Modelling of the effects of various water abstraction patterns on the ecology of the flood-pulsed Okavango Delta, Botswana

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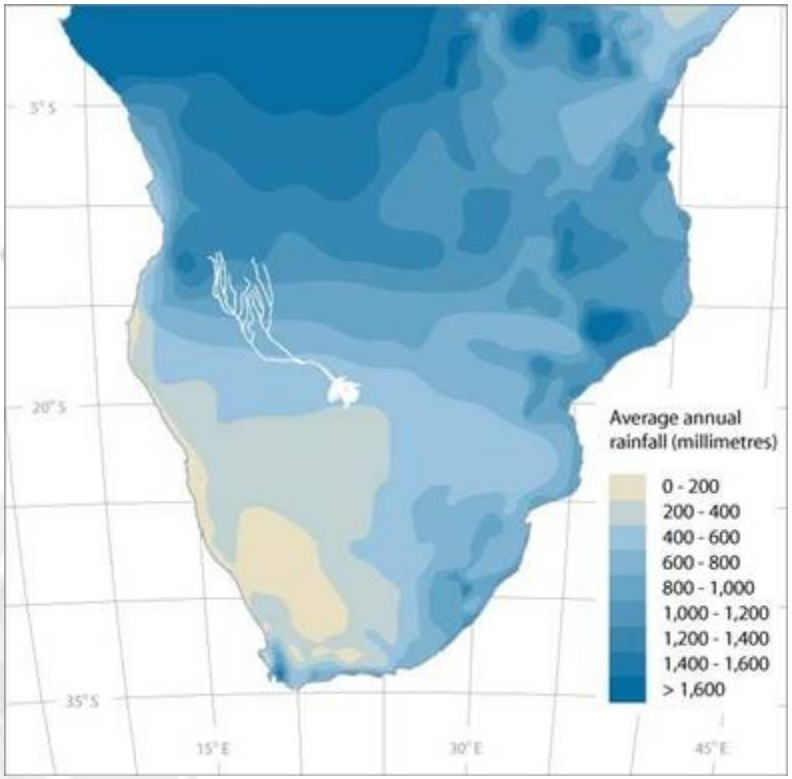
W3M Conference, Wierzba, Poland, 22-25 September 2005

In the next 14 minutes you will hear:

- what is the Okavango Delta
- why temporal abstraction pattern plays a role there
- what modelling approach was used
- what models were used
- what are the results

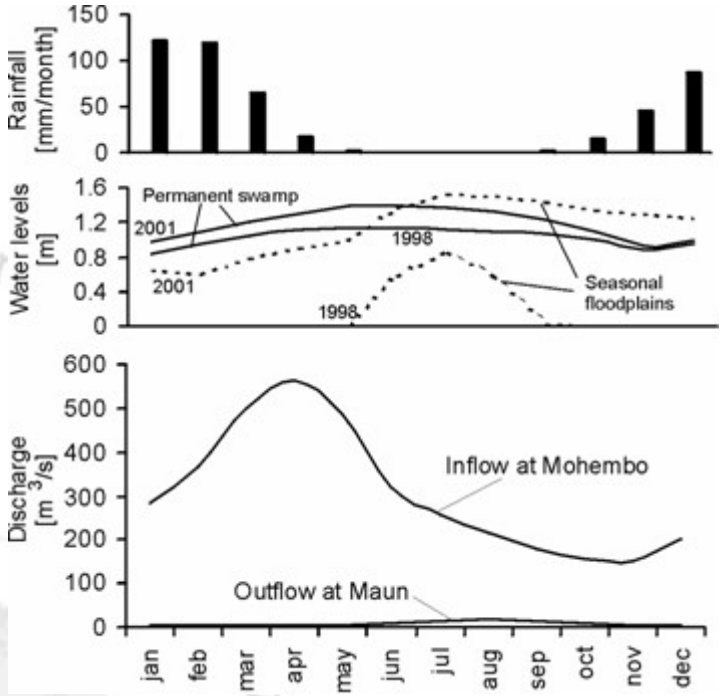
The Okavango Delta

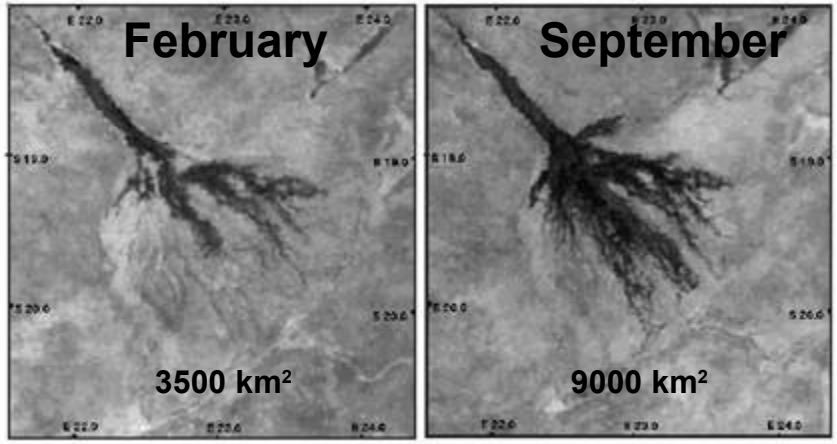
- 12000 km^2 wetland system in a semi-arid environment
- fed by the Okavango river (average discharge 10000 Mm^3/a) shared by Angola, Namibia and Botswana



The Okavango Delta

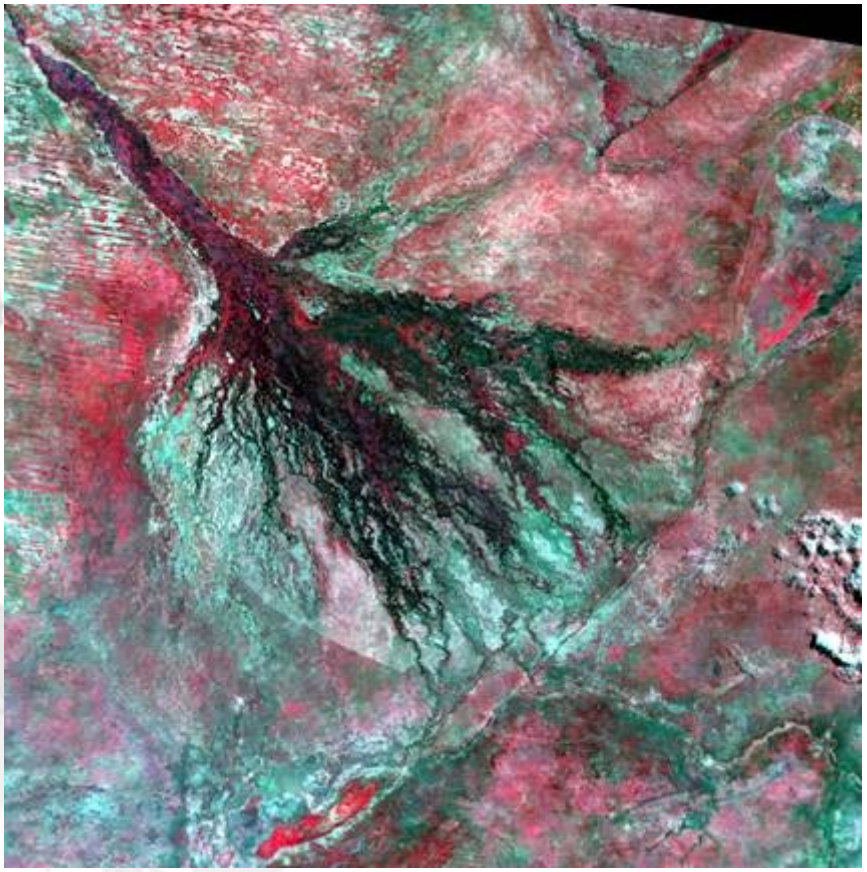
- flood-pulsed wetland, with an annual flood event
- flooding asynchronous with rainy season

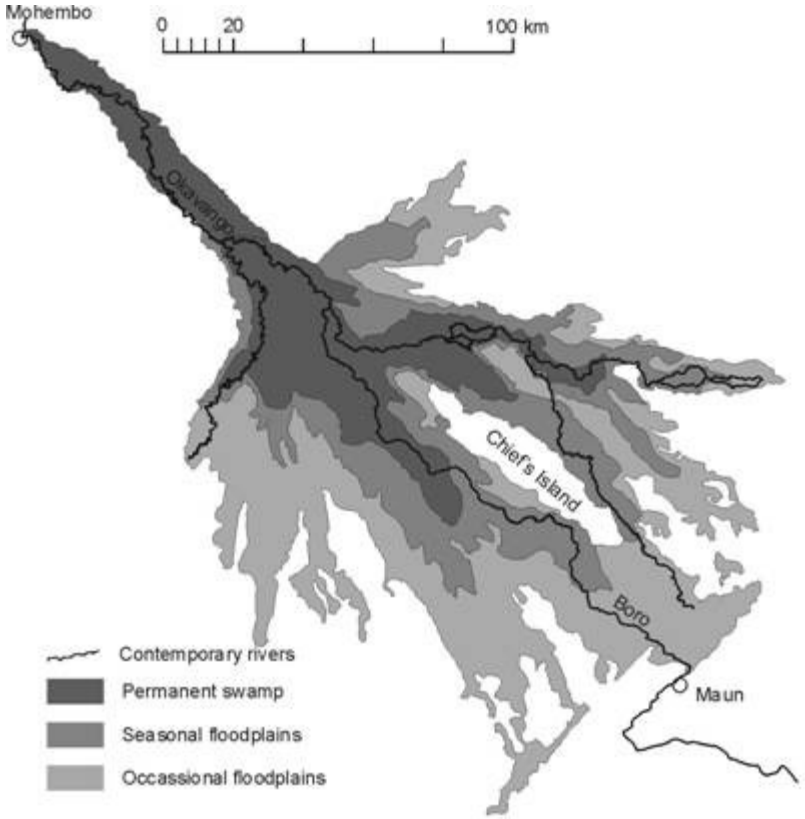




The Okavango Delta

- Frequency, duration and depth of inundation vary throughout the system





The Okavango Delta

The Okavango Delta

The Okavango Delta

The Okavango Delta

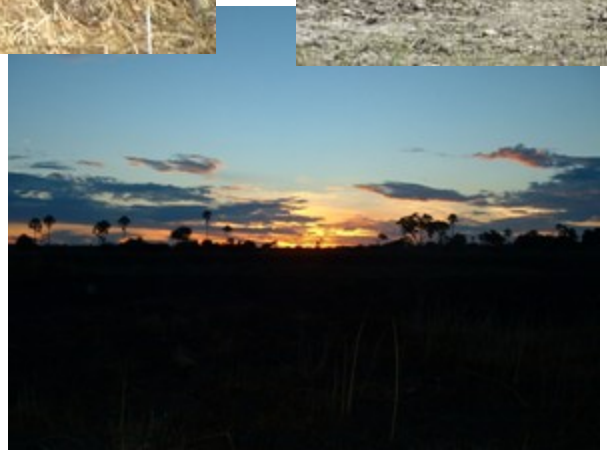
- Ecological function of various floodplains

- **Permanent swamp**
  - anoxic conditions
  - accumulation of peat, nutrients and C trapping
  - limited availability of vegetation to herbivores
  - channels and lagoons support fish
- **Seasonally (regularly, occasionally) inundated floodplains**
  - switching anaerobic-aerobic conditions
  - intensive nutrient recycling
  - high biomass and primary productivity
  - availability of plants to grazers during dry winter
- **Drylands**
  - rain-fed ecosystem
  - supports browsers (throughout the year) and grazers (during wet summer)

patchy distribution of these creates conditions for high biodiversity

The Okavango Delta

- Diverse ecosystem supporting wildlife-based tourism and local population (small-scale agriculture, use of wetland resources)



Past, present and future of the Okavango river basin

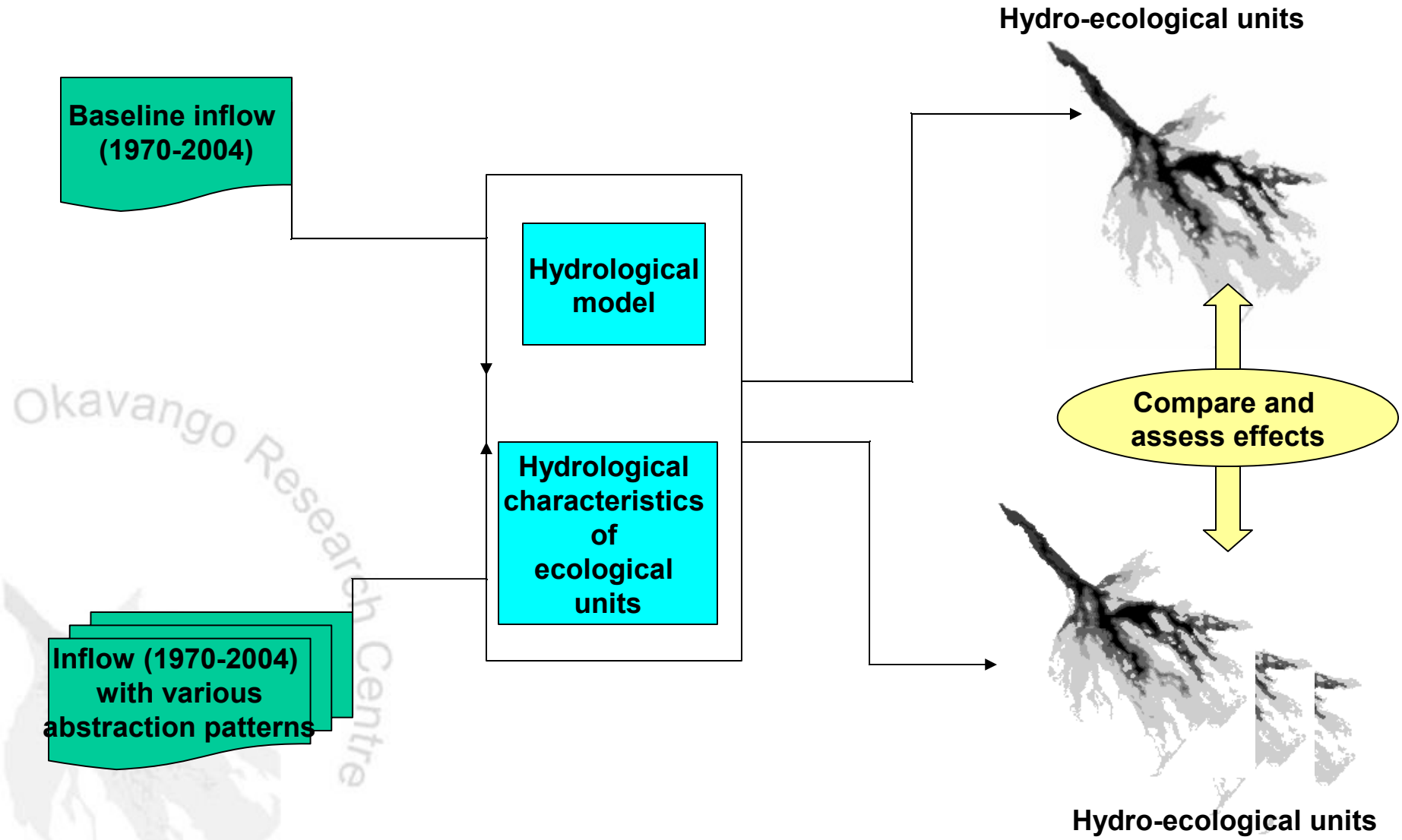
- **Angola**
  - population in the basin: 370000 (and even more land mines!)
  - civil war since the 1970s,
  - current abstractions - not a single organized water supply scheme!
  - Planned: development!
  - Possibly: 20000 ha under irrigation + 8 hydroelectric dams
- **Namibia**
  - population in the basin: 170000
  - low intensity (indigenous) agriculture
  - current abstractions - 20 Mm^3/a for irrigation (1000 ha) and domestic water use
  - planned: 100 Mm^3/a to Windhoek and 7200 ha under irrigation, a hydroelectric dam,
  - possible: further 20000 ha under irrigation
- **Botswana**
  - population in the basin: 60000
  - tourism, cattle, some agriculture, use of natural resources
  - current abstractions: 5 Mm^3/a
  - planned - no plans for the use of Okavango river

Problem statement

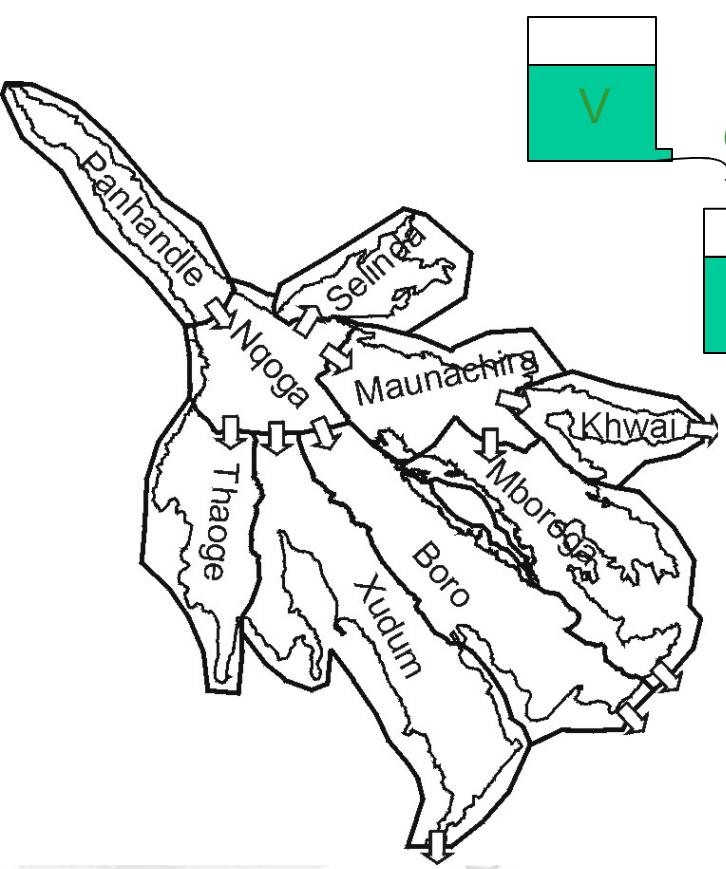
High abstractions for irrigation (935 Mm^3/a) are possible

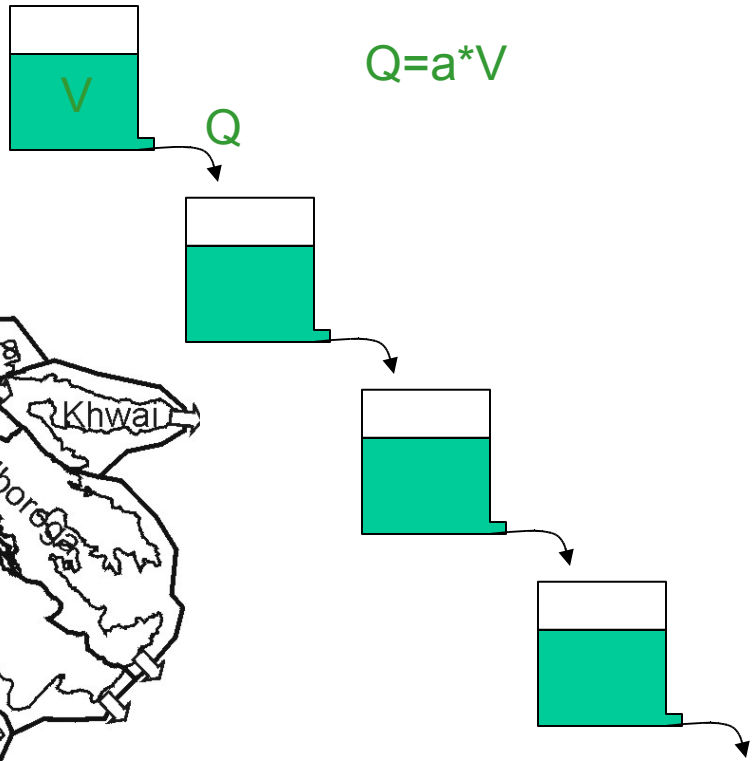
What temporal pattern of upstream abstractions would be the best (the least negative) for the hydro-ecological system of the Delta?

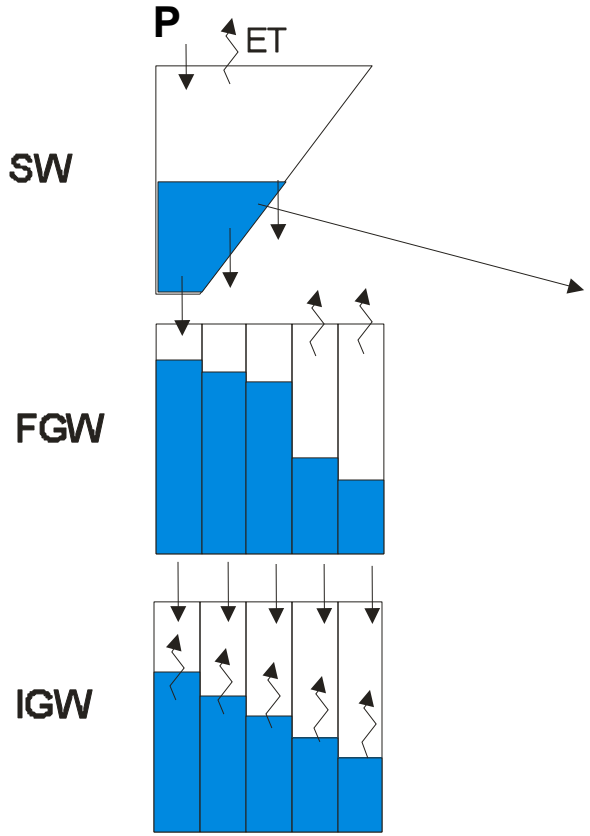
Approach



Hydrological model

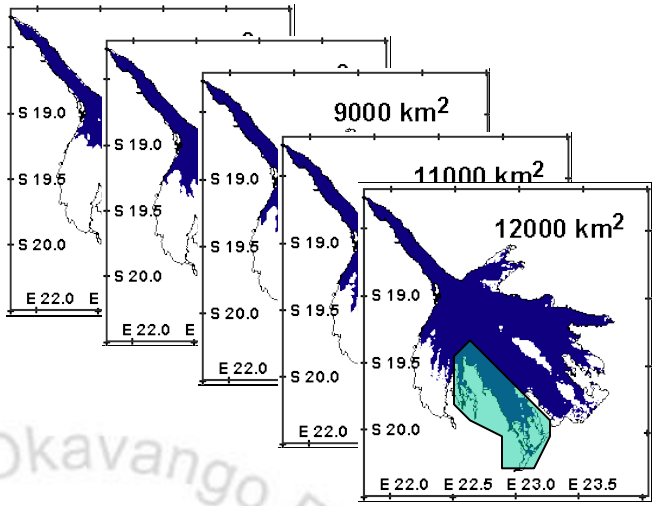


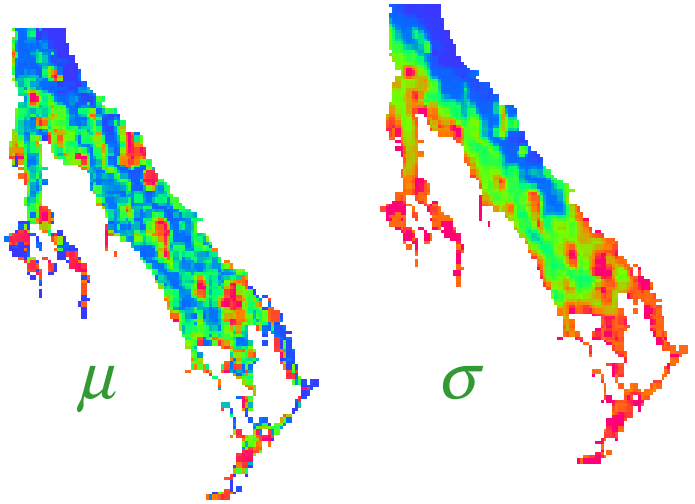




GIS model for flood distribution

Time series of flood maps





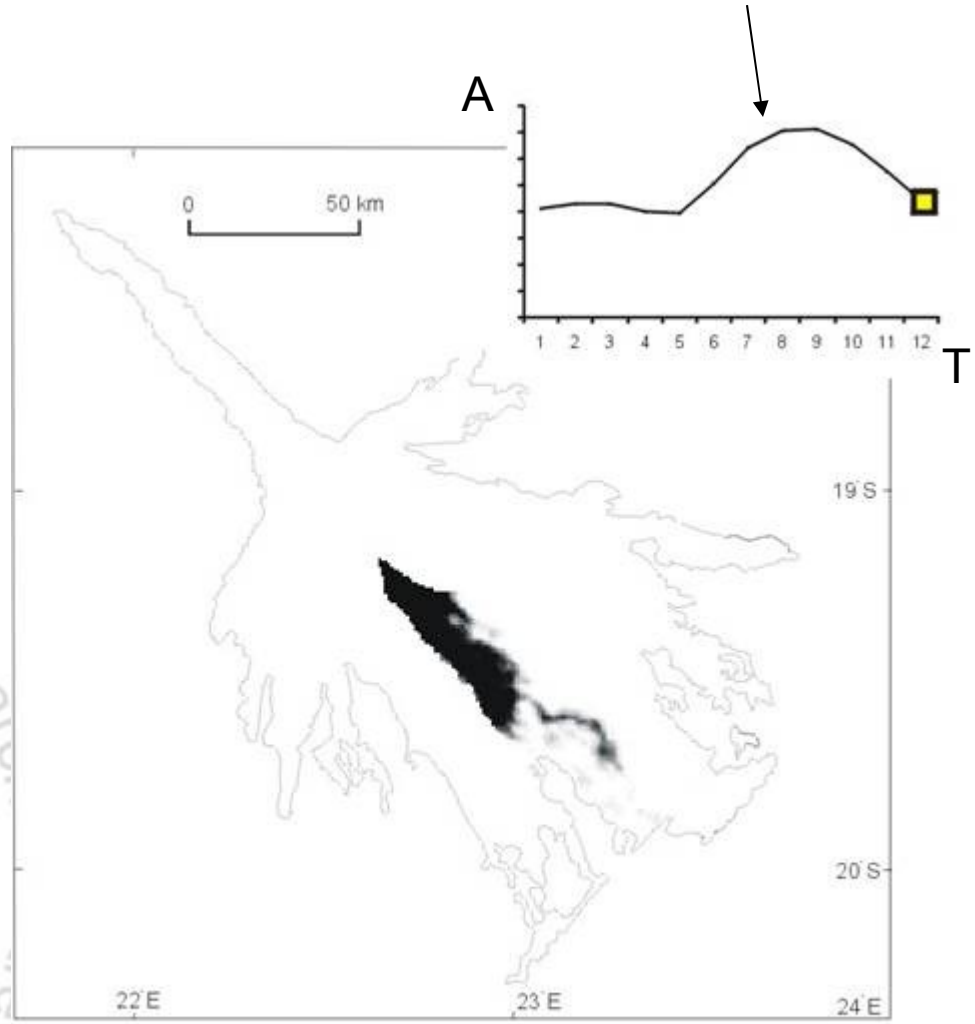
parameters of pdf

$$F(z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} e^{-u^2/2} du$$

$$z = \frac{x - \mu}{\sigma}$$

Probability of being inundated by a flood of size x described by a probability distribution function

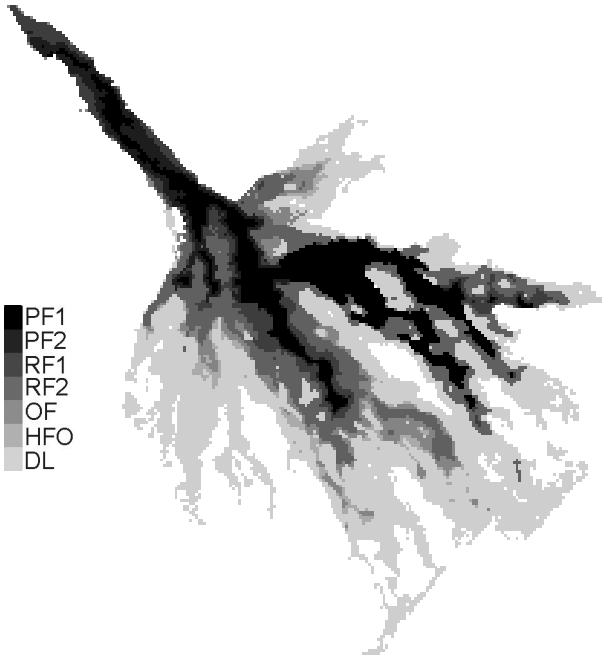
Inundation area from reservoir model



Link between hydrology and ecology

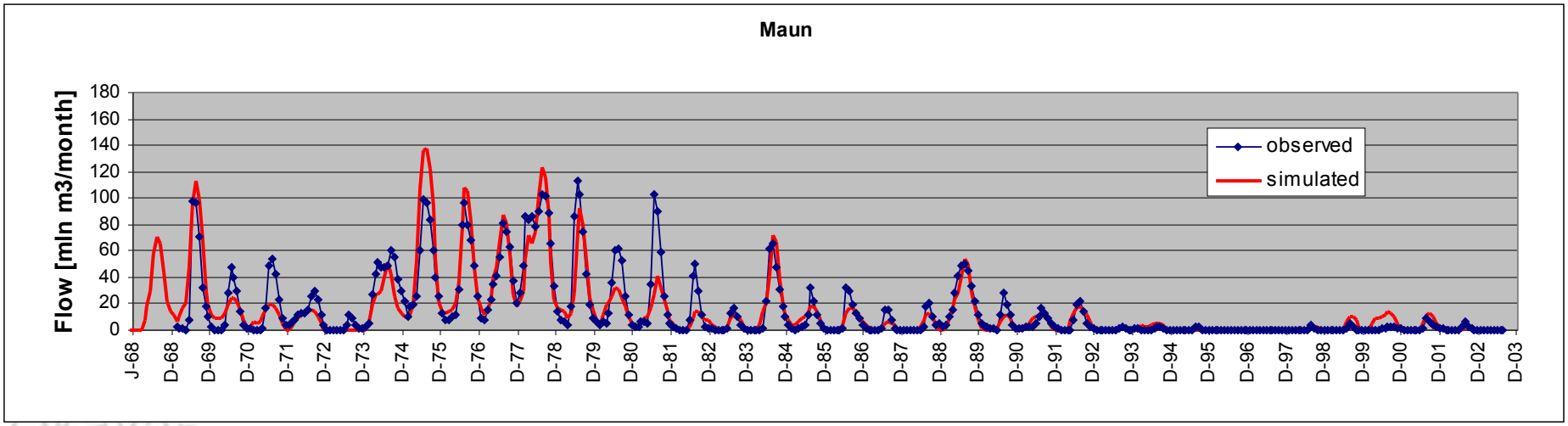
- Functional floodplain classes (hydro-ecological units)

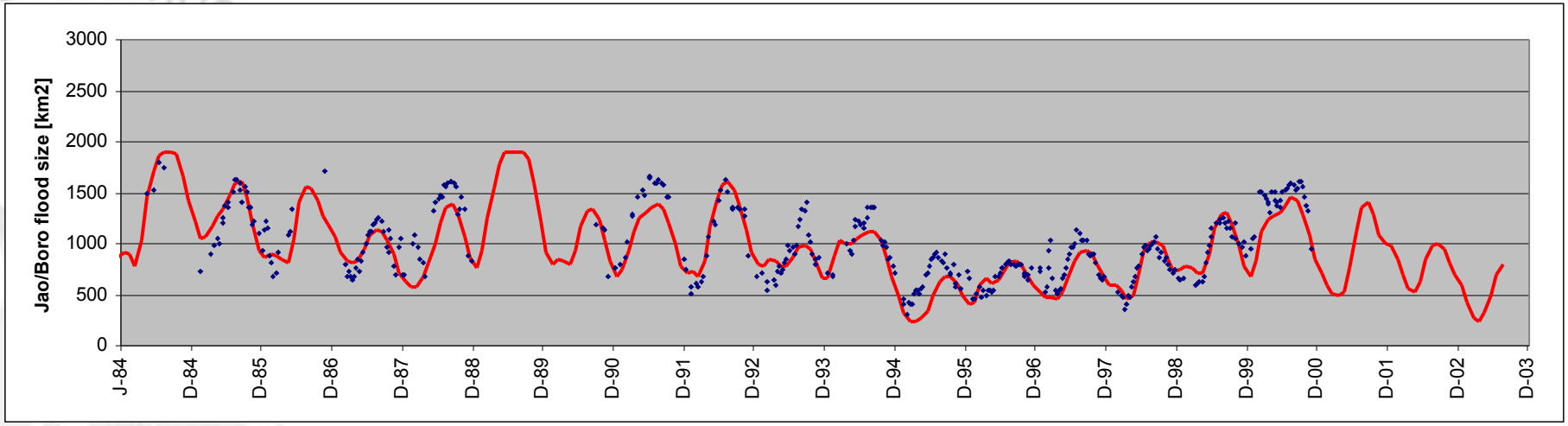
Floodplain class	Sub-class		flood frequency	flood duration (months/year)
Permanent floodplain	proper	PF1	1	12
	fringe	PF2	1	8-12
Regularly flooded seasonal floodplain		RF1	1	4 - 8
		RF2	0.5-1	
Occasionally flooded seasonal		OF	0.1-0.5	1-4
High floods only		HFO	<0.1	<2
Dryland		DL	0	0



After SMEC, 1989

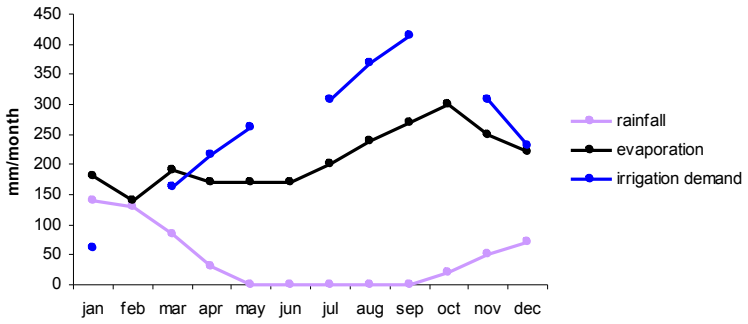
How does the model perform?

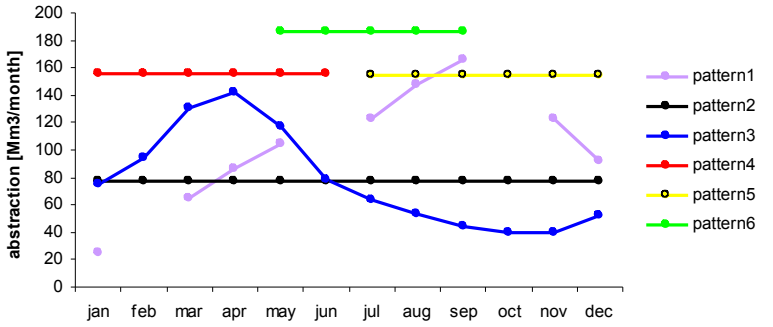


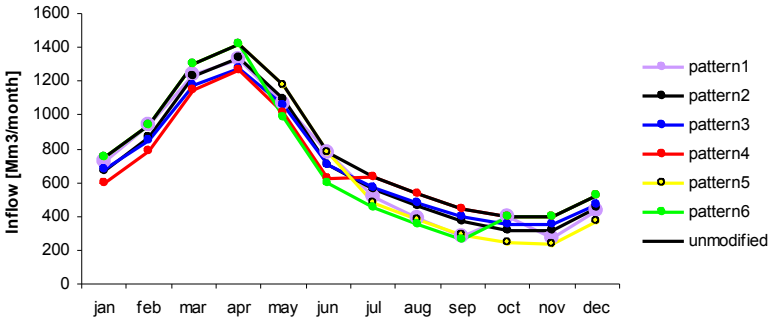


Abstraction patterns

935 Mm³/a



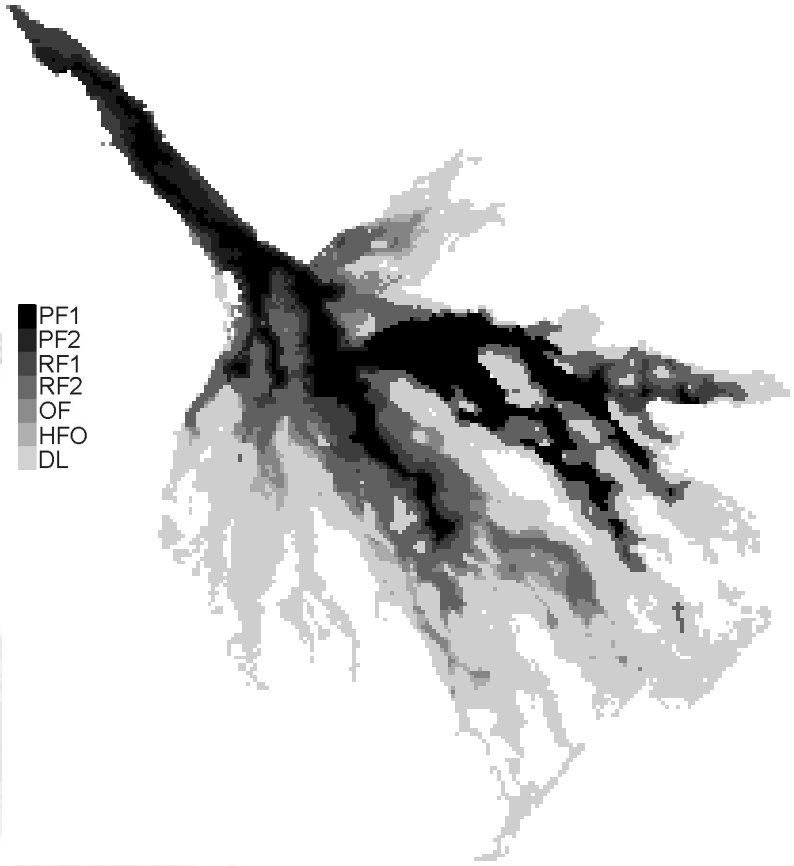




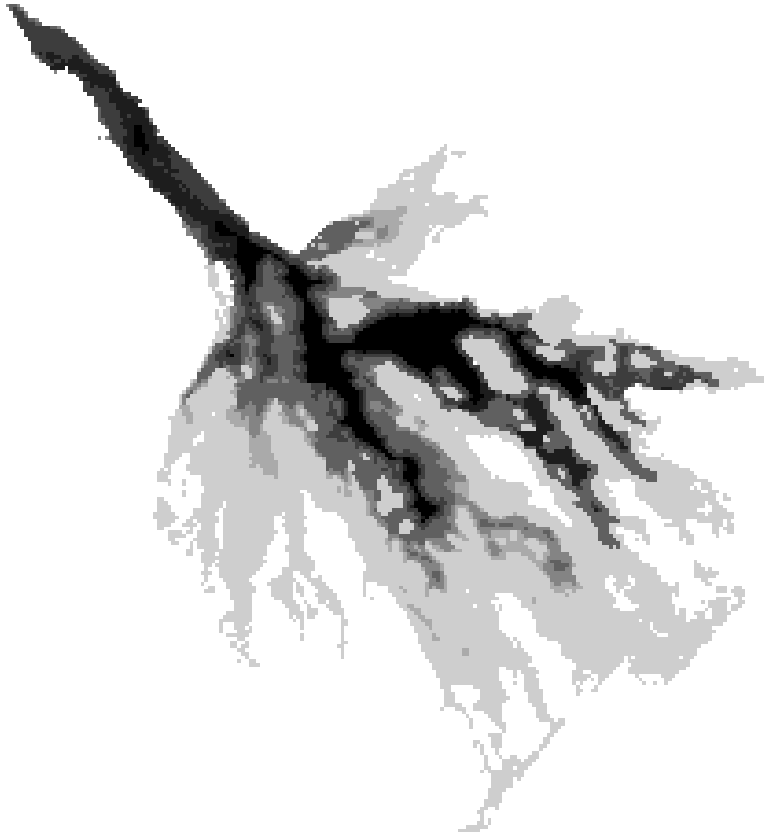
Results

Floodplain class maps

Baseline



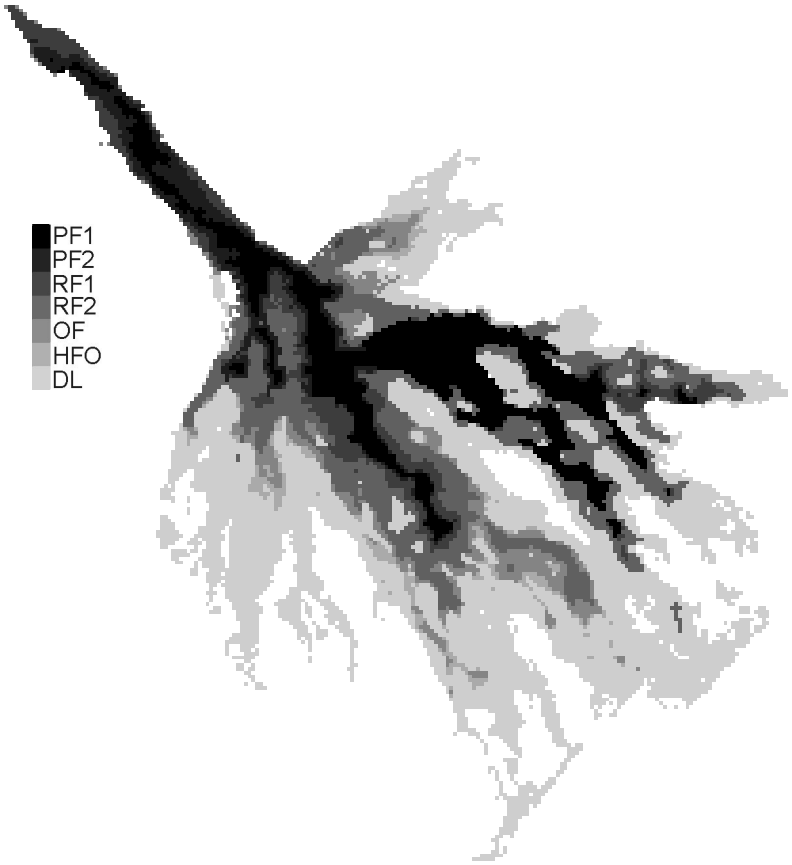
Pattern 1 (on demand)



Results

Floodplain class change maps

Baseline



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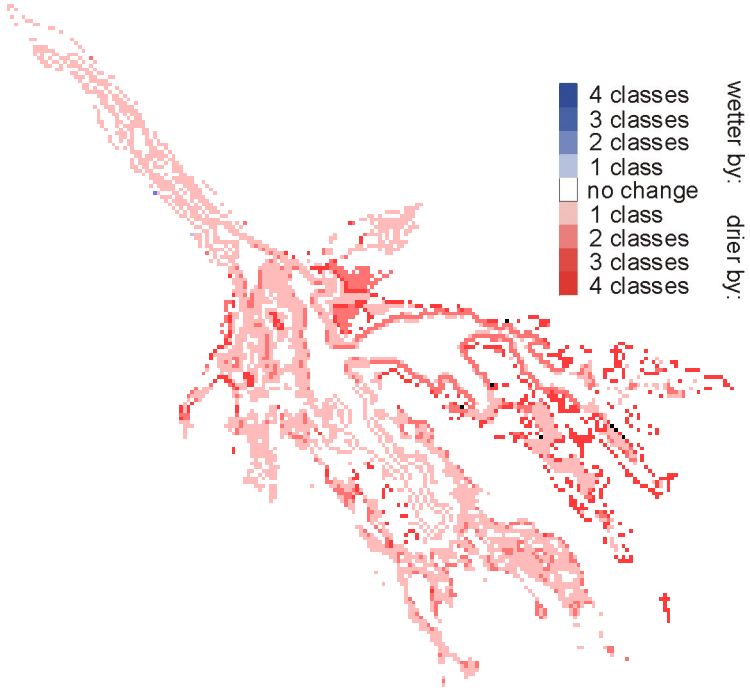
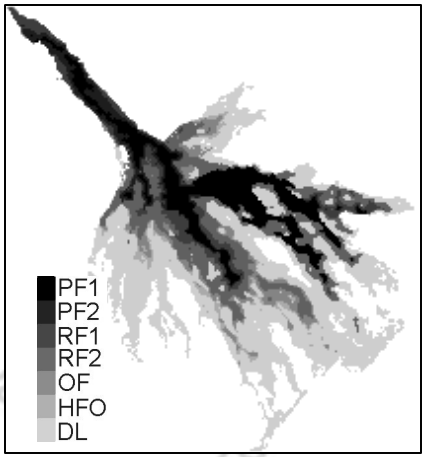
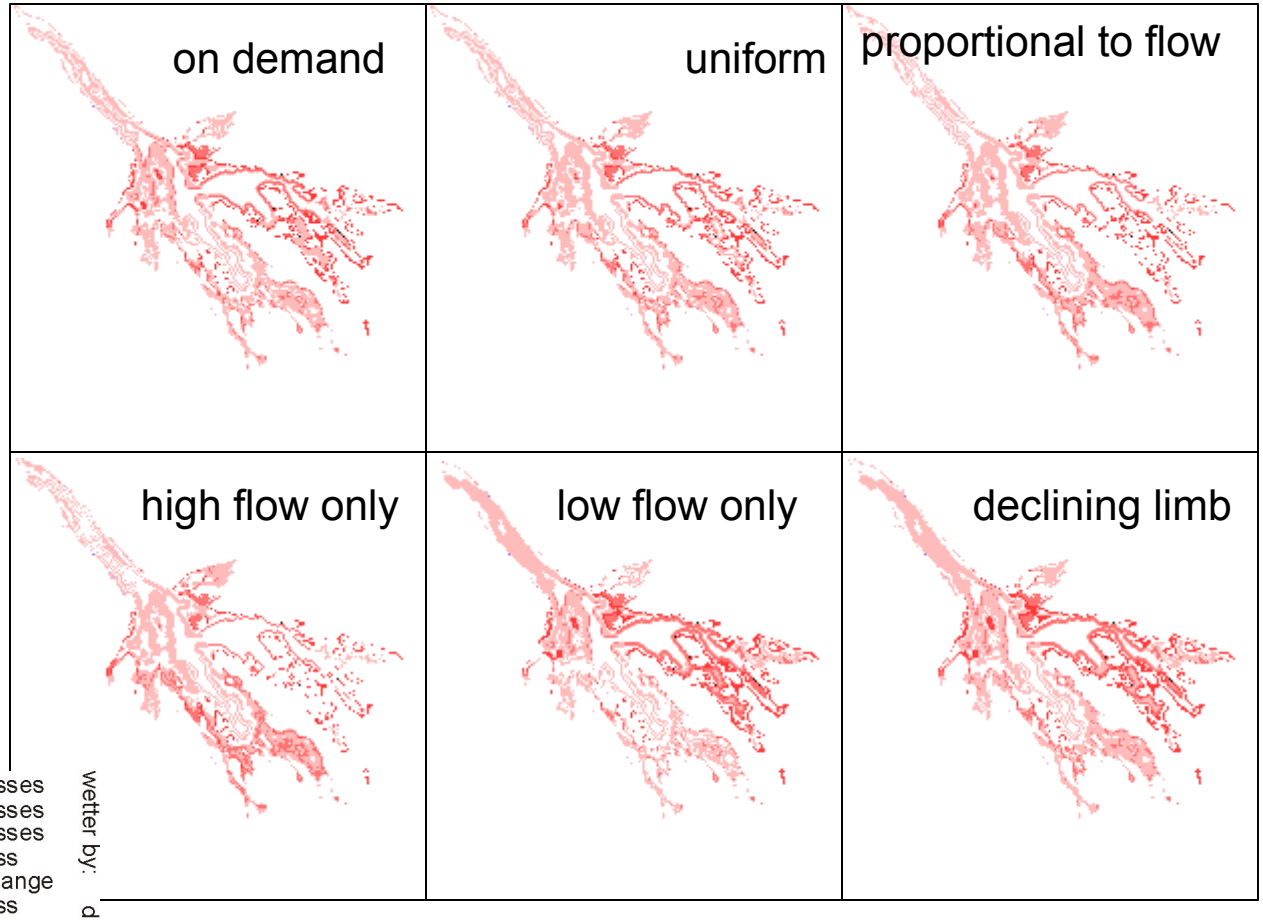


Results

Floodplain class difference maps (all maps)

Baseline

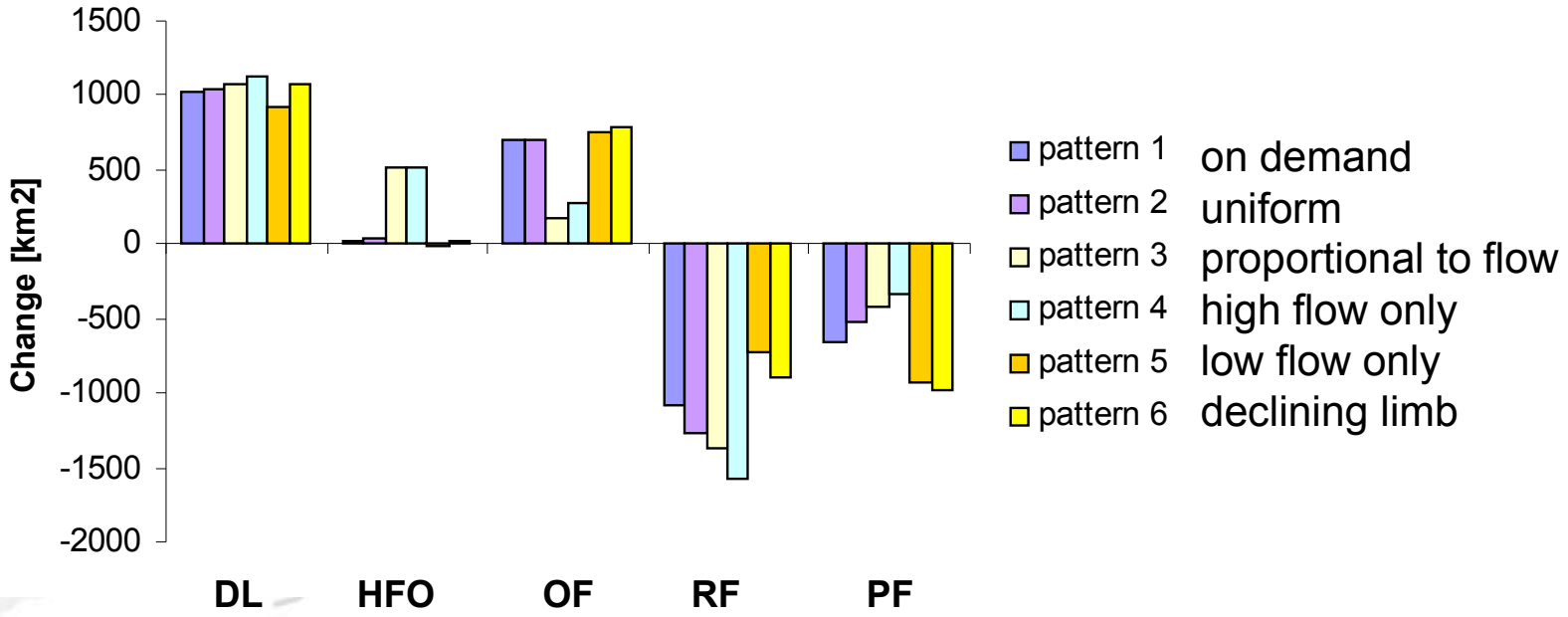




Results

Absolute change in floodplain classes area

Wet pluriannual conditions



Conclusions

Under current, eco-tourism oriented management regime, that aims at maintaining high biodiversity and productivity of the ecosystem:

- **high flow period abstractions have large impact on the system**
- **uniform abstractions - moderate impact**
- **low flow abstractions - low impact**

The effects of abstractions are visible throughout the system, and not only in its distal parts

Thank you