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

Simple, exploratory analyses on the Oueme basin, Benin

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1st **M**egha-**T**ropiques **G**round **V**alidation Workshop

Objectives

Background : hydrologic applications of satellite products

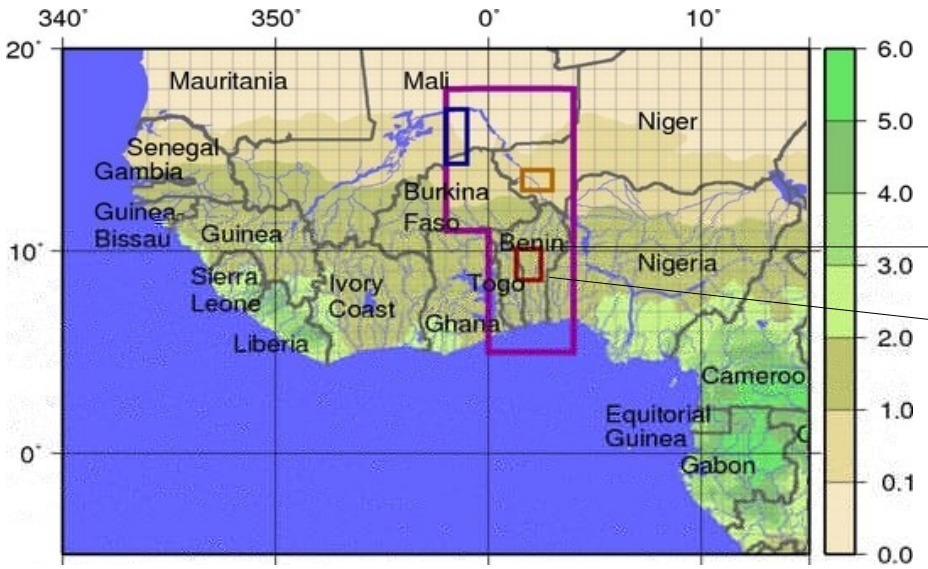
- Analyse
  - the sensitivity of (2) hydrological models to satellite rainfall products
  - “error”/uncertainies propagation

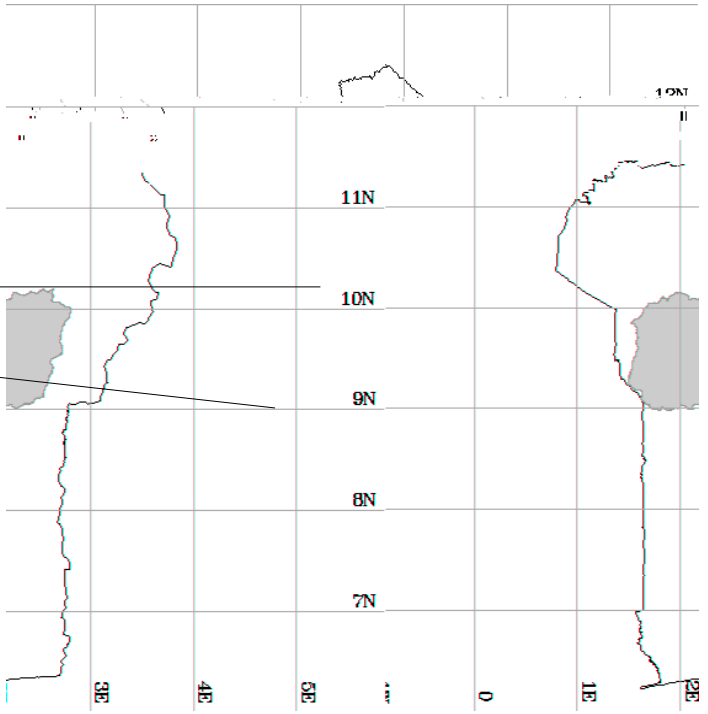
- Is product correct efficient ?

-

Test basin

- Watershed : Upper Ouémé (10 000 km2)
  - 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 :

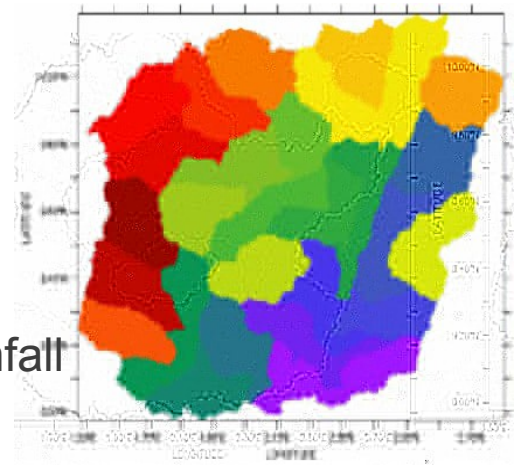
- CATCH : krigged rainfall from gages (cf Quantin et al,) - *our reference*
- 3B42v6 (TMPA) : monthly recalibrated with gages
- CMORPH : real time, uncalibrated product

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 →

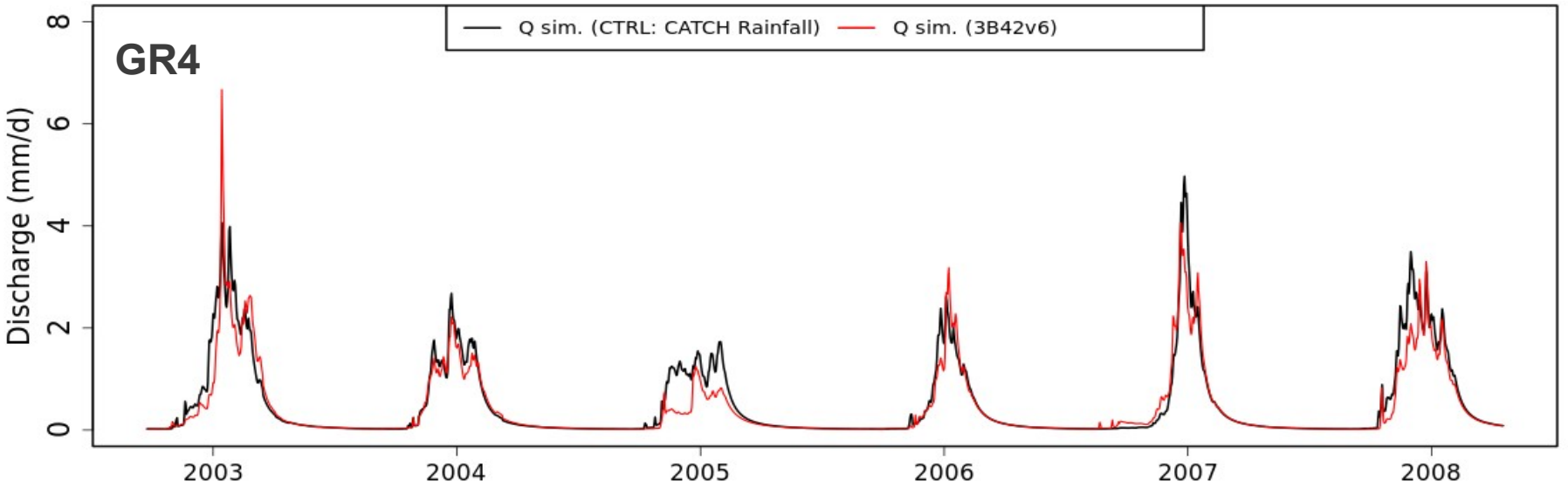


- Both models were first tuned on Obs discharge (Q) with CATCH rainfall on 2003-2008 → **CTRL run**
- Metrics used (Qobs vs Qsim goodness-of-fit) : Nash statistics] -inf ; 1]

1 = perfect fit, > 0.75 good, <0.5 bad

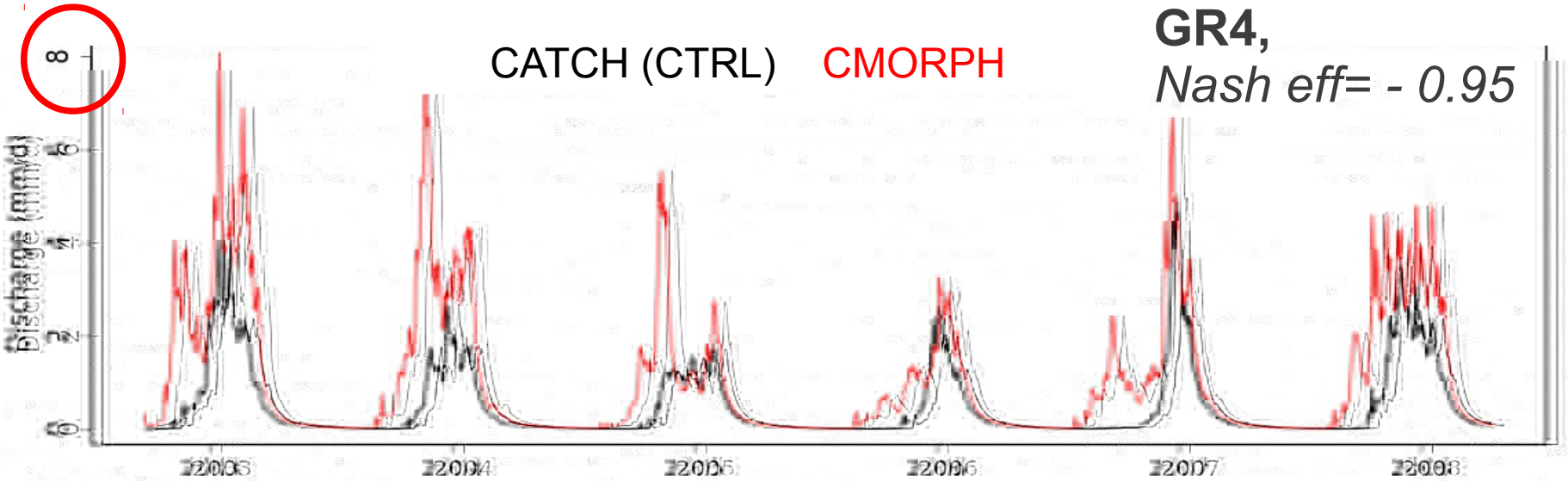
Control runs (calibrated) –

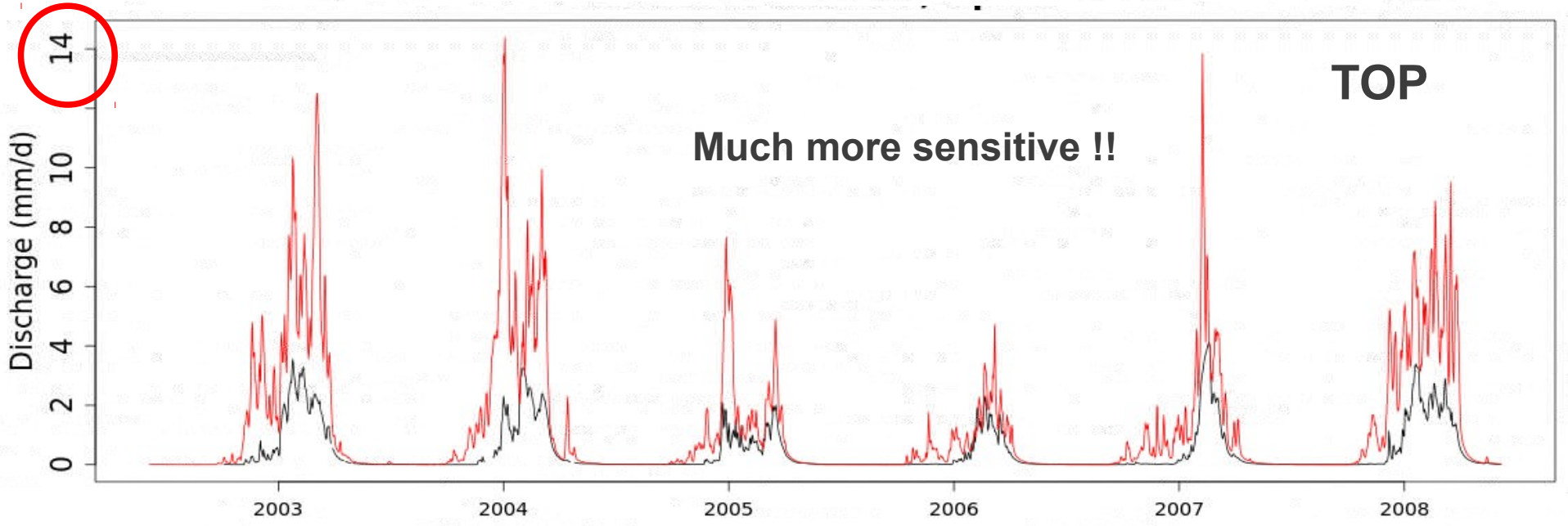
Simulation with sat. products : 3B42v6



TOP

Simulation with sat. products : CMORPH

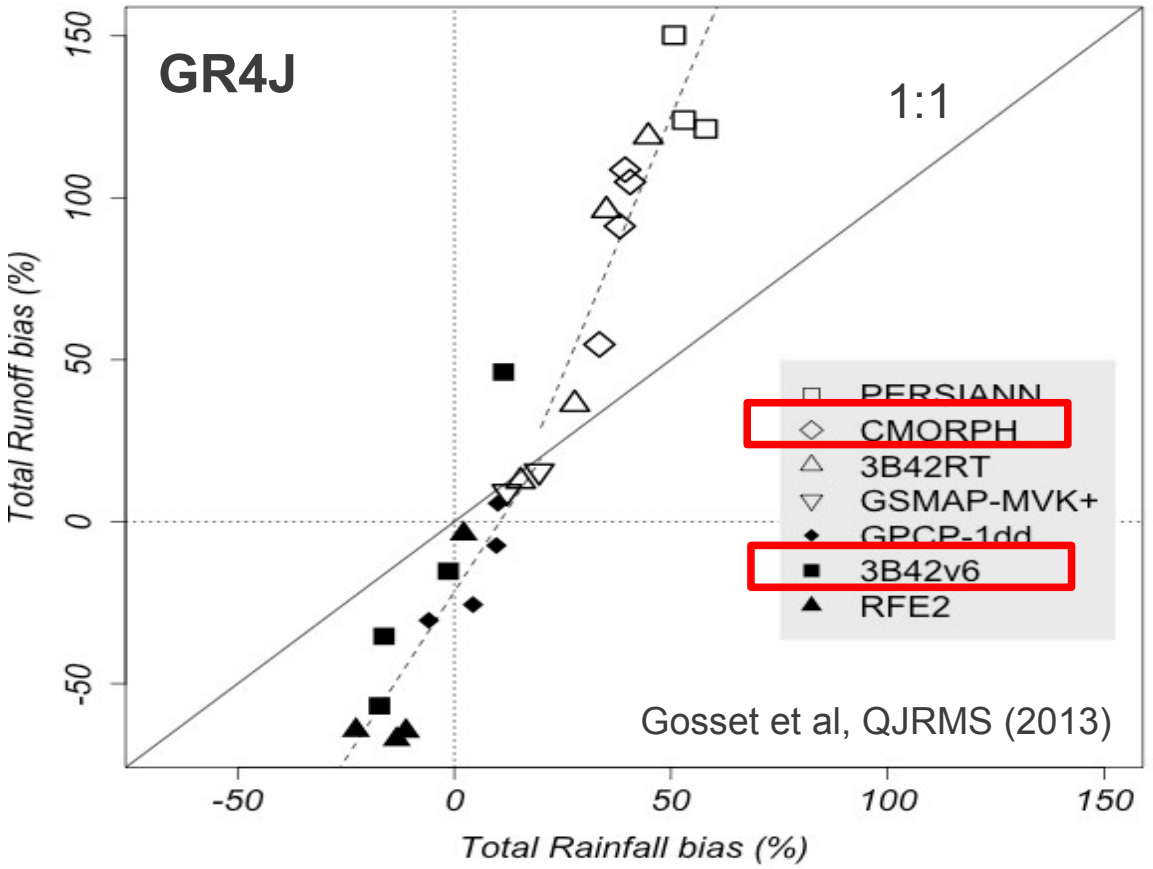




Bias propagation

Bias = (annual total from CATCH - annual total from Sat) / 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

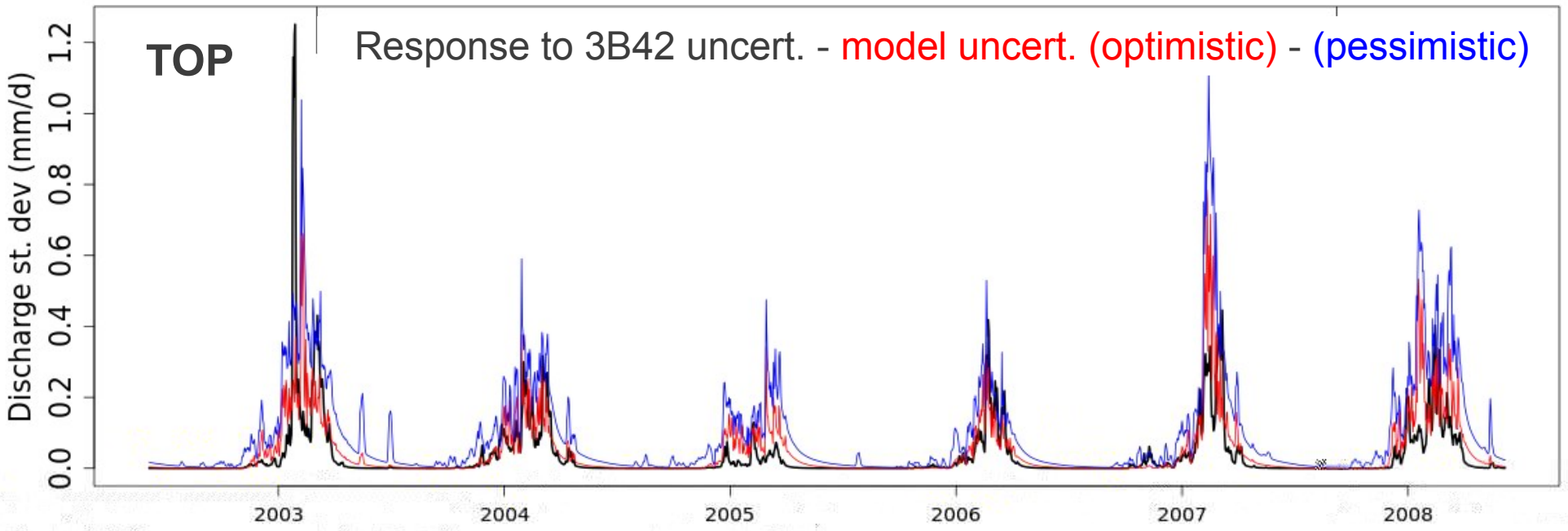
TOP and 3B42v6 perturbed with unif noise (20%), 20 members

Obs Sim +-1 std

TOP and CATCH : model 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 !!

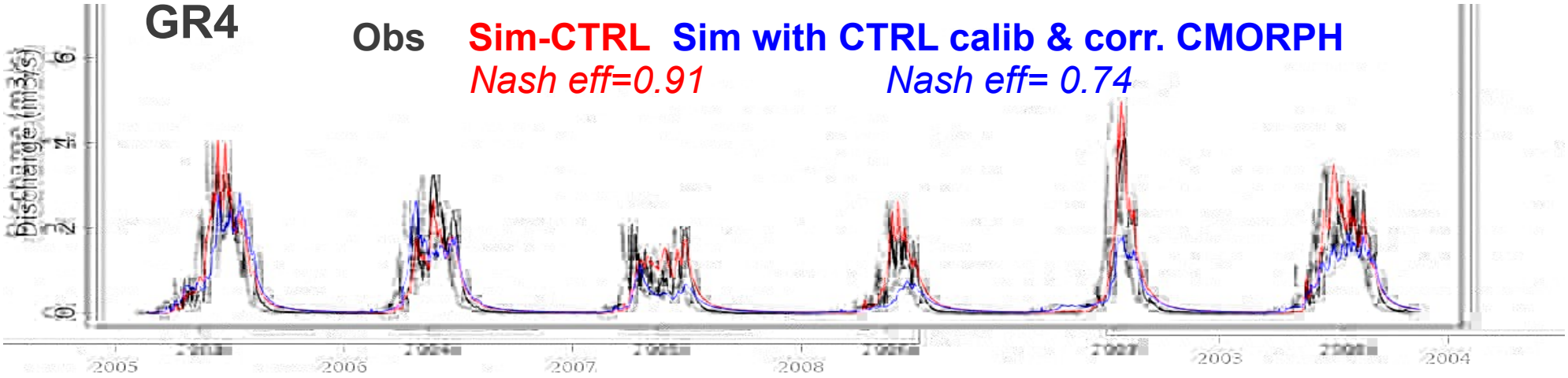
bias corrections ?

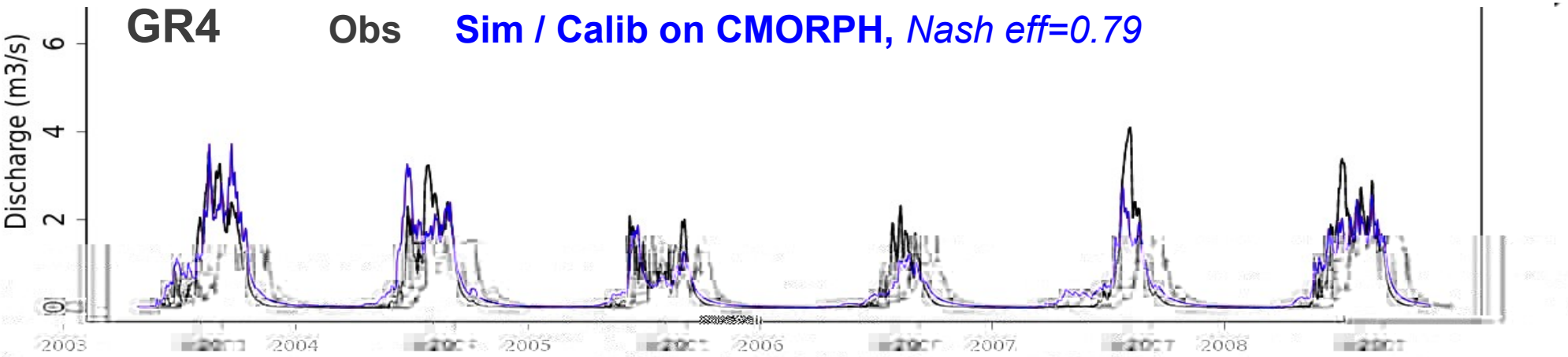
Specially needed for uncalibrated products (real-time, …)

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 functionning ?

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 ____

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
- 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