GUIDELINES

CONSTRUCTION OF INPUT METEOROLOGICAL DATA FILES FOR AUSPLUME

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INTRODUCTION

Meteorological data is one of the crucial inputs to air dispersion models. Preparation of this data must follow recognised and accepted procedures. These guidelines explain how to achieve this.

The methods to be used in the construction of an AUSPLUME meteorological data file (metfile) are described below.

The construction of a metfile involves 4 steps:

- compilation of all required meteorological data
- determination of vertical stability classes
- estimation of hourly mixing heights
- formatting all data/information into AUSPLUME-compatible file format.

CONTENT OF AUSPLUME INPUT METEOROLOGICAL DATA FILE

Hourly values (preferably hourly averages) of the following meteorological parameters are in the input file:

a) scalar wind speed (m/s) at 10 m height
b) wind direction (degrees measured clockwise from true north) at 10 m height
c) ambient temperature (°C)
d) vertical stability class (A-F)
e) mixing height (m)
f) 60-minute averaged sigma-theta (standard deviation of horizontal wind direction fluctuation)
g) vertical wind profile exponent
h) vertical gradient of potential temperature(°C/m)
i) decay constant
j) friction velocity (m/s)
k) Monin–Obukhov length (m)
l) precipitation code
m) precipitation rate (mm/hr)
n) convective velocity scale (m/s).

Table 1 in Appendix A illustrates the required format of the AUSPLUME meteorological file, together with a sample file (Figure 1).

Note that:

- parameters (a) to (e) are mandatory, with the remaining parameters optional
- parameters (a), (b), and (c) are based on direct measurements
- the remaining mandatory parameters ((d) – vertical stability class and (e) – mixing height) are derived parameters determined using other relevant information
- the file should cover at least a year and the coverage should be 90 per cent or better
- the file may contain missing days and the days need not be sequential, but there cannot be any missing hours in a day
- where site-specific data is required by the regulatory authority but there is none available, five years of site-representative data should be used to develop the input meteorological data file. This is specifically considered whenever a risk assessment is required.

CONSTRUCTION PROCEDURES

1 Data requirements and sources

Wherever possible, a site-specific meteorological data file constructed with at least 12 months of local or on-site meteorological data is to be used for AUSPLUME modelling.

Measured meteorological data using AS2923, *Ambient air guide for measurement of horizontal wind for air quality applications*, by a NATA-accredited laboratory is preferred. However, in the absence of such data, local meteorological measurements by the National Weather Service at the Bureau of Meteorology (BoM) may be used.

Quality mandatory data can be obtained from automatic weather stations (AWSs) operated by state environment authorities or similar organisations. Some industries often operate similar types of AWSs.

Supplementary data needed to determine stability classes and mixing heights should be obtained from a representative weather station maintained by the BoM.

Meteorological files constructed using data generated by prognostic models such as TAPM or MM5 may also be acceptable if there are no measured data.

Sources of mandatory measured meteorological data include the following.

1.1 Data measured by AS2923

This is measured meteorological data using AS2923.

Mandatory data required:

i. Hourly averaged scalar wind speed
ii. hourly averaged vector wind direction
iii. hourly averaged screen level temperature

Optional data parameter:

i. hourly averaged (60-minute) sigma theta

1.2 Data measured by the BoM

This means local meteorological measurements by the BoM.

Mandatory data required:

i. wind speed (last 10-minute average)
ii. wind direction (last 10-minute average)
iii. screen-level temperature (last 10-minute average or instantaneous)

Supplementary data needed to determine vertical stability class and mixing height:

i. surface pressure
ii. dew point
iii. hourly or 3 hourly total cloud cover or
    1. global exposure (total solar radiation)
    and
    2. net radiation
iv. rainfall rate
v. twice-daily vertical temperature and moisture profiles.

Notes for BoM-measured data:

1. Wind measurements and processing may not meet AS2923 at the BoM's weather stations.
2. Wind direction is recorded to a resolution of the nearest 10 degrees at weather stations. This wind direction should be randomised to the nearest one degree before use.
3. Wind speed, usually recorded in km/hr or knots, needs to be converted to m/s.
4. There are some BoM stations with one-minute or 10-minute averaged data. In this situation it is suggested to use the one-minute or 10-minute averaged wind and temperature data to create one-hour average winds and temperatures.

1.3 TAPM-generated data

For locations where there is no measured data available, the mandatory data and supplementary data required to construct an AUSPLUME meteorological data file may be generated by a prognostic meteorological model.

The prognostic model specified is the Meteorological module of TAPM (Version 4 or later, available from CSIRO).

TAPM setup

The following model setup is the minimum specification that must be used to generate required data.

- Outer grid resolution 10 km with nesting grids 3 km, 1 km and 0.3 km (note that nesting to an inner grid of resolution of 1 km is regarded as appropriate for flat country regions).
- 41-by-41 horizontal grid points, centred at the location of the required data point.
- 25 vertical levels.
- Nine-second terrain height database.
- TAPM default databases for land use and sea surface temperature (provided with TAPM software). Note that the default vegetation and soil type data may be modified if more representative site-specific data for the locality is available.
- Synoptic analysis data for the recommended year (can be purchased from CSIRO).

TAPM output

The following TAPM-generated parameters (data) extracted at the point of interest for the innermost grid (1 km or 0.3 km) are to be used to construct an AUSPLUME-type metfile:

1. 10 m wind speed (WSPD)
2. 10 m wind direction (WDIR)
3. screen-level temperature (TEMPSCR)
4. screen-level relative humidity (RHUM) – used in the calculation of convective mixing height
5. total solar radiation (TSR) – used in the calculation of daytime stability classification (see Table 2 in Appendix B)
6. net radiation (NETR) – used in the calculation of night-time stability class (see Table 4 in Appendix B)
7. mixing height (ZMIX) – only to be used where there are no upper air station/s in the region of interest.

Note that the option available in TAPM to generate complete AUSPLUME-type meteorological files is not acceptable, since the techniques for generating the stability class and mixing height differ from the techniques recommended in these guidelines (Refer to Appendix C).

2 Determination of vertical stability class

2.1 Measured meteorological data

The following methodologies are specified for the determination of vertical stability class using measured meteorological data:

Daytime – solar radiation and wind speed (see Table 2 in Appendix B).

Night-time – modified PG method (see Table 3 in Appendix B).

If there are no measurements of solar radiation, use equation 1 in Appendix B. This requires cloud observations from a representative station from BoM.

It is important to ensure that stability class D is assigned for one hour after sunrise and one hour before sunset. Night-time should be determined based on sunrise and sunset times (calculated for the location of interest).

2.2 TAPM-generated data

EPA Victoria specifies the following methodologies for the determination of vertical stability class using TAPM-generated data:

Daytime – TAPM-generated solar radiation and wind speed (see Table 2 in Appendix B).

Night-time – TAPM-generated net radiation and wind speed (see Table 4 in Appendix B).

Note again that it is important to ensure stability class D is assigned for one hour after sunrise and one hour before sunset. Night-time should be determined based on sunrise and sunset times (calculated for the location of interest).

3 Determination of mixing height

Ideally, the mixing height should be obtained from onsite measurements by an acoustic sounder. Alternatively, it can be calculated as follows.

3.1 Mechanical mixing height

Initially you should calculate mechanical mixing height for both day and night using surface wind speeds and roughness. You may use equation 2 in Appendix B.

This formula is valid only for stability class D and it is used for night-time since mixing heights are not used for any calculations with stability classes E and F.

3.2 Convective mixing height

Calculate using twice-daily temperature soundings plus hourly wind speeds and ambient ground temperatures, using the methodology described by Benkley and Schulman (*Journal of Applied Meteorology*, Volume 18, 1979, pp. 772–80). This requires upper-air observations containing temperature and moisture profiles (radiosonde) from the nearest upper-air observing station.

In summary, the convective mixing height is approximated by extrapolating up a pseudo adiabat from hourly surface station temperatures to the intersection with the morning radiosonde profile

The height of the convective boundary layer (convective mixing height) should be determined using a morning or daytime temperature sounding (vertical temperature and dewpoint profiles) in between sunrise and sunset. An evening or night-time sounding for the same day is used to adjust daytime sounding to calculate convective mixing height at different daylight hours (temperature difference at 700 hPa layer is used to correct for advection).

Note: If there is only one sounding for the day then you may skip the advection correction.

The larger value of the mechanical mixing height and convective mixing height is to be taken as the mixing height for daylight hours.

Note that upper-air (radiosonde) stations are sparse but the available upper-air stations represent a wider area (region).

If there are no weather stations and/or upper-air (radiosonde) station(s) in the region of interest, you may use a TAPM-generated mixing height.

4 Data format

AUSPLUME expects to read the meteorological data file in a fixed format. The first header line should be used to identify the file. This line can be up to 80 characters long. The lines after the initial header line should each contain a single hour of data.

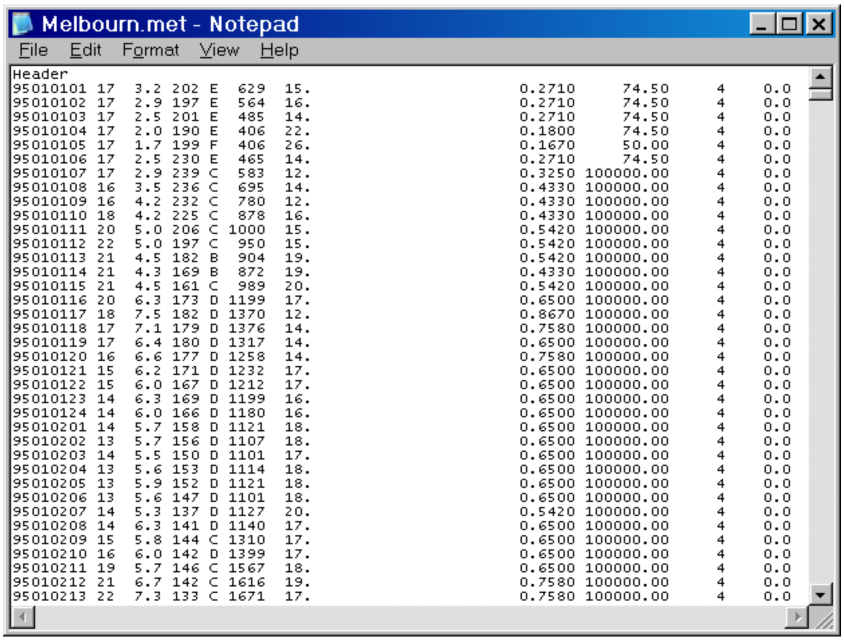
The Fortran language format specification is included in brackets after each data field. Each line contains, in this order, the year (I2), month (I2), day (I2), hour (I2), temperature (I3), wind speed (F5.0), wind direction (I4), stability class (1x,A1) and mixing height (I5).

It may also optionally contain information on sigma theta (F5.0), wind profile exponent F5.2), potential temperature gradient (F5.2), a decay coefficient (F10.0), surface friction velocities (F8.4), Monin-Obukhov length (F10.2) precipitation code (I6) and precipitation rate (1x,F6.1).

APPENDIX A: AUSPLUME METEOROLOGICAL DATA FILE: CONTENTS AND FORMAT

Table 1: AUSPLUME meteorological data file (metfile) format

Parameter	Starting column	Length	Notes
Year	1	2	
Month	3	2	
Day	5	2	
Hour	7	2	
Temperature (C)	9	3	Measured – hourly averaged
Wind speed (m/s)	12	5	Measured – hourly averaged
Wind direction	17	4	Measured – hourly averaged
PG stability Class	21	2	Estimated
Mixing height(m)	23	5	Estimated – daytime convective
Sigma theta (60-min Avg)	28	5	Optional
Wind profile exponent.	33	5	Optional
Temperature gradient (deg/m)	38	5	Optional
Decay constant	43	10	Optional
Friction velocity(m/s)	53	9	Optional
Monin-Obukhov length (m)	62	10	Optional
Precipitation code	71	6	Optional
Precipitation rate (mm/Hr)	77	7	Optional
Convective velocity scale W*	84	7	Optional




```
Header
95010101 17  3.2 202 E  629  15.                  0.2710     74.50    4   0.0
95010102 17  2.9 197 E  564  16.                  0.2710     74.50    4   0.0
95010103 17  2.5 201 E  485  14.                  0.2710     74.50    4   0.0
95010104 17  2.0 190 E  406  22.                  0.1800     74.50    4   0.0
95010105 17  1.7 199 F  406  26.                  0.1670     50.00    4   0.0
95010106 17  2.5 230 E  465  14.                  0.2710     74.50    4   0.0
95010107 17  2.9 239 C  583  12.                  0.3250 100000.00    4   0.0
95010108 16  3.5 236 C  695  14.                  0.4330 100000.00    4   0.0
95010109 16  4.2 232 C  780  12.                  0.4330 100000.00    4   0.0
95010110 18  4.2 225 C  878  16.                  0.4330 100000.00    4   0.0
95010111 20  5.0 206 C 1000  15.                  0.5420 100000.00    4   0.0
95010112 22  5.0 197 C  950  15.                  0.5420 100000.00    4   0.0
95010113 21  4.5 182 B  904  19.                  0.5420 100000.00    4   0.0
95010114 21  4.3 169 B  872  19.                  0.4330 100000.00    4   0.0
95010115 21  4.5 161 C  989  20.                  0.5420 100000.00    4   0.0
95010116 20  6.3 173 D 1199  17.                  0.6500 100000.00    4   0.0
95010117 18  7.5 182 D 1370  12.                  0.8670 100000.00    4   0.0
95010118 17  7.1 179 D 1376  14.                  0.7580 100000.00    4   0.0
95010119 17  6.4 180 D 1317  14.                  0.6500 100000.00    4   0.0
95010120 16  6.6 177 D 1258  14.                  0.7580 100000.00    4   0.0
95010121 15  6.2 171 D 1232  17.                  0.6500 100000.00    4   0.0
95010122 15  6.0 167 D 1212  17.                  0.6500 100000.00    4   0.0
95010123 14  6.3 169 D 1199  16.                  0.6500 100000.00    4   0.0
95010124 14  6.0 166 D 1180  16.                  0.6500 100000.00    4   0.0
95010201 14  5.7 158 D 1121  18.                  0.6500 100000.00    4   0.0
95010202 13  5.7 156 D 1107  18.                  0.6500 100000.00    4   0.0
95010203 14  5.5 150 D 1101  17.                  0.6500 100000.00    4   0.0
95010204 13  5.6 153 D 1114  18.                  0.6500 100000.00    4   0.0
95010205 13  5.9 152 D 1121  18.                  0.6500 100000.00    4   0.0
95010206 13  5.6 147 D 1101  18.                  0.6500 100000.00    4   0.0
95010207 14  5.3 137 D 1127  20.                  0.5420 100000.00    4   0.0
95010208 14  6.3 141 D 1140  17.                  0.6500 100000.00    4   0.0
95010209 15  5.8 144 C 1310  17.                  0.6500 100000.00    4   0.0
95010210 16  6.0 142 D 1399  17.                  0.6500 100000.00    4   0.0
95010211 19  5.7 146 C 1567  18.                  0.6500 100000.00    4   0.0
95010212 21  6.7 142 C 1616  19.                  0.7580 100000.00    4   0.0
95010213 22  7.3 133 C 1671  17.                  0.7580 100000.00    4   0.0
```

Figure 1: Sample:AUSPLUME meteorological data file.

APPENDIX B: DETERMINATION OF STABILITY CLASS

Table 2: Stability classification for daytime using solar radiation and wind speed

	Solar radiation (W/m²)			
Wind speed (m/s) at 10 m	≥925	≥675	≥175	< 175
< 2	A	A	B	D
< 3	A	B	C	D
< 5	B	B	C	D
< 6	C	C	D	D
≥ 6	C	D	D	D

Table 3: Modified Pasquill stability classes for night-time

Wind speed (m/s) at 10m	Within 1 h before sunset or after sunrise	Night-time cloud amount (octas)		
		0-3	4-7	8
≤ 2	D	F	F	D
≤ 3	D	F	E	D
≤ 5	D	E	D	D
≤ 6	D	D	D	D
> 6	D	D	D	D

Table 4: Stability Classification for Night-time Using Net Radiation and Wind Speed

	Net radiation (W/m²)			
Wind speed (m/s) at 10 m	≥ -14	≥ -28	≥ -56	≥ -70
< 2	D	F	F	F
< 3	D	E	F	F
< 5	D	D	E	E
< 6	D	D	D	D
≥ 6	D	D	D	D

1 Formula to calculate solar radiation (SR) in the absence of measurements

$$SR = [A_1 Sin(\alpha) + A_2]\left[1 + B_1\left(\frac{Octa}{8}\right)^{B_2}\right]$$

where **A_1** = 1150.

A_2 = -30

B_1 = -0.75

B_2 = 3.4

Octa is cloud amount in octas (8ths)

α = 90-zenith angle for the day, hour

2 Formula to calculate mechanical mixing height ($MixH_m$) for stability class D

$$MixH_m = 0.185 \frac{U^*}{C_{term}}$$

where $U^* = 0.35 \frac{Usfc}{Ln\left(\frac{Ht_{Anemo}}{Z_0}\right)}$

C_{term} = Coriolis term $= 2\,\Omega\,\text{Sin}(\phi)$

where Ω is the angular velocity of the earth

ϕ is the latitude

Ht_{Anemo} = anemometer height

Z_0 is the roughness length

APPENDIX C: STABILITY CLASS AND MIXING HEIGHT CALCULATION IN TAPM

Stability class

The stability class is calculated using TAPM outputs of wind speed, sensible heat flux and total solar radiation, in equations fitted to curves in Figure 6.13 of Pasquill (1974).

Convective mixing height

The convective mixing height (the boundary-layer height in convective conditions) is defined as the first model level above the surface for which the vertical heat flux is negative; while in stable/neutral conditions it is defined as the first model level above the surface that has a vertical heat flux less than five per cent of the surface value.

Note that neither of the methods above is consistent with EPA Victoria methods. The accuracy of those methods depends on the heat flux calculations.

APPENDIX D: BIBLIOGRAPHY

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