Review for the midterm

ATM2106

Energy budget

Radiative balance

- $dT/dt = E_{in} - E_{out}$

  - Solar radiation — Stefan's Law
  - albedo

- The role of the atmosphere in the energy budget
- The sensitivity of the emission temperature to the extra heat

Convection

- Why does it happen?
- Stability
- Convection in the air and in the water
- Lapse rate
- Stability of the air with the temperature determined by radiative equilibrium.

Energy Transport

- Energy imbalance in low and high latitudes.
- The actual pole-to-equator temperature difference v.s. the pole-to-equator temperature difference in the radiatively balanced earth.
- Who transport the energy from where to where?

Properties of the atmosphere

Temperature v.s. potential temperature

- Why do we need potential temperature?
- Is the atmosphere stable in the dry adiabatic condition?
- Dry potential T v.s. Equivalent potential T
- Specific humidity, Saturation specific humidity and relative humidity, and their distributions
- Saturated adiabatic lapse rate
- Is the atmosphere stable in the presence of moisture?

Geopotential height

- Meaning?
- What controls the Geopotential height?
- Map of geopotential height and pressure distribution.
- Thickness of the atmosphere

Wind

- Zonal wind v.s. meridional wind
- Zonal wind distribution
- Meridional overturning circulation
- Using streamfunction to get an idea of the meridional wind

Equations of motion

Eulerian derivative v.s. Lagrangian derivative

- What are the meaning of these derivatives?
- How are they related?
- Which derivative is directly related to the net forcing?

Forces

- Gravity
- Pressure gradient force
- Friction
- Coriolis force on the rotating system

Governing equations

- Momentum equations
- Mass conservation (although I skipped, it is one of the governing equations.)

Balanced flow - steady state

$$\frac{Du}{Dt} + \frac{1}{\rho}\frac{\partial P}{\partial x} - fv = F_x$$

$$\frac{Dv}{Dt} + \frac{1}{\rho}\frac{\partial P}{\partial y} + fu = F_y$$

→ Geostrophic wind

$$\frac{1}{\rho}\frac{\partial P}{\partial x} + g = 0$$

- Characteristics of geostrophic wind

Thermal wind equation

- What is the meaning of this equation?
- Estimate the geostrophic wind using temperature.

Subgeostrophic flow

- When do we have subgeostrophic flow?
- Characteristics of subgeostrophic flow?

General circulation of the atmosphere

Hadley circulation

- Extra energy in the tropics
- Extra angular momentum in the tropics
- Hadley circulation transports energy and momentum within the tropics
- Westerlies aloft but easterly near the surface because of the Coriolis force.
- Thermal wind, trade winds.

Transport by eddies

- When rotation becomes important, we see turbulent motions.

- These eddies are transport energy and momentum.

- Where is the energy source for eddies?

- What determines the way of releasing energy?

Total energy transport

- Potential energy, kinetic energy, internal energy, latent heat

- What contributes to the poleward total energy transport within the Hadley circulation?

- How is the total energy transported in the middle latitudes?

Ocean

The difference between the air and the ocean

- Compressibility
- Moisture
- Boundaries
- Heating
- Stress

Physical properties of the ocean

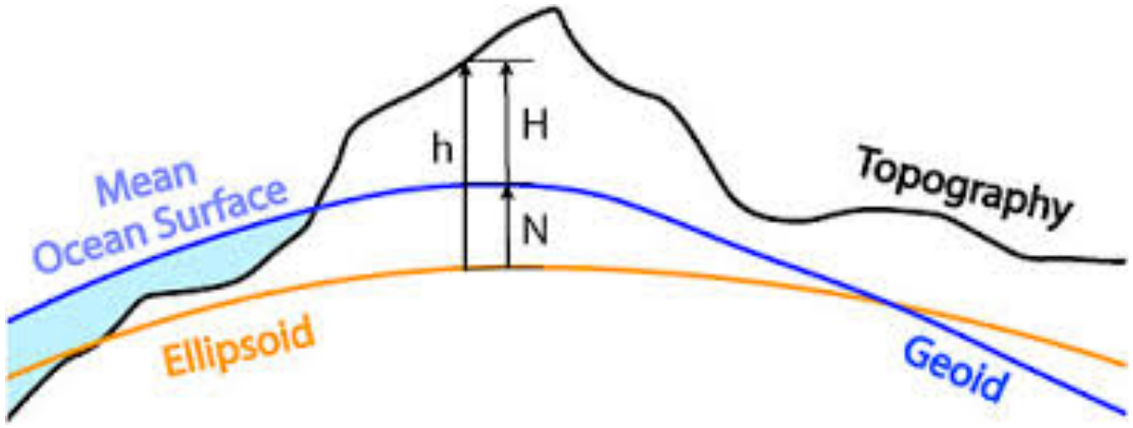
- Salinity
- Density
- Cryosphere
- Mixed layer

Equations of motion

- The same equations of motion as the atmosphere
- Density varies little: treat it as a constant in the horizontal momentum equations.
- Pressure increases linearly downward.
- Geostrophic approximation is more accurate than in the atmosphere.
- Thermal wind equations

Equations of motion

- Geostrophic current at the surface : Sea surface height
- Geostrophic current at depth : sea surface height + isopycnal



From wikipedia: The **geoid** is the shape that the surface of the oceans would take under the influence of Earth's gravity and rotation alone, in the absence of other influences such as winds and tides.

Ocean circulation

- Subtropical gyres
- Wind-driven circulation
- Ekman transport
- Ekman pumping / suction
- Western boundary current