$W = Fd$

$P = \frac{W}{t}$

$Q = mc\Delta T$

$Q = mL$

$E = \sigma T^4$

→ $P = \rho g h$

$PV = nRT$

$P = \rho RT$

$\rho = \frac{m}{V} = \frac{n}{V}$

→ $\rho = \frac{P \xleftarrow{} \text{can be 1 atm}}{R_{sp} T}$

$R_{sp} = \frac{R}{M} \leftarrow$ molar mass

$KE = \frac{1}{2} m v^2$

$PE = mgh$

thermal conductivity : $\lambda = \frac{Q \cdot L}{A \cdot \Delta T}$ ← thickness; area →; temp change

bulk modulus : $K = -V\left(\frac{\Delta P}{\Delta V}\right)$ ← $P = \rho g h$

% compression : $\frac{\Delta V}{V}$

$FDD = \left|\text{ambient temp below zero}\right| \times (\text{\# of days})$

relative humidity $= \frac{\text{mass of vapour}}{\text{mass of dry air}} = \frac{g}{kg}$

Total Pressure of gases $= \sum$ pressure of each gas

E = vapour pressure water

E* = saturated vap. pressure

$RH = \frac{E}{E^*} = [\%]$

ice growth height : $h_i = \overset{27}{k}\sqrt{FDD}$

Γ_d : dry adiabatic lapse rate $= \frac{-\Delta T}{\Delta z} = \frac{-g}{c_p}$

Γ_s : saturated adiabatic lapse rate : $\approx 6 \frac{°C}{km}$

Γ_e : environmental lapse rate (ELR) : actual ΔT measured

$\Gamma_e < \Gamma_s$	: stable	rising air sinks back
$\Gamma_e > \Gamma_d$	: unstable	air rises freely
$\Gamma_s < \Gamma_e < \Gamma_d$	: conditionally unstable	stable if dry, unstable if saturated

$\text{Efficiency} = \frac{E_{out}}{E_{in}} \times 100\%$

Peak sun angle = 90° − (latitude to middle)

Adiabatic : no energy is added or removed

Thermocline : ocean ΔTemp as Δdepth

Halocline : ocean Δsalinity as Δdepth

Chinook : bottom cold air rises then descends warm

Katabatic winds : top cold air descends

$R_{sun} = 696000$ km

$R_{Earth} = 6371$ km

$R_{moon} = 1737$ km

$D_{E \to S} = 149,097,500$ km

$D_{E \to M} = 384,400$ km

$\rho_{air} = 1.2$ kg/m³

$(\rho_{water})_{fresh} = 1000$ kg/m³

$(\rho_{water})_{salty} = 1025$ kg/m³

$\rho_{ice} = 916$ kg/m³

$(C_{air})_V = 1200$ J/m³·k

$(C_{air})_P = 1005$ J/kg·k

$C_{water} = 4180$ J/kg·k

$C_{ice} = 2100$ J/kg·k

energy density of gasoline $= \frac{32 \text{ MJ}}{1 \text{ L}}$

$\sigma = 5.67 \times 10^{-8}$ W/m²·k4

cumulus: unstable warm air rises

cumulonimbus: tall unstable clouds

Volume of air in 1 min : (Area)(velocity)(time) = $[m^2]\left[\frac{m}{s}\right][s]$

$m = V\rho \leftarrow \rho = \frac{P}{R_{sp} T}$

$E = \frac{1}{2} m v^2$

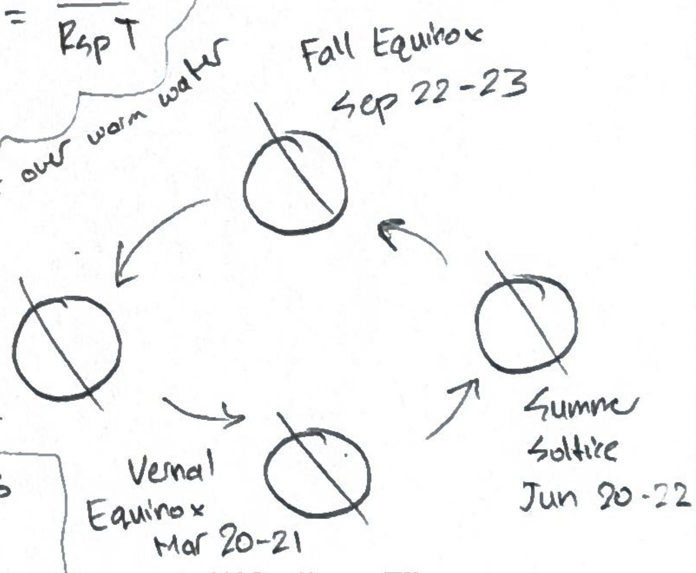
lake effect snow : cold air over warm water

$R = 8.314$ J/mol·k

Earth's energy budget $= 1.74 \times 10^{17}$ W

Solar insolation on Earth $= 342$ W/m²

$C_{light} = 3 \times 10^8$ m/s



$(L)_{\text{water to ice}} = 334,000$ J/kg

$(L)_{\text{water to gas}} = 2,260,000$ J/kg

$(L)_{\text{Earth evap water}} = 2.6 \times 10^6$ J/kg

perihelion : closest to sun, Jan W1,

aphelion : furthest " " ",

perigee : closest to moon

apogee : furthest to moon

NH winter : Earth tilts 23.5 away from the sun.

Polar, Ferrel, Hadley cell

albedo, transmittivity, absorptivity.

Zaeem Ahmad

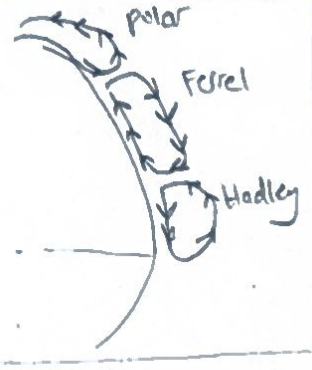
CIV300

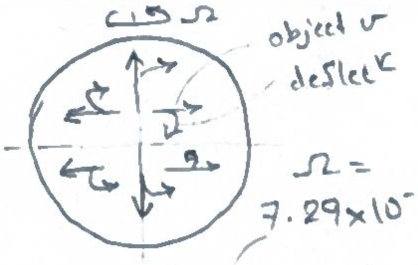
midterm

Oct 21, 2025

$K = C + 273.15$

$c = \sqrt{a^2 + b^2 - 2ab\cos\theta}$





$\Omega = 7.29\times10^{-5}$ rad/s

$$CF = \underset{\text{mass}}{m}(2\Omega \sin \underset{\text{lattitude}}{\phi})\underset{\text{velocity}}{v}$$

1) NH: deflects R
SH: deflects L
2) faster an object, greater deflection
3) max deflec^r tendency at poles, and least (none) at equator

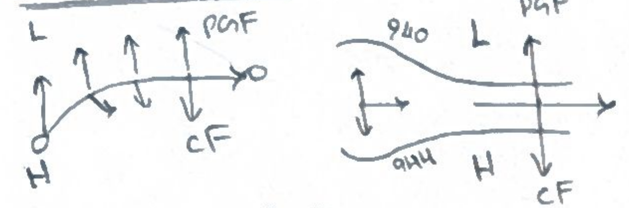
Pressure Gradient ≙ $\frac{\Delta Press}{\Delta Distance}$ eg: $PGF = \frac{1}{\rho}\frac{\Delta P}{\Delta x}$

Horizontal F: 1) PGF 2) CF 3) Friction

Vertical F: 1) Centrifugal and CF (ignored) 2) gravity via hydrostatic press 3) density-driven movements (instability, katabatic)

H —— net force PGF → L
← isobars (area of equal press) →

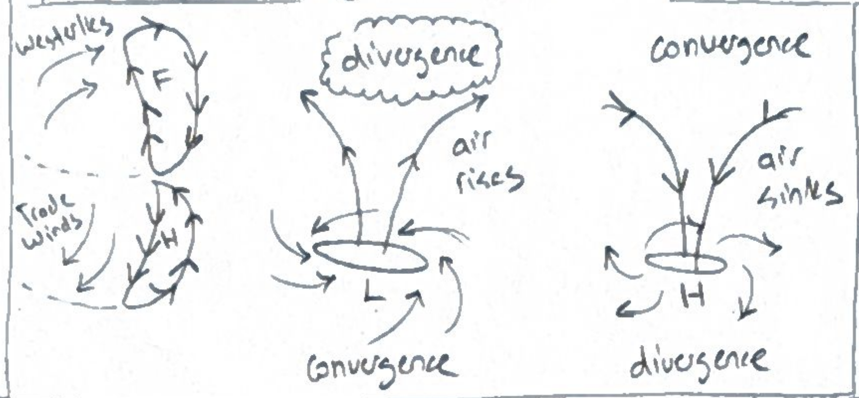
Geostrophic Winds: NH



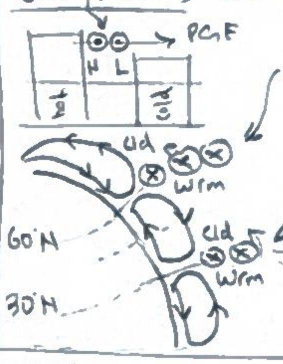
low altitude: fric^t weakens CF

(opposite spin on SH)

Surface Cell Winds (low altitude)

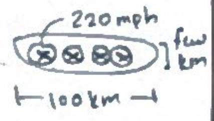


Jet Streams (cold air denser than hot)



polar jet 11-13km up

subtropical jet 12-15 km up

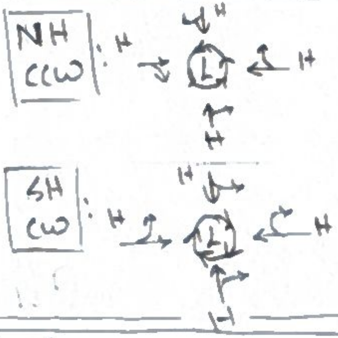


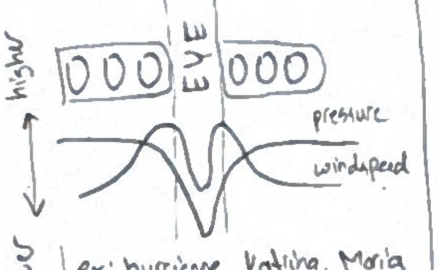
Hurricanes: Low press. sys. on steroids

tropical cyclone (circular winds)

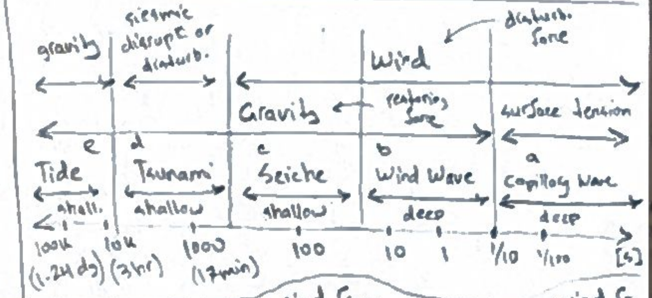
- tropical depression
- tropical storm
- hurricane or typhoon

— increasing severity/windspd ~ pgf →





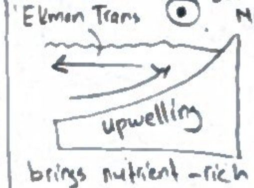
ex: hurricane Katrina, Maria



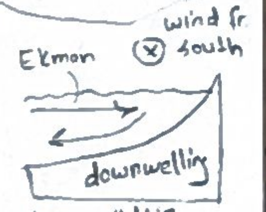
surface waves (no net water movem.)
- wind driven
- gravity-driven (tides)

Ocean currents (moves water + energy around)
- surface current (wind-driven, max 3% of wind)
- deep ocean current (density, salinity, gravity driven, over centuries)

Ekman

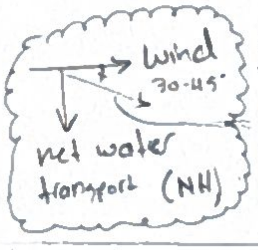


brings nutrient-rich water up to coast



less wildlife compared to upwell

① North Equatorial current
② Gulf stream
③ North Atlantic current
④ Canary Currer

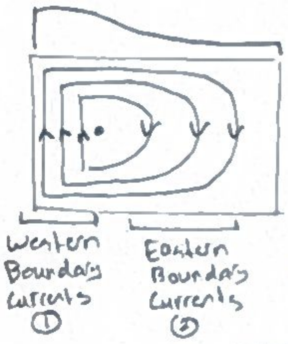


actual water transport since can only push so much water up water hill

El-Nino: bc trade winds weaker, warm unstable rainy weather moves East; East floody and West drought

LA-Nina: trade winds enhanced, so East gets cold/dry weather and West gets very warm wet weather → over Pacific O.

Water hill is further West:

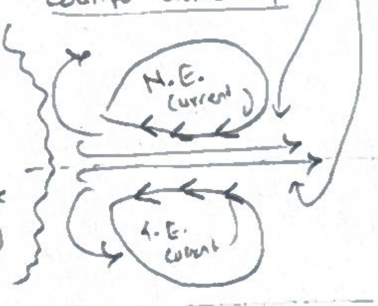


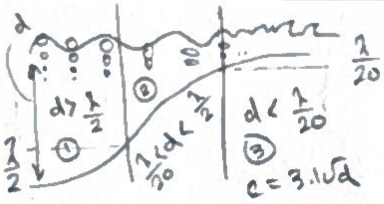
① Gulf Stream: deep, narrow

② shallow, broad, less noticeable

eg: Pacific garbage patch (stuck in gyre)

Transverse Currents ≡ Equitorial → Counter Currents





① $c = \frac{\lambda}{T}$ ⇒ $c = 1.249\sqrt{\lambda}$
$c = \sqrt{\frac{g\lambda}{2\pi}}$ $c = 1.56T$

② wave topple at shore when $d < \frac{3}{4}$ (wave amplit.) or if 7 wide : 1 height is exceeded

a) $\lambda < 1.73$ cm b)

$W = \frac{\rho g^2}{64\pi}h^2T$, fetch ↑, wave greater fully developped sea

c) $T \in [1min, 2min]$
$\lambda \simeq 2\times$ basin width

d) $\lambda = 100$-200 km
T = 10mins → 2h
deep ocean heigh low (.1m), c high, slows shore

Northern Japan, 2011: Pacific Plate thrust under Eurasian plate

Indonesia, 2004: worst tsunami in history: 230k ppl died

e) forced wave, $\lambda = \frac{1}{2}C_E \approx 20{,}000$ km

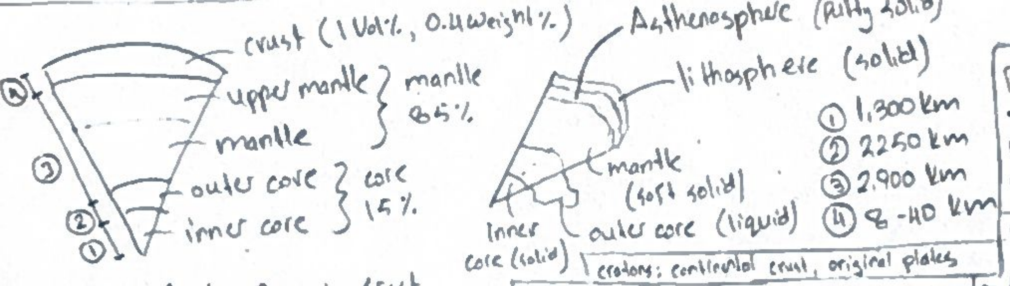
each high tide takes place 12 hr 25 mins after prev one.

$v_{wave} = 1600$ km/h

- semidiurnal = 2x a day
- diurnal = 1x day
- no tides at amphidromic pnts

0 day (spring):

7 day (neap):



cratons: continental crust, original plates

Continental Crust	Oceanic Crust
· granite	· basalt
· $\rho = 2700\ \frac{kg}{m^3}$	· $\rho = 2900\ \frac{kg}{m^3}$
· thicker, more buoyancy	· denser, sinks under continental

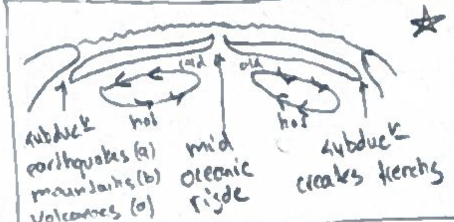


Plate tectonics driven by mantle convection (★)
- ring of fire, mid-Atlantic ridge, radioactive dating

Volcanism: proximity to mantle (thin crust = easier magma rise), mantle plumes/weak spots (Hawaii)

Forming Hurricane:
① L-press convergence, eye forms
② central press. drops bc air is ejected out → PGF↑ → wind↑, rate of energy import
③ rising air ejected, creates gale
④ some air pulled downward, stabilize eye
⑤ storm keeps growing while above and tide, warm >26.5C water

Dying Hurricane
① no warm water, no energy
② land friction slows wind, CF↓, L-press sys go away
③ eye disintegrates
④ weak til trop. depression
⑤ lots of rain

Isostatic Equilibr. and support: mountains deform asthenosphere and float like boat on mantle

Primary P waves: slinky
Shear S waves: jerked rope

Surface waves: cause most damage
Body waves: helped us understand Earth's internal struct. thru Snell's

a) b) c) and continents fitting 2gether suppor Wegener's Theory of Continental Drift

Zaeem Ahmad, CIV300
09/12/2025