

**Use MicroWave Radiative Transfer (MWRT) model  
for  
MET5471 SATELLITE REMOTE SENSING  
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ftp model code from [cirrus.met.fsu.edu](http://cirrus.met.fsu.edu)

**INSTALL:**

1. After ftp mwrt.tar.gz to your home directory, type:

- gunzip -d mwrt.tar.gz
- tar -xvf mwrt.tar
- cd mwrt
- make all ← \*

\* if your system uses f77 and cc as fortran and c compilers, change FC=f77 and CC=cc in the makefile under mwrt-directory.

2. add “~/mwrt/bin” to your path parameter in your ~/.cshrc file. Then type

- source ~/.cshrc

Now, installation is complete and you may run this program at any directory.

**HOW TO RUN:**

Make a directory with your favorite name, say, met5471 (mkdir met5471), cd to this directory and type: mwrt for 4-stream model, or mwrt32 for 32-stream model.

The program uses “vi” as text editor. Whenever you made changes to a text file, use wq to save and close it. (Should you like to use another editor available on your system, change the ED parameter in makefile.)

- 1) set atmospheric profiles
- 2) set surface type and temperature, etc
- 3) set non-precipitating cloud water parameters
- 4) set precipitation parameters
- 5) set frequency, output file and viewing geometry
- 6) make changes
- 7) Choose the output option and run

0. First, you will be asked whether to use old settings or start a new one. Answer “n” for a new one. If you answer “o” for old setting, the program will use the parameters you used during last run as baseline, and ask you whether you want to make any changes.

1. set atmospheric profiles

- You have the choice from several “standard” atmospheric profiles. Choose the one that is the most relevant to your project. If you want to use a profile created by yourself (such as an actual sounding), please refer the format of data files of ~/mwrt/dat/A# and consult with the instructor.

- there are three choices for vertical resolution, 0.5, 1, or 2 km

- you may change temperature and/or water vapor at certain layers at this point, choose the appropriate options at the prompt of the program.

## 2. set surface parameters

This is done by editing a file using “vi”. You may change the values in this file, but do NOT add/delete any lines.

*Surface Type*: only the first letter is significant. O=ocean, L=land, I=seaice, S=snow-covered surface

*Surface Temperature*: in K.

The next field means different things for different surface types:

Ocean: salinity in per thousand (nominal value 35)

Land: Emissivity (nominal value 0.9)

Sea-Ice: ice-type: 0=new ice, 1=2<sup>nd</sup> year ice, 2=multi-year ice

Snow-covered surface: 0=wet snow, 1=dry snow, 2=refrozen snow

*Wind speed*: in w/s, only used for ocean surface.

Use “:wq” to save the file and go to the next setting.

## 3. set cloud water parameters

This file is used to set the non-precipitating part of the hydrometeors, i.e., Cloud liquid water and cloud ice water. You may assign a cloud water content for any atmospheric layers. The layer’s depth is determined by your atmospheric profile data. Although the layer depths when using “standard” profiles are the same, this does not have to be the case if you use a “self-supplied” atmospheric profile.

*The third and fourth columns* are respectively the liquid and ice water content in g/m<sup>3</sup>. A negative value means that this layer will NEVER have cloud liquid/ice water as precipitation rate increases. A “0” means that there is no cloud liquid/ice water INITIALLY, but may have later when precipitation increases, dependently upon the settings of “Increase rate” given later.

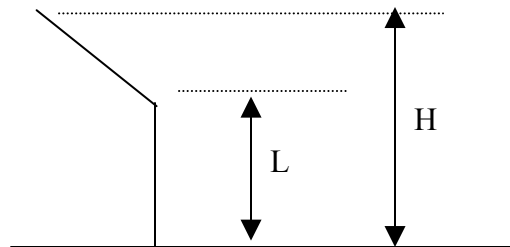
*Increase Rates* for cloud liquid and ice water: You may let cloud liquid or ice increases when precipitation increases (how precipitation increases will be determined in the setting for precipitation in the next step). The “rates” here determine how fast the cloud liquid/ice will increase. This increase will ONLY occur for those layers with an initial values  $\geq 0$ . So, if you want a layer not to have cloud water ever, put a NEGATIVE value (-9.99 for example) there.

For cloud ice, you may choose “ice type” (shape) and “mass median diameter” (determining the size distribution).

## 4. set precipitation parameters

You may calculate up to 25 precipitation rates by one model run. This file determines how the precipitation profiles change when the surface precipitation changes.

The precipitation profile have the following pattern:



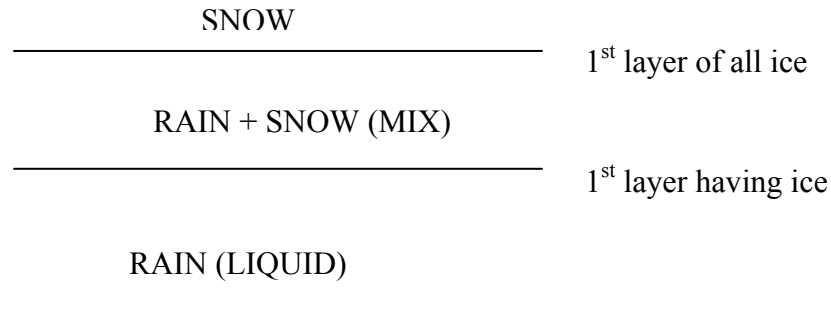
$$L=L_0+\text{Precip}/\text{LRAT}, \text{ but } L\leq L_T$$

$$H=H_0+\text{Precip}/\text{HRAT}, \text{ but } H\leq H_T$$

L0 and H0 is the values when Precip=0, where Precip is surface precipitation rate.

The precipitation profiles will be determined according to the values L0, LRAT, LT, H0, HRAT and HT provided in this file.

For the layers that air temperatures are colder than 0°C, you may set the hydrometeors are mixed phase or all ice phase. Two parameters here are used to set the first layer having ice and the first layer above which hydrometeors become all ice. Between these two layers, the ratio of ice/(liquid+ice) increases from 0 to 1.



\*\* The layer number here is counted from bottom, i.e., the lowest layer is layer no. 1.

Next is to set snow (precipitating ice) density in unit of g/cm<sup>3</sup>. For snowflakes, the typical value is 0.1, for graupels 0.5, for hail stones 0.8.

5. Set frequency, output files name, and viewing angle

Frequencies, up to 15 frequencies in GHz

Output file name: any thing you want

Viewing angle. Cosine of the satellite viewing zenith angle. For SSM/I and TMI, the angle is 53 degree and the cosine of it is ~0.6

6. Make changes. If you decide to make some changes to the settings you just did, here is the chance.

7. Choose the output option and run.

If you want the brightness temperatures received by a satellite, choose 1 TOA TB,

If you want the brightness temperatures received by a ground-based radiometer, choose 0 BOA TB,

If you want to simulate observations of an airborne radiometer, choose a layer number where the aircraft flies. NOTE: this time the layer number is counted from top, i.e., the highest layer is layer no.1.

## OUTPUT FILE FORMAT

1st rec: 1 0.60042 <- Tbs are at layer 1 (Top of Atmosphere) at angle 53.1 deg

2nd rec: 6 25 16 15 <- 6 frequencies, 25 rain rates, 32 stream(16\*2), 15 Mass Median Diameters (actually this is 1 in the test file)

After that, repeat the followings:

Frequency (e.g., 151 Ghz)

Mass median diameter (e.g., 100um)

Rainrate, total liquid water (rain+cloud), total ice water (cloud ice + snow)  
Vertical polarization Tb, Horizontal pol Tb  
rainrate, liquid, ice  
TBV, TBH  
... total repeat 25 times ...  
mass median diameter  
Rain, Liquid, Ice (repeat 25 times)  
....

The mass median diameter will repeat 15 times (only once for the test file)  
and frequencies repeat 6 times

You may design how many times the rain, diameter and frequency should repeat. The current maximum repeat times for rain=25, diameter=20, frequency=15.

If you remember when running the test case, you have to "vi" several files.  
All the settings occur when you "vi" those files (mostly you just used :q to close them in the test case).  
Also, in the test case, there are no "cloud ice" and "cloud water". The total liquid and total ice are from rain and snow. There are ways to only have 'cloud ice' and/or cloud liquid, or all of them by "vi" those files.  
The way to see cloud ice only is to set all rainrates 0 (but let it repeat many times) and for each rainrate let cloud ice increases a certain amount.

Regarding height:

You may provide your own atmospheric profile file, in which you specify how high the atmosphere goes. the format of that file should be:

surf\_temp(K) salinity\_or\_emissivity surf\_type wind\_speed <-- 1st record

NOTE: salinity in per 1000 only for ocean surface, emissivity only for land (typically 0.9), surface type: 0=land, 1=ocean, 2=sea ice, 3=snow cover. wind\_speed at surface in m/s only used for ocean.

total\_number\_of\_level <--- 2nd record

NOTE: This is the number of layers plus 1.

altitude(m) pressure(mb) temperature(K) relative\_humidity(%) <-- 3rd rec

... <-- repeat above

NOTE: Examples of the atmospheric profile can be found in ~mwrt/dat directory.

The depths of layers DO NOT have to be the same (although it is the same for the examples).

Maximum number of layers is 75 although we usually use only 15. You may make the layer depth small where the clouds locate while make the depth large where "nothing is going on".

## REFERENCE

Liu, G., 1998: A fast and accurate model for microwave radiance calculations. *J. Meteor. Soc. Japan*, **76**, 335-343.