Comments on "A Mesoscale Phenomenon Revealed by an Acoustic Sounder"

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We cannot agree with the interpretation of the acoustic sounder facsimile record published by Petersen and Jensen (1976). The narrow band acoustic echo which the authors interpret as a specular reflection from a mesoscale front separating moist land breeze air from colder air is not supported by the appearance of the facsimile record nor by the wind and temperature data presented in their Fig. 2. The initial rising trace of their Fig. 1 lasts for 2.5 h and passes through regions of marked turbulence on the facsimile record as at 0545, 0615 and 0650. How can the hypothesized sharp gradient (<5 m in thickness) maintain its integrity through such turbulent regions?

Then there are the sudden discontinuities in layer height as at 0635 and 0710. In the latter case the layer drops over 70 m instantaneously. Such transients do not occur geophysically, certainly not in nonturbulent environments where the layer appears to be at these times.

But let us assume for the moment that a smooth gradient of acoustic refractive index is the explanation of the layer. The velocity of sound c is given by

$$c=20.05\sqrt{T}(1+0.14e/p),$$

so that we must consider both changes in absolute temperature T and in water vapor pressure e (p is the atmospheric pressure) in calculating the change in refractive index from one air mass to the next. We see from Petersen and Jensen's facsimile record that the layer passed the instrumented 117 m level on the Risø tower at about 0635. Referring to the temperature trace at that time, we find that there are no inflections measured. On the contrary, there is a smooth linear increase in temperature from 0600 to 0700. Thus we must attribute the change in index to changes in water vapor pressure. Let us assume that the humid air, conditioned by passage over the nearby fjord is *saturated* and at a temperature of 3°C. We will assume that the land air is *completely dry.* Then the maximum possible difference in the index of refraction is $\Delta n=1.05\times10^{-3}$. As described by Ottersten (1970) the calculation of the layer reflectivity is sensitive to the precise profile of refractivity. A linear gradient through a depth h gives a power reflectivity of $R=(\lambda\Delta n/4\pi h)^2$. Assuming that $h=1$ m and $\lambda=0.2$ m yields the value $R=2.8\times10^{-10}$. We now inquire what value of the temperature structure parameter $C_T{}^2$ would provide the same returned power as the gradient reflectivity and find this value to be

$C_T^2 = 2\times10^{-3}$ K^2 m$^{-2/3}$. This value is somewhat less than hourly averages and much less than peak values of the temperature structure parameter observed in ground-based and elevated inversions (Neff, 1975).

In the specularly reflecting layer model used above, the discontinuous derivatives of the index of refraction at the boundaries of the layer lead to a *maximum* estimate of reflectivity. More realistic profiles with smoothly rounded edges lead to reflectivities *many orders of magnitude less* than the sharp edged model (Ottersten, 1970), but such weakly reflecting layers would be inconsistent with the observed layer echo which appears to equal in intensity the return from the turbulent ground-based layer in Petersen and Jensen's Fig. 1.

The shortest pulse usually available with the Aerovironment Type 300 Acoustic Radar used by the authors is $t=50$ ms, providing a spatial resolution $ct=16.7$ m. Their "specular" layer measures less than 10 m thick on the facsimile record, however. The more ragged layer, which rises to about 200 m shortly before 0800 and descends again before 0900, measures to be somewhat thicker than the minimum resolvable distance, or about 30 m, as one might expect for a turbulent region. We believe *this* layer is the land breeze interface: it reaches 117 m at 0745, just when the wind and temperature at that level change, and descends past 117 m at 0850 when the *in situ* instruments also show inflections.

The NOAA Atmospheric Acoustics Group has made several efforts in the past to identify unambiguously layers in the stable planetary boundary layer producing specular returns. The highly stable, low wind conditions at Fairbanks, Alaska, seemed to offer an optimum environment for such tests. However, no changes in facsimile intensity could be found for two acoustic sounders, one transmitting vertically and one tilted at an angle of 35° from the vertical (Beran *et al.*, 1973). Indeed, if the Petersen and Jensen layer were a specular reflector and the layer advected with the low-level winds of about 1 m s^{-1}, the rise of the layer from 200 to 500 m in 26 min would lead to a slope of the layer of greater than 10°; thus the specular return would not be seen by the sensitive main beam of the sounder but instead would return near the first null in the beam pattern.

We have observed fascimile records, similar to the authors', that have proved to be non-atmospheric, caused by acoustic noise background or equipment problems. At our Haswell, Colo., tower site, a narrow band of wind velocities causes the carriage cable on the tower to oscillate and clank against the tower structure. This background noise can be nearly synchronous with the sounder returns, producing sloping and curved *apparent layers* in the records. Occasionally, when we have had problems with triggering the transmit pulse in sounders, secondary pulses nearly synchronized with the pulse repetition rate have leaked through our diode protective bridge causing similar striped patterns. We suggest that such background noise sources or equipment problems are the more likely explanation for the thin layer echoes reported by Petersen and Jensen, and that specularly reflecting layers for acoustic energy at normal incidence have yet to be observed.

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