The “ageostrophic wind” and the "isallobaric wind"

- QG model emphasizes role of horizontal divergence, i.e. $$\frac{D_g \eta}{Dt} = -f_0 \nabla \cdot \vec{V}_{ag}$$
- $\boxed{\text{geostrophic wind}}$ (on an *f* plane**) is non-divergent, so interest is the ageostrophic wind $$\boxed{\vec{V}_g = \hat{k} \times \frac{1}{\rho f} \nabla P}$$
- above the friction layer, horiz. mtm eqns. can be written

$$\frac{Du}{Dt} = -\frac{1}{\rho}\frac{\partial P}{\partial x} + f\, v = f\,[v - V_g] = f\, v_{ag}$$

$$\frac{Dv}{Dt} = -\frac{1}{\rho}\frac{\partial P}{\partial y} - f\, u = -f\,[u - U_g] = -f\, u_{ag}$$

or $$\frac{\hat{k}}{f} \times \left[\frac{D\vec{V}}{Dt} - \cancel{\vec{F}_{\text{fric}}}\right] = \vec{V}_{ag}$$

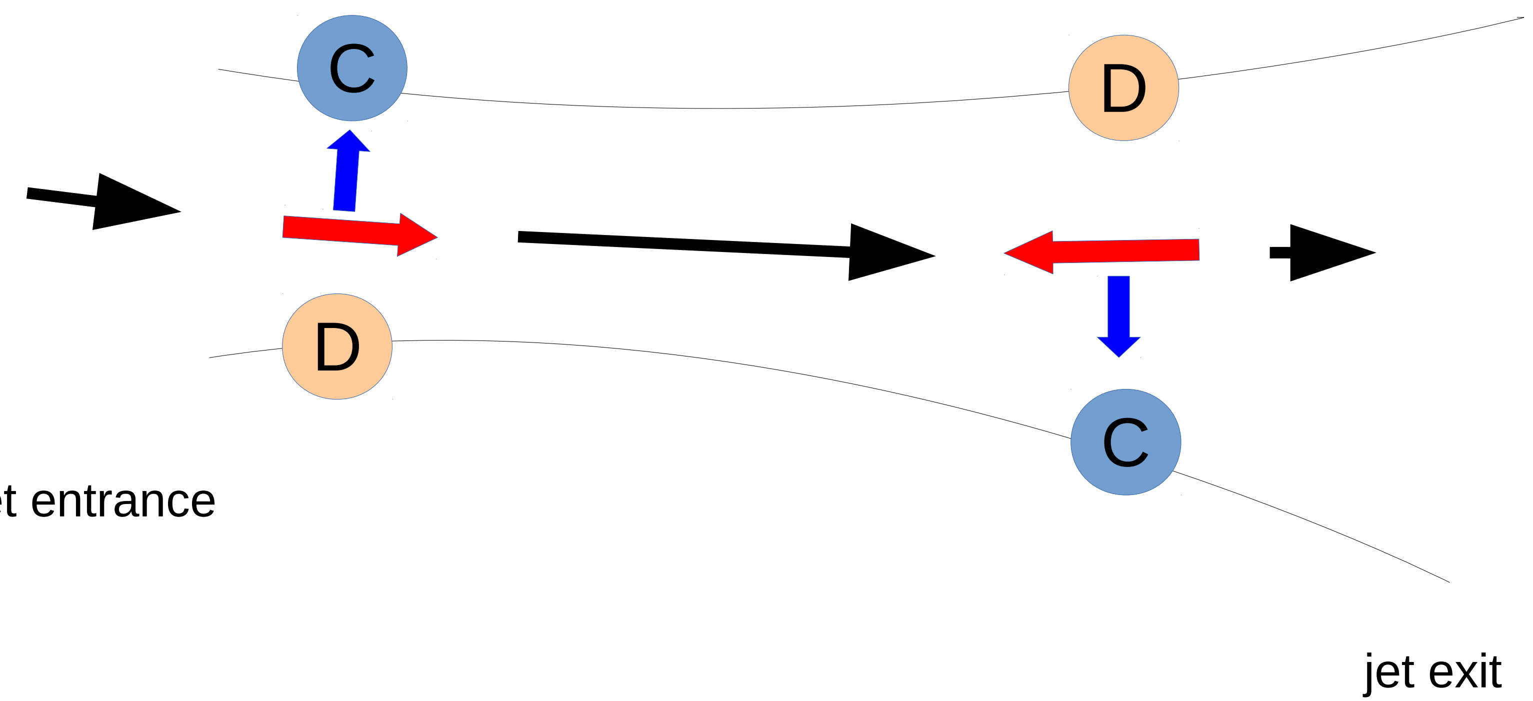
Terms (v-V_g) and (u-U_g) are identically the "geostrophic deficit" and the "ageostrophic wind." In absence of friction, acceleration of the flow equals the ageostrophic wind divided by the Coriolis time scale f^{-1}

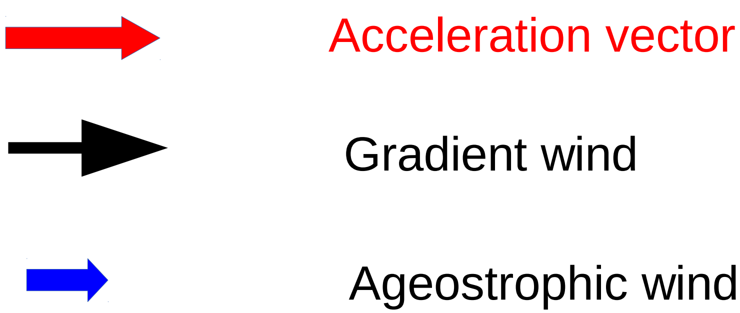
$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0 & 0 & 1/f \\ \frac{Du}{Dt} & \frac{Dv}{Dt} & 0 \end{vmatrix} = u_{ag}\,\hat{i} + v_{ag}\,\hat{j} + 0\,\hat{k} = \frac{-1}{f}\frac{Dv}{Dt}\,\hat{i} + \frac{1}{f}\frac{Du}{Dt}\,\hat{j} + 0\,\hat{k}$$

The ageostrophic wind is in the horiz. plane, perpendicular (and oriented to the left of) the acceleration vector

**A local approximation of the spherical earth as a plane normal to the zenithal component of the earth's rotation... *f* is assumed to be constant on the plane... valid in describing motions with time scales smaller than or comparable to 1/*f*. (AMS Glossary)... [as distinct from "beta plane" which allows linear variation of *f* with *y*]

“Ageostrophic wind” in relation to jet streaks: locations of con/divergence





$$\frac{\hat{k}}{f} \times \frac{D\vec{V}}{Dt} = \vec{V}_{ag}$$

The "isallobaric wind"

$$\vec{V}_{ag} = \frac{\hat{k}}{f} \times \left[\frac{\partial \vec{V}}{\partial t} + \left[\vec{V} \cdot \nabla\right] \vec{V} + \omega \frac{\partial \vec{V}}{\partial p} \right]$$

$$\boxed{\vec{V}_g = \hat{k} \times \frac{1}{\rho f} \nabla P}$$

Define the "isallobaric wind" to be that part of the ageostrophic wind that is contributed by the first term (non-stationarity). Under the approximation that terms on the rhs are evaluated using the geostrophic wind, the isallobaric wind is

$$\vec{V}_{ia} = \frac{\hat{k}}{f} \times \frac{\partial \vec{V}_g}{\partial t} = \frac{\hat{k}}{f} \times \frac{\partial}{\partial t} \left[\hat{k} \times \frac{1}{\rho f} \nabla P \right] = \frac{-1}{\rho f^2} \nabla \frac{\partial P}{\partial t}$$

- lines of constant surface pressure tendency are “isallobars”
- isallobaric wind “driven” by spatial gradient in pressure tendency
- or (equivalently) by tendency in the pressure gradient
- isallobaric wind blows PERPENDICULAR to isallobars

The "isallobaric wind"

Let coordinate *s* increase down the isallobaric gradient, i.e.

- from where *p* is rising rapidly towards where *p* is rising less rapidly, or
- from where *p* is rising towards where *p* is falling, or
- from where *p* is falling slowly towards where *p* is falling faster

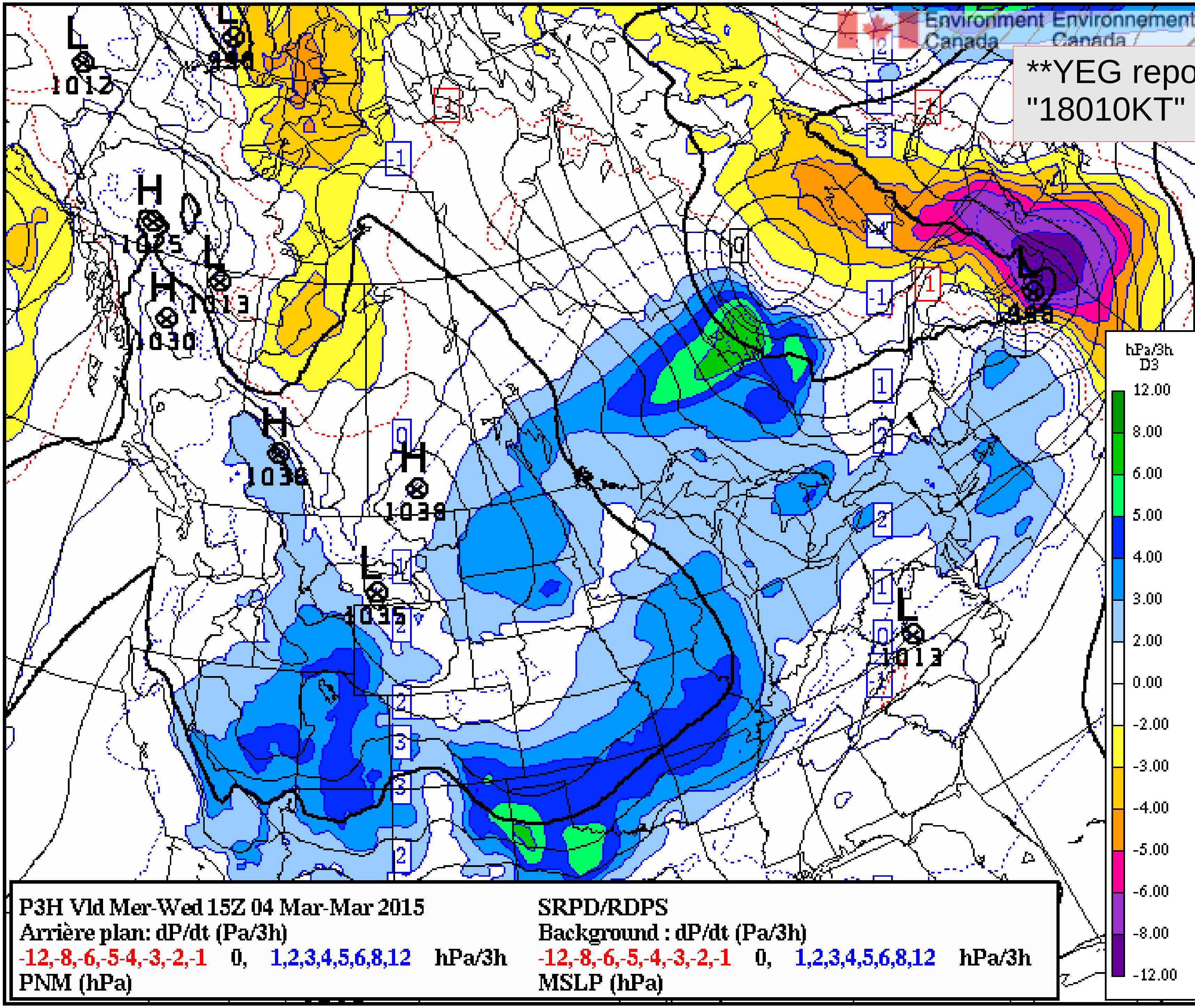
Then the isallobaric wind is

$$\vec{V}_{ia} = \frac{-1}{\rho f^2} \frac{\partial}{\partial s} \left[\frac{\partial P}{\partial t} \right]$$

Is this a "real" wind? Yes, it is one component of the departure from the geostrophic wind (within the ABL, and particularly near the surface, friction is liable to be a more important deviation). Furthermore its divergence is important (our starting point), given by

$$\nabla \cdot \vec{V}^{ia} = \frac{-1}{\rho f^2} \nabla^2 \frac{\partial P}{\partial t}$$

Isallobaric chart (from Vizaweb) – relevant to 12Z winds and our fcst for Wed. 12Z**



**YEG reported "18010KT" at 12Z Wed.