

Climate of Pennsylvania

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Pennsylvania Earth Science Teachers Association Conference

November 19, 2016

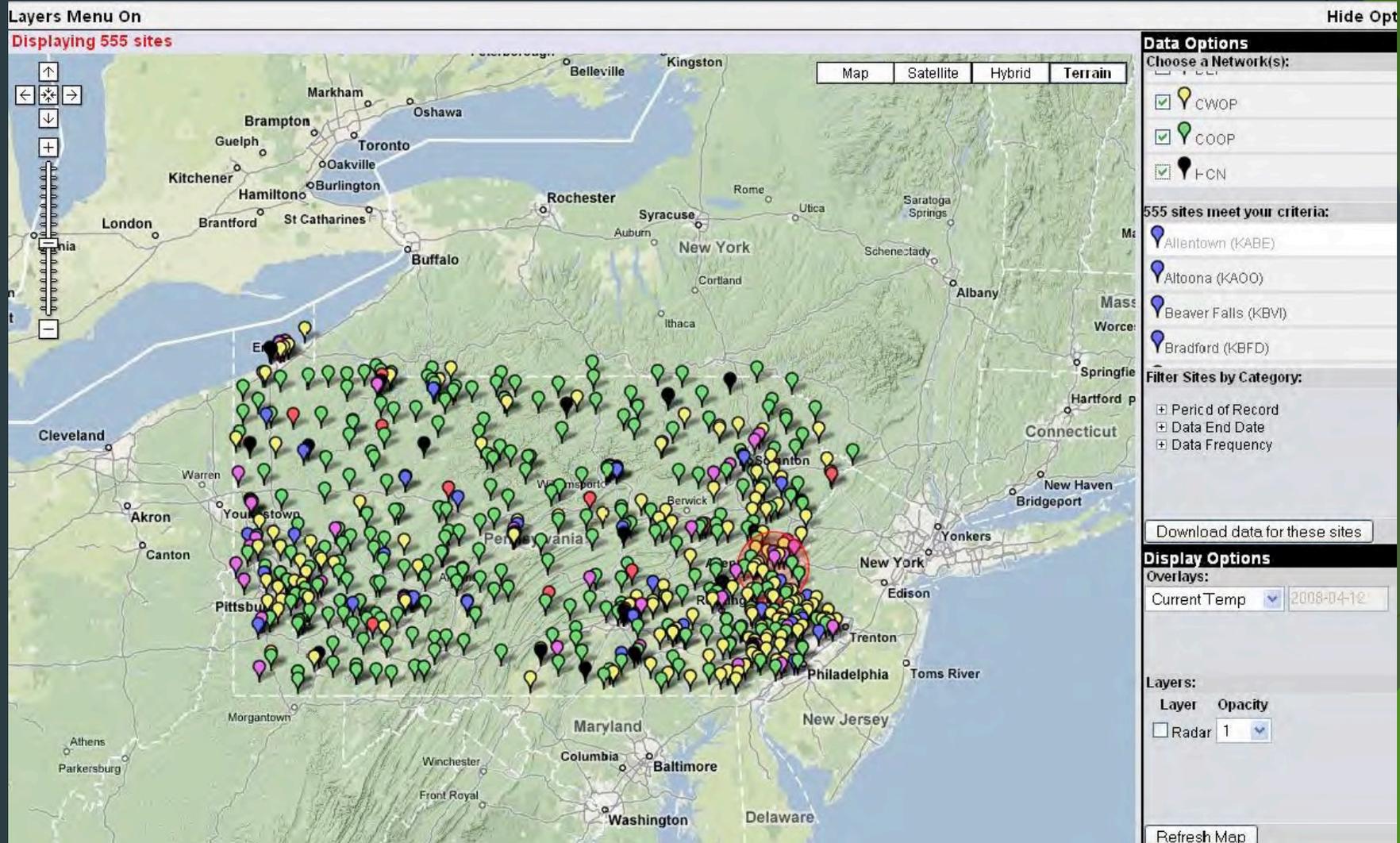
Overview

- ▶ Pennsylvania State Climate Office
 - ▶ What we do and what we provide
- ▶ Climate trends in Pennsylvania
 - ▶ Analysis of different climate variables
- ▶ Climate change and communication

Pennsylvania State Climate Office - What we do

- ▶ Provide climate services to clients across the commonwealth
- ▶ Manage archives of state weather data for multiple weather reporting networks
- ▶ Provide support for decision-making tools that require weather input
 - ▶ Agriculture, transportation, etc.
- ▶ Partake in research related to climate impacts and historical climate trends
- ▶ Website: <http://climate.met.psu.edu/>

Data Networks - Many across the state



Visualizing weather data

This current daily data is derived from real-time hourly observations recorded by the KABE ASOS/AWOS and should be treated as unofficial data. Contact our office for availability of official records.

Date	# obs	High Temp.	Low Temp.	Avg Temp.	Temp Departure	HDD	CDD	GDD	Avg Dewpoint	Avg RH	Avg Wind Speed	Avg Wind Dir	Avg Press	Total Precip
2016-11-10	23	58	38	48	4	17	0	0	33	59	8	261	1014.5	Trace
2016-11-09	24	55	43	49	5	16	0	0	43	80	5	209	1012.5	0.28
2016-11-08	24	68	30	48	4	18	0	0	33	60	3	137	1020.2	
2016-11-07	24	58	32	43	-2	22	0	0	29	60	3	131	1030.0	
2016-11-06	24	59	39	50	5	16	0	0	33	55	9	239	1025.0	
2016-11-05	24	64	32	49	4	16	0	0	36	63	6	220	1023.3	
2016-11-04	24	58	38	52	7	13	0	0	35	54	9	284	1021.5	
2016-11-03	24	70	48	57	11	8	0	2	50	79	5	151	1015.5	0.13
2016-11-02	24	71	43	56	10	9	0	1	48	76	4	158	1023.4	
2016-11-01	24	56	30	45	-1	20	0	0	35	70	4	126	1026.9	
Date	# obs	High Temp.	Low Temp.	Avg Temp.	Temp Departure	HDD	CDD	GDD	Avg Dewpoint	Avg RH	Avg Wind Speed	Avg Wind Dir	Avg Press	Total Precip
2016-10-31	24	54	35	46	-1	19	0	0	34	61	9	268	1022.2	
2016-10-30	24	79	51	63	16	2	0	8	52	70	6	181	1012.4	0.09
2016-10-29	24	65	32	50	3	15	0	0	39	66	3	95	1018.2	
2016-10-28	24	52	36	45	-3	20	0	0	34	67	9	257	1021.4	Trace
2016-10-27	24	47	38	43	-5	22	0	0	36	78	8	89	1024.6	0.55
2016-10-26	24	52	29	41	-7	24	0	0	26	59	5	162	1030.0	
2016-10-25	24	52	38	47	-1	18	0	0	29	49	7	265	1024.4	
2016-10-24	24	63	44	53	4	12	0	0	38	60	10	281	1015.0	0.10
2016-10-23	24	64	43	52	3	13	0	0	35	54	10	254	1011.0	
2016-10-22	24	54	47	49	0	16	0	0	38	65	14	302	1001.8	0.12
2016-10-21	24	79	54	68	18	0	3	13	58	72	9	214	1004.8	0.06
2016-10-20	24	76	58	66	16	0	1	11	56	70	8	81	1017.7	
2016-10-19	24	84	59	70	20	0	5	15	57	66	5	182	1015.8	
2016-10-18	24	84	53	68	17	0	3	13	58	74	4	121	1012.2	
2016-10-17	24	78	55	65	14	0	0	10	58	78	3	110	1014.4	0.04
2016-10-16	24	69	40	54	2	11	0	0	48	80	3	104	1021.3	
2016-10-15	24	67	33	49	-3	16	0	0	38	66	3	119	1028.4	
2016-10-14	24	64	40	52	0	13	0	0	37	61	3	140	1027.2	
2016-10-13	24	65	46	55	2	10	0	0	49	81	4	182	1020.1	0.05
2016-10-12	24	69	39	53	0	12	0	0	44	72	2	67	1026.2	
2016-10-11	24	67	34	51	-2	14	0	0	34	54	1	30	1030.3	

Taken from:

<http://climate.met.psu.edu/data/current/dailysum.php?id=KABE>

Data Archive



The Pennsylvania State Climatologist is a service to the Commonwealth by the College of Earth and Mineral Sciences and Penn State.

The Pennsylvania State CLIMATOLOGIST

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Data Archive - Historical observations from FAA, COOP, CWOP, and DEP observing sites.

[Current Airport Data](#) - Current hourly and daily observations from select cities across Pennsylvania. Information on visibility, pressure, temperature, dew point, relative humidity, wind speed and direction, rainfall, weather, and cloud cover.

[Divisional/Statewide Data](#) - Information on the geography and climatology of Pennsylvania. Also contains divisional climate data, degree day data, means & extremes, and other state-wide miscellaneous information.

[Hourly Climatology](#) - Hourly averaged values of temperature, dew point, pressure, and wind speed for select observing sites across Pennsylvania.

[Day Summaries](#) - Max/Min temperature and precipitation for a specified day over a range of years.

[FROST](#) - Information, training, and data from the FROST (Frost, Rain, Optics, Snow and Thunder) program.

[PA County Snowfall Status](#) - County snowfall map.

[PA Radar, Satellite and Snow Depth Archive](#) - Archive of radar, satellite, and snow depth images since February 19th, 2002.

[City Information](#) - Detailed information on select cities across Pennsylvania.

[Data Network Information](#) - Description of the data networks the Pennsylvania State Climatologist uses.

[Events Database](#) - Archive of multiple weather event types with significant societal and economic impacts.

Mailing Address:
Pennsylvania State Climatologist
503 Walker Building
University Park, PA 16802

Online:
[Data Request Form](#)
E-mail:
psc@meteo.psu.edu
Phone:
814-865-8732



Example: FAA Network Stations

The Pennsylvania State Climatologist is a service to the Commonwealth by the College of Earth and Mineral Sciences and Penn State.

The Pennsylvania State CLIMATOLOGIST

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PASC IDA Data Page

Select a network:
 Select a display option: List Map

Viewing Data Network FAA_RAW

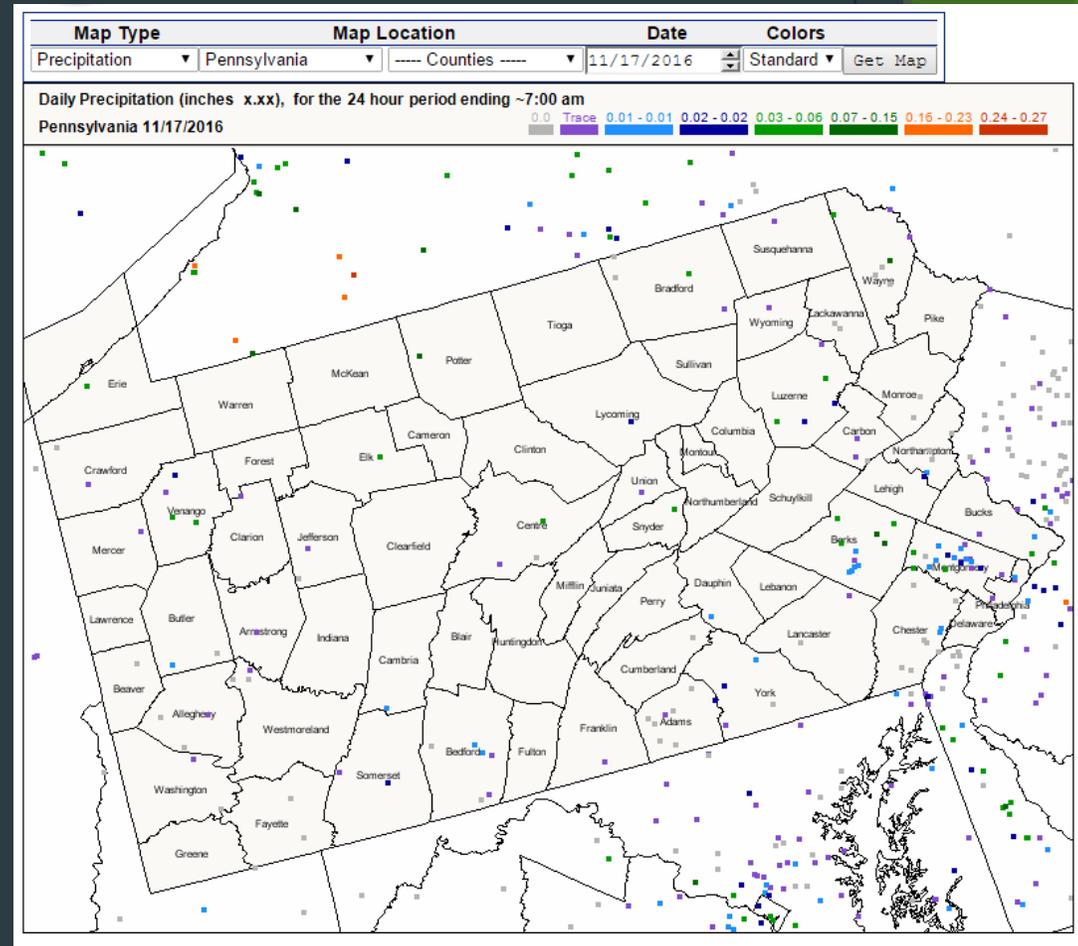
ID	Name	County	State	Lat	Lon	Elevation (feet)	Start	End
KABE	ALLENTOWN	LEHIGH	PA	40.650	-75.440	376.0	1948-02-01	2016-11-16
KAOO	ALTOONA	BLAIR	PA	40.290	-78.320	1504.0	1977-01-01	2016-11-16
KBVI	BEAVER FALLS	BEAVER	PA	40.770	-80.390	1230.0	1996-01-02	2016-11-16
KBFD	BRADFORD	MCKEAN	PA	41.800	-78.640	2142.0	1957-07-01	2016-11-16
KBTP	BUTLER	BUTLER	PA	40.770	-79.950	1250.0	1992-01-01	2016-11-16
KCXY	CAPITAL CITY	YORK	PA	40.220	-76.850	340.0	1996-01-01	2016-11-16
KFIG	CLEARFIELD	CLEARFIELD	PA	41.040	-78.410	1516.0	2001-01-01	2016-11-16
KDYL	DOYLESTOWN	BUCKS	PA	40.330	-75.120	394.0	1999-01-01	2016-11-16
KDUJ	DUBOIS	JEFFERSON	PA	41.180	-78.900	1814.0	1972-01-01	2016-11-16
KERI	ERIE	ERIE	PA	42.080	-80.170	730.0	1948-02-02	2016-11-16
KFKL	FRANKLIN	VENANGO	PA	41.370	-79.860	1540.0	1968-02-01	2016-11-16
KIDI	INDIANA	INDIANA	PA	40.630	-79.100	1400.0	1997-01-01	2016-11-16
KJST	JOHNSTOWN	CAMBRIA	PA	40.320	-78.830	2280.0	1972-01-01	2016-11-16
KLNS	LANCASTER	LANCASTER	PA	40.120	-76.290	403.0	1974-01-01	2016-11-16
KLBE	LATROBE	WESTMORELAND	PA	40.283	-79.400	1190.0	1996-01-01	2016-11-16
KGKJ	MEADVILLE	CRAWFORD	PA	41.620	-80.210	1400.0	1969-12-31	2016-11-16
KMDT	MIDDLETOWN	DAUPHIN	PA	40.190	-76.760	312.0	1948-02-01	2016-11-16
KMPO	MOUNT POCONO	MONROE	PA	41.140	-75.370	1895.0	1999-09-29	2016-11-16
KMUI	MUIR ARMY AIR FIELD	LEBANON	PA	40.430	-76.570	489.0	1996-01-02	2016-11-16
KPHL	PHILADELPHIA	PHILADELPHIA	PA	39.870	-75.240	27.0	1948-02-01	2016-11-16
KPNE	PHILADELPHIA NE	PHILADELPHIA	PA	40.080	-75.020	100.0	1996-01-01	2016-11-16

Climate Data Caveats!

- ▶ Be mindful of observation times/dates with climate datasets
- ▶ Airport locations (FAA/NWS) are automated weather stations - report hourly or sub-hourly - daily reports are usually midnight to midnight local time summaries of a particular calendar day (e.g. Dec. 22nd observations were from 12am Dec 22 to 12am Dec 23)
- ▶ NWS COOP sites are volunteer observers - they report 24-hour summaries once a day - typically taken between 6-8am each morning for the prior 24-hour period
 - ▶ The observation for Dec. 22nd is the 24-hour period prior to 7am Dec. 22nd - so, 7am Dec 21 through 7am Dec 22 local time is the Dec 22 observation
- ▶ This confuses the general public consistently (and you can see why)
- ▶ Just a note in case you ever are comparing inter-network observations

Community Collaborative Rain, Hail, & Snow Network (CoCoRaHS)

- ▶ I am the state coordinator for CoCoRaHS
- ▶ Report 24-hour precipitation totals once-a-day (similar to COOP - usually 7 or 8am local time)
- ▶ High-quality network of precipitation information
- ▶ In addition to precip, you can report observation notes (cloud cover, precip type falling now, frost present, etc.)
- ▶ Anyone can do this with a rain gauge and an interest in the weather!
- ▶ Potential learning opportunity for students
 - ▶ Contact me if any interest



Climate of Pennsylvania

- ▶ Because of our close proximity to bodies of water (Atlantic Ocean and Great Lakes) and frequent moisture transport from the Gulf of Mexico, PA is a persistently “wet” region
 - ▶ Extended periods of drought, while highly disruptive, are relatively rare
- ▶ Persistent winds from the west bring relatively frequent storms and disturbances in the atmospheric flow to the state
- ▶ Northwest winds in the winter bring relatively cold weather in the winter and southerly flow in the summer provides hot and humid weather
- ▶ PA is a unique state in that many “extreme” weather events can occur
 - ▶ Tropical cyclones, winter storms, severe storms/tornadoes, etc.

Changes in the Climate of Pennsylvania

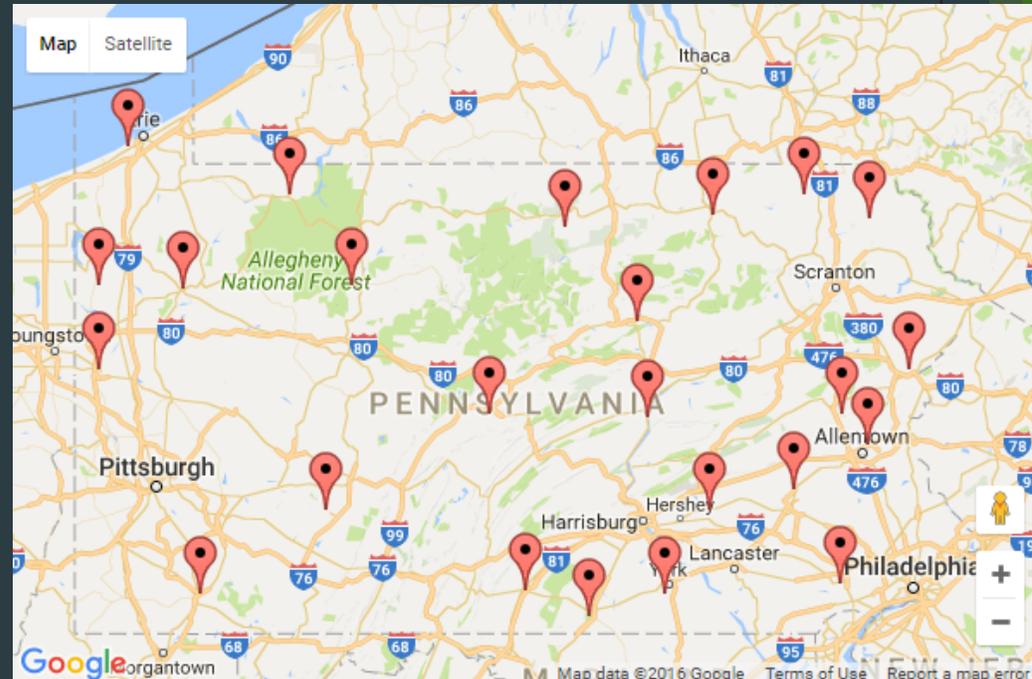
Pennsylvania Climate Divisions

- ▶ Most states are separated into climate regions, or divisions
- ▶ Each division is assigned based on basic climate characteristics that are similar across the division
- ▶ Historical trend analysis is typically done either with divisional data or Historical Climate Network stations

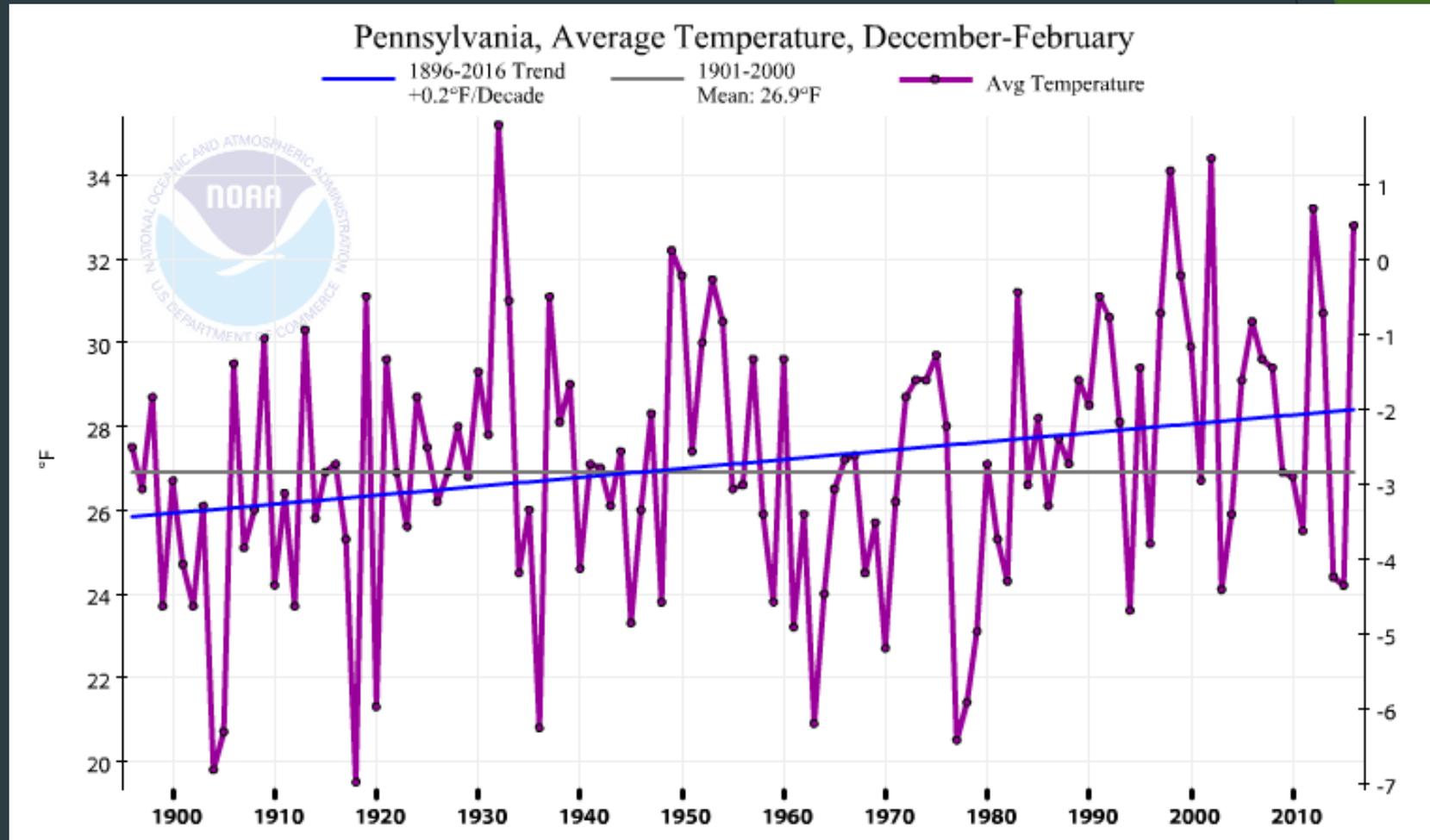


Pennsylvania Historical Climate Network (HCN) Stations

- ▶ 24 stations in Pennsylvania
- ▶ The US HCN is part of a global HCN that forms the basis of the Intergovernmental Panel on Climate Change (IPCC) reports and projections that are released at the international level
- ▶ Stations are part of the National Weather Service COOP network (report once a day)

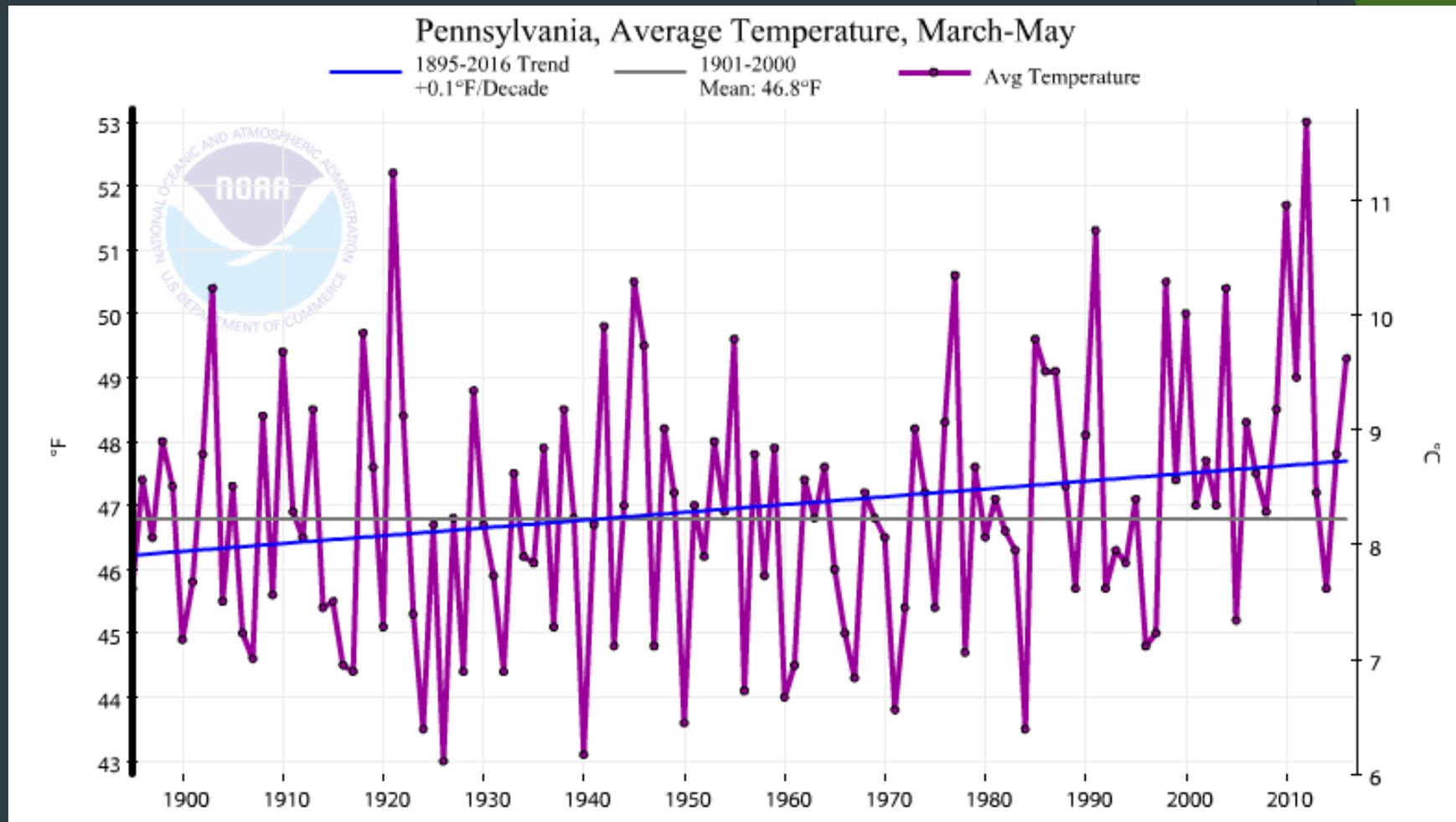


Statewide Winter Temperatures (Dec-Feb)



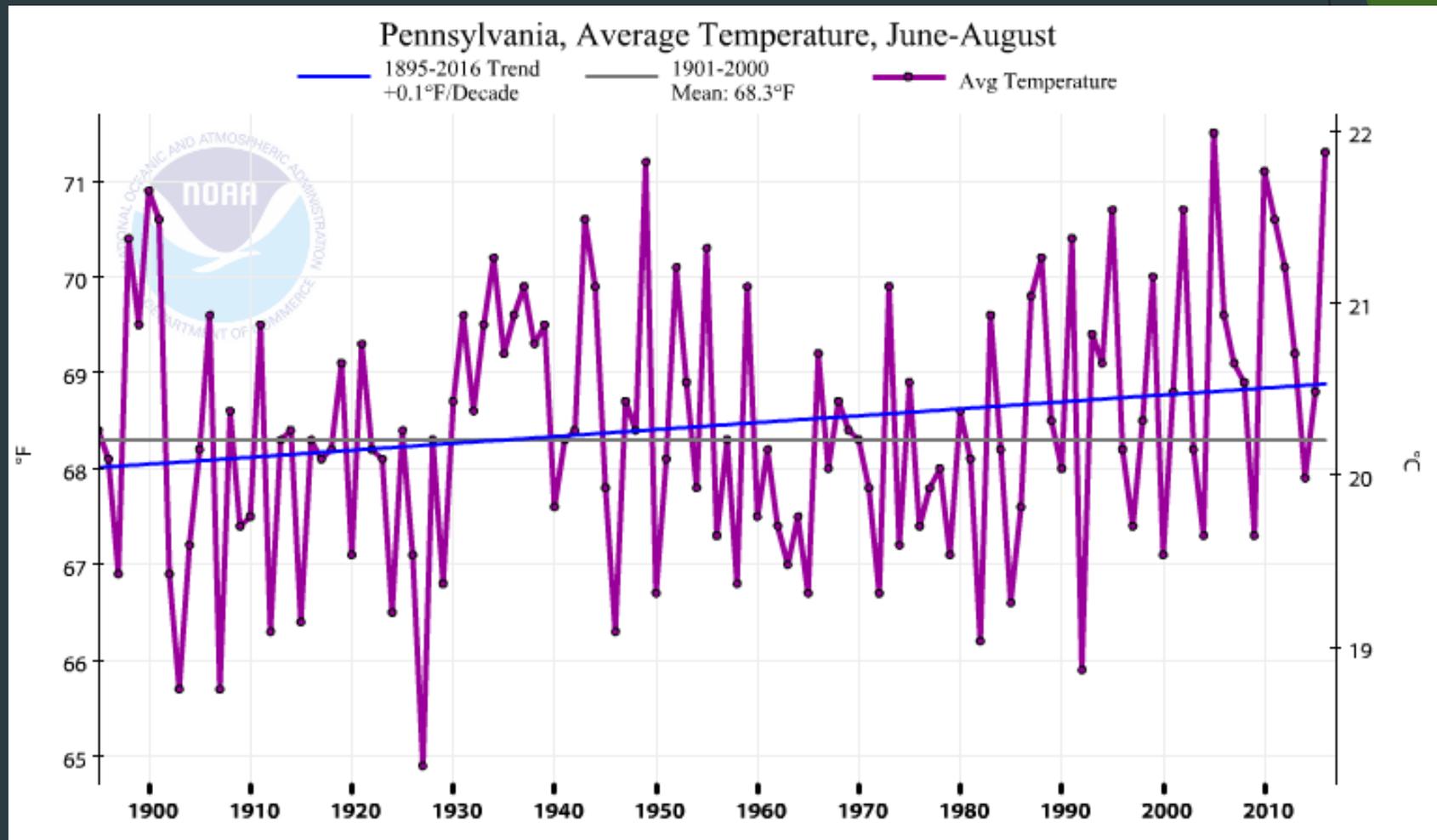
Trend: +0.20 degrees F per decade

Statewide Spring Temperatures (Mar-May)



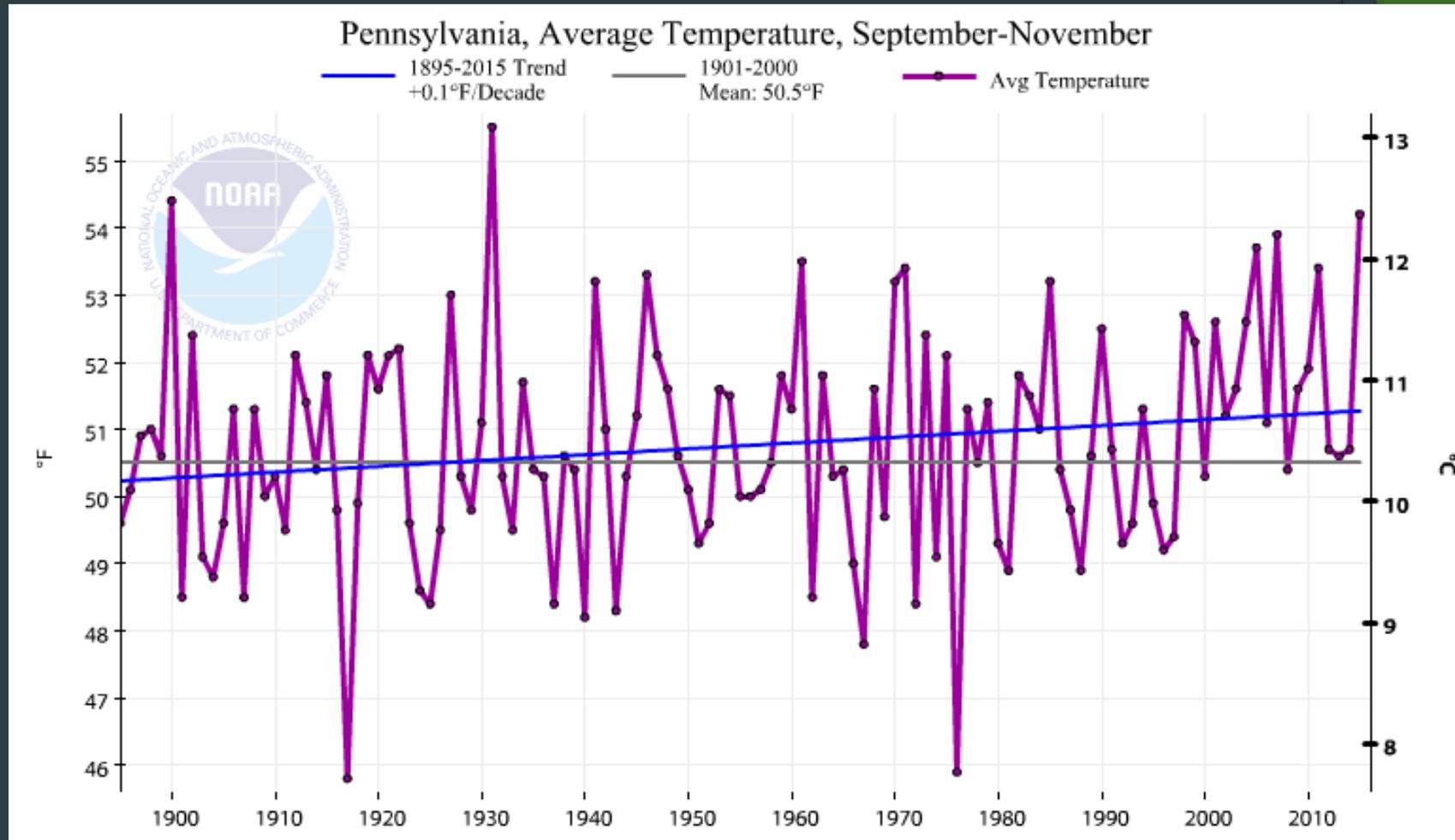
Trend: +0.10 degrees F per decade

Statewide Summer Temperatures (Jun-Aug)



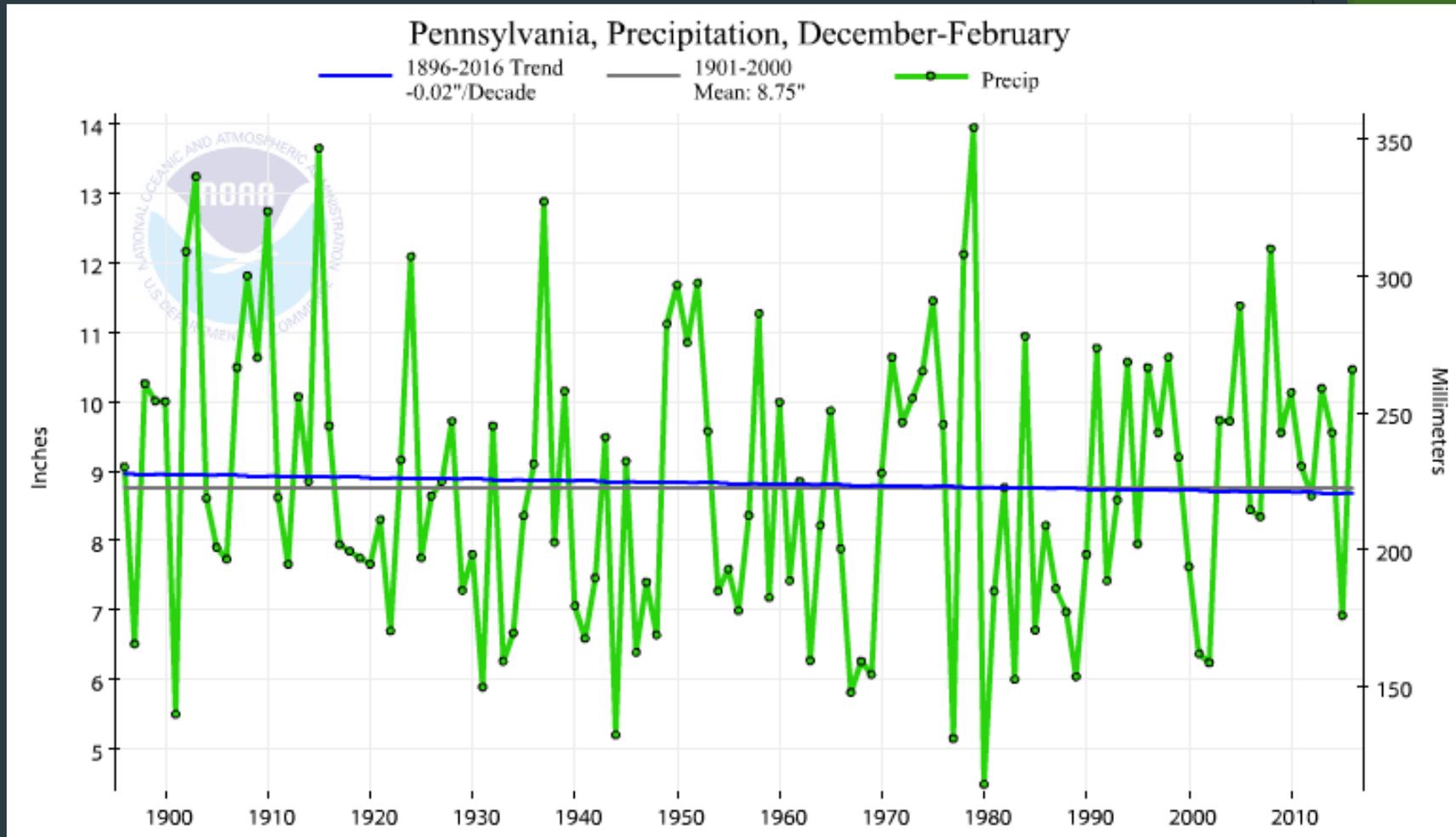
Trend: +0.10 degrees F per decade

Statewide Fall Temperatures (Sept-Oct)



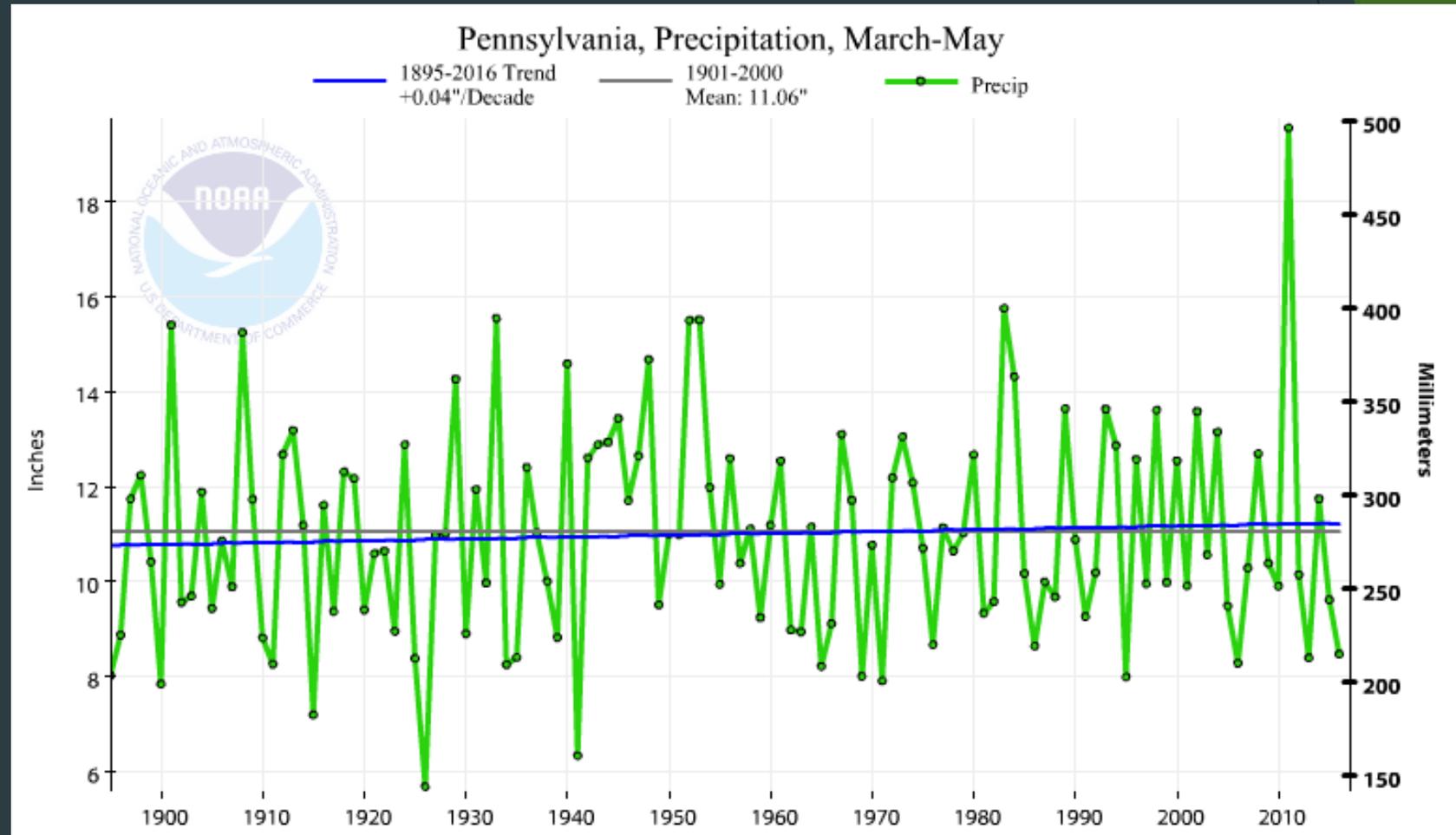
Trend: +0.10 degrees F per decade

Statewide Winter Precipitation (Dec-Feb)



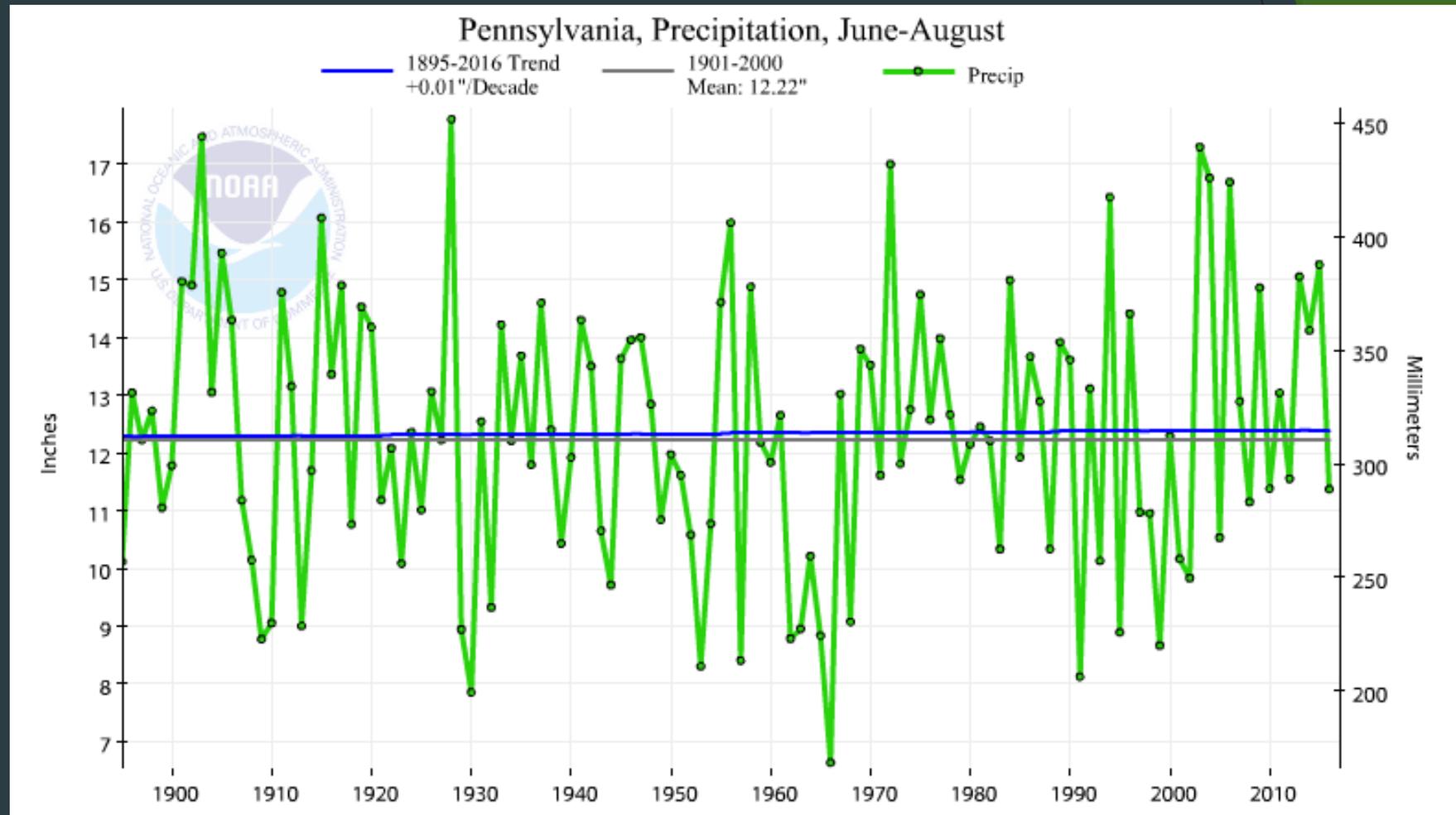
Trend: $-0.02''$ per decade

Statewide Spring Precipitation (Mar-May)



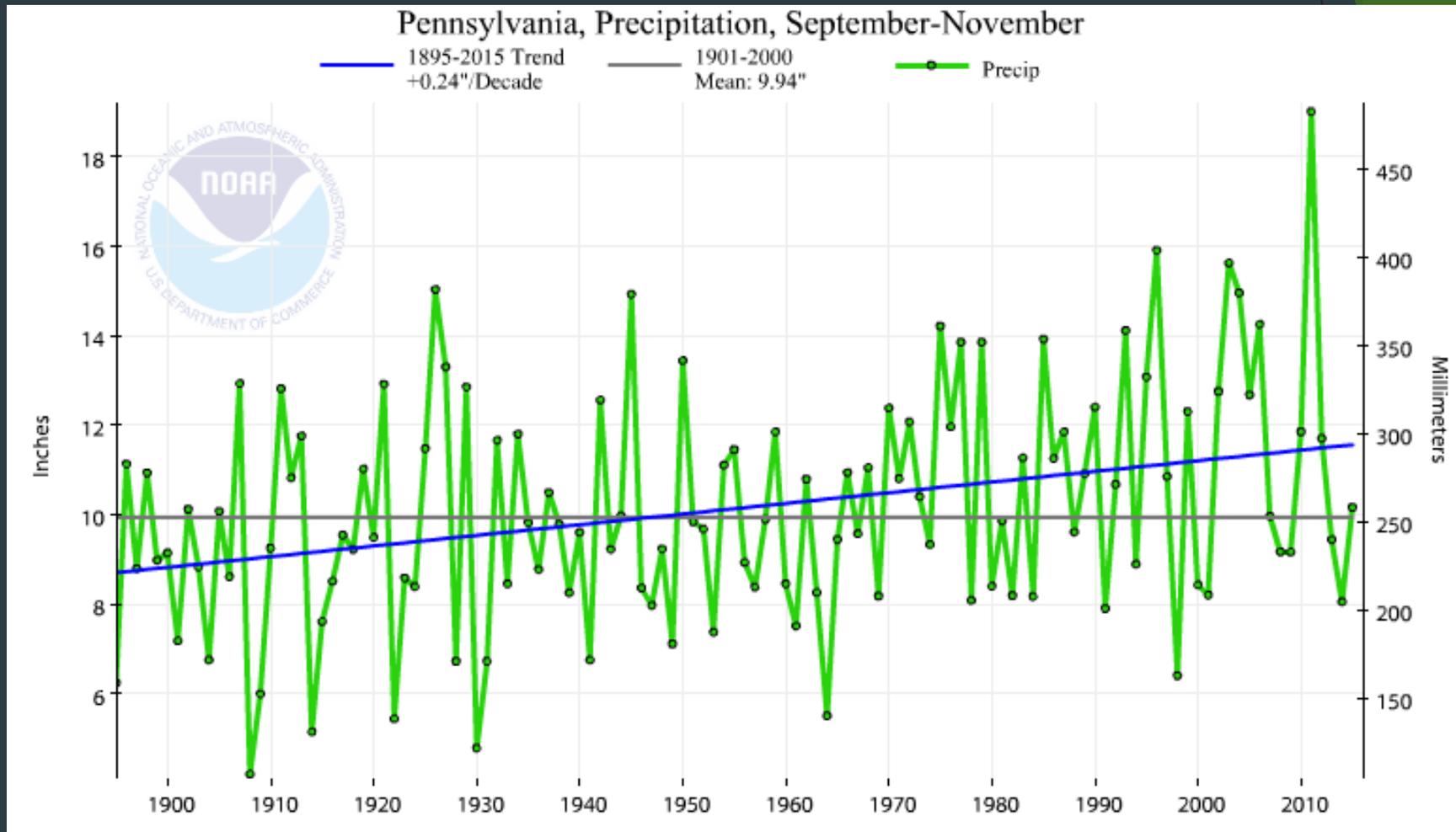
Trend: +0.04" per decade

Statewide Summer Precipitation (Jun-Aug)



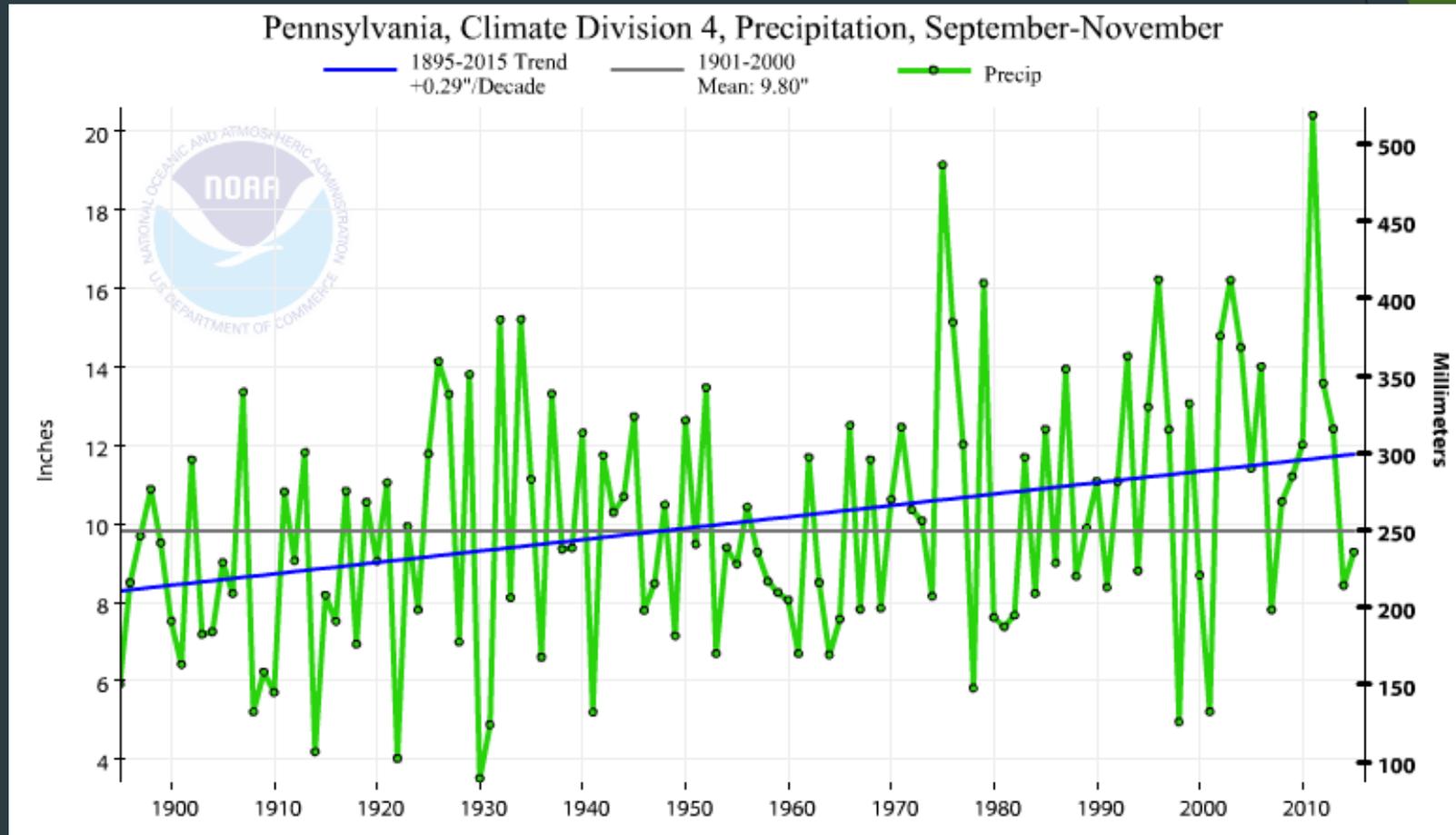
Trend: +0.01" per decade

Statewide Fall Precipitation (Sept-Nov)



Trend: +0.24" per decade

Largest Trend - Lower Susquehanna Climate Division

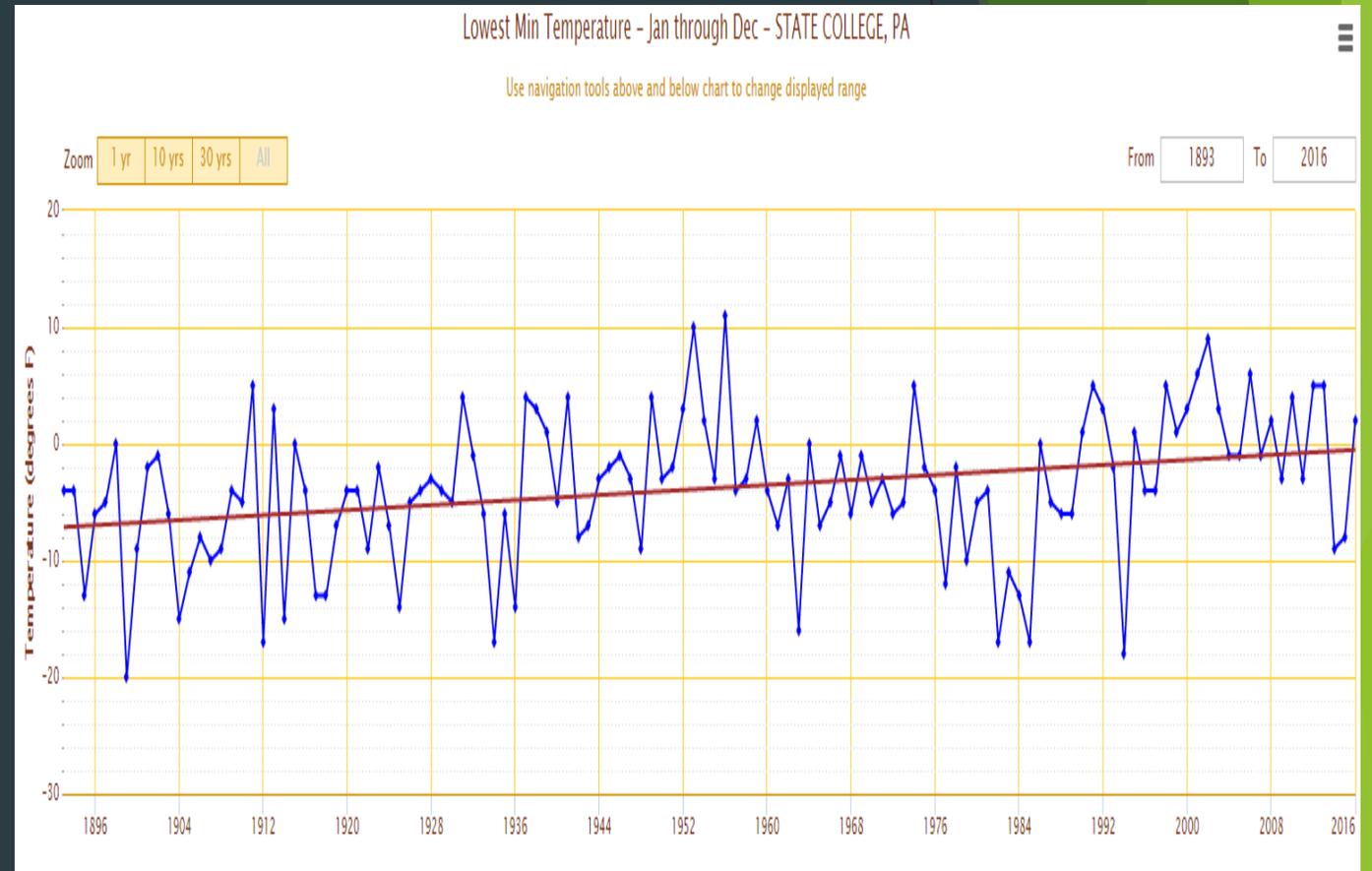


Trend: +0.29" per decade

Digging Deeper Into the Trends

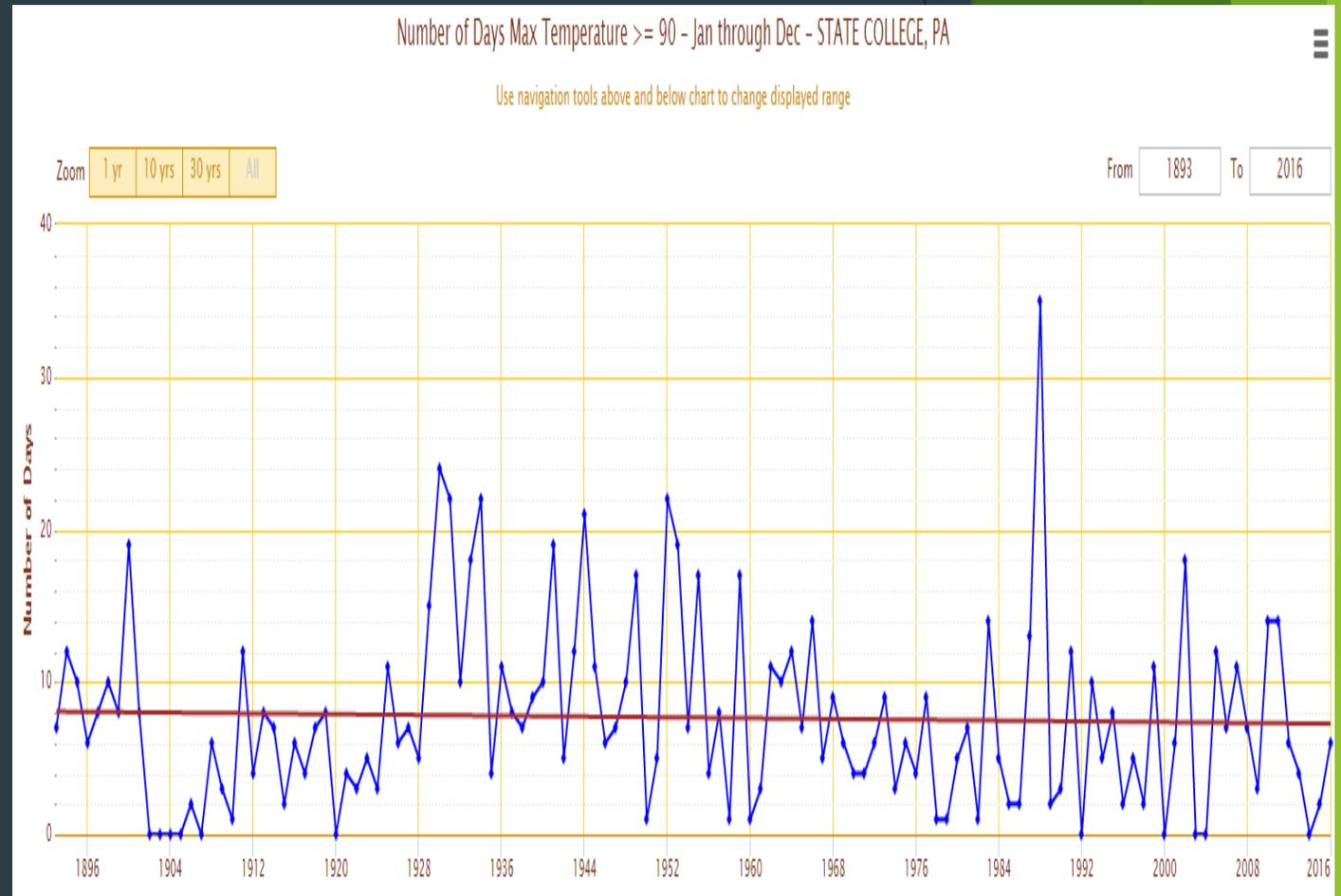
Cause of Rising Temperatures - Nighttime

- ▶ Lowest minimum annual temperature for State College 1893-2015
- ▶ Increased by between 5-8 degrees F over past ~125 years
- ▶ Why might this be the case?
 - ▶ Urbanization
 - ▶ Location of observation has moved
 - ▶ More cloud cover at night
 - ▶ Anthropogenic sources



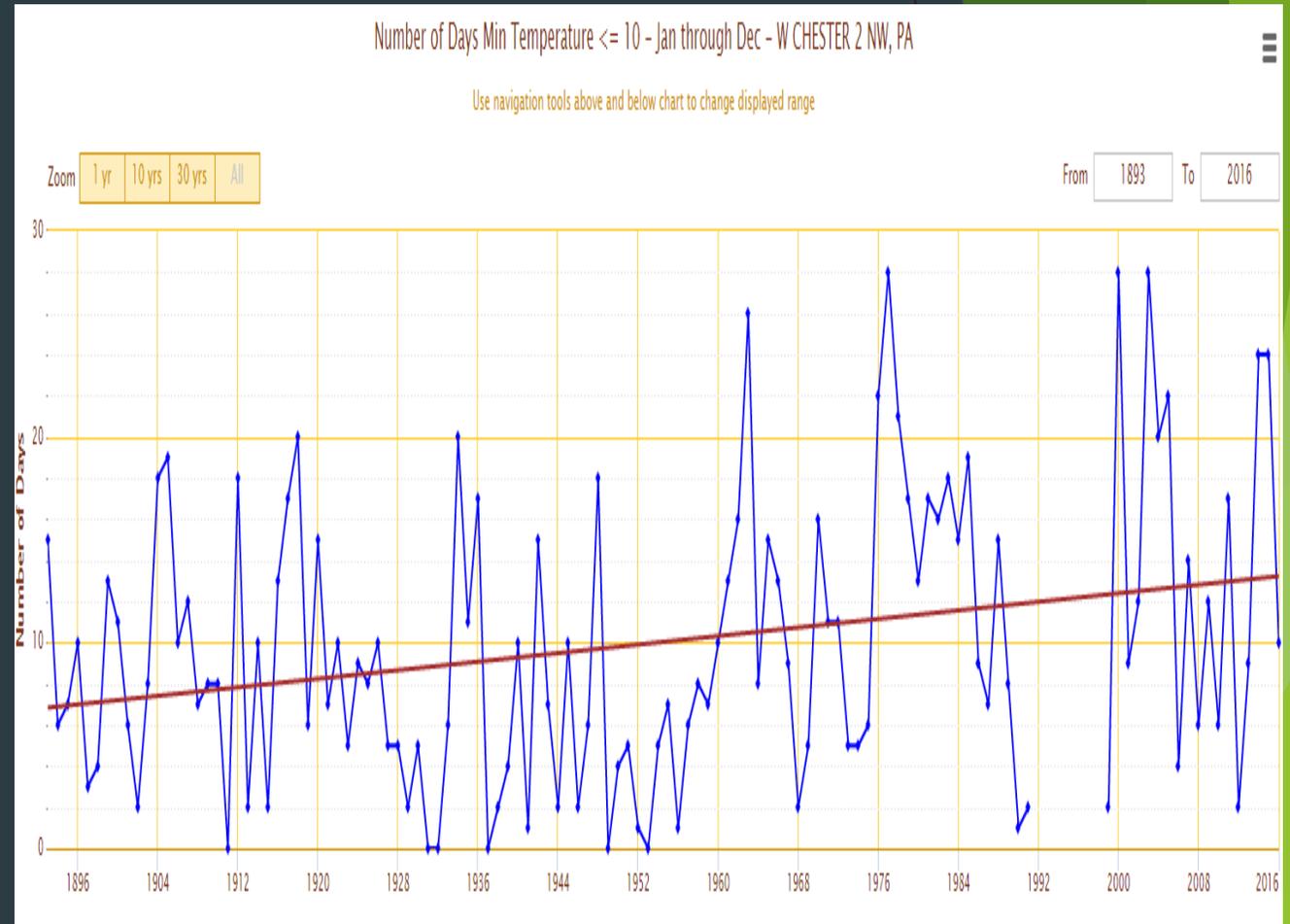
Number of “Hot” Days

- ▶ Days with high temperatures ≥ 90 degrees F
- ▶ Almost no trend - even slightly decreasing over the past ~125 years
- ▶ Goes against what may be “conventional wisdom”
- ▶ This does not mean that, on average, temperatures are not warming - just that very hot days are not increasing
- ▶ Why?
 - ▶ Urbanization (shadows, shade, etc.)
 - ▶ Increased moisture content
 - ▶ Foliage from nearby trees, etc.



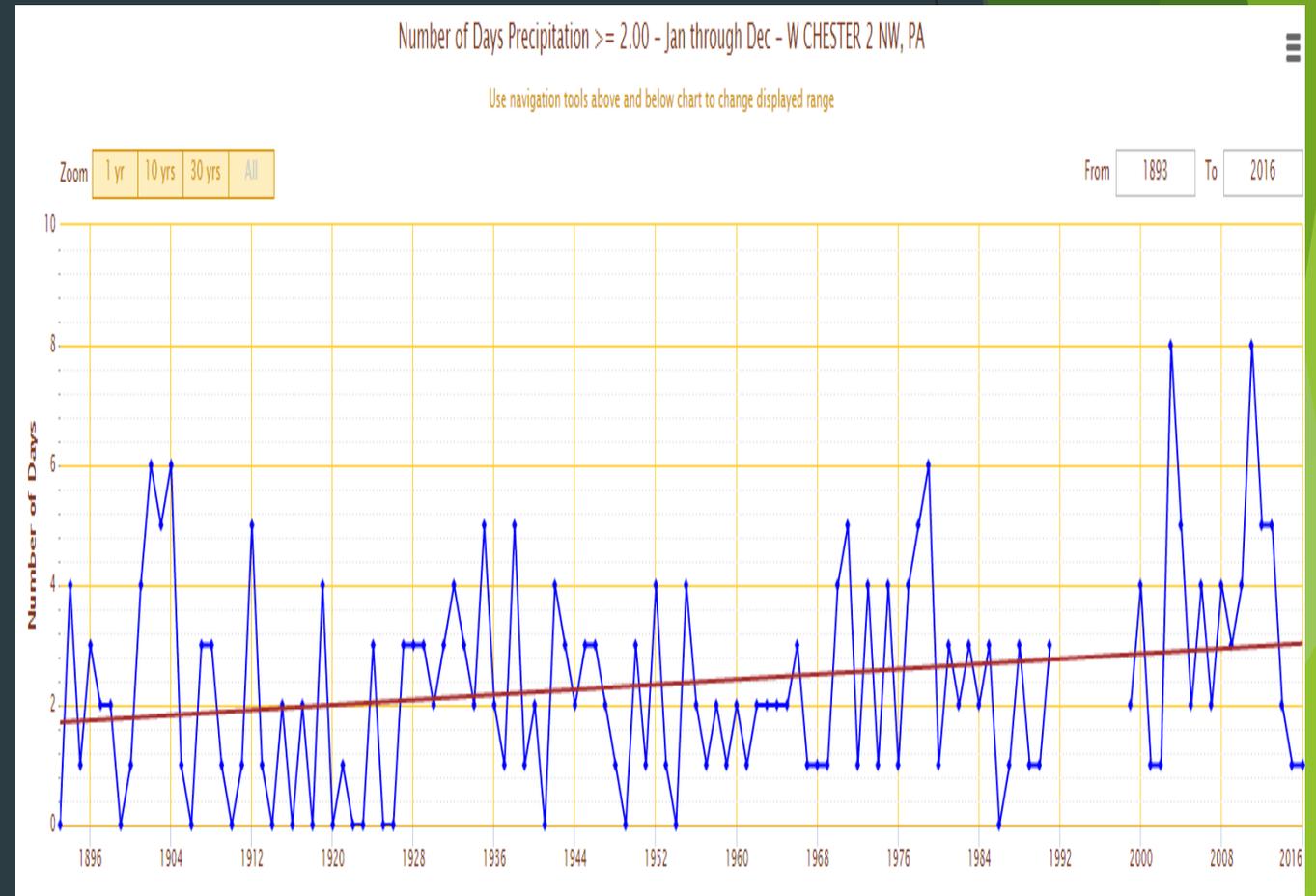
But it is not a crystal clear picture...

- ▶ Number of cold nights in West Chester, PA (when temps dropped to at or below 10 degrees F)
- ▶ Cold nights have increased over the past 125 years



What about extreme precipitation days?

- ▶ In addition to more precipitation over the course of a year, the number of very wet days has increased over the decades
- ▶ Notice that over the past decade or two, West Chester has not had a year in which there were 0 days of ≥ 2.00 " of precipitation



What does this all mean?

- ▶ The climate is changing - and the climate is always changing
- ▶ While the scientific consensus is that temperatures will generally rise over the next few decades along with increasing precipitation, how that is distributed across the globe is far from certain
 - ▶ In other words, State College, PA may cool consistently through the next 50 years while Chicago dramatically warms
 - ▶ Bradford, PA may become much wetter while Boise, ID becomes much drier

Global Climate Change and Scientific Communication

Scientific Communication

- ▶ This is a crucial aspect of any discipline, but especially in the sciences
- ▶ This is a problem not just in the climate community but weather forecasting, as well
- ▶ As educators, it is important to emphasize to students that communication is such a critical skill

Climate Change and Uncertainty

- ▶ What do we mean when we say scientific “consensus?”
 - ▶ Does this mean a consensus that the Earth is warming? That the Earth is warming and humans play *some* role in this trend? That the Earth is warming and humans play a larger role than any other influence on the climate? What does consensus even mean (e.g. 75% of scientists, 90% of peer-reviewed research, etc.)
- ▶ When looking at climate change projections - how good are the models?
 - ▶ How to accurately portray uncertainty in the forecast AND communicate this effectively to the public
- ▶ What does global average temperature actually mean to someone living in SE Pennsylvania?
- ▶ How does weather differ from climate? Are they the same?

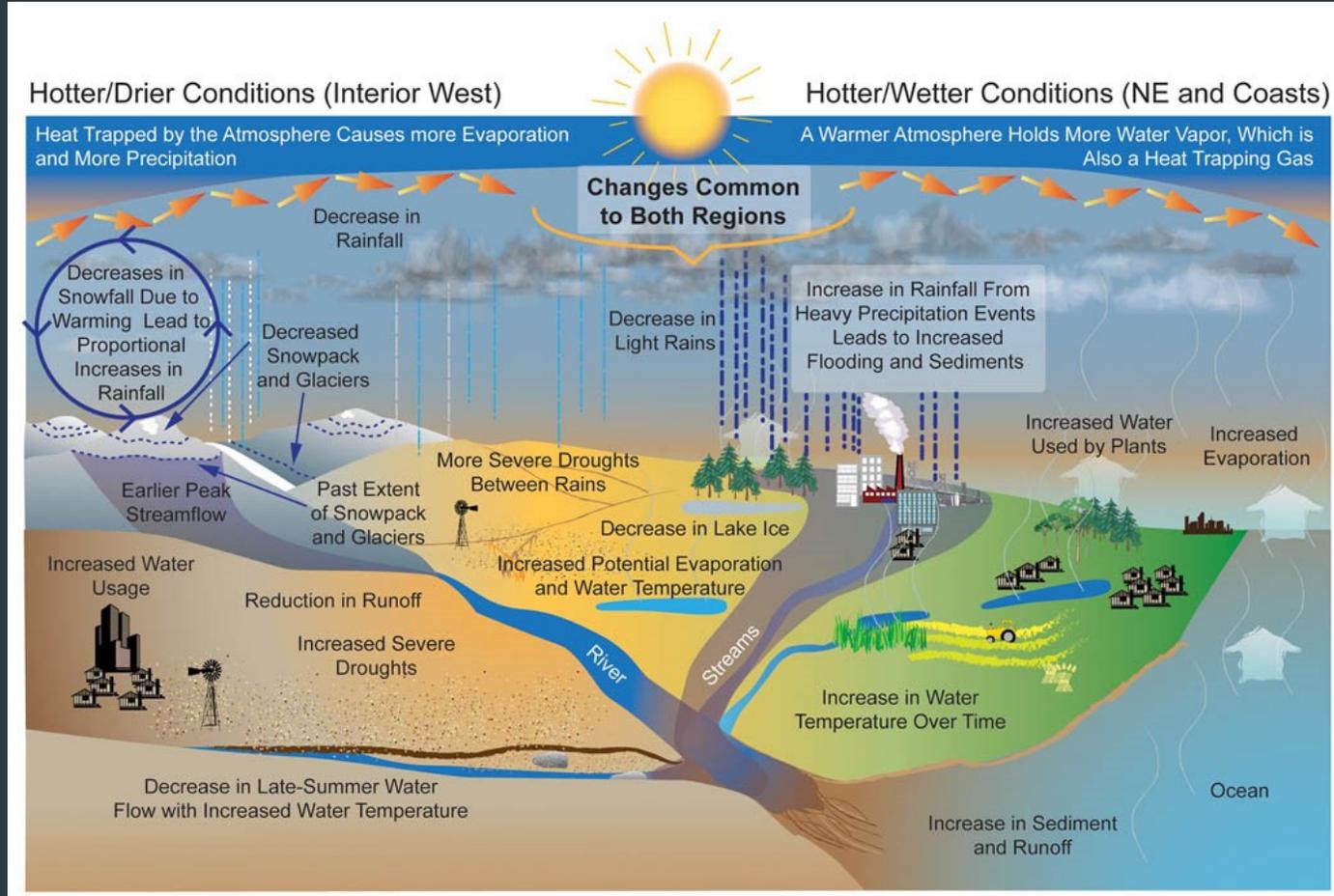
Some things to think about..

- ▶ Climate change will not affect everyone equally at a local level
 - ▶ Some places may even see cooling trends for a period of time
- ▶ It is important to differentiate local weather to global climate trends
 - ▶ For example, the number of wet days or hot days may not always increase in a given location for a period of time - this does not mean the climate is not changing, just that local effects play some role in the local climate
- ▶ Encourage students to analyze datasets for themselves
 - ▶ Critically thinking and analyzing data (especially large datasets) are always important skills for future scientists
 - ▶ Allows them to form conclusions for themselves

Communicate Additional Players in Climate

- ▶ The oceans play a key role in heat distribution
- ▶ Clouds (high, middle, and low) also affect heat distributions
- ▶ Surface reflectivity (snow, ice, forest, desert, etc.) of the Earth plays a role
- ▶ Many other factors, some better understood and quantified, than others are also part of the story

Climate Impacts



Courtesy of: US EPA

References

- ▶ Divisional Data - National Centers for Environmental Information Climate-At-A-Glance: <https://www.ncdc.noaa.gov/cag/>
- ▶ Station Data - Applied Climate Information System - <http://scacis.rcc-acis.org/>
- ▶ Climate Impacts Imagery: <https://www.epa.gov/climate-impacts/climate-impacts-water-resources>

Questions