# Global Transport Model

# Version 3.8

# User's Guide
# 14 April 2025

The Global Transport Model (GTM) is the stand-alone version of the Global Eulerian Model (GEM) which is integrated into the HYSPLIT distribution. The GTM code requires, at a minimum, two input files. The *emission.csv* file defines the annual emissions (by column) for each source location (by row). The annual emissions may be modulated by the optional file *monthly.csv* which defines monthly emission factors to adjust the annual rates up or down. The second required input file *default.dat* defines the critical simulation parameters such as starting time, output frequency, the meteorological input data files, and the model initialization method. If for the model initialization, the initial concentration field is zero, then no additional input files are required. Otherwise, either the *startup.txt* file is needed, which defines a latitudinal concentration gradient, or the three-dimensional binary file *gbl3dim.bin* is required, which defines the initial concentration values at all grid points. This binary file is normally produced as an output file by GTM so that the model can be restarted. One example usage would be to generate the 3D binary initialization file using coarse resolution meteorology and then restarting the computation for the period of interest, but this time using finer resolution meteorology.

## Input File: *emission.csv* – comma delimited annual emissions

An emission file is is required for all simulations and it may even contain data for time periods outside of the simulation period. In the simple example shown below, annual emission data in pBq are given for two US locations, at Hanford and Idaho, for the period 1948 through 1956. The first line identifies the number of data columns and their year. Each subsequent data line contains the 4-character source identification (in quotes) and the latitude and longitude in integer units, which are converted to the appropriate ground-level grid-cell index within the program.

```
Site, Lat,Lon,  1948,  1949,  1950,  1951,  1952,   1953,   1954,  1955,   1956
'HAUS',47,-115, 0.26,  0.12,  0.40,  0.59,  0.51,   0.90,   1.09,  1.71,   2.71
'IDUS',43,-112, 0.26,  0.12,  0.40,  0.59,  0.51,   0.90,   1.09,  1.71,   2.71
```

There are two acceptable formats for this file. In the example shown below, each yearly emission column has two values: an integer index value (shown in red) that represents a monthly emission factors, described in the next section, and the annual emission values. Note that if a monthly emission factors file is not provided, then the required format of this file is without the integer index value, only the annual totals are expected.

```
Site, Lat,Lon,    1948,  1949,   1950,   1951,   1952,   1953,   1954,   1955,   1956
'HAUS',47,-115, 1,0.26, 1,0.12, 1,0.40, 1,0.59, 1,0.51, 1,0.90, 1,1.09, 1,1.71, 1,2.71
'IDUS',43,-112, 1,0.26, 1,0.12, 1,0.40, 1,0.59, 1,0.51, 1,0.90, 2,1.09, 2,1.71, 3,2.71
```

In the above example, except for IDUS in 1954-1956, the monthly emission factors default to profile #1. In those last three years, the monthly profiles are either #2 or #3. These numbers represent the row number in the monthly emission factors file. Note these are just examples to illustrate the file format.

**Input File: *monthly.csv* – comma delimited monthly emission factors**

Monthly emission factors need be defined for each index number found in the *emission.csv* file. The monthly factors file consists of 12 numbers, one for each month from January to December. The trailing text information is ignored. Each number represents the fractional adjustment to the emission rate for that month. A value of 1.0 would use the annual average rate. If all emission sources use the annual average rate then the *monthly.csv* file is not required. The sum of the monthly factors should equal 12 so that the total annual amount emitted would equal the value tabulated in the *emission.csv* file. The index number in the *emission.csv* file corresponds to the row or line number in the *monthly.csv* file. In the example shown below, line 1 represents the default of no monthly adjustments, while rows 2 and 3 show different emission options, such as reduced emissions during the summer months.

```
1.00,1.00,1.00,1.00,1.00,1.00,1.00,1.00,1.00,1.00,1.00,1.00, Default #1
.86, .97,1.27,1.14,1.16,1.26, .48, .30,1.14,1.26,1.24, .92,  Profile #2
1.56,1.32, .96,1.44,1.80,1.80,.036,.012,.432, .96, .78,0.90, Profile #3
```

There is no limit to the number of monthly emission profiles that can be defined. They may be used to design year-to-year emission variations at one location as well as monthly variations between emission locations.

**Input File: *startup.txt* – space delimited free-format for latitudinal initialization**

Rather than starting a simulation with a uniform global concentration, the model initialization can be defined by a global latitudinal gradient, uniform over all longitudes.

```
 52 -30 0.75
 44 -30 0.74
 36 -30 0.73
 28 -30 0.72
 20 -30 0.71
 12 -30 0.70
  4 -30 0.69
 -4 -30 0.68
-12 -30 0.67
-20 -30 0.65
-28 -30 0.63
-36 -30 0.62
-44 -30 0.61
-52 -30 0.60
```

The file used to initialize the global concentration field consists of only data lines with integer values of latitude, longitude, and real values for concentration ($Bq/m^3$). The model's interpretation of these values depends upon the initialization method ($3^{rd}$ line in *default.dat*). For option #1 (bands), the longitude is ignored and only the latitudes are used in a hemispheric regression equation. For option #2 (dew-point), the dew-point temperature at each location is used to develop a regression equation to assign a concentration to each grid point. The dew point temperature is used as a surrogate for air mass identification. The interpolation is weighted to grid points with the same dew point temperature as the grid point of the concentration measurement. The *startup.txt* file is only required for initialization options #1 and #2.

**Input File: *default.dat* – space delimited free-format input for the simulation configuration**

```
48 01 01  | Start YY MM DD (inclusive)
25 01 01  | Stop YY MM DD (exclusive)
0         | Initialization (0:0 1:band 2:dewp 3:gbl3dim >3:val)
0.0 0.0   | Concentration range for initialization
2.0E+05   | Horizontal mixing coefficient at the equator
1.0       | Vertical velocity scaling factor (0.0 to 1.0)
0         | Vertical velocity computation method (0=data 1=div)
50.0      | Maximum vertical mixing (50 m2/s)
2         | Global Mass (0=skip 1=show 2=conserve)
2         | Source term frequency (0:none 1:once >=2:step)
1.0       | Source term base rate adjustment factor
24        | Concentration output frequency (hours)
0         | Initial output hour (0-24)
1         | Concentration output level (hPa or index)
1.0       | Concentration output units conversion factor
3930.0    | Pollutant half life (days)
'Kr85'    | Pollutant 4-character identification
```

Line 1: The start date of the simulation.

Line 2: The date that the simulation stops. The start and stop dates can be reversed. In that situation, the integration is performed "upwind".

Line 3: The concentration initialization uses the "*startup.txt*" file for initialization options #1 and #2 and reads the "*gbl3dim.bin*" file for option #3. Zero sets the initial concentrations to zero and a value of greater than three sets the global concentration to one tenth of the value on the initialization line (e.g. entry of 15 would be considered to be 1.5).

Line 4: The concentration range is the valid concentration range permitted as output from the regression equation for initialization options #1, #2, and #3.

Line 5: The horizontal mixing coefficient ($m^2/s$) is defined at the equator and is reduced toward the pole by the cosine of the latitude.

Line 6: A vertical velocity scaling factor is the multiplier to the vertical advection calculation. A value of one means that the value of "W" from the data file or as computed from the horizontal velocity divergence is used unaltered.

Line 7: The vertical velocities are obtained directly from the input data file (0) or computed from the divergence equation (1). The preferable method is to use the values from the input data file, unless the "W" field is not available.

Line 8: The maximum vertical mixing coefficient is just that – a scaling value used in conjunction with the Richardson number to compute the vertical mixing coefficient between each grid cell in a column.

Line 9: The global mass computation can be skipped (0), computed and shown (1), or computed and used as an adjustment factor to conserve (2) mass between time steps. Unless used for diagnostic purposes, this value should always be #2.

Line 10: The source term frequency can be none (0) to never emit material, or just once at model startup (1), or every time step (2). Normal simulations would use #2. Diagnostic simulations might use one of the other options.

Line 11: Source term base rate adjustment factor where 1.0 indicates no adjustment to the emissions. A value of 1.15 would increase overall emissions by 15%.

Line 12: The output frequency indicates the hourly interval at which the 2- dimensional (one level) concentration output file is written.

Line 13: The initial output hour indicates the output start time (UTC).

Line 14: The output level can either be a pressure level or index value (lowest level = 1 or 1013 hPa). The output file is always called "*sfc{yyyy}.bin*" regardless of the output level and named according to the simulation year.

Line 15: The output unit conversion factor converts the internal unit of $Bq/m^3$ to another output unit.

Line 16: The half-life is specified in days. A value of zero or less will result in no radioactive decay.

Line 17: The 4-character pollutant identification needs to be in quotes. The identification field is used in the internal records of the output data file "*sfc{yyyy}.bin*".

Line 18+ : One input line for each meteorology file and they should be in the time sequence required for the calculations. The model is coded to use either 2.5 deg or 1.0 deg resolution pressure level data files in the ARL (HYSPLIT compatible) format. If all the meteorology files are in the same directory and the naming convention follows the archive pattern (RP{yyyy}{mm}.gbl or gdas1.{mon}{yy}.w{x}) on the data server (https://www.ready.noaa.gov/archives.php), then only the first meteorology file needs to be defined. Subsequent file names are automatically generated in the program for access in the same directory as the first file. File name generation is disabled in the backward mode and each meteorological input file needs to be defined on its own line. Input data resolution cannot be changed during the simulation. Stop and restart the calculation from the *gbl3dim.bin* file when switching to a different resolution meteorological data file.

**Output Files:**

The *sfc{yyyy}.bin* file is a two dimensional HYSPLIT compatible concentration file with just one level. It is written in the HYSPLIT compatible binary format so that any HYSPLIT post-processing program can read the file. The file *gbl3dim.bin* is a binary dump of the 3-dimensional concentration field. This file can be used to restart the model or even re-initialize the model using a different meteorological data grid, such as going from a 2.5 degree simulation to a 1.0 degree simulation. It is created and overwritten daily and annually on January 1st when it is renamed *gbl{yyyy}.bin*.