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Integrating water resources management in eco-hydrological modelling

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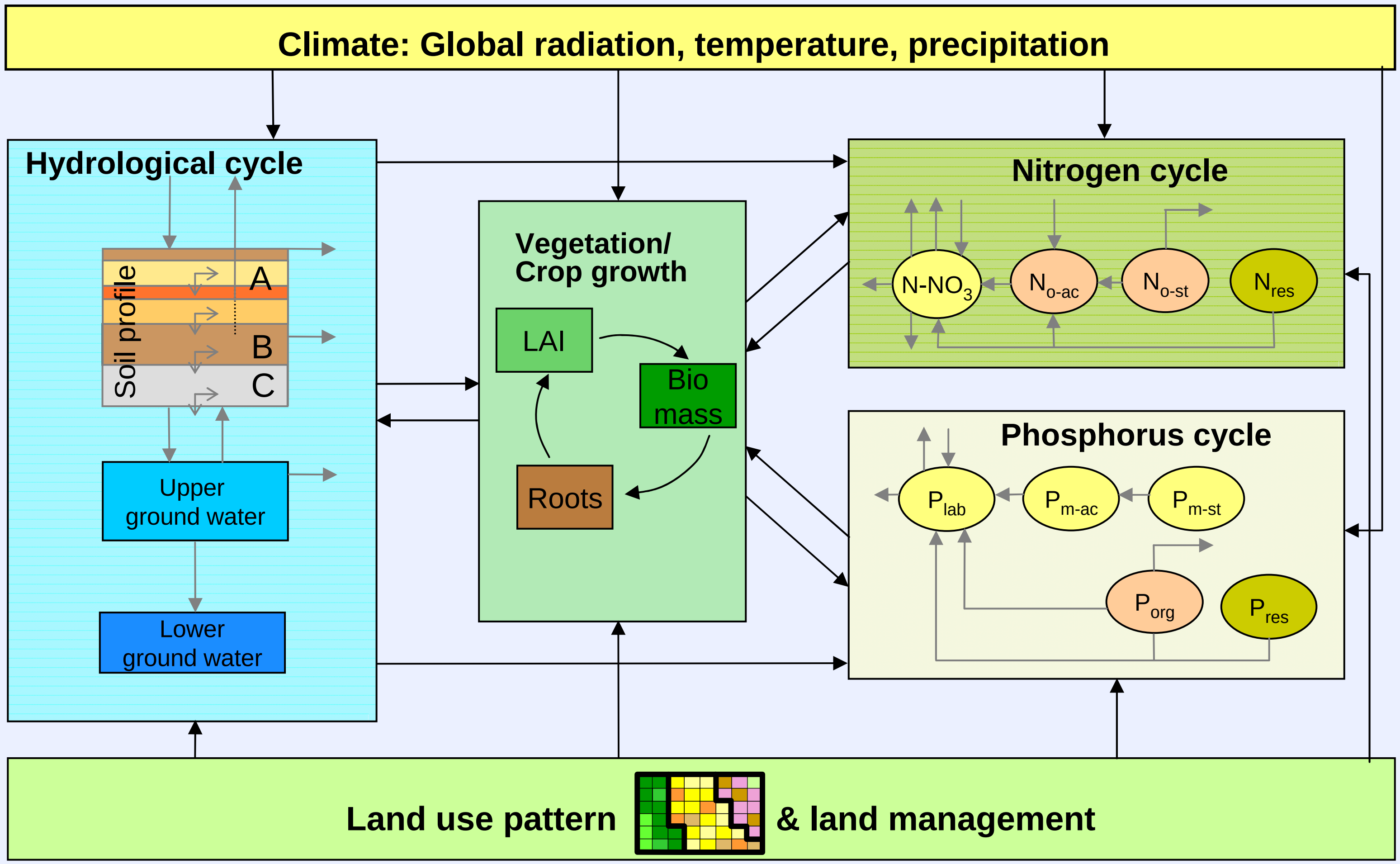
Overview

- The model SWIM
- Reservoir management
- Study Area
- Scenarios & Results
- Discussion / Conclusion

The Model SWIM (Soil and Water Integrated Model): Processes included



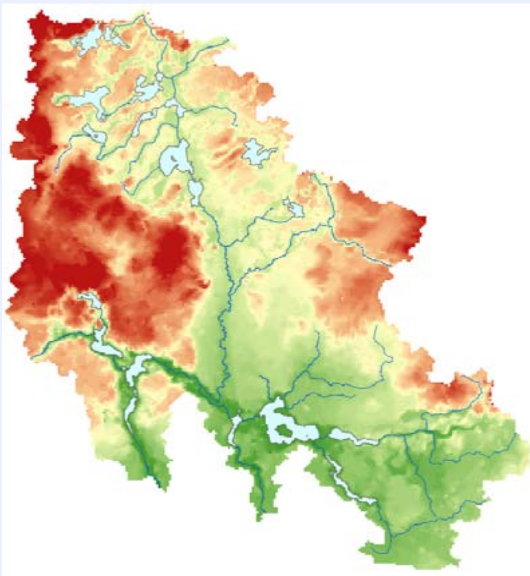
SWIM *was developed in PIK, Potsdam based on* ***SWAT-93*** *and* ***MATSALU*** *for climate and land use change impact studies*

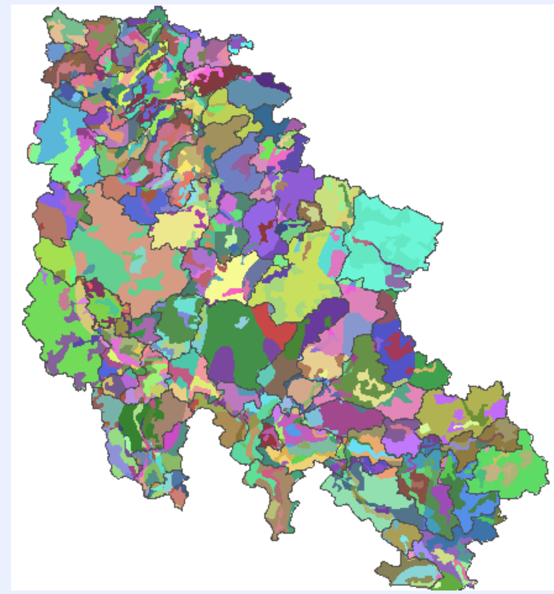
(Krysanova et al., 1998)

Source: Huang et al., PIK Potsdam

The Model SWIM (Soil and Water Integrated Model): Spatial disaggregation

Catchment → Subbasins → Hydrotopes



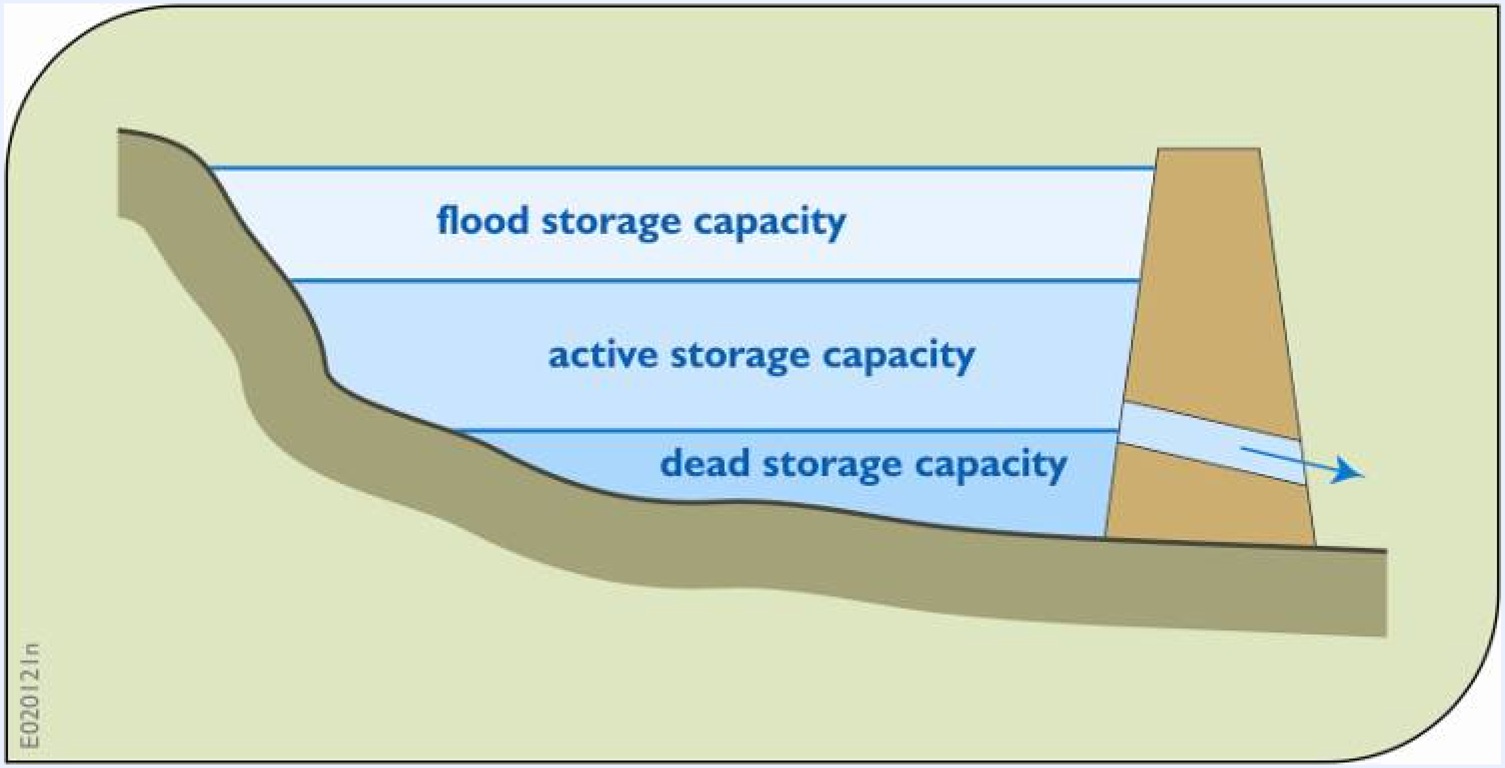


Routing in river (water, N, P, sediments) ← Aggregation of lateral flows ← Water, N, P cycles vegetation growth

Source: Huang et al., PIK Potsdam

- process based eco-hydrological model, simulates runoff generation, nutrient and carbon cycling, plant growth and crop yield, river discharge and erosion as interrelated processes with a daily time step on the river basin scale

Reservoirs: Overview



Loucks and van Beek, 2005

SWIM: the Reservoir model

The model provides three different reservoir management options:

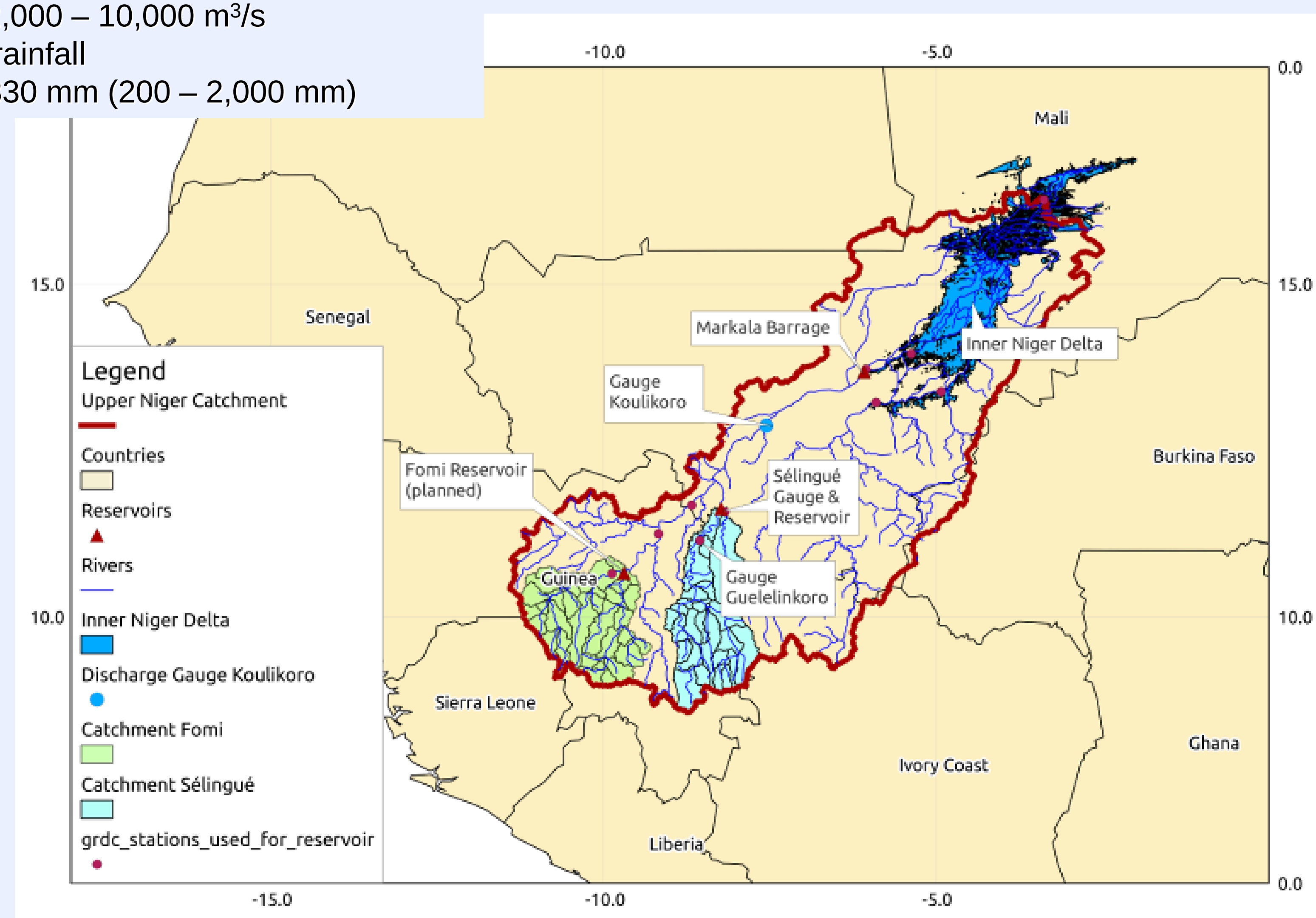
i) Variable daily minimum discharge to meet (e.g. environmental) targets downstream under consideration of maximum and minimum water levels in the reservoir

ii) Daily release based on firm energy yield by a hydropower plant: the release to produce the required energy is calculated depending on the water level (consideration of maximum and minimum water levels in the reservoir)

iii) Daily release depending on water level: rising/falling release with increased/falling water level, depending on the objective of reservoir management

The Upper Niger Basin

- Area: ~350,000 km^2
- Peak discharge: 2,000 – 10,000 m^3/s
- Monsoon-type of rainfall
- Annual rainfall: ~830 mm (200 – 2,000 mm)



SWIM: Calibration (1971-1975) & Validation (1976-1981)

year	1971		1972		1974		1975		1976	
	obs	sim	obs	sim	obs	sim	obs	sim	obs	sim
Mean [m^3/s]	300	302	252	292	347	337	439	322	349	325
RMSE [m^3/s]		101		70		149		247		124
BIAS [m^3/s]		2.0		8.1		-9.8		-116		-23
PBIAS [%]		1%		3%		-3%		-26%		-7%
NSE		0.94		0.95		0.89		0.69		0.89

Performance results for the SWIM model, gauge Guelelinkoro (inflow to Selingue dam)

Reservoir model – Data requirements

	Selingue		Fomi	
	dead storage	active storage	dead storage	active storage
volume [million m³]	238.0	1,928.7	2,460.0	3,700.0
max. water level [m a.m.s.l.]	342.2	349.2	380.0	390.5
min. water level [m a.m.s.l.]	338.5	342.2	351.0	380.0
max. water surface [km²]	50	500	450	507

Hydropower Plant (HPP)

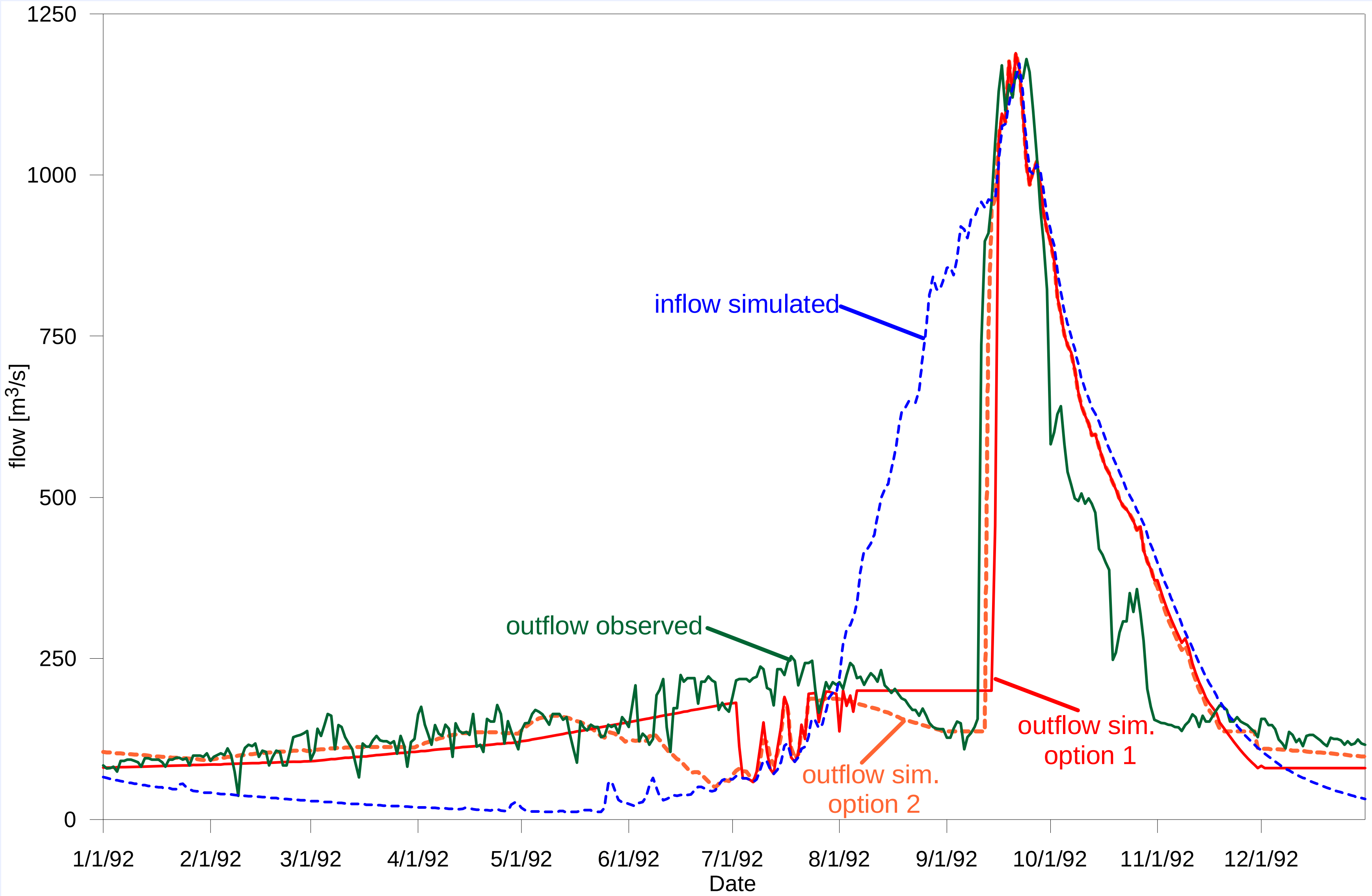
	Selingue	Fomi
max. fall height of HPP [m]	17.2	27.4
base of HPP [m a.m.s.l.]	332.0	363.1
capacity of HPP [m³/s]	360.0	421.0

- measurements of inflow to & outflow from reservoir

or

- planning values for release (rule curve) or for hydropower production

Test for Reservoir model (Selingue dam)



Scenarios: New reservoir & Climate change

Reservoirs:

i) Natural discharge without dams

ii) Discharge with existing Selingue dam

iii) Discharge with planned Fomi dam

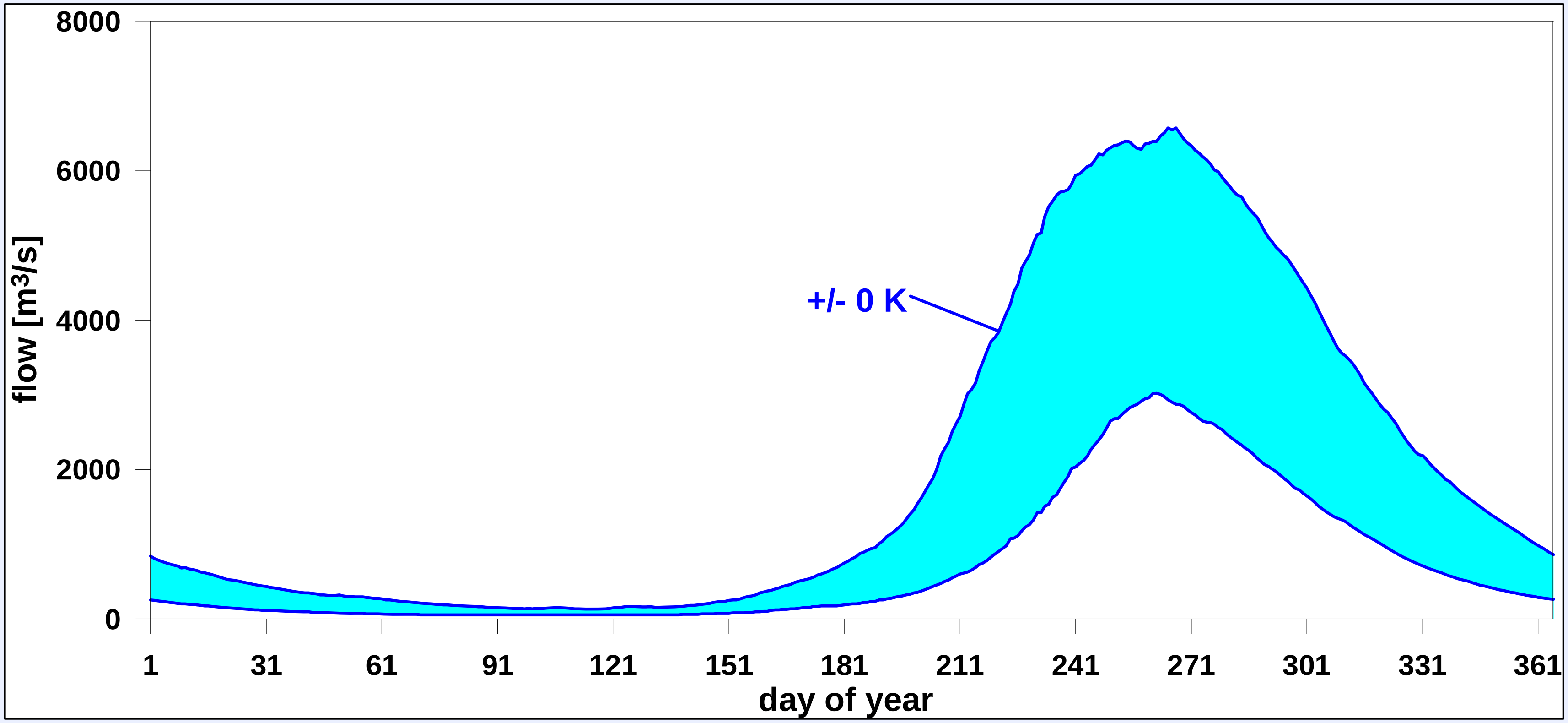
Climate change (100 Realisations each scenario):

i) +/- 0K

ii) + 1 K

iii) + 2 K

Results: Natural flow at gauge Koulikoro (Upstream of IND)



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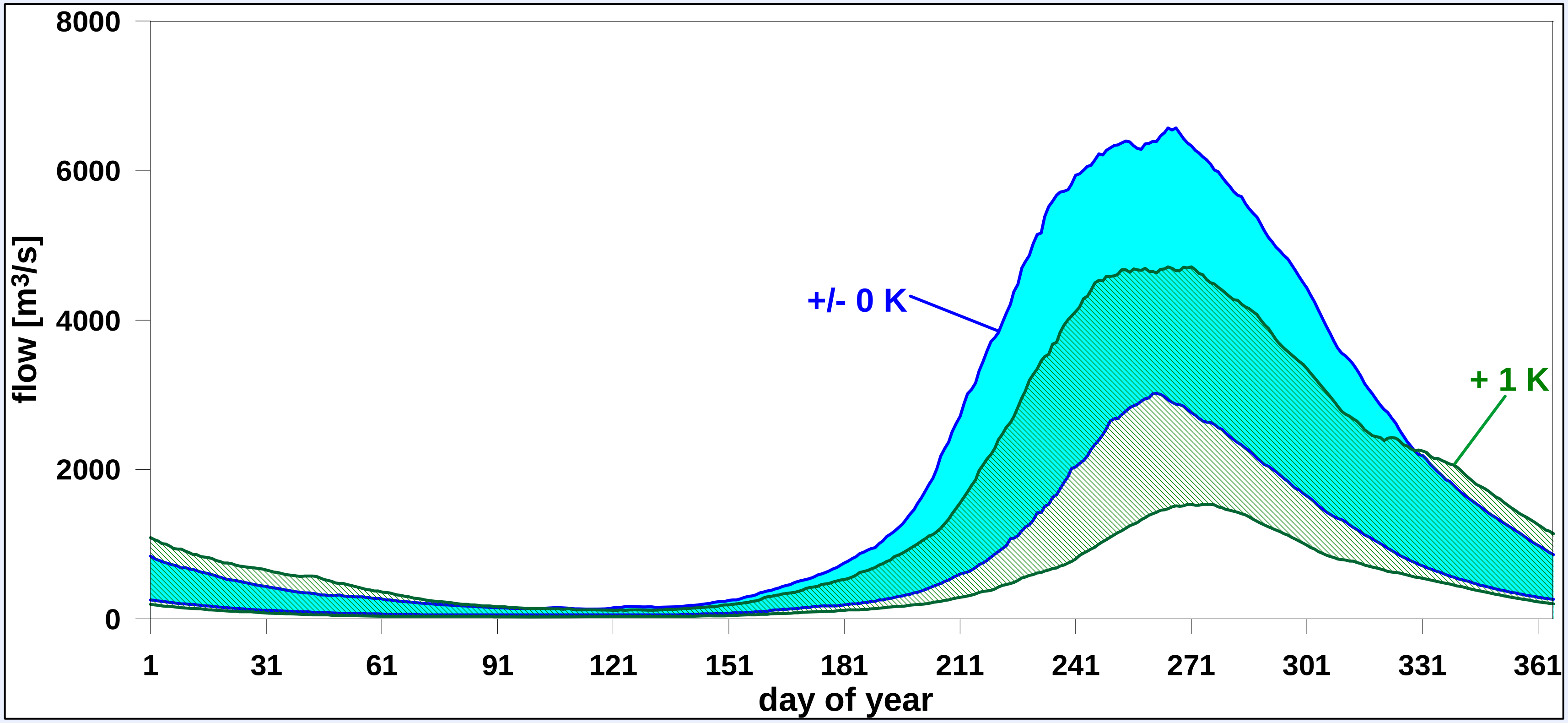

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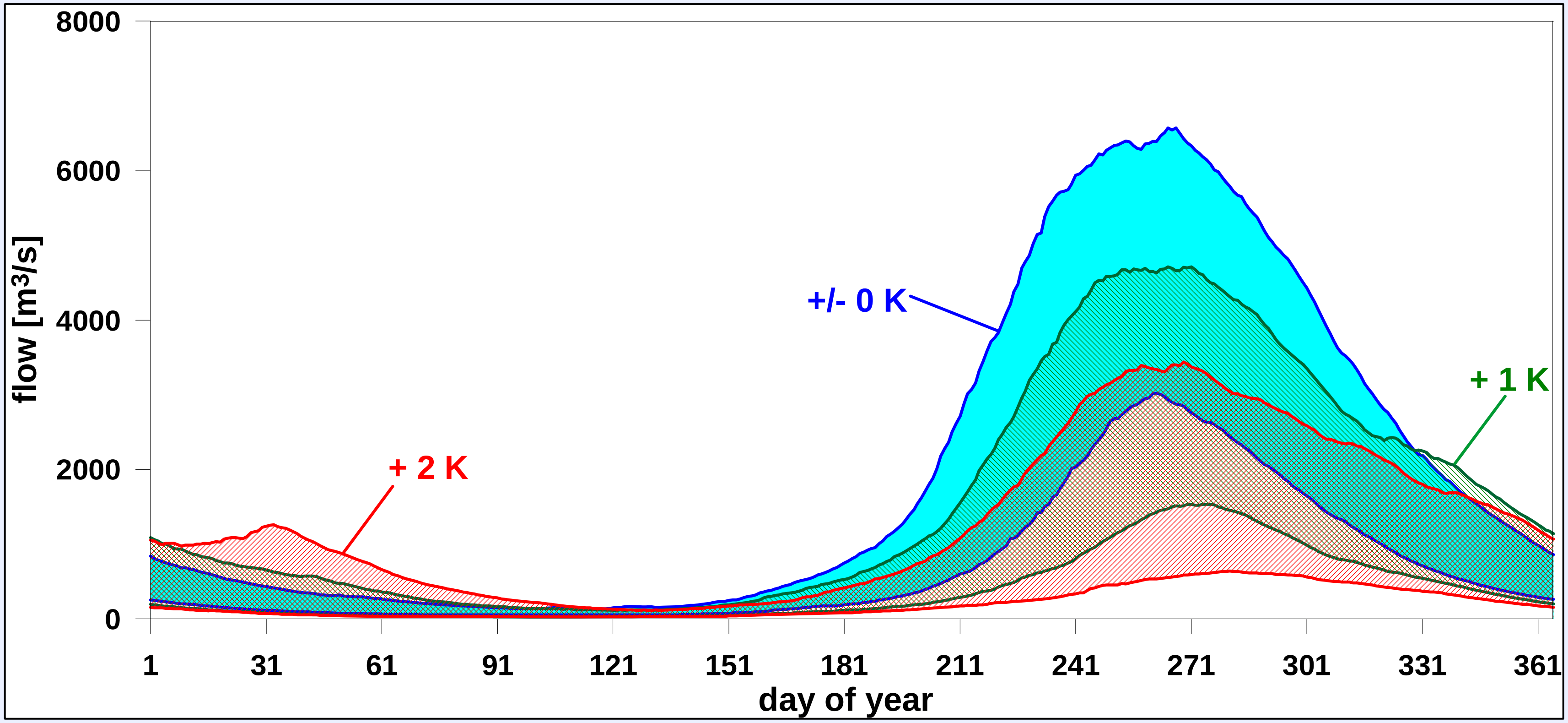
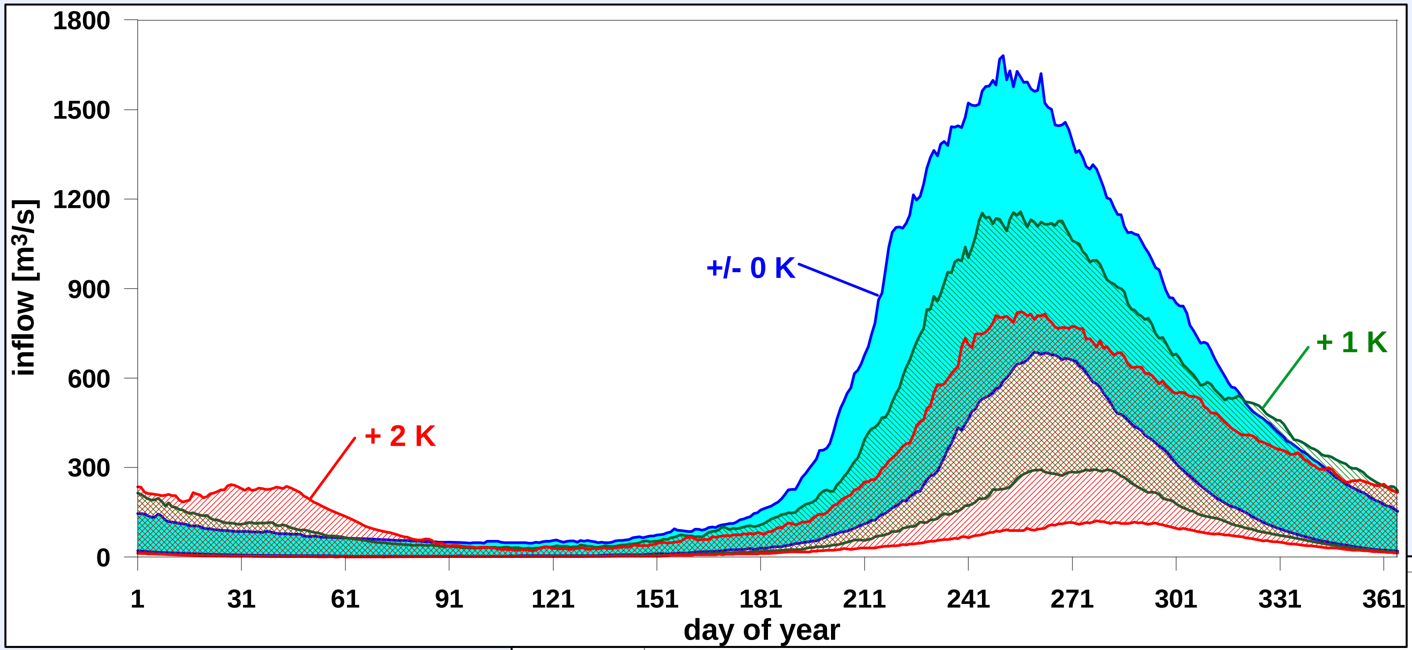
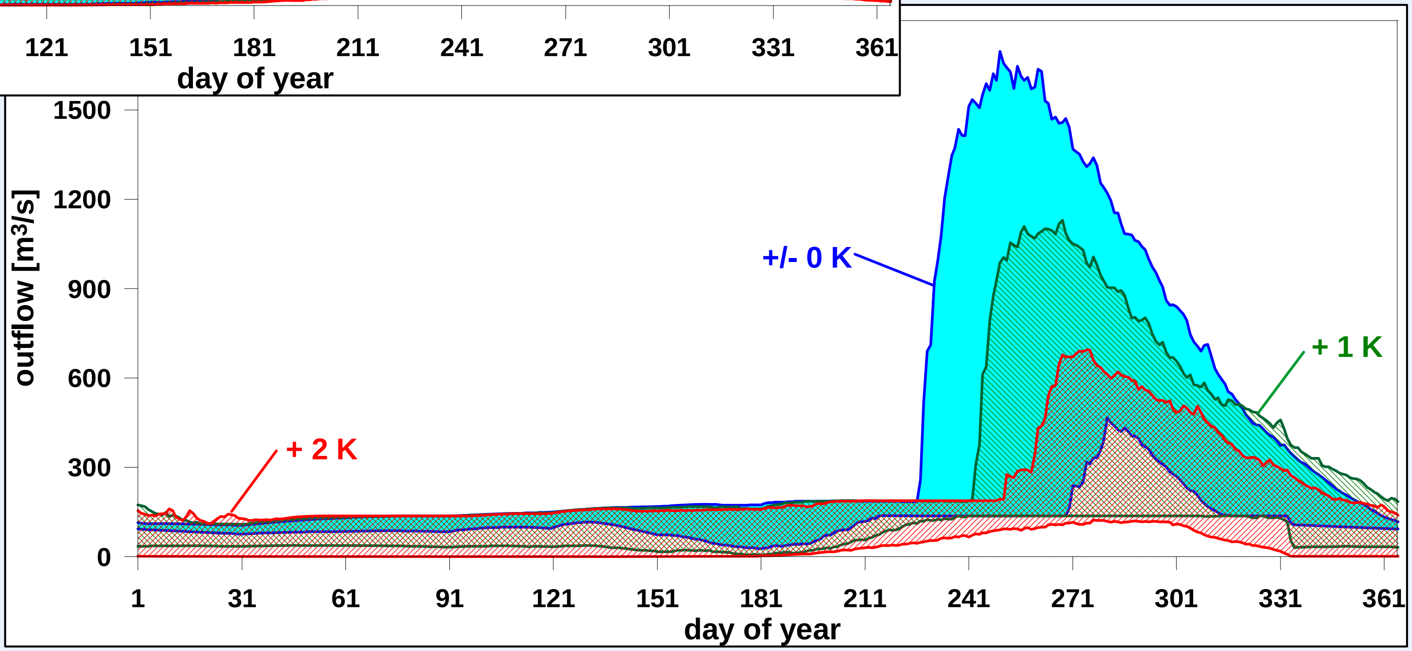
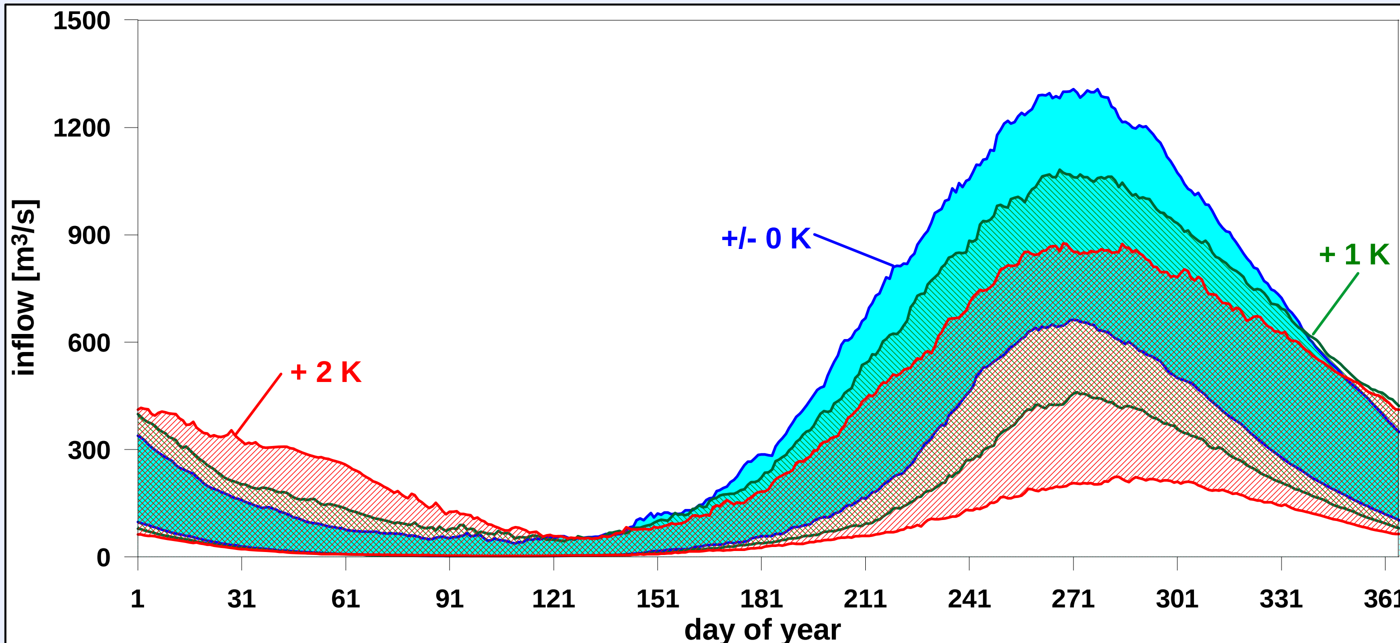


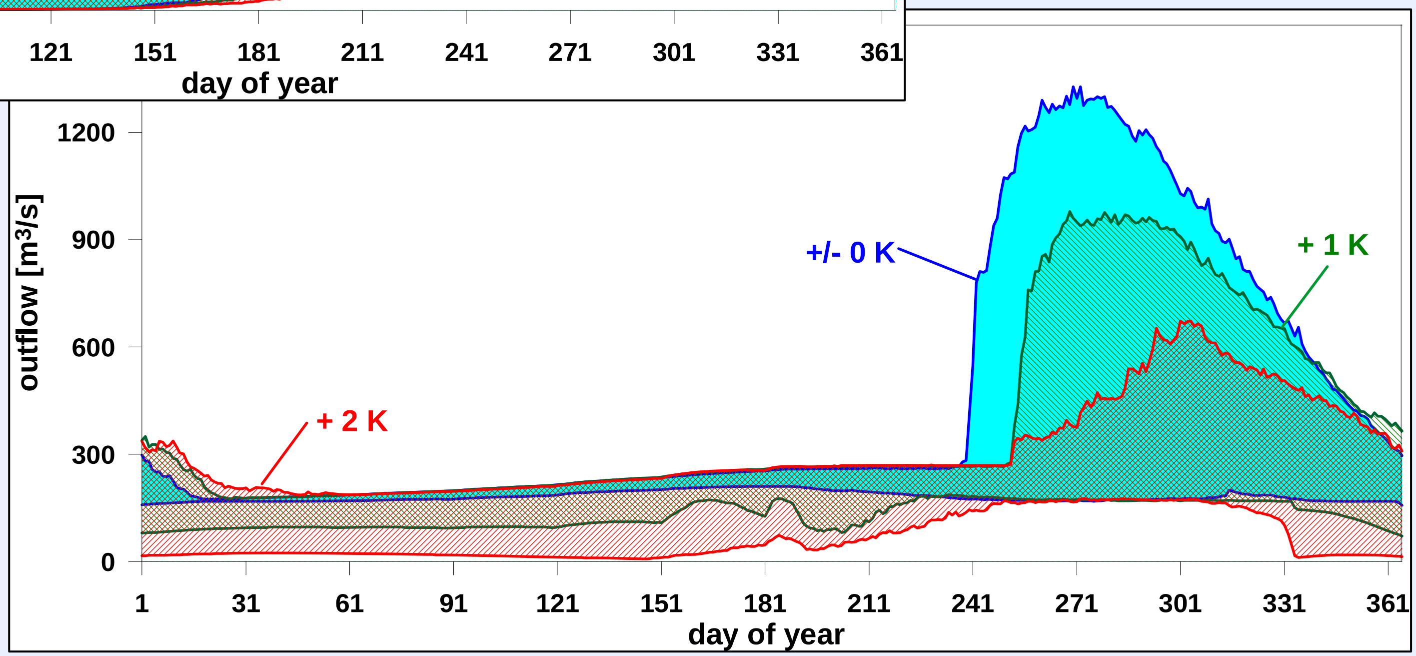
Reservoir model: Results Selingue dam



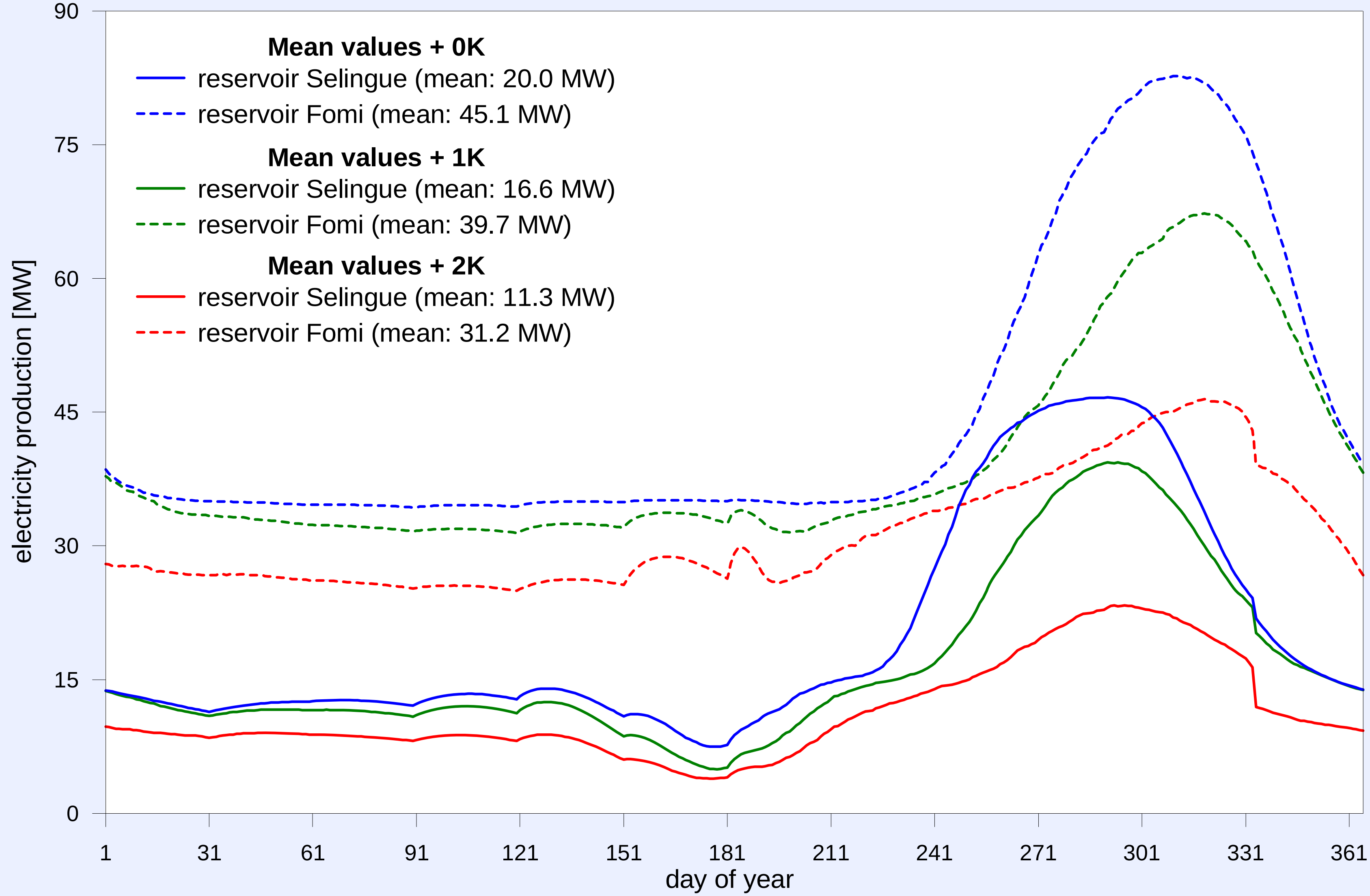


Reservoir model: Results planned Fomi dam



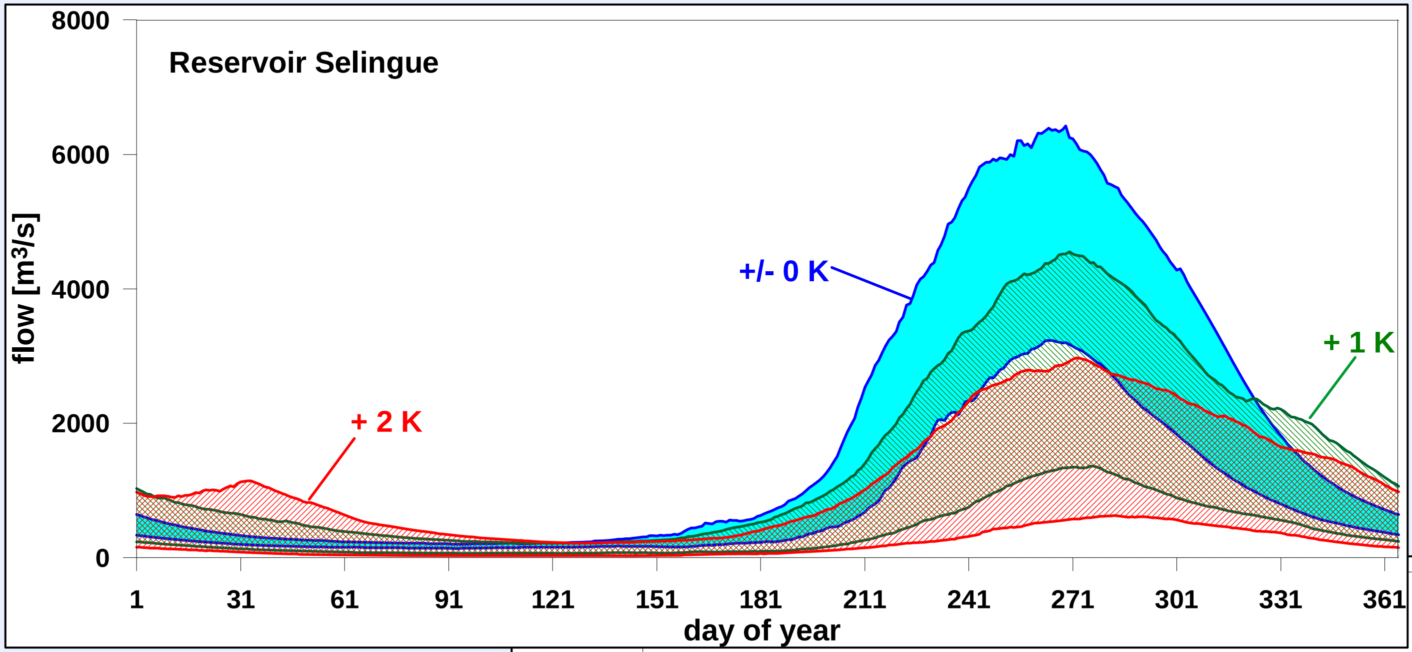


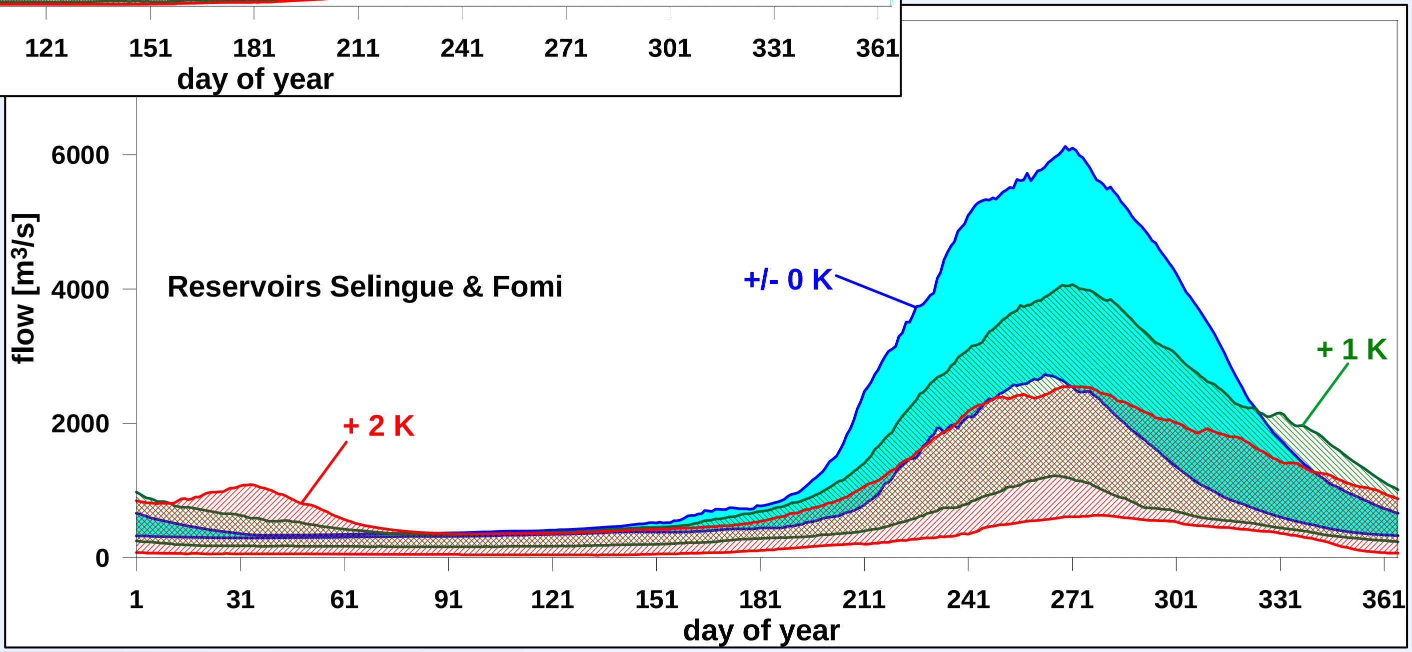
Reservoir model: Hydropower production



Mean electricity production Selingue dam (1982-2003): 19.5 MW (after Zwarts et al.)

Reservoir model: Results gauge Koulikoro (Upstream of IND)





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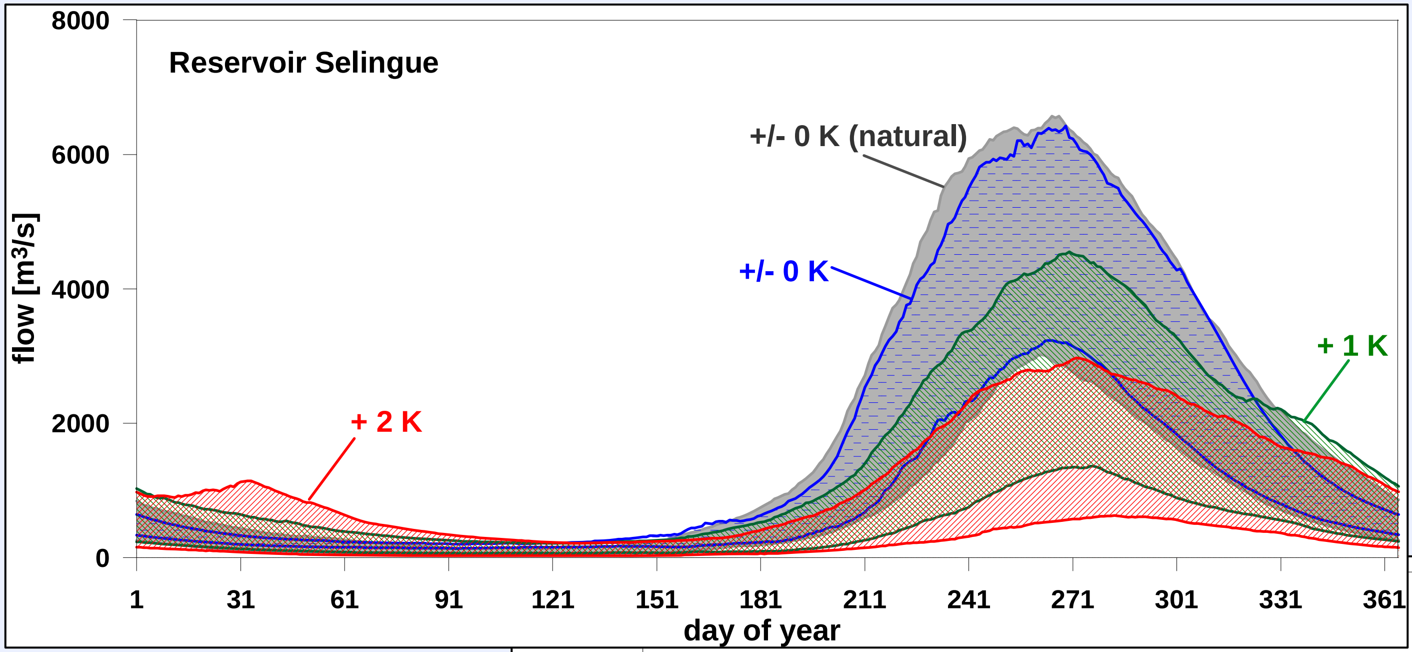

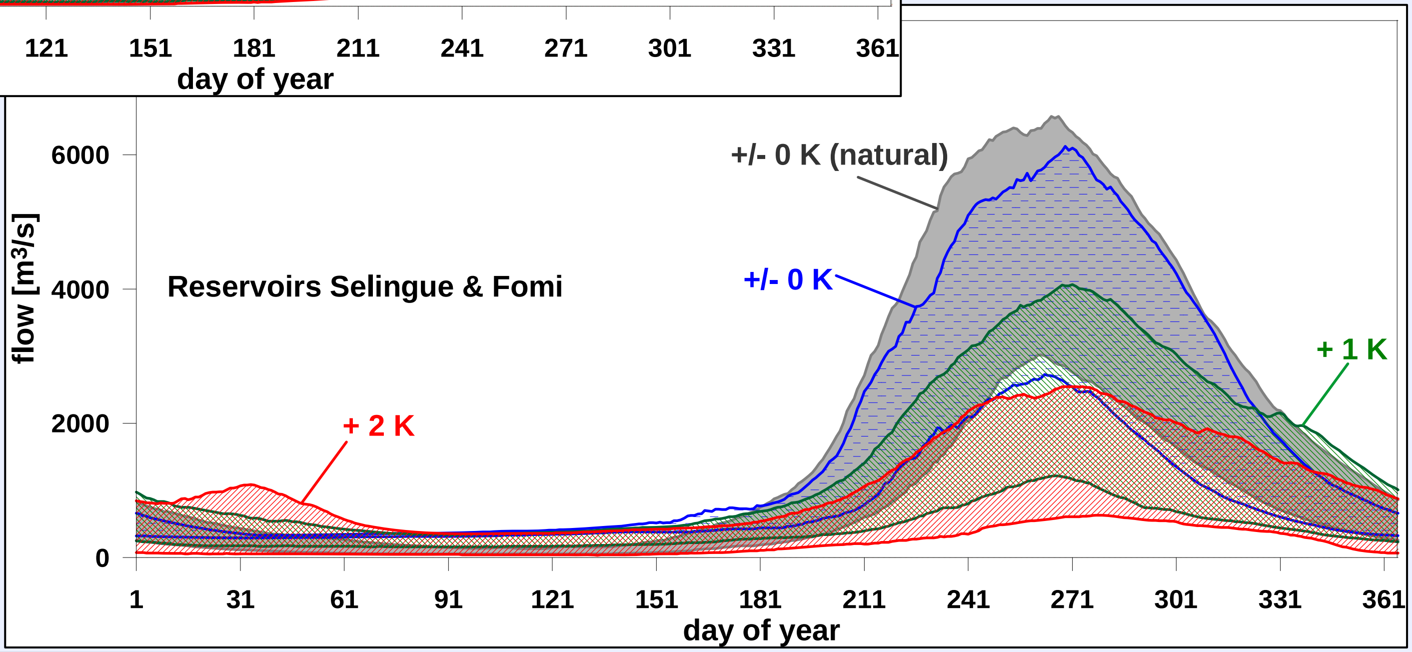

DISCUSSION / CONCLUSION

The new model

- **Reservoir model** can be used to simulate **effects of reservoir management** on downstream discharges and hydropower production within the eco-hydrological model SWIM; but "real" reaction on floods/droughts might not be simulated (flood storage, dead storage)

Purpose

- Simulation of possible **upstream-downstream conflicts** (here **hydropower** production - **agricultural** production)
- Simulation of impacts of **climate change** and variability
- **Adaptation** options can be simulated (changed reservoir management)

Thanks