

An error analysis indicated that the number of independent inferences was roughly linear (actually slightly curvilinear) with the number of decades change in the absorption parameter. Also a change by a factor of 1000 in the mean square error was equivalent to a change of about 2 decades (100) in the absorption parameter. However, in a given physical situation it is not generally possible to use a variation of many decades in the absorption parameter. For example, the variation in the absorption parameter for ozone is less than one decade.

Summarising, the speaker said that generally, given a set of data, an infinite number of solutions will satisfy the data. It is necessary to use an externally-based process of selection to choose the correct solution, e. g. a selection process based on *a priori* knowledge of the atmosphere.

It appears that the number of independent bits of information are related to the range of the input data, that is, the ratio of largest to smallest.

In answer to a query by Mr. McRae (Bureau of Meteorology), the speaker suggested that it might be preferable for any country receiving SIRS data to carry out the reduction locally rather than depend on the reduction of the launching country. In this way extra information might be obtained. A large number of radiosonde and aircraft upper air data could be used as a catalogue from which optimal empirical orthogonal functions could be derived which could be then used to optimize the SIRS temperature accuracy.

In reply to another question, the speaker said that the inversion process depended on an initial arbitrary estimate of the permissible error, then the procedure was standard and would produce a fixed answer that is objective, not subjective.

In a discussion with Mr. Clarke (C. S. I. R. O., Aspendale) it was stated that a point tropopause could not appear because such a tropopause represented a very high frequency which is well outside the capability of the present system.

F. C.

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CLEAR AIR TURBULENCE

by K. T. Spillane

Dr. Spillane, Superintending Meteorologist of the Research and Development Division, Bureau of Meteorology, discussed his analysis of Jindivik flight records. This study was initiated at the Meteorology Department, Melbourne University, by Radok and Rider and continued by Spillane as Senior Research Fellow with the support of a Department of Supply grant to the Meteorology Department. The Jindivik target aircraft at the time were the only aircraft aside from U2's regularly exploring the

lower stratosphere up to 65,000 ft, and the turbulence indications provided by their roll rate records showed up two significant peaks in frequency of occurrence, centred in the height ranges from 45,000 to 65,000 ft and from 20,000 to 45,000 ft, respectively. The latter is well known but the Jindivik data were the first to reveal the existence of the high frequency of CAT above 45,000 ft.

The analysis allowed for the different climb and descent paths in the two height ranges and contrasted the cases of "intermittent" turbulence - recorded only during ascent or descent - with the cases of "persistent" turbulence - recorded during both ascent and descent. The former carried the additional implication of limited horizontal extent whereas the latter implied coherent turbulence on horizontal scales of the order of 50 to 100 km.

Above 45,000 ft the results of the analysis suggested randomly scattered patches of slight turbulence, intersected on the average over a distance of 2.6 naut. mi. and through their side walls rather than their upper and lower boundaries. Encounters with moderate persistent turbulence averaged 5-6 naut. mi. and were also laterally limited in sampling, whereas for slight persistent turbulence the average flight distance in turbulence exceeded 7 naut. mi. and traverse was limited by upper and lower boundaries. No systematic height changes were found to occur in the 1-2 hour intervals between ascent and descent.

Below 45,000 ft intermittent turbulence encounters on the average extended over 2 flight miles. Regions of persistent turbulence appeared to be laterally limited and/or subject to spreading. The apparent depth of the turbulent layers was found to increase on the average by 50 percent between ascent and descent. Marked differences in the occurrence of intermittent CAT on ascent and descent occur with the displacement of a distinct frequency peak at 20-25,000 ft on ascent to 25-30,000 ft on descent some 45 minutes later.

The contrast between these two regions was interpreted as due to the fairly frequent contribution of a form of convection action in which individual turbulent patches measuring from 2-5 naut. mi and extending over 50 naut. mi laterally, tend to rise at the rate of 1 kt in the troposphere, but spread without further rises in the stratosphere. This is in accord with the inversion behaviour described by Ball (1960) applied to cells of action in which entrainment is through the upper boundary. The flux of turbulence energy would have to be achieved by relatively large scales, or internal waves, at lower and middle levels and degraded sharply at the upper boundary layers to scales noticeable by the Jindiviks. The actual propagation of the boundary is facilitated by wave action on the inversion interface. Careful temperature measurements would be needed to show the related fluxes of heat energy; however a projected meteorological instrument system for the Jindiviks (proposed and partly developed by D. W. Beran, a more recent holder of the same Senior Research Fellowship) had to be abandoned before such measurements could be seriously contemplated.

Support for the existence of such a mechanism contributing to the CAT observed was seen in the poor correlation between turbulence and various parameters of turbulence proneness in both the troposphere and the stratosphere. This suggested that the turbulence frequently originated remote from the region where it was sensed. It possibly reached the stratosphere in the form of internal waves which by non-linear effects cascaded to shorter internal waves in which locally the Richardson number dropped below the critical value of $1/4$ established by G. I. Taylor in 1932. Continuation of turbulence would then be possible whenever $Ri < 1$. It is of considerable interest that the areal incidence of the observed Jindivik turbulence in the stratosphere is in close accord with the frequency of such interfering wave packets or "blini" proposed in recent theoretical work on internal gravity wave propagation by Bretherton presented to the I. U. C. R. M. Colloquium on Spectra of Meteorological Variables, 1969.

U. R.