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**RISING WATERS**
Maryland Prepares for Floods & Sea Level Rise

2011 Water Resources Symposium

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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
Baltimore, MD. Annual Temperature 1817-2007
Observed Data and Trend Estimates (Linear, Quadratic, Cubic)

Baltimore, MD. Annual Precipitation 1817-2005
Observed Data and Trend Estimates (Linear, Quadratic, Cubic)
Maryland and Vicinity:
Observed Daily $T_{\text{max}}$ & $T_{\text{min}}$ are Available for More than 95 yr.
Stations Map
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
STATE AVERAGED MONTHLY PRECIPITATION
OBSERVED 1895-2010 MONTHLY MEANS

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

STATE AVERAGED MONTHLY PRECIPITATION
OBSERVED 1895-2010 CLIMATIC TREND

Precipitation, mm/d

Trend, (mm/d) / 100 yr

J F M A M J J A S O N D

NJ DE MD VA NC SC GA

J F M A M J J A S O N D
East Coast Rivers: Observed Seasonal Variations of Runoff and Trend

CATCHMENT AVERAGED MONTHLY RUNOFF
OBSERVED MONTHLY MEANS

- R. Delavare at Trenton, NJ, 1912-2010
- R. Potomac at Point of Rocks, MD, 1895-2010
- R. James at Cartersville, VA, 1899-2010
- R. Roanoke at Roanoke Rapids, NC, 1912-2010
- R. Wateree Nr. Camden, SC, 1929-2010
- R. Savannah at Augusta, GA, 1883-2010
- R. Altamaha at Doctortown, GA, 1931-2010

CATCHMENT AVERAGED MONTHLY RUNOFF
OBSERVED CLIMATIC TREND

Trend, (mm/dy), 100 yr

- R. Delavare at Trenton, NJ, 1912-2010
- R. Potomac at Point of Rocks, MD, 1895-2010
- R. James at Cartersville, VA, 1899-2010
- R. Roanoke at Roanoke Rapids, NC, 1912-2010
- R. Wateree Nr. Camden, SC, 1929-2010
- R. Savannah at Augusta, GA, 1883-2010
- R. Altamaha at Doctortown, GA, 1931-2010
STATE AVERAGED PRECIPITATION AND RIVER RUNOFF
AUTUMN (SON) MEANS & TRENDS

MD Precipitation
VA Precipitation
Potomac River Runoff
James River Runoff
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

Seasonal Cycle of Linear Trend
MARYLAND AVERAGED PRECIPITATION: 1895-2010

Trend, (mm/dy)/100 yrs

Seasonal Cycle of Linear Trend
VIRGINIA AVERAGED PRECIPITATION: 1895-2010

Trend, (mm/dy)/100 yrs

Seasonal Cycle of Linear Trend
POTOMAC RIVER BASIN RUNOFF: 1895-2010

Trend, (mm/dy)/100 yrs

Seasonal Cycle of Linear Trend
JAMES RIVER BASIN RUNOFF: 1899-2010

Trend, (mm/dy)/100 yrs
How well climatic models simulate seasonal variation of atmospheric precipitation?
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
GFDM CM2.1 Climate Model: IPCC SRES A1B Forcing Scenario
Time Series of Summer (JJA) Totals of Precipitation at MD & VA

S SUMMER RM
GFDM CM2.1 Climate Model: IPCC SRES A1B Forcing Scenario
Trends in Variance of Summer (JJA) Precipitation at MD & VA

Run 1

Run 2

Run 3
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**

GFDD CM2.1 Climate Model: IPCC SRES A1B Forcing Scenario

Time Series of Summer (JJA) Mean Temperature at MD & VA

- Run 1
- Run 2
- Run 3
How well climatic models simulate future MD climate change and variability?

**WINTER**

GFDL CM2.1 Climate Model: IPCC SRES A1B Forcing Scenario

Time Series of Winter (DJF) Mean Temperature at MD & VA

Run 1

Run 2

Run 3

GFDL CM2.1 Climate Model: IPCC SRES A1B Forcing Scenario

Trend in Variance of Winter (DJF) Mean Temperature at MD & VA

Run 1

Run 2

Run 3
What we are looking for:

1. Asymmetry in trends of $T_{\text{max}}$ & $T_{\text{min}}$. We expect that: Trend($T_{\text{min}}$) > Trend($T_{\text{max}}$).

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 $T_{\text{max}}$. Trends in variances of $T_{\text{min}}$ are uncertain.
1. The expected asymmetry of trends in $T_{\text{max}}$ & $T_{\text{min}}$ at Laurel and Oakland.

2. There is century-scale warm seasons decreasing in variance of $T_{\text{max}}$. 
• A century-scale warming trends can be clearly seen in observations of $T_{\text{max}}$ & $T_{\text{min}}$ at 5 of 9 chosen meteorological stations at Maryland.

• An expected asymmetry with $\text{Trend}(T_{\text{min}})>\text{Trend}(T_{\text{max}})$ is found in observations of 3 of 9 chosen stations. Five other stations display an opposite $\text{Trend}(T_{\text{min}})<\text{Trend}(T_{\text{max}})$.

• Century-scale decreasing trends in variance of $T_{\text{max}}$ 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.