

**WHAT CLIMATE CAN BE
EXPECTED IN SLOVAKIA
UP TO 2050 (2100) ?
AKÉ PODNEBIE BUDE NA
SLOVENSKU DO ROKU 2050 (2100)?**

Milan Lapin

***Faculty of Mathematics, Physics and Informatics,
Comenius University in Bratislava, Slovakia,
lapin@fmph.uniba.sk***

www.milanlapin.estranky.sk

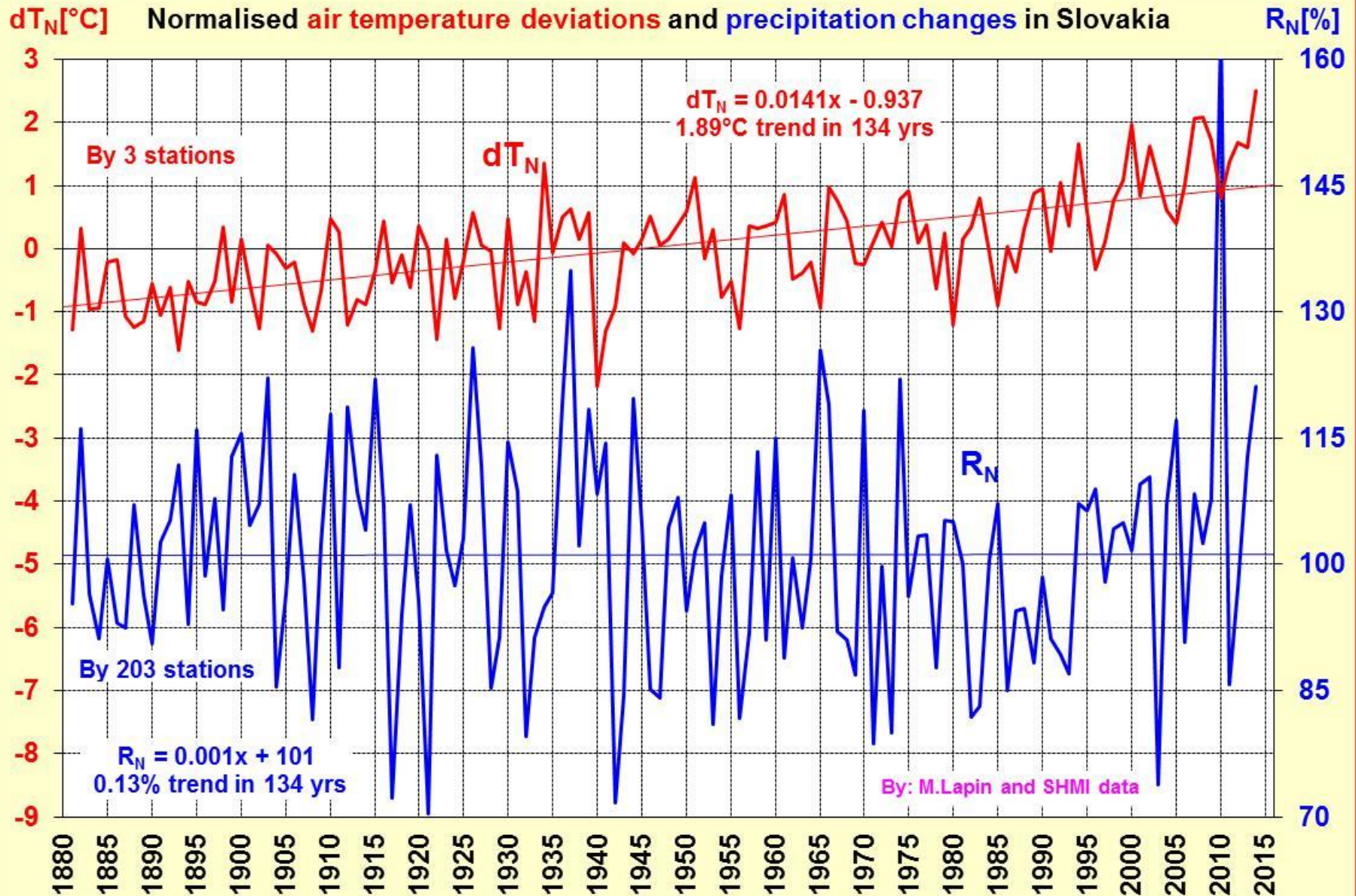
ABSTRACT

- Changes and trends of several climatic characteristics in Slovakia since 1881 and possible scenarios up to 2050 (2100) are presented
- **Air temperature, air humidity, precipitation, evapotranspiration..., all in the context of climate change scenarios (based on two global and 2 regional climate change models – General Circulation Models (GCMs))**
- **Air temperature T , humidity RH , precipitation R in 1881/1900-2014/5, actual (E) and potential (E_o) evapotranspiration** are based on Budyko-Tomlain Complex method – from monthly measured data in 1951-2014
- Based on these GCMs and RCMs models modified outputs the scenarios of daily T , daily R and daily RH in 1951-2100 for all available stations were prepared, only a sample from a broader elaboration is presented here as time series and scenarios for selected time frames
- The **combined scenarios** of potential evapotranspiration E_o are calculated using simple **Zubenok formula** and saturation deficit **D** (difference between modeled saturated and actual water vapor pressure)
- In Slovakia mainly the drought, flash flood and heat waves risk will be important – **Start with the history of climate change study in Slovakia**

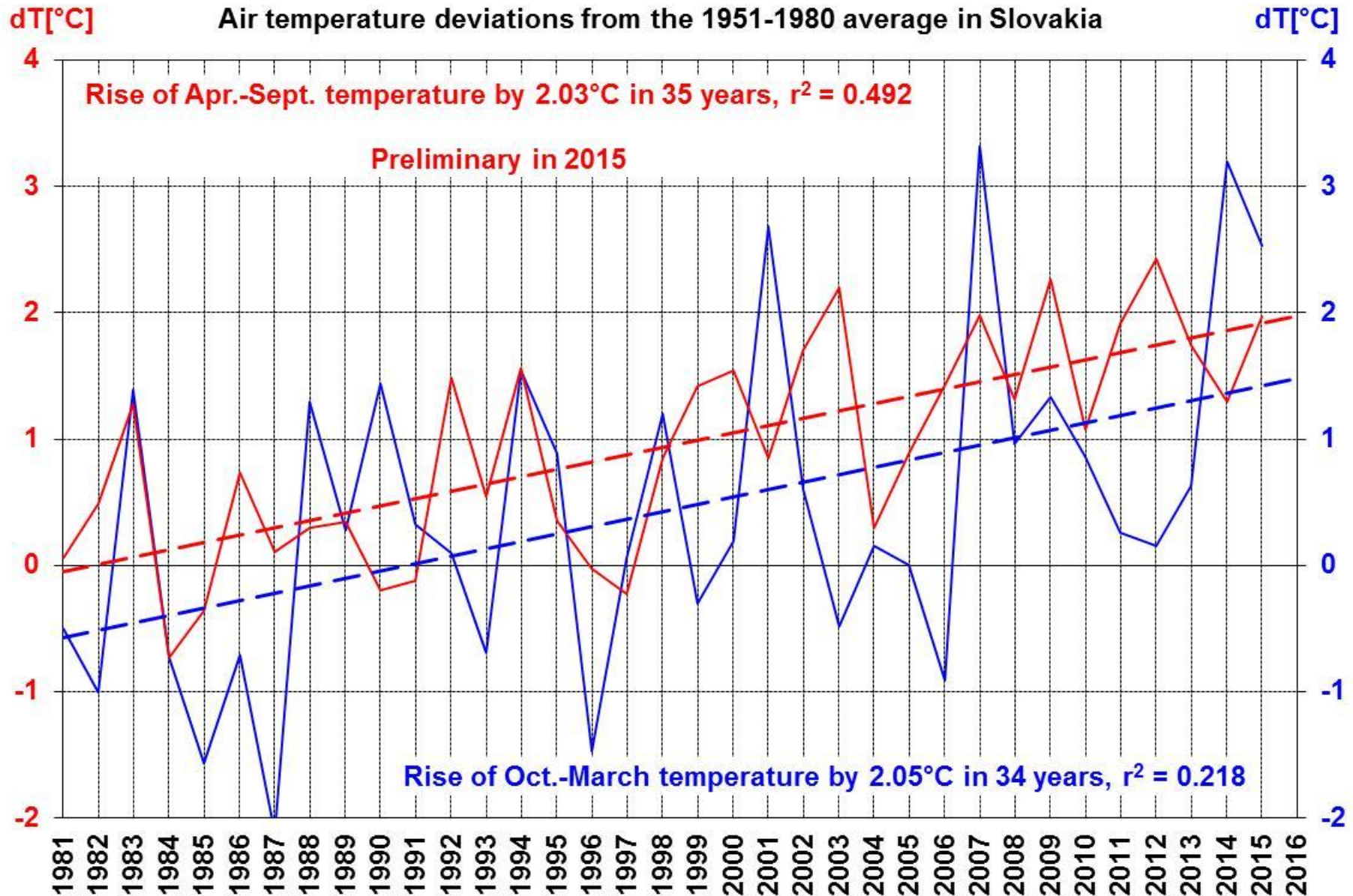
HISTORY

- The first studies on climate change and possible greenhouse effect enhancement impact have been issued by M. Konček and Š. Petrovič before 1970, the accent to long climatic series was presented
- **On January 1, 1991 the Czecho-Slovak National Climate Program was established according to the decision of Federal Minister of Environment (dr. Vavroušek), dr. B. Moldan was the NCP president**
- On January 1, 1993 creation of the Slovak National Climate Program in the SHMI was realized under the coordination of Slovak Ministry of Environment, dr. M. Lapin was the NCP president
- In 1994-1997 the international Project named US Country Study Slovakia and partly funded by US EPA was solved by about 20 Slovak partners
- 6 Slovak National Communication on Climate Change have been issued (1995, 1997, 2001, 2005, 2009, 2013), all approved by the Slovak Government and sent to the UN Commission of FCCC Parties
- **In Slovakia mainly the climate change impacts in the sectors as Water management, Agriculture and Forestry have been studied**

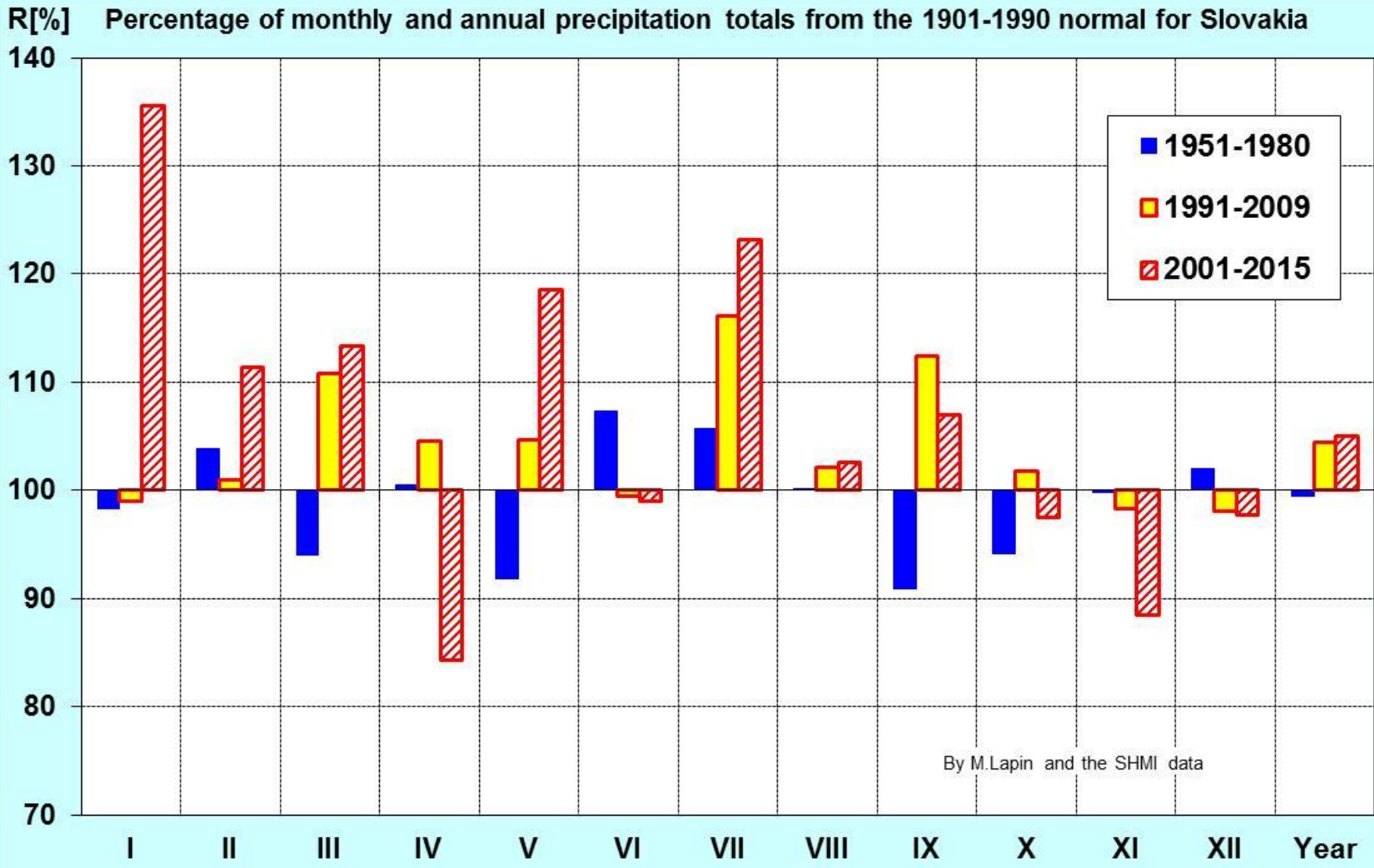
AIR TEMPERATURE AND PRECIPITATION TRENDS



AIR TEMPERATURE AND PRECIPITATION TRENDS

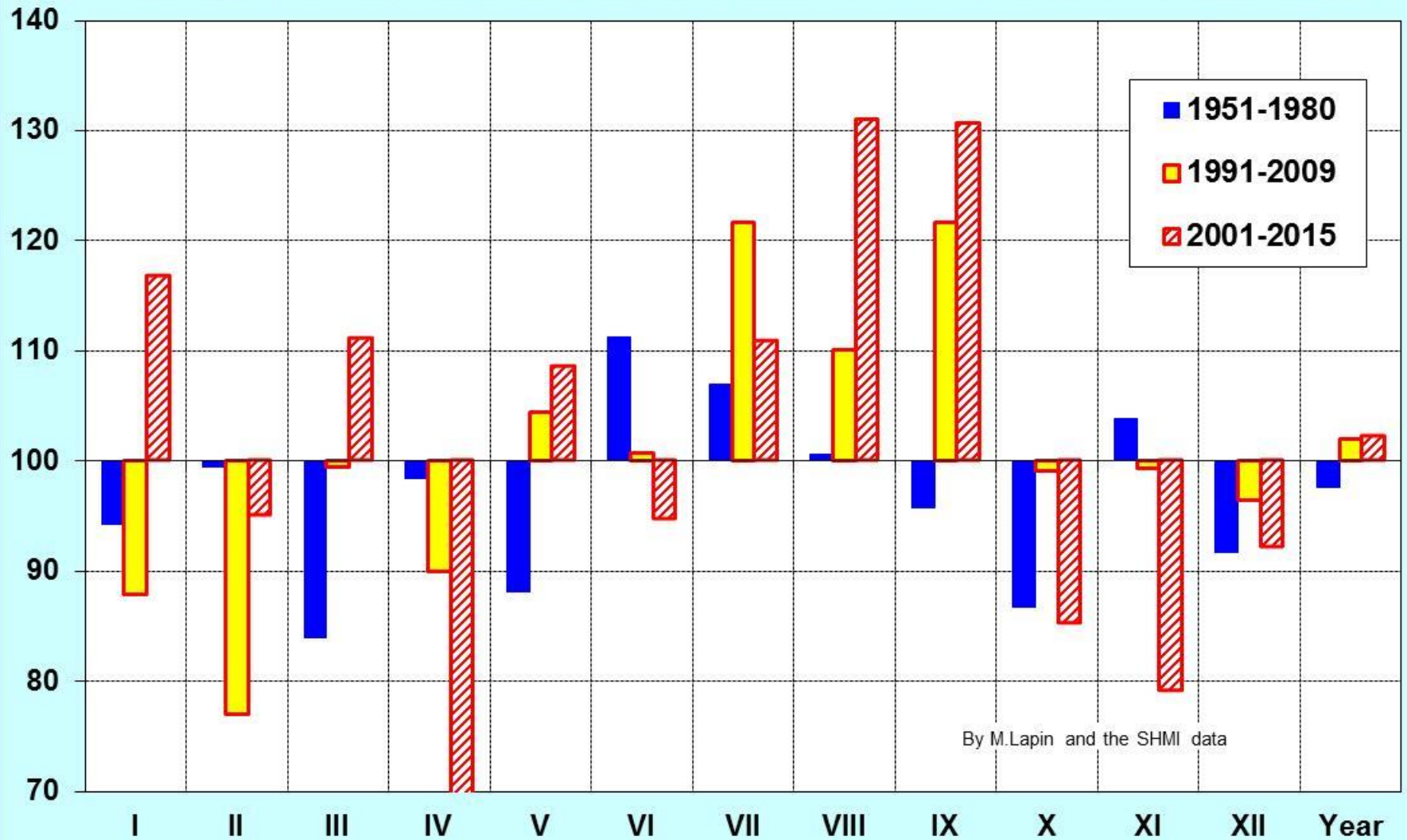


PRECIPITATION CHANGES IN SLOVAKIA (2015 from Jan. to Aug.)



PRECIPITATION CHANGES AT HURBANOVO (2015 from Jan. to Aug.)

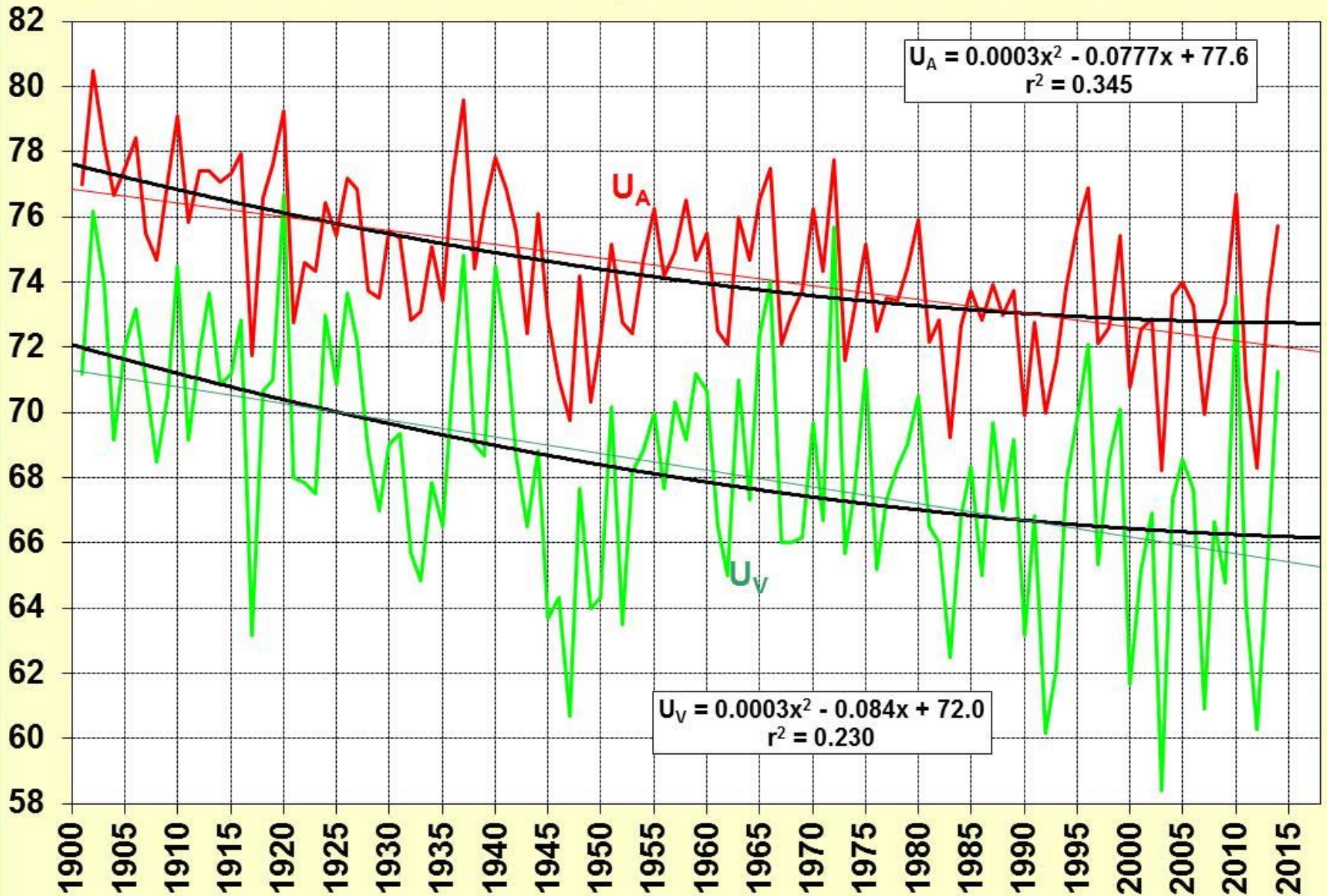
R[%] Percentage of monthly and annual precipitation totals from the 1901-1990 normal for Hurbanovo



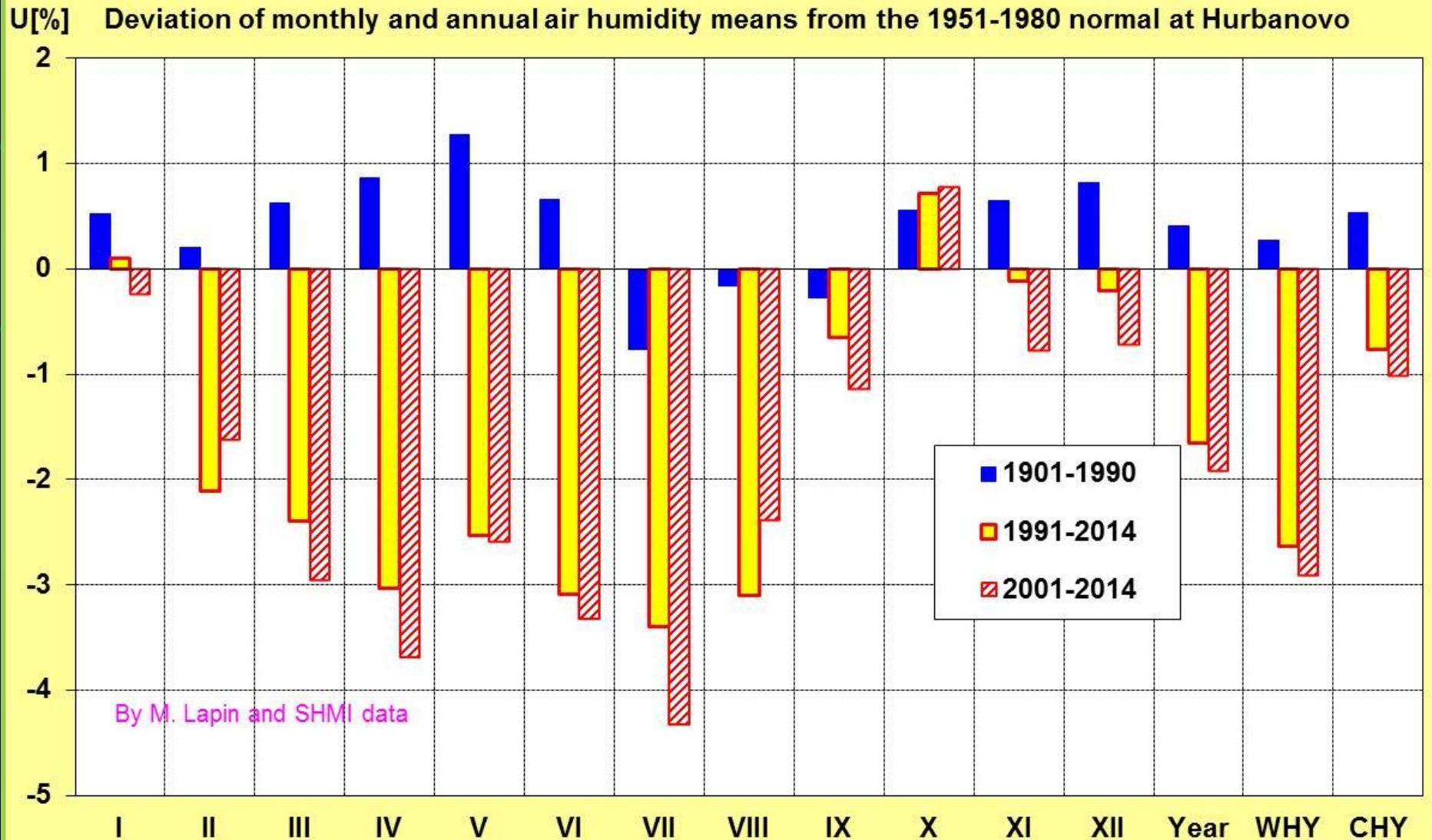
By M.Lapin and the SHMI data

AIR HUMIDITY TRENDS AT HURBANOVO, 1901-2014

U[%] Annual and Growing period (U_V) relative air humidity at Hurbanovo 1901-2014

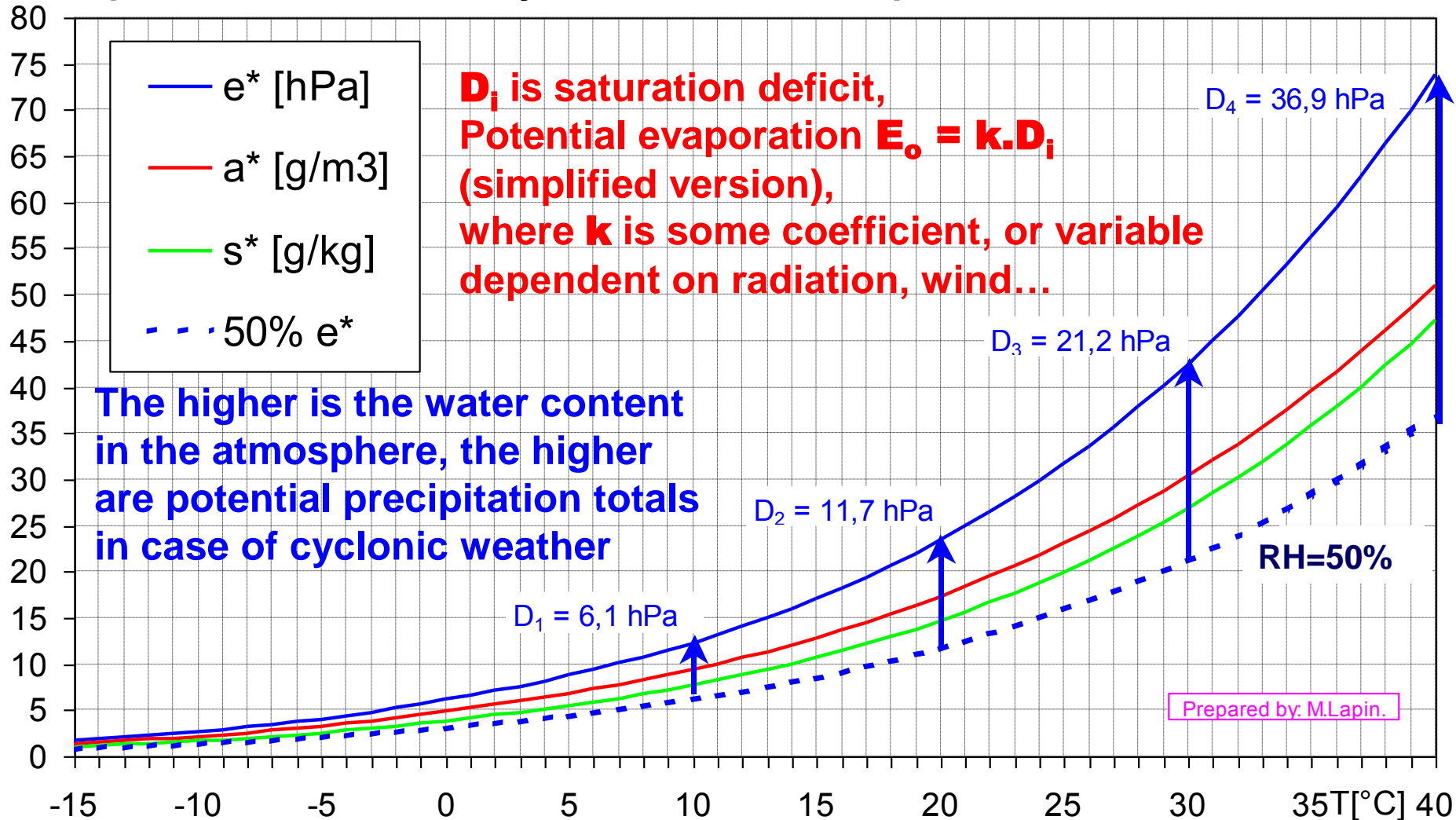


AIR HUMIDITY TRENDS AT HURBANOVO, 1901-2014



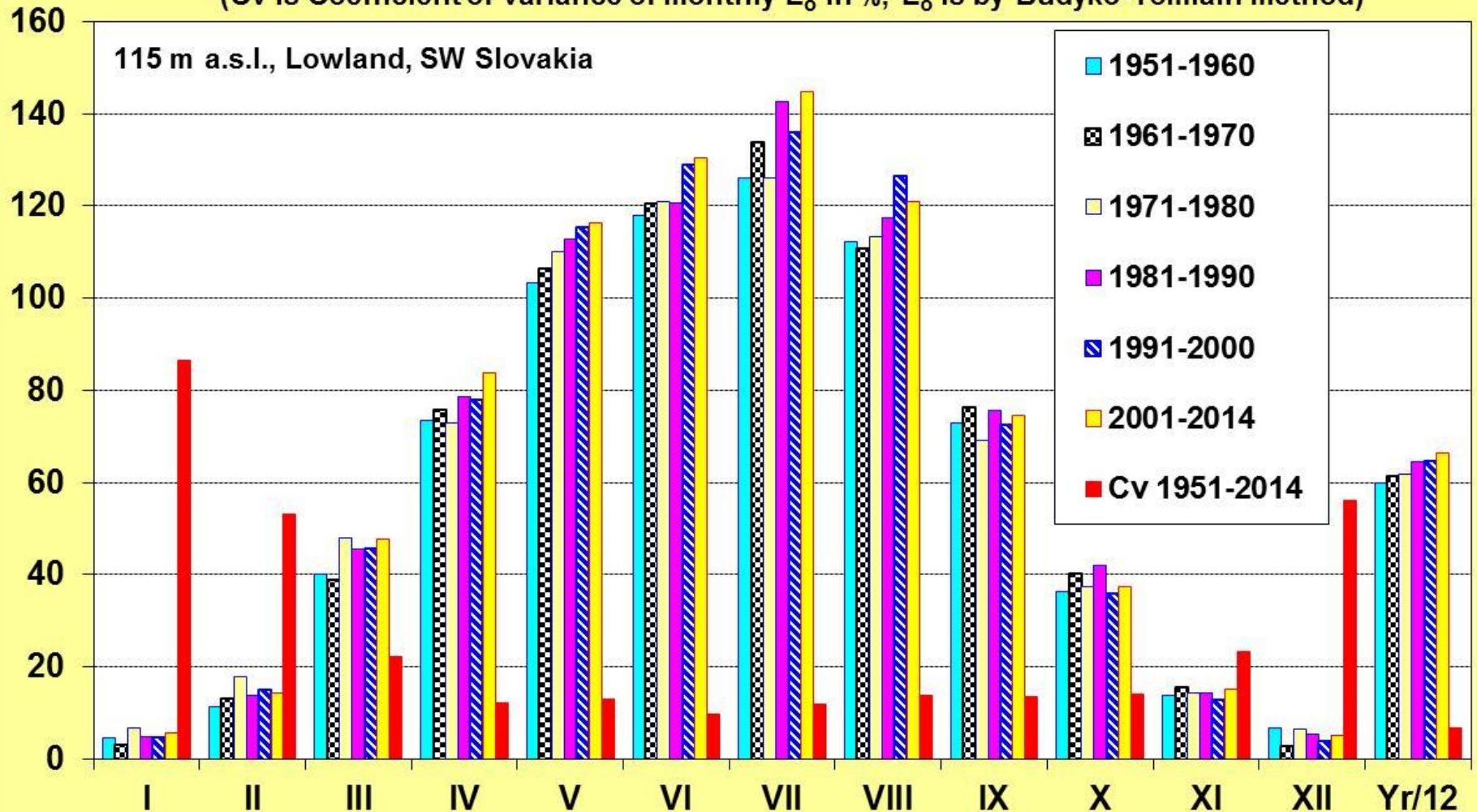
AIR HUMIDITY AND AIR TEMPERATURE

Dependence of air humidity variables on air temperature at about 1000 hPa

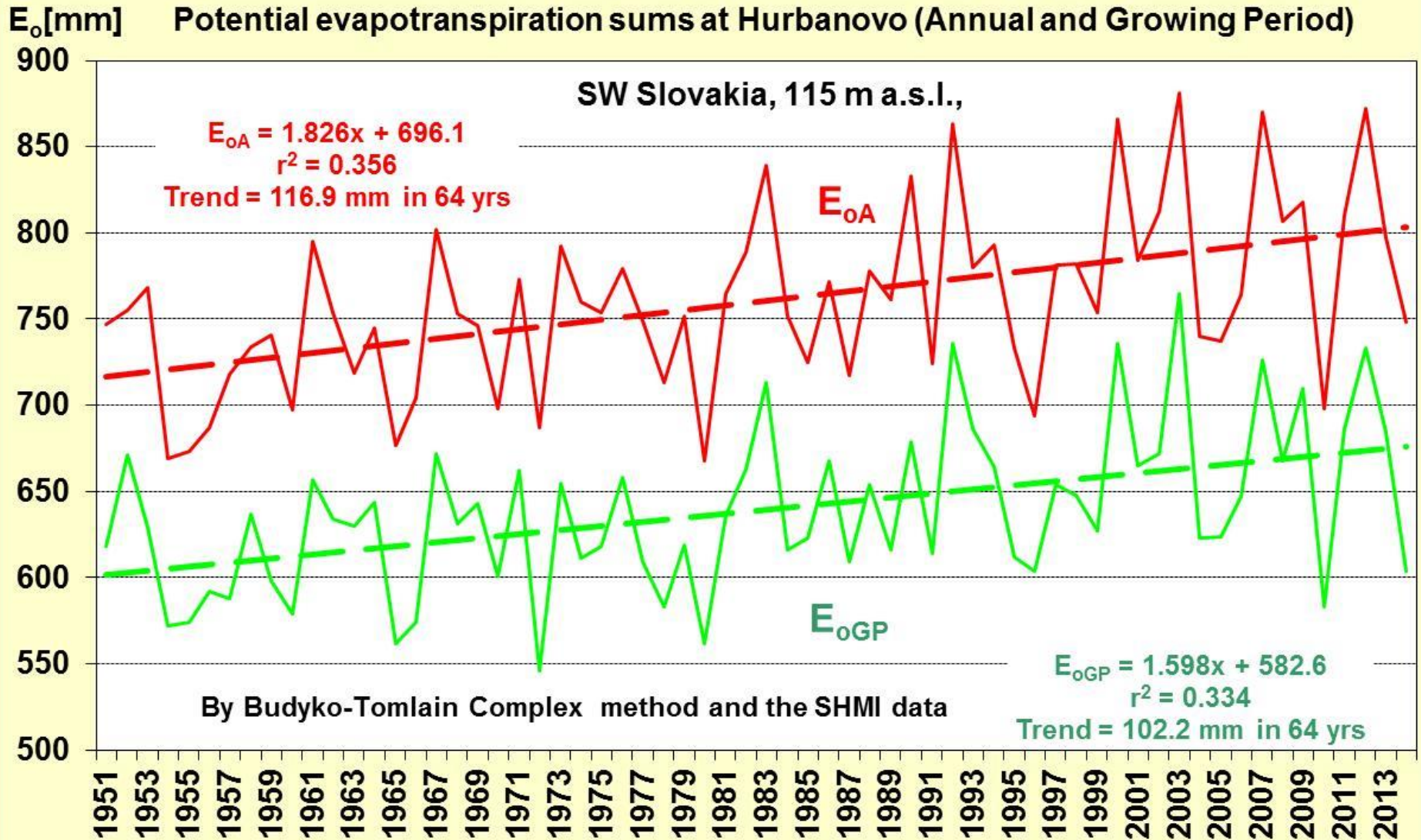


POTENTIAL EVAPOTRANSPIRATION TRENDS AT HURBANOVO, 1951-2014

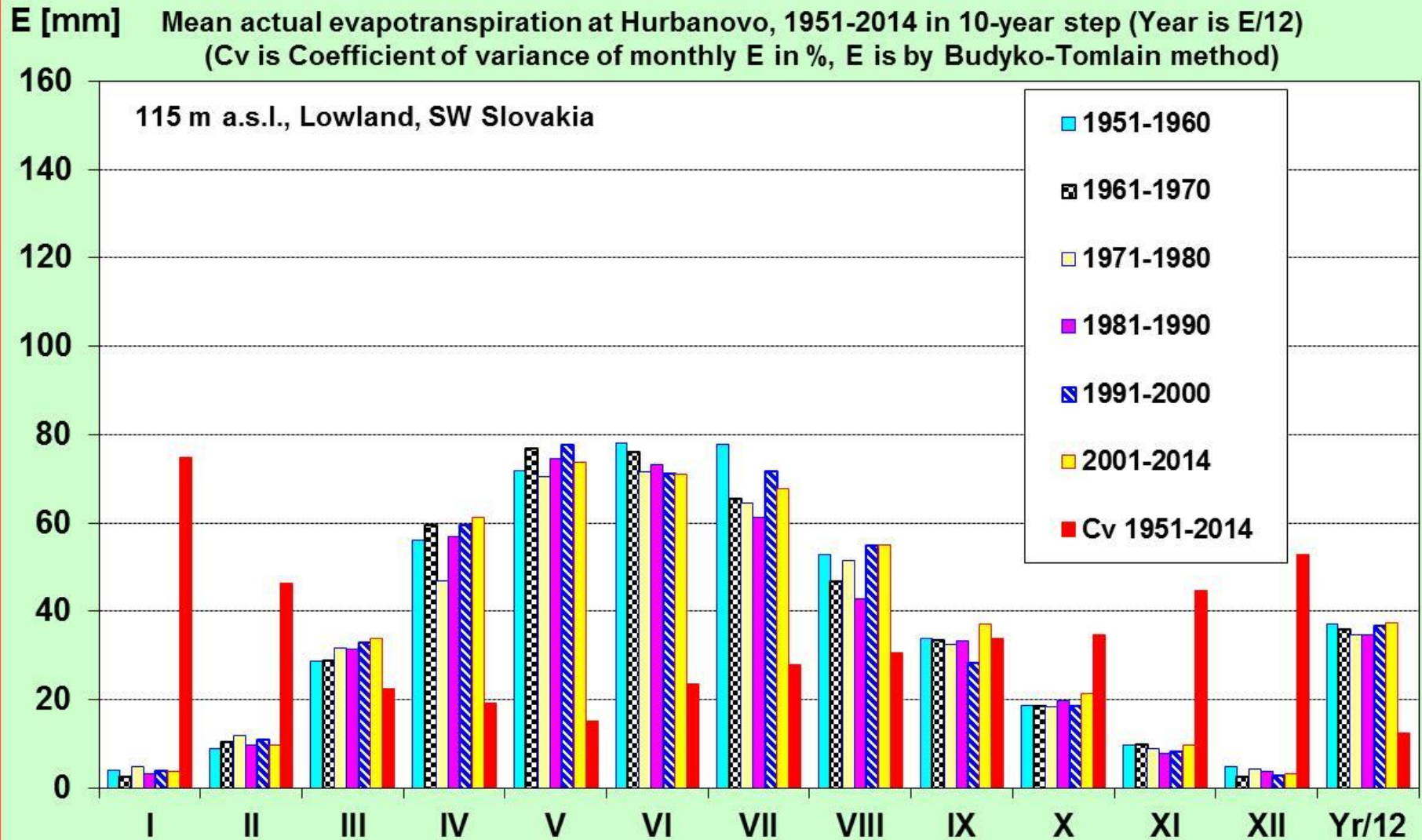
E_o [mm] Mean potential evapotranspiration at Hurbanovo, 1951-2014 in 10/14-year step (Year is $E_o/12$)
 (Cv is Coefficient of variance of monthly E_o in %, E_o is by Budyko-Tomlajn method)



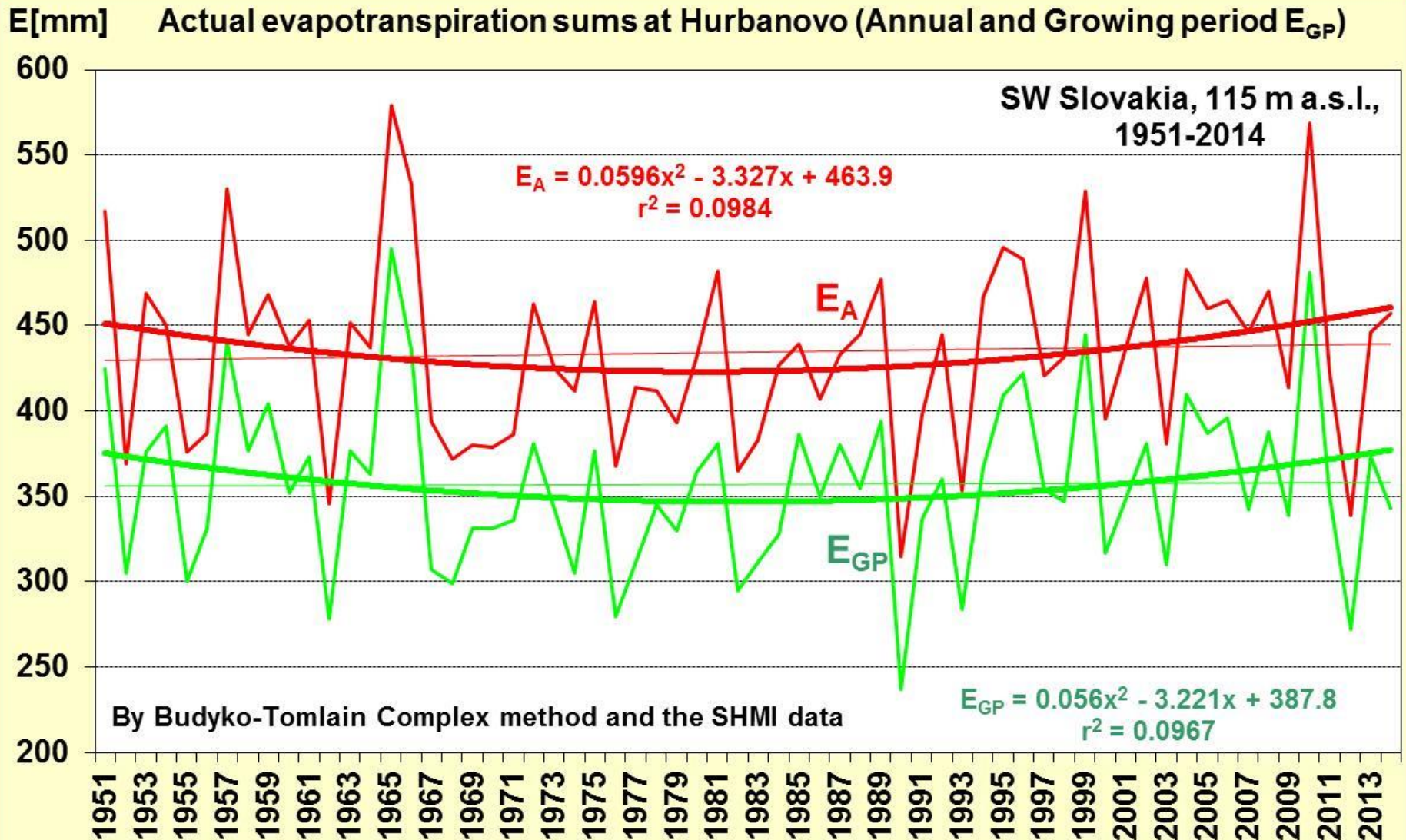
POTENTIAL EVAPOTRANSPIRATION TRENDS AT HURBANOVO, 1951-2014



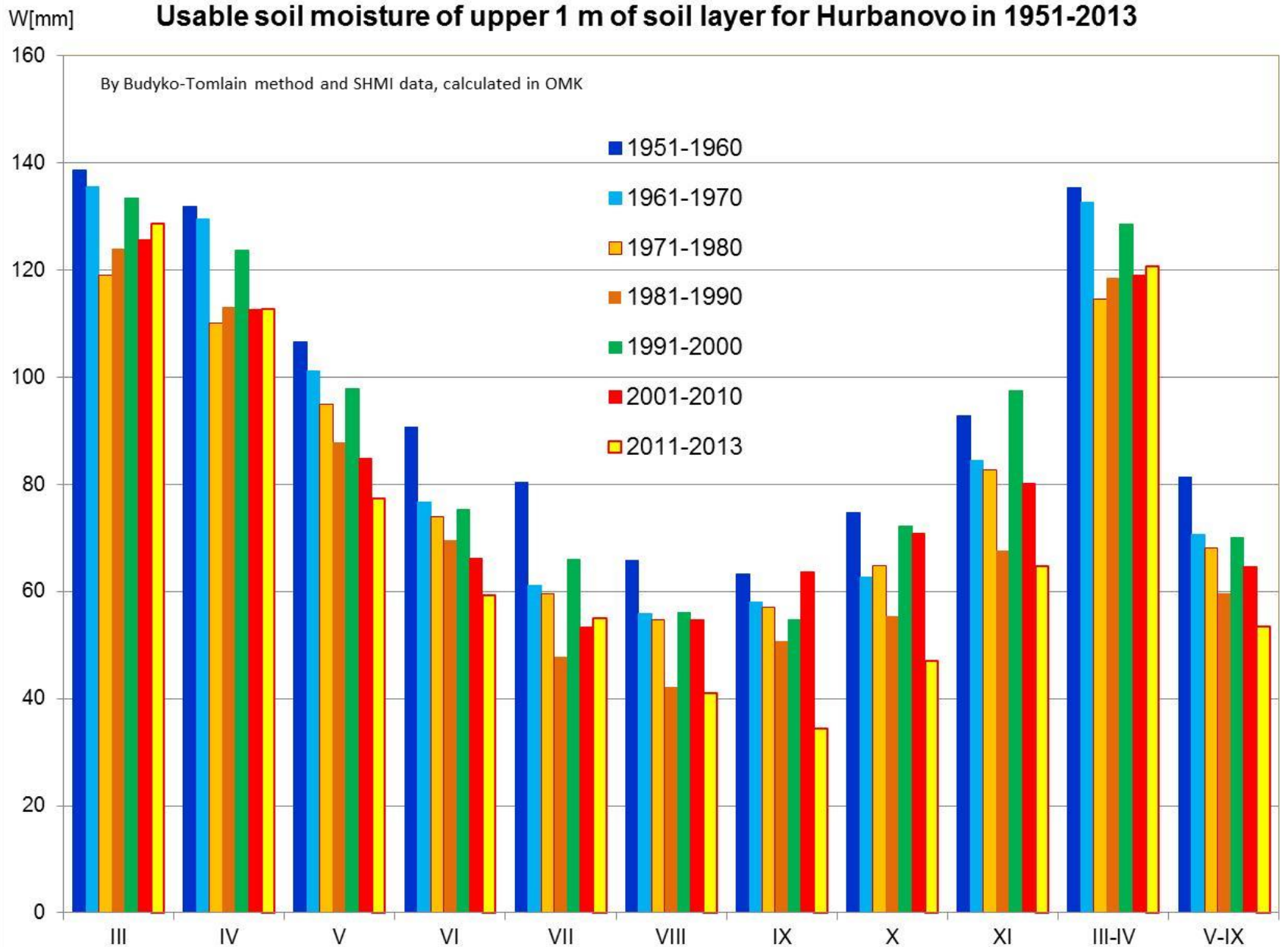
ACTUAL EVAPOTRANSPIRATION TRENDS AT HURBANOVO, 1951-2014



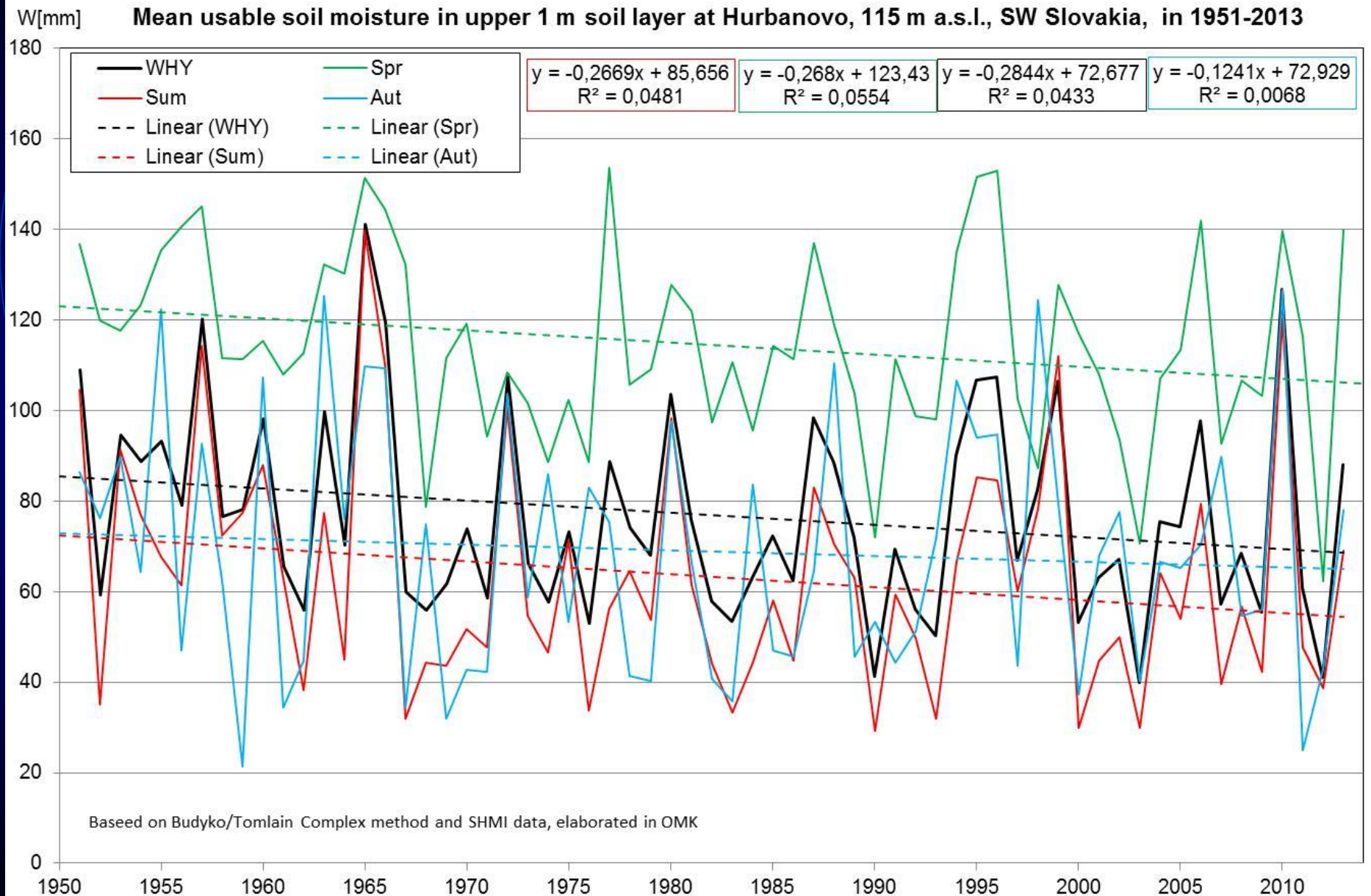
ACTUAL EVAPOTRANSPIRATION TRENDS AT HURBANOVO, 1951-2014



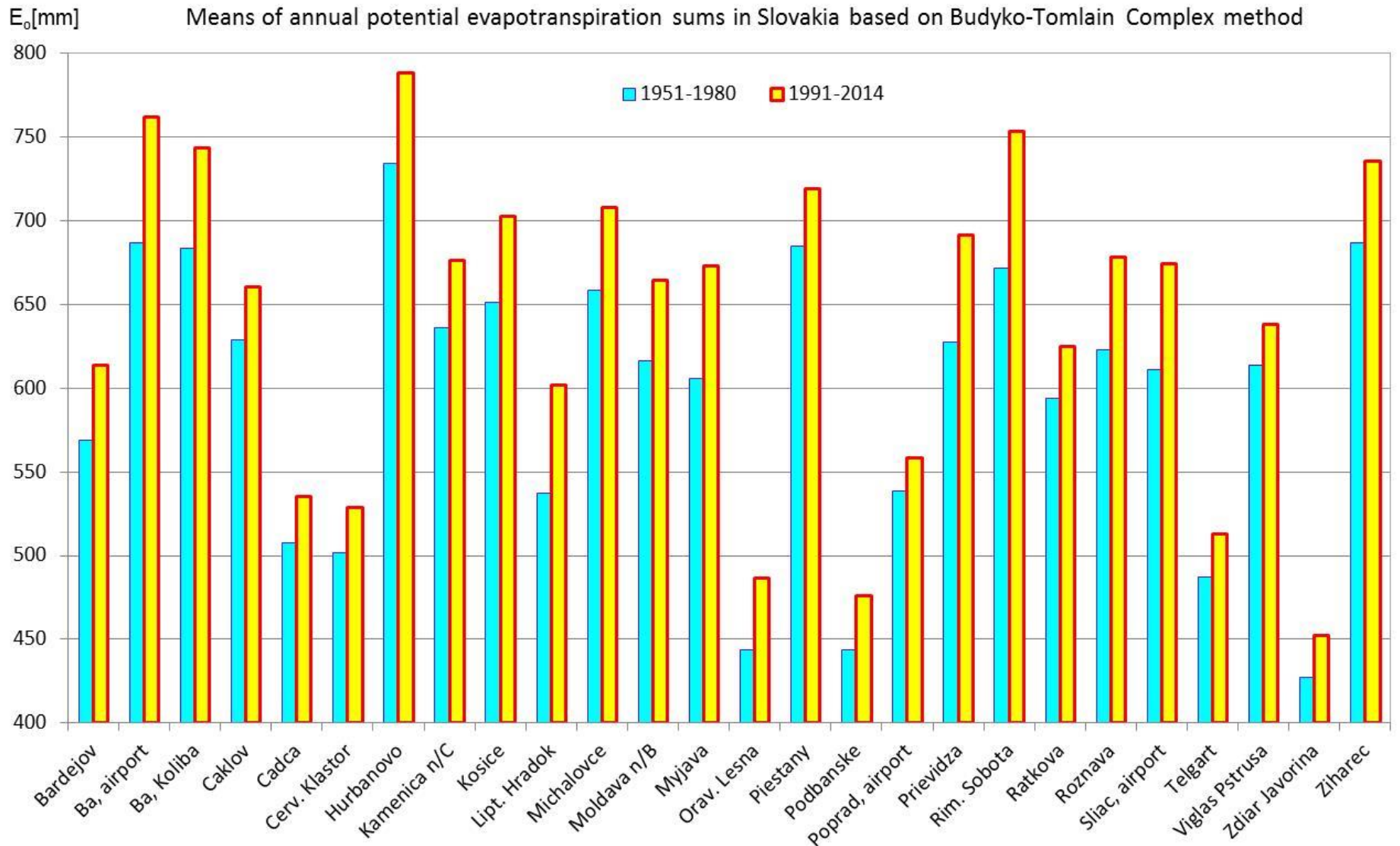
CALCULATED USABLE SOIL MOISTURE AT HURBANOVO



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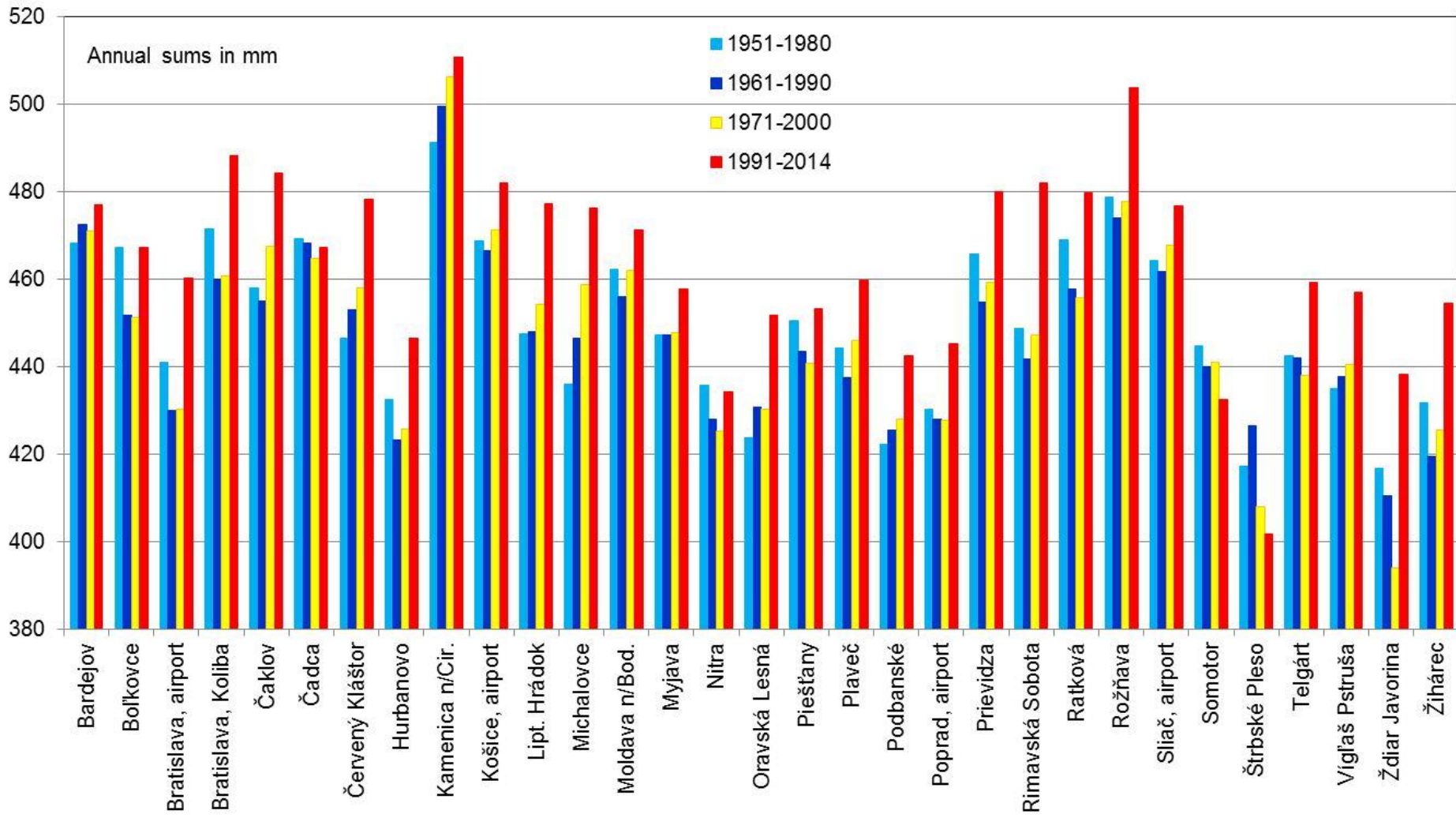


POTENTIAL AND ACTUAL EVAPOTRANSPIRATION TRENDS IN SLOVAKIA BY THE OMK AND SHMI DATA



POTENTIAL AND ACTUAL EVAPOTRANSPIRATION TRENDS IN SLOVAKIA BY THE OMK AND SHMI DATA

[E[mm] Evapotranspiration in Slovakia at SHMI stations and time frames from 1951 to 2014, calculated by Budyko-Tomlain Complex Method in OMK

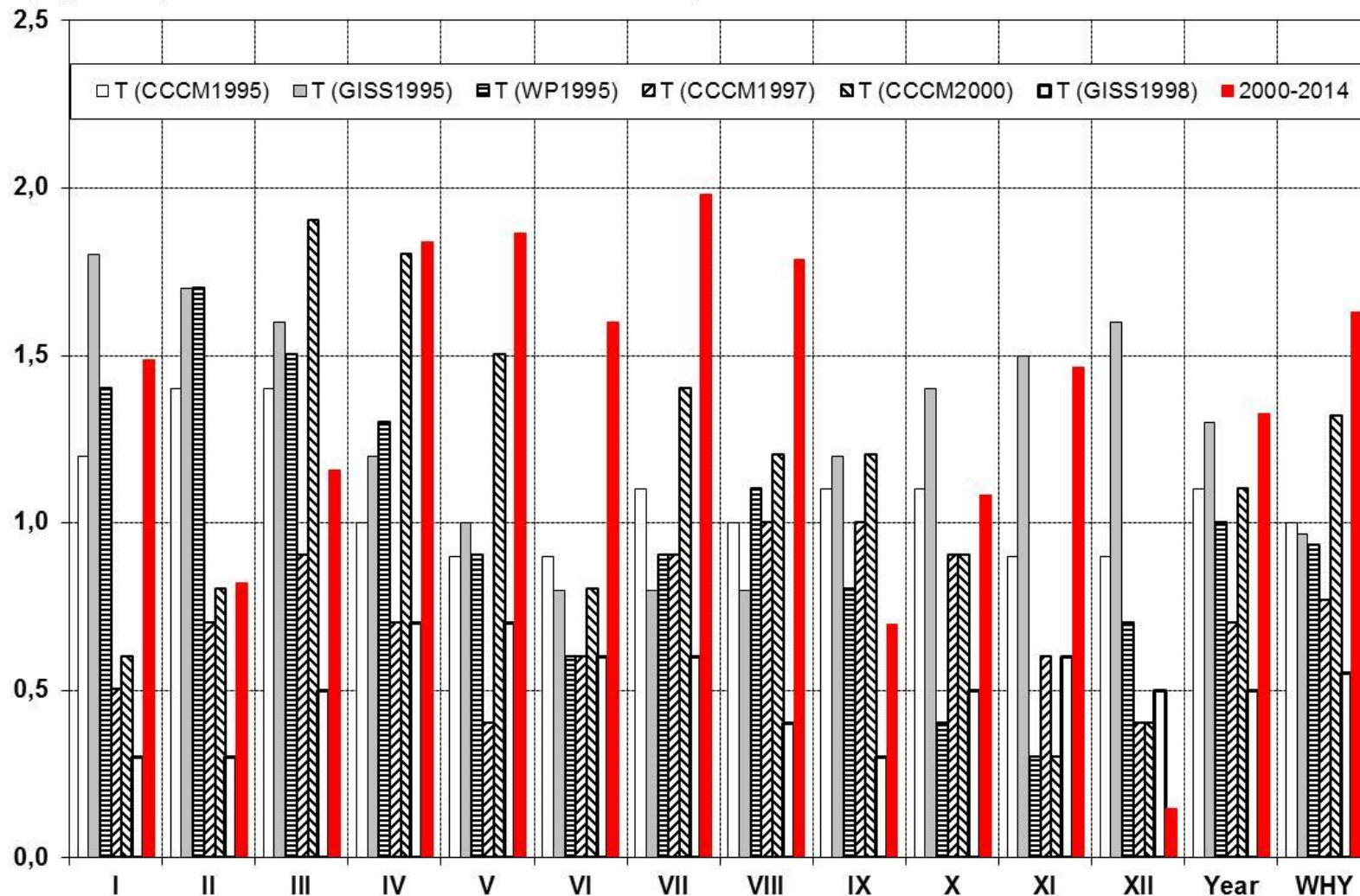


CLIMATE CHANGE SCENARIOS SUMMARY

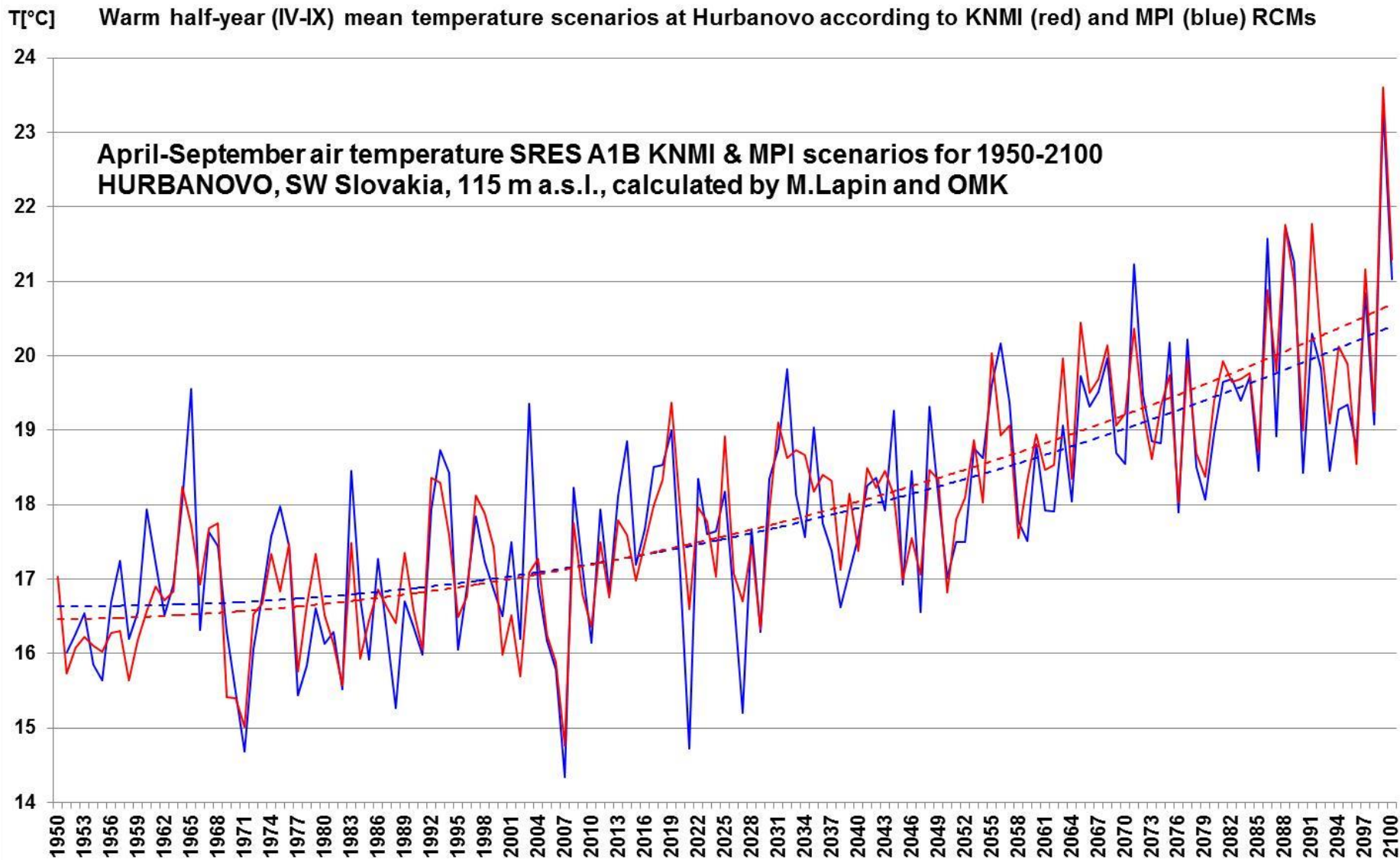
- Scenarios based on the Atmosphere General Circulation Models - GCMs (Atmosphere-Ocean Models and Regional Models at present)
- Scenarios based on historical analogues
- **Incremental scenarios – acceptable for impact models testing only**
- Stochastic weather generator based time series as scenarios
- **Combined scenarios – 1. Step: selection of reliable T (temperature), R (precipitation) and s (specific humidity) GCMs scenarios and 2. Step: calculation of analogs for other climatic/hydrologic elements using correlation/regression and simple modeling – scenarios for whole distribution range – Priority in Slovakia**
- **Scenarios for time frames, time series, extremes...**
- The first series of scenarios in 1995, the second in 1997, then in 2000 (all global), 2010 and 2014 (global and regional – 25x25 km)
- **Comparison of the first scenarios for 2010 time frame in the Graph**

CLIMATE CHANGE SCENARIOS FOR 2010 TIME FRAME EVALUATION

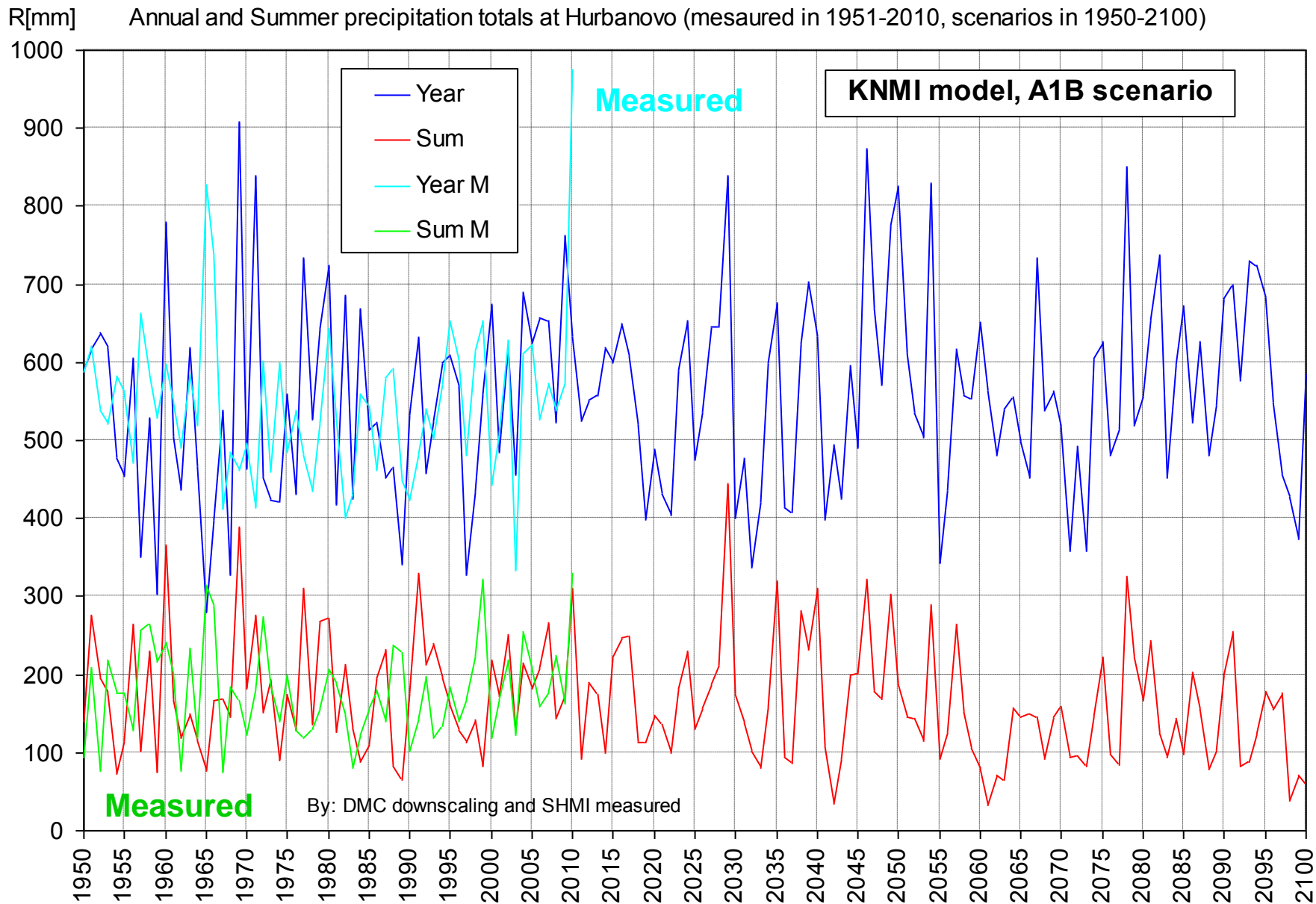
dT[°C] Air temperature scenarios for 2010 time frame and comparison of 2000-2014 measured means with 1951-1980 ones



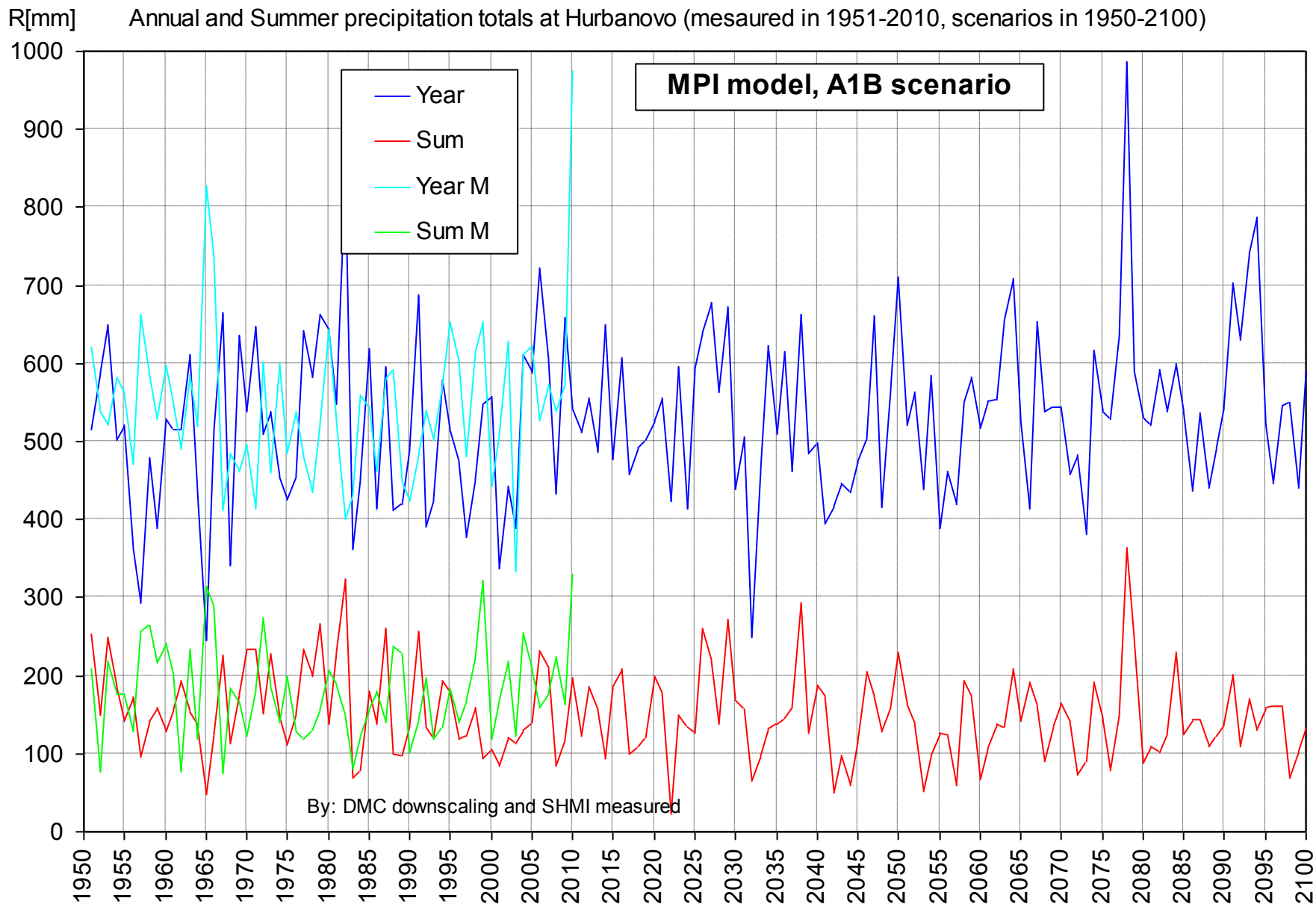
AIR TEMPERATURE SCENARIOS FOR HURBANOVO



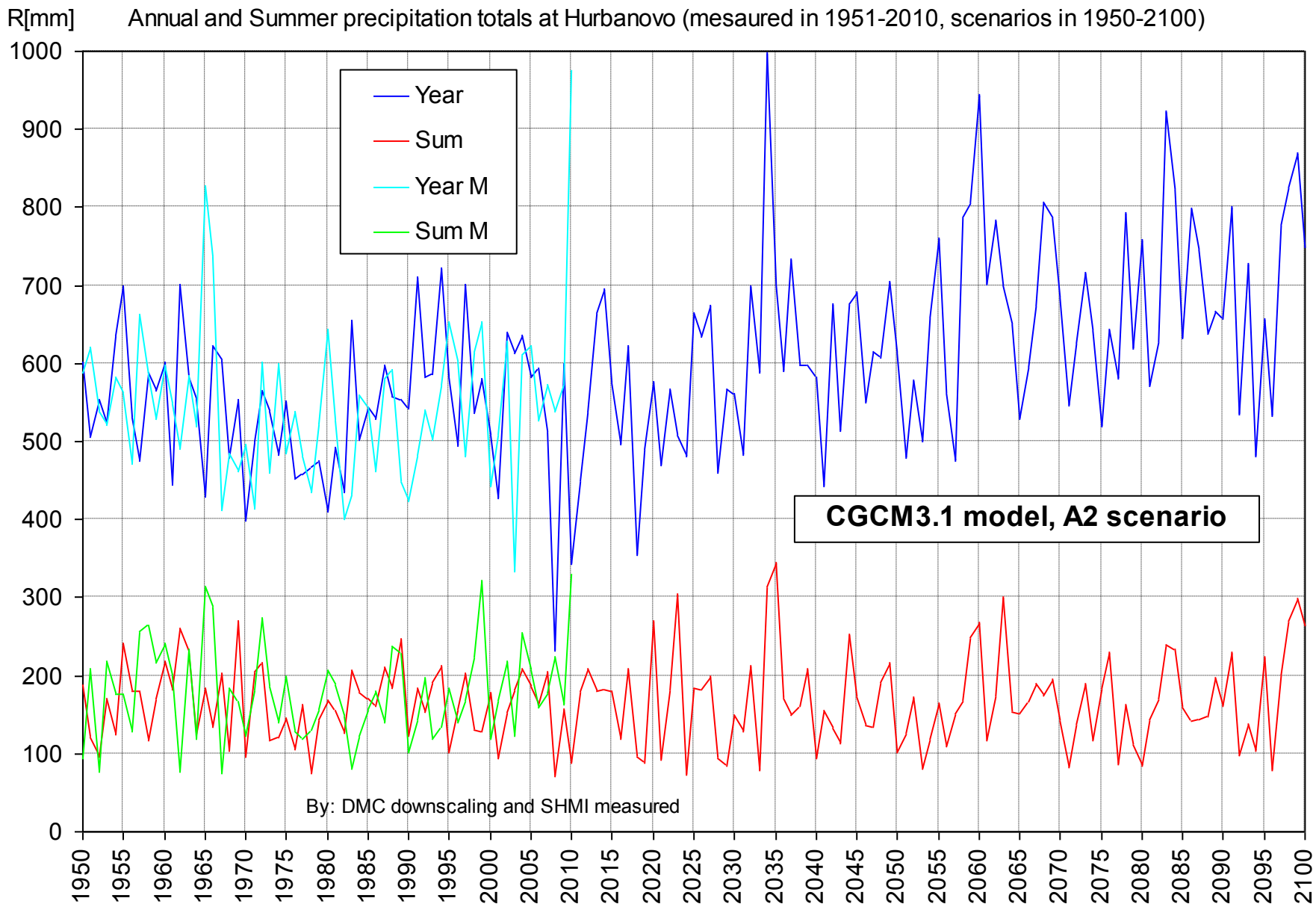
PRECIPITATION SCENARIOS FOR HURBANOVO, ANNUAL AND SUMMER



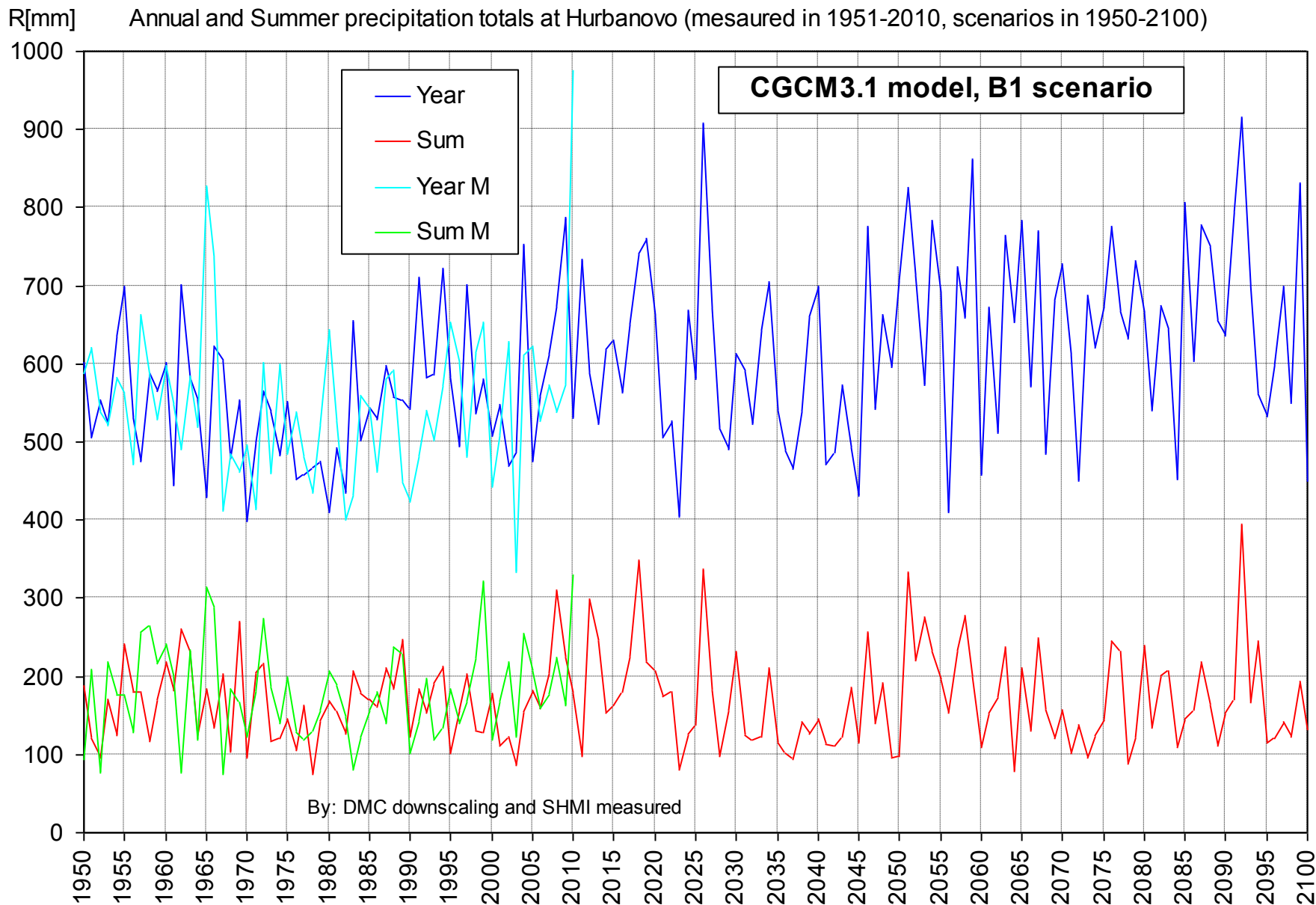
PRECIPITATION SCENARIOS FOR HURBANOVO, ANNUAL AND SUMMER



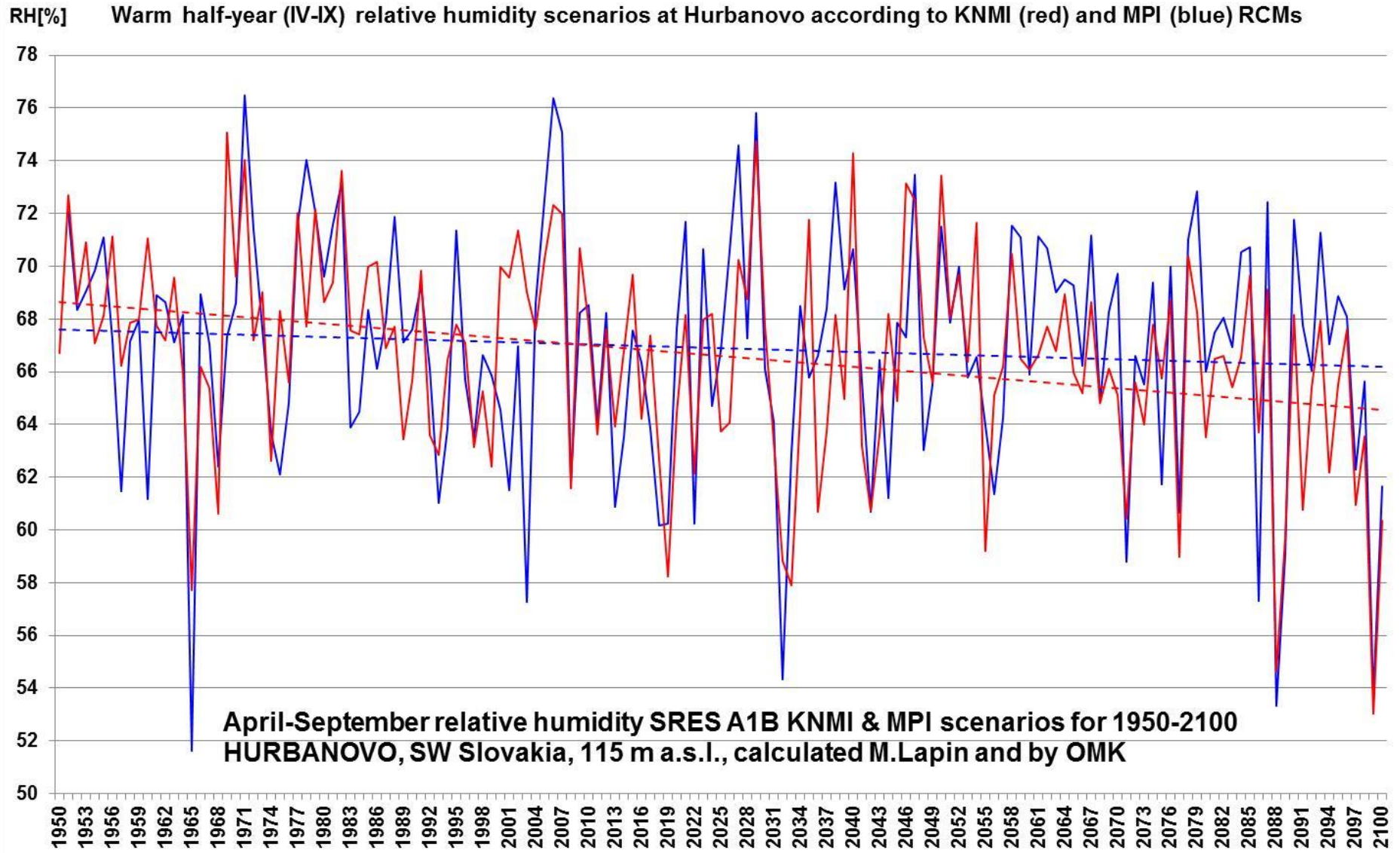
PRECIPITATION SCENARIOS FOR HURBANOVO, ANNUAL AND SUMMER



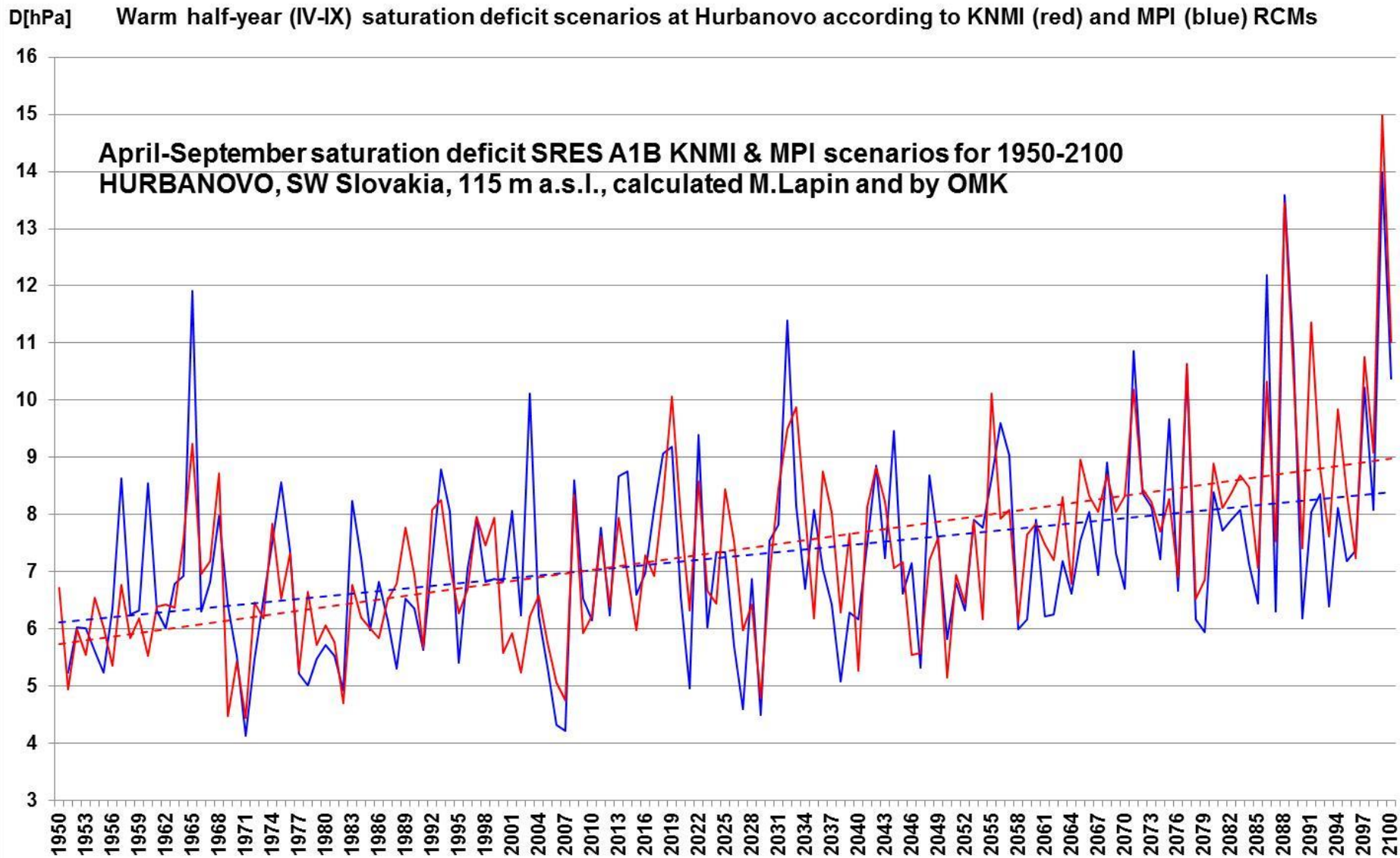
PRECIPITATION SCENARIOS FOR HURBANOVO, ANNUAL AND SUMMER



RELATIVE HUMIDITY SCENARIOS FOR HURBANOVO



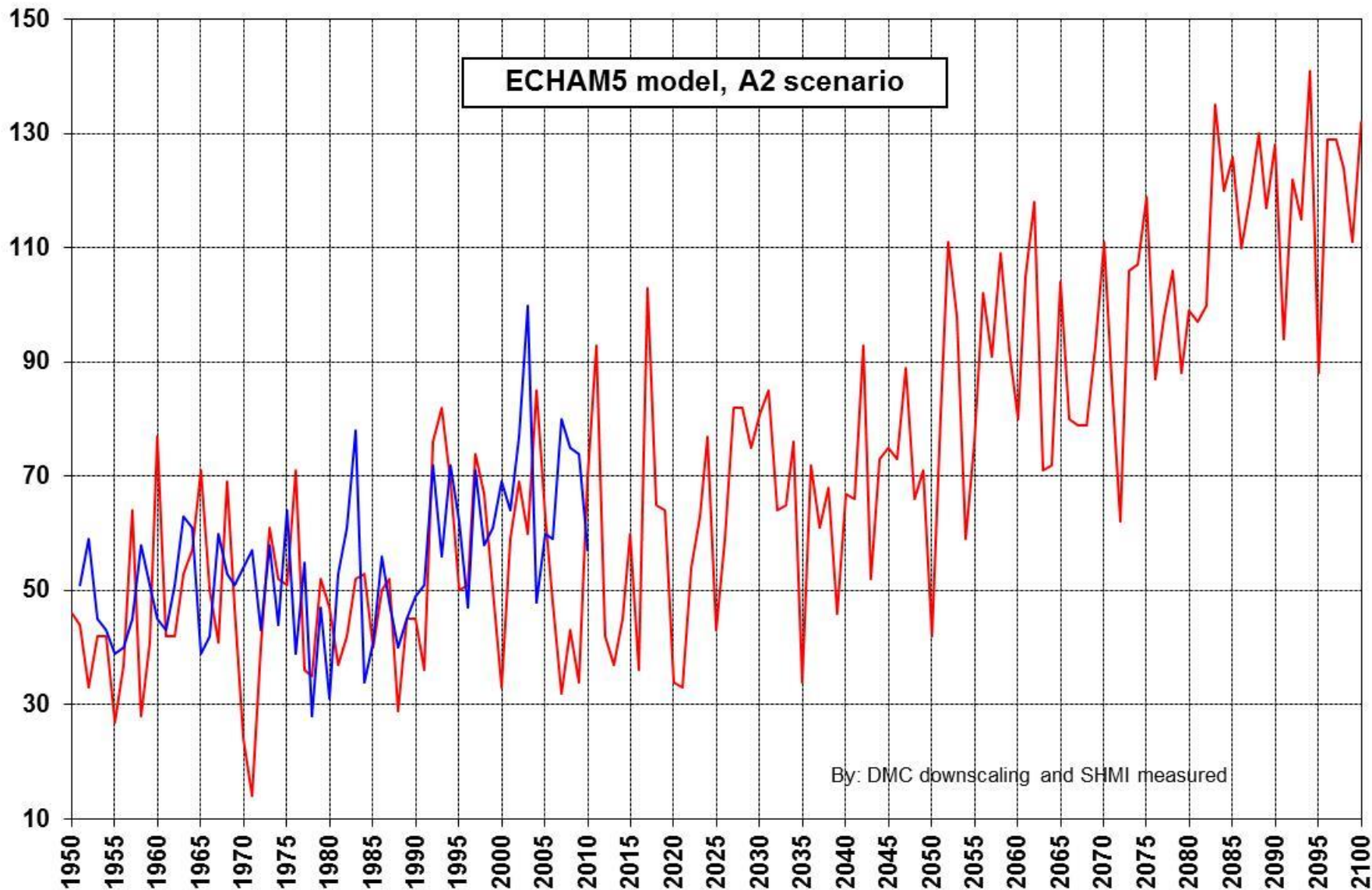
SATURATION DEFICIT SCENARIOS FOR HURBANOVO



TEMPERATURE SCENARIOS FOR HURBANOVO

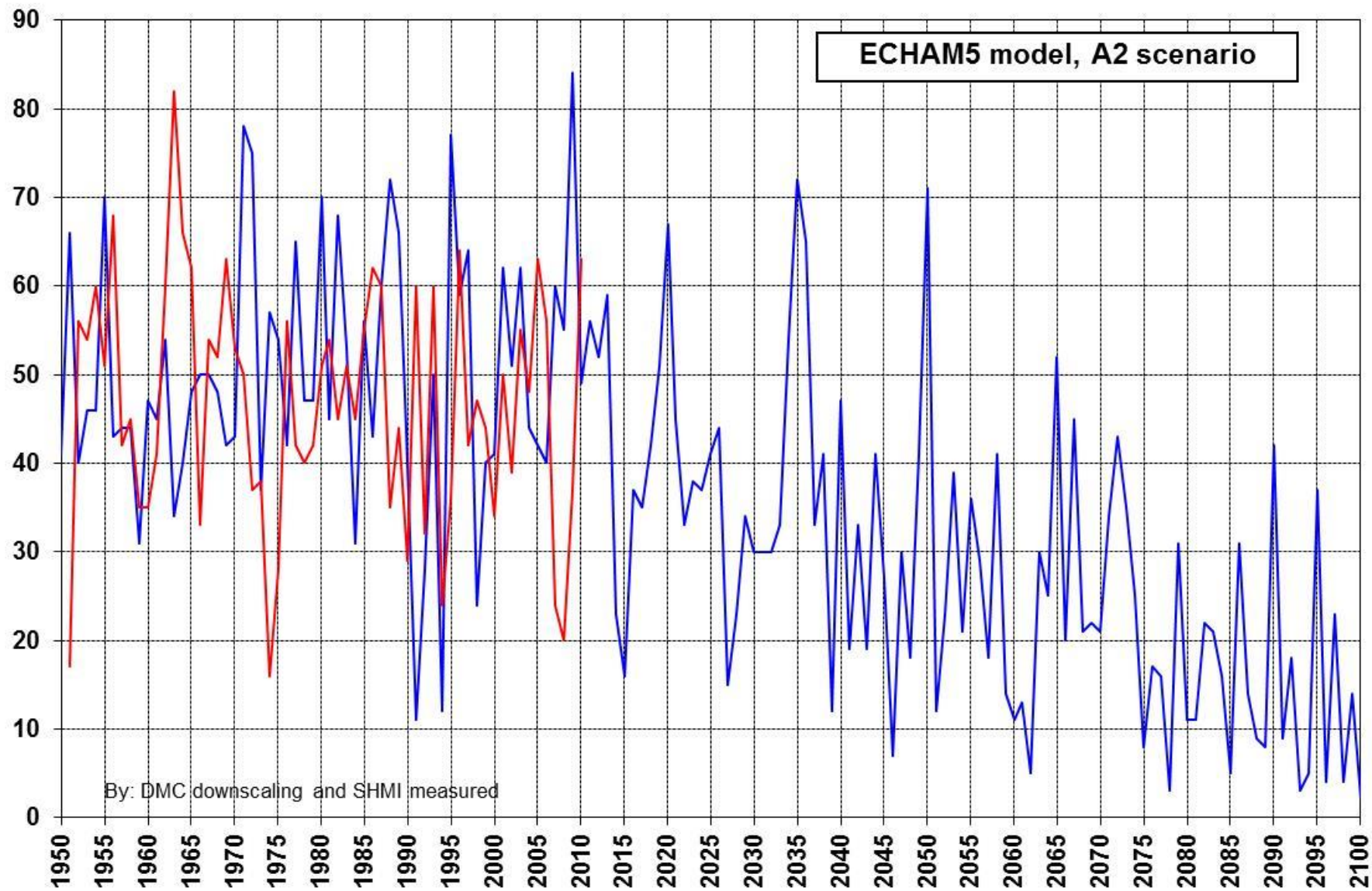
N[days] Annual number of days with mean air temperature $T > 19,9\text{ }^{\circ}\text{C}$ at Hurbanovo (mesasured in 1951-2010)

ECHAM5 model, A2 scenario

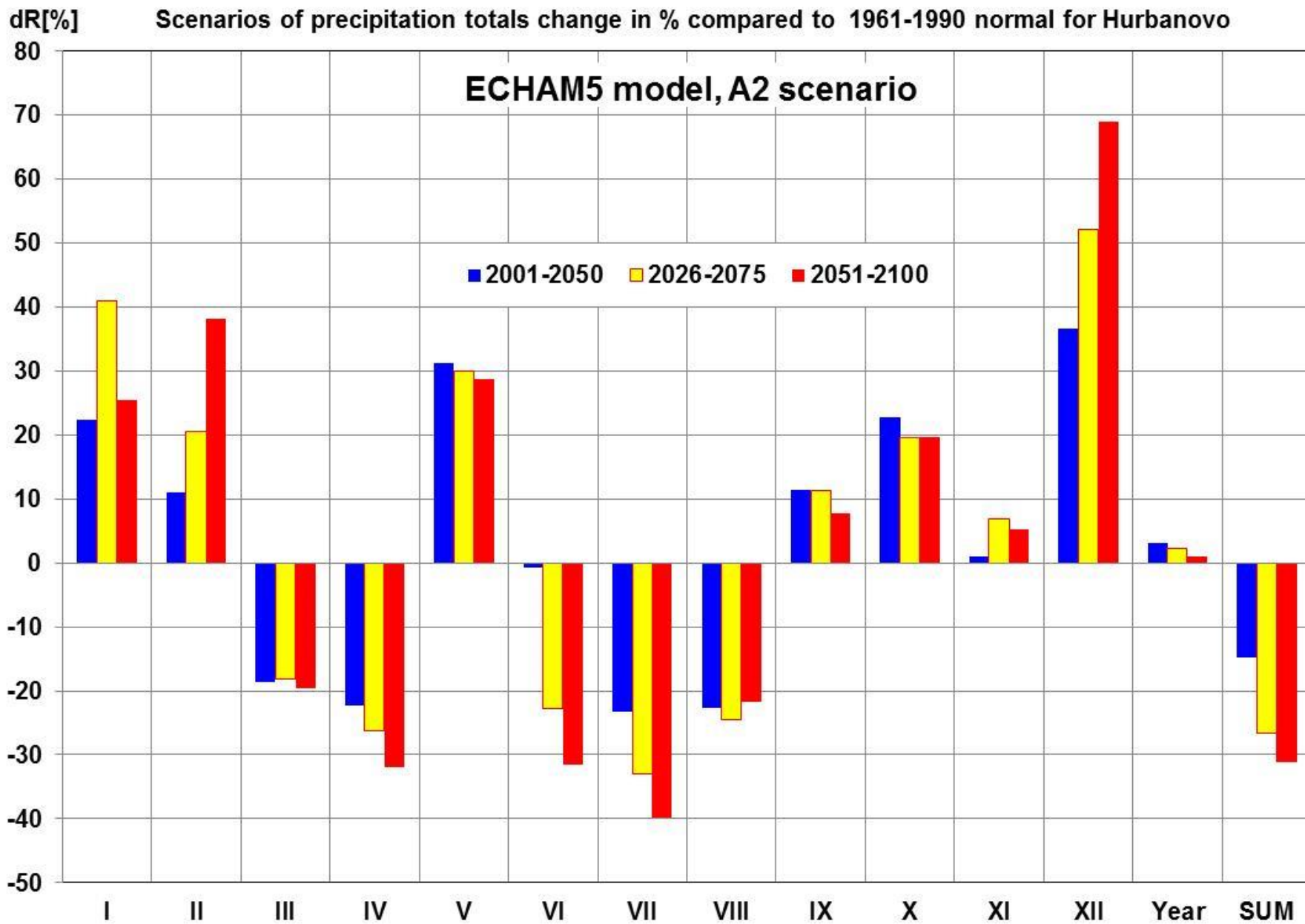


TEMPERATURE SCENARIOS FOR HURBANOVO

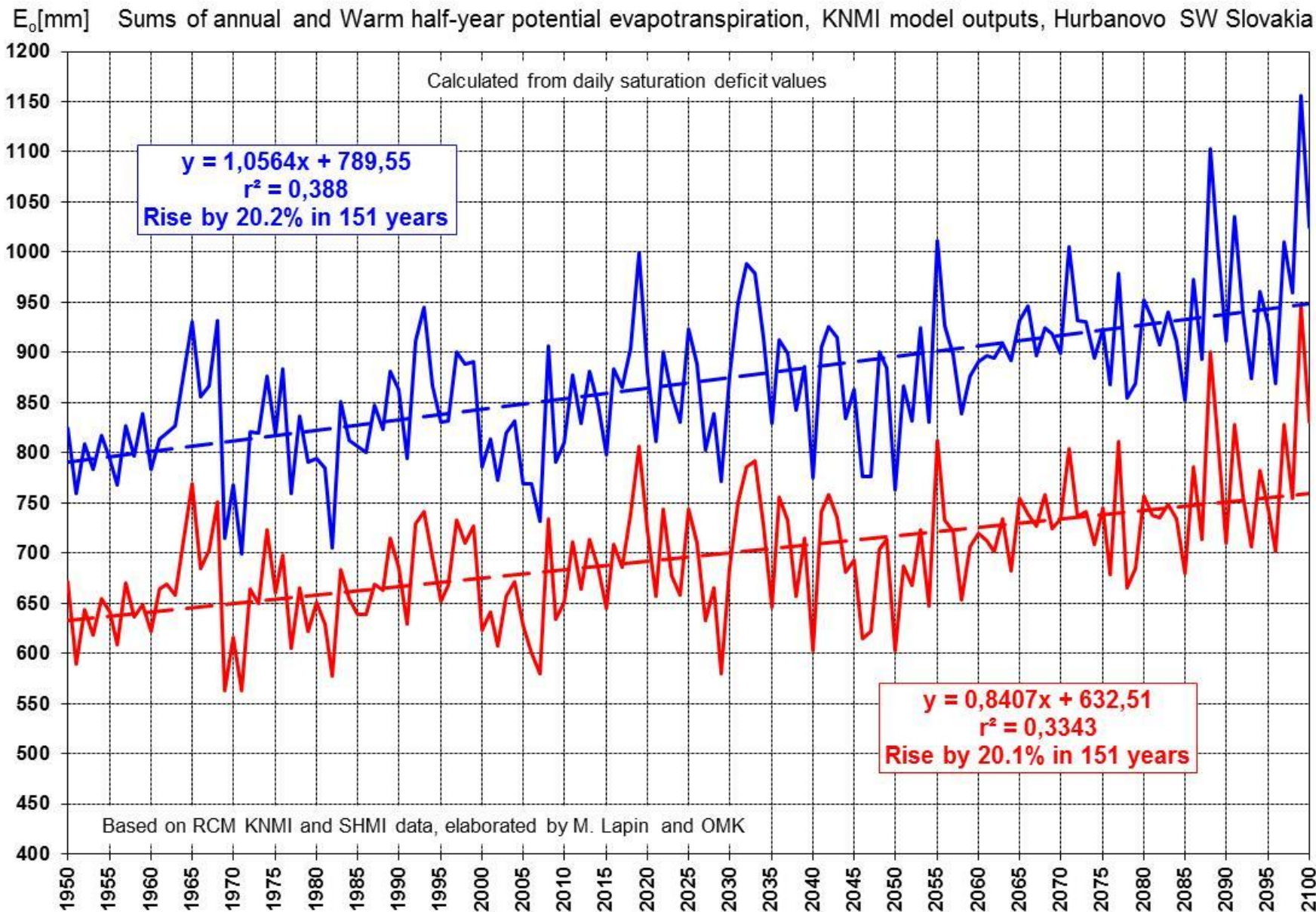
N[days] Annual number of days with mean air temperature $T < 0,0\text{ }^{\circ}\text{C}$ at Hurbanovo (mesasured in 1951-2010)



PRECIPITATION SCENARIO FOR HURBANOVO

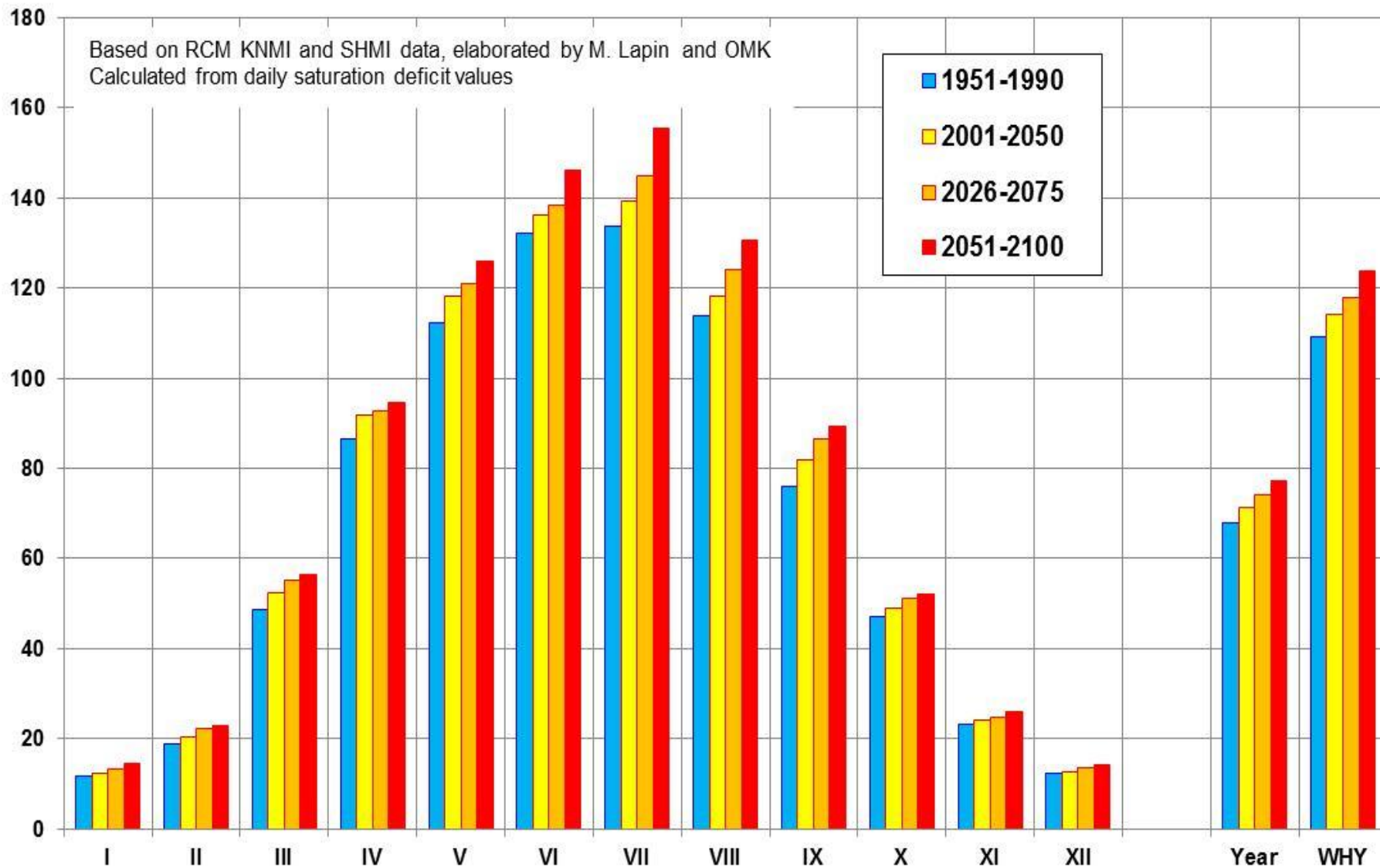


POTENTIAL EVAPOTRANSPIRATION SCENARIOS FOR HURBANOVO BY KNMI RCM, SRES A1B

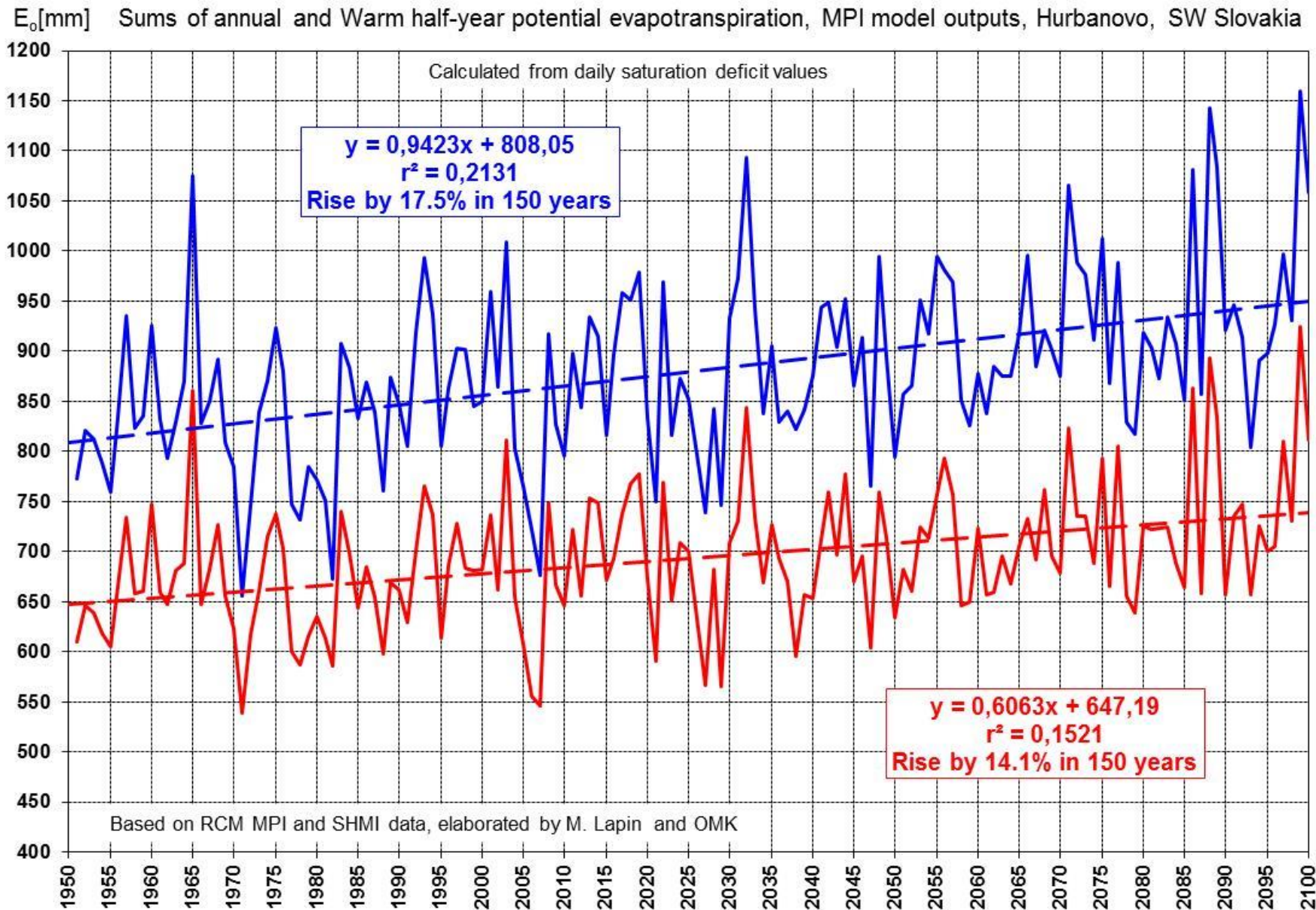


POTENTIAL EVAPOTRANSPIRATION SCENARIOS FOR HURBANOVO BY KNMI RCM, SRES A1B

E_o [mm] Mean sums of potential evapotranspiration, KNMI model outputs, Hurbanovo, SW Slovakia, 1951-2100 period

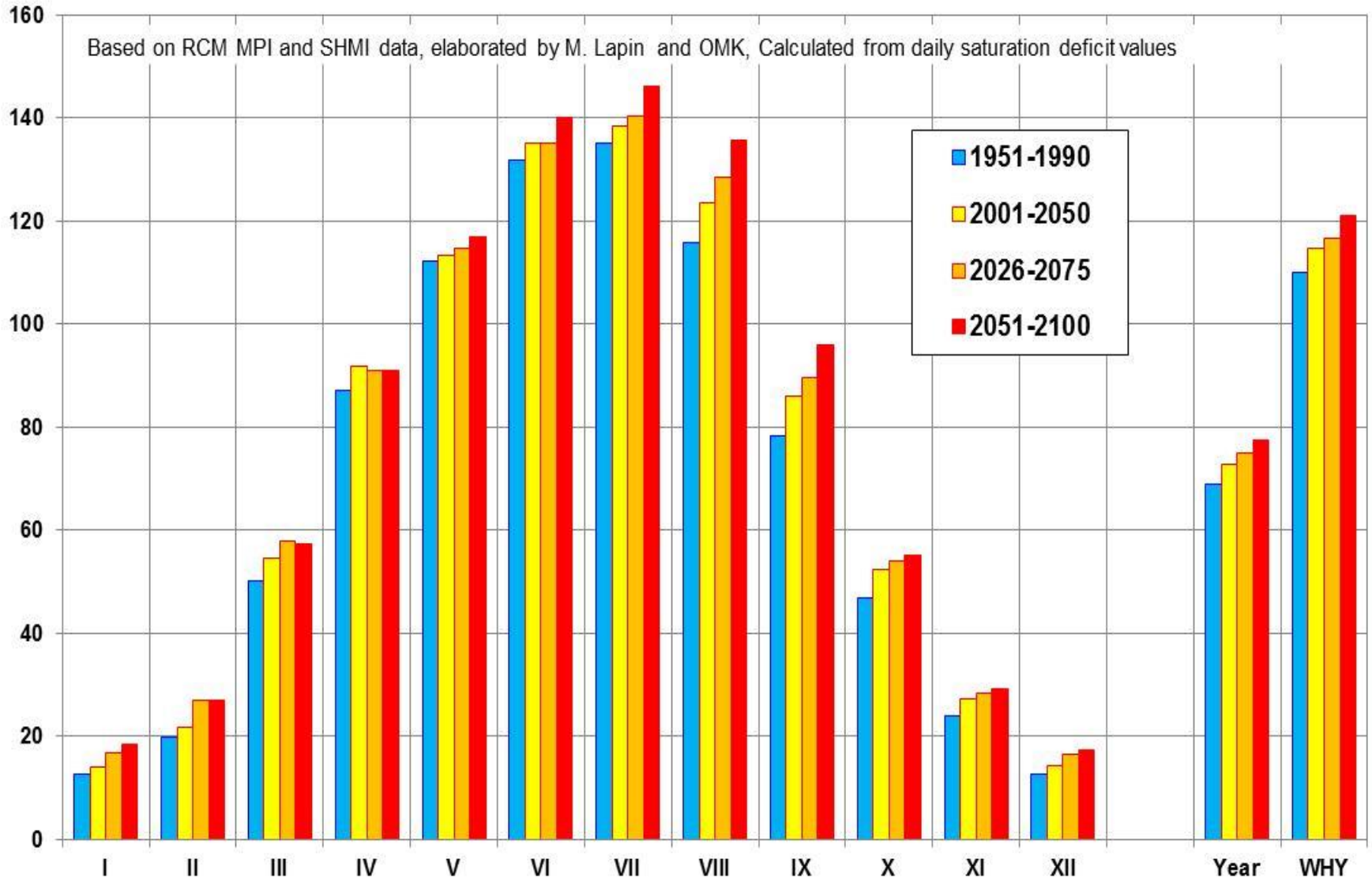


POTENTIAL EVAPOTRANSPIRATION SCENARIOS FOR HURBANOVO BY MPI RCM, SRES A1B



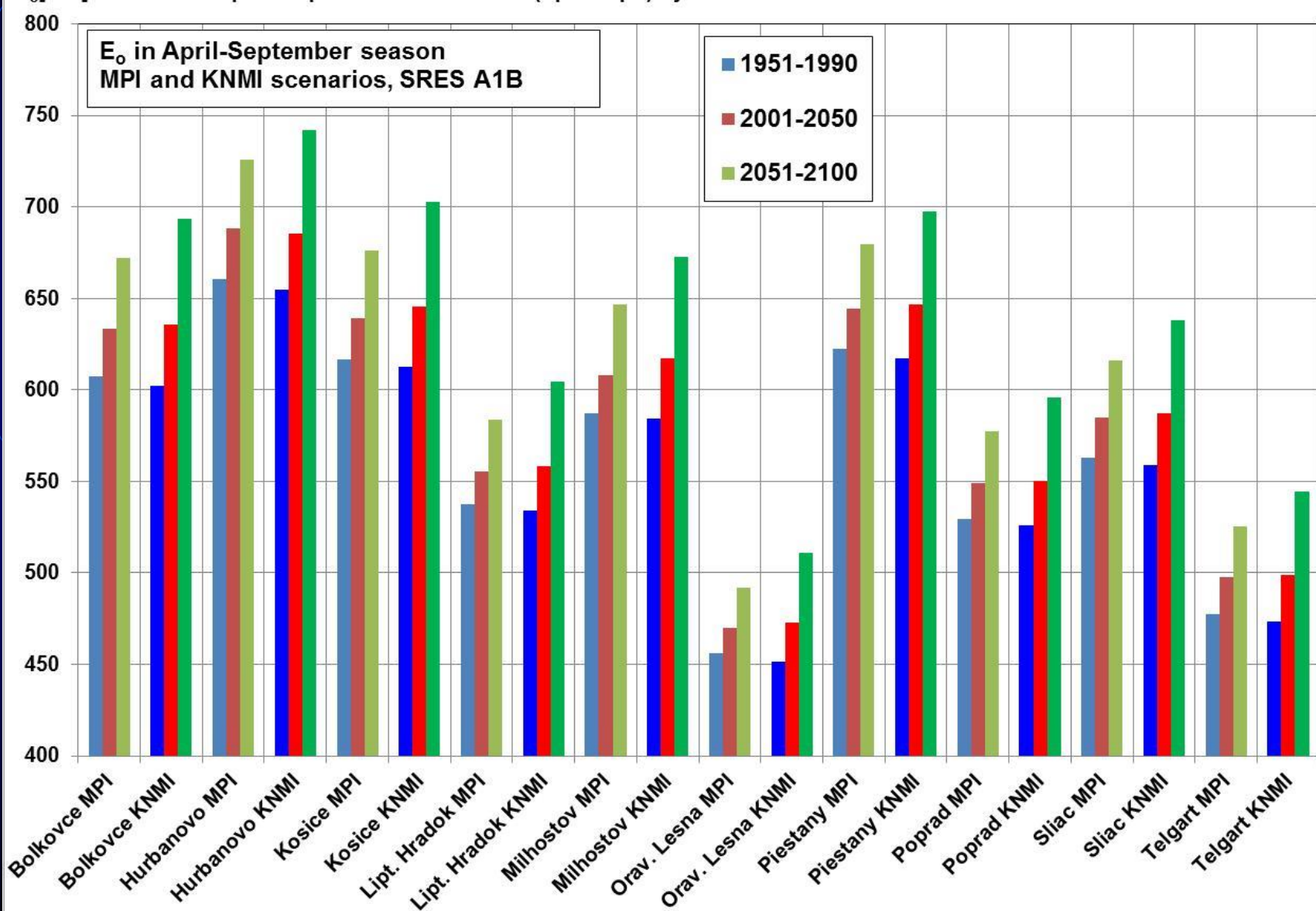
POTENTIAL EVAPOTRANSPIRATION SCENARIOS FOR HURBANOVO BY MPI RCM, SRES A1B

E_0 [mm] Mean sums of potential evapotranspiration, MPI model outputs, Hurbanovo, SW Slovakia, 1951-2100 period



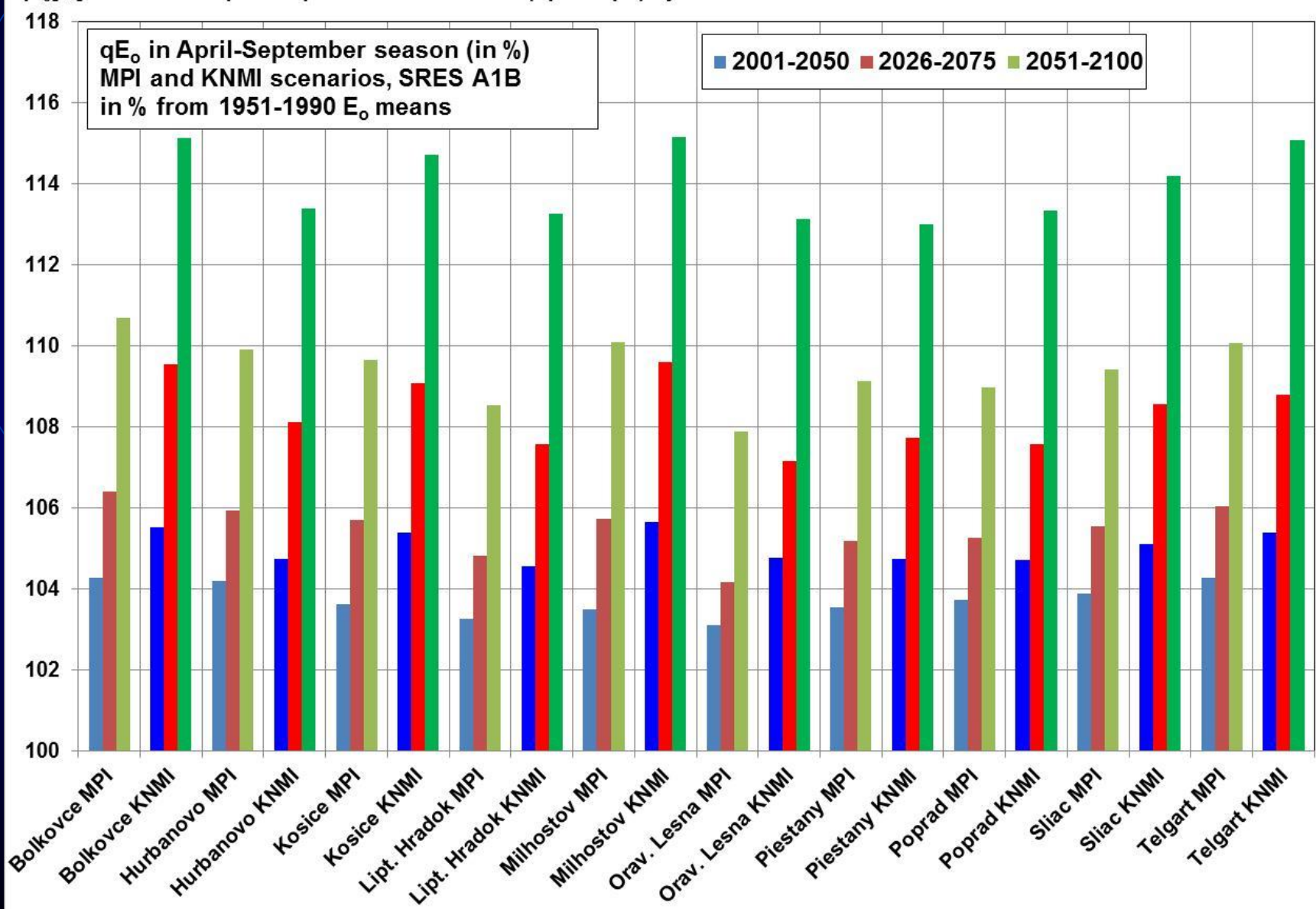
POTENTIAL EVAPOTRANSPIRATION SCENARIOS FOR 10 STATIONS BY MPI & KNMI RCMs, SRES A1B

E_o [mm] Potential evapotranspiration sums in WHY (April-Sept.) by MPI and KNMI D scenarios and Zubenok method in 1951-2100



POTENTIAL EVAPOTRANSPIRATION SCENARIOS FOR 10 STATIONS BY MPI & KNMI RCMs, SRES A1B

qE_o[%] Potential evapotranspiration sums in WHY (April-Sept.) by MPI and KNMI D scenarios and Zubenok method in 2001-2100



CONCLUSIONS

- The most reliable are air temperature scenarios, the precipitation, humidity and evapotranspiration change scenarios - very hard task
- Regional models are based on physical calculation above simplified topography as well, with partly unrealistic areal water balance
- This influences soil moisture, evaporation, precipitation and finally also air humidity in the Regional models (RCMs) output
- In spite of this, the newest KNMI and MPI RCMs offer much better results than any previous versions of GCMs
- Statistical downscaling from more dense grid-point network is much more convenient and results in very reliable data series also at relative humidity and saturation deficit
- These are needed steps prior the calculation of potential evapotranspiration sums and finally also actual evapotranspiration
- Further research will be focused to daily data variability changes in different geographical sites and collaboration with users

Thank You for the Attention

Further information on the websites:

www.milanlapin.estranky.sk

www.dmc.fmph.uniba.sk

or use

E-mail: lapin@fmph.uniba.sk