Weather Conditions over southern Ontario on the night of November 18, 2010 during the crash of a small aircraft

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Introduction

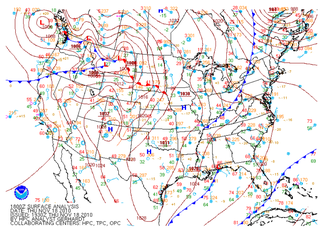
Weather conditions during the fatal crash of a small aircraft (Beechcraft Bonanza F-33A) on a training flight during a November evening, southeast of Lake Huron and Georgian Bay (northeast of Toronto), illustrate weather and icing conditions that may be experienced by low-flying aircraft downwind of the warm lakes on cool nights. The crash occurred at UTC 23:44 November 18, 2010 and the Transportation Safety Board investigation report indicated that adverse weather conditions including rain, snow and freezing rain were a factor and that aircraft icing may have worsened a wing stall that occurred shortly before the crash.

- Were conditions suitable for icing on aircraft surfaces?
- Were these conditions rare?
- Can these conditions be predicted and avoided?
- Analyses of winds, humidity and temperatures of air and lake surfaces are presented below.

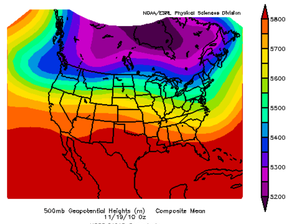
(Left) Beechcraft Bonanza F-33A (Courtesy of Wikipedia Commons)

Synoptic overview

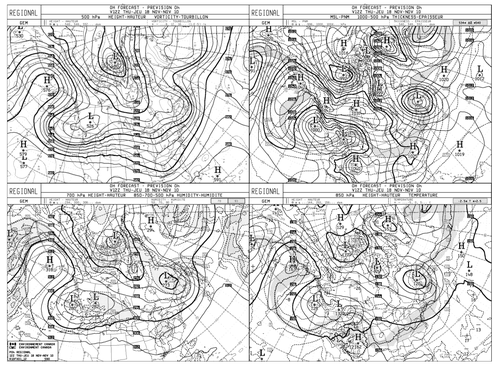
Following passage of a cold front earlier in the day, an upper trough to the east of southern Ontario and an upper ridge building over the western Great Lakes region caused a northwesterly flow over Lake Huron along with cold air advection and clearing skies.



Surface analysis for 18 UTC Nov. 18 shows a cold front moving eastward from southern Ontario and a high pressure ridge building over northern Ontario driving a cold front moving eastward from southern Ontario. (Courtesy of NOAA NCEP)



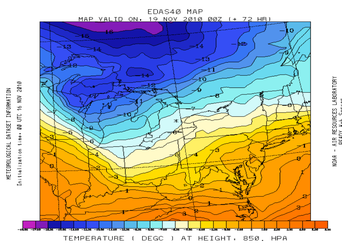
(Above) The 500 hPa geopotential ht. chart for 00 UTC November 19 shows the upper ridge building eastward over the Great Lakes and NW upper flow in place. (Courtesy of NOAA ESRL)



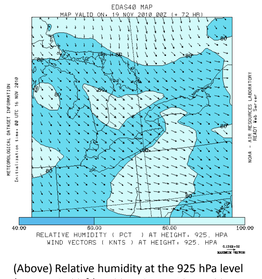
(Above) 4-panel chart for 12 UTC Nov. 18 shows trough at 500 and 700 hPa levels (LH side) over the Great Lakes region and a ridge west of the Great Lakes. The 850 hPa and surface charts (RH side) show NW flow across southern Ontario. (Courtesy of Environment Canada)

Factors favourable to icing conditions

- Winds from NW directly along the long axis of Georgian Bay, water temperatures of +8° to +10° C, 850 T between -8° to -10° C and nearly adiabatic lapse rates allowed for convection from the lake surface to 700 hPa (providing conditions suitable for pockets of moisture to rise from the lake surface to become clouds or patches of supercooled water droplets)
- Air temperatures near 0° C at the surface, and several degrees cooler near the flight level (approx. 925 hPa level) were optimum for icing conditions (maximum ability to hold supercooled water droplets)
- Temperatures near 700 hPa close to -20° C allowed convection well into the dendritic growth zone near -12° to -15° C and was ideal for precipitation to form
- NW winds aligned from Georgian Bay to the crash site provided conditions allowing clouds, patches of supercooled water droplets, or precipitation to be present in the vicinity of the crash site
- The time of the crash was in the period of optimum icing conditions. The typical trend involves instability following passage of the cold front, drier air and possibly clearing skies, increasing stability with a subsidence inversion developing as the high pressure ridge approaches, a nocturnal inversion forming when skies become clear and winds diminish, and diminishing wind shear as the upper ridge approaches. During the evening of Nov. 18, skies were mostly clear but the scattered clouds forming and occasional precipitation were indications of the pockets of instability and moisture present in the atmosphere

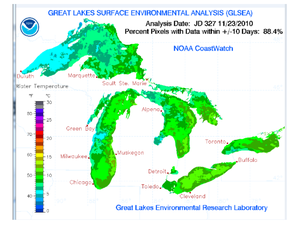


(Left) The 850 hPa temperature chart for 00 UTC Nov. 19 shows temperatures in the range of -8° to -10° over southern Georgian Bay. (Courtesy of NOAA Air Resources Laboratory)

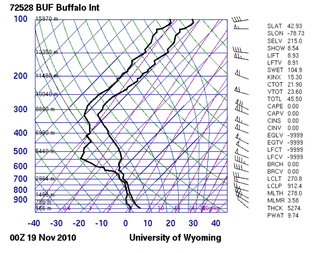


(Above) Relative humidity at the 925 hPa level (approx. 2500 ft) at 00 UTC Nov. 19 was 80-100% with winds directly along the length of Georgian Bay, providing maximum fetch for picking up moisture, and directly toward the crash site. (Courtesy of NOAA Air Resources Laboratory)

(Left) Topographic relief chart for the region of southern Ontario between Georgian Bay and Lake Ontario shows some rising terrain that may assist in orographic uplift in NW flow conditions. (Courtesy of NASA)



Great Lakes water surface temperatures on Nov. 23 were in the range 8°-10° C. (Courtesy of NOAA GLERL)

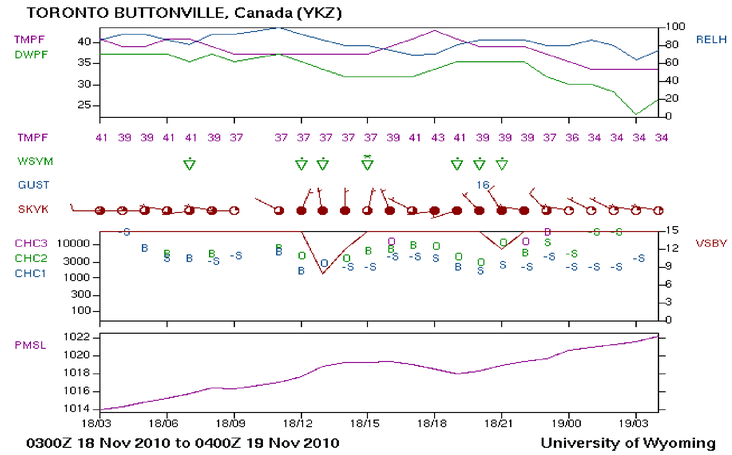


Upper air sounding at Buffalo NY for 00 UTC Nov. 19 shows a layer of nearly saturated air up to the 700 hPa level, temperatures at the 700 hPa layer near -20° C, and NW flow. The strong lapse rate from the surface to 700 hPa provided nearly ideal convective conditions for clouds to grow and form precipitation. (Courtesy of Univ. of Wyoming)

Observations and forecast TAFs

Several observations were recorded in the vicinity at Toronto Buttonville airport, CYKZ, located approximately 10.5 nautical miles (nm) west of the crash site and at Oshawa airport, CYOO, located approximately 10.4 nm east of the crash site.

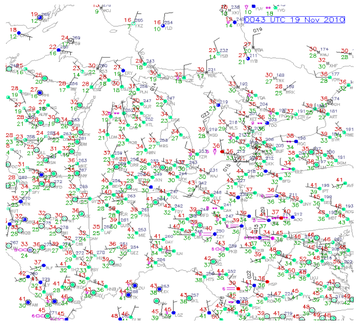
- CYKZ, UTC 00:00 Nov. 19, winds 280° at 6 knots, T = 2.3°, Td = −0.6°C, visibility 15 miles, a few clouds at 2000 and 5000 feet.
- CYOO, UTC 00:00 Nov. 19, winds 310° at 5 knots, T = 1°C, Td = 1°C, visibility 9 miles, scattered clouds at 3600 feet and broken clouds at 4500 feet.
- CYOO, UTC 00:19, winds 340° at 6 knots, variable from 290° to 350°, T = 1°C, Td = 1°C, visibility 9 miles, scattered clouds at 1500 feet, broken clouds at 2400 and 3600 feet.
- CYOO, UTC 00:23, winds 320° at 5 knots, T = 2°C, Td = 2°C, visibility 9 miles, scattered clouds at 1500 and 2000 feet, broken clouds at 2600 and 3400 feet.
- CYOO, UTC 00:32, winds 320° at 5 knots, T = 2°C, Td = 2°C, visibility 9 miles, scattered clouds at 1700 feet, broken clouds at 2200, 2900 and 3900 feet.
- CYOO, UTC 00:33, winds 310° at 6 knots, T = 2°C, Td = 2°C, visibility 9 miles in light rain, scattered clouds at 1700 feet, broken clouds at 2200 and 2700 feet, and overcast clouds at 3700 feet.



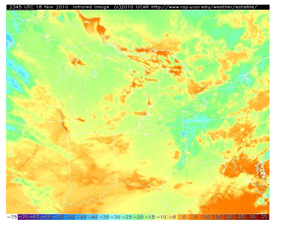
The meteogram for CYKZ for the 24-h period ending at 04:00 Nov. 19 shows the increasing barometric pressure (lowest panel), decreasing temperature and dewpoint but relative humidity remaining near 80% (top panel), NW winds, and sky cover reported as mostly light scattered clouds below 3000 ft several hours before and after UTC 00:00 (middle panel). (Courtesy of Univ. of Wyoming)

- CYKZ, UTC 01:00, winds 300° at 4 knots, T = 1.4°C, Td = −0.8°C, visibility 15 miles, a few clouds at 2000 and 22 000 feet.
- CYOO, UTC 01:00, winds 350° at 5 knots, T = 2°C, Td = 2°C, visibility 9 miles in light rain, and overcast clouds at 1400 feet.

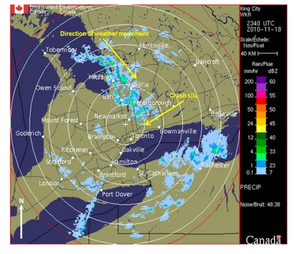
The forecast for the time period, indicated in the TAF for CYKZ, was for winds from 300° at 5 knots, visibility more than 6 miles, a few clouds at 3000 feet and broken clouds at 6000 feet. Temporarily reduced visibility to 5 miles in light rain showers and mist, with broken clouds at 2000 feet and winds from 330° at 10 gusting 20 knots was forecast to be over approximately 2 hours prior to the occurrence. The later part of the forecast period indicated winds from 320° at 5 knots, visibility more than 6 miles and a few clouds at 3000 feet.



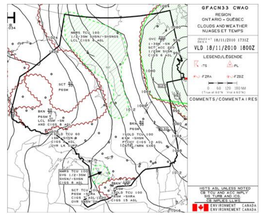
The plot of surface observations for 00 UTC Nov. 19 shows NW winds, temperatures several degrees above the melting point, and several observations of precipitation over southern Ontario southeast of Lake Huron and Georgian Bay. (Courtesy of UCAR)



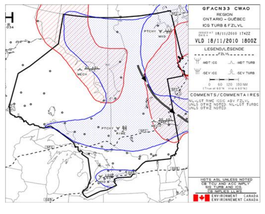
The GOES IR satellite image at UTC 23:45 Nov. 18 shows partly clear skies (warm temperatures) along with some cloudiness in the vicinity of Lake Huron and Georgian Bay. (Courtesy of UCAR)



The radar plot from King City (north of Toronto) at UTC 23:40 shows that substantial regions of precipitation existed downstream from Georgian Bay. (Image from TSB Aviation Investigation Report #A10O0240)



Graphical forecast area chart for clouds and weather during the afternoon of Nov. 18 shows that clouds, low ceilings, reduced visibility and light rain showers were forecast over the area southeast of Georgian Bay. (Courtesy of Environment Canada)



Graphical forecast area chart for icing for the afternoon of Nov. 18 shows that moderate icing was expected above 6000 ft (well above the flight path of the flight that crashed) and freezing level was 2500 ft ASL, or less than 2000 ft AGL, in the vicinity of the crash site. (Courtesy of Environment Canada)

Summary

- Wind direction, humidity, and lapse rates in the layer from the surface to the 700 hPa level were nearly ideal for convection from the lake surface to the dendritic growth zone and for moisture to be lifted and condense to form clouds, or to exist as patches of supercooled water droplets
- The observations at nearby Toronto Buttonville and Oshawa airports, and the available forecast guidance, all indicate the possibility of scattered clouds and precipitation in an otherwise mostly clear sky, as well as icing conditions
- Timing was suitable for icing conditions, and the period of several hours with maximum instability (deep adiabatic mixing to the 700 hPa level, no capping inversion and diminishing wind shear, suitable for cloud growth), clearing sky but sufficient moisture and uplift for scattered clouds to form, during a cool air outbreak over warm lake water, and with air temperatures just below 0 C, occurred during early to mid evening
- These meteorological conditions are not rare and occur periodically during autumn while the lake waters are warmer than the cold air in high pressure airmasses spreading across the lakes