ANALISIS OF OBSERVED GLOBAL AND REGIONAL CLIMATE CHANGE

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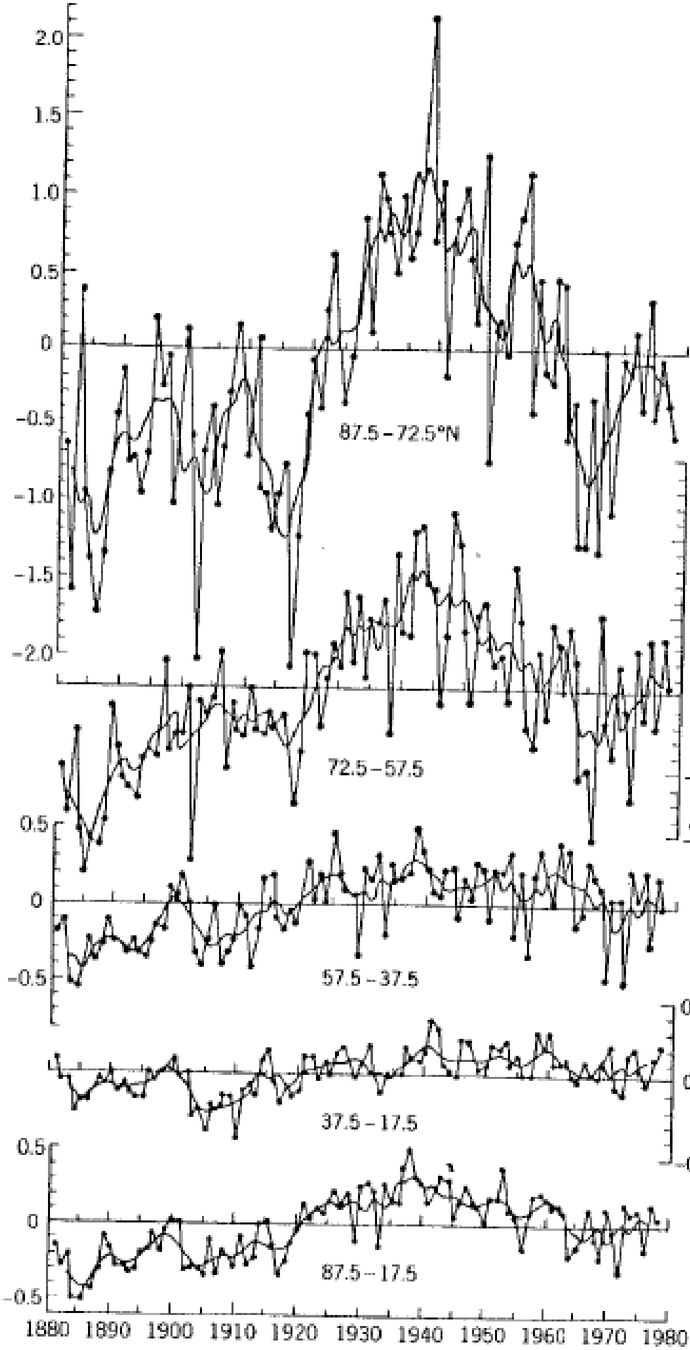
CLIMATE CHANGE ANALYSIS IN DATA OF SURFACE, SATELLITE & ASTRONOMICAL OBSERVATIONS

- *Global Surface Air is warming*
- *Arctic Sea Ice Extent is decreasing*
- *Global Tropospheric Air is warming*
- *Sea level rise – Antarctic melting*
- *Climate Variability is not increasing*
- *Climate in MD is changing*
- *Urbanization makes local climate better*
- *Air Pollution in MD is decreasing*

DETECTION OF SURFACE GLOBAL WARMING

Russia, 1976: DETECTION OF GLOBAL WARMING



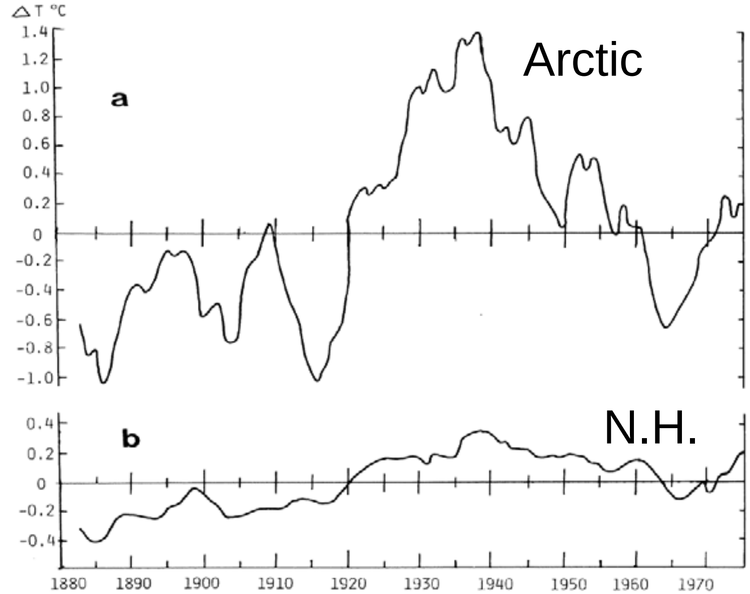
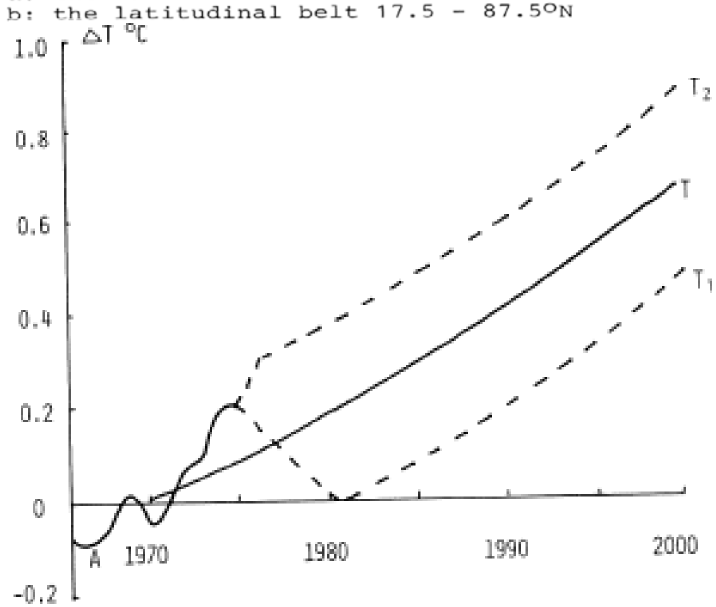


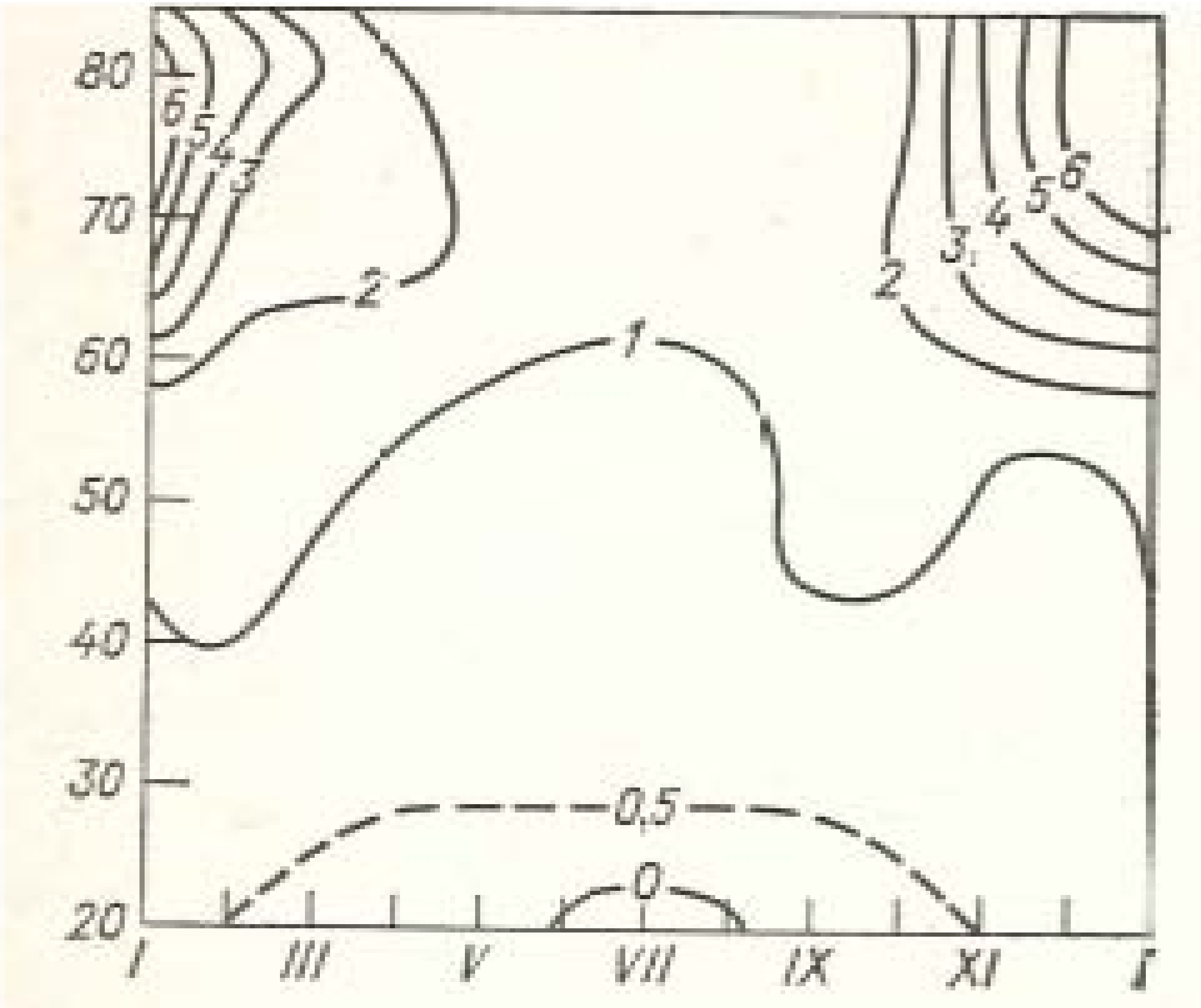
FIG. 1 – The long-term trend of the air temperature anomalies of the Northern Hemisphere (5-year running averages).
a: the latitudinal belt 72.5 – 87.5°N
b: the latitudinal belt 17.5 – 87.5°N



Budyko & Vinnikov, 1976

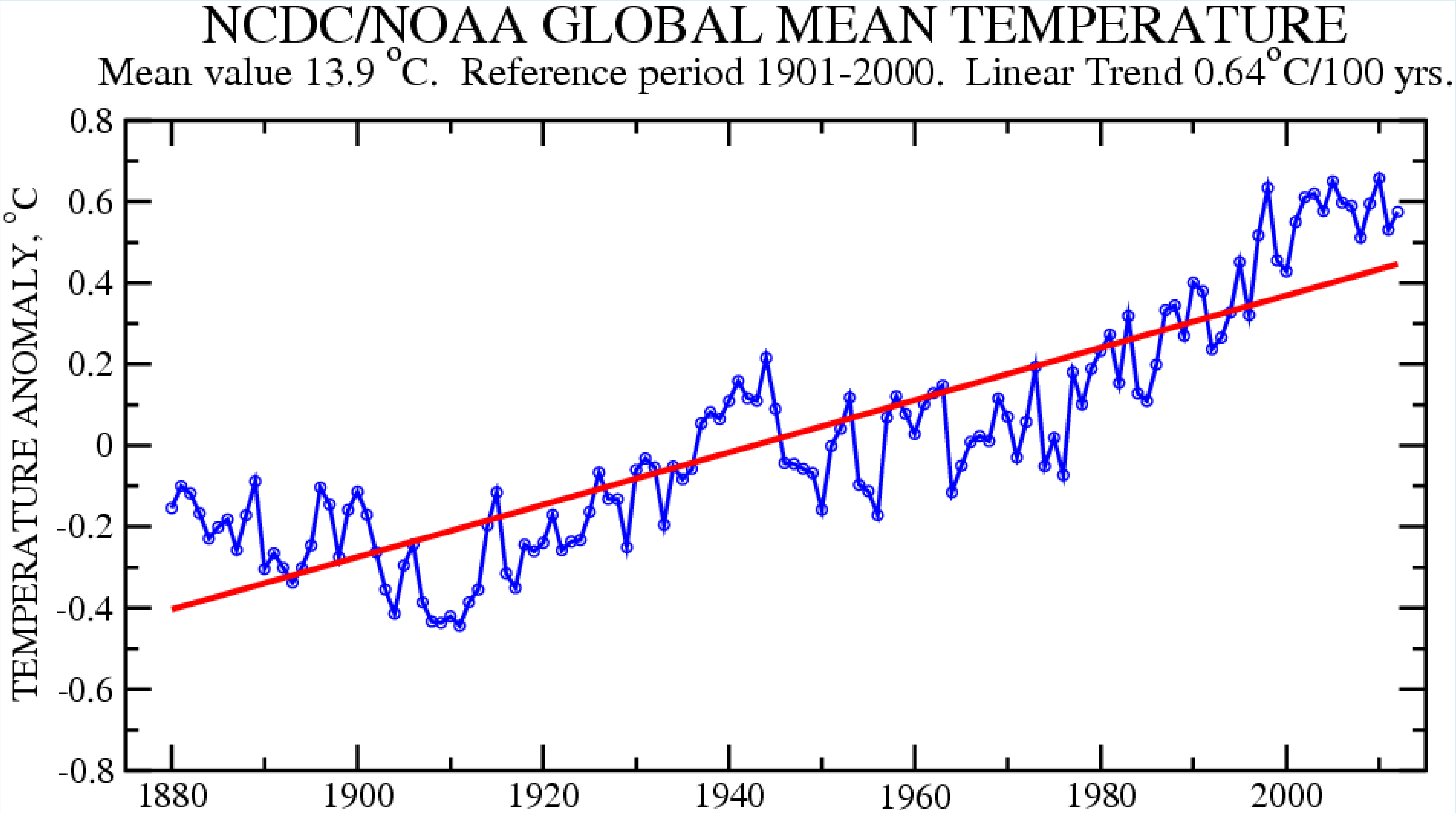
Global Warming Signature: POLAR & WINTER AMPLIFICATION

$$\alpha \approx \Delta T(Lat, Mon) / \Delta T_{AVERAGE}$$



Vinnikov, 1986

The Best of Currently Available Data Sets

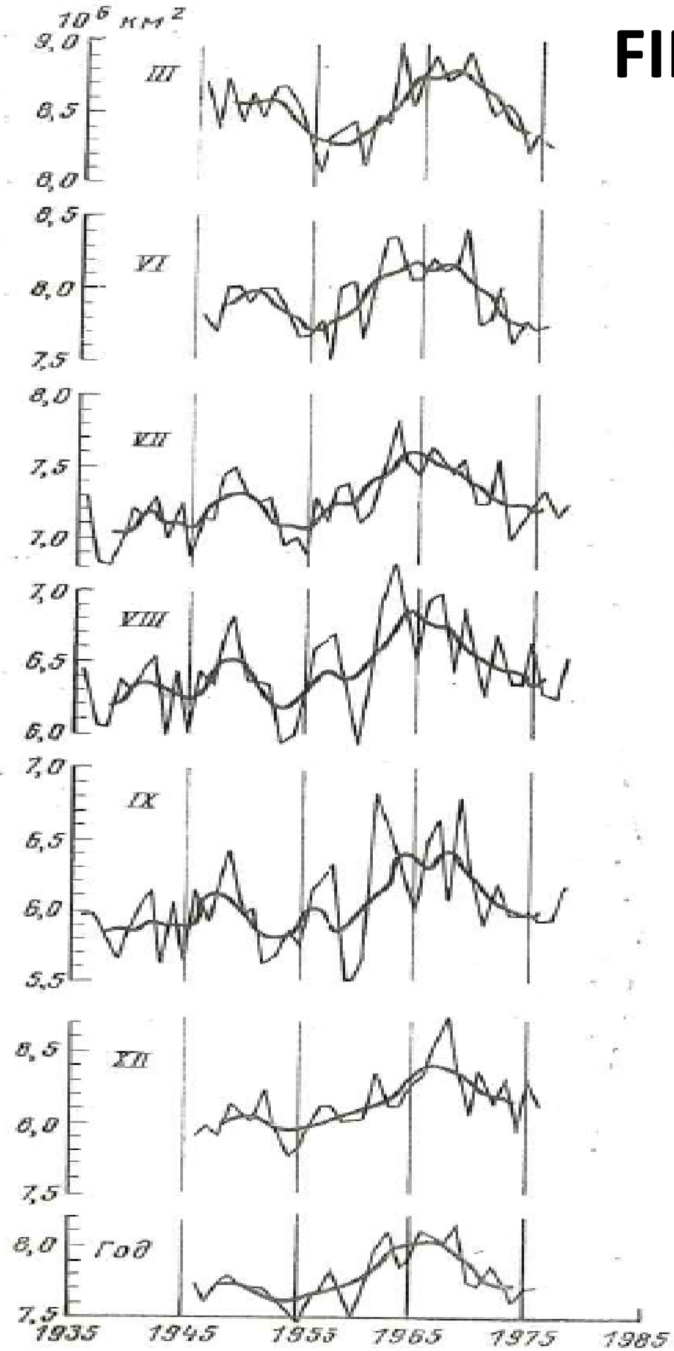


Vose et al., 2012

DETECTION OF ARCTIC SEA ICE EXTENT DECREASING

FIRST RUSSIAN DATA ON ARCTIC OCEAN SEA ICE EXTENT

Vinnikov et al., 1980



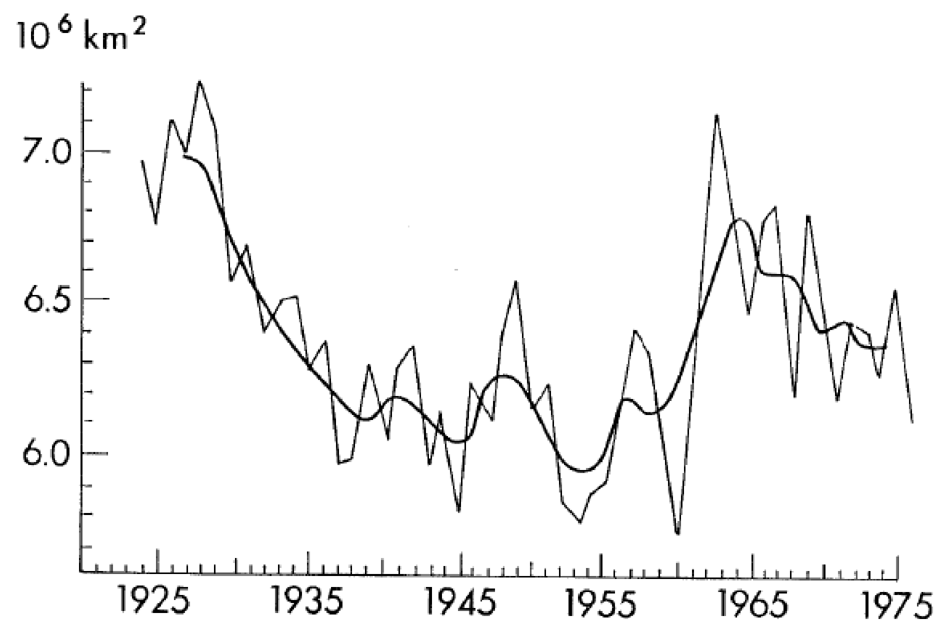
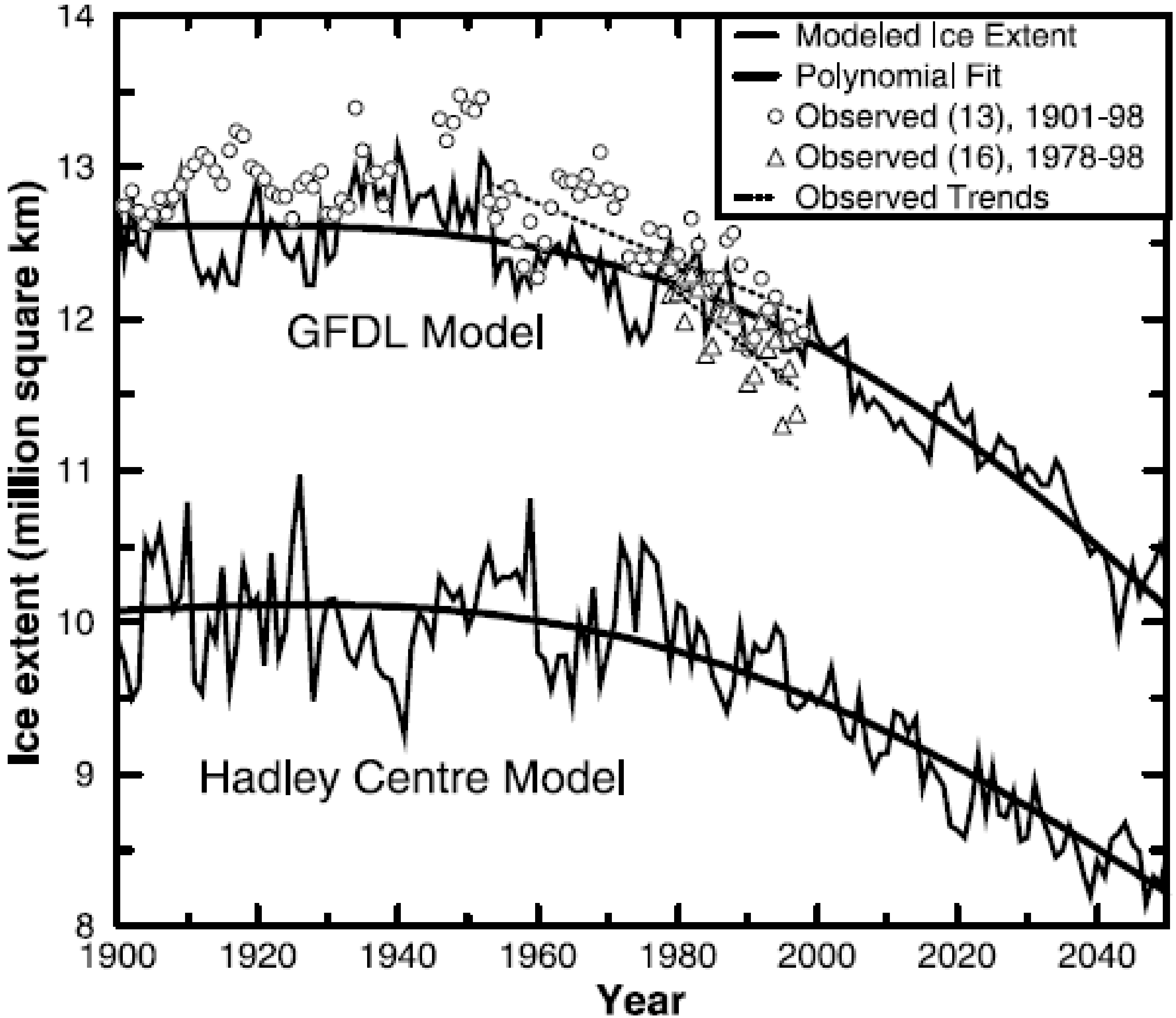


Figure 5. Secular Variation of the Annual and Five Year Mean Area Coverage of the Sea Ice Over the Arctic Ocean (Vinnikov et al., 1980).

OBSERVED AND MODELED NORTHERN HEMISPHERE SEA ICE EXTENT

Vinnikov et al., 1999



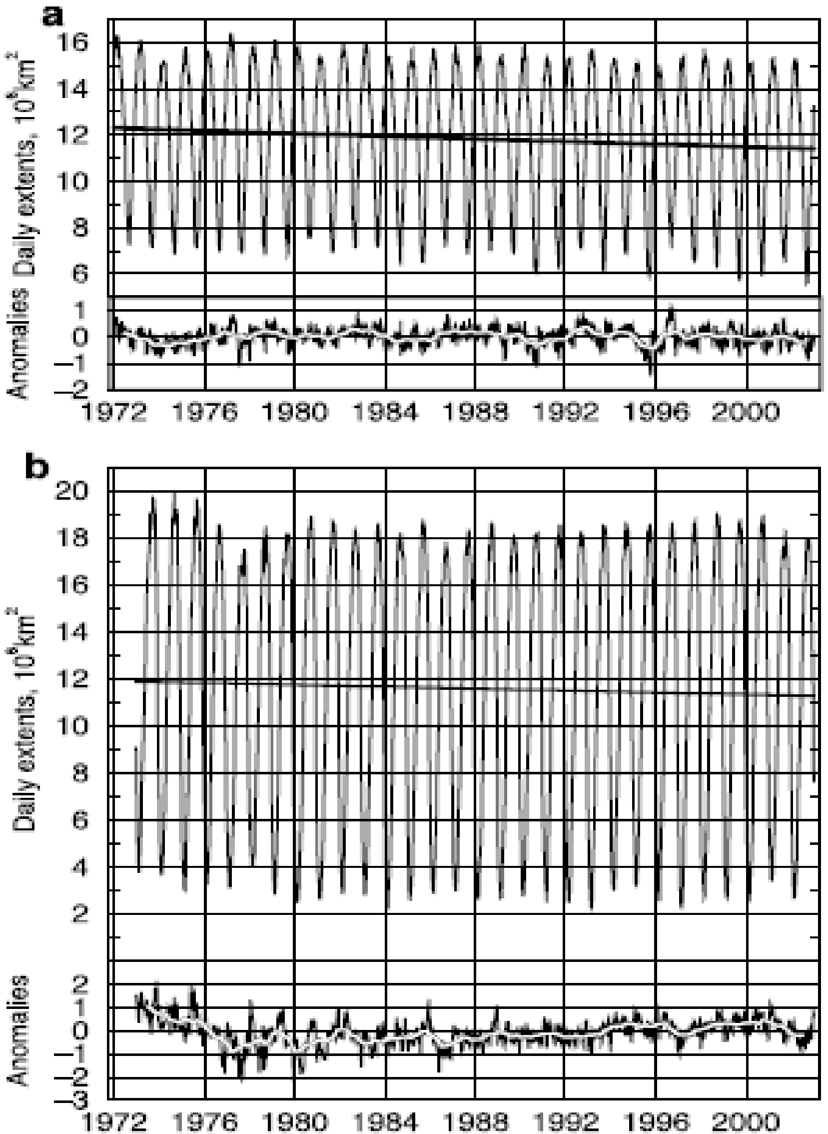
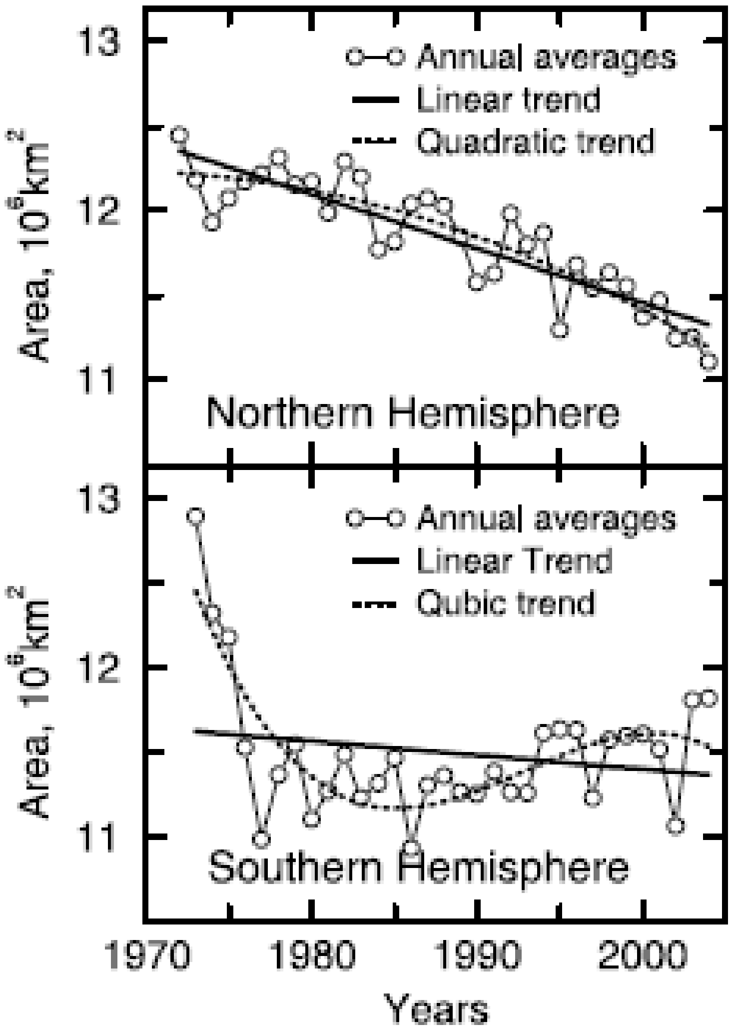


Figure 1. Matched sea ice extents from 1972/3 through 2002 and their anomalies are shown for (a) the Northern Hemisphere and (b) the Southern Hemisphere. Linear trend lines are indicated for each hemisphere, and a 365-day running mean of the anomalies is included on the anomaly plots.



Cavalieri et al, 2003;
Vinnikov et al., 2006.

DETECTION OF TROPOSPHERIC GLOBAL WARMING

SATELLITE MONITORING OF MEAN TROPOSPHERIC TEMPERATURE. Vinnikov & Grody, 2003

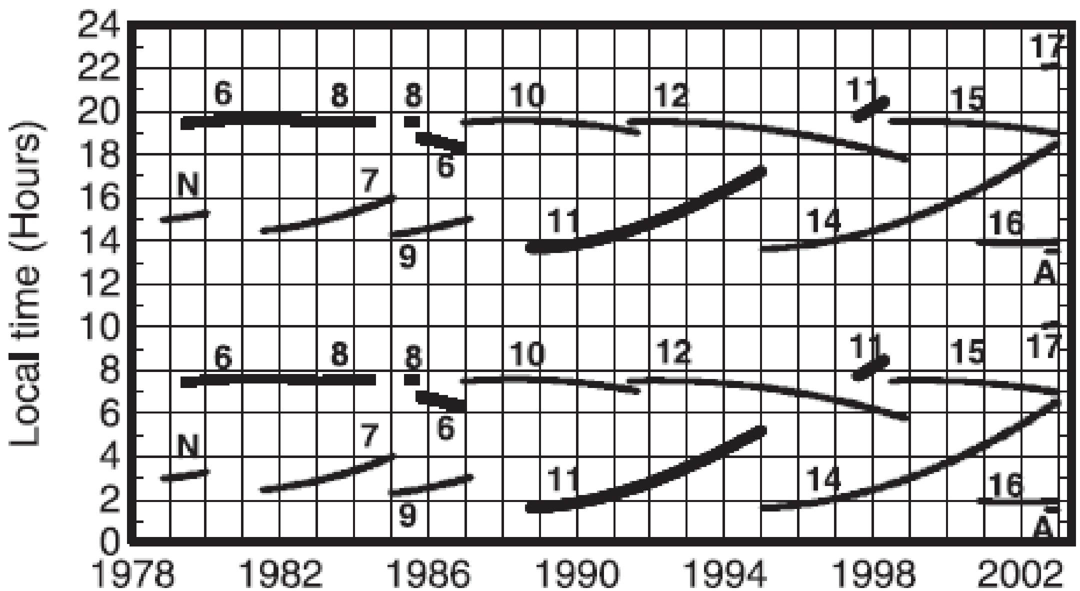
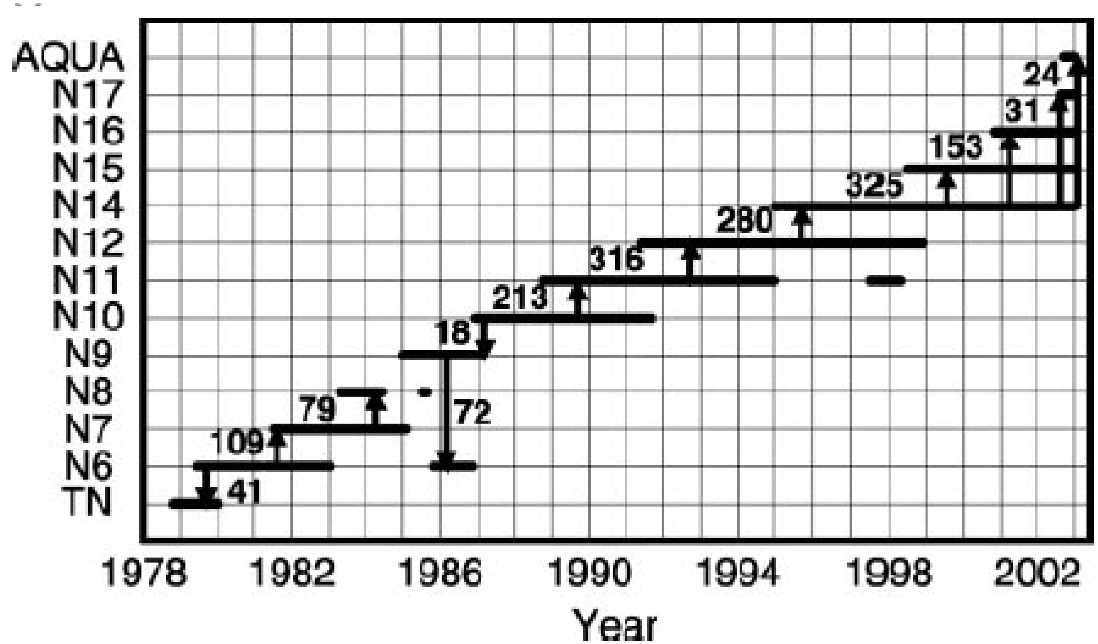


Fig. 1. Local equator-crossing time of MSU channel 2 and AMSU channel 5 on polar satellites. Line labels are the numbers of NOAA satellites; N is TIROS-N, and A is AQUA.

Fig. 2. Overlappings of satellite observations (in pentads) used to estimate instrumental biases from conditionally unbiased satellite NOAA-10. Connections of the satellites are shown with arrows. N, NOAA in the satellites' names; T-N, TIROS-N.



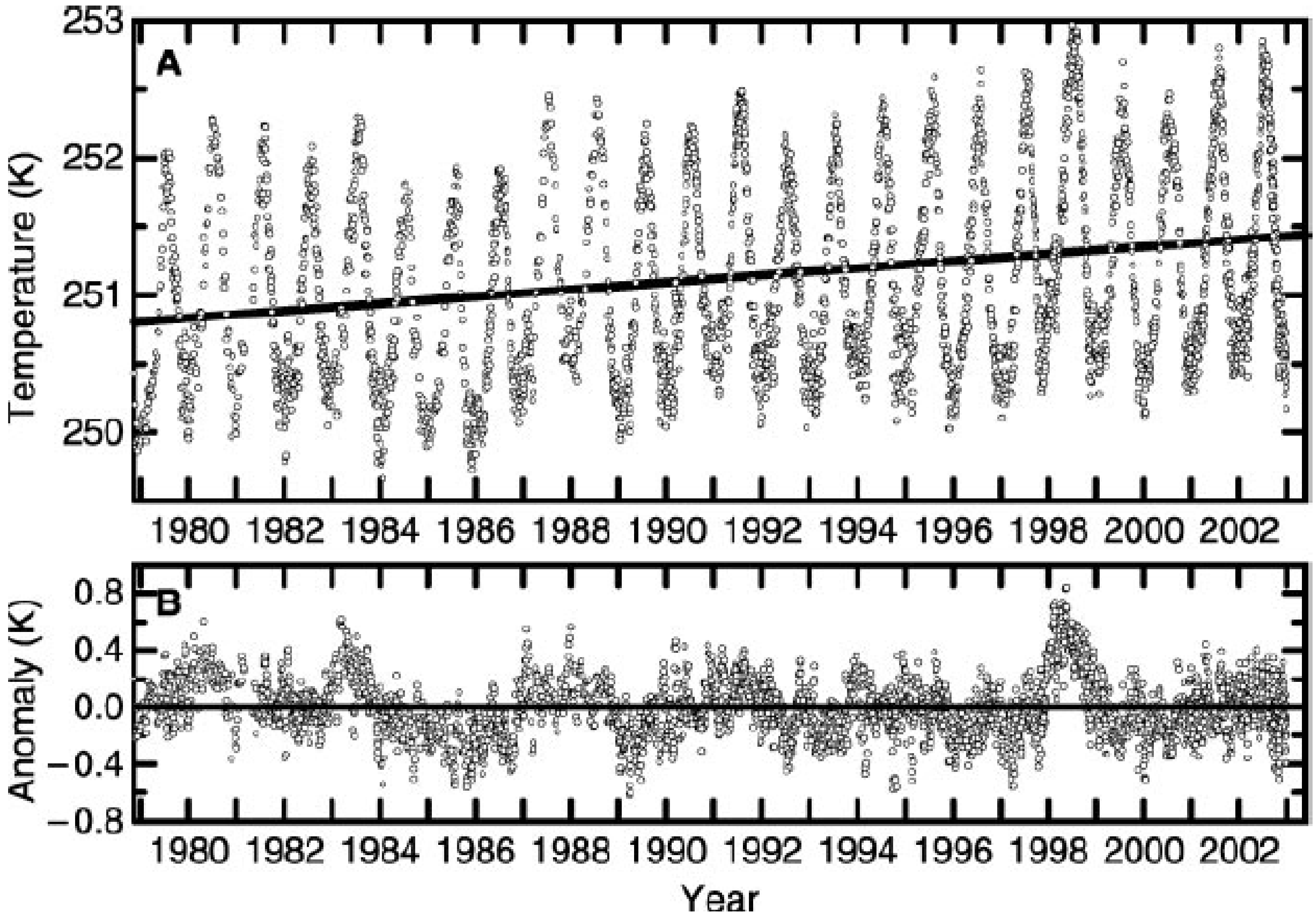


Fig. 3. (**A**) Bias-corrected globally averaged daily mean (pentad-averaged) satellite observed tropospheric temperatures (circles) and climatic trend $(a_{00} + b_{00}t)$ in annual averages (thick line). (**B**) Detrended, globally averaged daily mean (pentad averaged) anomalies, $y'(t) = y(t) - Y(t)$, of satellite observed temperature (circles).

Vinnikov et al., 2003

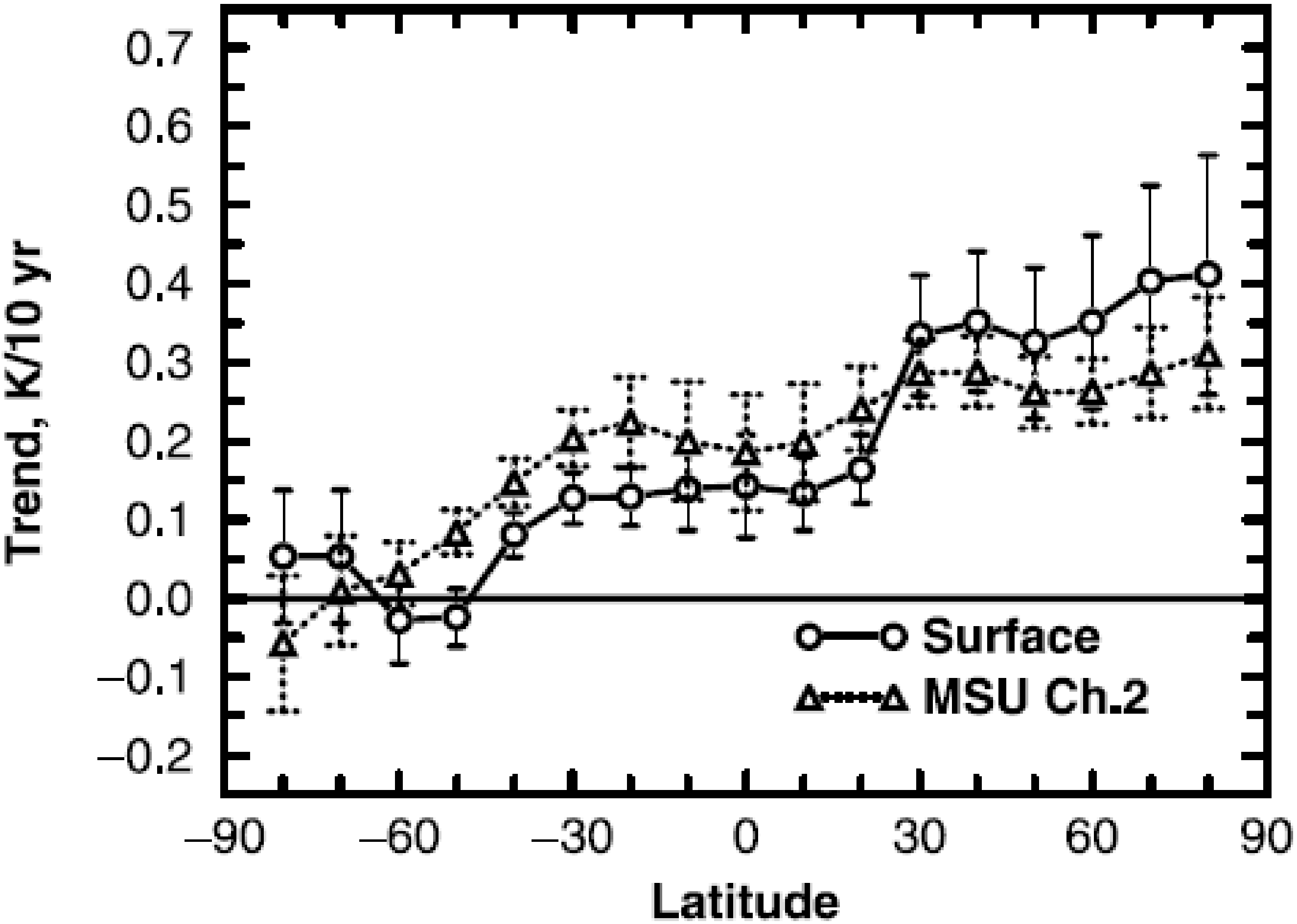


Figure 8. Zonally averaged 1978–2004 surface and satellite (MSU channel 2) observed air temperature trends. The vertical bars display the root mean square error of these trend estimates.

Vinnikov et al., 2005

Observed Trend in Polar Motion Suggests Accelerating Ice Loss from Antarctica

SEA LEVEL RISE and ANTARCTIC ICE SHEET MELTING

ETKINS & VINNIKOV, not yet published

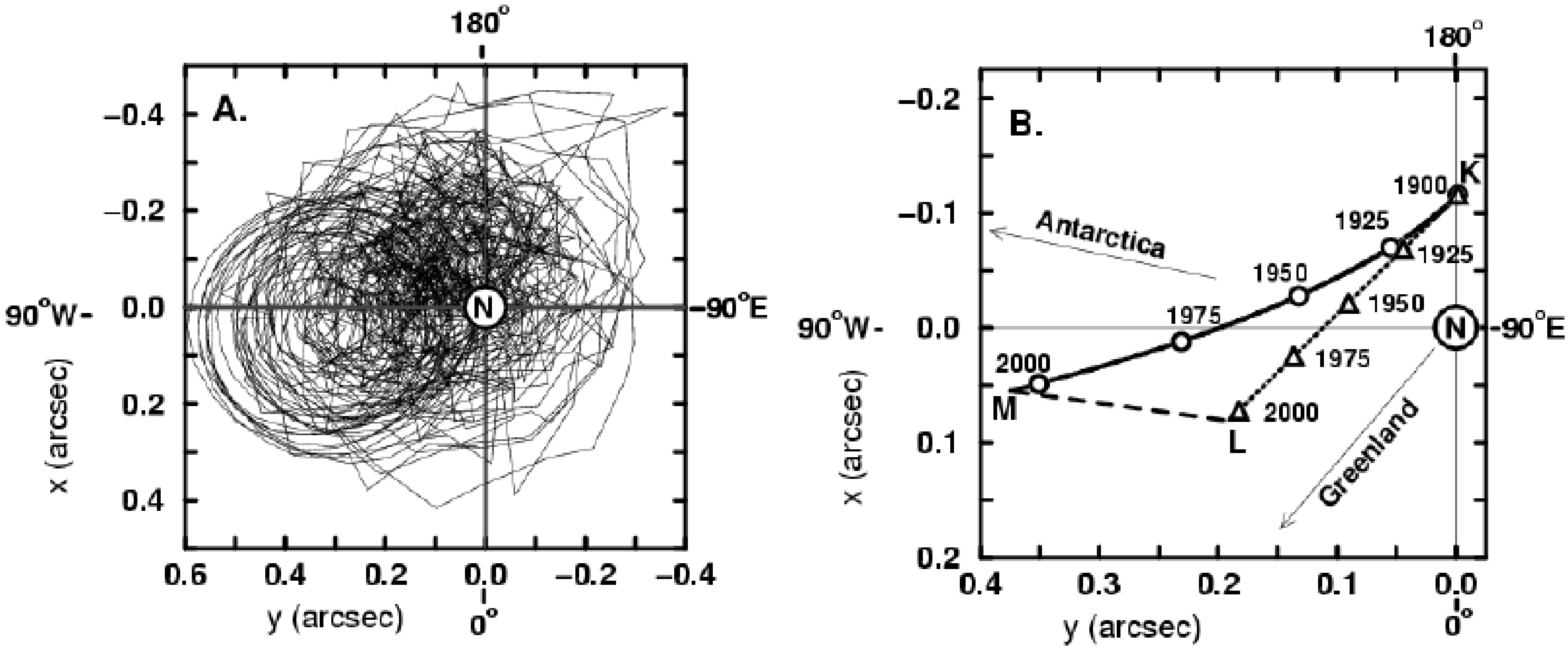
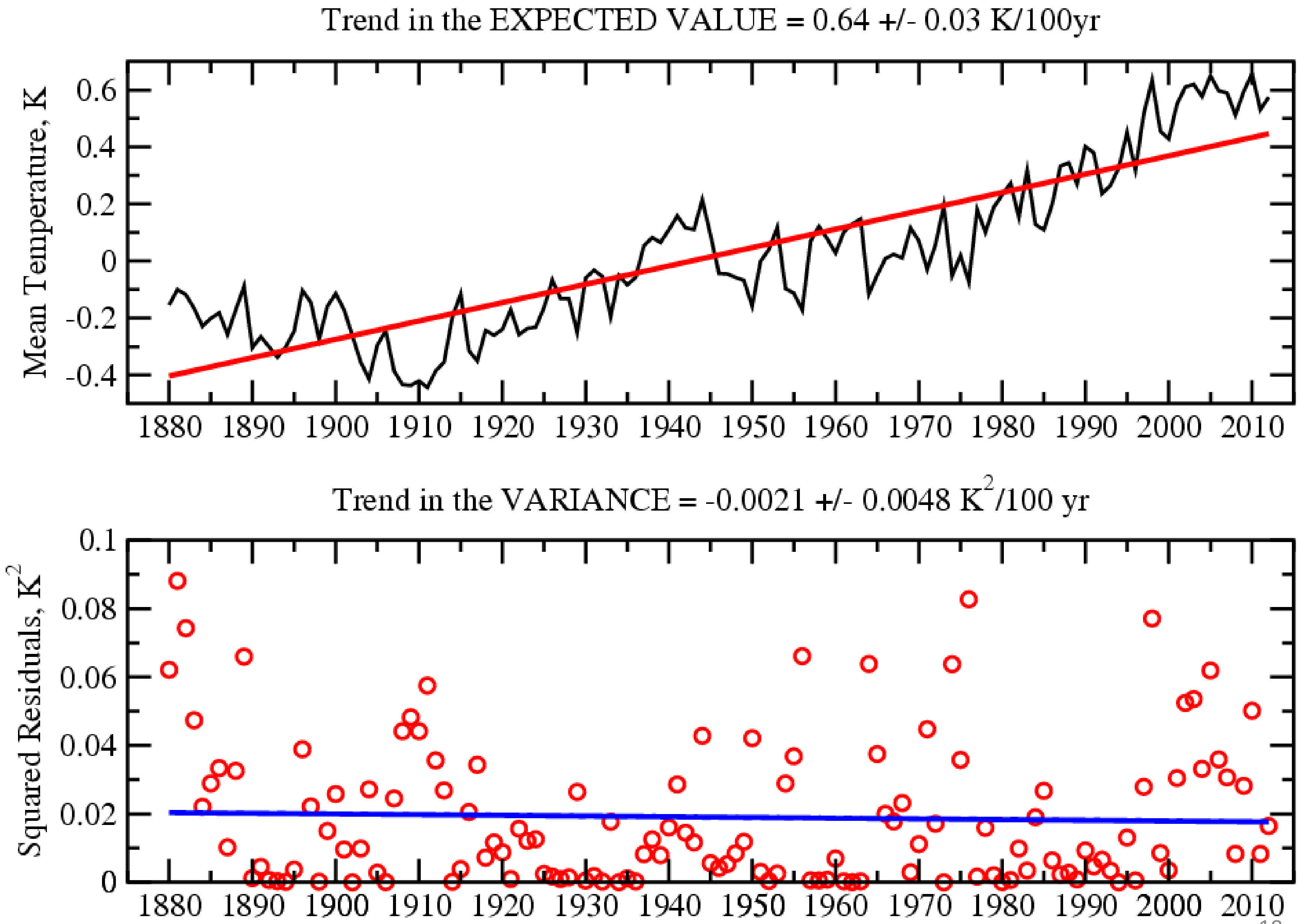


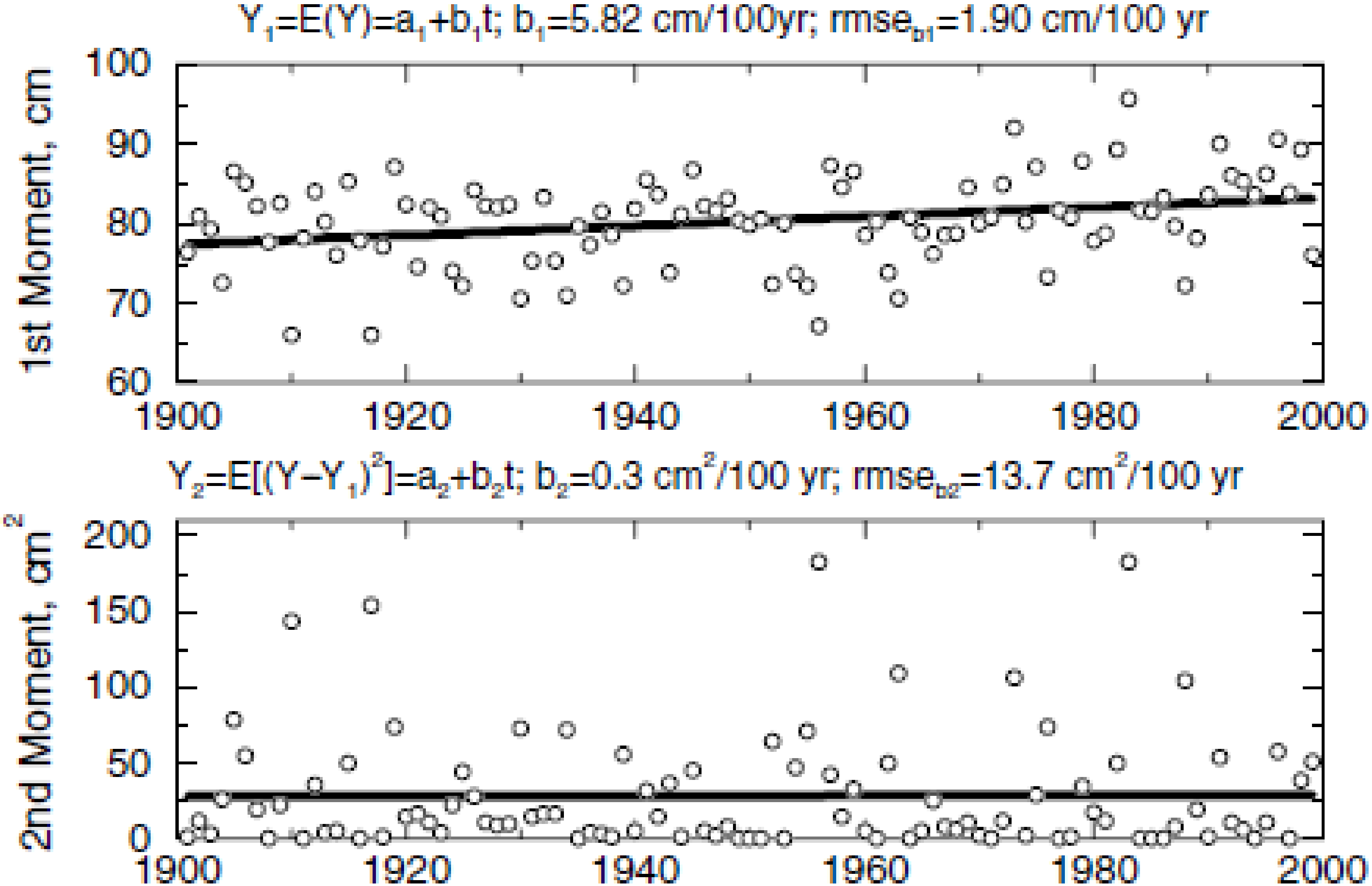
Figure 1. A. Observed polar motion for the period 1900-2004.4 showing the Chandler wobble with drift and with random errors which decrease with improvements in observational technology . B. Secular trend of the pole's mean position (solid line KM), and empirically estimated component of the trend presumably related to post-glacial rebound and melting from Greenland (dotted line KL). N is the position of the geographical reference North Pole. The two arrows show the directions of polar motion in response to melting from Antarctica and from Greenland, respectively.

TRENDS IN CLIMATE VARIABILITY

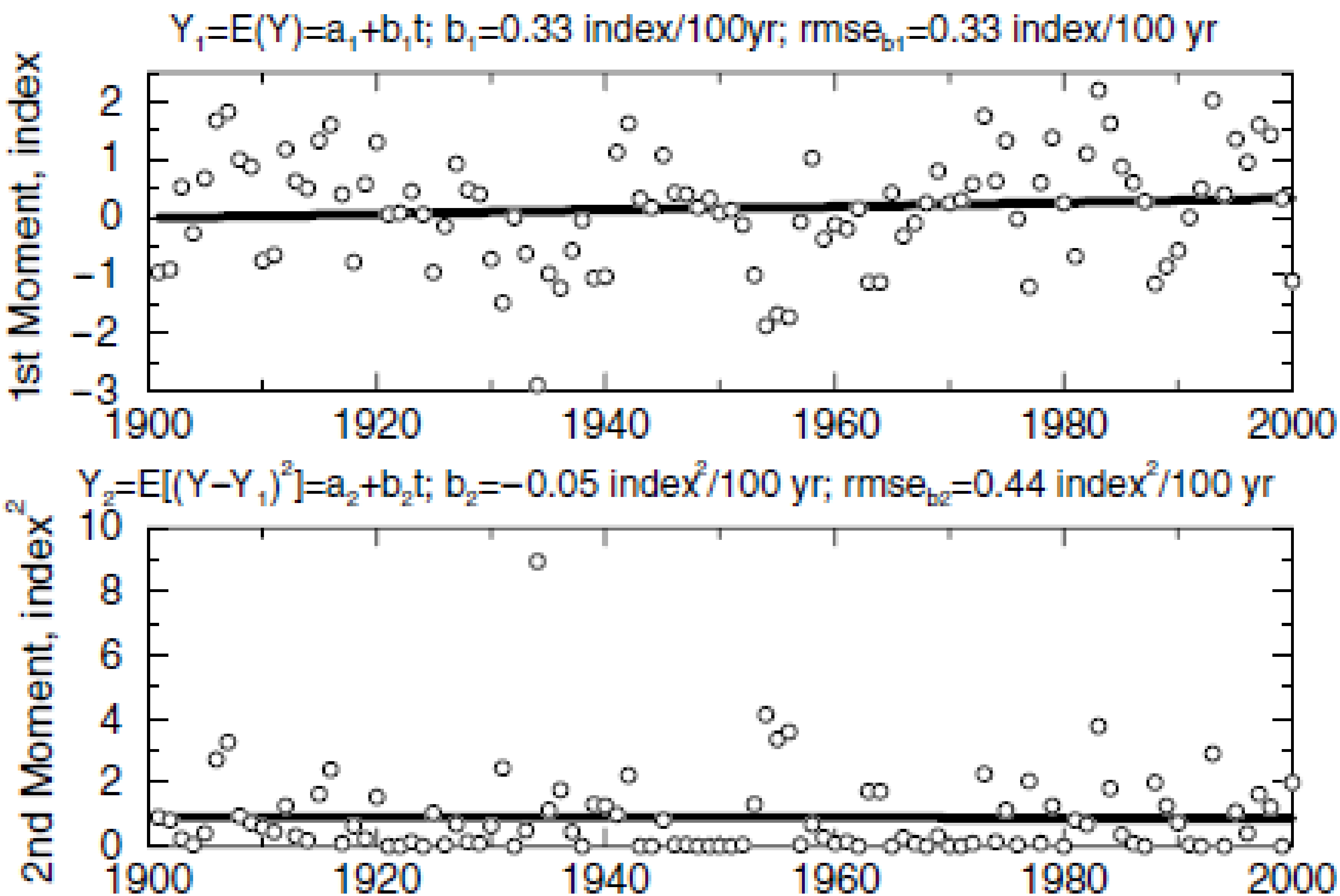
NCDC/NOAA GLOBAL MEAN TEMPERATURE



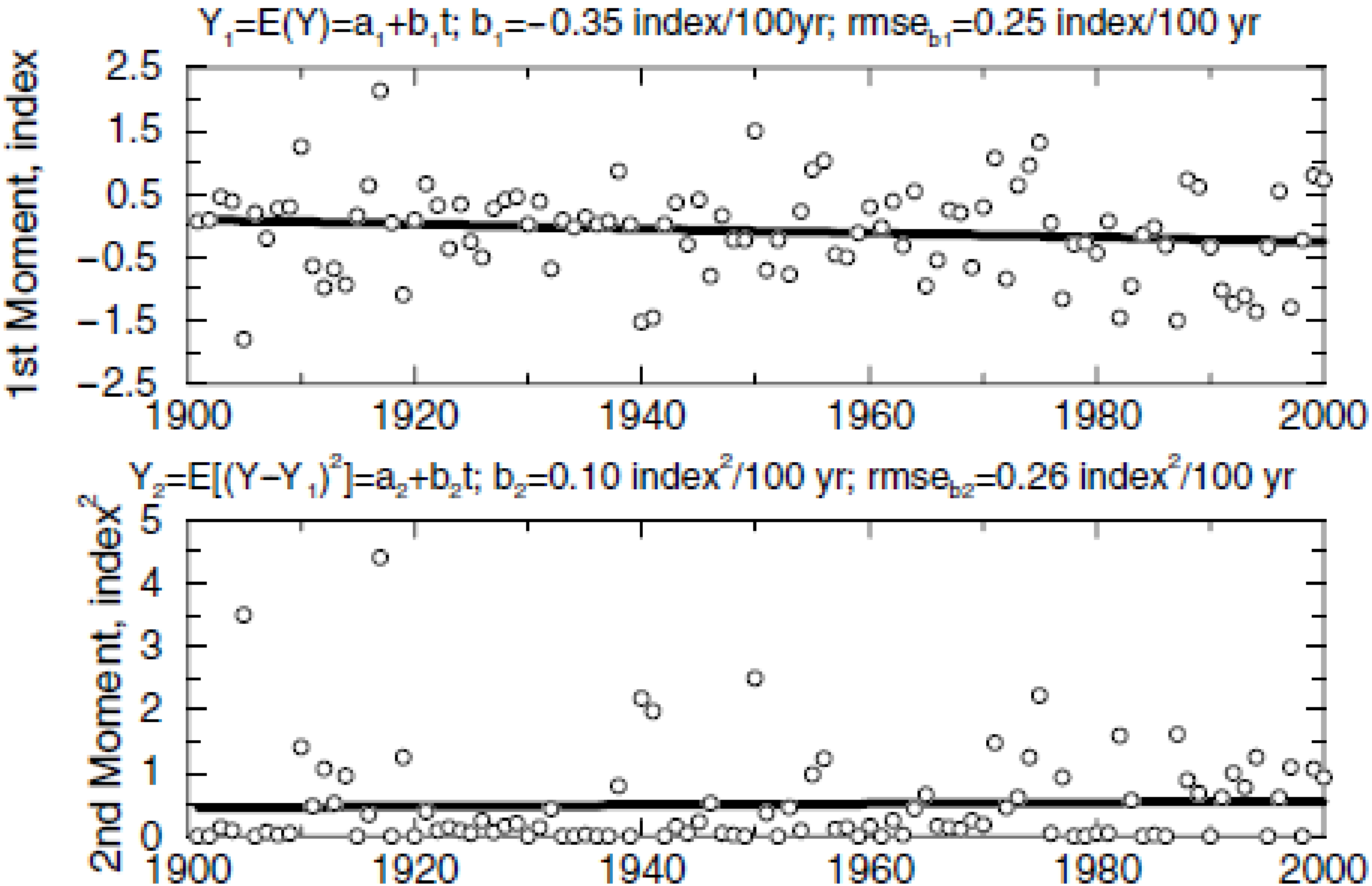
Stat. Moments of U.S. National Annual Precipitation



Stat. Moments of Modified Palmer Drought Severity Index, U.S.



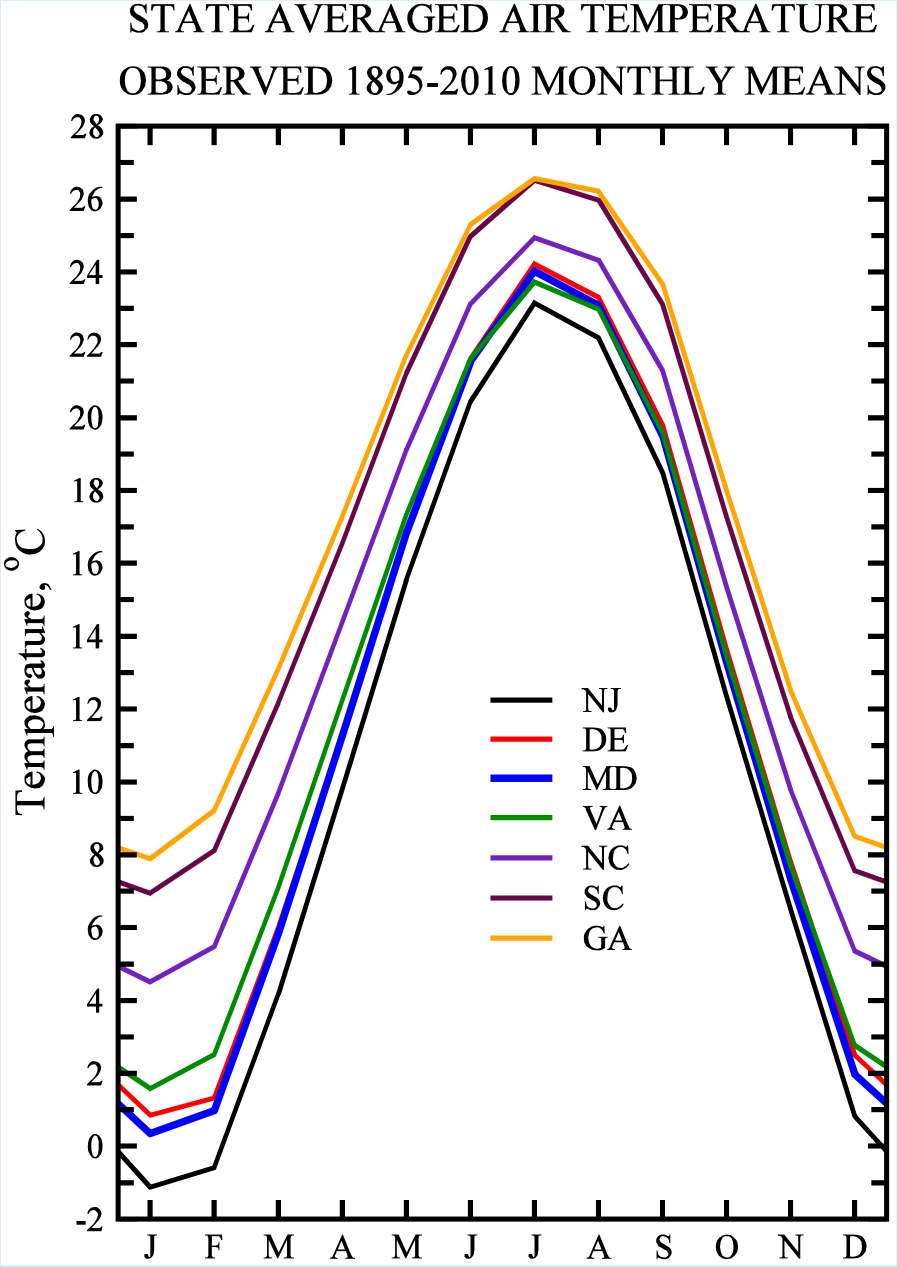
Stat. Moments of Southern Oscillation Index. Annual Averages

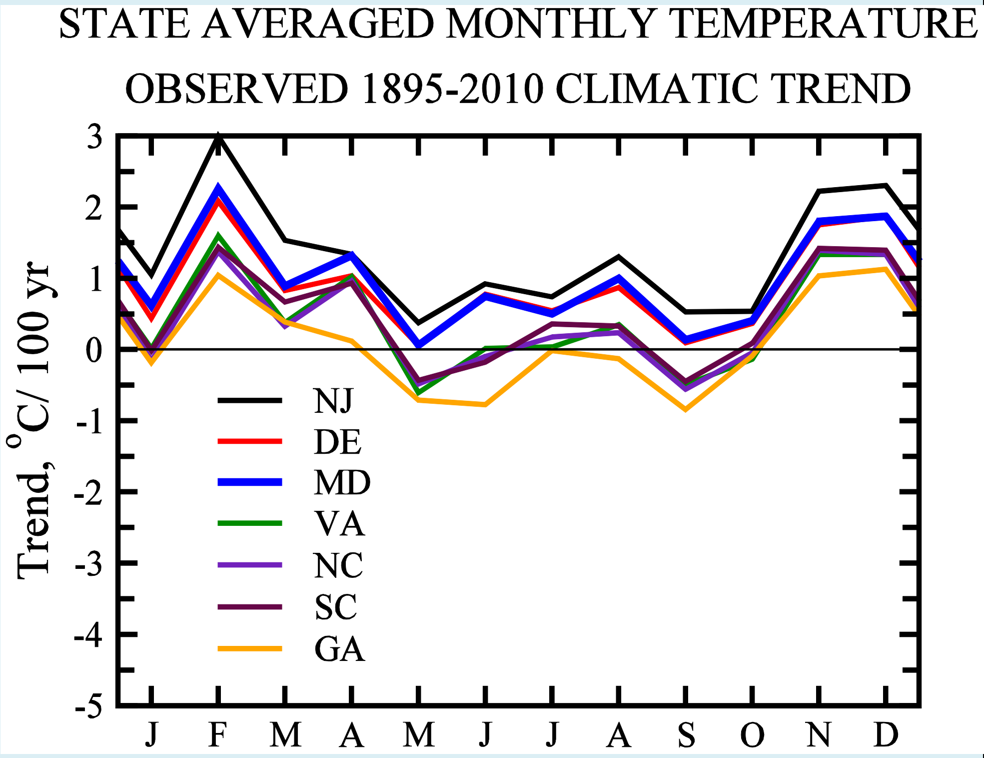


CLIMATE CHANGE IN MARYLAND

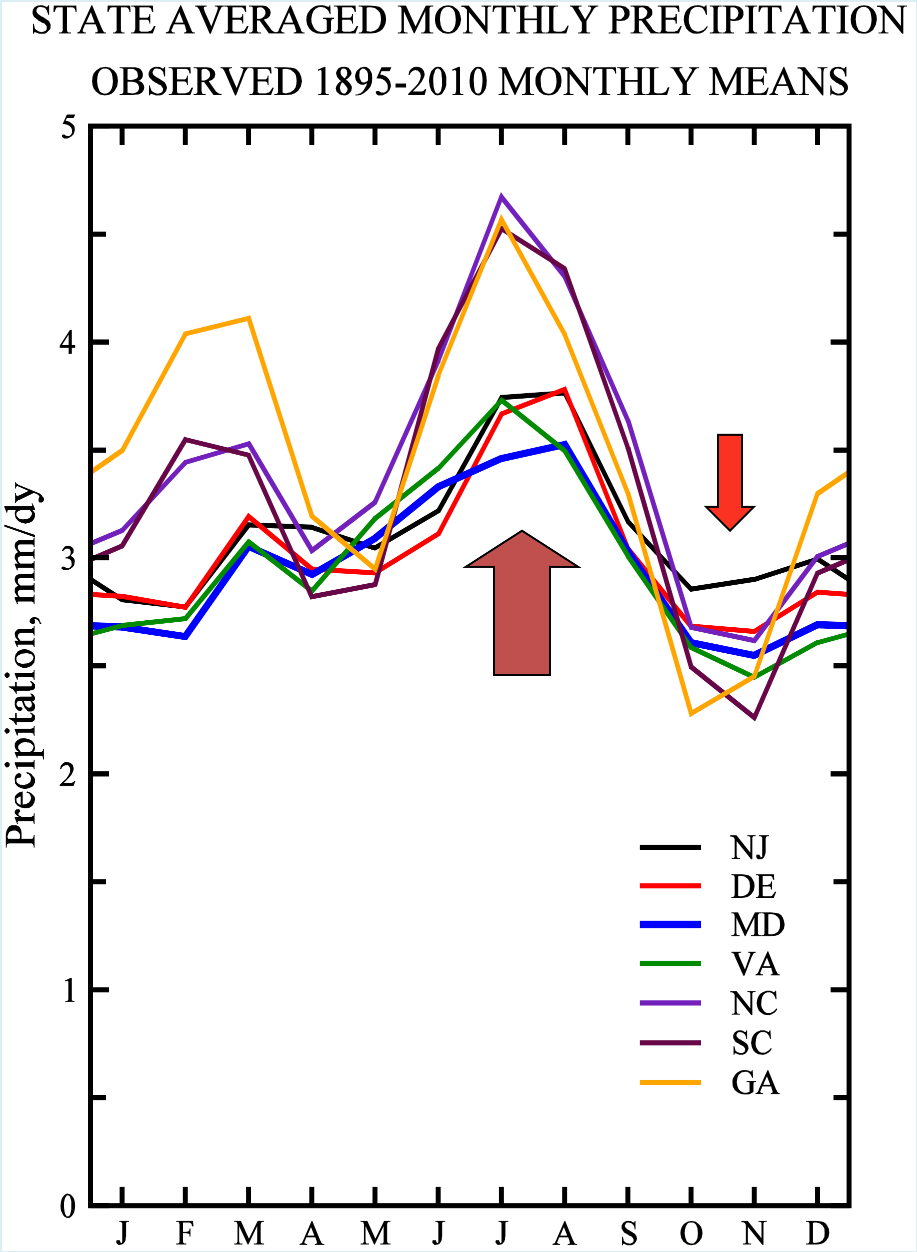
East Coast States:

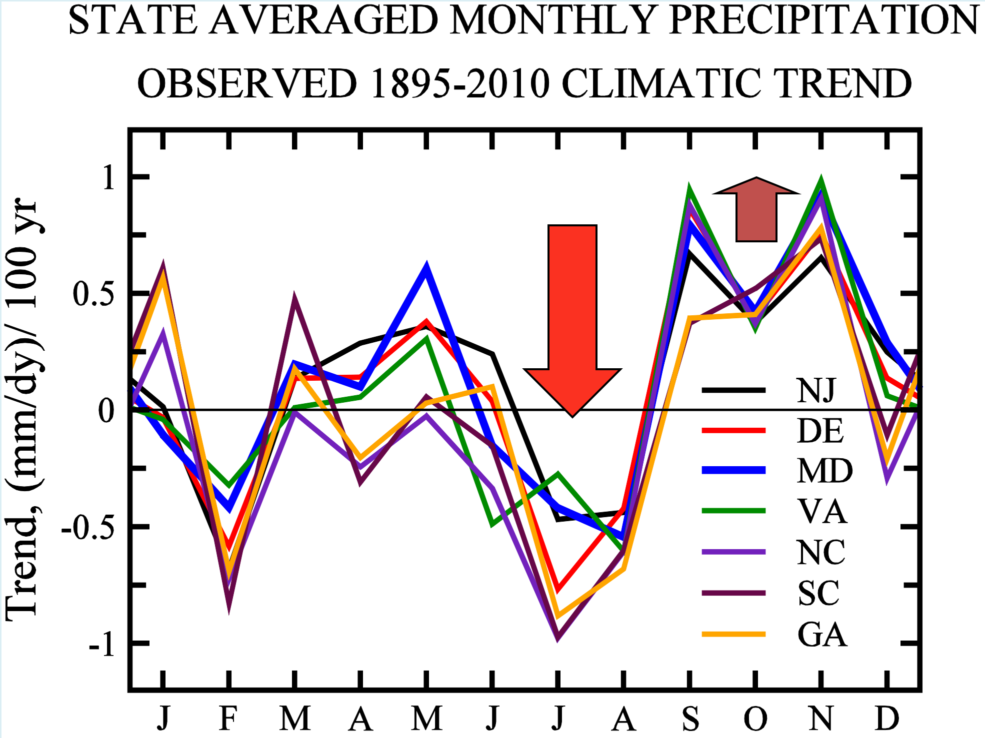
Observed Seasonal Variation of Mean Air Temperature and Trend



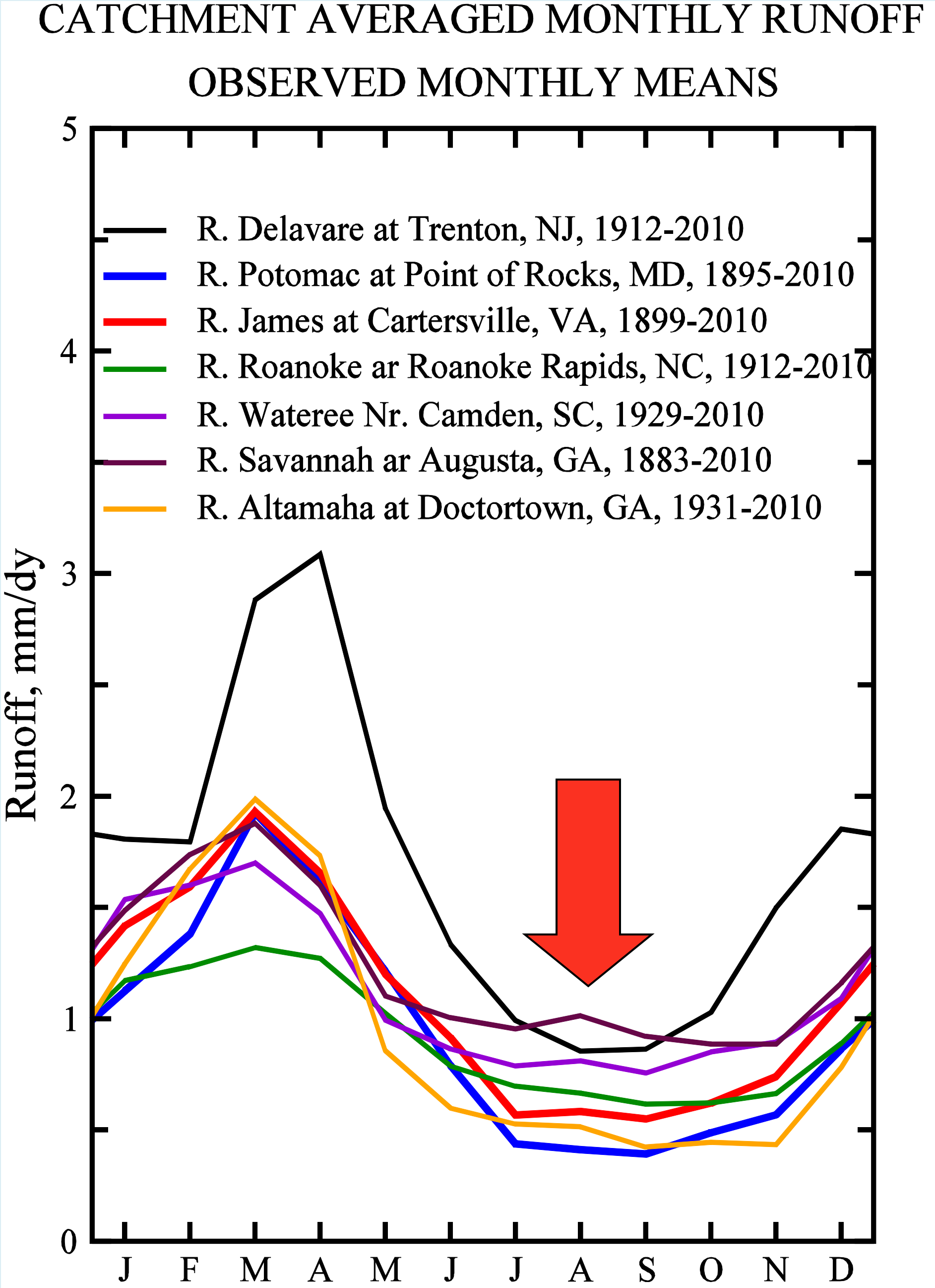


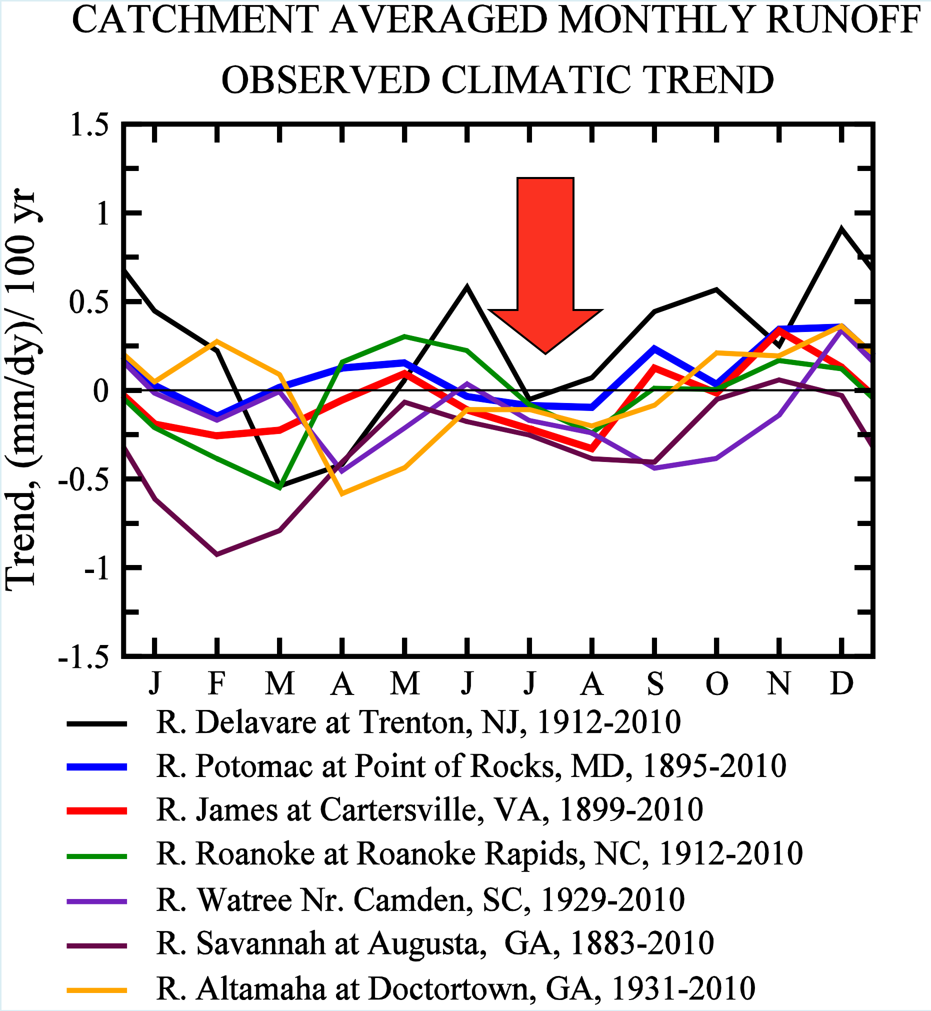
East Coast States: Observed Seasonal Variation of Mean Precipitation and Trend





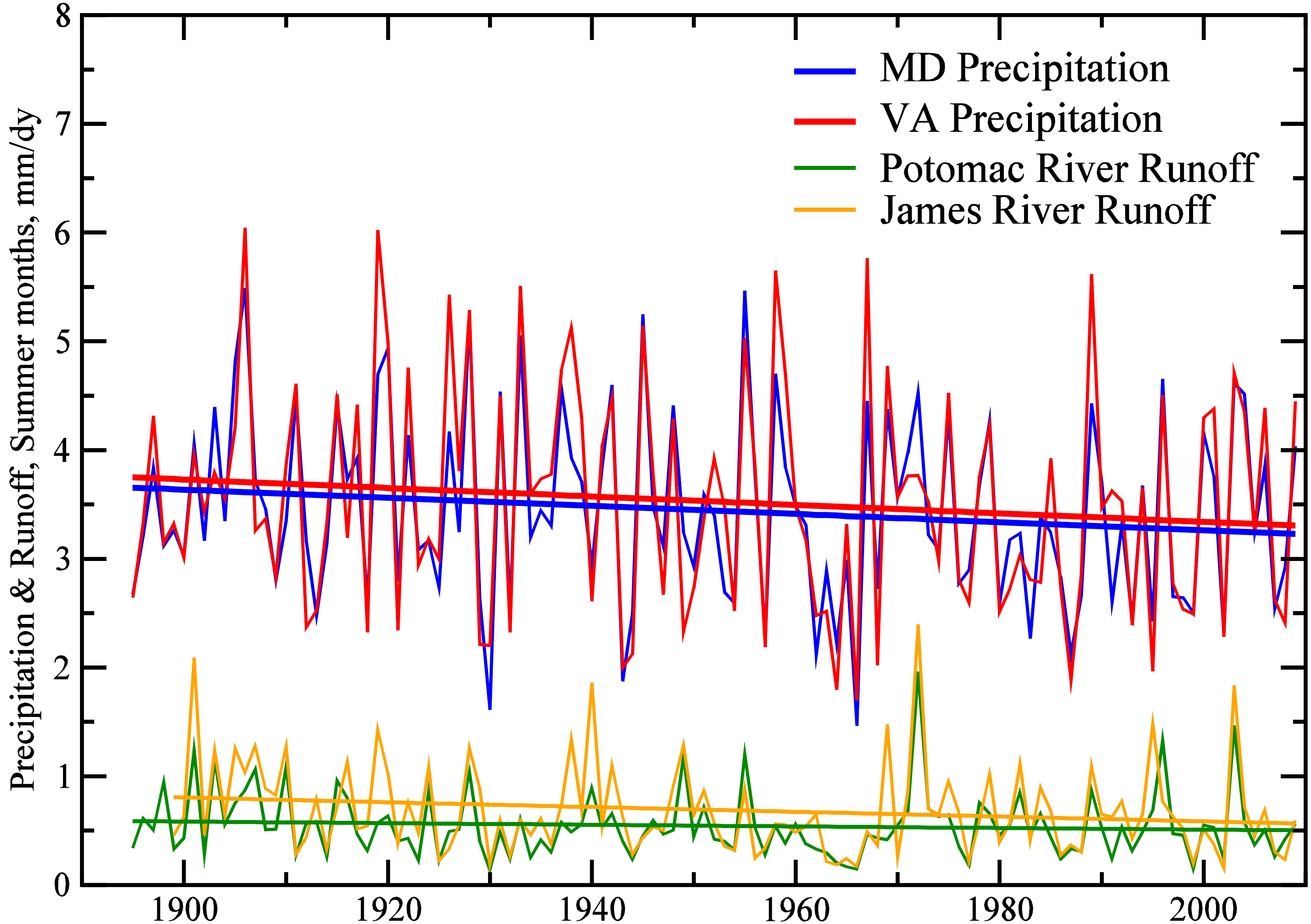
East Coast Rivers: Observed Seasonal Variations of Runoff and Trend

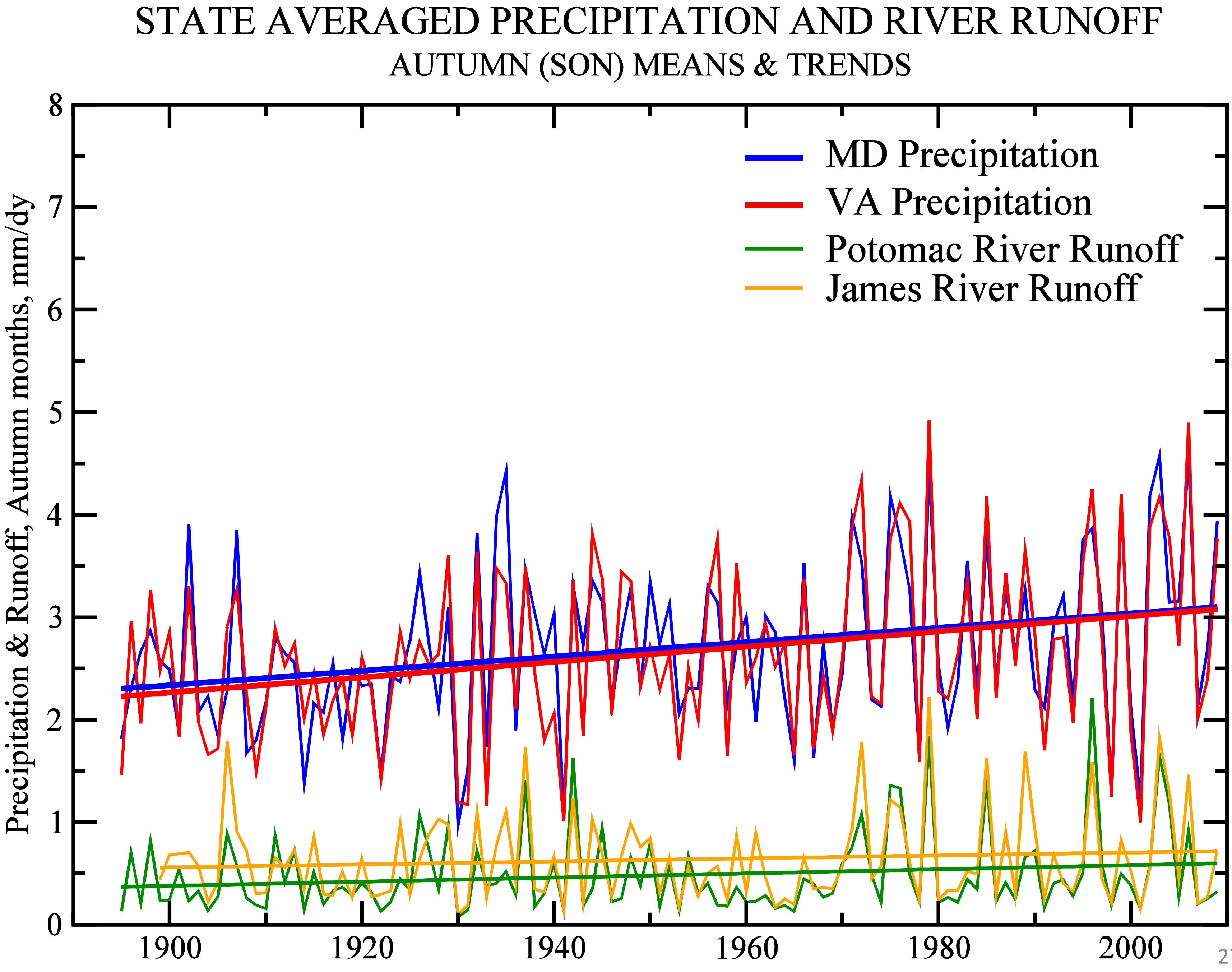


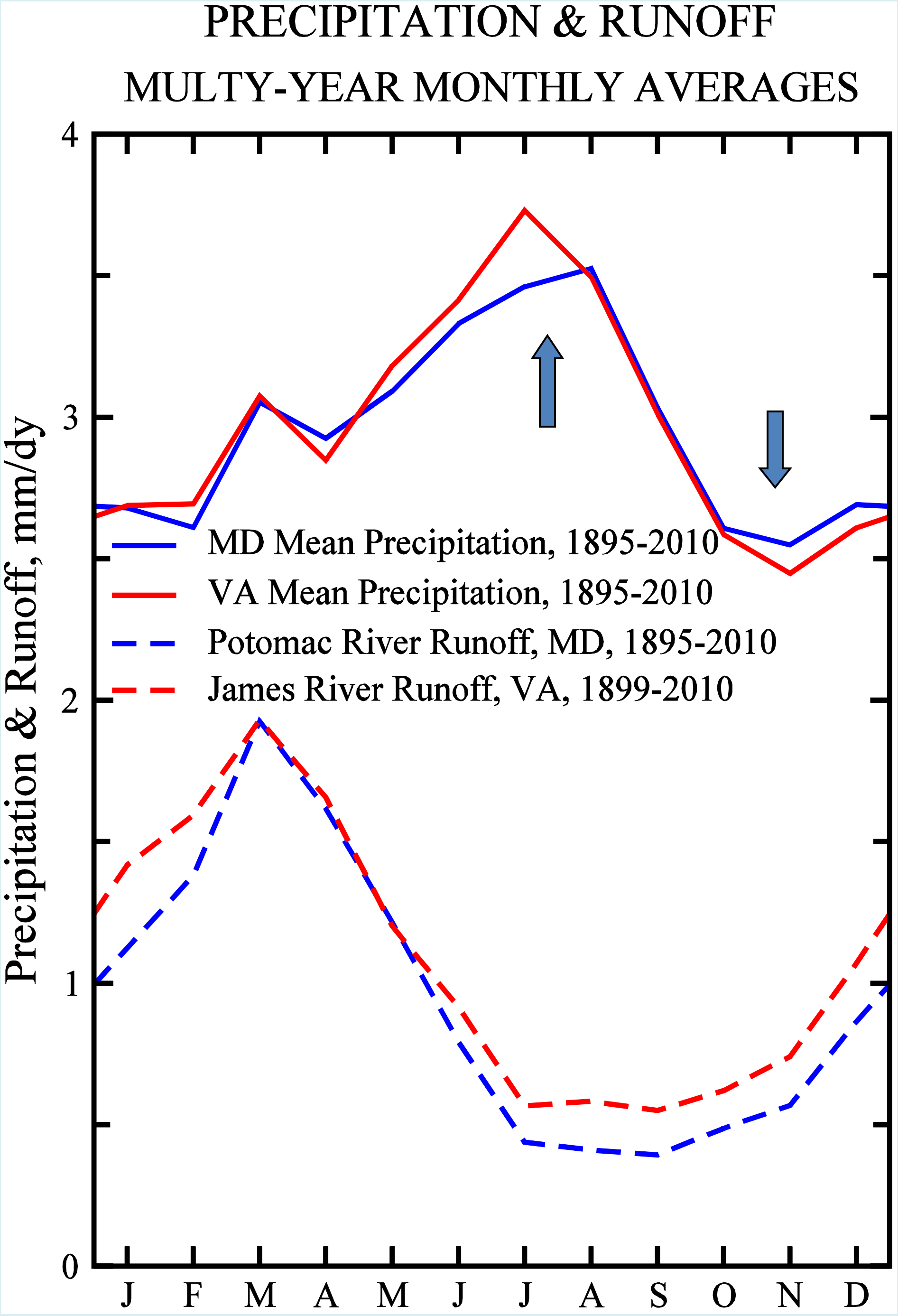


STATE AVERAGED PRECIPITATION AND RIVER RUNOFF

SUMMER (JJA) MEANS & TRENDS



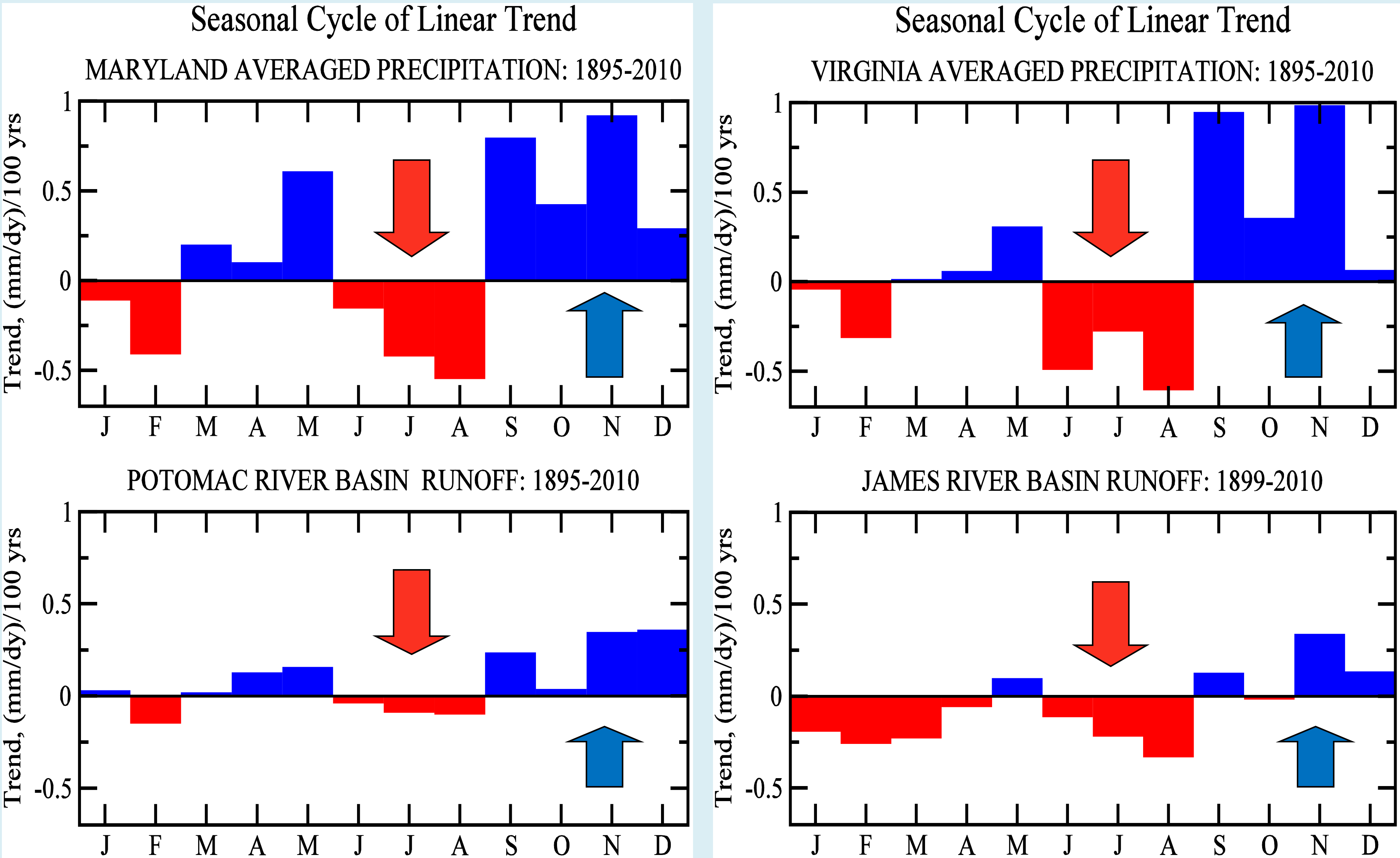

STATE AVERAGED PRECIPITATION AND RIVER RUNOFF
AUTUMN (SON) MEANS & TRENDS
MD Precipitation
VA Precipitation
Potomac River Runoff
James River Runoff
Precipitation & Runoff, Autumn months, mm/dy
0
1
2
3
4
5
6
7
8
1900
1920
1940
1960
1980
2000



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

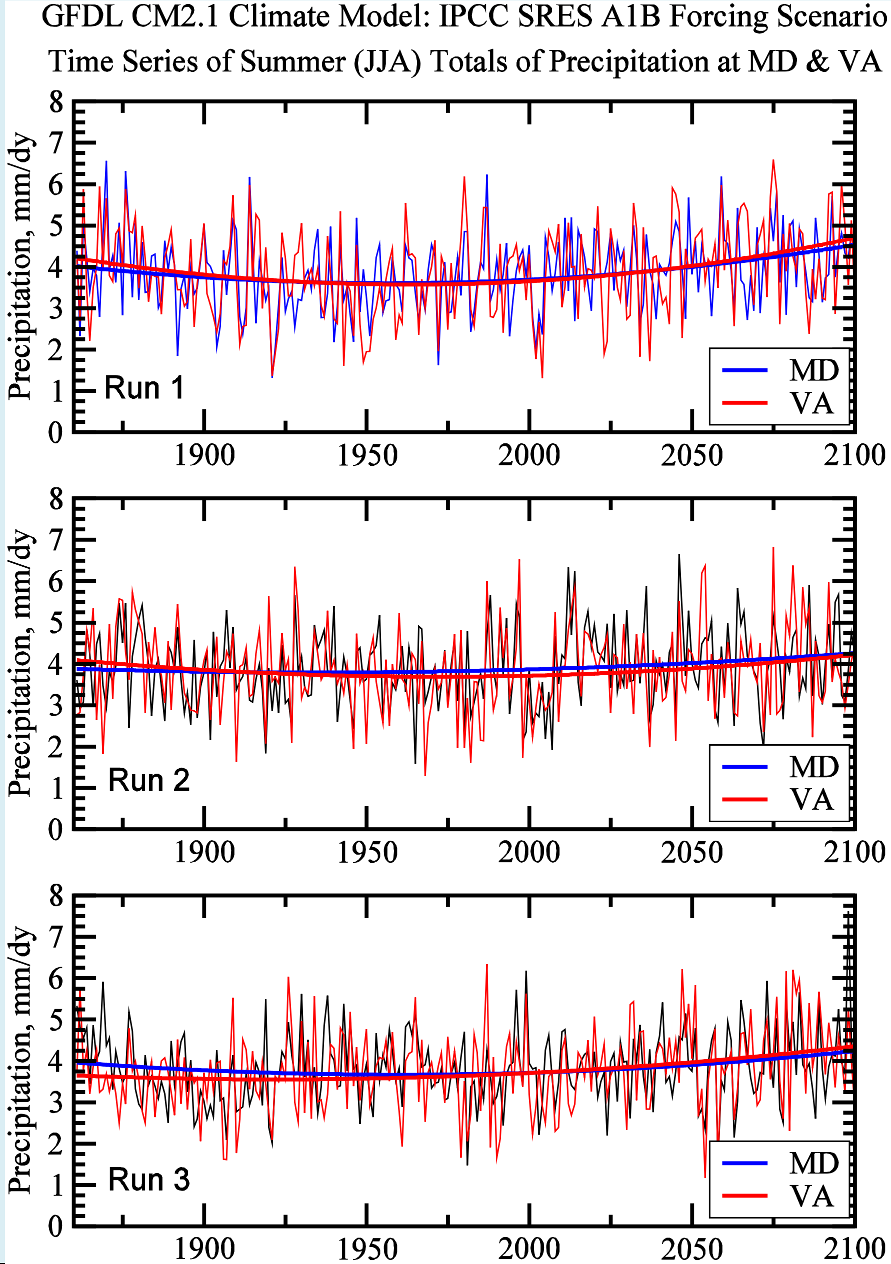
This makes our climate so nice.

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

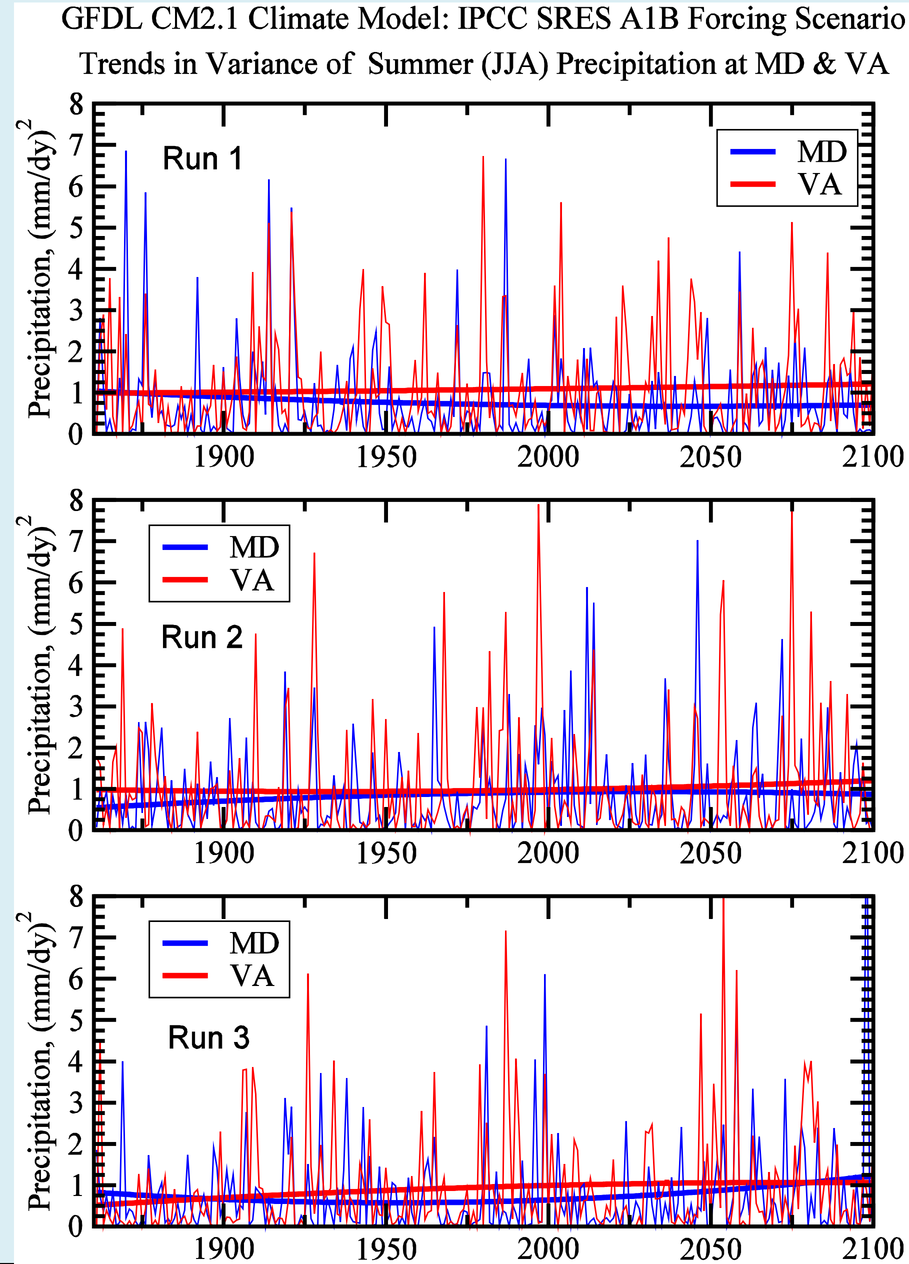


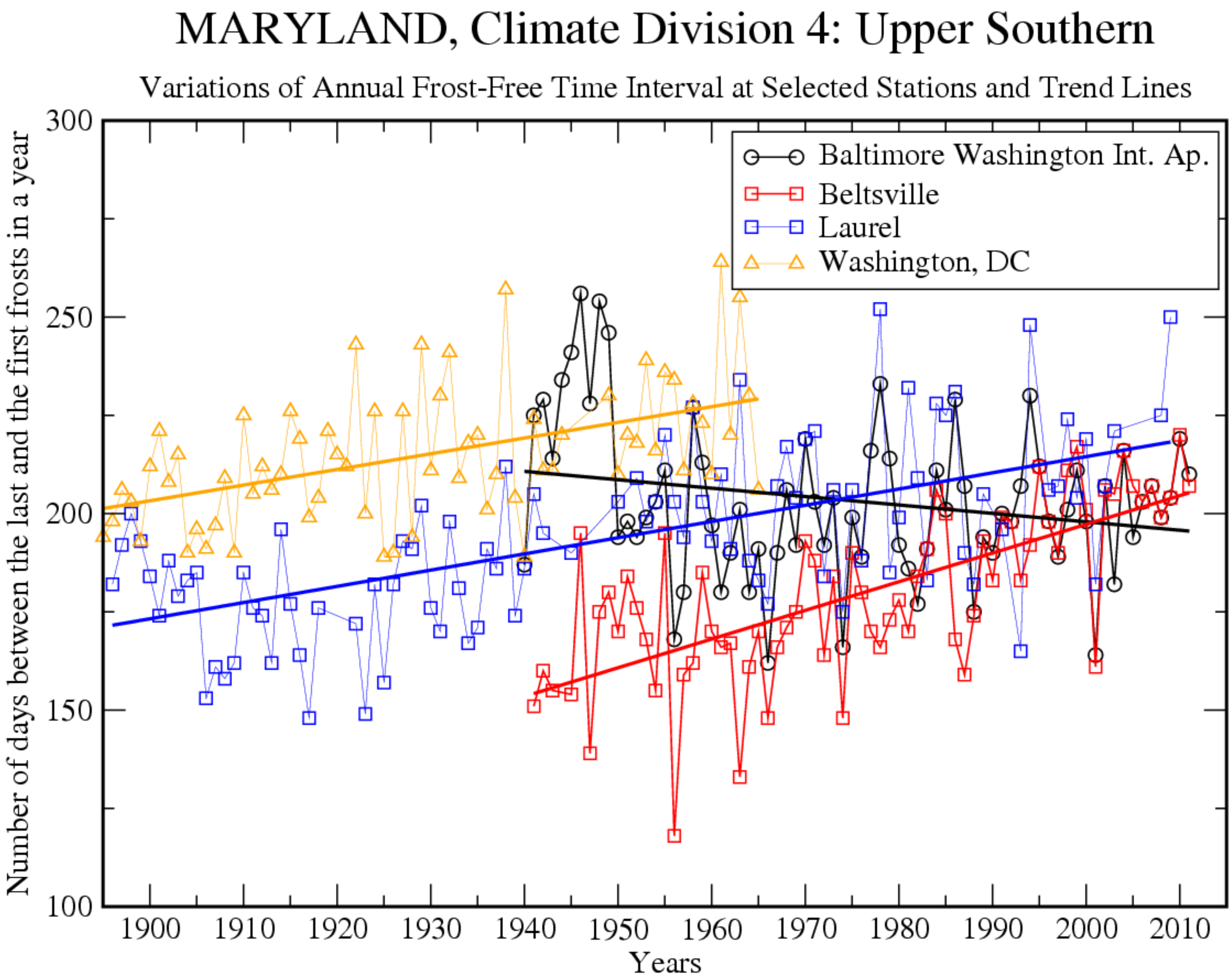
How well climatic models simulate future MD climate change and variability?

SUMMER

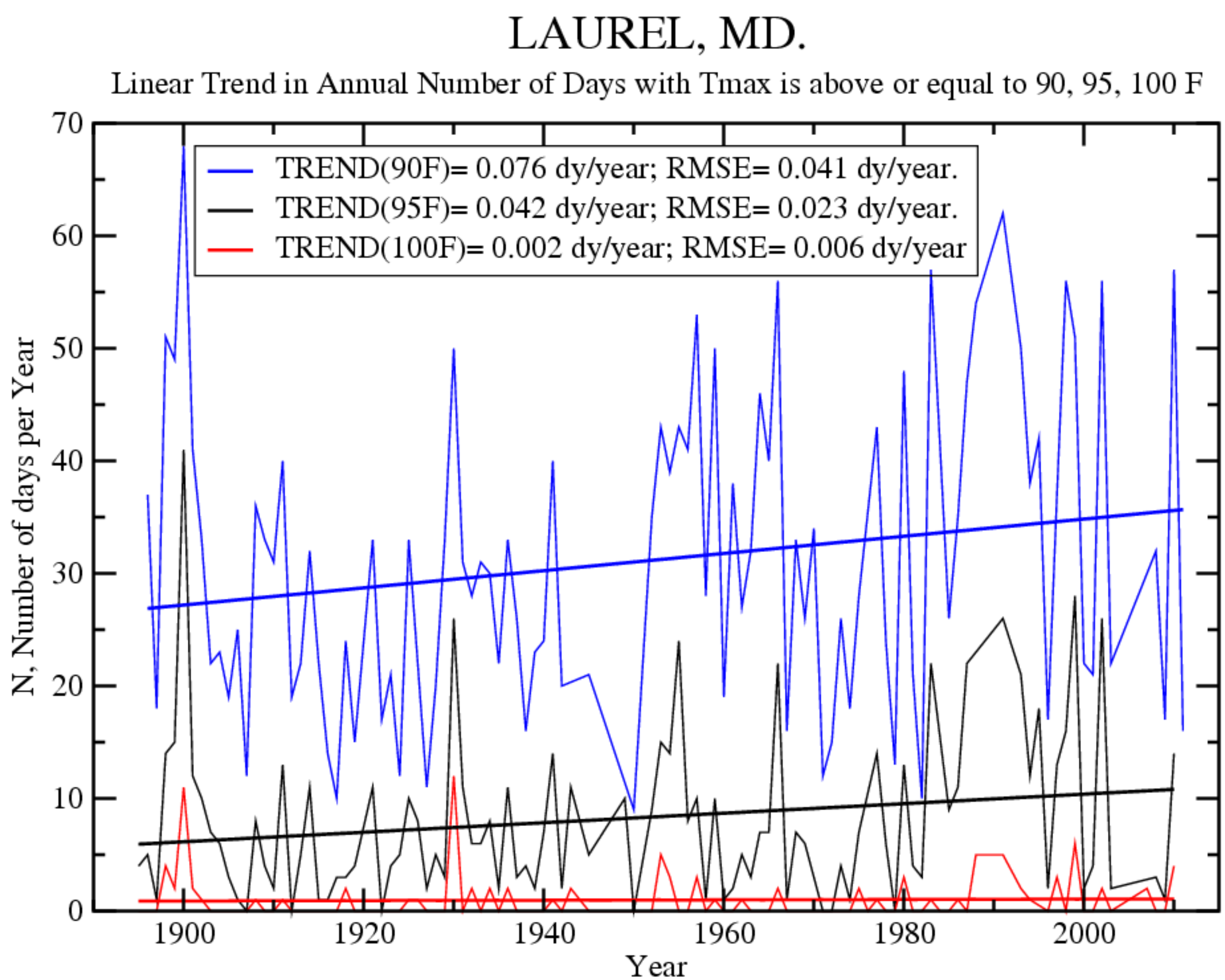


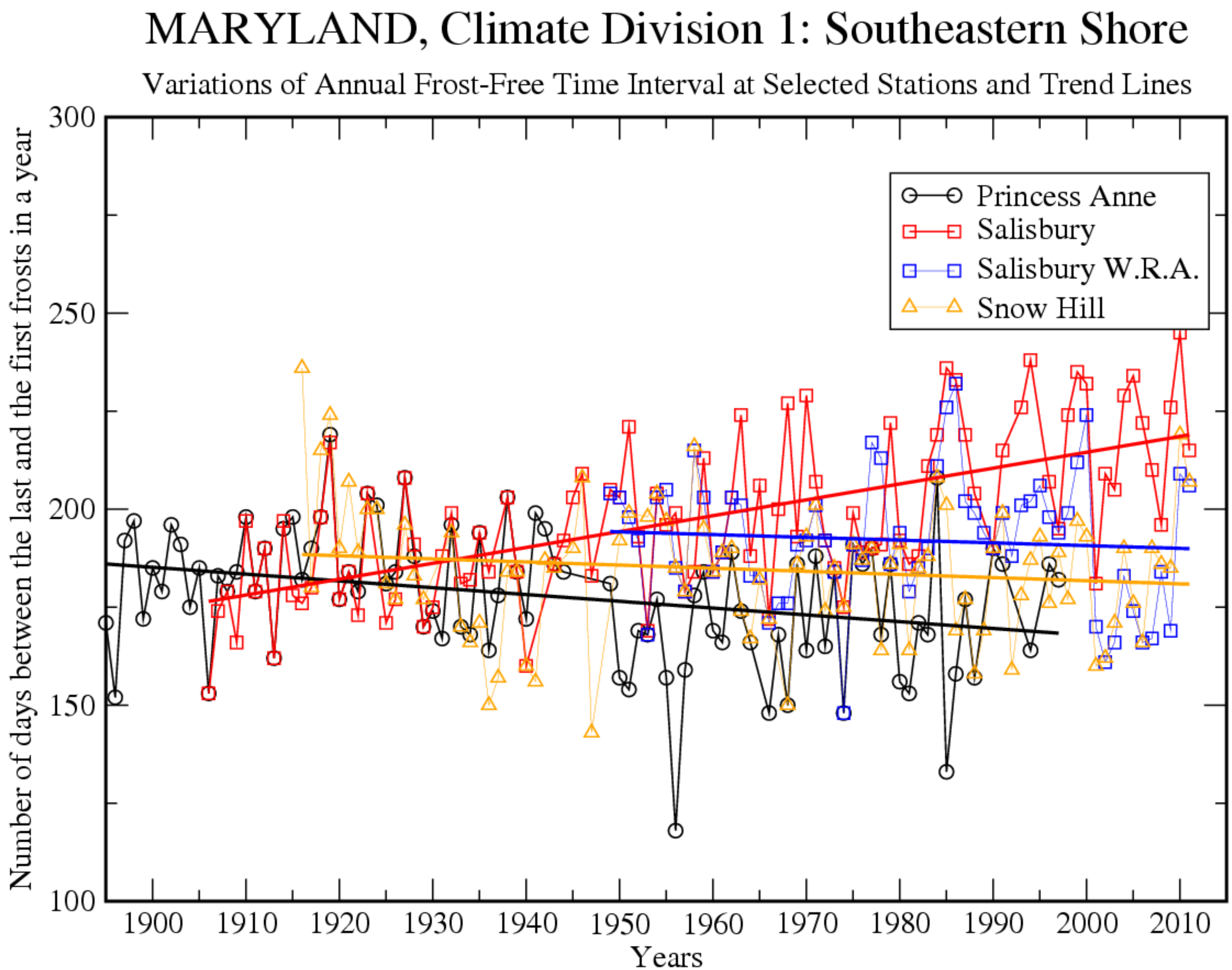
SUMMER



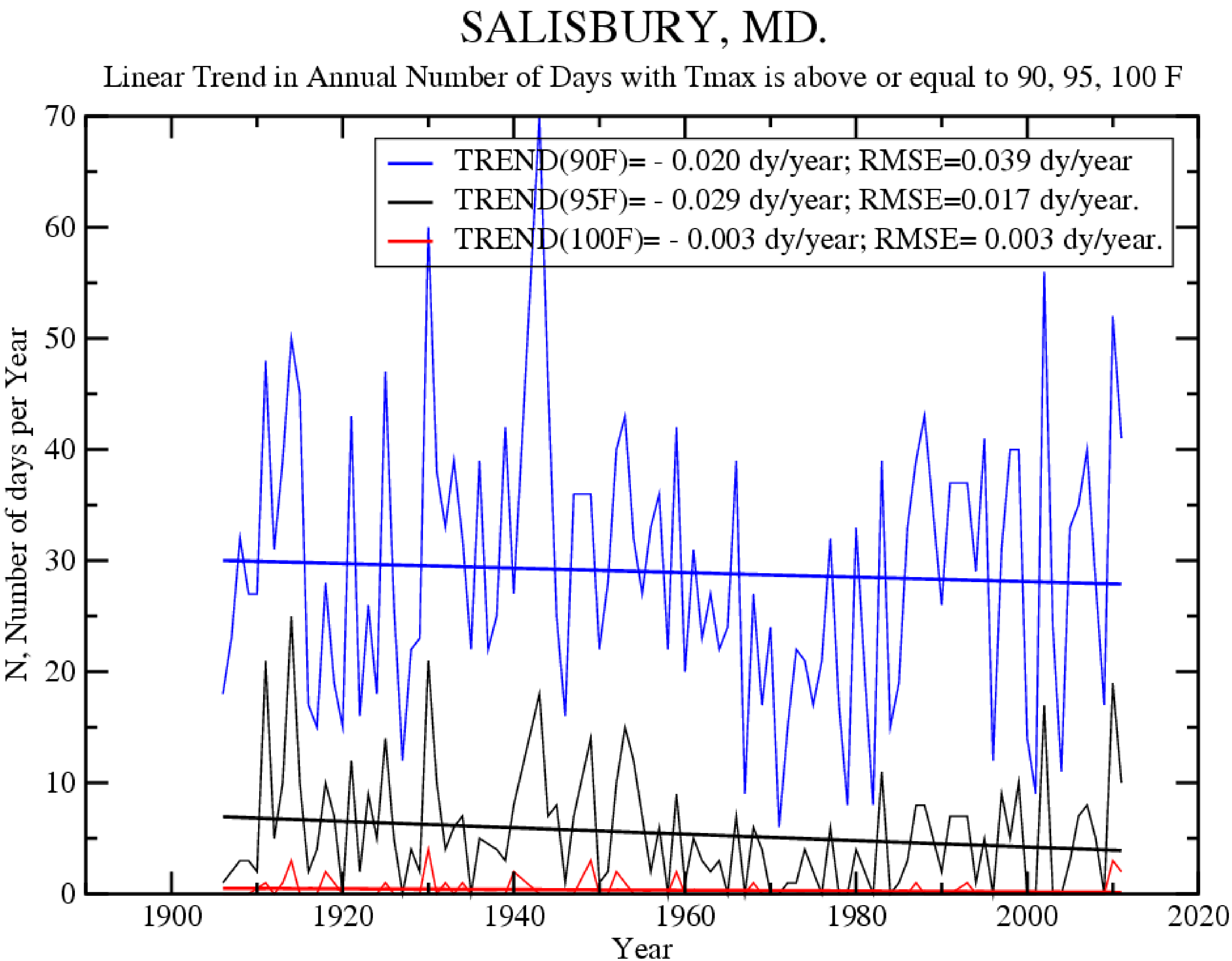


Frost Free Period is increasing at Urban stations and decreasing at BWI?


LAUREL, MD.
Linear Trend in Annual Number of Days with Tmax is above or equal to 90, 95, 100 F
TREND(90F)= 0.076 dy/year; RMSE= 0.041 dy/year.
TREND(95F)= 0.042 dy/year; RMSE= 0.023 dy/year.
TREND(100F)= 0.002 dy/year; RMSE= 0.006 dy/year
N, Number of days per Year
Year
0
10
20
30
40
50
60
70
1900
1920
1940
1960
1980
2000



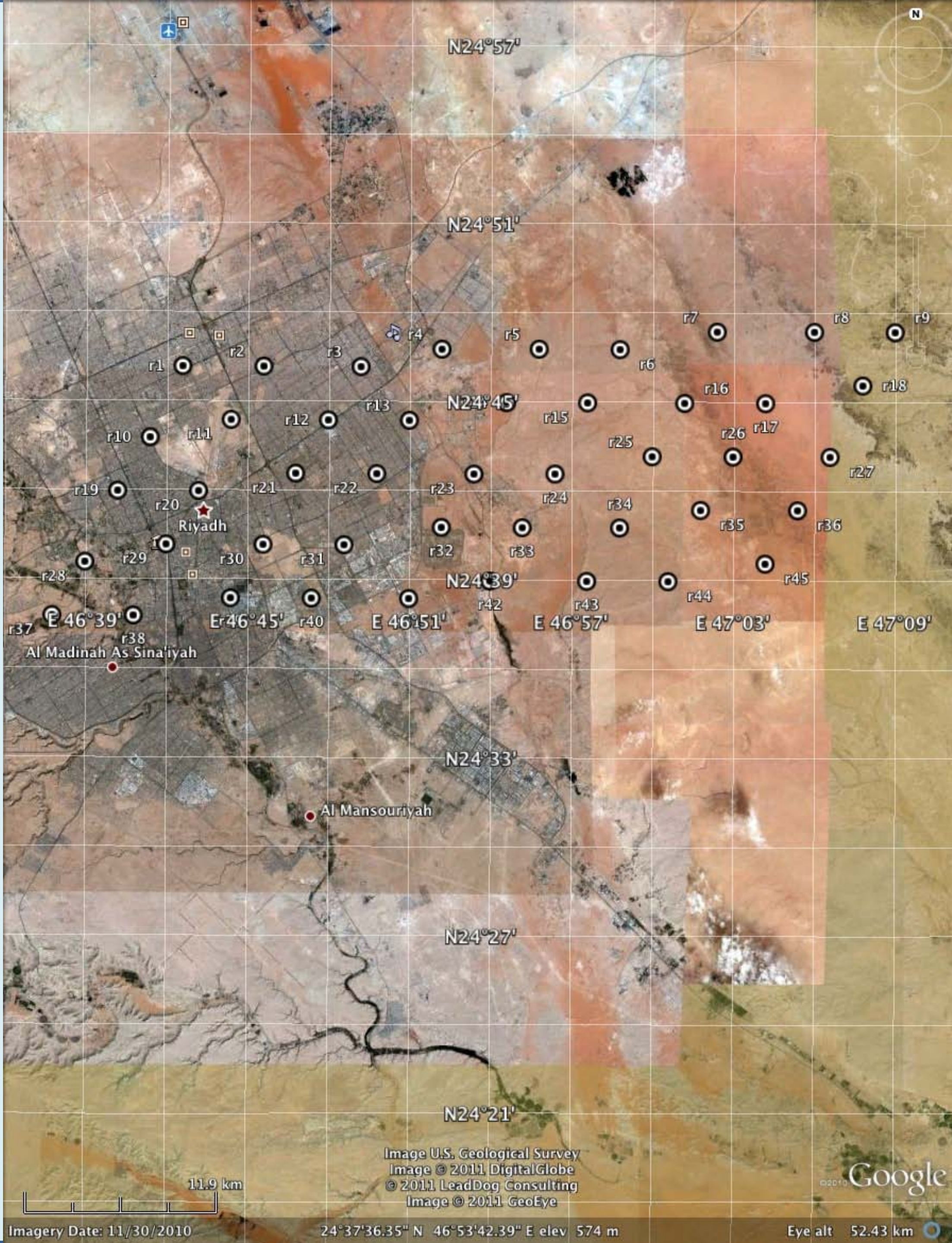
Decreasing of Frost Free Period.


SALISBURY, MD.
Linear Trend in Annual Number of Days with Tmax is above or equal to 90, 95, 100 F
TREND(90F)= - 0.020 dy/year; RMSE=0.039 dy/year
TREND(95F)= - 0.029 dy/year; RMSE=0.017 dy/year.
TREND(100F)= - 0.003 dy/year; RMSE= 0.003 dy/year.
N, Number of days per Year
Year
0
10
20
30
40
50
60
70
1900
1920
1940
1960
1980
2000
2020

Cities in Desert:
URBANIZATION MAKES LOCAL CLIMATE BETTER

RIYADH, SAUDI ARABIA

<LSTurban> - <LSTdesert>



<u>Urban pixels:</u>

1,2,12,21,22,29,31,39.

MEAN ANNUAL URBAN

<LST> = **27.8°C**

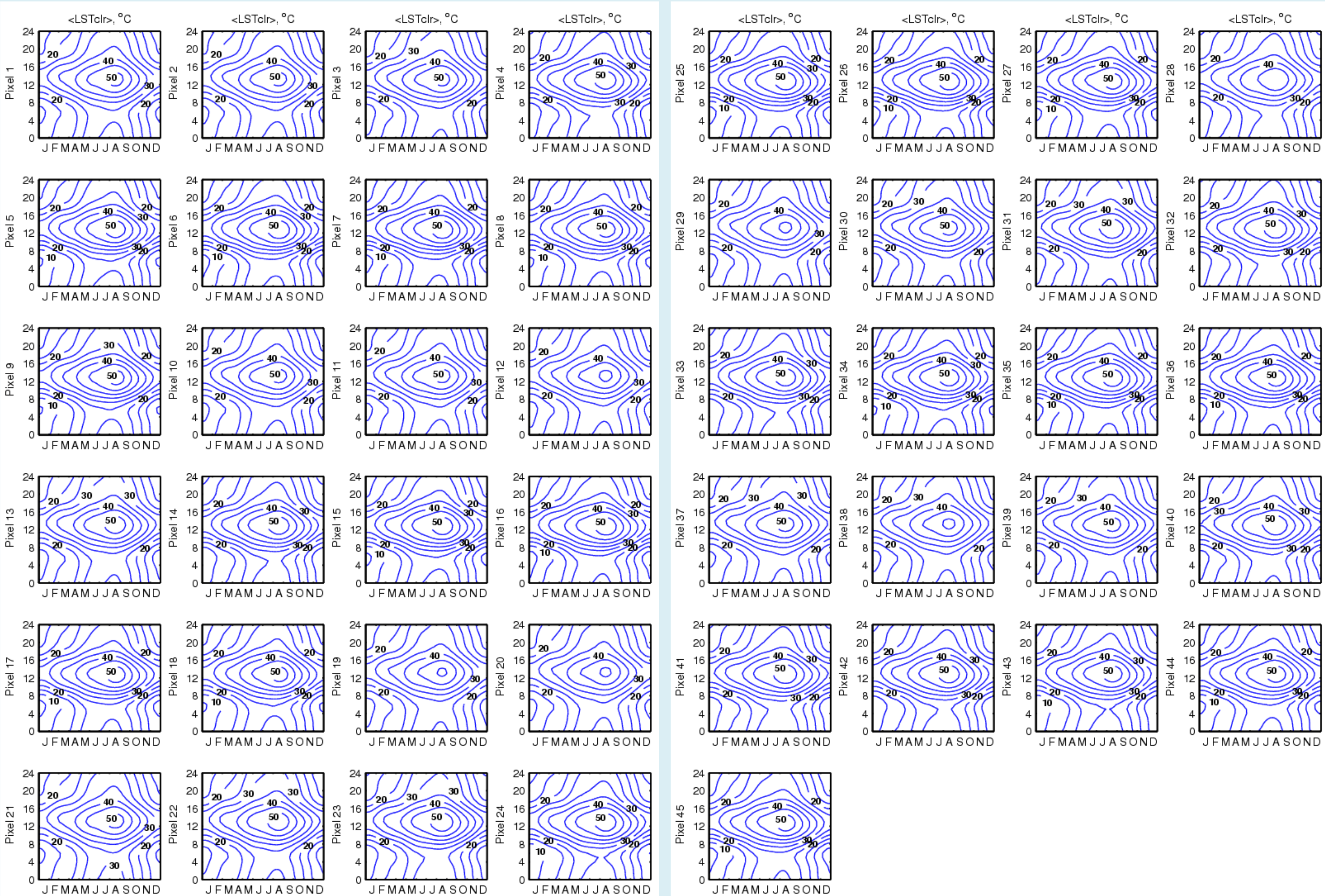
<u>Desert pixels:</u>

6,7,8,9,15,16,17,18,25,26,27,34,35,36,44,45

MEAN ANNUAL DESERT

<LST> = **25.0°C**

LST_{urb}-LST_{dsrt} = 2.8°C


<LSTclr>, °C
Pixel 1
Pixel 2
Pixel 3
Pixel 4
Pixel 5
Pixel 6
Pixel 7
Pixel 8
Pixel 9
Pixel 10
Pixel 11
Pixel 12
Pixel 13
Pixel 14
Pixel 15
Pixel 16
Pixel 17
Pixel 18
Pixel 19
Pixel 20
Pixel 21
Pixel 22
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Pixel 24
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Pixel 28
Pixel 29
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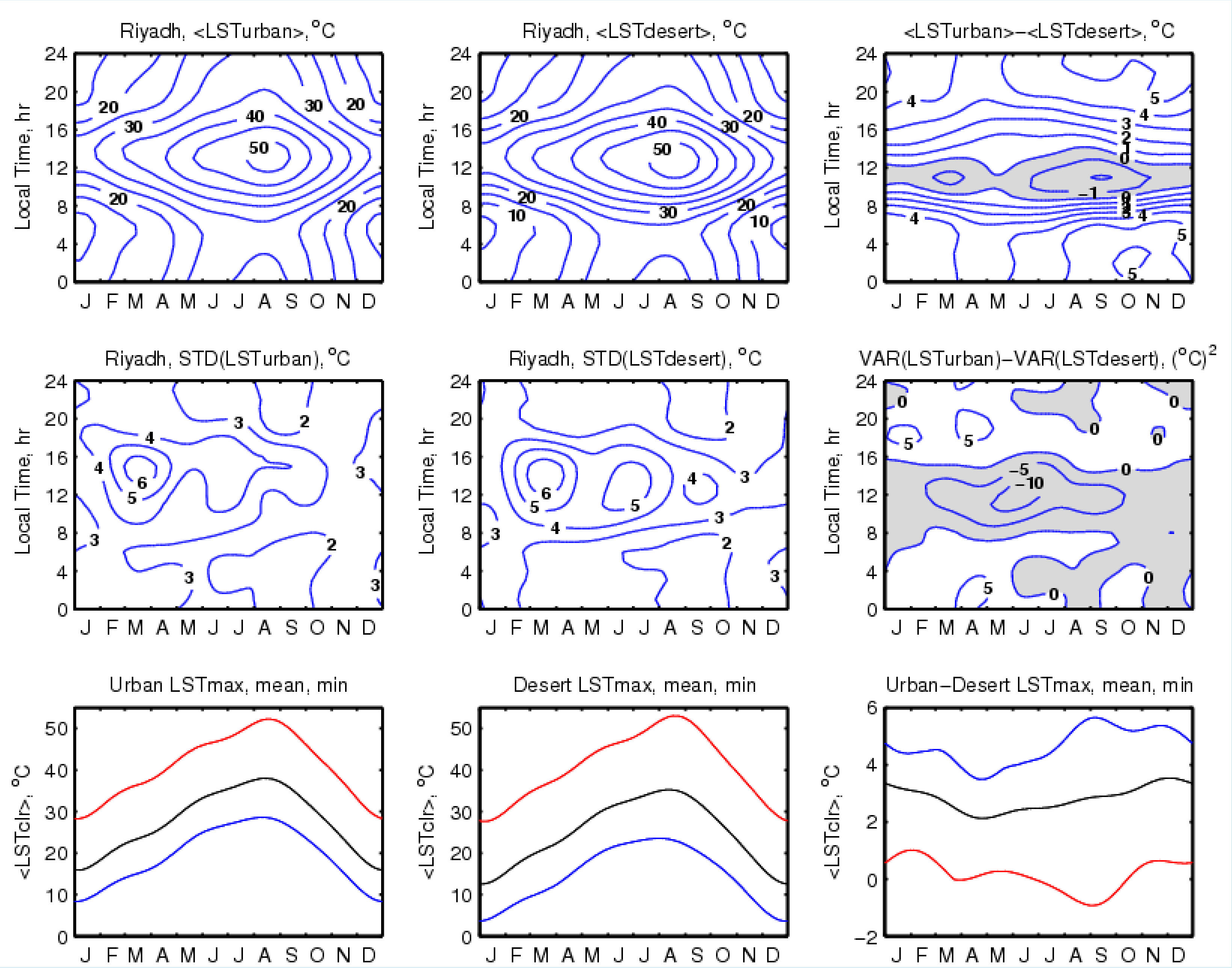
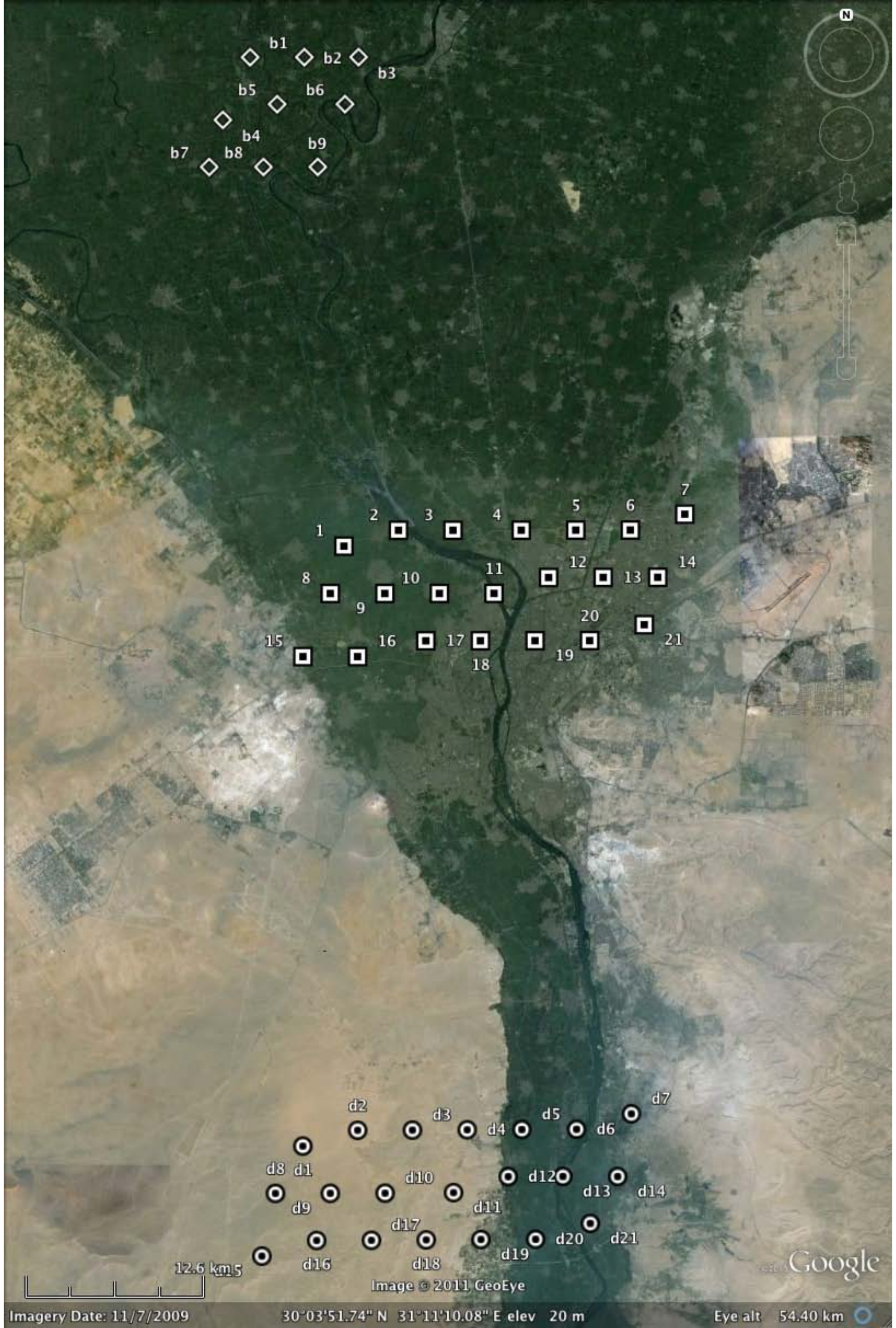
Pixel 31
Pixel 32
Pixel 33
Pixel 34
Pixel 35
Pixel 36
Pixel 37
Pixel 38
Pixel 39
Pixel 40
Pixel 41
Pixel 42
Pixel 43
Pixel 44
Pixel 45
0 4 8 12 16 20 24
J F M A M J J A S O N D

Estimates based on approximation with number of harmonics K=N=4



CAIRO, EGIPT

<LSTurban> - <LSTdesert>

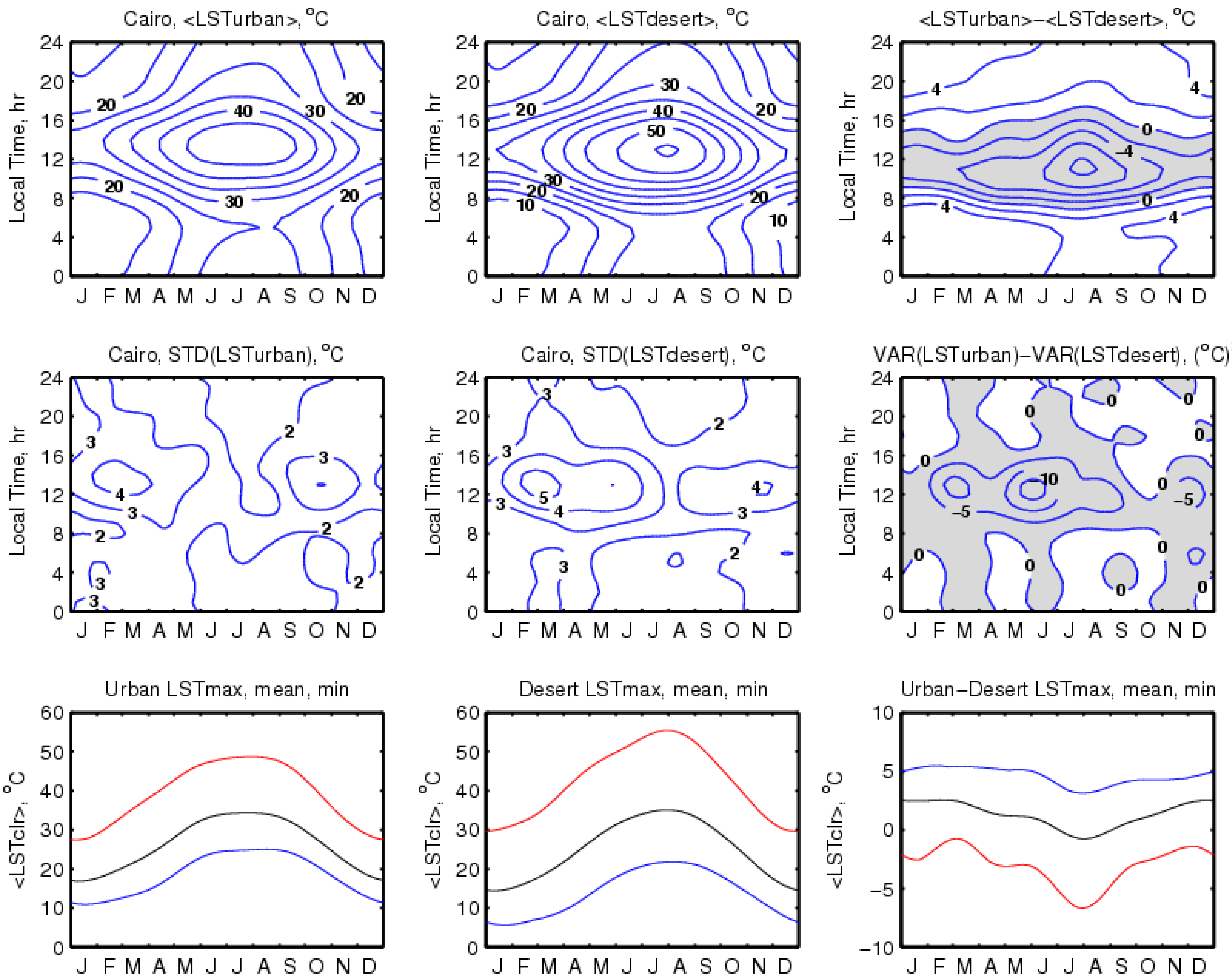


URBAN ## 13,14,19,20

DESERT ## d1, d2, d3, d8, d10, d15, d16, d17

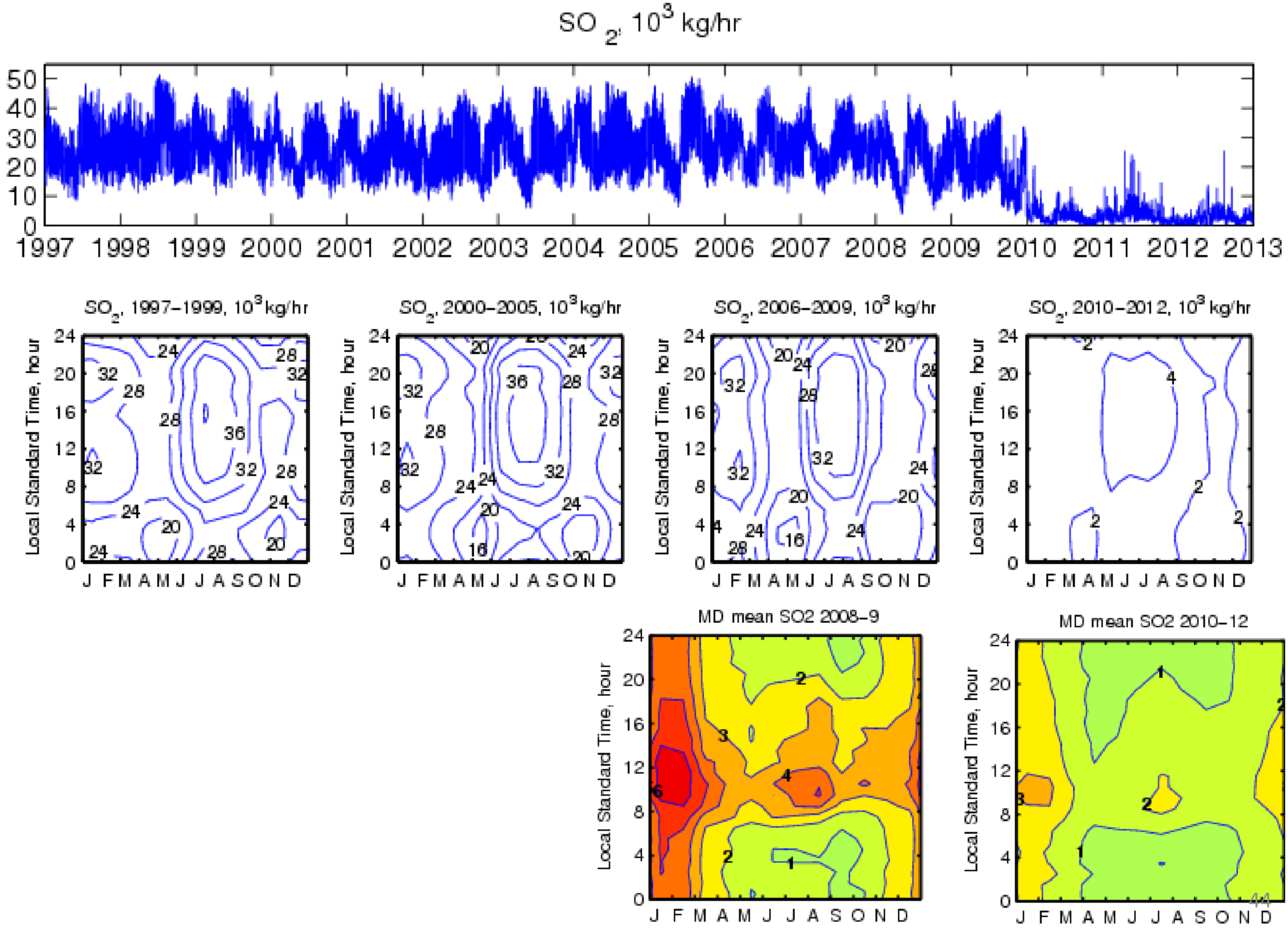
ANNUAL MEAN DIFFERENCES:

LSTurb-LSTdsrt = 1.3K


Cairo, <LSTurban>, °C
Cairo, <LSTdesert>, °C
<LSTurban>−<LSTdesert>, °C
Cairo, STD(LSTurban), °C
Cairo, STD(LSTdesert), °C
VAR(LSTurban)−VAR(LSTdesert), (°C)²
Urban LSTmax, mean, min
Desert LSTmax, mean, min
Urban−Desert LSTmax, mean, min
Local Time, hr
<LSTclr>, °C
J F M A M J J A S O N D

AIR POLLUTION IN MARYLAND

MARYLAND POWER PLANTS EMISSIONS



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THANK YOU!