# MP-G Icing Risk Identification

First RF, Radiometrics (RDX) and RHS Consulting (RHS) are developing icing hazard detection and avoidance capability using RDX G-band Microwave Profiler (MP-G) technology. RHS obtained airborne MP-G observations of orographic clouds including supercooled liquid water (SLW) and inherent icing risk. MP-G brightness temperature (Tb) observations and coordinated photos are presented below.

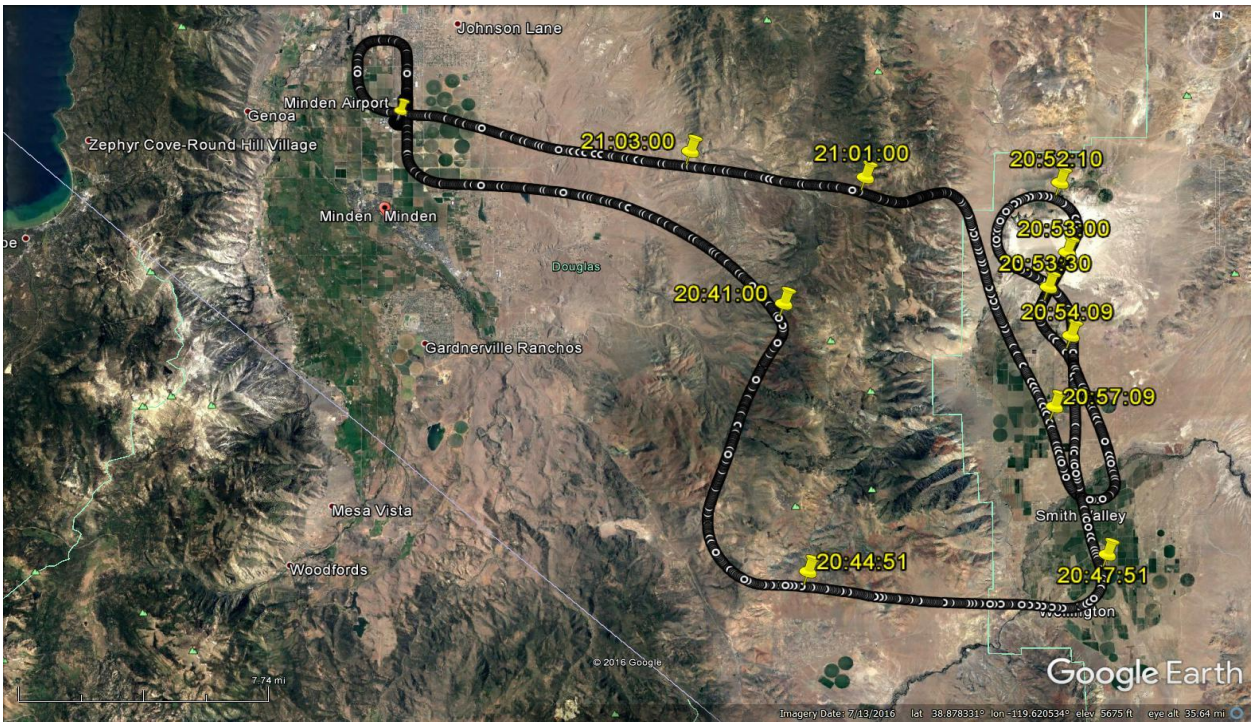


*Figure 1. Flight track encircling Pine Nut Mountains (24 Mar 2017).*

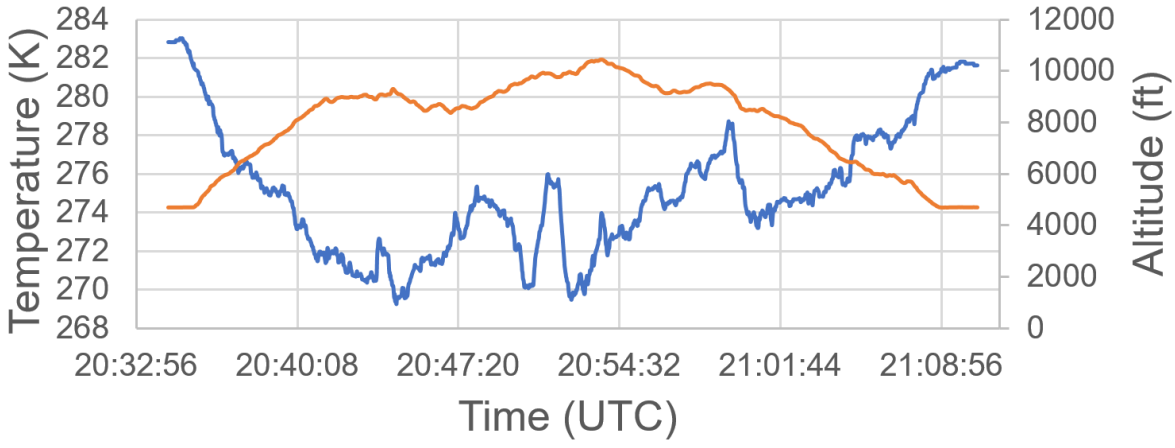


*Figure 2. Flight path temperature (blue) and altitude (orange).*

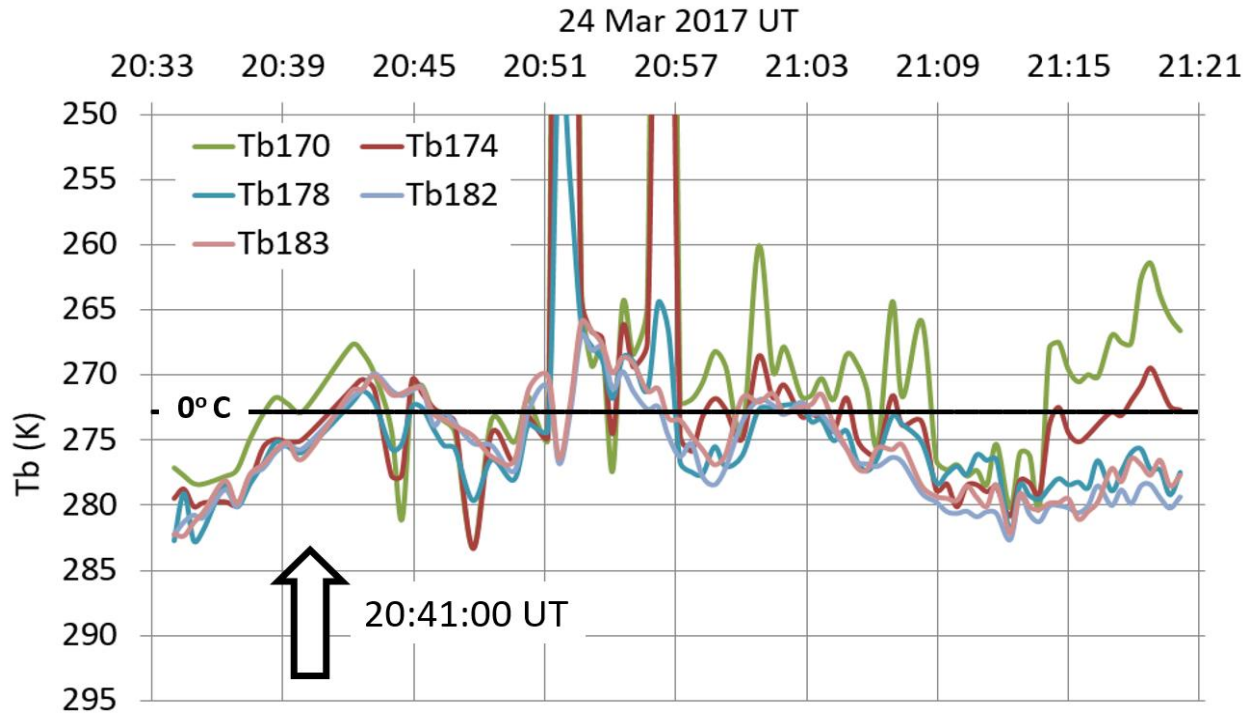


*Figure 3. 20:41 Right Bank, T=271.9 K, Z=8,725 ft.*

Looking upward through dense cloud, strong compression near 276 K (2.8) for $Tb_{174}$ to $Tb_{183}$ is consistent with liquid water in this direction. However, $Tb_{170}$ expansion to 273 K (~0 °C) is consistent with a moderate amount of above freezing liquid along this path with moderate icing risk.

*Note top panel upward Tb decrease on the vertical axis in accordance with standard atmospheric temperature lapse rate.*

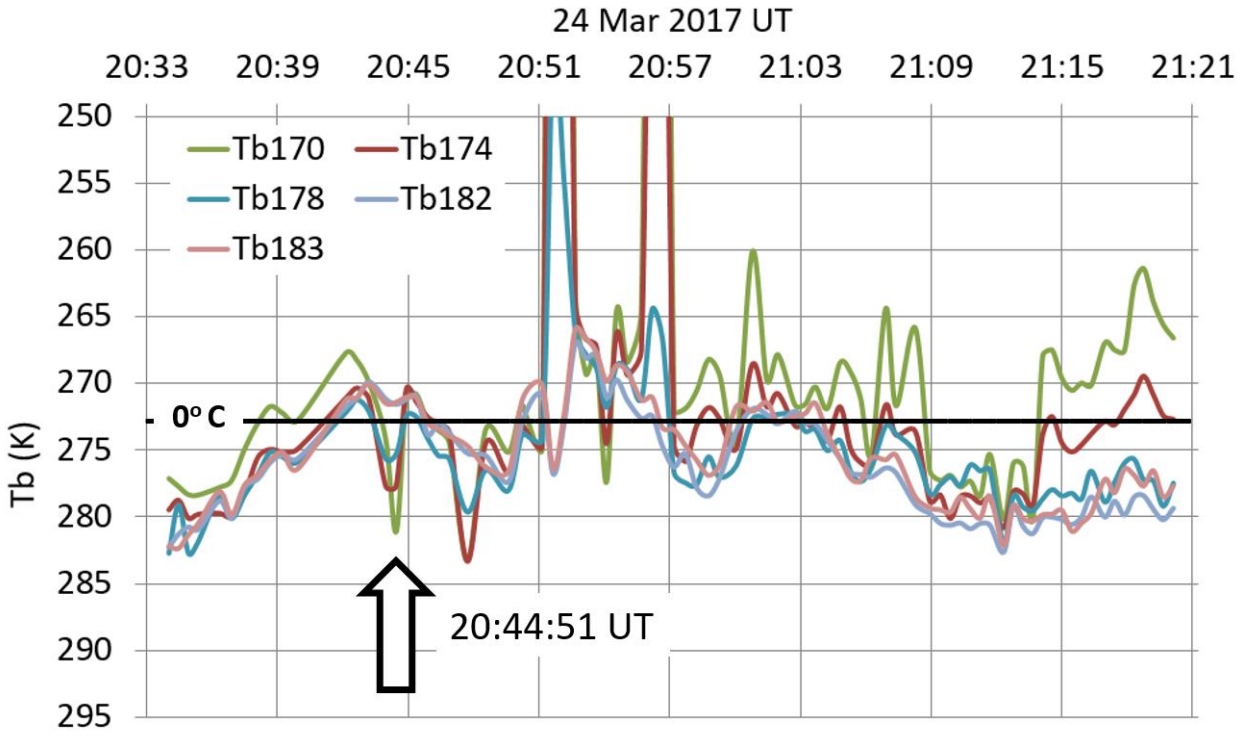


*Figure 4. 20:44:51, Left Bank, Southwest side of the Pine Nut Range, T=270.2 K, Z=9,297 ft.*

Looking down through clear air at terrain with partial snow cover. Tb expansion (10 K) due to warmer air at lower levels identifies a descending flight path free from icing risk.

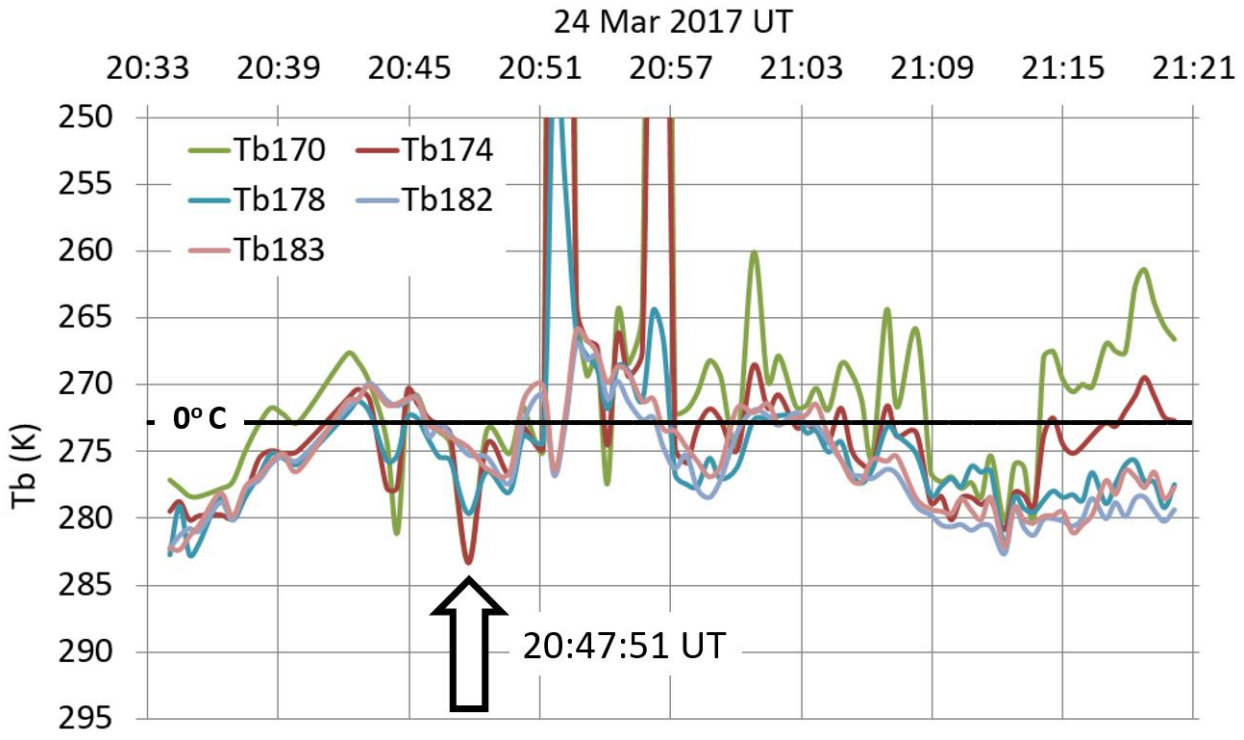


*Figure 5. 20:47:51, Left Bank, T=274 K, Z=8,552 ft.*

Looking down through clear air at valley floor. Tb expansion (8 K) is consistent with increasing air temperature at lower and terrain levels and corresponding absence of liquid water. A descending flight along this path would be free from icing risk.

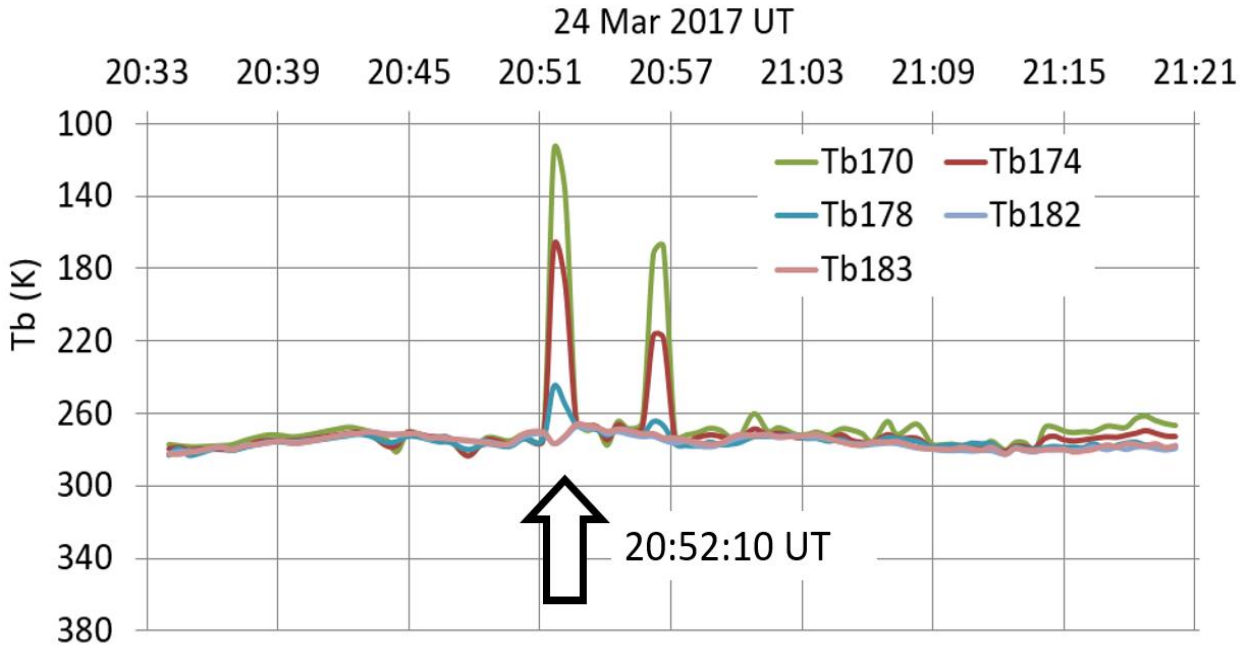


*Figure 6. 20:52:10, Steep Right Bank, T=271.1 K, Z=9,895 ft, GS=206 Knots, strong updraft.*

Looking upward through thin cloud and clear air shows $Tb_{183,182}$ near ambient temperature and $Tb_{170}$ much colder. Tb expansion (160 K) identifies low icing risk along this path.

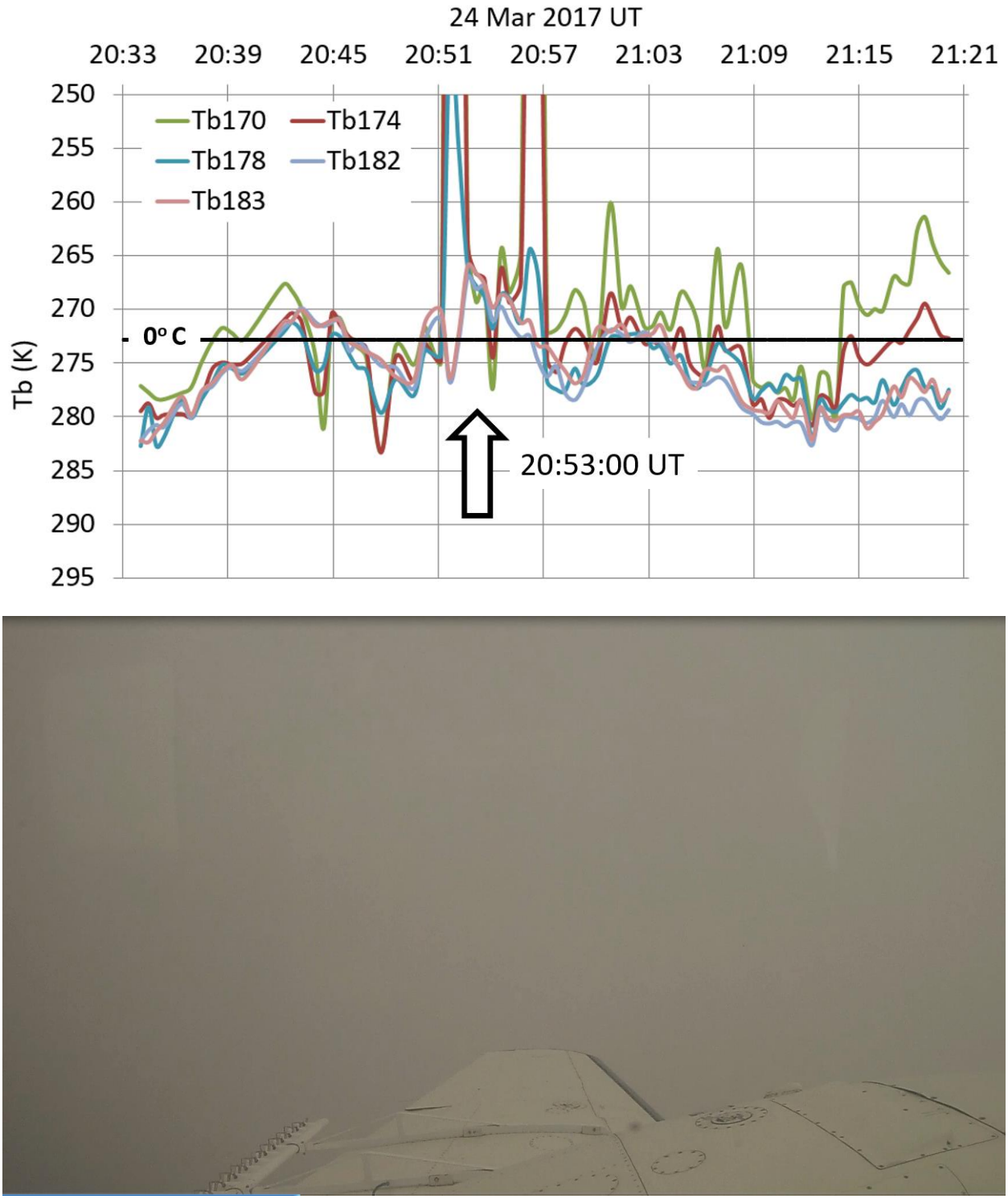


*Figure 7. 20:53, Steep Right Bank, T=269.8 K, Z=10,217 ft, strong compression consistent with updraft.*

Strong compression with all Tb close to 267 K identifies an upward flight path with high icing risk. Alternative upward flight paths recommended (e.g. Figure 7).

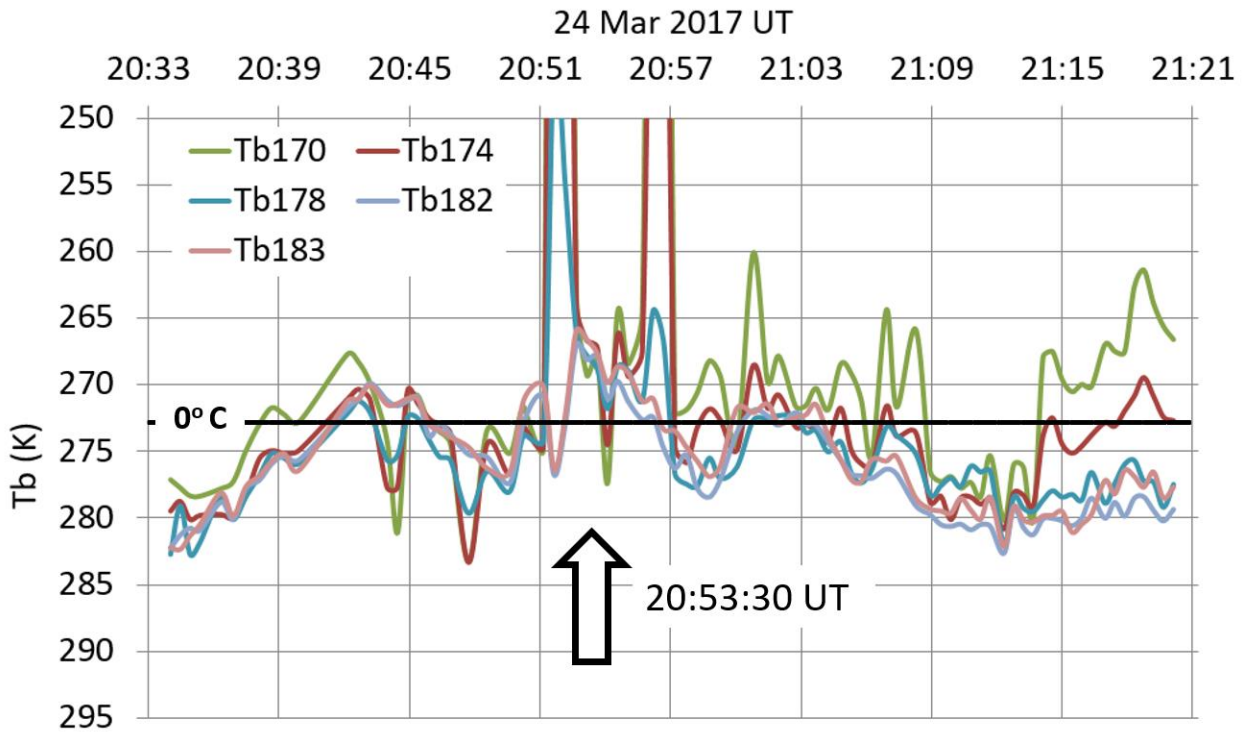


*Figure 8. 20:53:30, Leveling out, T=272.5 K, Z=10,360 ft.*

Strong compression with all Tb close to 267 K identifies a level potential flight path with high icing risk. Alternative level flight paths recommended.

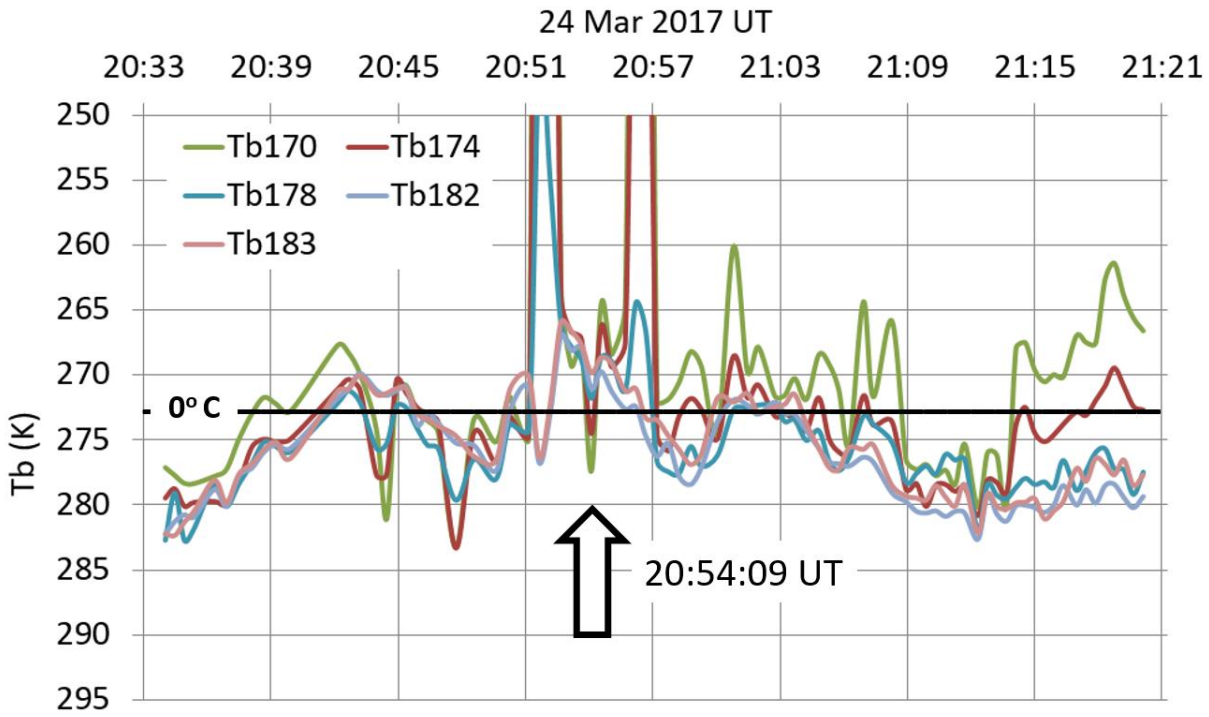


*Figure 9. 20:54:09, Left Bank, T=272 K, Z=10,321 ft.*

The wing camera shows clear air down to ground level during this left bank turn with increasing $Tb_{170}$ - $Tb_{183}$ expansion and identifies a low risk descending flight path.

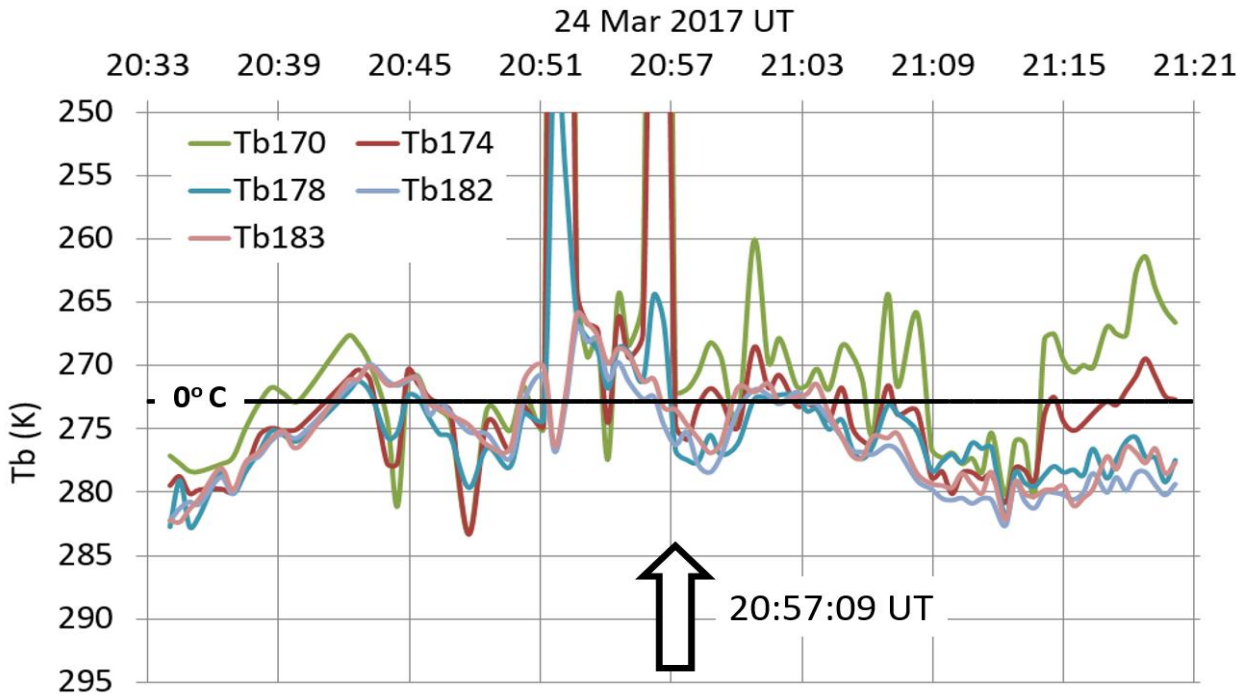


*Figure 10. 20:57:09, Level Flight, T=274.3 K, Z=9,173 ft.*

Near freezing $Tb_{183,182,178}$ are observed over their relatively short effective ranges during level flight. Subfreezing $Tb_{174,170}$ observations include snow-covered (colder temperature) mountain ridge in the radiometer field of view as shown by the elevation profile in the following figure.

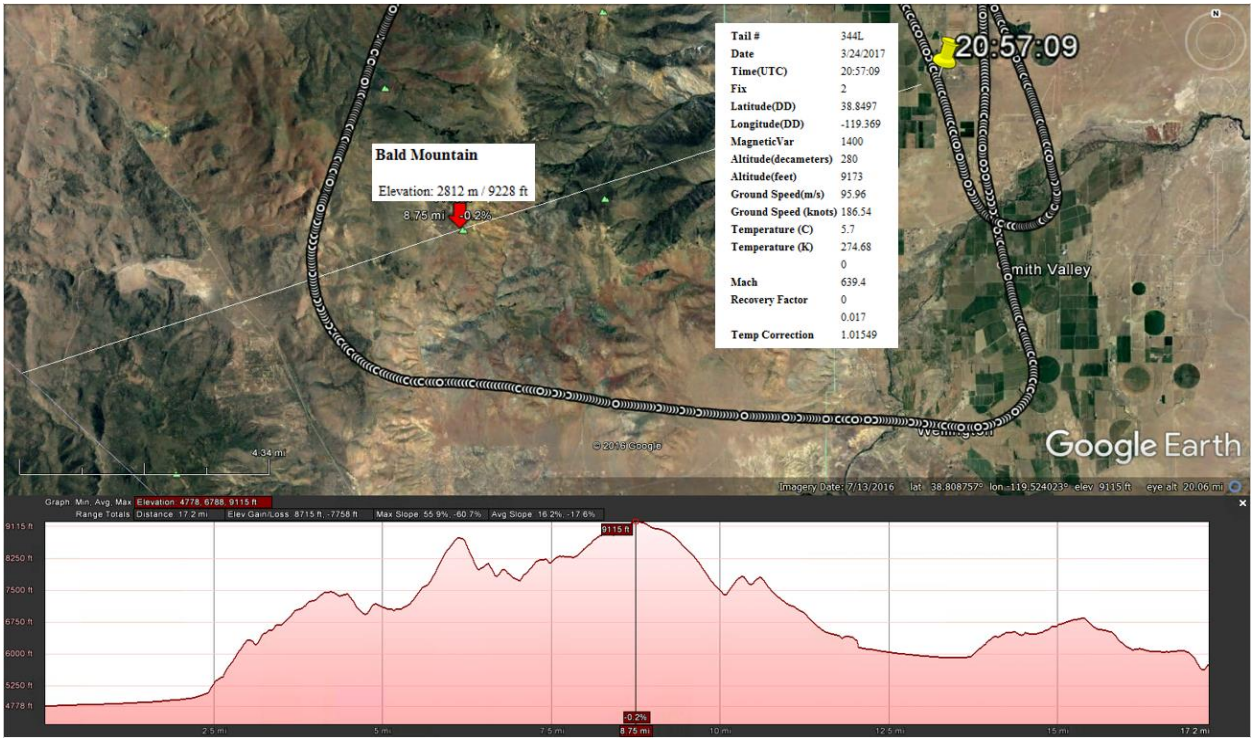


*Figure 11. Flight track with 20:57:09 aircraft location at 9,173 ft altitude and the elevation profile along the horizontal MP-G field of view (white line extending south-west-west of the time stamp). Bald Mountain (9,554 ft) lies within the radiometer field of view.*

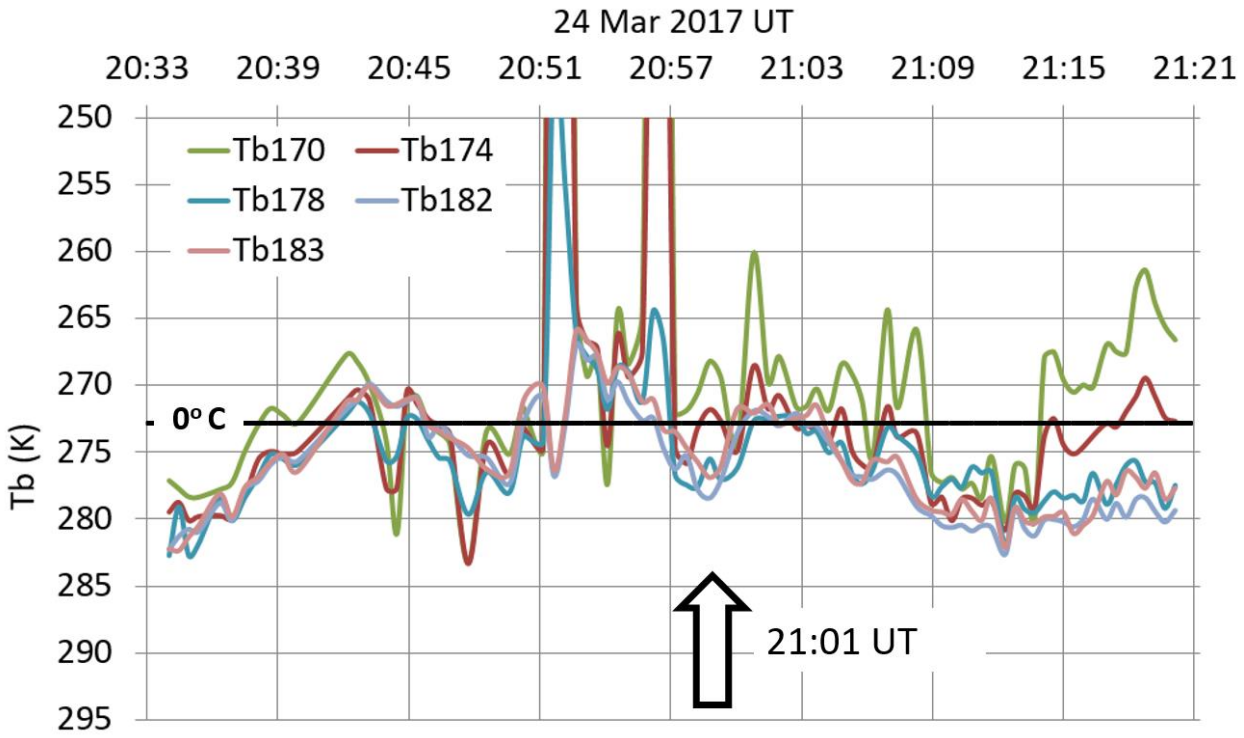


*Figure 12. 20:01:00, Level Flight, T=274.3 K, Z=9,173 ft.*

Level flight at 8,494 ft looking SSW at semi-transparent cloud along the elevation profile shown in Figure 13 ascending to 9,008 ft at 10 km distance. $Tb_{183,182,178}$ = 276 to 278 K, $Tb_{174}$ = 172 K and $Tb_{170}$ = 168 K were observed. This is consistent with low density liquid cloud in the field of view with the upper channels observing cloud

temperature at relatively short range and the lower channels observing colder temperatures of snow-covered high ground.

The aircraft temperature probe measured 274 K (Figure 12 caption) whereas the upper three channels measured 2 to 4 K warmer temperatures. These short range temperature variations are consistent with 6 K variation over short time periods and distances seen in Figure 2.

$Tb_{170}$ - $Tb_{183}$ expansion = 10 K is consistent with relatively low icing risk for a flight path in this direction due to relatively low density liquid.

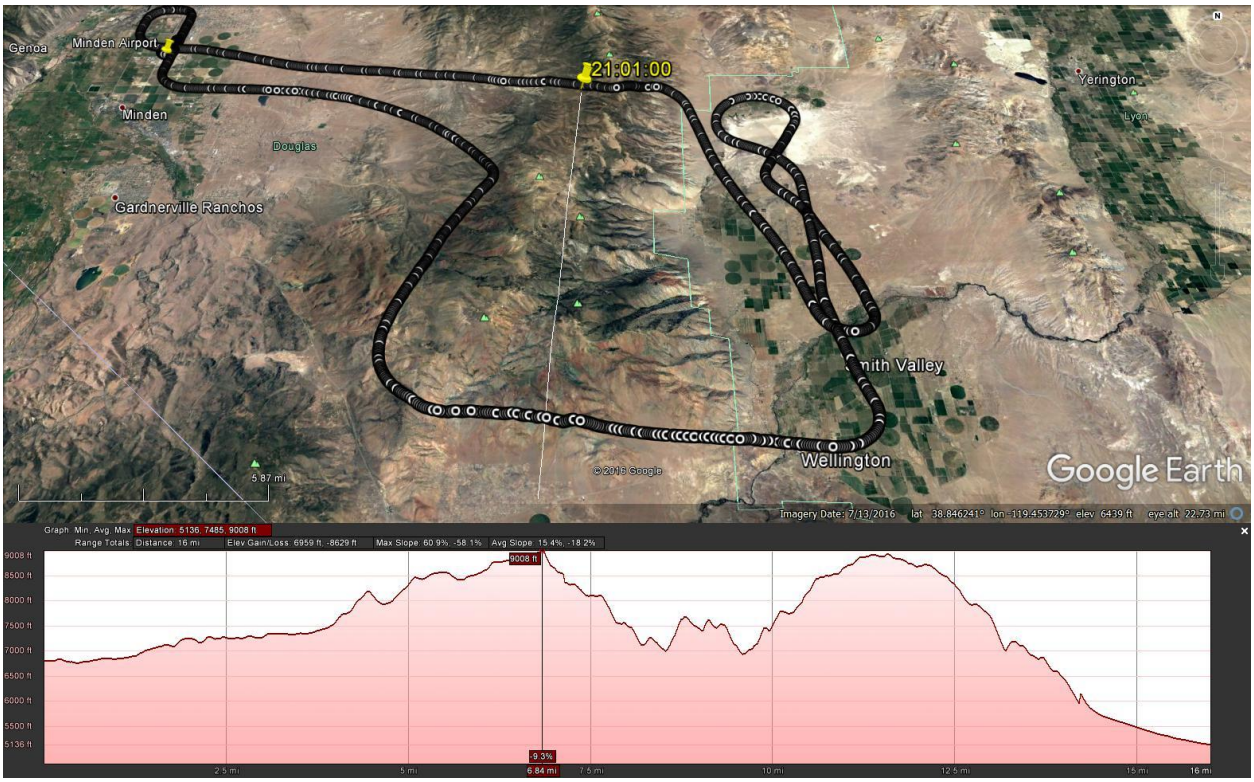


*Figure 13. Flight track with 21:01:00 aircraft location at 8,494 ft altitude and elevation profile along the horizontal MP-G field of view (white line extending south-south-east of the time stamp).*

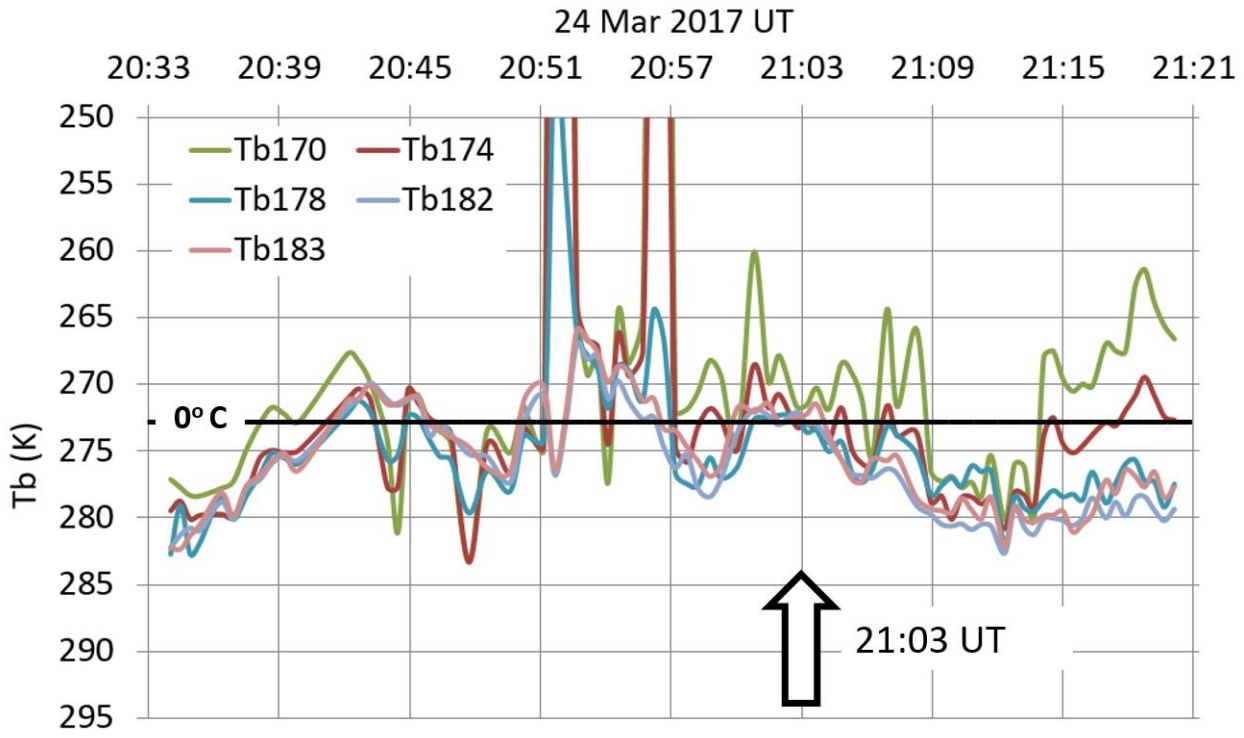


*Figure 14. 21:03:00, Level Flight, T=274.7 K, Z=7,530 ft.*

These level flight observations show all channel Tb compression near freezing temperature consistent with dense liquid in the radiometer field of view. Icing risk would be higher for a flight path in this direction compared with the direction viewed in Figure 13 with Tb expansion.

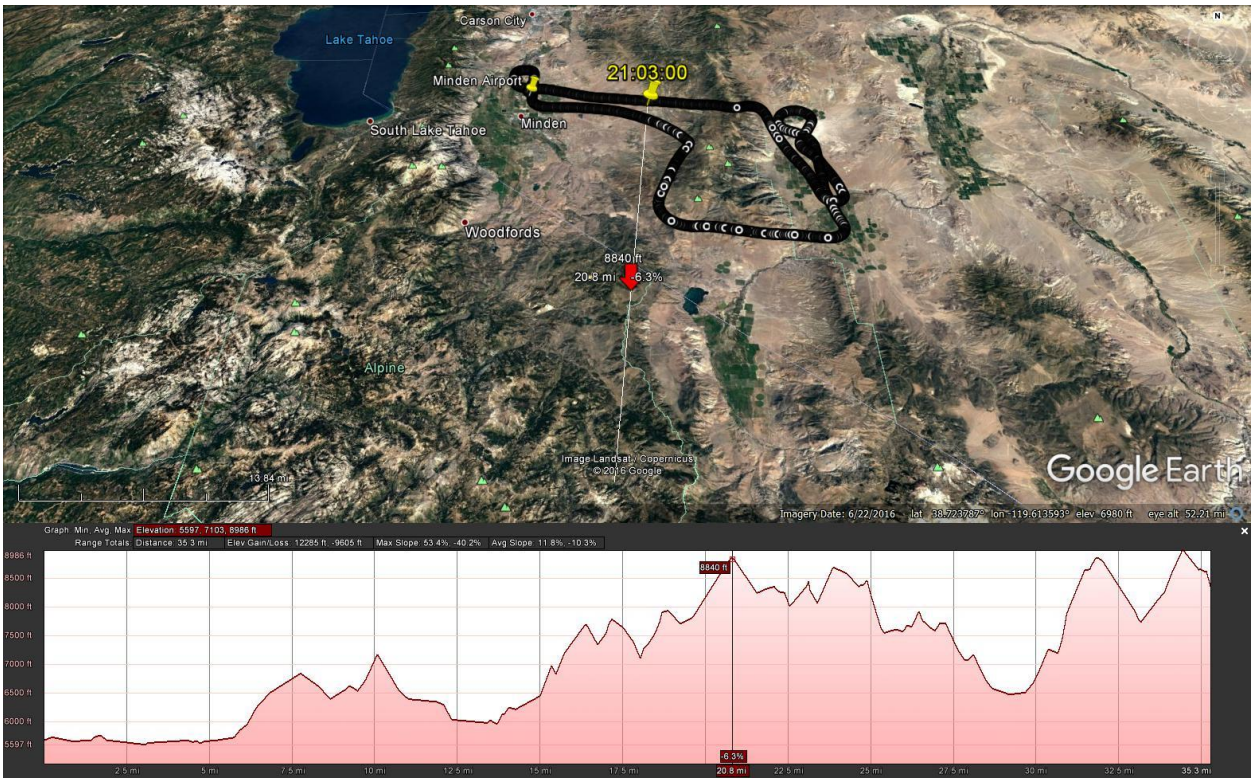


*Figure 15. Flight track with 21:03:00 aircraft location at 7,530 ft and elevation profile along the horizontal MP-G field of view (white line extending south-south-east of the time stamp).*

## Discussion

Side scanning MP-G observations in horizontal, upward and downward directions show multichannel Tb compression when liquid water resides in the radiometer field of view, in contrast with Tb expansion in the absence of liquid water. Cloud and clear air in the radiometer field of view was determined by coordinated wing camera photos. In addition to Tb expansion and compression, the multichannel Tb values provide liquid water temperature information that contributes to icing risk identification.

In summary, the flight data and analyses in this report demonstrate the promise of MP-G observations for reliable and accurate icing risk identification and avoidance.