Winter Thunderstorms in the Middle European Aera

By Dr. Jirí Förchtgott, Hydrometeorological Institute, Prague

Paper presented at the XI OSTIV Congress at Leszno

In Middle Europe thunderstorms are almost exclusively the phenomenon of warm seasons. 'Almost' refers to the very small number of days—2 % of the year—with thunderstorms that occur during winter months. By this statistical result there has been defined the official standpoint of some meteorologists to the reality of winter thunderstorms. They have been considered—as in the case of other rare but real meteorological phenomena—as an 'almost' non-existent exception of no practical importance.

But the exceptionality of the winter kind of thunderstorm does not end with the low percentage of its occurrence. It has been necessary to collect as much information as possible on the structure of this phenomenon, on account of very severe operational experience, both on the ground and in flight.

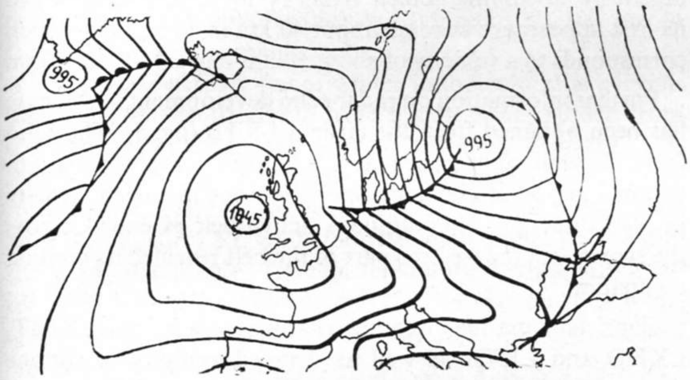


Fig. 1 – Synoptic situation typical of winter thunderstorm development in middle Europe area, 6th February 1964

In February 1964 there started the organised investigation, by collecting pilot reports, by evaluation of detailed meteorological material from a number of affected stations, and by analysis of aerological messages from the affected area.

There has been found a number of characteristics substantially different from those of the 'regular' 98 % of warm season thunderstorms. The first surprise represents the unusually low top of winter Cb producing real thunderstorms. It is rarely surpassing the level 600 mb, i.e. about 4500 m. Usually it is assumed that no thunderstorm at all can develop without Cb reaching or surpassing the level 500 mb, i.e. about 5500 m, which is the rule for warm seasons.

During winter the very rare instability within the air layer from the ground up to 600 mb level takes place exclusively in NW situations over Middle Europe bringing arctic maritime airmass from NW over the continent. The active low pressure centre is situated in the region of Finland, while high pressure is affecting France and Great Britain. The pressure difference between low and high pressure centers is about 40–50 mb (fig. 1).

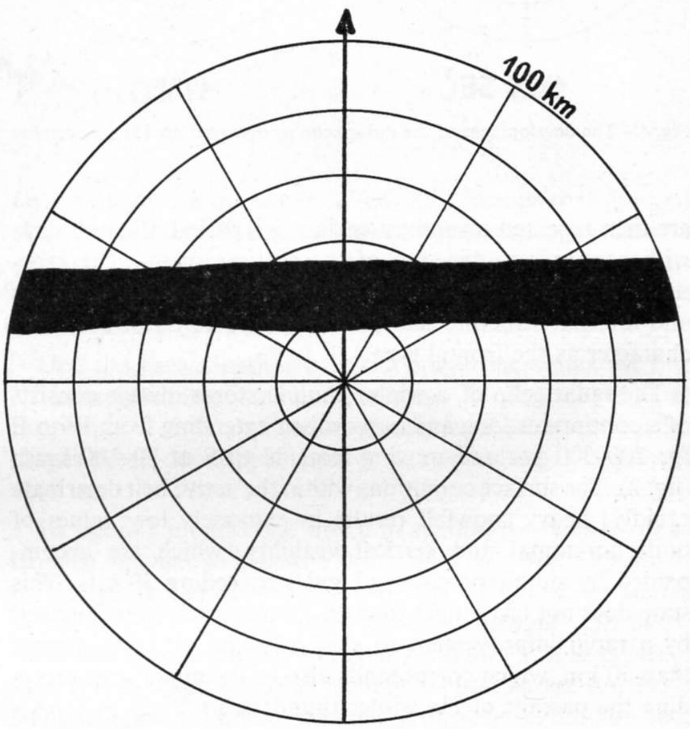
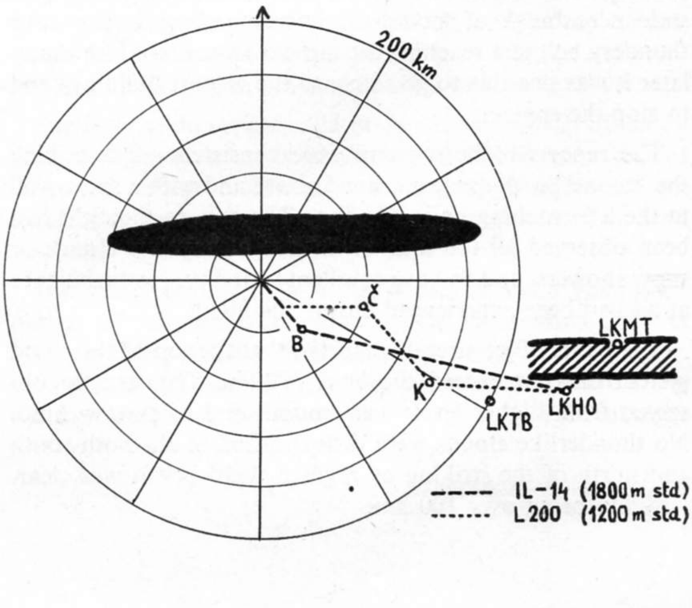


Fig. 2 – Typical radar echo of winter thunderstorm—according to observation in LKTB on 6th February 1964

The high pressure gradient produces strong northerly winds in middle Europe, which is a second substantial difference from warm season thunderstorms, which are mostly prevented by strong winds and wind shears.

The winter thunderstorms are usually initiated by the passage of an arctic cold front through Middle Europe, and

Fig. 3 – Radar echo of winter thunderstorm on 18th November 1964 with flight paths of two aircrafts flying by chance all the route of 250 km close in front of the active belt. The shadowed stripe to the right represents the position of the active belt of the landing of the first aircraft in LKHO



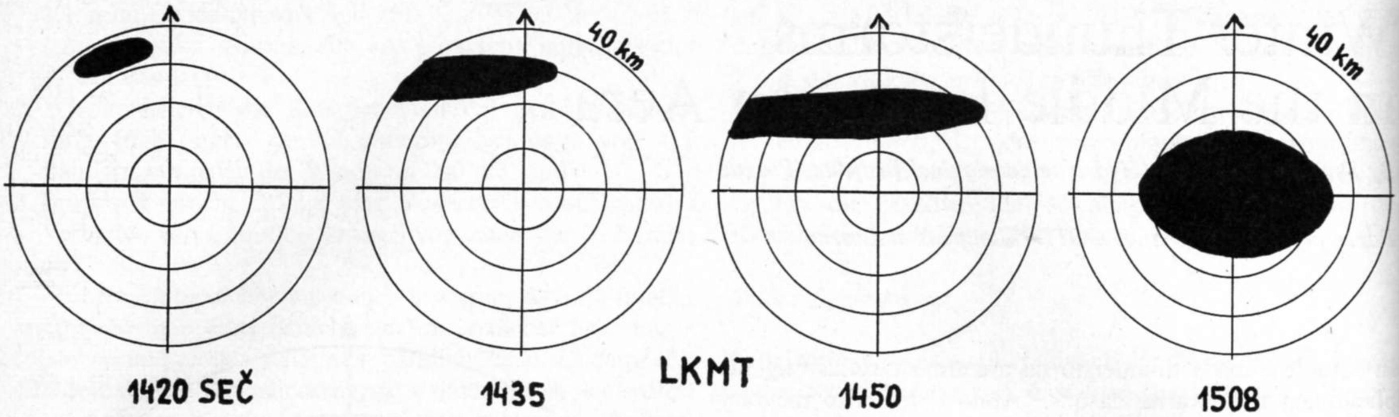


Fig. 4 – The development of the radar echo as observed on 18th November 1964 in LKMT

are then repeated several times during a period of 2 or 3 days with continuing advection of the arctic airmass. The repetitions are evidently of airmass origin although their intensity and internal structure has been observed to be of the same character as the frontal type.

The radar echo of a winter thunderstorm always consists of a continuous long and narrow belt extending from W to E for 200–300 km and moving from N to S at 80–100 km/h (fig. 2). The surface conditions within the active belt deterioate rapidly; heavy snowfall results in extremely low values of both horizontal and vertical visibility, which are accompanied by simultaneous wind gusts exceeding 30 m/s. This state does not last longer than 10–15 minutes and is followed by a rapid improvement to clear sky and visibility greater than 50 km, which corresponds also to the conditions preceding the passage of the winter thunderstorm.

On 18th November 1964 by chance two aircrafts were flying in close succession just in front of the active belt of a winter thunderstorm on the air route Prague–Holesov (LKPR-LKHO: 250 km). The first was a L-200 airtaxi departing from Prague to Ostrava (LKMT), but shortly after take-off it was forced by a dense snowwall aproaching from the left to turn off gradually more to the right in order to maintain VFR. Along all of the 250 km route there was no gap in the snow wall, which could allow VFR flight to the planned airfield Ostrava. Finally a landing was made on the airfield at Holesov 80 km south west of Ostrava (fig. 3).

The regular airliner landed shortly after the airtaxi in LKHO, too, but it had to stay at the runway owing to a sudden outbreak of snowstorm corresponding to the active thundery belt just reaching the airfield area. Only 10 minutes later it was possible to go safely to the airport buildings and to stop the engines.

The reports of both crews were consistent in describing the 'tunnel' with dense As cloud above and with a snow-wall to the left reaching up to the base. The area to the right had been observed all the time to be free of any low clouds or snow showers, and to have excellent visibility. No turbulence at all had been experienced during the flight.

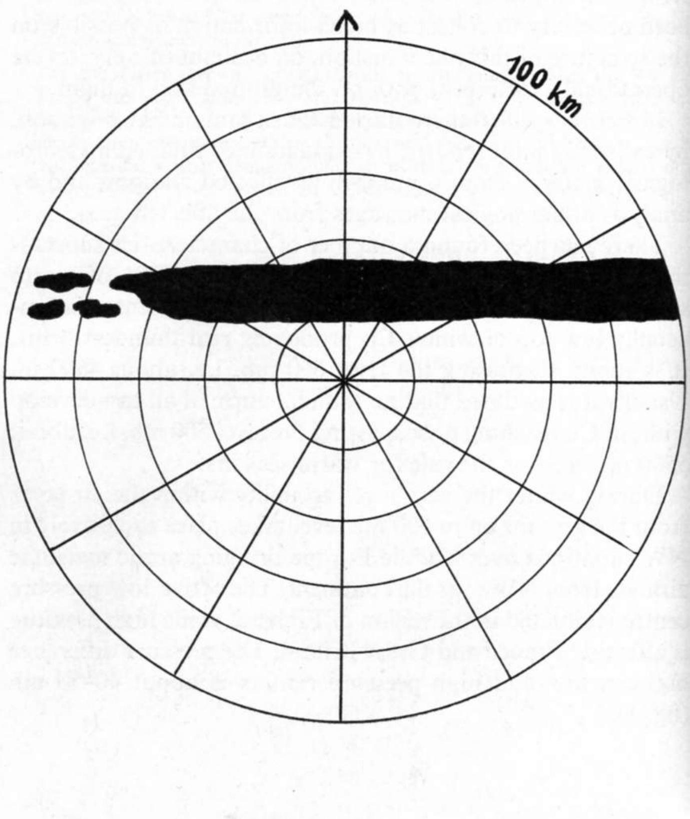
The pilots of jet aircraft reported that the top of the cloud system did not exceed the level 5000 m. The structre observed from higher levels was smooth and of a wavy kind. No thunderlike clouds were distinguished at all. Both south and north of the striking by regular cloud belt it was clear, visibility being over 100 km.

Other pilot on flights crossing the active cloud belt reported the presence of thunderstorms and heavy turbulence at levels below 2000 m. Interesting radar echo development was observed in LKMT (fig. 4). At first a small patch of active cloud appeared on the north-westerly margin of the screen. It propagated rather quickly in easterly direction, forming a continuous narrow belt which moved simultaneously down the screen from N to S. The echo from its first appearance covered about 40 km in 48 minutes which corresponds to a velocity of about 50 km/h in a N–S direction.

Further information on radar echo development in this case has been obtained from the airfield LKTB (fig. 5). The echo from its first appearance at 1505 MET covered 100 km within a period of one hour, showing twice the mean velocity in N–S direction. A continuous active belt extended across the screen, but the western part of the belt revealed its gradual dissipation.

Consistent gradual weather changes on stations LKMT, LKHO and LKTB as well as detailed analysis of surface

Fig. 5 – The radar echo of the winter thunderstorm on 18th November 1964 in LKTB



wind, pressure and temperature recordings corresponding to the passage of the winter thunderstorm have been used to construct its cross-section (fig. 6). The aerological messages as well as pilot reports completed the material used, and enabled a detailed picture to be deduced of the striking cloud system.

It seems likely that to some degree the initial stage of narrow and long cloud system is due to the effect of mountain ridges in north Bohemia and Moravia. From the structure of the surface wind and pressure changes occurring during the passage of the active cloud belt, it is deduced that a substantial element of that system is an unusually long and continuous circulation having a horizontal axis—analogous to the rotors and squalls in front of some warm season thunderstorms—imbedded in the strong northerly airflow. Once formed, due to the convenient topography, it is maintained in action for hours by combined thermodynamical effects established by thermal instability within the layer of rather strong airflow.

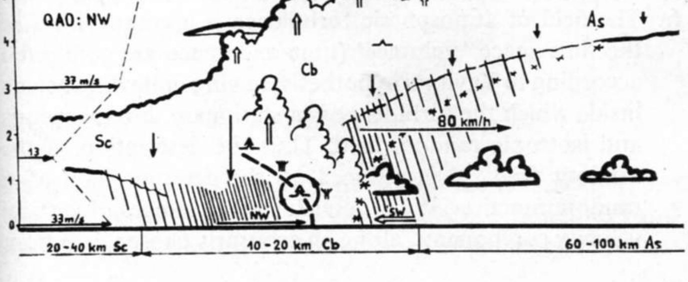
The accelerating penetration of the active belt, and its evident propagation to the east as well as its dissipation from the west, correspond well with this supposition (fig. 3, 4, 5). The cross section of the unusual cloud system is composed of three parallel zones of different structure. The As-zone represents the oldest and highest cloud parts, transferred by extremely strong upper winds a distance of 60–100 km in front of the narrow middle zone.

The intense activity the of winter thunderstorm is concentrated within the 10–20 km wide middle zone, hidden from the observer in the frontal area by increasing snowfall. This middle or rotor zone contains heavy turbulence due to the rotor action. The SW surface wind just in front of the rotor zone brings warm air, while the NW wind within and behind the rotor zone is cold. The registered abrupt temperature fall on 18th November 1964 was 6° C. The rear Sc-zone if the system is 20–40 km wide and follows just behind the snowy and gusty rotor zone.

The life-cycle of the system observed in November 1964 lasted about 3 hours and its dissipation took place about 300 km to the south as a belt of rapidly weakening snow showers becoming more and more isolated.

Taking into account the unexpected appearance of that system, its striking length as well as rapid motion, and its activity being well hidden from optical observation from any surface or airborne position—the danger to air traffic within the area of 60 000 to 90 000 km² covered during even the short life period of such a winter thunderstorm becomes obvious.

Fig. 6 – Cross-section of the cloud system corresponding to winter thunderstorms. The optically observable cloud parts are expressed by heavy lines. The upper wind profile and given dimensions correspond to the case of 18th November 1964



From the standpoint of glider pilots the most interesting region would be within the layer 2000–5000 m just above the northerly border of the rotor zone. Due to increasing upper wind velocity, the 200 or 300 km long active cloud barrier represents a slope of such a length, giving ware-type lift, marked out by lenticular clouds. It seems likely that rapid cross-country motorless flights up to 300 km could be realised in the winter season, which could represent a further property of the otherwise severe cloud system described.

Résumé

Le 2% des orages qui se produisent sur l'Europe centrale sont observés pendant l'hiver et sont souvent considérés comme n'ayant pratiquement aucune importance. Cependant, les orages peuvent aussi à cette saison avoir des incidences graves sur les opérations de vol.

Une des caractéristiques de ces orages hivernaux est que les cumulonimbus montent rarement à plus de 4500 m, tandis que la règle applicable aux saisons chaudes est que les orages ne se développent que lorsque ces nuages dépassent 5500 m.

La figure 1 montre une situation synoptique typique, dans laquelle peuvent se produire des orages en hiver, présentant un centre de basses pressions sur la Finlande et de hautes pressions sur la France et la Grande Bretagne. Un écho-radar caractéristique s'observe dans la figure 2. Il se présente sous forme d'une bande s'étendant d'ouest en est sur 200 à 300 km. Lorsque cette bande, qui se déplace du nord au sud, passe dans un endroit déterminé, on y observe de fortes chutes de neige réduisant beaucoup la visibilité, ainsi que des rafales dépassant 30 m/seconde. Toutefois, la visibilité redevient à nouveau bonne après 10 à 15 minutes.

Les figures 3 à 5 montrent les échos-radar observés pendant un orage le 18 novembre 1964 dans la région de la route aérienne Prague–Holesov. Les pilotes de deux avions ont observé un véritable mur de neige qui allait jusqu'à la base des nuages, sur toute la longueur de cette route de 250 km. Des pilotes d'avions à réaction volant au-dessus de l'orage ont rapporté que le sommet des nuages se trouvait vers 5000 m et présentait l'aspect d'ondes sans qu'on y voie les bourgeonnements caractéristiques des nuages d'orage. Les deux pilotes sumentionnés n'ont pas observé de turbulence, tandis que d'autres pilotes qui ont traversé la bande nuageuse au-dessous de 2000 m ont eu à souffrir de fortes turbulences.

Sur la base de rapports de pilotes et des observations du vent, de la température et de la pression à différentes stations terrestres, on a pu établir un profil de l'orage, représenté par la figure 6. Le cycle d'existence de cet orage a duré environ 3 heures.

Il pourrait être possible à des pilotes de vol à voile d'exploiter de tels orages en hiver, entre les niveaux 2000 et 5000 m, juste au-dessus de la limite nord de la zone du rotor. On pense qu'on pourrait effectuer ainsi des vols jusqu'à une distance d'environ 300 km. Eichenberger