

# Climate change impacts on water availability in three Mediterranean watersheds of Catalonia (NE Spain)



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**(CREAF)**

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# The project

## MAIN AIMS:

- 1. Assess **territorial vulnerability** of three diverse Mediterranean watersheds in Catalonia with regard to the main effects of **global change** on **water availability**
- 2. **Define** possible **adaptive options** based on the assessment of territorial and social vulnerability

The project has been developed during **three years** by **four** different **research institutions** with an interdisciplinary approach.



# Study areas



Study areas  
are three  
medium size  
**watersheds:**

- ⌄ Fluvià (977 mm, 13 °C)
- ⌄ Tordera (819 mm, 14 °C)
- ⌄ Siurana (589 mm, 13 °C)

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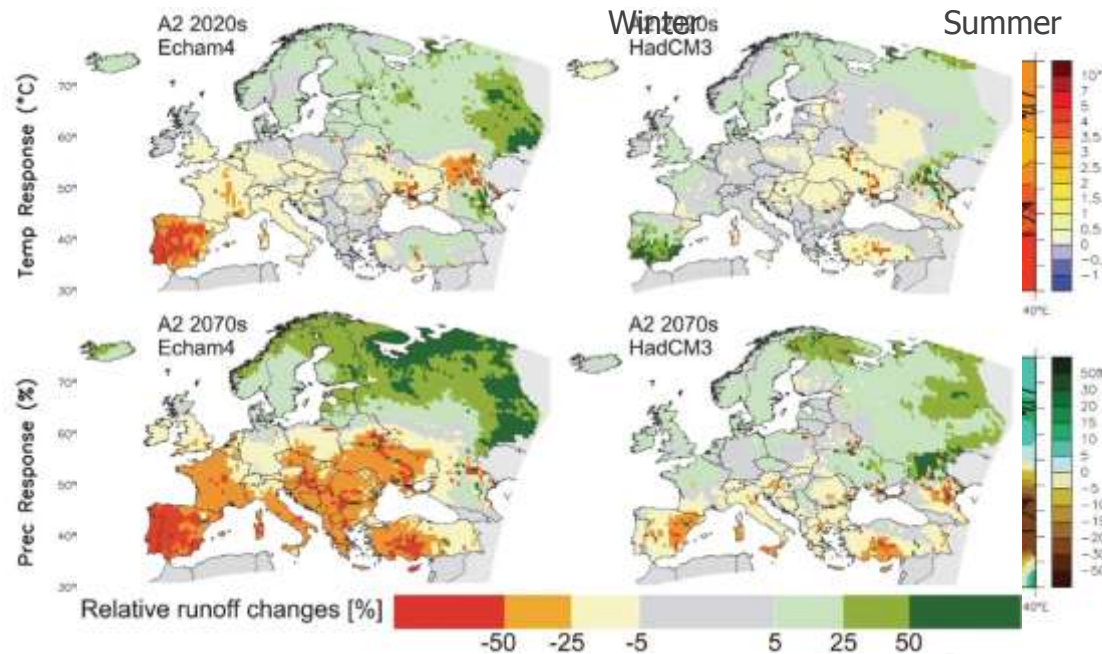
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# Background

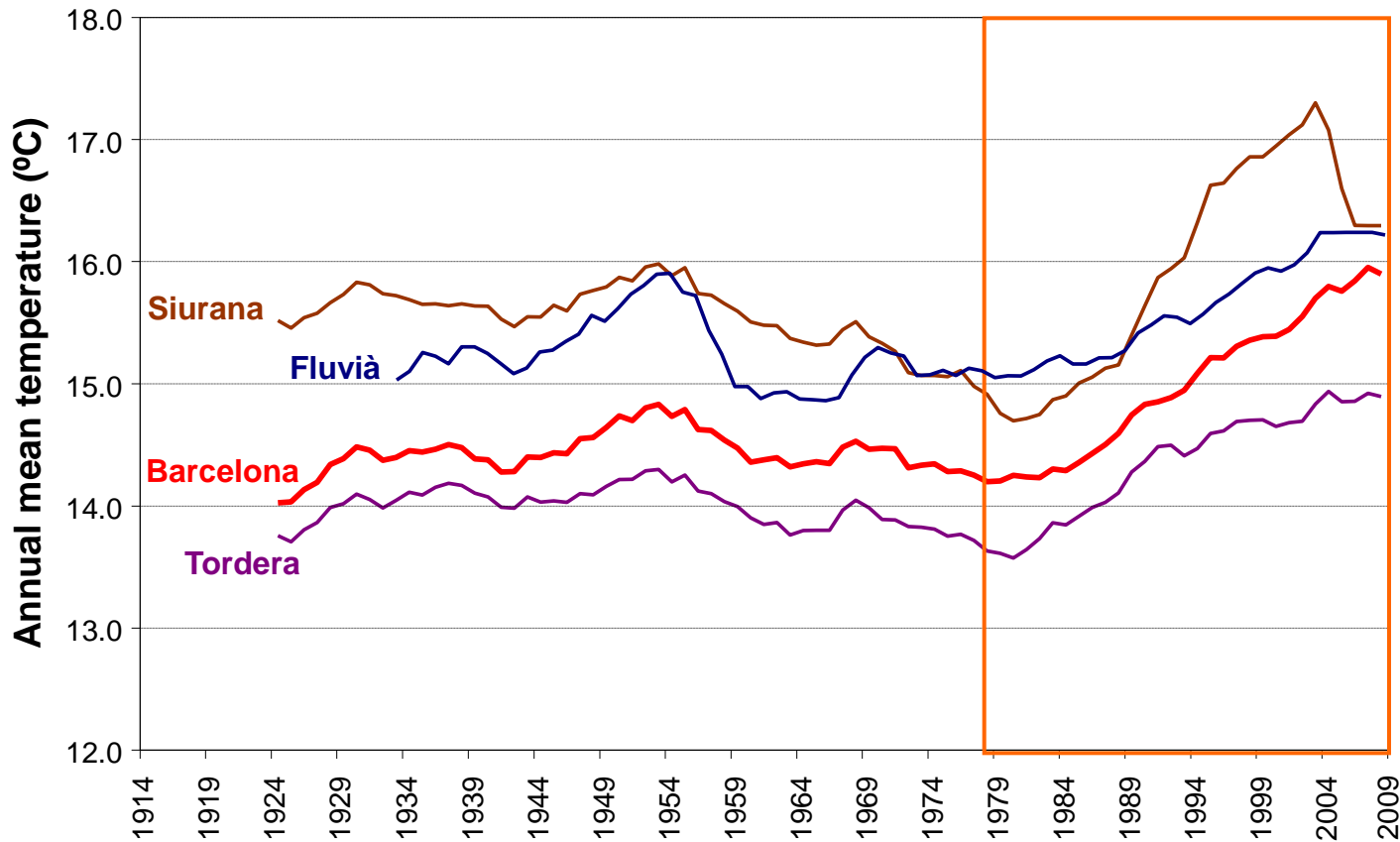
**Mediterranean** basin might become one of the **most vulnerable areas** in Europe regarding **climate change** at the end of the Century



**Mediterranean** basin might suffer a **significant decrease in runoff** at the end of the Century.

# Background

## CLIMATE: OBSERVED TEMPERATURE TRENDS (1914-2008)

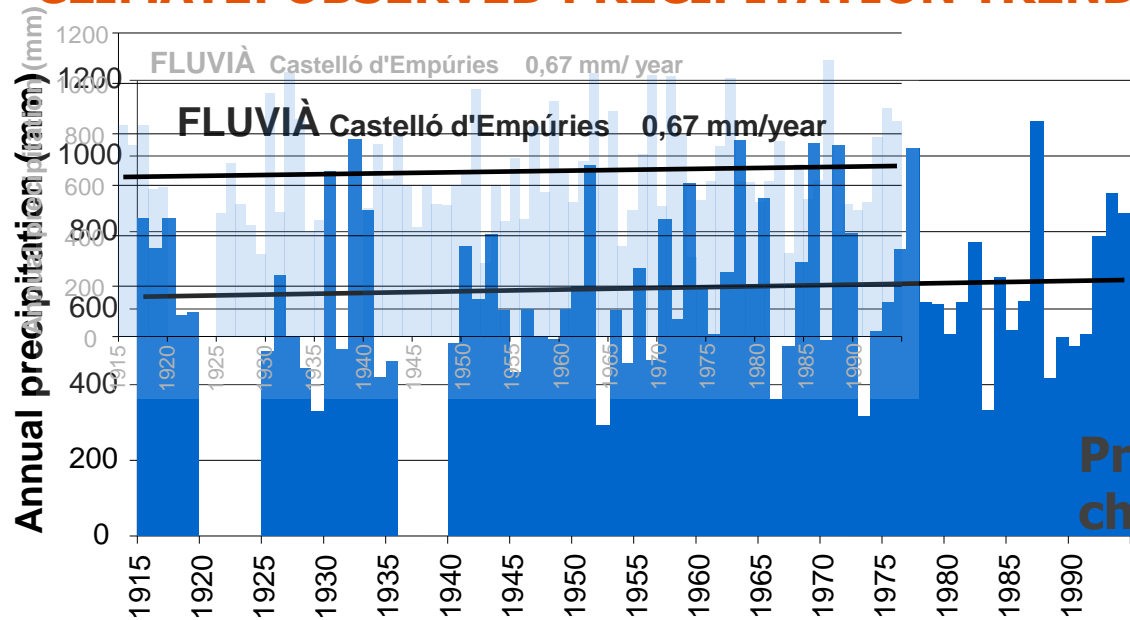


A **1.9 °C** temperature increase since **1979** has been monitored at the three watersheds



# Background

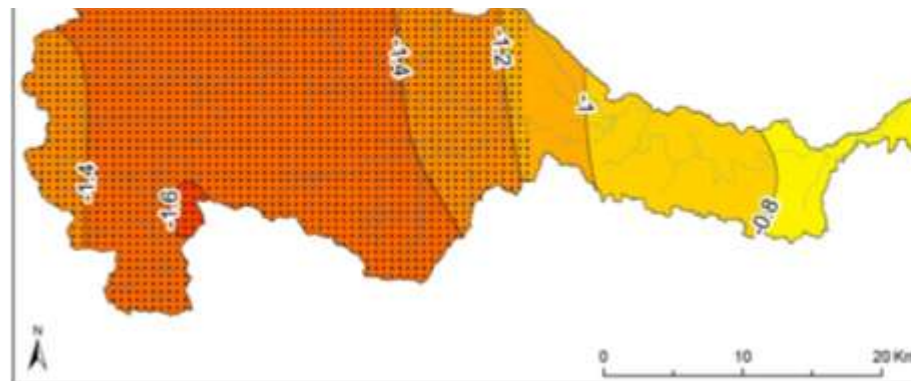
## CLIMATE: OBSERVED PRECIPITATION TRENDS



No **significant changes** in annual precipitation...

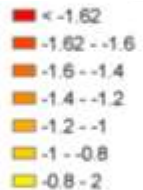
### Precipitation changes in March

...but significant changes in certain **months**



### Precipitation trends in March (mm/year) from 1951-2000

Precipitation changes in March (mm/year)



⋯ Significant area at 95% confidence level



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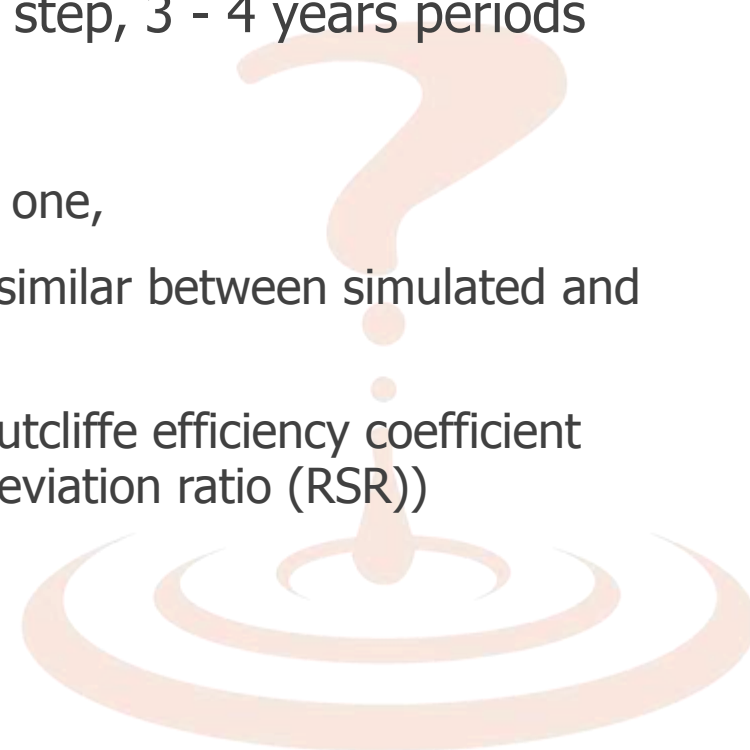
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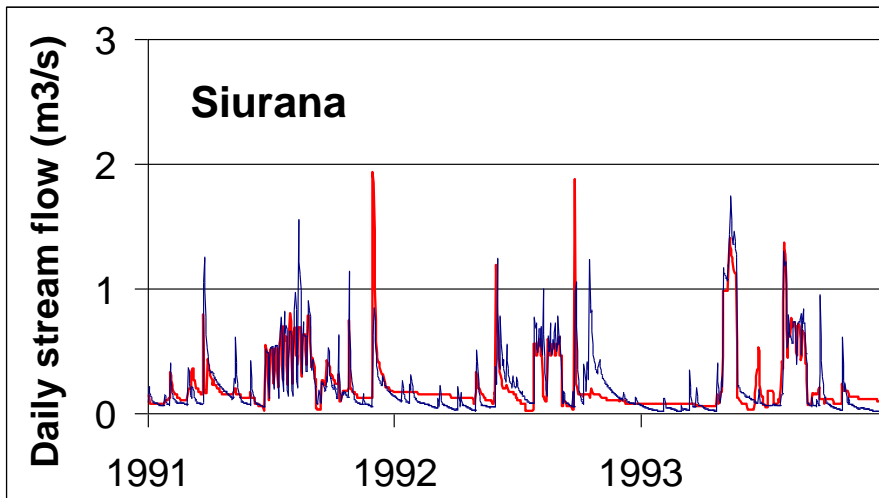
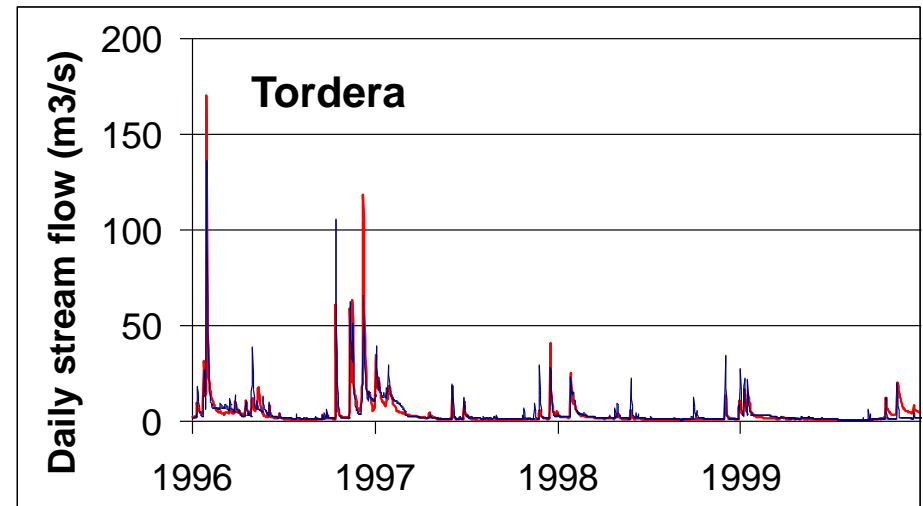
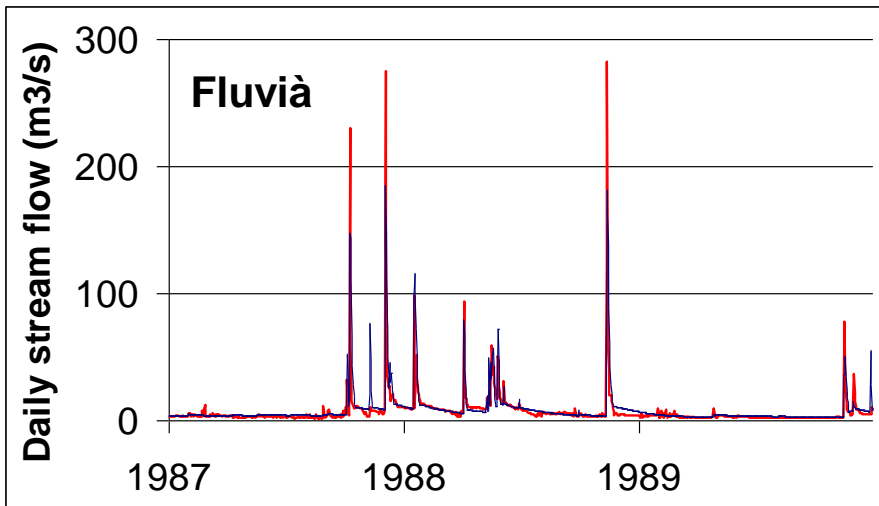


# SWAT calibration and validation

- 1 **Model calibration:** Based on stream flow series from 12 gauging stations and climatic series from 23 meteorological stations
- 1 **Available data:** 1984-2008 (25 years)
- 1 **Calibration and validation:** Daily time step, 3 - 4 years periods
- 1 **Objectives:**
  - 1 simulated hydrograph similar to observed one,
  - 1 mean flow values and total contributions similar between simulated and measured data,
  - 1 Adequate values of statistics (Nash and Sutcliffe efficiency coefficient (NSE) and RMSE-observations standard deviation ratio (RSR))



# SWAT calibration and validation

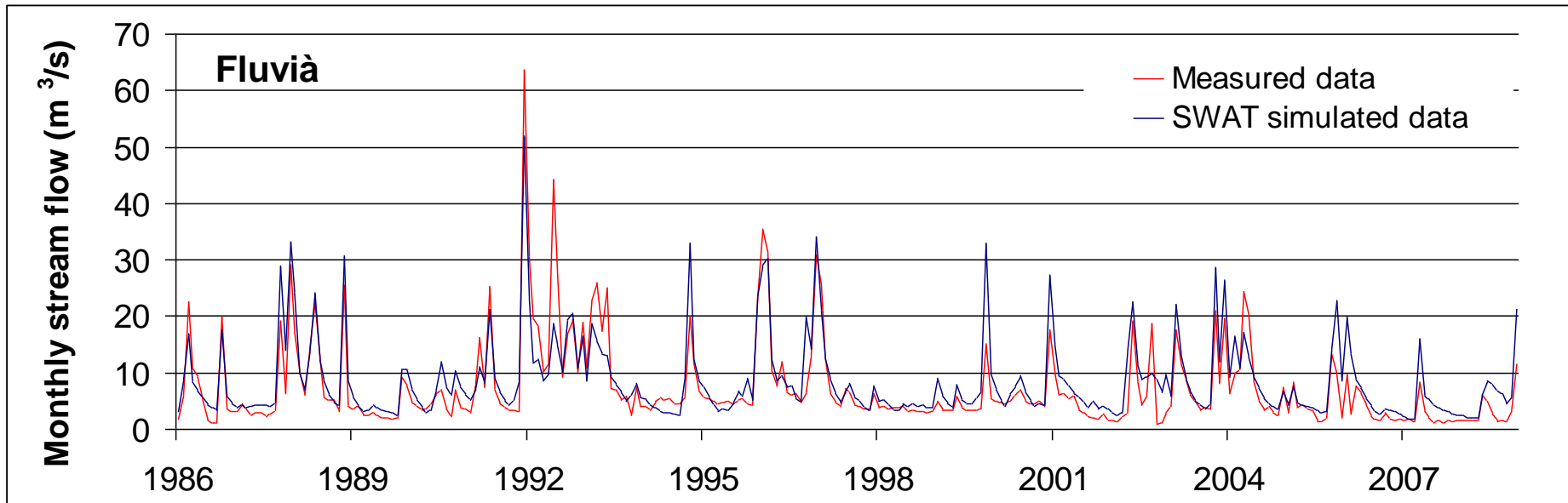


— Observed data  
— SWAT simulated data

**Daily data**

	Simulated mean daily discharge (m <sup>3</sup> /s)	Observed mean daily discharge (m <sup>3</sup> /s)	Statistics	
			NSE	RSR
Fluvià (Garrigàs)	9.1	7.1	0.5	0.7
Tordera (Can Serra)	4.3	3.6	0.5	0.7
Siurana (Cornudella)	0.2	0.2	0.6	0.7

# SWAT calibration and validation



	Simulated mean daily discharge ( $\text{m}^3/\text{s}$ )	Observed mean daily discharge ( $\text{m}^3/\text{s}$ )	Statistics	
			NSE	RSR
Fluvià (Garrigàs)	8.5	7.3	0.7	0.5
Tordera (Can Serra)	3.9	3.5	0.8	0.4
Siurana (Cornudella)	0.3	0.2	0.7	0.6

Monthly data

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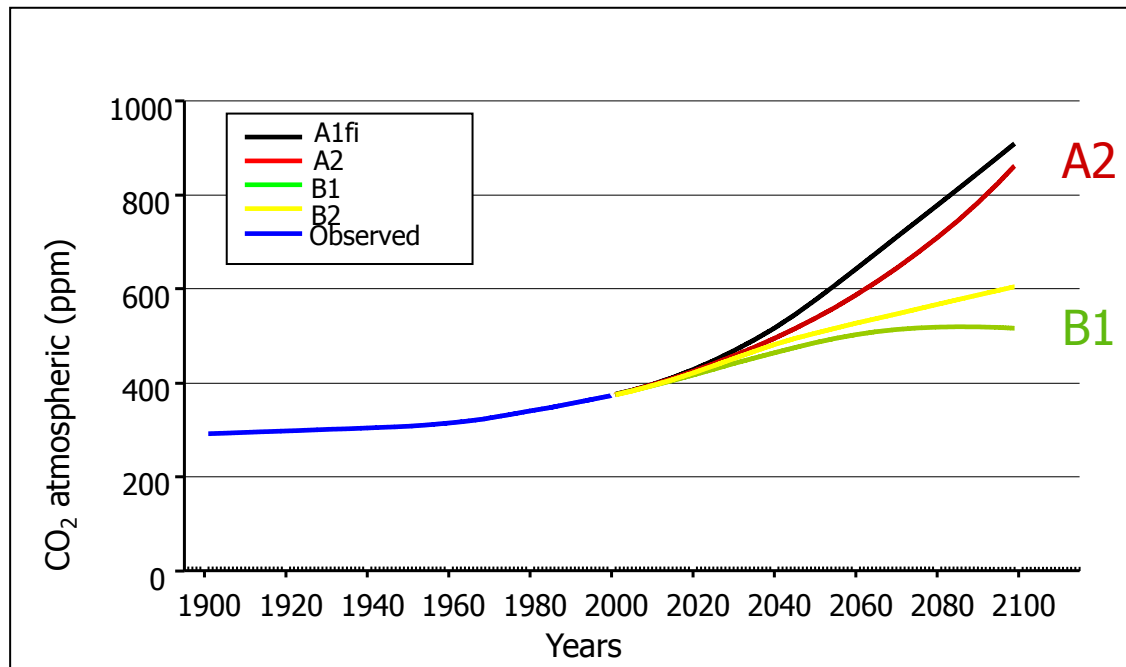
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# Climate projections at global scale

## CO<sub>2</sub> emissions global scenarios (IPCC): **B1, A2**



## Atmospheric and Oceanic General Circulation Model (AOGCM): **ECHAM5**

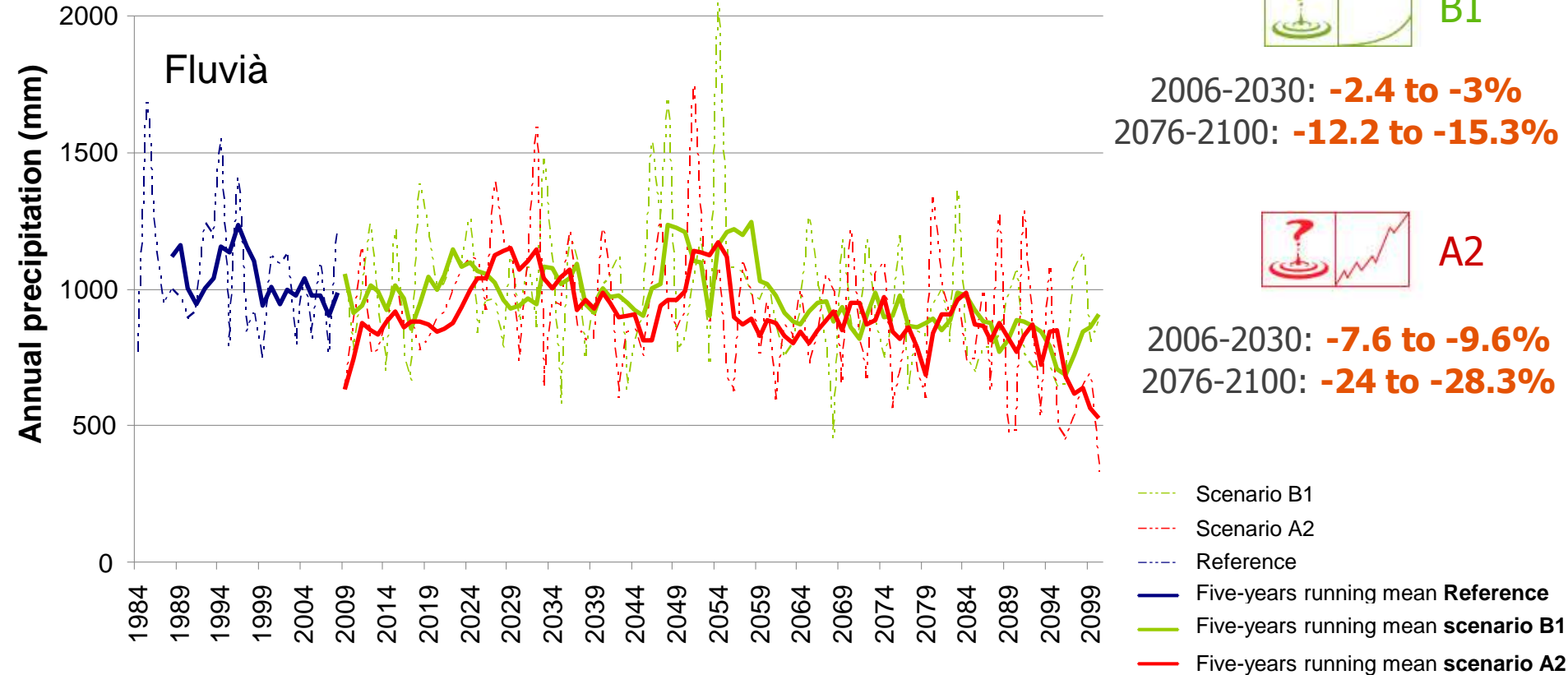
Dynamic downscaling (SMC): **high temporal** and **spatial resolution** (6 h and 15 km), period 2001-2100 and reference period 1971-2000



# Climate projections at regional scale

## FUTURE PRECIPITATION TRENDS

## FUTURE TEMPERATURE TRENDS

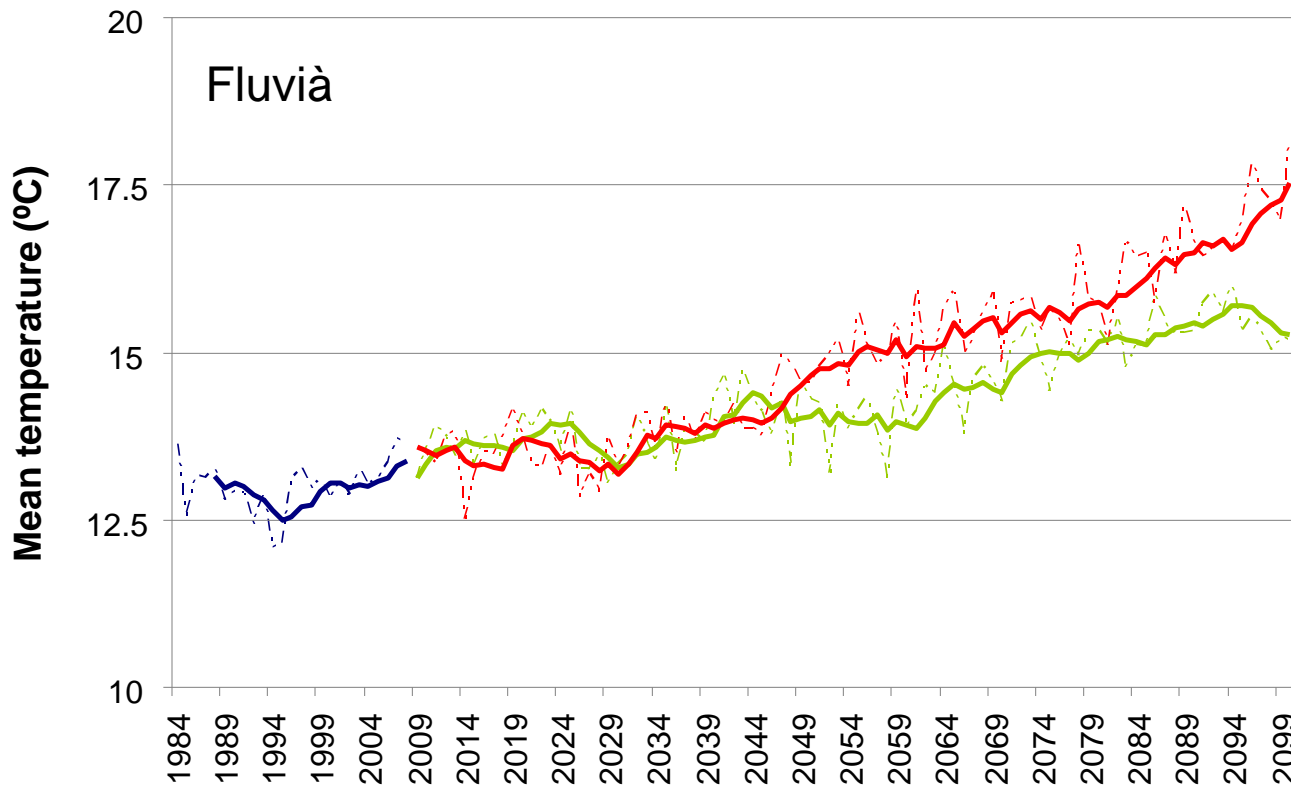


Source: SMC 2010 (Meteorological Service of Catalonia)

# Climate projections at regional scale

## FUTURE PRECIPITATION TRENDS

## FUTURE TEMPERATURE TRENDS



B1

2006-2030: **+0.51 to +0.58 °C**  
 2076-2100: **+2.2 to +2.3 °C**



A2

2006-2030: **+0.26 to +0.47 °C**  
 2076-2100: **+3.4 to 3.6 °C**

- Scenario B1
- Scenario A2
- Reference
- Five-years running mean **Reference**
- Five-years running mean **scenario B1**
- Five-years running mean **scenario A2**

# Precipitation spatial distribution

## PRECIPITATION REDUCTION AT XXI CENTURY (mm/decade)

**B1** 





**A2** climate scenario predicts stronger and significant **reductions**, specially on **headwaters**


**A2** 





### Precipitation trends (mm/decade)

 -53 - -40

 -39 - -30

 -29 - -20

 -19 - -10

 Significant area at a 95% confidence level

Source: SMC 2010 (Meteorological Service of Catalonia)

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# Results

## RELATIVE STREAM FLOW CHANGES RESPECT 1984-2008 (%)



### Short term (2006-2030)

	Stream flow variation at headwater			Stream flow variation at river mouth		
B1 	-14	-9	+4 %	-9	-9	+5 %
A2 	-20	-13	-16 %	-14	-18	-16 %
	Fluv	Tord	Siu	Fluv	Tord	Siu

↓ **Generalized stream flow reduction**, more severe at A2 scenario (**-33 to -39 %** at long term, scenario A2)

↓ Stronger reductions are expected at **Fluvià headwater** (**-20 to -48 %** at A2 scenario)

### Long term (2076-2100)

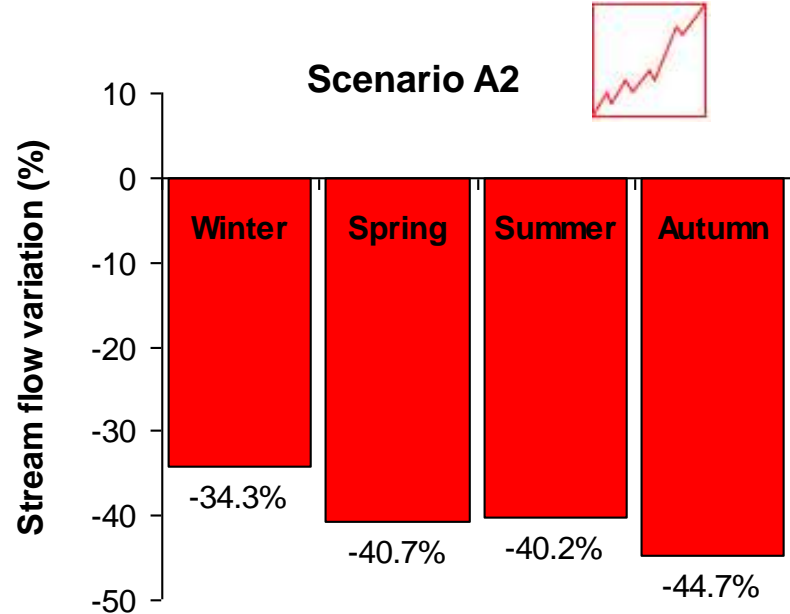
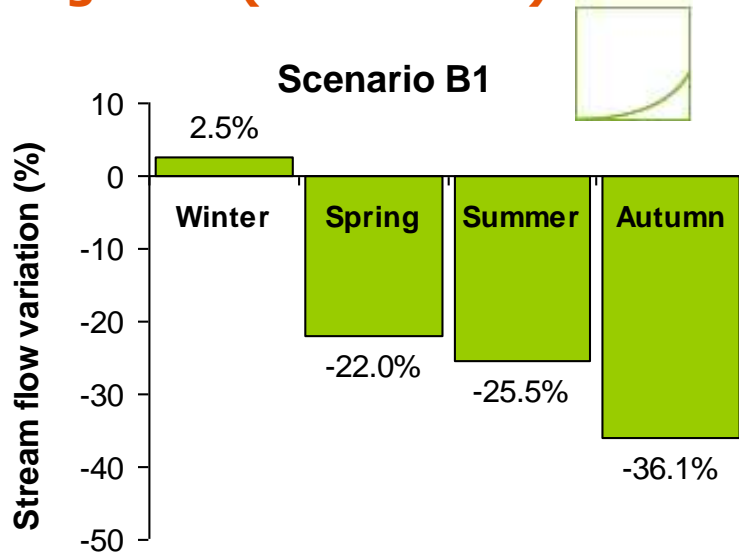
	Stream flow variation at headwater			Stream flow variation at river mouth		
B1 	-31	-22	-22 %	-22	-25	-22 %
A2 	-48	-33	-32 %	-39	-37	-33 %
	Fluv	Tord	Siu	Fluv	Tord	Siu

↓ Scenario B1 predicts a **slight** stream flow **increase** in **Siurana** basin at short term

# Results

## STREAM FLOW SEASONAL VARIATION (FLUVIÀ)

### Long term (2076-2100)

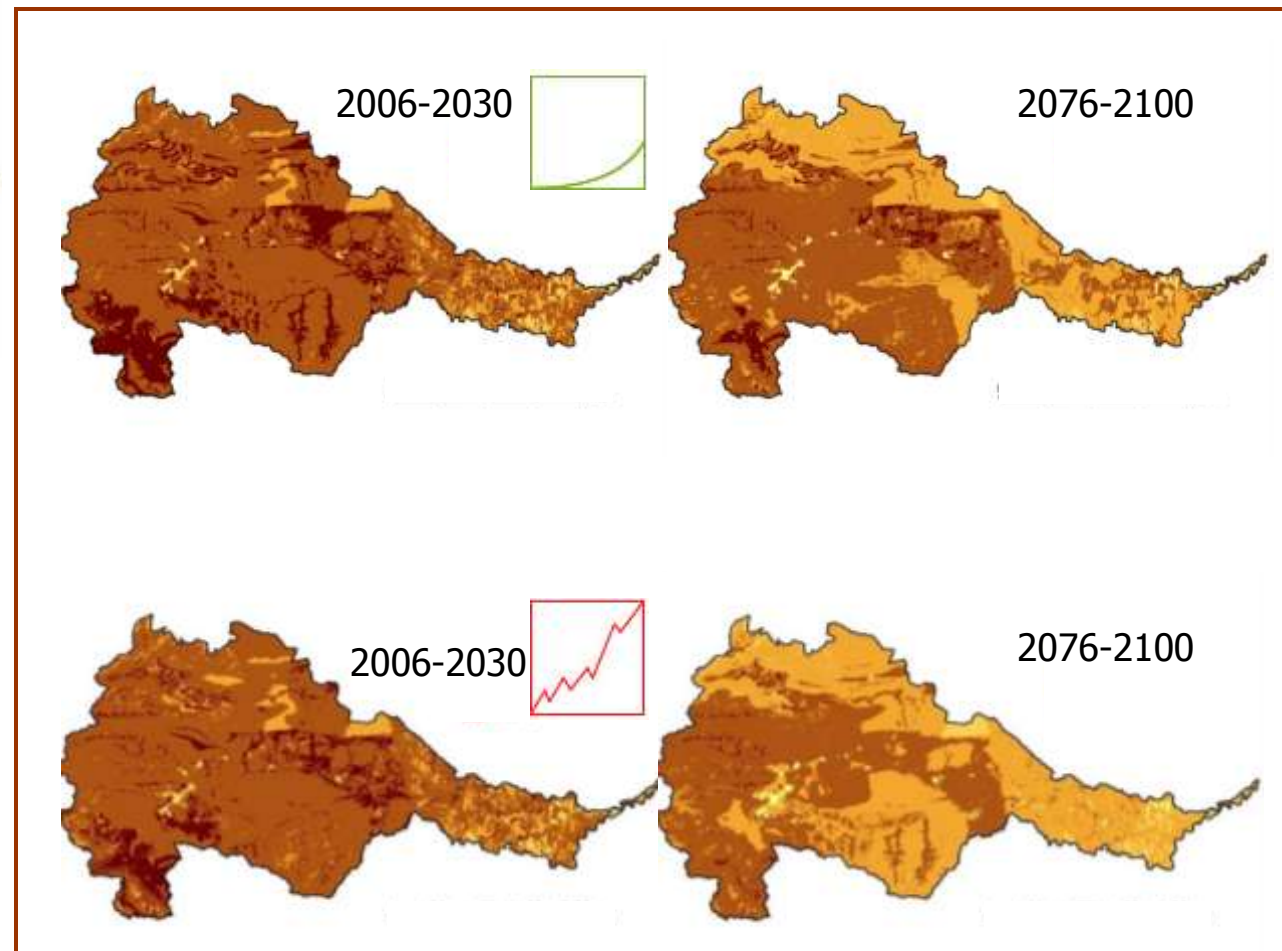
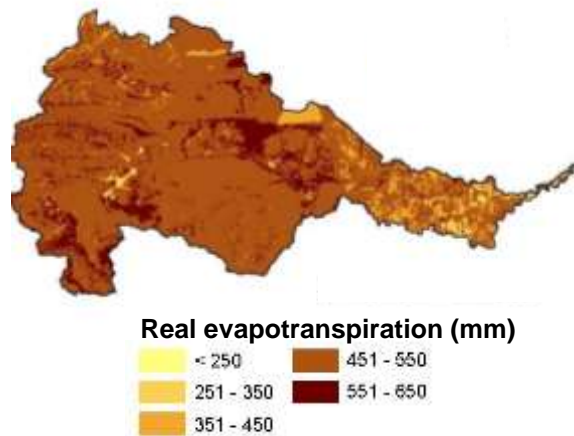


⚠ **Autumn** and **summer** will be the most affected seasons in both scenarios by the end of the Century.

⚠ **Seasonal changes** can affect **water supply** for agricultural and urban uses

# Results

## REAL EVAPOTRANSPIRATION (mm) (FLUVIÀ)

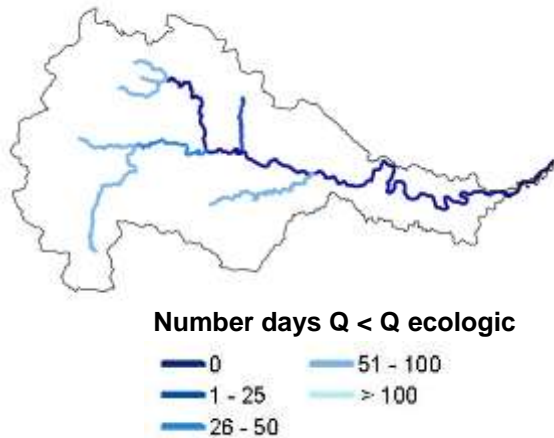


By the end of the Century, a **14 to 25 % reduction** of real evapotranspiration is expected

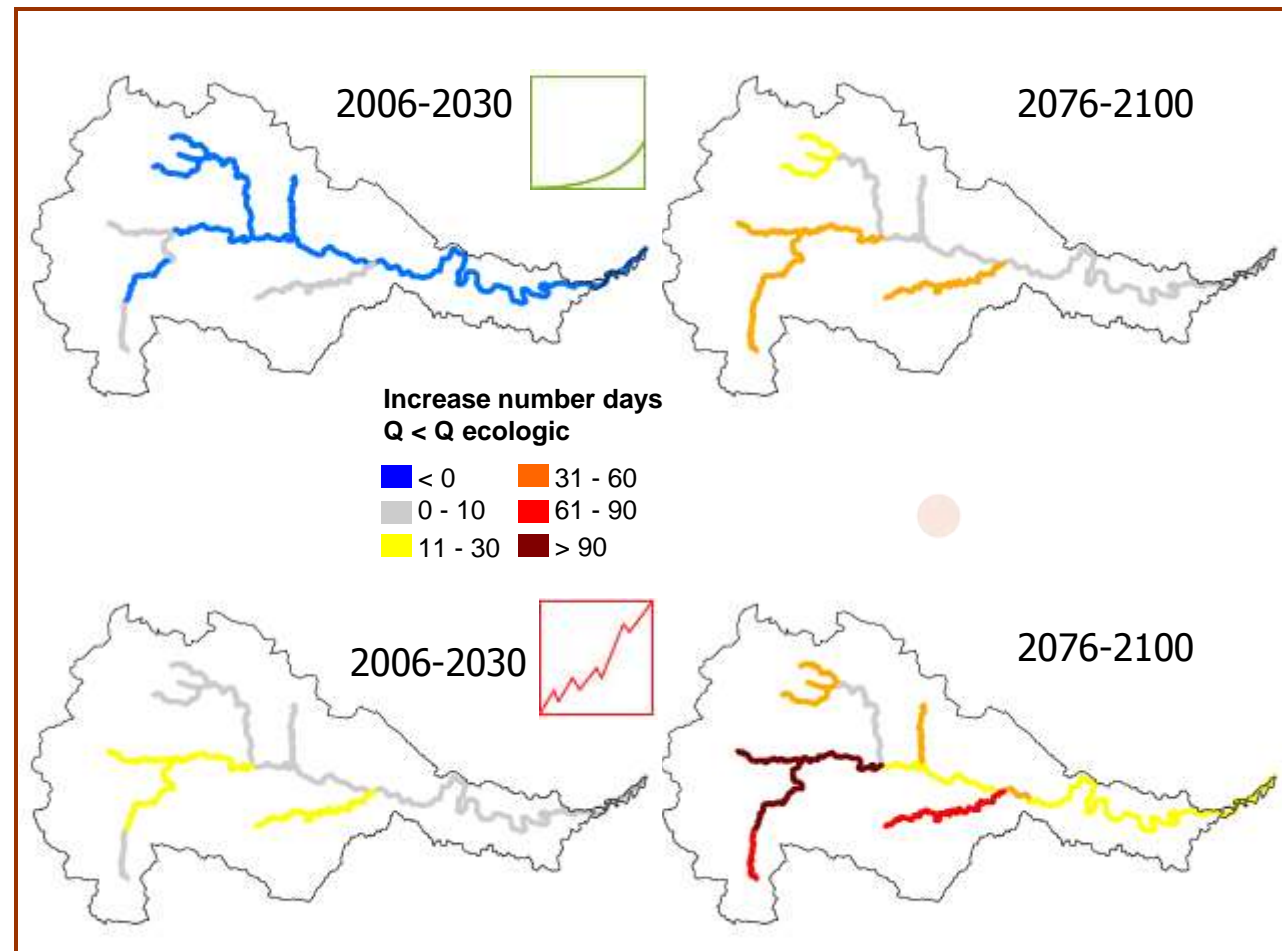


# Results

## ECOLOGICAL FLOW VARIATION (FLUVIÀ)



By the end of the Century, the number of days per year with stream flow **lower** than **ecological flow** will **increase** (more than 90 days in A2)



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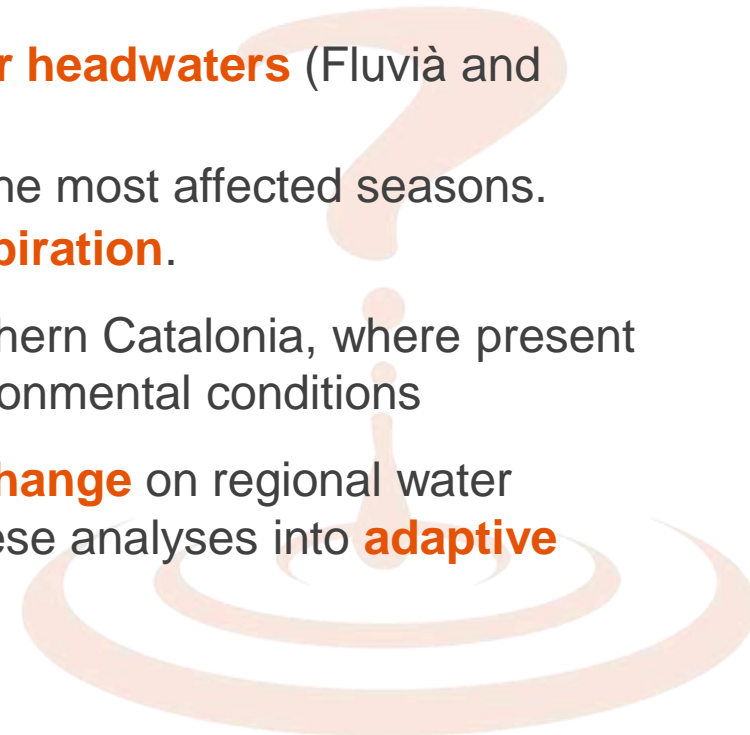
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## Discussion and conclusions

- ↓ **SWAT** is an **appropriate tool** to assess climate change impacts on Mediterranean watersheds
  - ↓ A strong alteration on **water dynamics** is expected during the **XXI Century**:
    - ↓ **22% to 48% reduction** of **stream flow**, more severe in the A2 scenario than in the B1
    - ↓ **Reductions** especially **severe** in the **wetter headwaters** (Fluvià and Tordera)
    - ↓ **Autumn** and **summer** are expected to be the most affected seasons.
    - ↓ **14% to 25% reduction** of **real evapotranspiration**.
  - ↓ **Greater vulnerability** of **wet watersheds** in northern Catalonia, where present ecosystems are more sensitive to changes in environmental conditions
  - ↓ Results highlight the **strong impact** of **climate change** on regional water resources and stress the need for incorporating these analyses into **adaptive management** in the Mediterranean region
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Thank you!

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