

551.509.326

A NEW SOLUTION DETERMINING THE STEERING CURRENT IN STORM TRAJECTORY FORECAST

1. For a long time the steering current concept has been used to forecast the storm's motion and many solutions are now available to compute the direction and speed of steering current. Riehl (1954) used the gradient wind rule to compute the components V and U of the steering current which correspond to the tangential (parallel) and perpendicular components to the storm's trajectory and showed that V is significantly larger than U (on average about 20 times). It is also mentioned that: "Tropical storm moves in the direction and with the speed of the steering current which is defined as the pressure-weighted mean flow from the surface to 300 hPa over a band 8° latitude in width and centered on the storm."

2. According to Riehl (1954) the steering current is the sum of motions of atmospheric elements around the storm. When atmospheric motion around the storm is symmetric with respect to storm's center, the steering current will be equal to zero. In case of asymmetric motion, the steering

current will not be equal to zero and the more the asymmetry is the more pronounced will be the steering current. According to gradient wind rule, the asymmetry of atmospheric motion can be estimated through the asymmetry of the pressure or geopotential field.

2.1. At a certain distance R_0 from storm's center, the pressure or geopotential field is symmetric with respect to storm's center, so the steering current inside the circle R_0 is equal to zero. R_0 is called the symmetrical radius of the storm and can be used to assess the atmospheric mass which will be translated by steering current outside.

2.2. At a certain distance R_e from storm's center, the asymmetry attains a maximum value, *i.e.*, the steering current attains a maximum. R_e is called the effective steering radius and can be measured in term of R_0 (of course, $R_e > R_0$, *i.e.*, $R_e = kR_0$ with $k > 1$, k in direct relation to the size of the weather systems and the lead time of forecast).

3. If V and U are the components of the steering current corresponding to the tangential (parallel) and perpendicular components to the storm's trajectory then according to Riehl's theory:

$$U \cong 0 \quad (1)$$

TABLE 1
Mean forecast errors with 24 h lead time during some tropical cyclones occurring over the East Sea of Vietnam
(Becky - 9016; Ed - 9018; Nat - 9120)

| Tropical cyclone | | n | Errors | | | SD (km) | Feature of motion and trajectory |
|------------------|----|----|------------|------------|---------------------------|------------|--|
| | | | EO (km) | EP (km) | $\frac{EO-EP}{EO}$ (%) | | |
| Becky (9016) | 1* | 2 | 160 | 153 | +4.4% | 40 | Straight and fast |
| | 2* | 15 | 141 | 153 | -8.5% | | |
| Ed (9018) | 1* | 6 | 78 | 135 | -73.0% | 42 | Light curve |
| | 2* | 28 | 153 | 135 | +11.8% | | |
| Nat (9120) | 1* | 17 | 150 | 194 | -29.3% | 78 | Recurvature many times |
| | 2* | 47 | 161 | 194 | -20.5% | | |

Where: n - Number of forecast, EO - Error Operation, EP - Error Persistence, SD - Square Departure

Note: 1* - Data from our experiment (one time per day), 2* - Data from the RSMC Tokyo Typhoon Center.

3.1. P_i (or H_i) are the pressure (or geopotential) values which are taken at the 8 points with uniform distance on the forward half of the circle R_e and P_i' (or H_i') on the rear half.

Then according to the gradient wind rule, the Eqn.(1) can be rewritten:

$$\sum_{i=1}^n (P_i - P_i') \cong 0$$

or

$$\sum_{i=1}^n (H_i - H_i') \cong 0 \quad (2)$$

3.2. The condition governed by Eqn.(2) will be used in the determination of the direction of the trajectory, *i.e.*, the direction of the steering current V in each atmospheric level.

3.3. Initially attribute a certain direction to the motion of the tropical storm. Using condition given by Eqn. (2) compute the value of the V through the gradient wind rule. Repeat this for other atmospheric levels and determine the

pressure — weighted mean steering current from surface to upper atmospheric level upto 300 hPa.

3.4. Experiments are made for the 10-year period (1986 - 95) with 284 forecasts during more than 100 tropical storms occurring over the East Sea of Vietnam. With a lead time of 24 h the mean error in forecast position is 134 km. Table 1 show forecasting errors of three tropical storms of them.

4. Our solution using Riehl's original ideas of the steering current is fairly accurate and stable. It is simple and easy to apply at any forecast center.

Reference

Riehl, H., 1954, "Tropical meteorology," Mc. Graw-Hill, New-York.

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19 November 1996, Modified 20 March 1998