Polar Lows as a cyclogeostrophic vortices

I.I. Mokhov

A.M. Obukhov Institute of Atmospheric Physics RAS, Moscow, Russia
mokhov@ifaran.ru

Relative contribution of relative role of cyclostrophic and geostrophic components for intense polar mesocyclones or Polar Lows is estimated with the use data from (Aakjaer, 1992).

In contrast to geostrophic regime with the balance of pressure gradient $(\rho^{-1}(\partial P/\partial r))$ and Coriolis force (fV) the centrifugal force (V^2/r) is significant in the gradient wind equation

$$V^2/r + fV = \rho^{-1}(\partial P/\partial r),$$

for Polar Lows. Here: $f=2\omega \sin\varphi$ – Coriolis parameter, ω - Earth rotation frequency, φ – latitude, ρ – density, V – velocity, P – pressure, r – radius of curvature.

For geostrophic vortices it follows from the equation

$$fV = \rho^{-1}(\partial P/\partial r)$$

that the pressure difference ΔP_c between the periphery and centre of cyclone is proportional to characteristic cyclone velocity V_c and radius r_c

$$\rho^{-1}\Delta P_c \sim f V_c r_c .$$

This regime is characterized by $Ro = V_c/(fr_c) << 1$.

Other asymptotic regime ($Ro = V_c/(fr_c) >> 1$) for cyclostrophic vortices is characterized by the equation

$$V^2/r = \rho^{-1}(\partial P/\partial r)$$

with

$$\rho^{-1}\Delta P_c \sim V_c^2 .$$

For intermediate regime with comparable Coriolis and centrifugal forces

$$V^2/r \sim fV ,$$

we have

$$Ro = V_c/(fr_c) \sim 1 .$$

In this case for polar latitudes with $\sin\varphi \sim 1$ the characteristic cyclone radius r_c is of the order of $V_c/2\omega$. Such vortices for intermediate regime between geostrophic and cyclostrophic ones can be defined as cyclogeostrophic vortices.

Relative role of cyclostrophic and geostrophic components for Polar Lows is characterized by $Ro \sim T_o/(2T_c)$, where $T_c=2\pi r_c/V_c$ and $T_o=2\pi/\omega$. Figure 1 shows dependences of Ro on diameter $2r_c$ and intensity ΔP_c for Polar Lows from (Aakjaer, 1992). According to Fig. 1 Polar Lows are cyclogeostrophic vortices with $Ro \sim 1$. Values of T_c are in the range from about $T_o/4$ = 6 hours (for small and less intensive Polar Lows) to about T_o = 24 hours (for large and most intensive ones).

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References

Aakjaer, P.D., 1992: *Tellus*, **44A**, 155.

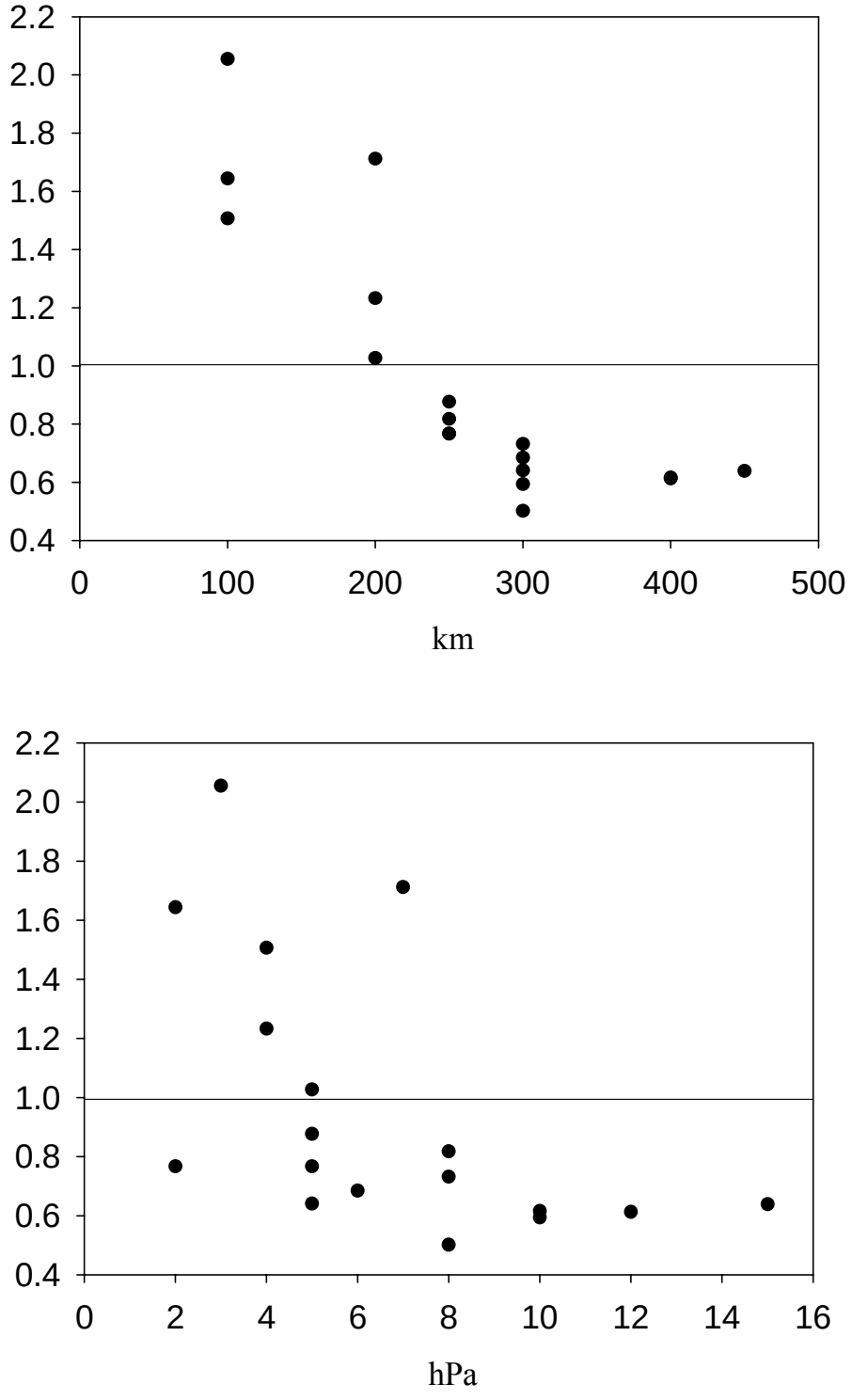

Figure 1. Dependences of *Ro* on diameter $2r_c$ (km) and intensity ΔP (hPa) for Polar Lows by data from (Aakjaer, 1992).