3rd INTERNATIONAL SCIENTIFIC MEUSE SYMPOSIUM

THE MEUSE DISTRICT : CHALLENGES FOR TOMORROW

LIEGE, April 22 – 23, 2010

AMICE – WP1 (Action 3)

Analysis of climate change scenarios and the impacts on hydrology of the Meuse basin

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Progress of Work-Package 1

Step 1 Step up of the Amice Transnational Online References Database

Step 2 Towards a common background…

→ Consultation with WP1 partners to share expertise in Meuse hydrology, databases and rainfall-runoff modelling practices

Step 3 Literature synthesis from the TORD

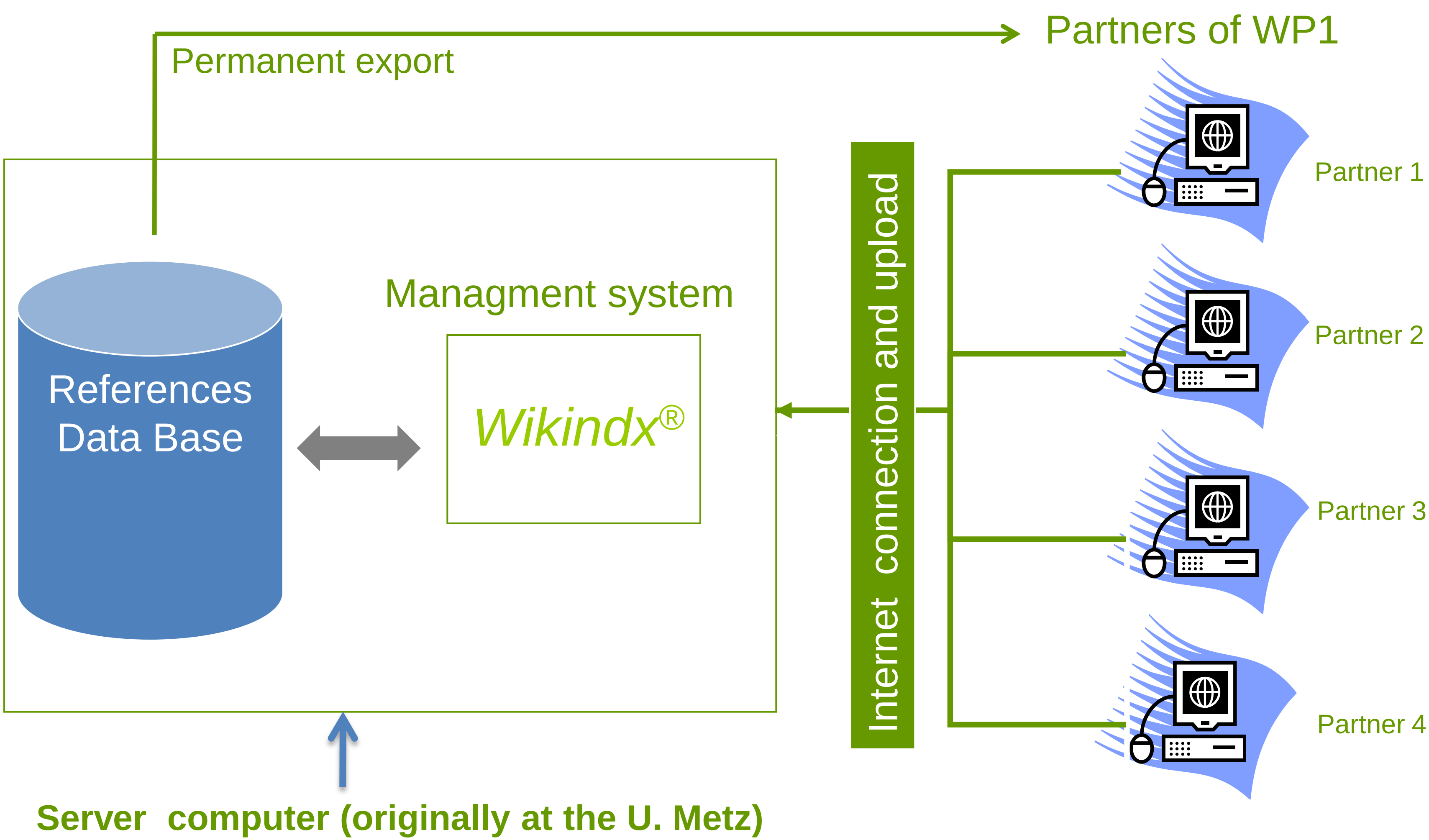
Step 4 Methodology for producing future climate scenarios

Step 5 Methodology for producing future hydrological scenarios

Step 6 Results of the hydrological simulations

Step 7 Selection of hydrological scenarios

Step 1 The AMICE Transnational Online References Database (TORD)



-> Software application **open for public consultation** but writable only for users having a login
-> More than **800 references** uploaded, now handing over to the EPAMA

Step 2 Towards a common background…

Consultation with WP1 partners through a questionnaire (May to Sept. 2009)

Question 1 : Do you know any high-resolution gridded climate database ready-to-use for carrying out a hydrological impact study (HIS) of climate evolution on the Meuse basin ?

Question 3 : Which climate scenarios do you recommend for the hydrological impact study on the Meuse basin and for which reasons ?

Question 7 : Which discharges do you recommend or do you need (in the framework of other Actions Plan of Amice) for the hydrological scenarios ?

etc.

Step 2 Towards a common background…

SYNOPSIS OF NECESSARY HYDROLOGICAL VARIABLES FOR DOCUMENTING "HYDROLOGICAL RELATED" AMICE ACTIONS (V.072009)

Partners	Low flows variables			
	abbreviation	definition	Application field	Useful For Action Plan…
EPAMA	-	-	-	-
RWTH	BFI	Base-flow index=baseflow/total streamflow	Important for low flow studies	-
	Q95	Ninety-five percentile flow	common low-flow index	-
	MQ, MNQ, NNQ	Mean Annual Flow, Mean Annual Minimum flow, Lowest Minimum Flow	Critical discharge for water related industries, drinking water supply, and ecology	23 - 24
Gx-ABT ULG RW-GTI	-	-	-	-
FHR		Peak over threshold selection of 1/Q to define low flow periods and there probability of occurrence	-	-
RIJKSWATERSTAAT	$Q_{avg,s}$	Average summer discharge	Low flow index	-
	Q_{def}	Discharge deficit accumulated over the season	Low flow index	-
	$Q_{month,min}$	Lowest monthly discharge (of year)	Low flow index	-
UNIVERSITY OF METZ (CEGUM)	QMNA / MAM7	Mean Monthly Minimum flow Mean Annual Minimum flow for 7 consecutive days	Critical discharge for water related industries, drinking water supply, and ecology	-

Step 2 Towards a common background…

Benchmarking of climate change experiments (v. Sept. 2009)

Existing climate scenarios databases…													vs AMICE PROJECT
SRES scenarios	**Climate experiment or model**	**Data provider and contact person**	**Downscaling method**	**Time step of simulation**	**Climate variables**	**Source of data**	**Data access and availability**	**Spatial resolution of the grid**	**Time period for the control run**	**Time period for the scenarios**	**Data format**	**Geographical area**	**Suitability of climate simulations for Actions Plan 6,7, 8, 23, 24**
A1B/A2/B1	ARPEGE-climat v4.6	Météo-France (L. Labbé)	Bias correction (Q-Q plot)	Daily	Tm, RH, precipitation, wind, PET	Meteo France	convention with EPAMA	25x25 km	1971-2000	2001-2100		French part of the Meuse basin	Not suitable for calculating the impact of climate change on High flow variables (e.g. Qhx100)
A1B/A2	ENSEMBLES	ENSEMBLES EU project	No bias correction	Sub-daily	Air temperature, precipitation, etc.	ENSEMBLES GCM/RCM	http://ensemblesrt3.dmi.dk/extended_table.html	25x25 km 50x50 km	1950-2000	2001-2100	Netcdf	Europe	ditto
A2-B2	HadCM2 CGCM1 CCI-HYDR	UK Canada KU Leuven (P. Willems)	By RMI (E Roulin) By RMI (E Roulin) Perturbation approach	Daily Daily Daily	P and ETo perturbations factors per season (winter – summer)		Restricted access Restricted access Public access, available	1 perturbation factor by tributary (2 tested)	1961-1990	2010-2039 2040-2069 2070-2099 2070-2099	ASCII ASCII	? ?	ditto ditto (only one future time slice available)
A2-B2	PRUDENCE GCM/RCM matrix	PRUDENCE EU project	No bias correction	Sub-daily	Air temperature, precipitation, etc.	PRUDENCE EU project	http://prudence.dmi.dk/, available	50x50 km	1961-1990	2070-2099	Netcdf	Europe	ditto (only one future time slice available)
A1B/A2/B1	ARPEGE-climat v4.6/15 IPCC GCMs	CERFACS (C. PAGE)	Weather regime	Daily, Hourly	Air temperature, precipitation, PET, etc.	CERFACS	Public access	8x8 km	1961-1990	2001-2100	ASCII	French part of the Meuse basin	Suitable for all Actions Plan Do not cover the whole basin

Qhx100 : annual maximum hourly discharge of a one hundred years return period

Outcomes from Step 2 + Step 3

(May to Sept. 2009)

Rainfall-runoff modelling

-> If necessary, a new hydrological modelling experiment is possible through available calibrated rainfall-runoff models

Benchmarking of climate simulations

-> No ready-to-use (i.e. bias corrected) climate simulations at the Meuse basin scale

-> Insufficient time to perform bias corrections for an ensemble of climate simulations

-> Most of the climate simulations are available only beyond 2050

-> Large uncertainty in ensemble climate simulations

Hydrological impact assessment

-> WP1 Partners agreed upon a set of gauging stations for the CC assessment
-> WP1 Partners agreed upon common HIV suitable for the other Amice actions (e.g. 6, 23, 24)

Outcomes from Step 2 + Step 3

(May to Sept. 2009)

Literature review on climate and hydrological scenarios for the Meuse river basin

-> **Gaps of knowledge** between published applicable information and quantifiable statements and Amice project requirements

Conclusion 1 : **A new modelling experiment** is required for producing hydrological scenarios for Amice

Conclusion 2 : **Synthetic nationally-based** climate scenarios should be defined

Conclusion 3 : **A transnational climate scenario** should be infered from national scenarios

Step 4 Methodology for producing future climate scenarios

Definition of a common background with WP1 partners (Sept. 2009)

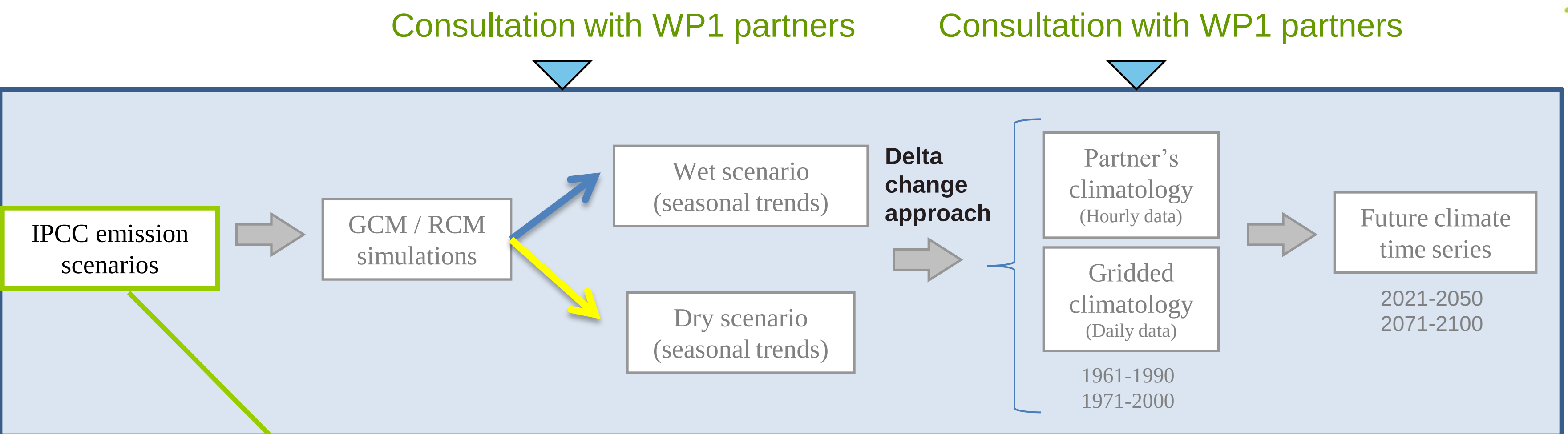
2 future time spans: 2021-2050 & 2071-2100

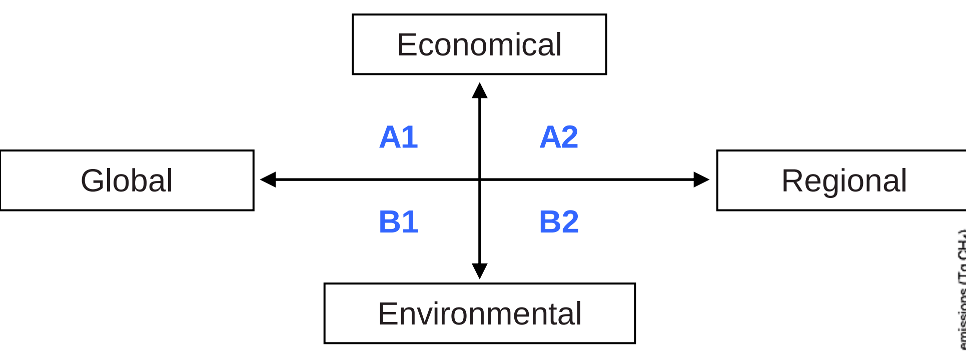
Control periods : 1961-1990 or 1971-2000

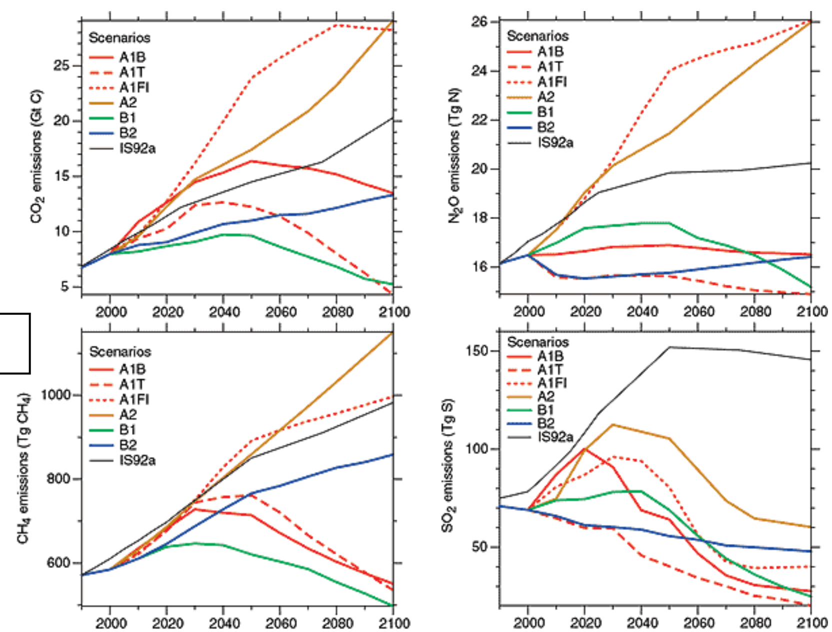
2 synthetic climate scenarios: **Wet** & **Dry**

Drainage basins for CC assessment: 11 gauging stations

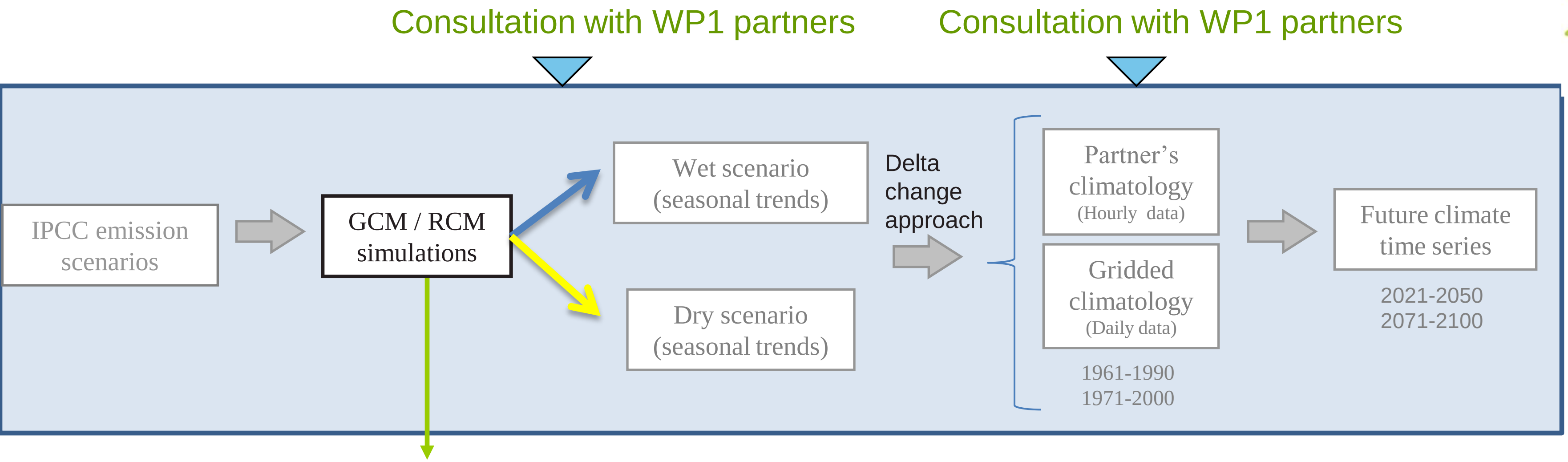
Step 4 Methodology for producing future climate scenarios







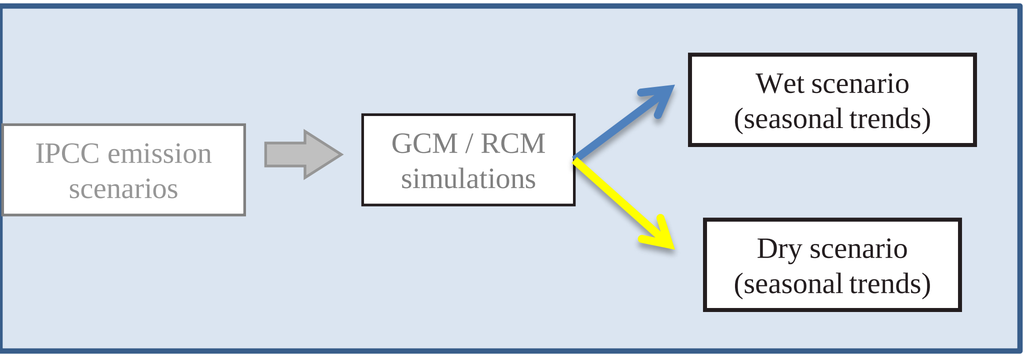
Step 4 Methodology for producing future climate scenarios



The nationally-defined wet and dry climate scenarios

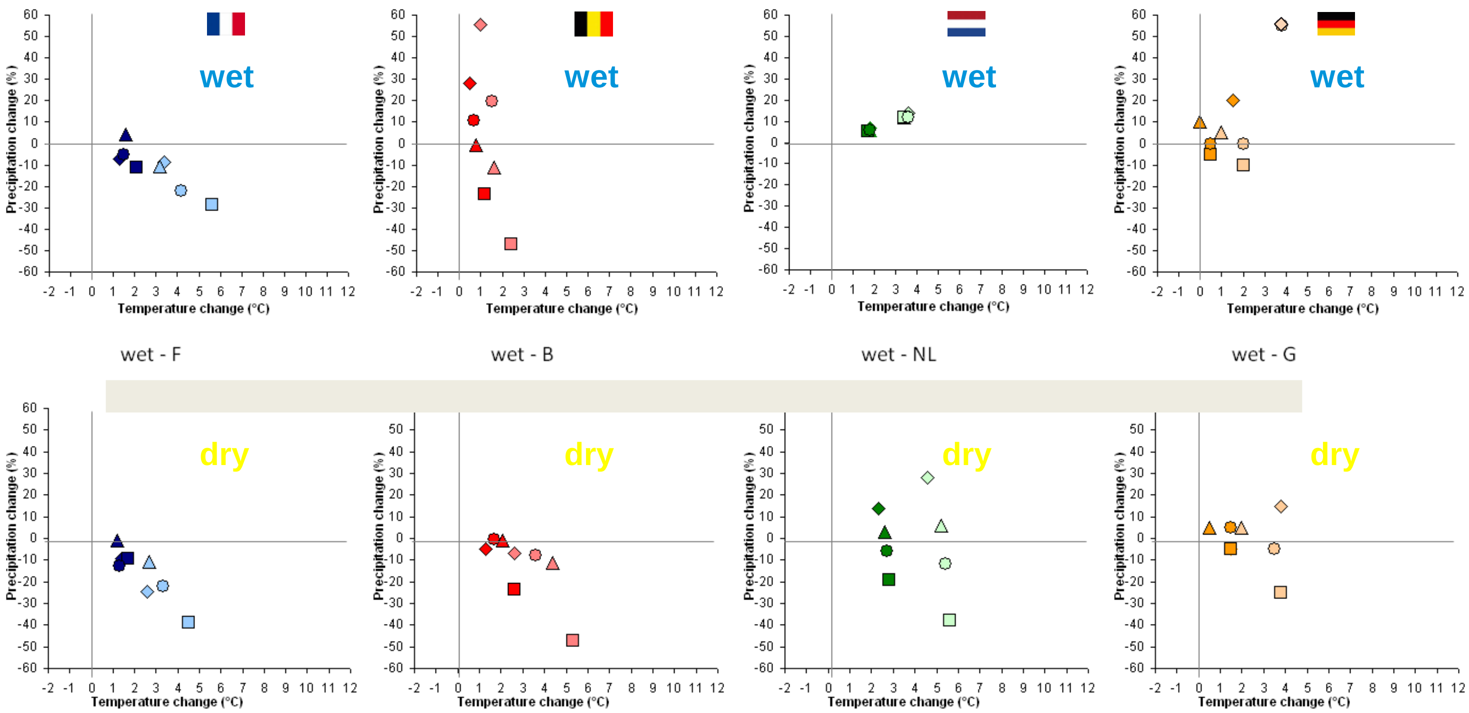
	SRES scenarios	Climate experiment or model	Data provider and contact person	Downscaling method	Source of data	Type of simulation	Time period for the control run
French part of the basin **EPAMA, Univ Metz**	A1B/A2	ARPEGE-climat v4.6	Météo-France (L. Labbé)	Bias correction (Q-Q plot)	Météo France	Transient simulation	1961-1990
Belgium part of the basin **Gx-ABT, Ulg, RW-GTI**	A1B/A2/B1/B2	CCI-HYDR Perturbation Tool	KU Leuven (P. Willems)	Perturbation approach	Sethy		1961-1990
German part of the basin **RWTH-LFI**	A1B	WETTREG (wet scenario) CLM (dry scenario)	DWD (T. Deutschländer)		WETTREG: Meteo Research pp Umweltbundesamt CLM: MPI-M-M/MaD pp BMBF	Transient simulation	1971-2000
Dutch part of the basin **RWS**	A1B/A2/B1/B2		KNMI		KNMI Scientific Report WR 2006-01 (Van den Hurk et al.)	Transient simulation	1961-1990

Step 4 Methodology for producing future climate scenarios



Dark color: 2021-2050
Light color: 2071-2100

- ◇ Winter
- △ Spring
- □ Summer
- ○ Autumn



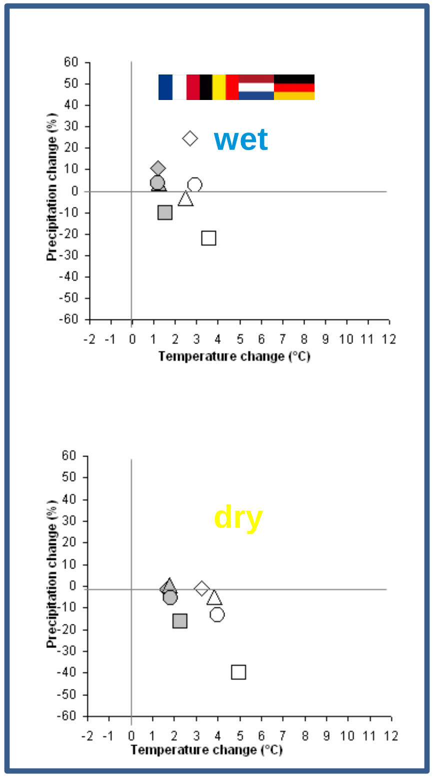
Step 4 Methodology for producing future climate scenarios

Nationally-defined climate scenarios

x

	Drainage area (km²)	Weights
France	10 120	0,31
Belgium	10 880	0,33
The Netherlands	8 662	0,26
Germany	3 338	0,10
Transnational	**33 000**	**1,00**

Transnational climate scenarios



Dark color: 2021-2050
Light color: 2071-2100

- Winter
- Spring
- Summer
- Autumn

Step 4 Methodology for producing future climate scenarios

AMICE transnational **wet** and dry scenarios vs PRUDENCE RCM simulations (2071-2100)

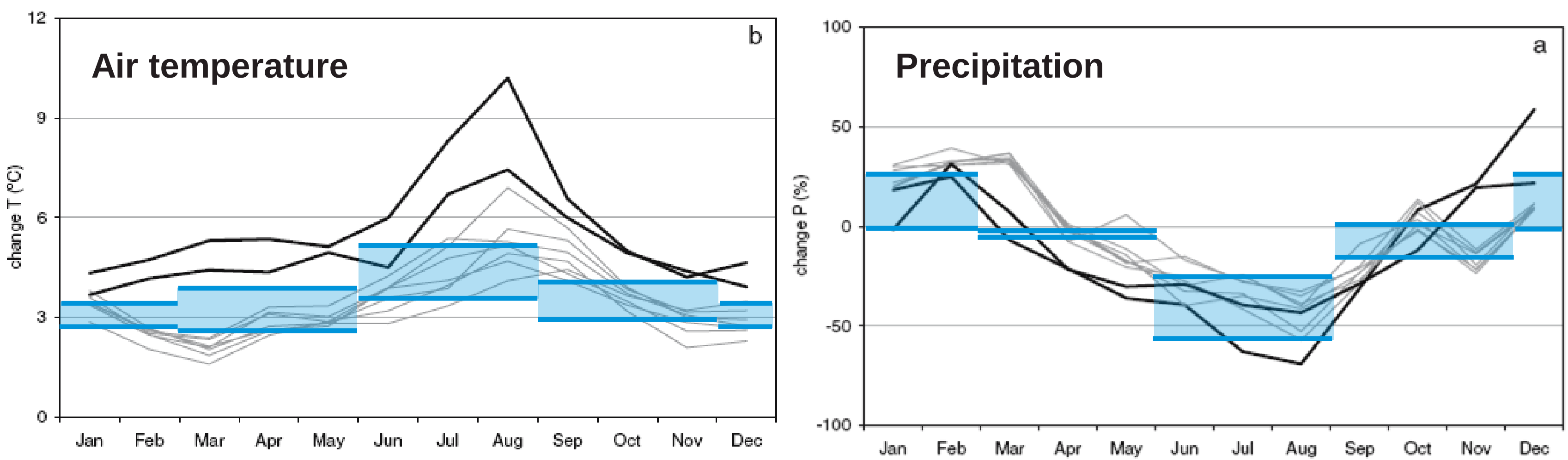
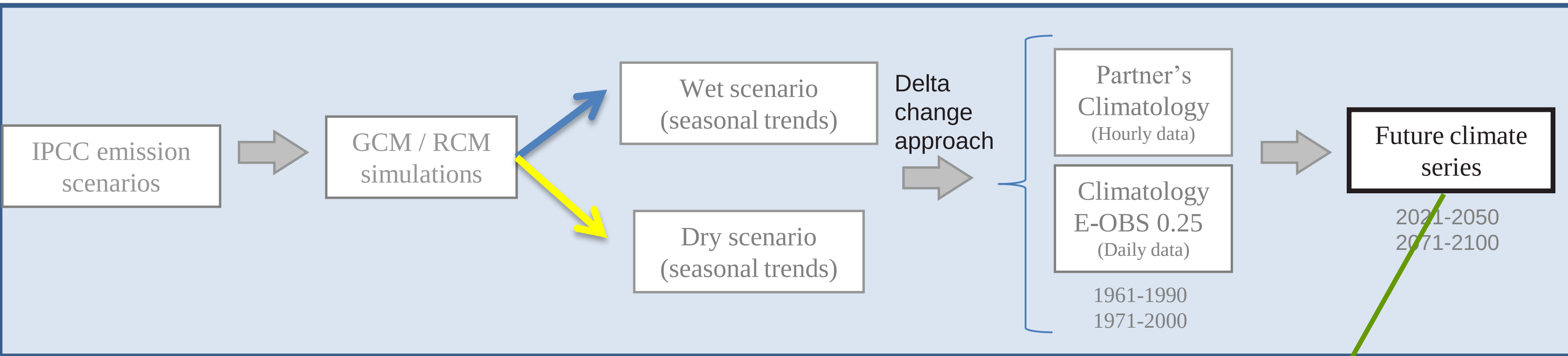


Fig. 4 Change in monthly precipitation (a) and temperature (b) in the Meuse basin derived from nine RCM simulations. *Bold lines* are RCMs driven by ECHAM4/OPYC, *thin lines* are RCMs driven by HadAM3H

In De Wit & al. (2007), *Climatic Change*

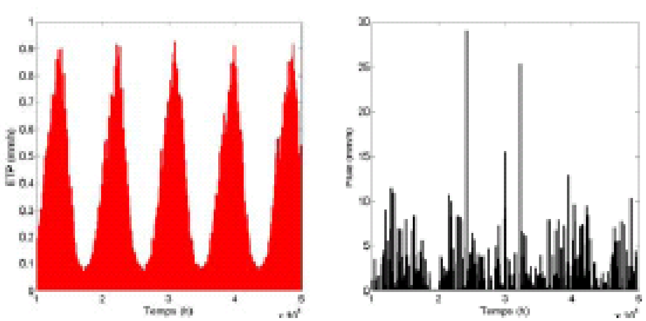
Seasonal bandwidths of the Amice transnational climate scenarios (wet and dry) are indicated in blue on the above figures

Step 4 Methodology for producing future climate scenarios



Present climate series

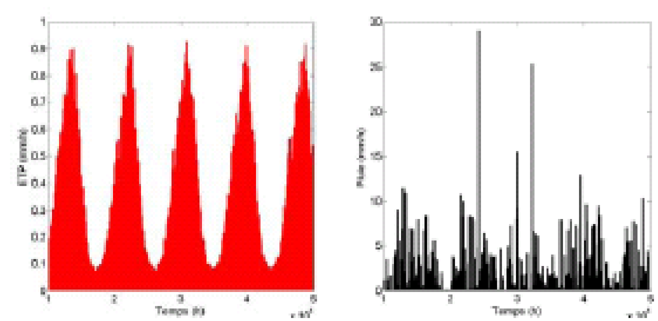
PET | precipitation



1 hourly time series per parameter
1 daily time series per parameter

Future perturbated* climate series

PET* | Precipitation*

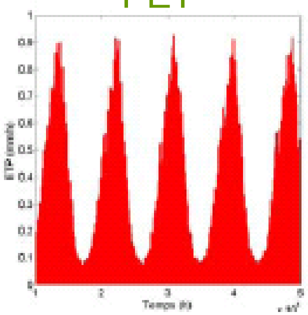


2 hourly time series per parameter and per time slice
2 daily time series per parameter and per time slice

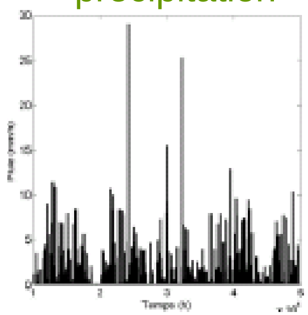
Step 5 Methodology for producing future hydrological scenarios

Present climate series

PET



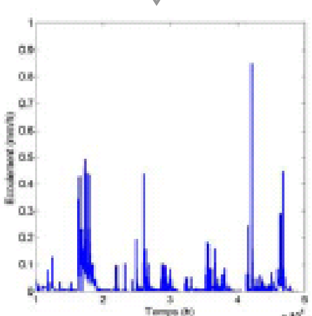
precipitation



1 hourly time series per parameter
1 daily time series per parameter

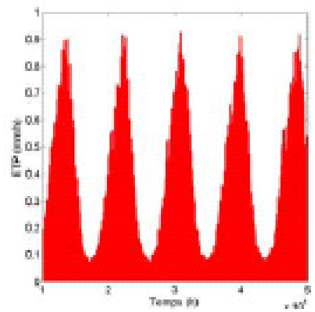
Calibrated R-R models (AGYR, HBV, etc.)

Simulated hydrographs

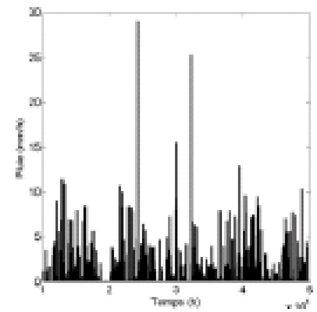


Future perturbated* climate series

PET*

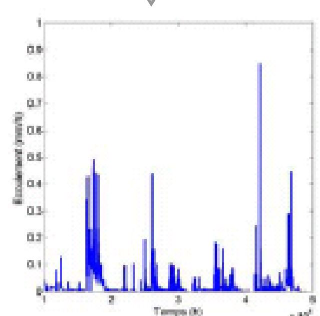


Precipitation*



2 hourly time series per parameter and per time slice
2 daily time series per parameter and per time slice

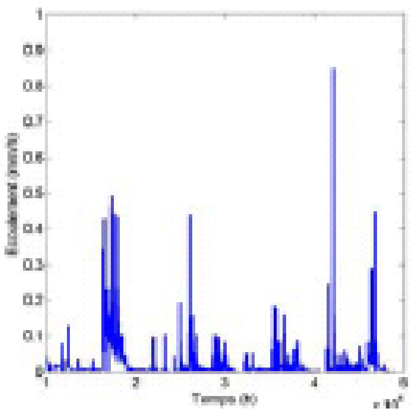
Calibrated R-R models (AGYR, HBV, etc.)



Simulated hydrographs

Instead of PET, a temperature dependent equation is used for HBV

Step 5 Methodology for producing future hydrological scenarios



Simulated hydrographs
(control period + 2021-2050 + 2071-2100)

Extraction of the hydrological impact variables

High flows

Qdx100 (annual daily maximum discharge)
Qhx100 (annual hourly maximum discharge)

Low flows

MAM7 (mean annual 7-day minimum flow)

Return periods

High flows

T[y] = 2 - 5 - 10 - 25 - 50 - 100 - 250 - 1250

Low flows

T[y] = 2 - 5 - 10 - 25 - 50

Step 6 Results of the hydrological simulations

High flows – Transnational scenario

Climate change factors* derived from winter maximum hourly discharge series (wet scenario and dry scenario /2021-2050)

T[y]	Meuse St-Mihiel	Meuse Stenay	Meuse Montcy	Meuse Chooz	Meuse Sint Pieter	Lesse Gendron	Vesdre Chaudfontaine
2	1.12 0.96	1.12 0.96	1.12 0.96	1.12 0.96	1.12 0.92	1.16 0.97	1.02 0.86
5	1.12 0.96	1.12 0.96	1.12 0.96	1.12 0.96	1.15 0.91	1.17 0.98	1.05 0.88
10	1.12 0.93	1.12 0.93	1.12 0.93	1.12 0.93	1.16 0.93	1.18 0.98	1.06 0.89
25	1.12 0.93	1.12 0.93	1.12 0.93	1.12 0.93	1.13 0.95	1.18 0.98	1.07 0.89
50	1.12 0.96	1.12 0.96	1.12 0.96	1.12 0.96	1.14 0.95	1.19 0.98	0.08 0.90
100	1.12 0.96	1.12 0.96	1.12 0.96	1.12 0.96	1.14 0.95	1.19 0.98	1.08 0.90

Climate change factors* derived from winter maximum hourly discharge series (wet scenario and dry scenario /2071-2100)

T[y]	Meuse St-Mihiel	Meuse Stenay	Meuse Montcy	Meuse Chooz	Meuse Sint Pieter	Lesse Gendron	Vesdre Chaudfontaine
2	1.27 0.89	1.27 0.89	1.27 0.89	1.27 0.89	1.21 0.79	1.32 0.84	1.11 0.74
5	1.27 0.89	1.27 0.89	1.27 0.89	1.27 0.89	1.30 0.88	1.40 0.86	1.18 0.77
10	1.29 0.81	1.29 0.81	1.29 0.81	1.29 0.81	1.33 0.92	1.45 0.87	1.21 0.78
25	1.29 0.81	1.29 0.81	1.29 0.81	1.29 0.81	1.31 0.90	1.49 0.88	1.23 0.79
50	1.27 0.89	1.27 0.89	1.27 0.89	1.27 0.89	1.32 0.91	1.52 0.89	1.25 0.80
100	1.27 0.89	1.27 0.89	1.27 0.89	1.27 0.89	1.33 0.91	1.55 0.90	1.27 0.81

*Qscenario/Qcontrol

Step 6 Results of the hydrological simulations

High flows - National scenarios

Climate change factors* derived from winter maximum hourly discharge series
(wet scenario and dry scenario /2021-2050)

T[y]	Meuse St-Mihiel	Meuse Stenay	Meuse Montcy	Meuse Chooz	Lesse Gendron	Vesdre Chaudfontaine	Rur Stah	Niers Goch
2	0.89 0.86	0.89 0.86	0.89 0.86	0.89 0.86	1,48 0,86	1,42 0,85	1.14 0.90	1.21 0.93
5	0.89 0.86	0.89 0.86	0.89 0.86	0.89 0.86	1,52 0,82	1,49 0,87	1.15 0.92	1.23 0.93
10	0.89 0.82	0.89 0.82	0.89 0.82	0.89 0.82	1,56 0,80	1,53 0,88	1.15 0.93	1.24 0.93
25	0.89 0.82	0.89 0.82	0.89 0.82	0.89 0.82	1,58 0,79	1,55 0,88	1.16 0.94	1.24 0.93
50	0.90 0.86	0.90 0.86	0.90 0.86	0.90 0.86	1,59 0,78	1,57 0,88	1.16 0.94	1.25 0.93
100	0.90 0.86	0.90 0.86	0.90 0.86	0.90 0.86	1,60 0,77	1,59 0,89	1.16 0.95	1.25 0.93

Climate change factors* derived from winter maximum hourly discharge series
(wet scenario and dry scenario /2071-2100)

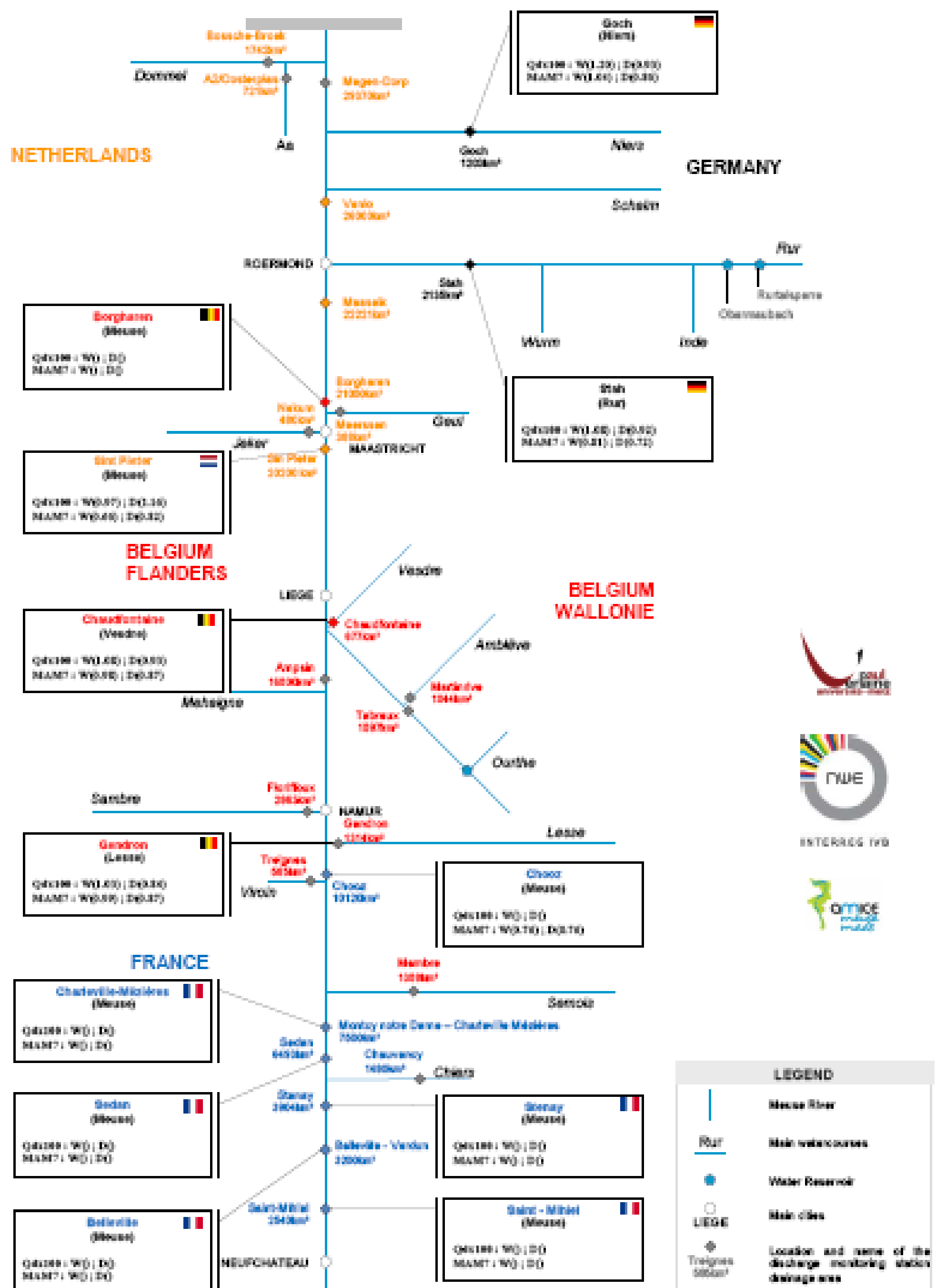
T[y]	Meuse St-Mihiel	Meuse Stenay	Meuse Montcy	Meuse Chooz	Lesse Gendron	Vesdre Chaudfontaine	Rur Stah	Niers Goch
2	0.84 0.64	0.84 0.64	0.84 0.64	0.84 0.64	1,79 0,79	1,66 0,81	1.46 0.92	1.62 1.00
5	0.84 0.64	0.84 0.64	0.84 0.64	0.84 0.64	1,81 0,75	1,76 0,81	1.48 0.96	1.70 1.02
10	0.74 0.56	0.74 0.56	0.74 0.56	0.74 0.56	1,82 0,74	1,81 0,81	1.48 0.97	1.73 1.03
25	0.74 0.56	0.74 0.56	0.74 0.56	0.74 0.56	1,83 0,72	1,84 0,80	1.49 0.99	1.75 1.04
50	0.83 0.63	0.83 0.63	0.83 0.63	0.83 0.63	1,83 0,72	1,87 0,80	1.50 1.00	1.77 1.04
100	0.83 0.63	0.83 0.63	0.83 0.63	0.83 0.63	1,84 0,71	1,89 0,80	1.50 1.01	1.78 1.05

*Qscenario/Qcontrol

Step 6 Results of the hydrological simulations

Climate change factors*
for the daily hydrological
impact variables
MAM7 & Qdx100
2021-2050

CLIMATE CHANGE FACTORS FOR THE DAILY HYDROLOGICAL IMPACT VARIABLES (2021-2050)
W = WET SCENARIO; D = DRY SCENARIO



*Qscenario/Qcontrol

Step 7 Selection of hydrological scenarios

Climate change factors derived from the transnational climate scenarios will be used to pertubate the discharges used for hydraulic simulations on the Meuse itself and its tributaries…

Thank you for your attention

And now…: let's move to Action 6 !

3rd INTERNATIONAL SCIENTIFIC MEUSE SYMPOSIUM

THE MEUSE DISTRICT : CHALLENGES FOR TOMORROW

LIEGE, April 22 – 23, 2010

AMICE – WP1 (Action 6)

Hydraulic simulation of the Meuse

S.DETREMBLEUR[1], B.J.DEWALS[1,2], M. PIROTTON[1].

[1]University of Liège, Belgium

[2] Fund for Scientific Research(F.R.S.-FNRS)

Transnational hydraulic modeling

Inundation modeling from spring to mouth for Q_{100} accounting for climate change and consistently with outcomes of AC3

Flood propagation between Ampsin and Maaseik

Collaboration between 4 countries and 8 partners

First step :
Questionnaire

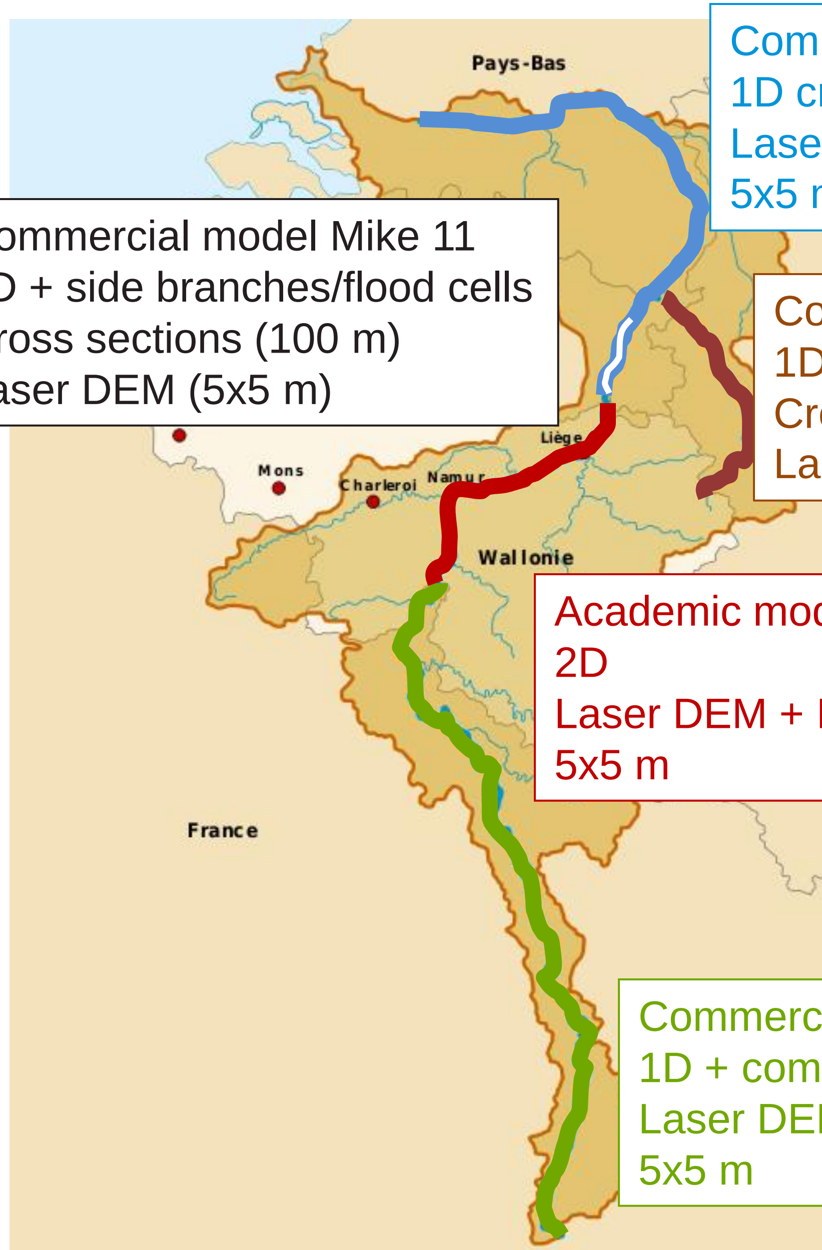
Second step :
Meeting in Metz for synthesis

Existing models cover the entire Meuse

Commercial model Sobek
1D cross sections for floodplains
Laser DEM
5x5 m ➔ 50x50 m

Commercial model Mike 11
1D + side branches/flood cells
Cross sections (100 m)
Laser DEM (5x5 m)

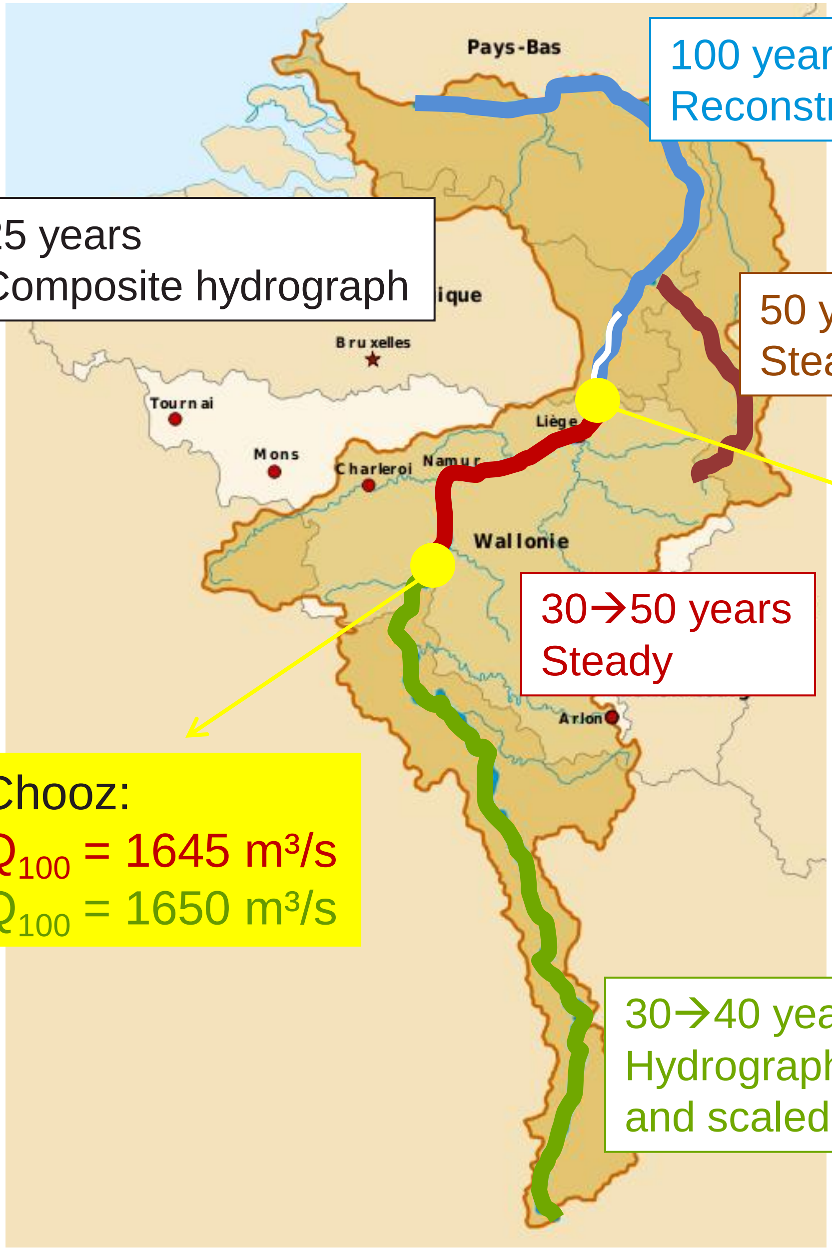
Commercial model Sobek
1D coupled with 2D for floodplains
Cross sections (100 m)
Laser DEM (10x10 m) → 2x2 m



Academic model Wolf2D
2D
Laser DEM + Bathymetry
5x5 m

Commercial model Stream
1D + compartments
Laser DEM + Bathymetry
5x5 m

Hydrological inputs



100 years at Borgharen
Reconstructed hydrograph

25 years
Composite hydrograph

50 years
Steady

Borgharen:
Q_{100} = 3109 m³/s
Q_{100} = 3184 m³/s

30→50 years
Steady

Chooz:
Q_{100} = 1645 m³/s
Q_{100} = 1650 m³/s

30→40 years
Hydrograph based on 1995 flood shape and scaled on statistical floods

Transnational hydraulic modeling

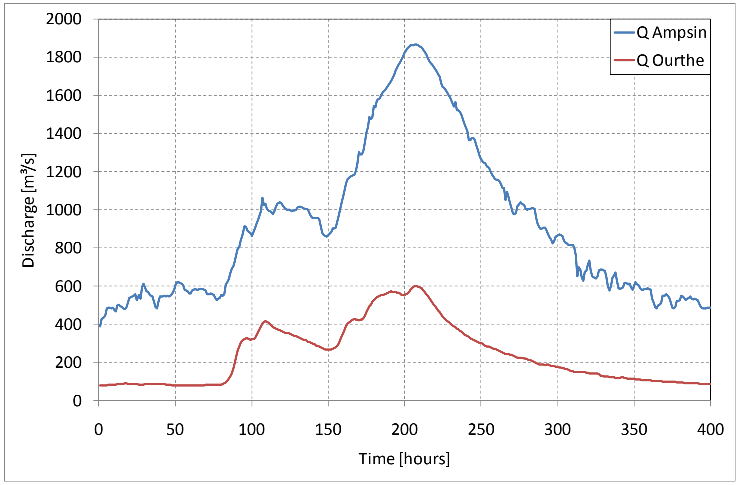
Inundation modeling from spring to mouth for Q_{100} accounting for climate change and consistently with outcomes of AC3

- Methodology
- Simulations
- Consistency check after parallel runs
- Re-runs if needed

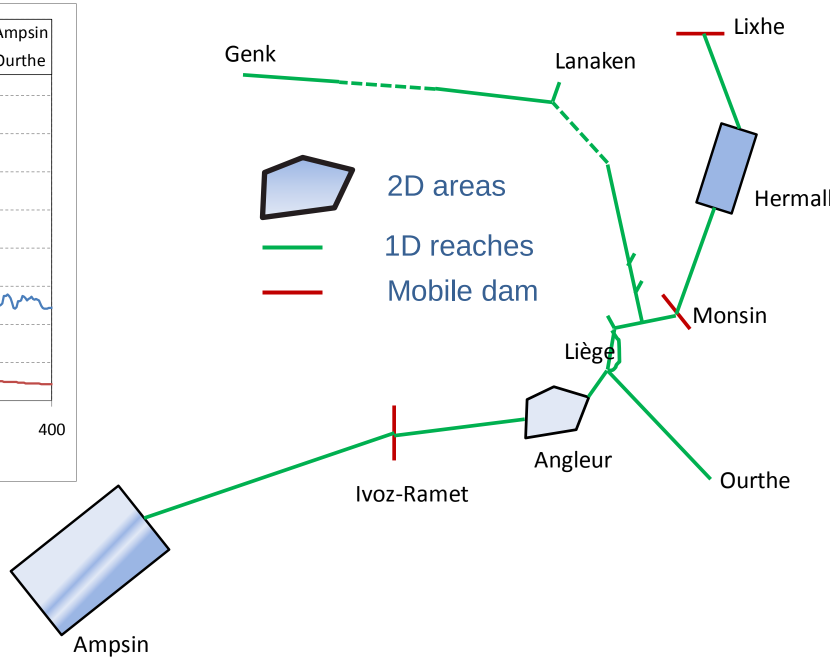
Flood propagation between Ampsin and Maaseik

- Past events
- Scenarios

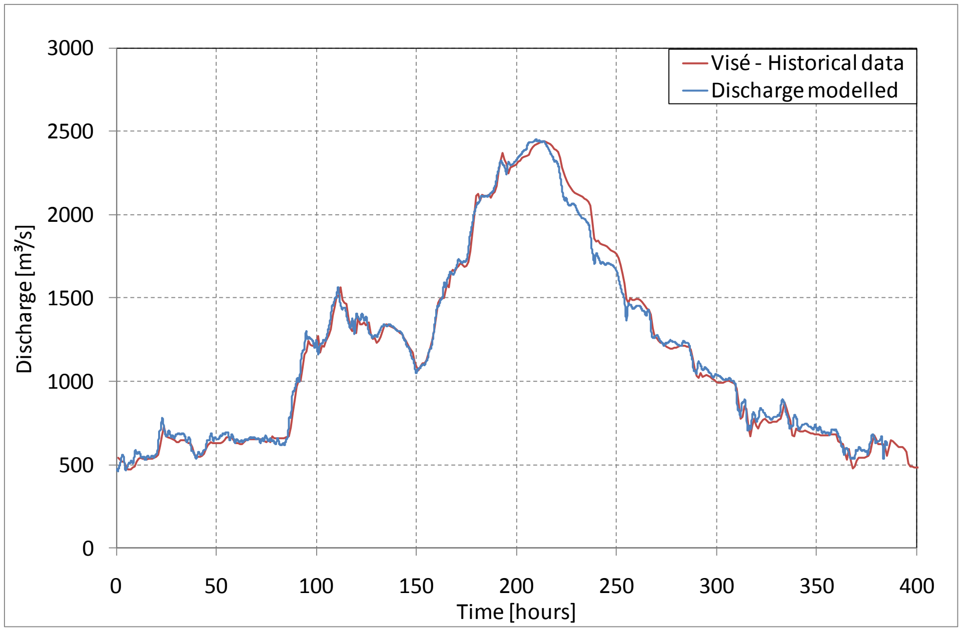
Ampsin-Maaseik modeling (B)



Discharge input for the flood of January 2003



Validation events :
01/2002→03/2002
11/2002
01/2003



Discharge measured and modeled in Lixhe

Thank you for your attention