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Climate change impacts on hydrological processes and river flow regime in the Danube including quantification of scenario uncertainty

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Climate Impacts & Vulnerabilities – Reseach Domain II

INTRODUCTION

The Danube river is the second longest river in europe and drains an area of about 810400 km^2. It starts its journey in the Black Forest Mountains in Germany and empties into the Black Sea via the Danube Delta in Romania and Ukraine.

Both increases and decreases of discharge are generally considered to be detrimental for aquatic ecosystems. As Europe's largest remaining natural wetland, the Danube Delta maintains an enormous biodiversity. Many of the species that live within the static freshwater ecosystems of the delta are unique to it, but its ecosystems are affected by changes upstream the Danube River.

Future discharge changes of the Danube due to climate change are still unclear.

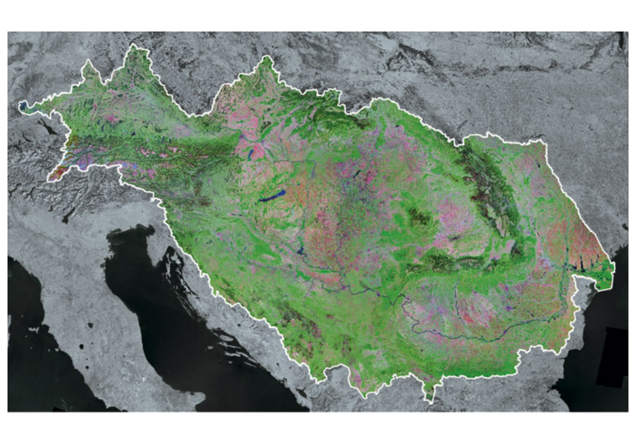

Fig. 1 Danube drainage basin area

METHODOLOGY

To quantify possible impacts of climate change on the Danube's discharge rates and flow regime, the eco-hydrological model SWIM (Soil and Water Integrated Model) is applied to simulate daily time series of river discharge. SWIM (Krysanova et al. 2000, PIK-Report, H.69) is based on the SWAT model.

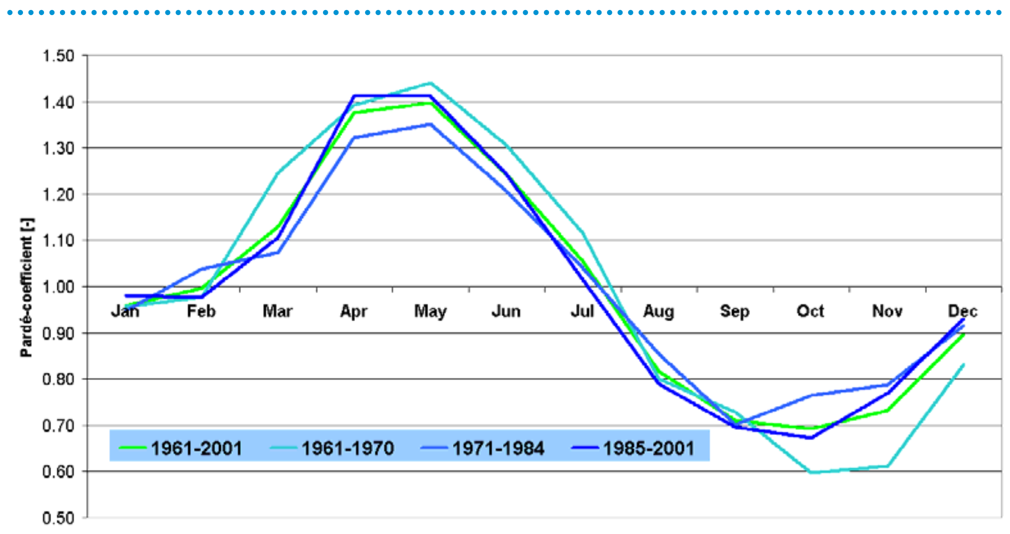

Fig. 2 Characterization of streamflow regime at Danube Delta inlet – Pardé diagram for the Lower Danube (gauging station Ceatal Izmail)

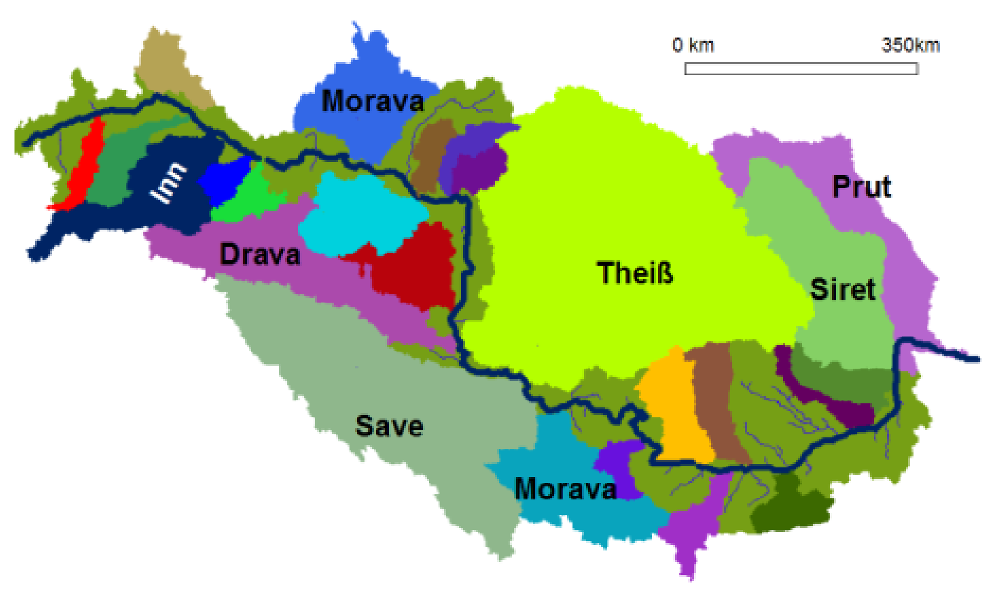

Fig. 3 Major subbasins of the Danube

The first model set-up includes the whole Danube basin with 266 subbasins and 11810 hydrotopes. The current model is calibrated for the period 1960-1971.

In further steps the model calibration and validation will be conducted for the major sub-catchments (Fig. 3, Fig. 4).

Natural flow regime is influenced by hydraulic structures (above all Iron Gate I Dam (1972) and Iron Gate II Dam (1985), as well as intense water use.

River flow regime

A river flow regime describes the average seasonal behaviour of flow and reflects the climatic and physiographic conditions in a basin. Differences in the regularity of the seasonal patterns reflect different dimensionality of the flow regimes, which can change due to changes in climate conditions. The monthly Pardé-coefficients are used to describe the annual distribution in discharge.

Pardé-coefficients are defined as:

$$PC_{m,a} = \frac{Q_{\text{mean month}\; m,a}}{Q_{\text{mean annual}\; a}} \qquad \text{m : month; a : year}$$

For the Lower Danube river flow regime, the spring/summer high-water flow contributes around 51% to the total annual flow discharged into the Black Sea (Fig. 2).

Quantification of climate change impacts

In Europe, impacts on water resources due to climate change are among its main concerns. Slight impacts on the water balance can already be observed (Fig. 5).

For this study climate data from various regional climate models based on different global climate models and scenarios are used as input for SWIM (Fig. 6). The results serve to quantify the range of scenario uncertainty providing probabilistic estimates of climatic risk.

Fig. 5a)

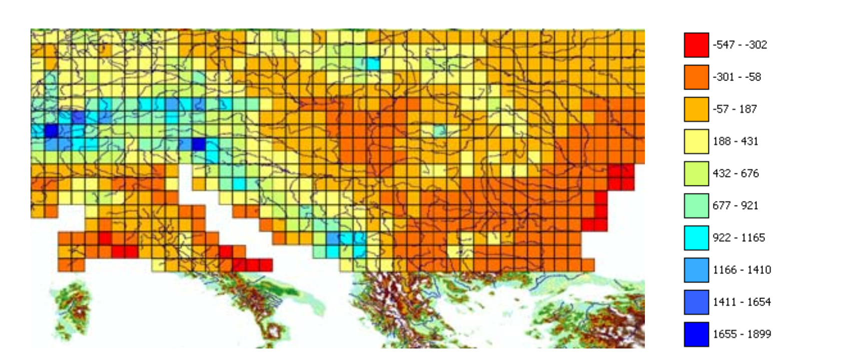

Fig. 5b)

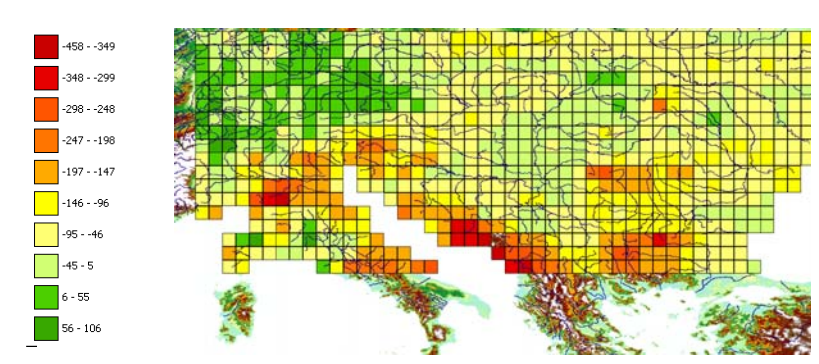

Fig. 5 Climatic Water Bilance (longterm average) [mm/year] a) 1987-2001 b) Changes 1987-2001 minus 1960-1974

CTL+A1B		Institute	ECMWF	HC	HC	HC	MPI-MET	CNRM	UIB
				HadCM3	HadCM3	HadCM3	ECHAM5		
		GCM	ERA40	Q0	Q3	Q16	r3	Arpege	BCM
Institute	RCM	Resolution							
C4I	RCA3	25 km	x			1951-2100			
DMI	HIRHAM5	25 km	x				1951-2100	1951-2100	1961-2099
ETHZ	CLM3.21	25 km	x	1951-2100					
HC	HadRM3 Q0	25km	x	1951-2100					
	HadRM3 Q3	25km	x		1951-2100				
	HadRM3 Q16	25km	x			1951-2100			
ICTP	REGCM3	25 km	x				1951-2100		
KNMI	RACMO2	25 km	x				1950-2100		
MPI	M-REMO	25km	x	1951-2100					
SMHI	RCA3	25km	x		1951-2100		1950-2100		1961-2100

Fig. 6 Climate prediction data of simulations with different Global and Regional Climate Model combinations

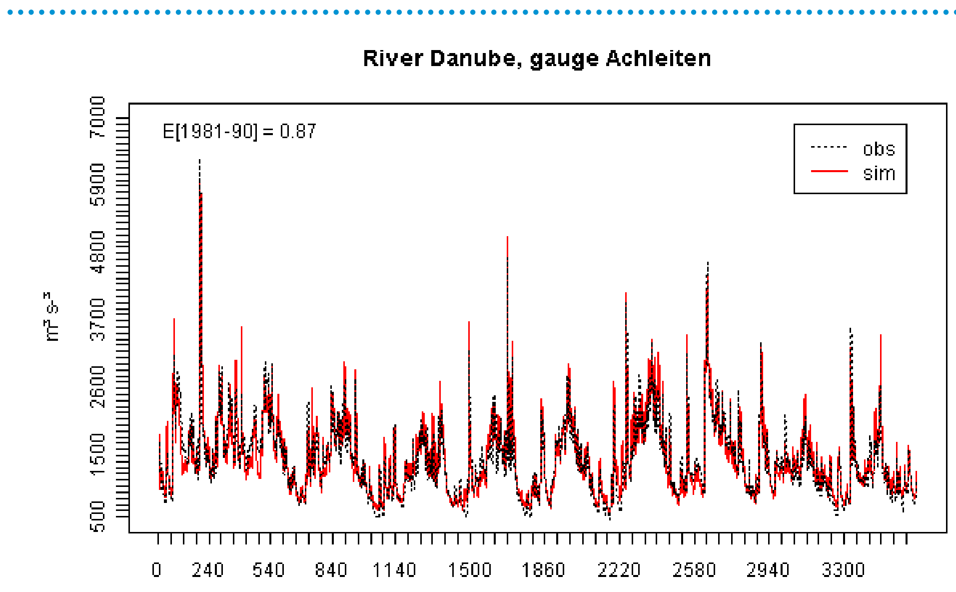

Fig. 4 Observed and simulated river discharges of the Upper Danube basin (Huang et al. 2010, Hydrol. Processes, 24 (23))

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