

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



CEN24FA160

METEOROLOGY

Specialist's Factual Report

September 24, 2024

TABLE OF CONTENTS

A. ACCIDENT.....	3
B. METEOROLOGY SPECIALIST	3
C. DETAILS OF THE INVESTIGATION	3
D. WEATHER INFORMATION.....	3
1.0 WEATHER RADAR.....	3
2.0 LIGHTNING.....	12
3.0 HRRR MODEL SOUNDING.....	13
4.0 SATELLITE IMAGERY	15
5.0 PILOT REPORTS	16
6.0 SURFACE OBSERVATIONS	17
7.0 TERMINAL AERODROME FORECASTS.....	19
8.0 AREA FORECAST DISCUSSION.....	19
9.0 SIGMETs.....	20
10.0 CWSU PRODUCTS.....	21
11.0 G-AIRMETs.....	21

A. ACCIDENT

Location: Hartsburg, Missouri

Date: 16 April 2024

Time: 1205 central daylight time (1705 UTC¹)

Aircraft: Type - Piper 46-350P; Registration - N451MA

B. METEOROLOGY SPECIALIST

Mike Richards

Senior Meteorologist

Office of Aviation Safety

Operational Factors Division (AS-30)

National Transportation Safety Board

C. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's meteorological specialist did not travel in support of this accident investigation and gathered all weather data remotely. Unless otherwise noted, all times are in central daylight time for 16 April 2024 (based upon the 24-hour clock), directions are referenced to true north, distances are in nautical miles and heights are above mean sea level (msl). The accident site was located at about: 38.7166° north latitude; 92.30164° west longitude at an elevation of about 595 feet.

This report provides information on weather conditions and forecasts applicable to the accident flight.

D. WEATHER INFORMATION

1.0 Weather Radar

WSR-88D² Level-II base reflectivity weather radar imagery from St. Louis, Missouri, (site: KLSX) is presented in Figures 1-6. KLSX was located approximately 76 miles east of the accident location with an antenna elevation of about 720 feet. Assuming standard refraction and considering the 0.95° beam width³ for the WSR-88D radar beam, the

¹ UTC - abbreviation for Coordinated Universal Time

² Weather Surveillance Radar 88 Doppler (WSR-88D)

³ Here we define the angular width of the radar beam as the region of transmitted energy that is bounded by one-half the maximum power. The maximum power lies along the beam centerline and decreases outward from the radar antenna.

KLSX 0.44° and 1.27° tilts would have “seen” altitudes above the accident location between about 4,300 and 11,900 feet, and between about 11,000 and 18,600 feet, respectively. Light to heavy values of reflectivity⁴ were present along and near the final portion of the accident aircraft’s flight path.

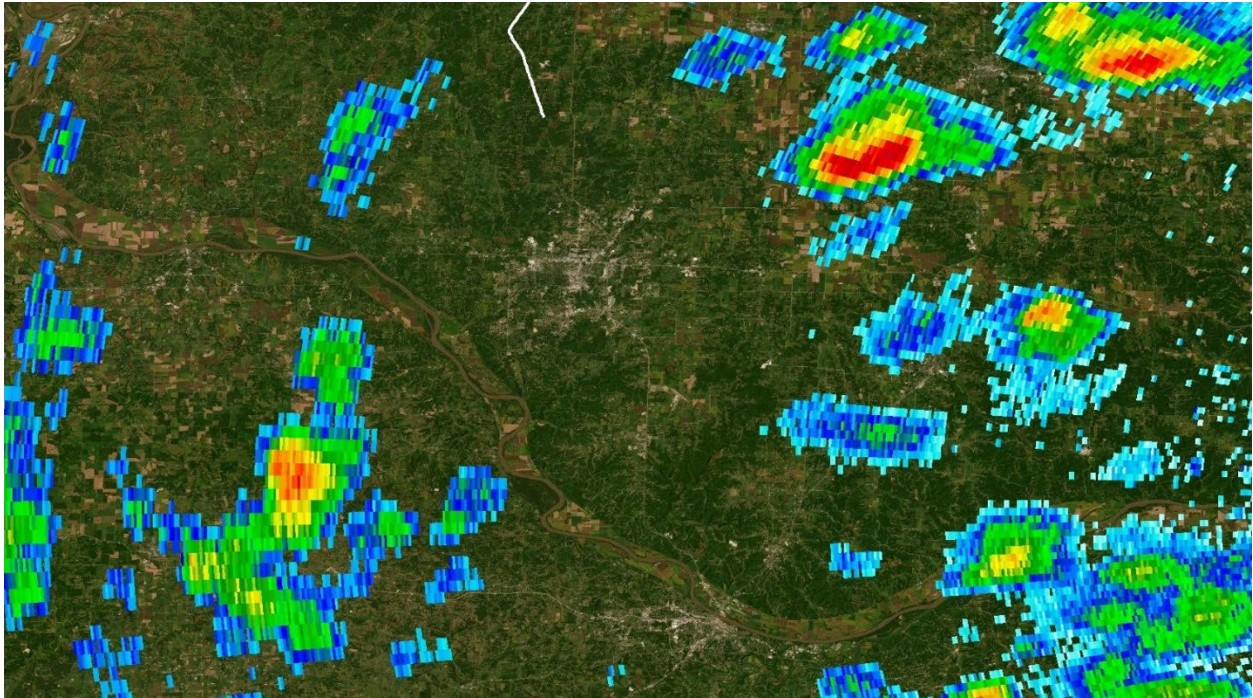


Figure 1 – KLSX 0.44° Level-II base reflectivity product from a sweep initiated at 1152:29. The accident aircraft’s flight path through about that time is represented by the white line.

4

https://www.faa.gov/sites/faa.gov/files/other_visit/aviation_industry/airline_operators/airline_safety/in_FO07008.pdf

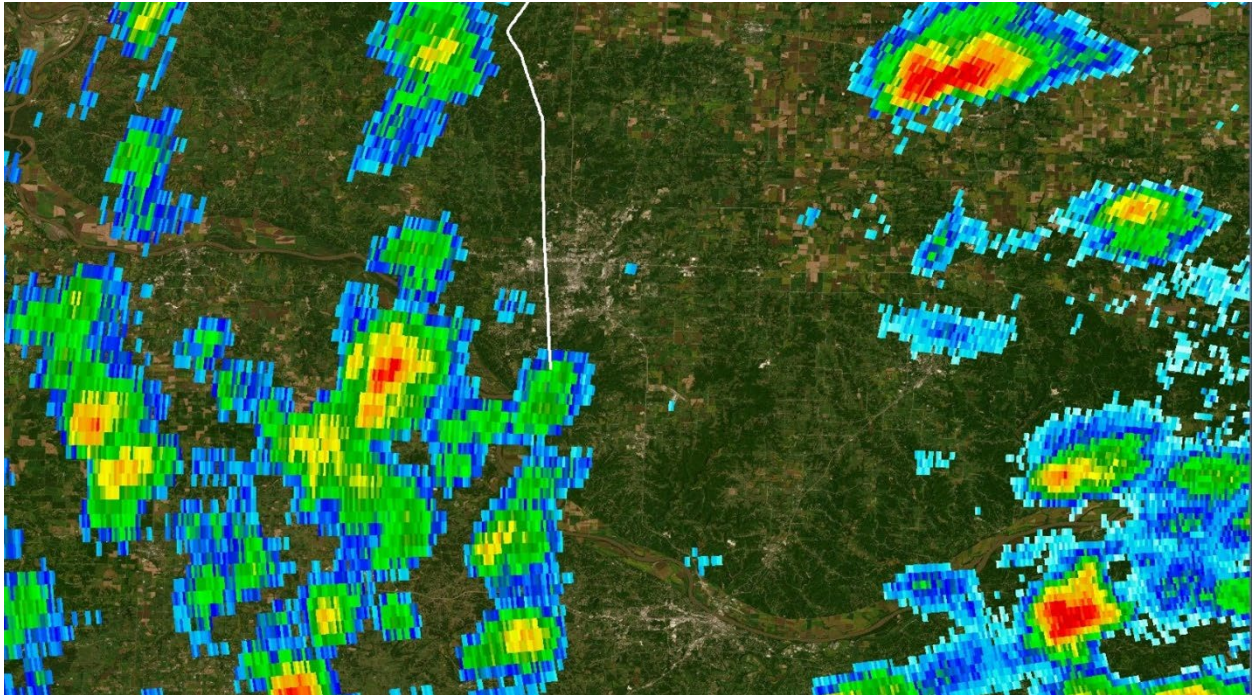


Figure 2 - KLSX 0.44° Level-II base reflectivity product from a sweep initiated at 1200:10. The accident aircraft's flight path through about that time is represented by the white line.

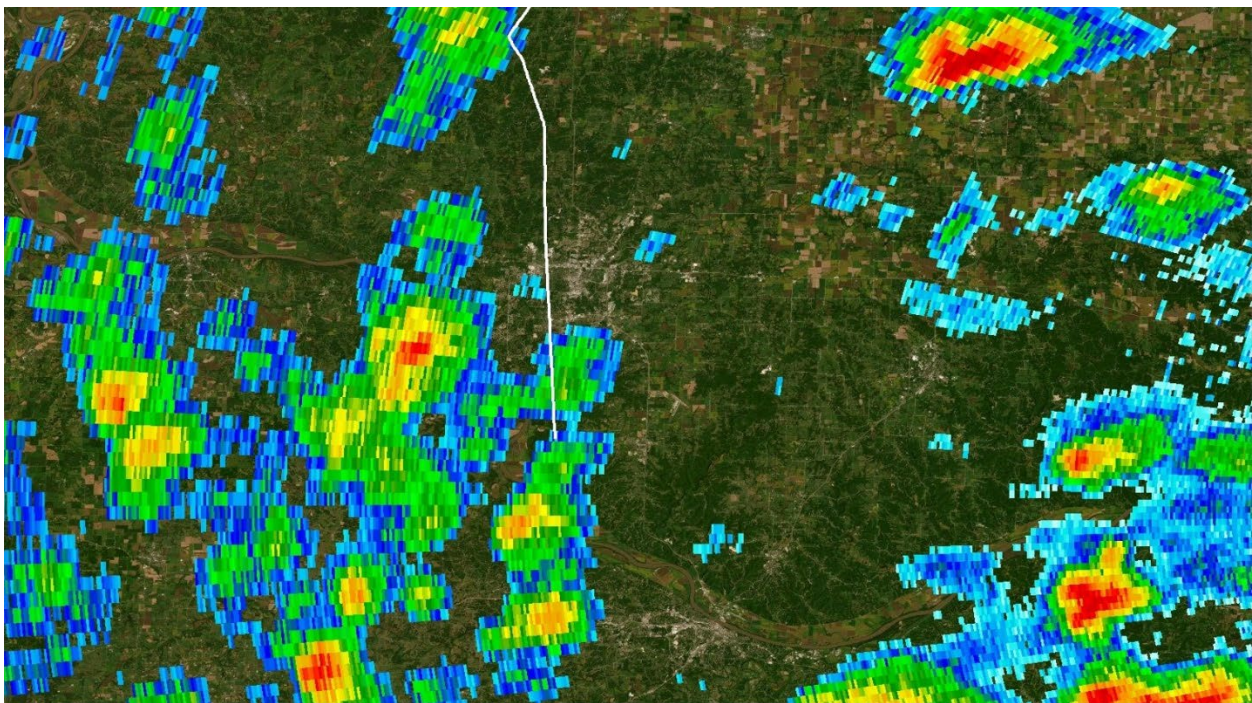


Figure 3 - KLSX 0.44° Level-II base reflectivity product from a sweep initiated at 1202:07. The accident aircraft's flight path through about that time is represented by the white line.

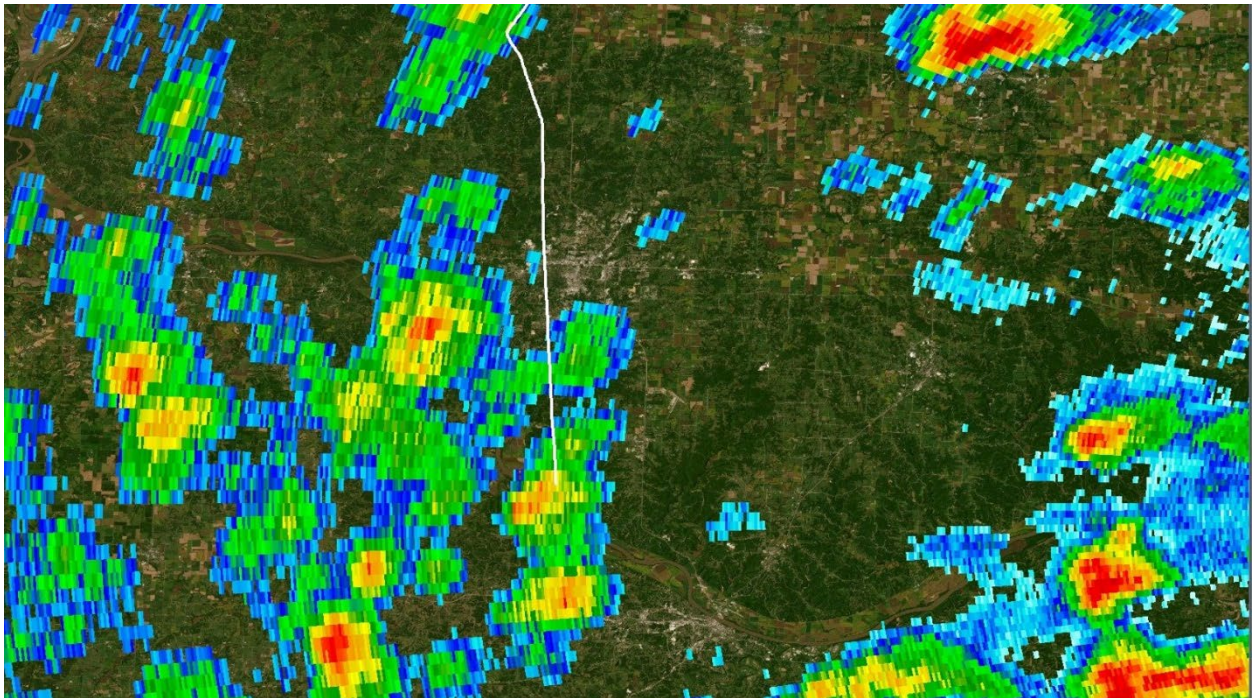


Figure 4 - KLSX 0.44° Level-II base reflectivity product from a sweep initiated at 1203:29. The accident aircraft's flight path through about that time is represented by the white line.

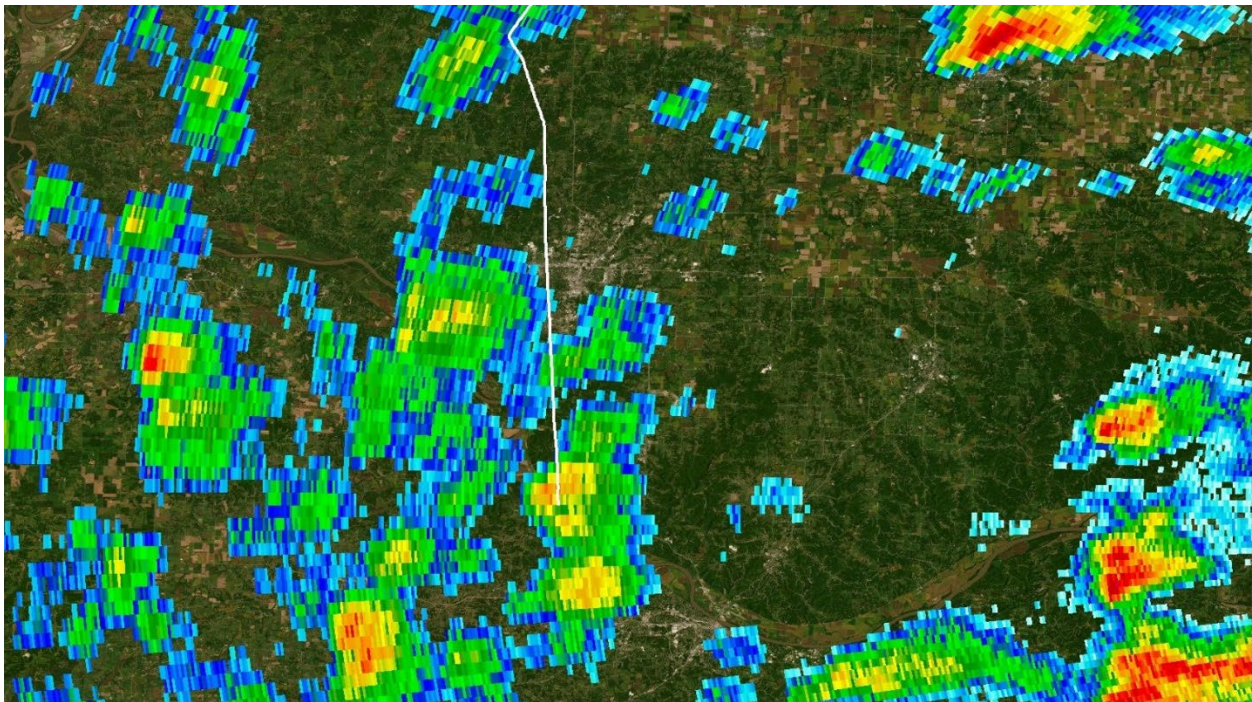


Figure 5 - KLSX 1.27° Level-II base reflectivity product from a sweep initiated at 1204:10. The accident aircraft's flight path through about that time is represented by the white line.

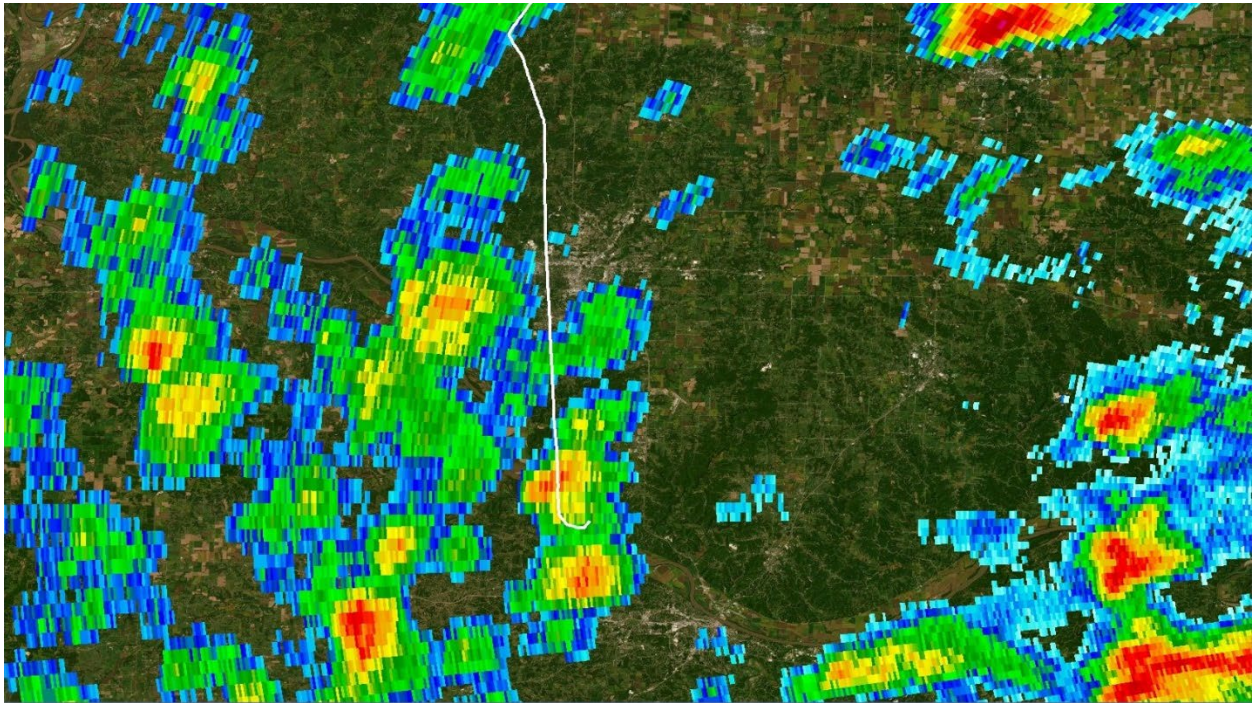


Figure 6 - KLSX 0.44° Level-II base reflectivity product from a sweep initiated at 1204:50. The accident aircraft's flight path through about that time is represented by the white line.

The NTSB requested reproductions of the weather radar mosaics broadcast via the Flight Information Service-Broadcast (FIS-B) applicable to the accident region during the accident flight from L3 Harris. L3 Harris based their mosaics on weather radar data mosaics provided by the Multi-Radar/Multi-Sensor System (MRMS)⁵ that were produced every two minutes, and public broadcast times for each L3 Harris mosaic were approximately two minutes after the creation time for each mosaic (for example, if a mosaic was created by L3 Harris that had a mosaic creation time of 1224, that mosaic would have been broadcast to the public via the FIS-B at about 1226; see Figure 11). Figures 7-10 present FIS-B weather radar mosaics created by L3 Harris, along with MRMS weather radar mosaics that were valid at the time that each FIS-B mosaic was broadcast to the public.

⁵ <https://mrms.nssl.noaa.gov/>

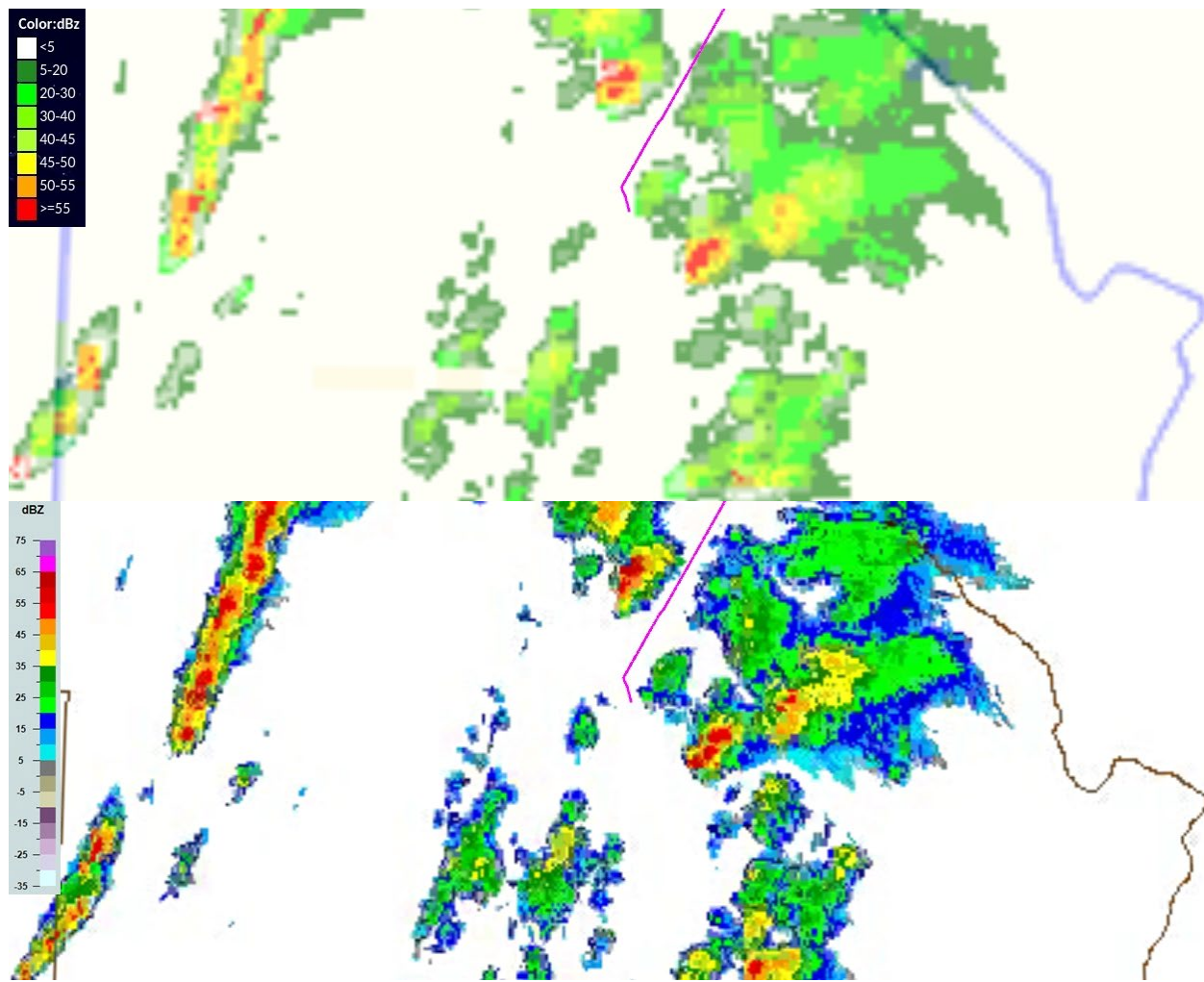


Figure 7 – Top: FIS-B weather radar mosaic created at 1150 and broadcast about 1152; Bottom: MRMS weather radar mosaic valid at 1152; accident aircraft's flight path through 1152:01 is represented by the pink line.

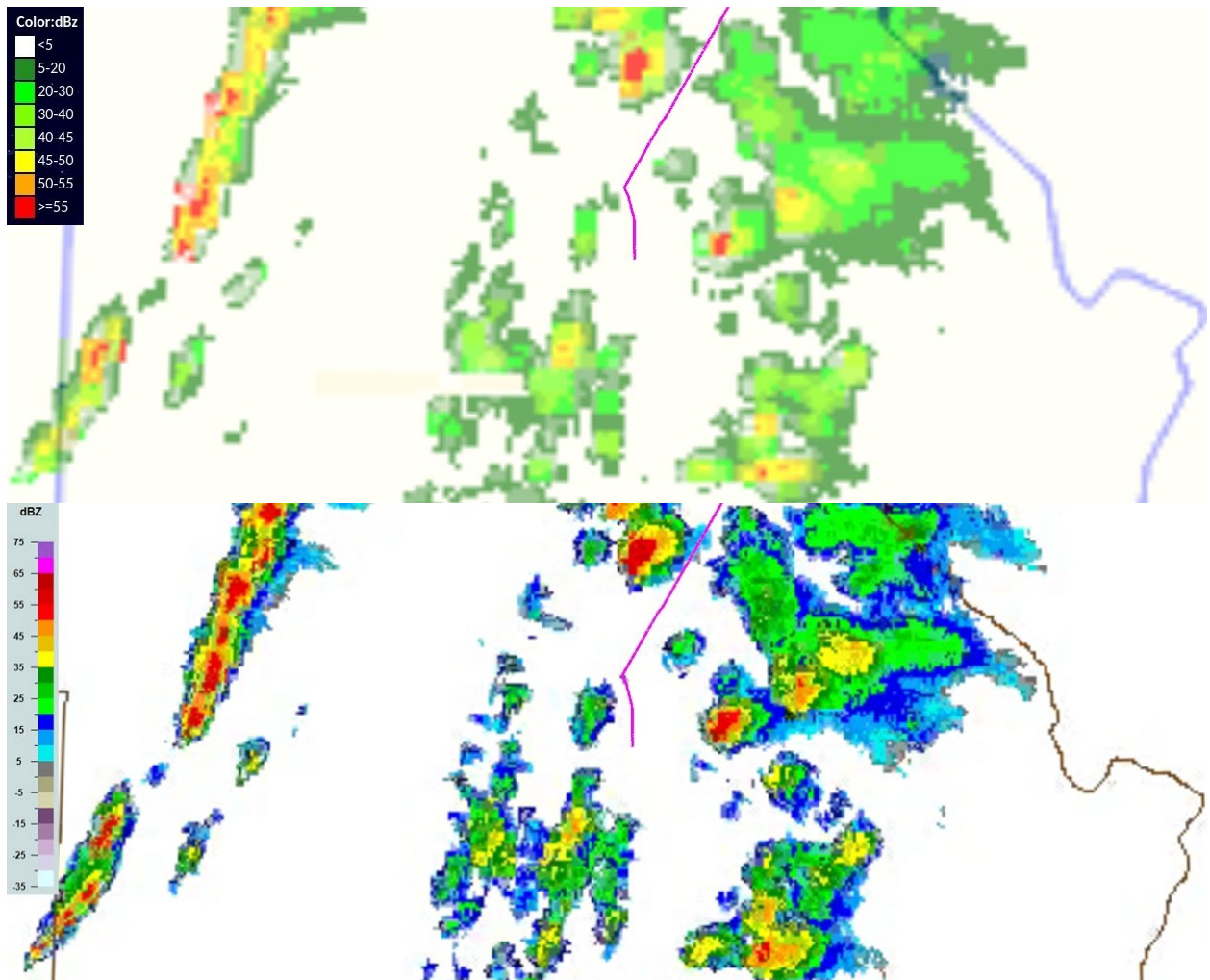


Figure 8 – Top: FIS-B weather radar mosaic created at 1154 and broadcast about 1156; Bottom: MRMS weather radar mosaic valid at 1156; accident aircraft's flight path through 1155:59 is represented by the pink line.

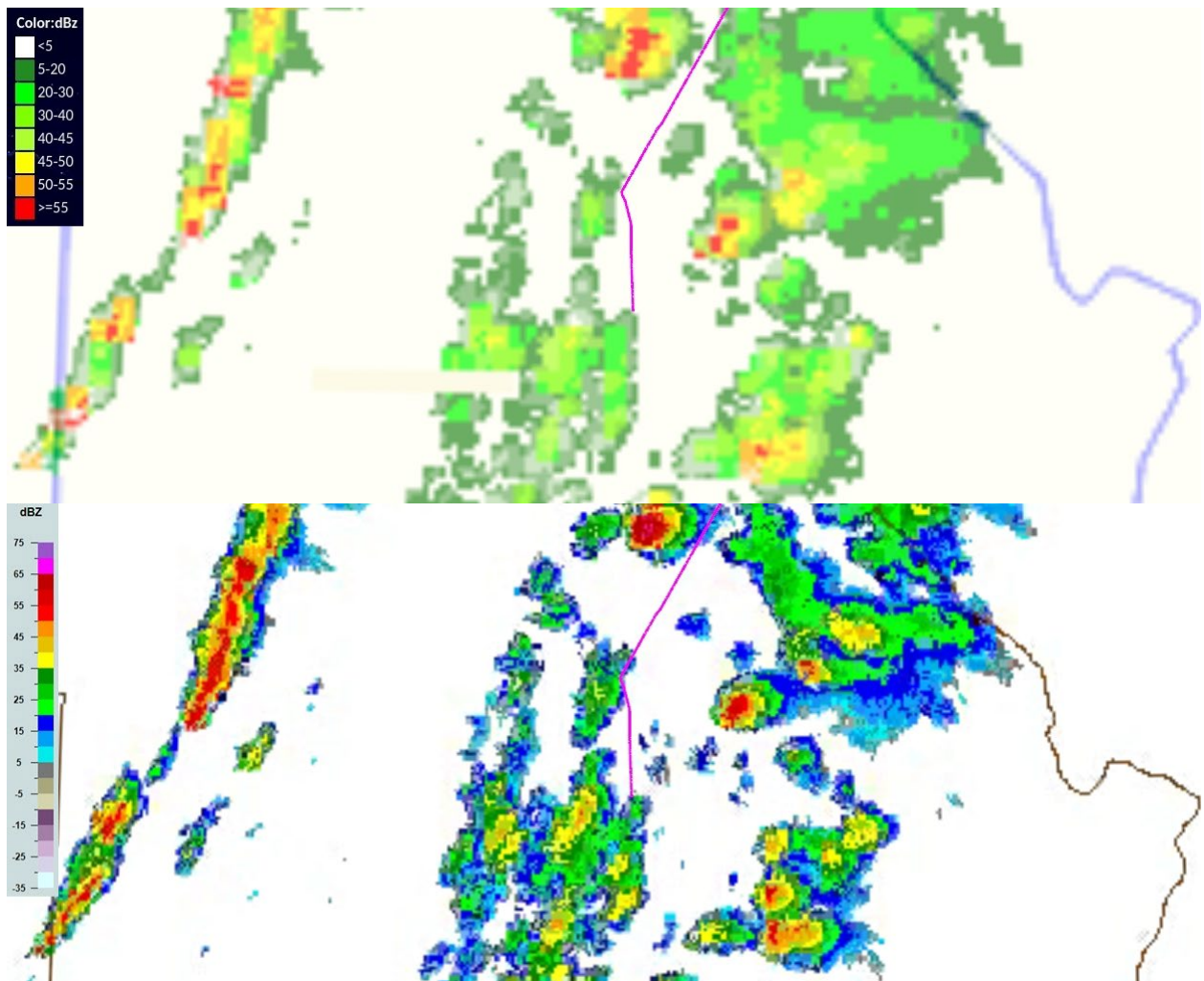


Figure 9 - Top: FIS-B weather radar mosaic created at 1158 and broadcast about 1200; Bottom: MRMS weather radar mosaic valid at 1200; accident aircraft's flight path through 1200:02 is represented by the pink line.

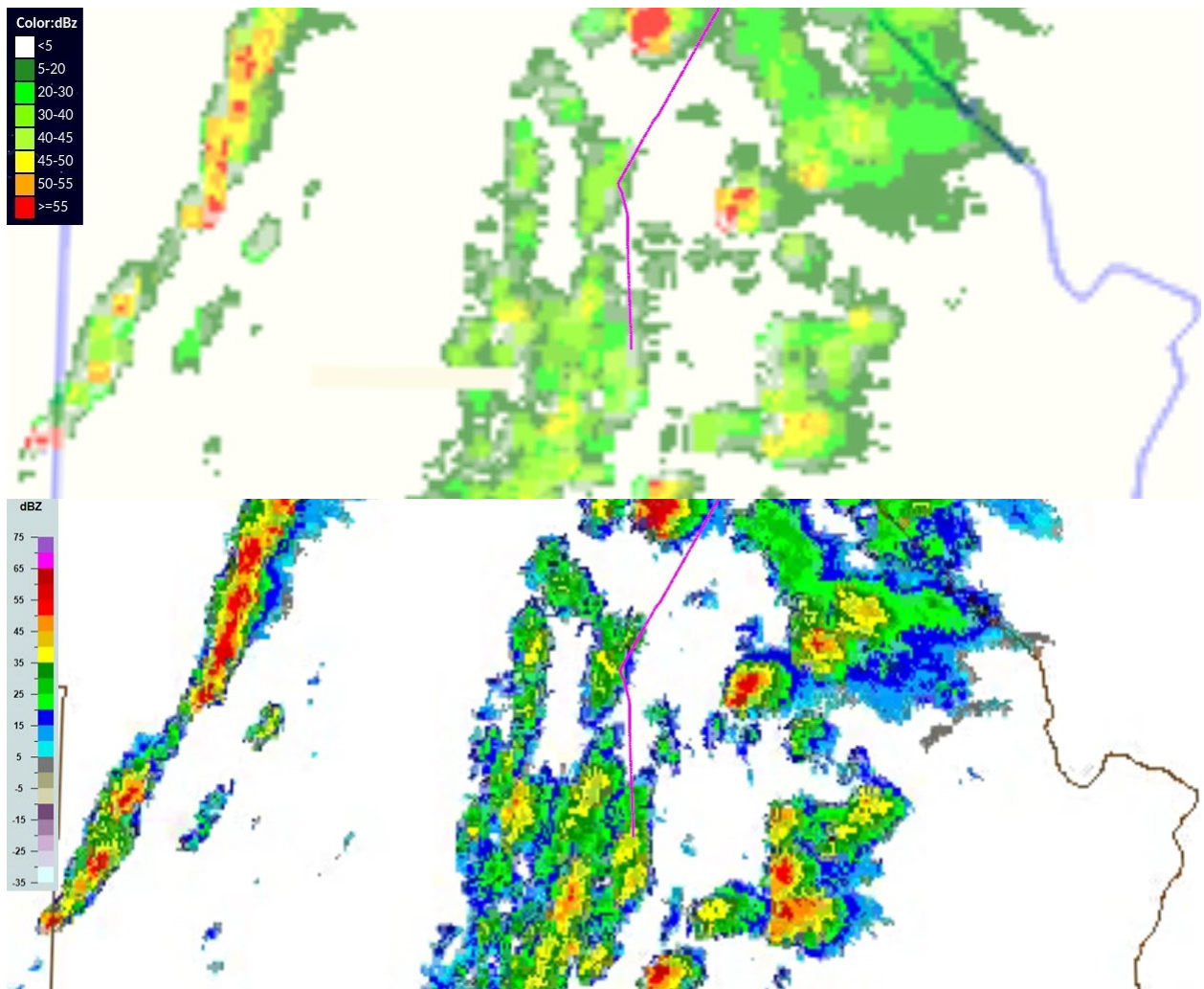


Figure 10 – Top: FIS-B weather radar mosaic created at 1202 and broadcast about 1204; Bottom: MRMS weather radar mosaic valid at 1204; accident aircraft’s flight path through 1204:00 is represented by the pink line.

Mosaic Creation Time (HH:MM) in APDU Header Time	FIS-B NEXRAD APDU Uplinked Start Time	FIS-B NEXRAD APDU Uplinked End Time
16:30z	16:32:01z	16:32:02z
16:32z	16:34:01z	16:34:03z
16:34z	16:36:04z	16:36:06z
16:36z	16:38:01z	16:38:03z
16:38z	16:40:01z	16:40:02z
16:40z	16:42:01z	16:42:21z
16:42z	16:44:01z	16:44:04z
16:44z	16:46:01z	16:46:03z
16:46z	16:48:01z	16:48:02z
16:48z	16:50:01z	16:50:02z
16:50z	16:52:01z	16:52:07z
16:52z	16:54:01z	16:54:03z
16:54z	16:56:01z	16:56:19z
16:56z	16:58:01z	16:58:03z
16:58z	17:00:03z	17:00:12z
17:00z	17:02:01z	17:02:03z
17:02z	17:04:01z	17:04:03z
17:04z	17:06:01z	17:06:03z
17:06z	17:08:01z	17:08:03z
17:08z	17:10:01z	17:10:21z
17:10z	17:12:01z	17:12:04z
17:12z	17:14:01z	17:14:03z
17:14z	17:16:11z	17:16:14z
17:16z	17:18:01z	17:18:03z
17:18z	17:20:01z	17:20:05z
17:20z	17:22:01z	17:22:03z
17:22z	17:24:01z	17:24:20z
17:24z	17:26:13z	17:26:15z
17:26z	17:28:01z	17:28:03z
17:28z	17:30:01z	17:30:03z

Figure 11 - L3 Harris weather radar mosaics broadcast intervals.

2.0 Lightning

A review of the Earth Networks Total Lightning Network (ENTLN) lightning database for a region surrounding the accident location⁶ near the accident time revealed no flash total lightning activity between 1155 and 1205.

⁶ The ENTLN was queried for a geographic area bounded by latitudes 38.9701°N and 38.5729°N, and longitudes 92.6656°W and 91.9089°W.

3.0 HRRR Model Sounding

A High-Resolution Rapid Refresh (HRRR) model⁷ sounding (Figure 12) for near the accident site⁸ at 1200 was retrieved from the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory and analyzed by the RAOB program. Broken to overcast clouds were identified between about 5,000 and 18,000 feet. The freezing level was at about 13,000 feet. The wind near the surface was from the south at about 20 knots. Above this level the wind veered⁹ slightly and steadily increased in magnitude to a southwest wind of about 75 knots near 25,000 feet. The most-unstable Convective Available Potential Energy (CAPE) parameter was 1,391 Joules/kilogram (from 975 hectopascals [hPa]). The Lifting Condensation Level (LCL) and the Level of Free Convection (LFC) (both surface-based) were at 3,689 feet and 4,359 feet, respectively. Downdraft CAPE (DCAPE; 6 kilometers above ground level; coldest wetbulb temperature method) was measured at 905 Joules/kilogram. Maximum vertical velocity (MVV) for this atmosphere was calculated as 48 meters/second (about 9,400 feet per minute).¹⁰ There were no areas of significant turbulence or icing identified by RAOB.

⁷ The HRRR is a NOAA real-time three-kilometer resolution, hourly-updated, cloud-resolving, convection-allowing atmospheric model, initialized by three-kilometer grids with three-kilometer radar assimilation. Radar data is assimilated in the HRRR every 15 minutes over a one-hour period.

⁸ Coordinates used for the model were latitude: 38.72°N; longitude: 92.30°W.

⁹ A veering wind's wind barbs turn clockwise with increasing height.

¹⁰ MVV is not usually considered a realistic estimate for maximum vertical velocity in a storm. Anecdotes suggest considering a value of MVV/2; however it is not well understood when or where such a half-value should be applied.

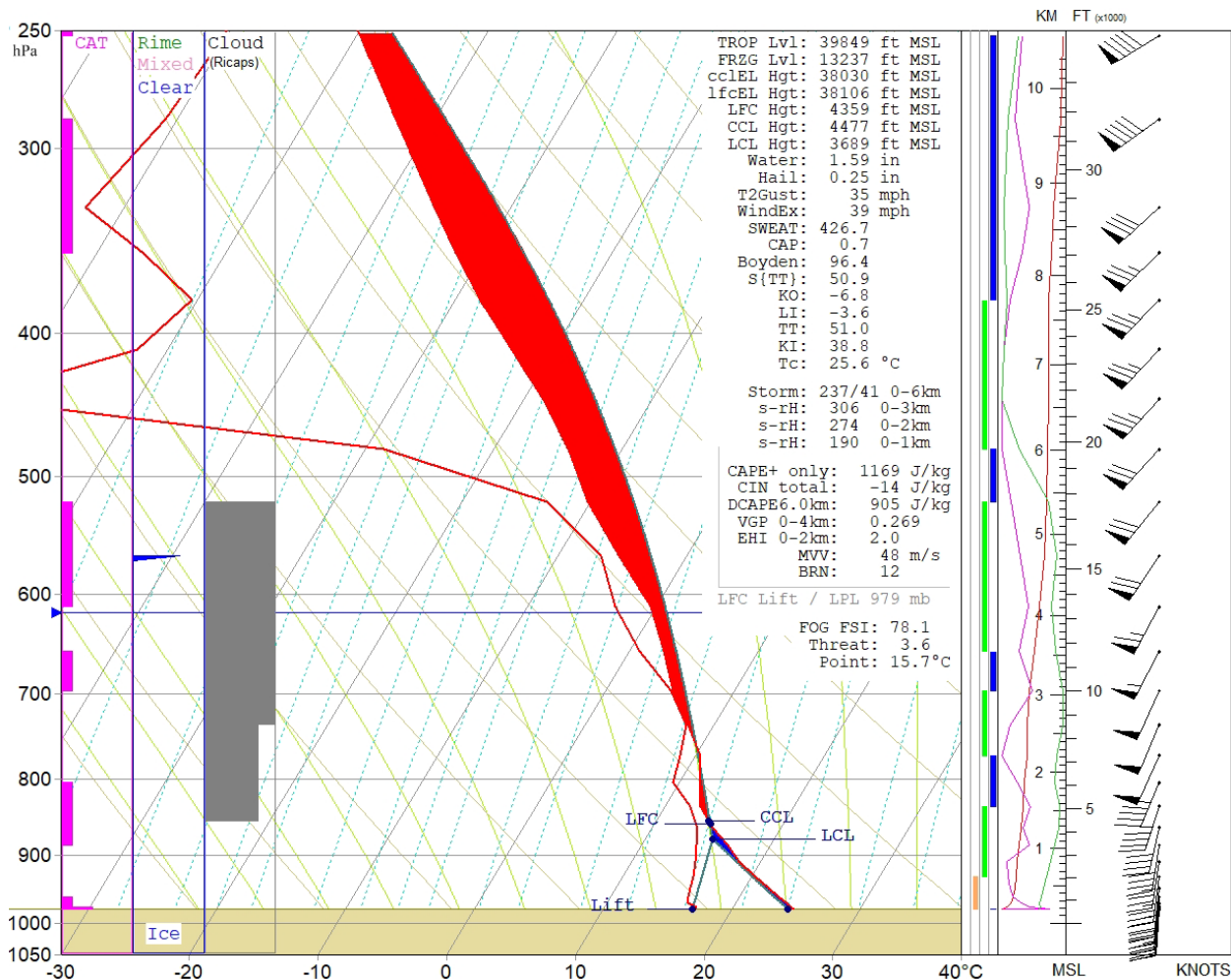


Figure 12 - HRRR model sounding data in SkewT/LogP format for 1200 near the accident site, surface to 250 hPa.

4.0 Satellite Imagery

Geostationary Operational Environmental Satellite (GOES)-16 visible (0.64 μm) and infrared (10.3 μm) data were obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison. Images from these data at 1201 are presented in Figures 13 and 14. Figure 13 presents a regional view of cloud coverage, which identifies cloudy conditions across the accident region. The coolest brightness temperatures (Figure 14) along the final portion of the accident aircraft's flight path were about -42°C , which, when considering the 1200 HRRR sounding, corresponded to a height of about 33,000 feet.

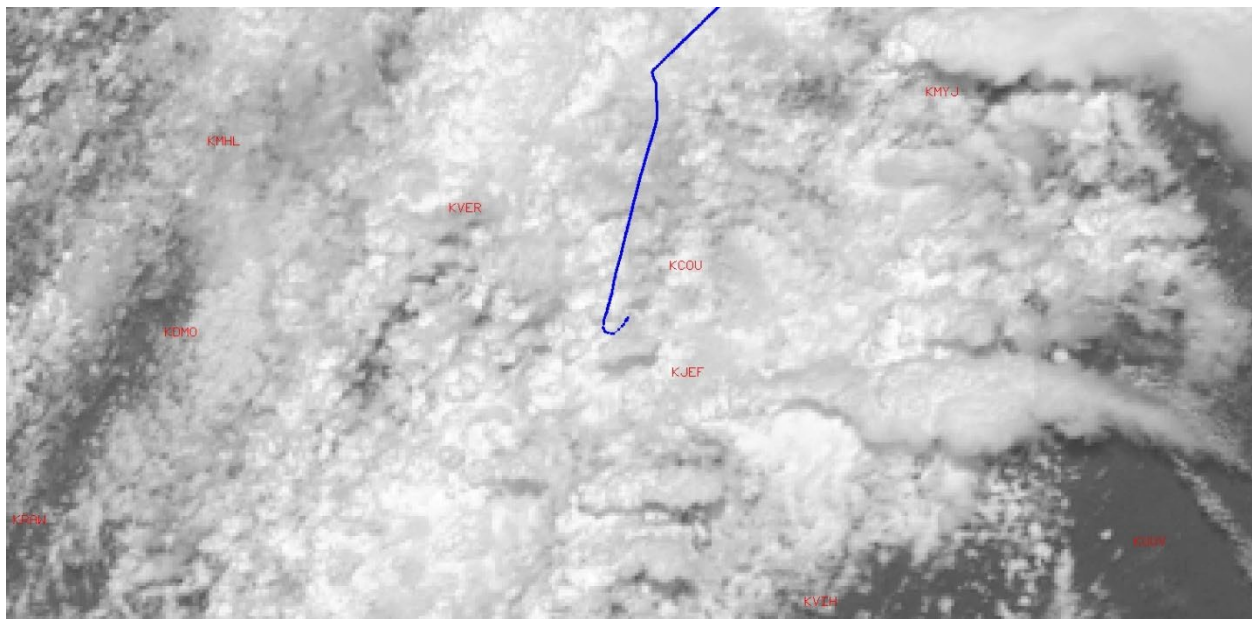


Figure 13 - GOES-16 visible imagery from 1201. Image is not corrected for parallax error. The accident aircraft's flight track is denoted by the blue line.

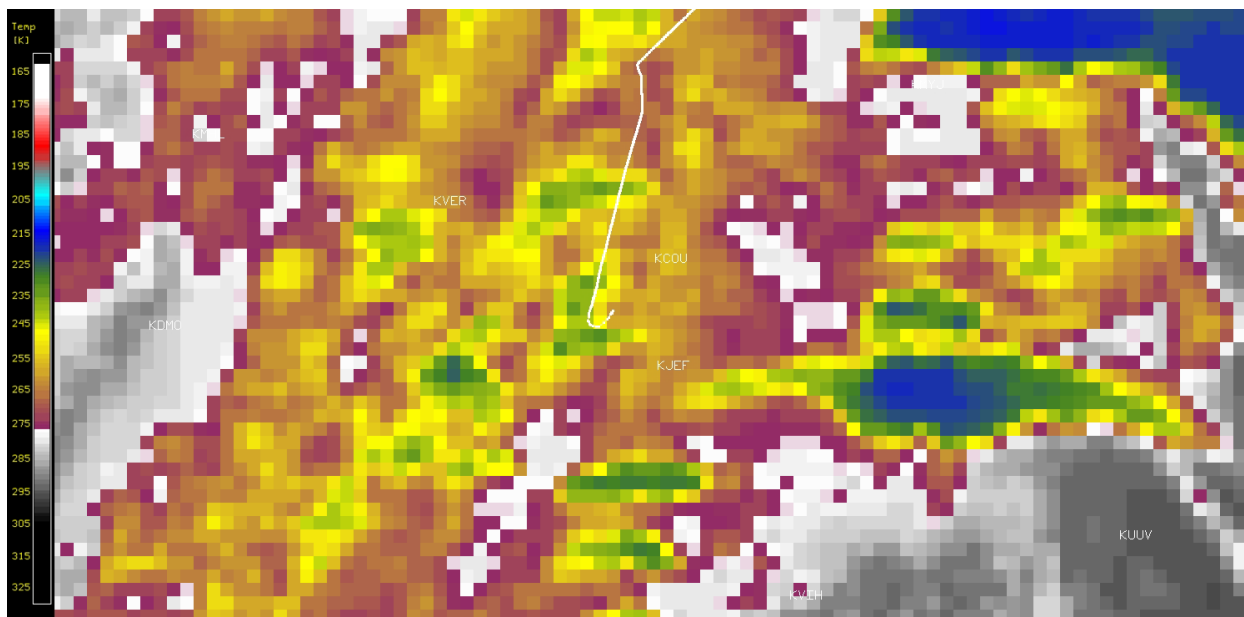


Figure 14 - GOES-16 brightness temperatures from 1201. Image is not corrected for parallax error. The accident aircraft's flight track is denoted by the white line.

5.0 Pilot Reports

Longline-disseminated pilot reports¹¹ (PIREPs) reported between 1000 and 1400 within 50 miles of the accident location are presented here.

COU UA /OV HLV110015/TM 1540/FL360/TP B738/TB LGT OCNL CHOP/RM /ZKCFDC

VIH UA /OV VIH/TM 1541/FL165/TP C208/TB LGT CHOP/RM /ZKCFDC

COU UA /OV HLV270040/TM 1604/FL360/TP B38M/TB NEG/RM ZKC FDC

COU UA /OV KCOU/TM 1617/FL038/TP E170/SK BKN038

COU UA /OV COU270020/TM 1732/FL030/TP BE36/TB LGT-MOD

¹¹ These do not include pilot reports only broadcast via radio.

6.0 Surface Observations

An Automated Surface Observing Station (ASOS) was located at Columbia Regional Airport (COU¹²) in Columbia, Missouri, which was located about 7 miles northeast of the accident site at an elevation of about 890 feet. It had a magnetic variation of about 0°. Augmented longline¹³ reports from the COU ASOS during the times surrounding the accident time are presented here.

[1119] KCOU 161619Z 18017G27KT 10SM -RA OVC035 22/17 A2968 RMK AO2
PK WND 17033/1603 LTG DSNT SW RAB12 P0000 T02220172

**[1154] KCOU 161654Z 17016G27KT 10SM OVC037 23/18 A2967 RMK
AO2 PK WND 17033/1603 RAB12E43 SLP038 P0000 T02280178**

**[1235] KCOU 161735Z 18021G31KT 7SM TSRA OVC035 22/17 A2965
RMK AO2 PK WND 17034/1715 LTG DSNT ALQDS RAB18 TSB29 TS
SW MOV NE P0002 T02170172**

[1254] KCOU 161754Z 18014G27KT 10SM VCTS BKN035 OVC045 22/17
A2964 RMK AO2 PK WND 17034/1715 LTG DSNT N AND NE RAB18E53
TSB29E54 SLP027 TS SW MOV NE P0007 60007 T02220172 10250
20200 58020

At 1154, the COU ASOS reported a wind from 170° at 16 knots with gusts to 27 knots, visibility 10 statute miles or greater, ceiling overcast at 3,700 feet above ground level (agl), temperature of 23°C and dew point temperature of 18°C, altimeter setting of 29.67 inches of mercury; Remarks: automated station with a precipitation discriminator, peak wind at 1103 from 170° at 33 knots, rain began at 1112 and ended at 1143, sea level pressure 1003.8 hPa, trace amount of liquid equivalent precipitation in the last hour, temperature of 22.8°C and dew point temperature of 17.8°C.

At 1235, the COU ASOS reported a wind from 180° at 21 knots with gusts to 31 knots, visibility 7 statute miles or greater, thunderstorm with moderate rain, ceiling overcast at 3,500 agl, temperature of 22°C and dew point temperature of 17°C, altimeter setting of 29.65 inches of mercury; Remarks: automated station with a precipitation

¹² This report uses the 3-digit International Air Transport Association format for airport identification, which does not use the geographic designating digit (e.g., "K" for stations in the continental U.S. and "P" for U.S. stations in Alaska and the Pacific region) as found in the 4-digit International Civil Aviation Organization (ICAO) identifier format. Weather observations from airports in this report are referenced by their reporting station's identifier (using ICAO format that includes the geographic designating digit), not by the airport at which the reporting station is located.

¹³ "Longline" refers to the dissemination of weather observations with the intent that they are available in near-real time to national databases (effectively, the whole world) and accessible to the general global public from a large number of vendors. This does not include public accessibility to observations from a reporting station's Very High Frequency (VHF; line-of-site) or telephone broadcast, where applicable. Longline-dissemination of weather observations is the primary vehicle through which the general global public has access to surface weather observations, particularly outside of the aviation community.

discriminator, peak wind at 1215 from 170° at 34 knots, lightning distant¹⁴ in all quadrants, rain began at 1218, thunderstorm began at 1229, thunderstorm to the southwest moving northeast, 0.02 inches of liquid equivalent precipitation since 1154, temperature of 21.7°C and dew point temperature of 17.2°C.

An ASOS was located at Jefferson City Memorial Airport (JEF¹⁵) in Jefferson City, Missouri, which was located about 10 miles southeast of the accident site at an elevation of about 550 feet. It had a magnetic variation of about 0°. Augmented longline¹⁶ reports from the JEF ASOS during the times surrounding the accident time are presented here.

[1053] KJEF 161553Z 18015G30KT 10SM SCT041 25/16 A2970 RMK AO2 PK WND 19030/1547 LTG DSNT SW SLP041 T02500161 \$

[1153] KJEF 161653Z 18014G30KT 10SM OVC037 24/17 A2968 RMK AO2 PK WND 19031/1556 LTG DSNT SE RAB1558E12 SLP035 P0000 T02440167 \$

[1255] KJEF 161755Z 18011G30KT 10SM OVC035 A2964

[1311] KJEF 161811Z 17012KT 10SM VCTS OVC035 24/17 A2964 RMK AO2 LTG DSNT ALQDS T02390172

At 1153, the JEF ASOS reported a wind from 180° at 14 knots with gusts to 30 knots, visibility 10 statute miles or greater, ceiling overcast at 3,700 feet agl, temperature of 24°C and dew point temperature of 17°C, altimeter setting of 29.68 inches of mercury; Remarks: automated station with a precipitation discriminator, peak wind at 1056 from 190° at 31 knots, lightning distant to the southeast, rain began at 1058, sea level pressure 1003.5 hPa, trace amount of liquid equivalent precipitation in the last hour, temperature of 24.4°C and dew point temperature of 16.7°C, maintenance needed on the system.

¹⁴ "Distant" means more than 10 statute miles from the point of observation (e.g., in a METAR) or from the center of the airport's runway complex (e.g., in a TAF).

¹⁵ This report uses the 3-digit International Air Transport Association format for airport identification, which does not use the geographic designating digit (e.g., "K" for stations in the continental U.S. and "P" for U.S. stations in Alaska and the Pacific region) as found in the 4-digit International Civil Aviation Organization (ICAO) identifier format. Weather observations from airports in this report are referenced by their reporting station's identifier (using ICAO format that includes the geographic designating digit), not by the airport at which the reporting station is located.

¹⁶ "Longline" refers to the dissemination of weather observations with the intent that they are available in near-real time to national databases (effectively, the whole world) and accessible to the general global public from a large number of vendors. This does not include public accessibility to observations from a reporting station's Very High Frequency (VHF; line-of-site) or telephone broadcast, where applicable. Longline-dissemination of weather observations is the primary vehicle through which the general global public has access to surface weather observations, particularly outside of the aviation community.

7.0 Terminal Aerodrome Forecasts

The closest National Weather Service (NWS) Terminal Aerodrome Forecast (TAF) site to the accident location was COU. According to NWS Instruction 10-813: "A NWS TAF consists of the expected meteorological conditions significant to aviation at an airport for a specified time period. For the U.S., this is the area within five (5) statute miles (SM) of the center of an airport's runway complex."¹⁷

At 1122, a TAF was issued for COU that forecasted for the accident time: a wind from 180° at 20 knots with gusts to 33 knots, visibility greater than 6 statute miles, thunderstorms in the vicinity¹⁸ and ceiling overcast at 4,000 feet agl in cumulonimbus formation; between 1200 and 1600 temporary conditions¹⁹ of a variable wind of 20 knots with gusts to 35 knots, visibility of 2 statute miles, thunderstorms in heavy rain, ceiling overcast at 2,000 feet agl in cumulonimbus formation.

KCOU 161622Z 1616/1712 **18020G33KT P6SM VCTS OVC040CB**
TEMPO 1617/1621 VRB20G35KT 2SM +TSRA OVC020CB
FM162200 18020G34KT P6SM VCSH BKN045
FM170000 19016G26KT P6SM SCT100=

8.0 Area Forecast Discussion

At 0616 the NWS St. Louis, Missouri, Weather Forecast Office issued the following Aviation section of an Area Forecast Discussion.

FXUS63 KLSX 161116
AFDLSX
Area Forecast Discussion...Updated Aviation
National Weather Service Saint Louis MO
616 AM CDT Tue Apr 16 2024
.AVIATION... (For the 12z TAFs through 12z Wednesday Morning)
Issued at 603 AM CDT Tue Apr 16 2024
Cirrus advecting from ongoing convection across western Missouri and eastern
Kansas will thicken through the morning. A strong surface low will approach the
region and strengthen winds generally out of the south this morning, gusting as
high as 35-40kts at times outside of any thunderstorms.

¹⁷ www.nws.noaa.gov/directives/sym/pd01008013curr.pdf

¹⁸ "In the vicinity" means 5 to 10 statute miles from the point of observation.

¹⁹ Temporary conditions - fluctuations to forecast conditions which are expected to last less than one hour in each instance and, in the aggregate, to cover less than half of the indicated period.

Storms will develop across north-central Missouri early this afternoon, but the southern extent of the convection is uncertain. VCTS was adjusted at the mid-Missouri terminals, but there is not enough confidence in direct terminal impact to include prevailing groups at this time. The initial round will move east, more likely impacting KUIN to some degree in the early afternoon. The St. Louis metropolitan terminals will also likely see some degree of thunder around this time, but the threat is again not certain enough to include prevailing thunder quite yet. Any of these storms could produce large hail, damaging wind exceeding 50kts, or a tornado. There is a threat for some MVFR clouds with any thunderstorms, but that will be the lower of the threats if thunderstorms impact the terminals. Convection will end from west to east this evening, ending completely by 03-05Z east of the terminals.

9.0 SIGMETs

There were no non-convective Significant Meteorological Information (SIGMET) advisories active for the accident flight.

At 1055, the NWS Aviation Weather Center (AWC) issued Convective SIGMET 79C that was active for the accident location and valid until 1255. It warned of an area of severe embedded thunderstorms with tops above FL450²⁰, tornadoes, hail to 2 inches and wind gusts to 60 knots possible. The Convective SIGMETs polygon was moving from 200° at 55 knots. Convective SIGMETs imply severe or greater turbulence, severe icing, and low-level wind shear.

WSUS32 KKC1 161555

SIGC

-MKCC WST 161555

CONVECTIVE SIGMET 79C

VALID UNTIL 1755Z

MO IA KS

FROM 50NW FOD-20E MCW-30WSW UIN-50SSE COU-40W BUM-50NW FOD
AREA SEV EMBD TS MOV FROM 20055KT. TOPS ABV FL450.

TORNADOES...HAIL TO 2 IN...WIND GUSTS TO 60KT POSS.

²⁰ Flight Level (FL) - a standard nominal altitude of an aircraft, in hundreds of feet. This altitude is calculated from the international standard pressure datum of 1013.25 hPa (29.92 inches of mercury), the average sea-level pressure, and therefore is not necessarily the same as the aircraft's true altitude either above msl or agl.

At 1155, the NWS AWC issued Convective SIGMET 83C, which superseded Convective SIGMET 79C, that was active for the accident location and valid until 1355. It warned of an area of severe embedded thunderstorms with tops above FL450, tornadoes, hail to 2 inches and wind gusts to 60 knots possible. The Convective SIGMETs polygon was moving from 200° at 55 knots.

WSUS32 KPCI 161655

SIGC

-MKCC WST 161655

CONVECTIVE SIGMET 83C

VALID UNTIL 1855Z

IL MO IA KS

*FROM 50NW FOD-40E MCW-40NNE UIN-40SSW STL-30NNW OSW-50NW
FOD*

AREA SEV EMBD TS MOV FROM 20055KT. TOPS ABV FL450.

TORNADOES...HAIL TO 2 IN...WIND GUSTS TO 60KT POSS.

10.0 CWSU Products

There were no Center Weather Advisories or Meteorological Impact Statements issued by the Center Weather Service Unit (CWSU) at the Kansas City Air Route Traffic Control Center that were active for the accident flight.

11.0 G-AIRMETS

A Graphical-Airmen's Meteorological Information (G-AIRMET) is a graphical advisory of weather that may be hazardous to aircraft but are less severe than what would be advised by a SIGMET. G-AIRMETS are only valid at discrete time "snapshots" that are three hours apart for a period of up to 12 hours into the future (i.e., 00-, 03-, 06-, 09- and 12-hour forecasts). They are issued at 0300 UTC, 0900 UTC, 1500 UTC and 2100 UTC (with updates issued as necessary).

G-AIRMETS for moderate turbulence from the surface to 12,000 feet and from 18,000 to 39,000 feet were issued at about 1000 and valid for both 1000 and 1300 for regions that included the accident location.

Submitted by:

Mike Richards
Senior Meteorologist