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# Project Summary

# COMPLEX/PFM Air Quality Model User's Guide

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**A user's guide has been assembled to describe the purpose, design, and operation of the COMPLEX/PFM air quality modeling system. The system combines the features of the Potential Flow Model (PFM) with those of the EPA COMPLEX I and COMPLEX II models to produce a potential flow complex terrain model for routine application.**

**Potential flow dispersion calculations may be selected as an option within COMPLEX/PFM. When this option is selected, the model requires hourly wind speed and temperature profiles to calculate hourly mixing heights, hourly plume rise using a layered-plume-rise equation, and hourly values of the critical dividing streamline height. A preprocessor is provided to interpolate hourly profile data from morning and evening radiosonde data. Potential flow calculations are made whenever the plume lies above the dividing streamline height, provided that the surface stability class is D, E, or F. COMPLEX I calculations are performed whenever the plume lies below the dividing streamline height, and COMPLEX II calculations are made whenever the surface stability class is A, B, or C.**

***This Project Summary was developed by EPA's Environmental Sciences Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).***

## Introduction

Potential flow theory was applied to the problem of predicting pollutant concentrations on significant terrain features. This approach produced the modeling system described in this manual. Two classes of meteorological conditions are often associated with the likelihood of large ground-level concentrations on elevated terrain features: (1) low wind speed and stable cases, and (2) moderate or high wind speed and neutral or slightly stable cases. The first class of conditions generally leads to high concentrations through direct plume impingement or terrain blocking. The second class promotes high concentrations because the plume is forced to pass close to the terrain surface. Physical mechanisms relevant to this class of conditions include terrain-induced alteration of the plume centerline trajectory and kinematic constraints on horizontal and vertical dispersion. Potential flow theory is particularly useful in modeling concentrations produced by the second class of conditions.

The objective of this user's guide was to generalize the PFM code to a complete modeling system. That modeling system is COMPLEX/PFM. The PFM calculations made by this model are applicable to bluffs and ellipsoidal terrain shapes. The host model, EPA COMPLEX, contains the structure for handling point sources, the hourly simulation of concentrations, and averaging and reporting air pollutant concentration statistics. The host model also provides pollutant concentration algorithms for impingement situations and strongly convective situations.

## Major Model Features

COMPLEX/PFM is a modified version of COMPLEX I/COMPLEX II, which contains the PFM algorithm option. If the PFM option is not invoked the model performs COMPLEX I (22.5° crosswind sector averaging and Gaussian vertical spread based on $\sigma_z$) computations for stability classes five and six (E, F), and COMPLEX II (bivariate Gaussian spread based on $\sigma_y$ and $\sigma_z$) computations for stability classes one through four (A through D). Both COMPLEX versions are based on the MPTER model with an expanded list of terrain algorithms. Some general features of COMPLEX/PFM modeling system are:

- Hourly meteorological data that may be read off punched cards for each hour, or from a tape (or disk) containing a year's data (same data as used for RAM or CRSTER)
- Optional terrain adjustments as a function of stability class
- Inclusion or omission of stack downwash
- Inclusion or omission of buoyancy-induced dispersion of pollutant during plume rise using the Pasquill method
- Input of anemometer height
- Input of wind profile power-law exponents as functions of stability
- Concentration contributions that are available per hour and/or for the selected averaging period at each receptor from up to 25 sources
- Concentrations available hourly and/or for the selected averaging period at each receptor
- Optional output of the following information: average concentration over length of record, plus highest five concentrations for each receptor for four end-to-end averaging times (1-, 3-, 8-, and 24-h), and an additional averaging time selected by the user
- Optional output files for further processing of concentrations
- Up to 50 point sources
- Up to 180 receptors

Special features introduced when the PFM option is invoked include the following:

- Hourly wind and temperature profiles (interpolated from radio sound observations taken twice daily) are required input
- Refined hourly mixing height calculation based on hourly wind and temperature profiles
- Layered plume rise calculations based on hourly wind and temperature profiles
- Assessment of wind-flow characteristics by a critical dividing streamline (HC) and Froude-number (FR) analysis based on the hourly wind and temperature profiles
- Selection of the COMPLEX I, COMPLEX II, or PFM algorithm based on the surface stability class, FR, HC, and initial plume height
- Inclusion of explicit plume size and trajectory deformations computed from potential flow theory when PFM is applicable
- An economical long-term version (PFM-Long) for computing annual average concentrations, for assessing regions of frequent high concentrations, and for identifying critical periods of meteorology that produce the highest expected pollutant concentrations
- A short-term, worst-case, or critical-period version (PFM-Short) for a refined analysis of maximum pollutant concentrations expected
- Selection of terrain features from 20 bluff profiles and an infinite number of ellipsoid shapes for PFM-Short, and 4 bluff profiles and 16 ellipsoid shapes for PFM-Long

There are several added restrictions to the original COMPLEX features when the PFM option is invoked:

- All sources (50 maximum) are at the same point
- The receptor pattern must be radial
- There is no gradual plume-rise option

The COMPLEX/PFM model should be viewed as a natural extension of the COMPLEX modeling system when representative profiles of wind and temperature are used. Characterization of the relationship between HC, FR, plume height, and terrain height is essential to assessing plume behavior and to choosing the most appropriate algorithm to simulate it. When plume impingement is likely, based on these quantities and not simply on the dispersion stability class of the surface layer, a VALLEY-like (COMPLEX I with the recommended parameter choices) computation is made. When potential flow theory applies, a PFM computation is performed. If the boundary layer is convectively unstable, a COMPLEX II computation is made with a suitable plume path coefficient.

## COMPLEX/PFM Modeling Package

The COMPLEX/PFM modeling package is schematically illustrated in Figure 1. The meteorological preprocessing steps on the left side of the figure are required by most sequential air quality dispersion models in use today, especially those available through UNAMAP. This preprocessor requires hourly surface data and morning and afternoon mixing height data.

The preprocessing steps on the right side of the figure pertain only to the PFM option within COMPLEX/PFM. For short-term runs, user-specified meteorological data may be input on cards. Hourly temperature and wind profiles are required when the PFM option is invoked. These can be constructed by the PROFIL preprocessor from radiosonde data taken twice daily and hourly surface data. When on-site tower data are available, tower wind and temperature data should also be included by the user, although the code for doing this is not included in the preprocessor.

All source, receptor, and program control data are entered by card deck. The control information determines which algorithms are to be used in the computations, and what sort of program output is desired.

Prior to execution, an unformatted look-up table of intermediate PFM computations must be prepared to use with the PFM-Long option. A formatted file of this table accompanies the COMPLEX/PFM source code. Program (SETUP Figure 1, lower right) converts this file to the form needed at execution time. SETUP must be run only once, when the model is first compiled on a new system.

The user's guide contains a technical description of the potential flow model along with user's instructions for the unique preprocessors and the COMPLEX/PFM model. Input format specifications are given along with instructions for determining obstacle shape for application in the model. A test case for the preprocessor and four test cases of the COMPLEX/PFM model are described. The COMPLEX/PFM model and the test case input and output data are contained on the User's Network for Applied Modeling of Air Pollution (UNAMAP) Version 5.

## Conclusions

A user's guide has been prepared for the COMPLEX/PFM dispersion model which applies potential flow theory for calculating the impact of non-reactive pollutants on the windward side of the first significant terrain feature downwind of a point source. The model represents a first step toward a refined complex terrain model. It offers realistic physical description of the interaction of plumes with terrain features; plume path and dispersion coefficients are modified based on the height of the plume relative to the height and shape of the terrain feature.

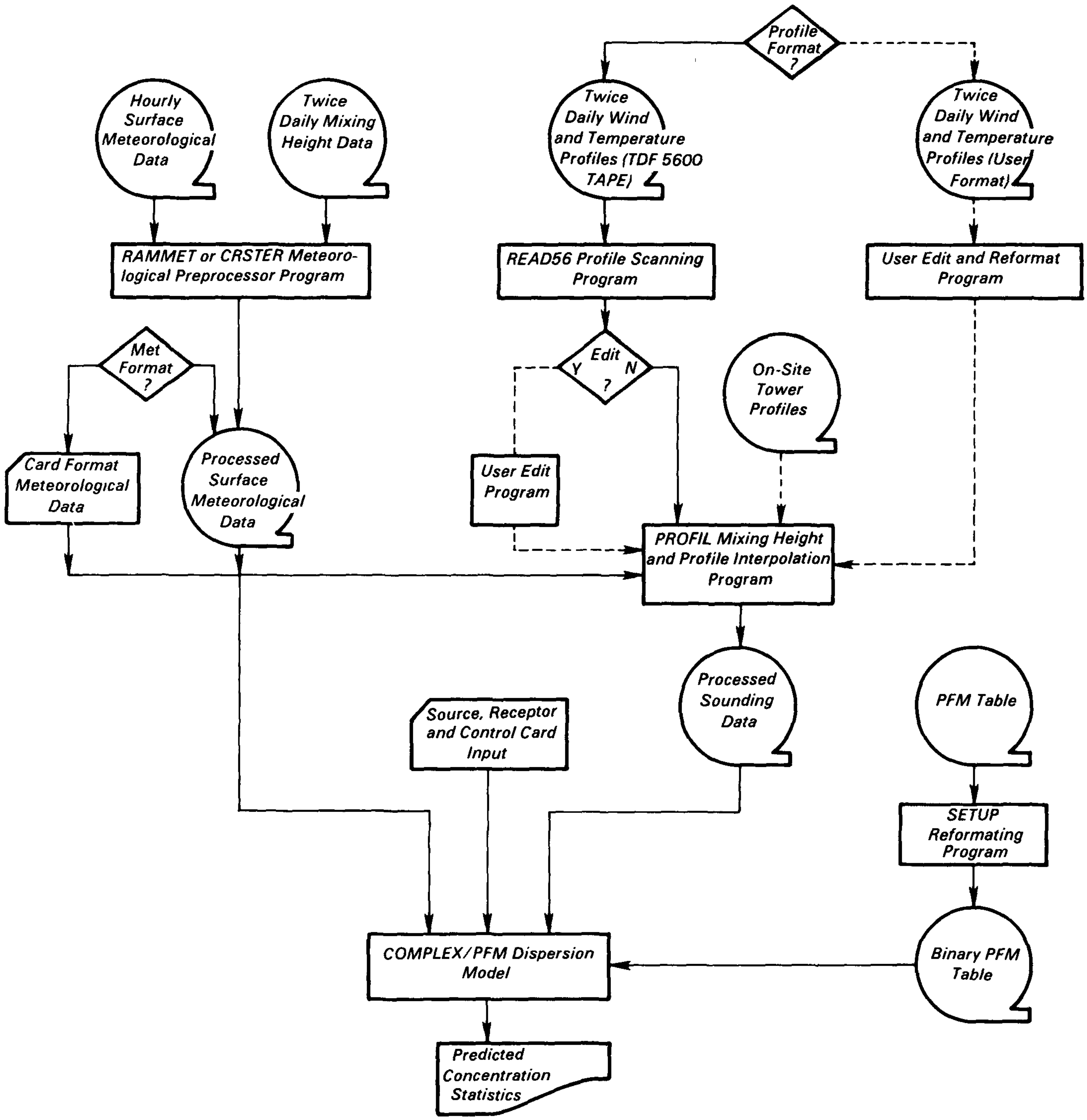


**Figure 1.** *The COMPLEX/PFM Modeling System*

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*The complete report, entitled "COMPLEX/PFM Air Quality Model User's Guide," (Order No. PB 83-200 626; Cost: $13.00, subject to change) will be available only from:*
*National Technical Information Service*
*5285 Port Royal Road*
*Springfield, VA 22161*
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