Divergence, Vorticity, Vertical Motion

Meteorology 311
Fall 2015
Expression of Winds

• Wind barbs (magnitude and direction)

• Meteorological degrees (magnitude and direction)

• Vector Components

• Taylor expansion of wind (three terms)
  – 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 → Upward motion
    • Clouds and precipitation
    • Continuity equation
  – Low level divergence → Downward motion
    • Fair weather

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

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

• 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.