2022 Online HYSPLIT Workshop
(Wrap-up: DAY 2 of 4)

NOAA Air Resources Laboratory
June 14-17, 2022
Workshop guidance and resources posted at Workshop Web Page

https://www.ready.noaa.gov/register/HYSPLIT_hyagenda.php

We will update this page each day to include any new materials or links that are relevant to the Workshop.
https://www.ready.noaa.gov/register/HYSPLIT_hyagenda.php

**Workshop Logistics**

**Webinar Links.** Unique sign-in URL's was emailed to each confirmed participant during the week before the Webinars and should not be shared.

**Handouts, Notes, and Recordings.** Videos of each day's on-line sessions are being created for review by participants and will be available online after the workshop for continued learning and online participation difficult. Processing of the videos to make them viewable takes significant time. When the videos are uploaded, you will see a link. When you click on one of these links, you should be able to view the video directly. To download a video right-click on the video area and right click the mouse. Choose the "Save As" menu.

- **Installation Day (Mon, June 13)**
  - Installation day introduction
  - Workshop video recording Installation day (MP4, 266 MB) and unfinished transcript (TEXT, 49 KB). The video is missing inaccurate captions. See the above paragraph on how to download the video file.

- **Workshop Day 1 (Tue, June 14)**
  - Day 1 handout (PDF, 4.7 MB).
  - Trajectory equation (PDF, 0.2 MB).
  - Day 1 wrap-up (PDF, 5.1 MB) without animations. Day 1 wrap-up (PPTX, 9.2 MB) with animations.
  - Workshop video recording for day 1 (MP4, 984 MB) and unfinished transcript (TEXT, 213 KB). The transcript is missing captions. See the above paragraph on how to download the video file.

- **Workshop Day 2 (Wed, June 15)**
  - Day 2 handout will be posted here.
  - Workshop day 2 video recording and transcript will be posted here when they become available.
# 2022 HYSPLIT Workshop Schedule

*Subject to change, depending on the progression of the course and at the discretion of the instructors*

<table>
<thead>
<tr>
<th>UTC</th>
<th>Eastern Daylight Time</th>
<th>Monday June 13, 2022</th>
<th>Tuesday June 14, 2022</th>
<th>Wednesday June 15, 2022</th>
<th>Thursday June 16, 2021</th>
<th>Friday June 17, 2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:00 - 14:00</td>
<td>9:00 - 10:00</td>
<td>OPTIONAL* 1a. Installing HYSPLIT on Windows PC</td>
<td>Introduction</td>
<td>7. Air Concentration calculations</td>
<td>11. Pollutant transformations and deposition (continued)</td>
<td>15. Radioactive pollutants and dose</td>
</tr>
<tr>
<td>14:00 - 15:00</td>
<td>10:00 - 11:00</td>
<td>OPTIONAL* 1b. Installing HYSPLIT on MAC</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
</tr>
<tr>
<td>15:00 - 16:00</td>
<td>11:00 - 12:00</td>
<td>One-on-one virtual installation sessions, by appointment</td>
<td>4. Trajectory Calculations</td>
<td>8. Configuring the CAPTEX simulation</td>
<td>12. Air Concentration Uncertainty</td>
<td>16. Volcanic eruptions with gravitational settling</td>
</tr>
<tr>
<td>16:00 - 17:00</td>
<td>12:00 - 13:00</td>
<td>One-on-one virtual installation sessions, by appointment</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
</tr>
<tr>
<td>17:00 - 18:00</td>
<td>13:00 - 14:00</td>
<td>One-on-one virtual installation sessions, by appointment</td>
<td>5. Trajectory Options</td>
<td>9. Air concentration parameter sensitivity</td>
<td>13. Source Attribution Methods</td>
<td>17. Custom Simulations</td>
</tr>
<tr>
<td>18:00 - 19:00</td>
<td>14:00 - 15:00</td>
<td>One-on-one virtual installation sessions, by appointment</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
<td>Break</td>
</tr>
<tr>
<td>19:00 - 20:00</td>
<td>15:00 - 16:00</td>
<td>One-on-one virtual installation sessions, by appointment</td>
<td>6. Trajectory Statistics</td>
<td>10. Alternate display options</td>
<td>14a. Wildfire Smoke</td>
<td>Day 1 Wrap-Up</td>
</tr>
<tr>
<td>20:00 - 21:00</td>
<td>16:00 - 17:00</td>
<td>One-on-one virtual installation sessions, by appointment</td>
<td>Day 1 Wrap-Up</td>
<td>11. Pollutant transformations and deposition</td>
<td>14b. Dust Storms</td>
<td>Day 2 Wrap-Up</td>
</tr>
</tbody>
</table>

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*Optional sessions may be included or excluded based on the instructors' discretion.*
Asking Questions

- Ask general or logistical questions about the Webinar or Go-to-Webinar in the Control Panel that was just discussed.
  ...if viewing a recording, can ask general questions by emailing arl.webmaster@noaa.gov

- Ask questions about HYSPLIT and the Tutorial in the HYSPLIT Forum.
  https://hysplitbbs.arl.noaa.gov/viewforum.php?f=76
Quick Recap of Logistics

➢ General questions:
  • use Go-to-Webinar Question box and we will do our best to answer
  • We are not using the “raise hand” feature for questions

➢ Detailed questions, e.g., about the model:
  • use the HYSPLIT Forum
  • if haven’t already, “register” in upper right corner of Forum web page

➢ Handouts:
  • Other documents – e.g., this presentation – provided as Handouts in Go-to-Webinar and also on the Workshop Web Page

➢ Recordings:
  • Each day’s recording will be posted to the Workshop Web Page as soon as it is ready, generally 4-8 hours after the day’s session ends.

➢ If not installed, or if get too far behind:
  • Perfectly ok to view one or more sessions as “demonstrations” and then go back and do the sessions on your own. The Tutorial is designed to be done on one’s own in self-paced environment.
With a real-world pollution release, there is always an expanding plume as the pollutants travel downwind.

The trajectory of a single computational point particle released from the source and simulated with the HYSPLIT Trajectory model is the center line of a plume of pollutants emitted from a source.
Atmospheric Turbulence → particles don’t follow simple paths, but follow “turbulent trajectories”
To simulate a plume from a source, we release many particles at a time, and this cloud of particles is transported downwind.

Each computational point particle gets additional motion based on the amount of turbulence in the atmosphere.

Here we are showing just 6 particles released at one time. In a real HYSPLIT run, you would release 100’s or 1000’s or even more particles at any given time.

If the pollutant release was ongoing, you would keep releasing particles from the source as long as you wanted to simulate the emissions.

As the wind changes speed and direction, and as the turbulence in the atmosphere changes, the plume will be dispersed in different directions and will be dispersed to different extents.

Plume simulation = A collection of turbulent particle trajectories
What do HYSPLIT *Computational Point Particles* actually represent?

- A small parcel of air that contain one or more pollutants
- Each *Computational Point Particle* (parcel) contains a vast multitude of actual pollutant entities
  - molecules (in gas phase)
  - and/or atmospheric pollutant particles
- Amount of actual pollutant associated with a *Computational Point Particle* is determined by the emissions rate divided by the number of *Computational Point Particles* released in the simulation. Both of these parameters are set by the user.
- Example: NO$_2$ emissions from a power plant.
  - Suppose there is a power plant that emits 1000 pounds of NO$_2$ per hour
  - Suppose we do a simulation that releases 500 *Computational Point Particles* per hour
  - You can calculate that there are $1.2 \times 10^{25}$ NO$_2$ molecules per HYSPLIT *Computational Point Particle*
  - *With the same emission rate, if you release 5000 Computational Point Particles per hour, there will 10x less NO$_2$ molecules per particle, e.g., $1.2 \times 10^{24}$*
Details of Calculation for NO₂ Emissions Example:

\[
\begin{align*}
1000 \left[ \frac{\text{pounds NO}_2}{\text{hour}} \right] & \times \frac{1}{500} \left[ \frac{\text{hour}}{\text{HYSPLIT particles}} \right] \times 454 \left[ \frac{\text{grams NO}_2}{\text{pound NO}_2} \right] \\
&= \frac{1}{46} \left[ \frac{\text{mole NO}_2}{\text{grams NO}_2} \right] \times 6.022 \times 10^{23} \left[ \frac{\text{molecules NO}_2}{\text{mole NO}_2} \right] = 1.2 \times 10^{25} \left[ \frac{\text{molecules NO}_2}{\text{HYSPLIT particle}} \right]
\end{align*}
\]
What do HYSPLIT *Computational Point Particles* actually represent?

- A small parcel of air that contain one or more pollutants

- Each *Computational Point Particle* (parcel) contains a vast multitude of actual pollutant entities
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- Example: particulate emissions from a fire.
  - Suppose there is a fire that is emitting 1000 pounds per hour of particulate (smoke), that the average particle size is 5 µm diameter, and the average particle density is 1 g/cm³
  - Suppose we do a simulation that releases 500 computational point particles per hour
  - You can calculate that there are $1.4 \times 10^{13}$ smoke particles per HYSPLIT computational point particle
Details of Calculation for Smoke Emissions Example:

\[
\begin{align*}
&\frac{1000 \text{ pounds smoke}}{\text{hour}} \times \frac{454 \text{ grams smoke}}{\text{pound smoke}} \times \frac{1.0 \times 10^{-6} \text{ m}^3}{\text{cm}^3} = 1.4 \times 10^{13} \text{ smoke particles per HYSPLIT particle} \\
&\frac{500 \text{ HYSPLIT particles}}{\text{hour}} \times \frac{\frac{4}{3} \pi \left(2.5 \times 10^{-6} \text{ meters}\right)^3}{\text{smoke particle}} \times \frac{1 \text{ gram smoke}}{\text{cm}^3 \text{ smoke}}
\end{align*}
\]
In a HYSPLIT Concentration simulation, you define one or more concentration grids, where you specify the horizontal and vertical grid spacing, the overall extent, and the time resolution. During the HYSPLIT simulation, the model outputs concentration results for each grid you have defined. These grids do not affect the simulation, they just affect what sort of output you get.

The concentration in each grid cell – over the user-specified averaging time -- is calculated as:

\[
\text{[the number of particles in the grid cell]} \times \text{[the mass of pollutant on each particle]} \div \text{[volume of the grid cell]}
\]
You can define more than one grid, each with its own specifications.

Depending on where the grid is and which way the wind is blowing during the simulation, you might not get any computational point particles in the grid, and all concentrations in the grid will be zero.

If a grid has very fine spacing, you might need to increase the number of computational point particles released in the simulation.

The particles are “discrete” and if there are too few of them, you aren’t really representing the continuous plume, and you can get very blotchy results.
<table>
<thead>
<tr>
<th>UTC</th>
<th>EDT</th>
<th>Agenda Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:00 – 13:15</td>
<td>09:00 – 09:15</td>
<td>Introduction to Day 3</td>
</tr>
</tbody>
</table>
 starters today or continue from yesterday |
| 14:15 – 14:30 | 10:15 – 10:30 | Break                                                                       |
| 14:30 – 16:00 | 10:30 – 12:00 | 12. Air Concentration Uncertainty                                           |
| 16:00 – 17:00 | 12:00 – 13:00 | Break                                                                       |
| 17:00 – 18:45 | 13:00 – 14:45 | 13. Source Attribution Methods                                              |
| 18:45 – 19:00 | 14:45 – 15:00 | Break                                                                       |
| 19:00 – 19:45 | 15:00 – 15:45 | 14a. Wildfire Smoke                                                         |
| 19:45 – 20:30 | 15:45 – 16:30 | 14b. Dust Storms                                                            |
| 20:30 – 20:45 | 16:30 – 16:45 | Day 3 Wrap-up / questions                                                   |

Note: all times are approximate
Extra Slides
HYSPLIT

- An atmospheric transport and dispersion model
- Continuous development at the NOAA Air Resources Laboratory since 1949
- Uses meteorological data and emissions data as inputs
- Estimates what happens when pollutants are emitted into the air
- 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.

A plume of air pollutants emitted from an industrial fire in Deer Park, Texas, March 2019. AP Photo: David J. Philip
What is HYSPLIT Used For?

- **Emergency Response** (within NOAA, other Fed, State, Local agencies, domestic and international)
  - Nuclear Accidents
  - Volcanic Eruptions (e.g., aviation impacts)
  - Wildfires
  - Industrial / Transportation Accidents releasing toxic chemicals
  - Insect dispersal (e.g., locusts)

- **Source-attribution**
  - Back-tracking from air pollution measurements
    - Genesis of ARL was to back-track from airborne radionuclide measurements to find site of Russian nuclear test site in 1949
    - Current support for Comprehensive Test Ban Treaty Organization

- **Planning, scenario investigations**
What is HYSPLIT Not Used For?

- Complex, non-linear atmospheric chemistry situations
  - E.g., atmospheric photochemistry (ozone, etc) where emissions from all sources must be modeled at the same time. For this type of atmospheric modeling situation, you would use a gridded Eulerian model like the Community Multiscale Air Quality (CMAQ) model.
  - HYSPLIT is a Lagrangian model – it follows plumes.
    - This makes it much, much faster than an Eulerian model like CMAQ
    - So, it can be used for Emergency Response
  - You can do more than one plume, but if there are chemical reactions between pollutants in one plume and another plume, HYSPLIT is not well suited to simulate that.
  - HYSPLIT has actually been applied to atmospheric photochemistry and related situations, and in these cases, the model has been expanded to incorporate an Eulerian (gridded) modeling approach. But these are not common applications of the model.
Different Ways to Use HYSPLIT

  - Secure applications for national security issues
  - Specialized applications for different needs
  - Researcher access
  - Public access

- **Download model (free) and run on your local computer**
  - GUI = **G**raphical **U**ser **I**nterface
  - Command Line / Scripts
  - Download met data to run HYSPLIT from ARL website
Two different kinds of HYSPLIT simulations

- **Trajectory**
  - Center-line of a plume -- an oversimplification, but can provide very useful information
  - Can go forward or backward
  - Does not factor in any deposition or chemistry

- **Concentration - Dispersion**
  - The full 3D transport and dispersion of a plume
  - Includes transport by wind, but also dispersion around center line
  - Gives air concentrations downwind -- (e.g., can compare with public health thresholds)
  - Can include chemistry and wet and dry atmospheric deposition
At its core, the HYSPLIT model just transports “particles” as they are blown along by the wind.
Meteorological Data Grid(s) - Required

- These are the outputs from a meteorological model
  - e.g. a weather forecasting model
  - wind speed & direction and other met data on a 3-D grid
- Data sets differ based on
  - What model was used to generate them
  - The horizontal grid spacing
  - The vertical grid spacing
  - The temporal resolution (e.g., data every hour)
- HYSPLIT must have these data to run
  - Data must be in “HYSPLIT format” (binary, ...)
  - ARL provides datasets for download (most from NOAA weather models)
  - HYSPLIT needs the filename and location on your computer
  - File must include the area and times that you are doing your run in
    - If a particle goes off the met data grid, it is terminated
    - If there are missing times, the model “crashes”
  - Can have multiple met files (e.g., several 1-day files for a multi-day simulation)
- Uncertainties
  - Weather model uncertainties (e.g., wind direction and speed not exactly right)
  - HYSPLIT interpolates between grid points (in space and time) to estimate the wind speed and direction at the actual location of a particle
<table>
<thead>
<tr>
<th>Dataset</th>
<th>Horizontal Resolution (km- approx.)</th>
<th>Full-grid dimensions</th>
<th>Temporal resolution (hrs)</th>
<th>Vertical Levels</th>
<th>Period of each file</th>
<th>Size of each file (GB)</th>
<th>Total size for one month of data (GB)</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRRR-3km</td>
<td>3</td>
<td>1799 x 1059</td>
<td>1</td>
<td>37</td>
<td>½ day</td>
<td>3.2</td>
<td>390</td>
<td>Jun 2015 -&gt; present</td>
</tr>
<tr>
<td>NAMS-12km Hybrid</td>
<td>CONUS - 12</td>
<td></td>
<td></td>
<td>40</td>
<td>1 day</td>
<td>1.0</td>
<td>30</td>
<td>2010 -&gt; present</td>
</tr>
<tr>
<td></td>
<td>Alaska - 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.64</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hawaii – 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.71</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>NAM-12km</td>
<td>12</td>
<td>614 x 428</td>
<td>3</td>
<td>27</td>
<td>1 day</td>
<td>0.395</td>
<td>12</td>
<td>May 2007 -&gt; present</td>
</tr>
<tr>
<td>WRF-ARW-27km</td>
<td>27</td>
<td>216 x 174</td>
<td>1</td>
<td>35</td>
<td>1 day</td>
<td>0.210</td>
<td>6.4</td>
<td>1980 -&gt; present</td>
</tr>
<tr>
<td>NARR-32km</td>
<td>32</td>
<td>309 x 237</td>
<td>3</td>
<td>24</td>
<td>1 month</td>
<td>2.8</td>
<td>2.8</td>
<td>1979 -&gt; 2019</td>
</tr>
<tr>
<td>EDAS-40km</td>
<td>40</td>
<td>185 x 129</td>
<td>3</td>
<td>27</td>
<td>½ month</td>
<td>0.6</td>
<td>1.2</td>
<td>2004 -&gt; 2018</td>
</tr>
<tr>
<td>Global</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GFS - 0.25°</td>
<td>27</td>
<td>1440 x 721</td>
<td>3</td>
<td>56</td>
<td>1 day</td>
<td>2.7</td>
<td>82</td>
<td>Jun 2019 -&gt; present</td>
</tr>
<tr>
<td>GDAS - 0.5°</td>
<td>55</td>
<td>720 x 361</td>
<td>3</td>
<td>56</td>
<td>1 day</td>
<td>0.468</td>
<td>14</td>
<td>Sep 2007 -&gt; Jun 2019</td>
</tr>
<tr>
<td>GDAS - 1°</td>
<td>111</td>
<td>360 x 181</td>
<td>3</td>
<td>24</td>
<td>1 week</td>
<td>0.571</td>
<td>2.5</td>
<td>Dec 2004 -&gt; present</td>
</tr>
<tr>
<td>Global Reanalysis - 2.5°</td>
<td>278</td>
<td>144 x 73</td>
<td>6</td>
<td>18</td>
<td>1 month</td>
<td>0.11</td>
<td>0.11</td>
<td>1948 -&gt; present</td>
</tr>
</tbody>
</table>
Domain of WRF-ARW-27km met data set

Horizontal spacing ~27 km
35 vertical levels
Data every hour
Each file is for one day
(~210 MB per file)
The simulated movement in the atmosphere of one “computational particle” is called a Trajectory.

- 3-dimensional movement (x, y, and z)
- If you started the trajectory at different times, it would go in different directions, depending on which way the wind was blowing.
- Think of this as the center line of a plume of pollutants emitted from a source.
When you hit “save”, the Graphical User Interface writes a CONTROL file to the hysplit\working directory.
<table>
<thead>
<tr>
<th>CONTROL file entry</th>
<th>Meaning</th>
<th>Notes / Comments</th>
</tr>
</thead>
</table>
| 04 05 01 00 00     | Start date / time for simulation (YR MO DA HR MN) | • All times in HYSPLIT are Universal Coordinated Time (UTC) (a.k.a. Greenwich Mean Time)  
• e.g. Eastern Daylight Time (EDT) = UTC – 4 hours  
• e.g. 11 AM EDT = 3 PM UTC  
• Minutes are optional  
• Each entry must be 2-digits (e.g., 04 rather than 2004) |
| 1                  | Number of starting locations                      | |
| 40.0 -77.0 100.0   | Starting location: latitude, longitude, height [meters above ground level (m-agl)] | • If there is more than 1 starting location or height, each must be on a separate line  
• West Longitudes are negative |
| 24                 | duration of run (hours)                           | |
| 0                  | vertical motion option (0 = just use the meteorological data) | |
| 10000              | top of model domain (meters)                     | • generally 10000 or 25000 |
| 1                  | number of met data files                         | |
| C:\hysplit\metdata\  | directory of 1st met file (must contain trailing "\") ("/" on MAC or LINUX) | • If there is more than 1 met file being used, then these two lines will be repeated for each met file. |
| wrfout_d01_20040501.ARL | name of 1st met file | |
Example of simple CONTROL file for a trajectory model run

04 05 01 00 00
1
40.0 -77.0 100.0
24
0
10000
1
C:\hysplit\metdata\
wrfout_d01_20040501.ARL
HYSPLIT Trajectory Model (hyts_std.exe)

Is there a CONTROL file in the directory you are running the model from?
• NO → model stops immediately
• YES → model tries to read CONTROL file to get required run parameters

Is the CONTROL file properly constructed, e.g., all expected lines present in the correct order, etc?
• NO → model stops with error message (...can be hard to understand)
• YES → model starts to run

Can the model find the met data file(s) you specified in the CONTROL file?
• NO → model stops with error message (cannot find file...)
• YES → model continues

Does your starting location and time fit within the domain of the met data file?
• NO → model stops with error message
• YES → model starts to simulate the trajectory

CONTROL file
• Required for HYSPLIT to run
• Must be an ascii-text file
• If you are having a problem with your run, look at the CONTROL file.
• If you are trying to get someone to help you figure out what happened or what went wrong, you will need to send them the CONTROL file
# Workflow associated with a typical HYSPLIT Trajectory simulation

<table>
<thead>
<tr>
<th>Command Line or Script</th>
<th>write CONTROL file</th>
<th>write SETUP.CFG file</th>
<th>hysplit\exec\hyts-std</th>
<th>hysplit\exec\trajplot</th>
<th>additional scripts</th>
</tr>
</thead>
<tbody>
<tr>
<td>GUI</td>
<td>Trajectory → Setup Run</td>
<td>Advanced → Config. Setup → Trajectory</td>
<td>Trajectory → Run Model</td>
<td>Advanced → View Messages</td>
<td>Trajectory → Special Runs</td>
</tr>
</tbody>
</table>

### INPUTS
- **CONTROL file** (required)
- **SETUP.CFG file** (optional)
- **Met Data File(s)**
- **HYSPLIT model** (hyts_std)

### OUTPUTS
- **Trajectory dump output file** (tdump.txt)
- **MESSAGE file**
- **Trajectory Plotting program** (trajplot)
- Additional post-processing programs, e.g. trajectory clustering, trajectory frequency
CONTROL file structure

1. **Basic parameters (Trajectory or Concentration)**
   - Start date / time for simulation (YR MO DA HR MN)
   - Number of starting locations
   - For each starting location: latitude, longitude, height
   - Duration of run (hours)
   - Vertical motion option (0=data)
   - Top of model domain (m)
   - Number of met data files
   - For each met file:
     - Directory for file
     - Name of file
2. **Emission parameters**
   - number of different pollutants
   - for each pollutant:
     - pollutant 4-character identification name
     - emissions rate (per hour)
     - hours of emissions
     - release start time
3. **Concentration Grids**

- Number of concentration grids
- For each grid:
  - center (Lat Long)
  - grid spacing (degrees) (Lat Long)
  - grid span (degrees) (Lat Long)
  - directory for grid output file
  - name of grid output file
  - number of vertical levels
  - height of level (m-agl)
  - sampling start time
  - sampling end time
  - sampling interval (type, hour, minute)
4. **Deposition parameters**

- number of pollutants depositing
- for each depositing pollutant:
  - particle diameter, density and shape
  - Deposition velocity (m/s), Pollutant molecular weight (Gram/Mole), Surface Reactivity Ratio, Diffusivity Ratio, Effective Henry’s Constant
  - Wet Removal: Actual Henry’s constant, In-cloud (GT 1 =L/L; LT 1 =1/s), Below-cloud (1/s)
  - radioactive decay half-life (days)
  - pollutant resuspension (1/m)
CONTROL file structure

1. **Basic parameters** (Trajectory or Concentration)
   - Start date / time for simulation  (YR MO DA HR MN)
   - Number of starting locations
   - For each starting location: latitude, longitude, height
   - duration of run (hours)
   - vertical motion option (0=data)
   - top of model domain (m)
   - number of met data files
   - for each met file:
     - directory for file
     - name of file

2. **Emission parameters**
   - number of different pollutants
   - for each pollutant:
     - pollutant 4-character identification name
     - emissions rate (per hour)
     - hours of emissions
     - release start time

3. **Concentration Grids**
   - Number of concentration grids
   - For each grid:
     - center (Lat Long)
     - grid spacing (degrees) (Lat Long)
     - grid span (degrees) (Lat Long)
     - directory for grid output file
     - name of grid output file
     - number of vertical levels
     - height of level (m-agl)
     - sampling start time
     - sampling end time
     - sampling interval (type, hour, minute)

4. **Deposition parameters**
   - number of pollutants depositing
   - for each depositing pollutant:
     - particle diameter, density and shape
     - Deposition velocity (m/s), Pollutant molecular weight (Gram/Mole), Surface Reactivity Ratio, Diffusivity Ratio, Effective Henry's Constant
     - Wet Removal: Actual Henry's constant, In-cloud (GT 1 =L/L; LT 1 =1/s), Below-cloud (1/s)
     - radioactive decay half-life (days)
     - pollutant resuspension (1/m)

Note that turning on deposition will result in the removal of mass and the corresponding reduction in air concentration, the deposition will not be available in any output unless height "0" is defined as one of the concentration grid levels.
SETUP.CFG file structure
GUI: Advanced → Configuration Setup → Concentration

Example of simple SETUP.CFG file (optional)

```
&SETUP
  numpar = 10000,
  maxpar = 240000,
/
```

- `maxpar` must generally be greater than or equal to the `run_duration * numpar`
- E.g., for a 24hr simulation, releasing 10,000 particles per hour, you need a maximum number of particles of 240,000
Workflow associated with a typical HYSPLIT Concentration simulation

Command Line or Script
- write CONTROL file
- write SETUP.CFG file
- hysplit\exec\hycs-std
- hysplit\exec\concplot
- hysplit\exec\con2asc
- hysplit\exec\con2stn

GUI
- Concentration → Setup Run
- Advanced → Config. Setup → Concentration
- Concentration → Run Model
- Advanced → View Messages
- Concentration → Display → Contours
- Concentration → Utilities → Convert to → Ascii (or Station)

CONTROL file (required), including Pollutant, Deposition, and Grids Setup...

SETUP.CFG file (optional)
- If a SETUP.CFG file is present, HYSPLIT will use it, even if it's not how you wanted to do the run!

HYSPLIT Concentration model (hycs_std.exe)
- binary output file for each concentration grid defined (cdump_1, cdump_2, cdump_3, ...)
- Concentration Plotting program (concplot)
- Additional post-processing programs, e.g.

Met Data File(s)

MESSAGE file
HYSPLIT Tips and Tricks

- **CONTROL file**: Look at this file if you are having a problem – sometimes you can see obvious errors.
- **GUI**: When you are using the GUI, most input and output files will be in `hysplit\working\`
- **Scripts**: usually create a new working directory, e.g., `hysplit\working_Workshop`
- **Met File(s)**: Correct directory and name; encompass time & spatial domain of your desired simulation.
- **Ascii text**: CONTROL, SETUP.CFG, MESSAGE, TDUMP files (trajectory output files), scripts
- **Binary**: Met data files, CDUMP files (concentration output files)
- **Options**: Not all available from GUI; can type executable name from command line to see options.
- **Many other HYSPLIT programs** in the HYSPLIT exec directory (e.g., met data analysis programs); some are available in the GUI, but not all.
- **Graphics**: HYSPLIT has some graphical capabilities – including some new Python graphics – but you can also display your model outputs using other graphics platforms (Google Earth, GIS, python, Matlab...)
- **Numerical Experiments**:
  - Do you have enough particles in your simulation? Increase the number and see if your answers change. Keep increasing until the answers level off. The finer the grid you use, the more particles you need.
  - Do the same simulation with different met data sets to evaluate sensitivity to met data uncertainties.
  - And you can do other sensitivity tests for other parameters.
Usage: trajplot -[options (default)]

- a [GIS output: (0)-none 1-GENERATE_points 3-KML 4-partial_KML 5-GENERATE_lines]
- A [KML options: 0-none 1-no extra overlays 2-no endpoints 3-Both 1&2]
- e [End hour to plot: #, (all)]
- f [Frames: (0)-all files on one 1-one per file]
- g [Circle overlay: ( )-auto, #circ(4), #circ:dist_km]
- h [Hold map at center lat-lon: (source point), lat:lon]
- i [Input files: name1+name2+... or +listfile or (tdump)]
- j [Map background file: (arlmmap) or shapefiles.<(txt)|process suffix>]
- k [Kolor: 0-B&W, 1-Color, N:colortraj1,...colortrajN]
  1=red, 2=blue, 3=green, 4=cyan, 5=magenta, 6=yellow, 7=olive
- l [Label interval: ... -12, -6, 0, (6), 12, ... hrs]
  <0=with respect to traj start, >0=synoptic times]
- L [LatLonLabels: none=0 auto=(1) set=2:value(tenths)]
- m [Map proj: (0)-Auto 1-Polar 2-Lambert 3-Merc 4-CylEqu]
- o [Output file name: (trajplot.ps)]
- p [Process file name suffix: (ps) or process ID]
- s [Symbol at trajectory origin: 0-no (1)-yes]
- v [Vertical: 0-pressure (1)-agl, 2-theta 3-meteo 4-none]
- z [Zoom factor: 0-least zoom, (50), 100-most zoom]

NOTE: leave no space between option and value

EXAMPLE: trajplot -itdump.txt -oFIRE -a3 -A3

- Not all program options available from GUI
- More options from scripts
- Type executable name from command line to see options
- At left: trajplot (the program that plots trajectories)
Many programs in the HYSPLIT exec directory (e.g., met data analysis programs); some in GUI, but not all

The programs underlined in red have been mentioned today
HYSPLIT Documentation and Learning Resources

- **HYSPLIT Tutorial**: detailed instructions on using the GUI + example scripts; can be run online or downloaded to local computer

- The GUI is a great way to learn HYSPLIT
  - even experienced users use it when trying something new
  - can create a run in the GUI, and then look at associated input/output files to tell you how to create a script to do similar simulations
  - you can do some relatively complicated procedures (e.g., trajectory clustering)

- **HYSPLIT Users Guide**: online (and also in hysplit/documents directory)

- **Download HYSPLIT and other resources**: [https://www.ready.noaa.gov/HYSPLIT.php](https://www.ready.noaa.gov/HYSPLIT.php)

- **HYSPLIT Cheat Sheet**

- **Model Overview**: [https://www.arl.noaa.gov/hysplit/hysplit/](https://www.arl.noaa.gov/hysplit/hysplit/)


- **HYSPLIT Forum**: [https://hysplitbbs.arl.noaa.gov/](https://hysplitbbs.arl.noaa.gov/)

- **HYSPLIT FAQ’s**: [https://www.arl.noaa.gov/hysplit/hysplit-frequently-asked-questions-faqs/](https://www.arl.noaa.gov/hysplit/hysplit-frequently-asked-questions-faqs/)


- **Stein et al., 2015**: NOAA’s HYSPLIT atmospheric transport and dispersion modeling system, *Bull. Amer. Meteor. Soc.*, 96, 2059-2077, [http://dx.doi.org/10.1175/BAMS-D-14-00110.1](http://dx.doi.org/10.1175/BAMS-D-14-00110.1)

- **Rolph et al., 2017**: Real-time Environmental Applications and Display sYstem: READY. *Environmental Modelling & Software*, 95, 210-228, [https://doi.org/10.1016/j.envsoft.2017.06.025](https://doi.org/10.1016/j.envsoft.2017.06.025)
# Agenda – Day 0

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<thead>
<tr>
<th>UTC</th>
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<th>Agenda Item</th>
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<tbody>
<tr>
<td>13:00 – 13:45</td>
<td>09:00 – 09:45</td>
<td>1-2: Installation on Windows PC’s</td>
</tr>
<tr>
<td>13:45 – 14:00</td>
<td>09:45 – 10:00</td>
<td>Break</td>
</tr>
<tr>
<td>14:00 – 14:30</td>
<td>10:00 – 10:30</td>
<td>1-2: Installation on Windows PC’s</td>
</tr>
<tr>
<td>14:30 – 15:00</td>
<td>10:30 – 11:00</td>
<td>Break</td>
</tr>
<tr>
<td>15:00 – 16:00</td>
<td>11:00 – 12:00</td>
<td>30-minute individual installation session as needed</td>
</tr>
<tr>
<td>16:00 – 17:00</td>
<td>12:00 – 13:00</td>
<td>Break</td>
</tr>
<tr>
<td>17:00 – 21:00</td>
<td>13:00 – 17:00</td>
<td>30-minute individual installation session as needed</td>
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Note: all times are approximate
## Agenda – Day 1

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<tbody>
<tr>
<td>13:00 – 13:30</td>
<td>09:00 – 09:30</td>
<td>Welcome, Introduction and Logistics</td>
</tr>
<tr>
<td>14:45 – 14:30</td>
<td>10:15 – 10:30</td>
<td>Break</td>
</tr>
<tr>
<td>14:30 – 16:00</td>
<td>10:30 – 12:00</td>
<td>4. Trajectory calculations</td>
</tr>
<tr>
<td>16:00 – 17:15</td>
<td>12:00 – 13:00</td>
<td>Break</td>
</tr>
<tr>
<td>17:15 – 18:30</td>
<td>13:00 – 14:15</td>
<td>5. Trajectory options</td>
</tr>
<tr>
<td>18:30 – 18:45</td>
<td>14:15 – 14:30</td>
<td>Break</td>
</tr>
<tr>
<td>18:45 – 19:45</td>
<td>14:30 – 15:45</td>
<td>6. Trajectory statistics</td>
</tr>
<tr>
<td>19:45 – 20:00</td>
<td>15:45 – 16:00</td>
<td>Day 1 Wrap-up</td>
</tr>
</tbody>
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Note: all times are approximate
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<th>Agenda Item</th>
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<tbody>
<tr>
<td>13:00 – 13:15</td>
<td>09:00 – 09:15</td>
<td>Introduction to Day 2</td>
</tr>
<tr>
<td>13:15 – 14:45</td>
<td>09:15 – 10:45</td>
<td>7. Air Concentration Calculations</td>
</tr>
<tr>
<td>14:45 – 15:00</td>
<td>10:45 – 11:00</td>
<td>Break</td>
</tr>
<tr>
<td>15:00 – 16:30</td>
<td>11:00 – 12:30</td>
<td>8. Configuring the CAPTEX simulation</td>
</tr>
<tr>
<td>16:30 – 17:30</td>
<td>12:30 – 13:30</td>
<td>Break</td>
</tr>
<tr>
<td>17:30 – 19:00</td>
<td>13:30 – 15:00</td>
<td>9. Air Concentration Parameter Sensitivity</td>
</tr>
<tr>
<td>19:00 – 19:15</td>
<td>15:00 – 15:15</td>
<td>Break</td>
</tr>
<tr>
<td>19:15 – 20:00</td>
<td>15:15 – 16:00</td>
<td>10. Alternate Display Options</td>
</tr>
<tr>
<td>20:00 – 20:45</td>
<td>16:00 – 16:45</td>
<td>11. Pollutant Transformations and deposition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(start this section if time permits)</td>
</tr>
<tr>
<td>20:45 – 21:00</td>
<td>16:45 – 17:00</td>
<td>Day 2 Wrap-up / Questions</td>
</tr>
</tbody>
</table>

Note: all times are approximate
## Agenda – Day 3

<table>
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<th>UTC</th>
<th>EDT</th>
<th>Agenda Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:00 – 13:15</td>
<td>09:00 – 09:15</td>
<td>Introduction to Day 3</td>
</tr>
</tbody>
</table>
  *(start today or continue from yesterday)* |
| 14:15 – 14:30 | 10:15 – 10:30 | Break                                                                       |
| 14:30 – 16:00 | 10:30 – 12:00 | 12. Air Concentration Uncertainty                                            |
| 16:00 – 17:00 | 12:00 – 13:00 | Break                                                                       |
| 17:00 – 18:45 | 13:00 – 14:45 | 13. Source Attribution Methods                                               |
| 18:45 – 19:00 | 14:45 – 15:00 | Break                                                                       |
| 19:00 – 19:45 | 15:00 – 15:45 | 14a. Wildfire Smoke                                                          |
| 19:45 – 20:30 | 15:45 – 16:30 | 14b. Dust Storms                                                             |
| 20:30 – 20:45 | 16:30 – 16:45 | Day 3 Wrap-up / questions                                                     |

Note: all times are approximate
Agenda – Day 4

<table>
<thead>
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<th>UTC</th>
<th>EDT</th>
<th>Agenda Item</th>
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</thead>
<tbody>
<tr>
<td>13:00 – 13:15</td>
<td>09:00 – 09:15</td>
<td>Introduction to Day 4</td>
</tr>
<tr>
<td>14:45 – 15:00</td>
<td>10:45 – 11:00</td>
<td>Break</td>
</tr>
<tr>
<td>15:00 – 16:30</td>
<td>11:00 – 12:30</td>
<td>16. Volcanic Eruptions with Gravitational Settling</td>
</tr>
<tr>
<td>16:30 – 17:30</td>
<td>12:30 – 13:30</td>
<td>Break</td>
</tr>
<tr>
<td>17:30 – 18:30</td>
<td>13:30 – 14:30</td>
<td>17. Custom Simulations</td>
</tr>
<tr>
<td>18:30 – 18:45</td>
<td>14:30 – 14:45</td>
<td>Break</td>
</tr>
<tr>
<td>18:45 – 19:45</td>
<td>14:45 – 15:45</td>
<td>Question and answer session with course instructors</td>
</tr>
<tr>
<td>19:45 – 20:00</td>
<td>15:45 – 16:00</td>
<td>Final course wrap-up</td>
</tr>
</tbody>
</table>

Note: all times are approximate