L J U B L J A N I C A   C O N N E C T S

LIFE10 NAT/SI/142

HYDROLOGICAL MODEL

Action: A3

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TABLE OF CONTENTS

DESCRIPTION OF THE LJUBLJANICA RIVER BASIN

The Ljubljanica river basin is a part of the Sava river basin and covers an area of 1883,78 km2, which represents about 9 % of the Slovenian territory.

The Ljubljanica is a typical karst river with mainly karst hinterland which consists of significantly cracked, porous, carbonate rock (limestone and dolomite). Only the northern part of the basin consists of non-carbonate rock. Because of the geological structure of the area the rivers are short and flow in the underground, which is also the reason for lower drainage density (0,98 km/km2).

Ljubljanica karstic hinterland collects waters from higher valleys, karst poljes and plateaus interconnected with underground streams. Some of the streams can be seen in the caves Golobina, Križna cave, Karlovica, Zelške caves, Tkalca cave, Planina cave, Postojna cave, Predjama, Logarček, Gradišnica and Najdena cave. Since the complete water course includes rivers wearing different names, it has been poetically named the river with seven names.

These are:

1. TRBUHOVICA springs at Prezidsko polje in Croatia. High waters sink at Babno polje.
2. OBRH flows over Loz valley, sinks there and wells at Cerkniško polje again.
3. STRŽEN sinks at Cerkniško polje, where also Cerkniščica flows from north and waters from Bloke plateau are added underground.
4. RAK flows through Rakov Škocjan, it has a confluence with river Pivka in Planina cave.
5. PIVKA flows over Pivka basin, through Postojna cave, it has confluence with river Rak in Planina cave.
6. UNICA is formed in Planina cave by confluence of rivers Pivka and Rak. It flows over Planinsko polje.
7. LJUBLJANICA wells near Vrhnika, flows through southern part of Ljubljana river basin, crosses Ljubljana moors, flows through Slovenian capital Ljubljana and into the river Sava near village Podgrad. Its slow course is only 41 km long.

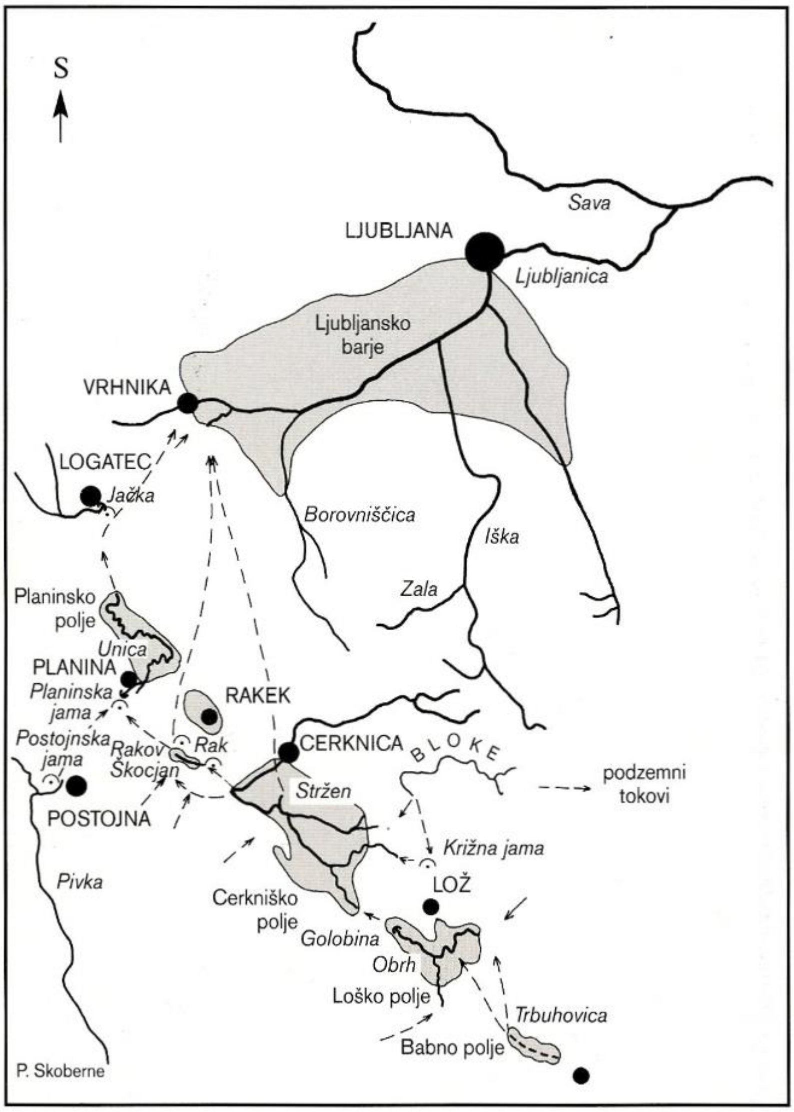


Figure 1: A simplified sketch of the Ljubljanica river basin

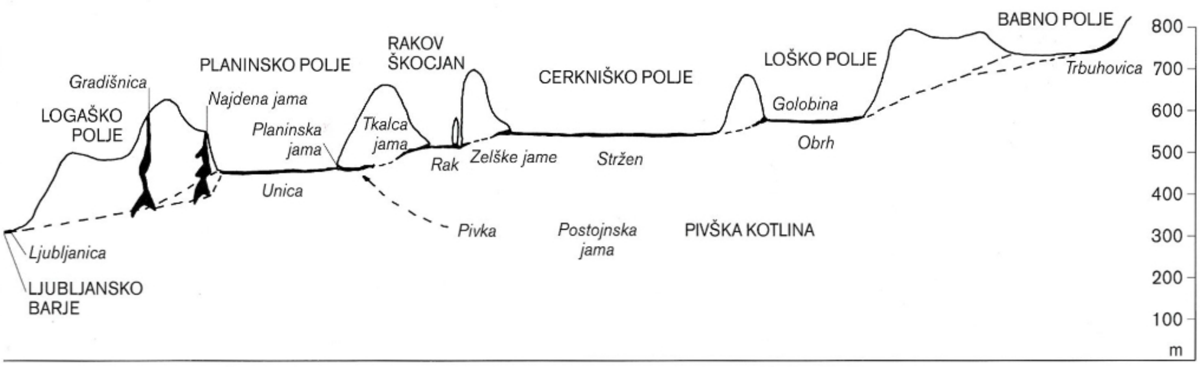


Figure 2: Cross section of river Ljubljanica system from Prezid to Vrhnika

According to the Watershed coding system of the Republic of Slovenia the Ljubljanica river basin is divided into 8 subareas:

Table 1: List of sub-basins according to the Watershed coding system of the Republic of Slovenia

Code	Name	Area (km^2)
141	Cerkniško jezero	270,42
143	Javorniški tok	278,12
144	Pivka z Nanoščico	234,14
145	Unica	231,99
146	Logaščica	83,13
147	Barjanska Ljubljanica	467,72
148	Gradaščica	158,82
149	Mestna Ljubljanica	159,45

The elevation of the basin is between 300 and 1300 m above the sea level. Most of the surface is covered with forest, except the areas of Barjanska and Mestna Ljubljanica, where the percentage of forest coverage is less than 50 %.

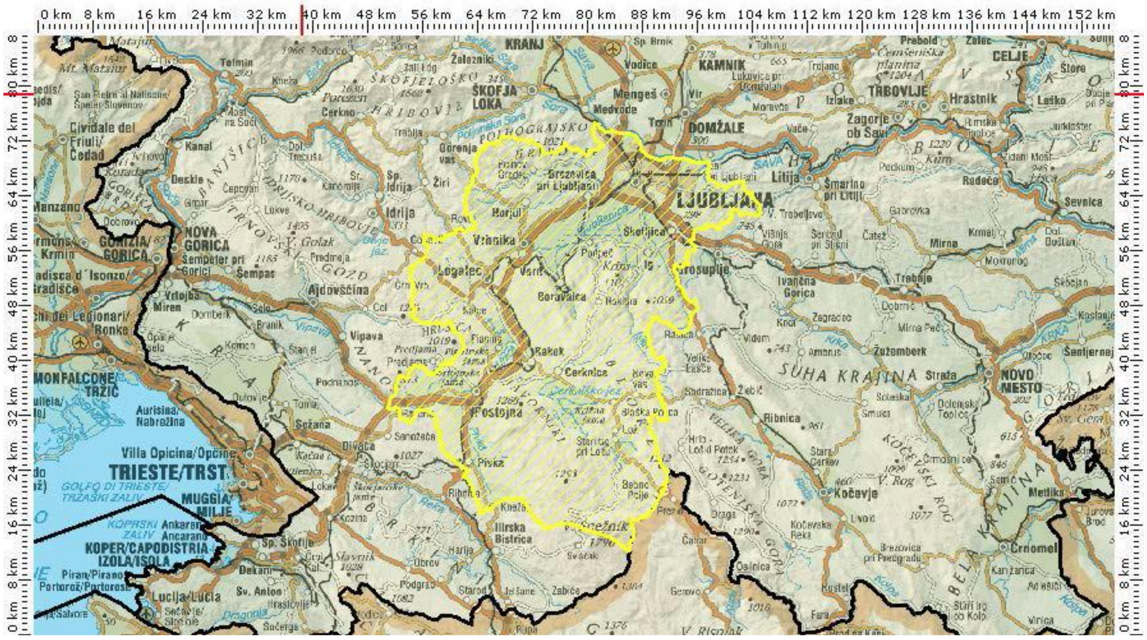


Figure 3: Area of the Ljubljanica river basin

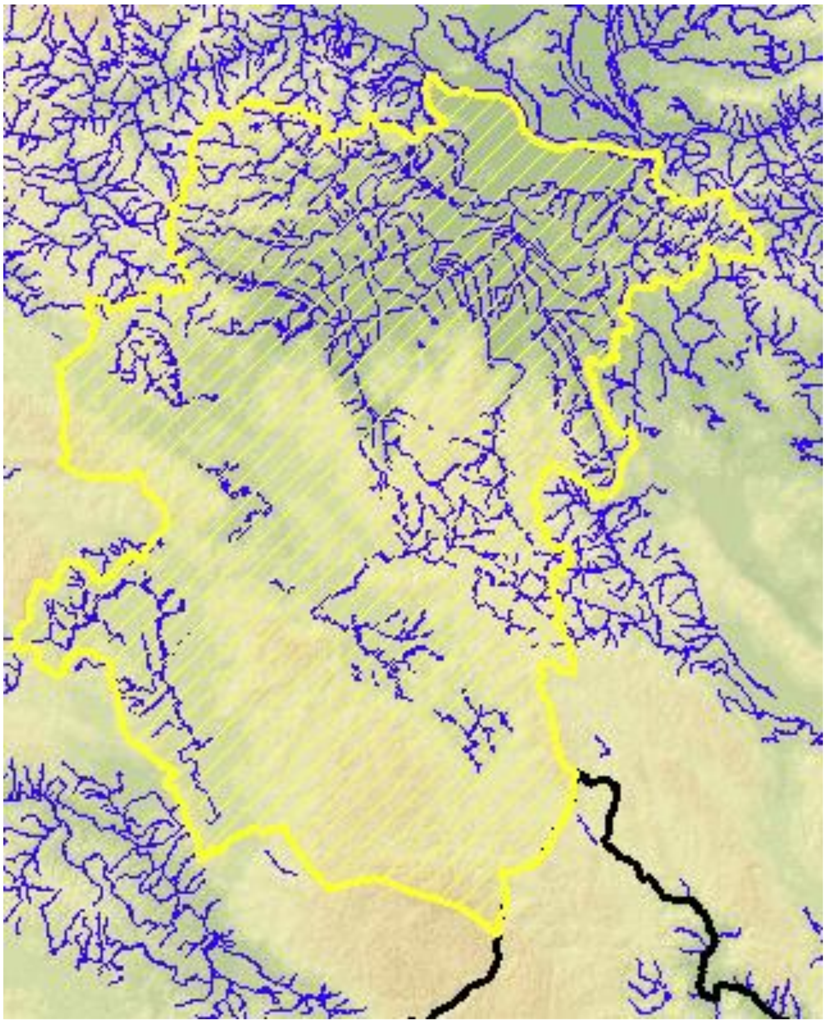


Figure 4: The Ljubljanica river basin with all tributaries

HYDROLOGICAL MODEL OF LJUBLANICA RIVER BASIN

Description of the HBV model

The HBV is a conceptual hydrological model for continuous calculation of runoff. It was originally developed by the water balance section of the Swedish Meteorological and Hydrological Institute (SMHI) to predict the inflow of hydropower plants in the 1970s. It can be used as a fully-distributed or a semi-distributed model by dividing the catchment into sub-basins. The HBV model consists of four main modules:

(1) Snowmelt and snow accumulation module;
(2) Soil moisture and effective precipitation module;
(3) Evapotranspiration module;
(4) Runoff response module.

Sub-basins of the Ljubljanica river basin

For the requirements of the model the Ljubljanica river basin is divided into 6 sub-basins with areas ranging from 83,13 km^2 to 744,25 km^2 (Table 2). The sub-basins are linked together and the outflow from the upstream ones is routed through the downstream ones.

Table 2: List of sub-basins and areas

Sub-basin number	Sub-basin name	Sub-basin area (km2)
I	Cerkniško jezero	270,42
II	Kras I	83,13
III	Kras II	744,25
IV	Ljubljanica I	467,72
V	Gradaščica	158,82
VI	Ljubljanica II	159,45

Figure 5: The Ljubljanica river basin with sub-basins

Geographical zones

The sub-basins are divided into elevation and vegetation zones. There is only one elevation zone for each sub-basin and two vegetation zones according to land coverage: forest and field (non-forest) (Table 3, Figure 3).

Table 3: List of sub-basins divided into geographical zones

Sub-basin number	Sub-basin name	Mean elevation (m a.s.l.)	Forest (km^2)	Field (km^2)
I	Cerkniško jezero	717	135,21	135,21
II	Kras I	628	58,19	24,94
III	Kras II	735	595,40	148,85
IV	Ljubljanica I	479	210,47	257,24
V	Gradaščica	518	79,41	79,41
VI	Ljubljanica II	264	55,81	103,64

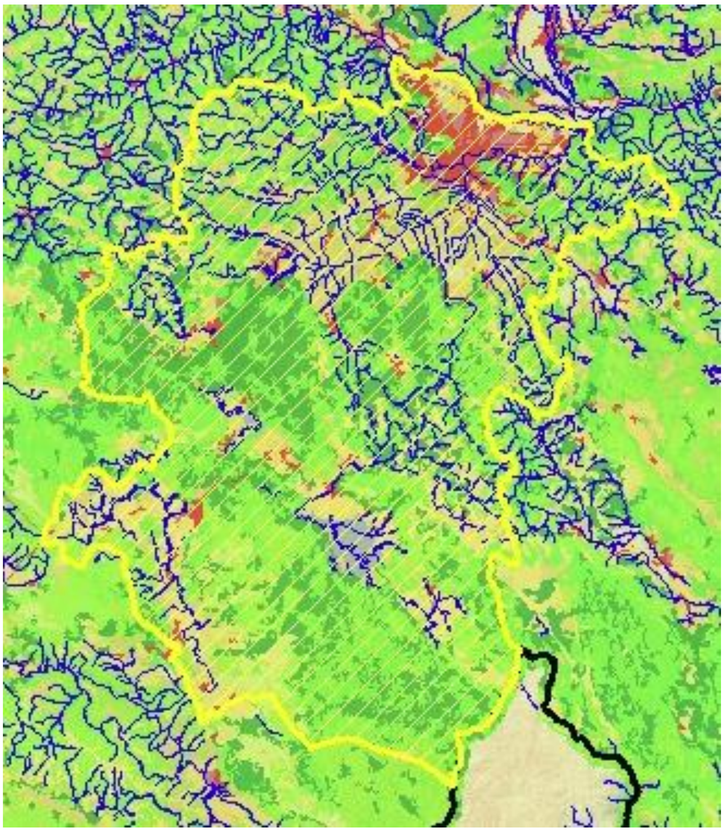
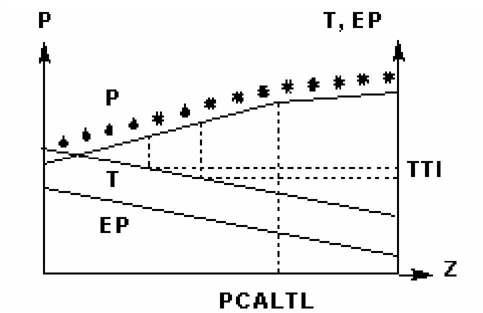


Figure 6: The Ljubljanica river basin (with forest coverage - green color)

The division into elevation and vegetation zones is especially important for the snow calculating routine. The routine is best described with the schematic chart below:



Z = Elevation,

PCALTL = Threshold for altitude correction,

P = Precipitation,

T = Temperature,

EP = Potential evapotranspiration,

It is based on the simple degree–day relation. In this routine, a threshold temperature (TT), which is usually close to 0° C, is used to define the temperature above which snow melt occurs. The threshold temperature usually decides whether the precipitation falls as rain or as snow. Within the threshold temperature interval (TTI), the precipitation is assumed to be a mix of rain and snow (decreasing linearly from 100% snow at the lower end and to 0% at the upper end).

Snow melt and water refreezing is calculated according to:

Snow melt = CFMAX · (T-TT)

Refreezing melt water = CFR · CFMAX · (TT-T)
Where:
CFMAX = melting factor
CFR = freezing factor
TT = Threshold temperature

The snowpack is assumed to retain melt water as long as the amount does not exceed a certain fraction (given by the parameter WCH) of the snow. When the temperature decreases below TT, the water refreezes according to the formula above.

Different melting and refreezing factors are used for forest and non-forest zones.

Input data

The following input data are required to calibrate/run the model:
- precipitation
- temperatures
- discharge data
- potential evapotranspiration

The temperature and precipitation data were prepared as a set of data with a one-day time-step. The time-step of evapotranspiration data is usually greater than that of the model. So a transformation to the model time-step is required. This is done automatically by the model. In this case average monthly values (mm/day) are transformed to the one-day time-step by linear interpolation and then modified by the ETF factor using the formula:

potential evapotranspiration = $E_{pot} * (1+ETF*(T-T_{norm}))$
where E_{pot} is the standard value of potential evaporation, T is actual temperature and T_{norm} is normal temperature for the current day of the year.

To describe areas of influence of points (which represent different stations) Thiessen polygons are used.

Table 4: List of temperature and potential evapotranspiration stations

Station name	Station number	Elevation (m a.s.l.)
Postojna	136	533
Ljubljana	192	299

Figure 7: The Ljubljanica river basin with temperature and potential evapotranspiration stations and Thiessen polygons.

Table 5: List of precipitation stations

Station name	Station number	Elevation (m a.s.l.)
Postojna	136	533
Hotedrščica	146	550
Rob	151	510
Sveti Vid	152	851
Cerknica	160	576
Smarata	162	580
Šentjošt (Horjul)	181	590
Črni vrh	186	830
Ljubljana	192	299
Črna vas	195	288
Želimlje	199	309
Prežganje	204	635

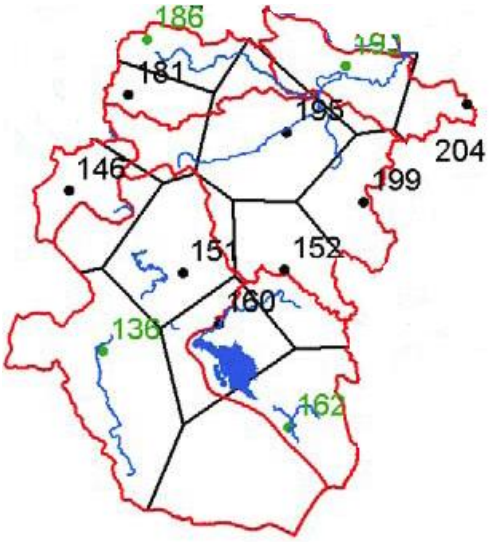


Figure 8: The Ljubljanica river basin with precipitation stations and Thiessen polygons

Table 6: List of discharge stations

Sub-basin name	Water station	WS Code
Gradaščica	Dvor	5500
Ljubljanica II	Moste	5080

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