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

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

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

u equation for definiteness:

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

$\frac{dx}{dt}$ 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)

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

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

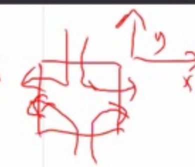
$$\left.\frac{\partial u}{\partial t}\right|_{x,y,p} = \left.-\frac{\partial \Phi}{\partial x}\right|_p + fv - u\left.\frac{\partial u}{\partial x}\right|_p - v\frac{\partial u}{\partial y} - \omega\frac{\partial u}{\partial p}$$

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}	spin 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)			

Stokes' theorem		$\oint \vec{V} \cdot d\vec{l} = \iint \zeta_a \, dA$	
Green's theorem		as above but for divergence $\iint \nabla \cdot v \, dA = \oint \vec{V} \cdot d\hat{n}$	
rate of expansion of area		(horizontal divergence is 1/A dA/dt)	
Hyperbolic flow (pure deformation)			
axis of dilatation (or stretching)			X (x,y)
axis of contraction			
frontal zone		region of sharp gradients (or "steep")	
passive tracer			
conserved, conservative tracer		$\frac{d}{dt}(\text{conserved}) = 0$	
~~concentration~~, mass mixing ratio, volume mixing ratio		$\left(\frac{Kg_v}{Kg_{air}}\right)$, "ppm"	
advected, horizontal advection		$-\vec{V} \cdot \vec{\nabla}\psi$	
gradient: up-gradient, down-gradient			
upstream, downstream			
sinusoidal wave		sin or cos	
trough, ridge		minima and maxima	
acceleration	m/s^2		
mass (and mass density)	Kg/m^3		
resultant or net or total force		sum of all forces	
apparent forces "Coriolis",		"fictitious" forces due to coordinate system rotation	
coordinate system			
frame of reference			
centrifugal force			



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github.com/ATMOcanes/ATM651_2020/blob/master/Exam_and_problems/Vocabulary_WHch7.md

gravitation vs. gravity (effective gravity)			$g = g^* + \Omega^2 R_e$
axis of rotation			
geopotential	$\Phi = gZ$	J/kg, $\frac{m^2}{s^2}$	potential energy (per kg)
transverse, streamwise (upstream/downstream)			
right hand rule	(for cross product)		
Coriolis parameter f	$2\Omega\sin\phi$	s^{-1}	a.k.a. planetary vorticity
unit vector	unitless	NONE!	e.g. $\hat{i}, \hat{j}, \hat{k}$ length 1, direction along coordinate
vertical, horizontal			
Real Forces			PGF, gravity, "friction"
pressure gradient force			
frictional force			
hydrostatic			(balance btw. PGF & gravity)
geometric height	z		
geopotential height	Z		
slope, curvature	measured by:		rise/run = $\frac{df}{dx}$ = slope, curvature = $\frac{d(\text{slope})}{dx} = \frac{d^2f}{dx^2}$ ∇^2 is N-dim second derivative
Laplacian operator			
orders of magnitude	factors of 10, powers of 10		
isobars	surfaces or contours or lines of constant p		
geopotential height contours	contours of Z on p surfaces		
pressure surfaces (or isobars in 2D)			plane or line of constant p
constant of proportionality			aka "coefficient"
density			
Mass			

geometric height, geopotential height: } g is not quite constant... sealevel (geoid) is $Z=0$ } we don't care for the atm.

slope, curvature; Laplacian operator: units m^{-2}, m^{-2}, m^{-2}

Brian Mapes' screen

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Pencil Only

anomalies	total series minus TIME average, might be a cyclic (seasonal "climatological") average — deviation from spatial averages are EDDIES
shear stress (Pa) — vertical exchange of horiz momentum	
rate of vertical exchange	flux or transport is what "exchange" means
scales of motion — "synoptic" — days in time, thousands of km. micro < meso < synoptic < planetary	
unresolved — too small to resolve on some grid or mesh	
vertical profile	
mixing	
vertical wind shear — change of hor wind with altitude.	
boundary layer — layer where friction & other surface effects are important	
horizontal equation of motion — F=ma	$d\vec{V}/dt = -\vec{\nabla}\Phi + f\hat{k}\times\vec{V} + \vec{F}$
local rate of change = sum of tendencies	Eulerian form of equations, like our numerical models are built on
empirical — observed to be true (specifically, not an explanation in terms of principles!)	
frictional drag (drag coefficient) C_D unitless	$F_{sfc} = C_D \cdot U_{ban}$?
magnitude	
roughness	
static stability	measures how θ (potential temp) increase with height
wind vector, components, vectorial form	$\vec{V} = u\hat{i} + v\hat{j} + w\hat{k} = \hat{i}u + \hat{j}v + \hat{k}w$
scalar — ∇ del operator	$= \hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z}$
speed (a scalar, as opposed to velocity, a vector)	$\lvert\vec{V}\rvert = V = \sqrt{u^2+v^2+w^2}$ — $V \rightarrow \vec{V}$
surface layer — lowermost boundary layer where friction is really important.	
Lagrangian (in frame of reference of air parcels) time derivative	

Units: pressure and stress are same!

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