The Chilling Result of Cold Temperatures on Barometric Altimeters

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Barometric altimeters on modern aircraft with digital Air Data Computers are very accurate most of the time and we rely on these altimeters in every aspect of today's air travel. For those of us in the Unites States, we diligently set the local altimeter settings prior to each takeoff and each approach but we do not routinely make any corrections for non-standard temperatures. Somewhere in my engineering background, I certainly knew that temperature affects air density but my aviation training has not included a procedure for making temperature corrections.

In ICAO PANS-OPS, Volume 1, in Section 3.5.4 titled "Final approach segment – precision approach – ILS" there is a table that shows altitude corrections to be made by the pilot when the airport temperatures are 0˚ C or below. Because this section applies only to a precision approach, my first impression was that it was only necessary to make adjustments to DH and the FAF for an ILS. The discussion below clearly shows that corrections needed are much more extensive.

Only recently have I started to understand the significant deficiencies associated with barometric altimeters in extremely cold conditions. As you know, barometric altimeters are calibrated to indicate true altitude under international standard atmosphere (ISA) conditions. Any deviation from ISA will result in an erroneous reading on the altimeter. We routinely set the altimeter for the local pressure when we are below the transition level but most of us in the United States do not consider the effect of cold temperatures. It never occurred to me that altimeter errors in cold conditions would be so large to exceed terrain clearance margins on departures or arrivals.

I finally understood cold temperature errors concerning barometric altimeters when I reviewed a recent incident by a southern operator who was making a non-precision approach to an airport in the interior of British Columbia. This approach was conducted in an MD-80 aircraft when the temperature at the airport was –27˚ C. This aircraft was cleared for an approach by Vancouver Center and told to contact the tower for landing clearance. A short time later the aircraft abandoned the approach and came back to the center frequency telling of a GPWS warning. The crew then successfully completed a different non-precision approach and landed safely.

Later, when that crew was questioned concerning the altitudes flown during the first approach, it became obvious that the crew had not applied a temperature correction to the procedure turn altitude. The published procedure turn altitude is 4900 feet above field elevation and with the field temperature of –27˚ C, the crew should have added 800 foot as the temperature correction to that published procedure turn altitude. A quick scan of the approach plate revealed that the mountain just east of the localizer was where the GPWS terrain warning occurred. It was estimated that the aircraft missed the top of the mountain by approximately 150 feet, which was confirmed by the crew's reported radio altimeter readings during the GPWS warning.

While Canada has been applying cold weather altimeter corrections for many years, the FAA is just now doing research on this problem but presently there is no official procedure for implementation of temperature corrections in the US. As each air carrier expands its sphere of operations, the risk increases that their pilots may encounter a situation similar to the incident above, where cold weather altitude corrections are critical. A few degrees cooler that day in British Columbia and that aircraft would likely have hit the top of the mountain.

Let's ask the question again, "Why didn't the local altimeter setting give that crew adequate protection for any approach to that airport?" As stated above, barometric altimeters are accurate only under ISA conditions. Any deviation in either pressure or temperature from ISA conditions will result in an erroneous reading on the altimeter. The local altimeter setting provides the necessary correction for the non-standard pressure in the local area but it does not correct for the effect of non-standard temperature for altitudes above field elevations. The pilot must make the altitude corrections if the temperature at the source of the altimeter setting is 0˚ C or below.

When the temperature is higher than ISA, the true altitude will be higher than the indicated altitude and that will cause little or no problems on any approach. It is only when the temperature is lower than ISA, that the true altitude will be lower than the indicated altitude. The altimeter error is relatively minor down to 0˚ C but it can be significant with extremely cold temperatures especially when you are dealing with the minimum altitudes required on some approaches to airports in mountainous areas. In the incident in British Columbia with the procedure turn altitude approximately 5000 feet above the field elevation, if the temperature had been –50˚ C, it would have required a correction of 1200 feet rather than 800 feet.

Flying into cold air has much the same effect as flying into a low-pressure area; that is, the aircraft is lower than the altimeter indicates. It is the temperature at the source of the local altimeter setting and the height above the elevation of the altimeter source that determines the correction to be applied. Remember, "Cold & low, look out below!" I had heard that before but without procedures to follow for cold temperatures, it fell on deaf ears.

In cold temperatures, altitude corrections must be applied by the pilot to all MEA's, sector altitudes, procedure turn altitudes, FAF crossing altitudes, DH, MDA and missed approach altitudes. These corrections need to be made anywhere cold temperatures are encountered, not just in mountainous terrain. We need to look at the data again on past accidents that may have been affected by cold temperature altimeter errors.

Radar vectoring altitudes are corrected for temperature in Canada but there is no guarantee in the rest of the world. I wasn't able to confirm whether there is any cold temperature correction of radar vector altitudes in the United States but my guess is that they do not correct for temperature. They may accommodate for it in other ways. The main issue here is that pilots need to be aware of the local practice on radar vector altitudes and operate accordingly. The bottom line is that the pilot has the responsibility to refuse a radar vector altitude if he does not think it provides adequate terrain separation.

Cold temperature errors affect Enhanced GPWS and most likely to GCAS in the same manner as they affect barometric altimeters. Unless temperature corrections for the altitudes used by EGPWS and GCAS are automated or greatly simplified, these new systems will always have a flaw that may someday come back to bite someone.

ALPA is fully supporting the FAA's efforts toward making cold temperature corrections a standard part of our operations in the US. We would endorse the effort that Canada has done and would hope that the FAA will soon provide similar procedures for US carriers to follow. We need to go beyond that and see that changes are made to ICAO so that it is clear that cold temperature corrections are applicable to all approaches, not just precision approaches. In addition, it must be clear to all pilots which altitudes must be corrected.