# HYSPLIT-WEB Short Course

*HY brid S ingle- P article L agrangian I ntegrated T rajectory Model*

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***NOAA Air Resources Laboratory***

**National Air Quality Conference**
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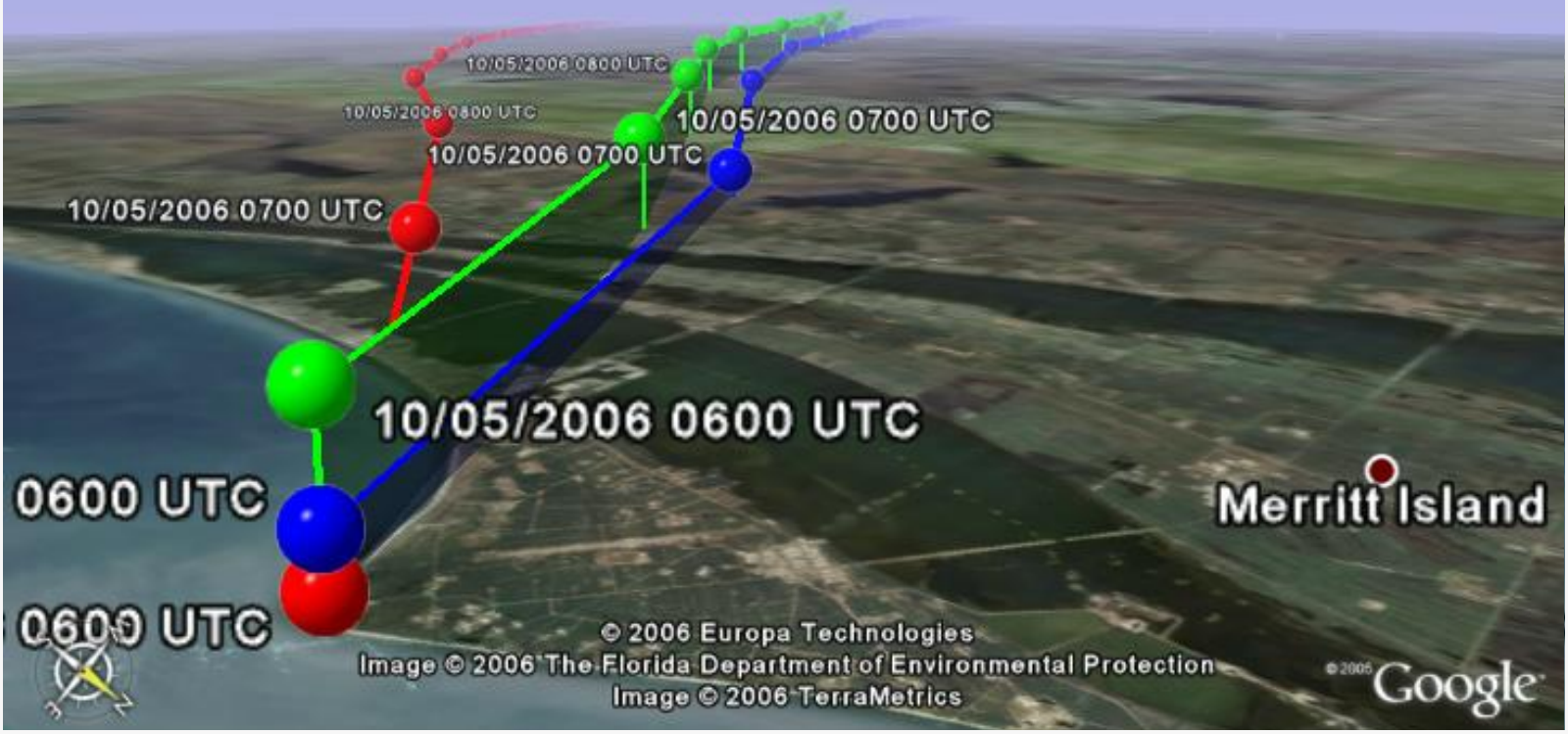
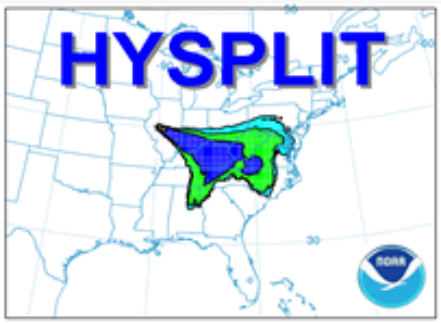



## Section I: Model Overview

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- PC Training Materials
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## HYSPLIT Trajectories in AIRNow-Tech

# Model History & Features



## Version History

**1.0 – 1979** rawinsonde data with day/night (on/off) mixing
NOAA Tech Memo ERL ARL-112 (1982)

**2.0 - 1983** rawinsonde data with continuous vertical diffusivity
NOAA Tech Memo ERL ARL-166 (1988)

**3.0 - 1987** model gridded fields with surface layer interpolation
NOAA Technical Memo ERL ARL-195 (1992)

**4.0 - 1996** multiple meteorological fields and combined particle-puff
NOAA Technical Memo ERL ARL-224 (1997)

**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 & use of polynomial
**4.3 – 3/2000** revised vertical auto-correlation for dispersion
**4.4 – 4/2001** dynamic array allocation and support lat-lon grids
**4.5 – 9/2002** ensemble, matrix, and source attribution options
**4.6 – 6/2003** non-homogeneous turbulence correction, dust storm
**4.7 – 1/2004** velocity variance, TKE, new short-range equations
**4.8 – 6/2006** CMAQ compatibility, expanded ensemble options, plume rise, Google Earth, trajectory clustering, staggered grids

**5.0 - 2008** direct I/O GRIB files and WRF interface

## 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 particles-in-cell or Top-Hat/Gaussian distributions
- Multiple simultaneous meteorology and/or concentration grid

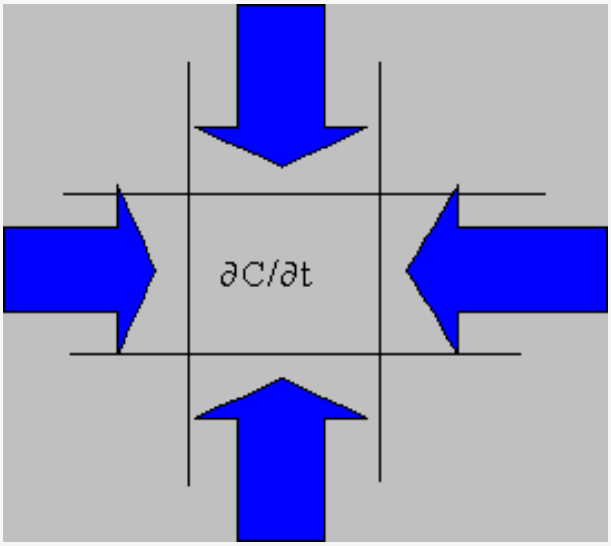
Refer to the HYSPLIT User's Guide to supplement this training material.

# Computational Methods



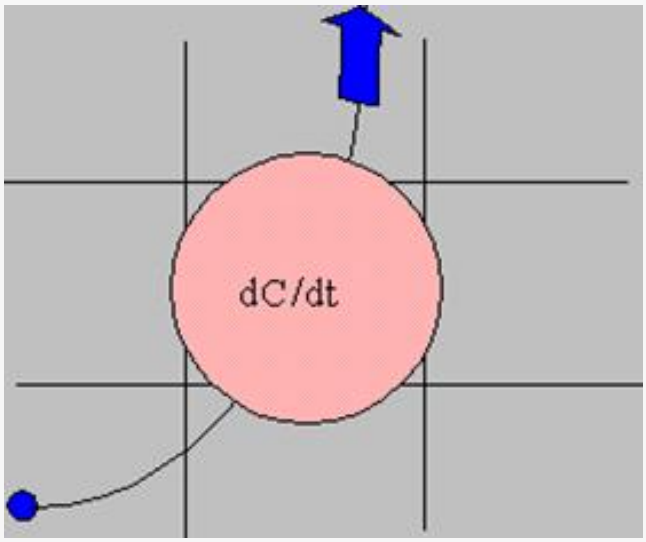
**HIGHLIGHTS**
- Lagrangian vs. Eulerian

### EULERIAN APPROACH




- Local derivative
- Solve over the entire domain
- Ideal for multiple sources
- Easily handles complex chemistry

### LAGRANGIAN APPROACH




- Total derivative
- Solve only along the trajectory
- Ideal for single point sources
- Implicit linearity for chemistry

In the **Eulerian** modeling approach, air concentrations are computed for every grid cell by integrating the pollutant fluxes at each grid cell interface due to diffusion and advection. In the **Lagrangian** modeling approach, air concentrations are computed by summing the contribution of each pollutant puff that is advected through the grid cell as represented by its trajectory. In a Lagrangian model, modeling the growth of the pollutant puff's 2nd moment or explicitly modeling the growth of a cluster of particles can simulate dispersion. Contrary to its acronym, **HYSPLIT** can simulate a pollutant distribution starting with a single particle or puff, or by following the dispersive motion of a large number of particles.

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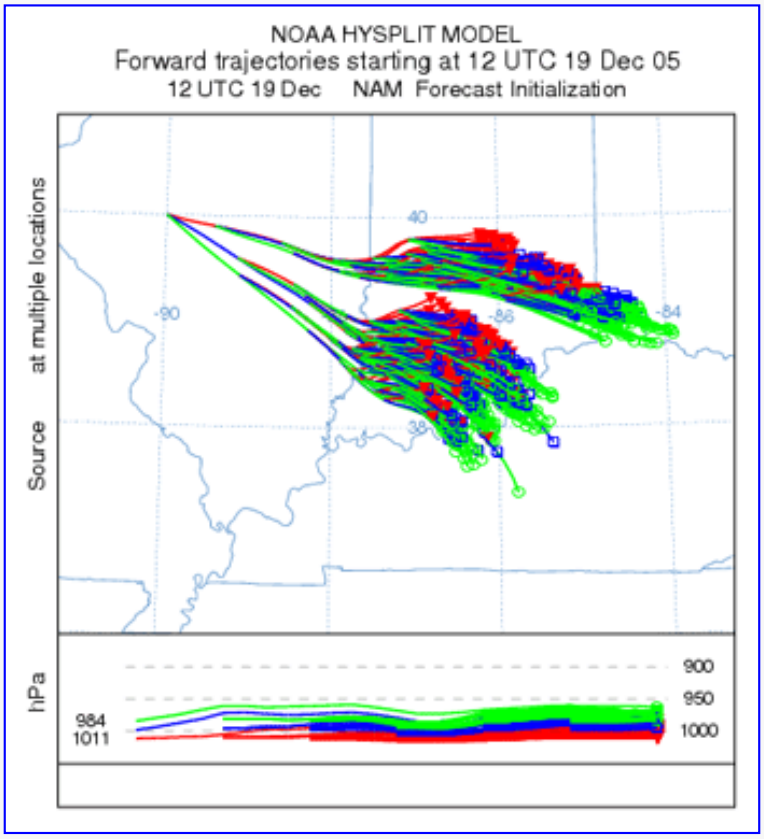
# Trajectories versus Concentration Plumes

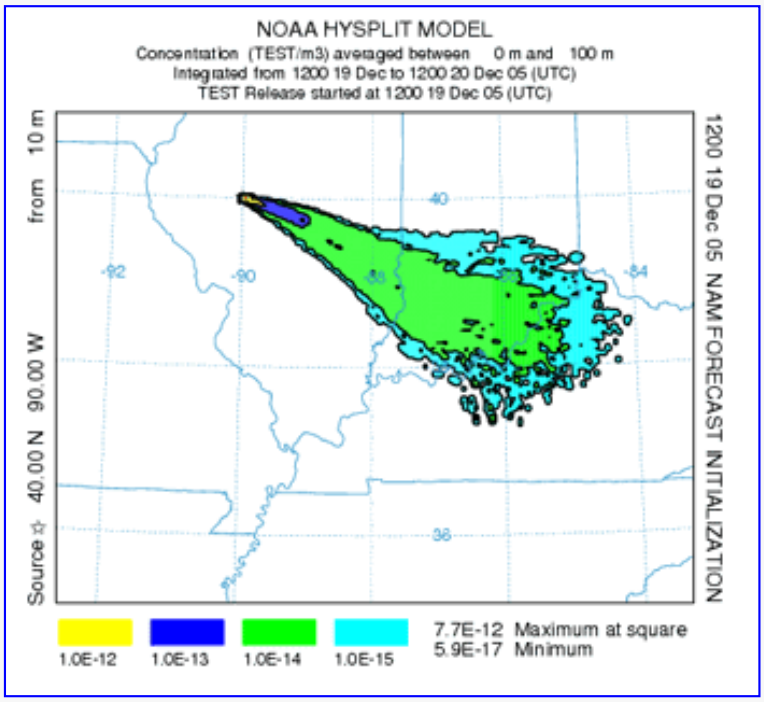


**HIGHLIGHTS**
- Particle, Puff, Hybrid

A “puff” following a single trajectory cannot properly represent the growth of a pollutant cloud when the wind field varies in space and height. In these situations, the single-puff must either split into multiple-puffs or the simulation must be conducted using many pollutant particles. On the left, new trajectories are started every 4-h at 10, 100, and 200 m AGL to represent the boundary layer transport using the NAM 40 km forecast data, while on the right, 2500 particles were used to simulate the air concentration plume. Note how the upper level trajectories (and particles) are to the right of the lower-level trajectories. The CONTROL and SETUP.CFG files used in both of these calculations can be viewed by clicking on the links below each figure.




control & setup.cfg




control & setup.cfg

An hourly animation of the particles used to create the figure on the right can viewed by clicking HERE.

**Particle**: The element (particle) is a point mass of contaminant. A fixed number of particles are released. They are moved by a wind having mean and random components. They never grow or split.

**Puff**: The element is a fully 3-D cylindrical puff (see figure below left), having a defined concentration distribution in the vertical and horizontal. Puffs grow horizontally and vertically according to the dispersion rules for puffs, and split if they become too large.

**Hybrid**: The element is a circular 2-D object (planar mass, having zero vertical depth), in which the horizontal contaminant has a “puff” distribution (see figure below right). There are a fixed number of these in the vertical because they function as particles in that dimension. In the horizontal dimension, they grow according to the dispersion rules for puffs, and split if they get too large.

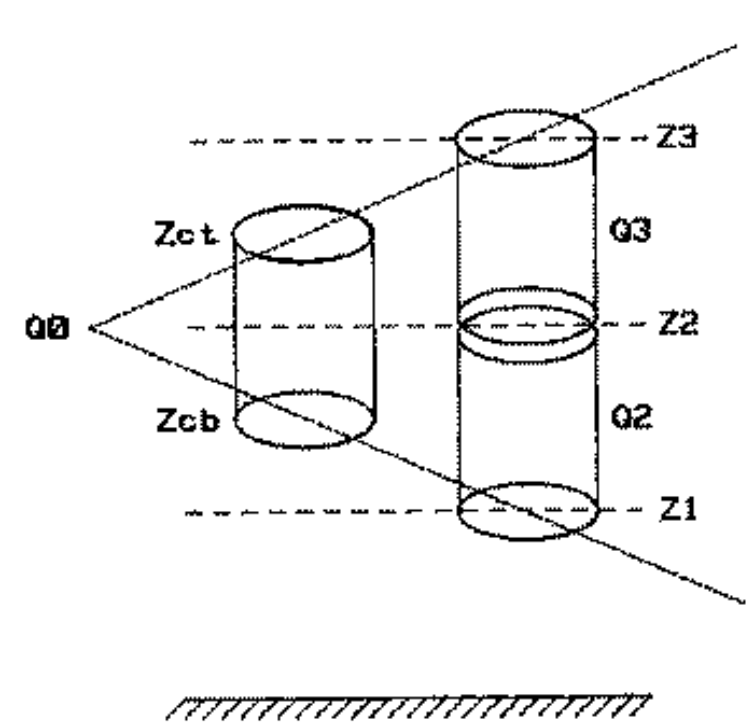



Illustration of how a single particle (Q0) splits due to vertical diffusion into two particles Q2 and Q3.

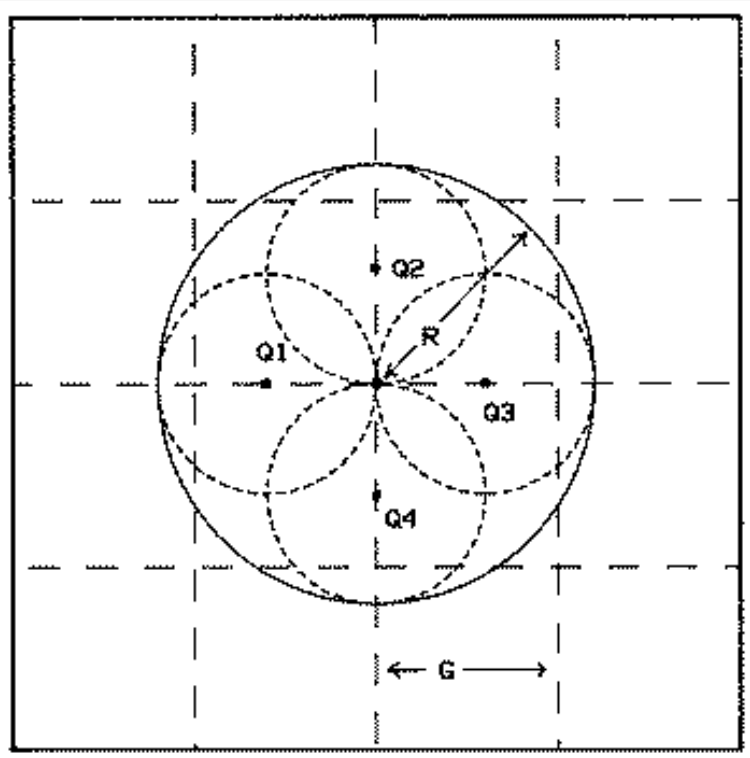



Illustration of how a single particle with radius R splits due to horizontal diffusion into four particles (Q1, Q2, Q3 and Q4) each with radius R/2.

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# Trajectory Equations



If we assume that a particle passively follows the wind, then its trajectory is just the integration of the particle position vector in space and time. The final position is computed from the average velocity at the initial position (P) and first-guess position (P').

$$P(t+\Delta t) = P(t) + 0.5\,[\,V(P,t) + V(P',t+\Delta t)\,]\,\Delta t$$

$$P'(t+\Delta t) = P(t) + V(P,t)\,\Delta t$$

The integration time step is variable:

$$V_{max}\,\Delta t < 0.75$$

The meteorological data remain on its native horizontal coordinate system. However, the meteorological data are interpolated to an internal terrain-following ($\sigma$) vertical coordinate system:

$$\sigma = (Z_{top} - Z_{msl}) / (Z_{top} - Z_{gl})$$

$Z_{top}$ - top of the trajectory model's coordinate system

$Z_{gl}$ - height of the ground level

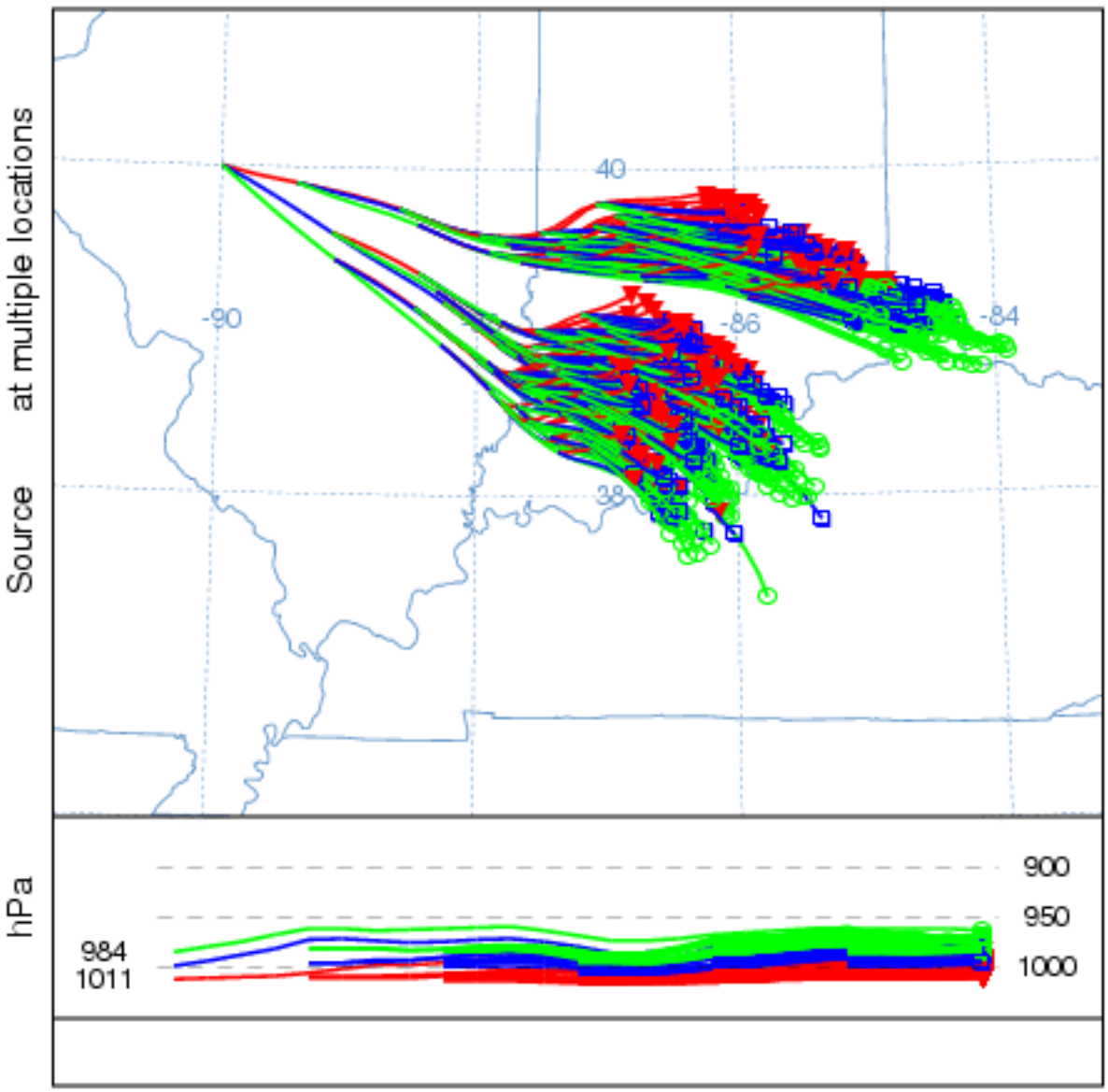
$Z_{msl}$ - height of the internal coordinate

The model's internal heights can be chosen at any interval, however a quadratic relationship between height and model level is specified, such that each level's height with respect to the model's internal index, k, is defined by

$$Z_{agl} = ak^2 + bk + c$$

The constants are automatically defined such that the model's internal resolution has the same or better vertical resolution than the input data.

NOAA HYSPLIT MODEL
Forward trajectories starting at 12 UTC 19 Dec 05
12 UTC 19 Dec NAM Forecast Initialization

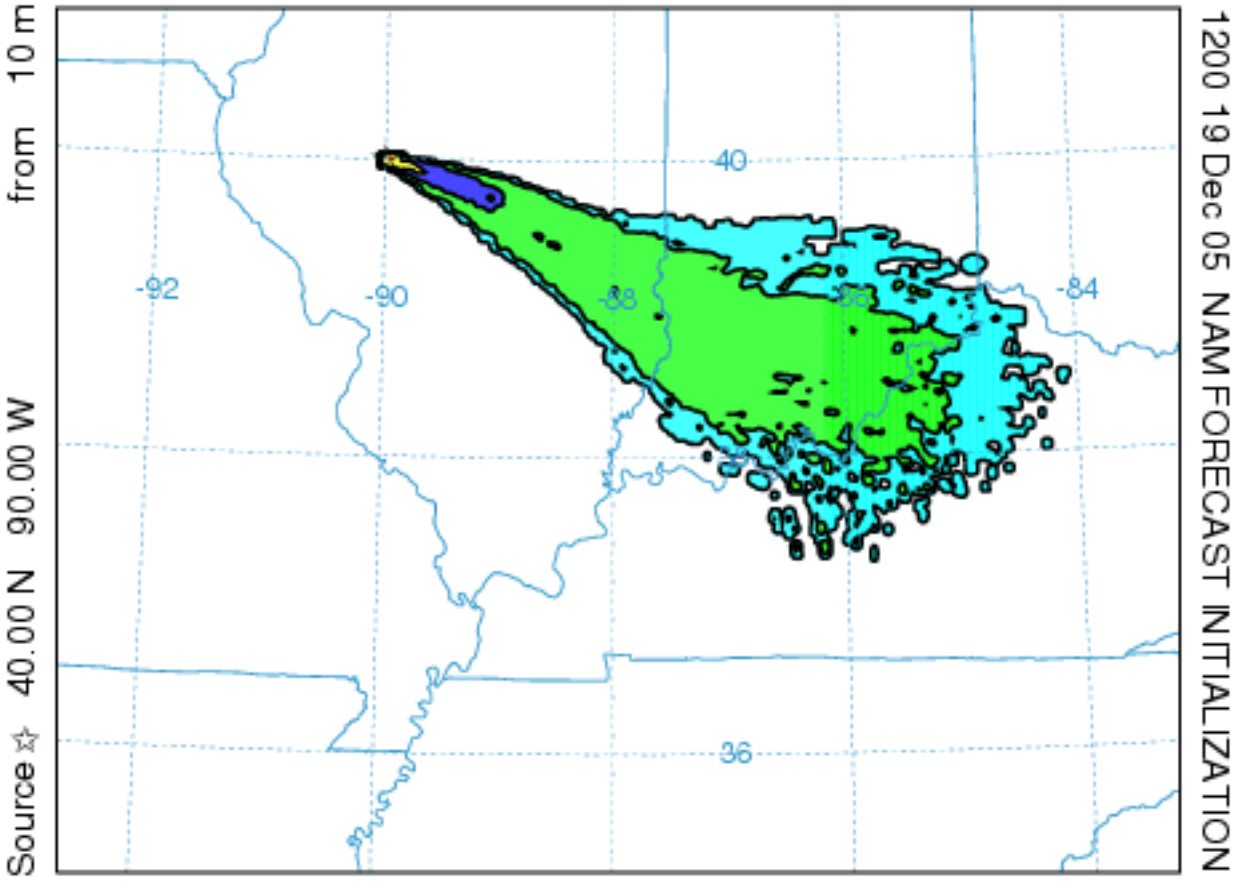


NOAA HYSPLIT MODEL

Concentration (TEST/m3) averaged between 0 m and 100 m

Integrated from 1200 19 Dec to 1200 20 Dec 05 (UTC)

TEST Release started at 1200 19 Dec 05 (UTC)




1.0E-12 1.0E-13 1.0E-14 1.0E-15

7.7E-12 Maximum at square

5.9E-17 Minimum

00 00 00 00
3
40.0 -90.0 10.0
40.0 -90.0 100.0
40.0 -90.0 200.0
24
0
10000.0
1
C:/hysplit4/working/
NAMF40
./
tdump

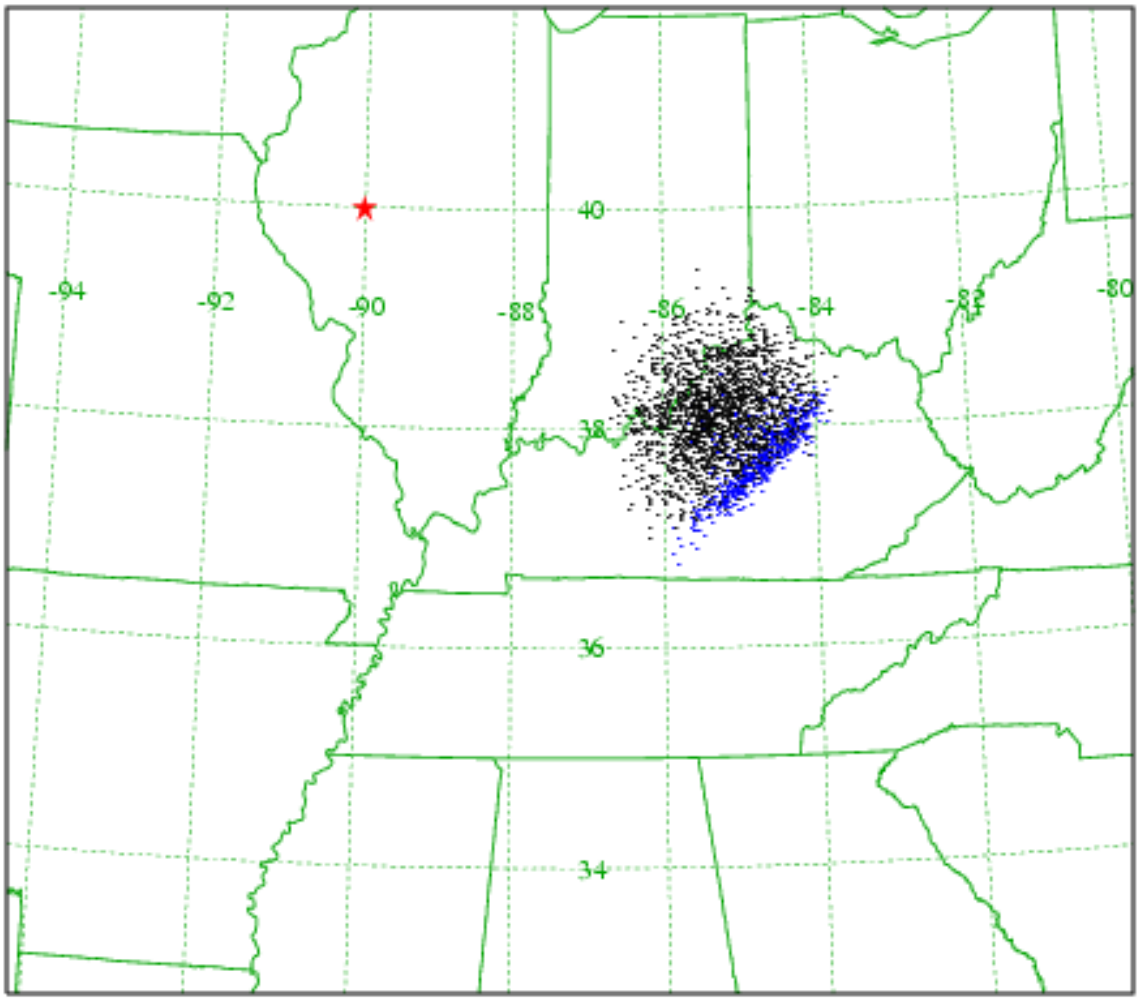
```
&SETUP
tratio = 0.75,
mgmin = 10,
khmax = 9999,
kmsl = 0,
nstr = 4,
mhrs = 9999,
nver = 3,
tout = 60,
tm_tpot = 0,
tm_tamb = 0,
tm_rain = 0,
tm_mixd = 0,
tm_relh = 0,
tm_dswf = 0,
tm_terr = 1,
dxf = 1.0,
dyf = 1.0,
dzf = 0.01,
/
```

00 00 00 00
1
40.0 -90.0 10.0
24
0
10000.0
1
C:/hysplit4/working/
NAMF40
1
TEST
1.0
1.0
00 00 00 00 00
1
0.0 0.0
0.03 0.03
20.0 20.0
./
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

```
&SETUP
tratio = 0.75,
initd = 0,
kpuff = 0,
khmax = 9999,
numpar = 2500,
qcycle = 0.0,
isot = 0,
ninit = 1,
ndump = 0,
ncycl = 0,
pinpf = 'PARINIT',
poutf = 'PARDUMP',
mgmin = 10,
kmsl = 0,
maxpar = 10000,
cpack = 1,
cmass = 0,
dxf = 1.0,
dyf = 1.0,
dzf = 0.01,
ichem = 0,
/
```

# NOAA HYSPLIT MODEL

PARTICLE POSITIONS AT 12 UTC 20 Dec 05




LAYER (m): < 500 < 1000 < 1500 < 2000 < 2500

NUMBER OF PARTICLES ON GRID: 2490

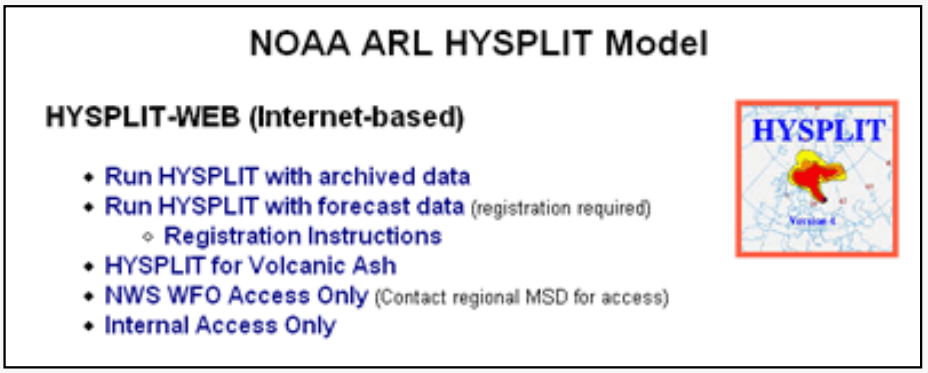
# HYSPLIT-WEB Interface



## Main Menu Overview

HYSPLIT-WEB is available in five versions or interfaces. An open version is available for running HYSPLIT using only archived meteorology (no forecasts can be run). This version is labeled, **Run HYSPLIT with archive data**, and is available as the first menu item on the main HYSPLIT-WEB page at:

**http://www.arl.noaa.gov/ready/hysplit4.html**




The second menu item labeled, **Run HYSPLIT with forecast data**, which this training is based on, requires a username and password and provides access to both archive and forecast meteorology as well as some advanced features of HYSPLIT. A username and password can be obtained by registering with NOAA ARL at the link provided on the web page. To qualify for registration the user must be affiliated with an institution engaged in atmospheric sciences or in the provision of atmospheric operational products, and whose credentials can be verified. However, some exceptions can be made on a case-by-case basis.

The third menu item labeled, **HYSPLIT for Volcanic Ash**, provides access to current ash forecasts, hypothetical eruptions, and the ability to run HYSPLIT preconfigured for volcanic ash simulations. This site is also open to the public.

The fourth menu item labeled, **NWS WFO Access Only**, provides National Weather Service Weather Forecast Offices (WFOs) access to a version of HYSPLIT preconfigured for NWS emergency response needs, This site is password- protected and is only available to WFOs.

The last menu item labeled, **Internal Access Only**, is used by NOAA ARL to test and evaluate new additions to HYSPLIT-WEB and to provide advanced options not yet implemented in the other versions. This site is also password-protected.

## Pre-installation Program Options

The following optional, but highly suggested, programs should be installed prior to running HYSPLIT-WEB. These programs may already be installed locally if PC HYSPLIT has been installed previously.

- Install Ghostscript and GSView to display and print the PostScript output
- Install ArcExplorer 2
- Install Google Earth

# Model Operation

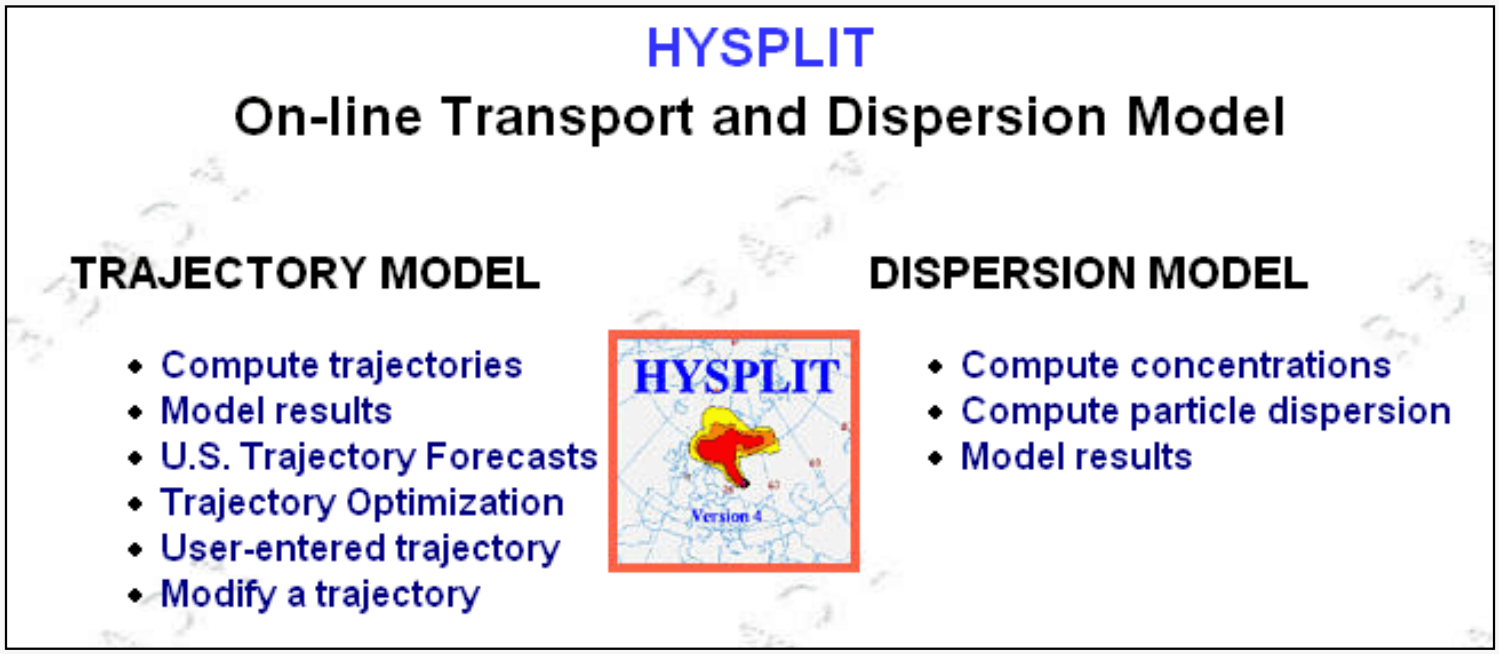


## Requirements

In both the PC and WEB versions of HYSPLIT 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 WEB interface, like the PC Graphical 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 any associated programs.

## Starting a HYSPLIT-WEB run

After clinking on the link labeled, **Run HYSPLIT with forecast data**, and entering your username (your email address) and password (both of which are case sensitive) a menu giving many additional options is presented. Throughout the remainder of this document, this menu will be referred to as the **Main Menu**. The Main Menu is divided into 2 sections, the Trajectory Model (left) and the Dispersion Model (right). This training will focus on the Trajectory Model and only on the first 3 options, **Compute trajectories, Model results, and U.S. Trajectory Forecasts. Compute trajectories** is the link to running HYSPLIT trajectories. **Model results** provides access to previously computed trajectories (up to 24 hours) and **U.S. Trajectory Forecasts** links to daily precomputed trajectories for various locations in the U.S.



Sample input CONTROL file

```
00 00 00 00             Start year, month, day, hour
1                       Number of starting locations
40.0 -90.0 10.0         Starting latitude, longitude, height
48                      Simulation duration in hours
0                       Vertical motion option
10000.0                 Top of model domain in meters
1                       Number of meteorological input files
../metdata/             Directory of 1st meteorological file
oct1618.BIN             Name of 1st meteorological file
1                       Number of pollutants emitted from source
TEST                    Four-character pollutant name
1.0                     Emission rate units per hour
1.0                     Emission duration in hours
00 00 00 00 00          Start time of emission year, month, day, hour, min
1                       Number of concentration output grids
0.0 0.0                 Center latitude,longitude of the grid
0.5 0.5                 Concentration grid resolution in degrees
30.0 30.0               Latitude and longitude span of the grid
./                      Directory of the output grid
cdump                   File name of the output grid
1                       Number of concentration output levels
100                     Height of the concentration output
00 00 00 00 00          Starting time of the output (y,m,d,h,m)
00 00 00 00 00          Ending time of the output (y,m,d,m)
00 12 00                Averaging flag, averaging interval hrs, and minutes
1                       Number of pollutants
0.0 0.0 0.0             Particle diameter, density, shape
0.0 0.0 0.0 0.0 0.0     Velocity, mol-wt, activity and diffusivity ratios, henry's
0.0 0.0 0.0             In cloud Henry's, and scavenging coef, and ratio
0.0                     Radioactive decay half-life
0.0                     Resuspension factor
```

Sample SETUP.CFG Namelist File

```
&SETUP
tratio = 0.75,      Time step stability ratio
initd = 4,          Initial particle distribution
khmax = 9999,       Maximum age of any particle
numpar = 500,       Particles released during ONE emission cycle
qcycle = 0.0,       Emission cycling interval in hours
isot = 0,           Isotropic turbulence flag
ndump = 0,          Initial particle dump in hours
ncycl = 0,          Particle dump interval in hours
mgmin = 10,         Initial meteorological sub-grid size
kmsl = 0,           Treat input heights as above mean-sea-level flag
maxpar = 10000,     Maximum number of particles permitted
cpack = 1,          Concentration packing flag
dxf = 1.0,          Ensemble option x-direction grid offset
dyf = 1.0,          Ensemble option y-direction grid offset
dzf = 0.01,         Ensemble option z-direction grid offset
ichem = 0,          Chemistry modules flag
/
```

# Meteorological Data Requirements



## File characteristics and projection

HYSPLIT requires that meteorological data fields be projected on a conformal map projection (Polar Stereographic, Lambert, or Mercator) or a regular latitude-longitude grid. The data must be organized with one record per variable per level and all records must have the same record length. Records are written in a forward time sequence. More details on the format and packing of the meteorological data can be found in the HYSPLIT User's Guide.

(The PC Version contains several command line programs (**chk_data**, **chk_rec**) and one GUI program (**chk_file**) that can be used to analyze a HYSPLIT compatible meteorological data file, however these programs are not available on HYSPLIT-WEB.)

## Meteorological Variables

A unique 4-character string identifies meteorological variables. The minimum requirements to run the model are the U and V wind components (**UWND**, **VWND**), ambient temperature (**TEMP**), height (**HGTS**) of the data level (if on pressure coordinates), and the surface pressure (**PRSS**). A sample extract of the **chk_file** program is shown below for the NAM 12 km data set for levels between the surface and 925 hPa.

```
Index     Level  #   Variable listing and checksum values
.....
   5   925.0000  7   UWND 108  VWND 236  HGTS 230  TEMP 123  WWND  82  RELH  20
                 TKEN  47
   4   950.0000  7   UWND 147  VWND 129  HGTS 103  TEMP  89  WWND 155  RELH 121
                 TKEN  86
   3   975.0000  7   UWND  47  VWND 209  HGTS 178  TEMP 193  WWND 125  RELH 252
                 TKEN  82
   2  1000.0000  7   UWND  49  VWND 234  HGTS 138  TEMP 124  WWND 234  RELH  62
                 TKEN 198
   1     0.0000 14   SHGT 101  MSLP 235  TPP3 184  CPP3 184  T02M 215  RH2M  41
                 U10M 119  V10M 212  PRSS  53  LHTF 120  SHTF 206  USTR 215
                 RGHS 177  DSWF 194
```

## Data Records

Each data record is composed of a 50 byte ASCII header portion, describing the data packing, followed by the packed data of length (I*J bytes). A one-byte per element “difference packing” is used for all data fields. The first data record (**INDX**) of each time period contains information on the variables, levels, grid, and checksums. A sample extract of the final section from **chk_file** is shown below for the NAM 12 km data set.

```
     #  YYMMDDHHFHLLGG FLD EXP    PRECISION       VAR(1,1)
```

```
 1   5121912 0 099INDX   0 0.0000000E+00 0.0000000E+00
 2   5121912 0 099SHGT  11 0.8062992E+01 0.0000000E+00
 3   5121912 0 099MSLP   4 0.6299213E-01 0.1016970E+04
 4   5121912 0 099TPP3   1 0.7874016E-02 0.0000000E+00
 5   5121912 0 099CPP3   1 0.7874016E-02 0.0000000E+00
 6   5121912 0 099T02M   4 0.6299213E-01 0.2983304E+03
 7   5121912 0 099RH2M   6 0.2519685E+00 0.8621770E+02
 8   5121912 0 099U10M   4 0.6299213E-01-0.7976649E+01
 9   5121912 0 099V10M   4 0.6299213E-01 0.1462120E+01
10   5121912 0 099PRSS   7 0.5039370E+00 0.1017162E+04
11   5121912 0 099LHTF   9 0.2015748E+01-0.1431365E+03
12   5121912 0 099SHTF   9 0.2015748E+01-0.1035156E+02
13   5121912 0 099USTR -25 0.1173320E-09 0.1000000E+00
14   5121912 0 099RGHS  -2 0.9842520E-03 0.1590000E-04
15   5121912 0 099DSWF   7 0.5039370E+00 0.0000000E+00
16   5121912 0 199UWND   4 0.6299213E-01-0.9166061E+01
17   5121912 0 199VWND   4 0.6299213E-01 0.1795837E+01
18   5121912 0 199HGTS   5 0.1259843E+00 0.1470268E+03
19   5121912 0 199TEMP   4 0.6299213E-01 0.2967743E+03
20   5121912 0 199WWND  -6 0.6151575E-04 0.8997059E-03
21   5121912 0 199RELH   6 0.2519685E+00 0.8856895E+02
22   5121912 0 199TKEN   4 0.6299213E-01 0.5000000E+00
23   5121912 0 299UWND   4 0.6299213E-01-0.9460953E+01
24   5121912 0 299VWND   4 0.6299213E-01 0.1790451E+01
25   5121912 0 299HGTS   5 0.1259843E+00 0.3694624E+03
26   5121912 0 299TEMP   4 0.6299213E-01 0.2946380E+03
27   5121912 0 299WWND  -5 0.1230315E-03 0.1221895E-02
28   5121912 0 299RELH   6 0.2519685E+00 0.9656725E+02
29   5121912 0 299TKEN   5 0.1259843E+00 0.7500000E+00
.........
```

## Concatenating Meteorology Files

HYSPLIT compatible meteorology files can be concatenated by using the UNIX *cat* or DOS *type* command. For example, to concatenate file2 to the end of file1 in a DOS window type:

**type file2 >> file1**

and for UNIX type:

**cat file2 >> file1**

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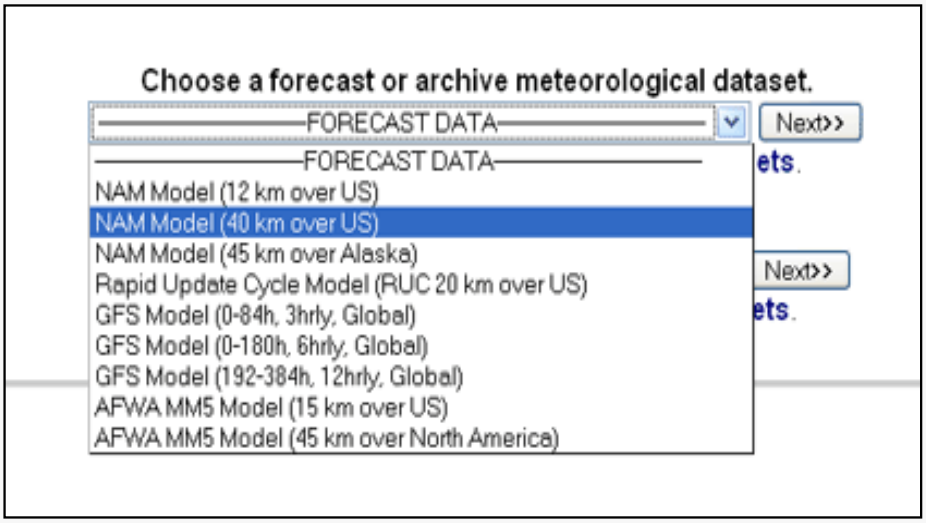
# Forecast Meteorological Data



**HIGHLIGHTS**
- Forecast meteorological data




The next menu presents the user with the choice of using forecast or archived meteorology. Drop-down menus list the data sets available for running HYSPLIT-WEB. Currently, there are 9 forecast data sets available under the **FORECAST DATA** drop-down menu, all of which are stored on internal NOAA ARL computers. The NAM, RUC and GFS data sets are obtained from **NOAA's National Centers for Environmental Prediction (NCEP)** in a standard format called **Gridded Binary (GRIB)** format and then automatically converted to HYSPLIT compatible format. The AFWA MM5 data sets are obtained in a similar fashion from the **Air Force Weather Agency (AFWA)**.

## Forecast Data Sets

The forecast data sets cover 3 geographic domains:
**Regional**

- **NAM Alaska** (North American Mesoscale - 45 km, 3 hourly to 36 hrs, 4 per day),

**North America**

- **NAM** (North American Mesoscale - 12 km, 3 hourly to 48 hrs, 4 per day),
- **NAM** (North American Mesoscale - 40 km, 3 hourly to 84 hrs, 4 per day),
- **RUC** (Rapid Update Cycle - 20 km, hourly to 12 hrs, 8 per day),
- **AFWA MM5** (Air Force Weather Agency MM5 - 15 km, 3 hourly to 48 hrs, 2 per day),
- **AFWA MM5** (Air Force Weather Agency MM5 - 45 km, 3 hourly to 72 hrs, 4 per day).

**Global latitude-longitude grids**

- **GFS** (Global Forecast System - 1 degree, 3 hourly to +3.5 days, 4 per day),
- **GFSX** (Global Forecast System - 1 degree, 6 hourly to +7.5 days, 4 per day),
- **GFSLR** (Global Forecast System - 2.5 degree, 12 hourly from +8 to +16 days, 4 per day).

More information on the forecast meteorological data can be found by clicking on the link below the drop-down list or by clicking here: **forecast data**.

| # | FIELD ID | CONVERSION FACTOR | UNITS | CONTOUR INTERVAL | DESCRIPTION |
|---|---|---|---|---|---|
| 3 | NULL | 1.00 | | 0.00 | MISSING DATA |
| 1 | TMPS | 1.00 | DEGC | 0.00 | SURFACE TEMPERATURE |
| 1 | VSBY | .001 | KM | 10.00 | VISIBILITY |
| 1 | MSLP | 1.00 | HPA | 4.00 | MEAN SEA-LEVEL PRESSURE |
| 1 | PRSS | 1.00 | HPA | 0.00 | SURFACE PRESSURE |
| 1 | ICWT | 1.00 | 0--1 | .00 | ICE-COVERED WATER |
| 1 | SNOW | 1.00 | 0--1 | .00 | SNOW COVERAGE |
| 1 | SNWD | 1.00 | CM | 1.00 | SNOW DEPTH |
| 1 | SHGT | 1.00 | M | 0.00 | SURFACE HEIGHT |
| 1 | TOPO | 1.00 | M | 0.00 | TOPOGRAPHY |
| 1 | CPPT | 1.00 | MM | 5.00 | CONVECTIVE PRECIPITATION |
| 1 | TPP3 | 1.00 | MM | 1.00 | 3-HOUR ACCUMULATED PRECIPITATION |
| 1 | CPP3 | 1.00 | MM | 1.00 | 3-HOUR ACC. CONVECTIVE PRECIPITATION |
| 1 | TPP6 | 1.00 | MM | 5.00 | 6-HOUR ACCUMULATED PRECIPITATION |
| 1 | CPP6 | 1.00 | MM | 5.00 | 6-HOUR ACC. CONVECTIVE PRECIPITATION |
| 1 | TPPT | 1.00 | MM | 5.00 | 12-HOUR ACCUMULATED PRECIPITATION |
| 1 | TPPA | 1.00 | MM | 5.00 | TOTAL ACCUMULATED PRECIPITATION |
| 1 | PRAT | 1.00 | KGM2 | 0.00 | PRECIPITATION RATE |
| 1 | HFLX | 1.00 | W/M2 | 25.00 | LATENT HEAT FLUX |
| 1 | SHTF | 1.00 | W/M2 | 0.00 | SENSIBLE HEAT NET FLUX |
| 1 | LHTF | 1.00 | W/M2 | 0.00 | LATENT HEAT NET FLUX |
| 1 | ULWF | 1.00 | W/M2 | 0.00 | UPWARD LONG WAVE RADIATION FLUX |
| 1 | DLWF | 1.00 | W/M2 | 0.00 | DOWNWARD LONG WAVE RADIATION FLUX |
| 1 | DSWF | 1.00 | W/M2 | 0.00 | DOWNWARD SHORT WAVE RADIATION FLUX |
| 1 | QSTR | 1000.00 | G/KG | 1.00 | FLUX MIXING RATIO |
| 1 | WFLX | 1000.00 | GM2S | 1.00 | WATER VAPOR FLUX |
| 1 | EXCO | 1000.00 | GM2S | 0.00 | EXCHANGE COEFFICIENT |
| 3 | MXLR | 1.00 | 0--N | 1.00 | NUMBER OF MIXED SIGMA LAYERS |
| 1 | MXHT | 1.00 | M | 0.00 | MIXED LAYER DEPTH |
| 1 | PBLH | 1.00 | M | 0.00 | PLANETARY BOUNDARY LAYER HEIGHT |
| 1 | THTS | 1.00 | DEFC | 5.00 | SURFACE POTENTIAL TEMPERATURE |
| 1 | U10M | 1.00 | M/S | .00 | 10 M U-WIND COMPONENT |
| 1 | V10M | 1.00 | M/S | .00 | 10 M V-WIND COMPONENT |
| 1 | UMOF | 1.00 | N/M2 | 0.00 | MOMENTUM FLUX, U-WIND COMPONENT |
| 1 | VMOF | 1.00 | N/M2 | 0.00 | MOMENTUM FLUX, V-WIND COMPONENT |
| 1 | MOMF | 1.00 | N/M2 | 0.00 | TOTAL MOMENTUM FLUX |
| 1 | DEPV | 1.00 | M/S | 0.01 | DEPOSITION VELOCITY |
| 1 | USTR | 100.00 | M/S | 10.00 | FRICTION VELOCITY |
| 1 | TSTR | 1.00 | DEGC | 0.00 | FLUX TEMPERATURE |
| 1 | VGTP | 1.00 | 0--1 | 1.00 | VEGETATION TYPE |
| 1 | T02M | 1.00 | DEGC | 5.00 | 2 M TEMPERATURE |
| 2 | TEMP | 1.00 | DEGC | 0.00 | TEMPERATURE |
| 2 | UWND | 1.00 | M/S | 5.00 | U-WIND COMPONENT |
| 2 | VWND | 1.00 | M/S | 5.00 | V-WIND COMPONENT |
| 2 | FLAG | 1.00 | KNTS | 0.00 | WIND FLAGS |
| 2 | WVCT | 1.00 | KNTS | 0.00 | WIND VECTORS |
| 2 | STRM | 1.00 | KNTS | 0.00 | STREAMLINES |
| 2 | WSPD | 1.00 | KNTS | 5.00 | WIND SPEED |
| 2 | WWND | 3600.00 | MB/H | 5.00 | W-WIND COMPONENT |
| 2 | SPHU | 1000.00 | G/KG | 1.00 | SPECIFIC HUMIDITY |

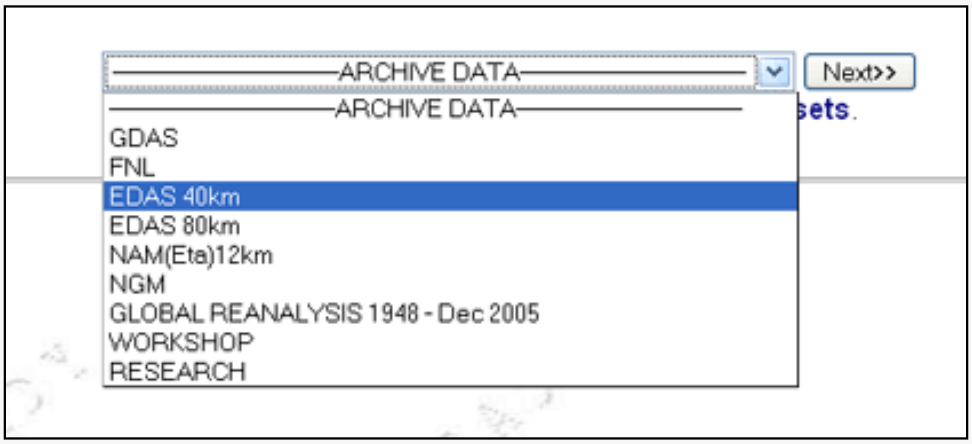
| | | | | |
|---|---|---|---|---|
| 2 RELH | 1.00 | PCT | 20.00 | RELATIVE HUMIDITY |
| 1 DP2M | 1.00 | DEGC | 0.00 | 2 M DEW POINT |
| 2 HGTS | 0.10 | DM | 6.00 | HEIGHT |
| 2 TKEN | 1.00 | JOUL | 0.00 | TOTAL KINETIC ENERGY |
| 2 PRES | 1.00 | HPA | 4.00 | PRESSURE |
| 1 THKN | 0.10 | DM | 6.00 | THICKNESS |
| 3 HGT1 | 1.00 | M | 60.00 | 1000 MB HEIGHT |
| 3 HGT5 | 1.00 | M | 60.00 | 500 MB HEIGHT |
| 3 ABSV | 100000.00 | /S | 2.00 | ABSOLUTE VORTICITY |
| 3 CONC | 1.00 | /M3 | .00 | CONCENTRATION |
| 1 SFCC | 1.00 | /M3 | .00 | SURFACE CONCENTRATION |
| 1 DEPS | 1.00 | /M2 | .00 | SURFACE DEPOSITION |
| 1 DEPO | 1.00 | /M2 | .00 | SURFACE DEPOSITION |
| 1 OPPT | 1.00 | MM | .25 | OBSERVED PRECIPITATION |
| 1 TPP1 | 1.00 | M | .00 | 1 HOUR ACCUMULATED PRECIPITATION |
| 1 SOLW | 1.00 | KG/M2 | .00 | 0 TO 200 CM SOIL MOISTURE CONTENT |
| 1 SOLT | 1.00 | DEGC | .00 | SOIL TEMPERATURE |
| 1 SOLM | 1.00 | KG/M2 | .00 | SOIL MOISTURE |
| 1 RH2M | 1.00 | PCT | 20.00 | 2 METER RELATIVE HUMIDITY |
| 3 P10M | 1.00 | K | .00 | POTENTIAL TEMPERATURE |
| 3 WESD | 1.00 | KG/M2 | .00 | WATER EQUIV. OF ACCUM. SNOW DEPTH |
| 3 SNOC | 1.00 | PCT | 10.00 | SNOW COVERAGE |
| 3 CSNO | 1.00 | 0--1 | .50 | CATEGORIAL SNOW (YES=1/NO=0) |
| 3 CICE | 1.00 | 0--1 | .50 | CATEGORIAL ICE PELLETS (YES=1/NO=0) |
| 3 CFZR | 1.00 | 0--1 | .50 | CATEGORIAL FREEZING RAIN (YES=1/NO=0) |
| 3 CRAI | 1.00 | 0--1 | .50 | CATEGORIAL RAIN (YES=1/NO=0) |
| 3 PTYP | 1.00 | 1--5 | 1.00 | PRECIPITATION TYPE (RA=1,TRW=2,ZR=3,ICE=4, SN=5) |
| 1 RGHS | 1.00 | M | .00 | SURFACE ROUGHNESS |
| 3 LCLD | 1.00 | PCT | 10.00 | LOW CLOUD COVER |
| 3 MCLD | 1.00 | PCT | 10.00 | MEDIUM CLOUD COVER |
| 3 HCLD | 1.00 | PCT | 10.00 | HIGH CLOUD COVER |
| 3 TCLD | 1.00 | PCT | 20.00 | AVERAGE TOTAL CLOUD COVER |
| 3 CWMR | 1.00 | G/KG | 0.00 | CLOUD WATER MIXING RATIO |
| 3 WTMP | 1.00 | DEGC | .00 | WATER TEMPERATURE |
| 3 LISD | 1.00 | DEGC | 3.00 | STANDARD LIFTED INDEX |
| 3 LIB4 | 1.00 | K | 3.00 | BEST 4-LAYER LIFTED INDEX |
| 3 CAPE | 1.00 | J/KG | .00 | CONVECTIVE AVAILABLE POTENTIAL ENERGY |
| 3 CINH | 1.00 | J/KG | .00 | CONVECTIVE INHIBITION |

# Archived Meteorological Data



**HIGHLIGHTS**
- Archived meteorological data

Likewise there are currently 9 archived data sets available under the **ARCHIVE DATA** drop-down menu, all of which are stored on internal NOAA ARL computers. All archived data sets except the **NCEP/ NCAR Global Reanalysis** are obtained from **NOAA's National Centers for Environmental Prediction (NCEP)** and have been automatically converted to HYSPLIT compatible format. The Global Reanalysis data sets are obtained in a similar fashion from the National Center for Atmospheric Research (NCAR).




## ARL Archive

**North America**

- **NAM** (North American Mesoscale - 12 km, 3 hourly, 31 day rotating files),
- **EDAS/NDAS** (NAM Data Assimilation System - 40 km, 3 hourly, 2005-present),
- **EDAS** (Eta Data Assimilation System - 80 km, 3 hourly, 1997-2004),
- **NGM** (Nested Grid Model - 91 km, 2 hourly, 1991-1997),

**Global**

- **GDAS** (Global Data Assimilation System - 1 degree lat/lon, 3 hourly, 2005-present),
- **FNL** (Global Data Assimilation System (Final) - 191 km, 6 hourly, 1997-2006),
- **NCEP/NCAR Reanalysis** 2.5 degree lat/lon, 6 hourly, 1948-present).

**Other**

- **WORKSHOP** - Meteorological data from HYSPLIT workshop,
- **RESEARCH** - Temporary data sets

More information on the archived meteorological data can be found by clicking on the link below the drop-down list or by clicking here: **archive data**.

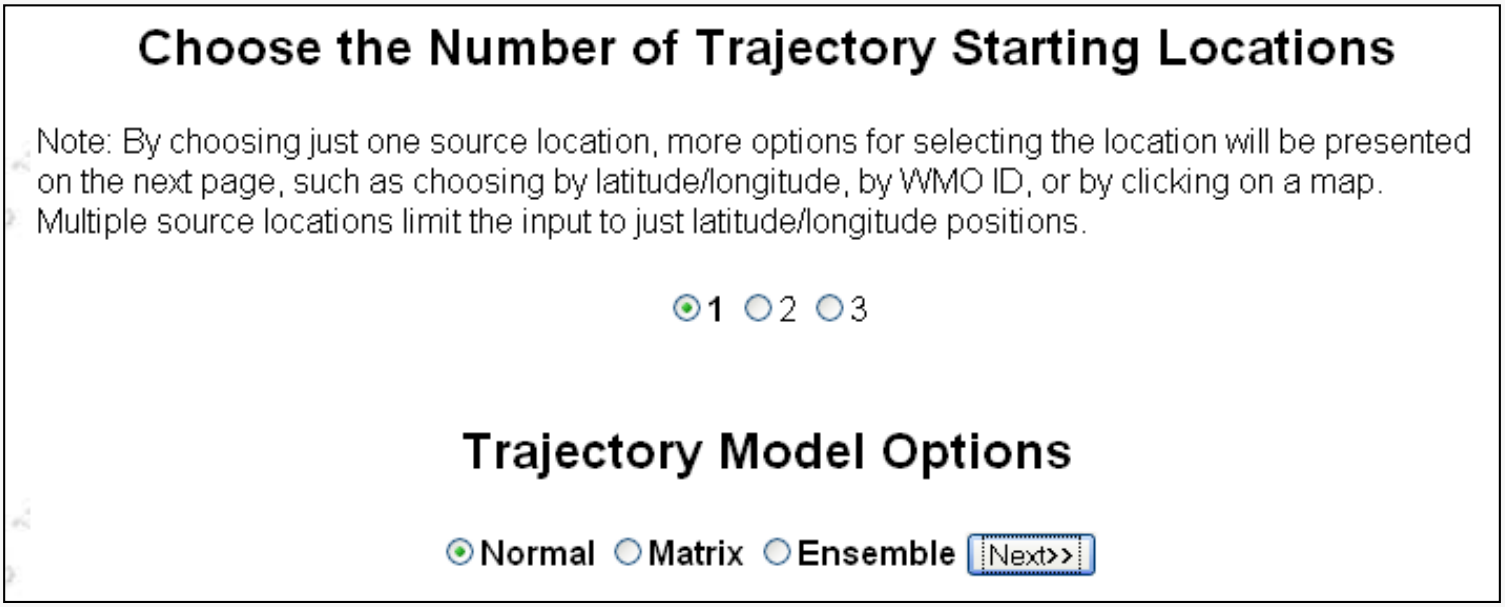
# Trajectory Example Calculation

| Previous | HOME | Next | HIGHLIGHTS |
|---|---|---|---|
| | | | • Run a simple trajectory<br>• Animation of a trajectory overlaid with meteorology |

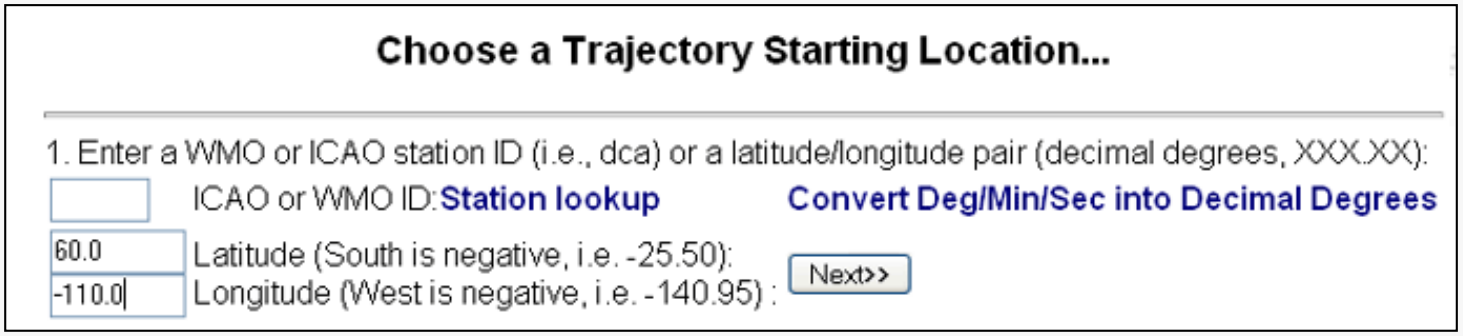
A pollutant particle's transport can be illustrated by running a simple single trajectory calculation using the HYSPLIT workshop archived meteorological data sets.

For this example, see Example 1 Powerpoint **(Ex1_hysplit.ppt)**
or,

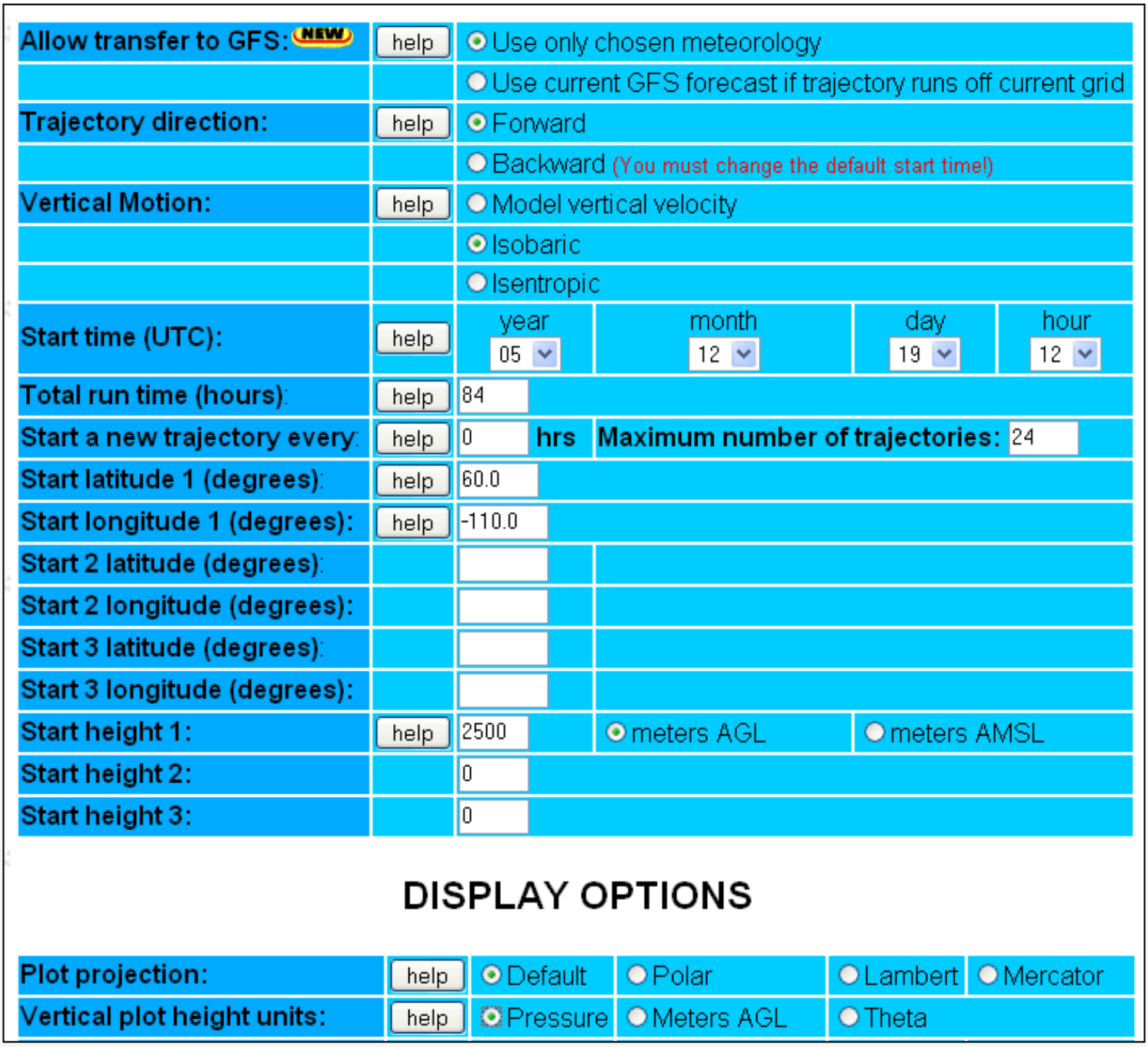
1. Choose the **WORKSHOP** data set from the archive meteorology pull-down menu and click **Next**
2. Choose the **NAM 40 km** data set from the next pull-down menu and click **Next**
3. Choose **1** trajectory starting location from the next menu, as shown below, and click **Next** (disregard the other trajectory model options for now)




4. Enter the source location as **60** degrees N latitude and **110** degrees W longitude

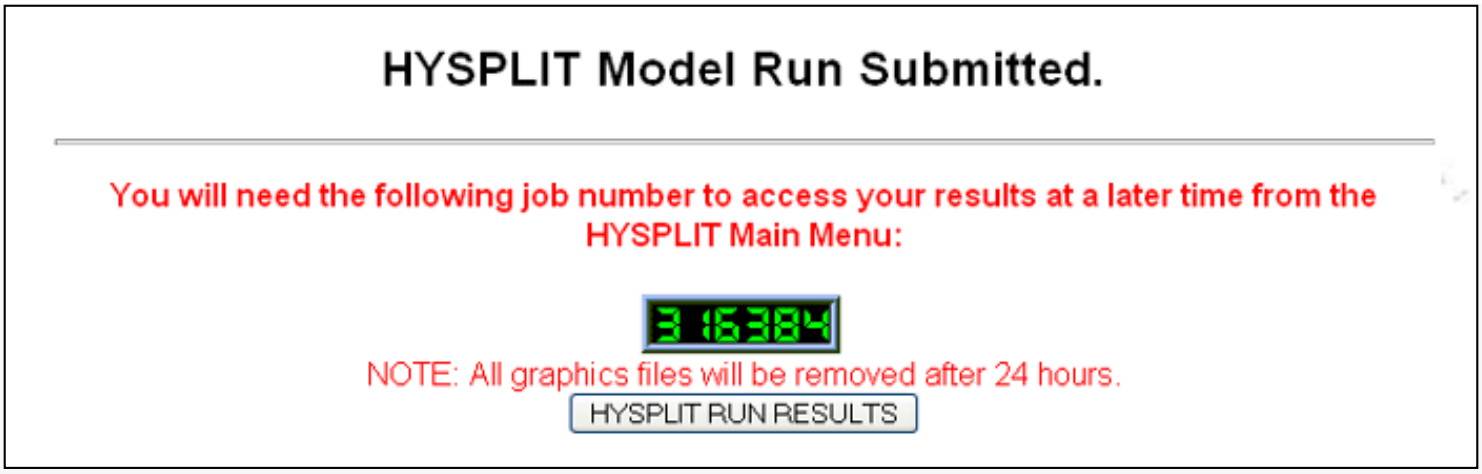



You will then be presented with the complete trajectory **model runtime option**menu as shown below.

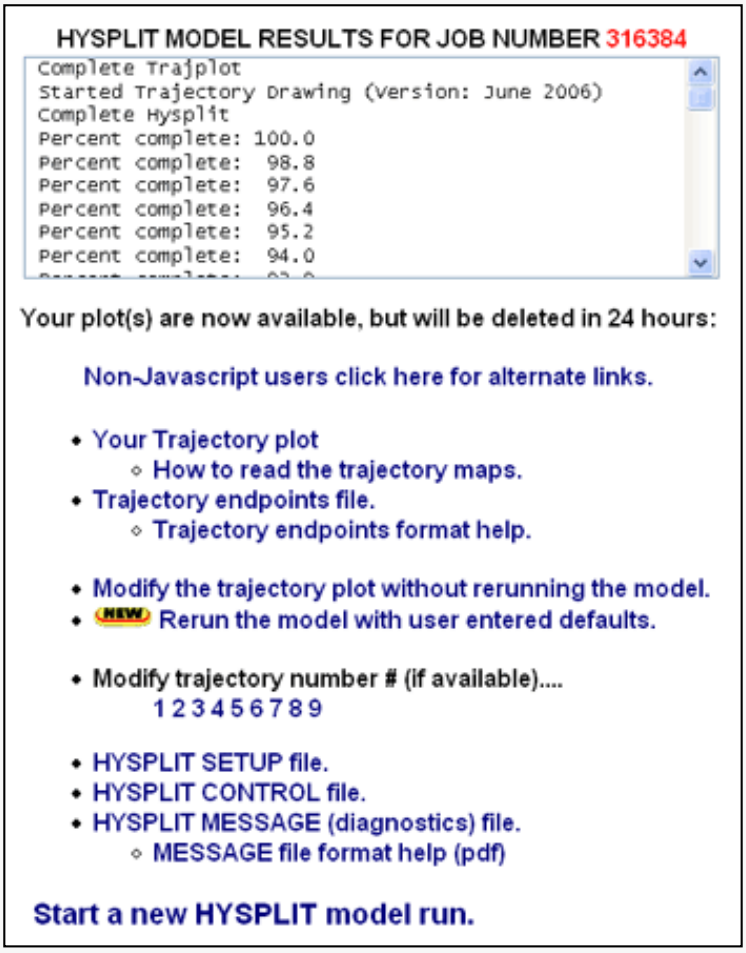


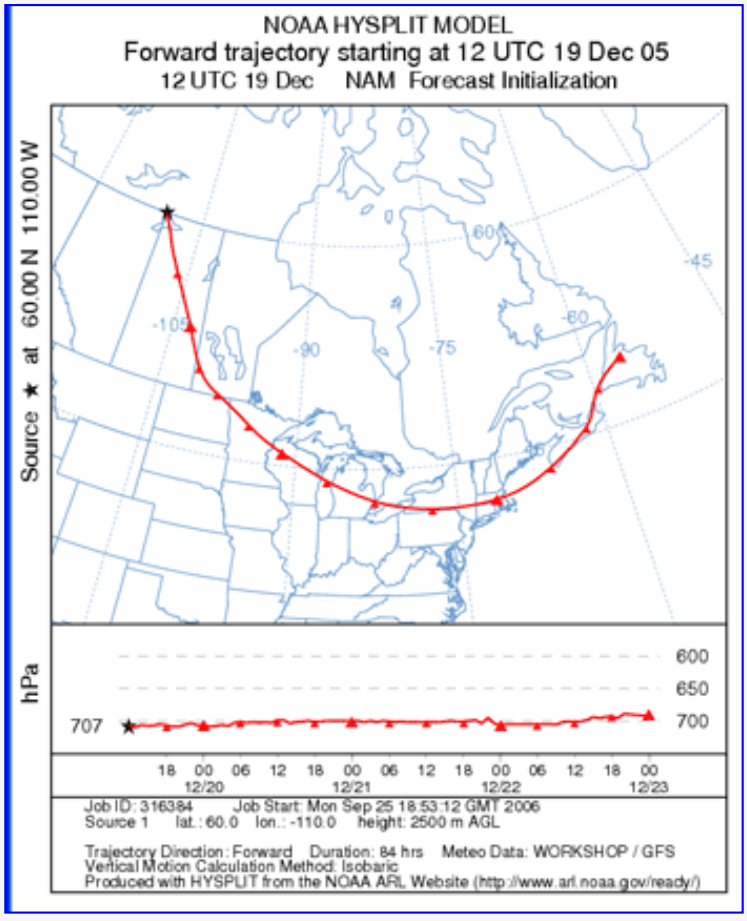

5. Set the vertical motion method to **isobaric**
6. Set the trajectory duration to **84** hours
7. Set the starting height to **2500 m AGL**, which is the approximate height of the 700 hPa level
8. and set the vertical plot height unit to **pressure** from the display options menu located below the model runtime options.

In this way we can compare the trajectory result to the 700 hPa height fields. When properly configured, the GUI menu should be similar to that shown above. Then click **Request Trajectory** from the bottom of the page to submit the model run. The next page will indicate the model **Job ID number** that can be used later to view a previously run job.




Click **HYSPLIT Run Results** to access the final page (below, left). This screen contains all the links needed to access the results of the run and to do other runs similar to the current run. click on the link titled **Your trajectory plot**. The resulting graphic should look like the image below, right (click on the image to enlarge).




The relationship of the trajectory to the temporal and spatial variations of the 700 hPA height field is illustrated in the attached **animation** which was created using the standard tools that come with PC HYSPLIT.

# Trajectory Model Configuration



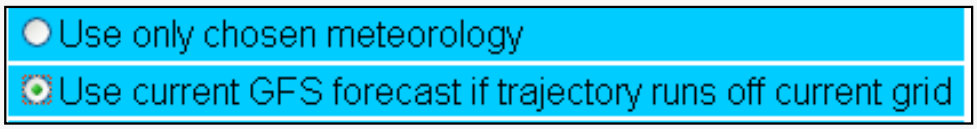
**HIGHLIGHTS**

- Trajectory Setup menu options
- *trajectory endpoints* and *MESSAGE* files

## Vertical Motion Method


The trajectory **Model Runtime Option** menu has several options that control the computation. Some of them should be left at their default values for most applications. For instance, computations should use the vertical motion field (**Model vertical velocity**) contained within the data file unless modeling the flow along constant pressure (isobaric) or constant theta (isentropic) surfaces is needed. In the previous example, isobaric was chosen to model the flow on the 700 hPa pressure surface. The model vertical motion field is normally the better choice because the vertical motions come directly from the meteorological model. More details on the vertical motion option will be given later.

## Meteorological Data File




One key feature is for any simulation is selecting the best meteorological data file. In the current web version only one meteorological data file may be selected per simulation (HYSPLIT is compiled to run with up to 12 files). However, an option is available in **forecast mode** to allow the model to switch to the Global Forecast System (GFS) global data file automatically if the trajectory runs off the chosen meteorological data set, either in time or space. When multiple files are defined within HYSPLIT, at each integration time step, the model finds the finest spatial resolution data set at the location and time of the trajectory end-point.

## Direction


Forward or backward trajectories can be calculated. When choosing backward trajectories the starting time is the time the trajectory will arrive a the entered location. This time will normally need to be changed because the default time given on the web form is the first record in the meteorological data file. In forecast data sets if the starting time is not changed from its default the backward trajectory will not run.

## Starting heights


Another important consideration when starting a trajectory is the starting height. The starting height can be defined as either meters above ground level (MAGL) or meters above mean sea-level (AMSL). MAGL refers to the terrain as it is

defined in the meteorological model, not the actual terrain height. The higher the resolution of the meteorological data, the better the terrain will be modeled. Since the meteorological data is sampled from selected points on a grid, valleys and mountains tend to get smoothed out. Therefore, when starting a trajectory at the top of a mountain it's important to realize that the meteorological model might resolve the mountain at only half the true height in some cases. If the height is entered as AMSL, HYSPLIT will convert the height to MAGL during the calculation, as the model is run on a terrain-following coordinate system. The web version allows up to three user-entered heights. More details on the starting height and model terrain height will be given later.

## Display Options

Most of the options available in the **Display Options** section are self-explanatory. Settings in this section control how the final graphic will appear and provide additional output capabilities beyond a standard graphic. A few of the options will be discussed in later sections.

## Example

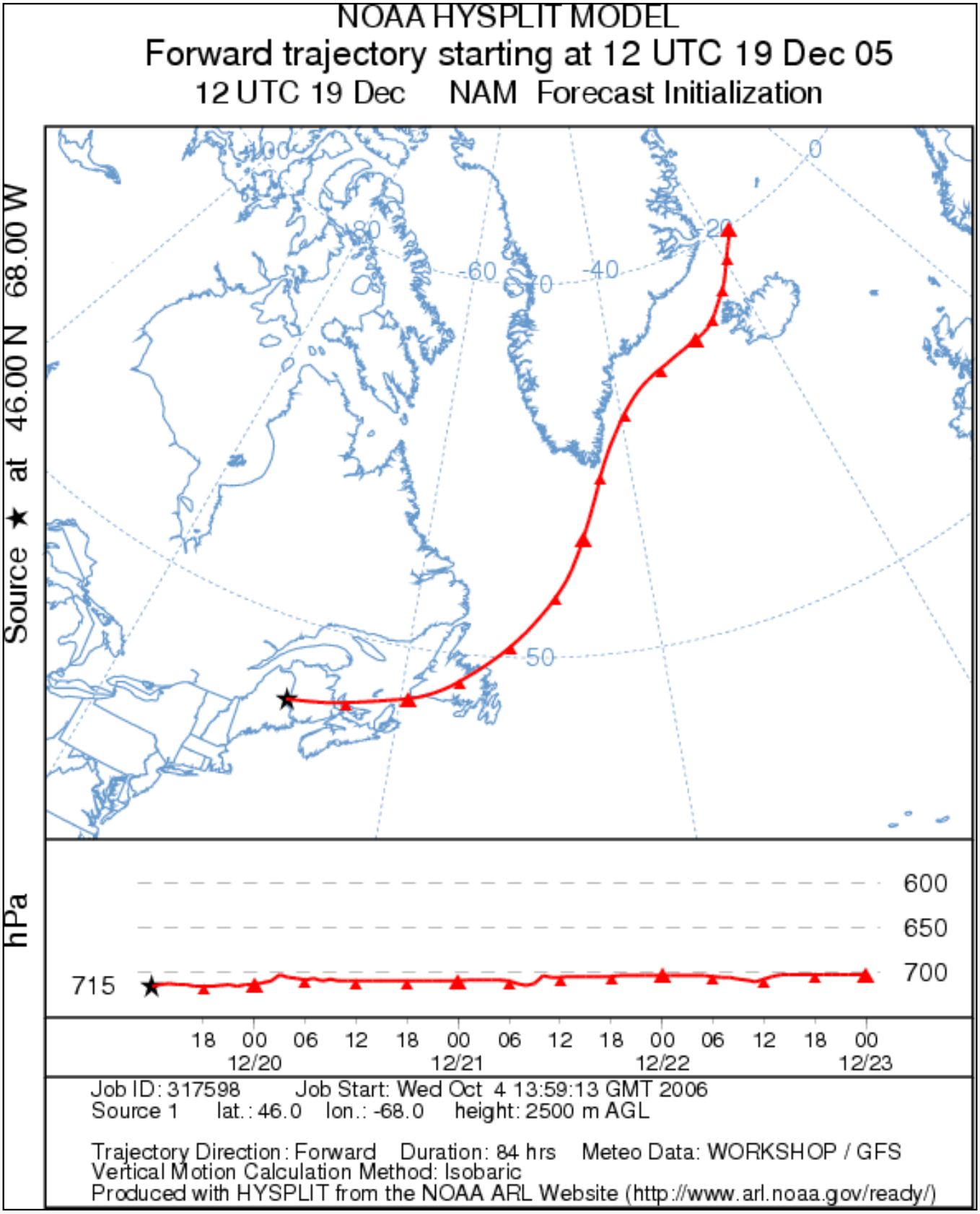
For the next example see Example 2 Powerpoint **(Ex2_hysplit.ppt)**
or,
select the following options:

- **NAM 40 km**
- source location: **46N, 68W**(Maine)
- starting height: **2500 m**
- vertical motion method: **isobaric**
- duration: **84 hrs**
- vertical plot height unit: **Pressure** (from the Display Options menu)
- **Use current GFS forecast if trajectory runs off current grid**

## MODEL RUNTIME OPTIONS

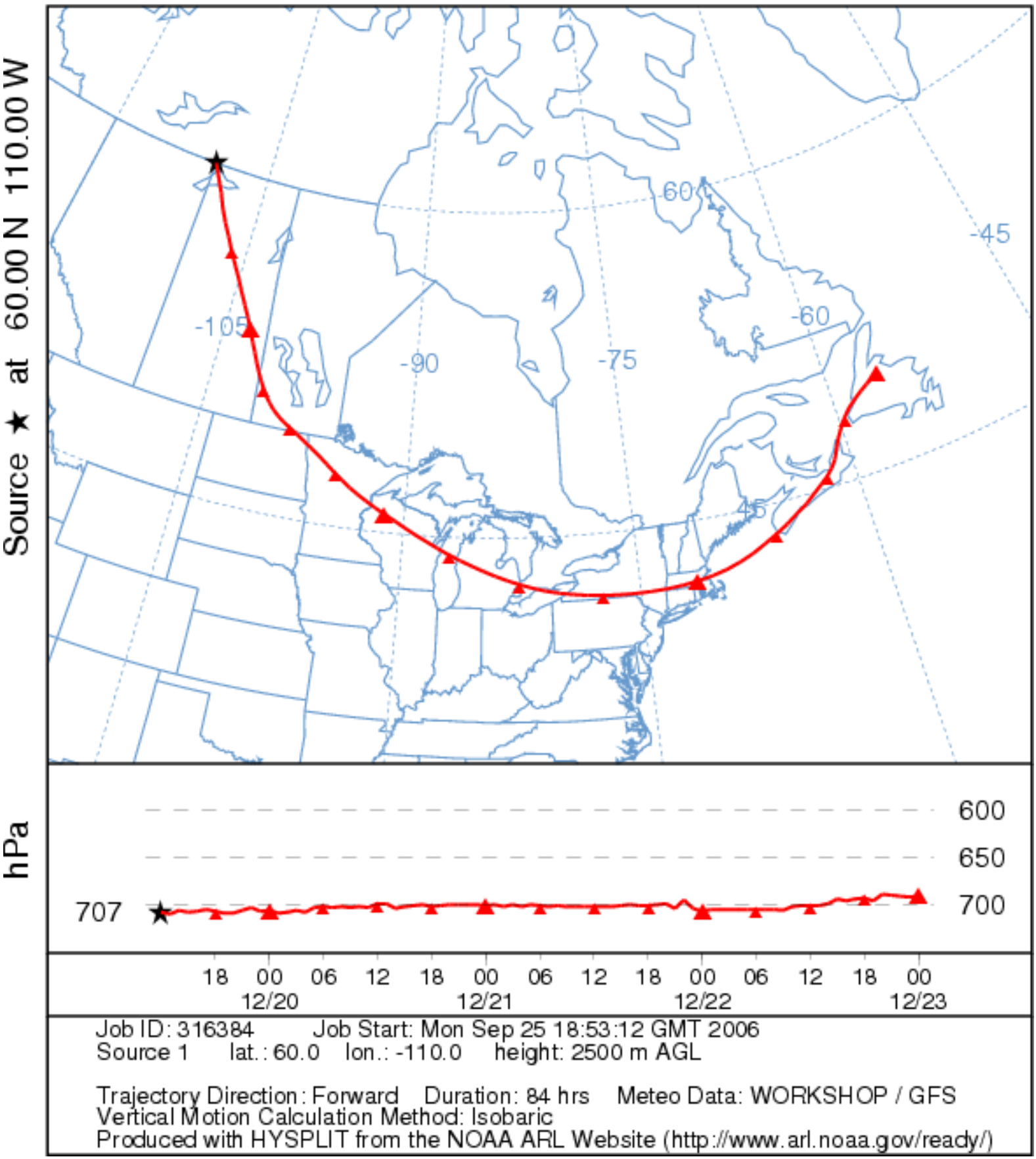
| | | | | | |
|---|---|---|---|---|---|
| **Allow transfer to GFS:** NEW | help | ○ Use only chosen meteorology | | | |
| | | ◉ Use current GFS forecast if trajectory runs off current grid | | | |
| **Trajectory direction:** | help | ◉ Forward | | | |
| | | ○ Backward (You must change the default start time!) | | | |
| **Vertical Motion:** | help | ○ Model vertical velocity | | | |
| | | ◉ Isobaric | | | |
| | | ○ Isentropic | | | |
| **Start time (UTC):** | help | year 05 | month 12 | day 19 | hour 12 |
| **Total run time (hours):** | help | 84 | | | |
| **Start a new trajectory every:** | help | 0 **hrs** | **Maximum number of trajectories:** 24 | | |
| **Start latitude 1 (degrees):** | help | 46.0 | | | |
| **Start longitude 1 (degrees):** | help | -68.0 | | | |
| **Start 2 latitude (degrees):** | | | | | |
| **Start 2 longitude (degrees):** | | | | | |
| **Start 3 latitude (degrees):** | | | | | |
| **Start 3 longitude (degrees):** | | | | | |
| **Start height 1:** | help | 2500 | ◉ meters AGL | ○ meters AMSL | |
| **Start height 2:** | | 0 | | | |
| **Start height 3:** | | 0 | | | |

Execution of the model for this case ***(CONTROL file)*** results in a trajectory that goes northeast using the NAM 40 km forecast file until running off the NAM domain where it then uses the GFS for the remainder of the calculation.



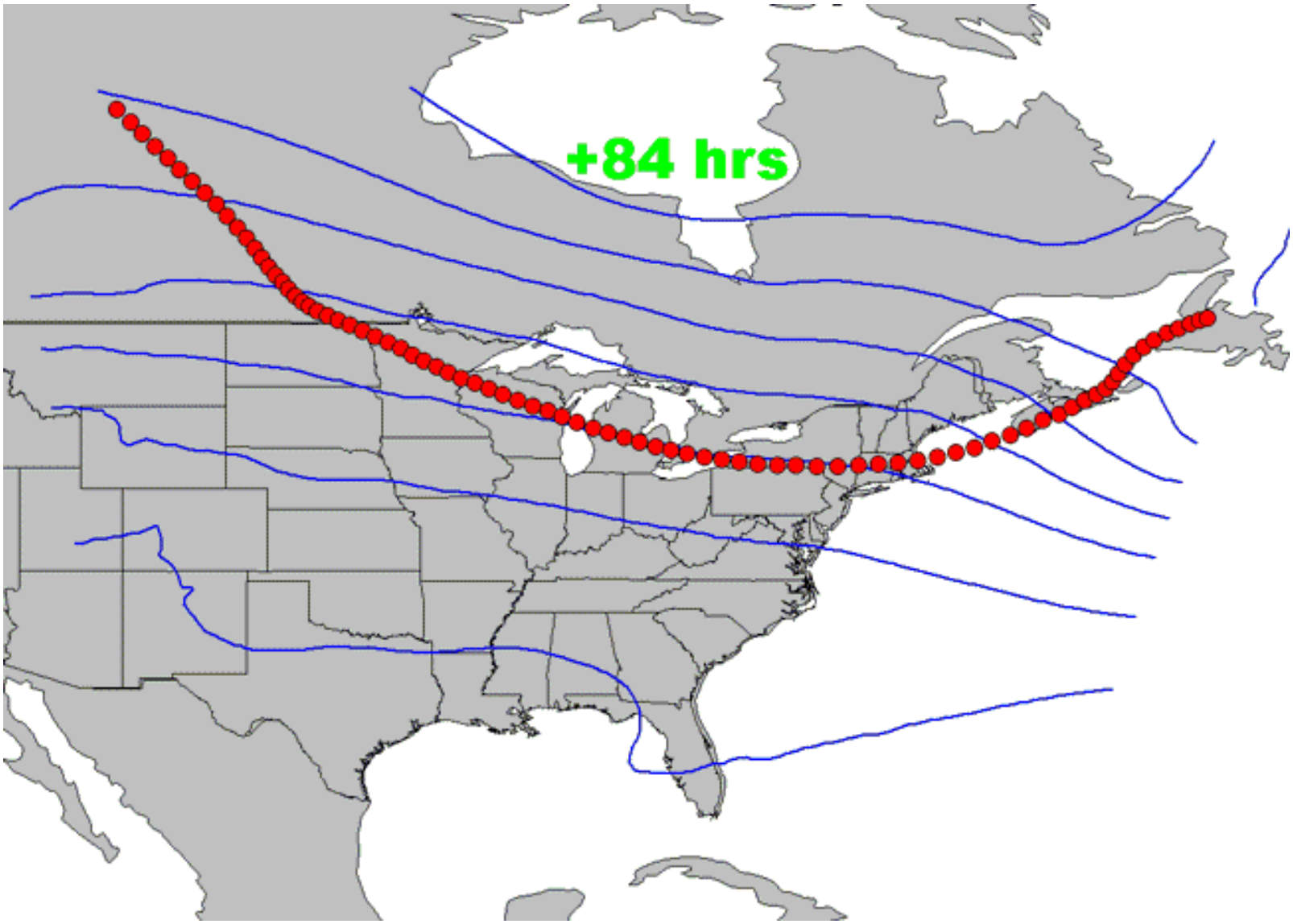

The meteorological file identifier is written with each end-point position in the second column of the ASCII ***trajectory endpoints*** output file, which can be viewed by clicking on the link on the model results page. The diagnostic ***MESSAGE*** file also provides additional detail about the calculation. In this example, the switch from NAM to GFS occurs after 0700 GMT on December 20, 2005, causing the 0600 and 0900 UTC data to be reloaded.

NOAA HYSPLIT MODEL
Forward trajectory starting at 12 UTC 19 Dec 05
12 UTC 19 Dec NAM Forecast Initialization




Job ID: 316384 Job Start: Mon Sep 25 18:53:12 GMT 2006
Source 1 lat.: 60.0 lon.: -110.0 height: 2500 m AGL

Trajectory Direction: Forward Duration: 84 hrs Meteo Data: WORKSHOP / GFS
Vertical Motion Calculation Method: Isobaric
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)


+84 hrs

# Trajectory Error



**HIGHLIGHTS**
- Trajectory computational error
- Plot multiple trajectories on map
- Estimate meteorological error

## Total Trajectory Error

A common question arises when running trajectories...."*What is the error associated with a given trajectory calculation.*" Overall, from the literature, one can estimate the total error to be anywhere from **15 to 30% of the travel distance**. The total error is composed of four error components:

1. **physical** error due to the inadequacy of the data's representation of the atmosphere in space and time,
2. **computational** error due to numerical inaccuracies,
3. **measurement** errors in creating the model's meteorological data fields,
4. **forecast** error if using forecast meteorology.

The **physical** component of the error is related to how well the numerical fields estimate the true flow field. There is no way of knowing this error without independent verification data.

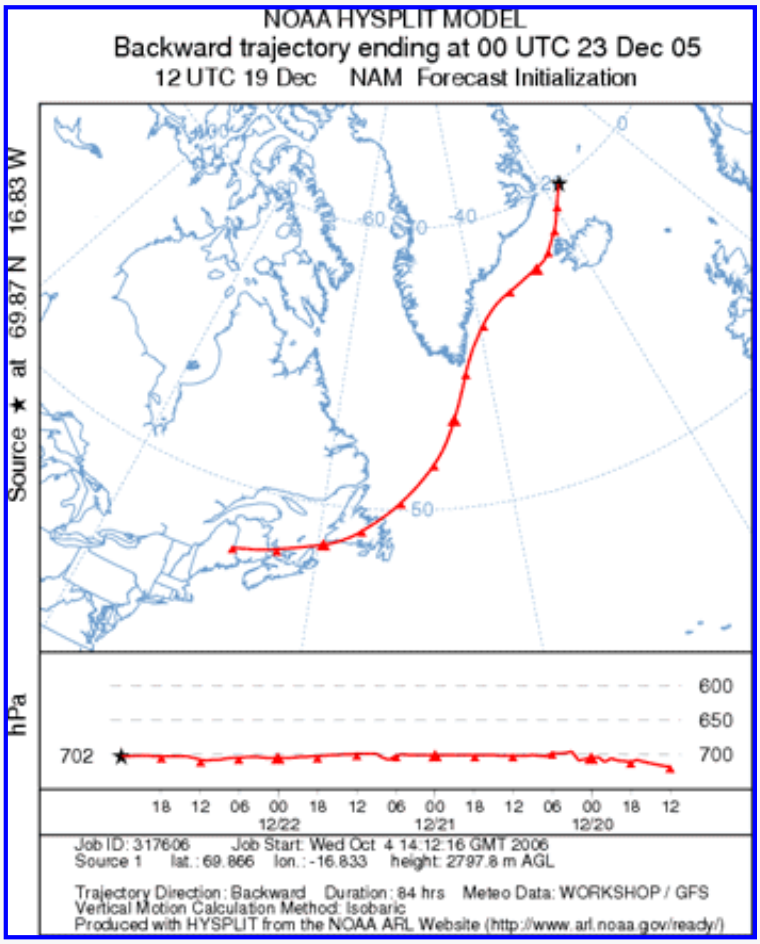
The **computational** component of the error is composed of the integration error (part of which is due to truncation) and a data resolution error, i.e., trying to represent a continuous function, the atmospheric flow field, with gridded data points of limited resolution in space and time. The integration error can be estimated by computing a backward trajectory from the forward trajectory endpoint. The error is then 1/2 the distance of the final endpoint and the starting point. The resolution error can be estimated by starting several trajectories about the initial point (offset in the horizontal and vertical). The divergence of these trajectories will give an estimate of the uncertainty due to divergence in the flow field. An initial offset should be used that is comparable to the estimated integration error. One component of the resolution error that is difficult to estimate relates to the size and speed of movement of various flow features through the grid. There should be sufficient number of sampling points (in space and time) to avoid aliasing errors. Typically a grid resolution of "**x**" can only represent wavelengths of "**4x**". This error will be a function of the meteorological conditions.

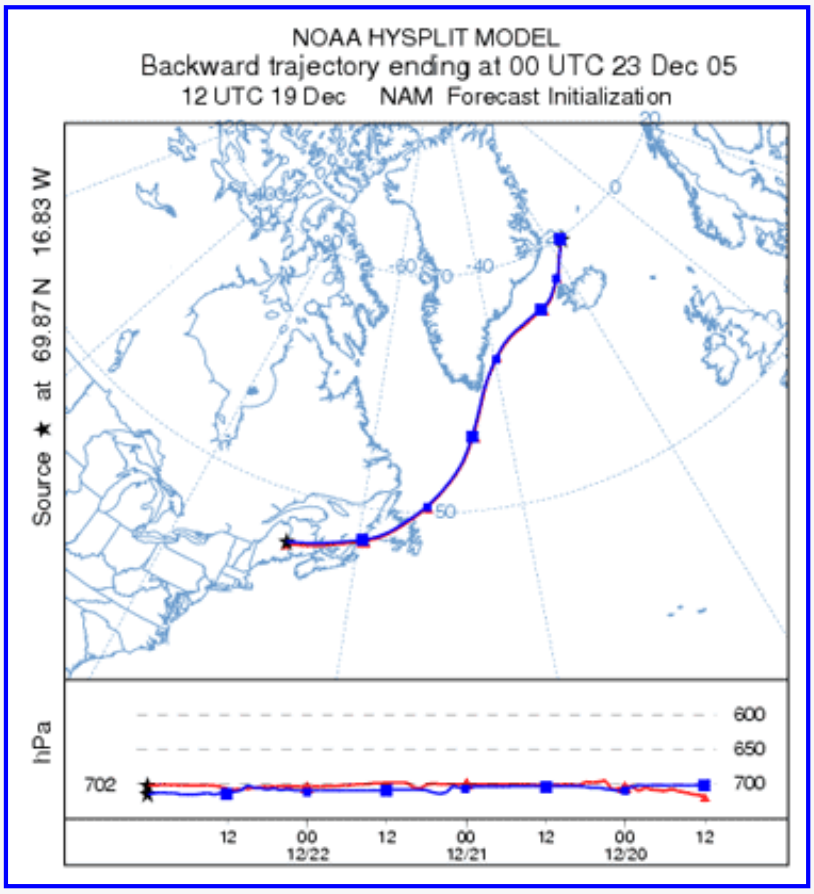
## Integration Error Example

The integration error component of the **numerical error** can be estimated by running a forward and backward trajectory to the origin point. See Example 3 Powerpoint **(Ex3_hysplit.ppt)**
or,
view the previous 700 hPA isobaric example **trajectory endpoints file**, and use the final position (69.866N, 16.833W, 2797.8 m AGL) as the starting point (on the 23$^{th}$ 0000 UTC) for a backward trajectory calculation. If performing this calculation using PC HYSPLIT, insure that the trajectory endpoints file names are **different** for both the forward and backward calculations so that both trajectories can be plotted on the same map. Unfortunately, multiple independent trajectories cannot be plotted on the same map using HYSPLIT-WEB.

| | | |
|---|---|---|
| Allow transfer to GFS: NEW | help | ○ Use only chosen meteorology |
| | | ◉ Use current GFS forecast if trajectory runs off current grid |
| Trajectory direction: | help | ○ Forward |
| | | ◉ Backward (You must change the default start time!) |
| Vertical Motion: | help | ○ Model vertical velocity |
| | | ◉ Isobaric |
| | | ○ Isentropic |
| Start time (UTC): | help | year 05 · month 12 · day 23 · hour 0 |
| Total run time (hours): | help | 84 |
| Start a new trajectory every: | help | 0 hrs · Maximum number of trajectories: 24 |
| Start latitude 1 (degrees): | help | 69.866 |
| Start longitude 1 (degrees): | help | -16.833 |
| Start 2 latitude (degrees): | | |
| Start 2 longitude (degrees): | | |
| Start 3 latitude (degrees): | | |
| Start 3 longitude (degrees): | | |
| Start height 1: | help | 2797.8 · ◉ meters AGL · ○ meters AMSL |
| Start height 2: | | 0 |
| Start height 3: | | 0 |

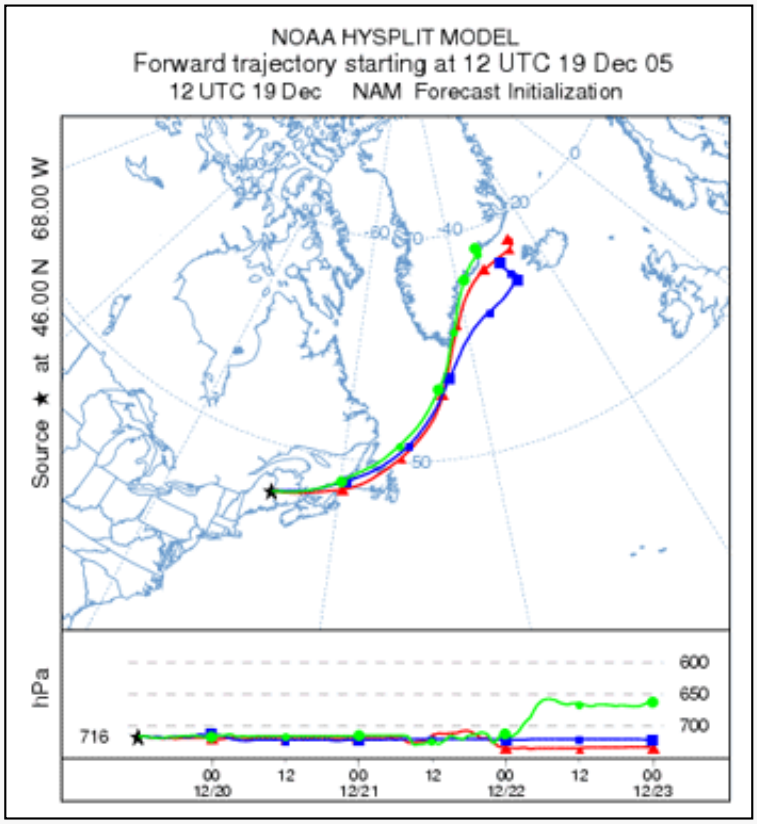
The plot on the left below is the backward trajectory. Note how the return trajectory endpoint is very close to the initial origin point indicating very little integration error. The plot to the right was generated by downloading both trajectory endpoints files and plotting them on the same map using PC HYSPLIT. You can see that the model automatically switched from the GFS back to the NAM 40 km grid at 0600 UTC on December 20 by viewing the **backward endpoints** file.




## Resolution Error Example

As mentioned before, a greater source of error, resolution error, is due to the difficulty in representing atmospheric variables, which are continuous in space and time, by discrete data points on a grid. This error is difficult to quantify, but a sense of the error can be determined by running trajectories using several different sources of meteorological data. In the adjacent calculation, trajectories have been computed using meteorological data from NAM (12 km)/GFS (red), RUC/GFS (blue), and MM545/GFS (green). After the first 36 hours, differences between trajectories are much greater than the numerical error. Note that the green trajectory went up near the end because it hit Greenland (HYSPLIT is terrain following). These calculations are more consistent than most simulations due to the isobaric assumption.




Previous HOME Next

05 12 19 12 #STARTING TIME: YEAR MONTH DAY HOUR
1 #NUMBER OF STARTING LOCATIONS
46.0 -68.0 2500 #STARTING 1: LATITUDE LONGITUDE HEIGHT (m-agl)
84 #TOTAL RUN TIME (hours)
1 #VERTICAL MOTION CALCULATION METHOD
6500 #TOP OF MODEL DOMAIN (m-AGL)
2 #NUMBER nextfile mfile OF INPUT DATA GRIDS
/pub/archives/workshop/
NAMF40
/pub/archives/workshop/
GFSFLL
/pub/ready/hysplitps/
tdump.317598

2 1
NAM 5 12 19 12 0
GFSG 5 12 19 12 0
1 FORWARD ISOBARIC
5 12 19 12 46.000 -68.000 2500.0
1 PRESSURE

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 5 | 12 | 19 | 12 | 0 | 0 | 0.0 | 46.000 | -68.000 | 2500.0 | 715.7 |
| 1 | 1 | 5 | 12 | 19 | 13 | 0 | 1 | 1.0 | 46.085 | -67.305 | 2527.7 | 713.2 |
| 1 | 1 | 5 | 12 | 19 | 14 | 0 | 2 | 2.0 | 46.181 | -66.620 | 2524.6 | 712.1 |
| 1 | 1 | 5 | 12 | 19 | 15 | 0 | 3 | 3.0 | 46.268 | -65.945 | 2571.1 | 713.2 |
| 1 | 1 | 5 | 12 | 19 | 16 | 0 | 4 | 4.0 | 46.366 | -65.252 | 2572.4 | 713.3 |
| 1 | 1 | 5 | 12 | 19 | 17 | 0 | 5 | 5.0 | 46.485 | -64.536 | 2632.2 | 715.3 |
| 1 | 1 | 5 | 12 | 19 | 18 | 0 | 6 | 6.0 | 46.619 | -63.815 | 2658.2 | 715.4 |
| 1 | 1 | 5 | 12 | 19 | 19 | 0 | 7 | 7.0 | 46.757 | -63.093 | 2659.4 | 715.2 |
| 1 | 1 | 5 | 12 | 19 | 20 | 0 | 8 | 8.0 | 46.895 | -62.364 | 2663.4 | 714.1 |
| 1 | 1 | 5 | 12 | 19 | 21 | 0 | 9 | 9.0 | 47.035 | -61.622 | 2661.8 | 713.8 |
| 1 | 1 | 5 | 12 | 19 | 22 | 0 | 10 | 10.0 | 47.170 | -60.880 | 2628.6 | 715.9 |
| 1 | 1 | 5 | 12 | 19 | 23 | 0 | 11 | 11.0 | 47.293 | -60.169 | 2657.4 | 713.0 |
| 1 | 1 | 5 | 12 | 20 | 0 | 0 | 12 | 12.0 | 47.411 | -59.487 | 2644.4 | 713.9 |
| 1 | 1 | 5 | 12 | 20 | 1 | 0 | 13 | 13.0 | 47.549 | -58.831 | 2554.9 | 711.3 |
| 1 | 1 | 5 | 12 | 20 | 2 | 0 | 14 | 14.0 | 47.715 | -58.200 | 2553.6 | 709.6 |
| 1 | 1 | 5 | 12 | 20 | 3 | 0 | 15 | 15.0 | 47.903 | -57.590 | 2421.9 | 702.7 |
| 1 | 1 | 5 | 12 | 20 | 4 | 0 | 16 | 16.0 | 48.109 | -56.995 | 2390.4 | 705.4 |
| 1 | 1 | 5 | 12 | 20 | 5 | 0 | 17 | 17.0 | 48.342 | -56.409 | 2413.5 | 706.6 |
| 1 | 1 | 5 | 12 | 20 | 6 | 0 | 18 | 18.0 | 48.606 | -55.828 | 2463.6 | 708.6 |
| 1 | 1 | 5 | 12 | 20 | 7 | 0 | 19 | 19.0 | 48.891 | -55.235 | 2546.2 | 706.9 |
| 1 | 2 | 5 | 12 | 20 | 8 | 0 | 20 | 20.0 | 49.191 | -54.605 | 2616.1 | 709.8 |
| 1 | 2 | 5 | 12 | 20 | 9 | 0 | 21 | 21.0 | 49.505 | -53.962 | 2655.5 | 707.6 |
| 1 | 2 | 5 | 12 | 20 | 10 | 0 | 22 | 22.0 | 49.837 | -53.310 | 2669.0 | 709.1 |
| 1 | 2 | 5 | 12 | 20 | 11 | 0 | 23 | 23.0 | 50.189 | -52.649 | 2672.0 | 709.3 |
| 1 | 2 | 5 | 12 | 20 | 12 | 0 | 24 | 24.0 | 50.557 | -52.000 | 2671.7 | 709.6 |
| 1 | 2 | 5 | 12 | 20 | 13 | 0 | 25 | 25.0 | 50.941 | -51.354 | 2670.4 | 709.6 |
| 1 | 2 | 5 | 12 | 20 | 14 | 0 | 26 | 26.0 | 51.349 | -50.707 | 2669.1 | 709.7 |
| 1 | 2 | 5 | 12 | 20 | 15 | 0 | 27 | 27.0 | 51.766 | -50.089 | 2668.3 | 709.7 |
| 1 | 2 | 5 | 12 | 20 | 16 | 0 | 28 | 28.0 | 52.193 | -49.479 | 2667.8 | 709.5 |
| 1 | 2 | 5 | 12 | 20 | 17 | 0 | 29 | 29.0 | 52.634 | -48.864 | 2667.1 | 709.3 |
| 1 | 2 | 5 | 12 | 20 | 18 | 0 | 30 | 30.0 | 53.075 | -48.297 | 2665.3 | 709.2 |
| 1 | 2 | 5 | 12 | 20 | 19 | 0 | 31 | 31.0 | 53.521 | -47.758 | 2664.0 | 709.7 |
| 1 | 2 | 5 | 12 | 20 | 20 | 0 | 32 | 32.0 | 53.986 | -47.242 | 2666.4 | 709.5 |
| 1 | 2 | 5 | 12 | 20 | 21 | 0 | 33 | 33.0 | 54.471 | -46.790 | 2668.8 | 709.5 |
| 1 | 2 | 5 | 12 | 20 | 22 | 0 | 34 | 34.0 | 54.982 | -46.367 | 2670.4 | 709.2 |
| 1 | 2 | 5 | 12 | 20 | 23 | 0 | 35 | 35.0 | 55.500 | -45.946 | 2671.3 | 709.0 |
| 1 | 2 | 5 | 12 | 21 | 0 | 0 | 36 | 36.0 | 56.040 | -45.556 | 2672.1 | 709.0 |
| 1 | 2 | 5 | 12 | 21 | 1 | 0 | 37 | 37.0 | 56.589 | -45.160 | 2673.0 | 708.6 |
| 1 | 2 | 5 | 12 | 21 | 2 | 0 | 38 | 38.0 | 57.114 | -44.762 | 2673.5 | 708.5 |

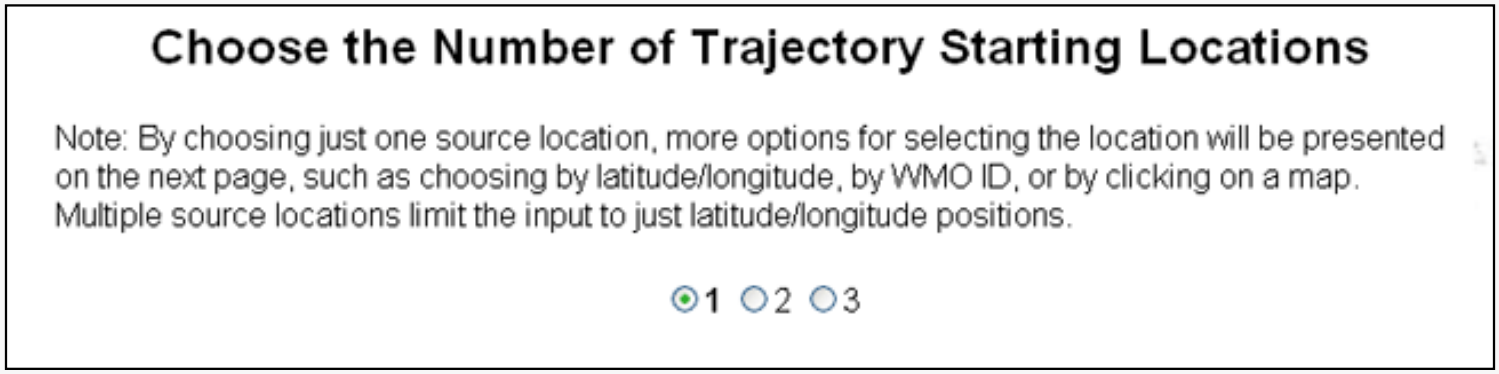
| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 5 | 12 | 21 | 3 | 0 | 39 | 39.0 | 57.647 | -44.387 | 2674.2 | 708.5 |
| 1 | 2 | 5 | 12 | 21 | 4 | 0 | 40 | 40.0 | 58.193 | -43.988 | 2673.7 | 708.3 |
| 1 | 2 | 5 | 12 | 21 | 5 | 0 | 41 | 41.0 | 58.725 | -43.601 | 2670.3 | 708.5 |
| 1 | 2 | 5 | 12 | 21 | 6 | 0 | 42 | 42.0 | 59.270 | -43.226 | 2654.4 | 709.0 |
| 1 | 2 | 5 | 12 | 21 | 7 | 0 | 43 | 43.0 | 59.807 | -42.773 | 2617.7 | 712.6 |
| 1 | 2 | 5 | 12 | 21 | 8 | 0 | 44 | 44.0 | 60.323 | -42.284 | 2606.8 | 714.4 |
| 1 | 2 | 5 | 12 | 21 | 9 | 0 | 45 | 45.0 | 60.871 | -41.693 | 2657.7 | 712.9 |
| 1 | 2 | 5 | 12 | 21 | 10 | 0 | 46 | 46.0 | 61.416 | -40.995 | 2696.8 | 703.3 |
| 1 | 2 | 5 | 12 | 21 | 11 | 0 | 47 | 47.0 | 61.920 | -40.318 | 2710.3 | 705.7 |
| 1 | 2 | 5 | 12 | 21 | 12 | 0 | 48 | 48.0 | 62.410 | -39.567 | 2720.8 | 705.1 |
| 1 | 2 | 5 | 12 | 21 | 13 | 0 | 49 | 49.0 | 62.859 | -38.756 | 2727.2 | 704.7 |
| 1 | 2 | 5 | 12 | 21 | 14 | 0 | 50 | 50.0 | 63.270 | -37.904 | 2732.1 | 704.6 |
| 1 | 2 | 5 | 12 | 21 | 15 | 0 | 51 | 51.0 | 63.632 | -36.977 | 2737.0 | 704.6 |
| 1 | 2 | 5 | 12 | 21 | 16 | 0 | 52 | 52.0 | 63.928 | -35.982 | 2744.4 | 704.3 |
| 1 | 2 | 5 | 12 | 21 | 17 | 0 | 53 | 53.0 | 64.167 | -35.017 | 2750.4 | 704.3 |
| 1 | 2 | 5 | 12 | 21 | 18 | 0 | 54 | 54.0 | 64.355 | -34.046 | 2756.8 | 704.3 |
| 1 | 2 | 5 | 12 | 21 | 19 | 0 | 55 | 55.0 | 64.519 | -33.105 | 2763.3 | 703.9 |
| 1 | 2 | 5 | 12 | 21 | 20 | 0 | 56 | 56.0 | 64.693 | -32.228 | 2767.8 | 703.9 |
| 1 | 2 | 5 | 12 | 21 | 21 | 0 | 57 | 57.0 | 64.846 | -31.317 | 2772.0 | 703.9 |
| 1 | 2 | 5 | 12 | 21 | 22 | 0 | 58 | 58.0 | 64.984 | -30.396 | 2776.0 | 703.8 |
| 1 | 2 | 5 | 12 | 21 | 23 | 0 | 59 | 59.0 | 65.128 | -29.503 | 2779.7 | 703.8 |
| 1 | 2 | 5 | 12 | 22 | 0 | 0 | 60 | 60.0 | 65.240 | -28.634 | 2783.6 | 703.8 |
| 1 | 2 | 5 | 12 | 22 | 1 | 0 | 61 | 61.0 | 65.337 | -27.871 | 2786.8 | 703.6 |
| 1 | 2 | 5 | 12 | 22 | 2 | 0 | 62 | 62.0 | 65.447 | -27.230 | 2788.4 | 703.5 |
| 1 | 2 | 5 | 12 | 22 | 3 | 0 | 63 | 63.0 | 65.556 | -26.663 | 2789.0 | 703.5 |
| 1 | 2 | 5 | 12 | 22 | 4 | 0 | 64 | 64.0 | 65.680 | -26.165 | 2787.4 | 703.5 |
| 1 | 2 | 5 | 12 | 22 | 5 | 0 | 65 | 65.0 | 65.829 | -25.716 | 2782.3 | 703.5 |
| 1 | 2 | 5 | 12 | 22 | 6 | 0 | 66 | 66.0 | 65.983 | -25.285 | 2768.6 | 704.5 |
| 1 | 2 | 5 | 12 | 22 | 7 | 0 | 67 | 67.0 | 66.151 | -24.867 | 2746.6 | 705.6 |
| 1 | 2 | 5 | 12 | 22 | 8 | 0 | 68 | 68.0 | 66.346 | -24.430 | 2706.6 | 705.6 |
| 1 | 2 | 5 | 12 | 22 | 9 | 0 | 69 | 69.0 | 66.550 | -23.936 | 2696.8 | 707.0 |
| 1 | 2 | 5 | 12 | 22 | 10 | 0 | 70 | 70.0 | 66.760 | -23.396 | 2691.6 | 708.2 |
| 1 | 2 | 5 | 12 | 22 | 11 | 0 | 71 | 71.0 | 66.976 | -22.848 | 2713.2 | 710.8 |
| 1 | 2 | 5 | 12 | 22 | 12 | 0 | 72 | 72.0 | 67.185 | -22.327 | 2745.9 | 707.2 |
| 1 | 2 | 5 | 12 | 22 | 13 | 0 | 73 | 73.0 | 67.400 | -21.841 | 2772.2 | 704.4 |
| 1 | 2 | 5 | 12 | 22 | 14 | 0 | 74 | 74.0 | 67.634 | -21.375 | 2787.0 | 702.6 |
| 1 | 2 | 5 | 12 | 22 | 15 | 0 | 75 | 75.0 | 67.883 | -20.917 | 2790.9 | 702.4 |
| 1 | 2 | 5 | 12 | 22 | 16 | 0 | 76 | 76.0 | 68.140 | -20.442 | 2791.3 | 702.8 |
| 1 | 2 | 5 | 12 | 22 | 17 | 0 | 77 | 77.0 | 68.391 | -19.964 | 2792.1 | 702.8 |
| 1 | 2 | 5 | 12 | 22 | 18 | 0 | 78 | 78.0 | 68.637 | -19.492 | 2793.3 | 702.7 |
| 1 | 2 | 5 | 12 | 22 | 19 | 0 | 79 | 79.0 | 68.877 | -19.005 | 2794.5 | 702.4 |
| 1 | 2 | 5 | 12 | 22 | 20 | 0 | 80 | 80.0 | 69.104 | -18.504 | 2795.1 | 702.3 |
| 1 | 2 | 5 | 12 | 22 | 21 | 0 | 81 | 81.0 | 69.312 | -18.012 | 2795.2 | 702.3 |
| 1 | 2 | 5 | 12 | 22 | 22 | 0 | 82 | 82.0 | 69.502 | -17.574 | 2795.5 | 702.4 |
| 1 | 2 | 5 | 12 | 22 | 23 | 0 | 83 | 83.0 | 69.683 | -17.192 | 2796.2 | 702.4 |
| 1 | 2 | 5 | 12 | 23 | 0 | 0 | 84 | 84.0 | 69.866 | -16.833 | 2797.8 | 702.4 |

# Multiple Trajectories



## Multiple Trajectory Starting Locations

After choosing the meteorological data set, the first menu (below) gives the user the option of computing trajectories from 1, 2 or 3 different starting locations. Choosing more than one can be useful if more than one trajectory is needed to be plotted on the same map. The only limitation is that the starting heights (up to 3) must be the same for each location.

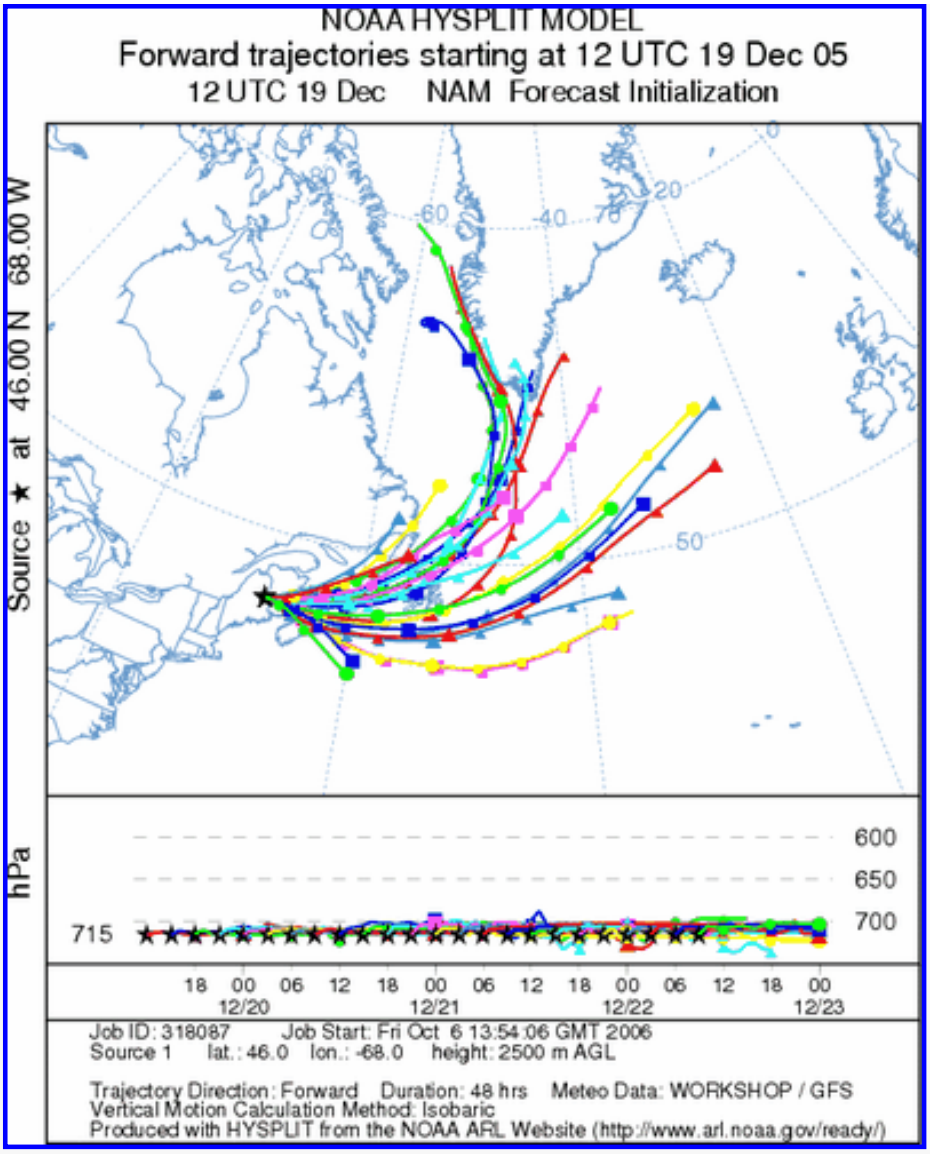



## Trajectory Restart Option


Normally trajectories are started only at the initial time at the locations and heights specified by the user. However, by entering a value (hours) in the **Start a new trajectory every** field, trajectories can be started at regular time intervals from the same location. At this time, a maximum of 24 trajectories for a total of 48 hours duration are allowed on HYSPLIT-WEB due to the resources needed to compute these trajectories.
To demonstrate this feature see Example 4 Powerpoint **(Ex4_hysplit.ppt)]**
or,
change the restart interval to **3** and leave all the other parameters the same as in the original 700 hPa isobaric trajectory, i.e.,

- **NAM 40 km**
- source location: **46N, 68W**(Maine)

- Start a new trajectory every: **3 hours**
- starting height: **2500 m**
- vertical motion method: **isobaric**
- duration: **84 hrs**
- vertical plot height unit: **Pressure**
- **Use current GFS forecast if trajectory runs off current grid**




The resulting trajectory graphic (above) shows new trajectories starting every 3 hours, terminating at the end of 48 hours. Trajectories starting after the initial time will have a shorter duration. In PC HYSPLIT all trajectories can be set to have the same duration or run for more than 48 hours.

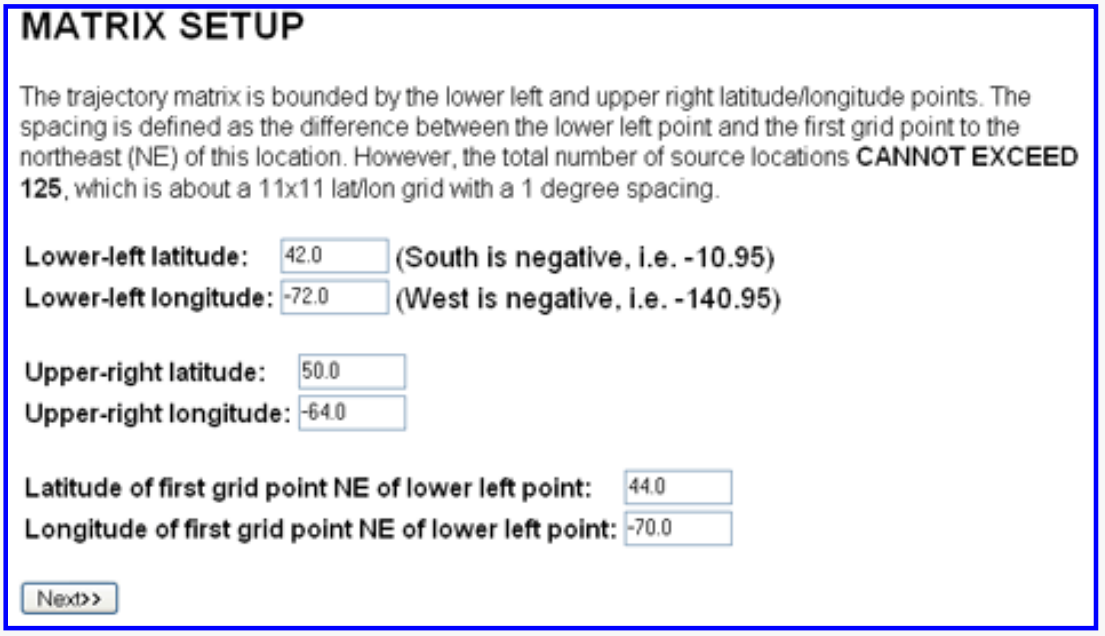
## Trajectory Matrix Option


Although HYSPLIT-WEB can be used to configure only up to 3 starting locations, the model can support an unlimited number of locations. HYSPLIT-WEB and PC HYSPLIT have a shortcut method to configure a regular matrix of locations by defining three points, representing the lower left, upper right, and location increment. HYSPLIT-WEB does have a limitation of 125 starting locations which represents about a 11x11 lat/lon grid with a 1 degree horizontal spacing.

## Trajectory Matrix Example

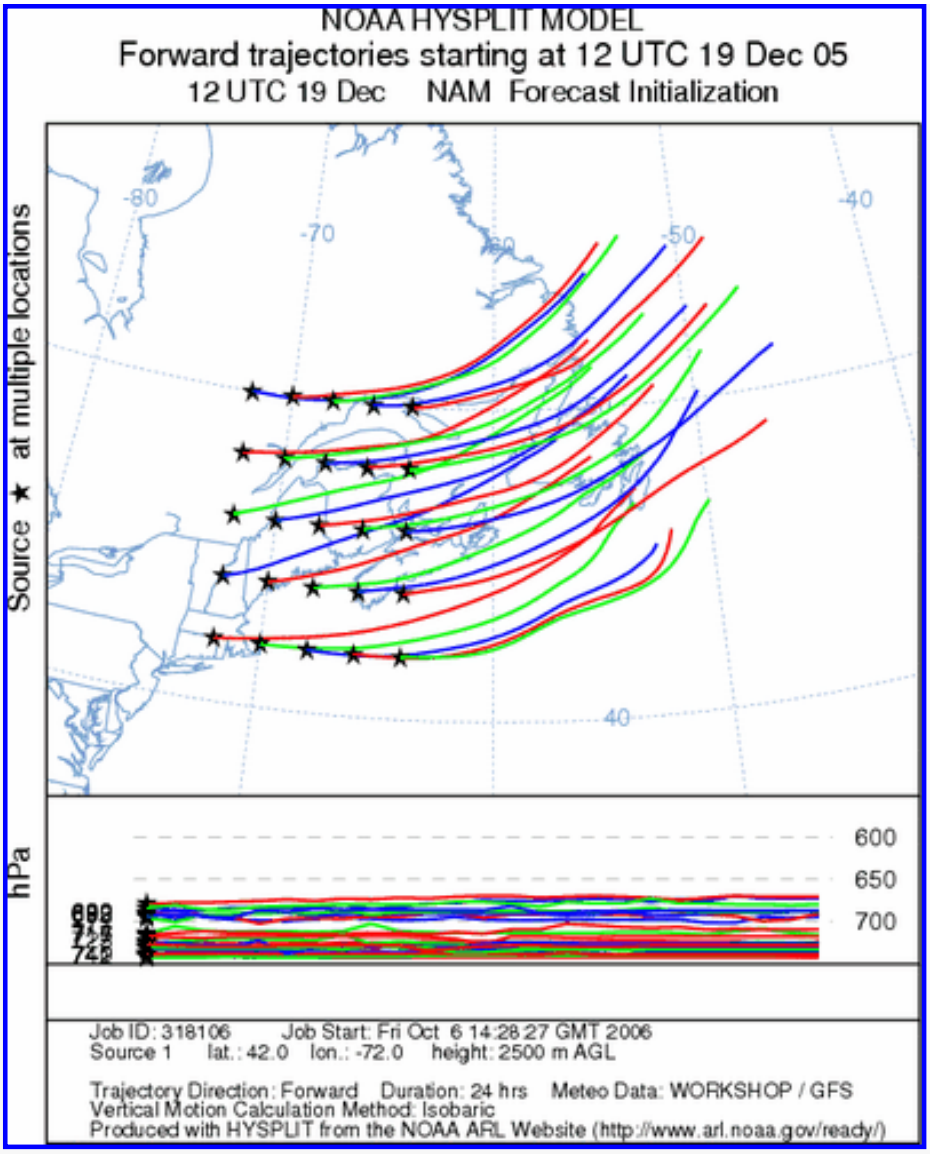
For this example see Example 5 Powerpoint **(Ex5_hysplit.ppt)**
or,

After choosing a **Matrix** run and clicking **Next**, a menu for entering the 3 matrix starting locations will be presented (right). Other than entering 3 locations the rest of the configuration is similar to a normal trajectory computation except that the locations defined by the matrix grid will be calculated and written to the **CONTROL** file before executing the run. Rerun the 700 hPa isobaric case again but change the **Total run time** to **24** hours and choose the 3 source locations as shown to the right (**42.0,-72.0**), (**50.0,-64.0**) and (**44.0,-70.0**). This configuration will produce 25 starting locations separated by 2 degrees of latitude (~222 km). Also, set the restart interval back to **0** if it is not 0.




- **NAM 40 km**
- **Matrix**
- starting location 1: **42.0N, 72.0W**
- starting location 2: **50.0N, 64.0W**
- starting location 3: **44.0N, 70.0W**
- starting height: **2500 m**
- vertical motion method: **isobaric**
- duration: **24 hrs**
- vertical plot height unit: **Pressure**
- **Use current GFS forecast if trajectory runs off current grid**

The resulting graphic (right) shows the matrix of 24-h duration isobaric trajectories. Again there is very little differences noted between the trajectories indicating small temporal and spatial differences in the meteorology in this region. Note that we are using spatial and temporal offsets to get at trajectory error or in this case sensitivity to the meteorological data.




## Trajectory Ensemble Option

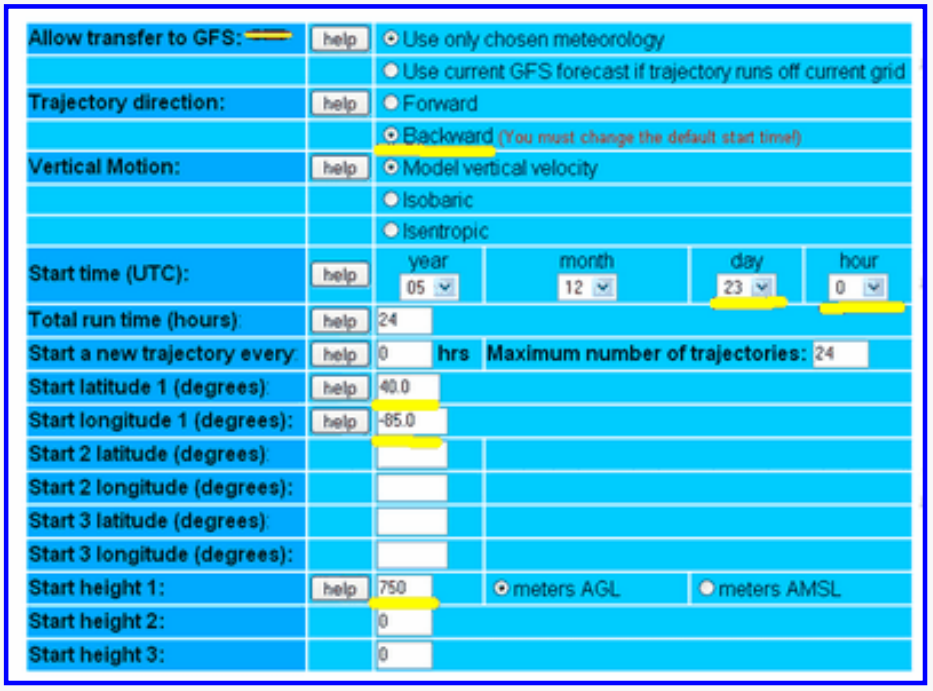

Frequently it is necessary to attribute a pollutant measurement to a specific source location. One approach is to compute a backward trajectory to determine the air's origin. Although it is not uncommon to see sources identified by a single trajectory, the uncertainties inherent in a single-trajectory can preempt its utility. One way to reduce those uncertainties would be to compute multiple trajectories, in height, time, and space. HYSPLIT can be configured to automatically run trajectories in an ensemble fashion from the chosen starting location. Each member of the trajectory ensemble is calculated by offsetting the meteorological data by a fixed grid factor (HYSPLIT-WEB assumes one meteorological grid point in the horizontal and 0.01 sigma units in the vertical). This results in 27 members for all-possible offsets in X,Y, and Z. Note: the starting height should be greater than 250 m for optimal configuration of the ensemble.

## Trajectory Ensemble Example

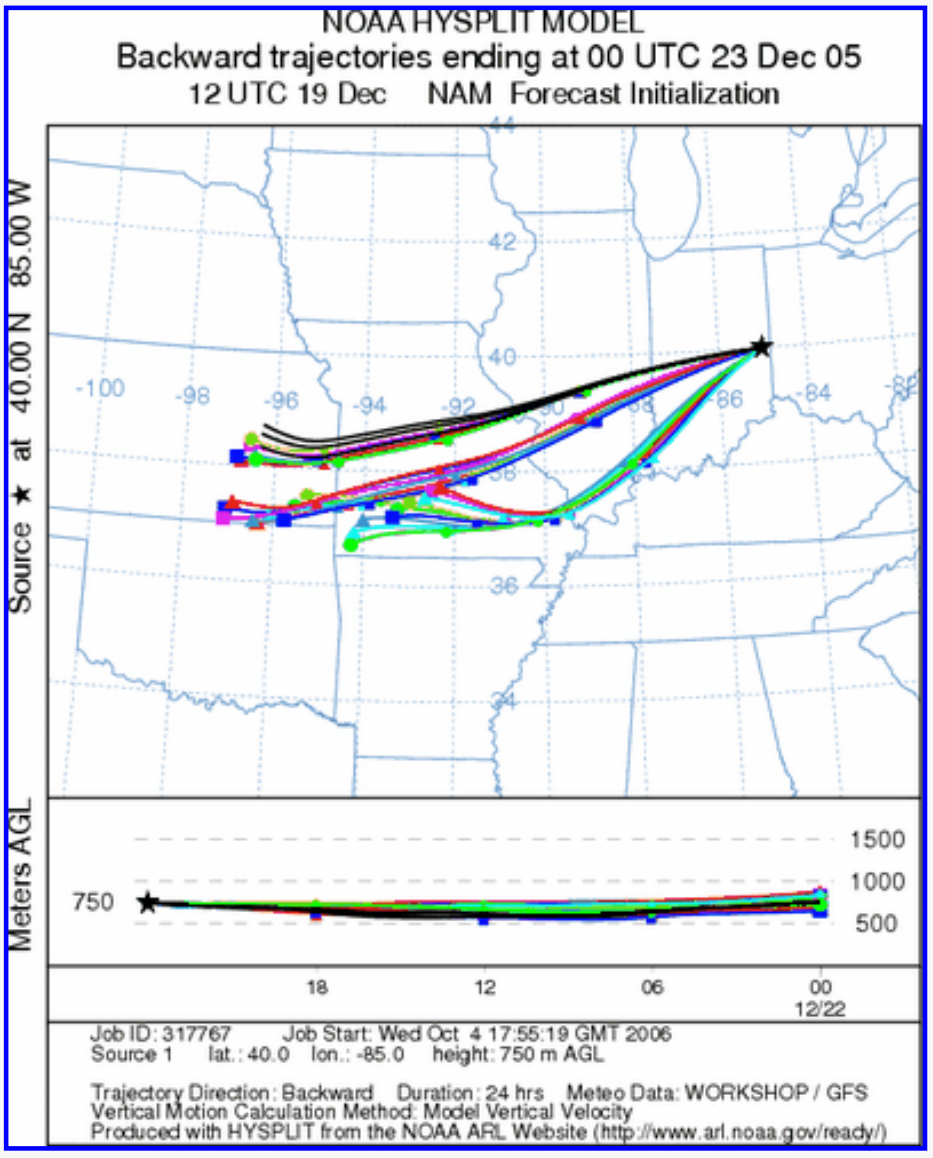
For this example see Example 6 Powerpoint **(Ex6_hysplit.ppt)**
or,

For this example choose:

- **NAM 40 km**
- **Ensemble**
- starting location: **40.0N, 85.0W**
- **Backward**
- starting date/time: **December 23 at 0000 UTC**
- starting height: **750 MAGL**




The resulting plot (right) shows that 3 different paths are possible depending on the selected location in X, Y, and Z. This method gives the user a sense of the sensitivity of the chosen starting location within the meteorological grid as well as an "envelope" of the uncertainty about the single trajectory result.





Previous

HOME

Next

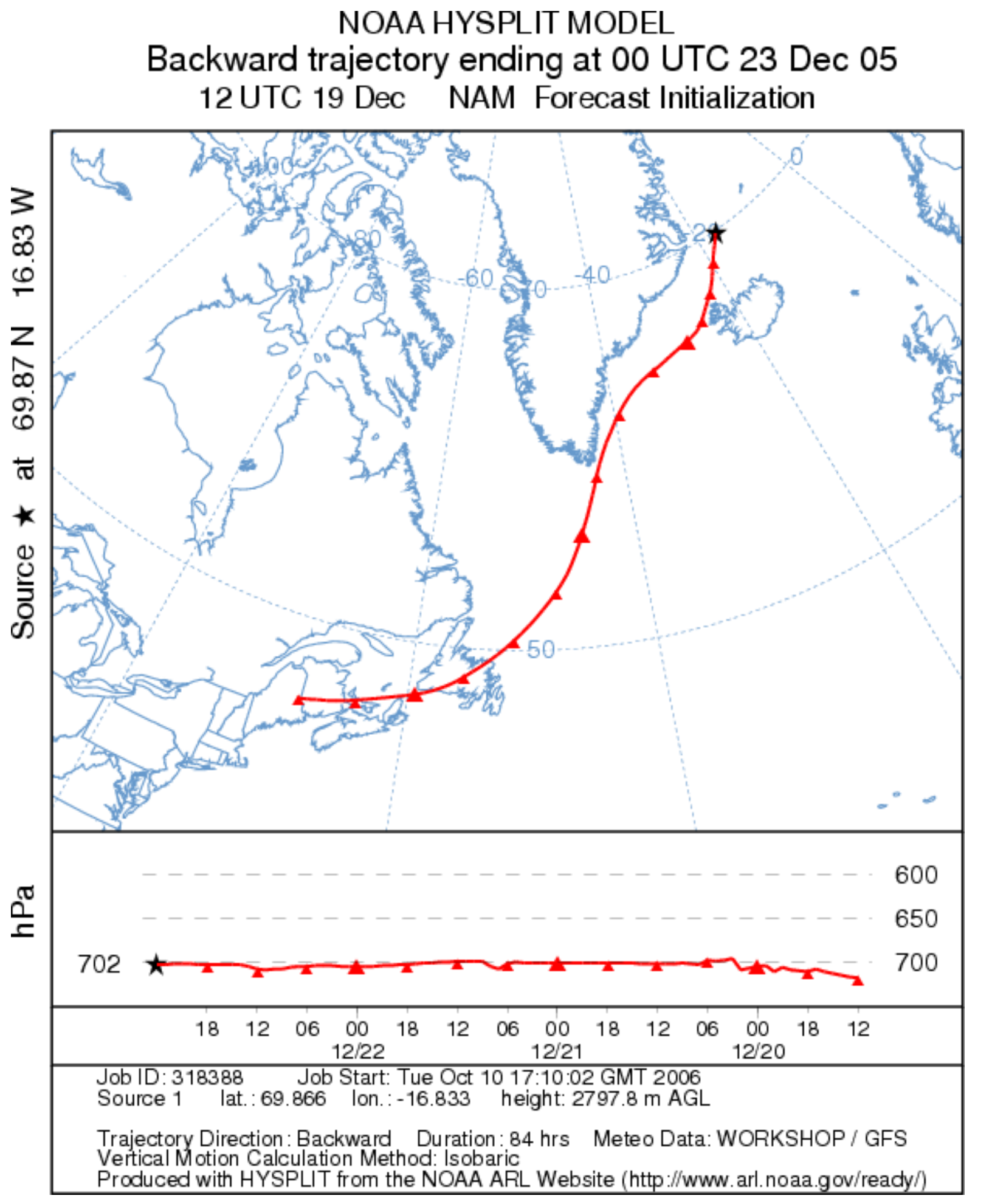
```
 2    1
 NAM    5   12   19   12    0
GFSG    5   12   19   12    0
 1 FORWARD  ISOBARIC
 5   12   19   12  46.000  -68.000  2500.0
 1 PRESSURE
 1    1    5   12   19   12    0    0    0.0   46.000  -68.000   2500.0    715.7
 1    1    5   12   19   13    0    1    1.0   46.085  -67.305   2527.7    713.2
 1    1    5   12   19   14    0    2    2.0   46.181  -66.620   2524.6    712.1

....

 1    2    5   12   22   22    0   82   82.0   69.502  -17.574   2795.5    702.4
 1    2    5   12   22   23    0   83   83.0   69.683  -17.192   2796.2    702.4
 1    2    5   12   23    0    0   84   84.0   69.866  -16.833   2797.8    702.4
```

| | | | | | |
|---|---|---|---|---|---|
| **Allow transfer to GFS:** NEW | help | ○ Use only chosen meteorology | | | |
| | | ◉ Use current GFS forecast if trajectory runs off current grid | | | |
| **Trajectory direction:** | help | ○ Forward | | | |
| | | ◉ Backward (You must change the default start time!) | | | |
| **Vertical Motion:** | help | ○ Model vertical velocity | | | |
| | | ◉ Isobaric | | | |
| | | ○ Isentropic | | | |
| **Start time (UTC):** | help | year 05 | month 12 | day 23 | hour 0 |
| **Total run time (hours):** | help | 84 | | | |
| **Start a new trajectory every:** | help | 0 **hrs** | **Maximum number of trajectories:** 24 | | |
| **Start latitude 1 (degrees):** | help | 69.866 | | | |
| **Start longitude 1 (degrees):** | help | -16.833 | | | |
| **Start 2 latitude (degrees):** | | | | | |
| **Start 2 longitude (degrees):** | | | | | |
| **Start 3 latitude (degrees):** | | | | | |
| **Start 3 longitude (degrees):** | | | | | |
| **Start height 1:** | help | 2797.8 | ◉ meters AGL | ○ meters AMSL | |
| **Start height 2:** | | 0 | | | |
| **Start height 3:** | | 0 | | | |

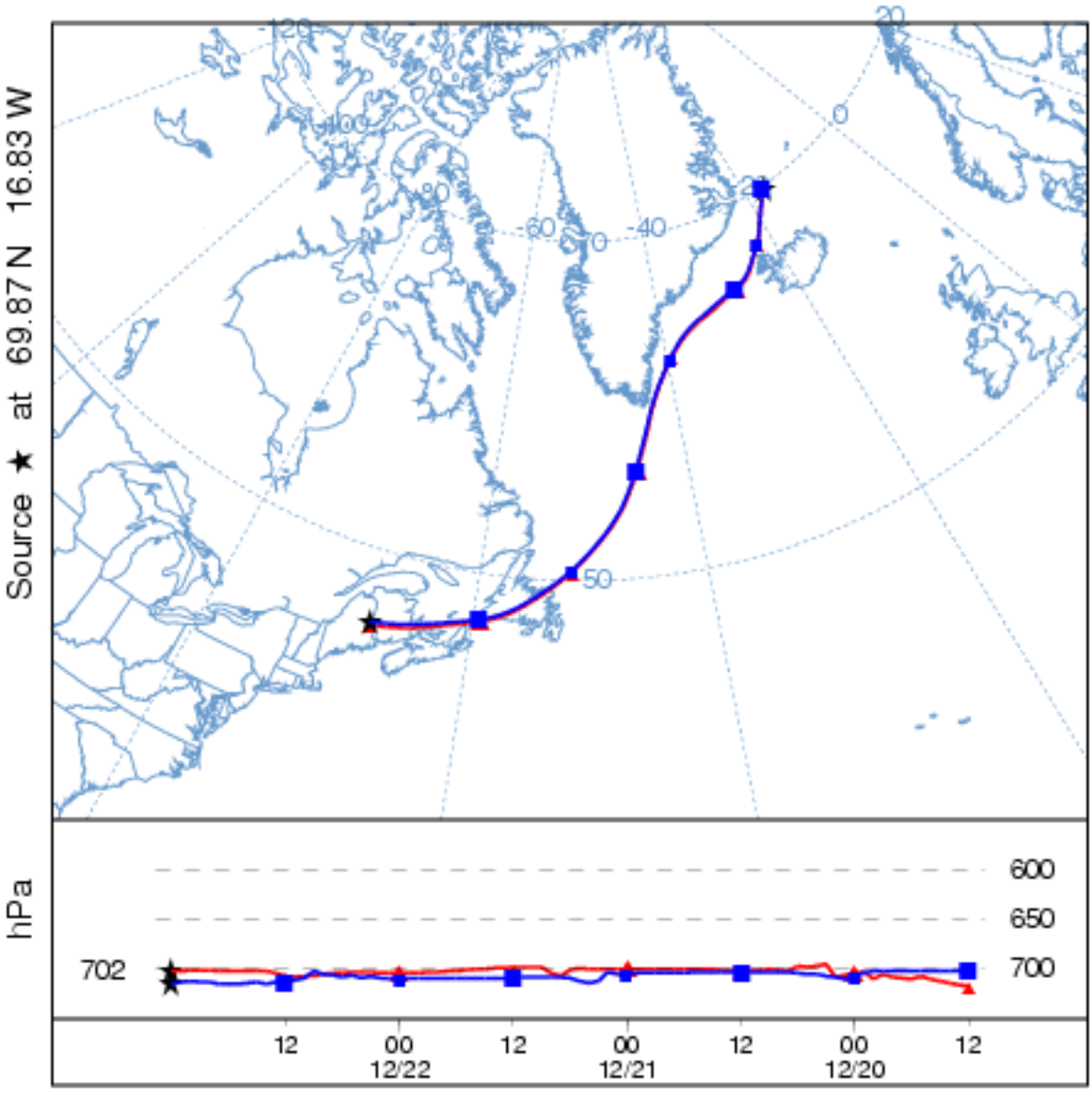
2 1
NAM 5 12 19 12 0
GFSG 5 12 19 12 0
1 BACKWARD ISOBARIC
5 12 23 0 69.866 -16.833 2797.8
1 PRESSURE

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 5 | 12 | 23 | 0 | 0 | 84 | 0.0 | 69.866 | -16.833 | 2797.8 | 702.4 |
| 1 | 2 | 5 | 12 | 22 | 23 | 0 | 83 | -1.0 | 69.683 | -17.197 | 2799.4 | 702.1 |
| 1 | 2 | 5 | 12 | 22 | 22 | 0 | 82 | -2.0 | 69.502 | -17.587 | 2800.3 | 701.9 |
| 1 | 2 | 5 | 12 | 22 | 21 | 0 | 81 | -3.0 | 69.311 | -18.037 | 2800.4 | 701.8 |
| 1 | 2 | 5 | 12 | 22 | 20 | 0 | 80 | -4.0 | 69.100 | -18.539 | 2800.0 | 701.9 |
| 1 | 2 | 5 | 12 | 22 | 19 | 0 | 79 | -5.0 | 68.868 | -19.048 | 2799.1 | 702.0 |
| 1 | 2 | 5 | 12 | 22 | 18 | 0 | 78 | -6.0 | 68.623 | -19.533 | 2797.5 | 702.3 |
| 1 | 2 | 5 | 12 | 22 | 17 | 0 | 77 | -7.0 | 68.371 | -20.002 | 2795.8 | 702.5 |
| 1 | 2 | 5 | 12 | 22 | 16 | 0 | 76 | -8.0 | 68.115 | -20.475 | 2794.6 | 702.5 |
| 1 | 2 | 5 | 12 | 22 | 15 | 0 | 75 | -9.0 | 67.855 | -20.942 | 2793.4 | 702.5 |
| 1 | 2 | 5 | 12 | 22 | 14 | 0 | 74 | -10.0 | 67.602 | -21.391 | 2787.6 | 702.8 |
| 1 | 2 | 5 | 12 | 22 | 13 | 0 | 73 | -11.0 | 67.365 | -21.852 | 2770.1 | 704.3 |
| 1 | 2 | 5 | 12 | 22 | 12 | 0 | 72 | -12.0 | 67.147 | -22.337 | 2740.9 | 707.5 |
| 1 | 2 | 5 | 12 | 22 | 11 | 0 | 71 | -13.0 | 66.935 | -22.850 | 2707.3 | 708.8 |
| 1 | 2 | 5 | 12 | 22 | 10 | 0 | 70 | -14.0 | 66.717 | -23.386 | 2687.0 | 707.4 |
| 1 | 2 | 5 | 12 | 22 | 9 | 0 | 69 | -15.0 | 66.504 | -23.915 | 2695.4 | 707.2 |
| 1 | 2 | 5 | 12 | 22 | 8 | 0 | 68 | -16.0 | 66.296 | -24.401 | 2708.1 | 705.3 |
| 1 | 2 | 5 | 12 | 22 | 7 | 0 | 67 | -17.0 | 66.098 | -24.830 | 2750.7 | 704.9 |
| 1 | 2 | 5 | 12 | 22 | 6 | 0 | 66 | -18.0 | 65.921 | -25.240 | 2773.1 | 704.2 |
| 1 | 2 | 5 | 12 | 22 | 5 | 0 | 65 | -19.0 | 65.759 | -25.655 | 2785.5 | 703.1 |
| 1 | 2 | 5 | 12 | 22 | 4 | 0 | 64 | -20.0 | 65.606 | -26.078 | 2788.1 | 703.2 |
| 1 | 2 | 5 | 12 | 22 | 3 | 0 | 63 | -21.0 | 65.480 | -26.544 | 2786.0 | 703.9 |
| 1 | 2 | 5 | 12 | 22 | 2 | 0 | 62 | -22.0 | 65.373 | -27.078 | 2783.3 | 704.2 |
| 1 | 2 | 5 | 12 | 22 | 1 | 0 | 61 | -23.0 | 65.263 | -27.689 | 2780.7 | 704.4 |
| 1 | 2 | 5 | 12 | 22 | 0 | 0 | 60 | -24.0 | 65.161 | -28.428 | 2778.3 | 704.5 |
| 1 | 2 | 5 | 12 | 21 | 23 | 0 | 59 | -25.0 | 65.044 | -29.290 | 2776.9 | 704.3 |
| 1 | 2 | 5 | 12 | 21 | 22 | 0 | 58 | -26.0 | 64.895 | -30.176 | 2777.1 | 704.0 |
| 1 | 2 | 5 | 12 | 21 | 21 | 0 | 57 | -27.0 | 64.753 | -31.067 | 2778.3 | 703.5 |
| 1 | 2 | 5 | 12 | 21 | 20 | 0 | 56 | -28.0 | 64.597 | -31.948 | 2780.1 | 703.0 |
| 1 | 2 | 5 | 12 | 21 | 19 | 0 | 55 | -29.0 | 64.426 | -32.809 | 2781.8 | 702.5 |
| 1 | 2 | 5 | 12 | 21 | 18 | 0 | 54 | -30.0 | 64.275 | -33.745 | 2782.6 | 702.0 |
| 1 | 2 | 5 | 12 | 21 | 17 | 0 | 53 | -31.0 | 64.105 | -34.720 | 2783.2 | 701.4 |
| 1 | 2 | 5 | 12 | 21 | 16 | 0 | 52 | -32.0 | 63.883 | -35.688 | 2784.9 | 700.6 |
| 1 | 2 | 5 | 12 | 21 | 15 | 0 | 51 | -33.0 | 63.607 | -36.688 | 2786.5 | 700.0 |
| 1 | 2 | 5 | 12 | 21 | 14 | 0 | 50 | -34.0 | 63.269 | -37.640 | 2787.5 | 699.5 |
| 1 | 2 | 5 | 12 | 21 | 13 | 0 | 49 | -35.0 | 62.876 | -38.521 | 2788.6 | 699.1 |
| 1 | 2 | 5 | 12 | 21 | 12 | 0 | 48 | -36.0 | 62.440 | -39.364 | 2789.2 | 698.8 |
| 1 | 2 | 5 | 12 | 21 | 11 | 0 | 47 | -37.0 | 61.952 | -40.145 | 2788.0 | 698.5 |
| 1 | 2 | 5 | 12 | 21 | 10 | 0 | 46 | -38.0 | 61.459 | -40.827 | 2784.0 | 698.4 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 5 | 12 | 21 | 9 | 0 | 45 | -39.0 | 60.908 | -41.568 | 2754.7 | 698.6 |
| 1 | 2 | 5 | 12 | 21 | 8 | 0 | 44 | -40.0 | 60.345 | -42.161 | 2704.9 | 704.3 |
| 1 | 2 | 5 | 12 | 21 | 7 | 0 | 43 | -41.0 | 59.815 | -42.657 | 2711.2 | 707.5 |
| 1 | 2 | 5 | 12 | 21 | 6 | 0 | 42 | -42.0 | 59.265 | -43.109 | 2743.6 | 701.3 |
| 1 | 2 | 5 | 12 | 21 | 5 | 0 | 41 | -43.0 | 58.710 | -43.478 | 2757.0 | 699.8 |
| 1 | 2 | 5 | 12 | 21 | 4 | 0 | 40 | -44.0 | 58.171 | -43.864 | 2760.5 | 700.2 |
| 1 | 2 | 5 | 12 | 21 | 3 | 0 | 39 | -45.0 | 57.622 | -44.259 | 2761.3 | 700.2 |
| 1 | 2 | 5 | 12 | 21 | 2 | 0 | 38 | -46.0 | 57.089 | -44.628 | 2761.2 | 700.3 |
| 1 | 2 | 5 | 12 | 21 | 1 | 0 | 37 | -47.0 | 56.565 | -45.024 | 2761.1 | 700.4 |
| 1 | 2 | 5 | 12 | 21 | 0 | 0 | 36 | -48.0 | 56.017 | -45.423 | 2760.4 | 700.7 |
| 1 | 2 | 5 | 12 | 20 | 23 | 0 | 35 | -49.0 | 55.481 | -45.821 | 2759.7 | 700.8 |
| 1 | 2 | 5 | 12 | 20 | 22 | 0 | 34 | -50.0 | 54.963 | -46.252 | 2759.9 | 700.9 |
| 1 | 2 | 5 | 12 | 20 | 21 | 0 | 33 | -51.0 | 54.451 | -46.681 | 2760.3 | 700.9 |
| 1 | 2 | 5 | 12 | 20 | 20 | 0 | 32 | -52.0 | 53.963 | -47.140 | 2760.9 | 700.7 |
| 1 | 2 | 5 | 12 | 20 | 19 | 0 | 31 | -53.0 | 53.495 | -47.667 | 2761.9 | 700.4 |
| 1 | 2 | 5 | 12 | 20 | 18 | 0 | 30 | -54.0 | 53.045 | -48.214 | 2763.2 | 700.2 |
| 1 | 2 | 5 | 12 | 20 | 17 | 0 | 29 | -55.0 | 52.599 | -48.789 | 2764.1 | 700.2 |
| 1 | 2 | 5 | 12 | 20 | 16 | 0 | 28 | -56.0 | 52.153 | -49.414 | 2763.6 | 700.5 |
| 1 | 2 | 5 | 12 | 20 | 15 | 0 | 27 | -57.0 | 51.721 | -50.036 | 2762.0 | 700.8 |
| 1 | 2 | 5 | 12 | 20 | 14 | 0 | 26 | -58.0 | 51.298 | -50.663 | 2760.6 | 701.1 |
| 1 | 2 | 5 | 12 | 20 | 13 | 0 | 25 | -59.0 | 50.882 | -51.315 | 2759.7 | 701.3 |
| 1 | 2 | 5 | 12 | 20 | 12 | 0 | 24 | -60.0 | 50.486 | -51.962 | 2758.8 | 701.5 |
| 1 | 2 | 5 | 12 | 20 | 11 | 0 | 23 | -61.0 | 50.107 | -52.609 | 2758.4 | 701.6 |
| 1 | 2 | 5 | 12 | 20 | 10 | 0 | 22 | -62.0 | 49.746 | -53.263 | 2753.3 | 701.3 |
| 1 | 2 | 5 | 12 | 20 | 9 | 0 | 21 | -63.0 | 49.411 | -53.905 | 2729.3 | 700.3 |
| 1 | 2 | 5 | 12 | 20 | 8 | 0 | 20 | -64.0 | 49.094 | -54.541 | 2693.3 | 701.3 |
| 1 | 2 | 5 | 12 | 20 | 7 | 0 | 19 | -65.0 | 48.792 | -55.197 | 2641.2 | 702.8 |
| 1 | 1 | 5 | 12 | 20 | 6 | 0 | 18 | -66.0 | 48.503 | -55.787 | 2566.1 | 697.9 |
| 1 | 1 | 5 | 12 | 20 | 5 | 0 | 17 | -67.0 | 48.237 | -56.364 | 2515.9 | 698.9 |
| 1 | 1 | 5 | 12 | 20 | 4 | 0 | 16 | -68.0 | 48.004 | -56.948 | 2495.0 | 697.5 |
| 1 | 1 | 5 | 12 | 20 | 3 | 0 | 15 | -69.0 | 47.797 | -57.543 | 2540.1 | 695.8 |
| 1 | 1 | 5 | 12 | 20 | 2 | 0 | 14 | -70.0 | 47.610 | -58.154 | 2663.7 | 708.3 |
| 1 | 1 | 5 | 12 | 20 | 1 | 0 | 13 | -71.0 | 47.443 | -58.788 | 2691.2 | 706.1 |
| 1 | 1 | 5 | 12 | 20 | 0 | 0 | 12 | -72.0 | 47.300 | -59.452 | 2750.8 | 704.3 |
| 1 | 1 | 5 | 12 | 19 | 23 | 0 | 11 | -73.0 | 47.170 | -60.142 | 2751.7 | 703.4 |
| 1 | 1 | 5 | 12 | 19 | 22 | 0 | 10 | -74.0 | 47.034 | -60.861 | 2682.2 | 710.0 |
| 1 | 1 | 5 | 12 | 19 | 21 | 0 | 9 | -75.0 | 46.892 | -61.606 | 2734.6 | 705.4 |
| 1 | 1 | 5 | 12 | 19 | 20 | 0 | 8 | -76.0 | 46.744 | -62.348 | 2729.3 | 708.6 |
| 1 | 1 | 5 | 12 | 19 | 19 | 0 | 7 | -77.0 | 46.597 | -63.073 | 2718.3 | 709.0 |
| 1 | 1 | 5 | 12 | 19 | 18 | 0 | 6 | -78.0 | 46.448 | -63.793 | 2724.1 | 710.2 |
| 1 | 1 | 5 | 12 | 19 | 17 | 0 | 5 | -79.0 | 46.304 | -64.513 | 2687.1 | 707.3 |
| 1 | 1 | 5 | 12 | 19 | 16 | 0 | 4 | -80.0 | 46.176 | -65.230 | 2614.3 | 710.8 |
| 1 | 1 | 5 | 12 | 19 | 15 | 0 | 3 | -81.0 | 46.075 | -65.928 | 2610.6 | 712.7 |
| 1 | 1 | 5 | 12 | 19 | 14 | 0 | 2 | -82.0 | 45.985 | -66.605 | 2592.9 | 714.6 |
| 1 | 1 | 5 | 12 | 19 | 13 | 0 | 1 | -83.0 | 45.886 | -67.283 | 2543.5 | 716.3 |
| 1 | 1 | 5 | 12 | 19 | 12 | 0 | 0 | -84.0 | 45.798 | -67.979 | 2518.3 | 717.1 |


NOAA HYSPLIT MODEL
Backward trajectory ending at 00 UTC 23 Dec 05
12 UTC 19 Dec NAM Forecast Initialization
Source ★ at 69.87 N 16.83 W
-60
-40
0
0
50
hPa
600
650
700
702
18 12 06 00 18 12 06 00 18 12 06 00 18 12
12/22
12/21
12/20
Job ID: 318388 Job Start: Tue Oct 10 17:10:02 GMT 2006
Source 1 lat.: 69.866 lon.: -16.833 height: 2797.8 m AGL
Trajectory Direction: Backward Duration: 84 hrs Meteo Data: WORKSHOP / GFS
Vertical Motion Calculation Method: Isobaric
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

NOAA HYSPLIT MODEL
Backward trajectory ending at 00 UTC 23 Dec 05
12 UTC 19 Dec NAM Forecast Initialization



# Terrain Height Issues



**HIGHLIGHTS**

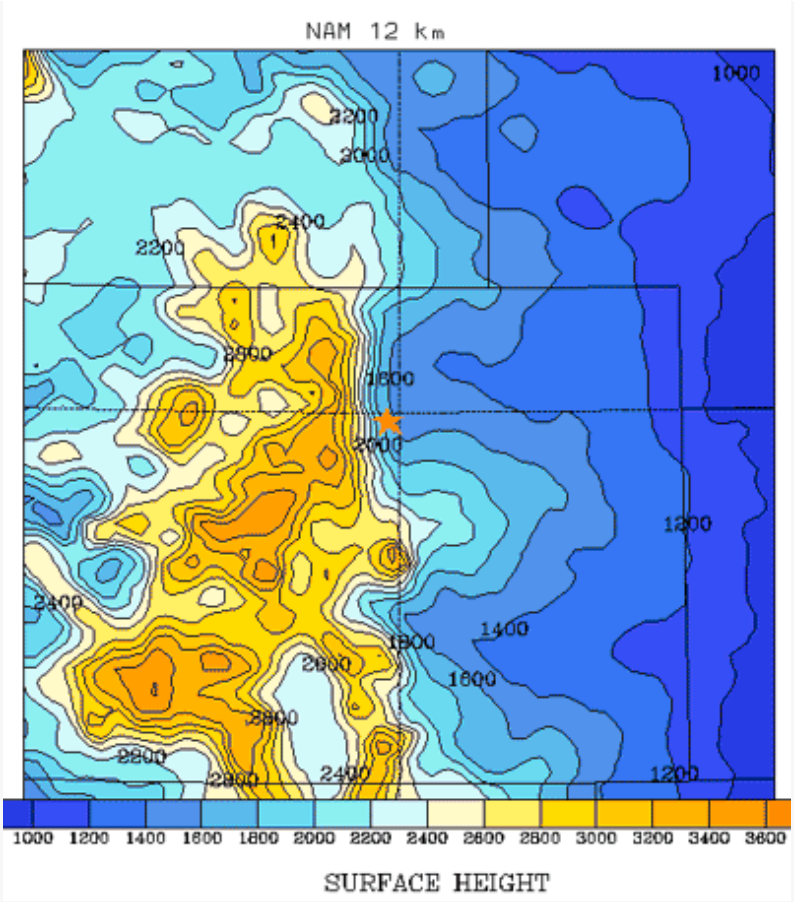
- Define trajectory starting heights
- Model vs actual terrain height

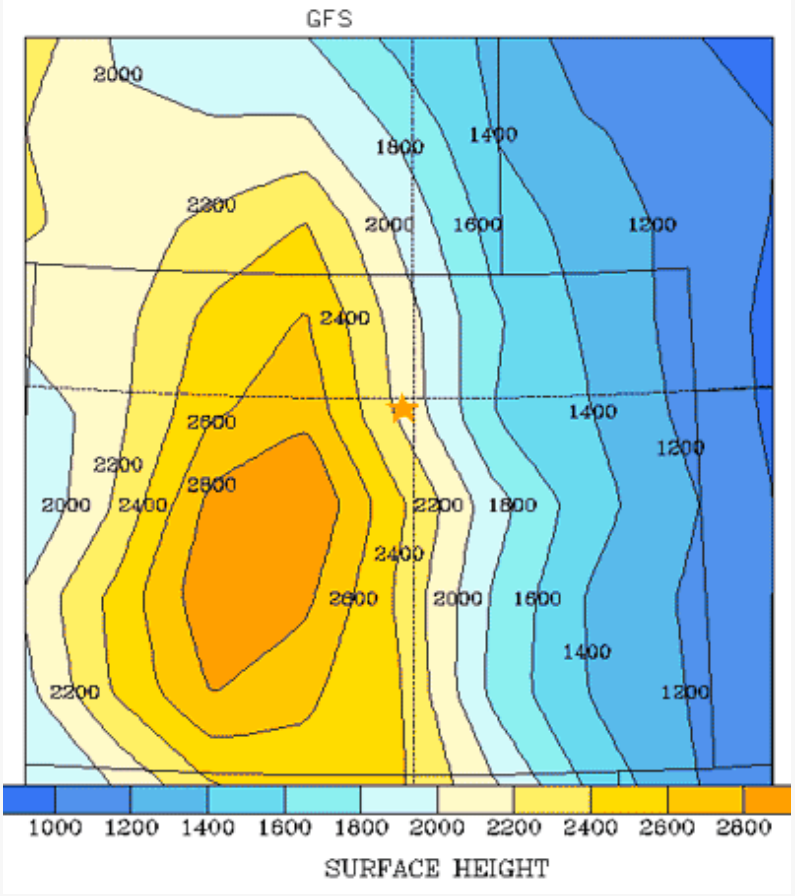
The trajectory starting height is defaulted to **meters AGL** (above ground level), however as shown earlier, height definitions can be changed to **meters AMSL** (above mean sea level) from the **Model Runtime Options** menu. Regardless of how the input heights are defined, internally HYSPLIT treats all heights in a terrain following coordinate system based on the chosen meteorological data. These heights may be quite different from the actual terrain height at a point of interest.

As an example of how one might define a starting trajectory height, examine the location for Broomfield (KBJC), Colorado, at 39.92N and 105.12W, which has a surface height of 1724 m AMSL. The terrain heights for the NAM 12 km (left) and GFS (right) are shown below (Bloomfield is indicated by the orange star). The terrain in the vicinity of Bloomfield is much smoother in the coarser GFS than the NAM and the terrain gradient is much steeper in the NAM, and therefore, we would expect to see differences in the terrain heights between the 2 models. Also, when the all model terrain heights (see table to the right) are consistently higher than the true terrain height, one might suspect that the station is located in a valley, as in this case. In this situation all one can do is assume that true ground-level is at the model's terrain height and proceed ... with the realization that the real lower levels of the flow field may at times be constrained in ways that are not evident in the coarser gridded meteorological data fields.

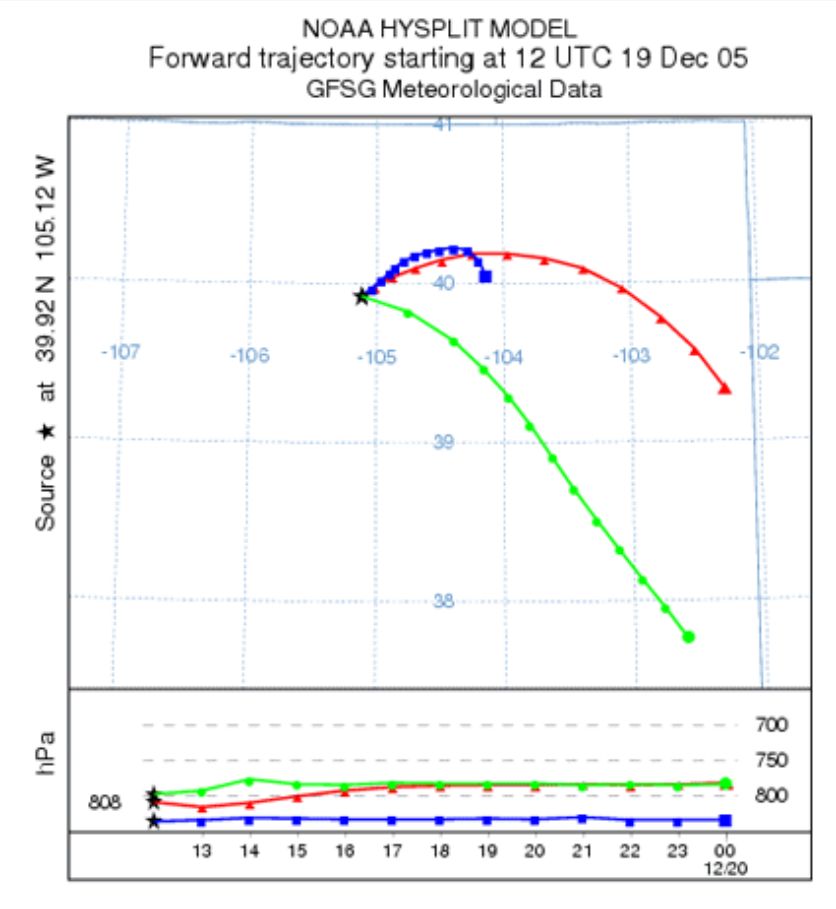
| Model | Resolution | Terrain |
|---|---|---|
| MM5 | 15 km | 2000 m |
| MM5 | 45 km | 2100 m |
| NAM | 12 km | 1970 m |
| NAM | 40 km | 1840 m |
| RUC | 20 km | 1890 m |
| GFS | 1 deg | 2020 m |

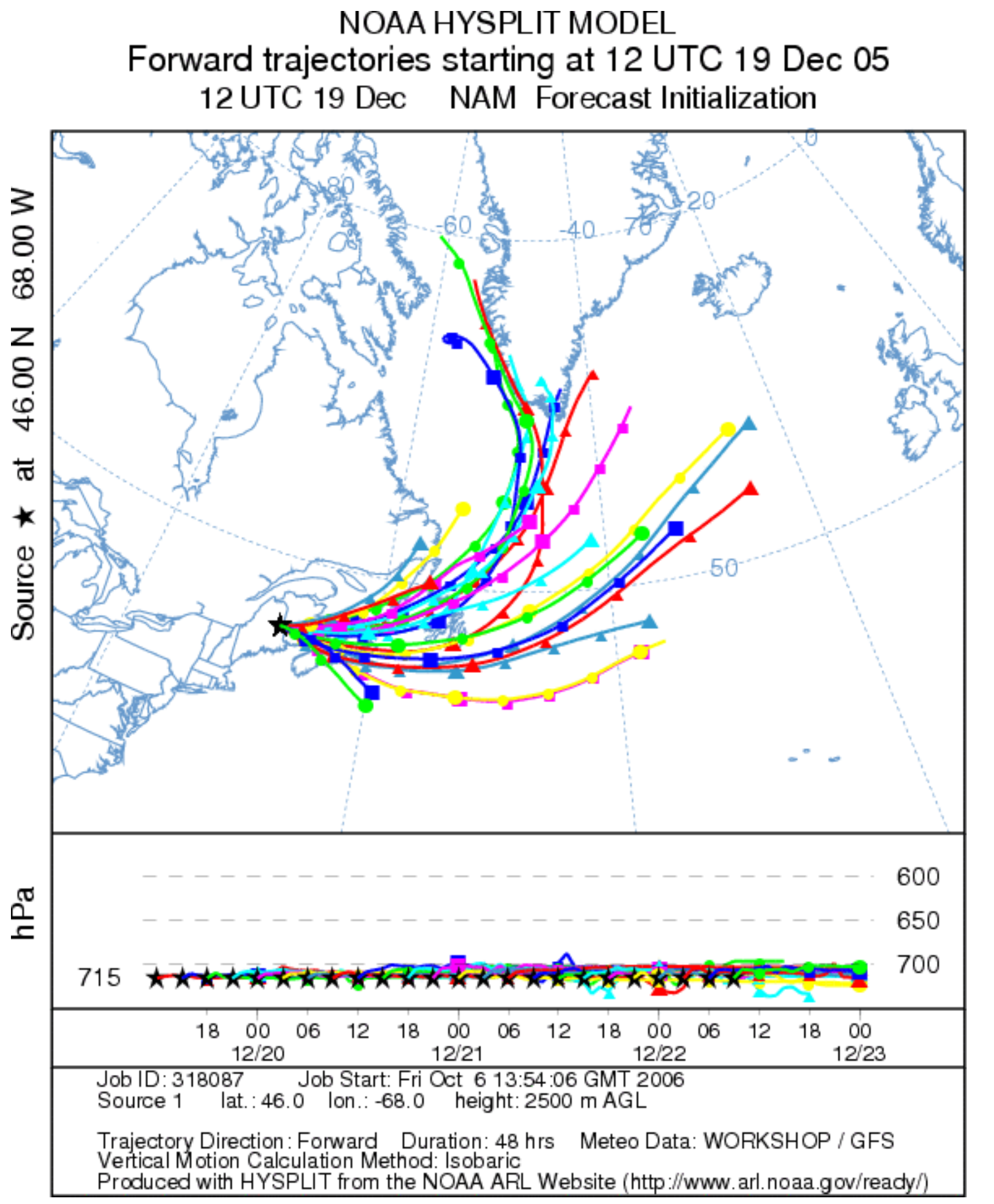
Surface elevations for Broomfield, CO, from various meteorological models.




In the example below we compare the NAM 12 km trajectory (blue) to the MM5 45 km (green), and the 1 degree GFS (red) originating from 10 m AGL. Even though all the trajectories start out at the same height AGL, they start at different pressure levels due to differences in elevation between the data.




NOAA HYSPLIT MODEL
Forward trajectories starting at 12 UTC 19 Dec 05
12 UTC 19 Dec NAM Forecast Initialization
Source ★ at 46.00 N 68.00 W
hPa
600
650
700
715
18 00 06 12 18 00 06 12 18 00 06 12 18 00
12/20 12/21 12/22 12/23
Job ID: 318087 Job Start: Fri Oct 6 13:54:06 GMT 2006
Source 1 lat.: 46.0 lon.: -68.0 height: 2500 m AGL
Trajectory Direction: Forward Duration: 48 hrs Meteo Data: WORKSHOP / GFS
Vertical Motion Calculation Method: Isobaric
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

# MATRIX SETUP

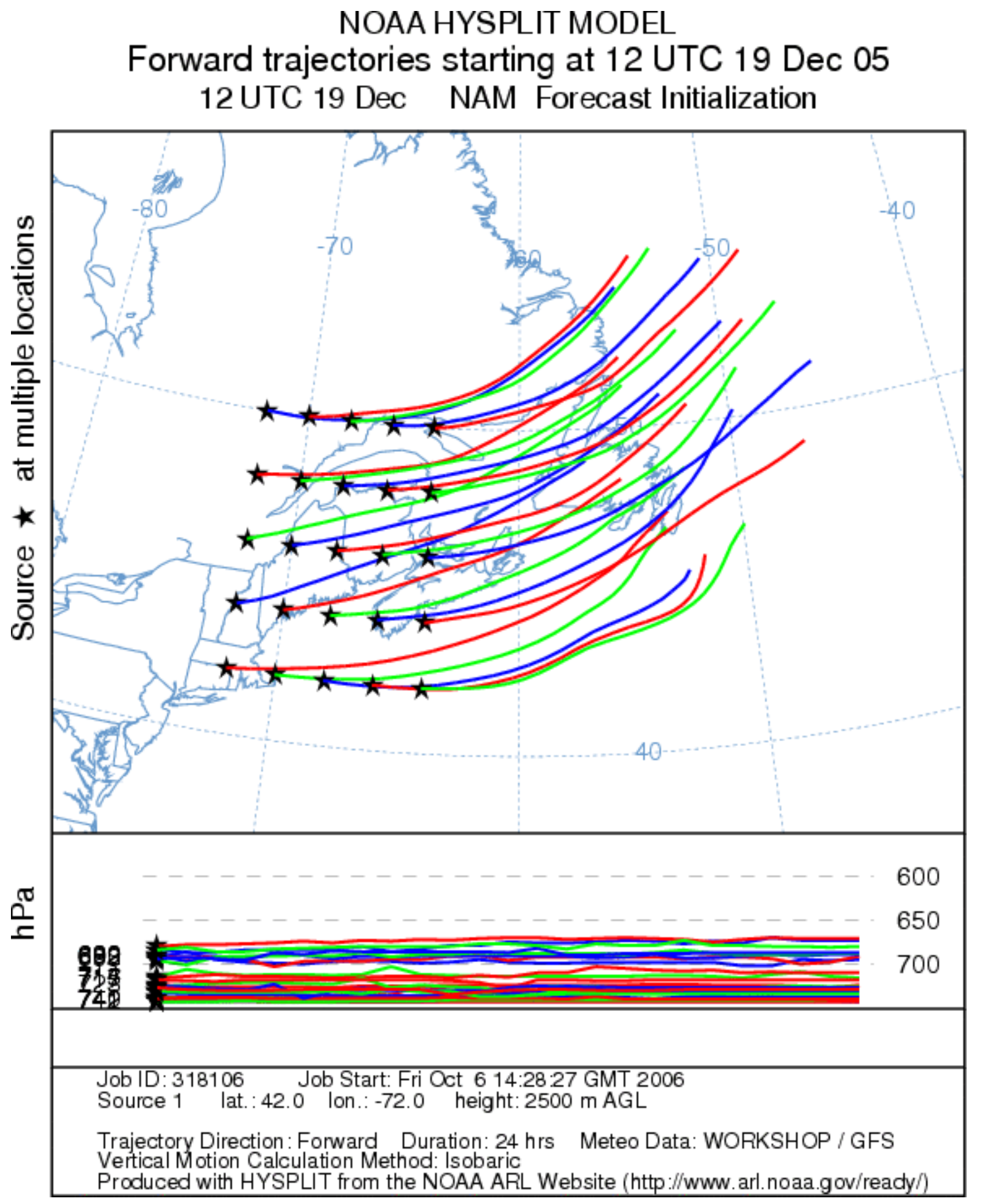
The trajectory matrix is bounded by the lower left and upper right latitude/longitude points. The spacing is defined as the difference between the lower left point and the first grid point to the northeast (NE) of this location. However, the total number of source locations **CANNOT EXCEED 125**, which is about a 11x11 lat/lon grid with a 1 degree spacing.

**Lower-left latitude:** 42.0 **(South is negative, i.e. -10.95)**
**Lower-left longitude:** -72.0 **(West is negative, i.e. -140.95)**

**Upper-right latitude:** 50.0
**Upper-right longitude:** -64.0

**Latitude of first grid point NE of lower left point:** 44.0
**Longitude of first grid point NE of lower left point:** -70.0

Next>>

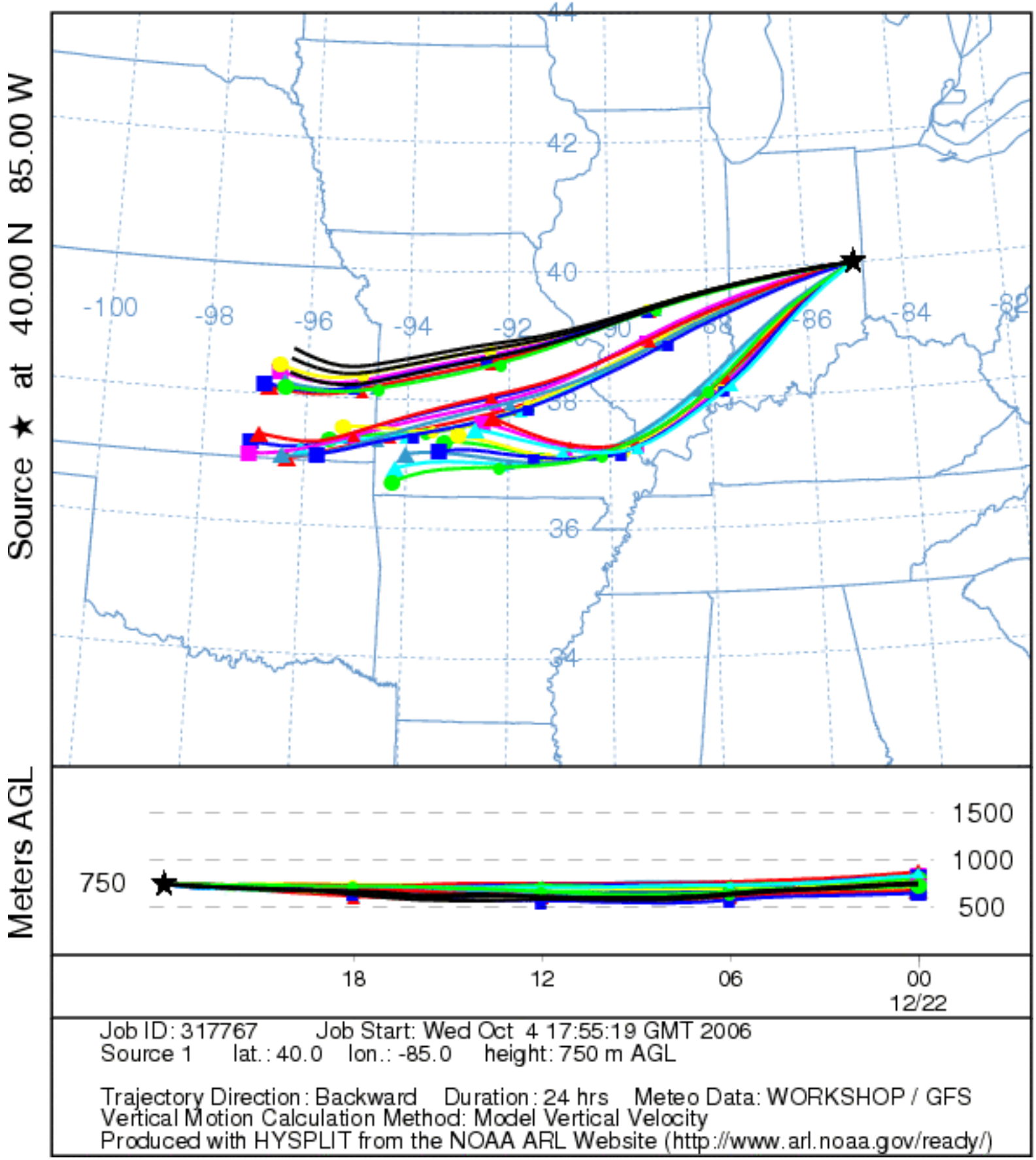

NOAA HYSPLIT MODEL
Forward trajectories starting at 12 UTC 19 Dec 05
12 UTC 19 Dec NAM Forecast Initialization
Source ★ at multiple locations
-80
-70
-60
-50
-40
40
hPa
600
650
700
Job ID: 318106 Job Start: Fri Oct 6 14:28:27 GMT 2006
Source 1 lat.: 42.0 lon.: -72.0 height: 2500 m AGL
Trajectory Direction: Forward Duration: 24 hrs Meteo Data: WORKSHOP / GFS
Vertical Motion Calculation Method: Isobaric
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

| | | | | | |
|---|---|---|---|---|---|
| **Allow transfer to GFS:** | help | ◉ Use only chosen meteorology | | | |
| | | ○ Use current GFS forecast if trajectory runs off current grid | | | |
| **Trajectory direction:** | help | ○ Forward | | | |
| | | ◉ Backward (You must change the default start time!) | | | |
| **Vertical Motion:** | help | ◉ Model vertical velocity | | | |
| | | ○ Isobaric | | | |
| | | ○ Isentropic | | | |
| **Start time (UTC):** | help | year 05 | month 12 | day 23 | hour 0 |
| **Total run time (hours):** | help | 24 | | | |
| **Start a new trajectory every:** | help | 0 **hrs** | **Maximum number of trajectories:** 24 | | |
| **Start latitude 1 (degrees):** | help | 40.0 | | | |
| **Start longitude 1 (degrees):** | help | -85.0 | | | |
| **Start 2 latitude (degrees):** | | | | | |
| **Start 2 longitude (degrees):** | | | | | |
| **Start 3 latitude (degrees):** | | | | | |
| **Start 3 longitude (degrees):** | | | | | |
| **Start height 1:** | help | 750 | ◉ meters AGL | ○ meters AMSL | |
| **Start height 2:** | | 0 | | | |
| **Start height 3:** | | 0 | | | |

NOAA HYSPLIT MODEL

Backward trajectories ending at 00 UTC 23 Dec 05

12 UTC 19 Dec NAM Forecast Initialization




Job ID: 317767 Job Start: Wed Oct 4 17:55:19 GMT 2006

Source 1 lat.: 40.0 lon.: -85.0 height: 750 m AGL

Trajectory Direction: Backward Duration: 24 hrs Meteo Data: WORKSHOP / GFS

Vertical Motion Calculation Method: Model Vertical Velocity

Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

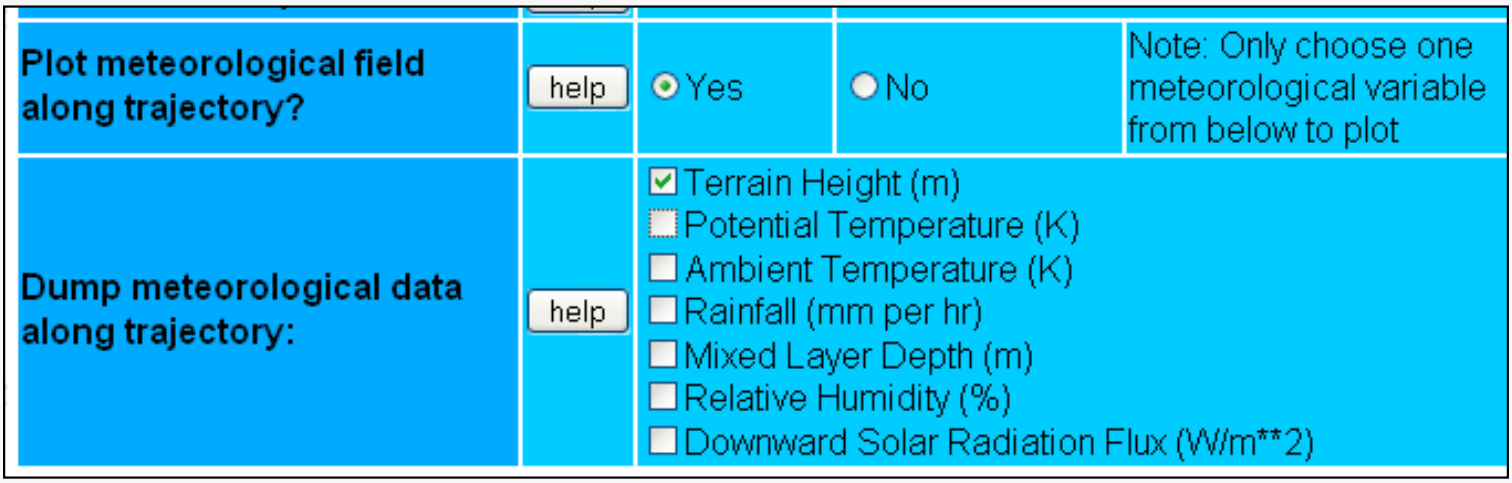
# Meteorological Analysis Along a Trajectory



**HIGHLIGHTS**

- Plot meteorology along a trajectory
- Trajectory vertical display coordinate
- Modify plot without rerunning the model
- Rerun the model with user defaults

HYSPLIT can provide details on some of the meteorological parameters along the trajectory if the appropriate boxes are selected by the user on the **Display Options** menu (see below). This information can be useful in diagnosing why a trajectory took the path it did, to show the underlying terrain height, to show the mixed layer depth along the trajectory, or to show if any precipitation was being produced along the trajectory path by the meteorological model. Currently only **ambient and potential temperature, precipitation, mixing depth, relative humidity, solar radiation, and terrain height** are available to output or display. One or more fields may be selected and all will be written to the trajectory endpoints file in the columns to the right, however only the rightmost (or last selected) variable will be plotted at the bottom of the trajectory map if the plotting option is enabled.

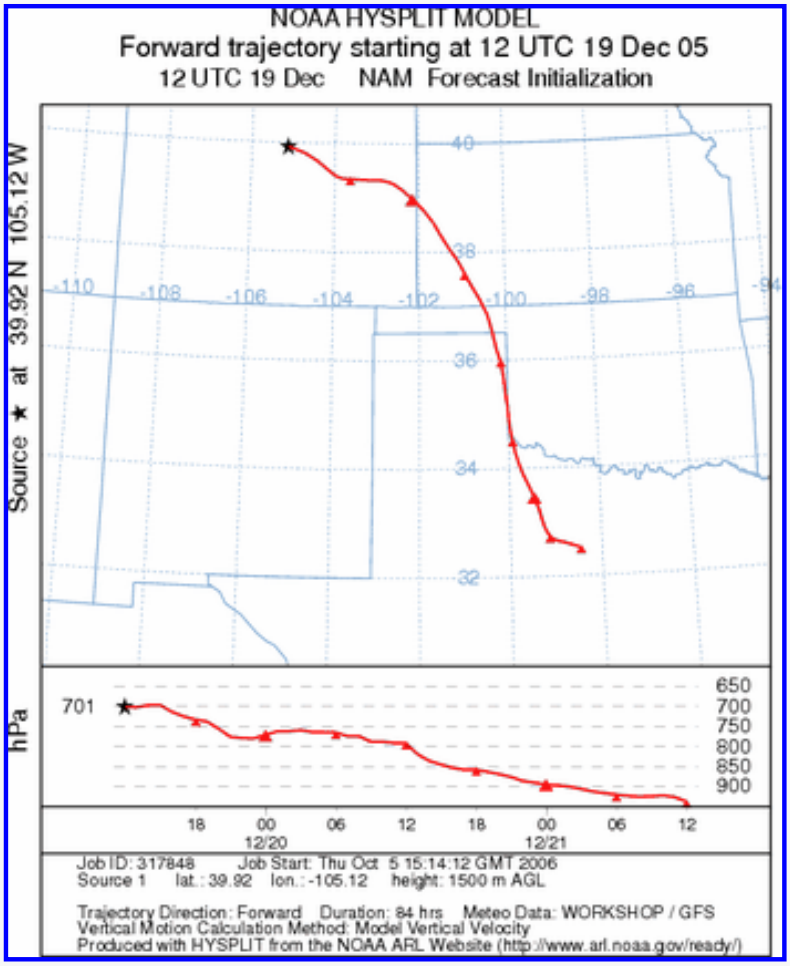


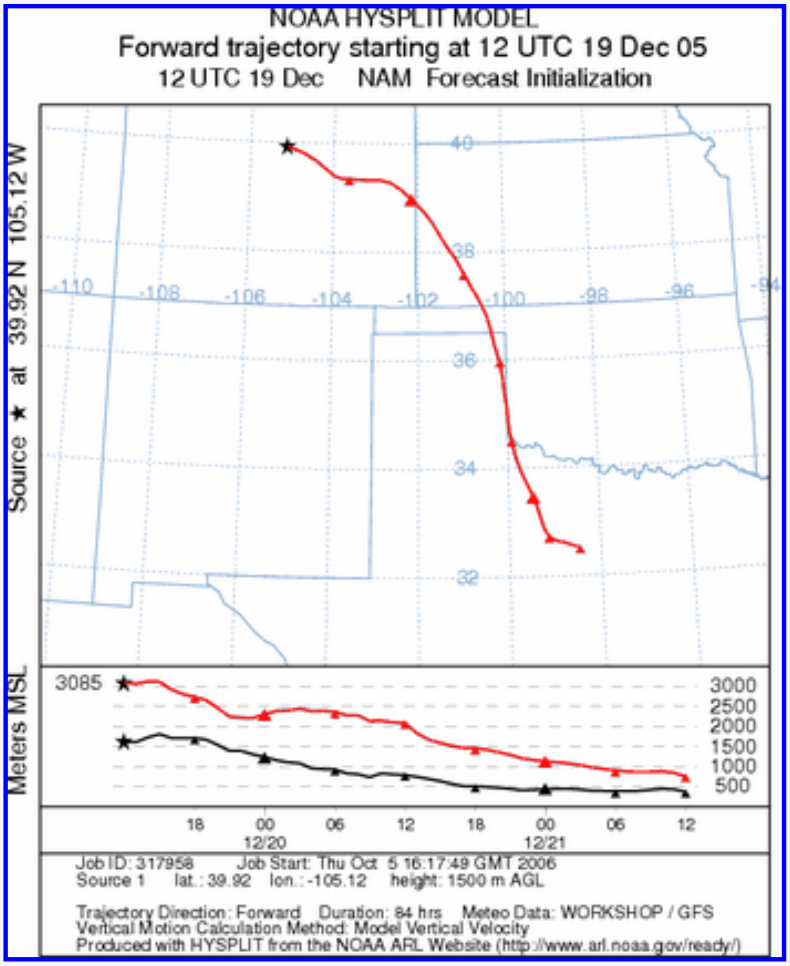

## Terrain Height Plotting Example

For this example see Example 7 Powerpoint **(Ex7_hysplit.ppt)]** or,
configure a normal trajectory simulation for Broomfield, CO, and check the box to dump the **terrain height** along the trajectory but not plot it.

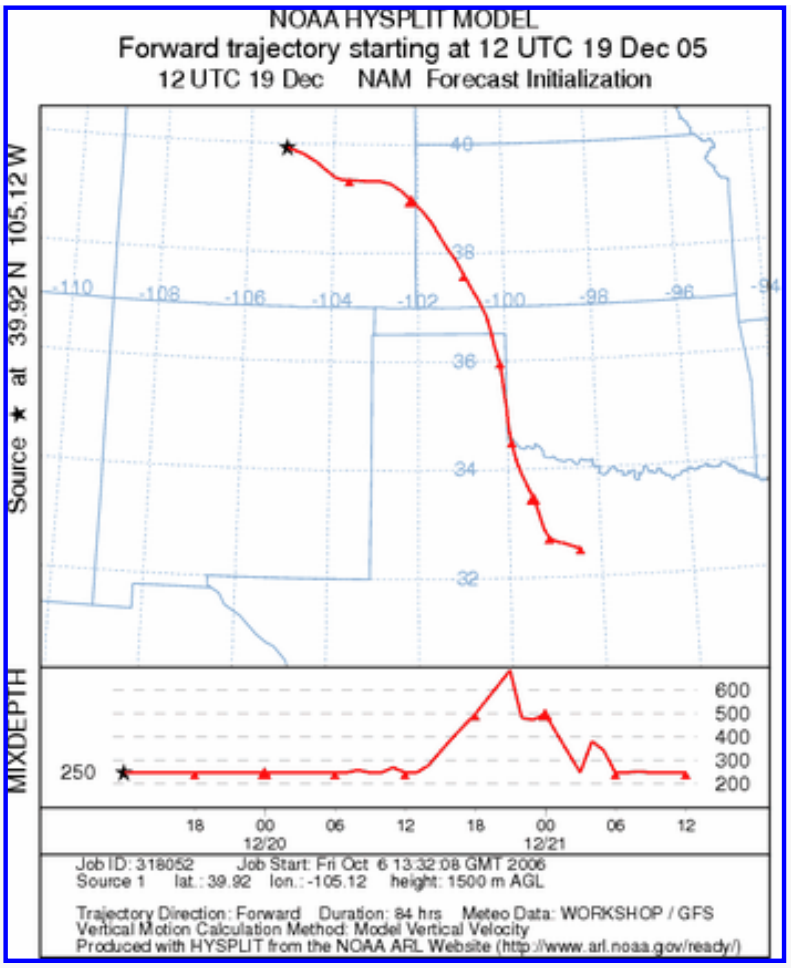
- **NAM 12 km**
- **39.92N** and **105.12W** (Broomfield, CO)
- starting height: **1500 m AGL**
- vertical motion: **model vertical velocity**
- total run time: **84 hours**
- vertical plot height units: **Pressure**
- plot meteorology: **No**
- dump meteorology: **Terrain height (m)**

The resulting trajectory (below, left) proceeds to the southeast into central Texas, descending from 700 hPa to nearly 950 hPa. Now, click on **Modify the trajectory without rerunning the model** and change the vertical plot height unit from Pressure to **Above model ground level**, then click **Request plot**. This will redraw the trajectory with meters above MSL as the vertical coordinate, and since the terrain height along the trajectory was already saved, it will be plotted below the trajectory (this can also be done by rerunning the model and clicking **Yes** to **plot the meteorological data along the trajectory**). The trajectory (below, right) actually follows the terrain for the most part, so care must be exercised when interpreting the up or down movement of trajectories with respect to height above model ground level and pressure vertical height coordinates. The terrain heights can be viewed as the right-most column of the [trajectory endpoints file (**tdump**)]



A recently added option, **Rerun the model with user entered defaults**, allows the user to rerun a model case without having to re-enter all the inputs previously entered. Click on this option and when presented with the **Display Options** menu, select **Yes** for plotting the meteorology along the trajectory and then uncheck the **terrain height** and check the box for **mixed layer depth**. Submit the job and display the results (right). This plot shows the mixed layer depth along the trajectory varied from 250 m (HYSPLIT sets the lower depth to a minimum of 250 m) to 687 m.

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# Vertical Motion Options



**HIGHLIGHTS**

- Trajectory vertical motion methods
- Isobaric & Isentropic trajectories

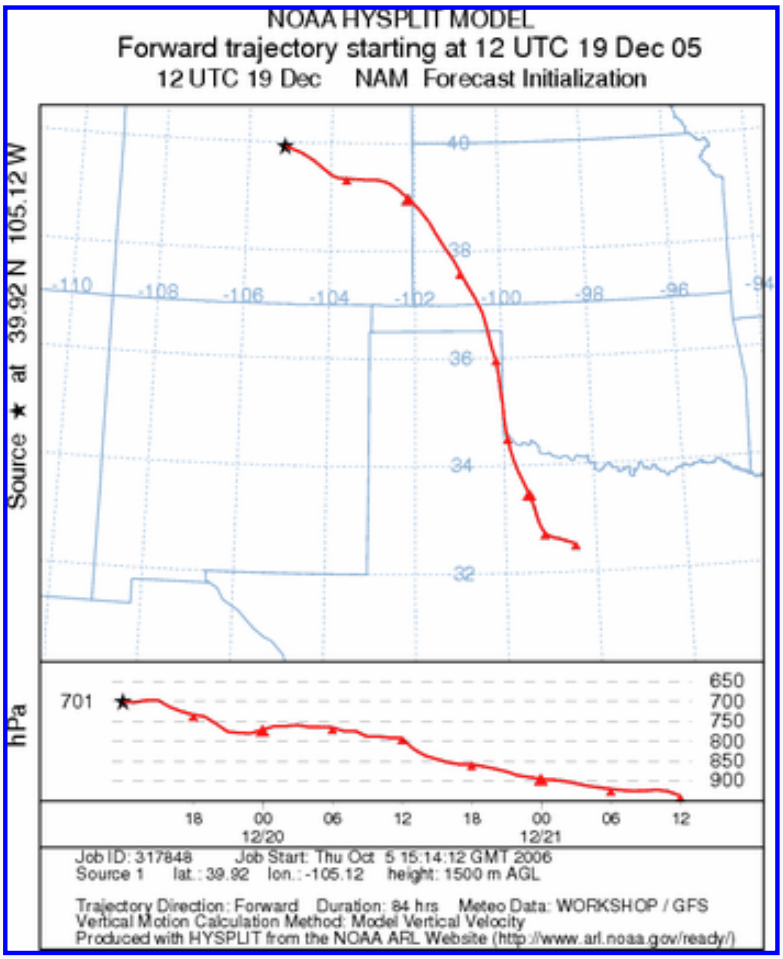
There are five different vertical motion options in HYSPLIT, three of which are currently implemented in HYSPLIT-WEB (**model vertical velocity, isobaric, isentropic**). As mentioned previously, the suggested default is to use the vertical velocity field that is included with most meteorological data. Other options may be required for special situations such as following the transport of a balloon on a constant density surface, comparing isobaric flow fields between data sets, or situations when the meteorological data's vertical velocity field may be too noisy compared with the time step at which the data are available (high spatial resolution simulations).

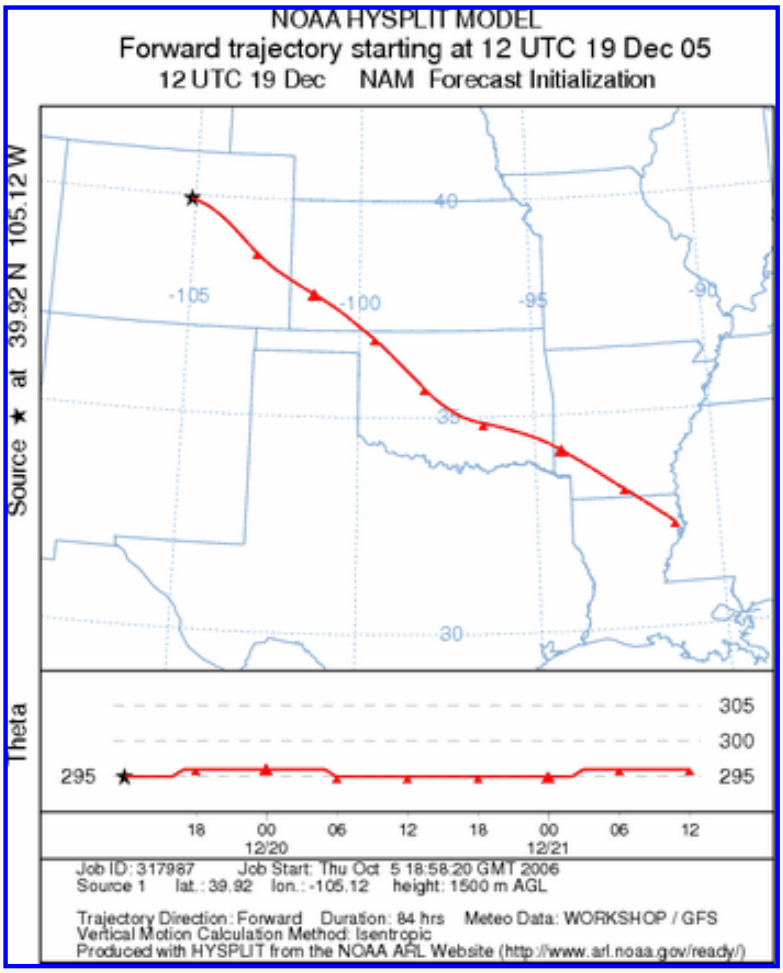

In the isobaric and isentropic modes, vertical velocities are computed from the equation,

$$W = (- \partial q/\partial t - u\, \partial q/\partial x - v\, \partial q/\partial y) / (\partial q/\partial z)$$

where **W** is the velocity required for the trajectory to remain on the **q** surface (pressure or potential temperature). Note that the equation results in only an approximation of the motion and a trajectory may drift from the desired surface.

Shown below left is the same trajectory from the previous example using the NAM 12 km vertical velocity fields. To the right is the same trajectory computed using the isentropic flow assumption and choosing the **Theta** vertical coordinate option from the **Display Options** menu. This graphic shows that the potential temperature varied by only about 1 degree, however by assuming adiabatic flow conditions the second trajectory ended in northeastern Louisiana after 84 hours instead of north central Texas. The validity of the adiabatic flow assumption would need to be assessed for this case.



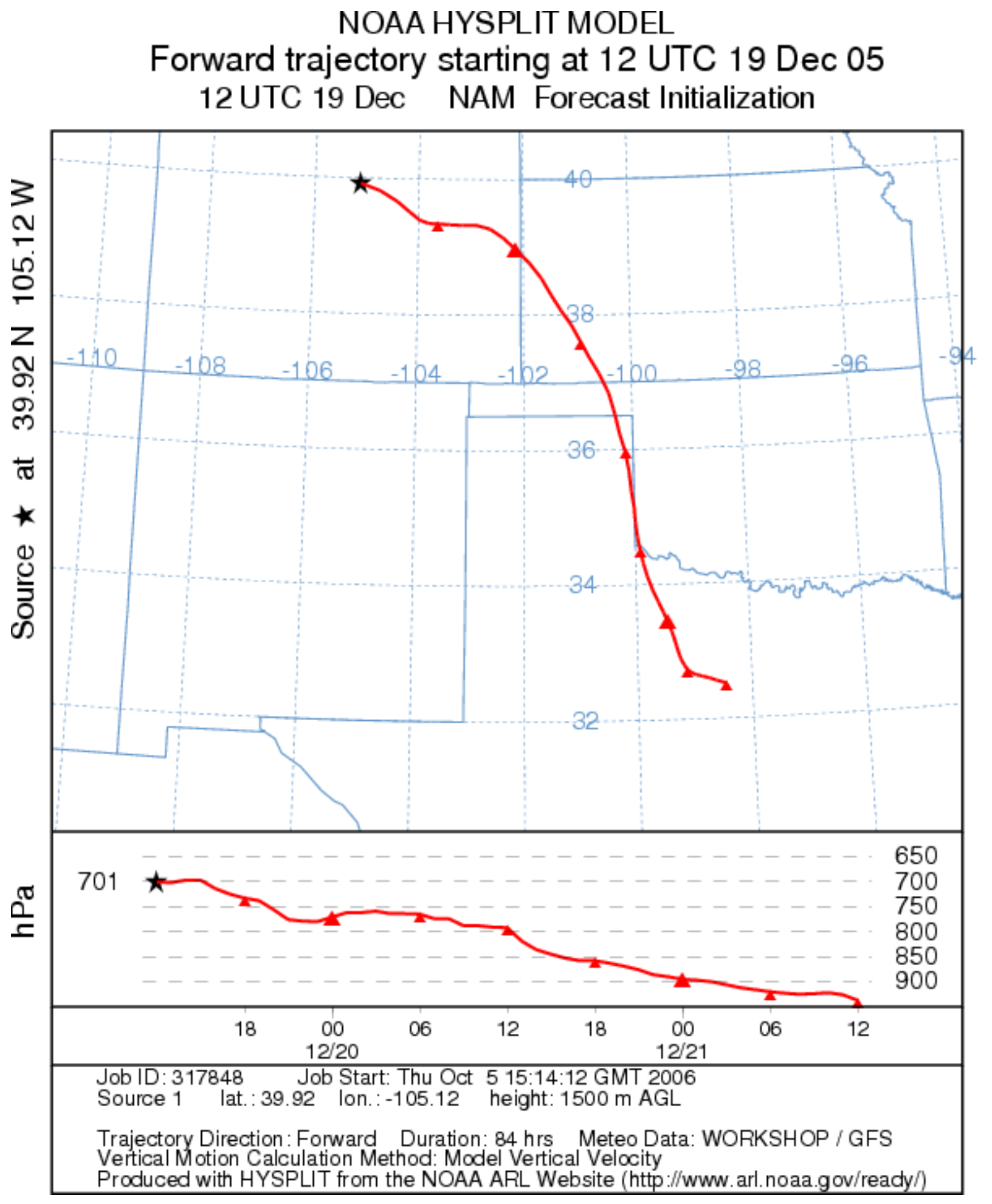



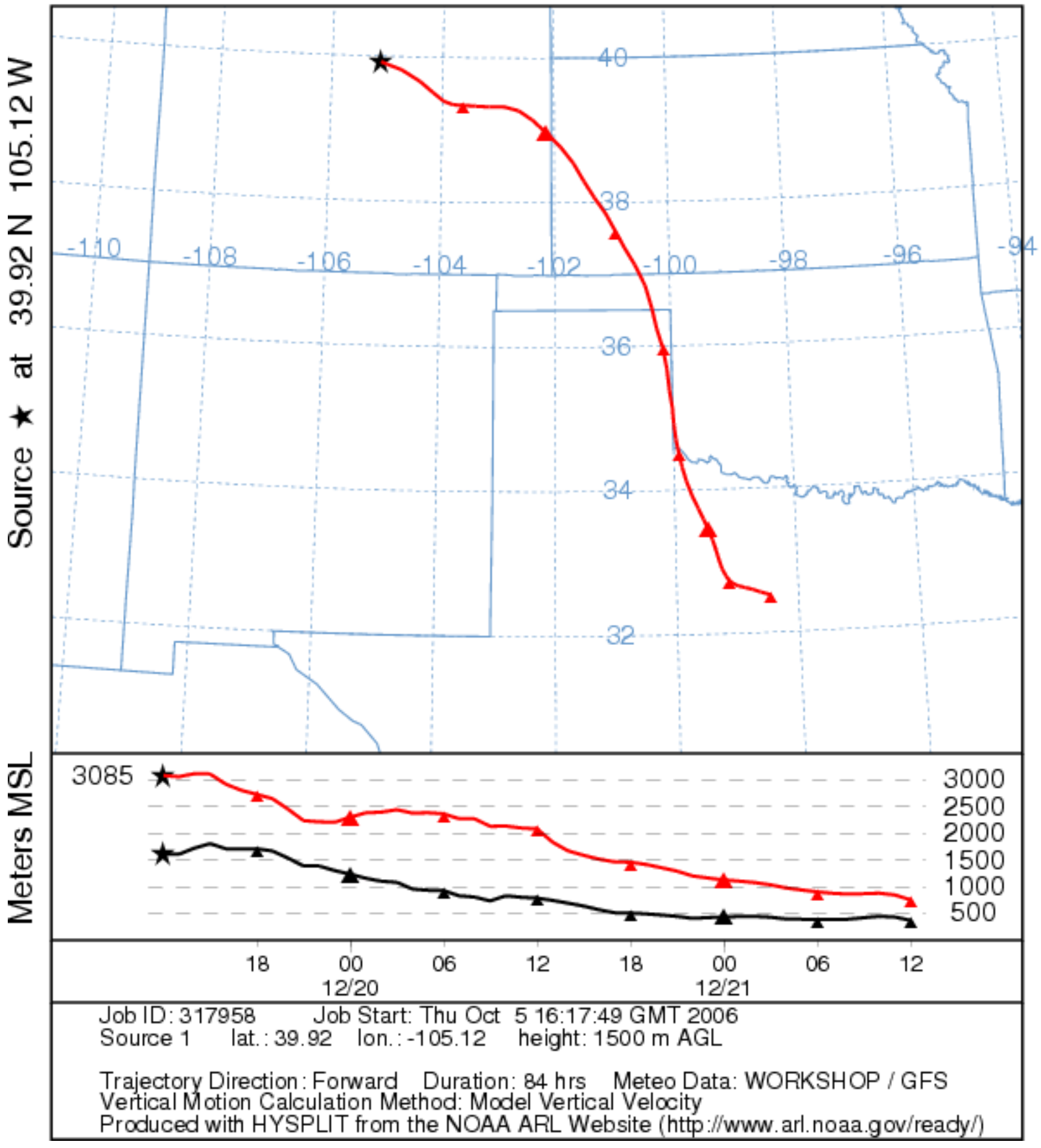

Previous HOME Next

1 1
NAM 5 12 19 12 0
1 FORWARD OMEGA
5 12 19 12 39.920 -105.120 1500.0
2 PRESSURE TERR_MSL

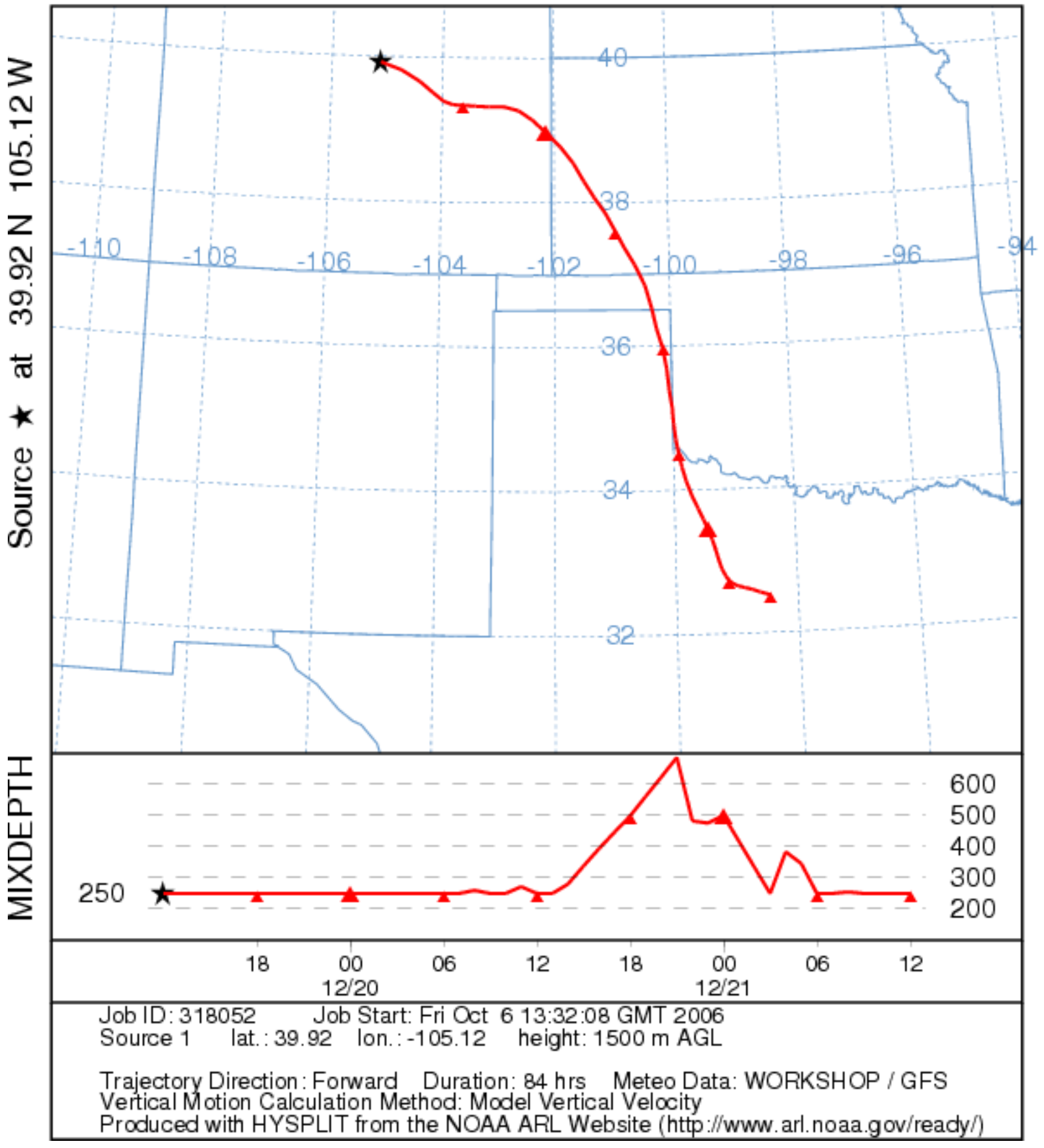
| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 5 | 12 | 19 | 12 | 0 | 0 | 0.0 | 39.920 | -105.120 | 1500.0 | 701.4 | 1585.5 |
| 1 | 1 | 5 | 12 | 19 | 13 | 0 | 1 | 1.0 | 39.815 | -104.741 | 1453.2 | 702.3 | 1610.1 |
| 1 | 1 | 5 | 12 | 19 | 14 | 0 | 2 | 2.0 | 39.664 | -104.413 | 1394.6 | 697.0 | 1726.4 |
| 1 | 1 | 5 | 12 | 19 | 15 | 0 | 3 | 3.0 | 39.512 | -104.172 | 1305.2 | 697.7 | 1809.5 |
| 1 | 1 | 5 | 12 | 19 | 16 | 0 | 4 | 4.0 | 39.394 | -103.976 | 1211.4 | 714.7 | 1714.3 |
| 1 | 1 | 5 | 12 | 19 | 17 | 0 | 5 | 5.0 | 39.348 | -103.807 | 1096.2 | 725.8 | 1712.0 |
| 1 | 1 | 5 | 12 | 19 | 18 | 0 | 6 | 6.0 | 39.342 | -103.620 | 1020.7 | 733.1 | 1712.0 |
| 1 | 1 | 5 | 12 | 19 | 19 | 0 | 7 | 7.0 | 39.332 | -103.398 | 980.4 | 738.5 | 1672.9 |
| 1 | 1 | 5 | 12 | 19 | 20 | 0 | 8 | 8.0 | 39.324 | -103.158 | 918.9 | 756.0 | 1539.1 |
| 1 | 1 | 5 | 12 | 19 | 21 | 0 | 9 | 9.0 | 39.327 | -102.898 | 848.7 | 776.1 | 1392.0 |
| 1 | 1 | 5 | 12 | 19 | 22 | 0 | 10 | 10.0 | 39.273 | -102.633 | 827.8 | 779.1 | 1391.9 |
| 1 | 1 | 5 | 12 | 19 | 23 | 0 | 11 | 11.0 | 39.144 | -102.384 | 904.9 | 780.3 | 1304.2 |
| 1 | 1 | 5 | 12 | 20 | 0 | 0 | 12 | 12.0 | 38.967 | -102.138 | 1066.2 | 771.5 | 1237.3 |
| 1 | 1 | 5 | 12 | 20 | 1 | 0 | 13 | 13.0 | 38.771 | -101.884 | 1227.1 | 762.6 | 1160.8 |
| 1 | 1 | 5 | 12 | 20 | 2 | 0 | 14 | 14.0 | 38.547 | -101.659 | 1295.9 | 762.7 | 1104.0 |
| 1 | 1 | 5 | 12 | 20 | 3 | 0 | 15 | 15.0 | 38.297 | -101.475 | 1360.0 | 759.1 | 1085.4 |
| 1 | 1 | 5 | 12 | 20 | 4 | 0 | 16 | 16.0 | 38.068 | -101.292 | 1423.6 | 764.8 | 958.6 |
| 1 | 1 | 5 | 12 | 20 | 5 | 0 | 17 | 17.0 | 37.846 | -101.096 | 1453.0 | 764.1 | 935.8 |
| 1 | 1 | 5 | 12 | 20 | 6 | 0 | 18 | 18.0 | 37.602 | -100.931 | 1439.0 | 765.7 | 929.6 |
| 1 | 1 | 5 | 12 | 20 | 7 | 0 | 19 | 19.0 | 37.366 | -100.773 | 1443.3 | 774.6 | 832.0 |
| 1 | 1 | 5 | 12 | 20 | 8 | 0 | 20 | 20.0 | 37.128 | -100.597 | 1466.6 | 774.1 | 808.5 |
| 1 | 1 | 5 | 12 | 20 | 9 | 0 | 21 | 21.0 | 36.838 | -100.426 | 1397.9 | 788.3 | 736.0 |
| 1 | 1 | 5 | 12 | 20 | 10 | 0 | 22 | 22.0 | 36.523 | -100.318 | 1307.5 | 788.0 | 832.0 |
| 1 | 1 | 5 | 12 | 20 | 11 | 0 | 23 | 23.0 | 36.249 | -100.244 | 1297.5 | 791.5 | 804.1 |
| 1 | 1 | 5 | 12 | 20 | 12 | 0 | 24 | 24.0 | 35.981 | -100.148 | 1298.4 | 792.1 | 789.9 |
| 1 | 1 | 5 | 12 | 20 | 13 | 0 | 25 | 25.0 | 35.683 | -100.082 | 1091.3 | 819.5 | 746.2 |
| 1 | 1 | 5 | 12 | 20 | 14 | 0 | 26 | 26.0 | 35.384 | -100.047 | 980.2 | 836.2 | 694.5 |
| 1 | 1 | 5 | 12 | 20 | 15 | 0 | 27 | 27.0 | 35.144 | -100.005 | 950.4 | 845.3 | 640.4 |
| 1 | 1 | 5 | 12 | 20 | 16 | 0 | 28 | 28.0 | 34.920 | -99.987 | 948.4 | 853.0 | 569.9 |
| 1 | 1 | 5 | 12 | 20 | 17 | 0 | 29 | 29.0 | 34.705 | -99.957 | 955.6 | 858.1 | 513.6 |
| 1 | 1 | 5 | 12 | 20 | 18 | 0 | 30 | 30.0 | 34.508 | -99.912 | 951.2 | 858.8 | 510.2 |
| 1 | 1 | 5 | 12 | 20 | 19 | 0 | 31 | 31.0 | 34.317 | -99.863 | 926.0 | 863.3 | 493.1 |
| 1 | 1 | 5 | 12 | 20 | 20 | 0 | 32 | 32.0 | 34.121 | -99.797 | 886.8 | 869.6 | 472.8 |
| 1 | 1 | 5 | 12 | 20 | 21 | 0 | 33 | 33.0 | 33.920 | -99.709 | 847.5 | 876.1 | 447.8 |
| 1 | 1 | 5 | 12 | 20 | 22 | 0 | 34 | 34.0 | 33.742 | -99.612 | 796.1 | 886.2 | 408.1 |
| 1 | 1 | 5 | 12 | 20 | 23 | 0 | 35 | 35.0 | 33.591 | -99.529 | 741.9 | 890.8 | 424.5 |
| 1 | 1 | 5 | 12 | 21 | 0 | 0 | 36 | 36.0 | 33.446 | -99.458 | 696.0 | 895.4 | 432.0 |
| 1 | 1 | 5 | 12 | 21 | 1 | 0 | 37 | 37.0 | 33.311 | -99.392 | 660.9 | 897.9 | 446.4 |
| 1 | 1 | 5 | 12 | 21 | 2 | 0 | 38 | 38.0 | 33.168 | -99.340 | 632.4 | 900.9 | 447.6 |
| 1 | 1 | 5 | 12 | 21 | 3 | 0 | 39 | 39.0 | 33.023 | -99.293 | 607.3 | 906.0 | 431.8 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 5 | 12 | 21 | 4 | 0 | 40 | 40.0 | 32.895 | -99.244 | 582.0 | 912.2 | 397.5 |
| 1 | 1 | 5 | 12 | 21 | 5 | 0 | 41 | 41.0 | 32.803 | -99.189 | 548.2 | 916.5 | 393.6 |
| 1 | 1 | 5 | 12 | 21 | 6 | 0 | 42 | 42.0 | 32.734 | -99.134 | 519.1 | 920.6 | 387.1 |
| 1 | 1 | 5 | 12 | 21 | 7 | 0 | 43 | 43.0 | 32.687 | -99.068 | 494.5 | 923.8 | 384.0 |
| 1 | 1 | 5 | 12 | 21 | 8 | 0 | 44 | 44.0 | 32.654 | -98.983 | 471.9 | 925.0 | 393.2 |
| 1 | 1 | 5 | 12 | 21 | 9 | 0 | 45 | 45.0 | 32.630 | -98.878 | 451.2 | 924.2 | 421.3 |
| 1 | 1 | 5 | 12 | 21 | 10 | 0 | 46 | 46.0 | 32.601 | -98.757 | 433.5 | 922.7 | 448.7 |
| 1 | 1 | 5 | 12 | 21 | 11 | 0 | 47 | 47.0 | 32.560 | -98.622 | 413.9 | 926.5 | 434.9 |
| 1 | 1 | 5 | 12 | 21 | 12 | 0 | 48 | 48.0 | 32.518 | -98.465 | 386.1 | 937.2 | 371.3 |


NOAA HYSPLIT MODEL
Forward trajectory starting at 12 UTC 19 Dec 05
12 UTC 19 Dec NAM Forecast Initialization
Source ★ at 39.92 N 105.12 W
40
38
36
34
32
-110
-108
-106
-104
-102
-100
-98
-96
-94
hPa
701
650
700
750
800
850
900
18
00
12/20
06
12
18
00
12/21
06
12
Job ID: 317848 Job Start: Thu Oct 5 15:14:12 GMT 2006
Source 1 lat.: 39.92 lon.: -105.12 height: 1500 m AGL
Trajectory Direction: Forward Duration: 84 hrs Meteo Data: WORKSHOP / GFS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)


NOAA HYSPLIT MODEL
Forward trajectory starting at 12 UTC 19 Dec 05
12 UTC 19 Dec NAM Forecast Initialization
Source ★ at 39.92 N 105.12 W
40
38
36
34
32
-110
-108
-106
-104
-102
-100
-98
-96
-94
Meters MSL
3085
3000
2500
2000
1500
1000
500
18
00
06
12
18
00
06
12
12/20
12/21
Job ID: 317958 Job Start: Thu Oct 5 16:17:49 GMT 2006
Source 1 lat.: 39.92 lon.: -105.12 height: 1500 m AGL
Trajectory Direction: Forward Duration: 84 hrs Meteo Data: WORKSHOP / GFS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

NOAA HYSPLIT MODEL
Forward trajectory starting at 12 UTC 19 Dec 05
12 UTC 19 Dec NAM Forecast Initialization




Job ID: 318052 Job Start: Fri Oct 6 13:32:08 GMT 2006
Source 1 lat.: 39.92 lon.: -105.12 height: 1500 m AGL

Trajectory Direction: Forward Duration: 84 hrs Meteo Data: WORKSHOP / GFS
Vertical Motion Calculation Method: Model Vertical Velocity
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

# GIS Shapefiles for ArcExplorer

HOME

**HIGHLIGHTS**

- HYSPLIT to GENERATE format
- GIS to ESRI Shapefiles
- ESRI ArcExplorer

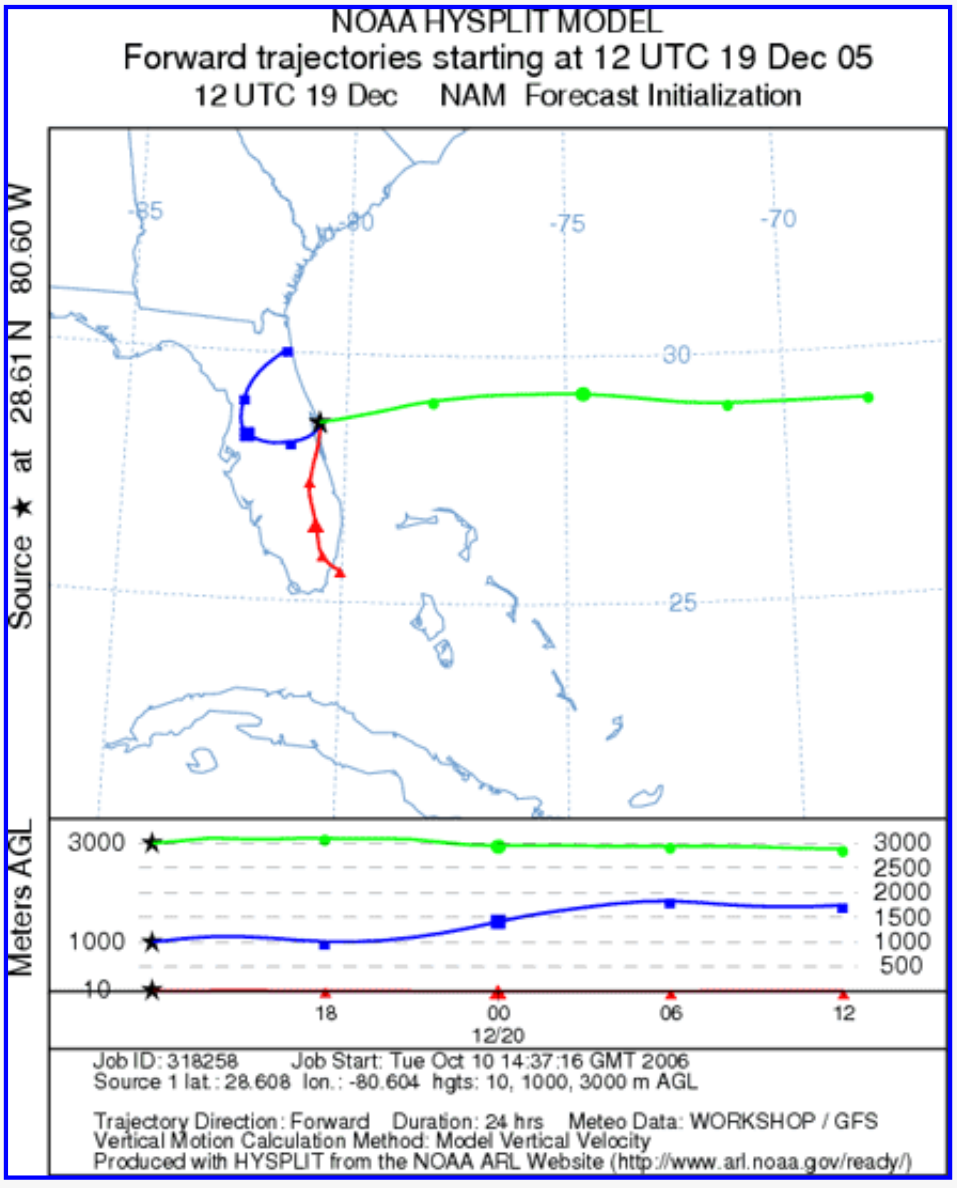
Most graphical output from HYSPLIT-WEB and PC HYSPLIT can be converted into an GIS shapefile format for use in programs such as the free ArcExplorer application.

## GIS Shapefile Example

For this example see Example 8 Powerpoint **(Ex8_hysplit.ppt)** or,
start trajectories at 3 different heights over Cape Canaveral, Florida:

- **NAM 12 km**
- starting location: **28.608N, 80.604W**
- total run time: **24 hours**
- starting height 1: **10 MAGL**
- starting height 2: **1000 MAGL**
- starting height 3: **3000 MAGL**

The result (right) shows a very complex wind pattern over Florida with all 3 trajectories moving off in different directions, however none varied much with height over the calculational period.

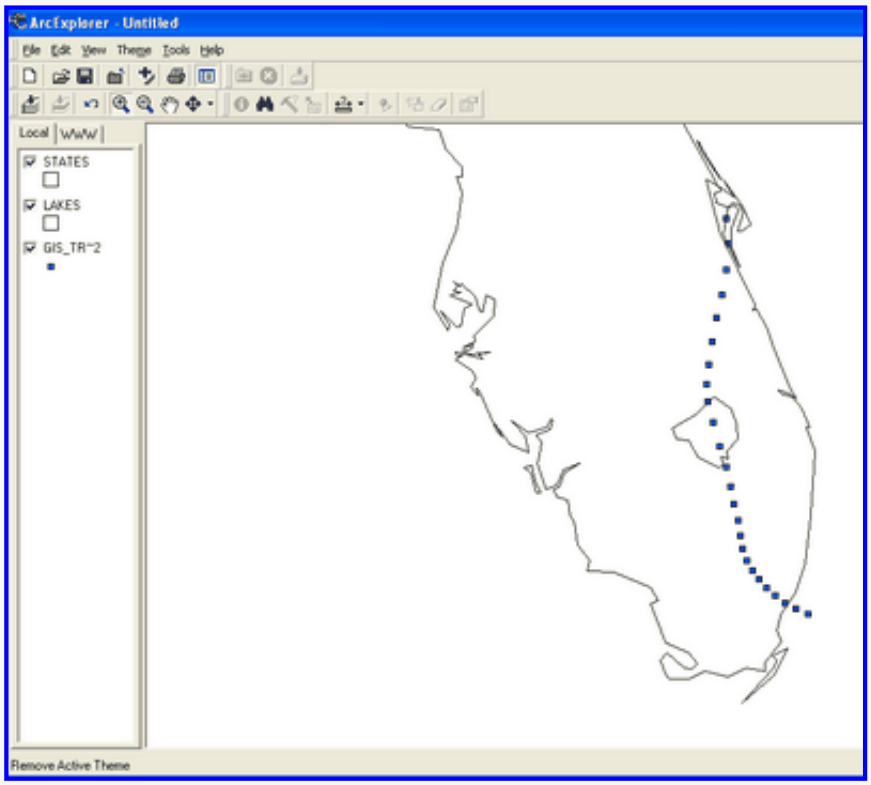



GIS output | help | No | ESRI Shapefiles | Google Earth

To create a GIS shapefile of this model result, choose to **modify the modify the trajectory plot without rerunning the model**. Then check the box for **ESRI Shapefiles** and request the plot. This will create a zipped file containing all the necessary files for viewing the output in ArcExplorer: a text file containing the **Generate format** output contains the latitude and longitude pairs that make up the trajectory and a series of files with the suffix “shp”, “shx”, and “dbf” that make up the shapefiles. Extract the files to a directory on the PC. At this time only the first trajectory can be plotted in

ArcExplorer.

Open ArcExplorer and click on the "**+**" button to search and add the shapefile just created. Also add the country map background theme (CNTRY94.SHP) from the C:\Program Files\ESRI\ArcExplorer2.0 \AETutor\ directory and then select both themes. Move the map background theme below the concentration theme by dragging the name below the trajectory name. To change the color of the fill and other attributes, double click on the theme name. In this case we made the map background transparent. To have each trajectory endpoint a different color, choose **Unique Values** from the **Classification Options** menu and then choose "id" from the Field pulldown menu.

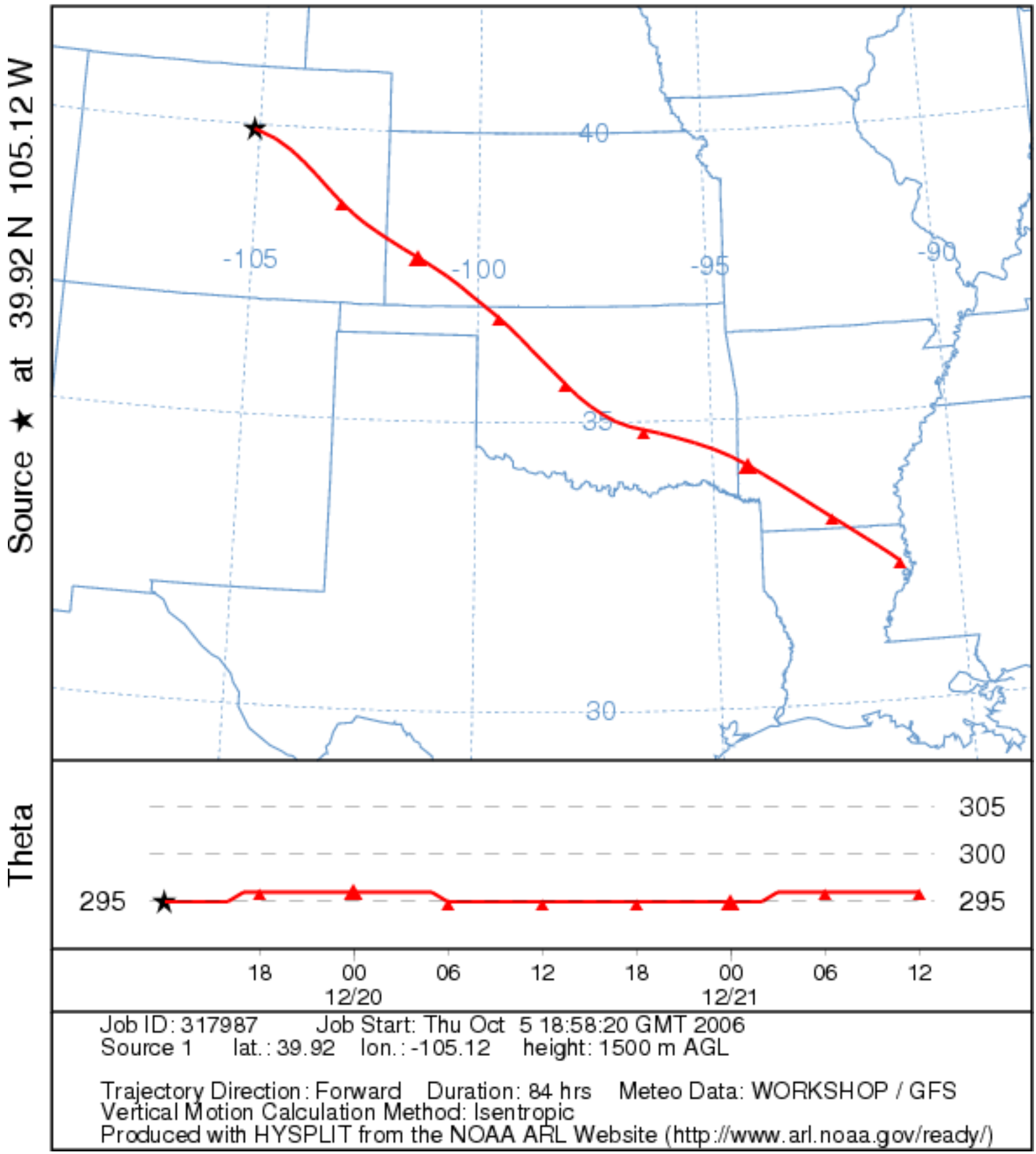



Previous HOME Next

05 12 19 12 #STARTING TIME: YEAR MONTH DAY HOUR
1 #NUMBER OF STARTING LOCATIONS
39.92 -105.12 1500 #STARTING 1: LATITUDE LONGITUDE HEIGHT (m-agl)
84 #TOTAL RUN TIME (hours)
0 #VERTICAL MOTION CALCULATION METHOD
5500 #TOP OF MODEL DOMAIN (m-AGL)
1 #NUMBER nextfile mfile OF INPUT DATA GRIDS
/pub/archives/workshop/
NAMF12
/pub/ready/hysplitps/
tdump.317975

05 12 19 12 #STARTING TIME: YEAR MONTH DAY HOUR
1 #NUMBER OF STARTING LOCATIONS
39.92 -105.12 1500 #STARTING 1: LATITUDE LONGITUDE HEIGHT (m-agl)
84 #TOTAL RUN TIME (hours)
2 #VERTICAL MOTION CALCULATION METHOD
5500 #TOP OF MODEL DOMAIN (m-AGL)
1 #NUMBER nextfile mfile OF INPUT DATA GRIDS
/pub/archives/workshop/
NAMF12
/pub/ready/hysplitps/
tdump.317987

NOAA HYSPLIT MODEL
Forward trajectory starting at 12 UTC 19 Dec 05
12 UTC 19 Dec NAM Forecast Initialization



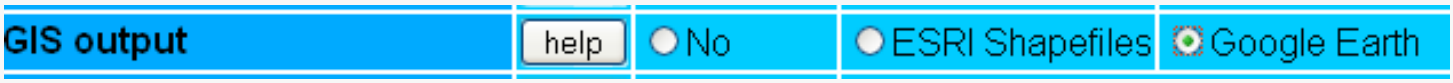

Job ID: 317987 Job Start: Thu Oct 5 18:58:20 GMT 2006
Source 1 lat.: 39.92 lon.: -105.12 height: 1500 m AGL

Trajectory Direction: Forward Duration: 84 hrs Meteo Data: WORKSHOP / GFS
Vertical Motion Calculation Method: Isentropic
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

# Google Earth Output

| | HOME | | **HIGHLIGHTS**<br>• HYSPLIT export to Google Earth |
|---|---|---|---|

Graphical output from the trajectory and concentration programs can be exported into a compressed file (*.kmz) for use in **Google Earth**; a software package to display geo-referenced information in 3-dimensions.



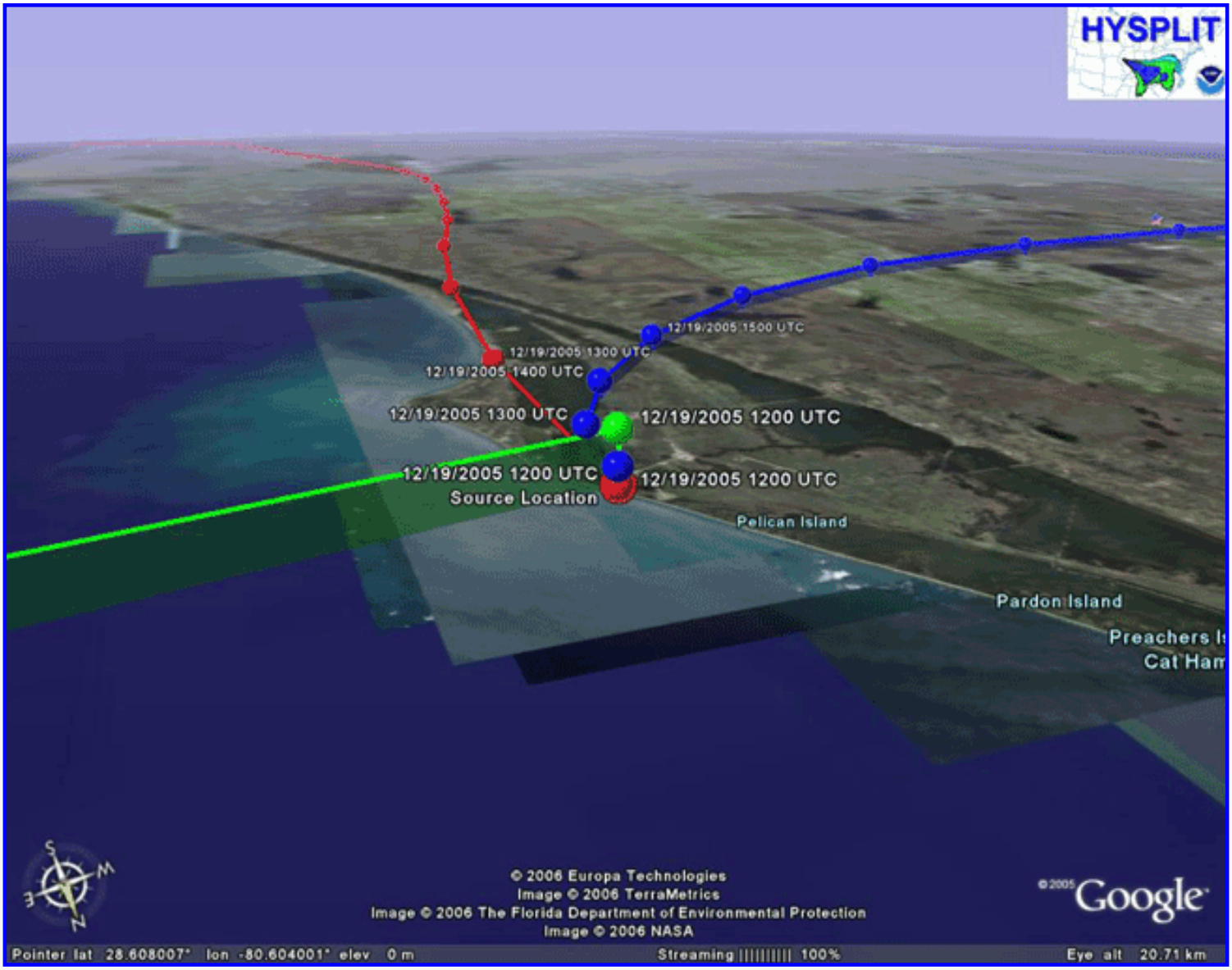

For this example see Example 8 Powerpoint **(Ex8_hysplit.ppt)**

or,

either rerun the Florida example or click on the **Modify the trajectory plot without rerunning the model** from the last run over Florida. To create the Google Earth formatted file check the **Google Earth** box in the **Display Options** menu. Make sure that the starting heights were set to **Meters-agl** for this model run, otherwise the labeling will be incorrect in Google Earth. This will result in the normal graphical file and a file called **HYSPLITtraj.kmz** that will be linked on the **Model Results** page.

- **NAM 12 km**
- starting location: **28.608N, 80.604W**
- total run time: **24 hours**
- starting height 1: **10 MAGL**
- starting height 2: **1000 MAGL**
- starting height 3: **3000 MAGL**

Double click on the Google Earth link and the file will automatically open in Google Earth and zoom in to the source location. Users can turn on/off the trajectories, terrain, and other features within Google Earth. Clicking once on any of the trajectory endpoints will cause an information box to appear giving the height and lat/lon location of the endpoint. Double clicking on an endpoint or any other feature will cause the program to zoom to that location. Expanding the menu along the left side of the display will reveal the different layers associated with the trajectory display. The jpg image below was created by doing a **File / Save Image** within Google Earth.



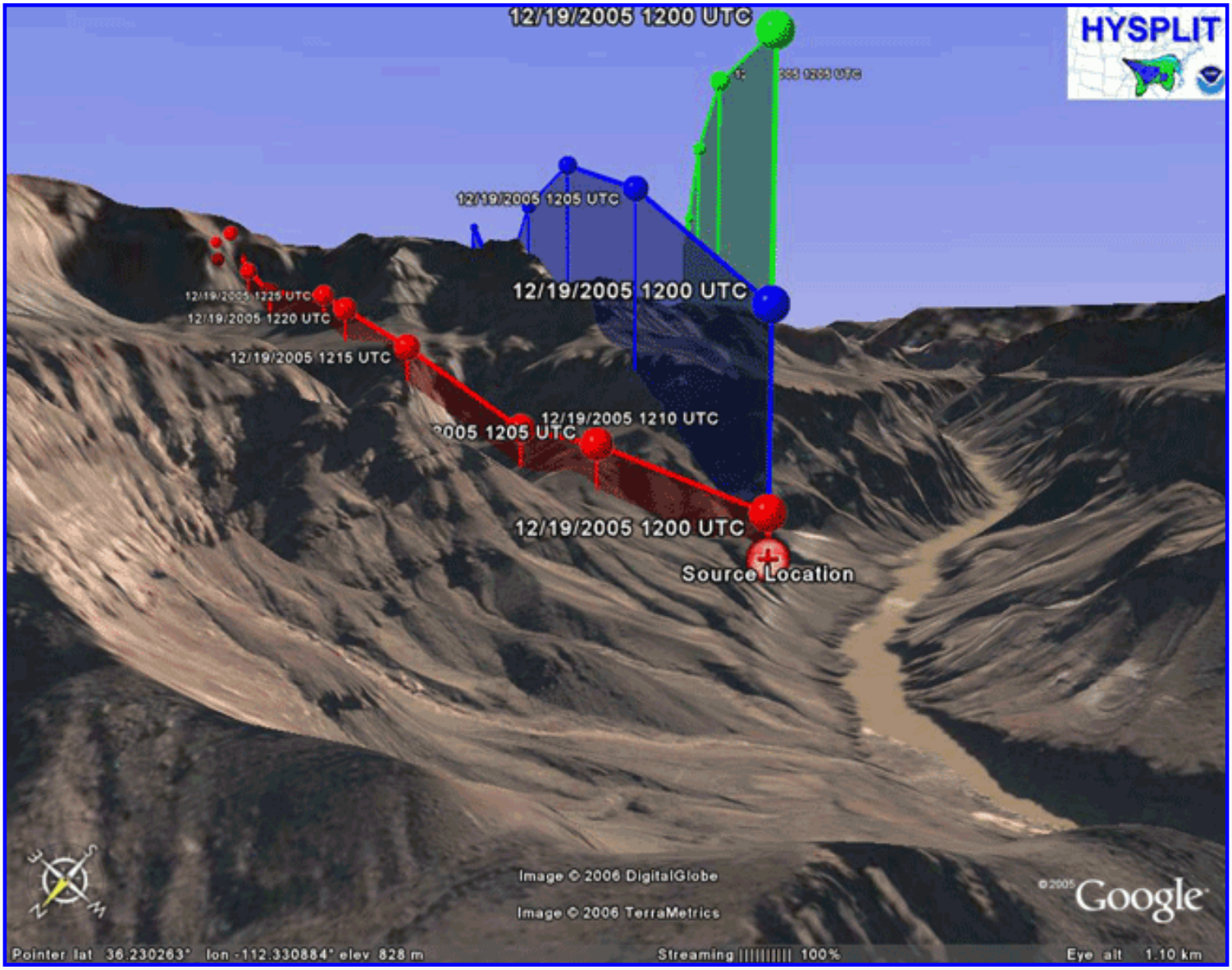

Finally, as an example to show the 3-dimensional terrain (NOTE: the Google Earth terrain is different from the meteorological model terrain so that the model contours and trajectories may be below or above the shown terrain), a trajectory run was produced from a location in the Grand Canyon. To run this case see Example 9 Powerpoint **(Ex9_hysplit.ppt)**

or,

use the following inputs:

- **NAM 12 km**
- starting location: **36.231N, 112.33599W**
- total run time: **1 hour**
- starting height 1: **100 MAGL**
- starting height 2: **500 MAGL**
- starting height 3: **1000 MAGL**

The resulting 1 hour **trajectory Google Earth file** (output is at 5 minute intervals when running a 1 hour duration trajectory) shows the trajectories climbing out of the remarkable landscape of the Colorado River basin.

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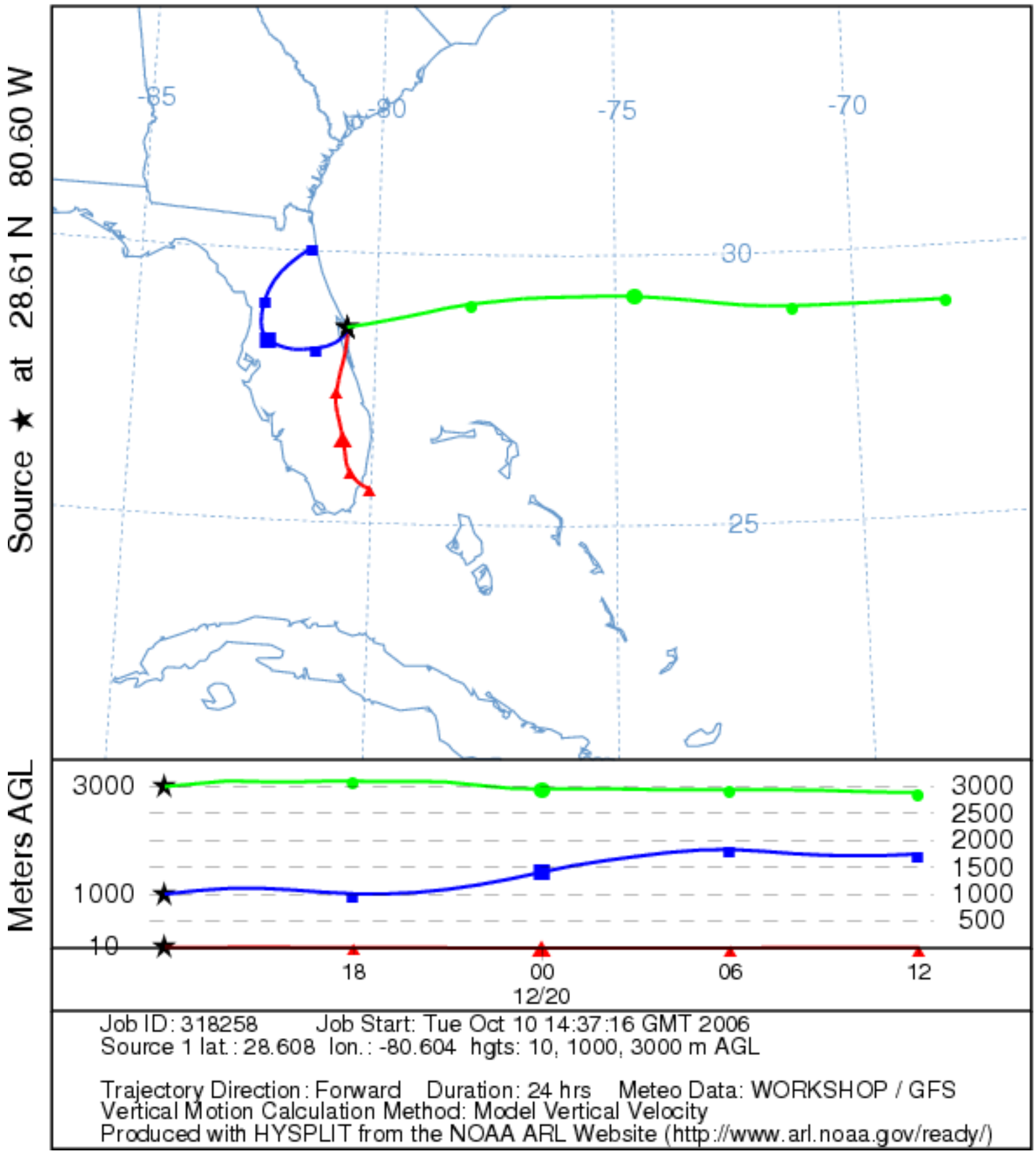
NOAA HYSPLIT MODEL

Forward trajectories starting at 12 UTC 19 Dec 05

12 UTC 19 Dec NAM Forecast Initialization



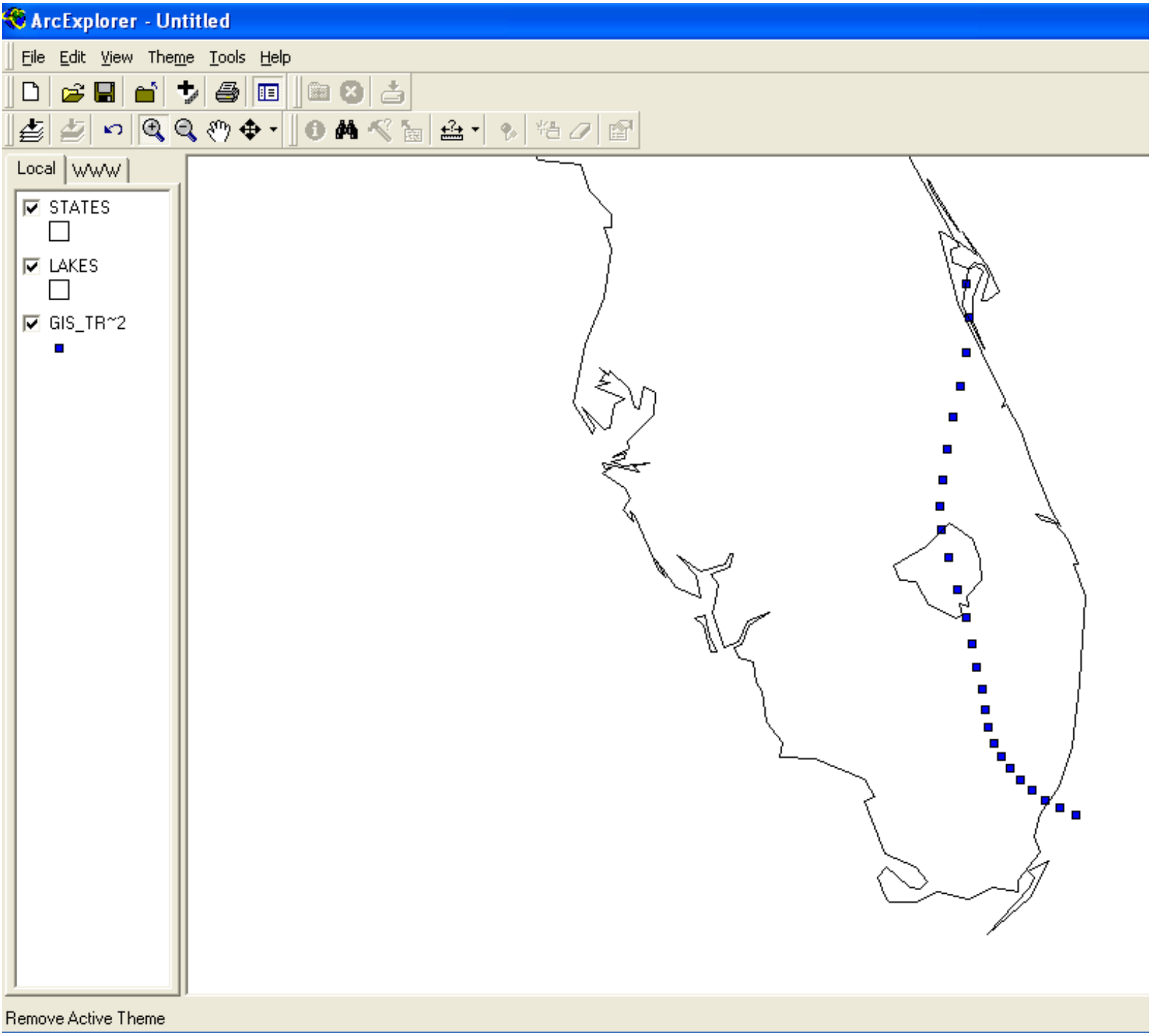

Job ID: 318258 Job Start: Tue Oct 10 14:37:16 GMT 2006

Source 1 lat.: 28.608 lon.: -80.604 hgts: 10, 1000, 3000 m AGL

Trajectory Direction: Forward Duration: 24 hrs Meteo Data: WORKSHOP / GFS

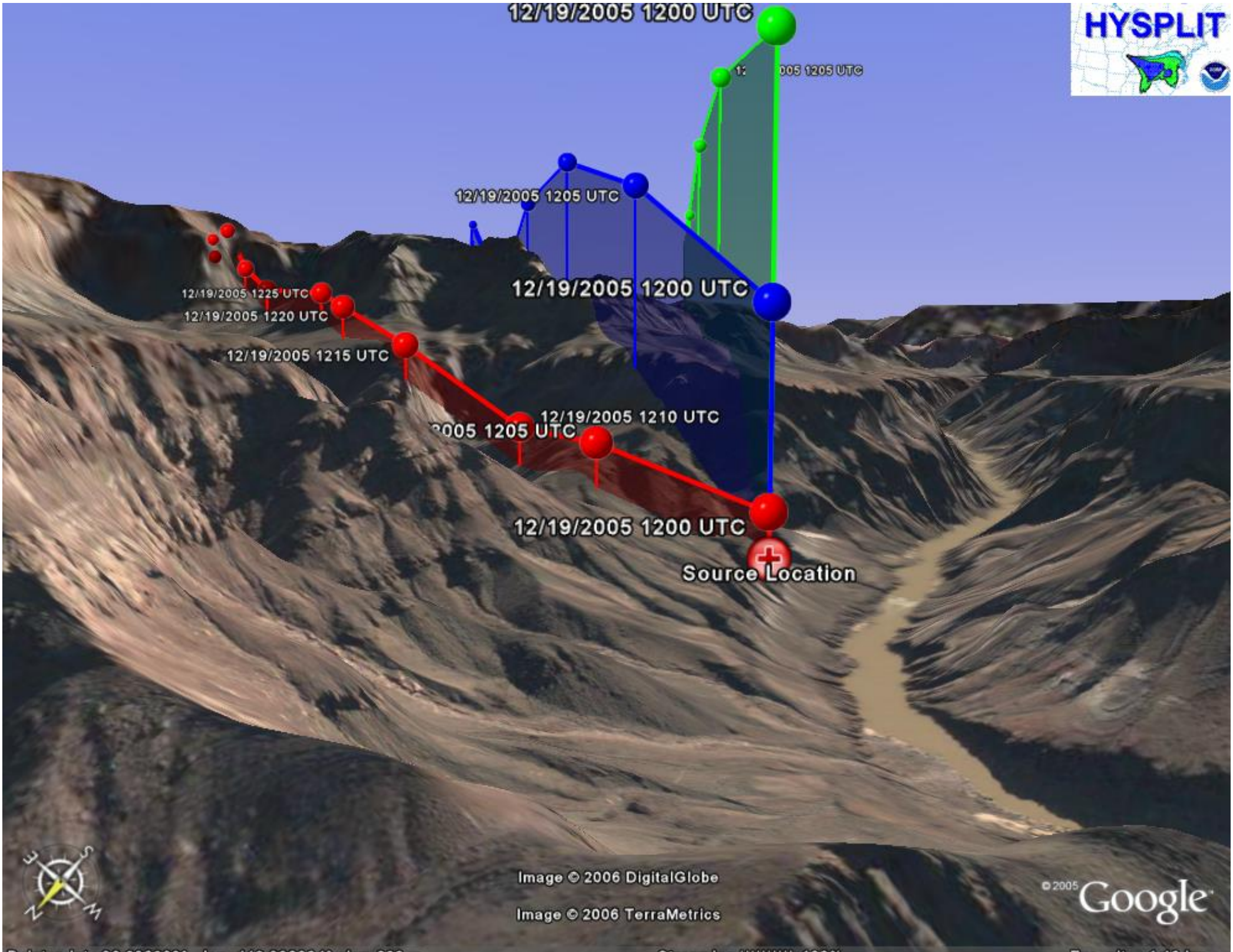
Vertical Motion Calculation Method: Model Vertical Velocity

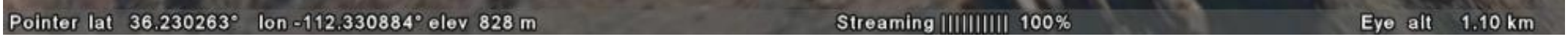
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)


ArcExplorer - Untitled
File Edit View Theme Tools Help
Local WWW
STATES
LAKES
GIS_TR~2
Remove Active Theme


HYSPLIT
12/19/2005 1500 UTC
12/19/2005 1300 UTC
12/19/2005 1400 UTC
12/19/2005 1300 UTC
12/19/2005 1200 UTC
12/19/2005 1200 UTC
12/19/2005 1200 UTC
Source Location
Pelican Island
Pardon Island
Preachers Is
Cat Ham
© 2006 Europa Technologies
Image © 2006 TerraMetrics
Image © 2006 The Florida Department of Environmental Protection
Image © 2006 NASA
© 2005 Google

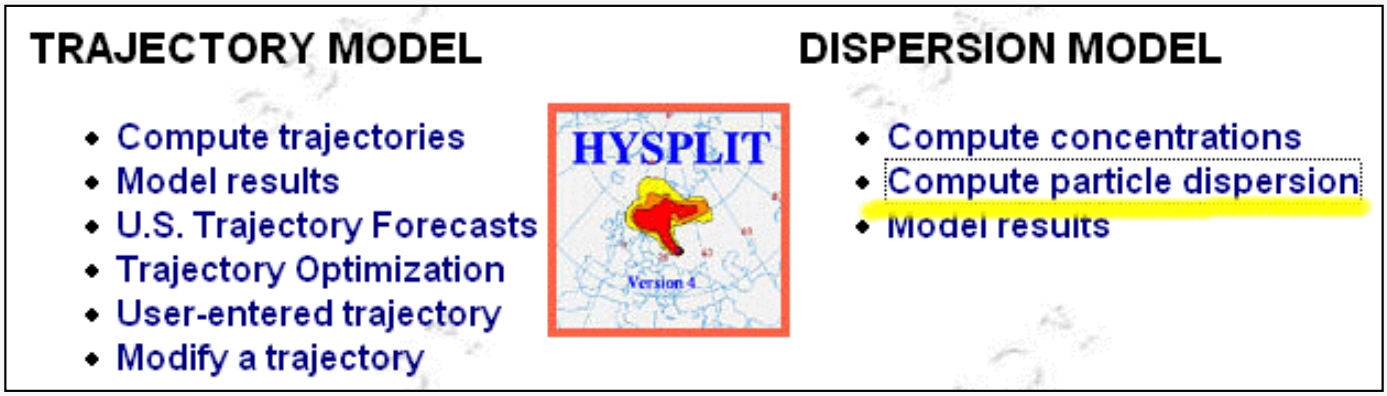

Pointer lat 28.608007° lon -80.604001° elev 0 m
Streaming ||||||||| 100%
Eye alt 20.71 km


12/19/2005 1200 UTC
HYSPLIT
12/19/2005 1205 UTC
12/19/2005 1205 UTC
12/19/2005 1225 UTC
12/19/2005 1220 UTC
12/19/2005 1200 UTC
12/19/2005 1215 UTC
12/19/2005 1210 UTC
12/19/2005 1200 UTC
Source Location
Image © 2006 DigitalGlobe
Image © 2006 TerraMetrics
© 2005 Google


Pointer lat 36.230263° lon -112.330884° elev 828 m
Streaming ||||||||| 100%
Eye alt 1.10 km

# Particle Dispersion Example

| Previous | HOME | Next | HIGHLIGHTS |
|---|---|---|---|
| | | | • Dispersion of many particles |

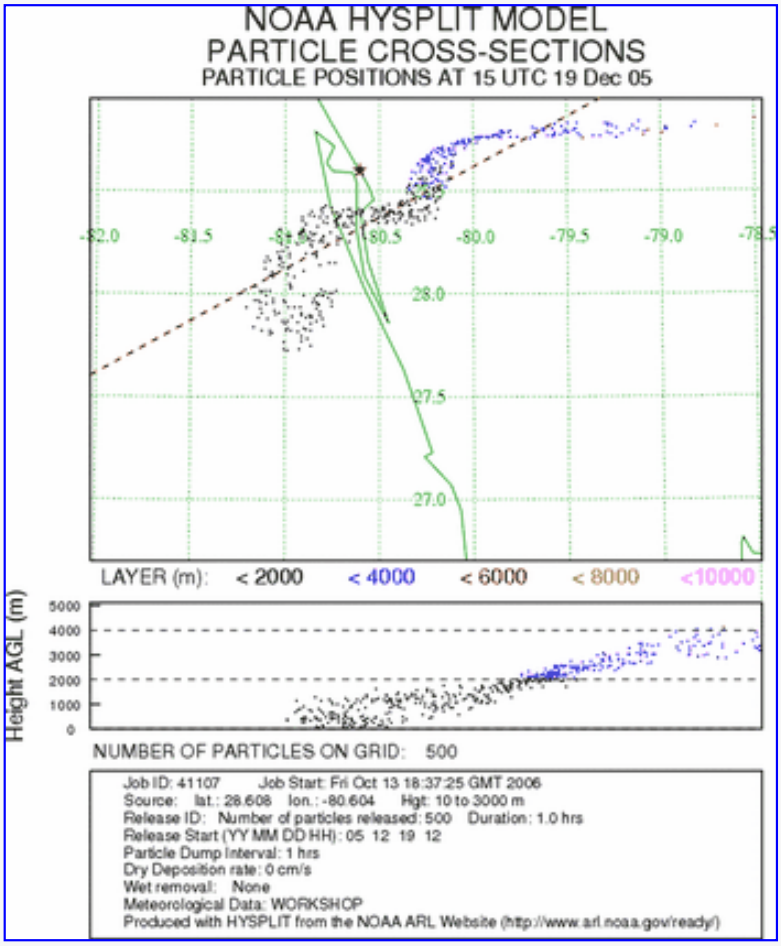


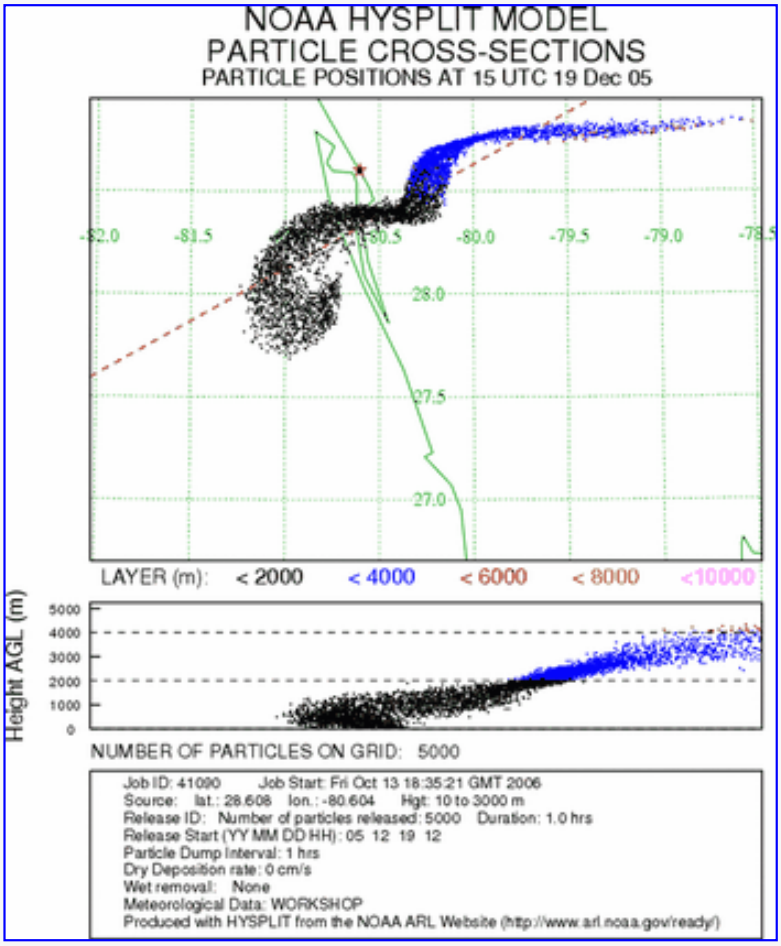

In order to take a single or a few individual particle trajectories to the next step of defining the air concentration, we can start by looking at the particle distribution at a particular time after the release of many particles.

For this example see Example 10 Powerpoint **(Ex10_hysplit.ppt)**
or,
from the Dispersion Model main menu click on the link **Compute particle dispersion** and choose the **NAM 12 km** data set from the **WORKSHOP** archive listing. Set the source location to the same Florida location as the Google Earth example (**28.608N, 80.604W**) with a release layer between **10 and 3000 MAGL** (the depth of the 3 trajectories calculated previously). Next, set the number of particles to be released per emission cycle to **500**, which is the usually the minimum number one should run with, and the number of hours to release them to **1 hour**. Finally, set the total run time to **9 hours** and the particle dump interval to **1 hour**, which will produce snapshots of the particle positions every hour.

- **NAM 12 km**
- source location: **28.608N, 80.604W**
- Hours of emission: **1**
- Total run time: **9 hours**
- Source top height: **3000 m**
- Source bottom height: **10 m**
- Number of particles released per cycle: **500**
- Particles dump interval: **1 hour**

The result (lower left) for hour 3 shows the particles moving away from the source to the east at the higher levels and toward the southwest at the lower levels, as was expected based on the 3 trajectories computed earlier. Click on the image to display a loop of the particle positions at each hour of the 9 hour simulation. Notice how the particles become few and far between with time. Next, rerun the same case (use the browser's Back button since this page does not have the rerun option available at this time), however increase the number of particles to 5000. The result (lower right) shows the same pattern, but with many more particles helping to define the plume shape. Again, click on the image to see the loop.

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# Simple Particle Concentration Example



The previous example showed a snapshot of the particle or puff center positions after 3 hours. To compute air concentrations, each particle's mass is summed as it passes over a concentration grid. PC HYSPLIT can be configured to compute concentrations in several methods:

- **3D Particle** (horizontal & vertical)
- **Gaussian Puff** (horizontal & vertical)
- **Top-Hat Puff** (horizontal & vertical)
- **Gaussian** (horizontal) & **Particle** (vertical)
- **Top-Hat Puff** (horizontal) & **Particle** (vertical)

However, HYSPLIT-WEB is only configured to run the default **Top-Hat Puff / Particle** mode, which means the concentration computation in the vertical is computed using the Particle method and in the horizontal using the Top-Hat Puff distribution.

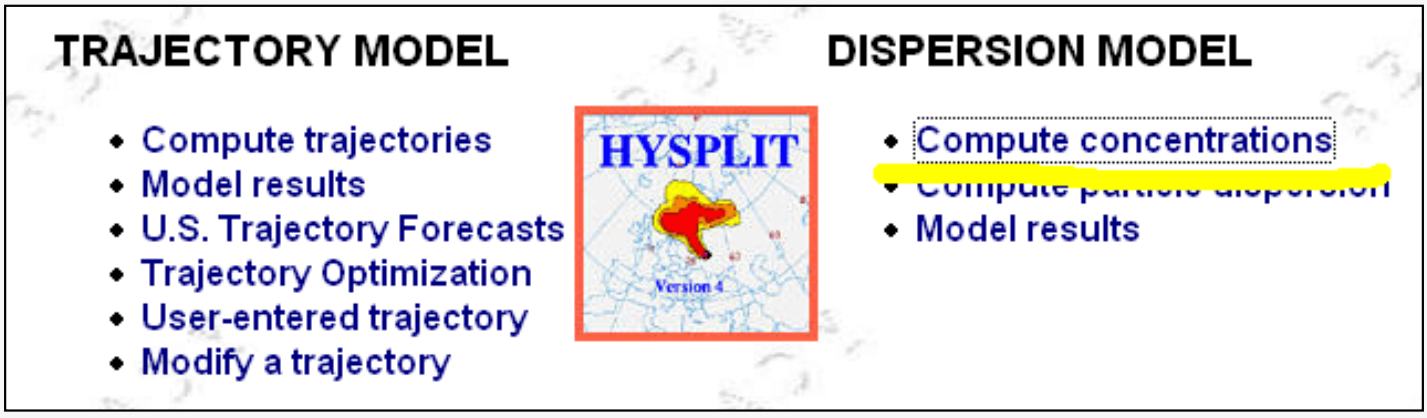
In the Particle mode, the concentration grid is treated as a matrix of cells, each with a volume defined by the grid dimensions. Therefore the concentration is just the particle mass divided by the cell volume.

**3D Particle:** $\Delta C = q(\Delta x\, \Delta y\, \Delta z)^{-1}$

In the Top-Hat Puff calculation, the concentration grid is considered as a matrix of sampling points, such that the Top-Hat Puff only contributes to the concentration as it passes over the sampling point. In the Top-Hat Puff calculation mode it is possible for a puff to pass between points and not be shown on the display.

**Top-Hat Puff:** $\Delta C = q(\Pi\, r^2\, \Delta z_p)^{-1}$

---

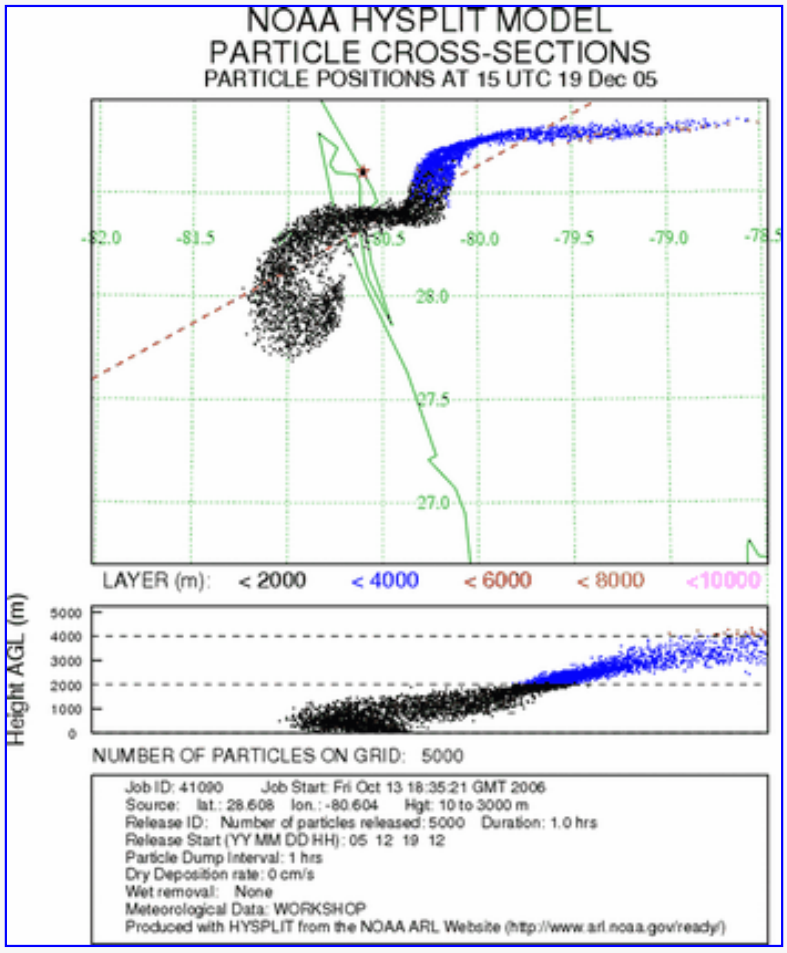


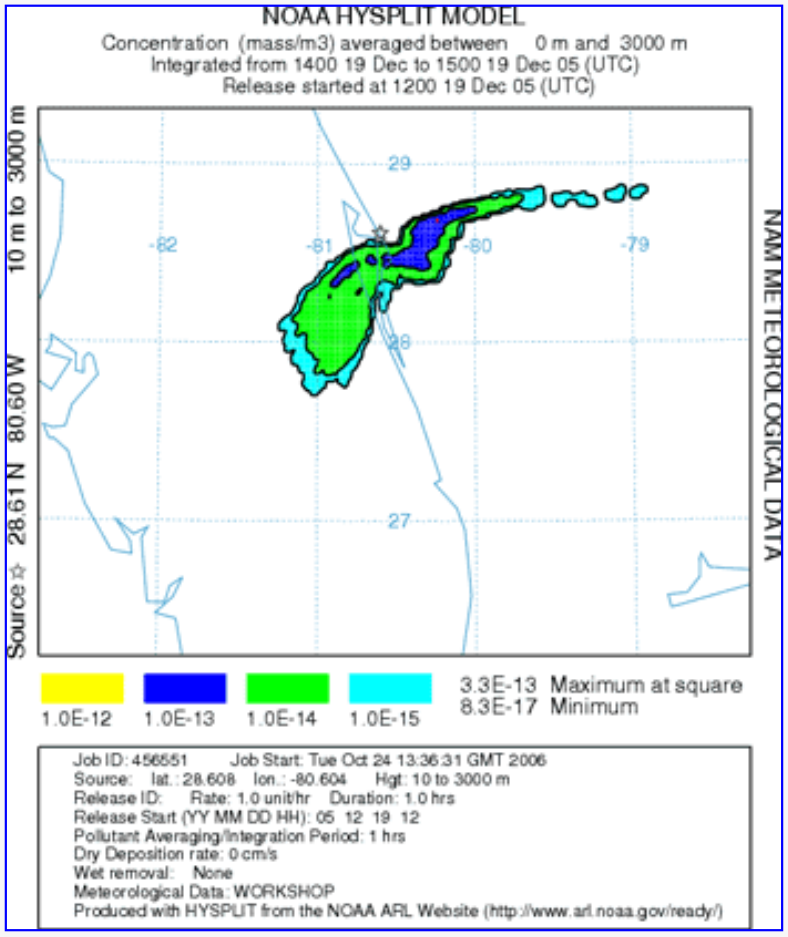
For this example see Example 11 Powerpoint **(Ex11_hysplit.ppt)]**

or,

from the main menu, run the **dispersion model** for the Florida case with the parameters shown to the right . Shown below-right is the resulting concentration pattern associated with the **Top-Hat Puff / Particle** distribution from the previous example over Florida (below-left). Note the concentration pattern is very similar to the particle pattern and, as expected, the highest concentrations are over the same area that has the highest density of particles. Over central Florida, where the particles are spaced farther apart, the concentrations are less.

- **NAM 12 km**
- source location: **28.608N, 80.604W**
- Hours of emission: **1**
- Total run time: **9 hours**
- Source top height: **3000 m**
- Source bottom height: **10 m**
- Top of averaged layer: **3000 m**
- Averaging period: **1 hour**
- Dry deposition velocity: **0.0**
- Wet deposition: **No**

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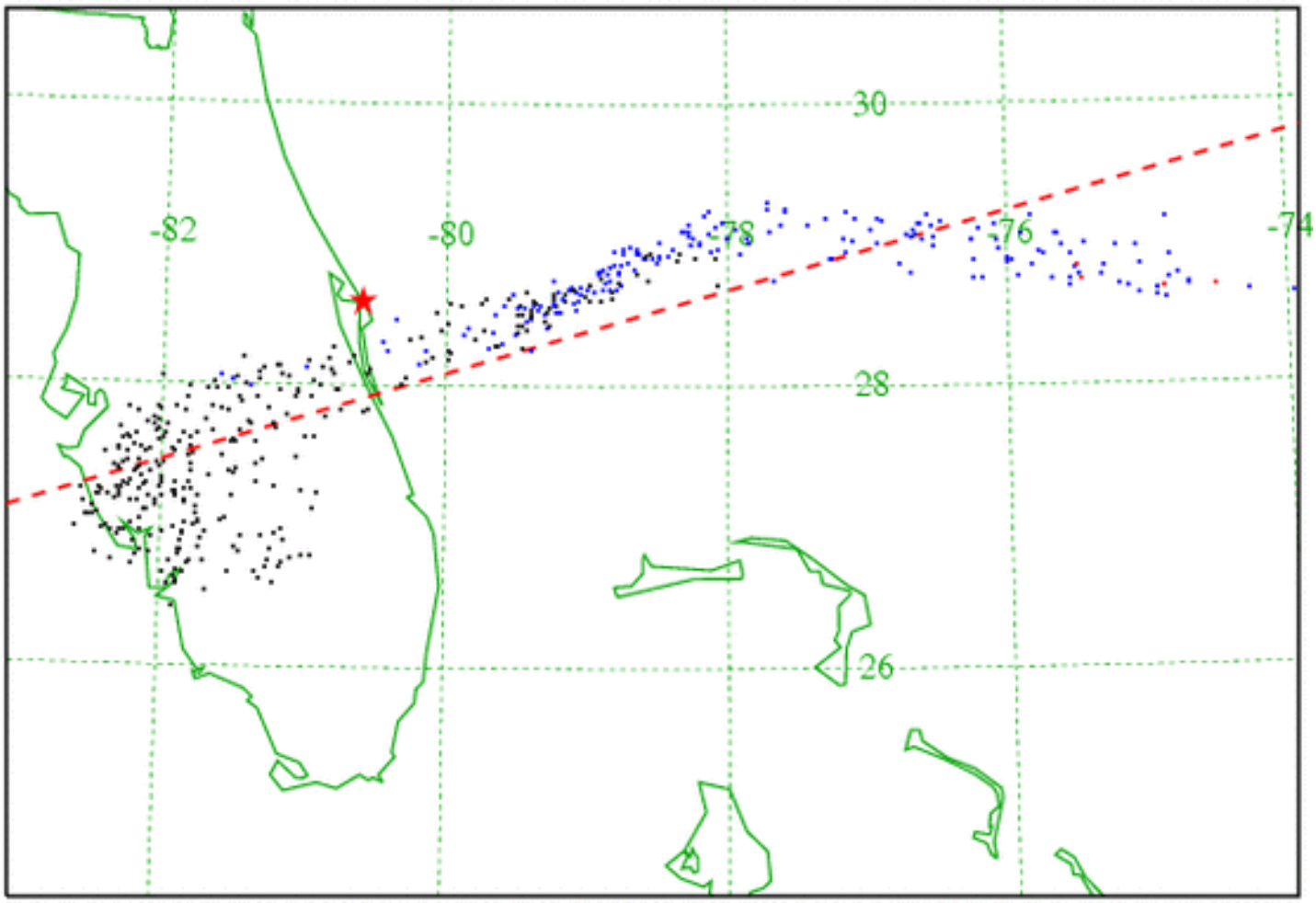
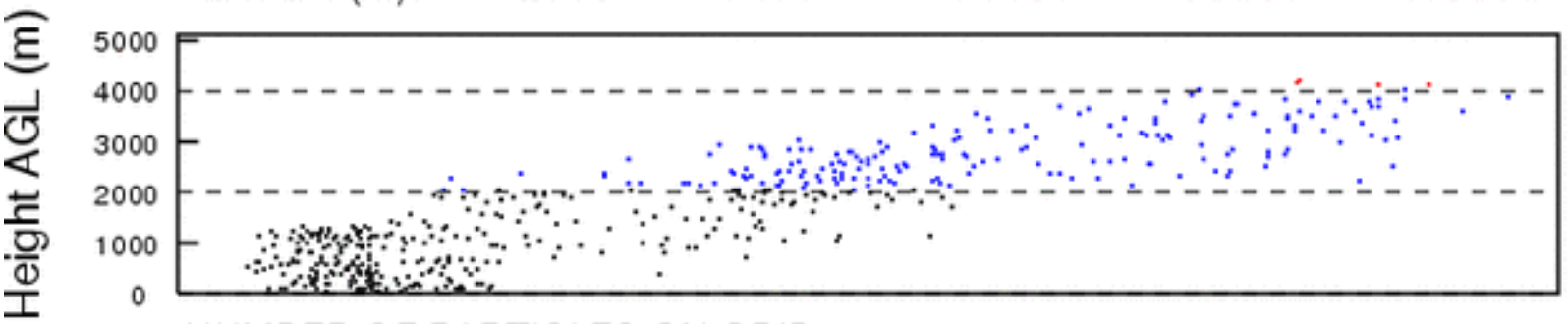
# NOAA HYSPLIT MODEL
# PARTICLE CROSS-SECTIONS
## PARTICLE POSITIONS AT 21 UTC 19 Dec 05



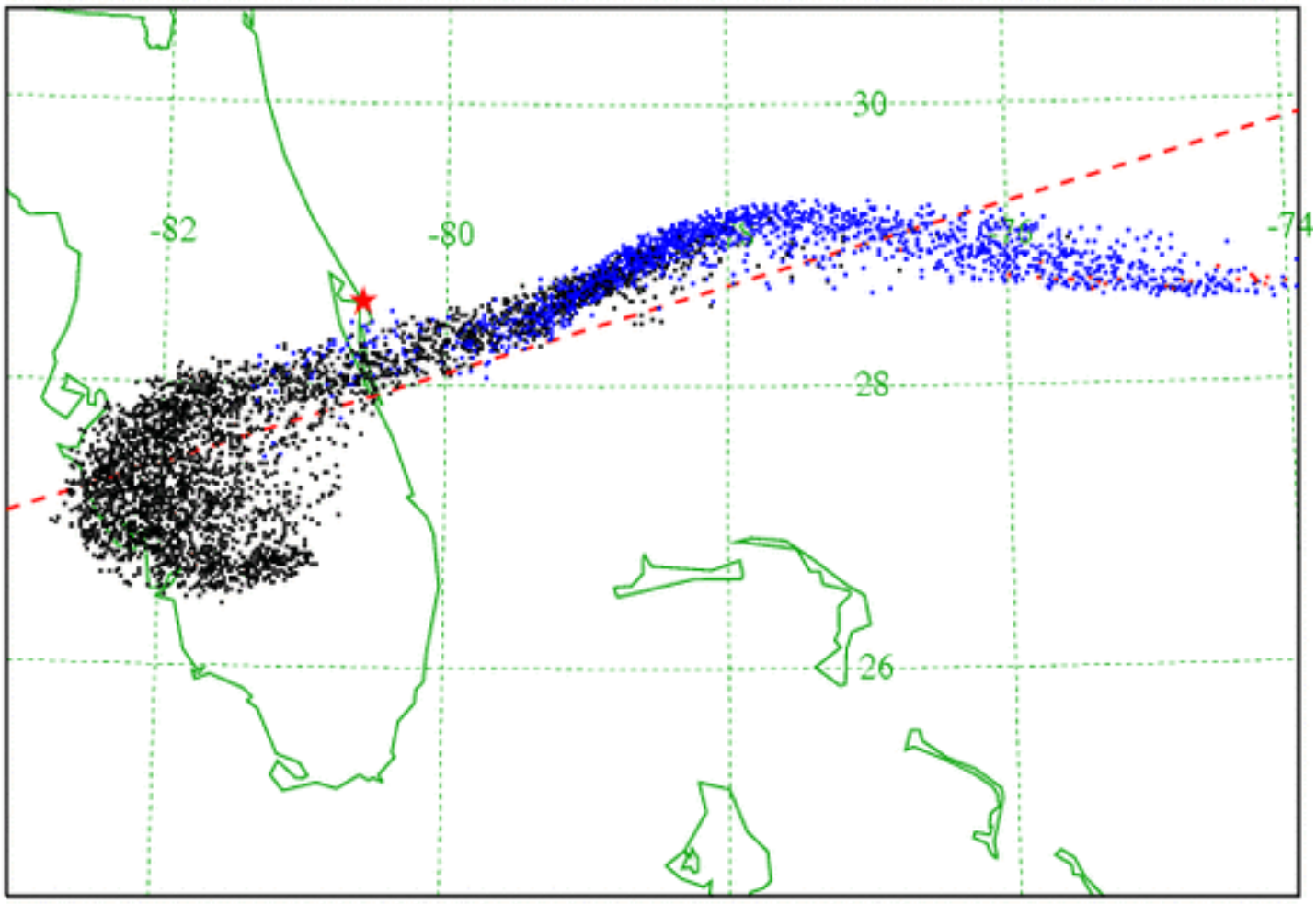

LAYER (m): < 2000 < 4000 < 6000 < 8000 <10000



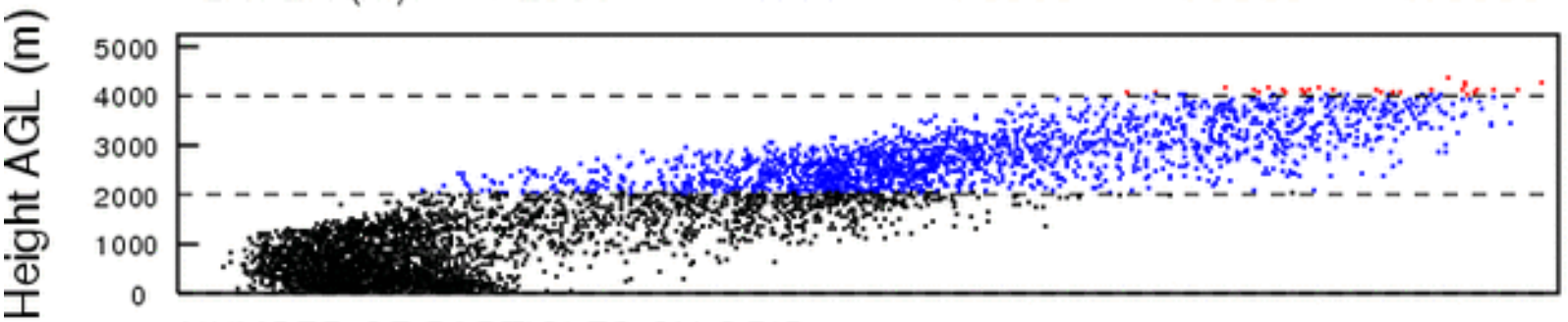

NUMBER OF PARTICLES ON GRID: 500

Job ID: 41047 Job Start: Fri Oct 13 18:20:05 GMT 2006
Source: lat.: 28.608 lon.: -80.604 Hgt: 10 to 3000 m
Release ID: Number of particles released: 500 Duration: 1.0 hrs
Release Start (YY MM DD HH): 05 12 19 12
Particle Dump Interval: 1 hrs
Dry Deposition rate: 0 cm/s
Wet removal: None
Meteorological Data: WORKSHOP
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

# NOAA HYSPLIT MODEL
# PARTICLE CROSS-SECTIONS
## PARTICLE POSITIONS AT 21 UTC 19 Dec 05




LAYER (m): < 2000 < 4000 < 6000 < 8000 <10000

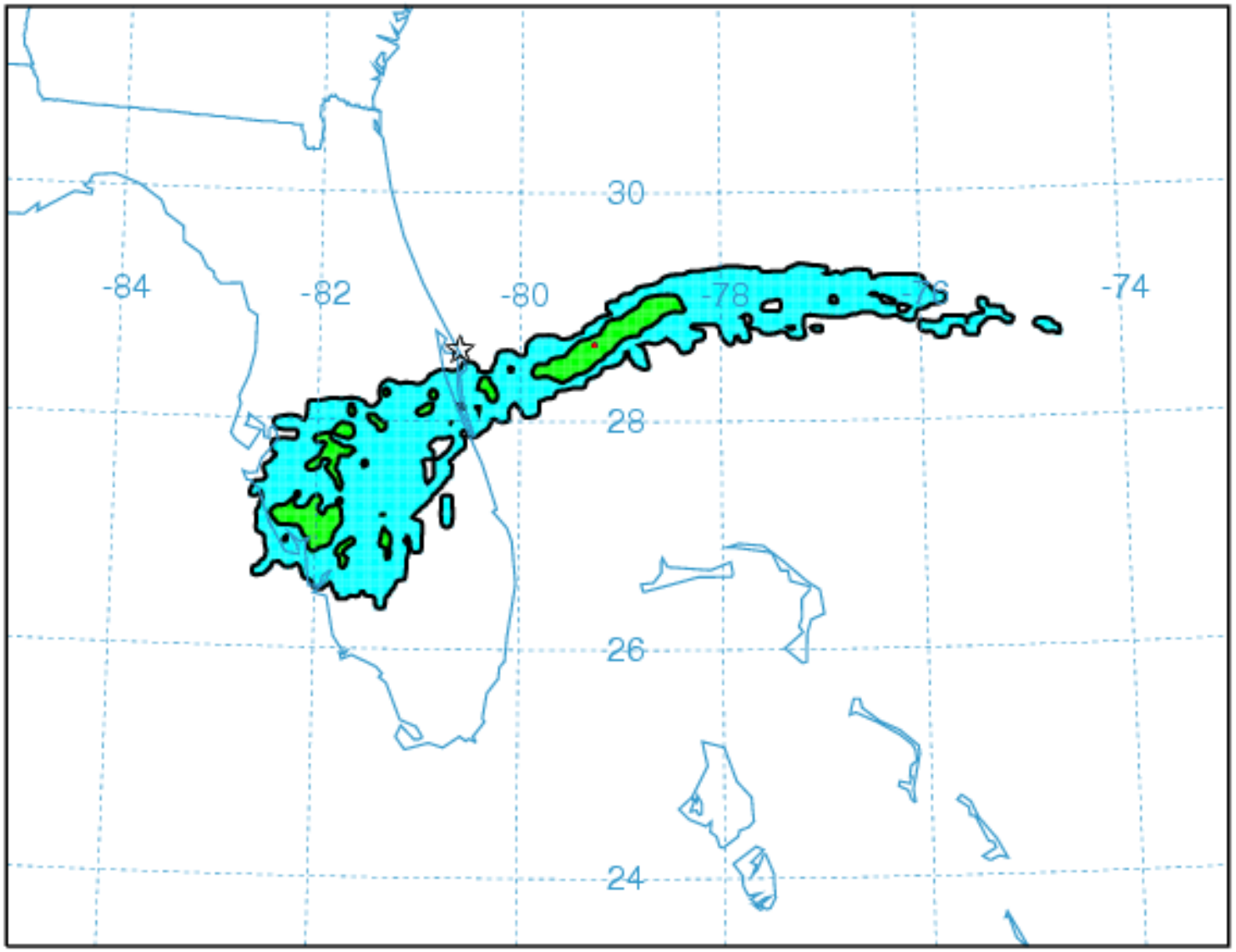



NUMBER OF PARTICLES ON GRID: 5000

Job ID: 41079 Job Start: Fri Oct 13 18:32:31 GMT 2006
Source: lat.: 28.608 lon.: -80.604 Hgt: 10 to 3000 m
Release ID: Number of particles released: 5000 Duration: 1.0 hrs
Release Start (YY MM DD HH): 05 12 19 12
Particle Dump Interval: 1 hrs
Dry Deposition rate: 0 cm/s
Wet removal: None
Meteorological Data: WORKSHOP
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)

# NOAA HYSPLIT MODEL

Concentration (mass/m3) averaged between 0 m and 3000 m
Integrated from 2000 19 Dec to 2100 19 Dec 05 (UTC)
Release started at 1200 19 Dec 05 (UTC)




1.0E-12 1.0E-13 1.0E-14 1.0E-15

2.5E-14 Maximum at square
3.8E-17 Minimum

Job ID: 456561 Job Start: Tue Oct 24 13:43:01 GMT 2006
Source: lat.: 28.608 lon.: -80.604 Hgt: 10 to 3000 m
Release ID: Rate: 1.0 unit/hr Duration: 1.0 hrs
Release Start (YY MM DD HH): 05 12 19 12
Pollutant Averaging/Integration Period: 1 hrs
Dry Deposition rate: 0 cm/s
Wet removal: None
Meteorological Data: WORKSHOP
Produced with HYSPLIT from the NOAA ARL Website (http://www.arl.noaa.gov/ready/)