5.2 COMPARISON OF DISPERSION MODEL UNCERTAINTY COMPONENTS

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1. INTRODUCTION

The uncertainty in the dispersion model results generally comes from the following three components: (1) variability due to random turbulence in the atmosphere, (2) input data errors, and (3) errors and uncertainties in model physics. Because of the turbulent nature of the atmosphere, the same meteorological conditions do not always lead to the same pollutant concentrations. Input data errors can be due to instrument errors or unrepresentative instrument siting. Errors and uncertainties in model physics can be due to factors such as inadequate physical formulation or uncertainties in the parameters used in these physical formulations. This paper investigates the relative contributions from random turbulence and from input data errors to the uncertainty in dispersion model results. The Dipole Pride 26 (DP26) field data and the Second-order Closure Integrated Puff (SCIPUFF) model are used to address the above issue.

2. DP26 FIELD DATA

The DP26 field experiments were conducted in November, 1996, at Yucca Flat (~37°N, 116°W), the Nevada Test Site, Nevada. Watson et al. (1998) and Biltoft et al. (1998) provide a detailed description of the experiments. Fig. 1 shows the test site and instrument layout.

The experiments involved instantaneous releases of SF_6 (~10 to 20 kg) at roughly 6 m above the ground, mostly in early morning or early afternoon hours. Depending on the prevailing wind directions at the test site, the release was either from the north (N2 or N3 in Fig. 1) or from the south (S2 or S3 in Fig. 1). Meteorological data were measured by a dense network of eight surface, one radiosonde, and two pibal stations. The main sampling array consisted of three lines, roughly 5, 10, and 20 km downwind from the source, where each line had 30 whole-air samplers, 1.5 m above the ground, with a 15-min sampling interval or averaging time. The average spacing between adjacent samplers was about 250 m. The total sampling period was three hours for each trial.

3. SCIPUFF DISPERSION MODEL

Because of its second-order turbulence closure formulation (Sykes et al. 1984), SCIPUFF (Sykes et al., 1998) is one of the first operational dispersion models that can predict both the mean and variance of concentration fields. In this study, SCIPUFF uses the SWIFT (Stationary Wind Fit and Turbulence) diagnostic model to create the gridded wind fields for dispersion calculations. SWIFT is adapted from the MINERVE diagnostic model (Perdriel et al. 1995).

4. UNCERTAINTY ASSESSMENT METHODOLOGY

The concentration variance (fluctuations) predicted by SCIPUFF is used to estimate the variability due to random turbulence. The data withheld technique (McNair et al. 1996, Bergin et al. 1999) is used to estimate the uncertainty due to input data errors. This technique involves a set of eight sensitivity runs, each with the meteorological data for one surface station withheld from the fitting of the gridded wind fields. (There are eight sensitivity runs because the number of surface stations for DP26 is eight.) For example, one such sensitivity run would be to conduct SWIFT/SCIPUFF modeling with the data for surface station M1 (see Fig. 1) withheld. The variance in the solutions among the eight sensitivity runs gives an estimate of the uncertainty due to input data errors.

Note that this data-withheld technique is the basis of the jackknife resampling method (e.g., Hanna et al. 1989), and addresses only the meteorological algorithms in the overall dispersion modeling process. The uncertainty in the source term is not included because it is well-defined for DP26. A formal uncertainty analysis for dispersion models typically involves a full-scale Monte Carlo uncertainty analysis that accounts for variations in all model inputs and algorithms (e.g., Hanna et al. 2001).

5. RESULTS AND DISCUSSIONS

This study compares the contributions of two model uncertainty components, i.e., the variability due to random turbulence and the uncertainty due to input data errors, based on the maximum dosage (concentration integrated with time, ppt-hr) along a sampling line. Fig. 2 shows the results, after taking the square root of the two uncertainty (variance) components. Different symbols are used to designate the near, middle, and far sampling lines downwind from the source. Recall that depending on the prevailing wind directions, a release can be from the north or from the south of the test domain.

In general, the contributions from the two processes are in the same order of magnitude, at least at the mesoscale distance scale considered in this study. The results also show that random turbulence is more

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important than are input data errors in contributing to model uncertainty at the closest sampling line (~5 km from the source), and is less important at the farthest sampling line (~20 km from the source). This is consistent with our intuition that when the puff is closer to the source, it is under the influence of smaller eddies, so that concentration fluctuations are higher due to these smaller eddies. Therefore, efforts to improve the quality of model inputs may not pay off, because turbulent eddies will cause more fluctuations anyway. As the puff travels farther downwind and grows in size, it is under the influence of larger eddies and thus has less fluctuations. At this point, it becomes more important to pay attention to the model uncertainty due to input data errors.

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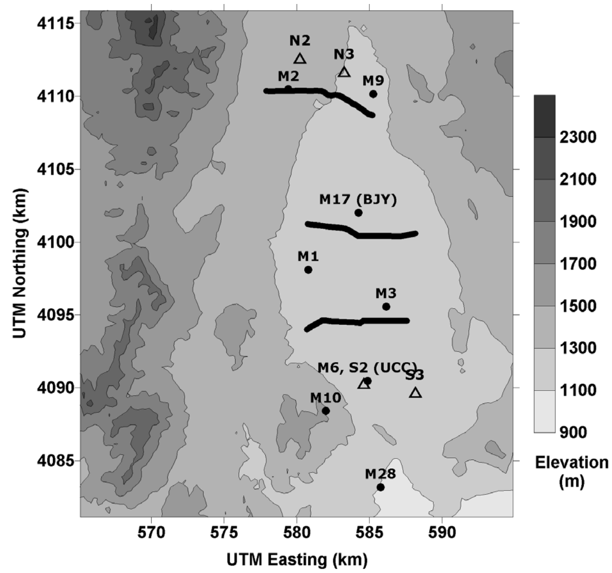

Fig. 1 Terrain elevation for the Dipole Pride 26 field study at Yucca Flat, the Nevada Test Site, Nevada. Also shown are the three SF_6 sampling lines (thick lines, 30 samplers per line), eight surface meteorological stations (solid circles; M1, M2, M3, M6, M9, M10, M17, and M28), and four possible release locations (open triangles; N2, N3, S2, and S3). There are also two pibal stations (BJY, near M17; and UCC, near M6), and one radiosonde station (UCC). The southwest corner of the map roughly corresponds to (36.9°N, 116.3°W).

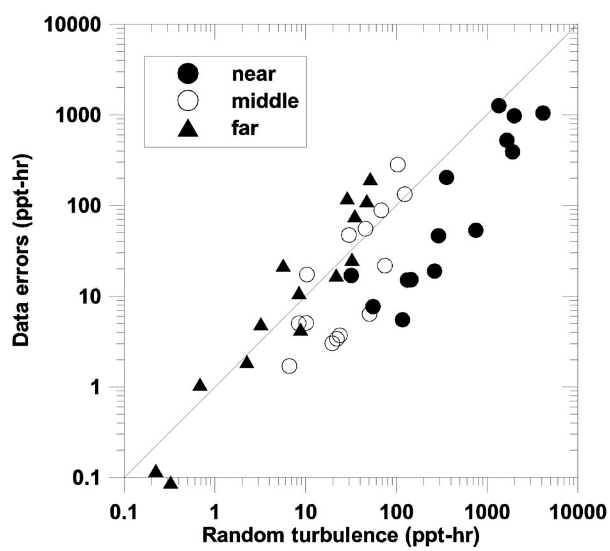

Fig. 2 Comparison of the variability due to random turbulence and the uncertainty due to input data errors, based on the maximum dosage (ppt-hr) along a sampling line. Different symbols are used to indicate whether the sampling line is near, middle, or far from the source. For example, depending on the prevailing wind directions, the northmost sampling line in Fig. 1 can be either near or far from the source.