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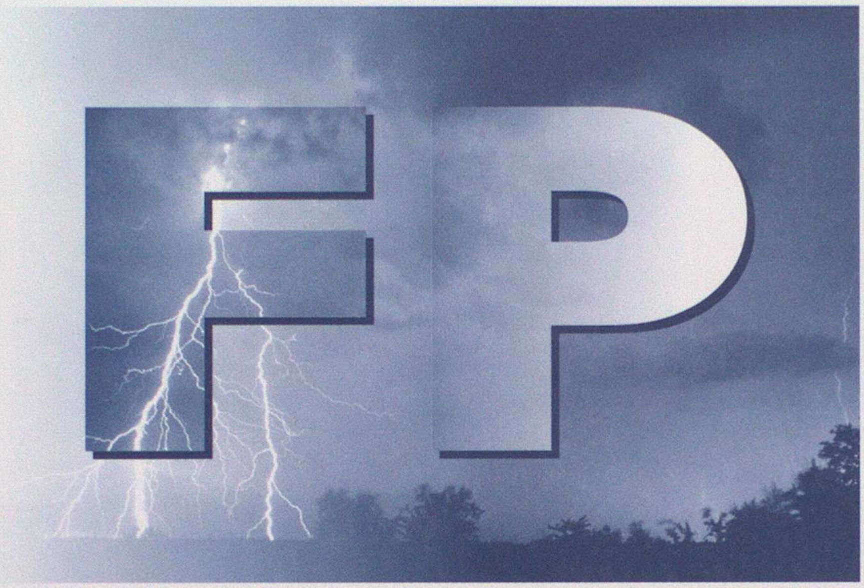

Research and Development

Forecasting Research
Technical Report No. 306

A Report on the Removal of Spurious Light Rain from the UM Rainfall Forecasts for Use in Nimrod

by

R.J. Standing

May 2000

The Met.Office

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A report on the removal of spurious light rain from the UM rainfall forecasts for use in Nimrod

By Richard Standing

20th March 2000

ABSTRACT

The Nimrod nowcasting scheme uses UM output to produce short range rainfall forecasts. During other research work for Nimrod, it became clear that the UM frequently forecast spurious regions of light rain. This report describes an attempt to improve the UM input to Nimrod (and hence the Nimrod output) by removing all UM rain below 1/16 mm/hr and hence remove these regions of spurious rain. An explanation of the statistical techniques used in evaluation is given, along with a review of the results obtained.

CONTENTS

1.0 Introduction

During the trials of the Imperial College/University College London disaggregation scheme (Standing 2000), it became apparent that spurious areas of uniform light dynamic rain were being created by the UM rainfall forecast. As well as being incorrect, they also produced an unrealistic speckled effect when disaggregated, and were adding unnecessary extra CPU time to the disaggregation. It was therefore decided to look into a way of trying to remove these areas within Nimrod.

2.0 Methodology

It was originally decided to tackle the problem by subtracting a certain amount from all pixels with a non-zero rainrate, then setting any resultant negative rainrates to zero. Initial trials centred around finding the best value to subtract, without unduly affecting those regions where the UM forecast rainrate was correct. Values of 1,2,3 and 4 32nds mm/hr were tried with 2/32nds being the optimum value. The code was then set up routinely to run on Nimr2 (the Nimrod back-up), using the Nimrod verification software. A set of statistics was also produced based on the original UM rainrate fields to provide a control. In addition, hourly model fields were displayed on the internal web in real time to provide a visual check. Whilst the fields looked good, the subtraction method was still adversely affecting regions with higher rainrates (>1mm/hr) by increasing the mean and RMS errors. The method was therefore changed to simply setting any rainrates less than 2/32nds mm/hr to zero.

2.1 Evaluation

The statistics produced by the Nimrod verification software were:

The Equitable Threat Score: A measure of how the forecast is likely to perform against "chance" forecasts. The ETS is given by the formula:

$$ETS = \frac{AD - BC}{(A+B+C+D)(B+C) + AD - BC}$$

where:
A=Number of occasions rain forecast and observed (Hit).
B=Number of occasions rain not forecast but observed (Miss).
C=Number of occasions rain forecast but not observed (False Alarm).
D=Number of occasions rain neither forecast nor observed (Correct Rejection).

The ETS is 100 per cent for a perfect forecast.

The Hit Rate: The percentage of times when rain was correctly forecast out of all the times when rain was observed. For a perfect forecast this has a value of 100%.

$$HR = \frac{A}{A+B}$$

The False Alarm Rate: The percentage of times when rain was forecast but not observed out of all the times it was observed. For a perfect forecast, this has a value of 0.

$$FAR = \frac{C}{A + C}$$

The Bias is a measure of whether the forecast predicts rain too often or not enough and is given by:

$$BIAS = \frac{A + C}{A + B}$$

using the definitions listed above. Note that:

1) For a perfect forecast, the Bias has a value of 1. This is most obvious if we take an example where rain is always forecast and it always rains. C and B are zero, so the Bias equals 1.
2) If rain is over – forecast, the Bias is greater than 1. This can be seen in a hypothetical case where rain is forecast all the time but it only rains half the time (i.e. C=A and B=0), where the Bias has a value of 2.
3) If rain is under – forecast, the Bias is less than one. In the reverse of the previous situation, if it rains all the time but is only forecast half the time (i.e. B=A and C=0) then the Bias is 0.5.

The mean and RMS errors, and MEANF and RMSF errors were used to verify the forecast rainfall rates. The MEANF and RMSF are a measure of what factor the forecasts are out by i.e. a MEANF of 2 means that the forecast predicts the rain to be twice as heavy as really happens on average.

$$RMSF = \exp\left[\frac{1}{N}\sum_{i=1}^{N} \log\left(\frac{F_i}{R_i}\right)^2\right]^{1/2}$$

$$MEANF = \exp\left[\frac{1}{N}\sum_{i=1}^{N}\log\left(\frac{F_i}{R_i}\right)\right]$$

where N = number of observations

F_i = Forecast rainrate at grid square i

R_i = Observed rainrate at grid square i

3.0 Statistical analysis

Table 1 shows the location statistics for the original and altered model fields for each of the months from October to February, with the exception of January, when the software was switched off for Y2K reasons. It can be seen that, apart from in October, the False Alarm Rate, ETS and bias of the altered fields was always better than for the original fields. In November and February, the decrease in the False Alarm Rate was greater than or equal to that in the Hit Rate. Incidentally, for all the months in question, the altered UM forecast had a better ETS than the Nimrod forecasts for the same month.

Table 1: Location statistics

TYPE	MONTH	NO. OF OBS	HR(%)	FAR(%)	ETS	BIAS
ORI	OCT	346	65	64	22	1.82
ALT	OCT	346	65	64	22	1.82
ORI	NOV	941	88	71	20	3.00
ALT	NOV	941	80	60	29	2.02
ORI	DEC	803	82	57	23	1.91
ALT	DEC	803	75	52	27	1.56
ORI	FEB	506	83	68	17	2.60
ALT	FEB	506	76	61	23	1.94

ORI=Original output
ALT=Altered output

Table 2 shows the rate statistics for the original and altered UM fields for the same months. It will be noticed that whilst the location statistics are generally improved by removing spurious rain, and the MEANF error was improved in all months, the other rate statistics got worse (at least at first glance). It was not too much of a surprise that the mean error was worse, as in October and December the UM was under predicting to begin with. It is thought that the worsening RMS and RMSF are due to a quirk of the verification method. The rain rate verification is run for all grid squares where either the analysis or the forecast has a non-zero rain rate. Where low rain rates were forecast but not observed, the small errors involved helped to keep the RMS and RMSF low. Ironically, by making these pixels correct, they were no longer counted in the verification statistics, so the RMS and RMSF went up! As the higher rainrates were unaltered, the statistics for rainrates > 1/16 mm/hr are the same for both the original and altered forecasts.

Table 2: Rain rate statistics

TYPE	MONTH	NO. OF OBS	MEAN ERROR (mm/hr)	RMS ERROR (mm/hr)	MEANF	RMSF
ORI	OCT	346	-.05	1.396	1.291	6.481
ALT	OCT	346	-.06	1.404	1.274	6.555
ORI	NOV	941	.09	.866	2.511	8.756
ALT	NOV	941	.09	.944	2.311	10.369
ORI	DEC	803	-.04	1.230	1.773	11.533
ALT	DEC	803	-.05	1.273	1.634	12.609
ORI	FEB	506	.02	.840	2.393	10.022
ALT	FEB	506	.01	.893	2.211	11.391

ORI=Original model field
ALT=Altered model field

4.0 Case Study

Figures 1 to 3 show the unmodified and modified UM fields, and the Nimrod analysis for comparison. Some, but not all, of the spurious light rain in the Bay of Biscay and the Republic of Ireland has been removed. By increasing the threshold below which rain is removed, the rest could also have been removed, however this could have led to the removal of "correct" rain, as has already happened in this case off Cornwall and close to Inverness. It is a delicately balanced compromise, but study shows the value of 2/32nds mm/hr to be about right.

5.0 Conclusions

The procedure for removing spurious light rain from UM fields seems promising. The location statistics show that implementing the procedure should improve the skill of the UM (and hence Nimrod) forecasts, especially since the skill of the altered UM fields appears to be approaching that of Nimrod. It is unfortunate that a scripting error meant that there were no figures to show the effects of the alteration on the Nimrod forecast during the months in question. The scheme can be implemented easily without too much of an increase in CPU time since the two lines of code required could easily be slipped into existing code, without requiring extra I/O etc. Probably the best place to implement this would be in the code that converts the UM files to Nimrod format, as this would ensure that the changed fields were used in all Nimrod code requiring UM rainrates, and as that code runs on the Cray T3E, it would not affect the Nimrod CPU time. It is recommended that this change should be implemented into the Nimrod system.

3.0 References

Standing (2000) R.J.Standing Report on Trials of the Imperial College/ University College London Disaggregation Scheme. *Forecasting Research Technical Report No. 298. February 2000.*

APPENDIX
Verification at separate model lead times

Table A1 shows the verification results for February 2000, at different model lead times, for both the original and altered UM forecast rainrate fields. It can be seen that whilst there is always a reduction in the Hit Rate for the altered fields, the size of the reduction is generally the same size as, or smaller than, the reduction in the False Alarm Rate, except at T+17 and T+18. The ETS and bias are always improved by removing the spurious light rain areas.

During February, there was general over prediction of rain rates, so the mean error usually stayed the same or improved (apart from T+14 and T+15 where there was already under prediction, so the mean error got worse). The MEANF also improved at all lead times, however the RMS and RMSF got worse at all lead times, for reasons explained in the main text.

Figure 1: UM forecast rainrate for 1400 23/3/2000

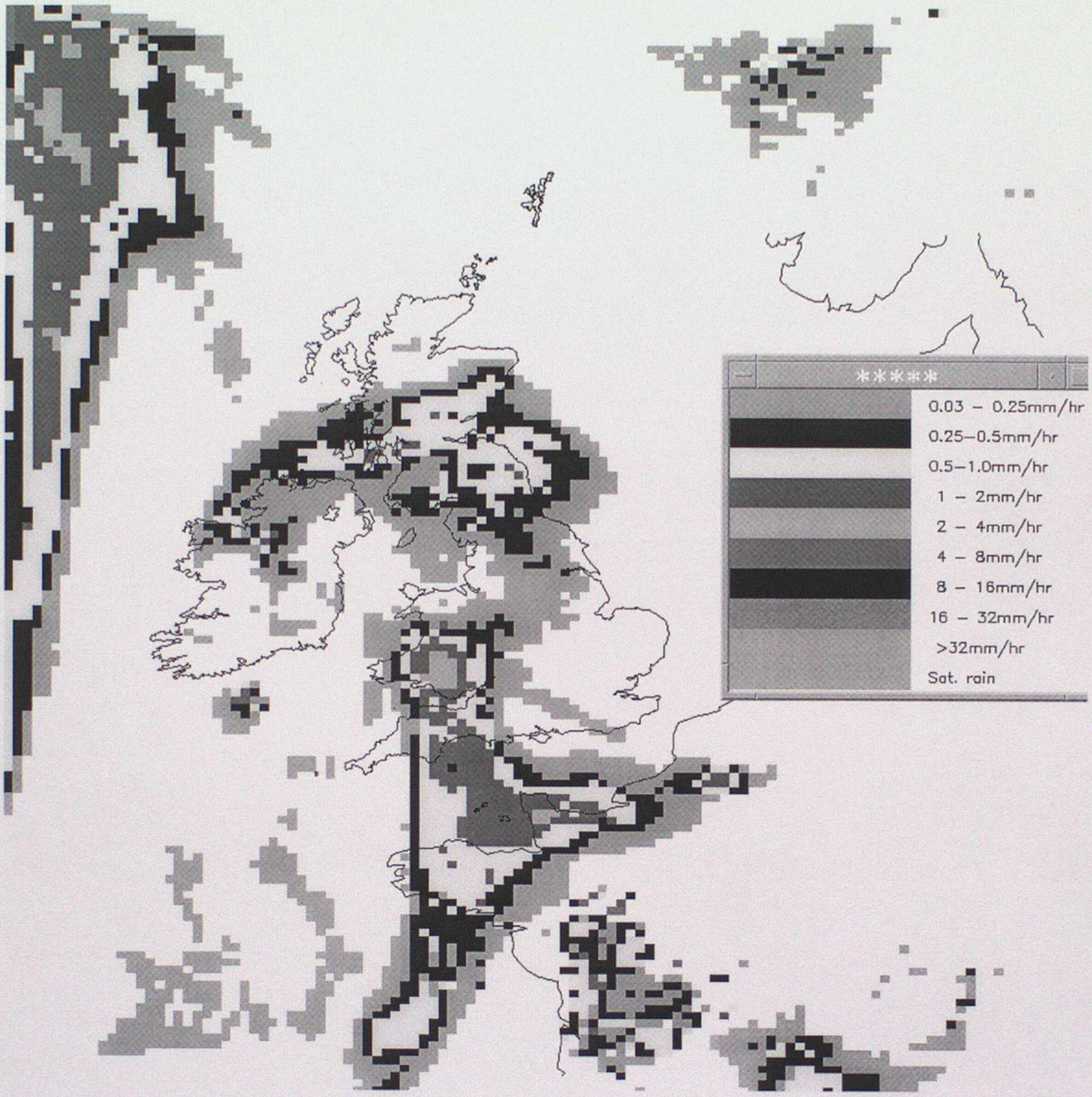

Figure 2: UM forecast rainrate for 14Z 23/3/2000 after removal of light rain

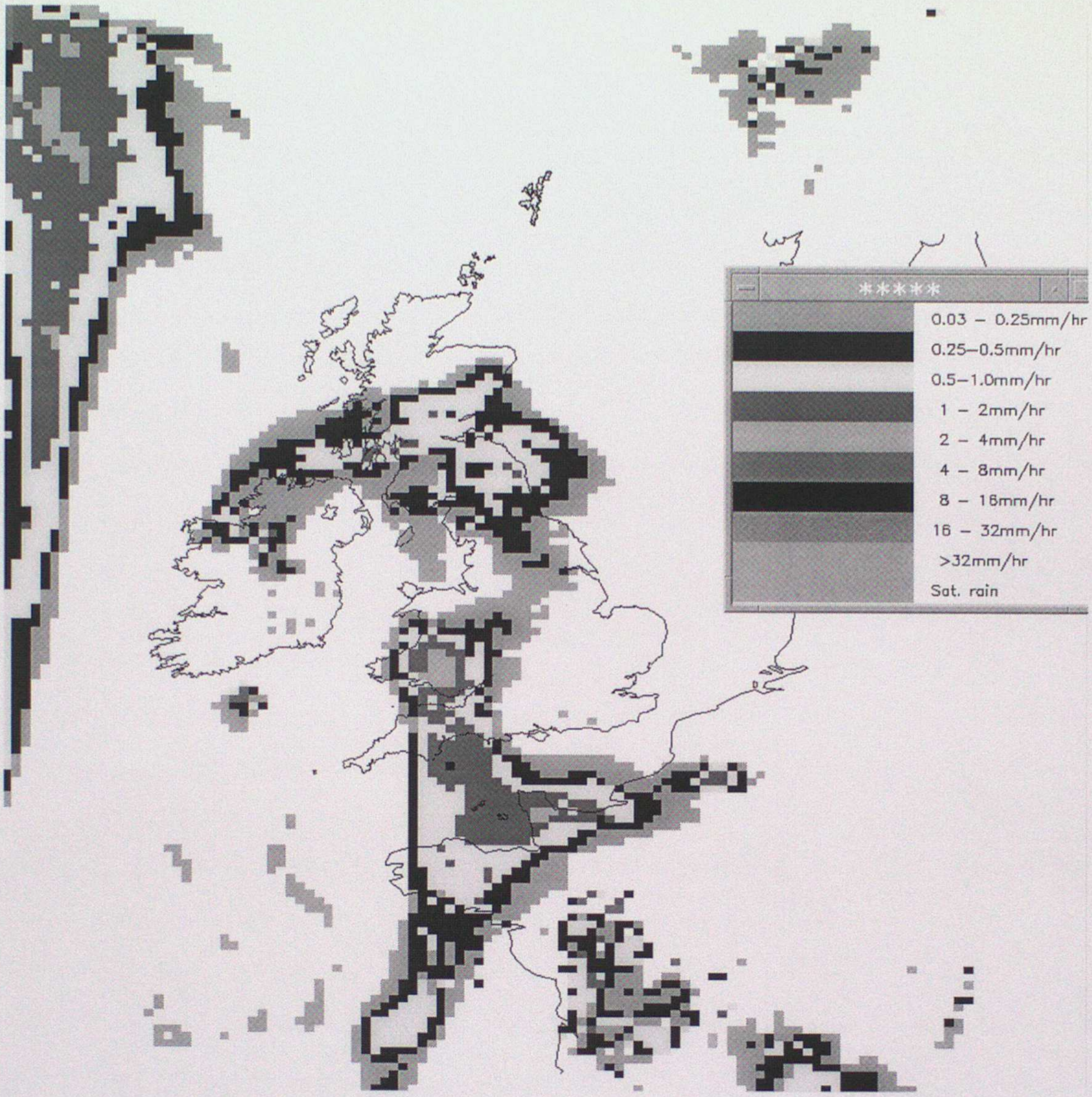

Figure 3: Nimrod analysis for 14Z 23/3/2000

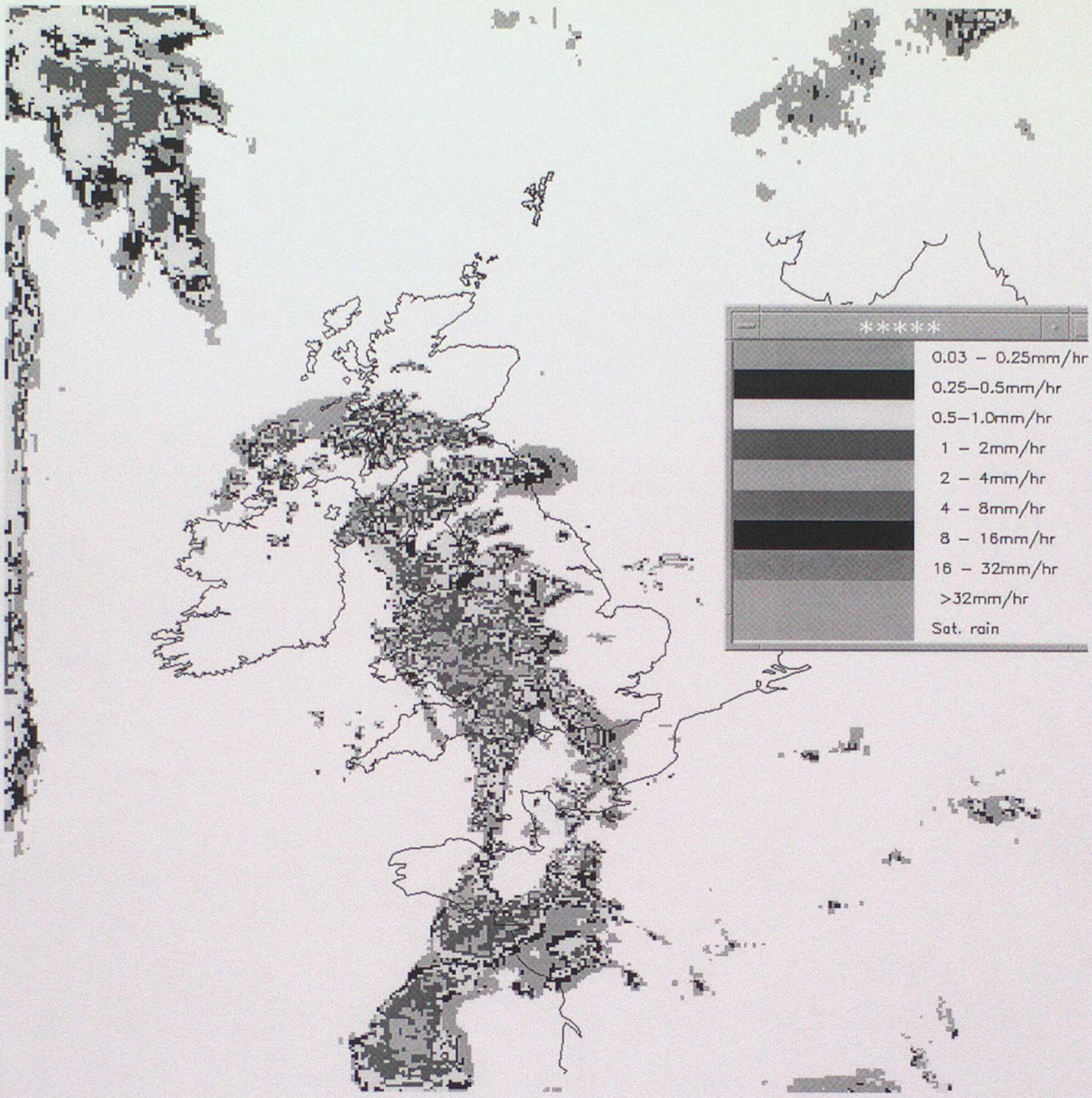

Table A1: Precipitation verification for February 2000

TYPE	N	HR	FAR	ETS	BIAS	MEAN	RMS	MEANF	RMSF
ORI 0240	54	86	67	18	2.64	.01	.815	2.341	9.065
ALT 0240	54	79	60	25	1.97	.00	.867	2.144	10.290
ORI 0300	53	84	69	16	2.68	.02	.826	2.394	9.529
ALT 0300	53	76	62	23	1.99	.01	.879	2.198	10.829
ORI 0360	53	83	69	16	2.67	.03	.822	2.414	9.862
ALT 0360	53	75	62	22	1.99	.02	.873	2.222	11.187
ORI 0420	50	83	69	16	2.67	.01	.811	2.400	9.840
ALT 0420	50	76	62	23	1.98	.00	.863	2.211	11.199
ORI 0480	48	85	67	18	2.60	.00	.821	2.429	9.791
ALT 0480	48	79	60	25	1.97	.00	.872	2.260	11.071
ORI 0540	47	85	67	18	2.60	.02	.832	2.444	9.748
ALT 0540	47	79	60	25	1.94	.01	.883	2.264	11.036
ORI 0600	46	84	68	17	2.66	.02	.863	2.445	9.976
ALT 0600	46	78	60	24	1.97	.01	.920	2.262	11.402
ORI 0660	43	84	69	17	2.71	.03	.847	2.513	9.734
ALT 0660	43	78	61	24	2.00	.03	.905	2.333	11.133
ORI 0720	34	84	67	18	2.57	.04	.836	2.481	9.445
ALT 0720	34	79	58	27	1.90	.04	.892	2.315	10.730
ORI 0780	27	83	67	18	2.52	.01	.851	2.437	10.251
ALT 0780	27	77	60	24	1.93	.00	.899	2.269	11.517
ORI 0840	24	81	66	17	2.41	-.03	.874	2.164	10.365
ALT 0840	24	74	59	23	1.82	-.05	.925	1.985	11.713
ORI 0900	21	82	65	17	2.36	-.01	.894	2.167	10.216
ALT 0900	21	75	57	25	1.74	-.02	.951	1.984	11.695
ORI 0960	20	78	68	15	2.46	.02	.849	2.188	10.726
ALT 0960	20	72	61	22	1.82	.02	.901	2.012	12.243
ORI 1020	18	77	72	12	2.72	.05	.828	2.479	11.253
ALT 1020	18	69	66	18	2.00	.05	.881	2.294	12.936
ORI 1080	22	75	70	13	2.50	.02	.865	2.289	11.988
ALT 1080	22	66	66	16	1.92	.01	.911	2.122	13.534

ORI=Original UM field
ALT=Altered field