POTENCIÁLNA A AKTUÁLNA EVAPOTRANSPIRÁCIA NA SLOVENSKU V OBDOBÍ 1951-2015 A SCENÁRE MOŽNÉHO VÝVOJA DO ROKU 2100

CLIMATE CHANGE AND CHANGES IN EVAPOTRANSPIRATION

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ABSTRACT

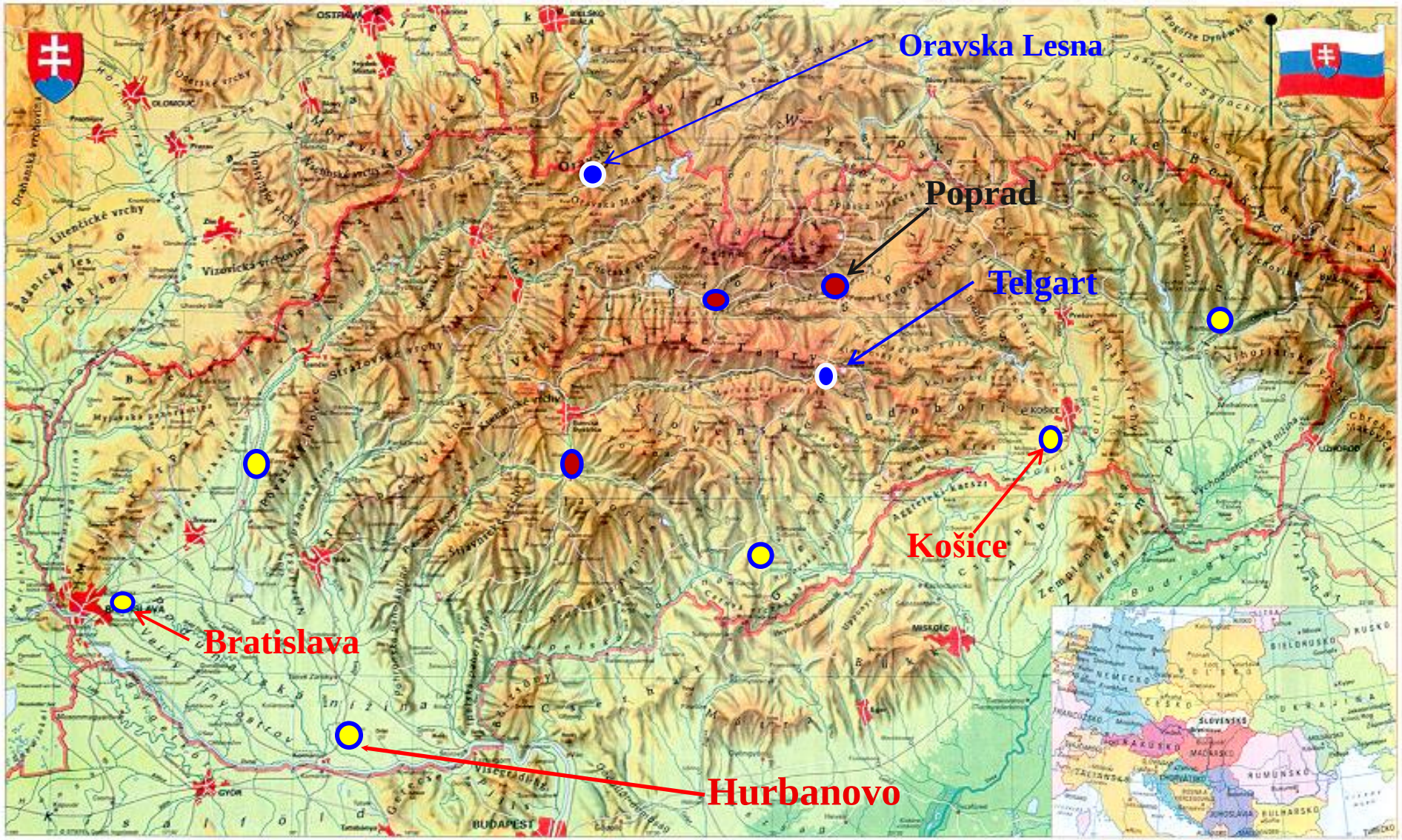
- **Potential (E_o) and actual (E) evapotranspiration are impossible to be measured correctly, we can calculate it with some accuracy and use it at soil moisture and hydrological balance evaluation and forecast**
- **Division of droughts: physiologic (plants), hydrologic (runoff, soil, ground water), meteorologic and climatologic (evapotranspiration), socio-economic (damages, losses)**
- **At any humidity/moisture analysis it is needed the evaluation of precipitation regime in relation with evapotranspiration needs**
- At present we will apply only climatologic analysis - calculation of water balance using relations of E_o, E and precipitation totals (R) for standard surface (short natural and horizontal lawn)
- E_o is sum of maximum possible evaporation + plants transpiration at given unchanged meteorological conditions in case of unlimited water supply
- Because of drought development analysis, we will evaluate first the past situation in 1951-2015 based on evapotranspiration calculation using Budyko-Tomlain Complex Method, further development will be assessed by scenarios of saturation deficit and Eo up to 2100 – Zubenok Method

HISTORY

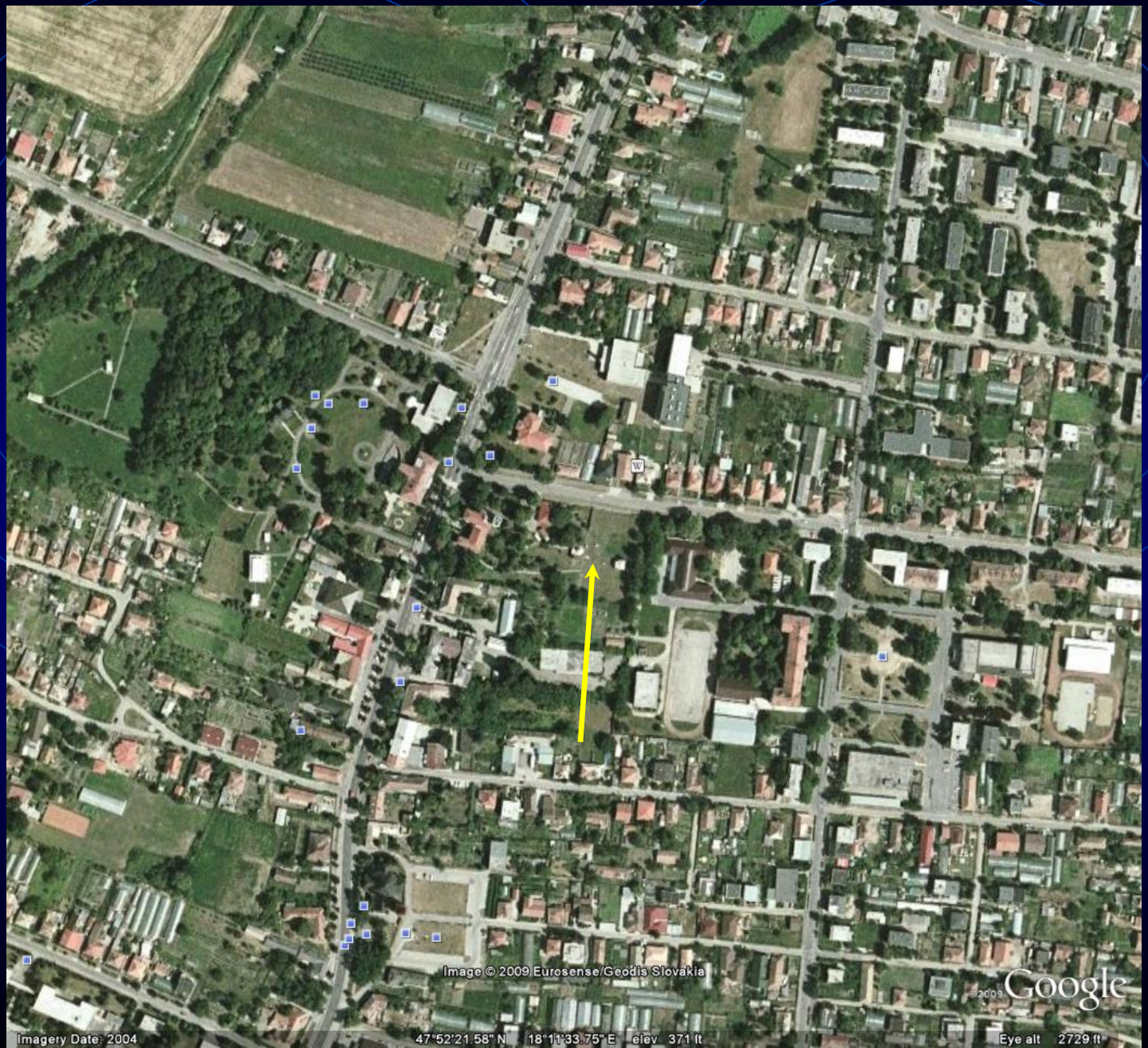
- **The first studies on soil moisture and drought analysis were issued by M. Konček and Š. Petrovič prior to 1970, they did also the first analyses of climate change impacts due to greenhouse effect change**
- **Well known is the Končeks' index of irrigation definition and drought spells calculation by Š. Petrovič and Š. Valovič (1 mm in 15 days…)**
- **Later we studied climate change impacts on drought and change of hydrologic balance in the framework of Slovak National Climate Program established on January 1st, 1991**
- The US Country Study Slovakia Project (partly funded by US EPA) was solved in 1994-1997, drought and hydrologic (soil water) balance were the most important, about 20 partners from Slovakia were engaged
- Six Slovak National Reports on Climate Change have been issued (1995, 1997, 2001, 2005, 2009, 2013), all in Slovak and English, agreed by the Slovak Government and sent to the UN Commission of FCCC Parties
- Climate Change impact studies (including drought and hydrologic balance) have been prepared mainly in agriculture, forestry and water sectors
- **The SHMI issues regularly information on drought risk in Slovakia**

SLOVAK REPUBLIC – 49 036 sq. km, 440 m mean elevation, 5.4 mil. inhabitants, 747 mm mean precipitation, 7.5 °C mean temp.

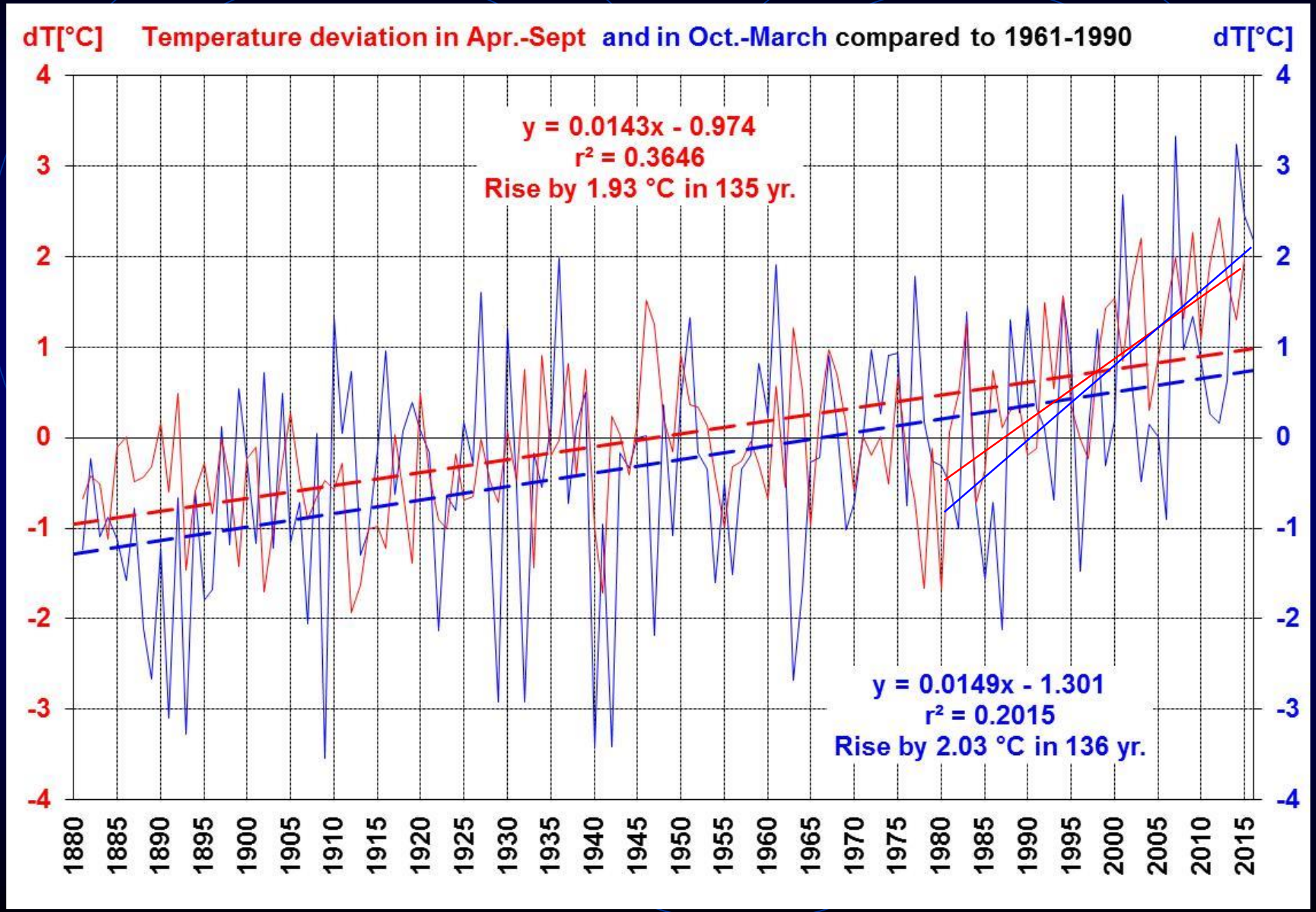
50% agricultural land, 41% forest land, 2% water area, 3% built-up areas, 5.4% above 1000 m



Meteo-Station Hurbanovo, 115 m a.s.l.



TRENDS OF TEMPERATURE AND PRECIPITATION



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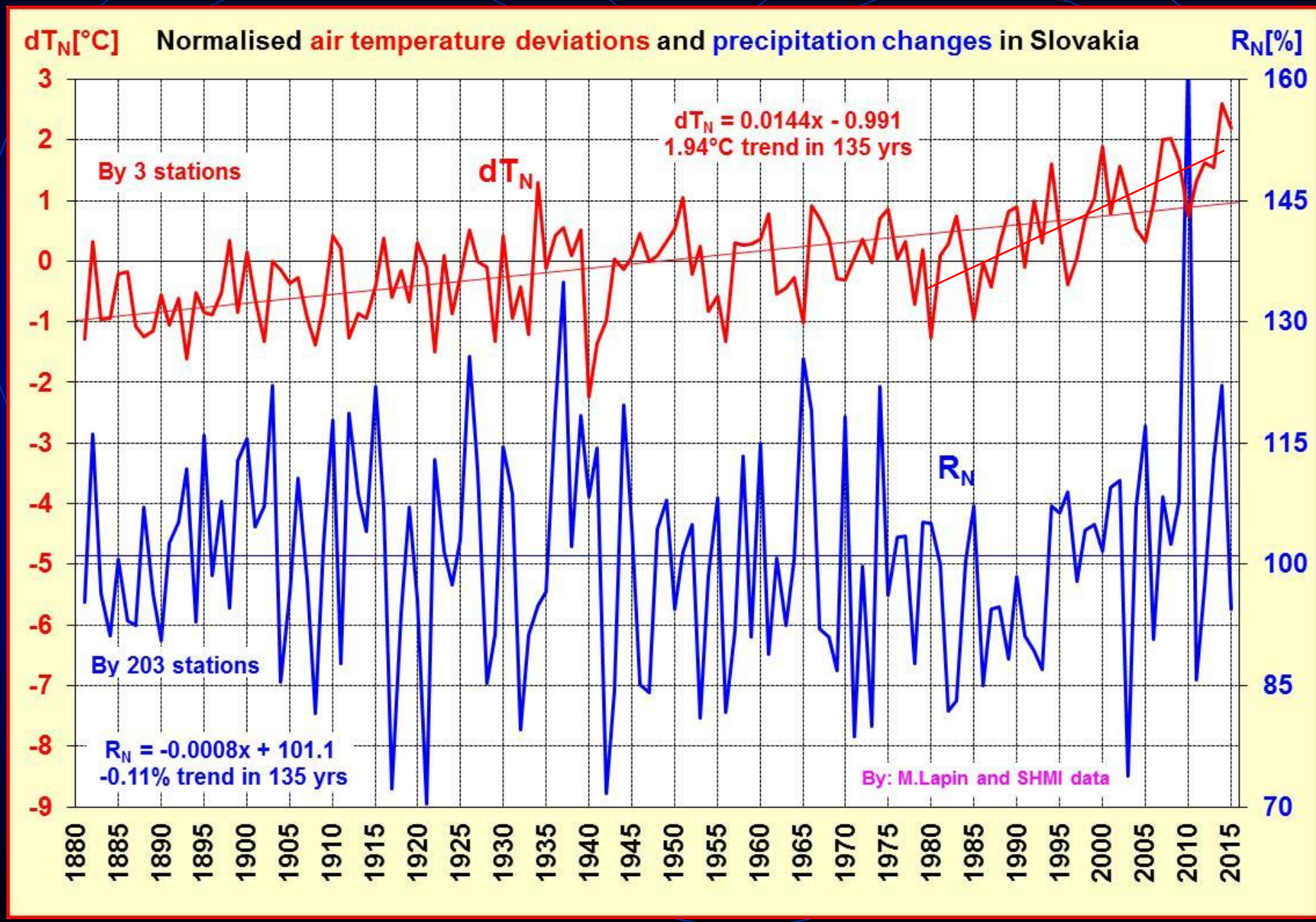
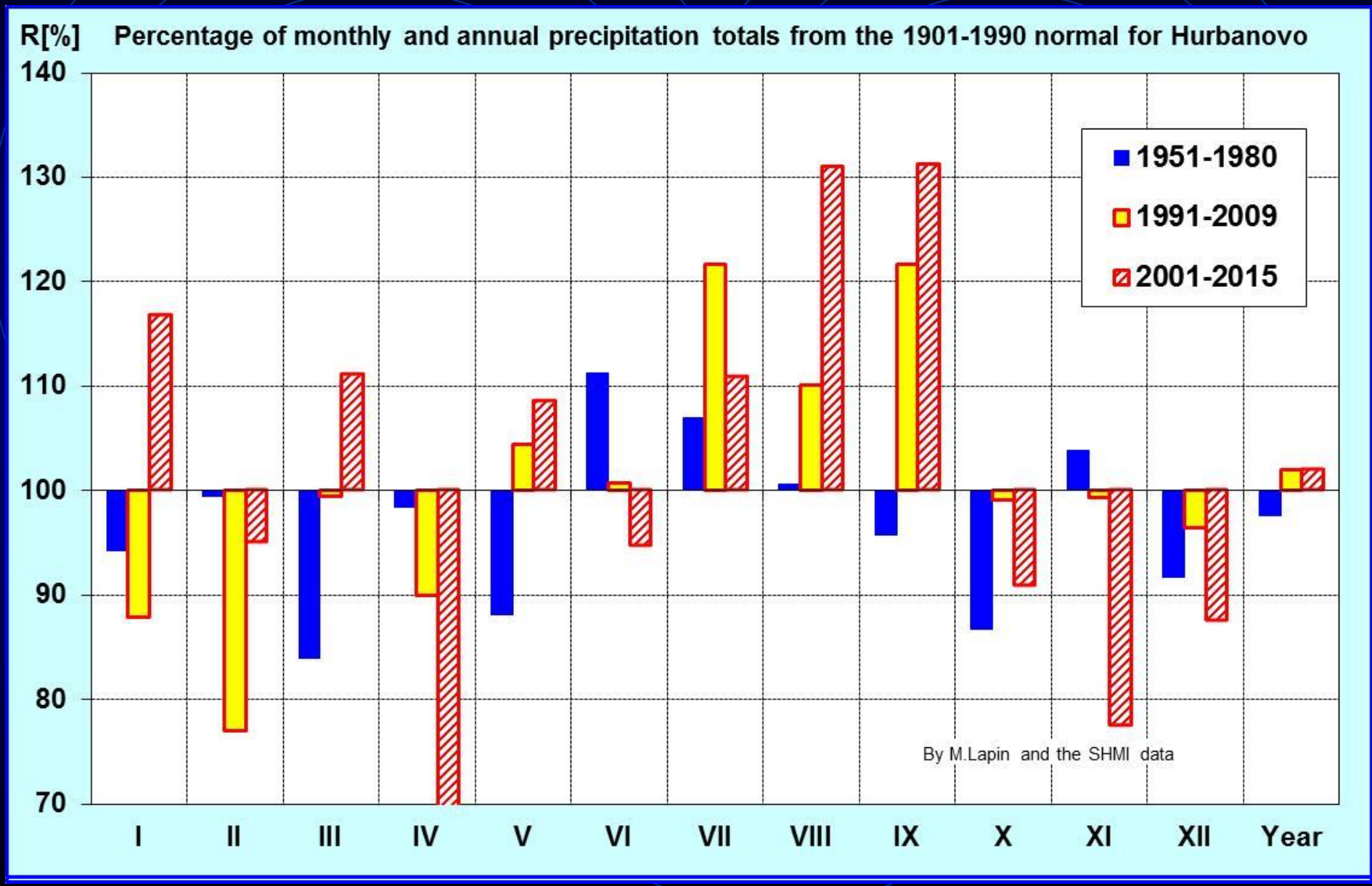
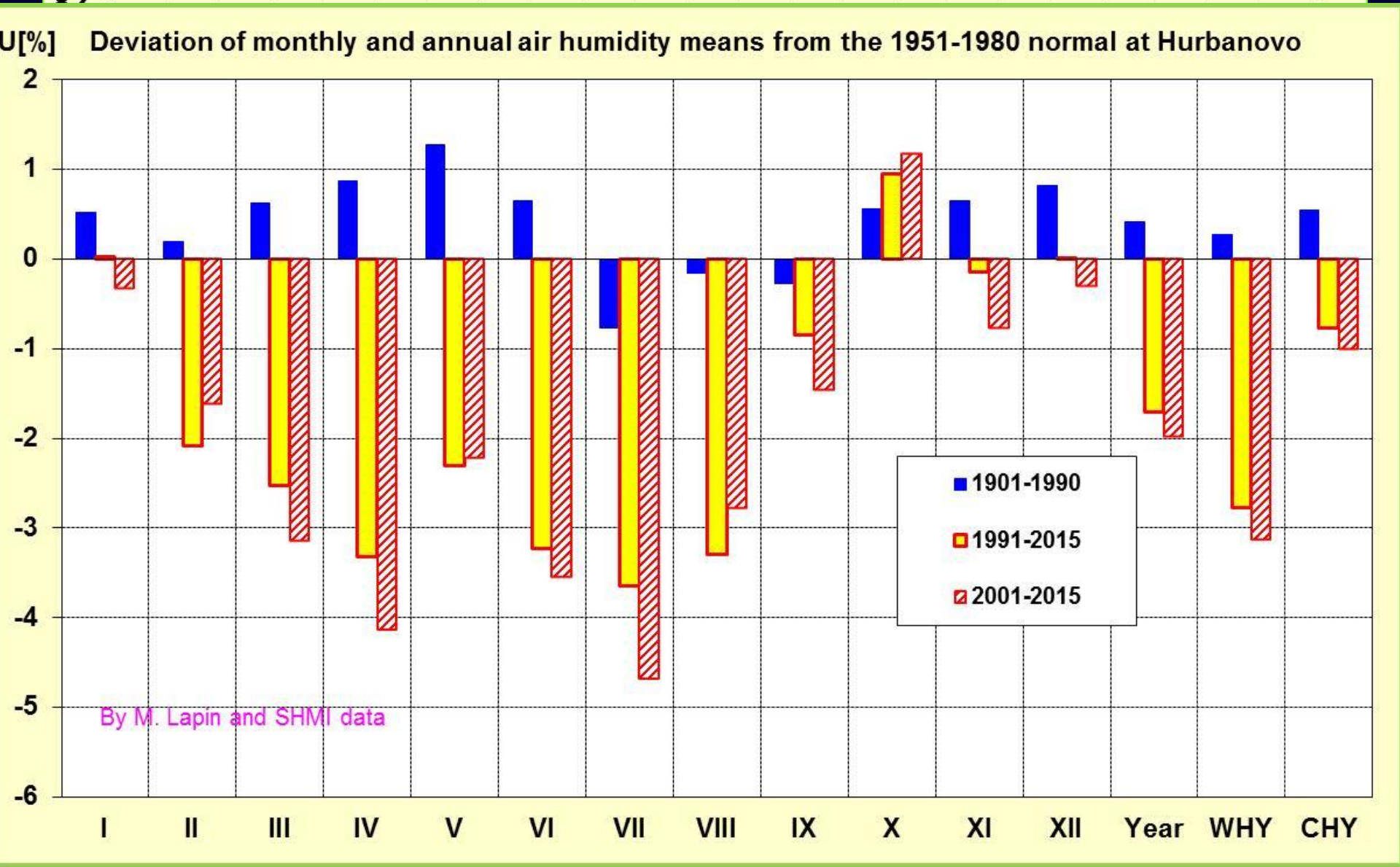


PRECIPITATION CHANGES IN SLOVAKIA AND AT HURBANOVO (in % of 1901-1990 average)

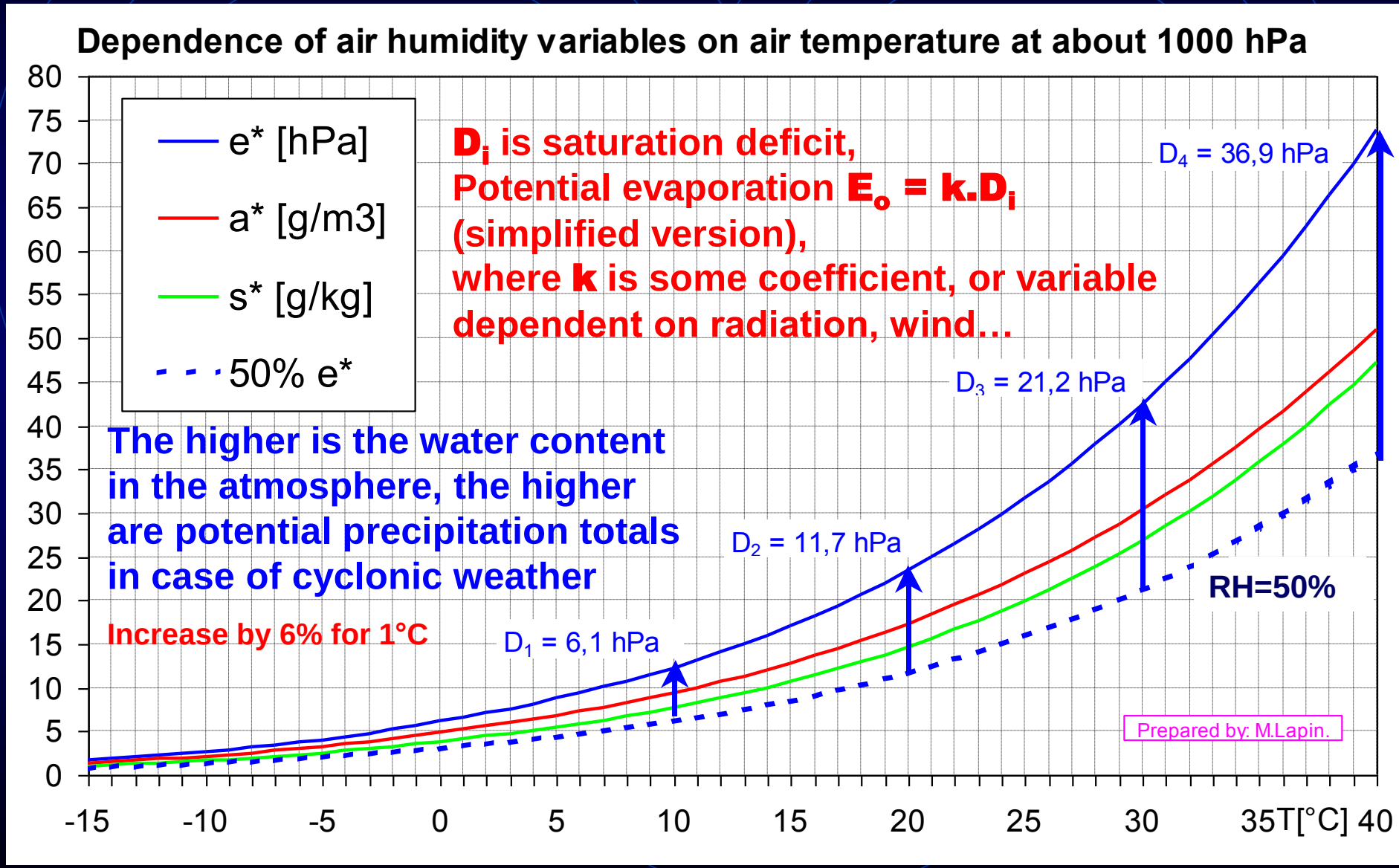


AIR HUMIDITY TRENDS AT HURBANOVO, 1901-2015

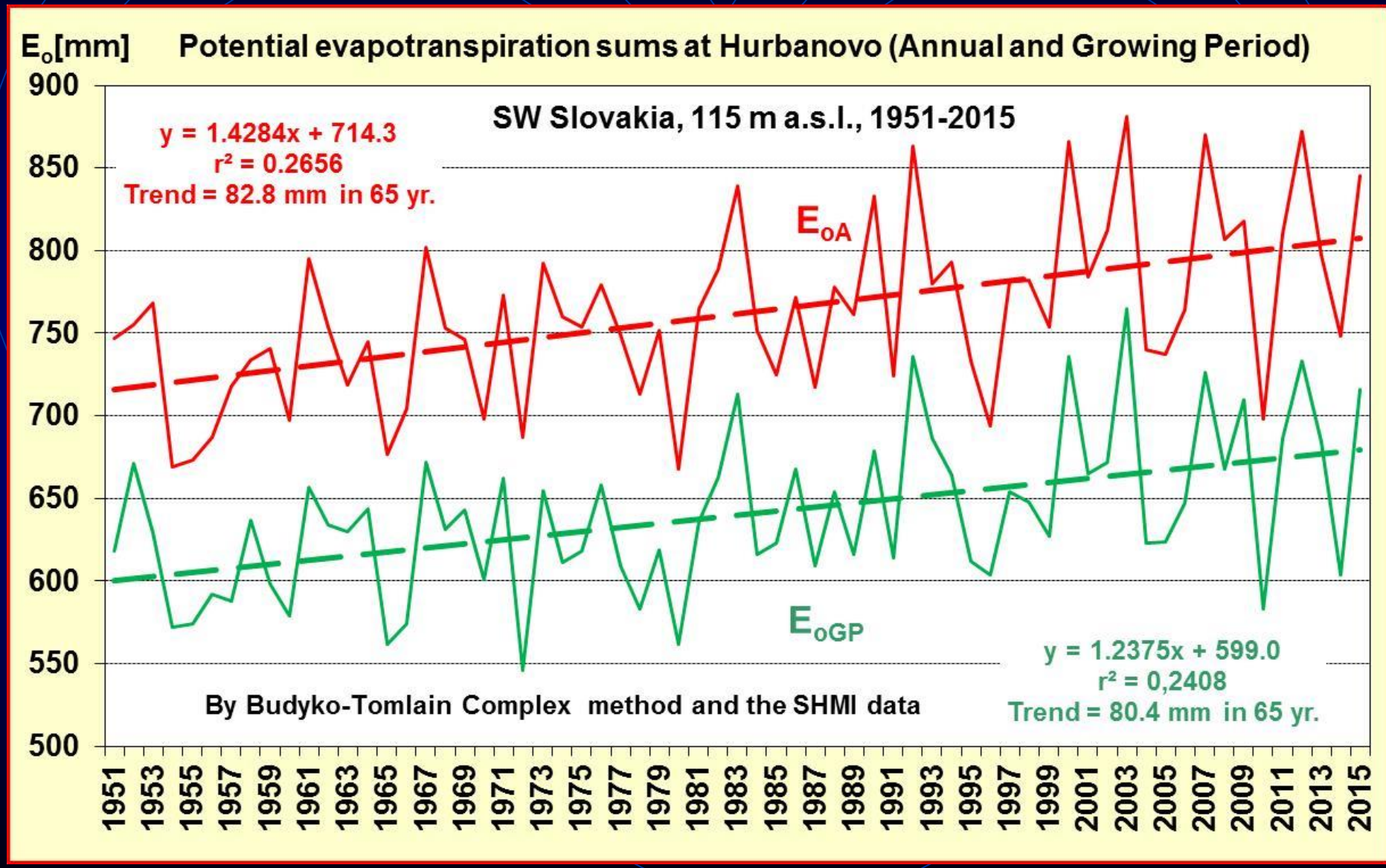
U[%] Annual and Growing period (U_V) relative air humidity at Hurbanovo 1901-2015



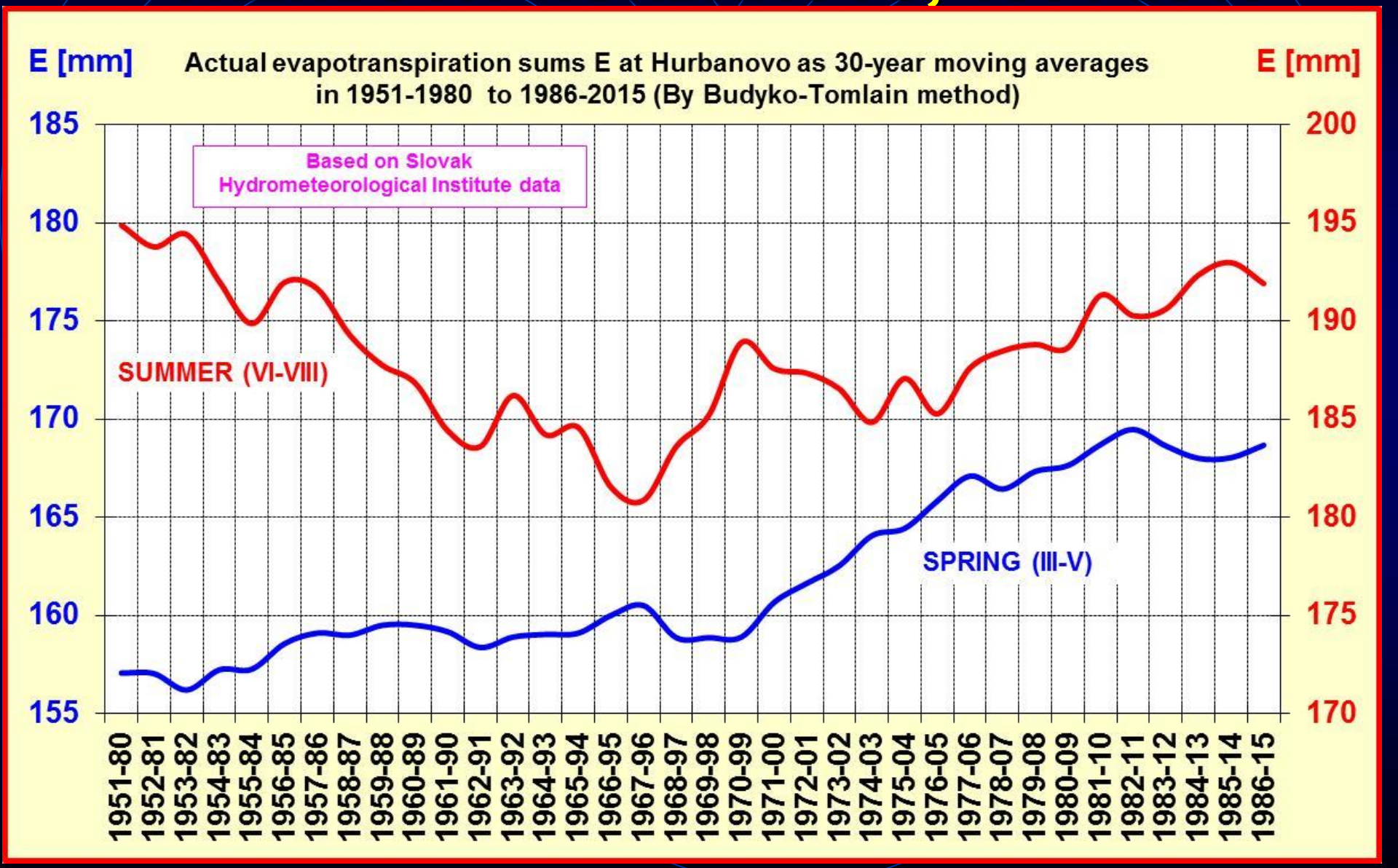
AIR HUMIDITY AND AIR TEMPERATURE



POTENTIAL EVAPOTRANSPIRATION TRENDS AT HURBANOVO, 1951-2015



ACTUAL EVAPOTRANSPIRATION TRENDS AT HURBANOVO, 1951-2015



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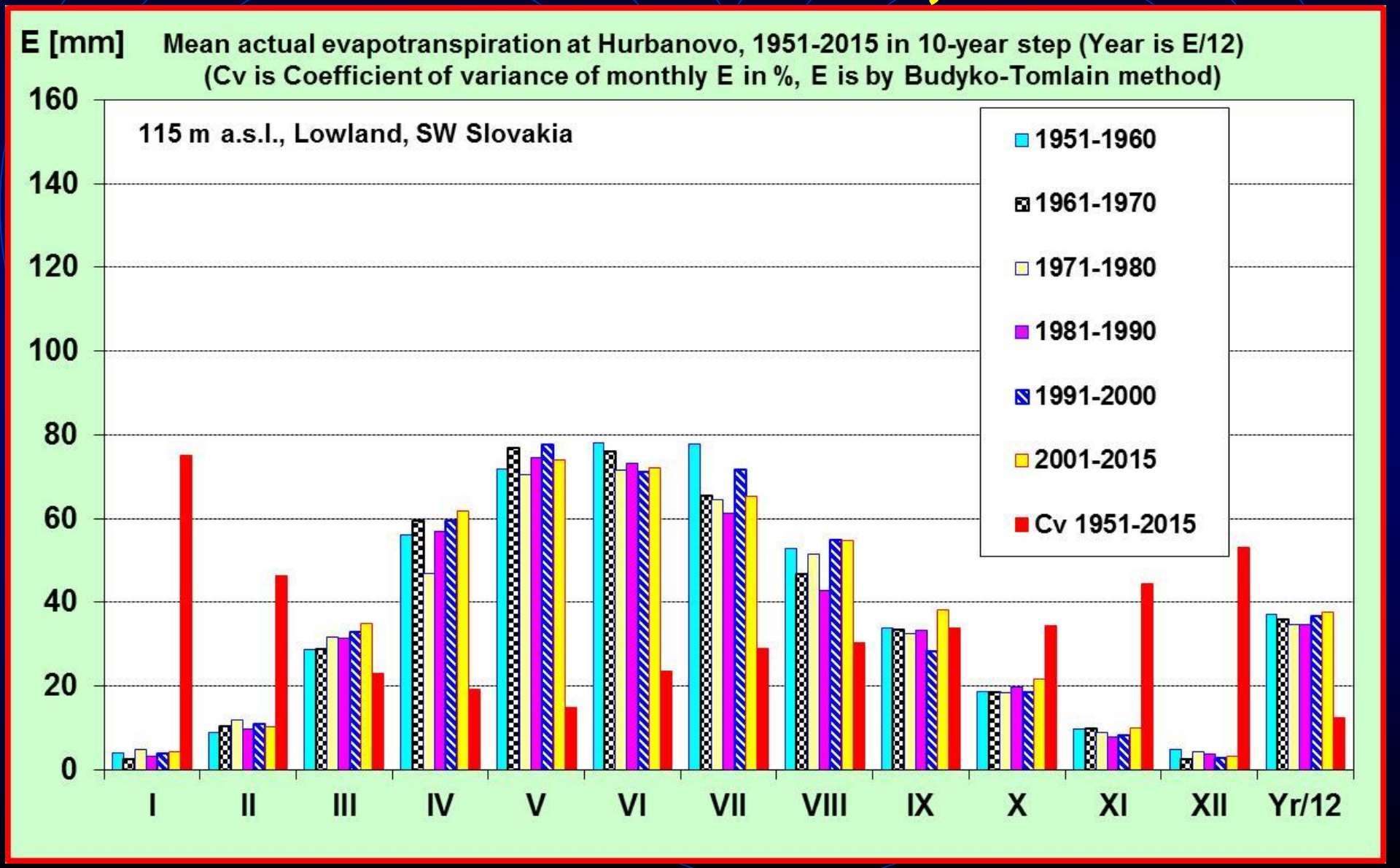
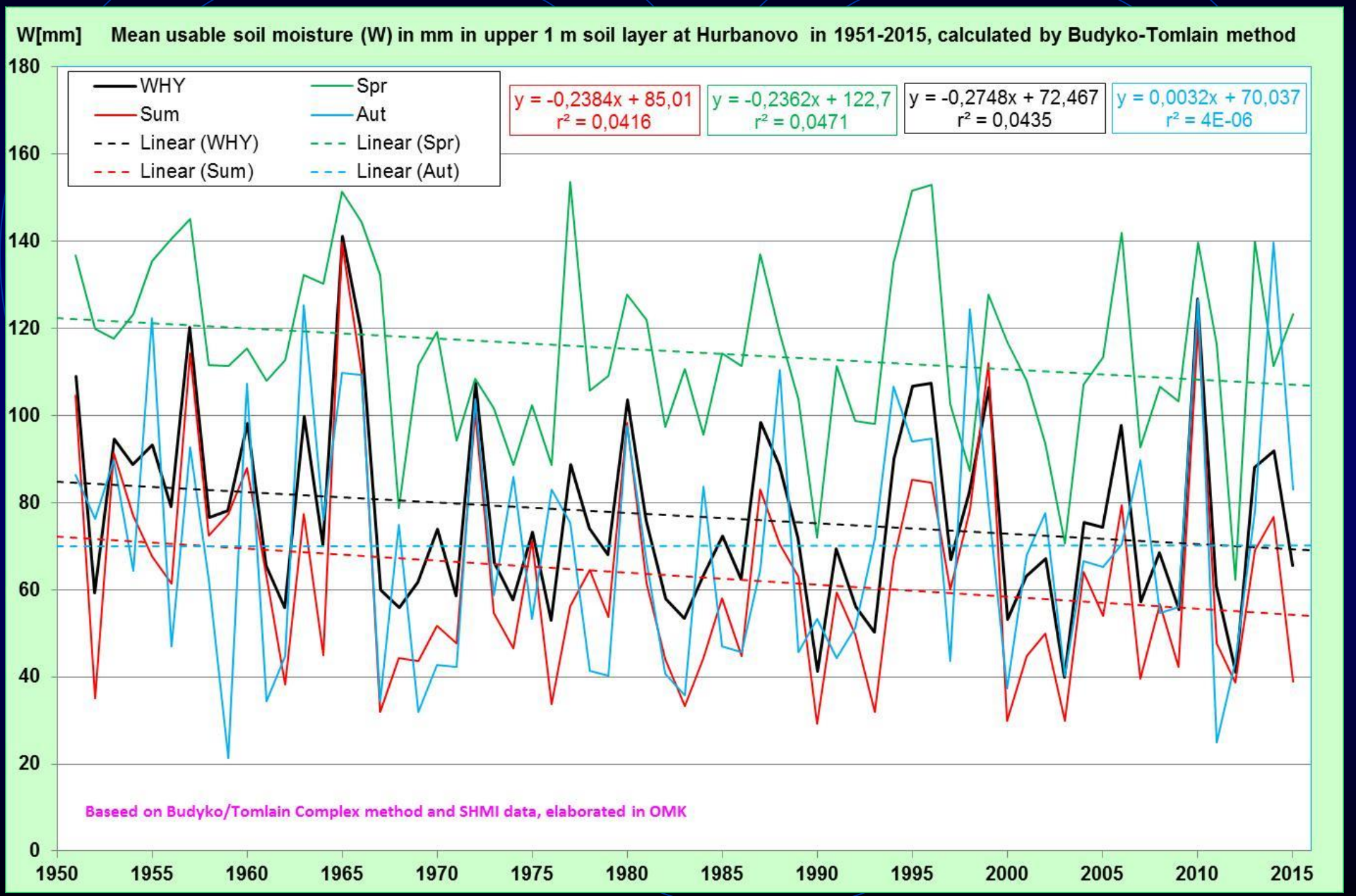
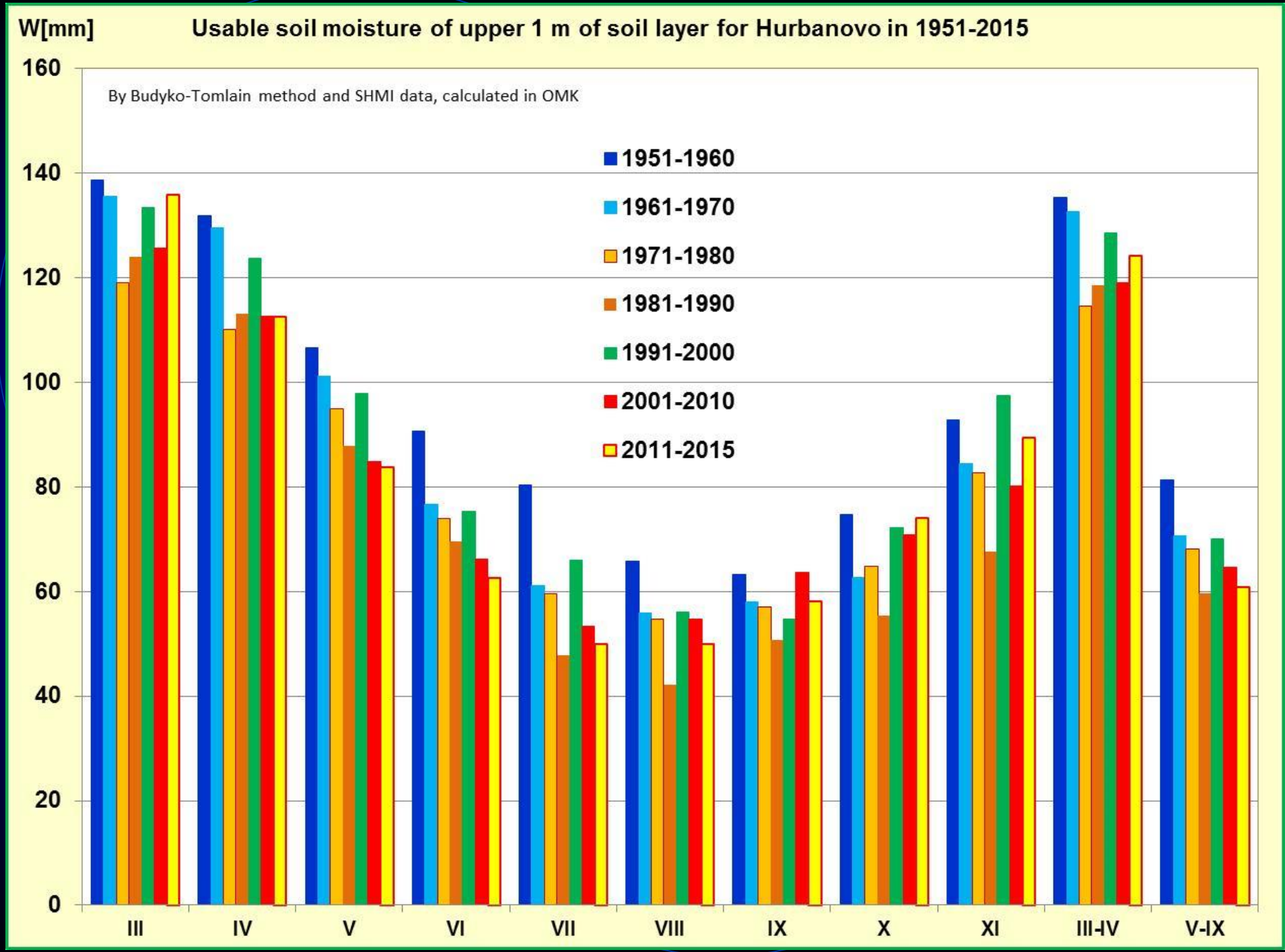
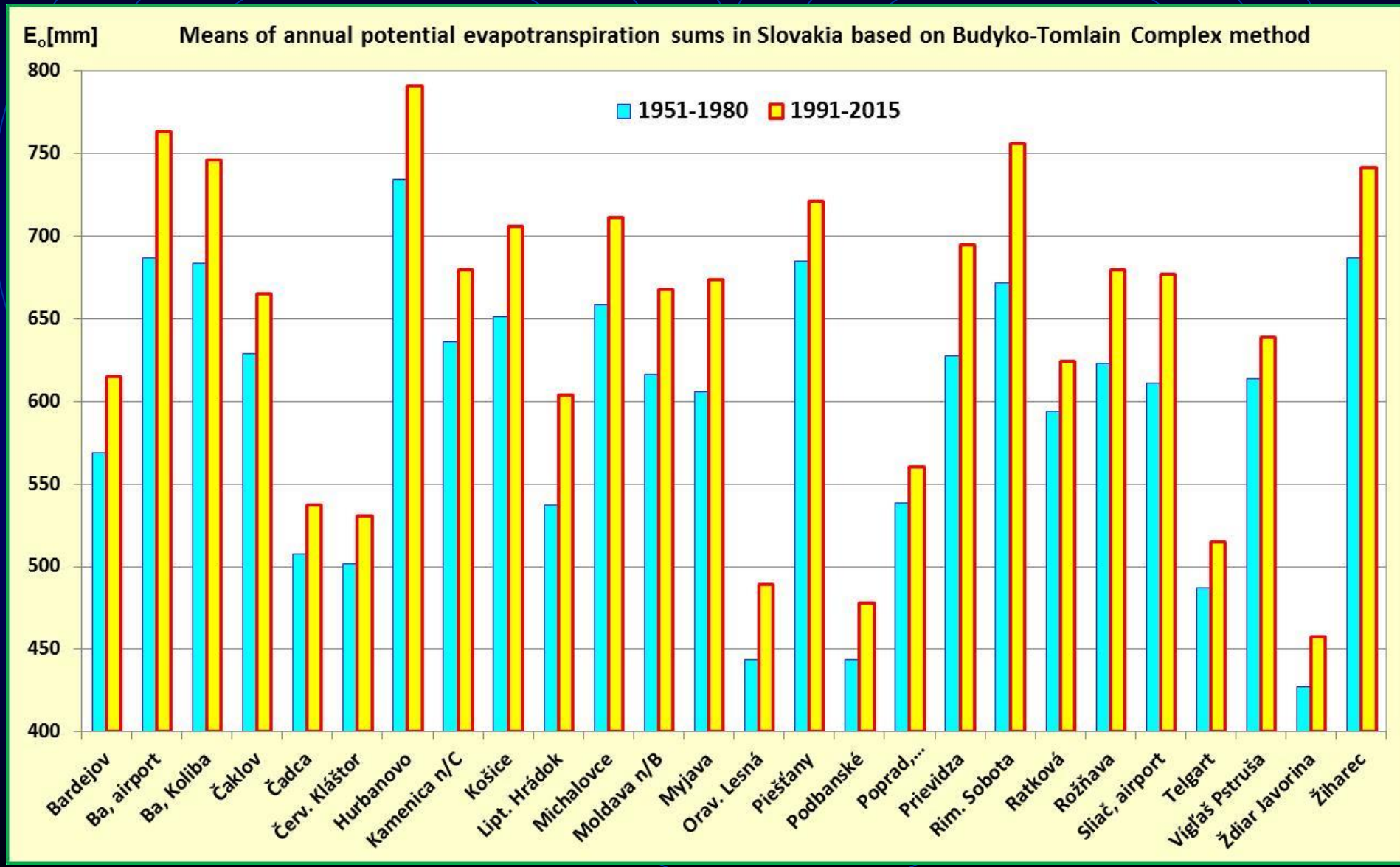


USABLE SOIL MOISTURE AT HURBANOVO




W[mm]
Usable soil moisture of upper 1 m of soil layer for Hurbanovo in 1951-2015
By Budyko-Tomlain method and SHMI data, calculated in OMK
1951-1960
1961-1970
1971-1980
1981-1990
1991-2000
2001-2010
2011-2015
160
140
120
100
80
60
40
20
0
III
IV
V
VI
VII
VIII
IX
X
XI
III-IV
V-IX

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



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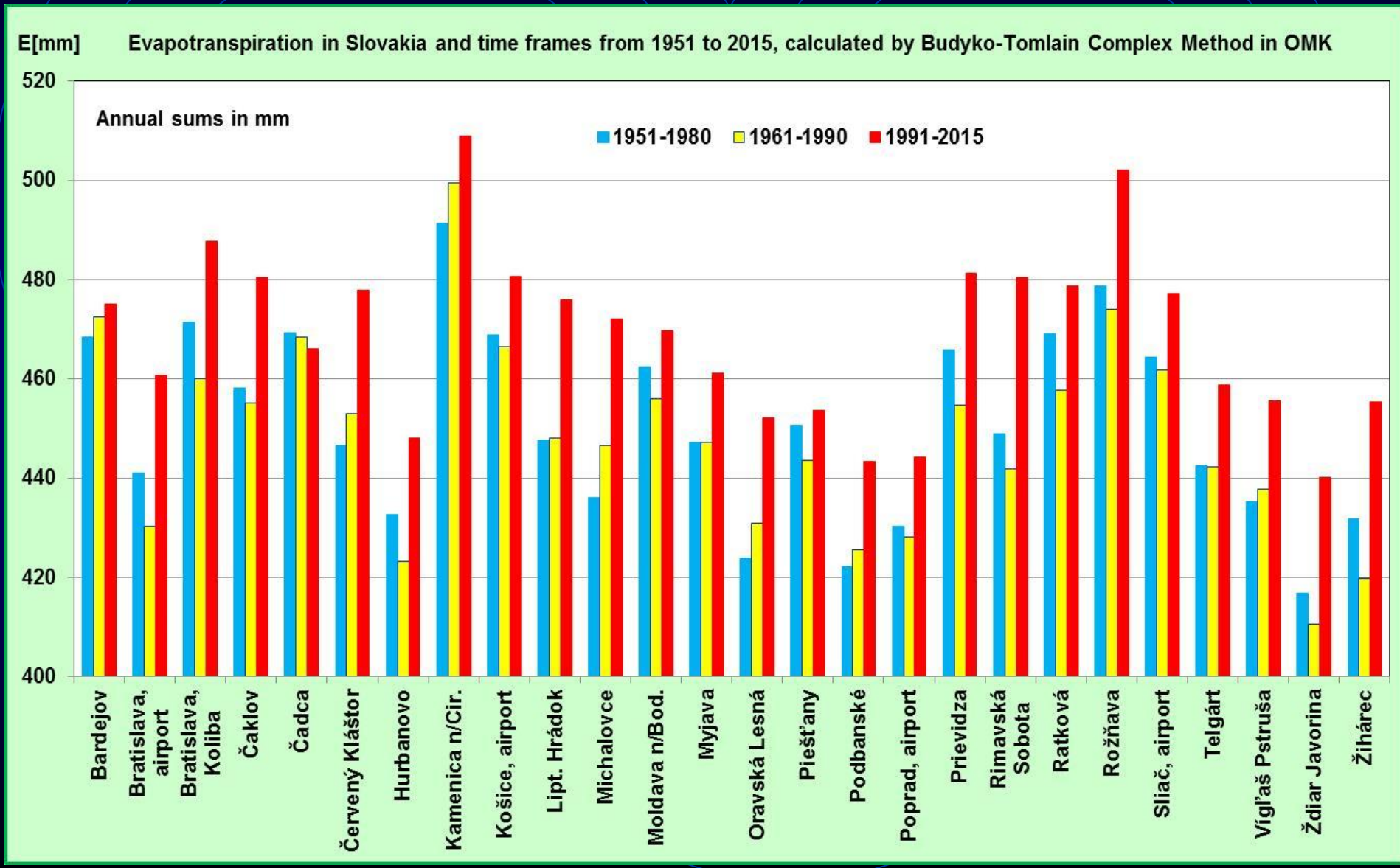


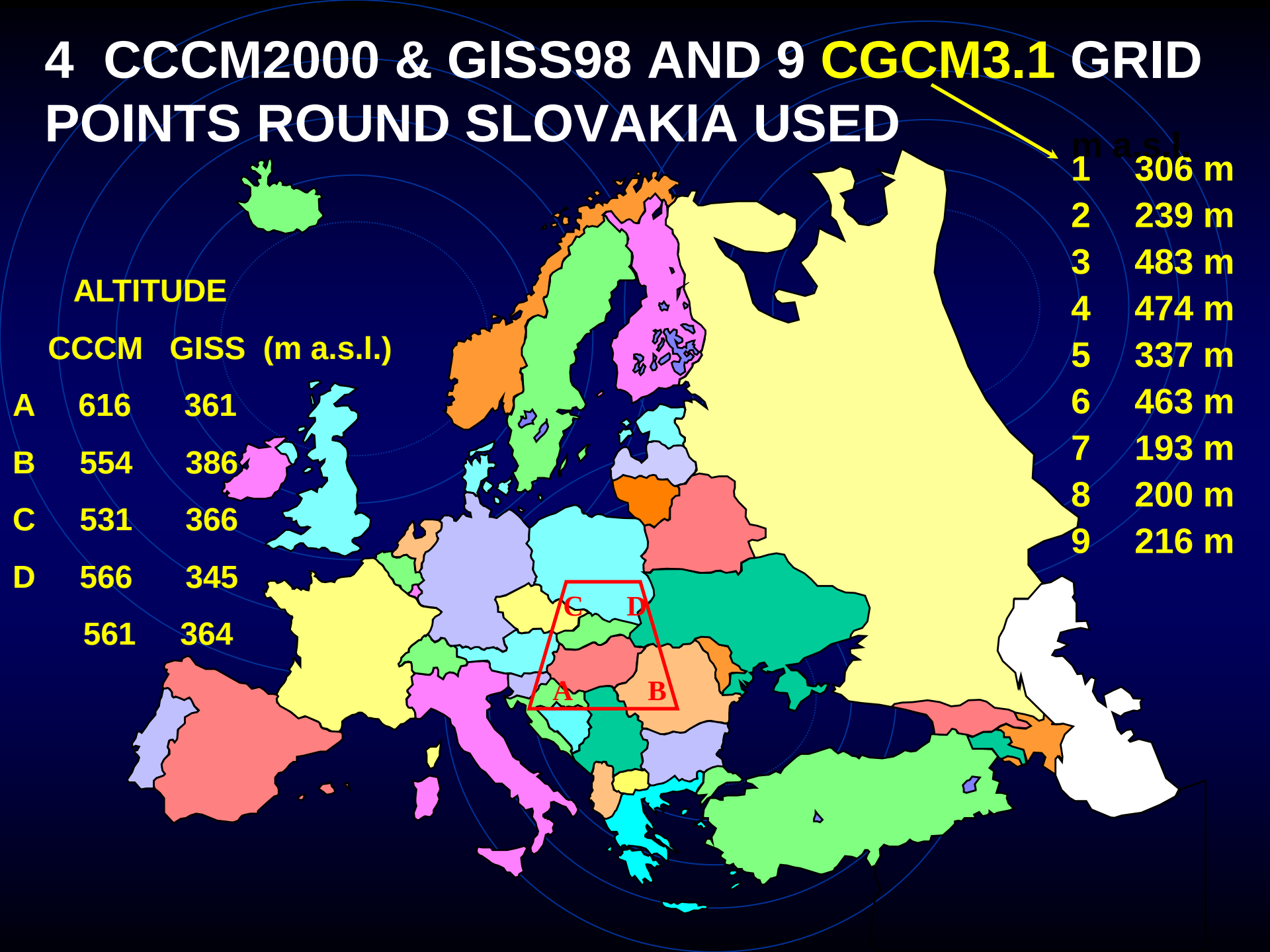
Comparison of different irrigation coefficients at Hurbanovo in 10-year periods, in whole period 1951-2010 and in 5-year period 2011-2015. The year 2010 was unusual wet and warm extreme, so it is evaluated separately (WHY – April-September, Spring, Summer and Autumn, E_o – potential evapotranspiration sum, E – actual evapotranspiration sum, R – precipitation total)

Coefficient	$K = E_o - R$ [mm]				$dE = E_o - E$ [mm]				$E_r = E/E_o$ [%]			
Period/Season	WHY	Spr	Sum	Aut	WHY	Spr	Sum	Aut	WHY	Spr	Sum	Aut
1951-1960	283.6	93.4	166.3	-8.6	236.6	58.9	147.4	63.8	61.4	73.2	59.1	49.4
1961-1970	300.3	101.9	175.1	-13.2	261.5	57.9	173.6	65.7	58.6	74.5	53.3	51.5
1971-1980	318.2	110.6	198.8	9.6	282.4	80.3	179.9	64.6	54.5	65.4	50.8	48.4
1981-1990	334.2	106.4	203.7	14.6	281.6	67.8	185.6	68.4	56.1	71.0	50.7	48.8
1991-2000	327.9	113.9	216.6	-45.9	296.2	75.2	192.7	63.6	55.1	69.3	51.1	48.5
2001-2010	379.5	134.7	218.9	5.7	321.8	77.4	218.3	61.6	53.5	69.9	46.1	53.2
2010	*-130*	*-101*	*36*	*-100*	*102*	*34*	*71*	*19*	*82.5*	*83.5*	*80.7*	*82.4*
2011-2015	*272.6*	*88.3*	*193.0*	*-26.6*	*294.2*	*79.4*	*190.4*	*61.2*	*56.4*	*68.5*	*52.5*	*54.4*
1951-2015	**320.6**	**108.7**	**196.8**	**-7.8**	**281.8**	**70.5**	**184.1**	**64.4**	**56.4**	**70.3**	**51.8**	**50.3**

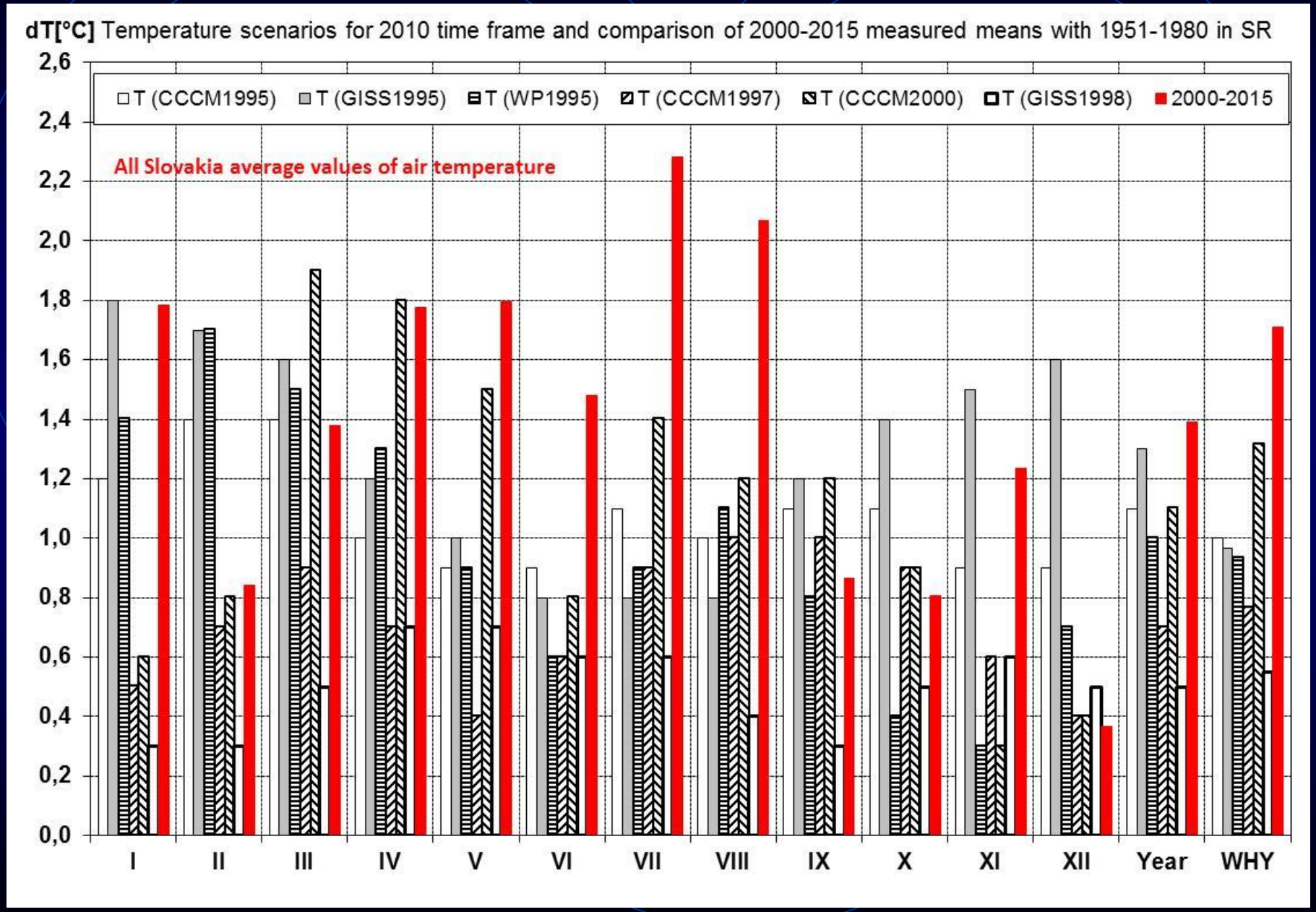
CLIMATE CHANGE SCENARIOS SUMMARY

- 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, 2010 and 2014 (comparison for 2010 time frame in the Graph)

4 CCCM2000 & GISS98 AND 9 CGCM3.1 GRID POINTS ROUND SLOVAKIA USED



CLIMATE CHANGE SCENARIOS



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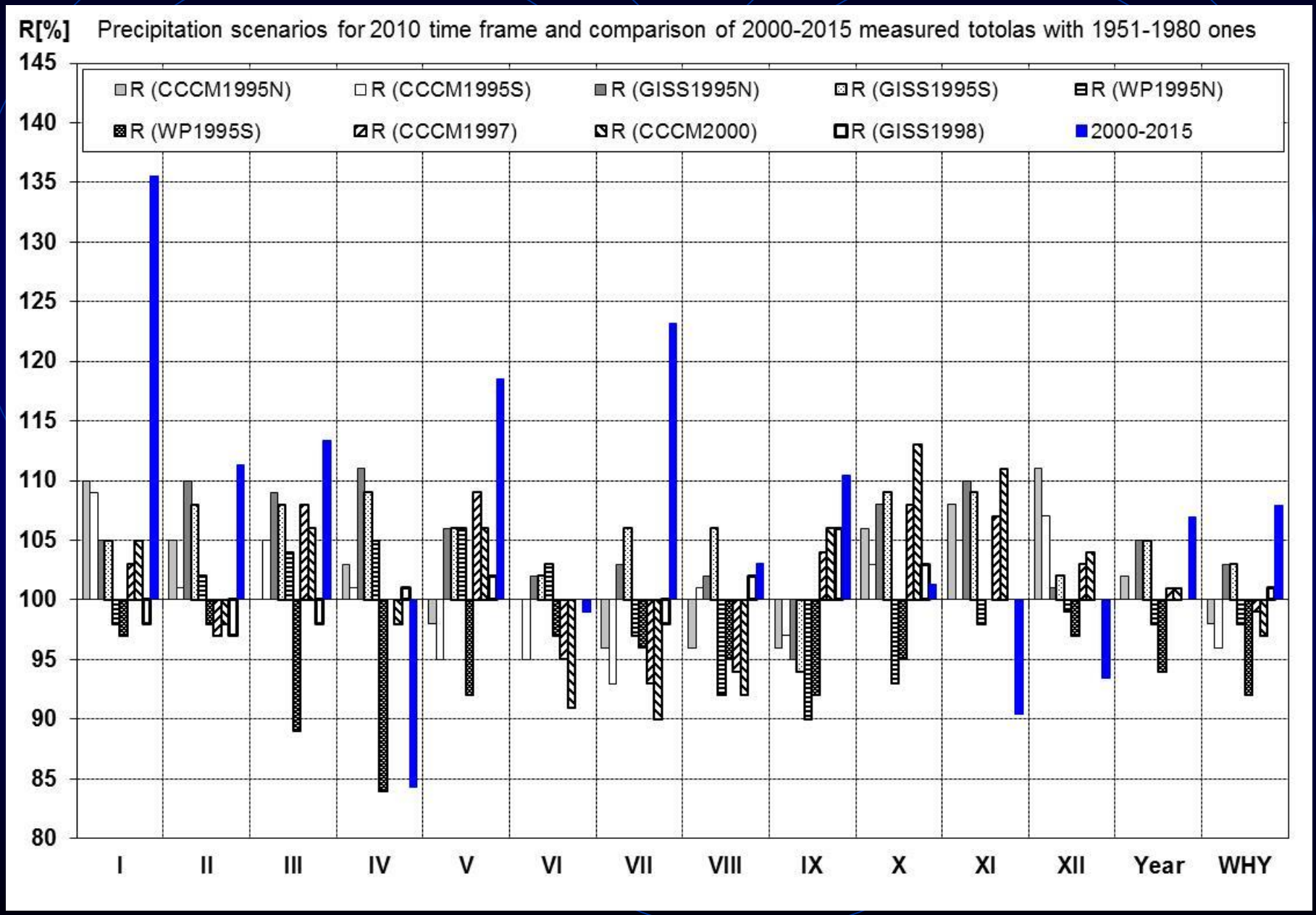
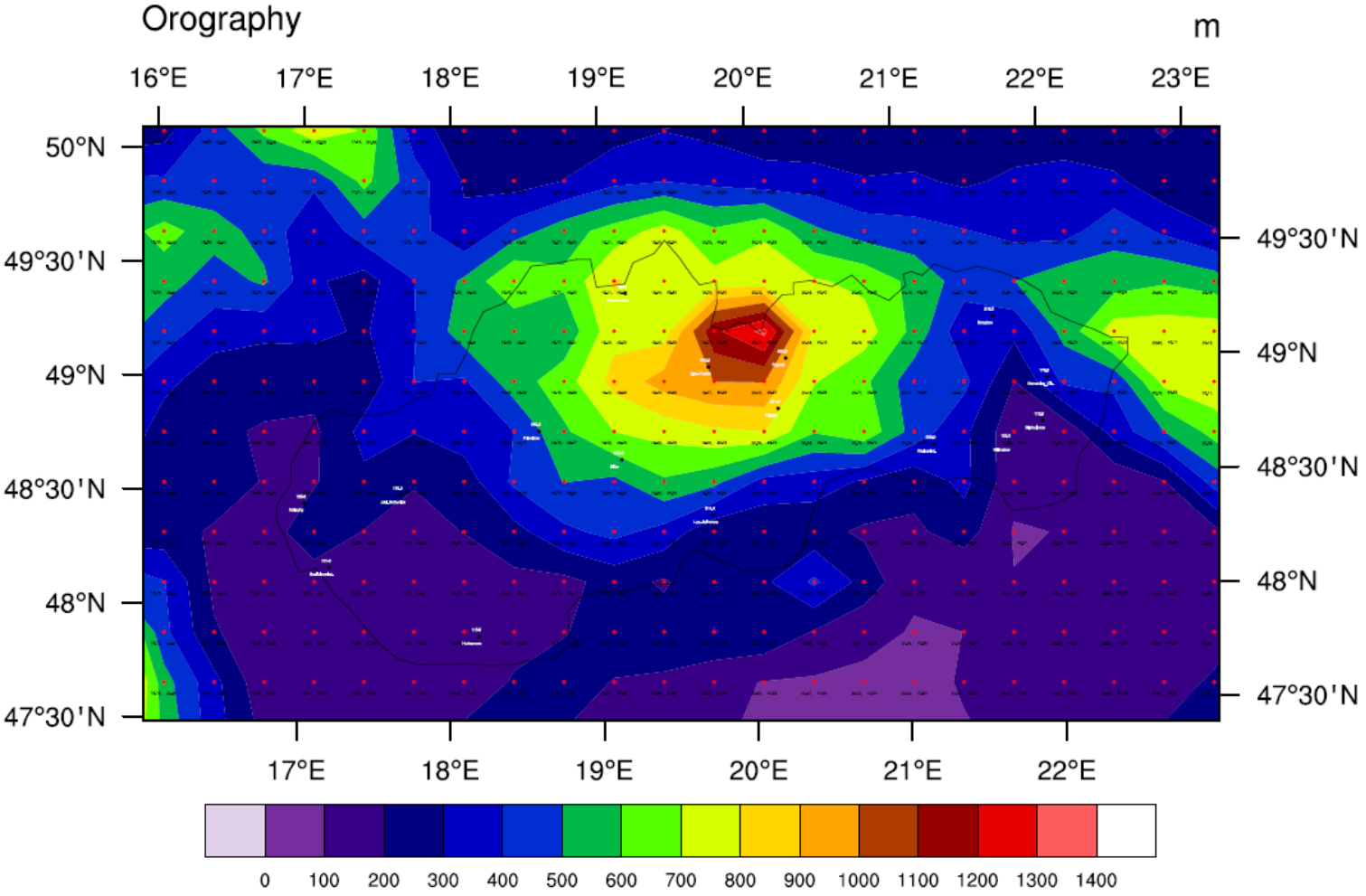


NEW REGIONAL CLIMATIC MODELS

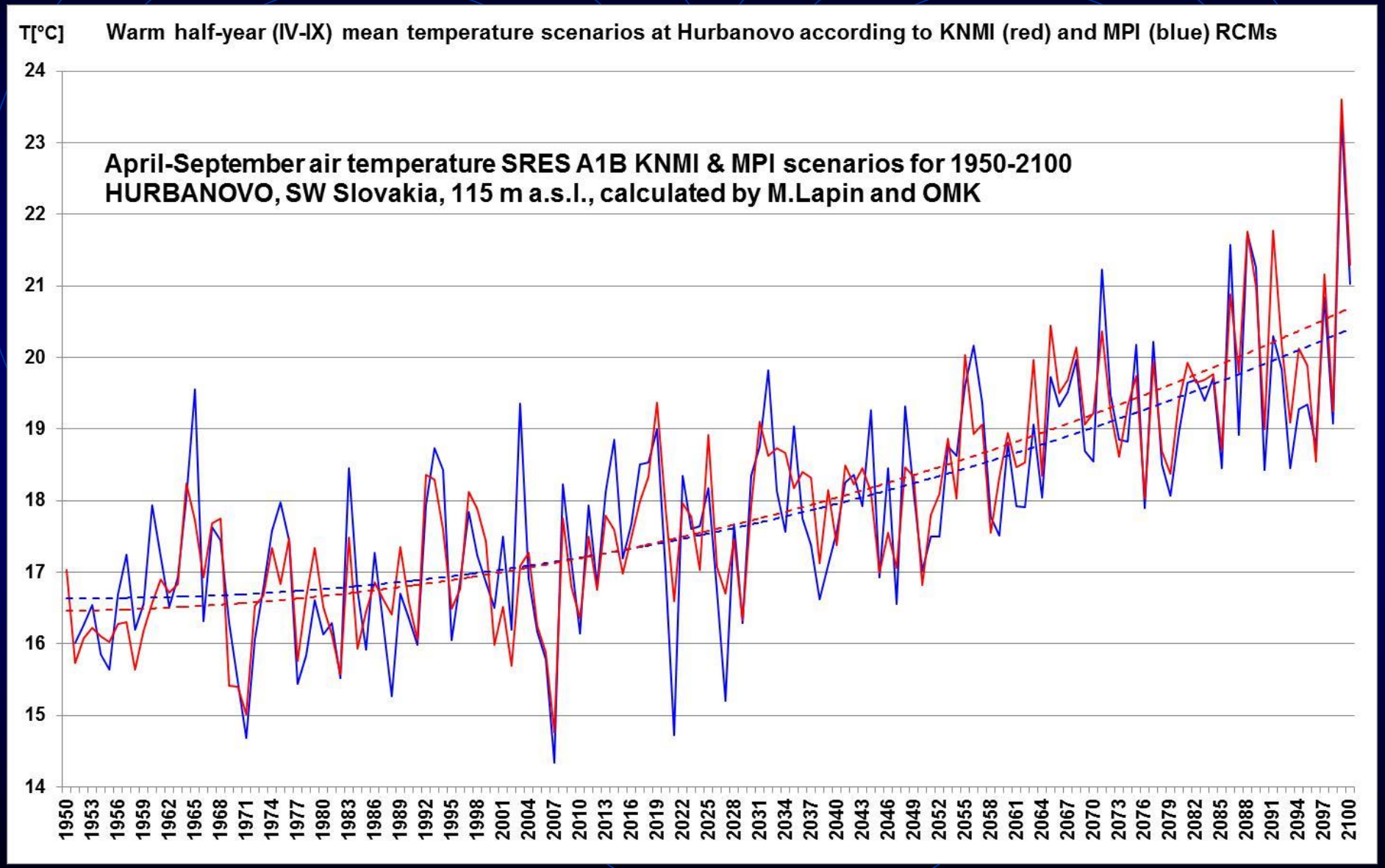
Dutch KNMI and German MPI based on Global model ECHAM5

Orography KNMI

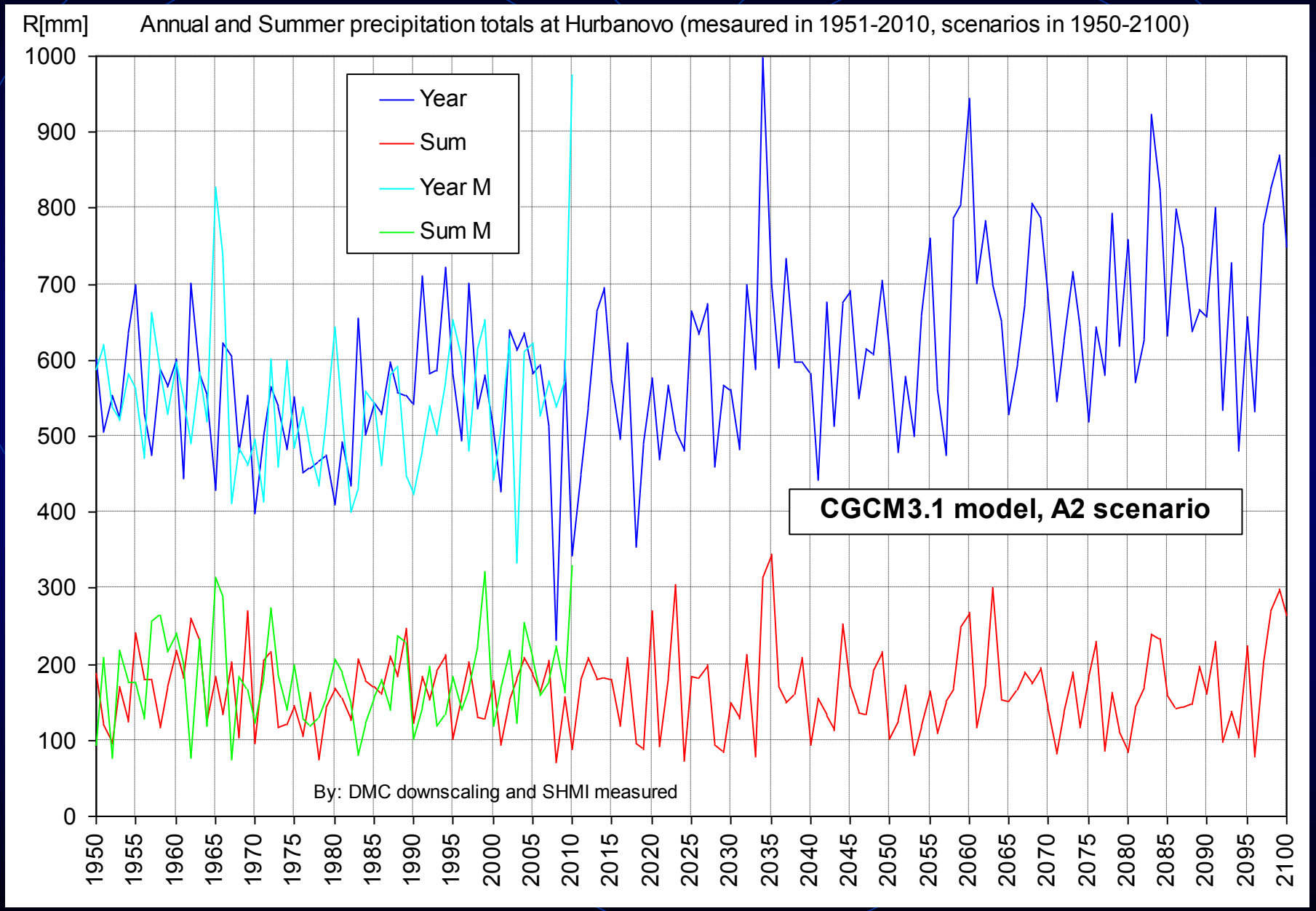
25x25 km



AIR TEMPERATURE SCENARIOS FOR HURBANOVO



PRECIPITATION SCENARIOS FOR HURBANOVO, ANNUAL AND SUMMER



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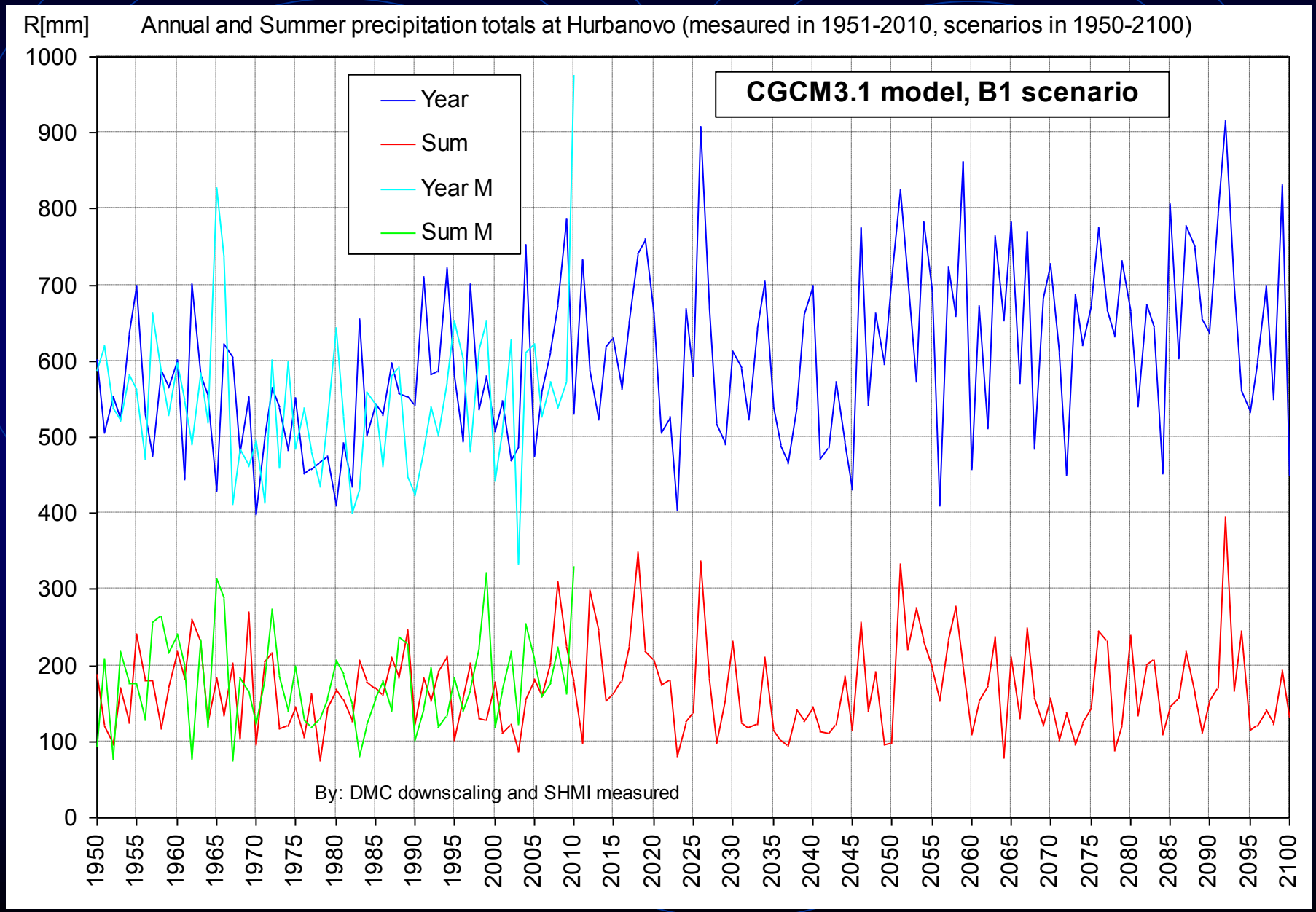
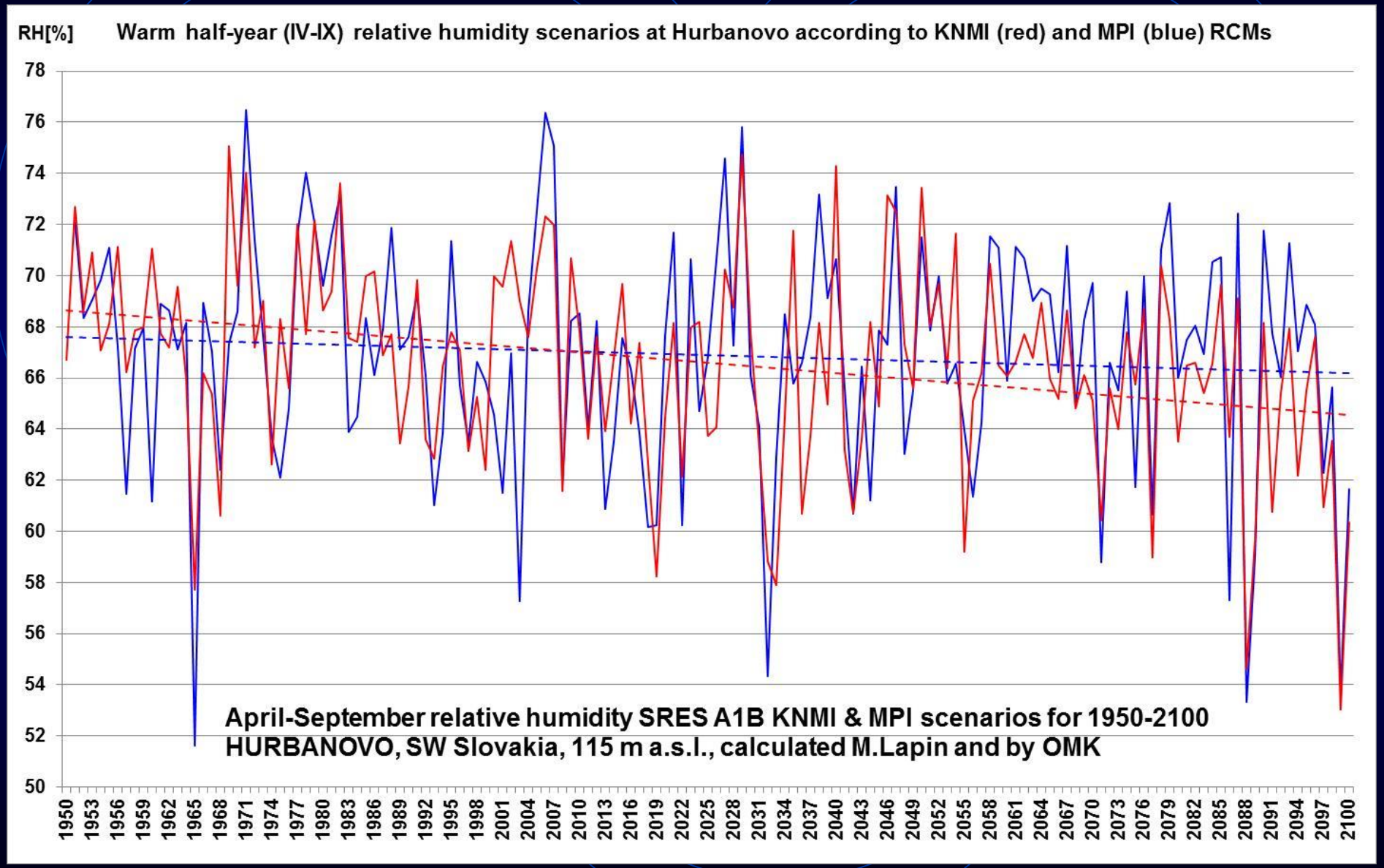
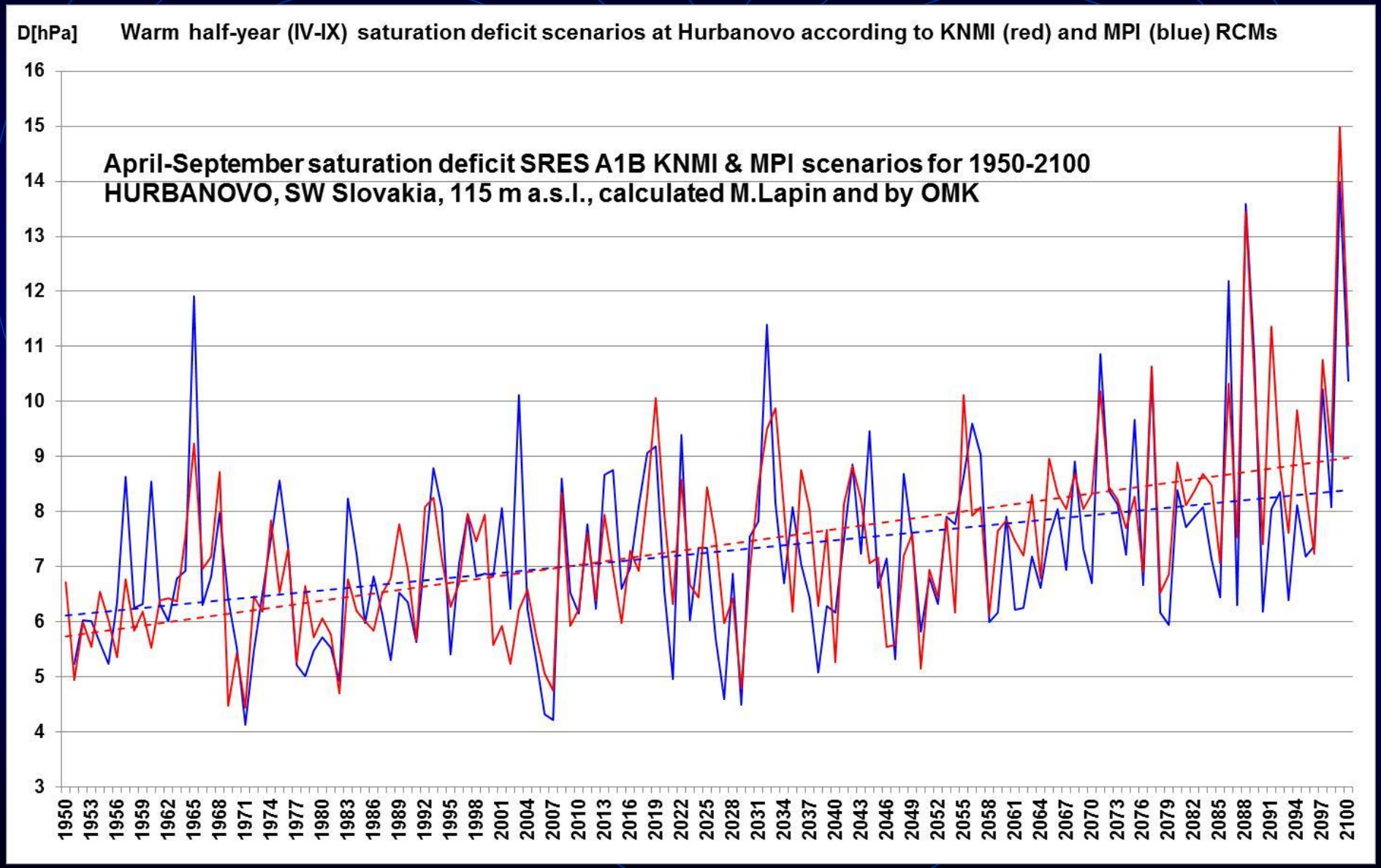


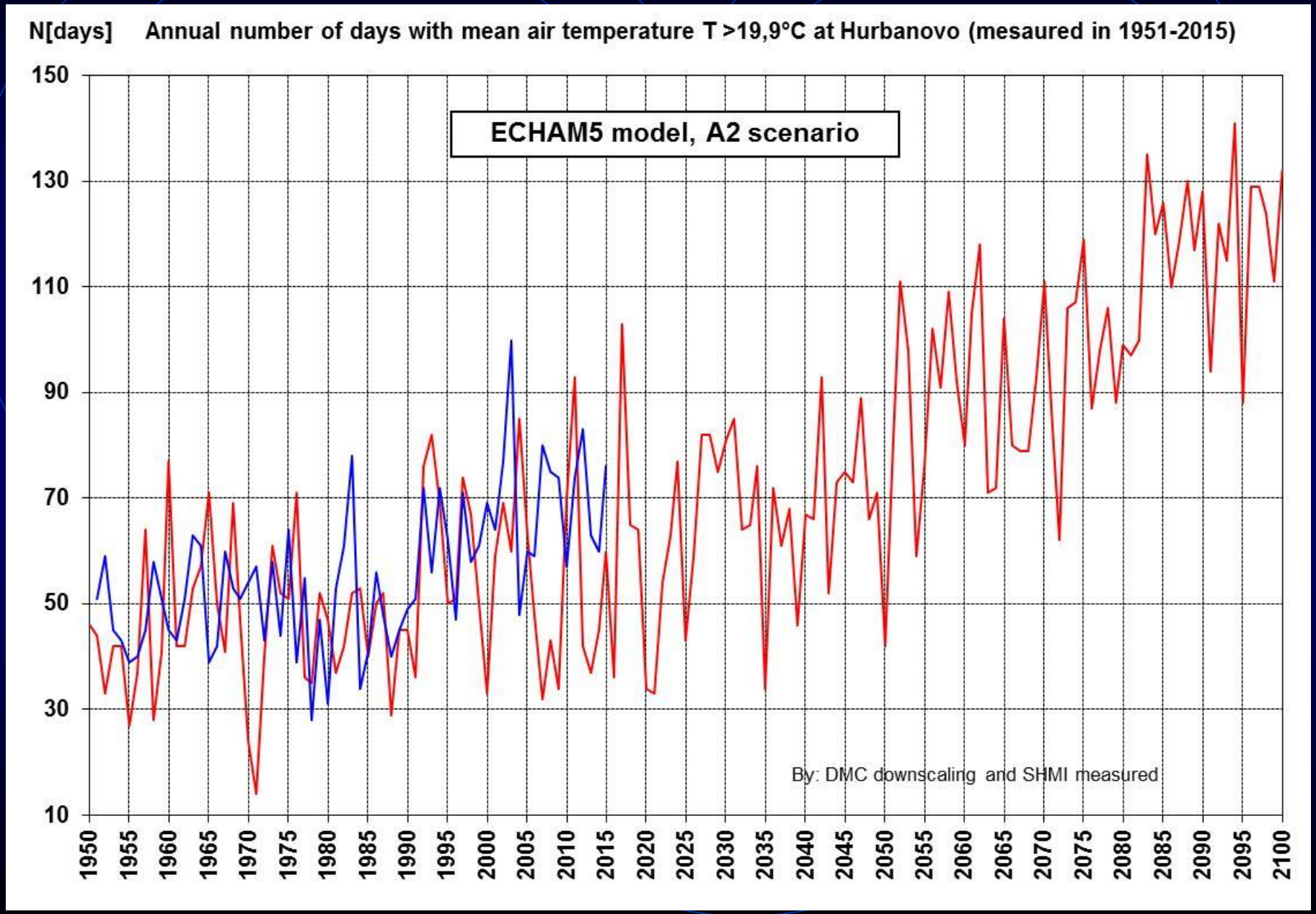
RELATIVE HUMIDITY SCENARIOS FOR HURBANOVO



SATURATION DEFICIT SCENARIOS FOR HURBANOVO



TEMPERATURE SCENARIOS FOR HURBANOVO



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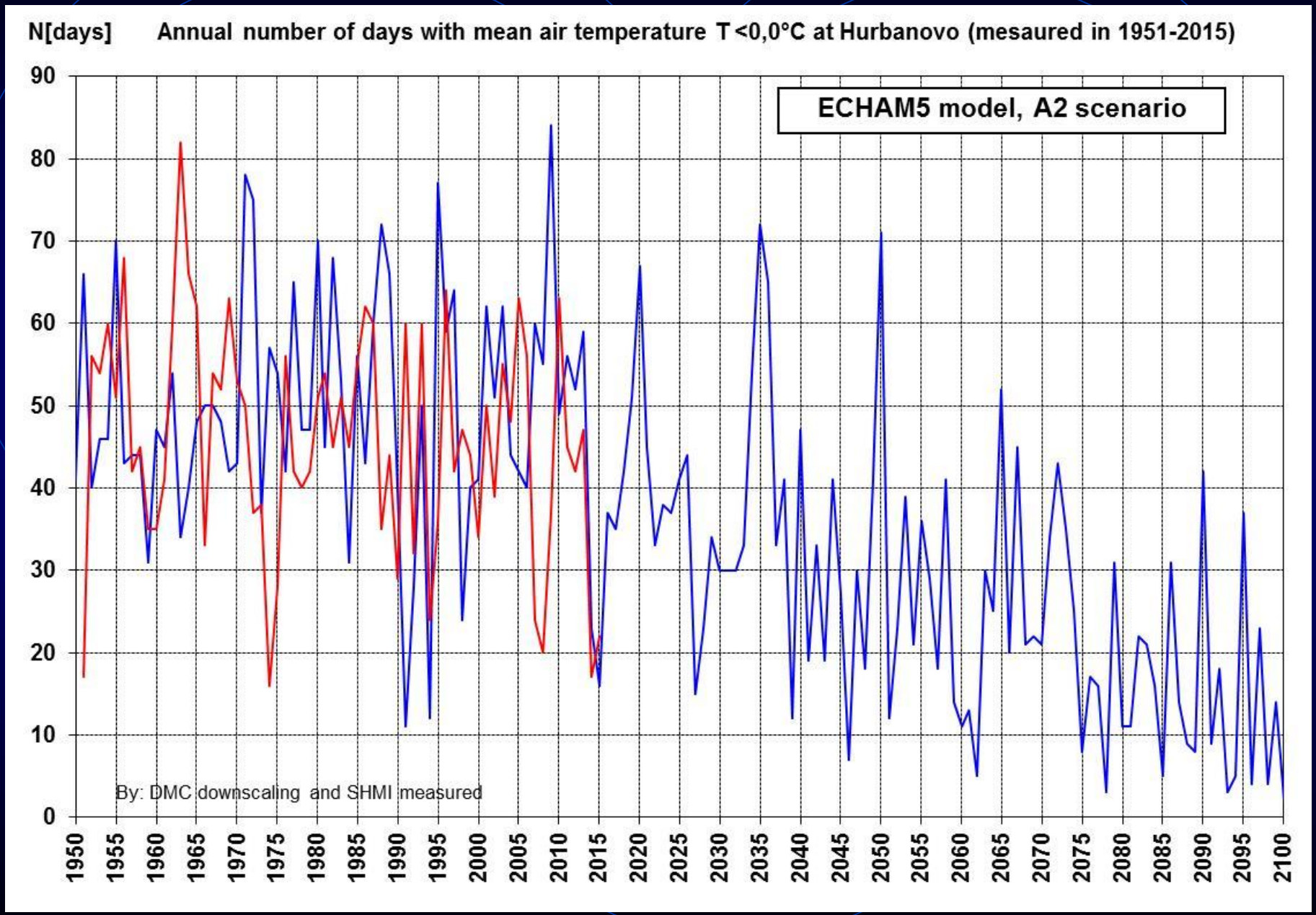
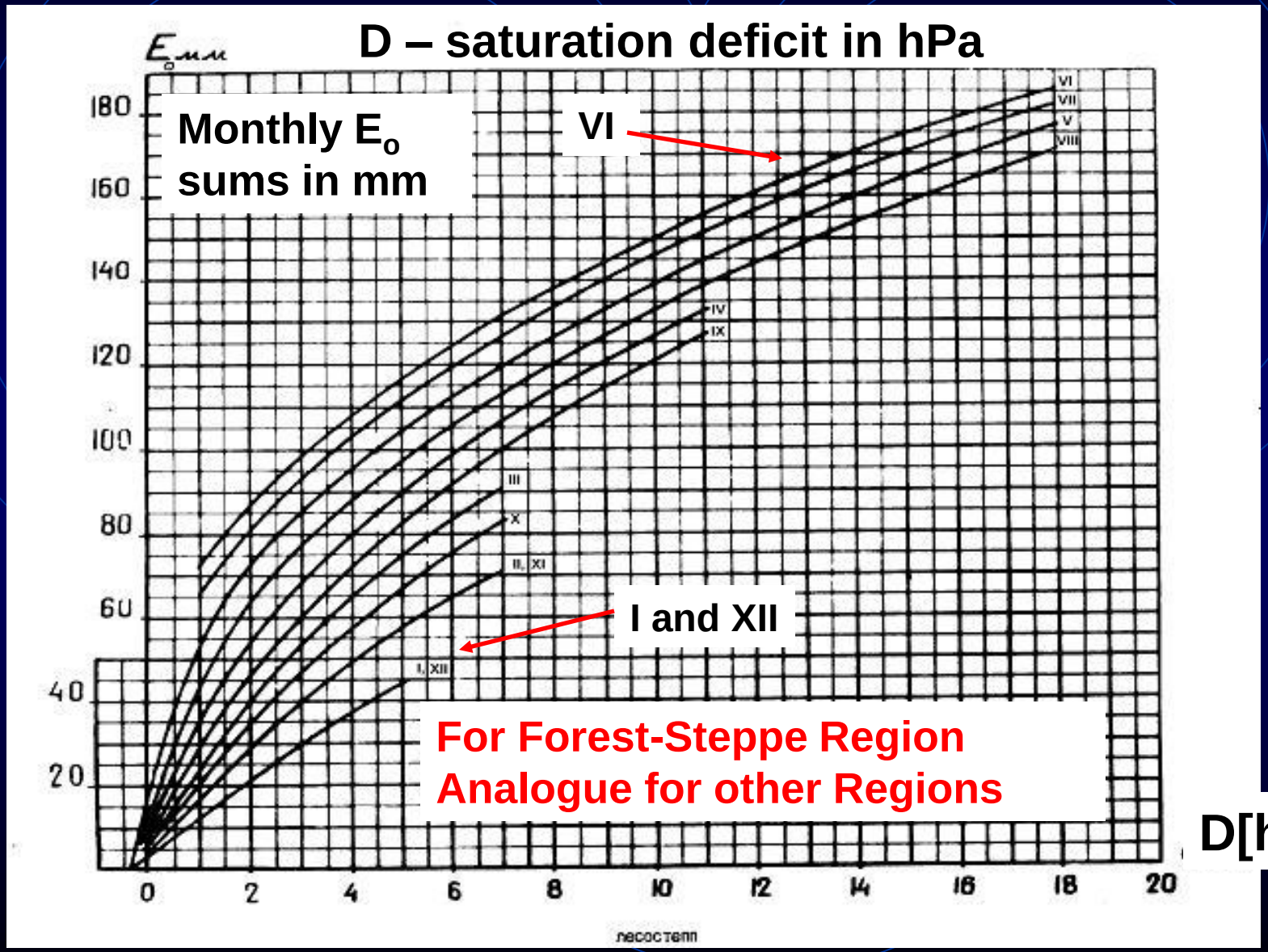
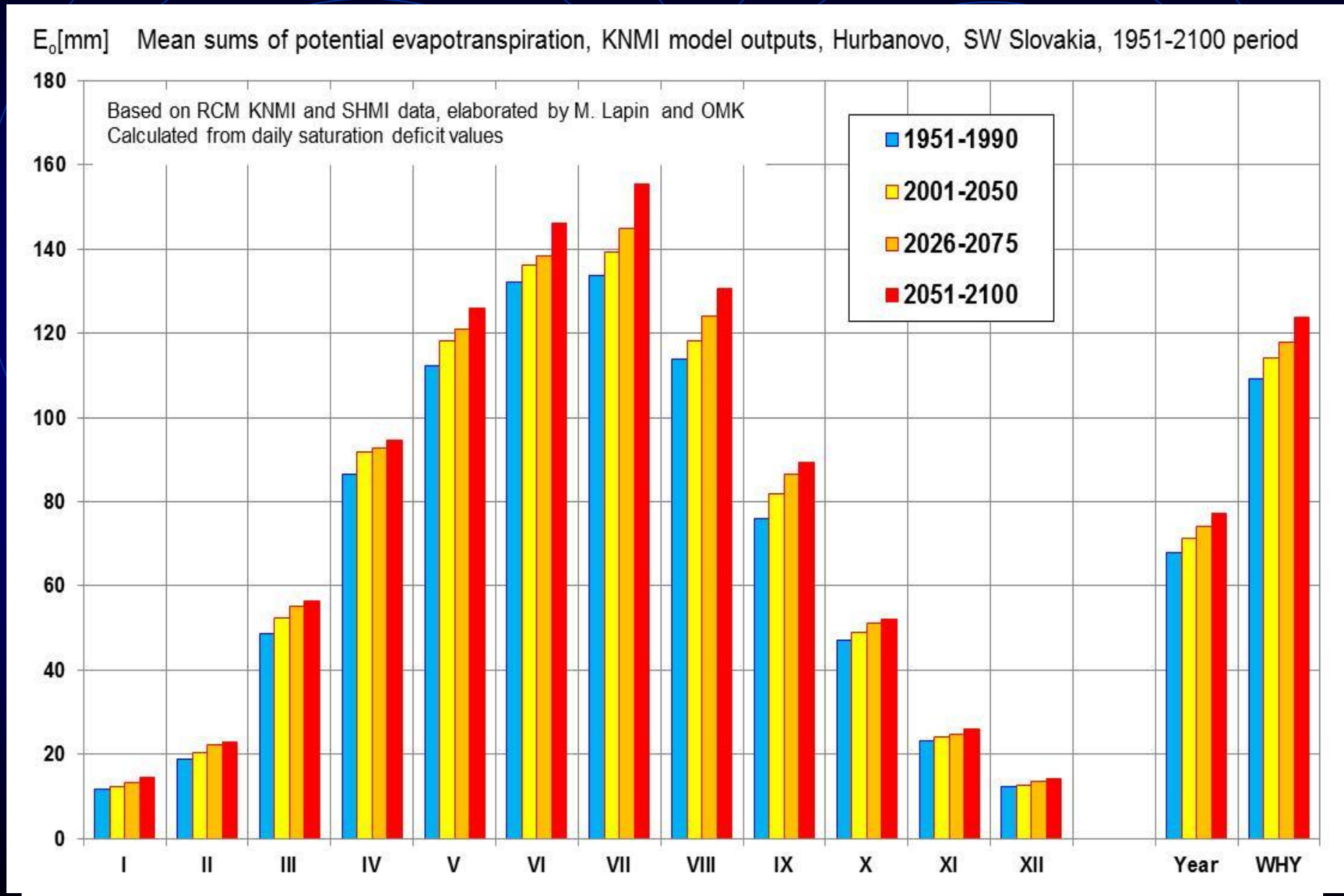


SIMPLE METHOD OF E_o CALCULATION

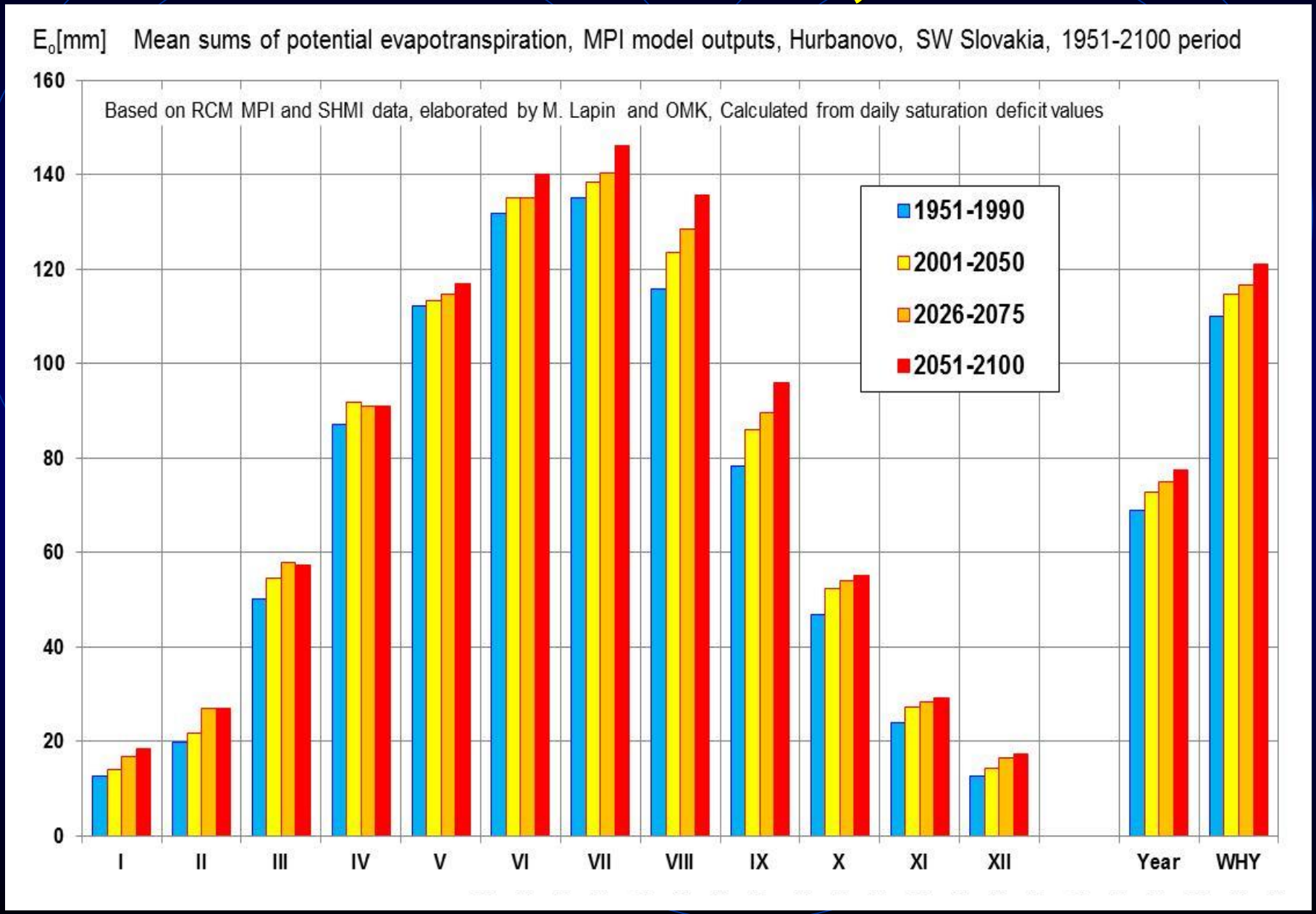
By Zubenok, L.I., agreed in Russia as official since 1976



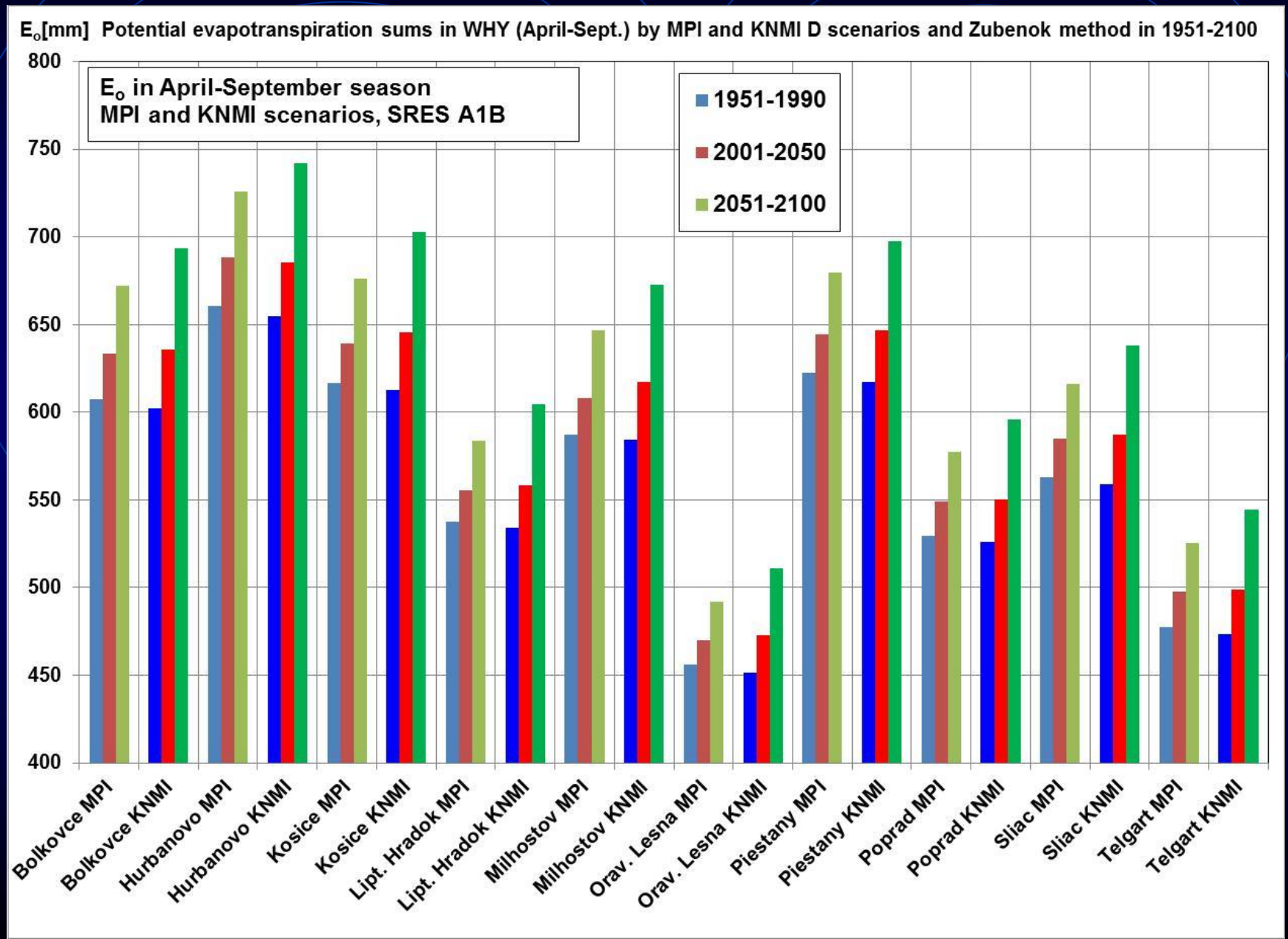
POTENTIAL EVAPOTRANSPIRATION SCENARIOS FOR HURBANOVO BY KNMI RCM, SRES A1B



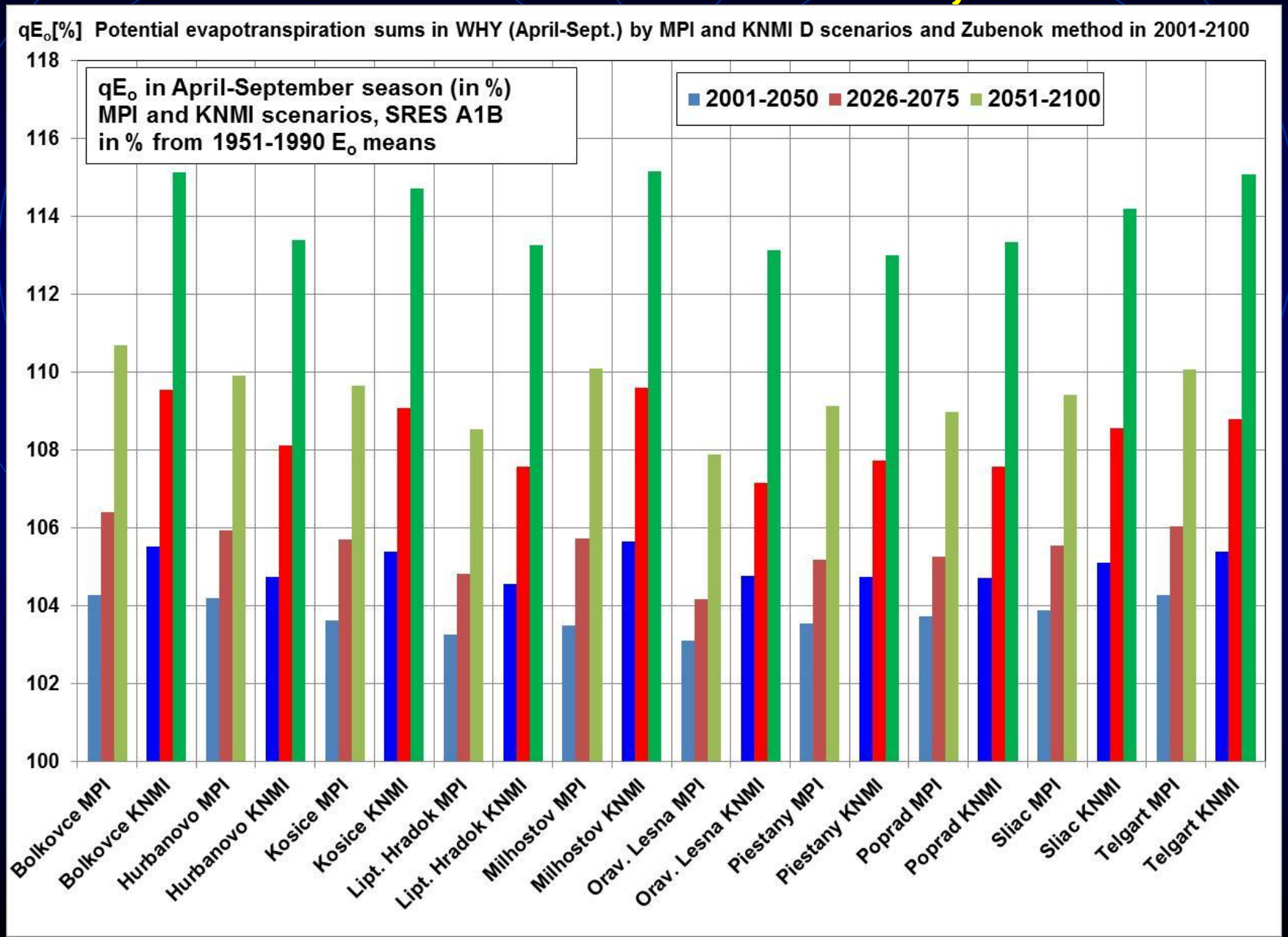
POTENTIAL EVAPOTRANSPIRATION SCENARIOS FOR HURBANOVO BY MPI RCM, SRES A1B



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



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



CONCLUSIONS

- According to reliability evaluation the temperature scenarios are the best, precipitation scenarios are partly uncertain with clear tendency – increase in winter (mainly in the North), small changes in Summer
- **Scenarios of hydrological balance elements, drought and soil moisture is a serious problem – basic tendency is also clear – increase of E_o, longer and more dangerous drought spells**
- Regional Circulation Models offer better results – more realistic topography, more reliable fields of climatic and hydrologic data
- This impacts also the reliability of scenarios for air humidity, precipitation, evapotranspiration and soil moisture regime
- **Several different GCMs/RCMs and Emission scenarios are needed**
- Statistical downscaling of outputs from 25x25 km grids enables quite detail assessment also in saturation deficit development
- This is inevitable step prior to E_o, E and soil moisture scenarios calculation for the selected sites in Slovak regions / river basins
- **Further development of these methods will be directed to the analyses of temporal and areal variability of hydrologic balance**

THANK YOU FOR THE ATTENTION

Further information can be found on:

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