INTERNATIONAL NETWORK OF BASIN ORGANIZATIONS

INBO Session

« Water resources management under extreme conditions »
MOSCOW, RUSSIA, June 5th, 2008

INTEGRATED MODELLING for the MANAGEMENT of EXTREME EVENTS

J. SMITZ

University of Liege, Belgium

j.smitz@ulg.ac.be

1

Introduction

Very few persons today contest the **interest** and the **importance** of **models** in order

- To gain a **better understanding** of the water resources systems
- To improve the integrated **management** of the water resources and, in particular, to help the design of DSS's

Developing models is today a <u>specific scientific activity</u> :
. Data collection and treatment
. Construction of the model
. Calibration and <u>validation</u> (historical situations / events)
. Elaboration of prospective scenarios
. Simulation of scenarios

2

Introduction

The European Water Framework Directive (WFD) requires that all measures taken to reach the good status must also **reduce the effects of floods and droughts**

In the scope of any Integrated Water Resources Management, including in the scope of the WFD, it is more and more important to take into account EXTREME EVENTS such as :

- *very high flows and floods*
- *droughts, very low flows*

The use of **classical models** for simulating (and managing) these extreme events is however **NOT** straightforward or easy

3

Introduction

Reasons why it is NOT easy to take into account extreme events in modelling exercices :

DATA

- relative scarcity of data for (rare) extreme events
- measurements more difficult under extreme conditions
- results are less precise / less reliable

MODELS

- relative importance of processes can be different under EC
- time / length scales can be different
- extreme events can be out of range of calibration or validation

4

Integrated models soil – groundwater – surface water

Characteristics of most of the existing hydrological models :
- semi-deterministic
- distributed
- runoff coefficients as functions of slope, soil type and land use
- groundwater is generally simulated by a linear reservoir

To improve the capacity and reliability of these models
to simulate the extreme events, it is necessary **modify the models**
in order to extend the domain of validity
(models must become more **robust** and more **physically-based**)

5

Integrated models soil – groundwater – surface water

To reach these objectives, a solution is to develop an integrated physically-based soil – groundwater – surface water model

Option 1 : to develop a single integrated model

difficulties : . tremendous task
. capacity of the computers

Option 2 : to assemble (existing) detailed deterministic models

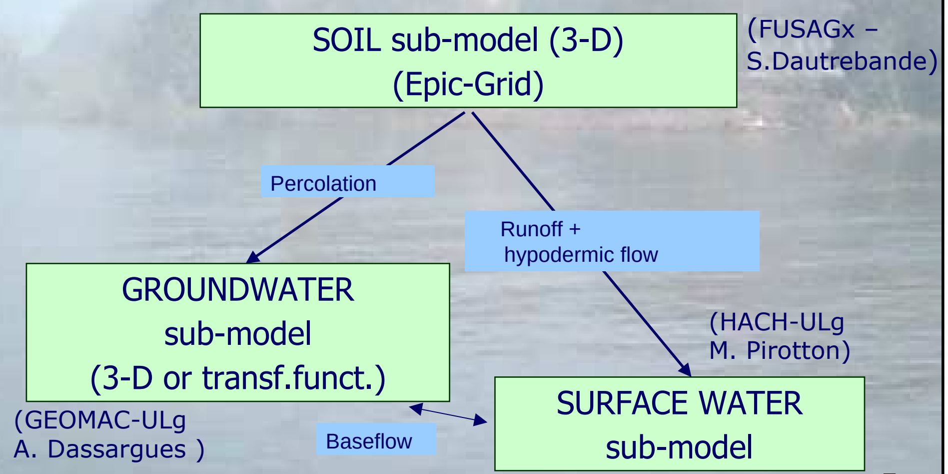
difficulties : . to make the models communicate
. computing architecture

Main scientific challenge :
to incorporate in the same model numerous interlinked processes which have very different time and/or space scales

6

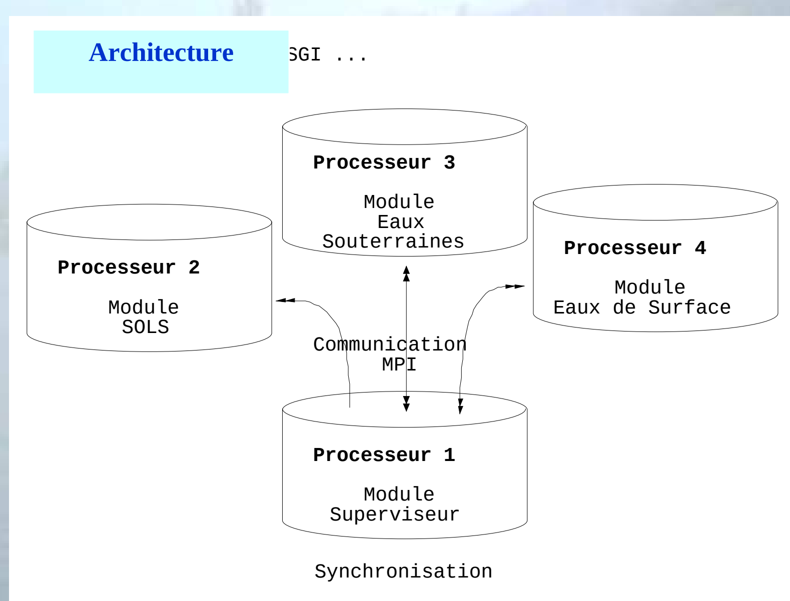
Integrated models soil – groundwater – surface water

Structure of an integrated model :



7

Integrated models soil – groundwater – surface water



8

Integrated models soil – groundwater – surface water

Model MOHISE

(FUSAGx + GEOMAC-ULG + CEME-ULG)

Financed by : Belgian Federal Science Policy Dpt

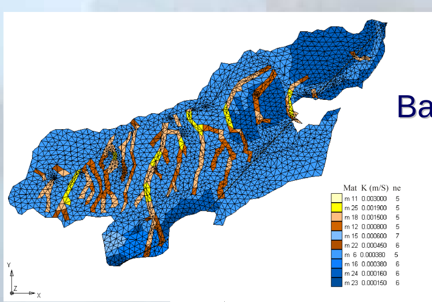
Objectives :
Long-term planning of water resources in hydrographic basins (> 30 years) + Effects of climate change scenarios

Approach :
- detailed models for soils (3-D) and ground water (3-D)
- time scale(s) : soil : 1 day
  groundwater : 1 – 10 days

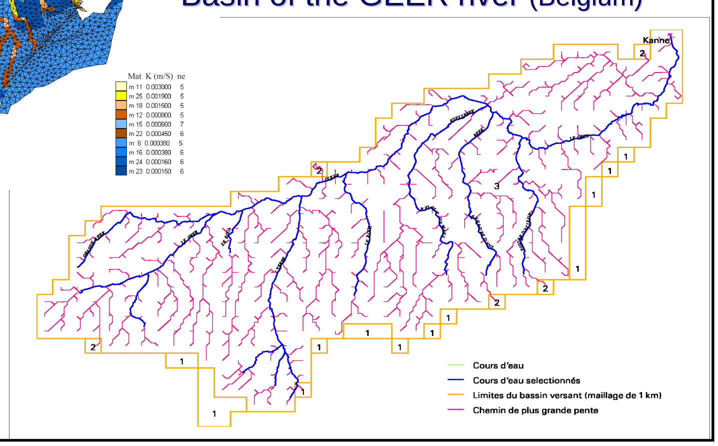
9

Integrated models soil – groundwater – surface water

Model MOHISE
(FUSAGx + GEOMAC-ULG + CEME-ULG)

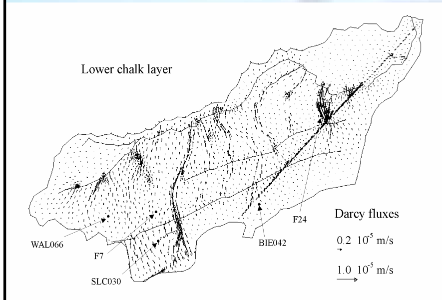


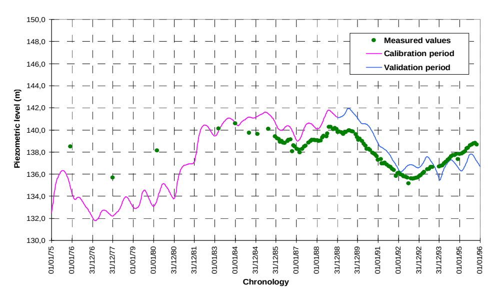
Basin of the GEER river (Belgium)

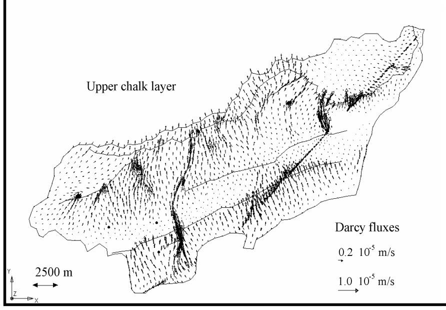


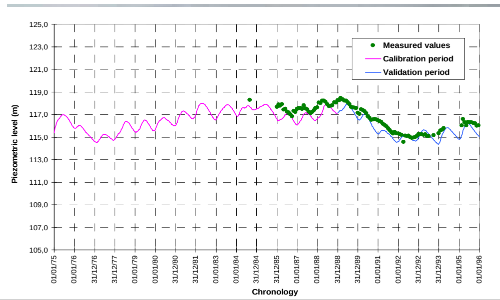
Integrated models soil – groundwater – surface water

Simulation of the historical period 1968 – 1995







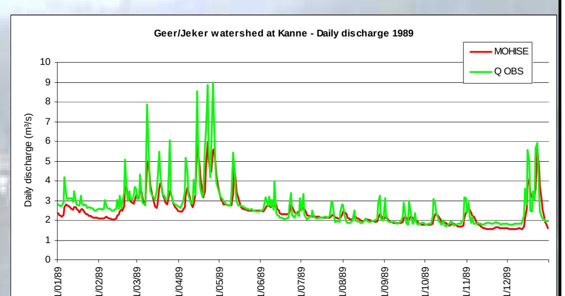


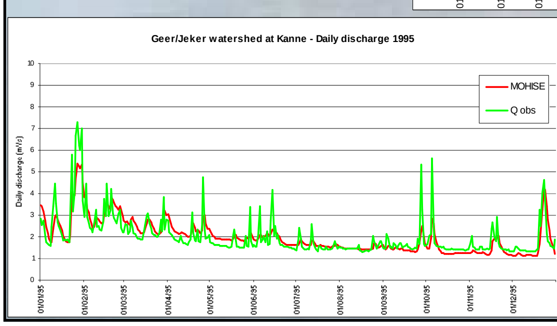
Integrated models soil – groundwater – surface water

Daily river flow
at the outlet (m3/s)

ex : year 1989

ex : year 1995





12

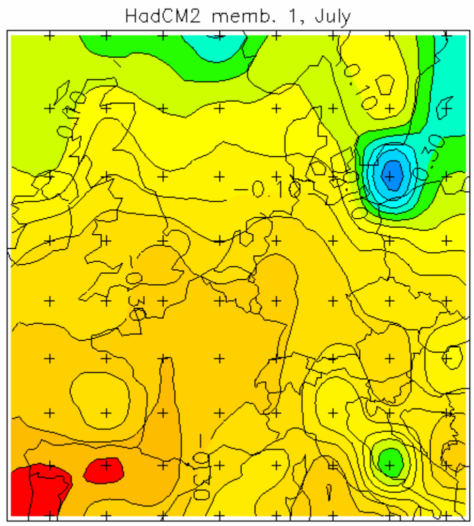
Integrated models soil – groundwater – surface water

SIMULATION of climate change scenarios from GCM's is possible using this kind of integrated model

Example :
Modification pattern of precipitation (relative values) during the month July
Period 2030 – 2070

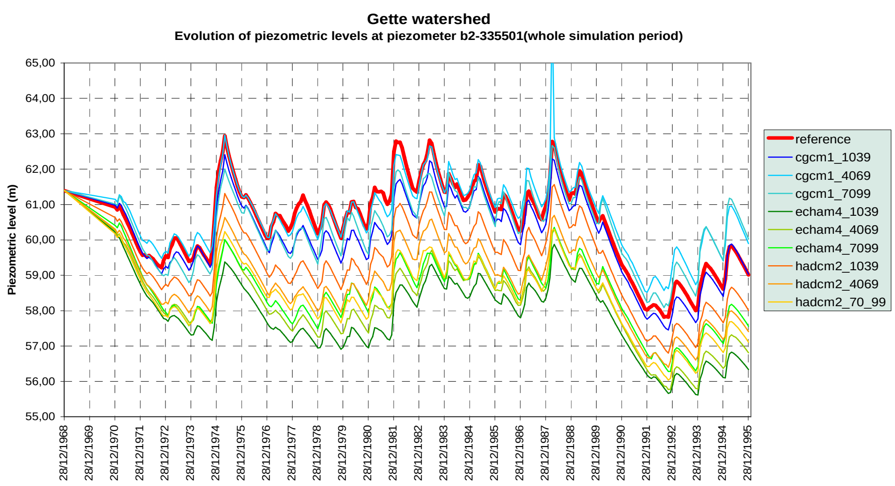
From
Hadley Climate model

Source :
IPCC,
Belgian Met. Institute



Integrated models soil – groundwater – surface water for the simulation of extreme events

SIMULATION of climate change scenarios from GCM's : results (GW)



Integrated models soil – groundwater – surface water

Conclusion :

- **Good capacity** of this kind of integrated model to simulate **very low flow events**
- **Computing time** remains a significant issue

From the experienced gained, the KEY FACTORS for the success of the modelling of DROUGHTS / LOW FLOWS extreme events using an integrated model are :

- A good knowledge of the space and time distribution of the precipitation (input data)
  ➔ make use of radar images for the calibration / validation
- A good knowledge of the soil & sub-soil characteristics
  ➔ make use of appropriate soil- and geological maps and data

15

Integrated models soil – groundwater – surface water

Model **MOHICAN**
(FUSAGx + GEOMAC-ULG + HACH-ULG + CEME-ULG)

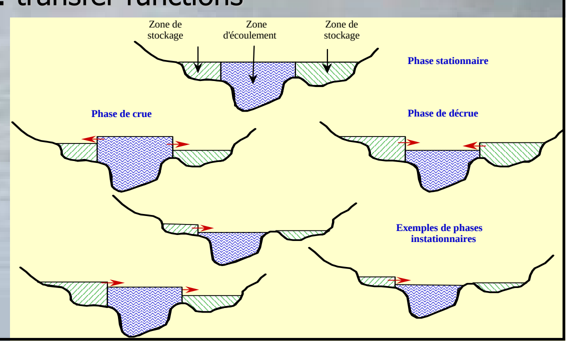
Objective : Simulation of high flows and floods

Financed by Ministry of Public Works and Transportation, Wallonia

Approach :

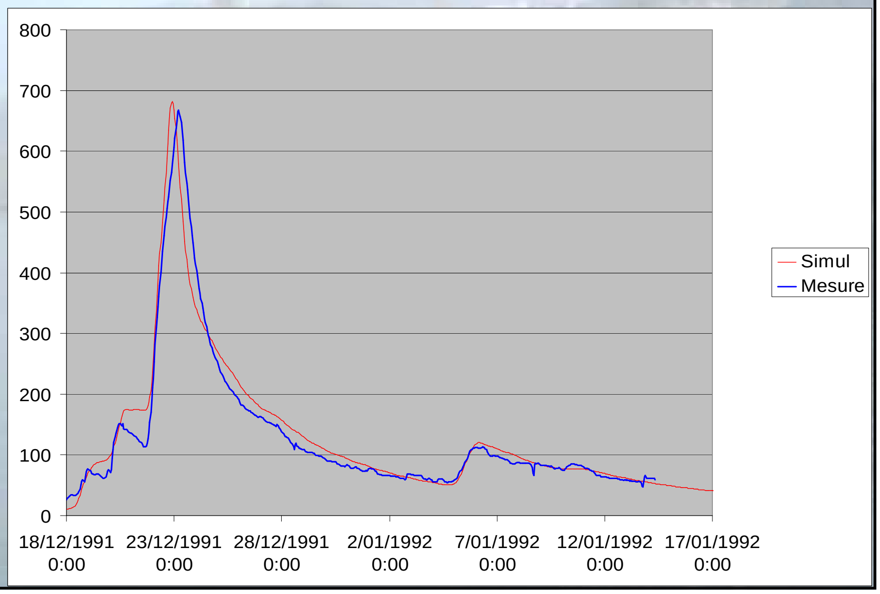
- Soil : detailed (3-D) model
- Groundwater sub-model : transfer functions
- Surface water : very detailed hydrodynamic model

- Time scale(s) :
  runoff : 1 h
  surface water : 1 h
  other processes : 1 day



Integrated models soil – groundwater – surface water

Simulation of a very high flow event (Dec 1991 – Jan 1992), Ourthe basin (Belgium)



Integrated models soil – groundwater – surface water

Conclusion :

- **Good capacity** of this kind of integrated model to simulate **very high flow events**
- **Computing time** remains also a significant issue

From the experience gained, the KEY FACTORS for the success of the modelling of HIGH FLOWS / FLOODS extreme events using an integrated model are :

- A good knowledge of the space and time distribution of the precipitation (input data) ➔ make use of radar images
- A good knowledge of the river bed- and banks geometric characteristics ➔ make use of appropriate sonar- and laser data

Note : Simulations of the effets of CLIMATE CHANGE scenarios on high flow events require a finer time resolution from the CC models which are not yet available at the present time (downscaling is possible but still difficult to validate)

18

Integrated models soil – groundwater – surface water for the simulation of extreme events

CONCLUSIONS and PERSPECTIVES

- **Reliable modelling** of EXTREME EVENTS is possible using improved tools such as e.g. **integrated models**
- These models need **specific developments and techniques**. These models must be fed by **appropriate input data** in order to garantee precision and reliability
- The first results are interesting and encouraging, but work is still to do (especially in order to extend the approach to large river basins)

19

Integrated models soil – groundwater – surface water

Aknowledgments

J.F. DELIEGE, E.EVERBECQ, Aquapole-*ULG*
A. DASSARGUES, S. BROUYERE, *Geomac-ULG*
M. PIROTTON, P. ARCHAMBEAU, *HACH-ULG*
S. DAUTREBANDE, C. SOHIER, *HAH-FUSAGx*

20


Thank you for your attention
21