CLIMATE CHANGES, POSSIBLE IMPACTS AND MITIGATION OPTIONS

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SLOVAK NATIONAL CLIMATE PROGRAM

Reviewer of IPCC Reports AR4 (2007) and TAR (2001)

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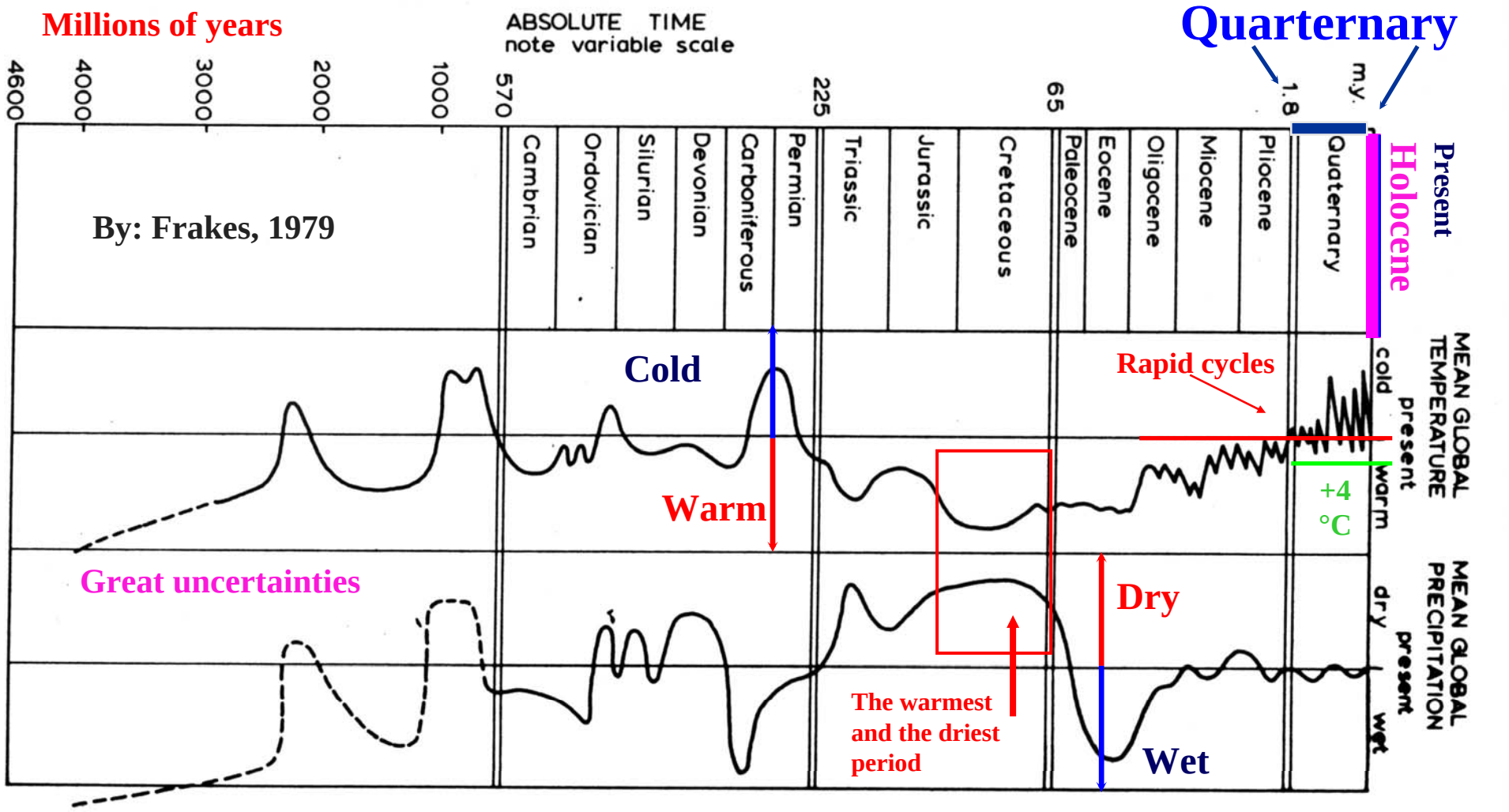
AIR TEMPERATURE AND PRECIPITATION ON EARTH CONTINENTS IN AVERAGE DURING ALL GEOLEOGIC PERIODS



ABSTRACT

- Slovakia, as a member state of the EU, is committed to an 8 % reduction of GHGs emissions compared to the base year 1990
- A reduction of total anthropogenic emissions of GHGs, stated as CO_2 equivalent – 30 % in 2002 compared 1990, small rise up to 2008
- In Dec. 2005 the 4th Slovak National Communication on Climate Change was issued by the Slovak Ministry of Environment
- In 1991 – established the Czecho-Slovak National Climate Program
- **The period 1991-2008 – significant in exceptional weather events occurrence in Slovakia (heat waves, flash floods, drought…)**
- **Very reliable time series of daily data measured by the Observatory at Hurbanovo, 115 m a.s.l., SW Slovakia, other 33 station since 1951 and 3 since 1881, about 100 reliable rain gage series since 1901**
- Nine GCMs outputs from 5 World Modeling Centers applied – CGCM2/3 and GISS 1998 the most frequently used, 15 other tested
- Water cycle, water resources, water management, agriculture, field ecosystems, forestry, forest ecosystems – impacts studied
- Mitigation measures and their co-ordination with adaptation options

VULNERABILITY TO CLIMATE CHANGE, IMPACTS, ADAPTING AND MITIGATION OPTIONS

- Slovak Republic's Country Study (U.S. Country Studies Program, 55 countries) in 1994-1997
- Slovak Republic's National Climate Program (SR NCP) in 1991-2001 and 2008 (funded by the Ministry of Environment – MZP SR), in 2002-2007 funded only by the Slovak Hydrometeorological Institute (SHMI)
- Inventory of greenhouse gases emission in Slovakia is coordinated by the MZP SR and SHMI since 1993
- Other scientific projects, coordinated by collaborating institutions (funded mostly by the Ministry of Land Management, Ministry of Education and by the Slovak Grant Agency -VEGA)
- These sources were a base for the preparing of Slovak National Communication on Climate Change approved by the Slovak Government in 1995, 1997, 2001, 2005, (2009?)

IMPACTS IN SOCIO-ECONOMIC SECTORS

- Climate in Slovakia (monitoring, analysis, scenarios…)
- Hydrological Cycle (runoff, evaporation, ground water…)
- Water Economy (management of water supply…)
- Water Resources (drinking water…)
- Agricultural Economy (management, plant production)
- Agricultural Ecosystems (pest, diseases, weeds…)
- Forestry (management…)
- Forest Ecosystems (instability, pest, diseases…)
- Biodiversity (instability, new species…)

Contacted Sectors – not participating

- Recreation and Tourism
- Health and Hygiene
- Economy, Civil engineering and Energy supply
- Transport and Telecommunications

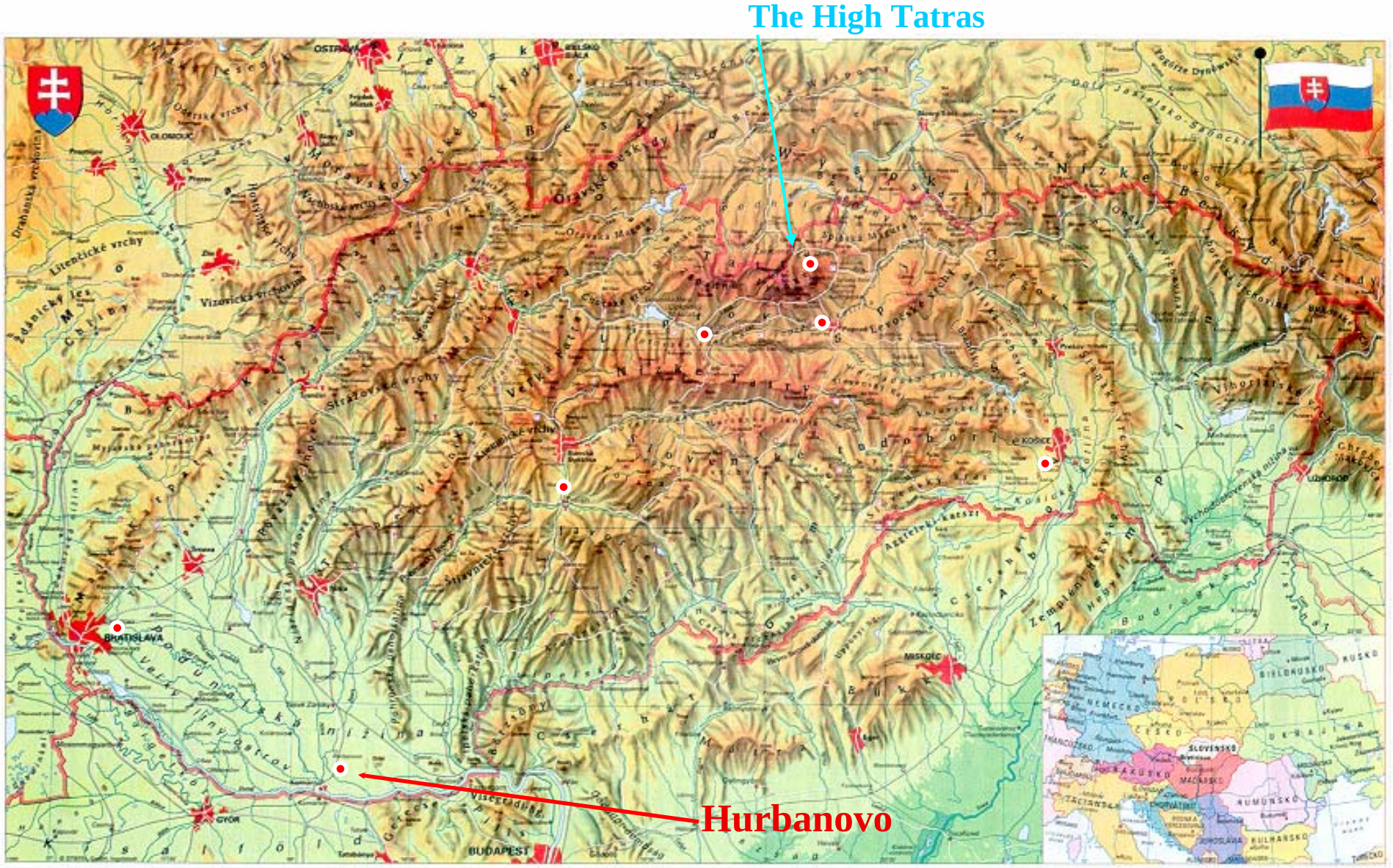
SCIENTIFIC THEORY OF CLIMATE CHANGE

- "**Climate Change**" – anthropogenic influence
- Physics, chemistry and biology of climate change and natural climate changes
- Socio-economic cross-correlation and impacts
- Natural ecosystems and climate change
- Positive and negative feedbacks and forcing
- Misinterpretations by some groups of experts

- **CLIMATE CHANGE MONITORING IN SLOVAKIA AS THE FIRST STEP**

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



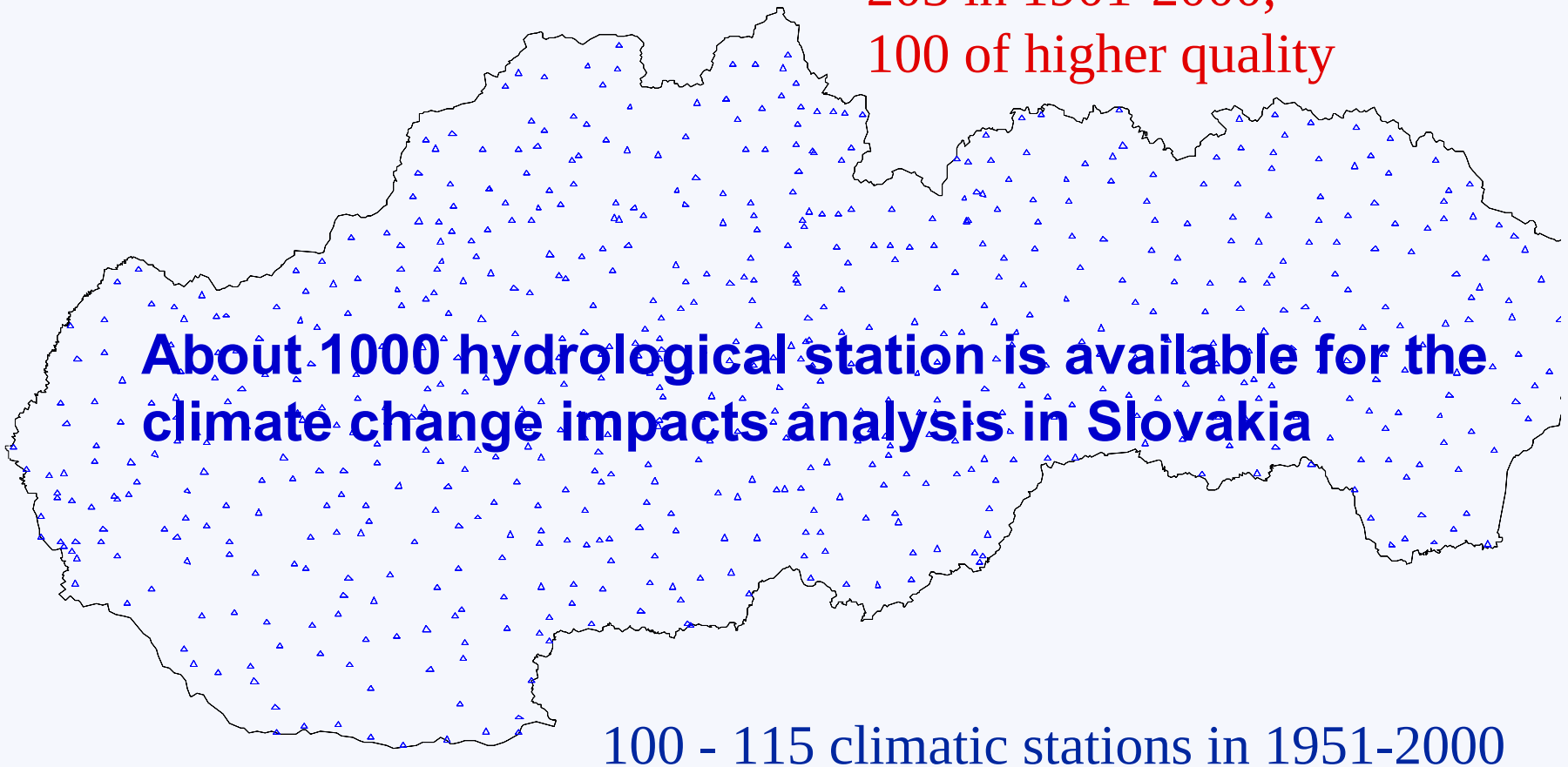
Observatory at the Lomnický štít, 2635 m a.s.l.

Hurbanovo Observatory, 115 m a.s.l., since 1871

PRECIPITATION STATIONS NETWORK IN SLOVAKIA

Figure 3 - National Observing System
Part D of the Surface Sub-system

607 stations in 1951-2000,
557 of higher quality
203 in 1901-2000,
100 of higher quality



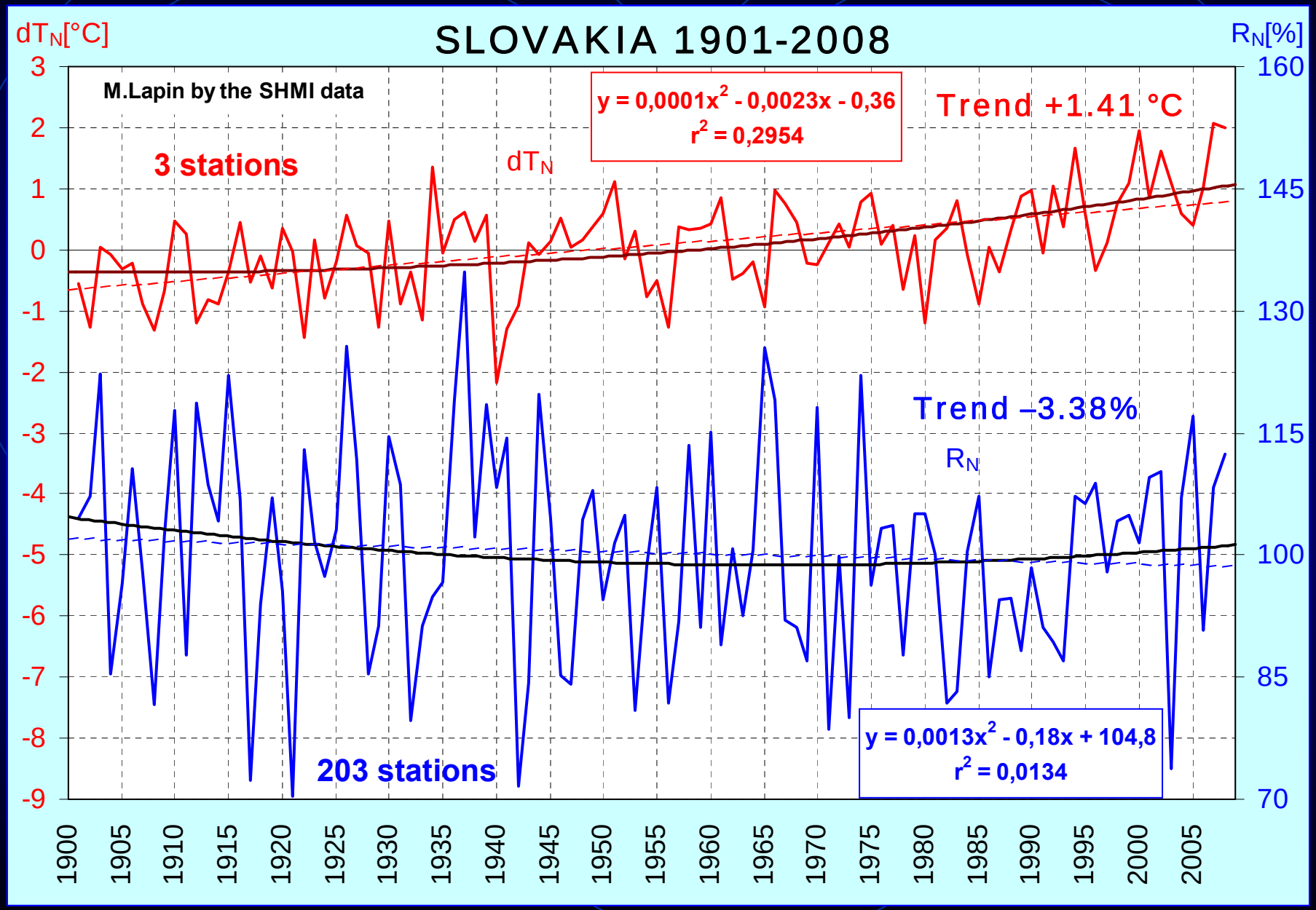
About 1000 hydrological station is available for the climate change impacts analysis in Slovakia

100 - 115 climatic stations in 1951-2000
35 complete stations in 1961-2000
3 complete in 1881-2000

Slovak Hydrometeorological Institute

D: Partial Observing System for Climatology - only stations with the Rainfall Programme (655)

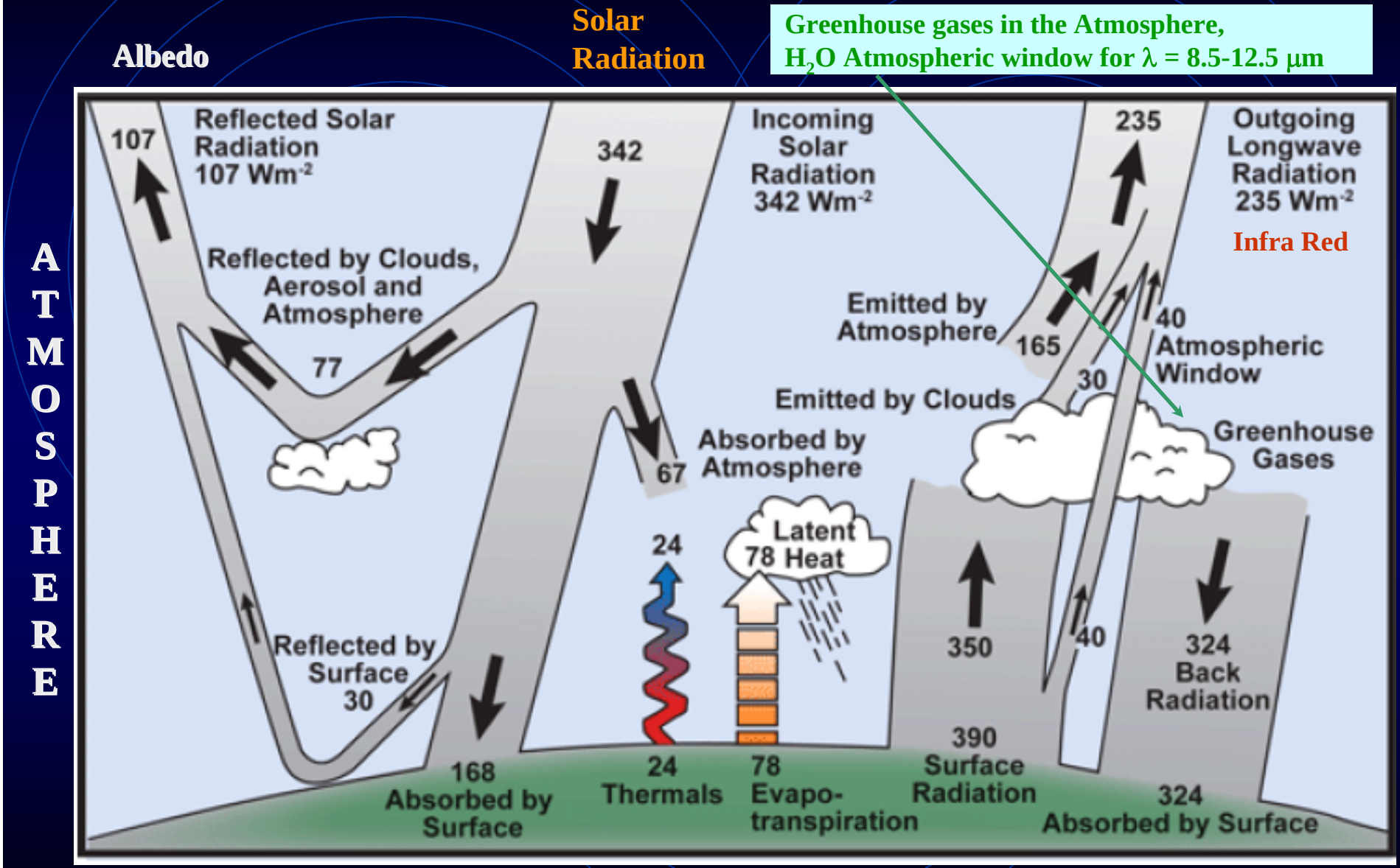
ANNUAL TEMPERATURE (dT) AND PRECIPITATION (R_N) DEVIATIONS



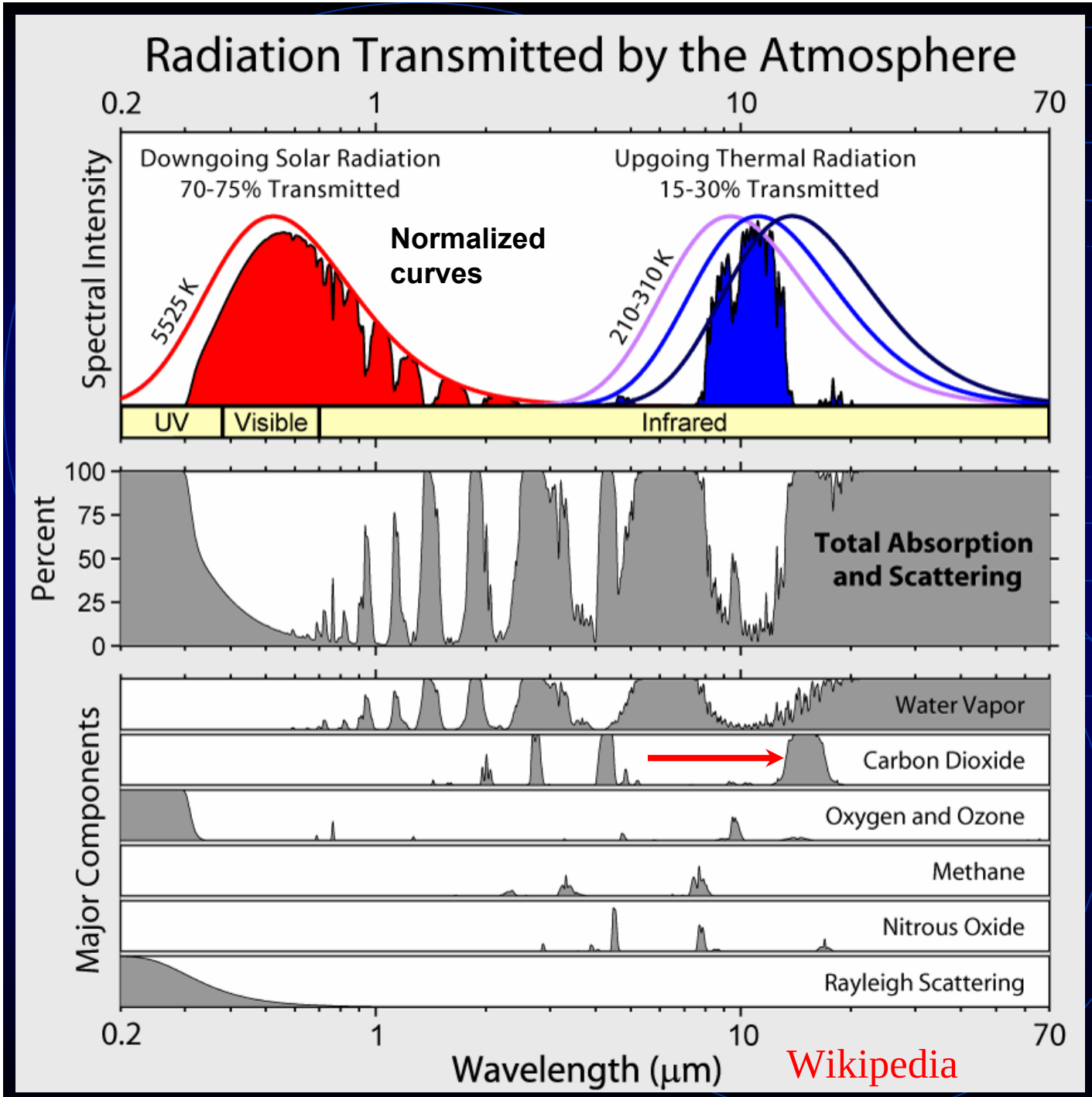
SCIENTIFIC THEORY OF CLIMATE CHANGE AND CLIMATE CHANGE SCENARIOS - SOME EXAMPLES

Most of these information are available on our web site www.dmc.fmph.uniba.sk

Annual values of Earth's surface and Atmosphere energetic balance



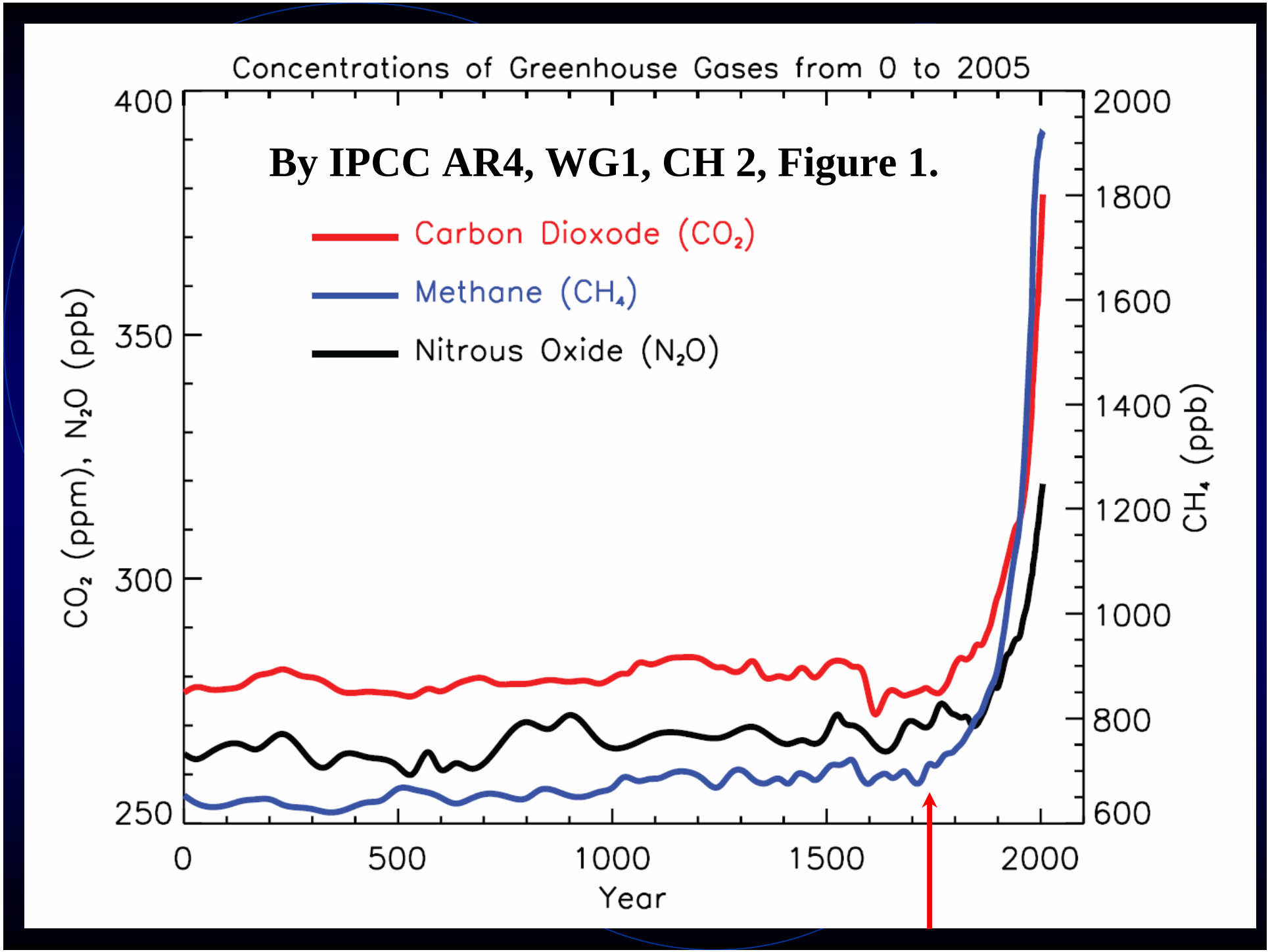
By IPCC 2007



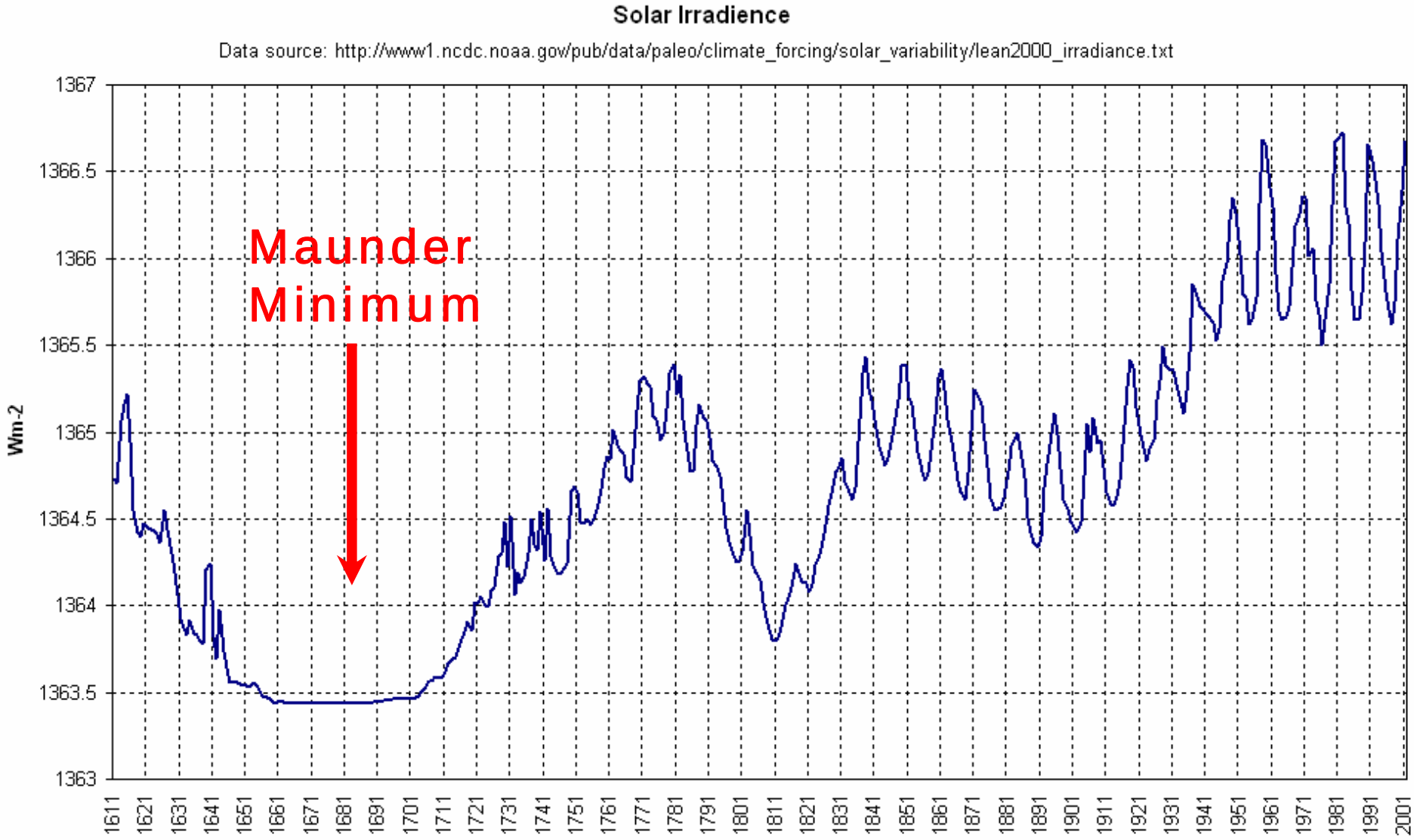
It is important, that total IR radiation can be absorbed in lower layer of the atmosphere, if some GHG increases its concentration.

The atmosphere produce IR radiation as well, and the absorption process continues up to the top of the atmosphere.

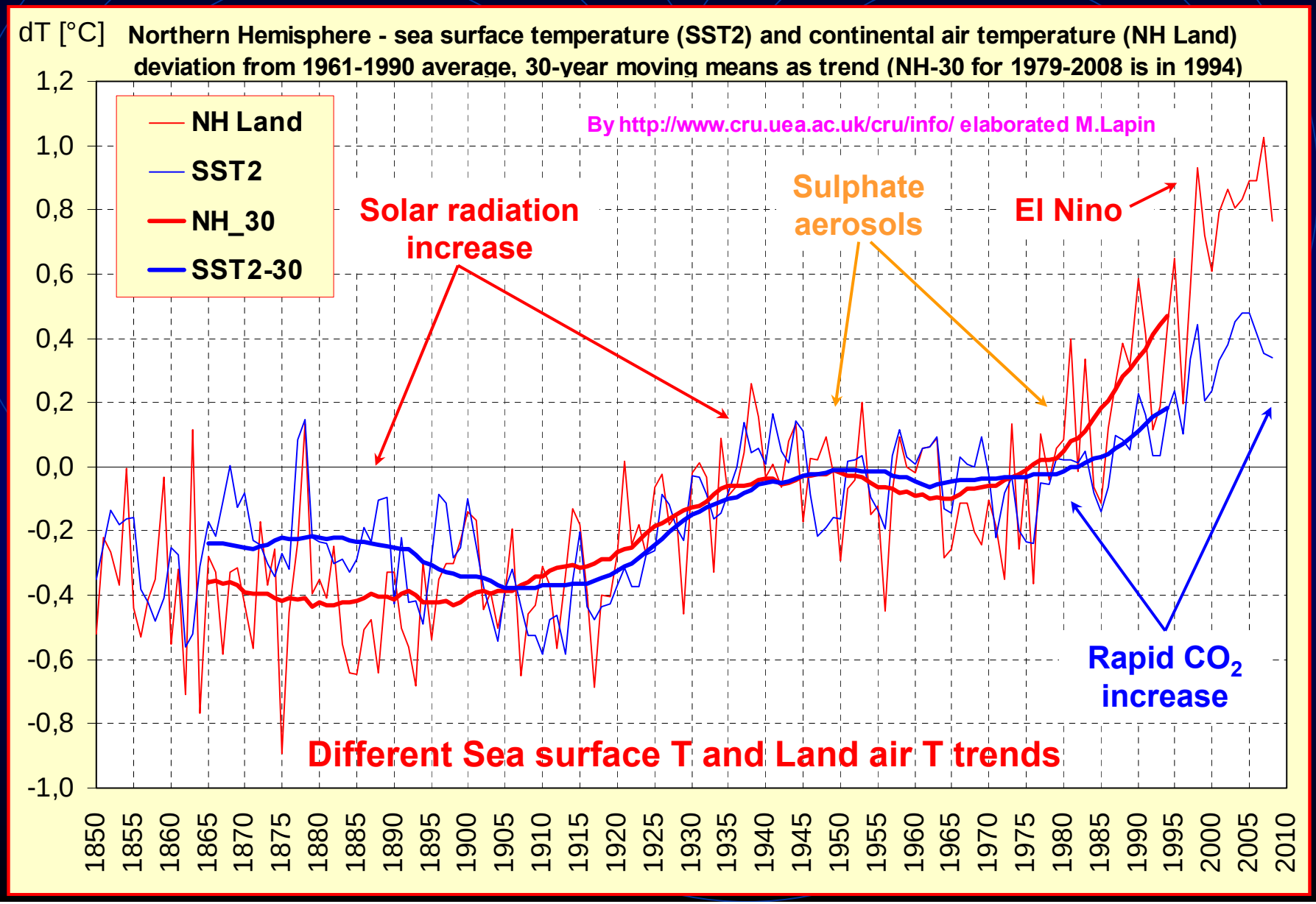
The higher is GHGs concentration in the atmosphere, the greater is increase of surface atmosphere temperature.


Concentrations of Greenhouse Gases from 0 to 2005
By IPCC AR4, WG1, CH 2, Figure 1.
Carbon Dioxode (CO_2)
Methane (CH_4)
Nitrous Oxide (N_2O)
CO_2 (ppm), N_2O (ppb)
CH_4 (ppb)
400
350
300
250
2000
1800
1600
1400
1200
1000
800
600
0
500
1000
1500
2000
Year

Natural forcing in the Earth's Climate System – Solar radiation



VARIABILITY OF ANNUAL TEMPERATURE DEVIATIONS FROM THE 1961-1990 AVERAGE IN THE NORTHERN HEMISPHERE IN 1850-2008 (Sea surface T a and Land air T, HADLEY, CRU UK DATA)

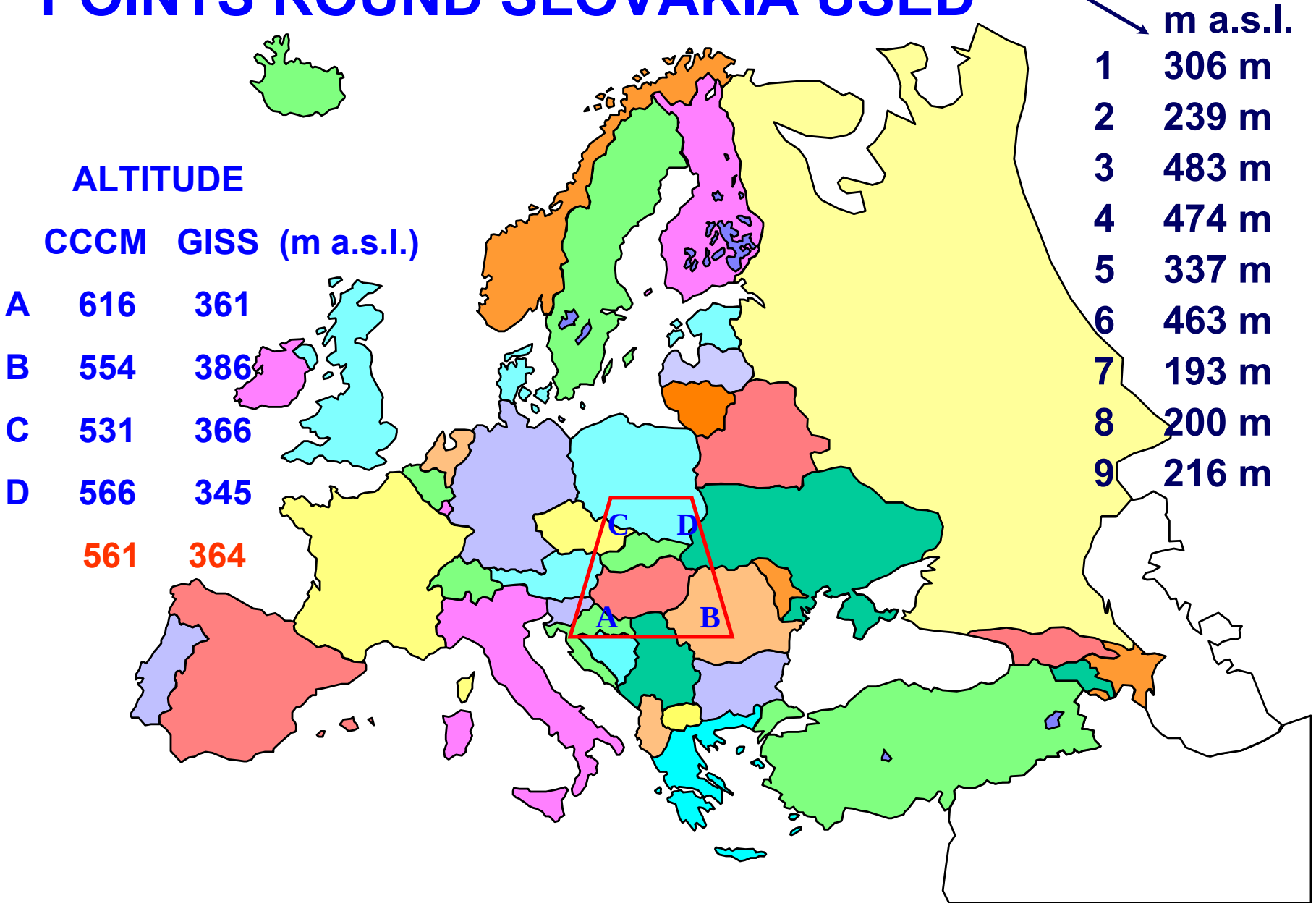


CLIMATE CHANGE SCENARIOS SUMMARY

- Scenarios based on the Atmosphere General Circulation Models - GCMs (Atmosphere-Ocean Models at present)
- Scenarios based on analogues – data from instrumental measurements or from paleoclimatic reconstruction
- Incremental scenarios – suitable combination of air temperature and precipitation increments (T increase by 1, 2, 3, 4 °C, R changes by 5, 10, 15, 20%) – acceptable for impact model 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...
- Based on these scenarios the impacts in socio-economic sectors

More details in: www.dmc.fmph.uniba.sk

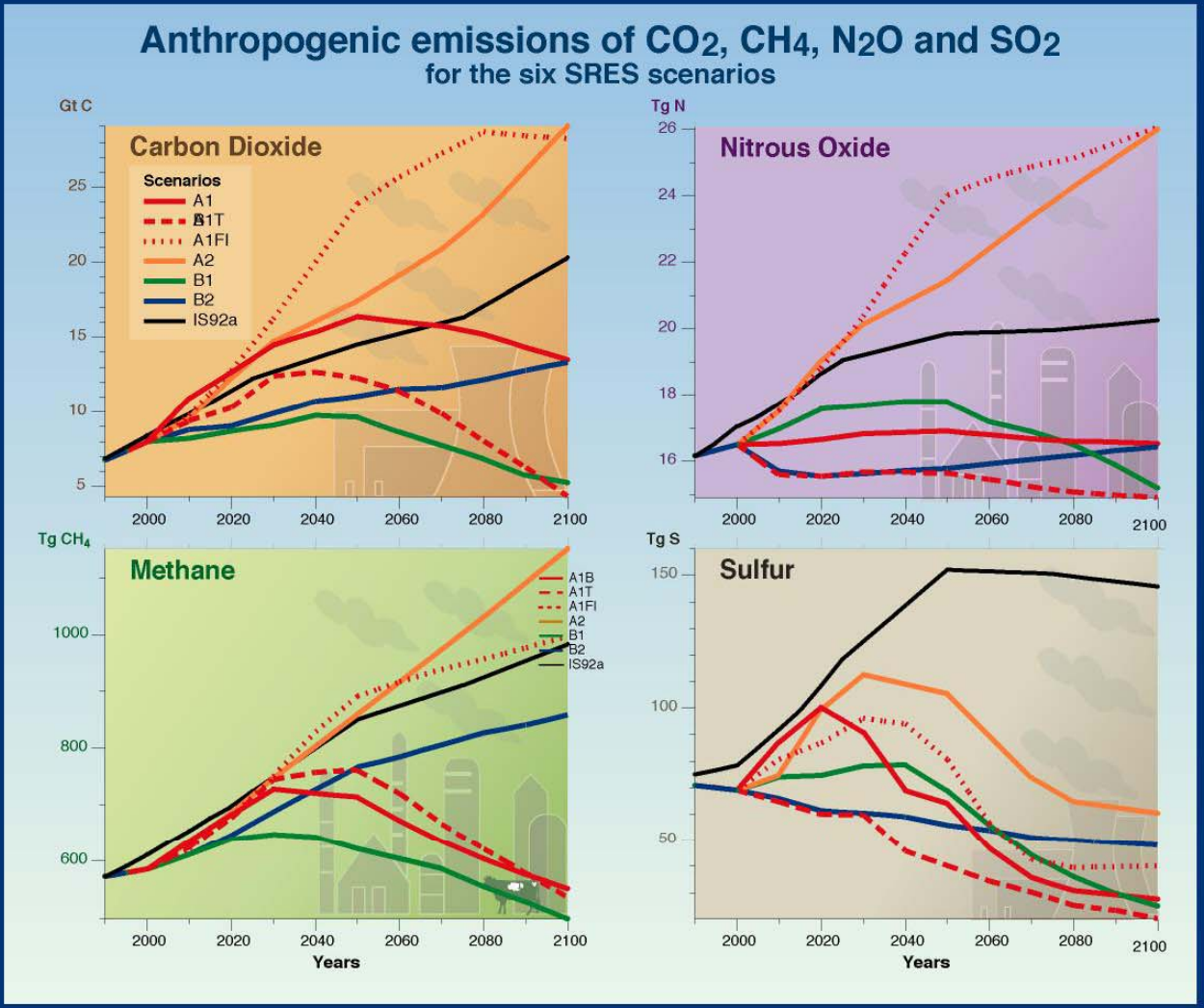
4 CCCM2000 & GISS98 AND 9 CGCM3.1 GRID POINTS ROUND SLOVAKIA USED



IPCC SRES SCENARIOS

- Outputs of the CGCM3.1 model contain results by SRES A2 and SRES B1 emission scenarios assessments
- The first one represent pessimistic supposition of mankind behavior up to 2100 and the second the optimistic one (IPCC 2000)
- Emission of **fossil Carbon** is supposed as 28.9 Gt by SRES A2 (cumulative 1773 Gt) and 5.2 Gt by SRES B1 (cumulative 989 Gt) in 2100.
- This difference is much more expressed in air temperature scenarios after 2040

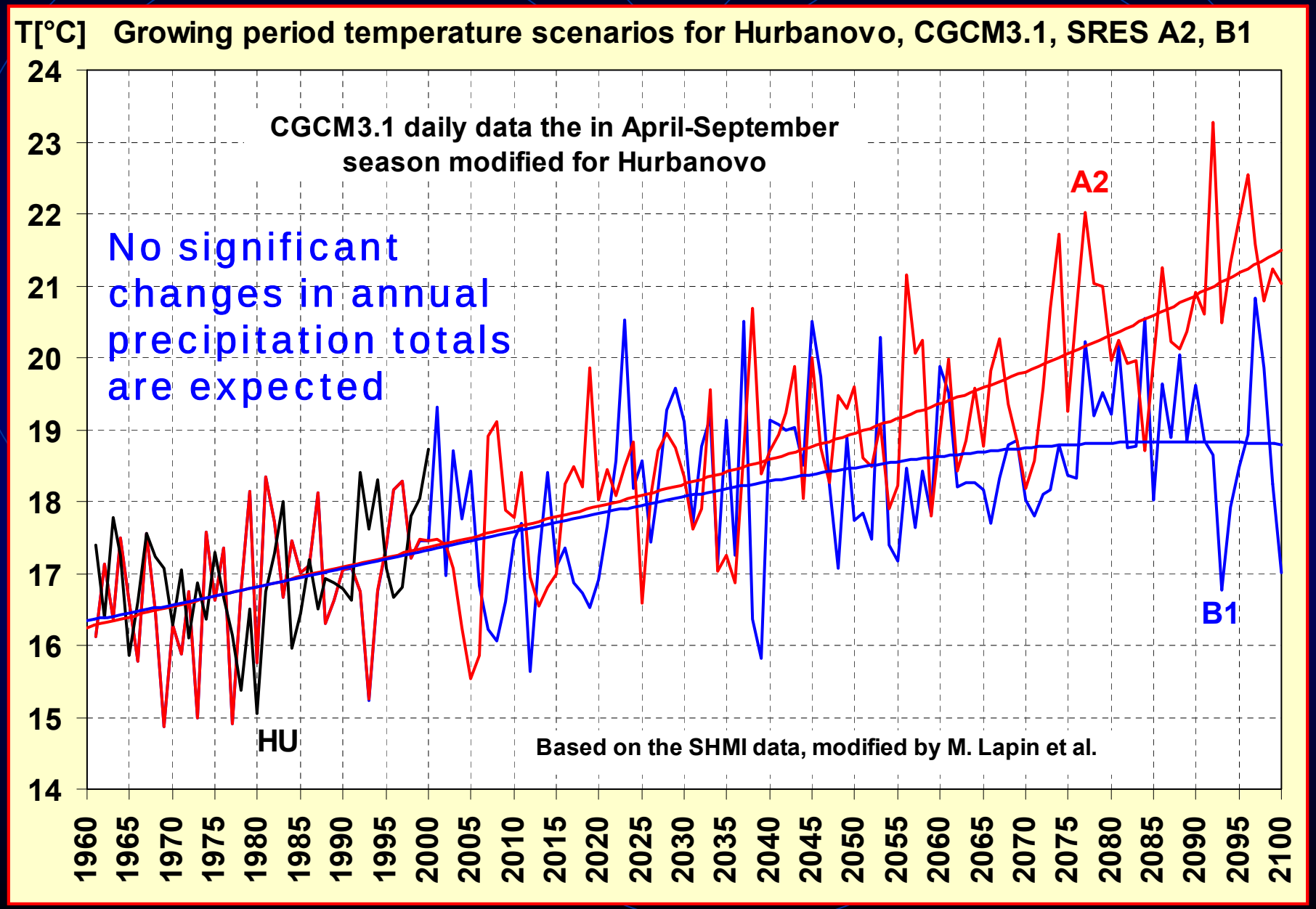
Emission scenarios A1, B1T, A1F1, A2, B1, B2 and older IS92a represent different ways of Climate Change mitigation



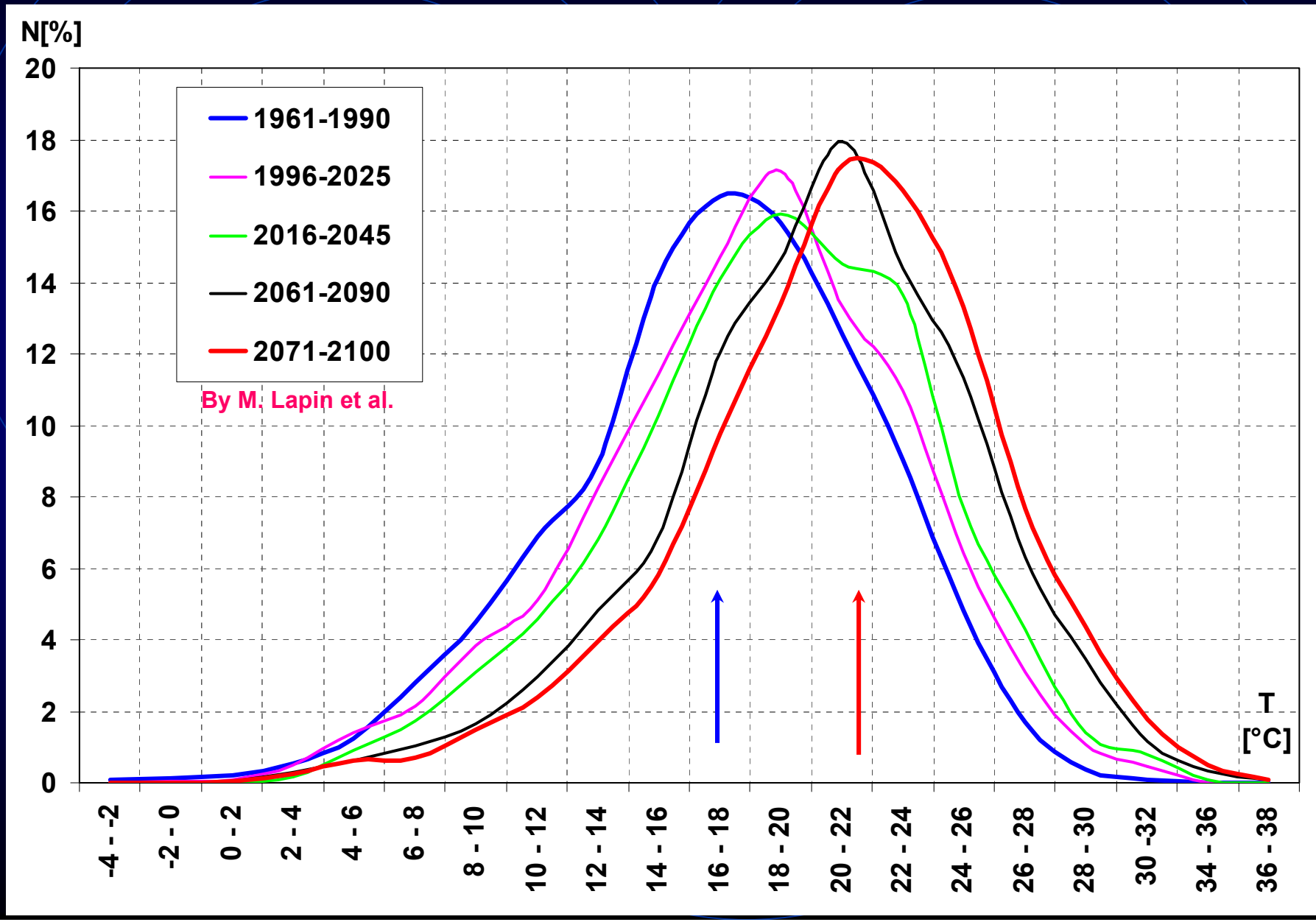
WG1 TS FIGURE 17

Alternative scenarios prepared by 6 different centers

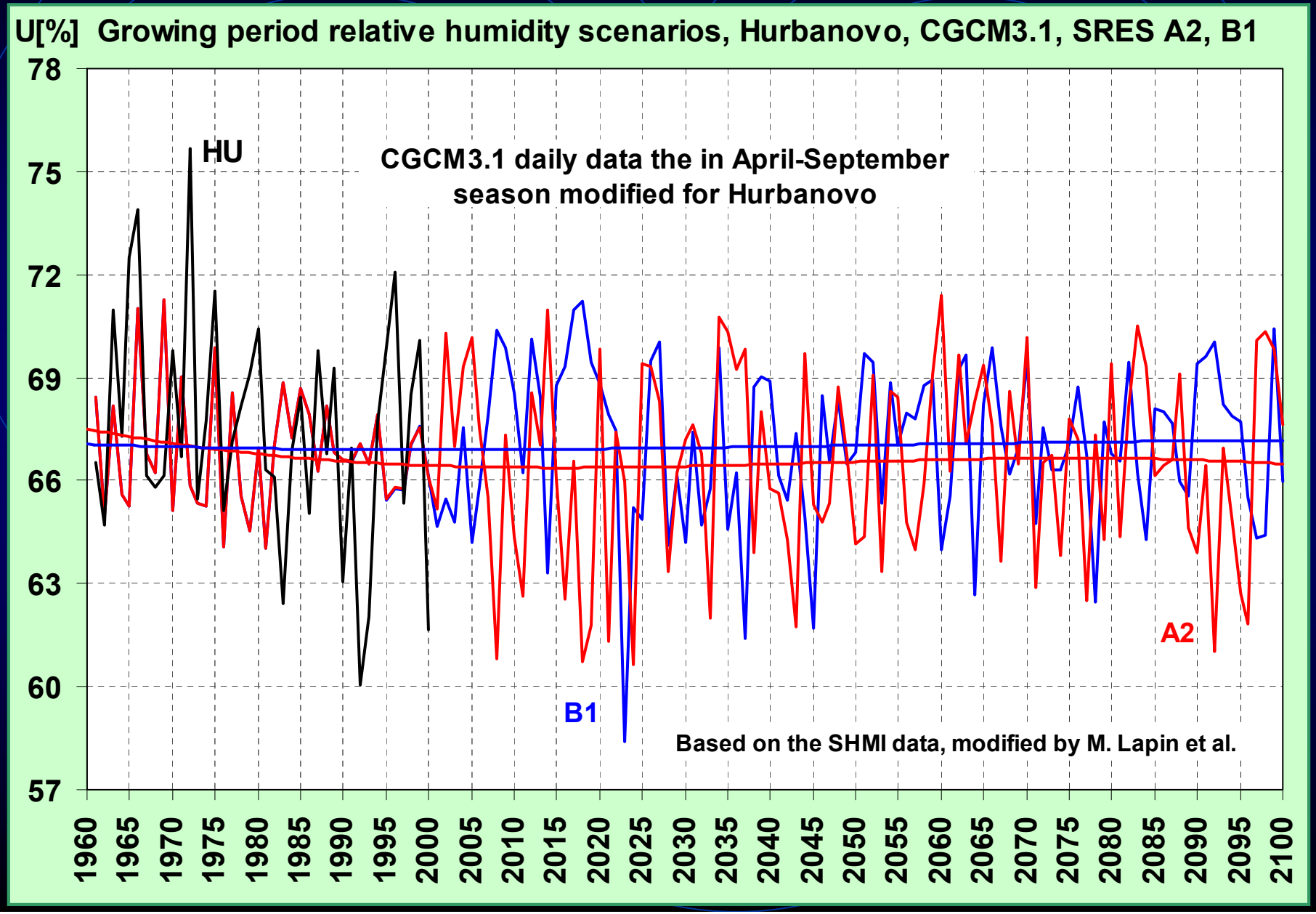
AIR TEMPERATURE SCENARIOS FOR HURBANOVO



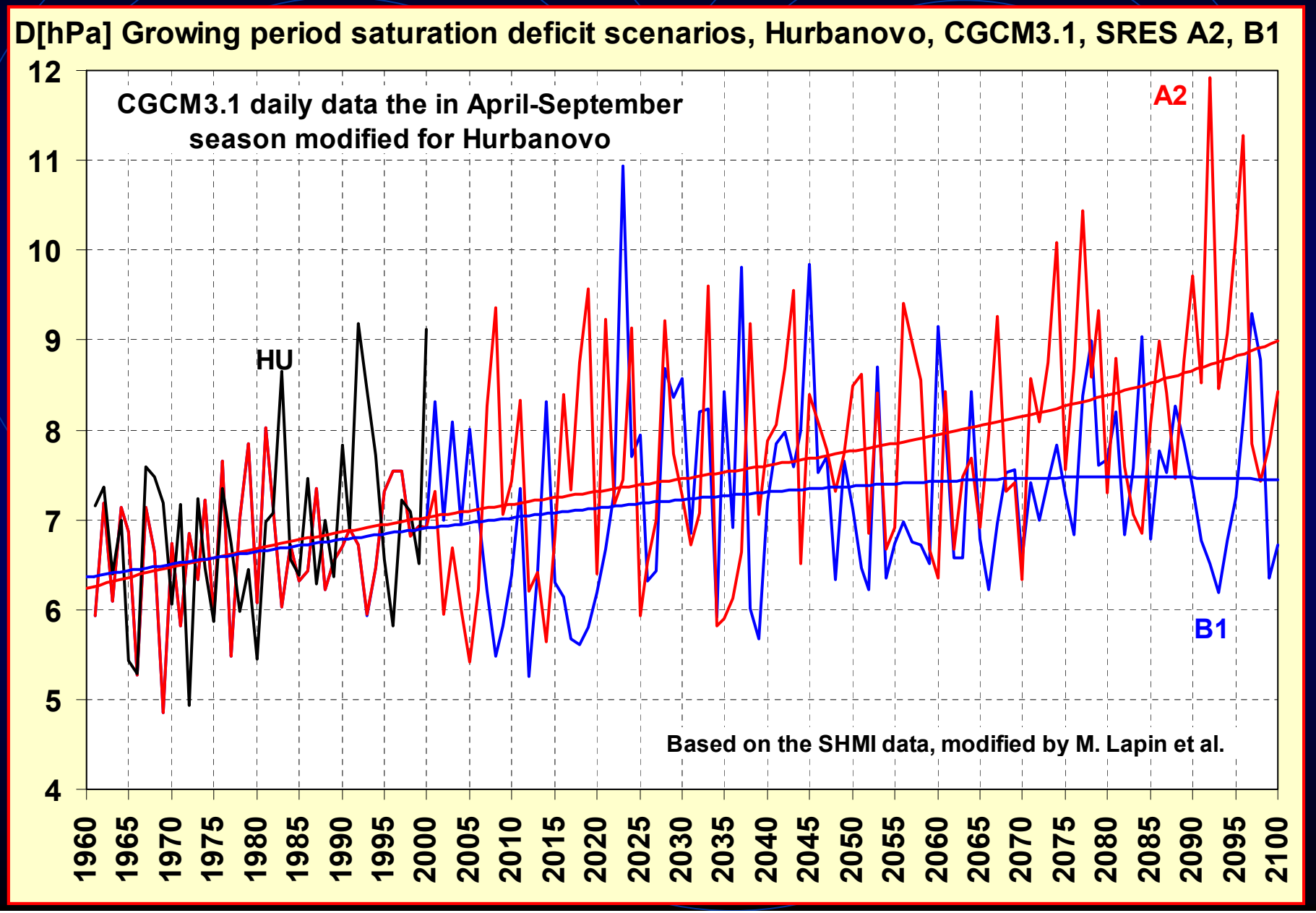
CGCM3.1 – A2 scenario for daily temperature means change up to 2100 (Hurbanovo, Apr.-Sept. season)



RELATIVE HUMIDITY SCENARIOS FOR HURBANOVO

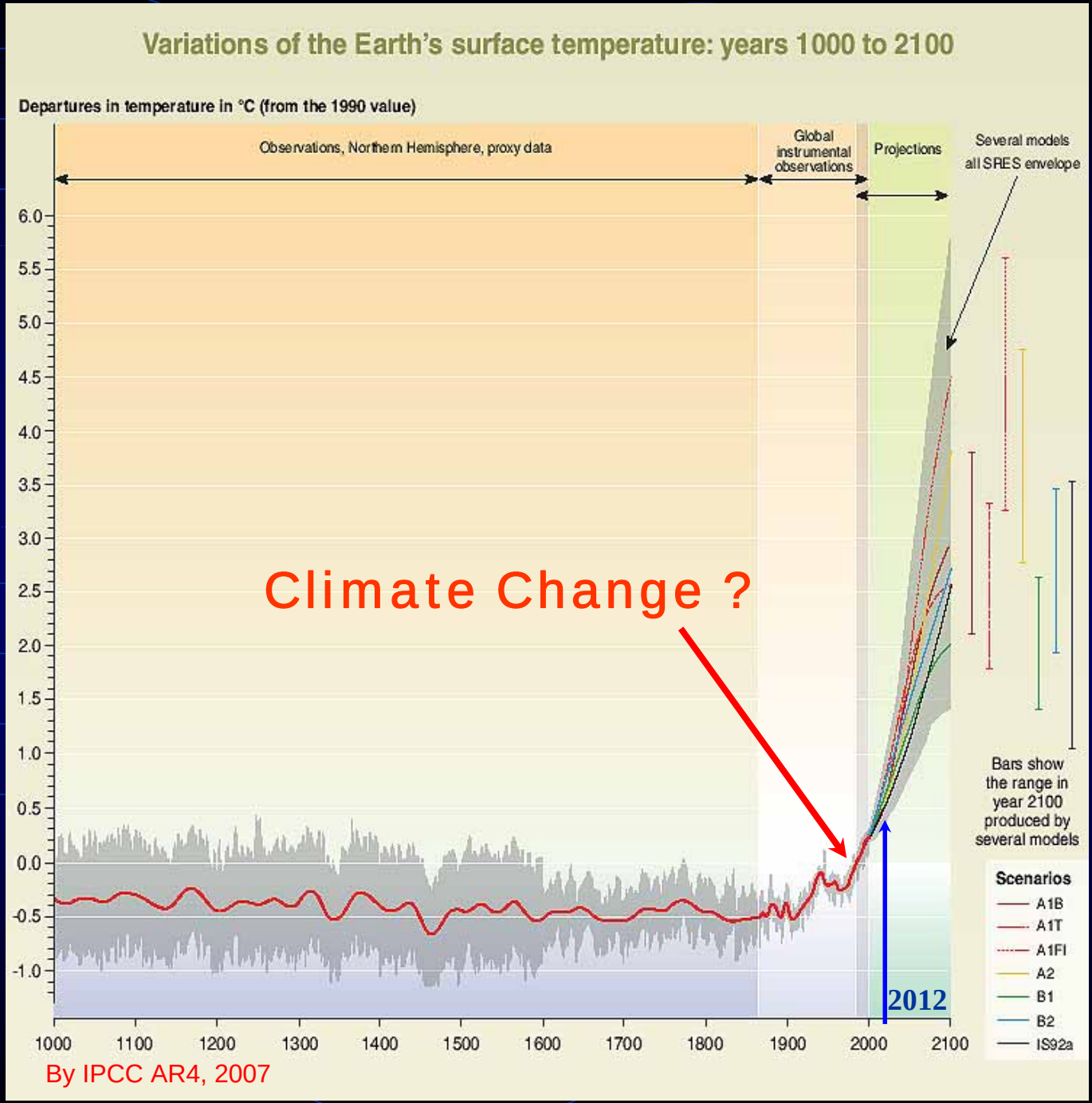


SATURATION DEFICIT SCENARIOS FOR HURBANOVO



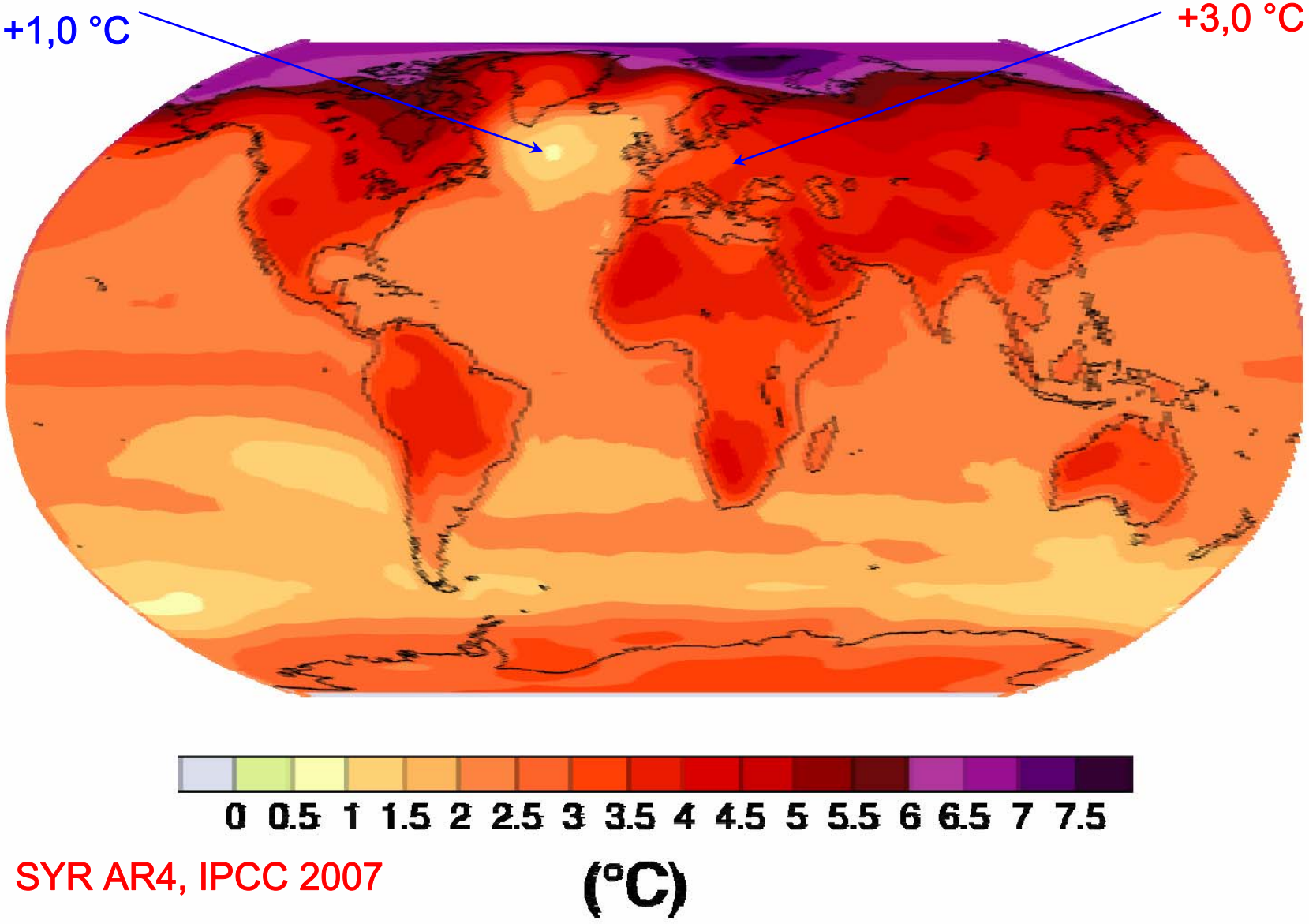
Measurements for 1861-2000, scenarios for 2001-2100

From year 1000 to year 1860 variations in average surface temperature of the Northern Hemisphere are shown (corresponding data from the Southern Hemisphere not available) reconstructed from proxy data (tree rings, corals, ice cores, and historical records). The line shows the 50-year average, the grey region the 95% confidence limit in the annual data.



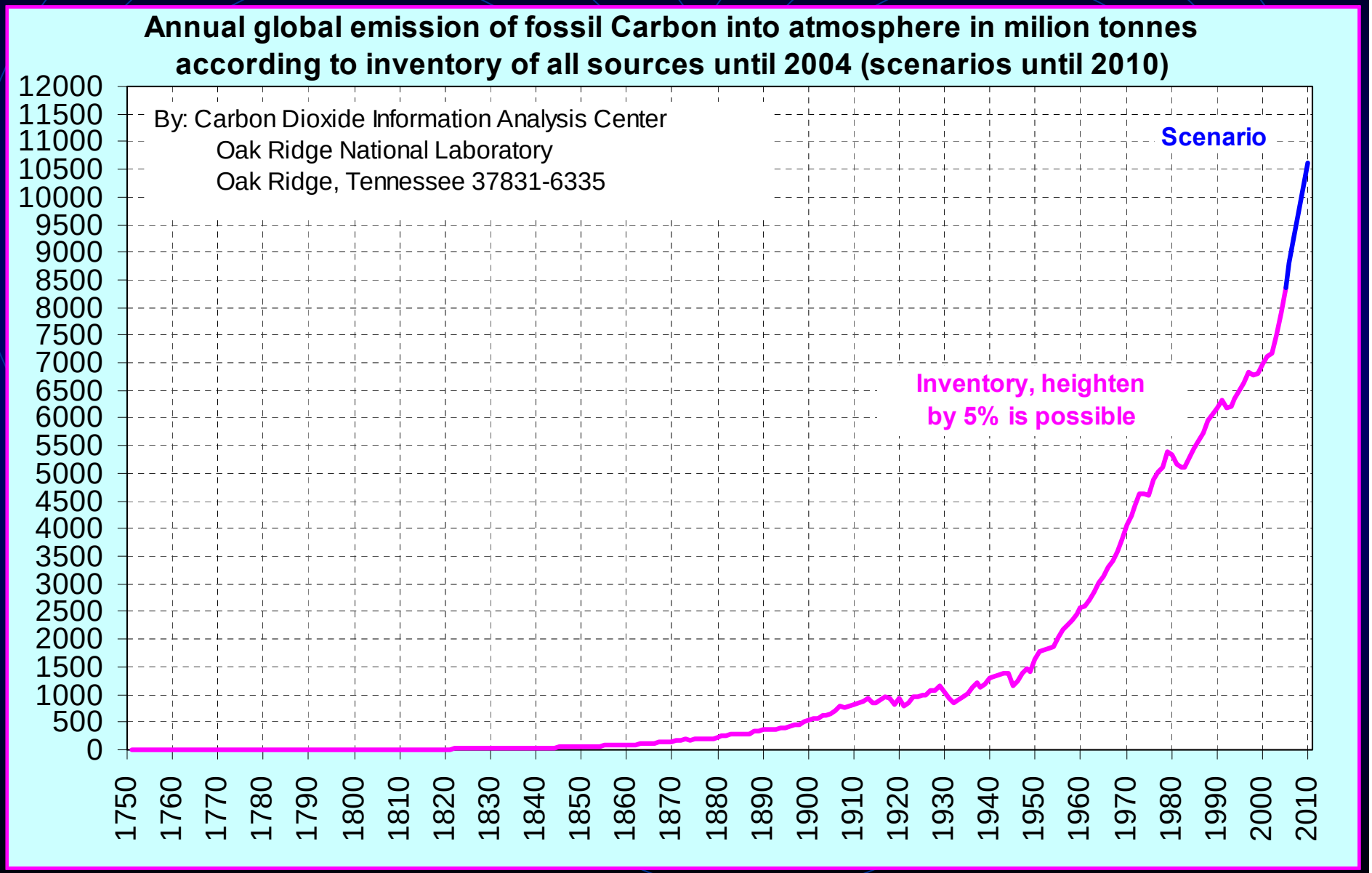
10-year mean warming in 2090-2099 compared to 1980-1999, A1B SRES

Geographical pattern of surface warming

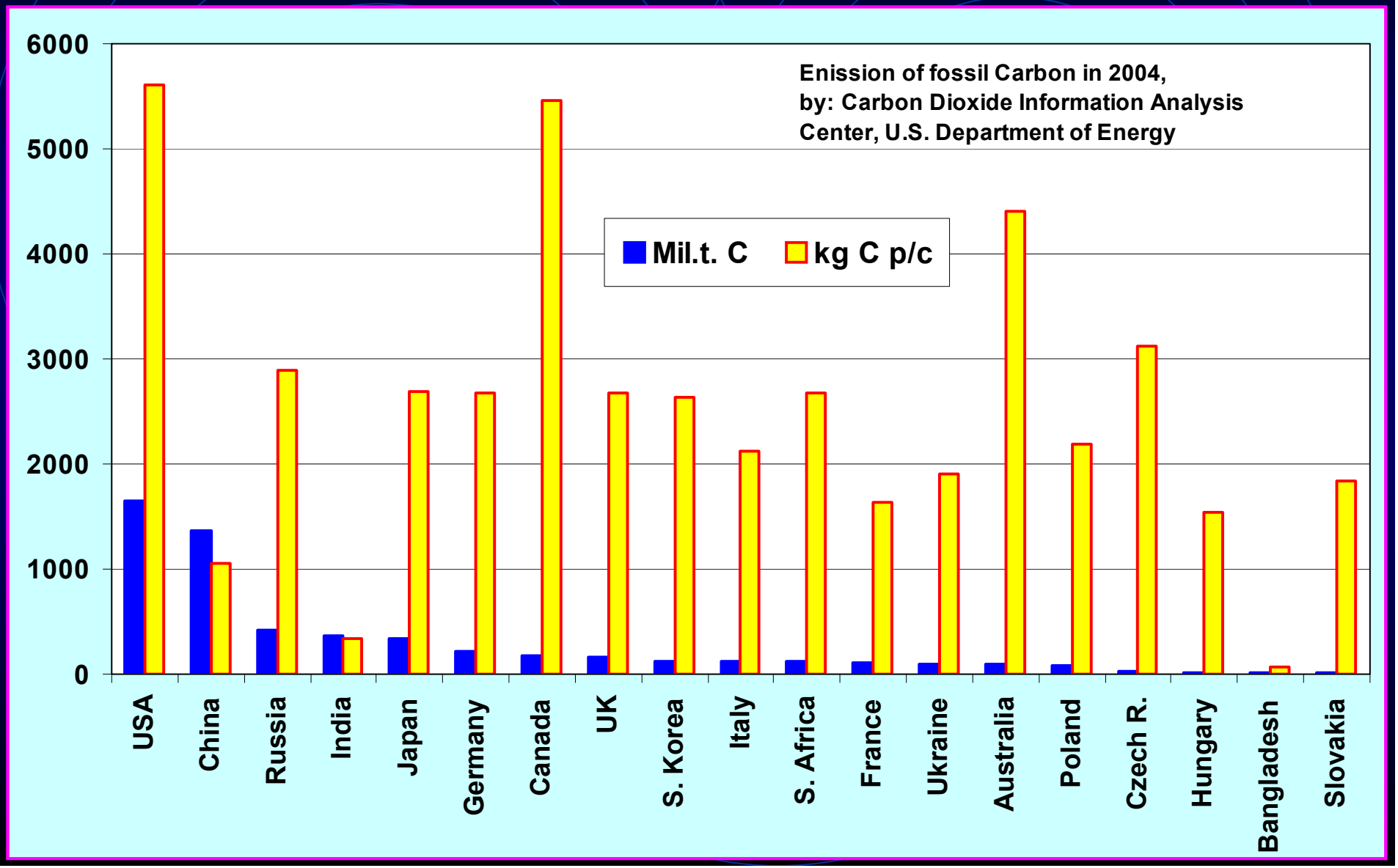


SYR AR4, IPCC 2007

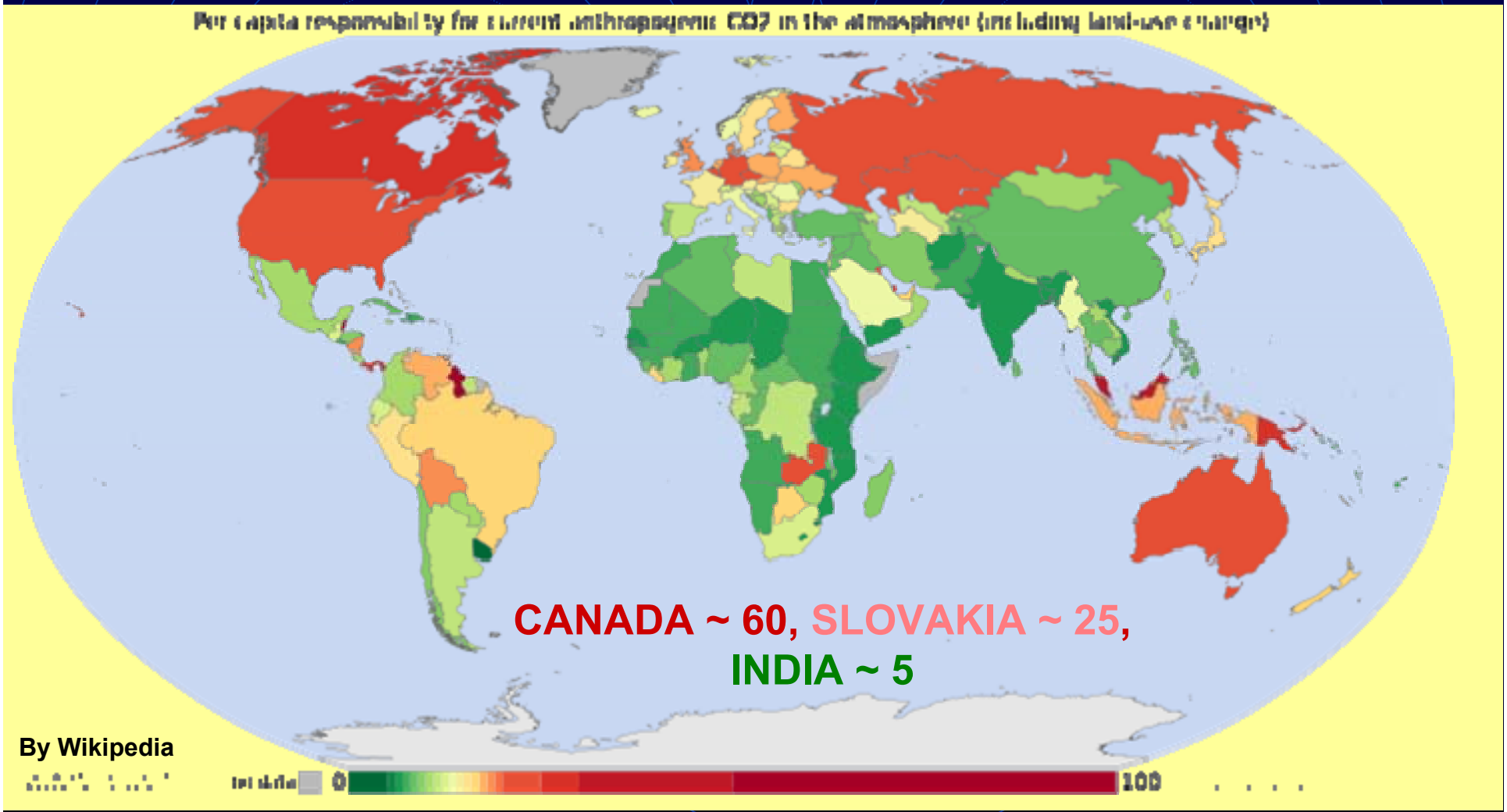
GLOBAL EMISSION OF FOSSIL CARBON IN MILLION TON IN 1951-2004 (PRELIMINARY IN 2005-2007, SCENARIOS IN 2008-2010



EMISSION OF FOSSIL CARBON IN MILLION TONNES IN 2004, CONTRIBUTION OF SELECTED COUNTRIES (USA, CHINA, RUSSIA ... – totally in mil. t. and per capita in kg)



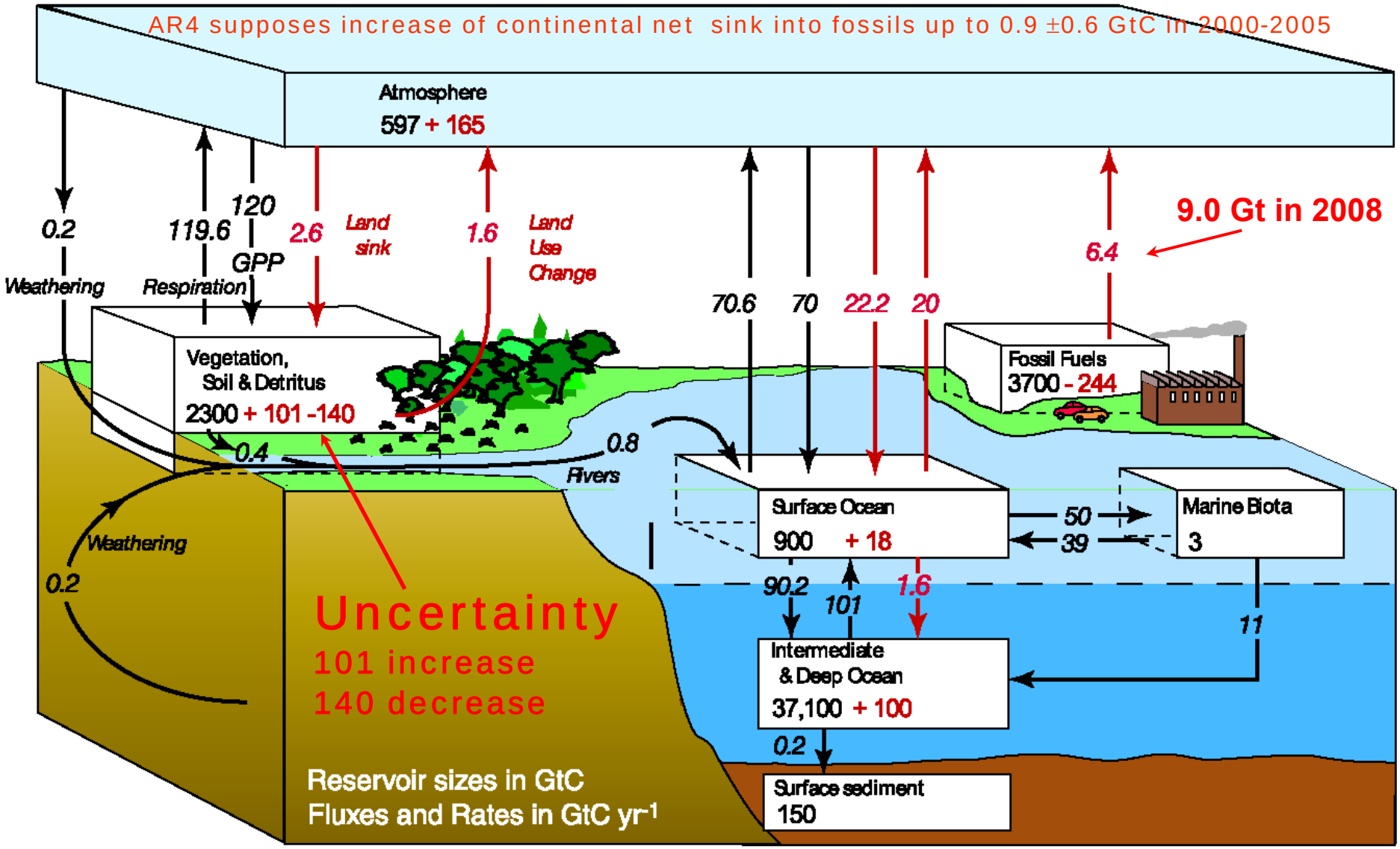
PER CAPITA RESPONSIBILITY FOR CURENT ANTHROPOGENIC CO_2 – INDEX from 0 to 100



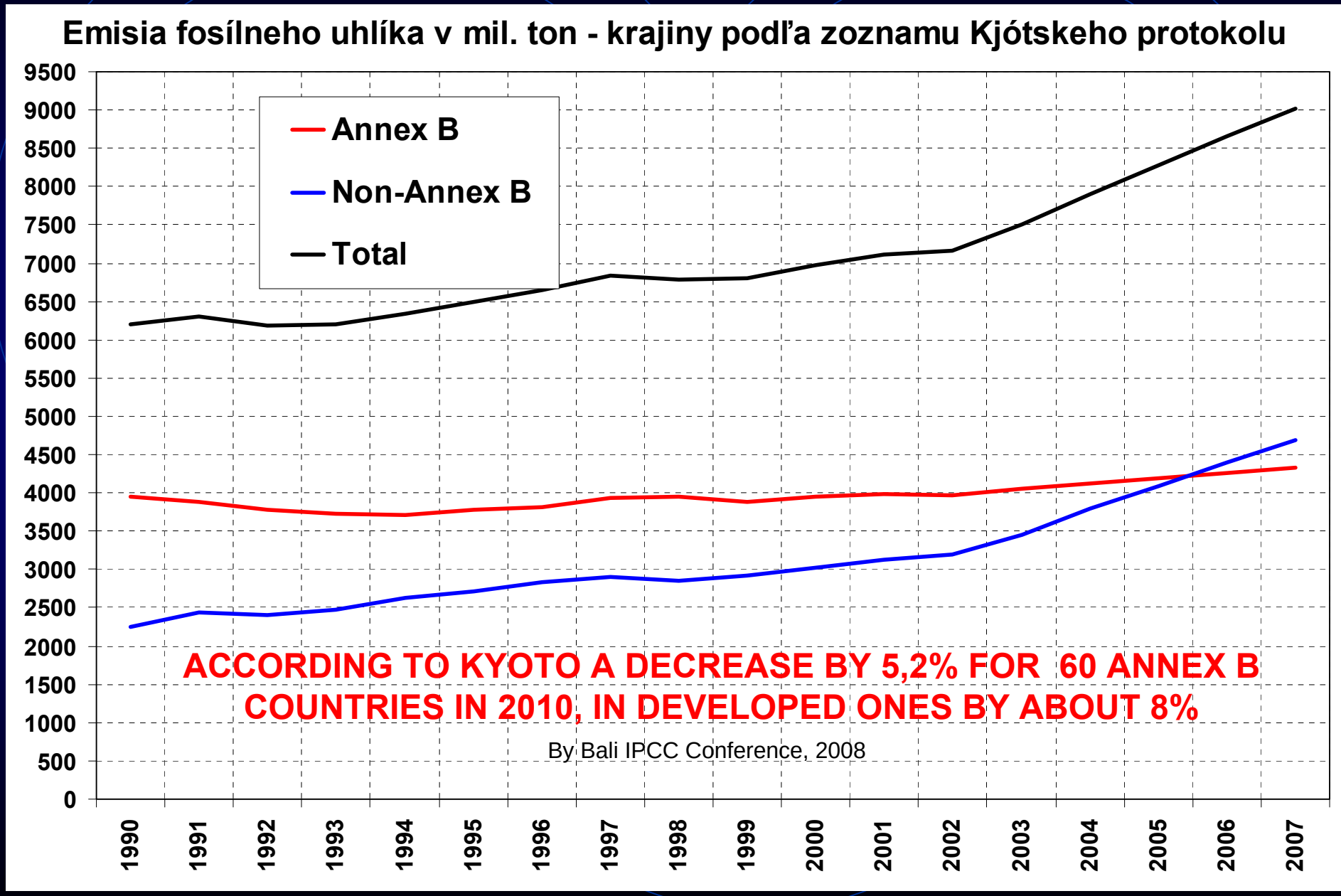
By Wikipedia

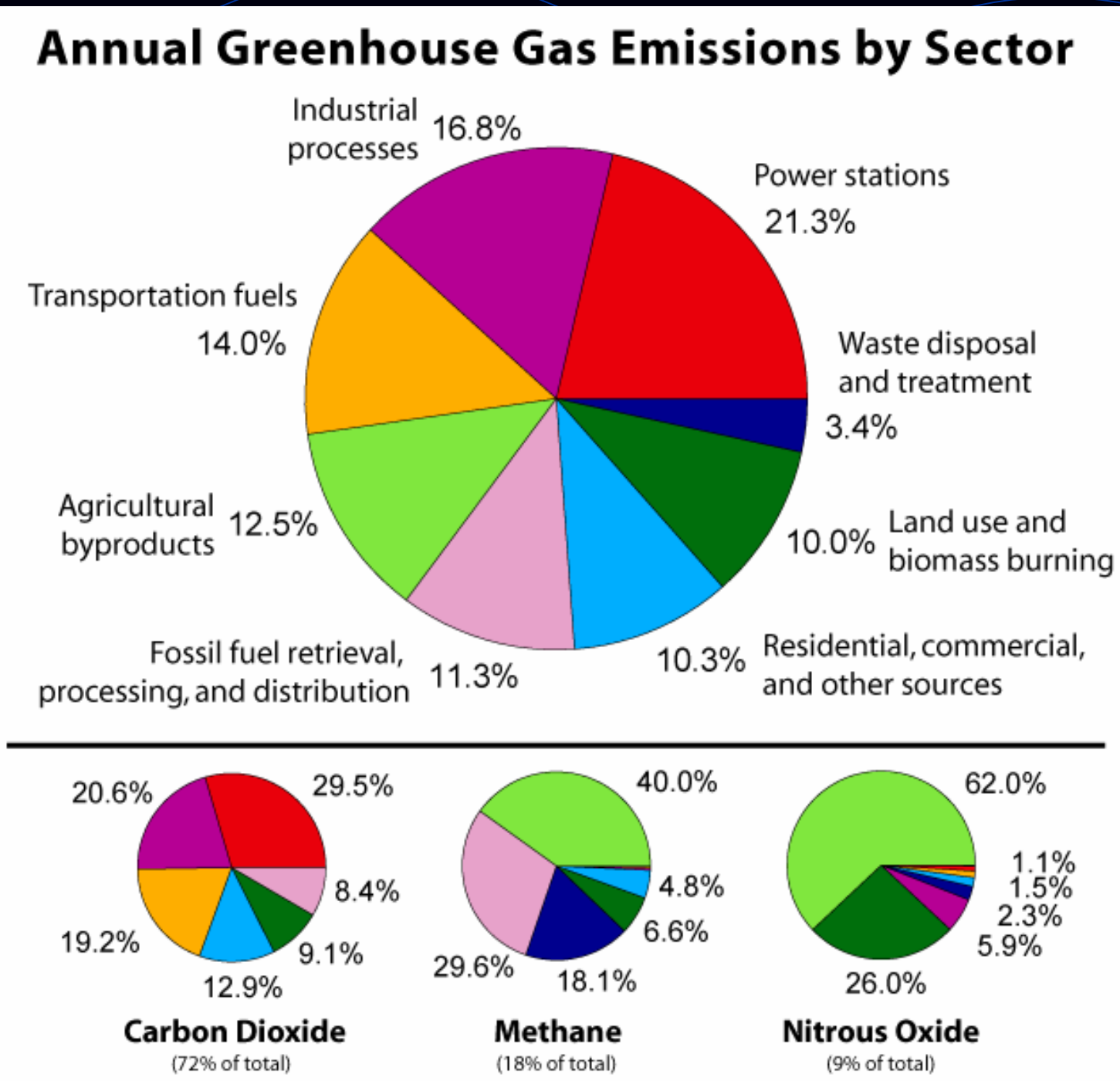
Global Carbon Cycle in 1990 (in GtC, IPCC 2007)

Anthropogenic share (red), deposition into fossil reservoirs only 0.5 GtC annually



Fossil Carbon Emission in million tons (Kyoto Protocol)





Summary of GHGs emissions by sectors in 2000

Source: Wikipedia

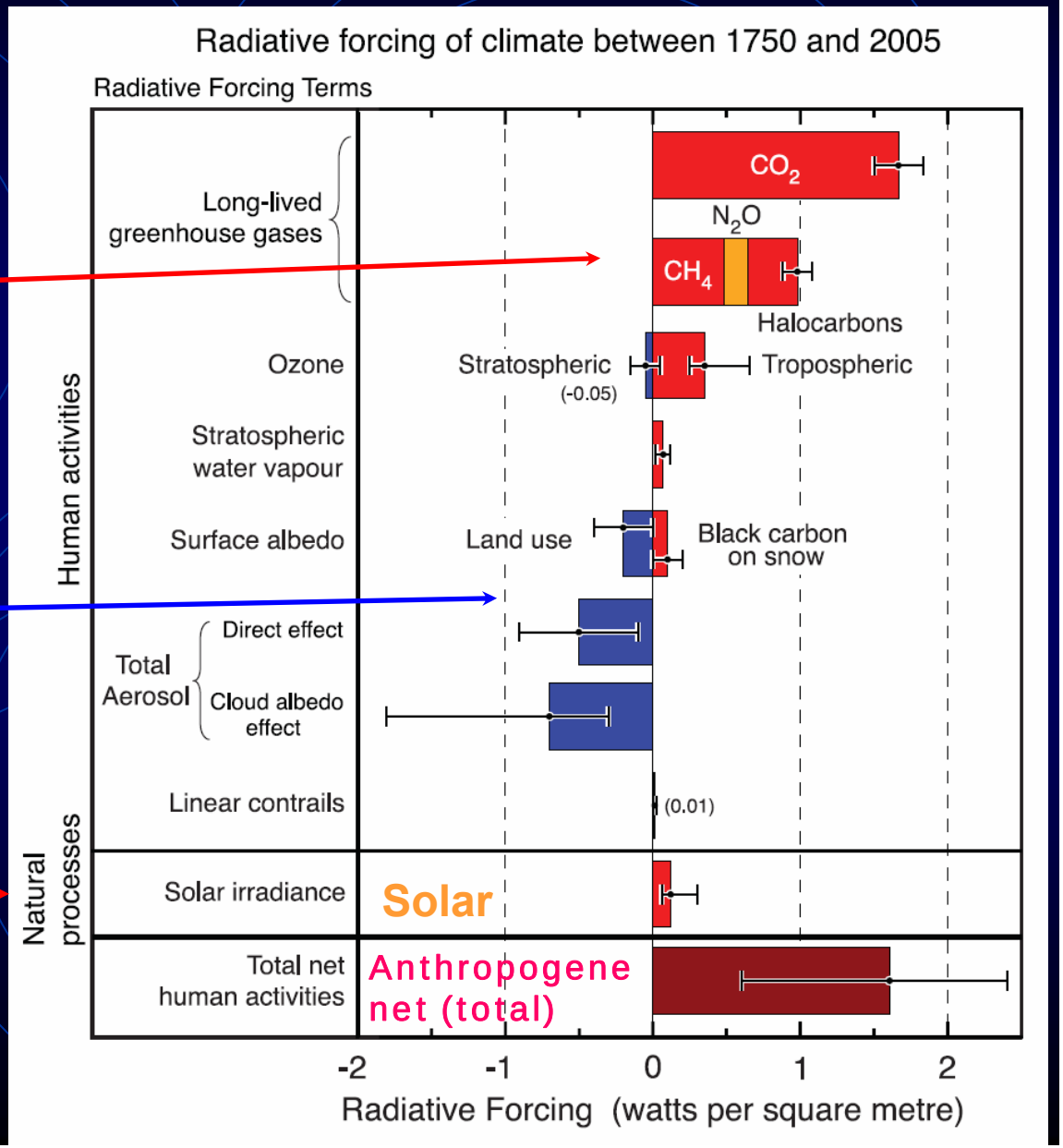
RADIATIVE FORCING IN EARTH'S CLIMATE SYSTEM SINCE 1750 (ANTHROPOGENIC AND NATURAL)

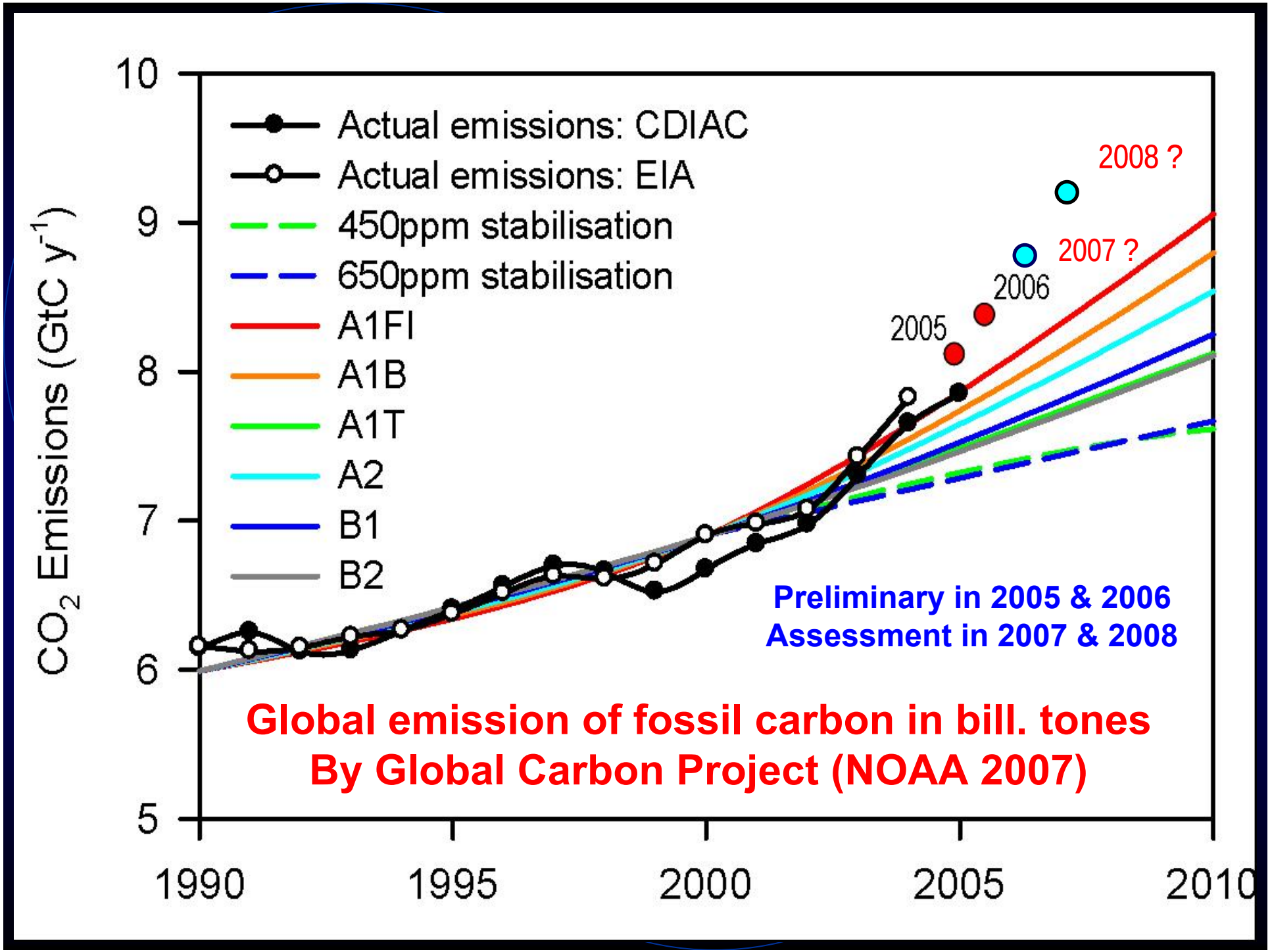
By IPCC 2007

Positive forcing of greenhouse gases increase in the atmosphere

Mostly negative forcing of aerosols and land use change

Comparison of anthropogene forcing with the Solar constant rise since 1750




10
9
8
7
6
5
1990
1995
2000
2005
2010
CO_2 Emissions (GtC y^{-1})
Actual emissions: CDIAC
Actual emissions: EIA
450ppm stabilisation
650ppm stabilisation
A1FI
A1B
A1T
A2
B1
B2
2005
2006
2007 ?
2008 ?
Preliminary in 2005 & 2006
Assessment in 2007 & 2008
Global emission of fossil carbon in bill. tones
By Global Carbon Project (NOAA 2007)

WHAT CAN WE DO?

- Is the greenhouse effect increase caused by human activities ?
- Can we separate the natural and anthropogenic impacts ?
- Is climate warming in Central Europe positive or not ?
- Can we mitigate Climate Change by GHGs emission reduction?
- Can we calculate the cost/benefit in case of mitigation ?
- How long in advance we need to prepare adapting measures ?
- Can we calculate the cost/benefit in case of adaptation ?
- Is there any possibility to assess Climate Change impacts on socio/economic sectors, sustainable development, natural ecosystems and on vanishing of biological species ?
- Is the economic effectiveness more important than the natural biodiversity or the healthy humans and ecosystems ?
- **Other questions ?**
- Can Climate Change cause great number of refugees ?

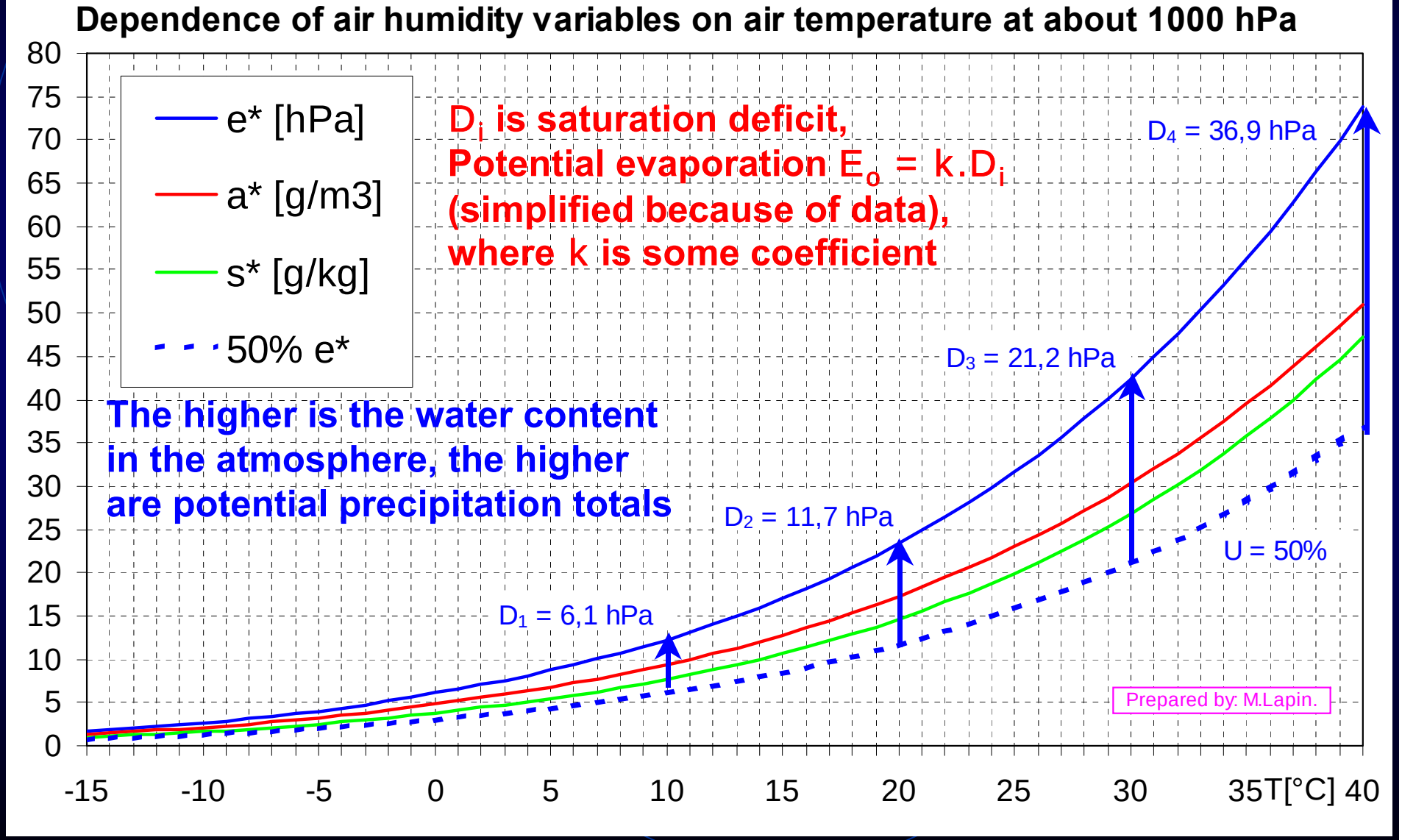
REAL OPTIONS ?

- Energy consumption is in SK 1.6 times higher compared to EU15 !
- New technologies and equipments can save > 20% energy !
- No significant investments are needed in household to save energy (heating, hot water use, air condition, equipments) !
- New transport devices can save > 20% energy !
- Renewable energy sources can save > 20% of fossil fuels !
- Recycling can save energy, raw materials and decrease CO_2 and other GHGs emission !
- Goods with long guarantee period can save energy and raw materials, that means also reduction of GHGs emission !
- Discipline at private and professional activities !
- CCS is not discussed in this presentation

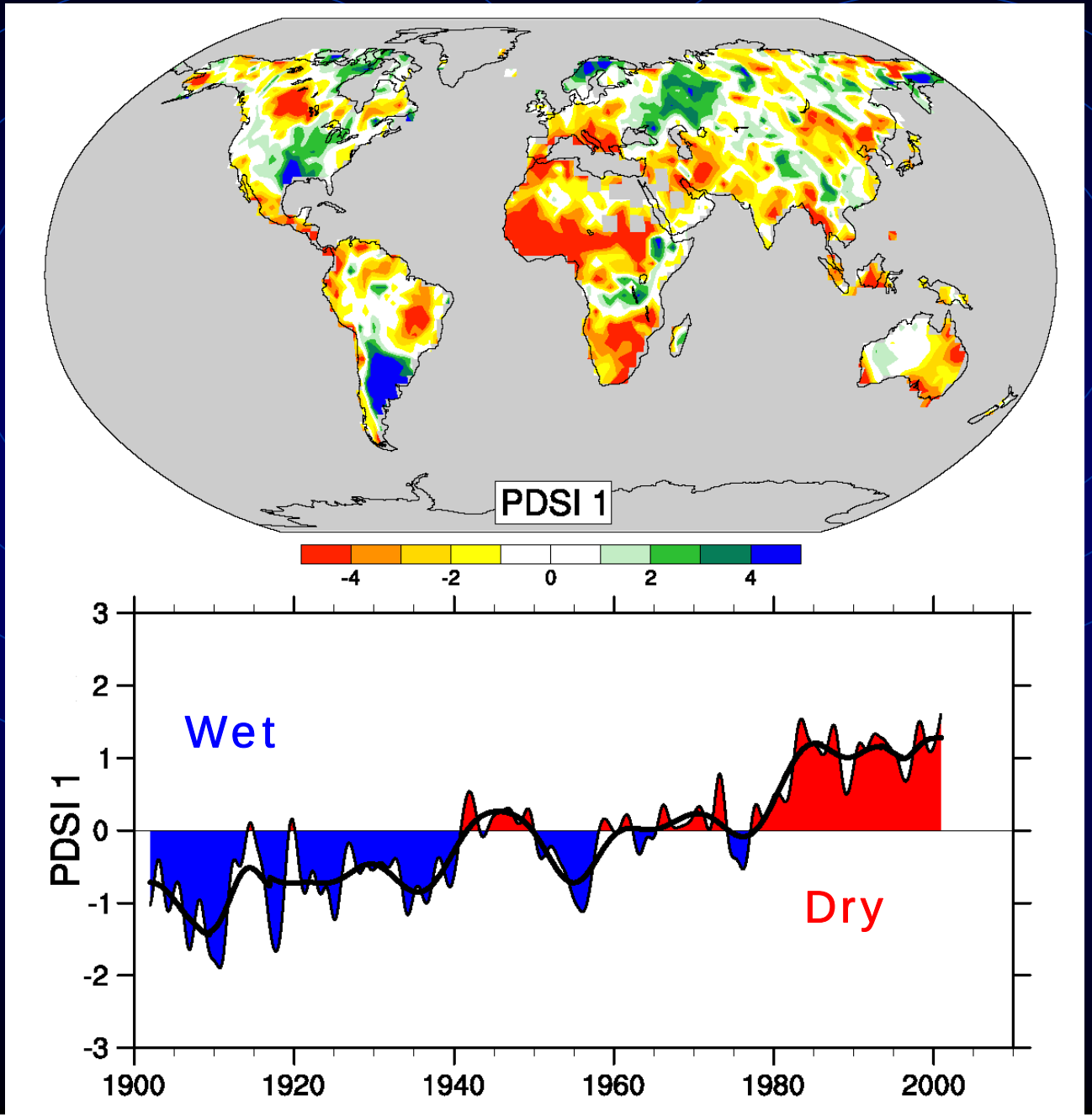
- **Other options ?**
- Each country has its own possibilities to save energy and raw materials and to reduce GHGs emission (nuclear energy….) !

And now some impacts -

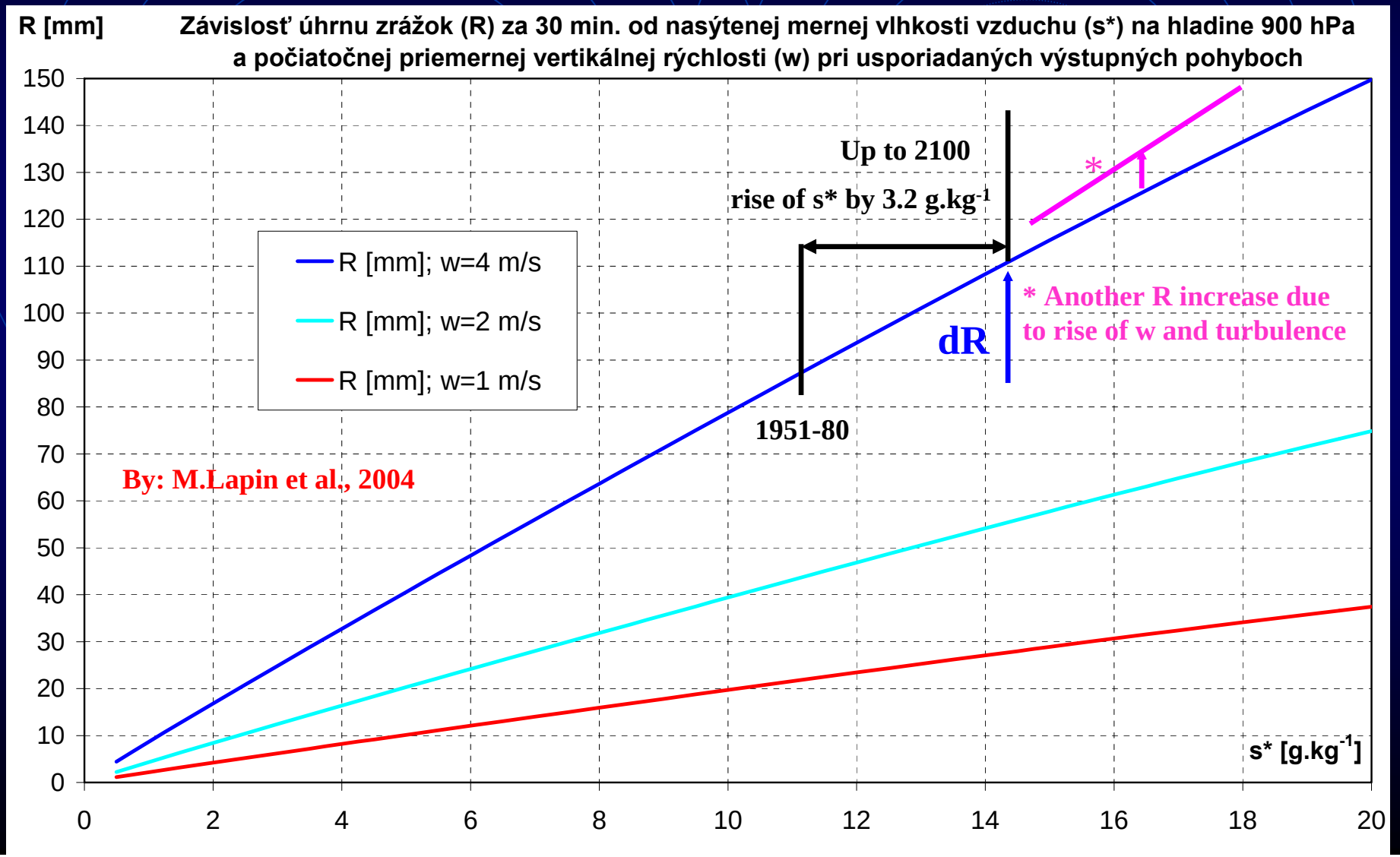
AIR HUMIDITY AND AIR TEMPERATURE



Trend of Palmer drought index since 1901 (IPCC 2007)

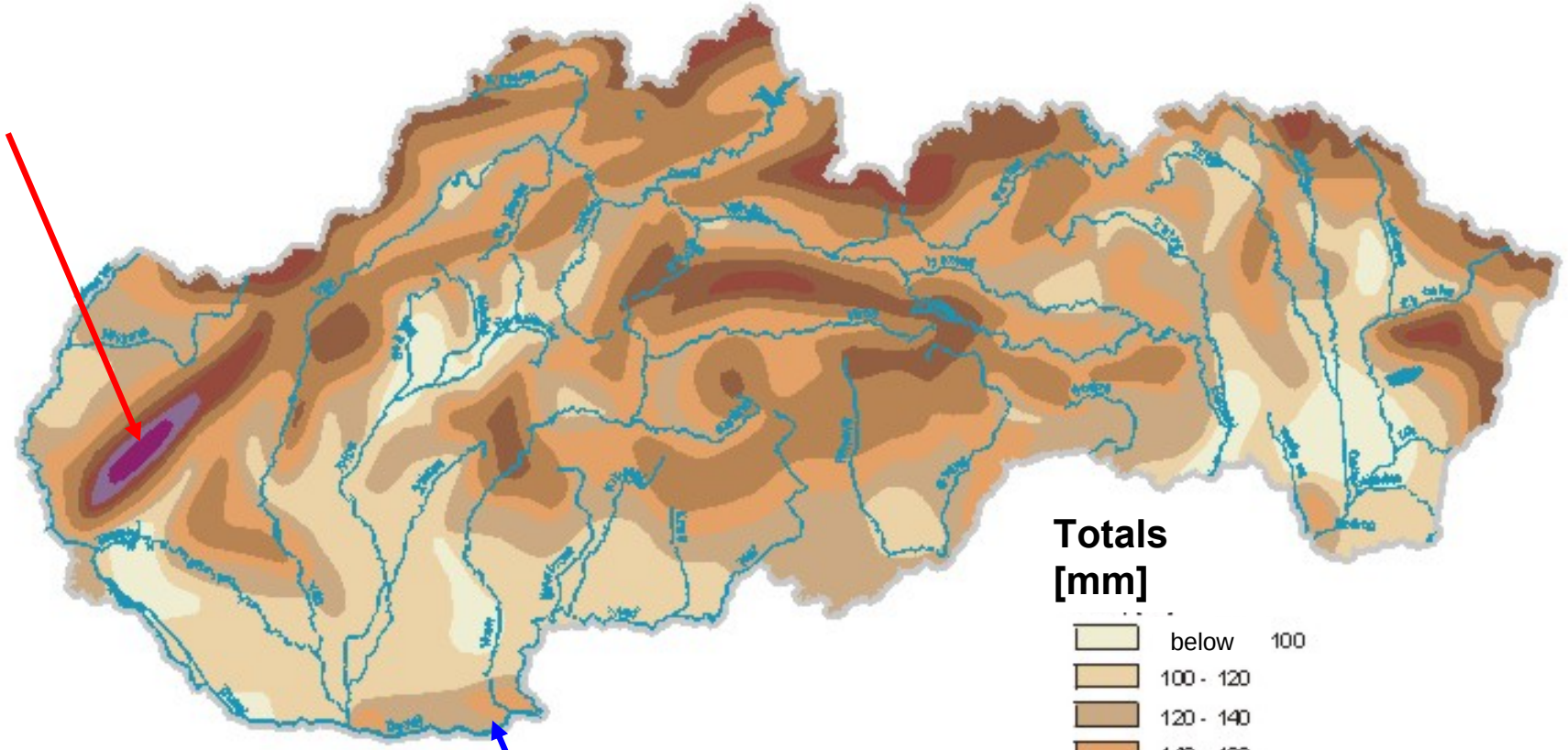


Possible changes in 30-minute precipitation totals (R) in dependence on increase of saturated specific humidity (s*) at 900 hPa and vertical velocity (w)



Slovakia - Annual maximum in 5-day precipitation totals with 100-year return period

Possible increase by 20-40% up to 2100



Totals [mm]

- below 100
- 100 - 120
- 120 - 140
- 140 - 160
- 160 - 200
- 200 - 240
- 240 - 280
- 280 - 320
- 320 and more

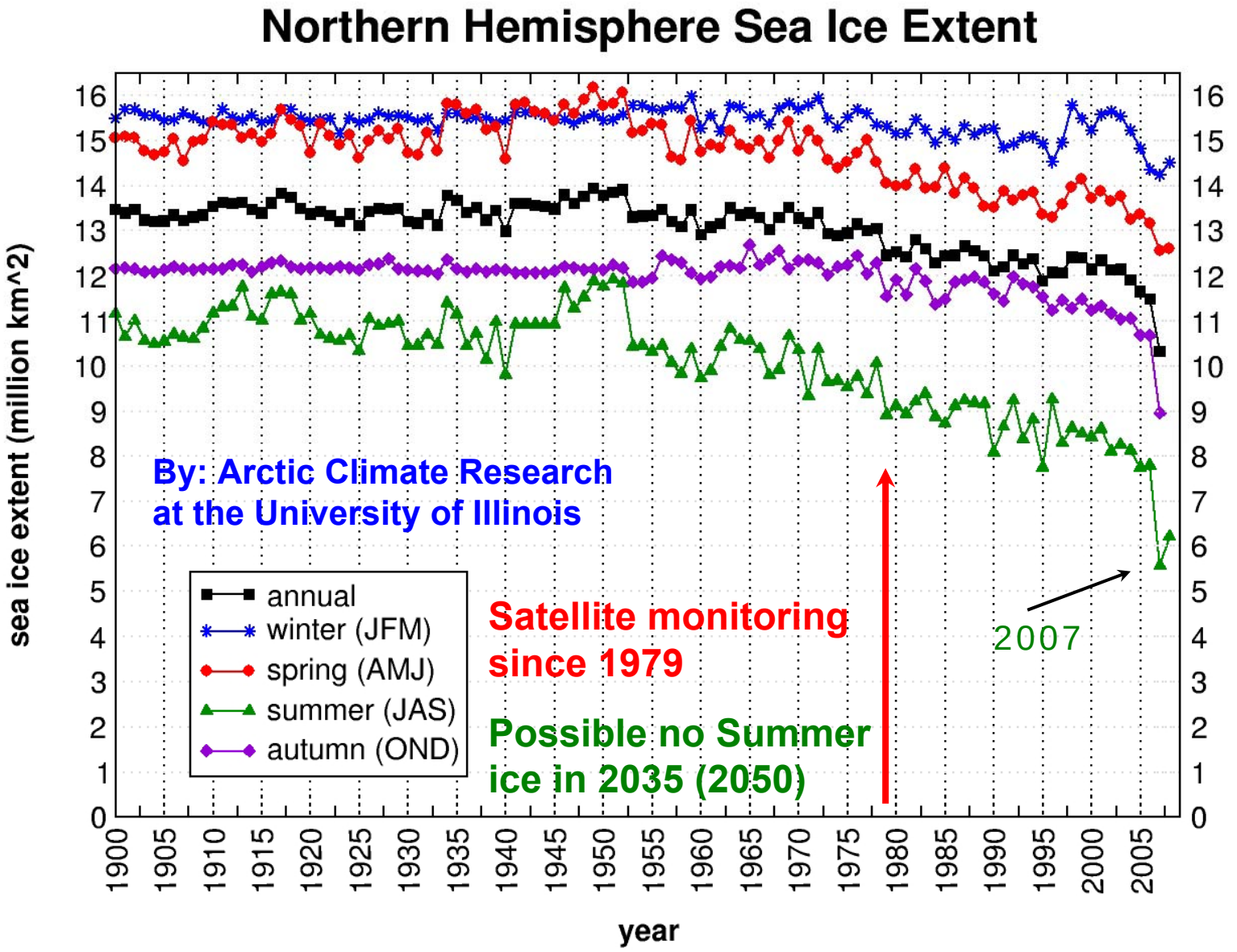
0 17.5 35 52.5 70 87.5 km

By M.Lapin et al., 2002

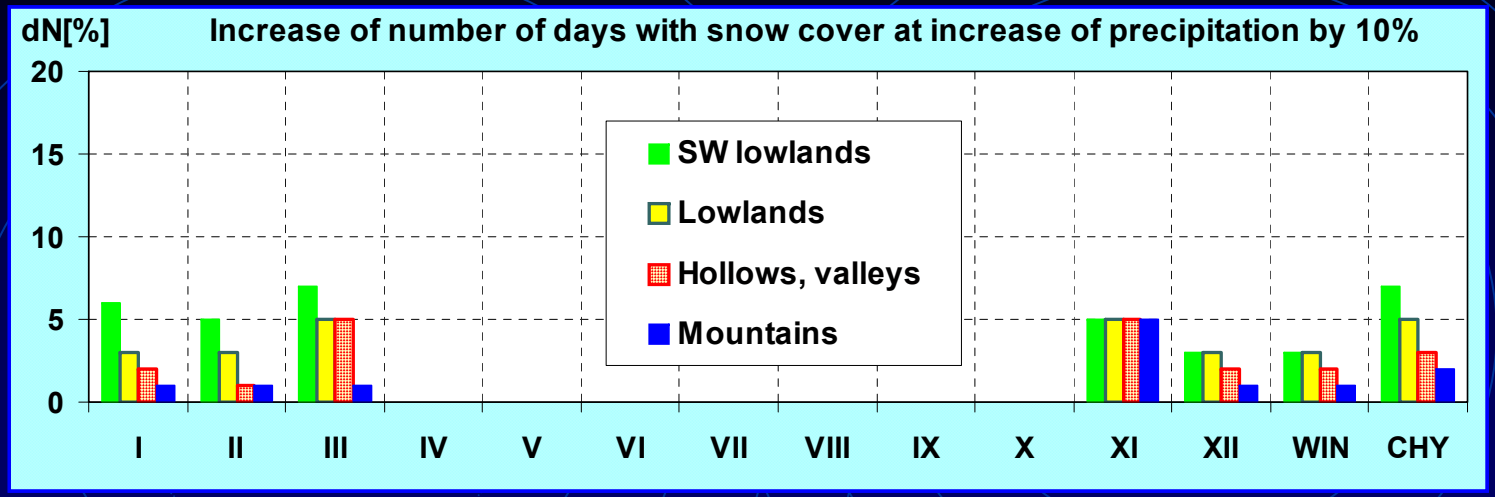
Vyhodnotenie maxím : P.Faško, M.Lapin
Spracovanie mapy: M.Lapin, L.Gaál, M.Martini

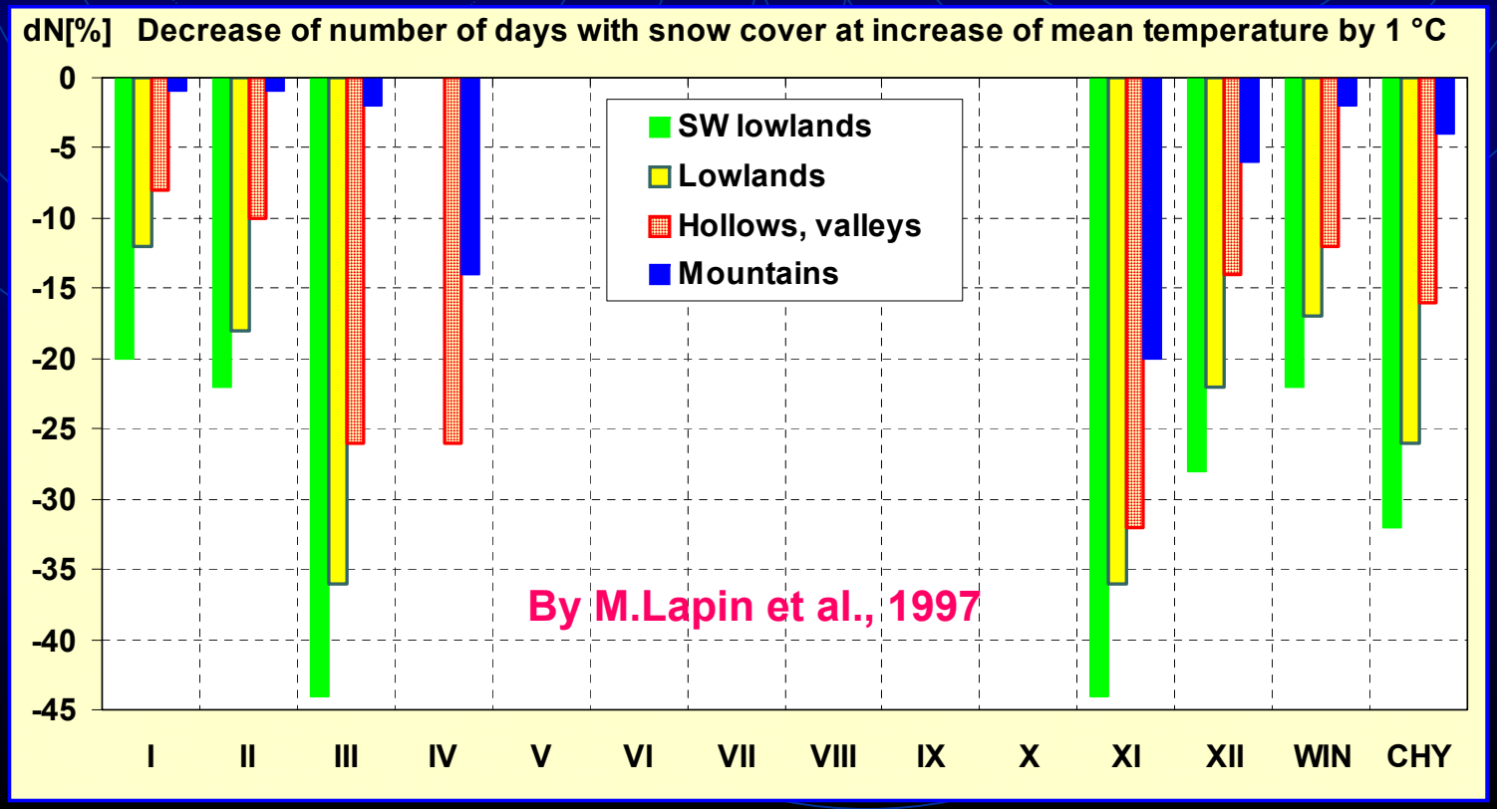
SHMÚ

CHANGE IN SEASONAL ARCTIC SEA ICE EXTENT



CHANGE OF SNOW COVER DAYS IN SLOVAKIA





CONCLUSIONS

- Climate change must be correctly defined, scientifically analyzed and the results properly applied by involved users, otherwise cannot be reliable any conclusions
- Climate change impacts are expected mostly as negative and only partly as positive (differently in some regions)
- The return periods of dangerous weather design values are based on past observations, it is sure that they will change
- Adapting and mitigation options are based on correct impacts analysis, differentiate of natural climate changes from the anthropogenic ones and analysis of cost/benefit
- Reduction of the atmospheric greenhouse gases concentration is the only possibility how to slow down the rapid global air temperature increase and to reduce the consequent climate change impacts

Thank You for the Attention

Further details on the website:

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or use

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