

HYSPLIT Cheat Sheet

This Cheat Sheet available at:

ftp://1397guest:2018arl@ftp.arl.noaa.gov/Workshops/Howard_2018/HYSPLIT_Summary.pdf

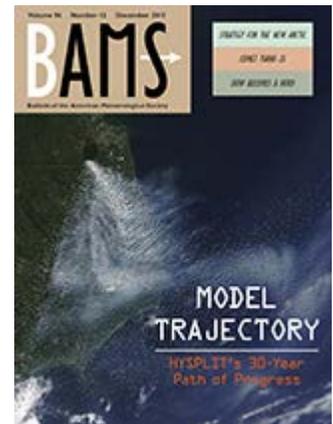
The Workshop PowerPoint will be posted soon after the workshop at:

ftp://1397guest:2018arl@ftp.arl.noaa.gov/Workshops/Howard_2018/HYSPLIT_Workshop.pptx

What is HYSPLIT?



- [The HYSPLIT model](#) is a system for computing simple air parcel trajectories, as well as complex atmospheric transport and dispersion simulations. (<https://www.arl.noaa.gov/hysplit/hysplit/>)
- HYSPLIT has been developed at the NOAA [Air Resources Laboratory](#) (ARL) for more than 30 years, and it is still undergoing development at ARL. (<https://www.arl.noaa.gov/>)
- Stein et al. (2016), [NOAA's HYSPLIT Atmospheric Transport and Dispersion Modeling System](#), *Bulletin of the American Meteorology Society (BAMS)*, 96(12): 2059-2077 (<https://doi.org/10.1175/BAMS-D-14-00110.1>)
- It requires meteorological data to run, but extensive HYSPLIT-compatible meteorological datasets are publically available on the ARL-HYSPLIT website (described below).
- The model has been tested extensively by comparison of its predictions against actual measurements of atmospheric concentrations and deposition.
- HYSPLIT is one of the most widely used atmospheric transport and dispersion models in the world.
- In addition to the basic trajectory and dispersion models, HYSPLIT contains a large suite of analysis, pre-processing, and post-processing programs that may be useful in different applications.



Different ways to run HYSPLIT

- Online, via the [READY website](https://www.ready.noaa.gov/index.php) (<https://www.ready.noaa.gov/index.php>)
 - for [trajectories](https://ready.arl.noaa.gov/HYSPLIT_traj.php) (https://ready.arl.noaa.gov/HYSPLIT_traj.php)
 - for [dispersion](https://ready.arl.noaa.gov/HYSPLIT_disp.php) (https://ready.arl.noaa.gov/HYSPLIT_disp.php)

Meteorology & Starting Location(s)

Trajectory Calculation

Meteorology: GDAS (1 degree, global, 2006-present) [More Info](#)

Source Location (enter using **one** of the following methods):

Open Map Display

Decimal Degrees Latitude: [] N [] Longitude: [] W

DDD/MM/SS Latitude: [] [] [] N [] [] [] W

City (Country or State: name: lat: lon): []

Airport or WMO ID (i.e., dca): [] [ID Lookup](#)

- Install on local computer, use Graphical User Interface (GUI)
- Install on local computer, use command line and/or scripts

Installation on your local computer

- Installation instructions are given on the web pages referenced below.
- HYSPLIT requires some additional “helper” programs, like Tcl-Tk. On Windows systems, it also requires Ghostscript and Ghostview and ImageMagick. These helper programs are freely available and can be downloaded from the HYSPLIT download page(s). ***You should install these first, in the order mentioned above, before you install HYSPLIT.***
- installation for [Windows](https://ready.arl.noaa.gov/HYSPLIT_hytrial.php) (https://ready.arl.noaa.gov/HYSPLIT_hytrial.php)
(Tutorial: https://ready.arl.noaa.gov/documents/Tutorial/html/install_win.html)
- Installation for [Apple-Mac](https://ready.arl.noaa.gov/hyreg/HYSPLIT_applehysp.php) (https://ready.arl.noaa.gov/hyreg/HYSPLIT_applehysp.php)
(Tutorial: https://ready.arl.noaa.gov/documents/Tutorial/html/install_mac.html)
- Installation for [Linux](https://ready.arl.noaa.gov/HYSPLIT_linux.php) (https://ready.arl.noaa.gov/HYSPLIT_linux.php)
(Tutorial: https://ready.arl.noaa.gov/documents/Tutorial/html/install_unix.html)

Should you become a *Registered User* ?

- Please do *not* register if you will *only* be using the HYSPLIT model with archived meteorological data (as opposed to forecast data) -- *this applies to most users*
 - Why might you need to become a registered user?
 - Registration required to use forecast met data for simulations
 - Registration required to obtain source code (e.g., for Linux compilation)
 - Registration information available [here](#)
(https://ready.arl.noaa.gov/HYSPLIT_register.php)
-

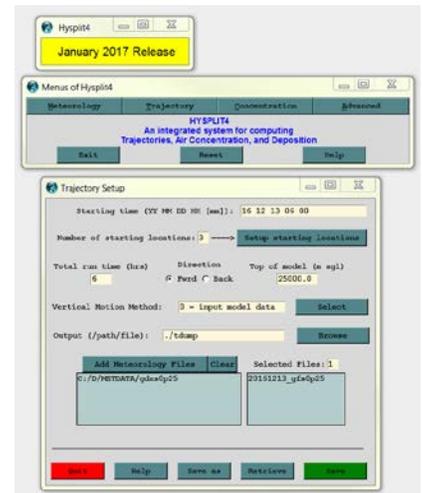
Learn to use HYSPLIT: 1. **Online-READY**

- Online READY system for trajectories and dispersion
 - [Rolph et al. 2017](#)
(<https://www.sciencedirect.com/science/article/pii/S1364815217302360>)
 - [READY Summary Handout](#)
(https://www.arl.noaa.gov/documents/Summaries/READY_2017.pdf)
 - [READY](#) is a relatively self-explanatory, menu-driven system, with *help*
(<https://ready.arl.noaa.gov/index.php>)



Learn to use HYSPLIT: 2. GUI, Local Installation

- Graphical User Interface (GUI) with locally installed HYSPLIT
- The GUI is a great way to learn HYSPLIT. Even if you are going to eventually run HYSPLIT using command-line and scripting (see next section), you often start in the GUI to learn how and what you want to do. Eventually, you might decide you want to automate the process in a script.
- [Tutorial](#) (online or download)
(https://www.ready.noaa.gov/HYSPLIT_Tutorials.php)
- [Annual Workshop](#) (in person or remotely) (next workshop: June 12-15, 2018, at NOAA Center for Weather and Climate Prediction (NCWCP), College Park, MD. Details and registration posted in the spring. (Hands-On)
(<https://www.arl.noaa.gov/hysplit/hysplit-workshop/>)
- Context-sensitive help throughout GUI
- [HYSPLIT Users Guide](#) (https://www.arl.noaa.gov/wp_arl/wp-content/uploads/documents/reports/hysplit_user_guide.pdf)
- [Frequently Asked Questions](#) (<https://www.arl.noaa.gov/hysplit/hysplit-frequently-asked-questions-faqs/>)
- [Forum - Bulletin Board](#)
(<https://hysplitbbs.arl.noaa.gov/>)
- Document folder in local installation

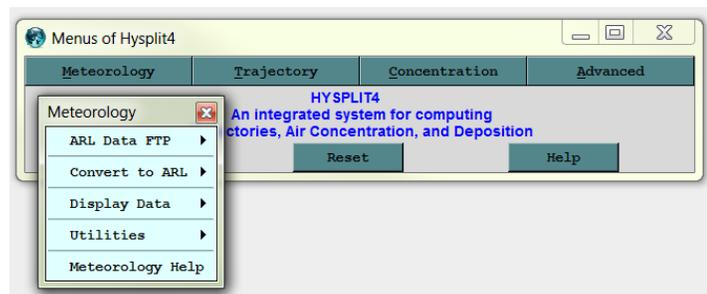


- arl-224.pdf
- EULA.txt
- hysplit_license.txt
- Readme_document.txt
- updates.txt
- user_guide.pdf

Meteorological Data

- Meteorological (“met”) data, in HYSPLIT-format, *must be provided to the model* to run a trajectory or dispersion (concentration) simulation.
- Met data includes things like wind speed and direction, temperature, humidity, and precipitation.
- Most met data used by HYSPLIT are *gridded* outputs created by meteorological models, including numerous models that are run at NOAA.
- Met data can be “forecast” or be “archived”. As noted above, you have to be registered user to use forecast data. For the typical user, however, archived data is generally used, e.g., to run the HYSPLIT model to help analyze air pollution measurements.
- Numerous regional, continental, and global meteorological datasets are archived at the Air Resources Laboratory, in HYSPLIT format, and are freely available.
- Several ways to obtain met data:
 - Through the GUI
 - Through the HYSPLIT [met data website](#) -- right click on a file and “save target as” (<https://ready.arl.noaa.gov/archives.php>)
 - Via an FTP browser (if you want to download a lot of files)

- Conversion programs are available in the HYSPLIT suite that can be used to convert user-generated met data to HYSPLIT format.



- HYSPLIT-format meteorological data files are in “binary” format, so you can’t readily examine them in a text editor or word-processor.
- But, met data can be examined with various tools and utilities through the Graphical User Interface (GUI), e.g., “text profile”
- The met data files can be large. A single one-day file of global met data at ¼ degree (~25 km horizontal resolution) is 2.7 GB. But some are relatively small: a one-month file of global met data at 2.5 degree horizontal resolution (~250 km) is only about 115 MB.
- Met data can also be examined, analyzed and processed by numerous different programs available in the HYSPLIT suite, e.g., the **Profile** program, which extracts the meteorological data at a given location from a given meteorological data file. An example of the use of the **Profile** program is given below in the “command line / scripting” section.

Meteorological Datasets Available from NOAA ARL Archives*

(<https://ready.arl.noaa.gov/archives.php>)

	Dataset	Horizontal Resolution (km- approx.)	Full-grid dimensions	Temporal resolution (hrs)	Vertical Levels	Period of each file	Size of each file (GB)	Total size for one month of data (GB)	Availability
North American**	HRRR-3km	3	1799 x 1059	1	37	¼ day	3.2	390	June 2015 ->
	NAM-12km	12	614 x 428	3	27	1 day	0.395	12	May 2007 ->
	WRF-ARW-27km	27	216 x 174	1	35	1 day	0.210	6.4	1980-2016
	NARR-32km	32	309 x 237	3	24	1 month	2.8	2.8	1979 ->
	EDAS-40km	40	185 x 129	3	27	½ month	0.6	1.2	2004 ->
Global	GFS - 0.25°	27	1440 x 721	3	56	1 day	2.7	82	June 2016 ->
	GDAS - 0.5°	55	720 x 361	3	56	1 day	0.468	14	Sept 2007 ->
	GDAS - 1°	111	360 x 181	3	24	1 week	0.571	2.5	Dec 2004 ->
	Global Reanalysis - 2.5°	278	144 x 73	6	18	1 month	0.11	0.11	1948 ->

* These are some of the most commonly used datasets. There are other datasets available in the archive, including datasets for Alaska and Hawaii.

** All North American datasets cover the Continental United States, but have varying coverage of Canada, Mexico, and adjacent oceanic regions.

What meteorological data should you use?

- There are generally numerous different data sets that you can use for any given analysis
 - Output from different meteorological models
 - Different horizontal, vertical, and temporal resolution
 - Different meteorological variables provided (but all must have wind speed & direction, etc.)
 - Different geographical coverage (regional, continental, global)
 - Available for different times periods
 - Some are reanalysis datasets, which are run after the fact, and extensively incorporate meteorological measurements to try to create the best possible characterization of the atmosphere
 - All things being equal, generally want to use the highest resolution met data that is available for your case, but this means that files will be bigger (more disk space on your computer), and runs will generally take longer.
 - It can be very useful to do your analysis with different met data sets, and examine the differences.
 - If the results are relatively similar with different met data sets, then you can be more confident that meteorological uncertainties are not playing a significant role.
 - If the results are very different with different met data sets, then there may be more uncertainty due to met data uncertainties
 - In complex terrain (e.g., in the mountains), or when there are sea-lake breezes (e.g., on the coast), the use of higher-resolution met data is more important. But, in these cases, caution is warranted, as the highest resolution data available to you (e.g., 12 km resolution) may be too coarse to really resolve meteorological phenomena. The same would be true in an urban setting, with street-canyon flows, etc.
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Trajectories

- A trajectory represents the “centerline” of a dispersion
- Can be run forward or backward
 - Forward trajectories tell you where the air will go
 - Backward trajectories tell you where the air came from
- Back-trajectories are commonly used to help interpret air pollution measurements
 - Where did the air come from corresponding to any given sample time?
 - Where did the air come from when the concentrations of the pollutant were high?
 - Where did the air come from when the concentrations were low?
- From the GUI:
 - Trajectory → Setup Run (creates a CONTROL file in the working directory)
 - Trajectory → Run Model (executes the hyts_std model)
 - Trajectory → Display → Trajectory (executes the trajplot program)
- Trajectory → Setup Run:

**All Times in HYSPLIT are UTC
Universal Time Coordinate
(Greenwich Mean Time)**

Longitudes in the Western Hemisphere are negative!

Might also want to save the setup to use later, by “save as” and then selecting a file name

Must hit “SAVE” when done.

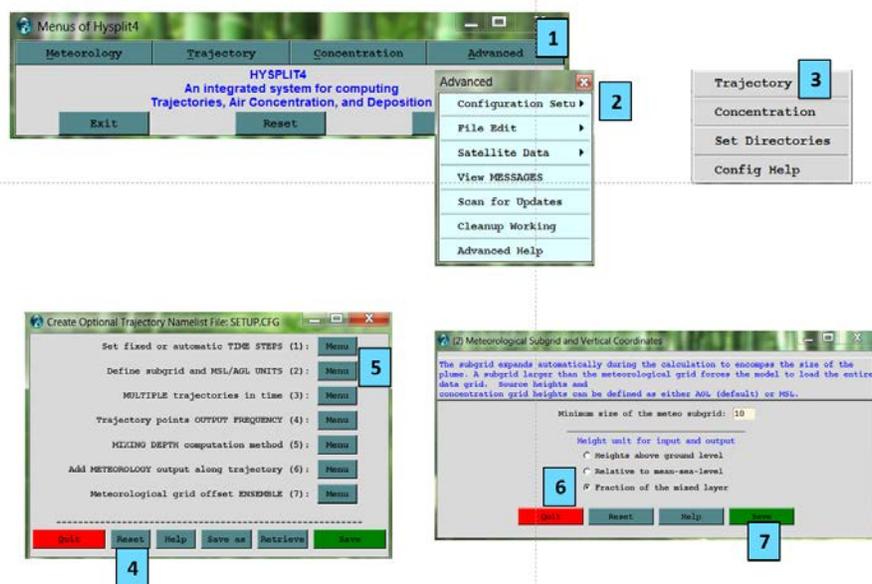
Behind the scenes, this writes a CONTROL file to the Working Directory

Meteorological file(s) you choose must contain the starting point and must cover the entire simulation period

To use the file you saved later, use “Retrieve”

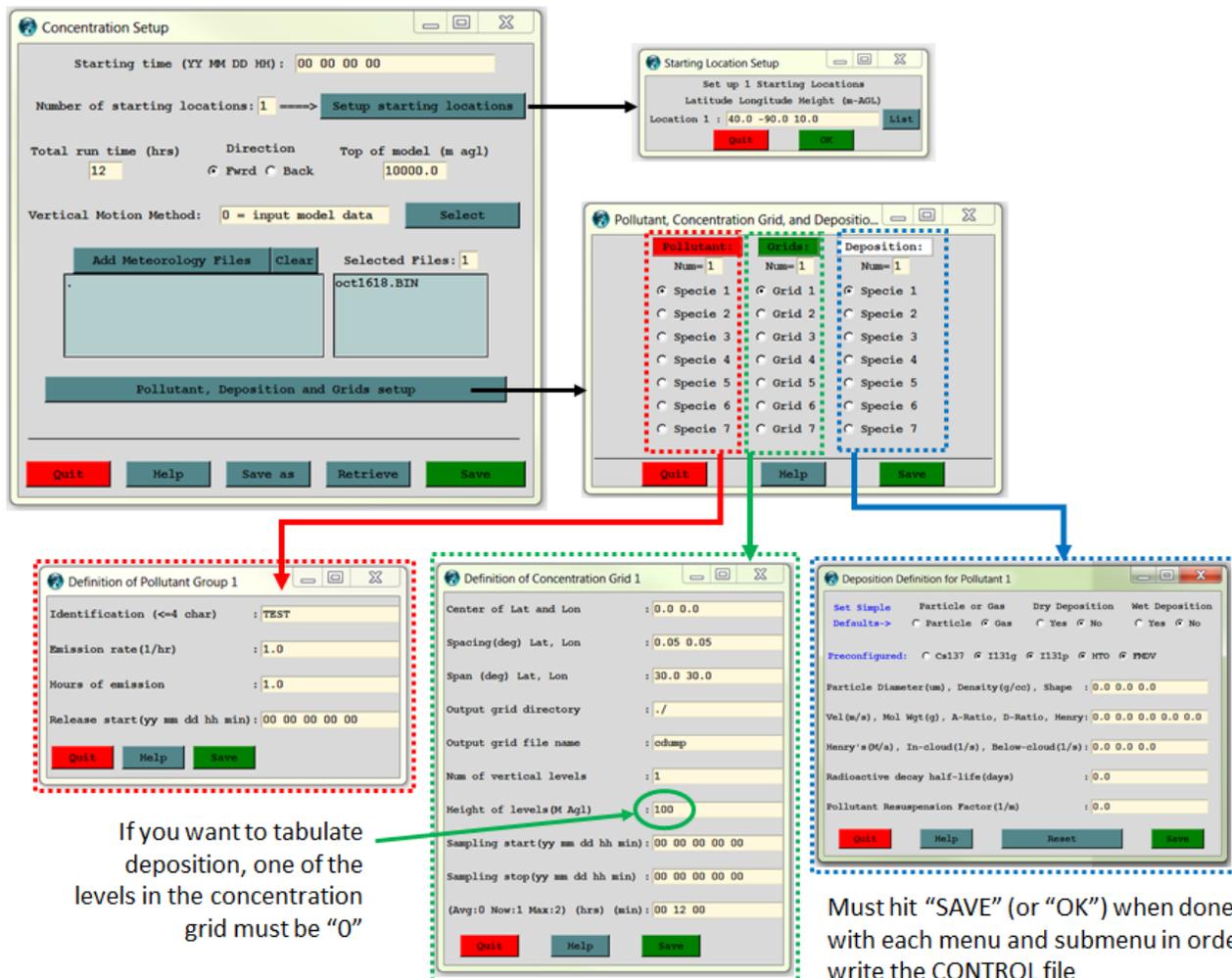
What height(s) should you start a back-trajectory at?

- Should you start it at the height of your sampler, e.g., 2 meters above the ground?
- Not recommended, as the trajectory can then easily hit the ground and lose accuracy
- If only starting at one height, then a good choice might be “½ of the height of the planetary boundary layer (PBL)” (aka mixed layer).
- This choice reflects the idea that what you are seeing at your sampler is the average concentration of pollutant in the well-mixed boundary layer.
- To use this option, you must use the Advanced menu in the GUI (or a SETUP.CFG file in command line or script execution)
- Advanced → Configuration Setup → Trajectory → Menu #2: Define subgrid and MSL/AGL units
→ Fraction of the Mixed Layer



Basic Concentration Simulations

- Can be run forward or backward
- Generally is run forward, to simulate what happens to a material after it is emitted to the air
- From the GUI:
 - Concentration → Setup Run (creates a CONTROL file)
 - Concentration → Run Model (hycs_std model)
 - Concentration → Display → Concentration → Contours (concpplot program)
- Concentration → Setup Run:



Learn to use HYSPLIT: 3. Command Line / Scripting

- Command Line / Scripting with locally installed HYSPLIT

2.2 Test Trajectory Calculation

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From the top bar of the main menu select the *Trajectory / Setup Run* tab to open the [setup menu](#). Press the **Save** button to close the menu, accepting the default settings. Then select the *Trajectory / Run Model* tab which immediately starts the trajectory model calculation. When it [completes](#), press the **Exit** button to close the window. Then select the *Trajectory / Display / Trajectory* tab to open the [display menu](#). Press the **Execute Display** button to show the test case [trajectory result](#).

- Tutorial shows example scripts on many pages
- Example scripts also provided in the “scripts” subdirectory of the HYSPLIT installation
- On any operating system, will need to open a “terminal”
- Navigate to HYSPLIT working directory
 - Windows: `cd c:\hysplit4\working` ↵
 - Mac/Linux: `cd ~/hysplit4/working` ↵ (case sensitive, may be Hysplit4)
- It’s generally a good idea to work in the “working” directory, but you can create additional working directories to use. When working with the GUI, files are placed into the “working” directory. When you are doing things from the command line or scripts, they will go in whatever directory you are working in, or to a path that you specify.
- If you execute any HYSPLIT program without any arguments, you will generally get a list of required and optional arguments

```
c:\hysplit4\working>..\exec\profile ↵
Usage: profile [-options]
-d[Input metadata directory name with ending /]
-f[input metadata file name]
-y[Latitude]
-x[Longitude]
-o[Output time offset (hrs)]
-t[Output time interval (hrs)]
-n[Hours after start time to stop output (hrs)]
-w[Wind direction instead of components=1]
-p[process ID number for output text file]
-e[extra digit in output values (0)-no,1=yes]
```

NOTE: leave no space between option and value

- Note- there are sometimes more options available in the command line (or script) execution than are available in the GUI

- In the above example, a “command line” or script execution of the program would look something like this:

```
c:\hysplit4\working>
..\exec\profile -d c:\metdata\ -f RP201612.gbl -y 40.2 -x -119.6 -w 1
```

- A “script” can be thought of as just a series of “command line” entries, one after another
- If writing scripts, make sure they are “plain text”
 - Windows: DOS Batch Scripts (tutorial examples), Python, etc.
 - Mac/Linux: Shell Scripts (tutorial examples), Python, etc.
- Why would you want to use scripts?
 - Have a record of what you have done, and can do it again, or modify it and do it again
 - You can set the script up to do multiple runs
 - But, the GUI is a great way to learn how to use HYSPLIT, and to gain a good understanding of the options. One often uses the GUI to explore and test what one wants to do, and then, once you’ve narrowed things down, you try to write a script to “automate” the process.
 - GUI: a big script (with many sub-scripts) written in the Tcl-Tk scripting language
- Basic architecture of a script to run HYSPLIT would do the following:
 - Write CONTROL file
 - Write SETUP.CFG file (optional)
 - Run HYSPLIT (e.g., hyts_std or hycs_std)
 - Create graphics (e.g., run trajplot or concplot)
 - Rename output files and move to results directory to save
- Common to use a “RUN” and “SET” script:
 - The “RUN” script sets some basic parameters for each run
 - The SET script is called from the RUN script and takes the variables provided
 - The SET script does everything you want (e.g., see preceding architecture example), and then returns execution to the “RUN” script, and then the next run is started (i.e., the next line), by calling the “SET” script with a new set of parameters.

Deeper HYSPLIT Background (equations, etc.)

- NOAA Technical Memorandum ERL ARL-224, [Description of the HYSPLIT-4 Modeling System](#), Revised Feb 2018
(https://www.arl.noaa.gov/wp_arl/wp-content/uploads/documents/reports/arl-224.pdf)
- [Supplementary Materials](#) for the BAMS article mentioned above
https://journals.ametsoc.org/doi/suppl/10.1175/BAMS-D-14-00110.1/suppl_file/10.1175_bams-d-14-00110.2.pdf