Air pressure

exp. decrease ↗

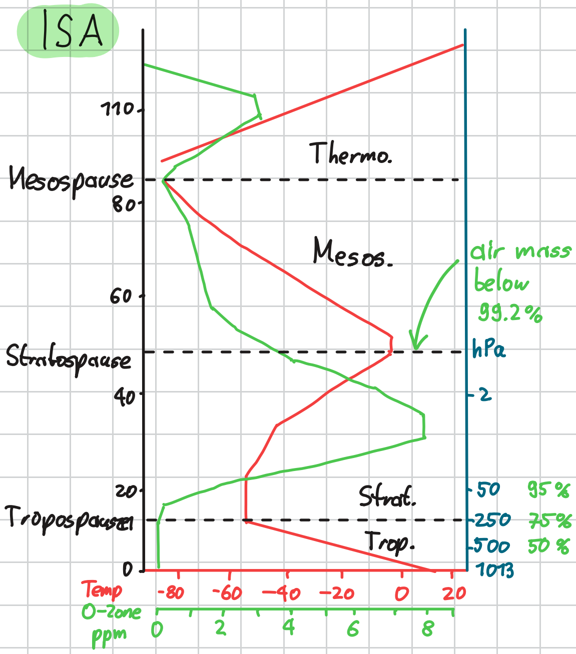
- 40k — embolism
- 26k — death zone
- 23k — spasm, palsy; muscle weakness
- 16k — unconciouness; weaker will
- 10k — false feeling of well beeing
- no loss of abilities

T p ρ relation

- alt ↗ = p ↘
- alt ↗ = ρ ↘
- alt ↗ = T ↘

850 hPa	= 1500 m
800 hPa	= 2000 m
700 hPa	= 3000 m
500 hPa	= 5500 m
300 hPa	= 9150 m

ISA



Troposphere holds:

- 80% of air mass
- 99% of water-vapor

Troposphere cooling: radiative cooling/expansion

Stratosphere warming: recombination of O and Ozone

Pressure

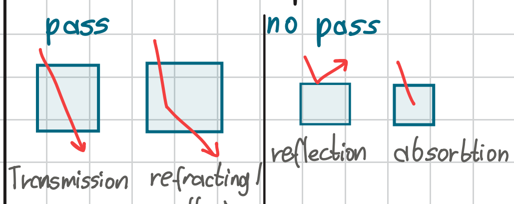
- QFE: field elevation
- QFF: amsl. actual atmosphere
- QNH: amsl. ISA
- QNE: std. 1013.25 hPa

Radiation

👁 shortwave: 200nm < λ ≤ 4 μm
↳ we only see part of it

longwave: 4μm < λ ≤ 100μm
↳ Infrarot

radiation w. Atmosphere



- ↳ clouds
- ↳ contrails
- ↳ molecules

Ragleigh-scattering
↳ sky is blue

Albedo: surf. ability to reflect

Emissivity: surf ability to emit

1 = black body

Stefan-boltzmann-law

$$J = \sigma \cdot \varepsilon \cdot T^4 \quad [W/m^2]$$

$\sigma = 5.67 \cdot 10^{-8}$, T in K

Thermodynamics

Tpot = Bubble down to sea using LR_{dry}

adiabatic: kein Wärmeaustausch

LAPS RATES

dry:

$$r_d = -9.8 \frac{K}{km}$$

wet: 5–6 K/km

$$r_w = g \frac{R_{sw} \cdot T^2 + H_v \cdot r \cdot T}{C_p \cdot R_{sw} \cdot T^2 + H_v^2 \cdot r \cdot \epsilon}$$

$H_v = 2.5 \cdot 10^6$; r = mixing ratio; $R_{sw} = (1-r) \cdot 287 + r \cdot 461$; $\epsilon = \frac{R_d}{R_v} = \frac{287}{461}$

Stability

stable: $T_{pot} > T_{GND}$

rising air parcel
→ colder & denser than surrounding
→ sinks back to original position
↳ clear & calm (smt. fog)

env. laps rate < adiabatic laps rate

unstable: $T_{pot} < T_{GND}$

rising air parcel remains warmer than surrounding → continues rise
↳ strong vertical mixing, cloud, showers

env. laps rate > adiabatic laps rate

Conditional:

stability depends on wether air is saturated or not
↳ cumulus clouds & showers

env. laps rate btw. dry & wet adiabatic

$r_w < r_e < r_d$

hp / colder:	−
lp / warmer:	+

Humidity Quantification

- Dry bulb T [T] ↳ Temperature of air
- Wet bulb T [T_{wo}] ↳ min. T reached trough evaporation
- Dew point T [T_D] ↳ T at which 100%
- mixing ratio [r] ↳ moisture mass per air

Water vapor pressure

$$e_0 \cdot e^{\frac{17.62 \cdot T - 4812.903}{T - 30.03}}$$

[e] ($e_{s,ice} < e_{s,wat.}$)
↳ actual
use T_{Dew}

[e_s]
↳ saturation vapor pressure
↳ use T_{actual}

$e_0 = 611.2$ Pa

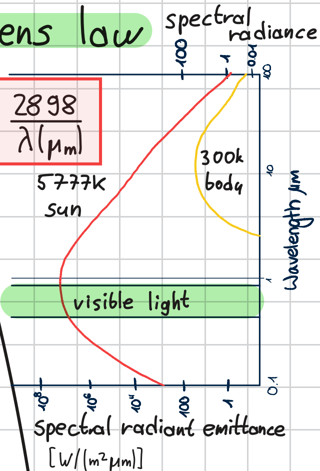
$$r_h = \frac{e}{e_s} \cdot 100\%$$

Psychometric chart

unten: e oben: e_s

Wiens law

$$T\,[K] = \frac{2898}{\lambda\,(\mu m)}$$



Dens-alt

- 1013 − QNH = x
- x · 28ft = y
- Pr. Alt = elev. + y
- ↳ std. Temp at PA: $15° - \left(\frac{PA}{1000} \cdot 2°\right) = t$
- ΔT actual & std.
- ΔT · 120ft = n
- DA = PA + n

Oliver Keller HS25

LCL : Lifting condensation level

1. Isoline (same g/kg) Linie von Boden T_{dew} ziehen,
2. Dry adiabatic Linie von T Boden ziehen
3. da wo sich Linien schneiden = LCL RH = 100 %

↳ Paket steigt ab da wet-adiabatic

LFC: Level of free convection

- erster Moment wo $T_{paket} > T_{Umgebung}$

↳ Paket steigt ab da frei, ohne äussere Energie

EL: Equilibrium level

- Moment wo T_{Paket} wieder kleiner als $T_{Umgebung}$

↳ steigen endet

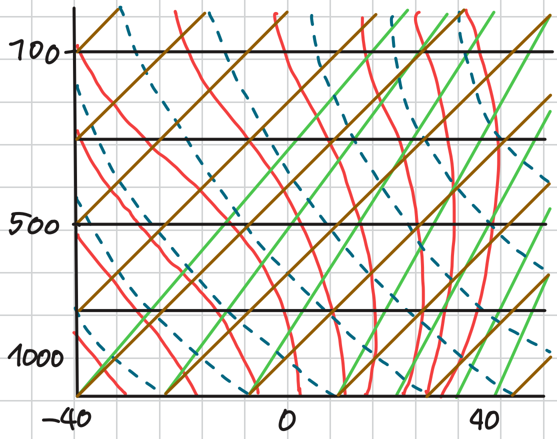
↳ Obergrenze von Wolken

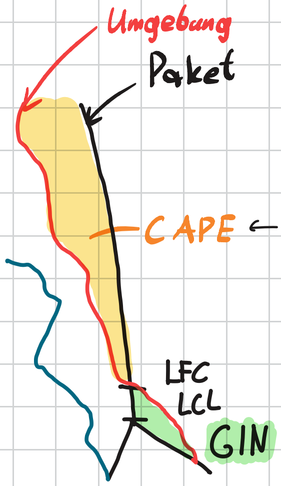
CAPE: Convective available potential energy

- wenn $T_{Paket} > T_{Atm.}$ → Convection
- Fläche zwischen Kurven = Konvektionsenergie

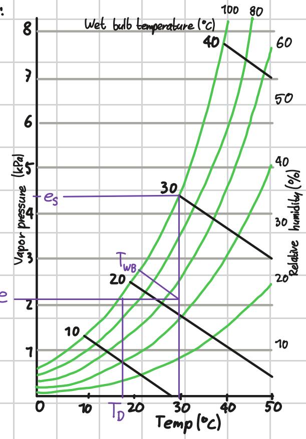
CIN: Convective Inhibition

- wenn $T_{Atm} > T_{Paket}$
- negative Konvektionsenergie
  ↳ muss überwunden werden damit LFC erreicht werden kann. (Fläche zw. Kurven)





example: T = 30°C RH = 50%



Allgemeines: • Messsonde ist Umgebung, Diagrammlinien sind Paket

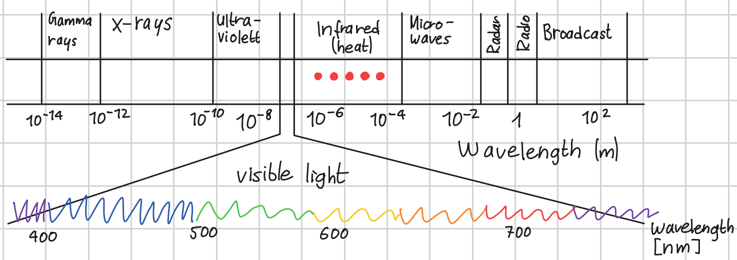
• Taupunkt von Luftmasse bleibt gleich solange Dry-Adiabatic
↳ Abs. Feuchtigkeit gleich

Cloud formation

soot, pollen, sea sand

\+ water vapor

\+ $T = T_{dew}$



Formulas

barometric: $p(z) = p_0 \cdot \left(1 - \frac{LR \cdot z}{T_0}\right)^{\frac{g}{LR \cdot 287}}$

hydrostatic: $p(z) = p_0 - (\rho \cdot g \cdot z)$

Energy: $m \cdot c \cdot \Delta T = [J]$

P_in : $A \cdot [W/m^2] \cdot (1 - Albedo)$

mixing ratio: $\frac{\varepsilon \cdot e}{P - e}$ (ε ← $\frac{287}{461}$)

$T_{dew} = \frac{4812.903 - 30.03 \cdot \ln\left(\frac{e(T_d)}{e_0}\right)}{17.62 - \ln\left(\frac{e(T_d)}{e_0}\right)}$

wind speed gradient (stabilized) $u = -\frac{fR}{2} + \sqrt{\left(\frac{fR}{2}\right)^2 + \frac{dp}{dr} \cdot \frac{R}{\rho}}$

wind speed geostrophic (stabilized). $V = \frac{\frac{1}{\rho} \cdot \frac{dp}{dx}}{2\Omega \cdot \sin(latitude)}$

Claudius clapeyron: $e(T) = e_0 \cdot e^{\left(\frac{L_V}{R_V}\left(\frac{1}{T_0} - \frac{1}{T}\right)\right)}$ (L_V ← $2.5 \cdot 10^6$, R_V ← 461)

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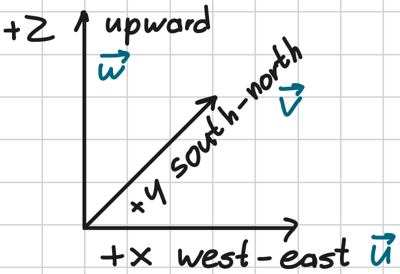
Wind



Forces on air-parcels

x-axis:

$$\frac{du}{dt} = -\frac{1}{\rho}\cdot\frac{dp}{dx} + f_c\cdot v - C_{Du}\cdot u + s\cdot v\cdot\frac{u}{R}$$

pressure gradient, coriolis, drag, centrifugal

NH

y-axis:

$$\frac{du}{dt} = -\frac{1}{\rho}\cdot\frac{dp}{dx} - f_c\cdot v - C_{Du}\cdot u - s\cdot v\cdot\frac{u}{R}$$

Coriolis force

$$f = 2\Omega\cdot\sin(\varphi)$$

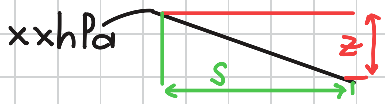
φ → latitude; Ω → $7.292\cdot 10^{-5}$

- 0 at equator, max. at poles
- NH: Right SH: Left
- ⊥ to motion
- changes direction, not speed

simplified →

$$U_{tot} = \frac{g}{f_c}\cdot\frac{dz}{ds}$$

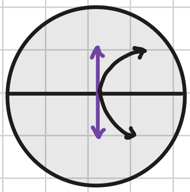
Neigung von pressure-ebene



Geostrophic Wind

straight Isobars

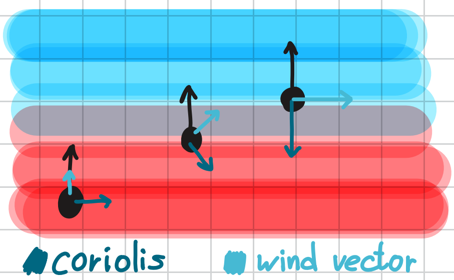
x-axis y-axis



$$\frac{du/v}{dt} = -\frac{1}{\rho}\cdot\frac{dp}{dx/y} + f_c\cdot v$$

derivative of wind in u-direction; pressure gradient; coriolis acceleration $2\Omega\cdot\sin(\text{latitude})$

Pgrad und coriolis gleichen sich aus
=> parallell zu Isobaren



Gradient wind

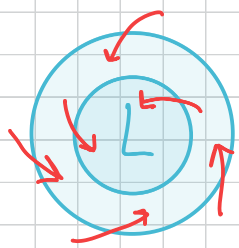
curved Isobars

now curved → adds centrifugal force

$$\frac{du/v}{dt} = -\frac{1}{\rho}\cdot\frac{dp}{dx/y} + f_c\cdot v + s\cdot v\cdot\frac{u}{R}$$

u ← Windbetrag; v ← Südwind

s: 1 bei linksrum, −1 bei rechtsrum



steady state

$$0 = -\frac{1}{\rho}\cdot\frac{dp}{ds} + f_c\cdot U_{tot} + \frac{s}{R}\cdot U_{tot}^2$$

$$U_{tot} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

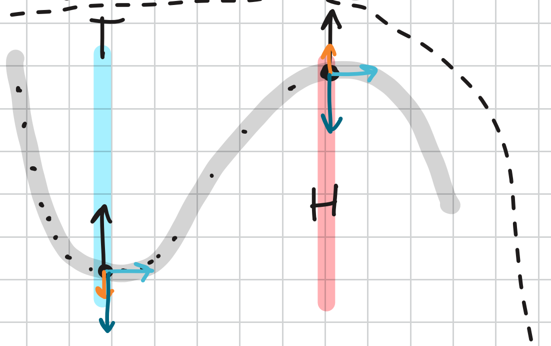
explicit formula

H $$U_{gr} = \frac{fR}{2} - \sqrt{\left(\frac{fR}{2}\right)^2 - \frac{dp}{dr}\cdot\frac{R}{g}}$$

L $$U_{gr} = -\frac{fR}{2} + \sqrt{\left(\frac{fR}{2}\right)^2 + \frac{dp}{dr}\cdot\frac{R}{g}}$$

around low: slower → subgeostrophic

around high: faster → supergeostrophic



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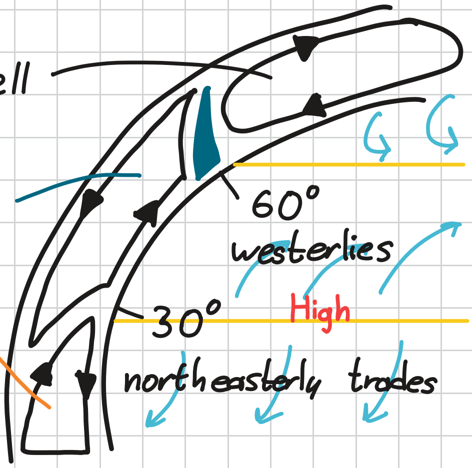
Near surface wind (friction)

- friction → less speed → weaker coriolis → flow turns towards low pressure
- Air crosses Isobars instead of following **Land: 45°** **Sea: 15–30°**
- consequences:
  - towards Low: convergence, rising air clouds/rain
  - towards high: divergence, sinking air clear weather

Global circulation



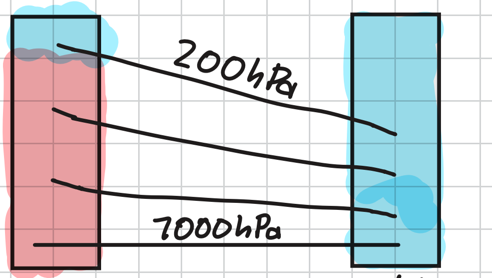
Polar cell
radiative cooling
=> no sunshine => cool
=> density gain => sinks

Ferrel cell (indirect)
link btw. Pol. & Had.
=> air at surface
=> to polar & east
=> "westerlies"
=> rises at 60°
=> meets polar air
=> storms

Hadley cell
Warm air rises (heating)
=> moves polewards
=> cools => sinks at 30°
=> creating high-pressure

Thermal winds

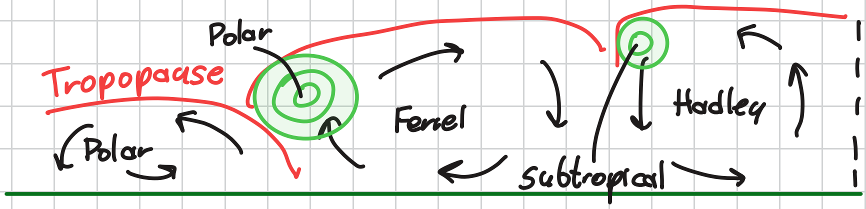
- change in geostrophic winds with altitude
  => results from horizontal temperature gradient
- explains why strong winds (jetstream) occur where there is a large temperature difference
- NOT a wind, diagnostic relationship between Temperature and windshear



Density: warmer air → less density
p decreases slower in warm air

Jetstreams

- fast & narrow wind band
- west → east ~60kts
- subtropical & Polar
- form where is strong horizontal temperature Δ
- forms along T-gradients (polar front) due T-Winds



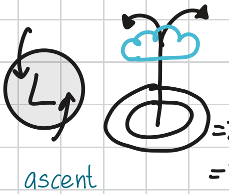
Rosby-Waves

- due to coriolis & change in rotation-speed with latitude
  circulation at mid lat:

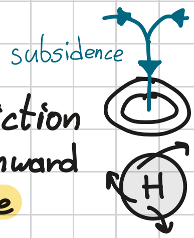
$$\text{vorticity} = \zeta = \frac{dv}{dx} - \frac{dv}{dy}$$

↳ +↺ − ↻

Ageostrophic flow



Surface-friction
=> slower + inward
=> low convergence
=> high divergence



SF
=> outward
=> low divergence
=> pulls upper air
=> high convergence

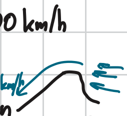
regional winds:

Sirocco: (L) mediterannian sea
southern winds
picks up dust in N-Africa = Saharast.

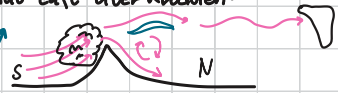
Bise: (H) NW (L) SE ⟩ über Mit. Meer
venturi → acceleration ↗ ~70km/h

Mistral: wie Bise + (L) über südfrankreich
Verlängerung von Bise ↗ ~100 km/h

Bora: H ↓ D ↓ L density driven,
It T Gc staut Luft über Kroatien



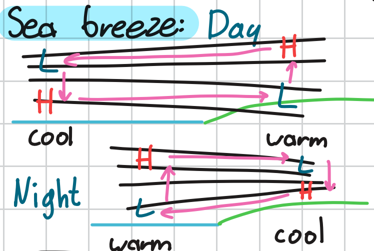
Südföhn: (T) NW ↗



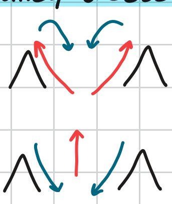
↳ Hazards: directional & speed shears

Local winds:

Sea breeze: Day



Valley breeze: Day Talwind



Hänge mehr Sonne
↓ density → steigt
↳ "saugt" luft nach

Night Bergwind
Hänge kühlen schneller ab
↗ density → Luft sinkt

Alpine Pumping: higher $\frac{A}{Vol}$ → heated faster
big sucking system

Turbulence:

EDR measures intensity
Transports: · Momentum · heat · water vapor · gas · dust

Occurs due to Windshear:

btw. cool & warm, wind layers, ground, jet stream, TS, Wake

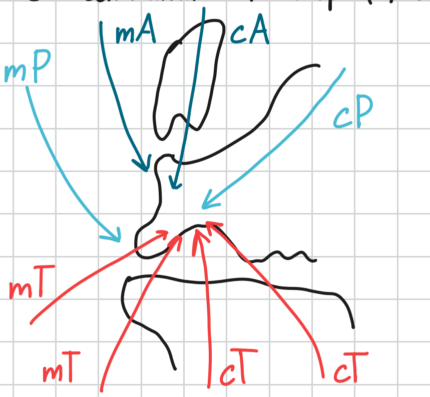
Forecast: PIREP from other acft.

Oliver Keller HS25

Air masses

large body of air having nearly uniform conditions

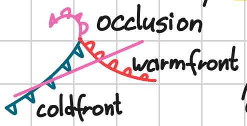
Humidity	Temperature
m = maritime	P = Polar A = Arctic
c = continental	T = Tropic (E) = Equatorial

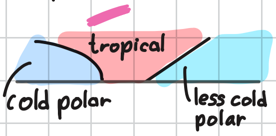


Fronts:

when air masses meet

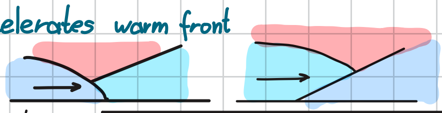
Tropical & Polar airmass kept from each other by Polar front





- cold front is faster, because more dense → pushes warm air easier
- precipitation cooling (evaporation) · accelerates cold front · decelerates warm front

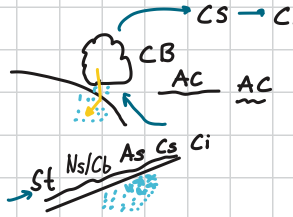
Occlusion point:



Clouds:

cold

warm



summary:

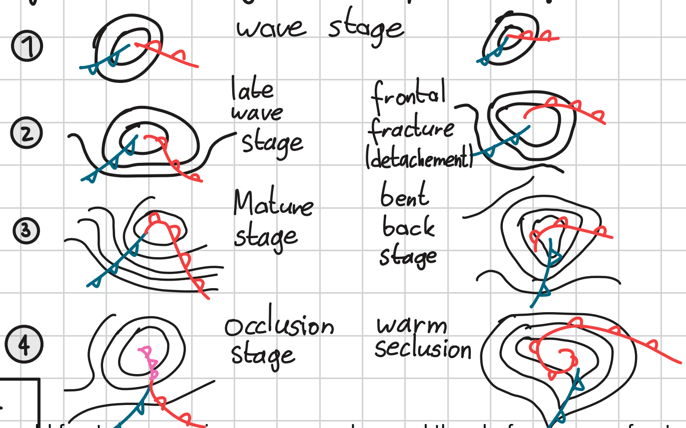
strong: · horizontal ΔT, Δ Moisture, Δ Wind

· vertical Δ Wind

· vorticity (flow curvature)

Conceptual models

Bjerknes-Solberg: / **Saphiro-Keyser:**

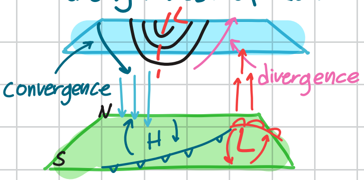


If behind a cold front, warmer air masses are observed than before a warm front, a c

Cyclogenesis: initiation/strenghtening

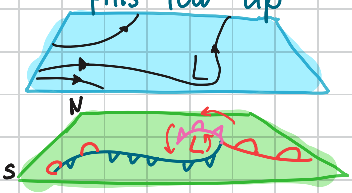
· surface p ↘

· trough west of Low



Cyclolysis: decay/weakening

fills low up



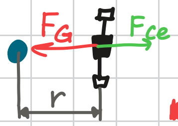
Weather Information

observations → (real time reports) → Model → Output

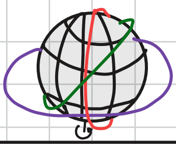
real time: · Metar · Radar

forecast: · TAF · GAFOR · SWC

Satellite orbit:

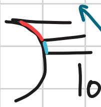


$F_G = F_{ce}$ $\quad v = \sqrt{\frac{G \cdot m_{earth}}{r}}$



- Polar 600-1200
- oblique
- geo-stationary um CG 35800

resolution:



gets worse

low orbit → higher

Tech. gets better

Satellite Images:

3 wave-lenghts

Problem: fog from snow? distinguish

- VIS
- IR ~10.8μm, "window" no absorbtion
- WV ~6.2μm, max absorbtion of only Water-vapor

IR: dark: hot, land

grey: warm, low clouds

white: cold, high clouds

VIS: fog: thick

cirrus: transparent

SNOW? → IR

Weather Radar:

- Pulse of el. mag. waves
- → cant see things smaller than own wavelength
- doesn't see droplets smaller than rain

· auf Bergen

· GND-Radar:

20x elevation sweeps

>55 dBz → Hail

measures:

- Echo · velocity
- polarization

wind shears erkennbar

strong Echo:

- lot particles
- reflection: water>ice

Errors: · ground clutter

· attenuation → Abschwächung

· interference → Überlagerung

processing needed

In Situ-sensing:

certified WMO

Challanges:

Therm: sun-protected

· air contact bugs/ice

Wind: · part movement rust/ice

distortion

relative topography

Δ of gpdm

$\bar{T}$ zwischen 2 Schichten

$$\int_{p_1}^{p_2} \frac{1}{p} dp = -\frac{g}{R_d} \int_{z_1}^{z_2} \frac{1}{T(z)} dz \Rightarrow \int_{z_1}^{z_2} \frac{dz}{T(z)} = \frac{\Delta z}{\bar{T}} \Rightarrow \frac{g \cdot \Delta z}{R_d \cdot \ln\left(\frac{p_1}{p_2}\right)} = \bar{T}$$

↑ hydrostatic + gas law

Oliver Keller HS25

Noise Emissions

sources:
- Eng. Fan/exhaust jet
- Airframe
- Gear/Flaps

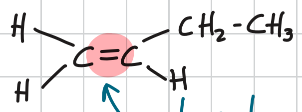
impacts:
- annoyance
- sleep disturbance
- impaired learning
- hypertension

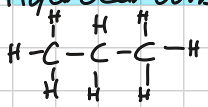
mitigation:
- Noise standards
- land use around APT
- OPS - procedures
- restricted OPS 23-6
- Tech: · Bypass eng.
  · chevron Nozzle

Exhaust Emissions

Fuel:

JET-A1, C8-C13 Hydrocarbons





↖ not saturated → harder to break } doesn't freeze, high octane → aromatics

- up to 1000PPM Sulphur
- additives

Combustion:

Exothermic

1kg Fuel → 3.1kg CO_2
1.4kg H_2O
+ zN_2 ← lot of N in air

$S + O_2 \rightarrow SO_2 \rightarrow H_2SO_4$

Nitrogen:

>1600° N and O react

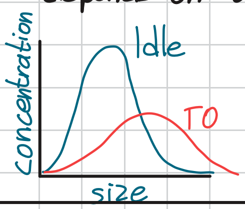
3 Varianten:
$N_2 + O \rightarrow NO + N$
$N + O_2 \rightarrow NO + O$ } NO_x
$N + OH \rightarrow NO + H$

reactions 1+2 dominate

Particulate Emissions

- 20-50 nm
- soot (Russ) non-volatile

depends on: aromatic & H content



Volatile: vPM
- flüchtig, ultrafine
- Gas → particles

from UHC, H_2SO_4, HNO_3
↳ in Nucleation-mode
- 15m behind exhaust greatest concentration

AFR Air/fuel-ratio

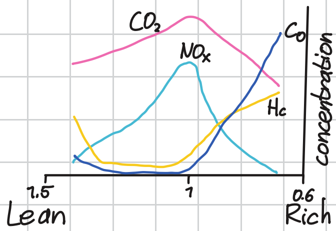
$$\lambda = \frac{AFR}{AFR_{stoic}}$$

<1 Rich: · low AFR · unburned HC → UHC
· CO instead of CO_2 · PM

=1 stoichometric: · complete combustion
· higher T → NO_x

>1 lean: · high AFR
· low to no HC or CO · low NO_x

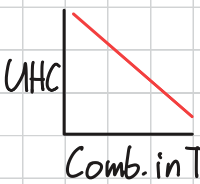
sinkt wieder weil Luft zu wenig O für Nebenprodukte und max T nicht erfüllt

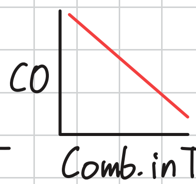


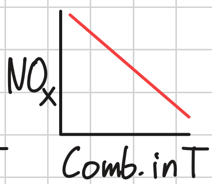
Ambient condition

cool: low inlet T → less effic. combustion
→ higher UHC, CO, PM (at low thrust)
→ lower NO_x, (at high thrust)

warm: higher inlet T → higher exhaust T
→ higher NO_x, noch mehr @↗thrust







SO_2: fuel sulfur
NO_x: high T oxidation of N in air
CO: incomplete combustion
UHC: "
PM: " + nucleation of gaseous pollutants
Lead: General Aviation

Exhaust Emissions impact

CO_2 H_2O NO_x CO SO_2 UHC PM

GHG: CO_2, H_2O, NO_x, CO

Pollutants: NO_x, CO, SO_2, UHC, PM

Ecosystem damage:
- acid rain
- Soil & water deterioration
- ozone chemistry & smog
- plant health

Human health:
- respiratory irritant
- cardiovascular health impact
- reproductive health
- carcinogenic, mutagenic, neurotoxin

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Aviation Hazards

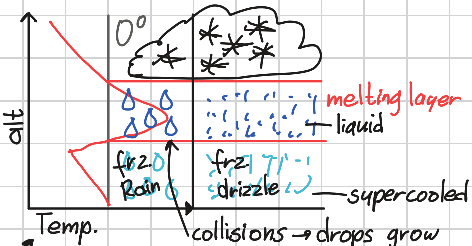
Accident statistics:
- Wind most of weather-related
- better prediction → acc. decrease

Icing

recipe:
- water
- cold (water or aircraft)
- most btw. -4° & -14°

- GA❗ transition layer 50% @FL 5-13

ice only (-40°)	FL250
mixed: ice (-20°) + supercooled water	FL180
liquid water only	0°



- often @ cold/warm fronts
- Ice nuclei needed❗ (Partikel)

classification
light: · no alt change
.6-2.5cm/h · no TAS change

moderate: · TAS loss
2.5-7.5cm/h

severe: anti-/deice can't cope → diversion

clear air icing
- in Ci clouds
- ice cristals → melt & freeze in engine

ice types
clear: · smooth, glossy
- large ◊ in cum. clouds
- freezing rain because of movement — slow

rime: · rough, coarse
- small supercooled ◊ in Stratus — quick

mixed: · hard, rough, conglomerate
- large & small ◊ · wet snow
- liquid & frozen ◊

icing effects:
- ↗ weight · ↘ lift · ↗ drag
- ↘ thrust (Prop/carb)

countermeasures
- Thermal anti-/de-ice
- de-icing boots · GND 50/50 wa./isopropyl
- weeping wing (glycol) DA42

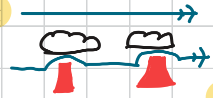
Turbulence

recipe: Wind shear❗ thermals, wake, mech. stress (near GND)

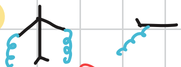
classification: light (alt), moderate (IAS), severe (alt, att, IAS), extreme (uncontrollable)

new ↘ old ↗				
EDR	NIL <0.1	light <0.2	mod. <0.45	sev. 0.45<

thermals:

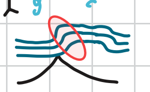


wake:



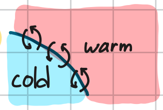
mech.:

free air: waves



Jet stream:

fronts:

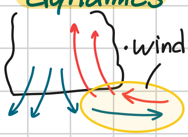


countermeasures:
- SIGMET · PIREP · Turb. forecast (GTG USA)

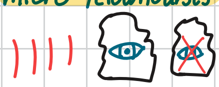
Thunderstorms
- strong up-/downdraft · icing
- windshear (vertical & horizontal) · turbulence

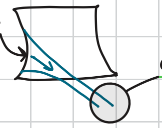
Hail

dynamics



micro-/downbursts cold air





other Hazards
virga downdraft
rain, air blw. cloud dry → evaporates → cooling → sinks

visibility
no problem with equipment

density altitude

Climate

effect on Global Warming:

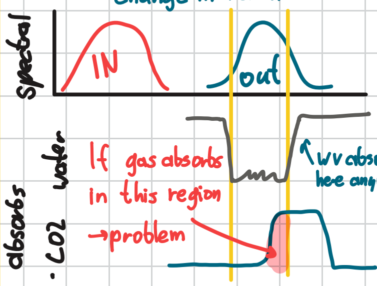
50%	CO_2	30% CH4
5%	N2O	15% F-Gas

Weather: · Cond. in Atm. (H)
· spontanous (L)

Climate: · WX over period (dry / Humid)
· whats expected (st)

Climate change: (effect) → global Warming
- change of tendencies in WX-Patterns
- change of prob. of extreme WX
- consequence of avg. glob. warm.

What causes Climate change?
· change in radiation



=> GHG ← Models
- T as func. of GHG conc.
- GHG as func. of sources/sinks (+/-)
- + Feedbacks (Rückkoppelung)
  - ↳ Output: prob. of WX-events

Climate variability:
- always changing

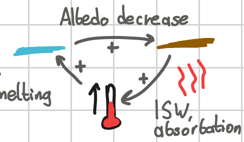
Ice: · gets denser
- core drilling → History 400ky
  - ↳ dry. spots ~150mm/y
  - ↳ ~3000m deep

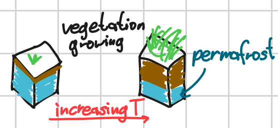
Infos: direct: Isotopes, Composition gas/ice ↳ GHG
indirect: ↳ age, temp

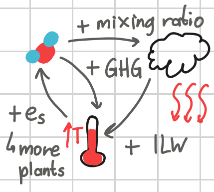
Isotopes: count of neutrons

Milankowich cycles:
main driver of climate variability
- Eccentricity: orbit form
- Obliquity: tilt → seasons
- Precession:

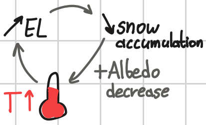
Arctic Amplification:
Feedback process







equilibrium line
höhe wo: + Schnee = -abfluss
↳ Regen statt Schnee
↳ EL höher ↗



enthalpy
Ice melting needs energy → "gut"/verzögernd
→ Energie geht in Atmos.

positive FB · amplifies itself
negative FB · limits itself

Future:

	41-60	81-100
low	1.6	~ 1.4
mid	2.0	~ 2.7
high	2.4	~ 4.4

- switzerland above avg.
- IPCC => Paris agreement
  - ↳ <2° → reduce risks
- Glaciers/greenland etc. once at spec. Temp → gone, not reversible

· Pläne jetzt nicht verschärfen
↳ 2.6-3.1° in 2100

RCP1.5 → +1.5 $\frac{W}{m^2}$ im 2100

Aviation:
GHG 1.9% CO_2 11.6%

Options: · contrail reduction
· SAF/net-0 fuel
· continous descend

Positive feedback:
T↗ → permafrost melts → methan release

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Numerical weather modelling

explosive cyclogenesis/Bombogenesis:

- more than 24hPa/24h pressure drop
- due to divergence over large area

Dry intrusion:

- in strong cyclones · density driven
- cold air from stratosphere "mega-downburst" to surface
- west of cyclone

ppmv → pppm $pp \hat{=} \cdot 1$

$$ppmv \cdot \frac{\text{Mol (von GAS)}}{\text{Mol (Luft)}} = ppmm$$

ppmm → kg

$$ppmm \cdot 10^{-6} \cdot total_{masse} = kg$$

Jet-$A_1 \approx C_{11}H_{21}$ full burn: $C_{11}H_{21} \rightarrow 11CO_2$

1. Mol-masse Fuel = $11 \cdot 12 + 21 \cdot 1 = 153 g/mol$
2. stoffmenge Fuel = $\frac{\text{kg Fuel}}{153} = x$ mol
3. stoffmenge $CO_2 = 11 \cdot x$ mol $= y$ mol
4. CO_2 Masse = 44g/mol · y mol (44g/mol ← gegeben)

Numerical models

- mathematical representation for:
  - wind · Temperature
  - pressure · moisture

model resolution:

- describes size of grid boxes
- Global: coarse resolution
- local/regional: fine resolution

Model initialization:

using initial atm. state + previous forecasts from: wx-stations, aircraft, radiosondes, buoys, satellites

discretization:

- model divides earth into 3D grid
- each grid contains avg. values
- changes step-by-step calculated

Parametrization:

- some prozesses are smaller than grid size → these processes can't be solved directly must be parametrized → major source of uncertainity clouds, condensation, surface

uncertainity:

- estimated using ensemble prediction system =?spaghetti
- many model runs with slightly different initial conditions or settings. Spread = forecast confidence

Basic equations for weather models:

conservation of momentum, energy, mass, moisture

Why is there wind? · change of velocity with time

$$\frac{\partial \vec{v}}{\partial t} = -(\vec{v} \cdot \nabla)\vec{v} - \frac{1}{\rho}\nabla p - \vec{g} - 2\vec{\Omega} \times \vec{v} + \nabla \cdot (K_w \nabla \vec{v}) - \vec{F}_d$$

- advection of momentum, change in pressure, vertical acceleration coriolis force, diffusion of Momentum, friction

why does it get colder/warmer?

$$\rho c_p \frac{\partial T}{\partial t} = -\rho c_p (\vec{v} \cdot \nabla) T - \nabla \cdot \vec{R} + \nabla \cdot (k_t \nabla T) + C + S$$

- Change of temperature with time = advection of temp., divergence of radiation, "diffusion" of temperature, heating through contact, heating through condensation

Why is there a flux of new air to a place where I take air "away"?

$$\frac{\partial \rho}{\partial t} = -(\vec{v} \cdot \nabla)\rho - \rho(\nabla \cdot \vec{v})$$

And what about moisture?

$$\frac{\partial q}{\partial t} = -(\vec{v} \cdot \nabla) q + \nabla \cdot (K_q \nabla q) + S_q + E$$

The formula defining how compressible fluids relate to p.V. and T

$$p = \rho R_d T$$

Radiation equilibrium temperature

$$P\_In = \pi \cdot r^2 \cdot S_0 \cdot (1 - Albedo)$$

(S_0 in [W/m²])

$$P\_out = \sigma \cdot \varepsilon \cdot T_{earth}^4 \cdot 4\pi \cdot r^2$$

$$P\_in = P\_out$$

$$T\_earth = \sqrt[4]{\frac{S_0 \cdot (1 - Albedo)}{4 \cdot \sigma \cdot \varepsilon}}$$

Pyranometer: short-wave

Pygrometer: long-wave