Section 1

INTRODUCTION

This document describes the general program design and organization of the PSU/NCAR mesoscale model (MM5). The basic model was originally developed at the Pennsylvania State University (PSU) and has undergone many changes and improvements at PSU and NCAR since documentation regarding the previous version of the model (MM4) was written (Hsie 1987 and Anthes et al. 1987). Description of the model structure and organization is given in enough detail to enable users to modify the code for their own research. This document should be read with the companion Technical Note *Description of the Fifth Generation Penn. State/NCAR Mesoscale Model (MM5)*, by G. Grell et al. (1994), which describes the governing equations, physical parameterizations, and numerical algorithms used in the model. In the Introduction, a general description of the model and source-code structure is given. Section 2 provides detailed information concerning allocation of memory. Section 3 describes the PARAMETER statements used in the model and section 4 the common block structure. The individual subroutines are discussed in section 5 and the subroutine arguments are defined in section 6. In section 7, variables in the NAMELIST records are defined. Flow charts of MM5 are shown in Appendix A and the UNICOS script from the standard job deck is presented in Appendix B.

1.1 General Description of the Model

The MM5 is a grid-point model with finite differences centered in space and time. Second-order finite differences are used for the advection terms, and an Asselin time filter is applied to all prognostic variables. The model can be either hydrostatic or non-hydrostatic. The hydrostatic option uses split semi-explicit time integration for efficient treatment of the fast gravity modes and the non-hydrostatic option uses semi-implicit time integration for the sound-wave modes.

The vertical coordinate, sigma, is defined as:

$$\sigma = (p - p_t)/p^*, \quad p^* = p_s - p_t ,$$

where p is pressure, p_s is surface pressure, and p_t is the pressure at the top of the model (Fig. 1). For the non-hydrostatic option, p, p_s, and p_t are defined in terms of reference pressures (see Grell et al. 1993). The prognostic variables are p*, p' (pressure perturbation), T, T_g (ground temperature), U, V, W (vertical velocity), q_v (water vapor), q_c (cloud water), q_i (cloud ice), q_r (rain water), and q_{ni} (snow). T_g, q_v, q_c, q_i, q_r, and q_{ni}, are optional; W and p' are for the non hydrostatic option. The variables are staggered horizontally such that U and V are defined on dot points (Fig. 2) and all other variables are defined on cross points. In the vertical, all variables except W are defined on the half-sigma levels.

1.2 Source-Code Structure

The source code of the model is written in Cray FORTRAN and stored on the NCAR mass storage system (MSS) in Cray Update form. The code is both multi-tasked and vectorized. A computer with large in-core memory (larger than one megaword) is needed to run the model because all data, arrays, and prognostic calculations are contained in the main memory of the computer. Locally parameterized dimensions in PARAMETER statements enable users to vary both the horizontal and vertical resolution, and also the number of domains for multi-nest levels. All major two-dimensional and three-dimensional arrays are stored in very large storage arrays (**ALLARR** and **INTALL**) which have parameterized dimensions and are located in common block /HUGE/. Further details concerning the memory and source code structure are given in section 2.

1.3 Options

Most input variables used to control selection of options are read in from four NAMELIST records in subroutine PARAM. Other input parameters regarding options affecting memory requirements (**IFDDA**, **INHYD**, **MAXNES**, etc.) are specified in PARAMETER statements. Users of MM5 should make sure that certain PARAMETER statements regulating model dimensions (for both coarse and nested domains) are compatible with those previously specified in the preprocessor programs of the MM5 modeling system.

1.4 Style Convention

All source-code variable names are shown in **BOLD UPPER-CASE** font. The names of subroutines, common blocks, and NAMELIST records are shown in standard upper-case font, but not bold upper case. In addition, common block names are bracketed with slashes /NAME/ and NAMELIST record names are delineated with a dollar sign $NAME. Examples of source code or UNICOS script taken directly from the FORTRAN or job deck appear in `typewriter` font.

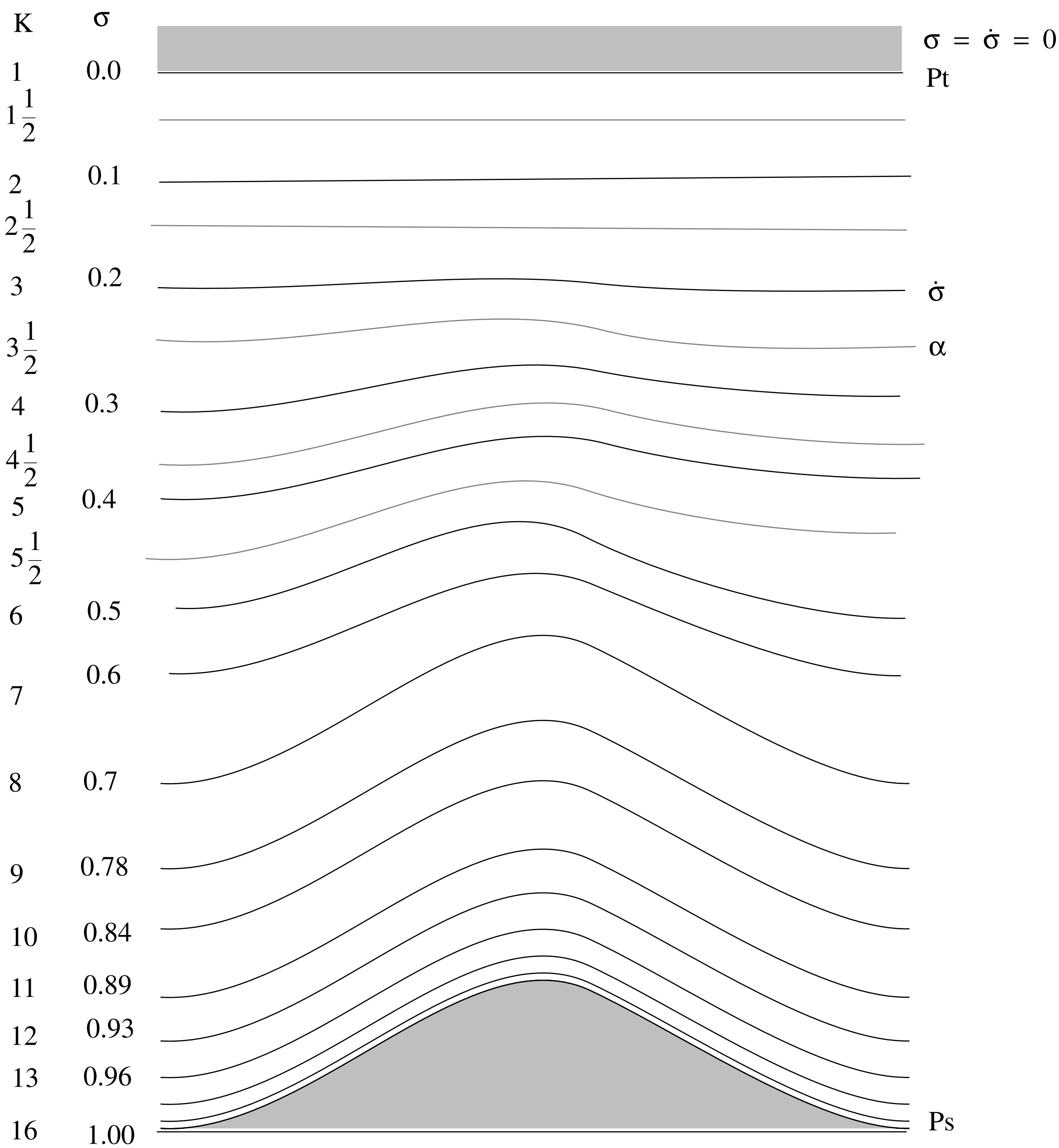

Figure 1. Schematic representation of the vertical structure of the model. The example is for 15 vertical layers. Dashed lines denote half-sigma levels, solid lines denote full-sigma levels.

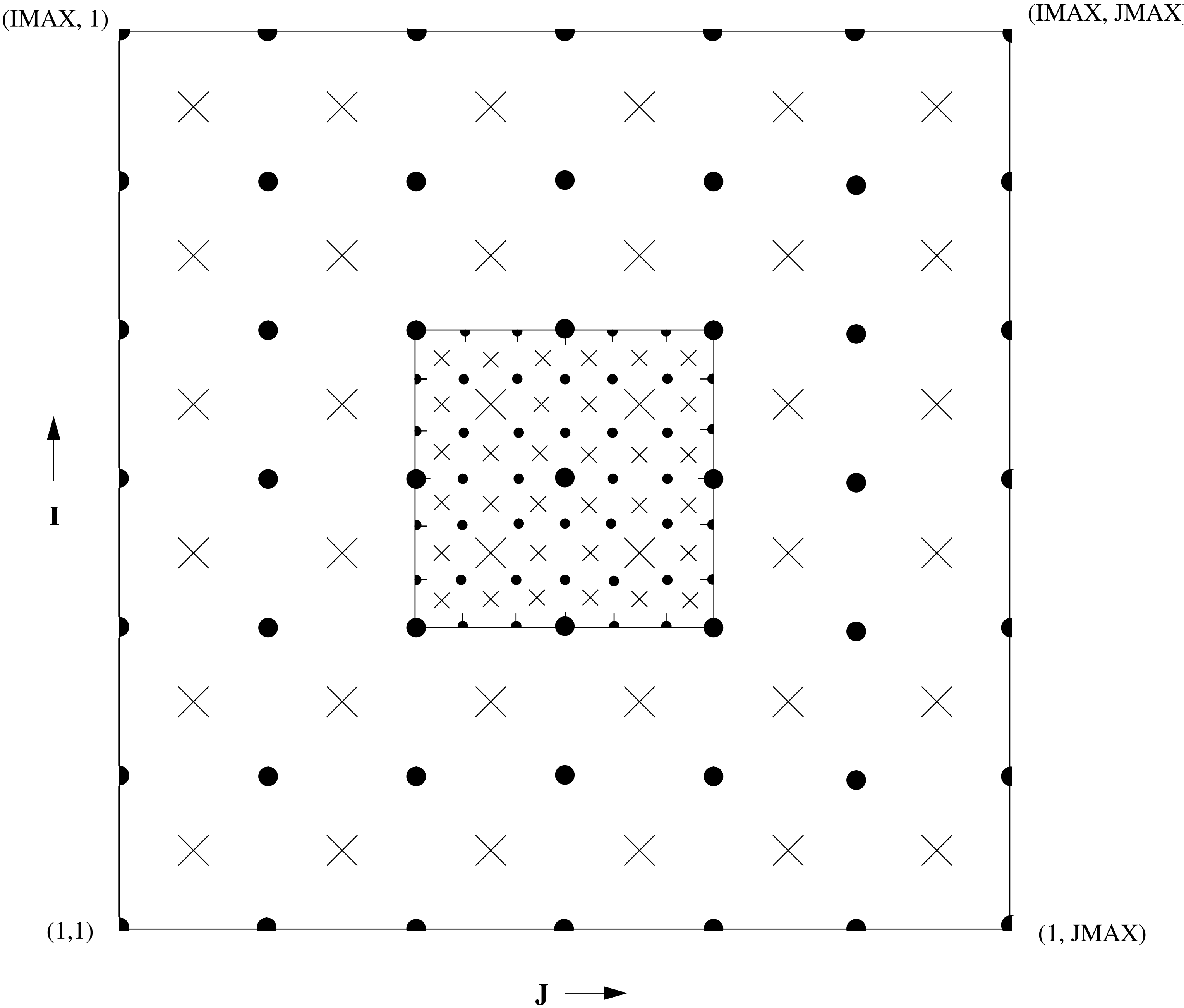

Figure 2. Schematic representation showing the horizontal Arakawa B-grid staggering of the dot (●) and cross (x) grid points. The smaller inner box is a representative mesh staggering for a 3:1 coarse-grid distance to fine-grid distance ratio.