RIP VERSION 3.0 MM5 VISUALIZATION SOFTWARE

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1. BACKGROUND

The official MM5 visualization software has historically been program "Graph". Another MM5 graphics package, however, whose use has been proliferating since its development in 1991, has been that of "RIP". Created by Dr. Mark Stoelinga of the University of Washington, RIP (derived from "**R**ead–**I**nterpolate–**P**lot") is Fortran-based software offering a multitude of plotting capabilities not found in Graph. Consequently, it has been a powerful alternative to the basic MM5 graphics routine.

As of June 2000, RIP will officially become part of the MM5 modeling system. This reflects not only the desire to accomodate RIP's growing use, but also the creation of a new version of the system, RIP 3.0 (V3.0). RIP 3.0 contains major enhancements over the preceding circulated version, 2.0 (made available in 1997), with the improvements being the product of a recent NCAR-University of Washington collaboration. The goals of this RIP Project were to unify the leading variants of the RIP code, to make substantial new capabilities for this unified version, and to integrate RIP officially into the MM5 modeling system.

This paper summarizes the structure and most significant features of RIP 3.0. For full details on the system, one may consult the documentation available at http://www.mmm.ucar.edu/mm5/doc.html.

2. RIP 3.0 FUNCTIONALITIES

Created as a tool for analyzing MM4/MM5 simulations, RIP was originally designed to render plots from model output files. Because of its relative ease of adaptability, its plotting capabilities have multiplied over the years. Its basic features have allowed:

- the creation of horizontal plots displaying contours, color fill, vectors, wind barbs, streamlines, or characters;
- the creation of horizontal plots on sigma, pressure, height, potential temperature, or equivalent potential temperature surfaces;
- the creation of vertical cross sections displaying contours, color fill, and wind vectors;
- the creation of vertical cross sections with vertical coordinates of sigma, pressure, height, log pressure, Exner function, potential temperature, or equivalent potential temperature;
- the creation of skew-T sounding plots (locatable by grid coordinates, lat/lon coordinates, or station identifiers);
- the calculation of backward or forward trajectories and diagnostic quantities along them; and
- extensive user control over the appearance of all plot aspects (color, line style, etc.).

While these capabilities continue in V3.0, numerous improvements have been added. RIP can now plot more with a wider range of plotting parameters and user control over image appearance than ever before. The list of plottable fields has lengthened, and V3.0 is more flexible in the specifications of time and vertical level ranges for its fields. For example, one may now request a range of times through limits and an increment, rather than by listing all individual times. As described in Section 2, user specification of plotting parameters in RIP is done via an input file. Regarding plot appearance, improvements have also been made addressing the overwriting of label bars in plot frames and the printing of more understandable field names (as opposed to RIP shorthand names).

RIP V3.0 offers significant new plotting capabilities and reflects structural and processing improvements over its predecessors. The main ones with respect to the latter are:

(1) a pressure data ingest capability,
(2) flexibility in reading 2-D and 3-D fields in the MM5 datasets, and

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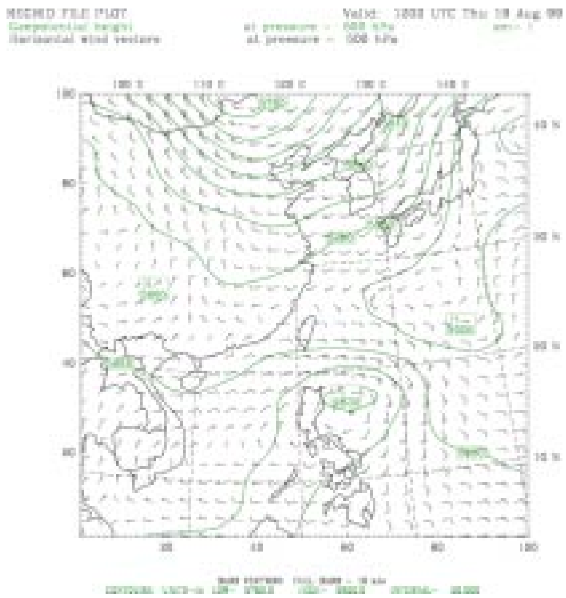

Figure 1. 500 mb heights and winds from MM5V3 Regrid file plotted by RIP 3.0.

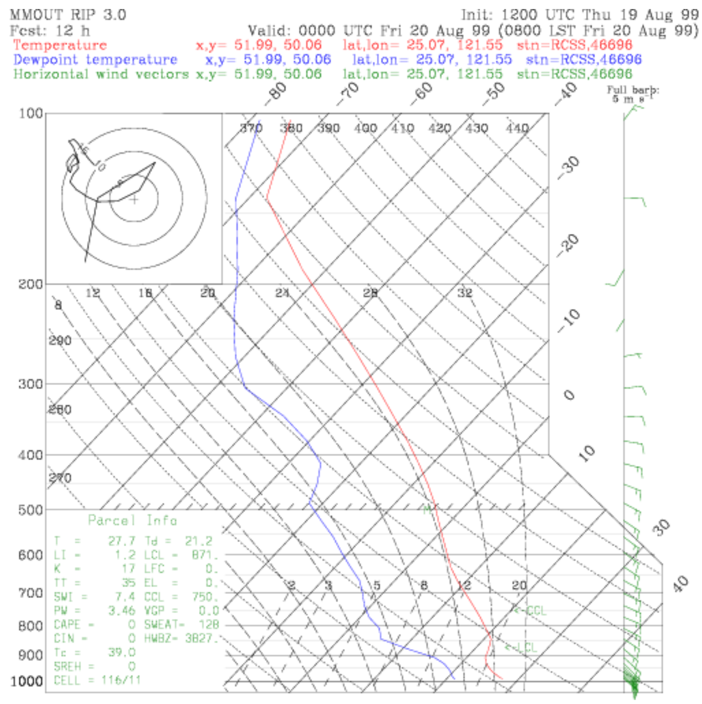

Figure 2. Sounding from MM5V3 output showing plotted convective parameter information (lower left corner) and hodograph (upper left corner), produced by RIP 3.0.

(3) the ability to avoid specified fields or times in preprocessing.

The first addition is the most significant: RIP can now read and plot pressure-level datasets. This addresses a long-standing need for its visualization of files produced by the MM5 preprocesors ($e.g.$, Regrid, Little-r). With this capability, RIP can plot the front-end datasets that previously only Graph could handle. Figure 1 presents a 500 mb height/wind plot generated by RIP 3.0 from an MM5V3 Regrid file.

Second, RIP can now read and process whatever 2- and 3-D fields are in the input or output for the given model run. Formerly, RIP's hardwired approach would disregard fields not expected to appear and be read, a problem when new MM5 releases featured new output fields. Now, V3.0 will ingest and preprocess any 2-D or 3-D field in the MM5 file and will parse a name for its intermediate RIP-format file. Such files are produced by the RIP preprocessor "ripdp" (discussed below) and are used in the plotting stage of RIP.

Third, the RIP system can now avoid preprocessing unwanted dataset times and variables. Previously, ripdp would process every field and time in the dataset, which increased both the run time of ripdp as well as the volume of intermediate files. By allowing the user to specify times and fields to be skipped, the new ripdp can conserve CPU time and disk space.

Other notable new features include: (i) the ability to handle an isothermal reference stratosphere, (ii) time/run differencing, (iii) sounding plot extensions, and (iv) profiling. Regarding (i), note that in MM5 Version 3 (MM5V3) users may specify a stratosphere with a constant reference temperature. RIP can now handle the output data from these runs, and do so without the user needing to supply extra input parameters. Item (ii) refers to RIP 3.0's ability to do difference plotting between separate model runs or different times in the same run. This is invaluable for experiment comparisons and analyses of run evolution. Item (iii) first refers to RIP 3.0's calculation and display of convective parameters on sounding plots. These include LCL, LFC, LI, CAPE, etc. RIP 3.0 can also print a hodograph on the sounding. Figure 2 presents an example of a sounding from an MM5V3 simulation plotted with convective parameter information and a hodograph. Lastly (iv), the capability to plot single-point profiles (pressure vertical coordinate) of any RIP diagnostic field (u, q_v, etc.) is now in RIP. Figure 3 shows an example of a vertical trace of water vapor (q_v).

3. RIP 3.0 OPERATION

3.1 *Environment*

RIP runs on UNIX and Linux systems. Within such environments, the basic platform requirements

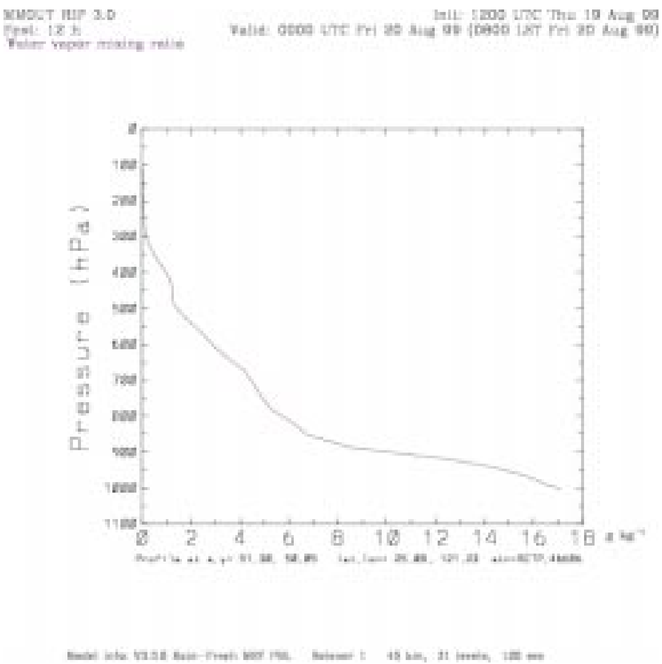

Figure 3. Profile plot of q_v at a single point from MM5V3 output, produced by RIP 3.0. Vertical coordinate= pressure; q_v units (abscissa)= g/kg.

for running RIP 3.0 are (i) a Fortran 77 or Fortran 90 compiler, (ii) a C compiler, (iii) adequate machine capacity (core memory and disk space), and (iv) NCAR Graphics (NCARG). First, the RIP system is written in Fortran, and so such compilers are necessary. The system programs ("ripdp" and "rip") may be compiled under either F77 or F90. Compilation of both ripdp and rip is now done in one step through a single makefile which includes NCARG linking directives. The makefile bundled with RIP 3.0 has compiler options for a number of architectures, as in the "configure.user" file from the MM5 system. Second, because a couple of special-purpose routines are written in C, a C compiler is also necessary.

Third, RIP can require substantial memory (more than Graph for the same MM5 dataset), with the specific demand reflecting the size of the MM5 file to be plotted. Adequate core is thus a necessity. In addition, the RIP system's preprocessor creates intermediate files which can be voluminous. A rule-of-thumb for the previous system had been that the amount of space available for the intermediate files should be on the order of the volume of the MM5 dataset itself. However, given that now the preprocessing can be limited to only those fields and times desired (rather than the whole MM5 output dataset), the disk demands can be greatly reduced.

Fourth, RIP requires the installation of NCAR Graphics (NCARG) on the operational platform. As in Graph, NCARG is fundamental to RIP plotting and image viewing. Information on the widely-used NCARG may be found at http://ngwww.ucar.edu. The output from RIP is in the Computer Graphics Metafile (CGM) format, a product of NCARG which is viewable with the NCARG utilities "idt", "ctrans", or "ictrans". Users may convert CGM files to other formats (*e.g.*, postscript) as their systems' utilities allow.

RIP can operate on a variety of platforms. It has been run on architectures including Compaq/DEC, Sun, SGI, Cray, and Fujitsu, as well as PCs operating Linux. Compatibility with additional platforms is expected as the use of RIP expands in the MM5 community.

3.2 *Procedures*

RIP 3.0 operation involves two stages: (1) preprocessing and (2) plotting. The first stage is the running of the preprocessor "ripdp", while the second is the running of program "rip" itself, which does the actual graphics generation.

First, ripdp reads the MM5 system data and generates files for each of the variables output at the stored times. These files are named according to a RIP field identifier reflecting the variable. Ripdp need only be run once to produce the intermediate files that the plotting program "rip" will use. Ripdp does no plotting, and, as mentioned above, it can now process only those subsets of the data that one will be analyzing.

The second, and main, stage of the RIP system entails the specification and generation of the MM5 plots themselves. This is done in batch mode with (i) a plotting parameter input file and (ii) the RIP executable. The desired plots are detailed to the user's specifications in the input file, and the RIP executable is invoked.

Following compilation of ripdp and rip, system commands for the two stages are similar, and only ripdp's differ from RIP 2.0. For the preprocessing stage, the syntax is:

ripdp — -n namelist file — casename — input datafile.

Here, "ripdp" is the executable, "namelist file" is the name of the file containing processing information for ripdp, "casename" is the root name of the intermediate files being created (used in the plotting stage of RIP), and "input datafile" is the name of the MM5 file to be plotted (e.g., MMOUT_DOMAIN1). Examples of the information in "namelist file" are the times for ripdp to process and any fields to skip in processing. If no namelist file is given, ripdp will default to processing all variables and times, as in RIP 2.0.

For the plotting stage, the syntax is:

rip — casename — input param file.

Here, "rip" is the executable, "model dataset name" is the prefix (root name) of the intermediate files, and "input param file" is the file specifying the plotting parameters (*e.g.*, "rip.in"). The input parameter file is the primary user interface. It is the means for selecting all plot attributes: field, contour interval, coloring, levels, vertical coordinate, etc. Details on plotting parameters and RIP's operation are available in the system documentation (see Section 4).

4. SUMMARY AND PLANS

The MM5 system now has a second supported option for model visualization: RIP Version 3.0. RIP 3.0 offers the MM5 user significantly-enhanced plotting capabilities compared both to Graph and to previously-circulated versions of RIP. These include more extensive user control over plot specifications and appearance, accomodation of the full range of MM5 datasets (Terrain through MM5), a newly-developed pressure-level dataset plotting capability, more fields and diagnostics, time- and run-differencing capabilities, and updated documentation. The RIP 3.0 system codes may be obtained at ftp://ftp.ucar.edu/mesouser/MM5V3, while the system and its operation are described in the userguide included in the code tar file at ftp://ftp.ucar.edu/mesouser/MM5V3 and linked under http://www.mmm.ucar.edu/mm5/doc.html.

The period following this release of RIP 3.0 will likely reveal bugs, and users are invited to communicate problems to the Mesouser. As the code itself is relatively flexible and easy to modify, the MM5 community is invited to work on additional desired features. Such improvements can be offered to the Mesouser and may be put into later releases as deemed appropriate.

The official incorporation of RIP into the MM5 system is aimed to advance MM5-based research and operations worldwide. The authors are grateful for the help offered by the Mesouser in supporting this powerful tool for the benefit of the MM5 community.

REFERENCES

Grell, G.A., J. Dudhia, and D.R. Stauffer, 1995: *A Description of the Fifth-Generation Penn State/NCAR Mesoscale Model (MM5)*, NCAR Tech. Note TN-398 + STR, 122 pp. [Available from UCAR Communications, P.O. Box 3000, Boulder, CO 80307.]