

Topic 17: Heat Waves and Great Storms

<https://geowiki.ucsd.edu/sio15>

test #5 today, due by midnight
topics 14-16, HW3
late submission subject to point reduction

short videos are
test material!

HW#5 due tomorrow
late submissions not eligible for extra/bonus credit

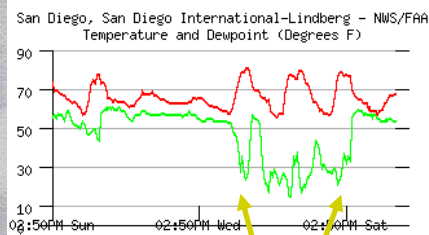
discussion session (TAs): 4 pm York 3030

office hour (Laske): 5 pm Zoom

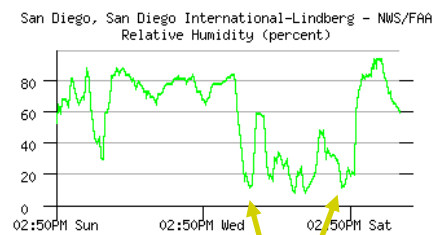
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Temperature and Dew Point

Student Question: Can T every go below dew point?



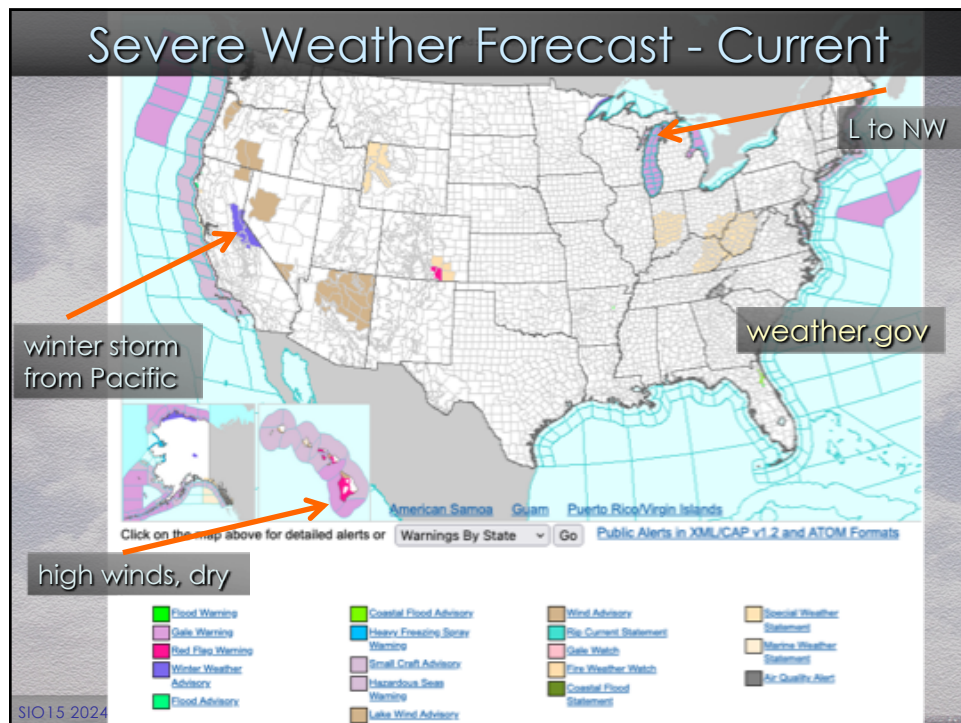
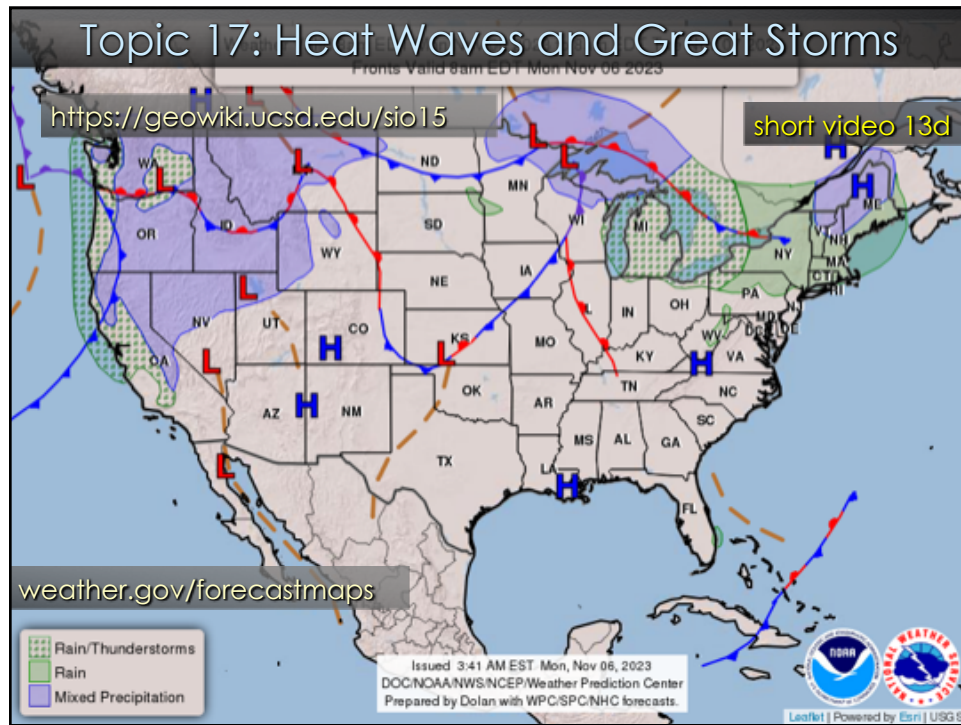
Santa Ana



Santa Ana

T air with current rel. hum. cannot go below dew point!

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Weather and Climate Extremes

highest T (global): 58°C (136°F) Libya (until 2012)
(N.A.): 57°C (134°F) Death Valley, CA

lowest T (global): -89°C (-129°F) Vostok, Antarctica
(N.A.): -63°C (-81°F) Yukon, Canada

top of troposphere: -60°C (-80°F)

Mercury:	day: 427°C	night: -173°C
Venus:	day/night: 462°C (865°F)	
Mars:	day: 20°C	night: -140°C

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Topic 1 - Fatalities from Heat Waves in the U.S.

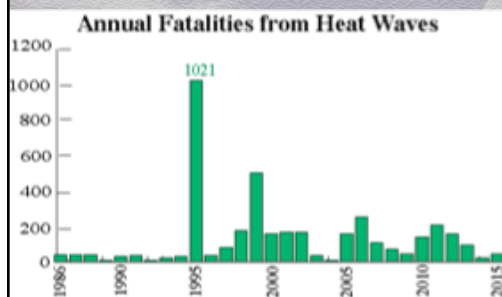
definitions vary!
depends on country/state/location/organization

World Meteorological Organization:

"daily max. temp exceeds average max. temp by 5°C (9°F) for > 5 consecutive days"

short video 13a

impact of heat waves
increasing



Typical Year - Last 20 Years
Hurricanes: 32
Heat Waves: 112

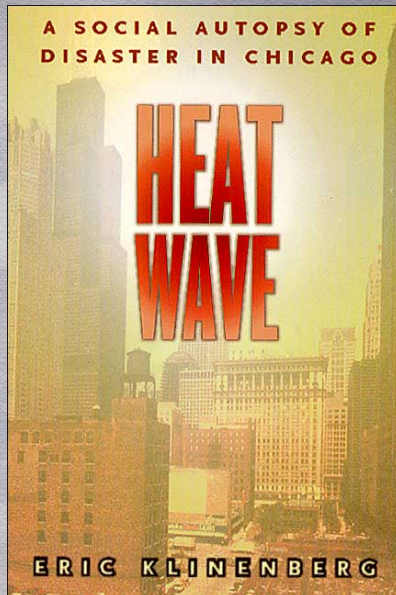
**Heat is currently #1 killer
and costs most!**

2003 Europe: 35k+
2010 Russia: 56k
2021 Pac NW: 1,400+
2022 Europe: 23k+

short video 13b

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Topic 1: The 1995 Chicago Heat Wave



- 700 fatalities in Chicago alone (> 1000 total)
- elderly (single males)
- poor, no functioning A/C
- black neighborhood

Aggravating Factors:

- **heat index**
- urban heat island effect
- power outages
- overtaxed emergency services
- lack of preparedness

high crime rate
-> people afraid of opening windows

short video 13b

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Poll

Question:

which heat is more dangerous: dry heat, moist heat?

short video 13a,b

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The Heat Index

- heat index: how hot air feels
- rel. humidity increases apparent T

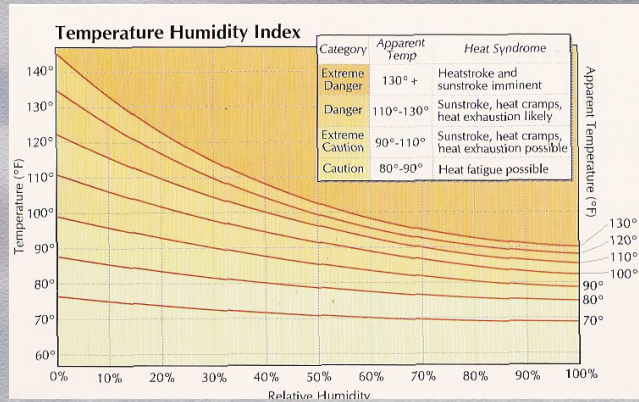


Fig 13.10

humid air:
sweat can't evaporate

short video 13a

Urban heat island:
* Paved surfaces retain heat
* Lack of trees
-> no evaporation

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The July 12-17, 1995 Chicago Heat Wave

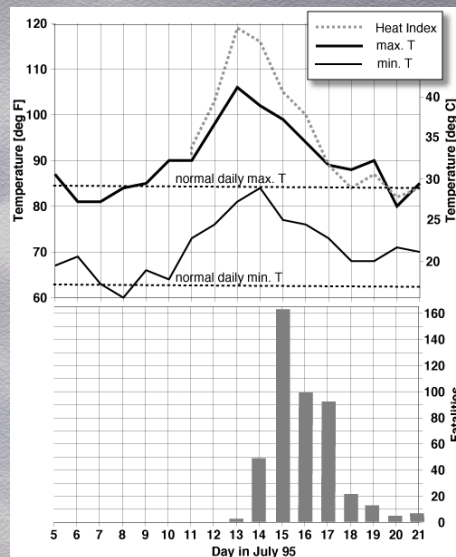


Fig 13.33

- ① prolonged
- ② $T > 100^{\circ}\text{F}$
humidity $> 50\%$ \Rightarrow HI 120°F
- ③ daily low above 80°F !

death rate lagged heat index!

- humans can cope for a while
- but, overtaxed emergency services -> lack of help

short video 13b

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Poll

Question:

When was the worst heat wave in the U.S.?

- 1900s
- 1930s
- 1970s
- 2011
- 2023

short video 13a,b

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Droughts, e.g. Dust Bowl in 1930s

- most intense heat wave in U.S.:
summer of 1936 (July-Aug);
absolute T record in 15 states (records still stand as of 2011)
(some surpassed in 2012??)
121°F in North Dakota!

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- Massive dust storms
- Aggressive Agriculture
- Soil Erosion (across Atlantic)

In U.S., it takes 30 year to
Grow 1 inch of topsoil

short videos 13a,b

2011 Texas Drought short video 13b

Sep 2011 (> 2 fatalities):

- * prolonged drought conditions
- strong winds
- driven by remnants of hurricane
- > 2000 homes destroyed
-aggressive development into wildland (just like S.D.) !

Oct 2011:

- * prolonged drought conditions
- strong winds
- 8000 ft high haboob
- driven by leading edge of cold front



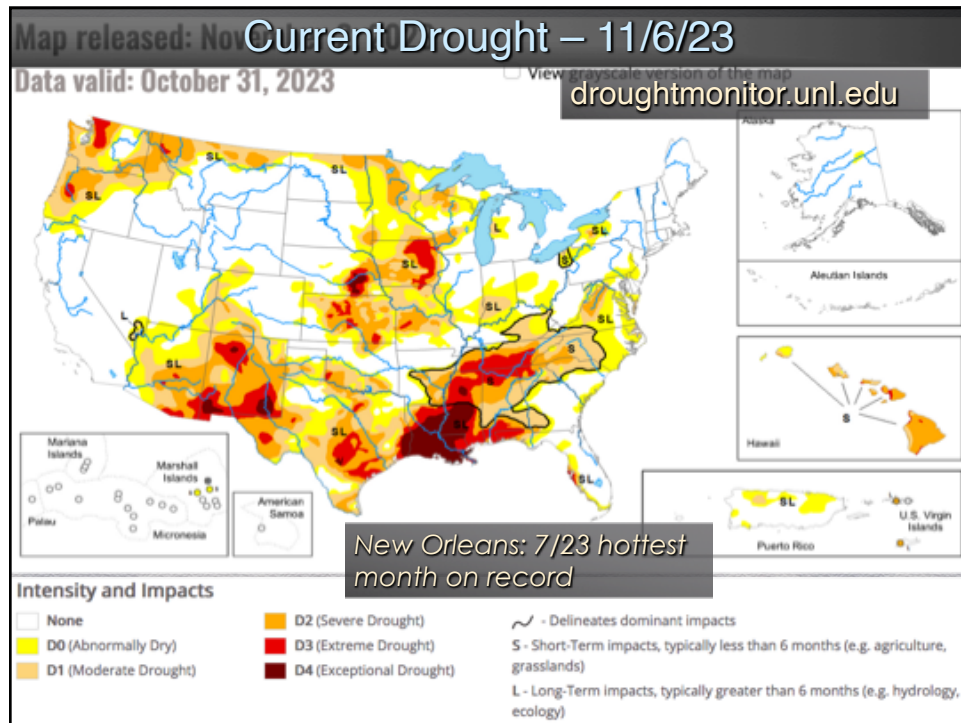

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2011 Texas Drought short video 13b

✧ wide-spread starvation/slaughter of cattle

✧ subsequent high prices for beef

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Cold Storms short video 13c

- arctic air spreads unusually far south
- ice storms:
rain falls at same time when
ground below freezing

greatest cold wave in U.S.:
10-14 Feb 1899
(Tallahassee -2°F ;
snow in New Orleans, 6.8°F;
ice floes into Gulf of Mexico)
100 deaths

also known as:
"Great Arctic Outbreak of 1899"
"Great Blizzard of 1899"

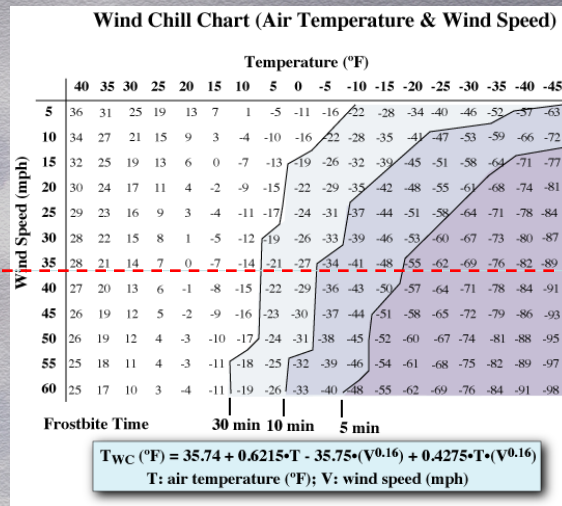
Snowball fight at Capitol Tallahassee

source: Wikipedia

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The Wind Chill Factor

short video 13c



- wind chill factor: winds blow away warm air around skin -> feels colder

- effect stronger at lower temperature

35 mph
(criterion for blizzard)

Fig 13.19

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Blizzards

short video 13c



criteria vary by country

in U.S.:


- sustained winds > 35 mph (56 km/h)
- duration: > 3h
- blowing snow
- visibility < 0.25 mi

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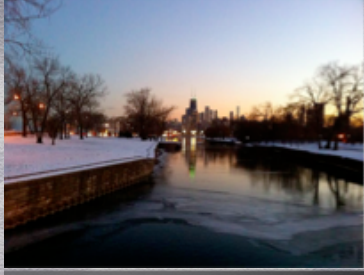
Blizzards

short video 13c

Groundhog Day Blizzard 2011 (ORD 1300 flights cancelled)



Chicago's Fullerton Harbor




... normally ...

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Blizzards

Groundhog Day Blizzard 2011; Chicago's Lake Shore Dr.



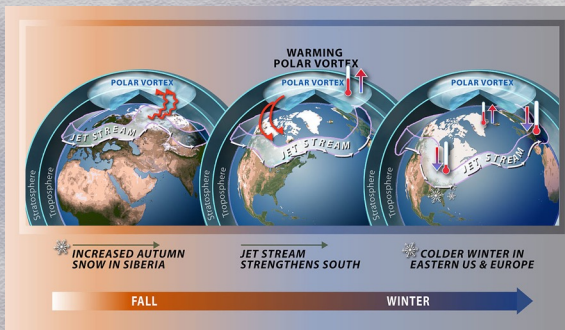
Also affected: Texas!

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The 2014 “Polar Vortex” short video 13c

2014 “Polar Vortex” event
 -Dec 1 – Apr 10
 -\$5 billion damage
 -21 fatalities
 -200 M people affected
 (transportation/electricity)

record T broken 5-7 Jan:
 (7 Jan, > 49 record lows across country)
 Green Bay, WI -18°F (1979)
 Chicago O'Hare, -16°F (1184/1988)
 Babbitt, MN -37°F coldest in U.S. 6 Jan
 Atlanta, GA 6°F (1970)
 Dallas, TX 16°F (??)

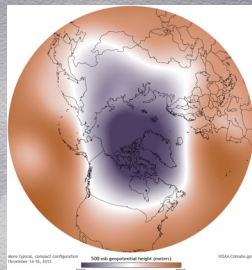


source: NSF/Wikipedia

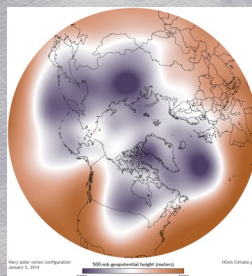
*Media confuse meaning
 Of Polar Vortex*

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The Polar Vortexit's NORMAL!



normal/strong **polar vortex**:
 large mass of cold air sinks -> surface H
 upper level L -> vortex (air goes W->E)
 jet stream around restricts cold air toward N
 stable over long time

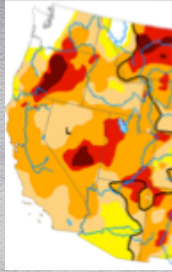


Breakdown not normal

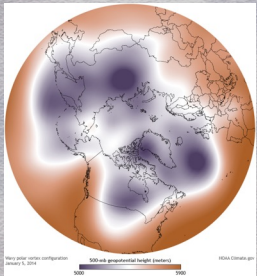
weak polar vortex (the media's “**Polar Vortex**”):
 warming in stratosphere
 -> upper level L disorganized
 -> jet stream undulates
 cold Arctic surface air allowed to reach far S

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Global Warming



BIG QUESTION:
Don't we just get more (extreme) heat waves?



SCIENCE:
Not necessarily
Instead: **MORE WEATHER EXTREMES**
first evidence points to warming Arctic
3x faster than the rest of N. hemisphere

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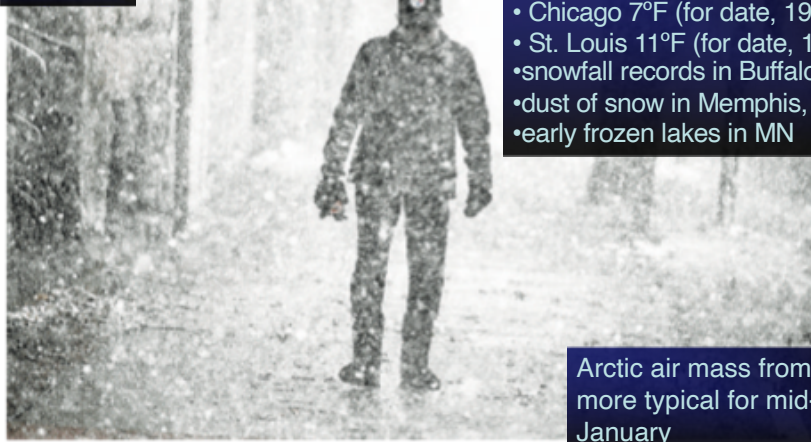
Poll

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The Fall 2019 “Arctic Blast”

source: S.D. Union Tribune

11/13/19



- 100s schools closed in northern New England
- Chicago 7°F (for date, 1986)
- St. Louis 11°F (for date, 1911)
- snowfall records in Buffalo, Detroit
- dust of snow in Memphis, TN
- early frozen lakes in MN

Arctic air mass from Siberia more typical for mid-January

A pedestrian walks through a snow squall in downtown Johnstown, Pa., on Tuesday. Snow and icy conditions snarled traffic in parts of Pennsylvania as road crews treated surfaces because of the bitter cold.

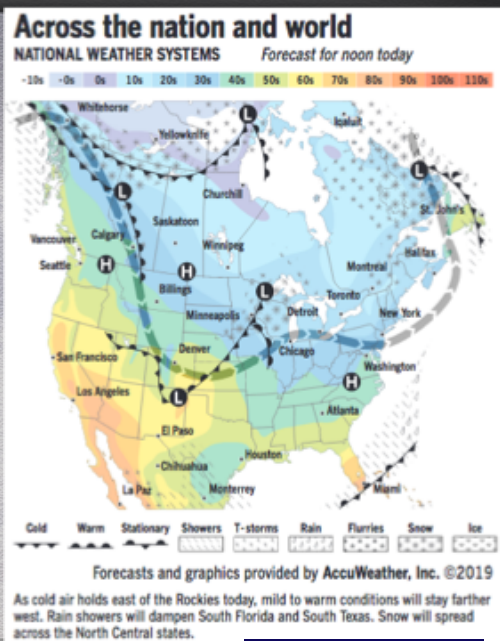
ARCTIC BLAST DRIVES RECORD LOW TEMPERATURES

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The Fall 2019 “Arctic Blast”

Nov 2019:
jet stream unusually far south

Normally, polar jet stream
Stays north in winter



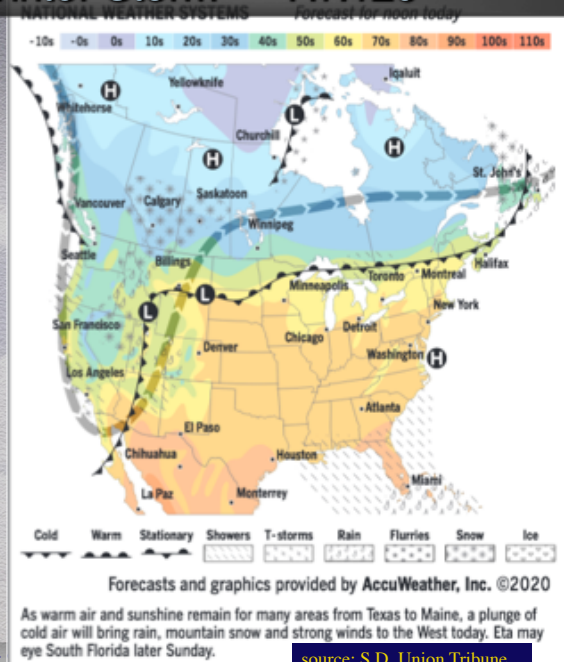
SIO15 2024: Topic 17 - Heat Waves and Great Storms

source: S.D. Union Tribune

Fall 2020 “Winter Storm” – 11/7/20

7 Nov 2020:
jet stream with extreme
Excursion - west

Normally, polar jet stream
Stays north in winter

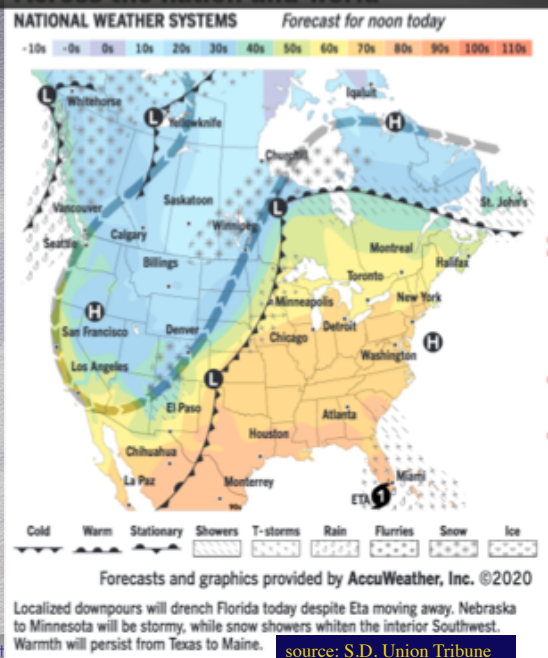


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Fall 2020 “Winter Storm” – 11/9/20

9 Nov 2020:
jet stream with extreme
Excursion - west

Normally, polar jet stream
Stays north in winter



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The Costliest Disasters in U.S. History

- **2021 Texas Freeze (\$197 Billion)**
- 2005 Hurricane Katrina (\$125 Billion)
- 2017 Hurricane Harvey (\$125 Billion)
- 2017 Hurricane Maria (\$92 Billion)
- 2012 Superstorm Sandy (\$69 Billion)
- 2021 Hurricane Ida (\$65 Billion)
- 2017 Hurricane Irma (\$ 65 Billion)
- **1989 N. A. Drought (\$53 Billion)**
- **2014 N.A. Drought (> \$50 Billion)**
- **1994 Northridge Earthquake (\$49 Billion)**
- 2008 Hurricane Ike (\$38 Billion)
- 2005 Hurricane Wilma (\$27 Billion)
- 1992 Hurricane Andrew (\$27 Billion)
- 2004 Hurricane Ivan (\$26 Billion)
- 2018 Hurricane Michael (\$25 Billion)
- **2018 Cali Wildfires (\$24 Billion)**
- 2020 Hurricane Laura (\$19 Billion)
- 2005 Hurricane Rita (\$19 Billion)
- 2004 Hurricane Charley (\$17 Billion)
- **1993 Mississippi Flood (>\$ 15 Billion)**
- 2016 Hurricane Matthew (\$15 Billion)

... NEVER MENTIONED IN ANY OFFICIAL LIST

Prolonged Floods: underappreciated less newsworthy No flood insurance

... but this one is SCARY !!!!

Not inflation-adjusted

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Source: wikipedia

The Feb 2021 Texas Freeze

Disaster in the Making

Groundhog Day blizzard
-> rolling blackouts over >75% of TX
-> boil-water advisories

Mid-Feb
* series of severe winter storms
* jet stream far south
-> record low T across TX (colder than Anchorage, AK)

13 Feb
Storm from Pac NW
- > 75% of lower 48 covered in snow
-> 10M people lost power (5.2/4.8 US/Mexico)

Next storm:
4 M lost power; 29 deaths;

- a series of winter storms
- power outages
- damage \$197 B
- 246 fatalities

Similar to Dec 1989 after which advisories to upgrade power grid were ignored
Feb 2011 TX power outage

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Source: wikipedia

The Feb 2021 Texas Freeze

Disaster in the Making

2011 Groundhog Day blizzard

• 246 fatalities

- home poorly insulated
- inefficient electrical heating
- TX power equipment not 'winterized' (equipment froze up)
- Residential water pipes froze/burst
- Food/water shortage
- extremely high power demand
- **Gas prices spiked**

- **car crashes**
- **drownings**
- **hypothermia**
- **house fires**
- **CO poisoning (e.g. run BBQ, generator indoors)**

SIO15 2024: Topic 17 - Heat Waves and Great Storms Source: wikipedia

The Feb 2021 Texas Freeze

Disaster in the Making

• Gas prices spiked
-> electricity prices spiked

Normal:
\$25/MWh

↔

Feb 2021 Texas Freeze
\$9000/MWh

Some folks' electricity bills were \$5000 for 5 days of service!

SIO15 2024: Topic 17 - Heat Waves and Great Storms Source: wikipedia

The Feb 2021 Texas Freeze

Disaster in the Making

Infrastructure

Fire hydrants unusable
 Plumbing in building burst (freezing)
 Damage due to flooding
 Shortage of plumbers
 Pollution due to stop/start of fossil fuel infrastructure
 Contamination of water infrastructure
 Loss of immense amounts of water

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Source: wikipedia

The Feb 2021 Texas Freeze

Disaster in the Making

Politics

figure pointing between state and feds
 Some investigation/discussion/lawsuits

Prep for Future

Little has changed
 el. Grid remains at risk

'winterization' would cost \$85-200 M/year

Cold snap Feb 2022: not as severe;
 12% natural gas systems failed
 Gas production fell 25%

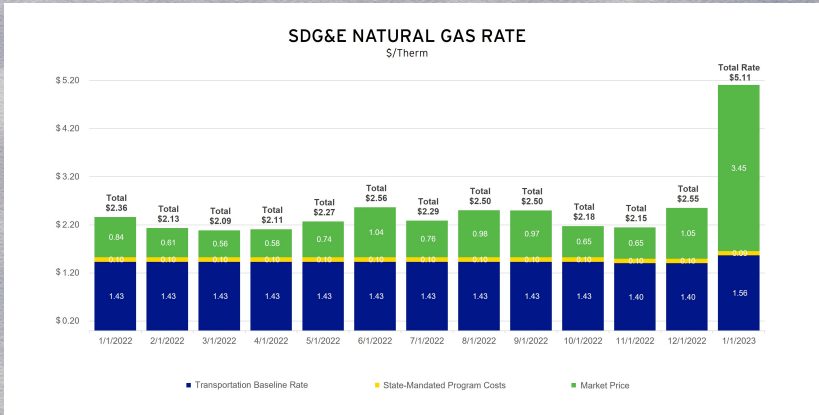
then Cali/SD crisis Jan 2023

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Source: wikipedia

The January 2023 SDG&E Gas Crisis

allegedly low gas storage



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Source: SDG&E

The Jun 2021 OR/WA Heat Wave

S.D. Union Tribune 2/11/22

> 1,400 fatalities



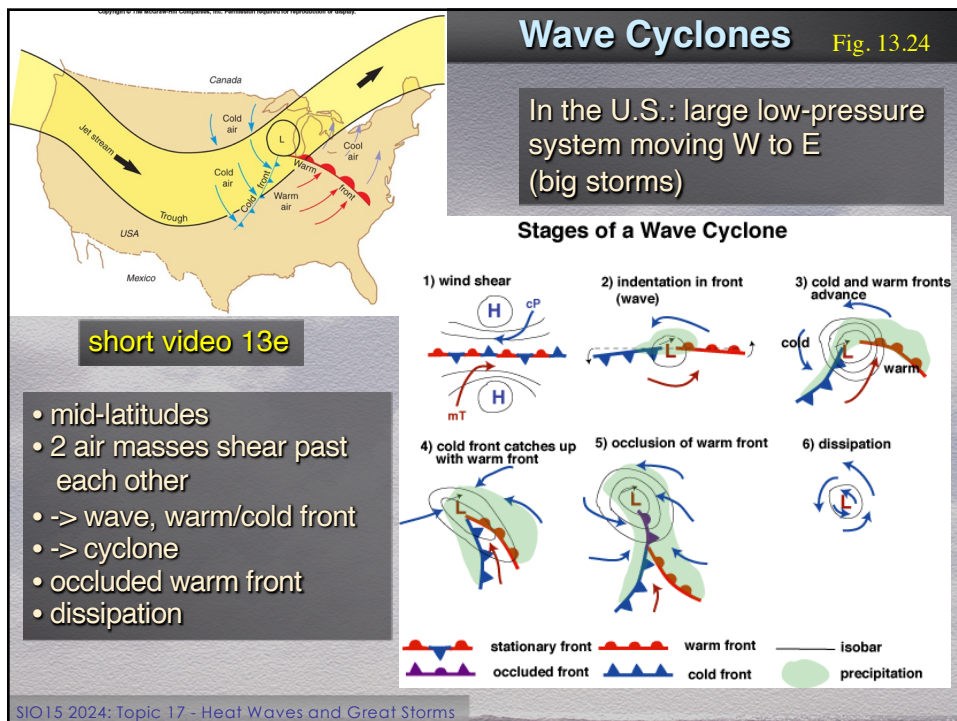
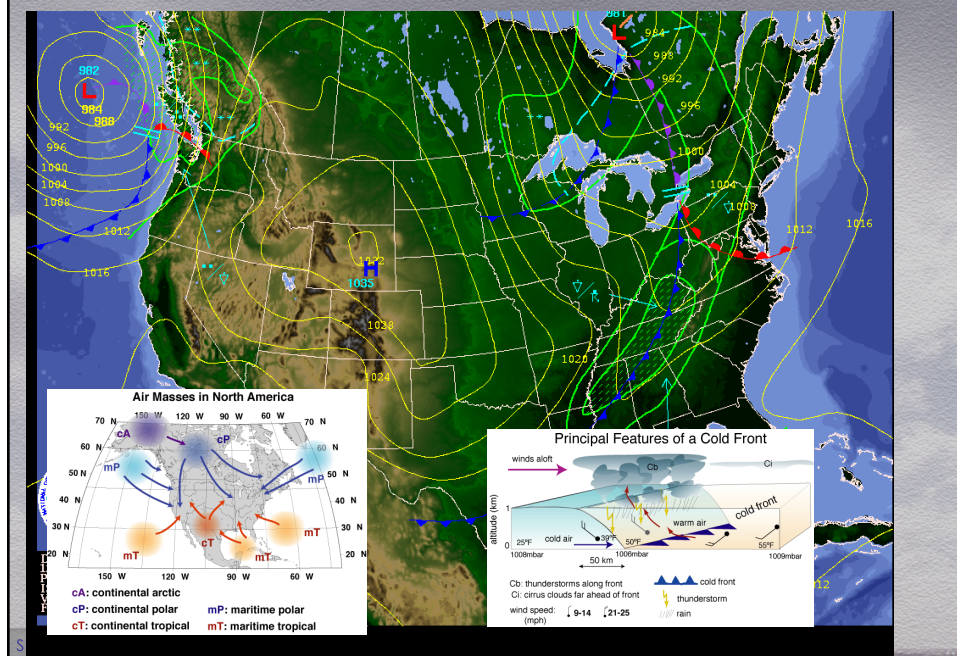
25-28 June 2021
 116°F Portland; 108°F Seattle
 Summer usually mild
 A/C 2019:
 U.S. 91%
 Portland 78%
 Seattle 44%

Article was about allocating funds for more cooling centers, residential A/C, 1/3 to low-income folks

Vulnerable power grid

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Air Masses, Fronts and Storm short video 13d



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Nor'Easters

short video 13f

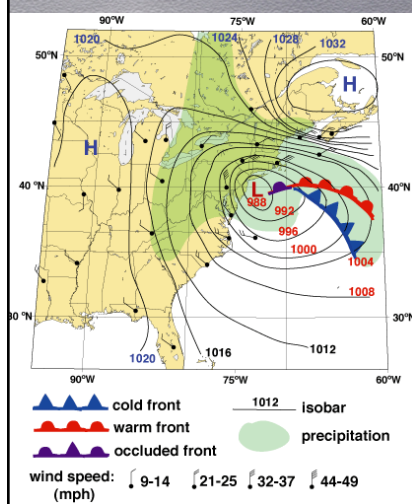


Fig. 13.29

- large extratropical/mid-latitude cyclones
- affect Atlantic coast
- almost as strong as hurricane; COLD core
- enhanced by H to the northeast
- usually late winter/early spring but can be as early as October (-> feed from dissipating hurricanes)

- gale-force northeasterly winds in NE
- high waves/coastal erosion
- heavy precipitation
- blizzards possible

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Nor'Easters

- Halloween 1991 "Perfect Storm"
- merged with Hurricane Grace
- 11m high waves
- Nova Scotia buoy: 30 m!

