

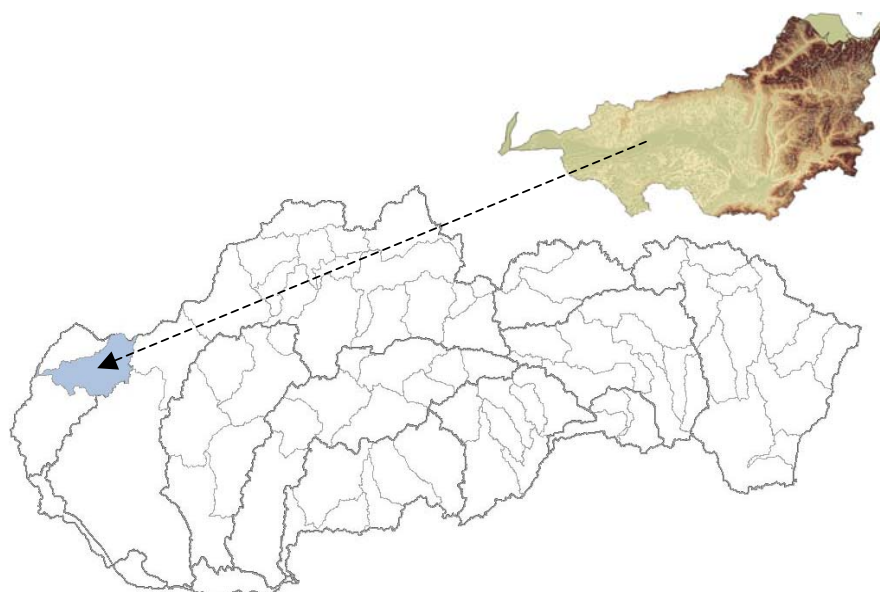


World Meteorological Organization



FORWARD INTEGRATION OF FLOOD WARNING IN AREAS PRONE TO FLASH FLOODS

SLOVAK REPUBLIC



Submitted by: Slovak Hydrometeorological Institute

For the WMO/GWP Associated Programme on Flood Management



NOTE

The designations employed and the presentation of material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Meteorological Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

It should be noted that this document is not an official WMO Publication and has not been subjected to the Organization's standard editorial procedures. The views expressed by individuals or groups of experts and published in this document do not necessarily have the endorsement of the Organization.



1. Geographical and hydrometeorological setting

Slovakia occurs in the middle of Europe and borders five states: Czech Republic, Austria, Hungary, Ukraine and Poland. The area of Slovakia is 49 036 km² and its number of inhabitants is app. 5, 38 mil. The northern part of the country crosses the European watershed divide between the Baltic and the Black Sea. From a hydrological point of view, Slovakia is divided in 11 main basins: Morava, Danube, Váh, Nitra, Hron, Ipel', Hornád, Bodrog, Bodva and Poprad.

Climatic conditions in Slovakia are influenced by its location in a moderate climatic zone of the Northern Hemisphere with regularly alternating seasons. Forests cover about 38% of the territory. The maximum long-term average annual temperature of 10.4 °C has been recorded at the "Lomnický štít" peak in the High Tatras Mountains. The Danube lowland is considered as the driest region of Slovakia with an average annual precipitation lower than 550 mm. Maximum values (above 2000 mm) are observed in the area of "Zbojnická chata" – cottage in the High Tatras Mountains.

The location of Slovakia on Central Europe's hydrological roof causes that almost one third of waters originating from its territory run beyond the country borders. The hydrological regime of Slovakia is characterized by high longitudinal river slopes, with torrential runoff especially for the so-called large waters.

2. Social profile

The Slovak Republic lies on Central Europe's continental divide, with much of the Carpathians range. The country's surface area is 49,034 km² with a population of 5.4 million in 2004. The population density (110 inh/km²) is relatively high given that just a small part of the Slovak territory is populated. The highest population concentrations are to be found in the basins and along the five major streams (Danube, Váh, Nitra, Hron and Bodrog rivers). The basin urbanization is one of the reasons for the high vulnerability due to considerable floods and related damages.

According to the 2001 census (Slovak Statistical Bureau), the City of Bratislava has a population of 428,672, followed by the cities of Košice (236,093), Prešov (161,782) and Žilina (156,361). Except for Žilina, these cities lie in flood-prone areas.

Following a peaceful split process in 1993, the Czech and Slovak parts of former Czecho-Slovakia became independent states. The Velvet Revolution of 1989 triggered a democratic change process. The democratization process in Czech and Slovak societies has become highly complex, building states ruled by laws and transparent democratic and institutional structures.

The democratization process characteristics are:

- Political pluralism;
- Free market economy;
- Respect for human rights;
- Peace and security.

The successful democratization process will bring more freedom of choice and civil liberties to Slovakia citizens as well as a greater social interaction. It will also encourage more individual and private initiative and social responsibility.

The independent Slovak market has already operated for over 15 years now and has not yet struggled with recession. The transformation from the planned economy into a market-driven one has been a success. The Economic Commission labeled Slovakia in its regular report as a functional market economy. Growth of the Slovak economy has been one of the most buoyant in Central and Eastern European countries over the last decade.



Nevertheless, lagging behind the EU average is still considerable. It will probably take a number of decades for the country to catch up with it. In terms of per capita GDP, the Slovak economy generates less than 50% of the EU average. Lagging behind on prices is even higher: prices in 2001 stood at a mere 37% of those of Germany. The situation has improved considerably, following the electricity, gas and water price deregulation between 2003 - 2005. The Slovak Republic has made considerable progress in roughly 80-90% of privately-owned economic activities, with a high rate of price liberalization, with the regime of an open foreign market and with the elimination of limitations on foreign investments. The new government, elected in September 2002 continued reform politics, including tax reform with a 19% flat individual and corporate income tax, reform on the Labor Code allowing more flexibility and pension reform with raising the retirement age and setting up a second pension pillar. GDP growth was the highest from among Central European countries, standing at 4.6% in 2002, supported by increased consumption, 4.5% in 2003 and 5.5% in 2004 as a result of growing exports.

GDP and FDI growth contributed to lowering the rate of unemployment, which had stood for a couple of years at about 18% and dropped to 15.2% and 14.3% in 2003 and late 2004, respectively.

Now that Slovakia has joined the EU, the government's ambition is to complete its reform program, meet the Maastricht Treaty criteria and join the European Monetary Union Eurozone in 2009. The creation of a favorable environment for business will secure sustainable growth and high FDI levels.

Despite these positive developments, the Slovak Republic faces numerous challenges. Key areas are fiscal strengthening, pension and health care reform, education funding, inflation, corruption and law enforcement. The successful handling of these matters will call for a high level of political stability and consistent course of action.

Vrbovce is located in the Senica district neighboring with the Czech Republic in the western part of Slovakia and is influenced by the effects of the Bratislava centralization. Before the Second World War, more than five thousand citizens were living there, whereas the number of inhabitants decreased step by step and at present less than 1600 persons live in the Vrbovces. Age structure is older comparing urban areas. Young families are mostly moving to the cities. Many of the houses are now used by urban people for recreation. The potential for tourism is large both in summer and in winter.

Former dominant agricultural activities were after collectivization intensified and most of working people are employed in Senica district city and in the area of Bratislava capital. Only less than one third is working in the village. The unemployment rate is 12%. There are 20 self entrepreneurs in the village and no large companies.

The social life is still very interesting. There are several areas for local activities, mainly church – both Roman Catholic and Evangelist Augsburg. There are also folklore, sport, hunt, and woman local organizations. For the flood protection system, there is an important fire brigade and a flood protection unit.

Mr. Mayor Samuel Redecha is, together with his local municipal office and local government a very active man. However, no woman was elected to the local government and three women are assisting the Mayor in his office.

After the transposition of several formerly central functions to the municipal level (few years ago – it was process of some years) the self responsibility of local people for their things is improving. It is necessary to emphasize that generally in Slovakia there is only little experience with self governing of local functions because of 40 years of strong central system in socialism.

This centralistic approach is also evident in flood protection functions. That is why strong education and introduction of stakeholder participation is necessary. Also proper cooperation of municipal,



district and regional offices is frequently a problem. The APFM project is therefore of very high importance for Vrbovce and Slovakia.

3. Flood characteristics

3.1 Flood problems in the recent past (regional, flash)

Recent floods in Slovakia

The recent years have seen a continuous rise in loss of life and damage caused by floods. Between 1996 and 2002, Slovakia has suffered from 80 major damaging floods, including the catastrophic flash floods in the middle and north part of the country. The majority of them have caused victims, the dislocation of hundreds of people and enormous economic losses.

In the summer of 1997, extensive and long-lasting floods originating from heavy rain, hit the majority of the rivers in Slovakia. The most hazardous situation was on the Morava river, where the highest degree of flood activity – emergency – continued during 21 days. The relief costs, preventive work and flood damages amounted to nearly 50 million USD. Floods affected 366 cities and municipalities, 8255 houses were inundated, from which 70 were completely destroyed.

The flash floods, which occurred on July 20, 1998, as a consequence of extreme storms, struck about 30 villages in the eastern part of Slovakia in the Hornád river catchment. The losses were catastrophic. Flood damages were estimated at 25 million USD, human losses were unprecedented in recent history – fifty people died.

The Bodrog river basin flood in March 1999 was of combination of snow melt and rain, as well as the flood in March/April 2000. Throughout the two floods, the highest water levels for a period of observation had been recorded in some of the hydrological stations in the catchment.

In the summer 2001, mainly the northern part of Slovakia, abounded in destructive flash floods. In 399 villages and settlements, 8039 houses were inundated and 19 828 inhabitants were being directly affected.

The flood on the Danube river in August 2002 with respect to the peak discharge $10\,390\text{ m}^3\text{s}^{-1}$ in the station Bratislava places in three highest recorded floods since 1862.



Danube, 2002





Flash flood in Jarovnica village, 1998

Flash flood in Štrba village, 2001

Spring flood in 2006 in the Morava river basin

The Pilot site Vrbovce belongs to the flood sensitive area of Slovakia. According to the analysis of recent flood events, Vrbovce and Čierny Balog were selected for building of local warning systems including local stations.

The pilot system Vrbovce was used and checked during spring flood in 2006. Huge amount of snow in the winter 2005/2006 in the whole Central Europe in combination with intensive precipitation caused flood on the whole section of rivers Morava, Nitra and Danube in the 3rd decade of March.

General meteorological situation

There was non-significant area of air pressure above Alps and Carpathians from March 20 March 21. On March 22, the anticyclone above Germany and Czech Republic became stronger. A cold air temporarily entered the Slovak area at the margin of above the mentioned anticyclone. In the next days the above mentioned anticyclone moved through Central Europe south-eastbound. At the same time a cyclone moved from the Atlantic to the west European coast. Warm and wet air started to flow above Central Europe from the southwest.

On April 2, a waved cold front connected with the cyclone over Scandinavia crossed Central Europe to the east. A jut of air of high pressure temporarily spread over the Alp region on April 4. A cold wet air from northwest started to flow above Central Europe. A cyclone started to develop above southern France and moved to the east. A waved cold front connected with it gradually affected the weather above the whole Danube basin. A jut of air of higher pressure started to spread over Central Europe on April 6 from the west. It even reached Belorussia in the following days. Since April 8, a warm air on the front side over the North Sea of the cyclone started to flow over Central Europe from southwest. A waved cold front connected with the cyclone started in the same time to move further to the east.

Snow conditions in the Morava river basin

A continuous snow cover at aof 400 m above the sea level altitude held till the 3rd decade of March. The snow layer thickness was in that time in Jeseniky hills and Ceskomoravska vrchovina hills from 29 to 100 cm. At the foot of mountains and in the Province of South Moravia was the snow cover non-continuous with thickness 0 - 7 cm. A gradual warming up occurred at that time: morning temperatures were above zero even in heights over 700 m above the sea level. These high temperatures caused a gradual melting of the snow. At the beginning of April there was no snow in Province of South Moravia and in the mountains, up to 700 m above the sea level. In higher areas there was about 10 cm of snow yet, but it melted in 2 days. A new snow layer with a thickness up to 7 cm melted in several hours and caused a runoff delay .

Temperature conditions in the Morava river basin.

Temperature conditions in the Morava river basin were similar to thoses in whole Slovakia and in the Danube river basin. Warming in heights up to 600 m above the sea level started on March 25 when the



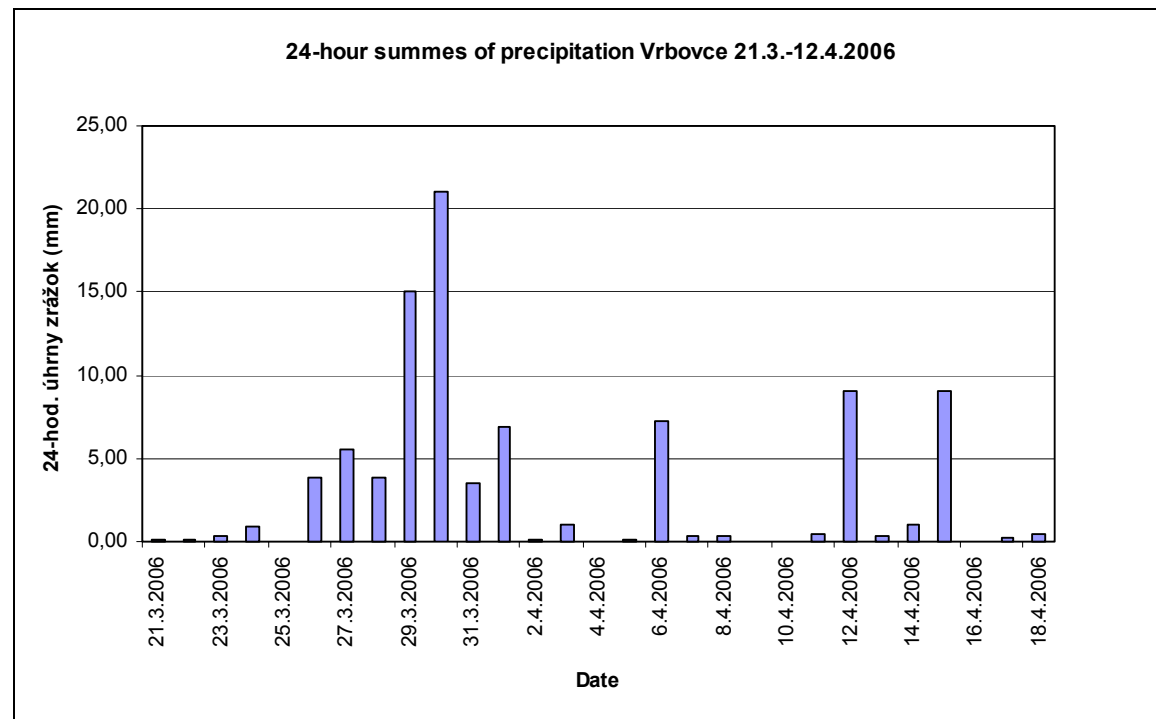
morning temperatures rose above zero at 6.00 o'clock. The next day morning temperatures were above zero also in height above 700 m above sea level. The development of daily temperatures was the same. They even went above 10 C° in higher situated areas. The highest temperatures, measured at 12.00 o'clock, especially in lower areas, reached 16 C° and more.

Precipitation conditions in the Morava river basin

Very rich precipitation totals occurred in the Morava river basin in the third decade of March. The biggest 24-hour precipitation totals were recorded in the period 28. – 29.3.2006 and they reached up to 17 mm. The 24-hour precipitation totals before and after this period were less (up to 7 mm).

Although it was raining for five days in the beginning of April, the 24-hour precipitation totals did not exceed 7 mm. Then, four almost dry days followed. The rain started again on 10.4, but precipitation totals did not exceed 5 mm (in some areas 14 mm - 11.4.2006). There was no rain after 18.4.

The 24-hour precipitation totals measured at station Vrbovce in the period from March 21 – April 18, 2006 are shown on the Figure.



Hydrological situation

Increased temperature from March 25 caused melting of snow in the whole Morava river basin. The runoff regime was affected especially by extreme supplies of snow at the end of winter period and warming. After rains in the period from March 25 to March 31 was the following runoff even more intensive. With respect to these conditions the extreme increase of water levels was expectable.

The water levels of river Myjava and its tributaries slowly started to lift up already from 21.3. Warming from March 25 caused sudden increase of water level in rivers.

The water level in river Morava in the village Moravský Svätý Ján reached its maximum on 3.4. at 20.45 o'clock at the level 618 cm. This corresponds to the 3rd Level of Flood Activity (SPA). During coming hours till 6.4. at 3.00 in the morning the water level culminated above 600 cm. The water table was kept above the 3. SPA (520 cm) from March 29, 7.00 o'clock to April 8, 13.00 o'clock, i.e. more than 10 days. It went down below the 1. SPA (420 cm), only on April 22.



Probable occurrence of the culminating flow at this station $Q = 1547 \text{ m}^3 \cdot \text{s}^{-1}$ can be stated as more than 100-year.

The similar situation was also at the station Záhorská Ves, which culminated from April 4, 2006 at 19.00 o'clock to 00.30 o'clock of the next day at the level of 720 cm, which was also exceeding of the 3. SPA. The third Level of Flood Activity at this station lasted from March 29 to April 9 at 22.00 o'clock, when it decreased below 550 cm. The 2nd SPA (490 cm) remained to April 15 at 10.00 o'clock. The water level on the level of 1st SPA (430 cm) lasted till April 21.

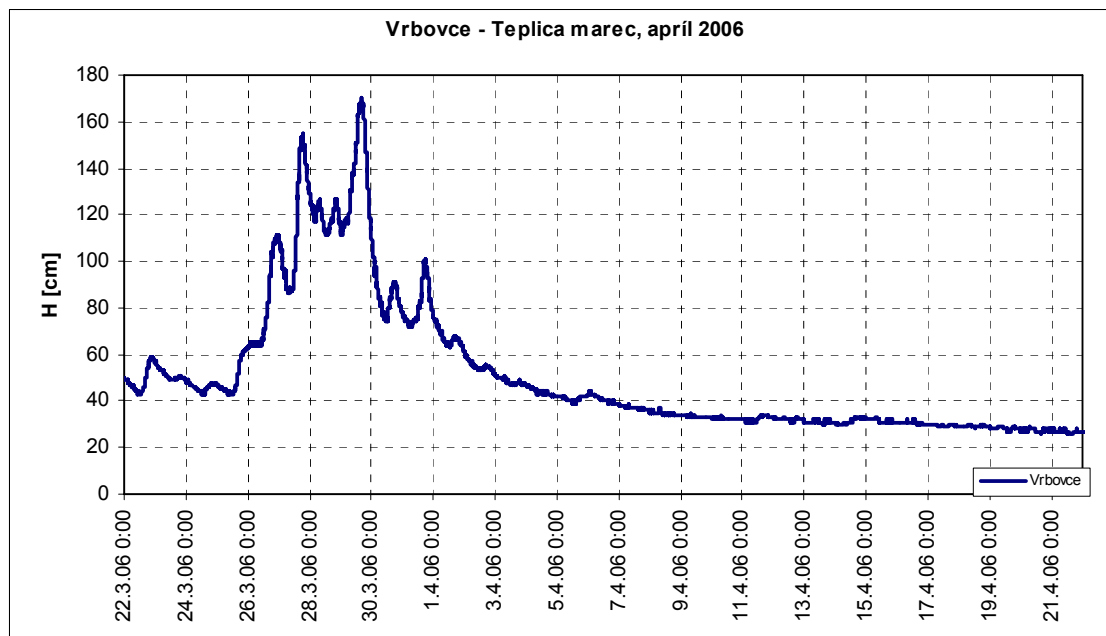
The culminating flow $1402 \text{ m}^3 \cdot \text{s}^{-1}$ corresponds to the level of 100-year flow.

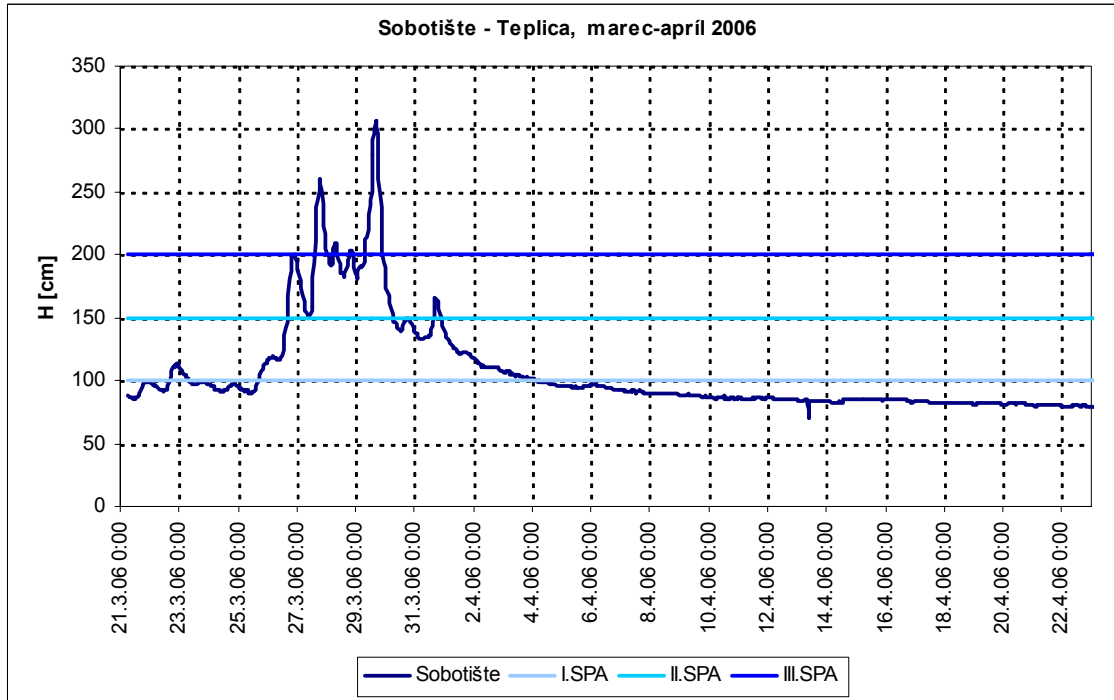
The 3rd levels of SPA were exceeded also on tributaries of river Morava, i.e. Chvojnica, Myjava, Teplica and Stupávka.

The flood situation occurred practically in the whole Morava river basin. Culminating values in particular stations are shown in the table. Courses of water levels on the Teplica stream are shown on the Figure

Tab. Culminating water levels and flows in selected hydrological stations

Station	Stream	Date	Time	H_{\max} [cm]	Q_{\max} [$\text{m}^3 \cdot \text{s}^{-1}$]	N- year occurrence	SPA
Kroměříž	Morava	30.3.	23.00	726	760	50	3.
Strážnice	Morava	29.3.	20.00-24.00	703	733	> 100	3.
Lopašov	Chvojnica	29.3.	15.00	201	3,441	> 1	3.
Kopčany	Morava	30.3.	8.15	670	617,4	50-100	3.
Myjava	Myjava	29.3.	15.30	168	16,09	10-20	3.
Jablonica	Myjava	30.3.	0.30-1.00	286	41,48	10-20	3.
Vrbovce	Teplica	29.3.	16.10	170			
Sobotište	Teplica	29.3.	17.30-17.45	309	37,19	20	3.
Šaštín – Stráže	Myjava	30.3.	0.45-1.30	391	54,98	5-10	3.
Moravský Sv. Ján	Morava	3.4.	20.45	618	1547	> 100	3.





3.2 POVAPSYS Project

Following the above mentioned floods, the effort to decrease negative impacts of the future floods led to the declaration of the special flood program. In January 2000, the Slovak Government adopted the "Flood Protection in the Slovak Republic by the Year 2010" programme, which consists of several projects.

In accordance with the Flood Protection Law, the Slovak Hydrometeorological Institute (SHMU) is responsible of providing all kinds of hydrometeorological information, forecasts and warnings in Slovakia. Therefore, the POVAPSYS project or "Flood Warning and Forecasting System of the Slovak Republic", has been delegated to the Institute.

The POVAPSYS primary goal is to improve the quality of the population life, in particular in flood hazard areas. In the context of flood protection, this goal will be delivered by:

- extending the lead time of forecasts and warnings, which will provide more time to competent organizations, authorities, units responding to an emergency and to people in flood hazard areas to get ready for taking flood protection action;
- providing more accurate and reliable forecasts and warnings;
- providing more forecasts for a certain period of time and for more locations across the country;
- providing model results and data continuously through effective ways such as the Internet in order to reach in due time key organizations, authorities, responding units and the public.

The typical project activities are:

- extension and upgrade of monitoring, processing and telecommunication system;
- completion of hydrometeorological information system and databases;
- implementation of research and technical projects results;
- international co-operation on the development and use of necessary hydrologic and meteorological model.



SHMU began implementing POVAPSYS in 2003 and is being executed by working groups in several subsystems or tasks, which have been slightly modified during the implementation. At present time, the POVAPSYS project consists of the following subsystems:

- Integrated Information System of POVAPSYS
- The Networks of the Terrestrial Stations
- Remote Methods of the Monitoring
- Forecasting Methods and Models
- Telecommunication Centre and Computer Techniques

The development of the system in each of the subsystems is being under way at two levels:

- Procurement, realization, installation and setting into operation of the necessary technical facilities for data monitoring, transmission and processing.
- Handling operational tasks, data management, conceptual tasks and research and development projects stemming from the system development.

Any flood forecasting system generally comprises four main components: data collection, data processing, forecasting procedures and distribution of information (Figure 1).

The last two components – presentation and distribution of data, information, forecasts and warning, and user's component played a crucial role in the project events for the pilot case Vrbovce. During the month of June exercise all aspects of these activities were organized.

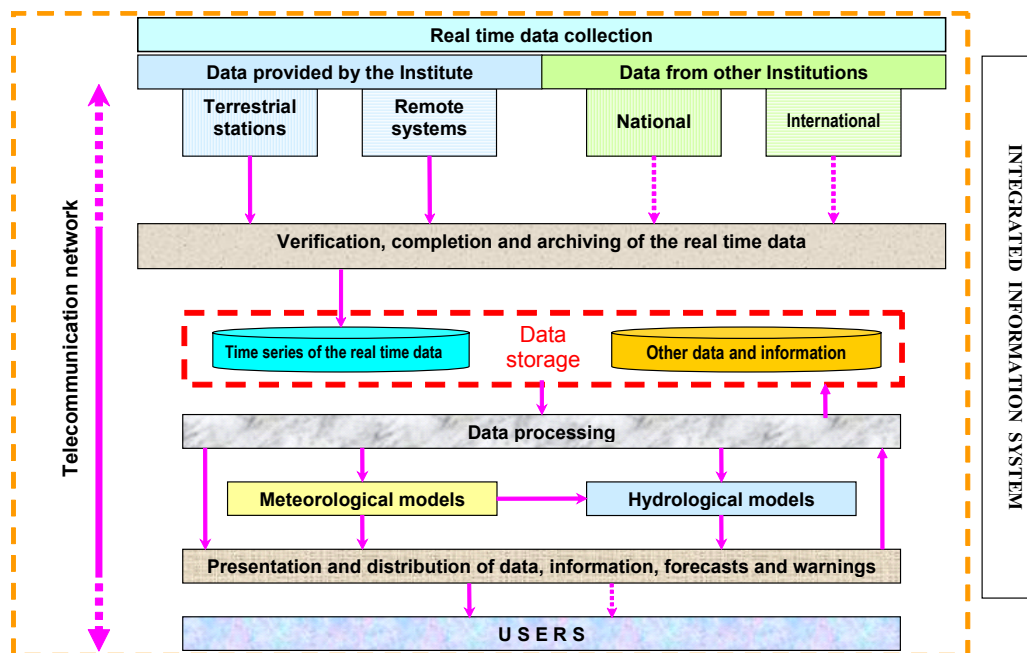


Figure 1. Flood Forecasting System



POVAPSYS – Flood Warning and Forecasting system of the Slovak Republic operated by SHMU – has to be in compliance with: organizational structure of the SHMU, integrity of the main catchments, its position determined by the Act on Flood Protection, its international position and hydrological forecasting practice at SHMU (Figure 2).

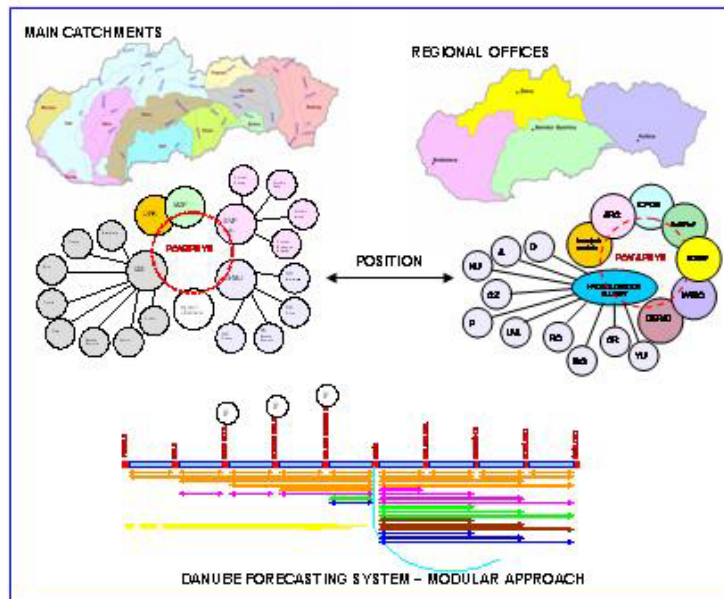


Figure 2. Position of the POVAPSYS

3.3 Flood types in Slovakia and their predictability

In Slovakia, there are four main types of floods:

- Regional floods
- Spring-time floods (snowmelt or combined)
- Ice floods
- Flash floods

Regional floods

Regional floods are associated with large scale or meso-scale weather patterns (intensive cold fronts, stationary fronts, rapid cyclogenesis, precipitation caused by interaction of larger scale patterns with orography). This kind of weather is predictable by current local area atmospheric models (LAM) usually up to two-three days ahead. However, there are still inaccuracies in precipitation location and intensity. There is an apparent need to determine the minimum size of river basin for which the local area model prediction is sufficiently accurate.

The frequency of this type of prediction for usage in hydrological models is driven by the frequency of local LAM, which is 4 times a day up to 72 hour ahead.

Spring-time floods

These floods are caused by the combination of melting snow and precipitation in the early spring. The larger precipitation amounts are associated with synoptic scale weather phenomena in early spring and therefore are predictable by the current LAM.

To forecast this kind of floods there is a need to have an operational snow model capable to analyze actual snow cover and to predict its dynamics. This prediction shall be based on LAM prediction. This snow analysis is at present missing in LAM and it would therefore be beneficial to test the inclusion of



snow analysis in the initial conditions of LAM and check its impact on the model results. The frequency of this kind of prediction is again determined by the local LAM frequency.

Ice floods

These floods are linked to ice phenomena on small and medium-sized streams. The cause is a high water level surged by an ice barrier. They occur in the wake of tough winters toward the end of the winter period involving temperature rise, ice cover disruption, floating icebergs which may cause the river profiles to get narrowed or even clogged and subsequently waters to overflow their banks.

The predictability of this kind of floods is very low and this topic is at present not covered by any meteorological and hydrological model. The present situation with various hydraulic structures on larger rivers and discharge control on dam and reservoirs significantly decreases risk of an ice jam flood.

Flash floods

Flash floods are caused by convective precipitation (local convection or larger scale organised convection). The natural predictability of local convective events is very short. Practical predictability is currently less than one hour with modern nowcasting systems. For instance, NOAA can issue warnings 43 minutes ahead in average. Current LAMs are not designed to predict such phenomena.

To capture this kind of floods, real-time analysis of actual precipitation intensities and accumulated amounts is needed using a combination of radar, rain gauges, satellite and SAFIR measurements. The frequency of this analysis has to be around 10-15 minutes, sufficiently shorter than the life cycle of the convective event.

To predict the flash floods, nowcasting tools capable to extrapolate measurements, using state of the art methods, have to be available. The length of prediction of nowadays nowcasting systems is 30-45 minutes for convective phenomena.

The frequency of flash flood prediction is determined by the frequency crucial observations (radar as unique source of precipitation distribution estimates). Currently it is 15 minutes. Every time when new observation is available, the nowcasting system shall carry out a new precipitation analysis and predict a nowcasting, which would be used as an input to associated hydrological models chain.

Because of small experiences on organizing flash flood events, the main focus of the project was to focus apply all relevant forecasting and dissemination possibilities in the case study area Vrbovce with the aim to collect features and proposals how to propose such procedures in the whole area of Slovakia that is threatened by flash floods.

3.4 Vulnerability to floods

Some efforts were already dedicated by hydrologists to understand the flood processes and to develop a proper and suitable strategy for flood control, for example by “vulnerability” or “sensitivity” investigation.

Territorial vulnerability to floods

Four criteria have been taken into consideration to derive the degree of vulnerability in 2,116 selected Slovak municipalities. These are:

- urbanistic (settlement significance, size, population, inundation area type, the occurrence of major structures, road and rail network, tourism, etc.),
- hydrologic (catchment area shape and size, river basin retention capacity, mean annual flowrate, hydrologic data reliability, the rate of forestation, geology, orography, morphology, land management method, etc.),
- water management (water management priorities, flood measures, stream modifications, etc.),



- environmental (occurrence of locations of relevance to environment conservation).

A map showing Slovakia's territory vulnerability to floods is given in Figure 3.

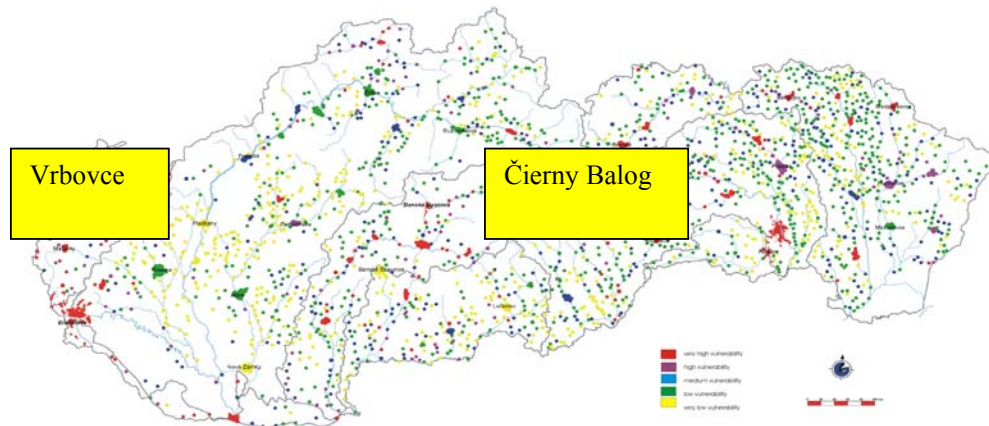


Figure 3. Flood hazard areas in Slovakia

Area division of the occurrence of floods

Statistical processing of the occurrence of floods at a variety of hydrologic stations for any floods in excess of 5-year ones (Q5) is graphically shown on the map in Figure 4.

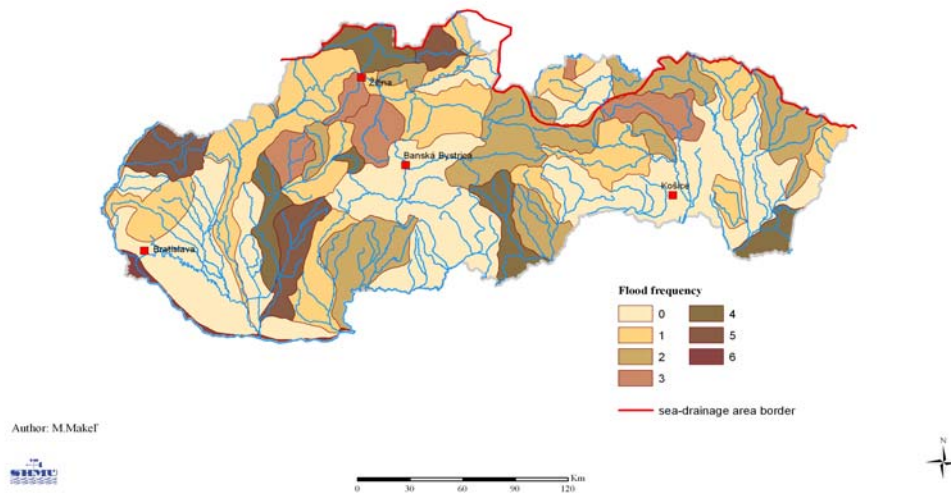


Figure 4. Areas of equal frequency of floods in excess of Q5 (1991 - 2002)

Seasonality of floods

In many regions, floods are seasonal in occurrence, varying from region to region. Also, the runoff seasonal behavior in watersheds should give more information about the main processes causing floods in these watersheds. As the season ability is linked to meteorological and hydrologic processes causing floods, these characteristics are valuable information to identify those regions in which they are homogeneous in regard of their flood behavior frequency.

The average flood occurrence date (DQ) is one of the most commonly used seasonality characteristics, representing a fictitious mean of occurrence $Q_{max,i}$ in the year and a weighed value of all the dates having the occurrence Q_{max} . Each date of the occurrence of culmination flow rates $Q_{max,i}$ is



converted into the day of occurrence (DQ_i) as a sum of all the previous days in a given year, including the day of occurrence.

A statistical processing of average data on the occurrence of floods is presented in the map in Figure 5. The map shows that the highest probability of flood occurrence is on average during the period between April and July.

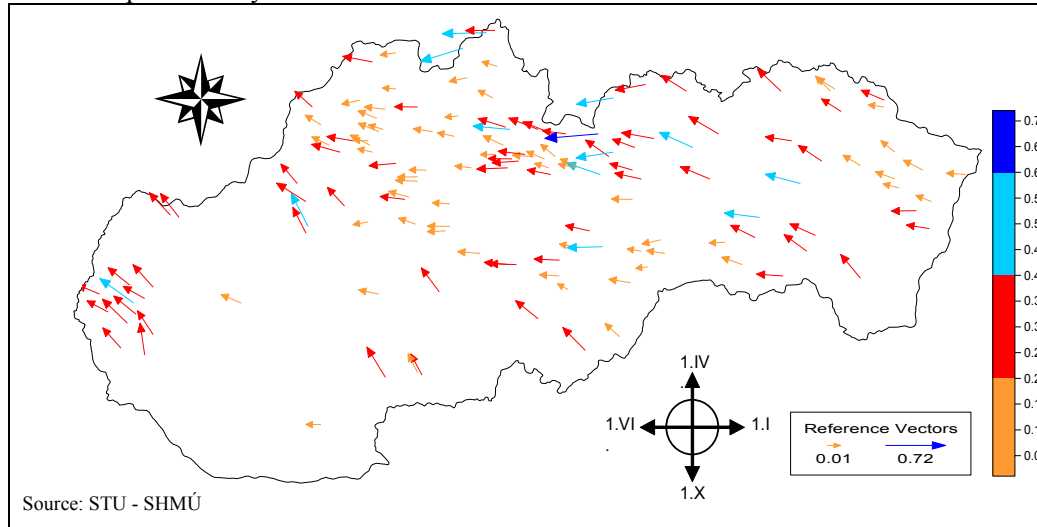


Figure 5. Seasonality of annual Q_{max} expressed by the average day of occurrence Q_{max} and the reference vector of seasonality concentration

The vector *direction* indicates the average day of occurrence with respect to circle-marked quarters. The vector *length* indicates a deviation from this average. A large length indicates a minor deviation from the average. By means of this map it can be roughly determined on which day the annual flood culmination occurs and also how the time of occurrence is variable within the season. Hence, the main flood season is on average between April 1 and July 1, with some areas closer to April 1 and others closer to July 1 or a bit later.

Sensitivity analysis to creation the floods

To begin with, regions with the highest occurrences of classical regional floods as well as flash flood with extreme effect are determined. The idea of “flood index” (K) had been applied to determine sensitivity of the Slovak territory to the formation of flood extremes.

$$K = \frac{1}{n} \sum \frac{Q_{\max}}{Q_{\text{annual}}}$$

- Q_{max} - maximum discharge Q observed in the water gauge station for considered period
 Q_{annual} - annual Q in the water gauge station
 n - number of years of hydrological series

Results, which we obtained from data processing, contain an evaluated K index from 300 water gauge stations:

- For 12 year series of vegetation season (April – September)
- For 12 year series of the hydrological year

As follows from the definition – the higher K indicates, the more significant is the flood situation. In other words – the region of basin, resp. basins are more sensitive to floods. For the vegetation period,



particularly summertime, which is connected with increasing storm activities and frequent heavy precipitation occurrence, K values reach higher values.

According to the “flood index” K, criterion, the selected regions (included basins or linked small basins) were indicated as

Very sensitive	K = 30 and above
Sensitive	K = interval (20 - 30)
Less sensitive	K = interval (10 - 20)
Negligible sensitive	K = less than 10

Spatial matrix of flood index K for vegetation period and for year period (processing data from 1989 to 2000) documented in Figure 6 and Figure 7.

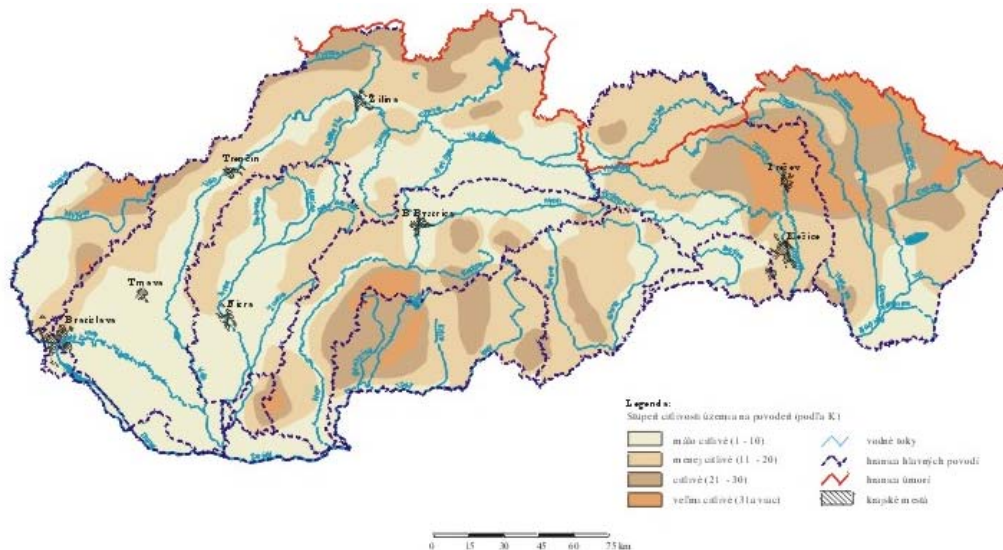


Figure 6. Flood index K for year period

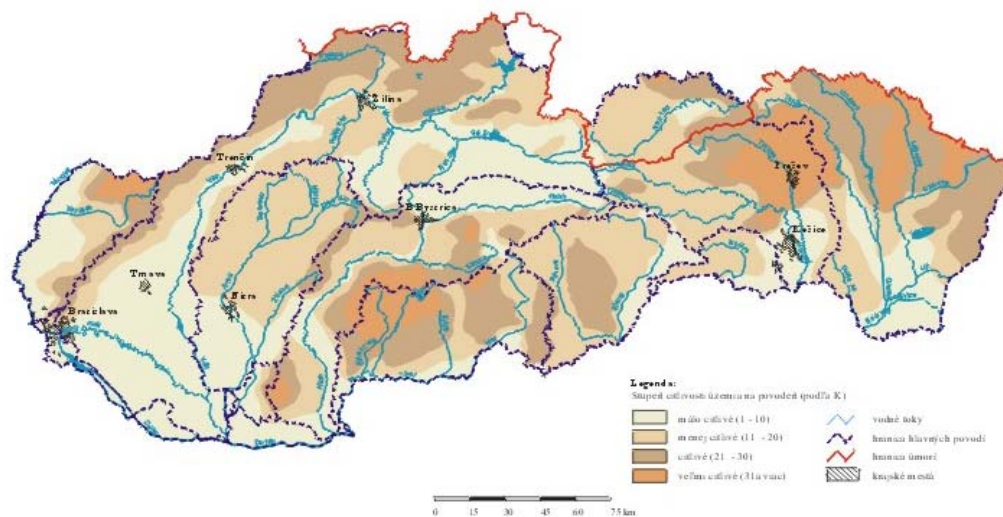


Figure 7. Index K for vegetation period



4. Link with policies and other projects

The Slovak Republic respects the sustainable development principles. The Slovak Hydrometeorological Institute contributes through meteorological and hydrologic monitoring, operative use of data, forecast processing and climatic and hydrologic regime development monitoring to sustainable development in relation to nature environment, economy and society. This helps at the same time to cope with natural disasters, major floods and droughts, provides effective warnings against imminent natural phenomena, and is an instrument in lowering risks and consequences of natural disasters.

The legal framework setting forth SHMÚ obligations and tasks relating to flood protection and management, including warnings and forecasts, and water management in general is as follows (all legal documents are available on the web page of the Ministry of Environment <http://www.enviro.gov.sk/servlets/page/166>):

Act on waters No. 364/2004 Coll. and MoE Decree No. 221/2005 Coll.

By virtue of this Act and Decree SHMÚ was charged by MoE as a special organization responsible, inter alia, for surface water quantity monitoring. Hence POVAPSYS's monitoring network will be part of the state monitoring network.

Act on flood protection No. 666/2004 Coll.

Flood situations are managed under Art. 8 whereas lays down the obligations of the forecasting, reporting and warning service (SHMÚ):

- The forecast flood service shall be obliged to notify promptly state administration flood protection authorities (see Fig. 5) and other authorities of risk of flood risk, occurrence of flood and further possible developments thereof, of hydrometeorological conditions affecting the occurrence and developments thereof, in particular of current and expected water levels and flow rates in select profiles of streams.
- The flood warning service shall warn the public against a hazard at the point of occurrence or possible occurrence of flood, at the point of hazard and at downstream points and shall advise state administration and flood protection authorities of flood situation developments, give them reports necessary to evaluate it and instructions to manage flood protection measures.

Act No. 666/2004 Coll. is further supported by the following Slovak Government Decree and MoE Decrees laying down various SHMÚ obligations in more detail:

- *Slovak Government Decree No. 31/2000*

Given the gravity of the situation and the urgent need to cope with flood protection, MoE issued a document titled "Draft Systematic Solution to the Flood Protection and the Method of Funding Flood Consequences - Flood Protection Program by the Year 2010", including a set of scientific and technical projects and the Integrated Information System for the Flood Warning and Forecasting System of the Slovak Republic (POVAPSYS). The document was discussed by the Slovak Government and passed by virtue of Slovak Government Decree No. 31 of 19 January 2000).

- *MoE Decree No. 385/2005 laying down particulars of the performance of the forecasting flood service and of the reporting and warning service*

Pursuant to the Decree, SHMÚ provides daily reports and extraordinary reports via the Internet, by fax, phone or e-mail.

A daily report contains hydrometeorological information at "crucial" water gauging stations, hydrologic situation and forecasts (hydrologic situation developments) for the Slovak



Republic's streams. Daily reports are available to all state administration flood authorities on the Internet.

An extraordinary report is a warning against flood hazard, flood situation and flood occurrence; hydrologic reporting on the current situation on streams during the flood situation and warning flood reports. Extraordinary reports are issued if based on the meteorological forecast at the following hours and days strong precipitation, abrupt temperature rise and subsequent snow thawing and strong precipitation are expected at the following hours and days, if the formation of ice congestions is expected, and the like. An extraordinary report is broadcast with a frequency according to the state of the flood activity (3, 6, 12 hours).

- *MoE Decree No. 386/2005 laying down particulars of submission of continuous informative reports during floods and summary reports on course and consequences of floods and on measures taken*

A legal entity authorized by MoE, SHMÚ provides hydrometeorological background documents for continuous informative reports to state administration flood protection authorities and the administrator of streams of relevance to water management. Continuous informative reports are prepared during flood activity stages 2 and 3 under the established scheme whose paragraphs I.1. through I.4. are drawn up by SHMÚ. Other paragraphs of the scheme are drawn up by flood protection authorities and the stream administrator.

- *MoE Decree No. 384/2005 laying particulars of contents of flood plans, approval and update thereof.*

Developed by state administration flood protection authorities flood plans contain flood plans for protection and rescue works. SHMÚ draws up Annex 10 titled Specific Curves, containing specific curves for crucial and select auxiliary water gauging stations, graphic and written relation curves of water gauging stations, flood wave advance times tables indicating the time validity.

The development of local warning systems is interlinked with the POVAPSYS project, with is solving general flood warning problems in Slovakia within “Program of Flood Protection of Slovakia until 2010” approved and financed by Government of Slovakia. There are also other related projects especially in the framework of EU Community Initiative INERREG III B CADSES Neighborhood Programme:

- **HYDROCARE** – Hydrological cycle of the CADSES regions
- **MOSES** – Improvement of flood management system
- **FLOODMED** – Monitoring, forecasting and best practices for flood mitigation and prevention in the CADSES region



5. Inter-institutional collaboration

The competent authorities for flood protection in the Slovak Republic are:

- The Ministry of the Environment
- Regional and district environmental offices
- Municipalities.

Besides of these authorities Ministry of Interior, Ministry of Agriculture and other ministries and institutions are involved in the flood protection.

The Government of the Slovak Republic authorizes the Central Flood Commission and regional, district and municipal flood commissions by operation of law. The chairman of the Central Flood Commission is the Minister of the Environment, and the vice-chairman is the Minister of the Interior. The government appoints other members of the Commission at the behest of the chairman of the Central Flood Commission. The activities of the Central Flood Commission are derived from its own bylaws, which have been approved by the Slovak Government.

Under the Constitution of the Slovak Republic, all water bodies are owned by the state. The Slovak Water Management Enterprise is a state-owned organization dedicated to the satisfaction of the public needs, public policies concerning water bodies, water, and flood management and protection. The Slovak Water Management Enterprise is managed and controlled by the Ministry of the Environment of the Slovak Republic, and is part of the Water Section. The time schedule for the realization of flood protection measures are summarized in “Program of flood protection in the Slovak Republic until the year 2 010”.

Flood protection activities require a monitoring and information system, which is closely linked to the meteorological and hydrological forecasting and warning system of the Slovak Hydrometeorological Institute.

The Flood Commission manages and inspects the activities of all the bodies and organizations functioning in the flood protection system before, during and immediately after floods. One of the most important tasks of the Central Flood Commission is co-operation on flood prevention measures with Slovakia’s neighboring states (Austria, the Czech Republic, Hungary and Ukraine in the Danube River basin).

Each flood commission has a technical staff composed of expert, consultative, and executive teams. The head of the technical staff of the Central Flood Commission is the Director of the Water Courses Department of the Ministry of the Environment. The subhead of the technical staff of the Central Flood Commission is the President of the fire and rescue brigades. The members of the technical staffs in the regional, district and municipal commissions are representatives of the public authorities, the relevant river basin authorities, fire and rescue brigades, army, police, civil defense, health service and other experts, who are appointed by the head of the environmental office in the relevant territory.



Contingency planning, emergency measures planned

Flood Plans

The preparations for flood prevention are included in the flood plans. The flood plans are organizational and technical documents, which include the roles and responsibilities of the flood bodies, the river basin authorities and the owners and managers of the water structures, water equipment and other subjects involved in flood prevention activities.

A flood plan must be developed for every building or technological structure at or close to rivers and creeks. The river basin authorities organize the development of the floodplains according to the natural hydrological basins. The municipal governments as well as the district and regional authorities devise the plans for flood prevention work and salvage operations. The fire and rescue brigades develop their own plans of preventive work within a specified range.

The extent of the flood risk determines the order of the flood prevention activities:

- State of alert
- State of danger
- State of emergency.

The individual states depend on the water levels or discharges, which are defined for every section of the river according to the flood plans. A state of alert generally occurs when the water level rises above the river channel. The state of danger and state of emergency are proclaimed at the behest of the competent river basin authority with reference to the hydrological forecast:

- The mayor for the region of a municipality;
- The head of the district environmental office for several municipal regions;
- The head of the regional environmental office for the territories of several districts.

The state of alert is cancelled after the water level recedes into the river channel and when the water level stage has a decreasing trend. The competent authority cancels the state of danger or emergency when the reasons for its proclamation have ceased.

For the case study Vrbovce are relevant the following plans: Vrbovce municipality flood protection plan, Senica district, and Myjava district plans, and regional plans for Trnava and Trenčín regions because of the two level organizations – river basin and administrative functions.

Flood inspections

The goal of flood inspections is to detect defects in river channels and on floodplains, which might create a flood risk. The river basin authorities execute flood inspections in cooperation with other flood prevention bodies after every relevant flood episode or at least once a year. The owners, administrators or users of structures near the river must eliminate any defects by a stated time.

Patrol service

The patrol service follows up the evolution of a flood course directly on-site. The river basin authorities appoint a patrol service during a state of danger, and the municipalities appoint a patrol service during a state of emergency.

Flood prevention work

Flood prevention work represents a large complex of organizational and technical measures. Their purpose is the observation of a flood's route and the prevention of the occurrence of dangerous situations. The river basin authorities, which collaborate with the owners of structures near rivers in the execution and pursuance of this work, carry out flood prevention work initially.

Flood salvage operations

Flood salvage operations concentrate on rescuing the civilian population and the safekeeping and salvage of property on endangered floodplains, one component of which is the potential evacuation of

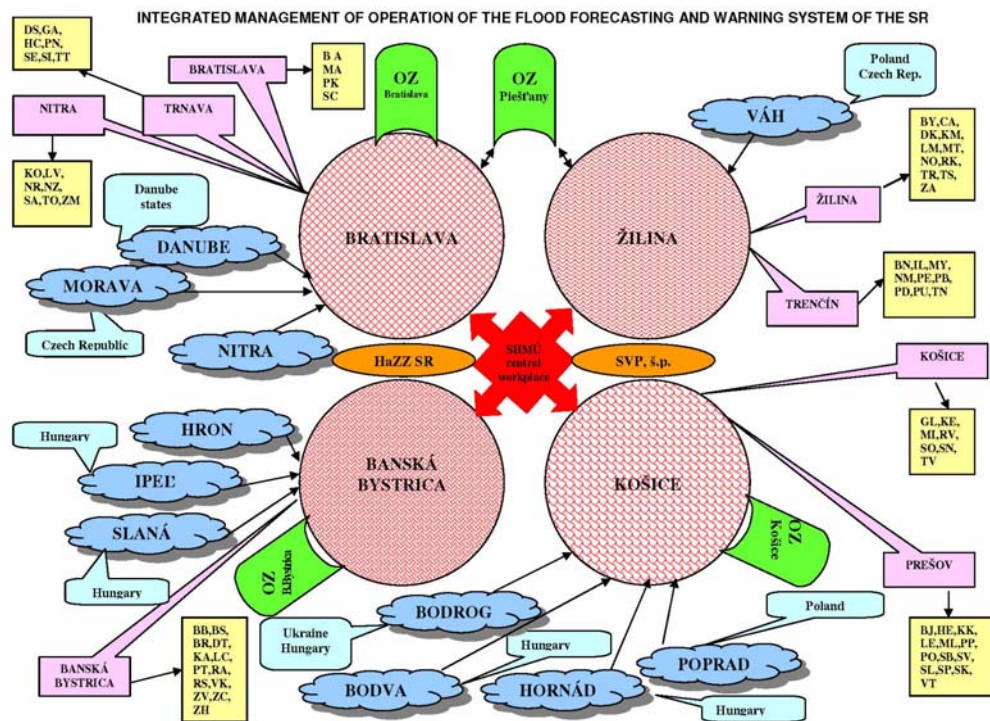


the population. Part of the salvage operations includes humanitarian, safety, sanitation and hygienic measures.

Because the majority of rivers flow from Slovakia or cross its territory, effective tools for cooperation are very important for flood protection.

6. Relationship with the national disaster management mechanisms

Several ministries responsible for national disaster management cooperate also in the flood protection activities. Ministry of interior and his Office for civil defense have the main responsibilities for disaster management in Slovakia. The interrelations of the flood warning system and other institutions are displayed in the following picture.



For pilot site Vrbovce following bodies are relevant:

- Central services of Slovak hydrometeorological institute, Slovak water management authority, Ministry of interior (civil protection and fire units), Ministry of Environment (flood protection unit),
- Regional offices for environment, civil protection, and fire protection
- District offices for environment, civil, and fire protection
- Municipality – mayor, and local government

The functionality of these relations was checked during flood event exercise in June.

There are official links from the centre to municipality, and local links based on Vrbovce information system that is working independently via mobile facilities.



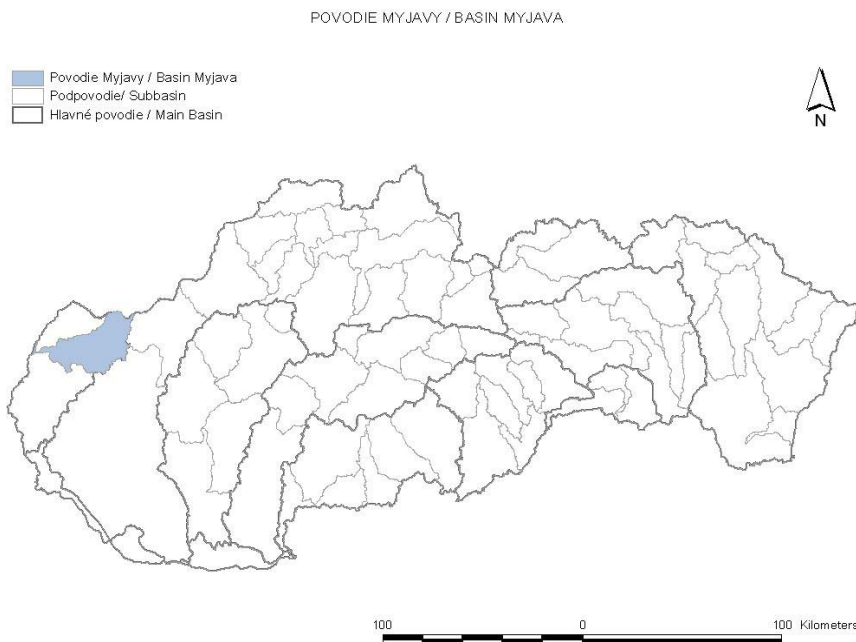
7. Technological aspects of forecasts (including links between local and national level)

Description of river basin

The Vrbovce village is situated in the Myjava river basin.

Almost the whole Myjava river basin (hydrological number 4-13-03), with an area of 745.12 km², is situated in Western Slovakia. The spring area of the Myjava river with an area of 0.850 km², as well as the spring area of its right side tributary Teplica with an area of 19.40 km² are both situated in the Czech Republic. The Myjava river basin is the sub-basin of the Morava river basin (26 580 km²) and occupies 2.8 % of its area. The Myjava river is the left side tributary of river Morava. The whole Morava river basin belongs to the Danube river basin.

The Myjava river runoff the water from the area delineated by the Biele Karpaty mountains (White Carpathians) (spring area) and Malé Karpaty mountains (Little Carpathians), southwestbound from their connection line. This area is internally formed Myjava hills and Borska Lowland. The estuary river Myjava into the river Morava is situated in Dolnomoravsky úval.



Orographic, geomorphologic and morphometric conditions

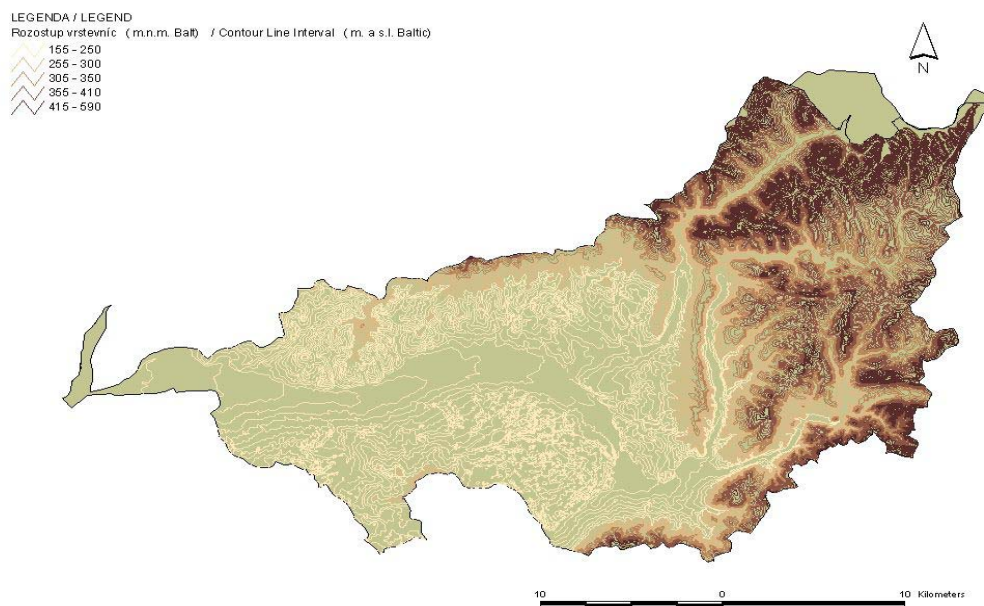
The described river basin is situated at the boundary of 2 main orographic provinces: Western Carpathians and Westpannonian basin.

The Westpannonian basin is the province of the subsystem Pannonian basin which, together with the subsystem Carpathians forms the Alp – Himalayan system. It is represented by one subprovince – Vienna valley. The Southmoravian basin area with the whole Dolnomoravský úval (Dolnomoravsky water cut) (estuary of river Myjava) is the part of the Vienna valley. It is another part of the Záhorská lowland. Here, the Myjava stream forms the Myjavskú plain, which has a character of a non-dissected plain. Southbound from it, there is the Borská lowland, it has got a lowland relief with an average slope 0 – 5°. Its centre is Lakšárska hills with a height going up to 297 m over the sea level. It is mean – medium dissected hill land. Northbound from the plain is the Gbelský Bor, a part of Borská lowland, which is copying the Dolnomoravský úval from the eastern side. The hill area Chvojnicka pahorkatina is situated eastbound from Gbelský Bor. Its central part, Zámčisko with its height of 434 m over the sea level does not fully correspond to the criterion “lowland”. The significant parts of Chvojnická



pahorkatina hills that belong to the Myjava river basin are its southern slopes – Unínska and Senická pahorkatina hills. It is a medium dissected upland from the morphometric point of view.

The Western Carpathians province is represented by both its subprovinces, i.e. Inner Western Carpathians and Outer Western Carpathians. The Inner Western Carpathians are formed by the Fatransko – Tatranska area represented by Little Carpathians. The northern part of the Myjava river basin is delineated by the White Carpathians which belong to the area of Slovak – Moravian Carpathians. They are the part of the subprovince Outer Western Carpathians. The White Carpathians enter the Myjava river basin with the southeastern part of Žalostínska upland, with its highest point Žalostinná 622 m over the sea level, and with the southern part of Javorinska highland with the highest point of the river basin – mountain Čupec 819 m over the sea level. The terrain is upland (mean to medium dissected) up to upland (medium dissected). The average slopes of the terrain are quite significant - 10 - 15°. The part of White Carpathians is the southbound Myjavská pahorkatina hills with Brančské Bradla hills – Bradlo 543 m over the sea level. It is formed by flat ridges, which are changing with valleys with the depth of 40 - 180 m. It is a very dissected hilly land up to very dissected upland. Little Carpathians enter the Myjava river basin with its northern part – Brezovské Carpathians (Klenová 585 m over the sea level). They have a middle mountain character with changing slope 5 - 30°. It is a very dissected hilly land up to very dissected upland.



Hydro-geological conditions

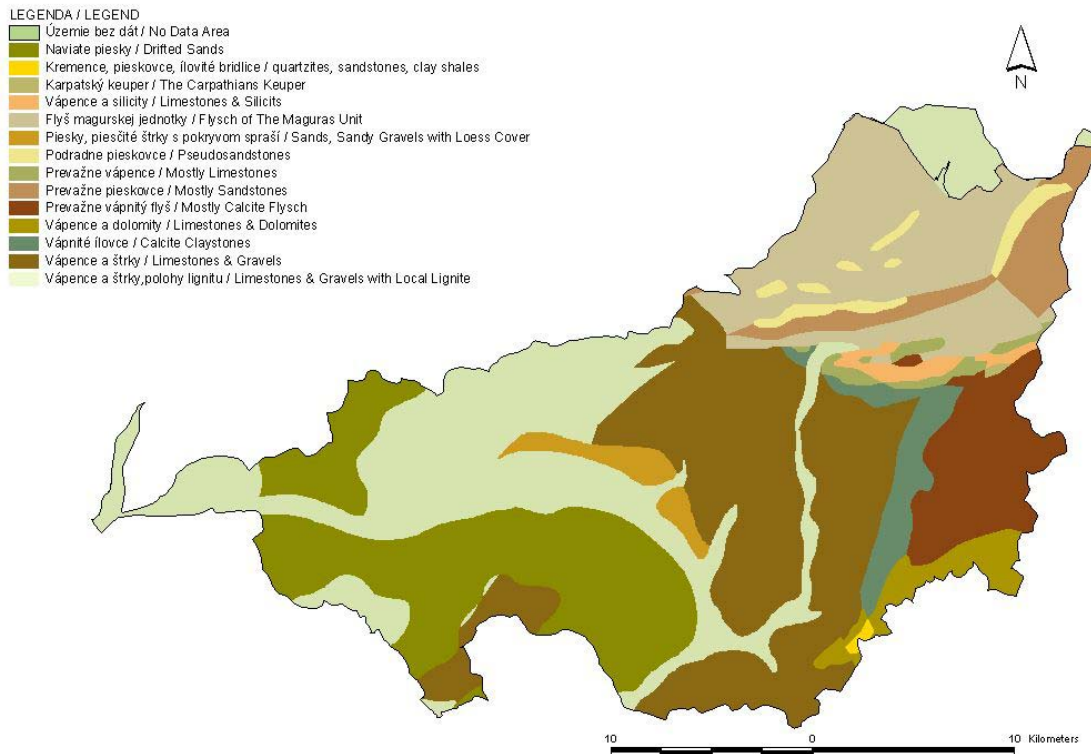
The White Carpathians are the outer part of flysch belt (paleocene – upper eocene), they are formed by sand stones, claystones, fine-grained conglomerates with very weak fissure permeability. Springs with changing yields occur.

Klippen belt is built by different rocks of klippens, like limestones, marlites, different sandstones, shales, uponlavské conglomerates and flysch co-layers obalu. Non-important aquifer with small springs with very much changing yield occurs.

Soil types in the area of Borska lowland are mostly regosols and Cambisol, locally in depressions occur also light gleys. They have a very small retention capacity and a very high permeability. In the area of Chvojnická pahorkatina hills prevail **hnedozeme kultizemné lokálne modálne a erodované, they mostly have a medium or high retention capacity with a medium permeability. **Na nive Myjav



sú čiernice kultizemné a fluvizeme kultizemné modálne, čiernice glejové a gleje ľahké. Here prevails a small retention capacity and a high permeability. In the area of Slovak-Moravian Carpathians and especially in the western part of Myjavská pahorkatina hills prevail modal Cambisols from grusses. Here prevails medium retention capacity and medium permeability. In the area of Brezovské Carpathians prevail **rendziny a kambizeme rendzinové, lokálne rendziny sutinové from grusses. Especially in southwestern part of Brezovské Carpathians occur also **luvizeme modálne. Here prevails a high retention capacity and a medium permeability.



River network

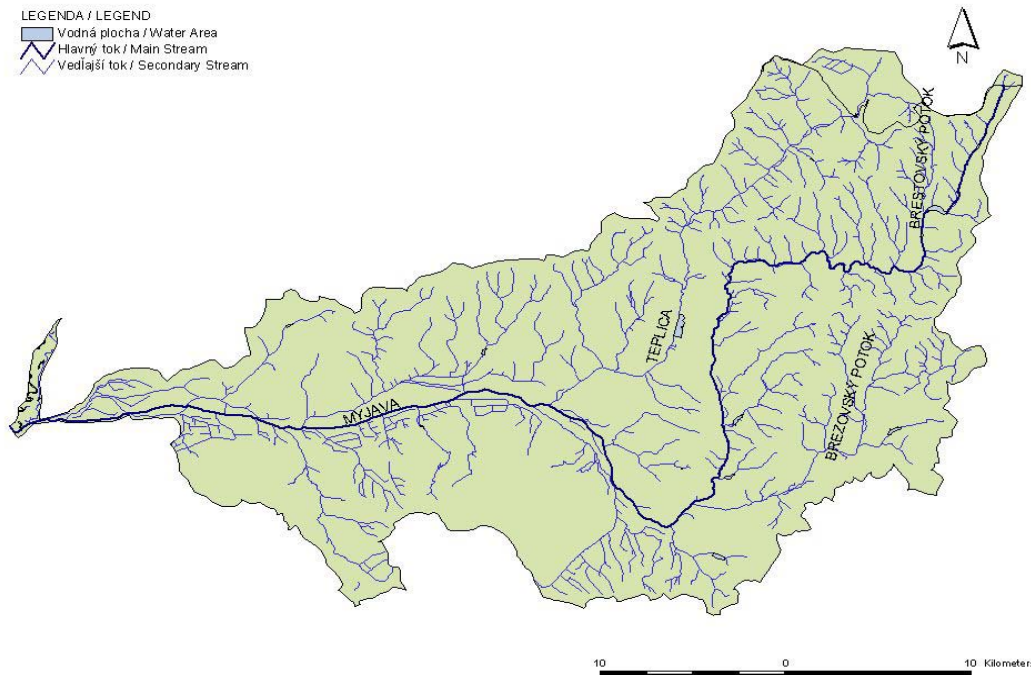
The river network is the result of historically developed geological and climatic conditions. It is characterised by its density and slope conditions, which also affect the runoff regime. The basic characteristics include the river basin area (F), the length of the stream (L), the index of development of the river network – shape of the river basin (F/L) and character of the river basin $\alpha = F/L^2$. They were derived following margins for α :

- - long shape river basins: $\alpha_1 = 0,07 - 0,24$
- Fan shape river basins: $\alpha_2 = 0,24 - 0,50$

The following table shows these characteristics for selected profiles in the Myjava river basin.

**Table. Characteristics of the river basin**

Stream – profile	F [km ²]	L [km]	F/L [km]	$\alpha=F/L^2$
Brestovecký creek – Brestovec	9,364	5,177	1,809	0,349
Brestovecký creek – estuary	9,364	5,180	1,808	0,349
Brezovský creek – Brezová p. Bradlom	35,86	8,300	4,320	0,521
Brezovský creek – estuary	86,13	19,825	4,345	0,219
Teplica – Sobotište	85,58	20,500	4,175	0,204
Teplica – Senica	152,01	31,500	4,826	0,153
Teplica – estuary	152,84	32,500	4,703	0,144
Myjava – Jablonica	238,45	40,60	5,873	0,145
Myjava – Šaštín-Stráže	644,89	63,820	10,105	0,158
Myjava – estuary	745,12	79,000	9,43	0,12



7.1. Meteorological systems

Meteorological terrestrial stations

Meteorological stations in number of 34 are fully compliant with the recommendation of the WMO. The program of observation includes the SYNOP messages, which are part of the international program of meteo data exchange. Such messages are extremely important for implication in meteorological forecasting due to the complex terrestrial meteorological information. This set of stations is also providing online information about the precipitation intensity and totals. Data are transmitted through the dedicated telephone lines. Within the POVAPSYS, seven new meteorological stations were set up. The network of meteorological stations will be completed by five additional stations.



Precipitation stations are equipped with the heated weighted type of rain gauge. Data are transmitted using GPRS (General Packet Radio Service) technology or satellite connection in localities without mobile operators signal covering. At the present time, a number of 72 new precipitation stations are in operation. Further 88 will be built within the POVAPSYS (Figure 8).

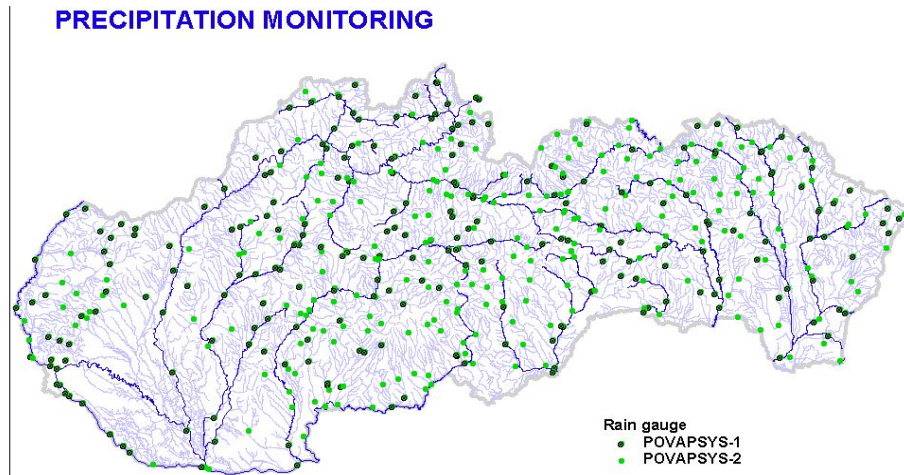


Figure 8. Real time precipitation monitoring

Station network in Myjava basin

There are 15 stations in the Myjava river basin, where basic climatic elements are measured. According to the type of climatic element, way of measuring and frequency of recording we distinguish following types of stations:

- **KKS – Classic climatic stations** are those, where meteorological quantities: air temperature, cloudiness, precipitation, sunshine, snow cover thickness, water value of snow are measured 3 times a day.
- **AKS – automatic climatic stations** provide data in 1-minute step. There are: precipitation total, precipitation duration, precipitation intensity, air temperature (2 m above ground), ground air temperature (5 cm above ground), relative humidity of the air, direction and velocity of the wind, duration of sunshine, snow cove thickness, soil temperatures.
- **ZAS – precipitation gauging automatic stations** measure precipitation totals with a one hour frequency.
- **ZKS – precipitation gauging classic stations** daily manually measure precipitation totals, kind of precipitation, snow cover thickness and water value of snow.
- **ASTA – automatic precipitation gauging stations** established in the autumn 2004, which only measure precipitation totals.

**Table. List of precipitation gauging stations in the Myjava river basin**

**indikativ	Station	Kind of station
11805	SENICA	AKS
11806	MYJAVA	KKS
15020	MYJAVA	ZAS, ASTA
15040	TURA LUKA	ZKS
15060	BREZOVA POD BRADLOM	ZKS
15080	JABLONICA	ZKS
15100	VRBOVCE	ZKS, ASTA
15120	SOBOTISTE	ZKS
15140	SENICA	ZKS
15150	ČASTKOV - HAVRAN	ZKS
15180	MIKULASOV	ZKS
15200	SASTIN-STRAZE	ZKS
15220	BORSKÝ JUR	ZKS

Meteorological radar data

Historical overview

At the Centre for Radar and Satellite Meteorology Malý Javorník measurements by meteorological radars started in 1972. At the beginning, the weather radar MRL-2 was used, later MRL-5 was installed and used for measurements of cloud top height, precipitation intensity and dangerous phenomena detection. Measurements were performed manually, by tracing the cloud echoes from the screen to paper sheets. The horizontal resolution of these measurements was 30x30 km², the resolution of the radar reflectivity 6 dBz and the resolution of the echo tops 0.5 km. The maximum range used for echo top measurement was 300 km and for precipitation 150 km.

A similar methodology was used also at the weather radar site Libuš in Prague. These two sites formed the first Czechoslovak weather radar network in the 1979-1993 period. Measured data were exchanged by means of long-wave facsimile transmitter. Compositing of the radar data was performed also only manually. Measured data and composite pictures were exchanged by means of a long-wave transmitter and distributed to various users.

The estimation of the precipitation intensity method consisted of the reflectance measurements on 1 km horizontal height level. Data interpretation from this level was distinguished according to the height of zero isotherm level compared with the elevation of the 850 hPa pressure-pattern. In the case of $H_{0^{\circ}\text{C}} > H_{850\text{hPa}}$, precipitation was classified as liquid, whereas the case of $H_{0^{\circ}\text{C}} \leq H_{850\text{hPa}}$ meant solid precipitation.

In April 1992 a new automated system for MRL-5 weather radars was completed and installed in the Malý Javorník and Kojšovská hoľa sites. Kojšovská hoľa was built as a new weather radar site in the eastern part of Slovakia. These two sites form the Slovak weather radar network at the present time.

Present technical situation

One Doppler weather radar type DWSR-98C has the full functionality since 1997 in Slovakia, it is located near Bratislava in the Small Carpathian region at Malý Javorník. Iiii = 11812, h=600 m+MSL, coordinates in S-JTSK [in meters] are x = -569068, y = -1268808.

The second existing weather radar site at Kojšovská hoľa (East Slovakia) Iiii = 11958, h = 1242 m+MSL. coordinates in S-JTSK [in meters] are x = -228212, y = -1231690 is equipped with the new Doppler radar RDR250-GC.

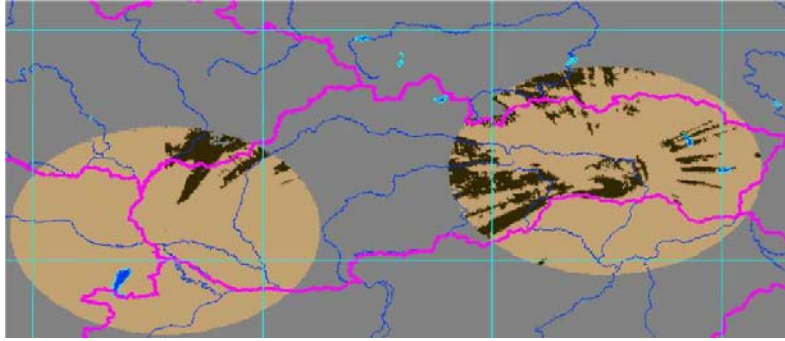


Figure 9. Two radars monitoring the Slovak Republic territory

Concerning the terrain and the shape of the country, two weather radars are not sufficient to cover the whole area even for the synoptic meteorology purposes. The most important condition for the weather radar site is a good clear radar horizon, free of obstacles.

The range of one radar for quantitative rainfall measurement and wind speed measurement is about 80-120 km for nowcasting and as much as 200-250 km for tracking storms. Precision is higher by single phenomena analysis, but by increasing density of sources (obstacles for the radar beam) for reflection (clouds cells) the precision is falling down with increasing distance from the radar station.

Within the POVAPSYS Project, the problem of the radar network optimization was analyzed. It was concluded, after the evaluation of all aspects, that the use of only two additional radar sites in the Central Slovakia would provide sufficient coverage for POVAPSYS objectives as it is shown in Figure 10.

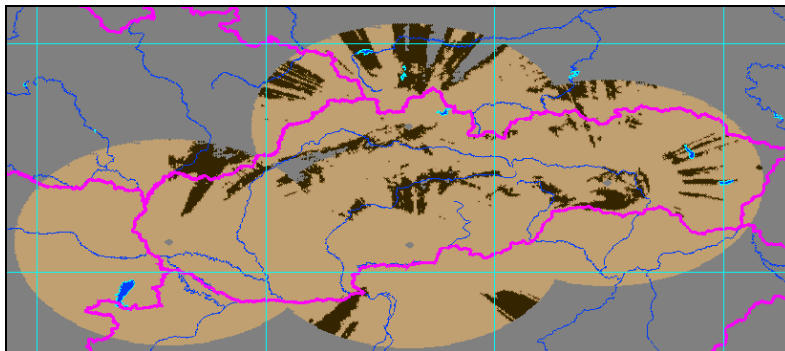


Figure 10. Four radars providing complete monitoring the Slovak Republic territory

Conclusions:

- The enlarged four weather radar network is necessary to ensure a reliable monitoring of both “long-term” intensive precipitation connected with stratiform cloudiness and short-term flash floods usually affecting small limited areas.
- The location of the two new weather radar sites should be based on the location study, not taking into account weather radar from neighboring countries. Only then, can timely information on possible flash flood conditions be obtained.
- For flash floods, the processing of the weather radar information should be nearly automatical; information about the expected risk level should be just verified before releasing the warning message.
- To develop a methodology for checking weather radar precipitation data for reliability, in accordance with WMO regulations and recommendations.
- Extended processing of full radar information to all 11 main river basins.
- (Pre-)processing of radar data at the central computer centre to the maximal possible extend.



Meteorological satellite data

At present, SHMU has *geostationary* satellite data at its disposal, with a resolution of 4 km at Slovakia's latitude (1-2 km near the equator). Since the source satellite is geostationary, the data are almost continuously available. Data from the *polar orbiting* satellites have a resolution of 1 km at each area of interest. However, they are available at that resolution only when the satellite is orbiting just above the Slovak territory. This gives at present the finest commonly used resolution for products generated from satellite data for hydrological purposes (probability of the rain fields, correction of other precipitation measurements – weather radars, snow cover distribution, etc).

The integrated and balanced information from the remote sensing is one of the conditions for improving the flood forecast in such a grid size, which could satisfy detailed precipitation nowcasting and forecasting for sub-basins related to all selected forecasting stations. It is therefore recommended that SHMU should have data receiving and processing facilities for both types of satellites.

A number of products based on satellite data for the detection of convective phenomena are available. Nowcasting tools based on the polar orbit satellite data can be used for improved detection and classification of convective clouds, automated tracking of their path and development of the cloud top temperature and the height during the cloud life cycle. SHMU currently operates some of the nowcasting tools on the basis of existing satellite and weather radar data. Further development is needed:

For creating satellite products useful for hydrological forecasts, the stationary and polar orbiting satellite receiving system is needed.

Computer hardware and software capacity at SHMU should be kept up-to-date to be able to receive and process the full content of satellite information for hydrological forecast purposes.

Improve and develop integrated processing of all available remote sensing information for nowcasting purposes.

SAFIR lightning detection system

Due to the fact that the system completing for the territory of Slovakia is improving quality of risky precipitation forecast for nowcasting by giving information about the possible occurrence of thunderstorm cells sooner than they are visible by radar, it is recommended to extend the SAFIR network with a fourth station and to upgrade the central processing station.

Meteorological models (precipitation nowcasting and forecasting)

In order to forecast weather and precipitation in particular from 0 up to 72h ahead, two meteorological forecasting systems are available at SHMU, nowcasting system and short-range forecasting system.

Nowcasting system (0 – 2 h)

Nowcasting represents analyses of actual stage of the atmosphere and forecast in the range of 0 – 2 h and is particularly important with respect to flash floods. At present, there is no specialized system and staff at SHMU that would deal with nowcasting only. The ALADIN model (see below) is not designed for nowcasting purposes. Warnings on severe weather phenomena are at present provided at the forecasting office subjectively. Available tools for quantitative information about potential weather hazards are missing.

At present, nowcasting is based on:

- monitoring the synoptical situation for possible conditions for extremely high precipitation intensities and totals;
- monitoring the radar and SAFIR results in risky situation in as short as possible time step;
- having an overview about the vertical instability of the troposphere in its full vertical extend (based on radio sounding by equipment transported by balloons and specific forecast); in case



that the “over-adiabatic” vertical temperature and air humidity gradient is expected or already observed, to start internally some higher alertness, and, if possible or already needed, to start shortening the time step in weather radar monitoring cycle;

- composition of an automatic evaluation of precipitation and
- investigation of threshold levels settings in precipitation intensities and/or totals (depth – area – duration analysis acceptable limits), exceedance of which would trigger a system of warnings

Short-range forecasting system (2-72h forecasts), LAM model

The crucial input into hydrological models is the quantitative precipitation forecast (QPF). The quality of standard meteorological precipitation forecast and/or forecast based on modeling, determines the quality of the hydrological forecast and consequently the quality of the flood forecast itself.

Short range QPF at SHMU is based on the high resolution Limited Area numerical meteorological Model “LAM” ALADIN since 1998. This model represents a calibrated localized modeling system, which is bounded in real time (4 times a day) with the global ARPEGE model running in the France meteorological service. The ARPEGE model provides the localized modeling system ALADIN with dynamic boundary conditions defining the general synoptical situation and pressure field forecast in reference points.

The model has a set of calibration parameters which have been optimized for modeled and measured precipitation on the territory of Slovakia. Since July 2004, the model is running on a high performance computer directly in SHMU Bratislava. It has a horizontal resolution of 9 km and is running for Slovak purposes with a time resolution of 1 hour (if necessary this can be reduced to 15 min) for QPF. The minimum size of a catchment for which QPF can be processed is given approximately by the resolution of ALADIN, or roughly estimated as 50 times the area of a grid square of 9 x 9 km which gives a size of around 4000 km² with current operational model.

The present areal extend used by the ALADIN model is shown in Figure 11a. Graphical presentation of the ALADIN forecast output is presented in Figure 11b.

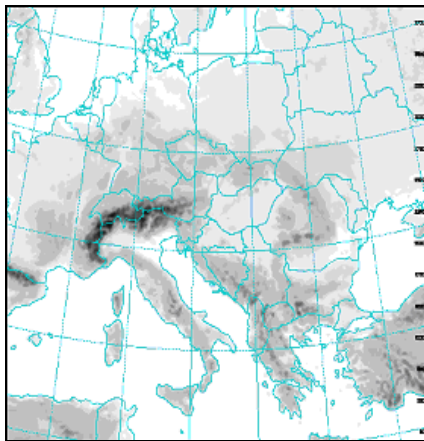


Figure 11a. ALADIN model domain and orography

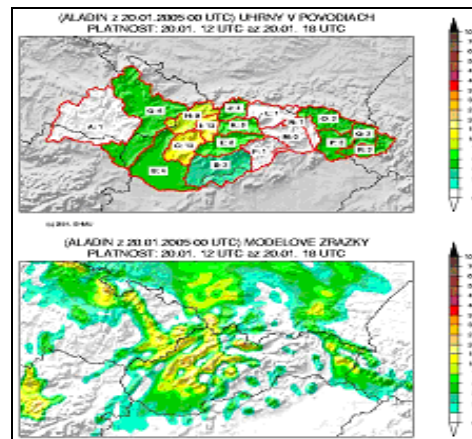


Figure 11b. Forecast of precipitation produced by ALADIN for selected regions

As already mentioned above, model ALADIN is used in SHMU regularly since 1998 and staff is not only familiar with usage of this model but takes part in the international co-operation on further development. This is a great advantage due to the fact that involved experts can approach individual subroutines to modify/improve any part of the model. The model is localized for the Slovak



orographical territory by calibration of set of parameters and is running (at present) 4 times a day. Operation of the model is managed in such a way that in case of hardware and/or software problems the technician on duty is obliged to overcome difficulties within 30 minutes, so it means that the risk of failure of the forecasting system is very low.

7.2. Hydrological systems

Hydrological data

Under Act on Waters, SHMU has been appointed by the Ministry of Environment as the professional organization responsible for monitoring the quantity of surface waters.

The selection of the stations of the monitoring network is determined by their location, their technical equipment, their representativity, and their physico-geographical conditions and purpose. Hydrological stations are proposed on rivers and at locations such that the monitoring network will reflect the hydrological regime of Slovak rivers in the best way and that the data obtained from it will be sufficient for the operational hydrological performance with regard to flood protection and other purposes (water balance, cooperation on border rivers, long-term evaluation of design characteristics etc.). Individual hydrological stations fulfill the general conditions for their installation such as optimal location in respect of the water flow in the riverbed, regular cross section, access to the station, availability of volunteer observer, distance to the settlements (protection against vandalism) etc.

At the hydrological stations where the discharges are quantified, regular direct hydrometric measurements by using the propeller-type current meter are performed. The measurements are carried out 5-6 times per year in each hydrological station, furthermore during extreme water levels, and in the case of border rivers, on the basis of international agreements.

The indicators of the quantity of surface waters are monitored in cross sections of hydrological stations, which are defined by the databank number, the hydrographic number, the river chainage, the catchment area, the altitude of the gauge datum and by the geographical coordinates. Apart from the listed indicators monitored at the hydrological stations it is necessary to monitor factors, which have an important influence on the status of surface waters: physico-geographical characteristics of catchments upstream of the hydrological stations (slope of the river, slope of the catchment, exposure of slopes, geological conditions, agricultural land use, forest coverage of basin etc.)

Hydrological stations are divided according to their purpose into:

- Hydrological forecasting stations – HPS
- Hydrological operational stations – HOS
- Hydrological regime stations – HRS

HPS

A number of 74 hydrological forecasting stations are daily in operation. On this basis, the hydrological situation on the Slovak rivers is daily issued. In flood situations, the HPS are decisive in accordance with the Act on the Flood Protection and the hydrological situation is evaluated at shorter intervals (12, 6, 3-hours) and alerts and warnings are issued. During flood conditions the peak water level and its time of occurrence are forecasted for the majority of HPSs. Within the POVAPSYS, HPSs were equipped with the new automatic data monitoring and transmission system. In addition, all HPS are operating by voluntary observers.

HOS

Similar to HPSs, hydrological operational stations are equipped with the automatic data monitoring and transmission system. Due to the economic reasons (telecommunication service fee), they were supposed to be in “sleeping mode” and only after exceeding set limits they indicate and issue the alert and change to active mode. Moreover, if an extreme precipitation activity is expected, these stations are activated into regular polling mode for the analysis of the hydrological situation. In the standard



situation they are polled only two times per month to supply the database with data and also to check their functioning. Recently, GPRS technology provided by mobile networks operators eliminated the economic problem, and data from some of the HOS stations are transmitting practically continuously.

HRS

The purpose of the hydrological regime stations is to collect river water level and discharge data which are stored in SHMU's historical database to be used for further elaboration: to characterize the hydrological regime of the river, for statistical analyses, to establish design values for planning purposes, etc.

As soon as the modernization of the hydrological network is finished (end of 2006), it will consist of 148 hydrological regime stations (HRS), 205 hydrological operational stations (HOS) and 79 hydrological forecasting stations (HPS), or 432 stations in total (Figure 12).

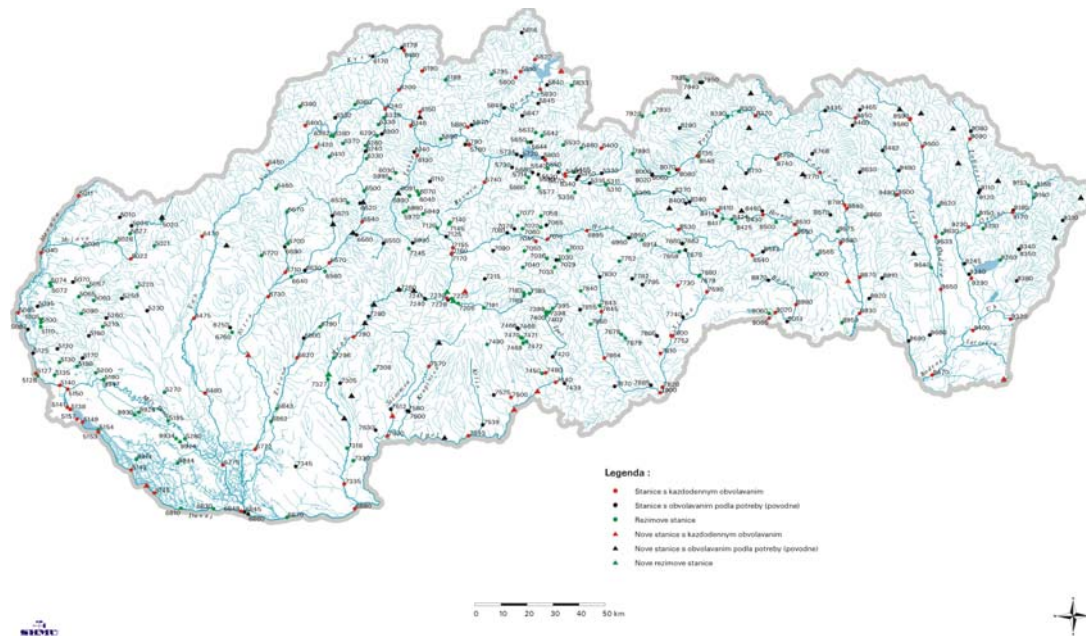


Figure 12. Hydrological monitoring

Hydrological conditions in the Myjava river basin

Network of hydrological stations

According to their way of use, we divide hydrological stations into operative stations and regime stations. Operative hydrological stations can be primary or secondary.

- Primary operative stations are those, which prepare 24-hour forecast of water level and flow, respectively prognosis of development of hydrological situation for 24 hours.
- Secondary operative stations are those, which have especially informative importance in the time of generation and duration of higher water levels (SPA). Water levels and flows are not forecasted for these profiles under normal conditions.
- Regime stations are used for the evaluation of hydrological regime and hydrological processes.

There are nine hydrological stations in the Myjava river basin. None of them is primary operative. Five stations are secondary operative and four are regime stations.

**Table. List of secondary operative stations in the Myjava river basin**

No.	Database number	Station	Stream	River KM	River basin area [km ²]	Height over the sea level "0" VDC [m]	Observation since the year		
							H	Q	T
1	5017	Brestovec	Brestovecký creek	0,003	9,364	342,69	2005	2005	2005
2	5020	Myjava	Myjava	72,20	32,02	324,34	1974	1974	
3	5022	Jablonica	Myjava	38,40	238,45	203,57	1980	1980	1980
4	5025	Sobotište	Teplica	12,00	85,58	236,29	1973	1974	
5	5030	Šaštín-Stráže	Myjava	15,18	644,89	164,25	1968	1969	1969

Table. List of regime stations in the Myjava river basin

No.	Database number	Station	Stream	River KM	River basin area [km ²]	Height over the sea level "0" VDC [m]	Observation since the year		
							H	Q	T
1	5021	Brezová p. Bradlom	Brezovský p.	11,5	35,86	259,37	1988	1989	1989
2	5023	Štefanov	Myjava	20,70	548,56	173,70	1922	1931	1961
3	5027	Kunov	Teplica	8,50	94,53	215,27	1992	1992	1992
4	5028	Senica	Teplica	1,00	152,01	188,50	1992	1992	1992

Hydrological forecasting

At present time, the hydrological forecasting service in Slovakia is functioning as a specialized department of the SHMÚ, the Department of Integrated Forecasting and Warning Service belonging to the Division of Integrated Management. In addition to the main centre for Hydrological Information and Forecasting Service (HIPS) in Bratislava there are three regional centers at regional offices of the Institute in operation: in Žilina for Northern Slovakia, in Banská Bystrica for Central Slovakia and in Košice for the eastern part of the state. The main centre in Bratislava is responsible for Western-Slovakia region and serves also as the coordinator for the whole territory of the state.

Presently, regular hydrological forecasts for the next 24 hours are issued for 15 hydrological stations and 9 water reservoirs. A 48 hours period forecast is issued only for the hydrological station Devín (Danube). Furthermore, during flood situations, forecasts are issued for almost all hydroprognostic stations (both peak time and water level). The Hydrological Information and Forecasting Service (HIPS) at the SHMU is equipped with several mathematical models and forecasting methodologies that are used for the issuing of the forecasts and warnings. The methods used range from the simple empirical relation to more sophisticated hydrologic or hydrodynamic models:

- Incremental method of H (IMH) – change in river level in upstream station is multiplied by the incremental coefficient and added to the river level in downstream station reflecting the travel time
- Incremental method of Q (IMQ) – change in discharge in upstream station is multiplied by the incremental coefficient and added to discharge in downstream station reflecting the travel time
- Peak Flow and Travel Time Relations (PFTR) – relationships between the river levels in upstream and downstream stations and travel time between two stations. For these relationships are used corresponding peak river levels.
- Corresponding Water Flows (CWF) – time corresponding water flows on the main stream and tributary reflecting the travel time for given hydrological station after confluence are



multiplied by the coefficient of the corresponding water flows and subsequently added, while the result is reflecting the travel time for this hydrological station.

- Rainfall – Runoff (R-R) (API) – multiple regression relation between precipitation amount in the catchments area for 24 hours, API for 10 days and increase of water level in the closing hydrological station of the watershed.
- Muskingum method (MM) – river routing procedure, conceptual hydrological model consisting of fictive homogeneous river reaches.
- NLN – river routing model, conceptual hydrological model consisting of cascade of fictive nonlinear reservoirs.
- Regression relations method (RRM) – relations between river levels and water flows in upstream and downstream hydrological stations based on the regression analysis.
- ERM – precipitation-runoff model, simple predictive algorithm with an efficient updating procedure (combined with the YETI 01 snow melting and accumulation).
- MIKE11 NAM – deterministic hydrological precipitation-runoff model with snow storage component.
- MIKE11 HD – hydrodynamic river routing model

However, the performance of the flood forecasting system is no longer sufficient to cover the needs of the operational managers (missing complexity, not user friendly, no possibility to change the frequency of calculations and repetition for different inputs, no possibility for graphical outputs, etc.). Moreover, hydrological forecasts are issued every day only for a limited number of hydrological stations and the lead time is generally 24 hours. In the case of flood events, mainly simple empirical relations (based on the travel times and related river levels) are used by HIPS to produce the forecasts. Therefore a significant role in the process of forecast development is the experience of the forecaster in charge. Furthermore, in the case of small river basins, methods for the hydrological forecasts have not (yet) been developed.

One of the main innovations of POVAPSYS is the improvement of flood forecasting methods by using adequate hydrologic models, reducing the uncertainty of flood forecasts and increasing the lead times of the forecasts for a large number of hydrological stations. It was decided to subdivide the territory of Slovakia into 11 main watersheds and develop complex forecasting systems for each of them by using the above-mentioned modular approach. Generally, it is expected to incorporate into the forecasting system several models either according to the hydrological processes (river reaches, rainfall-runoff, snow melting, etc.) or to the type (conceptual, physically based, simple, etc.).

8. Methodologies and tools for involving the local communities, including warning dissemination methods

Stakeholder participation including public is a crucial task of the flood information system. In particular, the cooperation between the respective civil defense services (e.g. fire brigade, police) and the local community disaster preparedness groups is important. According to several consultations with relevant stakeholder and mainly with the local authorities, the Slovak Hydrometeorological Institute organized the case study “Local warning System Vrbovce” as part of the project „Forward Integration of Flood Warning in Areas Prone to Flash Floods”, within the framework of the WMO/GWP Associated Programme on Flood Management (APFM).

Overall objective of involvement the local communities

Increase the awareness, preparedness and response capacity of the local authorities and population in flash flood prone pilot communities to forecasts and warnings issued by respective authorities in order to reduce the vulnerability of the affected population, and develop recommendations for integrated flood management

**Expected outputs**

- Local flash flood warning system in pilot community
- Dissemination of forecasts and warnings in user-friendly formats for different user groups
- Analysis of different scenarios, use and assessment of flood mitigation strategies with respect to specific climate variability, morphologies of the river basin and social context
- Increased capacity of the local municipality for flash flood management
- Guidance on public behavior in relation to flash flood (before, during and after flood)

Undertaken activities

- Concept of the nowcasting procedure for Vrbovce
- Description of the Pilot Basin including socioeconomic aspects
- Review of the current warning mechanism and system by a team of local representatives and flash flood experts and preparation of improvement proposals of the system
 - Local
 - National
- Organization of a planning and consultation workshop with local community with the aim to compile a plan a local flood warning system smoothly working in selected site, The workshop will include a participatory flash flood hazard mapping exercise based on the experience of local residents and the findings of SHMI. Definitions of roles and responsibilities of local stakeholders.
- Preparation of training materials and guidance for local population.
- Organization of a training and information event for local people on how to behave before, during and after flash flood
- Mitigation strategy for Vrbovce – possible structural and non structural measures
- Dissemination of results via various channels

8.1 Vrbovce case study for stakeholder participation

In the beginning of the APFM II project Vrbovce municipality was selected for active stakeholder participation in the case of flash floods. Several consultations mainly with the mayor of the village were organized in November and December 2005. A stakeholder meeting with all relevant parties from local Vrbovce communities and from all relevant agencies and services met in March 29, 2006. A similar meeting was organized in Lokca municipality on March 24, 2006. Serious flooding from snow melting and intensive precipitation happened accidentally during that day in Vrbovce and in neighboring villages.

Part of the workshops was dedicated to discussions and specification of responsibilities of local stakeholders and their coordination. Discussions with following stakeholders were evaluated:

- Municipality
- Civil defense unit
- Fire unit
- Water management authority
- Agriculture Company
- Farmers
- Sport club
- Hunting unit
- State forestry unit
- Folklore group
- In the case of Lokca several school teachers participated.



The discussions were organized on the stakeholder meeting according the following agenda:

- Opening and self introduction of participants
- Information about current flood event. Discussion concerning actual problems including cooperation of individual stakeholders and services.
- Information on APFM II project
- Hydrological information and forecasting service, warning system
- System POVAPSYS, local warning system
- Vrbovce local warning system
- Experiences from flash flood events in recent years in the area
- Mayor: experiences from operation of Vrbovce local warning system
- Discussion of local stakeholders on Vrbovce local warning system and flood problems
- Proposals for better cooperation of services and stakeholders
- Preparation of simulated flash flood event in June
- Summary and recommendations.

23 participants attended this stakeholder meeting. A common lunch was organized at the end of the meeting with informal consultations. Participants visited local hydro meteorological stations and the hydrological station upstream the village.

8.2 Local warning system (LWS) – information in brief

Vrbovce local warning system (developed together with Cierny Balog system in Slovakia) was designed in the framework of SHMI activities for the preparation of sample or standard solution of local flood problems during the year 2005. The aim was to prepare a system for application in flash prone areas on whole territory of Slovakia. The general principles are explained in the following text.

Goals of local warning systems: To provide the local authorities with sufficient lead time to warn about the origination of floods in small basins and to eliminate their destructive consequences.

The sensitivity of basins to the occurrence of flood extremes can be applied using “flood index” K

Selection of regions according to the “flood index” K criteria:

- Very sensitive $K = 30$ or more
- Sensitive at an interval of $K = 20 - 30$
- Less sensitive K at an interval of $10 - 20$
- Negligible sensitivity K of less than 10

Several criteria were considered in the selection of these basins:

- Sensitive regions according to K
- Climatological indicators such as the intensity of the precipitation, the mapping of any storms, etc.
- Locality of the basins: upper part of the Myjava basin – the western part of Slovakia, $K = 30$
tributary of the upper part of the Hron river basin – the Čierny Hron brook, $K = 20$

In the selection of a LWS, we followed the experience of the NOAA National Weather Service and selected an approach – Automated Local Evaluation in Real Time (ALERT) – favored by it. The system is based on a so-called one-way road – the warning is received by the coordinator/operator responsible for organizing any salvage operation. The system has been purchased and is being operated by villages, firms, small settlements, etc. A LWS contains the following:

- Equipment for monitoring a hydrometeorological network – remote
- Indicator equipment, monitoring network
- Communication system



- Local coordinator
- Models/scenarios for the hydrological response
- Municipal Flood Plan – rescue team’s work

Additional information, such as saturation of the basin, a radar estimate of the total precipitation, and any meteorological warnings can enter the system from SHMI.

Information from the monitoring network – automated stations with remote data transmission and a warning system for defining rainfall intensity and increases in water stages: Precipitation measuring stations and water gauge stations. Both kinds of equipment have to be installed to provide adequate information in space and time.

The communication system – data transmission via a radio network, GMS, etc., from the stations to a central PC - provides warnings by SMS message (and if possible) to mobile phones of certain users. It is possible to distribute SHMI products to the local centers.

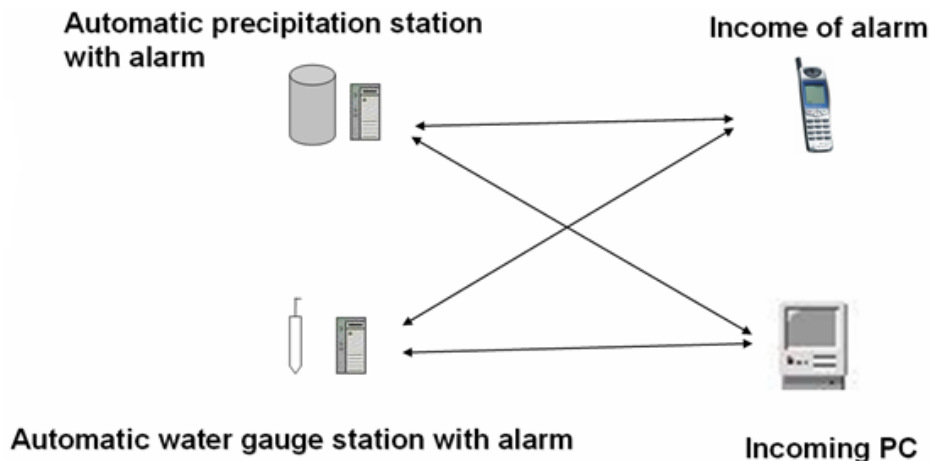
Control computer – data collection and archiving, adjustment of projection parameters.

Hydrological model / scenario – from inputs from a rainfall–runoff model:

- processing scenarios of responses for a basin
- outputs from the system – the basis for beginning any flood salvage operations according to the municipal flood plan

Local administrator – system coordinator – receives warnings and manages salvage operations, including humanitarian, safety, sanitation and hygienic measures.

The administrator supervises and controls the system operations.



Scheme of the Local Warning System

All information available for flood information users in Slovakia is available also for the Vrbovce pilot site. This information (actual measurements, evaluations and forecasts) is disseminated via public telephone networks and via Internet, and was used during flood exercise. Offices of the Ministry of interior (civil protection and fire protection) and Water management authority have other (not public) independent networks. These authorities are responsible to operate these information systems. Nevertheless, all these facilities can frequently collapse in the case of sudden events. The local warning system can operate independently.



The SHMI products for the LWS (not a necessary part) consist of:

- Monitoring the saturation of a basin (API) from precipitation
- Meteorological forecasting
- Quantitative precipitation forecast

Legal approach:

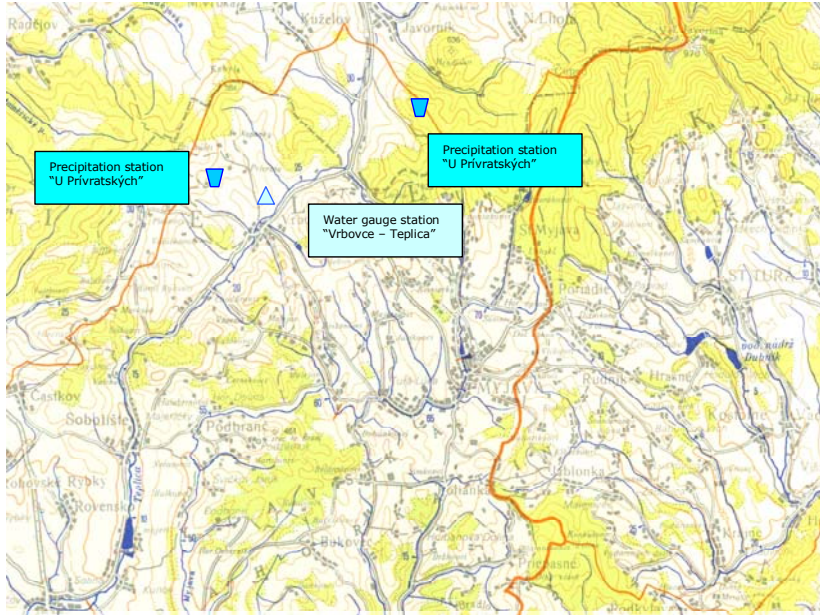
- LWS is loaned to a municipality for 5 years – (village, etc.)
- Maintenance and operation – financed by SHMI
- After 5 years, the system becomes the property of the municipality; further operations are financed by the municipality

Additionally, the alerts have given limits for both precipitation and water gauge stations as well and estimated maximum discharge Q (experimentally by T year Q) in different scenarios for API and precipitation.

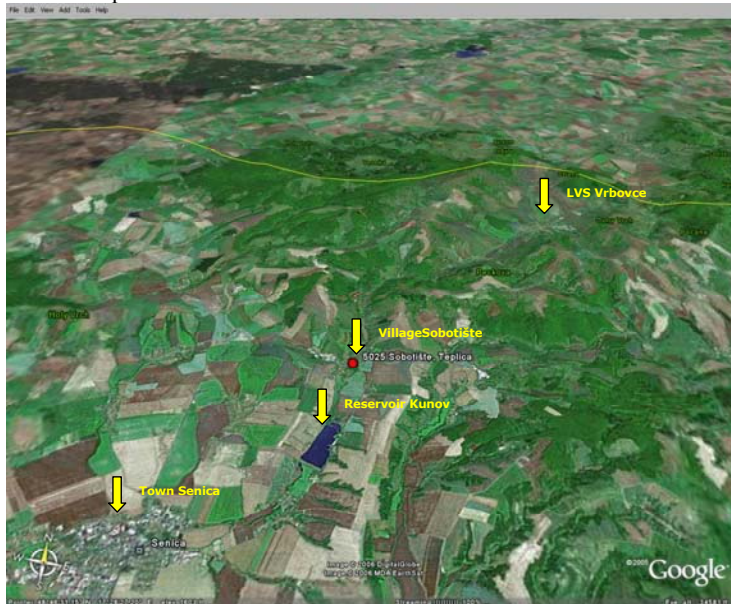
Implementation of local warning system in the village of Vrbovce:

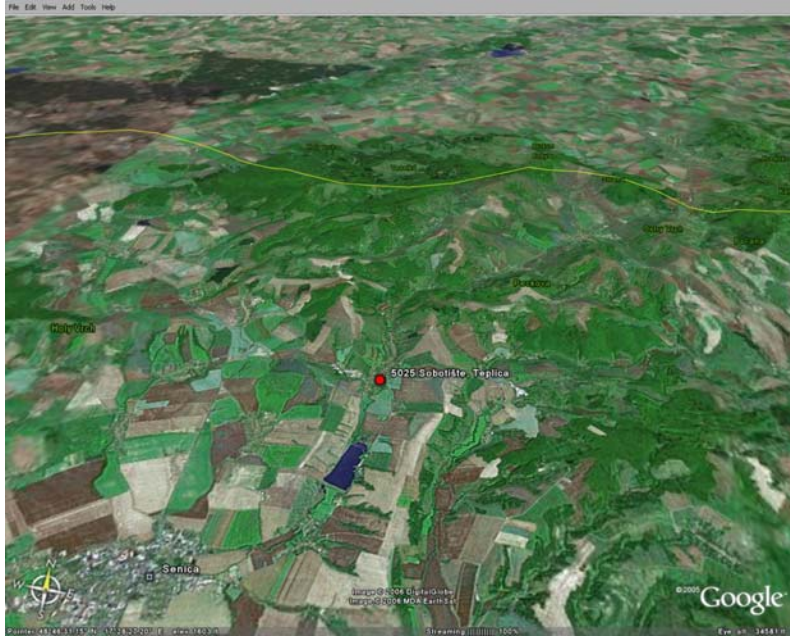
- 2 precipitation stations
- 1 river water gauge station
- 1 central unit.

Localization of stations are marked on the following maps:



Ortofotomapa





8.3 Vrbovce flash flood exercise June 11 to 12

The preparation of the exercise was initialized by Mr. Peter Rončák, Director General of SHMI via letter to directors general of governmental bodies responsible for the flood protection with the request of nominations of responsible persons. Also responsible persons of regional and local bodies were nominated. During meetings of these experts the preparation of scenario of flash flood simulation and organization aspects were the main goal. During the meeting on May 26, the final proposal was approved.

The exercise of individual services, authorities, local and regional stakeholders was organized during Sunday June 11th 2006 and Monday 12th June 2006. The main goal of the exercise was to check affectivity of information exchange and processing with special attention to local players. Each participating organization recorded individual steps during the event. Final evaluation of functionality of the system was done. In the Appendix 4 the event is documented. JPG files are available for web purposes. .

For the dissemination of information, several media were used, mainly local broadcasting, web pages, and National wide (public) TV I. The availability of this information for further dissemination is under preparation.

Scenario agreed in advance:

- Friday June 6, 2006: regular announcement – concerning forthcoming simulation event (general information that something can happen)
- Sunday June 11 (starting point for simulation), 2006 at 8:00 h. regular news service: because of precipitations during recent week, catchments are saturated and according to meteorological forecasts, following rainfall is expected:
First day 20 mm
Second day 40 mm
- Sunday June 11, 15:00 h forecast for the Bratislava region, Trnava, Trenčín for
Period 12.06.2006 08:00 to 12.06.2006 18:00 sums 40 to 60 mm
Warning



- Monday June 12, 2006 08:00 Standard message: catchment saturation was increased to Index of Recent Precipitation = 55. Forecast of rainfall:
First day 50 mm
Second day 10 mm
- Monday June 12, 2006 10:00: Forecast for the Myjava mountains area
Period 12.062006 10:00 to 12.06.2006 16:00 sums 60 to 80 mm
Warning
- Monday June 12, 2006 12:00 beginning of flash flood rainfall
12:01 LVS-Z1 rainfall warning
12:03 LVS-Z2 rainfall warning
12:20 water gauge station LVS-H warning
12:47 end of rainfall event (precipitation of 78.5 mm during 45 min)
13:15 Water gauge culmination
14:00 End of exercise
- Tuesday June 13, 2006 – regular evaluation and reporting

During exercise, all responsible services, authorities, regional and local stakeholder registered messages (received and produced) for evaluation purposes. Each participant evaluated the event separately and prepared proposals and recommendations for improvement of the system. Final summarization will be completed during the September meeting of cooperating parties.

From the preliminary evaluation it is clear, that the strengthening of the cooperation of regional offices is necessary, e.g. regional office of environment is not working during holidays. Anyhow the final recommendations will be organized during evaluation meeting in October 2006. All participants expressed the opinion that improvement of actions for case of flash floods is necessary although most of players were excellent.

During event on Monday the meeting session in Vrbovce was organized in parallel way to players working and simulating actions directly in the exercise.

9. Educational and awareness building

An essential part of the warning system of flash floods is among others the dissemination system. A proper dissemination system contributes to educational and awareness building. The National Hydrometeorological service is using the advanced technologies for forecasting floods and their distribution, to the flood management and to the general public. Dissemination of flood warnings has improved in recent years as well, largely in response to the enhanced coverage and attention of the local media (such as TV, radio, newspapers), which could have a direct communication with the Hydrometeorological service. Different arrangements for individual media were used for these direct communications.

Proactive preparedness programs remain indispensable for loss of life and flood damage reduction. Flood management and crisis management should take actions to educate the general public, regarding the occurrence and destructive force of the flash floods. These activities are essential to live with floods, due to facts that floods have been, are, and will occur. Flood management plans should be developed with direct involvement of the public participation.

In the case study, several local, regional and nation wide possibilities were used for dissemination of information, for rising the awareness and learning. During the workshop in Lokca, 16 participants - teachers from the area of flash prone area around Lokca discussed possibilities how to improve the



education process concerning water issues in general, and flood warning in special. The proposals for improvement of learning methods and timetable were developed. School representatives discussed problems together with municipality representatives that are responsible for education, according to the new legislation in Slovakia.

TV message during prime time documented the flood exercise in Vrbovce during June 11 and 12, 2006 was an excellent contribution in rising public awareness in the flood theme.

Three posters were prepared, printed and distributed:

- Importance of protection against floods (Appendix 5)
- Vrbovce – local warning system (Appendix 6)
- Ten steps for preparation for floods and flash floods (Appendix 7)

All posters are available in JPG forms for dissemination purposes.



10. Possible performance indicators for the proposed approach

When estimating efficiency of flood flash warning system it is necessary to examine the project costs and benefits from a broader economic and public benefit perspective. This means that not only direct system costs and benefits but also expected indirect impacts in other sectors of the economy and society as a whole are taken into consideration. The project is, in other words, assessed in regional and even national economy terms, not only with respect to several economic factors which are directly affected.

The most important benefit to society of the flood warning system is a better flood protection condition, allowing earlier and more appropriate preparations of both the public and the private sectors. The principal socio-economic benefit expected of the system is a reduced number of (substantially as compared with the previous flood years nearing zero) casualties due to floods, including savings on costs incurred by lost labor.

Similarly, the proposed approach is expected to cut the number of the injured and corresponding health costs and to a certain extent also the amount of flood damage and the loss of property during floods. This concerns public and private organizations and individual properties. The result of the longer lead time of a forecast is the possibility of avoiding some costs from economically productive time losses, although the system net impact on this variable is limited.

11. Sustainability of the process

The proposed approach will ensure the sustainability of the considered objectives by bringing together a broad range of partners (local municipalities, state agencies, water management organizations, NGOs and enterprises). Partners involved in the sophisticated system will benefit from the program activities, leading to the improvement of their institutional arrangements and thus ensuring for sustainability of program results.

Positive experiences in Vrbovce influenced people in the village to keep the concern in protection of lives and property against floods. They found out that small amount of investments and operation costs can significantly improve their possibilities to be ready for actions. Several mayors of other municipalities expressed their intention to introduce such warning systems. SMI can support such approach in the framework of some projects.

Several other municipalities participated on the project mainly during the March workshop and June exercise. Especially neighboring mayors were active in discussions. E.g. Sobotište village located downstream Vrbovce directly participated to the events. Posters and other materials were distributed in these villages. The necessity to distribute project materials to broad audience of Slovakia was declared in final conclusions of those meetings.

12. Proposed national outreach strategy

The proposed strategy is fully in accordance with the SHMI policy. Experiences from the stakeholder participation approach used in the project will be applied in other areas of Slovakia.

The development of local warning systems is interlinked with the POVAPSYS project, which is solving general flood warning problems in Slovakia within “Program of Flood Protection of Slovakia until 2010” approved and financed by Government of Slovakia.

There are also other related projects, especially in the framework of EU Community Initiative INERREG III B CADSES Neighborhood Programme:

- **HYDROCARE** – Hydrological cycle of the CADSES regions



- **MOSES** – Improvement of flood management system (Romania, Hungary, Ukraine, Germany are partners of the project, Slovakia plays the role of Lead Partner)
- **FLOODMED** – Monitoring, forecasting and best practices for flood mitigation and prevention in the CADSES region

Especially MOSES could contribute to follow up positive experiences of the APFM II project in much broader extent in Slovakia and in partner countries (project budget is 2,02 mil. EUR. The main focus of the project is Implementation and management including further development and adjustment to the local situation of a unified GIS based digital flood information management system in the region capable for managing on line hydrometeorological and hydrological data by selected forecasting and scenario analysis models. Dissemination of reliable flood information on two levels: expert and system info layers for organizations obliged by law to perform emergency operation and management activities to the public, professionals and organizations as well as to the media.

In the framework of the MOSES project there are important working packages:

- WP 3 External coordination, tuning to other projects and initiatives in field of flood management
- WP 4 Implementation (application of individual activities)
- WP 5 Dissemination (developing and implementation of strategy for dissemination flood information)
- WP 6 Evaluation

The MOSES follow up of the APFM II activities can significantly extend positive results rising from Vrbovce case study in Slovakia and cooperating countries. The MOSES web page is under preparation. The link for cooperation within the framework of APFM will be ensured.