

State of the Climate at the Blue Hill Observatory: 1885-2020

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**Virtual Seminar
28 April 2021**



Outline

- Big Picture of Global Climate Change
- Recent Global and National Trends
- Blue Hill Climate Record
(Observations began February 1, 1885)



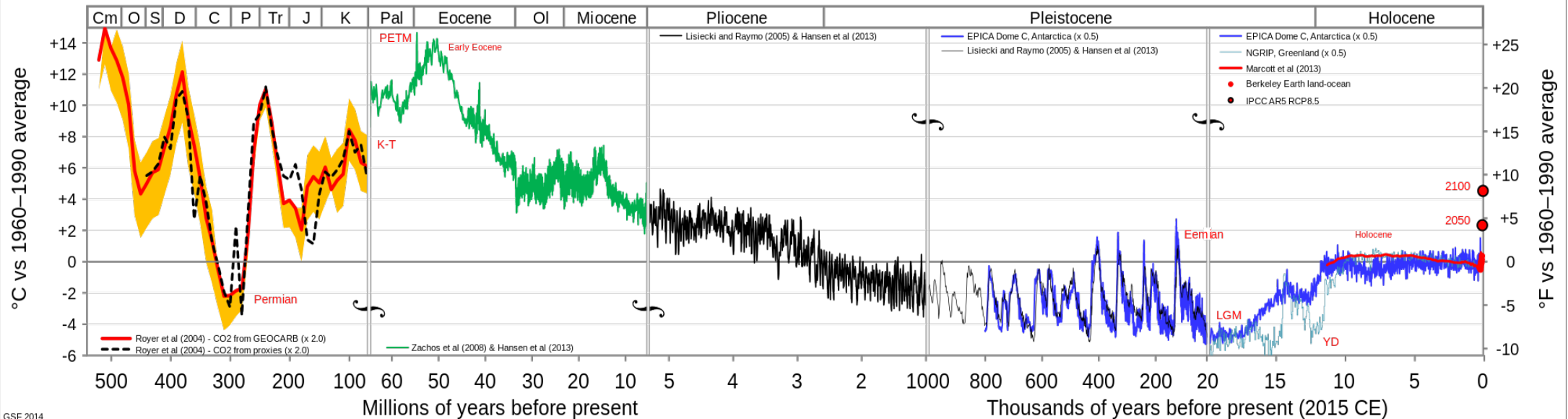
bluehill.org/observatory

BHO Mission:

"Our mission is to foster public understanding of Earth's weather, climate and environmental systems and to continue to produce, maintain, and analyze a meticulous, consistent record of weather and climate observations."

Climate Change: What's the Big Picture?

Temperature of Planet Earth

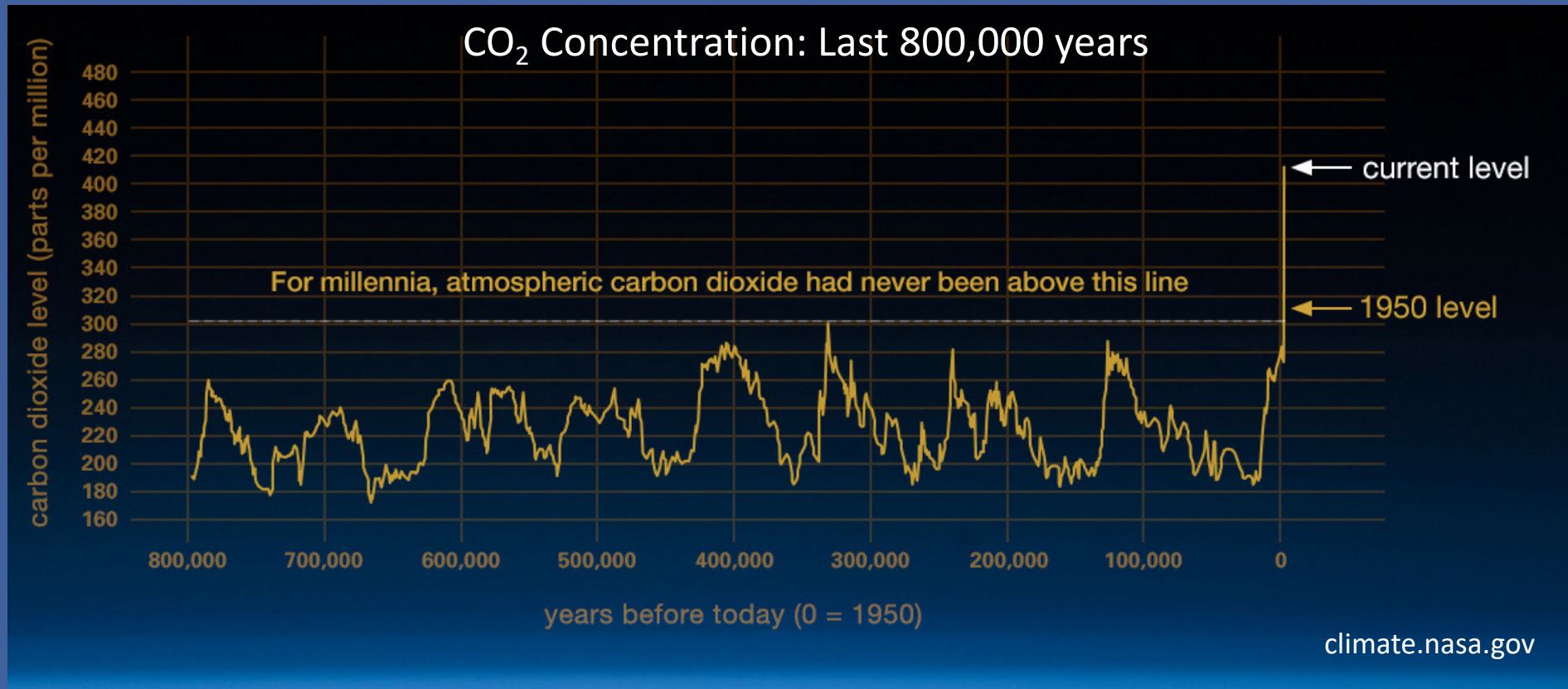


- 8-10 degrees F colder during last Ice Age (18-20,000 years ago)
- 20-25 degrees F warmer at times (more than 50 million years ago)
- Stable climate for the last 10,000 years is very unusual

Climate Change: What's the Big Picture?

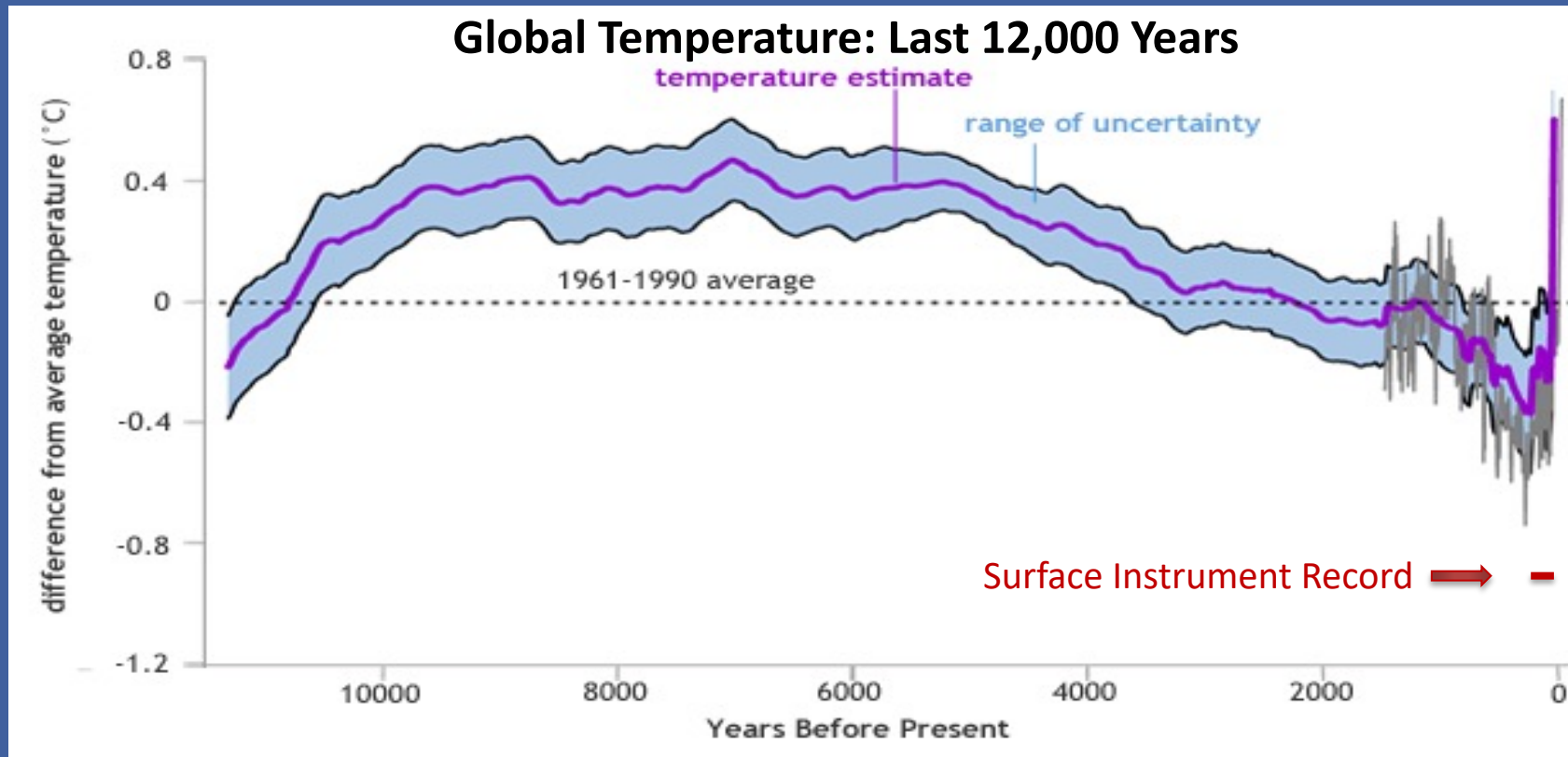
- Large climate changes on long time scales have occurred regularly in Earth's history due to natural factors:
 - Orbital variations (change incoming solar energy)
 - Earth's axis tilt (affects role of seasonal cycles)
 - Volcanic eruptions (vent greenhouse gases: CO₂; warming)
 - Volcanic eruptions (eject material into stratosphere; cooling)
 - Asteroid impacts (eject material that obscures sun; cooling)
 - Continental drift (alters air and ocean circulation)
- Currently recovering from last Ice Age in an inter-glacial period with some ice cover in polar areas

Climate Change: What's the Big Picture?



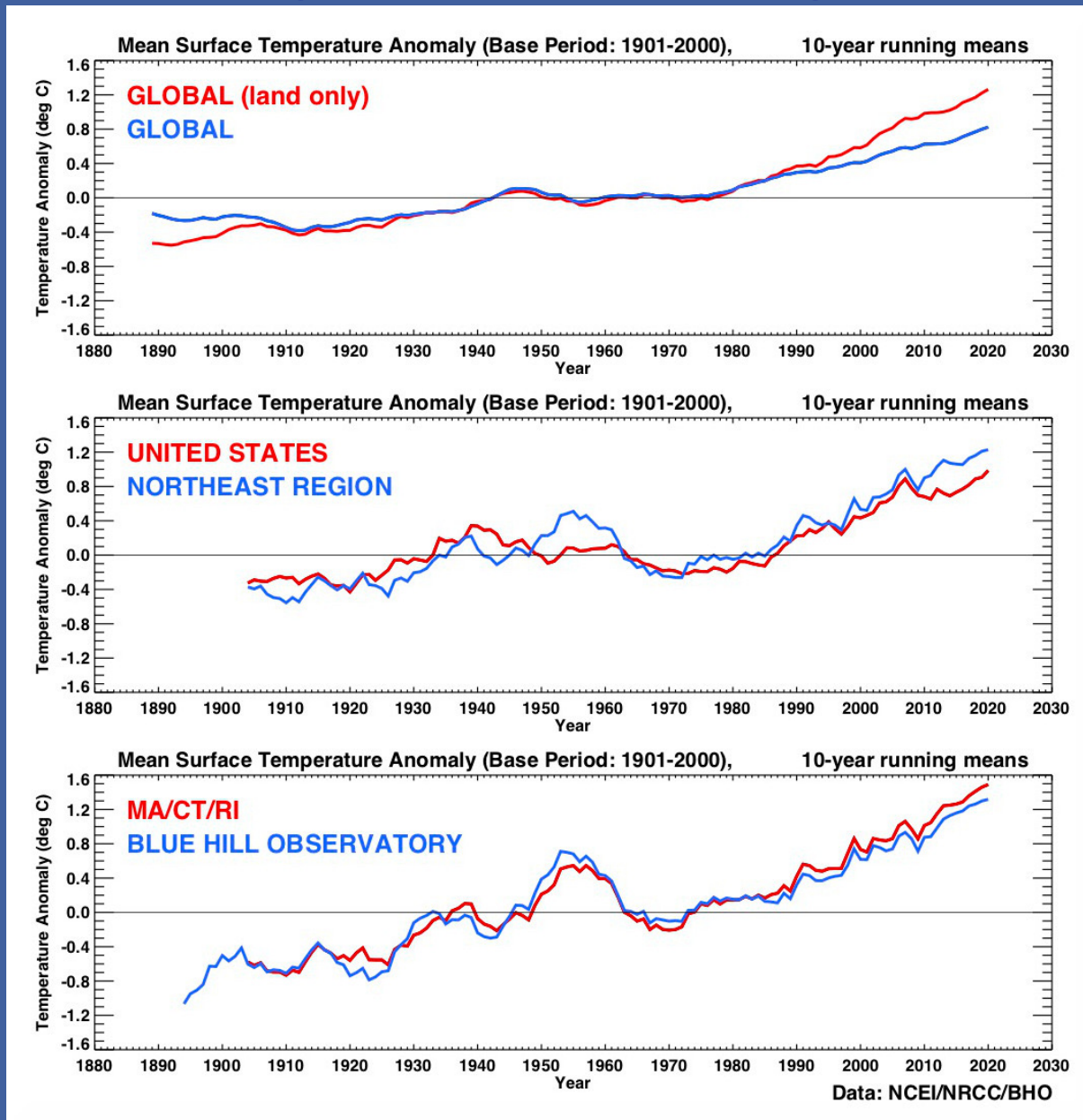
- Human Factor: Fossil fuel use has increased atmospheric carbon dioxide to **420 ppm as of April 2021** (highest level in 2.3 million years; was 280 ppm 200 years ago)

Climate Change: What's the Big Picture?



- Global mean temperature down during last 8,000 years, but...
- None of the long-term factors can be causing the upward surge in the last 150 years (during the instrumental record)
- Critical need for high quality observations...

Climate Change: What's the Big Picture?



Mean Temperature

- Global Change:
+1.1 deg C,
+2.0 deg. F
since 1880
- National Change:
+1.3 deg C,
+2.3 deg. F
since 1895
- BHO Change:
+2.3 deg C,
+4.2 deg. F
since 1885

BHO Climate: Observations

- Parameters

Temperature
Relative Humidity
Precipitation
Snowfall
Snow Depth
Wind Speed / Direction
Peak Wind Gust
Station Pressure
Sunshine Duration
Cloud Cover
Cloud Type
Weather Type
Pond Freeze/Thaw
Visibility, etc.



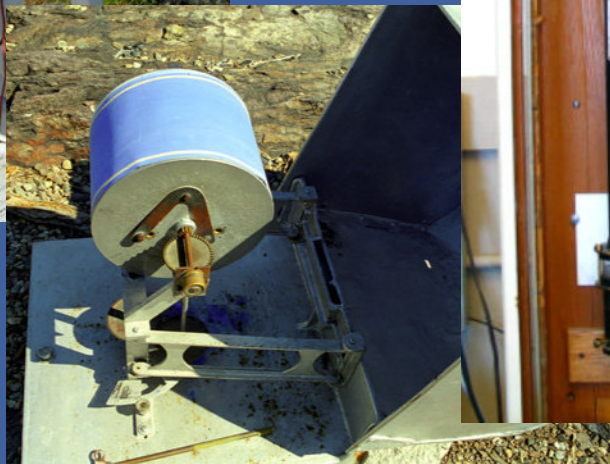
Outdoor instrument enclosure at BHO

BHO Climate: Observations

Traditional Instruments and Methods



Hazen
temperature
shelter



Ombroscope



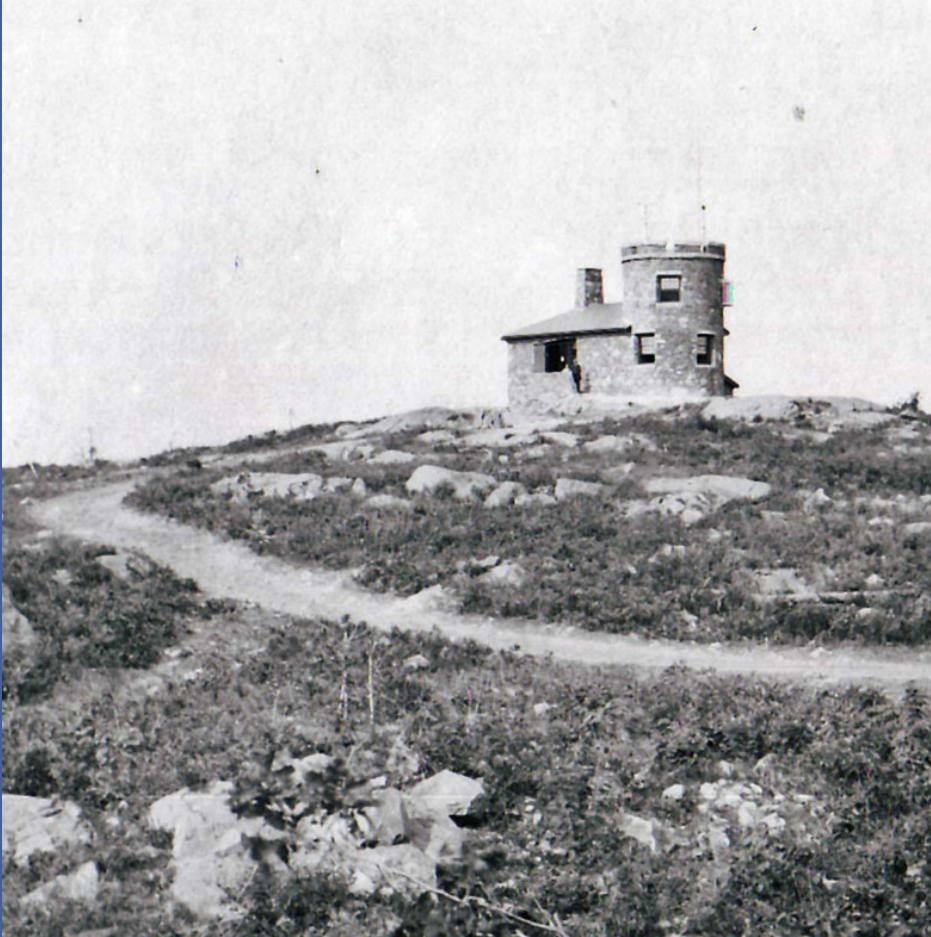
Mercury
barometers



Sunshine recorder

BHO Climate: Observatory

1885

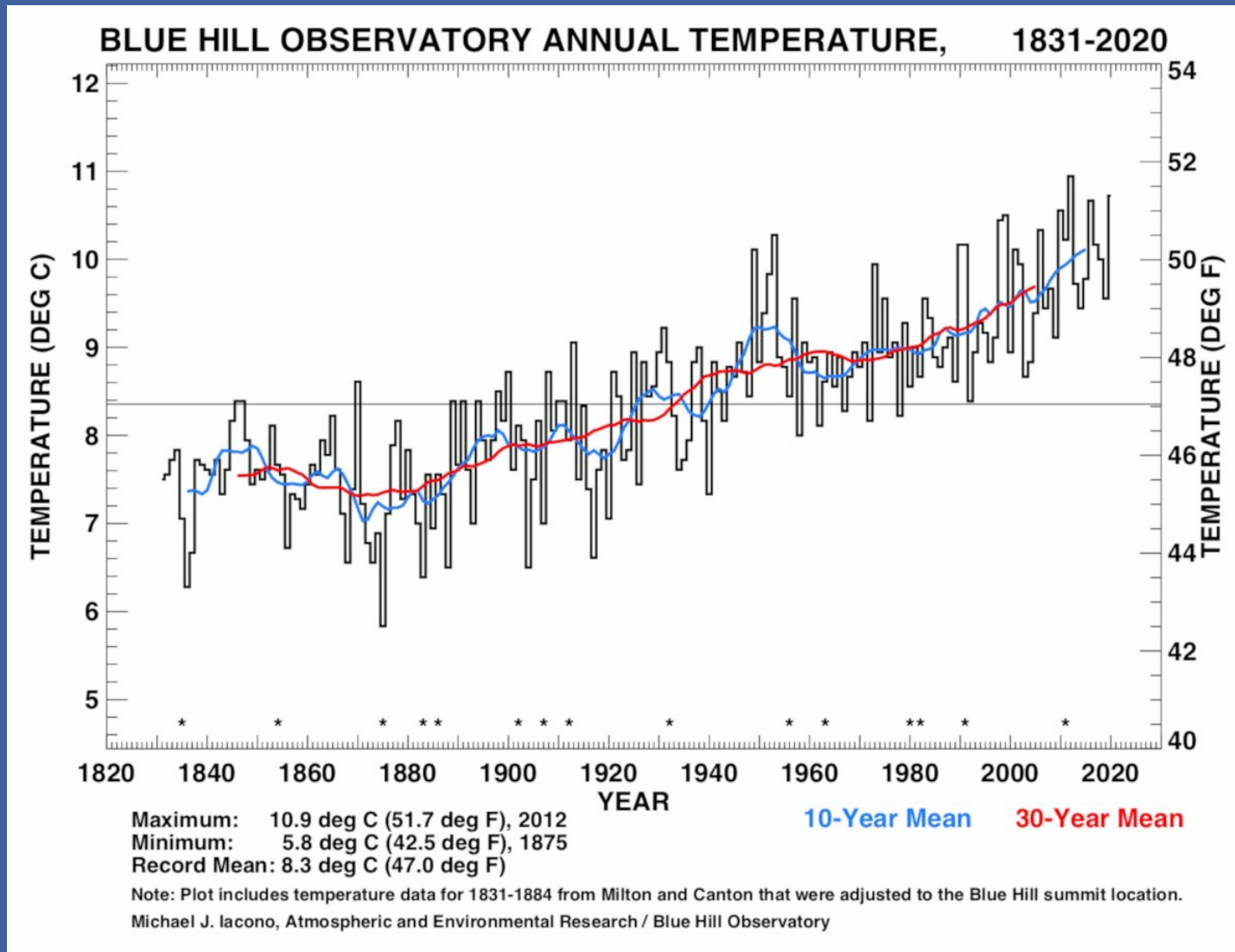


Blue Hill Observatory,
Great Blue Hill, Milton, MA

2011

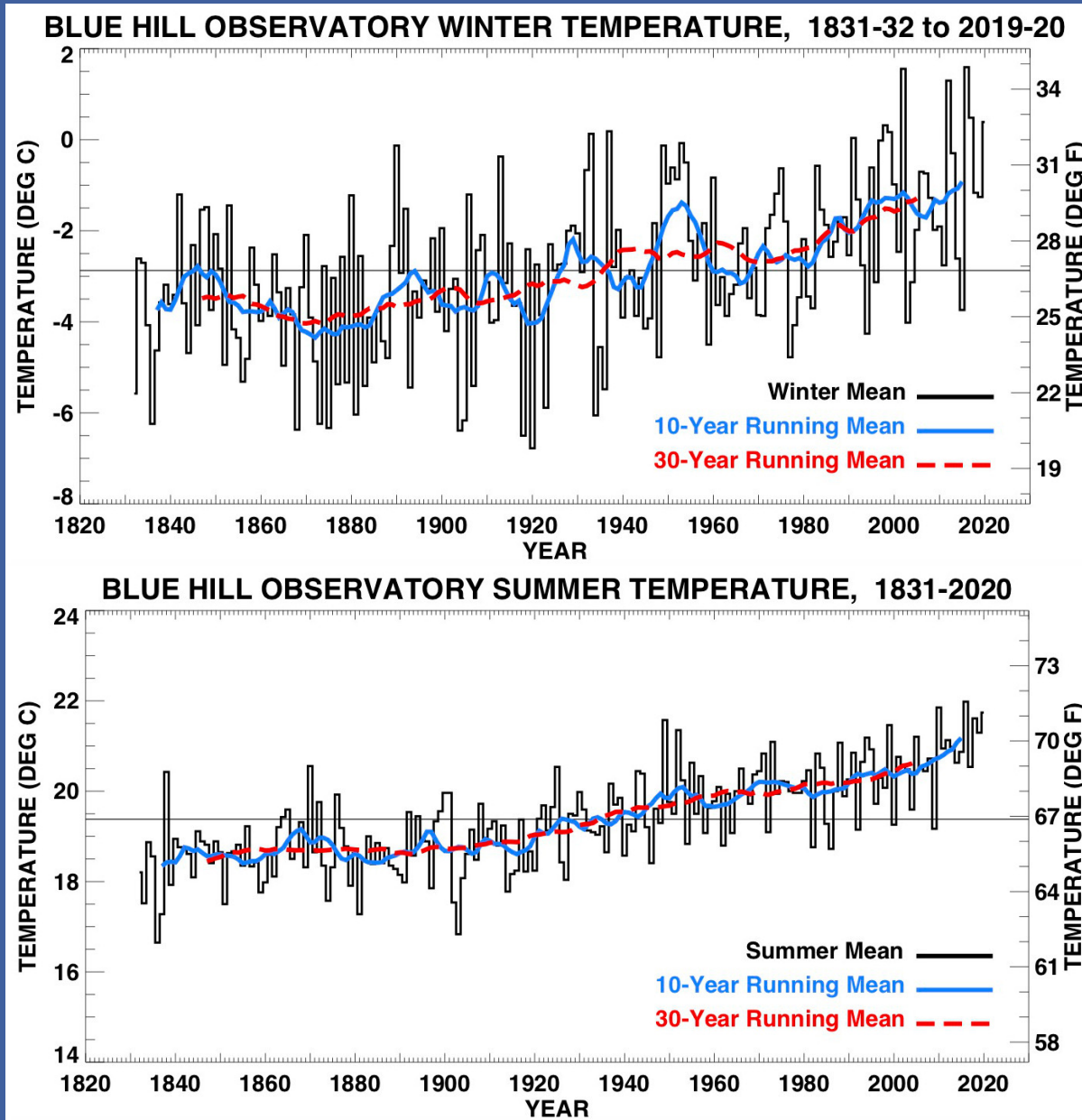


BHO Climate: Annual Mean Temperature



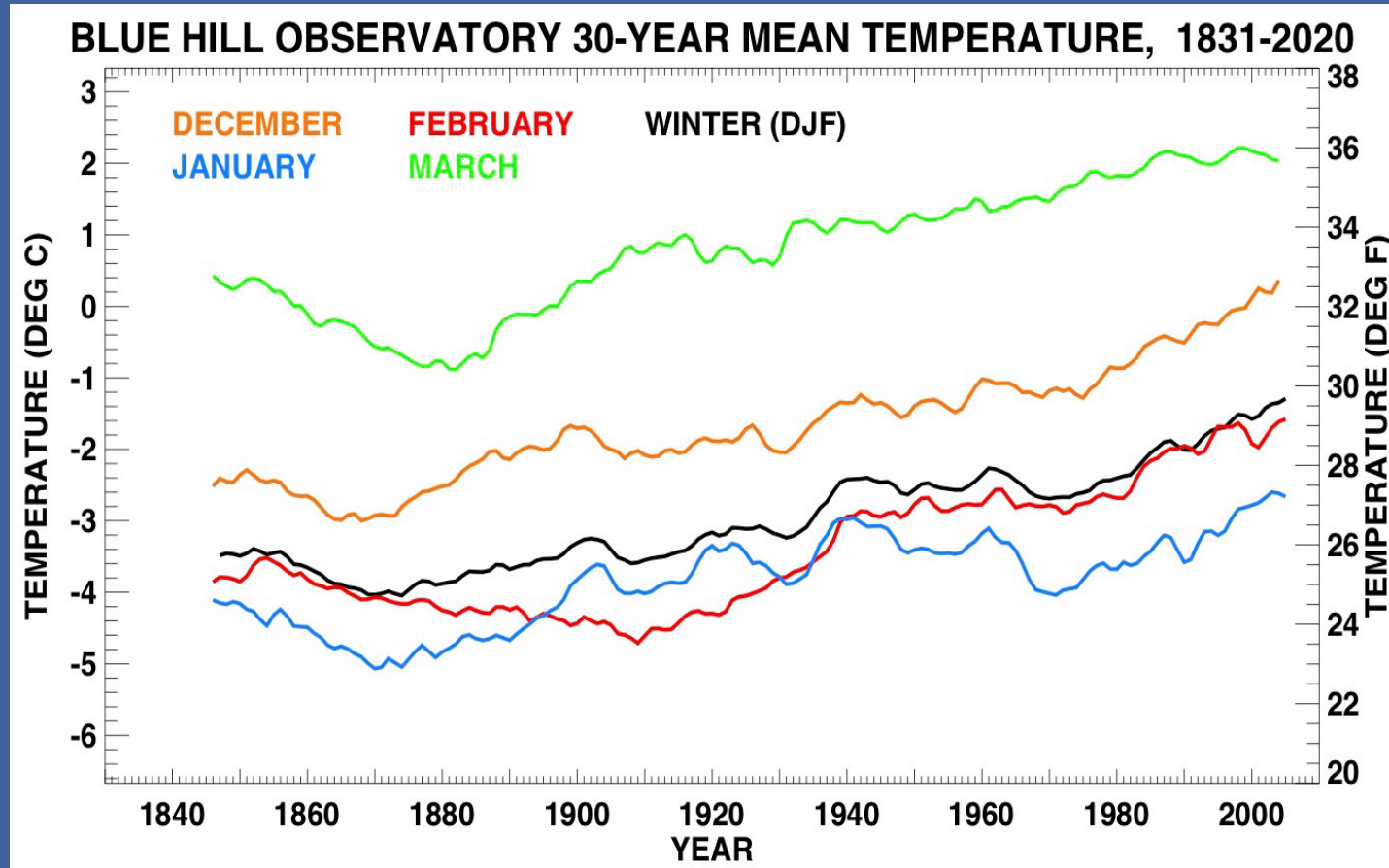
- Upward Trend:
+0.32 deg. F/decade,
+4.2 deg. F since 1885
- Trend statistically significant to 99.9% due to:
 - a) Long duration
 - b) Size of trend relative to annual variations
- Volcanic eruptions marked with "*"

BHO Climate: Seasonal Mean Temperature



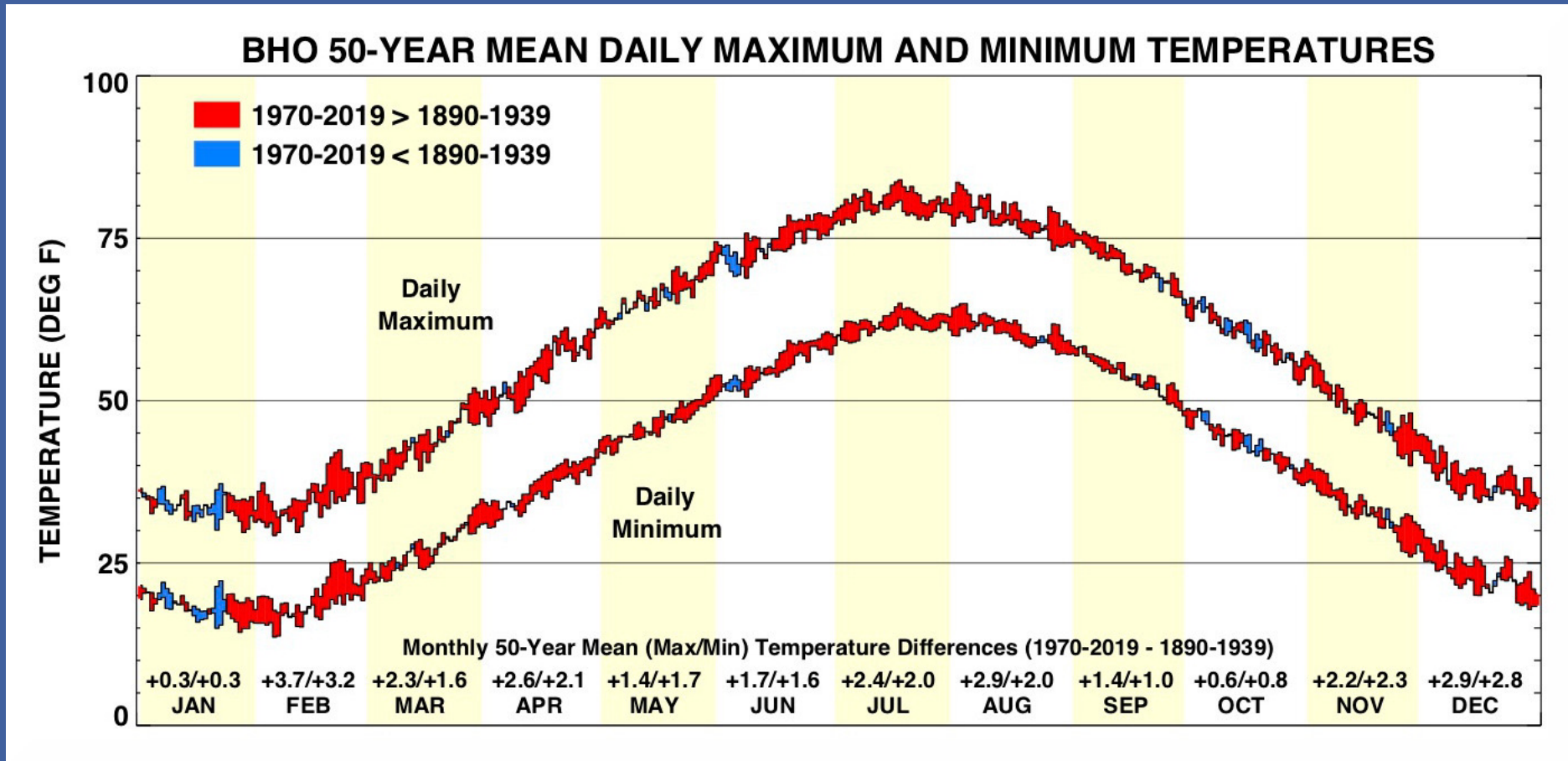
- Winter Trend:
+0.35 deg. F/decade,
+4.5 deg. F since 1885
- Summer Trend:
+4.3 deg. F since 1885
- Winter temperature
much more variable
than summer
- Spring Trend:
+3.9 deg. F since 1885
- Fall Trend:
+3.7 deg. F since 1885

BHO Climate: Winter Mean Temperature



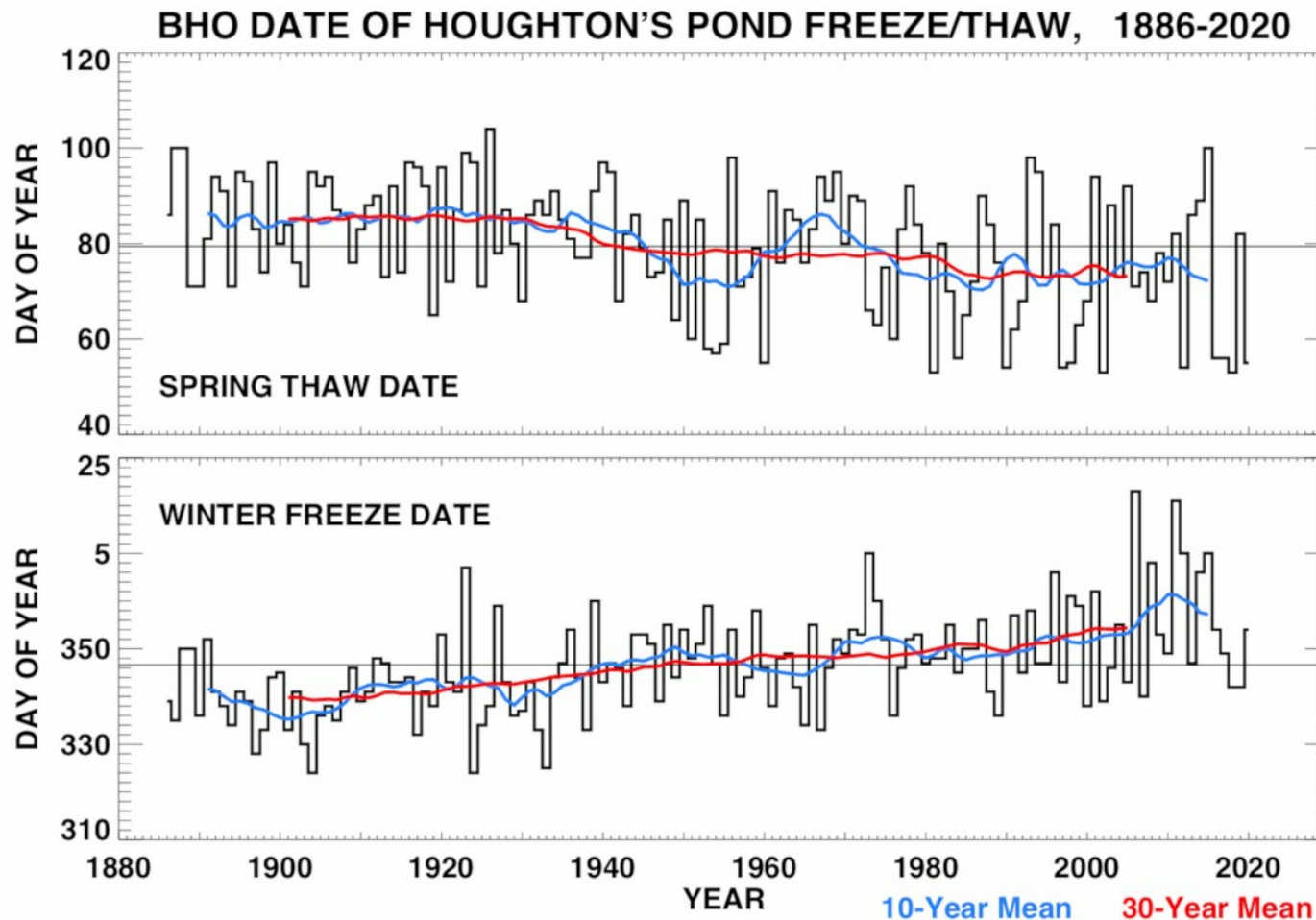
- January and February temperature trends are very different
- January now much colder than February
- January shows large decadal variability

BHO Climate: Daily Mean Temperature



- Daily means over two 50-year periods: 1890-1939 and 1970-2019
- Recent period warmer (red); recent period colder (blue)
- Minimal changes in early January; February now much warmer

BHO Climate: Pond Freeze/Thaw Dates



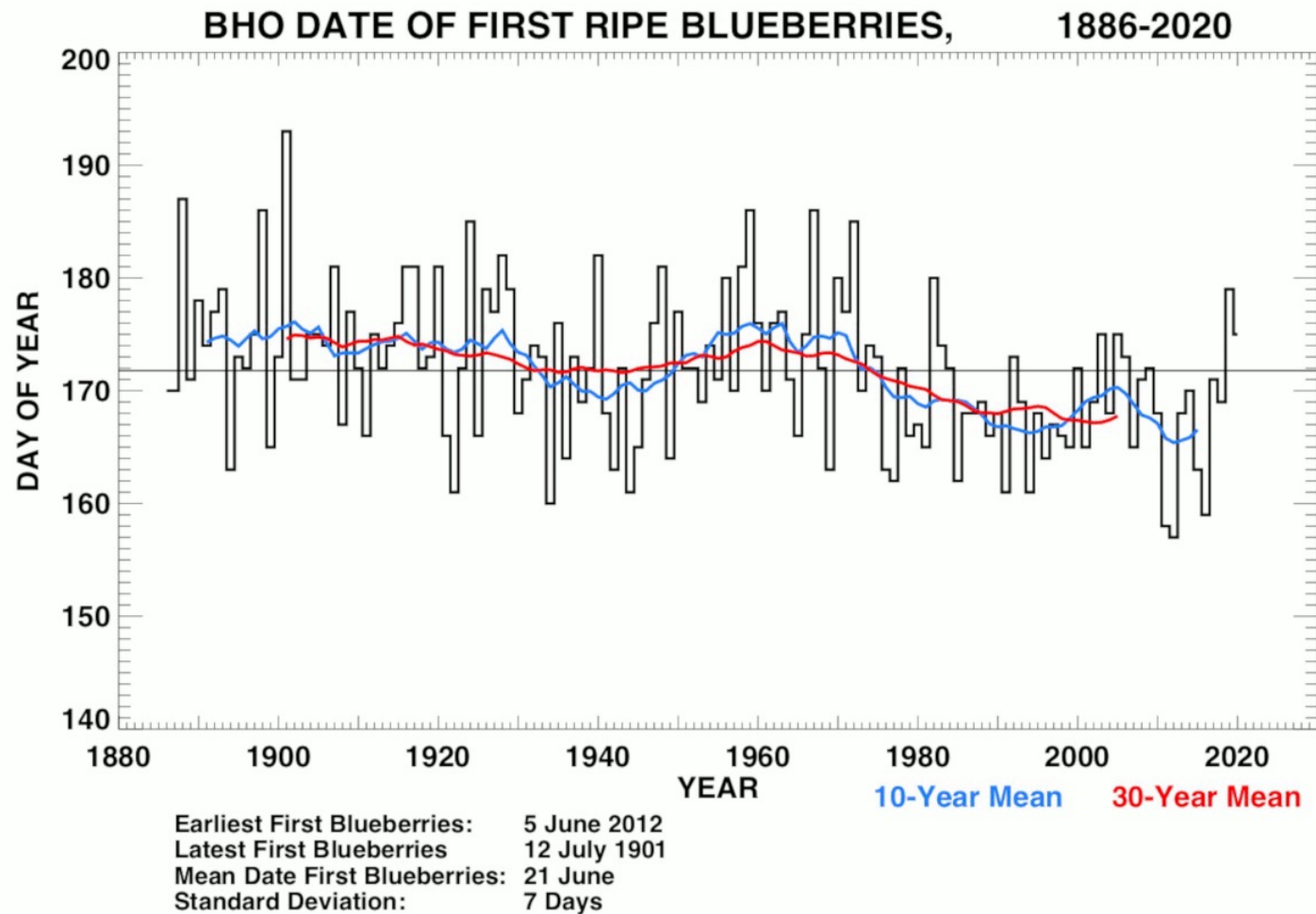
Earliest Pond Freeze: 19 November 1904, 1924	Earliest Pond Thaw: 22 February 1981
Latest Pond Freeze: 18 January 2007	Latest Pond Thaw: 14 April 1926
Mean Pond Freeze: 12 December	Mean Pond Thaw: 21 March
Standard Deviation: 10 Days	Standard Deviation: 13 Days

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- Length of time local pond remains frozen during winter has decreased by two weeks since 1880s
- Represents a natural indicator of temperature changes



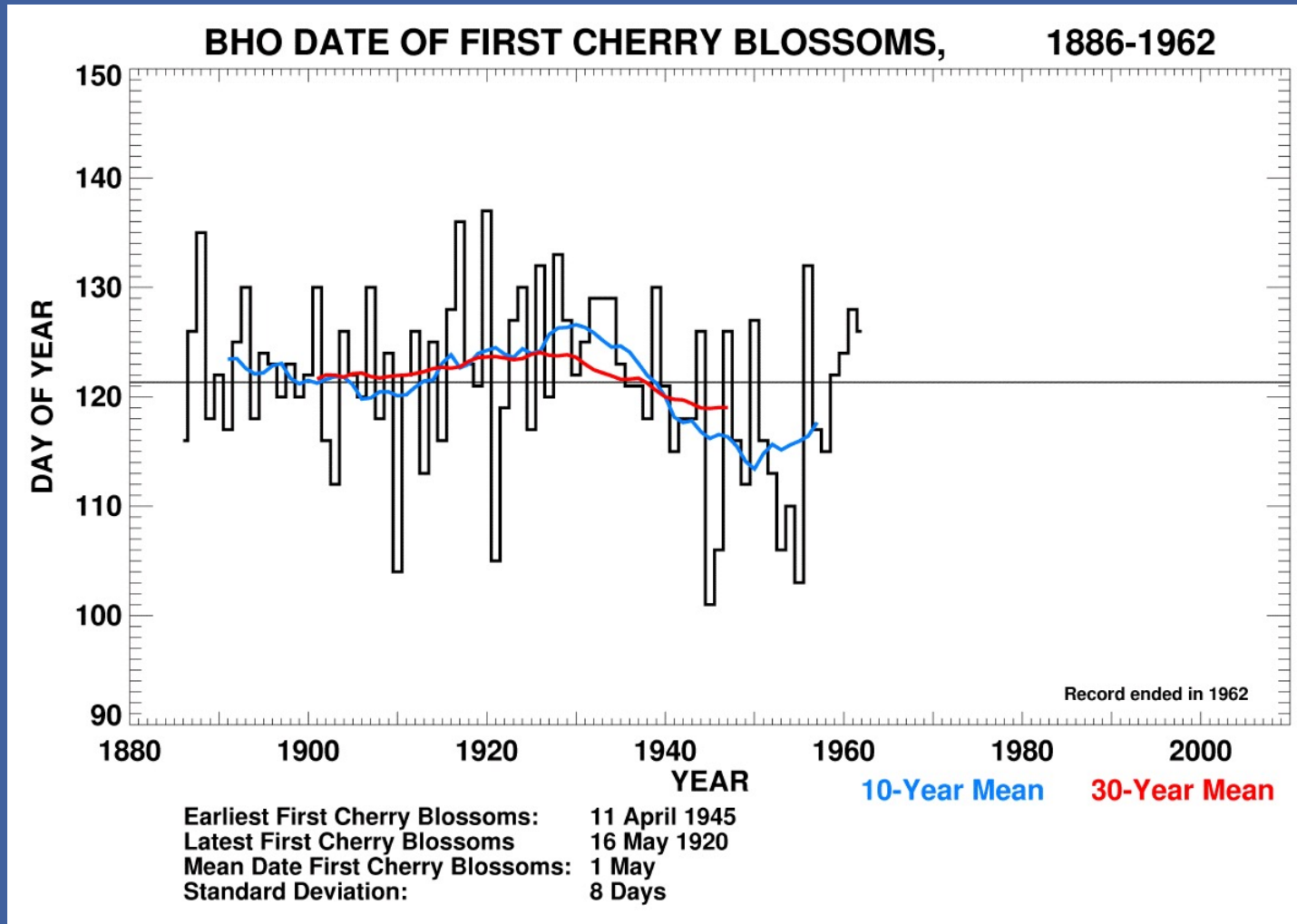
BHO Climate: First Ripe Blueberry Dates



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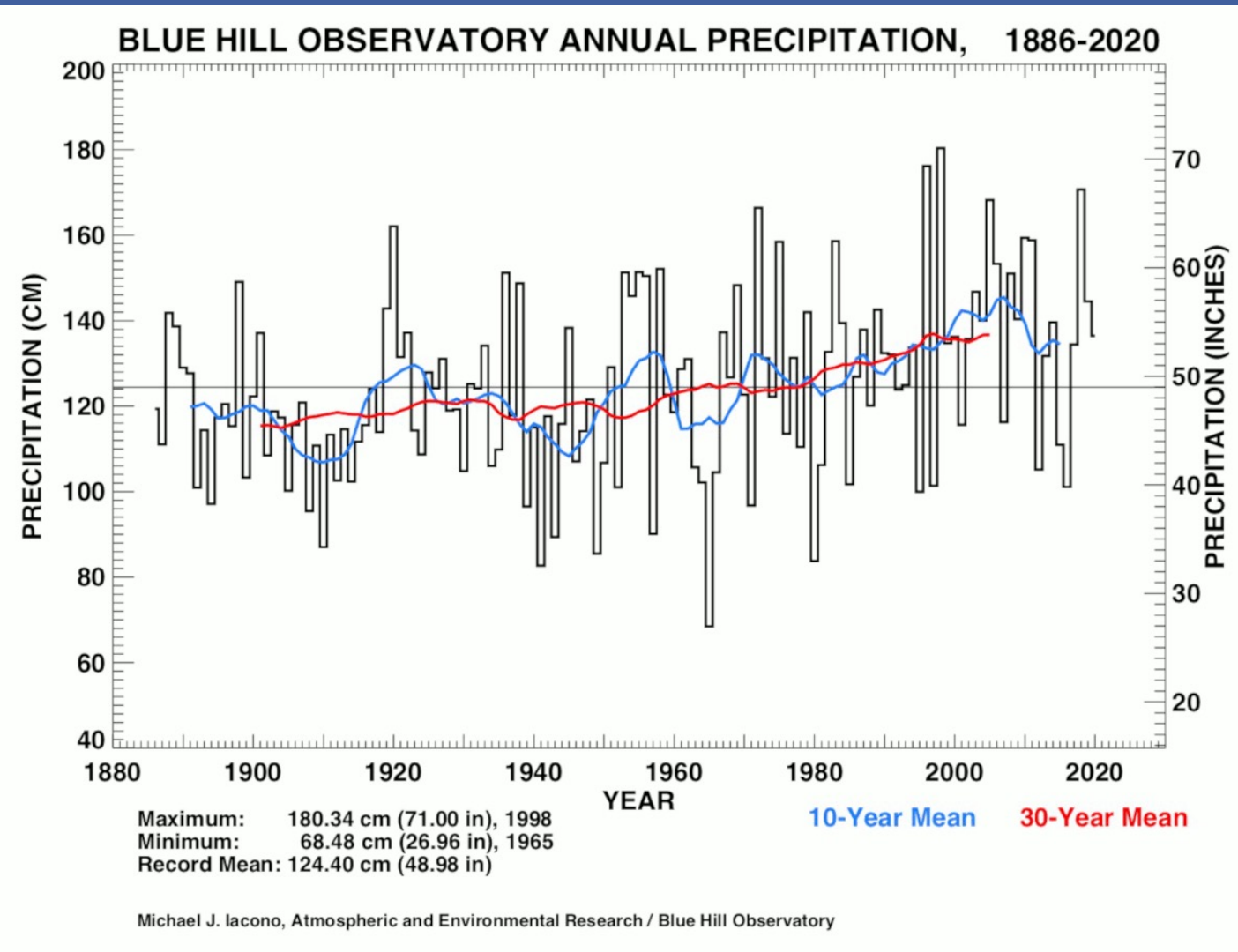
- First ripe blueberries on Great Blue Hill arrive about one week earlier on average since 1880s
- Natural indicator of temperature changes

BHO Climate: First Cherry Blossom Dates



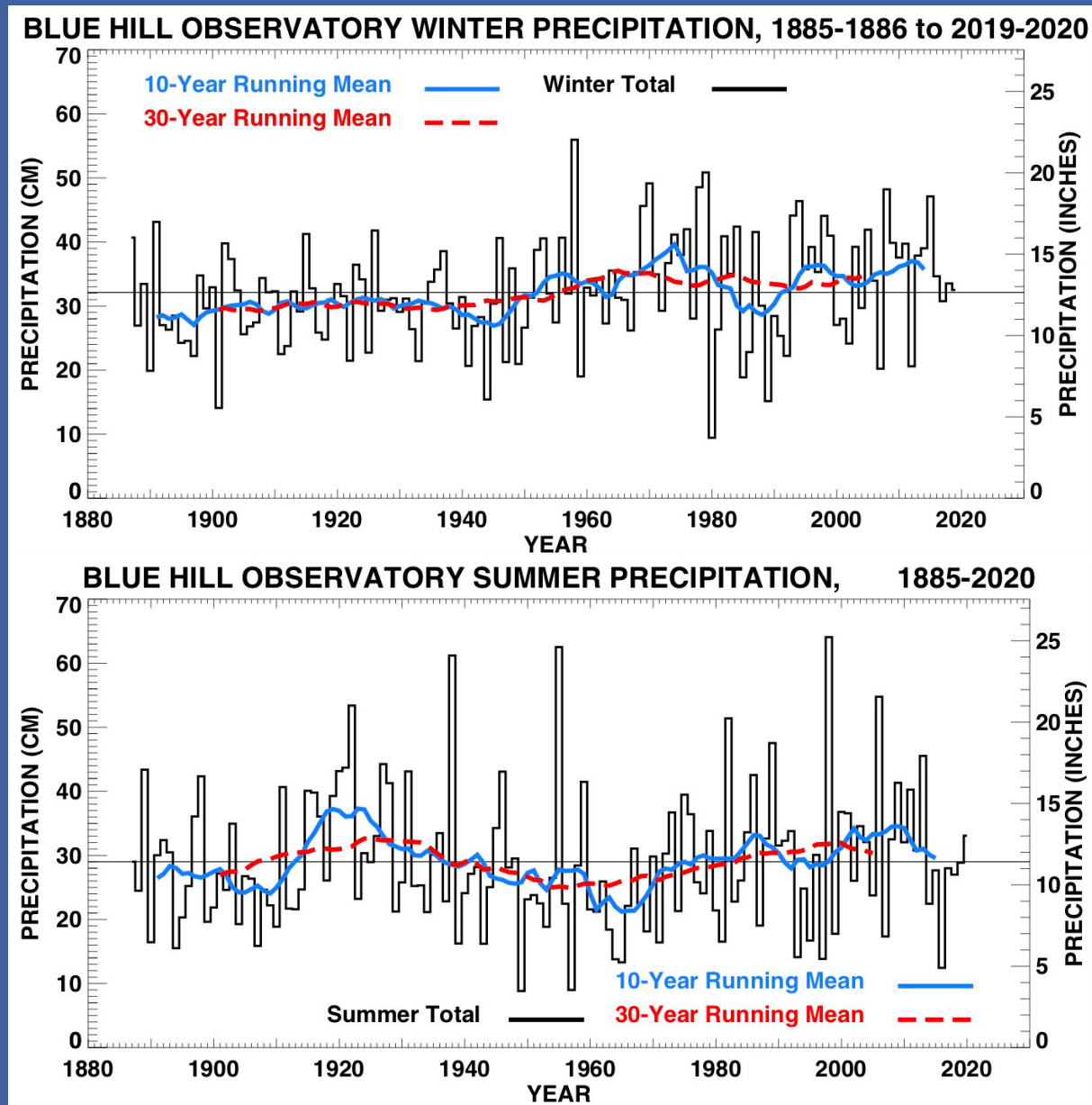
- First cherry blossoms at Base Station began arriving earlier in mid-20th century
- Record suspended in 1962
- Nearby cherry tree observed in bloom on April 11, 2021 (day of year 101)

BHO Climate: Annual Precipitation



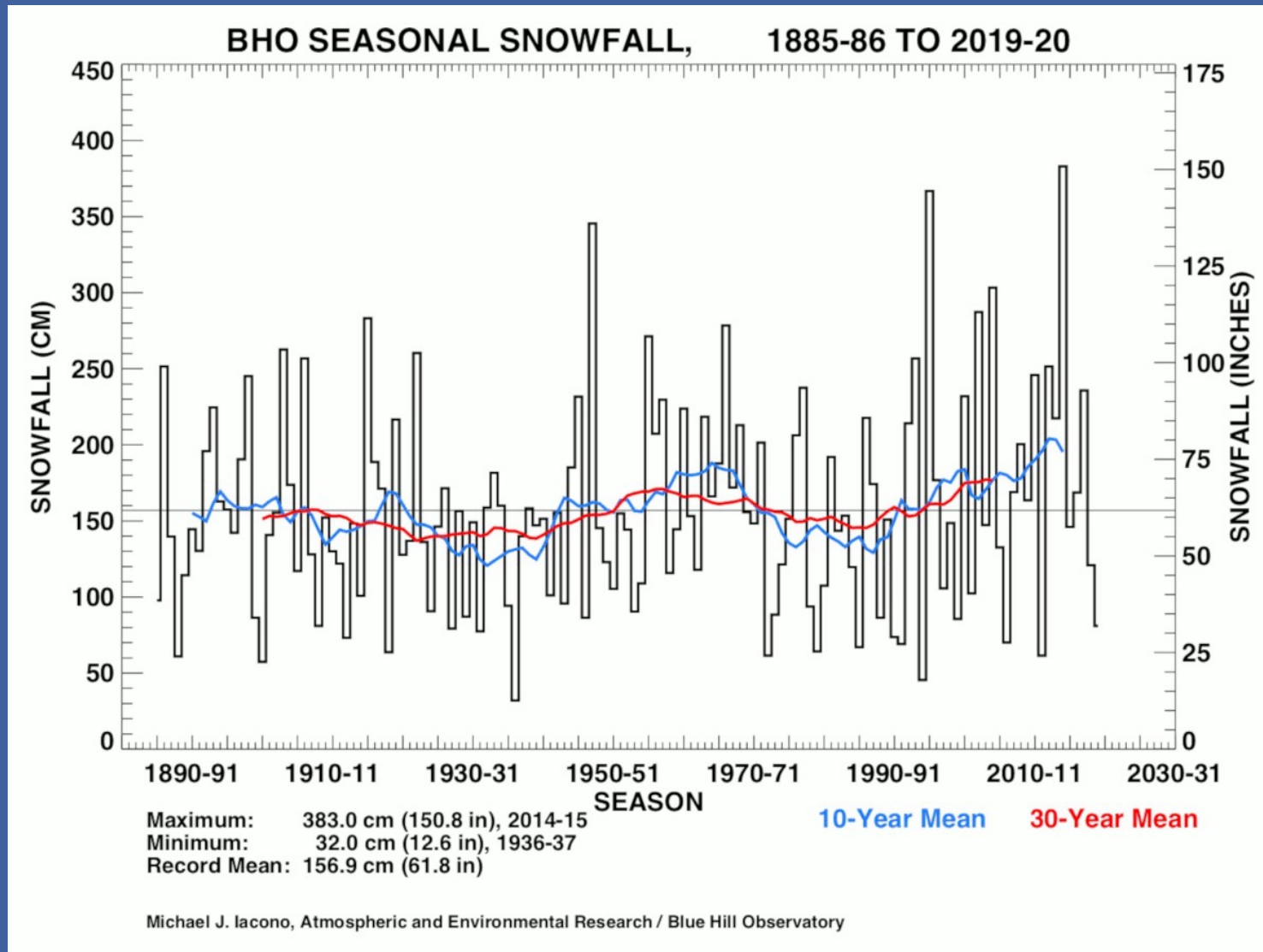
- Total precipitation (rain plus melted snow) is increasing **+0.67 in/decade** **+8.7 inches since 1885**
- High variability from year to year, upward trend is statistically significant

BHO Climate: Seasonal Precipitation



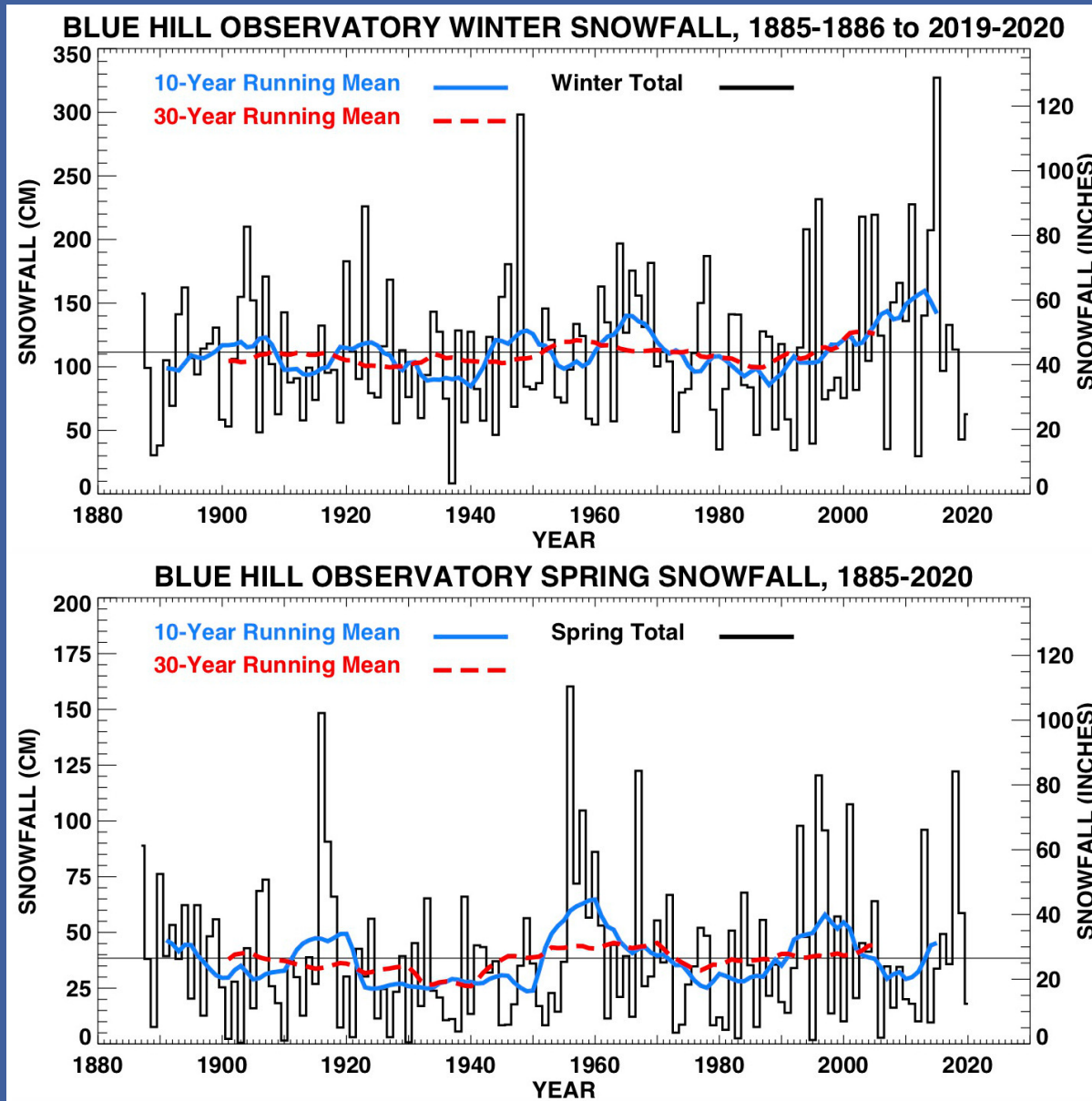
- Winter Trend:
+0.24 in/decade,
+3.2 inches since 1885
- Summer Trend:
+0.8 inches since 1885
- Summer precipitation
much more variable
than winter
- Spring Trend:
+3.0 inches since 1885
- Fall Trend:
+2.4 inches since 1885

BHO Climate: Seasonal Snowfall (Oct-May)



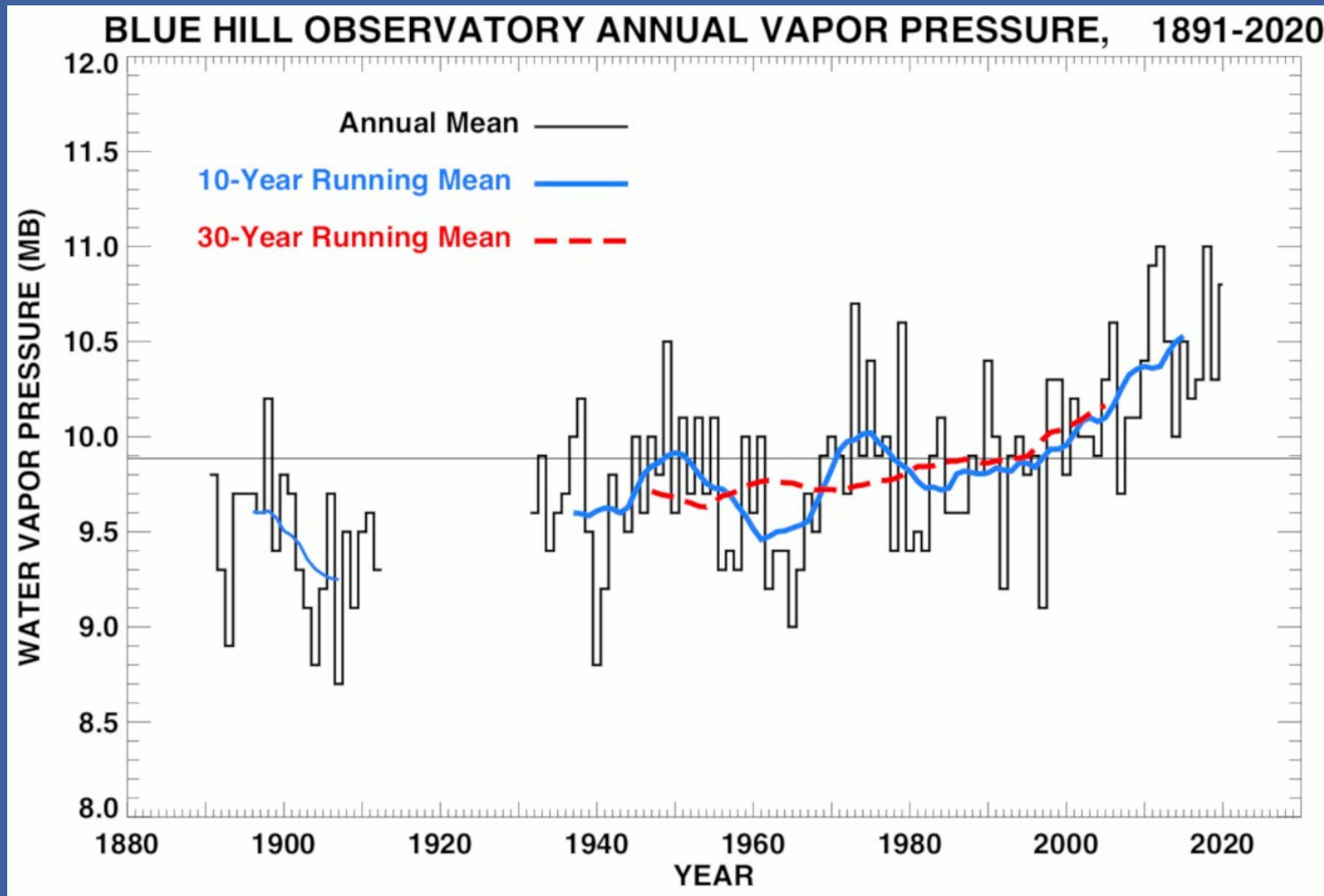
- Seasonal snowfall shows a small upward trend
- Trend not statistically significant
- Very high variation from year to year
- Decadal variability, 50-year cycle

BHO Climate: Seasonal Snowfall (Winter/Spring)



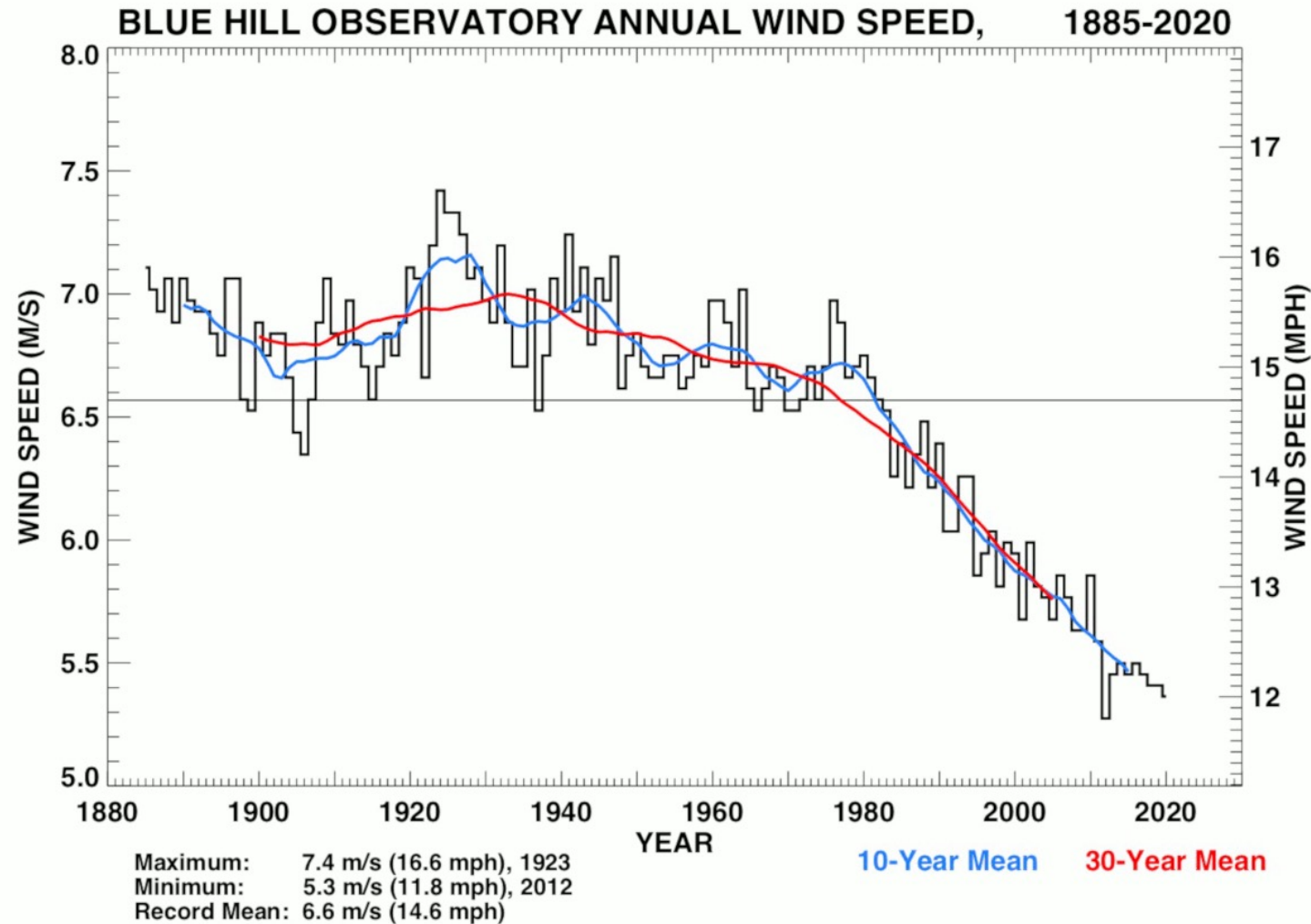
- Winter Trend:
+0.7 in/decade,
+9 inches since 1885
- Spring Trend:
+2 inches since 1885
- Fall Trend:
-0.5 inches since 1885

BHO Climate: Annual Water Vapor Pressure



- Vapor pressure is the contribution of water vapor to total surface pressure (about 1%)
- Absolute measure of atmospheric moisture
- Increasing about 5% per degree C of temperature change since the middle 20th century

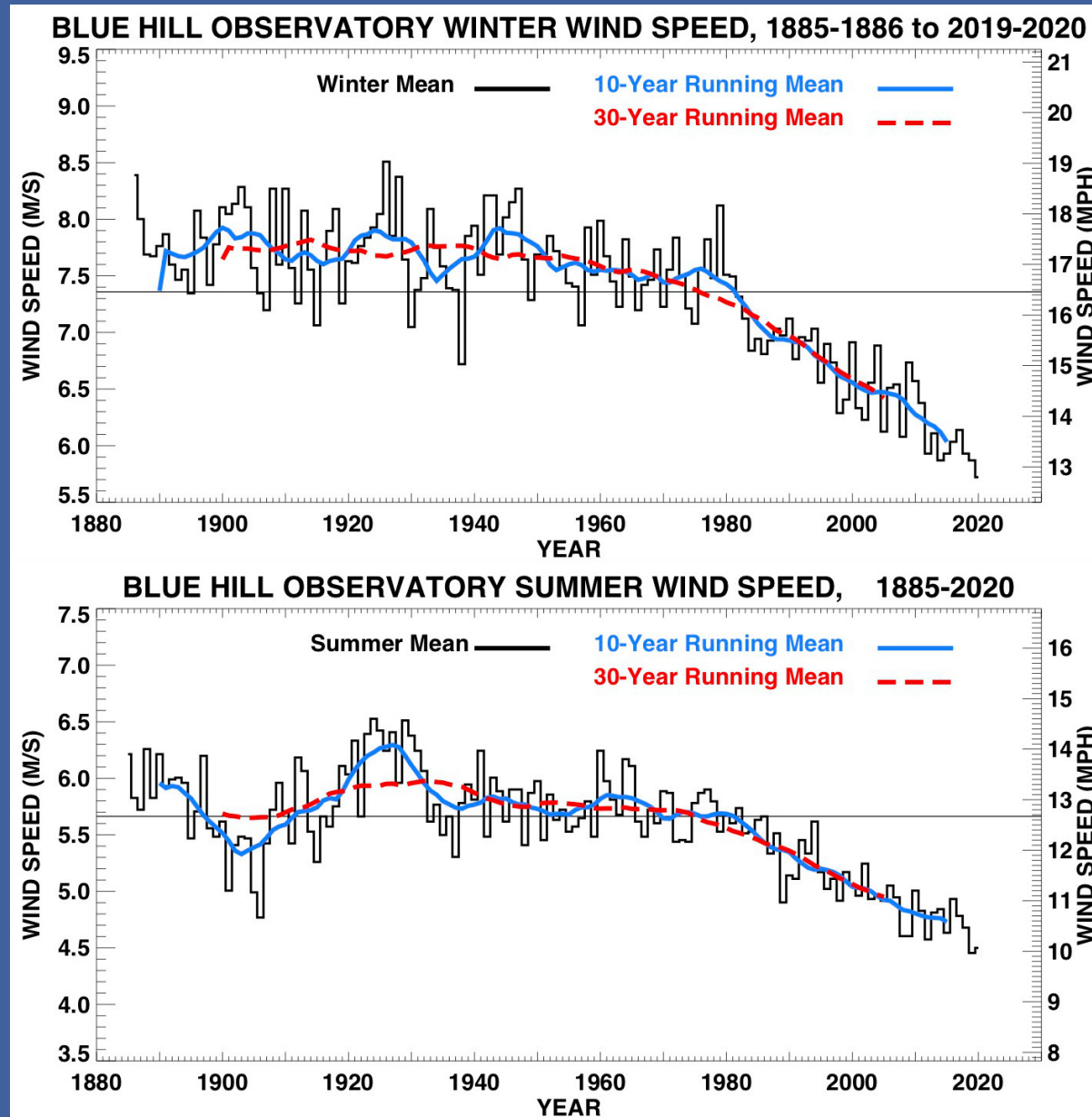
BHO Climate: Annual Mean Wind Speed



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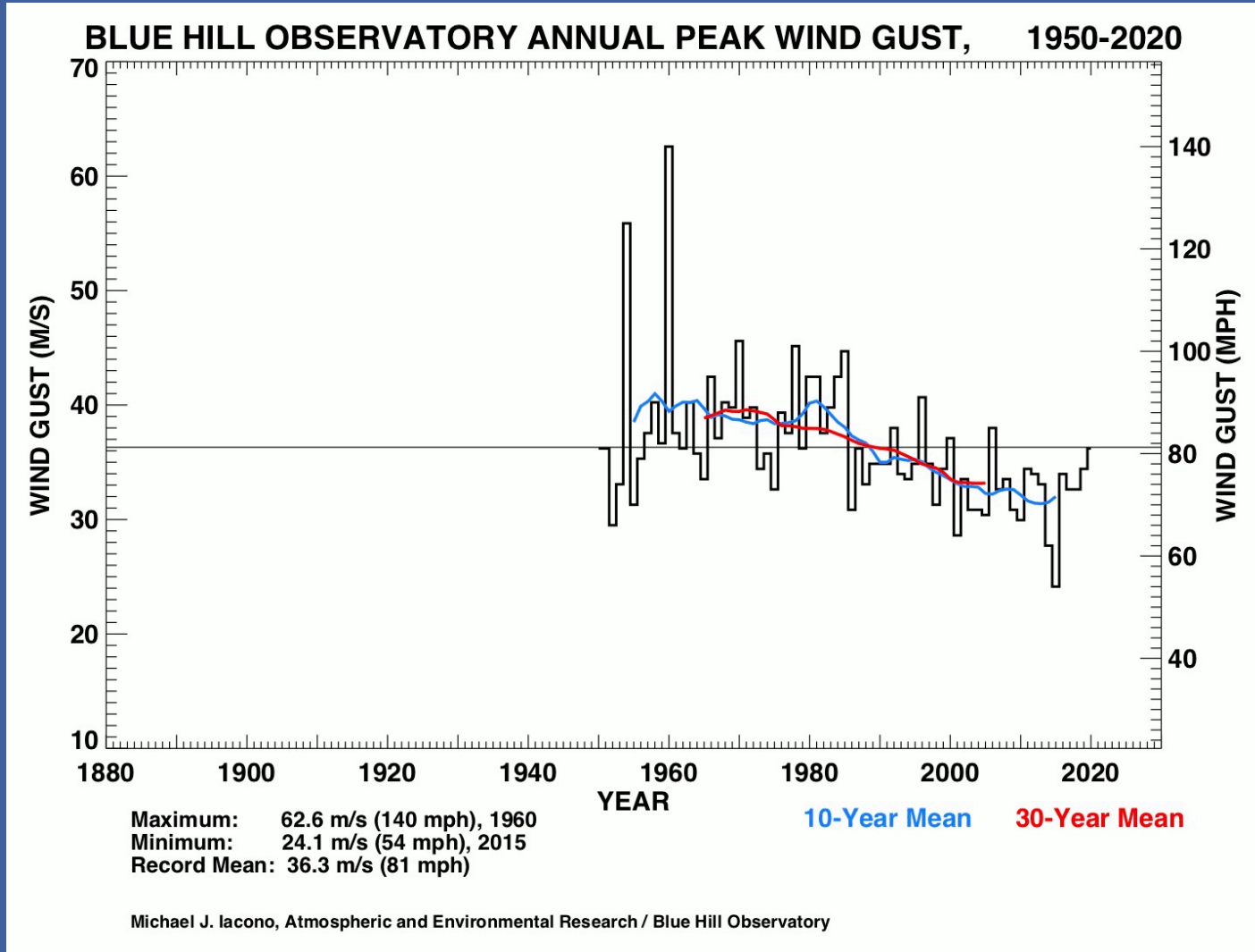
- Annual wind speed falling dramatically since 1980
- Uncertain cause:
 - reforestation
 - global wind pattern changes
- Global stilling since 1960's is stalling in some areas in the last five years; no sign of this at BHO

BHO Climate: Seasonal Mean Wind Speed



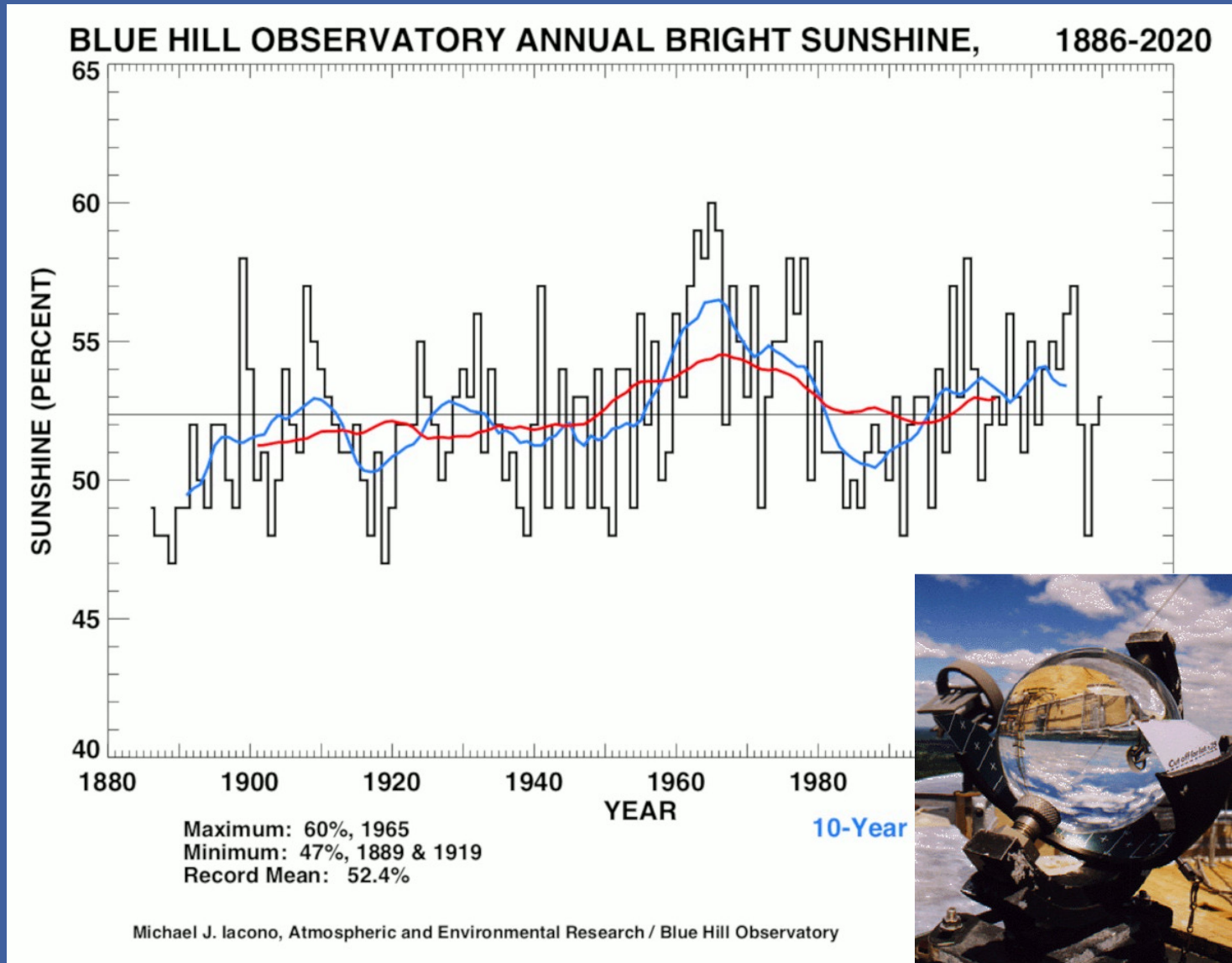
- Winter Trend:
-3.0 mph (about 20%)
since 1980
- Summer Trend:
-2.1 mph (about 17%)
since 1980
- Winter wind speed
more variable and
extreme than summer

BHO Climate: Annual Peak Wind Gust

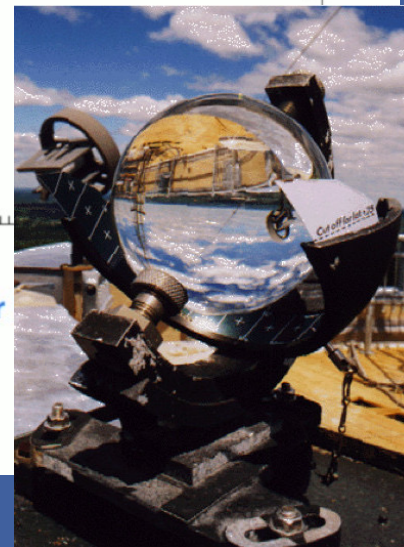


- Annual peak wind gusts are falling since 1960's
- Earlier data are 5-minute average speeds
- Hurricane Donna: 140 mph (1960)
- Hurricane Carol 125 mph (1954)
- Last wind gust to 100 mph or more occurred in 1985 (Hurricane Gloria)

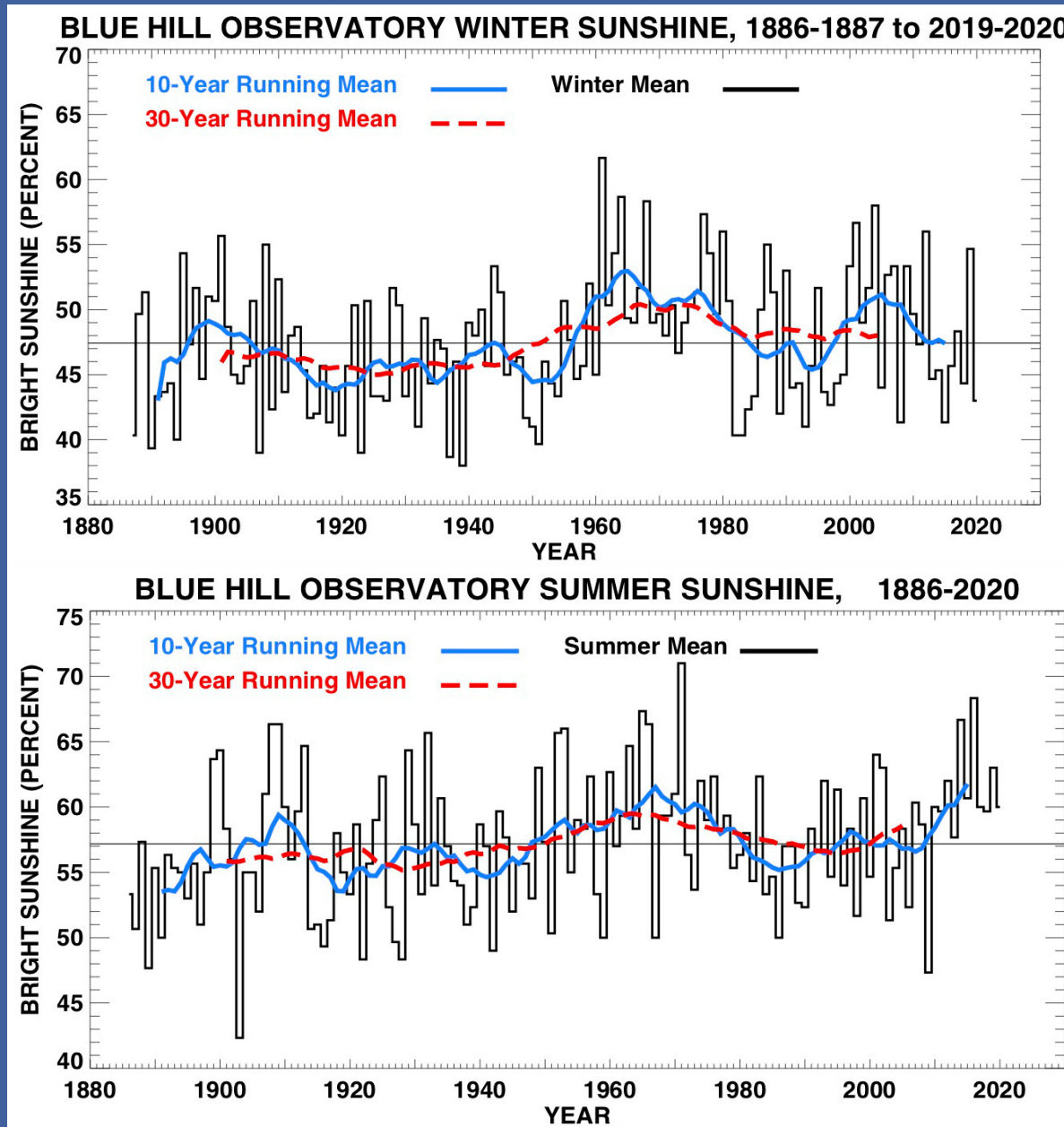
BHO Climate: Annual Mean Sunshine Duration



- No significant overall trend in bright sunshine
- Decadal variations since 1950's reflect changes in clouds and air quality (air pollution)
- Sunshine has increased since 1990's due to less air pollution
- Sunniest years (1963-1966) were also very dry

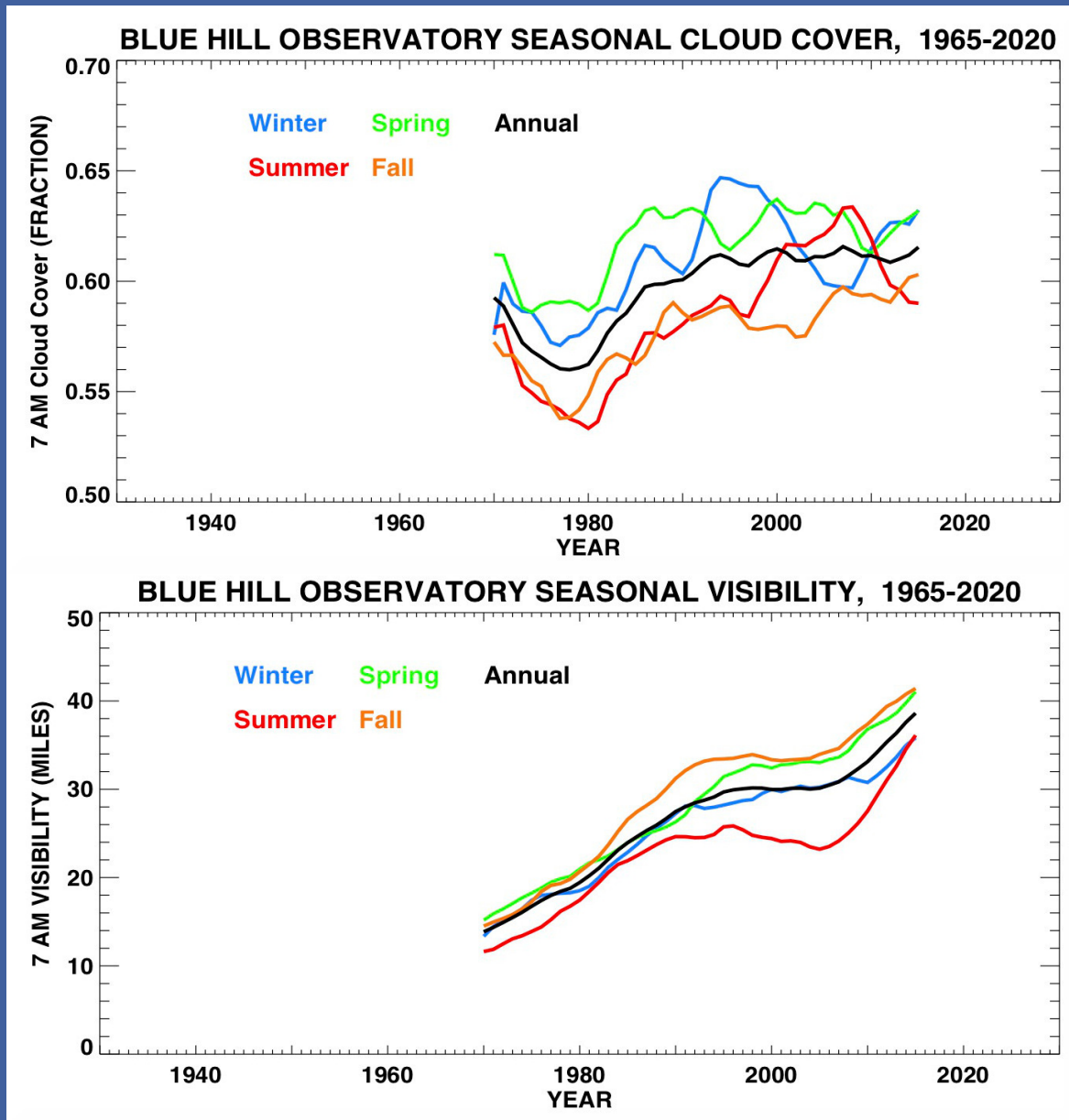


BHO Climate: Seasonal Mean Sunshine Duration



- Highest values in 1960's in winter and summer
- Reduced sunshine during 1980's into 1990's
- Response since 1990 differs by season likely due to clouds

BHO Climate: Mean Cloud Cover and Visibility



- Cloud cover and visibility observed at 7 AM local time
- Cloud changes depend on season
- Visibility rising significantly in all seasons due to less air pollution

BHO Climate: Summary

- Earth has experienced large swings in temperature in distant past
- Upward temperature trend in last 150 years due to CO₂ emissions is unusually sudden
- BHO and Northeastern US are warming faster than US and global average
- Climate change at BHO apparent across multiple parameters
- Accurate surface observations are critical to understanding climate changes
- Extensive BHO climate record is an invaluable resource for Earth science research and education



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Thank You!

Questions, Ideas and Volunteers are Welcome
(Email: miacono@bluehill.org)