MEGAN FORTRAN code v2.04 User Guide

October 29, 2007

Christine Wiedinmyer, Tanarit Sakulyanontvittaya, and Alex Guenther

The latest version of this guide and any updates to the MEGAN code and input files are described at http://acd.ucar.edu/~guenther/MEGAN/MEGAN.htm

This code is a FORTRAN version of the Model of Emissions of Gases and Aerosols from Nature, version 2 (MEGAN 2.0) which is described by Guenther et al. (2006). The model calculates hourly emissions of 20 compounds/compound classes, representing 138 compounds, which can be grouped into various chemical mechanisms. MEGAN was originally written as an ACCESS-VBA code by Alex Guenther. Jack Chen (Washington State University) developed the initial FORTRAN framework and I/O formats for an earlier version of MEGAN. The current version (2.04) was written in FORTRAN by Tanarit Sakulyanontvittaya (University of Colorado).

The MEGAN code and input files are available at no cost. File descriptions and procedures for accessing these files are provided in the MEGAN Data Portal User Guide (see http://acd.ucar.edu/~guenther/MEGAN/MEGAN.htm)

MEGAN version 2.04 requires two types of input files:

1. **Landcover Data:** Monthly average Leaf Area Index (LAI), Plant Functional Type (PFT), and emission factors (EF) must be averaged for each grid location in your model domain and compiled in comma-delimited ASCII format table. At a minimum, the LAI values must include the months of your model simulation and the preceding month. The monthly LAI is used to estimate the response of emissions to variations in leaf age (using equations 16-19 in Guenther et al. 2006) and LAI (using equation 15).
2. **Weather Data:** Temperature and solar radiation variables output from MCIP (see www.cmascenter.org) are used to estimate the response of emissions to variations in temperature (equation 14 in Guenther et al. 2006) and light (equations 11-13 in Guenther et al. 2006). MCIP processes either WRF or MM5 output for input to the CMAQ chemical transport model.

Note that the NetCDF (http://www.unidata.ucar.edu/software/netcdf/) and the I/O API (http://www.cmascenter.org) libraries must be installed to run this code.

PREPROCESSING the Lancover data

Before this MEGANv2.04 code can be run, two landcover input files (comma-delimited ASCII format) must be created. The User Guides available at http://acd.ucar.edu/~guenther/MEGAN/MEGAN.htm describe how to access the global landcover data (Input Data User Guide) and regrid the files for a specific domain (Input Data Preprocessor User Guide).
The two input files include

(1) EFMAP_LAI.csv: This file contains information about the model domain, emission factors, and monthly LAI;
(2) PFTF.csv: This file contains information about the percent Plant Functional Type (PFT) cover for each model grid cell.

The first file (EFMAP_LAI.csv) contains cell information, emission factors, and monthly Leaf Area Index (LAI) values for each grid in the model domain. The fields for EFMAP_LAI.csv are:

CELL_ID (a unique identifier for each model grid cell)
I (the index for the columns)
J (the index for the row)
LAT (the latitude (DD) of the center of the grid cell)
LONG (the longitude (DD) of the center of the grid cell)
TZONE (Time zone (hours from GMT) of the grid cell) **(NOTE: Not currently used)**
D_SRAD (daily averaged solar radiation (W/m2) if available)
D_TEMP (Daily averaged air temperature (K) if available)
ISOP (Standard emission factor for ISOPRENE, $\mu g\ m^{-2}\ hr^{-1}$)
MBO (Standard emission factor for MBO, $\mu g\ m^{-2}\ hr^{-1}$)
MYRC (Standard emission factor for MYRCENE, $\mu g\ m^{-2}\ hr^{-1}$)
SABI (Standard emission factor for SABINENE, $\mu g\ m^{-2}\ hr^{-1}$)
LIMO (Standard emission factor for LIMONENE, $\mu g\ m^{-2}\ hr^{-1}$)
3CAR (Standard emission factor for 3-CARENE, $\mu g\ m^{-2}\ hr^{-1}$)
OCIM (Standard emission factor for OCIMENE, $\mu g\ m^{-2}\ hr^{-1}$)
BPIN (Standard emission factor for b-PINENE, $\mu g\ m^{-2}\ hr^{-1}$)
APIN (Standard emission factor for a-PINENE, $\mu g\ m^{-2}\ hr^{-1}$)
FARN (Standard emission factor for FARNESENE, $\mu g\ m^{-2}\ hr^{-1}$)
BCAR (Standard emission factor for b-CARYOPHELLENE, $\mu g\ m^{-2}\ hr^{-1}$)
MEOH (Standard emission factor for METHANOL, $\mu g\ m^{-2}\ hr^{-1}$)
ACTO (Standard emission factor for ACETONE, $\mu g\ m^{-2}\ hr^{-1}$)
ACTA (Standard emission factor for ACETALDEHYDE, $\mu g\ m^{-2}\ hr^{-1}$)
FORM (Standard emission factor for FORMALDEHYDE, $\mu g\ m^{-2}\ hr^{-1}$)
CH4 (Standard emission factor for METHANE, $\mu g\ m^{-2}\ hr^{-1}$)
NO (Standard emission factor for NITROGEN OXIDE, $\mu g\ m^{-2}\ hr^{-1}$)
OMTP (Standard emission factor for Other MONOTERPENES, $\mu g\ m^{-2}\ hr^{-1}$)
OSQT (Standard emission factor for Other SESQUITERPENES, $\mu g\ m^{-2}\ hr^{-1}$)
CO (Standard emission factor for CARBON MONOXIDE, $\mu g\ m^{-2}\ hr^{-1}$)
LAI1 (Leaf Area Index for JANUARY)
LAI2 (Leaf Area Index for FEBRUARY)
LAI3 (Leaf Area Index for MARCH)
LAI4 (Leaf Area Index for APRIL)
LAI5 (Leaf Area Index for MAY)
LAI6 (Leaf Area Index for JUNE)
LAI7 (Leaf Area Index for JULY)

LAI8 (Leaf Area Index for AUGUST)
LAI9 (Leaf Area Index for SEPTEMBER)
LAI10 (Leaf Area Index for OCTOBER)
LAI11 (Leaf Area Index for NOVEMBER)
LAI12 (Leaf Area Index for DECEMBER)

As of October 2007, emission factor maps for isoprene, methylbutenol, methanol, nitrogen oxide, 3-carene, limonene, myrcene, ocimene, α-pinene, β-pinene, and sabinene are available. These values can be included in EFMAP_LAI.csv. All other emission factor fields of EFMAP_LAI.csv should be set to **1.0.**

Note on Emission Factors:
You have the option to:
(1) input the EFs in the EFMAP_LAI.csv (if maps of the compound EFs are available). If this is the case, the user must set the EFs for those compounds in the EF_MGN20.EXT file to 1.0.
(2) use the PFT-specific emission factors (in the Table EF_MGN20.EXT). If this is the case, the EFs for those compounds/classes must be set to 1.0 in EFMAP_LAI.csv.

The second input file (PFTF.csv) contains grid information and the percentage of PFT types assigned to each grid cell. The fields in PFTF.csv are:

CELL_ID (a unique identifier for each model grid cell)
I (the index for the columns)
J (the index for the row)
LAT (the latitude (DD) of the center of the grid cell)
LONG (the longitude (DD) of the center of the grid cell)
PFTF_BT (Percentage of BROADLEAF TREES)
PFTF_NT (Percentage of NEEDLE LEAF TREES)
PFTF_SB (Percentage of SHRUBLANDS)
PFTF_HB (Percentage of HERBACEOUS cover)

MODEL DESCRIPTION

MEGANv2.04 consists of 3 modules.
These are:

1) MG2IOAPI
This module will convert text format to IOAPI-netCDF format. This reads in the preprocessed EFMAP_LAI.csv and PFTF.csv, and converts them to I/O API format.

2) MEGAN

This is the primary MEGAN module. The gamma values are calculated within this module.

3) MG2MECH
This model calculates the final emission rates and speciates and/or convert MEGAN emission output to chemical mechanism species. The current available mechanisms include CBMZ, SAPRC99, RADM2, and RACM. These conversions were developed by Tanarit Sakulyanontvittaya (University of Colorado) with assistance from Jana Milford (U. Colorado), Christine Wiedinmyer and John Orlando (National Center for Atmospheric Research), William Stockwell (Howard University), Greg Yarwood (ENVIRON), and Rahul Zaveri (Pacific Northwest National Laboratory).

TO RUN MEGAN

To install MEGAN and its other programs,

1) Unzip and untar "megan_install.tar.gz"

By doing this, it will create this directory structure

```
MEGANv2.0
 |
 - bin
 |
 - doc
 |
 - Input
 |   |
 |    - MAP
 |   |
 |    - MCIP
 |
 - lib
 |   |
 |    - ioapi_3
 |   |   |
 |   |    - fixed_src
 |   |   |
 |   |    - Linux2_x86pg
 |   |
 |    - netCDF
 |        |
 |         - include
 |        |
 |         - lib
 |
 - Output
 |   |
 |    - ITMDT
 |
```

```
 - src
|    |
|     - EMPROC
|    |    |
|    |     - INCDIR
|    |
|     - MECHCONV
|    |    |
|    |     - INCDIR
|    |
|     - TXT2IOAPI
|         |
|          - INCDIR
|
 _ work
```

2) Set up paths and directories for MEGAN. Edit the environmental variables defined in the file called “setcase”

```
  Edit MEGANv2.0/setcase
    setenv MGNHOME  /MEGANv2.0
    setenv MGNSRC  $MGNHOME/src
    setenv MGNLIB  $MGNHOME/LIB
    setenv MGNEXE  $MGNHOME/bin
    setenv MGNRUN  $MGNHOME/work
    setenv MGNINP  $MGNHOME/Input
    setenv MGNOUT  $MGNHOME/Output
```

MGNHOME is where the MEGAN model will be installed

```
  Invoke setcase by
  > source $MGNHOME/setcase
```

3) Install ioapi and netCDF

Please check ioapi and netCDF websites (See above) for download and installation. After ioapi and netCDF are installed. The libraries and include files can be simply linked to MEGAN by "ln -s" command.

```
ln -s /home/EDSS/ioapi_3.0/ioapi/fixed_src/* $MGNLIB/ioapi_3/fixed_src

ln -s /home/EDSS/ioapi_3.0/Linux2_x86pg/libioapi.a
$MGNLIB/ioapi_3/Linux2_x86pg

ln -s /home/EDSS/netcdf-3.5.1/include/* $MGNLIB/netCDF/include

ln -s /home/EDSS/netcdf-3.5.1/lib/libnetcdf.a $MGNLIB/netCDF/lib
```

4) Set up paths and directories for makefiles

There are 3 makefiles have to be edited for your particular case:

Makefile.mg2ioapi located in $MGNSRC/TXT2IOAPI/
Makefile.megan located in $MGNSRC/EMPROC/
Makefile.mg2mech located in $MGNSRC/MECHCONV/

Library files and include file directories has to be point to the files and include file directories as installed in step (3).

5) Check to ensure that the paths of libraries are correct.

Just invoke make_all_programs.scr by
> $MGNSRC/make_all_programs.scr

6) Run Model

To run the model, all the running scripts are located in $MGNRUN
The running scripts should be self described. The input, mcip, output, and log files and parameters have to be specified by the user prior to running the model.

To run mg2ioapi, invoke mg2ioapi
> run.mg2ioapi.csh

To run megan, invoke megan
> run.megan.csh

To run mg2mech, invoke mg2mech
> run.mg2mech.csh

OTHER MODEL NOTES:

The various parameters of the model can be edited, by changing various *.EXT files.
Here is a list of the various *.EXT files used by the program. The user can edit these tables to change emission factors and other model parameters.

- Emission factors
  $MGNHOME/src/MECHCONV/INCDIR/EF_MGN20.EXT

- Emission Fractions
  $MGNHOME/src/MECHCONV/INCDIR/EFFS_MGN20T138.EXT

- Temperature dependent parameters
  $MGNHOME/src/EMPROC/INCLDIR/TEMPD_PRM.EXT

- Light dependent factors
  $MGNHOME/src/EMPROC/INCLDIR/LD_FCT.EXT

- RADM2 and RACM mechanism conversions
  $MGNHOME/src/MECHCONV/INCDIR/MAP_CV2RADM2.EXT
  $MGNHOME/src/MECHCONV/INCDIR/SPC_RADM2.EXT
  $MGNHOME/src/MECHCONV/INCDIR/MAP_CV2RACM.EX
  $MGNHOME/src/MECHCONV/INCDIR/SPC_RACM.EXT

References

Guenther, A., T. Karl, P. Harley, C. Wiedinmyer, P. Palmer, and C. Geron, Estimates of global terrestrial isoprene emissions using MEGAN (Model of Emissions of Gases and Aerosols from Nature), Atmos. Chem Phys., 6, 3181-3210, 2006.