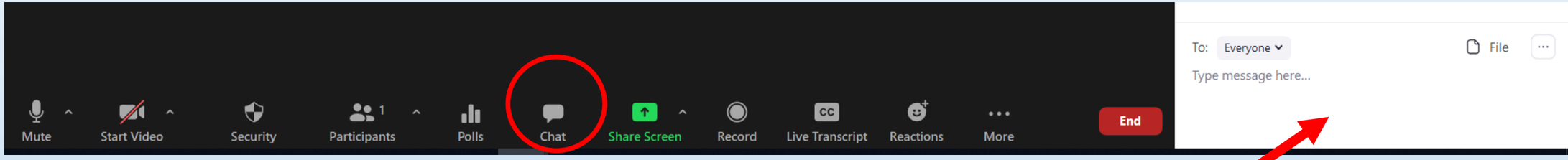
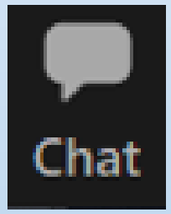
Introduction to Meteorological Monitoring

February 8 & 10 2022

Webinar Logistics





Click on the “Chat” icon to submit questions in the “Chat" pane

Click raise “Hand” icon if you would like to be unmuted

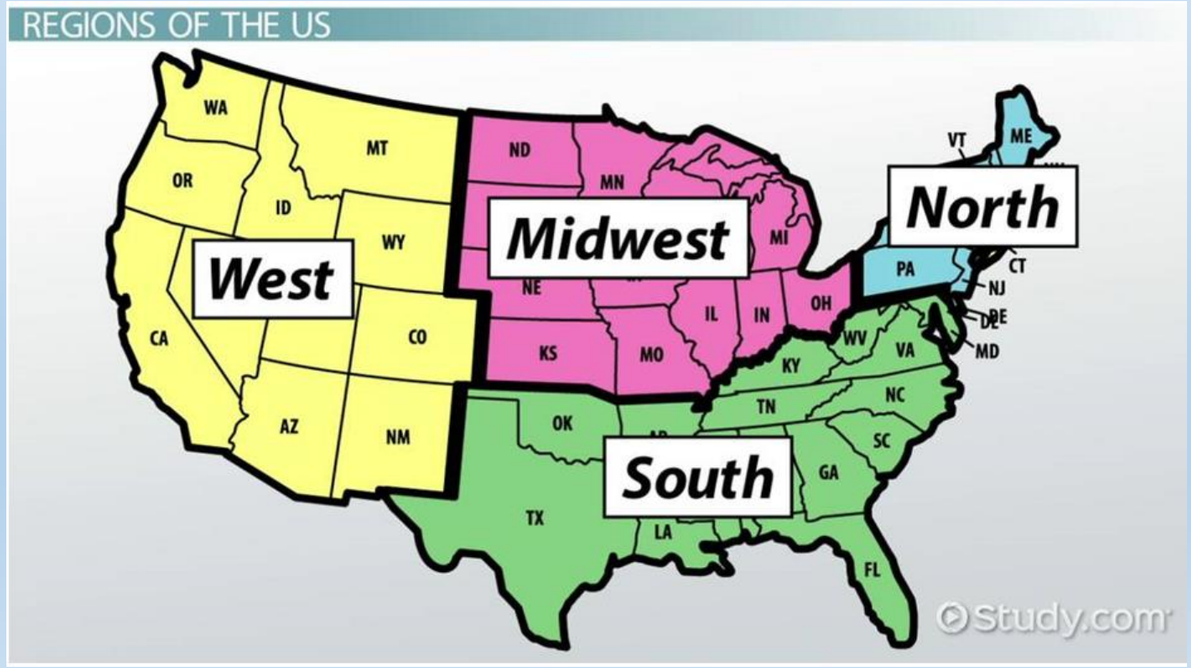
This webinar is being recorded – URL for the recording will be shared in post webinar email

Presented by the Institute for Tribal Environmental Professionals
American Indian Air Quality Training Program
Questions? Contact Christal.Black@nau.edu

Polling Question

Poll Question 1

- Climate and weather changes in different areas. What part of the U.S. do you reside?
  - Alaska
  - West
  - Midwest
  - North
  - South



Presenters

Michael King
NAU ITEP TAMS Center
michael.king@nau.edu

Daniel Berc
National Weather Service, NOAA
daniel.berc@noaa.gov

Introduction to Meteorology

Dan Berc

WARNING COORDINATION METEOROLOGIST

NATIONAL WEATHER SERVICE - LAS VEGAS, NV

WHO WE ARE

122
Forecast Offices

21
Aviation Offices

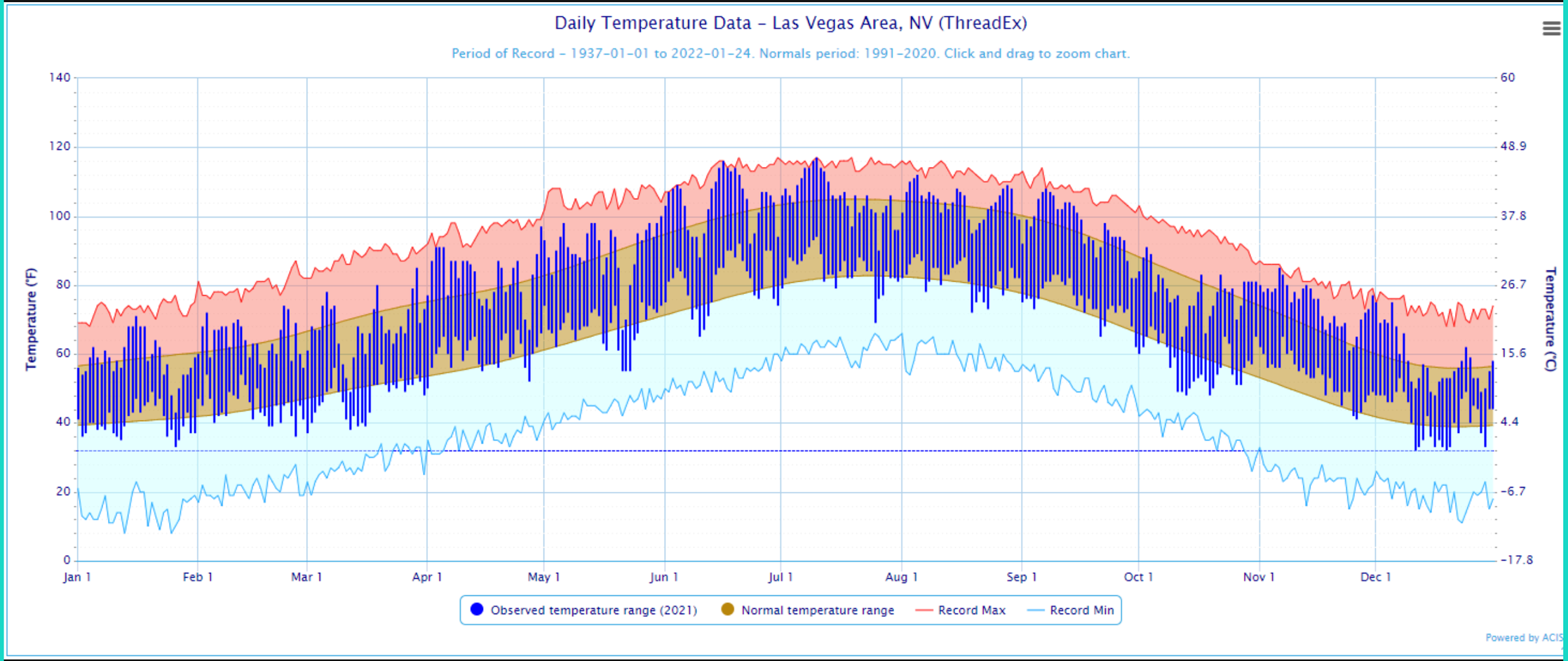
13
River Centers

9
Other Centers

Why do we need the NWS?

- **Since 2010…**
- More than 500 Americans die each year in weather and flood events
- More than 5,000 are injured
- Weather damages cost Americans more than $87 Billion each year

Climate vs. Weather



12 daily record highs set or tied in 2021

Last daily record low in Las Vegas: June 4, 1999

METEOROLOGY

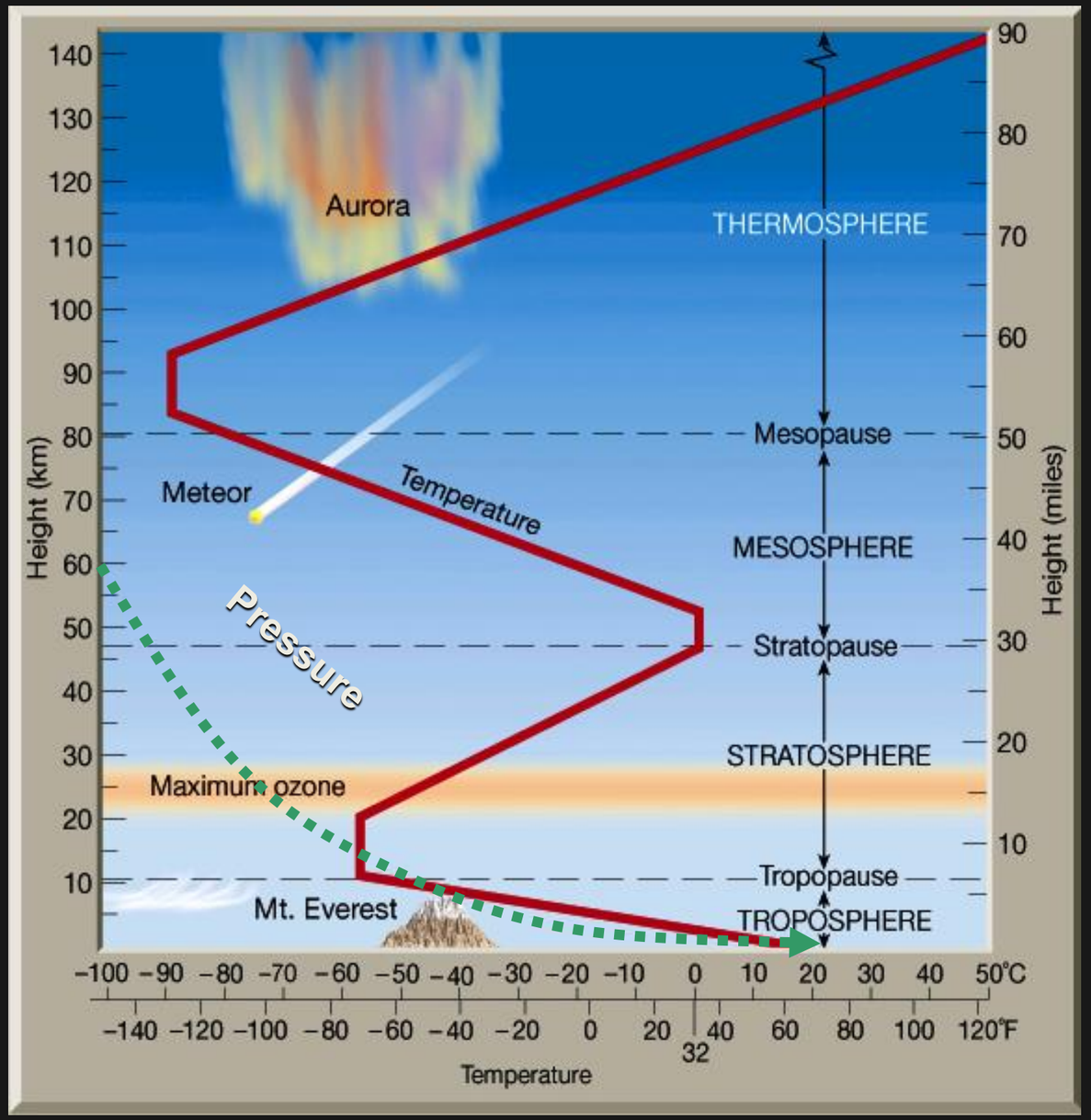
The Atmosphere

Composition of the Atmosphere

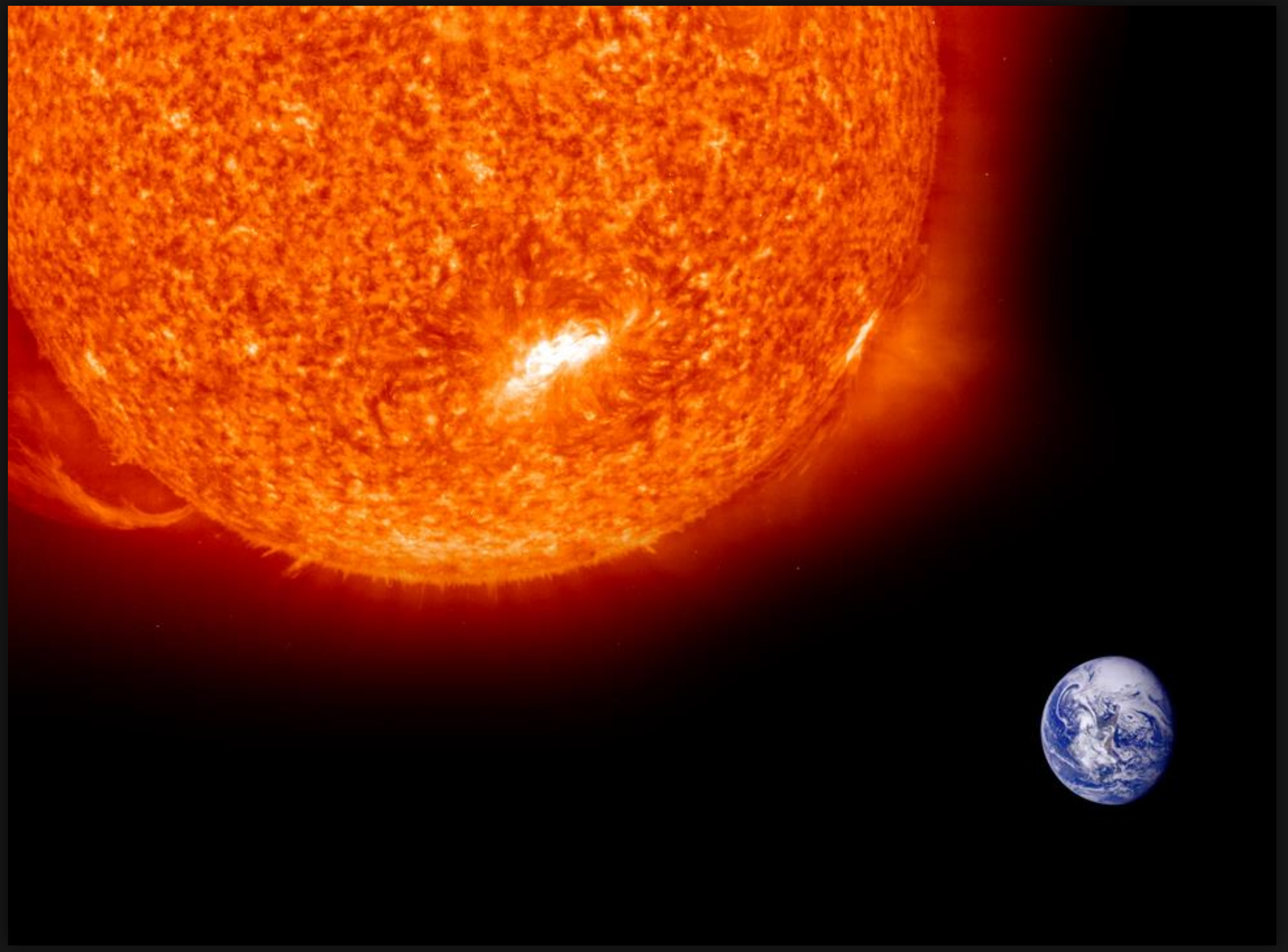
Gas	Symbol	Content	
Nitrogen	N_2	78.084%	99.998%
Oxygen	O_2	20.947%	
Argon	Ar	0.934%	
Carbon Dioxide	CO_2	0.033%	
Neon	Ne	18.20 parts per million	
Helium	He	5.20 parts per million	
Krypton	Kr	1.10 parts per million	
Sulfur dioxide	SO_2	1.00 parts per million	
Methane	CH_4	2.00 parts per million	
Hydrogen	H_2	0.50 parts per million	
Nitrous Oxide	N_2O	0.50 parts per million	
Xenon	Xe	0.09 parts per million	
Ozone	O_3	0.07 parts per million	
Nitrogen dioxide	NO_2	0.02 parts per million	
Iodine	I_2	0.01 parts per million	
Carbon monoxide	CO	trace	
Ammonia	NH_3	trace	

+ Water vapor!

Profile of the Atmosphere



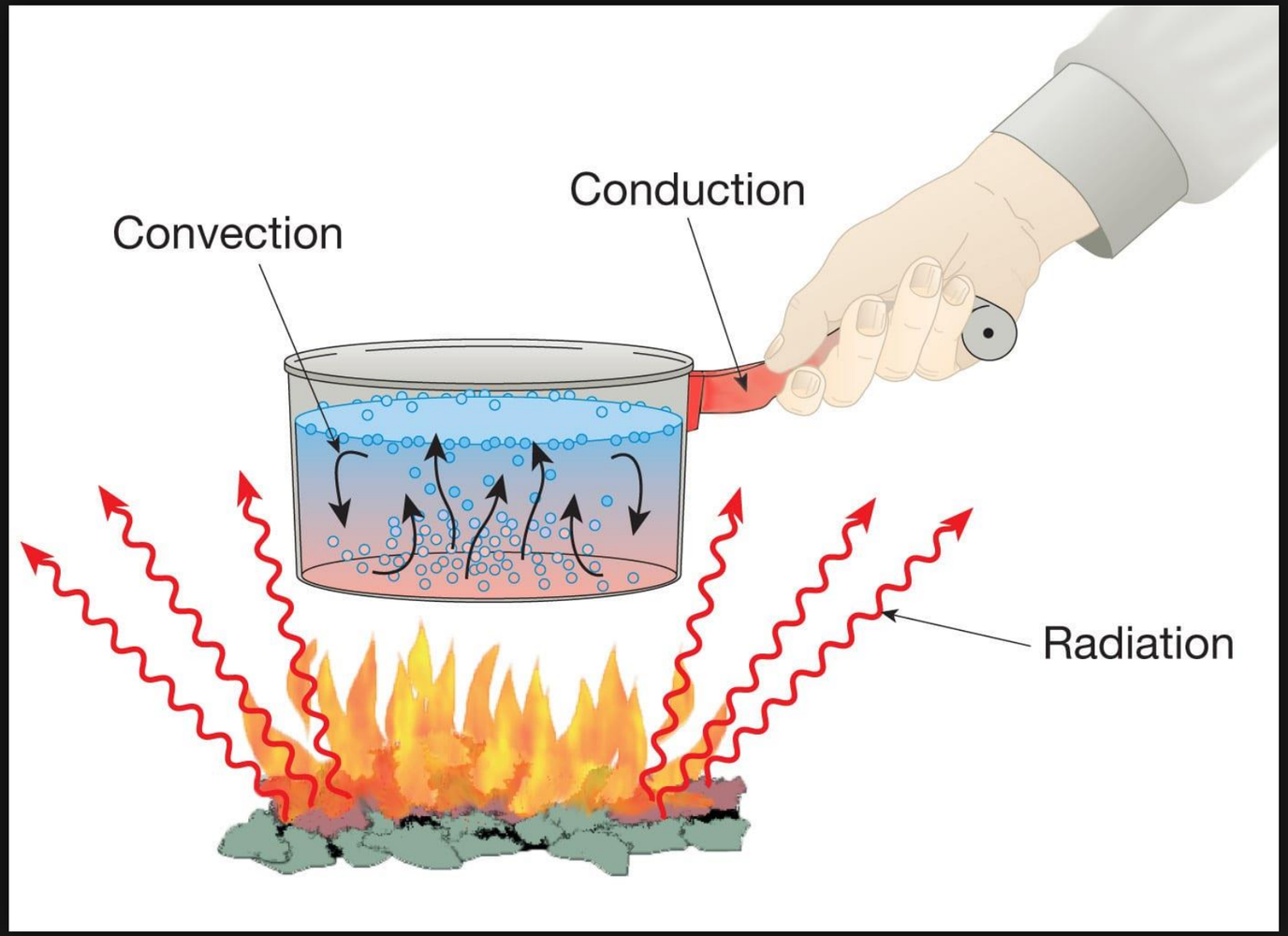
The Source of all Weather!



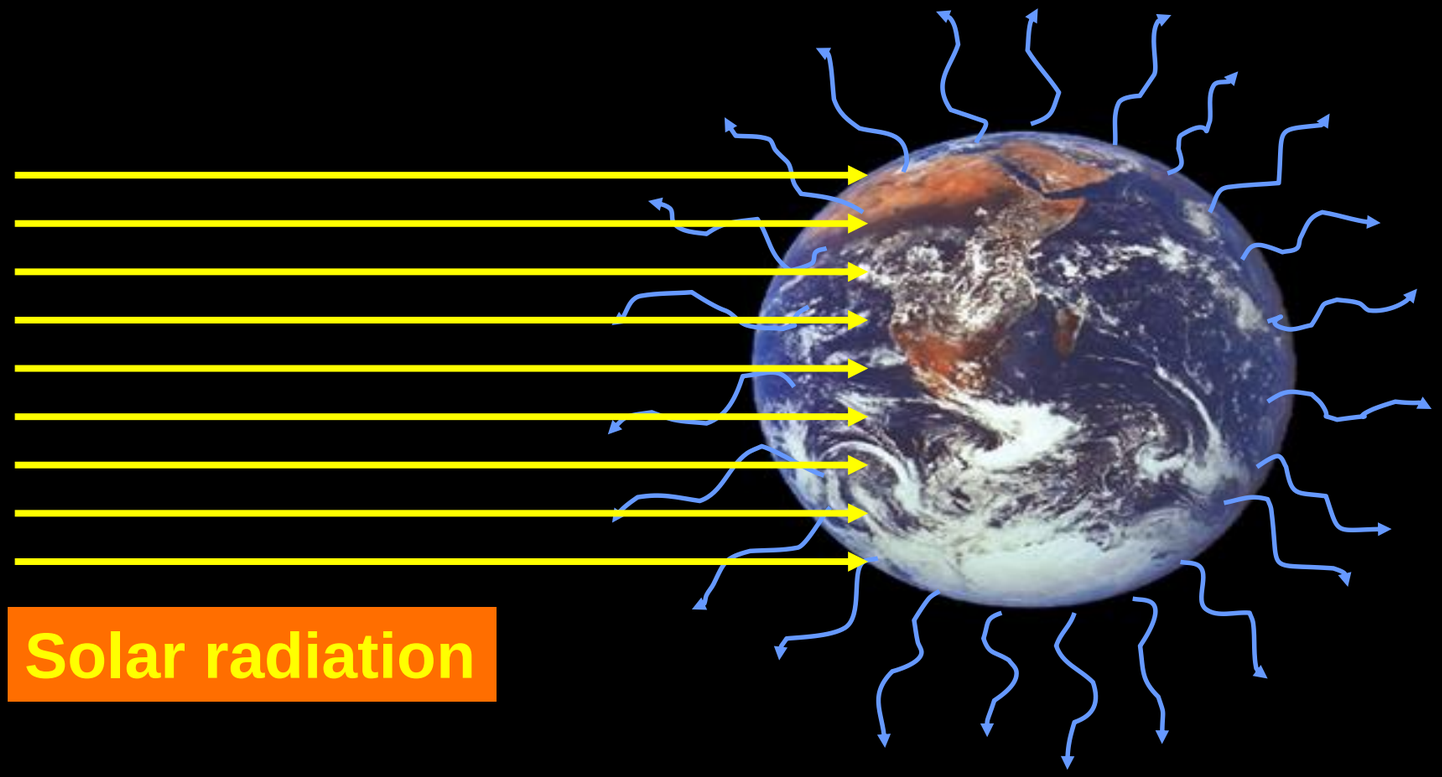
Heat Transfer

- Conduction: Transfer of heat from molecule to molecule within a substance (i.e. metal spoon)
- Convection: Transfer of heat by mass movement of a fluid (such as water and air) through currents (i.e. boiling water)
- Radiation: Transfer of heat by waves, by a source emitter and received by a cooler body

Heat Transfer

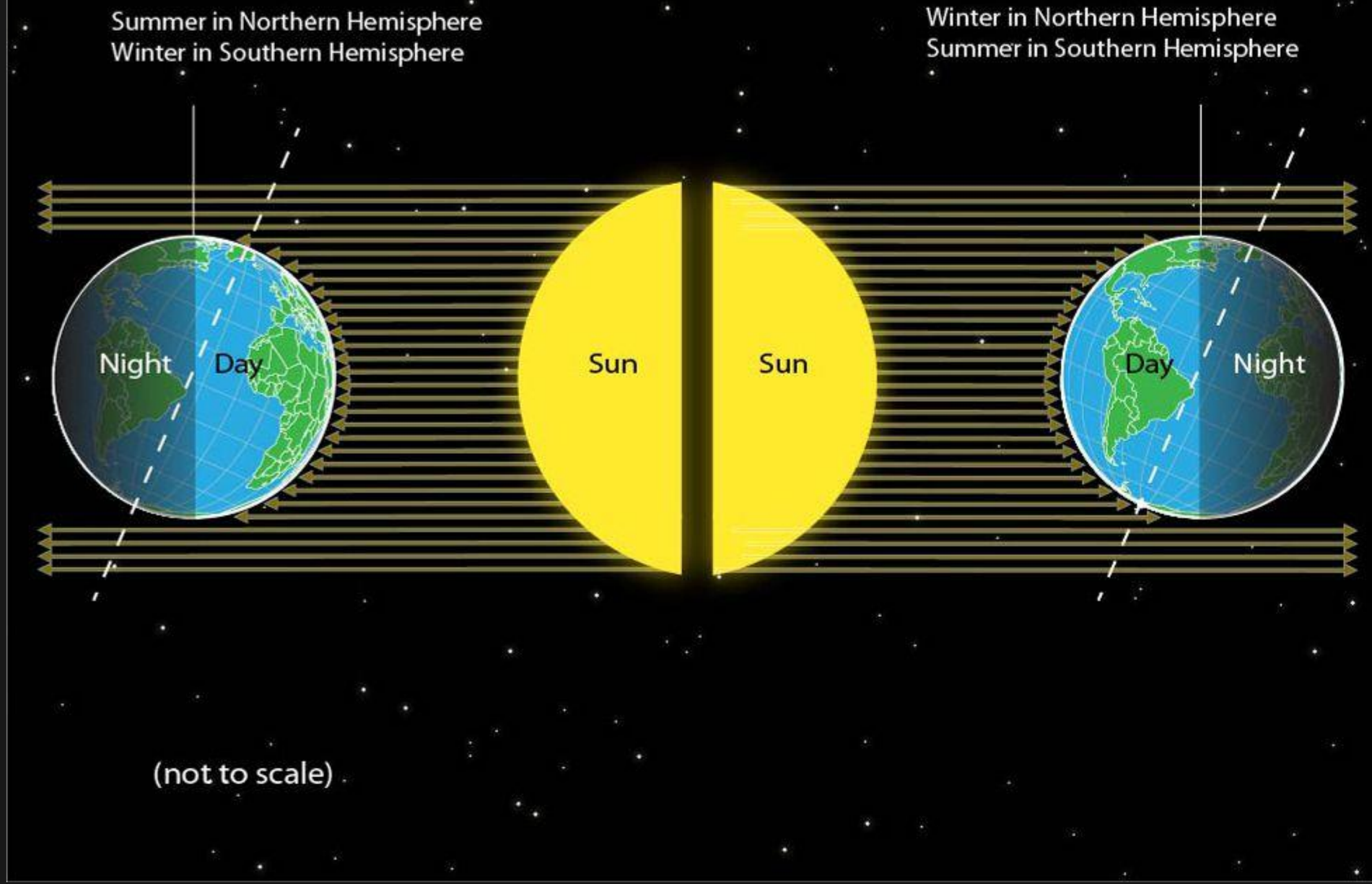


Outgoing vs. Incoming Radiation

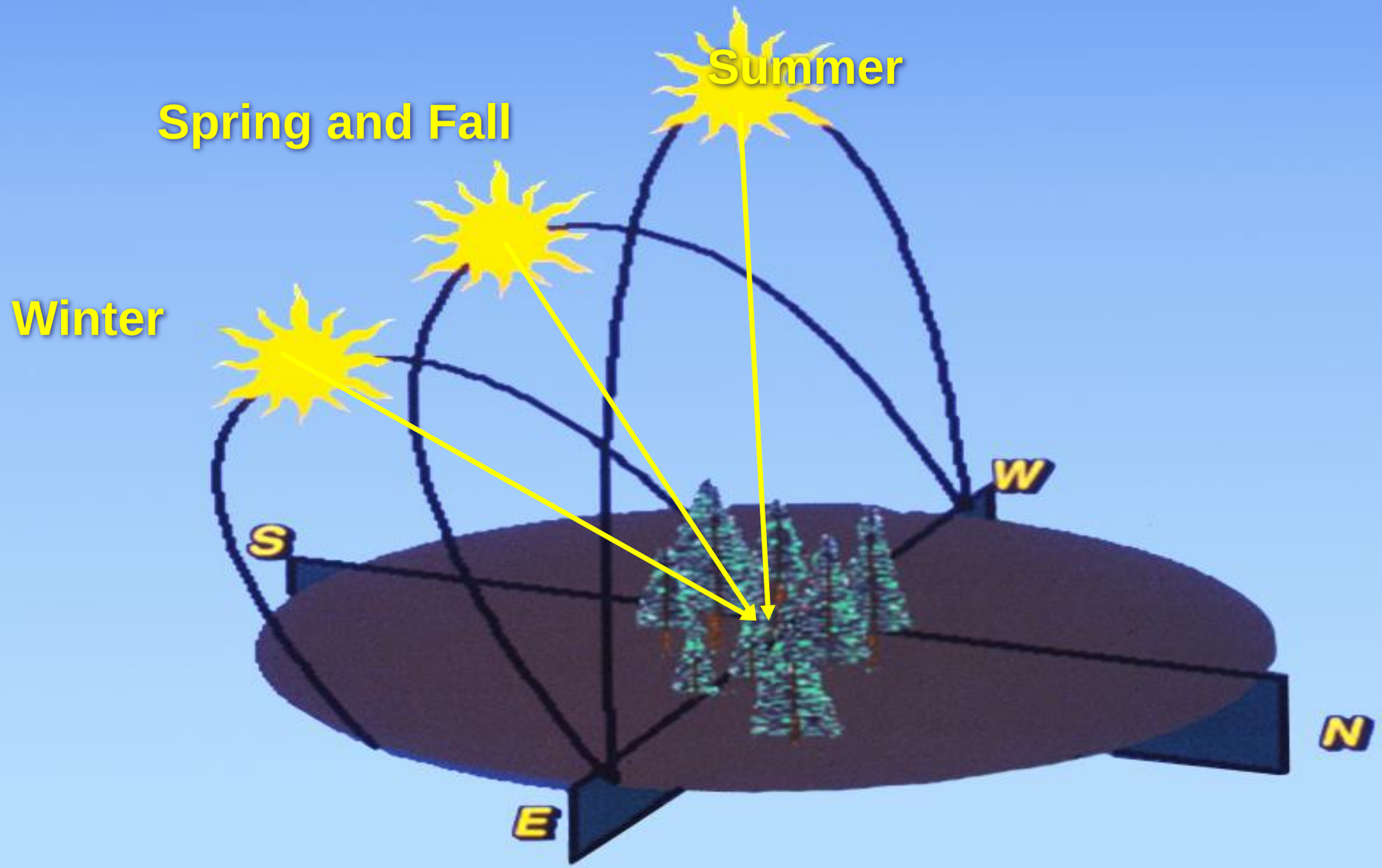


Outgoing thermal radiation = Incoming solar radiation

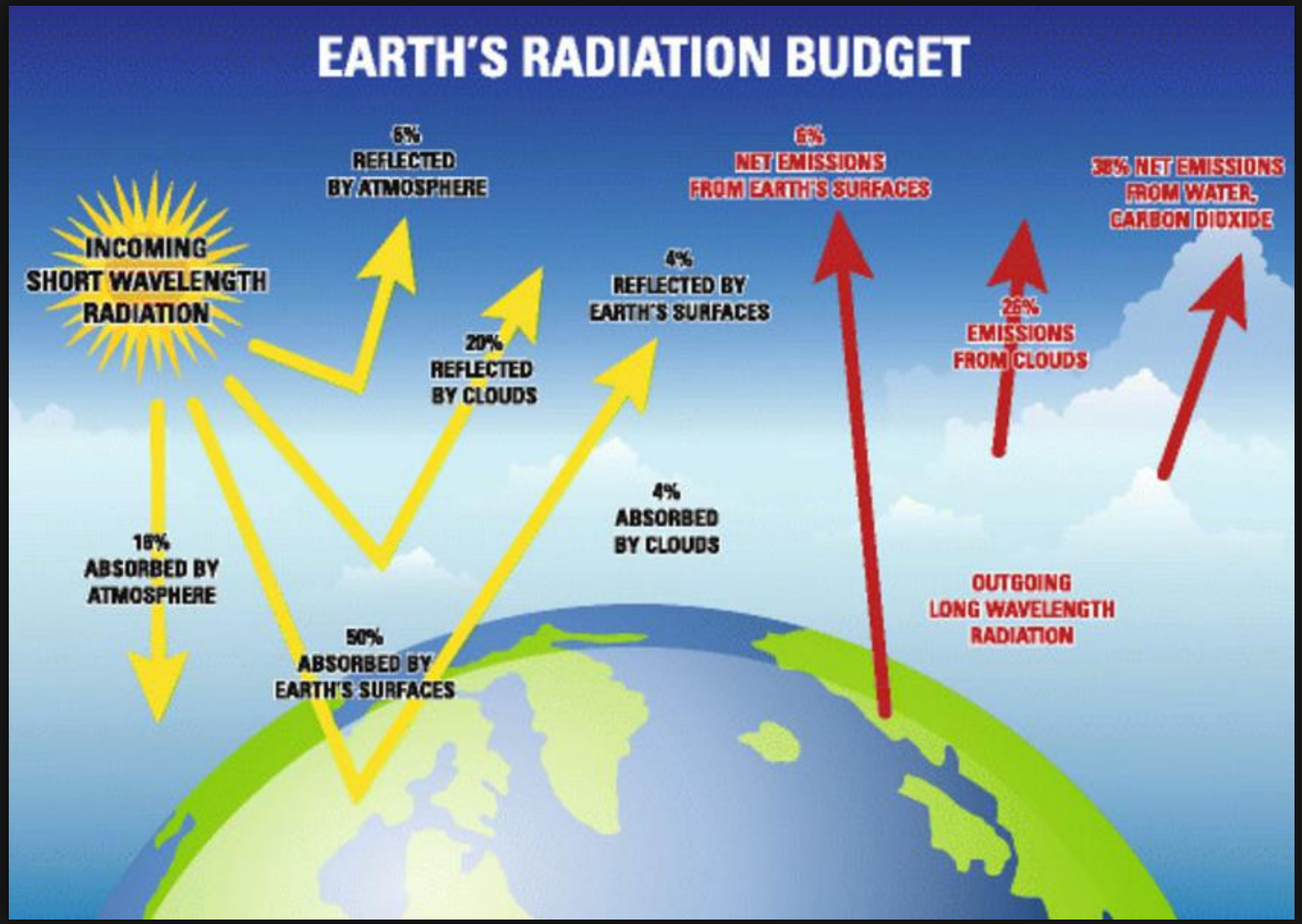
Seasons


Summer in Northern Hemisphere
Winter in Southern Hemisphere
Winter in Northern Hemisphere
Summer in Southern Hemisphere
Night
Day
Sun
Sun
Day
Night
(not to scale)

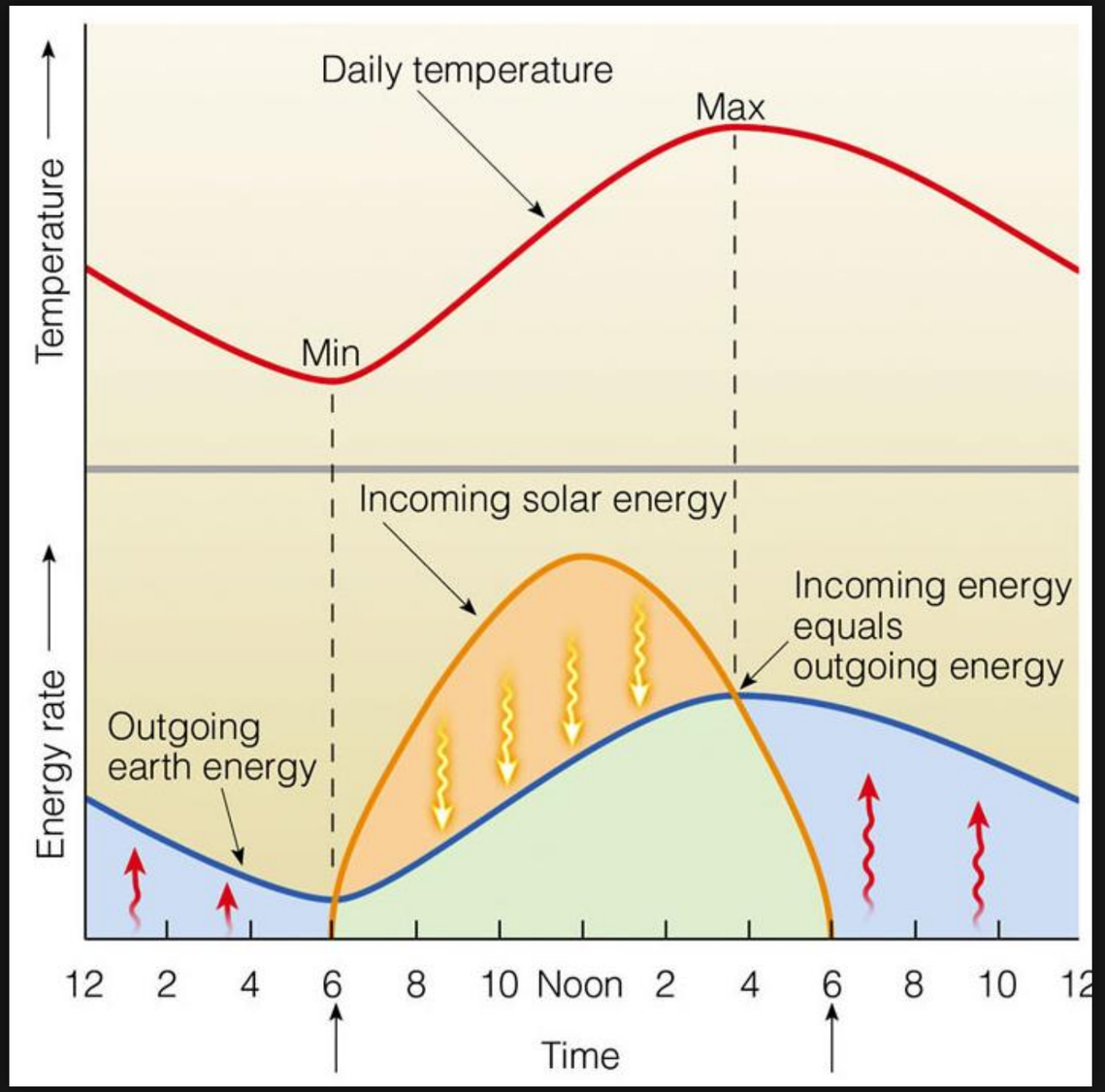
Solar Angles by Season



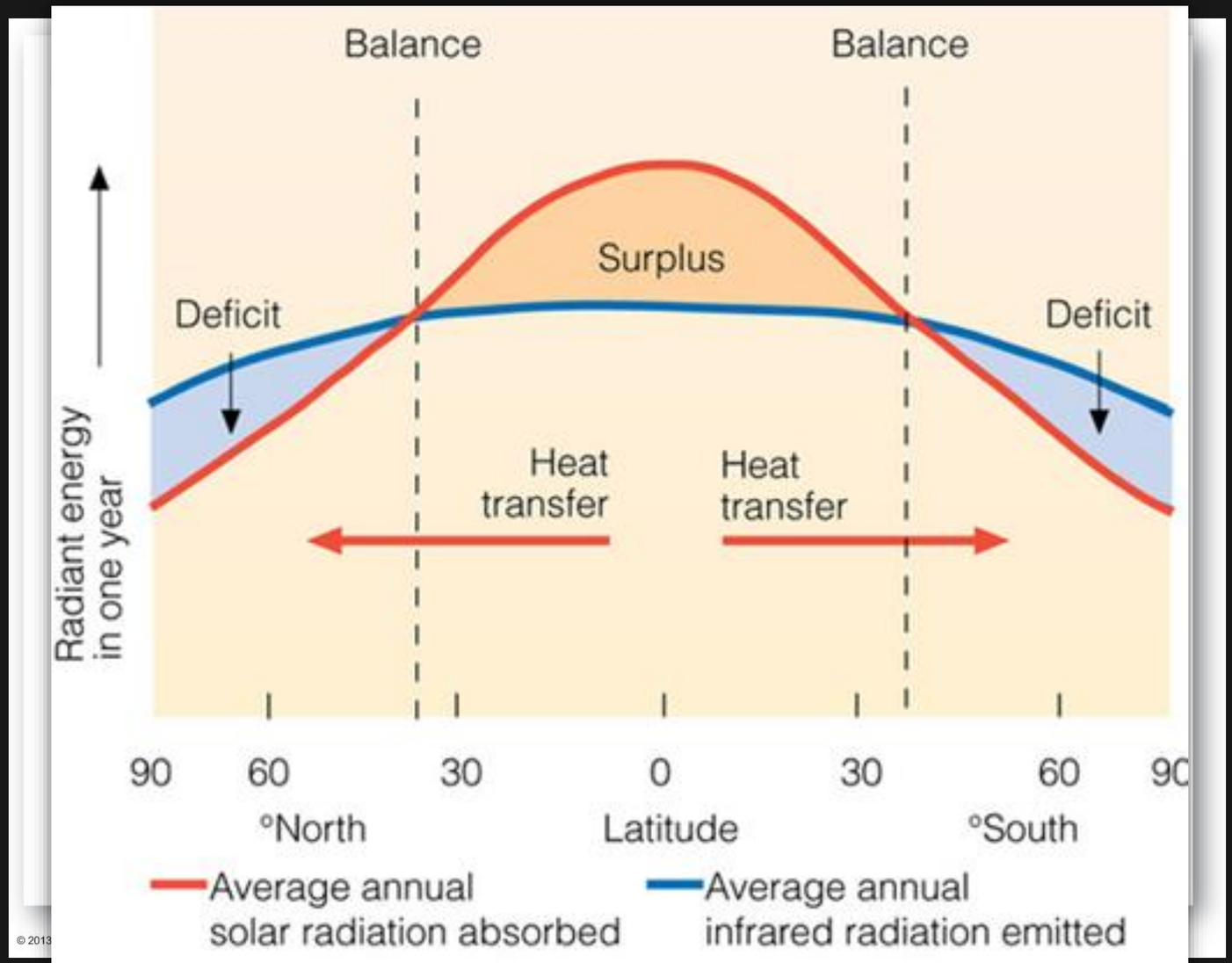
The Solar Radiation Budget



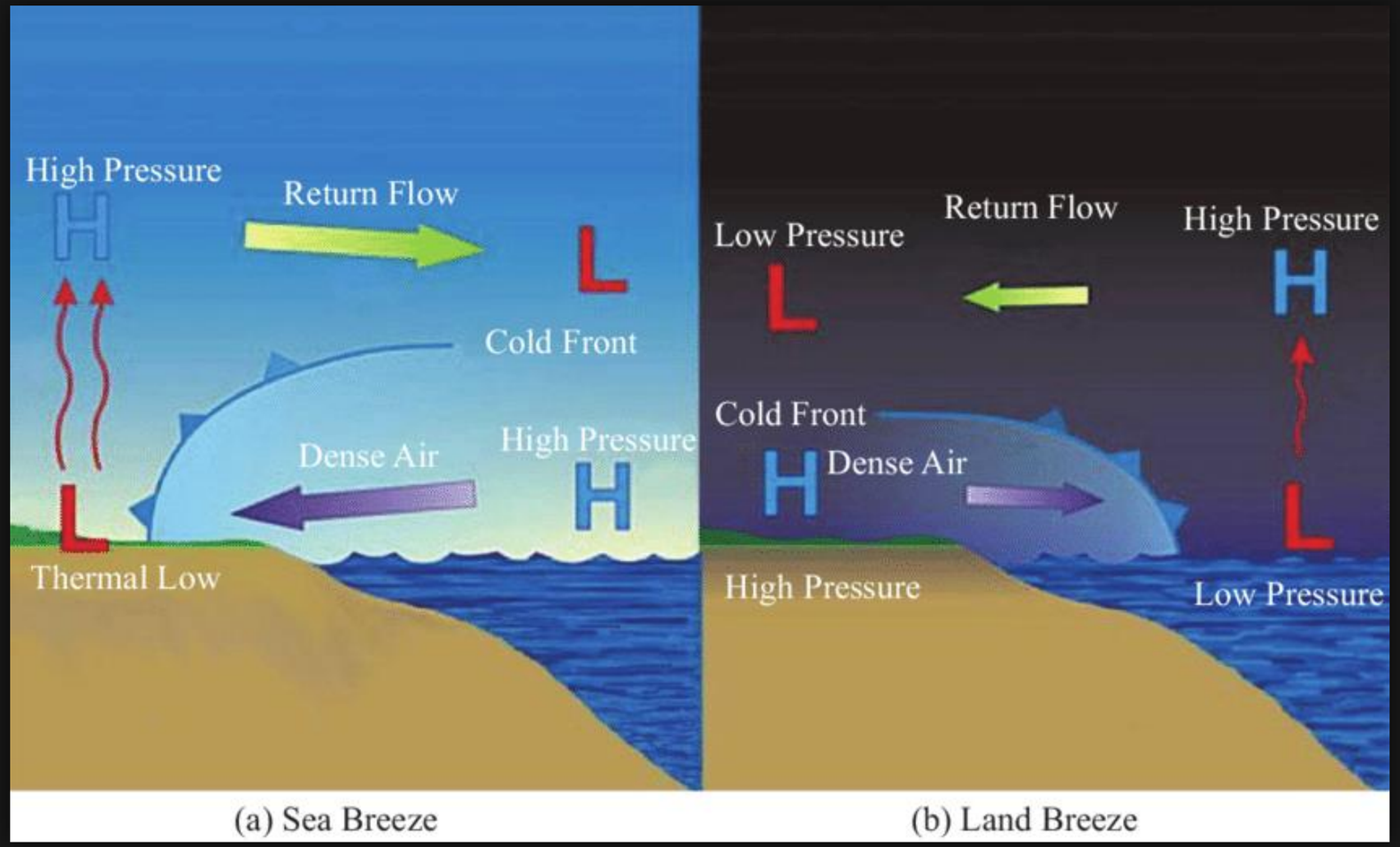
The Solar Radiation Budget



Outgoing vs. Incoming Radiation



Differential Heating

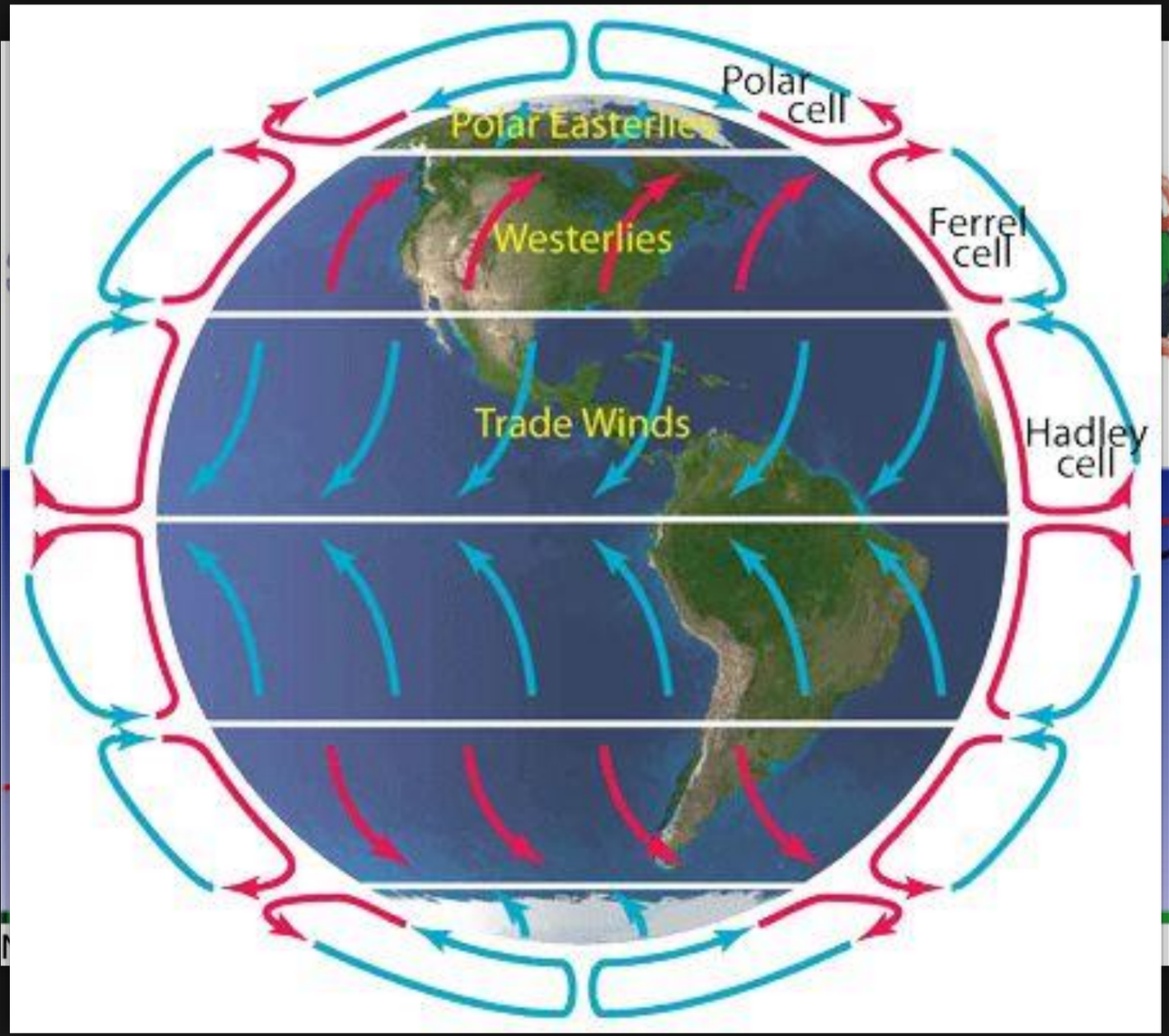


Global Air Circulation

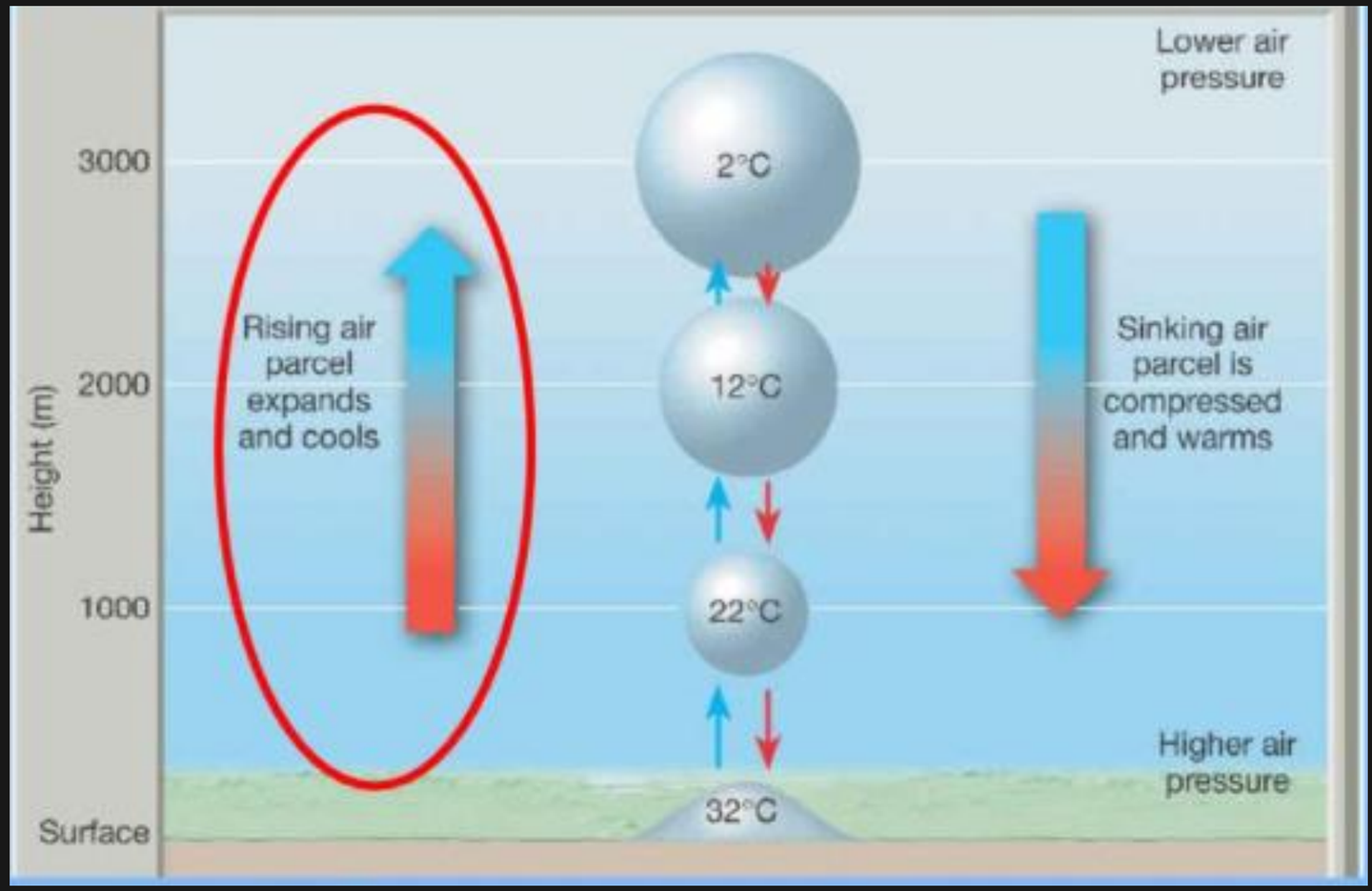
1. **Hadley cell** - Low latitude air movement toward the equator that with heating, rises vertically, with poleward movement in the upper atmosphere. This forms a convection cell that dominates tropical and sub-tropical climates.

2. **Ferrel cell** - A mid-latitude mean atmospheric circulation cell for weather named by Ferrel in the 19th century. In this cell the air flows poleward and eastward near the surface and equatorward and westward at higher levels.

3. **Polar cell** - Air rises, diverges, and travels toward the poles. Once over the poles, the air sinks, forming the polar highs. At the surface air diverges outward from the polar highs. Surface winds in the polar cell are easterly (polar easterlies).



Expansion/Cooling of Air



- As air rises, it cools and expands
- As air descends, it warms and compresses
- Cold air is denser than warm air

Moisture

Dew Point: Temperature to which air must be cooled to reach saturation point

Wet Bulb: Lowest temperature to which air can be cooled by evaporating water into it at constant pressure

Relative Humidity: Ratio of amount of moisture actually in air to amount of moisture air could hold at same temperature, if saturated. Expressed as percent

Dew Point

The temperature to which air must be cooled to reach saturation (i.e. 100% relative humidity)

- This is the best measure of how much moisture is in the atmosphere.

Relative Humidity

Ratio of the amount of moisture currently in the air to the amount the air could hold at the same temperature if completely saturated

- Tends to be highest at night and early morning
- Tends to be lowest in the afternoon
- This is due more to the change in temperature from night to afternoon than to any significant change in moisture in the atmosphere.

Sources of Moisture

Relative Humidity

warm warmer even warmer

The warmer the air, the more water vapor it can hold

Temperature vs. RH

40° F

100%

60° F

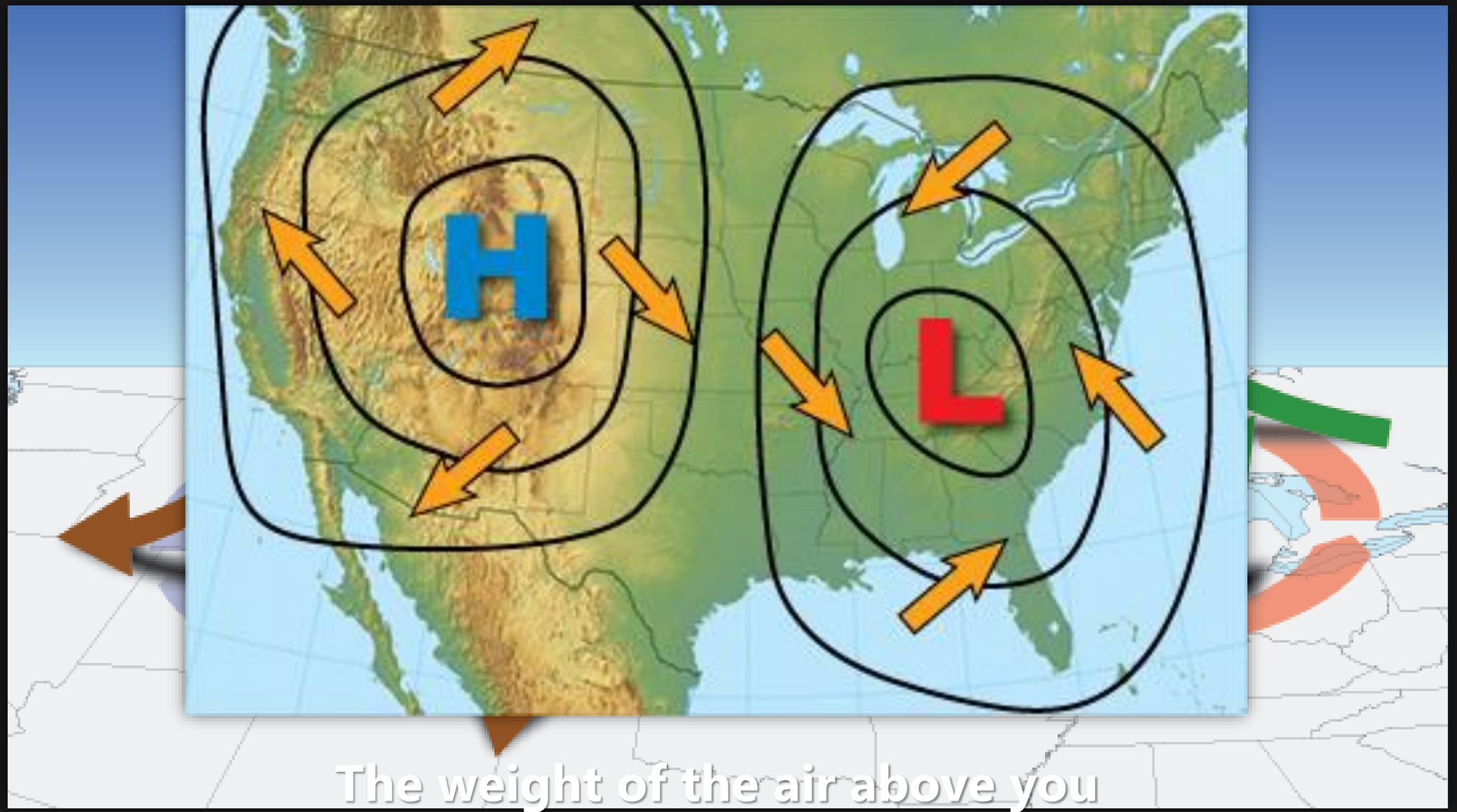
48%

80° F

24%

Relative humidity decreases as temperature increases, even though the actual amount of water vapor in the containers doesn't change. Thus, the term"relative."

Air Pressure



The weight of the air above you

Atmospheric Stability

STABILITY

Stability is the atmosphere's resistance to vertical motion

Atmospheric Stability

STABILITY

Stability = vertical motion
Wind = horizontal motion

Inversions

Inversion: Layer in atmosphere where temperature increases with height. Essentially: Warm air over cold air.

This is opposite of the normal situation where temperatures decrease with height

Inversions

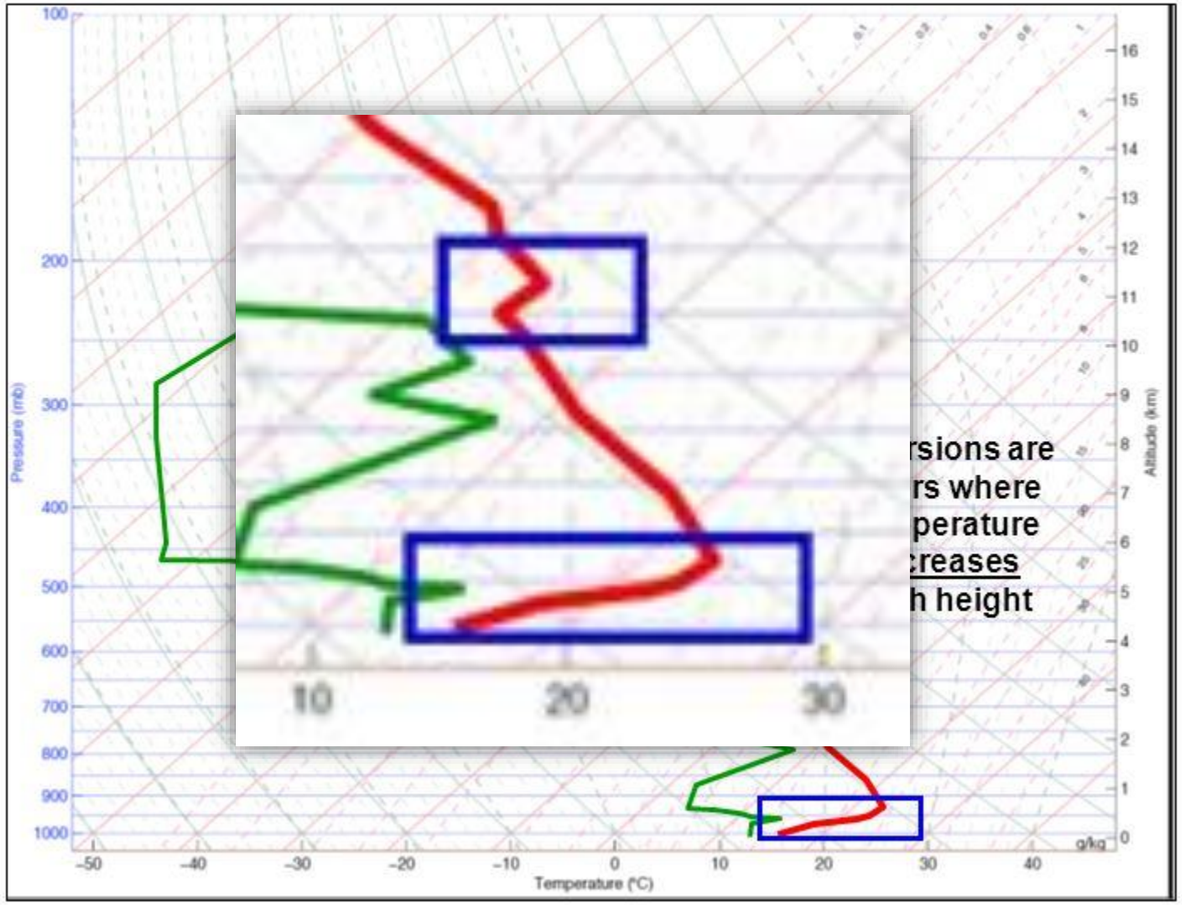
In fires burning under inversions, smoke undergoes limited rise, then flattens out as it reaches inversion

Inversions are areas of very stable air

Inversions

Skew-T Applications

Identify Temperature Inversions

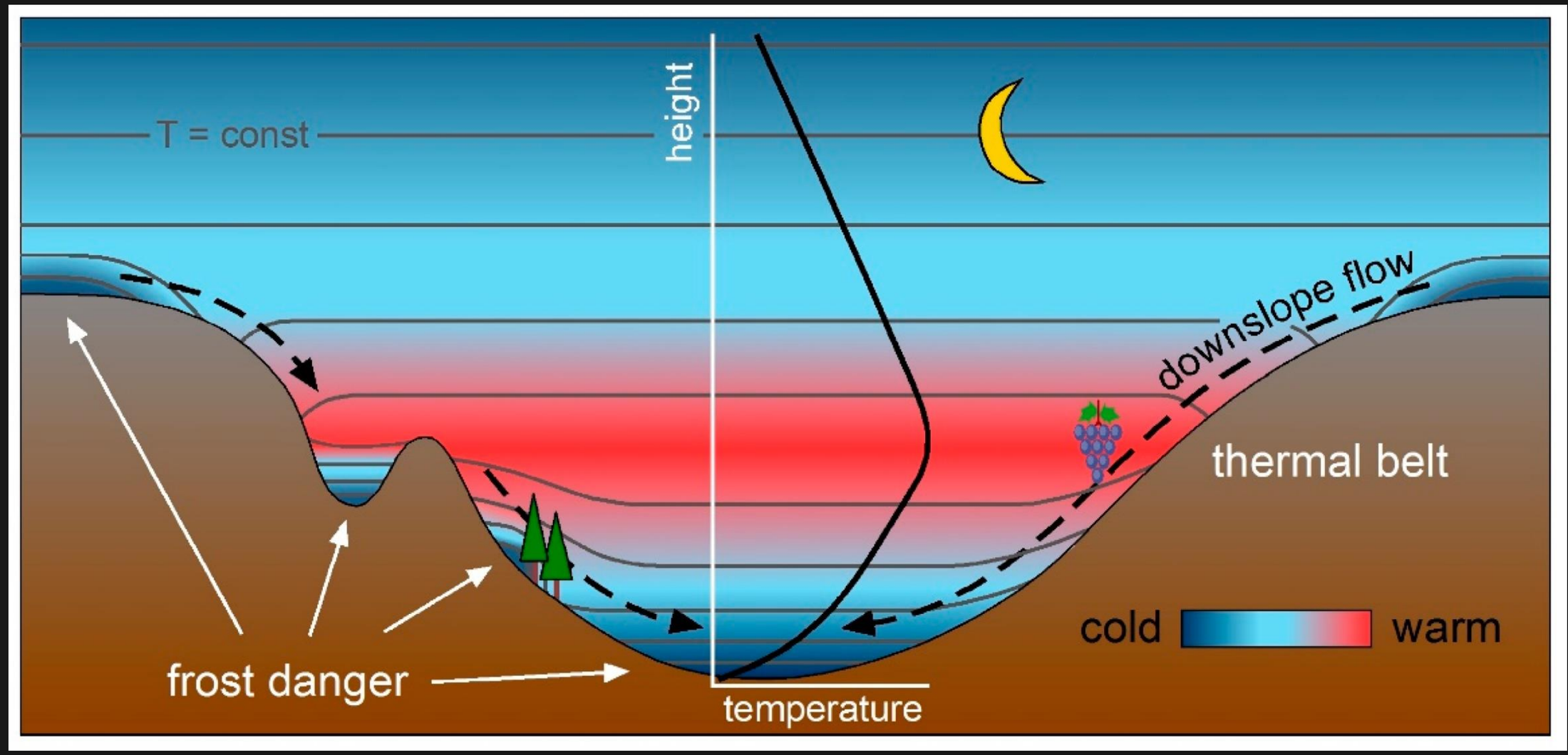


rsions are
rs where
perature
creases
h height

Inversion Types

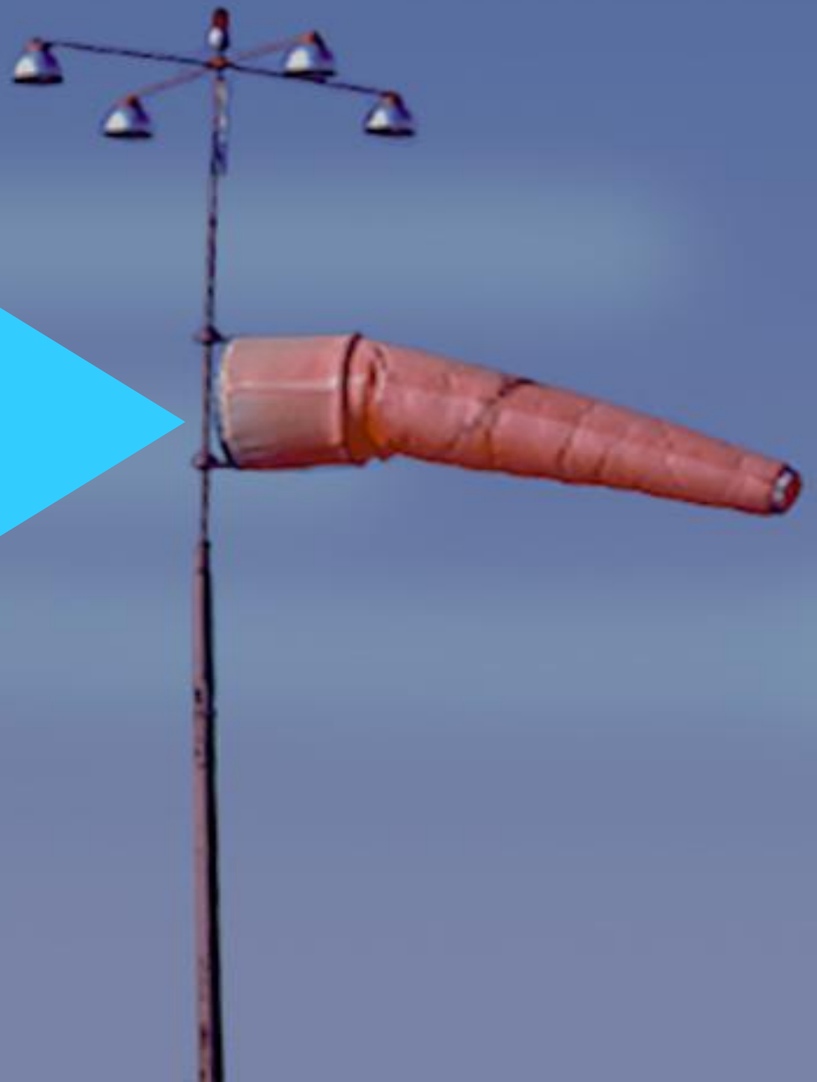
- Radiational or nighttime – form because the ground cools off faster at night than the air above it.
- Frontal – form as a cold front undercuts warmer air.
- Marine – form due to cooler marine air moving onshore, displacing warmer air above it.
- Subsidence – form as air underneath high pressure systems aloft sinks and warms.

Valley Inversions



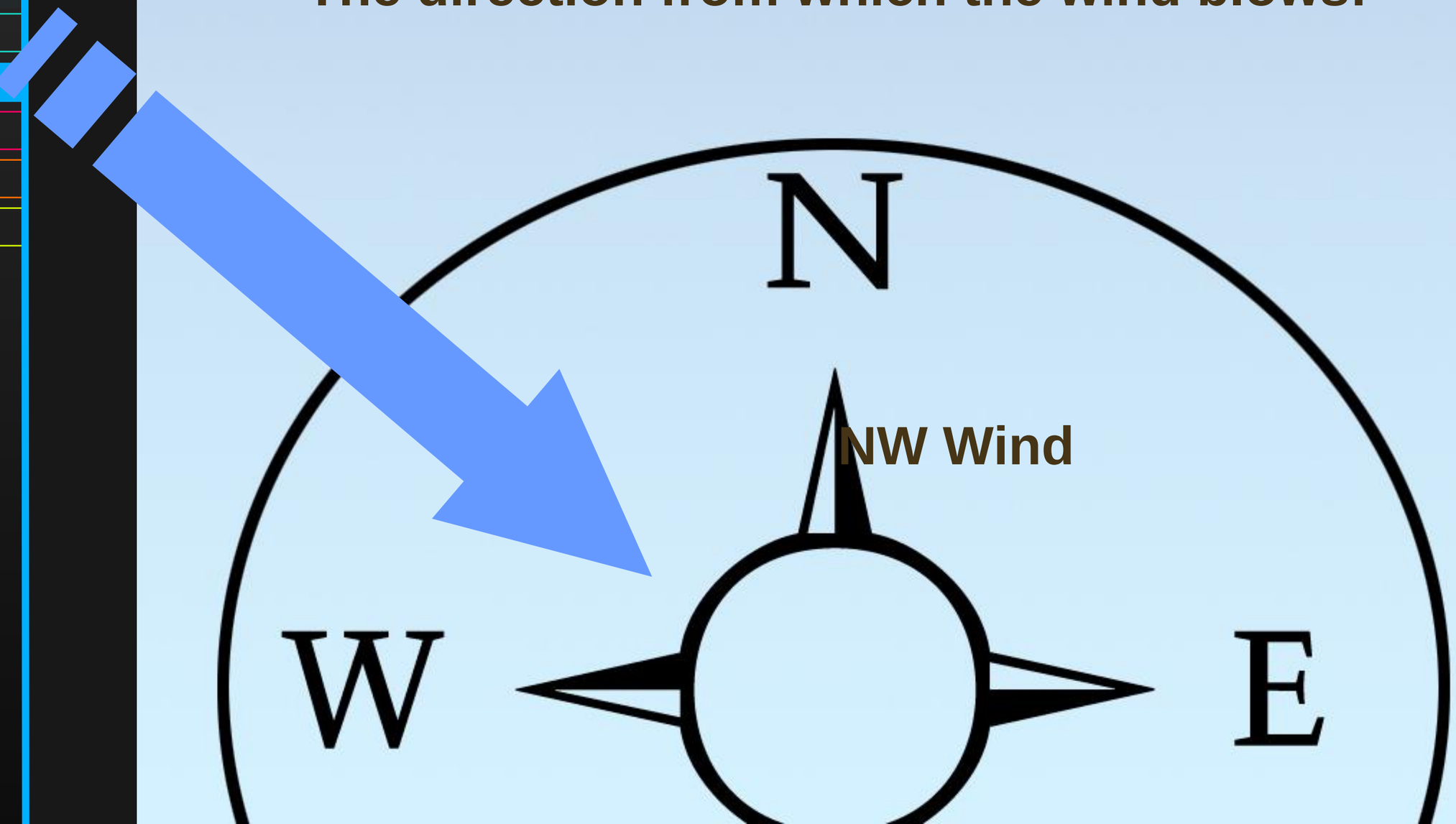
Wind

Horizontal movement of air

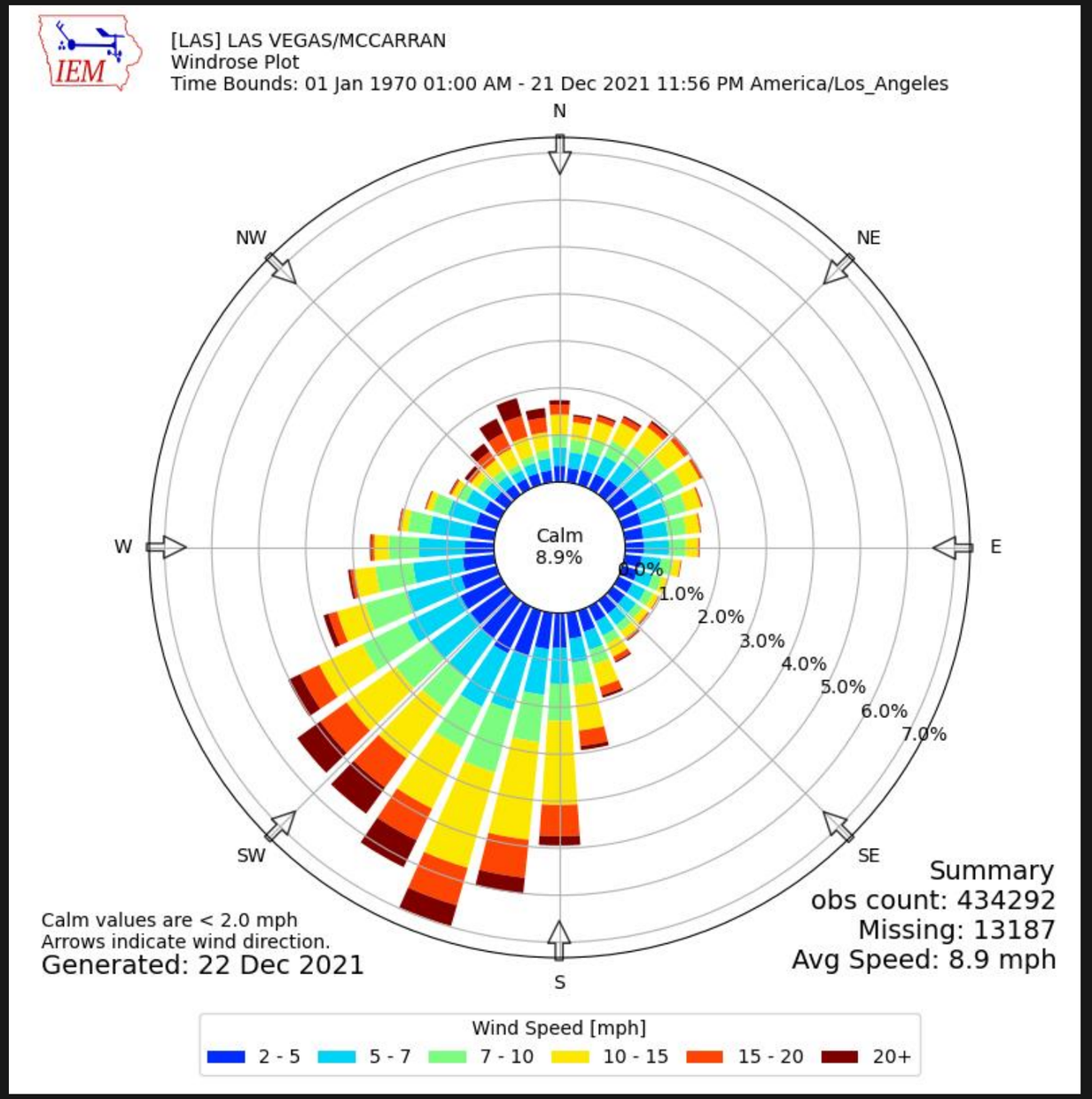


Wind

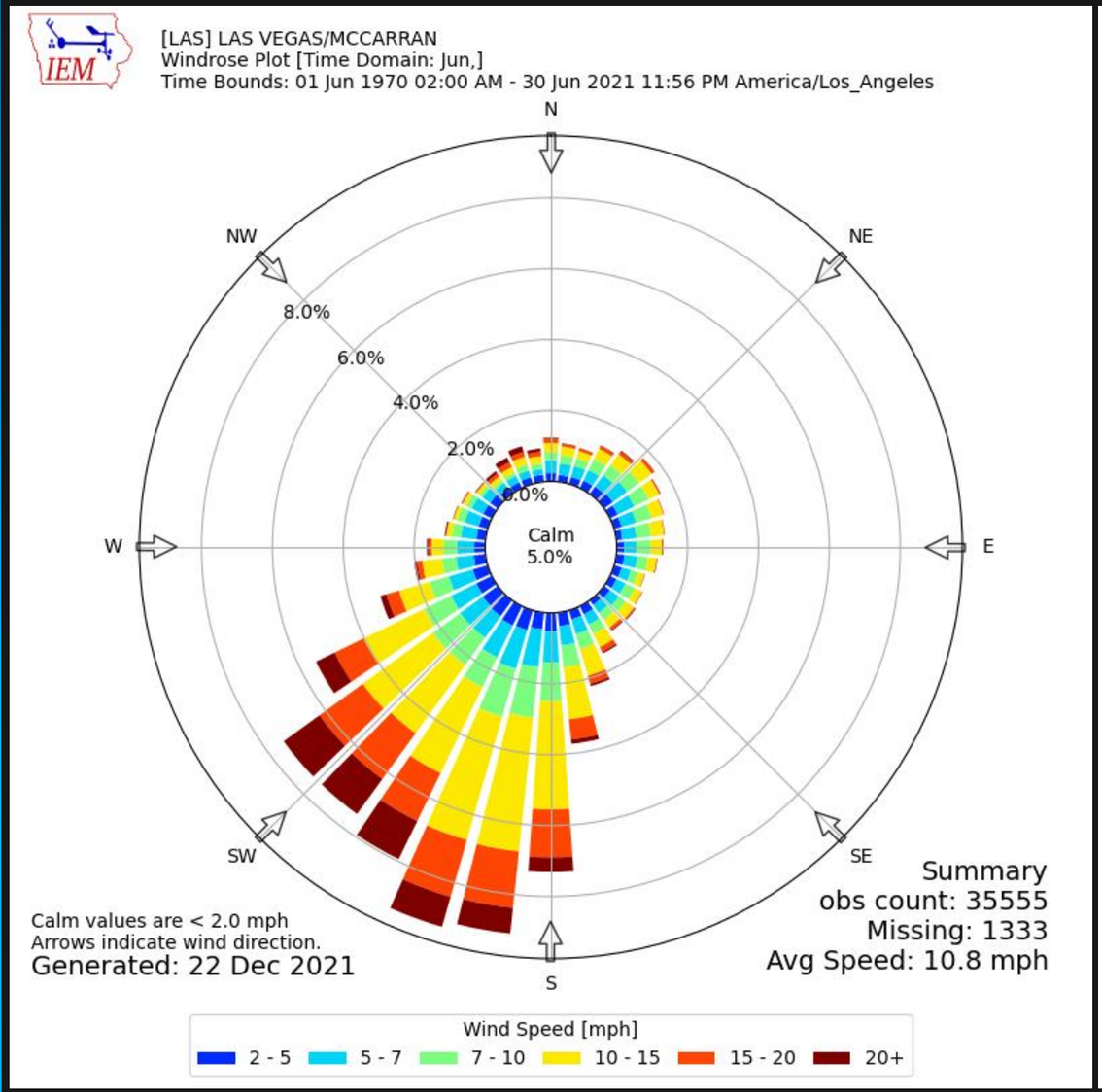
The direction from which the wind blows!

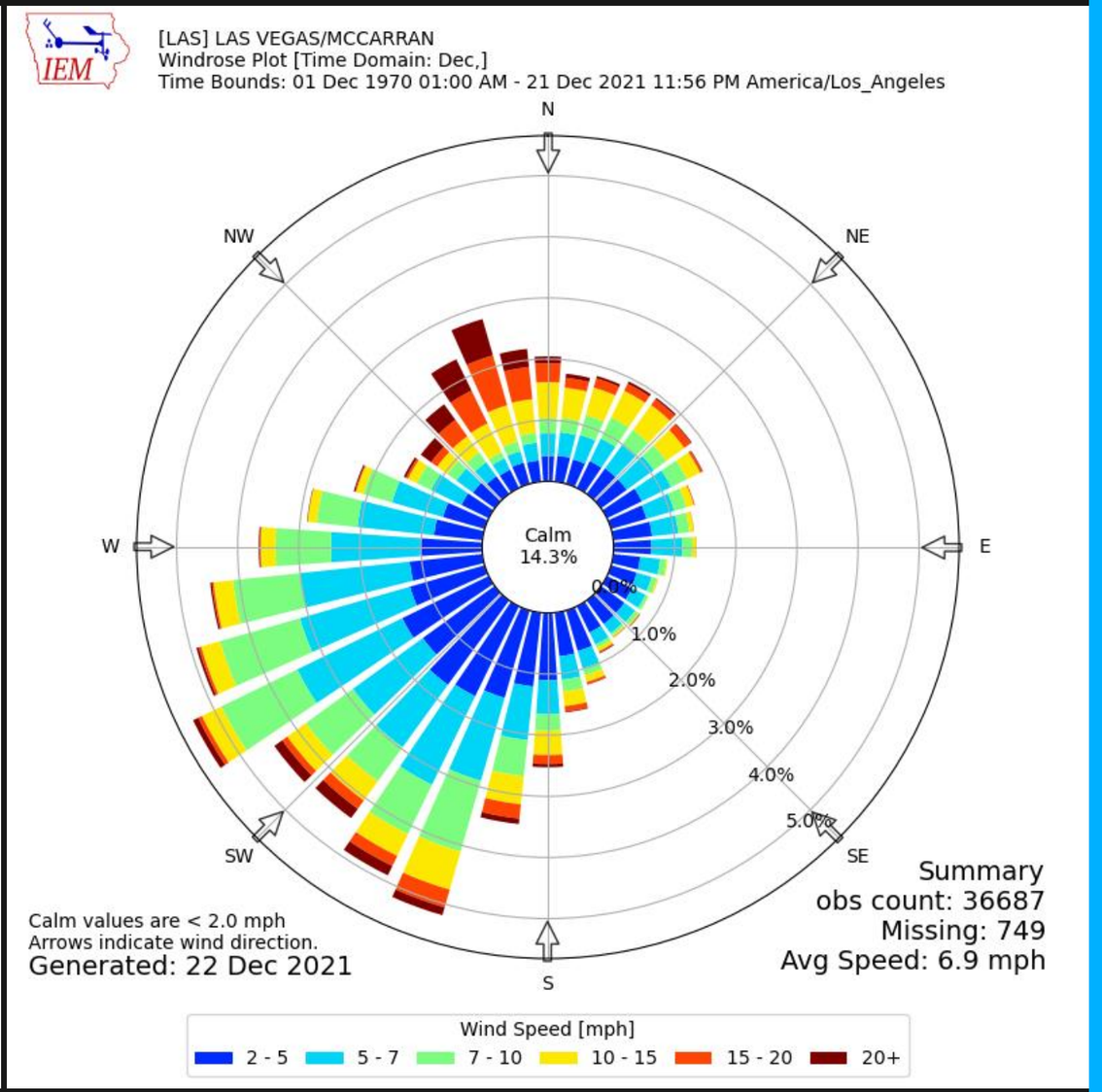


Wind Rose

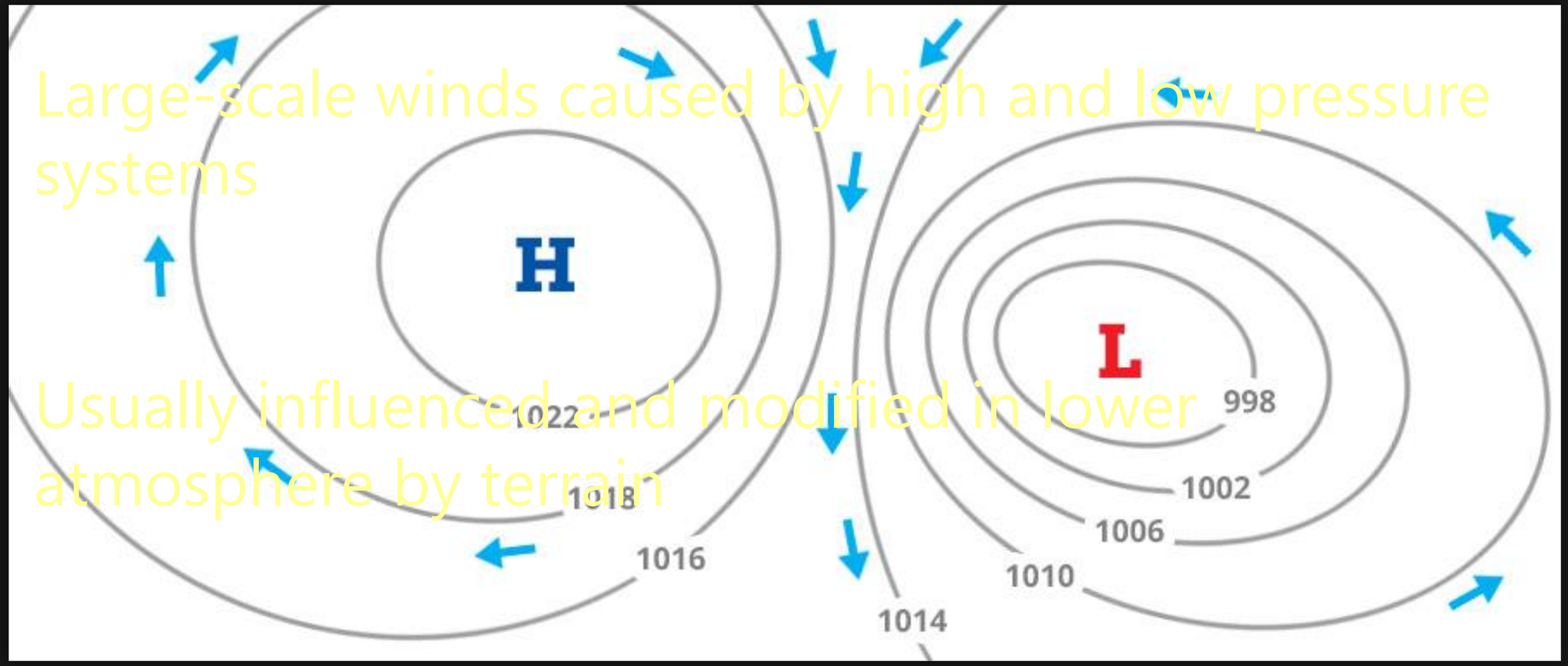

[LAS] LAS VEGAS/MCCARRAN
Windrose Plot
Time Bounds: 01 Jan 1970 01:00 AM - 21 Dec 2021 11:56 PM America/Los_Angeles
N
NE
E
SE
S
SW
W
NW
Calm
8.9%
1.0%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
Calm values are < 2.0 mph
Arrows indicate wind direction.
Generated: 22 Dec 2021
Summary
obs count: 434292
Missing: 13187
Avg Speed: 8.9 mph
Wind Speed [mph]
2 - 5
5 - 7
7 - 10
10 - 15
15 - 20
20+

Wind Rose


[LAS] LAS VEGAS/MCCARRAN
Windrose Plot [Time Domain: Jun,]
Time Bounds: 01 Jun 1970 02:00 AM - 30 Jun 2021 11:56 PM America/Los_Angeles
N
NE
E
SE
S
SW
W
NW
8.0%
6.0%
4.0%
2.0%
Calm
5.0%
Calm values are < 2.0 mph
Arrows indicate wind direction.
Generated: 22 Dec 2021
Summary
obs count: 35555
Missing: 1333
Avg Speed: 10.8 mph
Wind Speed [mph]
2 - 5
5 - 7
7 - 10
10 - 15
15 - 20
20+


[LAS] LAS VEGAS/MCCARRAN
Windrose Plot [Time Domain: Dec,]
Time Bounds: 01 Dec 1970 01:00 AM - 21 Dec 2021 11:56 PM America/Los_Angeles
N
NE
E
SE
S
SW
W
NW
Calm
14.3%
1.0%
2.0%
3.0%
4.0%
5.0%
Calm values are < 2.0 mph
Arrows indicate wind direction.
Generated: 22 Dec 2021
Summary
obs count: 36687
Missing: 749
Avg Speed: 6.9 mph
Wind Speed [mph]
2 - 5
5 - 7
7 - 10
10 - 15
15 - 20
20+

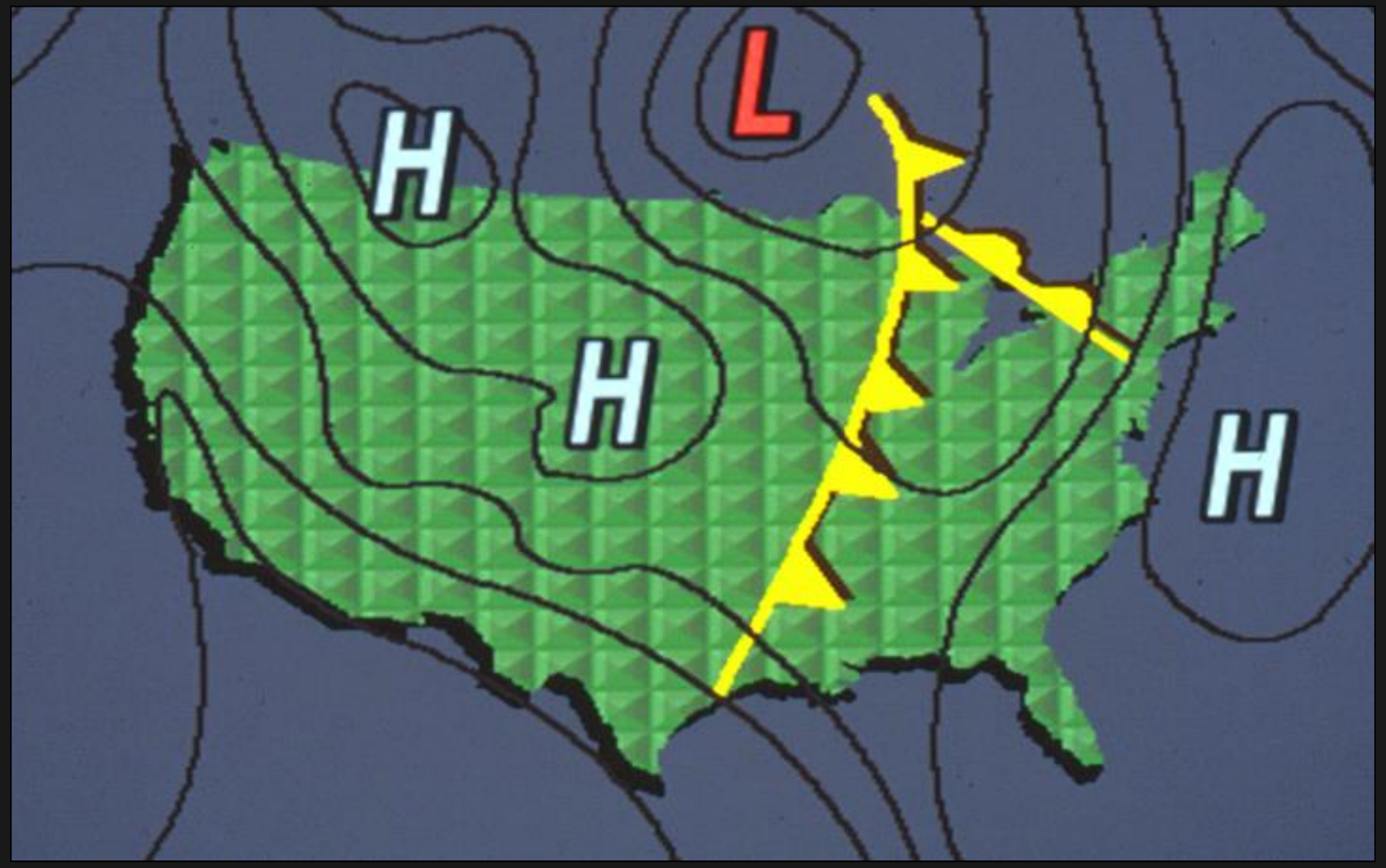
Gradient Wind



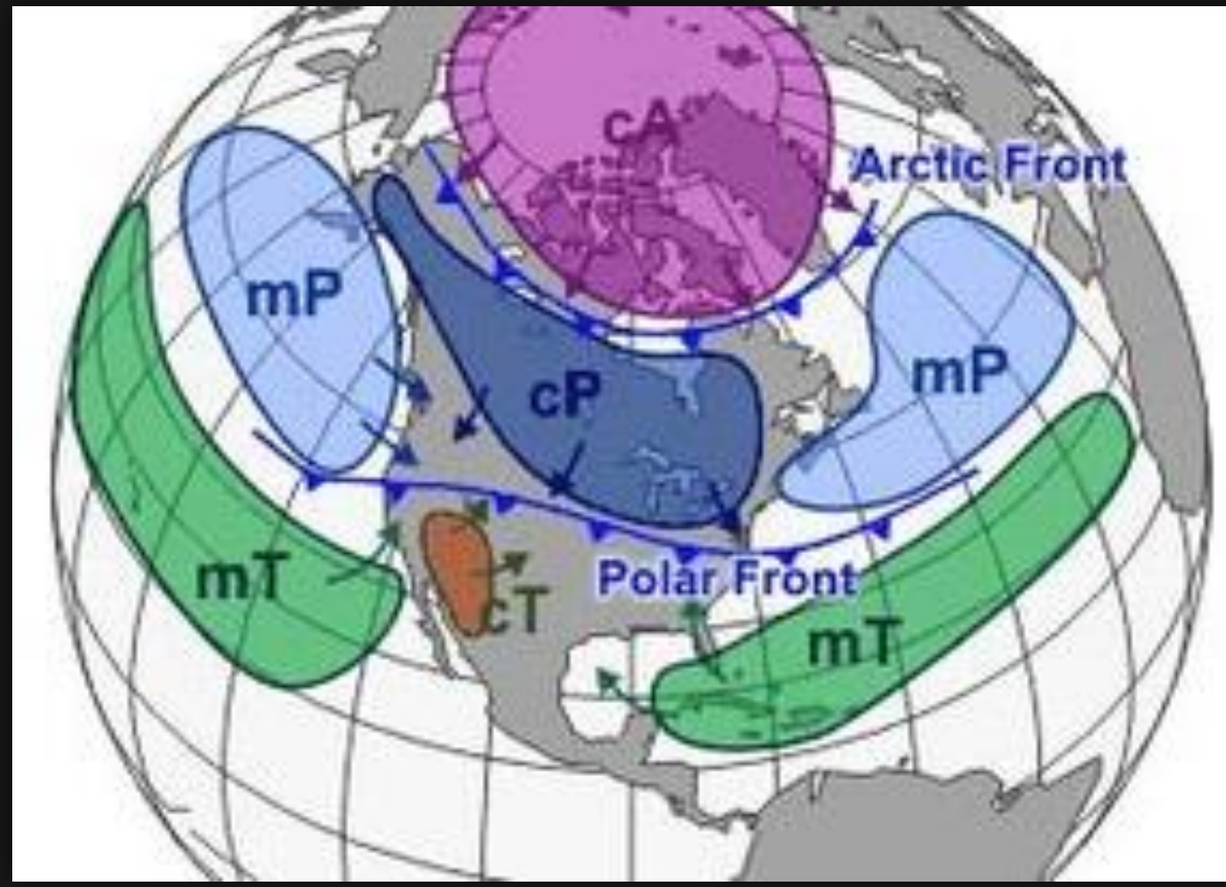
Large-scale winds caused by high and low pressure systems

Usually influenced and modified in lower atmosphere by terrain

Large-Scale Pressure Systems and Fronts



Air Masses



mP *Maritime Polar*

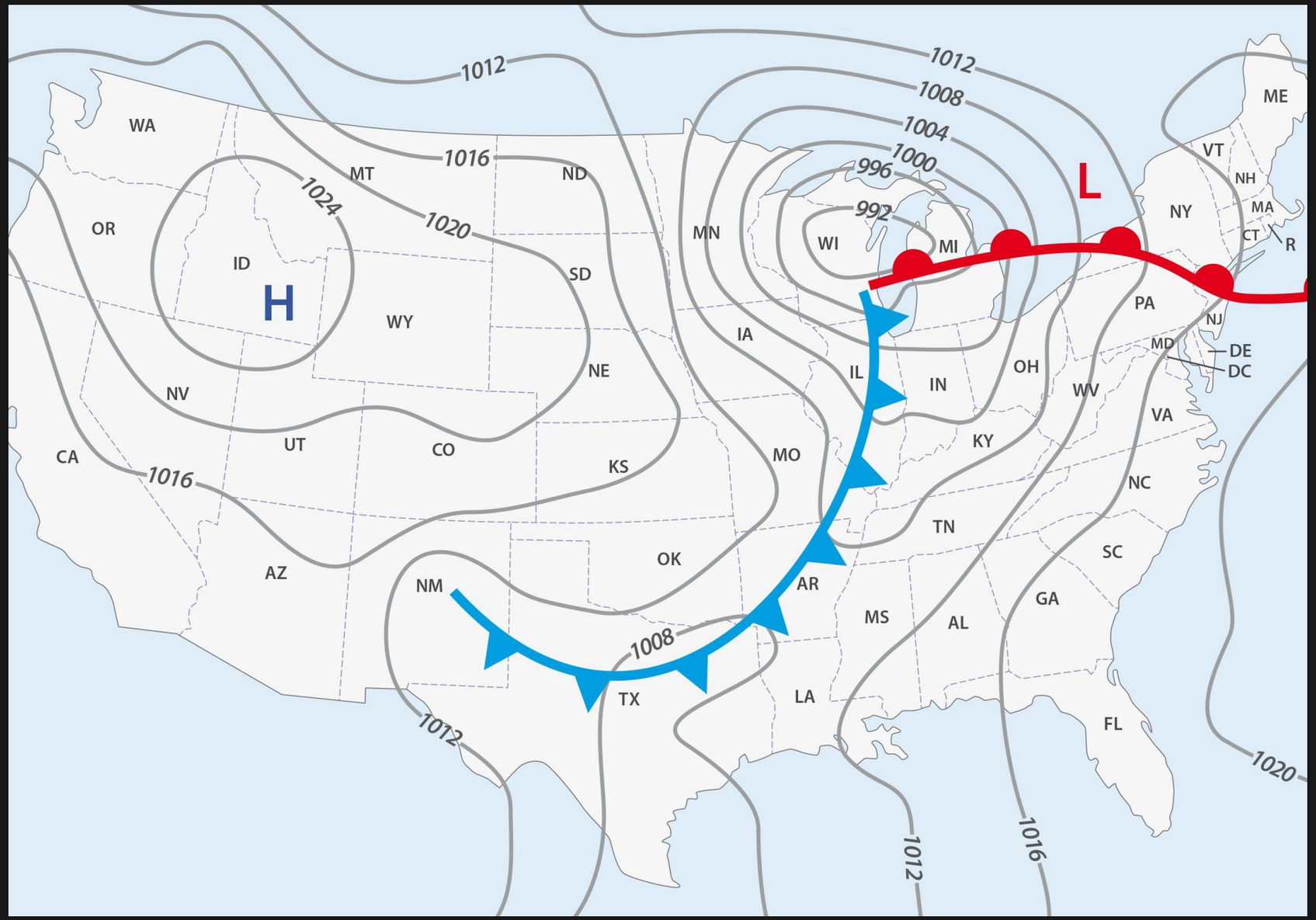
mT *Maritime Tropical warm, moist*

cT *Continental Tropical hot, dry*

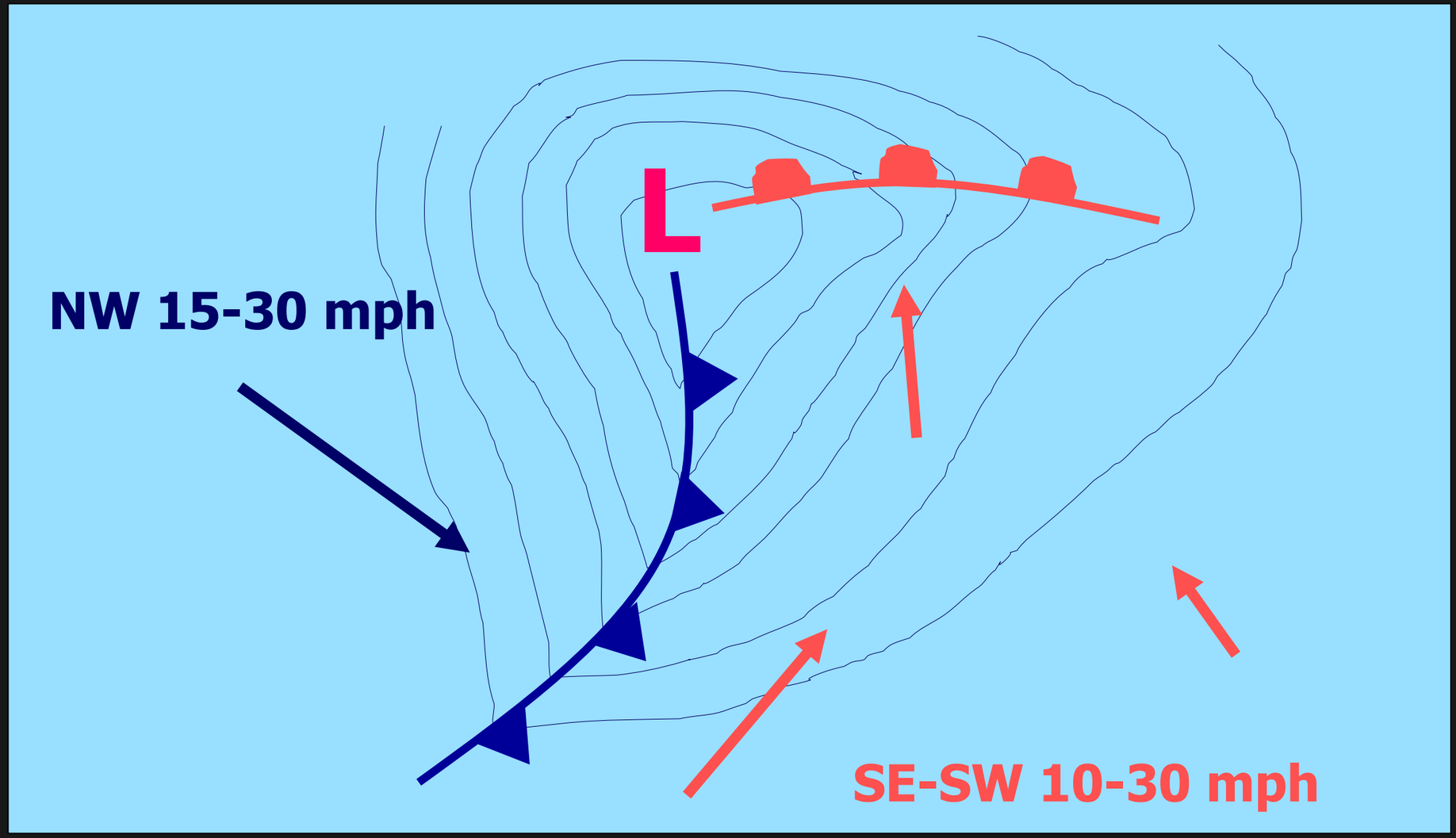
cA *Continental Arctic very cold, dry*

cP *Continental Polar cold, dry*

Pressure Systems and Fronts



Frontal Wind Patterns



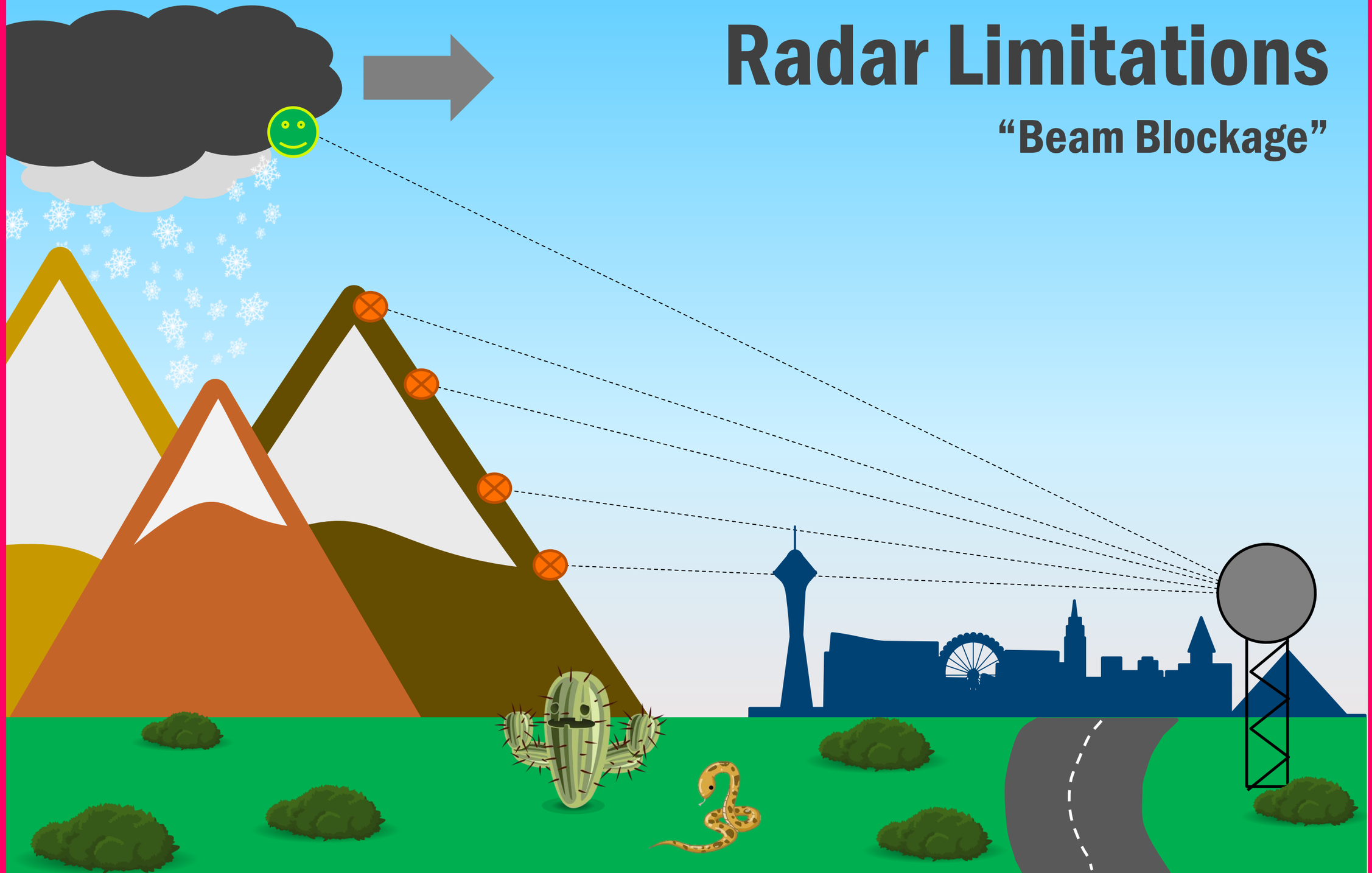
DATA COLLECTION


HARMLESS WEATHER INSTRUMENT


SAFARI
SAFARI

Radar Limitations

"Beam Blockage"



HAZARDS

Hazards Out West

Flash Floods

Extreme Heat

Dust Storms

Hail

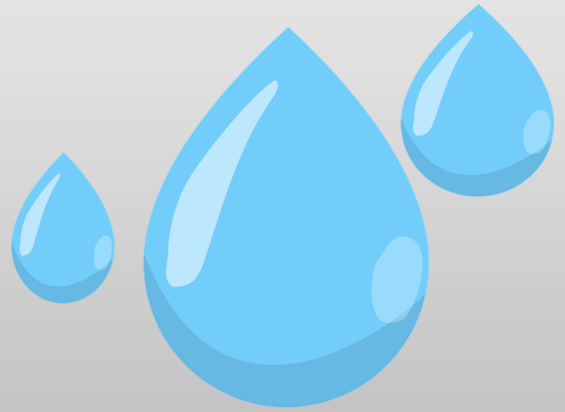
Lightning

Microbursts

Thunderstorms

How do thunderstorms form?

Ingredients

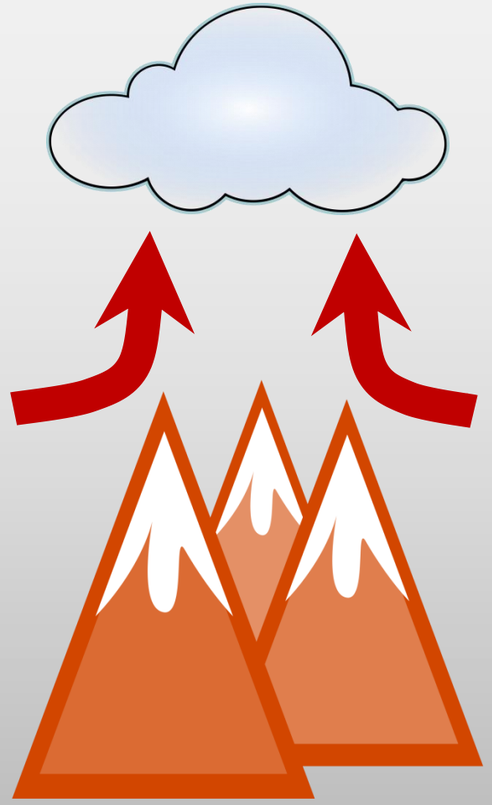


Moisture

"Fuel" source for thunderstorms.

Instability

The tendency for air to rise on its own.



Lift

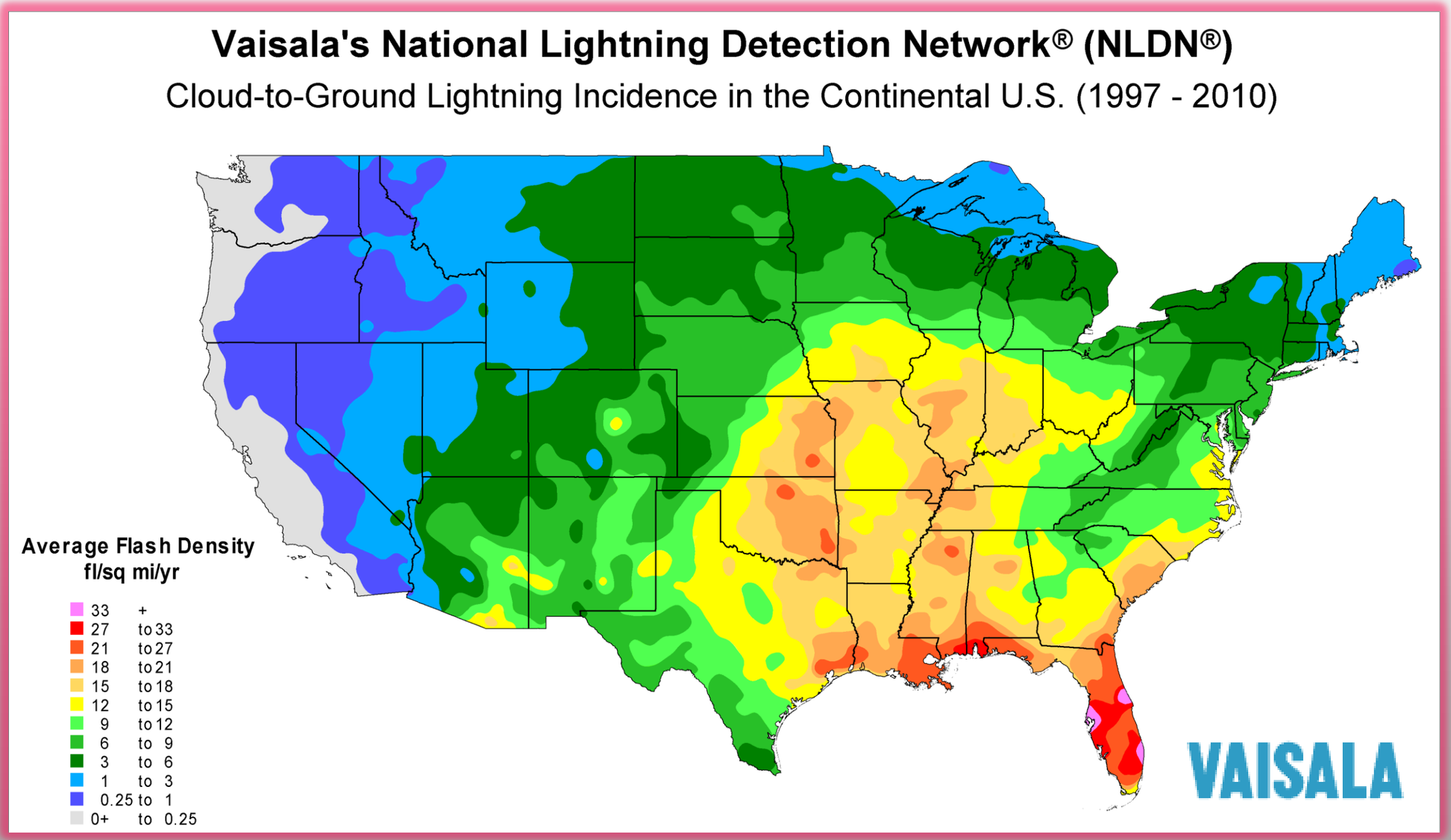
Mountains, fronts, low pressure systems, and thunderstorm outflows.

Severe Thunderstorms

Wind Shear

A change in wind speed or direction with altitude

Thunderstorm Frequency



Lightning

Lightning strikes over the Las Vegas Valley. Photo by Caleb Steele.

Lightning Safety

- Seek shelter if you hear thunder.
- There is no “safe” place outdoors.
- Vehicles with the windows rolled up are the safest alternative if a solid structure is not available.
- If you can’t get to a shelter or vehicle, avoid tall trees, power lines, or tall objects.
- Be the lowest point.

Hail

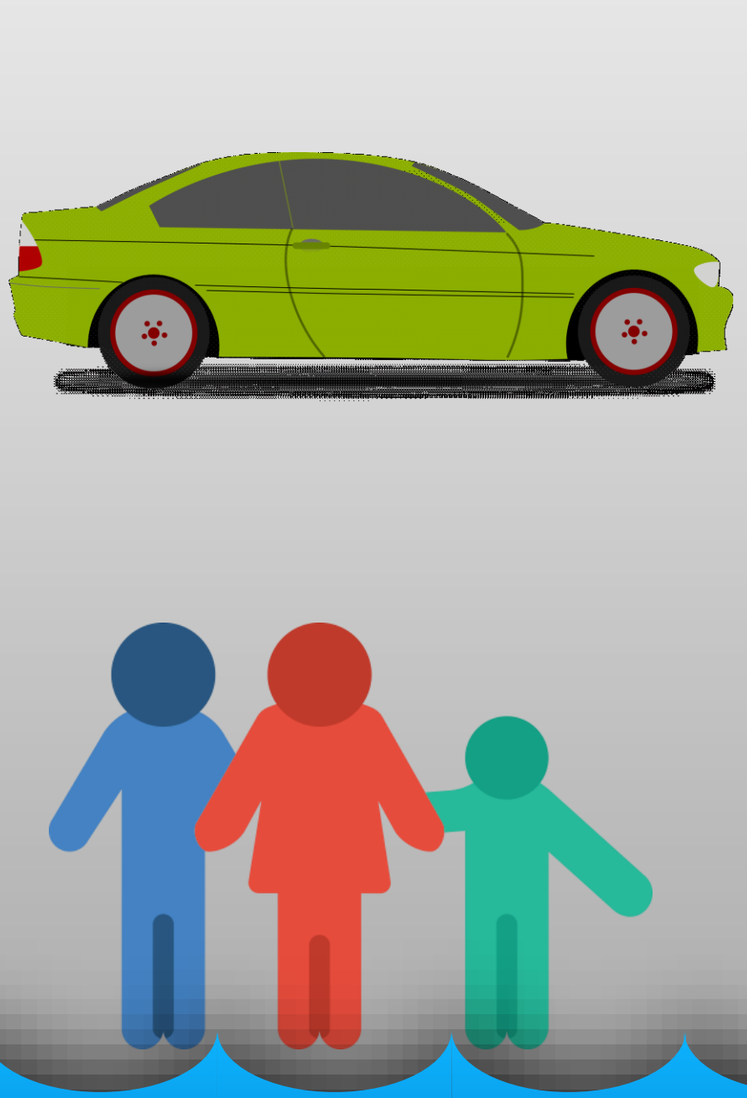
Jan 2016 – Largest hailstone in California, observed in Red Bluff, CA. 3” diameter

Flash Floods

#2 Weather-Related Killer

Flash Floods

2 feet of flowing water can wash away most cars



6 inches of flowing water can wash away people

Flash Floods

Flash Flood near Moapa, NV

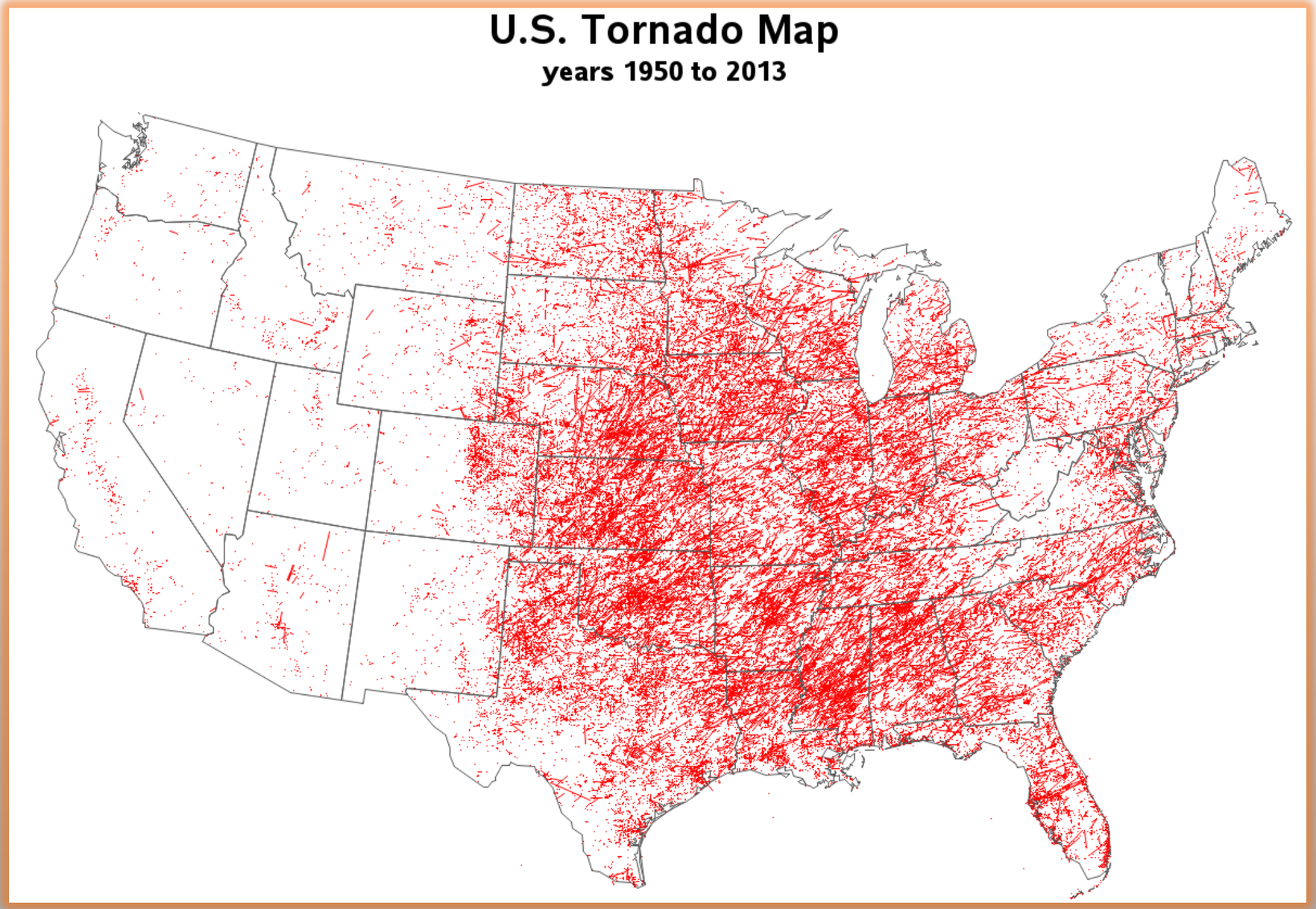
Microburst

Tornadoes

Tornado near Desert Center, CA (Brigitte Jerke, April 21st, 2015)

Tornadoes – Owens Valley 3/3/2018

Tornado Alley



Weather Alerts

Watch

Occurrence, location and/or timing uncertain

Warning

Is occurring or imminent

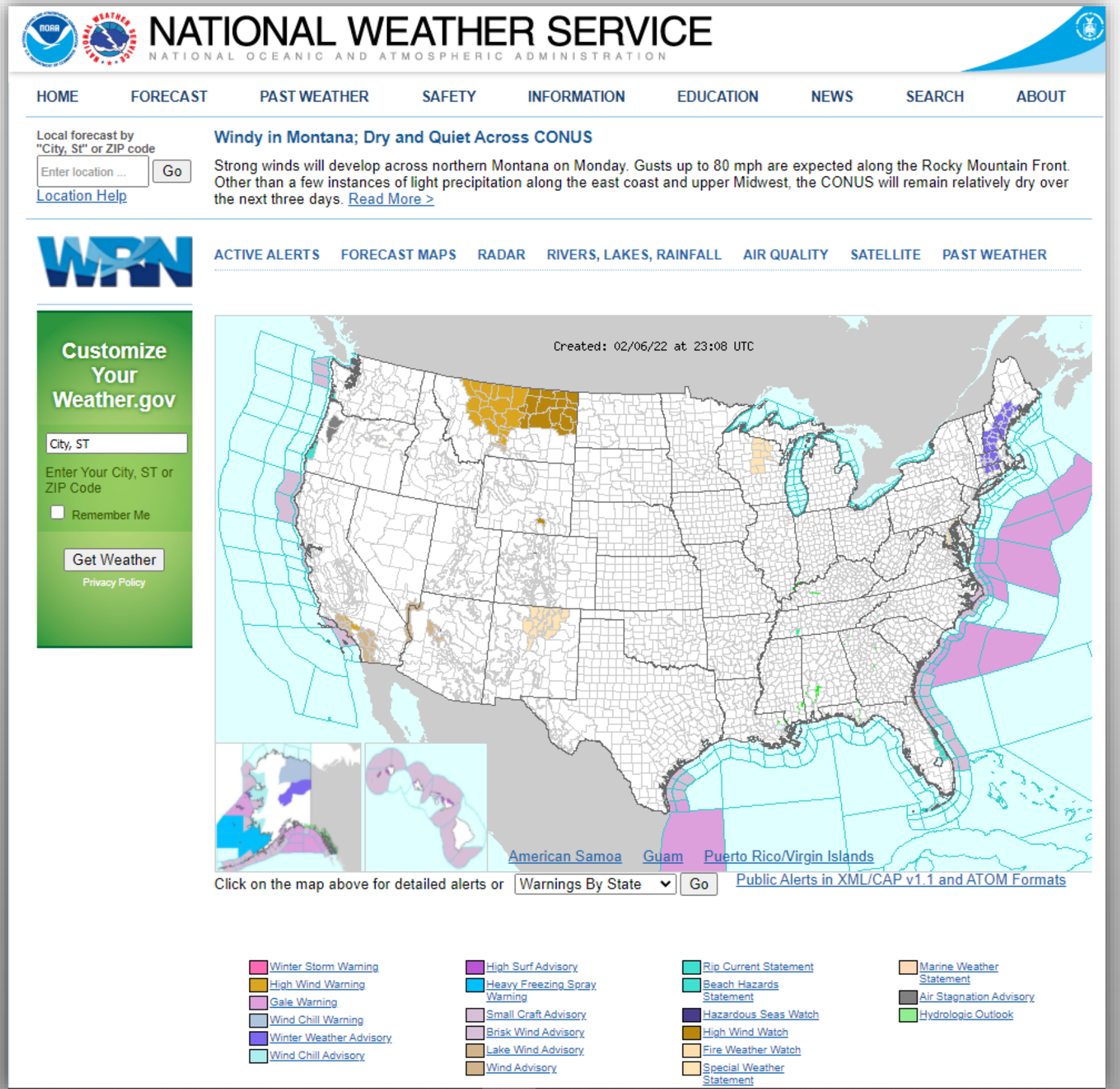
Advisory

May cause serious inconvenience

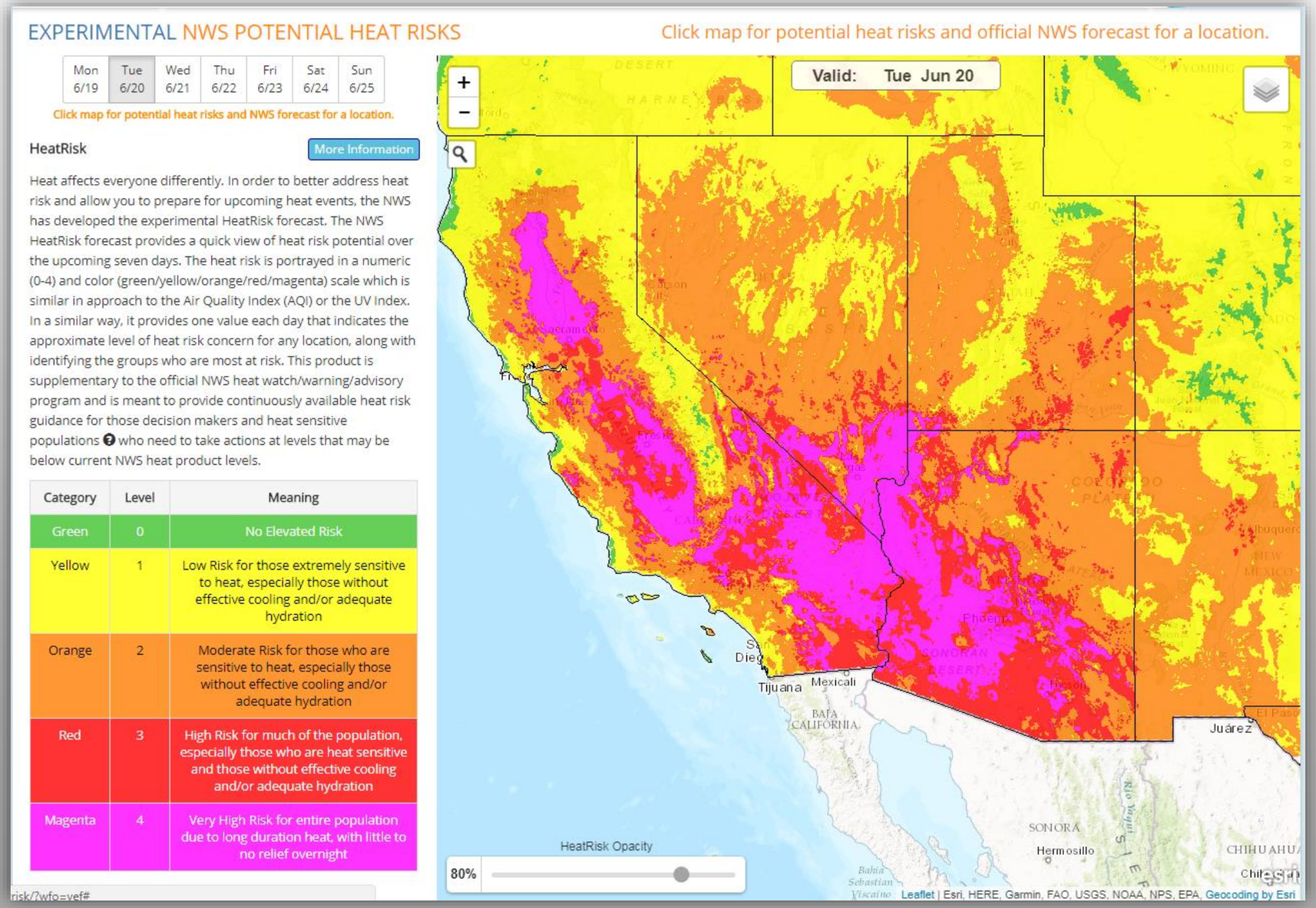
RESOURCES

- WELCOME
- METEOROLOGY
- DATA COLLECTION
- HAZARDS
- RESOURCES

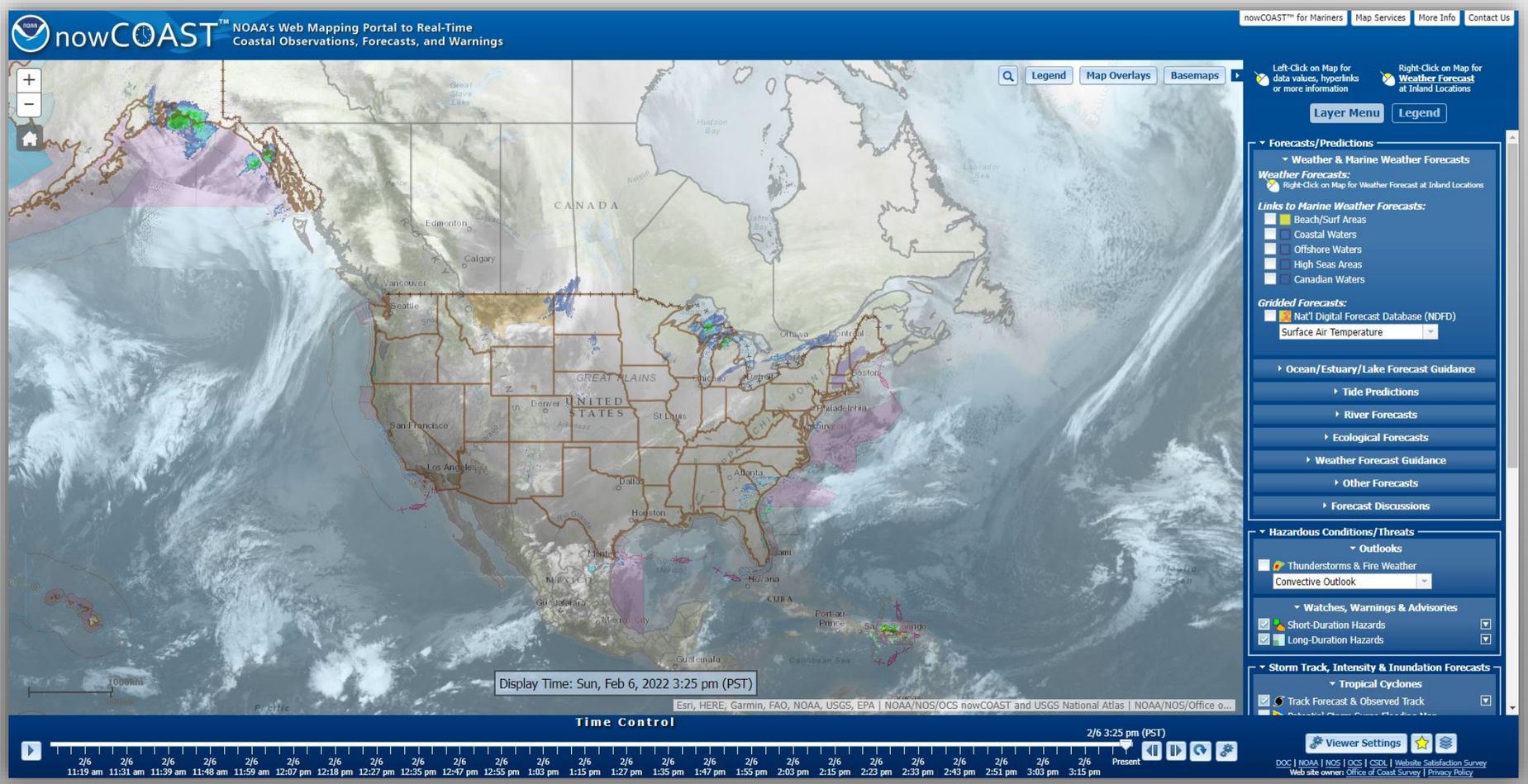
• weather.gov



- weather.gov
- HeatRisk



- weather.gov
- HeatRisk
- NowCoast



- weather.gov
- HeatRisk
- NowCoast
- StormReady
- WRN Ambassador

WRN Ambassador

Your Organization	NOAA/NWS
✓Promotes Weather-Ready Nation (WRN) messaging	✓Provides outreach content & training opportunities
✓Demonstrates commitment to public safety	✓Explores collaboration opportunities with your organization
✓Collaborates on innovation opportunities with NOAA	✓Assists with StormReady opportunities for communities
✓Shares success stories	✓Recognizes your organization as a WRN Ambassador
✓Takes ownership by using the WRN Ambassador Logo	✓Provides means of two-way communication with NOAA

AMBASSADOR™
WRN
WEATHER-READY NATION

- weather.gov
- HeatRisk
- NowCoast
- StormReady
- WRN Ambassador
- Facebook
- Twitter

- weather.gov
- HeatRisk
- NowCoast
- StormReady
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Thank You!

Dan Berc
National Weather Service Las Vegas
Phone: 702-263-9753
Email: daniel.berc@noaa.gov
Facebook: facebook.com/NWSVegas
Twitter: @NWSVegas