Impact of climate change and climate variability on the hydrology of the Sudd wetland

Yasir A. Mohamed
04 June, 2012

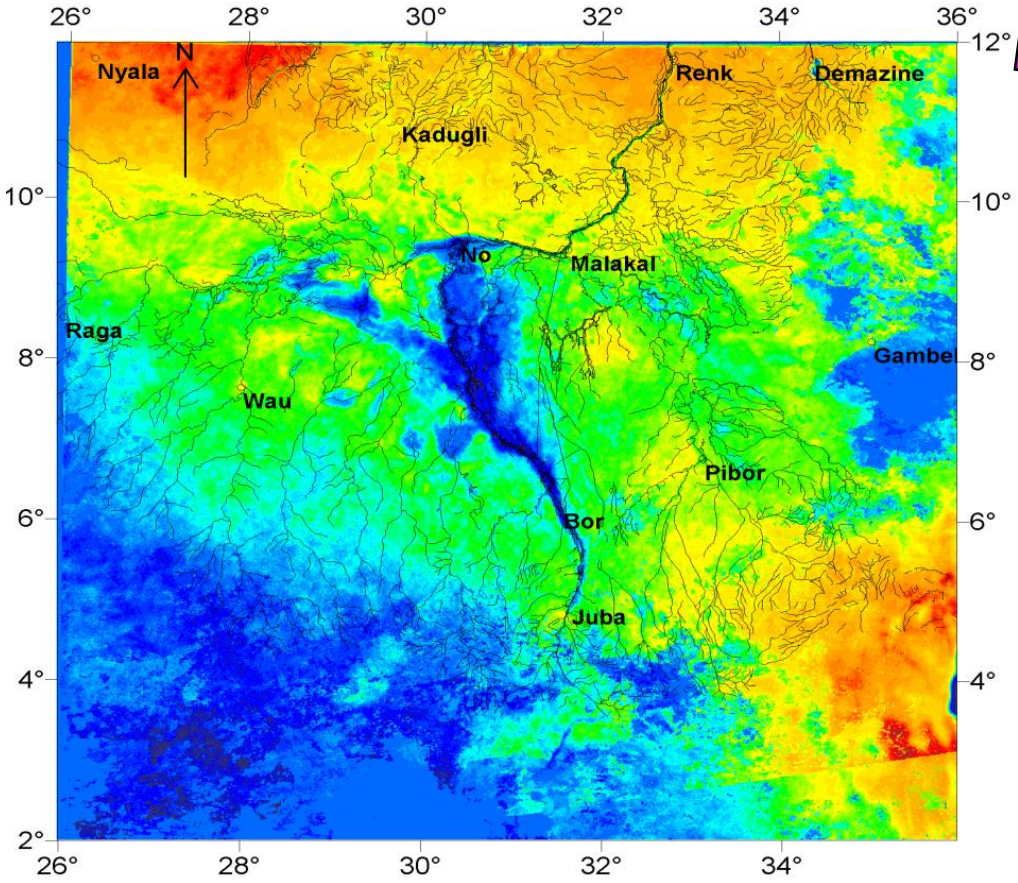
UNESCO-IHE
Institute for Water Education

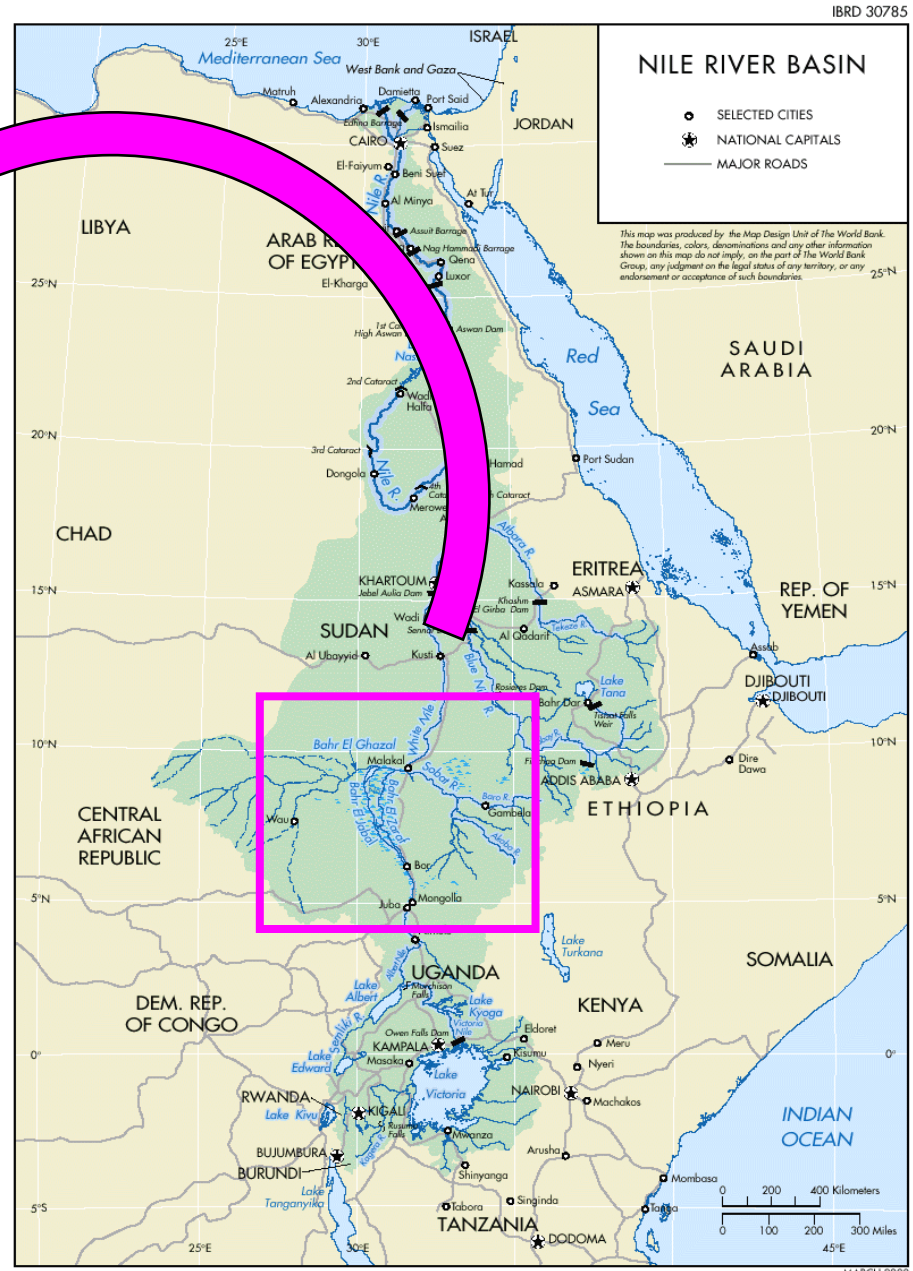
HRS-Sudan

Content

- The Sudd wetland
- Hydroclimatology of the Sudd
- Sudd water balance
- Trend analysis
- Conclusions

Location of the Sudd Wetland

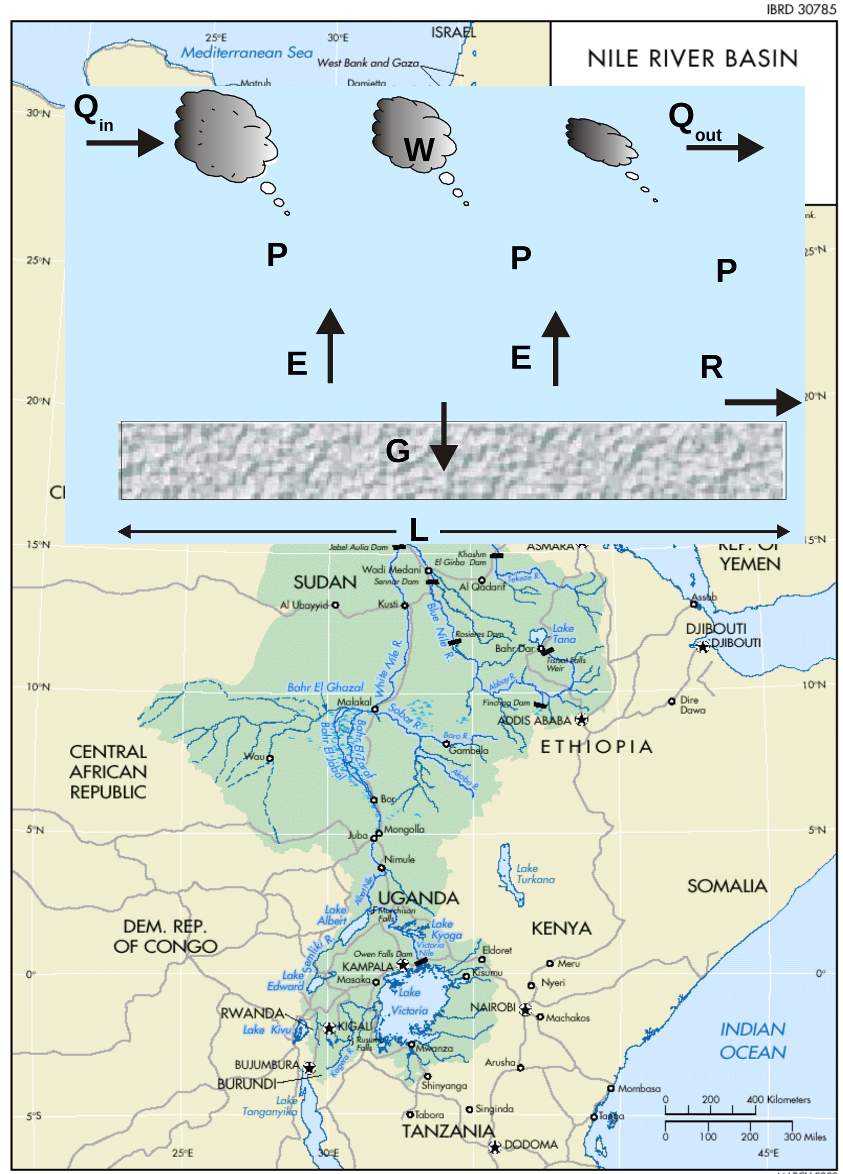




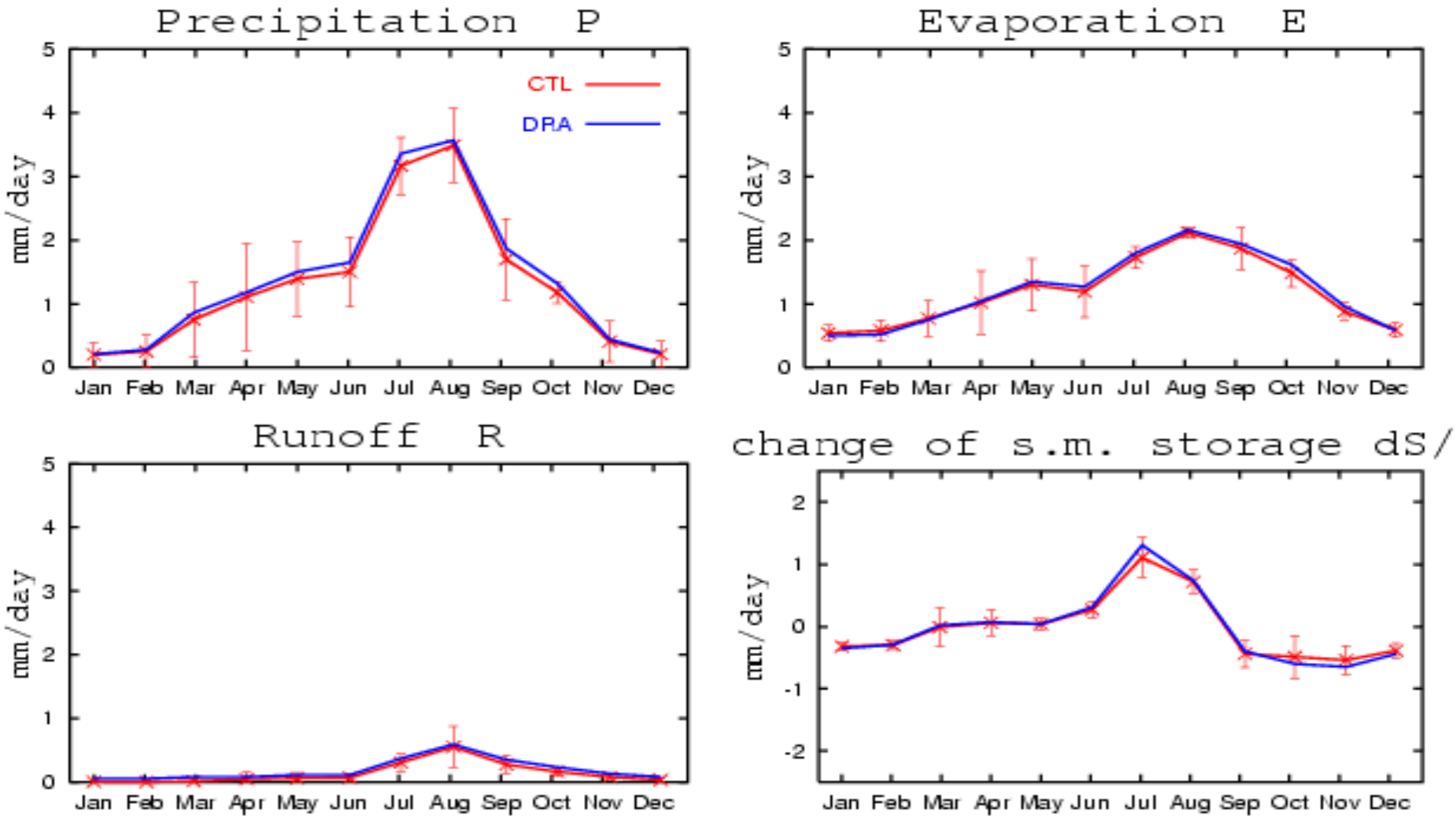
Importance of the Sudd wetland

Hydroclimatology of the Sudd

- hydrological influence from upstream (Lake Victoria)
- defines d/s outflow
- little impact on regional climate,
- direct impact on local climate



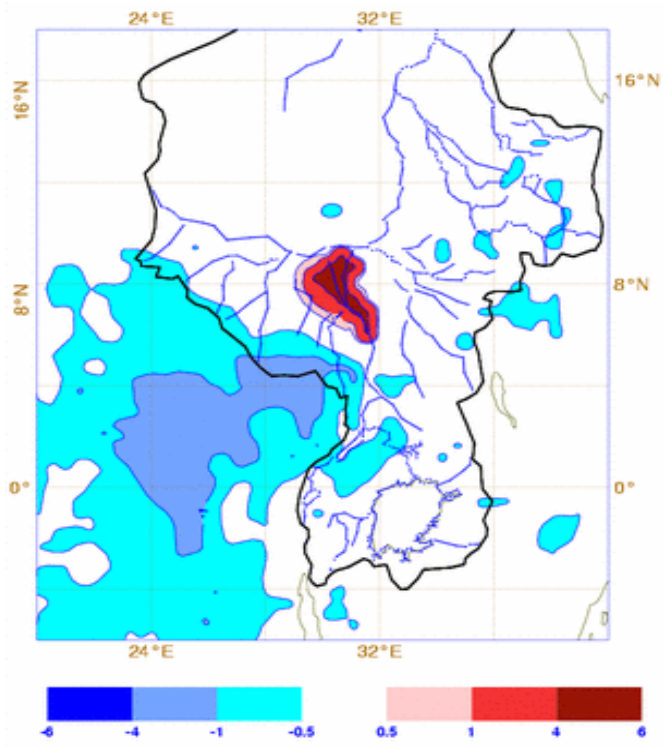
Impact on Nile Water cycle



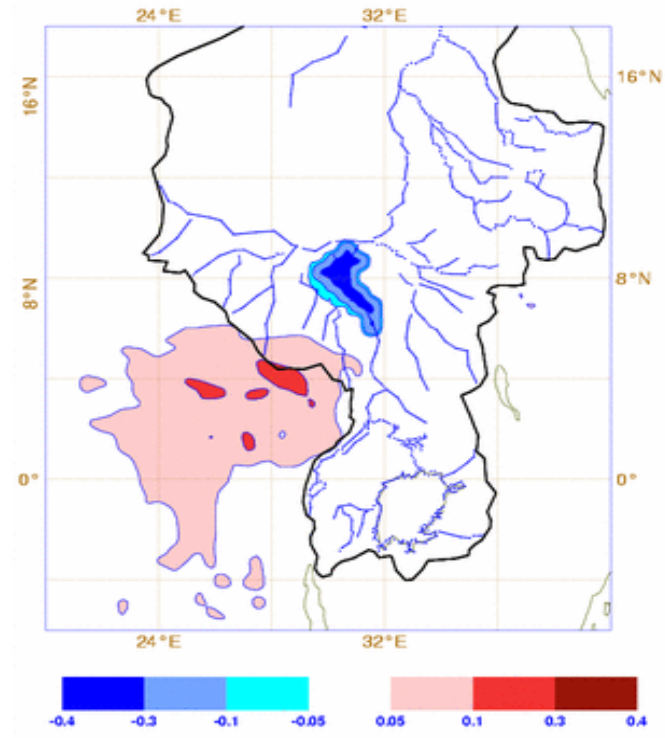
Source: Mohamed et al., 2005

Impact on Temprature and Relative Humidity

ΔT dry season



ΔRH dry season



Source: Mohamed et al., 2005

Water balance of the Sudd

$$V_{i+1} = V_i + Q_{in} - Q_{out} + kV_i(P - E)$$

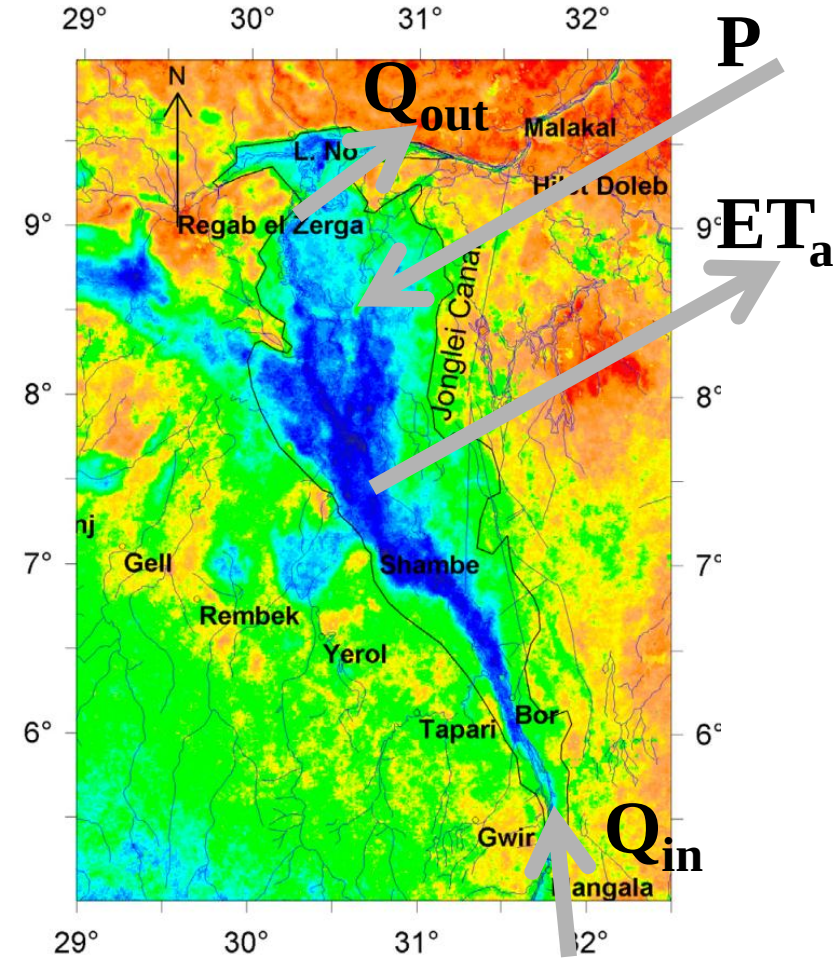
Source: Sutcliffe and Parks, 1987

Q_{in} = measured at Mangala

Q_{out} = measured at exit (Malakal – H.D.)

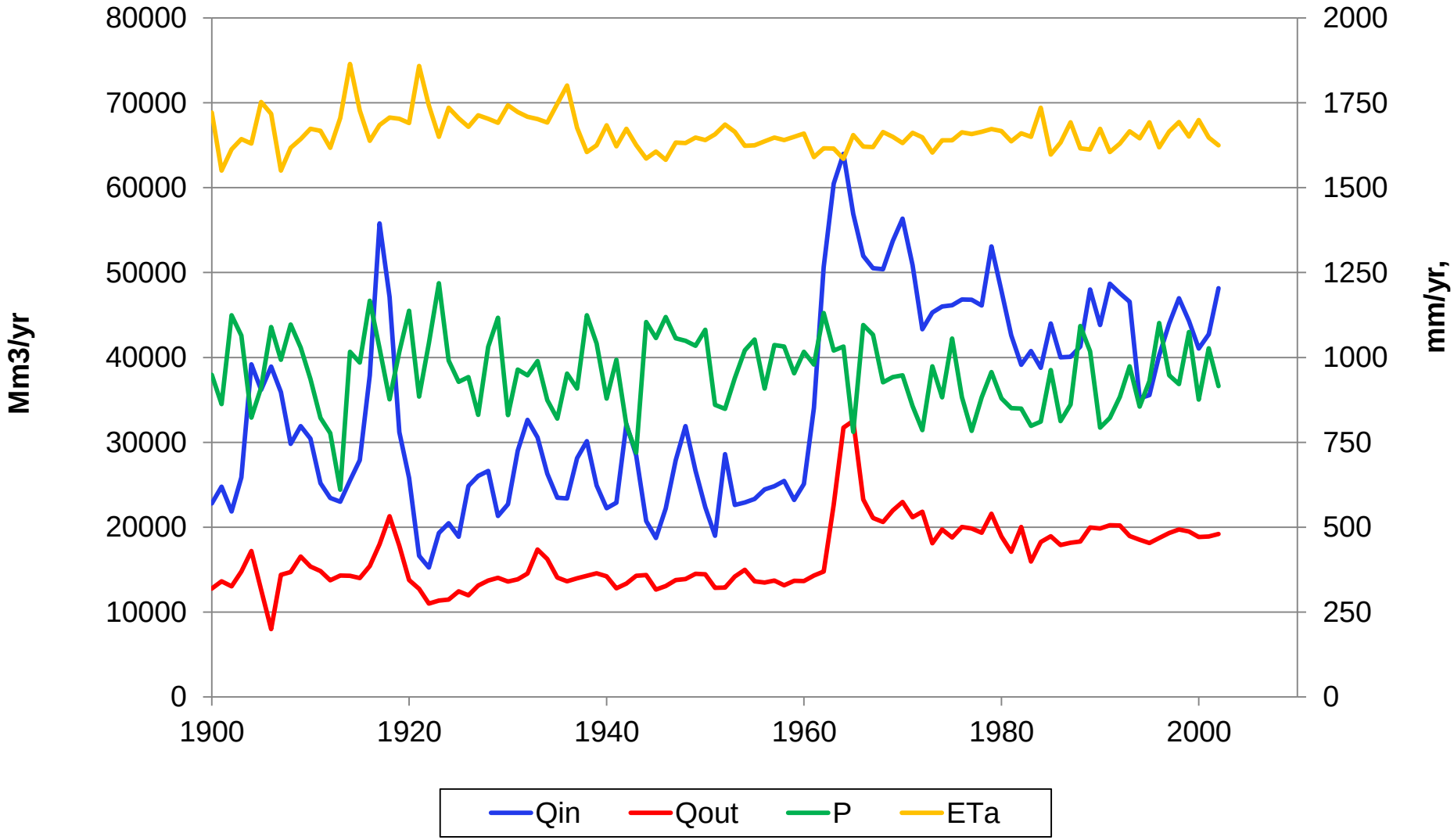
P = average of three stations

ET_a = ET_0 time series scaled based on 3 years data

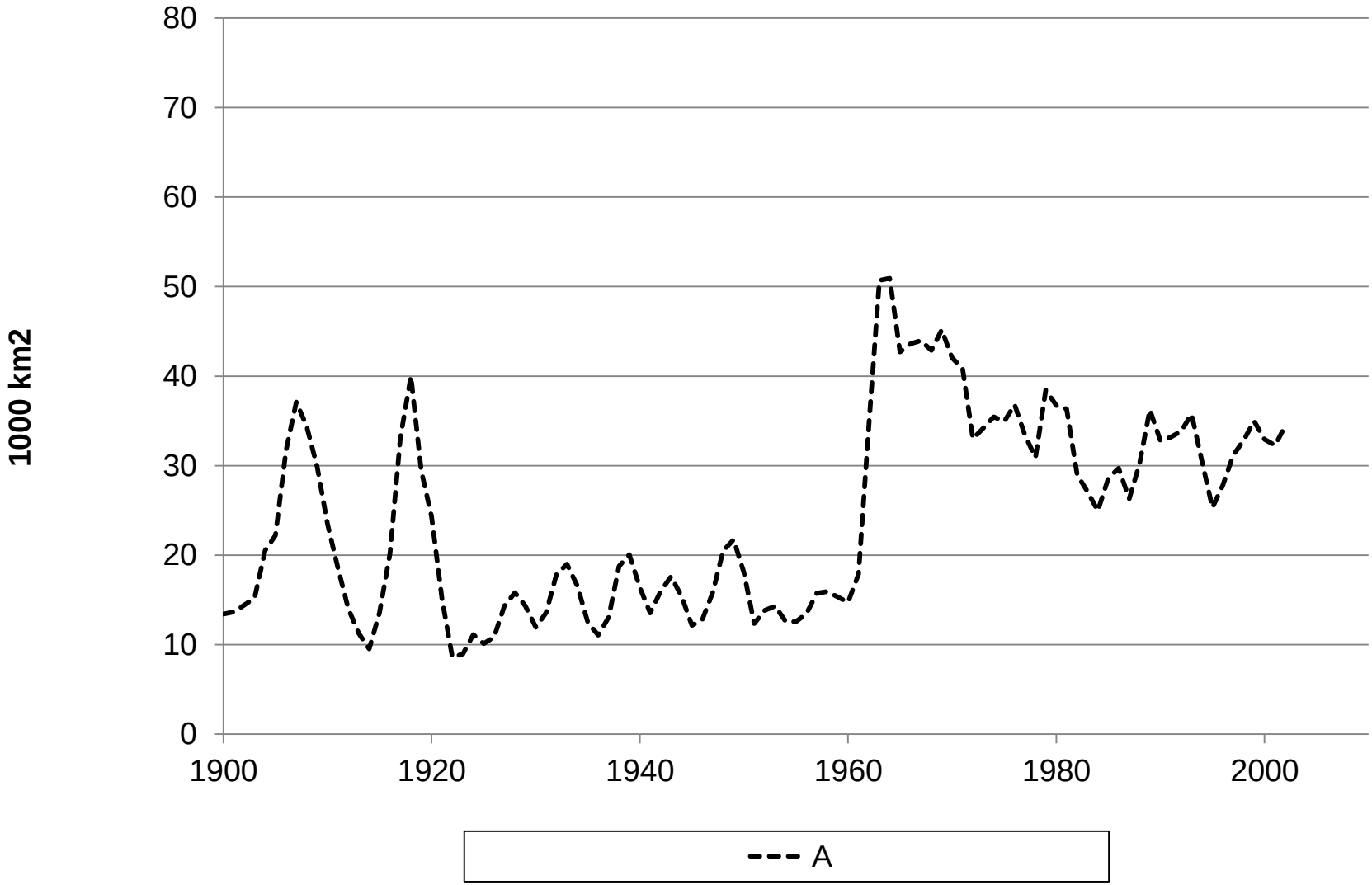


How does the trends of the water balance components affect the Sudd area?

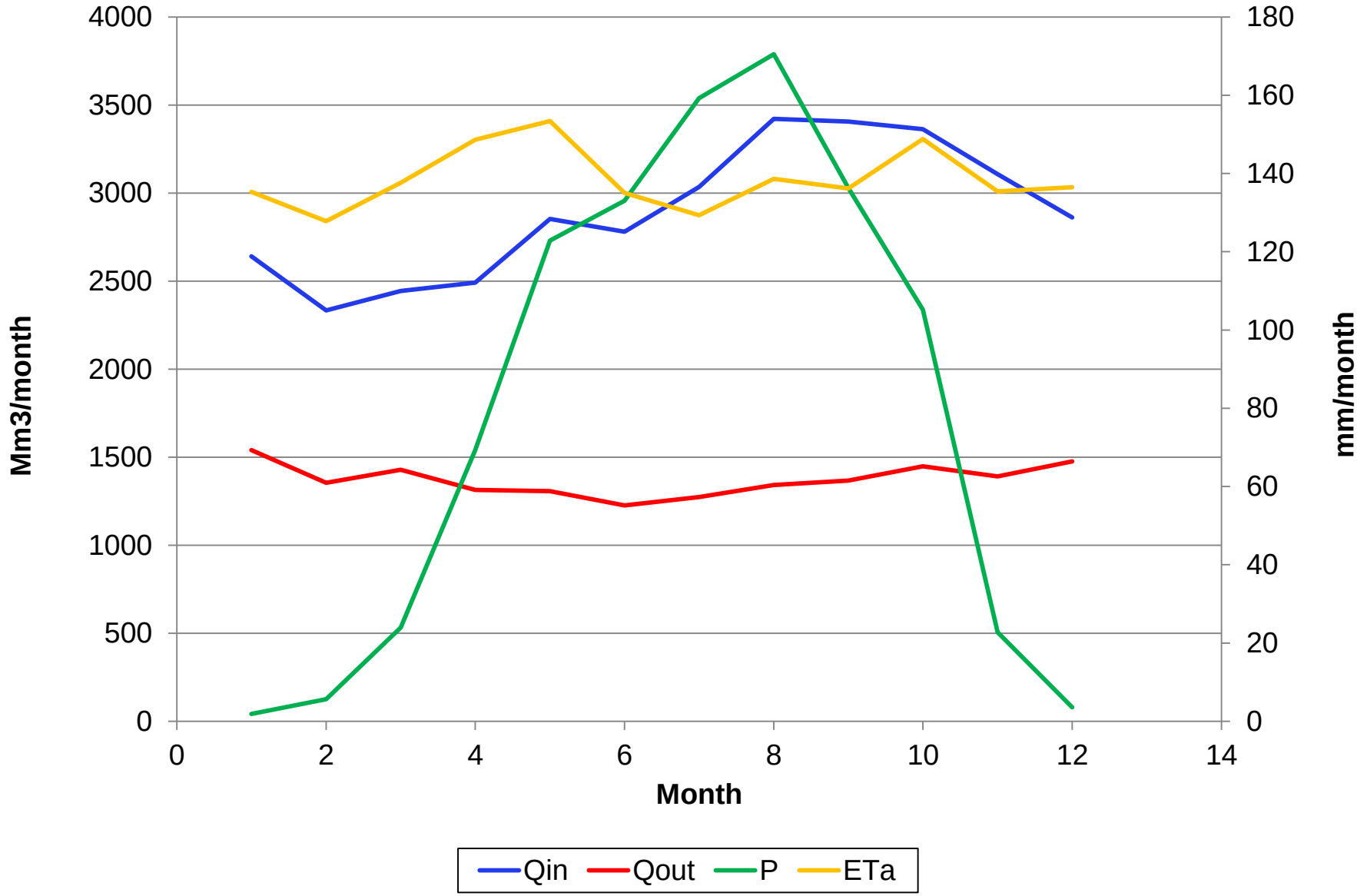
Water balance results



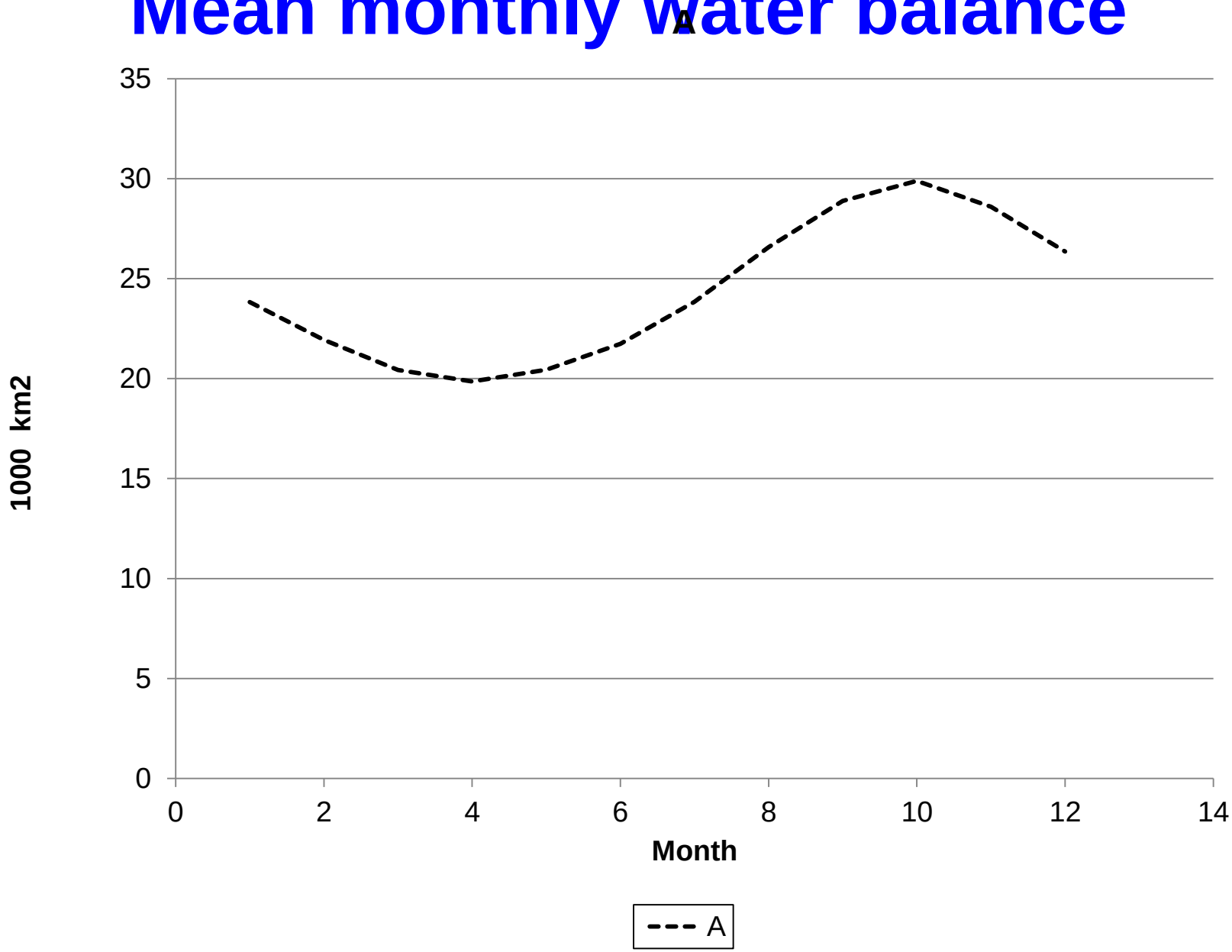
Water balance results



Mean monthly water balance



Mean monthly water balance



Trend analysis: Mann-Kendall test

$$S = \sum_{i=1}^{n=1} \sum_{j=i+1}^{n} \operatorname{sgn}\left(x_j - x_i\right), \textbf{ Where } \operatorname{sgn}(\theta) = \begin{cases} +1 & \theta > 0 \\ 0 & \text{If} \quad \theta = 0 \\ -1 & \theta < 0 \end{cases}$$

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{V(S)}} & S > 0 \\ 0 \quad \text{If} & S = 0 \\ \dfrac{S+1}{\sqrt{V(S)}} & S < 0 \end{cases}$$

Serial correlation of time series was removed first by TFPW method

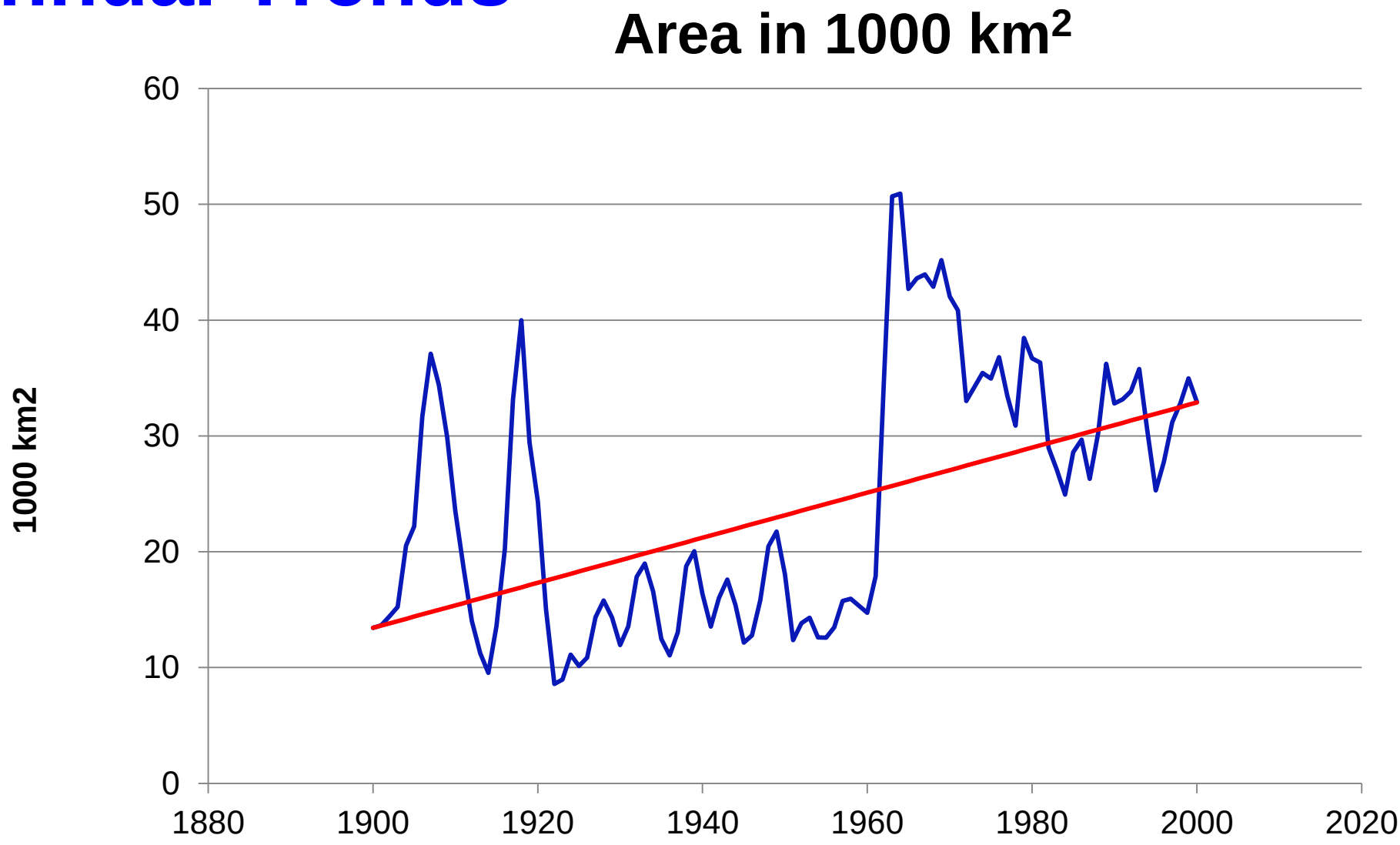
$$Var(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{t=1}^{m} t_i (t_i - 1)(2t_i + 5) \right]$$

MK test Results (time series 1900 to 2000)

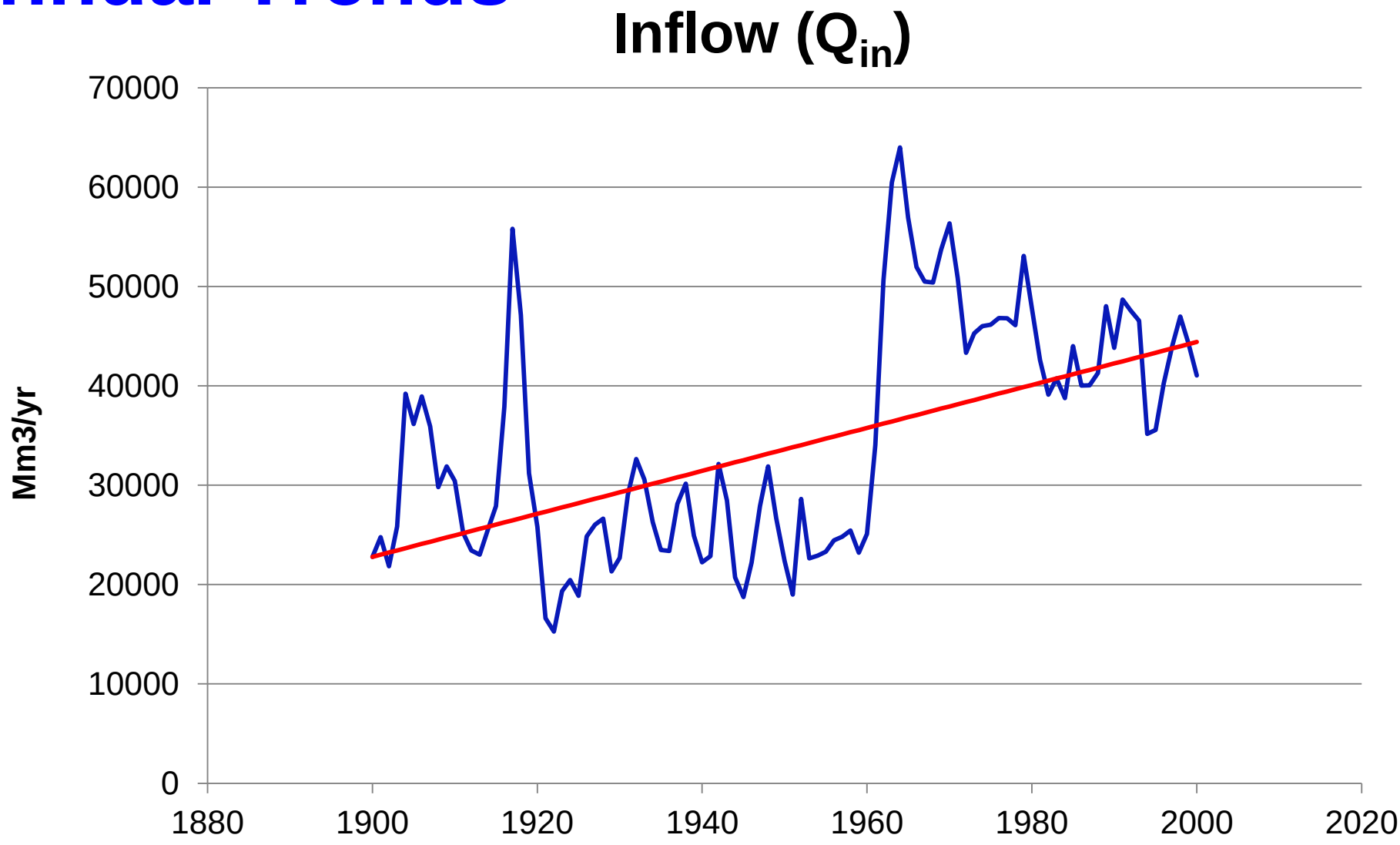
Statistical significance at 5% level is: (**Z<-1.96, Z>1.96**)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
Q_{in}	**8.3**	**9.0**	**8.8**	**8.7**	**7.8**	**8.1**	**7.5**	**6.2**	**6.0**	**7.0**	**7.8**	**8.2**	**8.8**
Q_{out}	**5.7**	**6.3**	**7.5**	**7.8**	**8.1**	**7.9**	**7.2**	**8.2**	**7.3**	**6.6**	**7.1**	**6.6**	**8.7**
P	**2.0**	-0.4	0.1	0.4	-1.7	1.1	1.4	0.5	-0.6	0.8	0.5	0.3	-0.4
ET_a	**-4.0**	**-2.7**	**-3.2**	-1.1	-1.7	1.1	1.8	**2.4**	0.5	-0.9	-0.8	**-3.4**	-1.6
Area	**5.1**	**5.0**	**4.9**	**4.9**	**4.8**	**4.8**	**4.9**	**5.0**	**5.0**	**5.1**	**4.9**	**4.9**	**4.9**
T_{max}	0.6	1.7	0.7	0.8	0.8	**3.4**	**4.0**	**5.1**	**2.7**	**1.9**	0.9	0.5	**3.5**
T_{min}	**3.9**	**3.8**	**6.1**	**4.0**	**5.4**	**5.4**	**4.4**	**5.3**	**5.5**	**6.0**	**4.5**	**4.3**	**7.0**
RH	**-4.8**	**-4.6**	**-4.5**	**-3.8**	**-3.6**	**-3.2**	**-4.3**	**-4.2**	**-3.9**	**-3.9**	**-3.0**	**-3.6**	**-5.5**
n	**-4.2**	**-3.8**	**-3.7**	**-2.9**	**-3.8**	**-5.2**	**-2.7**	**-1.9**	**-2.0**	**-1.6**	**-2.8**	**-5.6**	**-6.6**

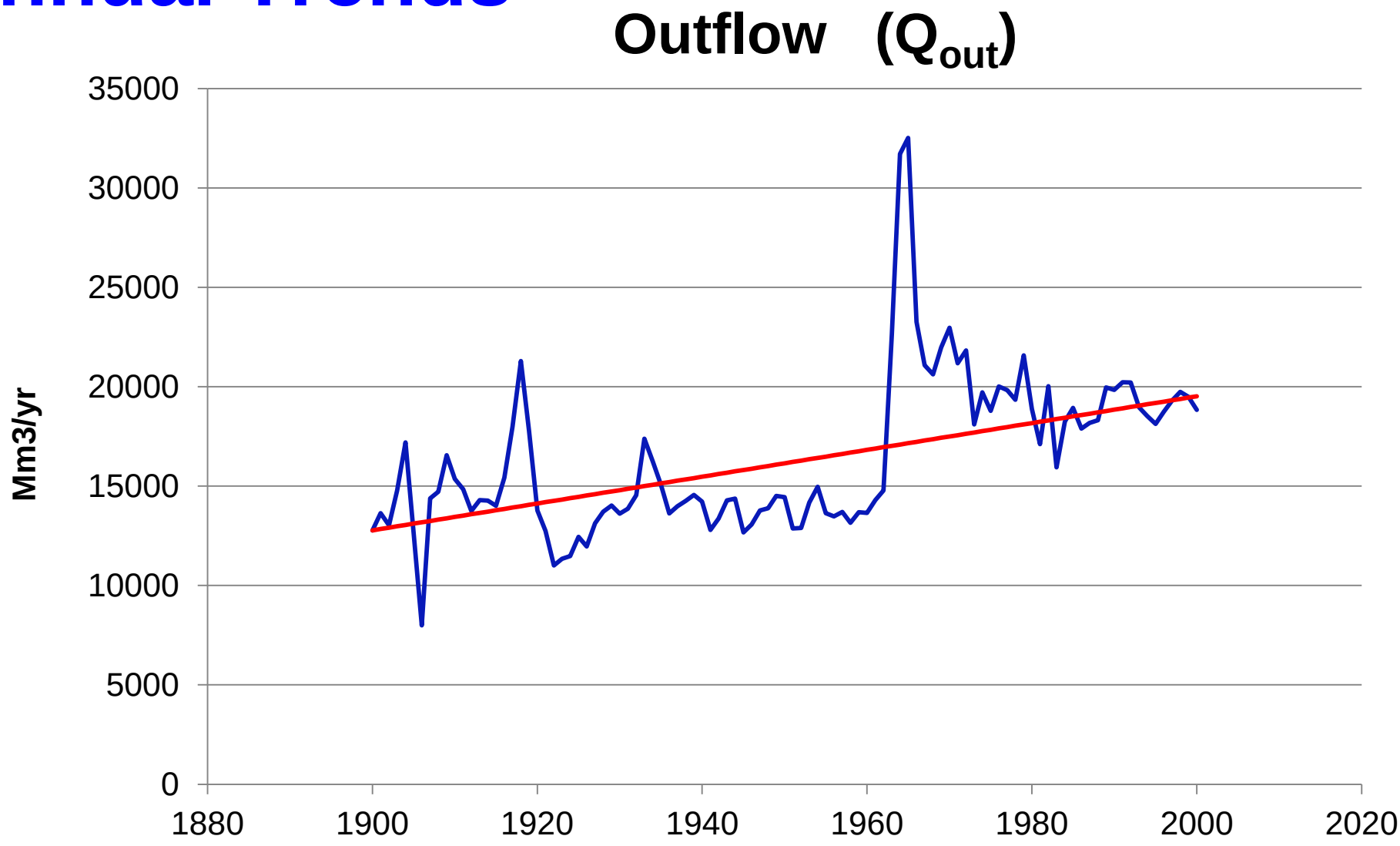
Annual Trends



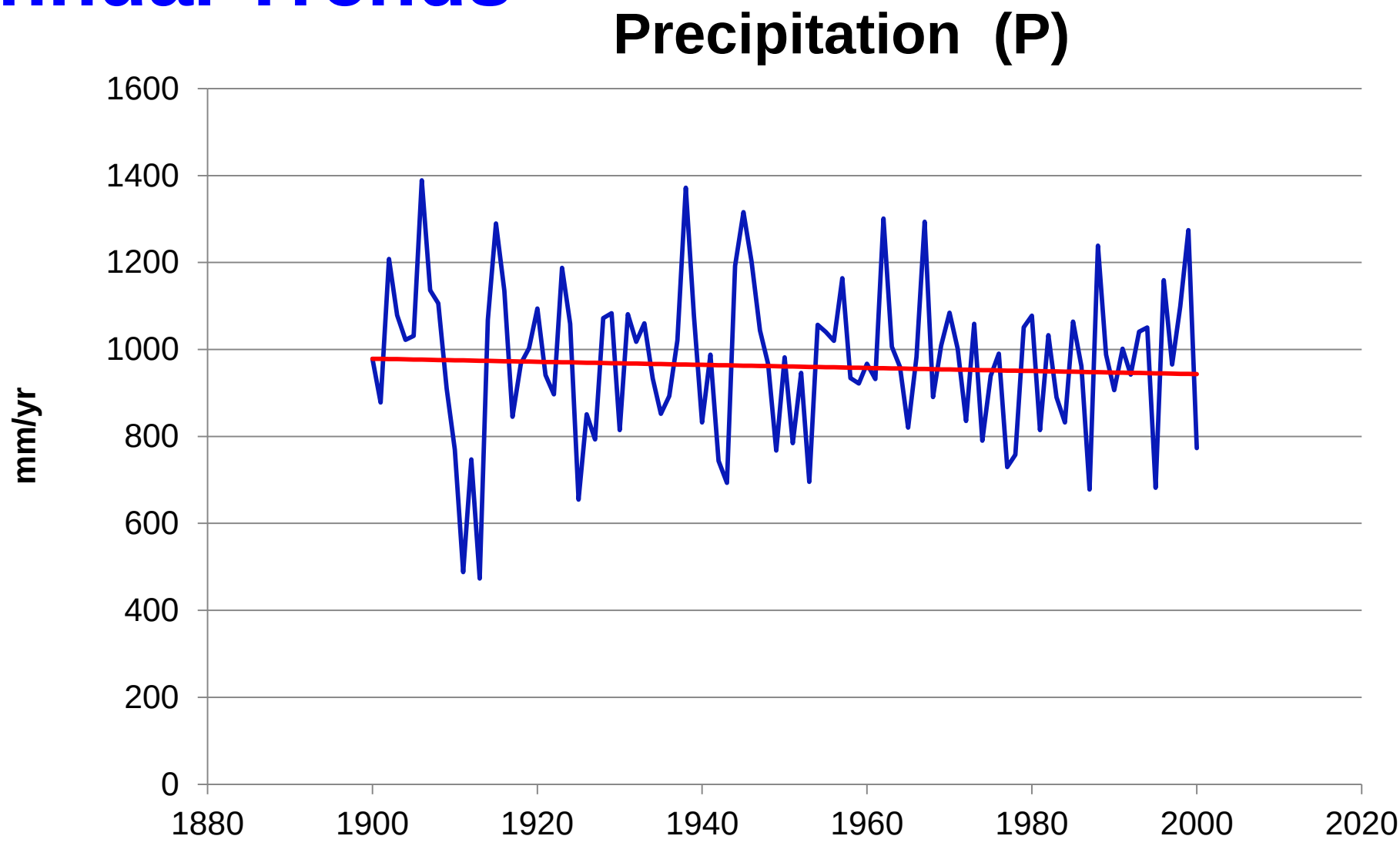
Annual Trends



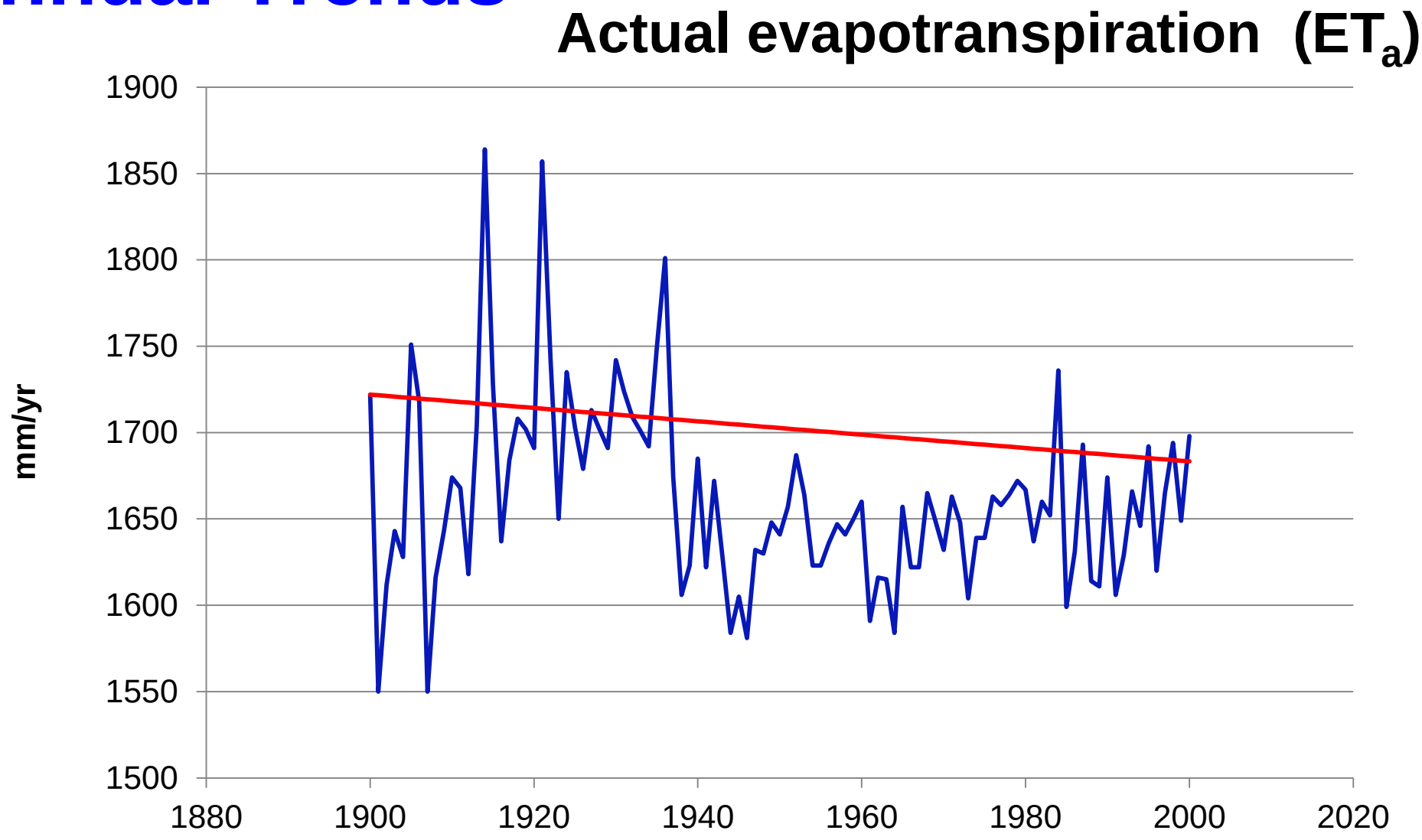
Annual Trends



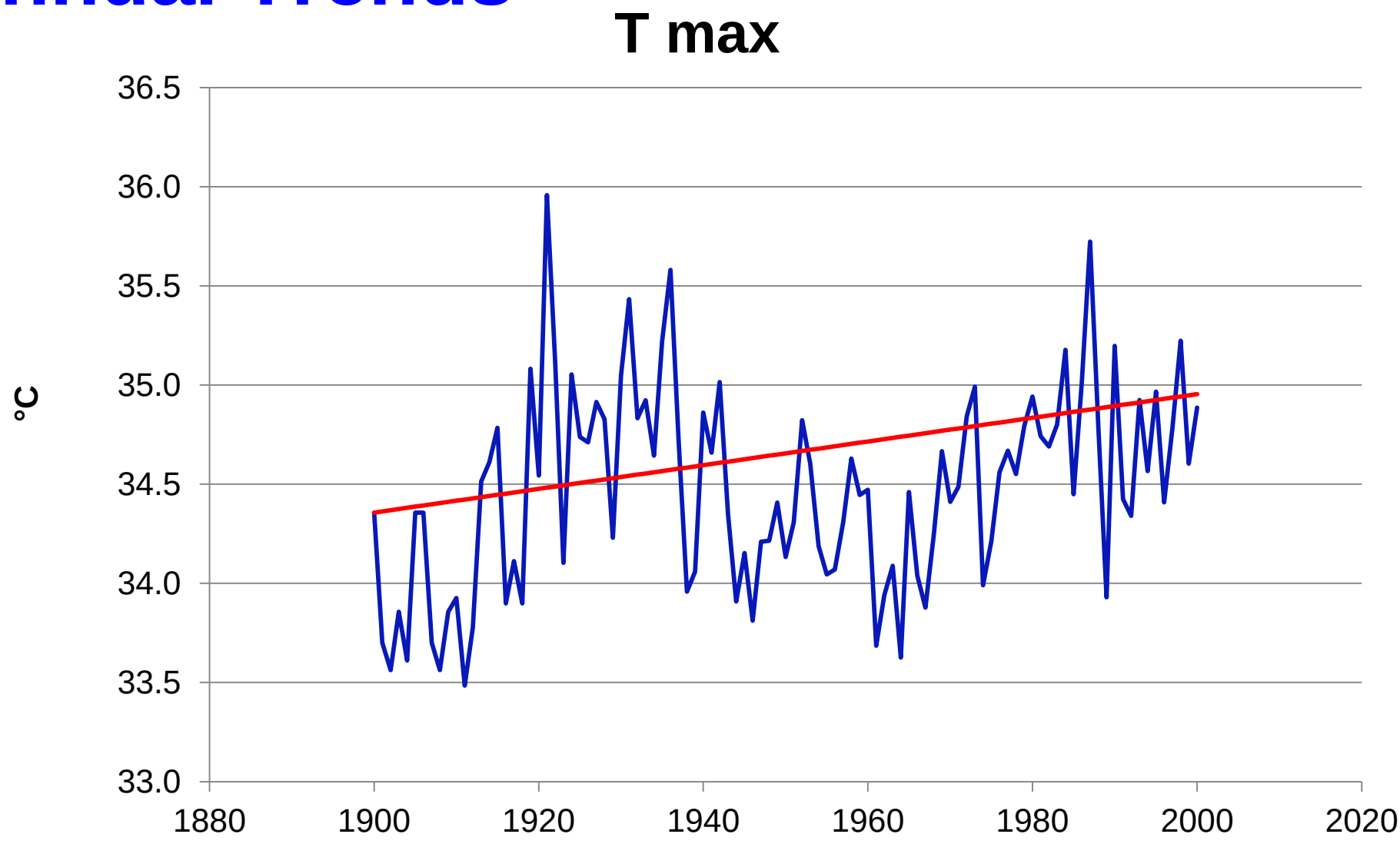
Annual Trends



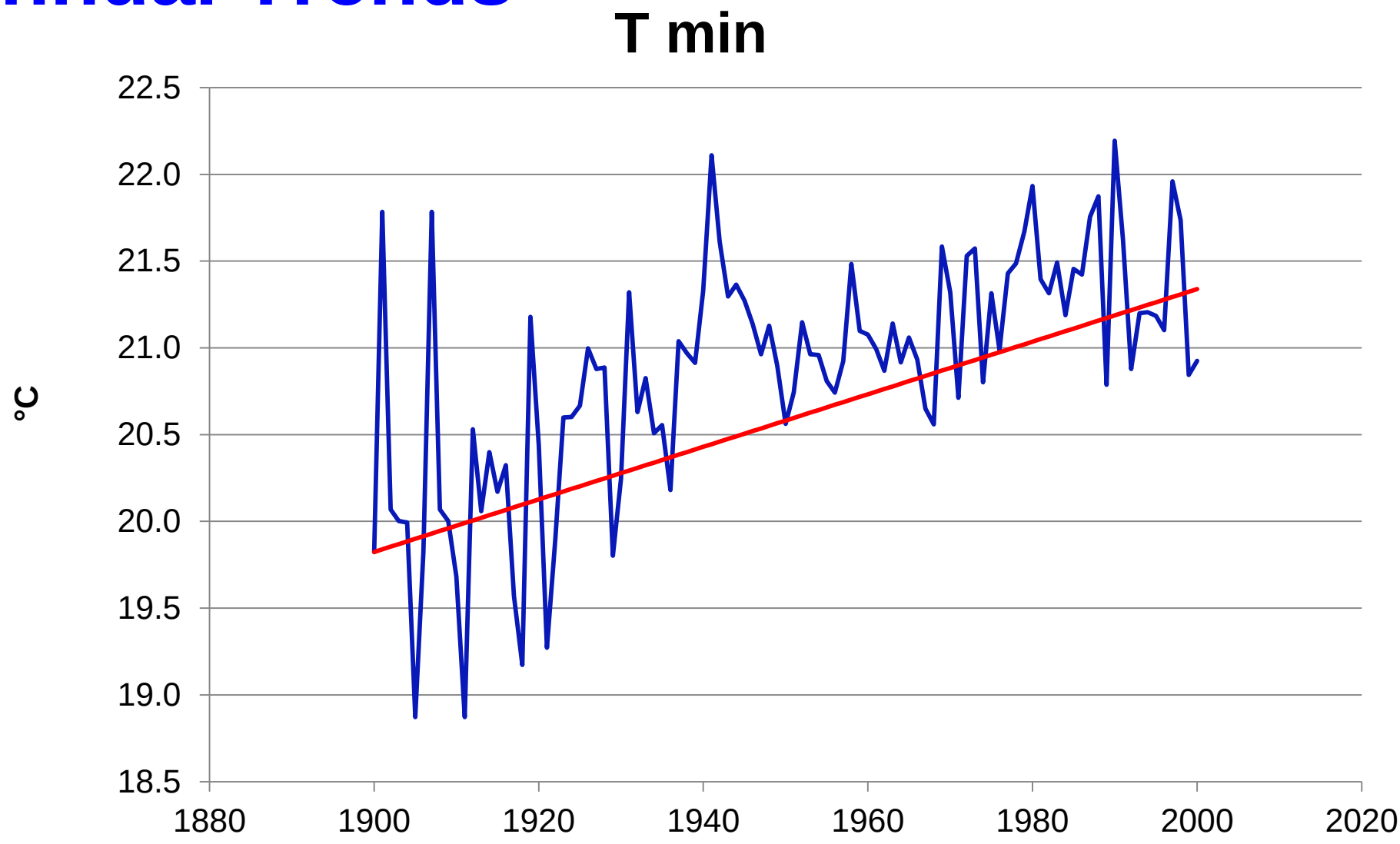
Annual Trends



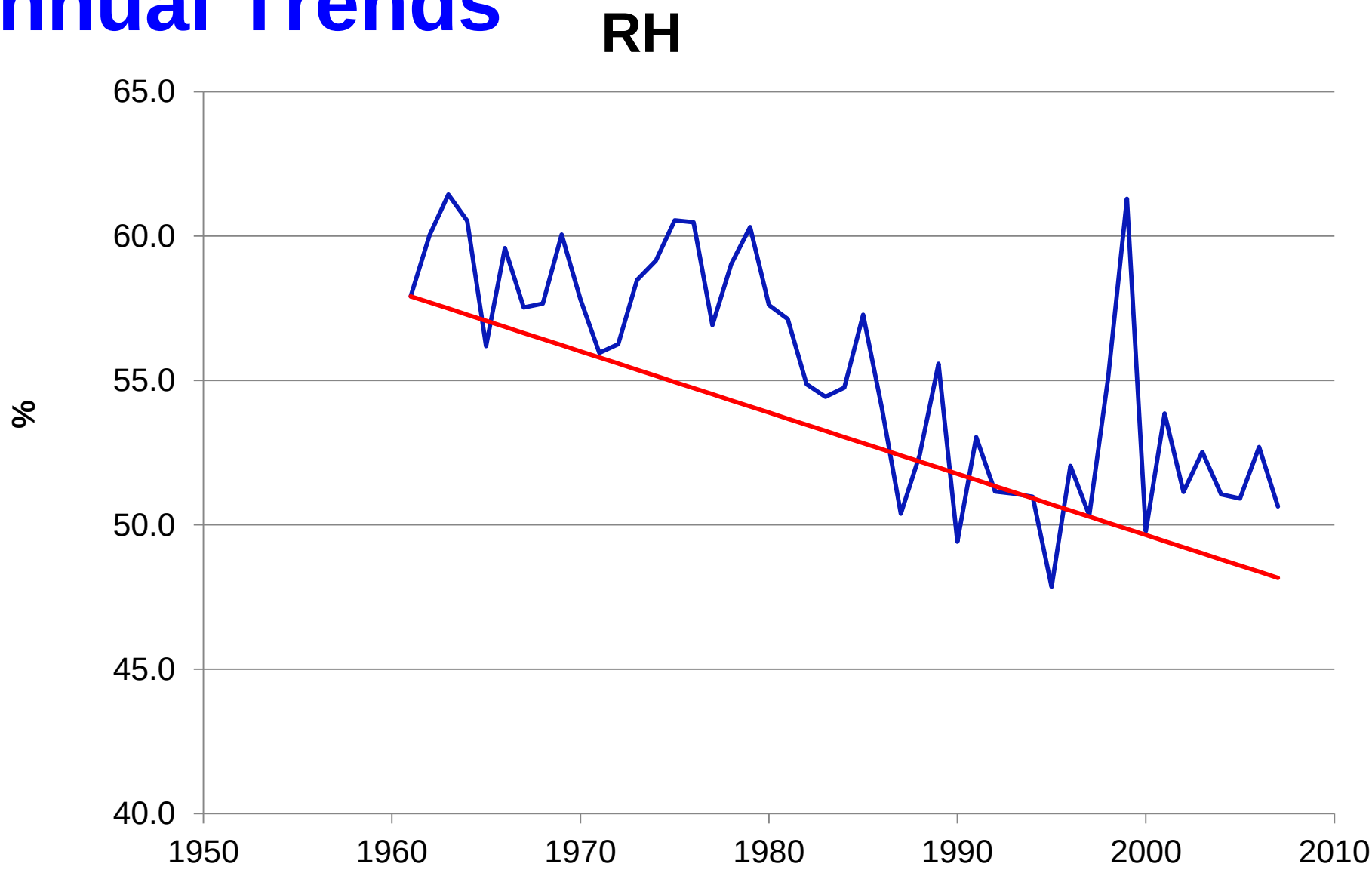
Annual Trends



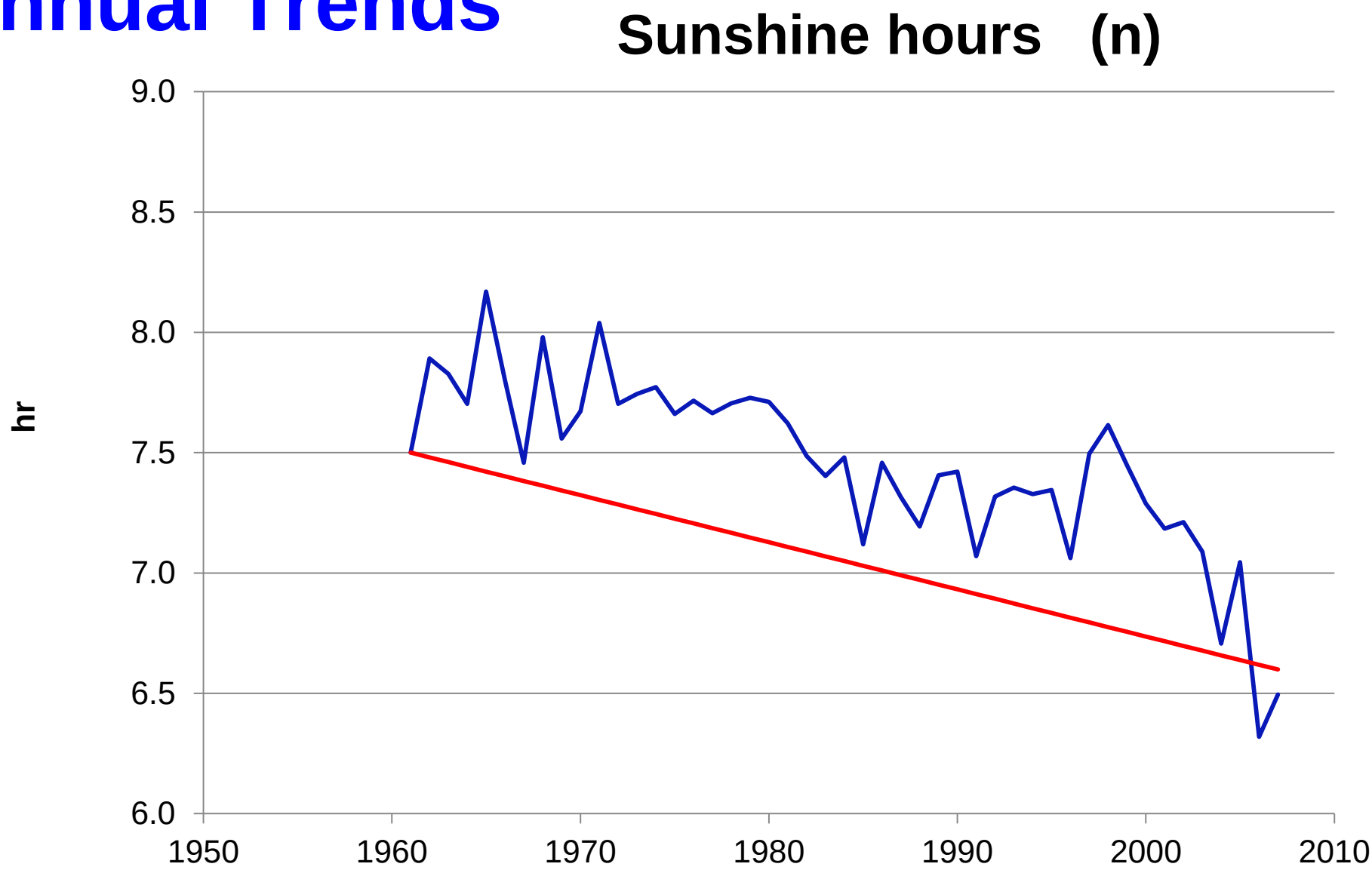
Annual Trends



Annual Trends



Annual Trends



Conclusions

- **Local climate of the Sudd is changing:**
  - **ΔT_{max} = +0.6°C in 100 yr**
  - **ΔT_{min} = +1.5 °C in 100 yr**
  - **ΔRH = -10% in 50 yr**
  - **Sunshine hours Δn = -1 hr in 50 yr (~10%)**
- **Neither rainfall, nor ET_a are statistically changing over the Sudd.**
- **However, the Sudd area is (significantly) increasing: ΔA= +19.6 Gm^2 in 100 year (80% increase); attributed to increasing inflows (Lake Vic.)**
- **Based on RCM experiment (Mohamed et al., 2005):**
  - **The Sudd has negligible impact on regional water cycle; but very high impact on local climate (T, RH).**
- **Therefore, the Sudd hydrology is largely influenced by upstream climate than local climate.**
- **Information about Sudd hydrology is key for wetland management**

Thank you