

# Grid FINN

## FINNv2.5 emissions

FINNv2.5 emissions are available in 2 formats: text files for each fire (as for previous versions) and in 0.1x0.1 degree gridded files from the NCAR RDA (<https://rda.ucar.edu/datasets/ds312.9/>) and on the NCAR computer casper (/glade/campaign/acom/acom-weather/emmons/emissions\_finn/finn2.5\_grid\_0.1x0.1/).

The "fire\_emis" fortran program described below reads the text files of each fire emissions. Note that "emis\_finn" does not work for some regionally refined grids, so for these cases we recommend regridding the 0.1 gridded files with other standard mass-conserving regridding tools (such as <https://ncar.github.io/CAM-chem/examples/functions/Regridding.html>).

## fire\_emis fortran gridding program

**fire\_emis** is a fortran program that grids FINNv1.5 or FINNv2 fire emissions (text files from Christine Wiedinmyer, available at: <http://bai.acom.ucar.edu/Data/fire/>) and produces netcdf files for WRF-Chem, global regular lat-lon grids, and Spectral Element unstructured grids. The same source code is used to produce any of the model formats, as specified in an input namelist. Please address any questions about this code to the WRF-Chem Fire\_Emis Forum: [https://groups.google.com/a/ucar.edu/forum/?hl=en#!forum/wrf-chem-fire\\_emiss](https://groups.google.com/a/ucar.edu/forum/?hl=en#!forum/wrf-chem-fire_emiss)

NOTE: FINNv1.5 and FINN2 files contain different species and different numbers of columns. Please read the FINN2 README for more details (at: <http://bai.acom.ucar.edu/Data/fire/>).

Get the fire\_emis code at: <https://github.com/NCAR/IPT/tree/master/Emissions/Fire/FINN>

### Compiling the fire\_emis source code

To create the executable program, in the grid\_finn\_fire\_emis source code directory (./src/) issue the command: ./make\_fire\_emis

The make\_fire\_emis script is presently set up to compile on linux/unix systems using the Portland Group Fortran90 compiler, pgf95. If you need to use another compiler such as the Gnu Fortran90 compiler, gfortran, you can set the environment variable FC before invoking make\_fire\_emis. As an example, you would issue the command "export FC=gfortran" in the sh, bash, or ksh Linux shells or "setenv FC gfortran" in the csh or tcsh shells.

On [cheyenne.ucar.edu](http://cheyenne.ucar.edu): load module pgi before running 'make\_fire\_emis'.

Presently the make\_fire\_emis utility recognizes the following FC settings: pgf90 (PGI), gfortran(GNU) or ifort (Intel).

The fire\_emis utility requires the netcdf library and make\_fire\_emis will attempt to locate the libnetcdf.a library. However, this is not a foolproof process and thus you may need to set the environment variable NETCDF\_DIR to the directory containing the file lib/libnetcdf.a. As an example, in the ksh shell, if you issued the command :

```
export NETCDF_DIR=/usr/local/netcdf-3.6.2
```

then make\_fire\_emis would look for the file libnetcdf.a in the directory /usr/local/netcdf-3.6.2/lib (make\_fire\_emis automatically appends the /lib string to the NETCDF\_DIR string).

### Running fire\_emis

To run fire\_emis issue the command:

```
fire_emis < fire_emis.inp > fire_emis.out
```

Redirected input is required. Redirected output to *fire\_emis.out* is optional. The *fire\_emis.inp* and *fire\_emis.out* filenames are for illustration only; you may use any valid filename in place of them. Examples and descriptions of the namelist \*.inp file are given below. The fire\_emis.out file records runtime log messages.

The resulting netcdf emissions files are written in the directory where you run fire\_emis, so you may wish to issue the run command in a new directory: copy your namelist file to where you wish to have your output and then use the path of the executable, e.g.,

```
/home/FINN/src/fire_emis < fire_emis.inp > fire_emis.out
```

### Input Namelist Description ("*fire\_emis.inp*")

To run fire\_emis you must provide a namelist of input variables. Several examples are provided in the /run/ directory.

Namelist variable	Description

fire_directory	The directory storing the raw FINN data files (*.txt). Note that fire_directory must end with a "/" as in: /myhome/FIRE_data/
fire_filename(1)	The file name of the raw FINN data (must be .txt format). You can optionally add up to 5 files here by adding a new line fire_filename(2), etc. If you specify multiple fire filenames the times in the input files must be consecutive with no gaps.
start_date	The start date of the output emissions in YYYY-MM-DD format.
end_date	The end date of the output emissions in YYYY-MM-DD format.
output_timing	The output timing: 'daily' or 'monthly'
Model	'WRF' or 'CAMFV' or 'CAMSE'. Determines how other namelist variables are used and determines the output grid
wrf_directory	Specifies the directory of the WRF input files wrfinput_d<nn>. Note that wrf_directory must end with a "/".
mdIFilename	ONLY FOR CAMSE: The file describing the grid (must be .nc format), see examples provided.
mdIDir	ONLY FOR CAMSE: The directory storing the grid data files. Default is the current working directory ('.').
resolution	<p>CAMFV: The resolution of the output grid. Possible options:</p> <p>'0.5x0.5' (720x360); '1x1' (360x180); 'T42LR' (Lin-Rood, 128x64); 'T63LR' (192x96); 'T85LR' (256x128); 'T106LR' (320x160); 'T170LR' (512x256);</p> <p>'1.9x2.5' (144x96); 0.9x1.25 (288x192)</p> <p>CAMSE: label for output files only</p> <p>WRF: not used</p>
EmissionType	The emission type (only used for naming the output files): a label such as 'bb_surface'.
FINNVersion	The FINN Version: '1.5' or '2.2MOD' or '2.2MODVIRS' (only used for naming the output files).
defaultUnits	The default units (molecules/cm <sup>2</sup> /s). This namelist value is only used for adding unit attributes to the output files. If you want to convert to different units, you must update this name and use the glb2fire_map namelist parameter with the appropriate scaling factors for unit conversion. All unit conversions beyond molecules/cm <sup>2</sup> /s are done in this namelist, and not by the code itself (see examples). If you want to change units for only certain species, use the optional_non_default_unit_attribute in the glb2fire_map namelist parameter, as explained below.

glb2fire_map	<p>CAMFV or CAMSE:</p> <p>Specifies the mapping between global model variables and fire emission variables. glb2fire_map is a character array of size 500. If you enter more than 500 variables there is no error halt but only the first 500 will be mapped.</p> <p>Generally the format for <b>gases</b> is 'OUTPUT_SPECIES_NAME -&gt; SCALE_FACTOR*INPUT_SPECIES_NAME' Note that for gases the units in FINN are moles/day and the code will automatically convert to molecules/cm<sup>2</sup>/s.</p> <p>Generally the format for <b>aerosols</b> is 'OUTPUT_SPECIES_NAME -&gt; SCALE_FACTOR*INPUT_SPECIES_NAME;aerosol' Note that for aerosols, the units in FINN are kg/day and the code will automatically convert to molecules/cm<sup>2</sup>/s as long as you add ';aerosol', as shown above.</p>
wrf2fire_map	<p>WRF:</p> <p>Specifies the mapping between WRF variables and fire emission variables, as with <i>glb2fire_map</i>. Each entry is limited to 164 characters. Examples:</p> <p>wrf2fire_map = 'co -&gt; CO' maps the FINN variable CO to the WRF variable co.</p> <p>wrf2fire_map = 'co -&gt; CO', 'hc3 -&gt; alk2 + 1.11 * alk3 + 0.4 * meoh'</p>
domains	<p>WRF (optional): default = 1</p> <p>If you set domains = 2 then fire_emis will expect to find files wrfinput_d01 and wrfinput_d02 in the directory indicated by the wrf_directory variable.</p>
maxfire_size	<p>WRF (optional): default = 2 (square kilometers)</p>
diag_level	<p>Specifies the level of diagnostics output when running fire_emis. The default value of 100 results in the minimum diagnostic output. The diag level is set in multiples of 100. Setting diag_level to 400 produces maximal diagnostics and is appropriate when a prior fire_emis invocation has failed.</p>

#### Notes for MOZART-T1 chemistry with MAM4 aerosols in CESM2

Note the aerosol particle number variables (num\_bc\_a4 and num\_pom\_a4) have different units ((particles/cm<sup>2</sup>/s)(molecules/mole)(g/kg)) and the formulas for their calculation are provided below:

General formula: emis\_num = emis\_mol \* mw / (rho \* (PI/6) \* (diam)<sup>3</sup>)

For num\_bc\_a4:

$$\text{emis\_num\_BC} = \text{emis\_mol\_BC} * 12. / (1700. * (PI/6) * (0.134e-6)^3) \text{ or } \text{emis\_num\_BC} = \text{emis\_mol\_BC} * 5.60298303e18$$

For num\_pom\_a4:

$$\text{emis\_num\_OC} = \text{emis\_mol\_OC} * 1.4 * 12. / (1000. * (PI/6) * (0.134e-6)^3) \text{ or } \text{emis\_num\_OC} = \text{emis\_mol\_OC} * 1.33350996e19$$

The formulas to calculate IVOC and SVOC (VBS-SOA precursors):

$$\begin{aligned} \text{IVOC} = & 0.2*42./184.*\text{C3H6} + 0.2*44./184.*\text{C3H8} + 0.2*30./184.*\text{C2H6} + 0.2*28./184.*\text{C2H4} \\ & + 0.2*56./184.*\text{BIGENE} + 0.2*72./184.*\text{BIGALK} + 0.2*58./184.*\text{CH3COCH3} \\ & + 0.2*72./184.*\text{MEK} + 0.2*44./184.*\text{CH3CHO} + 0.2*30./184.*\text{CH2O} \\ & + 0.2*78./184.*\text{benzene} + 0.2*92./184.*\text{toluene} + 0.2*106./184.*\text{xylene} \end{aligned}$$

For FINNv1.5 where TOLUENE is a lumped aromatic (sum of benzene+toluene+xylenes), use:

$$\begin{aligned} \text{IVOC} = & 0.04565217*\text{C3H6} + 0.04782609*\text{C3H8} + 0.03260870*\text{C2H6} + 0.03043478*\text{C2H4} \\ & + 0.06086957*\text{BIGENE} + 0.0782609*\text{BIGALK} + 0.06304348*\text{CH3COCH3} \\ & + 0.0782609*\text{MEK} + 0.04782609*\text{CH3CHO} + 0.03260870*\text{CH2O} + 0.1*\text{TOLUENE} \end{aligned}$$

For FINNv2 (with BENZENE, TOLUENE, XYLENES each available), use:

$$\begin{aligned} \text{IVOC} = & 0.04565217*\text{C3H6} + 0.04782609*\text{C3H8} + 0.03260870*\text{C2H6} + 0.03043478*\text{C2H4} \\ & + 0.06086957*\text{BIGENE} + 0.0782609*\text{BIGALK} + 0.06304348*\text{CH3COCH3} \\ & + 0.0782609*\text{MEK} + 0.04782609*\text{CH3CHO} + 0.03260870*\text{CH2O} \\ & + 0.0848*\text{BENZENE} + 0.1*\text{TOLUENE} + 0.1152*\text{XYLENE} \end{aligned}$$

SVOC =  $0.6 \times 12 / 310 \times 1.4 \times \text{OC}$ , which is in the namelist: SVOC = 0.03251613\*OC;aerosol

#### **SPECIAL NOTES FOR WRF:**

- WRF fire emissions datasets are created in a format for input into WRF-Chem simulations employing the plume rise option. When using the provided "base" fire emissions the created wrffirechemi\_d<nn>\_<date>\_<time> files will include BOTH smoldering and flaming emissions. The resulting netcdf files are named wrffirechemi\_d<nn>\_<date>\_<time>.
- The WRF fire emissions datasets contain species fire emissions and related fire size and vegetation cover type variables. The species emissions are denoted as ebu\_in\_<species\_name> where <species\_name> is a valid WRF species name such as co. The species emissions have units of moles/km<sup>2</sup>/hr or ug/m<sup>2</sup>/s for gas phase or aerosol species respectively. The fire size and vegetation cover type variables are denoted as MEAN\_FCT\_<type> and FIRESIZE\_<type> where <type> is: AGTF = "tropical forest", AGEF = "extra tropical forest", AGSV = "savanna", AGGR = "grassland". The MEAN\_FCT\_<type> variable represents the mean area fraction for each of the four vegetation cover types per WRF horizontal grid cell. The FIRESIZE\_<type> variable represents the fire size in km<sup>2</sup> for each of the four vegetation cover types per WRF horizontal grid cell. Presently the FIRESIZE\_<type> variables are limited to 2 km<sup>2</sup>. Vegetation maps used for gridding are available at: <http://bai.acom.ucar.edu/Data/fire/> and must be placed in the same directory as the original FINN text files.
- For WRF, before invoking fire\_emis you must have a WRF initial condition file per WRF domain. Standard WRF initial condition files are denoted **wrfinput\_d<nn>** where <nn> represents the domain number in two-digit, integer format. Thus, the standard initial condition file for WRF domain number 1 is 'wrfinput\_d01'.
- fire\_emis outputs hourly WRF emission files by applying a diurnal factor to the daily emissions. Presently the "WRAP" diurnal factor is applied.
- WRF fire emissions datasets are created in a format for input into WRF-Chem simulations employing the plume rise option. When using the provided "base" fire emissions the created wrffirechemi\_d<nn>\_<date>\_<time> files will include both smoldering and flaming emissions. Users need to set the *scale\_fire\_emiss* variable in namelist.input to *.true.* and ensure to select a chemistry option that enables this scaling.