

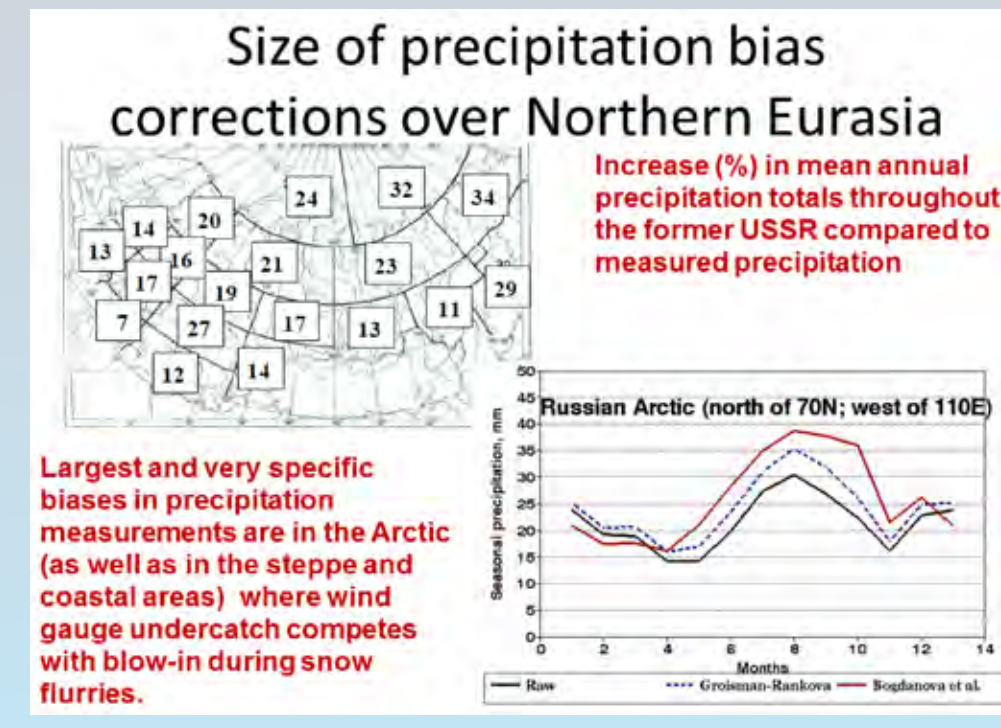
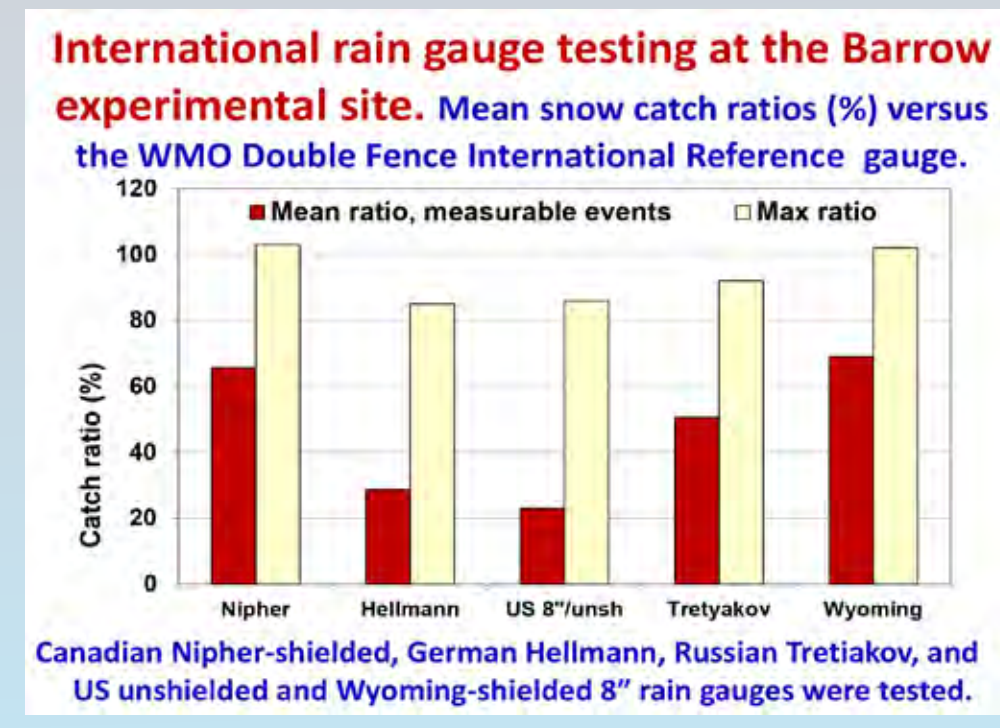
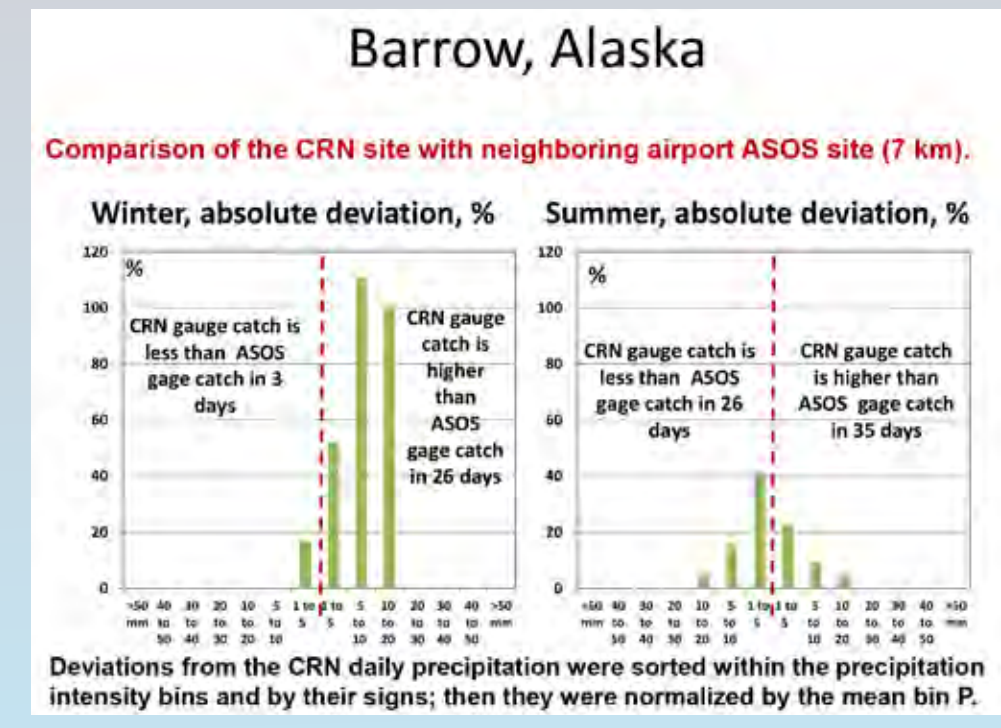
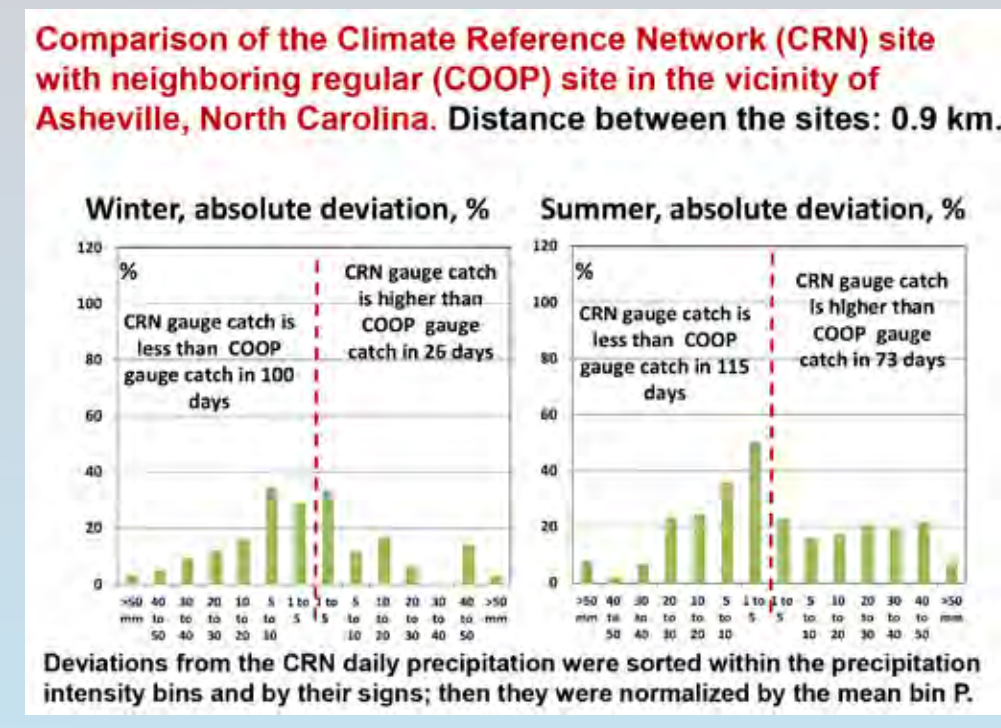
Precipitation Intensity and Events Distribution Changes in the Extratropics

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Part 1: Precipitation measurements

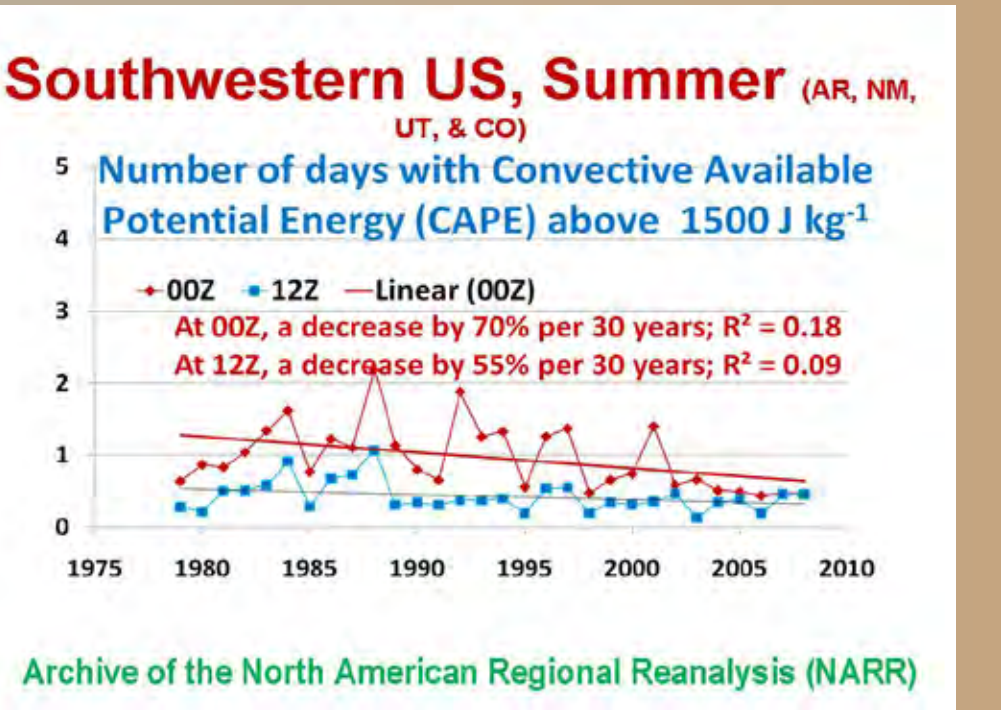
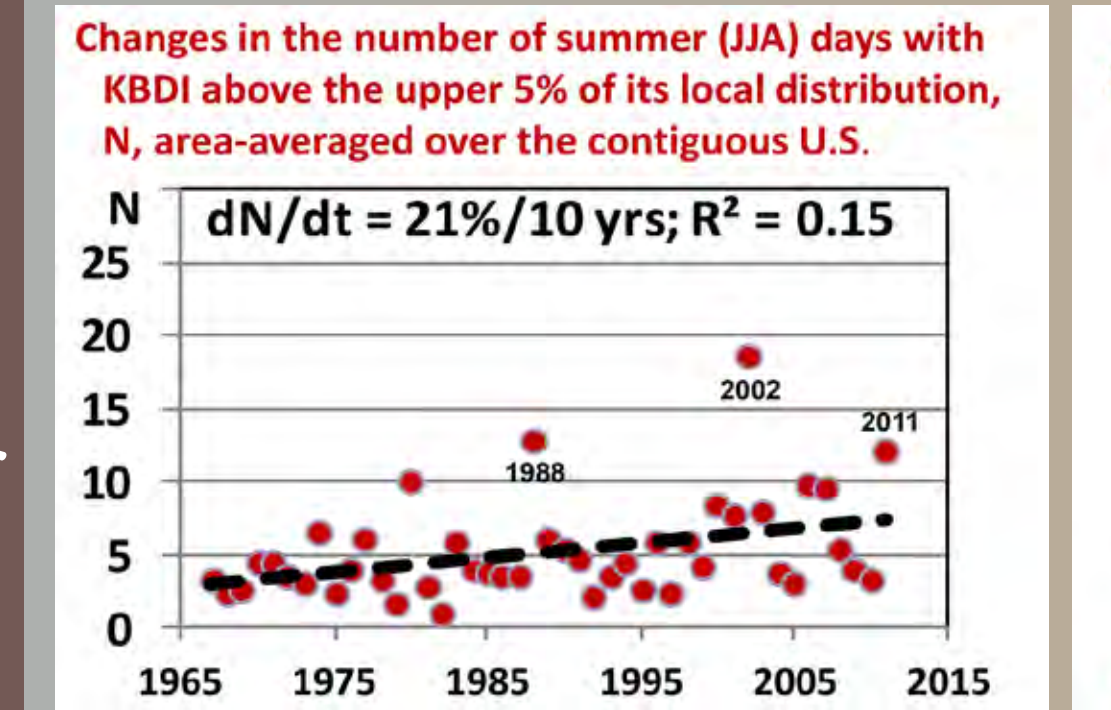
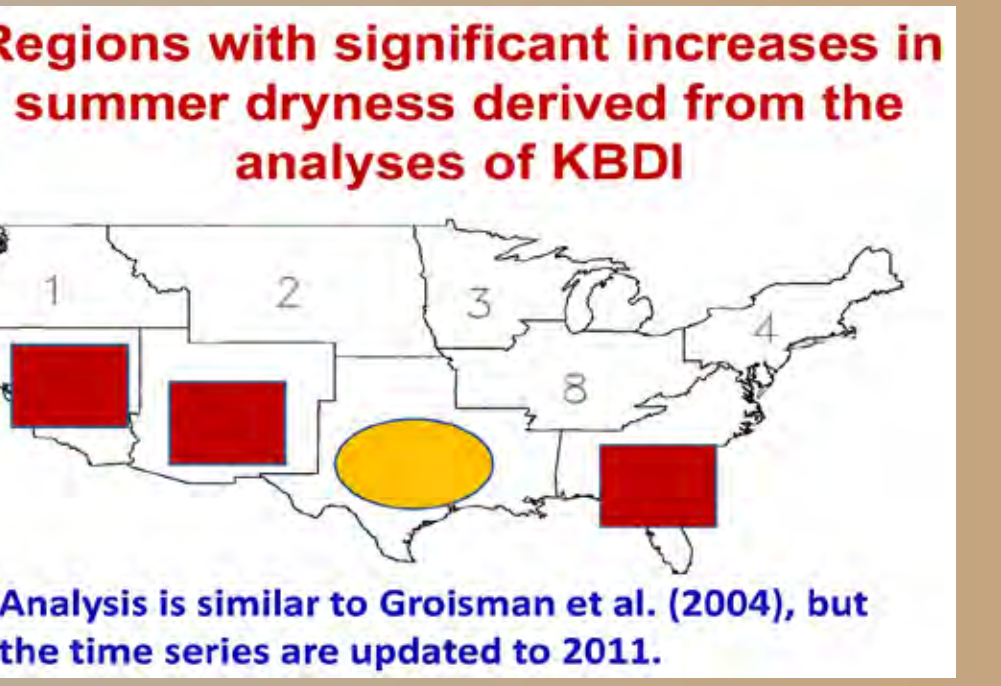
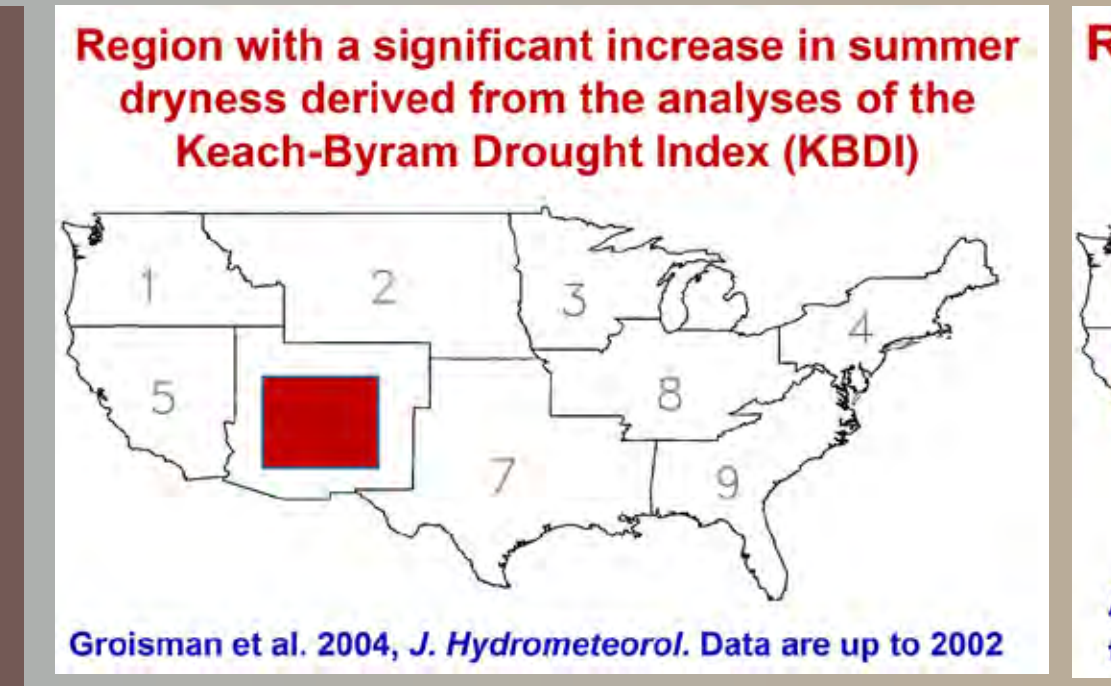
Problems with precipitation measurements

- No WMO standards for precipitation
- A sophisticated function of wind at the gauge orifice, weather type, gauge type, and observational practice is reported instead of "ground true" values (especially, for frozen precipitation)
- Enormous need for the data (i.e., dense network)
- Effects of climatic and practice changes
- Must make changes nationwide and secure homogeneity



Wright, C.K. et al., 2009: *Environ. Res. Lett.*, 4, 045020
"Reanalysis data underestimate significant changes in growing season weather in Kazakhstan" based on in situ network acquired by NCEP in 2007.

- Accumulated growing season precipitation (APPT) and accumulated growing degree-days (AGDD) were significantly decreased (APPT) and increased (AGDD) over the 2000-2005 period. Pervasive drought conditions and higher temperature excursions were the likely drivers of APPT declines observed in Kazakhstan over the same period.
- Comparison of the APPT and AGDD trends with results from trend analysis of gridded precipitation from the Global Precipitation Climatology Centre (GPCP) Full Data Reanalysis v4 and gridded daily near surface air temperature from the NCEP Reanalysis (NCEP R2) shows substantial deviation between the station and the reanalysis trends.
- Conclusion: GPCP and NCEP data substantially underestimate the geographic extent of recent drought in Kazakhstan.



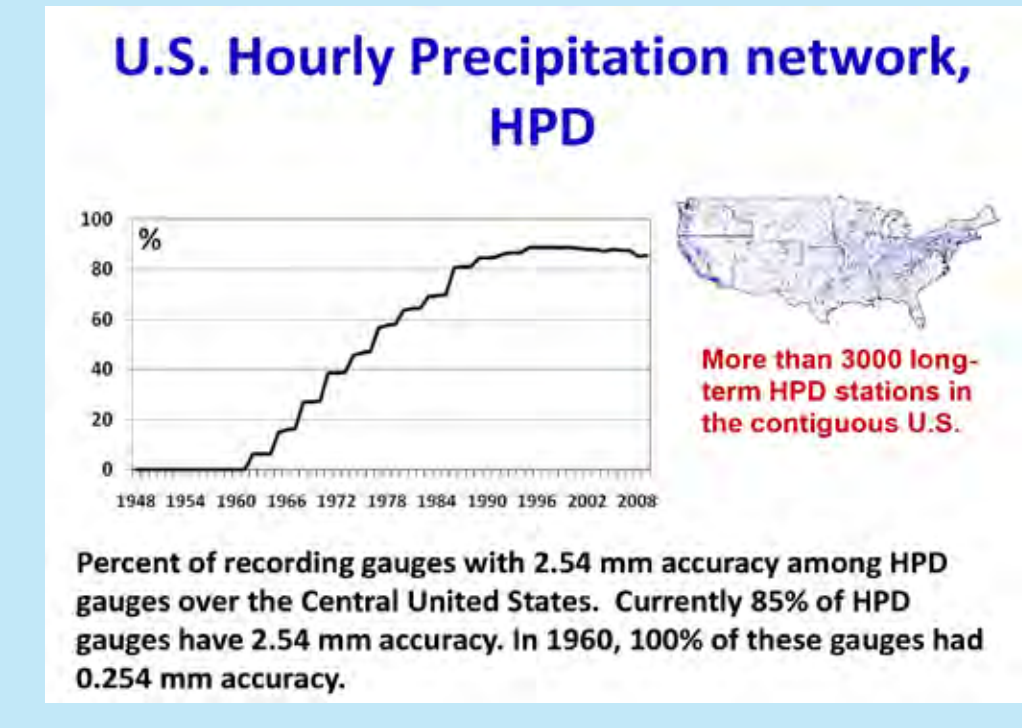
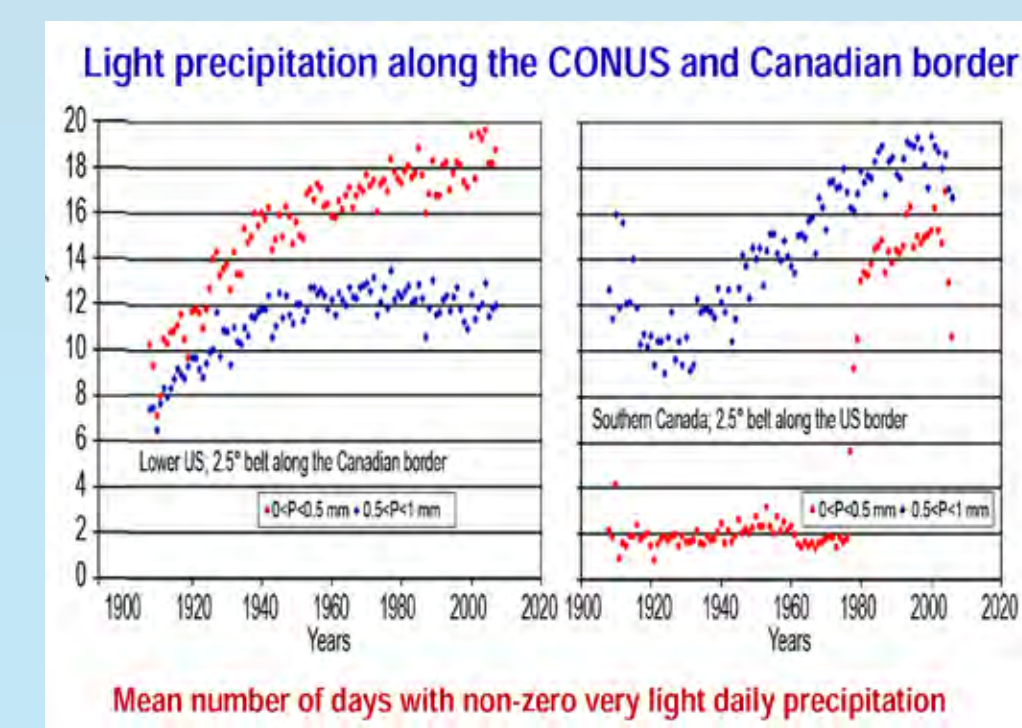
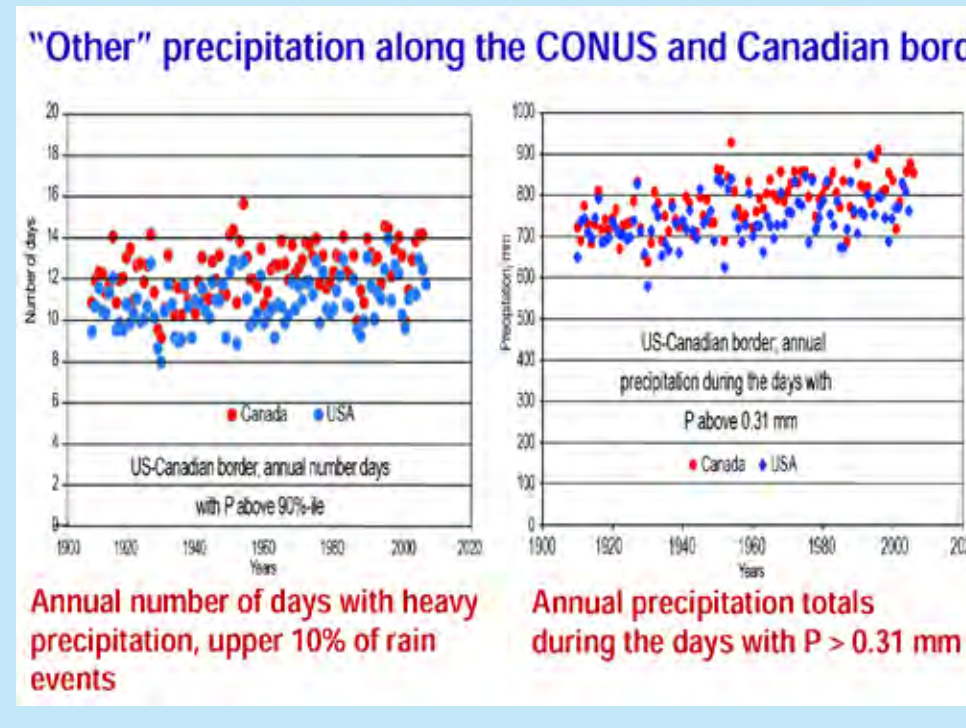
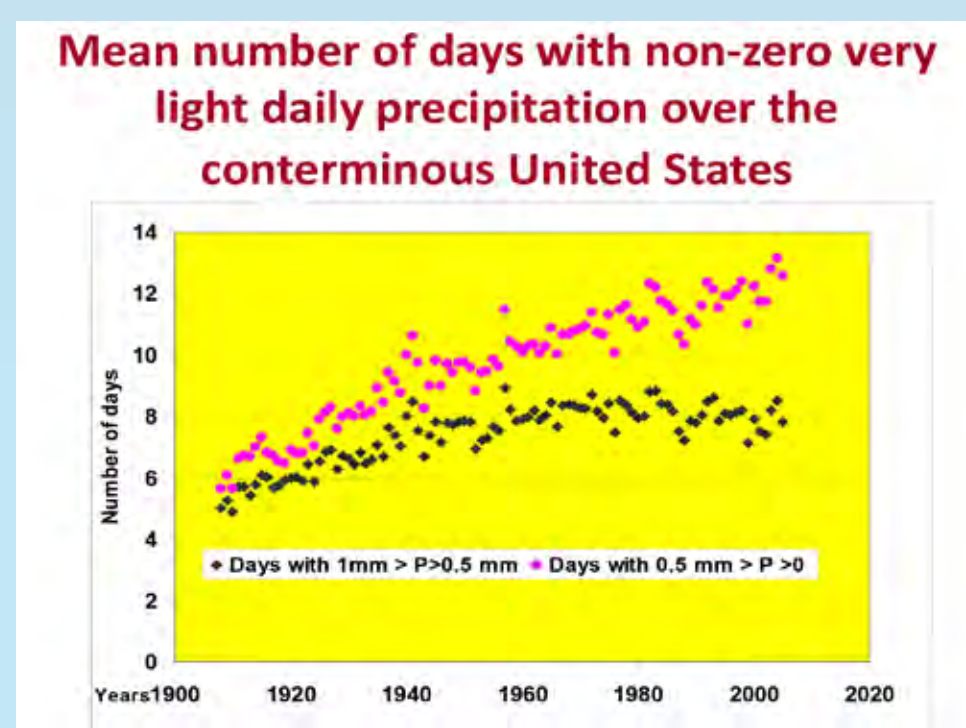
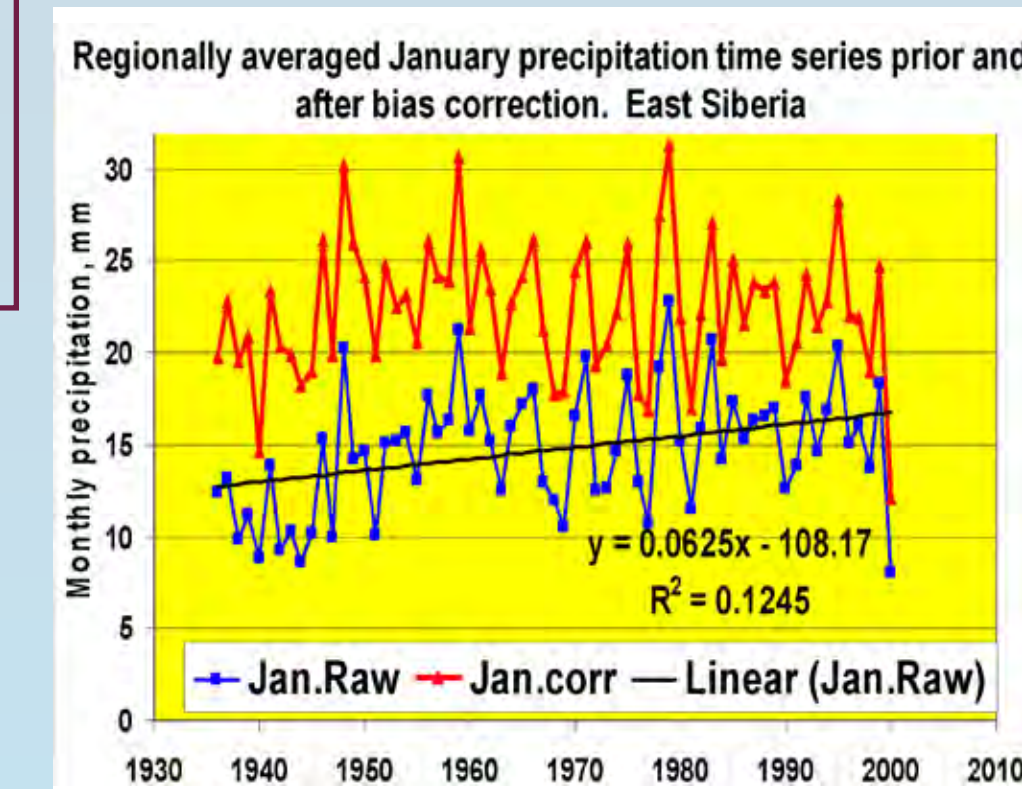
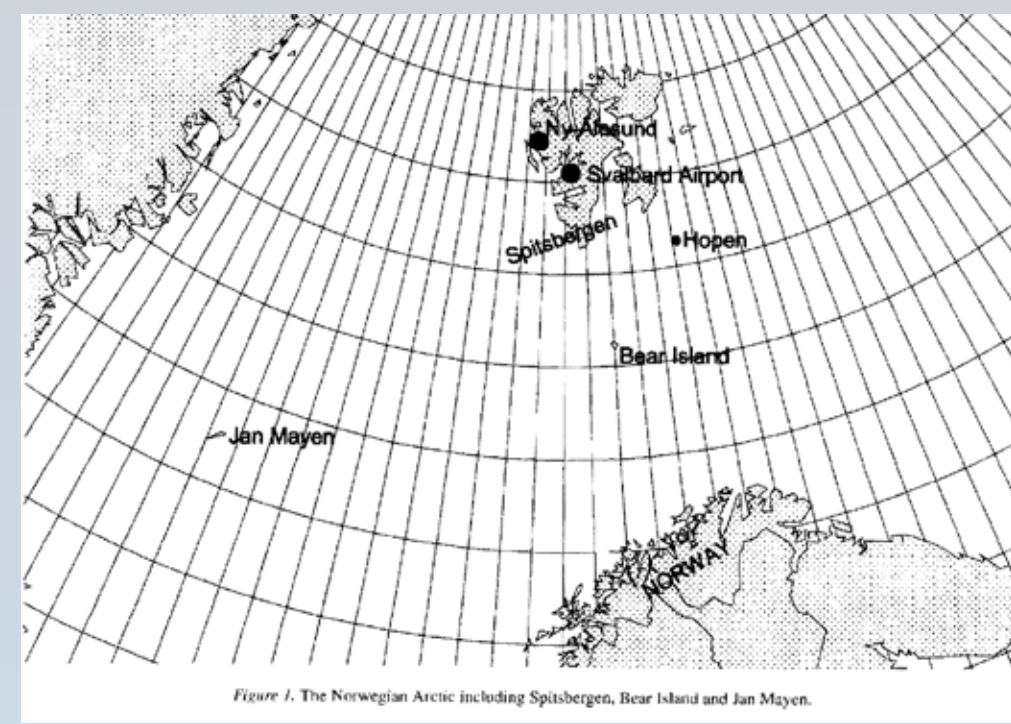
Part 2: Changes, true or false?

Changes in biases associated with climate change:

Example Norwegian Arctic

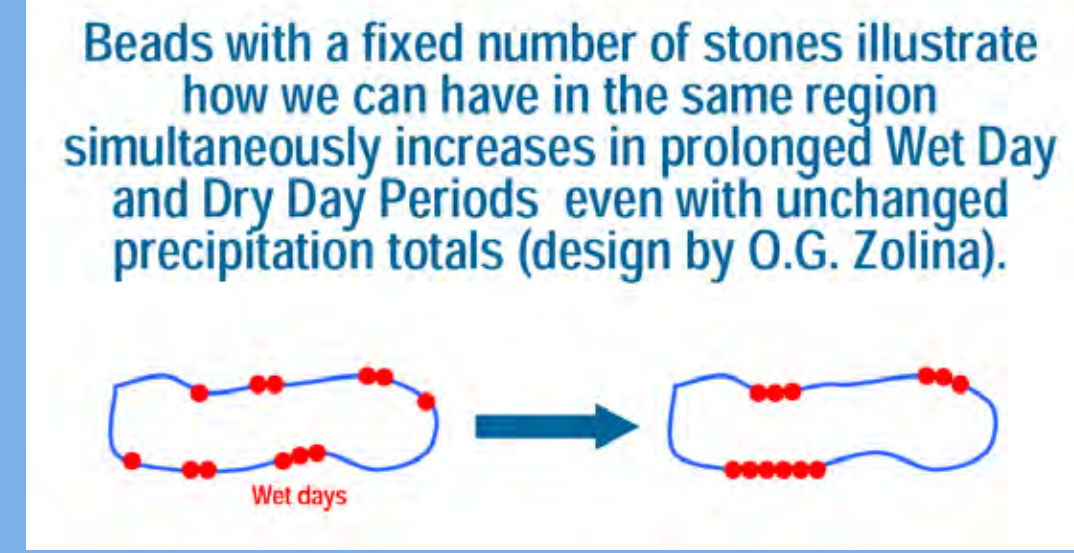
- In the Svalbard region the "true" annual precipitation is more than 50% higher than the measured values. The undercatch is substantially larger for solid than for liquid precipitation
- Measured annual precipitation in the Svalbard region and at Jan Mayen has increased substantially (20-30%) during the latest 7-8 decades
- About half of this increase is fictitious due to redistribution of liquid and frozen precipitation with the regional warming.

Source: Førland, E. J. and I. Hanssen-Bauer, 2000: Increased precipitation in the Norwegian Arctic: True or false? *Climatic Change*, 46, 485-509.

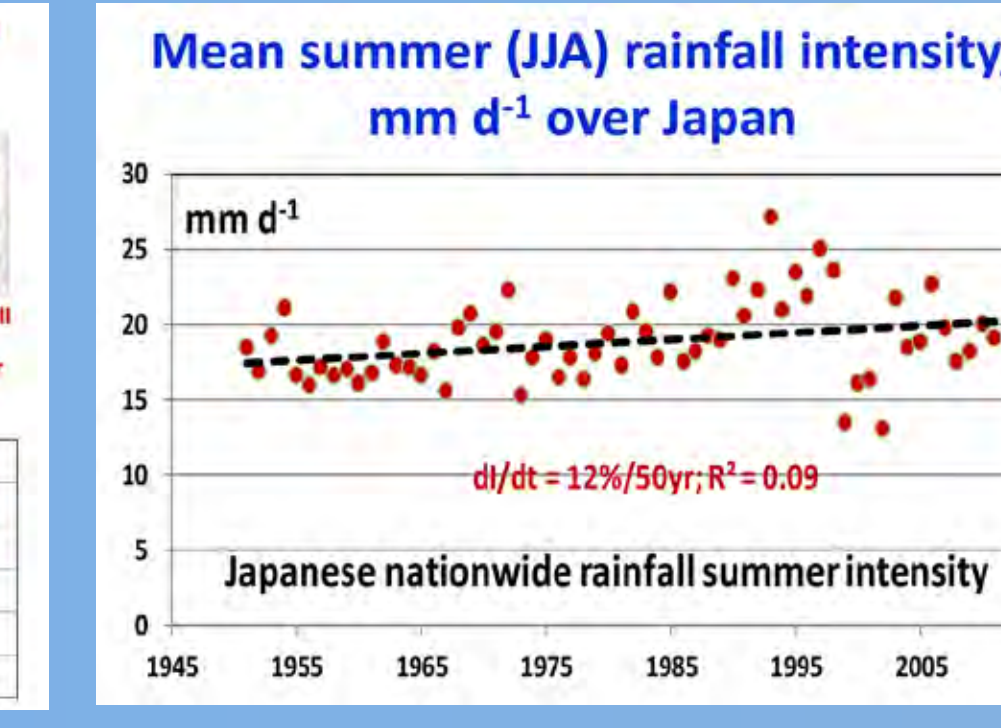
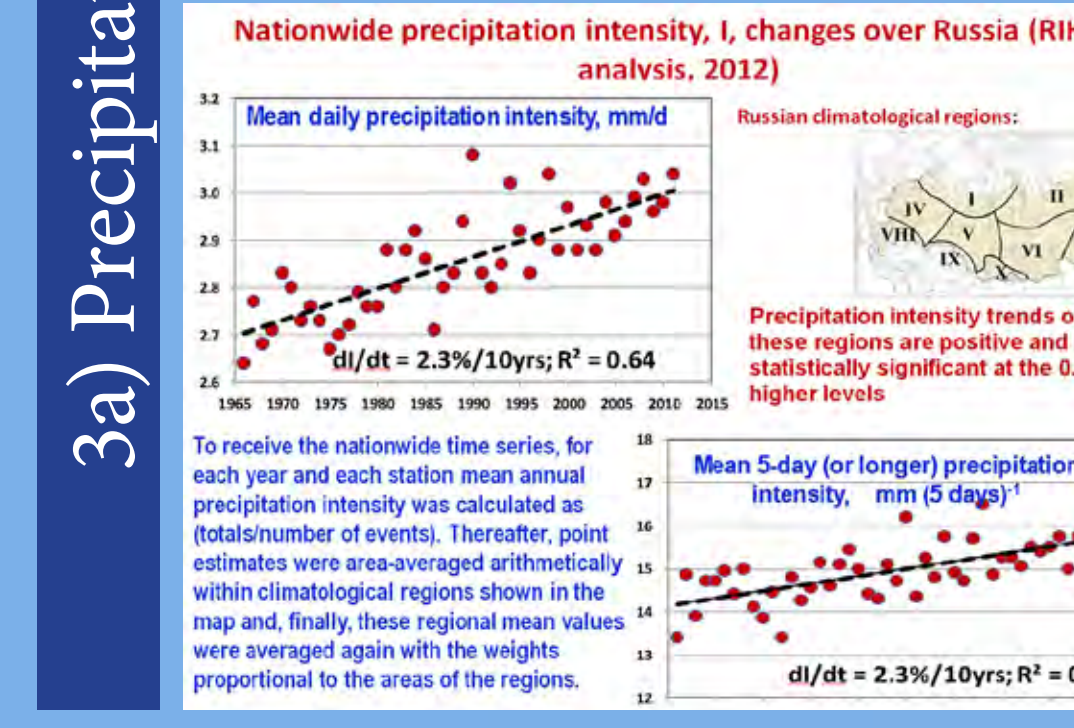
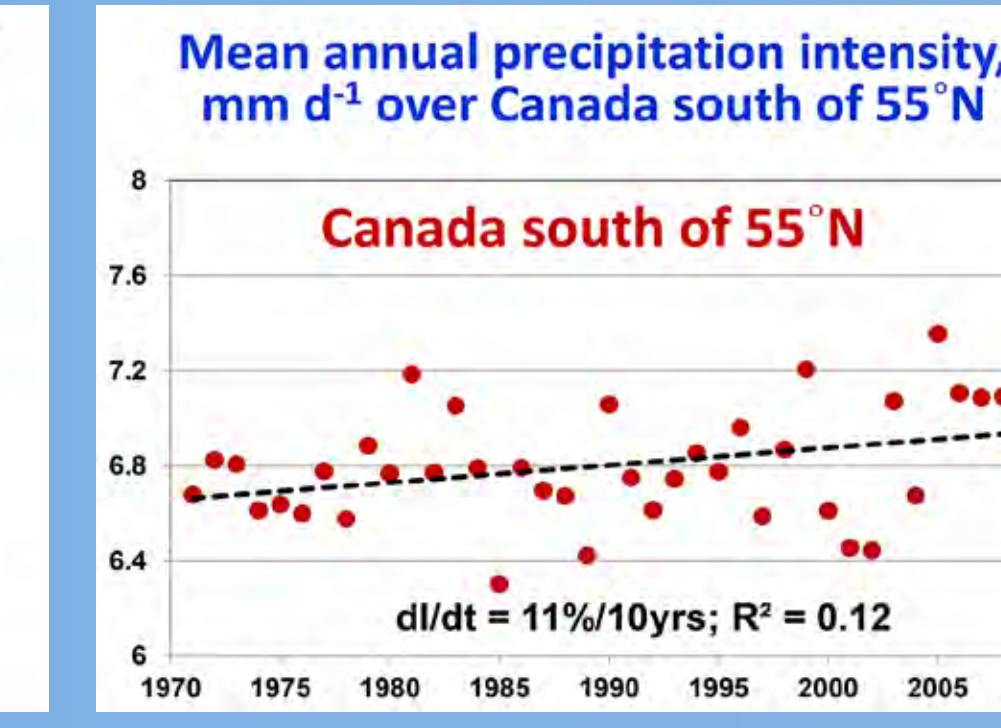
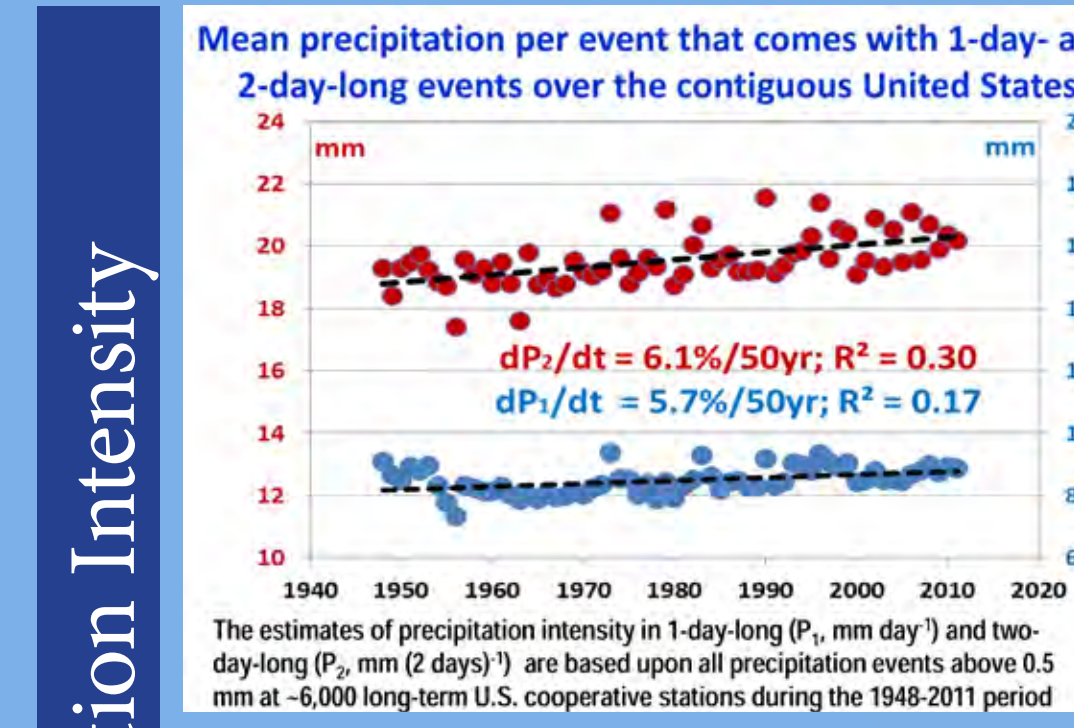
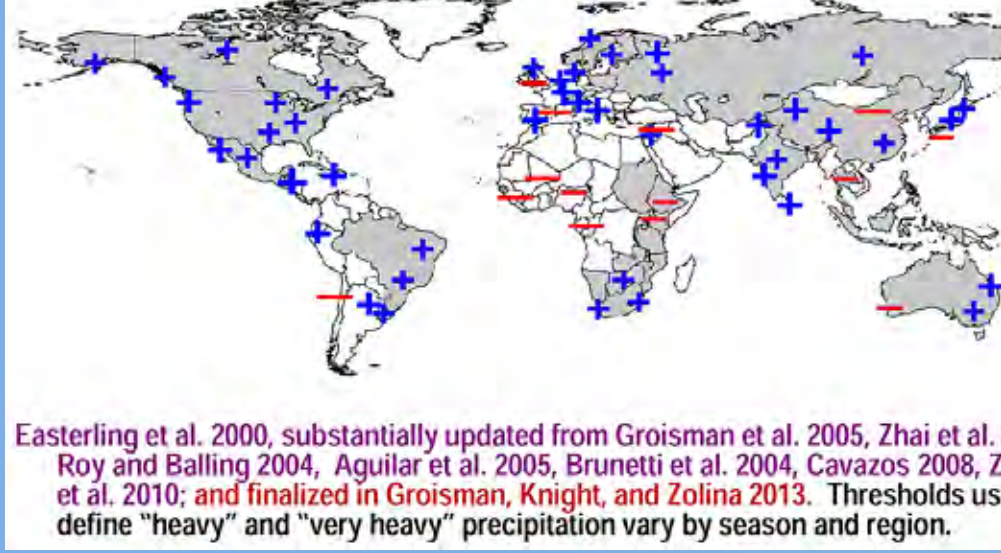


Part 3: Changes in intense, heavy, very heavy, extreme precipitation, and droughts

Apparently, changes in precipitation extremes (very heavy rainfall, prolonged wet and dry spells) may occur independently from the changes of mean precipitation and have different signs

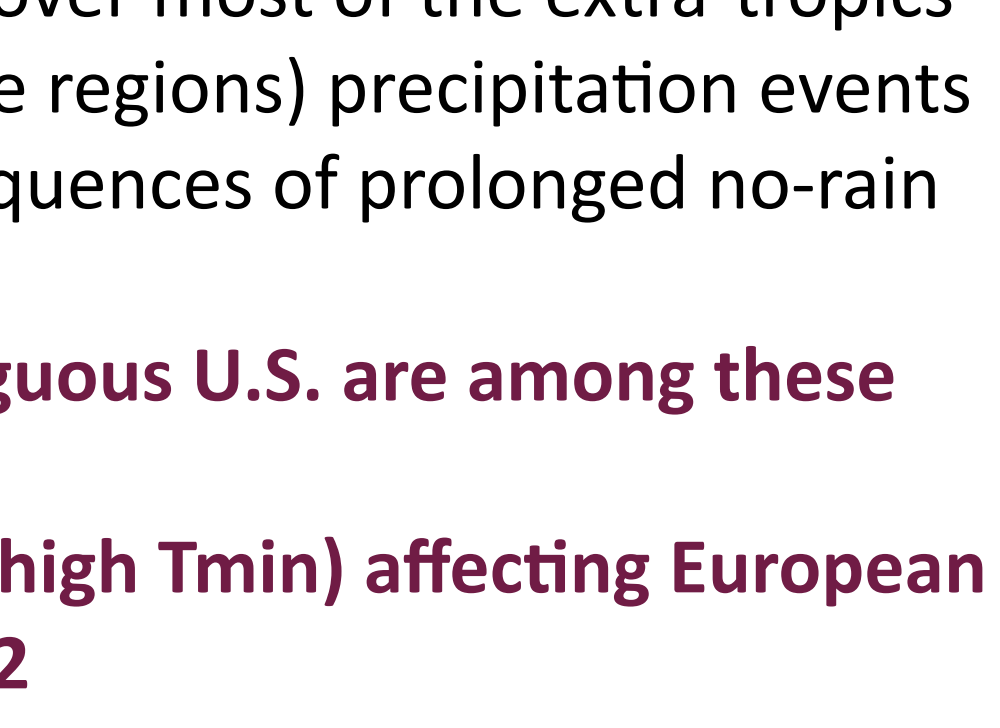
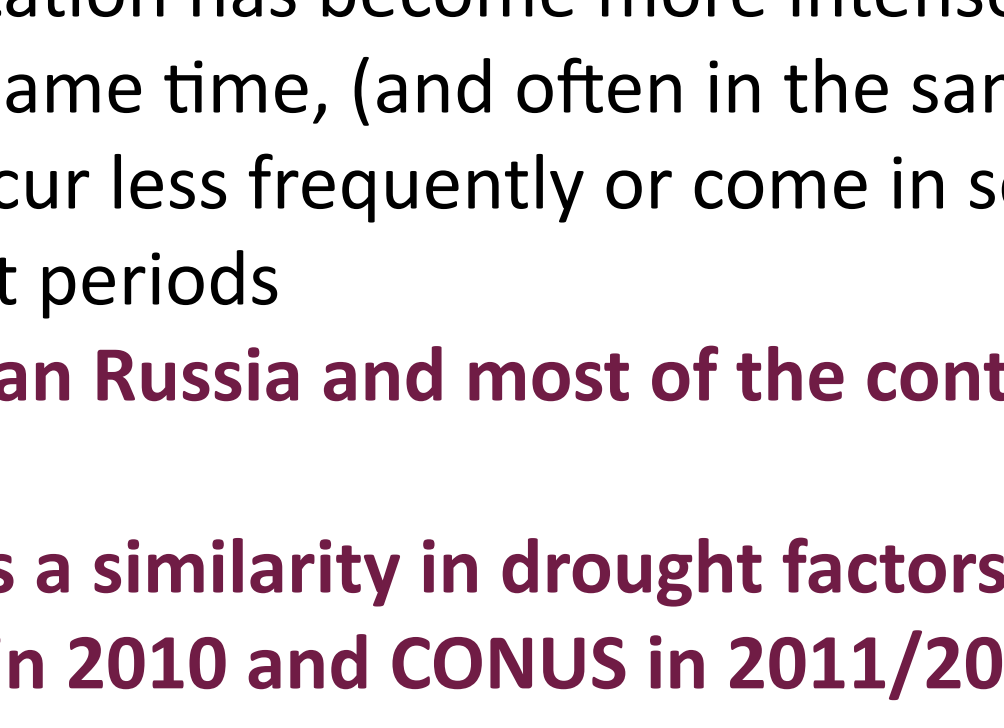
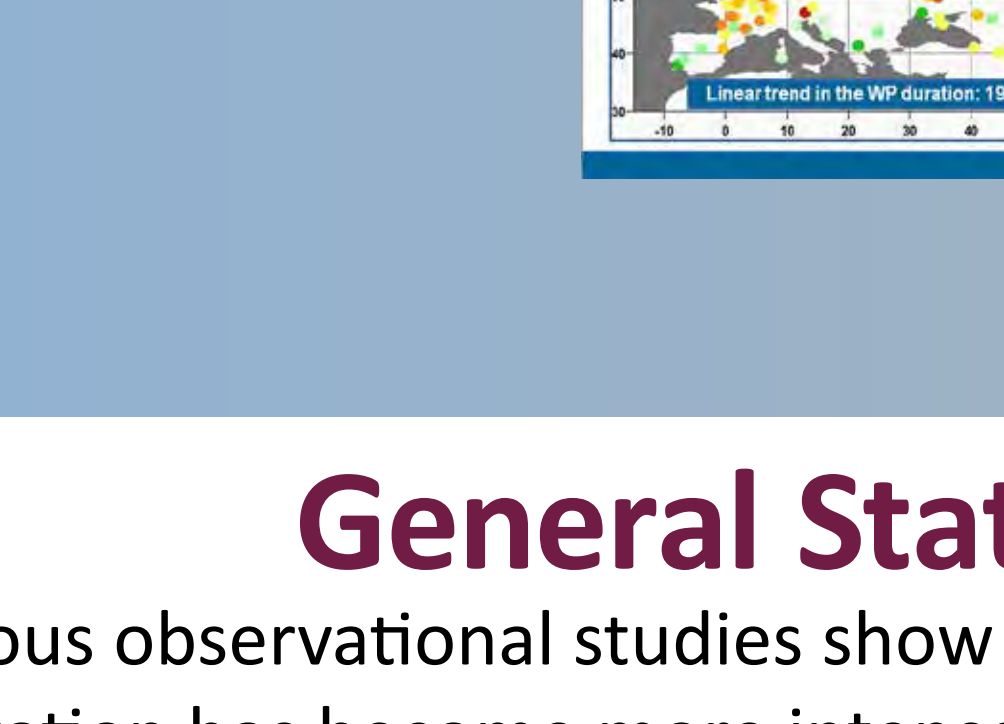
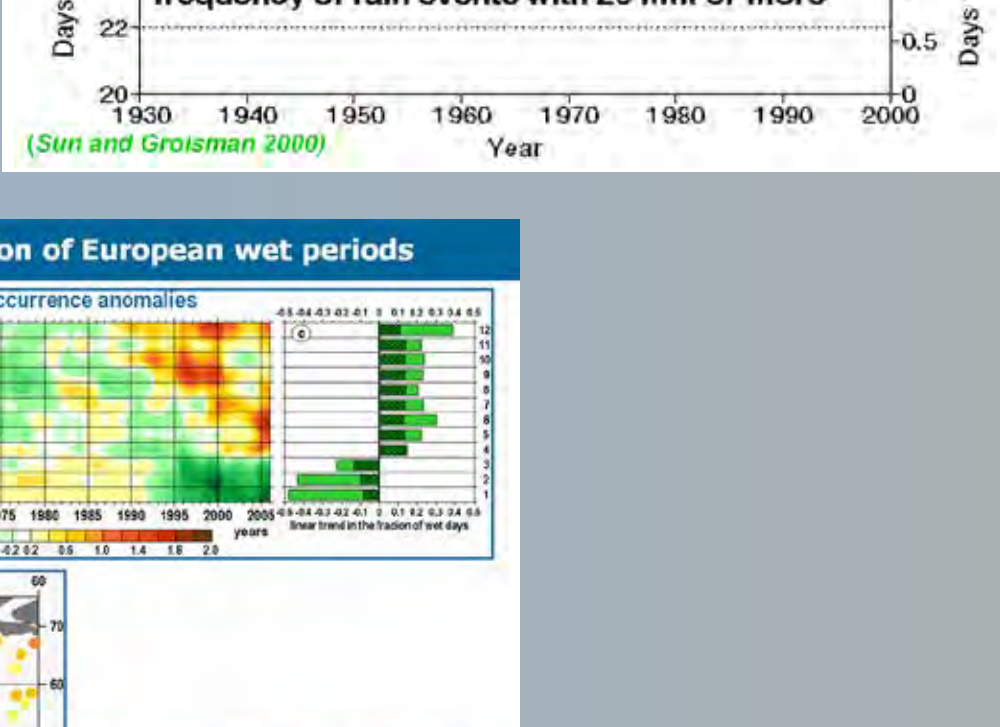
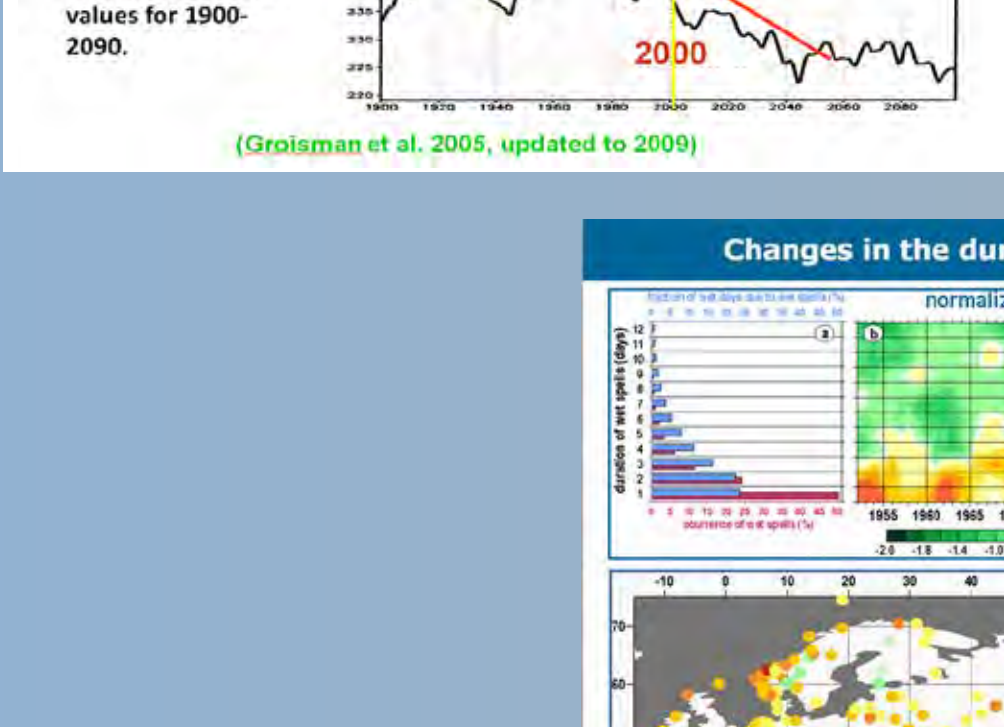
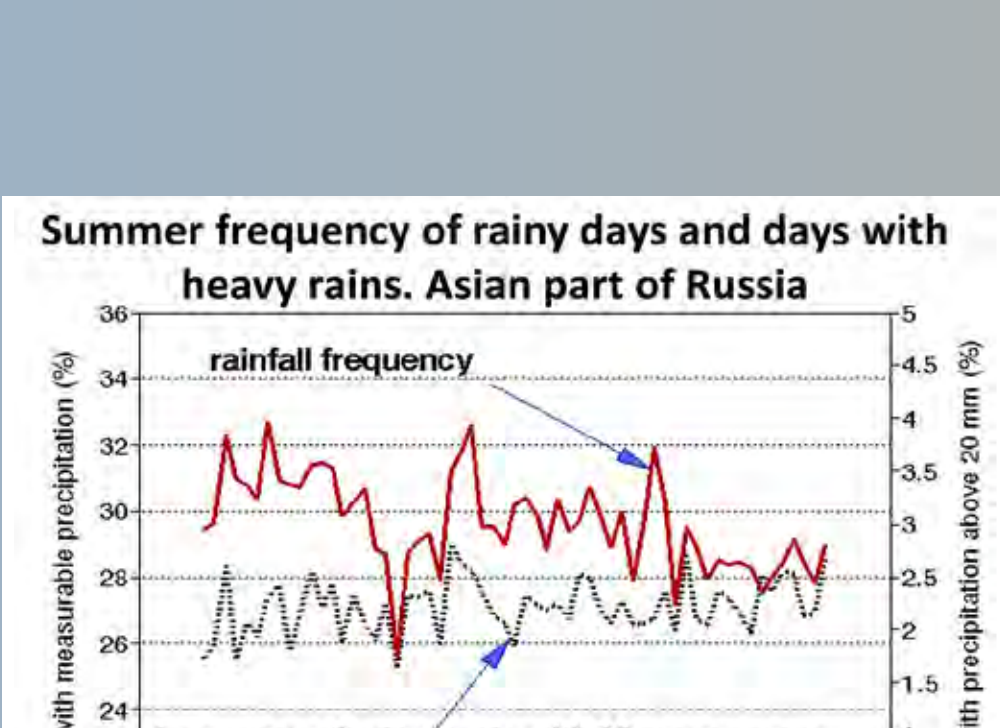
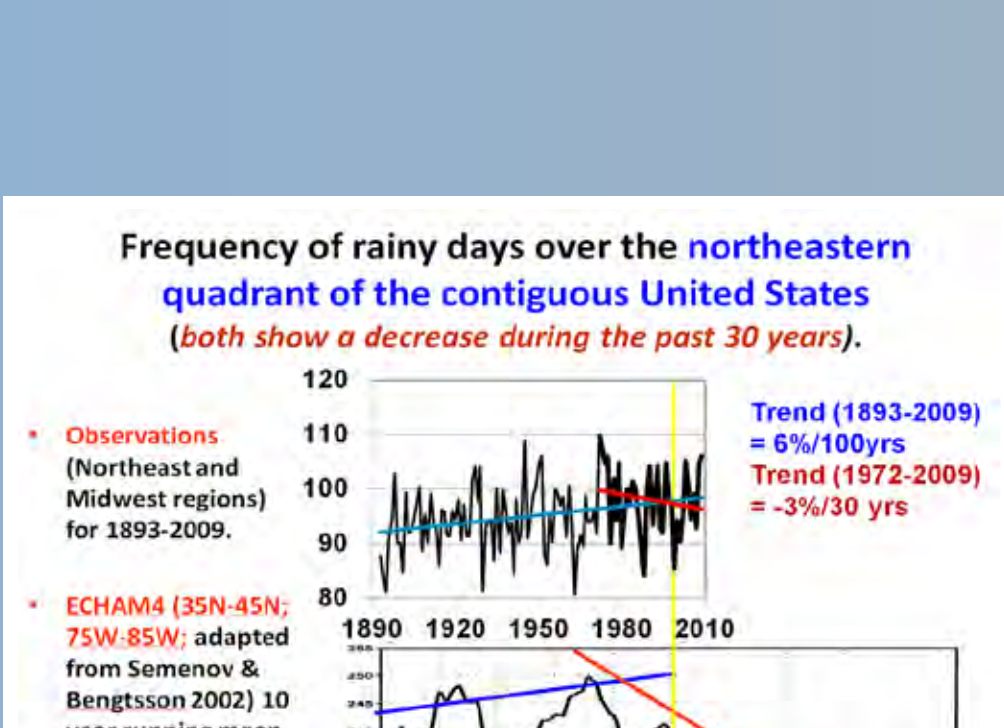
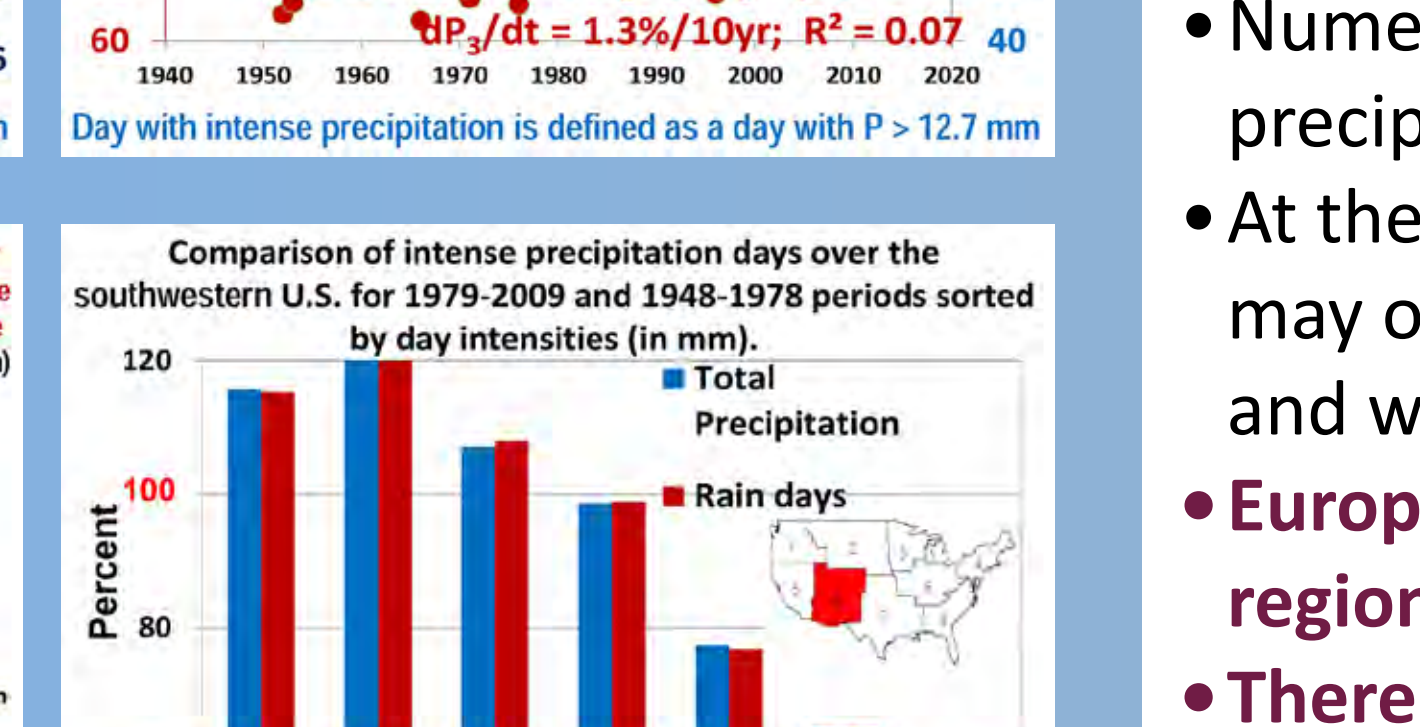
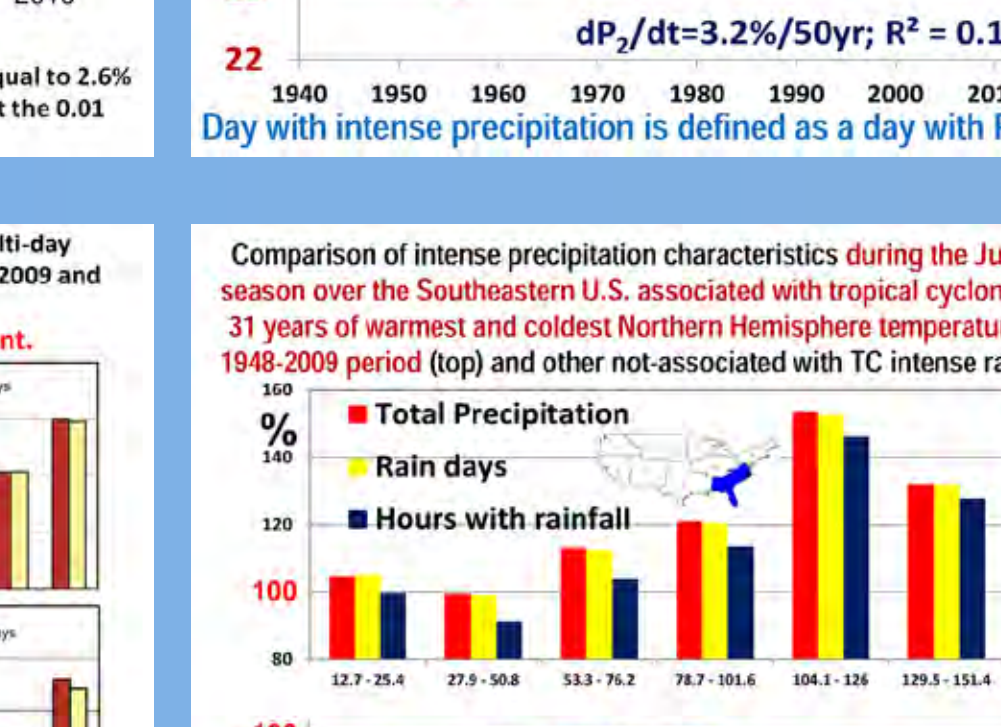
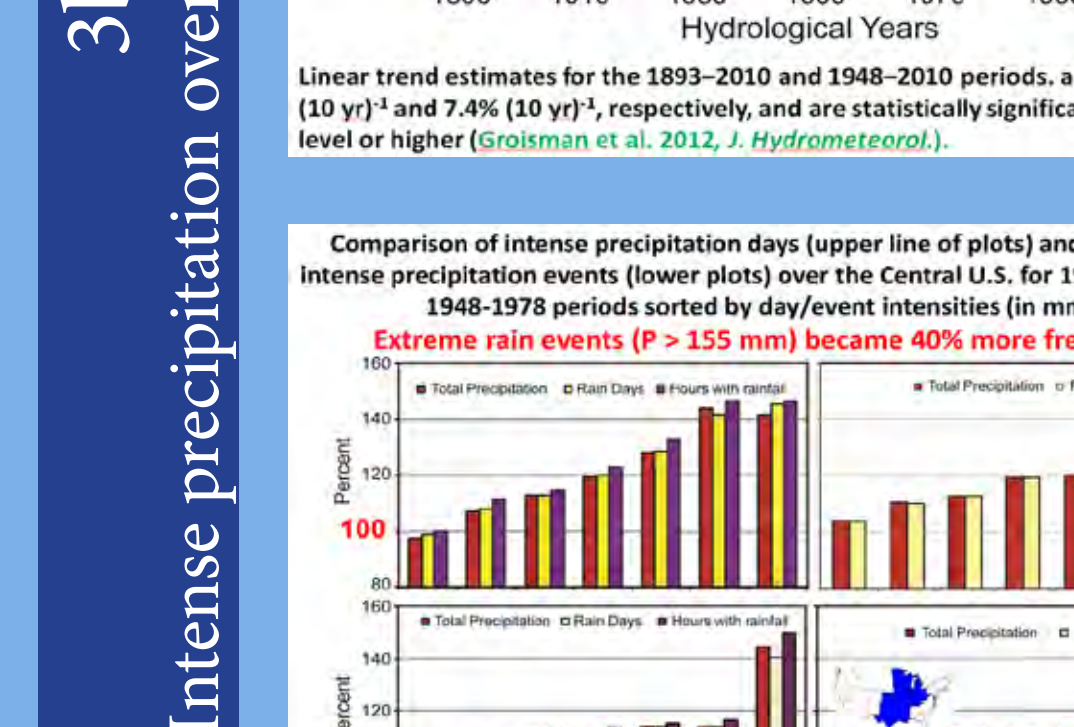
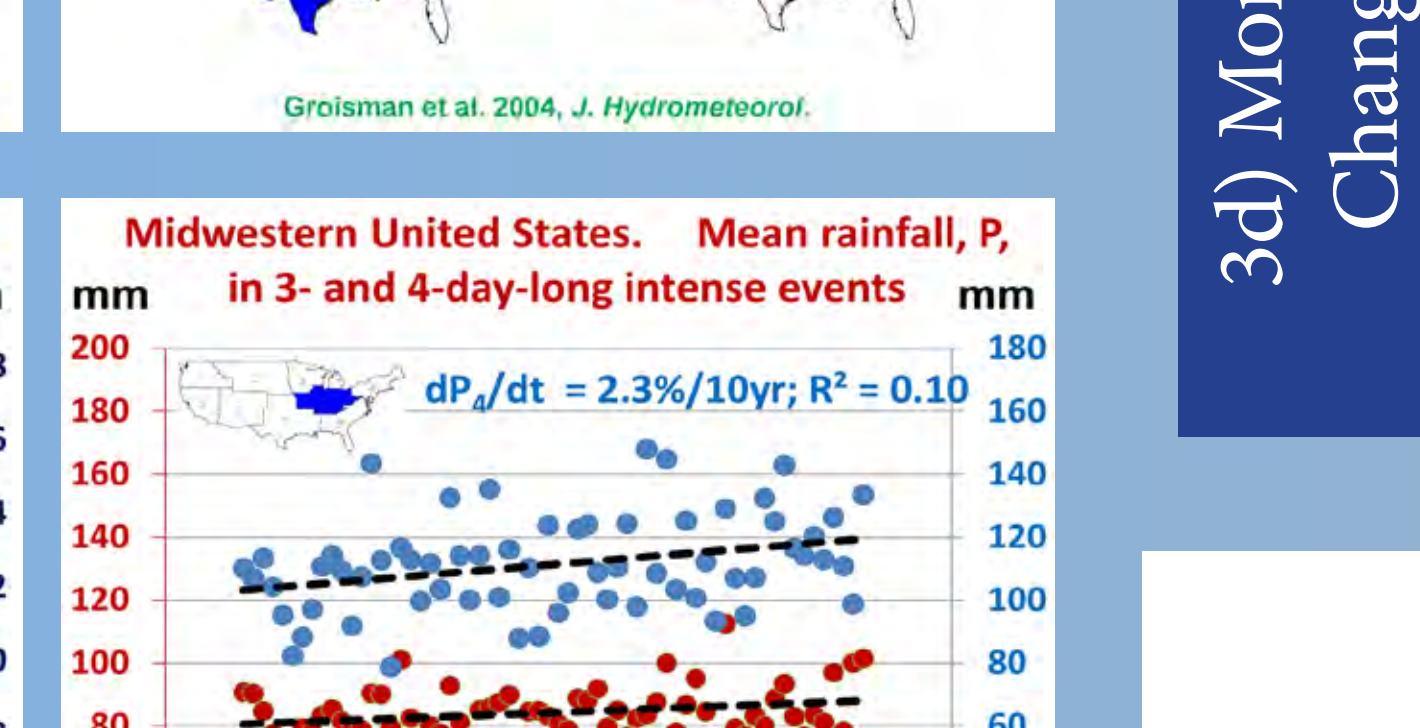
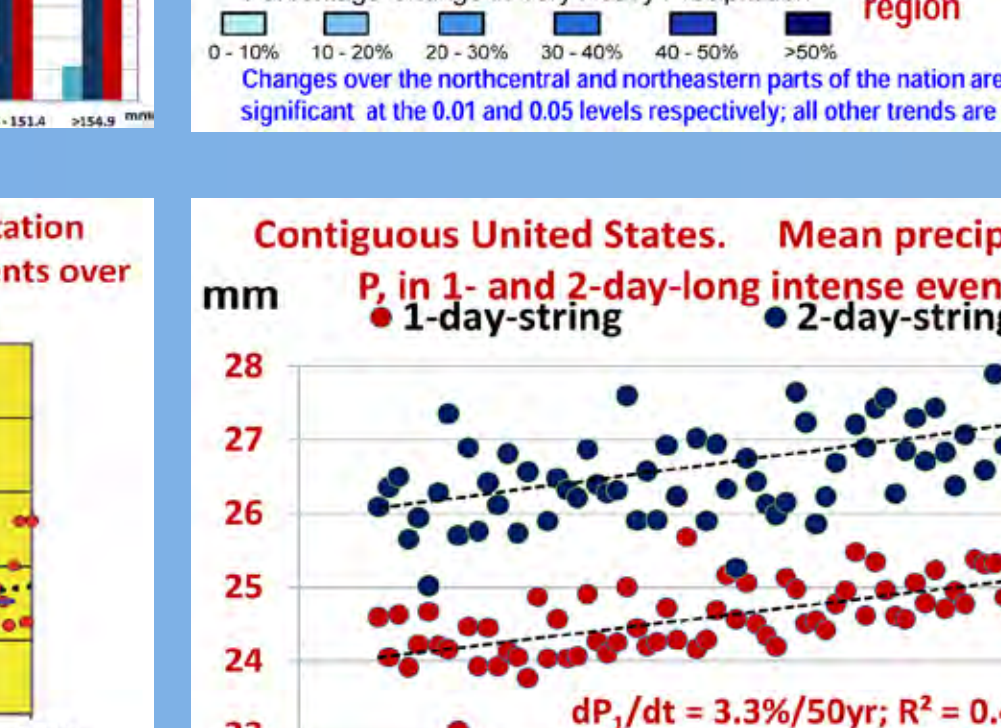
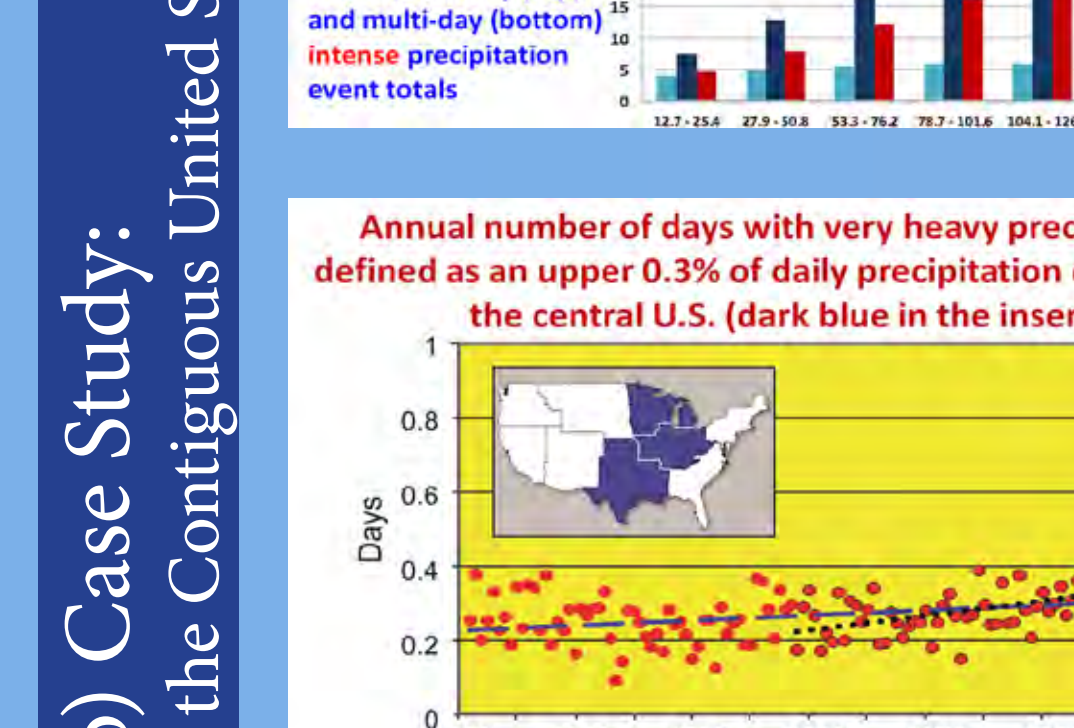
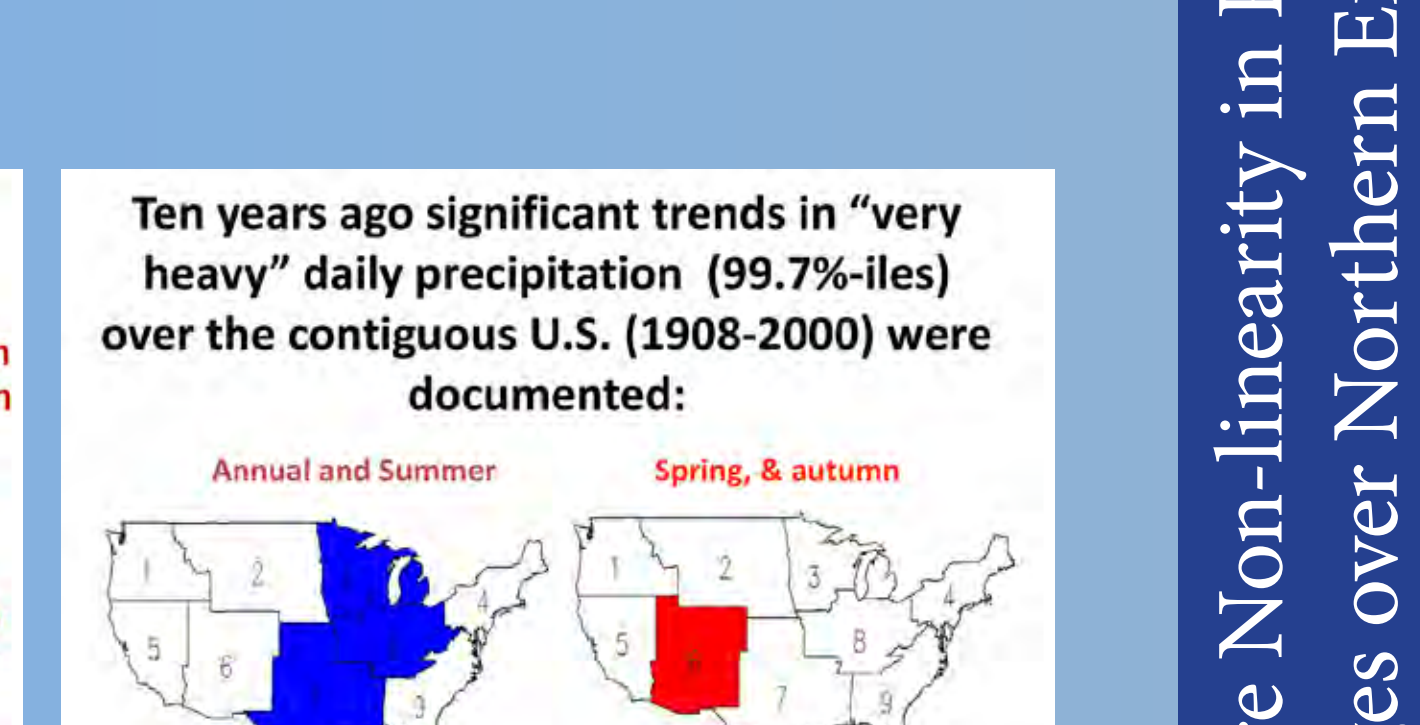
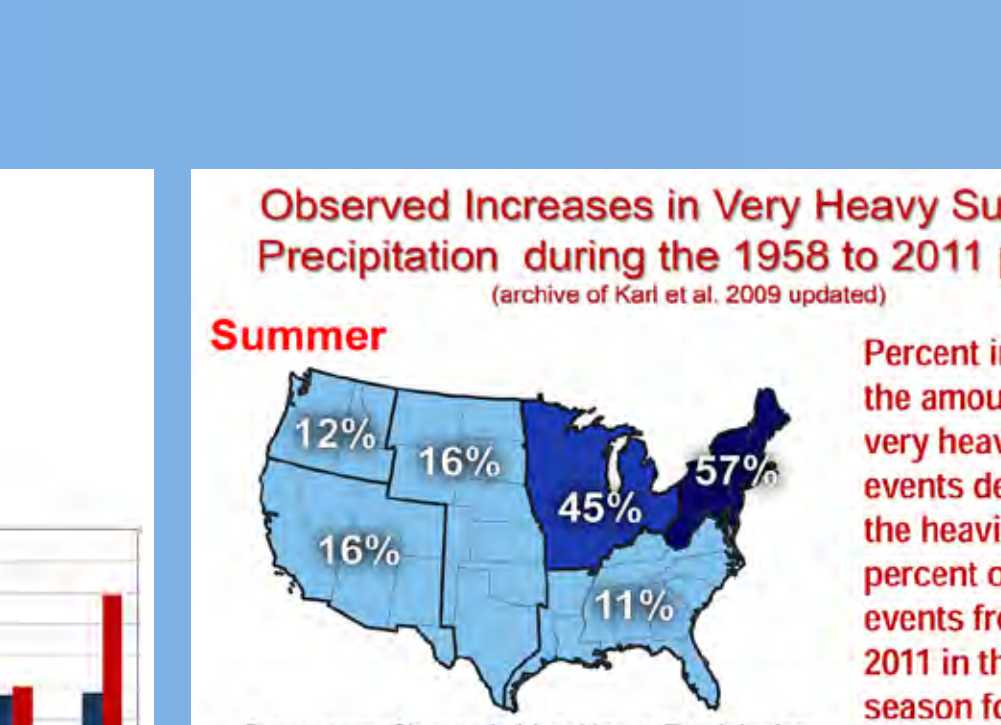
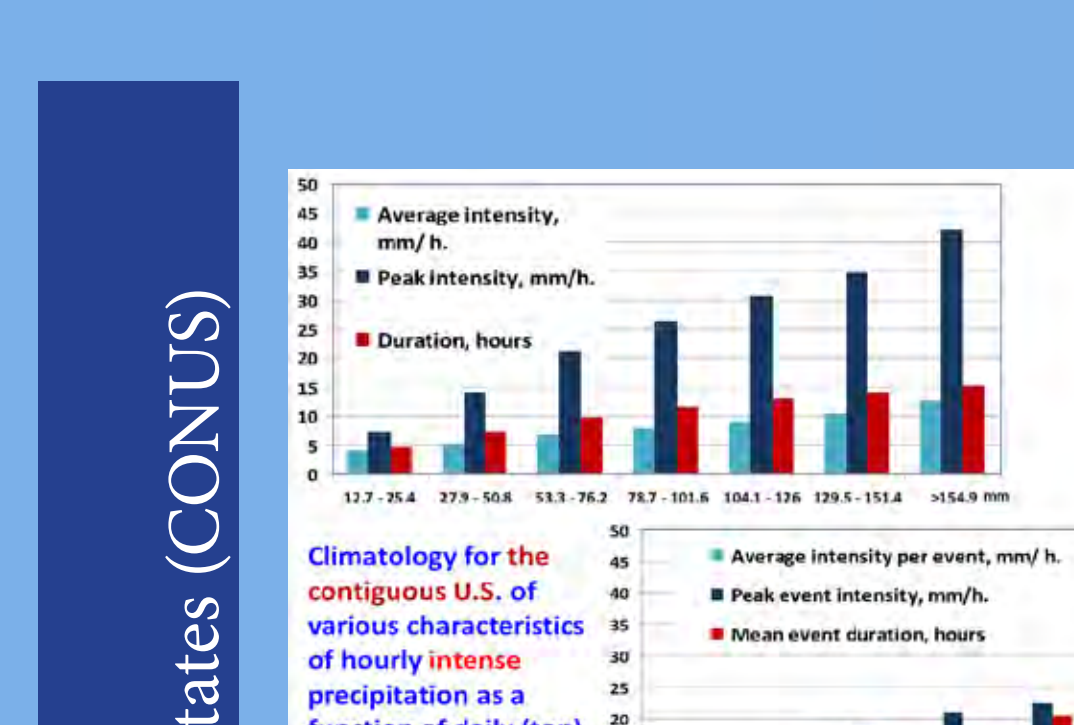
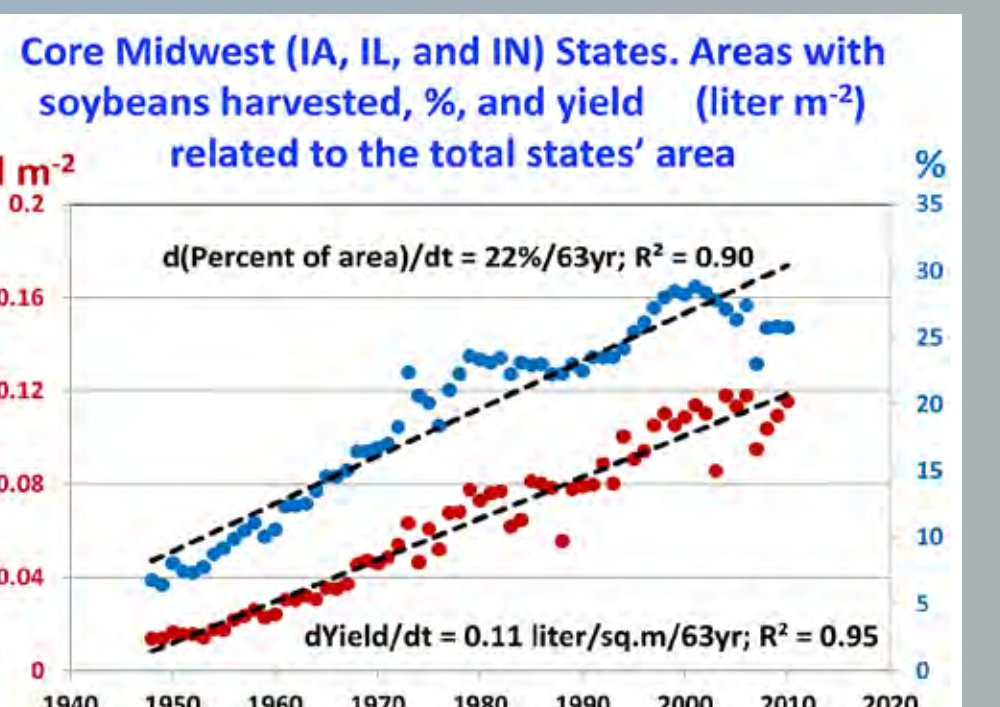
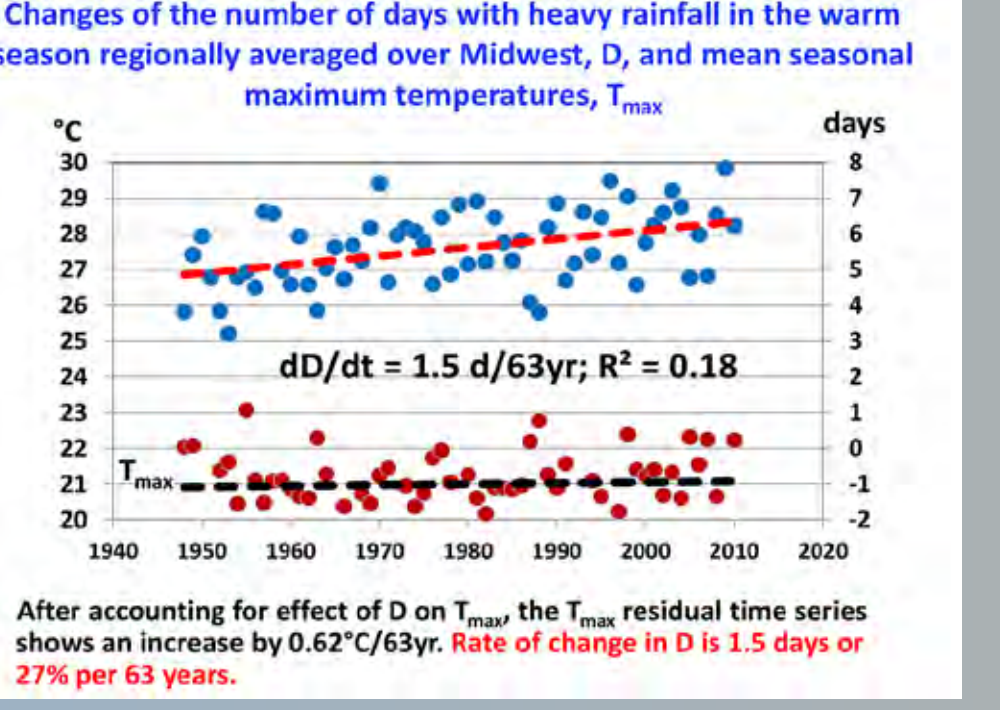
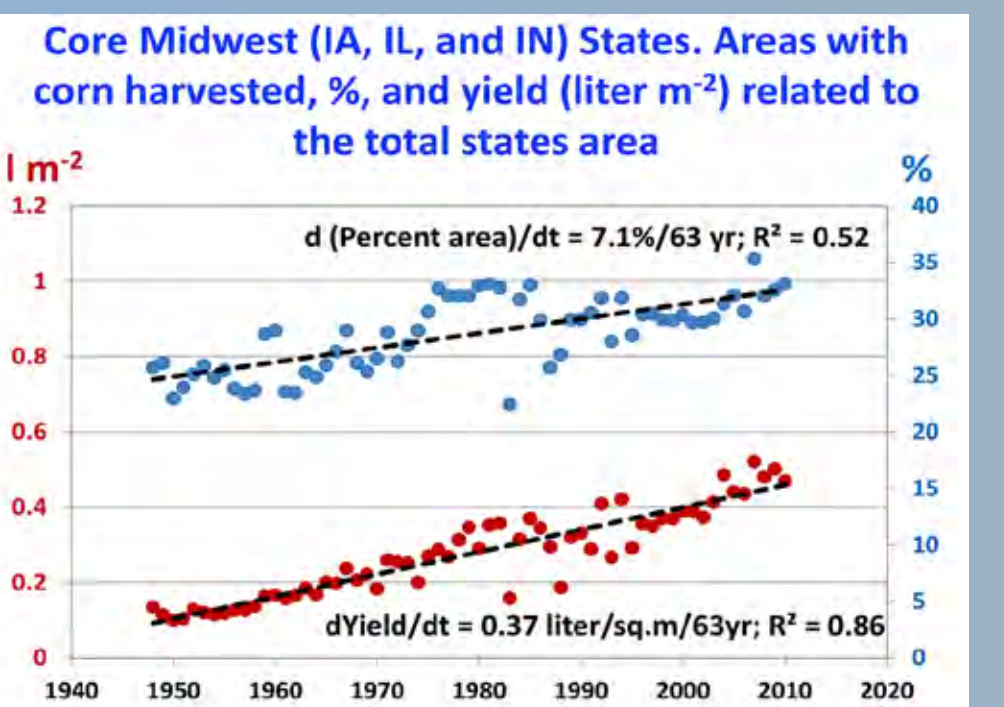
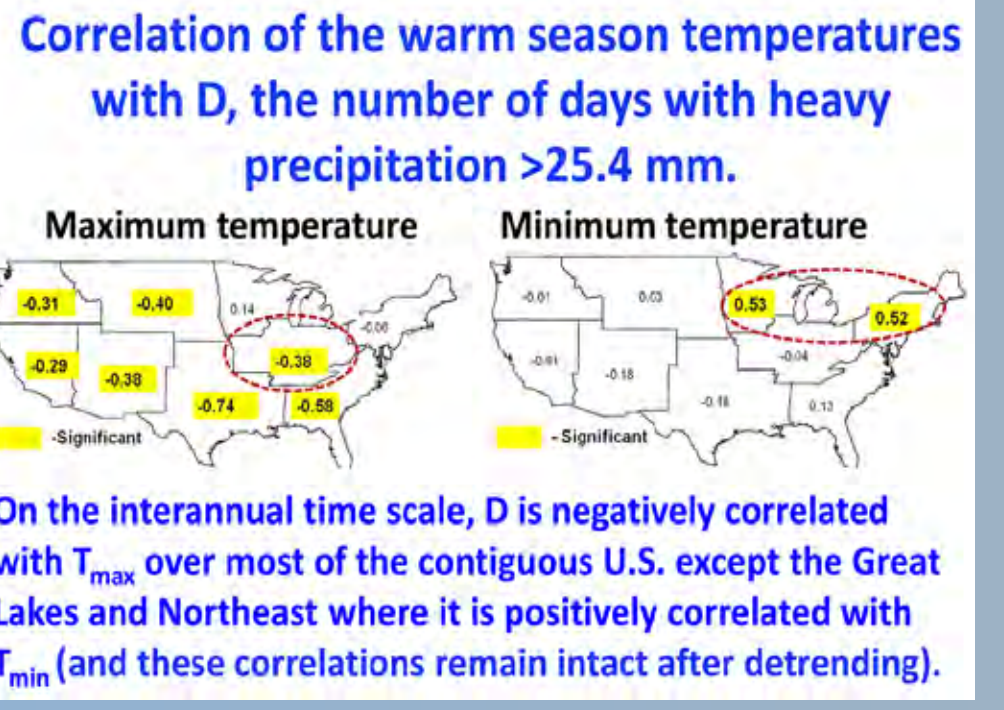
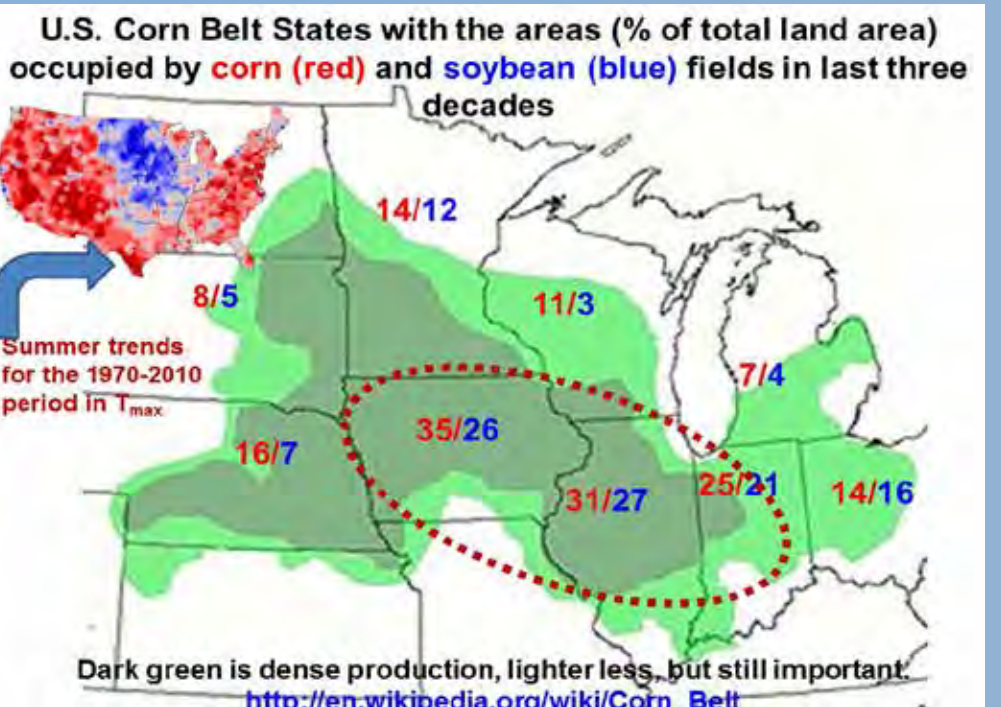
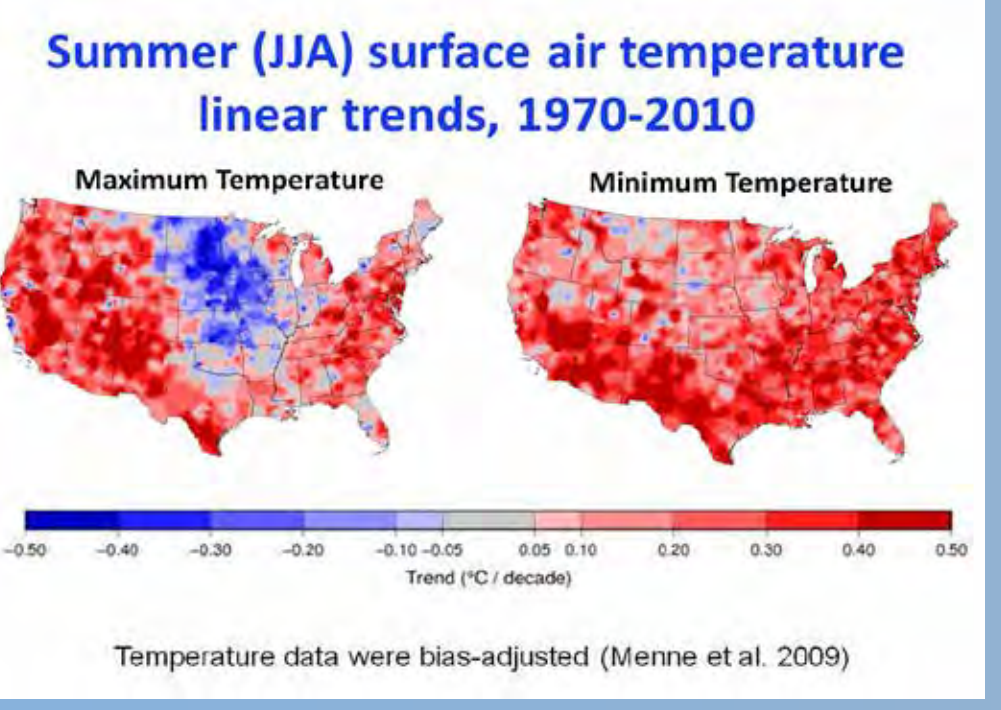


Regions with disproportionate changes in intense precipitation during the past decades compared to the change in the annual and/or seasonal precipitation



3c) Intensification of Land Use over Central CONUS: Interplay between intense rainfall and T_{max}

A dramatic increase in heavy rainfall "explains" a singularity of T_{max} trends in the Midwest. The cause of the rainfall changes requires a thorough investigation to partition the impact between global factors and the regional land use change.



3d) More Non-linearity in Precipitation Changes over Northern Extratropics

General Statements

- Numerous observational studies show that in the past several decades precipitation has become more intense over most of the extra-tropics
- At the same time, (and often in the same regions) precipitation events may occur less frequently or come in sequences of prolonged no-rain and wet periods
- European Russia and most of the contiguous U.S. are among these regions
- There is a similarity in drought factors (high T_{min}) affecting European Russia in 2010 and CONUS in 2011/2012

3e) Warm Season Dryness

3f) Case Study: European Russia



Intense precipitation over the Contiguous United States (CONUS)

3b) Case Study: Intense precipitation over the Contiguous United States (CONUS)