



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

December 2, 2019

Weather Study

METEOROLOGY

DCA20LA013

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A. ACCIDENT

Location: Chicago, Illinois
Date: November 11, 2019
Time: 0743 central standard time
1343 Universal Coordinated Time (UTC)
Airplane: Envoy Air flight 4125, Embraer EMB145; Registration: N619AE

B. METEOROLOGIST

Don Eick
Meteorologist Specialist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's Senior Meteorologist was not on scene for this investigation and conducted the meteorology phase of the investigation from the Washington D.C. office, collecting data from official National Weather Service (NWS) sources including the Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). All times are central standard time (CST) based upon the 24-hour clock, local time is -6 hours from UTC, and UTC=Z. NWS airport and station identifiers use the standard International Civil Aviation Organization 4-letter station identifiers versus the International Air Transport Association 3-letter identifiers, which deletes the initial country code designator "K" for U.S. airports. Directions are referenced to true north and distances in nautical miles. Heights are in feet (ft) above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The accident site was located at latitude 41° 58' 09.81" N and longitude 87°54' 43.87" W, at an elevation of approximately 641 ft.

D. WEATHER INFORMATION

1.0 Synoptic Conditions

The synoptic or large-scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction (NCEP) located in College Park, Maryland. These are the base products used in describing weather features and in the creation of forecasts and warnings. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC 00-45H change 2.

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart for 0600 CST is included as figure 1 with the accident site marked by a red star. The chart the primary feature as a low pressure system at 1010-hectopascals (hPa)¹ over northern Texas associated with a developing frontal wave with a cold front extending southwestward and a stationary front extending east-northeastward into southern Illinois, where another low pressure system was located at 1014-hPa. To the west over Montana and South Dakota two high pressure systems at 1047- and 1045-hPa respectively were located with a ridge of high pressure extending southeastward. The accident site was located on the cold air side and north of the stationary front and east-southeast and east of the cold core high pressure systems that were associated with an arctic airmass.

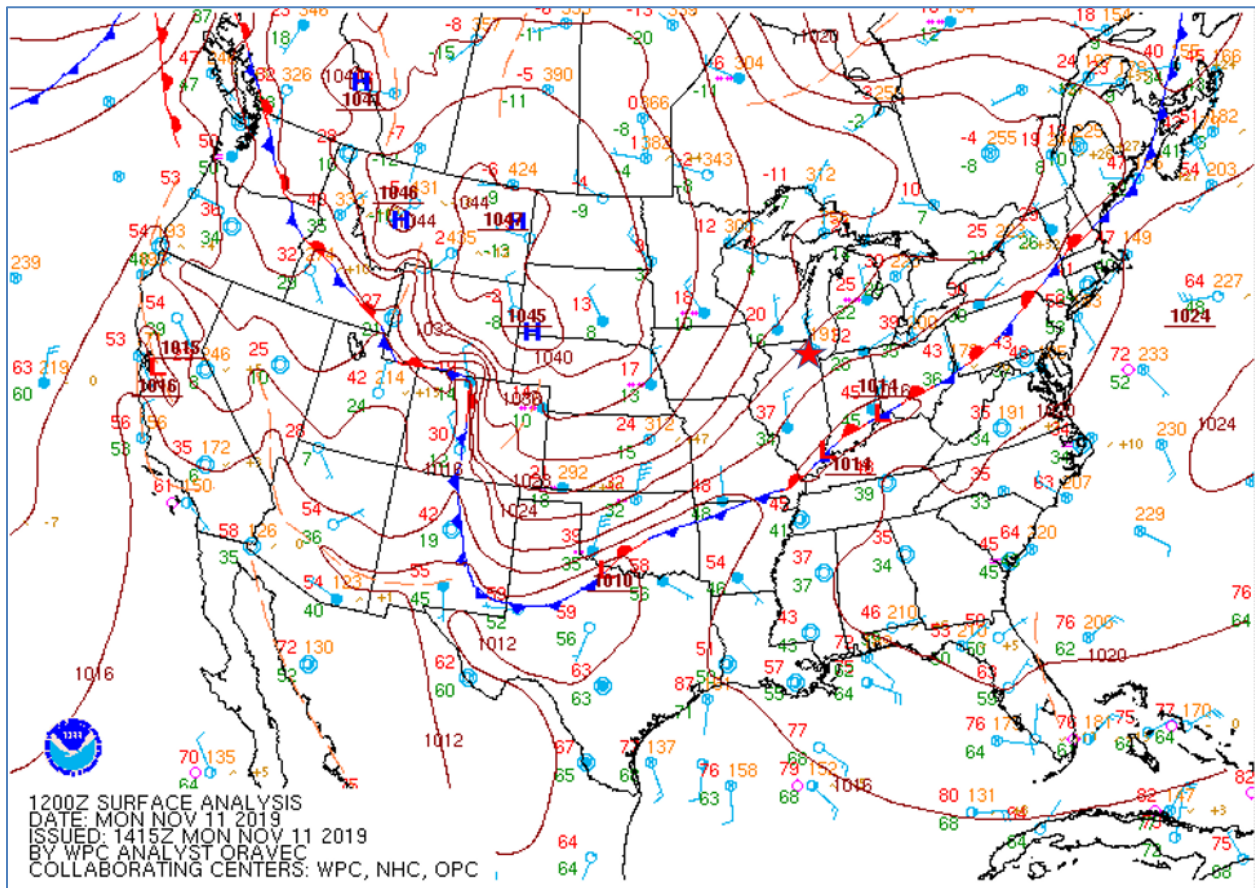


Figure 1 - NWS Surface Analysis Chart for 0600 CST

Figure 2 is a close-up of the NWS Surface Analysis Chart for 0600 CST with the accident site is located within the red circle and the station models depicted. The chart depicted an extensive area of overcast cloud cover along and north of the stationary front, with the stations reporting visibility restricted in light snow and/or fog. The station model for Chicago indicated a wind from the north at 15 knots, light continuous snow, overcast cloud cover, temperature 25° Fahrenheit (F), dew point temperature of 23° F.

¹ Hectopascals is the new NWS reference for reporting sea level pressure and is interchangeable with the former term millibar (mb) with the same units. Standard sea-level pressure is 1013.25-hPa at 59° Fahrenheit (F) or 15° Celsius (C).

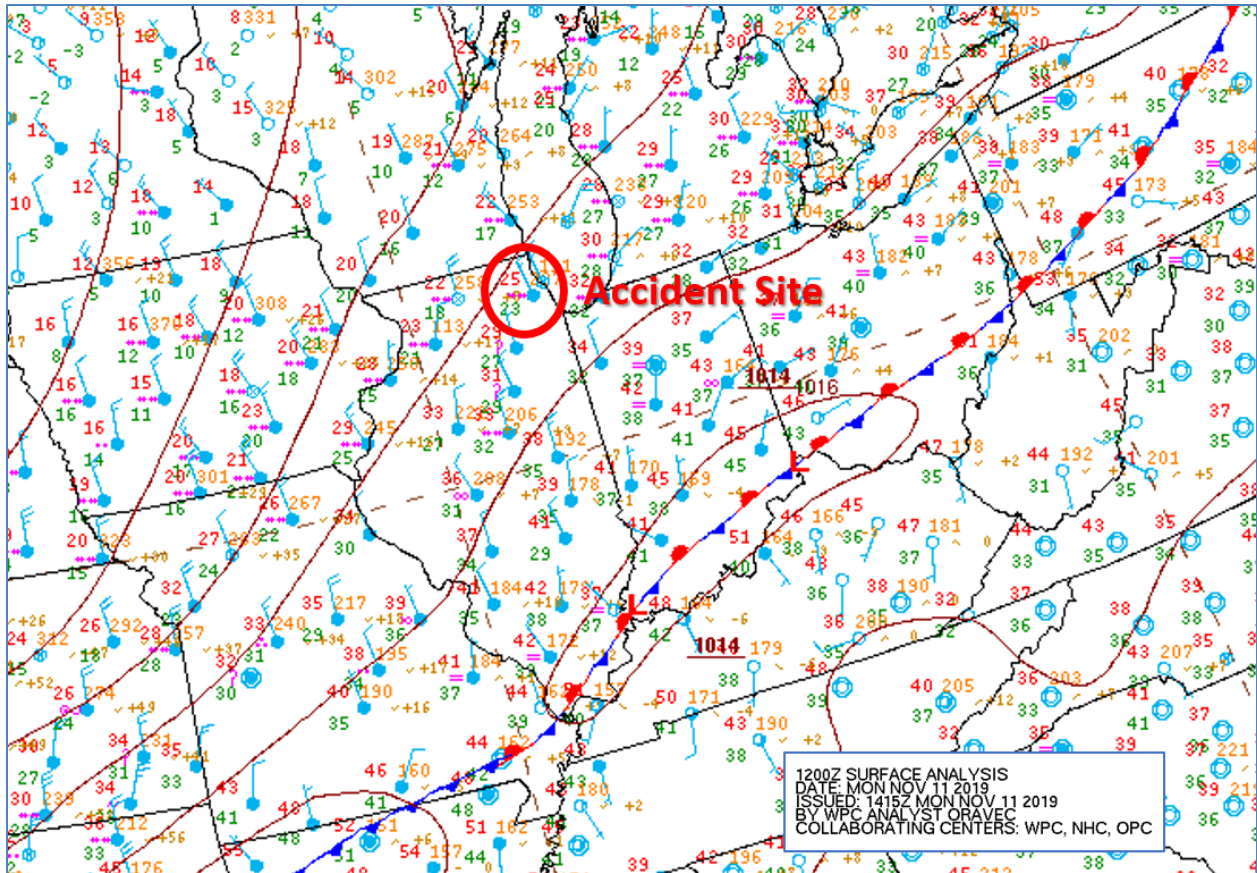


Figure 2 - Close-up of the NWS Surface Analysis for 0600 CST with station models depicted

1.2 National Composite Radar Mosaic

Figure 3 is the National Composite Radar Mosaic for 0740 CST (1340Z) with KORD marked by the red star. The image depicted a band of precipitation echoes associated with snow showers extending from Michigan west-southwestward across Lake Michigan, northern Indiana and Illinois into Missouri.

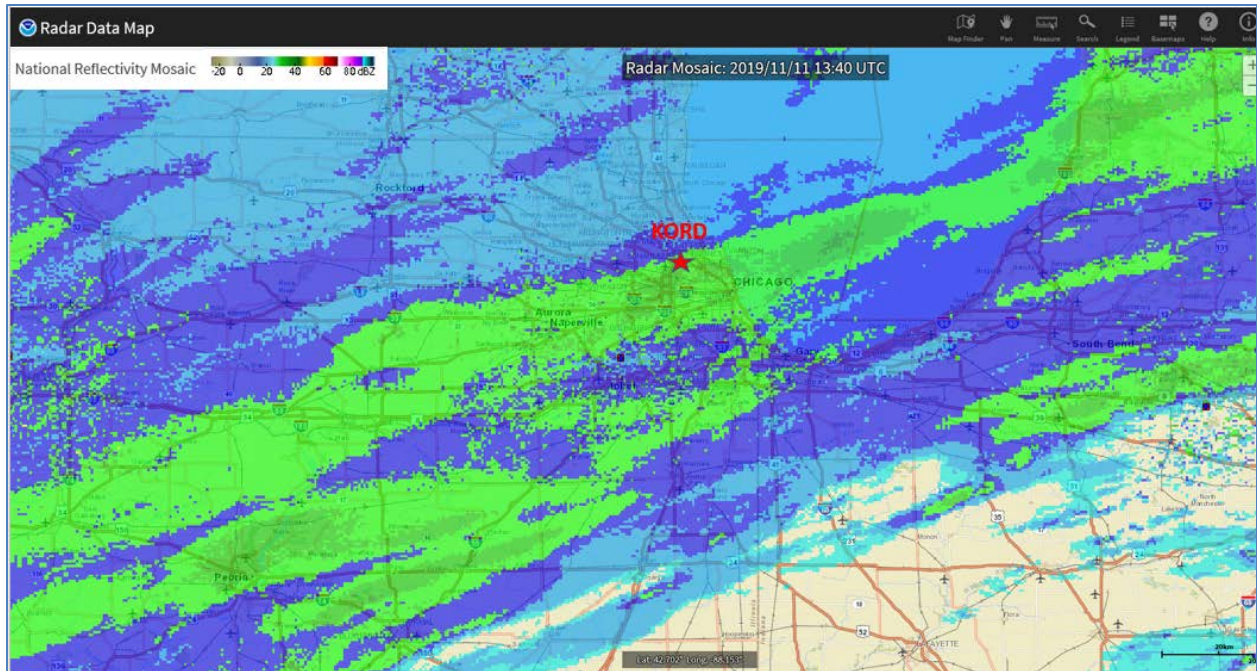


Figure 3 - National Composite Radar Mosaic for 0740 CST over northern Illinois

1.3 NWS 12-hour Surface Prognostic Chart

Figure 4 is the NWS 12-hour Surface Prognostic Chart depicted the expected conditions at 1200 CST. The chart continued to depict the primary low-pressure system having moved to northeastern Texas with the cold front trailing back to the southwest, and a stationary front back to a cold front to the east-northeast of the low into Arkansas, Tennessee, Kentucky, Indiana, into Ohio where another low pressure system was indicated. The high pressure system was depicted over South Dakota with a ridge extending southward. An extensive area of precipitation was depicted along and north of the front, with snow continuing into the Chicago area. The chart continued to infer northerly winds over the Chicago area.

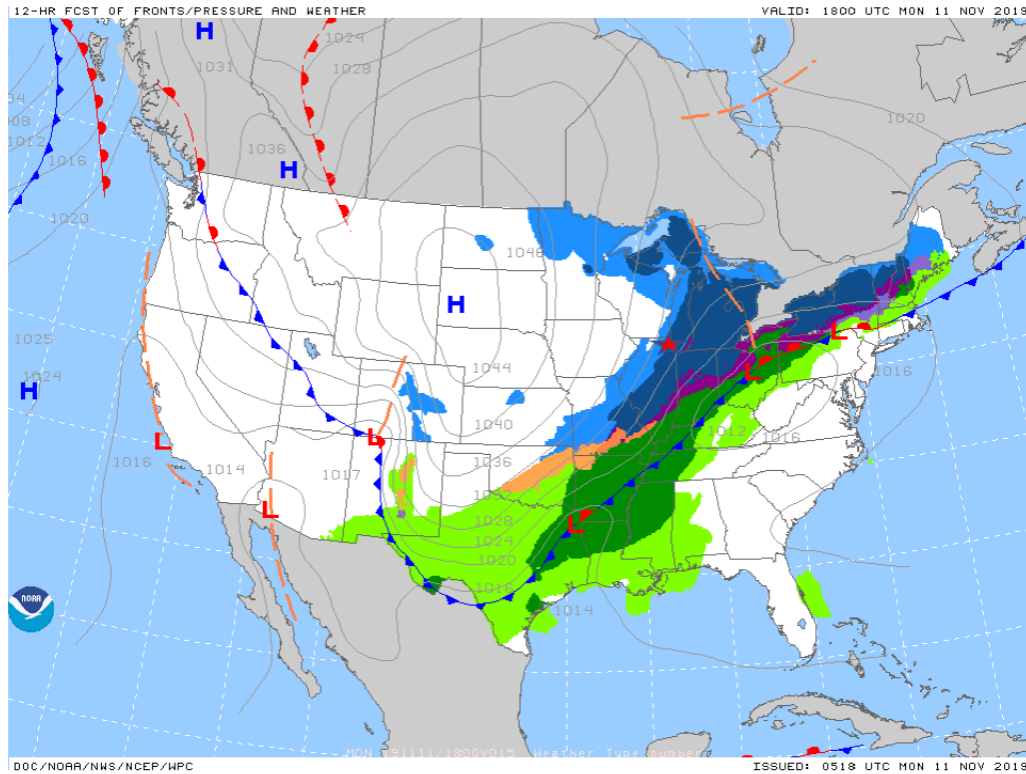


Figure 4 - NWS 12-hour Surface Prognostic Chart valid for 1200 CST

2.0 Observations

The official observations issued surrounding the accident site were documented using standard meteorological aerodrome reports (METARs) and specials (SPECI). Cloud heights are reported above ground level (agl) in the following section.

2.1 Chicago O’Hare International Airport

Chicago O’Hare International Airport (KORD), Chicago, Illinois, had a federally installed and maintained Automated Surface Observation System (ASOS), which was augmented by certified weather observers. The airport listed an elevation of 680 ft and a magnetic variation of 3° W. The following conditions were reported surrounding the time of the accident.

KORD special weather observation at 0702 CST, wind from 350° at 13 knots gusting to 25 knots, visibility 3/4 mile, runway 10L visual range 4,000 ft variable 5,500 ft², present weather light snow and blowing snow, vertical visibility 1,000 ft agl, temperature -5° Celsius (C), dew point temperature -6° C, altimeter 30.19 inches of mercury (Hg).

² The Runway Visual Range (RVR) included in the METAR is a 10-minute average reading, the FAA tower reports the current 1-minute or 45-second RVR data.

Remarks: automated station with a precipitation discriminator, hourly precipitation (since 0651 CST) 0.01 inches, temperature -5.0° C, dew point -6.1° C, maintenance required³.

KORD weather observation at 0751 CST, wind from 350° at 17 knots gusting to 26 knots, visibility 3/4 mile, runway 10L visual range 4,000 ft variable 5,000 ft, present weather light snow and blowing snow, vertical visibility 1,100 ft agl, temperature -5° C, dew point temperature -6° C, altimeter 30.22 inches of Hg. Remarks: automated station with a precipitation discriminator, peak wind from 350 at 28 knots recorded at 0731 CST, sea level pressure 1024.0-hPa, hourly precipitation (since 0651 CST) 0.01 inches, temperature -5.0° C, dew point -6.1° C, maintenance required.

The general flight categories⁴ and raw observations from approximately 0350 through 0950 CST were as follows:

LIFR METAR KORD 110951Z 35013KT 3/4SM R10L/4000V5000FT -SN BR OVC007 M02/M02 A3015 RMK AO2 SLP218 P0004 T10171022 \$

LIFR METAR KORD 111051Z 35013KT 3/4SM R10L/P6000FT -SN BR OVC007 M03/M03 A3017 RMK AO2 SLP224 P0002 T10281033 \$

LIFR METAR KORD 111151Z COR 35016G25KT 3/4SM R10L/P6000FT -SN BR OVC009 M04/M05 A3018 RMK AO2 SLP227 P0001 60014 70018 4/002 T10391050 10006 21039 \$

LIFR SPECI KORD 111217Z 35015G27KT 3/4SM R10L/P6000FT -SN BR VV009 M04/M06 A3018 RMK AO2 PK WND 35027/1211 P0001 T10441056 \$

IFR SPECI KORD 111225Z 35016KT 1SM R10L/P6000FT -SN BR VV011 M04/M06 A3019 RMK AO2 PK WND 35027/1211 P0001 T10441056 \$

IFR METAR KORD 111251Z 35016G22KT 1SM R10L/5000VP6000FT -SN BLSN VV011 M04/M06 A3019 RMK AO2 PK WND 35027/1211 SLP232 P0001 T10441061 \$

LIFR SPECI KORD 111302Z 35013G25KT 3/4SM R10L/4000V5500FT -SN BLSN VV010 M05/M06 A3019 RMK AO2 P0001 T10501061 \$

Accident 1343Z

LIFR METAR KORD 111351Z 35017G26KT 3/4SM R10L/4000V5000FT -SN BLSN VV011 M05/M06 A3022 RMK AO2 PK WND 35028/1331 SLP240 P0001 T10501061 \$

³ The maintenance indicator (\$) flags that one or more sensors are operating below required limits or are inoperative and need servicing.

⁴ As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories based on weather conditions reported:

- Low Instrument Flight Rules (LIFR*) – ceiling below 500 ft above ground level (agl) and/or visibility less than 1 statute mile.

- Instrument Flight Rules (IFR) – ceiling between 500 to below 1,000 feet agl and/or visibility 1 to less than 3 miles.

- Marginal Visual Flight Rules (MVFR**) – ceiling from 1,000 to 3,000 ft agl and/or visibility 3 to 5 miles.

- Visual Flight Rules (VFR) – ceiling greater 3,000 ft agl and visibility greater than 5 miles.

* By definition, IFR is a ceiling less than 1,000 ft agl and/or visibility less than 3 miles while LIFR is a sub-category of IFR.

**By definition, VFR is a ceiling greater than or equal to 3,000 ft agl and visibility greater than 5 miles while MVFR is a sub-category of VFR.

LIFR METAR KORD 111451Z 34014G25KT 1/2SM R10L/4500V5500FT SN BLSN VV011 M06/M07 A3024
RMK AO2 PK WND 35027/1440 SLP247 SNINCR 1/3 P0001 60003 T10561067 53019 \$

LIFR METAR KORD 111551Z 34015G23KT 3/4SM R10L/P6000FT -SN BLSN VV013 M06/M07 A3024 RMK
AO2 PK WND 35028/1540 SLP250 P0001 T10561072 \$

A review of the observations for KORD indicated that precipitation started in the form of light rain at 2036 CST and changed over to light snow at 2351 CST on November 10, 2019, with temperatures falling through the period to -6.1° C (21° F). Snow ended at 1735 CST on November 11th, with a total of 3 inches of snow reported. At 0551 CST the station reported 2 inches of snow on the ground with light continuous snow continuing through the time of the accident. IFR conditions prevailed through the period, with LIFR conditions with visibility under 1 statute mile at the time of the accident. Moderate snow was reported at 0851 CST, which resulted in a 1-inches/per hour snowfall rate. The disseminated reports prior to 0851 CST all reported light snow.

2.2 5-min ASOS observations

A review of the KORD 5-minute ASOS observations indicated that the system was displaying the following conditions at 0740 CST through the time of the accident:

KORD weather 0740 CST, wind from 350° at 18 knots gusting to 28 knots, visibility 3/4 mile, runway 10L visual range 3,500 ft variable 5,000 ft, present weather light snow and blowing snow, vertical visibility 1,100 ft agl, temperature -5° C, dew point -6° C, altimeter 30.21 inches, pressure altitude 420 ft, relative humidity 92%, density altitude -1,900 ft, magnetic wind from 350° at 18 knots gusting to 28 knots. Remarks; automated observation with a precipitation discriminator, peak wind from 350° at 28 knots occurred at 0731 CST, hourly precipitation 0.01 inches, temperature -5.0° C, dew point -6.1° C, maintenance indicator on.

The raw 5-minute ASOS observation recorded during the period from 0700 through 0800 CST were as follows, with the local time in parentheses:

(07:00:31) 5-MIN KORD 111300Z 35013G25KT 3/4SM R10L/4000V6000FT -SN BLSN VV010 M05/M06 A3019
430 92 -1800 350/13G25 RMK AO2 P0001 T10501061 \$

(07:05:31) 5-MIN KORD 111305Z 35014G22KT 3/4SM R10L/4000VP6000FT -SN BLSN VV010 M05/M06 A3019
430 92 -1800 350/14G22 RMK AO2 P0001 T10501061 \$

(07:10:31) 5-MIN KORD 111310Z 35017G22KT 3/4SM R10L/4000VP6000FT -SN BLSN VV010 M05/M06 A3020
430 92 -1800 350/17G22 RMK AO2 P0001 T10501061 \$

(07:15:31) 5-MIN KORD 111315Z 35017KT 3/4SM R10L/5000VP6000FT -SN BLSN VV010 M04/M06 A3020 430
88 -1800 350/17 RMK AO2 P0001 T10441061 \$

(07:20:31) 5-MIN KORD 111320Z 35018KT 3/4SM R10L/5000VP6000FT -SN BLSN VV011 M04/M06 A3020 420
88 -1800 360/18 RMK AO2 P0001 T10441061 \$

(07:25:31) 5-MIN KORD 111325Z 35017KT 3/4SM R10L/5000VP6000FT -SN BLSN VV011 M05/M06 A3020 420
92 -1900 350/17 RMK AO2 P0001 T10501061 \$

(07:30:31) 5-MIN KORD 111330Z 35018G27KT 3/4SM R10L/4500VP6000FT -SN BLSN VV011 M05/M06 A3020
420 92 -1900 350/18G27 RMK AO2 PK WND 35027/1330 P0001 T10501061 \$

(07:35:31) 5-MIN KORD 111335Z 35019G28KT 3/4SM R10L/4500V6000FT -SN BLSN VV011 M05/M06 A3021 420 92 -1900 350/19G28 RMK AO2 PK WND 35028/1331 P0001 T10501061 \$

(07:40:31) 5-MIN KORD 111340Z 35018G28KT 3/4SM R10L/3500V5000FT -SN BLSN VV011 M05/M06 A3021 420 92 -1900 350/18G28 RMK AO2 PK WND 35028/1331 P0001 T10501061 \$

Accident 1343Z

(07:45:31) 5-MIN KORD 111345Z 34019G26KT 3/4SM R10L/3500V5000FT -SN BLSN VV011 M05/M06 A3021 410 92 -1900 350/19G26 RMK AO2 PK WND 35028/1331 SLP239 P0001 T10501061 \$

(07:50:31) 5-MIN KORD 111350Z 35017G26KT 3/4SM R10L/4000V5000FT -SN BLSN VV011 M05/M06 A3022 410 92 -1900 350/17G26 RMK AO2 PK WND 35028/1331 SLP240 P0001 T10501061 \$

(07:55:31) 5-MIN KORD 111355Z 35017G26KT 3/4SM R10L/4000V4500FT -SN BLSN VV010 M05/M06 A3022 410 92 -1900 350/17G26 RMK AO2 P0000 T10501061 \$

(08:00:31) 5-MIN KORD 111400Z 34014G24KT 3/4SM R10L/4000V4500FT -SN BLSN VV010 M05/M06 A3022 410 92 -1900 340/14G24 RMK AO2 P0000 T10501061 \$

Based on the 5-minute observation for 0740 CST resulted in a crosswind of 18 to 28 knots and 3 to 5 knot tailwind component for runway 10L which lists a true heading of 090°. With light snow being reported during the period..

2.3 1-min ASOS Wind Information

The KORD 1-minute observations include the average 2-minute wind, which is updated every 5-seconds and reported every minute. The second value is maximum 5-second wind reported during the minute, which is used to report gust values and peak wind. The observations from 0700 through 0800 CST were as follows:

Time (CST)	2-min Average Wind	Max 5-sec Wind
0700	346° 13	347° 17
0701	345° 12	350° 18
0702	346° 13	340° 18
0703	349° 15	349° 17
0704	347° 13	347° 15
0705	346° 14	351° 20
0706	346° 16	337° 22
0707	348° 17	340° 22
0708	353° 17	008° 19
0709	352° 16	353° 22
0710	350° 17	353° 22
0711	352° 18	359° 21
0712	352° 18	355° 23
0713	352° 18	355° 22
0714	352° 17	347° 20
0715	349° 17	344° 22
0716	350° 18	355° 23
0717	354° 19	354° 22
0718	355° 18	357° 21

0719	353° 18	358° 23
0720	353° 18	352° 22
0721	350° 16	346° 18
0722	346° 14	339° 18
0723	346° 15	346° 21
0724	345° 16	344° 22
0725	345° 17	348° 22
0726	345° 16	346° 18
0727	345° 15	350° 20
0728	346° 15	345° 20
0729	346° 16	336° 22
0730	347° 18	349° 27
0731	349° 20	351° 28
0732	351° 20	354° 24
0733	352° 19	355° 23
0734	349° 19	340° 23
0735	346° 19	339° 24
0736	345° 19	335° 23
0737	348° 18	342° 20
0738	348° 17	354° 20
0739	345° 18	351° 26
0740	345° 18	352° 19
0741	344° 16	350° 22
0742	344° 15	342° 19
0743	345° 16	346° 24
0744	345° 19	344° 26
0745	344° 19	348° 24
0746	345° 18	342° 21
0747	348° 17	353° 21
0748	350° 17	360° 21
0749	352° 17	359° 26
0750	351° 17	350° 21
0751	348° 17	344° 20
0752	345° 16	349° 19
0753	344° 17	355° 24
0754	346° 19	350° 22
0755	347° 17	346° 19
0756	344° 14	348° 17
0757	342° 14	345° 19
0758	340° 15	333° 21
0759	337° 15	340° 21
0800	337° 14	345° 18

Based on the 2-minute average wind at 0743 CST the crosswind component for landing on runway 10L was 15 knots with a 4 knot tailwind and based on the 5-second maximum wind was a crosswind of 23 knots with a 6 knot tailwind. The maximum wind noted was reported at 0731 CST or 12-minutes prior to the accident and was from 351° at 28 knots and raised the crosswind to 28 knots and the tailwind component to 5 knots.

2.4 METAR Display

The NWS Aviation Weather Center's (AWC) METAR display for 0750 CST (1350Z) with the radar overlaid is included as figure 5. The chart shows the general flight categories by the station code and indicated LIFR to IFR conditions prevailing over the area in light to moderate snow. Temperatures and dew point temperatures are displayed in °F.

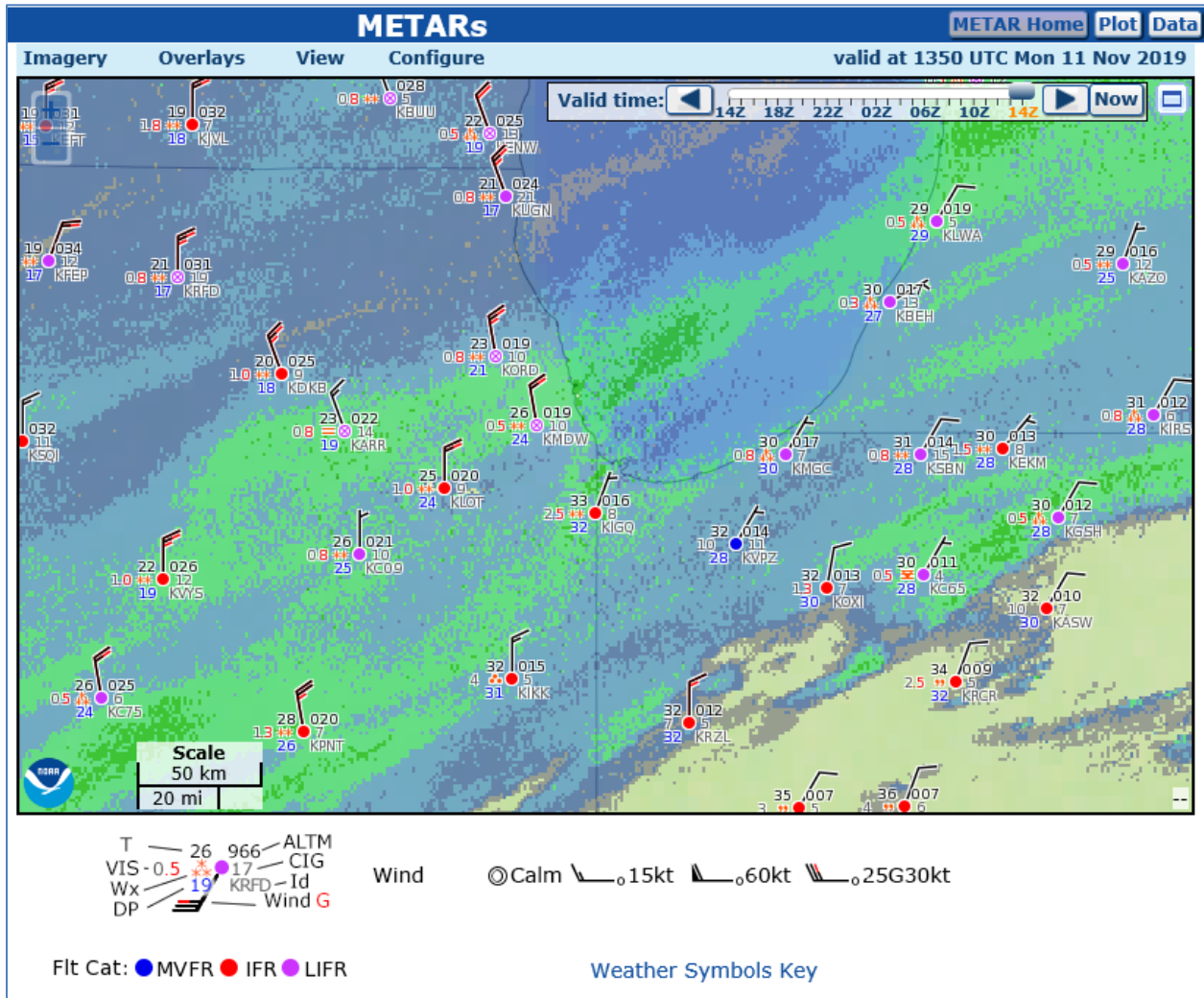


Figure 5 - NWS Aviation Weather Center's METAR display at 0750 CST showing general flight categories

3.0 Sounding

To determine the vertical structure and state of the atmosphere a High-Resolution Rapid Refresh (HRRR)⁵ numerical model over the airport was obtained from archive data from the

⁵ The HRRR is a National Oceanic and Atmospheric Administration (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.

NOAA Air Resources Laboratory and plotted on a standard Skew T log P diagram⁶ using the complete Rawinsonde Observation RAOB program software⁷. Figure 6 is the HRRR 0800 CST numerical model sounding from the surface to 450-hPa or about 21,000 ft. The HRRR sounding depicted a near surface temperature of -5° C (23° F), a dew point of -6° C (21° F), with the lifted condensation level (LCL)⁸ and level of free convection (LFC)⁹ at 529 ft agl, and convective condensation level at 611 ft agl. The sounding had a relative humidity greater than 90% from the surface through 12,600 ft and support nimbostratus type clouds with the RAOB indicating rime type icing conditions through 16,000 ft. The precipitable water content was 0.47 inches. The sounding also depicted a frontal inversion between about 1,500 ft through 2,500 ft and between 6,800 ft through 9,200 ft, with the temperatures remaining below freezing through the depth of the sounding.

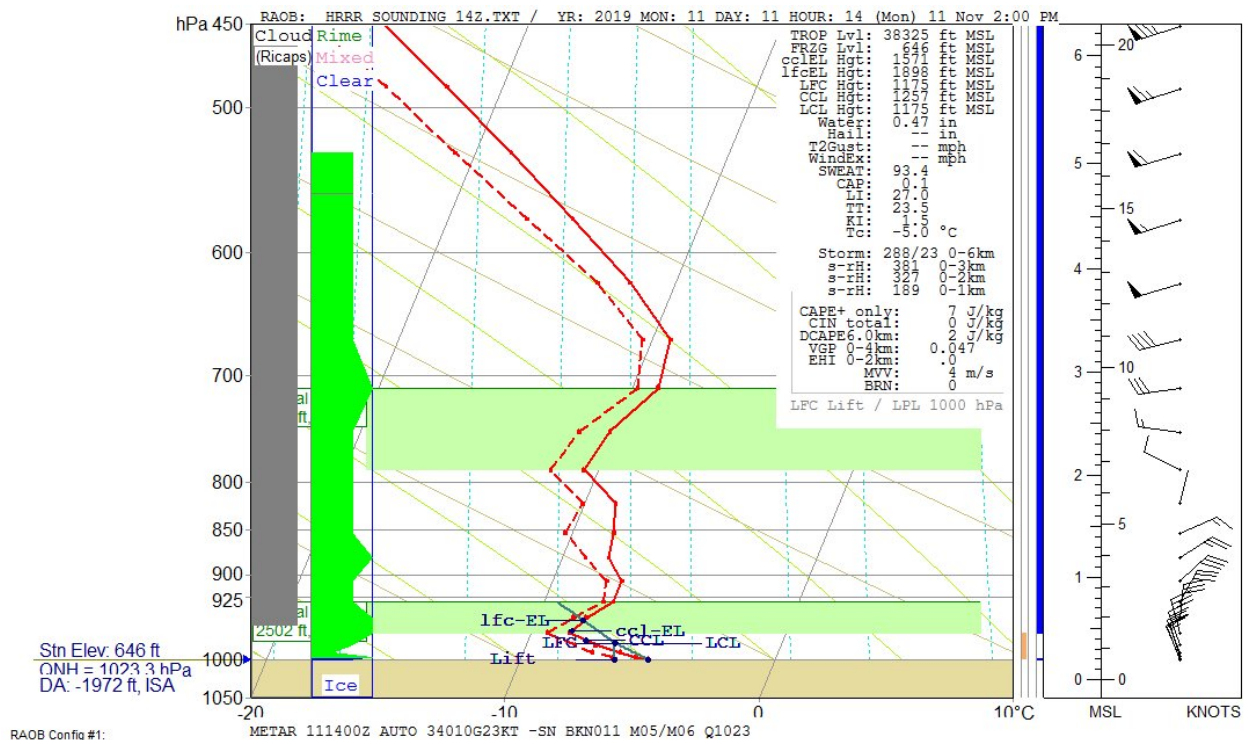


Figure 6 - HRRR numerical model over KORD for 0800 CST

The HRRR wind profile on the right side of the diagram indicated a surface wind from 340° at 10 knots, with winds veering to the northeast through 5,000 ft. A low-level wind maximum was identified at 2,500 ft with winds from about 030° at 31 knots. Above 7,000 ft or near the base of the frontal inversion, the winds backed to the west with increasing wind speeds. The mean 0 to 6

⁶ Skew T log P diagram – is a standard meteorological plot or thermodynamic diagram using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

⁷ RAOB software – The complete RAwinsonde OBServation program is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania, for plotting and analyzing upper air data

⁸ Lifting Condensation Level (LCL) - the level at which a lifted parcel becomes saturated. The LCL height corresponds to cloud base height for forced ascent.

⁹ Level of Free Convection (LFC) - the last level where a parcel becomes buoyant, or "warmer" than the environmental temperature at the same level. The LFC represents the bottom of the layer containing CAPE.

km wind was from 260° at 31 knots, with a maximum wind at 38,000 ft from 260° at 121 knots. The sounding indicated a high probability of light-to-moderate turbulence below 2,000 ft and low-level wind shear.

4.0 Satellite Imagery

The Geostationary Operational Environmental Satellite number 16 (GOES-16) data was obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System (McIDAS) software. The infrared long wave and visible imagery were obtained surrounding the time of the accident, with the images closest to the time of the accident documented below. The infrared long wave imagery (band 13) at a wavelength of 10.3 microns (μm) provided radiative cloud top temperatures with a nominal spatial resolution of 2 km. The visible (band 2) at a wavelength of 0.64 μm images at a resolution of 0.5 km.

Figure 7 is the GOES-16 band 12 infrared satellite image for 0741 CST at 2X magnification with a standard MB temperature enhancement curve applied to highlight the higher and colder cloud cover. The image depicted several deep bands of clouds extending southwest to northeast across Illinois, Lake Michigan, into Michigan, with another band further north in Iowa, Wisconsin, into northern Michigan. The radiative cloud top temperature over the KORD areas was 229° Kelvin or -44° C, which corresponded to cloud tops near 29,000 ft based on the HRRR model sounding.

Figure 8 is the GOES-16 band 2 visible image at -2X magnification for 0741 CST with the surface fronts from 0600 CST overlaid. The extensive cloud cover obscures the KORD area.

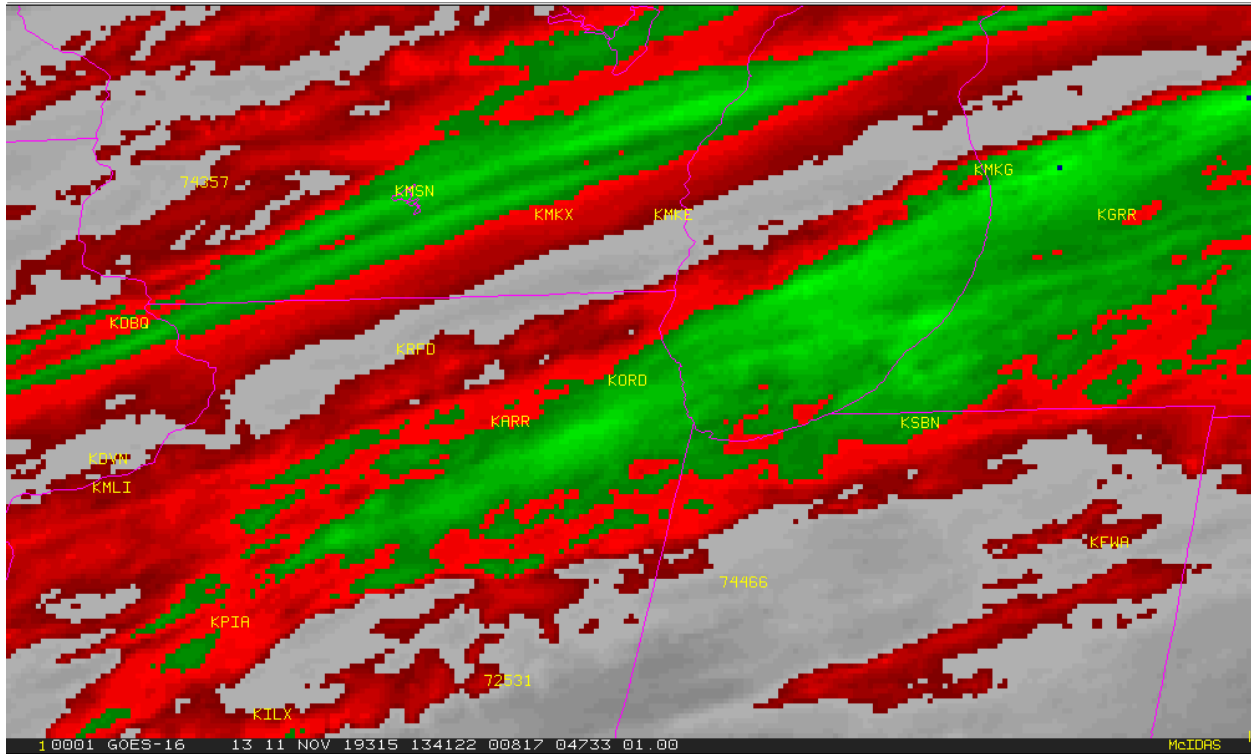


Figure 7 – GOES-16 infrared satellite image for 0741 CST at 2X magnification

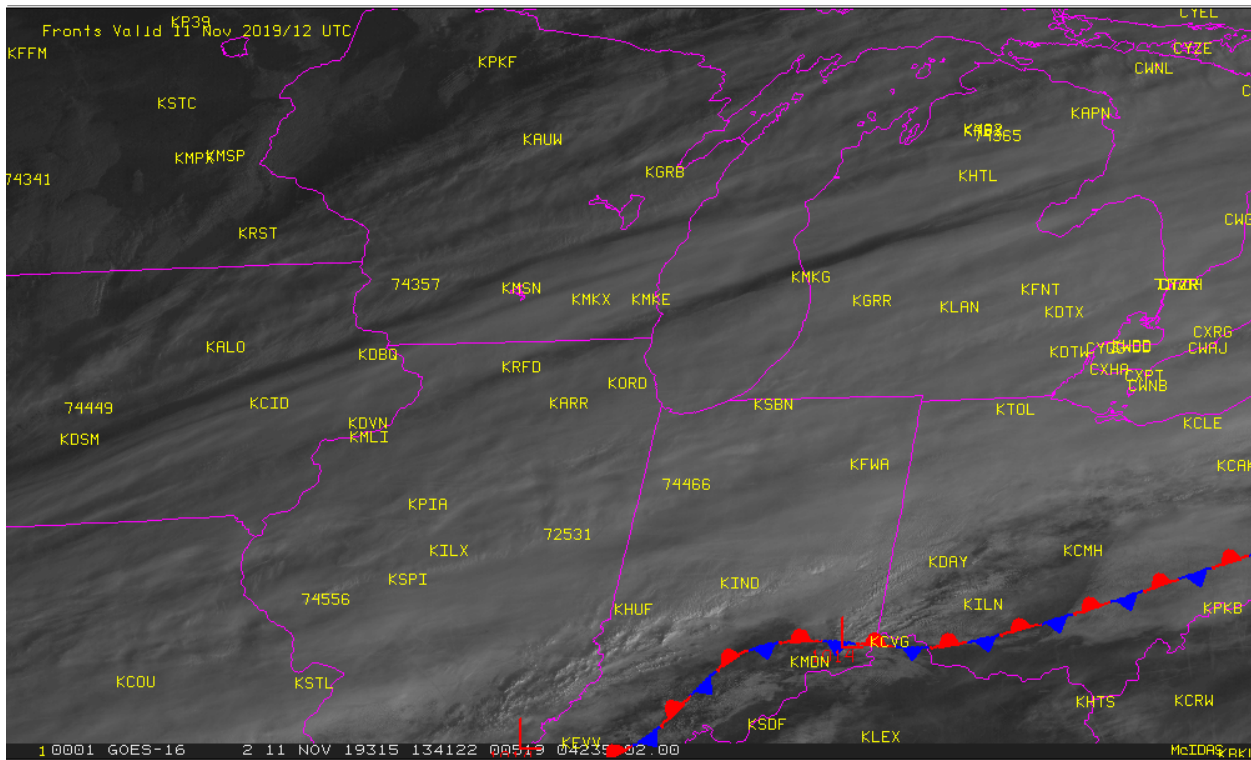


Figure 8 - GOES-16 visible image for 0741 CST with surface fronts

5.0 Weather Surveillance Radar Imagery

The closest NWS Weather Surveillance Radar 1988 Doppler (WSR-88D) was located approximately 24 miles south-southwest of the accident site in Chicago/Romeoville (KLOT), Illinois. The level II archive data was obtained from the NCEI using the Hierarchical Data Storage System and displayed using the NWS NEXRAD Interactive Viewer and Data Exporter software.

The WSR-88D is a S-band 10-centimeter wavelength radar with a power output of 750,000 watts, with a 28-foot parabolic antenna concentrating the energy into a 0.95° beam width. The radar produces three basic types of products reflectivity, radial velocity, and spectral width.

5.1 Volume Scanning Strategies

During the period the KLOT WSR-88D was operating in the clear-air mode volume scan pattern 35 (VCP-35), where the radar makes 9 different elevation scans in 7 minutes. The following chart provides the beam height for the various elevation scans based on the distance and the antenna height of 760 ft.

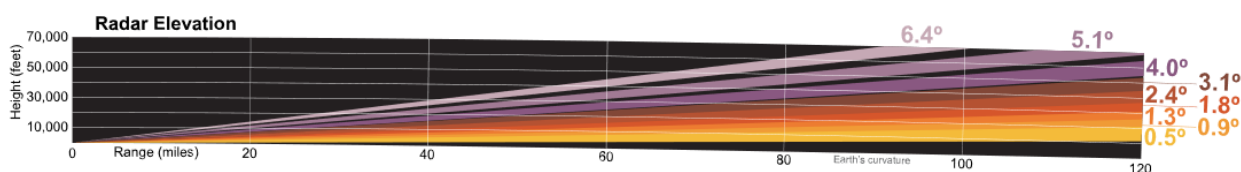


Figure 9 - VCP-35 scan elevation angles

The center of the KLOT WSR-88D lowest approximately 0.5° beam assuming standard refraction was scanning the altitudes between 1,200 ft and 3,620 ft over KORD.

5.1 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors, it is a function of the drop size distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect. Reflectivity is normally displayed in decibels (dBZ^{10}) and is a general measure of echo intensity. Figure 10 relates the NWS former video integrator and processor (VIP) intensity levels (1-6) versus the WSR-88D's display levels (0-15), precipitation mode reflectivity in decibels (DBZ), and rainfall rates.

¹⁰ $\text{dBZ} = 10 \log Z_e$

NWS VIP/DBZ CONVERSION TABLE

NWS VIP	WSR-88D LEVEL	PREC MODE DBZ	RAINFALL
0	0	< 5	
	1	5 to 9	
	2	10 to 14	
1 Very Light	3	15 to 19	.01 in/hr
	4	20 to 24	.02 in/hr
	5	25 to 29	.04 in/hr
2 Light to Moderate	6	30 to 34	.09 in/hr
	7	35 to 39	.21 in/hr
3 Strong	8	40 to 44	.48 in/hr
4 Very Strong	9	45 to 49	1.10 in/hr
5 Intense	10	50 to 54	2.49 in/hr
6 Extreme	11	55 to 59	>5.67 in/hr
	12	60 to 64	
	13	65 to 69	
	14	70 to 74	
	15	> 75	

Figure 10- NWS VIP/DBZ intensity levels and rainfall rates

The FAA has taken the NWS previous VIP levels 1 to 6 intensity levels and has redefined the intensity levels for pilots in Advisory Circular AC 00-24C - “Thunderstorm”. That AC further defines echoes less than 30 dBZ as “light” in intensity, “moderate” echoes 30-40 dBZ, “heavy” with echoes of >40-50 dBZ, and “extreme” intensity with echoes above >50 dBZ. These are the standard radio phraseology terms used by air traffic controllers to describe weather conditions to pilots as shown in figure 11.

Reflectivity (dBZ) Ranges	Weather Radar Echo Intensity Terminology
< 30 dBZ	Light
30 – 40 dBZ	Moderate
>40 – 50 dBZ	Heavy
>50 dBZ	Extreme

Figure 11 - FAA ATC broadcast reflectivity intensity levels

5.2 Base Reflectivity Image

Figure 12 is the KLOT WSR-88D 0.44° base reflectivity image for 0746 CST over the KORD area. Echoes of 20.5 to 29.0 dBZ “light” intensity echoes extend over the area and were associated with the light snow being reported. A review of the base velocity data indicated northerly winds of 22 knots over KORD with no significant divergent couplets or boundaries identified.

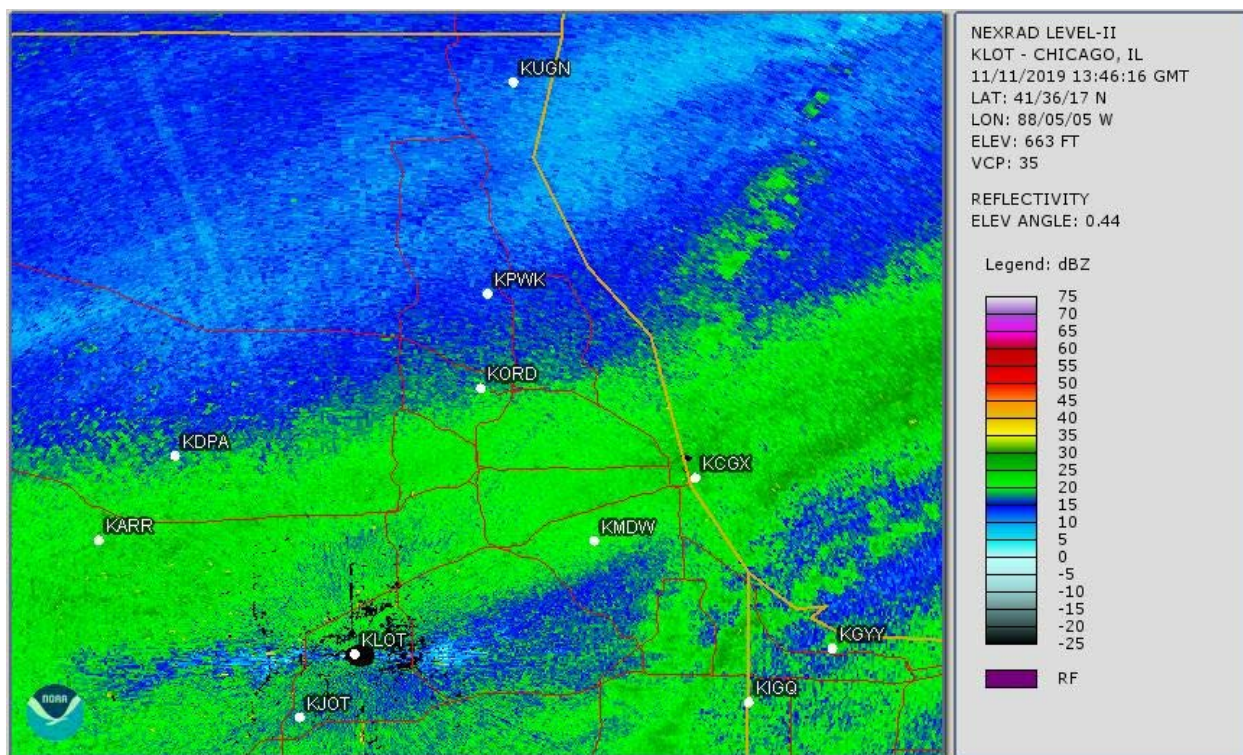


Figure 12 - KLOT WSR-88D 0.44° base reflectivity image for 0746 CST

6.0 Pilot Reports

The following pilot reports or PIREPs were reported within 100 miles of KORD and between 0500 CST through 1000 CST. The reports are in original coded format with abbreviations and time in UTC, followed by a decoded report in plain language with time converted to local CST. The reports were as follows:

ORD UA /OV ORD320025/TM 1120/FL080/TP B739/TA 01/IC MOD MIXD

KORD routine pilot report(UA); Over – 25 miles northwest of ORD; Time – 0520 CST; Altitude – 8,000 ft; Type aircraft - Boeing 737-900; Temperature – 01° C; Icing – moderate mixed icing.

RFD UA /OV RFD/TM 1154/FL190/TP MULTI/TB LGT CHOP/IC NEG/RM WB KORD DEPARTURES AND FYTTE5 ARRIVAL AOB FL230

Chicago/Rockford International Airport (RFD) routine pilot report (UA); Over – RFD VORTAC¹¹ (55 miles west-northwest); Time – 0554 CST; Flight Level – 19,000 ft; Type aircraft – multiple aircraft; Turbulence – light chop; Icing – negative; Remarks – westbound Chicago departures and FYTTE5 arrivals at or above 23,000 ft.

ORD UA /OV MDW180020/TM 1203/FL100/TP B737/TA M06/IC LGT RIME

¹¹ A VORTAC is a radio-based navigational aid for aircraft pilots consisting of a co-located VHF omnidirectional range (VOR) beacon and a tactical air navigation system (TACAN) beacon. Unless otherwise noted collocated with airport city location.

ORD routine pilot report (UA); Over – MDW 20 miles south; Time – 0603 CST; Altitude 10,000 ft; Type aircraft – Boeing 737; Temperature – minus 6° C; Icing – light rime type icing.

MDW UA /OV KMDW/TM 1210/FLSFC/TP TBM7/IC LT TRACE ICING UNTIL FAF/RM BREAKING ACTION GOOD

Chicago Midway International Airport (MDW) routine pilot report (UA); Over – KMDW; Time – 0610 CST; Altitude – surface; Type aircraft – SOCATA TBM-700; Icing – light trace icing encountered until on final approach; Remarks – braking action good on landing.

BMI UA /OV BMI/TM 1220/FL080/TP CRJ9/TA UNKWN/IC LGT RIME 030-080

Central Illinois Regional Airport (BMI) routine pilot report (UA); Over – BMI (located 100 miles south-southwest); Time – 0620 CST; Altitude – 8,000 ft; Type aircraft – Bombardier CRJ-900; Temperature – unknown; Icing – light rime icing between 3,000 and 8,000 ft.

JOT UA /OV JOT270017/TM 1221/FL150/TP E145/IC NEG

Joliet Regional Airport (JOT) routine pilot report (UA); Over – JOT VORTAC 270° azimuth at 17 miles (30 miles southwest); Time – 0621 CST; Altitude – 15,000 ft; Type aircraft – Embraer EMB-145; Icing – negative.

ORD UA /OV ORD/TM 1232/FL1230/TP B738/RM RWY 10L BRAKING MEDIUM. POOR AFTER TWY N3.

ORD routine pilot report (UA); Over – ORD; Time – 0632 CST; Altitude – 1,230 ft; Type aircraft – Boeing 737-800; Remarks – runway 10L braking action medium and poor after taxiway N3.

MDW UA /OV KMDW/TM 1230/FLSFC/TP LJ60/SK CIG 010SCT/WX -SN/IC NO ICING/RM BREAKING ACTION GOOD

MDW routine pilot report (UA); Over – KMDW; Time – 0630 CST; Altitude – surface; Type aircraft – Bombardier Learjet; Sky cover – ceiling 1,000 ft scattered; Weather – light snow; Icing – no icing; Remarks – braking action good.

MDW UA /OV 10 SE MDW/TM 1248/FL060/TP LJ60/TA -2/IC LGT RIME

MDW routine pilot report (UA); Over – 10 miles southeast of MDW; Time – 0648 CST; Altitude – 6,000 ft; Type aircraft – Bombardier Learjet; Temperature – minus 2° C; Icing – light rime type icing.

MDW UA /OV KMDW/TM 1250/FLSFC/TP LJ45/SK CIG OVC009 MSL/WX -SN/TA M02/IC LT RM/RM BREAKING FAIR

MDW routine pilot report (UA); Over – KMDW; Time – 0650 CST; Altitude – surface; Type aircraft – Bombardier Learjet; Sky cover – ceiling overcast at 900 ft msl; Weather – light snow; Temperature – minus 2° C; Icing – light rime type icing; Remarks – braking action fair.

ORD UA /OV ORD/TM 1315/FLSFC/TP B738/RM RWY 10L BRAKING POOR.

ORD routine pilot report (UA); Over – ORD VORTAC; Time – 0715 CST; Altitude – surface; Type aircraft – Boeing 737-800; Remarks – runway 10L braking action poor.

MDW UA /OV KMDW/TM 1315/FLSFC/TP C560/SK CIG OVC009 MSL/WX -SN/TA 00/RM BREAKING ACTION GOOD

MDW routine pilot report (UA); Over – KMDW; Time – 0715 CST; Altitude – surface; Type aircraft – Cessna Citation; Sky cover – ceiling overcast 900 ft msl; Weather – light snow; Temperature – 0° C; Remarks – braking action good.

Accident 1343Z

DPA UA /OV KDPA/TM 1349/FL013/TP C56X/SK OVC/IC NEG ICE/RM DURD RY2L RWY IN SIGHT AT 500AGL

DuPage Airport (DPA) routine pilot report (UA); Over – KDPA (approximately 16 miles west of KORD), Time – 0749 CST; Altitude – 1,300 ft; Type aircraft – Cessna Citation; Sky cover – overcast; Icing – negative icing; Remarks – during descent to runway 2L, runway in sight at 500 ft agl.

ORD UA /OV ORD/TM 1400/FLSFC/TP B738/RM RWY 10C BRAKING MEDIUM

ORD routine pilot report (UA); Over – ORD VORTAC; Time – 0800 CST; Altitude – surface; Type aircraft – Boeing 737-800; Remarks – runway 10C braking action medium.

ORD UA /OV ORD/TM 1410/FLSFC/TP CRJ2/RM RWY 10C BRAKING MEDIUM-POOR.

ORD routine pilot report (UA); Over – ORD VORTAC; Time – 0810 CST; Altitude – surface; Type aircraft – Canadair CRJ-200; Remarks – runway 10C braking action medium-to-poor.

MDW UA /OV KMDW/TM 1443/FLSFC/TP B737/SK CIG OVC003 AGL/WX FZFG -SN/RM BREAKING ACTION GOOD

MDW routine pilot report (UA); Over – KMDW; Time – 0843 CST; Altitude – surface; Type aircraft – Boeing 737; Sky cover – ceiling overcast at 300 ft; Weather – freezing fog and light snow; Remarks – braking action good.

ORD UA /OV ORD/TM 1537/FLSFC/TP E145/RM RWY 9R BRAKING MEDIUM-POOR

ORD routine pilot report (UA); Over – ORD VORTAC; Time – 0937 CST; Altitude – surface; Type aircraft – Embraer EMB-145; Remarks – runway 9R braking action medium-to-poor.

ORD UA /OV ORD040014/TM 1539/FL070/TP B738/TA -6/IC TRACE RIME

ORD routine pilot report (UA); Over – ORD VORTAC 040° azimuth at 14 miles; Time – 0939 CST; Altitude – 7,000 ft; Type aircraft – Boeing 737-800; Temperature – minus 6° C; Icing – trace rime ice.

MDW UA /OV KMDW/TM 1545/FLSFC/TP B737/SK CIG OVC005 AGL/WX -BLSN/RM BRAKING ACTION GOOD

MDW routine pilot report (UA); Over – KMDW; Time – 0945 CST; Altitude – surface; Type aircraft – Boeing 737; Sky cover – ceiling overcast at 500 ft agl; Weather – light blowing snow; Remarks – braking action good.

ORD UA /OV ORD/TM 1546/FLSFC/TP E145/RM RWY 9L BRAKING MEDIUM

ORD routine pilot report (UA); Over – ORD VORTAC; Time – 0946 CST; Altitude – surface; Type aircraft – Embraer EMB-145; Remarks – runway 9R braking action medium.

ORD UA /OV 8 SE ORD/TM 1558/FL100/TP B737/TA M2/IC LIGHT RIME

ORD routine pilot report (UA); Over – 8 miles southeast of ORD VORTAC; Time – 0958 CST; Altitude – 10,000 ft; Type aircraft – Boeing 737; Temperature – minus 2° C; Icing – light rime.

There were numerous PIREPs of light rime icing conditions surrounding the period into the KORD area, with reports of braking action ranging from medium to poor prior to the accident.

7.0 NWS Forecasts

7.1 Terminal Aerodrome Forecasts

The NWS Chicago (KLOT) Weather Forecast Office (WFO) located in Romeoville, Illinois, was responsible for the issuance of the Terminal Aerodrome Forecast (TAF) for KORD. A TAF is a concise statement of the expected meteorological conditions at an airport during a specified period (usually 24 hours). TAFs are valid for a 5 mile radius around an airport's center point. The forecasts issued surrounding the period relevant to the preflight planning and the time of the accident were as follows.

***TAF AMD KORD 110901Z 1109/1212 01014G22KT 1SM -SN BR OVC006
TEMPO 1110/1114 03015G25KT 1/2SM SN BLSN VV006
FM111600 35016G25KT 1SM -SN BLSN OVC012
FM111900 35015G25KT 3SM -SN BLSN OVC015
FM112100 34015G25KT P6SM BKN025 OVC035
FM120000 32013G20KT P6SM FEW035=***

The amended forecast issued at 0301 CST expected from 0300 through 1000 CST wind from 010° at 14 knots gusting to 22 knots, visibility 1 mile in light snow and mist, ceiling overcast at 600 ft agl. The forecast did not include any low-level wind shear warnings below 2,000 ft.

The next regular TAF forecast was issued at 0525 CST and was as follows:

***TAF KORD 111125Z 1112/1218 36015G23KT 1SM -SN BR OVC007
TEMPO 1112/1114 1/2SM SN BLSN VV006
FM111400 35016G25KT 1SM -SN BLSN OVC012
FM111900 35015G25KT 3SM -SN BLSN OVC015
FM112100 34015G25KT P6SM BKN025 OVC035
FM120000 32013G20KT P6SM FEW035=***

The forecast issued at 0525 CST expected wind from 360° at 15 knots gusting to 23 knots, visibility 1 mile in light snow and mist, ceiling overcast at 700 ft agl, with a temporary period between 0600 and 0800 CST of visibility 1/2 mile in moderate snow and blowing snow with sky obscured and a vertical visibility 600 ft agl.

7.2 Area Forecast Discussion

The NWS Area Forecast Discussions (AFD) are issued by each WFO to describe the short term weather conditions within their region with an aviation section that includes the general conditions as it relates to the creation of the TAF. These are useful for additional aviation-related issues that cannot be encoded into the TAF. The discussion also gives some reasoning behind the forecast. These are generated roughly every 6 hours and corresponds to the release of the latest TAFs for that office. The long term and marine sections have been excluded. The forecast discussion issued at 0544 CST was as follows.

*FXUS63 KLOT 111144
AFDLOT
Area Forecast Discussion
National Weather Service Chicago/Romeoville, IL
544 AM CST Mon Nov 11 2019*

*..SHORT TERM...
340 AM CST*

Today through Tuesday Night...

Immediate focus is on accumulating snow which will affect the forecast area today. Have added remaining southeast cwa counties to the winter weather advisory in concert with ILX and IND this morning, where first accumulating snow of the season and the potential for some minor blowing or drifting may cause at least minor travel impacts.

Early morning water vapor imagery depicts a strong mid-level short wave trough digging southeastward from the Canadian prairies, with a strong upper level jet streak evident downstream across the northern Great Lakes. This short wave is progged to continua to amplify the upper trough across the upper Midwest and Great Lakes through Tuesday. In the process, unseasonably cold Arctic air will spread into the region.

Ageostrophic response was occurring ahead of the amplifying trough, including the strengthening of the upper jet and tightening of the low-mid level baroclinic zone associated with yesterday's cold frontal passage. These responses were in turn increasing forcing for ascent across the area, with upper level divergence in the favorable right entrance region of the jet streak and a broad region of mid-level frontogenesis aiding in developing an area of light-moderate precipitation across far northern IL early this morning. This precip, which was generally occurring north of the I-80 corridor as of 3 am, will continue to spread south/southeast this morning. Most of the current radar-detectable precip is falling as snow, though there remains some rain or a rain/snow mix along the southern periphery of the precip shield and likely along the immediate Lake Michigan shore from Chicago southeastward. Any rain/snow mix should turn over to all snow fairly quickly as the column cools with southward expansion of the precip shield this morning. Also seeing some lake-enhancement of radar returns occurring along the IL shore. Web cams indicate accumulation occurring across far northern IL, with some accumulation on roads noted across the northern tier of IL counties. Conditions will likely deteriorate farther south as snow persists this morning, and surface temperatures fall.

Guidance remains in good agreement with fairly impressive QPF amounts across the forecast area today, supportive of widespread 3-5" accumulations north of the I-80 corridor, and 2-3" amounts farther south. Some concern with amounts along Lake Michigan, where an onshore component of milder marine air may hold amounts down a bit. Tough to account for the opposing factors of lake-enhanced precip rates and warmer temps in these early season events. Lake enhanced banding should become more progressive with time as winds back from NNE to NNW and eventually NW through this afternoon, shifting focus from NE IL this morning into IN this afternoon and tonight. By evening, lake effect focus should generally be from Porter county eastward. Could potentially see some 4-6" amounts across northern Porter county before the main convergent axis shifts east later tonight/early Tuesday.

Northerly winds gusting 25-30 mph may produce some minor blowing and drifting and open areas today. Areas near Lake Michigan in northwest Indiana will see some gusts in the 35-40 mph range which may produce more of an issue there. These strong winds blowing down the length of the lake will also produce high waves, which will likely result in lakeshore flooding and beach erosion. Have added Cook county to the lakeshore flood warning along with Lake and Porter counties in Indiana.

With Arctic air flooding into the area, temps will fall into the low-mid 20s area-wide today. Lows tonight are expected to dip into the single digits across far northern IL, and into the teens over east central IL and northwest IN. May be close to some record mins by midnight tonight for the 11th, with record lows and low-maxes likely in jeopardy in many spots for the 12th. Wind chills will likely dip into the negative single digits in some spots tonight, before winds diminish Tuesday/Tuesday night.

Ratzer

.CLIMATE...

Record minimum temperature for November 11th

-Chicago: 15 in 1950

-Rockford: 10 in 1926

Record low maximum temperature for November 11th

-Chicago: 28 in 1894

-Rockford: 26 in 1986

Record minimum temperature for November 12th

-Chicago: 8 in 1986

-Rockford: 7 in 1986

Record low maximum temperature for November 12th

-Chicago: 28 in 1995

-Rockford: 27 in 1940

Record minimum temperature for November 13th

-Chicago: 6 in 1986

-Rockford: 3 in 1986

Kluber

.AVIATION...

For the 12Z TAFs...

544 AM...Forecast concerns include...

Snow this morning...ending early this afternoon.

Blowing snow possible today.

Strong/gusty north/northeast winds shifting north/northwest.

Light snow will continue across northern Illinois through early this afternoon as it slowly tapers off. A band of moderate snow is likely this morning which may lower visibility to 1/2sm at times. There is some uncertainty regarding the exact end time for the snow but it will be tapering off in the early afternoon and timing tweaks can be expected with later updates.

The latest guidance is favoring northerly winds turning to the north/northwest sooner than previously expected at ord. North/northeast winds are still possible for a few hours this morning...especially at MDY and GYY but have trended winds north/northwest a little faster with this forecast. Wind directions will then remain north/northwest for the rest of today turning more northwest by this evening. Gusts into the mid 20kt range are expected which will slowly diminish into this evening. Gusts to 30kts are possible near the lake and at GYY. As temperatures fall and the snow becomes drier...blowing and drifting snow will be possible into this afternoon. cms

.LOT WATCHES/WARNINGS/ADVISORIES...

IL...Lakeshore Flood Warning...ILZ014 until noon Tuesday.

Winter Weather Advisory...ILZ005-ILZ006-ILZ012-ILZ013-ILZ014-ILZ019-ILZ020-ILZ021-ILZ022 until 2 PM Monday.

Lakeshore Flood Advisory...ILZ006 until noon Tuesday.

Winter Weather Advisory...ILZ023-ILZ033-ILZ039 until 6 PM Monday.

Winter Weather Advisory...ILZ032 until 2 PM Monday.

Winter Weather Advisory...ILZ003-ILZ004-ILZ008-ILZ010-ILZ011 until noon Monday.

7.3 Winds and Temperature Aloft Forecast

The NWS Winds and Temperature Aloft Forecast bulletin (FBUS) current for the route at the time of the accident from 3,000 ft to 39,000 ft are included below. The forecast was based on data from 0000 CST and was valid for 0600 CST and for use between 0200 through 0900 CST.

WINDS ALOFT FORECASTS

DATA BASED ON 110600Z

VALID 111200Z FOR USE 0800-1500Z. TEMPS NEG ABV 24000

<i>FT</i>	<i>3000</i>	<i>6000</i>	<i>9000</i>	<i>12000</i>	<i>18000</i>	<i>24000</i>	<i>30000</i>	<i>34000</i>	<i>39000</i>
<i>RDU</i>	<i>2311</i>	<i>2213+10</i>	<i>2222+04</i>	<i>2427-01</i>	<i>2439-13</i>	<i>2444-26</i>	<i>255842</i>	<i>265850</i>	<i>276862</i>
<i>ROA</i>	<i>2914</i>	<i>2324+09</i>	<i>2328+03</i>	<i>2433-03</i>	<i>2446-15</i>	<i>2551-27</i>	<i>256042</i>	<i>266651</i>	<i>267262</i>
<i>TRI</i>		<i>2216+08</i>	<i>2223+04</i>	<i>2330-02</i>	<i>2441-16</i>	<i>2547-26</i>	<i>265840</i>	<i>267150</i>	<i>277962</i>
<i>CRW</i>	<i>2515</i>	<i>2429+07</i>	<i>2433+03</i>	<i>2436-03</i>	<i>2549-16</i>	<i>2555-28</i>	<i>256243</i>	<i>267151</i>	<i>267863</i>
<i>CMH</i>	<i>2505</i>	<i>2418+04</i>	<i>2438+01</i>	<i>2548-05</i>	<i>2561-17</i>	<i>2565-29</i>	<i>257545</i>	<i>268053</i>	<i>269263</i>
<i>CVG</i>	<i>2207</i>	<i>2426+05</i>	<i>2439+01</i>	<i>2446-04</i>	<i>2556-17</i>	<i>2659-29</i>	<i>266744</i>	<i>267752</i>	<i>268262</i>
<i>LOU</i>	<i>2515</i>	<i>2428+08</i>	<i>2333+02</i>	<i>2339-03</i>	<i>2553-16</i>	<i>2655-28</i>	<i>266442</i>	<i>267451</i>	<i>277762</i>
<i>IND</i>	<i>1307</i>	<i>2425+04</i>	<i>2435-01</i>	<i>2449-05</i>	<i>2560-17</i>	<i>2665-29</i>	<i>267244</i>	<i>268153</i>	<i>269364</i>
<i>FWA</i>	<i>1312</i>	<i>2519+01</i>	<i>2433-03</i>	<i>2448-07</i>	<i>2568-18</i>	<i>2676-30</i>	<i>268346</i>	<i>269254</i>	<i>270365</i>
<i>JOT</i>	<i>0532</i>	<i>2809-06</i>	<i>2435-05</i>	<i>2445-09</i>	<i>2668-19</i>	<i>2579-31</i>	<i>269446</i>	<i>269955</i>	<i>276165</i>

The closest forecast point to the accident site was from Joliet Regional Airport (JOT) approximately 30 miles southwest of KORD. The JOT wind forecast for 3,000 ft was from 050° at 32 knots, at 6,000 ft wind from 280° at 9 knots with a temperature of -6° C.

8.0 NWS Inflight Weather Advisories

Inflight Aviation Weather Advisories are forecasts to advise en route aircraft of development of potentially hazardous weather. Inflight aviation weather advisories in the conterminous U.S. are issued by the NWS AWC, as well as from the Center Weather Service Units (CWSU) associated with FAA ARTCCs. There are four basic types of inflight aviation weather advisories: the Significant Meteorological Information (SIGMET), the Convective SIGMET, the AIRMET, and the Center Weather Advisory (CWA). Inflight advisories serve to notify en route pilots of the possibility of encountering hazardous flying conditions which may not have been forecast at the time of the preflight briefing. Whether or not the condition described is potentially hazardous to a particular flight is for the pilot to evaluate on the basis of experience and the operational limits of the aircraft.

During the period surrounding the time of the accident the NWS AWC had no SIGMETs, Convective SIGMETs current, and the Chicago (KZAU) CWSU had no CWA or Meteorological Impact Statements (MIS) bulletins current during the period. The NWS AWC did have two AIRMETs current for the during the period for instrument flight rule (IFR) conditions and for icing conditions. There were no advisories current for low-level turbulence, high winds, or low-level wind shear current for the area.

8.1 AIRMETs

The Graphic AIRMETs (G-AIRMET) Sierra for IFR conditions and Zulu for icing conditions issued at 0400 CST and valid at the time of the accident are graphically depicted below in figures 13 and 14 respectively. The full text of AIRMET Zulu for moderate icing follows the G-AIRMET Zulu.

SIERRA 2019-11-11 12:00:00

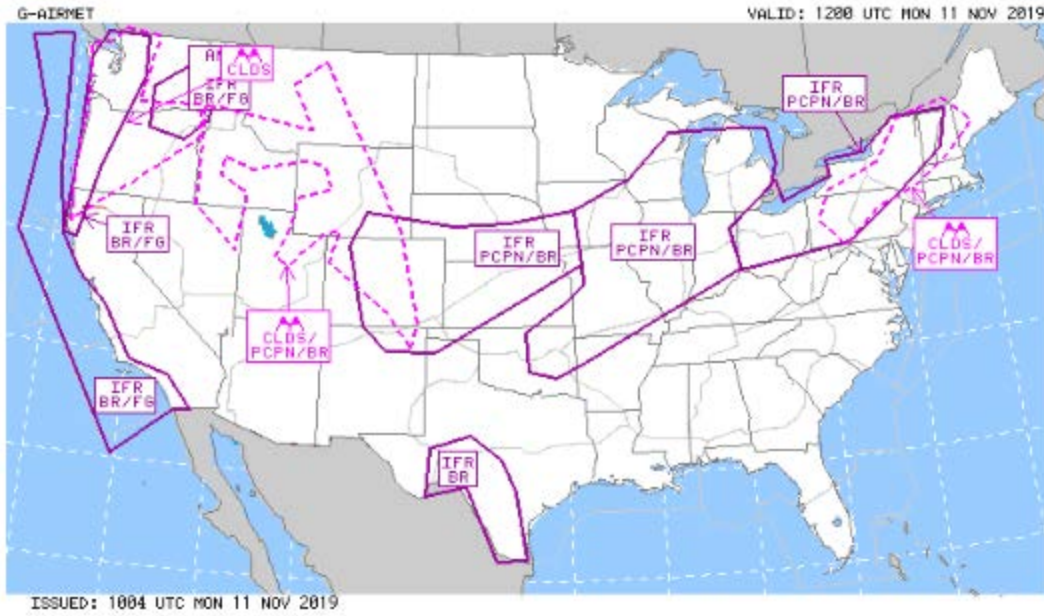


Figure 13 - G-AIRMET Sierra for IFR conditions valid for the period of the accident

ZULU 2019-11-11 12:00:00

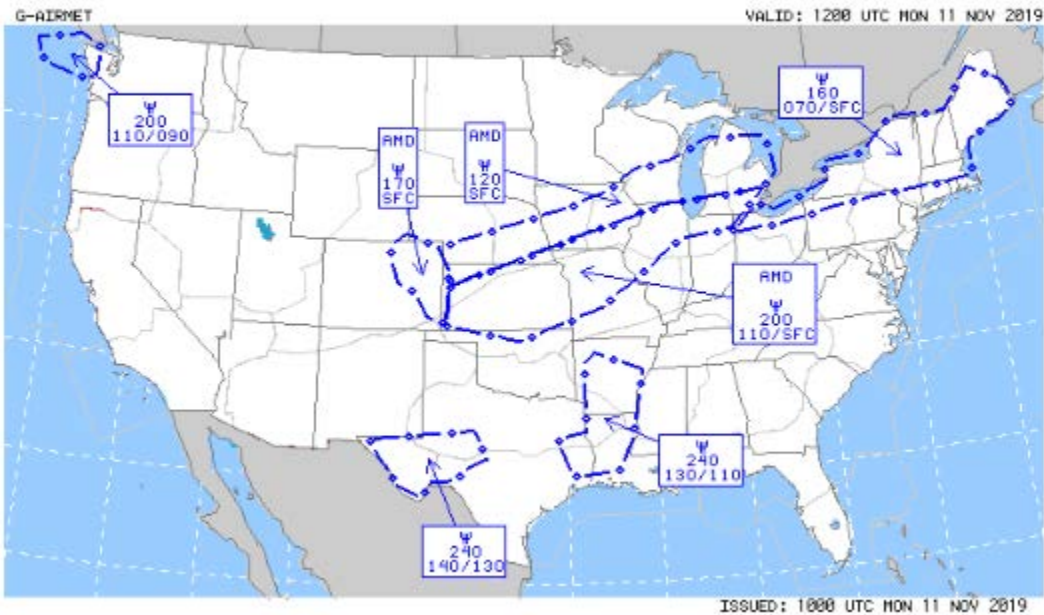


Figure 14- G-AIRMET Zulu for moderate icing conditions valid at the time of the accident

WAUS43 KKCI 111000 AAA
 WA3Z
 -CHIZ WA 111000 AMD
 AIRMET ZULU UPDT 3 FOR ICE AND FRZLVL VALID UNTIL 111500

AIRMET ICE...NE KS IA MO WI LM MI LH IL IN OK TX AR...UPDT
FROM 50ENE ECK TO FWA TO 50S FWA TO 20NNE TTH TO 20ESE FAM TO 40W RZC TO 20NW
OKC TO 30SSW MMB TO 50W LBL TO GLD TO 20SE SNY TO 40SW OBH TO 50ENE ECK
MOD ICE BTN FRZLVL AND FL200. FRZLVL SFC-110. CONDS CONTG BYD 15Z THRU 21Z.

9.0 Preflight Weather Briefing

The pilots received a weather document for their preflight planning, and it is included in the Operations Group attachments in the docket and includes the notices to airmen (NOTAMs) and field conditions current prior to departure.

10.0 Astronomical Conditions

The following astronomical conditions were obtained from the Multiyear Interactive Computer Almanac (MICA) software developed by the United States Naval Observatory for November 11, 2019 for Chicago, Illinois. The time of the accident is included in bold italic type for reference.

<u>SUN</u>	
Begin civil twilight	0607 CST
Sunrise	0636 CST
<i>Accident</i>	<i>0743 CST</i>
Transit	1136 CST
Sunset	1635 CST
End civil twilight	1704 CST

At the time of the accident the Sun was located at 10° above the horizon at an azimuth of 125°.

Submitted by:

Don Eick
Senior Meteorologist