

Divergence, Vorticity, Vertical Motion

Meteorology 311
Fall 2007

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 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, \hat{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 $v \sim 10$ m/s
 - $w \sim 1$ cm/s
- Weather balloons: $\sim 10\%$ 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 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.