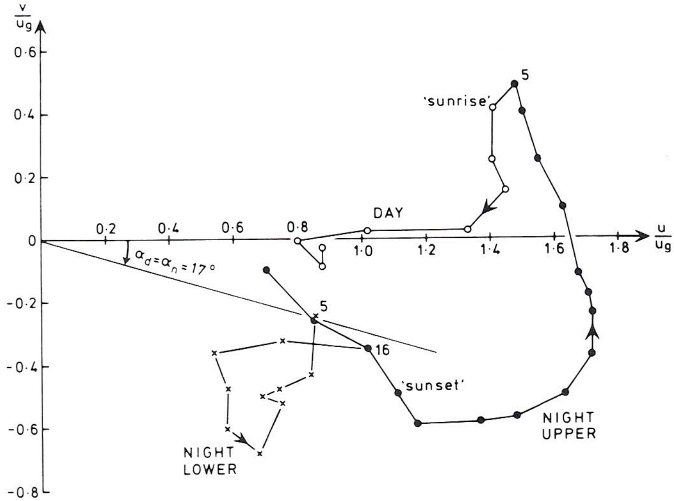
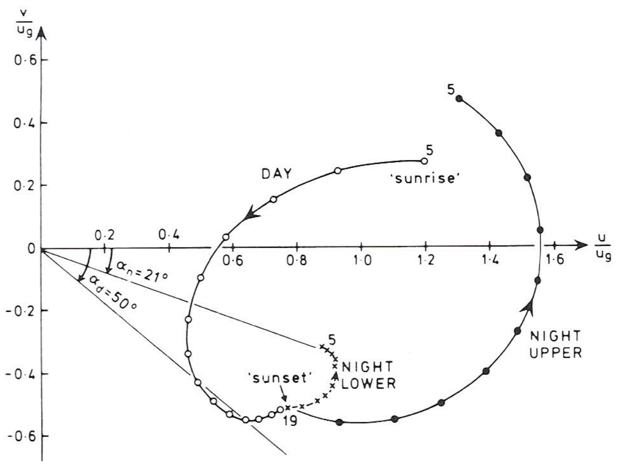
## 9.7 The Nocturnal Jet

There is a feature in the atmosphere called the nocturnal jet that in its dynamics has features in common with the inertial oscillations studied earlier in this chapter. It occurs during the night in inland regions, and the basic reason for its existence was given by Blackadar (1957). The phenomenon tends to occur when, during the heat of the day, the boundary layer is deep and convectively mixed. At nighttime, the ground cools and a stable layer is formed near the ground. Frictional effects are confined to this layer, so the region above, which was in the boundary layer during the day, has effectively been released from frictional influence, i.e., the stress term suddenly drops to zero about sunset. In response, the wind begins an inertial oscillation that proceeds until mixing resumes the next day.

A simple model of the process by Thorpe and Guymer (1977) uses methods already developed in this chapter, and Fig. 9.5 shows a comparison between the model and observation. During the day, there is assumed to be a well-mixed boundary layer of depth $H_{\text{mix}} = 800$ m at which the stress varies linearly in accord with (9.3.4). The stress is related to the velocity in the layer by a drag law (a linear relation was used for the model). Consequently, a velocity is obtained in this layer that tends with time toward the equilibrium value, which is rotated cyclonically relative to the geostrophic wind. At sunset, the mixed layer is assumed to suddenly become only 200-m thick. Consequently, the wind in the layer between 200 and 800 m begins to rotate anticyclonically and in the hodograph (i.e., the $u$, $v$) plane, is represented by a circle centered on the point that represents the geostrophic wind (see Fig. 9.5). This inevitably leads to a supergeostrophic wind in this layer. At sunrise, mixing over the full 800 m is supposed to resume, so the momentum of the two layers is mixed to give a uniform velocity over 800 m. This wind is not in balance with the pressure gradient and drag, and therefore it adjusts toward equilibrium until the mixed layer suddenly reduces in thickness again at sunset.




(a)




(b)

**Fig. 9.5.** (a) Averaged velocities at 1-hr intervals on day 13/14 of the Wangara experiment 27/28 (July 1967). The values at night are averaged over 0–200 m (×) and 200–800 m (●). During the day, the values are averaged over 0–800 m (○). Numbers against points denote Eastern Standard Time. [From Thorpe and Guymer (1977, Fig. 6).] (b) Corresponding model results. In the model, the upper layer undergoes half an inertial oscillation, represented by a semicircle centered on the point $u = u_g$, $v = 0$ representing the geostrophic wind. The wind vector rotates anticyclonically (the observations are in the southern hemisphere), giving model nighttime winds in the upper layer that are about 60% greater than the geostrophic wind. (In practice the nocturnal jet was even stronger.) At sunrise, the two layers are assumed to have their momentums mixed together, and the wind adjusts toward a frictional balance. At sunset, the upper layer becomes uncoupled from frictional influence, and so begins another inertial oscillation. [From Thorpe and Guymer (1977, Fig. 7).]