BALLOONS IN THE AIR: UNDERSTANDING WEATHER AND CLIMATE

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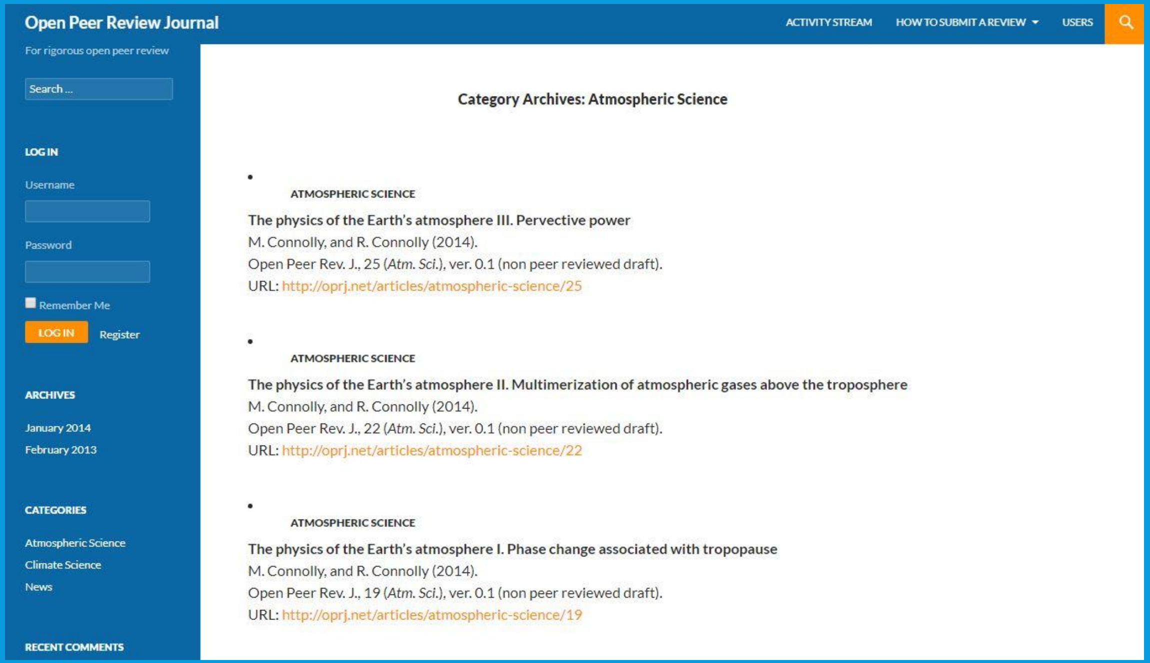
OUR EARLY FINDINGS (2010-2014) AVAILABLE AT OPEN PEER REVIEW JOURNAL



Screenshot of www.oprj.net

2010-2014:

- We spent several years analysing the data.
- A **lot** of important results
- Contradicted several key paradigms
- Too much for a standard peer-reviewed paper
- We decided to set up a new Open Peer Review Journal (www.oprj.net) and put all our analysis online in one go for everyone to look at.

2014-2019:

- 15,000 downloads since launch in 2014
- Discussed our work with hundreds of scientists around the world

2019-present:

- To be discussed in Part 3 of this talk!

STRUCTURE OF THIS TALK

1. History of atmospheric measurements & theories

2. Summary of our early findings (2010-2014)

3. Our latest findings (a sneak preview)

1. HISTORY OF ATMOSPHERIC MEASUREMENTS & THEORIES

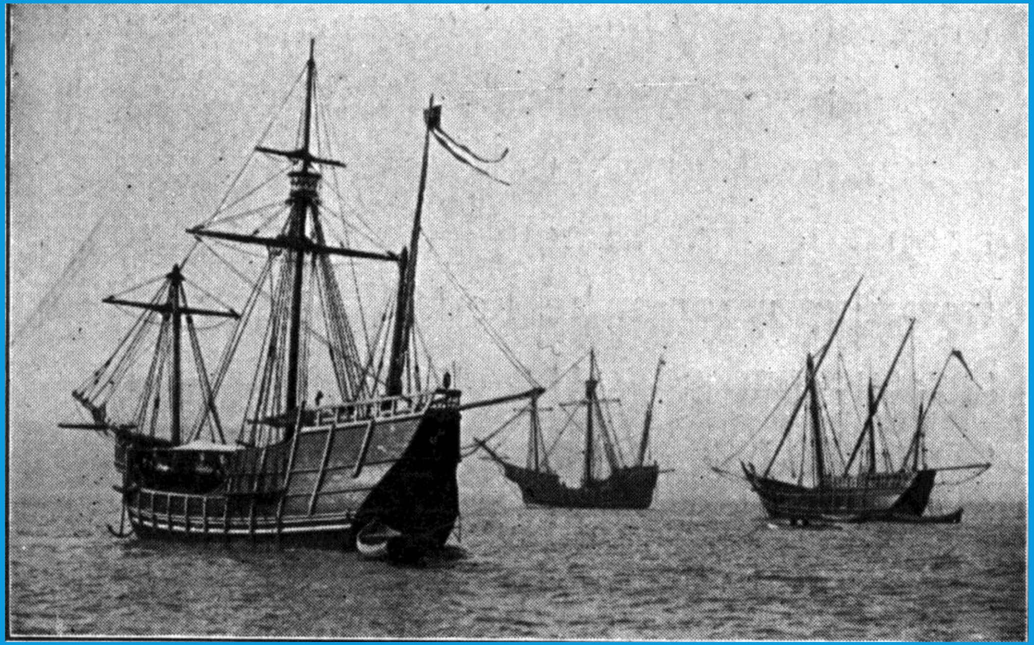
(a) Ground-based measurements

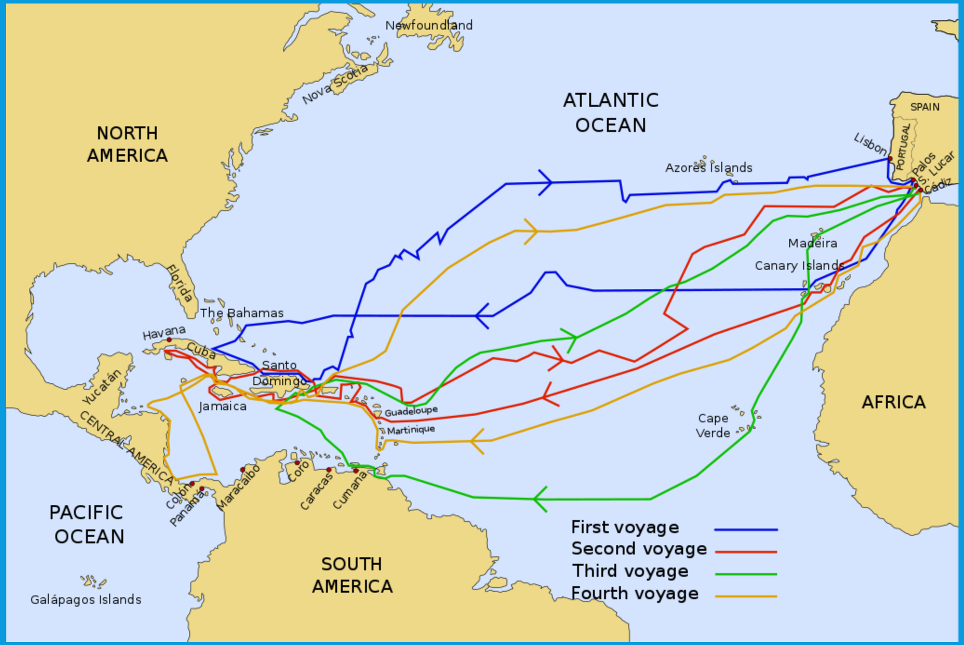
(b) Satellite-based measurements

(c) Direct atmospheric measurements

(d) Development of climate models

SAILORS: DISCOVERY OF THE TRADE WINDS





1. 1492: Columbus's voyages on Niña, Pinta & Santa Maria (photo is of 1893 replicas)
2. They used the "trade winds" to speed up their journey
3. 1600s-1800s: Hadley, Halley, Ferrell, etc. developed "atmospheric circulation models" to try and explain these prevailing winds

METEOROLOGISTS: CLIMBING MOUNTAINS

"Descent from Mont-Blanc in 1787 by H.B. de Saussure"
(Christian von Mechel, 1790)

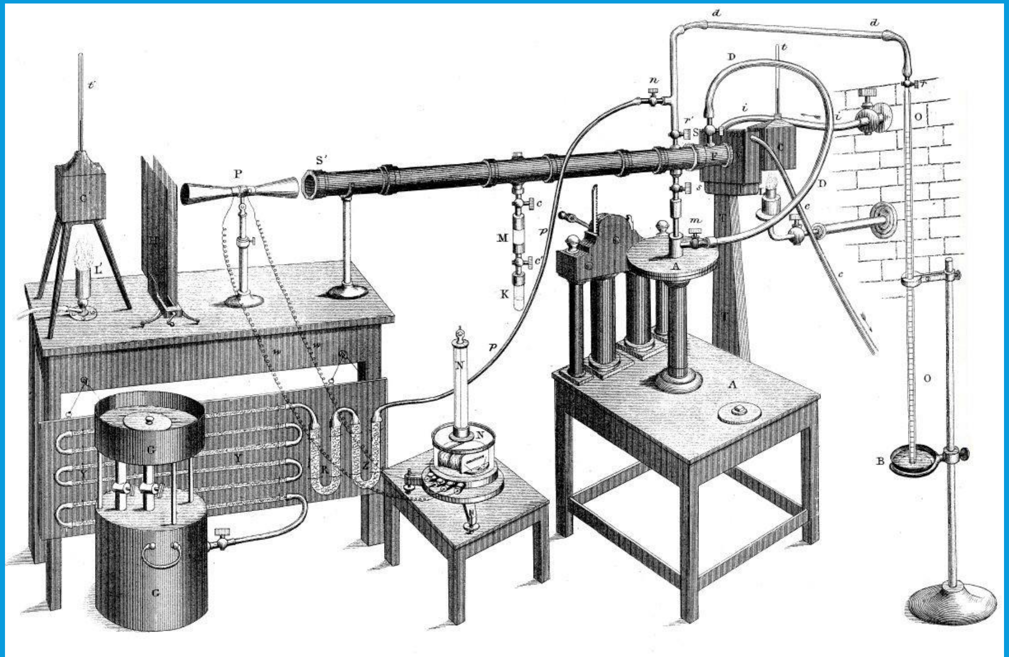
Early meteorologists would take "high altitude" measurements by climbing hills

It was shown that the atmosphere gets colder with height.

The "Lapse Rate" = -6.5°C/km

Mont-Blanc is the highest mountain in Europe (4.8km above sea level), and so was a particularly important location.

GROUND-BASED SPECTROSCOPY



The apparatus used by John Tyndall to determine that H_2O, CO_2 and CH_4 are “infra-red active” gases, but O_2 and N_2 are not (1862)

One of the Brewer ozone spectrophotometers developed by Brewer in the 1920s to study “the ozone layer”

1. HISTORY OF ATMOSPHERIC MEASUREMENTS

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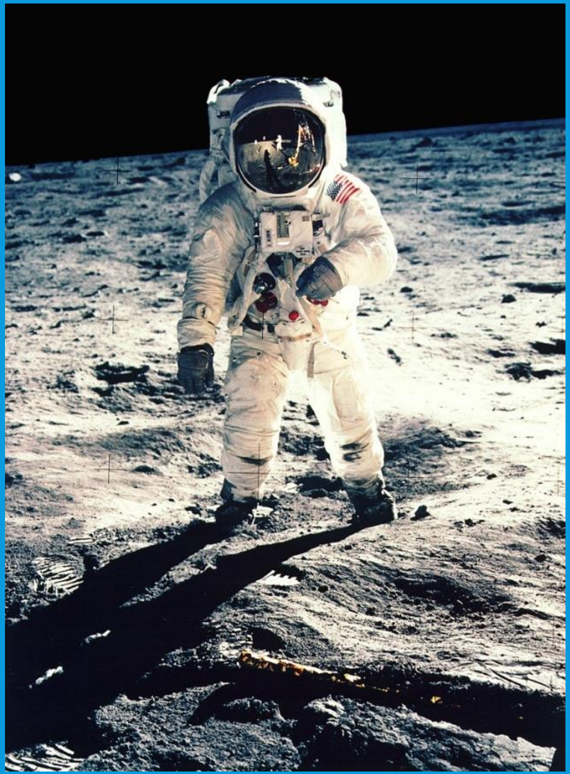
THE SPACE RACE

Apollo 11 moon landing

Exactly 50 years ago today: July 20th, 1969



THE SATELLITE ERA

- 1957: USSR launched Sputnik
- 1958: USA launched Explorer
- 1960: USA launched TIROS-1 (lasted 3 months)
- The TIROS ("Television Infrared Observation Satellite") were the world's first weather satellites
- NOAA-19 is the 45th in the TIROS series and has been active since 2009

LOOKING FROM ABOVE AND BELOW

From the ground

Benjamin Franklin's "Kite experiment" 1752
(*Currier & Ives, 1892*)

From space

The "Blue Marble" photo – Apollo 17 crew, 1972
(*Eugene A. Cernan, Ronald E. Evans, Harrison H. Schmitt*)

1. HISTORY OF ATMOSPHERIC MEASUREMENTS

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WEATHER BALLOONS

At the end of the 19th century, several European groups began using weather balloons (manned and unmanned) to study the atmosphere

The German group (led by Prof. Richard Aßman) used manned and unmanned, e.g., see drawing

The French group (Léon Teisserenc de Bort) used unmanned balloons

In 1902, both groups announced the discovery of the tropopause, although it was initially called the "stratosphere"

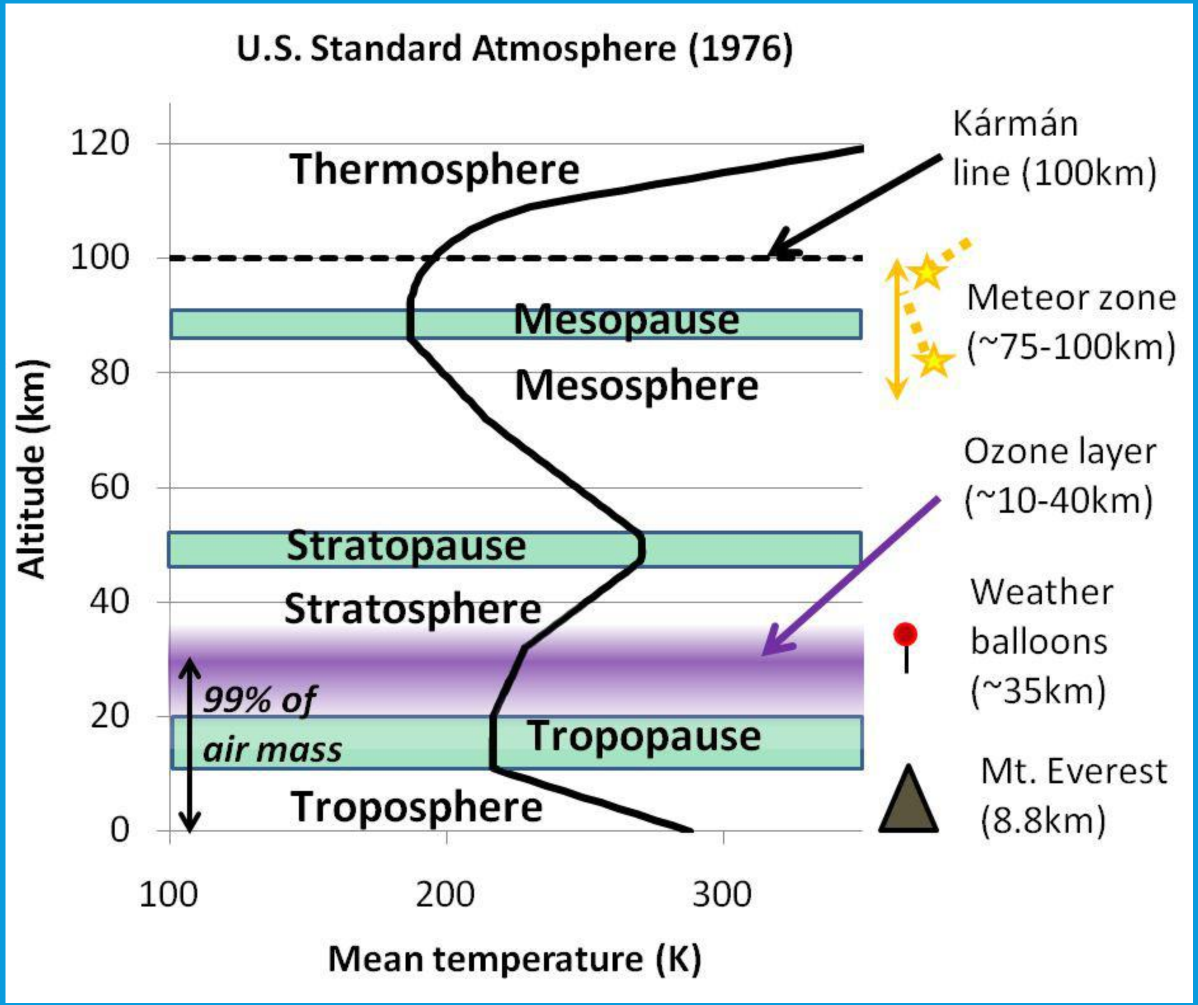
Arthur Berson (meteorologist, left); Hans Groß (pilot, right) in Phoenix *(1894). Drawing by Hans Groß*

THE DISCOVERY OF THE "STRATOSPHERE"

- Everybody knew that it got colder as you went up in the air – that's why it snows on mountaintops. But, now a new region where temperatures remained constant with height!
- People assumed this meant the air was static and "stratified". Therefore, "stratosphere" vs. "troposphere" ("tropos" = turning or mixing)

- Lindemann and Dobson (1922) proposed a **<u>third</u>** layer where temperatures increased with height!
- The new layer kept the "stratosphere" name, and the original "stratosphere" was renamed the "tropopause" (because the temperature "paused")

THE REGIONS OF THE ATMOSPHERE



- Air craft = Mostly troposphere (typically up to 5-10km)
- Rocketsondes = Upper stratosphere to thermosphere (40-120 km)
- Weather balloons = Troposphere, tropopause and stratosphere (up to 35km)

ADVANCES IN WEATHER BALLOONS

- A balloon's measurement is called a "sonde" (from the French for "sounding")

- When an unmanned balloon burst, it could land 200 miles away. So, needed to include "return to sender" note
- In the 1930s, cheap radio transmitting instruments were developed.

- Now called "radiosondes".
- Records temperature, pressure, humidity & wind speed
- Launched 1 to 4 times/day, 2000 stations around the world
- Can reach 30-35 km (18-21 miles) before bursting

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TWO BIG PUZZLES IN EARLY 20TH CENTURY

In the late 19th/early 20th century, the two biggest climate/atmosphere puzzles were:

1. Why did ice ages occur in the past?
   It was known that there were at least 4 in the last million years

2. Why was there a tropopause/stratosphere?

Most people assumed that the tropopause/stratosphere **probably** had something to do with the ozone layer which was discovered by Fabry & Buisson (1912)

ICE AGE CLIMATE CHANGE THEORIES (1860-1960)

Changes in the Earth's orbit and solar variability	• 1870s: James Croll – changes in Earth's orbit • 1910s: Milutin Milanković – changes in Earth's orbit • 1920s: George Simpson = solar (& H_2O, clouds)
Changes in H2o or cloud cover	• 1860s: John Tyndall = H_2O • 1920s: George Simpson = H_2O, clouds (& solar)
Changes in CO_2	• 1890s: Svante Arrhenius = CO_2 only • 1930s: Guy Callendar = CO_2 only • 1950s: Gilbert Plass = CO_2 only
Volcanic eruptions	• 1890s: Thomas Chamberlin – warming from extra CO_2 • 1960s/70s: Reid Bryson, Hubert Lamb, Mikhail Budyko, etc. – cooling from extra dust and/or aerosols

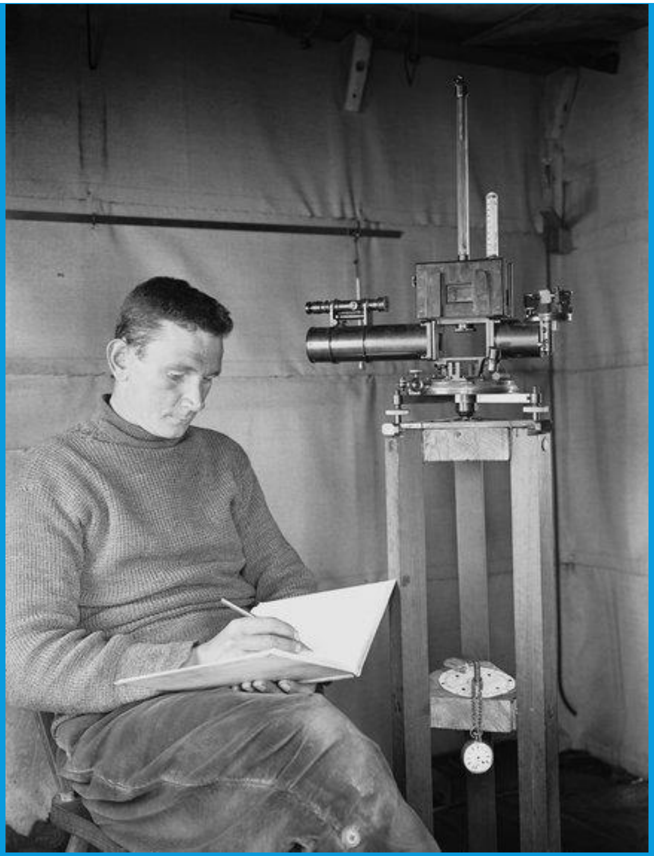
THE SWEDISH CLIMATE DEBATE

Svante Arrhenius (1859–1927)

- Arrhenius argued that changes in CO_2 could cause the ice ages
- He calculated that changes in CO_2 would significantly alter the rate at which the Earth cooled to space and that this would change the surface air temperatures.
- Ångström disagreed. He argued his experiments showed CO_2 was not a major driver of air temperatures

Knut Ångström (1857-1910)

SIR GEORGE C. SIMPSON (1878-1965)



George Simpson making scientific observations at the base camp on Scott's Antarctic Expedition (1910-1912).

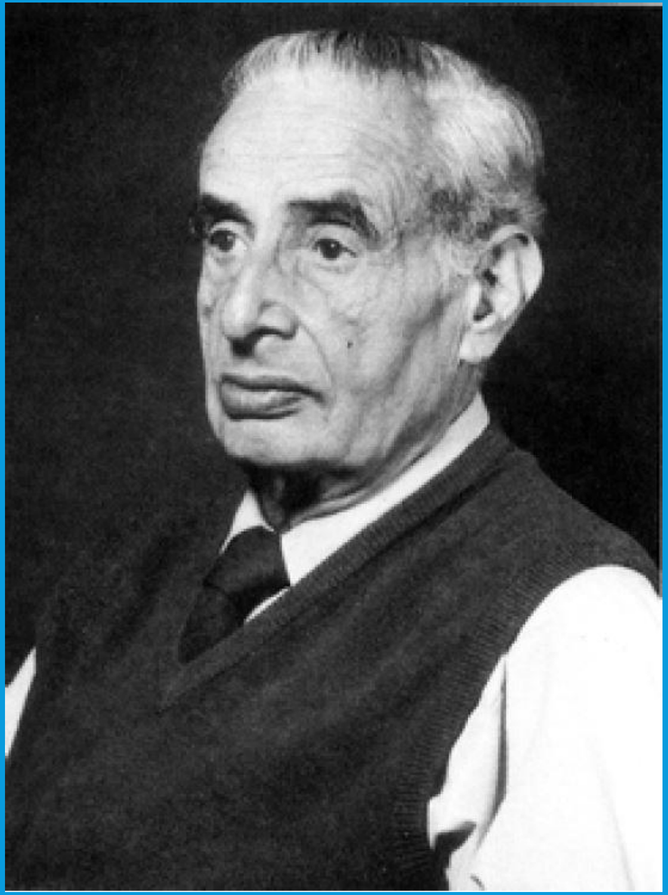
- 1910-1912: One of the surviving members of Robert Scott's Antarctic Expedition
- 1920-1938: Director of the British Meteorological Office
- 1939-1947: Director of Kew Observatory

In 1920s-30s, he carried out detailed calculations on our two big puzzles using latest meteorological data, including weather balloons

He concluded:

1. CO_2 was **not** a driver of climate change
2. Temperatures in the troposphere were **not** driven by radiative processes. Instead, he argued convection was more important
3. But, in the stratosphere, radiative processes might be the driver
4. It **<u>probably</u>** had something to do with ozone, but there were odd puzzles as to why the effects were greatest at the poles.

THE "**PICK ONE THING**" APPROACH



Walter M. Elsasser (1904-1991)

Walter Elsasser

- 1937-1941 (CalTech): calculated effects of infrared radiation transfer in atmosphere – **only** radiative processes
- Moved to Harvard (until called to duty) where he wrote up his calculations as Elsasser (1942)
- Rebranded much of Einstein's work as "Kirchoff's laws"

Gilbert Plass

- In 1950s, tried to explain CO_2 as driver of **all** climate change

Syukuro Manabe & Robert Strickler, 1964

- ***Tried*** to build computer model from Elsasser (1942) to explain troposphere/stratosphere with radiative processes…

THE “CONVECTIVE ADJUSTMENT”

The Problem!!!

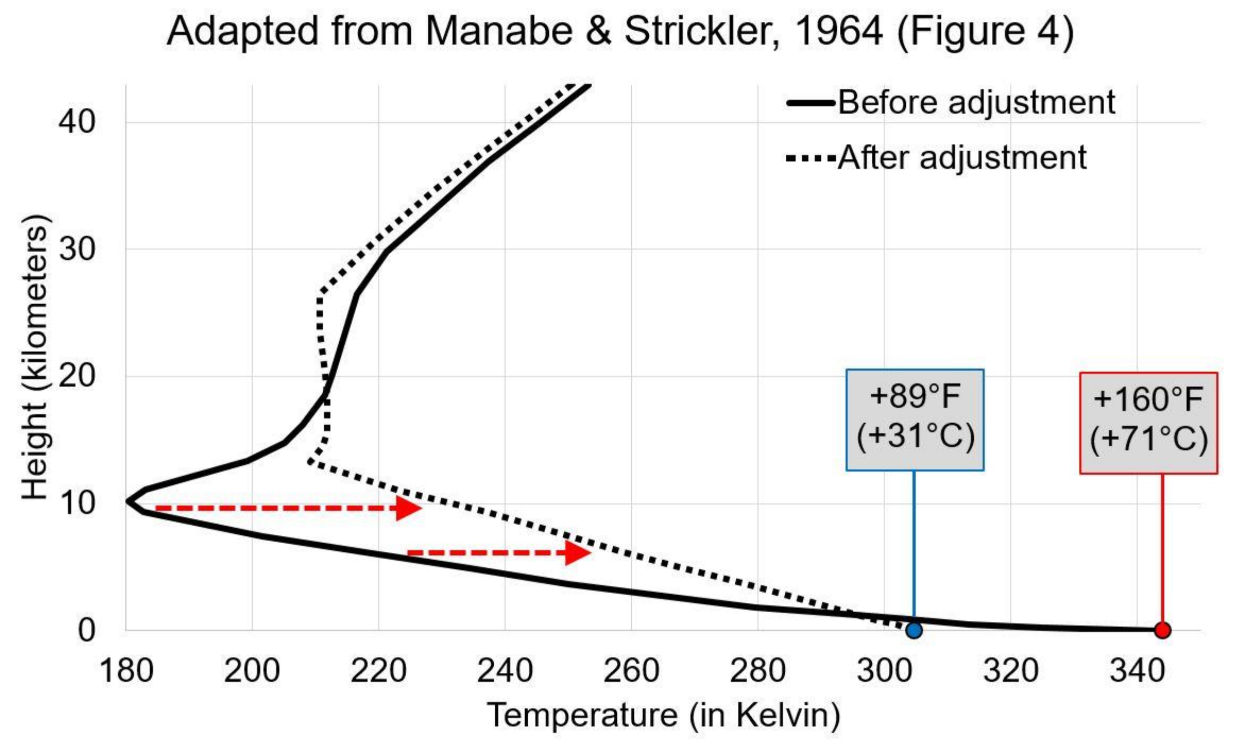
- Lapse rate = rate of change of temperature/km
- Average lapse rate in troposphere = -6.5°C/km
- But, using “radiative processes” = -16°C/km!
- Also, ground temperature = +160°F!!!
- Stratospheric trends were kind of ok though

George Simpson’s conclusion (1930s)

- Stratosphere is radiatively-dominated, but troposphere is **not**!

Manabe & Strickler’s conclusion (1964)

- Just remember to keep manually “adjusting” the data every time the lapse rate gets too fast
- It’s probably something to do with convection…



SUPERCOMPUTERS IN THE 1960S

IBM 7090 operator's console at the NASA Ames Research Center (1961)

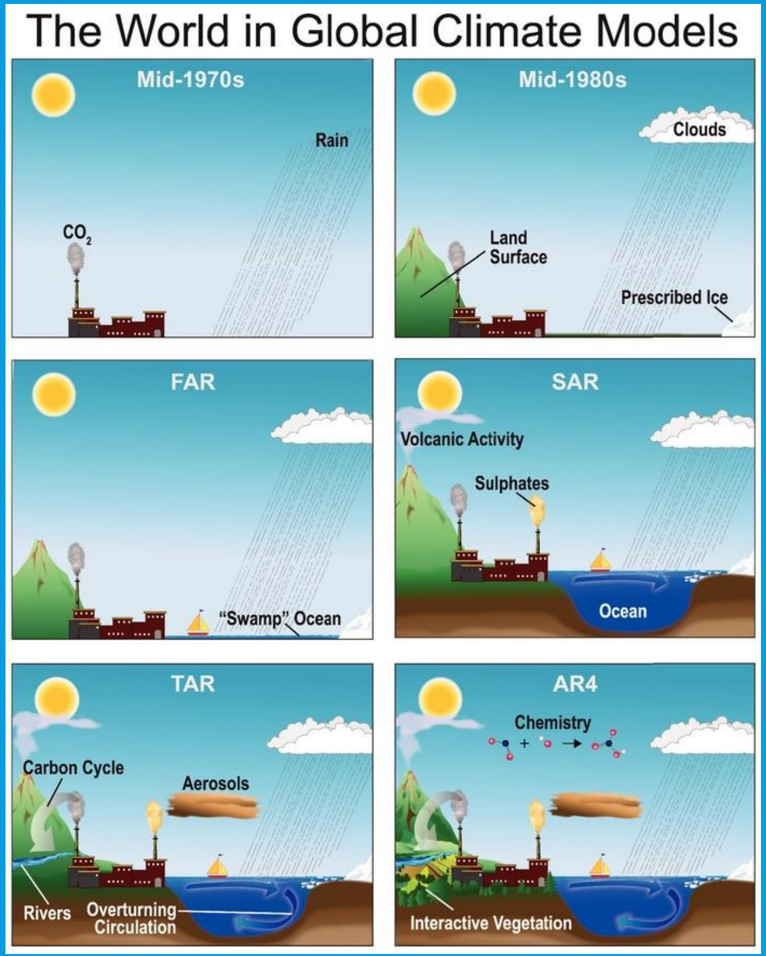
- CPU speed = 200,000 FLOPS
- RAM = 4 kB
- Size = occupies several rooms

Vs.

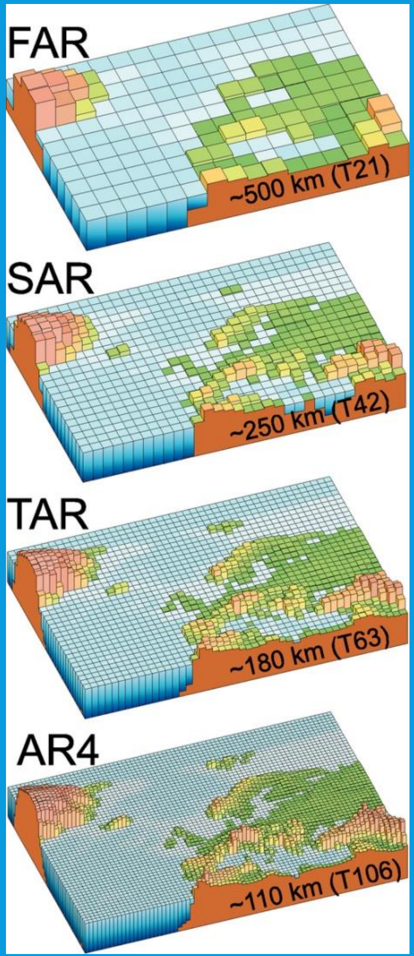
Samsung Galaxy S6 (2015)

- CPU speed = 35,000,000,000 FLOPS
- RAM = 3,000,000 kB ("3GB")
- Size = 5.1" screen

THE GLOBAL CLIMATE MODEL APPROACH



- Current supercomputers are <u>**far**</u> more powerful than 1960s!!!
- The resolution has improved:
  - Horizontally (500km in 1990 to 100km today)
  - Vertically (2-3km in 1990 to 500-1000m today)
- Extra components (ice, oceans, aerosols, changing Sun) have been added
- But, Elsasser, 1942's key assumption that radiative physics is the main driver was never checked until now! <u>**It was wrong**</u>.



IMPLICATIONS OF CONVECTIVE ADJUSTMENT

- The computer models assume that the atmospheric temperature profile is determined by the concentrations of infrared-active gases
- So, Manabe & Wetherald (1967) predicted doubling CO2 would cause global warming
- Unfortunately, 1940s-1970s global temperatures were cooling…
- But, in 1980s, warming started again and the computer modellers declared vindication!

Dr. James Hansen, who co-developed the NASA GISS climate model building on the Manabe model, in his 1988 US Congressional testimony where he claimed:

"It is time to stop waffling so much and say that the evidence is pretty strong that the greenhouse effect is here."

BOTH SIDES

"I've looked at clouds from both sides now
From up and down and still somehow
It's cloud's illusions I recall
I really don't know clouds at all"

- Joni Mitchell, "Both Sides, Now" (1969)

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THE MAJOR CONCEPTS IN SCIENCE

1. **Facts:** Experimental observations or results.
2. **Laws:** A statement based on repeated experimental observations, generally an equation. Tells **what** and **how** something happens, but **not why** it happens.
3. **Hypothesis:** A guess at explaining the facts. A starting point for developing a theory
4. **Theory:** An explanation acquired through repeated testing using the scientific method. A theory explains **why** things happen.
5. **The Scientific Method:** Subject your hypothesis to as many tests as you can. If it cannot explain all the facts, it is **wrong**. If it explains all the known facts you have a theory.
6. **The Principle of Occam's Razor:** If two or more theories explain all the known facts pick the simplest one

WEATHER BALLOON DATA AND THE GAS LAWS

In our analysis of the weather balloon data, we used only the experimental observations and the gas laws.

We did not use models.

AN EXAMPLE OF A RADIOSONDE RESULT: TUCSON, AZ (JULY 20TH, **2018**)

Measures :

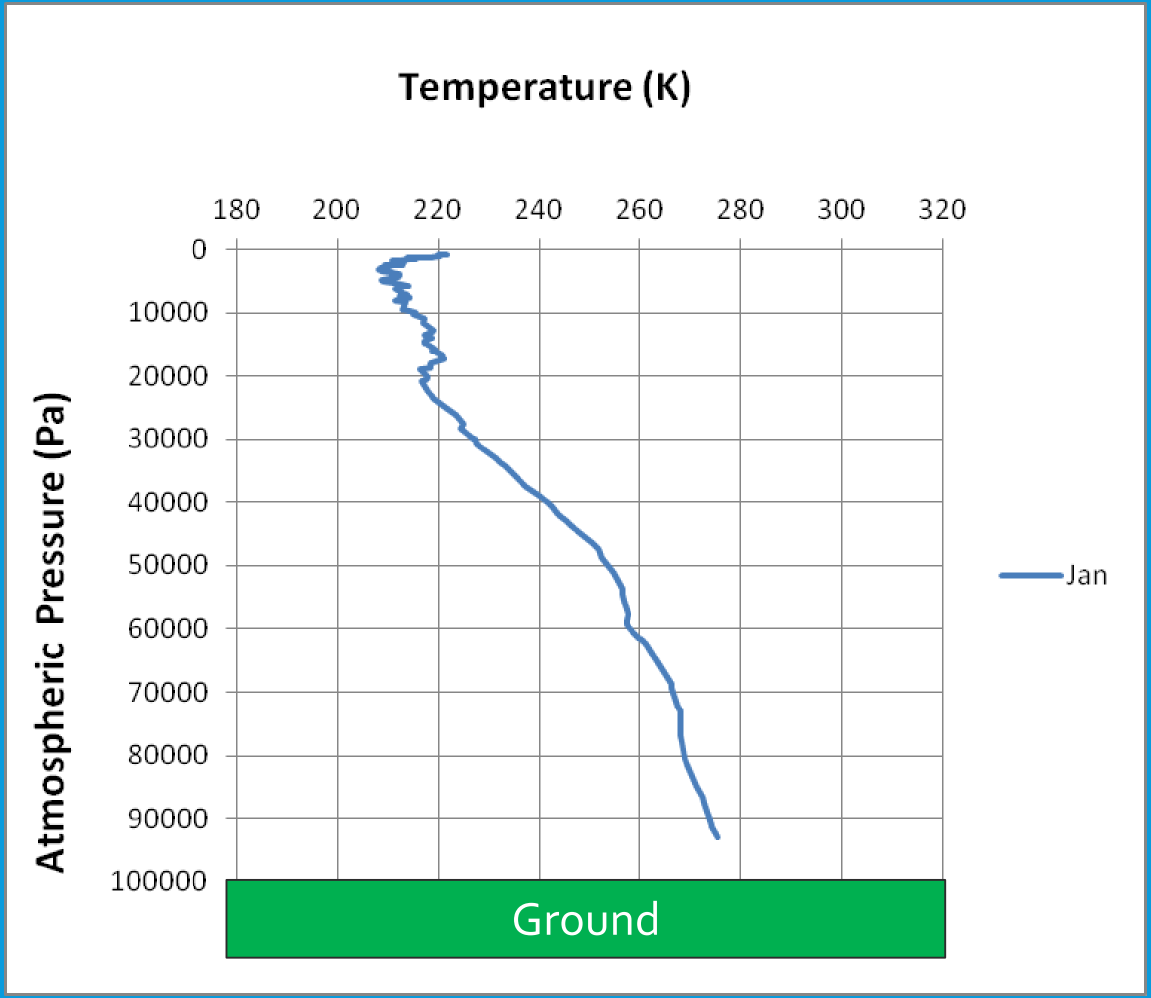
- Pressure
- Temperature
- Humidity
- Horizontal wind speed and direction

Mandated pressure levels (hPa or mb) = 1000, 925, 850, 700,500, 400,300,250,200,150,100, 70, 50, 30, 20, 10, 7, 5, 3, 2 & 1

72274 TUS Tucson Observations at 00Z 20 Jul 2018

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1000.0	61									
927.0	751	35.8	15.8	30	12.32	320	5	315.7	354.6	318.1
925.0	767	35.2	16.2	32	12.68	320	7	315.3	355.2	317.7
921.0	806	34.2	16.2	34	12.73	317	8	314.7	354.6	317.1
910.0	914	33.2	16.1	36	12.79	310	10	314.7	354.8	317.1
879.6	1219	30.3	15.7	41	12.95	310	12	314.8	355.4	317.2
850.0	1526	27.4	15.4	48	13.11	300	11	314.8	355.9	317.3
821.2	1829	24.6	14.7	54	13.01	290	12	314.9	355.7	317.4
798.0	2081	22.2	14.2	60	12.92	286	9	315.0	355.5	317.5
793.1	2134	21.9	13.4	58	12.34	285	8	315.3	354.0	317.6
765.8	2438	20.4	8.8	47	9.40	240	6	316.8	346.7	318.6
762.0	2482	20.2	8.2	46	9.03	239	6	317.0	345.8	318.8
739.2	2743	18.4	5.7	43	7.80	230	6	317.8	342.8	319.3
730.0	2850	17.6	4.6	42	7.34	229	7	318.1	341.7	319.5
700.0	3207	14.2	4.2	51	7.44	225	11	318.2	342.1	319.6
663.3	3658	10.5	1.9	55	6.67	160	2	318.9	340.6	320.2
649.0	3841	9.0	1.0	57	6.38	148	6	319.2	340.0	320.5
627.0	4126	6.6	2.1	73	7.15	129	12	319.7	342.9	321.0
621.0	4205	6.2	1.7	73	7.02	124	14	320.1	342.9	321.4
616.4	4267	6.0	-1.1	60	5.75	120	15	320.5	339.4	321.6
613.0	4312	5.8	-3.2	52	4.95	121	15	320.8	337.2	321.8
598.0	4514	4.6	-11.4	30	2.69	124	16	321.7	330.9	322.2
587.0	4666	3.6	-8.4	41	3.47	127	16	322.2	334.0	322.9
572.0	4875	2.4	-13.6	30	2.35	130	17	323.2	331.4	323.7
571.9	4877	2.4	-13.6	30	2.36	130	17	323.2	331.4	323.7
561.0	5032	1.2	-10.8	40	3.01	127	19	323.6	333.9	324.2
550.6	5182	0.5	-15.4	29	2.10	125	20	324.5	331.8	324.9
540.0	5339	-0.3	-20.3	20	1.42	128	19	325.4	330.5	325.6
531.0	5473	-1.3	-16.3	31	2.03	130	18	325.7	332.9	326.1
525.0	5563	-1.5	-23.5	17	1.10	131	18	326.6	330.6	326.8
510.1	5791	-3.3	-25.9	16	0.92	135	16	327.1	330.5	327.3
500.0	5950	-4.5	-27.5	15	0.80	135	16	327.5	330.5	327.6
497.0	5997	-4.9	-27.9	15	0.78	132	16	327.6	330.5	327.7
491.0	6092	-4.9	-31.9	10	0.54	125	16	328.7	330.8	328.8
490.8	6096	-4.9	-31.9	10	0.54	125	16	328.7	330.8	328.8
453.5	6706	-8.6	-37.2	8	0.35	145	15	331.6	333.0	331.6
421.0	7282	-12.1	-42.1	6	0.23	107	18	334.2	335.2	334.3
419.2	7315	-12.3	-39.4	8	0.30	105	18	334.4	335.6	334.4

Tucson, AZ
January 1st 2019; 7:40am local time



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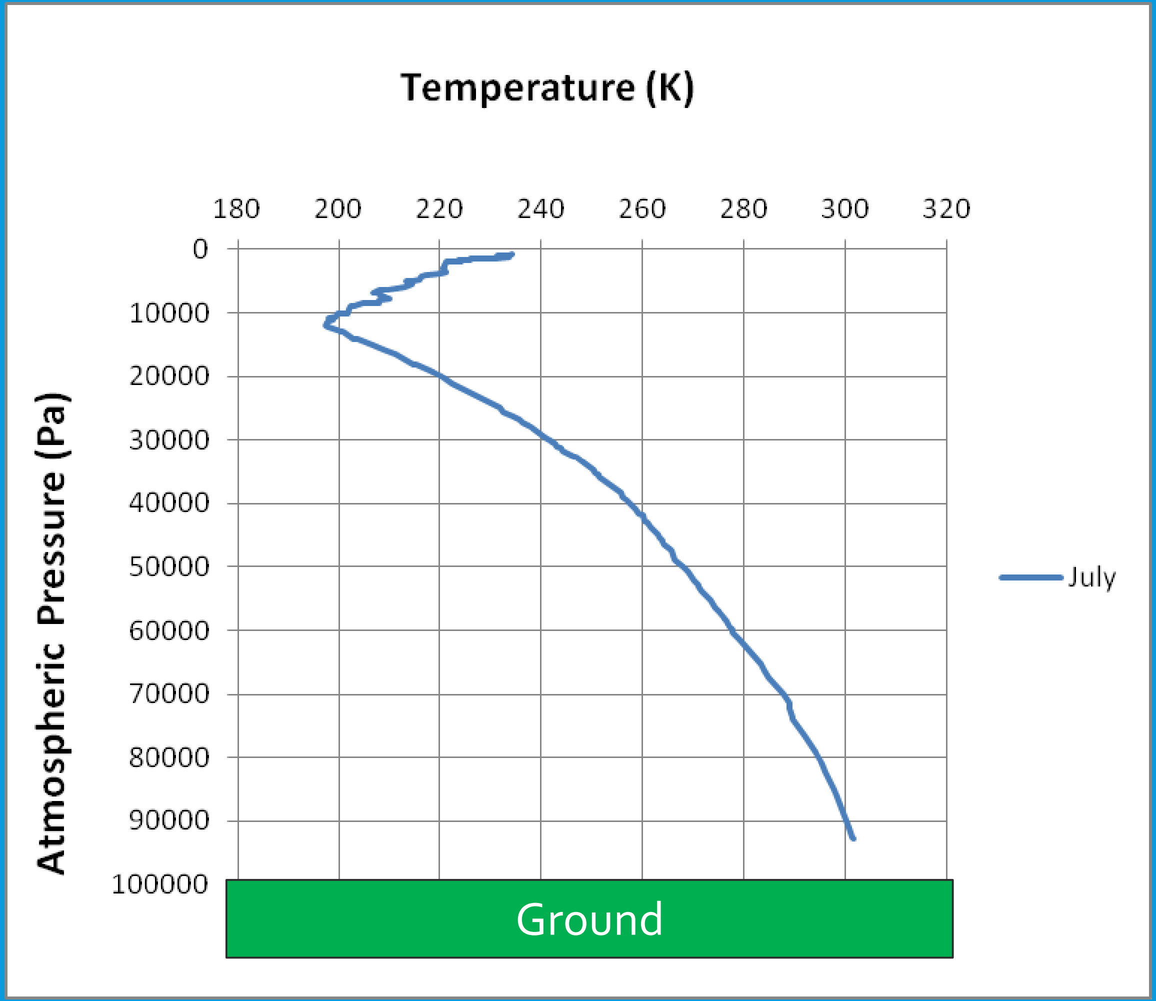
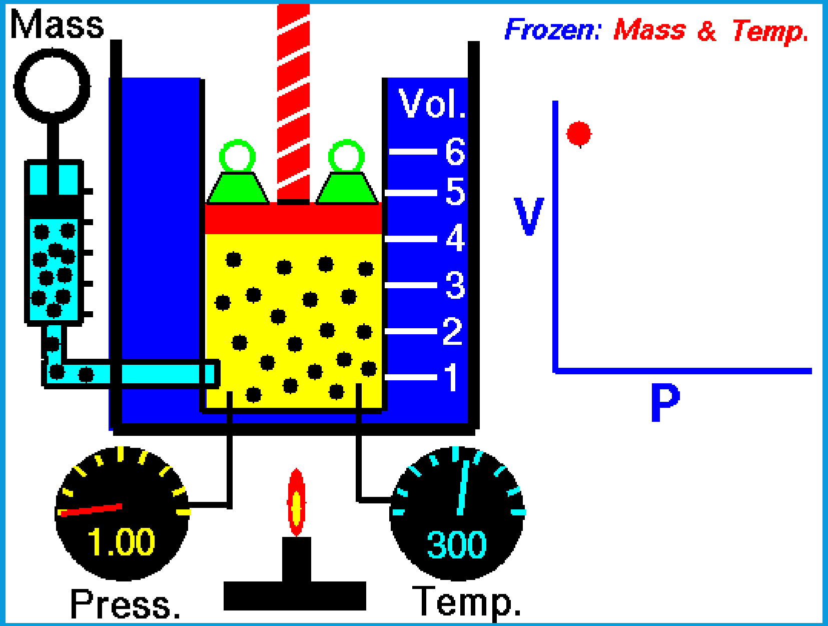


The gas laws

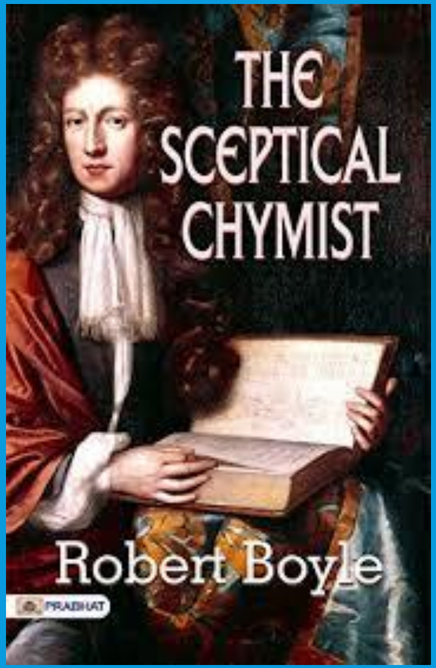
BOYLE'S LAW

Boyle's law states that for a given amount of gas if the temperature stays the same then the pressure times the volume stays constant:

PV=C



Source NASA's Glenn Research Center

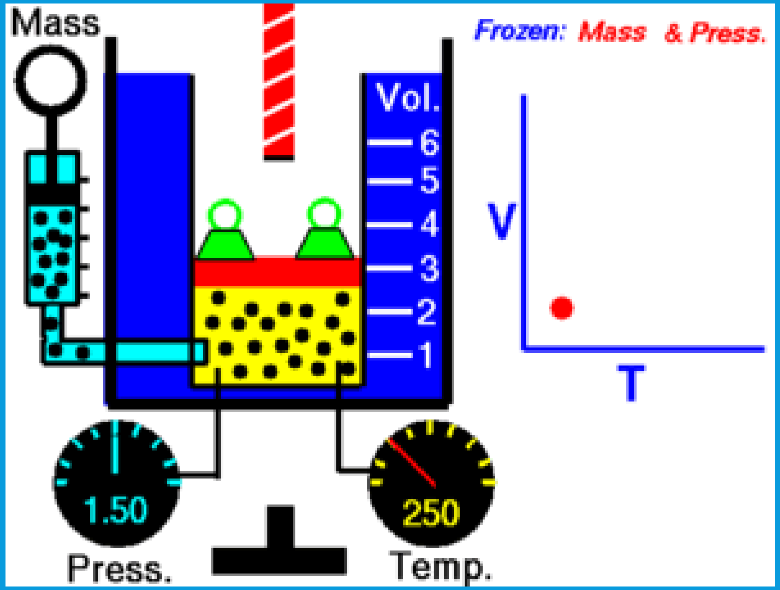


Robert Boyle (1627-1691)
Ireland
Published book on gases:
"The Sceptical Chymist" (1680)

CHARLES'S LAW

Charles's Law states that if the pressure on a fixed amount of gas remains the same, then the volume divided by temperature remains constant:

V/T= C



Source NASA's Glenn Research Center

Jacques Charles
(1749-1823)
France
Scientific career in Physics and maths,
First manned balloon flight
Discovered Charles law

AVOGADRO'S LAW

Avogadro's law states that, "equal volumes of all gases, at the same temperature and pressure, have the same number of molecules

This means that the volume of a gas at a given temperature and pressure depends on the number of molecules and not the weight of the molecules

V Proportional to **n**

The number of molecules is measured in moles.
1 mole ≈ 602,300,000,000,000,000,000,000 molecules!

Normally written as 6.023×10^{23} ("Avogadro's number")

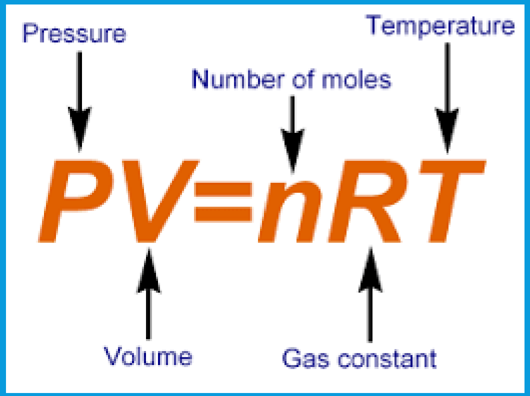
Amedeo Avogadro (1776-1856)
Italy
Scientific career: Physicist and held posts dealing with statistics and meteorology
Discovered Avogadro's Law

THE IDEAL GAS LAW

By combining the last three gas laws together we get an equation which is called the ideal gas law.

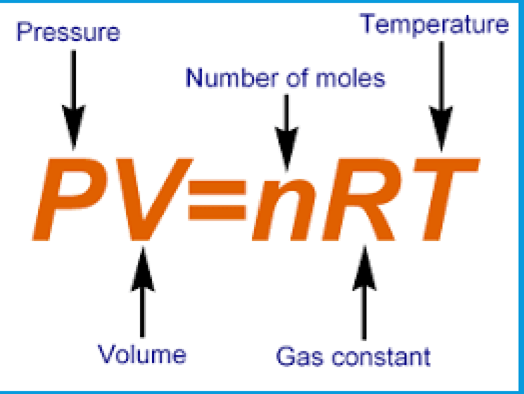
It is also known as the thermodynamic equation of state of an ideal gas.

THE IDEAL GAS LAW



MOLAR DENSITY, D

(THE NUMBER OF MOLECULES MEASURED IN MOLES PER M^3)



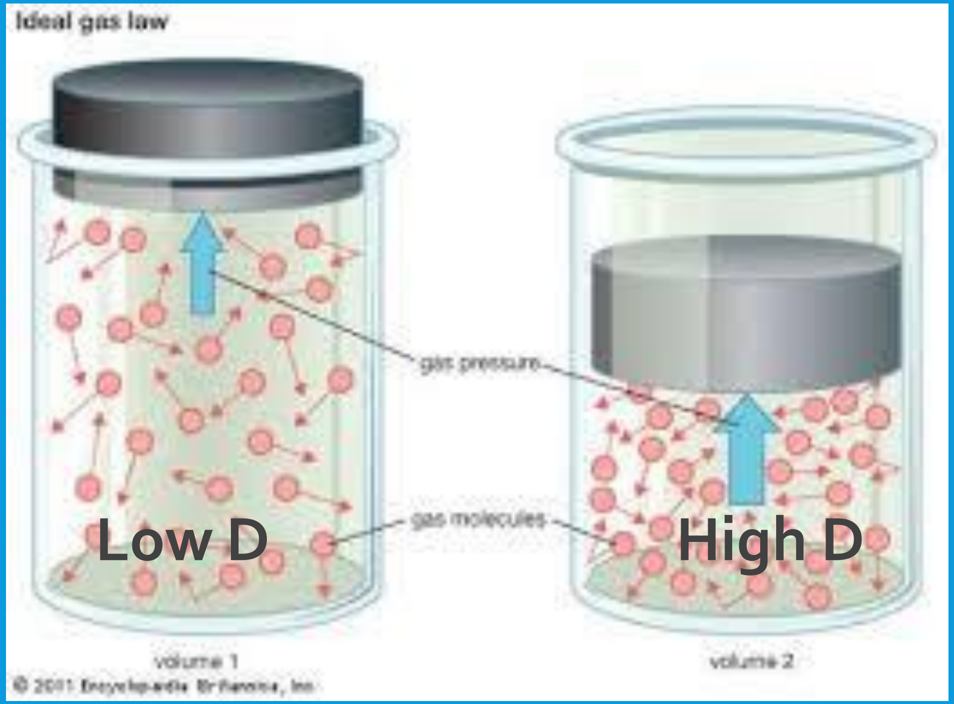
By Rearranging the equation of state we get

$$n/V = P/RT$$

Since the molar density (D) is given by

$$D = n/V$$

Then $$D = P/RT$$



Why is there a Tropopause?

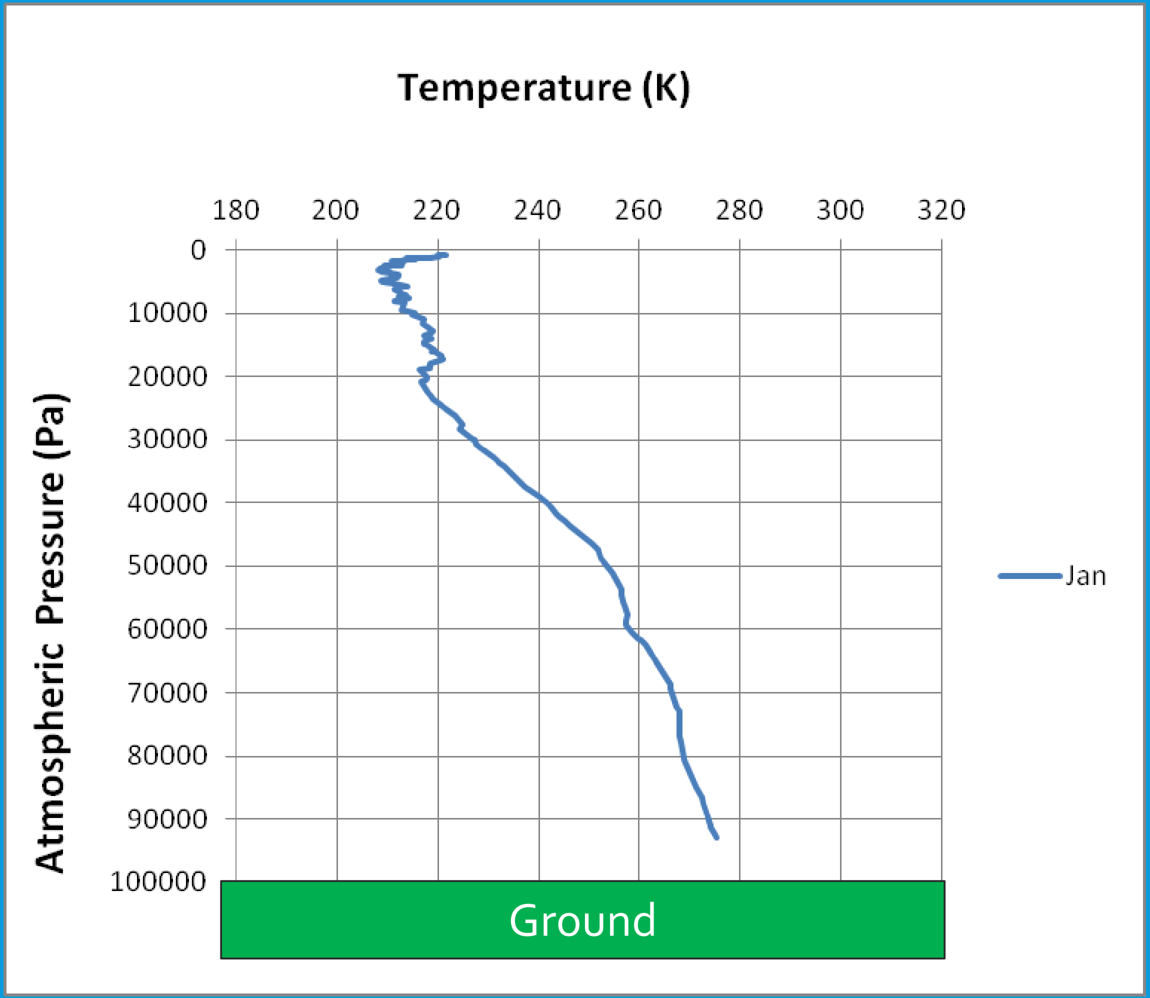
Hypothesis

Absorption of ultraviolet (“UV”) light by ozone heats up the air to form the stratosphere and tropopause

Can weather balloon data be used to test this hypothesis?

The answer is yes!

Tucson, AZ
January 1st 2019; 7:40am local time



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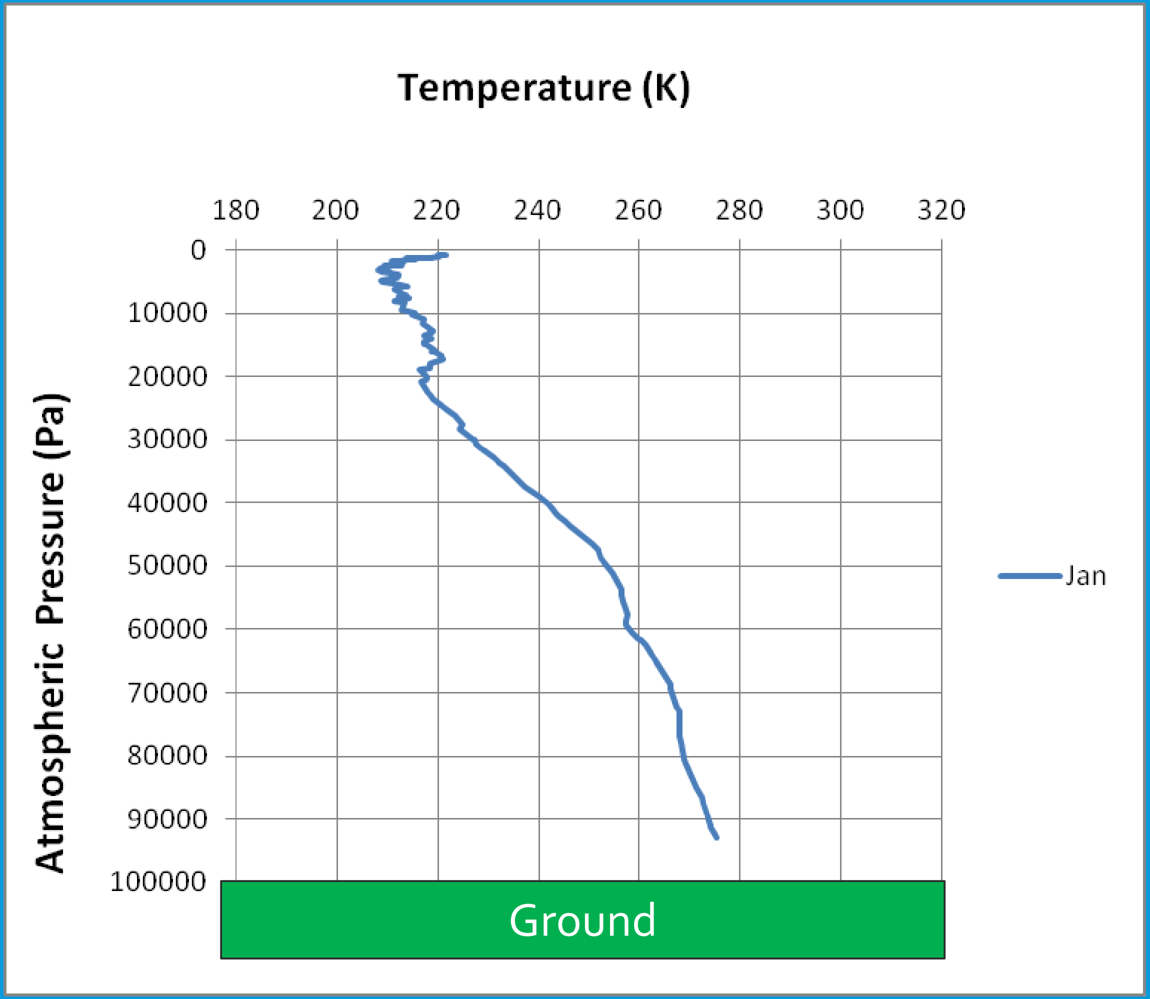

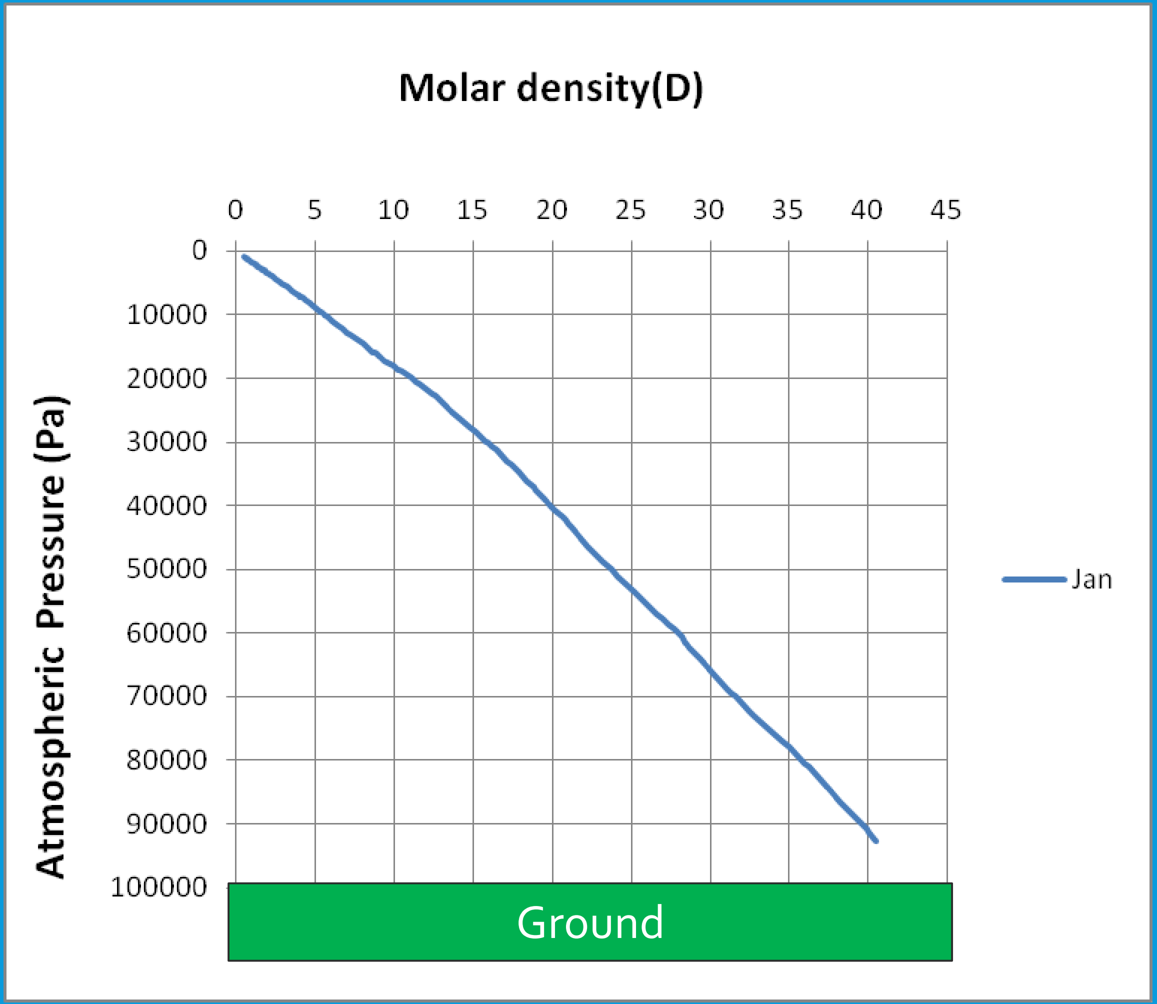

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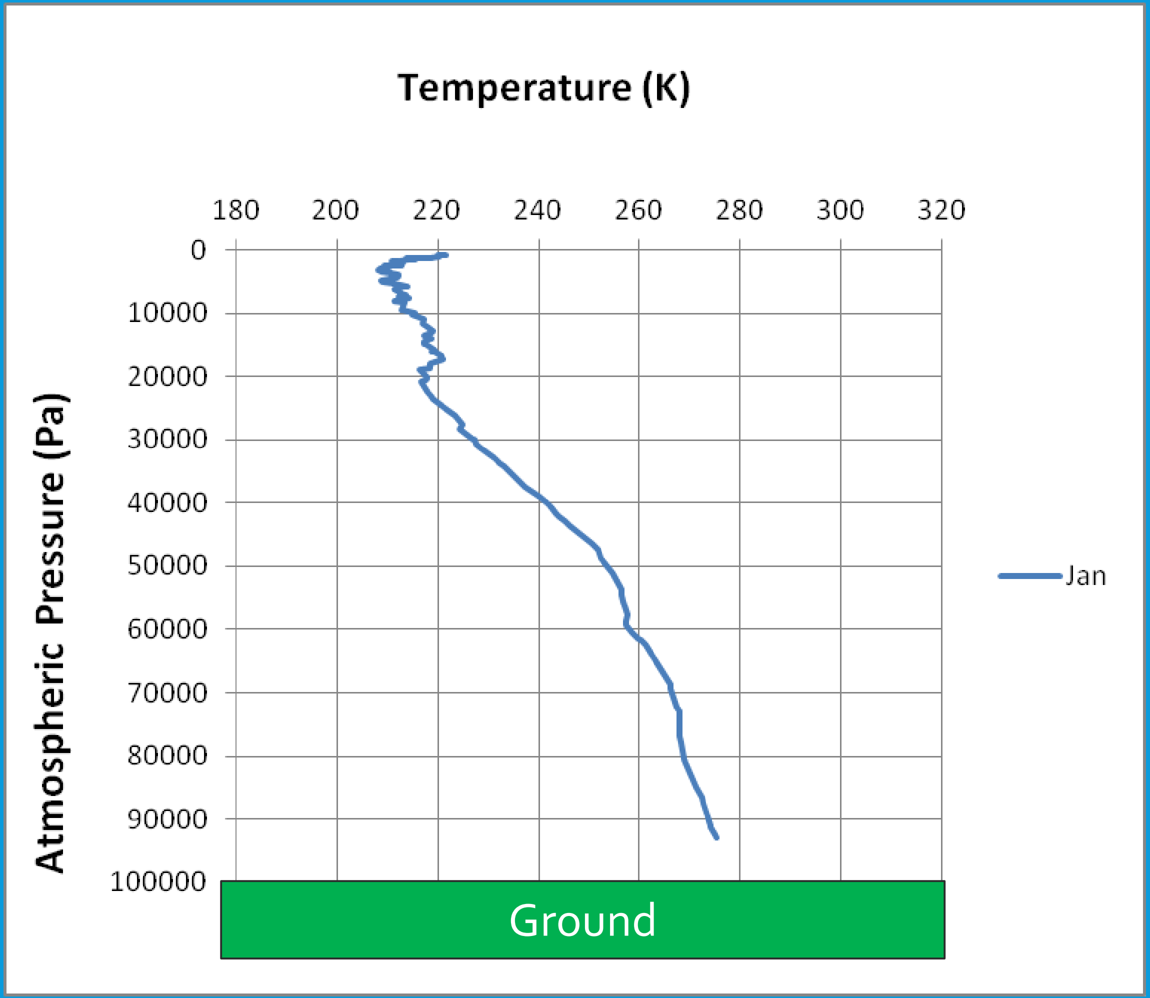
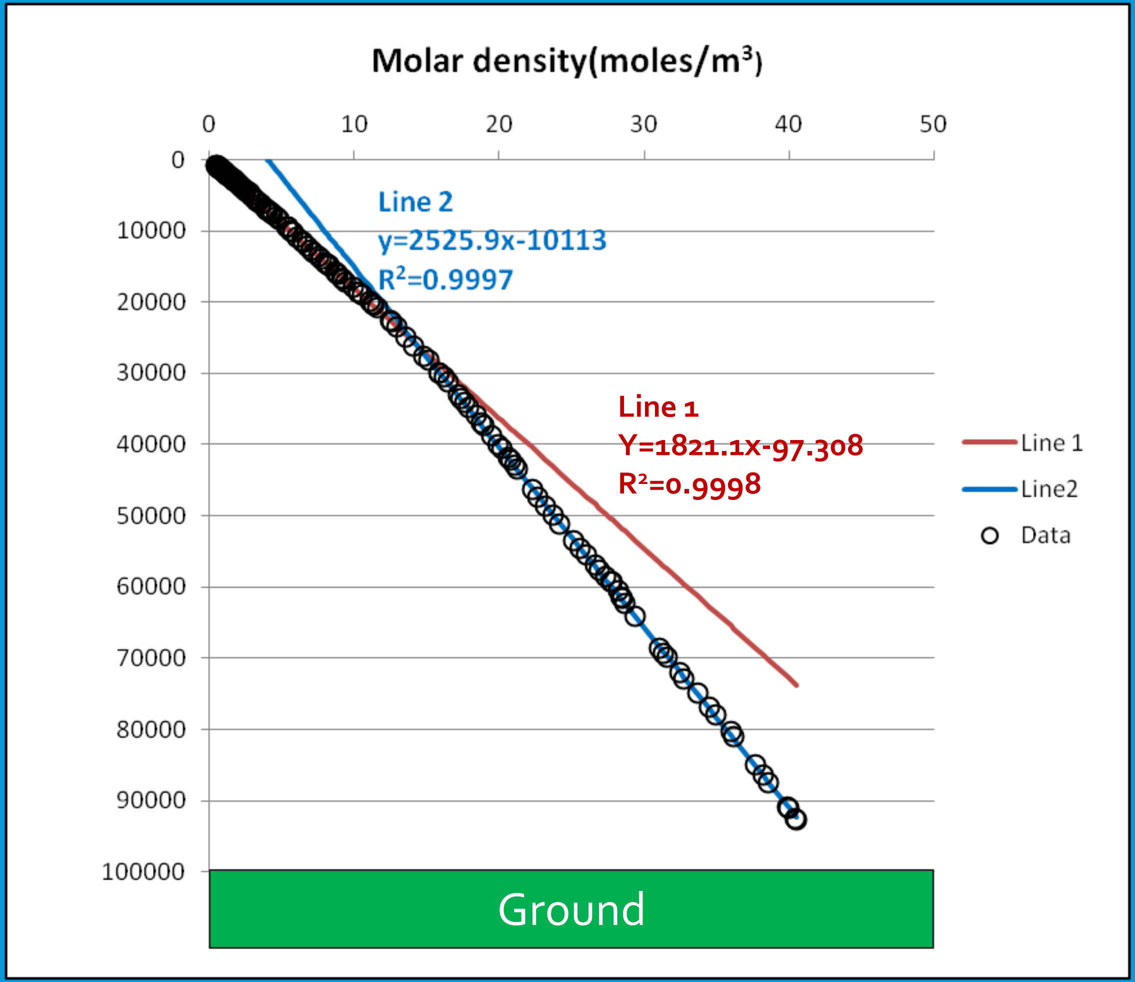
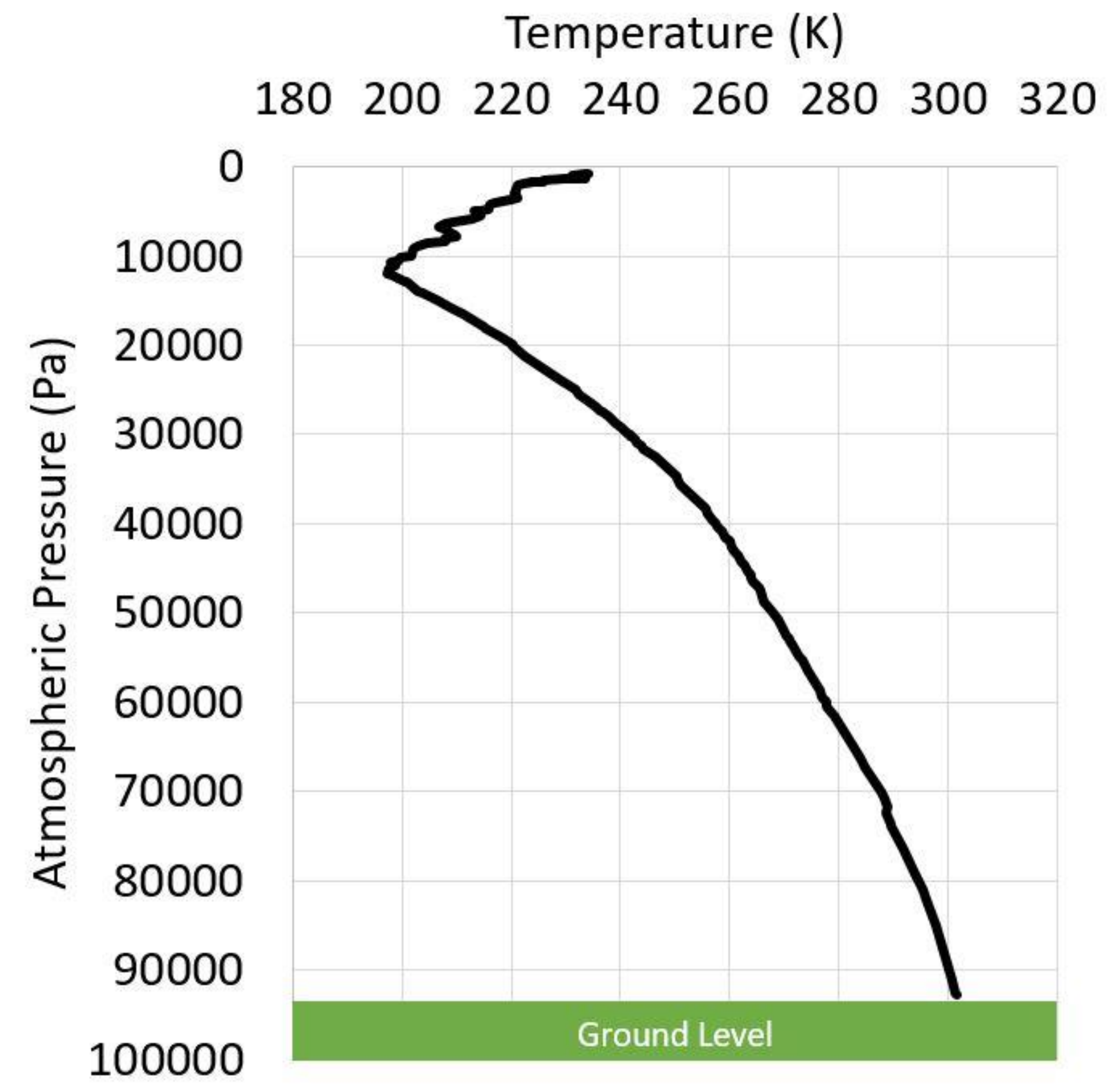
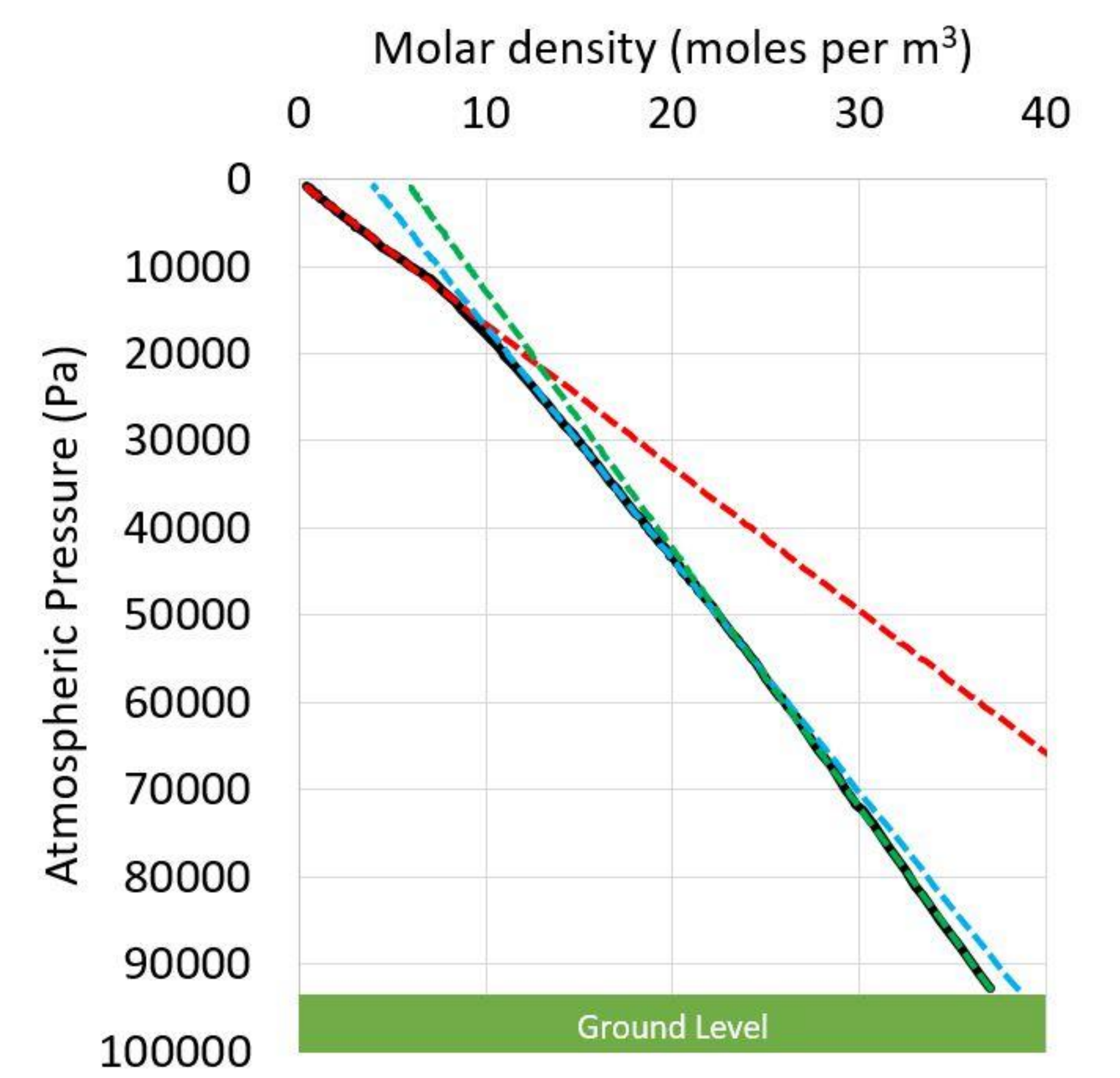




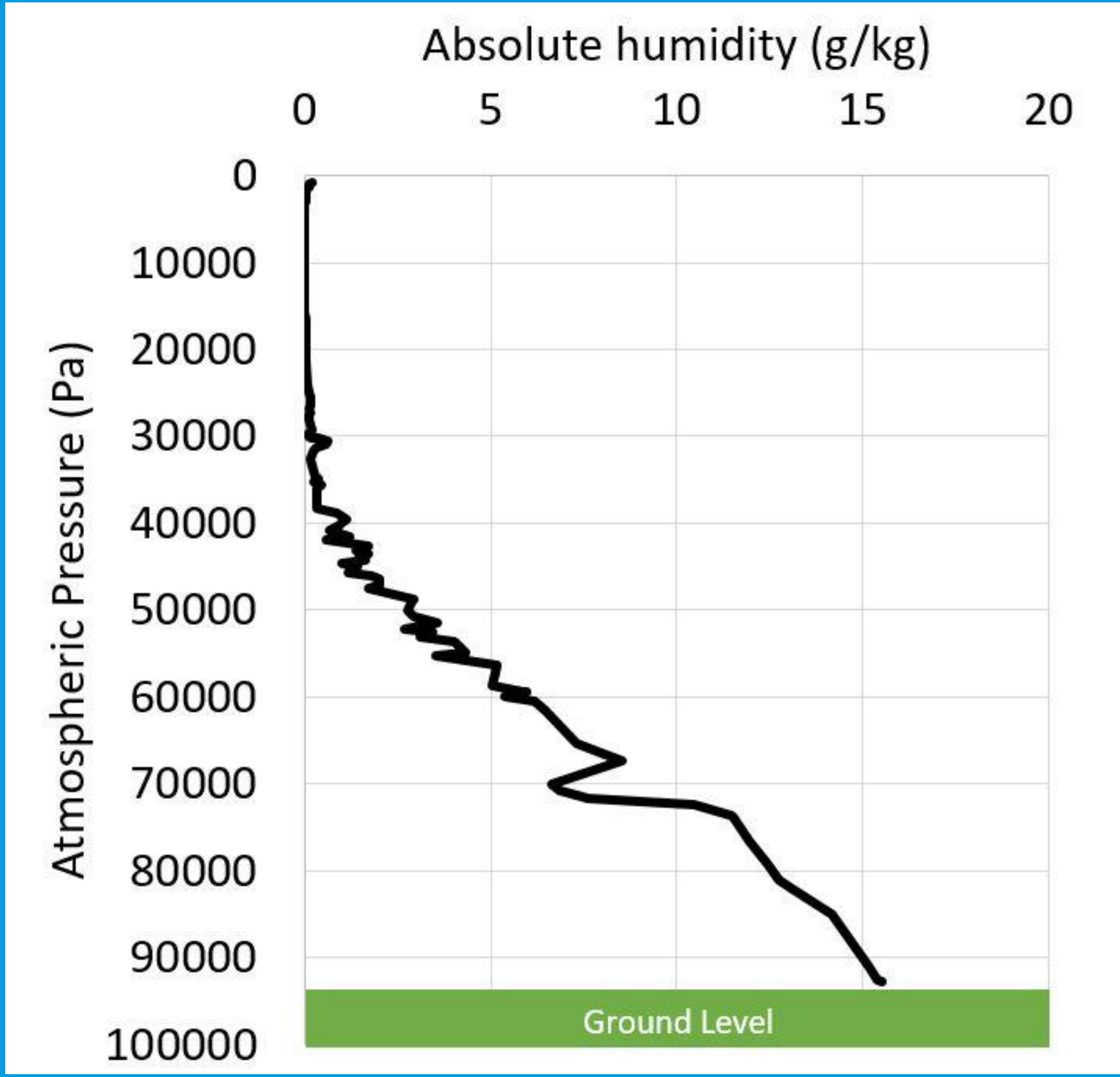
Tucson, AZ

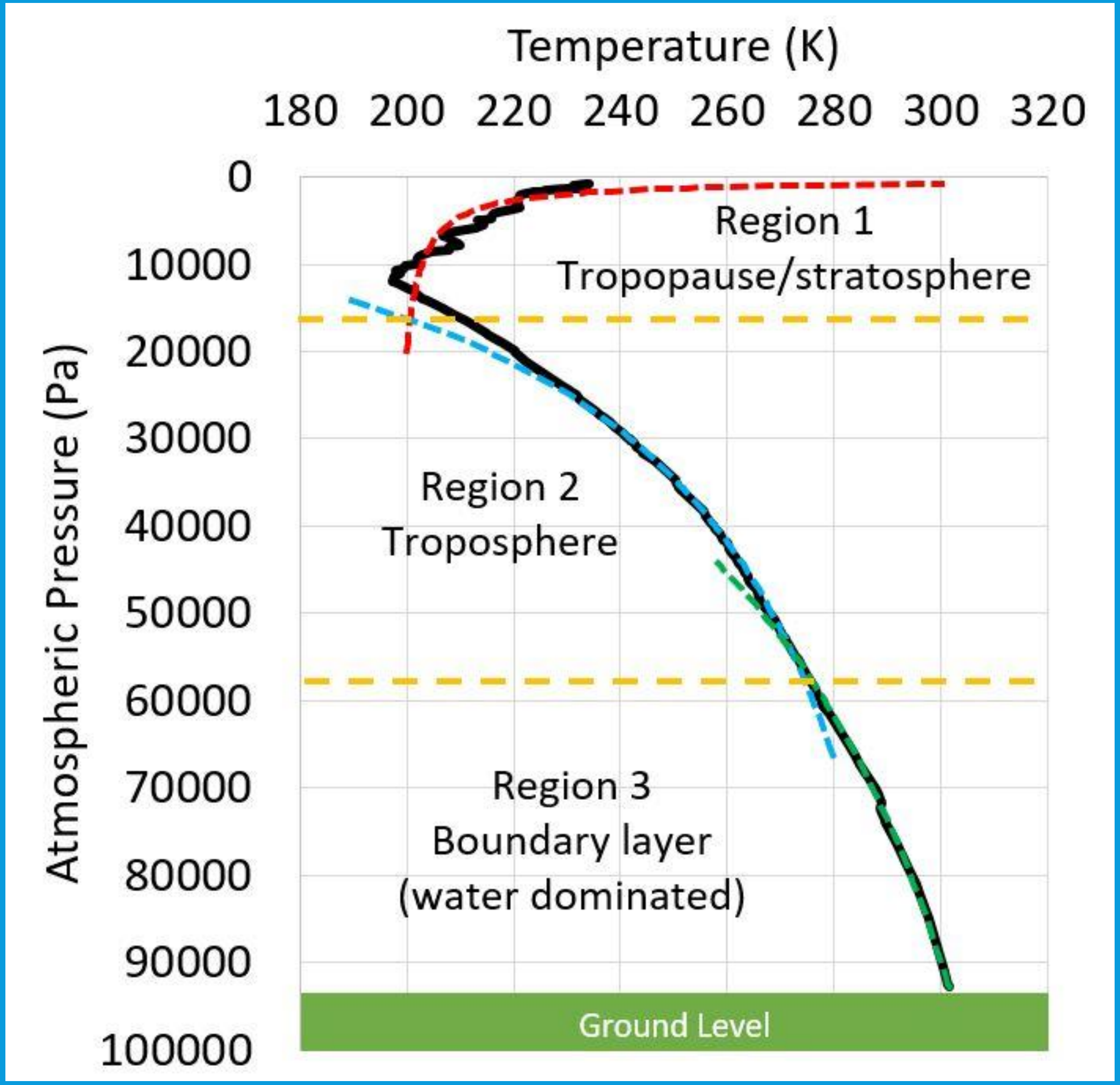
July 20th 2018; 7:40 pm local time





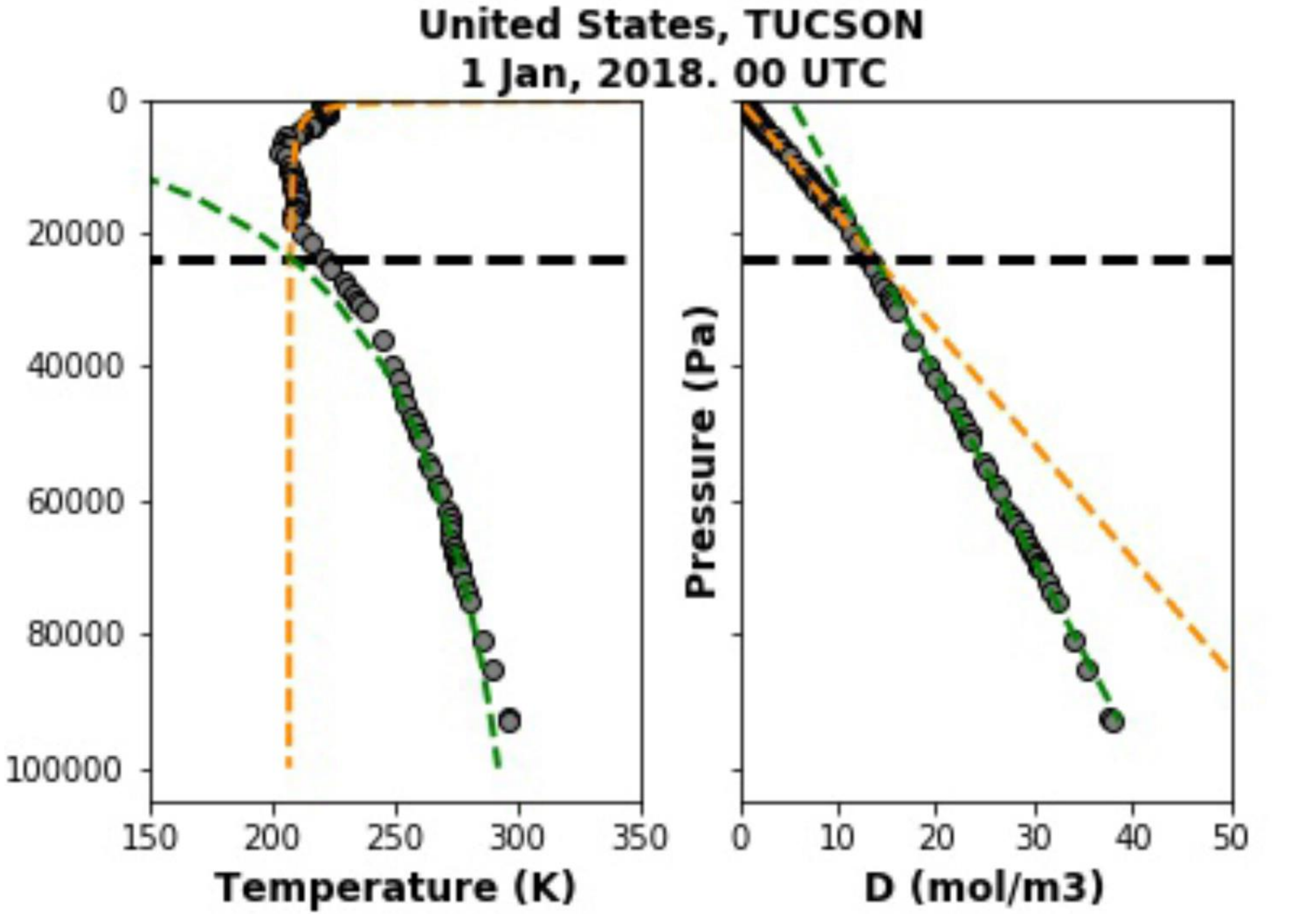
Tucson, AZ
July 20th 2018; 7:40 pm local time





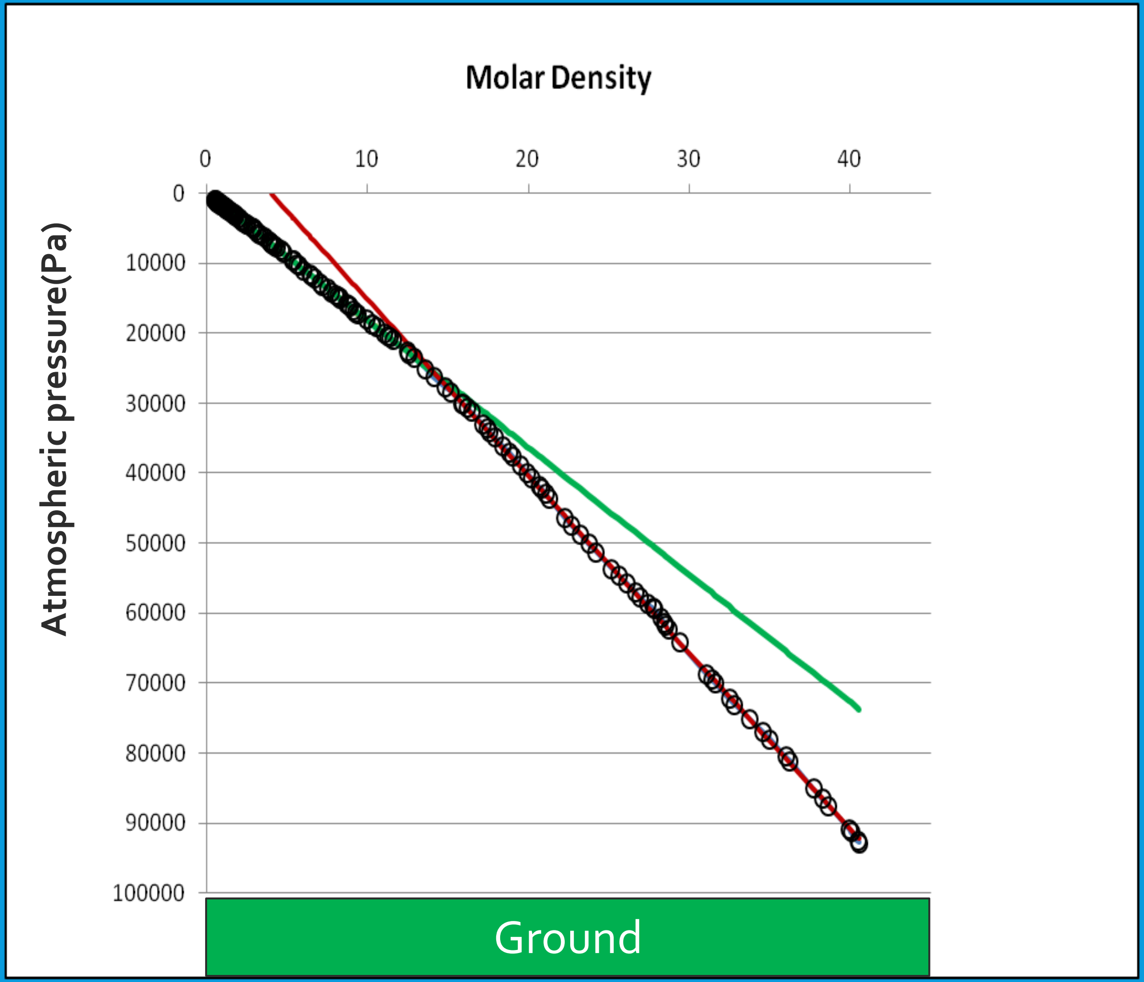
We find that for all 20 million weather balloons we get either 2 or 3 straight lines when we plot the molar density vs pressure.

The following video shows the molar density plots for all weather balloons launched from this Tucson station last year


United States, TUCSON
1 Jan, 2018. 00 UTC
Pressure (Pa)
Temperature (K)
D (mol/m3)
0
20000
40000
60000
80000
100000
150
200
250
300
350
0
10
20
30
40
50

Tucson , AZ 1st Jan 2019 7.40am

For our analysis it is easier if we rotate our plots so that Pressure is on the x-axis instead of the y-axis



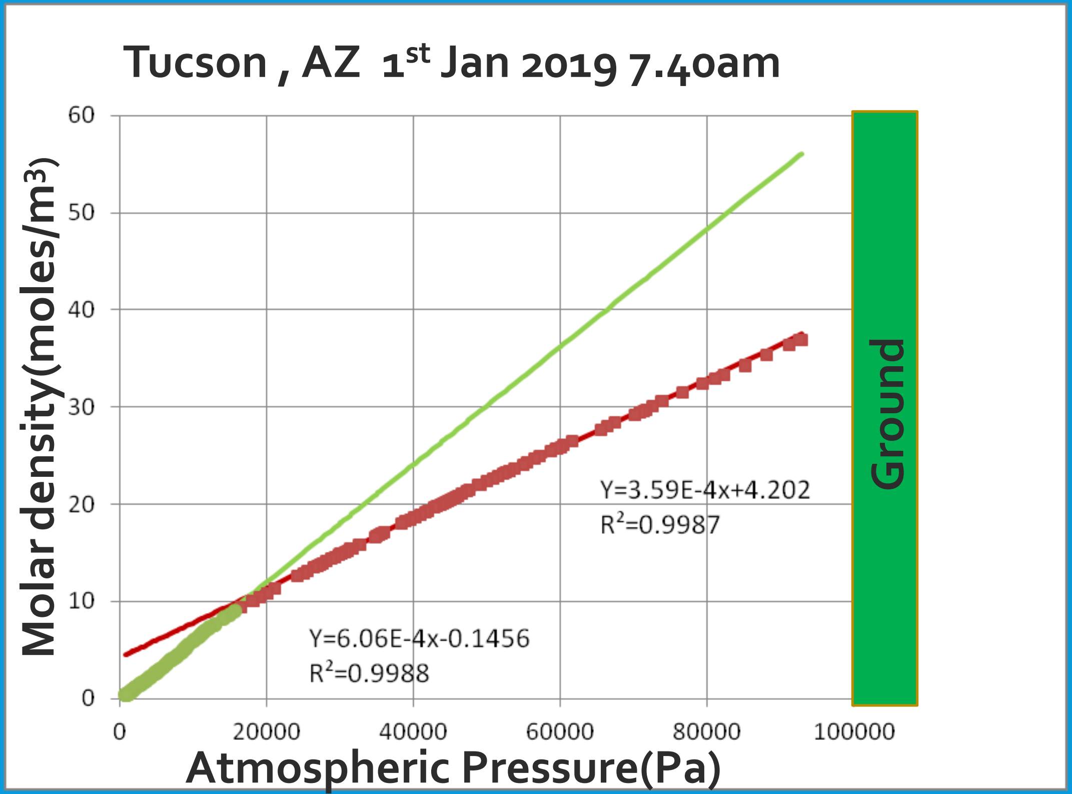
IMPLICATIONS OF THIS TWO-PHASE BEHAVIOUR

For a gas the plot of Molar Density versus Pressure is normally a single straight line, and the slope tells us the **compressibility** of the gas.

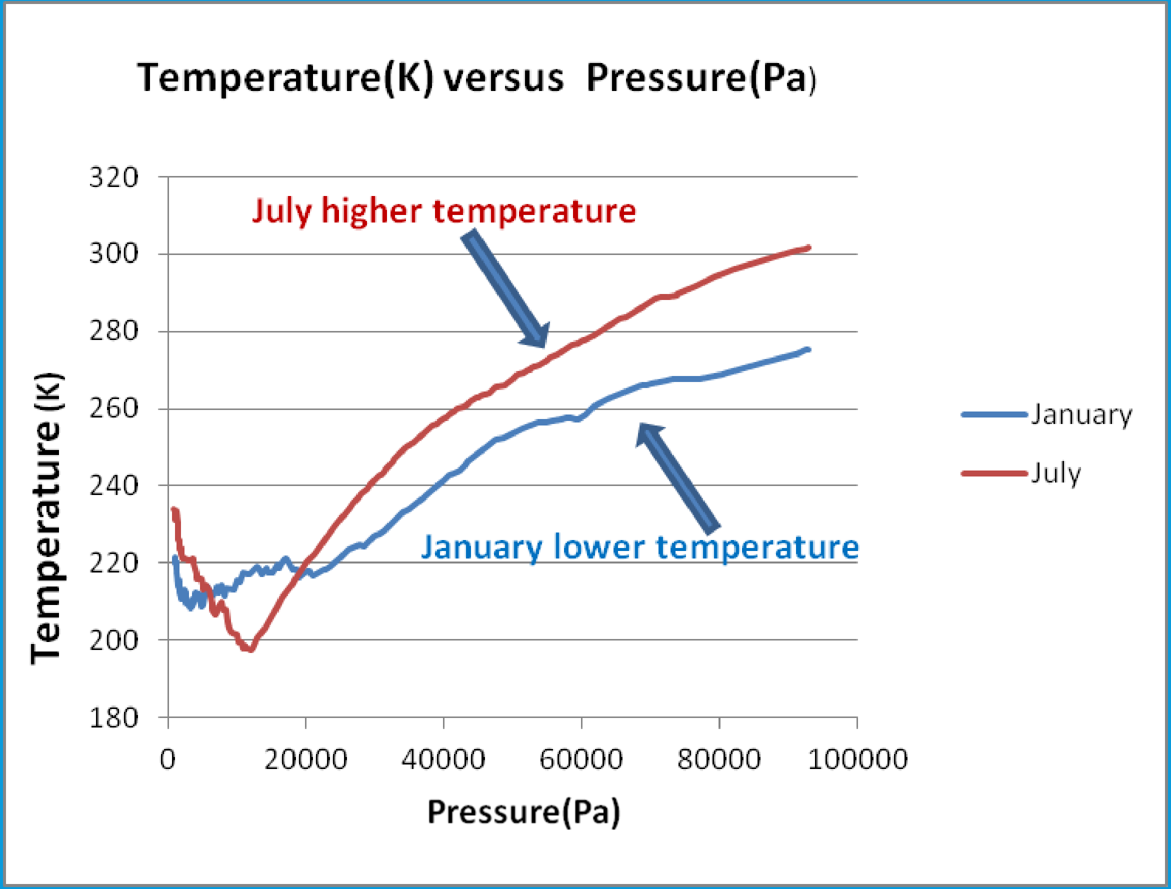
The bigger the slope the easier it is to compress the gas.

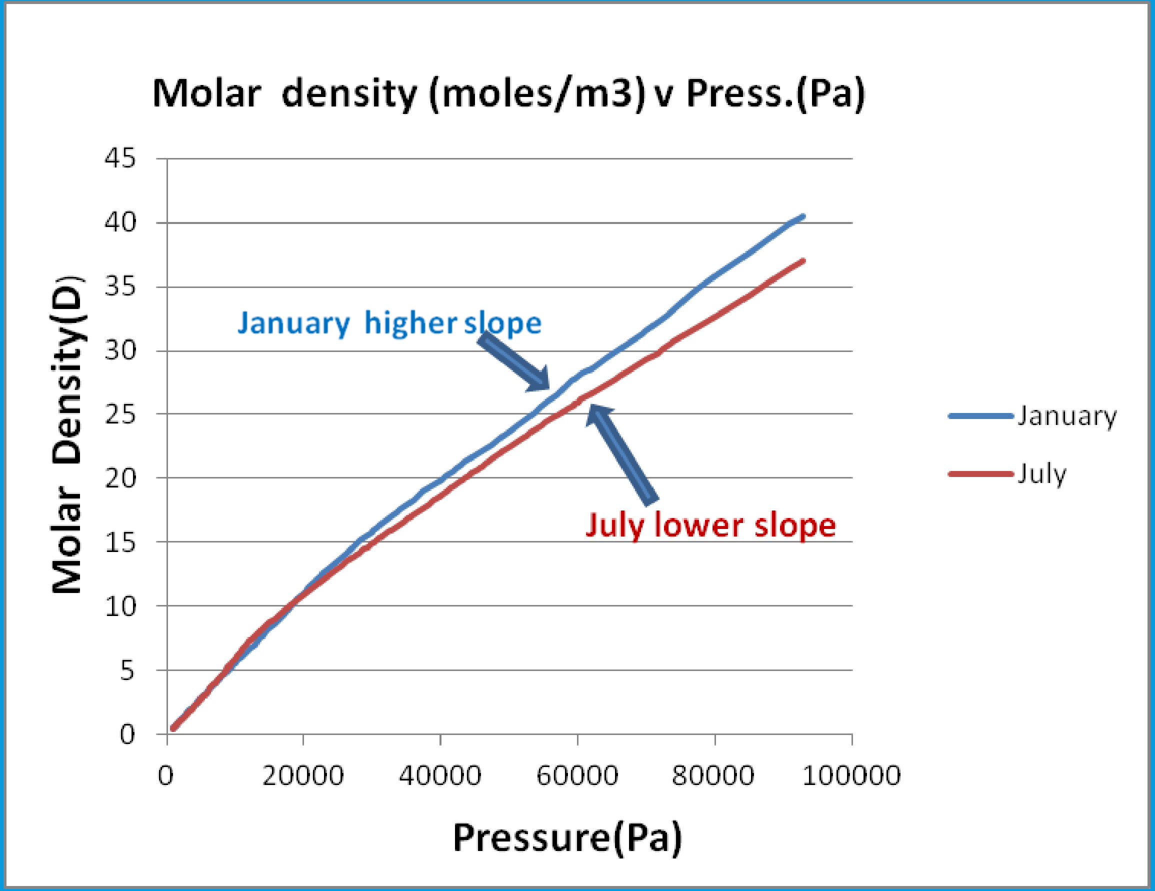
So why does the air in the Tropopause suddenly become easier to compress.

According to the ozone heating hypothesis it should be harder to compress



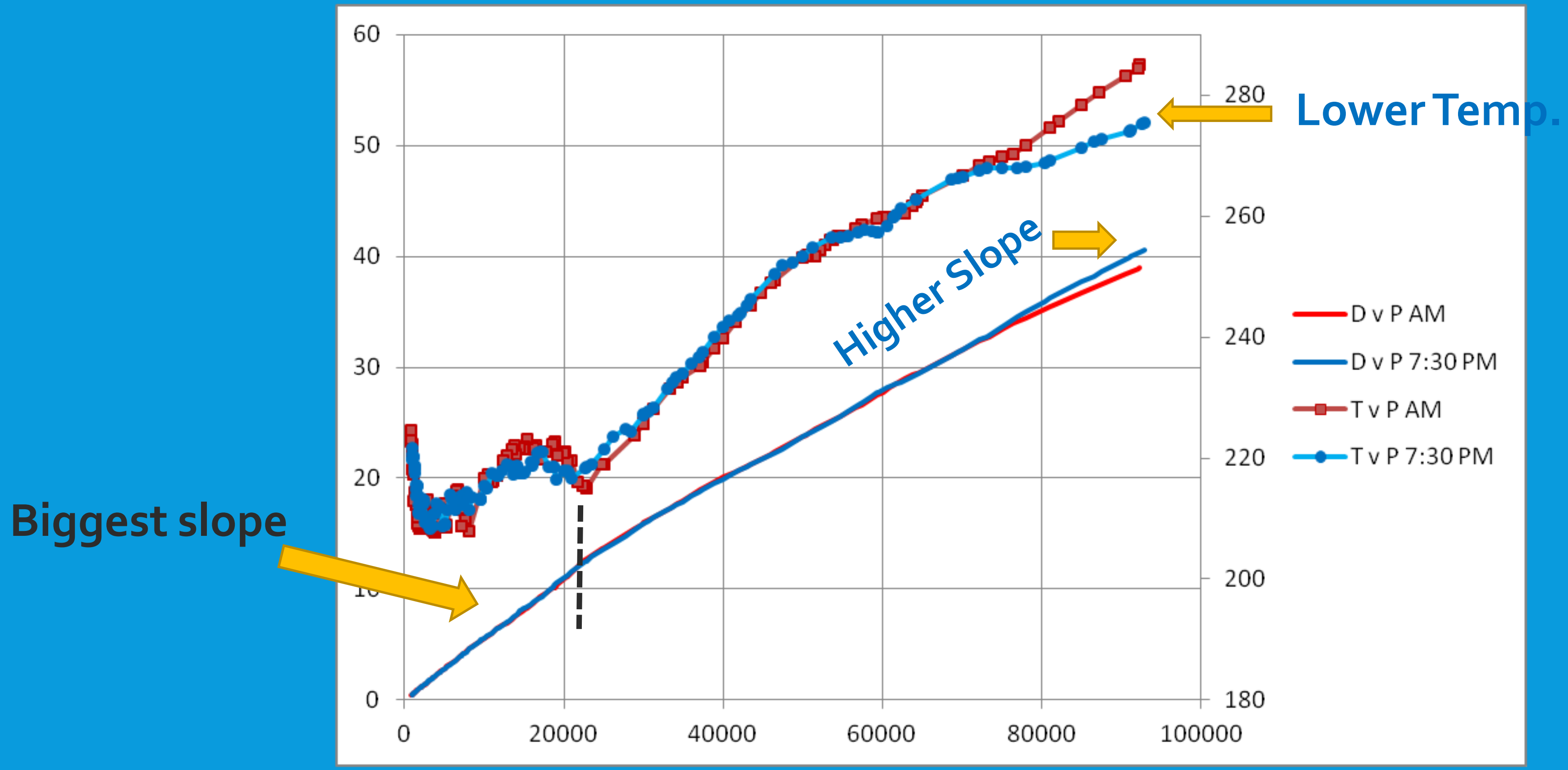
Comparing Winter and Summer, (July 20th & January 1st) Radiosonde Temperature and Molar Density plots, for Tucson, AZ.



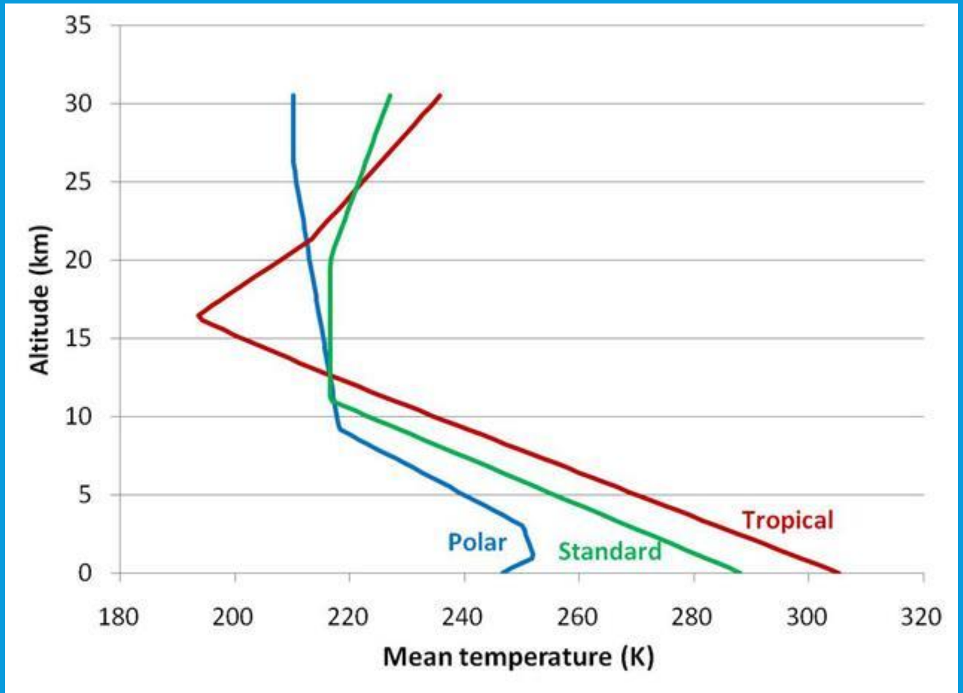


COMPARING DAY AND NIGHT

Tucson , AZ 1st Jan 2019 7.40 am & 7:40 pm

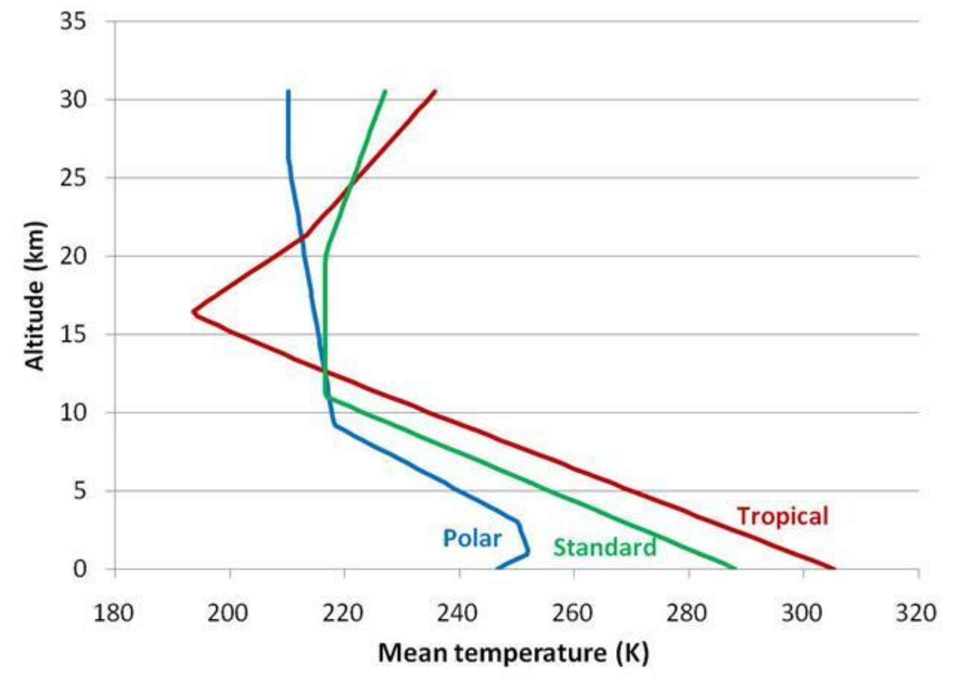


PROBLEMS WITH THE OZONE HEATING EXPLANATION



PROBLEMS WITH THE OZONE HEATING EXPLANATION

1. Why is there a tropopause in the polar winter?
2. Why is the polar winter Tropopause warmer than the tropical summer Tropopause?
3. In terms of molar densities, the Tropopause should be **<u>less</u>** compressible if it was due to ozone heating
4. The ozone layer occurs much higher than the phase change (i.e., at 40km instead of 10-15km)
5. Why does the "phase change" boundary change so quickly – within hours?
6. If the upper atmosphere is so "stratified" and poorly mixed, why are we able to fit the entire atmospheric temperature profiles so well with our 2-3 molar density vs. pressure linear fits?



CONCLUSION

The ozone heating hypothesis fails to explain most of the facts associated with the tropopause/stratosphere.

Therefore it must be scrapped !

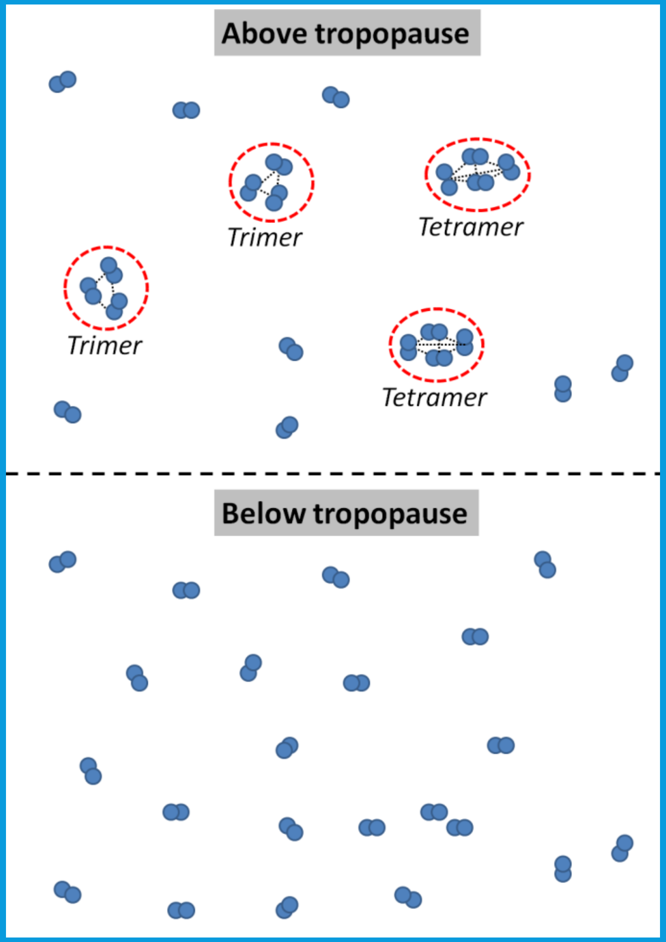
We need a new Hypothesis.

OUR HYPOTHESIS… SO FAR

- If the air above the troposphere is more compressible, then this suggests a significant change in molecular composition or structure is occurring
- But, ratio of nitrogen, oxygen, argon, etc. seems to be fairly constant (from chemical sampling)
- **Not** related to water as absolute humidity is very low

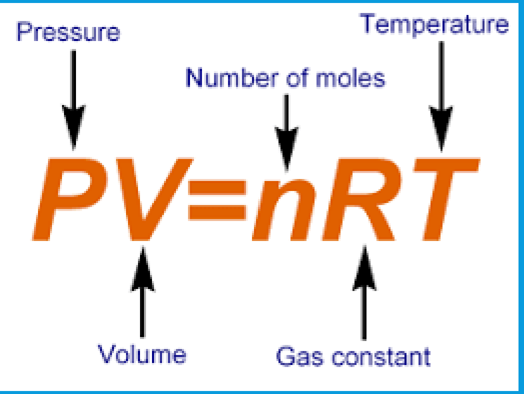
- We propose that oxygen molecules combine together to form large multi-molecular "*van der Waals*" complexes, or "*multimers*"

- See Paper 2 for a more detailed discussion



MOLAR DENSITY, D

(THE NUMBER OF MOLECULES MEASURED IN MOLES PER M^3)



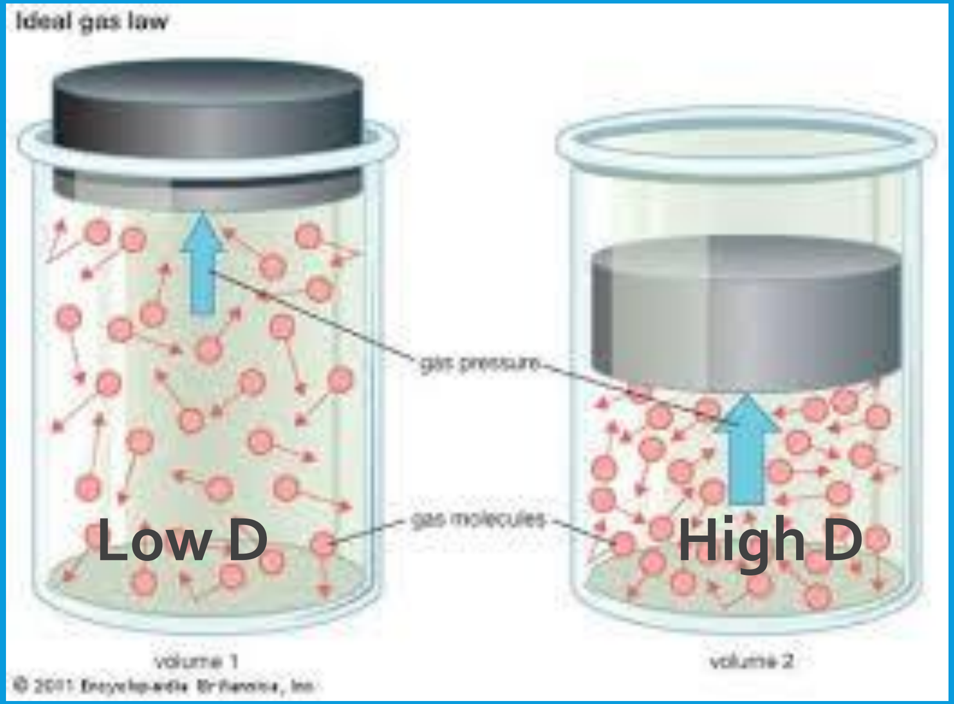
By Rearranging the equation of state we get

$$n/V = P/RT$$

Since the molar density (D) is given by

$$D = n/V$$

Then $$D = P/RT$$



Why do ice ages come to an end?

There are a number of Hypothesis to explain why ice ages end, but the one that weather balloon date allows us to test is the following one.

Hypothesis:
Increases in greenhouse gases traps heat in the atmosphere, which causes global warming and helps to end the ice ages

We can use the weather balloon data and the laws of thermodynamics to test this hypothesis

BACK TO THE IDEAL GAS LAW

(or the equation of state of an ideal gas)

$$PV = nRT$$

The ideal gas law is the thermodynamic equation of state for an ideal gas

What it really states is that in thermodynamic equilibrium the mechanical and thermal energy are balanced

$$PV = nRT$$

Mechanical or work energy

Thermal or heat energy

CALCULATED TEMPERATURE PROFILES

We saw that if we know P & T we can calculate D

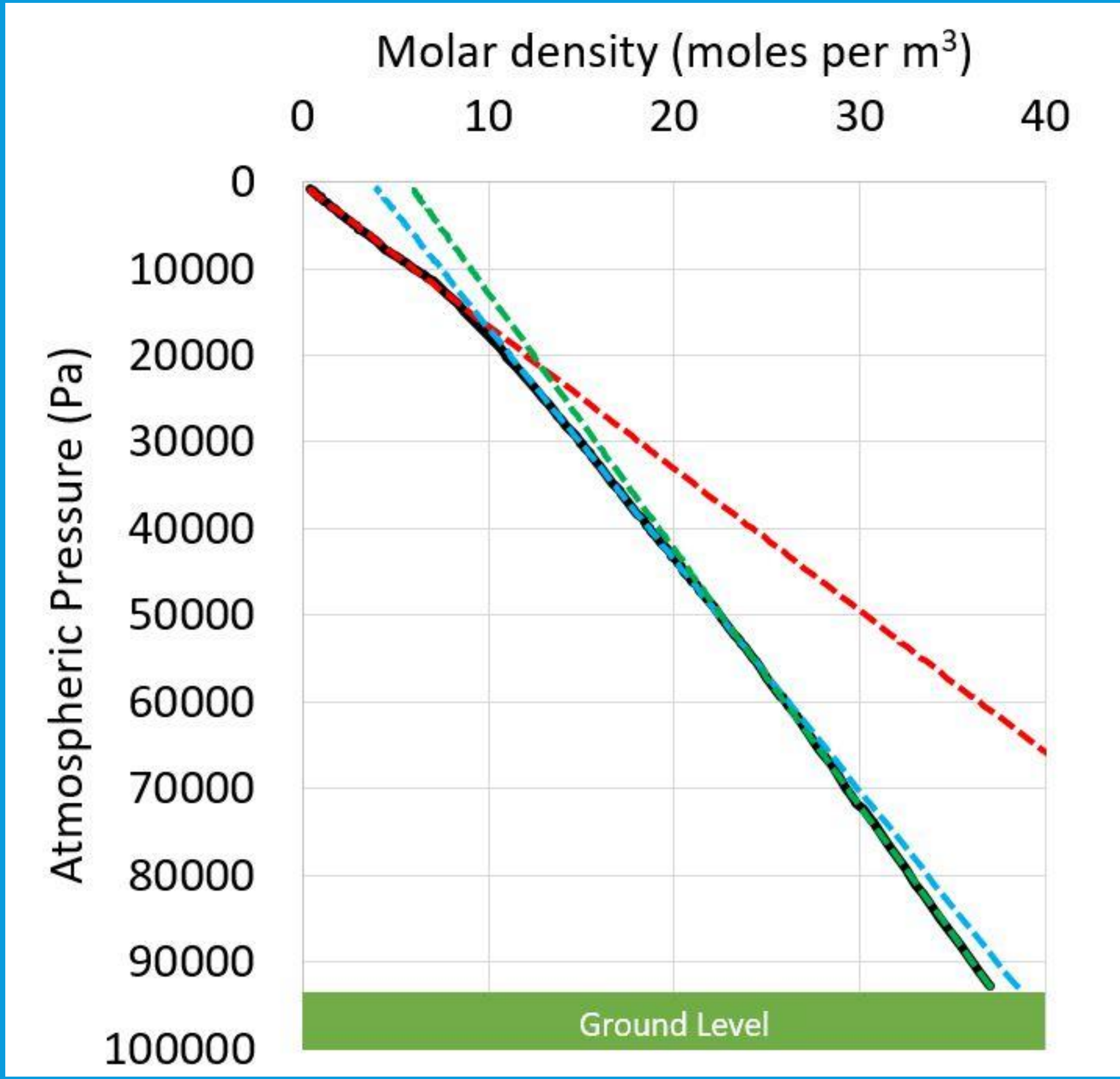
$$D = P/RT,$$

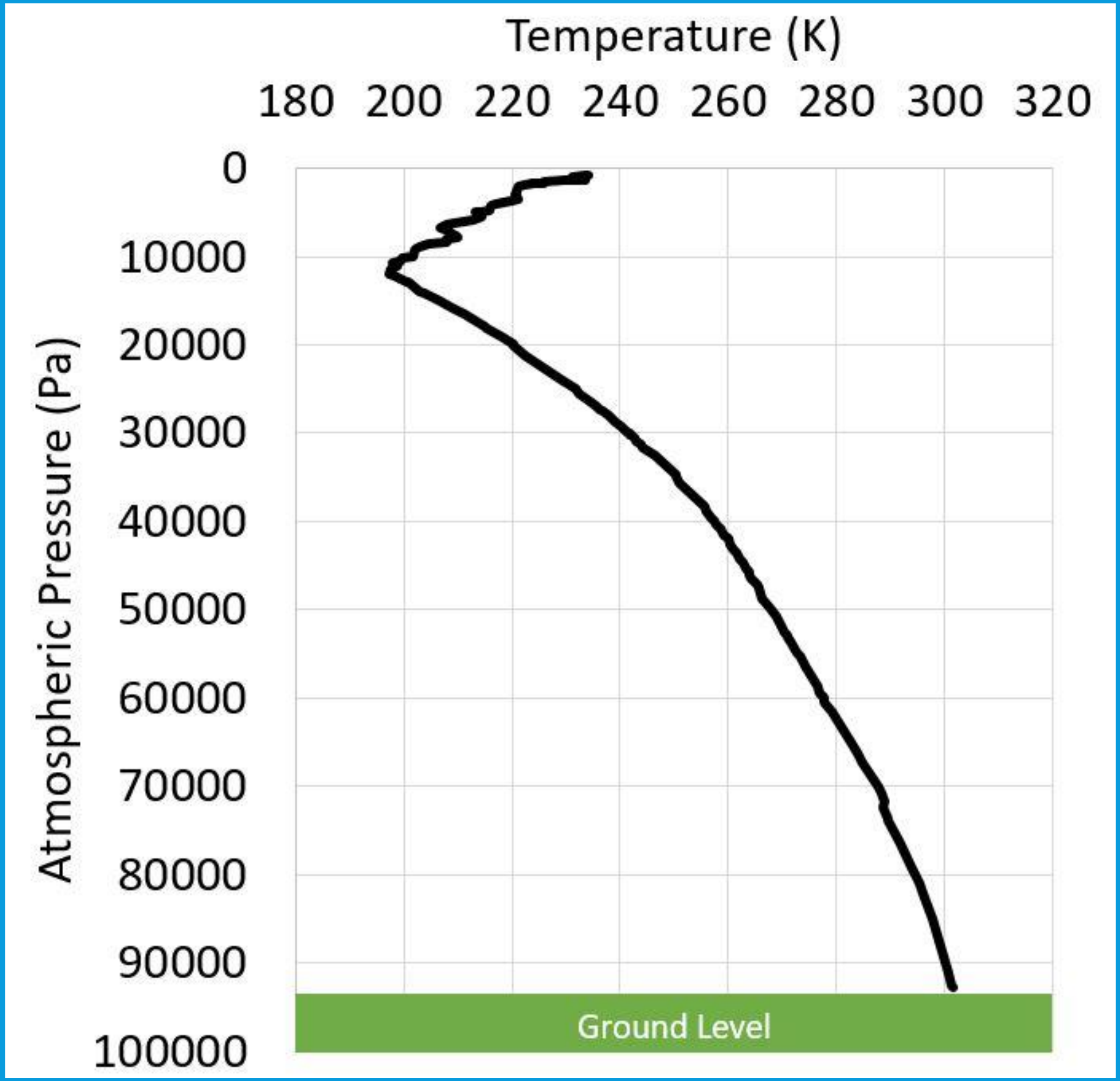
Equally if we know D and P we can calculate T

$$T = P/RD$$

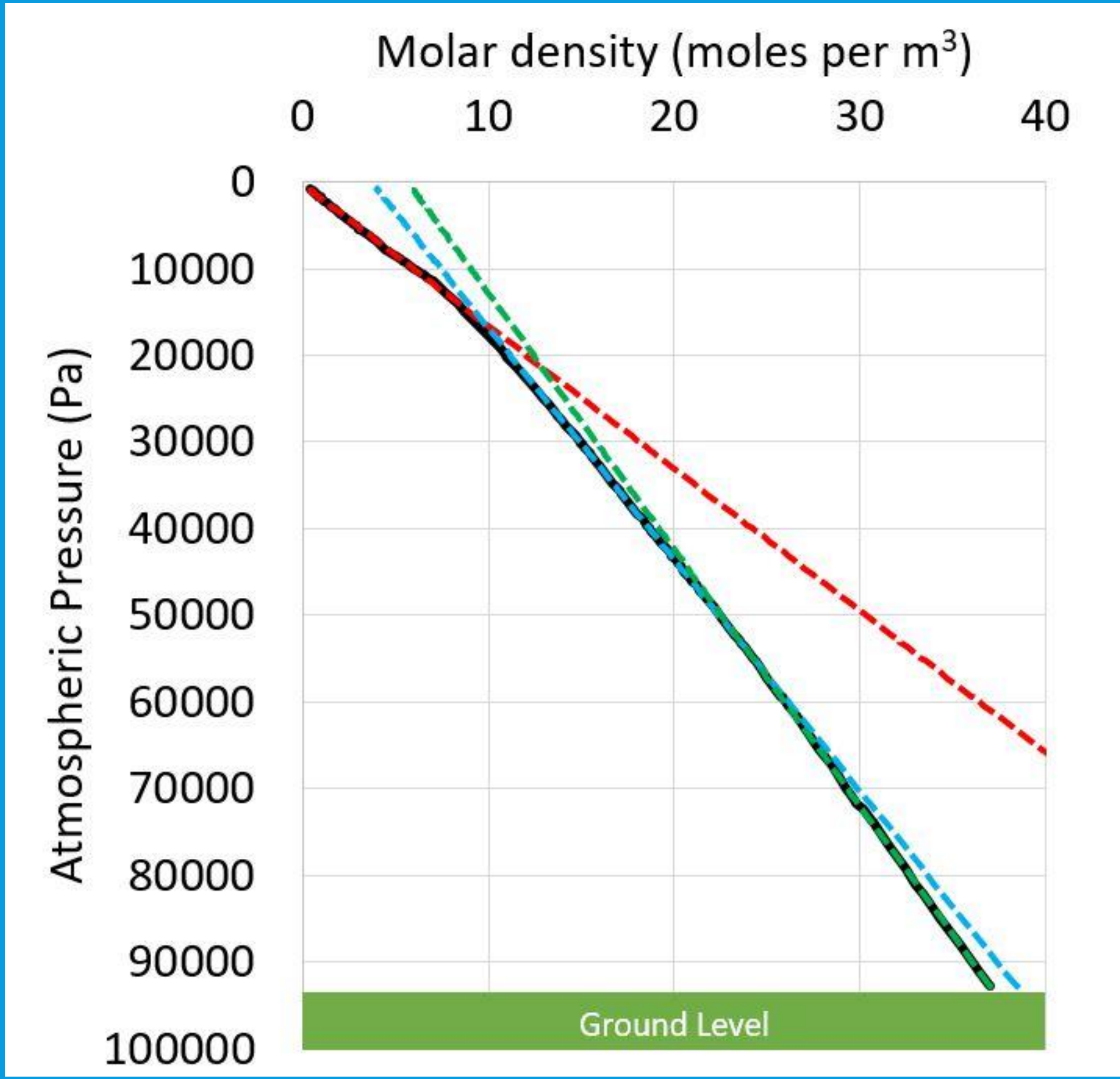
Therefore, we can calculate the temperature profiles using the equations for the straight line we got from the Molar Density plots.

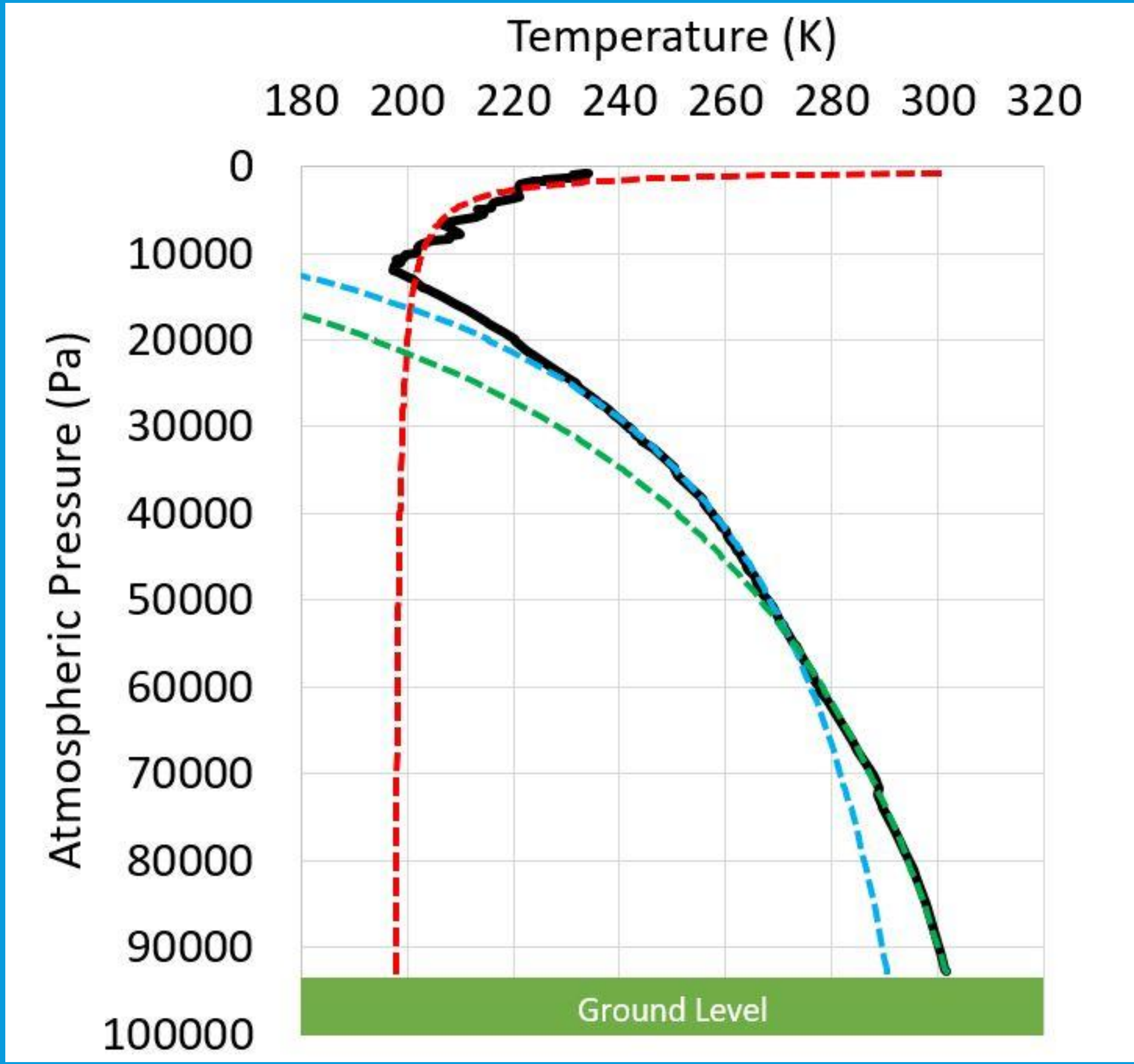
Tucson, AZ (July 20th 2018; 7:40 pm local time)



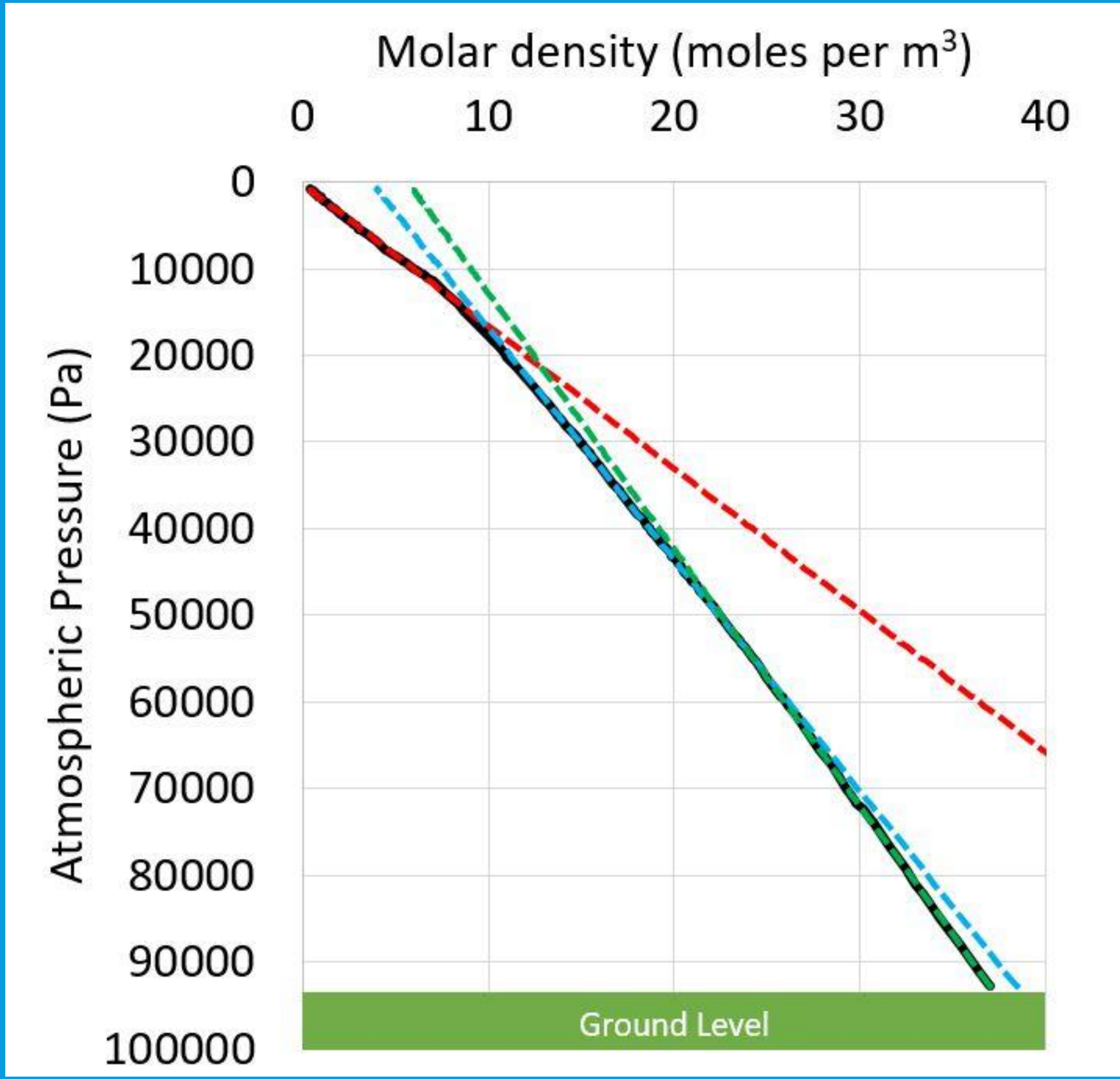


Tucson, AZ (July 20th 2018; 7:40 pm local time)

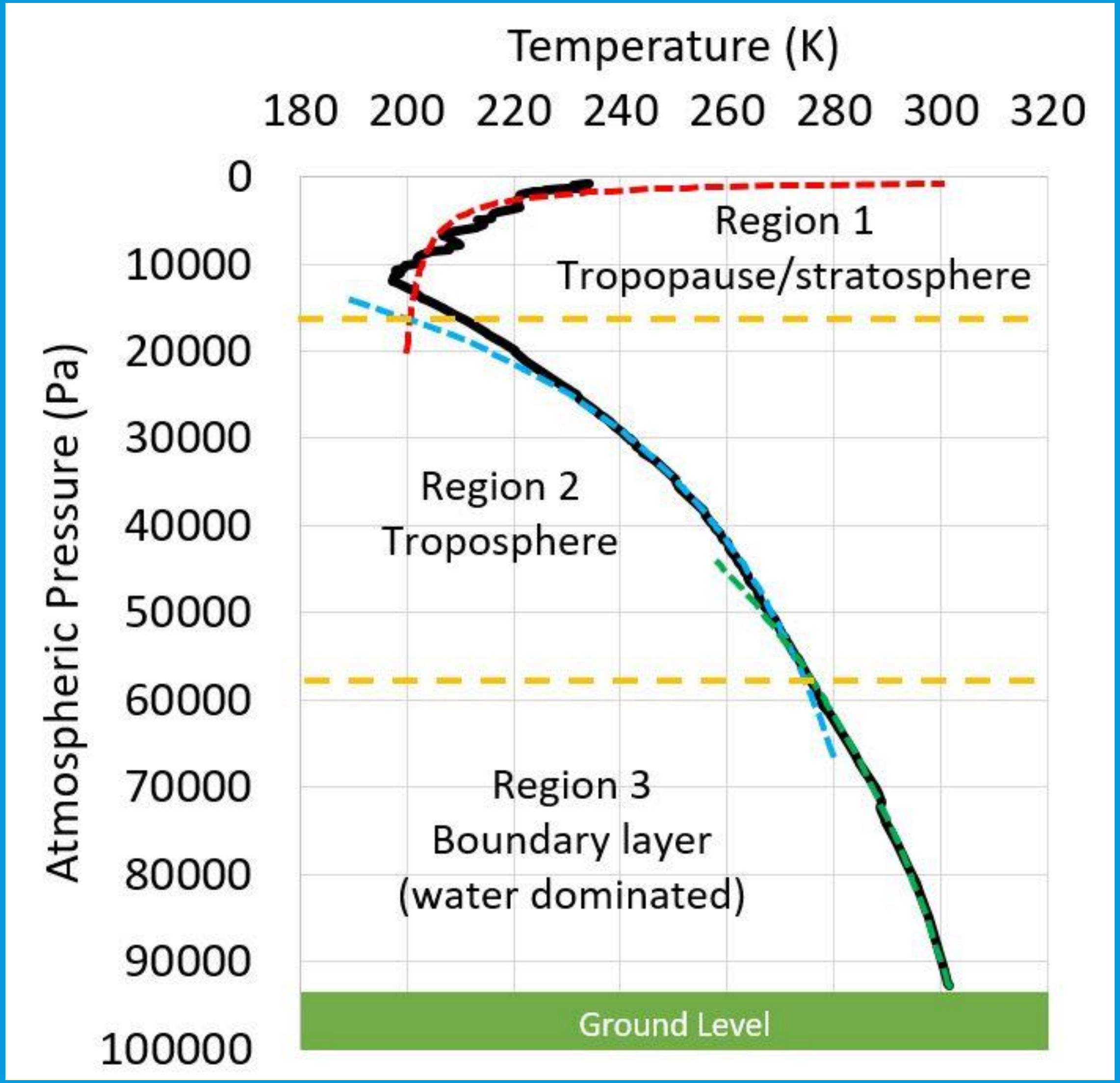




Tucson, AZ (July 20th 2018; 7:40 pm local time)

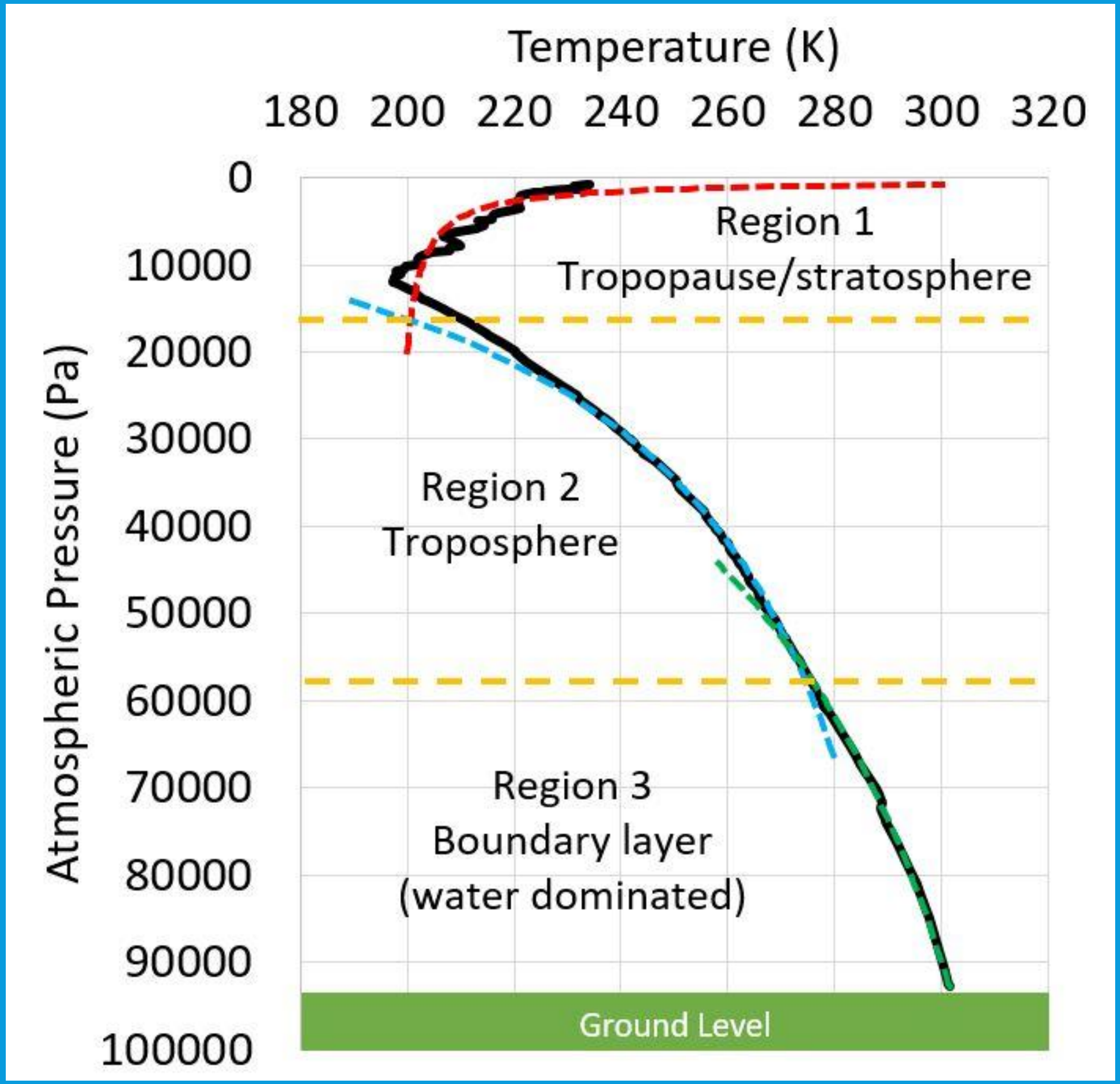


Three equations of state model



Tucson, AZ (July 20th 2018; 7:40 pm local time)

Three equations of state model

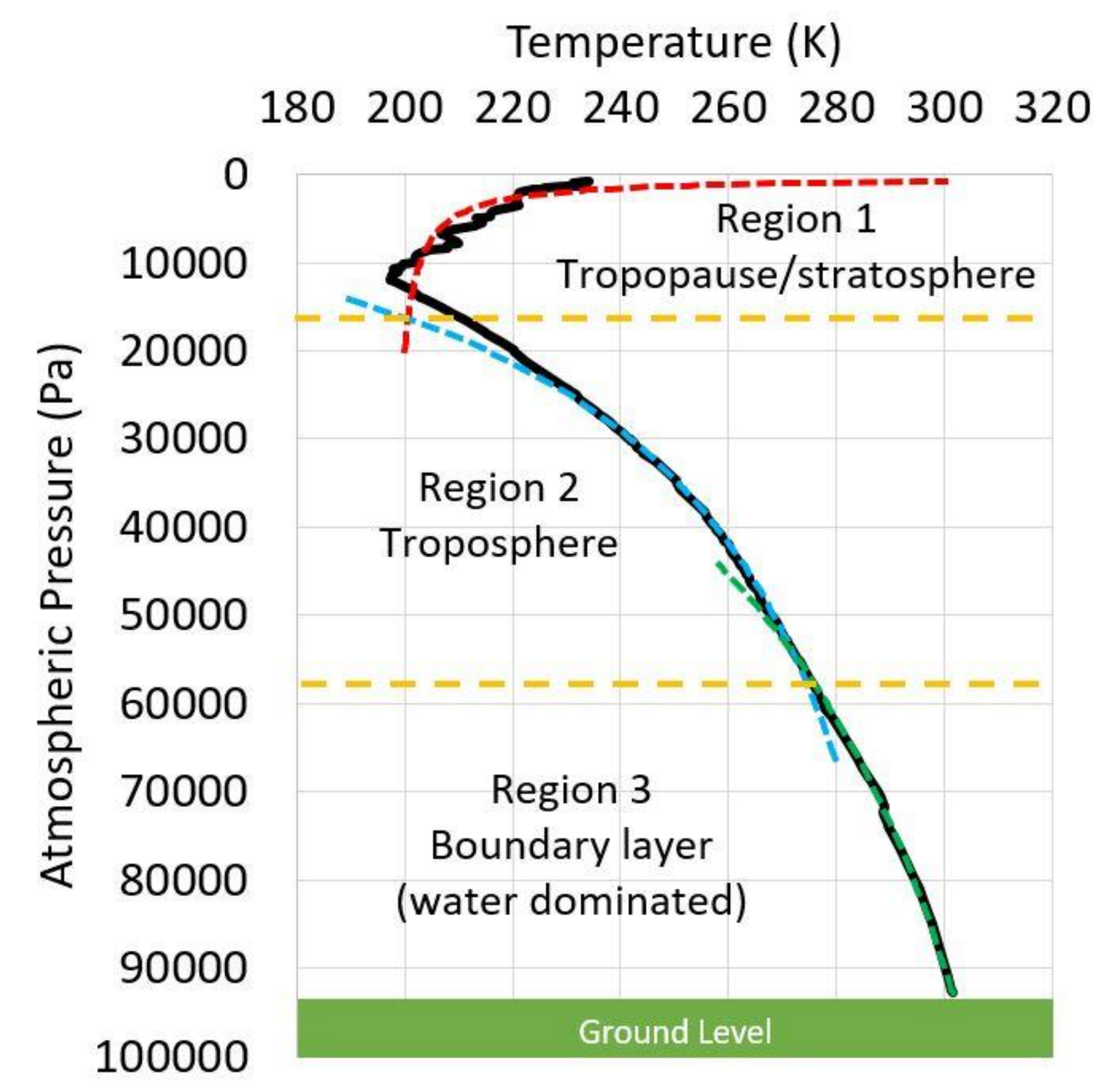


<u>**Summary so far**</u>

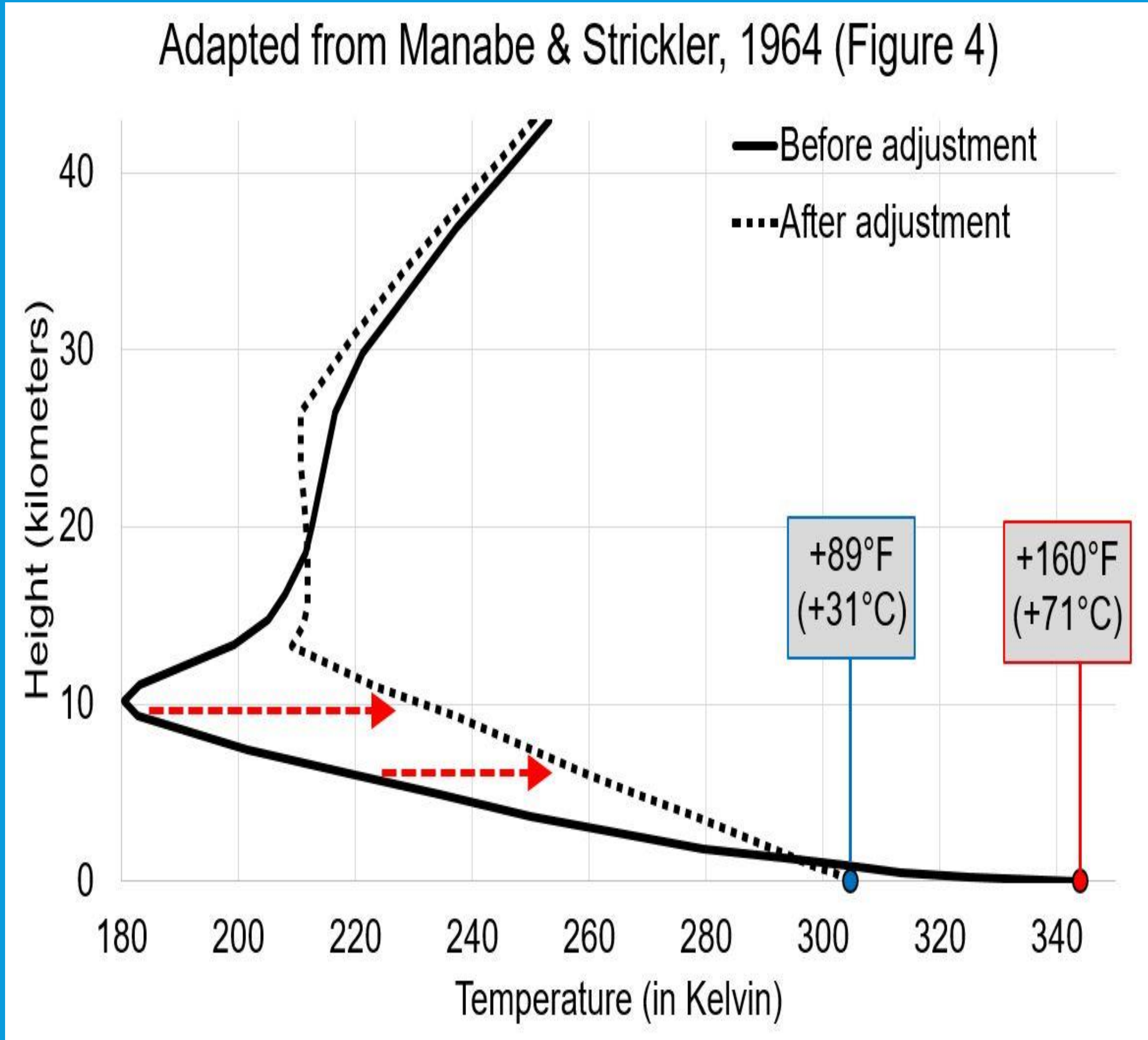
- By plotting molar density against pressure, we identify three different regions with straight lines i.e. Each region has its own equation of state
- When we convert the slopes of these lines back into calculated T, we can explain the entire temperature profile very well
- Region 3 has water but the upper troposphere, tropopause and stratosphere are **dry** regions

Tucson, AZ (July 20th 2018; 7:40 pm local time)

Three equations of state model



Radiative Convective Model



THERMODYNAMICS

Thermodynamics describes the relationship between **thermal** energy and mechanical ("**dynamic**") energy

19th century: Steam engines could transform thermal energy into mechanical energy

Thermodynamics developed mainly from trying to understand and improve the efficiency of steam engines

THERMODYNAMICS

The first law of thermodynamics states that energy cannot be created or destroyed

However it can be changed from one form to another and can be transmitted from one location to another

The first law does not say any thing about how fast any of these processes can happen

ENERGY TRANSMISSION IN AIR: THERMAL VS. MECHANICAL

Thermal energy transmission

1. Thermal conduction (*energy is transmitted "through mass", very low for air*)
2. Thermal convection *(energy is transported by "mass flow")*:
   i. Sensible heat (we can "sense" the temperature changes when hot air blows)
   ii. Latent heat (e.g., water changes from liquid to gas)
3. Radiation (*energy is transmitted by the emission and absorption of light*)

Mechanical energy transmission

1. Kinetic convection, e.g., "wind" *(energy is transported by "mass flow")*
2. Acoustic energy transmission (*very little*)

"Frictional loss" = conversion of mechanical energy into thermal energy

IS THERE ANYTHING MISSING?

- We saw that something funny is happening in terms of compressibility
- Until now, climate models have focused on <u>**thermal**</u> energy transmissions – particularly radiation
- <u>**Some**</u> mechanical energy transmission is implicit in the primitive equations
- But, is there anything missing?

- Yes… watch this experiment…

SUMMARY OF “PERVECTION” EXPERIMENT

Maximum rates of energy transmission by the known mechanisms:

- Conduction = 0.00015 Watts/m^2
- Kinetic convection = 0.0000075 Watts/m^2
- Enthalpic convection = 0.14 Watts/m^2
- Radiation = 0.29 Watts/m^2
- Acoustic transmission = 1.37 Watts/m^2

Observed rate of energy transmission = 2400± 80 Watts/m^2

In **this** particular controlled experiment, the energy was **not** transmitted by conduction, convection, radiation or acoustic. Therefore, there is some other key energy transmission mechanism available for air

"THROUGH MASS" MECHANICAL ENERGY TRANSMISSION (OR "PERVECTION")

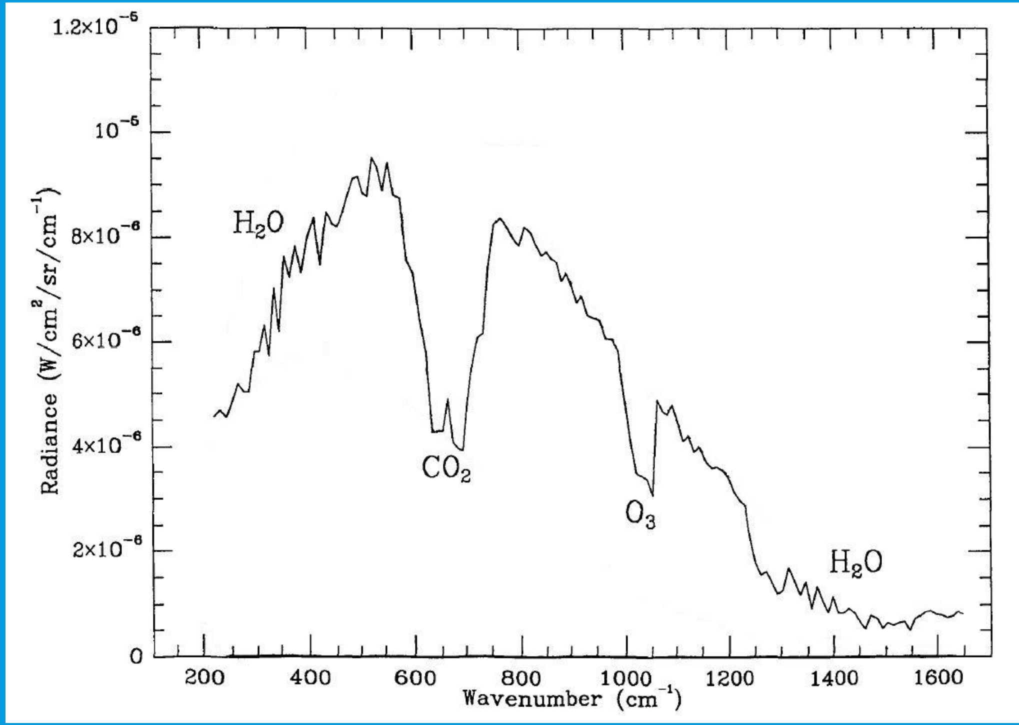
- In a "Newton's Cradle", the mechanical energy is transmitted from one side to the other
- But, the balls haven't moved. The energy is transmitted "through" the mass ("per-")
- The same happens with conduction, except conduction involves transmission of thermal energy
- With convection, the energy is transported **with the** mass
- This is different. It is "through-mass" mechanical energy transmission

- "*con-*" = with; "*-vection*" = carried; "*per-*" = through

YES, CO_2 IS AN INFRARED-ACTIVE GAS

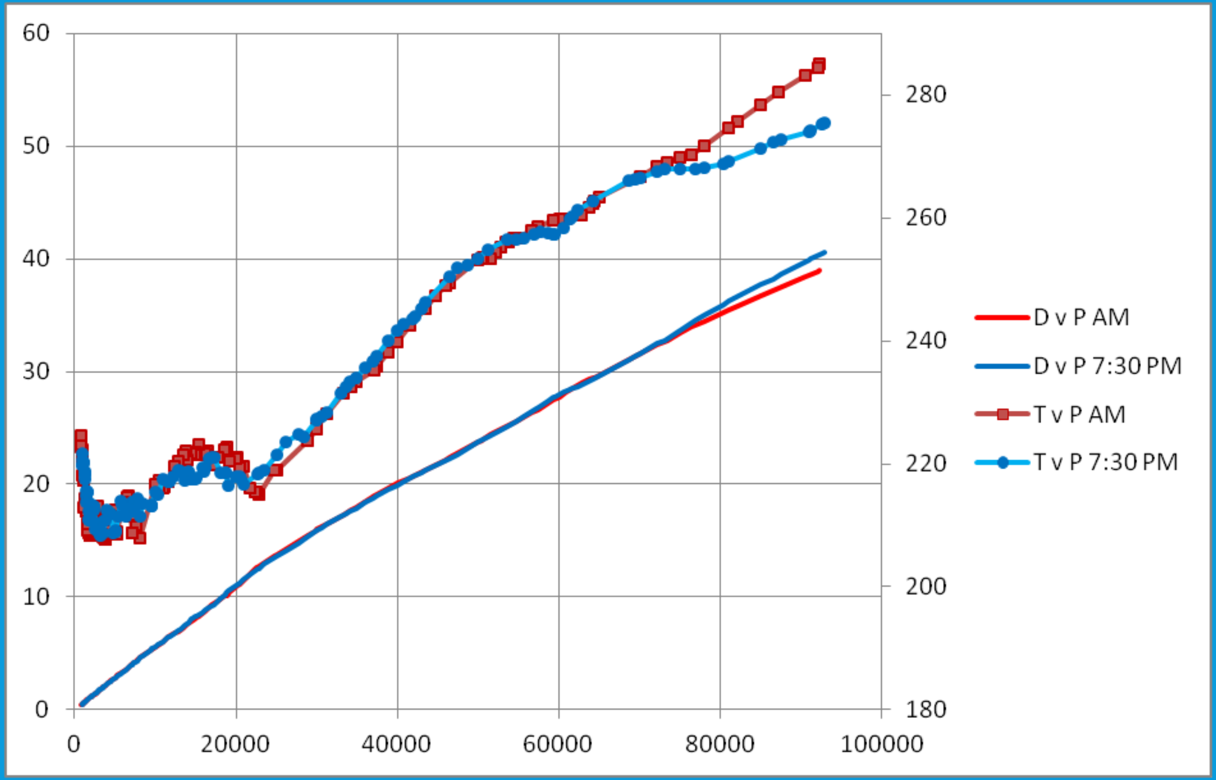
- H_2O, CO_2, and other "greenhouse gases" are indeed infrared-active (Tyndall, 1861)
- This means they absorb **and** emit at fixed wavelengths/frequencies (Einstein, 1916)
- CO_2 can absorb and emit at 666 cm^{-1} and we see these CO_2 peaks in the atmosphere
- Does this alter the atmospheric temperature profile?
    - According to the Global Climate Models, **yes!**
    - According to the weather balloon data, **no!**

Spectra of Earth's atmosphere as recorded by the Mars probe after leaving Earth (1997)



COMPARING DAY AND NIGHT

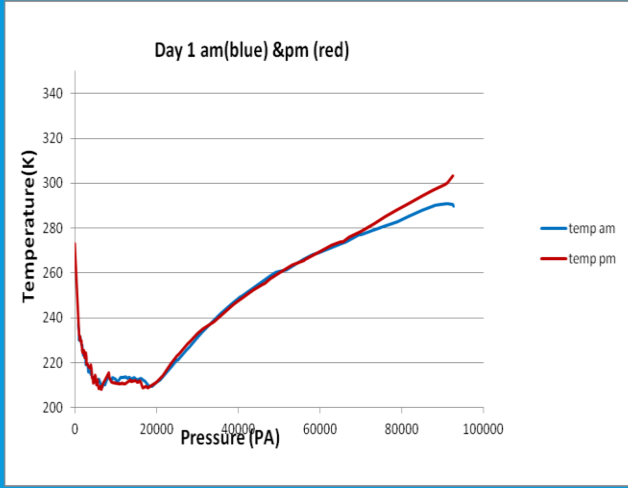
Tucson , AZ 1st Jan 2019 7.40 am & 7:40 pm

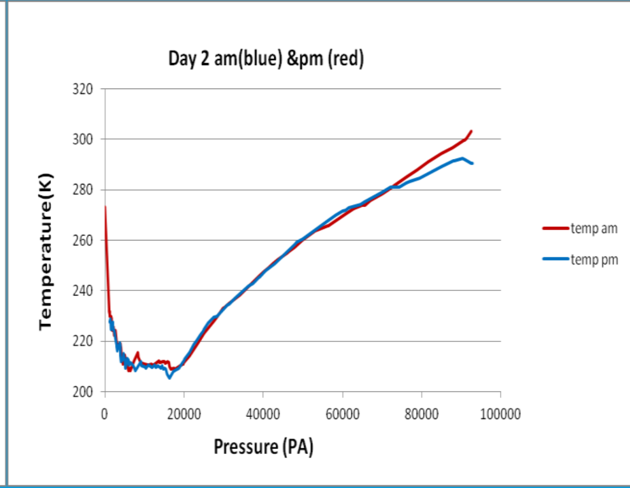


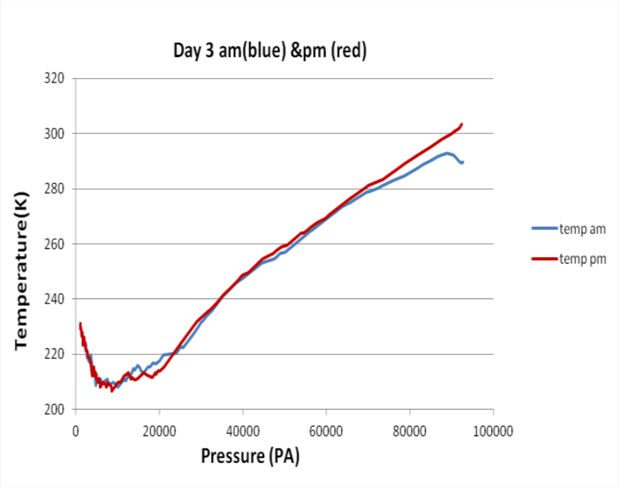
COMPARING DAY AND NIGHT

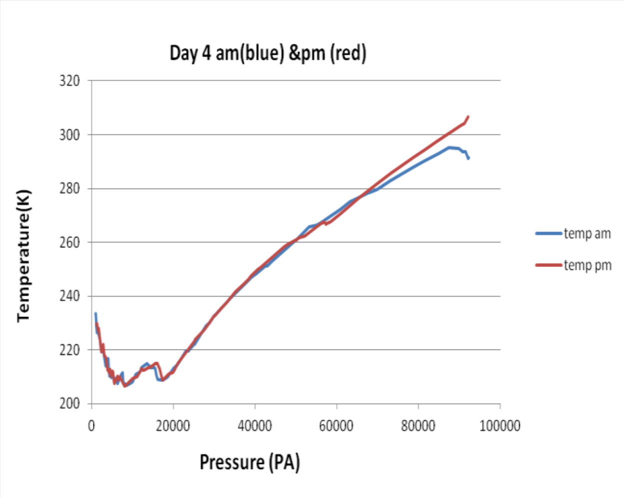
Daily temperature plots for the first week in May

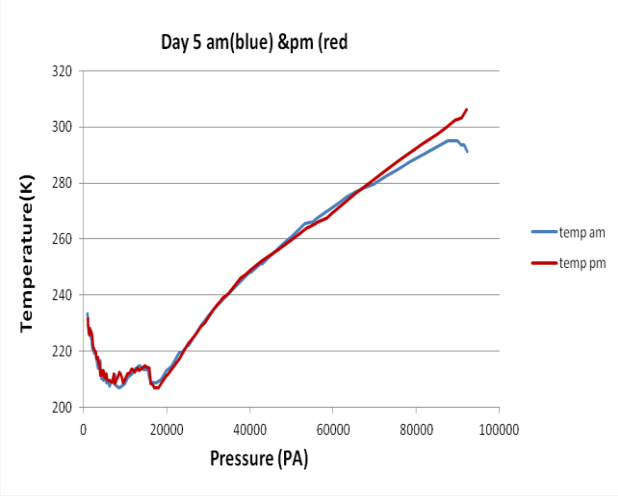
- During the day the sun heats the boundary layer
- Need a separate equation of state for this layer
- During the night energy is dissipated
- You no longer need a separate equation of state for the boundary layer

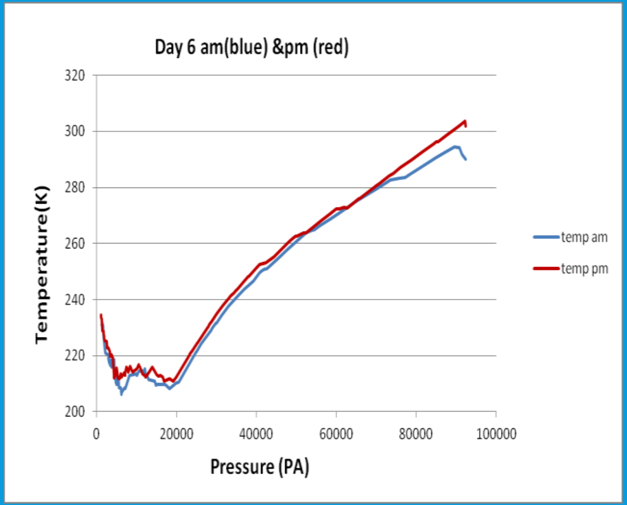












COMPARING DAY AND NIGHT

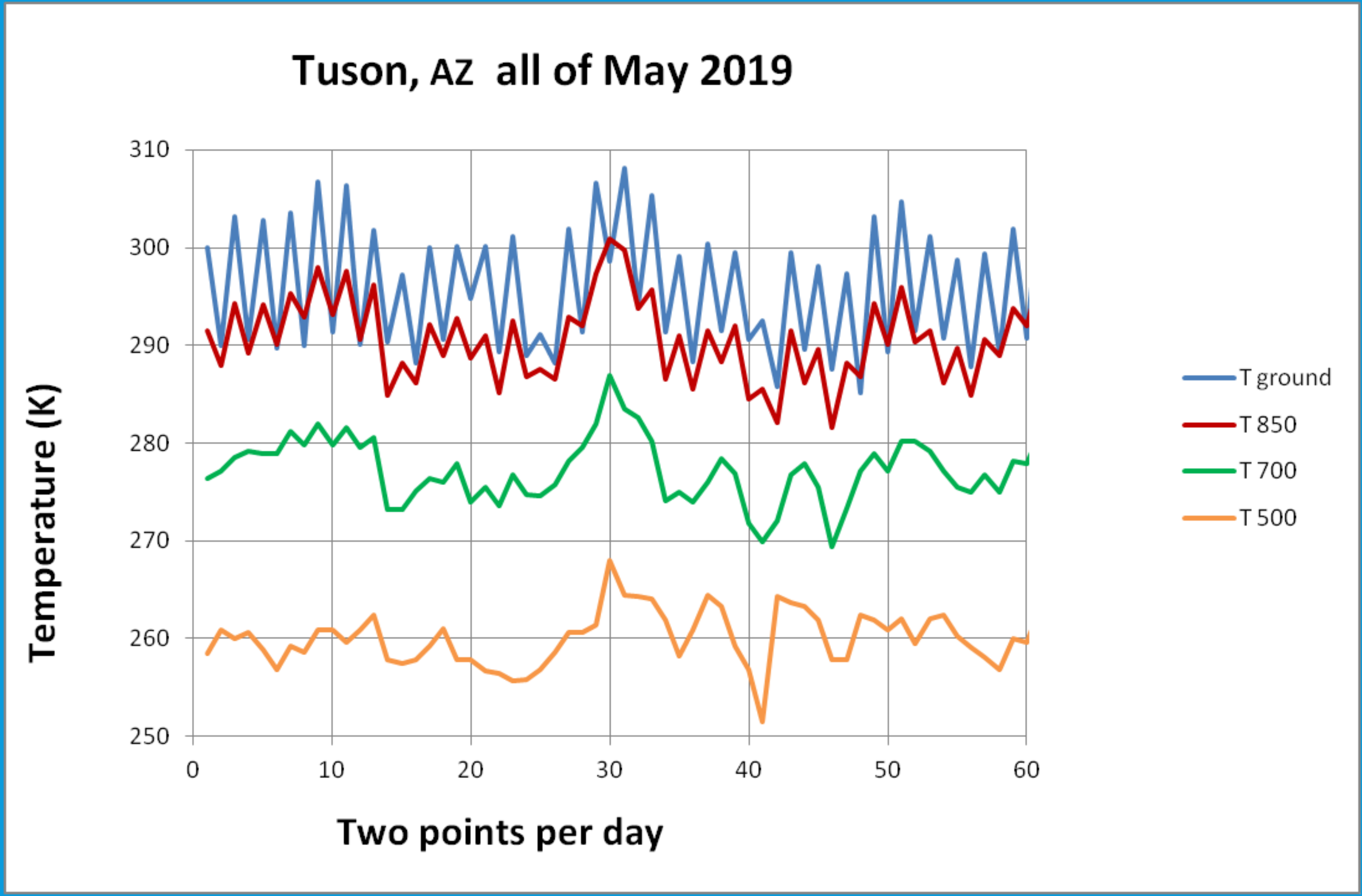
Temperatures are taken twice per day at 7:40am & 7:40pm

At ground level the difference between 7:40am & 7:40pm is 8K to 15K

At the 850 hPa pressure the difference is down to 3K to 5K

At the 700 hPa pressure the difference is down to about 1K

At 500hPa there is no am-pm pattern

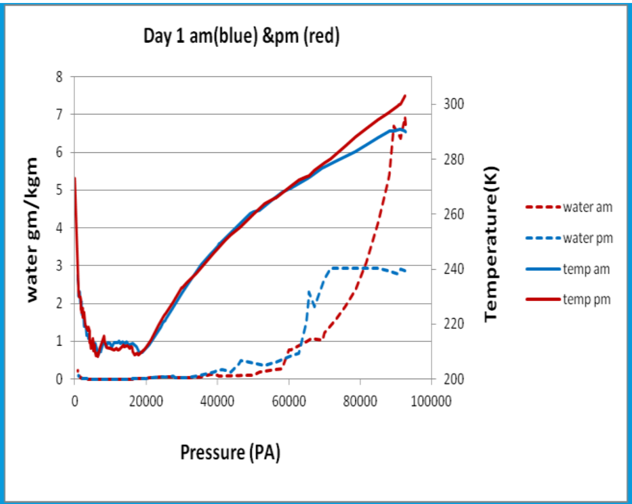


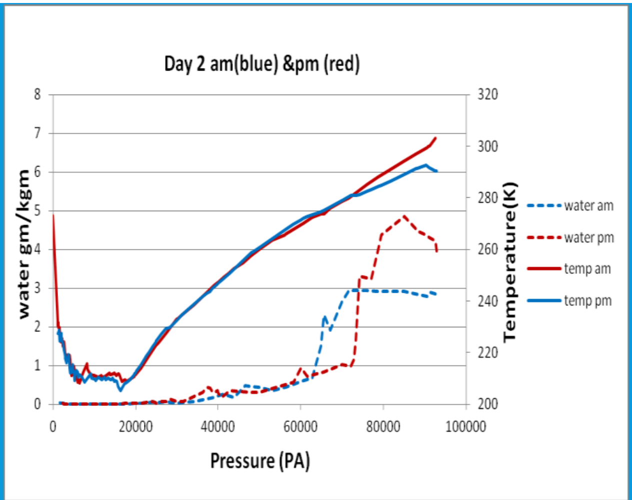
COMPARING DAY AND NIGHT

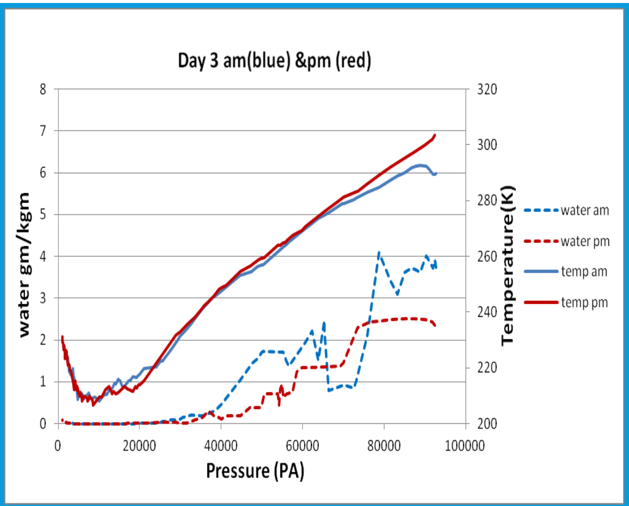
Daily temperature and water plots for a week in May

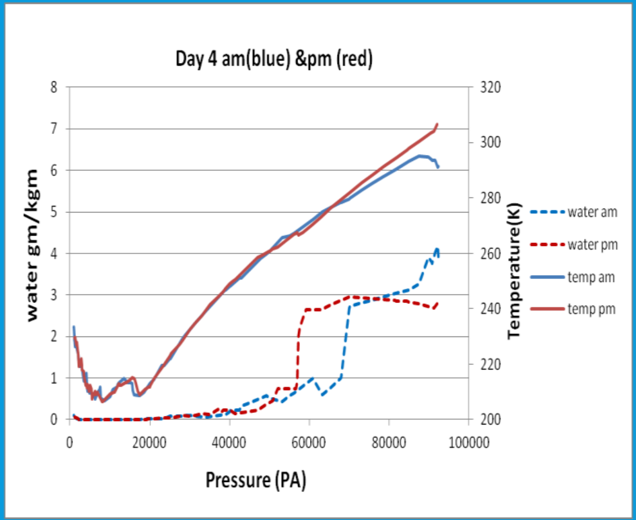
Water in the mid-troposphere **cools** the mid-troposphere at **night** (image day 3)

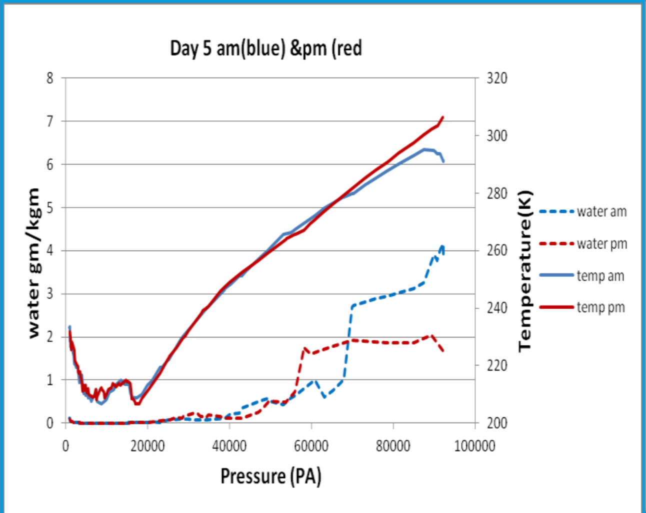
Water in the mid-troposphere **heats** the mid-troposphere during the **day**(image day 6)

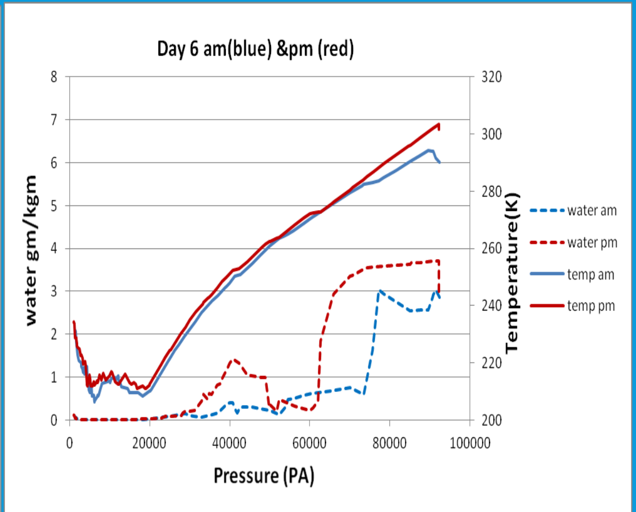








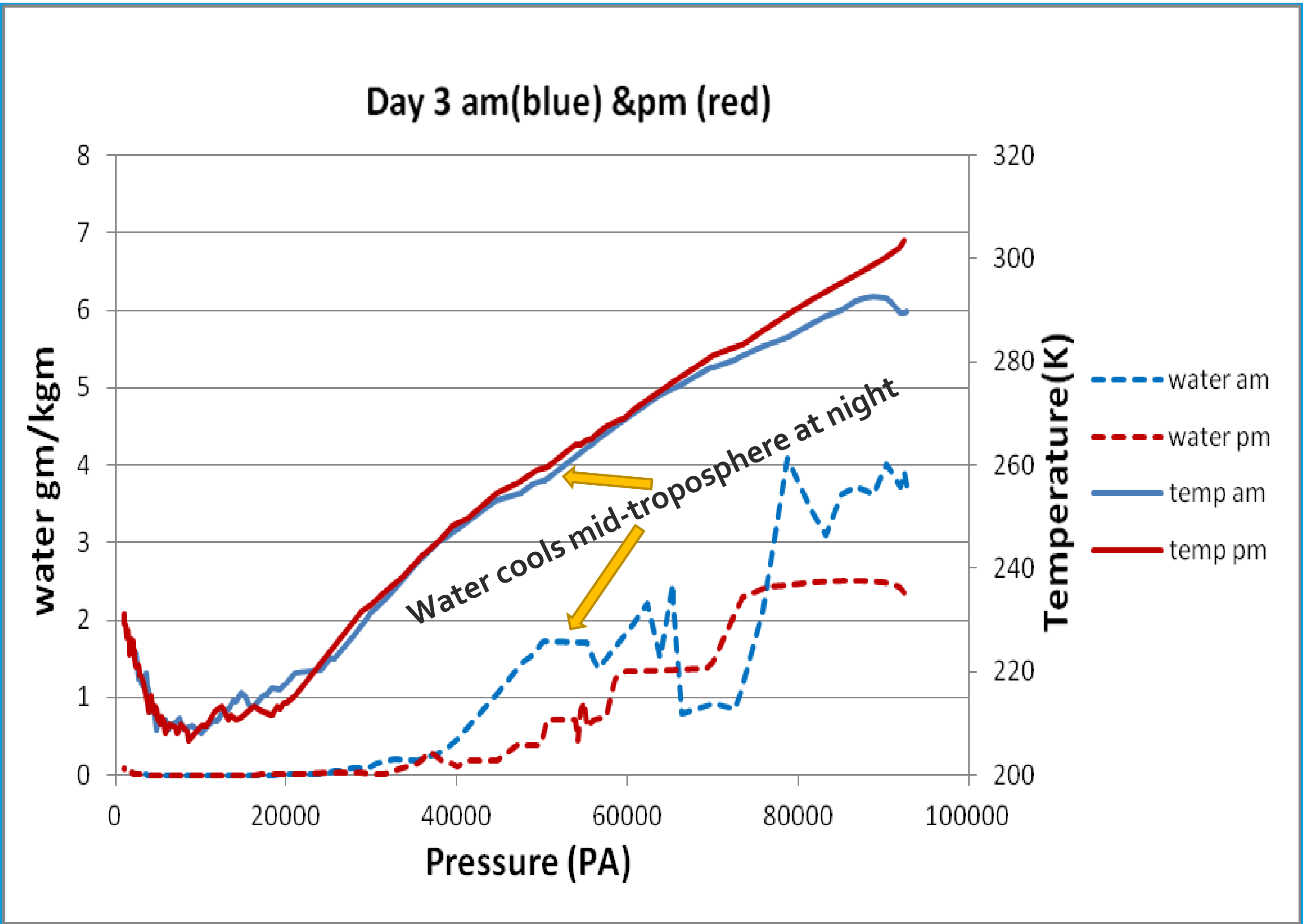




COMPARING DAY AND NIGHT

Daily temperature and water plots for a week in May

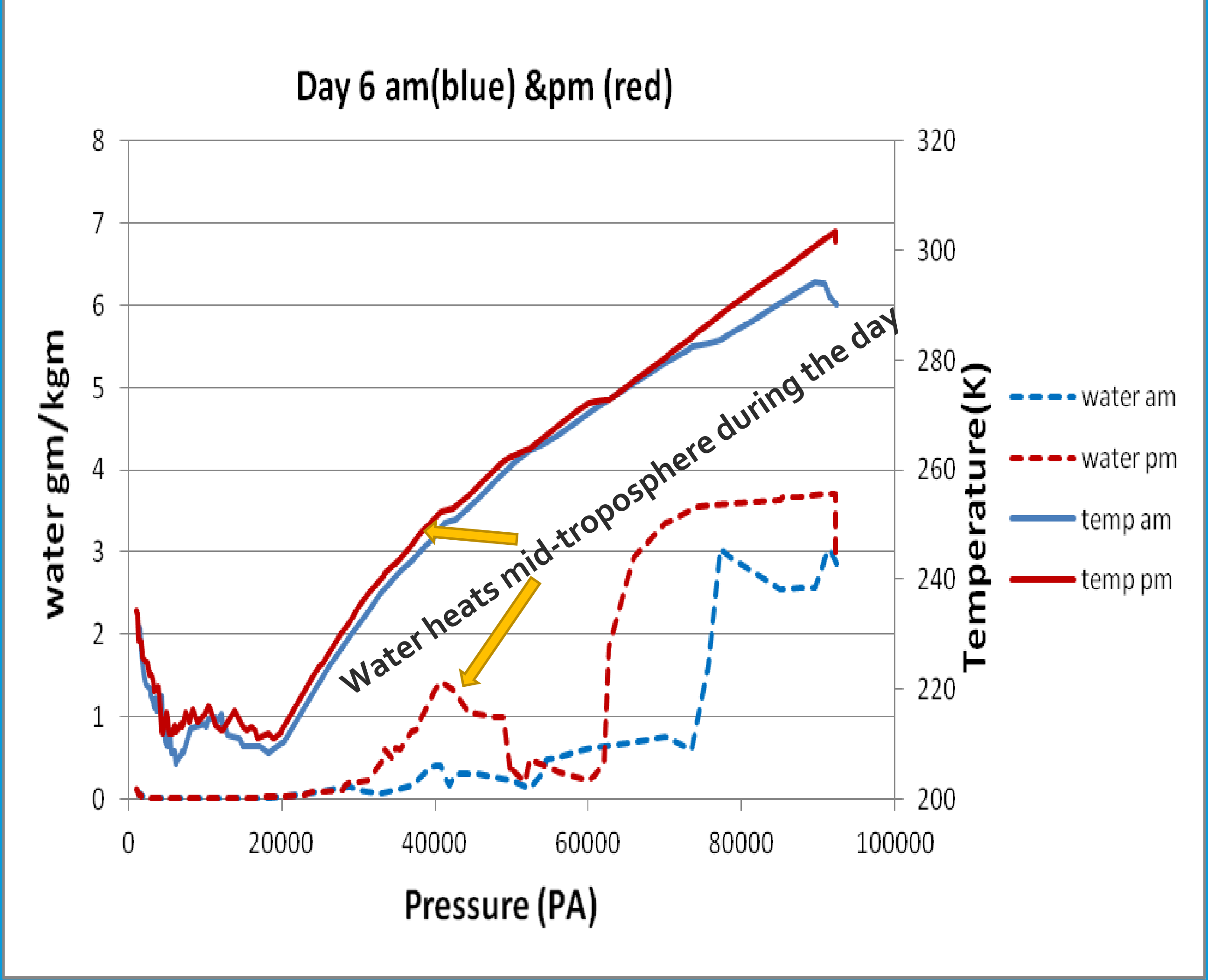
Water in the mid-troposphere **cools** the mid-troposphere at **night** (image day 3)



COMPARING DAY AND NIGHT

Daily temperature and water plots for a week in May

Water in the mid-troposphere **heats** the mid-troposphere during the **day**(image day 6)



IMPLICATIONS OF OUR 2014 ANALYSIS

We agree that :

- CO_2 is an infrared-active gas ("greenhouse gas")

- Radiation is an important mechanism for energy transmission in the atmosphere

- Arrhenius, Elsasser, Manabe, Plass, Hansen and others **assumed** this meant that the atmospheric temperature profiles were determined mainly by CO_2 and other infrared-active gases

- But, the data shows that they were **wrong**!

WHAT IS WRONG WITH THE CO_2 HYPOTHESIS?

1. Neglected the possibility of “through-mass” mechanical energy transmission
2. Cannot explain the troposphere/tropopause phase change in molar density behaviour
3. It was mostly based on extrapolating ground-based measurements
4. It was an interesting hypothesis that **might** have been valid… The modellers were correct to consider it. But the problem was that it never was tested against the data until now.

Hypotheses should be rigorously tested against the data **before** we treat them as valid theories

STRUCTURE OF THIS TALK

1. History of atmospheric measurements

2. Summary of our early findings (2010-2014)

3. Our latest findings (a sneak preview)

3. OUR LATEST FINDINGS (A SNEAK PREVIEW)

The following results are adapted from the results of some new papers that we are preparing to submit for peer review shortly

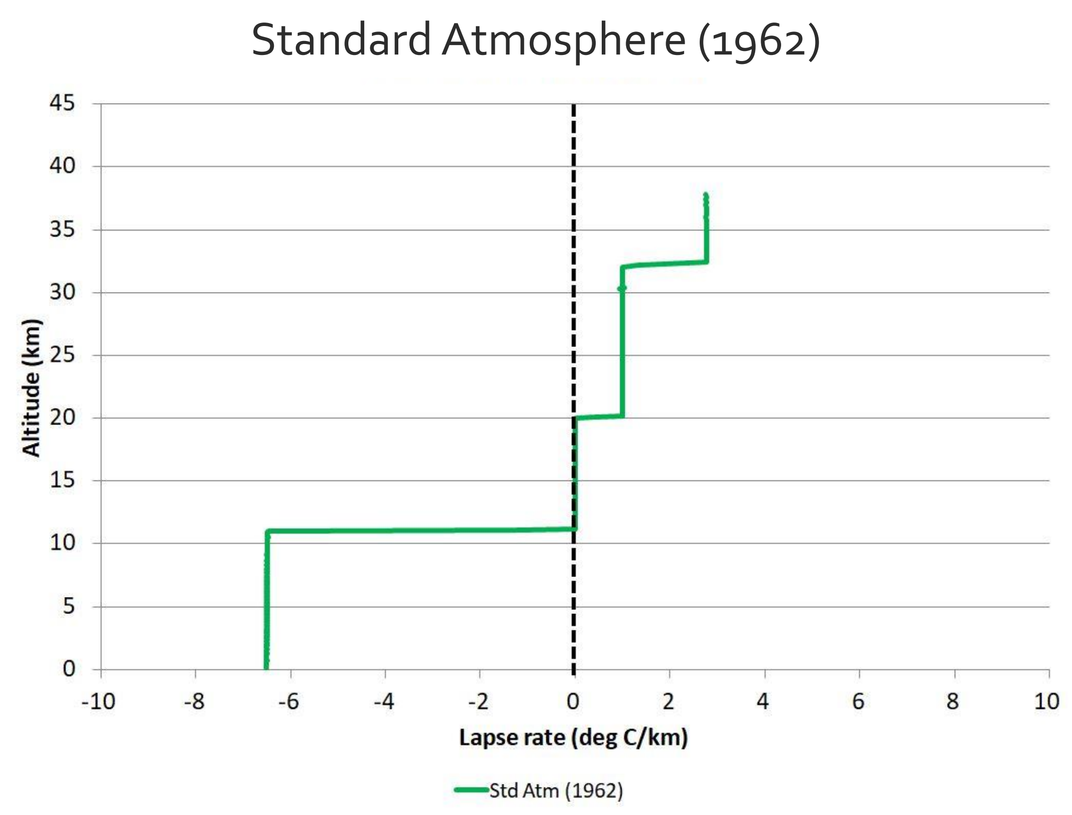
3. OUR LATEST FINDINGS (A SNEAK PREVIEW)

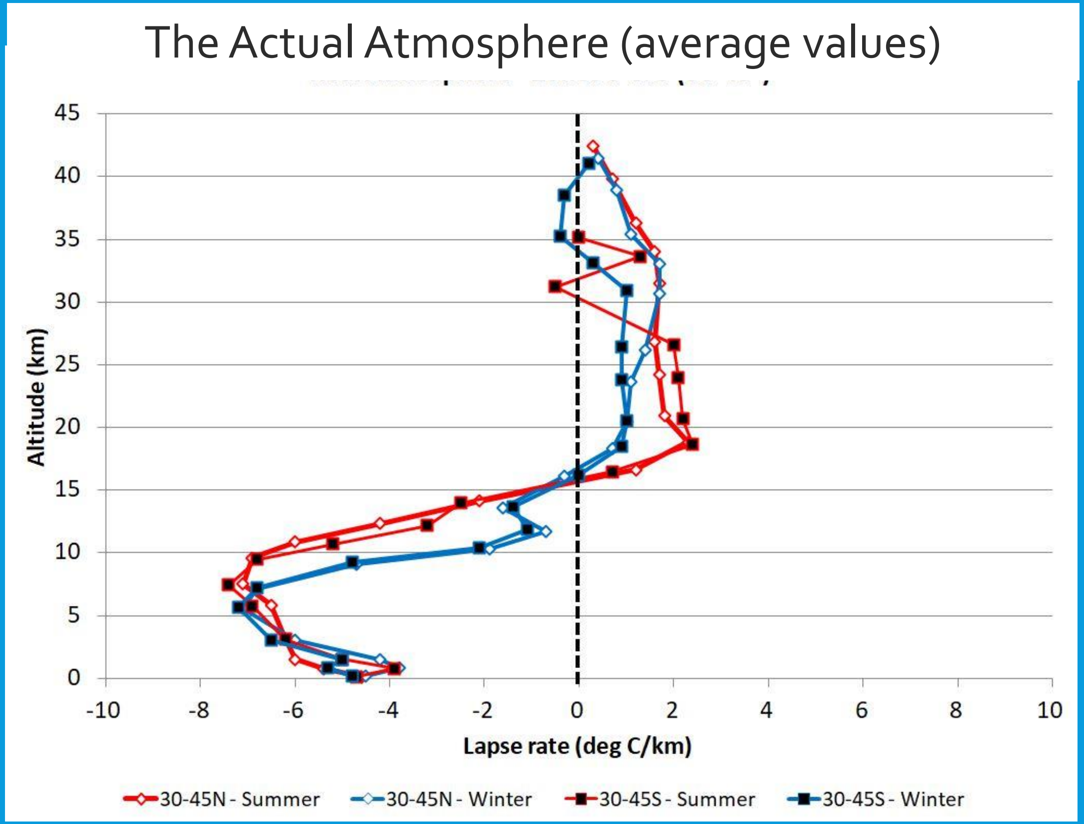
(a) The Lapse Rate

(b) Day/night temperature variability

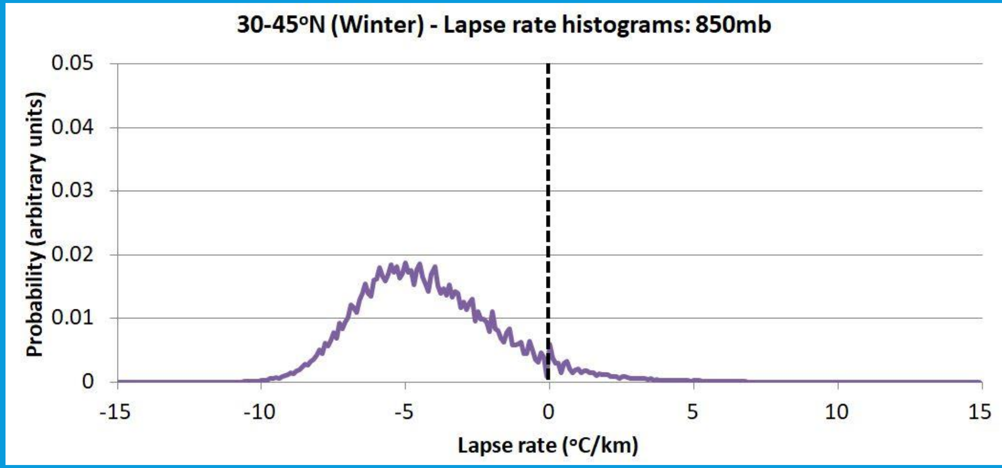
(c) Climate variability in terms of the phase change

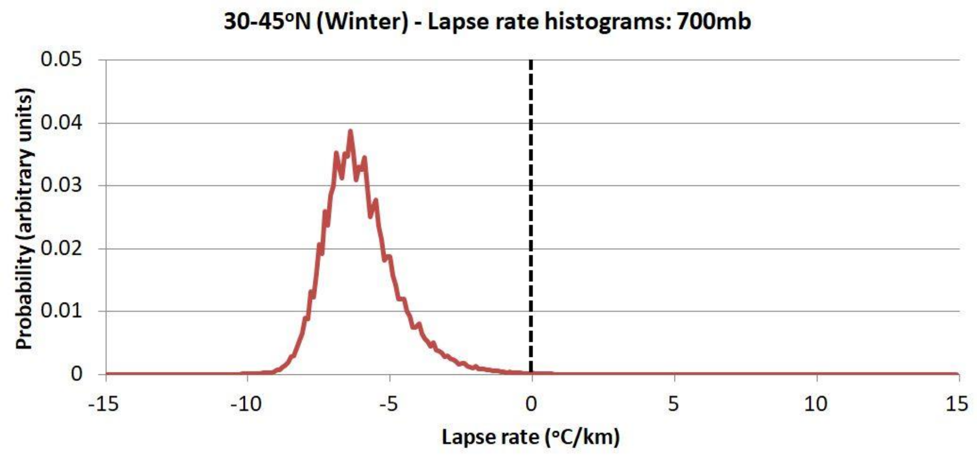
THE LAPSE RATE:
THEORY VS. OBSERVATIONS

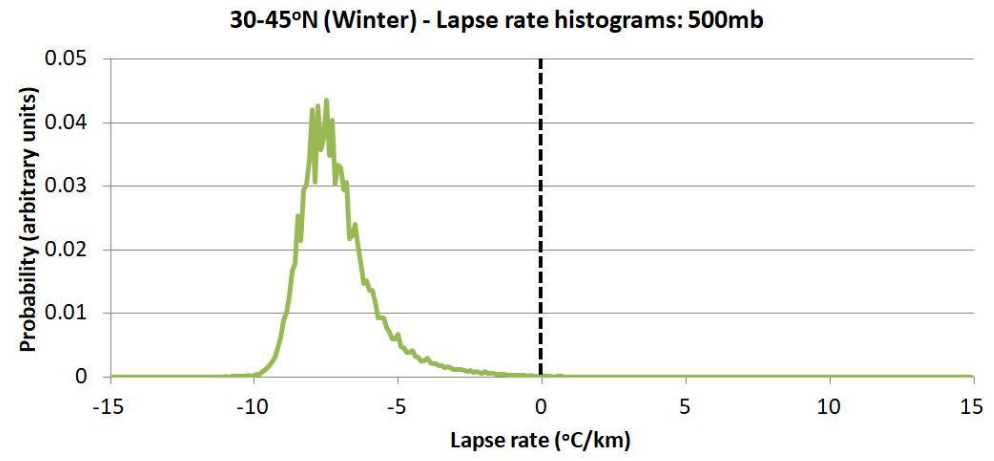


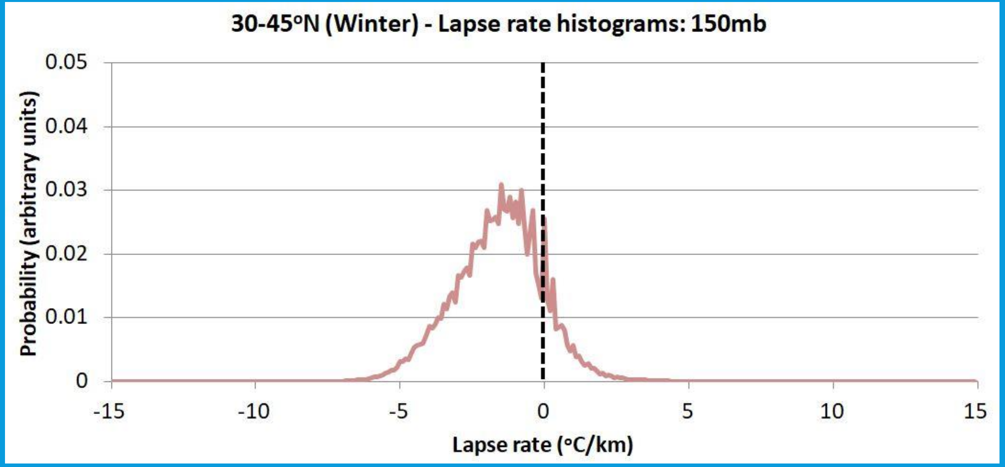


THE LAPSE RATE:
NOT CONSTANT – NEED TO USE HISTOGRAMS









THE LAPSE RATE:
PROBLEMS WITH CURRENT MODELS

- Manabe & Strickler's "convective adjustment" assumed that the lapse rate in the troposphere was exactly -6.5°C/km

- The average lapse rate **is** about that, but there is a lot of variability

- A climate model lapse rate paradox:

  The models assume a constant lapse rate in the troposphere, so any "greenhouse forcing" gets propagated down to ground.
  But, the "greenhouse forcing" implicitly assumes that each model grid box is thermodynamically isolated from the ones above it

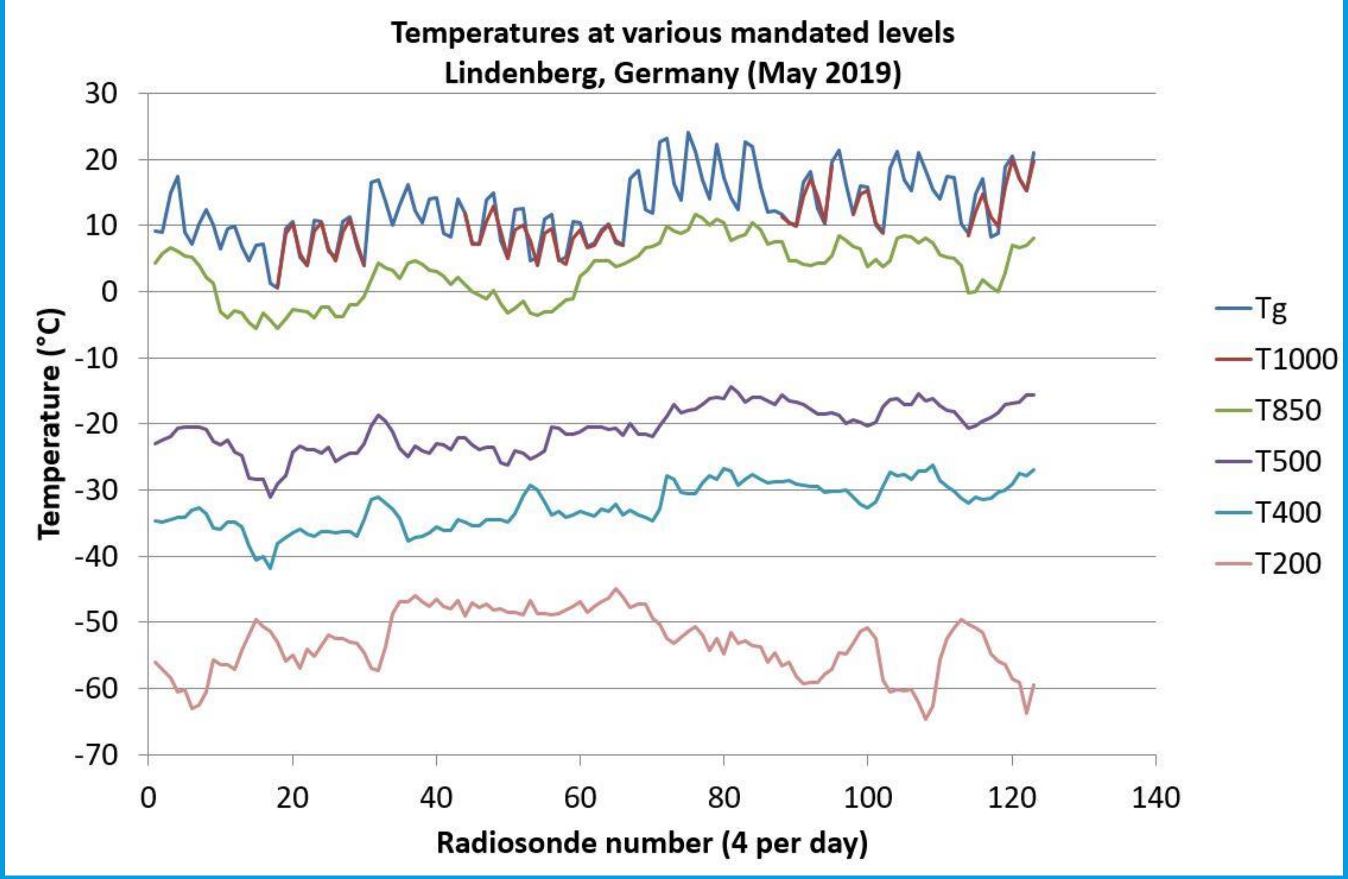
3. OUR LATEST FINDINGS (A SNEAK PREVIEW)

(a) The Lapse Rate

(b) Day/night temperature variability

(c) Climate variability in terms of the phase change

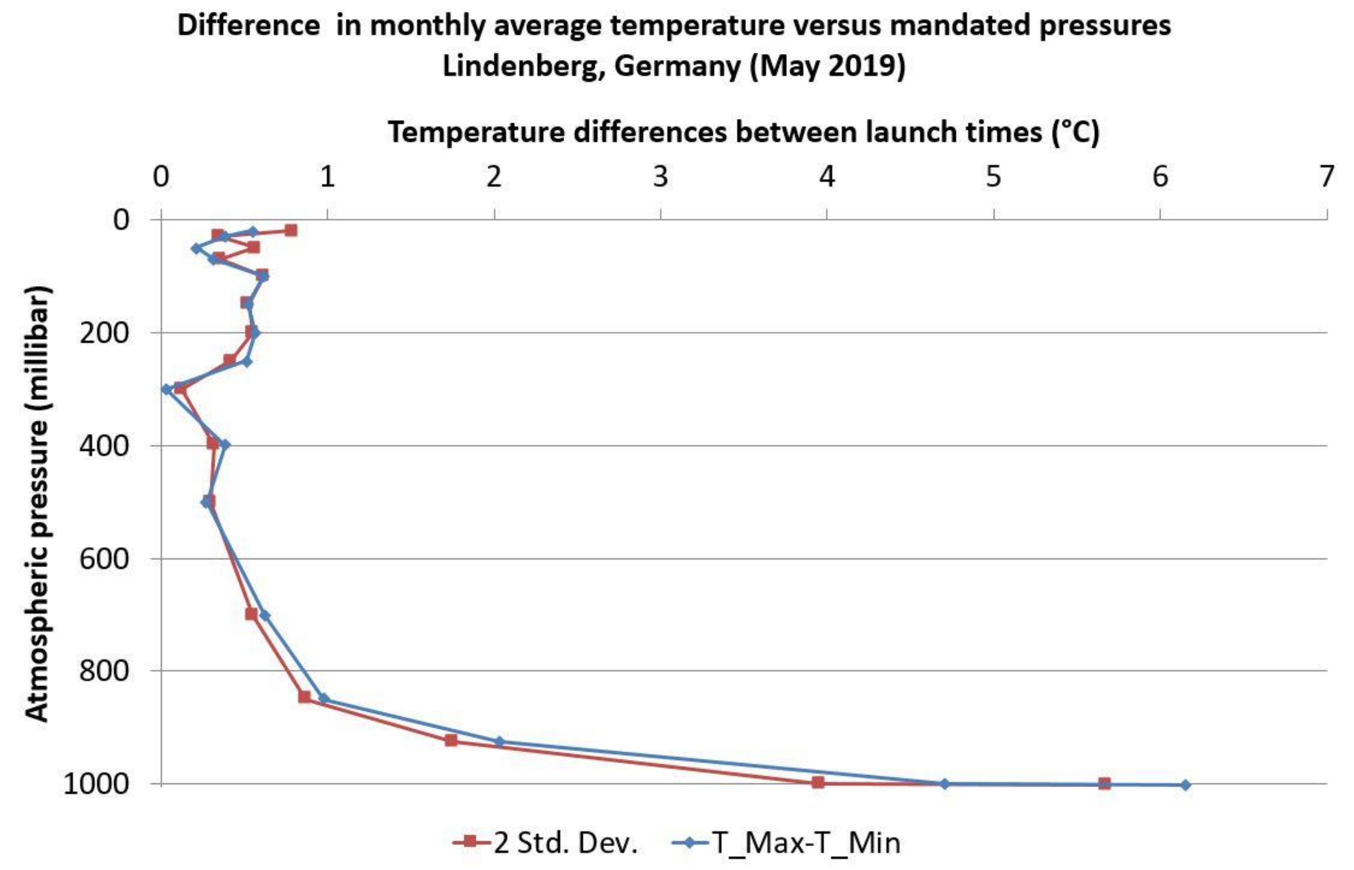
“NIGHT AND DAY, YOU ARE THE ONE”



Case study: Lindenberg, Germany

- Launches 4 balloons/day
- Temperature trends in troposphere are correlated to those at ground
- Ground trends are slightly anti-correlated to tropopause trends
- Night vs. day temperature variations at ground disappear

NIGHT VS DAY



- The average difference between night and day was 6°C for May 2019 at the ground
- But, above 800 hPa (or millibar), the night/day difference is less than 1°C

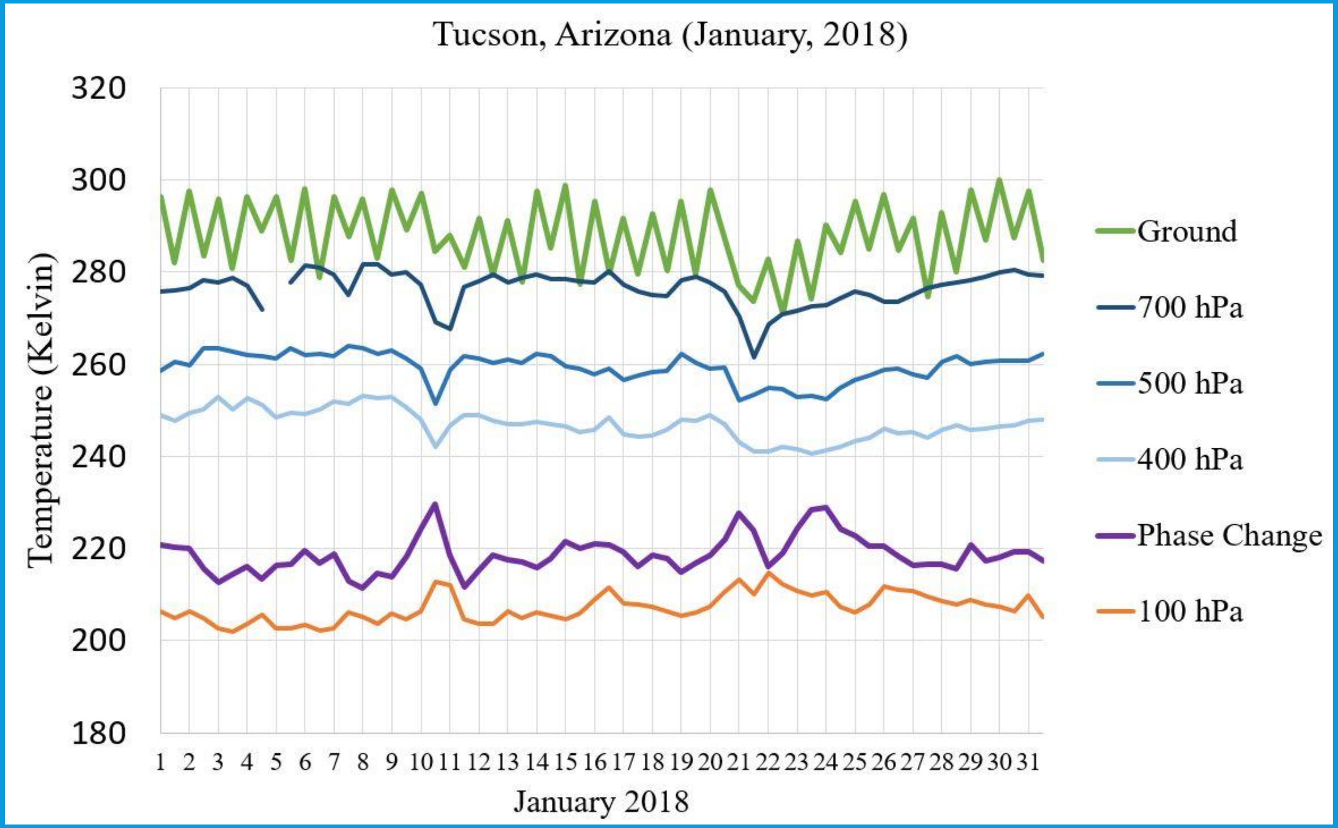
3. OUR LATEST FINDINGS (A SNEAK PREVIEW)

(a) The Lapse Rate

(b) Day/night temperature variability

(c) Climate variability in terms of the phase change

TEMPERATURE CHANGES AT EACH LEVEL

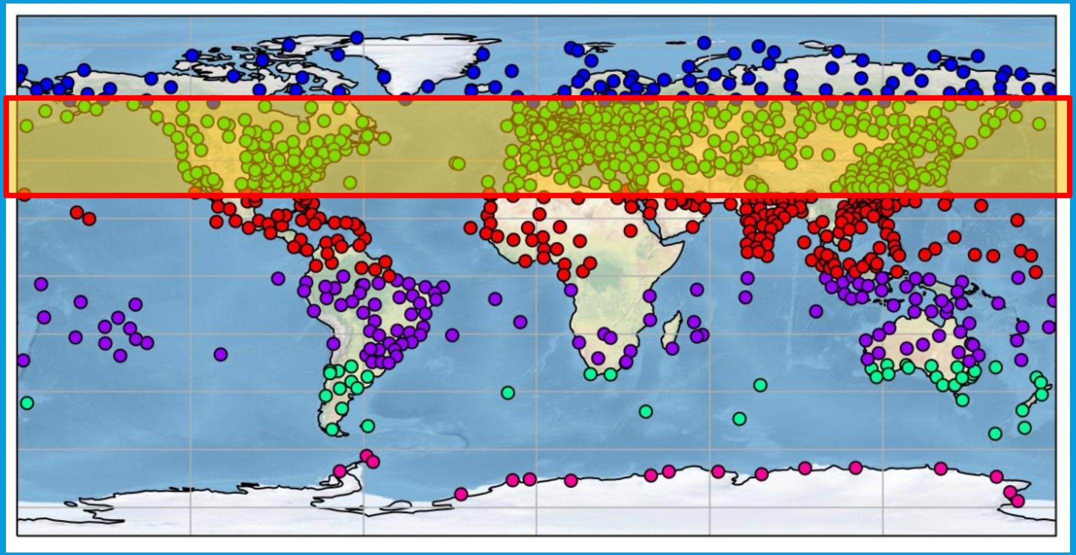


- Temperatures at each level are different
- But, temperature **changes** are similar

- We will calculate the correlation between the temperature changes at each mandated level (T_m) and those at ground (T_g) or the phase change (T_p)

- Correlation, r
  - r = -1 (anti-correlated)
  - r = 0 (no correlation)
  - r = 1 (exactly correlated)

TEASER: RESULTS FOR ZONE 4 (30-60°N)



Analysing all stations:

- With elevation <1km
- With 30 years of data (1989-2018)
- Sorted into 6 latitudinal zones

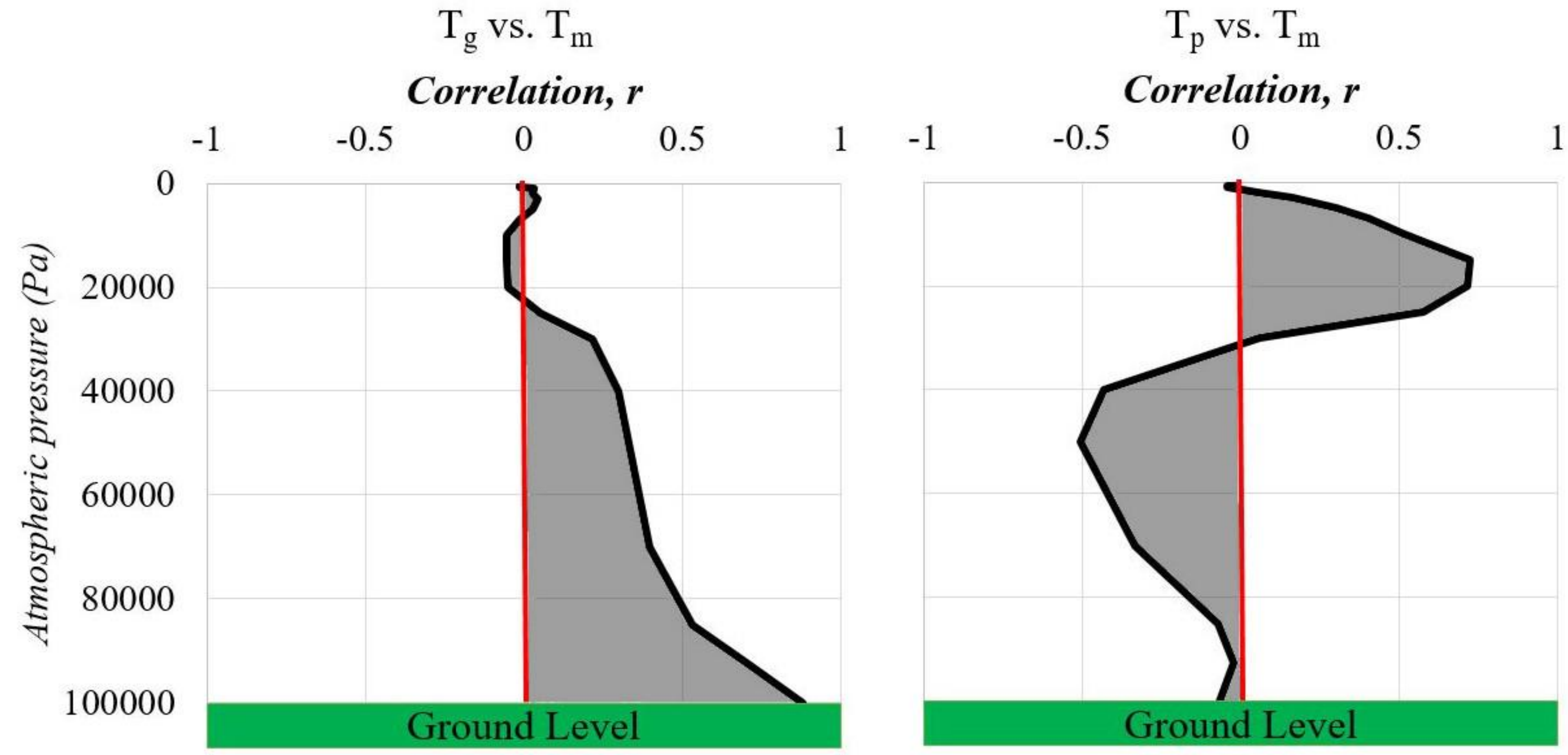
<u>1989-2018 analysis periods</u>

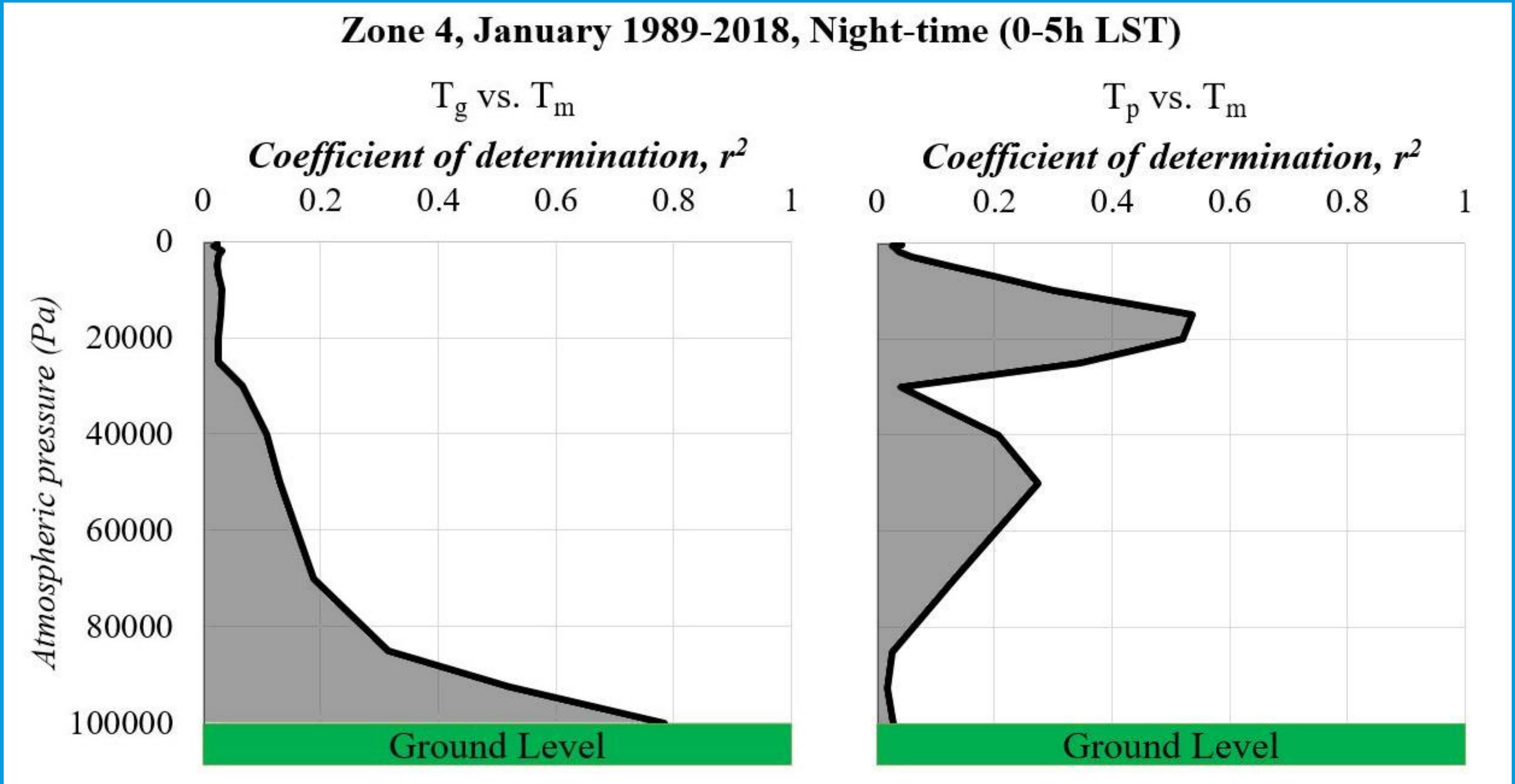
Zone 4 = 471 stations

~10,000,000 usable balloons

Results sorted according to Local time zones

Zone 4, January 1989-2018, Night-time (0-5h LST)





- The correlation with T_g (ground T) falls off rapidly with height
- The correlation with T_p (phase change T) is better for most of the atmosphere – except near ground, i.e., the "boundary layer"

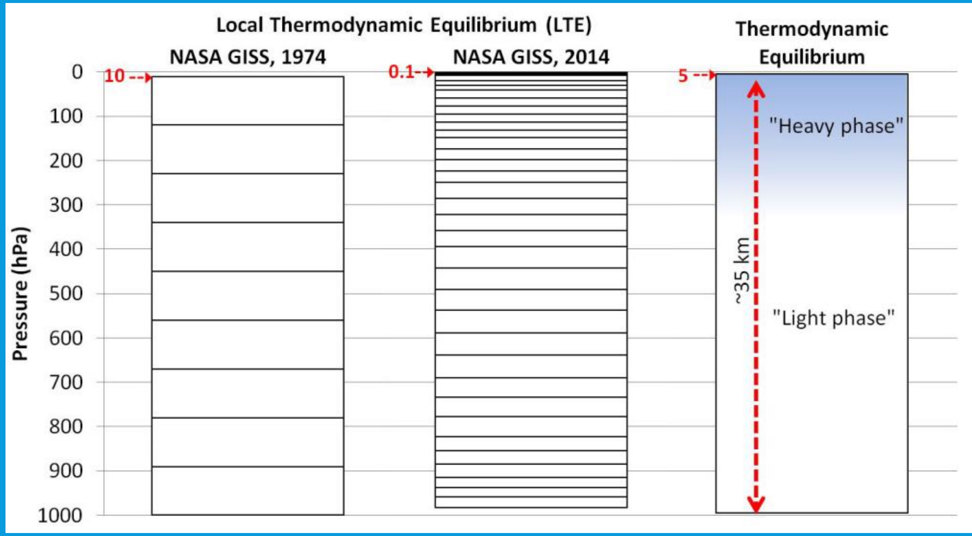
CONCLUSIONS AND IMPLICATIONS

OUR PROPOSED APPROACH TO CLIMATE MODELLING **AND** WEATHER FORECASTING

Top changes needed for climate modelling

1. Recognise the existence of the two phases (*whatever the nature of the "heavy phase" transpires to be!*)
2. Stop assuming each 1km vertical layer is "thermodynamically isolated" from the others
3. Use molar density (*D*) calculations in our analysis
4. Use T_p vs. T_m correlations as well as T_g vs. T_m
5. Stop assuming lapse rate is constant

Schematic comparing the current approach (left and middle) to our new approach (right)



SUMMARY FOR POLICYMAKERS

- The **IPCC was wrong** to conclude recent climate changes were due to greenhouse gases. Computer models they were relying on were based on flawed early 20th century science. "Carbon mitigation" should no longer be considered a priority.

- The **current climate model temperature projections are worthless** for the same reason. Policies considering climate change should be primarily based on observed historical climate variability instead

- But, this **does not** mean we should be polluting the planet! We should continually be fighting to reduce water and air pollution, and protecting natural ecosystems.

- Negative environmental impacts of **all** energy sources – including renewables – should be monitored

ANY QUESTIONS?

THE “PRIMITIVE EQUATIONS”

- Approximations for describing the mass flow of a fluid, e.g., air or water
- First written down by Prof. Vilhelm Bjerknes (1862-1951)
- Key component of climate models
- Includes Bernouli’s principle and the Navier-Stokes equations
- Since 2000, the Clay Mathematics Institute has offered $1 million to anybody that can mathematically prove the Navier-Stokes equations

$$PV + \frac{1}{2}mv^2 + mgh + \text{frictional energy} + \text{rotational energy} = \text{constant}$$

BALLOON DATA AVAILABLE

There are several gridded and averaged datasets that use balloon data, e.g., HadAT, RATPAC and RICH

But, for raw individual balloon data we use two sources:

1. **University of Wyoming's "Atmospheric Soundings" website**. Great for exploratory research. Easy to download a few balloons and look at in Excel. http://weather.uwyo.edu/upperair/sounding.html

2. **NOAA's Integrated Global Radiosonde Archive (IGRA)**. Better for more systematic research. All balloons back to the early 20th century. Suitable for analysing with computer scripts. 20 Gigabytes (20 Gb) https://www.ncdc.noaa.gov/data-access/weather-balloon/integrated-global-radiosonde-archive

IMPLICATIONS FOR OUR UNDERSTANDING OF THE ATMOSPHERE AND CLIMATE

George Simpson's assessment (1930s):

- Radiative processes **<u>can't</u>** explain the temperature profile in the troposphere
- So, it's probably dominated by convective processes
- Radiative processes "probably" are involved in the tropopause/stratosphere, though

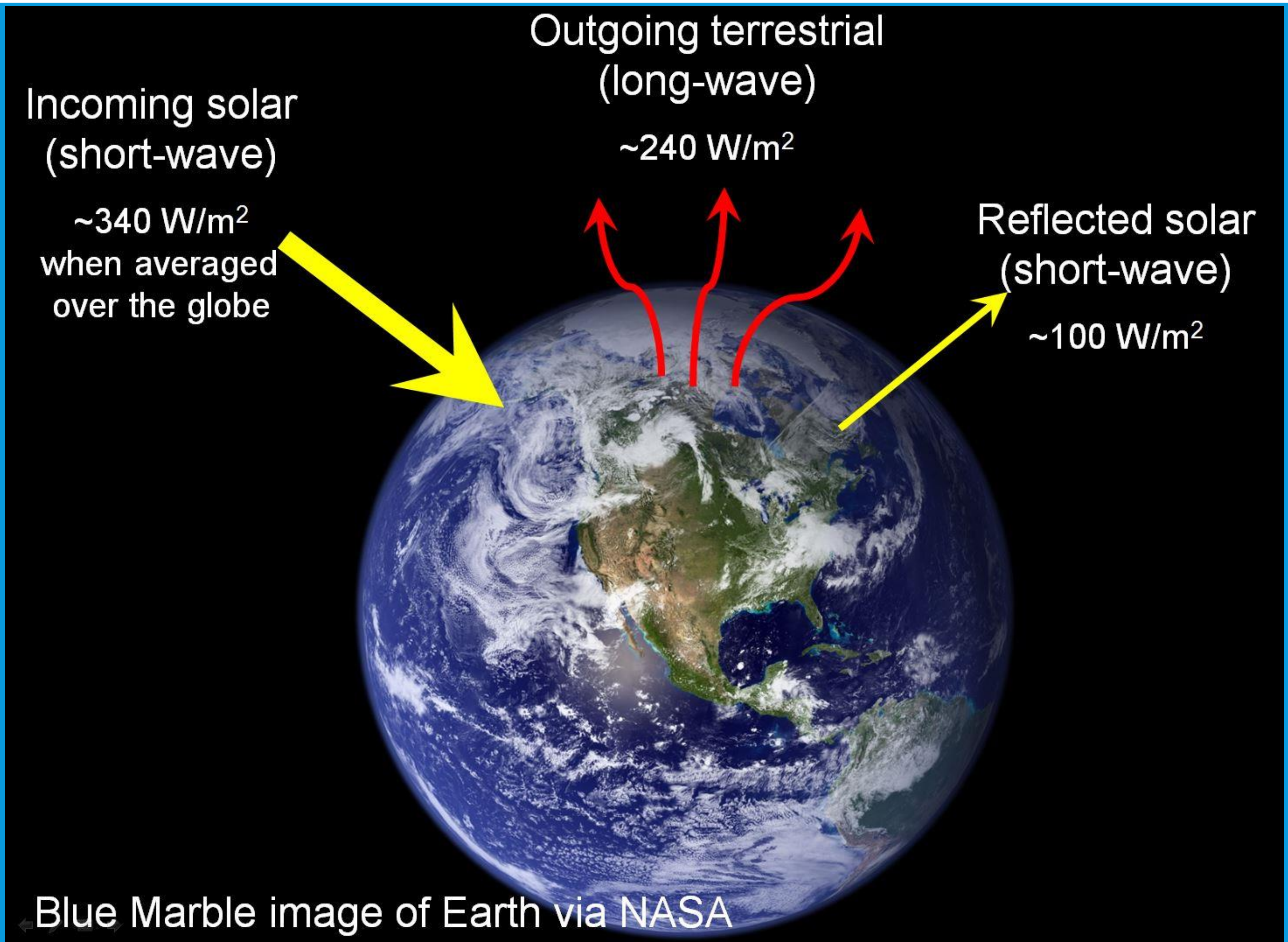
Approach of current climate models (since 1960s):

- **<u>Assume</u>** radiation is the primary energy transmission method (*following Elsasser, 1942*)
- Apply "convective adjustment" to make the tropospheric temperature profile look more realistic (*following Manabe & Strickler, 1964*)

Our new approach (present):

- Radiation is only one of the mechanisms for energy transmission
- Continually check our models against observations

A QUICK RADIATIVE PHYSICS PRIMER: 1) EARTH'S ENERGY BUDGET



- The Earth is continuously heated by energy radiating from the Sun ("sunlight")
- The Earth is continuously cooling because it is surrounded by Space (T = 3K or -270°C or -458°F)

- Incoming radiation is mostly ultraviolet and visible light (because Sun is hotter)
- Outgoing radiation is mostly infrared "light"

IN SUMMARY

1)The Sun heats the troposphere more in the Summer than in the Winter.

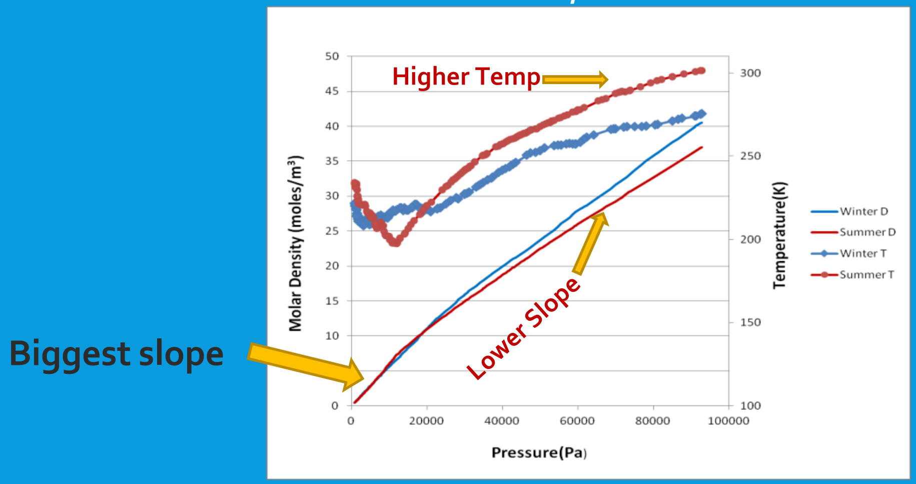
2)The Sun heats the boundary layer during the Day but not at Night.

3)In both cases heating the air causes the air to be less compressible, as you would expect from Charles Law.

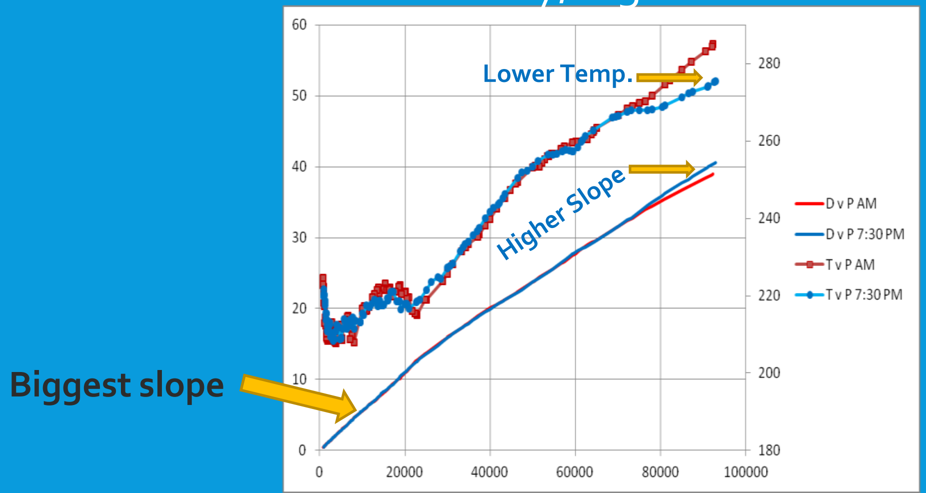
4) The Tropopause is colder in the Summer than in the Winter

5) At the Tropopause the air becomes **more** compressible

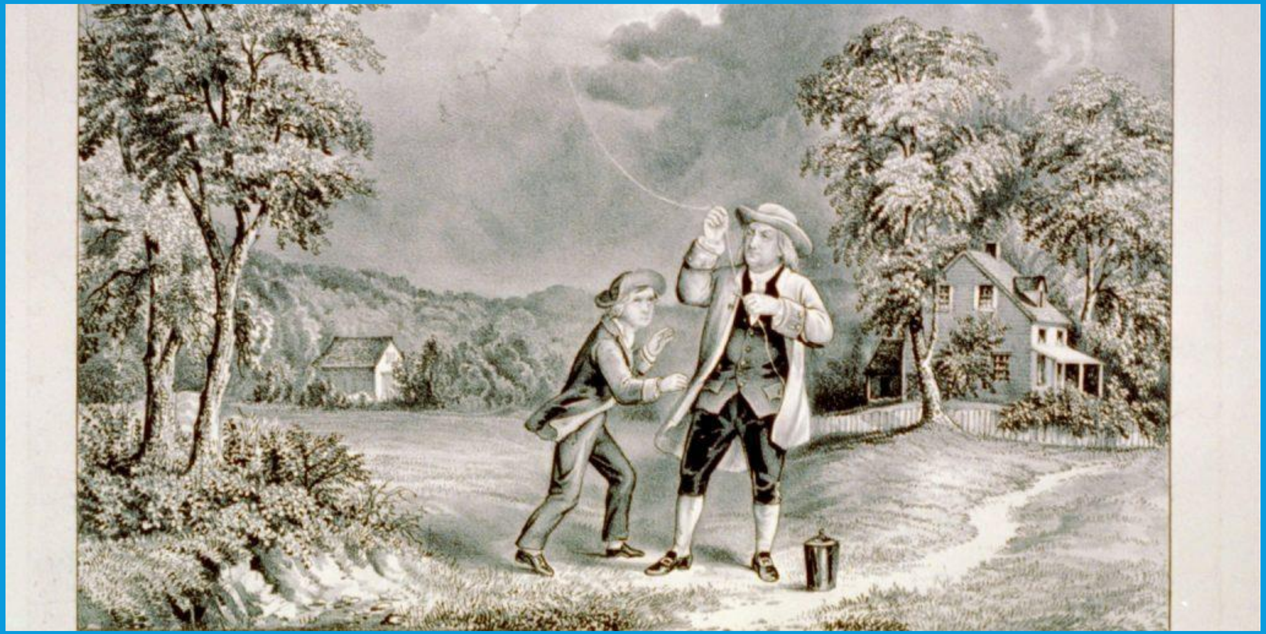
Summer /Winter



Day/Night



KITES & TOWERS: A BIT ABOVE GROUND



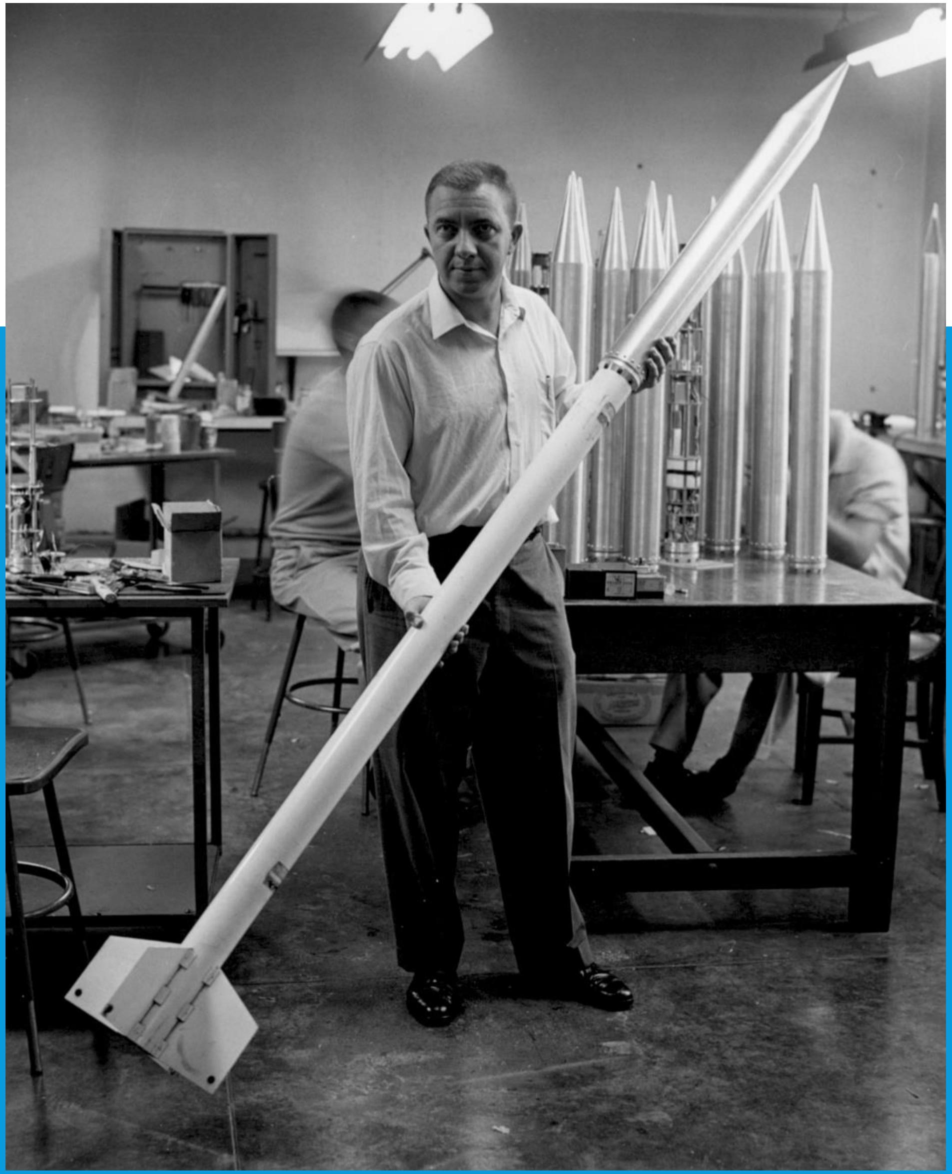
"Franklin's Experiment, June 1752. Demonstrating the identity of Lightning and Electricity, from which he invented the Lightning Rod." (Currier & Ives, 1892)

- Kites were one of the earliest ways of measuring the atmosphere above the ground
- Benjamin Franklin's famous 1752 experiment during a thunderstorm
- Another method would be to take measurements from tall towers, but until the 20th century, this only got you a few hundred metres up!
- e.g., Leaning Tower of Pisa = 56m; Eiffel Tower = 324m

ROCKET-SONDES

- In 1955, US Navy converted old missile rockets like the *Loki* into meteorological rockets

- Flight-time is 5-20 minutes
- Takes at least 3 months to prepare
- Covers the region 40-120km (24-72 miles). This is just **above** where the balloons burst



Prof. James Van Allen holding a Loki instrumented "Rockoon". Credit: NASA JPL

AIRCRAFT MEASUREMENTS

A WC-130J Hercules plane, 53rd Weather Reconnaissance Squadron Hurricane Hunters. Credit: United States Air Force/Tech. Sgt. James B. Pritchett (2007)

- Some measurements are also made using weather monitoring aircraft.
- Particularly useful in monitoring hurricanes
- However, mostly used for studying lower troposphere (up to about 10km/6 miles)

A QUICK RADIATIVE PHYSICS PRIMER: 2) ABSORPTION AND EMISSION

- Heat energy can be transmitted by:
  a) Conduction
  b) Convection
  c) Radiation

- In terms of radiation, in 1860s, John Tyndall showed that O_2 and N_2 are basically transparent to infrared light, but H_2O, CO_2, CH_4 (and ozone) are infrared-active

- Albert Einstein won the 1921 Nobel Prize in physics for his studies on radiation. Part of this work showed that different molecules absorb and emit light at fixed "quantised" energies. Led to quantum mechanics

- If a molecule, e.g., CO_2, absorbs at an infrared frequency, it can also emit at that

CONCLUSIONS

1) The neglect of through air mechanical energy has led to the hypothesis that the atmosphere is only in local thermodynamic equilibrium i.e. conduction convection and radiation cannot transmit energy fast enough to maintain thermodynamic equilibrium with altitude . This was a mistake.
2) If the atmosphere can transmit energy quickly enough to restore thermodynamic equilibrium, our results say that it can, then as Einstein showed in his 1919 paper the rate of absorption of radiation by IR active gases is equal to their rate of emission i.e. IR active gases (so called greenhouse gases) do not trap or store energy for systems in thermodynamic equilibrium .
3) However greenhouse gases do absorb and emit radiation and can also absorb and loose energy due to collision with other gases . But as can also be shown from Einstein's 1919 work, that where a thermal gradient exists, due to the photo induced emission component of Einstein's equation the net effect of greenhouse gases is to increase the flow of IR radiation from hot to cold and not the other way round.
4) Einstein's 1919 work and our balloon work shows that increasing the concentrations of the so called greenhouse gases does not cause global warming.