AN UPDATE ON POST-PROCESSING AND VISUALIZATION TOOLS FOR THE WRF MODEL

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1. Introduction

WRF Working Group 6 (Post-Processing) has been promoting and overseeing the active development and/or modification of tools to analyze and visualize output data from the WRF model. Since the initial development of a basic package of NCAR Command Language (NCL) scripts for WRF, several new tools have become available or are becoming available through the efforts of many individuals and facilities. This talk will describe a set of five visualization tools that are currently freely available to the WRF user community in the spirit of "open source", and have been made compatible with WRF output. Their various capabilities and limitations will be presented. In addition, we will also discuss remaining needs for improvement of the compatibility between these tools and the variety of data types produced by the WRF system.

2. Visualization tools

a. NCL

The NCAR Command Language (NCL) is a very powerful scripting language which has many advantages over the traditional NCAR Graphics codes that use Fortran or C. In particular, the file I/O language constructs make it very easy to read data from netCDF, HDF, GRIB, and binary format files. Plotting is done using either the low level NCL commands or a higher level interface called GSUN (short for Getting Started Using NCL). NCL can also interface with Fortran and C subroutines in a relatively straightforward manner.

Ethan Alpert (formerly NCAR/SCD), Bill Skamarock, Wei Wang, and Cindy Bruyere (NCAR/MMM) have developed a set of NCL scripts for reading WRF output and creating a variety of plots.

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b. GrADS

The Grid Analysis and Display System (GrADS) is an interactive observational and model output data visualization tool developed at IGES/COLA, originally under the support of NASA. It has an interactive interface that allows the user to generate or change plots instantaneously, as well as a scripting language that allows for batch jobs. It can ingest either binary, GRIB, NetCDF, or HDF-SDS (Scientific Data Sets) data formats.

No modification to the standard GrADS code itself is required in order to use it to visualize WRF model output. However, GrADS expects data in a particular format. Song-You Hong (Yonsei University, Korea) and Cindy Bruyere (NCAR/MMM) have developed a WRF-to-GrADS tool that converts WRF output into flat binary files ingestible by GrADS. The tool works with mass and height coordinate WRF model output in NetCDF format.

c. RIP

Read/Interpolate/Plot (RIP) is a Fortran program that utilizes the NCAR Graphics System Plot Package Simulator suite of plotting routines for creating 1- and 2-D plots from numerical model output. It was developed at NCAR and the University of Washington, and has been used widely within the MM5 community. RIP is capable of producing horizontal or vertical cross section plots of scalar fields (contours) or vector fields (barbs or arrows), vertical profiles and soundings, and trajectories. Its primary strengths are its portability, its complete and up-to-date documentation, and its extensive set of derived diagnostic quantities that are available for calculation and plotting.

The RIP visualization program was originally coded to handle only the MM5 model's sigma vertical coordinate grid. In addition, RIP expects data in a particular format, created with a conversion program called RIPDP. Mark Stoelinga

(U. Wash.) and Wei Wang (NCAR/MMM) have generalized the RIP code to handle data in any vertical coordinate, and have created a version of RIPDP for ingesting and converting WRF model output, making the RIP package fully compatible with WRF output.

d. Vis5D

Vis5D is a popular tool among the meteorological research community for visualizing model output in three and four dimensions, including contours, vectors, isosurfaces, and trajectories. It was created at the University of Wisconsin-Madison's Space Science and Engineering Center (SSEC).

No modification to the standard Vis5D code itself is required in order to use it to visualize WRF model output. However, Vis5D expects data in a particular format. Bill Skamarock and Wei Wang (both NCAR/MMM) have created a WRF-to-Vis5D converter. In addition, RIP (discussed above) has an option to create a Vis5D data set that includes any of the many diagnostic quantities available in RIP.

e. IVE

The Interactive Visualization Environment (IVE) is a software package developed at the University of Washington, for the interactive display and analysis of gridded data. It creates 1- and 2-D plots of scalar profiles, contours, and vectors. It's primary strength is its fully interactive capability by means of a graphical user interface. It require data in NetCDF format.

Because of its versatility in handling a variety of vertical coordinates and grid staggering schemes, IVE is capable of ingesting and displaying WRF model output directly with minor modifications to its NetCDF I/O routines. Dale Durran, Neal Johnson, and David Warren (Univ. of Wash.) are completing this work and testing the new "WRF-compatible" IVE.

3. Future work

All of the above tools have generally been made compatible with NetCDF-format output from "real-weather" applications of the mass-core WRF model. However, there is a potentially much wider variety of data that can be produced by the WRF system as a whole, and most of the tools described above have not been made versatile enough to handle these other types of data, which include:

- Output from both the mass-core and NMM-core (Nonhydrostatic Mesoscale Model)
- Output from the model itself and from front-end applications such as the Standard Initialization (SI)
- Output in formats other than NetCDF (such as HDF)
- Output not only from "real-weather" applications, but also from idealized or 2-D applications of the WRF model

Finally, the five tools described above by no means represent a comprehensive list. There are many other visualization software packages available that may suit some WRF users' needs better than those described above. Working Group 6 encourages users to explore such tools and develop converter applications or code modifications for WRF compatibility that can be shared with the wider WRF user community.