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Is There a Ring of Violent Upward Convection in Hurricanes and Typhoons?

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IN THE MAY 1945 issue of the *Bulletin of the American Meteorological Society*, Colonel Wood and Major Wexler give evidence for the existence of a rather narrow ring of violent upward convection in the September 1944 hurricane when off Cape Henry, Virginia. Outside this ring they found an extensive area of appreciable downward convection. Major Wexler writes:

"One is led to the conclusion that the major portion of this hurricane cloud was caused by a strong but narrow area of ascending air near the center of the storm, and that outside this area descending air was found, at least in the lower portion of the cloud and below it. This is rather a surprising consequence of the observations and differs from the accepted theory, which postulates ascending motion throughout the hurricane except for descending motion at the very center (eye) of the storm."

A). With regard to the narrow zone of violent upward convection, it may be of interest to quote at some length the following from pp. 33–34 of my "Some Characteristics of Philippine Typhoons" (Manila, Bureau of Printing, 1939).

"(*c*). *Possible ring of intense upward convection and lack of dynamic equilibrium.*—But must the wind at or near the very center of the typhoon always follow the gradient? In other words must we really always postulate dynamic equilibrium conditions, when we have such turbulent chaos near the typhoon center? Remember too that most equations in common use practically ignore the upward convection term. Should we not take more into consideration a possible sudden upward convection and its effect on the barometer underneath? . . . Near the center of the storm in the wild region of hurricane winds there must be very sudden "kinks" of pressure formed in the upper atmosphere consequent upon the large-scale condensation of water vapor with resulting torrential rain so usual in typhoons. This "sink" would almost at once show itself in the barometer of the underlying station, but would the winds there be able to follow the change so quickly? Such sinks can be very local. Note for instance the remarkable 5 mm quick descent and return some hours before the minimum at Borongon November 1, 1910, . . . with the barometric trace at Tacloban . . . 40 miles away almost smooth! Such phenomena are especially likely in the ring of very violent winds just surrounding the central calm. One can see on many barograms for this region jagged darts of minimum at the beginning or end of the flat calm. . . .

"All in all we see that the phenomena (i.e., of relation of wind to barometric gradient) are indeed very complicated and we can not hope in this paper to probe matters to the limit, but we think enough has been said to set forth the difficulties of the situation and to warrant the following tentative conclusions. . . .

(*3*). There seems good evidence for a region of violent sudden and often irregular upward convection in a ring around the central calm which may prevent the usual equations of dynamic equilibrium from being applicable."

B). A little calculation will show that if the upward convection in a typhoon is violent, then the ring of upward convection should be rather narrow. In a monograph concerning upper-air winds around typhoons, destroyed in the siege of Manila, the author showed from actual data that, except for the sector of a typhoon occupied by the southwest monsoon, the average 50° surface convergence of the winds on land already ended aloft between the first and second kilometers. We can therefore get quite a good estimate of the mass of air drawn upward within the area bounded by a circular isobar by estimating the mass of air traveling *across* this isobar for the 1.5 kilometers. With 50° convergence (also checked recently from actual data for Philippine typhoons on land) the velocity radially inward is two-thirds the actual horizontal velocity. Furthermore we must allow for a change of density as we go aloft, e.g. we may take the rising air column as in the mean about seven-tenths as dense as the surface air being drawn in. If R is the radius of the

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