Correspondence

USE OF TETROONS FOR MESOMETEOROLOGICAL INVESTIGATIONS

J. K. ANGELL

U.S. Weather Bureau, Washington, D.C.
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In a recent article House [1] discussed the optimum spacing of upper-air observations for the detection of mesoscale meteorological systems such as instability lines. In the conclusion to this article it is stated that the probability of detection of an instability line with the existing time and space distribution of upper-air stations does not exceed 10 percent. It is further stated that doubling the number of upper-air stations would increase the probability of detection by about 20 percent. Doubling or redoubling the existing number of upper-air stations is an expensive way to obtain the requisite data and as the author states, ". . . a network as dense as that suggested here by the computation of optimum spacing for incipient instability lines may never become economically feasible. . . . "

In view of the above, the question arises as to whether the problem should be considered only from the Eulerian or fixed-station standpoint. Recently, the Special Projects Section of the Office of Meteorological Research has been carrying out experiments on radar tracking of small, metalized, constant-level (superpressured) balloons. These balloons or tetroons (tetrahedron-shaped balloons) are 42 inches on a side, and with a weight of only 200 grams represent no danger to aircraft. With the addition of a radar reflective mesh, tetroon flights at levels under 5,000 feet have been tracked 100 miles. In the course of this tracking the horizontal wind field is obtained in detail and the vertical wind field can be closely approximated since the superpressured tetroons are rather easily forced off their equilibrium density surface by vertical air motions. With an accurate radar, such as the FPS-16, 3-dimensional wind velocity data accurate to 0.1 knot can be obtained at 30-second intervals. The obtaining of vertical motion in such detail is certainly unique. Furthermore, if a triad of tetroons could be released to float very nearly at the same level, the resulting distortion of the triad would indicate directly the vertical component of vorticity, the horizontal divergence, and the shearing and stretching deformation in the horizontal.

Drawbacks to the use of tetroons for mesometeorological investigations include the problem of when and where to launch, the problem of the tetroon being forced off its equilibrium floating level upon entering a region of precipitation, and the problem of tracking the tetroon when there are numerous precipitation echoes on the radar scope. An extremely light-weight transponder has been developed for attachment to the tetroons and this may mitigate the latter problem. A more general problem involves the fact that knowledge of the horizontal and vertical temperature field is also of great importance in mesometeorological studies and this cannot be obtained readily from tetroon flights at the present time.

In summary, the horizontal sounding system seems a logical complement to the vertical sounding system. Just as it is natural that the wind and temperature structure in the vertical be delineated by vertical soundings, so it is natural that the wind and temperature in the horizontal be delineated by horizontal soundings. In the past we have not had the capability for carrying out extended, constant-level balloon flights without the use of a ballasted system, but the superpressured-balloon technique appears to provide a highly suitable solution to this problem. Furthermore, the steady expansion of radar networks and the overlapping coverage of large areas represents an "in being" tracking system. While not all of the strictly weather radars are really suitable for tracking purposes, their capabilities could be explored. In particular, the usefulness of the WSR-57 radar for tetroon tracking should be determined. Given a radar tracking network, the cost of the tetroon system is modest, only about $20 apiece for balloon and radar-reflective mesh. This is considerably less than the cost of rawinsonde expendables. Therefore, it would appear desirable to make a few trial tetroon flights in the vicinity of severe storms, both for the purpose of delineating the problems involved and for the purpose of illustrating the usefulness of the resulting Lagrangian-type data.

REFERENCE

1. D. C. House, "Remarks on the Optimum Spacing of Upper-Air Observations," *Monthly Weather Review*, vol. 88, No. 3, Mar. 1960, pp. 97-100.

REPLY

D. C. HOUSE

Severe Local Storms Center, U.S. Weather Bureau, Kansas City, Mo
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Dr. Angell brings up for discussion the question as to whether the problem of securing upper-air observations should be considered only from the Eulerian or fixed-station standpoint, particularly with regard to the problem of detection of mesoscale meteorological systems.

There are several reasons why such a discussion is timely. Foremost among these is the fact that the press of modern living demands that the weather forecast be more precise in regard to time or occurrence, amount, and location of any hazardous meteorological event. Alternatively, it has been suggested that the meteorologist produce a forecast in terms of the probability of the meteorological event occurring. Simultaneously, more of the National Meteorological Services' budget is being expended for fewer upper-air observations. This has come about in recent years through the utilization of more expensive and more accurate fixed-station observational equipment. Concurrent with this development there has been a significant reduction in the number of supplementary wind observations from the pibal network. Even though the meteorologist may have the knowledge and skill required to render a precise prediction and/or a statement of the probability of the event occurring, his ability to produce consistent results is in the final analysis related directly to the extent to which the observational network approaches an optimum design with respect to the scale (time and space) of the meteorological event he must predict.

The question is frequently asked as to the number and frequency of upper-air observations needed to predict severe local storms. The same question must also be asked with respect to other hazardous phenomena such as hurricanes, heavy rains, and heavy snows. The question of course cannot be answered meaningfully unless it is qualified by the acceptable time and space tolerances for the prediction. Once the tolerances have been decided upon, a network of surface and upper-air observations can be designed and its cost weighed against the economic benefit to be derived.

The development of an optimum network need not be entirely of the fixed-station type. As Dr. Angell suggests, there are strong arguments for the type of horizontal sounding system complementing the existing vertical sounding system. This argument stems from the basic equations of motion and the derived equations such as the vorticity equation and the divergence equation whose practical solutions are at present only approximations because of our inability to measure with precision such variables as the deviation between actual and geostrophic wind. An experimental network of stations capable of releasing and tracking the tetroons preceding a severe local storm outbreak or preceding the occurrence of heavy precipitation would indeed be invaluable in delineating the problems involved and subsequently for determining the optimum network needed for prediction.