Stochastic Time-Inverted Lagrangian Transport (STILT) Model How To

by

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Fair Use Policy

Please notify us of any publication plans involving STILT. Depending on the role played by STILT and the accompanying analysis tools, we may ask to be acknowledged or offered participation as authors. We assume that an agreement on such matters will be reached prior to publishing.

Publications

<u>The formal reference describing the STILT model is:</u>

Lin, J.C., C. Gerbig, S.C. Wofsy, A.E. Andrews, B.C. Daube, K.J. Davis, and C.A. Grainger, A near-field tool for simulating the upstream influence of atmospheric observations: the Stochastic Time-Inverted Lagrangian Transport (STILT) model, *Journal of Geophysical Research*, *108* (D16), 4493, doi:10.1029/2002JD003161, 2003.

<u>Papers that use STILT:</u>

Gerbig, C., J.C. Lin, S.C. Wofsy, B.C. Daube, A.E. Andrews, B.B. Stephens, P.S. Bakwin, and C.A. Grainger, Toward constraining regional-scale fluxes of CO_2 with atmospheric observations over a continent: 1. Observed spatial variability from airborne platforms, *Journal of Geophysical Research*, *108* (D24), 4756, doi:10.1029/2002JD003018, 2003.

Gerbig, C., J.C. Lin, S.C. Wofsy, B.C. Daube, A.E. Andrews, B.B. Stephens, P.S. Bakwin, and C.A. Grainger, Toward constraining regional-scale fluxes of CO_2 with atmospheric observations over a continent: 2. Analysis of COBRA data using a receptor-oriented framework, *Journal of Geophysical Research*, *108* (D24), 4757, doi:10.1029/2003JD003770, 2003.

Content of Distribution Package

`Exe`	multiple copies of the STILT executables
`Boundary`	tracer boundary conditions, valid for the middle of the Pacific
`Fluxes`	surface flux grids over North America
`Rsc`	R scripts to run STILT and the ROAM framework (Receptor-Oriented Atmospheric Model)—i.e., calculating tracer concentrations at the particle starting location (“receptor”) by having the STILT particles pick up tracer fluxes and tracer boundary conditions (see section on ‘R scripts’)
`src`	source code for the STILT model

Model Files Needed

The current version of the STILT model has been compiled to run on Linux machines running Redhat.

<u>a) Essential files:</u>

i) `hymodelc` compiled model executable file
ii) `CONTROL` file containing the main control parameters for the model
iii) `SETUP.CFG` file containing the secondary control parameters

<u>b) Optional files</u>

`ASCDATA.CFG`—configuration file defining data structure of `LANDUSE.ASC` & `ROUGLEN.ASC`
`LANDUSE.ASC`—text file containing land-use data
`ROUGLEN.ASC`—text file containing roughness length data

Note: The files above must be placed in the same directory.

Meteorological Files Needed

STILT is built upon the HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) model developed by NOAA-ARL (Air Resources Laboratory). The input meteorological files required by STILT are in NOAA-ARL format.

Archived meteorological files are available for download from NOAA-ARL:
http://www.arl.noaa.gov/ss/transport/archives.html

A webpage that discusses the NOAA-ARL data format, with conversion programs, is available at:
http://www.arl.noaa.gov/ready/hysp_data2arl.html

The relevant papers describing the HYSPLIT model and the format of the NOAA-ARL meteorological files are:

Draxler, R.R., HYSPLIT_4 User's Guide, *NOAA Technical Memorandum ERL ARL-230*, 1999.

Draxler, R.R., and G.D. Hess, Description of the HYSPLIT_4 modeling system, *NOAA Technical Memorandum ERL ARL-224*, 1997.

Draxler, R.R., and G.D. Hess, An overview of the HYSPLIT_4 modelling system for trajectories, dispersion, and deposition, *Australian Meteorological Magazine*, *47*, 295-308, 1998.

Please properly acknowledge NOAA ARL as appropriate and please be aware of limitations when publishing results using forecast meteorology from ARL. The following are instructions from https://www.arl.noaa.gov/ready/sec/hysplit4.html:

Publications using HYSPLIT results, maps or other READY products provided by NOAA ARL are requested to include an acknowledgement of, and citation to, the NOAA Air Resources Laboratory. Appropriate versions of the following are recommended:

Citation

Draxler, R.R. and Rolph, G.D., 2003. HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) Model access via NOAA ARL READY Website (http://www.arl.noaa.gov/ready/hysplit4.html). NOAA Air Resources Laboratory, Silver Spring, MD.

Rolph, G.D., 2003. Real-time Environmental Applications and Display sYstem (READY) Website (http://www.arl.noaa.gov/ready/hysplit4.html). NOAA Air Resources Laboratory, Silver Spring, MD.

Acknowledgment

The authors gratefully acknowledge the NOAA Air Resources Laboratory (ARL) for the provision of the HYSPLIT transport and dispersion model and/or READY website (http://www.arl.noaa.gov/ready.html) used in this publication.

Redistribution Permission

Permission to publish or redistribute HYSPLIT model results using forecast meteorological data from NOAA ARL can be obtained by providing relevant information (reason, to whom, from whom) via email to permission@www.arl.noaa.gov.

Structure of CONTROL file

Here is a sample CONTROL file (with explanation following # sign):

```
0 8 26 18            #yr ('0'=>2000), mon, day, hr [UT]
1                    #number of starting locations
45 -90.2 5           #starting location:  lat, lon, height [m AGL]
48                   #number of hours to run model (negative numbers denote backward run)
0                    #vertical motion option (0:data 1:isob 2:isen 3:dens 4:sigma)
10000.0              #top of model domain [m AGL]
1                    #number of input meteorological data
/users/jcl/Metdat/   #meteorological data directory
edas.subgrd.aug00.002      #meteorological filename
1
test
1
0.01
00 00 00 00 00
1
0.0 0.0
0.5 0.5
30.0 30.0
./
cdump
1
100
00 00 00 00 00
00 00 00 00 00
00 24 00
1
0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0
0.0
0.0
```

Structure of `SETUP.CFG`

`SETUP.CFG` is a ‘namelist’ file, which can alter the behavior of the model without having to recompile it.

Here is a sample `SETUP.CFG` file:

```
$SETUP
NUMPAR=50,
DELT=30,
TRATIO=0.75,
ISOT=0,
TLFRAC=0.1,
OUTFRAC=0.9,
NDUMP=1,
RANDOM=1,
OUTDT=0.0,
VEGHT=0.5,
NTURB=0,
ICONVECT=0,
WINDERRTF=0,
ZICONTROLTF=0,
IVMAX=11,
VARSIWANT='time','indx','lati','long','zagl','zsfc','samt','temp','dswf','mlht','dmas',
$END
```

Explanation of parameters in `SETUP.CFG`:

`NUMPAR`—number of particles to be run (default: 100)

`DELT`—integration timestep [min]; if set to 0.0, then timestep is dynamically determined

`TRATIO`—maximum fraction of gridcell to be traveled by a particle in a single integration timestep. This determines the timestep is DELT is set to be dynamic (default: 0.75)

`ISOT`—flag used to set the isotropic turbulence option. The default value of 0 results in the computation of horizontal turbulence from wind field deformation. Setting this flag to 1 results in the horizontal turbulence to be the same in both the U- and V- directions. (default: 0)

`TLFRAC`–the fraction of T_L (Lagrangian timescale) to set as timestep in dispersion subroutine. The smaller this fraction is, the more finely the turbulence is resolved. (default: 0.1)

`NDUMP`—is a flag that can be set to dump out all the particle/puff points at the end of a simulation to a file called `PARDUMP`. This file can be read at the start of a new simulation to continue the previous calculation. Valid `NDUMP` settings: 0 - no I/O, 1- read and write, 2 - read only, 3 - write only (default: 0)

`RANDOM`–flag that tells random number generator whether to have a different random sequence each time model is run (0-FALSE; 1-TRUE); if set FALSE, then generates same random sequence each time, which is useful for debugging purposes (default: 1)

`OUTDT`–interval to output data to `PARTICLE.DAT` [min]; 0.0 means output is written every timestep (default: 0.0)

`NTURB`–No Turbulence flag; 1 sets run to simulate mean trajectories, 0 sets run to include turbulence (default: 0)

`VEGHT`–height [fraction of PBL ht or m] below which a particle’s time spent is tallied; useful if want to specify a certain ht as ‘seeing’ ground vegetation. If <=1.0, then specifies fraction of PBL ht (default: 0.5)

`OUTFRAC`—the fraction of particles that are allowed to leave model domain (given by met. data); if exceeded, model stops (default: 0.9)

`ICONVECT`—flag for convection. If set to 1, then runs excessive convection as described in Gerbig et al., *J. Geophys. Res.*, *108* (D24), 4757, doi:10.1029/2003JD003770, 2003. For specialized

RAMS output, the particles will be vertically redistributed according to the outputted convective mass fluxes (default: 0)

`WINDERRTF`—flag that specifies whether to have particle motions be affected by horizontal wind errors. (default: 0) If set to 1, then STILT looks for file called "WINDERR" that has four lines, with one number on each line: 1. Standard deviation of errors [m/s] 2. Correlation timescale of errors [min] 3. Vertical correlation lengthscale of errors [m] 4. Horizontal correlation lengthscale of errors [km]. All the statistical properties specified in 1.~4. are applied equally to the U- and V- wind components.

`ZICONTROLTF`—flag that species whether to scale the PBL heights in STILT uniformly in the entire model domain. (default: 0) If set to 1, then STILT looks for file called 'ZICONTROL' that species the scaling for the PBL height. The first line of ZICONTROL indicates the number of hours that the PBL height will be changed, and each subsequent line indicates the scaling factor for that hour. A sample ZICONTROL file could contain:

```
2
1.5
0.4
```

This file would alter the PBL heights for the first two hours of the model runtime, increasing the PBL height by 50% during the first hour and decreasing it to only 40% of the original value.

`IVMAX`—the total number of variables to be outputted (see VARSIWANT) (default: 5)

`VARSIWANT`—a list of 4-letter codes specifying variables to be outputted. See next section for complete list of variables that can be outputted (default: 'time', 'indx', 'long', 'lati', 'zagl')

List of Variables that can be Outputted from STILT

The following are the 4-letter codes of variables that should be specified for VARSIWANT in 'SETUP.CFG' to get the output.

The output from STILT will be in a file called 'PARTICLE.DAT'.

`time`	time since start of simulation; negative if going backward in time [min]
`indx`	particle index
`long`	longitude position of particle [degrees]
`lati`	latitude position of particle [degrees]
`zagl`	vertical position of particle [m above ground level]
`sigw`	standard deviation of vertical velocity; measure of strength of vertical turbulence [m/s]
`tlgr`	Lagrangian decorrelation timescale [s]
`zsfc`	terrain height [m above sea level]
`icdx`	cloud index when using RAMS (Grell scheme) [`1=updraft,2=environment,3=downdraft`]
`temp`	air temperature at lowest model layer [K]
`samt`	amount of time particle spends below VEGHT (see section on 'SETUP.CFG') [min]
`foot`	'footprint', or sensitivity of mixing ratio to surface fluxes [ppm/(μmole/m^2/s)]
`shtf`	sensible heat flux [W/m^2]
`lhtf`	latent heat flux [W/m^2]
`tcld`	total cloud cover [%]
`dmas`	particle weight changes due to mass violation in wind fields [initial value = 1.0]
`dens`	air density [kg/m^3]
`rhfr`	relative humidity fraction [0~1.0]
`sphu`	specific humidity [g/g]
`solw`	soil moisture
`lcld`	low cloud cover [%]
`zloc`	limit of convection heights [m]
`dswf`	downward shortwave radiation [W/m^2]
`wout`	vertical mean wind [m/s]
`mlht`	mixed-layer height [m]
`rain`	total rainfall rate [m/min]
`crai`	convective rainfall rate [m/min]

R scripts to Run STILT

In the Rsc/ directory are scripts to run STILT and to calculate tracer concentrations at the particle location ("receptor") using a "receptor-oriented framework". A description of the receptor-oriented framework employing STILT is:

Gerbig, C., J.C. Lin, S.C. Wofsy, B.C. Daube, A.E. Andrews, B.B. Stephens, P.S. Bakwin, and C.A. Grainger, Toward constraining regional-scale fluxes of CO_2 with atmospheric observations over a continent: 2. Analysis of COBRA data using a receptor-oriented framework, *Journal of Geophysical Research*, *108* (D24), 4757, doi:10.1029/2003JD003770, 2003.

The scripts are written in the R language (OpenSource implementation of the S-statistical analysis language). The source code, installation files, and documentation on R can be downloaded from the R Project for Statistical Computing: http://www.r-project.org/ .

See the file 'Rsc/00README.TXT' for a description of how to run the R scripts. In particular, the function 'Trajec' can be used in R to automatically generate the CONTROL and SETUP.CFG configuration files, call the Fortran executable 'hymodelc', and read in the output.

In addition, there's a short tutorial 'Rsc/0stilt_tutorial.r' that generates sample output and illustrates how STILT can be run with the R scripts.