# • CLIMATE CHANGES

## Key questions and key findings

**What is the trend in the greenhouse gases emissions in Slovakia?**

- **Trend in the development of total emissions suggests that measured greenhouse gases emissions have been decreasing. In terms of international comparisons, Slovakia shows values that are below the EU-27 average. Greenhouse gases emissions over a longer time horizon have been permanently declining. (when the figures for 2011 are compared to 1990, there is a 36.9% reduction) However, it must be said that during the years 1996-2008, emissions showed roughly the same values. Following the years of 2008 and 2009 affected by the recession, there was a slight increase in emissions, spurred by the reviving economy. Between years, (2010-2011) greenhouse gases emissions experienced a decline by 1.3%.**

**What is the observable impact of climate changes in the Slovak territory?**

- **Change in climate has been most noticeable in the change to air temperatures. Rise in air temperature is definite. Average annual air temperature over the years 1981-2010 at Hurbanovo reached 10.6°C, which is 0.7°C more than in 1951-1980.**
- **Over the last twenty years the rising air temperature has been most prominent. 8 out of 10 warmest years since 1871 at the Hurbanovo station in terms of the average annual air temperature fall into this time period. The following years were included: 1992, 1994, 2000, 2002, 2003, 2007, 2008, 2009.**
- **There was also a declining trend in total annual atmospheric precipitations, relative air humidity, and snowcap for almost the whole Slovak territory (slight increase in upper mountain regions)**
- **Characteristics of the potential and actual evaporation, soil humidity, global radiation and radiation balance also prove that the south of Slovakia is gradually drying up (potential evapo-transpiration rises and soil humidity decreases); however, no substantial changes were detected in solar radiation characteristics (with the exception of temporary reduction in the years 1965-1985).**
- **There has been a significant increase in weather variability, especially rainfall totals. Over the last 15 years, there has been a significant increase in the occurrence of extreme daily precipitation figures, which consequently produced an increased risk in local floods in various regions of Slovakia.**
- **On the other hand, much more often than before there would occur local or large-scale droughts caused mostly by prolonged periods of relatively warm weather with little rainfall totals during a particular part of the vegetation period. Especially harmful were droughts in the periods of 1990-1994, 2000, 2003, 2011, and 2012.**
- **Reactions of flora and fauna are the practical consequence of the trend in the climate system. Within the phenological phases i.e. expressions of the life cycle of plants and animals, certain destabilising tendencies were noticed. These tendencies may relate also to the complex natural conditions that exist in Slovakia. Noticeable also are changes in the distribution areas of animals and in the changes of their behaviour.**

## Balance of greenhouse gases emissions

**Total anthropogenic greenhouse gases emissions** in 2001 were 45 294 620 tons (expressed as $CO_2$ equivalents).

Compared to 1990, total emissions **declined** by 36.9% and compared to 2010 they declined by 1.3%. Following a significant decline in 2009 due to the economic crisis, the trend in total

anthropogenic emissions for the years 2010 and 2011 has remained relatively stable and the emissions still have not reached the level from before 2009.

After a significant reduction in emissions after 1990 due to declining economic performance, Slovakia was able to maintain the trend in reducing the carbon intensity also after 1997, e.g. during the period of revived economic growth. While the country was able to maintain the so-called "decoupling" e.g. slower growth in emissions compared to the GDP growth dynamics.

**Road transport** is a significant sector where Slovakia has not been able to stabilise the growth in greenhouse gases emissions. Share of emissions within the sector of **power industry,** including transport, in total greenhouse gases emissions in 2011 was almost 70% (expressed in CO equivalents), with the emissions from transport within power industry generating 20%. While the share of emissions from stationary sources declines, share of emissions from transport still continues to grow. Since 1950, emissions from transport have grown by 27% and in 1990 reached only 9%. Another area where the greenhouse gases emissions have yet been effectively regulated is **burning fossil fuels in households**, so-called local heating places.

The sector of **industrial processes** is the second most significant sector with 18.2% share in total greenhouse gases emissions in 2011.

The sector of **agriculture** in 2011 contributed with 6.9% to total greenhouse gases emissions. Emissions within this sector declined sharply as early as after 1990. Since 2000, their trend has remained stable and affected only by prices and subsidies of agricultural commodities. More significant decline in the nineties was caused mainly as a consequence of total reduction in the consumption of nitrogen fertilisers and reduction in the volume of livestock. Improvements in agricultural practices together with the introduction of ecological farming create further conditions for positive trend in emissions within this sector also for the years to come.

The sector of **waste** in 2011 contributed with almost 5% to total greenhouse gases emissions. After the introduction of methodology for determining the methane emissions from municipal waste landfills, more exact data were obtained, which resulted in the increase of emissions estimates for this category.

The sector of **using solvents** is less significant and contributed to total greenhouse gases emissions in 2011 only by less than 1%. Emissions in this sector are produced mainly in cleaning facilities, car paint shops and the industries using volatile organic substances.

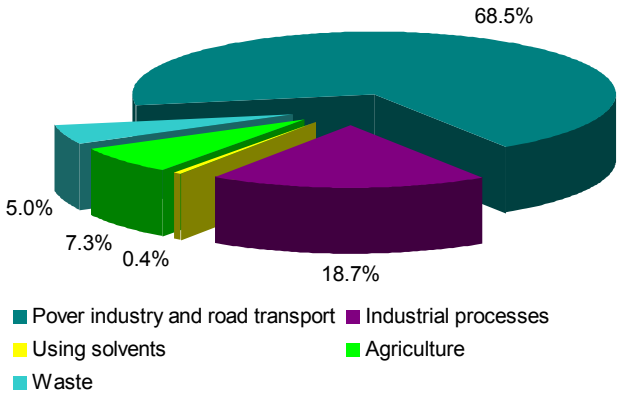
Share of individual sectors in total greenhouse gases emissions in 2011 has not differed much since the separation in 1990.

**Aggregated emissions of greenhouse gases (Tg) in $CO_2$ equivalents**

| Year | 1990 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net $CO_2$ | 59.61 | 30.57 | 33.61 | 31.60 | 32.55 | 33.06 | 36.07 | 33.22 | 31.72 | 33.24 | 28.32 | 30.96 | 30.16 |
| $CO_2$* | 60.75 | 41.37 | 44.17 | 42.41 | 42.84 | 42.74 | 42.22 | 41.72 | 39.86 | 40.49 | 35.80 | 37.91 | 37.67 |
| $CH_4$ | 4.41 | 4.25 | 4.29 | 4.90 | 4.73 | 4.60 | 4.36 | 4.44 | 4.36 | 4.38 | 4.20 | 4.11 | 4.14 |
| $N_2O$ | 6.35 | 3.58 | 3.76 | 3.74 | 3.79 | 3.81 | 3.77 | 4.04 | 3.97 | 3.85 | 3.54 | 3.42 | 3.01 |
| HFCs | NA, NO | 0.08 | 0.10 | 0.13 | 0.15 | 0.18 | 0.21 | 0.25 | 0.28 | 0.34 | 0.38 | 0.42 | 0.44 |
| PFCs | 0.27 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.04 | 0.02 | 0.04 | 0.02 | 0.02 | 0.02 |
| $SF_6$ | 0.00 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| **Total (with net $CO_2$)** | **61.76** | **38.58** | **41.85** | **40.44** | **41.31** | **41.74** | **44.49** | **42.04** | **40.42** | **41.90** | **36.52** | **38.98** | **37.83** |
| **Total*** | **71.78** | **49.30** | **52.36** | **51.21** | **51.54** | **51.38** | **50.60** | **50.50** | **48.52** | **49.11** | **43.96** | **45.90** | **45.30** |

*Emission were assessed by 15.04.2013* Source: SHMI
*The table shows calculated years 1990-2010*
** Emissions without deducting the sinks in the sector of LULUCF (Land use-Land use change and forestry)*
NA = no applicable, NO = no occurrence

**Share of individual sources on greenhouse gases emissions in 2011**




*Emission were assessed by 15.04.2013* Source: SHMI

**Aggregated emissions of greenhouse gases (Tg) by sectors in $CO_2$ equivalents**

| | 1990 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Power Industry*** | 53.86 | 35.65 | 38.13 | 35.85 | 36.52 | 35.44 | 35.50 | 34.43 | 32.75 | 33.55 | 30.20 | 31.79 | 31.53 |
| **Industry Processes**** | 9.54 | 8.29 | 8.77 | 9.15 | 9.02 | 10.13 | 9.41 | 10.25 | 10.01 | 9.90 | 8.37 | 8.62 | 8.25 |
| **Using solvents** | 0.15 | 0.09 | 0.10 | 0.13 | 0.14 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 | 0.16 | 0.16 | 0.17 |
| **Agriculture** | 7.12 | 3.50 | 3.54 | 3.48 | 3.36 | 3.17 | 3.17 | 3.12 | 3.23 | 3.13 | 3.05 | 3.10 | 3.12 |
| **LULUCF** | -10.02 | -10.71 | -10.51 | -10.77 | -10.24 | -9.63 | -6.10 | -8.46 | -8.10 | -7.22 | -7.44 | -6.92 | -7.47 |
| **Waste** | 1.09 | 1.78 | 1.81 | 2.58 | 2.50 | 2.47 | 2.35 | 2.53 | 2.36 | 2.37 | 2.16 | 2.22 | 2.23 |

*Emission were assessed by* 15.04.2013 Source: SHMI
*The table shows calculated years* 1990-2010
** Including the traffic ** Including the F-gases*

## International obligations in the area of climate changes

At the UN Conference on Environment and Development (Rio de Janeiro, 1992) was adopted **framework UN Framework Convention on climate change** – basic international legal instrument for

protection of global climate. The Convention became effective in Slovakia on March 21, 1994. Slovak Republic accepted all the obligations of the Convention ratified by 183 countries and the EU as to date.

The Kyoto Protocol (KP) was adopted at the COP - Conference of Parties in December 1997. Slovakia along with other EU countries (EU obligation was assumed as a joint obligation, the so-called burden sharing agreement) approved a reduction target for the period of 2008-2012 not to exceed the average level of greenhouse gases emissions of 1990 reduced by 8%.

In the spring of 2007, the European Parliament adopted a unilateral obligation to reduce the greenhouse gases emissions within the EU by at least 20% by 2020, compared to 1990. Next, there was a declaration that the EU will extend this obligation to a 30% reduction provided that such is adopted also by other world developed countries and that developing countries with more advanced economies will follow, assuming obligations adequate to their responsibility and capacities.

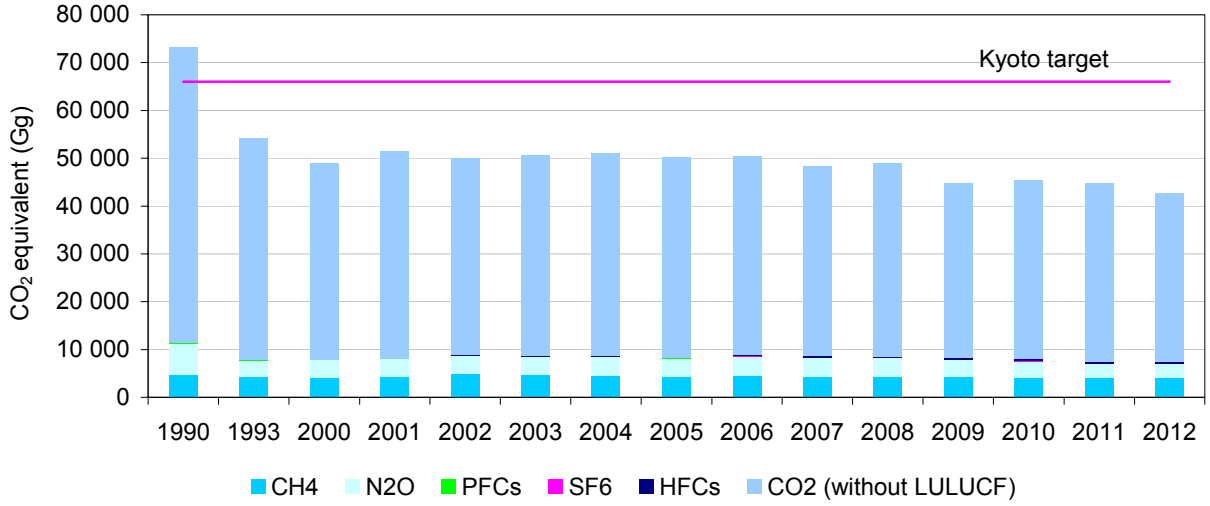
The integrated climate-energy package officially presented by the European Commission in January 2008 is a basic, complex and very ambitious approach to reduce greenhouse gasses emissions, increase the energy efficiency, reduce the consumption of fossil fuels, and support innovative, low-carbon technologies.

Slovakia has been meeting the mentioned international obligations and expects to do so in the years to come.

Trading with the emission allowance as mentioned in article 17 of the Kyoto Protocol constitutes one of the flexible mechanisms how to achieve the Protocol's objectives. The EU has undertaken to adopt, beyond the scope of the international trade with the emission allowance limits, its own instrument through which it sets its own rules.

Adopting the European Parliament and of the Council Directive 2003/87/EC of October 13, 2003 establishing the scheme for greenhouse gas emission allowance trading within the Community gave rise to the legal framework for the function of EU ETS.

**Assessment of anthropogenic emission of greenhouse gases under compliance with the Kyoto protocols outcomes**




Source: SHMI

## Trend in the selected climate change assessment indicators

**Trend in the development of the climate** has been assessed on the basis of trends that exist within large-scale time sequences (1951-2012) for individual climate elements, and on the basis of a comparison of individual years to the normal reference period of 1961-1990. Beside the climate elements, assessed are also the selected hydrological flow characteristics that immediately react to the trends in climate development. (i.e. atmospheric precipitations, air and vapour temperature) Two monitoring stations were selected for the purposes of carrying out a representative assessment of indicators in relation to Slovakia's altitude. The station of Hurbanovo is to provide data for the lowland-type areas, and the stations of Liptovský Hrádok or Oravská Lesná will gather data from the areas of higher altitude.

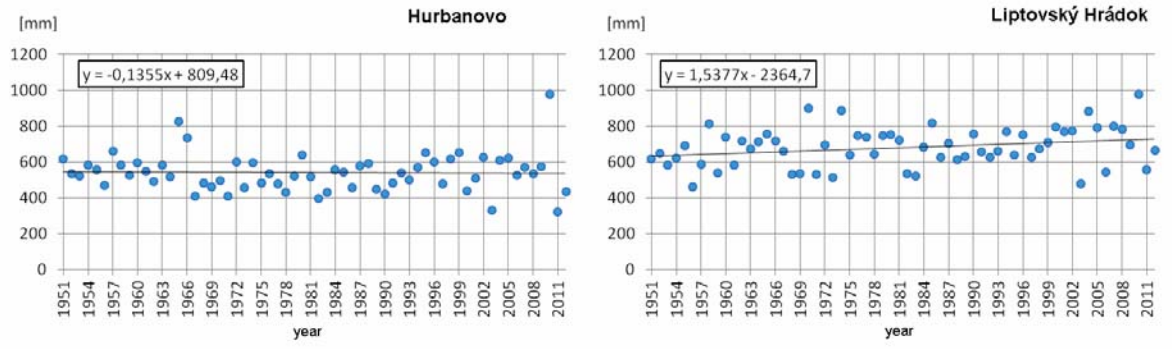
### ♦ Climate elements

**Total annual atmospheric precipitations (1951 - 2012)**

The lowland areas of Slovakia showed a **declining trend** of total annual precipitations over the years 1951-2012 (8 mm at Hurbanovo), while the trend was rising in the northern and high-altitude areas. (94 mm at Liptovský Hrádok)

**Significant below-the-limit** years assessed at the Hurbanovo station on the basis of the annual total precipitations within the interval below 10% of occurrence compared to the normal level included the following years: 1967, 1971, 1978, 1982, 1990, 2003 and 2011and at the Liptovský Hrádok station: 1956, 1968 - 1969, 1973, 1983 and 2003. On the contrary, **significantly humid years** with the annual total precipitations above 90% compared to the normal values recorded at Hurbanovo included the years 1957, 1965-1966, 1980, 1995, 1999, 2010, and in 1958, 1970, 1974, 1985, 2004, 2007, 2010 at Liptovský Hrádok.

**Total annual atmospheric precipitations in Hurbanovo and Liptovský Hrádok (1951-2012)**



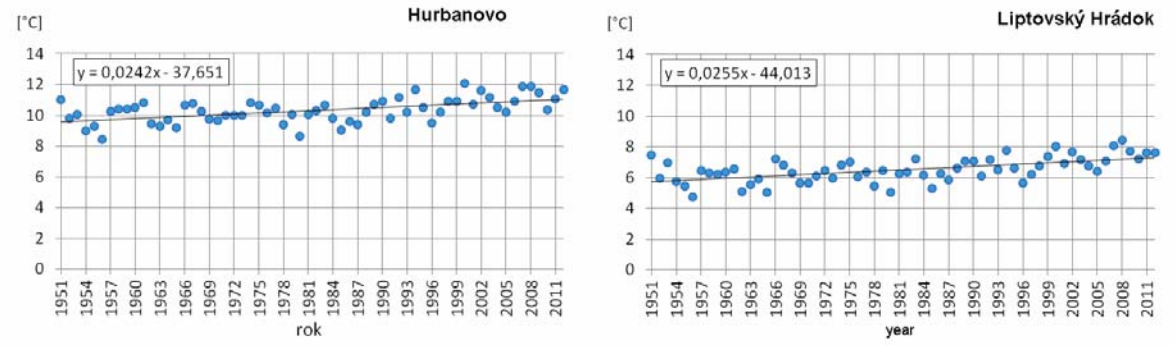

Source: SHMI

**Average annual air temperature (1951-2012)**

Both, lowland and highland areas show a **rising trend** in the average annual air temperature. (1.5°C at Hurbanovo, and 1.6°C at Liptovský Hrádok)

Significantly **below normal temperatures** recorded at Hurbanovo were the years 1954-1956, 1963, 1965, 1980, 1985, and 1955-1956, 1962, 1965, 1978, 1980, 1985 at Liptovský Hrádok. Significantly **above normal temperatures** recorded at Hurbanovo were the years 1994, 2000, 2002, 2007-2009, 2012 and in 1994, 2000, 2002, 2007-2009, 2011 at Liptovský Hrádok.

**Average annual air temperature in Hurbanovo and Liptovský Hrádok (1951-2012)**



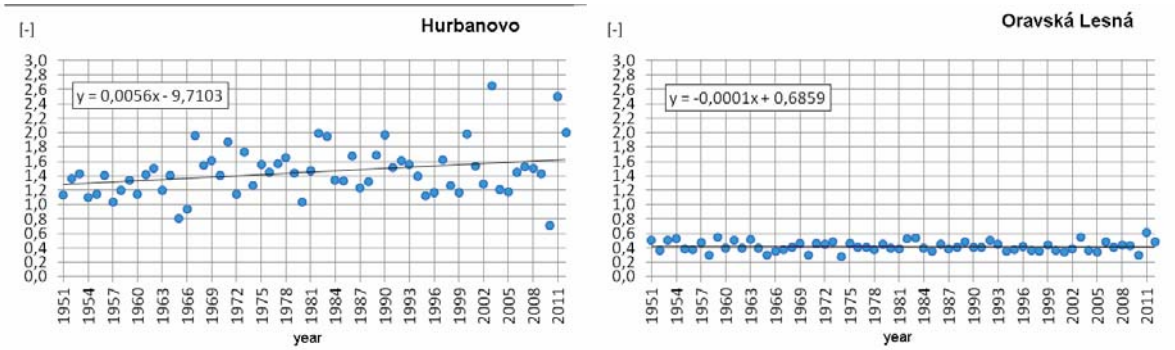

Source: SHMI

**Drought index (1951-2012)**

**Drought index** is based on the comparison (ratio) of the annual sum of potential evapo-transpiration and the total annual atmospheric precipitations. The lowlands of Slovakia recorded a rising trend in the drought index (0.34 at Hurbanovo), while in the highland areas this index shows practically zero trend. (0.01 at Oravská Lesná)

Statistically **significant drought** occurred especially in the southern parts of Slovakia (Hurbanovo) in the years 1967, 1982, 1990, 2000 and 2011-2012. On the contrary, **very humid years** detected at Hurbanovo included the year 1954, 1957, 1965-1966, 1980, 1995 and 2010 while the far northern part of the territory did not record any significant dry seasons.

**Drought index in Hurbanovo and Oravskaá Lesná (1951-2012)**



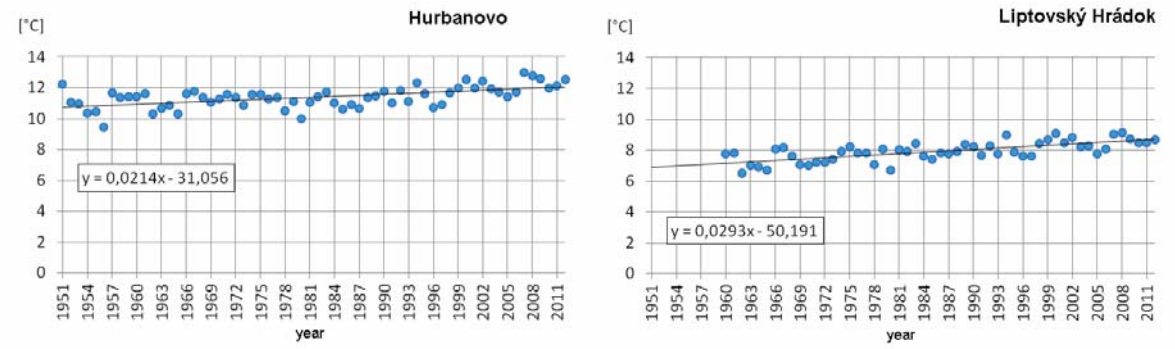

Source: SHMI

**Annual soil temperature in the depth of 10 cm (1951-2012)**

Both, lowland and highland areas show a **rising trend** in the average annual soil temperature in the depth of 10 cm (1.3°C at Hurbanovo, and 1.8°C at Liptovský Hrádok).

Statistically **above-normal years** in annual soil temperature in the depth of 10 cm at Hurbanovo were 1994, 2000, 2002, 2007-2009, 2012 and at Liptovsky Hrádok 1994, 2000, 2002, 2007-2009.

**Annual soil temperature in the depth of 10 cm in Hurbanovo and Liptovský Hrádok (1951-2012)**



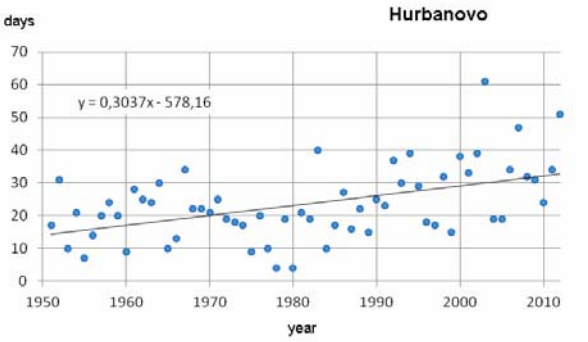

Source: SHMI

**Heat waves (number of tropical days) (1951-2012)**

Both, lowland and highland areas show a rising trend in the number of tropical days. (19 more at Hurbanovo and 8 more at Liptovský Hrádok)

Strong, **above-normal number** of tropical days occurred at Hurbanovo in 1983, 1994, 2000, 2002-2003, 2007, 2012, and in 1992, 1994, 1998, 2006-2007, 2010 and 2012 at Liptovský Hrádok. On the contrary, strong **below-normal number** of tropical days was recorded at Hurbanovo in 1953, 1955, 1960, 1965, 1975, 1977-1978, 1980, 1984 and at Liptovský Hrádok in 1953, 1955-1956, 1960, 1966, 1970, 1973, 1975, 1977-1980, 1982, 1985-1986 and 2008.

**Number of tropical days in Hurbanovo (1951-2012)**



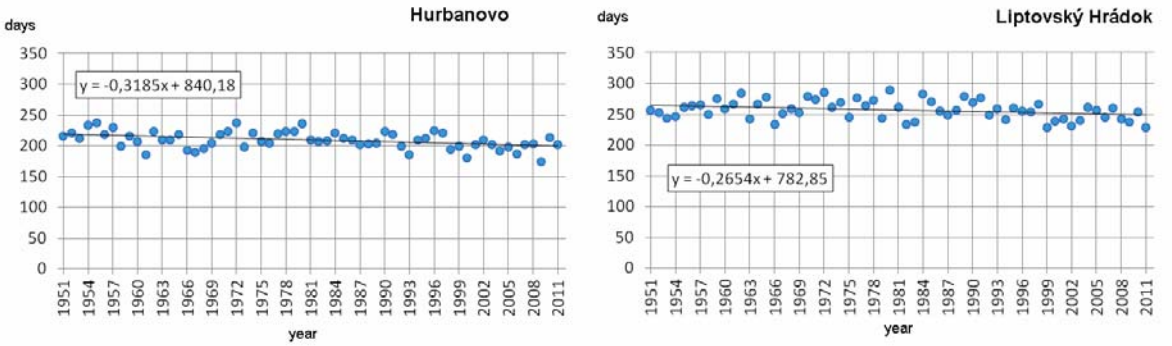

Source: SHMI

**Heating period of 1951-2012**

Lowland as well as highland areas show a declining trend in the **number of heating days,** specifically by 20 days less at Hurbanovo, and 17 days at Liptovský Hrádok.

Statistically significant **low number of heating days** was recorded at Hurbanovo in the years 1961, 1967, 1993, 2000, 2004, 2006, 2009 and in 1966, 1982-1983, 1999, 2002, 2009 and 2011-2012 at Liptovský Hrádok. On the contrary, statistically strong **high number** of these days was recorded at Hurbanovo in 1954-1955, 1957, 1972, 1980, 1996 and at Liptovský Hrádok in 1962, 1965, 1970, 1972, 1980, 1984 and 1989.

**Number of heating days in Hurbanovo and Liptovský Hrádok (1951-2012)**




Source: SHMI

## ♦ Hydrological elements

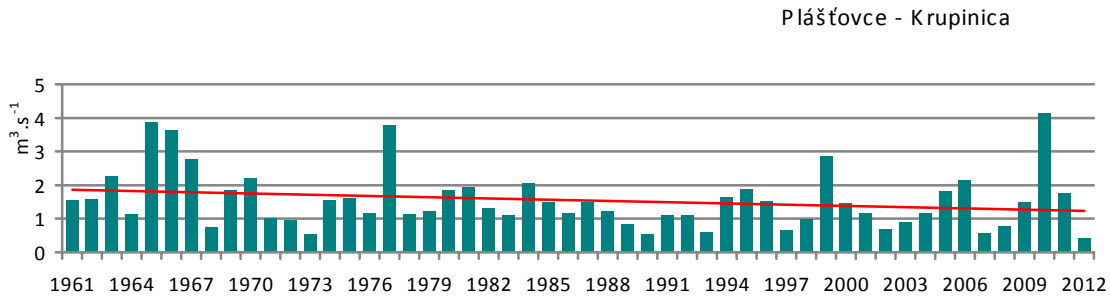
### Annual flows

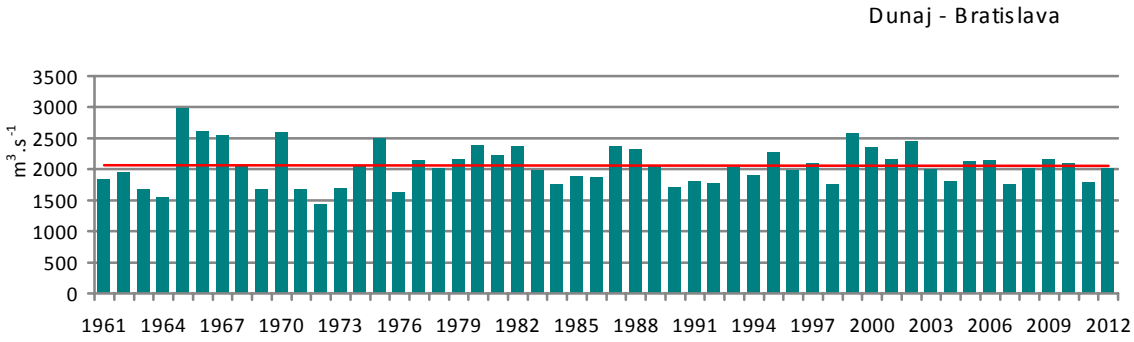
Watershed area of the southern part of Slovakia (Slovakian part of the Morava river watershed along with the watersheds of Nitra, Hron, Ipeľ, Slaná, and Bodva) show slight to significant decreasing trend in **average annual flows** for all monitored periods. (e.g. Krupina in Plášťovce) Watershed areas of the north-western, northern, and north-eastern Slovakia show, over the entired monitored period, very slightly declining, balanced, or even slightly rising trend in average annual flows for all monitored periods. (e.g. Kysuca in Čadca). Notwithstanding the legth of the period, introduced water course of Danube has shown a balanced characteristics in average annual flows.

Trends in **minimum annual flows** essentially copy the trends in average annual flows in southern and northern watersheds of Slovakia. (e.g. Krupina in Plášťovce) Minimum annual flows recorded on Danube in Bratislava show a slightly rising trend.

Unlike the average annual flows, the trend in **maximum annual flows** provides no sufficient basis to **define similar areas.** Surprisingly, most monitored watercourses over the last decades show declining or balanced trend in maximum annual flows. (e.g. Krupina in Plášťovce). Trend in maximum annual flows on Danube in Bratislava for the period beginning at the start of the last century as well as since the start of monitoring in 1961, has been rising significantly.

**Average annual flows (1961-2012)**






Source: SHMI

### ♦ Run-off distribution over the year

No significant changes in run-off distribution over the long-term horizon have been detected in Slovakia for selected time periods.