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hosted by the Maryland Water Resources Research Center
at the University of Maryland, College Park
on Tuesday, Nov. 15, 2011

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2011 Maryland Water Resources Symposium,
"Rising Waters: Maryland Prepares for Floods and Sea Level Rise"

MARYLAND'S CLIMATE: VARIABILITY AND CHANGE

Dr. Konstantin Vinnikov, Acting State Climatologist for Maryland

University of Maryland at College Park, MD

Stamp Student Union, University of MD at College Park, November 15, 2011

MARYLAND --

WEATHER SERVICE

VOLUME ONE

BALTIMORE
THE JOHNS HOPKINS PRESS
1899

MARYLAND–

WEATHER SERVICE

VOLUME TWO

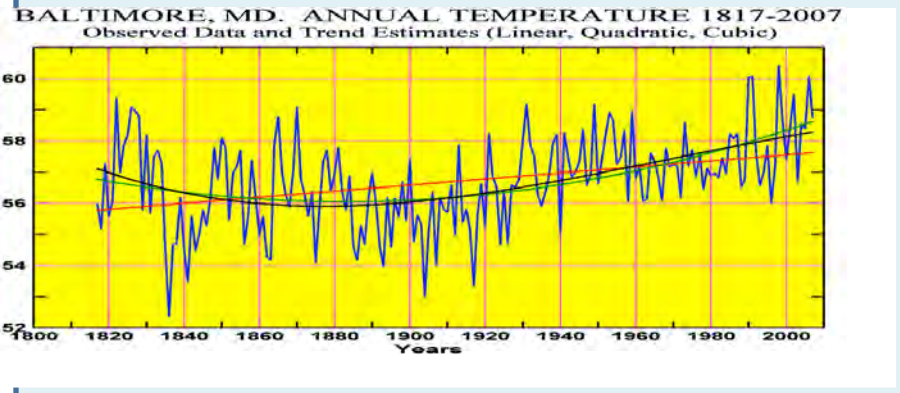
BALTIMORE
THE JOHNS HOPKINS PRESS
1907

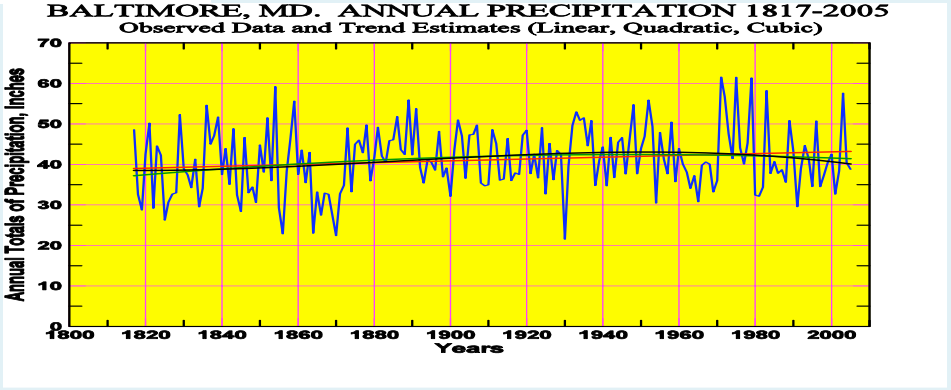
MARYLAND

WEATHER SERVICE

VOLUME THREE

BALTIMORE
THE JOHNS HOPKINS PRESS
1916.





Maryland and Vicinity:
Observed Daily T_{max} & T_{min} are Available for More than 95 yr.
Stations Map

DATA SOURCES

1. NCDC:

1.1. USHCN Version 2, Adjustments by *Menne and Williams (2010)*

1.2. STATEWIDE AVERAGES OF TEMPERATURE AND PRECIPITATION, USHCN v2 data, AVERAGING by *Vose (2010)*

2. GFDL:

2.1. GFDL CM2.1 CLIMATE MODEL, 20C3M and SRESA1B FORCING, THREE ENSEMBLE RUNS (VARIABLES: TEMPERATURE AND PRECIPITATION)

3. USGS:

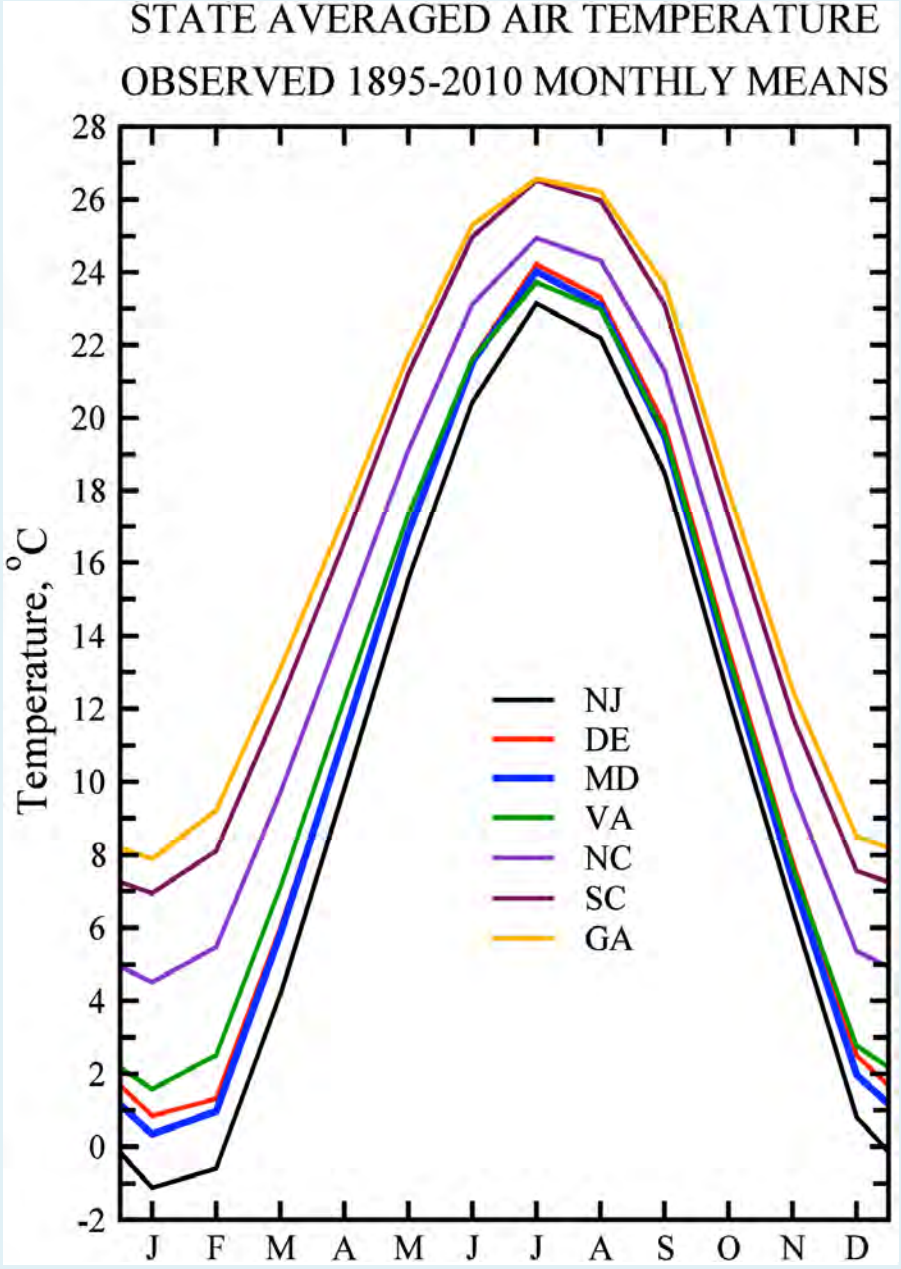
3.1. MONTHLY RIVERS DISCHARGE TIME SERIES

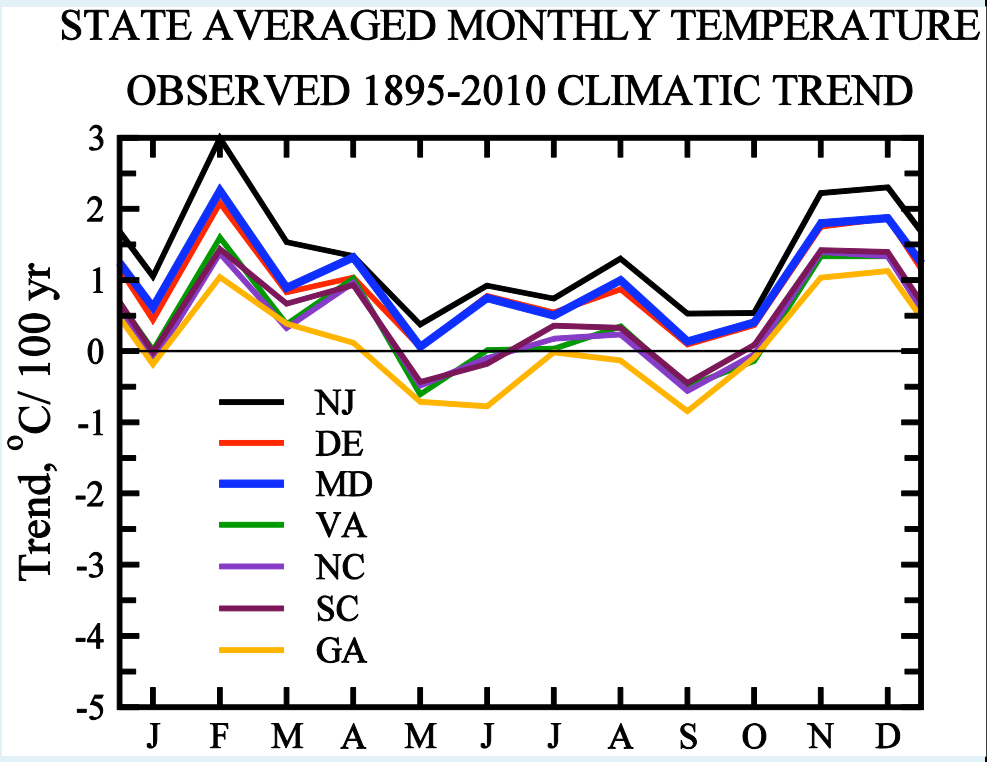
GLOBAL WARMING SIGNATURE IN CLIMATIC RECORDS:

. Warming trend	**(YES)**
. Polar amplification	**(YES in Arctic, NO in Antarctic)**
. Winter amplification	**(YES)**
. Diurnal asymmetry	**(?)**
. Increasing of precipitation	**(Seasonal)**
. Summer desiccation	**(?)**

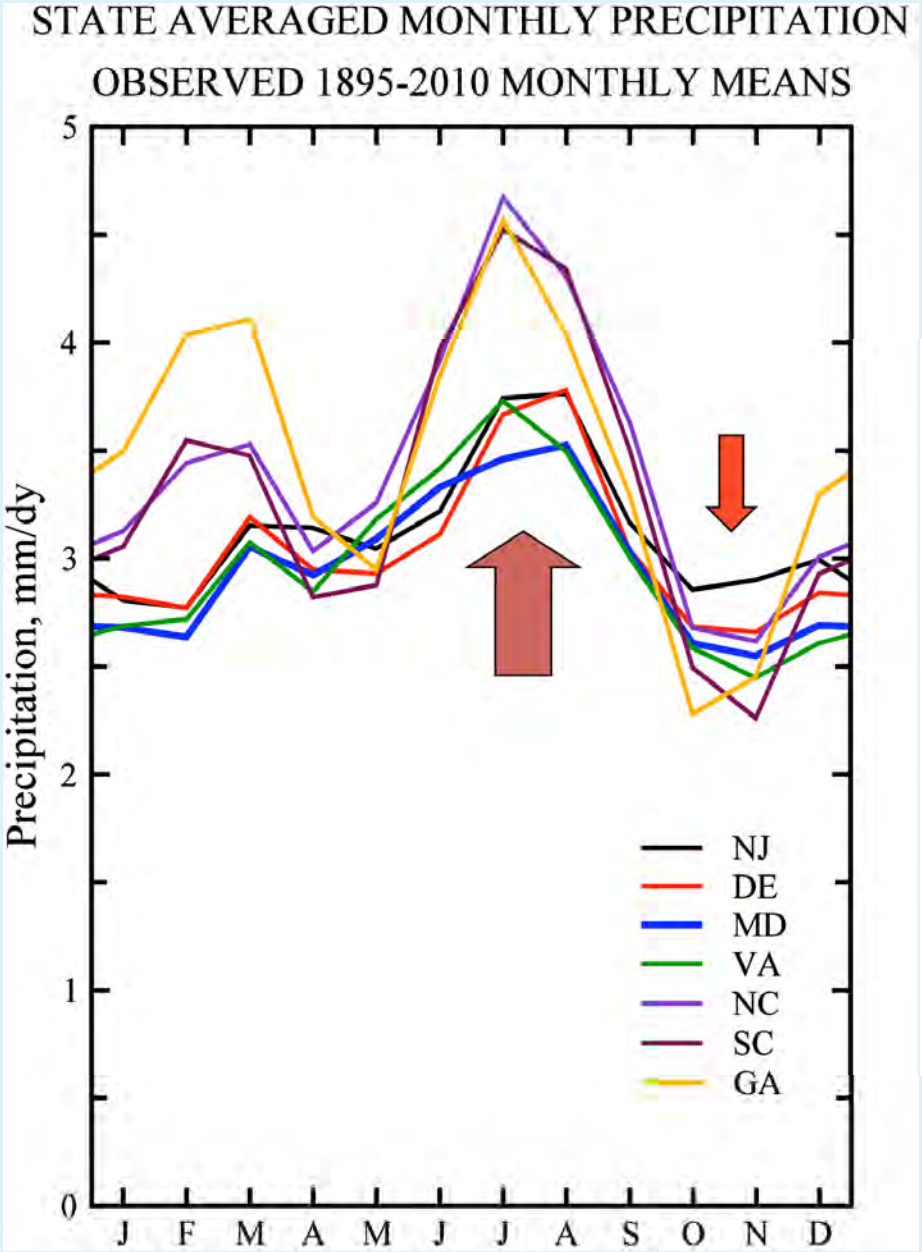
East Coast States:

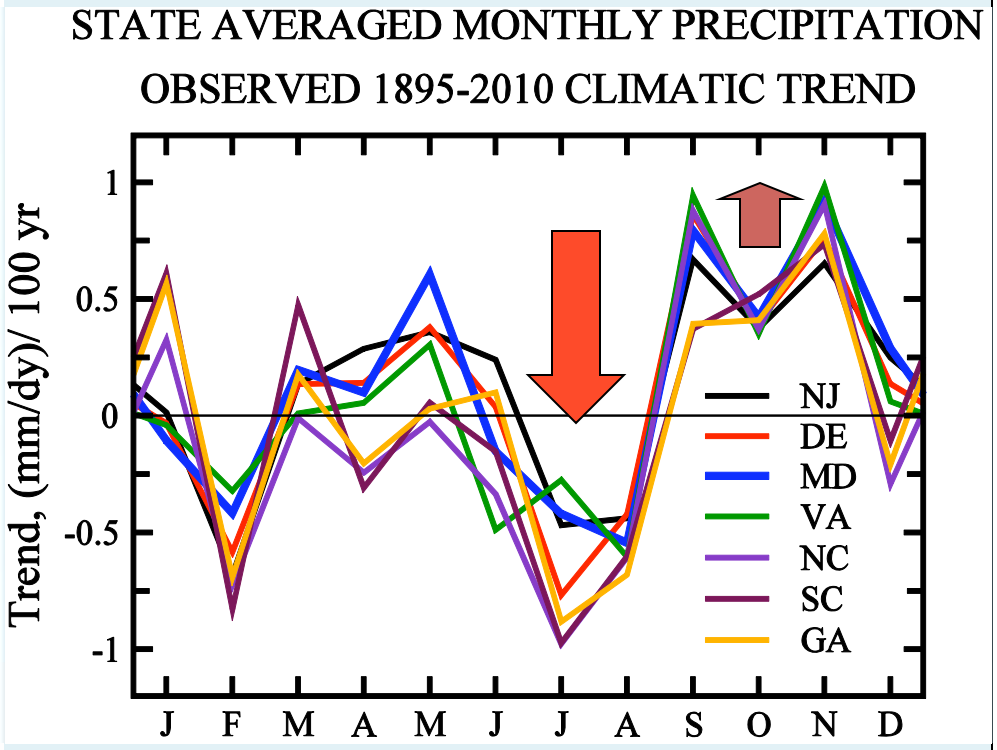
Observed Seasonal Variation of Mean Air Temperature and Trend



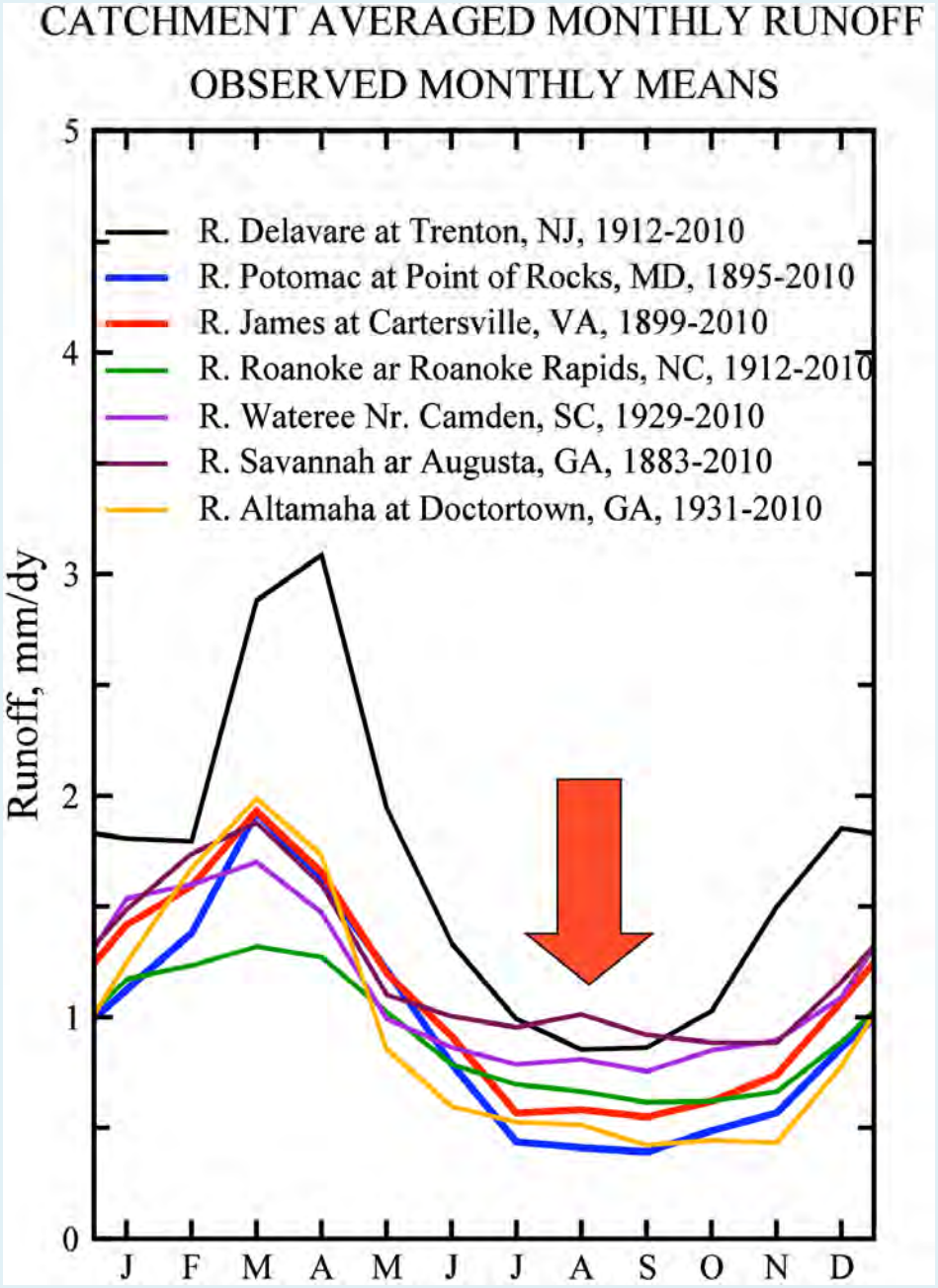


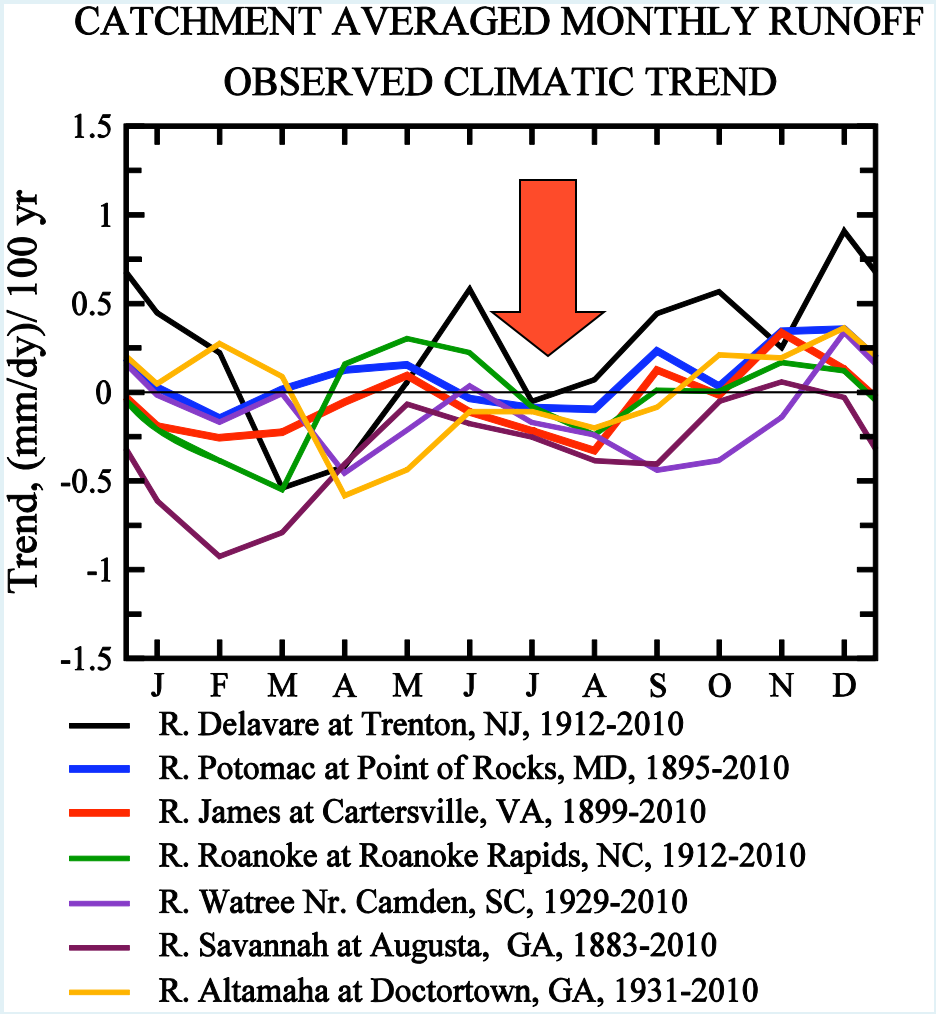
East Coast States: Observed Seasonal Variation of Mean Precipitation and Trend

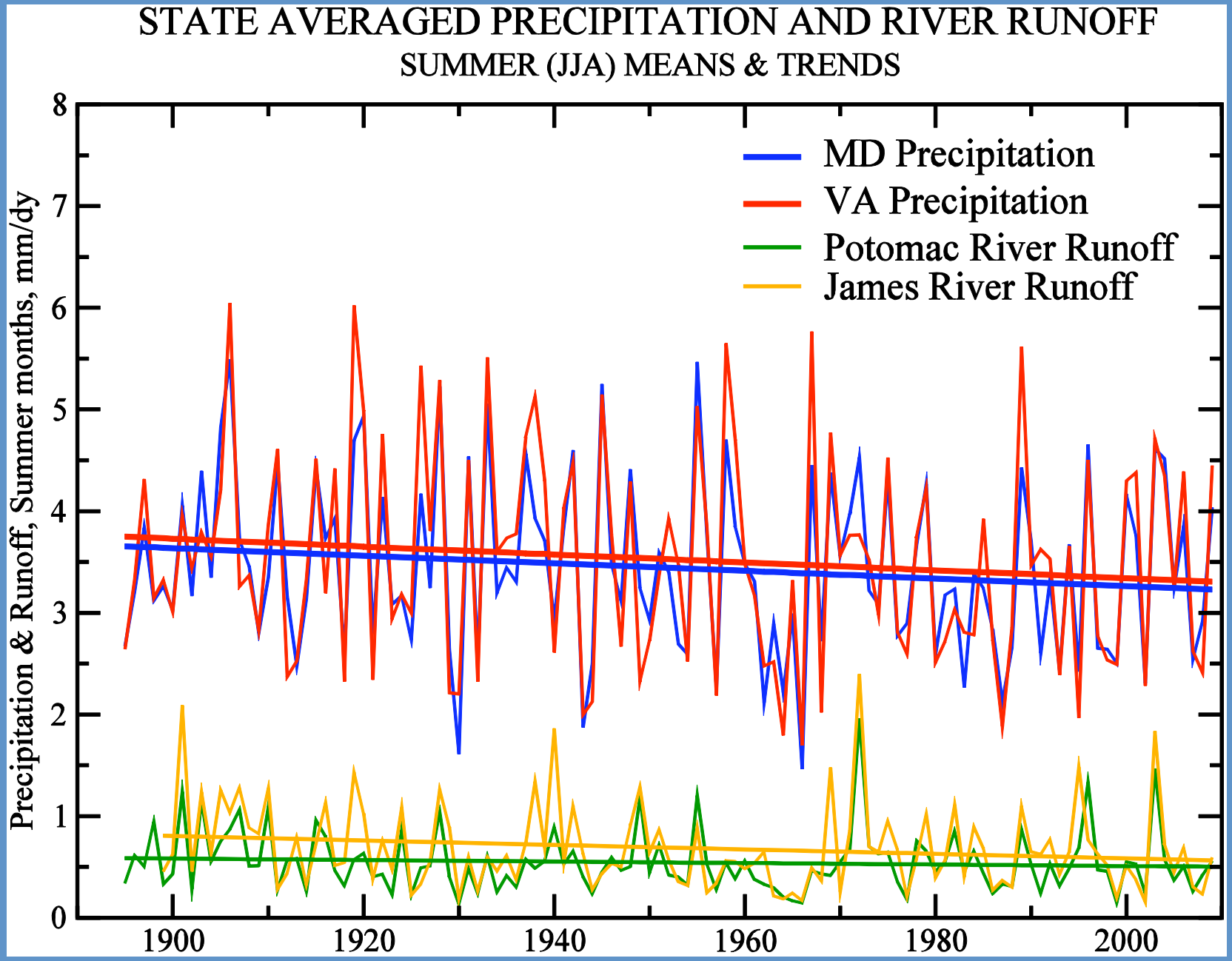


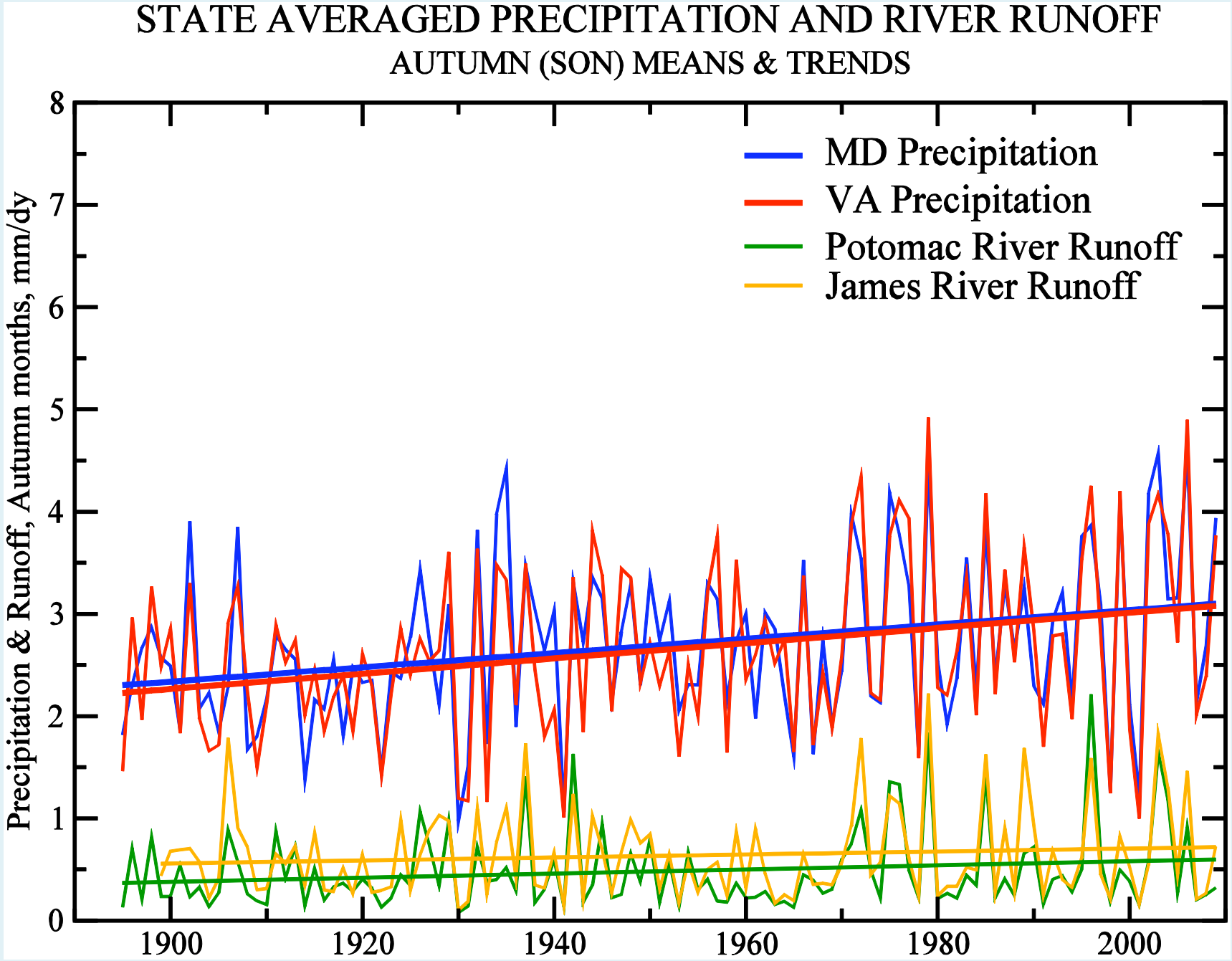


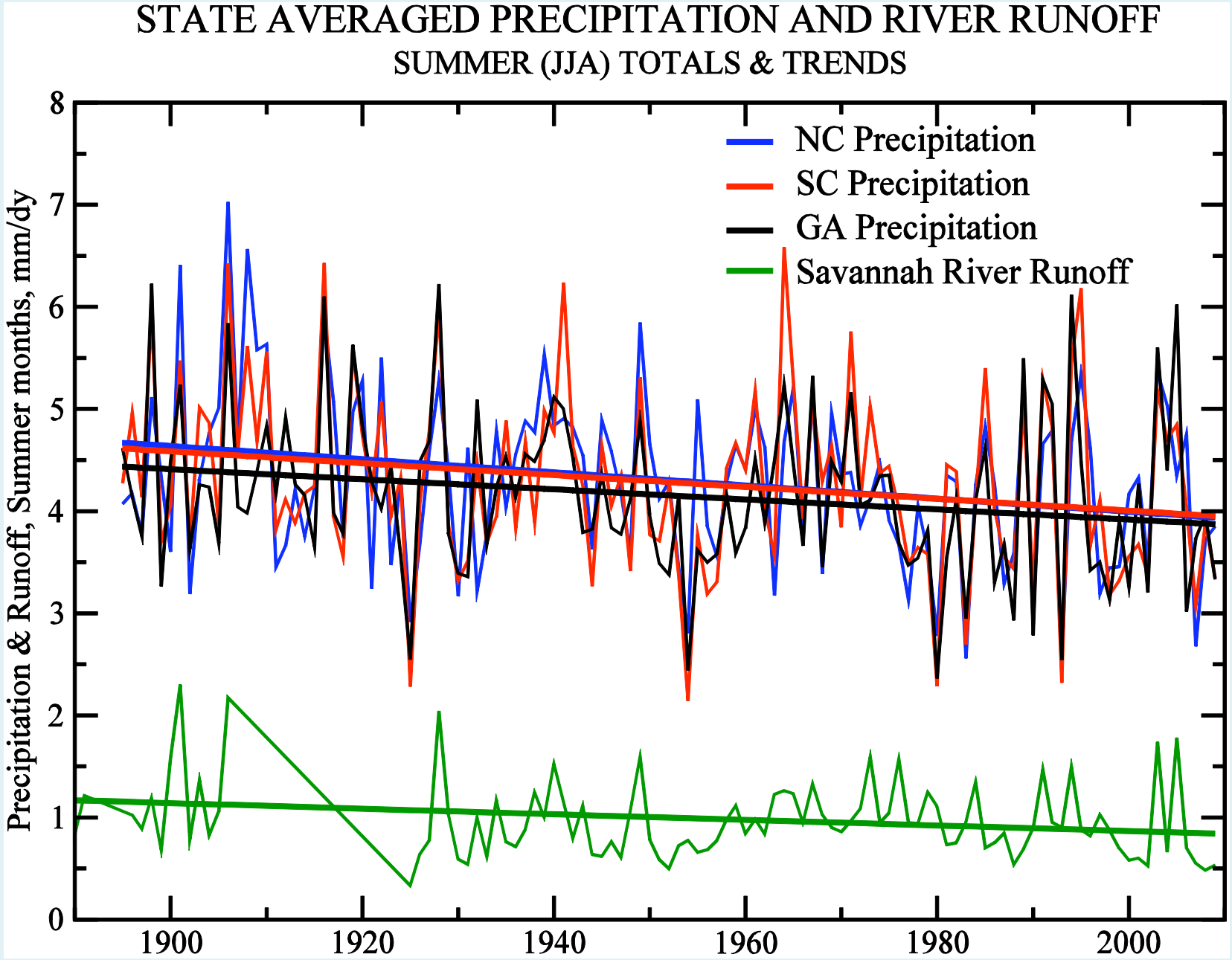
East Coast Rivers: Observed Seasonal Variations of Runoff and Trend

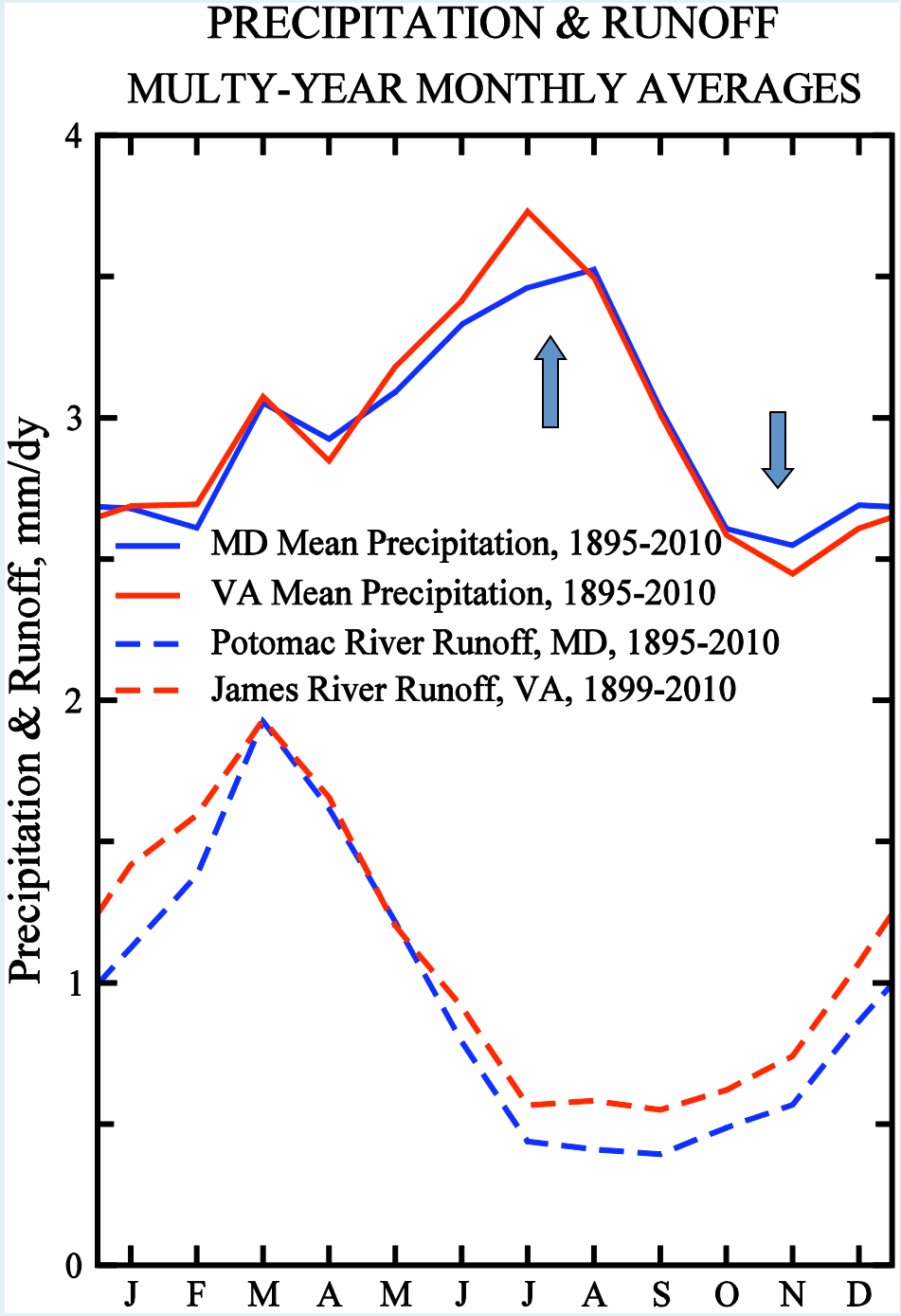





STATE AVERAGED PRECIPITATION AND RIVER RUNOFF
SUMMER (JJA) MEANS & TRENDS
Precipitation & Runoff, Summer months, mm/dy
MD Precipitation
VA Precipitation
Potomac River Runoff
James River Runoff
0
1
2
3
4
5
6
7
8
1900
1920
1940
1960
1980
2000


STATE AVERAGED PRECIPITATION AND RIVER RUNOFF
AUTUMN (SON) MEANS & TRENDS
Precipitation & Runoff, Autumn months, mm/dy
0
1
2
3
4
5
6
7
8
1900
1920
1940
1960
1980
2000
MD Precipitation
VA Precipitation
Potomac River Runoff
James River Runoff

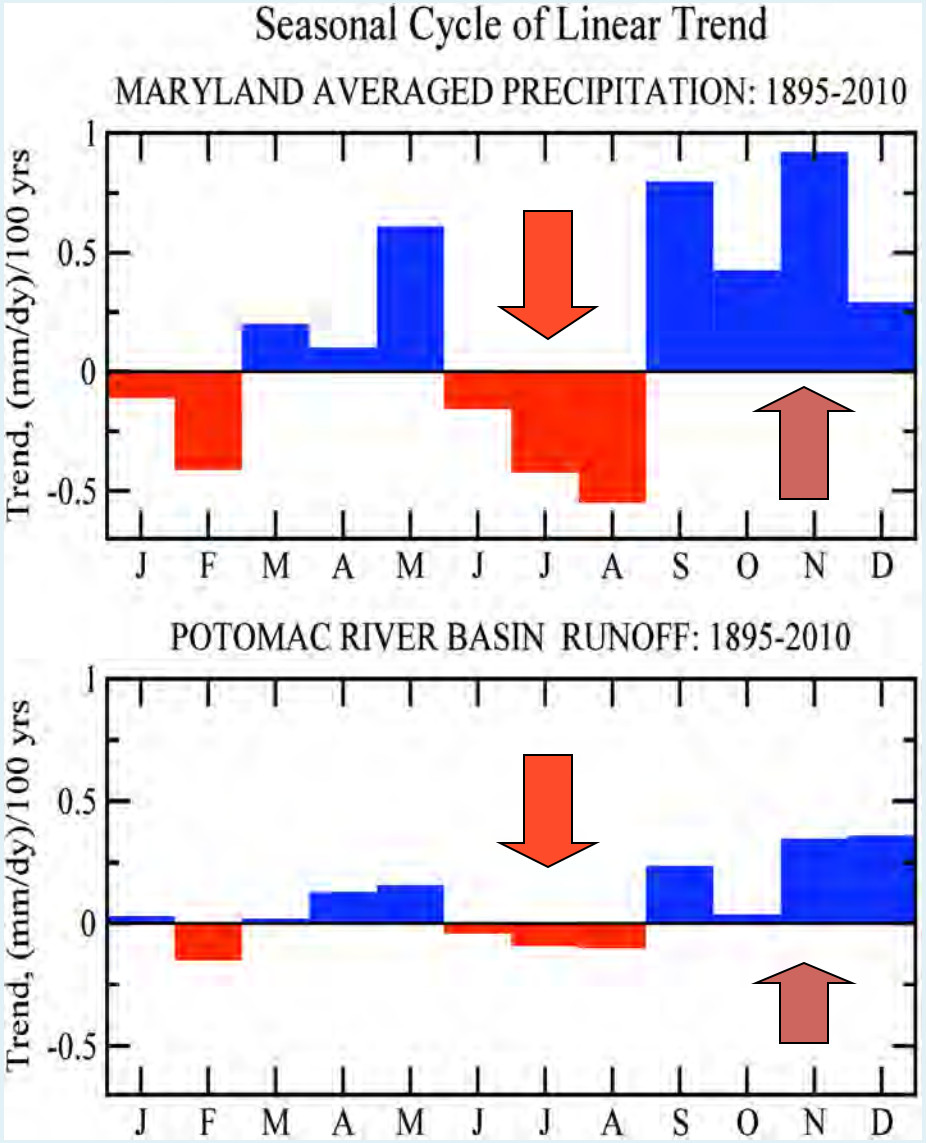

STATE AVERAGED PRECIPITATION AND RIVER RUNOFF
SUMMER (JJA) TOTALS & TRENDS
Precipitation & Runoff, Summer months, mm/dy
NC Precipitation
SC Precipitation
GA Precipitation
Savannah River Runoff
0
1
2
3
4
5
6
7
8
1900
1920
1940
1960
1980
2000

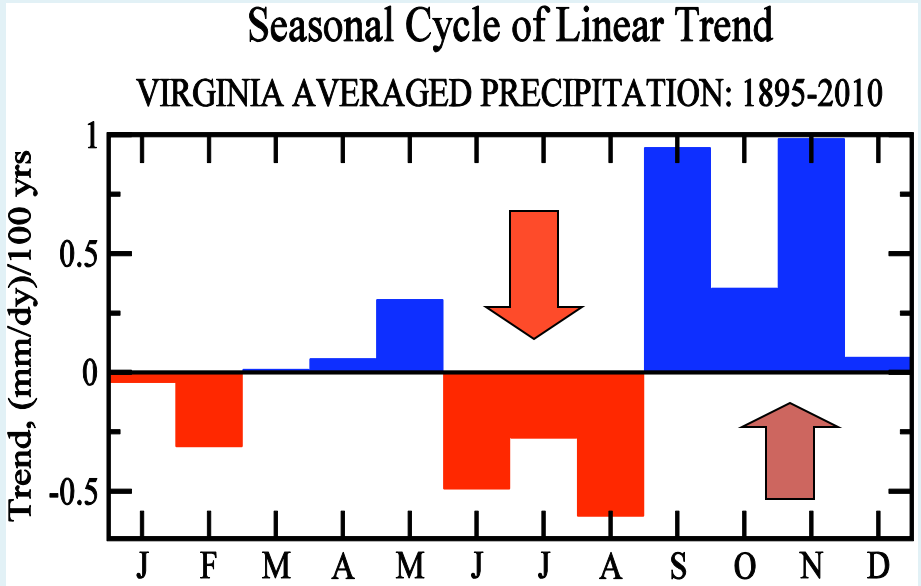


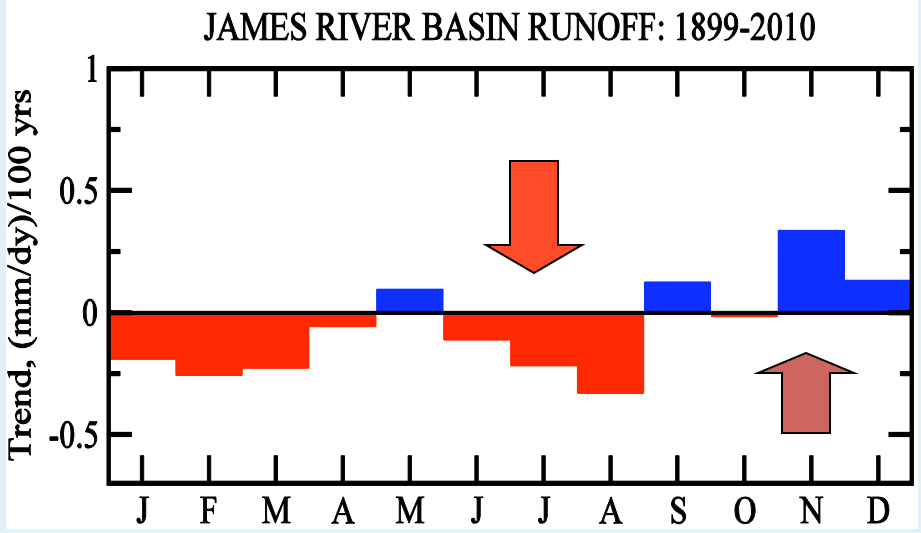
Annual Cycle of Precipitation at MD and VA has MAX in the Summer and MIN in the Autumn.

This makes our climate so nice.

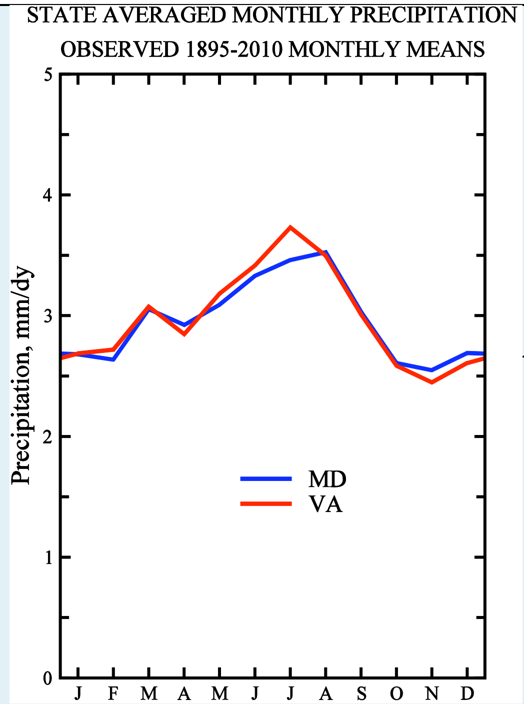
The most important observed century scale climatic trends at Maryland and Virginia





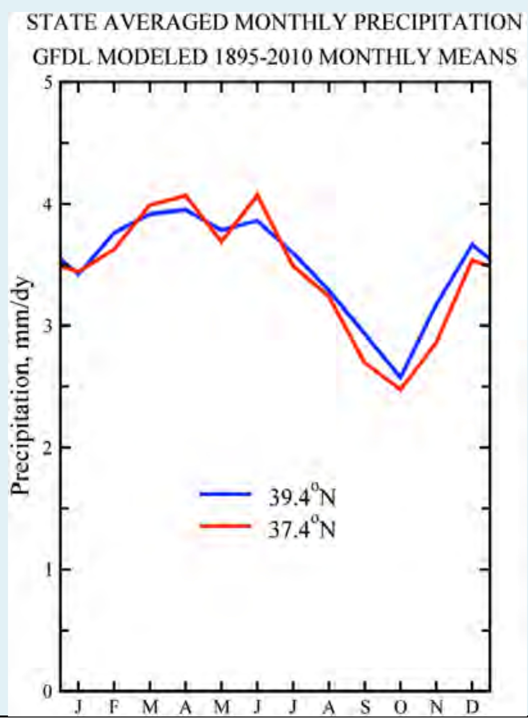


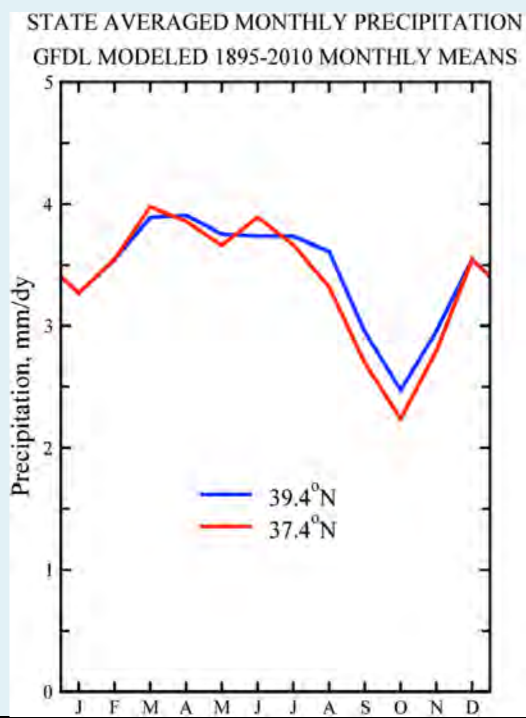
How well climatic models simulate seasonal variation of atmospheric precipitation?

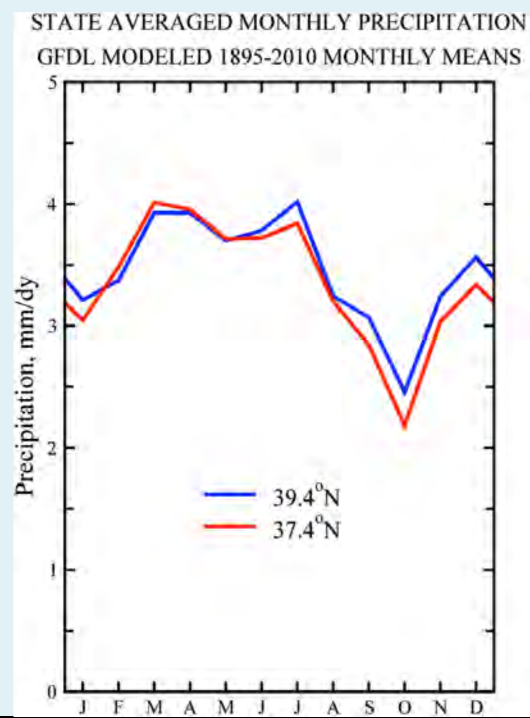


OBSERVED

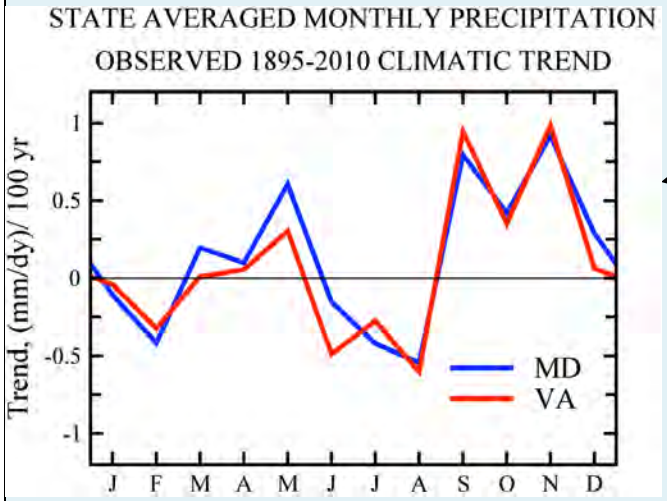
MODEL SIMULATIONS





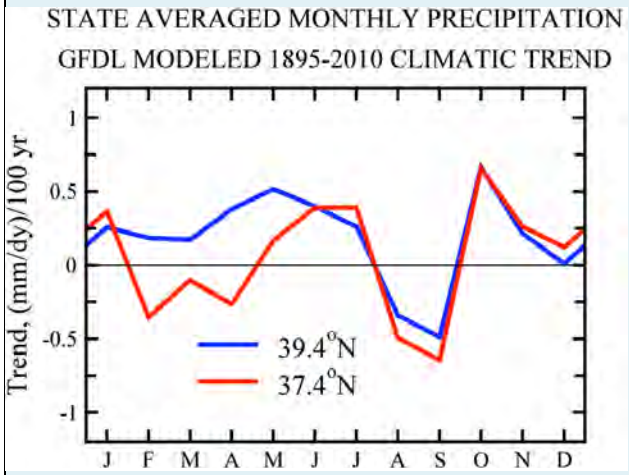


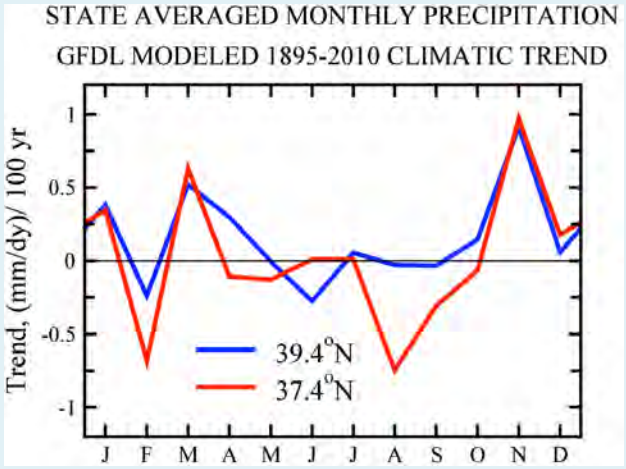
How well models reproduce observed 1895-2010 climatic trends in precipitation?

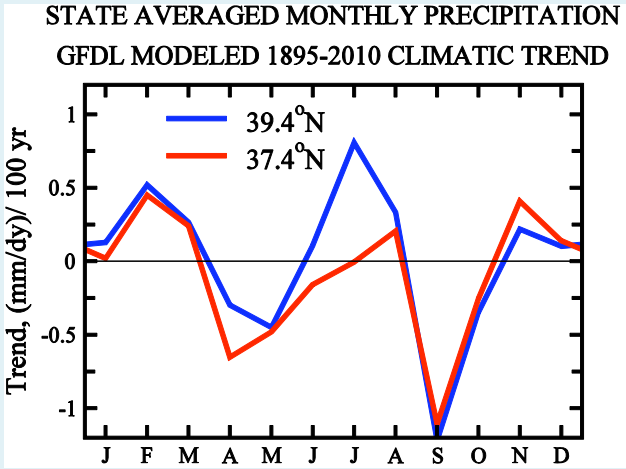


Observed trends

Trends in model simulated climate variations

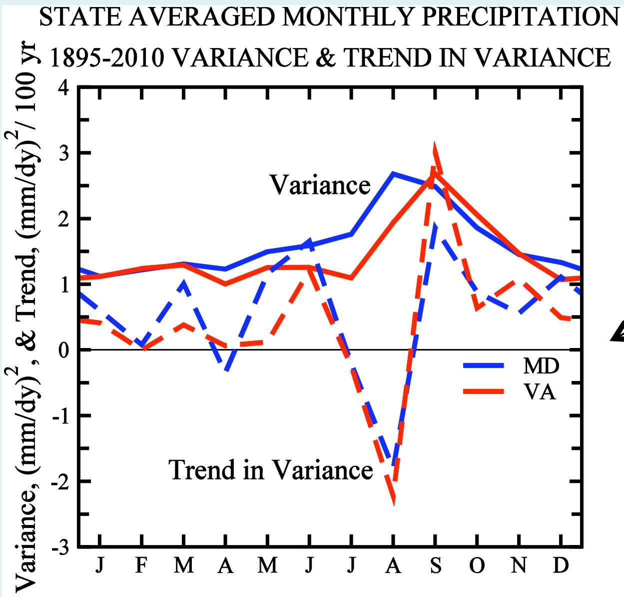




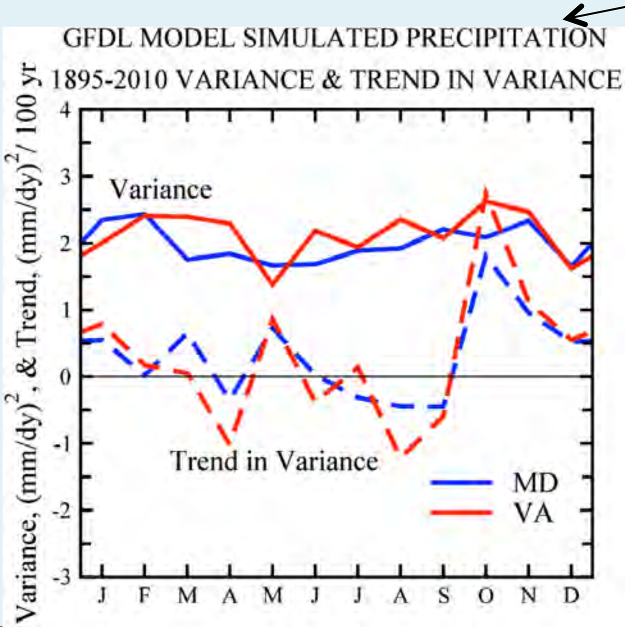


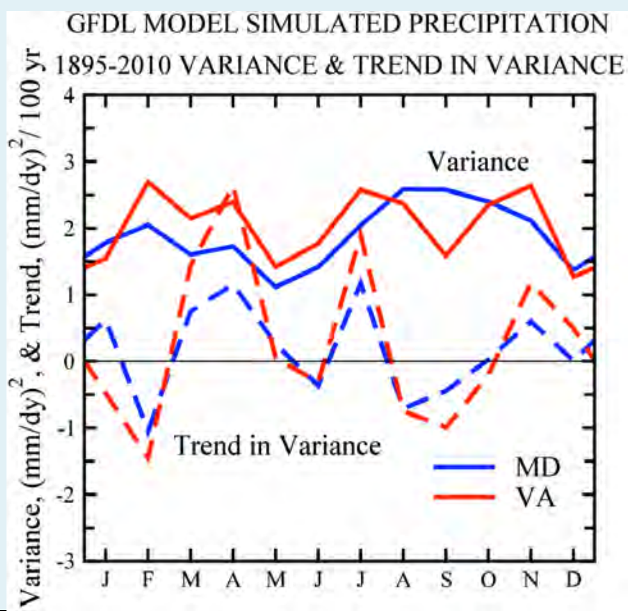
How well models reproduce 1895-2010 precipitation variance and its trend?

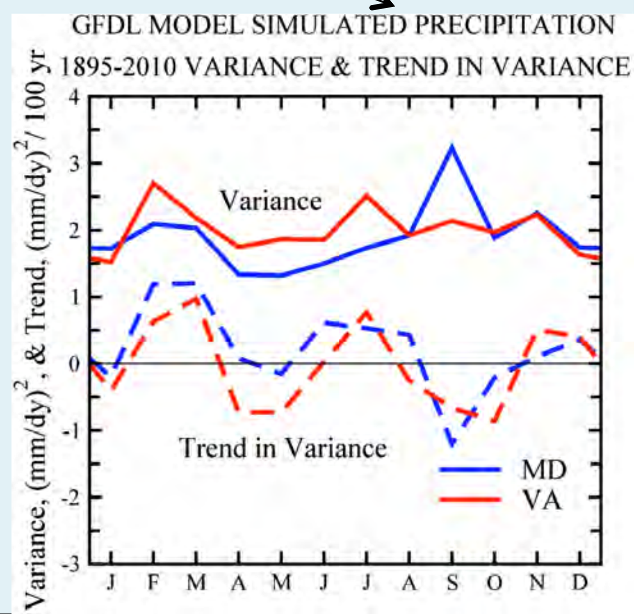
Observed variance and trend in variance



Variance and variance trend in model simulated precipitation

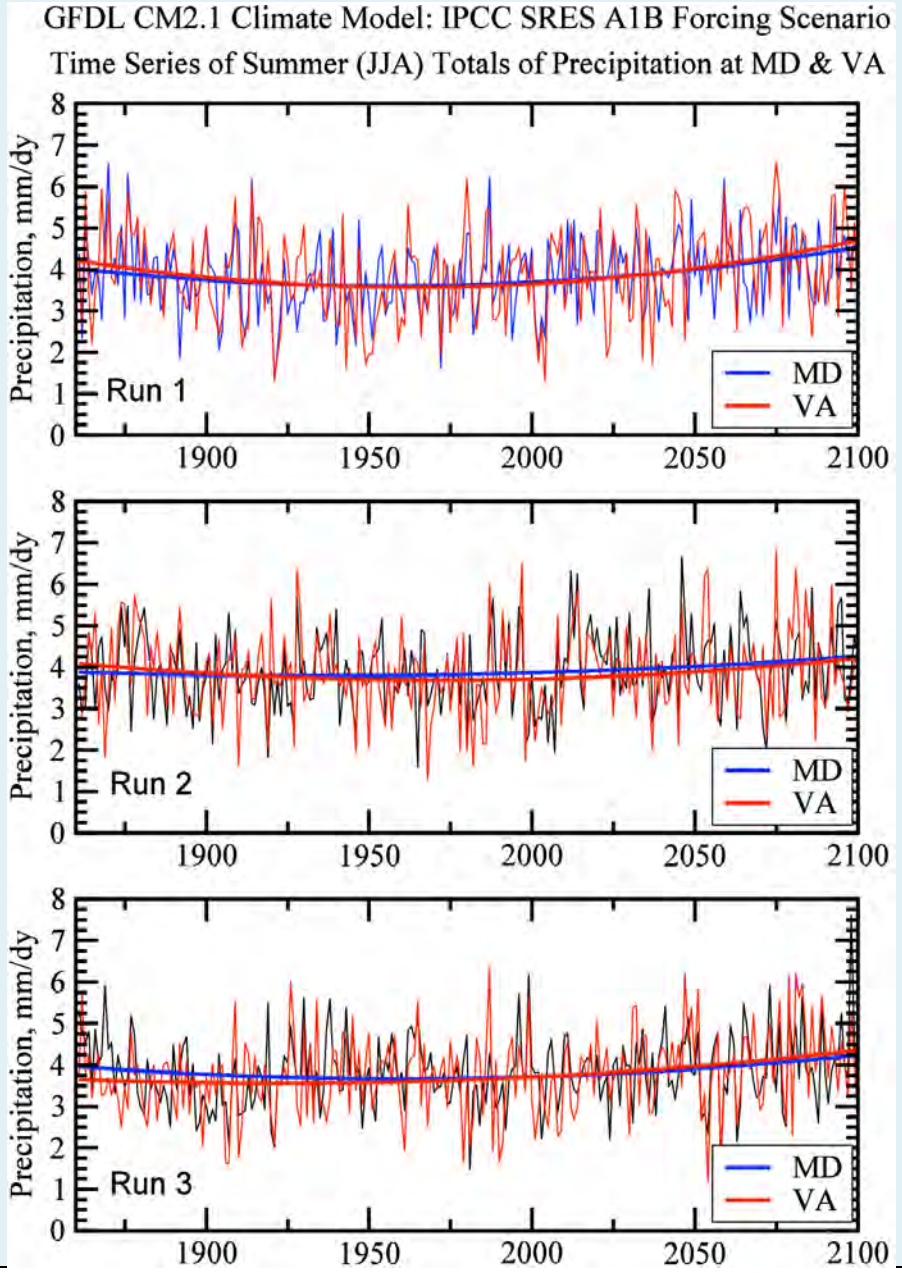




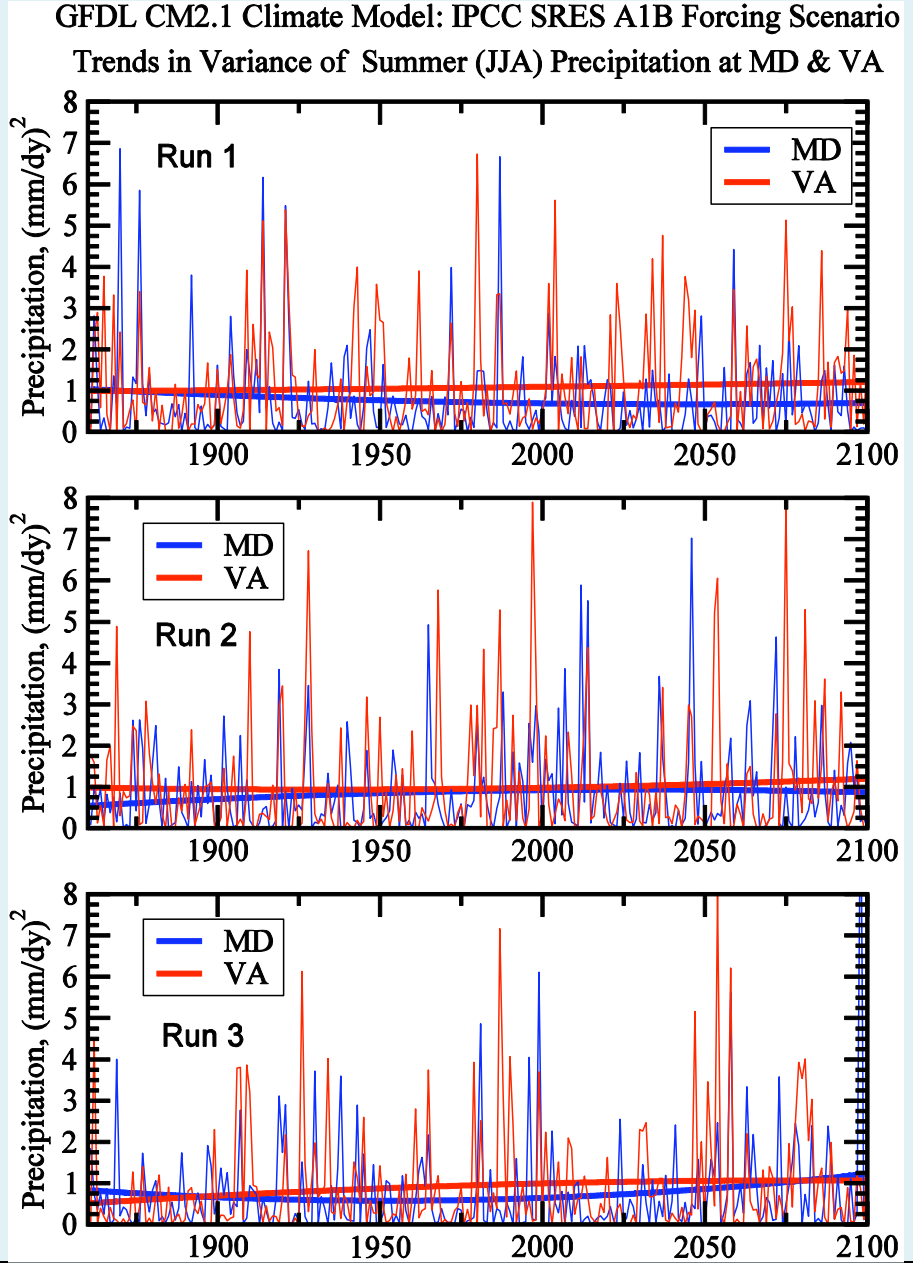


How well climatic models simulate future MD climate change and variability?

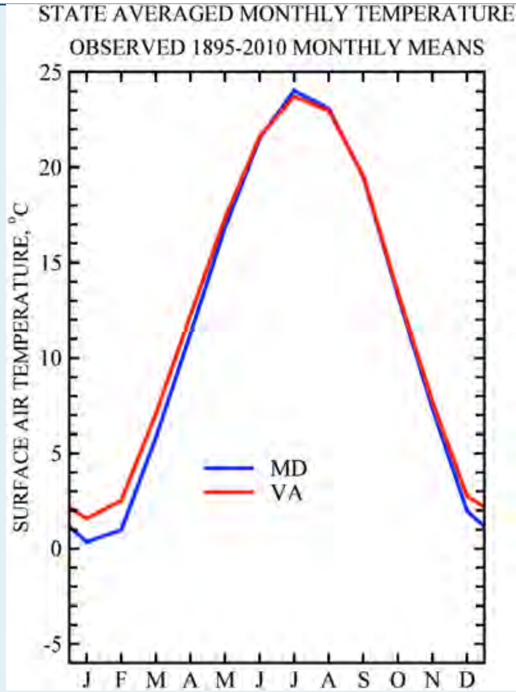
SUMMER



SUMMER

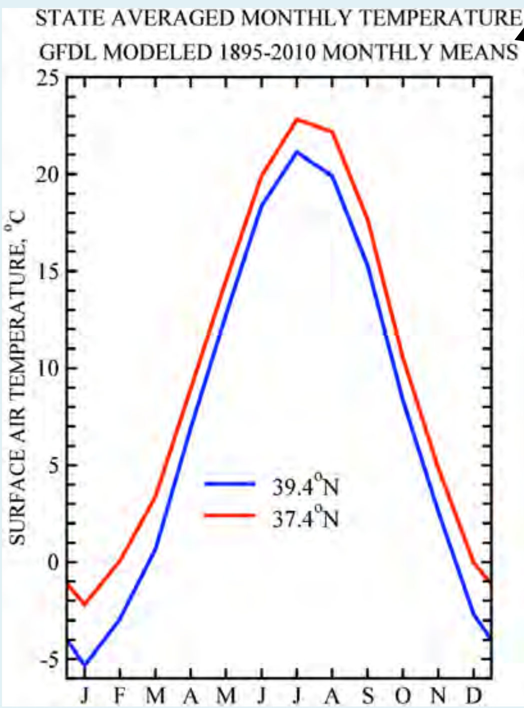


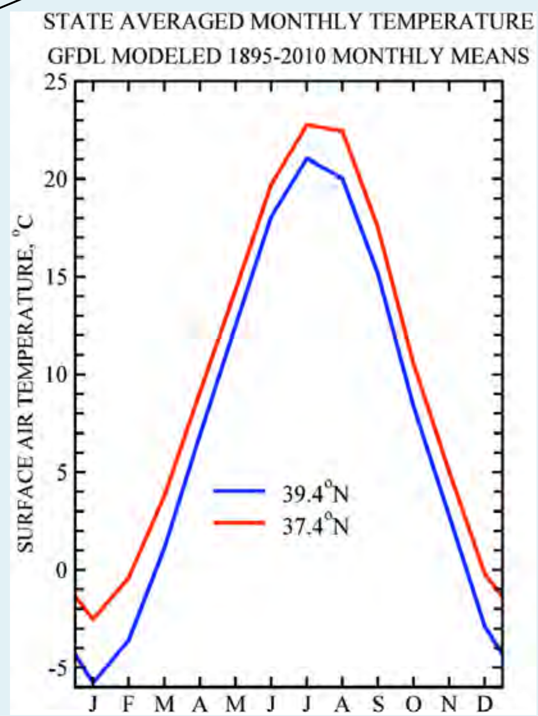
How well climatic models simulate seasonal variation of Surface Air Temperature?

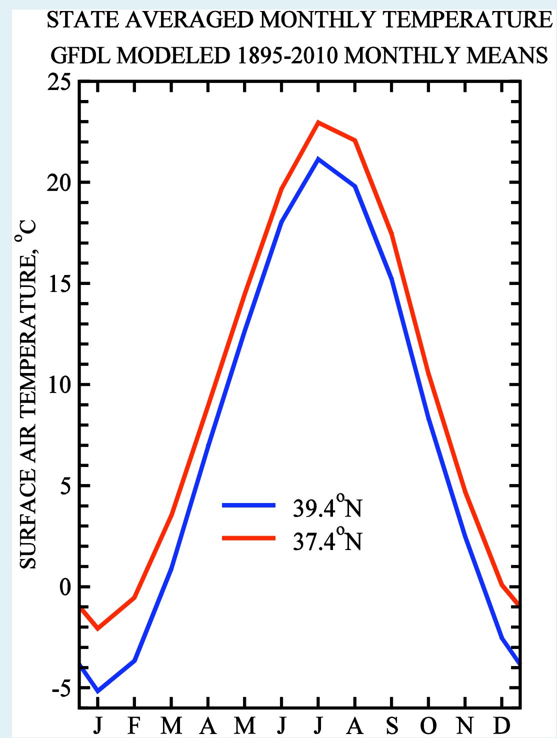


Observed

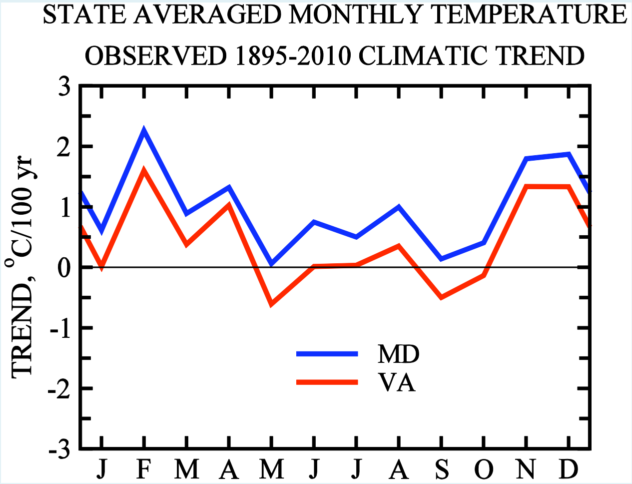
Model simulated





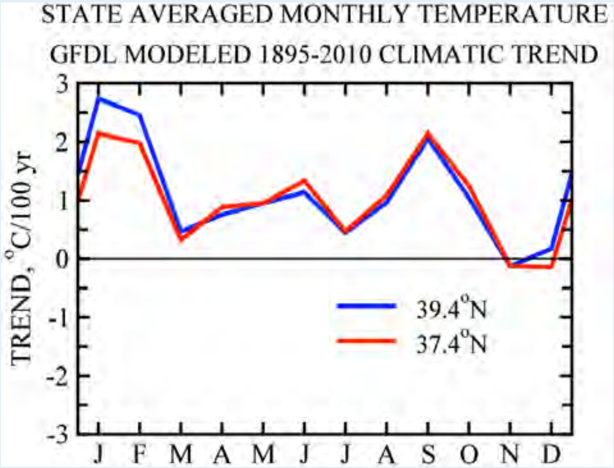


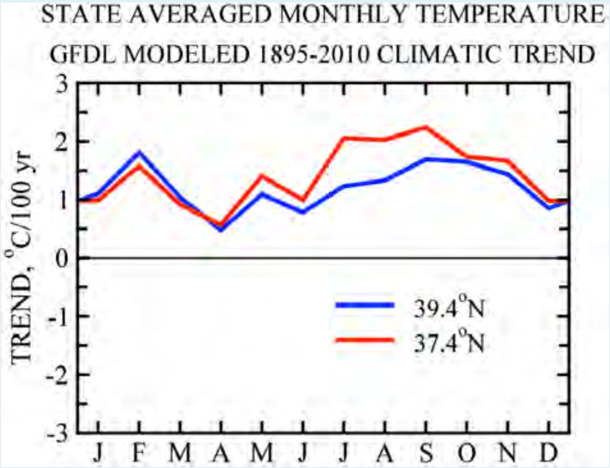
How well models reproduce observed 1895-2010 climatic trends in Temperature?

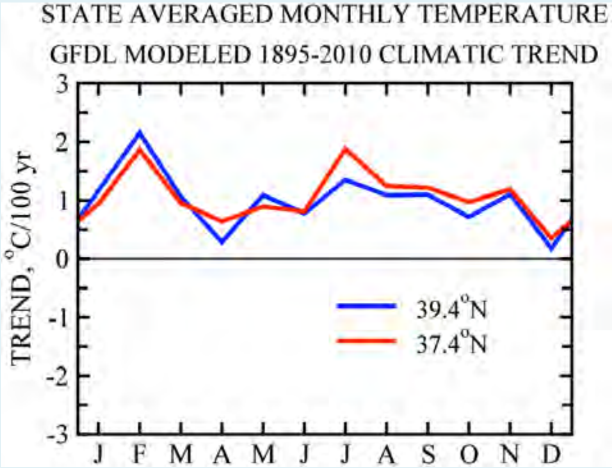


Observed trends

Trends in model simulated temperature variation

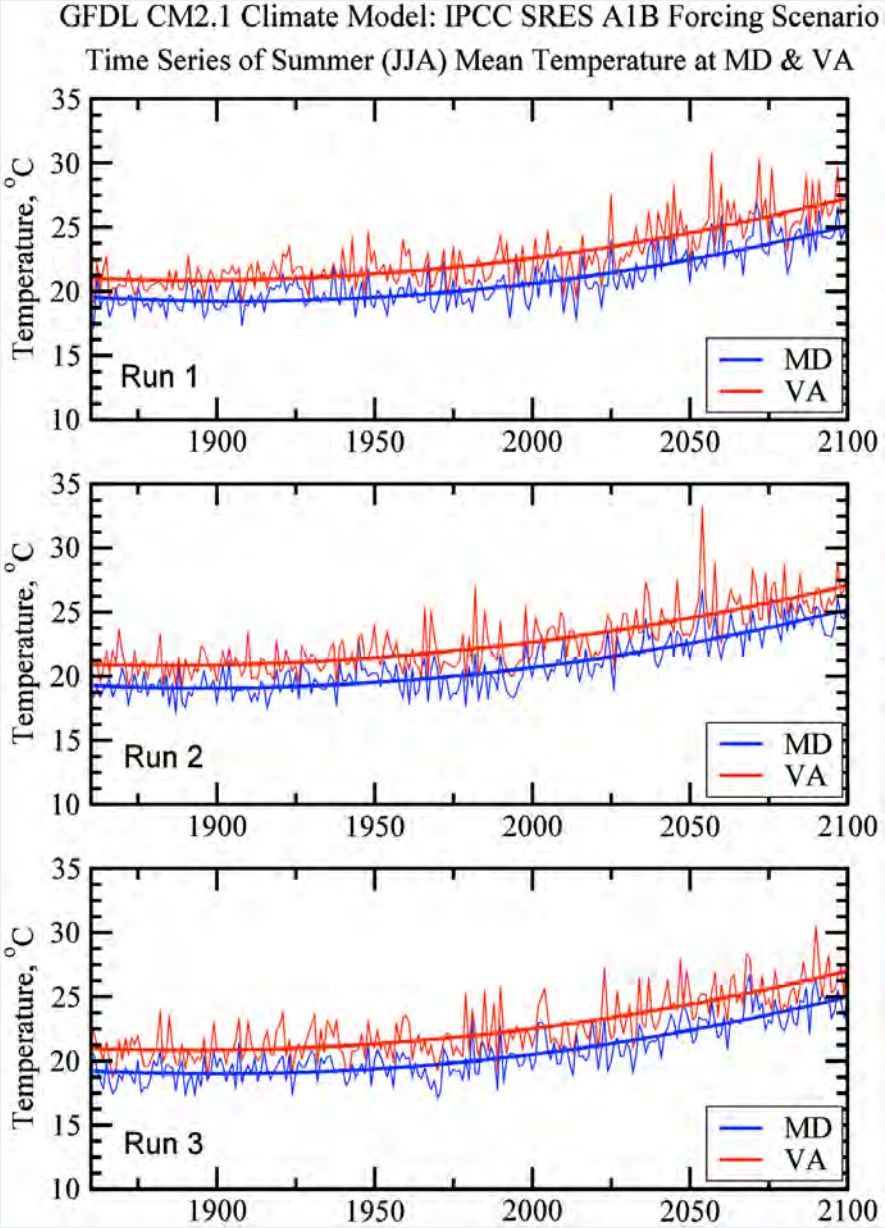




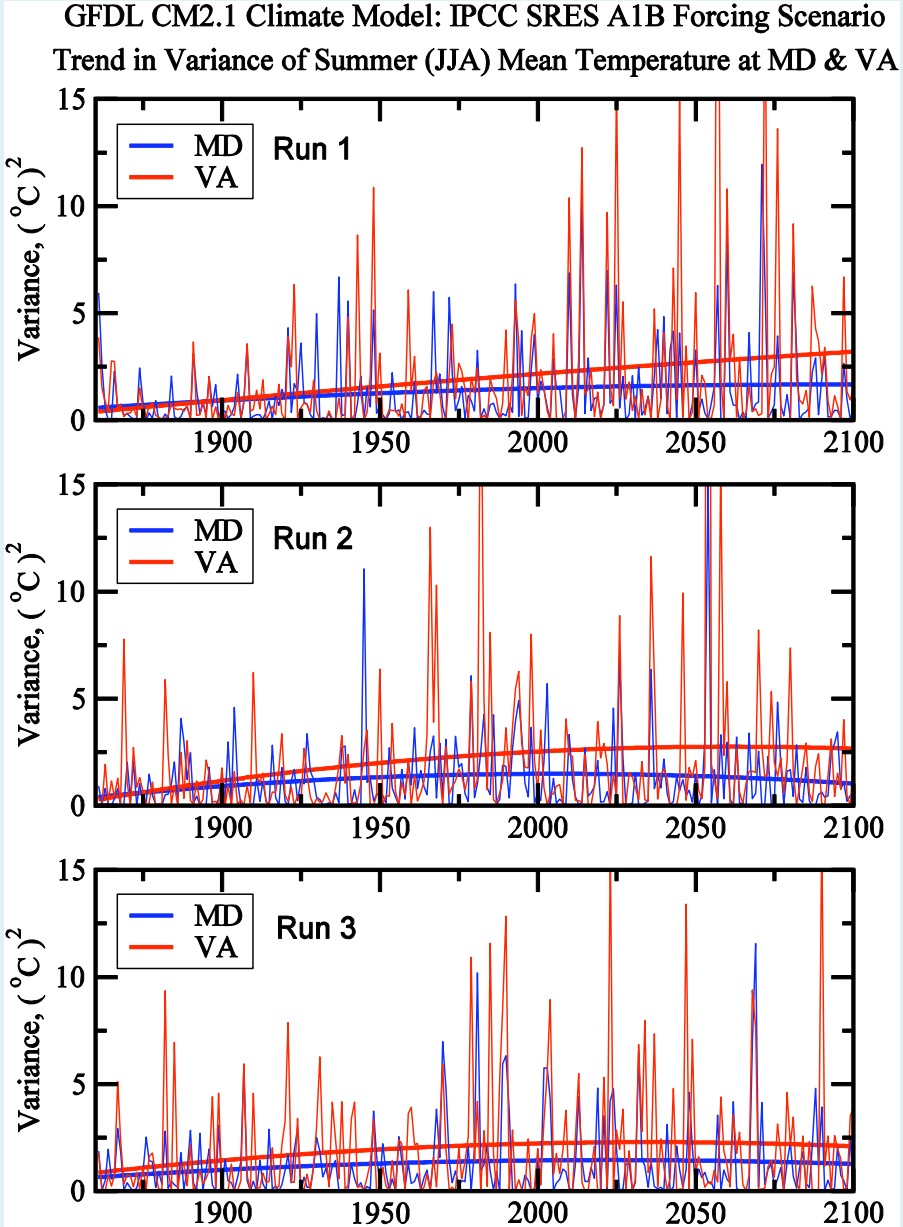


How well climatic models simulate future MD climate change and variability?

SUMMER

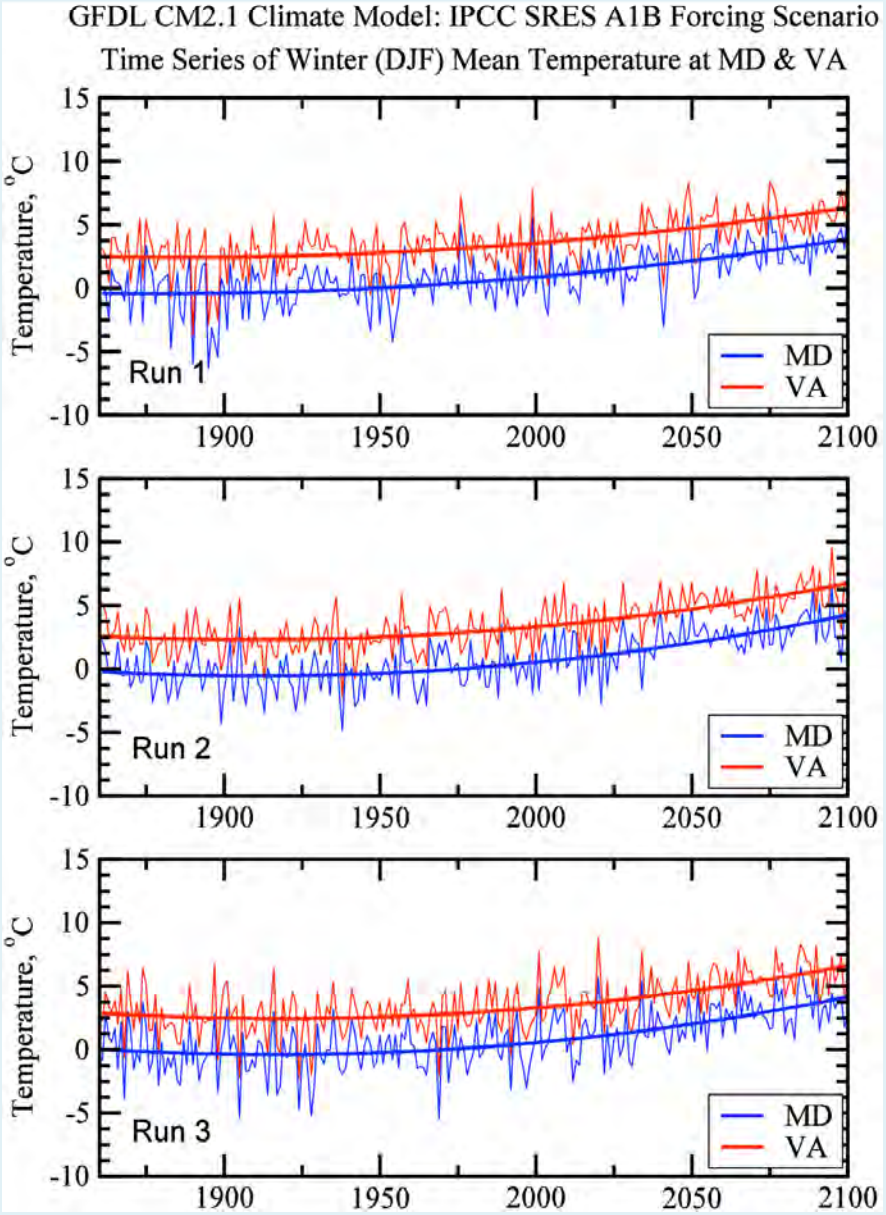


SUMMER

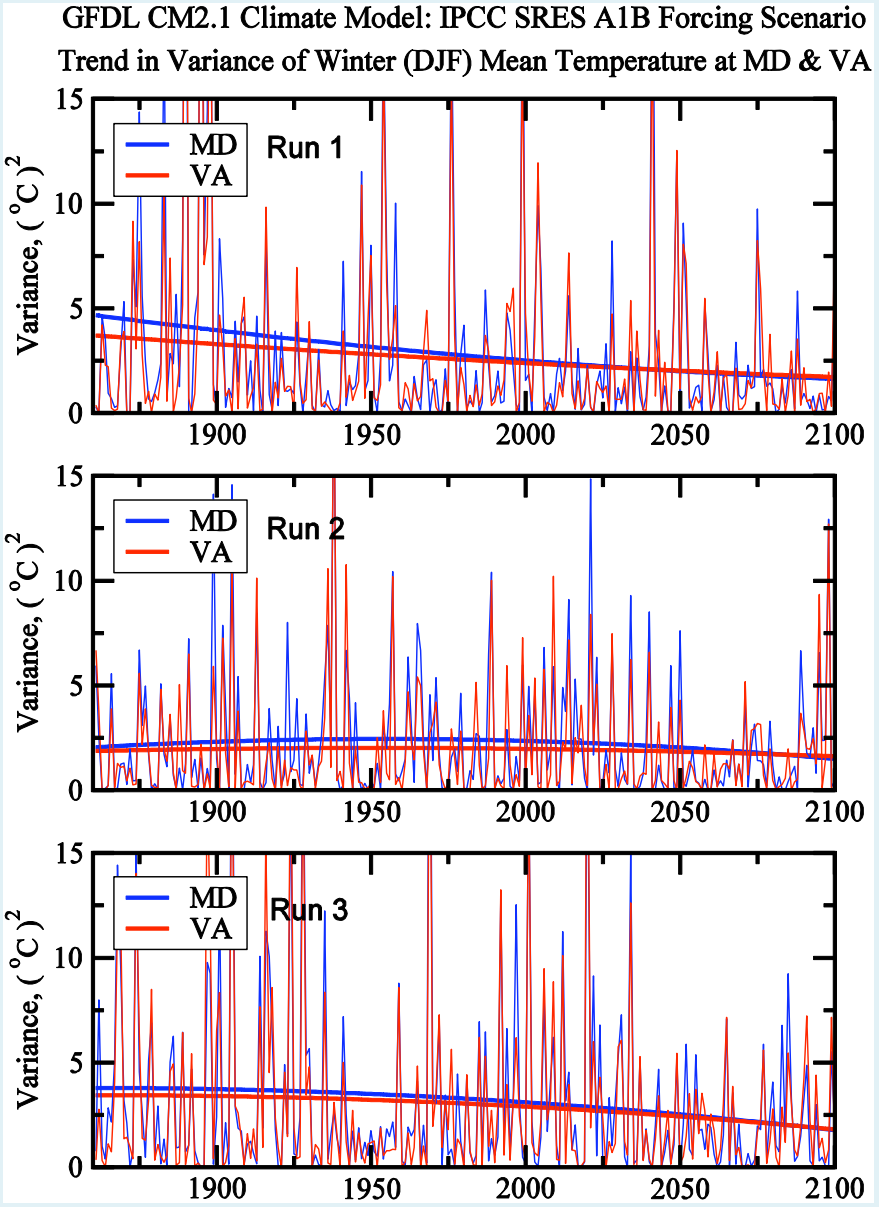


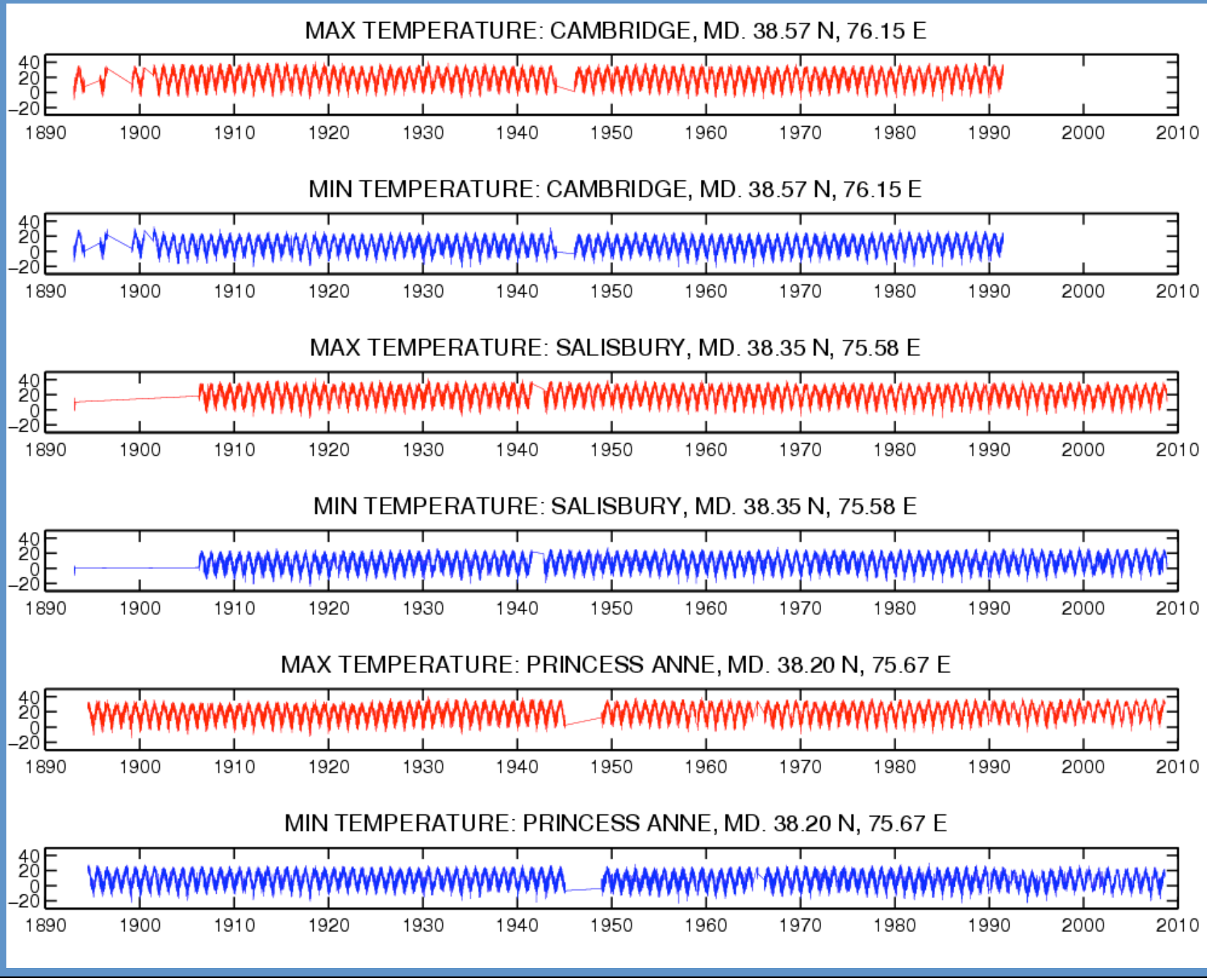
How well climatic models simulate future MD climate change and variability?

WINTER



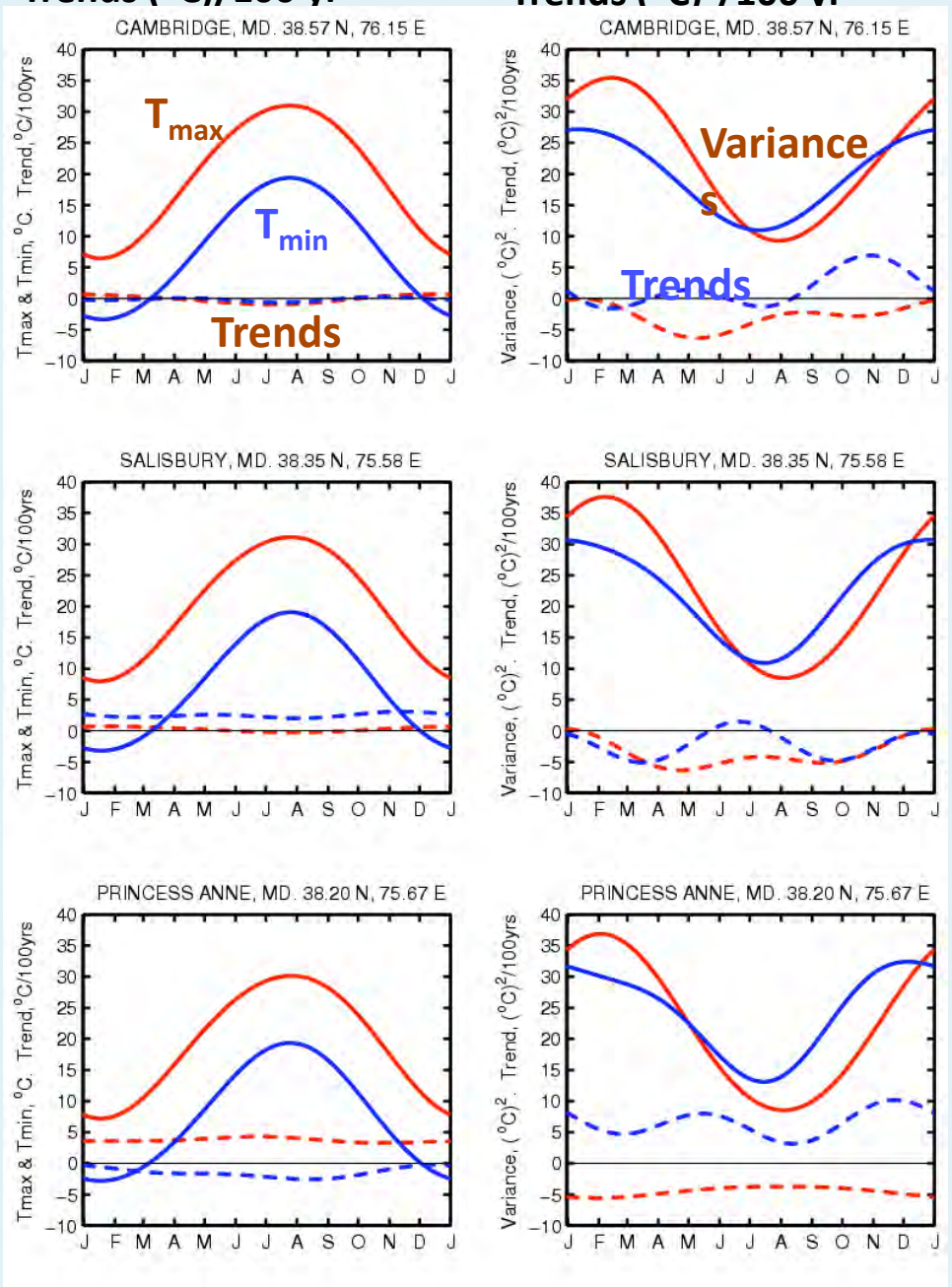
WINTER




MAX TEMPERATURE: CAMBRIDGE, MD. 38.57 N, 76.15 E
MIN TEMPERATURE: CAMBRIDGE, MD. 38.57 N, 76.15 E
MAX TEMPERATURE: SALISBURY, MD. 38.35 N, 75.58 E
MIN TEMPERATURE: SALISBURY, MD. 38.35 N, 75.58 E
MAX TEMPERATURE: PRINCESS ANNE, MD. 38.20 N, 75.67 E
MIN TEMPERATURE: PRINCESS ANNE, MD. 38.20 N, 75.67 E
40
20
0
−20
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

100 yr Averages (ºC) & Trends (ºC)/100 yr

Mean Variances (ºC)^2 & Trends (ºC)^2/100 yr

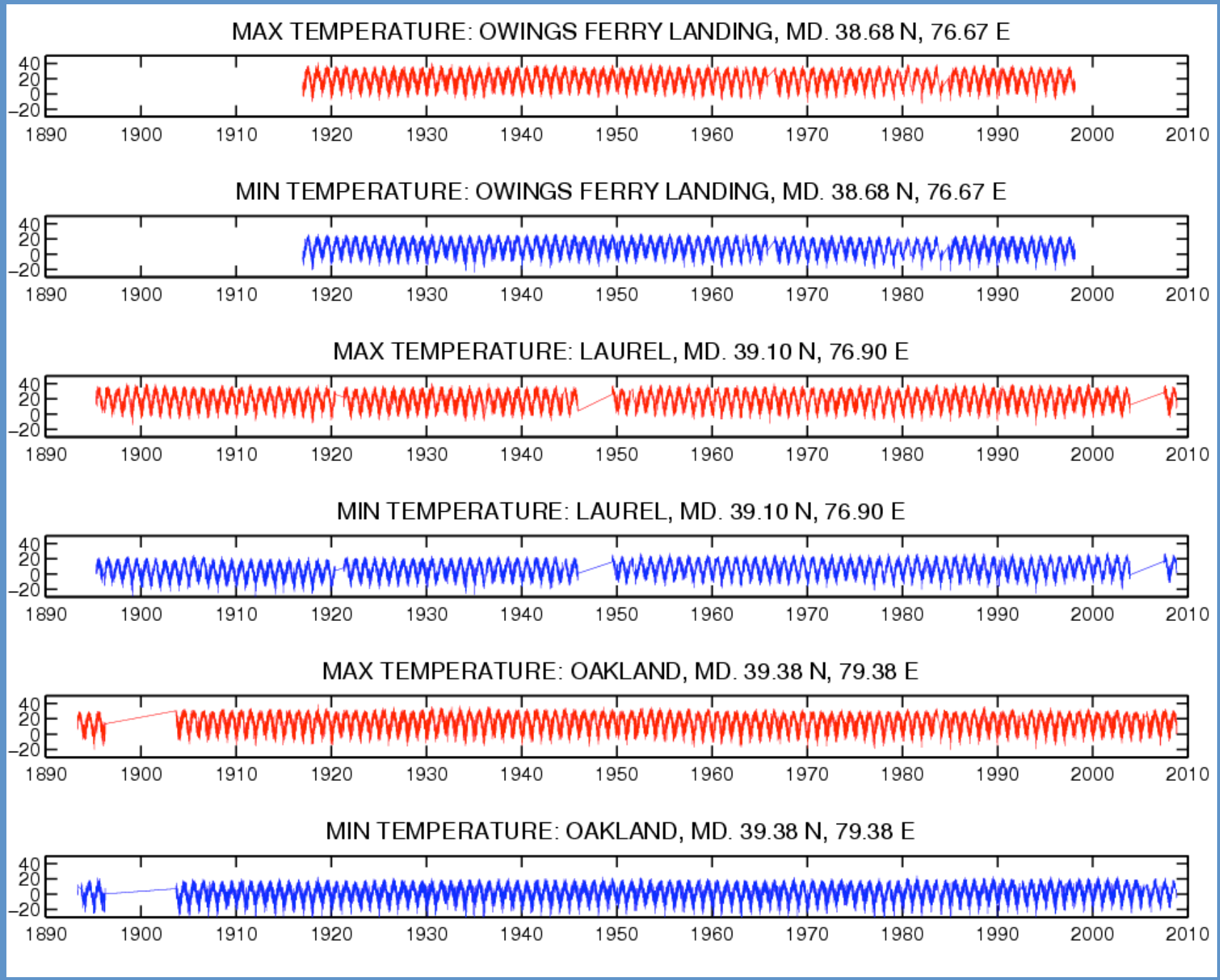


What we are looking for:

1. Asymmetry in trends of T_{max} & T_{min}. We expect that: Trend(T_{min}) >Trend(T_{max}).
2. Trends in Variances.

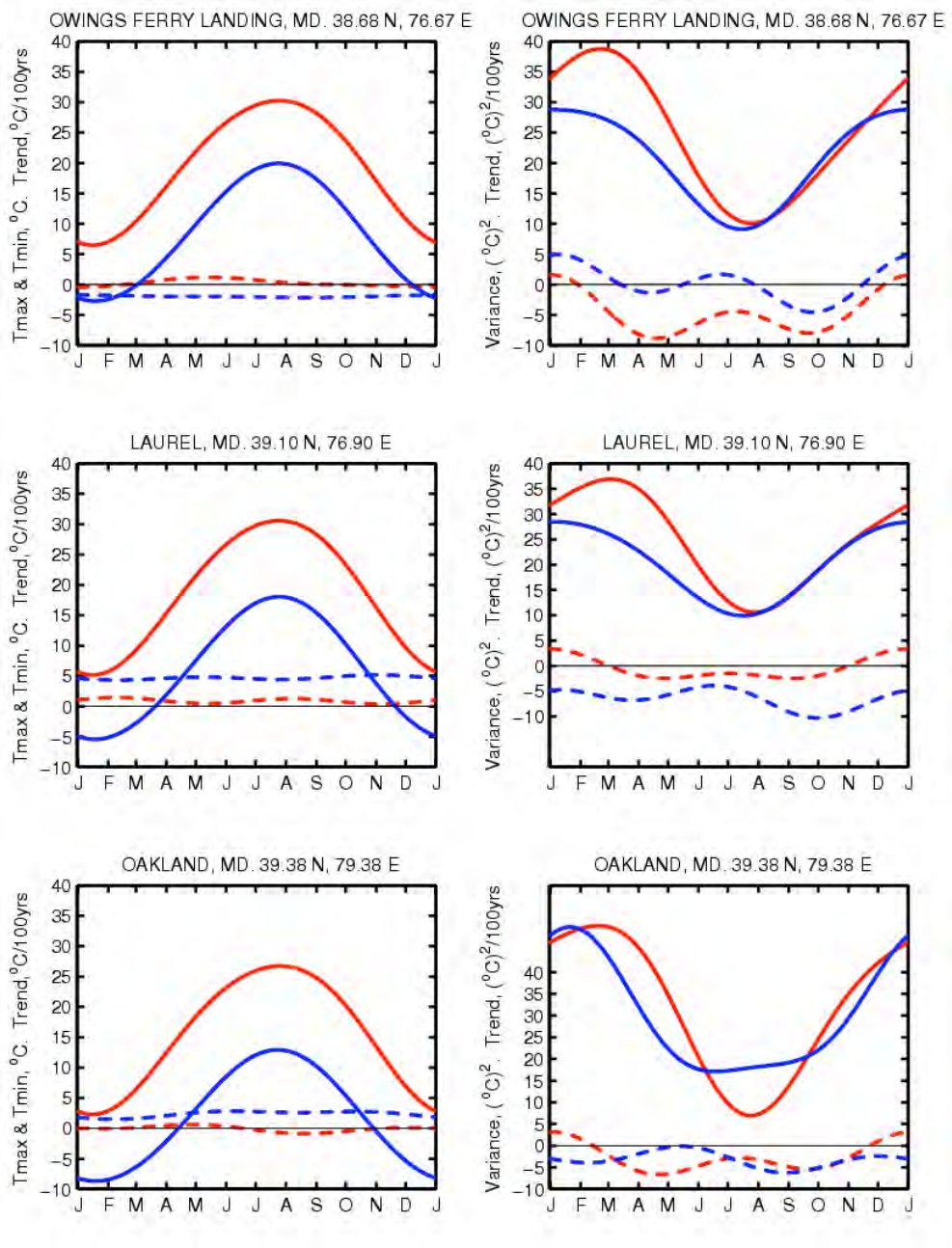
What we see here:

1. An Asymmetry does depend on station.
2. All these three stations display a century scale decreasing trend in variances of T_{max}. Trends in variances of T_{min} are uncertain.


MAX TEMPERATURE: OWINGS FERRY LANDING, MD. 38.68 N, 76.67 E
MIN TEMPERATURE: OWINGS FERRY LANDING, MD. 38.68 N, 76.67 E
MAX TEMPERATURE: LAUREL, MD. 39.10 N, 76.90 E
MIN TEMPERATURE: LAUREL, MD. 39.10 N, 76.90 E
MAX TEMPERATURE: OAKLAND, MD. 39.38 N, 79.38 E
MIN TEMPERATURE: OAKLAND, MD. 39.38 N, 79.38 E
40
20
0
−20
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

100 yr Averages (ºC) & Trends (°C)/100 yr

Mean Variances (ºC)^2 & Trends (°C)^2/100 yr



1. **The expected asymmetry of trends in T_{max} & T_{min} at Laurel and Oakland.**

2. **There is century-scale warm seasons decreasing in variance of T_{max}.**

- A century-scale warming trends can be clearly seen in observations of T_{max} & T_{min} at 5 of 9 chosen meteorological stations at Maryland.
- An expected asymmetry with Trend(T_{min})>Trend(T_{max}) is found in observations of 3 of 9 chosen stations. Five other stations display an opposite Trend(T_{min})<Trend(T_{max}).
- Century-scale decreasing trends in variance of Tmax are found in observations at of 8 of 9 chosen meteorological stations.

CONCLUSIONS:

- **Mid-East Coast states enjoy beautiful climate with seasonal Maximum of precipitation in the Summer and Minimum - in the Autumn.**
- **Global warming 1895-2010 has been accompanied by a decrease in Summer - and increase in Autumn precipitation in MD, VA, and other Mid-East Coast states.**
- **These observed changes in precipitation are real and result in the observed Summer decrease and Autumn increase of river runoff.**
- **GFDL/NOAA Climate Model global warming scenario simulations give us hope that the observed century scale Summer precipitation trend in MD & VA is going to change from a decreasing trend to an increasing trend.**
- **We should not expect an increasing of MD climate variability.**