



Intensification du cycle hydrologique en Afrique de l'Ouest

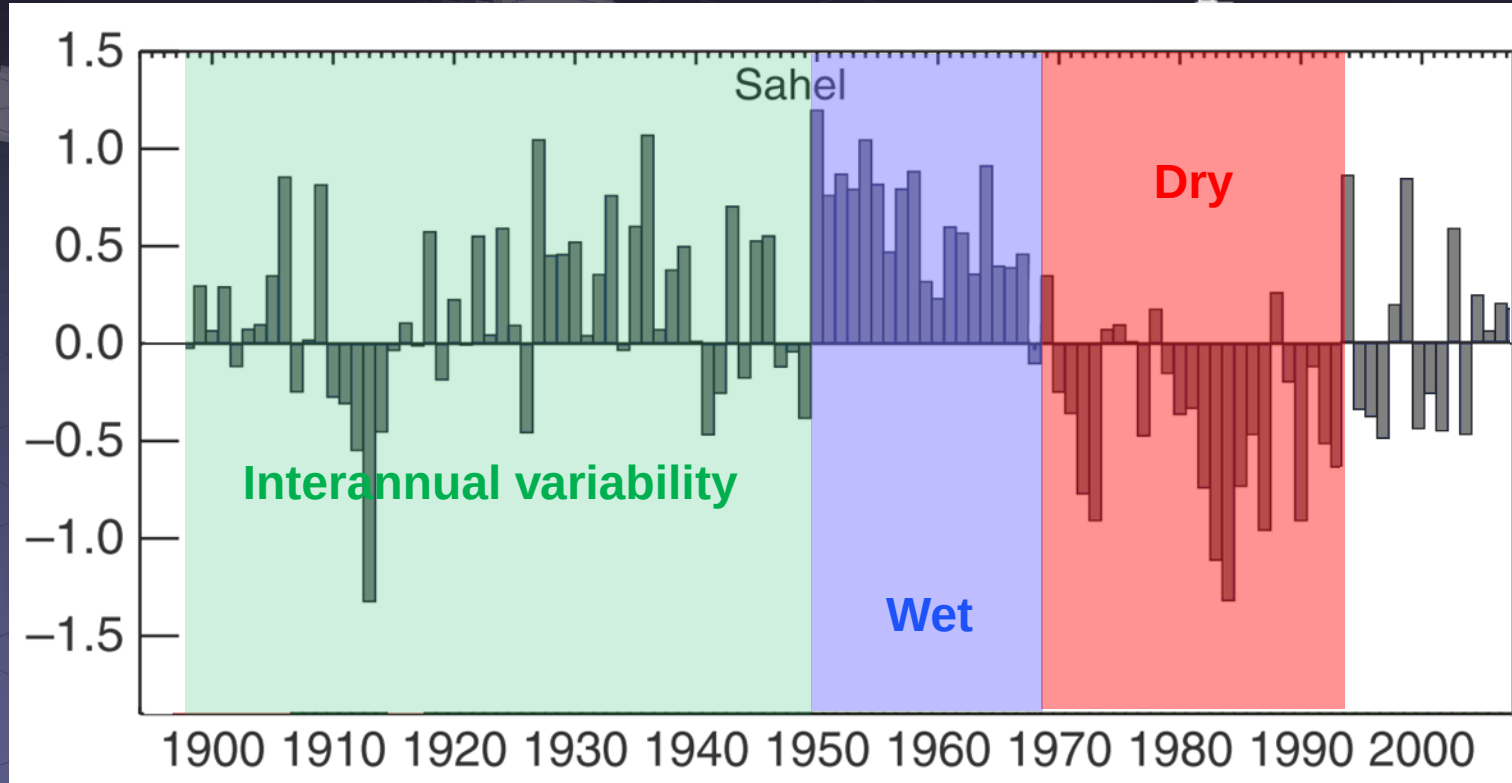
Défis pour la modélisation hydro-climatique



Vischel T.*, Wilcox C.*, Panthou G.*, Quantin G.*, Harris P.▲, Blanchet J.*,
Aly C.*, Taylor C.▲, Berthou S.♦, Vanderveare J-P.*, Sané Y.■, Lebel T.*,
Stratton R.♦, Miller J.▲, Tazen F.●, Bouvier C.



Pluie annuelles au Sahel



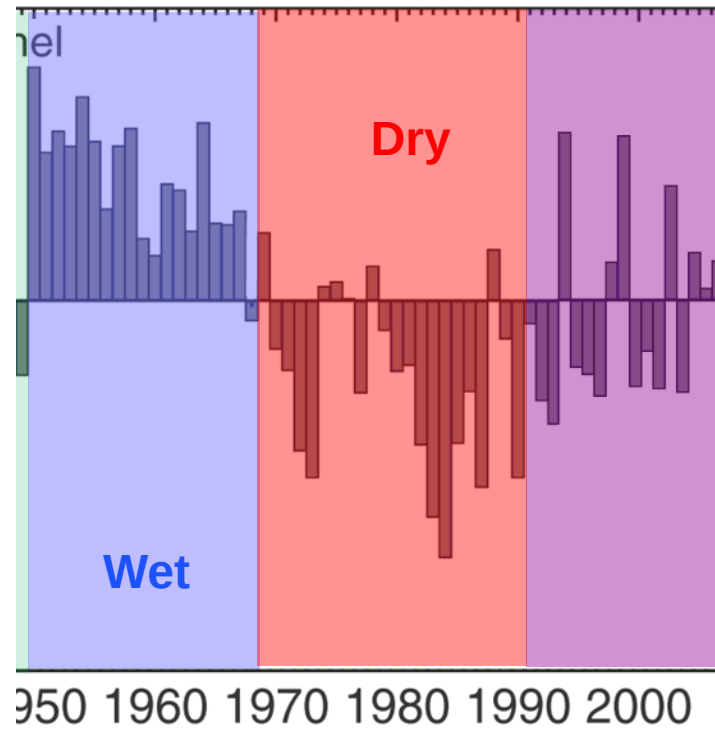
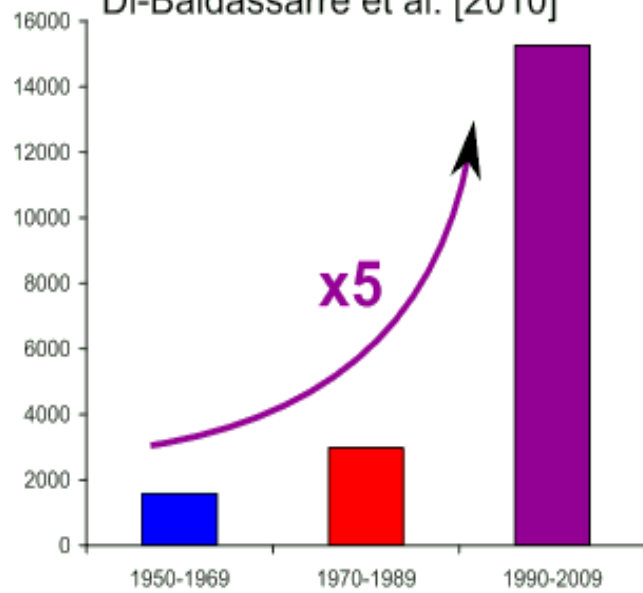
Ressources agricoles



Ressources en eau



Fatalities caused by floods
Di-Baldassarre et al. [2010]



Ressources agricoles



Ressources en eau

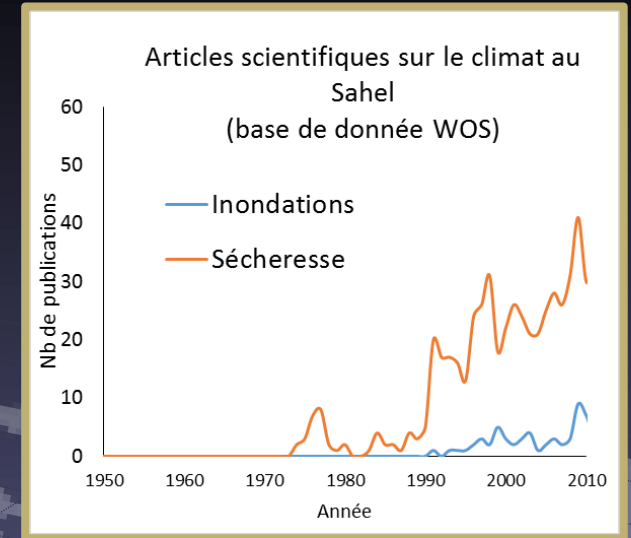


Inondations



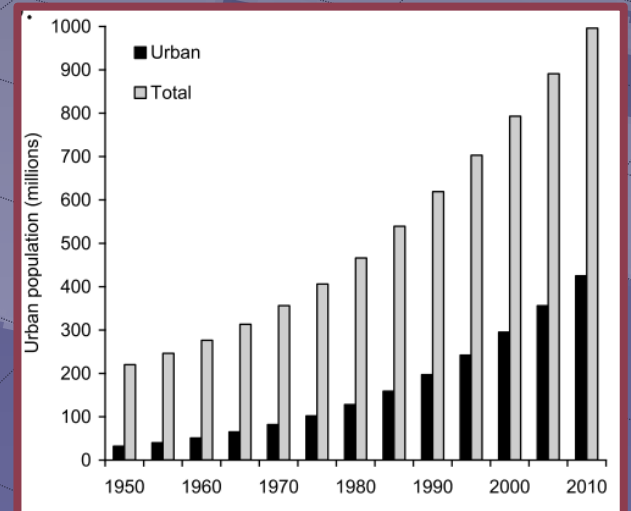
Aléa hydrologique

- Peu d'études sur les inondations
- Peu d'étude sur les extrêmes hydrologiques

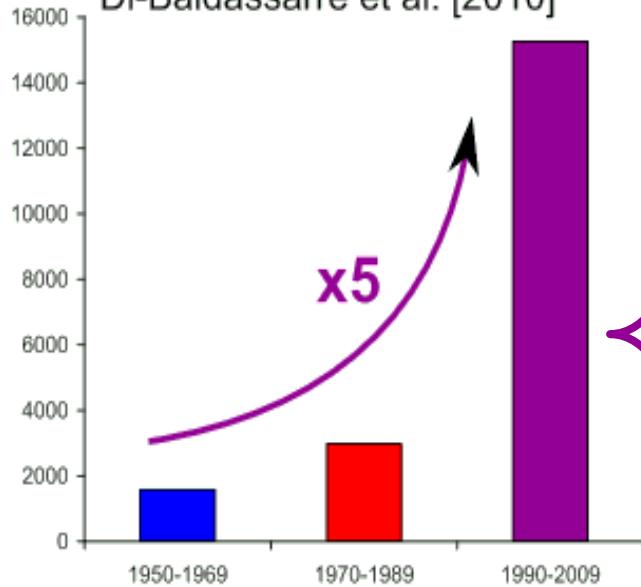


Exposition

- Croissance démographique
- Concentration urbaine
- Habitation en zones inondables
- Problèmes de planification urbaine



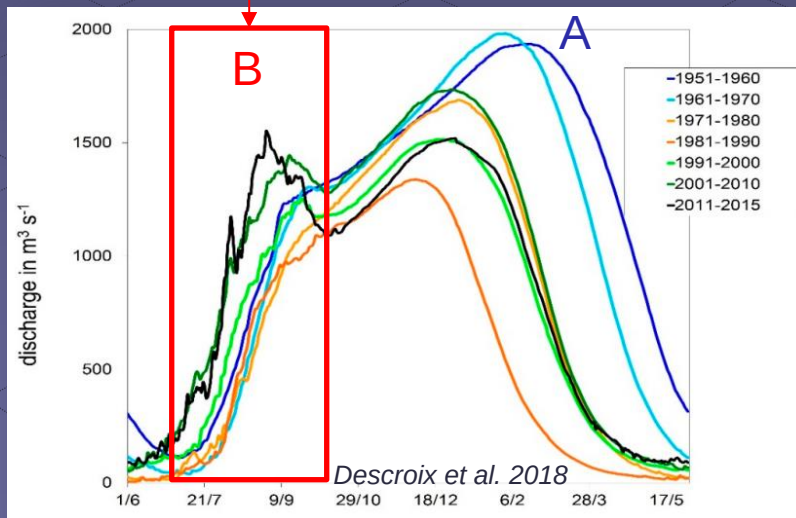
Fatalities caused by floods
Di-Baldassarre et al. [2010]



Aléa hydrologique

Evolution des crues

Régime du fleuve Niger à Niamey

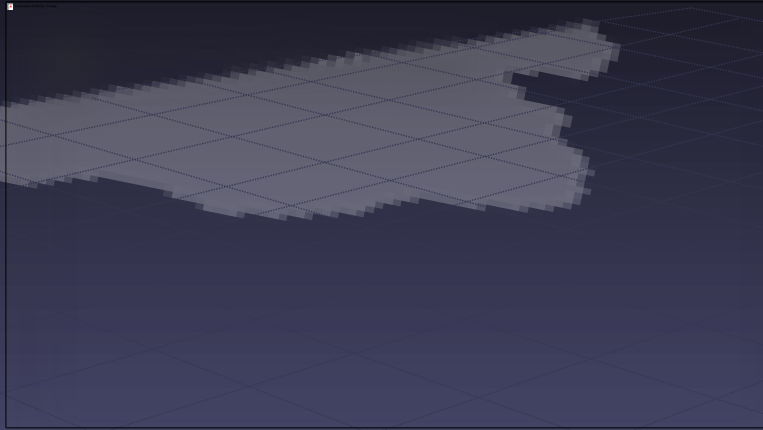


Niger River

Wilcox et al. 2018, JH

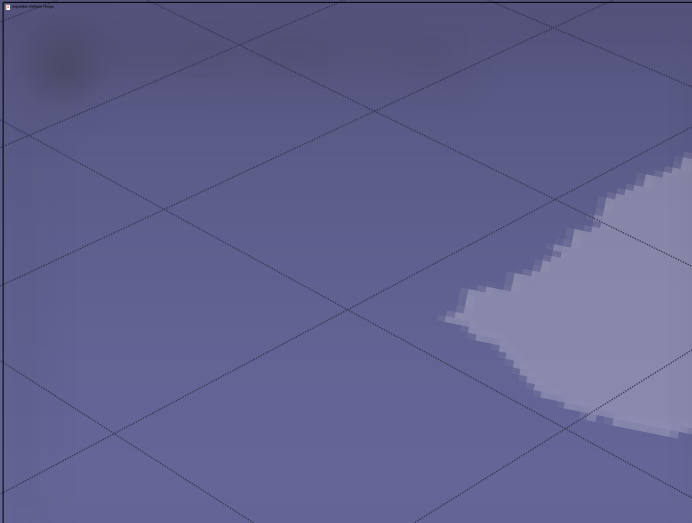
Facteurs d'influence

Dégradation des sols



Favreau et al. 2009 WRR, Descroix et al. 2009 JH, 2018 Water

Intensification des précipitations



Panthou et al. 2014 IJOC, 2018 ERL, Taylor et al. 2017 NATURE

Aléa hydrologique

Intensification
du
cycle hydrologique

Evolution des crues



Wilcox et al. 2018, JH

Facteurs d'influence

Dégradation des sols

Société (local)

Attribution
hydrologique

Climat

Intensification des précipitations

Attribution
climatique

Société (global)

Intensification
du
cycle hydrologique

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graph LR; S1[Société (local)] --- B1[ ]; A1[Attribution hydrologique] --- B1; C1[Climat] --- B1; B1 --- I1[Intensification du cycle hydrologique]; S2[Société (global)] --- B2[ ]; A2[Attribution climatique] --- B2; B2 --- I2[Intensification du cycle hydrologique]; I1 --- I2;
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Facteurs d'influence

Dégradation des sols

Société (local)

Attribution
hydrologique

Climat

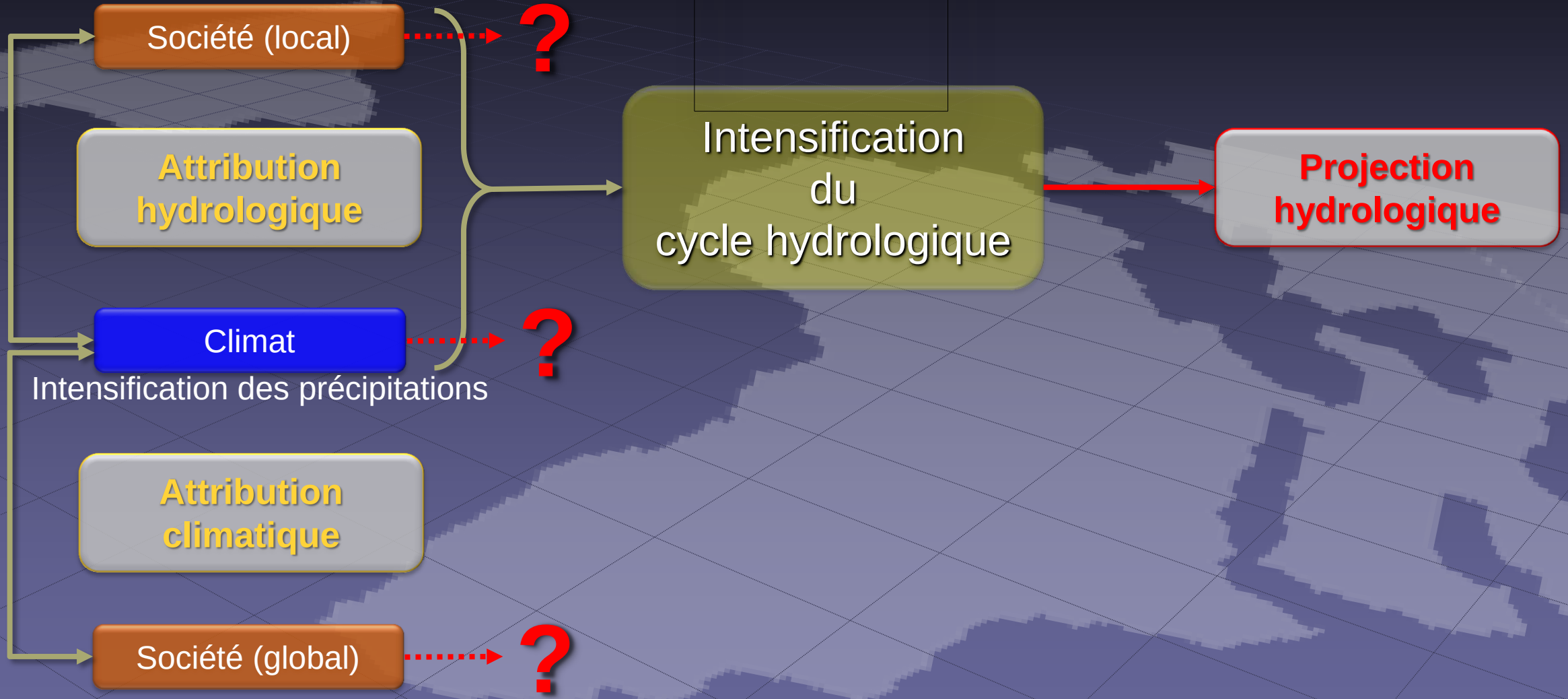
Intensification des précipitations

Attribution
climatique

Société (global)

Intensification
du
cycle hydrologique

Projection
hydrologique



Facteurs d'influence

Dégradation des sols

Société (local)

Attribution
hydrologique

Climat

Intensification des précipitations

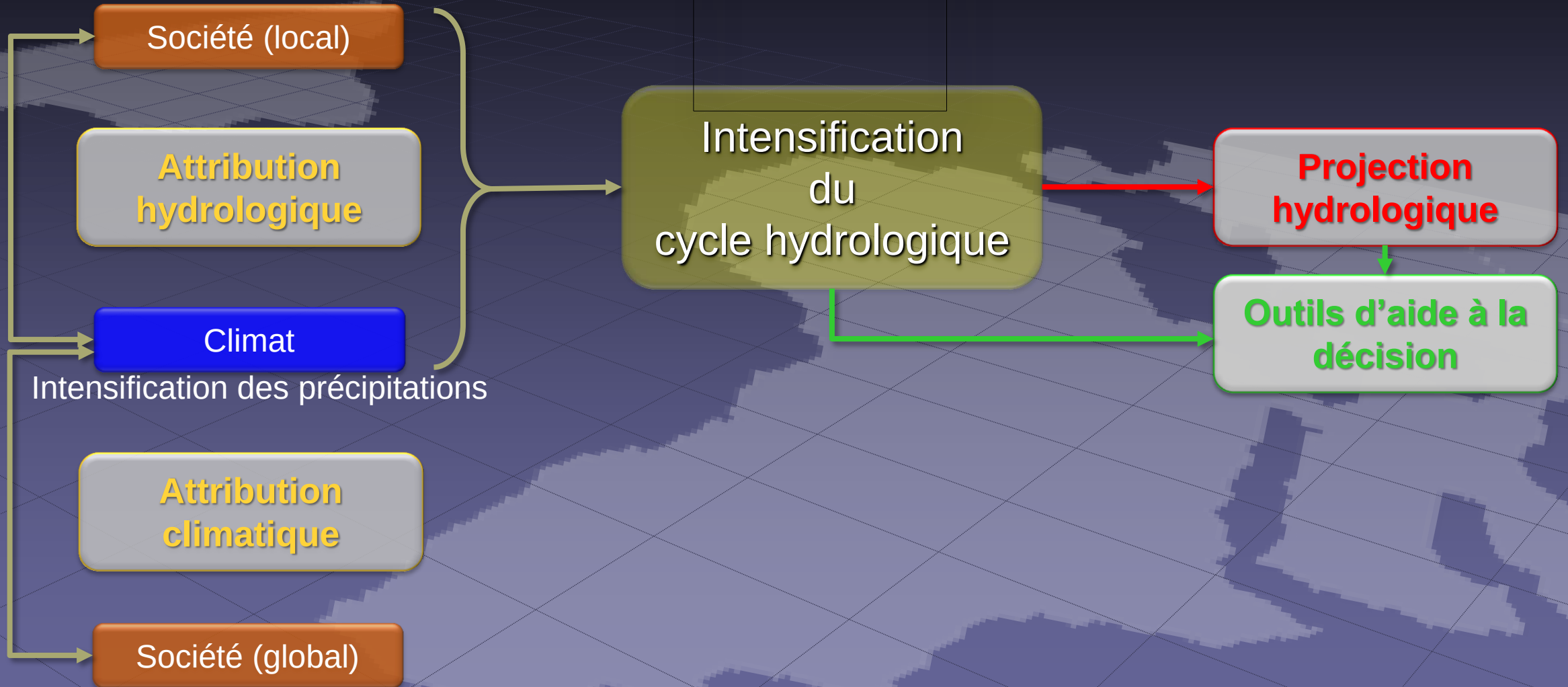
Attribution
climatique

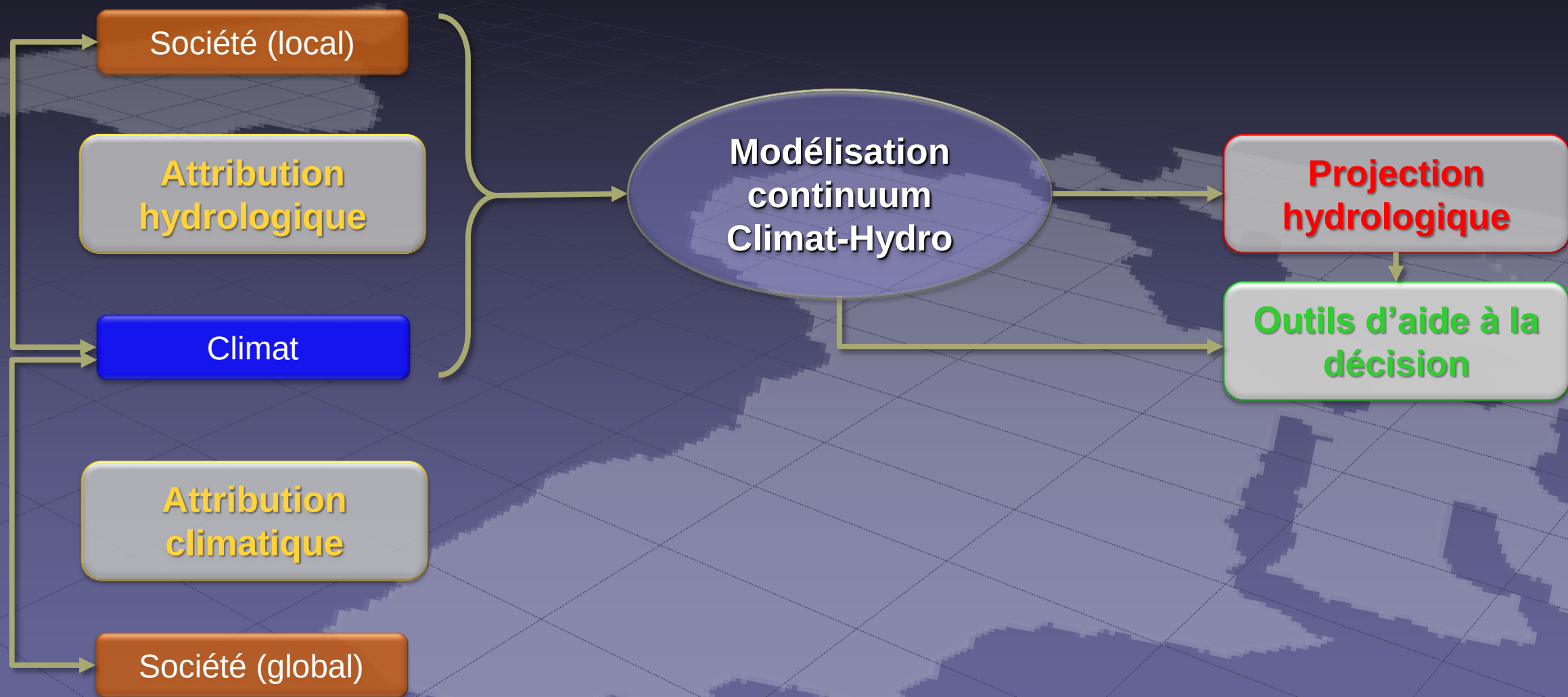
Société (global)

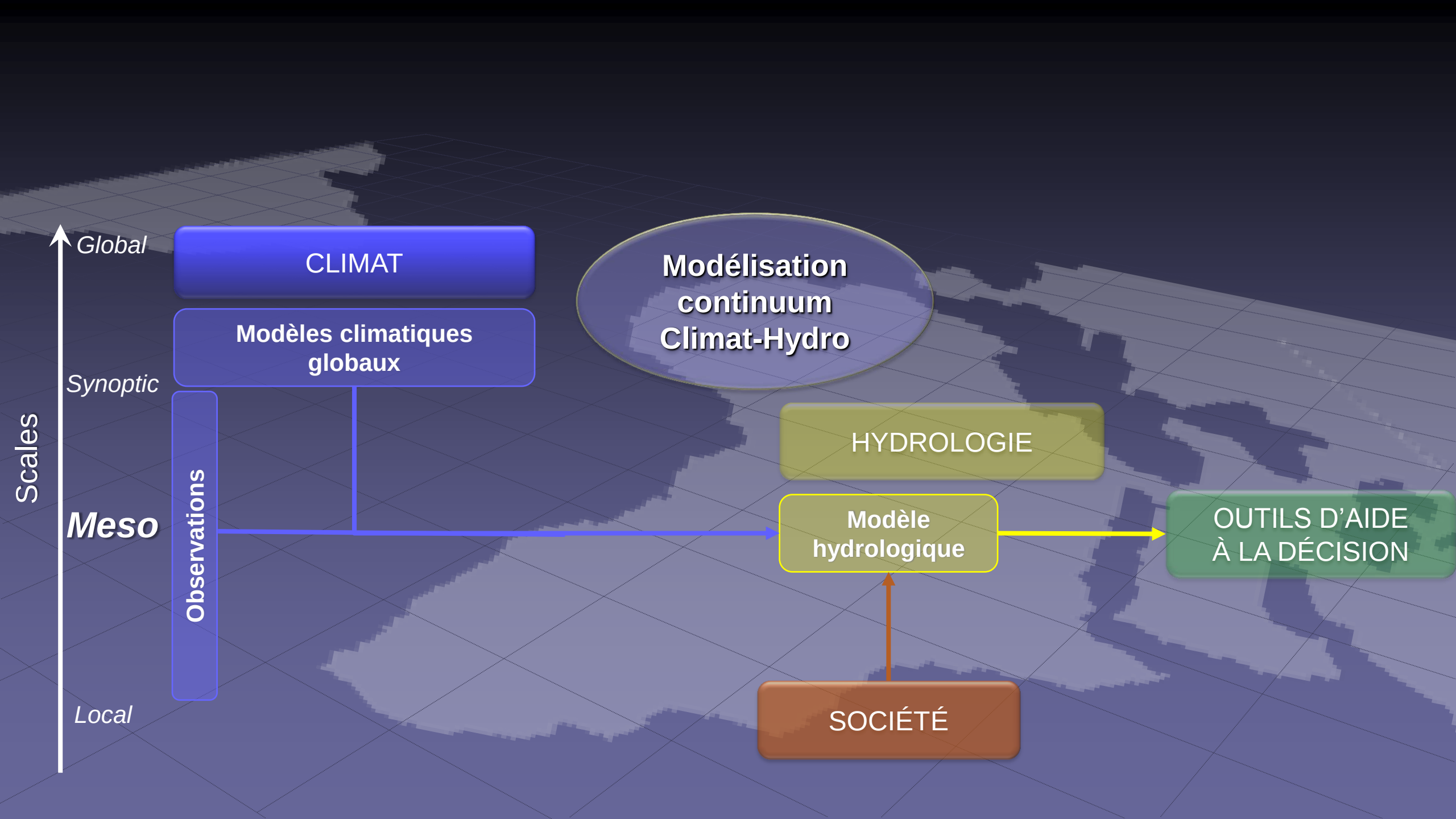
Intensification
du
cycle hydrologique

Projection
hydrologique

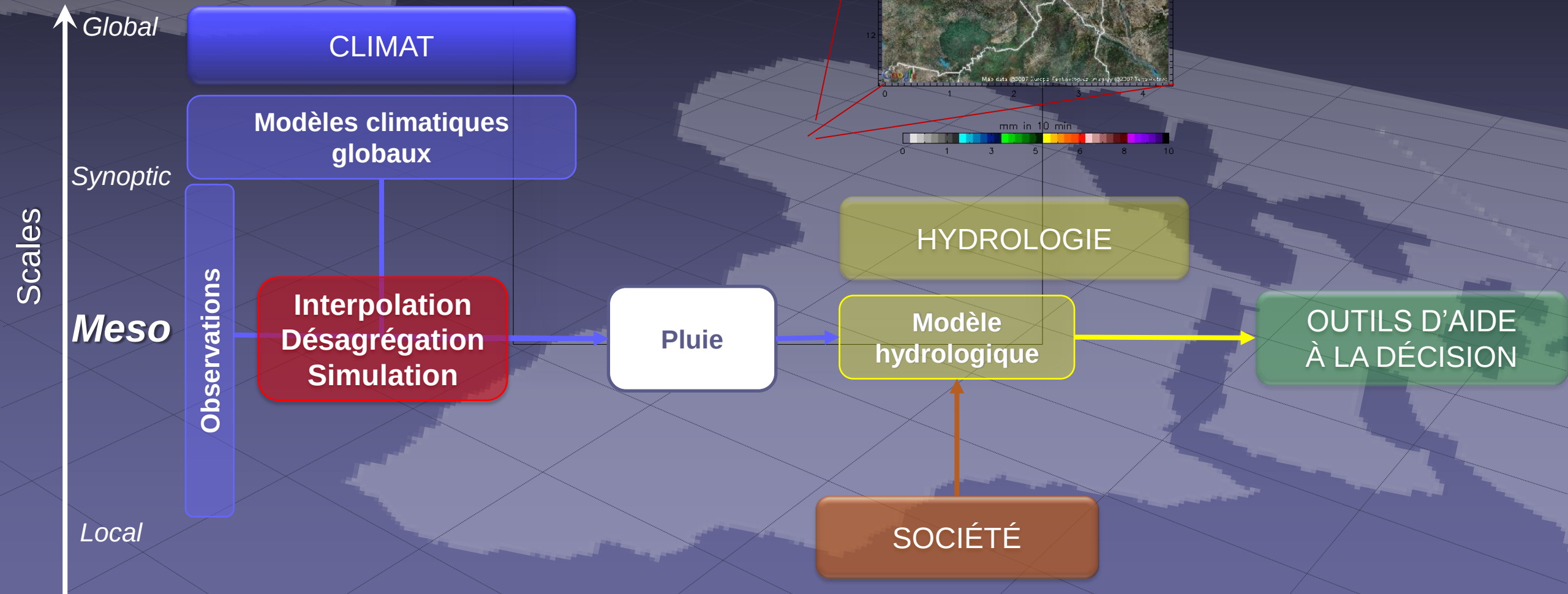
Outils d'aide à la
décision







**Défi n°1
PROBLEMES
D'ECHELLES**

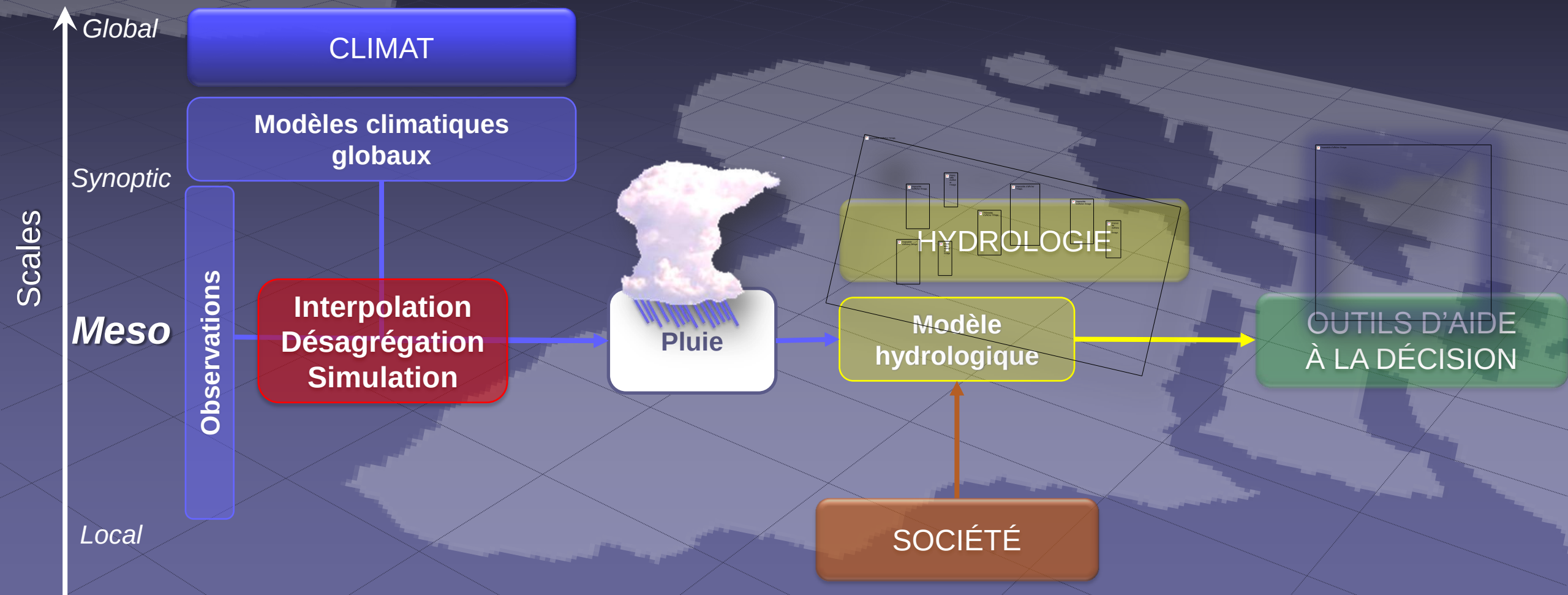


Défi n°1
PROBLEMES
D'ECHELLES

Défi n°2
EXTREMES

Défi n°3
MODELES
PROCESS-
BASED

Défi n°4
CO-
CONSTRUCTION

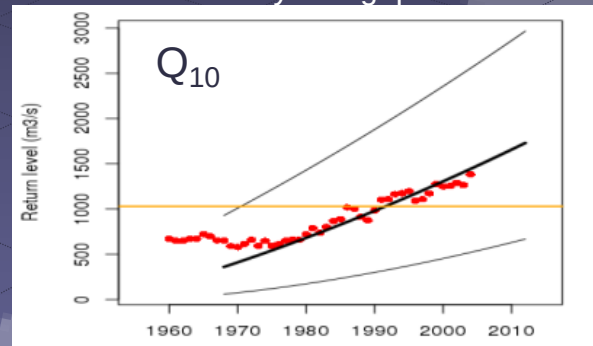




Courbes intensité-durée-fréquence

Panthou et al. 2014, HESS
Sané et al. 2018, NHESS

Alea hydrologique



Wilcox et al. 2018, JH

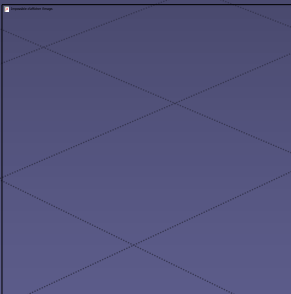
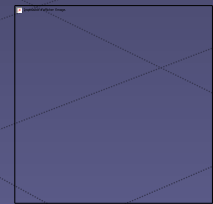
Cartes d'inondations



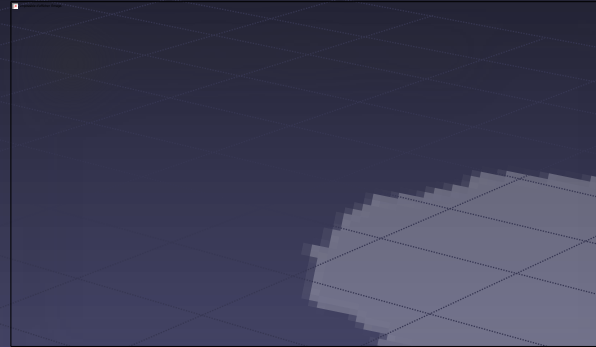
Miller et al. in prep.

OUTILS D'AIDE
À LA DÉCISION

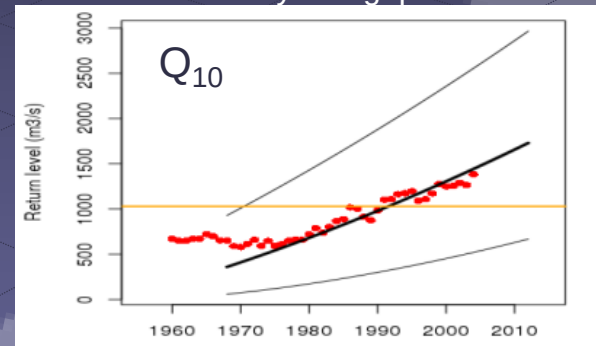




Courbes intensité-durée-fréquence



Alea hydrologique



Cartes d'inondations



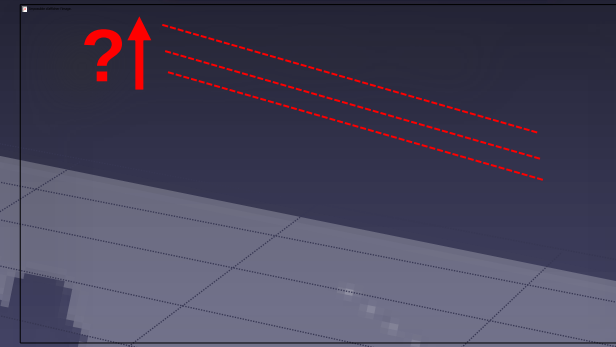
en 2050?



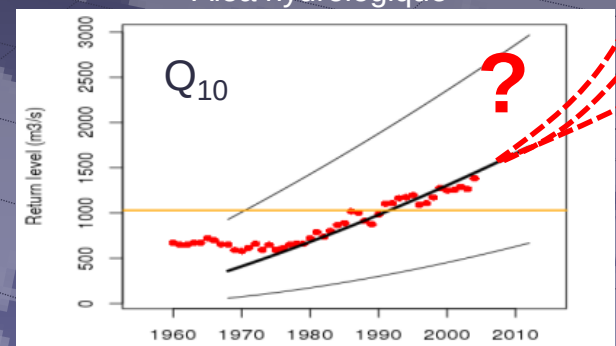
en 2100?

**Défi n°4
CO-
CONSTRUCTION**

Courbes intensité-durée-fréquence



Alea hydrologique



Cartes d'inondations



Défi n°1
PROBLEMES
D'ECHELLES

Défi n°2
EXTREMES

Défi n°3
MODELES
PROCESS-
BASED

Défi n°4
CO-
CONSTRUCTION

Unif. Mod.
Met Office

CP4-Africa

CDF-t

Stochastorm

Phorm

GCM

RCM

Bias
correction

Stochastic
Rainfall
Generator

Mesoscale
Rain fields

Rural
Hydrologi
cal model

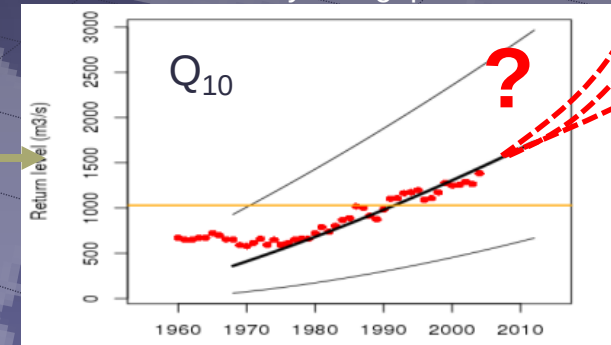
ATHYS

Design
storms

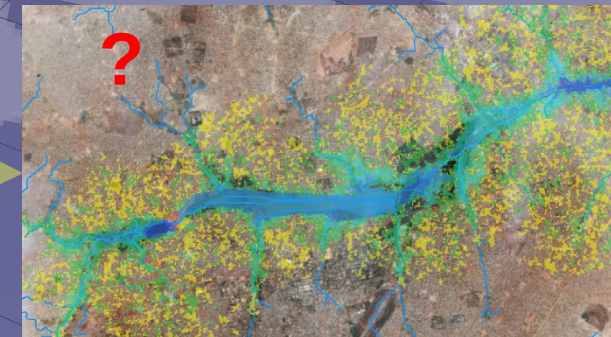
Urban
Hydrologi
cal model

?

Alea hydrologique



Cartes d'inondations



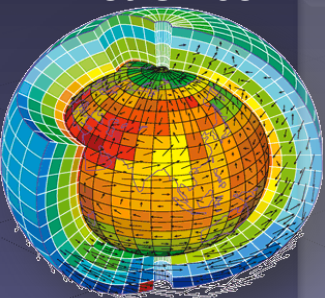
Défi n°1
PROBLEMES
D'ECHELLES

Défi n°2
EXTREMES

Défi n°3
MODELES
PROCESS-
BASED

Défi n°4
CO-
CONSTRUCTION

Unif. Mod.
Met Office



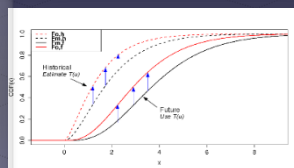
GCM

CP4-Africa



RCM

CDF-t

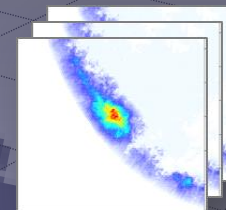


Bias
correction

Stochastorm

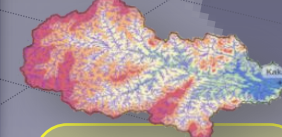


Stochastic
Rainfall
Generator



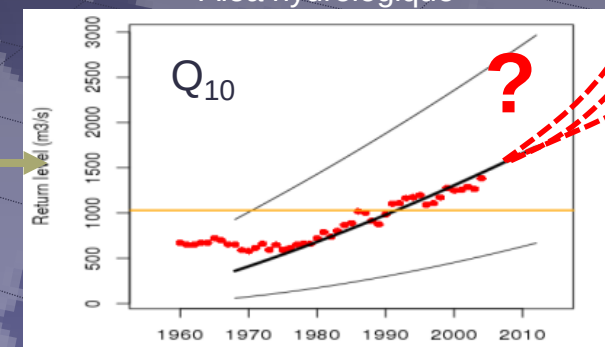
Mesoscale
Rain fields

Phorm



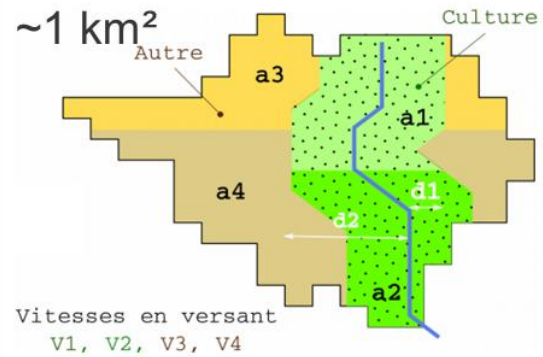
Rural
Hydrologi
cal model

Alea hydrologique

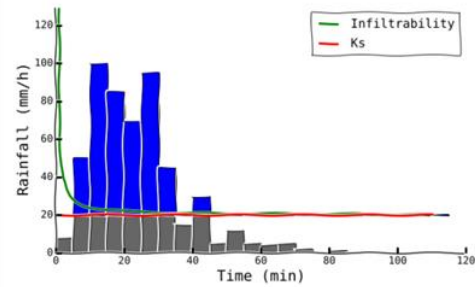


PHORM Purely HOrtonian Runoff Model

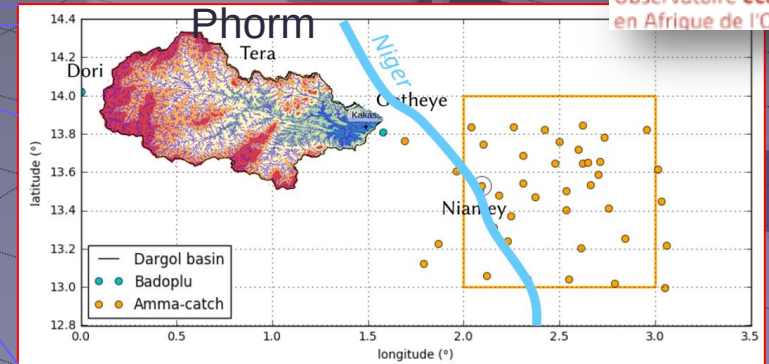
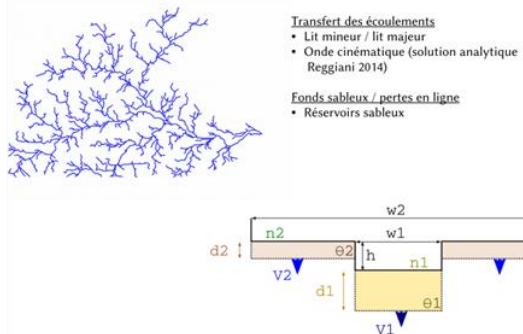
Discretization



Production



Transfer



Quantin et al. in prep.

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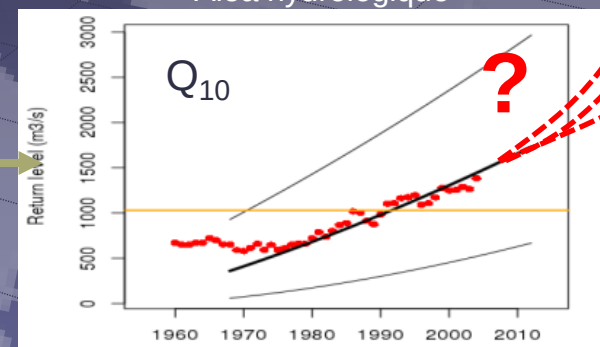
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	Object	Function	Parameters	f(t) degree	Fitting method
Occurrence	Start Date	Gauss	mean std	μ_s σ_s	- likelihood
	End Date	Gauss	mean std	μ_e σ_e	- likelihood
	IET	Gamma	shape rate	α β	3 2 likelihood
	Big vs small	Bernoulli	ratio	K	- moment

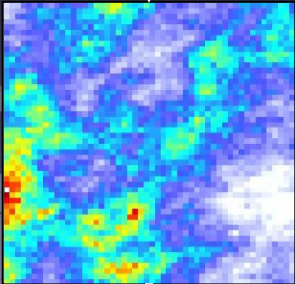
Event Rain field	Marginal	Big events	F0-Gamma	atom	F_0	3	Censored likelihood
				shape	α_B	1	
				rate	θ_B	3	
		Small events	GPD	threshold	λ	-	likelihood
				scale	σ_{GPD}	-	
	Variogram	Big events	Double exponential	shape	ξ_{GPD}	-	likelihood
				range	φ_1	-	
				range	φ_2	-	
		Small events	Exponential	anis. coef.	a_1	-	Censored likelihood
				anis. coef.	a_2	-	

Sub-event Rain field	Big events	Hyetogram shape	-	
		Propagation	Mean speed	
			Mean direction	
	Small events	Hyetogram shape	-	

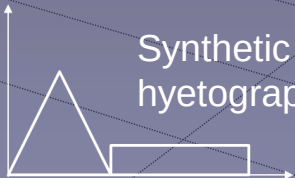
Stochastorm



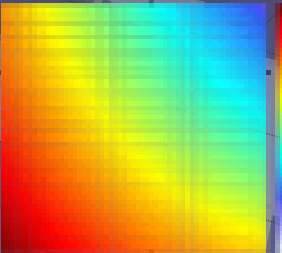
Guillot and Lebel, 1999, JGR
Vischel et al. 2009, JH
Wilcox et al. in prep, JHM



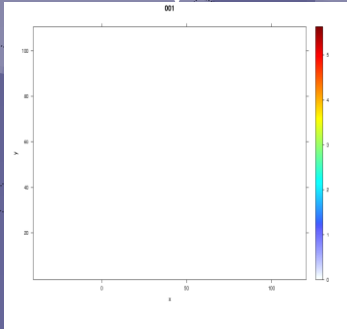
CDF
Spatial covariance



Synthetic
hyetograph



Propagation



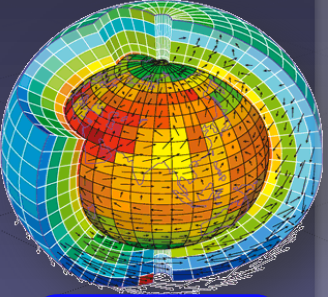
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D'ECHELLES

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EXTREMES

Défi n°3
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PROCESS-
BASED

Défi n°4
CO-
CONSTRUCTION

Unif. Mod.
Met Office



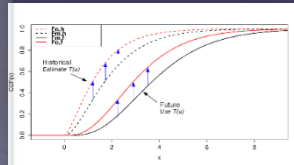
GCM

CP4-Africa



RCM

CDF-t

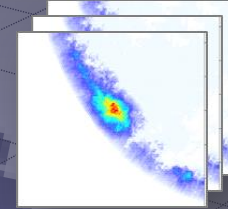


Bias
correction

Stochastorm

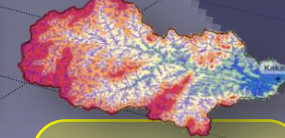


Stochastic
Rainfall
Generator



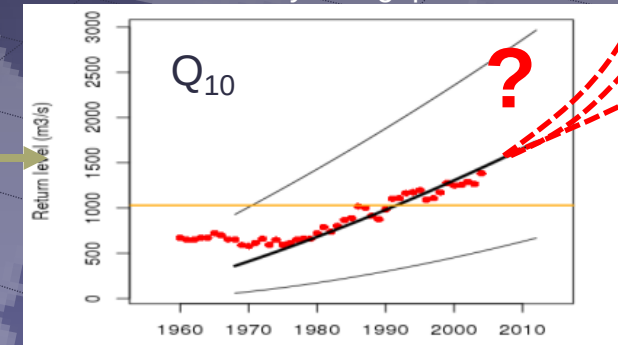
Mesoscale
Rain fields

Phorm



Rural
Hydrologi
cal model

Alea hydrologique





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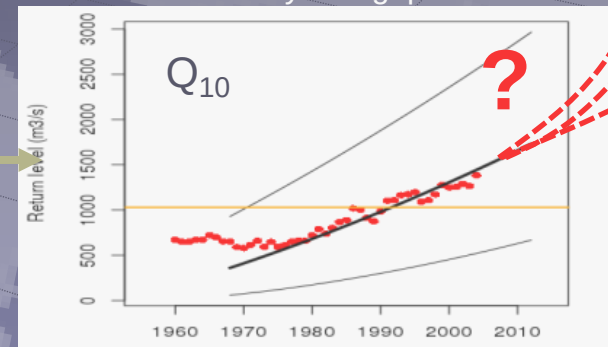
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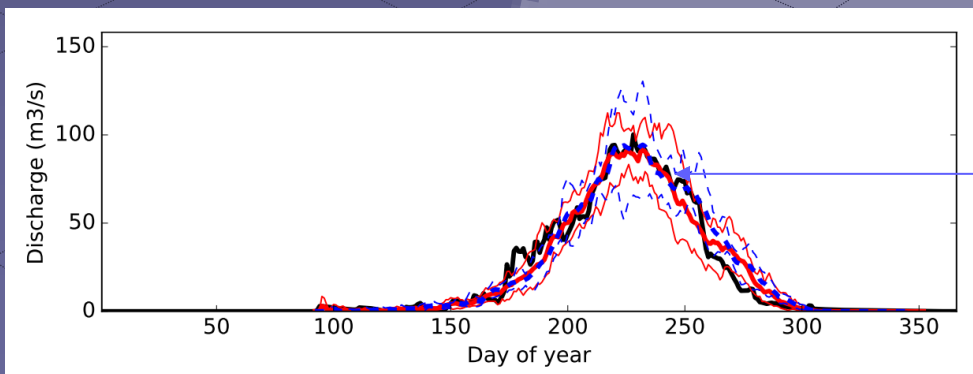
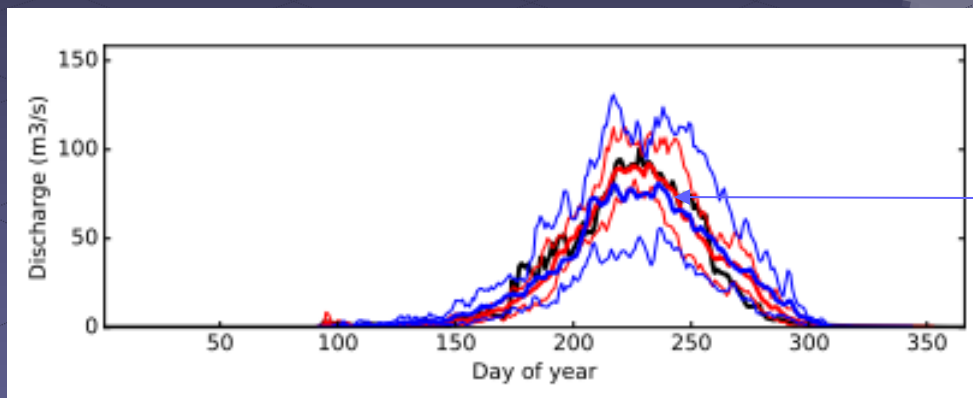
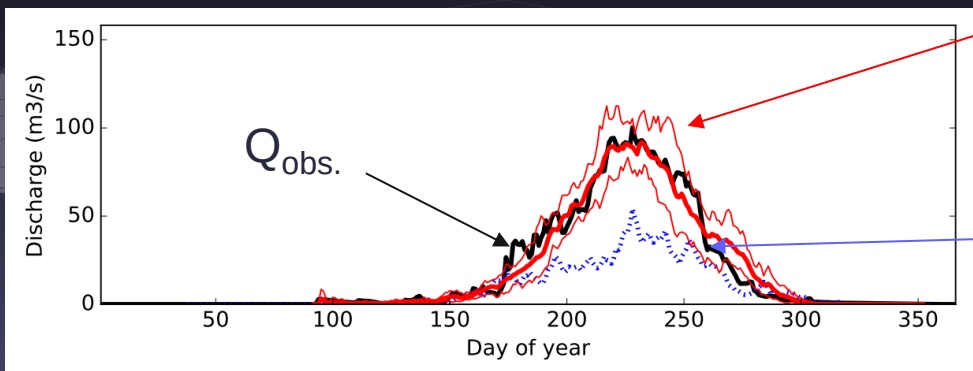
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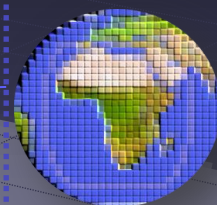
Régime hydrologique Dargol (Période de contrôle)



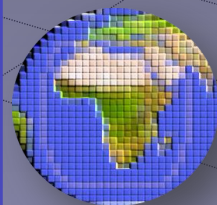
Stochastorm



CP4-Africa



CP4-Africa



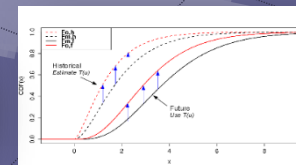
Stochastorm



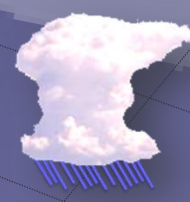
CP4-Africa



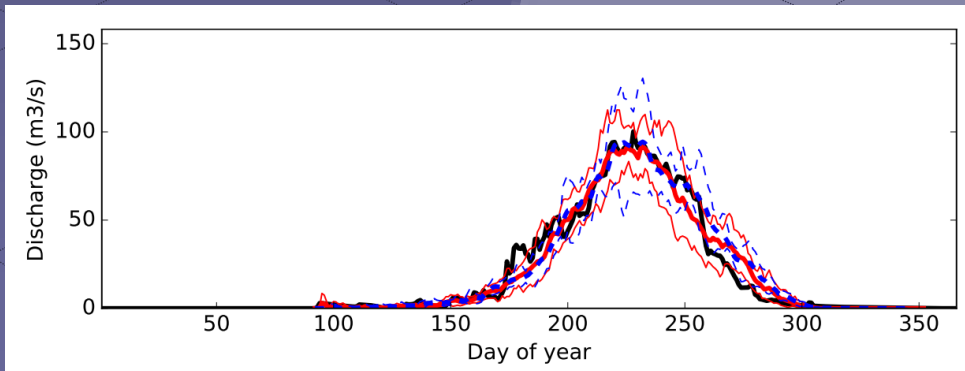
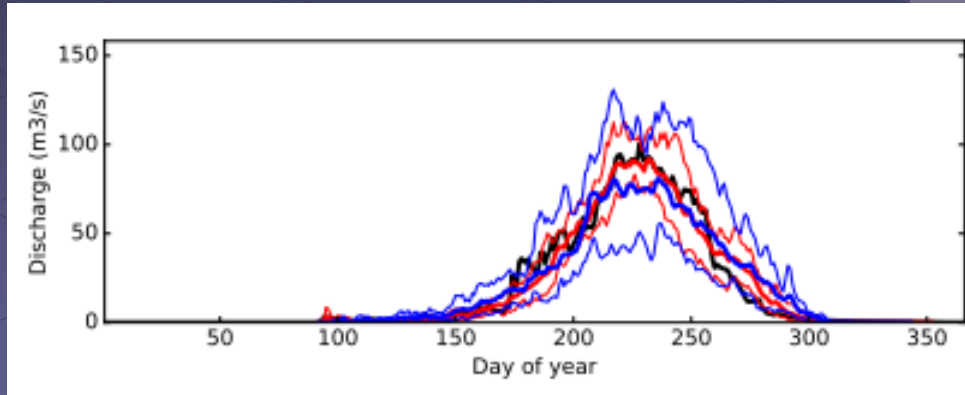
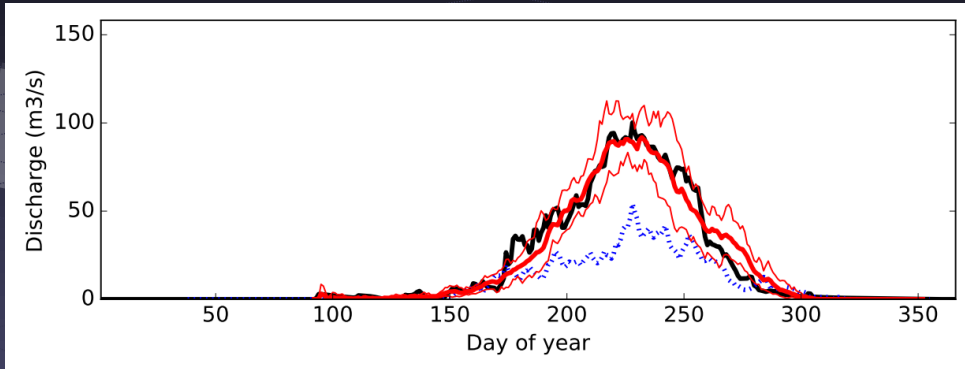
CDF-t



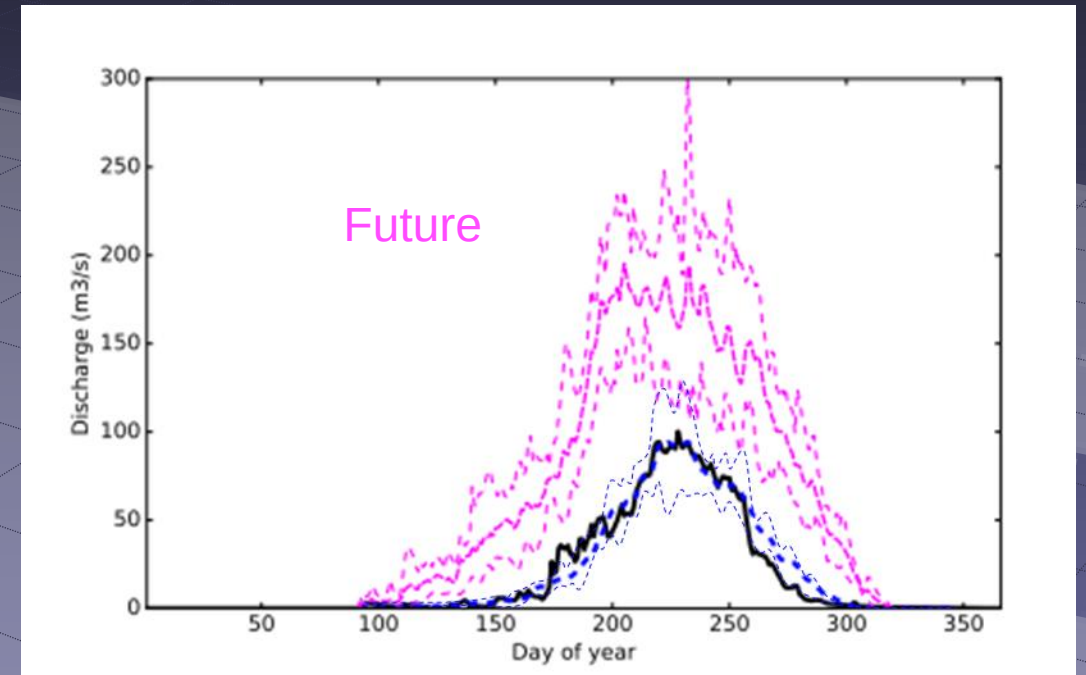
Stochastorm



Régime hydrologique Dargol (Période de contrôle)



Régime hydrologique Dargol (Période future ~2080-2100)



Bilan

- Mise en place d'une chaine de modélisation climat-impact
 - Répondre à une demande pressante d'outils d'aide à la gestion structurelle du risque inondation
 - Prise en compte des échelles et processus clé de la variabilité hydrologique
- Preuve de concept...Résultats incertains.

Défi n°1
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D'ECHELLES

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Bias
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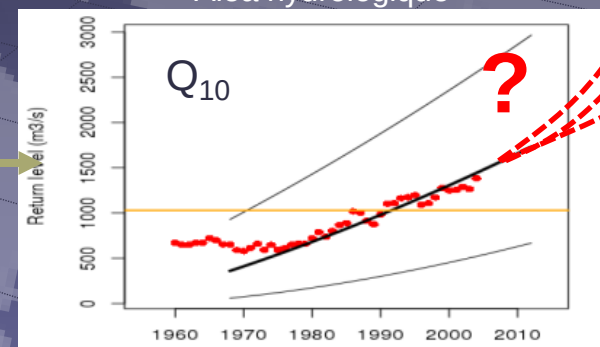
Stochastic
Rainfall
Generator

Mesoscale
Rain fields

Rural
Hydrologi
cal model

Défi n°5
INCERTITUDE
CLIMATIQUE

Défi n°6
INTERACTIONS
HYDROLOGIE-
SOCIETE





MERCI POUR VOTRE ATTENTION