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**
Sub-basins for CC assessment:	11 gauging stations selected

Step 4 Methodology for producing future climate scenarios

Consultation with WP1 partners

Consultation with WP1 partners

IPCC emission scenarios

GCM / RCM simulations

Wet scenario (seasonal trends)

Dry scenario (seasonal trends)

Delta change approach

Partner's climatology (Hourly data)

Gridded climatology (Daily data)

1961-1990
1971-2000

Future climate time series

2021-2050
2071-2100

Economical

Global

Regional

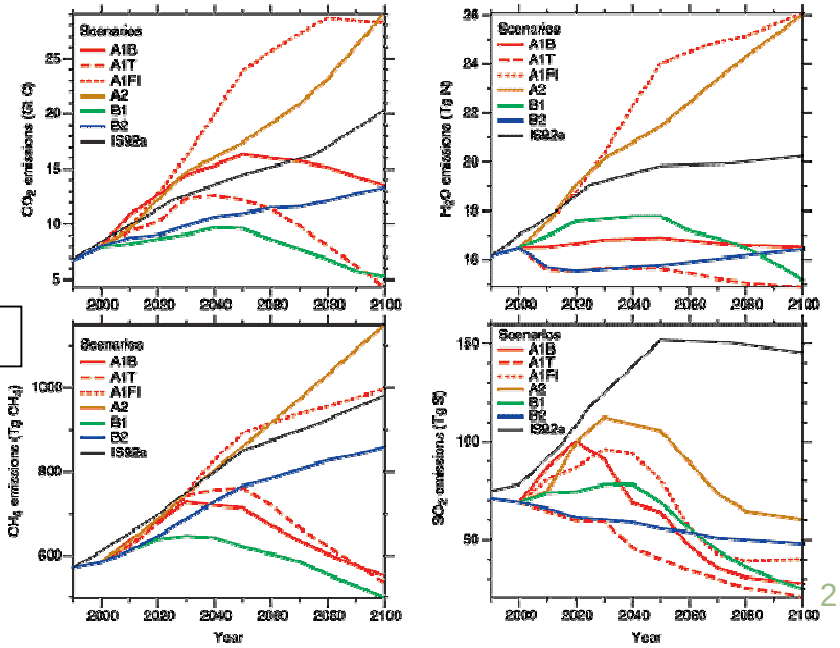
Environmental

A1

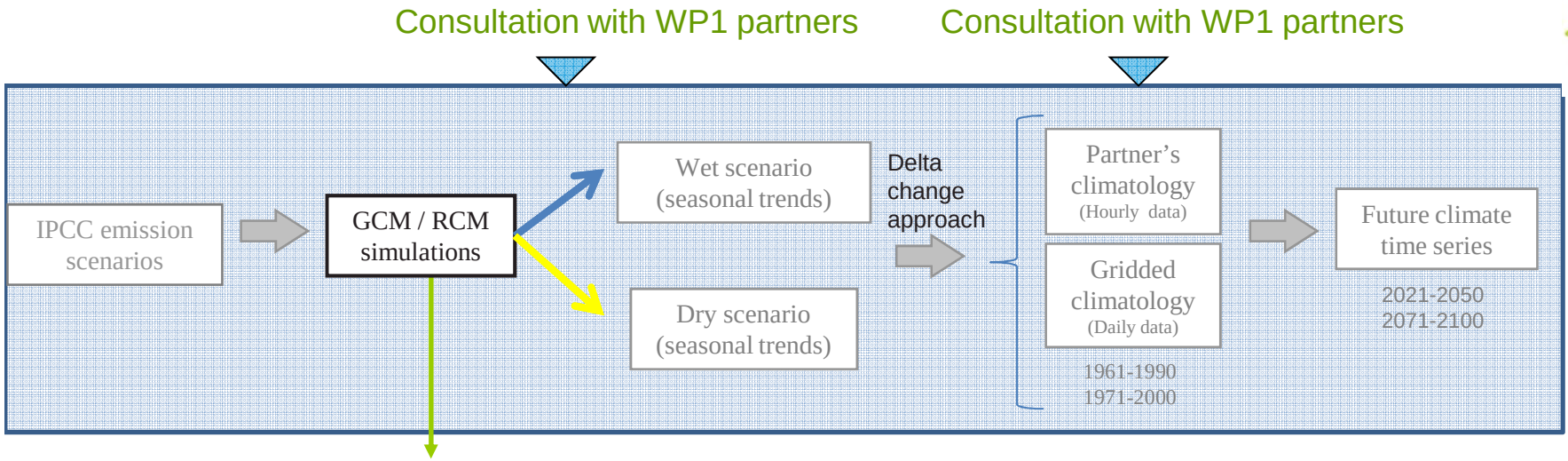
A2

B1

B2



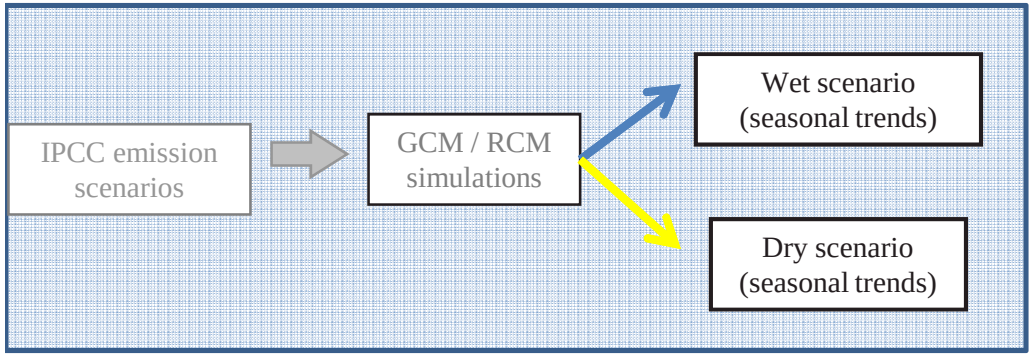
Step 4 Methodology for producing future climate scenarios



The nationally-defined **wet** and **dry** climate scenarios

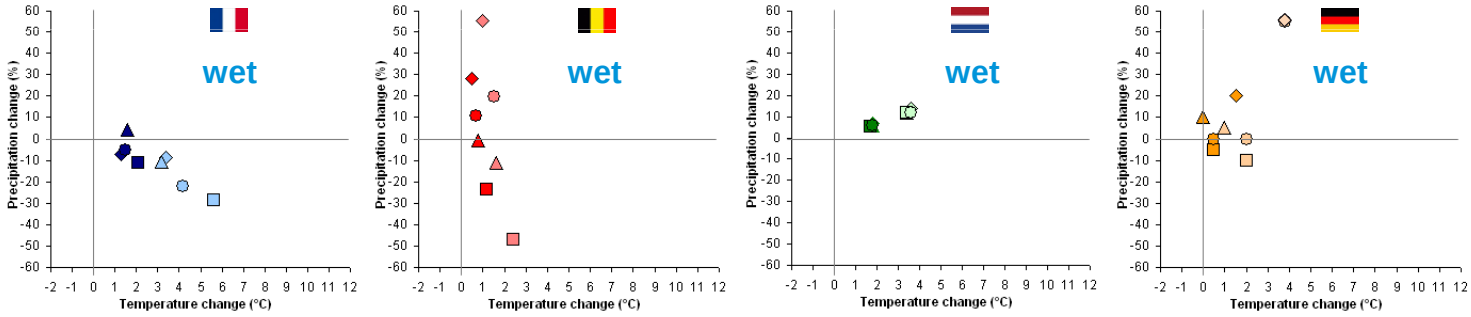
	SRES scenarios	Climate experiment or model	Data provider and contact person	Downscaling method	Source of data	Type of simulation	Time period for the control run
French part of the basin **EPAMA, Univ Metz**	A1B/A2	ARPEGE-climat v4.6	Météo-France (L. Labbé)	Bias correction (Q-Q plot)	Météo France	Transient 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

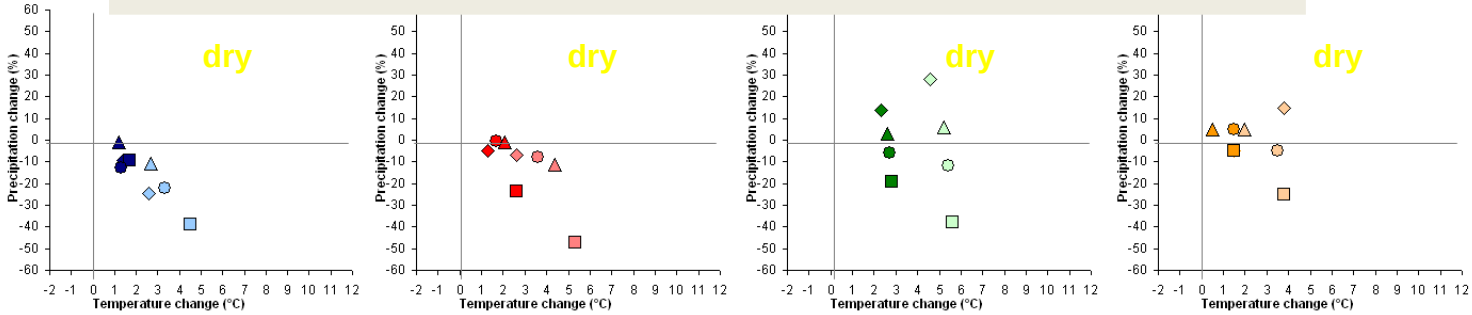


Dark color: 2021-2050
Light color: 2071-2100

- Winter
- Spring
- Summer
- Autumn



wet - F | wet - B | wet - NL | wet - G

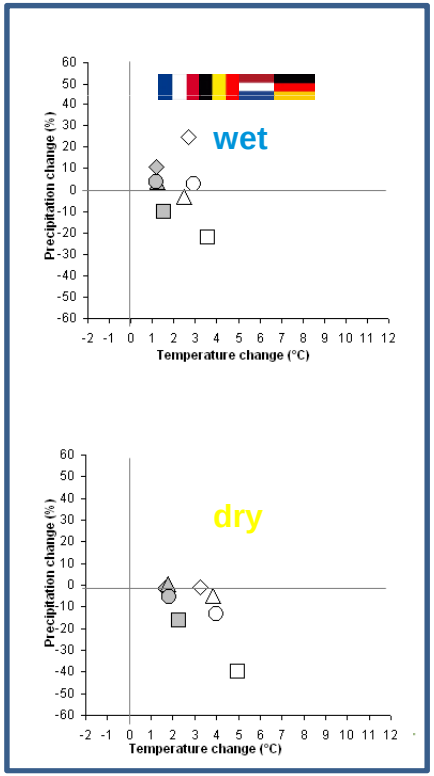


Step 4 Methodology for producing future climate scenarios

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**



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

- Winter
- Spring
- Summer
- Autumn

Transnational climate scenarios

Step 4 Methodology for performing future climate scenarios

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

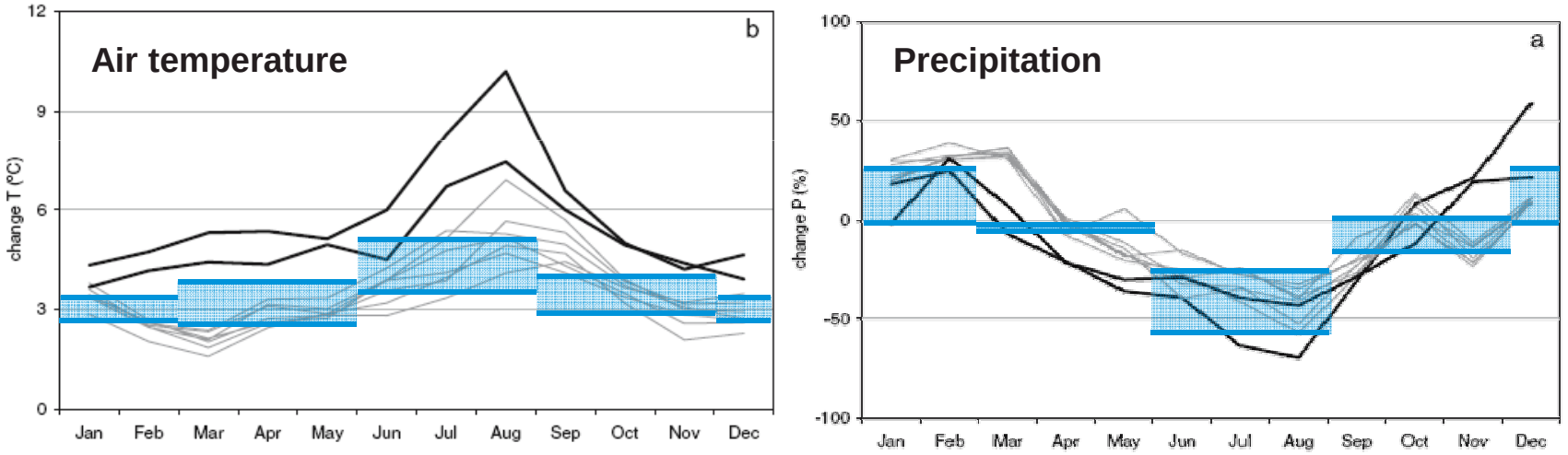
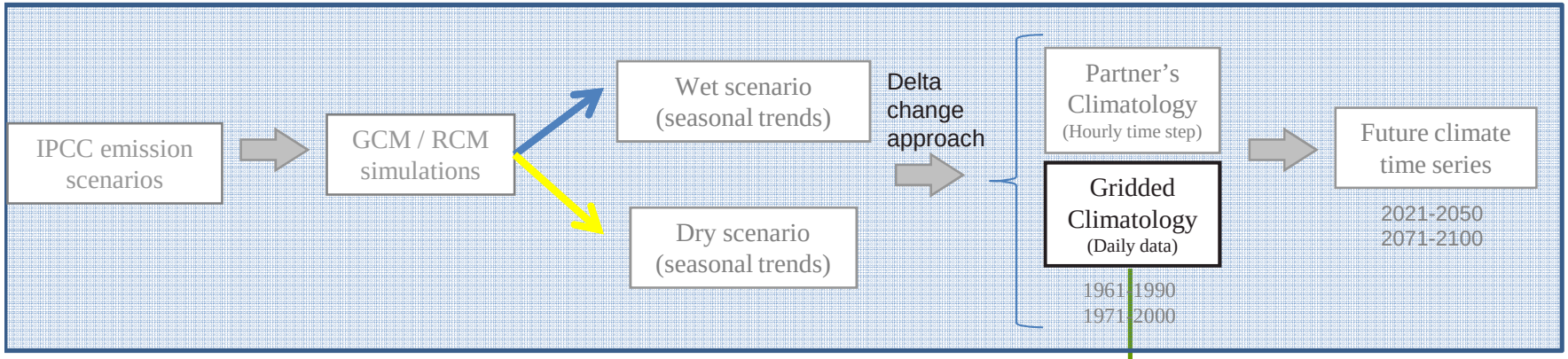


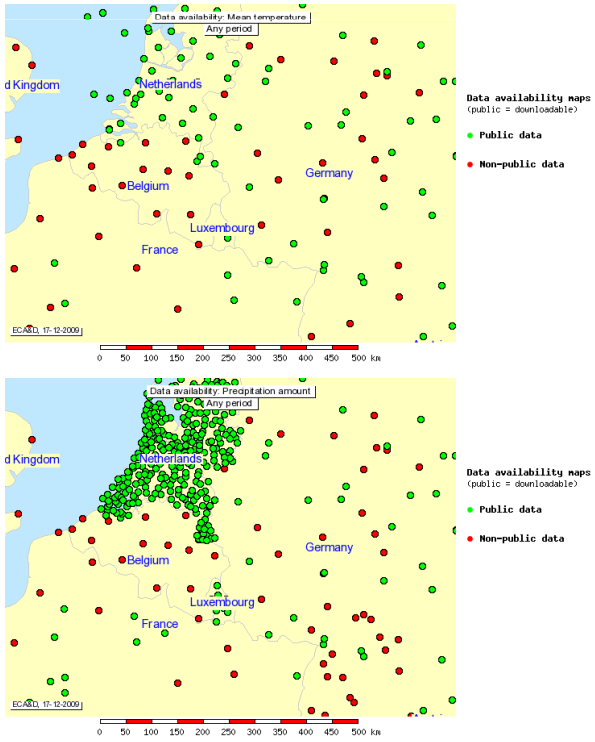
Fig. 4 Change in monthly precipitation (a) and temperature (b) in the Meuse basin derived from nine RCM simulations. *Bold lines* are RCMs driven by ECHAM4/OPYC, *thin lines* are RCMs driven by HadAM3H

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

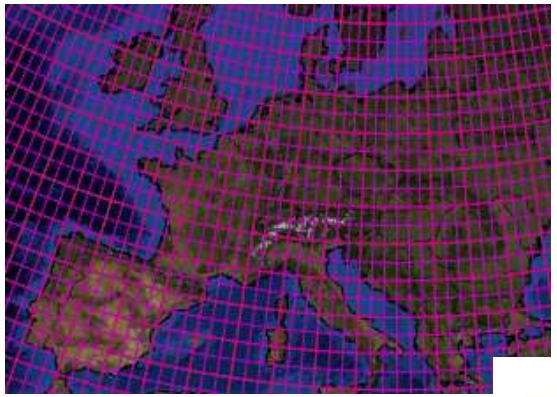
Seasonal bandwidths of the Amice transnational climate scenarios (wet and dry) are indicated in blue on the above figures

Step 4 Methodology for performing future climate scenarios

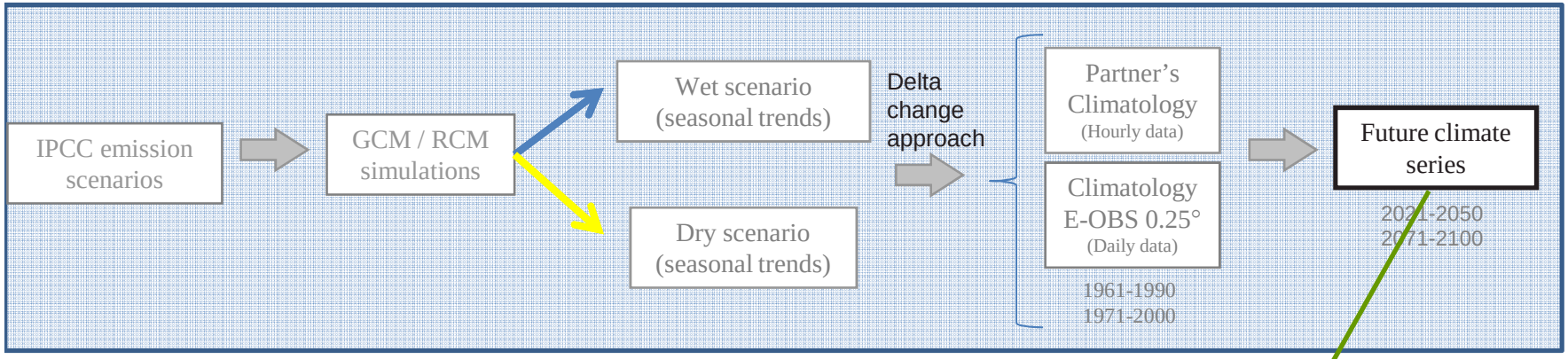




e.g. E-OBS from Haylock et al. (2008), JGR

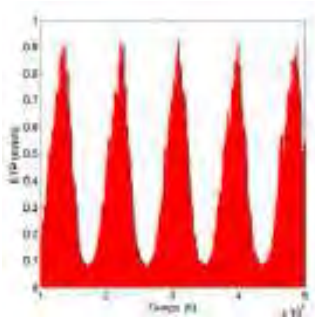


Step 4 Methodology for performing future climate scenarios

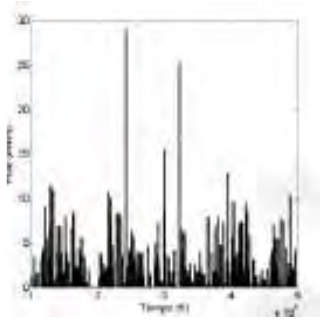


Present climate series

PET



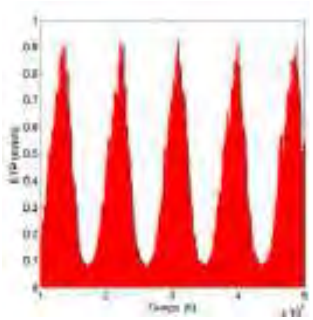
precipitation



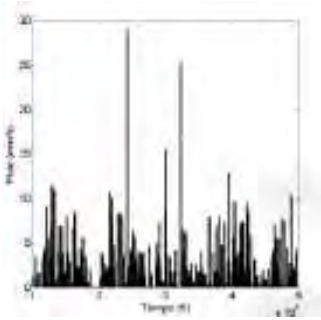
1 hourly time series per parameter
1 daily time series per parameter

Future perturbated climate series

PET



precipitation

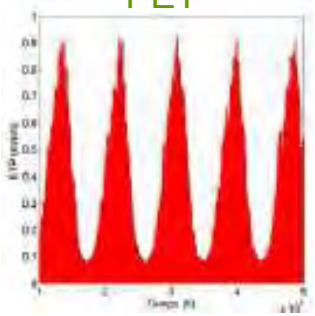


2 hourly time series per parameter and per time slice
2 daily time series per parameter and per time slice

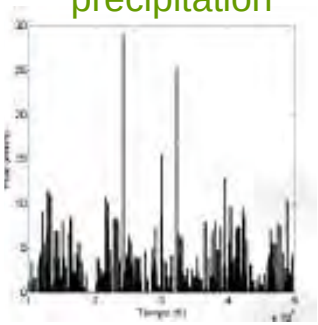
Step 5 Methodology for performing future hydrological scenarios

Present climate series

PET*



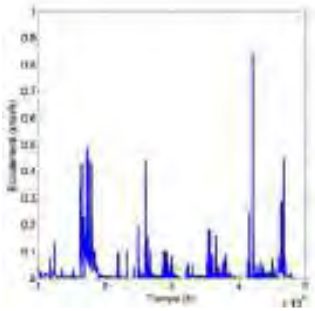
precipitation



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

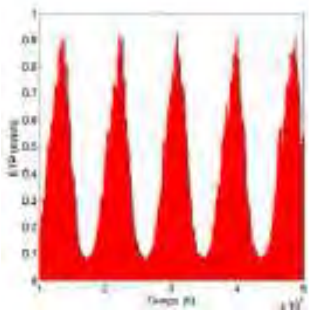
Calibrated R-R models
(AGYR, HBV, etc.)

Simulated hydrographs

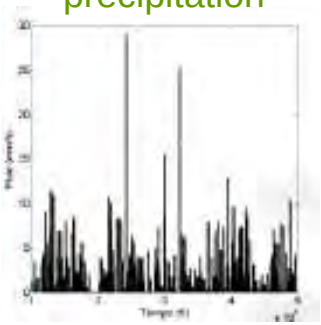


Future perturbated climate series

PET*



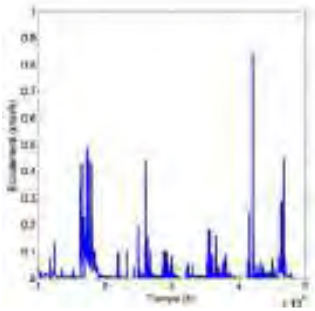
precipitation



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

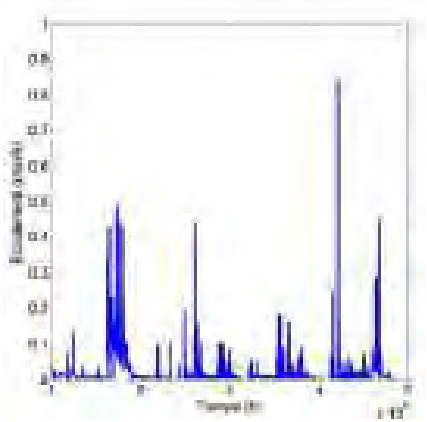
Calibrated R-R models
(AGYR, HBV, etc.)

Simulated hydrographs



*instead of PET, a temperature dependent equation is used for HBV

Step 5 Methodology for performing future hydrological scenarios



Simulated hydrographs

→ 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

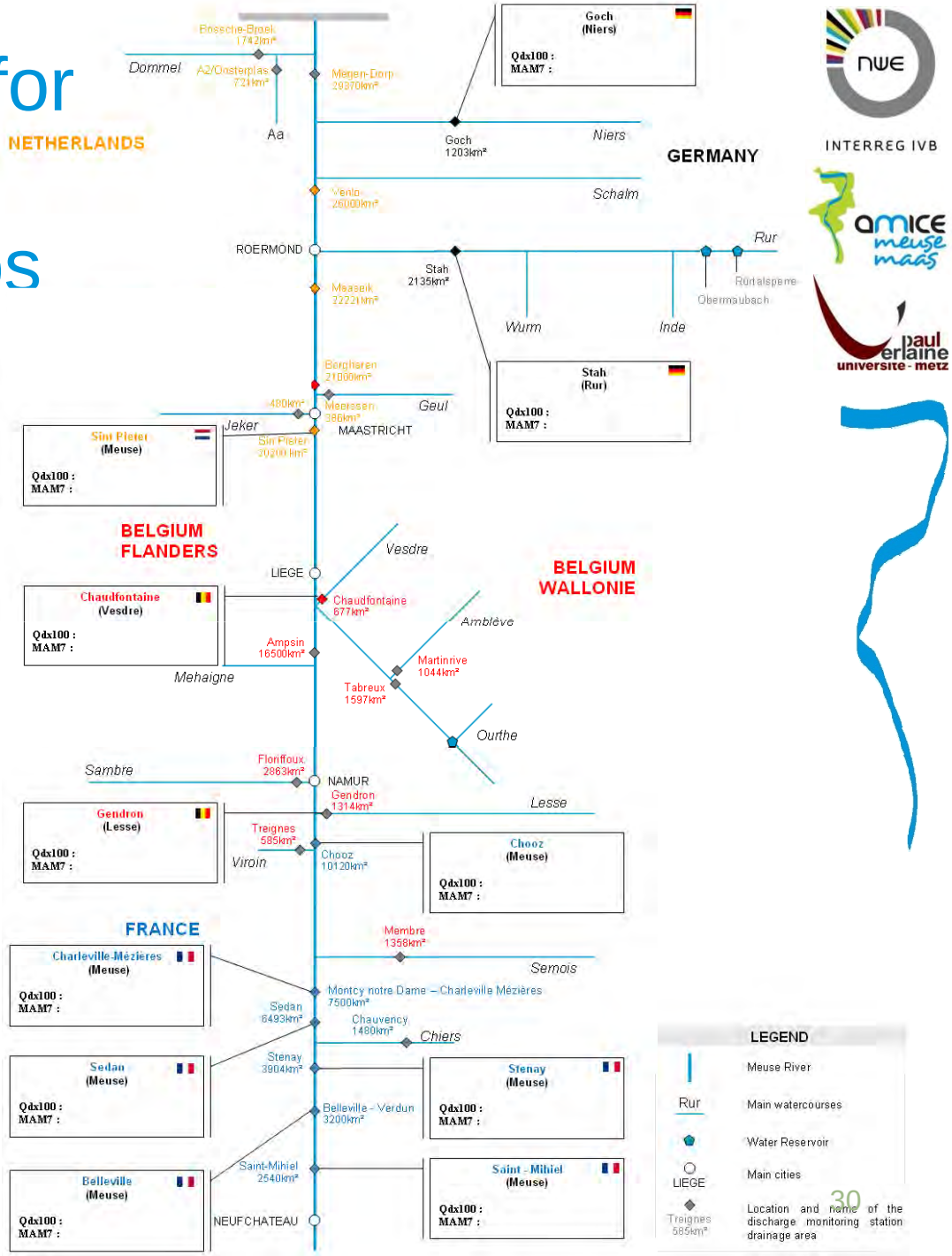
T[y] = 2 - 5 - 10 - 25 - 50 - 100 - 250 - 1250

Low flows

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

Step 5 Methodology for performing future hydrological scenarios

Spatial distribution of the 11 gauging stations on the Meuse river and its tributaries



Step 6 Results of the hydrological simulations

High flows – Transnational scenario

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

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

Climate change factors derived from winter maximum hourly discharge series: 2071-2100 - wet scenario and dry scenario

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

*Qscenario/Qcontrol

Step 6 Results of the hydrological simulations

High flows – Transnational scenario

Simulated winter maximum hourly discharges (in m^3/s)
2021-2050 - wet scenario and dry scenario

T[y]	Meuse St-Mihiel	Meuse Stenay	Meuse Montcy	Meuse Chooz	Lesse Gendron	Vesdre Chaudfontaine	Meuse Sint Pieter
2	335 286	320 273	542 463	743 634	95.1 79.3	75.2 63.3	1876 1545
5	455 388	428 365	736 628	1041 889	169 141	105 87.7	2193 1728
10	515 427	500 414	861 714	1263 1047	229 190	121 101	2494 2004
25	573 475	584 484	1011 838	1572 1303	316 261	138 115	2885 2417
50	622 534	656 564	1140 979	1833 1575	389 321	149 124	3157 2644
100	659 566	722 620	1259 1081	2107 1810	469 387	159 132	3430 2872
250							3791 3173
1250							4374 3659

Simulated winter maximum hourly discharges (in m^3/s)
2071-2100 - wet scenario and dry scenario

T[y]	Meuse St-Mihiel	Meuse Stenay	Meuse Montcy	Meuse Chooz	Lesse Gendron	Vesdre Chaudfontaine	Meuse Sint Pieter
2	379 266	361 254	613 430	839 589	108 68	81.6 54.5	2028 1314
5	513 361	483 339	831 584	1176 826	202 124	118 77.0	2475 1680
10	591 374	573 363	987 625	1448 917	281 169	138 89.3	2863 1979
25	656 416	669 424	1158 734	1802 1141	398 236	159 102	3339 2286
50	707 490	746 517	1296 898	2084 1444	499 293	173 111	3675 2516
100	749 519	821 569	1431 991	2395 1659	611 356	186 119	4013 2747
250							4459 3051
1250							5177 3543

Step 6 Results of the hydrological simulations

High flows – Transnational scenario

Simulated winter maximum daily discharge (in m^3/s) 2021-2050 - wet scenario and dry scenario

T[y]	Lesse at Gendron	Vesdre at Chaudfontaine
2	157 138	84.8 72.9
5	229 197	114 98.1
10	279 236	135 116
25	345 287	163 140
50	396 326	185 159
100	447 365	208 179
250		
1250		

Simulated winter maximum daily discharge (in m^3/s) 2071-2100 - wet scenario and dry scenario

T[y]	Lesse at Gendron	Vesdre at Chaudfontaine
2	173 115	86.2 60.1
5	249 164	117 78.5
10	301 197	139 89.4
25	369 241	169 102
50	420 274	193 111
100	473 307	217 119
250		
1250		

Step 6 Results of the hydrological simulations

High flows - National scenarios

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

T[y]	Meuse St-Mihiel	Meuse Stenay	Meuse Montcy	Meuse Chooz	Rur Stah	Niers Goch
2	0.89 0.86	0.89 0.86	0.89 0.86	0.89 0.86	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	1.15 0.92	1.23 0.93
10	0.89 0.82	0.89 0.82	0.89 0.82	0.89 0.82	1.15 0.93	1.24 0.93
25	0.89 0.82	0.89 0.82	0.89 0.82	0.89 0.82	1.16 0.94	1.24 0.93
50	0.90 0.86	0.90 0.86	0.90 0.86	0.90 0.86	1.16 0.94	1.25 0.93
100	0.90 0.86	0.90 0.86	0.90 0.86	0.90 0.86	1.16 0.95	1.25 0.93

Climate change factors derived from winter maximum hourly discharge series: 2071-2100 - wet scenario and dry scenario

T[y]	Meuse St-Mihiel	Meuse Stenay	Meuse Montcy	Meuse Chooz	Rur Stah	Niers Goch
2	0.84 0.64	0.84 0.64	0.84 0.64	0.84 0.64	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	1.48 0.96	1.70 1.02
10	0.74 0.56	0.74 0.56	0.74 0.56	0.74 0.56	1.48 0.97	1.73 1.03
25	0.74 0.56	0.74 0.56	0.74 0.56	0.74 0.56	1.49 0.99	1.75 1.04
50	0.83 0.63	0.83 0.63	0.83 0.63	0.83 0.63	1.50 1.00	1.77 1.04
100	0.83 0.63	0.83 0.63	0.83 0.63	0.83 0.63	1.50 1.01	1.78 1.05

*Qscenario/Qcontrol

Step 6 Results of the hydrological simulations

High flows - National scenarios

Simulated winter maximum hourly discharges (in m^3/s)
2021-2050 - wet scenario and dry scenario

T[y]	Meuse St-Mihiel	Meuse Stenay	Meuse Montcy	Meuse Chooz	Rur Stah	Niers Goch
2	264 256	252 244	428 415	585 568	90,45 71,64	22,49 17,32
5	358 347	337 327	580 562	820 796	123,67 99,33	32,60 24,73
10	409 375	396 364	683 627	1001 920	145,67 117,66	39,29 29,63
25	451 417	463 425	801 736	1246 1145	173,46 140,83	47,74 35,82
50	501 477	529 503	918 874	1477 1406	194,08 158,01	54,01 40,42
100	530 505	582 554	1014 966	1697 1616	214,54 175,07	60,23 44,98
250					241,49 197,53	68,43 50,99
1250					288,71 236,89	82,79 61,51

Simulated winter maximum hourly discharges (in m^3/s)
2071-2100 - wet scenario and dry scenario

T[y]	Meuse St-Mihiel	Meuse Stenay	Meuse Montcy	Meuse Chooz	Rur Stah	Niers Goch
2	250 191	239 182	405 308	554 422	115,82 73,04	30,16 18,53
5	339 259	319 243	549 419	777 592	159,03 103,23	45,02 27,07
10	340 257	329 249	568 430	833 630	187,64 123,22	54,86 32,72
25	377 286	385 291	666 504	1036 784	223,78 148,48	67,29 39,85
50	456 346	482 366	837 635	1346 1021	250,60 167,21	76,52 45,15
100	483 367	530 402	924 701	1546 1174	277,21 185,81	85,67 50,40
250					312,26 210,30	97,73 57,32
1250					373,68 253,22	118,86 69,44

Step 6 Results of the hydrological simulations

High flows - National scenarios

Simulated winter maximum daily discharge (in m^3/s) 2021-2050 - wet scenario and dry scenario

T[y]	Rur at Stah	Niers at Goch
2	81,58 66,42	23,96 18,79
5	107,39 89,24	33,93 26,49
10	124,49 104,36	40,53 31,59
25	146,08 123,45	48,87 38,03
50	162,10 137,62	55,05 42,81
100	178,01 151,68	61,19 47,55
250	198,95 170,20	69,28 53,79
1250	235,64 202,65	83,45 64,74

Simulated winter maximum daily discharge (in m^3/s) 2071-2100 - wet scenario and dry scenario

T[y]	Rur at Stah	Niers at Goch
2	96,54 63,60	30,38 19,66
5	128,20 88,25	44,14 28,60
10	149,17 104,57	53,25 34,52
25	175,65 125,18	64,76 42,00
50	195,31 140,48	73,30 47,55
100	214,81 155,66	81,78 53,06
250	240,49 175,65	92,94 60,31
1250	285,50 210,69	112,50 73,02

Step 6 Results of the hydrological simulations

Low flows

Simulated MAM7 values (April-Sept – in m^3/s)
2021-2050 - wet scenario and dry scenario

T[y]	Meuse **Chooz**	Lesse **Gendron**	Vesdre **Chaudfontaine**	Rur **Stah**	Niers **Goch**
2	25.9 25.8	2.40 2.13	2.59 2.23	10,72 9,55	3,86 3,17
5	19.1 18.8	1.90 1.65	2.03 1.70	9,51 8,40	2,86 2,33
10	16.3 15.9	1.63 1.4	1.78 1.46	8,93 7,86	2,45 1,99
25		1.34 1.13	1.53 1.23	8,36 7,32	2,08 1,67
50		1.16 0.97	1.38 1.1	8,01 6,99	1,86 1,50

Transnational Meuse scenario — French/German national scenarios

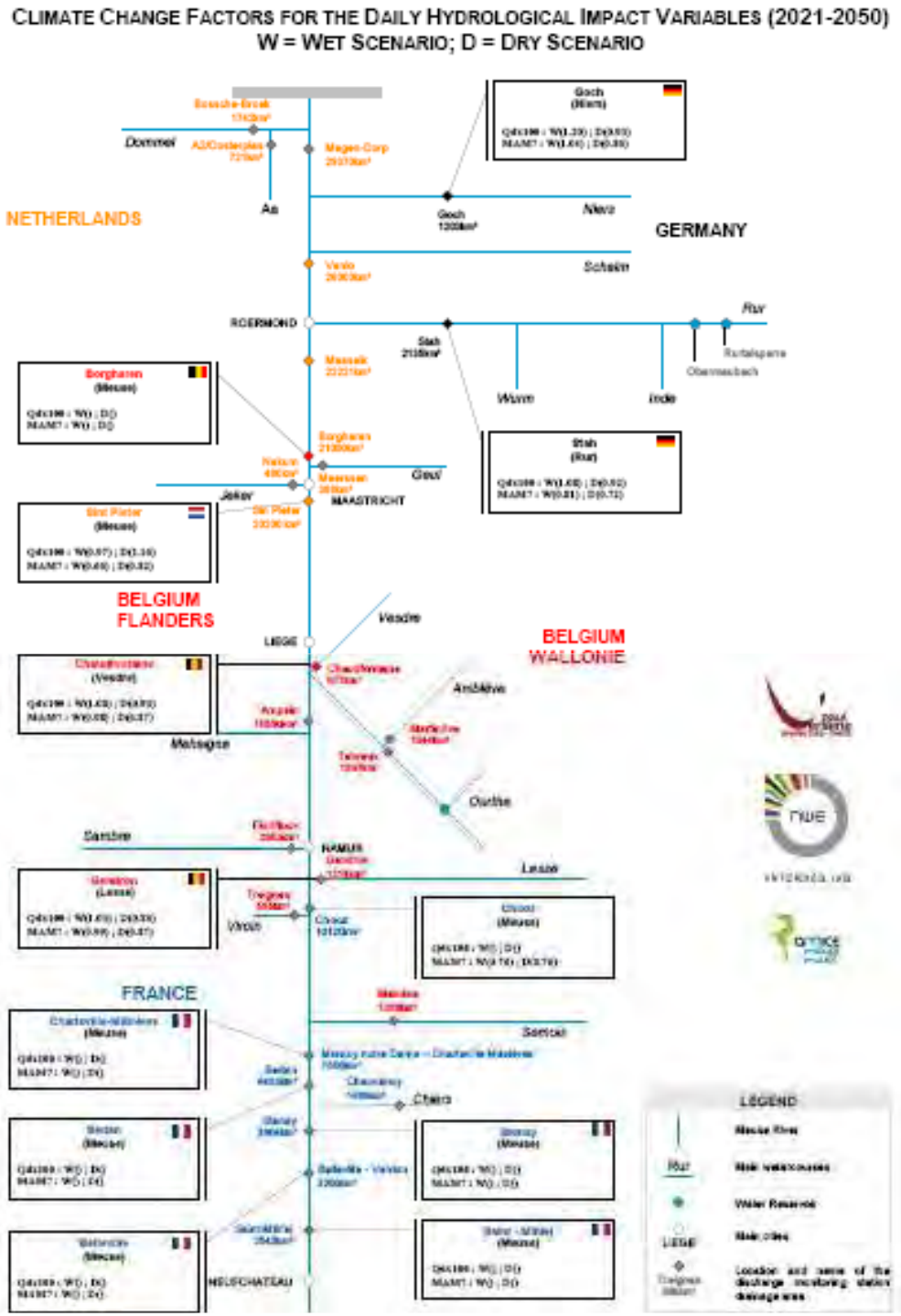
Simulated MAM7 values (April-Sept – in m^3/s)
2071-2100 - wet scenario and dry scenario

T[y]	Meuse **Chooz**	Lesse **Gendron**	Vesdre **Chaudfontaine**	Rur **Stah**	Niers **Goch**
2	14.9 14.1	2.31 1.67	2.52 1.79	12,86 10,31	3,48 2,00
5	11.5 11.1	1.82 1.24	1.95 1.31	11,38 9,01	2,55 1,44
10	10.1 9.8	1.56 1.02	1.69 1.06	10,68 8,40	2,17 1,21
25		1.28 0.79	1.45 0.81	9,98 7,79	1,82 1,00
50		1.11 0.66	1.3 0.67	9,56 7,42	1,63 0,89

Transnational Meuse scenario — French/German national scenarios

Step 6 Results of the hydrological simulations

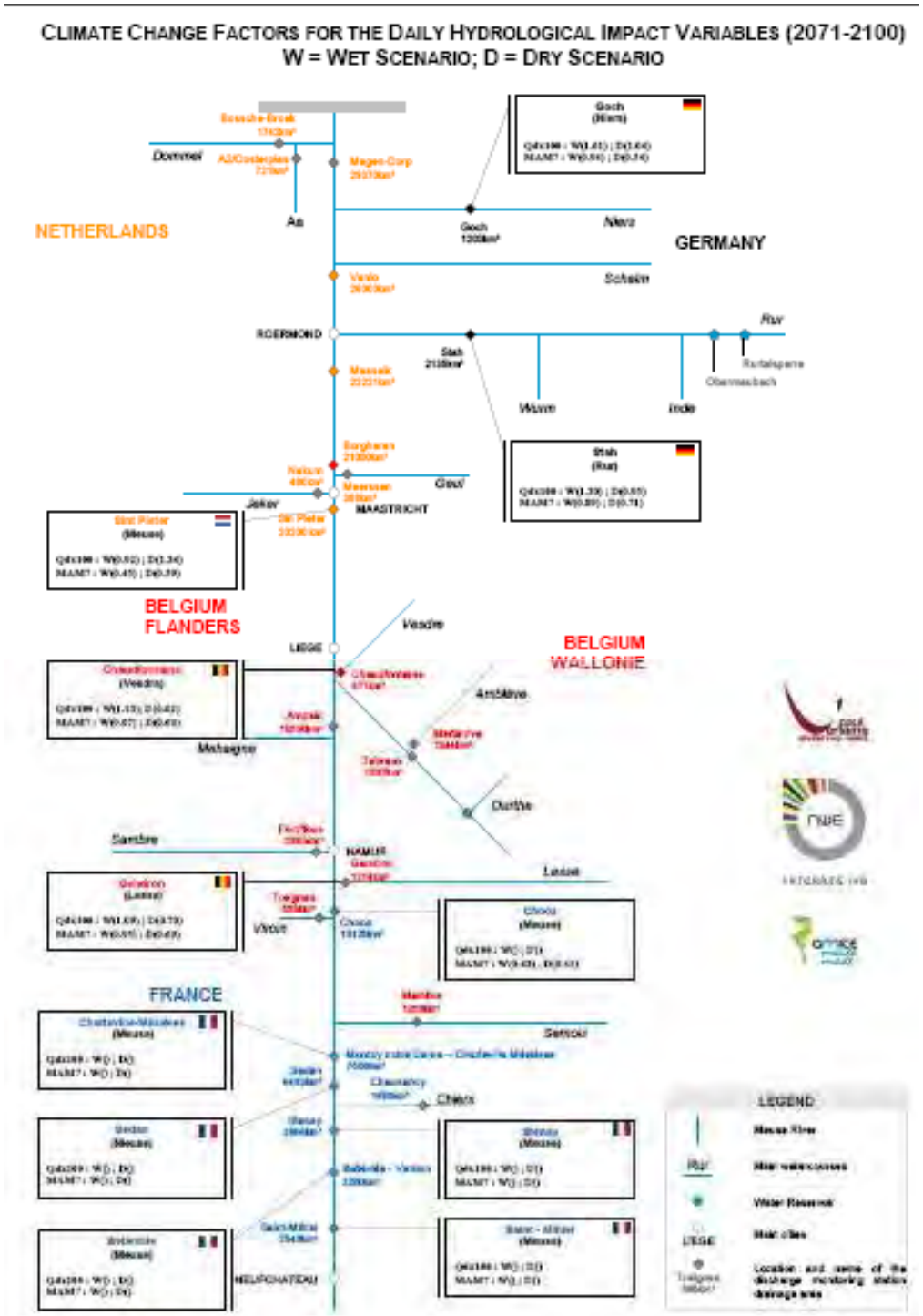
Climate change factors*
for the daily hydrological impact variables
MAM7 & Qdx100
2021-2050



*Qscenario/Qcontrol

Step 6 Results of the hydrological simulations

Climate change factors*
for the daily hydrological impact variables
MAM7 & Qdx100
2071-2100



*Qscenario/Qcontrol

WP1 Action 3

Main results…

1. Weak climate evolution : spring + autumn

2. Strong climate evolution : summer + winter

3. Summer season is definitely a « hydrological hot spot »

4. Transnational wet climate scenario -> Increase of 30 % for the magnitude of floods

5. Transnational dry climate scenario -> -40 % for low flows

Step 7 Selection of hydrological scenarios

• Climate change factors (slide n°31) derived from the tr ansnational climate scenarios (slide n°24) will be used as input for h ydraulic simulations on the Meuse itself and its tributaries…