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Meteorological aspects of Ice accretion over Assam air routes

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ABSTRACT. The debriefing reports for 1954-56 received from Dakota aircraft in respect of ice accretion on Assam air routes have been studied in conjunction with synoptic charts and aerological data. A study of the freezing level on these routes, which is intimately connected with icing conditions has also been made.

1. Introduction

In view of the increase in flying activities in Assam at present, the problem of the incidence of icing on the air routes in Assam, is of practical interest both to the aviators and the meteorologists. To a certain extent, this problem assumes a greater importance on account of the hilly terrain of Assam which precludes the possibility of avoiding icing by flying low.

The present note is based on a study of the debriefing reports received in the Main Meteorological Office at Gauhati during the years 1954-56, and the experiences of a large number of aviators who had been flying over these routes very frequently during the last few years. The debriefing reports as well as the experiences of the pilots pertain to icing conditions at the usual flying levels of Dakota aircraft. These reports have been studied in conjunction with the synoptic charts and the available upper air soundings.

2. Debriefing Reports

Although the number of debriefing reports studied was only 21, the following facts stand out prominently—

(*i*) Icing was reported only during the winter months (December to March), and

(*ii*) icing was most frequent over and near the hills*.

3. Experiences of Pilots

To supplement the data available from the debriefing reports, over forty pilots, some of them with a record of six to ten years of flying experience on these routes, were interviewed individually, and information about *their own* experiences of icing were collected. A general summary of the icing conditions as gathered verbally from them, is given below—

(*a*) *Locality*—Icing occurs mainly over the hills and the neighbourhood and occasionally in the Assam Valley also.

(*b*) *Season*—Icing is confined mostly to the winter months.

(*c*) *Heights of Icing*—In winter, icing generally occurs between 7000′ and 11,000′ a.s.l. going upto 11,000′ to 14,000′ a.s.l. during the summer and the monsoon months.

(*d*) *Frequency*—The frequency of ice accretion met with by each pilot was not very high.

(*e*) *Type of Icing*—Light icing was reported by most of the pilots with a few reporting moderate to heavy icing.

(*f*) *Weather and Cloud systems*—Icing was encountered in rain or in thick stratified clouds.

(*g*) *Temperature*—Only a few could give details about the temperatures when icing

*Hills refer to Khasi-Garo-Jaintia hills, the same terminology will be used in the subsequent paragraphs also

occurred. The temperatures were reported on some occasions as definitely above 0°C; the range reported was + 4°C to a few degrees below 0°C.

(*h*) *Other interesting details*—(*i*) According to some of the pilots, one should not conclude that heavy icing is not probable on these routes merely from the fact that moderate to heavy icing is not frequently reported.

(*ii*) Icing is met with only under certain optimum conditions. Pilots have reported cases when they had experienced icing over a certain locality on the onward trip, but had no icing at all while returning through the same locality a little while later, under the same meteorological conditions.

4. Synoptic situation and upper air conditions

The synoptic and upper air conditions on days when ice accretion was reported in the debriefing reports are discussed below—

(*i*) *Synoptic situation*—On days when icing occurred, active western disturbances were moving across northeast India; in most cases, they were associated with active secondaries at lower latitudes and well-marked upper air discontinuities.

(*ii*) *Weather and Clouds*—The associated weather on these occasions had been heavily clouded skies with rain or drizzle. The cloud systems were extensive altos or high *Sc* or *St*. Thunderstorms and large *Cu* or *Cb* clouds were observed only on a few occasions.

(*iii*) *Convective Instability*—In the cases analysed, the air mass was convectively unstable in quite a number of cases.

(*iv*) *Humidity Mixing Ratio*—Icing conditions, among other things, depend to a large extent, on the liquid water concentration which in its turn is a function of the mixing ratio. Hence a high value of the humidity mixing ratio (particularly in lower levels) should be a sufficient basis to indicate heavy icing.

5. Freezing level

(*i*) The average and the minimum values of the freezing level for each month for Shillong* and Gauhati are given in Table 1. The earlier data† available for Agra and Calcutta are also included for purposes of comparison.

(*ii*) A comparison of day to day values of the freezing levels during the periods of passage of western disturbances, when icing was reported in the Assam routes showed that—

(*a*) The passage of a disturbance was associated with a depression in the freezing level, and

(*b*) the freezing levels on such occasions became below the average value for the month.

The first conclusion was also verified to be true in a large number of cases in the winter (Nov-Mar) of 1954 and 1955. The freezing level (of Shillong and Gauhati) suddenly dropped with the occurrence of some weather in Assam (due to passage of western disturbance). This lowering of the freezing level is due to the fact that in the waves in the westerlies, in winter, the upper trough is cold relative to its surroundings (Riehl 1954).

(*iii*) It is also noticed over Assam, that—

(*a*) there is a greater range of variation of the freezing level in the winter months and

(*b*) during the monsoon, it is more or less constant.

*Radiosonde station at Shillong was started on 27 April 1953, taking one ascent daily at 1800 GMT; on 22 July 1955, it was shifted to Gauhati. Although Gauhati takes two ascents daily (at 0300 and 1500 GMT) for the sake of uniformity and also camparability with the earlier Shillong data, only the 1500 GMT data were considered in working out the means etc.

†From *India met. Dep. Tech. Note*, 2, "Ice Accretion in India".

TABLE 1

Monthly average and minimum freezing levels (ft a.s.l.)

Month	Shillong and Gauhati			Agra		Calcutta	
	No. of Obsns.	Average*	Min.	Average	Min.	Average	Min.
Jan	93	11400	7500	12000	8500	13500	10000
Feb	83	12700	8400	11000	7800	13000	10000
Mar	90	13500	8900	13000	10000	13000	12000
Apr	88	14900	11400	14000	12000	15000	13000
May	53	14700	13100	15000	13000	17000	14000
Jun	57	18100	14400	17000	14000	18000	15000
Jul	86	18500	14400	19000	16000	18000	15000
Aug	82	17900	15000	19000	16000	18000	15000
Sep	86	17200	14100	18000	14000	16500	14000
Oct	90	16200	12900	15000	12000	16500	13000
Nov	86	14800	9300	14000	9000	15500	12000
Dec	93	12200	8200	13000	8000	15500	10000

*The day-to-day figures were rounded off to the nearest hundreds of feet and the averages were worked out

The greater range during the winter is apparently caused by the frequent passage, across Assam, of western disturbances and the associated changes in the air masses, while the absence of such moving "lows" during the monsoon, except in the 'break' periods, keeps the freezing level more or less the same during whole monsoon.

6. Conclusions

From the above discussion the following conclusions are drawn which may be of help to the meteorologist in his day to day work of forecasting for these routes where Dakotas are the common operating aircraft.

(*i*) Icing occurs on these routes mostly in the winter or early premonsoon months.

(*ii*) Icing conditions are met with only during the passage of active western disturbances (associated with secondaries) when extensive cloud systems and precipitation areas form over these routes.

(*iii*) Icing occurs mainly over and near the hills and to some extent in the Assam Valley.

(*iv*) Icing occurs with temperatures below zero as well as a little above zero. During the passage of western disturbances the freezing level comes down. The incidence of icing in *Cu*, *Sc*, *St* or alto clouds, in view of their extensive nature, appears to be a greater probability than in *Cb*.

(*v*) Ice accretion depends on various factors such as temperature, drop size, liquid water content, and the shape and speed of the aircraft. As a result, icing occurs only selectively.

(*vi*) Icing is generally light to moderate; however, heavy and rapid icing is not ruled out.

(*vii*) The stability of the air mass as well as the humidity mixing ratios as revealed by the radiosonde ascents from stations

on the route, should be assessed to see whether heavy and rapid icing will be encountered.

The above ideas may be helpful in forecasting icing conditions in these routes and also in advising pilots regarding diversions and alternate flight levels which can be profitably adopted to avoid flying in icing conditions (either anticipated or actually reported).

7. Acknowledgement

The author would like to record his gratitude to the pilots who gave their debriefing reports and discussed about their experience of icing.

REFERENCE

Riehl, H. 1954 *Tropical Meteorology*, pp. 270-271.