Title:

Theory of Exposure Models: Derivation of an Indoor-Outdoor Averaging Time Model from the Mass Balance Equation

Author(s):

Paul Switzer and Wayne Ott

Technical Report number (Dept. of Statistics, Stanford Univ.):

2001-22

Date:

September, 2001

Abstract:

Averaging time models based on empirical measurements have been developed for ambient data, but most have lacked a theoretical basis, and few averaging time models have been developed for indoor air quality and exposure assessment applications. Previous human activity pattern-exposure models have required improved ways for handling the serial autocorrelation of pollutant concentrations in indoor and in-transit microenvironments. Because existing exposure models often sample concentrations from microenvironmental distributions for different averaging times, one approach for handling this autocorrelation is to develop an averaging time model for each microenvironment of importance. This paper explores a new approach for developing averaging time models: deriving the model theoretically from the mass balance equation, which describes the relationship between the time series of the input and output concentrations of any pollutant introduced into a well-mixed microenvironment. Solutions to the mass balance equation have been successfully validated for indoor and in-transit settings. Beginning with the mass balance equation, this paper derives an averaging time model that predicts the mean, variance, and autocorrelation of the time series of pollutant concentrations in a well-mixed chamber for any averaging time. This paper considers the case of a discrete model in which the input source concentration is an autocorrelated time series of piecewise-constant concentrations of equal duration while the air exchange rate remains fixed. The autocorrelation structure of the source concentration is known, allowing the autocorrelation structure of the indoor concentration to be predicted. Because the model is derived theoretically, the model is exact for the conditions specified. The goal of this research is to provide human exposure researchers with basic concepts for designing and developing useful, practical algorithms for future human exposure and indoor air quality models.