Formation of Wind

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Background:

Wind in simple terms is the movement of air. Often, this movement is caused by temperature differences in the atmosphere due to solar heating.

Tornadoes are formed when two regions of air, one hot and one cold, meet and create violent funnels of wind.

Goal:

- Calculate wind location, direction, and speed from different sets of initial conditions

Objectives:

1. Collect and organize data for initial conditions
2. Track pressure changes in the atmosphere down to ground level and calculate wind speed on the ground assuming that everything begins at isobaric, thermal equilibrium (to eliminate other effects)
3. Simulate the movement of a cloud
4. (stretch goal) Simulate a tornado from the necessary initial conditions

Approach:

Necessary Data:

- atmospheric layer locations
- distribution of solar radiation energy
- air temperatures
- air moisture levels
- air densities

Steps:

1. create 3D array of air densities, moisture levels, pressures, temperatures and velocities
2. calculate energy being added to air
3. calculate air pressures
4. calculate velocities of air
5. calculate resultant change in pressures
6. calculate new pressures
7. repeat steps 4-6 for all time steps

Important Equations and Techniques:

- F=ma
- zeta = curl(v)
- dzeta/dt = -zeta*D
- du/dt = -1/rho grad(p) + g + F
- -grad(p)/rho - grad(phi) = 0
- (ug, vg) = 1/(rho*f)(-dp/dy, dp/dx)

Objective 1:

- Look at resources

Objective 2:

1. Use a big array (each point represents ~10 m^3 of space, look at ~100x100x100000 m (top of atmosphere to top of Mt. Everest at (~9000 m above sea level))
2. Simulate
3. Plot wind velocities in space over time

Objective 3:

1. Use a small array (each point represents ~10 m^3 of space, look at ~100x100x100 m)
2. Use initial conditions from Objective 1
3. Scale the moisture levels of a region to the moisture levels of a cloud
4. Simulate
5. Plot moisture levels in space over time

Objective 4:

1. Use a big array (each point represents ~10 m^3 of space, look at ~1000x1000x5000 m)
2. Use initial conditions from Objective 1
3. Scale two areas of the array to create one hot and one cold region (conditions for tornado)
4. Simulate
5. Plot wind velocities in space over time

Resources:

- http://www.uio.no/studier/emner/matnat/geofag/GEF4500/h08/unisdyn1.pdf
- http://www.cgd.ucar.edu/staff/islas/teaching/2_Equations.pdf
- timeanddate.com