Organization of Course

INTRODUCTION

1. Course overview
2. Air Toxics overview
3. **HYSPLIT overview**

HYSPLIT Theory and Practice

4. Meteorology
5. Back Trajectories
6. Concentrations / Deposition
7. HYSPLIT-SV for semivolatiles (e.g, PCDD/F)
8. HYSPLIT-HG for mercury

Overall Project Issues & Examples

9. Emissions Inventories
10. Source-Receptor Post-Processing
11. Source-Attribution for Deposition
12. Model Evaluation
13. Model Intercomparison
14. Collaboration Possibilities

HYSPLIT Model Overview

- **Trajectories and Dispersion (two completely different models)**
- **Used around the world for**
  - Emergency Response
  - Aviation Safety (volcanos)
  - Comprehensive Test Ban Treaty
  - Interpretation of Pollutant Measurements
  - Fate and Transport Modeling of Pollutants
  - Balloon Flights
- **Lagrangian Model**
  - (but new version 4.9 integrated with Eulerian model)
- **Can be Used in Many Ways:**
  - Via the web
  - On your own computer:
    - From a GUI on your own computer
    - From the command line on your own computer
    - Using batch files and scripts on your own computer
- **"Off-the-Shelf" HYSPLIT**
- **Special Research Versions** – two examples are:
  - HYSPLIT-SV (semivolatiles), e.g., Dioxin, PCB's
  - HYSPLIT-HG (mercury)

Model History

Version (more details at: http://www.arl.noaa.gov/HYSPLIT_updates.php)

1.0 - 1979 rawinsonde data with day/night (on/off) mixing
2.0 - 1983 rawinsonde data with continuous vertical diffusivity
3.0 - 1987 model gridded fields with surface layer interpolation
4.0 - 1996 multiple meteorological fields and combined particle-puff (NOAA Technical Memo ERL ARL-224)

4.0 - 8/1998 - switch from NCAR to PostScript graphics for PC
4.1 - 7/1999 - isotropic turbulence for short-range simulations
4.2 - 12/1999 - terrain compression of sigma and use of polynomial
4.3 - 3/2000 - revised vertical auto-correlation for dispersion
4.4 - 4/2001 - dynamic array allocation and support of lat-lon grids
4.5 - 9/2002 - ensemble, matrix, and source attribution options
4.6 - 6/2003 - non-homogeneous turbulence correction and dust storm
4.7 - 1/2004 - velocity variance, TKE, new short-range equations
4.8 – 2006+ - CMAQ compatibility, expanded ensemble options, plume rise, Google Earth, trajectory clustering, staggered grids
4.9 – 2/2009 - new defaults, transfer particle mass to Eulerian dispersion module, shapefile map backgrounds, improved GUI

A Bit of History…

In the 1940s, with the emergence of the nuclear age, it was clear there was need to understand and predict the transport, dispersion and fallout of radioactive material.

The “Air Resources Laboratory” was first established in 1948 as a Special Projects Section of the U.S. Weather Bureau, now known as the National Weather Service, to provide meteorological expertise for this critical research.

One of the Section’s early tasks was using weather charts and radioactive samples collected by aircraft to estimate the location of the Soviet Union’s atomic bomb test range.

These were some of the first “back-trajectories”

HYSPLIT can be run directly via the internet

ARL Air Resources Laboratory — READY

HOME | HYSPLIT | DISPERSION MODELING | METEOROLOGY | EMERGENCY ASSISTANCE | STATUS | CONTACTS

HYSPLIT
On-line Transport and Dispersion Model

TRAJECTORY MODEL

- Compute trajectories
- Model results
- U.S. Trajectory Forecasts

DISPERSION MODEL

- Compute concentrations
- Model results

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.

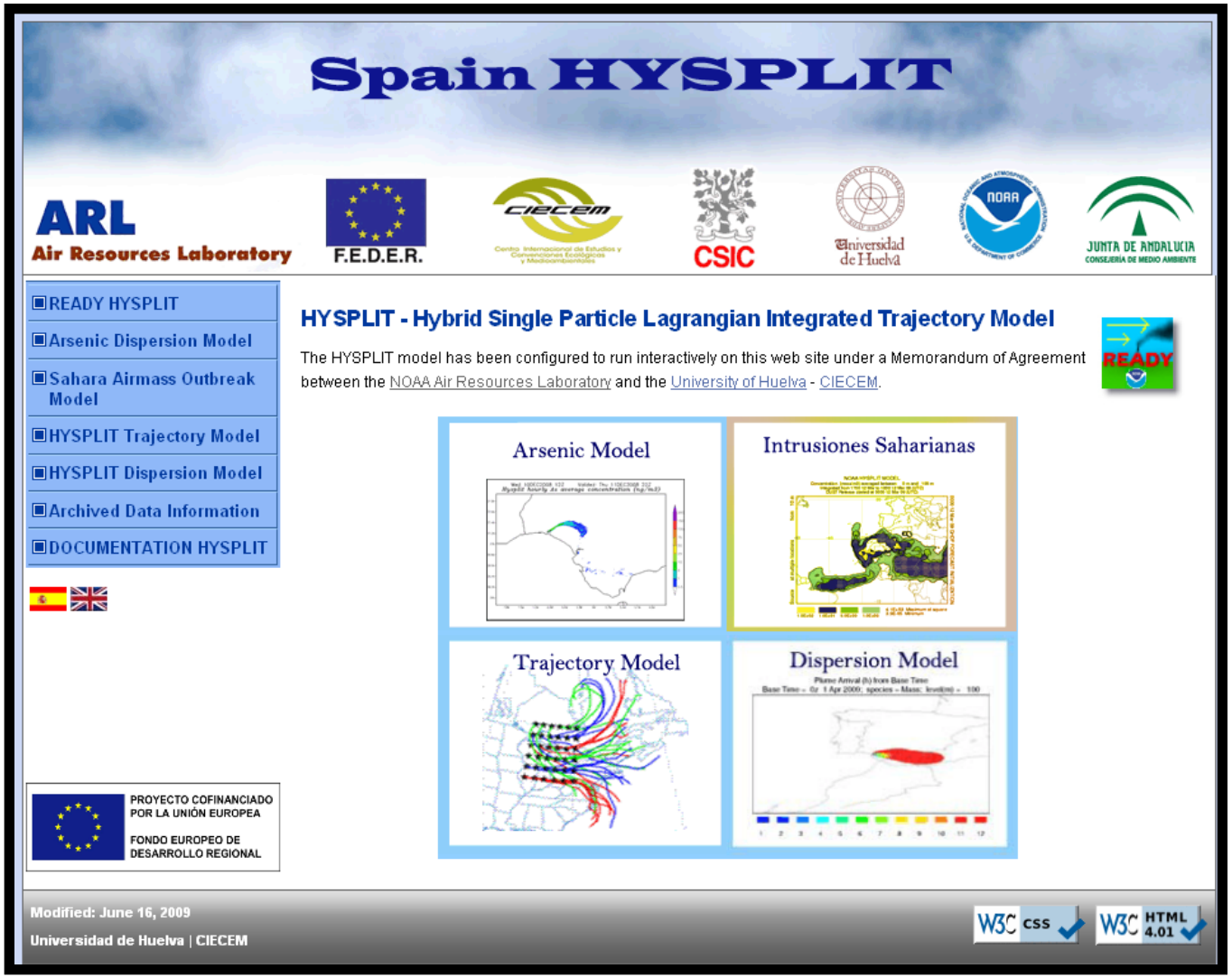
Acknowledgment

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.

- HYSPLIT Use Agreement
- What is UTC, GMT, Z time?
- Questions/Comments?

http://www.ready.noaa.gov/ready/open/hysplit4.html

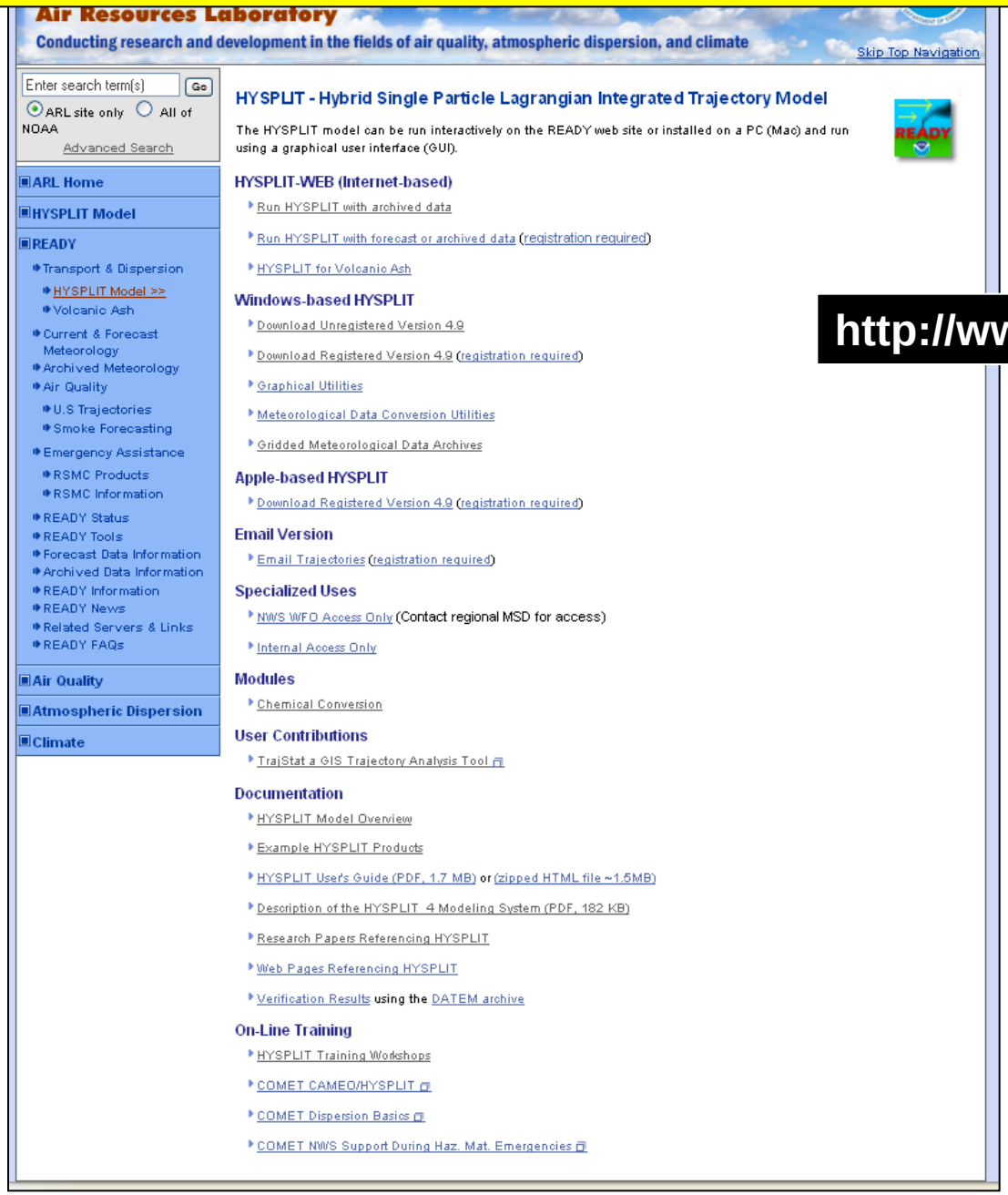
Spanish Version HYSPLIT Web Site being developed in Spain:



They have only translated a few things for now, but are working to make the site fully translated into Spanish

http://www.ciecem.uhu.es/hysplitweb08/HYSPLIT.php

HYSPLIT and its documentation can be downloaded



Air Resources Laboratory

Conducting research and development in the fields of air quality, atmospheric dispersion, and climate

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    - U.S Trajectories
    - Smoke Forecasting
  - Emergency Assistance
    - RSMC Products
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  - Forecast Data Information
  - Archived Data Information
  - READY Information
  - READY News
  - Related Servers & Links
  - READY FAQs
- Air Quality
- Atmospheric Dispersion
- Climate

HYSPLIT - Hybrid Single Particle Lagrangian Integrated Trajectory Model

The HYSPLIT model can be run interactively on the READY web site or installed on a PC (Mac) and run using a graphical user interface (GUI).

HYSPLIT-WEB (Internet-based)

- Run HYSPLIT with archived data
- Run HYSPLIT with forecast or archived data (registration required)
- HYSPLIT for Volcanic Ash

Windows-based HYSPLIT

- Download Unregistered Version 4.9
- Download Registered Version 4.9 (registration required)
- Graphical Utilities
- Meteorological Data Conversion Utilities
- Gridded Meteorological Data Archives

Apple-based HYSPLIT

- Download Registered Version 4.9 (registration required)

Email Version

- Email Trajectories (registration required)

Specialized Uses

- NWS WFO Access Only (Contact regional MSD for access)
- Internal Access Only

Modules

- Chemical Conversion

User Contributions

- TrajStat a GIS Trajectory Analysis Tool

Documentation

- HYSPLIT Model Overview
- Example HYSPLIT Products
- HYSPLIT User's Guide (PDF, 1.7 MB) or (zipped HTML file ~1.5MB)
- Description of the HYSPLIT_4 Modeling System (PDF, 182 KB)
- Research Papers Referencing HYSPLIT
- Web Pages Referencing HYSPLIT
- Verification Results using the DATEM archive

On-Line Training

- HYSPLIT Training Workshops
- COMET CAMEO/HYSPLIT
- COMET Dispersion Basics
- COMET NWS Support During Haz. Mat. Emergencies

http://www.arl.noaa.gov/HYSPLIT.php

3-Day PC-HYSPLIT Course at NOAA given every Spring

(…we won't be able to cover everything today…)

Model Overview

- Model history and features
- Computational method
- Trajectories versus concentration
- Code installation
- Model operation
- Example calculations
- Updating HYSPLIT

Meteorological Data

- Data requirements
- Forecast data FTP access
- Analysis data FTP access
- Display grid domain
- Vertical profile
- Contour data

Examples 1-5

Particle Trajectory Methods

- Trajectory computational method
- Trajectory example calculation
- trajectory model configuration
- Trajectory error
- Multiple trajectories
- Terrain height
- Meteorological analysis along a trajectory
- Vertical motion options

Pollutant Plume Simulations

- Modeling particles or puffs
- Concentration prediction equations
- Turbulence equations
- Dispersion model configuration
- Defining multiple sources
- Simulations using an emissions matrix / file
- Concentration and particle display options
- Converting concentration data to text files
- Time of arrival graphic
- Example local scale dispersion calculation

Special Topics

- Automated trajectory calculations
- Trajectory cluster analysis
- Concentration ensembles
- Chemistry conversion modules
- Pollutant deposition
- Source attribution using back trajectory analysis
- Source attribution using source-receptor matrices
- Source attribution functions
- GIS Shapefile output
- KML/KMZ output
- Customizing map labels
- Scripting for automated operations

Extra Topics

- Modeling PM10 emissions from dust storms
- Restarting the model from a particle dump file

The following documents were used in the first HYSPLIT Training Workshop held in Silver Spring, Maryland, in June 2004.

English Versions

- Agenda: http://www.arl.noaa.gov/documents/workshop/hysplit1/english/agenda.pdf
- Course: http://www.arl.noaa.gov/documents/workshop/hysplit1/english/workshop.pdf

Spanish Versions:

- **Agenda: http://www.arl.noaa.gov/documents/workshop/hysplit1/spanish/agenda.pdf**
- **Course: http://www.arl.noaa.gov/documents/workshop/hysplit1/spanish/workshop.pdf**

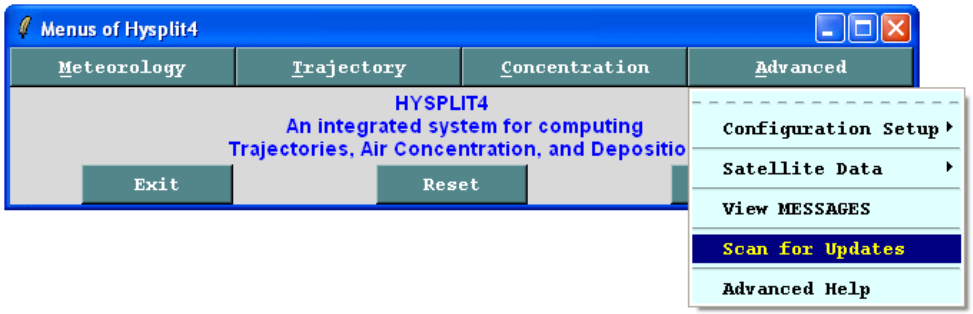
- Example Scripts and Meteorological data from training workshop ftp://arlftp.arlhq.noaa.gov/pub/archives/workshop/hysplit1/working/

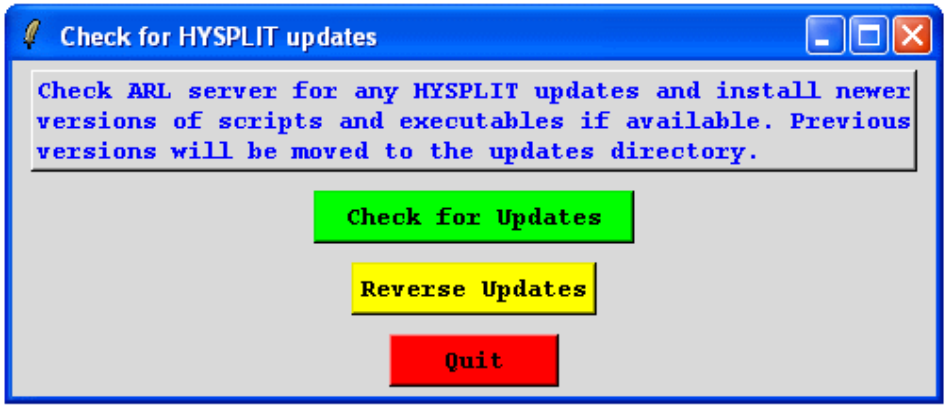
- README: ftp://arlftp.arlhq.noaa.gov/pub/archives/workshop/hysplit1/working/Readme.txt

Updating HYSPLIT

Scan for Updates

- A recent feature was added to the **Advanced** menu called **Scan for Updates**.
- Choosing **Check for Updates** will check the dates of your executables and scripts with those on the ARL server, and if more recent ones are available you will be prompted to replace each with the update.
- Replaced executables and scripts are placed in the updates folder and may be reversed if needed with the **Reverse Updates** option.
- Once a significant number of updates are made, a new version will be posted to the website and must be downloaded and installed manually.
- Only updates to the same version are permitted.





This is the end of the slides to be presented in this portion of the HYSPLIT workshop

The following “extra” slides have been included for reference if needed

Model Features

- Predictor-corrector advection scheme
- Linear spatial & temporal interpolation of meteorology from external sources
- Vertical mixing based upon SL similarity, BL Ri, or TKE
- Horizontal mixing based upon velocity deformation, SL similarity, or TKE
- Puff and particle dispersion computed from velocity variances
- Concentrations from particle-in-cell or top-hat/Gaussian distributions
- Multiple simultaneous meteorology and/or concentration grids

Model Operation

Requirements

A trajectory or concentration simulation only requires one file called CONTROL, which defines various model parameters and other input and output files. An optional file called SETUP.CFG may be present to define more advanced simulation features. The Graphical User Interface (GUI) provides a user-friendly way to create these files, set any other command line options that some of the post-processing graphics programs may require, and run HYSPLIT and associated programs. Alternatively, the **CONTROL** and **SETUP.CFG** files can be created with any text editor, such as Notepad, and then HYSPLIT and its associated programs can be run from the DOS command line.

Starting the model from the GUI

After a successful install, the PC desktop should contain a HYSPLIT shortcut with the following properties:

Target: \hysplit4\guicode\hysplit4.tcl

Start in: \hysplit4\working

The HYSPLIT "Start in" directory contains sample **CONTROL** files that can be used for initial guidance to set up more complex simulations. These can be loaded into the GUI from the **Retrieve** menu tab under the **Trajectory Setup Run** or **Concentration Setup Run** menus. Examples include:

- sample_conc - concentration simulation example from users guide
- sample_traj - trajectory simulation example from users guide
- back_conc - backward dispersion simulation for concentration
- back_traj - backward trajectory simulation

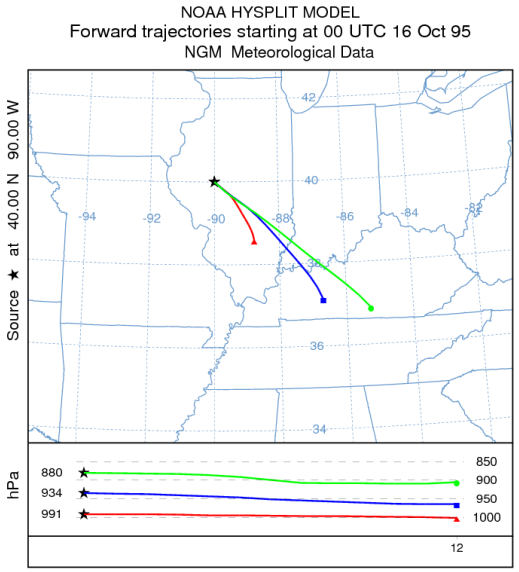
Example Trajectory

Follow these steps to run the sample trajectory case provided with the default installation of PC HYSPLIT

- Start the model by double clicking the HYSPLIT icon on the desktop.
- Click on the green **Menu** button at the bottom of the first screen.
- Click on the **Trajectory** menu tab and choose **Setup Run.**
- Click on the **Retrieve** button at the bottom of the menu.
- Click the **Browse** button and find the file **sample_traj** in the working directory.
- Click **OK.**
- Click **Save** to save the configuration settings.
- Click on the **Trajectory** menu tab and choose **Run Model.**

  (Note: if a menu pops up says that a SETUP.CFG namelist file was found, choose **Delete file then Run)**
- When the model is complete (**Complete Hysplit** is shown), click on the **Exit** button.
- Click on the **Trajectory** menu tab and choose **Display** and then **Trajectory.**
- Click on the **Execute Display** button to display the trajectory in the GSview viewer.

  (Note: if your GSview is not registered, just click the **Ok** button.)
- The resulting 3 trajectories should be identical to those shown to the right. More details on the trajectory model configuration will be given later.



Errors, Etc.

- Occasionally, the HYSPLIT GUI's may become confused if the user enters information and then cancels those inputs prior to running the model. If this occurs, or if any problems prevent the model from producing expected results, exit the model GUI and restart.
- Minor differences in your results compared to the examples in this documentation can be expected due to the random dispersion component generated by the user's computer.

Code Installation

The following optional, but highly suggested, programs should be installed prior to installing HYSPLIT. All of these programs are contained in the Utilities Package (utilities.exe) that can be downloaded from http://www.arl.noaa.gov/HYSPLIT_util.php. (These programs are no longer included in the HYSPLIT installation file.) Install all programs in the suggested default directories to make HYSPLIT installation easier.

- Tcl/Tk - Although the model can also be run from a DOS window using a command line interface, it is easier for novice users to use the GUI menus provided with the installation. These GUI menus use the Tcl/Tk interpreter.
  - Get Tcl/Tk 8.4.14
  - Tcl/Tk Website

- Ghostscript/Ghostview - By default, HYSPLIT creates high-resolution, publication quality graphics in PostScript format. These can be printed directly on any PostScript printer or viewed on the standard PC display and printed on any printer (even non-Postscript) if Ghostscript has been installed.
  - Get Ghostscript 8.13
  - Get Ghostview 4.6
  - Ghostscript Website

- ImageMagick - One feature of the GUI is the ability to convert the Postscript graphics output file to other graphical formats. This capability is enabled through the installation of ImageMagick, which requires the prior installation of Ghostscript.
  - Get ImageMagick 6.3
  - ImageMagick Website

Code Installation

The following optional programs are used to display the HYSPLIT output in a GIS format. In the past we recommended installing ESRI ArcExplorer to display shapefiles (ESRI GIS format), and Google Earth to display kml/kmz files. However, both ESRI's ArcGIS Explorer and Google Earth can now display shapefiles and kml/kmz files. The choice of which one to use is up to you. Install all programs in the default directories to make HYSPLIT installation easier.

- ESRI ArcExplorer - a free GIS application to overlay HYSPLIT output with other GIS layers. ESRI no longer makes version 2.0.800 available on its website, however ArcExplorer 9.2 Java Edition has been tested and does work with HYSPLIT shapefiles. This training uses version 2.0.800.
  - Get ESRI ArcExplorer Version 2.0.800
  - ESRI Website
- Info-ZIP - used to compress kml files into kmz files for use in Google Earth and ESRI ArcGIS.
  - Info-ZIP website
- ESRI ArcGIS - a free GIS application to overlay HYSPLIT output with other GIS layers. Similar to Google Earth, it can display both shapefiles and kml/kmz.
  - ESRI ArcGIS website
- Google Earth - Graphical output from the trajectory and concentration programs can be exported into a compressed kml file (*.kmz) for use in Google Earth; a software package to display geo-referenced information in 3-dimensions. Make sure to read the licensing requirements before installing.
  - Google Earth website

Code Installation

HYSPLIT self-installing executables

Two versions of PC HYSPLIT are available and can be downloaded from the HYSPLIT website. (An Apple version is also available on the website, however this workshop will use the PC version). It is recommended that HYSPLIT be installed in the C:\hysplit4 directory, however it can be installed in other locations. (This document will assume HYSPLIT is installed in the C:\hysplit4 directory).

- setup48U.exe - (~37 Mb) – unregistered version, does not support forecast dispersion simulations, no registration required
- setup48R.exe - (~35 Mb) – registered version, requires web site registration to download

The following sub-directories will be installed with a proper installation of HYSPLIT:

bdyfiles	– surface height, land-use, and roughness length files
cluster	– scripts and files to create trajectory cluster analysis
data2arl	– programs to convert meteorological data into HYSPLIT compatible format
document	– most recent version of the technical documents and User's Guide
examples	– example scripts and configurations
exec	– model executable files
graphics	– map backgrounds, shapefiles, and map customization files
guicode	– tcl scripts required to run the GUI
html	– help document files
qwikcode	– HYSPLIT QWIK user interface (not supplied with public distributions)
testing	– scripts and model configurations to test model from one version to another
uninstall	– programs to uninstall HYSPLIT
updates	– download directory for model updates
utilities	– graphical display utilities
working	– output written here; sample CONTROL files