified to fly in LWCs of up to 0.4 gm^{-3} indefinitely and 0.8 gm^{-3} for limited

periods. Thus there were a relatively small number of categories of box.

The whole verification process was carried out twice, once including both observations and model values of zero LWC, and once neglecting them. The above process will be applied to boxes having horizontal dimensions of 4*4, 8*8 and 16*16 grid points horizontally and 1, 2 and 4 levels vertically (the boxes used during winter 1991 were approximately 8*8*2). Note that the time of the observations and the time of the forecast with which it is compared may differ in time by up to 1.5 hours. A time scale of 1.5 hours corresponds to a length scale of 54km (assuming an advecting velocity of 10 ms^{-1}). It is inappropriate, therefore, to consider verification on scales of less than 4*4 grid points (the mesoscale model gridlength is 15km). The range of the forecast was between T+6 and T+12.

The following table shows the results of this verification. They comprise a number of 5*5 tables, summarising results for three of the days (it was not possible to recover the mesoscale model forecast for the fourth). In each table individual columns relate to observational data and individual rows to model forecasts data. The first of the five rows (or columns) indicates the number of aggregated values lying between 0.0 and 0.2 g/kg, the second the number of values lying between 0.2 and 0.4 g/kg and so on, with the fifth row indicating the number of values greater than 0.8 g/kg. Thus a perfect forecast, with this discretisation, would be indicated by a table with only the diagonal elements (top left to bottom right) non-zero. The 9 sets of tables shown down the page relate to different horizontal and vertical scales, while the 4 tables across the page relate to mean and maximum LWCs and to whether or not zero LWCs were included.

Although tables are shown for all the scales and for mean and maximum LWCs both including and excluding zero values, caution should be exercised interpreting some of the results. For example, for the smallest scale, the mean LWCs from the observed data will almost invariably have been calculated from a single report, and so should not be regarded as terribly reliable. The conclusions to be drawn from the tables are that at the smaller scales the model shows very little skill, and at the larger scales forecasts of maximum LWC appear better than forecasts of mean LWC, with the exclusion of zero values giving rise to

a slight improvement. The fact that in the table giving results for boxes comprising $16*16*4$ grid points for maximum LWCs there is a zero in the element relating to forecast values of less than 0.2 g/kg and observed values of between 0.6 and 0.8 g/kg is considered encouraging: it is saying that on this scale the model always forecasts observed maxima in excess of 0.2 g/kg (although there are a considerable number of false alarms). Note that this statistic also pertains on scales of $16*16*2$ grid points and $8*8*4$ grid points. The latter scale is the one favoured for future forecast promulgation.

References.

Lunnon, R.W., (1990) *A comparison of helicopter reports of icing conditions with mesoscale model forecasts for winter 1989/90* Met Office Short Range Forecasting Research Technical Note No 50

Lunnon, R.W., (1991) *Numerical forecasting of liquid water content to assess airframe icing risk* in proceedings 4th International Conference on Aviation Weather Systems, American Met Soc, Paris, June 1991

Including zero LWC					Excluding zero LWC				
Mean LWC					Maximum LWC				
Mean LWC					Maximum LWC				
Horizontal scale 4 * 4 grid points, vertical scale 1 grid point					Horizontal scale 1 grid point				
74 15 3 4 0	59 18 4 3 0	36 21 3 4 0	31 18 4 3 0						
4 0 0 0 0	6 1 0 3 0	1 1 0 0 0	4 1 0 3 0						
0 0 0 0 0	2 2 0 0 0	0 0 0 0 0	0 2 0 0 0						
0 0 0 0 0	2 0 0 0 0	0 0 0 0 0	0 0 0 0 0						
0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0						
Horizontal scale 8 * 8 grid points, vertical scale 1 grid point					Horizontal scale 1 grid point				
64 13 3 3 0	39 13 4 2 0	30 18 4 2 0	22 13 4 2 0						
2 1 0 0 0	11 2 0 3 0	1 2 0 1 0	4 2 0 3 0						
0 0 0 0 0	4 4 0 1 0	0 0 0 0 0	2 4 0 1 0						
0 0 0 0 0	2 0 0 0 0	0 0 0 0 0	1 0 0 0 0						
0 0 0 0 0	1 0 0 0 0	0 0 0 0 0	0 0 0 0 0						
Horizontal scale 16 * 16 grid points, vertical scale 1 grid point					Horizontal scale 1 grid point				
44 9 1 3 0	15 8 2 1 0	22 17 3 2 0	10 8 2 1 0						
0 1 0 0 0	13 5 2 2 0	1 1 0 1 0	9 5 2 2 0						
0 0 0 0 0	2 2 0 2 0	0 0 0 0 0	2 2 0 2 0						
0 0 0 0 0	2 0 0 1 0	0 0 0 0 0	1 0 0 1 0						
0 0 0 0 0	1 0 0 0 0	0 0 0 0 0	0 0 0 0 0						
Horizontal scale 4 * 4 grid points, vertical scale 2 grid points					Horizontal scale 2 grid points				
71 14 3 3 0	46 15 4 3 0	33 20 2 3 0	24 15 4 3 0						
4 0 0 0 0	11 3 0 2 0	1 1 1 0 0	5 3 0 2 0						
0 0 0 0 0	4 2 0 1 0	0 0 0 0 0	1 2 0 1 0						
0 0 0 0 0	4 0 0 0 0	0 0 0 0 0	1 0 0 0 0						
0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0						
Horizontal scale 8 * 8 grid points, vertical scale 2 grid points					Horizontal scale 2 grid points				
57 10 4 1 0	24 9 4 1 0	25 14 5 1 0	12 9 4 1 0						
4 1 0 0 0	14 2 0 3 0	2 2 0 0 0	7 2 0 3 0						
0 0 0 0 0	8 5 0 0 0	0 0 0 0 0	3 5 0 0 0						
0 0 0 0 0	5 0 0 1 0	0 0 0 0 0	2 0 0 1 0						
0 0 0 0 0	1 0 0 0 0	0 0 0 0 0	0 0 0 0 0						
Horizontal scale 16 * 16 grid points, vertical scale 2 grid points					Horizontal scale 2 grid points				
40 6 2 1 0	9 5 2 0 0	19 13 4 1 0	5 5 2 0 0						
0 0 0 0 0	11 3 2 2 0	1 1 0 0 0	8 3 2 2 0						
0 0 0 0 0	4 3 0 1 0	0 0 0 0 0	3 3 0 1 0						
0 0 0 0 0	4 0 0 2 0	0 0 0 0 0	3 0 0 2 0						
0 0 0 0 0	1 0 0 0 0	0 0 0 0 0	0 0 0 0 0						
Horizontal scale 4 * 4 grid points, vertical scale 4 grid points					Horizontal scale 4 grid points				
66 12 3 3 0	29 13 3 2 0	27 18 2 3 0	14 13 3 2 0						
0 0 0 0 0	14 3 1 3 0	3 1 1 0 0	6 3 1 3 0						
0 0 0 0 0	5 2 0 1 0	0 0 0 0 0	2 2 0 1 0						
0 0 0 0 0	7 1 0 0 0	0 0 0 0 0	4 1 0 0 0						
0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0						
Horizontal scale 8 * 8 grid points, vertical scale 4 grid points					Horizontal scale 4 grid points				
53 9 3 1 0	12 6 2 0 0	20 13 4 1 0	7 6 2 0 0						
0 0 0 0 0	13 3 2 4 0	3 1 1 0 0	5 3 2 4 0						
0 0 0 0 0	10 4 0 0 0	0 0 0 0 0	3 4 0 0 0						
0 0 0 0 0	8 1 0 0 0	0 0 0 0 0	5 1 0 0 0						
0 0 0 0 0	0 0 0 1 0	0 0 0 0 0	0 0 0 1 0						
Horizontal scale 16 * 16 grid points, vertical scale 4 grid points					Horizontal scale 4 grid points				
30 6 1 1 0	2 2 1 0 0	15 11 3 1 0	1 2 1 0 0						
0 0 0 0 0	6 4 3 2 0	1 1 0 0 0	5 4 3 2 0						
0 0 0 0 0	6 3 0 1 0	0 0 0 0 0	3 3 0 1 0						
0 0 0 0 0	6 0 0 1 0	0 0 0 0 0	5 0 0 1 0						
0 0 0 0 0	0 0 0 1 0	0 0 0 0 0	0 0 0 1 0						

Appendix: description of the program used to generate the tables

The program processes a set of helicopter observations for one day. For each observation the longitude, latitude and height are converted into x, y, and level coordinates respectively. The x and y coordinates refer to a 32 by 32 grid which covers the part of the North Sea where the helicopter observations took place. This grid in turn corresponds with part of the mesoscale model grid. The level coordinate represents the level of the mesoscale model. Observations are excluded where the temperature is positive, the coordinates fall outside the range of the mesoscale model or if they were recorded over land.

Next the necessary mesoscale model forecast fields for that day are accessed.
Forecast fields

at 3 hour intervals are used, starting at 0600 hrs. Forecasts of LWC are extracted for a sub-domain of $32 * 32$ grid points and for levels 13 to 20 (corresponding to a height range of 630m to 2695m, which is sufficient to include all the helicopter reports). Land grid points and grid points where the temperature is positive are excluded from the verification.

The next part applies to one block size and one verification. First the $32(x) \text{ by } 32(y) \text{ by } 8(\text{level})$ space is split up into blocks of equal size. These blocks are discrete and completely cover the entire space. Each observation is associated with a particular block. All the blocks with one or more observations are recorded and the mean and maximum observed LWC for these blocks are calculated. These will be known as observation blocks. Next the blocks of mesoscale model data that correspond with the observation blocks have their mean and maximum LWC calculated. These will be known as model blocks. Each observation and model block is categorized depending on what range the mean and maximum LWC lies in. All the observations are compared with the nearest forecast, for example a 0745 observation is compared with 0900hr forecast.

The categories of each observation block are compared with the categories of model block and recorded in a contingency table. The final output are contingency tables. In these 5 by 5 tables we compare the mean of the observation block with the mean of the mesoscale block for

one table and the max for the other table.

The above procedure is repeated for all 9 block sizes and 2 verifications.

Short Range Forecasting Division Technical Reports

This is a new series to be known as Short Range Forecasting Division Technical Reports . These will be reports from all three sections of the Short Range Forecasting Research Division i.e. Data Assimilation Research (DA), Numerical Modelling Research (NM), and Observations (OB) . This series succeeds the series known as Short Range Forecasting Research / Met O 11 Technical Notes.

1. ON THE TIME SAVING THAT CAN BE ACHIEVED BY THE USE OF AN OPTIMISED COURSE IN AN AREA OF VARIABLE FLOW R. W. Lunnon
A. D. Marklow
September 1991
2. Treatment of bias in satellite sea surface temperature observations R. S. Bell
August 1991
3. FINITE DIFFERENCE METHODS M. J. P. Cullen
August 1991
4. Representation and recognition of convective cells using an object-orientated approach W. H. Hand
30th September 1991
5. Sea-ice data for the operational global model. C. P. Jones
November 1991.
6. Tuning and Performance of the Atmospheric Quality Control. N. B. Ingleby.
December 1991.
7. More satellite sounding data - can we make good use of it? R. S. Bell
January 1992.
8. WAM/UKMO Wind Wave model Intercomparison Summary Report Heinz Gunther
ECMWF
Martin Holt
UK Met Office
January 1992
9. Spin up problems of the UKMO Mesoscale Model and moisture nudging experiments Akihide Segami
JMA
February 1992
10. A comparison of 2nd generation and 3rd generation wave model physics M. W. Holt
B. J. Hall
February 1992
11. RETRIEVAL AND ASSIMILATION: SYSTEM CONSIDERATIONS Andrew C Lorenc
March 1992

Short Range Forecasting Division Technical Reports

- | | | |
|-----|--|---|
| 12. | Detection of Precipitation by Radars in the UK Weather Radar Network | M. Kitchen
P. M. Brown
April 1992 |
| 13. | THE VALUE OF WIND OBSERVATIONS FOR WEATHER FORECASTING AND CLIMATE STUDIES | Andrew C Lorenc
April 1992 |
| 14. | An investigation into the parameters used in the analysis scheme of the Mesoscale Model | G. Veitch
B. J. Wright
S. P Ballard
May 1992 |
| 15. | THE VERIFICATION OF MESOSCALE MODEL FORECASTS OF LIQUID WATER CONTENT USING HELICOPTER REPORTS OVER THE NORTH SEA DURING WINTER 1991 | M. Ahmed
R. W Lunnon
R. J. Graham
May 1992 |