A Measurement of the Winds Aloft During a Cold Front Passage

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On the island of Väddön in the archipelago of Stockholm (Fig. 1) last summer the ascents of a number of pilot balloons were followed by means of radar. Particularly interesting were the ascents on July 15 because this day the balloons passed through a cold front surface and the wind shift line aloft could be illustrated very clearly.

The wind measurements were made with two radar sets independent of each other and placed, one at Ytterskär and the other at Gåsvik (Fig. 1) at a distance of 5 kilometers from each other.

To obtain an idea of the accuracy of the radar wind measurements, pilot balloons have been followed simultaneously by means of

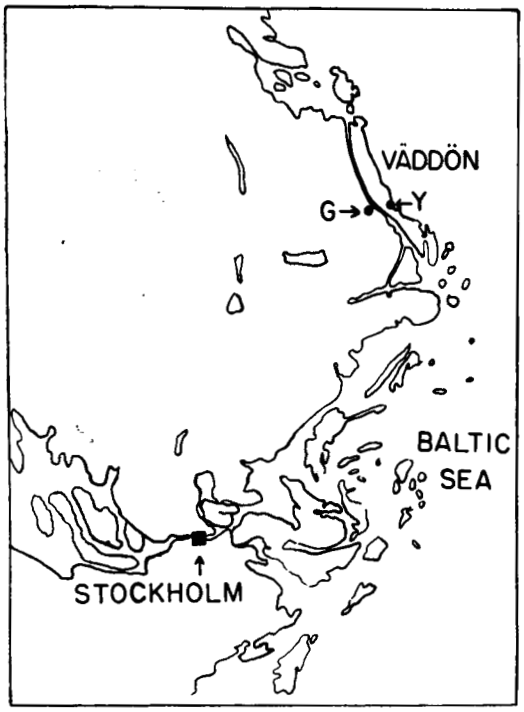

Fig. 1. The location of the observation points G: Gåsvik; Y: Ytterskär

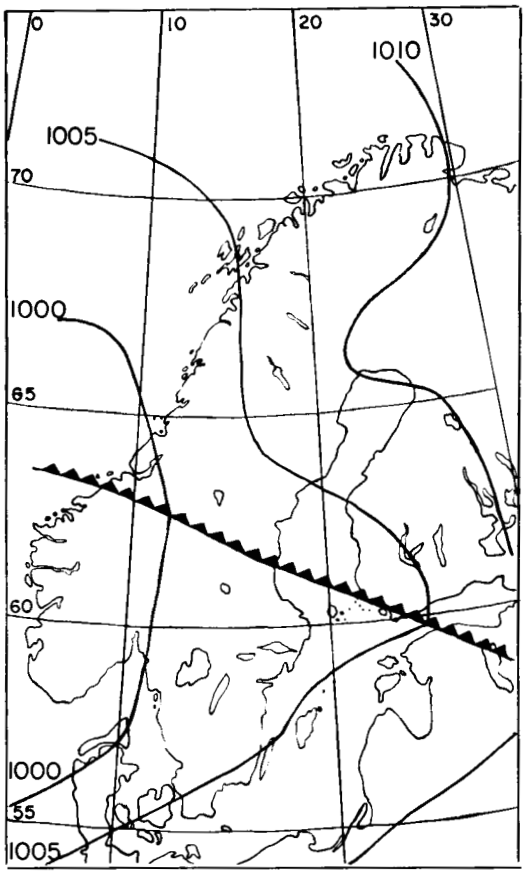

Fig. 2. Location of front and distribution of pressure July 15, 1953, 1300 swedish standard time.

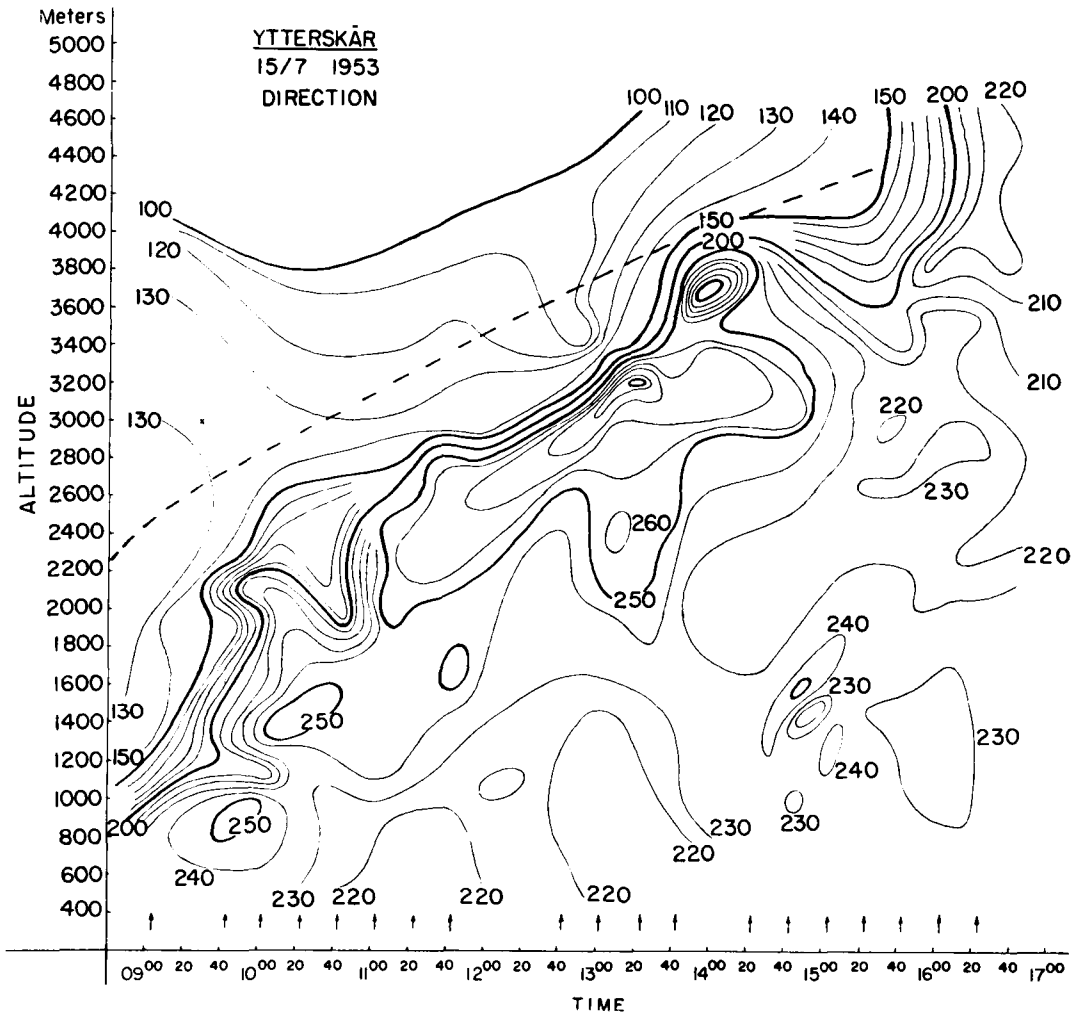

Fig. 3. Time section of wind direction at Ytterskär July 15, 1953, 0900—1620 Swedish standard time. Arrows indicate the time of the ascents.

radar and by using three theodolites. The comparisons between the results of the two methods are not yet finished, but preliminarily one can say that the radar here used gives the wind with errors not exceeding ± 0.5 m/sec in velocity and ± 5° in direction and that the relative error in altitude is ± 2 %.

The weather situation was as follows: On July 14 a cold front type occlusion belonging to a cyclone east of Scottland had moved in over the southern part of Sweden and there, as usual in summer, changed into a cold front. This front passed Väddön about 0730 o'clock, and, as the wind measurements started at about 0900 o'clock, the pilot balloons thus passed right through the cold front surface.

A pilot balloon was sent up about every 20 minutes. The ascent times are marked by ↑ on the time scale in Figures 3—5. The results of the wind measurements are illustrated by means of isopleths for direction and velocity. The isopleths are drawn for every tenth degree, respectively, every m/sec.

Because of a defect of the radar at Gåsvik, the diagrams from this place only show the winds during the afternoon, but the diagrams from Ytterskär (Figs 3—5) show some properties characteristic of a cold front surface such

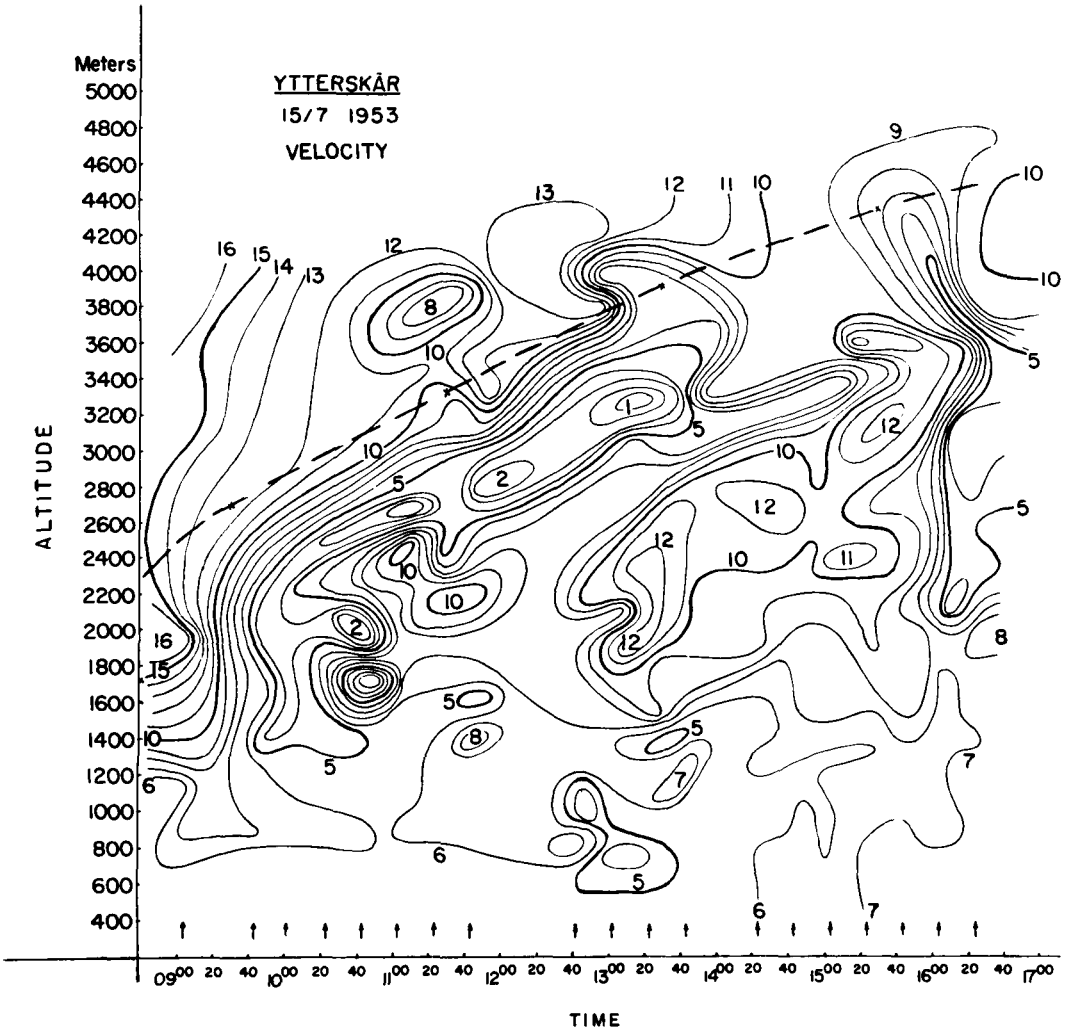

Fig. 4. Time section of wind speed at Ytterskär, July 15, 1953, 0900—1620 Swedish standard time. Arrows indicate the time of the ascents.

as the steep slope in the lower parts, the less steep slope higher up and the increase of wind velocity, when passing through the surface from cold to warm air.

The altitude of the front surface at different places has been estimated from the soundings at Bromma (Stockholm) and at Copenhagen and from weather reports (Fig. 5). In the sounding at Bromma it is evident from wind and Θ_w (wet-bulb potential temperature) that the isothermal layer at 2,500—3,000 m belongs to the front surface. A comparison of the two soundings from Copenhagen indicates that on July 14 at 1600 the front surfaces was at 5,500—5,800 m and that on July 15 at 0400 the temperature had fallen above this altitude to about 9,000 m. Thus it is probable that the position of the front surface on July 15 at 0400 was at about 9,000 m over Copenhagen. Thus the dashed line on Fig. 6 shows approximately the altitude of the front surface. Assuming the shape of the surface to have remained unaltered during the day, the dashed line of Fig. 6 is plotted also on Figs 3—4. The correspondence between this line on Figs 3—4 and the isopleths is not perfect but this may depend on

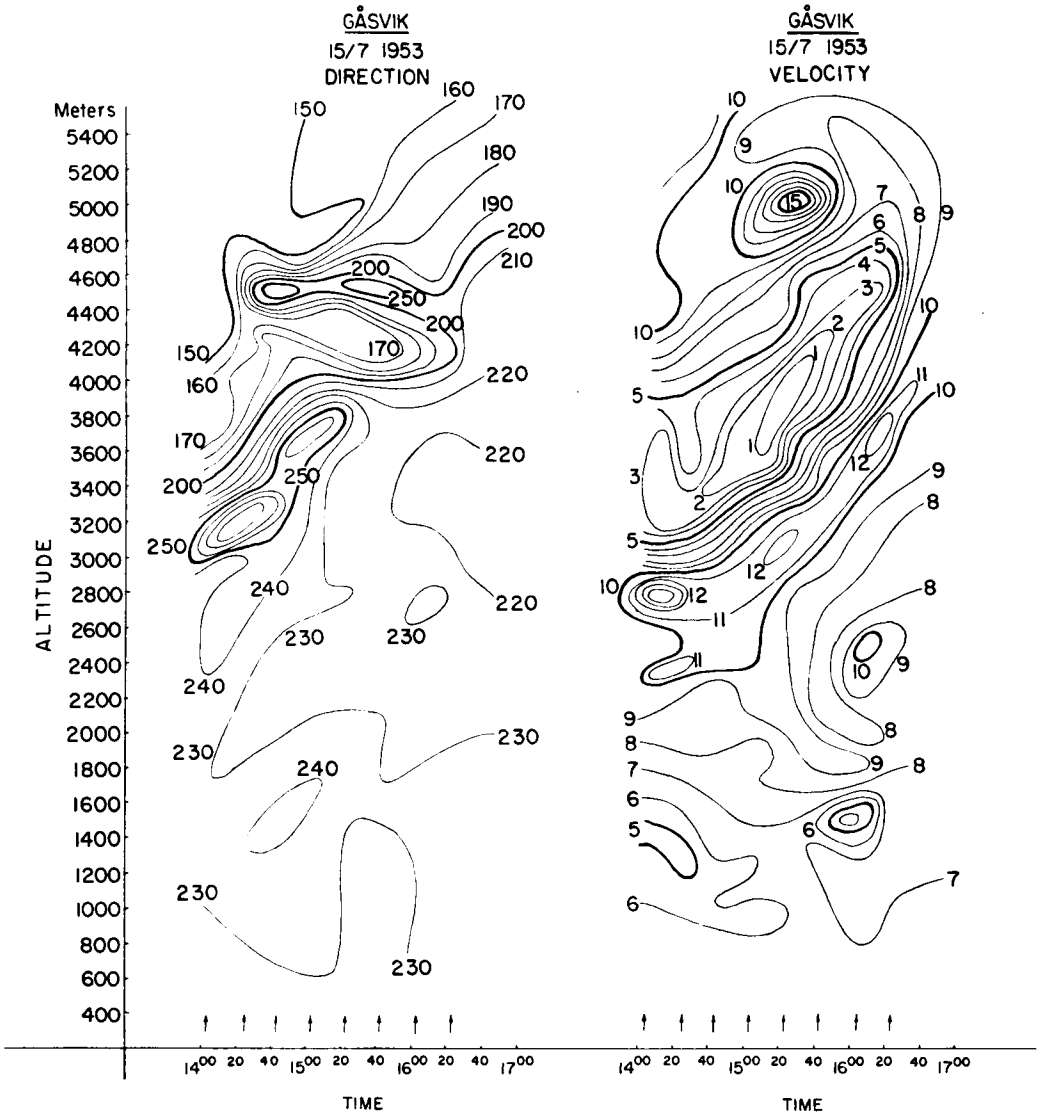

Fig. 5. Time sections of wind direction and speed at Gåsvik July 15, 1953, 1400—1620 Swedish standard time. Arrows indicate the time of the ascents.

the difficulty to determine the exact position of the frontal surface from the soundings and the weather reports available.

Fig. 2 shows the estimated position of the front and the pressure distribution over Scandinavia at 1300 on July 15.

However, it is evident that wind measurements of this kind represent a rather good method to supplement the standard aerological soundings. It is also probable that the position of front surfaces is more easy to determine from wind measurements than from soundings, particularly when the temperature difference between the two air masses is small.

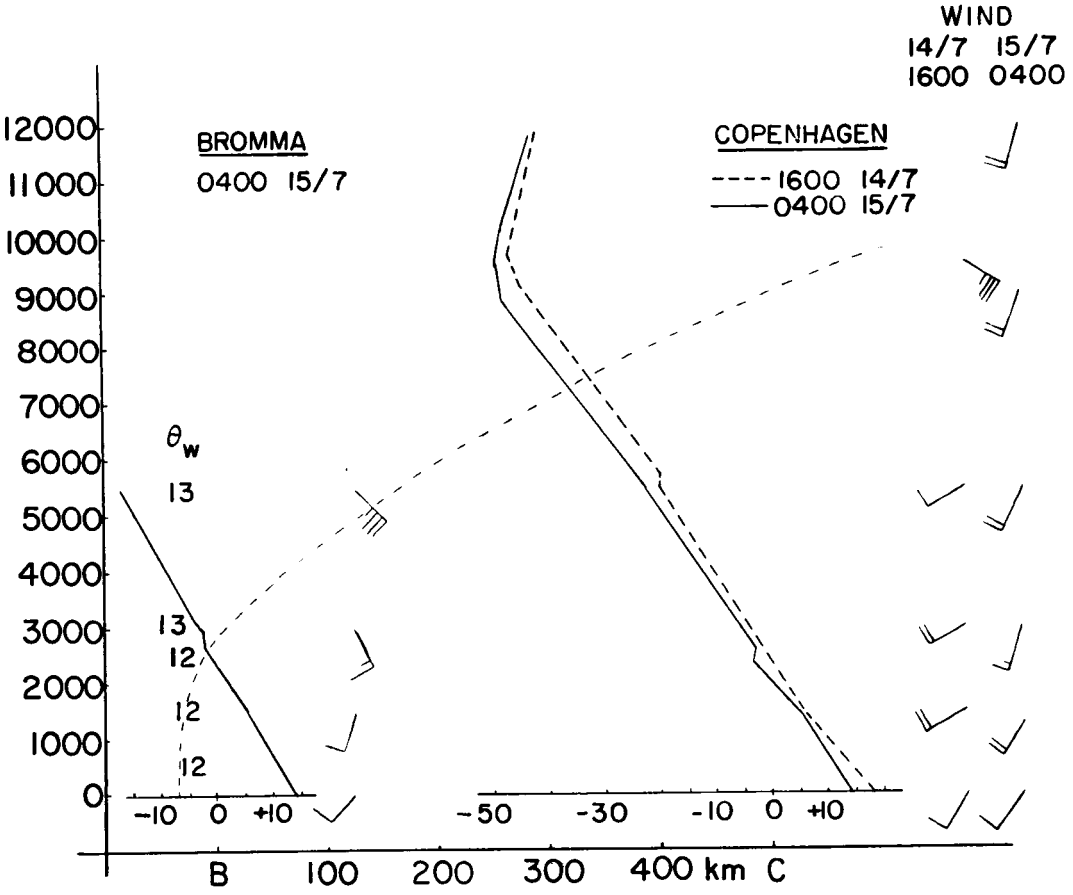

Fig. 6. Radiosonde ascents and winds at Bromma and Copenhagen July 14 and 15, 1953. The slanting curve indicates approximate location of the front.