MDTERP—A Narrowband Longwave Radiation Model with a Graphical User Interface

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Abstract

Maryland Terrestrial Radiation Package (MDTERP) is a combination of a graphical user interface (GUI) and an existing narrowband longwave radiation model. Using the GUI, the user can input two soundings and then automatically display the results for each sounding or the differences between the results. This is considerably simpler than other models, where the user has to generate an input file and then glean results from an output file. The ease of use and ability to automatically compare results makes MDTERP suitable for classroom use when longwave calculations are required. There are two versions of MDTERP, one for Macintosh® platforms and one for IDL® platforms with Fortran 90. Both are downloadable from the Web.

Introduction

In the past ten years, both the hardware and software components of computer technology have improved dramatically. The computational power of computers has increased by orders of magnitude. Workstations now perform calculations that required supercomputers only a decade ago. At the same time, computers have become easier to use because of the development of GUIs. The operating systems for computers now incorporate a Windows®- or Mac OS®-type GUI.

The field of atmospheric radiation has taken advantage of the increase in computational power. For example, detailed line-by-line models such as the Line-by-Line Radiative Transfer Model (LBLRTM) (Clough et al. 1992) are routinely run on workstations. Aside from being faster, radiation models are not significantly easier to use. Their interfaces have not changed very much; very few have incorporated GUIs to make themselves easier to use (SBDART is one exception, http://arm.mrcsb.com/sbdart/). It can be difficult to learn to make a proper input file and then pick out the desired results from the output file. To be easier to use, radiation models should use GUIs for both input and output. It should be just as easy to see a graph of the results, as it is to specify the atmospheric state. Radiation models can become radiation packages—a GUI for input and output wrapped around a radiation computational model.

MDTERP is a longwave radiation package. It is based on a narrowband model; the computations are quite fast, typically less than 10 seconds for a clear-sky calculation with 33 levels. MDTERP can run comparisons between atmospheres; the users can select plots of the differences between the results for the atmospheres as well as the individual results for each atmosphere. This comparison feature makes it easy to answer "What if…" questions such as: "What if CO_2 doubles?" or "What if water vapor increases above 10 km?" Because it is flexible and easy to use, MDTERP can be used in atmospheric radiation classes when longwave computations are required.

MDTERP Specifications

The radiation transfer model for MDTERP is based on Ellingson and Gille (1978). It calculates the spectral radiance at various angles and uses them to compute the upward, downward, and net fluxes and the heating rates. The model assumes a plane parallel atmosphere, local thermodynamic equilibrium, and a black surface. Gaseous absorption by H_2O, CO_2, O_3, CH_4, and N_2O is based on the 1992 high-resolution transmission (HITRAN) data base and fit to LBLRTM calculations as described in Warner and Ellingson (1999). The model uses 305 spectral intervals from 0 cm^{-1} to 3000 cm^{-1}.

Using the GUI, the user specifies the pressure, temperature, H_2O, and O_3 profiles from the surface to the top of the atmosphere. The user also selects the amount of the well-mixed gases: CO_2, CH_4, and N_2O. These quantities can be taken from the Air Force Geophysics Laboratory (AFGL) standard atmospheres: mid-latitude summer (MLS), mid-latitude winter (MLW), sub-arctic summer (SAS), sub-arctic winter (SAW), and tropical (TRP); they can also be read in from files. Users can also specify up to six black cloud layers.

Versions of MDTERP have been written for both Macintosh® Power PCs and platforms with Interactive Display Language® (IDL) and a Fortran 90 compiler. The Macintosh® platforms should have 12MB RAM and 2MB free disk space; tests have been performed on Power Mac 8100/80&100, several different G3 powered models. It is available at *http://metosrv2.umd.edu/~bobe/mdterp.* The IDL®/Fortran 90 platforms should have 10MB RAM and 8MB free disk space; tests have been performed on DEC Alpha 250 4/266, 64MB RAM, IDL® 5.0, Digital 4.0 UNIX. It is available at *http://metosrv2.umd.edu/~ezra/MDTERP.dir.*

Overview of the Macintosh® Version

Figure 1 shows the first input window after starting the Macintosh® version. The user has a choice of calculation types: default, special, sensitivity, and perturbations. The default calculation is a single calculation for one of the standard atmospheres, MLS, MLW, SAS, SAW, and TRP. The special calculation allows the user to mix and match the standard profiles or supply a profile from a file. The sensitivity calculation compares two different profiles, and the perturbation calculation shows the effect of perturbing values for a single profile.

Figure 2 shows the three input windows for a default calculation. The user chooses the MLS, MLW, SAS, SAW, or TRP sounding. Then the user chooses the levels at which to perform the calculation, and the cloud levels.

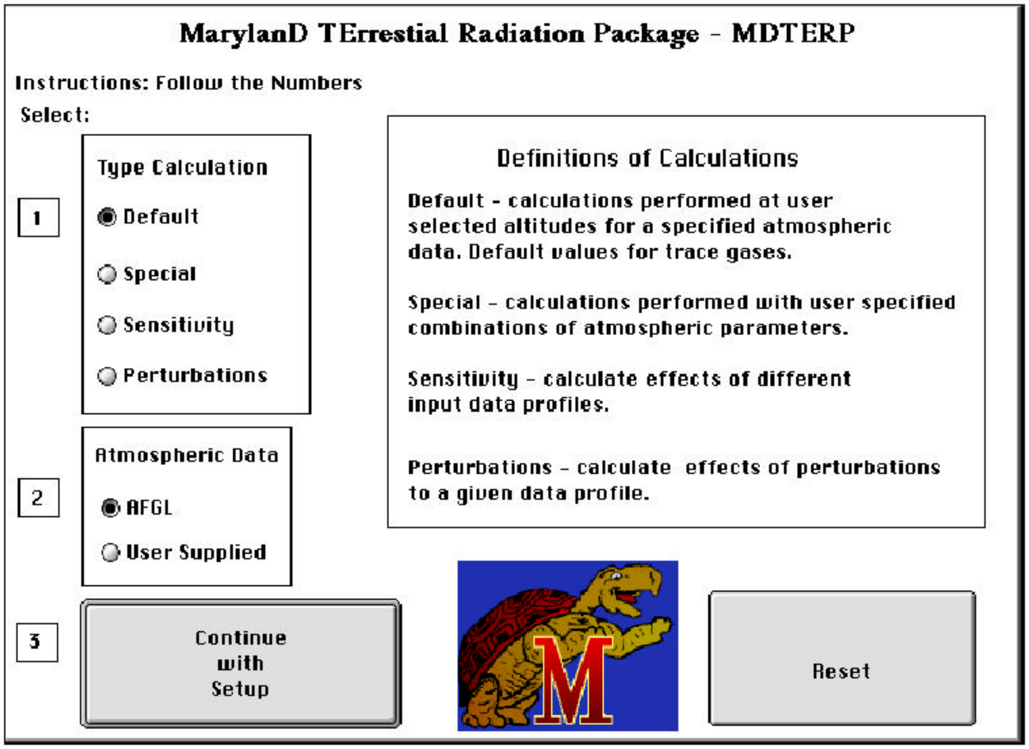

Figure 1. First input window for Macintosh® version of MDTERP.

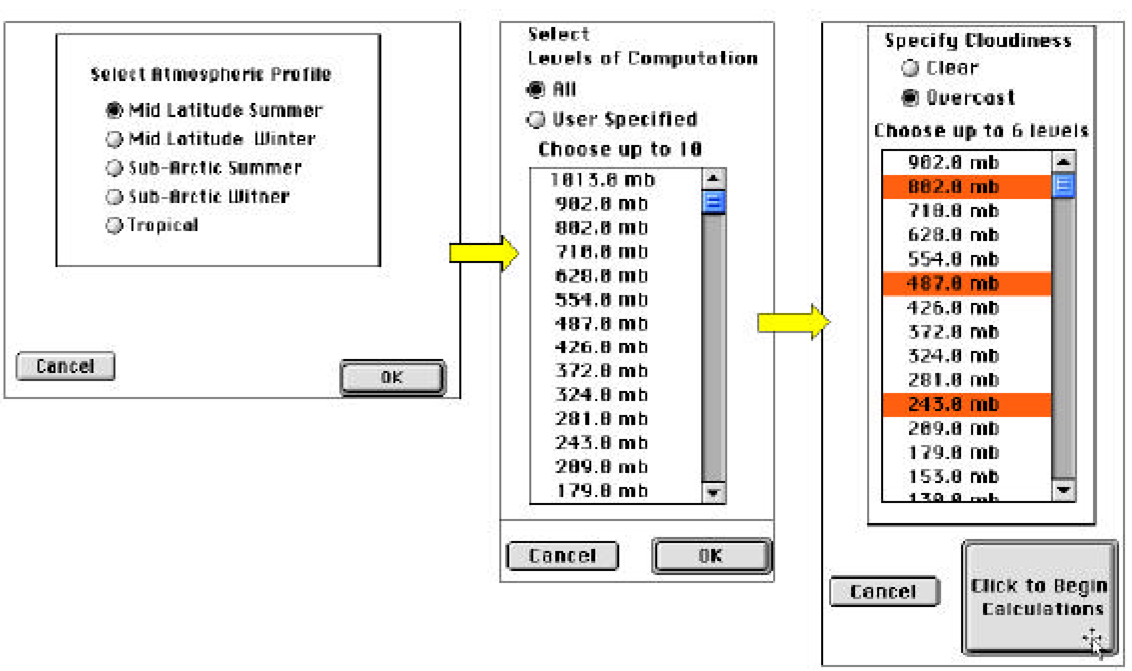

Figure 2. Successive input windows allow a user to select the source of data, levels of computation, and to specify the presence and location of clouds.

Figure 3 shows the input window for a special calculation. Using the radio buttons, the user can mix and match temperature, H_2O, and O_3 profiles from the standard soundings or choose a constant value for all levels. The user can also specify the concentrations of CO_2, CH_4, and N_2O. When the user chooses a sensitivity calculation, two different soundings are compared; so the user will use this window twice. Results for both soundings are calculated and can be easily compared.

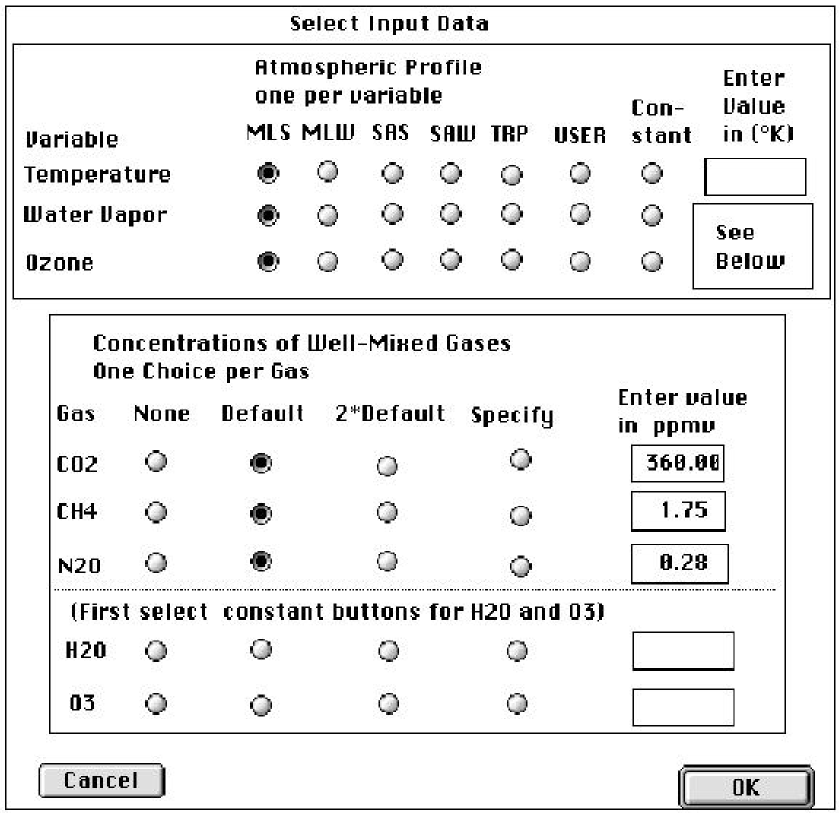

Figure 3. The special calculation allows the user to select different profiles of temperature and gas concentration. It is possible to specify isothermal conditions and/or fixed concentrations of individual gases (including none).

Figure 4 shows the input window for a perturbation calculation. As the name implies, the perturbation calculation involves perturbations to a reference sounding. After specifying the reference sounding with an input window as in Figure 3, the user can choose systematic or percentage changes to the temperature and gas concentrations. As in the sensitivity calculation, results for both the reference and perturbed soundings are computed.

After the soundings are input, the results are calculated. Because the output GUI manipulates the detailed output of the computational model to generate the text output and plots, the user can review the results over any spectral interval. The user can also switch the clouds on and off, see the results for clear

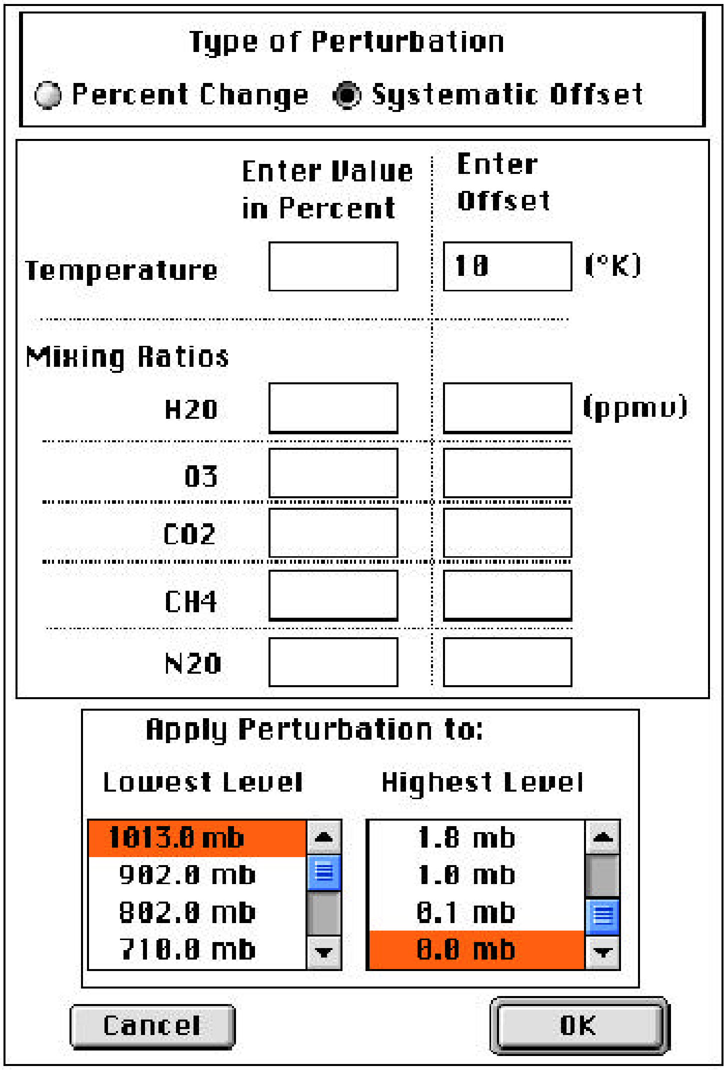

Figure 4. For a perturbation calculation, the user perturbs the temperature and/or the gas concentrations used in a given profile. Either percentage or systematic offsets are permitted.

skies, a single specified cloud, or all clouds. For the sensitivity or perturbation calculations, the user can also see the differences between the results of the two soundings. Figure 5 shows the sequence to generate a text output window for fluxes and heating rates. Note selection options for showing differences, setting the spectral interval, and switching clouds. Similar text windows can be generated for spectral radiances. Figure 6 shows the sequence to generate the spectral radiance plot. Again, the user can plot the differences between soundings, specify the spectral interval, and switch clouds. The other available plots are angular distributions of radiances, the Clough plot (the spectral-altitude distribution of cooling rate), and flux and cooling rate plots.

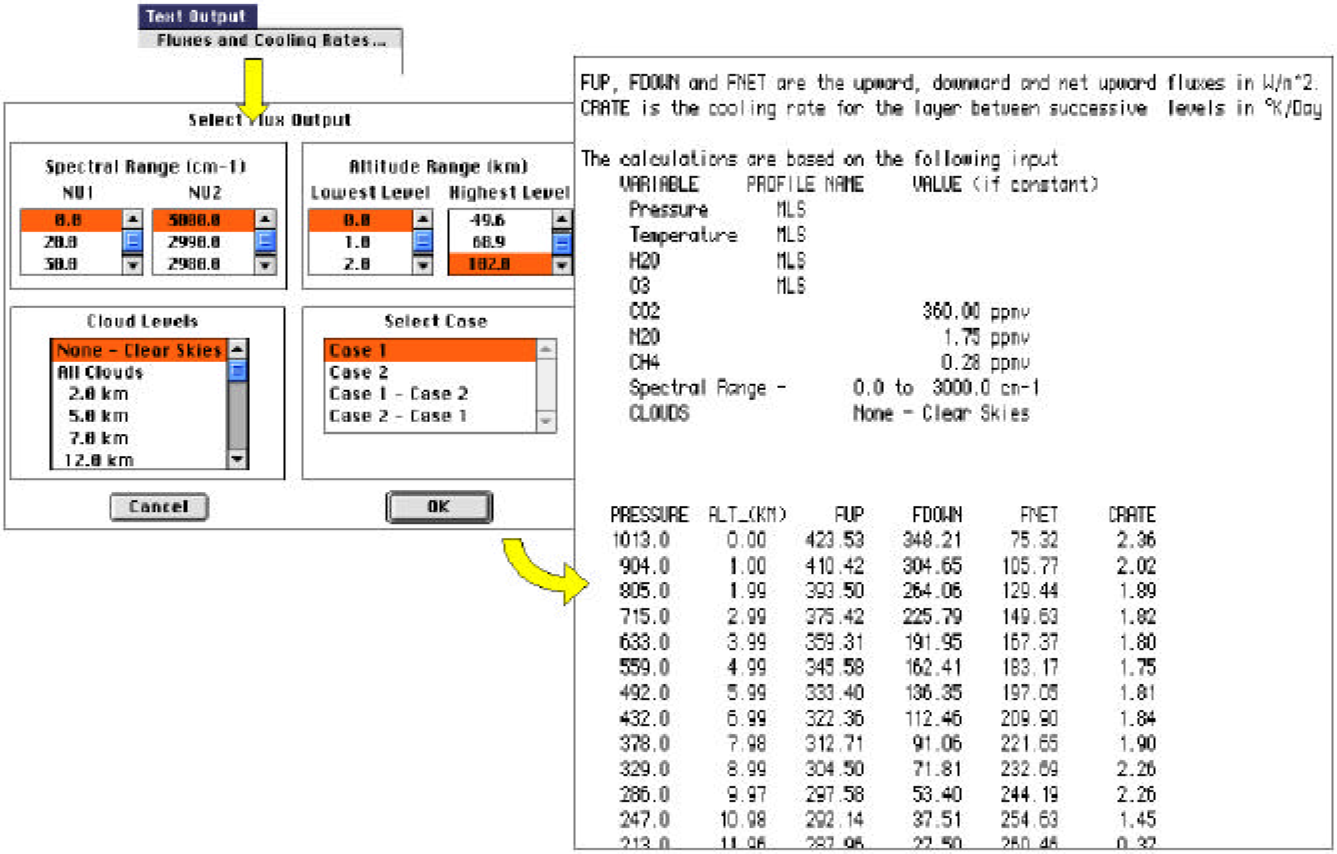

Figure 5. The sequence of windows to generate the text output window for fluxes and heating rates.

Conclusions

While atmospheric radiation models have benefited from the improvements in computing power, they have not taken advantage of the development of GUIs to make themselves easier to use. By combining a GUI with an existing longwave radiation model, MDTERP addresses this problem. The GUI makes it easy for the user to learn how to use the model; the user can easily input the necessary atmospheric data and see the results of the model. Since the GUI manipulates the detailed computational output, the user can review the results at the basic spectral and vertical resolution of the model. Also, when the user analyzes multiple soundings, the GUI supports plots and text output showing the differences between the results for the soundings. Since it is both easy to use and reasonably powerful, the education community can use MDTERP when longwave radiation calculations are necessary.

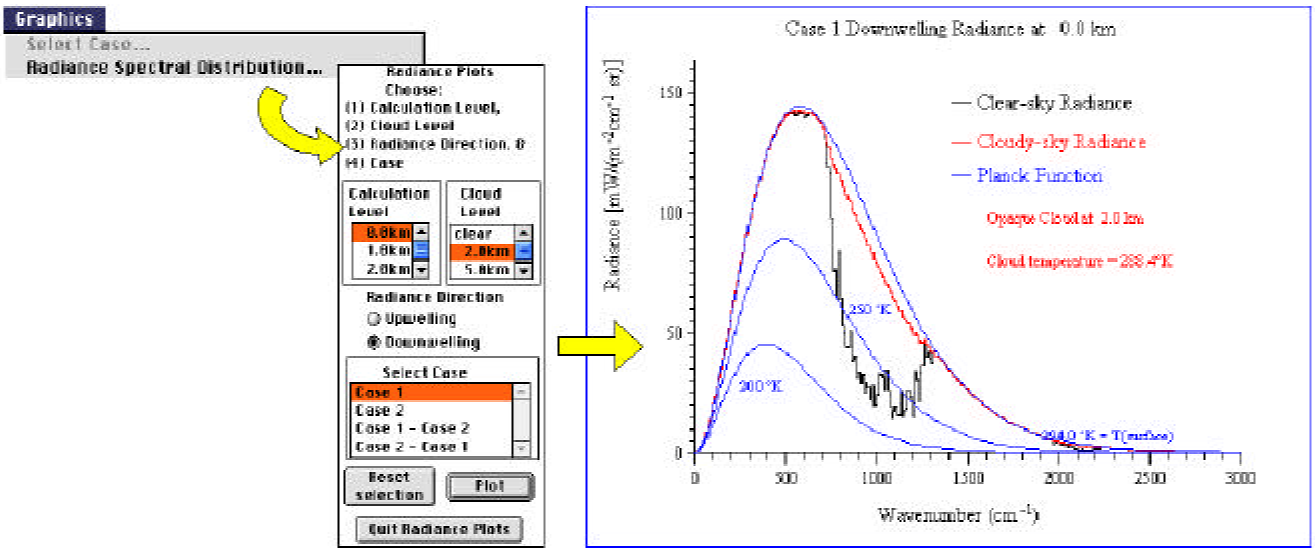

Figure 6. The sequence of windows to generate the spectral radiance plot.

Acknowledgments

This paper was sponsored in part by the U.S. Department of Energy's Atmospheric Radiation Measurements (ARM) Program under grant DEFG0294ER61746.

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