A PROPOSED SCHEME FOR OBJECTIVE ANALYSIS OF THE TROPICAL WIND FIELD

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As a result of examining many analyses of the low latitude wind field produced here at ECMWF using the FGGE data and assimilation cycle, I have concluded that:

1. Statistical (optimum) interpolation as practiced today is only partly successful in analyzing realistic wind fields in areas where the divergence is of similar magnitude or larger than the vorticity. On scales much larger than the $6^{o}x6^{o}$ analysis box area, and in the presence of sufficient data density, the statistical interpolation scheme does a reasonable job most of the time. The two major contributors to inconsistent performance are the data selection portion of the scheme and the use of non-divergent structure functions in the interpolation scheme.

2. There is a very good relationship between the strength of the divergent component of the observed winds and the spatial orientation of this divergence to deep convection (or scales > $2\text{-}3^{o}$) as measured by satellite outgoing infrared radiometry. As mentioned above, on the occasion of adequate wind observation density and appropriate spatial scale, this relationship is apparent in the Level III-b analyses (Julian, 1981).

Based upon these observations, I believe that it is reasonable to attempt to modify the data assimilation procedures in the tropics to; first, remove the quasi non-divergence (on scales less than 10^{o} or so) built into the interpolation procedure <u>and</u> second, to attempt to use the satellite radiometry itself to assist the analysis in the location and intensity of strong convergence/divergence fields. A previous attempt to do the latter has been given by Sumi (1979).

Recall the statistical interpolation matrix equation

$$\underline{v}_i = \underline{v}_i^g + \sum_{k=1}^{N} \underline{A}_k (\underline{v}_k^o - \underline{v}_k^g) \text{ for point i with N observations}$$

Also, recall that the modelling of the covariance statistics necessary to the calculation of the weight matrix A is conventionally done by the use of a stream function. Now, if a realistic estimate of the irrotational component is contained in the guess field, $\underline{v}^g$, the interpolation procedure is required to analyze an increment using a non-divergent structure function and essentially observations containing no divergence. The ability of the scheme to perform satisfactorily is thus dependent upon how realistic the irrotational component of the guess field is. There are some identifiable reasons why, I believe, current forecast tropical wind fields do not contain a realistic enough irrotational component.

1. The initialization procedure may remove or modify the divergence field significantly and the forecast model then be unable to regenerate it fast or accurately enough. This seems to be the case for adiabatic non-linear normal mode techniques.

2. The diabatic physics in the model may interact with the normal modes of the model in such a manner that mis-specification of the appropriate forcing takes place. The result is an incorrect excitation of model modes with resulting unrealistic forecasts of the tropical wind field (see Wergen, this volume).

3. In the data selection portion of the assimilation scheme, valid observations that contain or reflect strong divergence may thus be rejected. The result of these rejections, of course, then feedback into subsequent analysis steps.

4. Given the density of conventional wind observations over the tropics, it is unlikely that a sufficiently accurate estimate of both the rotational and irrotational fields will be possible. This is particularly true on horizontal scales from, say, $10-20^{\circ}$ down to the grid mesh scale.

The algorithm I have experimented with uses a scaling of the infrared radiometer data, which can be thought of as giving a Planck cloud-top temperature, directly to divergence/convergence. This scaling produces a divergence profile as a function of pressure for each $2.5^{\circ}x2.5^{\circ}$ infrared datum. The particular scaling used has been derived partly by data in the literature (e.g., Frank (1978)) and partly by experimentation. Although there might be reason to expect any quantitative relationship between convective cloud depth and the horizontal convergence/divergence field to be complicated, there is adequate evidence in the literature that to a first approximation a universal divergence profile exist (e.g., McBride and Gray, (1980)).

The steps in algorithm are given, briefly, here:

1. The IR data is rescaled to divergence using a scaling table as function of pressure and IR value.

2. A high-pass emphasis filter is applied to divergence estimates to amplify spatial scales $\lesssim 10^{\circ}$ latitude.

3. Boundary conditions at $\pm$ 30° for velocity potential are specified from the guess analysis.

4. Poisson equation is solved for velocity potential; the mean meridional velocity profile from guess field used to adjust zonal mean potential field.

5. The guess field for the statistical interpolation scheme is prepared by adding this irrotational field to rotational guess field.

6. Single-level optimum interpolation procedure is applied to the wind field only.

To illustrate how the algorithm performs, consider first Figs. 1 and 3. Here, for 00 to 180°E longitude, 10 May 1979, 00 GMT, the bottom panels show the velocity potential field derived from the algorithm. This field may be compared with the top panels which show the velocity potential field derived from the FGGE III-b ECMWF analysis. The two fields are in general agreement except for the location of the "source" region over Africa and the intensity of the "source" region north of New Guinea. The differences in the irrotational flow should be obvious. Figs. 2 and 4 show the result of the statistical analysis using the algorithm (bottom) and the III-b analysis (top). I point out that a much better fit to the observations results from the IR-based potential field. In particular, the group of observations from 0 to 10°S and 5 to 20°E which are slighted in the III-b analyses are nicely accommodated by the algorithm. Other examples may be found. The algorithm has been tested on a sample of seven cases during SOP I and II including the cases selected for study by WGNE. In general, the algorithm performs satisfactorily. A number of further studies to test, objectively, the fit to observations has been carried out.

References

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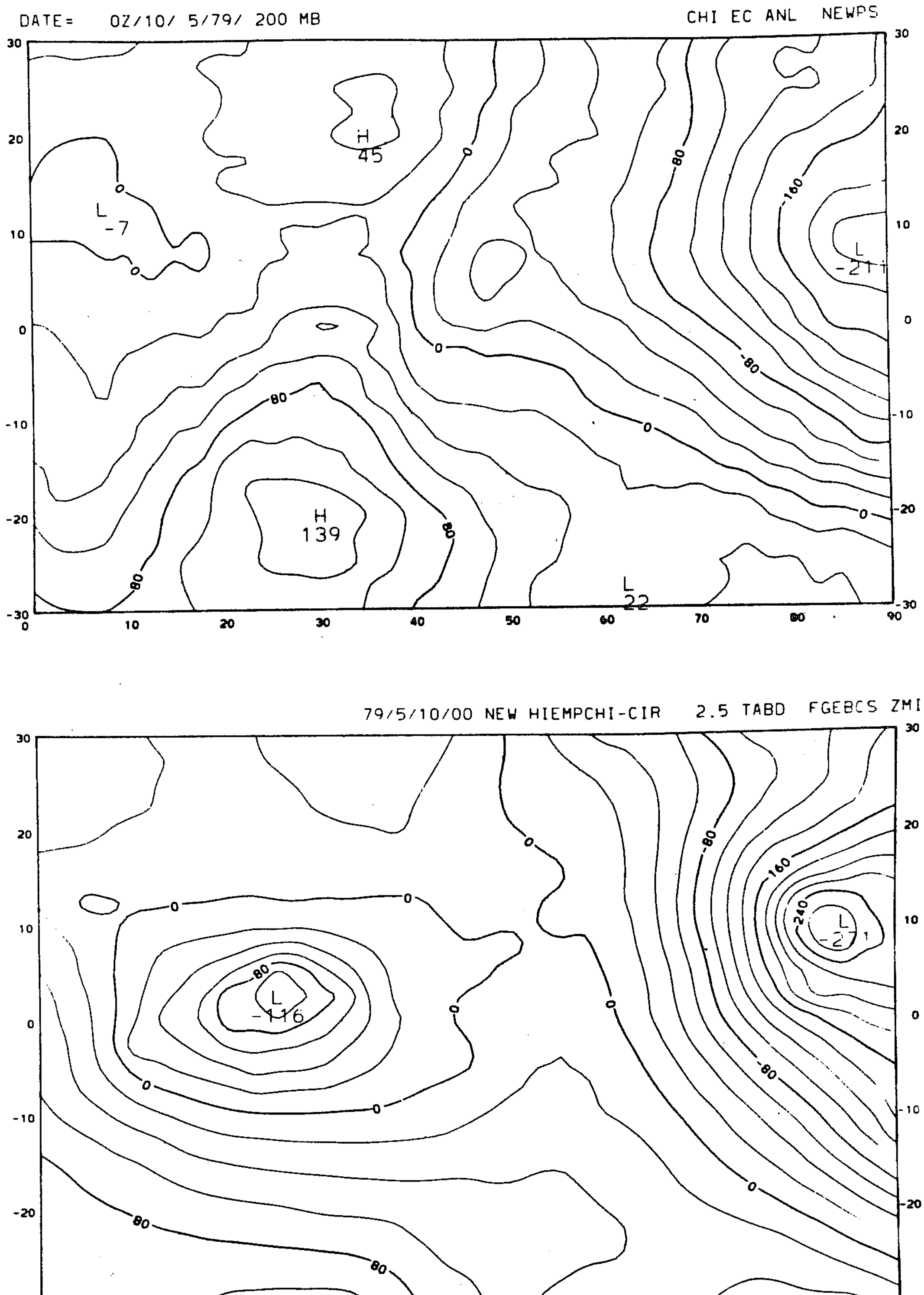


Figure 1. Top: Velocity potential derived from ECMWF Level III-b analysis, 10 May 1979, 200mb, for the quadrant 0 to 90E. Bottom: The same except derived by algorithms described in text and based upon outgoing IR values. Contour interval in both is 2.10^6 m^2/s. Note the very different configuration of the divergent flow over Africa.

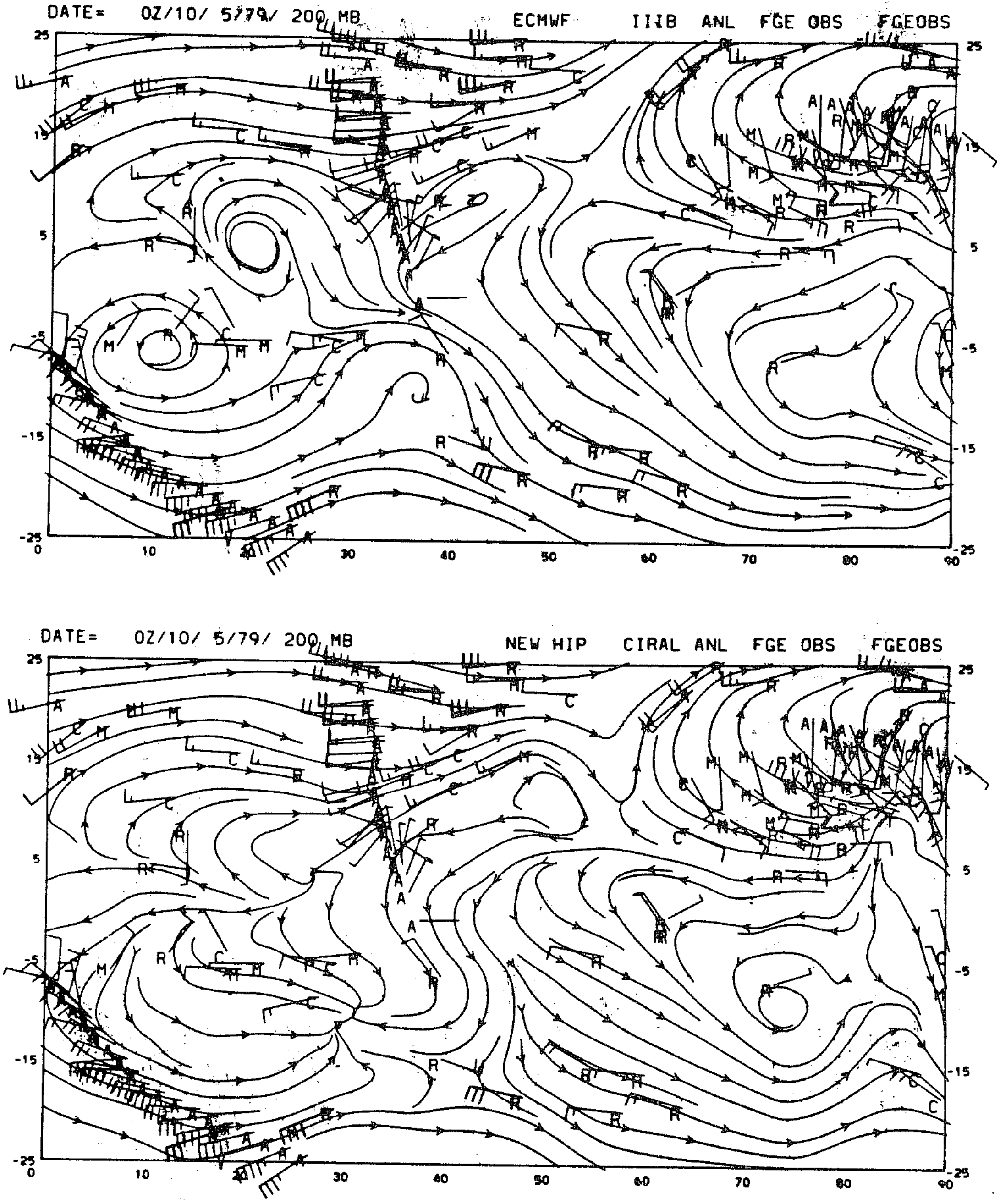


Figure 2. Top: Streamline analysis, same as Fig. 1, for ECMWF II-b analysis. Bottom: Streamline analysis resulting from analysis algorithm described in text. Note the much better agreement with the observations (R = rawin, C = cloud motion vector, M = super ob cloud motion vector) over Africa. Differences in the divergent component in the two analyses also results in slightly better fit to observations (bottom) for Indian Ocean rawins.

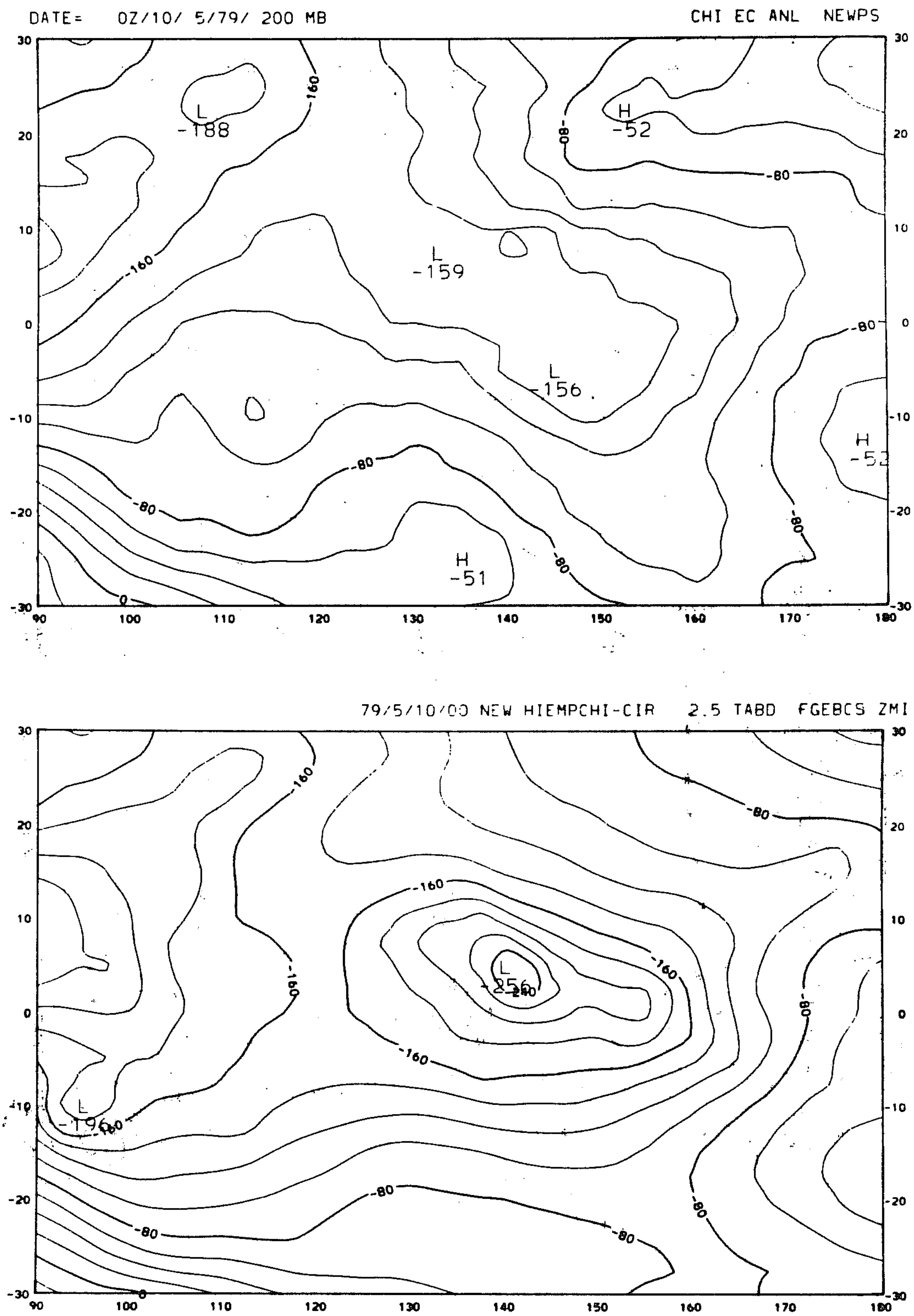
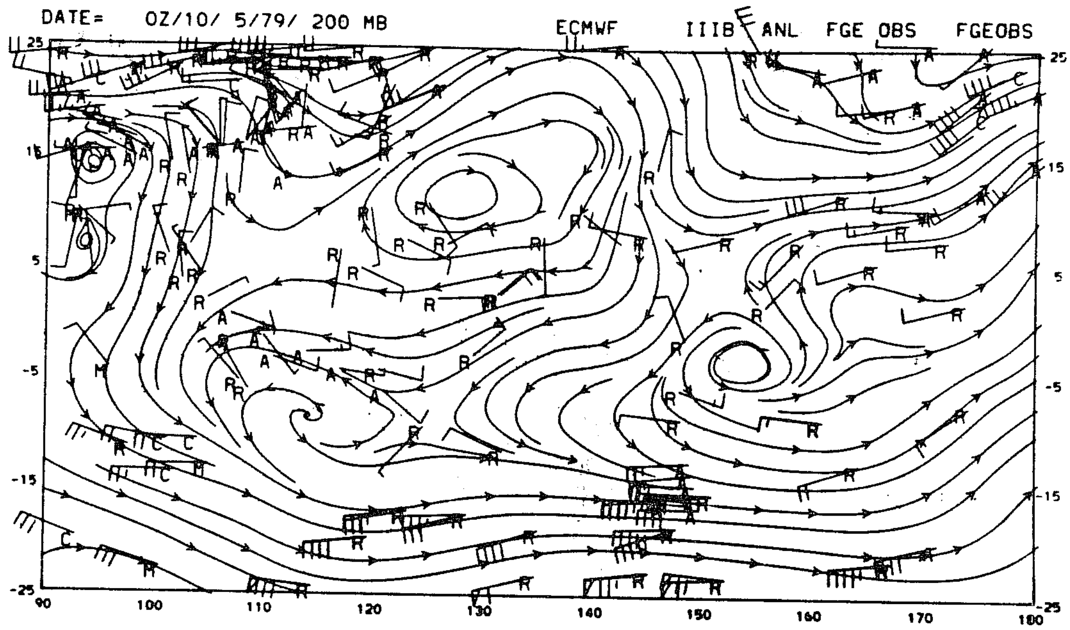


Figure 3. Same as Figure 1, but for 90E-180. Note the more intense divergent flow indicated (bottom) north of New Guinea.



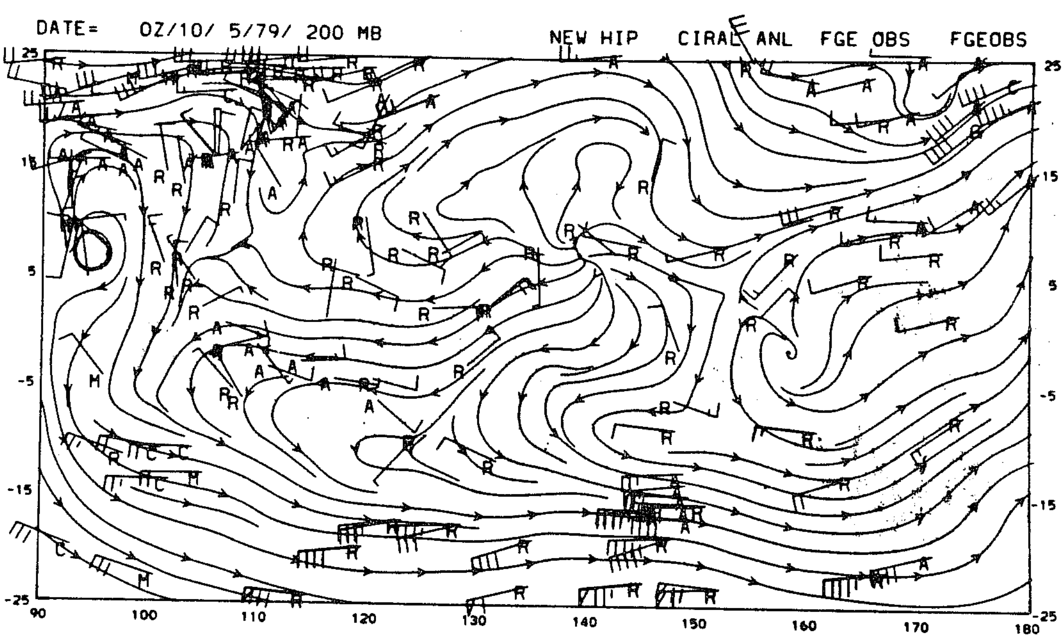


Figure 4. Same as Figure 2, but for 90E-180. The improved estimate of the divergent flow (bottom) results in the analysis having much better fit to the rawin observations in the western Pacific.