Hydrological and water resource responses to climate change for a temporary river: implications for river ecosystems

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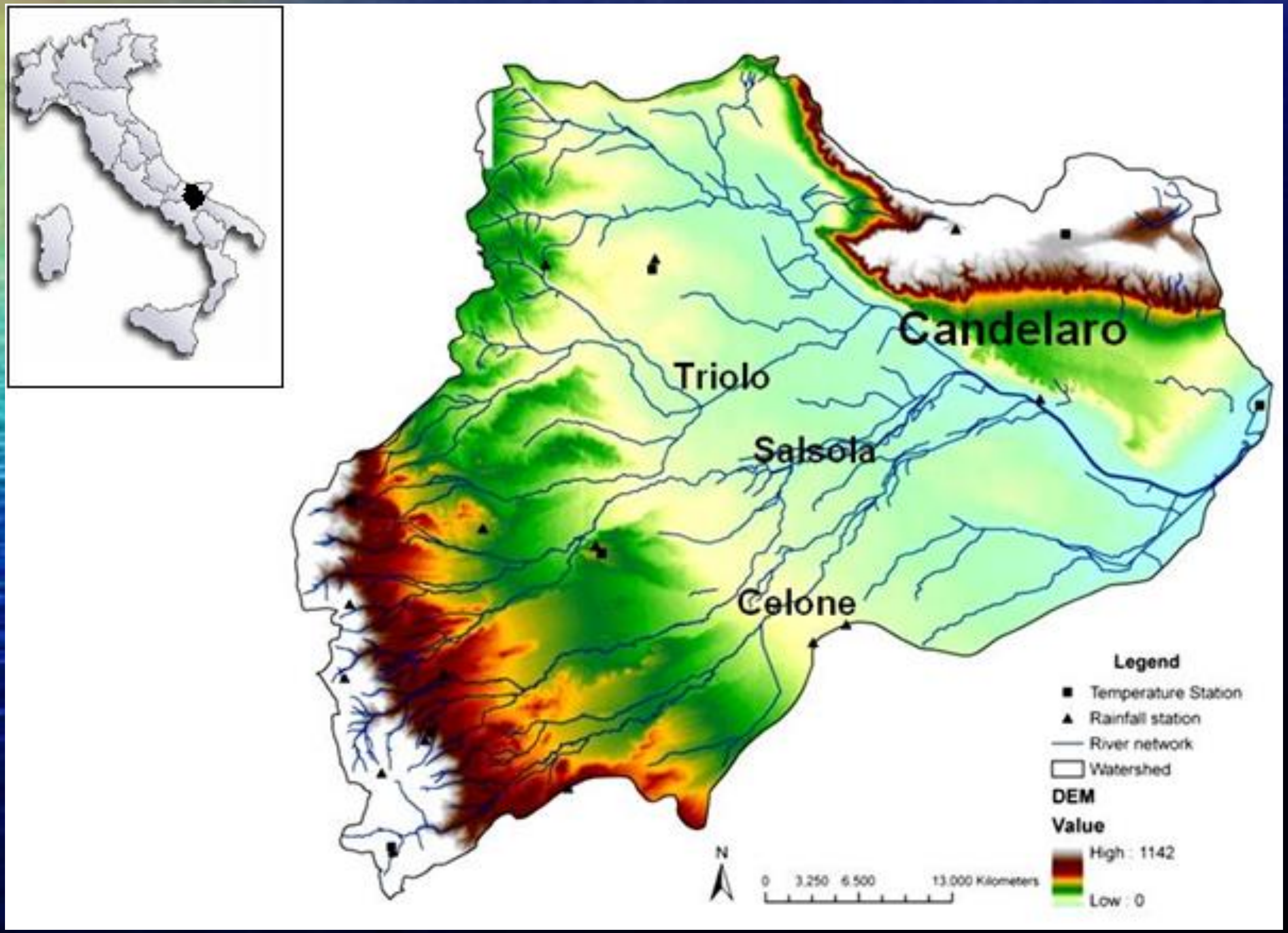
Objectives

- To analyze the potential impacts of future climate scenarios on water balance and flow regime in intermittent rivers.
- To contribute to the scientific understanding of climate change impact on water resources in Mediterranean Basin and provide information to support long-term water resources management and planning.

Steps

- Adopt 3 climate scenarios (2030-2059) and implement a statistical downscaling procedure .
- Use SWAT to simulate water balance at basin scale and streamflow in a number of river reaches for all the climatic scenarios.
- Assess flow regime alterations under changing climate by using the Indicators of Hydrological Alterations (IHA)

Study area: the Candelaro River



- The basin is located into the **second large plain** in Italy
- It includes large **intensive irrigated agricultural areas** (cereals, horticulture, energy crops). Irrigation uses water resources from groundwater and neighbouring Regions. Trade-off of such resource use has been matter for complex negotiations between Regions.
- Water for **irrigation** is distributed by the largest irrigation consortium in Italy (and in the EU).
- Part of the catchment belongs to the Gargano **National Park** including an important wetland (Ramsar site).
- The area has been classified as a **hot spot** area under risk of **desertification**
- Severe **flood** events happen frequently (damages and casualities) and alternate with **droughts**

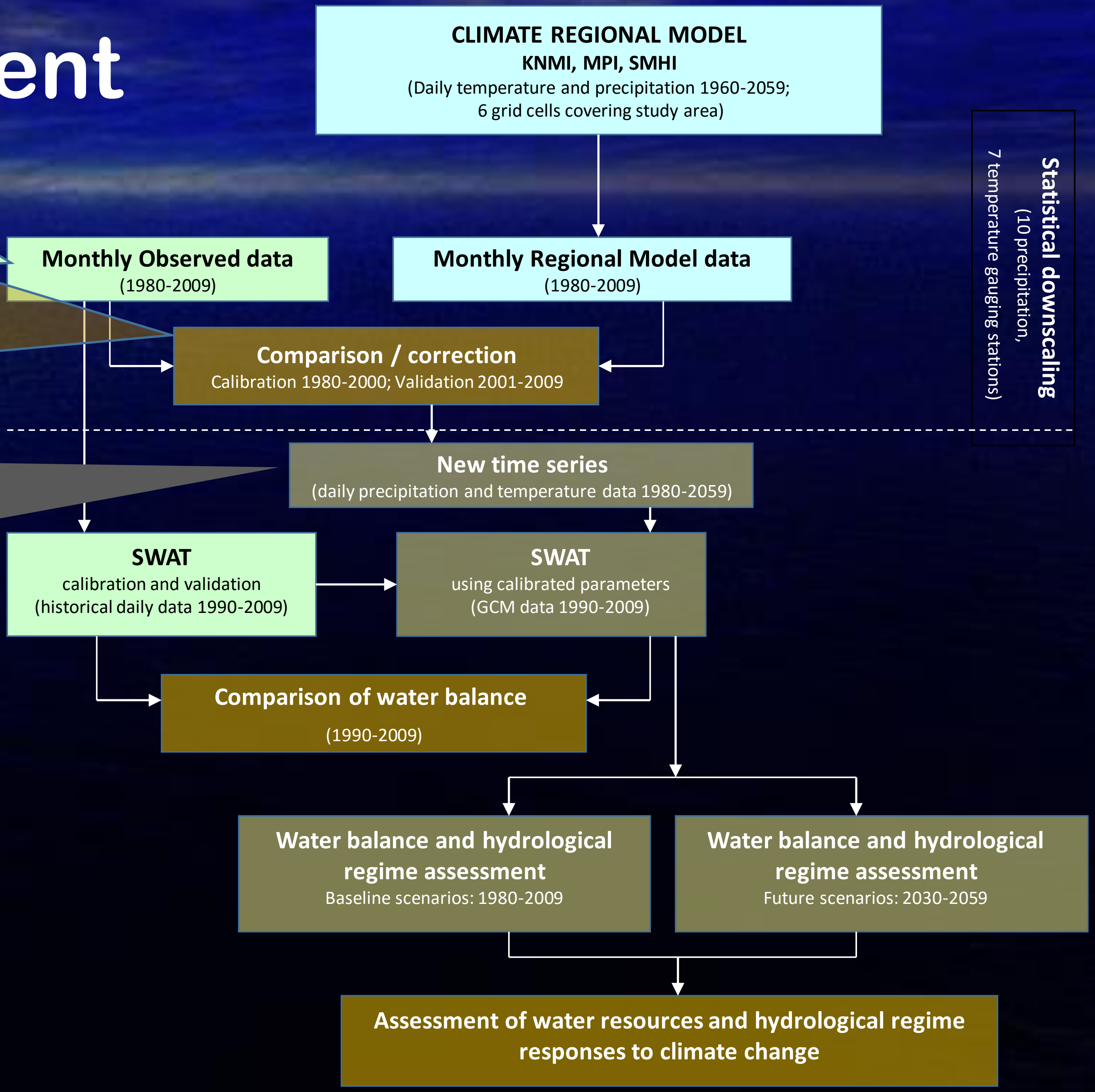
Relevance of the flashy / intermittent rivers

- **Streamflow affects numerous processes**, including sediment regime, channel formation, floodplain and flood processes, groundwater and surface water interactions, nutrient delivery, water quality and ecosystem support to living communities.
- In the Mediterranean region intermittent and ephemeral streams are **very common** fluvial systems.
- These rivers show a **high rate of change** in streamflow, high peak discharges and low baseflow.
- A large part of their annual volume flows in a **few days**, delivering a great part of their sediment and nutrient loads.
- The **EU Water Framework Directive** pays little attention to this kind of rivers (classification, monitoring, program of measures, …)
- Despite the limited streamflow, these rivers play a huge role in securing **water resources** to a large number of human communities

Climate data treatment

The **baseline period** (**1980-2009**) is representative of the recent average climate in the study region and features a range of climatic variations, including severe droughts and cold seasons (IPCC, 1994).

representing the current climate condition; with those resulted from the GCMs in order to fit the monthly empirical relationships between GCM data and observed data.



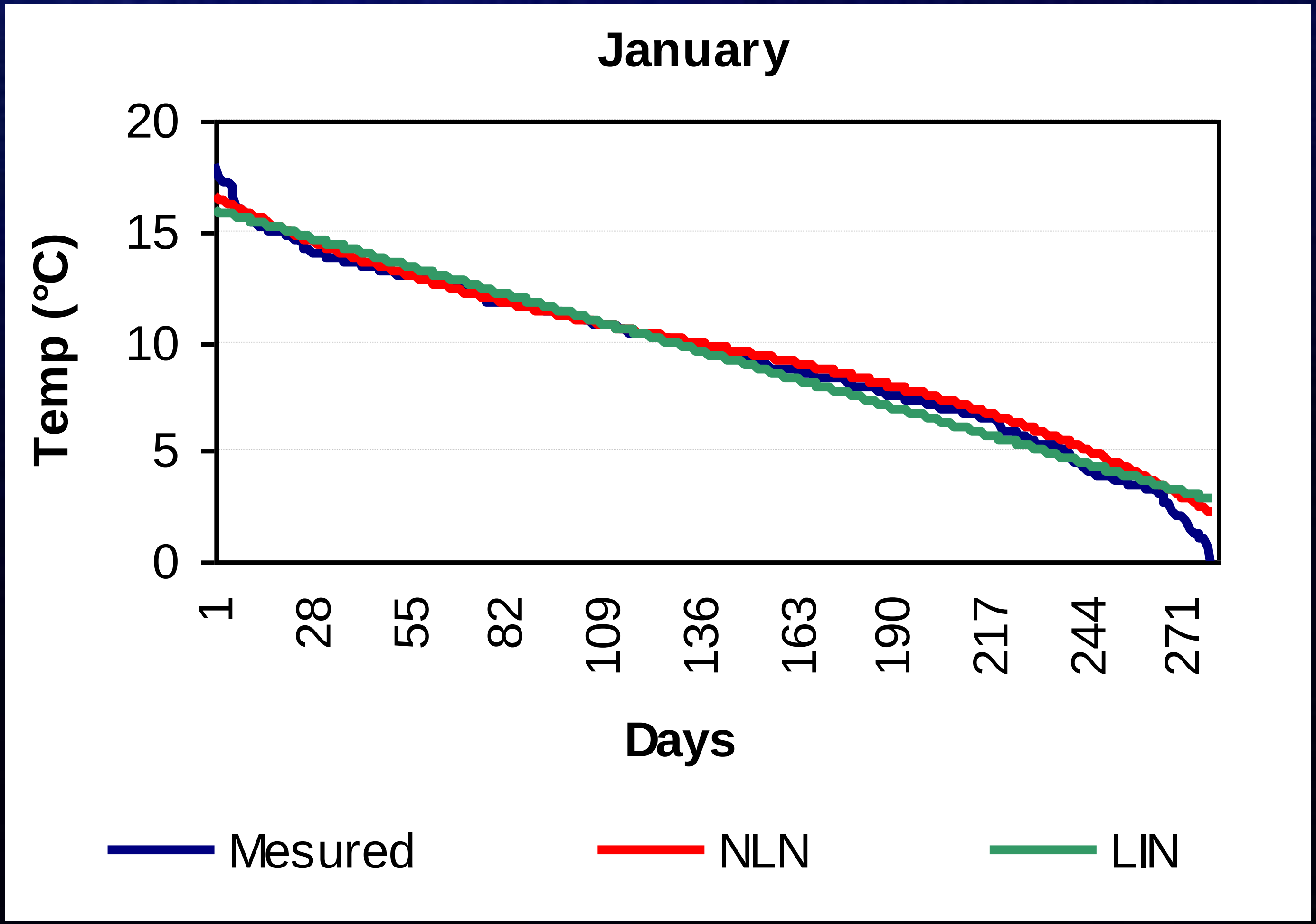
Climate scenarios (A1 family):

- (S1) **KNMI**_RACMO_ECHAM5
- (S2) **MPI**_REMO_ECHAM5
- (S3) **SMHI**_RCA_ECHAM5

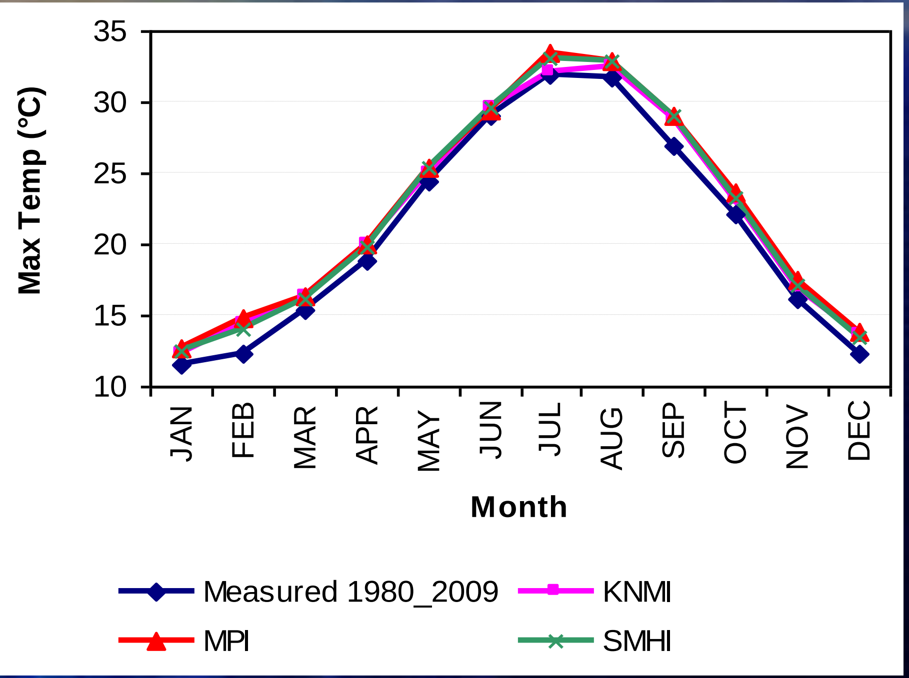
Baseline: 1980-2009
Future: 2030-2059

Comparison between measured data and modelled baseline

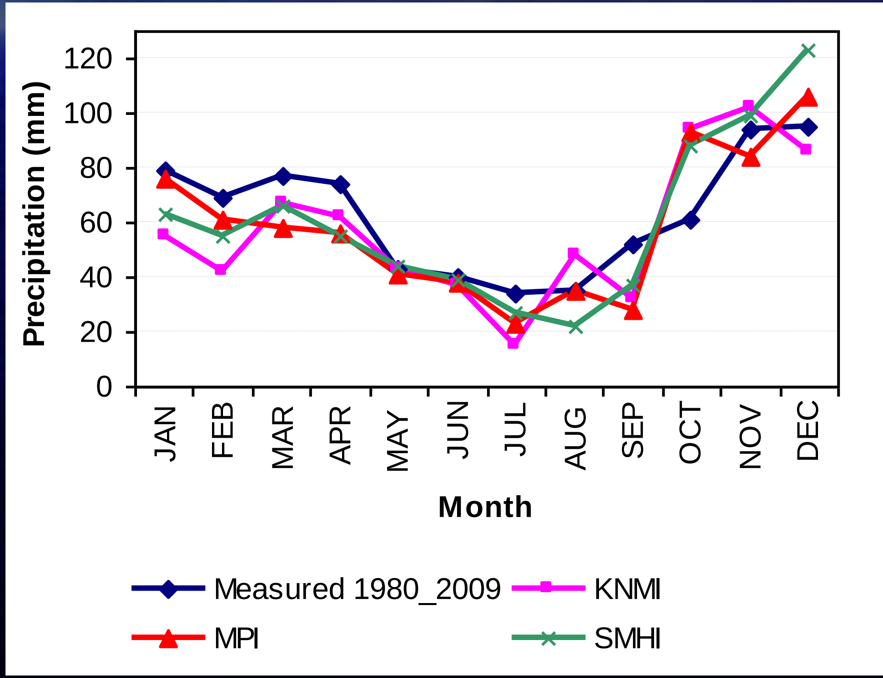
Measured and downscaled Tmax daily data for the months of January over the validation period (2000-2009) at one of the gauges (Troia).
Non linear regression (NLN; R2=0.995) and linear regression (LIN; R2=0.979).



Downscaled vs Measured data



Tmax



Precipitation

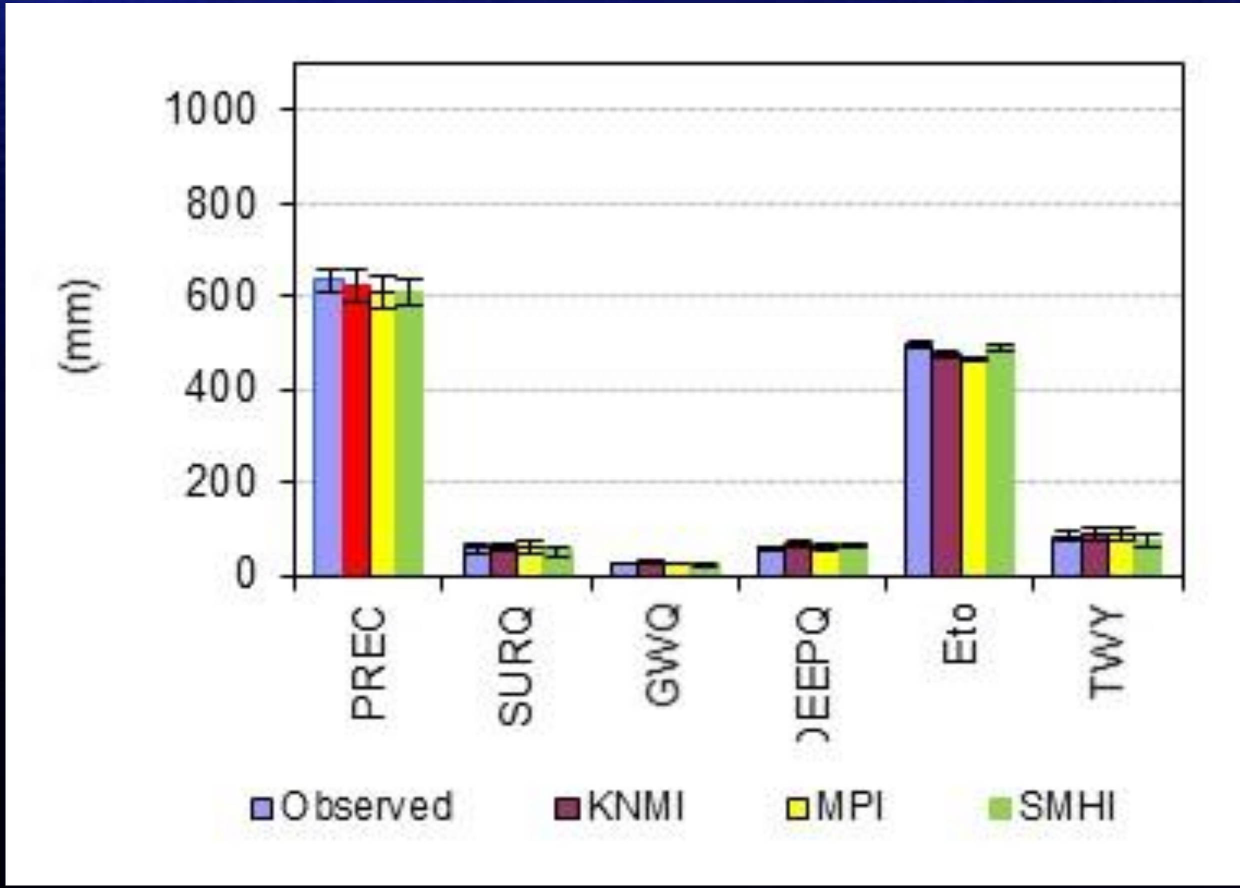
All the scenarios gave rather similar results

Slight increase of temperature all along the year

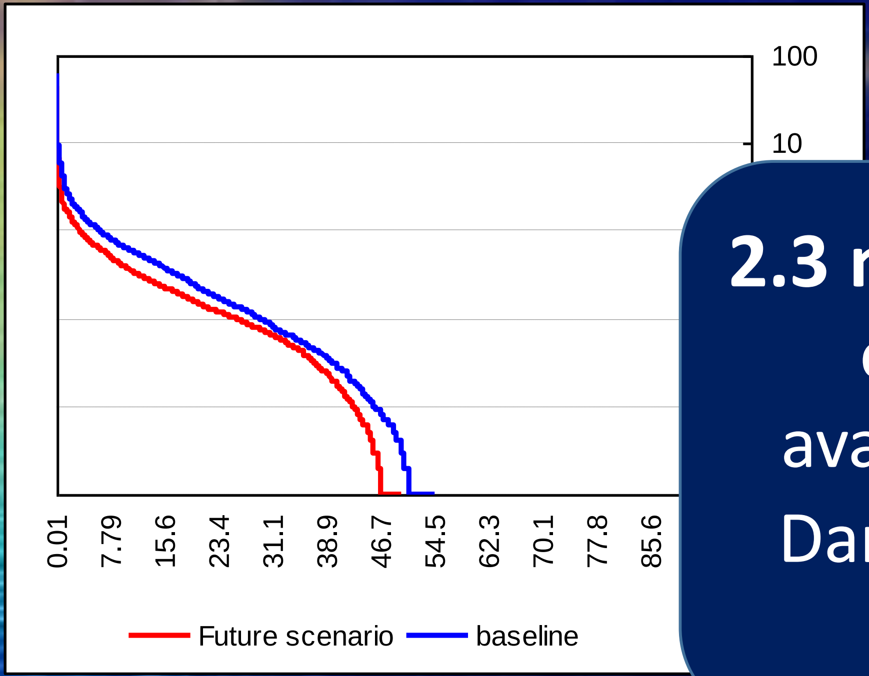
Decrease in precipitation, mostly in January-April

Water Balance changes

- No land use changes has been assumed for the future
- An increase of 4% in irrigation has been considered only for currently irrigated areas
- A decrease of blue water forecasted for all scenarios (up to 18%)
- A decrease in Eta (up to 3%)

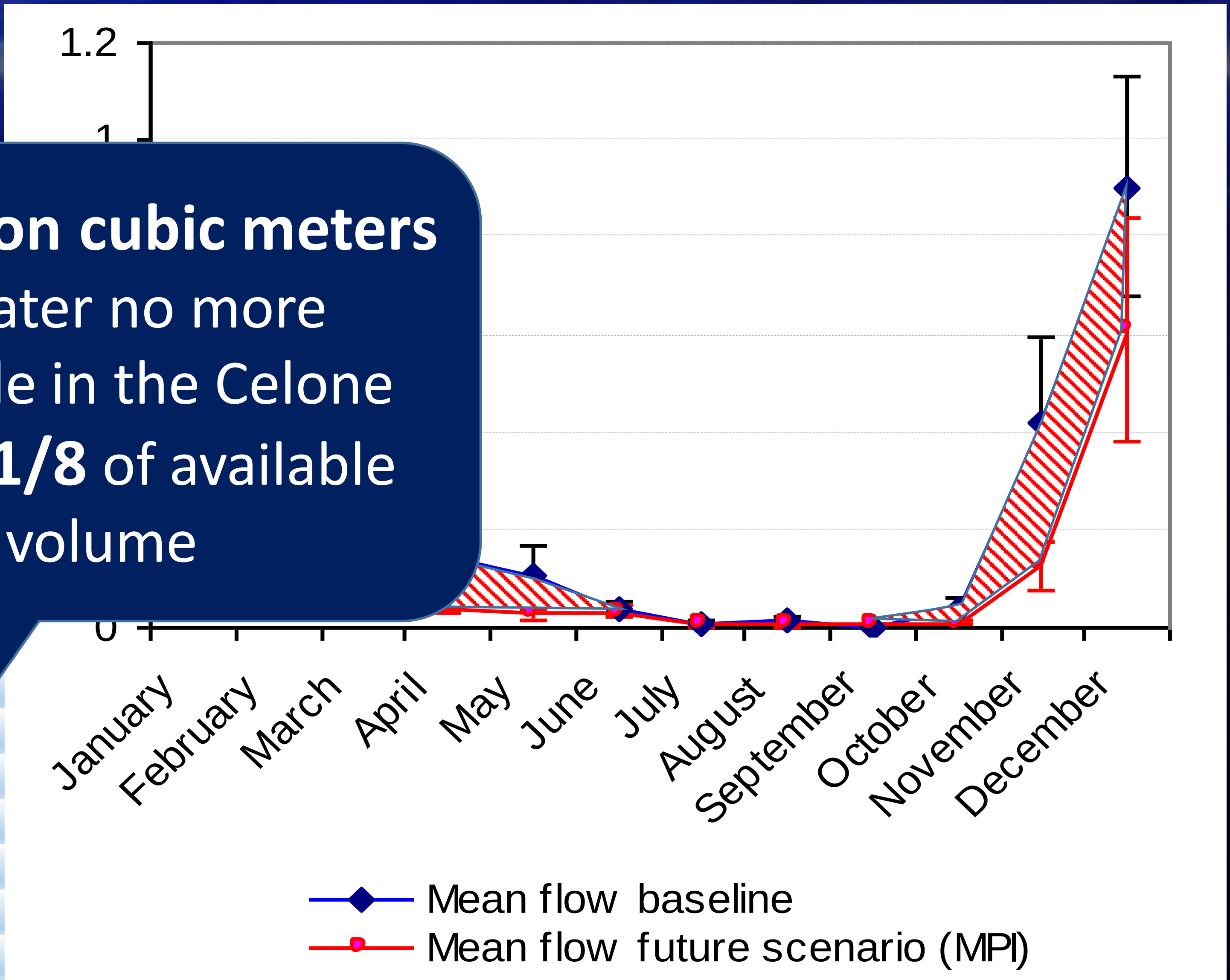


Change in available water resources

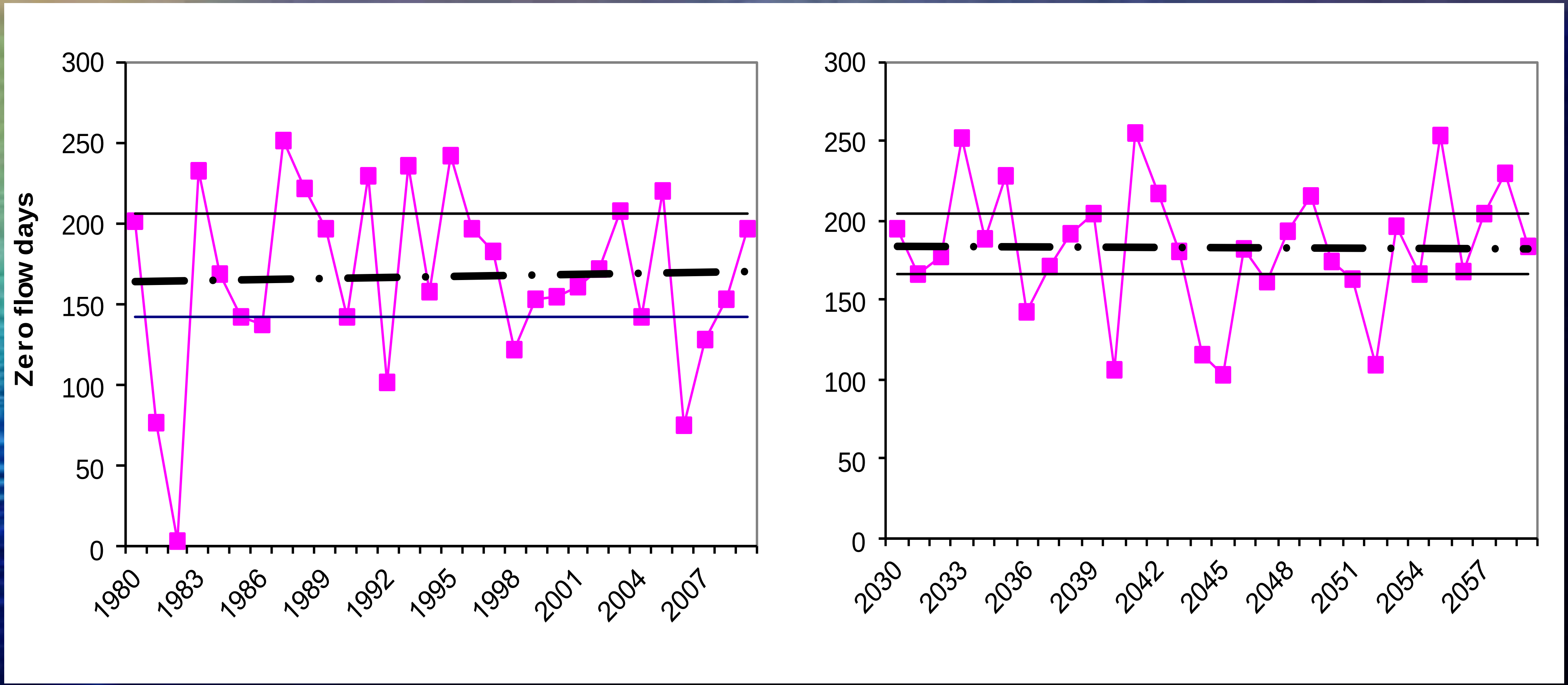


2.3 million cubic meters of water no more available in the Celone Dam = **1/8** of available volume

	Observed (1990-2009)	Current scenario (1980-2009)	Fu… (2…
		MPI	
Rainfall (mm)	635	614	5…
Diff. In rain (%)			-…
Blue water (mm)	142	146	120
Diff. blue water (%)			**-18**
Green water flow (mm)	497	475	459
Diff. Green water flow (%)			3



“Zero flow” days tendency



Increase of over 20 days of “zero flow”

Permanent, intermittent-pools, intermittent-dry or episodic?

Stream type	*Flow duration*	*Pools duration*	*Dry period*
P Permanent	*≥ 10 months per year*	*≤ 2 months per year*	*No occurrence*
I-P - Intermittent-pools	*≥ 3 months per year*	*≤ 9 months per year*	*≤ 1 month*
I-D - Intermittent-dry	*≥ 3 months per year*	*≥ 1 but < 3*	*≥ 1 month*
E - Ephemeral-Episodic	*< 2 months per year*	*< 2 months*	*≥ 10 months*




Changes in stream classification

Mf: relative annual number of months with flow

Sd6: six-month dry season defined by the Equation:

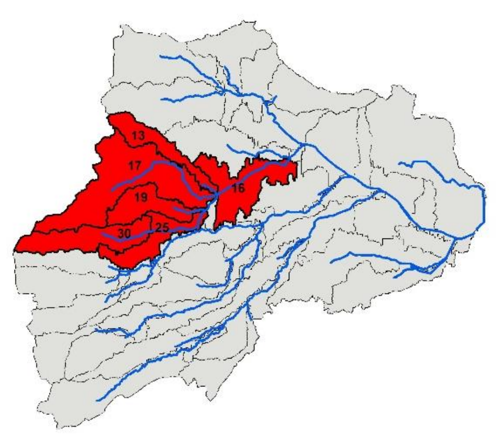
$$Sd_6 = 1 - \left(\sum_1^6 Fd_i / \sum_1^6 Fd_j \right)$$

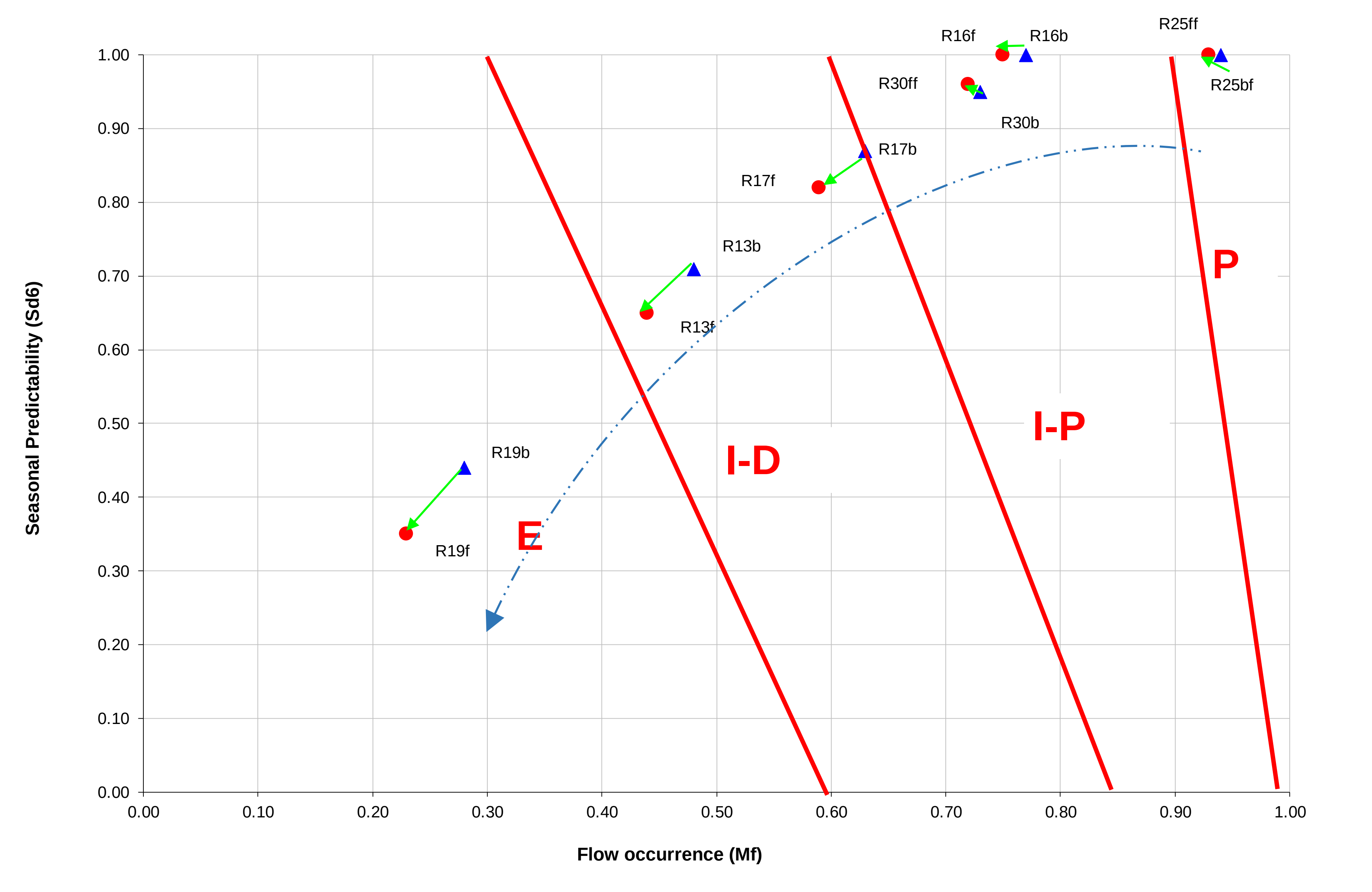
Where

Fdi is the multi-annual frequency of the zero-flow months for the contiguous six wetter months per year

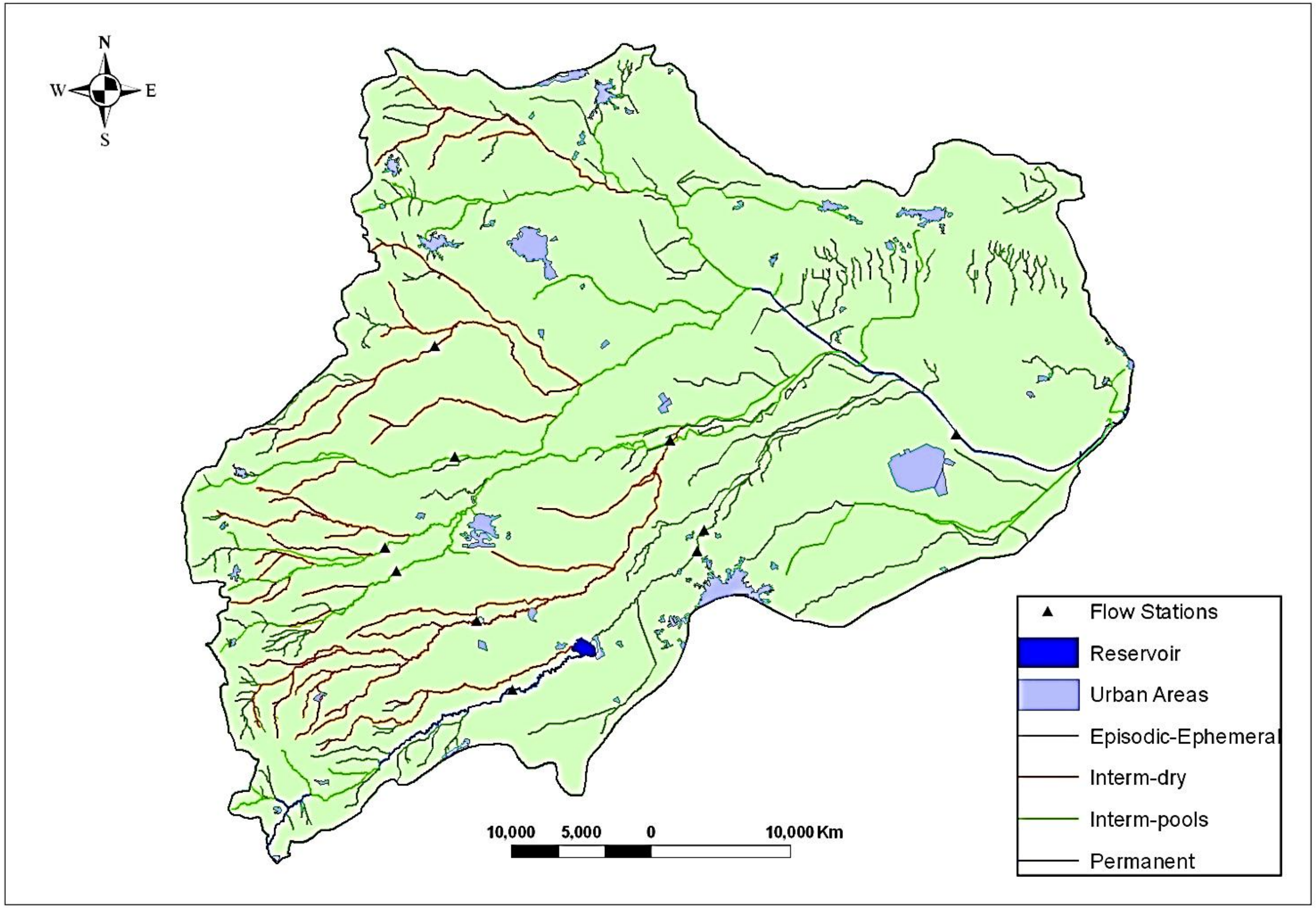
Fdj is the multi-annual frequency of the zero-flow months for the remaining drier six months.

P: Permanent
I-P: Intermittent-Pools
I-D: Intermittent –Dry
E: Ephemeral-Episodic





Types of temporary streams (baseline)



General Classification	Number of River Segments	River Length, Km	Total Length %
Episodic	123	350.01	31.57
Intermittent Dry	55	368.46	33.23
Intermittent Pools	53	316.49	28.55
Permanent	12	73.70	6.65

Relevance of elongated low flow period in ecohydrology

- River segment remained dry for a long time and the water content in the alluvial soil constituting the river bed became similar to the surrounding **terrestrial soil**. Consequently, a different ecosystem may colonize the stream whose river bed may be invaded by plants and terrestrial fauna.
- Flow permanence can become too short for aquatic fauna to re-colonize the stream (Munné and Prat, 2011)
- An increase in lentic flow-related habitat may determine a decrease in the values of metrics used to evaluate Ecological Status. Thus, if these conditions are due to a natural variability in streamflow, a correction of ES assessment systems is needed in order to avoid an underestimation of the ecological quality (Buffagni et al., 2009).

Conclusions

- In the Mediterranean area **accurate downscaling** of climate models is needed
- **Moderate expected changes** in forcing variables can result in **sensible changes in the water balance**, in the flow regime and in the capability of river systems to support biological communities
- Sensible **water resources reductions** can be expected
- **Longer low and zero flow conditions** can be expected, that can impair the survival and reproductive success of several organisms
- The **classification of streams** (WFD) can change along the time
- River Basin management (**POMs**) must **adapt** to changing climate





Thank you for your attention !