

HISTORICAL TRENDS IN SKEWNESS AND EXTREMES OF TEMPERATURE, MOISTURE, SUNSHINE, AND WIND SPEED SINCE 1885 AT THE BLUE HILL OBSERVATORY

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Blue Hill Observatory History & Climate

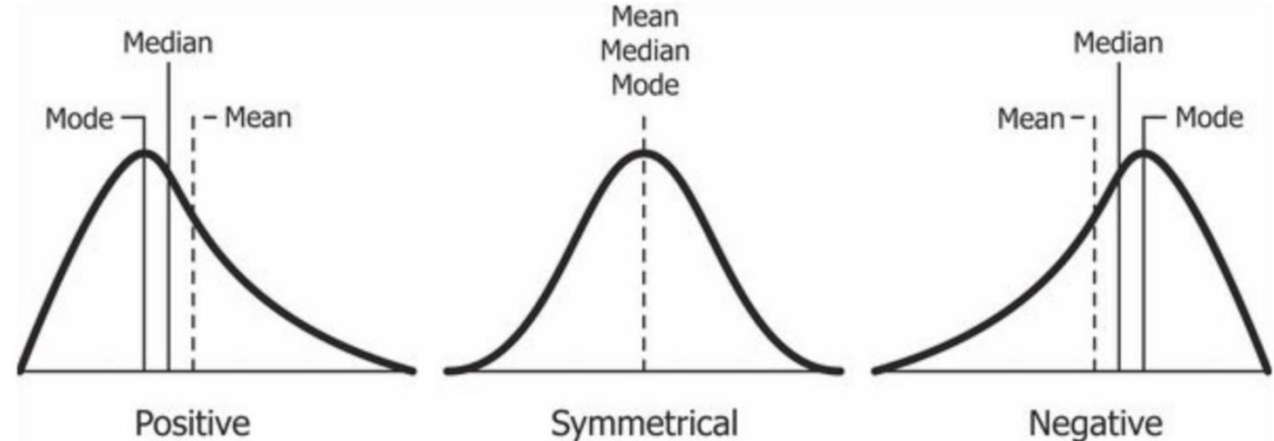
- Location:** Summit of Great Blue Hill, Milton, Massachusetts (10 miles SSW of Boston)
- Founded:** By Abbott Lawrence Rotch on February 1, 1885
- Elevation:** 635 feet (194 m) above mean sea-level
- Data Continuity:** Continual use of manual methods and instruments since 19th century
- Data Extent:** Temperature, dew point, precipitation, snowfall, snow depth, wind speed and direction, peak gust, sunshine duration, pressure, cloud cover, visibility, phenology, etc.
- Webpage:** For more information visit www.bluehill.org



Statistics: Skewness and Kurtosis

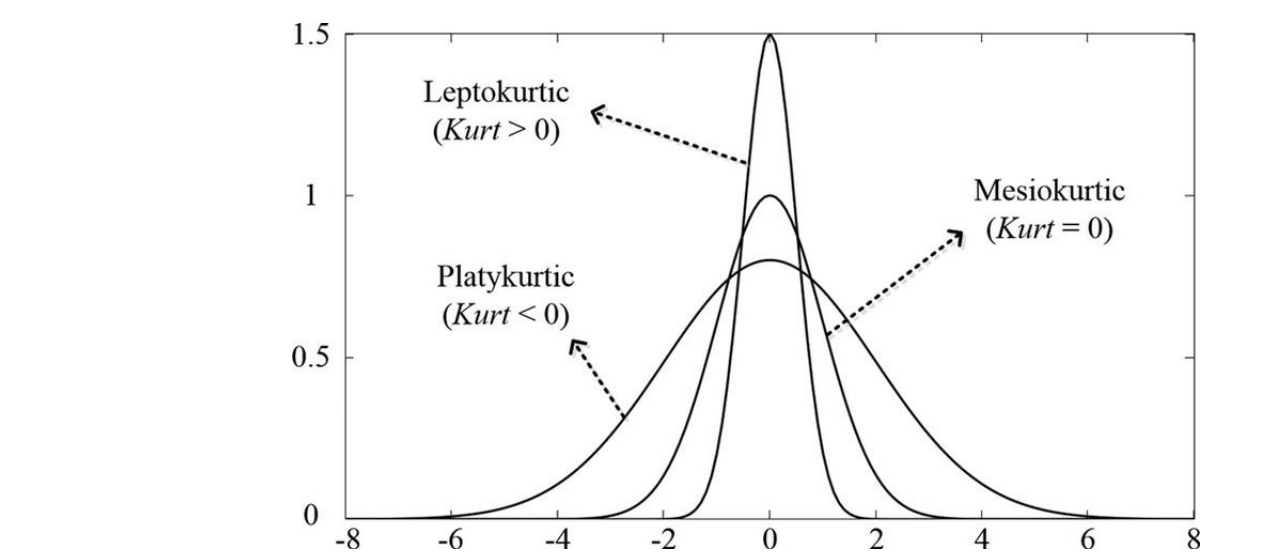
Skewness

- Positive:** Distribution has more warm years and seasons, stronger upward trend
- Negative:** Distribution has fewer warm years and seasons, weaker upward trend



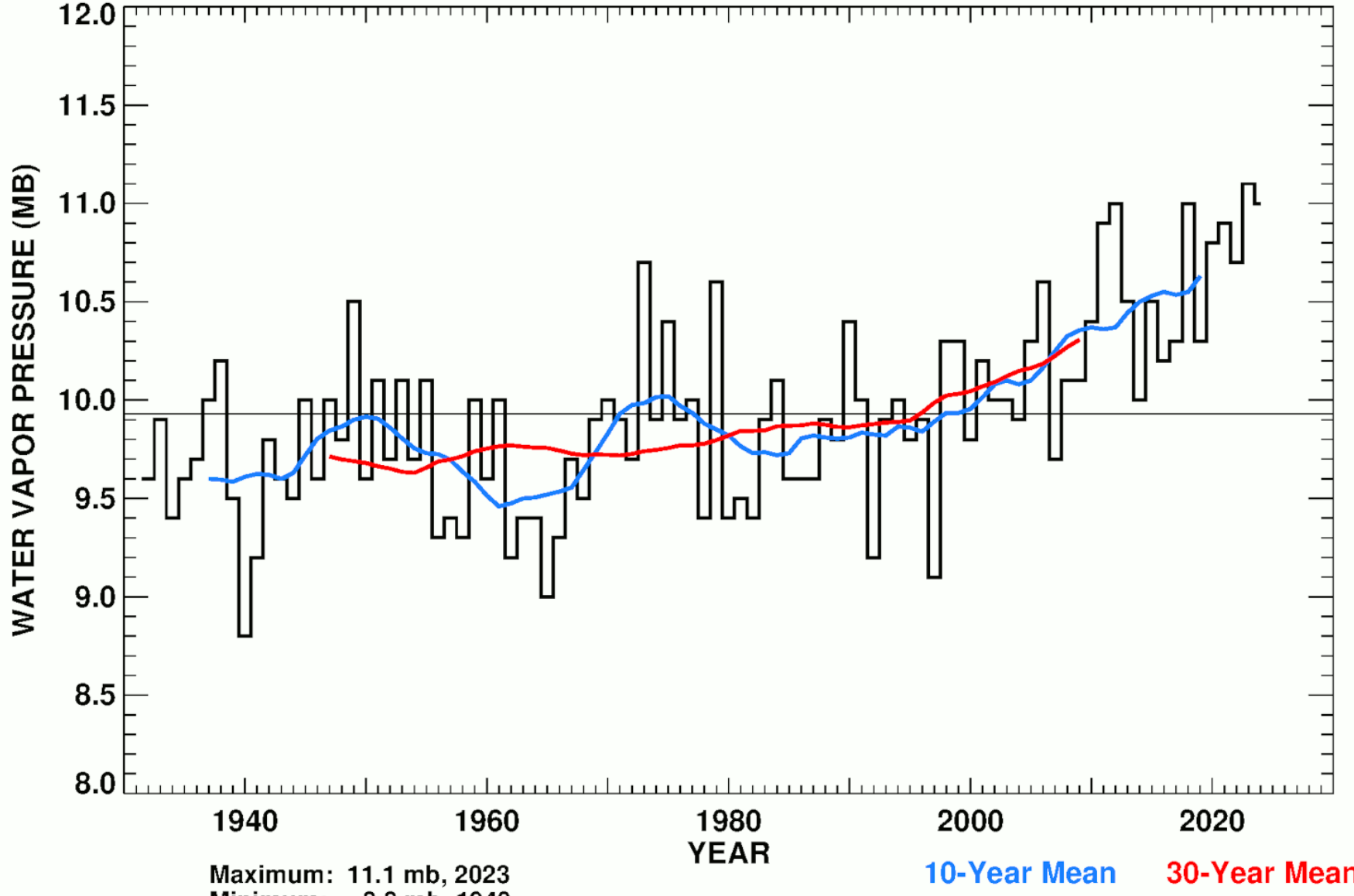
Kurtosis

- Positive:** Distribution has less variability from mean and fewer extremes
- Negative:** Distribution has more variability from mean and more extremes



Water Vapor Pressure Statistics

BLUE HILL OBSERVATORY ANNUAL VAPOR PRESSURE, 1932-2024



Annual Water Vapor Pressure

- Source:** Derived from dew point, which is calculated from dry and wet bulb psychrometer readings
- Daily Value:** Average of 7 AM and 7 PM observations
- Trend:** Rising steadily over last several decades

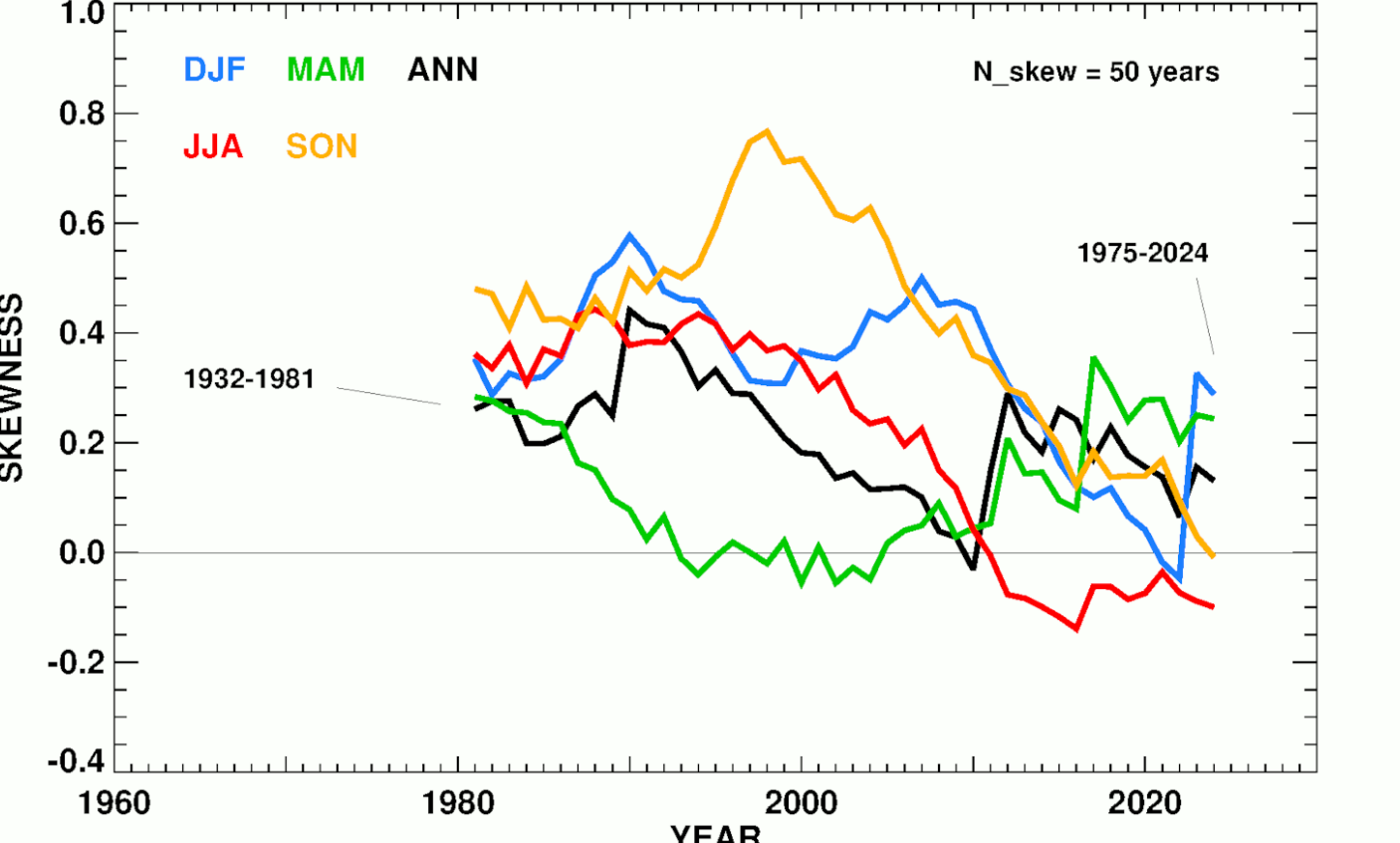
Skewness (50-year intervals)

- Generally positive, but shifting toward neutral over time in summer

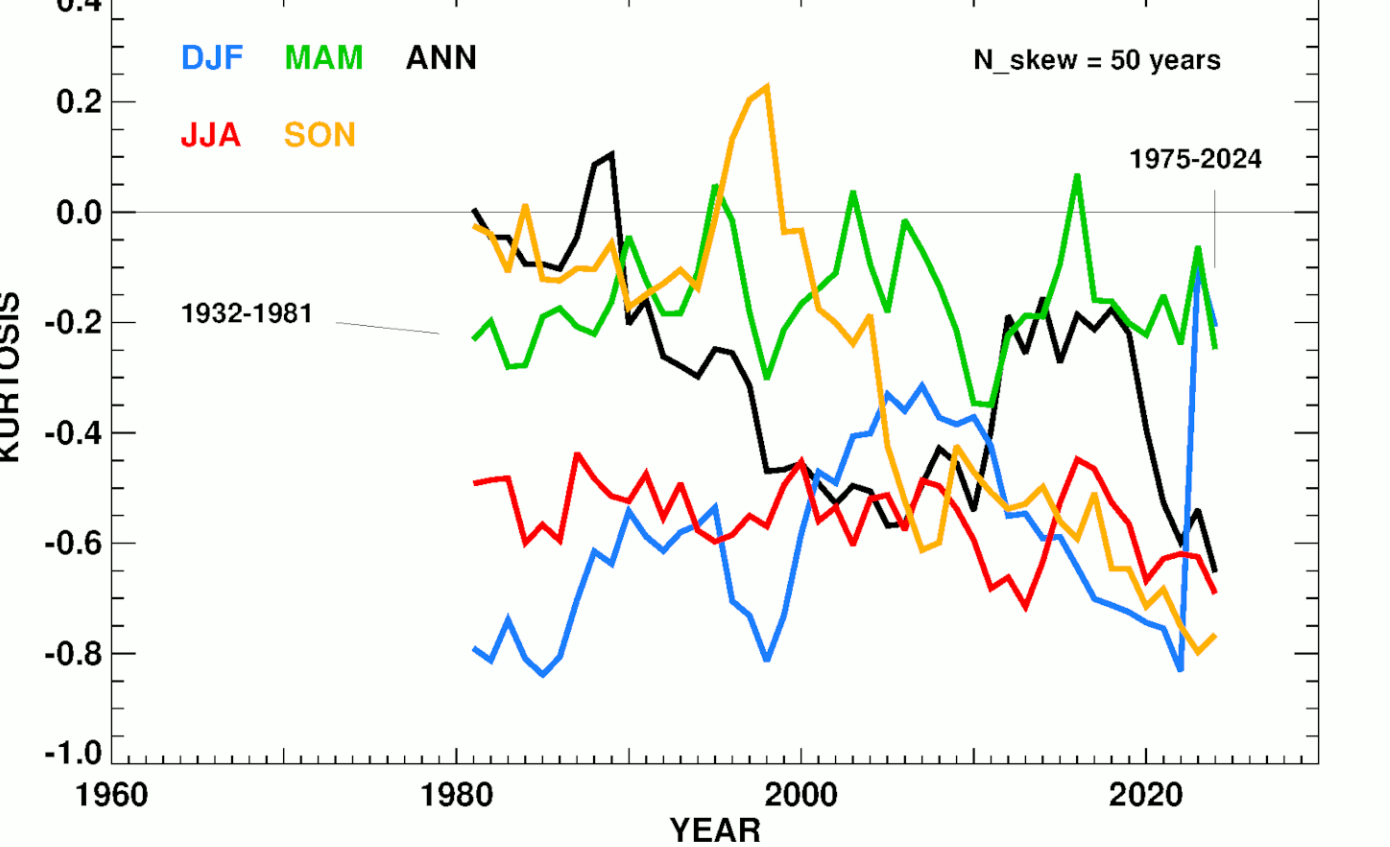
Kurtosis (50-year intervals)

- Generally negative, largest shift toward more variability in fall

BLUE HILL OBSERVATORY WATER VAPOR PRESSURE SKEWNESS

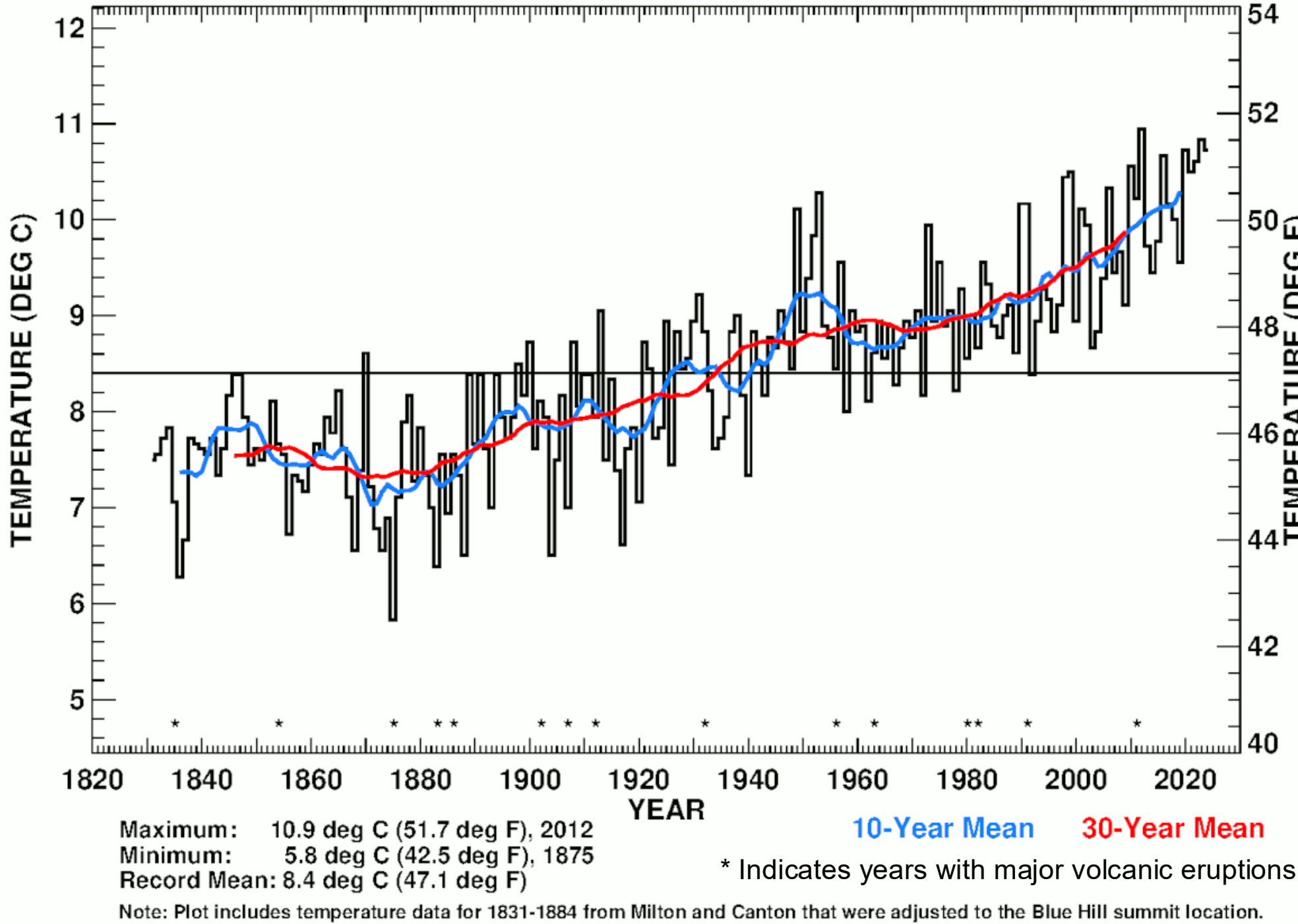


BLUE HILL OBSERVATORY WATER VAPOR PRESSURE KURTOSIS



Temperature Statistics and Extremes

BLUE HILL OBSERVATORY ANNUAL TEMPERATURE, 1831-2024



Annual Temperature

- Trend:** Annual and all seasonal changes strongly positive and statistically significant
- Changes Since 1850:** All seasons are well above critical global threshold of +1.5 °C

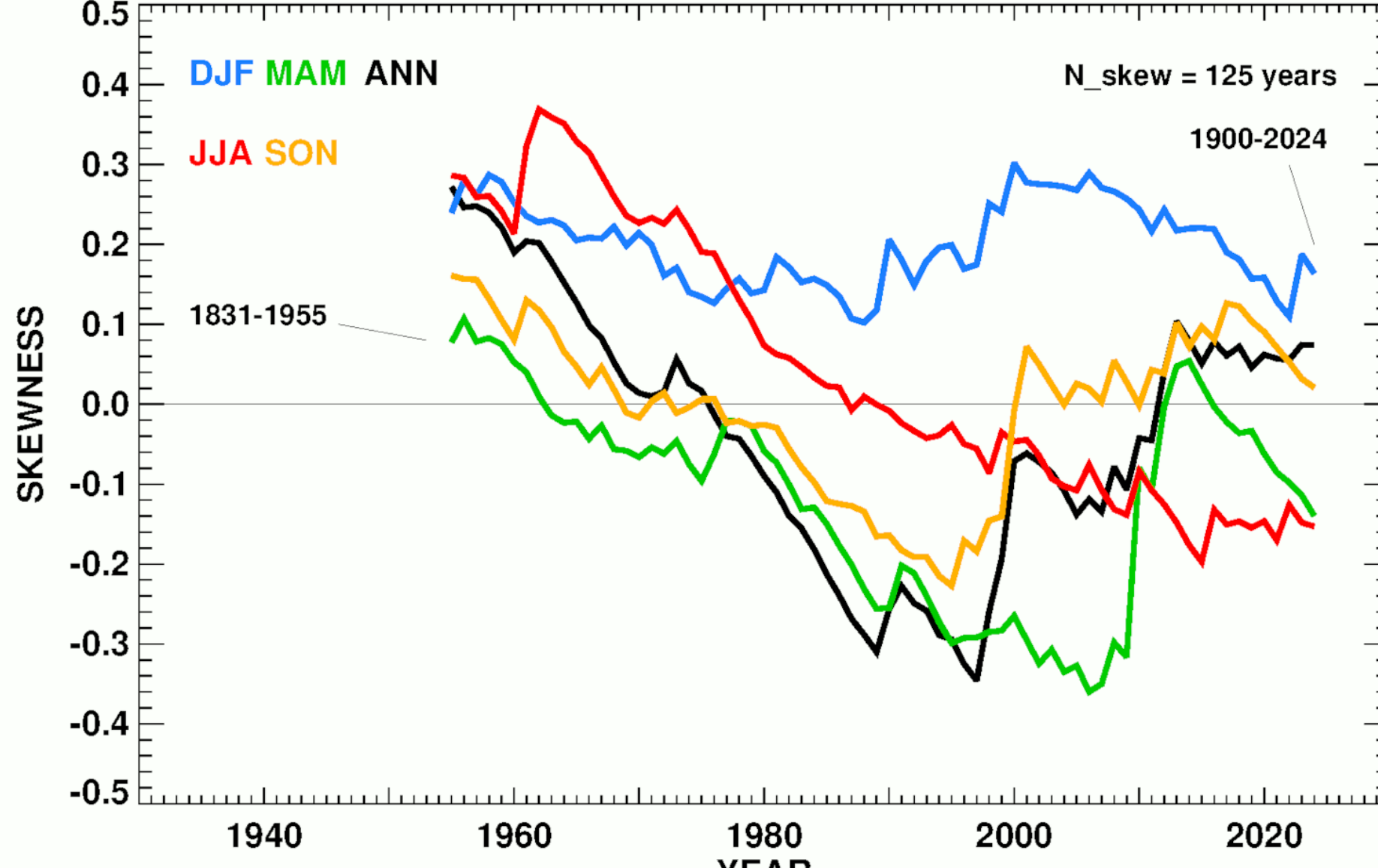
10-Year Mean Temperature Changes Since 1850

Annual	+2.44 °C	+4.39 °F
DJF	+2.47 °C	+4.44 °F
MAM	+2.28 °C	+4.11 °F
JJA	+2.66 °C	+4.79 °F
SON	+2.27 °C	+4.08 °F

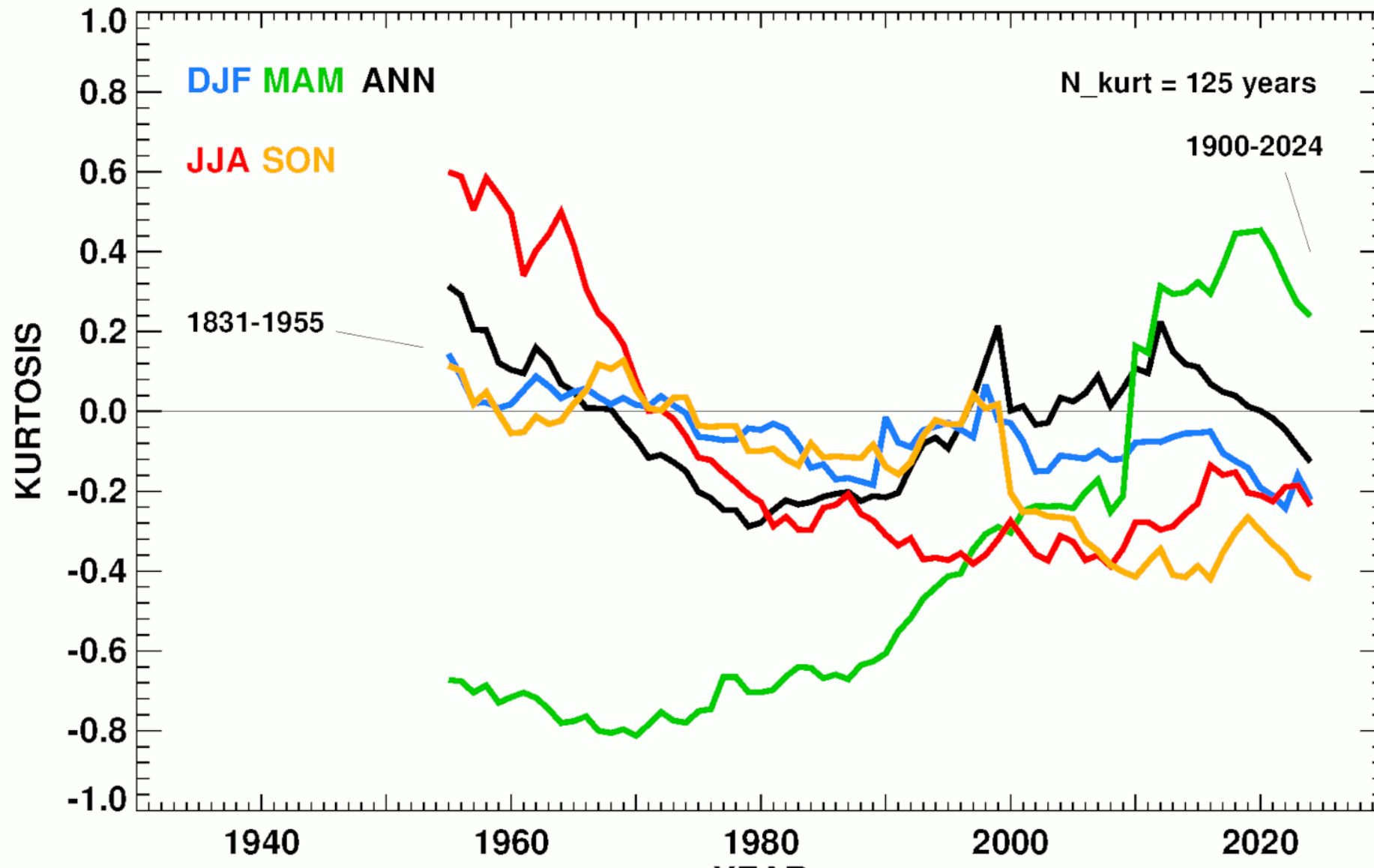
Temperature Skewness

- Intervals:** 125 years (shown for all periods from 1831-1955 through 1900-2024)
- Annual:** Sharp increase since 2000 due to climb from lowest temperatures in 1870's
- Winter:** Skewness is consistently positive
- Summer:** Decreasing skewness shows upward temperature trend is slowing in summer

BLUE HILL OBSERVATORY TEMPERATURE SKEWNESS



BLUE HILL OBSERVATORY TEMPERATURE KURTOSIS

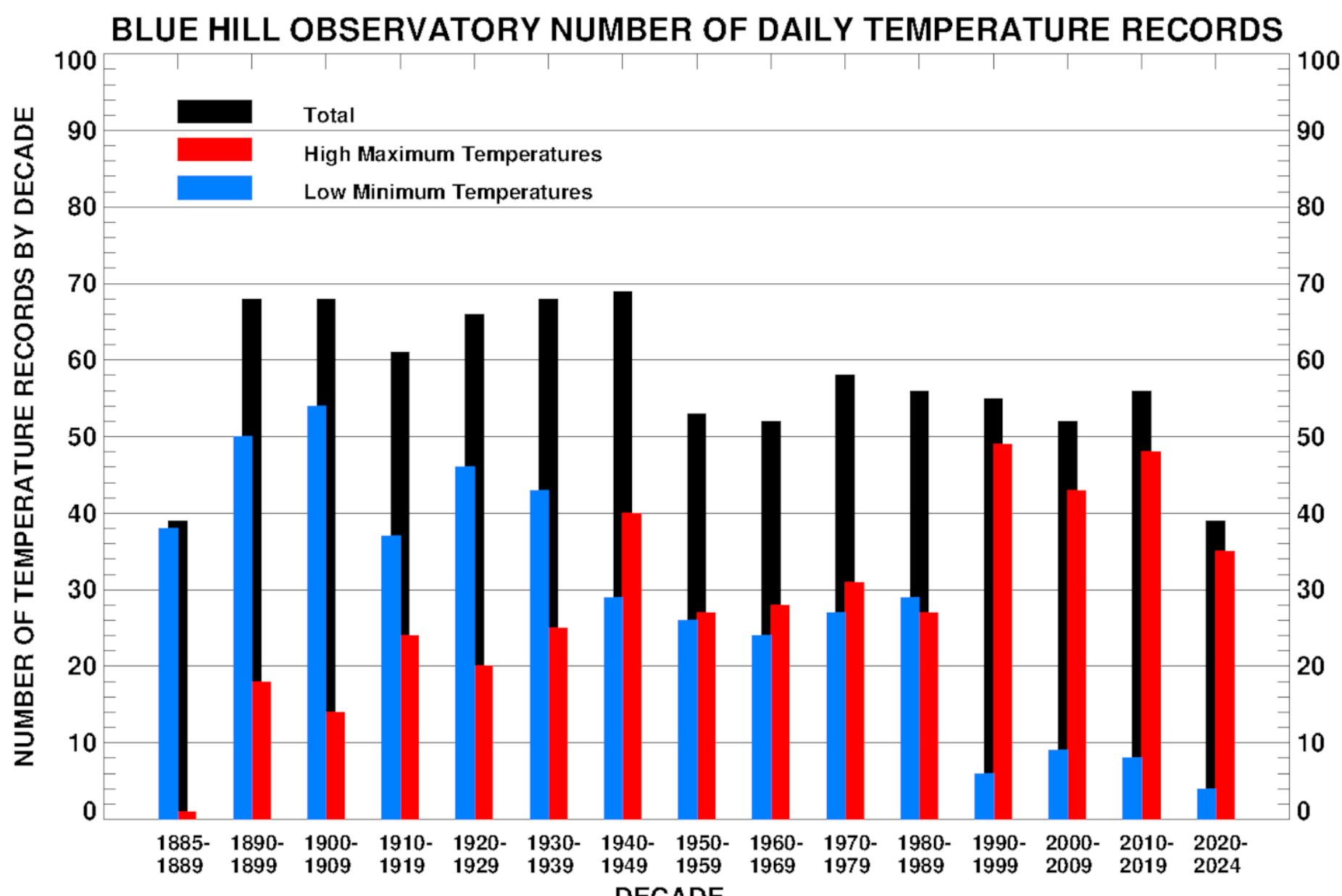


Temperature Kurtosis

- Intervals:** 125 years (shown for all periods from 1831-1955 through 1900-2024)
- Annual:** Relatively neutral
- Spring:** Sharp increase over time suggests less variability from mean
- Summer:** Steady decrease over time suggests more variability from mean

Temperature Extremes

- Data:** Decadal Number of Daily High and Low Temperature Records
- Record High Temperatures:** Increasing steadily throughout the period of record
- Record Low Temperatures:** Decreasing steadily throughout the period of record
- 2020's** on pace to exceed all previous decades for daily record high temperatures



Wind Speed Statistics

Annual Wind Speed

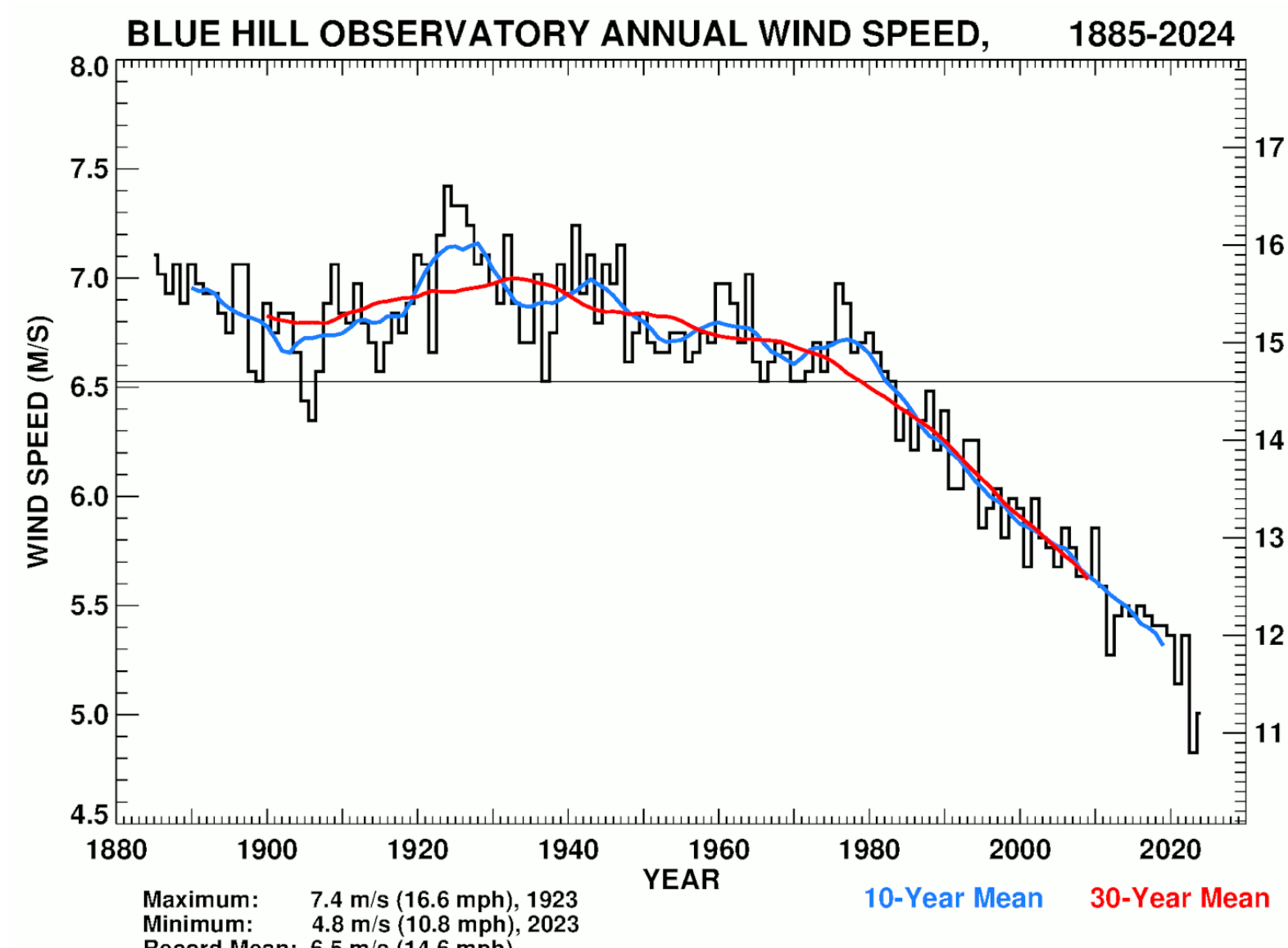
- Source:** Derived from continuity-adjusted daily speeds from contacting anemometer located on top of Observatory tower mast
- Trend:** Sharply decreasing since 1980

Skewness (70-year intervals)

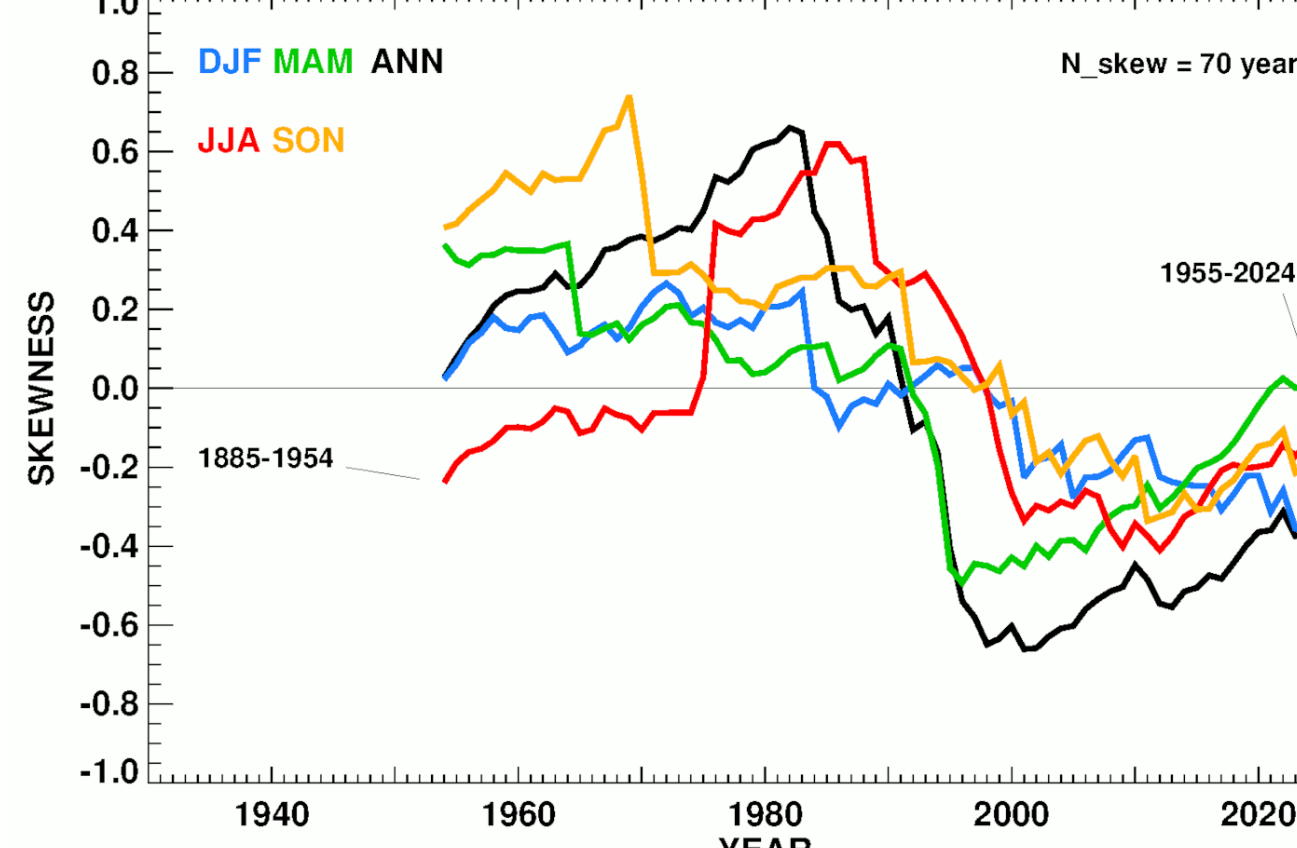
- Shifting toward negative values (lower speeds) in all seasons

Kurtosis (70-year intervals)

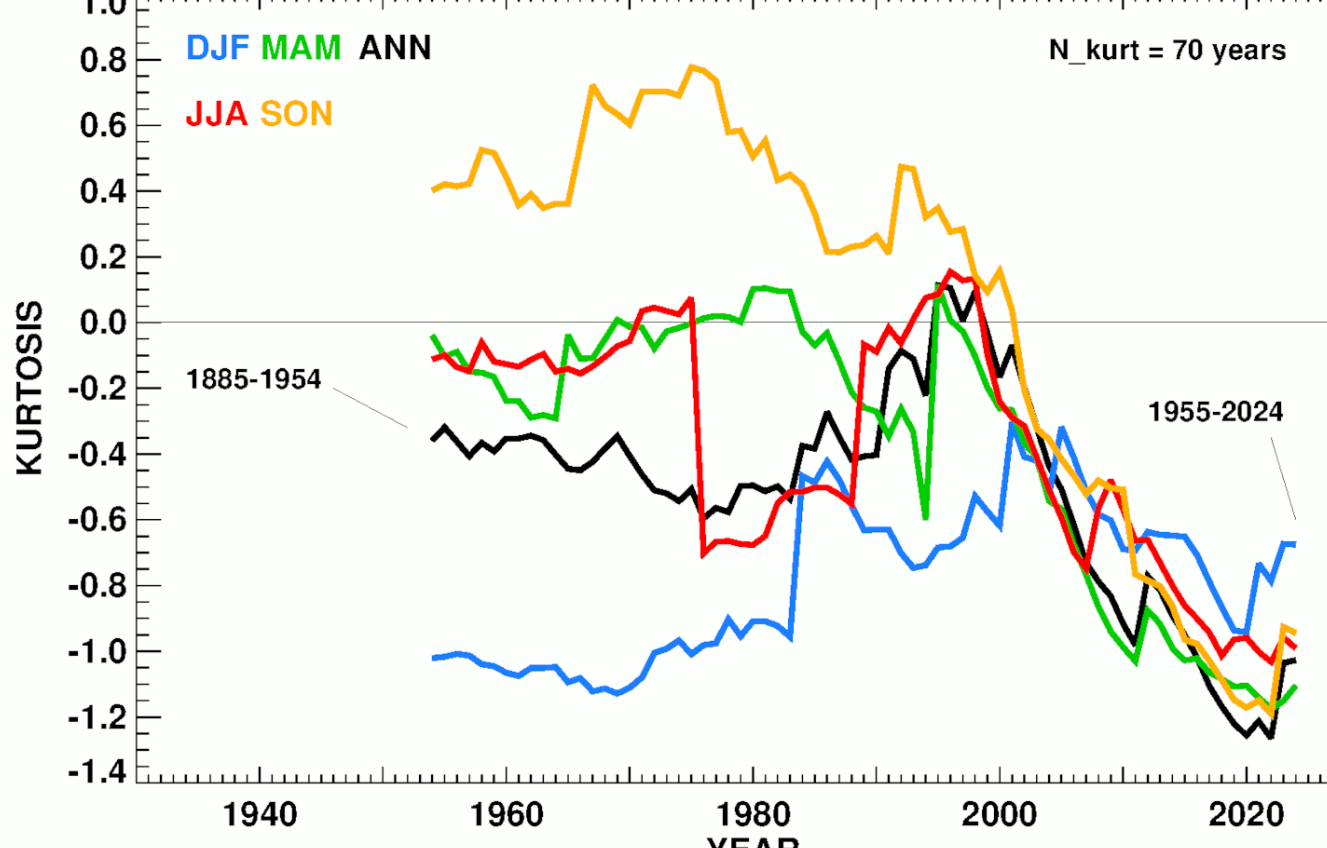
- Shifting toward more negative values (more variability) in all seasons



BLUE HILL OBSERVATORY WIND SPEED SKEWNESS

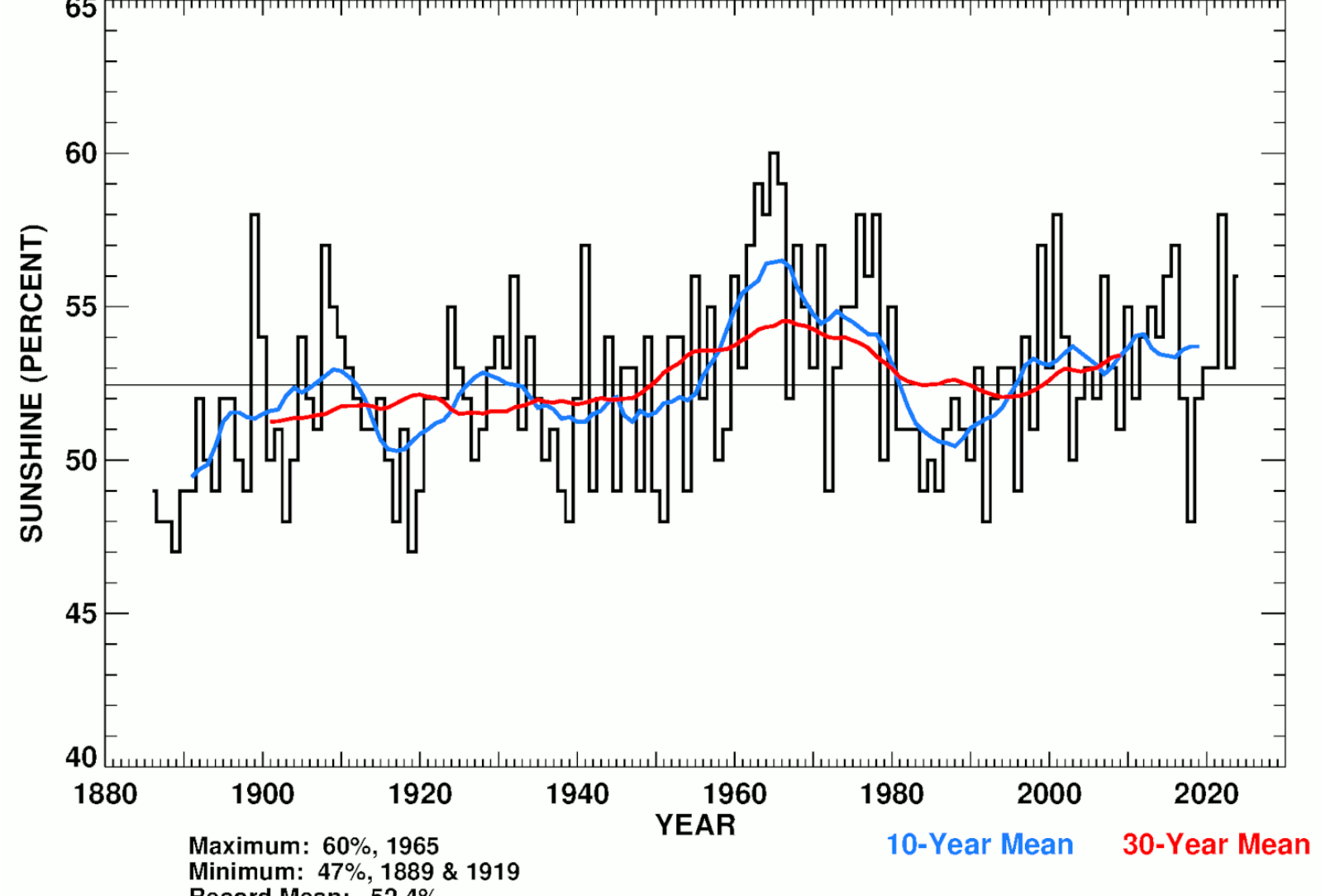


BLUE HILL OBSERVATORY WIND SPEED KURTOSIS



Sunshine Duration Statistics

BLUE HILL OBSERVATORY ANNUAL BRIGHT SUNSHINE, 1886-2024



Annual Sunshine

- Source:** Percent of possible sunshine derived from minutes of bright sunshine observed with Campbell-Stokes sunshine recorder on Observatory tower
- Trend:** Decadal variability due to changes in aerosols and clouds

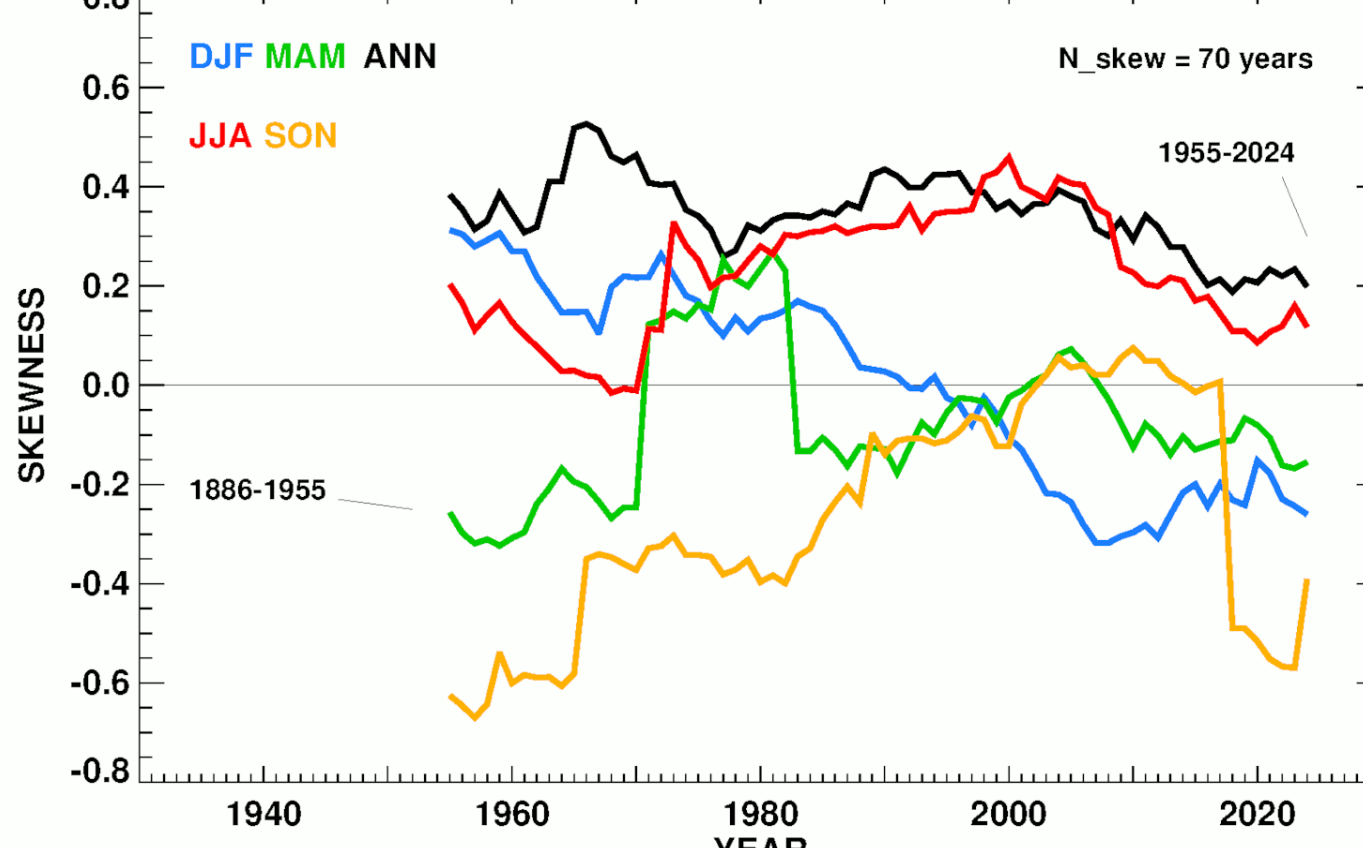
Skewness (70-year intervals)

- Generally positive for annual and summer sunshine

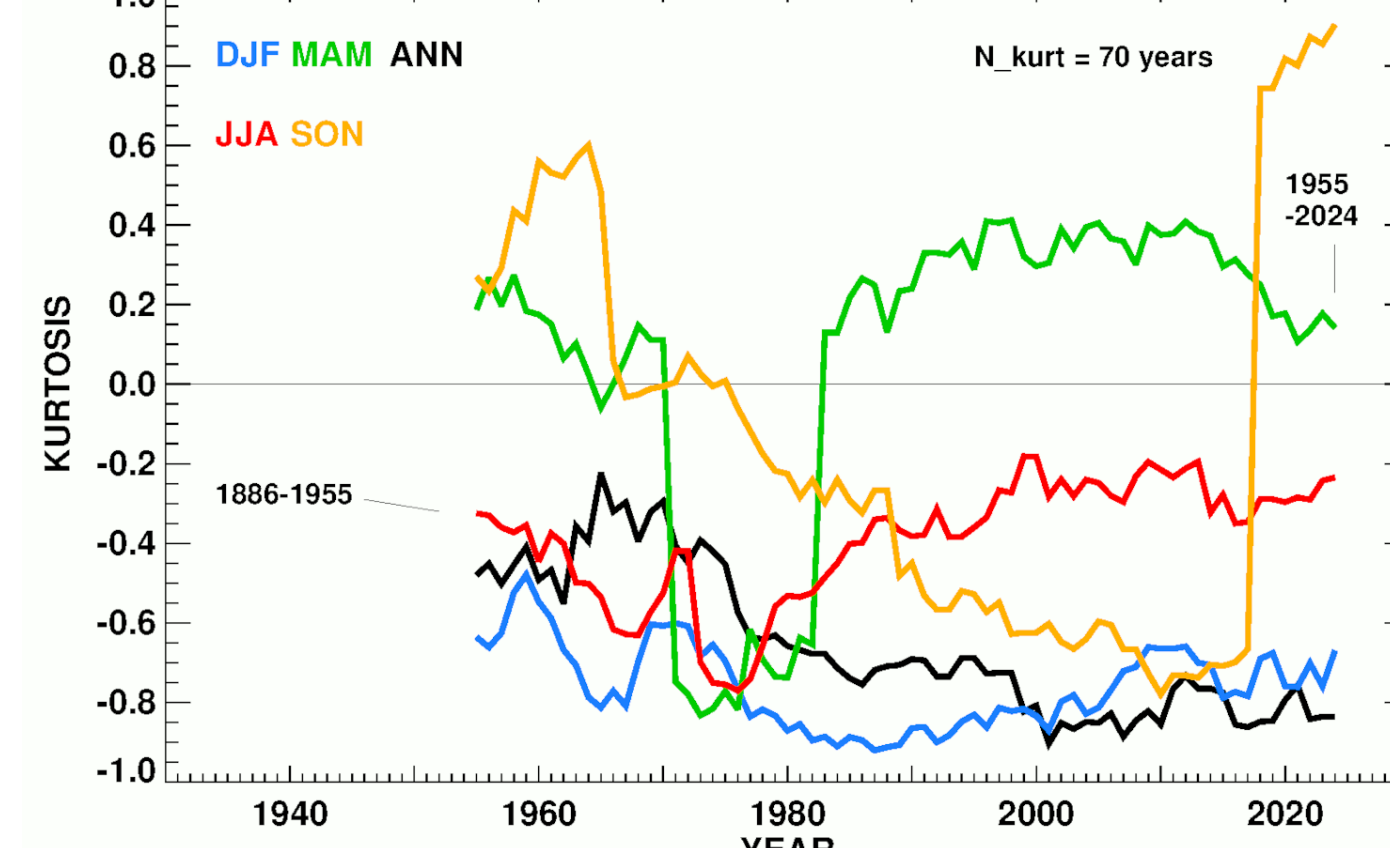
Kurtosis (70-year intervals)

- Generally negative (more variability) especially in winter; generally positive in spring
- Sudden large shifts due to outlier years

BLUE HILL OBSERVATORY BRIGHT SUNSHINE SKEWNESS



BLUE HILL OBSERVATORY BRIGHT SUNSHINE KURTOSIS



Summary

- Statistical analysis of variability is essential to understanding long-term climate changes
- Annual and seasonal Blue Hill Observatory temperature, moisture, wind speed and sunshine were examined to assess changes in variability at this site
- Temperature:** Mean trend strongly increasing since 1870's, positive skewness (upward trend) once highest in summer is now highest in winter; spring has largest decrease in variability; large shifts in daily temperature extremes since late 19th century
- Water Vapor:** Increasing in response to temperature change; skewness generally positive; variability increasing
- Wind Speed:** Annual means continue steady decline since 1980; skewness and kurtosis generally negative
- Sunshine Duration:** Large decadal changes in mean; skewness weakly positive in summer and annual data; lowest kurtosis (highest variability) seen in winter