Clear-Air Turbulence and Sporadic E Activity

Abstract. *Pilots' reports of clear-air turbulence correlate inferentially with sporadic E activity observed by backscatter radar. A cursory survey was made of 19 reports of turbulence between 1 and 20 August 1964 over the western United States; all but three correlate with sporadic E patches.*

The advent of high-altitude jet aircraft and the certain introduction of supersonic transports within the next 5 years have focused attention on the atmospheric phenomenon known as clear-air turbulence. This attention is understandable in view of the severe structural damage to aircraft that have encountered such turbulence (*1, 2*).

Clear-air turbulence is known to exist primarily in a zone between the tropopause and the stratosphere at an average altitude of 11,000 m, but pilots of military aircraft have reported its occurrence at altitudes of two and three times this average (*2*). Since the optimum cruising altitudes for both subsonic and supersonic aircraft fall within these limits, advance detection or prediction of turbulence is of prime importance.

Attempts have been made to correlate the occurrence of turbulence with other atmospheric phenomena such as jet-stream activity, time-rate of change of Richardson's number, horizontal and vertical wind shear, and differential vertical temperature advection (*3*). These phenomena may be described as macroscopic (large-scale), and correlations based on them have, at best, been weak. Clear-air turbulence has been described as a microscale phenomenon that may erupt from an infinitesimal initial perturbation lacking a visible source (*1*); one possible source is an electric field in the atmosphere.

Turbulence in a mildly conducting, moving, fluid stream has been known to produce a fluctuating electrokinetic potential at the electrodes of a probe placed in the stream (*4*). The corona discharge rate from aircraft has been reported to increase significantly just before encounter with turbulence, the indication being presence of a higher-than-normal electrical field (*5*). Thus is inferred the association of turbulence—especially clear-air turbulence—with atmospheric electrical phenomena.

Since sporadic E (E_s) activity in the lower ionosphere (about 91,500 m) may be considered an electrical phenomenon, a possible connection between E_s activity and clear-air turbulence was explored. For several years Utah State University has recorded both the location and time of occurrence of E_s; its backscatter-radar facility has a range of about 1000 km centered on Logan, Utah. The U.S. Weather Bureau in Salt Lake City supplied pilots' reports of aircraft encountering turbulence between 1 and 20 August 1964; these reports included severity of turbulence, type of aircraft, location, altitude, and time. All reports were of turbulence at least 4270 m above mean sea level, with 90 percent above 6100 m. All aircraft reporting were of the heavy category (including such types as the Boeing-720, B-727, B-52, DC-8, and others).

Table 1. Reports of clear-air turbulence between 1 and 20 August 1964; times are relative to times of detection by radar of E_s in the same areas.

Reported occurrences	
Time: between (hr min)	No.
0650 and 0140 before	2
0140 and 0026 before	3
Simultaneous with	8
0000 and 0100 after	2
0100 and 0500 after	1

All 23 individual reports were of occurrences on 1 of 12 days within the period. The radar equipment was inoperative on 4 of these 12 days, and 19 incidents of turbulence were reported on the 8 days when the radar was in operation.

Because the backscatter radar can indicate a patch of E_s activity only above a certain level of intensity (the minimum level is unknown), the turbulence data are reported (Table 1) in terms of time before or after detection of E_s activity in the immediate vicinity. Reports of turbulence both concurrent with and directly below E_s activity are considered positive. A typical radar plot and aircraft position report are shown in Fig. 1.

Correlation of the data may be considered at best inferential and perhaps inconclusive. However, the implication is somewhat stronger when one considers that pilots' reports to only one out of five weather offices covering flights originating in or passing through the area of radar coverage have been checked (*6*).

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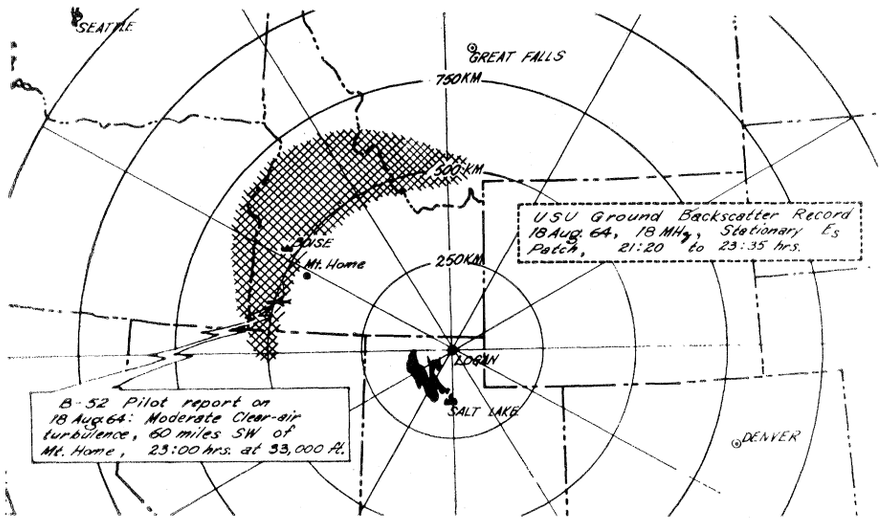

Fig. 1. Typical pattern of E_s activity detected by radar; the elevation, given by a pilot's report of turbulence, is indicated at 10,000 m (33,000 feet).

References and Notes

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6. Great Falls, Mont.; Seattle, Wash.; San Francisco, Calif.; Denver, Colo.; and Salt Lake City, Utah.
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