Divergence, Vorticity, Vertical Motion

Meteorology 3110

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_o, y_o) 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 90º to the left.
- $\hat{s}$ is aligned with wind, n is positive to the left.
- $u = |V| \cos \theta_b$, $v = |V| \sin \theta_b$
- θ_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 ~ 10 m/s
  - w ~ 1 cm/s
- Weather ballons: ~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 ω in an equation, you can solve for it.
- Remember ω?
  - Think about the sign.
- Five techniques for estimating w or ω.

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.