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

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Outline

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

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 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 irrereplaceable 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)
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

- 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!