



**National Transportation
Safety Board**

Memorandum

Date: June 2, 2017

To: Brian Rayner
Air Safety Investigator, Eastern Region

From: John O'Callaghan
National Resource Specialist – Aircraft Performance

Subject: Plots of ADS-B data and performance estimates for ERA17FA140

References:

1. Raytheon Aircraft Company – Beechcraft, *Beech Bonanza® A36 (Serials E-1946, E-2104, E-2111 thru E-3629 and E-3631 thru E-3635) Pilot's Operating Handbook and FAA Approved Airplane Flight Manual*, P/N 36-590002-37B, Reissued November, 2002; P/N 36-590002-37B2, Revised January, 2006
2. Federal Aviation Administration, *DRAFT Memorandum from Atlanta Air Route Traffic Control Center to Aircraft Accident File ZTL-ARTCC-0297, dated May 19, 2017, Subject: INFORMATION: Partial Transcript, Aircraft Accident, N8169Y, Alexander City, AL, March 28, 2017*
3. AccuWeather Enterprise Solutions, *Aviation Weather Package Prepared for Continental Motors, Inc., Beechcraft A36, N8169Y, Dadeville, Alabama, March 28, 2017*

Brian:

Attached please find plots of performance data and glide trajectory estimates for the Beechcraft A36 Bonanza (N8169Y) incident in Dadeville, AL on March 28, 2017 (ERA17FA140). The plots present Automatic Dependent Surveillance – Broadcast (ADS-B) data from N8169Y, performance parameters computed from the ADS-B data, and theoretical zero-thrust glide trajectories based on the best-glide performance data published in the Pilot's Operating Handbook (POH, Reference 1), and a matrix of assumed starting points and heading changes along N8169Y's recorded ADS-B trajectory. The time, altitude, location, and content of communications between the pilot and Air Traffic Control (ATC) (as documented in Reference 2) are annotated on two of the trajectory plots (Figures 1g and 1h), where the scale of the underlying map supports these annotations. Because of space limitations, the content of the communications are denoted on plots as abbreviated codes; Table 3 on page 6 depicts the full content of the communications corresponding to each code.

The ADS-B data for the airplane was provided by the Federal Aviation Administration (FAA) and consisted of:

- Time of the ADS-B position message from the airplane in UTC time, at a frequency of 1 report every second (1 Hz);
- Airplane latitude, as determined by the airplane's Global Positioning System (GPS) receiver;
- Airplane GPS longitude;
- Airplane pressure altitude to the nearest 100 feet (i.e., within an uncertainty of ± 50 ft.)

Although the ADS-B GPS position of the airplane is provided at a relatively high sample rate (1 Hz) and accuracy (compared to radar data), computing groundspeed from the data directly, without any filtering or other corrections, resulted in unrealistic noisiness or "spikes" in the result. To reduce this spurious noise, the GPS positions were smoothed using a cubic-spline smoothing algorithm. Groundspeed and the other performance parameters presented below were then computed based on this smoothed data.

Similarly, to obtain smooth rate of climb and flight path angle calculations, the recorded pressure altitude was smoothed, while respecting the ± 50 ft. uncertainty bounds of the data. In addition, Mean Sea Level (MSL) altitude was computed by adding 100 ft. to the recorded pressure altitude (corresponding to an altimeter setting of 30.03 "Hg, as reported by the 16:55Z METAR from Alexandria City (KALX) (see Reference 3).

The engine-out glide performance was determined based on a simple aerodynamic model of the airplane's lift and drag coefficients (C_L and C_D , respectively), computed using the best glide speed and glide ratio published in Reference 1, and textbook methods. The glide calculations were performed at two assumed airspeeds: the best glide speed noted in Reference 1 (110 KCAS), and the lowest airspeed computed from the ADS-B data and assumed winds (80 KCAS; the wind assumptions are described below).

A precise airplane weight for the flight was not available (in part because the empty weight of the airplane is unknown¹), and so a gross weight of 3400 lb. was used for the calculations, based on the following assumptions:

- A "typical" empty weight of 2517 lb.²;
- A full fuel load at takeoff of 480 lb.¹;
- Pilot and passenger weights of 200 lb. each¹;
- 40 lb. of baggage;
- 43 lb. of fuel consumed during the climb and cruise to the point of the declared emergency, per performance data published in Reference 1.

The glide calculations consisted of computing the airplane's path over the ground as it descended without engine power from the starting point of the calculation to the elevation of the accident site (650 ft. MSL). To determine the glide range of the airplane from various starting points during its

¹ Per an email from Brian Rayner to John O'Callaghan, dated April 4, 2017.

² See https://en.wikipedia.org/wiki/Beechcraft_Bonanza#Model_36_Bonanza

recorded descent and in different directions from those starting points, a matrix of starting points (times and altitudes) and assumed heading changes³ were evaluated. The starting times and altitudes are listed in Table 1.

Starting Point #	Starting Time (HH:MM:SS CDT)	Starting Altitude (feet MSL)
1	11:56:00	5000
2	11:56:40	4660
3	11:57:20	3780
4	11:58:00	2850
5	11:58:40	1820
6	11:59:20	1100

Table 1. Starting times and altitudes for the matrix of glide calculations.

At each starting point, the heading changes listed in Table 2 are evaluated by assuming the airplane rolls into a 30° roll angle immediately at the start of the scenario, using roll rate of 10°/s. The airplane rolls out of the turn at approximately 10°/s to end up on the new, target heading, and maintains that heading until descending to the accident elevation. The effects of the roll angle on the airplane’s glide performance during the turns are accounted for in the calculations.

Heading Change #	Heading Change (degrees)
1	-180
2	-135
3	-90
4	-45
5	0
6	45
7	90
8	135
9	180

Table 2. Heading changes assumed for the matrix of glide calculations.

The glide calculation results are shown in Figures 1a through 1h. The glide range in different directions is affected strongly by the winds; the prevailing winds were westerly, and so the glide range to the east is greater than the glide range to the west. The assumed wind direction and speed as a function of altitude are shown in Figure 2, and are taken from the rawinsonde sounding from Birmingham / Shelby County, AL (KBMX) at 12:00 UTC (07:00 CDT), as provided in Reference 3.

Figures 1a – 1c show the glide range for the airplane starting at 11:56:00, around the time it started to descend from 5000 ft. (and presumably the time that the engine problems reported by the pilot started). The plots differ in the background image presented; Figure 1a shows a simple grid background, Figure 1b shows a VFR sectional chart background, and Figure 1c shows a *Google*

³ Actually, the calculations evaluate a series of ground track (vs. heading) changes; in other than calm winds, the ground track changes will differ slightly from heading changes. For simplicity of discussion, however, these ground track changes are referred to here as “heading changes.”

Earth satellite image background. Figures 1d – 1h (which show the glide results starting at later times and lower altitudes) are all shown with *Google Earth* image backgrounds only.

The actual airplane trajectory recorded by the ADS-B data is depicted by the thickest lines in Figures 1a – 1h. The glide trajectories at the best glide speed (110 KCAS) are depicted by the medium-thickness lines; and the glide trajectories at an airspeed of 80 KCAS are depicted by the thinnest lines. The color of the lines depicts the altitude at each point, as shown in the legend.

The crash site coordinates plotted in Figures 1a – 1h are those recorded by Textron Aviation, which appeared to be most consistent with the recorded ADS-B trajectory of the airplane:

32° 49' 43.68" N, 085° 42' 51.12" W

The Figure 1 coordinates of the crash site are: east = -0.01 nm, north = -0.12 nm.

Altitude vs. time and altitude vs. distance for both the recorded ADS-B data and the glide performance calculations (with zero heading change) are shown in Figures 3 and 4, respectively. These plots show the reduced glide distance that results when flying at 80 KCAS instead of the optimal glide speed of 110 KCAS.

Figure 5 shows the speeds, rate of climb, and glide ratio for N8169Y during its descent, as computed from the smoothed ADS-B data and the winds aloft shown in Figure 2. The glide ratio relative to the air is greater than that relative to the ground after about 11:57:30 because after this time the airplane was headed into the wind. Note that the airplane did not achieve the best glide ratio relative to the air noted in Reference 1 (1.7 nm per 1000 ft. of altitude), even when the computed calibrated airspeed was near the optimal glide speed of 110 KCAS. This deficiency may be the result of:

- Errors in the assumed winds aloft; if the headwind were greater than that implied by the winds shown in Figure 2, then the glide ratio relative to the air while the airplane is flying into the wind would also be greater. Uncertainty in the winds is probably the greatest factor affecting the accuracy of the glide calculations.
- Greater drag on the airplane than that assumed in Reference 1. This could occur as a result of an airplane configuration different from that specified for best glide Reference 1 (for example, if the propeller were not feathered by pulling the propeller lever fully back to the low RPM position).

The discrepancy between the computed glide ratio relative to the air and the best glide ratio published in Reference 1 is also reflected in Figure 6, which shows plots of C_L vs. C_D for both the aerodynamic model based on the Reference 1 best-glide data, and for the values computed from the ADS-B data and assumed winds. The bottom of Figure 6 presents a plot of horsepower required vs. time. These plots indicate that:

- Using the assumed winds results in a C_D generally greater than that implied by the C_L vs. C_D model based on the Reference 1 best glide data; and

- Negative horsepower (i.e., additional drag) is required beyond the assumed C_L vs. C_D model to fly the trajectory recorded by the ADS-B data in the winds shown in Figure 2.

These observations are consistent with the glide ratio discrepancy noted above, and can result from the same causes: a greater than assumed headwind (a very plausible explanation), and / or an airplane configuration that differs from the optimal (which because of the wind uncertainty, would be difficult or impossible to ascertain).

Finally, Figure 7 presents several flight angles computed from the smoothed ADS-B data and assumed winds, including the pitch angle, flight path angles relative to the air and to the ground, roll and drift angles, and heading and ground track angles. These calculations assume:

- A lift-curve slope (C_L vs. angle of attack (α)) computed from the best-glide data published in Reference 1, and textbook methods
- A zero-lift ($C_L = 0$) α based on the computed lift curve slope, and an assumption that $\alpha = 0^\circ$ in level, cruise flight (153 KCAS airspeed and 3400 lb. gross weight)
- Turns are coordinated (lateral load factor and sideslip angle = 0°)

As noted above, the content of ATC communications shown in Figures 1g and 1h are presented as abbreviated codes. The full transcript text from Reference 2 corresponding to these codes is presented in Table 3 on page 6.

If you have any questions about the data shown in the plots or the calculations, please let me know.

Regards,

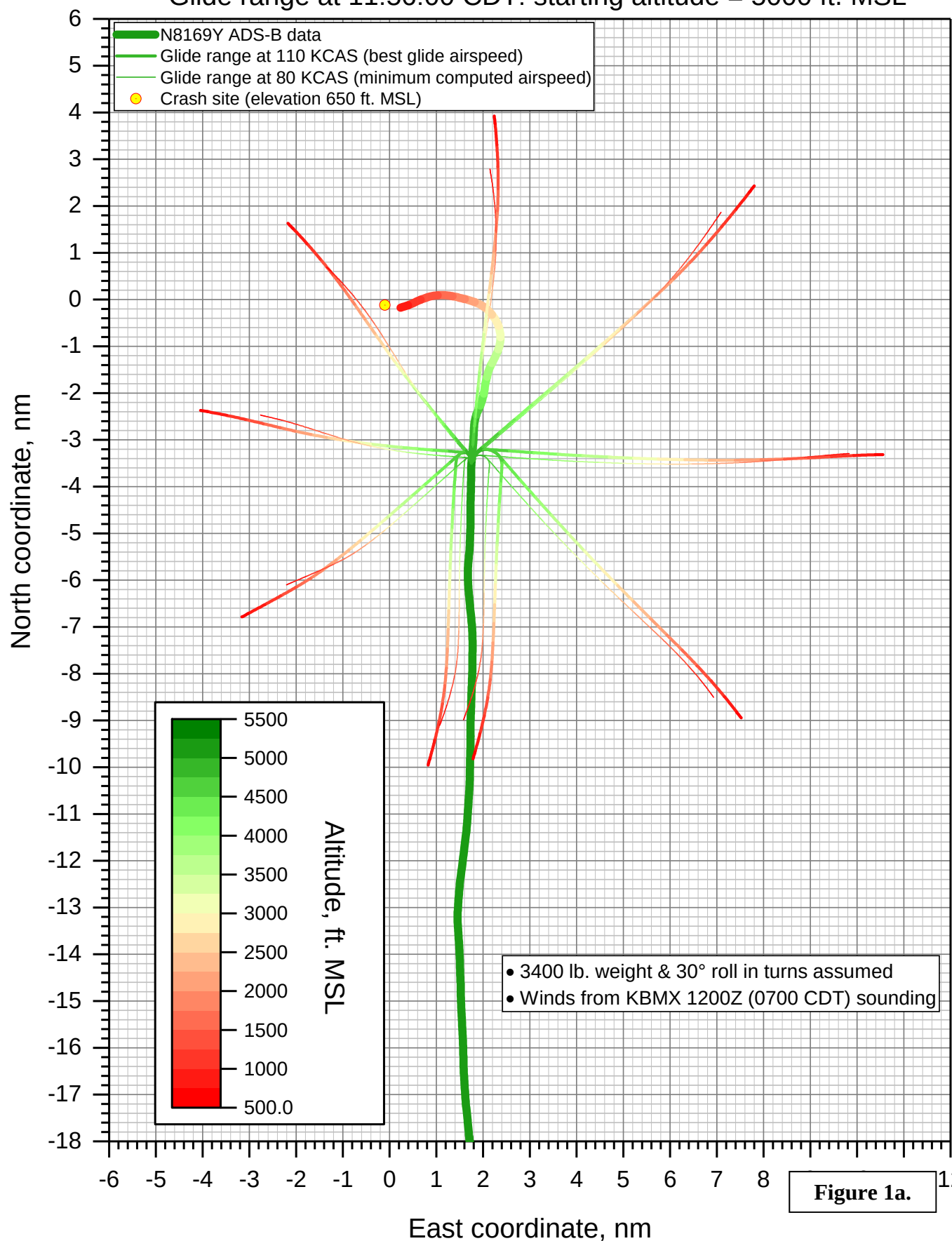
John O'Callaghan

Time, HH:MM:SS CDT	Text code	Full ATC transcript text
11:57:07	[R09 C1]	[R09] N8169Y Atlanta
11:57:11	[N8169Y C1]	[N8169Y] 8169Y I have a it appears to be an engine failure declare an emergency at this time
11:57:19	[R09 C2]	[R09] N68169Y roger you need to go to an airport
11:57:22	[N8169Y C2]	[N8169Y] yes sir I need an airport
11:57:24	[R09 C3]	[R09] alright the closest one I've got is up to your northwest heading 295
11:57:29	[N8169Y C3]	[N8169Y] OK 295
11:57:30	[R09 C4]	[R09] it's gonna be Alexander City N69Y- ah now if you see a big lake ah over to your left it's ah Lake Martin there's a ah private runway close to Lake Martin I believe it's on the northeast corner of it
11:57:47	[N8169Y C4]	[N8169Y] OK and that was 295 right
11:57:52	[R09 C5]	[R09] affirmative Alexander City is ah about 15 miles away
11:57:56	[N8169Y C5]	[N8169Y] okay
11:57:57	[R09 C6]	[R09] If you can't make that if you can't make that it there is an airport there is a runway ah south of that it's ah from your position it's just about due west it's over if you see it if you see Lake Martin it's kinda on the north edge of it
11:58:36	[R09 C7]	[R09] and in that local area N69Y the minimum obstruction altitude's about 1500 feet
11:58:42	[N8169Y C6]	[N8169Y] okay sir
11:58:58	[N8169Y C7]	[N8169Y] Atlanta 69Y it looks like I'm coming down ain't nothing I can do about a thing I don't see a runway in sight
11:59:06	[R09 C8]	[R09] N69Y it's ah you're you're still a pretty good ways away ah do you see ah you see a road a big pasture or anything like that there's ah a ah there's gonna be a lake ah at ah twelve o'clock maybe eleven o'clock so you probably don't wanna go there and I'm looking looking at my map up here I don't see anything big but there is a highway four twenty one somewhere out there

Table 3. Full ATC transcript text corresponding to text codes in Figures 1g and 1h.

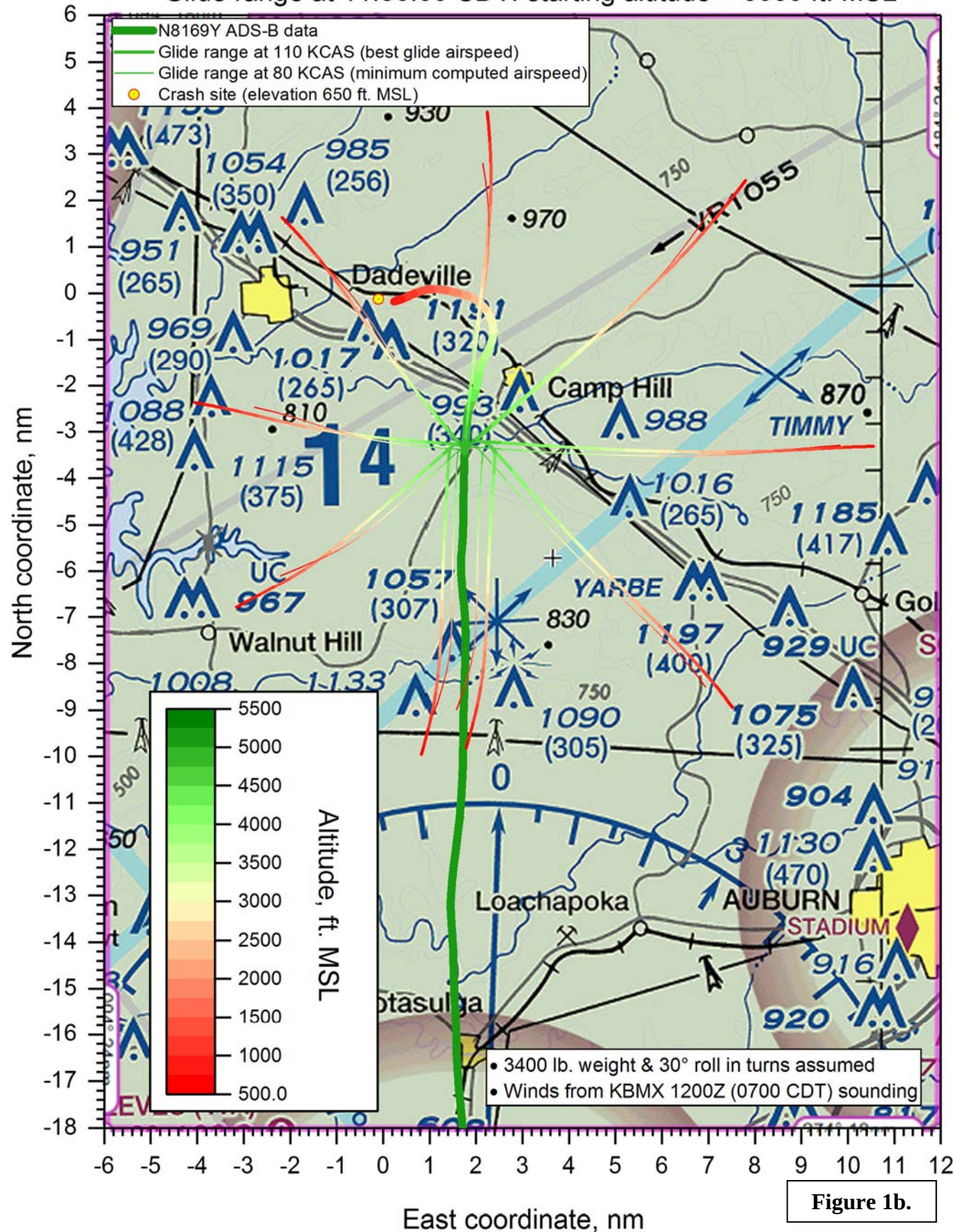
ERA17FA140: Beech A36, N8169Y, Dadeville, AL, 03/28/2017

Glide range at 11:56:00 CDT: starting altitude = 5000 ft. MSL



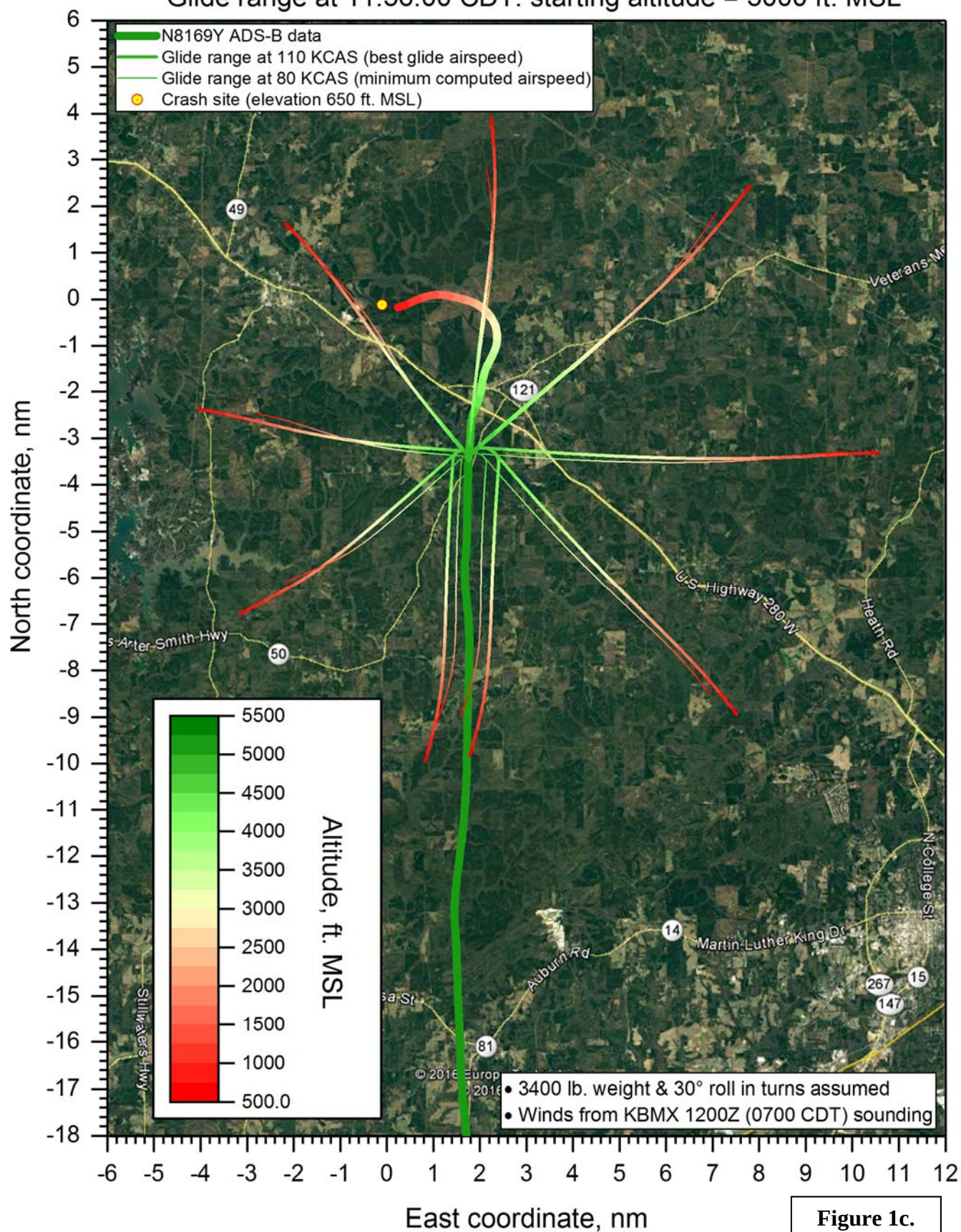
ERA17FA140: Beech A36, N8169Y, Dadeville, AL, 03/28/2017

Glide range at 11:56:00 CDT: starting altitude = 5000 ft. MSL



ERA17FA140: Beech A36, N8169Y, Dadeville, AL, 03/28/2017

Glide range at 11:56:00 CDT: starting altitude = 5000 ft. MSL



ERA17FA140: Beech A36, N8169Y, Dadeville, AL, 03/28/2017

Glide range at 11:56:40 CDT: starting altitude = 4660 ft. MSL

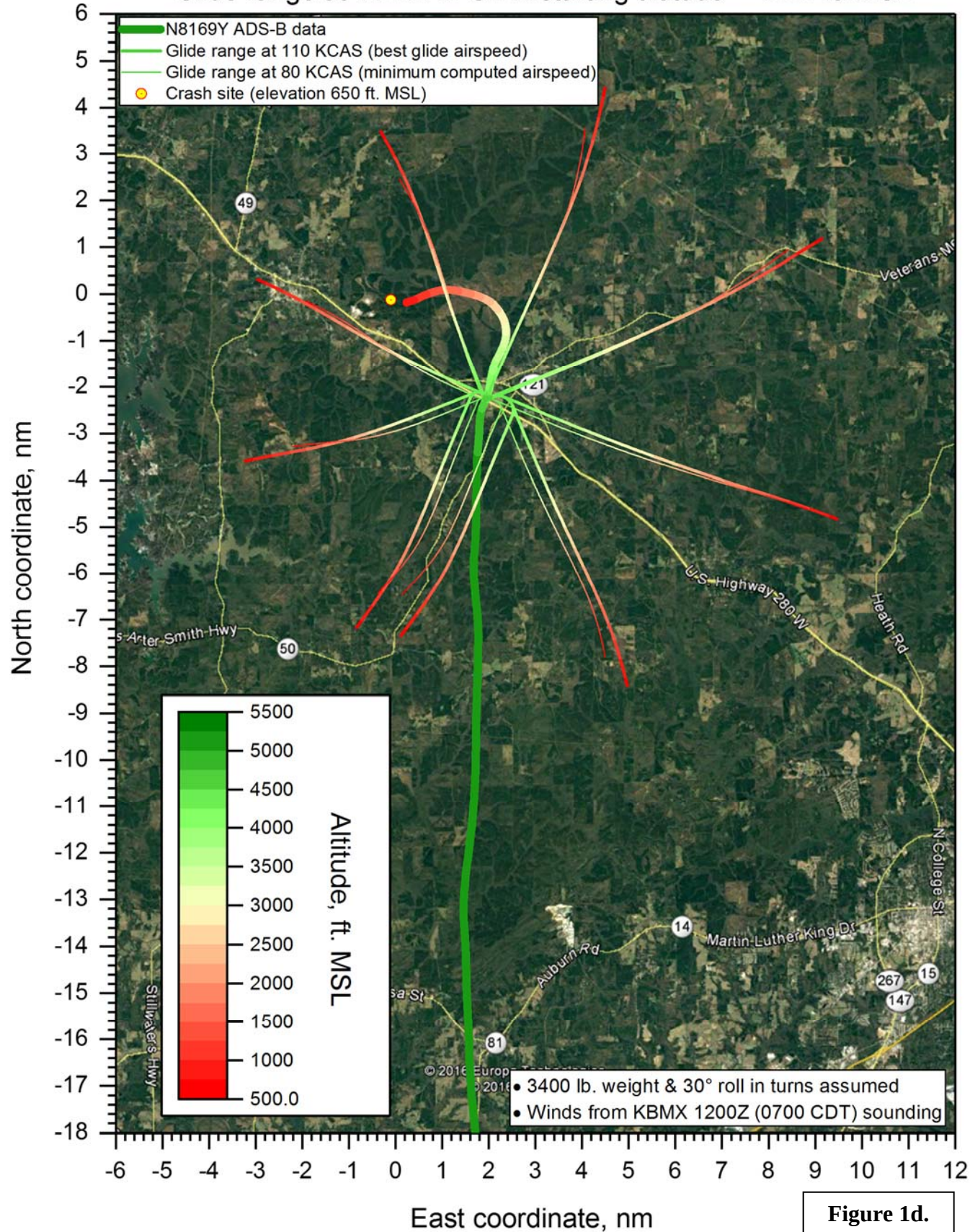


Figure 1d.

ERA17FA140: Beech A36, N8169Y, Dadeville, AL, 03/28/2017

Glide range at 11:57:20 CDT: starting altitude = 3780 ft. MSL

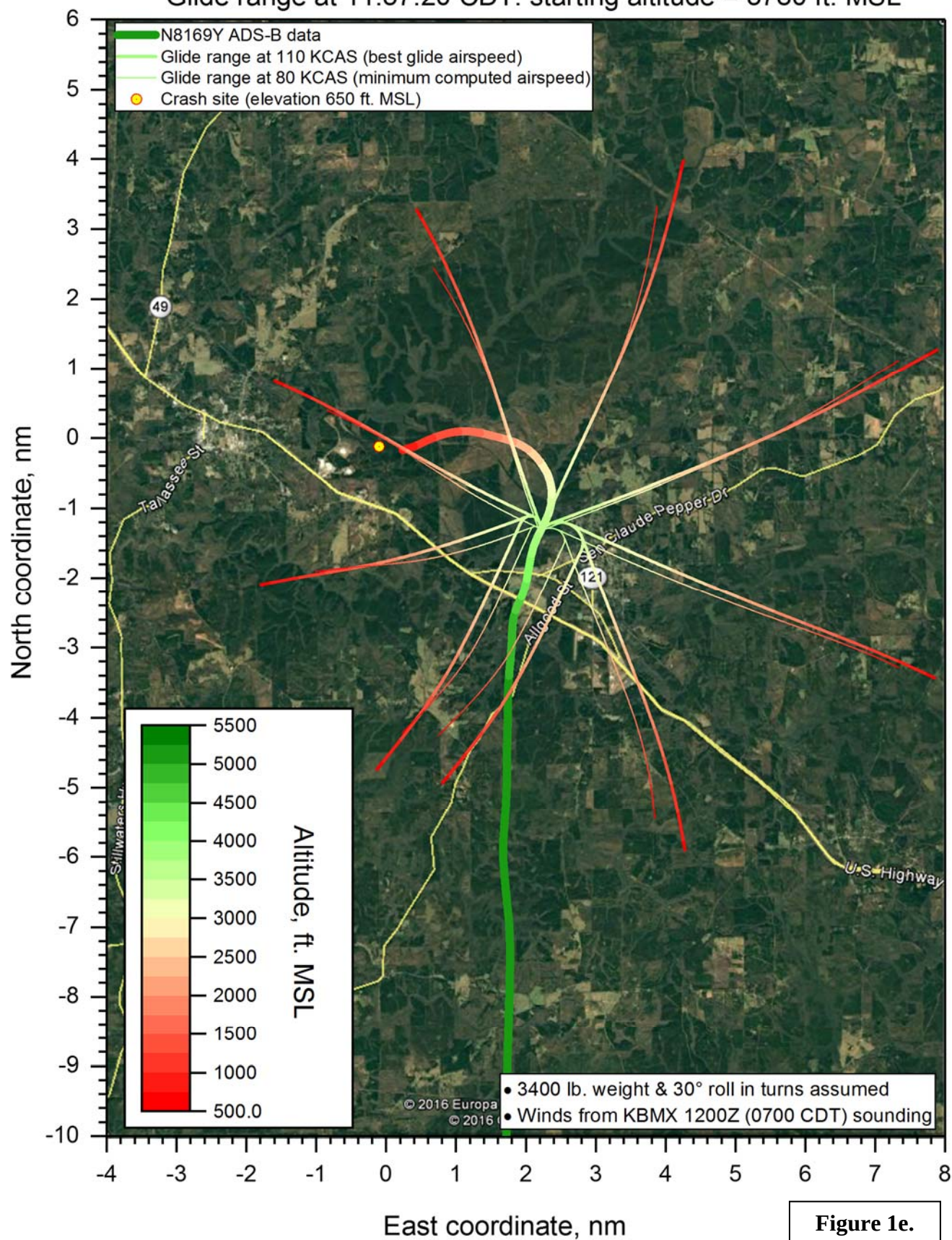


Figure 1e.

ERA17FA140: Beech A36, N8169Y, Dadeville, AL, 03/28/2017

Glide range at 11:58:00 CDT: starting altitude = 2850 ft. MSL

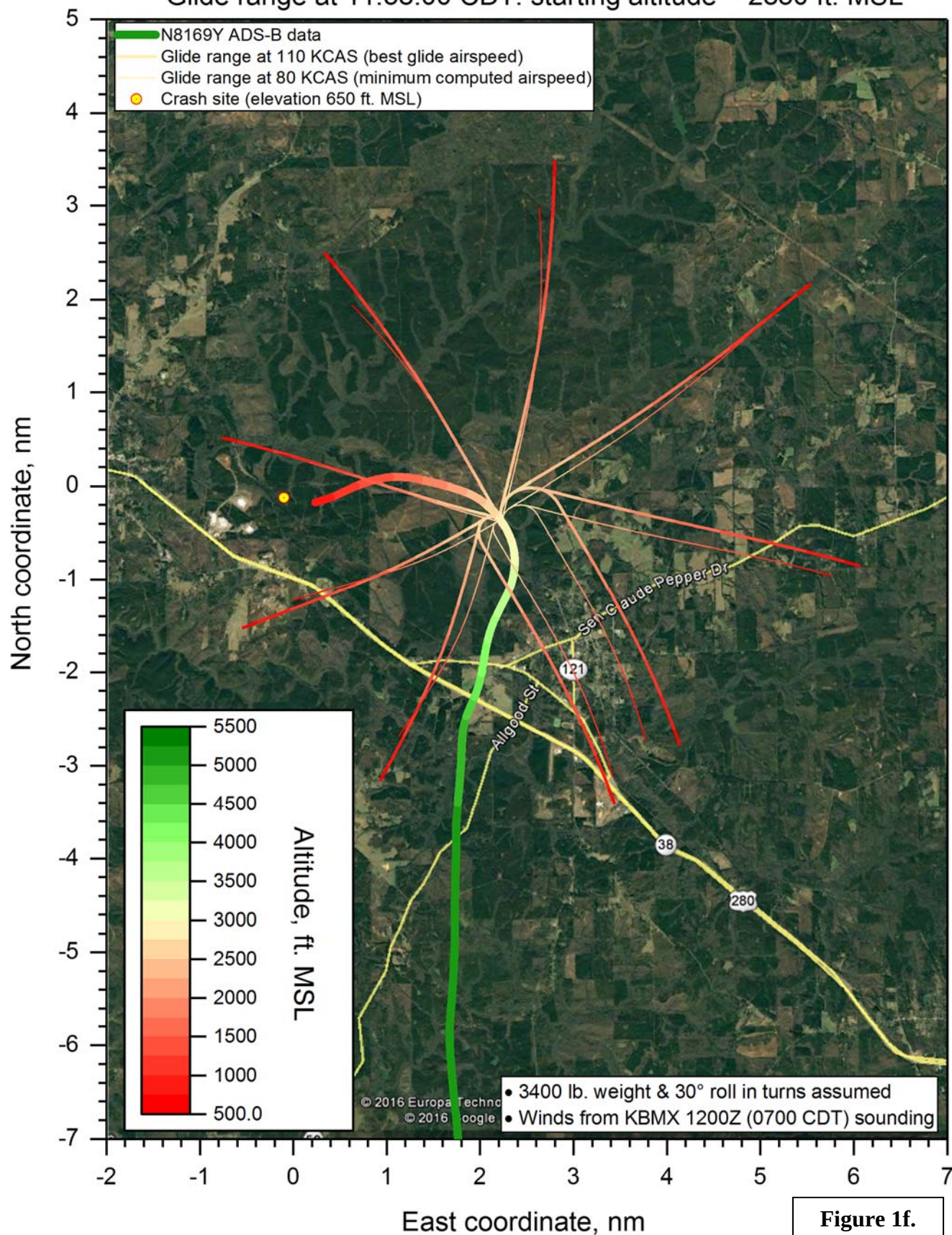
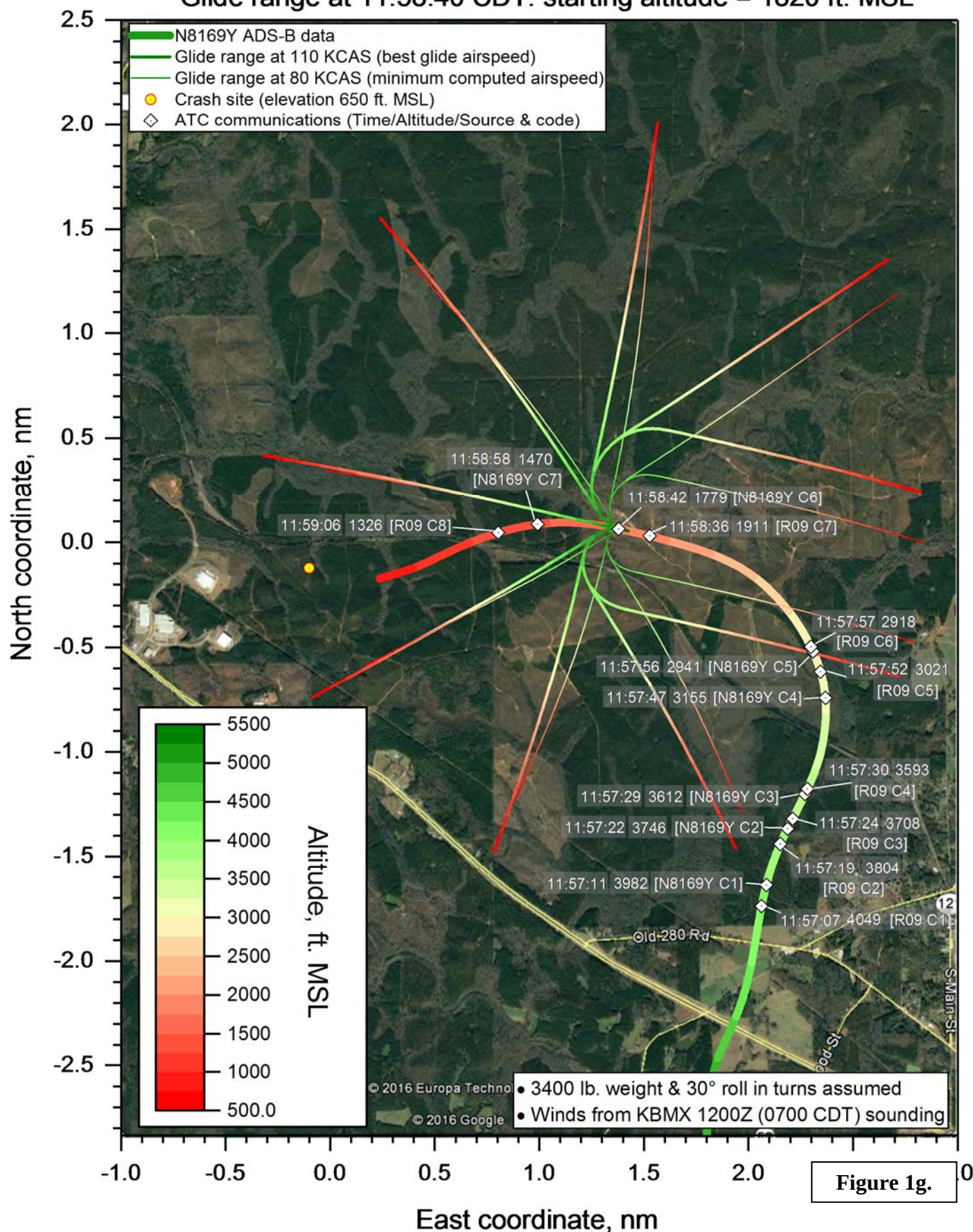


Figure 1f.

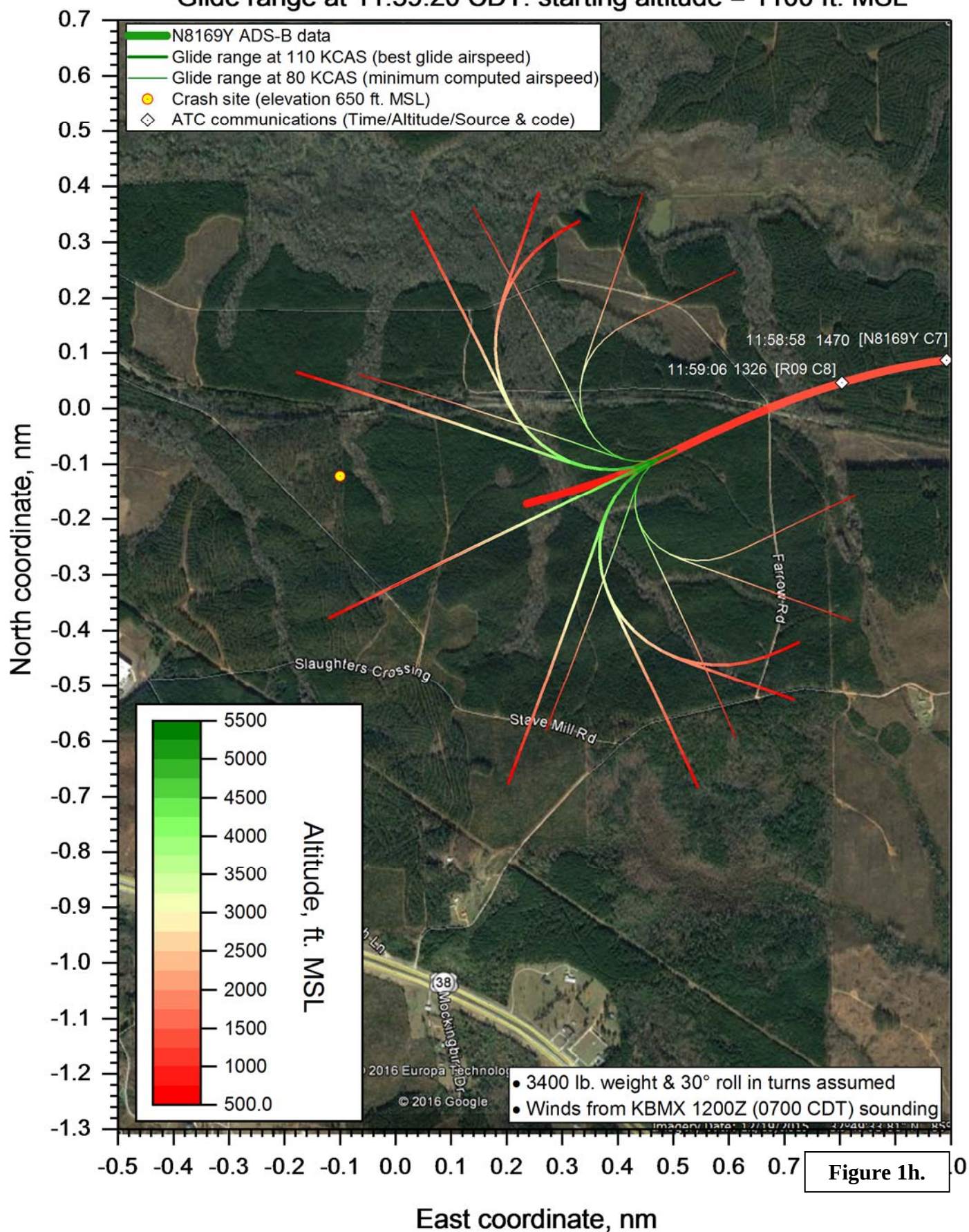
ERA17FA140: Beech A36, N8169Y, Dadeville, AL, 03/28/2017

Glide range at 11:58:40 CDT: starting altitude = 1820 ft. MSL



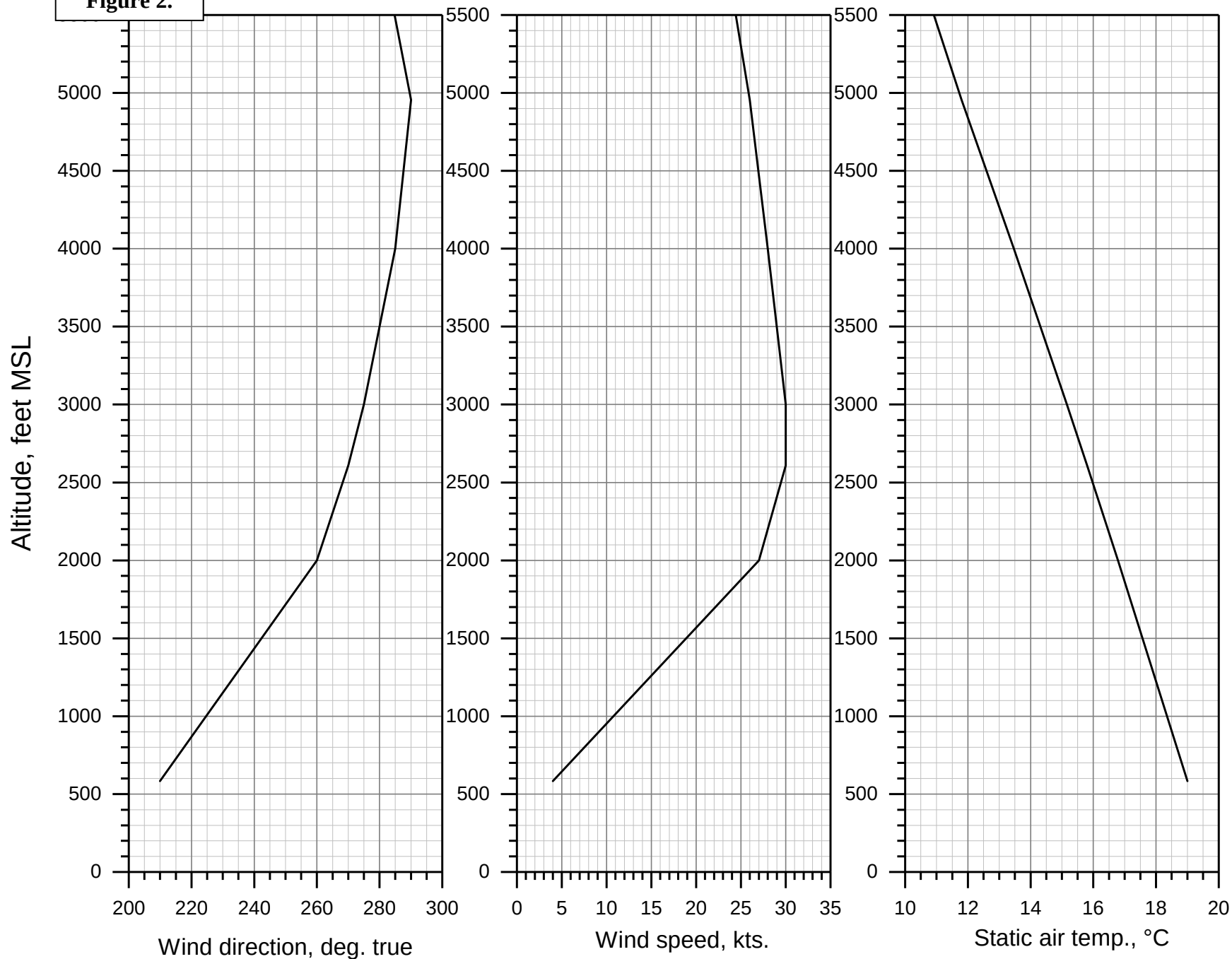
ERA17FA140: Beech A36, N8169Y, Dadeville, AL, 03/28/2017

Glide range at 11:59:20 CDT: starting altitude = 1100 ft. MSL



Winds aloft from rawinsonde launch from KBMX at 1200Z (0700 CDT)

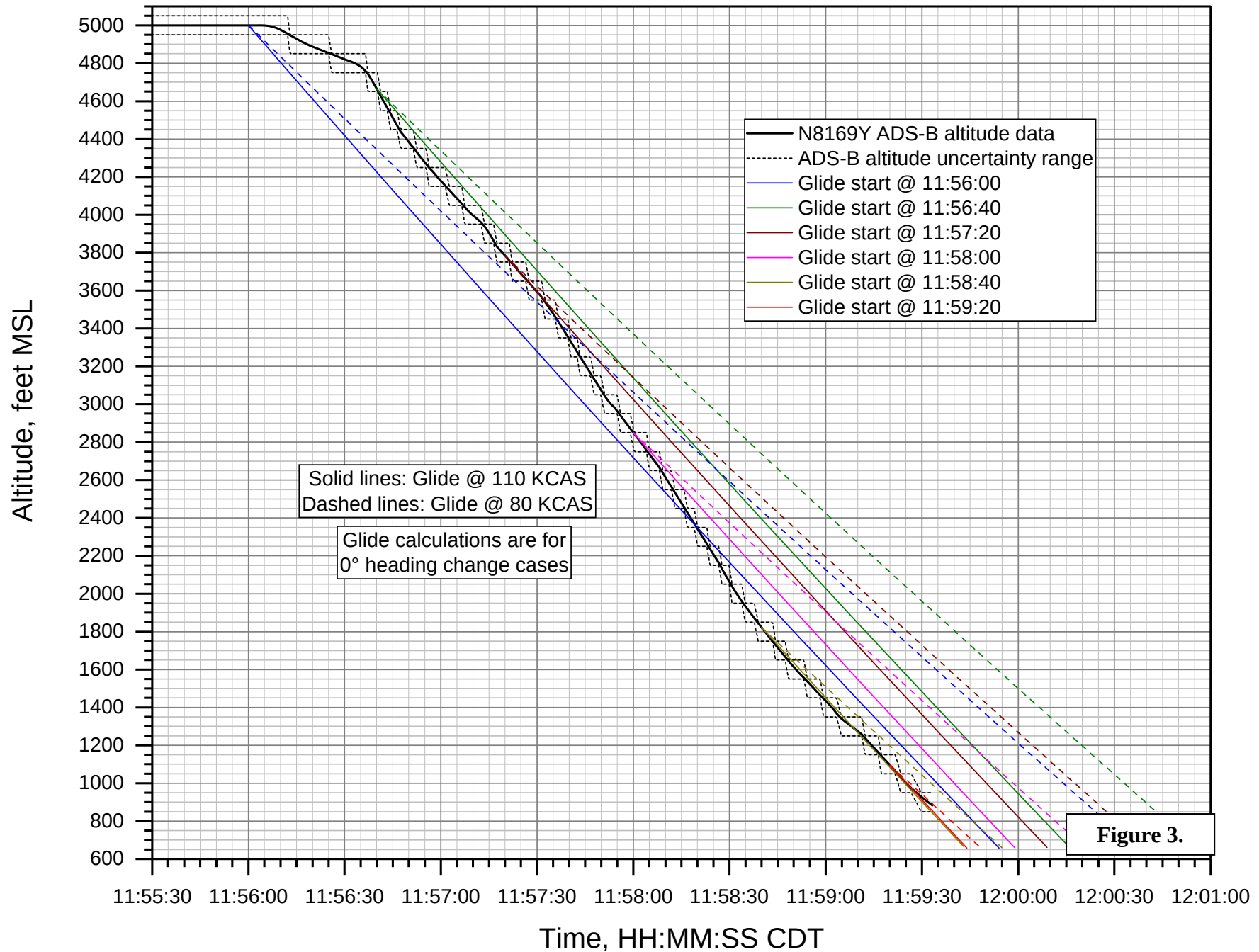
Figure 2.



ERA17FA140: Beech A36, N8169Y, Dadeville, AL, 03/28/2017

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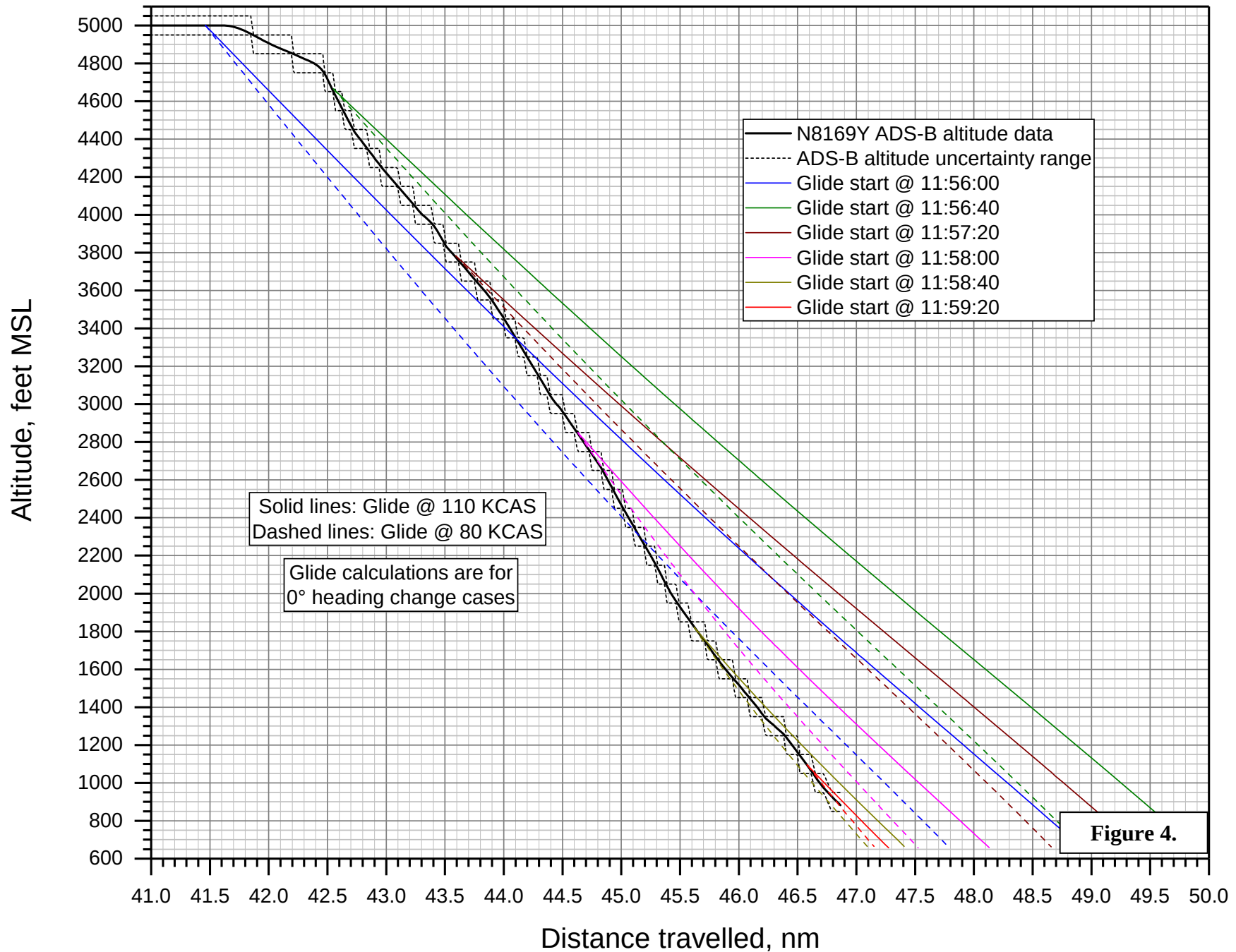
Altitude vs. time: ADS-B data compared to glide performance calculations



ERA17FA140: Beech A36, N8169Y, Dadeville, AL, 03/28/2017

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Glide range: ADS-B data compared to glide performance calculations



ERA17FA140: Beech A36, N8169Y, Dadeville, AL, 03/28/2017

Speeds based on ADS-B data and assumed winds aloft

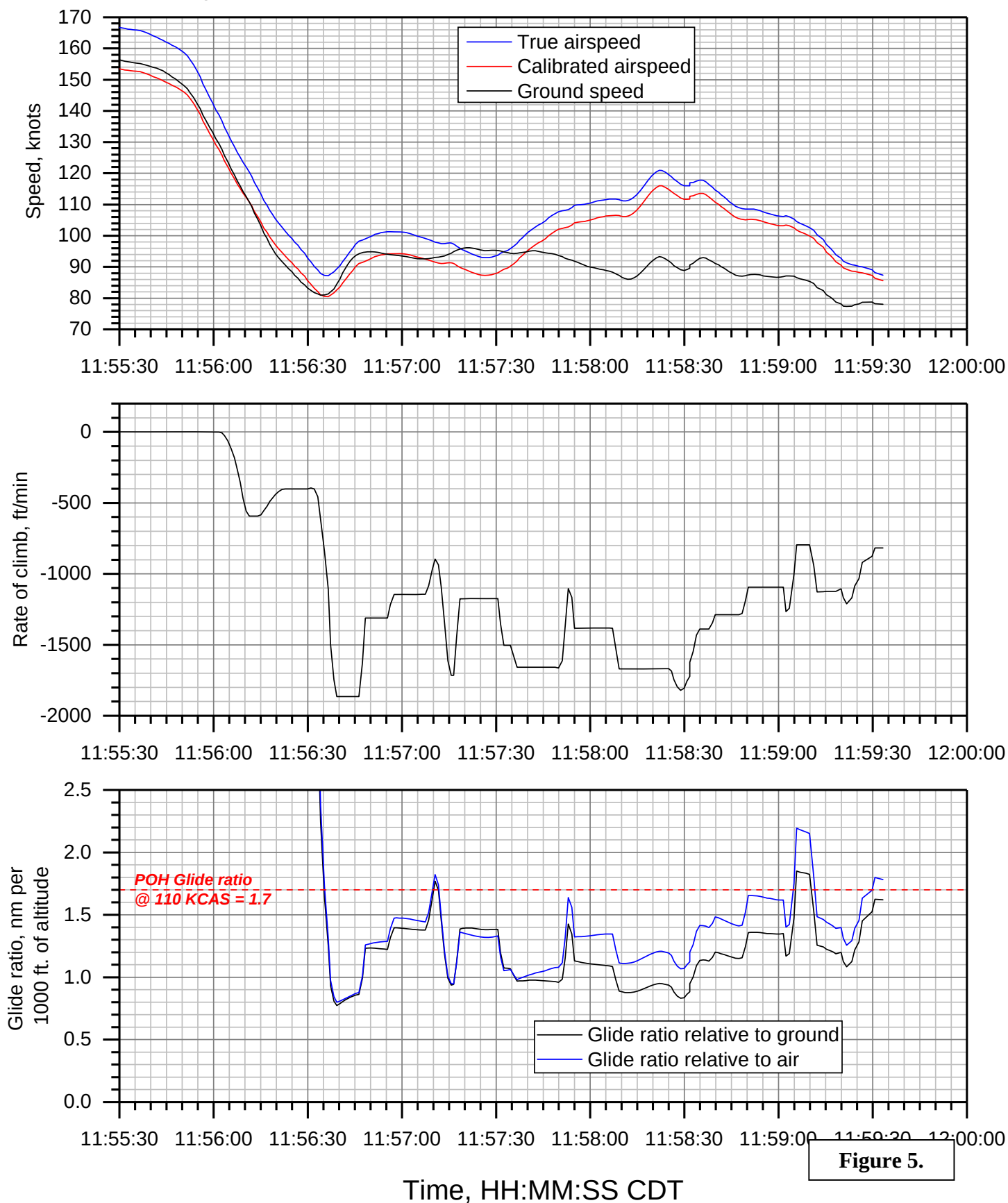


Figure 5.

ERA17FA140: Beech A36, N8169Y, Dadeville, AL, 03/28/2017

Aerodynamic coefficients and power calculations

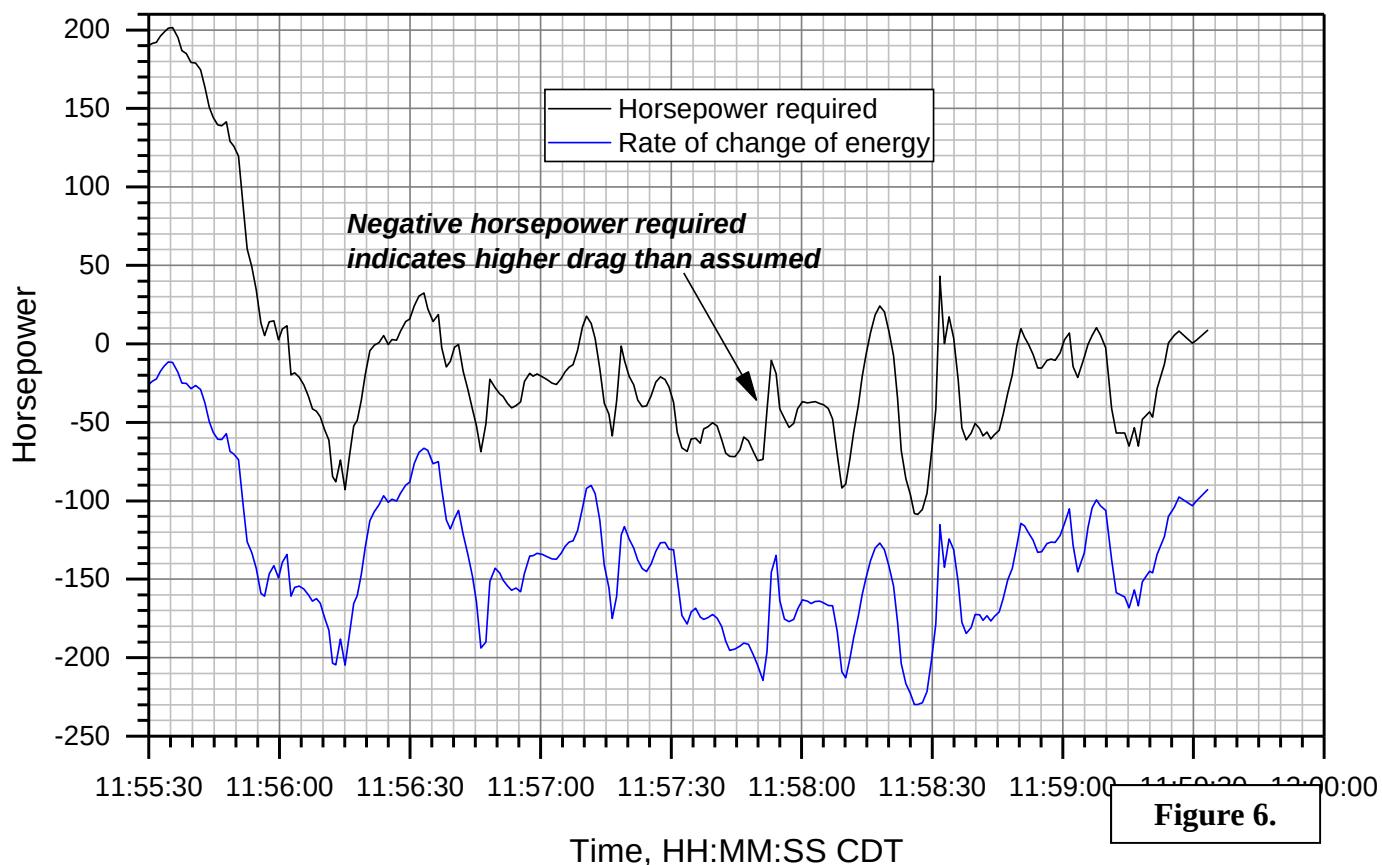
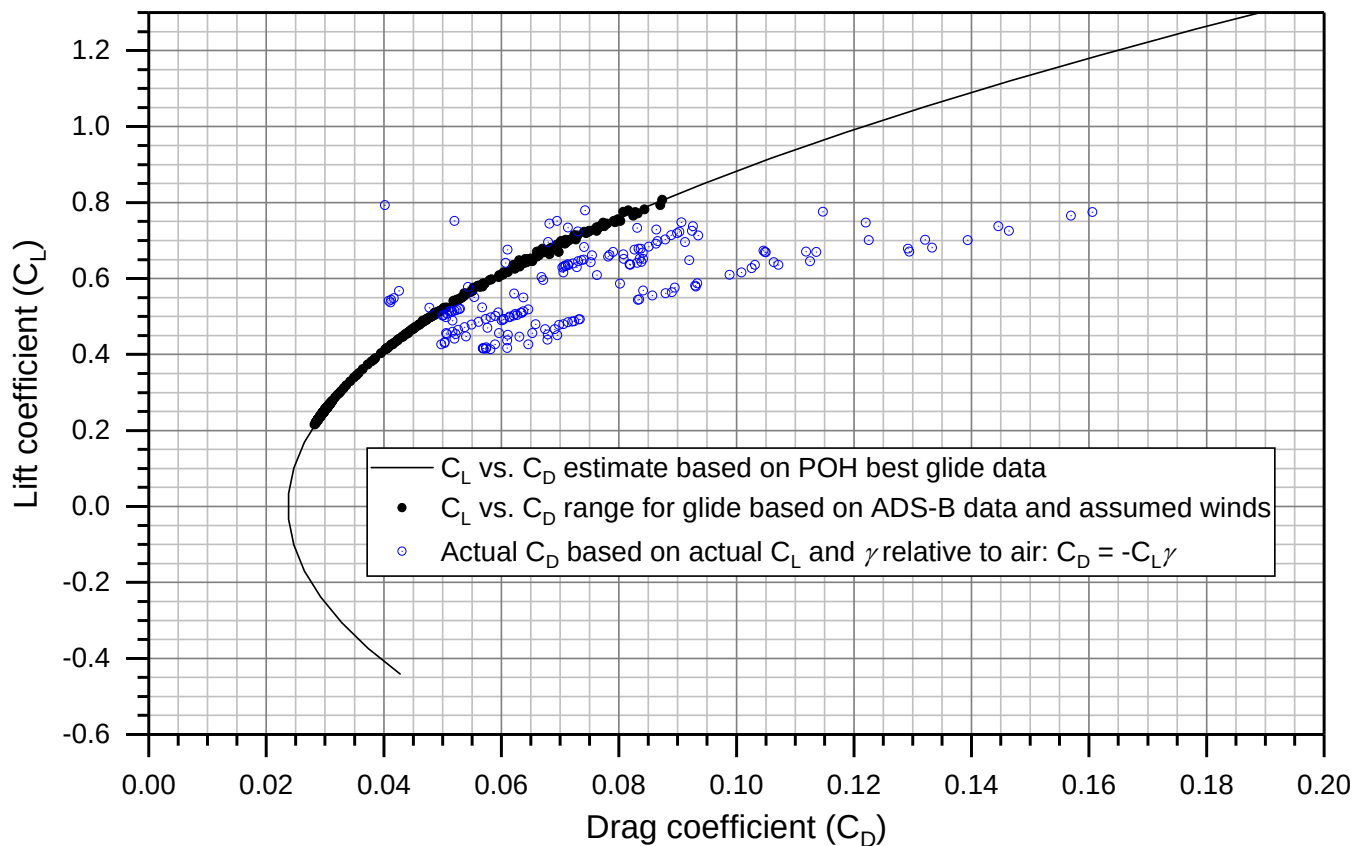


Figure 6.

ERA17FA140: Beech A36, N8169Y, Dadeville, AL, 03/28/2017

Euler angles based on ADS-B data and assumed winds aloft

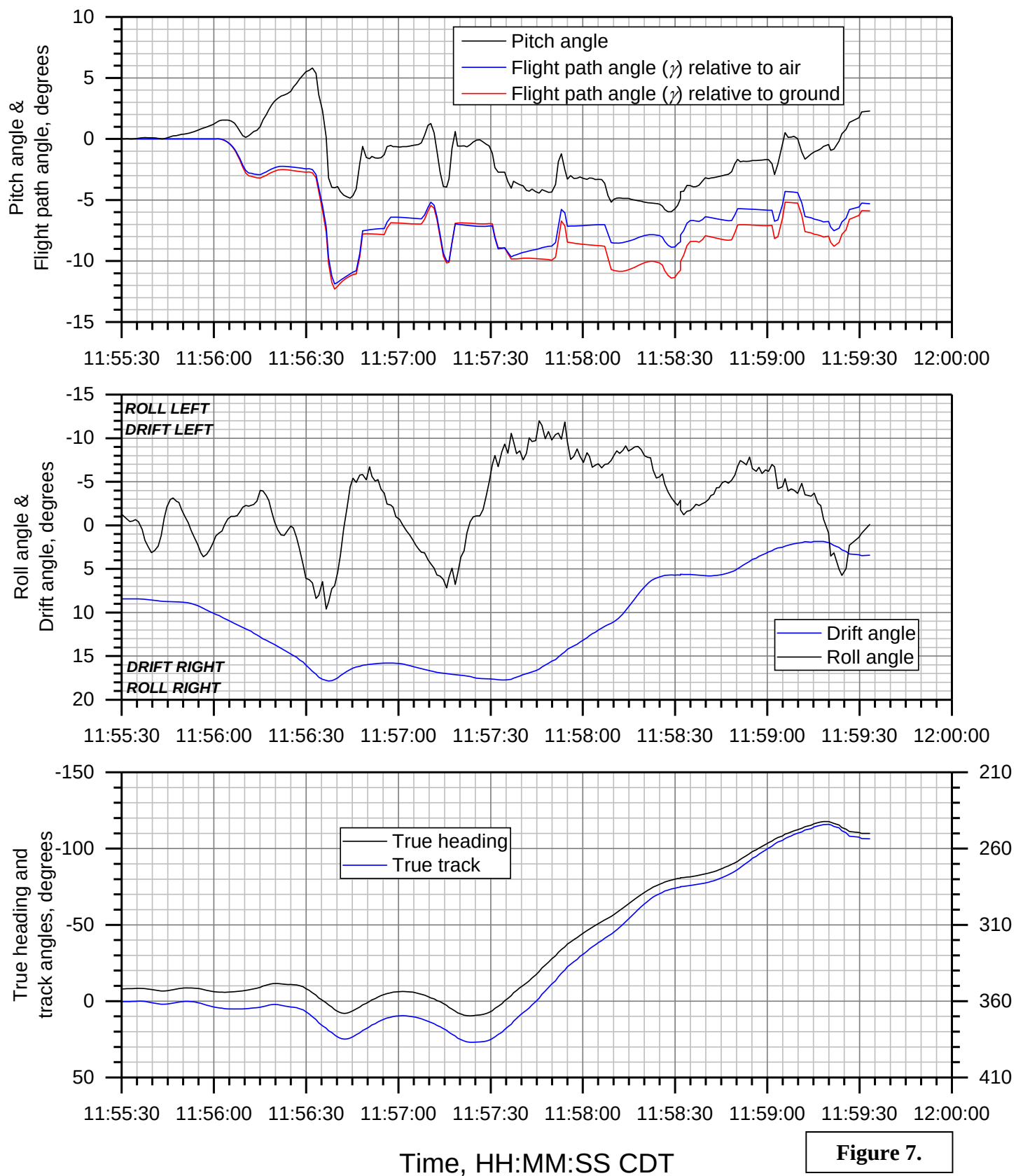


Figure 7.