Divergence, Vorticity, Vertical Motion

Meteorology 311
Fall 2021
Expression of Winds

- Wind barbs (magnitude and direction)
- Meteorological degrees (magnitude and direction)
- Vector Components
- Wind at any point \((x,y)\) and be written as the wind at \((x_0, y_0)\) using a Taylor expansion.
  - Three main terms emerge
  - Divergence, vorticity, deformation
Divergence

• $\delta > 0$ : Expansion of a parcel
  – After construction zone

• $\delta < 0$ : Compression of a parcel
  – Before construction zone

• Calculation of divergence/convergence is difficult when not on a Cartesian grid.
  – What do we do?
Natural Coordinates

- Rotate axis so X-Axis points along the wind, Y-Axis is 90° to the left.

- \( \hat{s} \) is aligned with wind, \( n \) is positive to the left.

- \( u = |V| \cos \theta_b \), \( v = |V| \sin \theta_b \)

- \( \theta_b \) is angle which you have rotated the coordinate system.
Divergence (Natural Coordinates)

• Terms are usually both large and have opposite sign.

• Hard to tell if there is divergence (convergence) just because there is confluence (diffluence).
Vorticity (Natural Coordinates)

• Spin of a parcel

• Horizontal spin is most important to meteorologists.
  – z component.

• Counterclockwise spin: positive vorticity
• Clockwise spin: negative vorticity
• Cyclonic vorticity: having the same direction of rotation as the Earth.
• Anticyclonic vorticity: Opposite direction.
Why is this important?

• Divergence/Convergence
  – Low level convergence $\rightarrow$ Upward motion
    • Clouds and precipitation
    • Continuity equation
  – Low level divergence $\rightarrow$ Downward motion
    • Fair weather

• Vorticity
  – PVA $\rightarrow$ Upward motion
    • Downstream of a vorticity maximum
    • Clouds and precipitation
  – NVA $\rightarrow$ Downward motion
    • Fair weather
  – Usually looked at high up in the atmosphere.
Vertical Motion

• Synoptic scale
  – $u$ and $v \sim 10$ m/s
  – $w \sim 1$ cm/s

• Weather ballons: $\sim 10\%$ error in measuring horizontal winds (1 m/s)
  – Not good enough.
  – Effectively impossible to measure $w$.

• What do we do?
What do we do?

• Diagnose \( w \) from other relationships.

• If you have \( w \) or \( \omega \) in an equation, you can solve for it.

• Remember \( \omega \)?
  – Think about the sign.

• Five techniques for estimating \( w \) or \( \omega \).
Methods

- Kinematic Method
  - Continuity equation.
  - Most commonly used.

- Adiabatic Method
  - Thermodynamic equation.

- Isentropic Method
  - Isentropic coordinate (adiabatic motion)

- Vorticity Method
  - Vorticity equation.

- Satellite Method
  - Determine cloud-top temperature changes with time.