

Watching the Weather Since 1885: The History and Climate Record of the Blue Hill Meteorological Observatory

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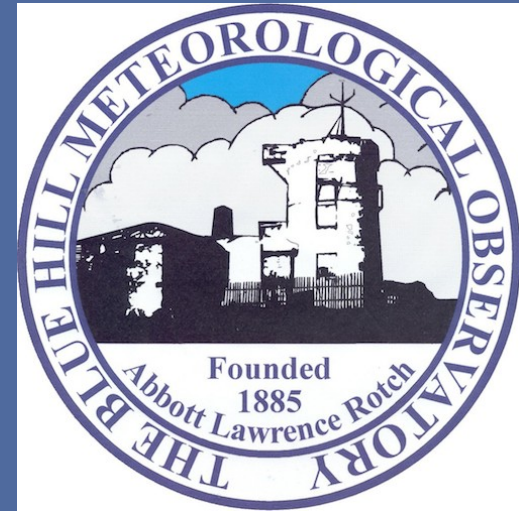
Atmospheric and Environmental Research, Blue Hill Meteorological Observatory

**Massachusetts Watchmakers
and Clockmakers Association
19 November 2019**



Outline

- Long View of Climate Change
- Observatory History
- Traditional Instruments
- Blue Hill Climate

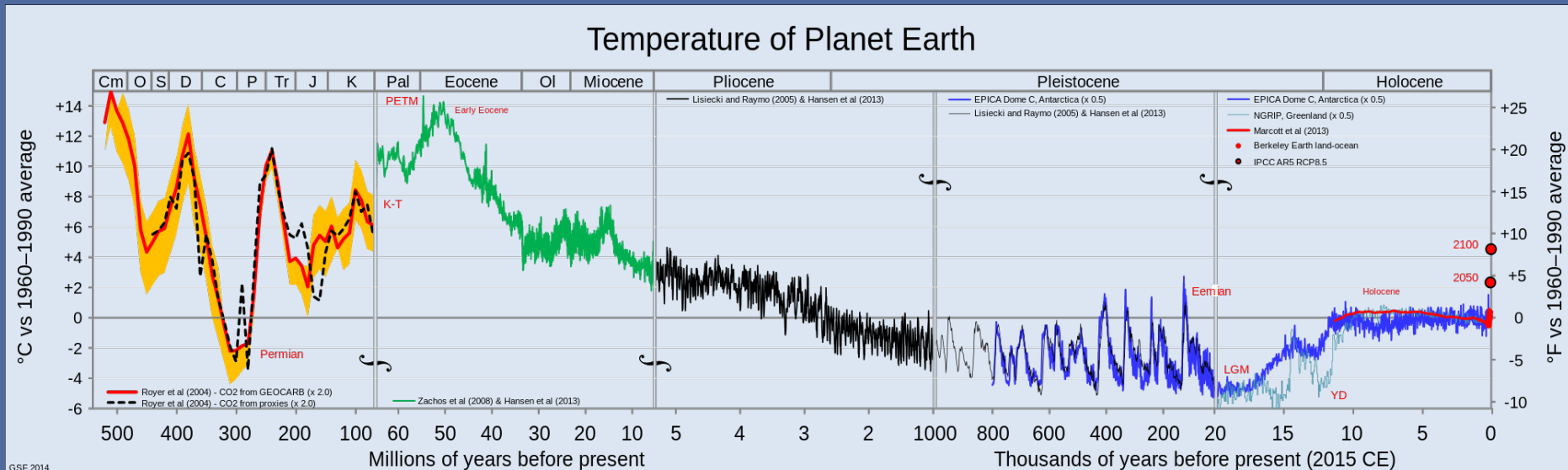


bluehill.org/observatory

BHO Mission:

"To foster public understanding of and appreciation for atmospheric science, while continuing to maintain a meticulous record of weather observations for the long-term study of climate."

Climate Change: What's the Big Picture?



- 5-10 degrees F colder during last Ice Age (20,000 yrs ago)
- 10-20 degrees F warmer during Jurassic Period (65 Mya)
- Stable climate for the last 10,000 years very unusual

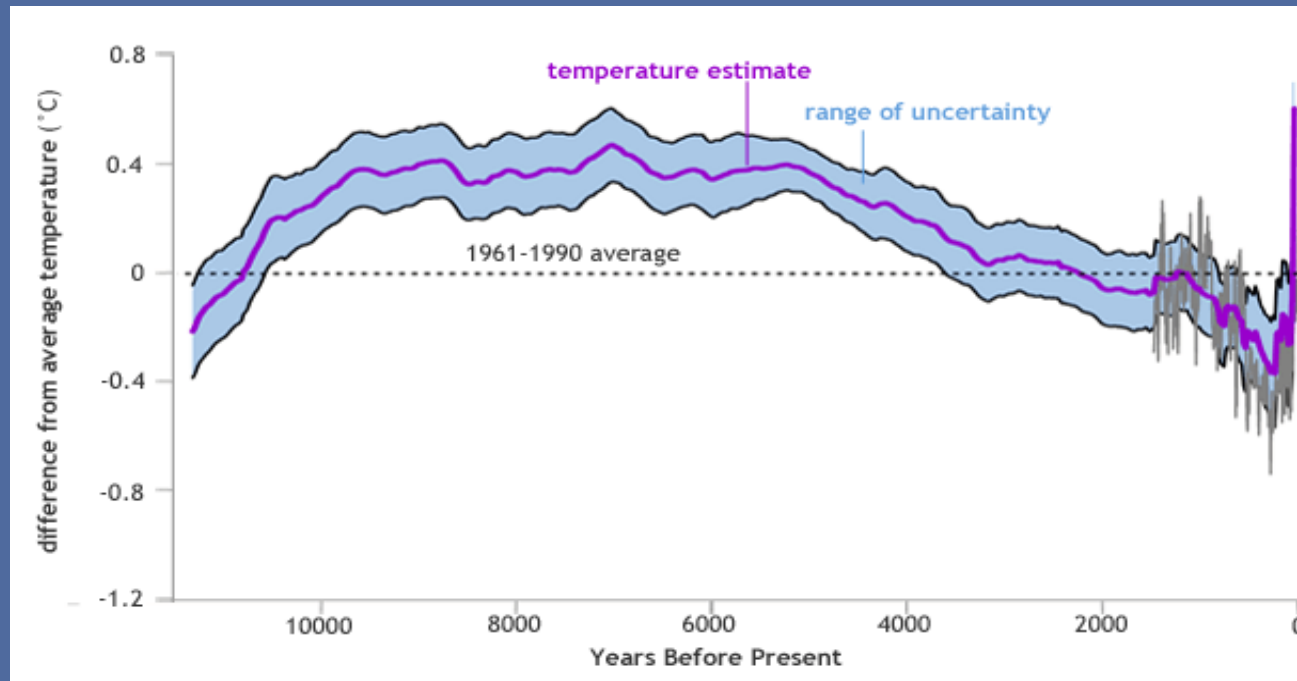
Climate Change: What's the Big Picture?

- Large climate changes have occurred regularly in Earth's history due to natural factors:
 - Orbital variations (change incoming solar energy)
 - Volcanic eruptions (vent greenhouse gases: CO₂)
 - Asteroid impacts (eject material that obscures sun)
 - Continental drift (alters air and ocean circulation)
- Currently in inter-glacial period with some ice cover
- Human Factor: Fossil fuel use has increased carbon dioxide to highest level in 3 million years (up from 280 to 415 ppm in 150 years)

Climate Change: Role of Orbital Variations

- Changes in Earth's movement affect climate
 - Can think of Earth and Sun as precise time pieces
- Earth's Axis Tilt (23.5 degrees; affects change of seasons)
 - Controls which part of Earth gets the most sunlight
 - Varies more than ± 1 degree over 41,000 years
- Precession (time of year when Earth closest to Sun)
 - Now NH closer to Sun in Jan and farther in July
 - Seasons amplified during opposite period of cycle
 - 23,000-year cycle
- Eccentricity (shape of Earth's orbit)
 - Controls distance of Earth from Sun during year
 - Varies from 0 to 6 percent over 100,000 years

Climate Change: What's the Big Picture?



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

Blue Hill Observatory Location

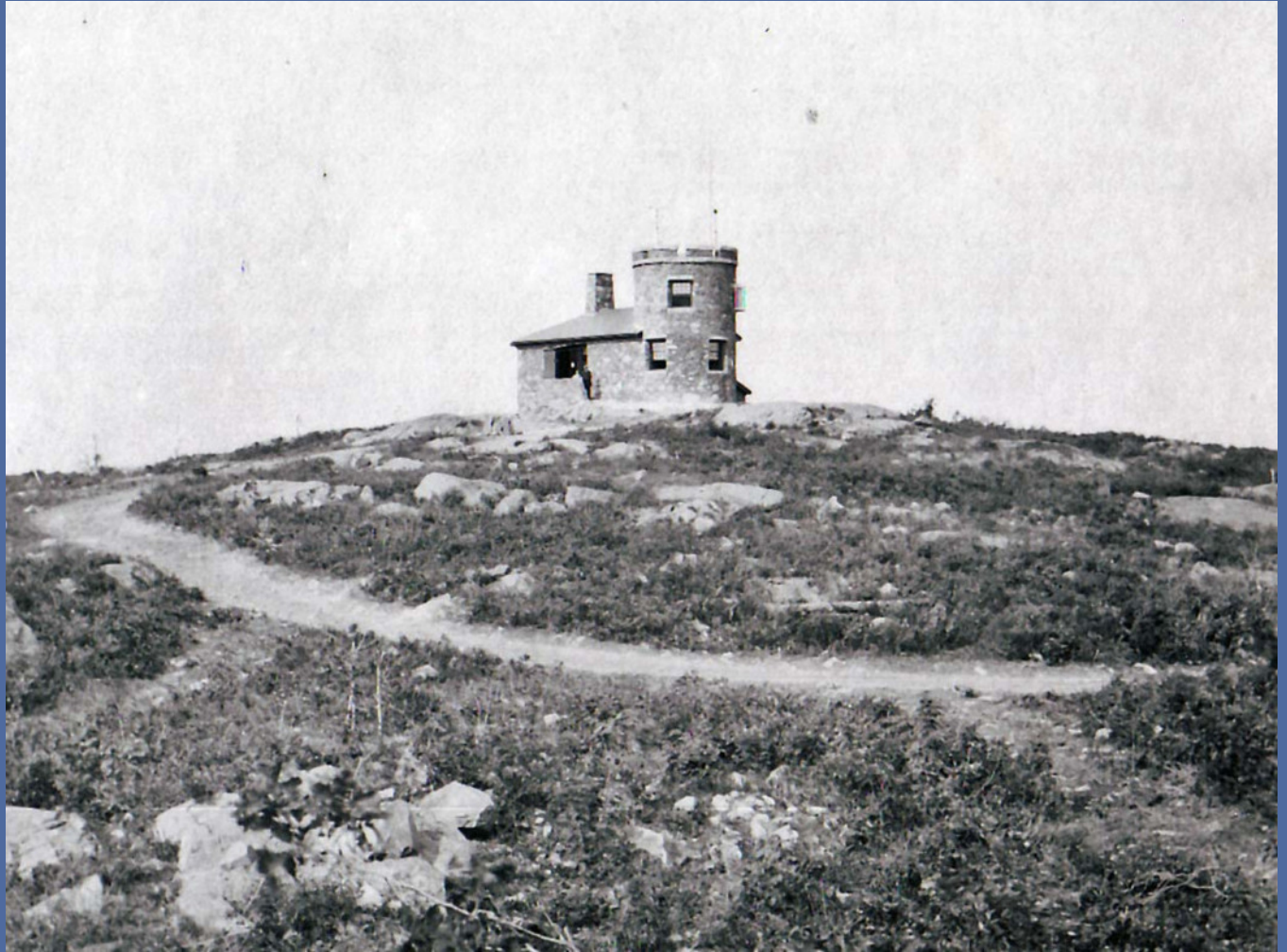


Blue Hill Observatory Highlights

- Founded by Abbott Lawrence Rotch on February 1, 1885
- Very accurate, complete and extensive climate record
- High **consistency** across the decades through the use of traditional instruments and methods
- Mission expanded to include science education and public outreach
- BHO data are an irreplaceable resource for climate education and research
- Addresses critical need for validation of modern instruments and climate model predictions

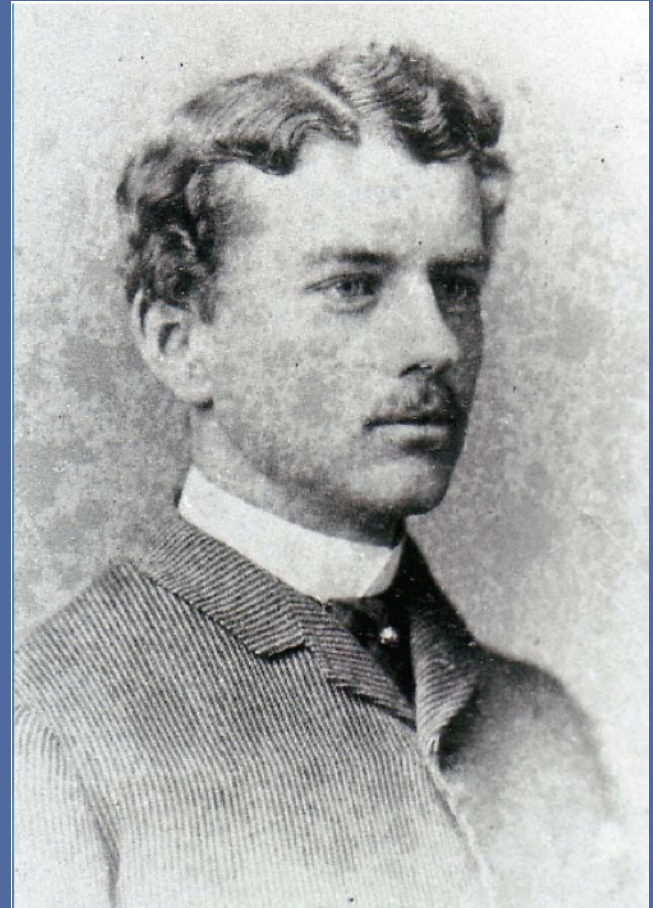
BHO History

Original
Observatory,
Great Blue Hill
c. 1885



Abbott Lawrence Rotch (1861-1912)

- Boston native; MIT graduate
- Later became Professor of Meteorology at Harvard
- Committed to advancement of meteorology and aerology
- Travelled extensively to other observatories
- Corresponded with the Wright brothers



Early Accomplishments

- Consistent weather observing
- Weather forecasting (flag signals)

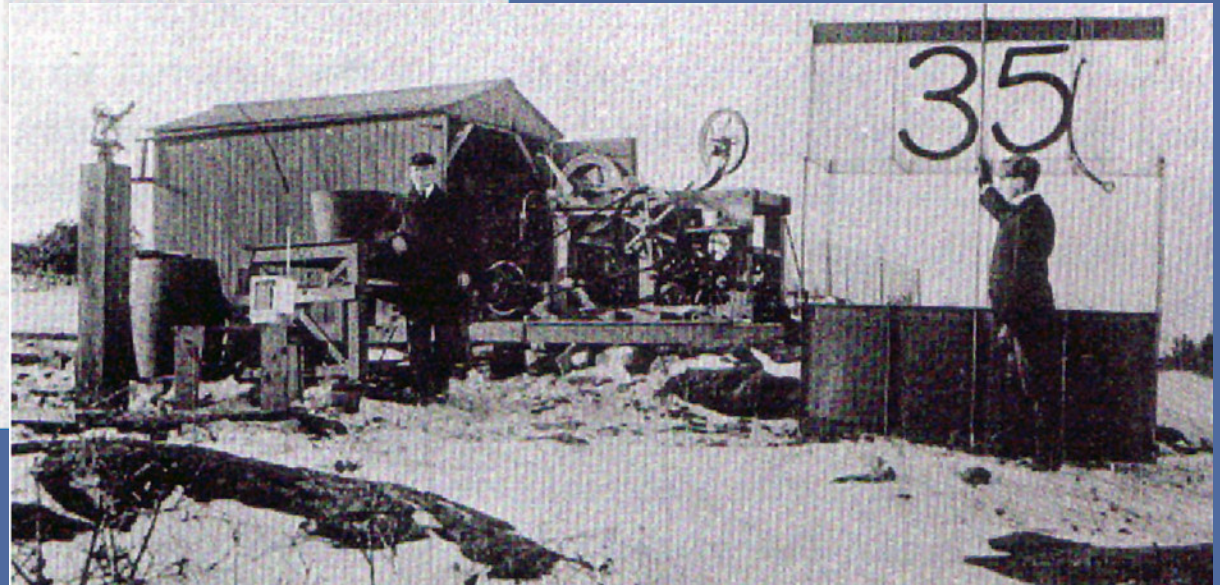
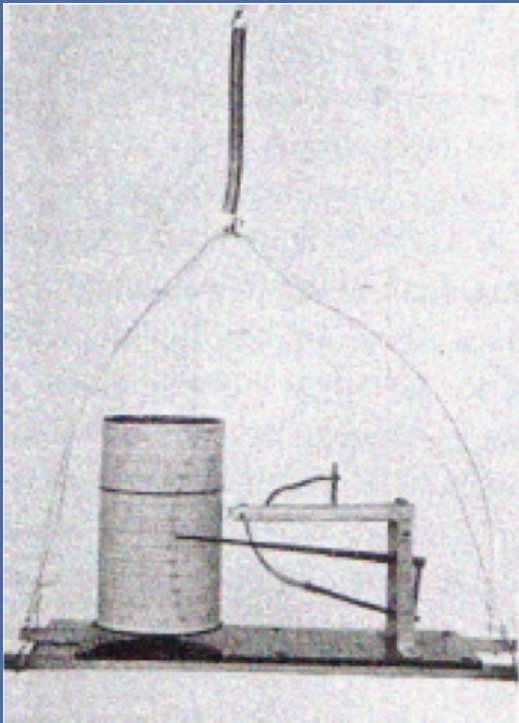


February 1, 1885.		
Precipitation.		
Kind		Snow
Time of beginning		AM 10:55
Direction of wind at beginning		S.E.
Time of ending		P.M. 6:40 P.M.
Direction of wind at ending		W.
Changes in direction of wind		Veered from S.E. to W.
Amount of rain		
Amount of melted snow by gage		.09 in.
Amount of melted snow by section		
Estimated depth of snow		1 1/2 in.
Self Registering Thermometers		
7 A.M.	Minimum thermometer	18.1
	Corrected minimum	18.1
	Minimum thermometer	15.7 by exposed.
	Maximum thermometer	30.4 by exposed.
	Corrected minimum	15.7
11 P.M.	Corrected maximum	30.4
	Range	14.7
	Minimum after setting	15.0
	Maximum after setting	15.8
Wind		
	Maximum velocity	
	Time of maximum velocity	
	Minimum velocity	
	Time of minimum velocity	
	Changes in direction	NE veering to W
	Number of miles in 24 hours	4.20
Miscellaneous.		
Wind Velocity of 36 miles noted at 8 P.M.		
"	"	42 " " 8.30
"	"	48 " " 10

Early Accomplishments

- Sounding of atmosphere with kites (1890-1910)
- Greatest height attained: 4,815 meters MSL (19 July 1900)

(15,797 feet)



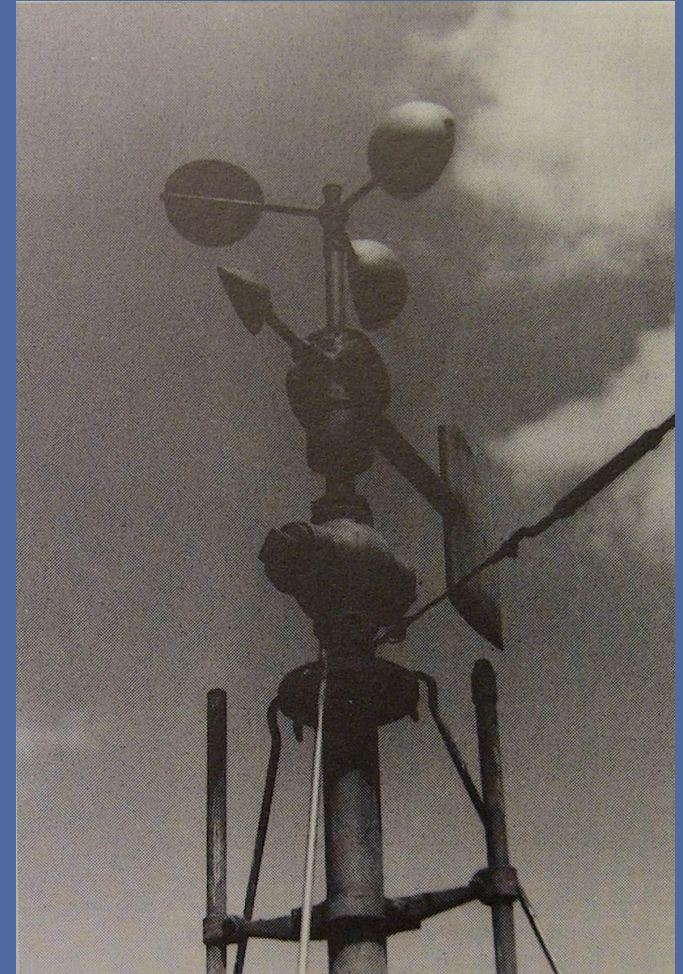
Early Accomplishments

- Pioneered use of radio to transmit weather data in 1930s (precursor to current weather balloon sounding)
- First successful radio-meteorograph transmission from a free balloon was made at BHO in 1935



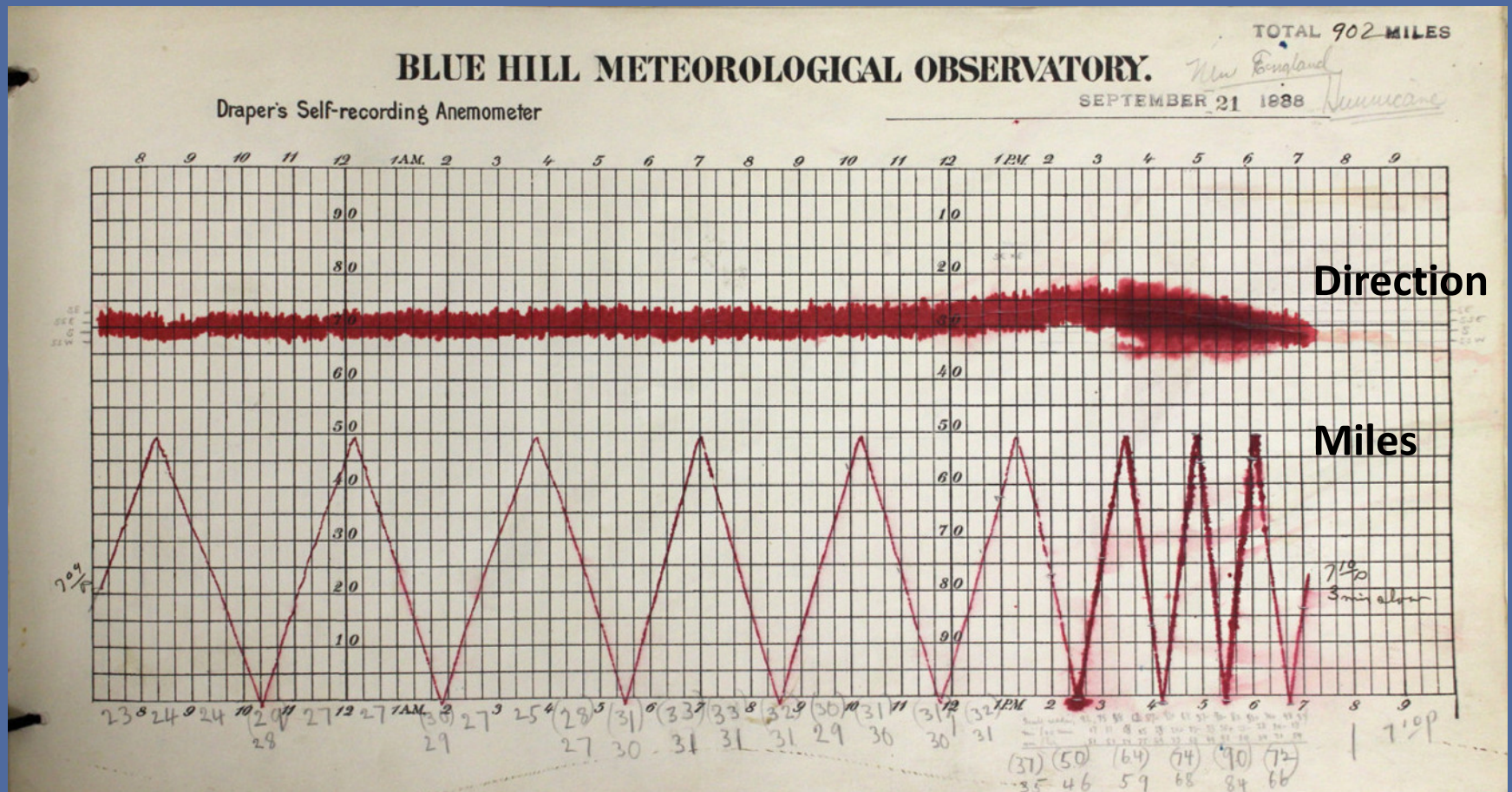
Early Accomplishments

- Survived Great New England Hurricane on September 21, 1938
- Highest 5-minute average speed: **121 mph, S** (6:11-6:16 PM; Draper anemometer and recorder)
- Highest wind gust: **186 mph, S** (calculated from 5-min avg. with error of +/- 30-40 mph)
- Lowest pressure: 29.01" (5:17 PM)
- Precipitation: 0.13"!



Early Accomplishments

- Great New England Hurricane original wind chart



BHO Instruments and Climate

Sun pillar
February 7, 2009



How Does BHO Measure the Climate/Weather?

- “Climate is what you expect...weather is what you get”
- 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.



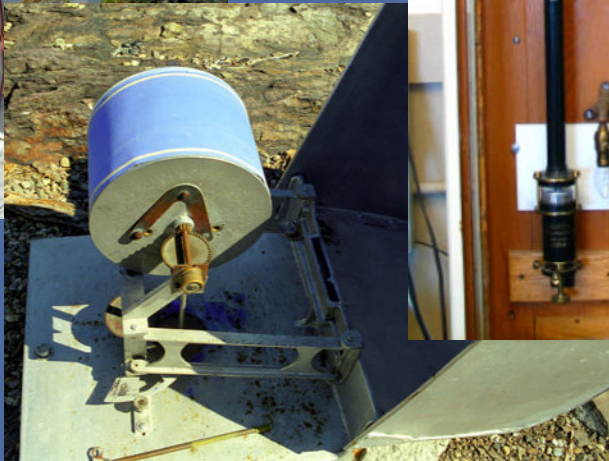
Outdoor instrument enclosure at BHO

How Does BHO Measure the Climate/Weather?

Traditional instruments



Hazen
temperature
shelter



Ombroscope



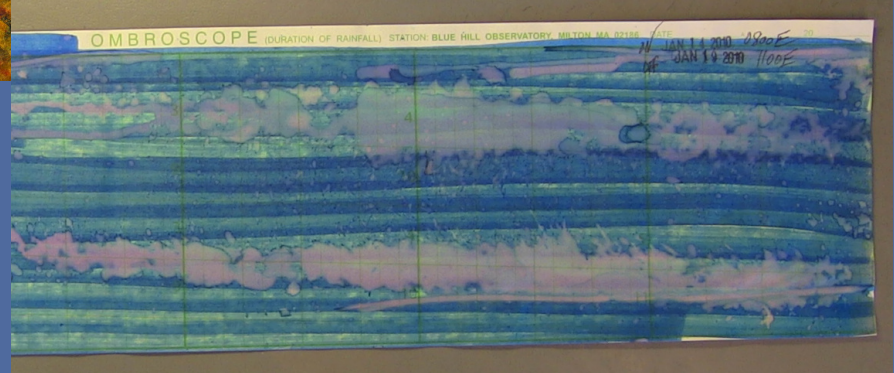
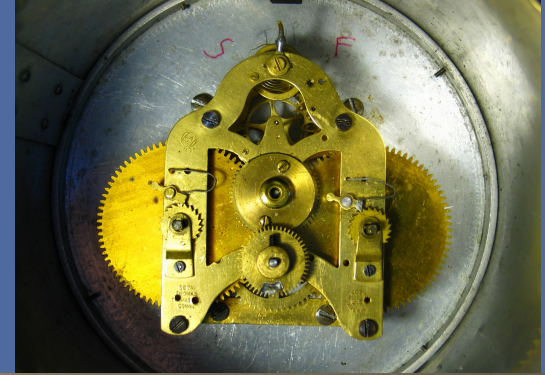
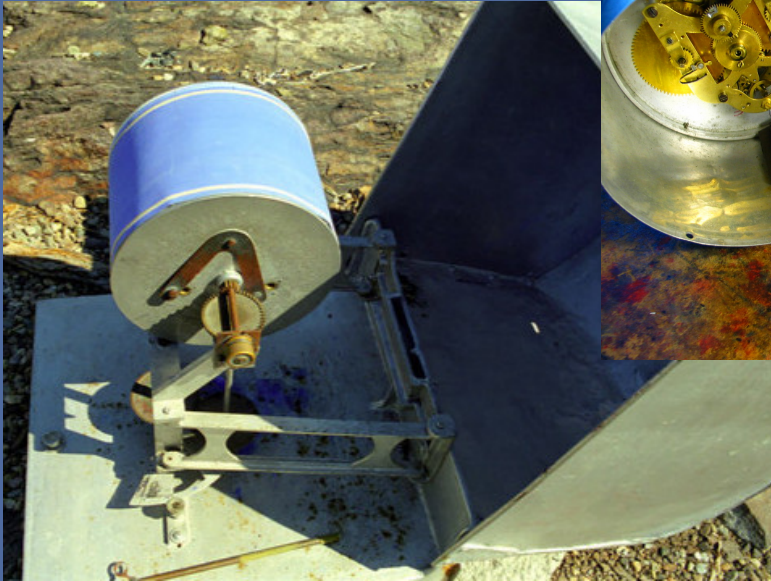
Mercury
barometers



Sunshine recorder

How Does BHO Measure the Climate/Weather?

Ombroscope (1940)



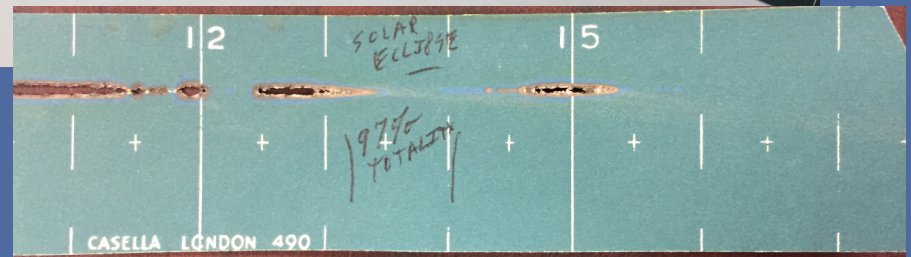
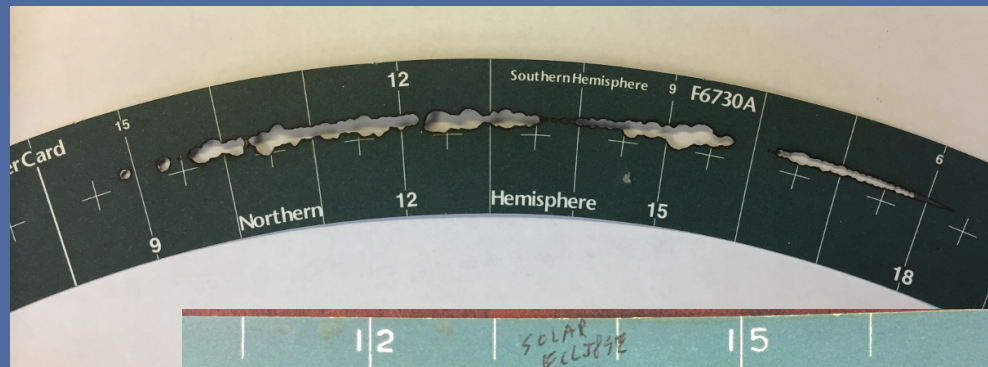
- Records time of precipitation as rain or snow stains paper wrapped around rotating cylinder
- Dual-spring Seth-Thomas clock mechanism inside cylinder
- Still running thanks to James Peghiny and Sue!

How Does BHO Measure the Climate/Weather?

Sunshine Recorder (1886, 1898, 2003)



- Records duration of bright sunshine as direct sun burns card below glass
- Works in solar time, must be converted to local time
- No winding needed!



How Does BHO Measure the Climate/Weather?

Friez Weighing Rain Gauge (early 20th Century)



- Converts weight of collected rain/snow to precipitation as a continuous trace on a clock-driven chart

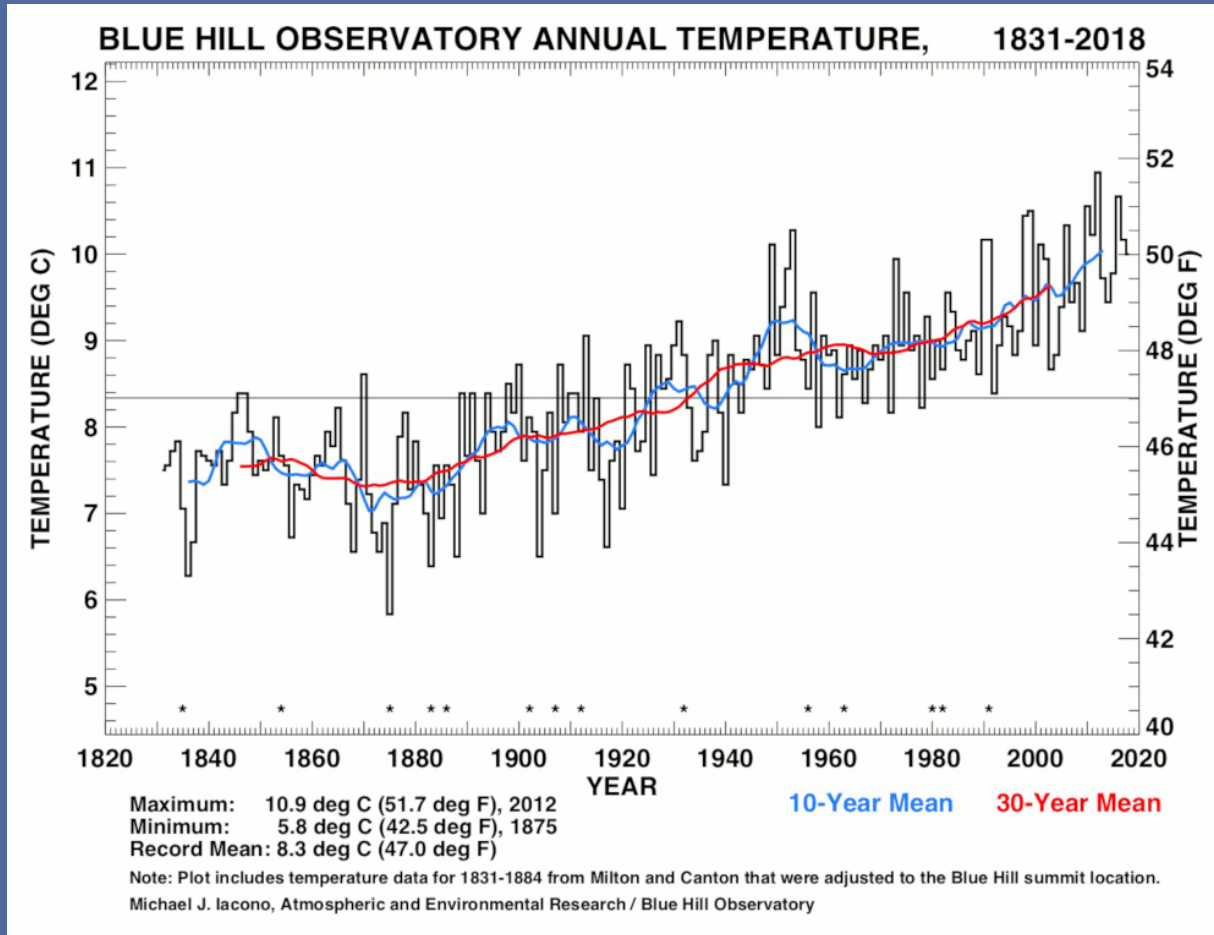
How Does BHO Measure the Climate/Weather?

Thermograph (circa 1915)



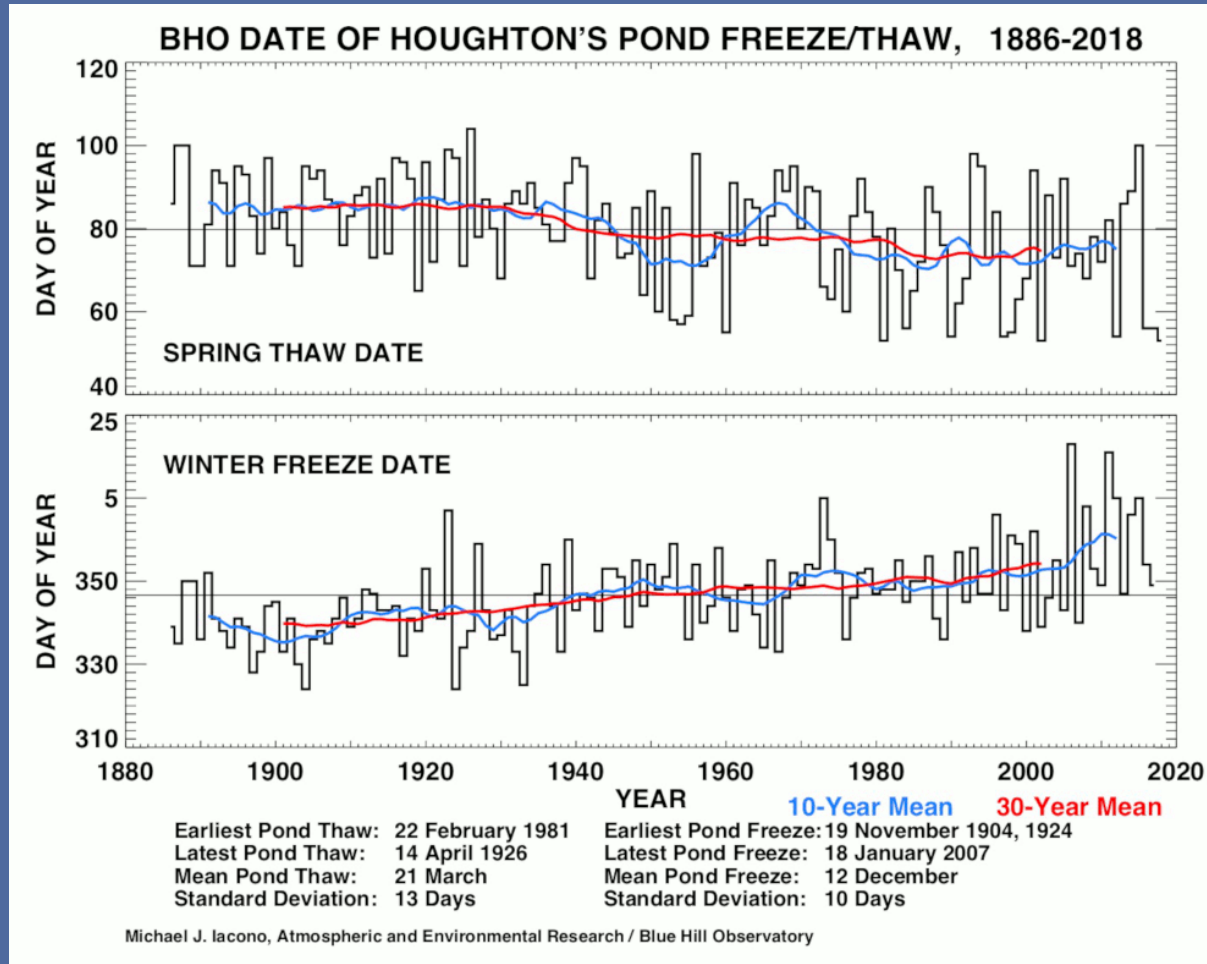
- Converts expansion/contraction of metal coil to temperature as a continuous trace on a clock-driven chart
- Donated to BHO by James Peghiny in 2013

Temperature: Annual Mean



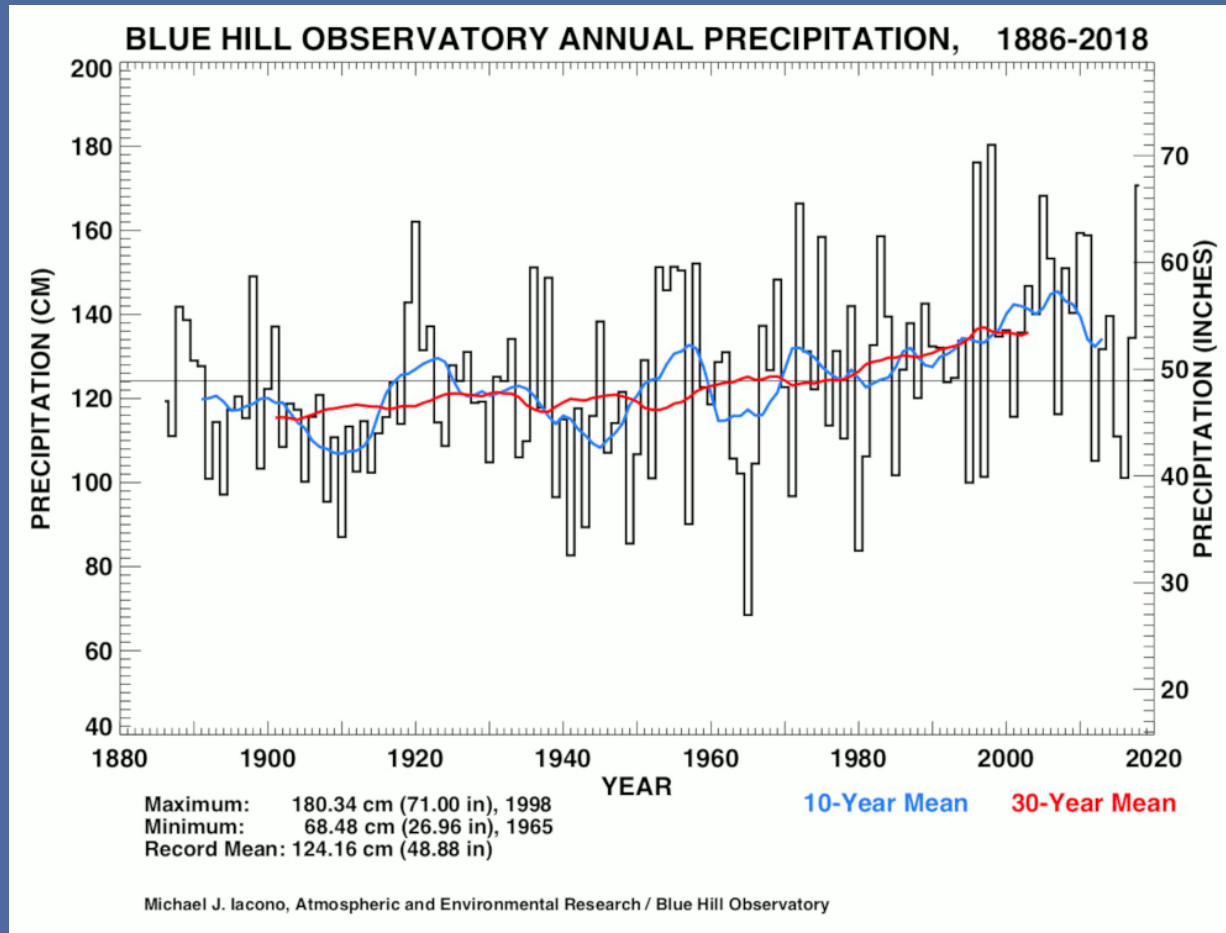
- Upward Trend:
+0.31 deg. F/decade,
+4.0 deg. F since 1885
- Trend statistically significant to 99.9% due to:
 - Long duration
 - Size of trend relative to annual variations

Temperature: Pond Freeze/Thaw Dates



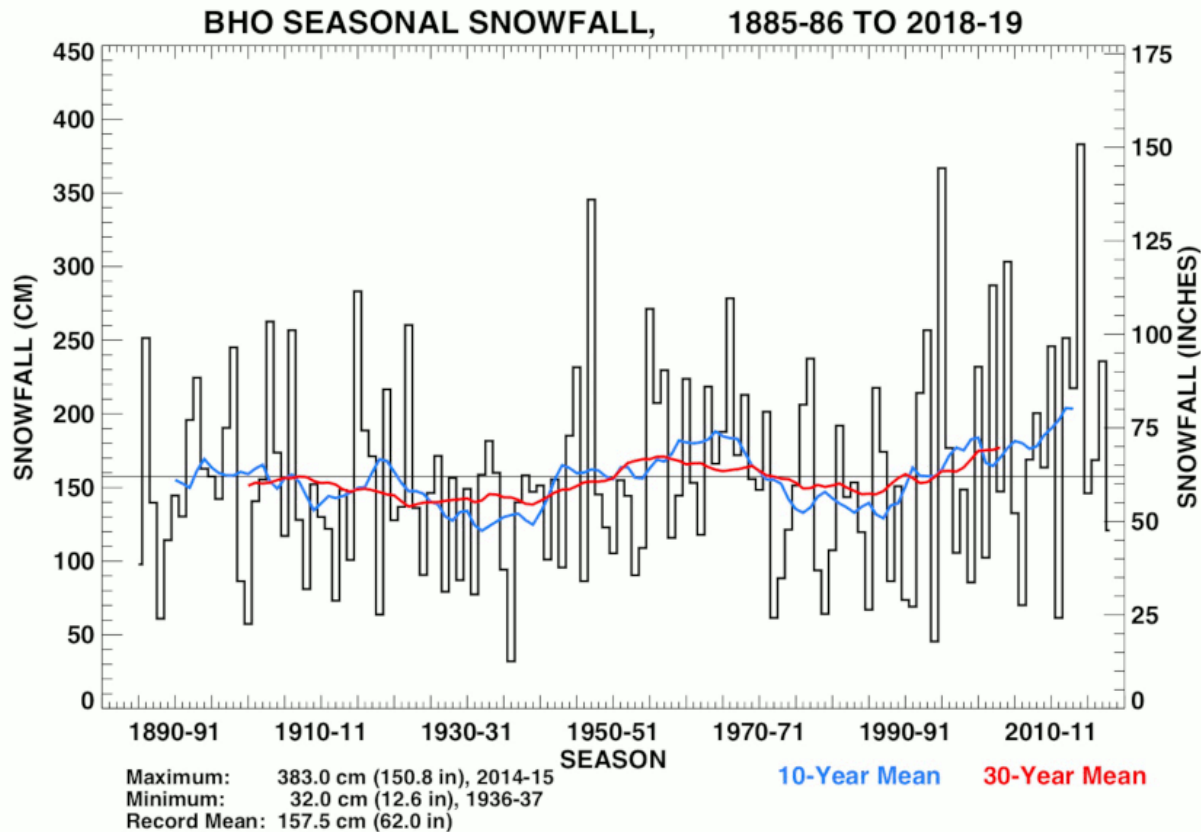
- Length of time local pond remains frozen in winter has decreased by two weeks since 1880s
- Represents a natural indicator of climate change

Precipitation: Annual Total



- Total precipitation (rain plus melted snow) is increasing +0.60 in/decade
- High variability from year to year, upward trend is statistically significant

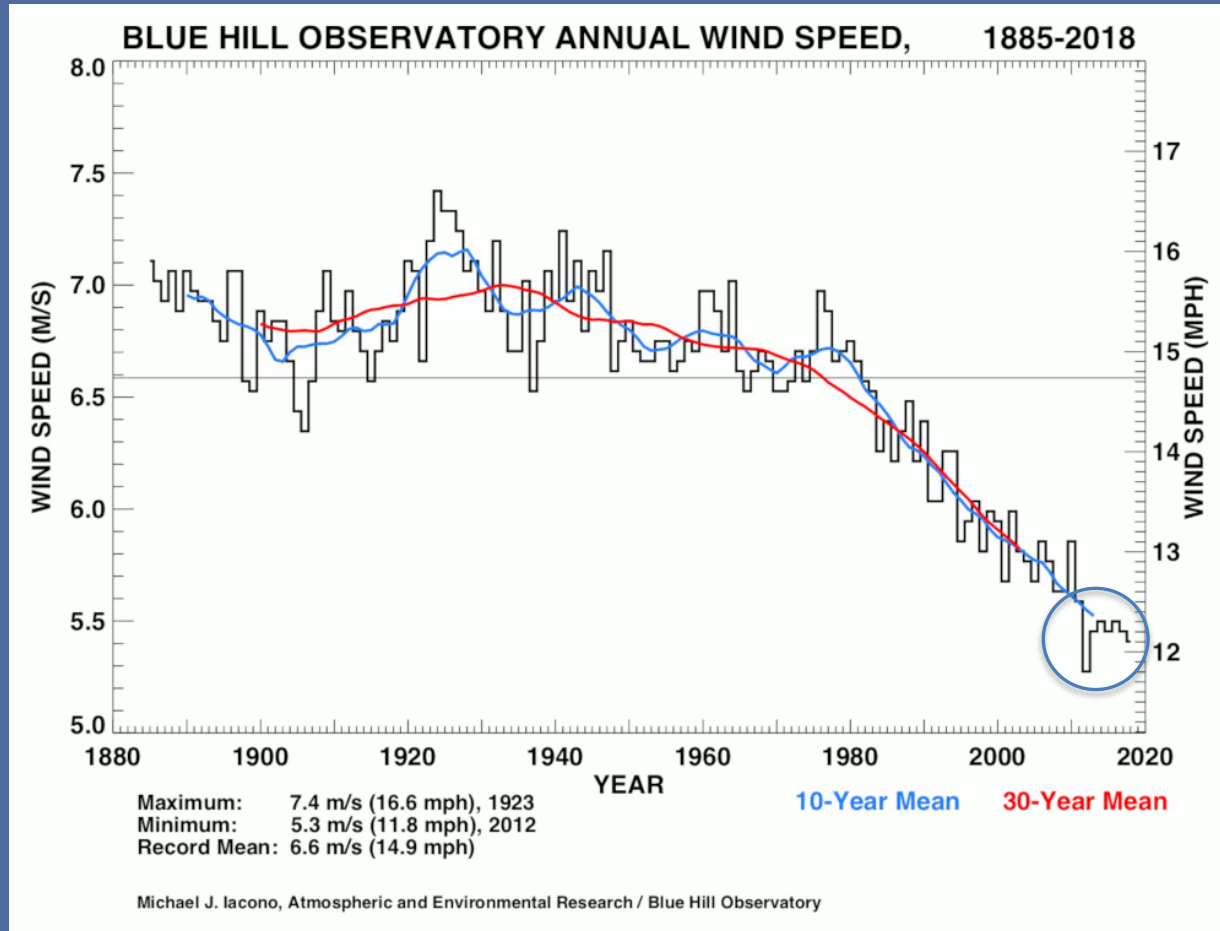
Snowfall: Seasonal Total



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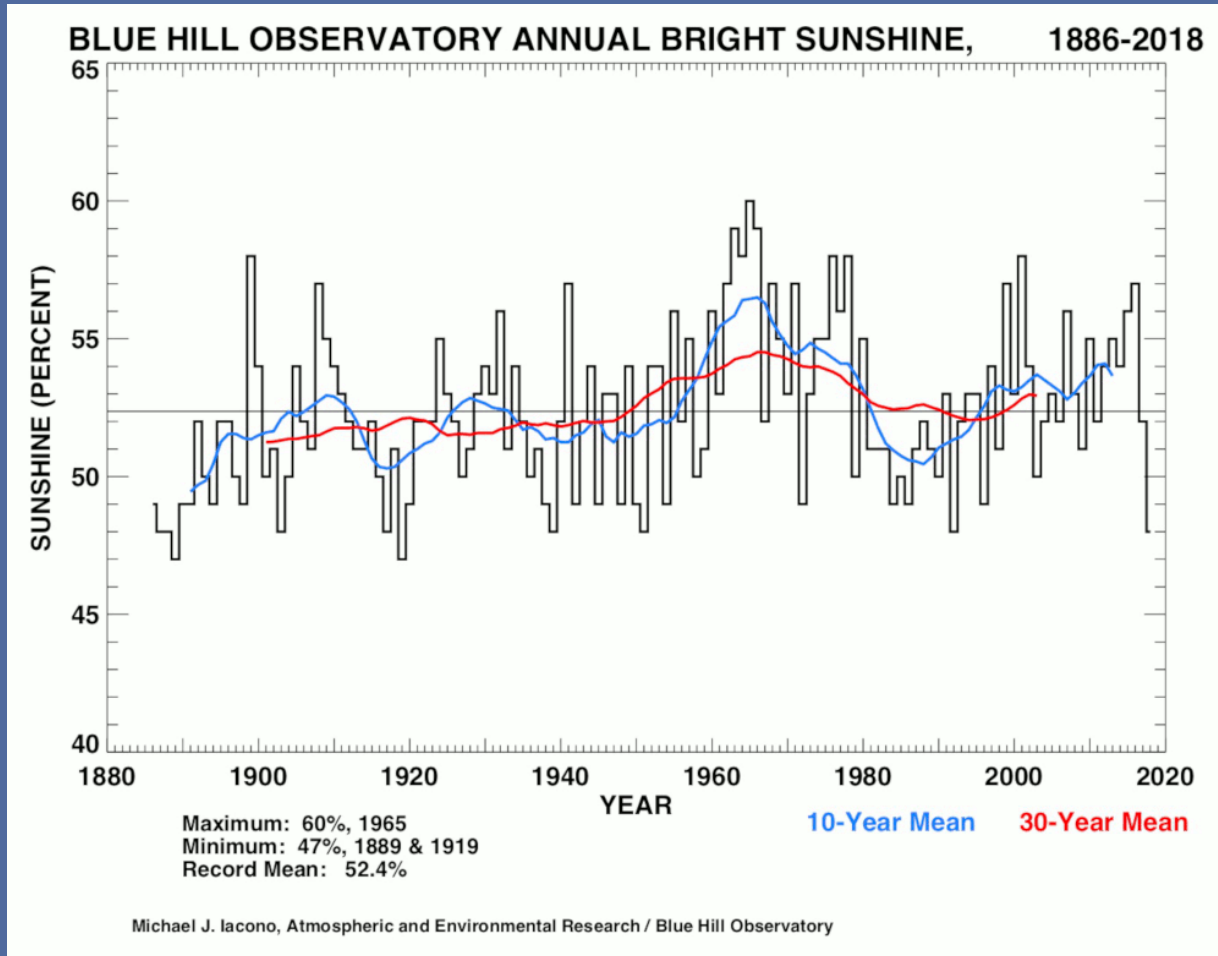
- Seasonal snowfall shows no significant trend
- Very high variation from year to year
- Decadal variability

Wind Speed: Annual Mean



- Annual wind speed falling dramatically since 1980
- Uncertain cause:
 - reforestation
 - global wind pattern changes
- Global stilling since 1960's reported in the literature has stalled in the last five years

Sunshine Duration: Annual Mean



- Reflects changes in both cloud cover and aerosols
- Sunshine dropped during 1960's and 1970's due to more pollution/aerosols
- Sunshine has increased since 1990's due to less air pollution

Future Objectives

- Continue tradition of high-quality observing program critical to validating and understanding climate change
- Enhance Blue Hill's role in climate education
- Increase accessibility of BHO climate data
- Develop new programs and advance public outreach to promote better public understanding about climate



Thank You!