Graphical Addition and Subtraction

Computation of the sum or difference between two meteorological fields has many practical applications.

Among them are:

1. Thickness analysis

   e.g., 1000 – 500 mb thickness = $Z_{500} - Z_{1000}$. Once you have the thickness field, you know the thermal wind. (more later).

2. Tendency fields

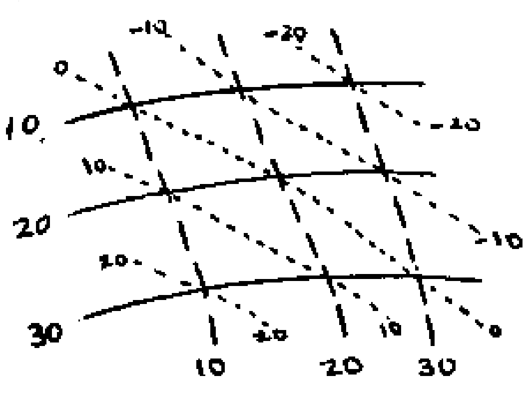
   (a) 3-hr surface pressure tendency = $p_t - p_{t-\Delta t}$
   (b) 12-hr height tendency = $z_t - z_{t-\Delta t}$

3. Forecast verification

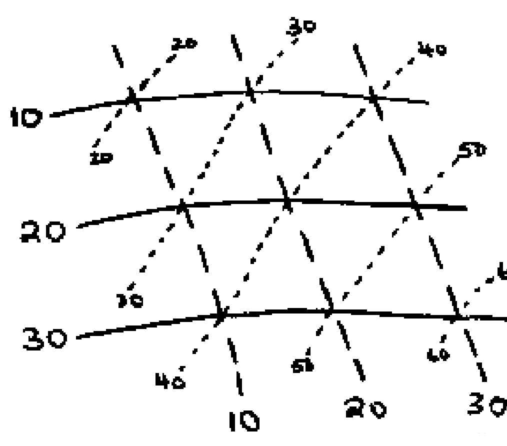
   (a) forecast minus observed fields
   (b) compare two forecasts made for the same time period by:
       (i) another model
       (ii) earlier run of same model
   (c) forecast versus climatology or persistence

Note that these are all examples of <u>subtraction</u>! Addition would be used, e.g., to compute the <u>mean</u> of two fields.

Although addition or subtraction of two fields is trivial on a computer, it can also be easily done graphically. Simply overlay one scalar field on top of another one (valid at another level or time), add or subtract the intersecting values to generate a third scalar field and do a scalar analysis of that field. In the two examples below, the original scalar fields are solid and dashed, and the resulting field is dotted.



Subtraction (solid – dashed)



Addition (solid + dashed)

One can see that the symmetry of the analysis makes it proceed much faster than a typical scalar analysis. If the two original analyses and the graphical operation are done properly, your graphical product will automatically satisfy the rules of scalar analysis. Note that:

1. Your isopleths will have the same properties as the original pair (i.e., – they will have the same contour interval and be divisible by that interval).

2. All intersections must be crossed in a graphical operation.

3. No sum or difference line can cross any isopleth on either field except at intersections.

4. When a maximum or minimum is crossed on one field, a local max or min is reached in the sum or difference. Thus the curvature of the sum or difference represent isopleths which change at the maxima or minima on either of the original fields.

5. When differencing, the isopleths go in the same sense on both fields, that is, toward low values on both fields, or toward high values on both fields. When summing, the isopleths go in the opposite sense; a constant sum requires that one field increases while the other one decreases.

6. When one field is flat and the other is not, a sum or difference field exists but it will closely resemble the changing field.

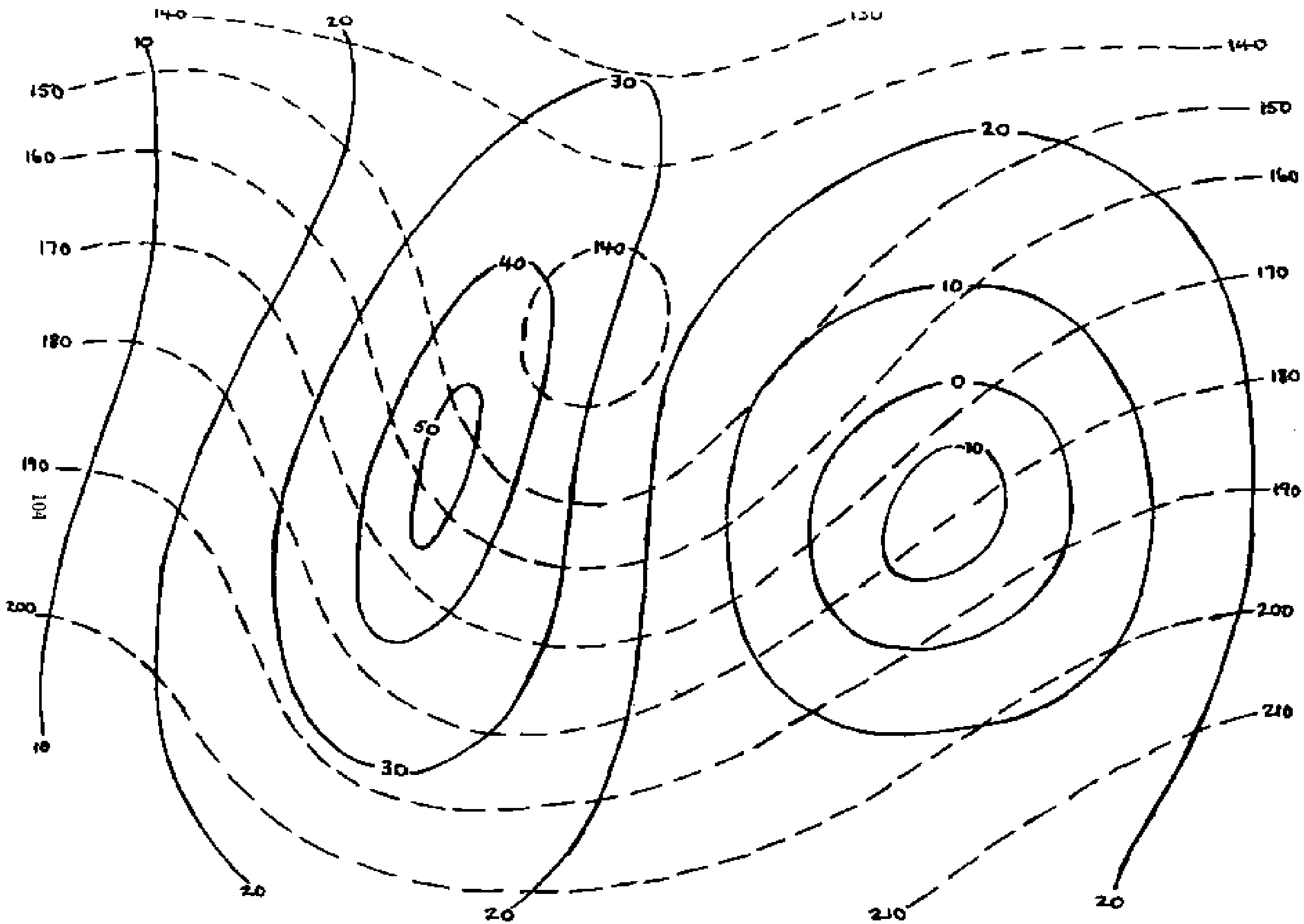
7. The accuracy of these graphical operations is about plus or minus one quarter of the contour interval.

8. The sum of smooth fields is smooth.

9. If intersections are scarce, sketch intermediate isopleths on both fields. Intersections between intermediates yield non-intermediate values (i.e. – regular isopleths) in the third field.

10. If one original field has a different contour interval than the other, draw intermediate contours on the one with the larger intervals so that both maps have the same interval.

For an in-class exercise, subtract the solid lines from the dashed (i.e., difference = dashed field minus the solid field). Use a contour interval of 10.



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