

# Hydrological Model response to Satellite-based rainfall forcing : sensitivity and “error” propagation

Simple, exploratory analyses on the Oueme basin, Benin

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# Objectives

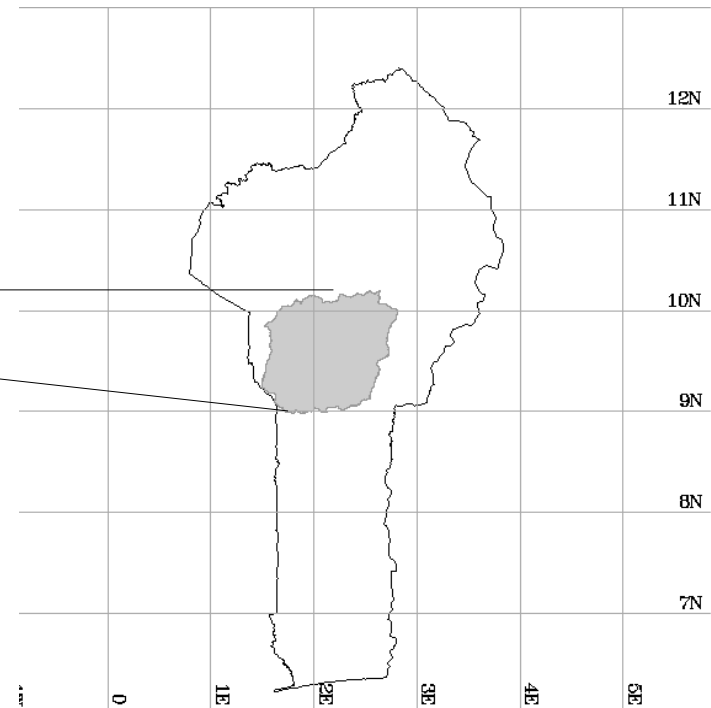
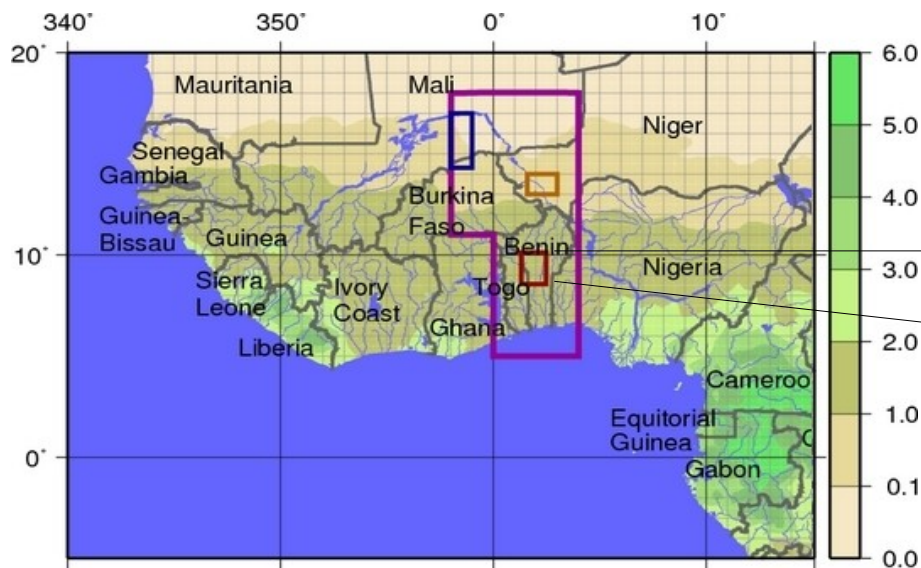
Background : hydrologic applications of satellite products

- Analyse
  - the sensitivity of (2) hydrological models to satellite rainfall products
  - “error”/uncertainies propagation
- Is product correct efficient ?



# Test basin

- Watershed : Upper Ouémé (10 000 km<sup>2</sup>)
  - tropical basin (1 season, 1200 mm yearly rainfall)
  - heavily instrumented (AMMA-CATCH observation system)
  - no complex terrain issues, (no snow !)



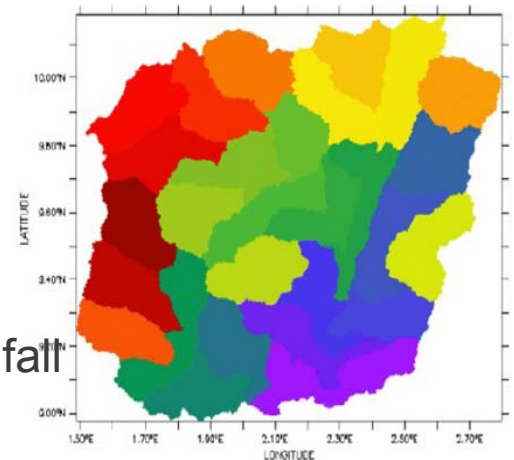
# Methodology

## 3 daily rain products :

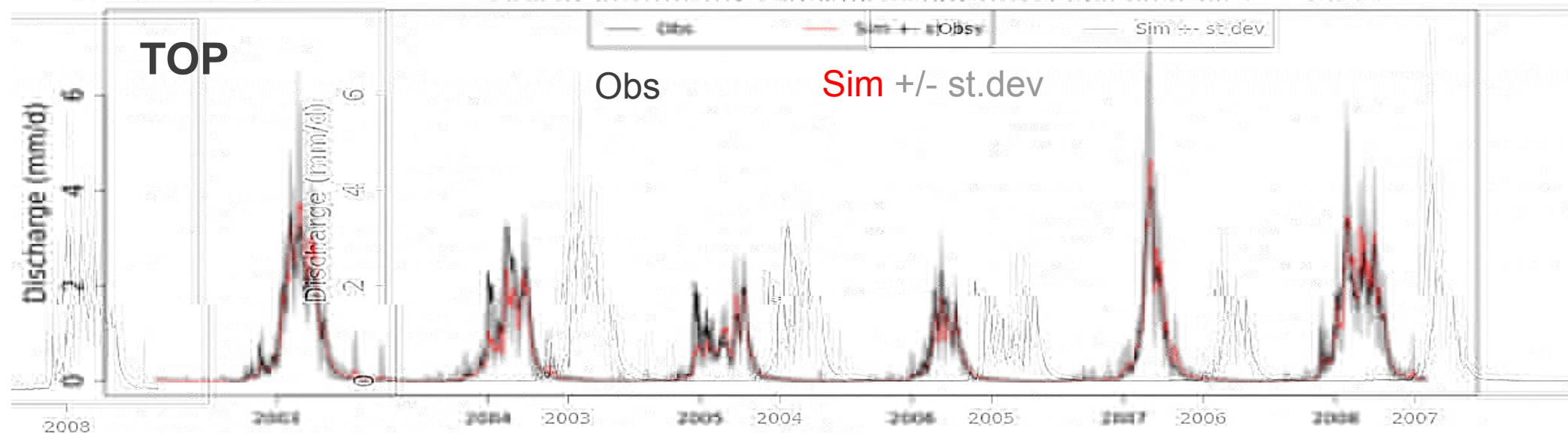
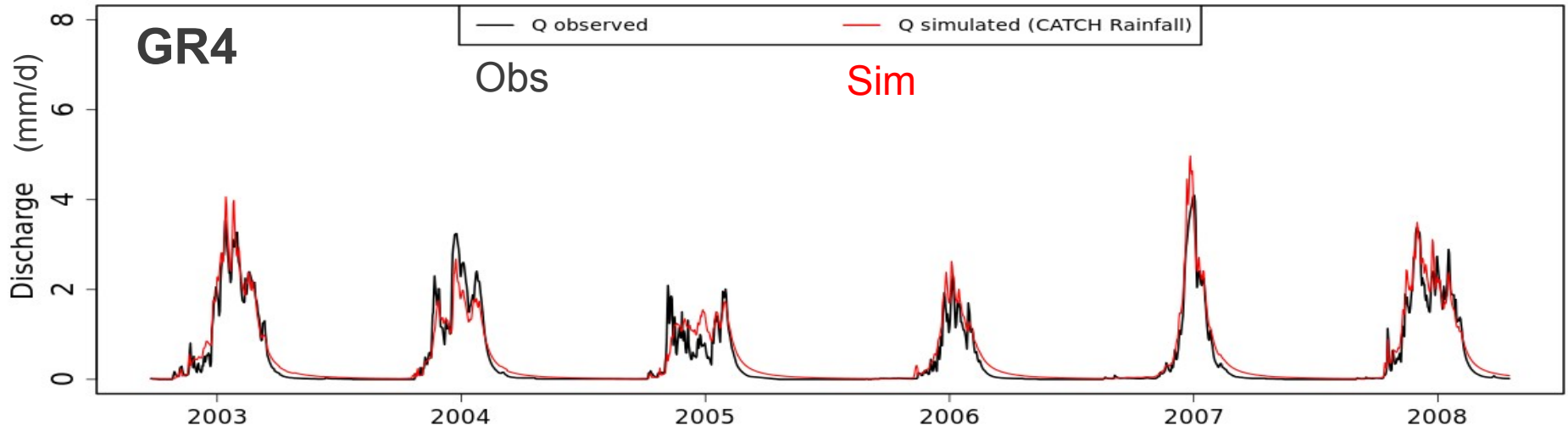
- CATCH : krigged rainfall from gages (cf Quantin et al,) - *our reference*
- 3B42v6 (TMPA) : monthly recalibrated with gages
- CMORPH : real time, uncalibrated product

## 2 models (daily time step) :

- **GR4J** : lumped, bucket-type model ; uniform rainfall and parameters
  - **TOPAMMA** (Top-model “family”),  
physically based, topography accounted for ;  
uniform parameters, semi-distributed rainfall
- 
- Both models were first tuned on Obs discharge (Q) with CATCH rainfall on 2003-2008 → **CTRL run**
  - Metrics used (Qobs vs Qsim goodness-of-fit) : Nash statistics  $[-\infty ; 1]$   
1 = perfect fit, > 0.75 good, <0.5 bad

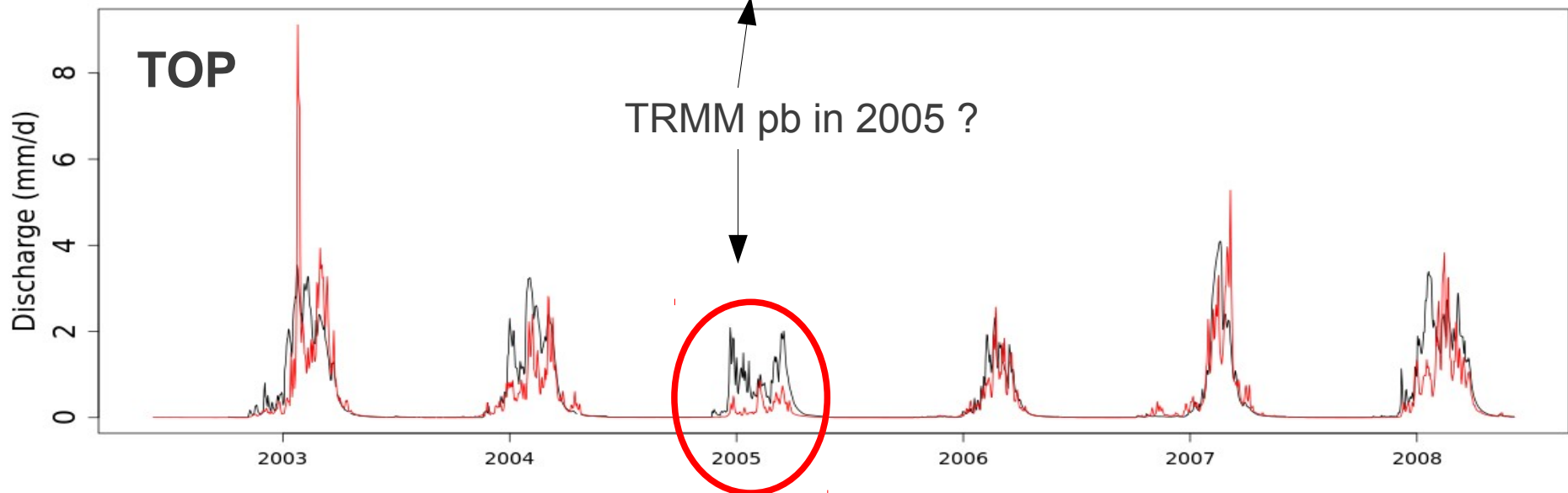
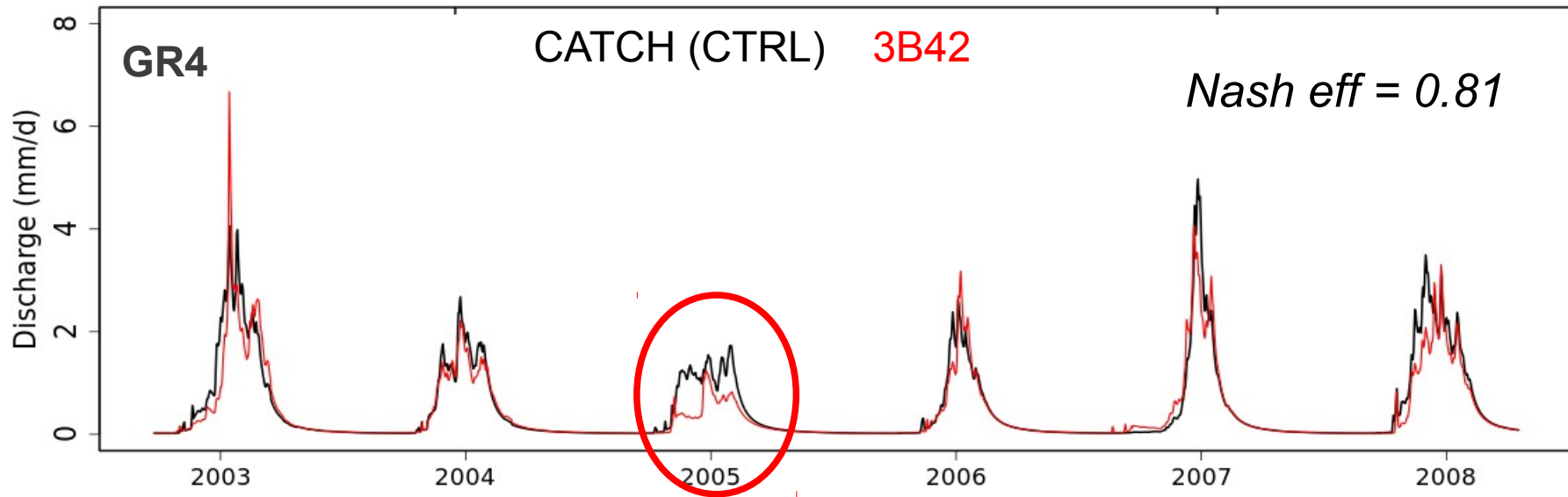


# Control runs (calibrated) – Nash Efficiency $\sim 0.9$

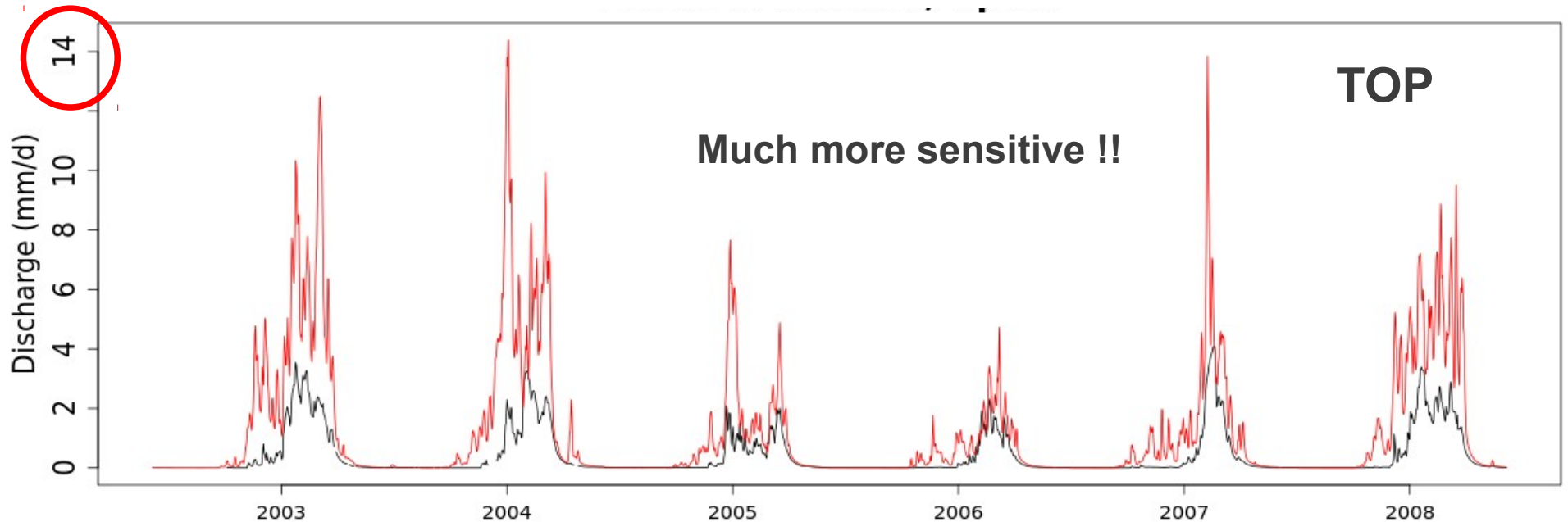
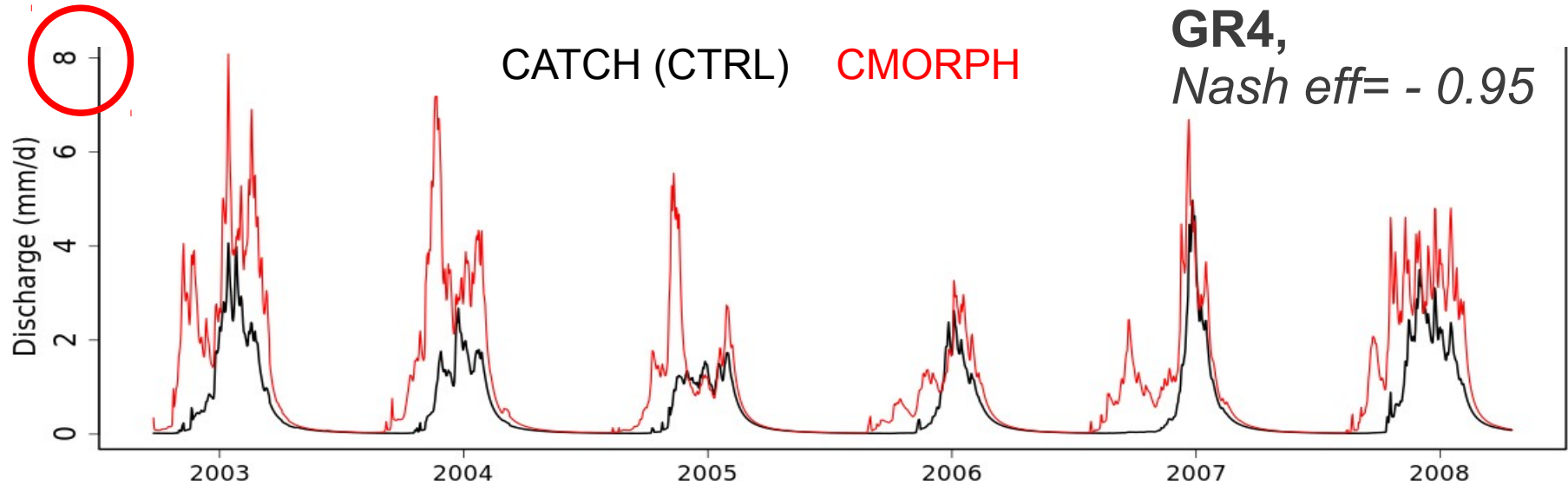


Model uncertainty estimation (GLUE-like ensemble method)

# Simulation with sat. products : 3B42v6



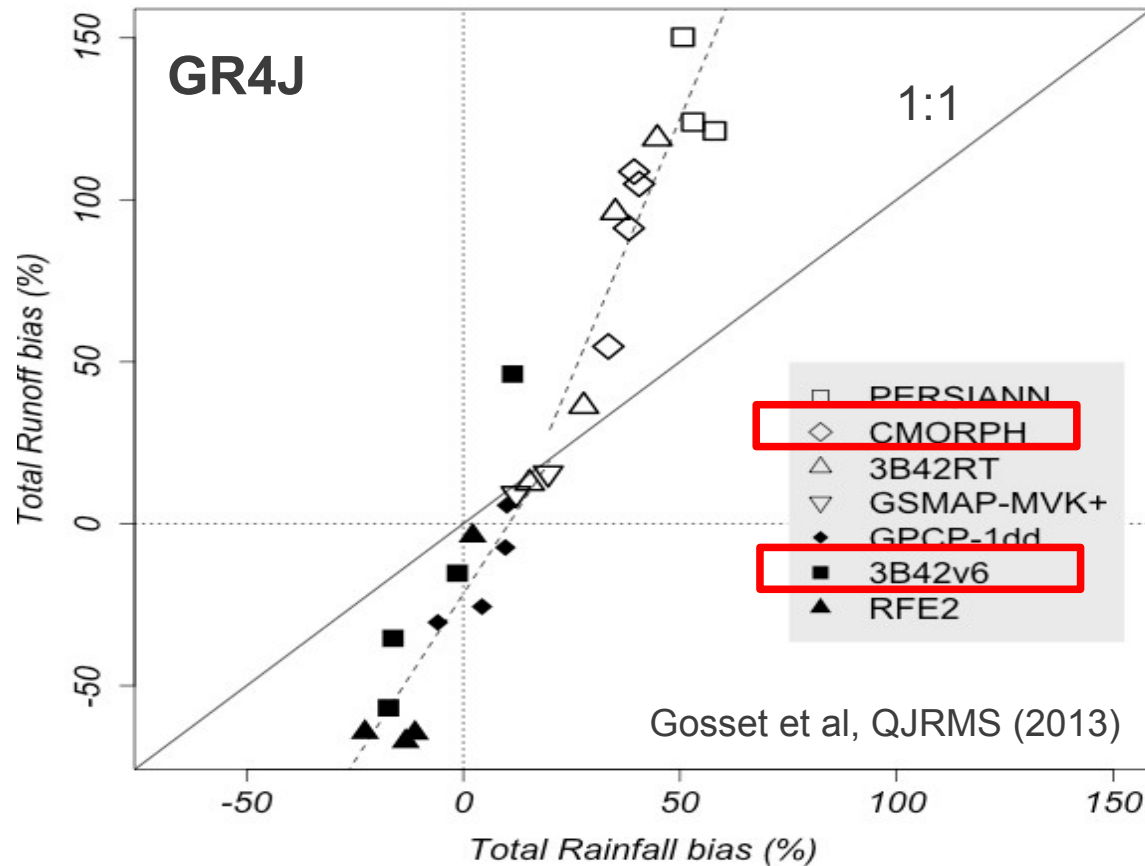
# Simulation with sat. products : CMORPH



# Bias propagation

$$\text{Bias} = \frac{(\text{annual total from CATCH} - \text{annual total from Sat})}{\text{annual total from CATCH}}$$

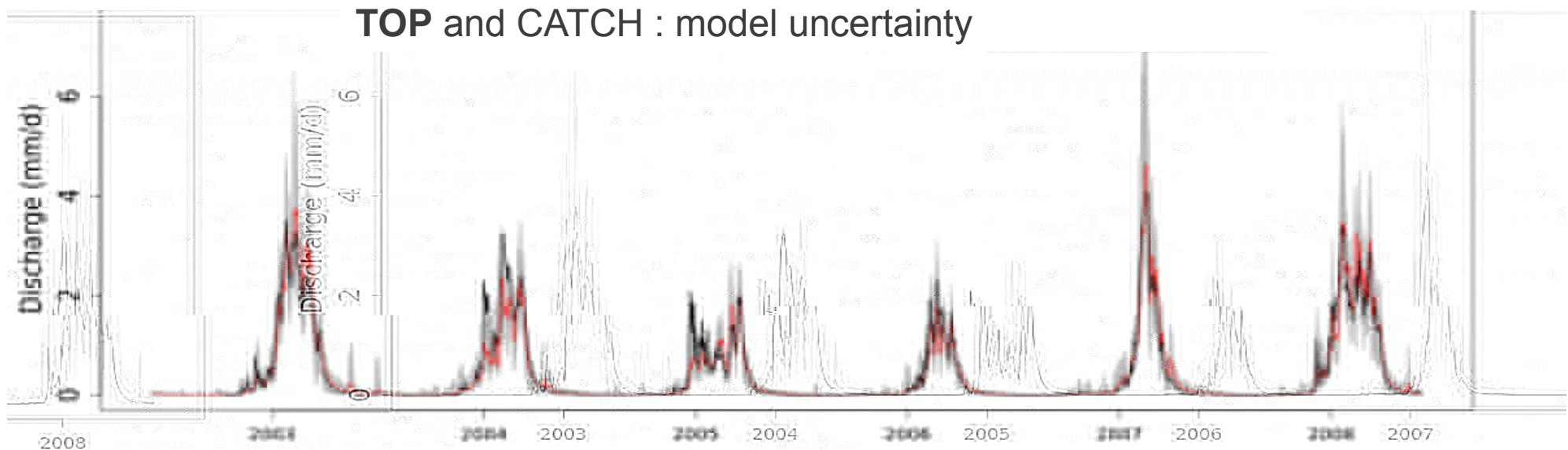
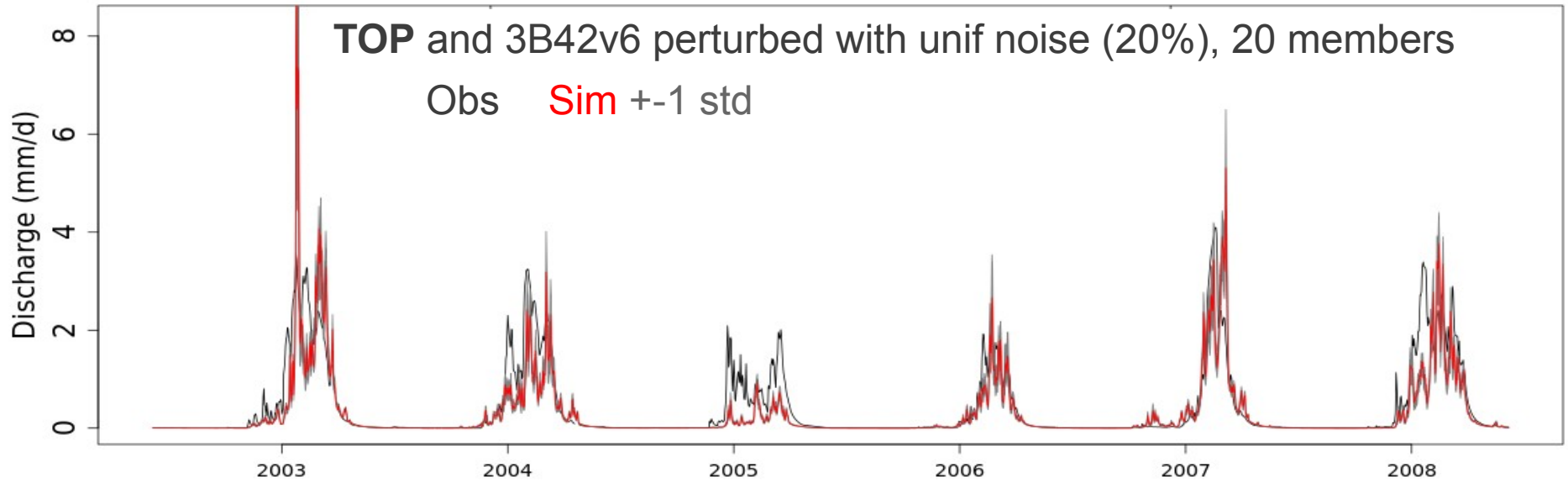
1 symbol per year,  
2003-2008



biases are amplified by the model  
amplification is higher when rainfall bias >0 ( ie overestimated Sat rainfall)  
( Non linearities in hydro response !!)

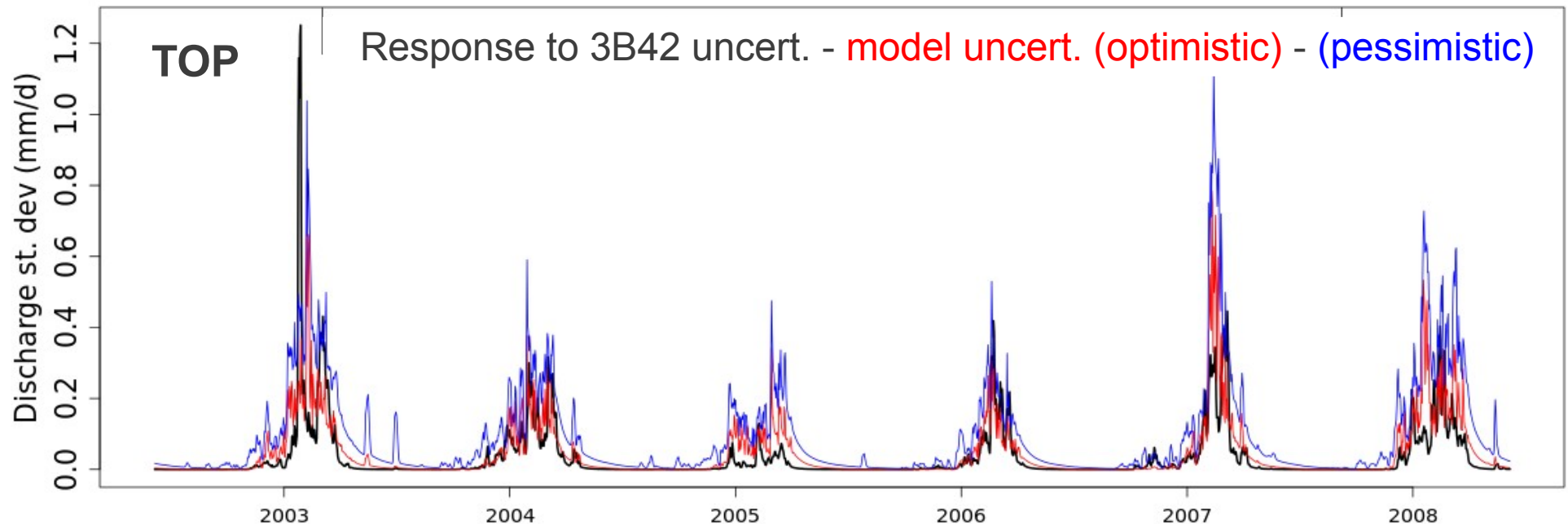


# Model uncertainty vs response to rain uncertainty



# Model uncertainty vs response to rain uncertainty

Comparison of ensemble st. dev



Model uncertainty > response to rain uncertainty  
(3B42 has low biases)

!! in this case : check for generality is needed !!

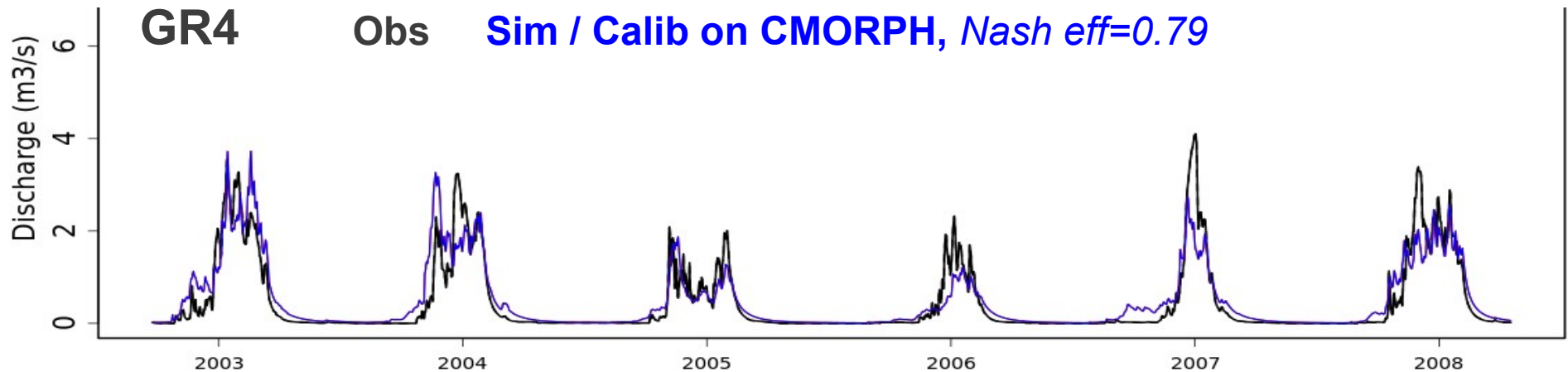
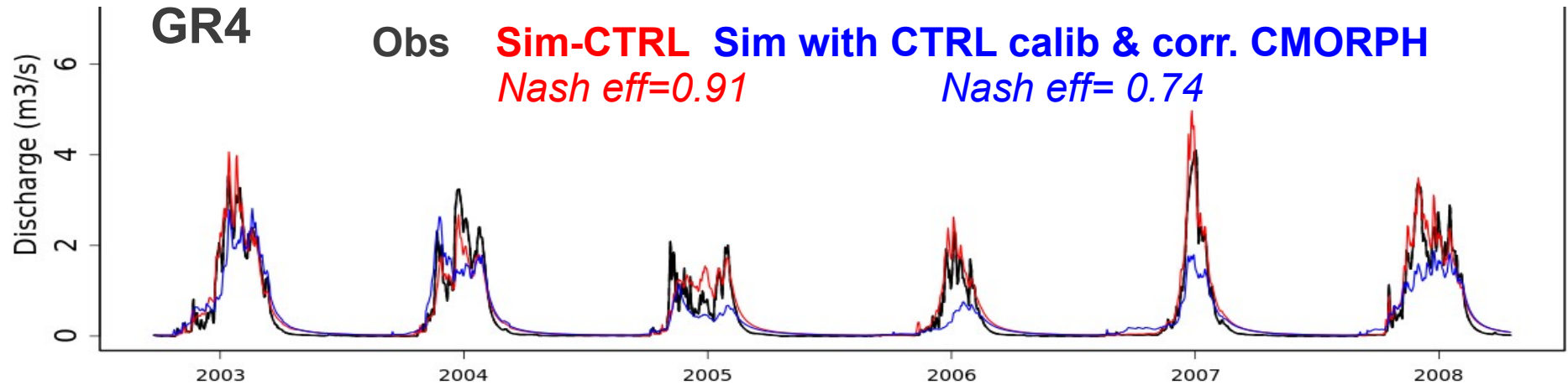
# bias corrections ?

Specially needed for uncalibrated products (real-time, ...)

2 possible ways tested here (with CMORPH) :

- product correction (6th order polynom, Gosset et al)
- use an *ad hoc model* calibration, specific to the product

# Bias corrections ?



→ Correction/calibration improves hydrological simulation,..... but ....

# bias corrections ?

Is an ad hoc calibration relevant w.r.t. hydrologic functioning ?

GR4 Model Param	X1	X2	X3	X4
Phys. meaning	Bucket capacity (mm)	Drainage coef (-)	routing	
CRTL Calib	177	39	391	3.5
CMORPH Calib	589	82	391	3.5

In the CMORPH-calibrated model → more storage, more drainage  
→ more water abstraction from the surface as CMOPRH provides too much rain **here**

In the mathematical sense : good signal (Nash=0.79), but  
... do we still have a physically sound model ? (*supposing we had it in the CTRL calib ...*)  
... (*good results for good reasons is the St Graal of hydro modellers*)

The *ad hoc* model is more likely a “sophisticated filter”, product/basin/period specific  
→ too specific for “generic” uses ?

# Conclusions

- Hydrological models are sensitive to the rainfall product used (hopefully !!)
- The sensitivity varies depending on the model
- Rainfall biases are amplified in the simulated response ;
  - $>0$  biases more amplified than  $<0$  ones
- Model uncertainty  $>$  response to rainfall uncertainty (in this analysis)
- For hydrological applications : better use calibrated products, or correct uncalibrated ones (***Be careful with raw RT products...***)
- Preliminary work !

# Perspectives

Future directions :

- characterize the biases/errors/differences in the rainfall estimates  
(May be region/product/... dependent, may vary with rainfall intensities)
- Estimate their diverse impacts on the hydrological response
  - not only on discharges : soil moisture, ground water recharge ...)
  - separate model specific response vs general behaviours

Take advantage of model sensitivity to evaluate/validate rainfall products

- Hydro model = spatio-temporal integrator, related to “actual” hydro. processes
- → “hydrologically sound” evaluations
- Operating a discharge station (1 per basin) easier than a raingage network
- → towards a “hydrologic benchmarking” of rainfall products ?  
(series of contrasted test basins and models)

Thank you