Temperature and Radiation
AOSC 200

Tim Canty

Class Web Site: http://www.atmos.umd.edu/~tcanty/aosc200

Topics for today:

- Climate
- Weather Observations

Lecture 02

Aug 29 2019

Weather and Climate

What is Weather?

Weather is the conditions of the atmosphere at a specific place over shorter time periods.

There are many things we can measure to determine weather, for example

- Precipitation
- Temperature
- Wind speed
- Wind direction

Scientists would say that these observations describe the ***STATE*** of the atmosphere

What is Climate?

"The slowly varying aspects of the atmosphere–hydrosphere–land surface system"

http://glossary.ametsoc.org/wiki/Climate

Climate is often thought of as the "average weather" or "average conditions"

When a meteorologist says…

"Average high temperatures for today are 85°F"

…. they're talking about climate

What is Climate Change?

"Any systematic change in the long-term statistics of climate elements (such as temperature, pressure, or winds) sustained over several decades or longer."

http://glossary.ametsoc.org/wiki/Climate_change

What this means:

Average conditions (temperature, snow fall, fog, etc.) are different now than some time in the past.

Weather and Climate

Climate is the set of conditions that prevails in a region over a ~30 year period.

- **Precipitation**
- **Temperature ← most commonly talked about**
- **Wind speed**
- **Wind direction**
- **Ocean height**

Reasons to learn about climate:

- **Good to be prepared**

  Will there be water restrictions or flooding? Will I need a better air conditioner or heater?

- **Limit risk to lives and property**

  Will hurricanes become more frequent? What will the growing season be like?

- **Wedding planners would love to know what the weather will be like in 10 years!**

What is Science?

Science is an organized body of knowledge on a specific subject

AND

it is also a process of learning about the natural world through the scientific method:

1) **Ask a question ("Why is the sky blue?")**
2) **Read up on what other people have done**
3) **Come up with a hypothesis ("It reflects blue light from the ocean")**
4) **Build an experiment to prove this ("Cover the ocean with purple plastic wrap and the sky will turn purple")**
5) **Analyze your data ("The sky did not turn purple")**
6) **Conclusion ("The sky is not blue because of the ocean. Also, don't cover the ocean with plastic wrap")**

What is Climate Change?

"Any systematic change in the long-term statistics of climate elements (such as temperature, pressure, or winds) sustained over several decades or longer."

http://glossary.ametsoc.org/wiki/Climate_change

Stop with that crazy science talk!

Climate change means that average trends are different now than at some time in the past.

What is Climate Change?

"But" *insert politician, radio talk show host, blogger, etc name here* "says that…."

This is a very contentious issue and it is my job to explain the current understanding of the SCIENCE.

"You're just another libtard overpaid government hack leaching off tax payers and making shit up to save his job"

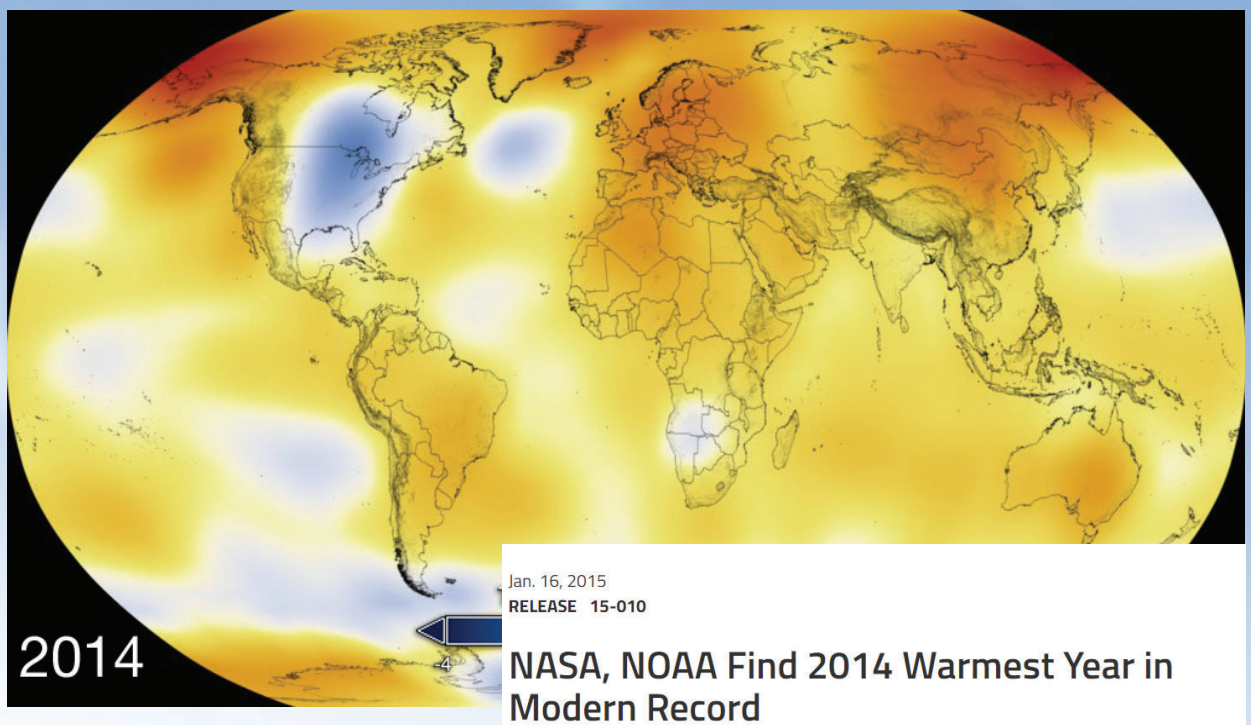
1) **I've never been paid for my climate research**

2) **Not only does my family not speak to me about this but I've also been publicly ridiculed by some of the top climate scientists in the world**

3) **My research group is the "radical middle"**

"You know, I think it's weather patterns, frankly. And you know, and they change, as I said. It rained yesterday, it's a nice pretty day today. So the climate does change in short increments and in long increments."

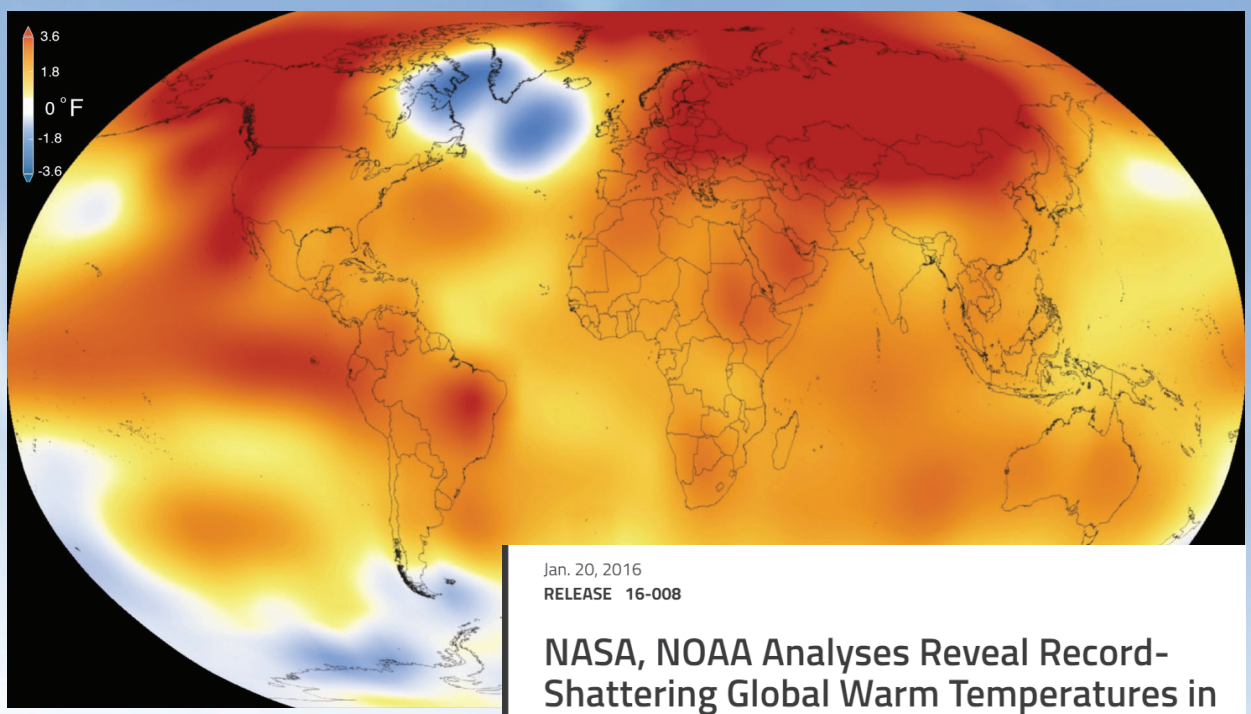
– US Government Official



Jan. 16, 2015
RELEASE 15-010

NASA, NOAA Find 2014 Warmest Year in Modern Record

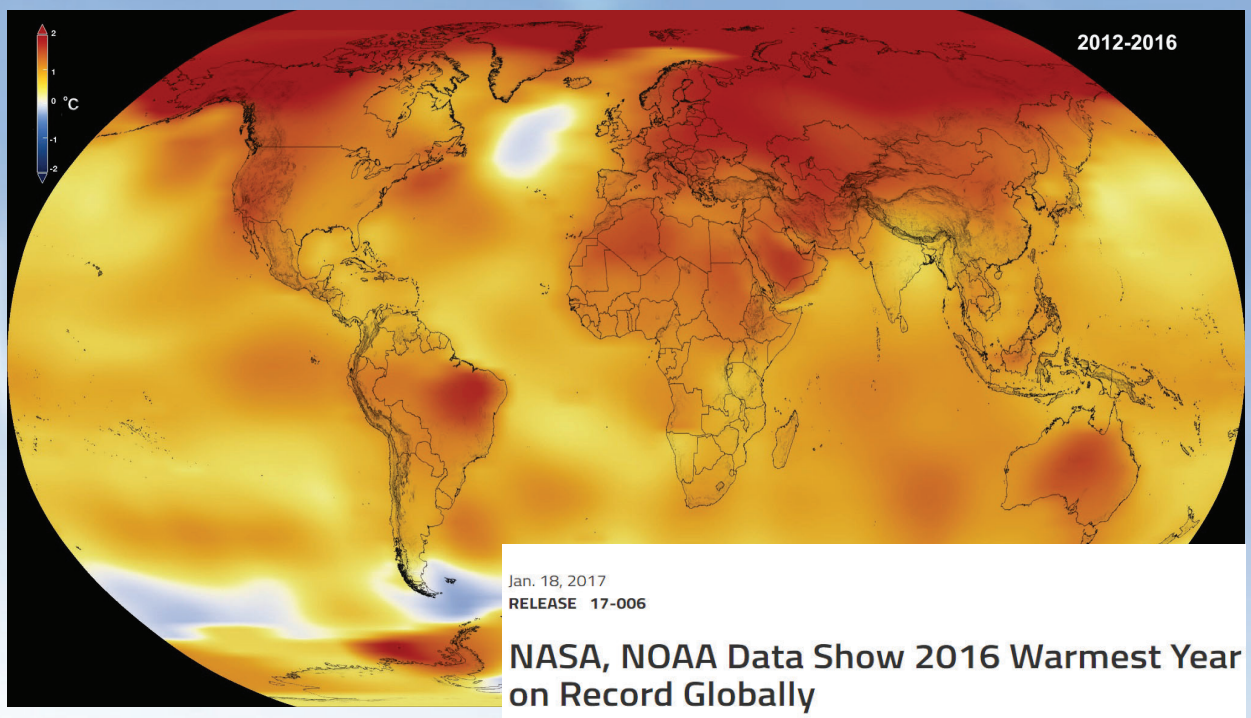
https://www.nasa.gov/press/2015/january/nasa-determines-2014-warmest-year-in-modern-record



Jan. 20, 2016
RELEASE 16-008

NASA, NOAA Analyses Reveal Record-Shattering Global Warm Temperatures in 2015

http://www.nasa.gov/press-release/nasa-noaa-analyses-reveal-record-shattering-global-warm-temperatures-in-2015

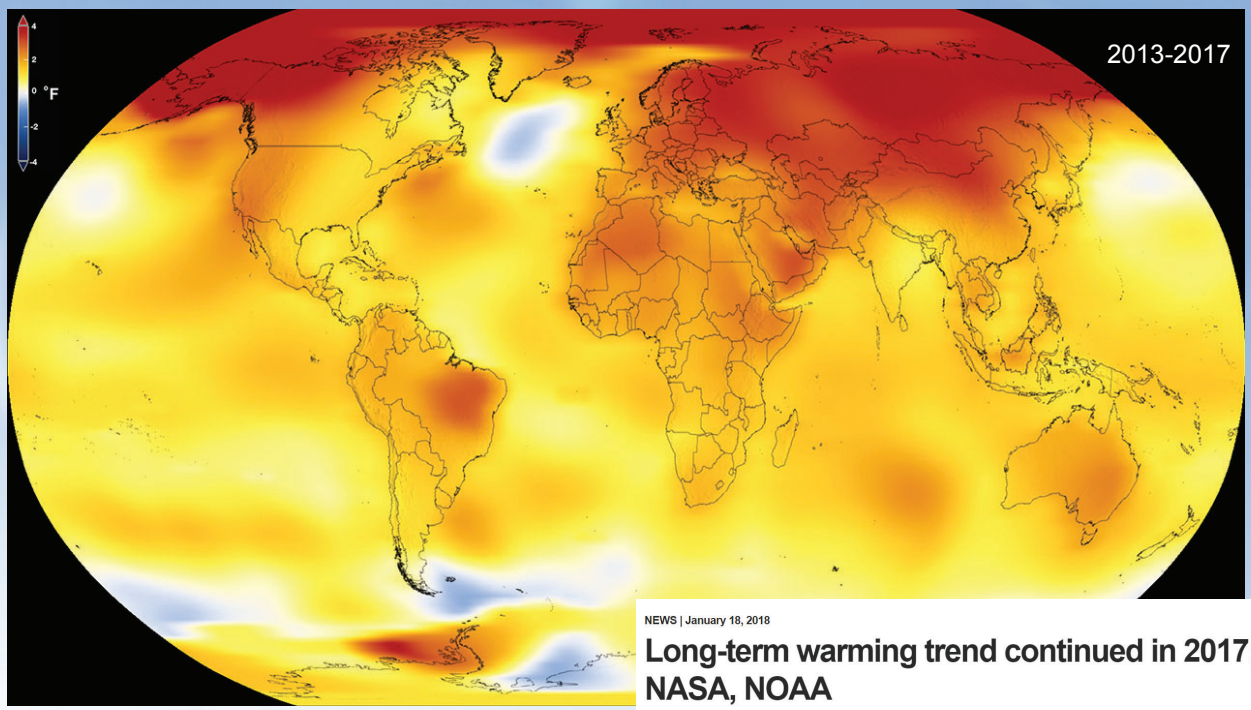


Jan. 18, 2017
RELEASE 17-006

NASA, NOAA Data Show 2016 Warmest Year on Record Globally

Earth's 2016 surface temperatures were the warmest since modern recordkeeping began in 18

https://www.nasa.gov/press-release/nasa-noaa-data-show-2016-warmest-year-on-record-globally

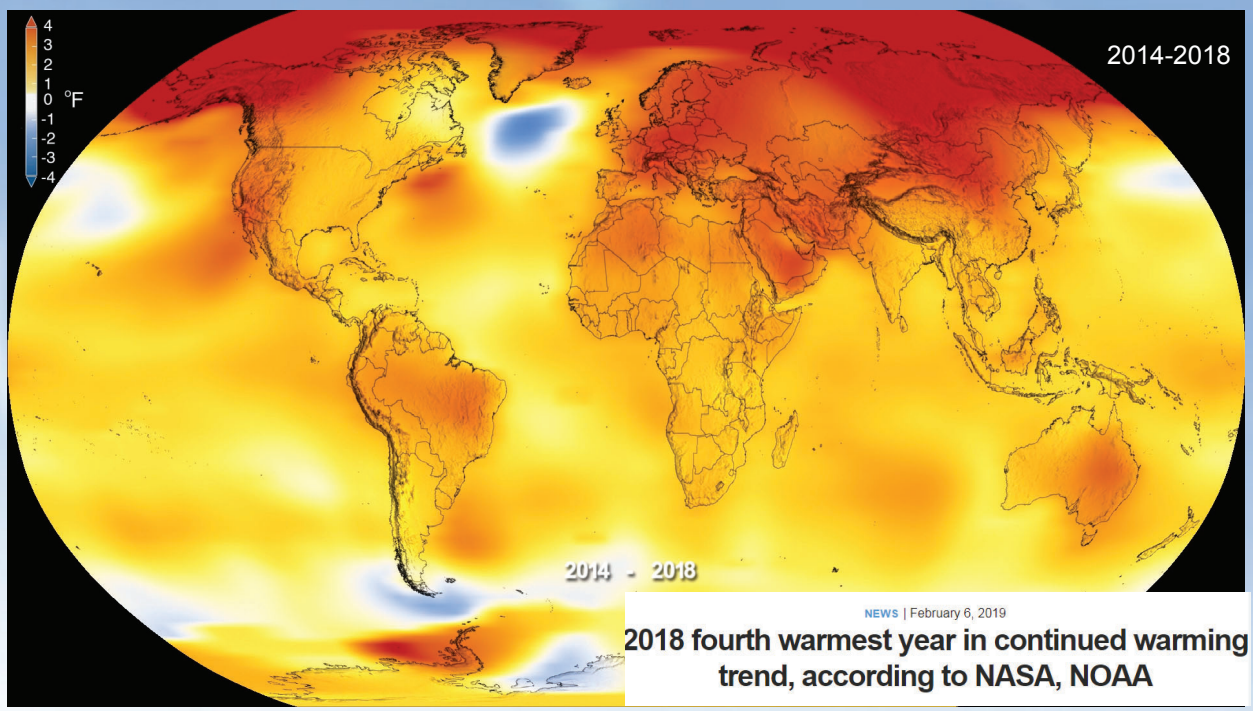


NEWS | January 18, 2018

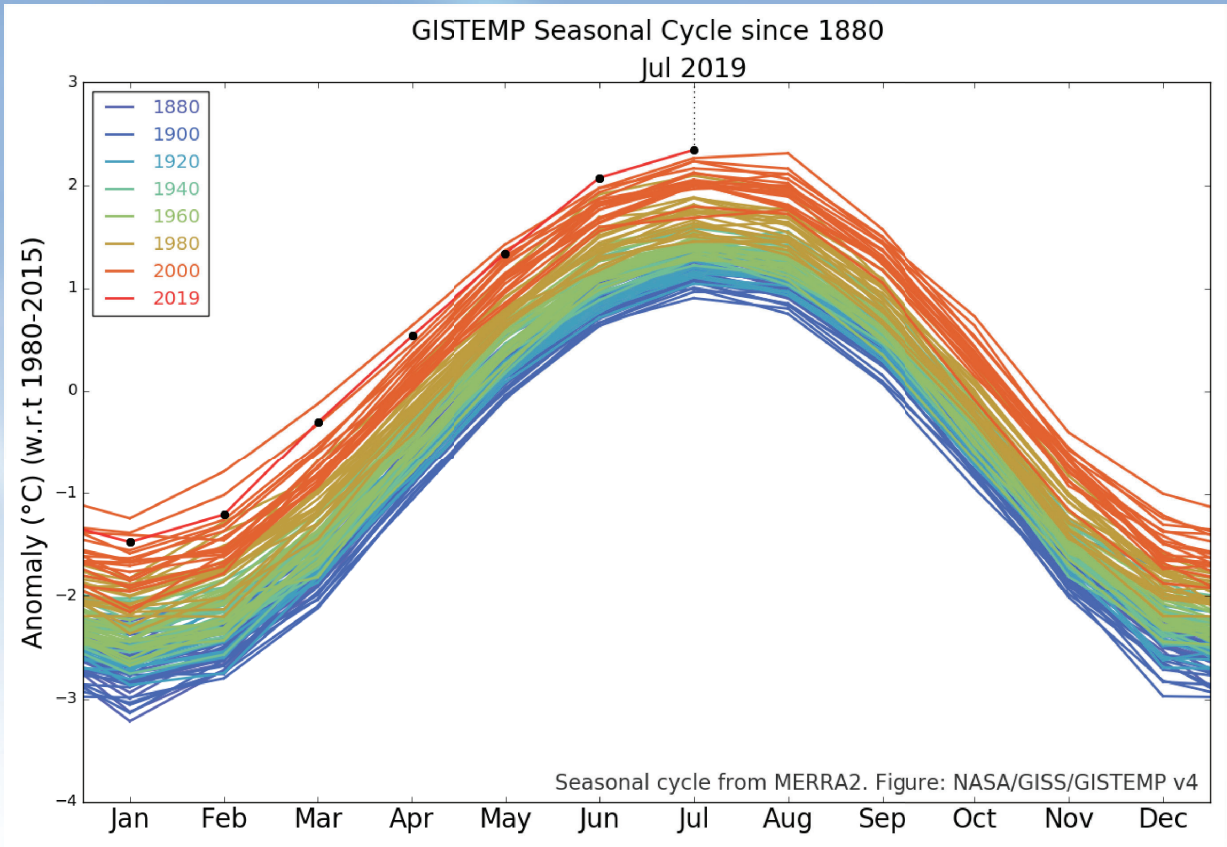
Long-term warming trend continued in 2017: NASA, NOAA

From NASA

https://climate.nasa.gov/news/2671/long-term-warming-trend-continued-in-2017-nasa-noaa/

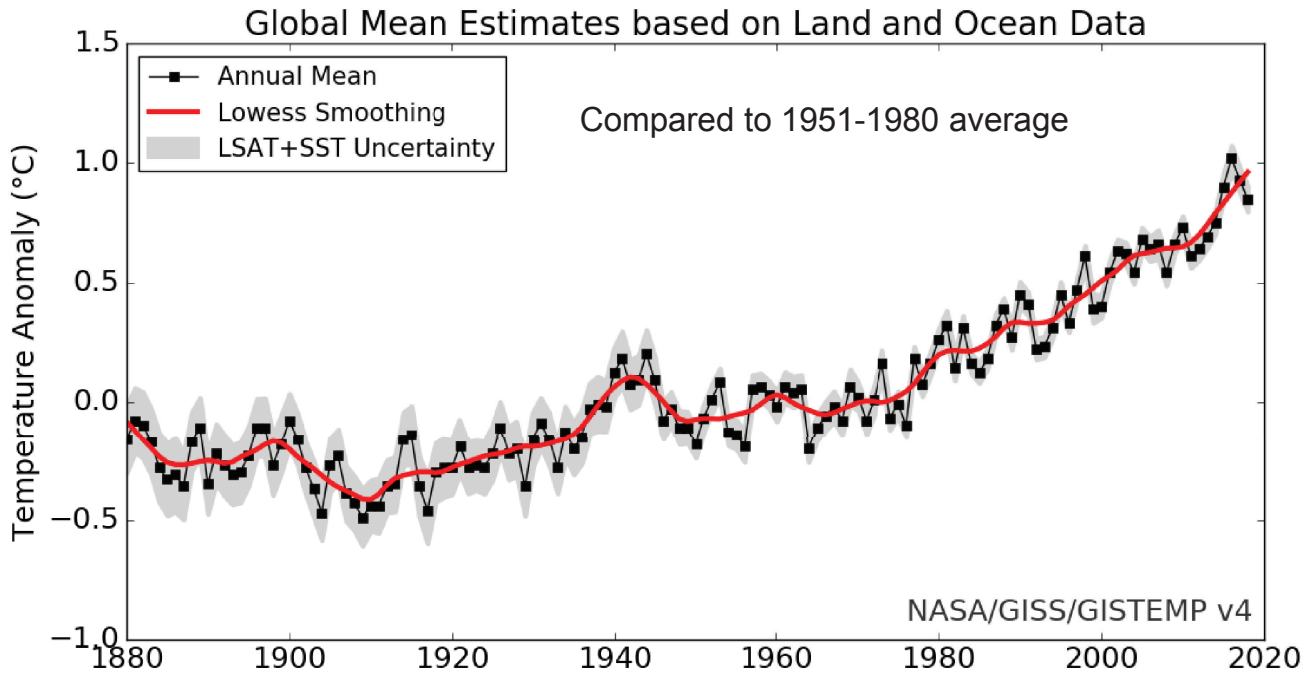


https://climate.nasa.gov/news/2841/2018-fourth-warmest-year-in-continued-warming-trend-according-to-nasa-noaa/



https://data.giss.nasa.gov/gistemp/graphs/

Temperature anomaly: difference between temperature at a specific time to a 30 yr average



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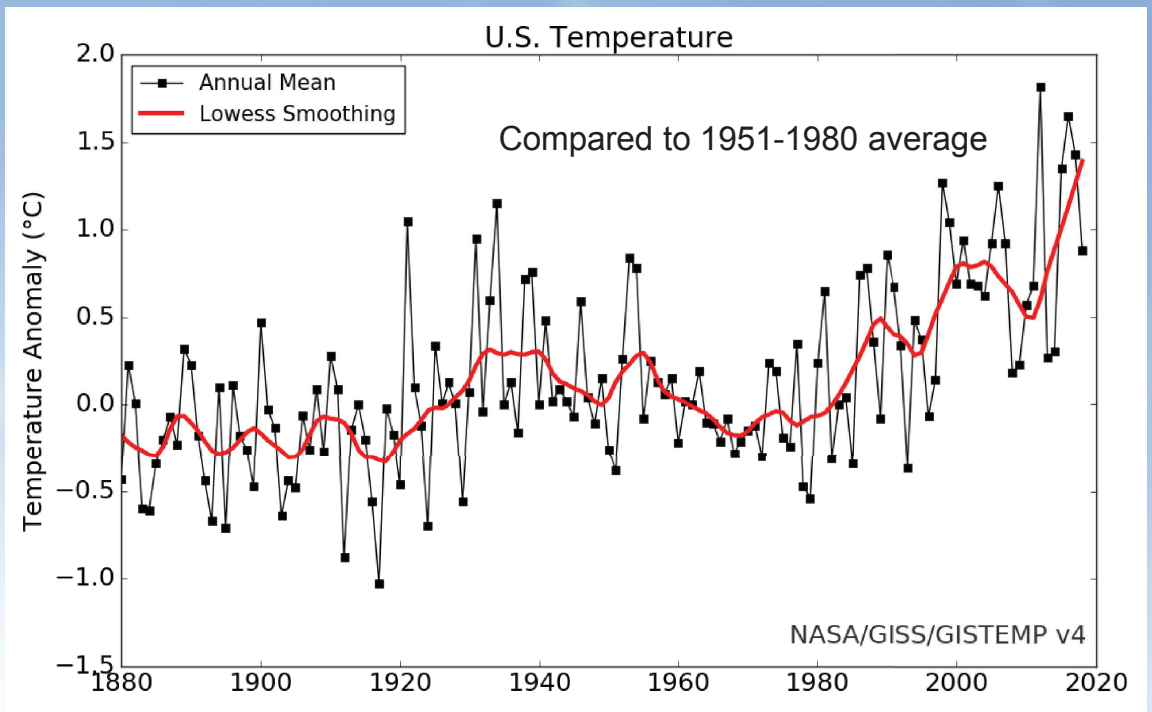
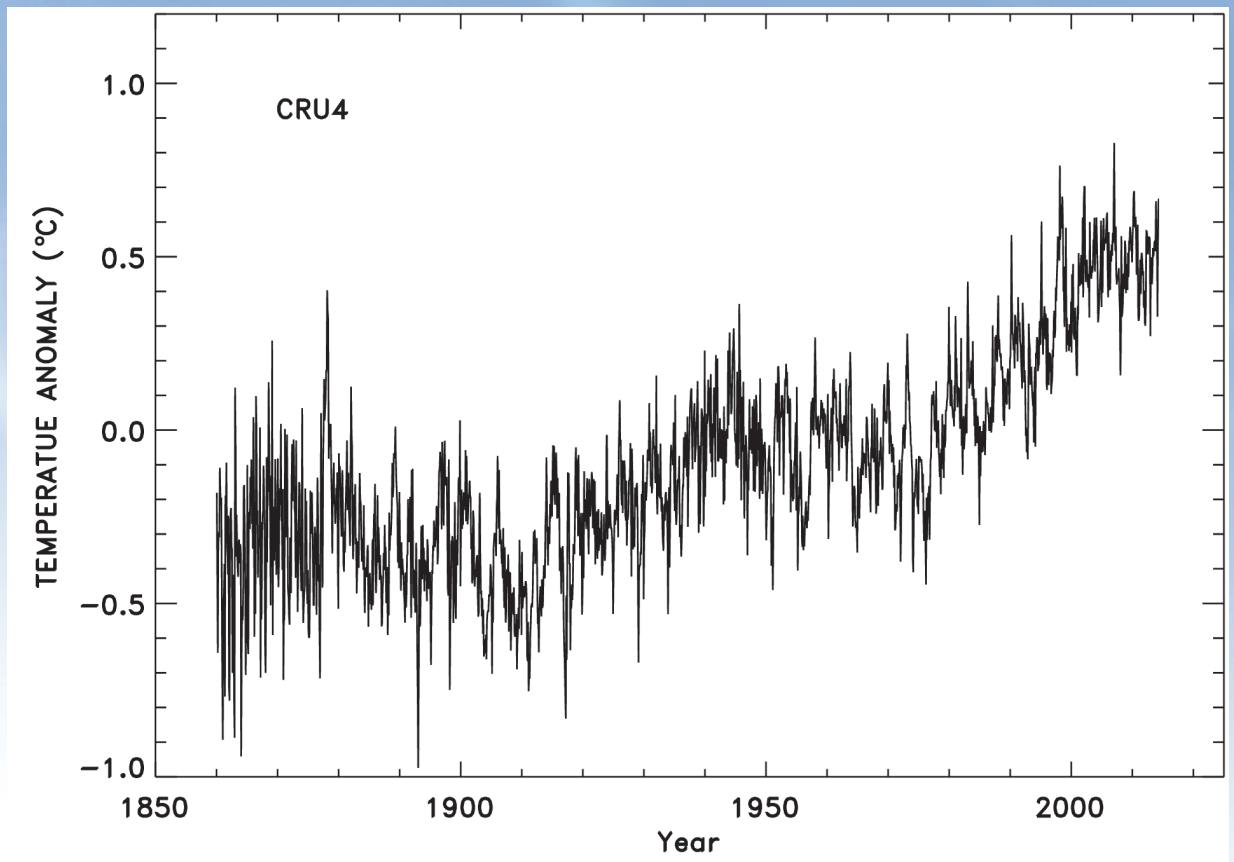
Temperature anomaly: difference between temperature at a specific time to a 30 yr average

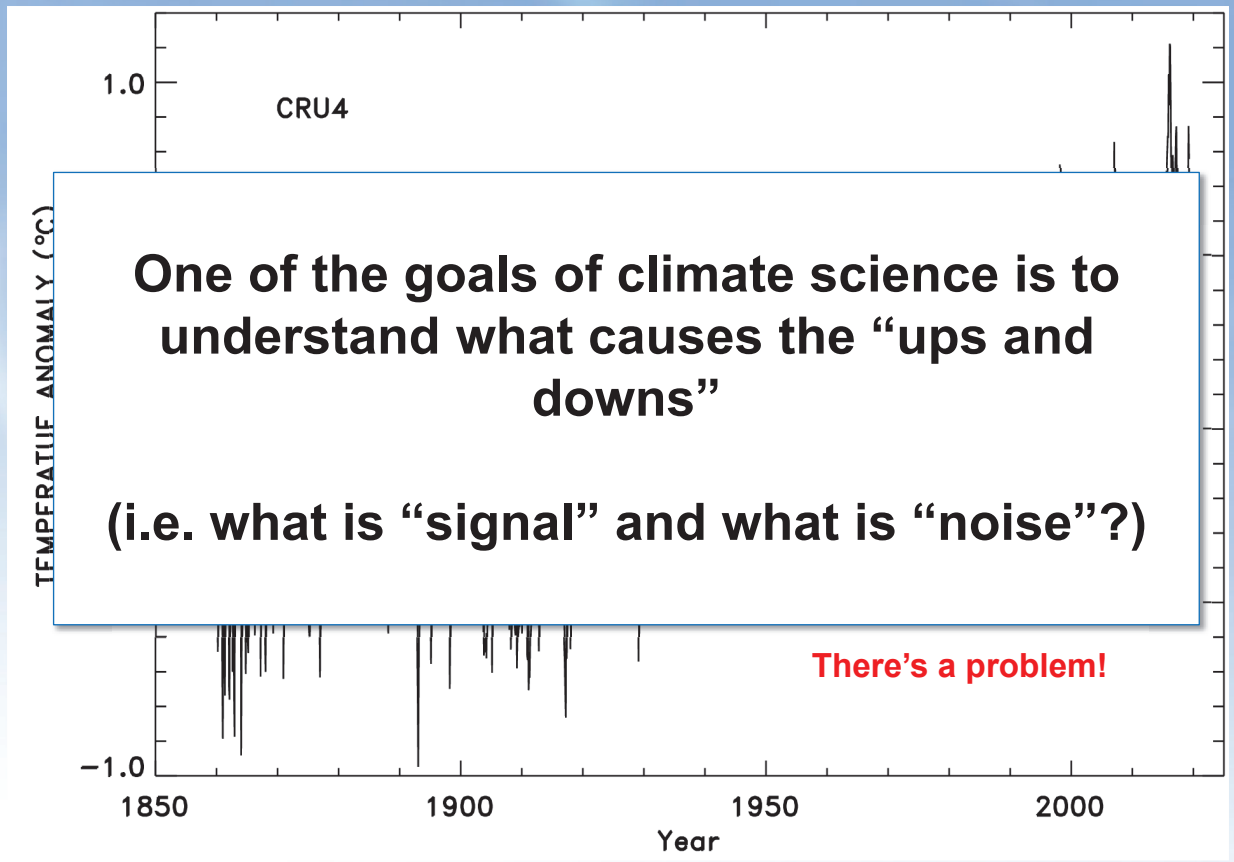


http://data.giss.nasa.gov/gistemp/graphs/

Global Monthly Temperature



Global Monthly Temperature



One of the goals of climate science is to understand what causes the "ups and downs"

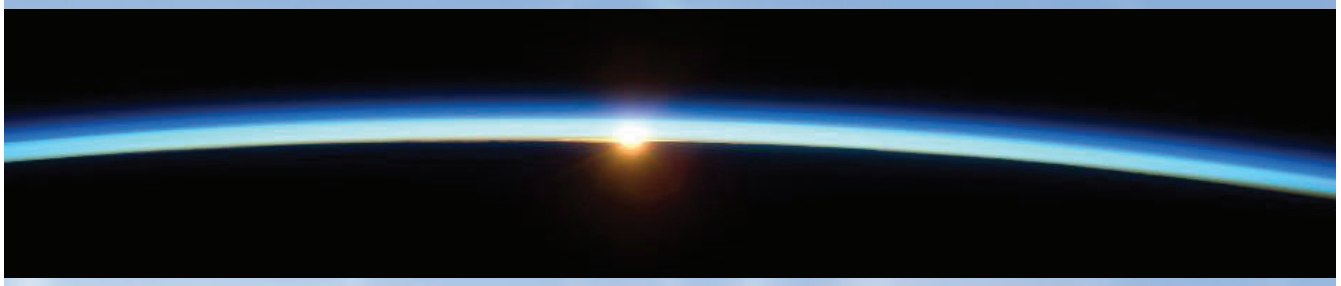
(i.e. what is "signal" and what is "noise"?)

There's a problem!

Weather and Climate

1°C rise in temperature…..so what?

Understanding the Atmosphere



Weather and climate are easy to talk about. Do a google search on the words "climate change" and see how many hits you get.

As scientists, we need to understand fundamentally what affects both weather and climate and how the two can interact.

This means we're going to have to dig into some details.

Meteorological Observations

Can be as simple as checking the thermometer outside

Can be as complicated as the next generation of weather satellite

https://www.nesdis.noaa.gov/GOES-16

Meteorological Observations

Temperature: A measure of the kinetic energy of molecules

Kinetic Energy: energy of motion

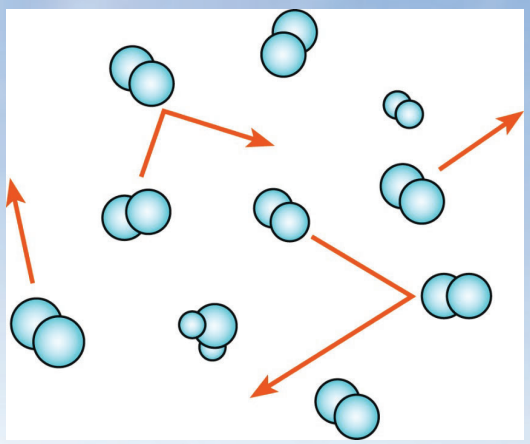


Fig 1-1 *Weather: A Concise Introduction*

Meteorological Observations

Celsius: melting point of water is 0°C and the boiling point is 100°C.

Fahrenheit: melting point of water is 32°F and the boiling point is 212°F.

Kelvin: similar to Celsius but the coldest temperature is 0K. (Kelvin scale never goes negative)

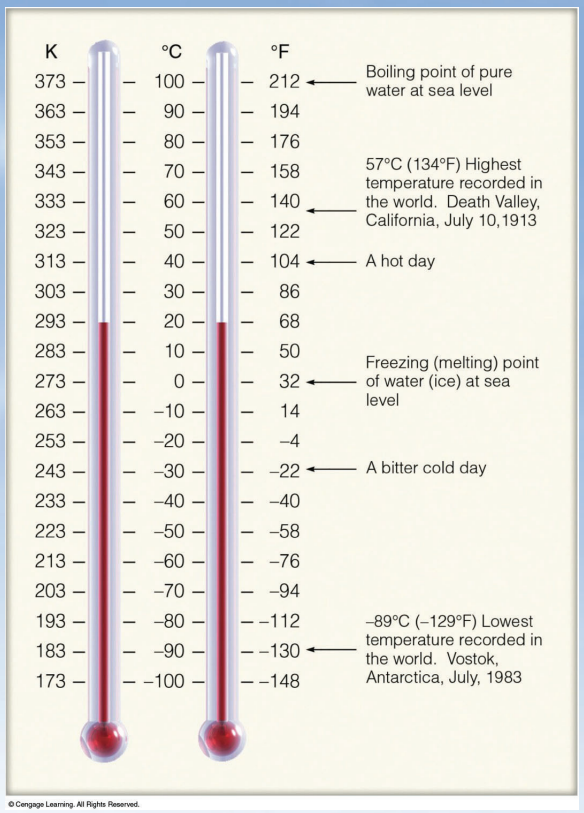


Fig 2.2: *Essentials of Meteorology*

Meteorological Observations

We measure temperature using a thermometer

Must remember that temperature and pressure are closely related

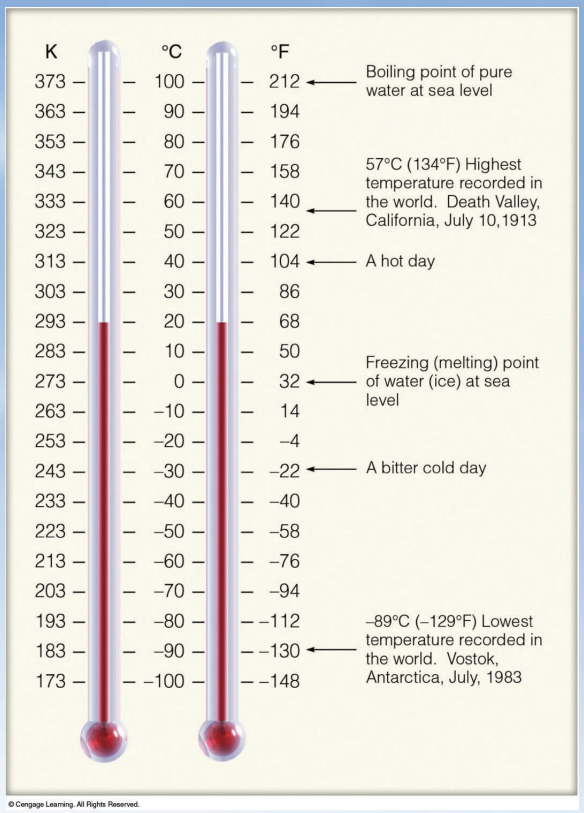


Fig 2.2: *Essentials of Meteorology*

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Understanding Pressure

Ideal Gas Law

pressure × volume = constant × temperature

or

pressure = density × temperature × constant

Understanding Pressure
(for the uber nerds and students in AOSC 201)

Ideal Gas Law

pressure = density × temperature × constant

sometimes written as

$$p=Nk_bT$$

where

p = pressure (mbar)
N = number density (or concentration) (molecules / cm^3)
K_b = Boltzmann's constant (1.38 x 10^{-19} mbar • K^{-1} • cm^3)
T = temperature (Kelvin)

Temperature and Density

Ideal Gas Law

$$\text{pressure} \times \text{volume} = \text{constant} \times \text{temperature}$$

As temperature rises either pressure increases or volume increases

Temperature and Density

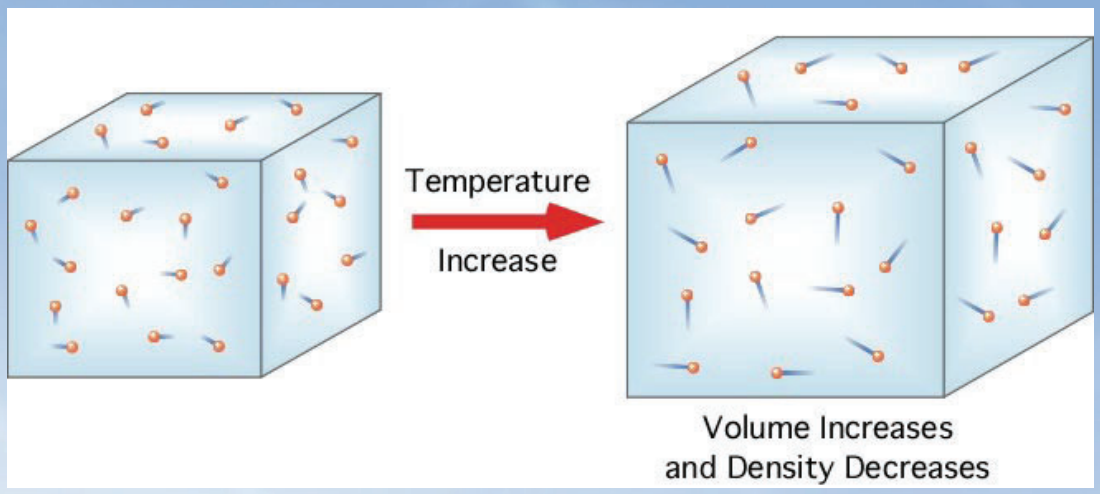
Ideal Gas Law

$$\text{pressure} = \text{density} \times \text{temperature} \times \text{constant}$$

$$\text{density} = \frac{\text{pressure}}{\text{temperature} \times \text{constant}}$$

As temperature rises, density falls

Temperature and Density



As temperature rises and the parcel expands the air inside the parcel gets less dense

(all of the air molecules are spread out over a larger volume)

http://www.our-planet-earth.net/learning/3c.html

Understanding Pressure

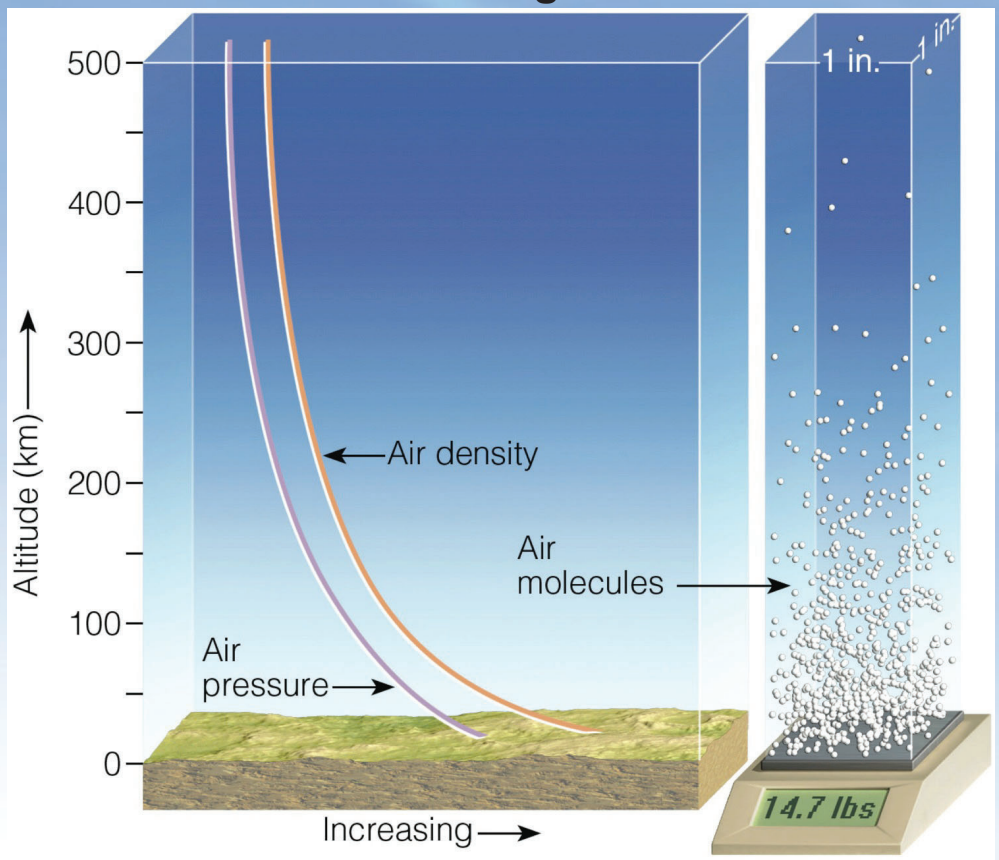
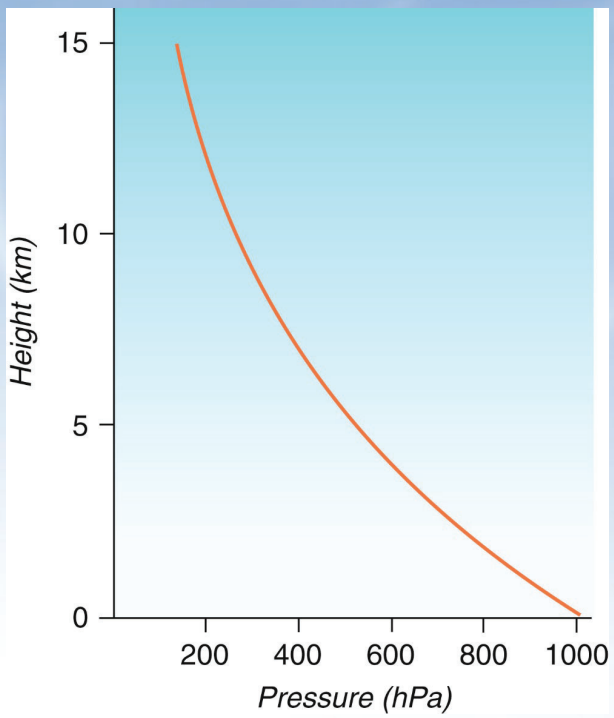


Fig 1.7: ***Essentials of Meteorology***

Understanding Pressure

Fig 1-6 *Weather: A Concise Introduction*



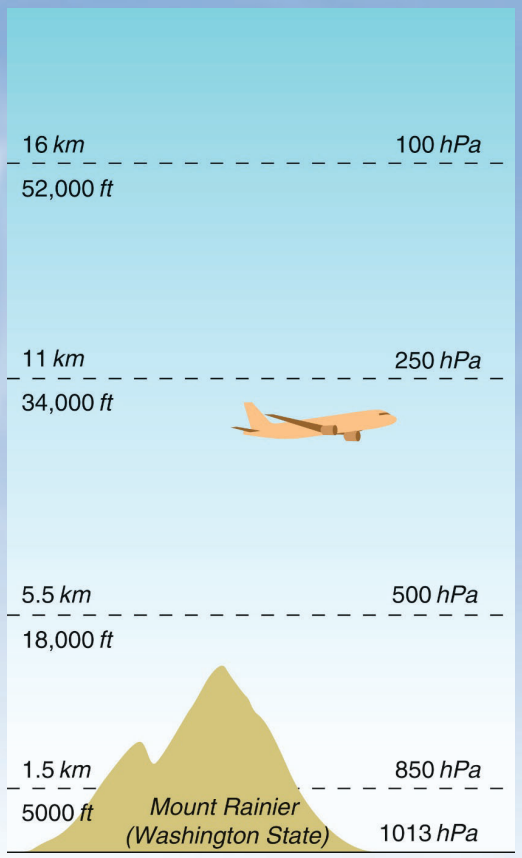


Fig 1-9 *Weather: A Concise Introduction*

Understanding Pressure

We measure pressure using a barometer.

In meteorology the terms we use to describe pressure is

hPA "hectopascal"

or

mbar "millibar"

(They're the same thing!)

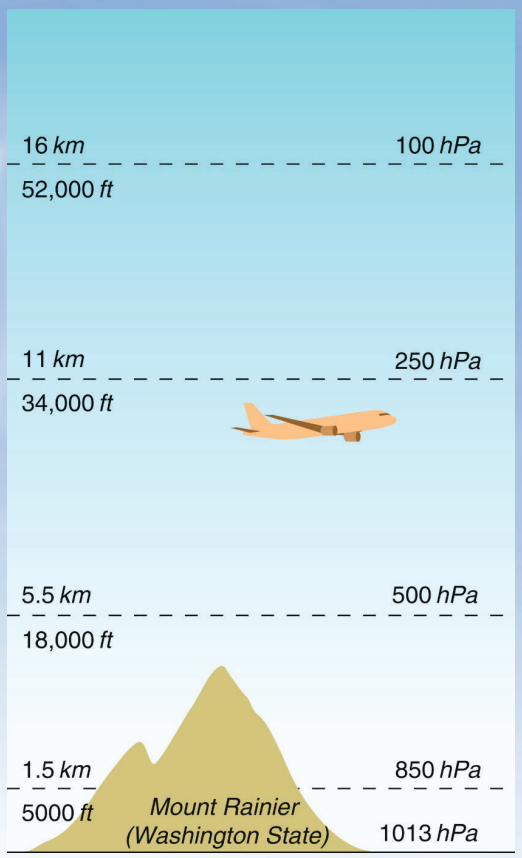
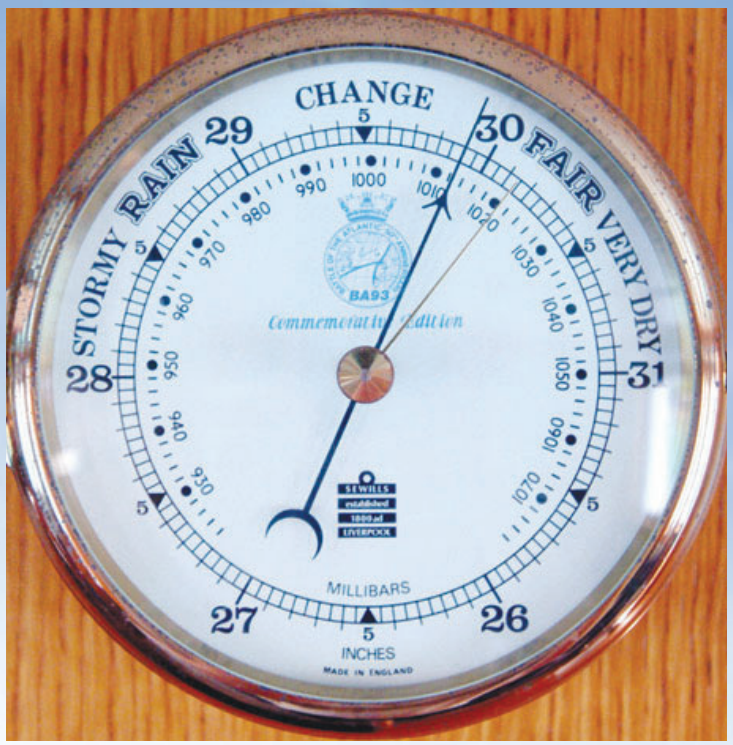


Fig 1-9 *Weather: A Concise Introduction*

Pressure: Aneroid Barometer

Low Pressure



High Pressure

Fig 5-3b *Meteorology: Understanding the Atmosphere*

Wind Speed and Direction

A wind vane points in the direction the wind is coming from

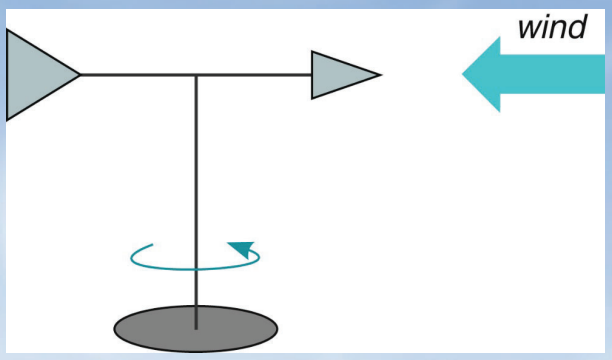


Fig 1-10 *Weather: A Concise Introduction*

A westerly wind means winds are coming from the west

Can also use degrees from North.

(can you spot the mistake in the figure?)

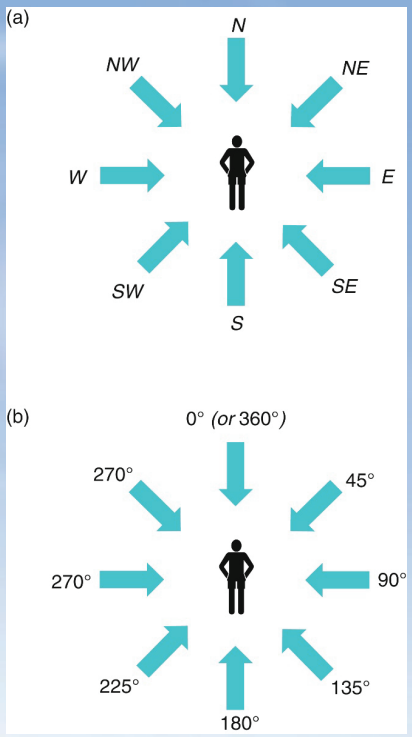


Fig 1-11 *Weather: A Concise Introduction*

Wind Speed and Direction

An anemometer measure wind speed

Fig 5-5 *Meteorology: Understanding the Atmosphere*

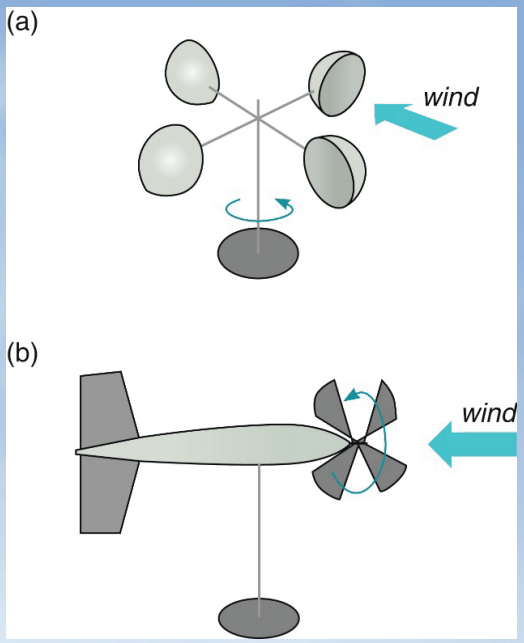
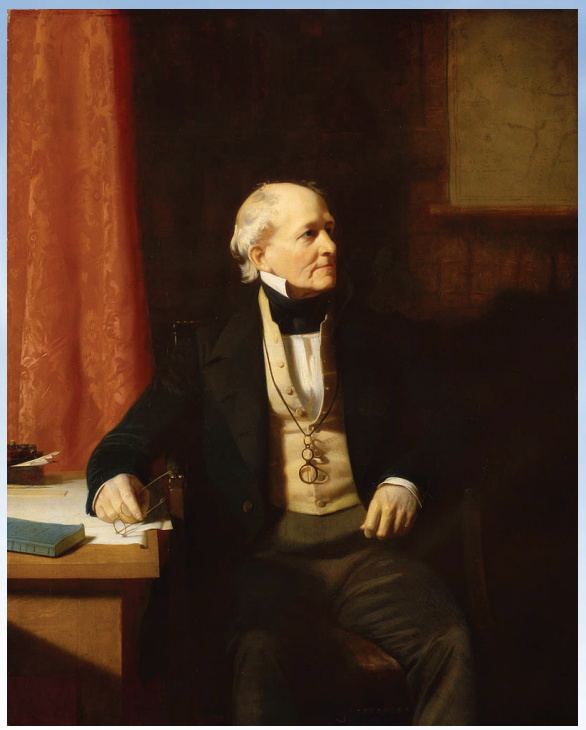


Fig 1-12 *Weather: A Concise Introduction*

Wind Speed and Direction

Beaufort Scale: Devised in 1805 to standardize reporting of wind based on observable conditions. This did not require exact knowledge of wind speed.



Beaufort Scale

Beaufort number	Wind Speed (mph)	Seaman's term		Effects on Land
0	Under 1	Calm		Calm; smoke rises vertically.
1	1-3	Light Air		Smoke drift indicates wind direction; vanes do not move.
2	4-7	Light Breeze		Wind felt on face; leaves rustle; vanes begin to move.
3	8-12	Gentle Breeze		Leaves, small twigs in constant motion; light flags extended.
4	13-18	Moderate Breeze		Dust, leaves and loose paper raised up; small branches move.
5	19-24	Fresh Breeze		Small trees begin to sway.
6	25-31	Strong Breeze		Large branches of trees in motion; whistling heard in wires.
7	32-38	Moderate Gale		Whole trees in motion; resistance felt in walking against the wind.
8	39-46	Fresh Gale		Twigs and small branches broken off trees.
9	47-54	Strong Gale		Slight structural damage occurs; slate blown from roofs.
10	55-63	Whole Gale		Seldom experienced on land; trees broken; structural damage occurs.
11	64-72	Storm		Very rarely experienced on land; usually with widespread damage.
12	73 or higher	Hurricane Force		Violence and destruction.

Rain: rain gauge

Measures total rainfall over a time period but it has to be emptied periodically

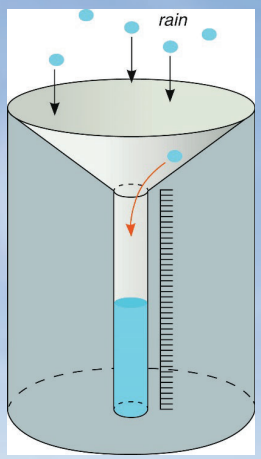
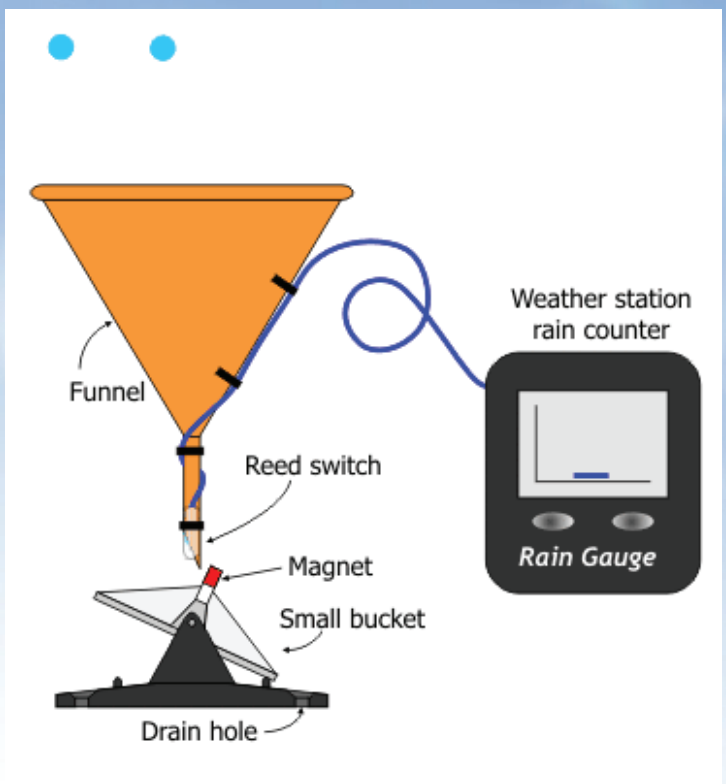


Fig 1-17 *Weather: A Concise Introduction*

Rainfall less than 1mm is reported as a "trace" amount

Rain: tipping bucket rain gauge



After the bucket fills and tips, a small signal is sent and recorded

Meteorological Observations

Automated Surface Observing System (ASOS)

Meteorological Observations

Automated Surface Observing System (ASOS)

Measures:

- cloud height
- visibility
- precipitation
- pressure
- temperature
- dew point
- wind direction
- wind speed
- rainfall amount

Meteorological Observations: College Park

Weather observations for the past three days

College Park Airport

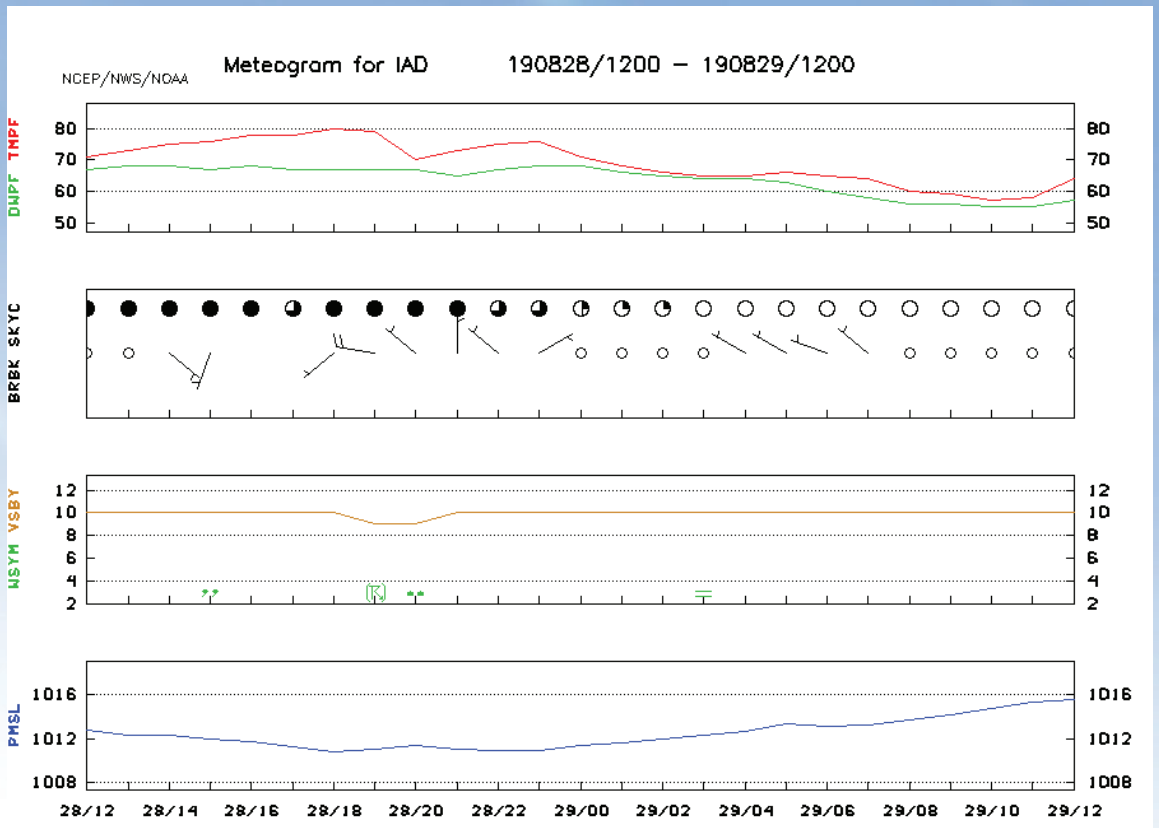
weather.gov

Enter Your "City, ST" or zip code Go metric

Date	Time (edt)	Wind (mph)	Vis. (mi.)	Weather	Sky Cond.	Temperature (°F)				Relative Humidity	Wind Chill (°F)	Heat Index (°F)	Pressure		Precipitation (in.)		
						Air	Dwpt	6 hour Max.	6 hour Min.				altimeter (in)	sea level (mb)	1 hr	3 hr	6 hr
29	08:03	NW 5	10.00	Fair	CLR	67	54			62%	NA	NA	29.97	NA			
29	07:03	NW 3	10.00	Fair	CLR	62	54			74%	NA	NA	29.96	NA			
29	06:43	Calm	10.00	Fair	CLR	61	54			76%	NA	NA	29.96	NA			
29	06:03	Calm	10.00	Fair	CLR	65	54			67%	NA	NA	29.94	NA			
29	05:03	Calm	10.00	Fair	CLR	65	55			69%	NA	NA	29.93	NA			
28	22:43	Calm	10.00	Fair	CLR	NA	NA			NA	NA	NA	29.88	NA			
28	22:03	Calm	10.00	Partly Cloudy	SCT110	65	63			94%	NA	NA	29.88	NA			
28	21:43	Calm	10.00	Partly Cloudy	SCT110	65	63			93%	NA	NA	29.87	NA			
28	21:03	Calm	10.00	Mostly Cloudy	BKN110	66	63			89%	NA	NA	29.87	NA			
28	20:43	Calm	10.00	Mostly Cloudy	BKN110	67	60			78%	NA	NA	29.87	NA			
28	20:23	Calm	10.00	Mostly Cloudy	BKN100	68	59			75%	NA	NA	29.87	NA			
28	20:03	Calm	10.00	Partly Cloudy	SCT100	69	59			72%	NA	NA	29.86	NA			
28	19:43	Calm	10.00	Mostly Cloudy	BKN100	70	59			68%	NA	NA	29.86	NA			
28	19:23	N 3	10.00	Mostly Cloudy	BKN100	71	59			66%	NA	NA	29.86	NA			
28	19:03	N 5	10.00	Overcast	OVC100	72	58			63%	NA	NA	29.85	NA			
28	18:43	N 7	10.00	Overcast	OVC100	72	58			62%	NA	NA	29.85	NA			
28	18:03	N 6	10.00	Overcast	SCT049 SCT070 OVC110	72	65			80%	NA	NA	29.85	NA			
28	17:43	NW 7	10.00	Overcast	BKN060 OVC070	71	65			81%	NA	NA	29.85	NA			
28	17:23	N 6	10.00	Overcast	SCT039 SCT045 OVC060	72	65			79%	NA	NA	29.84	NA			
28	17:03	NW 9 G 16	10.00	Overcast	OVC039	72	66			83%	NA	NA	29.85	NA			

http://w1.weather.gov/obhistory/KCGS.html

Meteorological Observations: Meteogram



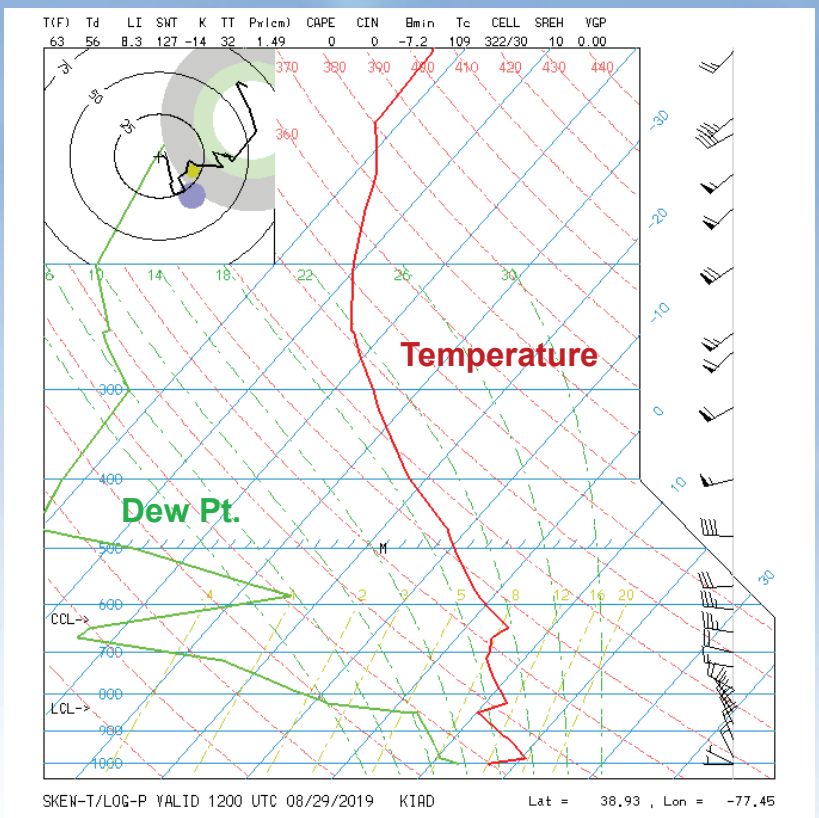
https://www.ametsoc.org/amsedu/dstreme/images/met_IAD.gif

Radiosondes

Weather doesn't just happen at the surface!!!

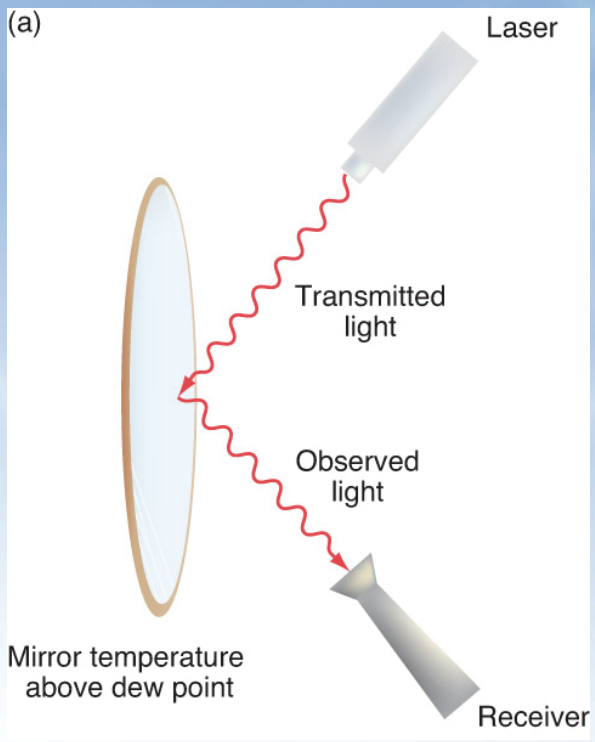
Radiosondes

Position of balloon



http://weather.rap.ucar.edu/upper/iad.gif

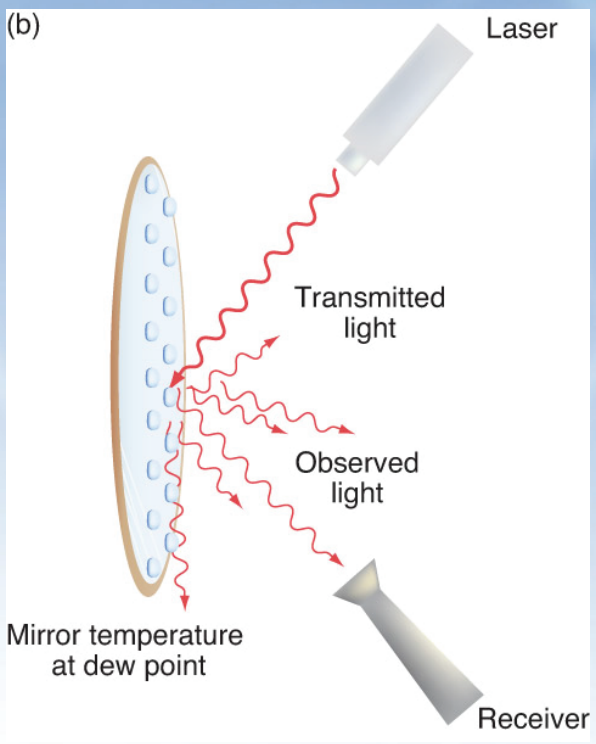
Dew Point Hygrometer



When temperature is above the dew point, observed light is unchanged

Fig 5-3a *Meteorology: Understanding the Atmosphere*

Humidity: Dew Point Hygrometer



When temperature reaches dew point, water condenses on surface and observed light is scattered

Fig 5-3b *Meteorology: Understanding the Atmosphere*