Configuring HYSPLIT for the Particle Release Number

The 3D particle simulation (INITD=0) is the most sensitive to particle number. To estimate the number of particles required to simulate an instantaneous release follow the steps indicated in the next paragraph. This value would then be corrected for other release scenarios.

1) From the "Quick Long-Range Dispersion Estimate" nomogram determine the normalized concentration at the required downwind distance (by travel time). For instance, if sampling is planned at 2 days downwind of the source for a ground-level release, the normalized concentration is 10^{-14} particles per cubic meter.
2) Estimate the minimum volume of the HYSPLIT sampling grid in cubic meters as was set in the CONTROL file. For instance, if the concentration grid consisted of a one by one degree grid (1 deg = 100 km) of one layer with a depth of 100 m, then the approximate volume of a grid cell is 10^5 x 10^5 x 10^2 or 10^{12} m^3.
3) The maximum grid cell particle number is then estimated from the product of the two previous results or in the case of the example 0.01 particles (10^{-14} x 10^{12}).
4) Because one would want at least 100 particles per concentration grid cell, the number of particles that should be released would be 100/0.01 or 10,000 in the example calculation.

As a first approximation, the hybrid puff simulation (INITD=4) can be set to release about 1/100 of the 3D simulation rate because hybrid puffs will split horizontally as they expand beyond the size of the meteorological grid. Only enough puffs are required to properly sample the vertical distribution.

In the case of a continuous release, with non-steady state meteorological conditions, adjust the above instantaneous release estimate by the following steps.

1) Determine the particle residence time in the sampling grid. In the previous example, the concentration grid length was about 10^5 meters. If we assume an average transport wind speed of 10 m/s, then the residence time is 10^4 seconds.
2) Compute the particle release rate required to give the minimum particle number for the residence time. In the case of the example 10,000 particles in 10,000 seconds, or the release rate should be around 3600 particles per hour.

In the case of steady-state meteorology, the continuous particle release rate can be comparable to the number of particles required for an instantaneous release. Also note that the particle number requirements can be lowered by increasing the grid-cell size. For instance, in well mixed conditions, concentrations may be very similar at 100 m and 500 m, if the boundary-layer depth is large. In that situation, a larger vertical grid-cell dimension would require fewer particles.

QUICK LONG-RANGE DISPERSION ESTIMATE

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October 24, 1994

Objective

To produce a quick estimate of the maximum ground-level air concentrations and deposition that can be expected for a given release amount at downwind distances after travel times of one to five days after release.

Guidance

The procedure used is a result of analytical and experimental studies and is summarized in a simple nomogram giving the normalized concentration as a function of travel time for a release within the atmospheric boundary layer and for a release above the boundary layer.

QUICK DISPERSION ESTIMATE REFERENCE

INTRODUCTION

A long-range tracer experiment[1] conducted during the months of January through March of 1987, showed that the maximum concentrations measured (Fig. 10 in ref. 1) during any 24 hour sampling period followed the simple Gaussian model form for an instantaneous release (see Eq. 5.21 in ref. 2) as shown below:

$$\chi/Q = [\ 0.5\ (2\pi)^{3/2}\ \sigma_x\ \ \sigma_y\ \ \sigma_z\ ]^{-1},$$

where we will assume that $\sigma_z = (2Kt)^{1/2}$ and that the vertical mixing coefficient K has an average value of 5 m^2s^{-1} in the atmospheric boundary layer (near the ground) and about 1 m^2s^{-1} in the upper regions of the atmosphere[3]. The along-wind and cross-wind dispersion coefficients are assumed both to be equal to 0.5 times the downwind travel time in seconds[4]. The equation in this form has each exponential term for the along-wind, cross-wind, and vertical offset set to one, to yield the maximum ground-level concentration.

If the release occurs above the boundary layer, a correction of the form

$$\exp\ [\ -0.5\ (\ H\ /\ \sigma_z\ )^{1/2}\ ]$$

is applied to the normalized concentration to obtain an estimate of the ground-level concentration.

An estimate of the maximum deposition can be obtained from the nomogram by multiplying the air concentration by the vertical dispersion parameter. This result would then assume that all the material in the air is removed at that time.

PROCEDURE

(1) Determine if the release is ground-level or elevated. An elevated release is assumed to be due to a large thermal source or explosion resulting in most of the material being ejected above the boundary layer. The calculations assume an average elevated release to be about 1500 m above ground. Normal stack emissions are to be considered as a ground-level release.

(2) Determine the time after the accidental release for which the concentration estimate is desired in units of days. Other analysis methods must be employed to determine the location of this estimate. For instance a simple trajectory or projection based upon wind speed might be sufficient depending upon the circumstances.

(3) Go along the abscissa of Fig. 1 to the desired downwind travel time and read the normalized concentration from the appropriate release height curve. The concentration is in units of m^{-3}.

(4) Determine the total amount of material emitted in mass units and multiply this by the previous result. Do not use a release rate (mass/time) as the nomogram is based upon the total emission. If the release was given in Ci the result is now Ci m^{-3}.

(5) The dashed line on the nomogram gives an estimate of the deposition (use the same ordinate values but units are per square meter). It is assumed that all the airborne material is available for ground deposit at each downwind time. Fractional removal requires subsequent deposition and air concentrations to be adjusted accordingly.

QUALIFICATIONS

It should be clear from Fig. 1 that there can be large variations in the estimate if the height of release is incorrect. These calculations assume a non-depositing material and therefore the ground-level estimate will always be the more conservative. It should be noted that elevated releases of depositing material can show much higher concentrations downwind than ground-level releases due to their initial lack of deposition.

The estimates from Fig. 1 are much more appropriate at longer downwind distances, when the spreading of the material is comparable to the 24 hour sampling time that was used to verify this approach. At travel times less than one day the average dispersion parameters that were used are difficult to justify.

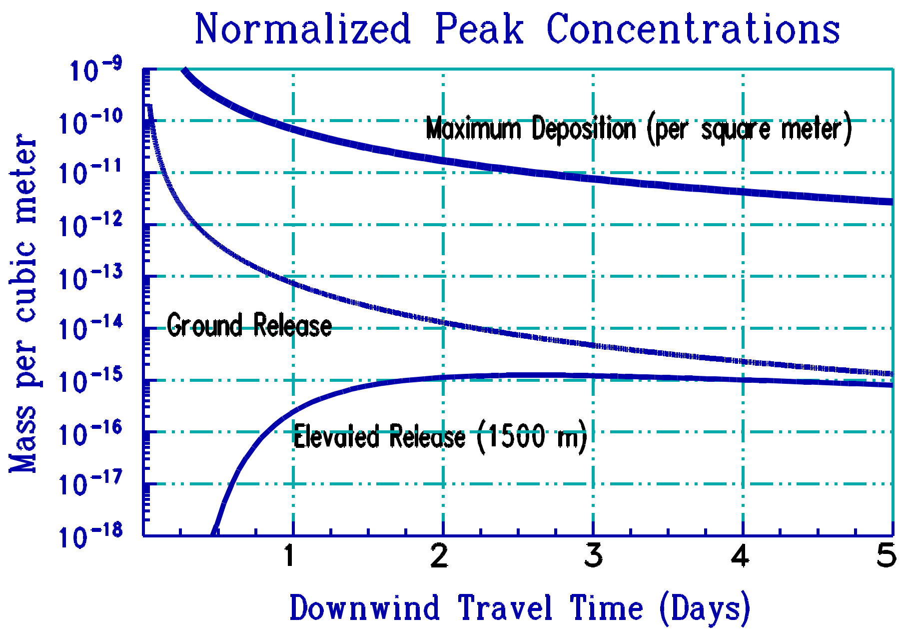

Figure 1. Normalized peak concentrations as a function of downwind travel time for a near-ground and elevated release.

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