Guide to HYSPLIT Model Products in Spot Weather Forecasts

This is an evaluation of the HYSPLIT trajectory model information provided by the National Weather Service (NWS) as part of a spot weather forecast. HYSPLIT is a NOAA model that uses forecasted modeled meteorology to determine plume trajectories. In the case of the NWS spot weather forecast, the HYSPLIT information provided includes smoke plume trajectories at three different starting atmospheric heights (500 m, 1500 m, and 3000 m above ground level) for typically 36 to 42 hours after the requested time (typically the ignition time). This is an experimental product; NWS is accepting comments on this product until December 31, 2012. Comments are welcome at: http://www.weather.gov/survey/nws-survey.php?code=NSWHT.

How to Request HYSPLIT Modeling. When you request your spot forecast, enter the phrase "hysplit to email@domain.gov" in the remarks, which automatically initiates the run and sends it to the email address provided. You can send the model results to multiple e-mail addresses – just separate each e-mail by a space.

What is a trajectory? A trajectory is a graphic display of the path of an air parcel released from a specified location and atmospheric height above ground level at a specific start time. The trajectory is the path of the parcel as it is carried by the 3-dimensional wind field, and shows the location and height above the ground for each hour after the release of the parcel.

In terms of smoke management, the trajectories provided by NOAA can be used to provide information on whether the smoke plume is forecasted to pass near any sensitive receptors, as well as the plume's relative height above ground level at a specified time.

A trajectory **does not** provide any information pertaining to smoke concentrations or actual plume dispersion (width, depth, density, etc.).

What is provided by NWS? The product provided through the NWS spot webpage provides trajectory information for three atmospheric heights above ground level – 500 m, 1500 m, and 3000 m – which represent simulated plume injection heights. The starting time used is the time of ignition as requested in the spot forecast. This model uses the predicted meteorological variables from the NWS forecast models, and the ignition time and the lat/long of the burn. It does not include information from the spot weather forecast.

The modeled results are e-mailed in three different formats:

1. A table showing the hour by hour raw data results, embedded into the e-mail.
2. An attached file showing the results in .gif format.
3. An attached file with the results in .kml format for uploading into Google Earth.

The following is a brief discussion of each format:

Embedded Table The tabulated results are embedded in the e-mail, and will look like this:

====> The HYSPLIT Email service is using the current version on www.arl.noaa.gov <=====

Please see the disclaimer and use agreement at:
http://ready.arl.noaa.gov/disclaimer.php
http://ready.arl.noaa.gov/HYSPLIT_agreement.php

======> tdump <======
for more info see http://ready.arl.noaa.gov/HYSPLIT_trajinfo.php
(copy and paste URL into browser if needed)

Traj# Meteo# Year Month Day Hour Min FcstHr TrjAge latitude longitude metersAGL Pressure(hPa)

2 1
NAM 11 10 10 12 0
NAM 11 10 12 12 0
3 FORWARD OMEGA
11 10 13 16 48.800 -115.115 500.0
11 10 13 16 48.800 -115.115 1500.0
11 10 13 16 48.800 -115.115 3000.0
1 PRESSURE

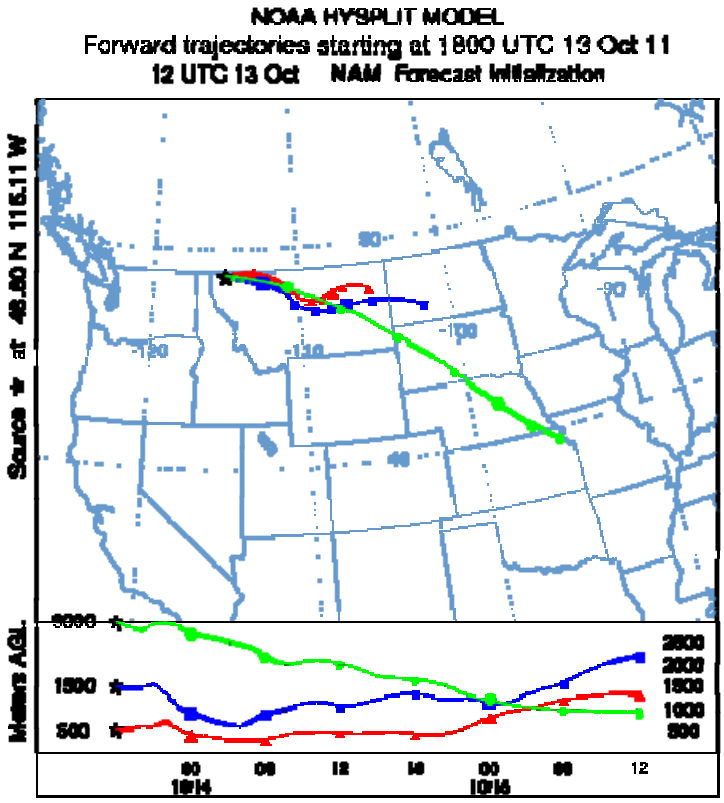
1	1	11	10	13	16	0	28	0.0	48.800	-115.115	500.0	828.3
2	1	11	10	13	16	0	28	0.0	48.800	-115.115	1500.0	729.9
3	1	11	10	13	16	0	28	0.0	48.800	-115.115	3000.0	600.1
1	1	11	10	13	17	0	29	1.0	48.794	-114.859	626.5	799.5
2	1	11	10	13	17	0	29	1.0	48.675	-114.583	1486.5	701.4
3	1	11	10	13	17	0	29	1.0	48.650	-114.198	2910.1	592.4
1	1	11	10	13	18	0	30	2.0	48.766	-114.494	643.2	776.1
2	1	11	10	13	18	0	30	2.0	48.545	-114.048	1402.0	730.0
3	1	11	10	13	18	0	30	2.0	48.486	-113.178	2723.6	592.5
1	1	11	10	13	19	0	31	3.0	48.758	-114.126	666.7	784.1
2	1	11	10	13	19	0	31	3.0	48.433	-113.477	1308.8	693.6
3	1	11	10	13	19	0	31	3.0	48.348	-112.295	2814.9	620.0
1	1	11	10	13	20	0	32	4.0	48.729	-113.658	760.8	740.5
2	1	11	10	13	20	0	32	4.0	48.332	-112.840	1092.4	749.5
3	1	11	10	13	20	0	32	4.0	48.270	-111.444	2780.9	634.5
1	1	11	10	13	21	0	33	5.0	48.689	-113.145	541.1	794.4
2	1	11	10	13	21	0	33	5.0	48.226	-112.315	949.8	782.8
3	1	11	10	13	21	0	33	5.0	48.143	-110.575	2728.7	647.5
1	1	11	10	13	22	0	34	6.0	48.618	-112.696	357.1	837.6
2	1	11	10	13	22	0	34	6.0	48.104	-111.854	933.8	795.5
3	1	11	10	13	22	0	34	6.0	47.945	-109.622	2700.6	634.8
1	1	11	10	13	23	0	35	7.0	48.522	-112.281	289.1	855.9
2	1	11	10	13	23	0	35	7.0	47.988	-111.417	889.8	805.3
3	1	11	10	13	23	0	35	7.0	47.714	-108.673	2601.4	659.5
1	1	11	10	14	0	0	36	8.0	48.430	-111.884	225.8	872.1
2	1	11	10	14	0	0	36	8.0	47.870	-110.996	773.1	824.6
3	1	11	10	14	0	0	36	8.0	47.397	-107.851	2530.5	671.7
1	1	11	10	14	1	0	37	9.0	48.331	-111.522	200.2	878.7
2	1	11	10	14	1	0	37	9.0	47.737	-110.608	727.9	828.4
3	1	11	10	14	1	0	37	9.0	47.035	-106.978	2404.9	669.9
1	1	11	10	14	2	0	38	10.0	48.226	-111.175	186.8	885.2
2	1	11	10	14	2	0	38	10.0	47.581	-110.207	755.6	819.8
3	1	11	10	14	2	0	38	10.0	46.693	-106.137	2278.9	687.0
1	1	11	10	14	3	0	39	11.0	48.146	-110.830	172.1	889.4
2	1	11	10	14	3	0	39	11.0	47.400	-109.840	829.1	809.0

…continued until the end of the run.

The first eight lines identify the model parameters, the meteorological model used (NAM), the starting date and time (in UTC), and starting location and atmospheric height. The remaining lines are the tabulated data, based on the column labels that appear at the top (beginning with Traj#). The columns are as follows:

Traj#	The trajectory number. 1 = 500 m, 2 = 1500 m, and 3 = 3000 m
Meteo#	Meteorological Grid number (always 1)
Year	Date and time (in UTC) of the trajectory point.
Month	
Day	
Hour	
Min	
Fcsthr	The forecast hour (elapsed time after the beginning of the meteorological model run) of the trajectory point.
TrjAge	Number of hours after the beginning of the trajectory run. 0 = starting point of trajectory run.
latitude	Coordinates of current trajectory point.
longitude	
metersAGL	Height (meters above ground level) of the current trajectory point.
Pressure (hPa)	Atmospheric pressure (used as a diagnostic variable)

.gif file The first e-mail attachment is a .gif file showing all three trajectories, with points located every 6 hours from the start of the trajectory run. The following is an example:



The map portion shows the location of the trajectory points over time. In this picture:

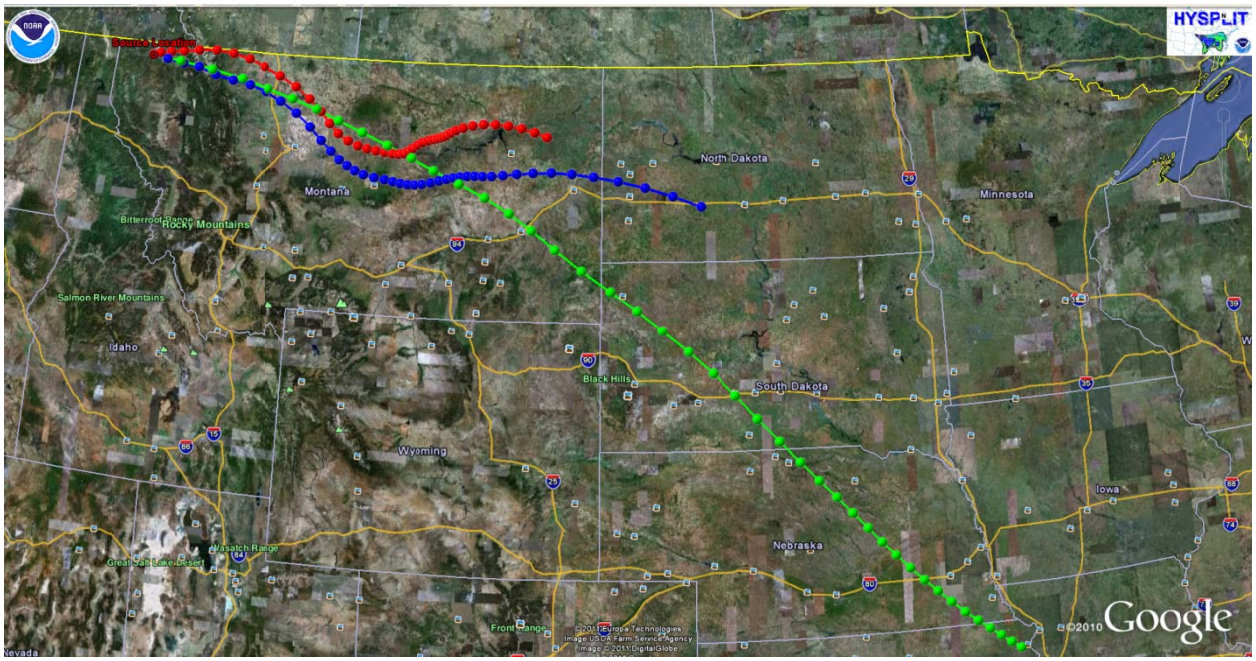
Red = 500 m trajectory line
Blue = 1500 m trajectory line
Green = 3000 m trajectory line

A trajectory line depicts the centerline movement of that parcel of air released at the time specified in the spot forecast and does not account for the plume widening both vertically and horizontally nor whether smoke would actually reach a location with a specific concentration of an air pollutant. Below the map is a graph showing the same three trajectory points over time, but depicting the trajectory height above ground level. All times are in UTC.

The .gif file is advantageous over the tabular data in that you can graphically see the trajectory lines and also get a sense of where they are relative to ground level. However, there are disadvantages with this presentation as well:

- It depicts data every six hours.
- Only state outlines are on the map so it is difficult to determine if there are sensitive receptors along the forecasted trajectory path.

Google Earth (.kmz) file The second e-mail attachment is a .kmz file of the data that can be opened up in Google Earth. The data will be presented in a manner similar to this:



As with the .gif file, the same color scheme applies:

Red = 500 m trajectory line
Blue = 1500 m trajectory line
Green = 3000 m trajectory line

The Google Earth presentation is the most useful of the three data presentations.

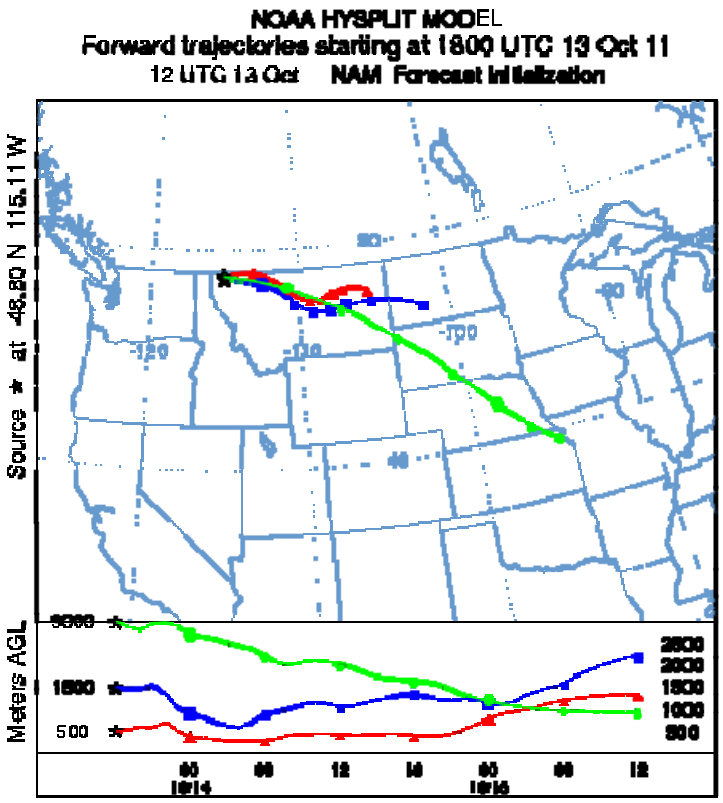
- It provides each hourly point, as opposed to every six hours for the .gif file. Clicking on a specific point will bring up specific information, including the latitude/longitude and the height above ground level.
- With Google Earth you can zoom in and determine if the trajectories pass near any sensitive receptors.
- The trajectory line depicts the centerline movement of that parcel of air released at the time specified in the spot forecast and does not account for the plume widening both vertically and horizontally nor whether smoke would actually reach a location with a specific concentration of an air pollutant.
- The Google Earth file also has a box in the upper left hand corner (not shown here) which allows you to step through the trajectory on an hour by hour basis. It can be set to display the steps in your local time, so you can avoid the need to convert from UTC.

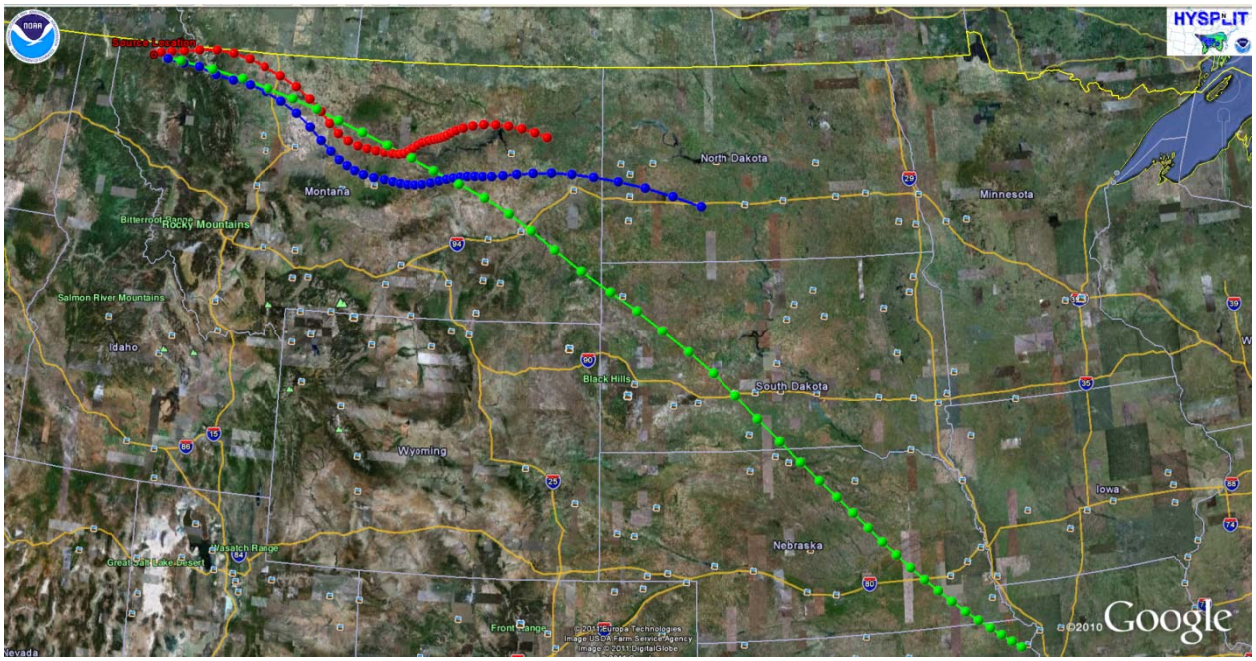
Utility of the trajectories for managing smoke impacts. HYSPLIT trajectories can provide useful information. As mentioned, the trajectories can be used to determine where the smoke plume may go and whether there are sensitive receptors on or near the forecasted path. One must remember though,

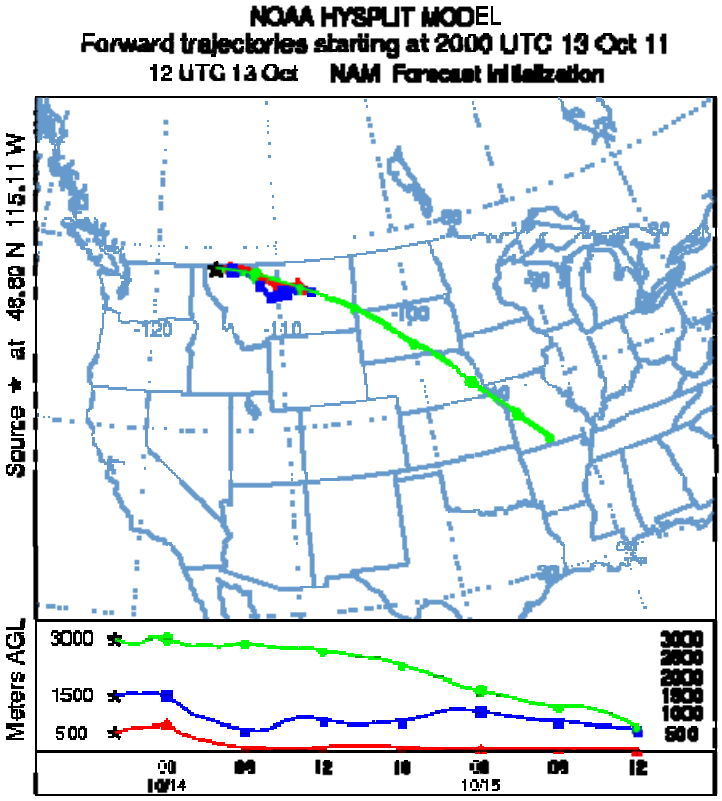
that the trajectory only forecasts where an air parcel starting at a specified height, location, and time may be in the atmosphere after a given amount of time, so one must assume that there is smoke in that air parcel. Knowing the atmospheric height at each point is useful as well; if the trajectory is forecasted to be at or near ground level at a certain point that may indicate an area that needs to be monitored for potential smoke impacts. The challenge with this is that the area may be several hundred miles away, and since the trajectories provide no information with regards to smoke concentration or dispersion, there is no guarantee that any smoke would be present.

In order to properly assess the usefulness of the NWS product, it is important to also consider the context in which the information would be requested. For prescribed burning, spot forecasts are typically requested on behalf of on scene personnel looking for localized weather information for the specified time of ignition. Will the HYSPLIT trajectories provide value-added information over and above what is in the spot forecast? It would likely take a landscape-scale prescribed burn in heavy fuel loading to generate a smoke column that would reach 3000 m in atmospheric height. A large majority of prescribed burning would likely have columns that would not reach 1500 m in height. So the 500 m trajectory line would likely provide the most value-added information for most prescribed burning with the 1500m and 3000m potentially useful for wildfire or larger or heavier fuel burns. The HYSPLIT output has limited utility for determining near burn impacts, when there is very light wind such as typically found at night and when winds are influenced by local winds such as slope, valley or seabreeze situations.

A further point of assessment is that, much like the spot forecast itself, the HYSPLIT trajectories only provide information about conditions (air parcels) at the time of ignition. Smoke generated one or two hours later may encounter different conditions, and thus different trajectories. This is illustrated by the two HYSPLIT runs shown on the following pages – the first being the .gif and Google Earth files previously shown (a run starting a 1200) and the second being .gif and Google Earth files of a HYSPLIT run starting at 1400. Even though the files are on different scales, you can see the differences in the path of the trajectory lines. Also note the differences in the atmospheric height charts between the .gif files. If additional information on smoke transport or dispersion is necessary such as potential movement of the smoke plume towards the ground and areas of concern, consider HYSPLIT Dispersion or 3-D particle model at the NOAA Air Resources Laboratory (ARL) web page http://ready.arl.noaa.gov/HYSPLIT.php or WFDSS Air Quality products http://firesmoke.us/wfdss/ .


NOAA HYSPLIT MODEL
Forward trajectories starting at 1800 UTC 13 Oct 11
12 UTC 13 Oct NAM Forecast Initialization
Source ★ at 48.80 N 115.11 W
Meters AGL
1500
500
00
12
00
12
00
12
1814
1815


HYSPLIT
North Dakota
Minnesota
Montana
Rocky Mountains
Salmon River Mountains
Idaho
Black Hills
South Dakota
Wyoming
Iowa
Nebraska
Wasatch Range
Front Range
Google


NOAA HYSPLIT MODEL
Forward trajectories starting at 2000 UTC 13 Oct 11
12 UTC 13 Oct NAM Forecast Initialization
Source ★ at 48.80 N 115.11 W
Meters AGL
3000
1500
500
00
10/14
06
12
18
00
10/15
06
12


HYSPLIT
North Dakota
Minnesota
Montana
Bitterroot Range
Salmon River Mountains
Idaho
Black Hills
South Dakota
Wyoming
Michigan
Wisconsin
Iowa
Nebraska
Illinois
Wasatch Range
Great Salt Lake Desert
Front Range
Nevada
Utah
Colorado
Kansas
Missouri
Google

Consideration when using HYSPLIT trajectory :

- It provides information only on conditions at the time of ignition; smoke generated one or two hours after ignition may have a different trajectory, and a separate run would likely be required.

- Training will be needed to support field use of this tool and subsequent follow-up model runs if needed.

- Trajectory data provides no information with regards to smoke concentration or smoke dispersion such as plume width vertically or horizontally nor whether smoke would actually reach a location as the output does not vary the fire source information.

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