commentary and analysis

Migrating Soaring Birds Align along Sea-Breeze Fronts; First Evidence from Israel

Sea-breeze fronts (henceforth SBF) in Israel are quite vigorous but mostly appear without clouds because of the frequent dry subsidence above the sea breezes and are therefore difficult to directly detect by radar (Alpert et al. 1982). It has been found, however, that not infrequently, the migrating birds soaring over Israel identify the SBFs and actively search the upward motion associated with the converging lines of the SBF in their migration through the country. Here, we present, for the first time, an example (out of hundreds available) from 10 September 1995 in which migrating birds of the species honey buzzard (*Pernis apivorus*) (see Fig. 1) are seen by the radar of Ben-Gurion (Tel Aviv) International Airport as biological target lines that are very closely aligned with the SBF convergence lines. Radar pictures were shown quite effective (Leshem and Yom-Tov 1998; Johnson 1997–98) in following the migrating birds. Radar echoes are used in Israel, regularly, to follow the bird migration and to provide advanced warnings to aircraft during the high migration in the transition seasons. It is interesting to note that Berson and Simpson (1971) have already made an early recommendation to exploit radar for information about birds.

FIG. 1. One of 850 000 honey buzzards (*Pernis apivorus*) that migrate over Israel twice a year. The weight is estimated to be 800 g with a wing span of about 1.4 m. (Photo: P. Doherty).

The situation in Israel is quite different compared to other regions with low numerical bird concentrations where clear-air coastal radar bands were associated primarily with insects or aerial plankton and much less to their predators (e.g., Sauvageot and Despaux 1996; Russell and Wilson 1997).

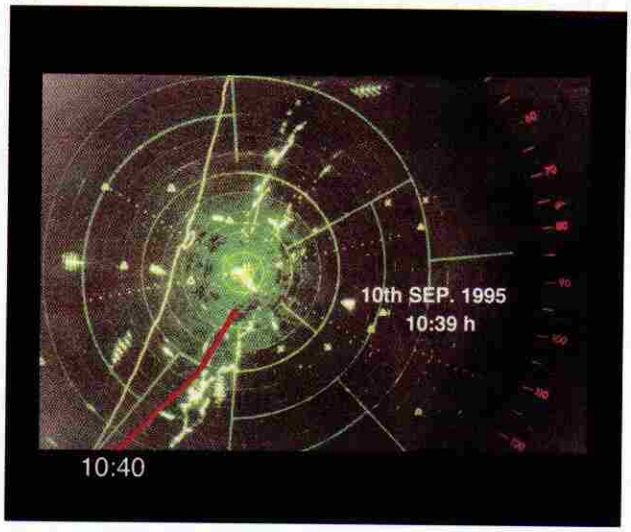
The SBF lines were identified using a dense net of 18 air quality monitoring surface stations over southern Israel, an area of about 600 km^2 between the Mediterranean southeastern coastline and 20–25 km inland (Rabinovitch 1995; Kravitz 1997; Alpert and Rabinovitch-Hadar 2000, unpublished manuscript). In the latter studies, continuous records of winds, temperatures, gustiness, and humidities at the surface were analyzed for sharp variations every 5 min in order to define the exact temporal and spatial structure of the sea-breeze front lines.

Figures 2a–c show the front isolines (in red) along with the radar pictures for the lines of migrating birds for 10 September 1995 at 1039, 1242, and 1343 LST, respectively. In addition, times of the SBFs (in accordance with Fig. 3) are denoted at the bottom of each figure below the red line. Indeed, the SBF isolines continue northward up the coast and probably along the bird echoes as in the southern section plotted. This extension, however, is not plotted in Fig. 2 because the high-resolution monitoring network employed in resolving the SBF lines was available only at the southern section; see Fig. 3. The number of birds composing the radar line echoes in each picture is estimated to be in the range of 10 000–15 000 (e.g., Leshem and Yom-Tov 1998).

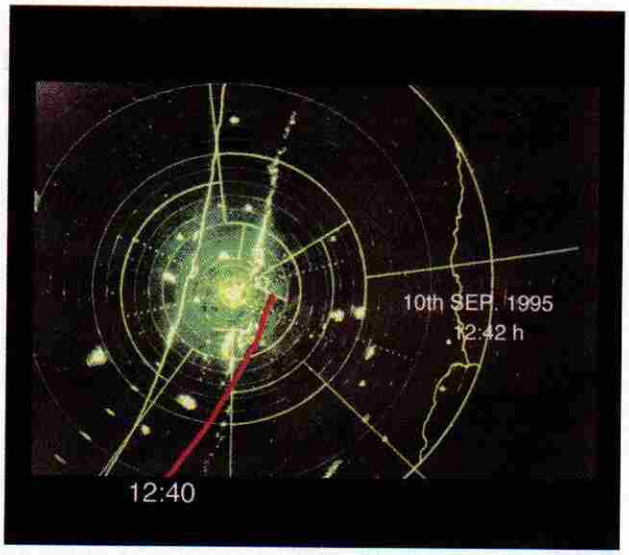
Figure 3 shows the SBF isolines each hour from 0900 to 1300 LST above the map with the surface station along with the SBF passage time at each point. The location of the Ben-Gurion airport radar is at grid point (140,155); see the **X** above the upper-right corner in Fig. 3.

Figure 4 presents the sea level pressure along with the 500-hPa synoptic chart for 10 September 1995, 1200 UTC. It shows a subtropical west-to-east ridge,

(a)



(b)



(c)

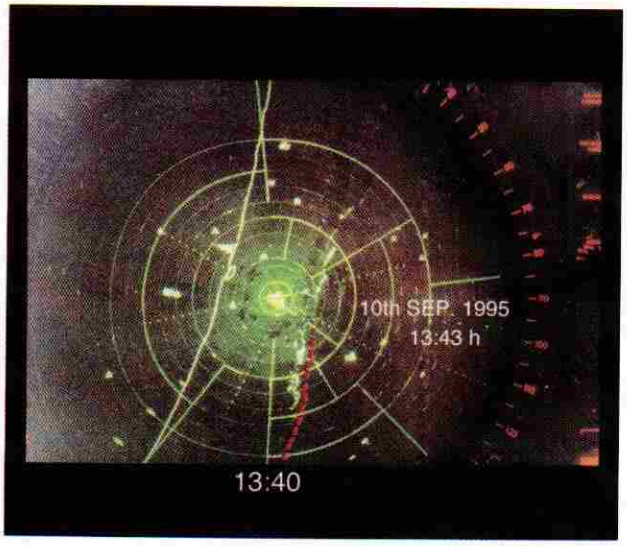


FIG. 2. Three photographs from a continuous sequence of flocks of honey buzzard (*Pernis apivorus*) taken on the Ben-Gurion airport radar, 10 Sep 1995 at (a) 1039, (b) 1242, and (c) 1343 LST, respectively. The center of the circles is Ben-Gurion airport and the circles are at radial intervals of 2 n mi. The brighter circles are at 5, 10, 15, . . ., n mi. The thin line crossing the figures approximately from north to south is the Mediterranean coastline. The thicker lines east of the coastline are the flocks of the migrating birds. The thick red line shows the location of the sea-breeze front at the pertinent hour; for more details see Fig. 3. Time of the SBF is indicated at the bottom of each figure below the red line, in accordance with Fig. 3. The red line is dashed in Fig. 2c in order to indicate some uncertainty in the exact front's location associated with the reduced number of monitoring stations farther inland. Radar type is ASR-8 (approach surveillance radar), S band, with the wavelength of 10 cm and a pulse width of 0.6 μs. The antenna aperture size is 4.9 m and its rotation rate is 12.5 rpm.

extending over the southeast Mediterranean, that dominates our study region (indicated by the rectangle at about 31.5°N, 34°E) and yields clear skies, particularly at around noontime.

Soaring birds are known (Leshem and Yom-Tov 1998) to have a well-developed ability to identify rising air due to the large eddies or thermals in the atmospheric planetary boundary layer with typical scales of 1–3 km (e.g., Stull 1988). This is, however, the first evidence showing the ability of the bird flocks to identify and wisely exploit the upward motion on a much larger mesoscale of about 50 km typically associated with the sea breezes in Israel.

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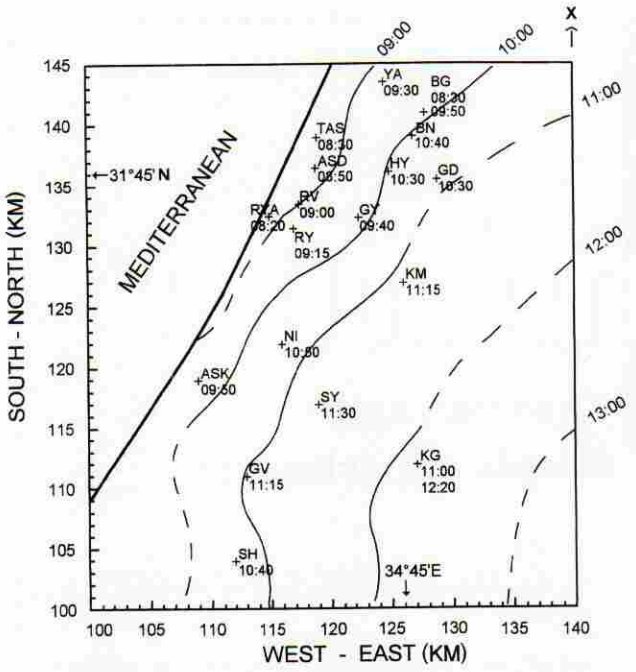

FIG. 3. Isolines for the locations of the sea breeze front at 0900, 1000, 1100, 1200, and 1300 LST as deduced from surface winds (speed and direction), temperatures and humidities at 18 stations reporting every 5 min. Numbers below each point indicate passage time of the sea breeze as defined by objective criteria. Further details on the objective and computerized method to identify SBF passage can be found in Rabinovitch (1995), Kravitz (1997), and Alpert and Rabinovitch-Hadar (2000, unpublished manuscript). The dashed lines indicate a higher degree of uncertainty due to the stations' sparsity. The location of the Ben-Gurion airport radar is at grid point (140,155); see the **X** above the upper-right corner.

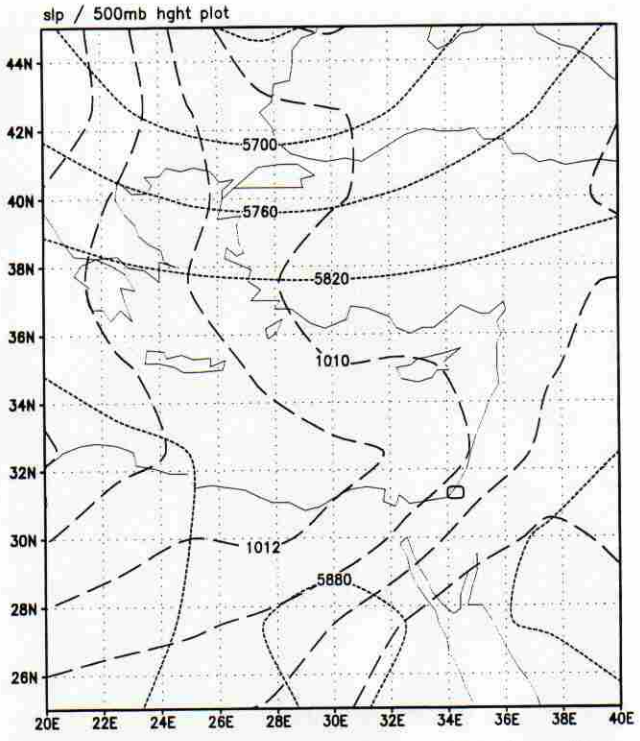

FIG. 4. Sea level pressure (dashed isobars, hPa) along with the 500-hPa (dotted isohypses, m) chart for 1200 UTC 10 Sep 1995, with contour intervals of 2 hPa and 60 m, respectively. The study region is indicated by the rectangle at about 31.5°N, 34°E. Maps are based on National Centers for Environmental Prediction reanalysis, National Oceanic and Atmospheric Administration–Cooperative Institute for Research in Environmental Sciences Climate Diagnostics Center.

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