in (x, y, z, t) coordinates we had $\underbrace{u, v, w, T, p, \rho}_{6}$. (our starting point)

$$PGF = -\frac{1}{\rho}\vec{\nabla} p$$

$$\frac{d\vec{u}}{dt} = -\frac{1}{\rho}\vec{\nabla} p + f\hat{k} \times \vec{V}$$

u equation for definiteness:

$$\left.\frac{\partial u}{\partial t}\right|_{x,y,z} = -\frac{1}{\rho}\left.\frac{\partial p}{\partial x}\right|_z + fv - u\left.\frac{\partial u}{\partial x}\right|_z - v\frac{\partial u}{\partial y} - w\frac{\partial u}{\partial z}$$

$\frac{dx}{dt}$ same? $\frac{dz}{dt}$

same?

not quite!

Primitive Equations: make p the coordinate in the vertical.

(x, y, p, t) coordinates

(u, v, ω, T, Z) variables (5)

$\frac{dp}{dt}$ following an air parcel

$$\frac{du}{dt} = -\nabla(\underbrace{gZ}_{\Phi}) + f\hat{k} \times \vec{V}$$

$$\left.\frac{\partial u}{\partial t}\right|_{x,y,p} = -\left.\frac{\partial \Phi}{\partial x}\right|_p + fv - u\left.\frac{\partial u}{\partial x}\right|_p - v\frac{\partial u}{\partial y} - \omega\frac{\partial u}{\partial p}$$

same?

$\frac{dx}{dt}$ same? yes bcs. x, y are still horizontal

Vocabulary item	or term, units	Concept (words)	Concept (sketch)
Kinematics $\frac{\partial(\text{velocity})}{\partial(\text{space})}$	s^{-1}	(wind) Descriptions of vector field variations in space only (no time evolution, *not dynamics*)	(arrows on a plane)
streamlines, 3D or horizontal		instantaneous – parallel to velocity at each point at this instant.	
trajectories, 3D or horizontal		time path of a parcel of air	
isotachs	m/s	line of constant speed	
natural coordinates	s & n	streamwise (along flow) and normal (left of s) 90°	
Curvature		rate of change of direction in downstream direction	
cyclonic		rotation in same direction as Earth's turning	
Diffluence/confluence		streamlines apart/together (without divergence, perhaps)	
Dilation/contraction		the two axes of deformation	
Stretching	opposites		
Deformation			
Vorticity	s^{-1}	s in of a parcel locally	
Divergence	s^{-1}	$\frac{1}{A}$ dA/dt of a patch A	
Shear	s^{-1}	1 part vorticity + 1 part deformation	
Circulation		the area-integral of vorticity, equal to line integral of tangential wind by Stokes' Theorem	
Stokes' theorem			
Green's theorem		as above but for divergence	
rate of expansion of area		(horizontal divergence is 1/A dA/dt)	
Hyperbolic flow (pure deformation)			