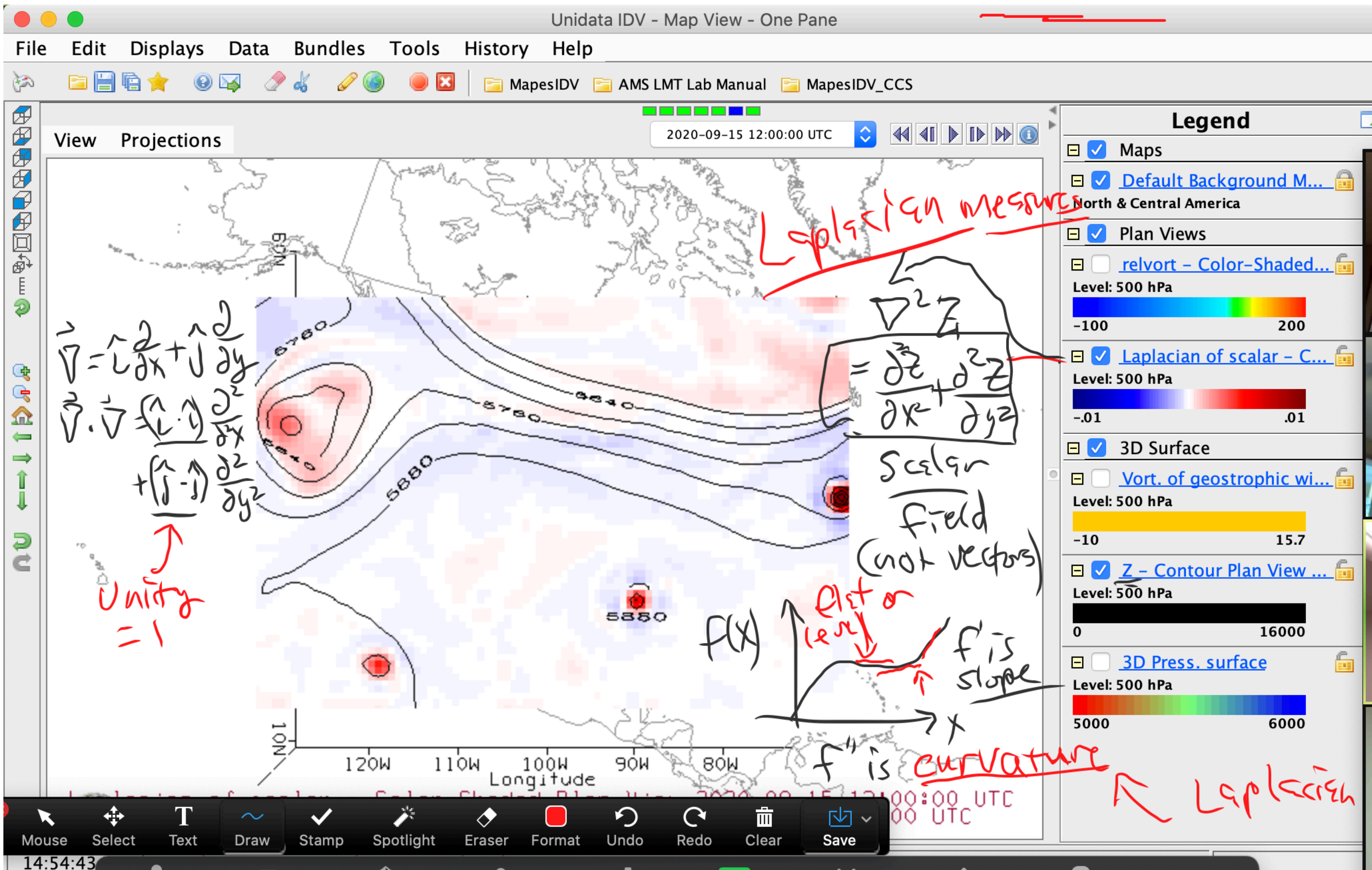

Unidata IDV - Map View - One Pane
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MapesIDV AMS LMT Lab Manual MapesIDV_CCS
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Legend
Maps
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North & Central America
Plan Views
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Laplacian of scalar - C...
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3D Surface
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Z - Contour Plan View ...
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3D Press. surface
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5760
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5840
5880
60N
10N
120W 110W 100W 90W 80W
Longitude
Laplacian measures
$\nabla^2 Z = \frac{\partial^2 Z}{\partial x^2} + \frac{\partial^2 Z}{\partial y^2}$
Scalar field (not vectors)
$\vec{\nabla} = \hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y}$
$\vec{\nabla} \cdot \vec{\nabla} = (\hat{i}\cdot\hat{i})\frac{\partial^2}{\partial x^2} + (\hat{j}\cdot\hat{j})\frac{\partial^2}{\partial y^2}$
Unity = 1
f(x)
flat or level
f' is slope
x
f'' is curvature
Laplacian
Mouse Select Text Draw Stamp Spotlight Eraser Format Undo Redo Clear Save
14:54:43

Vorticity: the strategic view.

- We have admired & understood eq's like

hungry for this

$$\underbrace{\frac{d}{dt}(\text{conserved}) = 0}_{\text{transport only!}} + \text{complications (sources minus sinks)}$$

- Reading Ch 7 starts in on momentum

$$\frac{d}{dt}\begin{pmatrix}\text{momentum}\\ \text{per unit}\\ \text{mass}\end{pmatrix} = 0 + P + C + F \quad (7.12)$$

terrible approximation!

stuck with this eq.

$$\left\{ a = \frac{d\vec{V}}{dt} = -\vec{\nabla}\Phi + F\hat{k}\times\vec{V} + \vec{F} \quad (7.14)\right.$$

Hungry mind looks at (7.13b) in ϕ coordinates

$$\frac{\partial}{\partial y}\left[\frac{du}{dt} = -\frac{\partial \Phi}{\partial x} + fv + F_x\right]$$

$$-\frac{\partial}{\partial x}\left[\frac{dv}{dt} = -\frac{\partial \Phi}{\partial y} - fu + F_y\right]$$

Want less on right!

How?

1. about F_x & F_y : ignore it (above PBL upper level focus)

2. About Φ and PGF:
take y-derivative of u equation,
subtract x-derivative of v equation

$$\underline{\frac{\partial}{\partial y}\left(\frac{du}{dt}\right)} - \underline{\frac{\partial}{\partial x}\left(\frac{dv}{dt}\right)} = \underline{0!!!} + \left[\frac{\partial}{\partial y}(fv) - \frac{\partial}{\partial x}(-fu)\right] + \cancel{(\text{curl of friction})}$$

ignore

Hungry mind clobbered PGF ($-\vec{\nabla}\Phi$) term!
At what price?

$$\frac{\partial}{\partial y}\left(\frac{du}{dt}\right) = \text{how many terms?}$$

$$\underbrace{\frac{\partial}{\partial y}\left(\underbrace{\frac{\partial u}{\partial t}}_{\left(\frac{\partial^2 u}{\partial y\,\partial t}\right)\ 1} + \underbrace{u\frac{\partial u}{\partial x}}_{\text{chain rule} \to 2\text{ terms}} + \underbrace{v\frac{\partial u}{\partial y}}_{2} + \underbrace{w\frac{\partial u}{\partial z}}_{2}\right)}_{7}, \quad \underbrace{\text{same for } \frac{\partial}{\partial x}\left(\frac{dv}{dt}\right)}_{7}$$

7.6-7.10 Dynamics Homework copy (1 page) — Edited

7.7 $\nabla\cdot\vec{V} = \frac{\partial v}{\partial y} = \frac{-8\cos(60)-(5\cos(180-150))}{3^\circ \cdot 1.11\times10^5\ m/deg} = \frac{-4-4.33}{3.33\times10^5} = -2.5\times10^{-5}s^{-1}$

RR: $-\frac{\nabla\cdot\vec{V}}{2}\frac{\Delta p}{g}\omega = -2.5\times10^{-5}s^{-1}\cdot\frac{1}{2}\cdot\frac{(1010-900\ mb)}{9.8\ m/s^2}\cdot .02\ g/kg = 2.81\times10^{-4}\ kg/s = 2.42\ kg/d$

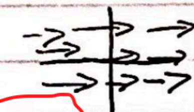
dp/g units: kg per sq m

$\frac{\Delta P}{g} = \frac{Pa}{m/s^2} = \frac{N/m^2}{m/s^2} = \frac{kg\,\frac{m}{s^2}/m^2}{m/s^2}$ → kg/m^2 of sfc

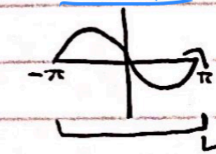
7.8 $\nabla\cdot\vec{V} = \frac{\partial u}{\partial x}+\frac{\partial v}{\partial y} \rightarrow \frac{\partial}{\partial x}\left(-\frac{\partial\psi}{\partial y}\right)+\frac{\partial}{\partial y}\left(\frac{\partial\psi}{\partial x}\right) = 0$ ✓

$\zeta = \frac{\partial v}{\partial x}-\frac{\partial u}{\partial y} \rightarrow \left(\frac{\partial}{\partial x}\left(\frac{\partial\psi}{\partial x}\right)\right)-\left(\frac{\partial}{\partial y}\left(\frac{\partial\psi}{\partial y}\right)\right) = \frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2} \rightarrow \nabla^2\psi = \zeta$ ✓

7.9 a. $\psi = my$, $m>0$



b. $\psi = my + n\cos\frac{2\pi x}{L}$, $m>0$



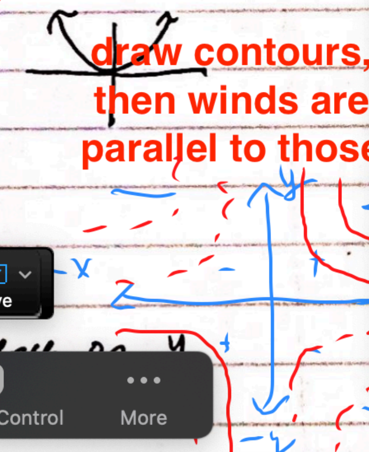
c. $\boxed{\psi = m(x^2+y^2)}$ (r^2), $m>0$

solid body rotation

pure deformation

d. $\boxed{\psi = m(xy),\ m>0}$

draw contours, then winds are parallel to those



7.10 a. $\frac{\partial^2\psi}{\partial x^2} = 0 = \frac{\partial^2\psi}{\partial y^2}$, no vorticity in straight flow $\zeta = 0$

b. $\zeta = \nabla^2\psi = (2\pi/L)^2 n\cos\left(\frac{2\pi x}{L}\right)$ oscillates in x, no dependence on y

d. $\frac{\partial^2\psi}{\partial\ldots} = 0$

Homework lessons for our vortex interaction

topic:

HW prob → (7.6): $\perp$ distance tangential flow "induced" in the far field advects tracers (like vorticity)

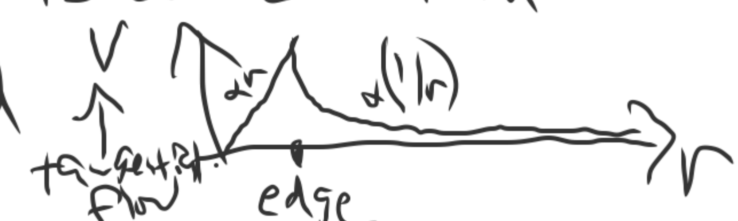
HW prob (7.7): $\psi = m(x^2+y^2) = m(r^2)$

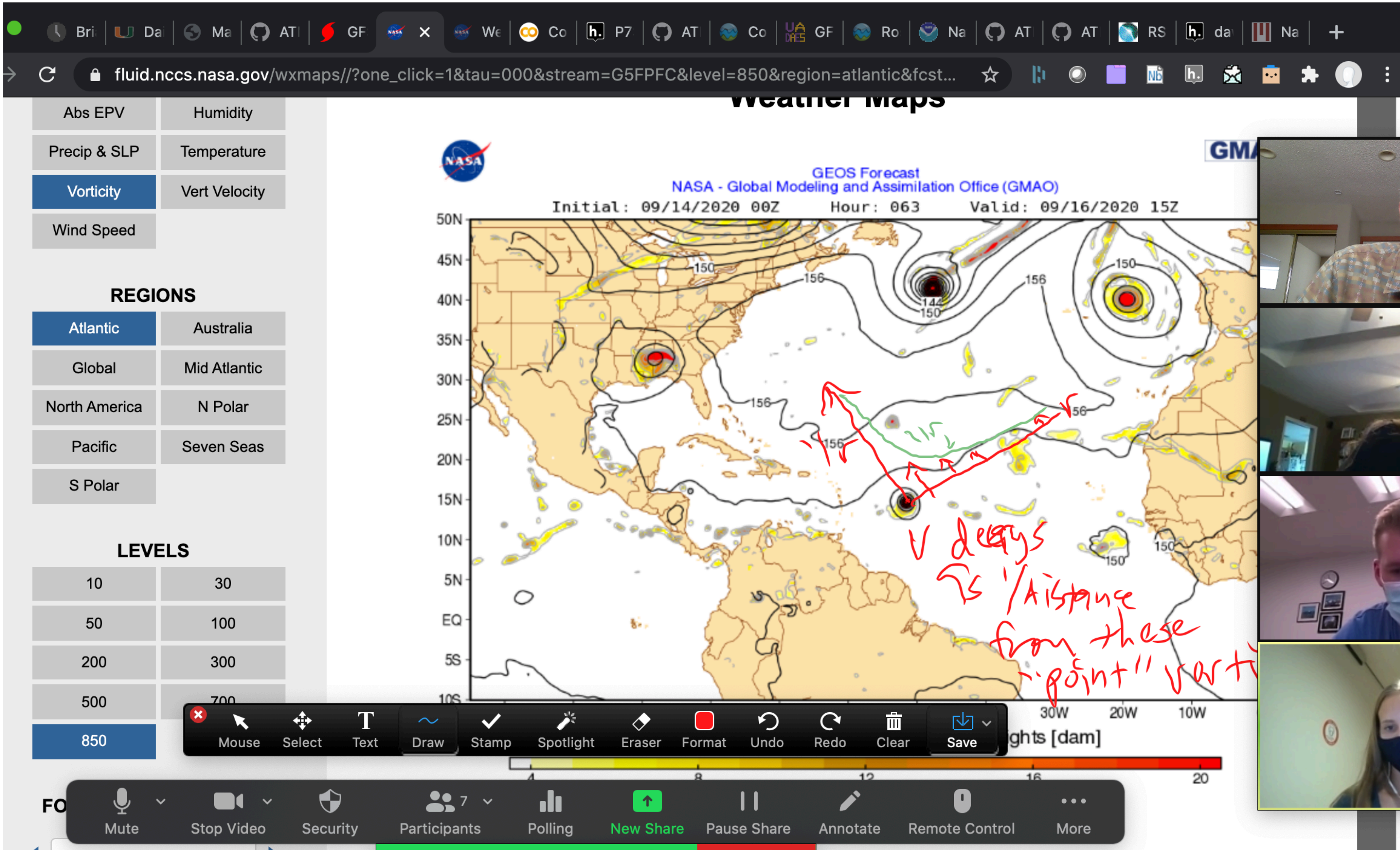
near-field paradigm: solid body rotation

$$\zeta = \nabla^2 \psi = 4m$$

Combine these views:

$\boxed{\text{a Rankine vortex}} \Leftarrow \begin{cases} \zeta = \text{constant to some radius} \\ \zeta = 0 \text{ beyond} \end{cases}$

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Vert Velocity
Wind Speed
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Australia
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North America
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Pacific
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Remote Control
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Stop Share