Basic parameters: Temperature

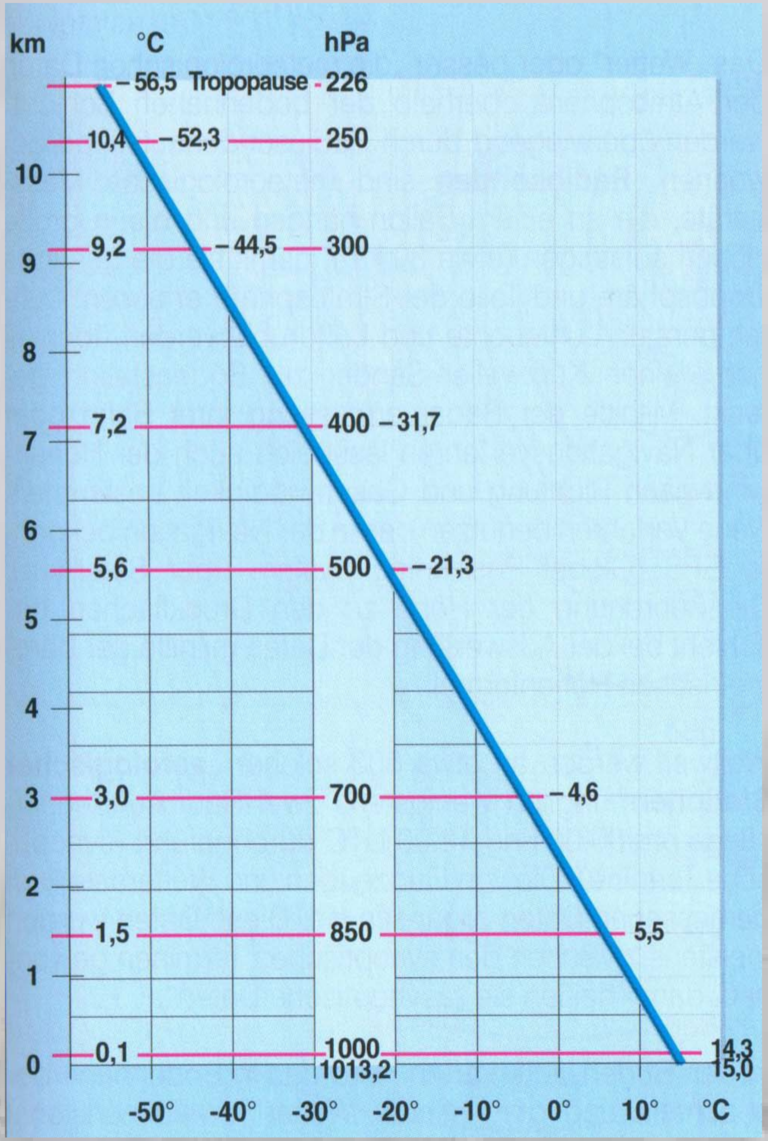
- The temperature of a gas is a function of the mean velocity of its molecules, thus describing its internal energy

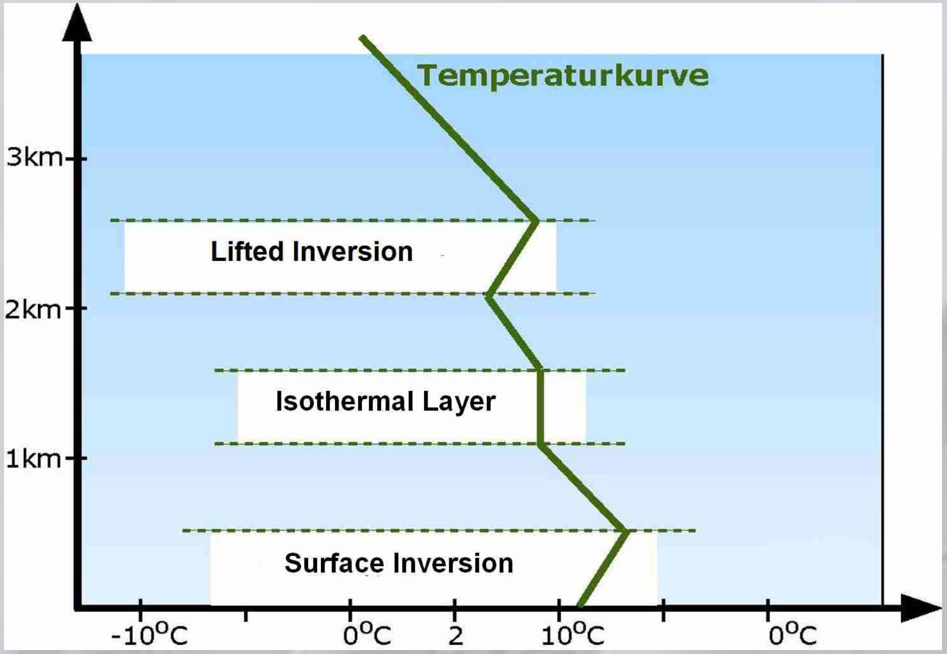
- The temperature is measured either by
  - direct using a thermometer or
  - remote detecting IR radiation with a sensor

- **Temperature scales**
  - most common, also SI-unit: Celsius (°C).
  - used in the USA: Fahrenheit (°F).
  - SI-unit, used in physics and technology: Kelvin (K)

very cold winter in the Netherlands:	-17.8 °C = 0 F
freezing point of water:	0 °C = 32 F = 273.15 K
body temperature of man:	37.8 °C = 100 F
boiling point of water:	100 °C = 212 F

VERTICAL STRUCTURE OF THE ATMOSPHERE: INVERSIONS





Temperature Inversion

instead of T-decrease with height

sometimes T-increase with height

Inversions are vertically impermeable

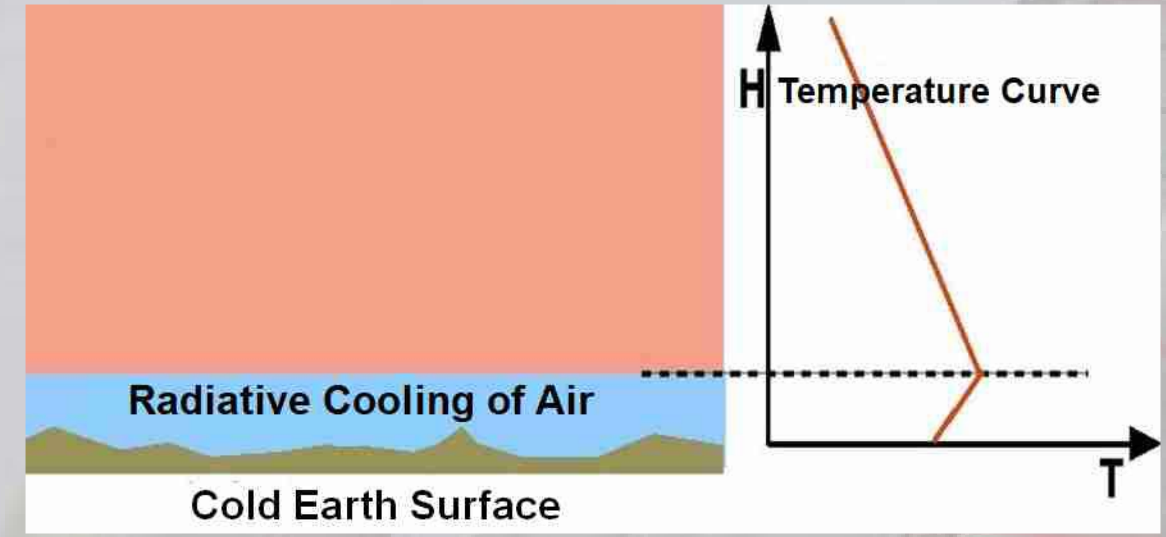
(e.g. low-exchange weather condition)

VERTICAL STRUCTURE OF THE ATMOSPHERE: INVERSIONS

How can the Air Temperature be changed ?

How does this change the Vertical Temperature Profile ?

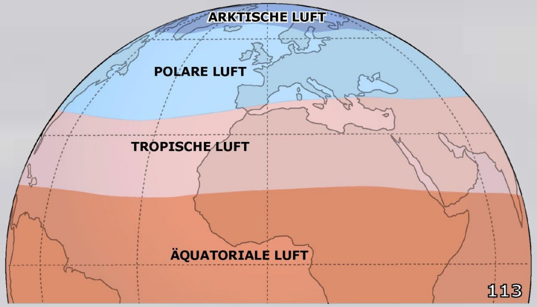
1. Radiative Heating / Cooling



Radiative inversion

Cooling due to outgoing IR-radiation
(sky clear / few clouds conditions)

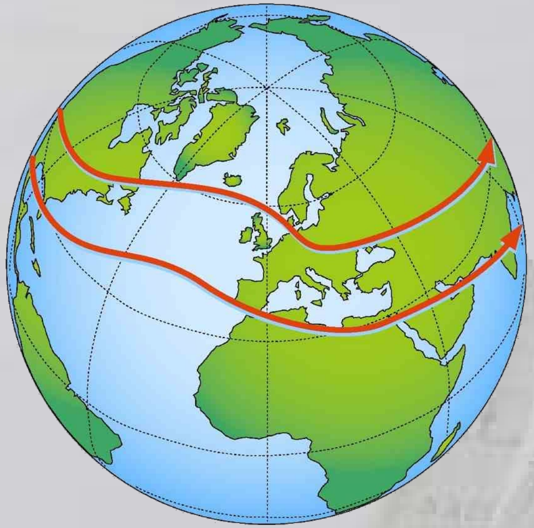
BASIC PARAMETERS: TEMPERATURE

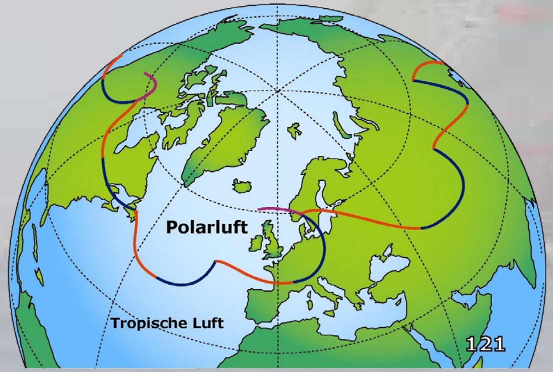


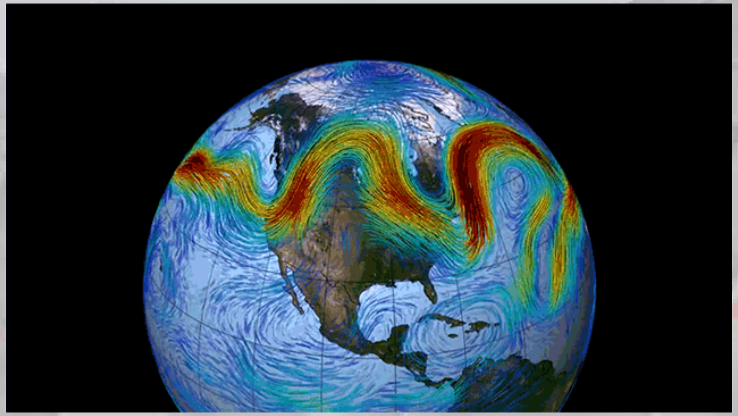
How can the Air Temperature be changed ?

How does this change the Vertical Temperature Profile ?

2. Cold / Warm Air Advection

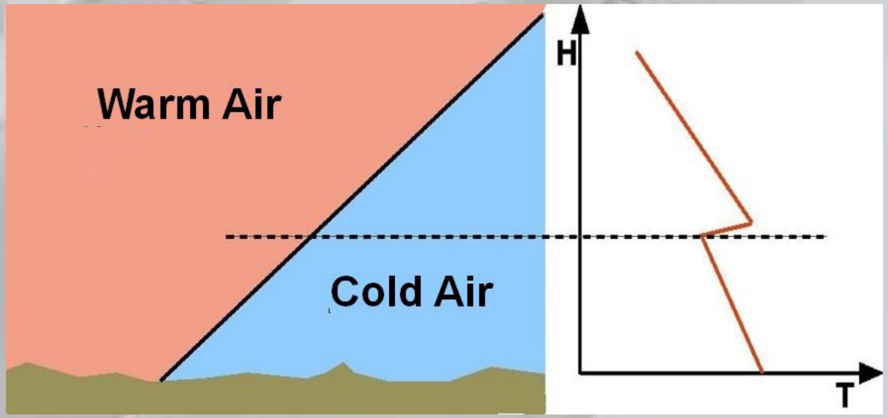






Global Circulation

Jetstream

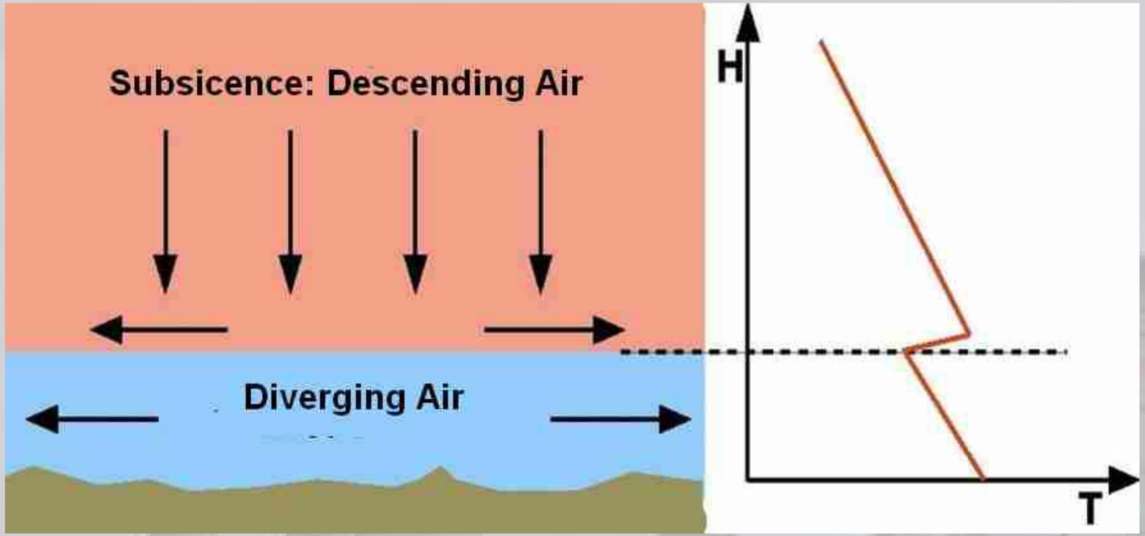


Upslide inversion

Upslide motion of warm air (warmfront)

VERTICAL STRUCTURE OF THE ATMOSPHERE: INVERSIONS

3. Adiabatic Compression / Expansion



Subsidence inversion

Subsidence in a High (warming to compression of air like in air pump)

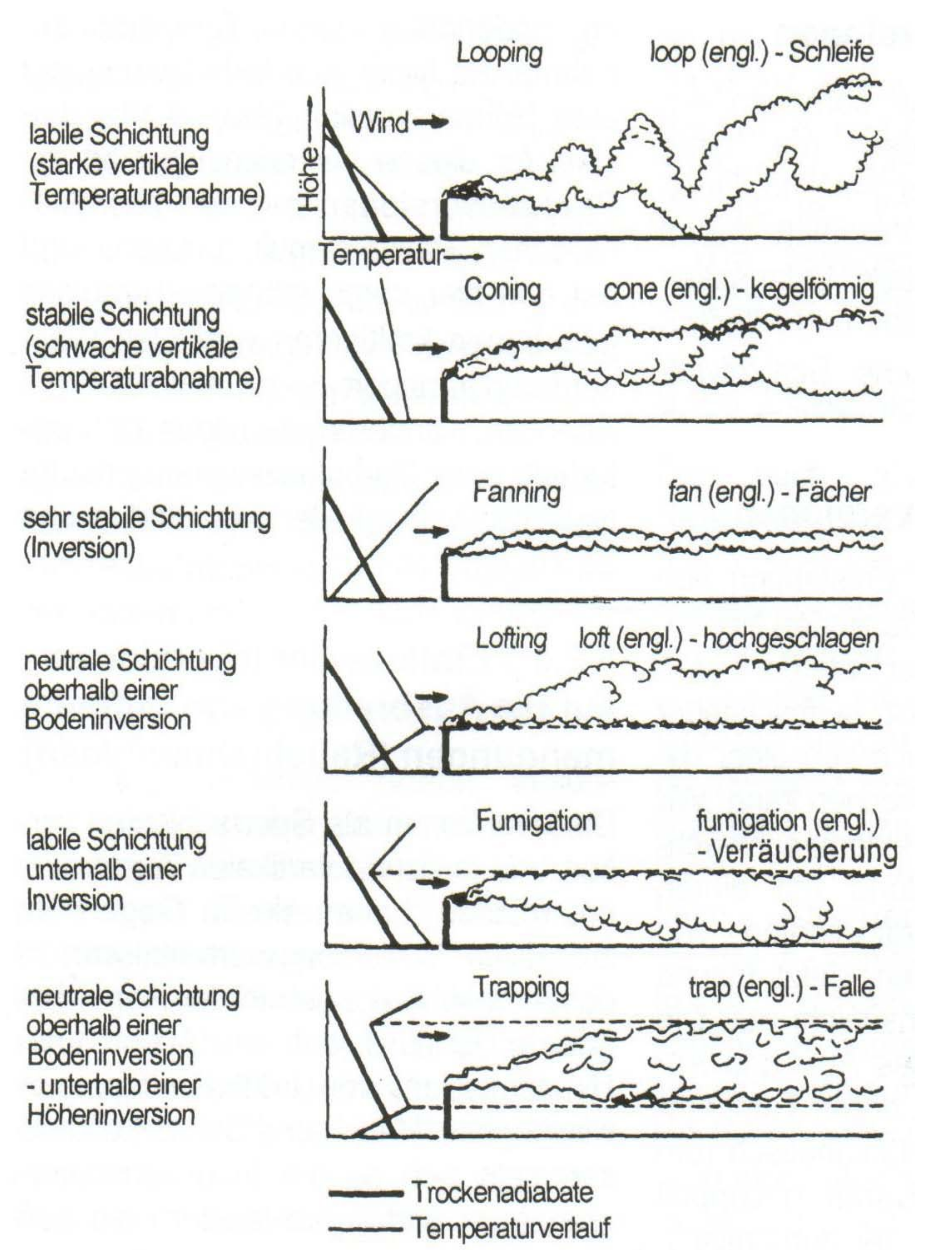
Atlantic Trade wind inversion

High pressure situation in winter low-exchange weather condition
Smog below inversion

High pressure situation in general

In the mountains:
Valley situation: overcast
Summit situation: sky clear

Stability, inversions and plumes



Looping
Unstable, vertical temperature gradient > 1°/100m

Coning
Stable, vertical temperature gradient < 1°/100m

Fanning
Very stable, high inversion

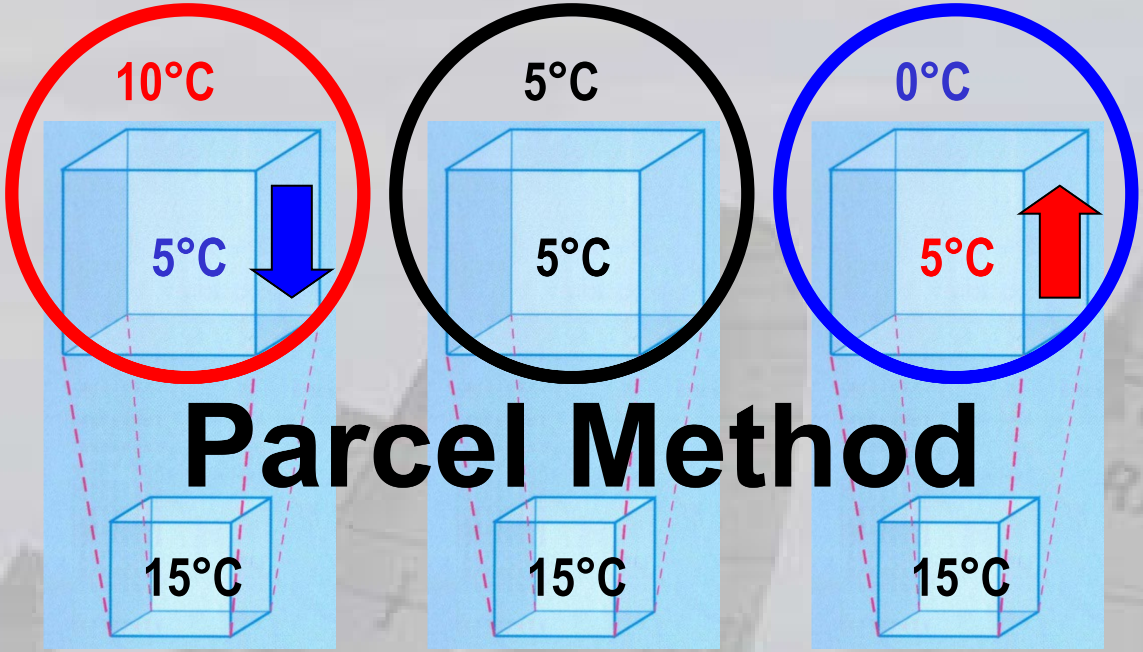
Lofting
Indifferent stratification, above inversion

Fumigation
Unstable, below inversion

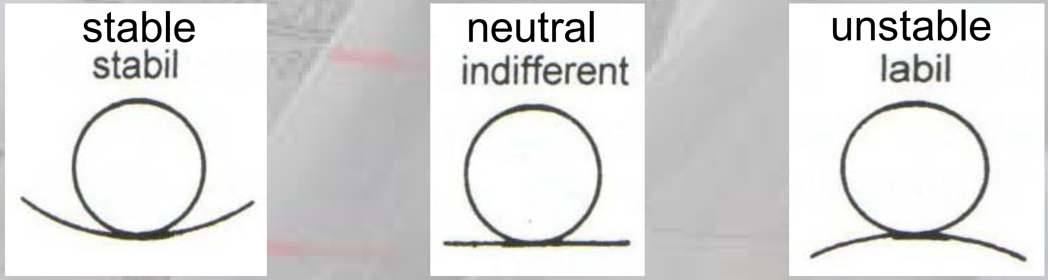
Trapping
Between two inversions

Parcel Method

Airmass	Height	Warm air		Cold air
T_e Environment	1000 m	10°C	5°C	0°C
T_p Air parcel	1000 m	5°C	5°C	5°C
T_p Air parcel	0 m	15°C	15°C	15°C

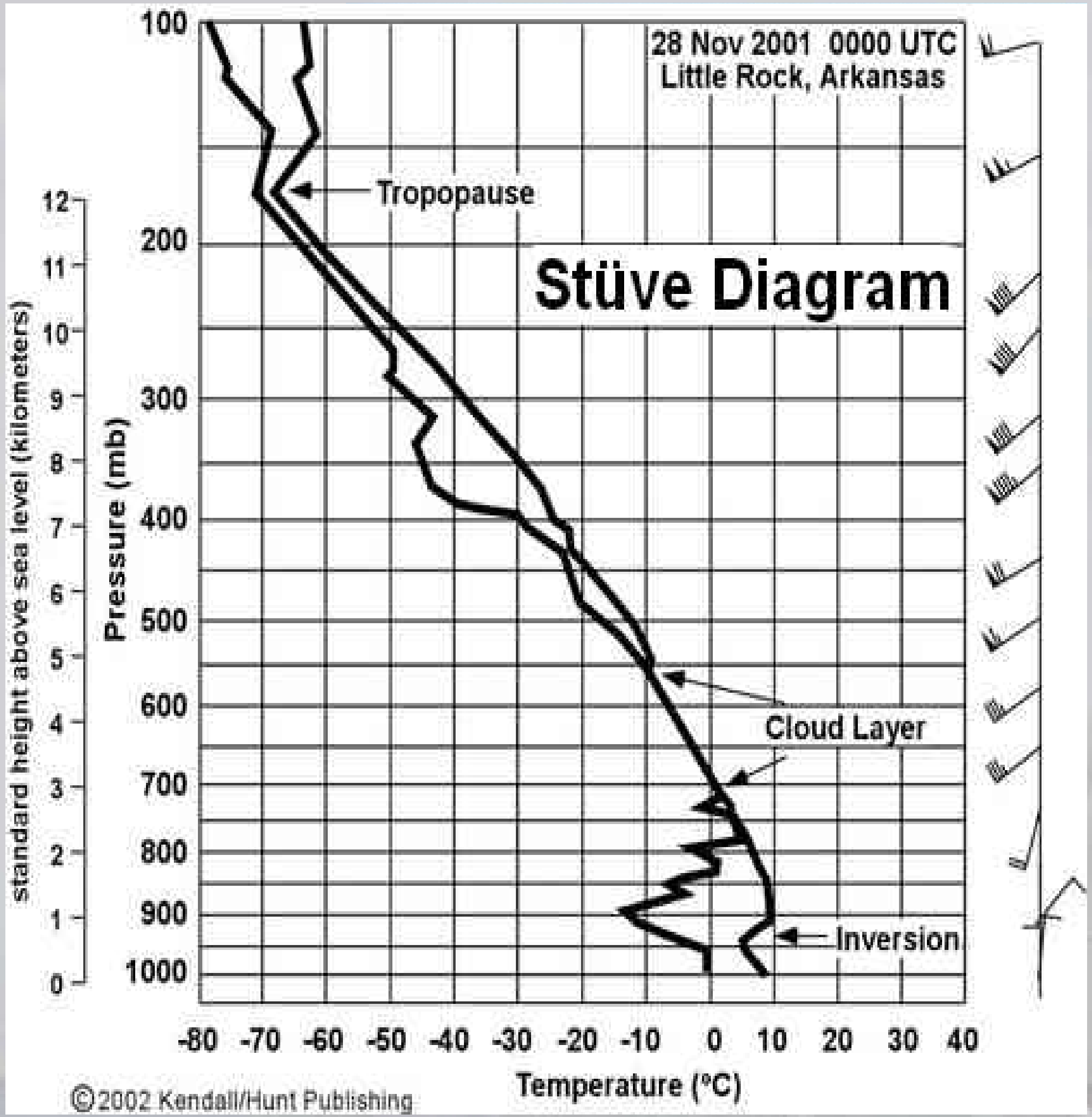


Vertical stability



High	> 6 km	Cirro-Stratus		Cirro-Cumulus
Middle high	2 - 6 km	Alto - Stratus		Alto - Cumulus
Low	NN - 2 km	Stratus	Stratocumulus	Cumulus
Other clouds:	NN - Tropopause	Nimbostratus		Cumulonimbus

TEMPERATURE: ICAO STANDARD ATMOSPHERE



ICAO Standard Atmosphere

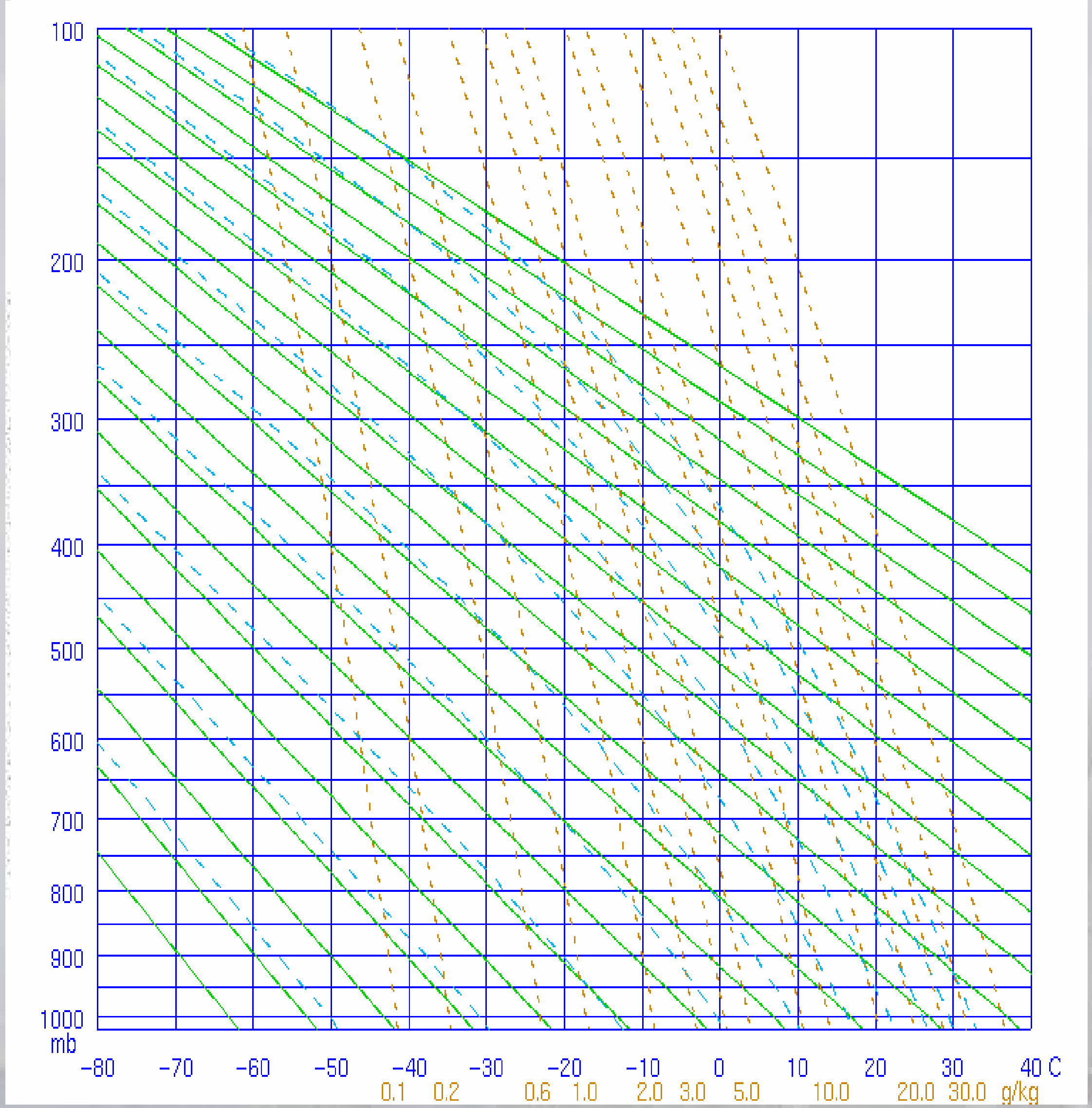
Temperature at MSL: 15 °C

Temperature	**Lapse rate :**	**0.65 °C / 100m**
Dry-adiabatic	Lapse rate:	1.00 °C / 100m
Moist-adiabatic	Lapse-rate	0.65 °C / 100m

Tropopause	**Height:**	**11 km**
Tropopause	**Temperature:**	**-56 °C**

The ICAO Standard Atmosphere is dry, no Moisture is considered

THERMODYNAMIC DIAGRAM



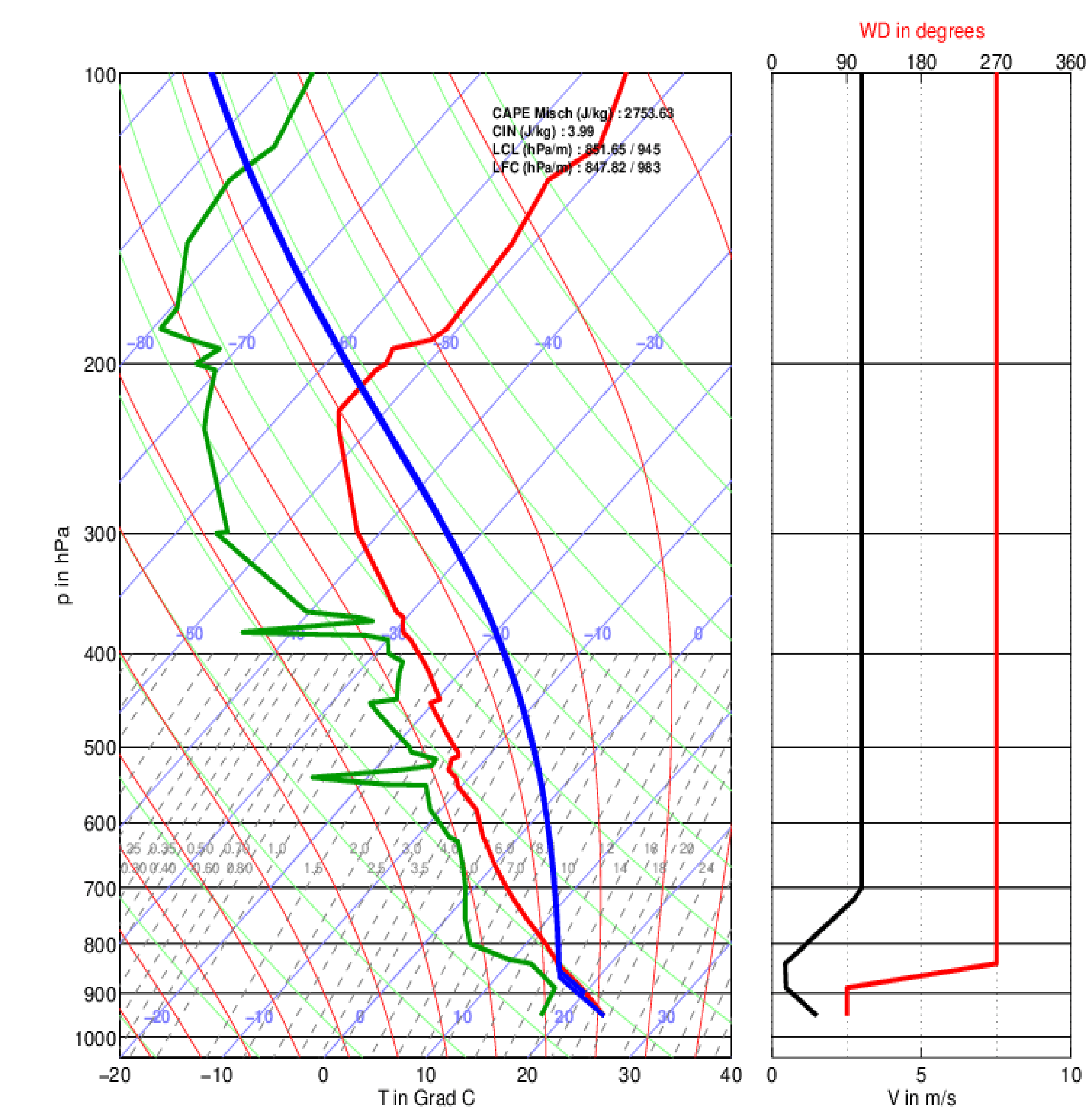
Stüve ‚Stuve‘ Diagram

Temperature at MSL: 15 °C

Temperature	Lapse rate :	0.65 °C / 100m
Dry-adiabatic	**Lapse rate:**	**1.00 °C / 100m**
Moist-adiabatic	**Lapse-rate**	**0.65 °C / 100m**

- Shows the vertical change of Temperature / Hiumidity
- Shows vertical stability/instability (Shower/Thunderstorm)
- Shows cloud base / cloud tops
- Shows beginning of convection (Release Temperature)
- Shows inversions
- Shows Aviation Hazards

THERMODYNAMIC DIAGRAM



SkewT – logP (used in USA and Military)

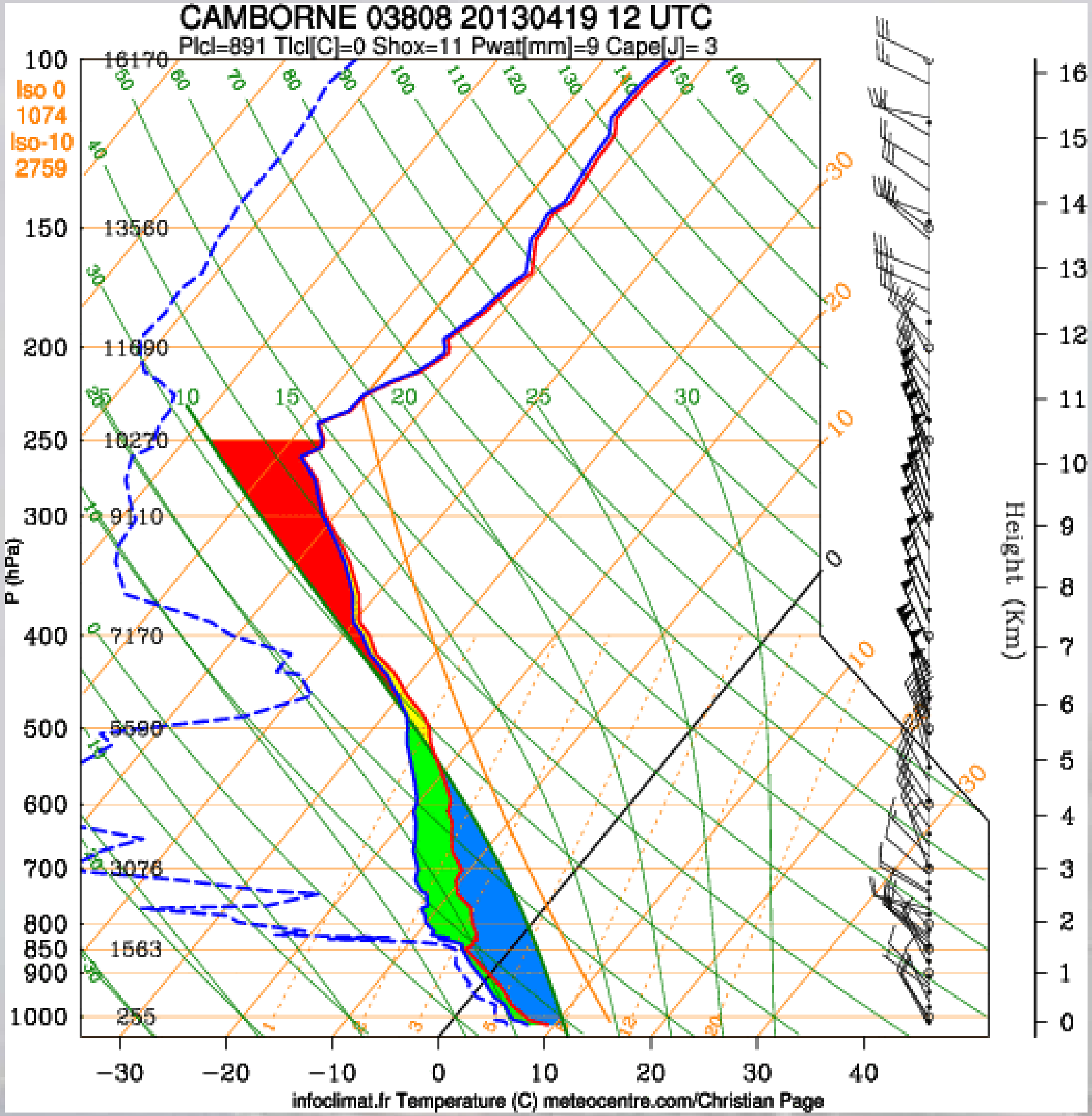
Temperature at MSL: **15 °C**

Temperature	Lapse rate :	0.65 °C / 100m
Dry-adiabatic	**Lapse rate:**	**1.00 °C / 100m**
Moist-adiabatic	**Lapse-rate**	**0.65 °C / 100m**

- Shows the vertical change of Temperature / Hiumidity
- Shows vertical stability/instability (Shower/Thunderstorm)
- Shows cloud base / cloud tops
- Shows beginning of convection (Release Temperature)
- Shows inversions
- Shows Aviation Hazards
- (ICING, Vertical Wind Shear knots/1000ft)

- **Areas are proportional to the energy !**

Thermodynamic Diagram



Tephigram (used in UK)

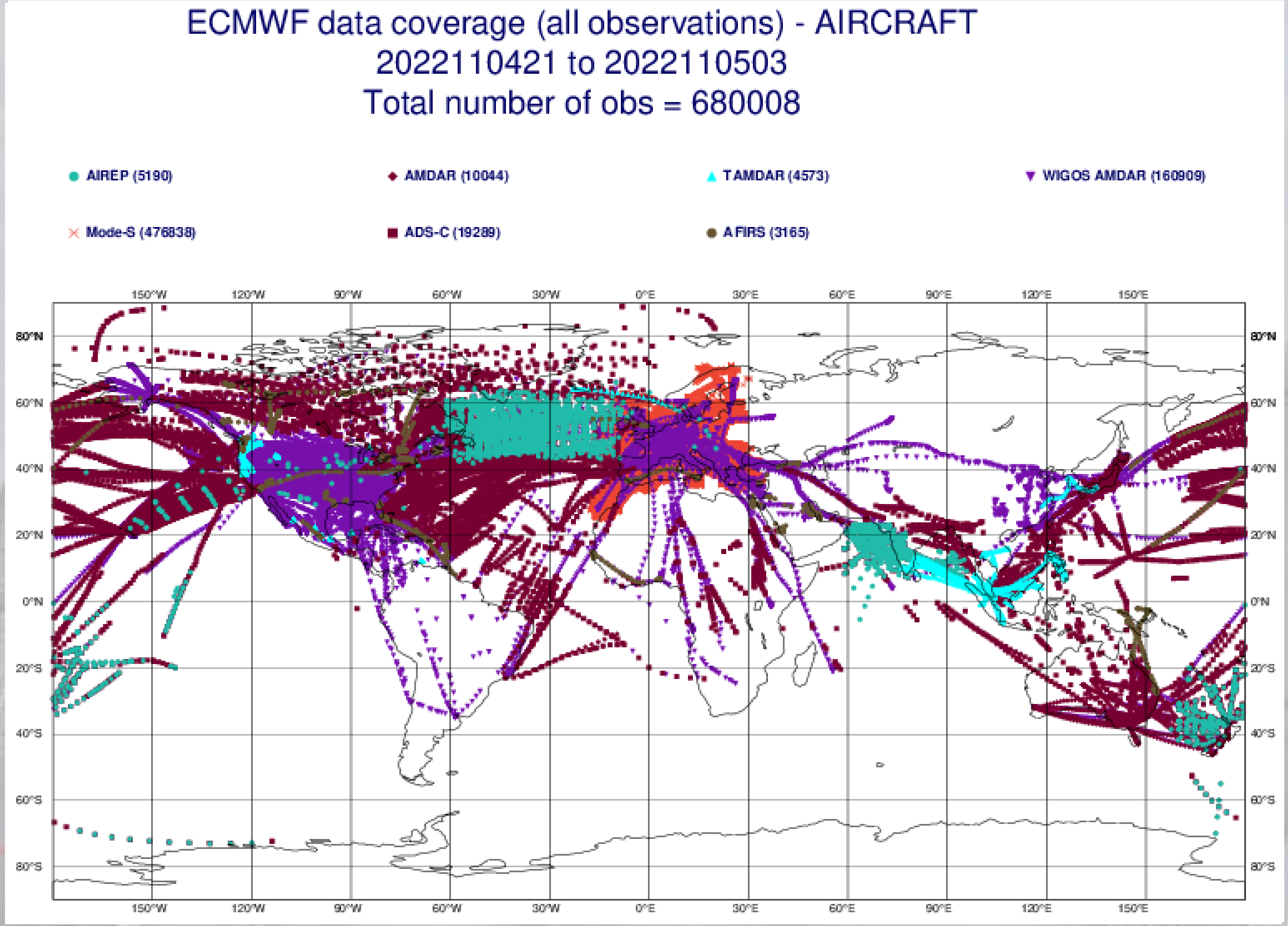
Temperature at MSL: 15 °C

Temperature	Lapse rate :	0.65 °C / 100m
Dry-adiabatic	**Lapse rate:**	**1.00 °C / 100m**
Moist-adiabatic	**Lapse-rate**	**0.65 °C / 100m**

- Shows the vertical change of Temperature / Hiumidity
- Shows vertical stability/instability (Shower/Thunderstorm)
- Shows cloud base / cloud tops
- Shows beginning of convection (Release Temperature)
- Shows inversions

- ***Areas are proportional to the energy !***

GLOBAL COVERAGE OF RADIOSONDES



Checklist Thermodynamic Diagram

Thermodynamic Diagram

- ✓ Different Types: Stüve – SkewT-logP - Tephigram
- ✓ Stüve: Othogonal x-y-Diagram
- ✓ SkewT-logP: Tilted to provide visually energy proportional to area
- ✓ Tephigram: dto

- ✓ Information about the vertical structure of the atmosphere
  - ✓ Stability, instability, Convection, PROB TS,
  - ✓ Aviation Hazards
  - ✓ Wind Profile, Jetstream, Vertical Windshear
  - ✓ ICING: -8D – Curve
  - ✓ TURBULENCE:
    - ✓ Vertical Windshear produces turbulence
    - ✓ Vertical Stability decreases / damps turbulence
    - ✓ Ratio between both: Richardson Number Ri
      - ✓ Ri < 1: RISK OF TURB
      - ✓ Ri > 1: NO RISK OF TURB

Thermodynamic Diagram