4.20 A COMPARISON OF BOUNDARY LAYER HEIGHTS IN ATMOSPHERIC DISPERSION MODELS AND POSSIBLE CONSEQUENCES FOR MODELLING EMISSIONS FROM TALL STACKS

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INTRODUCTION

A difference in the predicted concentrations arising from two dispersion models (ADMS 3.1 and AERMOD PRIME 02222) when modelling tall stacks (259 m) was found. After investigation this difference appeared to be possibly due to the differing predictions for the boundary layer height H within the models. In order to examine the problem in more detail, 10 met data sites were chosen in the UK and the predictions for the boundary layer heights and ground level concentrations compared between models.

PREDICTED BOUNDARY LAYER HEIGHT COMPARISON.

The list of met stations and associated roughness lengths are shown in Table 1. Various methods of processing the met data were compared (note that AERMOD PRIME has a separate met pre-processor called AERMET (version 02222 in this study) and that ADMS has a built in met pre-processor). A selection of results are presented here.

Table 1. Met data sets used in this study and their associated roughness length

Met Station	Roughness Length, m	Met Station	Roughness Length, m
Aberporth 1993	0.15	Herstmonceux 1997	0.4
Boulmer 1995	0.05	Leeds 1996	0.1
Culdrose 1997	0.1	Shawbury 1996	0.3
Finningley 1990	0.25	Valley 1997	0.25
Finningley 1994	0.25	Wattisham 1997	0.15

Table 2 displays the percentage of the year for which the modelled boundary layer height was below a given value. In this case the met processing in both models was carried out using the default values for albedo, Bowen ratio (AERMET) and the Priestley-Taylor parameter (ADMS 3.1). The roughness length used at the site of the stack was 0.25m for all runs. The roughness lengths used at the met sites are shown in Table 1. Table 3 gives typical values of the boundary layer depth quoted in Clarke et al, 1979.

As can be seen AERMET is predicting more frequent occurrences of higher boundary layer heights relative to ADMS 3.1. This would be expected to alter the differences between models in predicting ground level concentrations for those hours where the plume is predicted to interact with or penetrate the top of the boundary layer in one model but not the other.

Table 4 displays the boundary layer height statistics for the case presented in Table 2 for Leeds 1996 met data, and for a case using an albedo of 0.20 for both models and a Bowen ratio (AERMET) and Priestley-Taylor parameter value (ADMS) for dry grass (1.75 and 0.45 respectively). This would be expected to lead to more partitioning of net radiation into sensible heat, and subsequently greater boundary layer heights due to increased convection. As can be seen AERMET predictions are largely unaltered. ADMS predictions are for higher boundary layer depths relative to using its default (moister) values as shown in Table 2.

Table 2 Percentage of the year predicted to fall below or equal to the given boundary layer height, for ADMS 3.1 and AERMOD PRIME (via AERMET), for a set of 10 met data sites.

Model	Met site	Percentage of the year <= the given boundary layer height.											
		<= 50 m	<= 100 m	<= 150 m	<= 200 m	<= 250 m	<= 300 m	<= 350 m	<= 400 m	<= 500 m	<= 600 m	<= 800 m	> 800 m
Aermod	**Ab93**	1	2	3	4	5	6	8	10	13	17	26	74
Adms	**Ab93**	4	6	9	12	16	19	21	25	32	39	51	49
Aermod	**Bo95**	1	10	12	15	19	23	26	29	37	44	58	42
Adms	**Bo95**	14	20	27	33	40	44	49	53	60	66	77	23
Aermod	**Cu97**	0	3	6	8	10	13	16	18	22	27	40	60
Adms	**Cu97**	4	10	17	22	26	30	34	39	47	54	68	32
Aermod	**Fi90**	0	9	10	13	16	19	22	24	29	34	45	55
Adms	**Fi90**	15	20	25	31	36	40	45	49	55	61	72	28
Aermod	**Fi94**	0	8	9	11	13	16	19	22	28	34	45	55
Adms	**Fi94**	14	18	23	29	35	40	45	49	57	63	73	27
Aermod	**He97**	2	10	12	13	16	21	22	25	31	37	49	51
Adms	**He97**	18	20	28	35	39	44	48	52	59	65	75	25
Aermod	**Le96**	5	15	21	24	28	33	37	41	50	57	71	29
Adms	**Le96**	22	32	40	48	54	59	63	67	73	77	84	16
Aermod	**Sh96**	0	7	9	10	12	14	18	21	27	33	44	56
Adms	**Sh96**	14	16	22	27	33	38	43	47	55	61	71	29
Aermod	**Va97**	1	5	6	8	9	11	13	14	18	22	30	70
Adms	**Va97**	8	12	16	20	23	25	29	31	37	42	54	46
Aermod	**Wa97**	1	4	6	8	12	14	19	22	29	36	49	51
Adms	**Wa97**	6	11	18	27	35	41	45	50	58	64	74	26

Table 3 Typical values of the boundary layer depth, H quoted in Clarke et al, 1979.

Stability Category	Typical value of H	Stability Category	Typical value of H
A	1300 m	E	400 m
B	900 m	F	100 m
C	850 m	G	100 m
D	800 m		

Table 4 Percentage of the year predicted to fall below or equal to the given boundary layer height for Leeds 1996 met data. "Le96" refers to where the met data has been processed as described for Table 2. "Drier" refers to dry grass conditions for the Bowen ratio and Priestley-Taylor parameter, with an albedo of 0.2 being used for both models.

Model	Met site is	Percentage of the year <= the given boundary layer height (m)											
		<= 50	<= 100	<= 150	<= 200	<= 250	<= 300	<= 350	<= 400	<= 500	<= 600	<= 800	> 800
Aermod	**Le96**	5	15	21	24	28	33	37	41	50	57	71	29
Adms	**Le96**	22	32	40	48	54	59	63	67	73	77	84	16
Aermod	**Drier**	5	15	21	24	28	33	37	41	50	57	71	29
Adms	**Drier**	20	29	36	43	48	53	57	60	65	69	76	24

GROUND LEVEL CONCENTRATIONS COMPARISON

Since ADMS 3.1 is predicting lower boundary layers more frequently than AERMET, it is expected that for tall stacks with buoyant plumes ADMS 3.1 is more likely to predict that some of the plume penetrates the upper inversion layer and hence to predict lower ground level concentrations.

Using the various met data sets the predicted annual mean and 99.9th percentiles of hourly averages were compared for the two models for a 259 m and 50 m stack. An example of the results are shown in Figures 1 and 2 for Leeds 1996 met data. The emission characteristics are: Temperature = 90 ^{o}C; Volume Flow Rate = 2000 m^3 s^{-1}; Stack Diameter = 12.93 m.

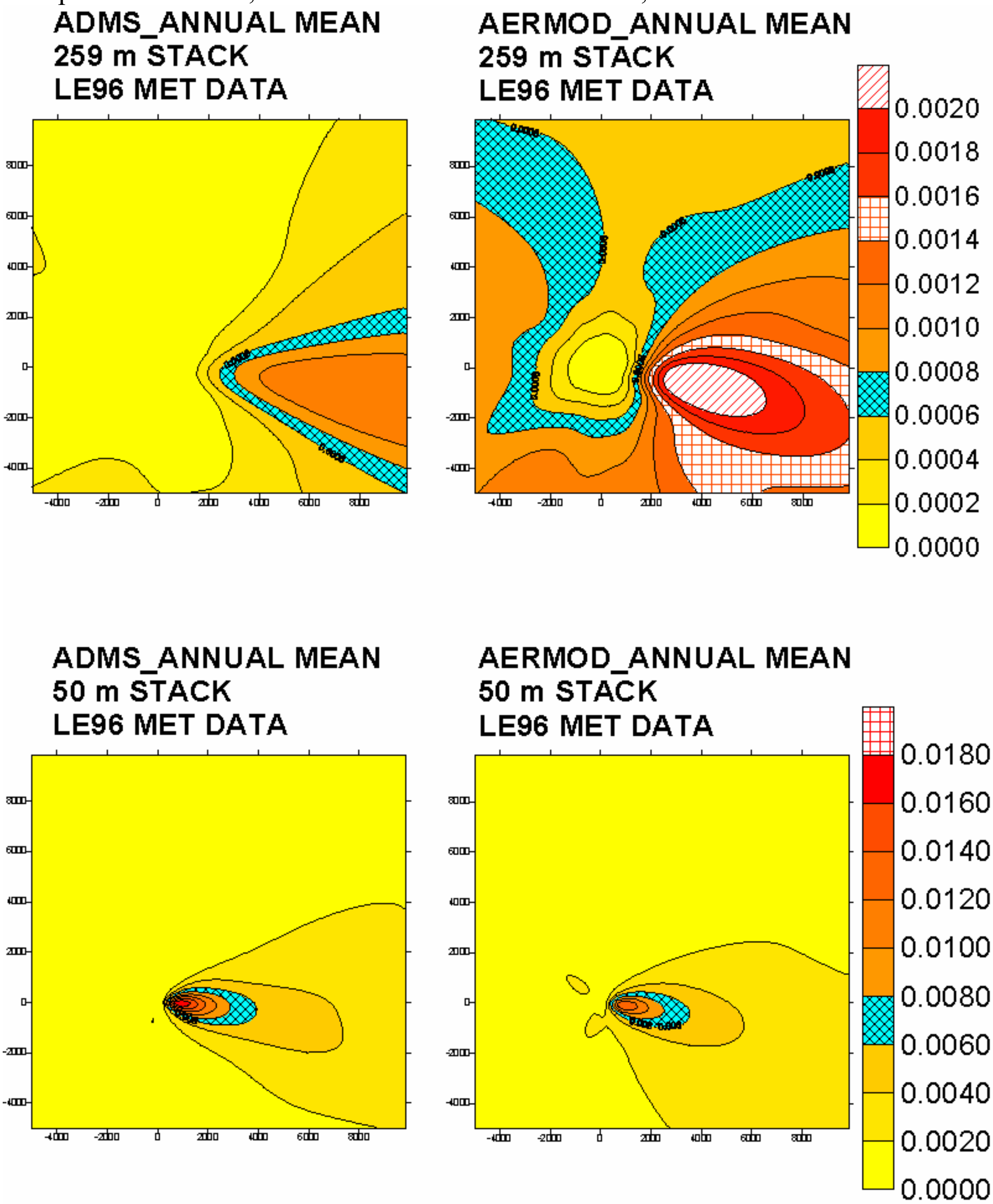

Figure 1. Annual mean predicted ground level concentrations in μg m^{-3} for ADMS 3.1 and AERMOD PRIME, for a 259 m and 50 m stack.

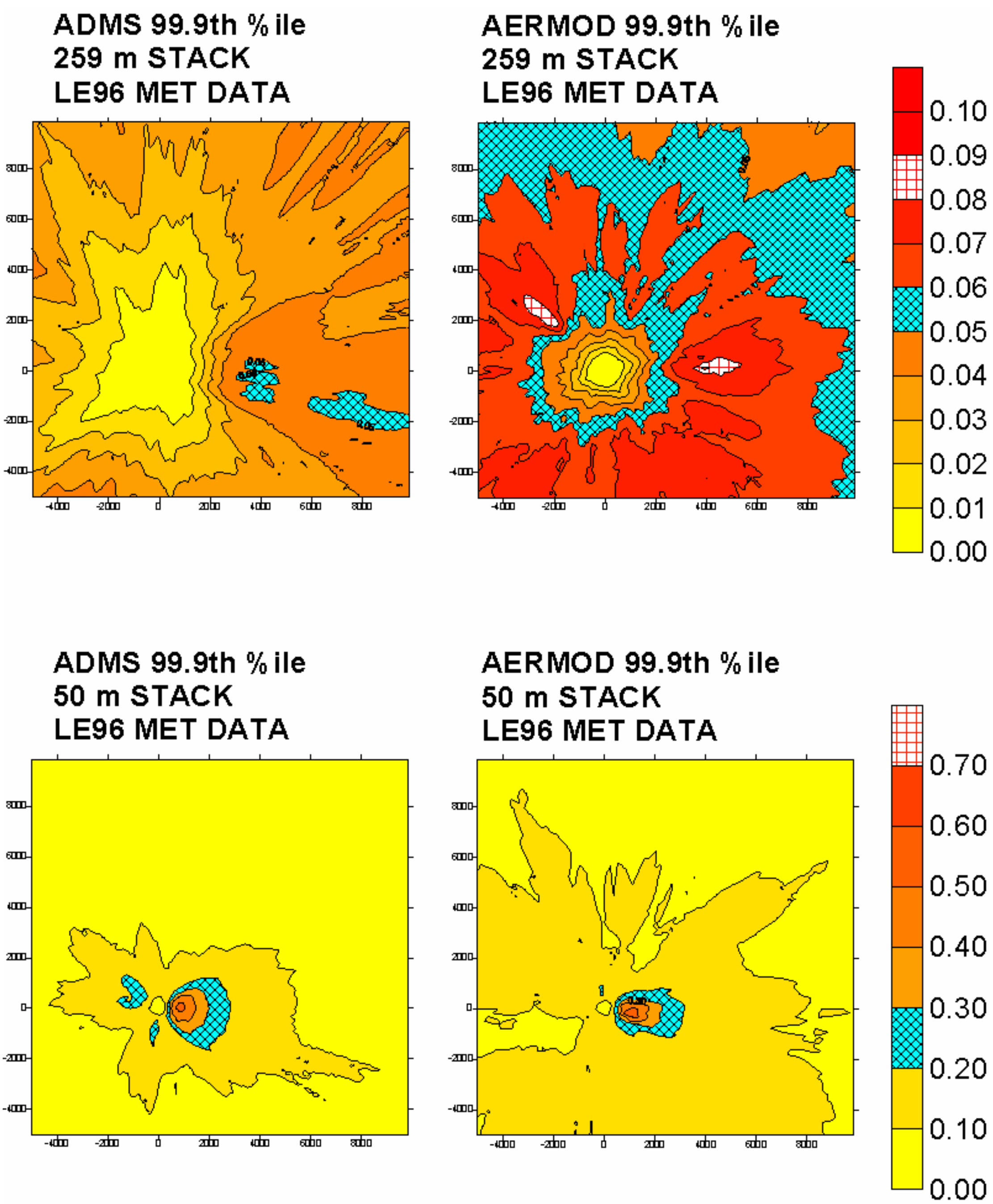

Figure 2. Predicted 99.9th percentile of hourly average ground level concentrations in $\mu g\ m^{-3}$ for ADMS 3.1 and AERMOD PRIME, for a 259 m and 50 m stack

GROUND LEVEL CONCENTRATIONS COMPARISON FOR ALTERNATIVE MET PROCESSING SCENARIOS

A run was made where the boundary layer heights predicted by AERMET were given to ADMS 3.1 as input. The annual mean ground level concentrations resulting from this run are shown in Figure 3. As can be seen the differences between the models are partially reduced.

A run was also made comparing the model predictions for the met data processed for dry grass conditions and an albedo of 0.2 as described for Table 4. The annual mean ground level concentrations resulting from this run are shown in Figure 4. As can be seen the differences between the models are much reduced.

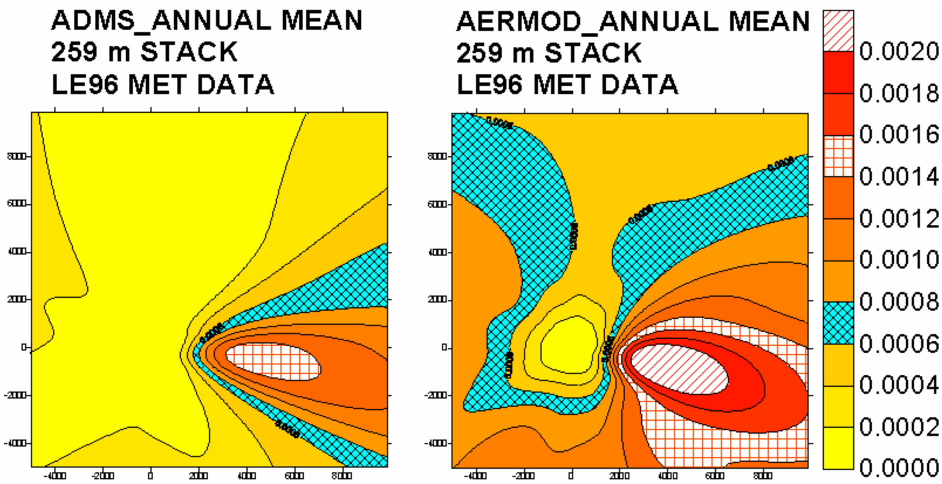

Figure 3. Annual mean predicted ground level concentrations in µg m^{-3} for ADMS 3.1 and AERMOD PRIME, for a 259 m stack. Here ADMS 3.1 used the boundary layer heights predicted by AERMET

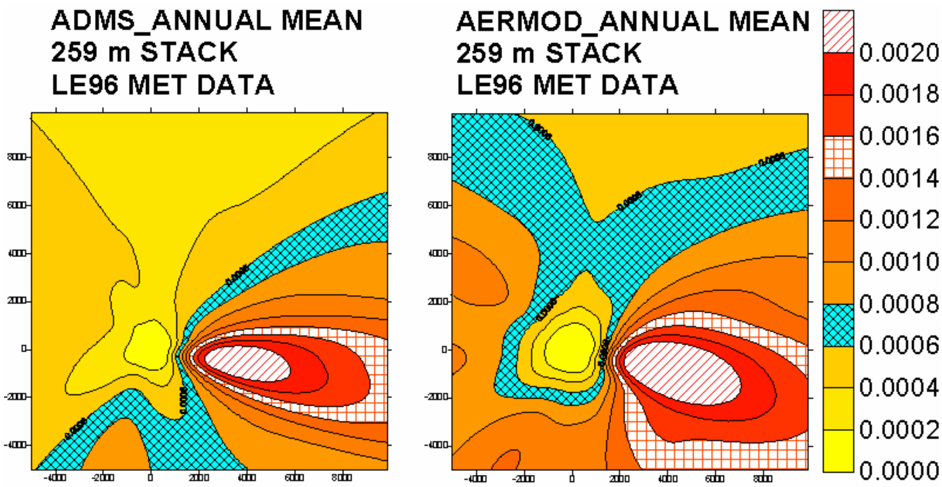

Figure 4. Annual mean predicted ground level concentrations in µg m^{-3} for ADMS 3.1 and AERMOD PRIME, for a 259 m stack. Here ADMS 3.1 and AERMOD PRIME/AERMET used an albedo of 0.2 and dry grass Priestley-Taylor and Bowen ratio values.

CONCLUSIONS

It is important to note that in order to determine whether one model or the other is better at predicting the boundary layer height for UK conditions it is necessary to compare the model predictions against measurements. Further work is required to determine how much of the difference in predicted ground level concentrations can be attributed to the differing predictions for boundary layer depth as opposed to other factors. The conclusion can be drawn that for tall stacks with buoyant emissions the spatial distribution and maximum value of ground level concentrations for both the annual mean and higher percentiles can differ significantly between different models. It is recommended for decision making that more than one model be made use of in cases involving tall stacks.

REFERENCES

Clarke, R.H. et al, 1979: A model for short and medium range dispersion of radionuclides released to the atmosphere, National Radiological Protection Board, NRPB-R91.