



eurokarst 2018  
BESANÇON  
2 - 6 July

# Modeling the global change impacts on the Lez karst aquifer

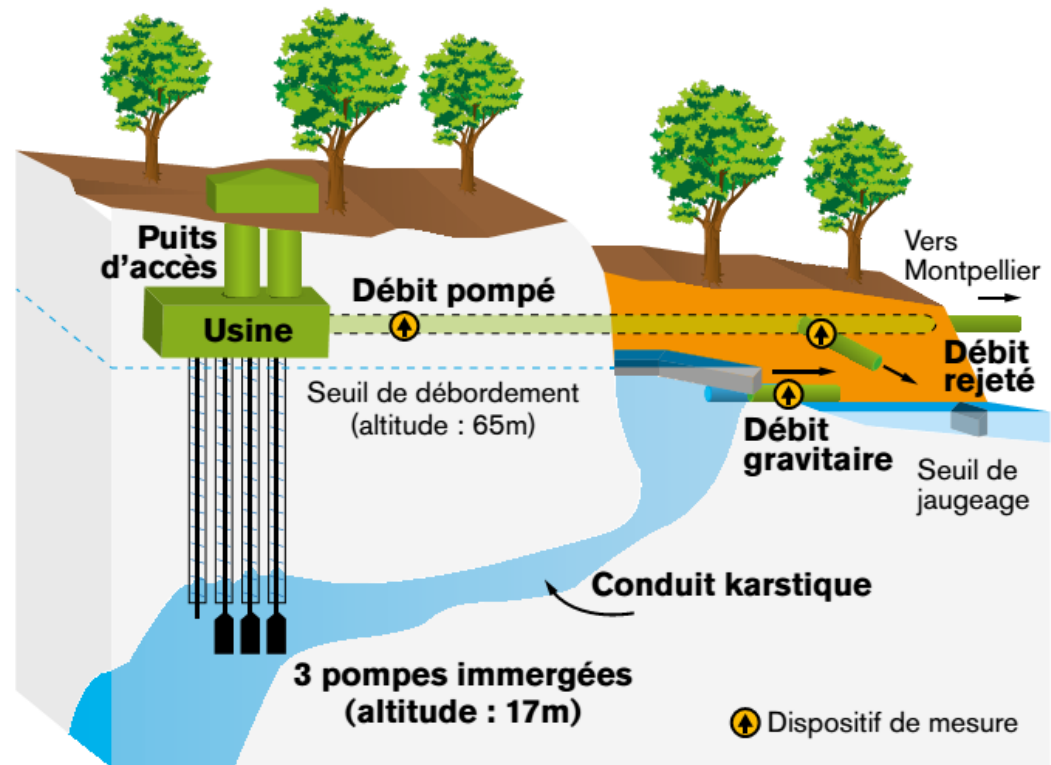
Ladouche B., Caballero Y., Maréchal J.C.



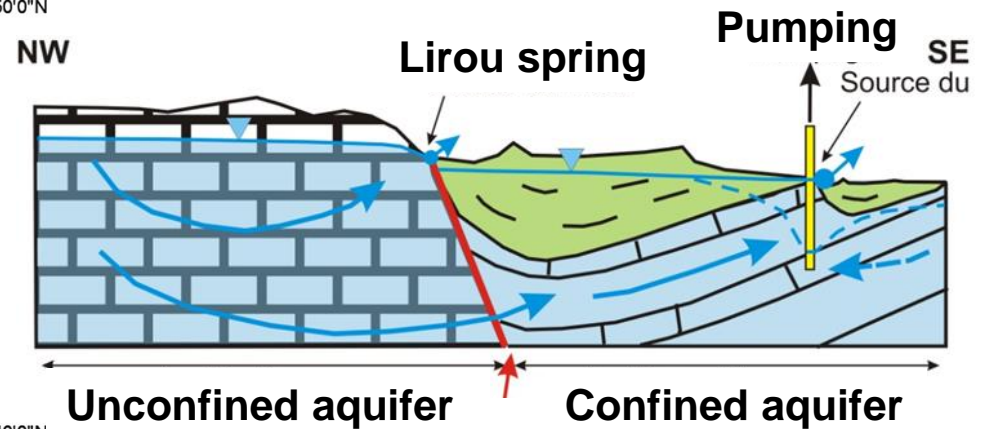
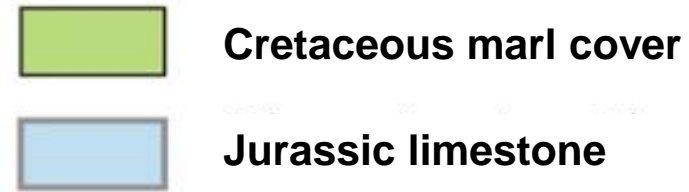
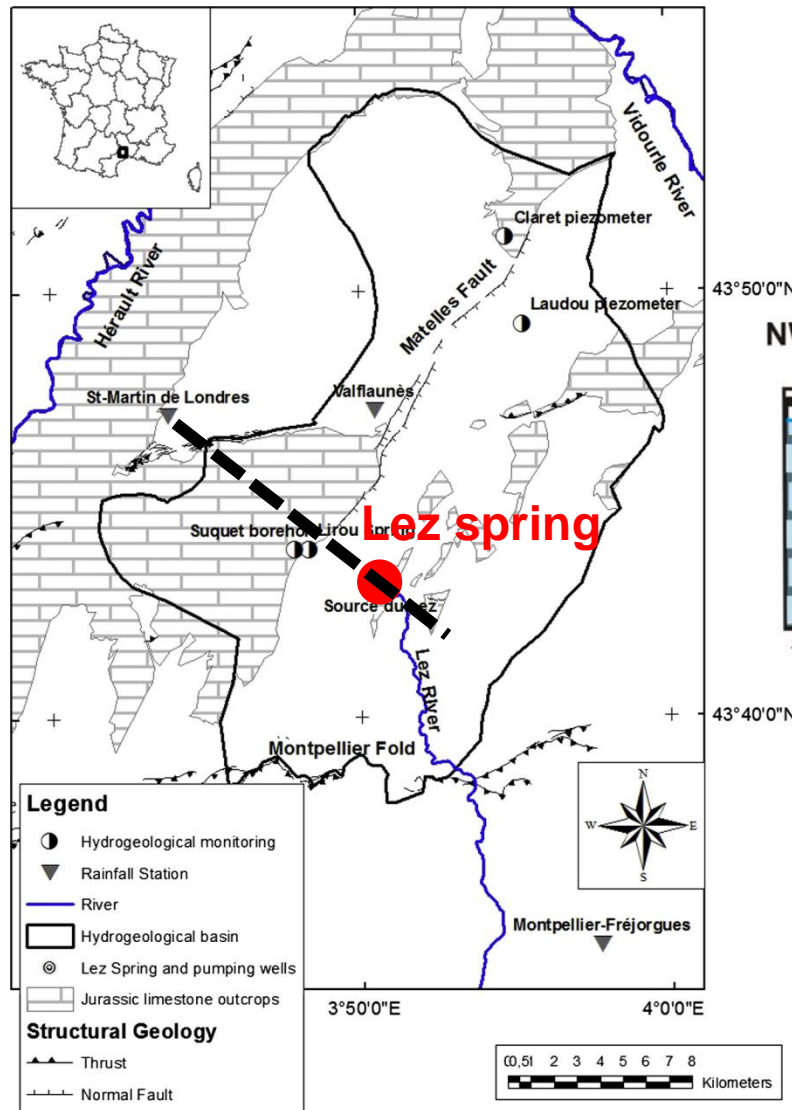
# Drinking water supply to Montpellier city



- > Since 1860, water from the Lez spring is collected for supplying Montpellier city
- > In 1968, set-up of 3 pumps into the spring
- > In 1982, building of the pumping system

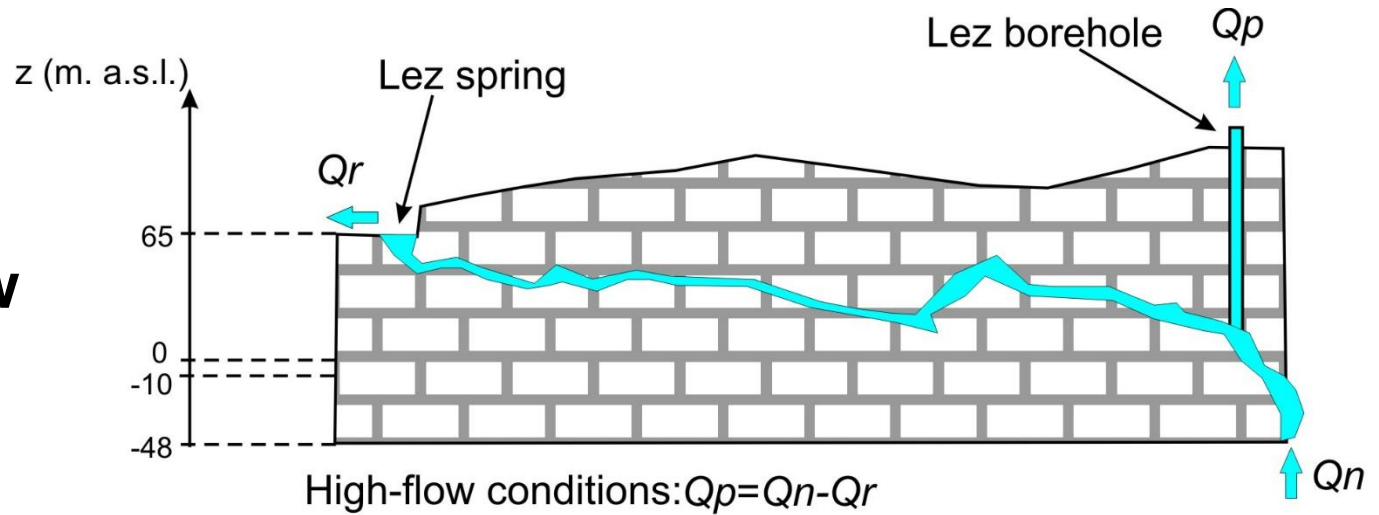


# Lez karst system



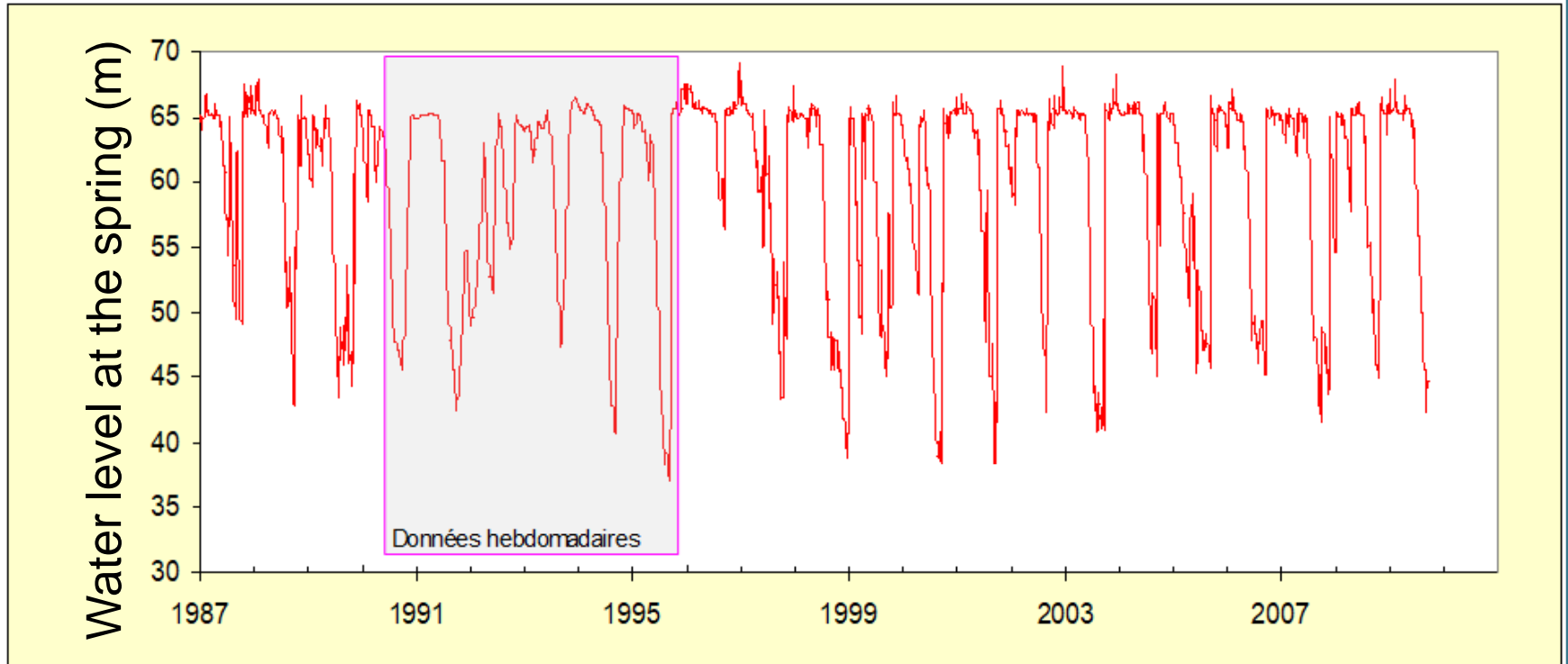
# Active management of the resource

**High flow**

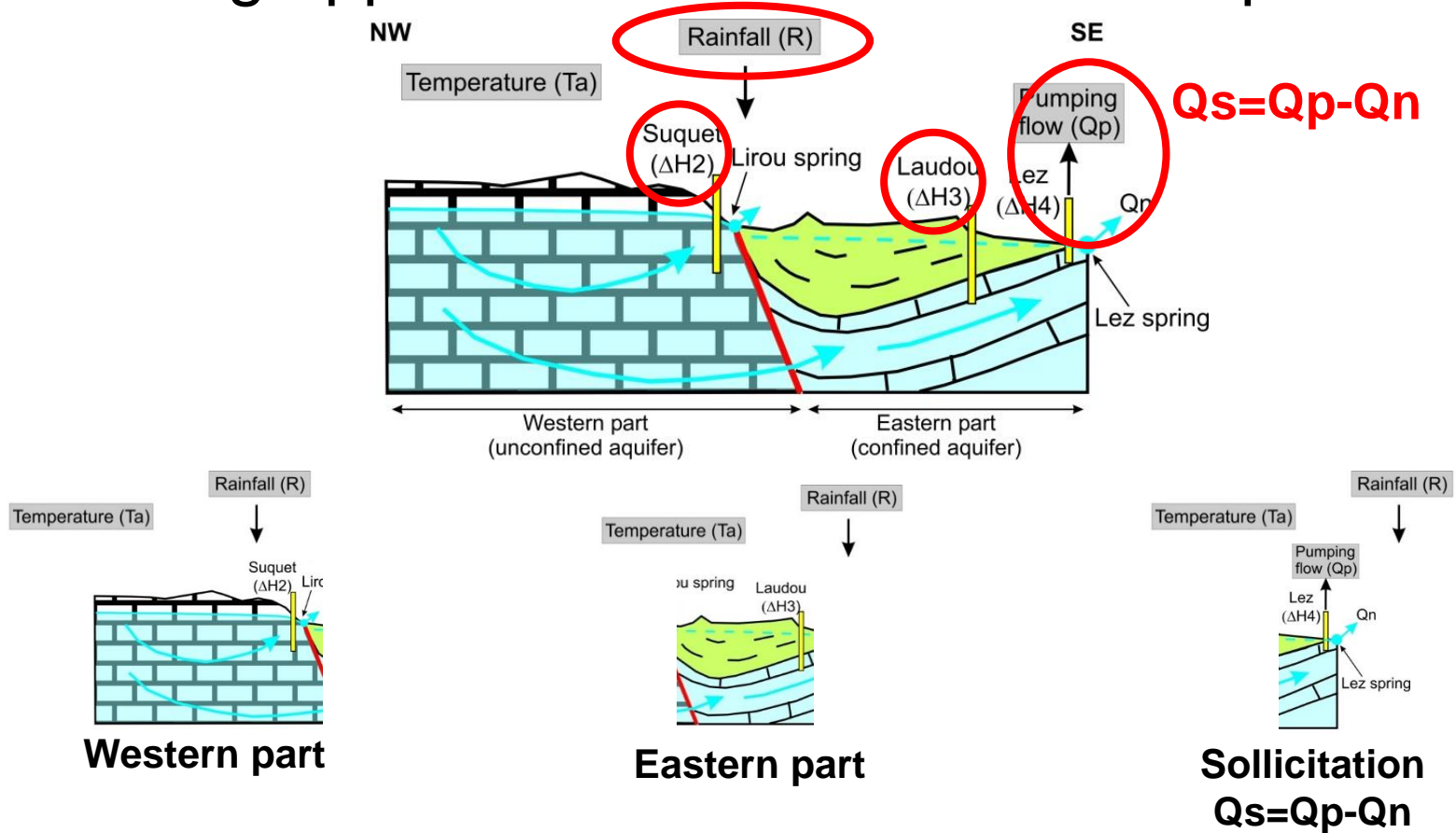


1976-2010:  $Q_n = 1850$  l/s,  $Q_p = 1000$  l/s

# Resulting water level fluctuations

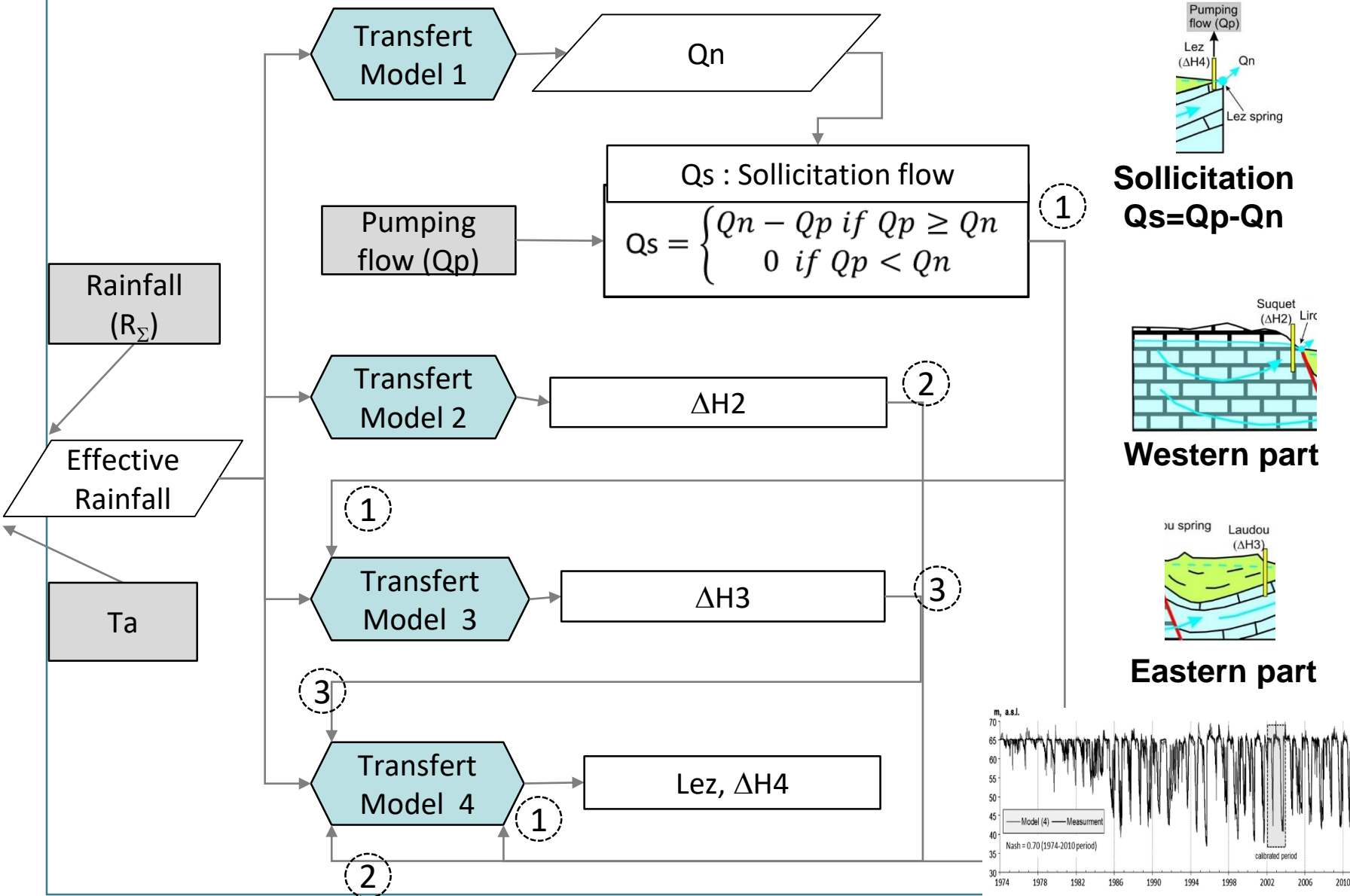


# Modelling approach: semi-distributed lumped model

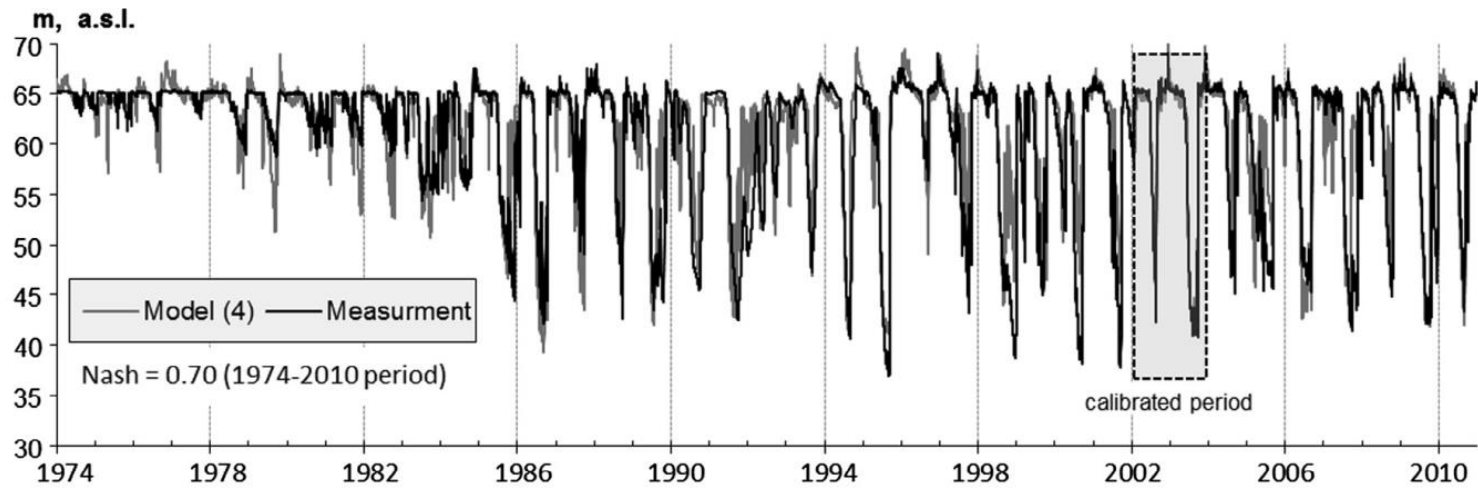


- Hydrogeologic modeling was performed using transfer methods implemented with TEMPO software
- Calculation of the impulse responses of the transfer modules is achieved by inverse modeling

# Lumped model architecture



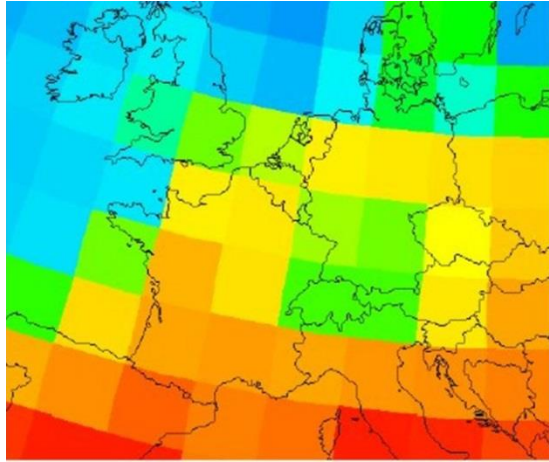
# Results



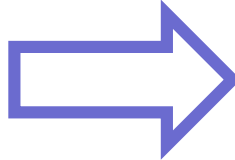


# Climate change scenarios (methodology)

Climate models meshing

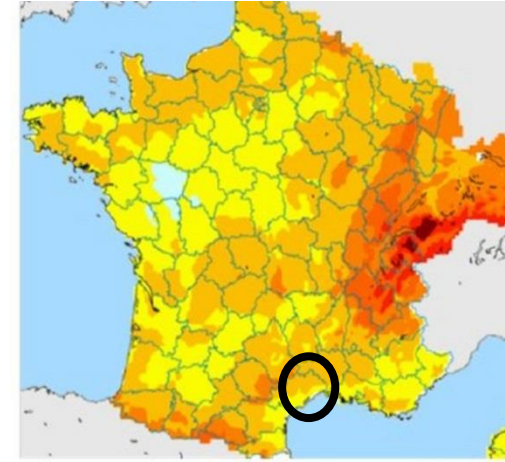


Downscaling



CERFACS (Toulouse)  
SCRATCH 2010

SAFRAN meshing (8 x 8 km)



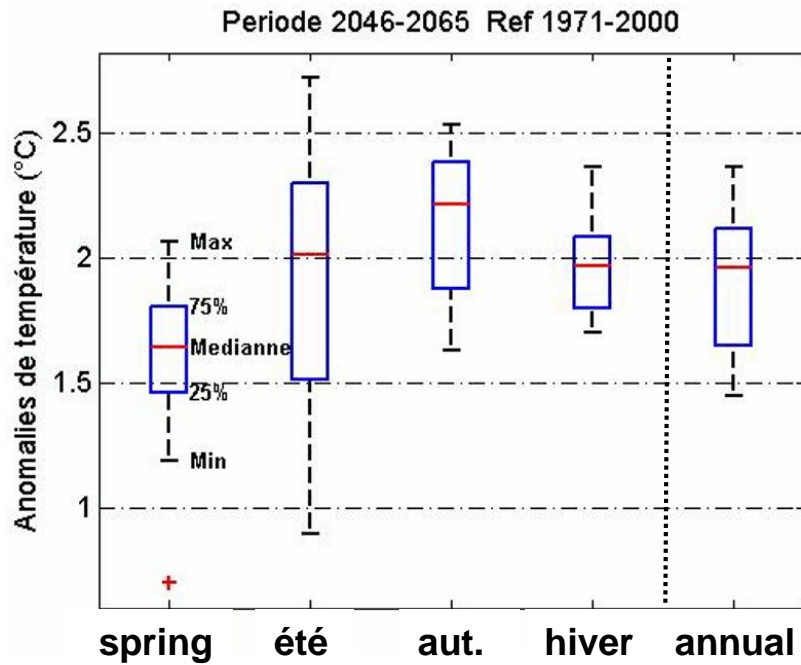
## 9 MCG (SRES A1B):

Present: 1971-2000

Future: 2045-2065

- ◆ CNRM – Météo France (2);
- ◆ CCCMA - Canada
- ◆ NOAA – USA
- ◆ NASA – USA
- ◆ IPSL – Paris ;
- ◆ MPI – Germany ;
- ◆ MRI - Japan ;
- ◆ NCAR – USA ;

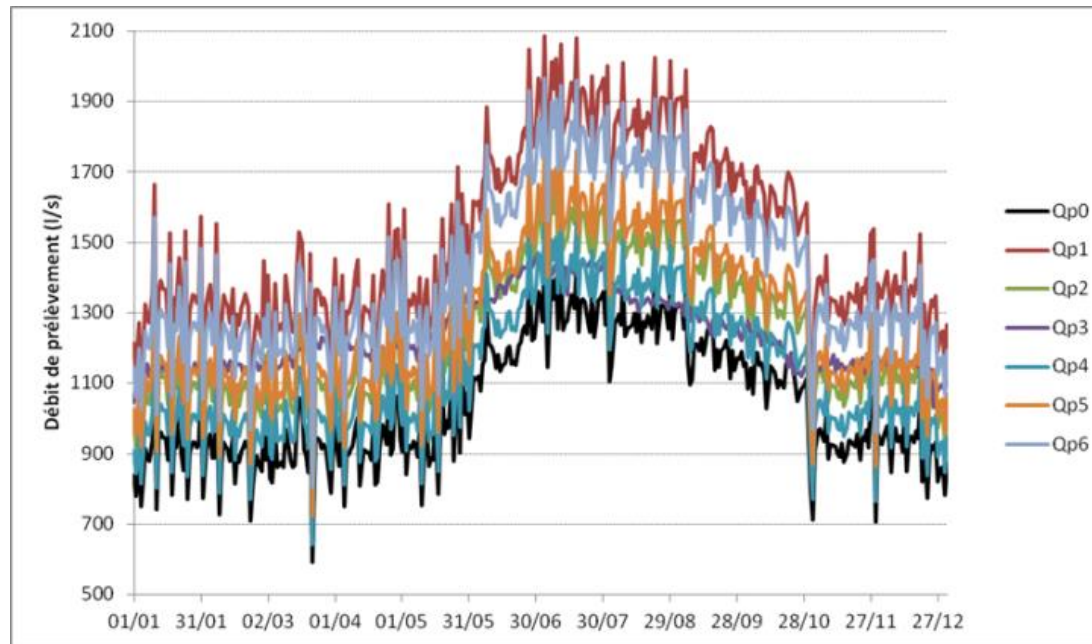
# Climate scenarios (results)



Temperature



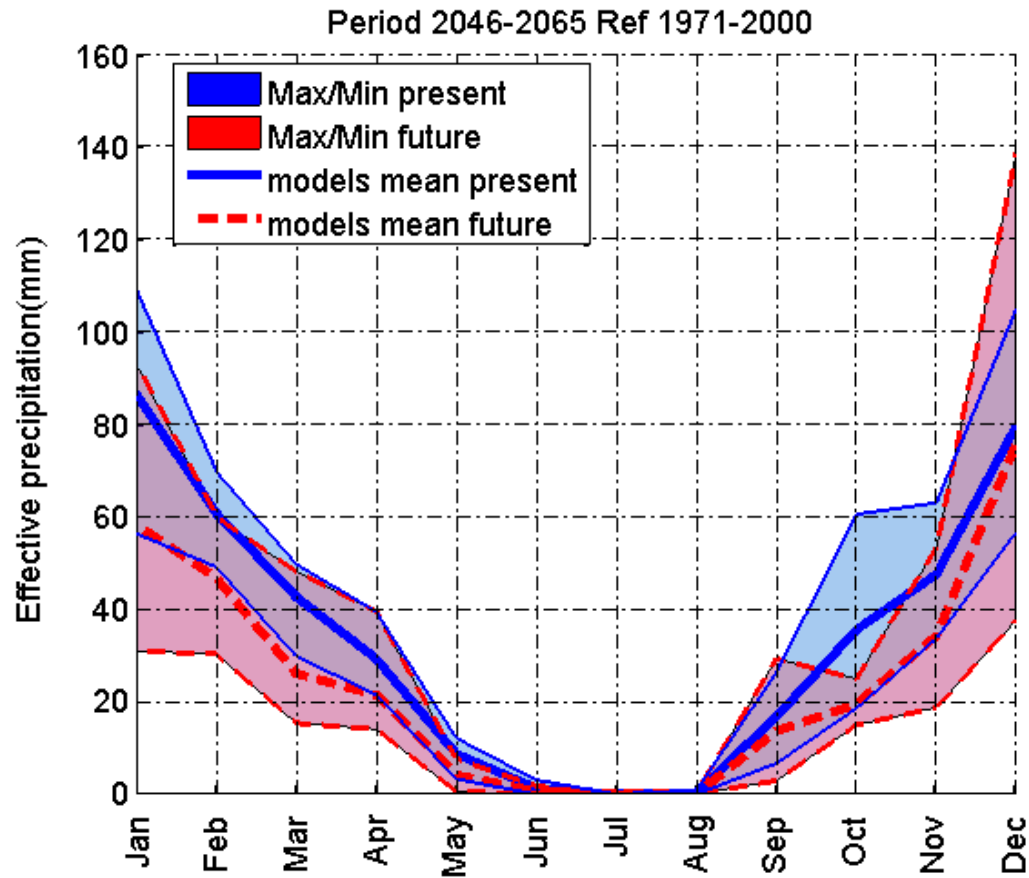
# Demand change: evolution of pumping



## Hypothesis:

- Population increase (0,9 %/yr)
- Present consumption rate
- 10% decrease of consumption rate
- Present area
- Extended area

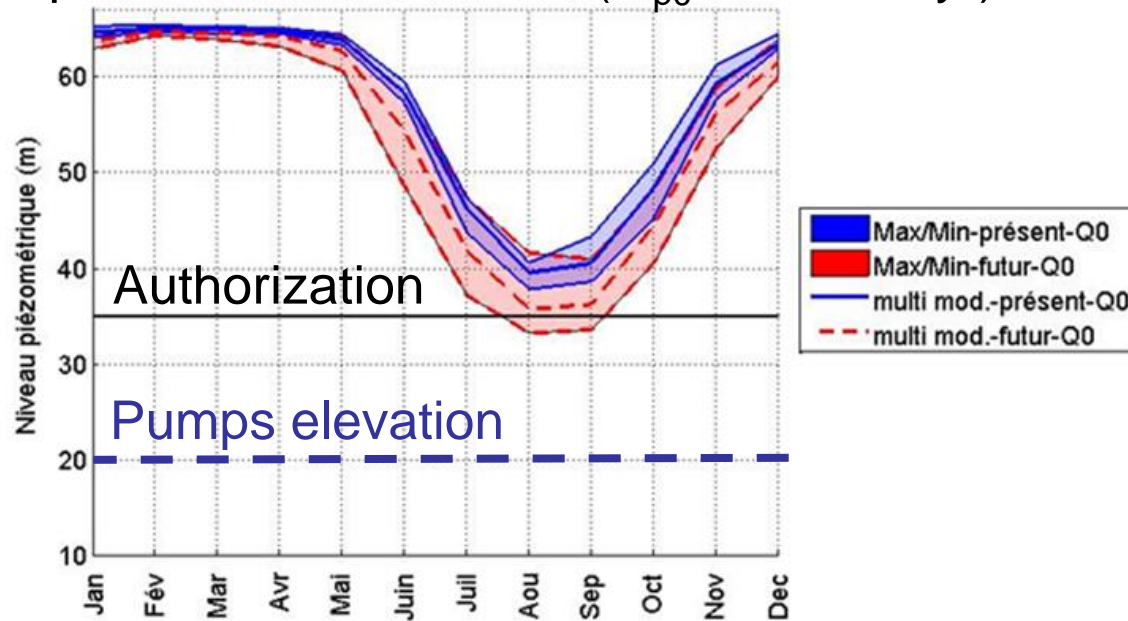
# Impact of climate change on effective rainfall



**- 30 % effective rainfall**

# Results: impact of climate change on the aquifer

Comparison present and future water levels with present extraction rate ( $Q_{p0} = 33 \text{ Mm}^3/\text{yr}$ )



**Occurrence frequency of water levels at the spring**

**Occurrence frequency of overflow discharge**

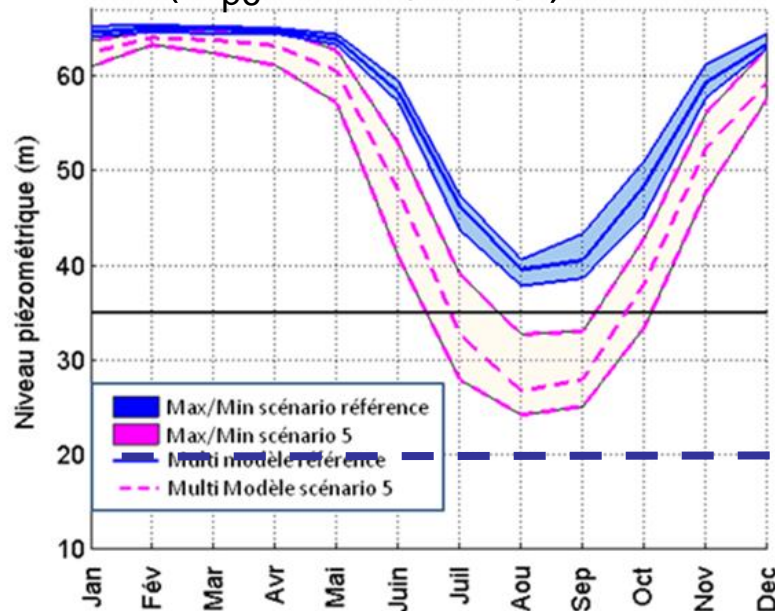
	[45 à 35 m]	[< 35 m]	[< 30 m]	[<20 m]	[<10 m]	Qd<160 l/s	Qd>160 l/s
Present (1970 – 2000)	9%	0%	0%	0%	0%	46%	54%
Future (2045-2065)	15%	15%	4%	0%	0%	54%	46%

Present (1970 – 2000)

Future (2045-2065)

# Results: impact of global change on the aquifer

Comparison between present ( $Q_{p0} = 33 \text{ Mm}^3/\text{an}$ ) and future ( $Q_{p6} = 44 \text{ Mm}^3/\text{an}$ ) water levels



## Occurrence frequency of water levels at the spring

	[45 à 35 m]	[< 35 m]	[< 30 m]	[<20 m]	[<10 m]
Present (1970 – 2000)	9%	0%	0%	0%	0%
Future (2045-2065)	10%	27%	21%	3%	0%

## Occurrence frequency of overflow discharge

	$Q_d < 160 \text{ l/s}$	$Q_d > 160 \text{ l/s}$
Present (1970 – 2000)	46%	54%
Future (2045-2065)	61%	49%

# Conclusion

- Semi-distributed global modeling approach has been developed in order to simulate water levels in the different parts of the aquifer and the discharge rate at the spring ;
- Climate change would induce a decline of recharge rate → water levels and discharge rates decrease;
- Aquifer active management could allow an adaptation to global change;
- Pumping system could allow an increase of abstraction rate in the future BUT a pumping test in real conditions is necessary to investigate the hydrodynamic properties of the aquifer in low flow conditions ;
- Mediterranean karst aquifers could constitute promising water resources in the future.
- Reference: *Ladouche & al. Journal of Hydrology 2014*



**Merci !**