Danube Water Nexus

case study Sava

Ad de Roo[1,2], Giovanni Bidoglio[1], Faycal Bouraoui, Peter Burek, Alberto Pistocchi, Arnaud Reynaud, Luc Feyen, Jutta Thielen, Peter Salamon, et al.

[1]European Commission, Joint Research Centre
[2]Faculty of Earth Sciences, Utrecht University

Overall aim:

Multi-criteria hydro-economic optimisation of water resources in Europe

supporting the EU Blueprint to safeguard Europe's waters, the EU Danube Strategy, the WFD, the FD

Aim of project

The project Danube Water-Agriculture-Energy-Ecosystems Nexus (Danube Water Nexus) aims to provide input to decision makers (EC DG's: ENV, REGIO, CLIMA, AGRI) and managers in the region about ***sustainable futures*** *of water resources usage.*

Danube Water Nexus

JRC: further model applications, R&D

- **Hydro-economics**
- **Optimisation**
- **LISFLOOD, LISQUAL, EPIC, SWAT**

Expert studies (with Danube experts)

- **Previous modelling studies**
- **Scenario requirements**
- **Navigation**
- **Sediments**
- **Groundwater**
- **Water quality**

Case Studies (with Danube experts)

- **Tisza (irrigation)**
- **Sava**
- **Prut/Siret (groundwater)**

Danube Water Nexus

Additional inputs from Danube Soils Nexus

- **Improved soils datasets Danube region**

Inputs from JRC agricultural group (MARS)

- **Potential adaptation measures in agriculture**

Inputs from climate risks group (EFAS, EDO)

- **Bias corrected climate scenarios**

Danube Spatial Data Infrastructure

- **Harmonized data infrastructure (public domain)**
- **A large range of geospatial data**

Added to Water Framework Directive & Floods Directive:

European Commission

2012 EU Water Blueprint: The water milestone in the 2020 Roadmap to a Resource Efficient Europe


EUROPEAN COMMISSION

Brussels, 14.11.2012
SWD(2012) 381 final

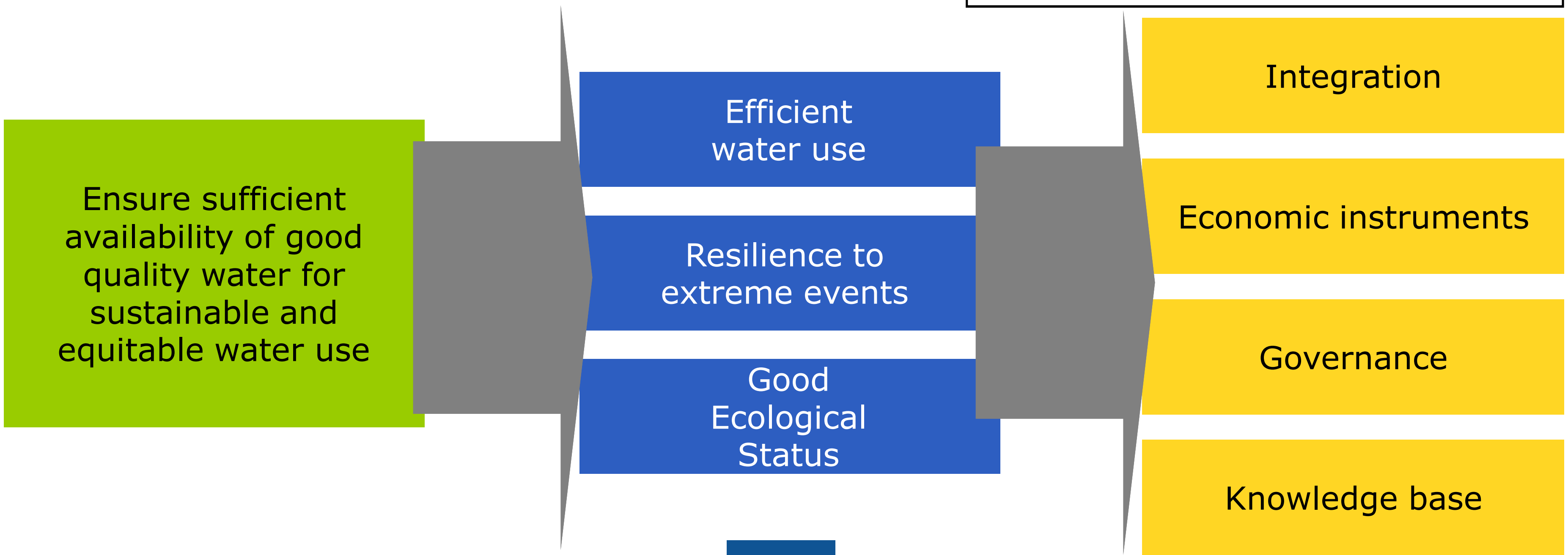
COMMISSION STAFF WORKING DOCUMENT

EXECUTIVE SUMMARY OF THE IMPACT ASSESSMENT

Accompanying the document

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

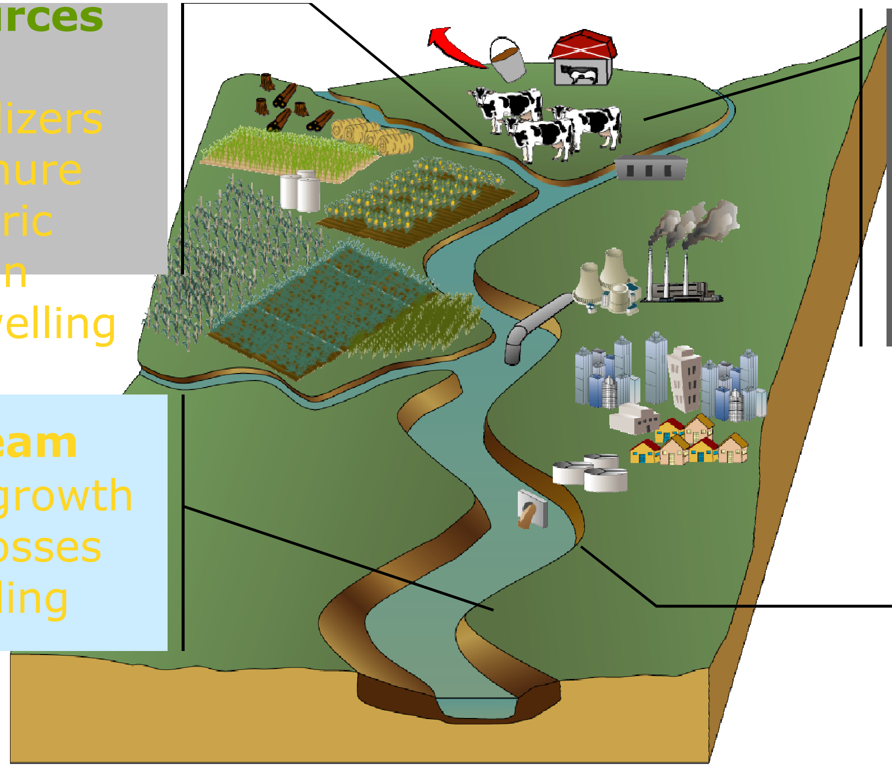
A Blueprint to Safeguard Europe's Water Resources



GREEN model: Geospatial Regression Equation for European Nutrient losses

Diffuse sources (Dsrc):
Mineral fertilizers
Animal manure
Atmospheric deposition
Scattered dwelling

R_{riv} (in-stream losses): plant growth
Atmospheric losses
Nutrient settling



R_{land} (Diffuse losses):
Crop uptake
Soil storage
Atmospheric losses

Point sources (Psrc):
WW treatment plants
Industrial loads
Paved areas

$$Nflx = \left[Dsrc\, \alpha_P f(Rain) + (Psrc + Nup) \right] \alpha_R f(Len) * \alpha_{Lake}$$

R

Rive

SWAT – Soil Water Assessment Tool

Spatially semi-distributed

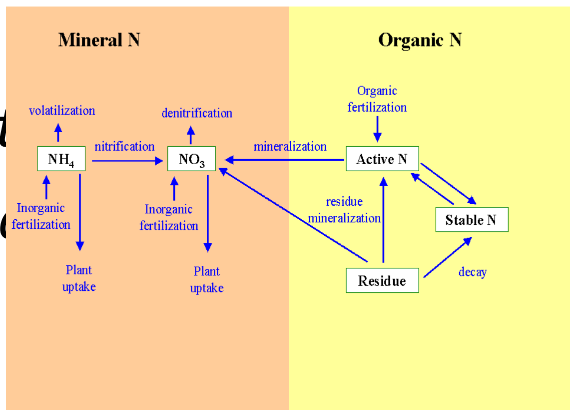
- **Subdivides a basin into subbasins connected by a stream network, and further Hydrologic Response Units (HRUs)**

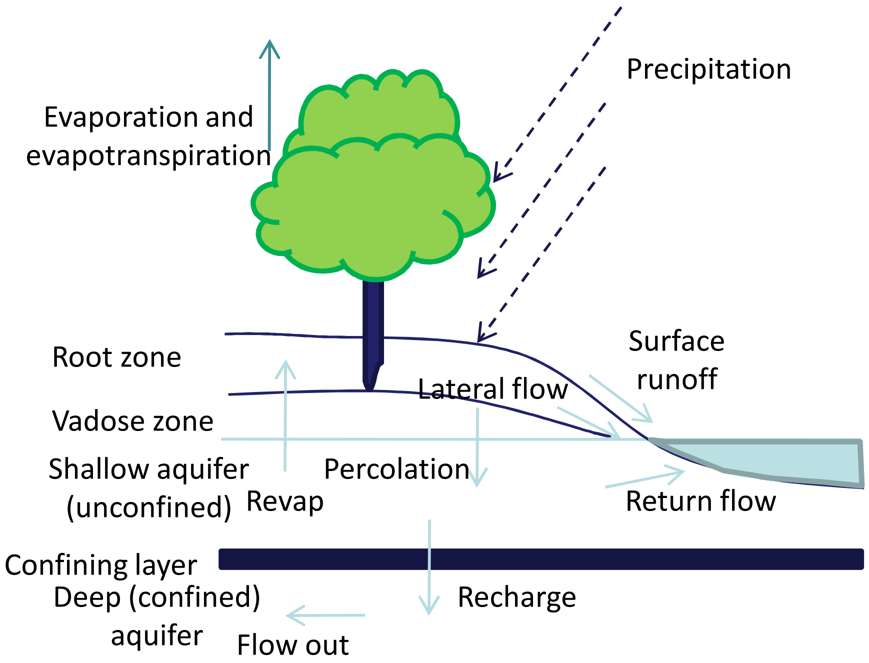
$$SW_t = SW_0 + \sum_{i=1}^{t} (R_{day} - Q_{surf} - E_a - w_{seep} - Q_{gw})$$

Water balance

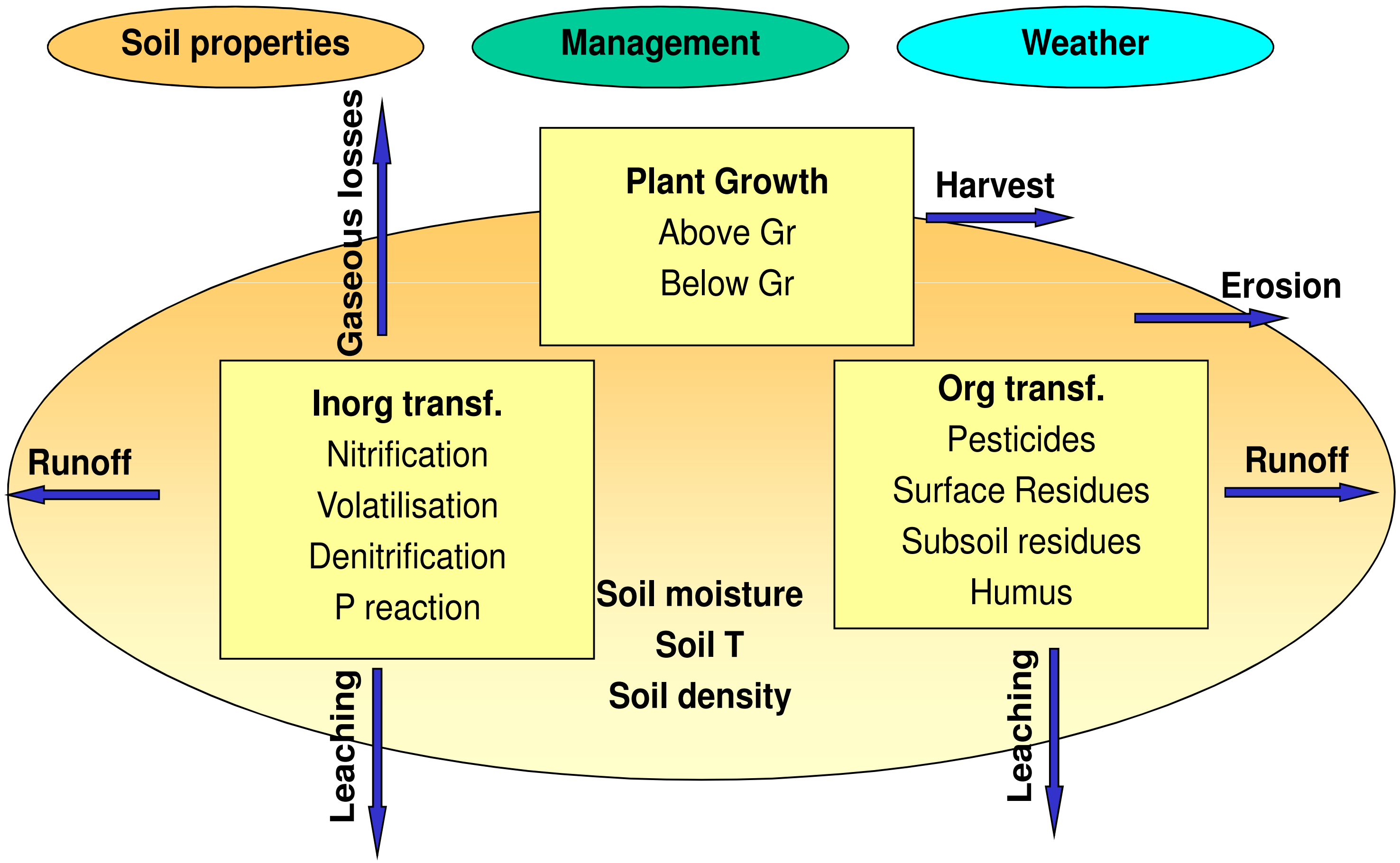
- *Erosion*
- *Nutrient*
- *Pesticid*

Nitrogen model

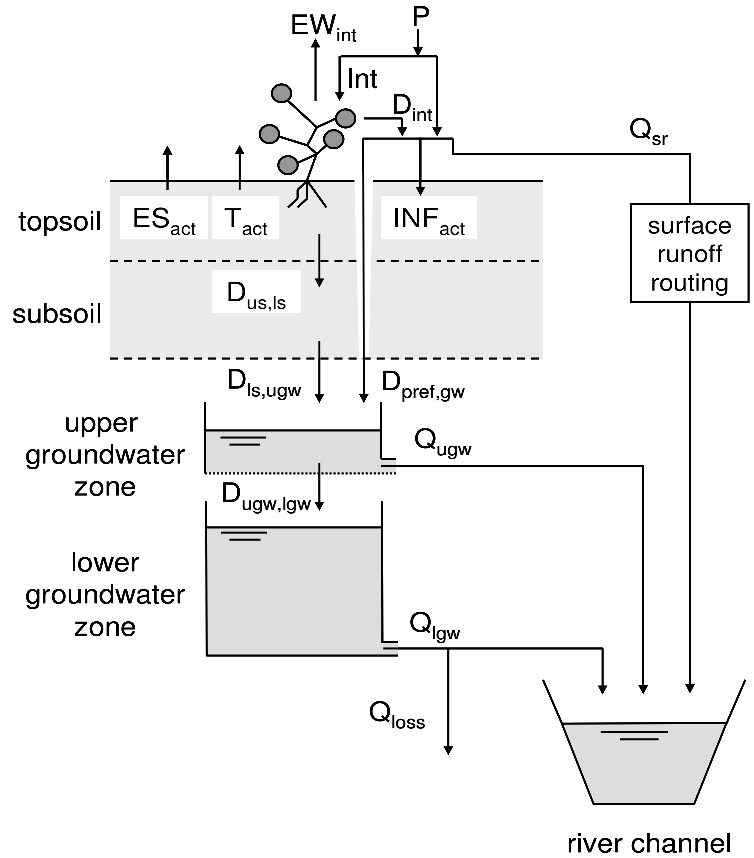




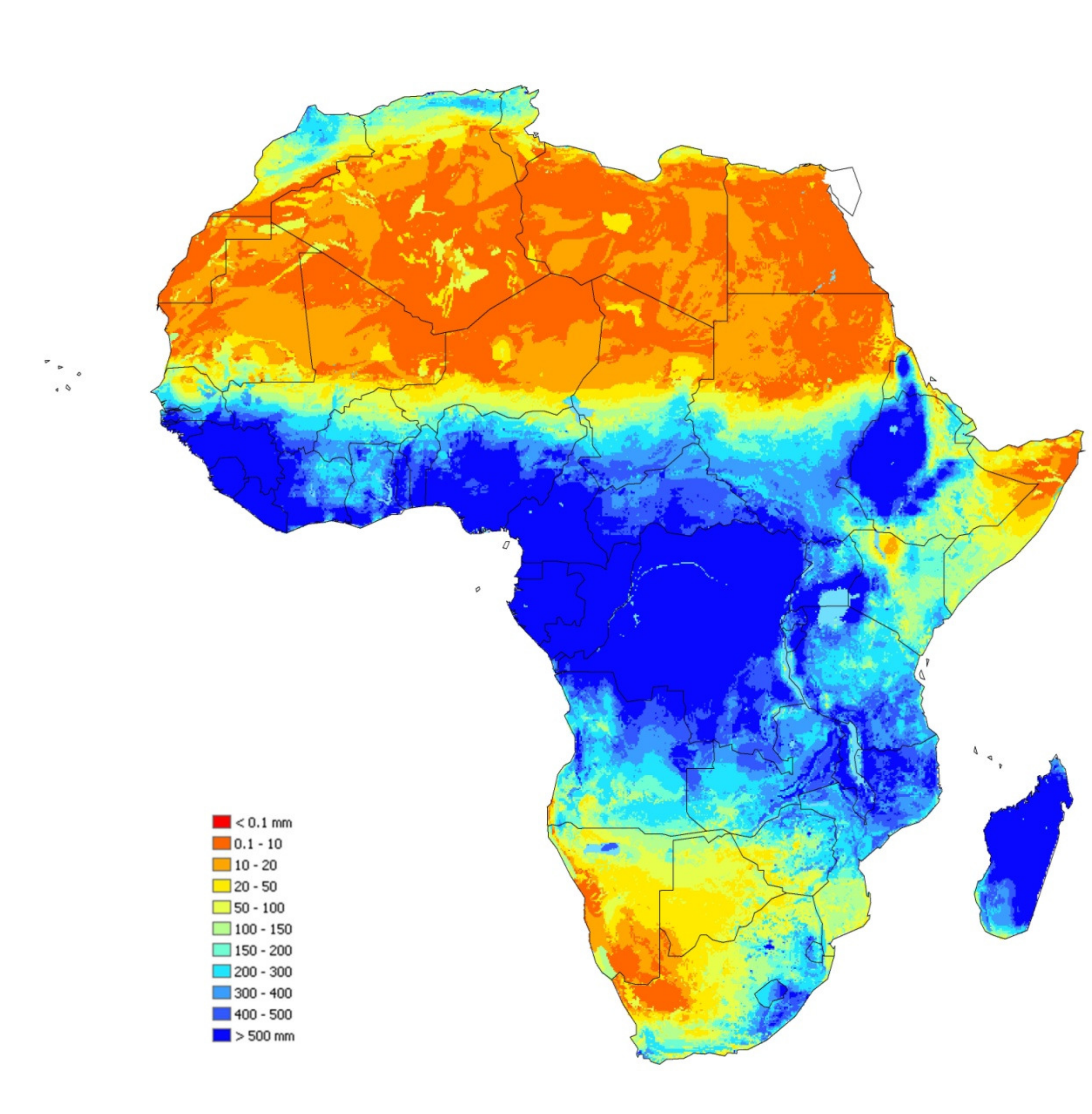
EPIC modeling structure

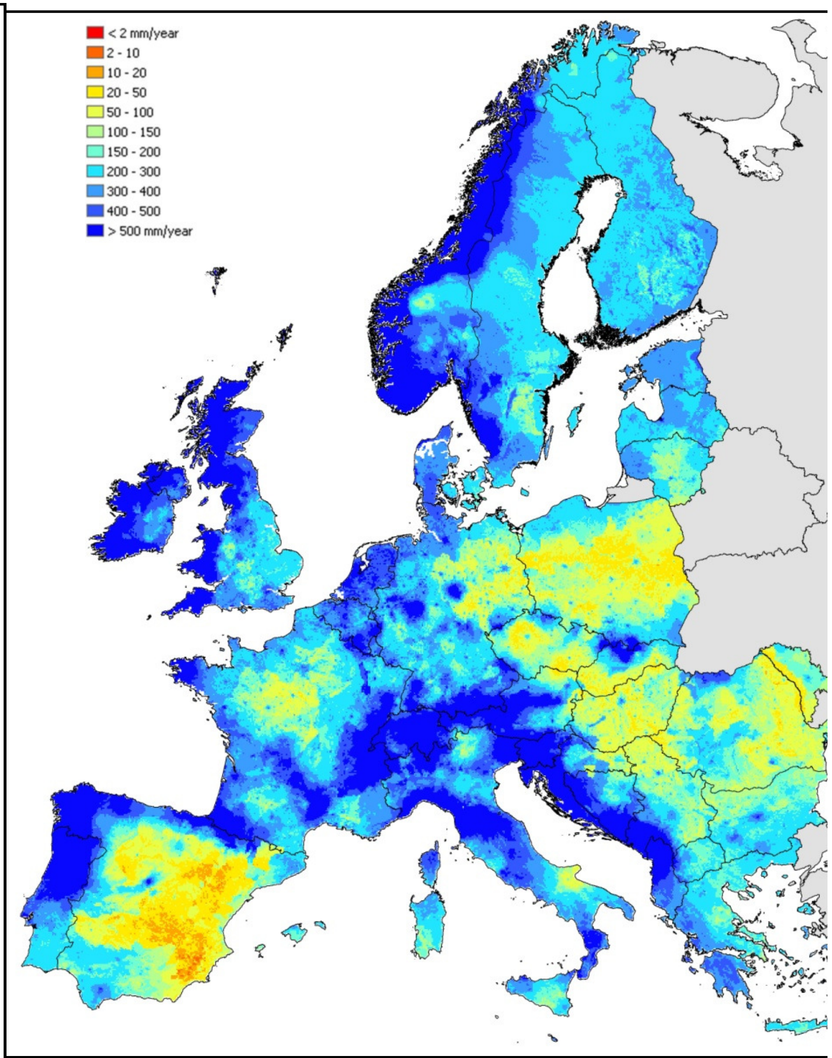


Hydrological model LISFLOOD



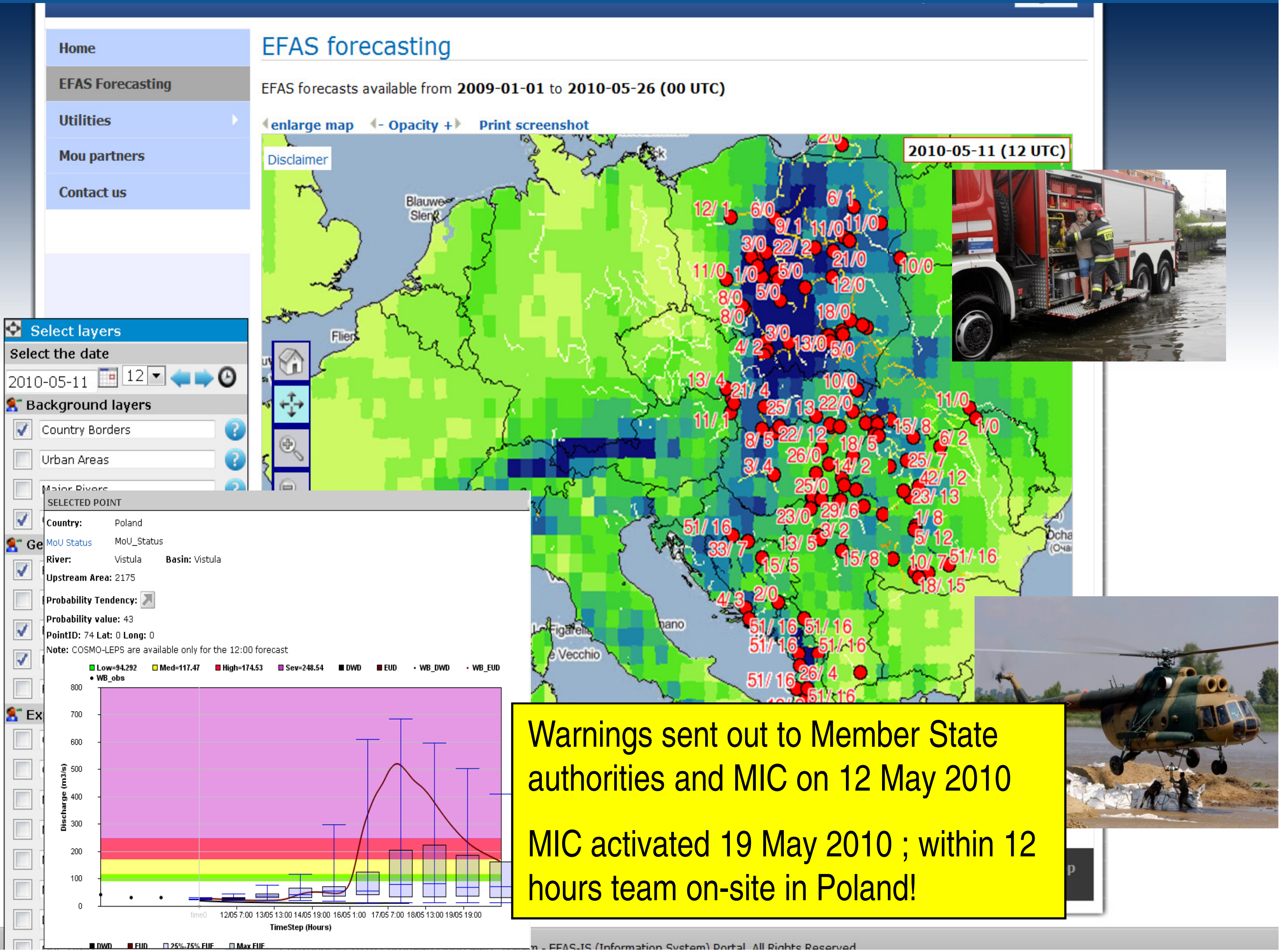
Estimated current annual freshwater 'production'





EFAS : European Flood Awareness System

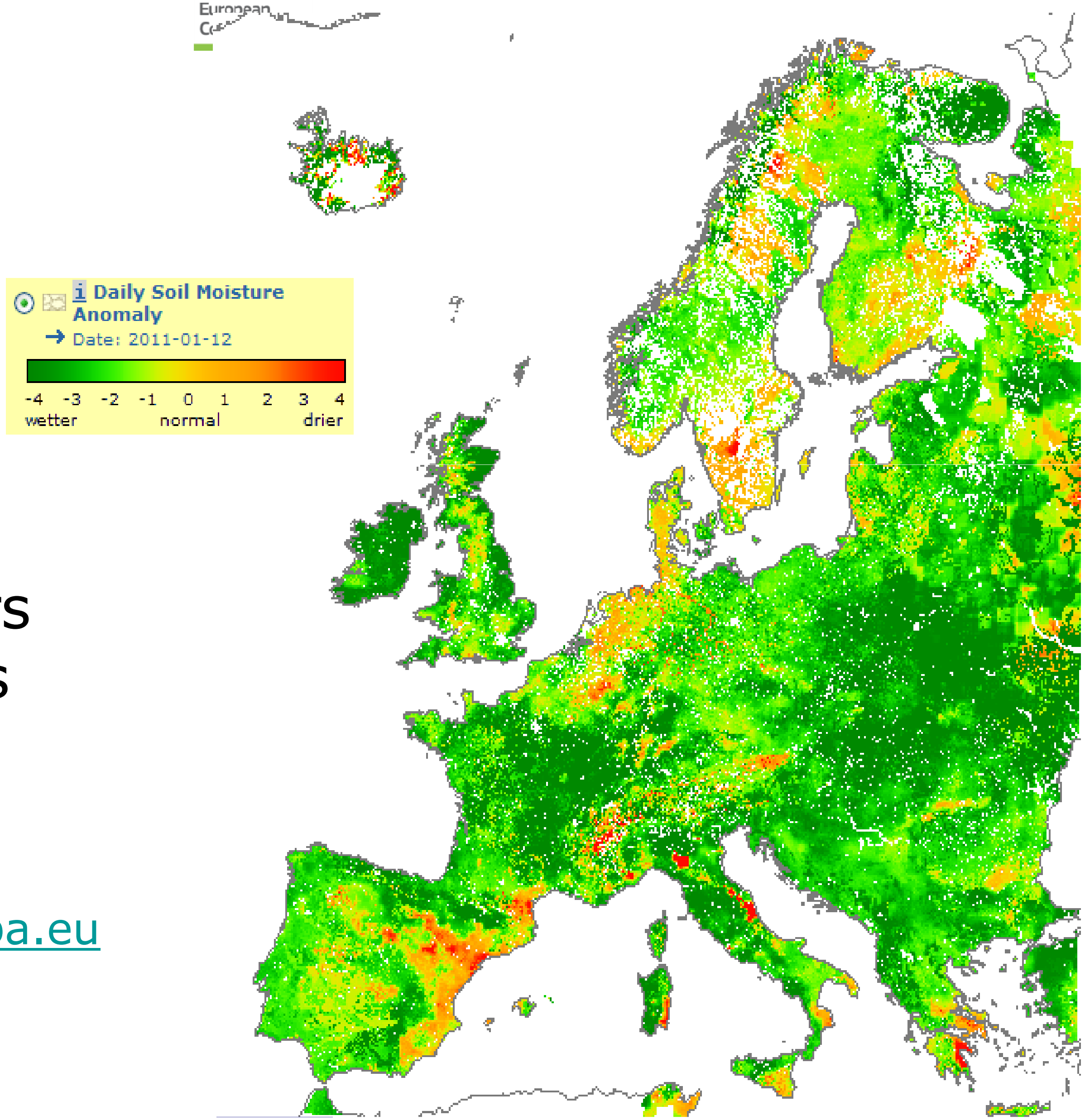
developed since 1999, operational in 2011 with GMES and ECHO/MIC budget



Warnings sent out to Member State authorities and MIC on 12 May 2010

MIC activated 19 May 2010 ; within 12 hours team on-site in Poland!

EDO: European Drought Observatory



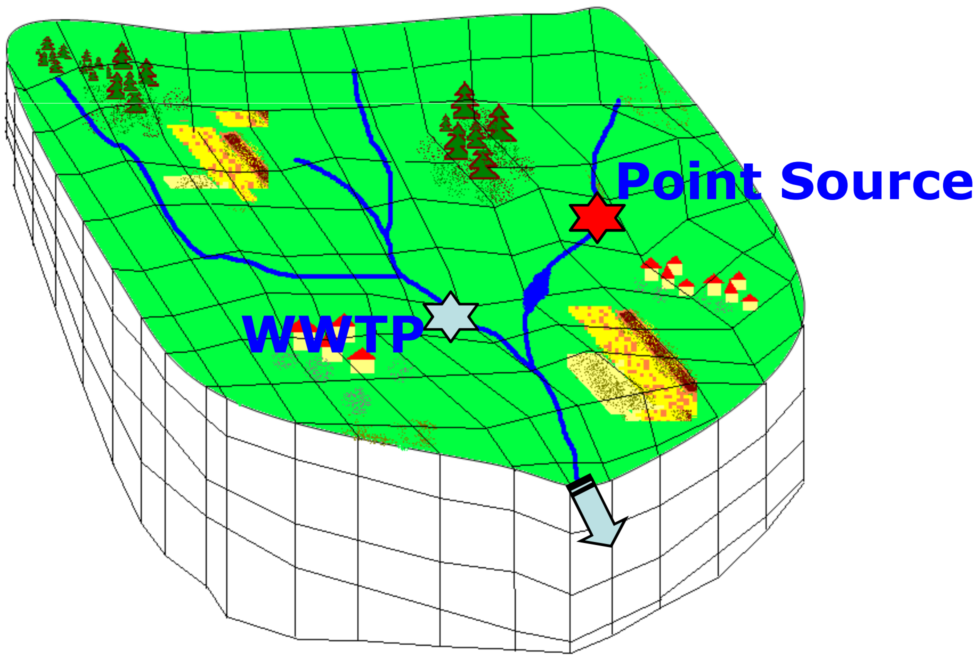
provides
drought indicators
At various scales

Contact:
Juergen.vogt@jrc.ec.europa.eu

The LISQUAL model

distributed routing model for Q, N and P, with decay functions and point sources, water scarcity indicators, and including functions to estimate monetary loss due to water scarcity

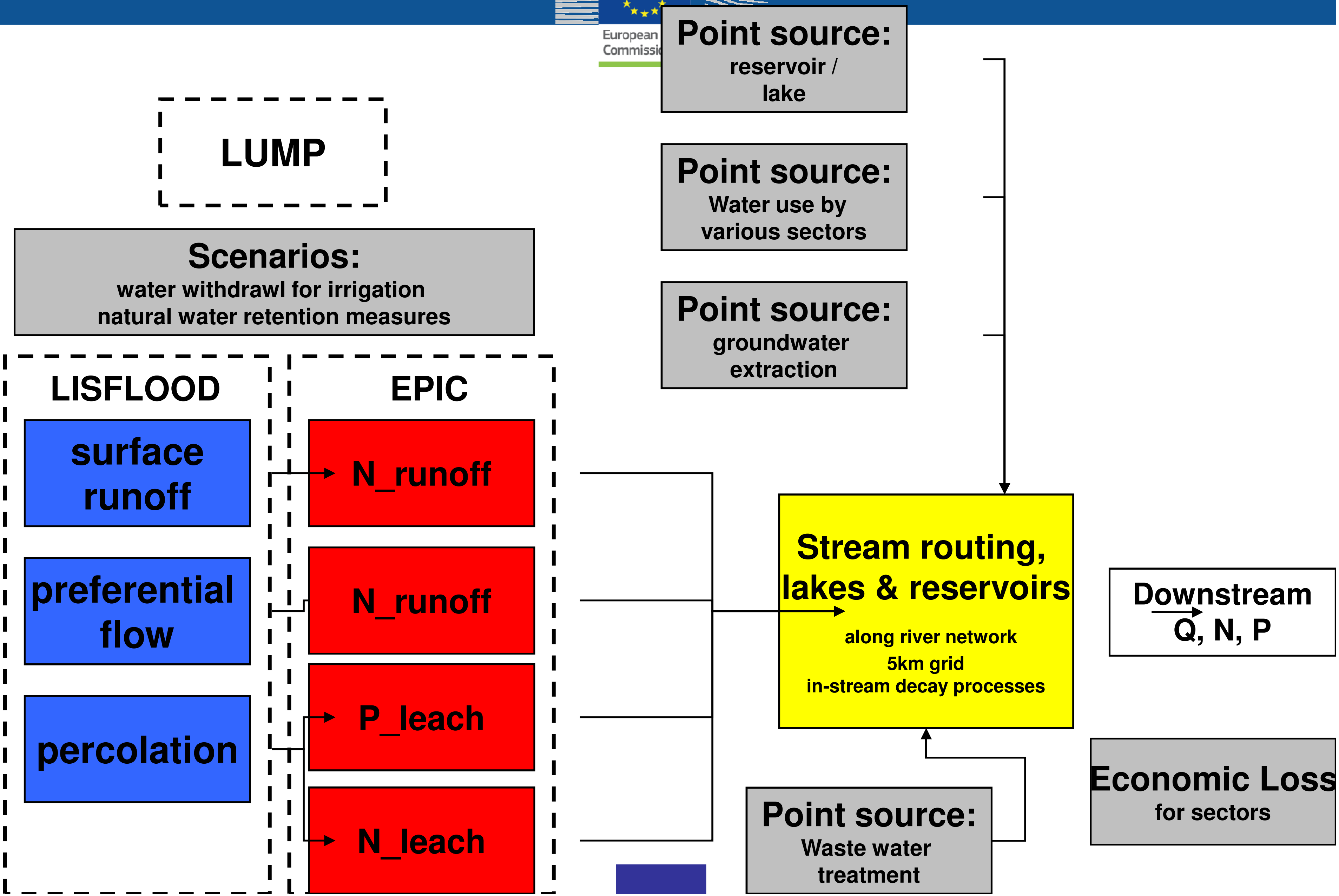
Q, N, P daily local fluxes from LISFLOOD & EPIC



Spatial resolution : 5 x 5 km for Europe (with sub-grid info)

Calibration parameters are uniform over each sub-basin

LISQUAL bio-physical model



JRC LUMP Land Use Modelling Platform

European Commission

using the land use model
Eu-ClueScanner (JRC)

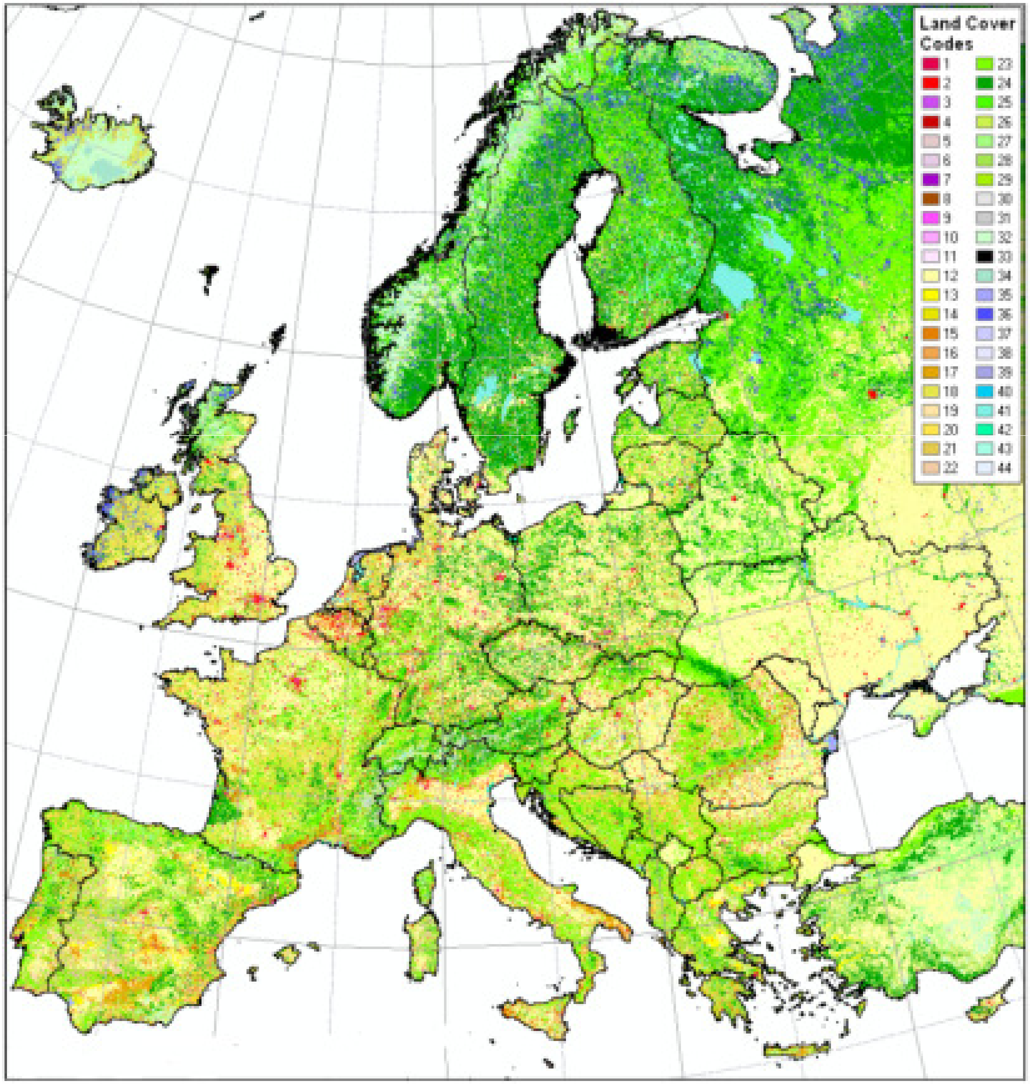
Land use / land cover change
scenarios until 2030

Common Agricultural Policy (CAP)
consistent (using CAPRI boundary
conditions for 2030)

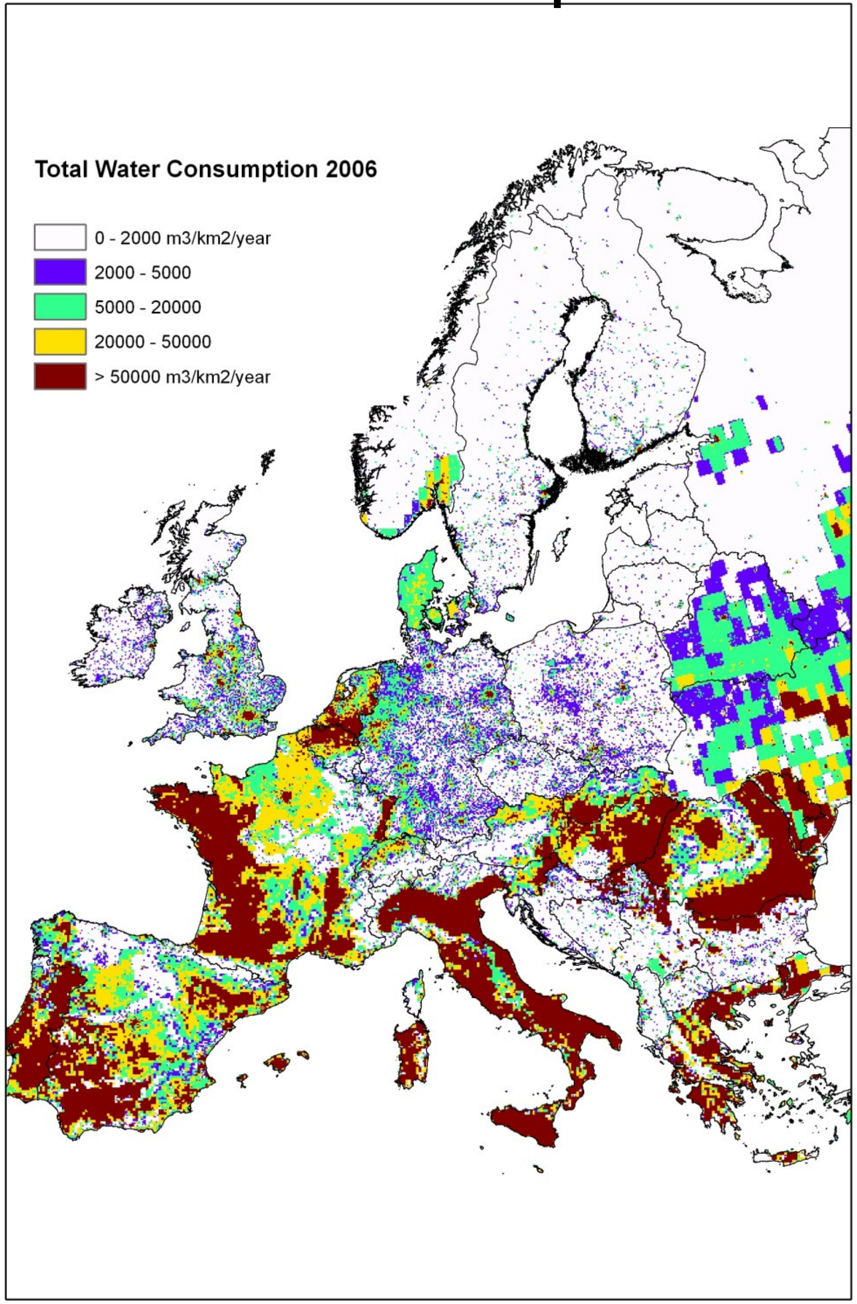
Socio-Economic data used from
Eurostat

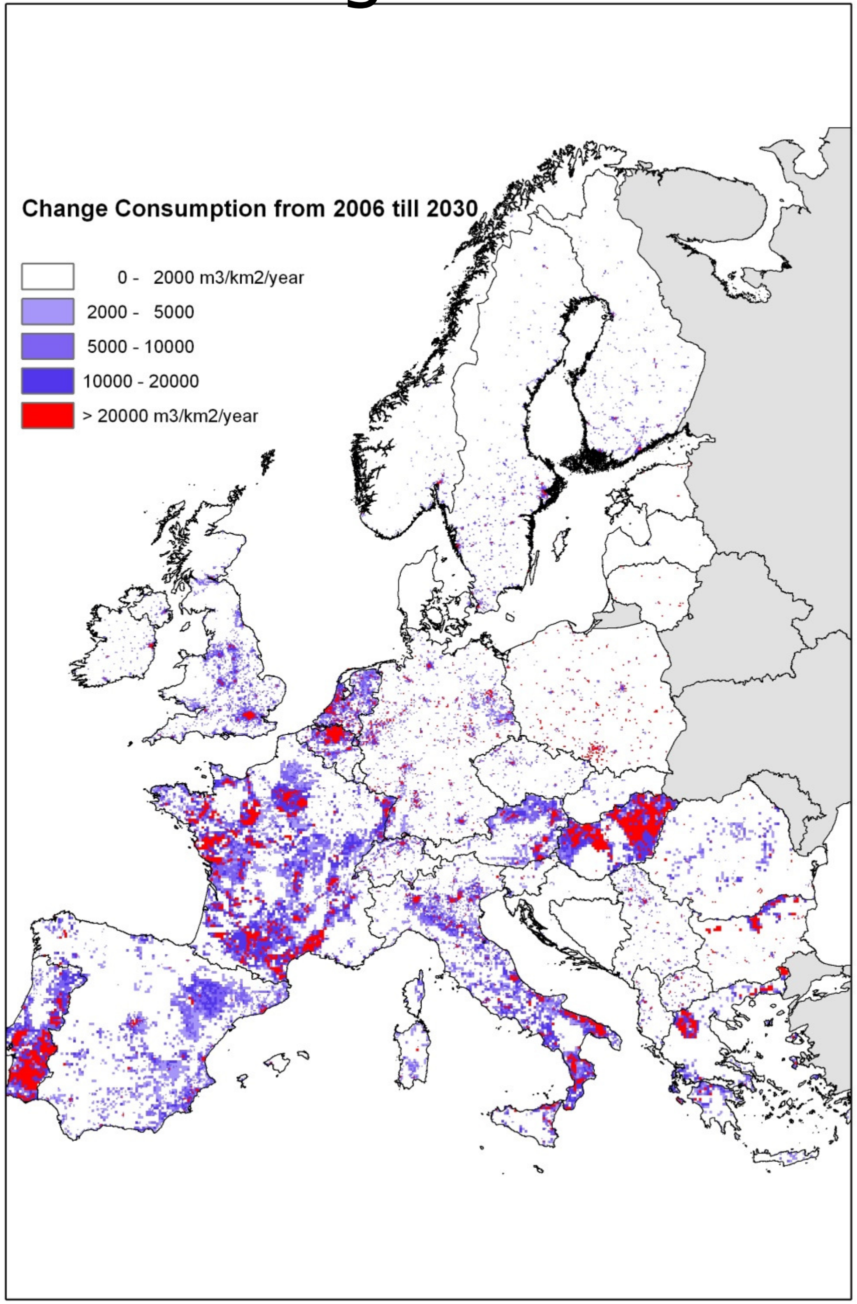
100m spatial resolution

Pan-European

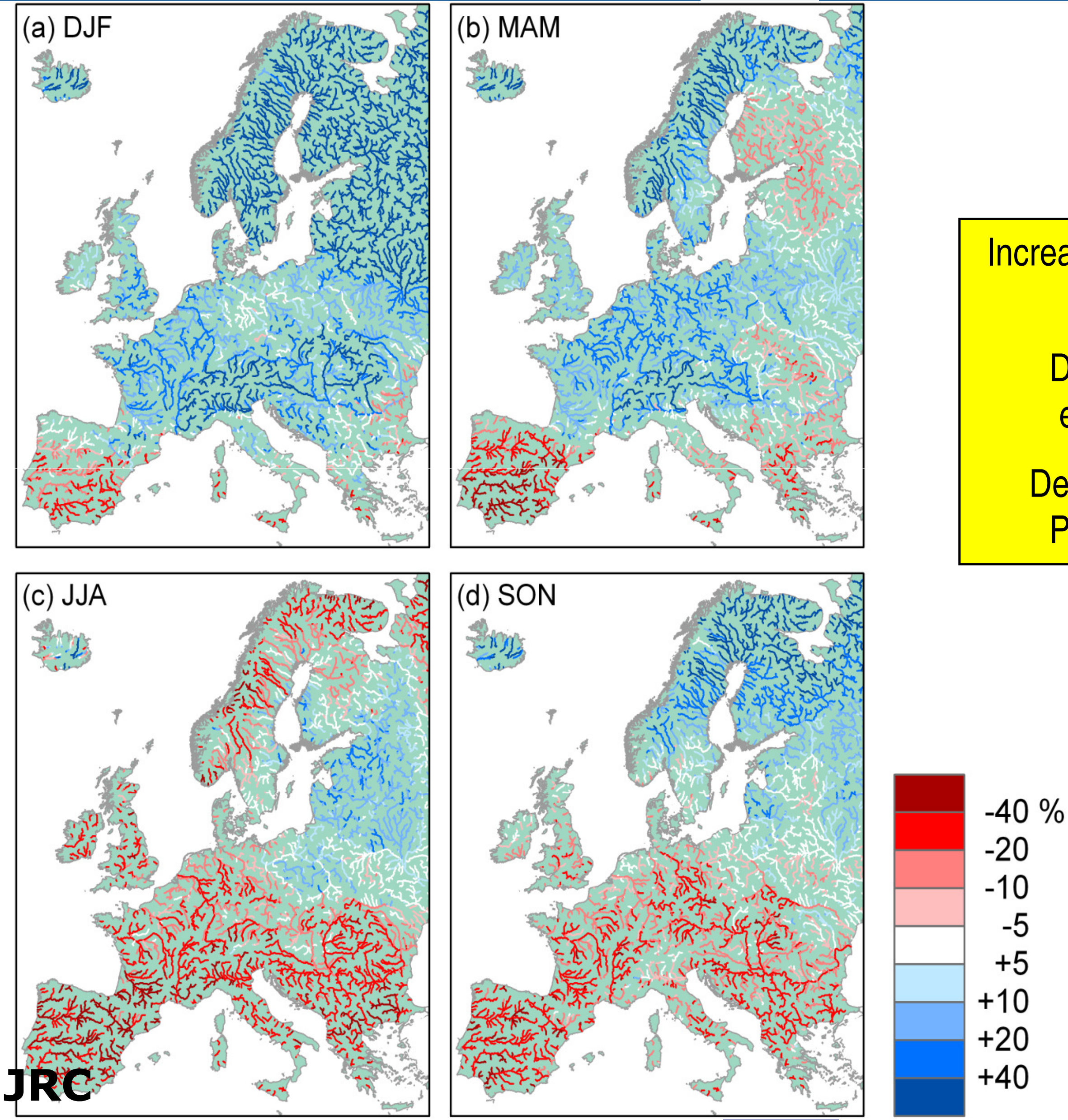


Water consumption 2006 and changes until 2030





Climate change effects on river flow:
hydrological model simulations with bias-corrected climate scenarios forcing



changing amounts of available water, with regional and seasonal variations

Increase of river flow in winter and spring in Central and N-NE Europe

Decrease of summer discharge, everywhere except NE Europe

Decrease in ALL seasons in Spain, Portugal, Southern Italy, Greece

Consequences:

- Flood Hazard
- River Transport (low flows)
- Hydropower (energy production)

Example LISQUAL outputs

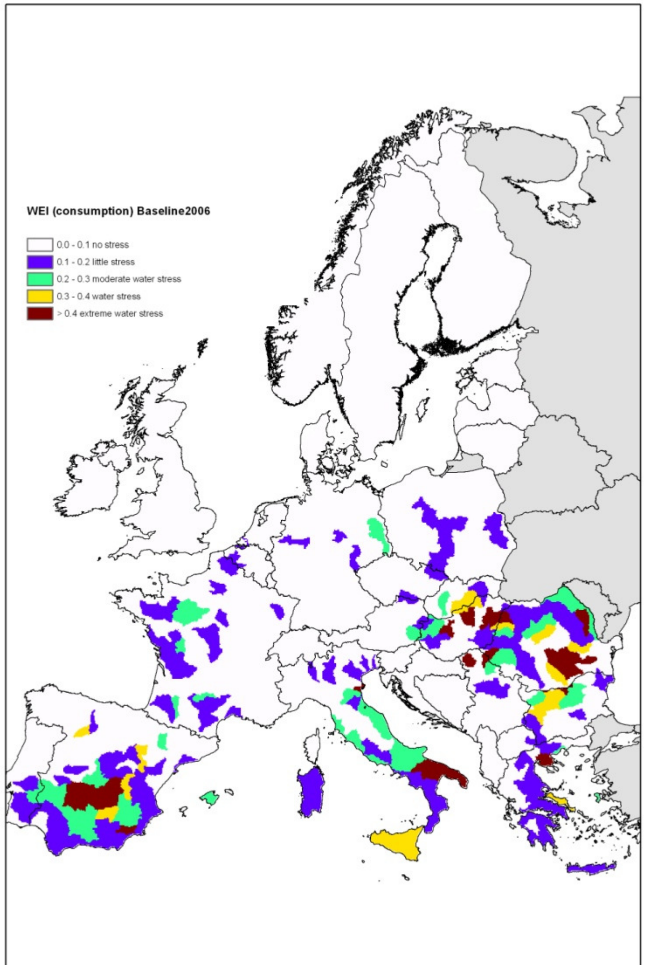
European Commission

- **River discharge (daily, m3/s, spatial)**
  - flood damage (using 100m SRTM & landuse in post-processing)
- **Nitrate concentration (daily, mg/l, spatial)**
- **Phosphorous concentration (daily, mg/l, spatial)**
- **Environmental Flow indicator (daily, spatial)**
  - 10^{th} percentile monthly flows (spatial)
  - 25^{th} percentile monthly flows (spatial)
- **Water Exploitation Index (1 Oct – 1 Oct) (annual, regions)**
  - abstraction / available water
  - consumption / available water
- **Economic Loss (annual, million Euros, regions)**
  - domestic sector
  - industry/manufacturing sector
  - energy sector
  - irrigation

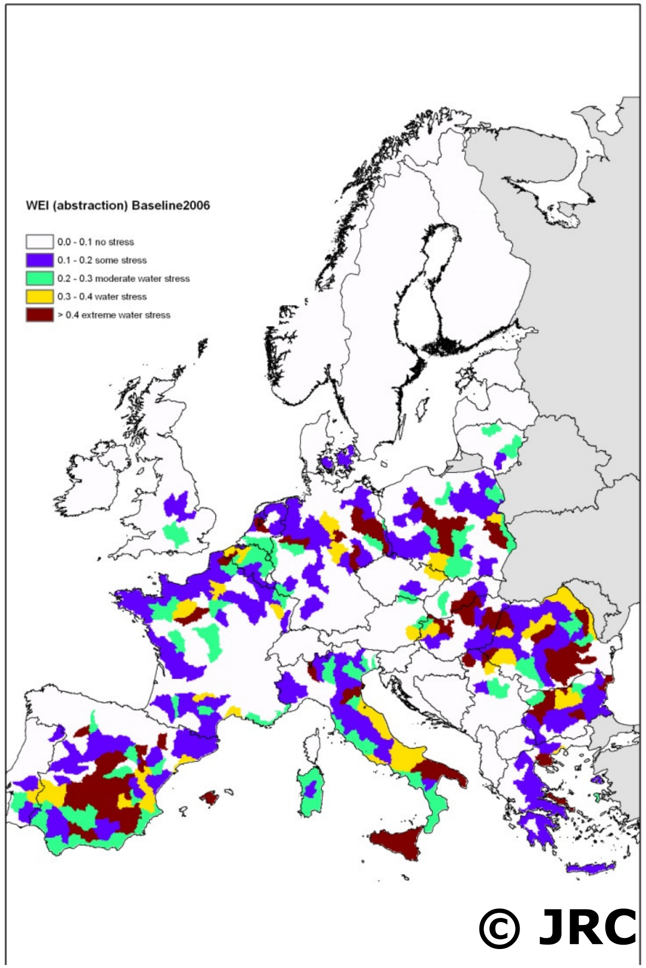
LISQUAL output: Water Exploitation Index

WEIcns= (Abstraction – ReturnFlow) / (Local runoff + Incoming runoff)

WEIcns (WEI+, consumption only)



WEIabs (abstraction only)



Scenarios (1)

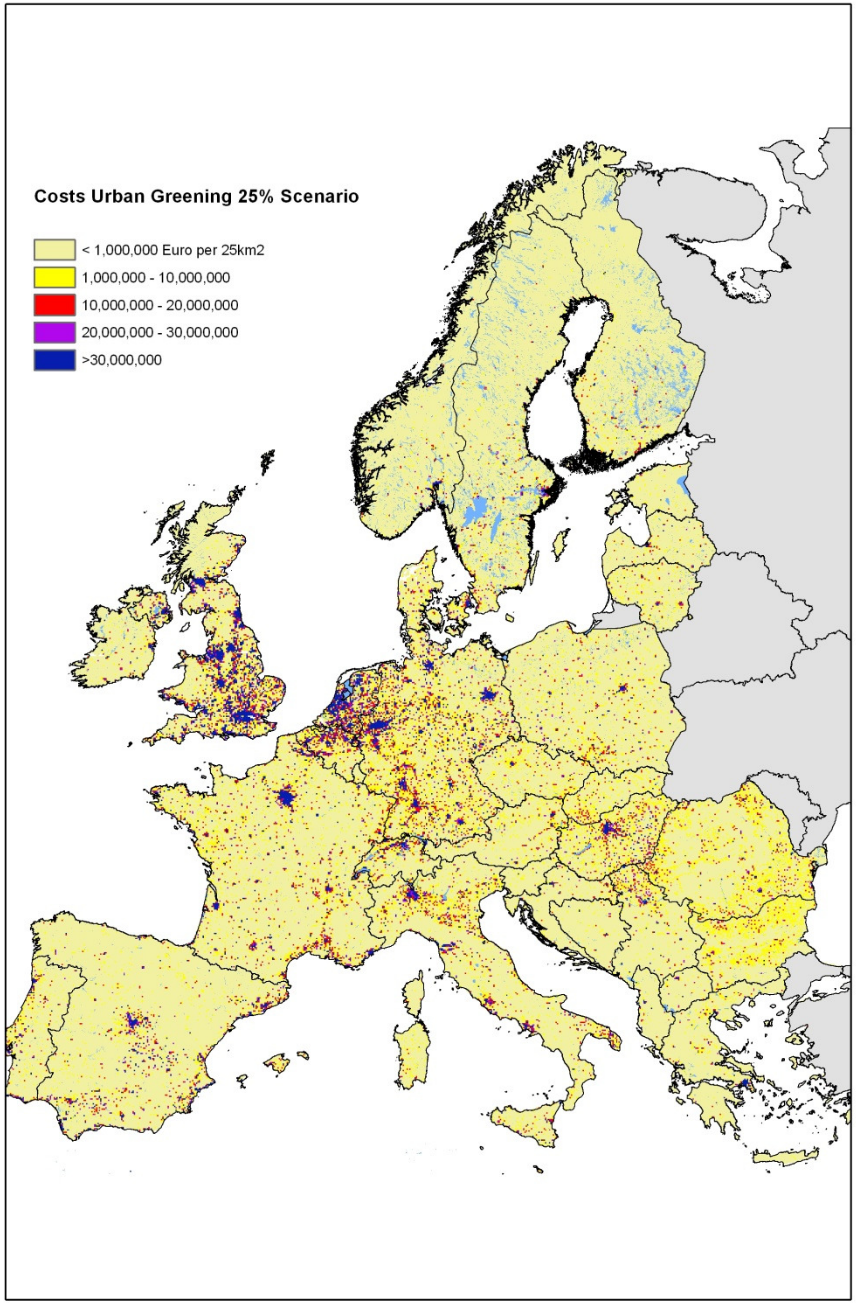
Category	Scenario	Description
BASELINE2030	0.0 Baseline 2030	LUMP 2030, 2010 fertilisation application, 2010 point sources
BASELINE2006	0.1 Baseline 2006	As Baseline 2030, but with Landuse 2006
1-FOREST	1.1 Riparian Afforestation, CAP consistent	Afforest areas from LUMP-CAP scenarios
	1.2 Afforestation in mountainous areas	Afforest areas in mountainous areas (LUMP)
2-URBAN	2.1 50% Green	Green infrastucture, Green roofs, Rain Gardens, Park Depressions; For all urban areas: Direct Runoff Fraction << 50%, Evapotanspiration >> 50%
	2.2 25% Green	Green infrastucture, Green roofs, Rain Gardens, Park Depressions; For all urban areas: Direct Runoff Fraction << 25%, Evapotanspiration >> 25%
3-AGRICULTURE	3.1 Grassland	Convert areas from LUMP-CAP scenarios to grassland
	3.2 Buffer strips	5m wide grass buffer strips within arable fields, on slopes < 10%, every 200m; 2.5% of arable land converted to grassland, only on slopes < 10%
	3.3 Grassed waterways	10m wide grass-covered areas in valley-bottom; 1% of arable land converted to grassland, in valley-bottoms > 5%
	3.4 Crop practicies	Reverse OM decline and increase mulching; increased infiltration, porosity, modified hydraulic parameters
4-NATURAL RETENTION	4.1 Wetlands	Riparian wetlands along rivers; Change cross section
	4.2 Polders	Introduce flood retention polders along rivers
	4.3 Re-meandering	
	4.4 Buffer ponds in headwater areas 1	natural retention ponds in headwater areas with 5000 m3 storage per 25km2
	4.5 Buffer ponds in headwater areas 2	natural retention ponds in headwater areas with 10000 m3 storage per 25km2
5-NUTRIENTS	5.1 N-fixing winter crops	updated N & P fluxes
	5.2 optimum fertilisation application	updated N & P fluxes

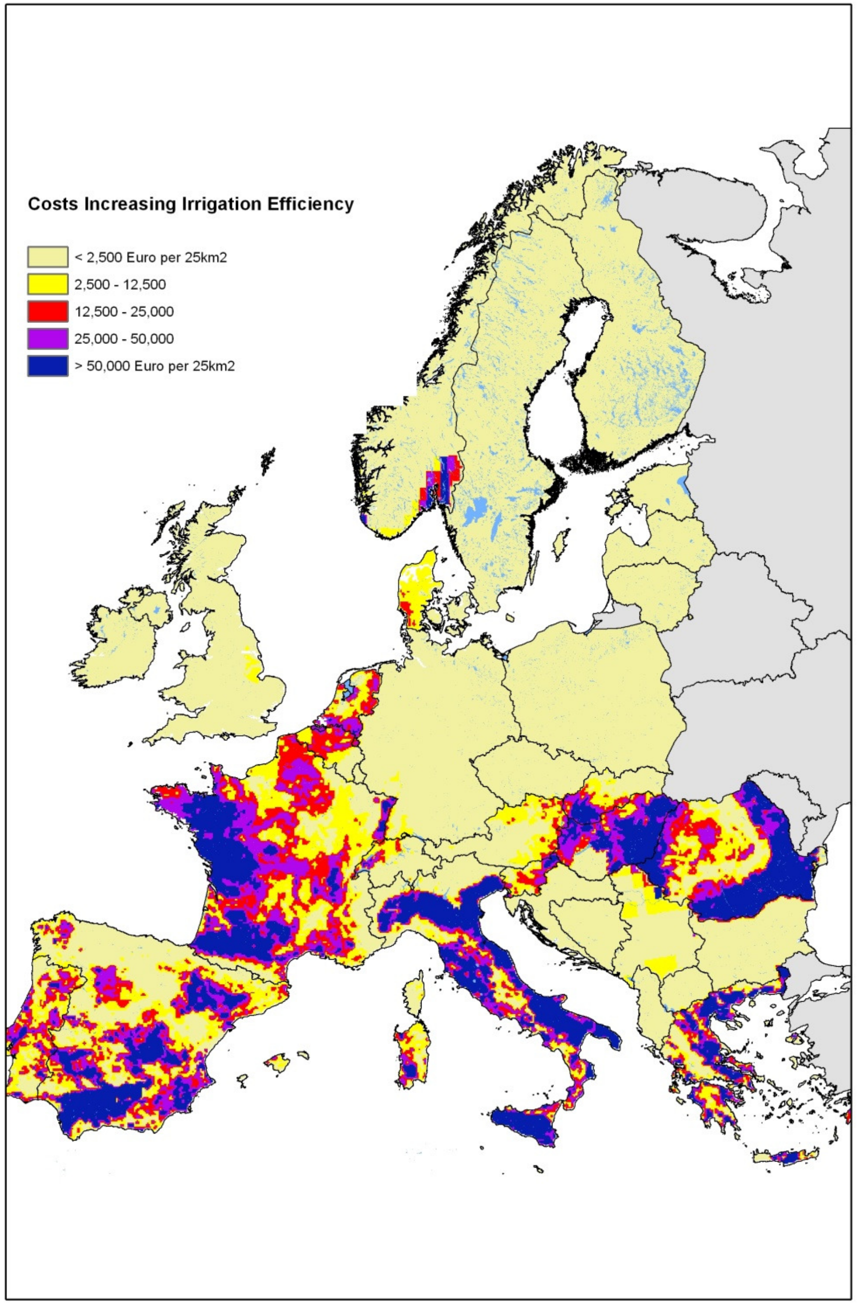
Scenarios (2)

European

Category	Scenario	Description
6-POINT SOURCES	6.1 New wastewater treatment plants (WWTP)	updated point information
	6.2 Changing type of WWTP	updated point information
7. WATER SUPPLY	7.1 groundwater extraction	updated point water availability
	7.2 desalination	updated point water availability
	7.3 large-scale water-transfer infrastructures	transfer of water between river basins
8. TECHNICAL RETENTION	8.1 constructing dams and reservoirs	new dams/resoirvoir to temporarily store water
	8.2 hard infrastructure for flood risk	
9. EFFICIENCY	9.1 Irrigation management	optimizing crop water requirements
	9.2 Water efficiency in power generation	Save water in power generation, as compared to current use
	9.3 Water efficiency in industrial processes	Save water in industry, as compared to current use
	9.4 Water efficiency in Buildings/households	Save water in households, as compared to current use
	9.5 Leakage reduction	Fix all leakages 90% or 100% (reduce water abstraction)
	9.6 Wastewater reuse for irrigation	Reduce deep groundwater use for irrigation and replace by treated wastewater

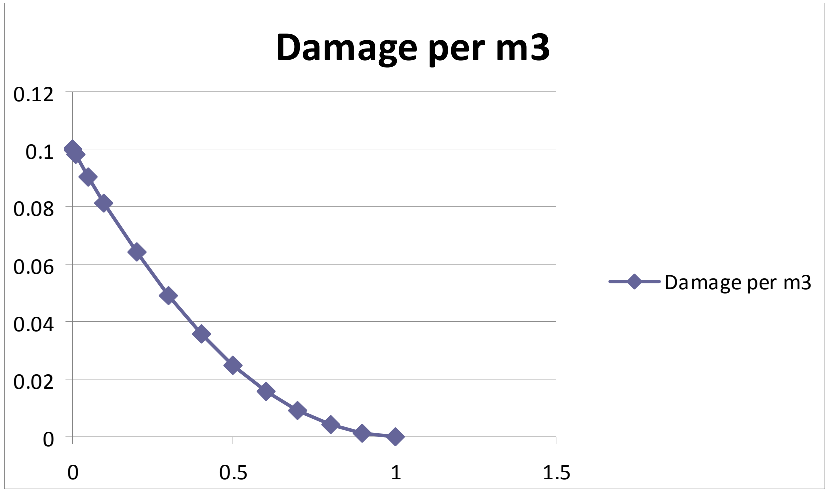
Cost of scenarios





Economic Loss model irrigation

Total water delivered	2.00E+06	m3	based on page 13 of (	
Total damage	200000	Euro		
Ratio	1.00E-01	Euro/m3	RealW	2.00E+06
Water delivered Fr	Damage per m3		Water(m3)	Damage(E
0	0.1		0.00E+00	2.00E+05
0.001	0.0998001		2.00E+03	2.00E+05
0.01	0.09801		2.00E+04	1.96E+05
0.05	0.09025		1.00E+05	1.81E+05
0.1	0.081		2.00E+05	1.62E+05
0.2	0.064		4.00E+05	1.28E+05
0.3	0.049		6.00E+05	9.80E+04
0.4	0.036		8.00E+05	7.20E+04
0.5	0.025		1.00E+06	5.00E+04
0.6	0.016		1.20E+06	3.20E+04
0.7	0.009		1.40E+06	1.80E+04
0.8	0.004		1.60E+06	8.00E+03
0.9	0.001		1.80E+06	2.00E+03
1	0		2.00E+06	0.00E+00



Assumptions:
- Ratio delivered water <> value is taken as 0.1
- Quadratic function

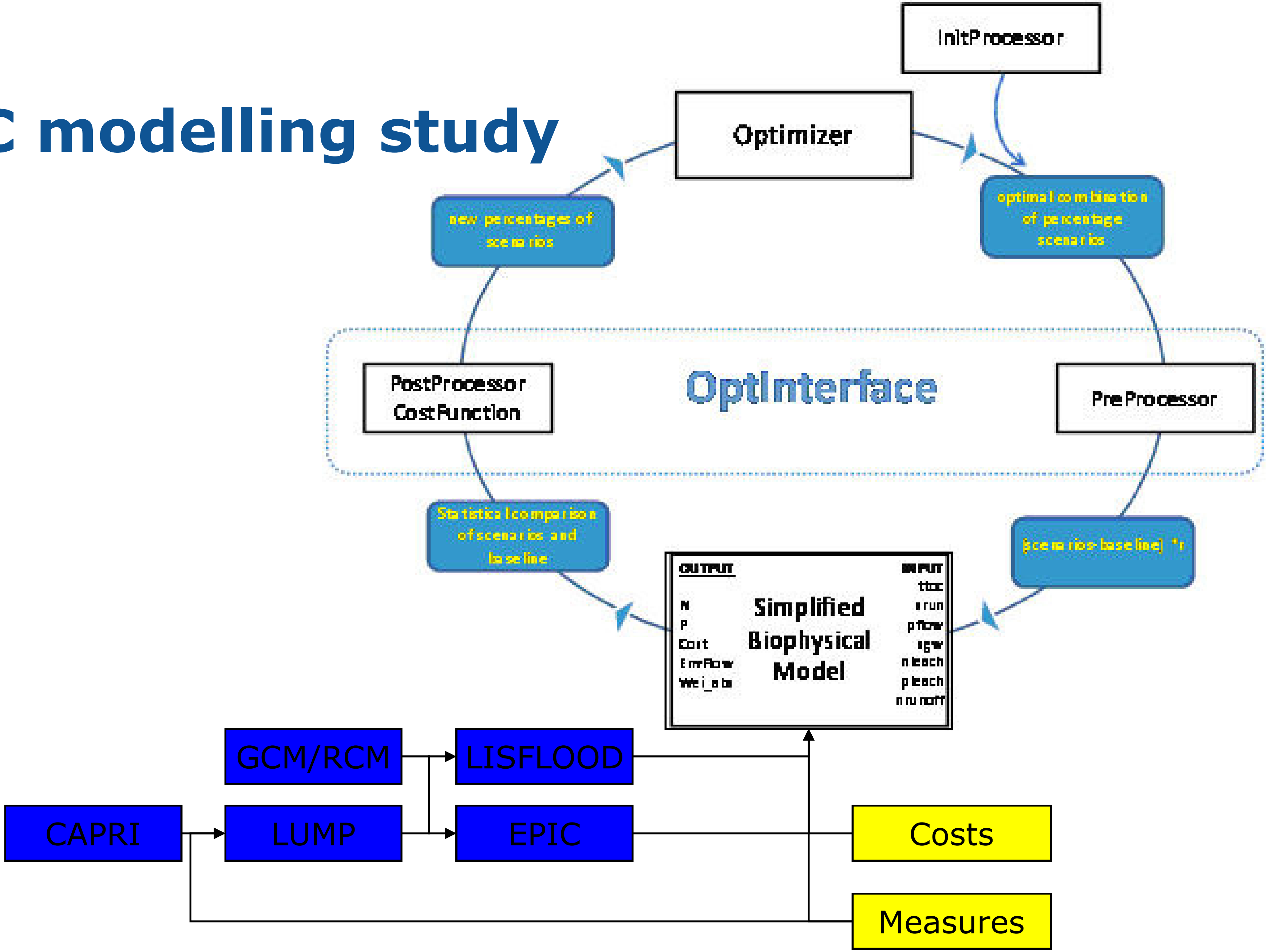
*This results in that for every m3 water that is not available for irrigation, the damage is maximally the **choke price** (0.1 euro in this example)*

So, e.g, if the required amount of water for irrigation area is 1 Mm3, and

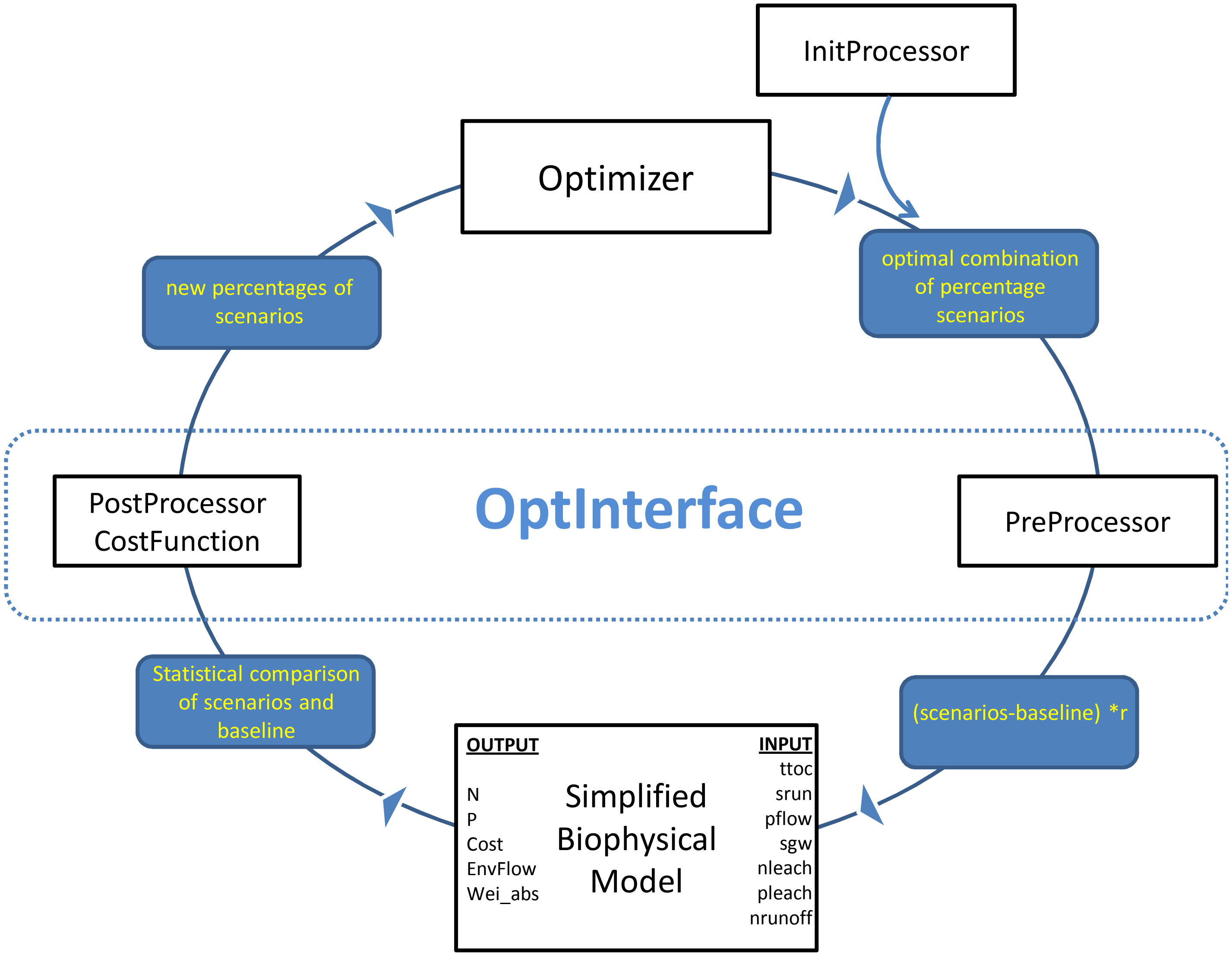
Available water (Mm3)	***Loss (MEuro)***
1.0	*0.0 MEuro*
0.5	*0.025 MEuro*
0.1	*0.081 MEuro*
0	*0.1 MEuro*

Choke price:
0.35 Euro/m3 (low value crops)
1.25 Euro/m3 (high value crops)

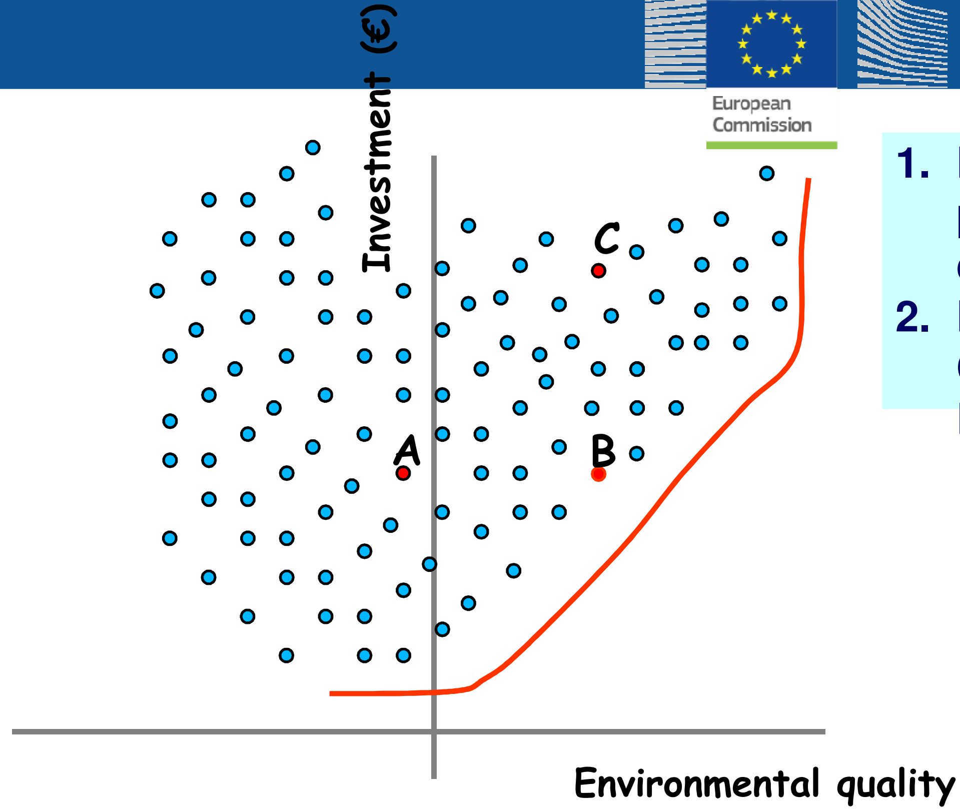
JRC modelling study



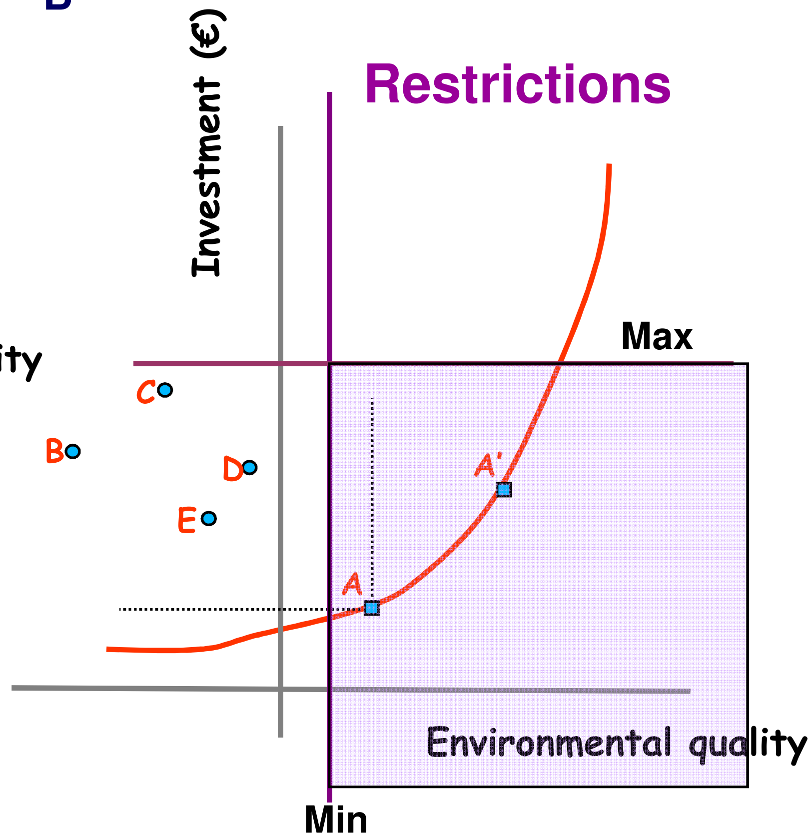
Optimization



Multicriteria Optimization

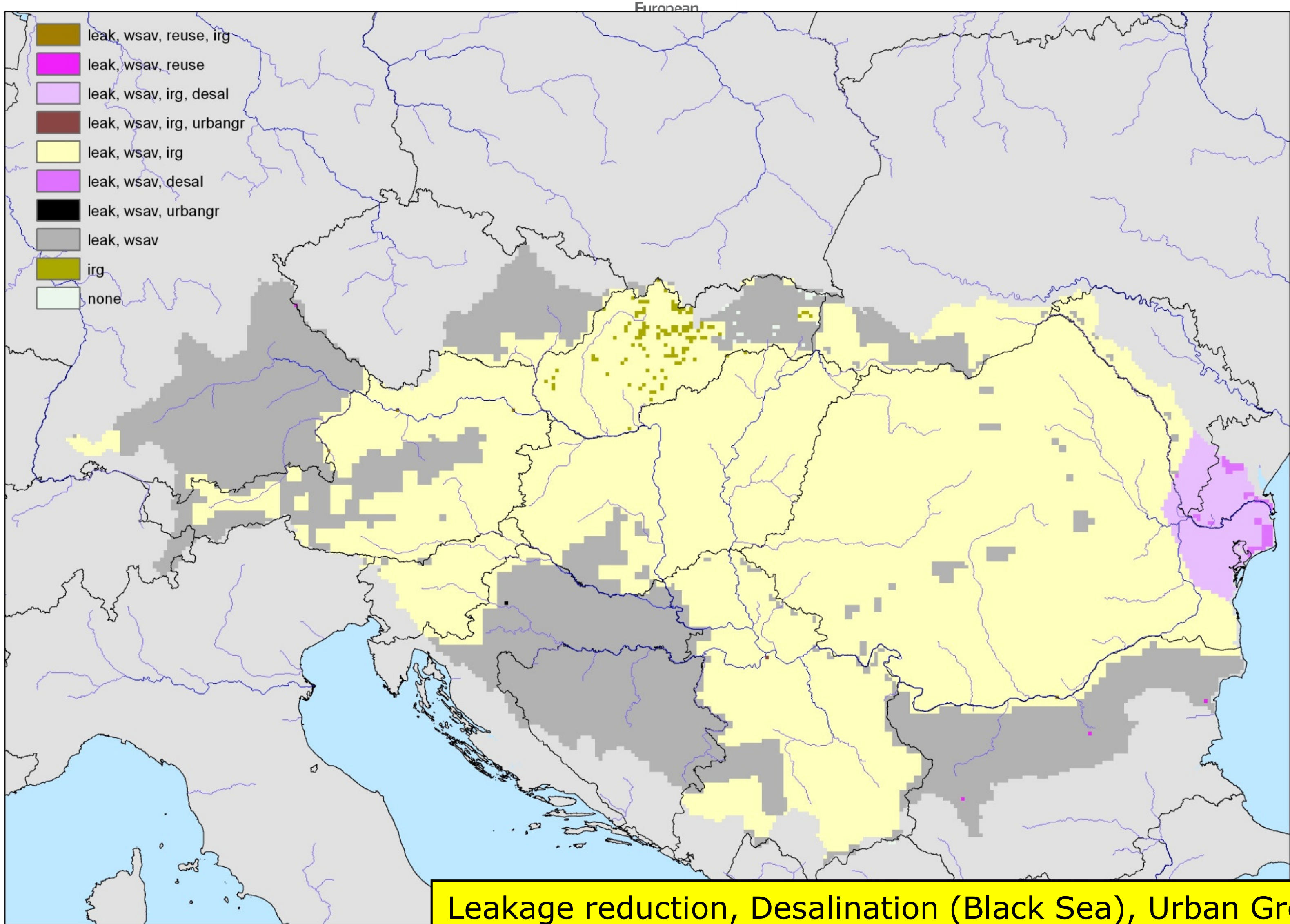


1. Point A and B same investment but point B has better Env. quality – I chose B
2. Point C and B same Env. quality but C needs higher investment – I chose B



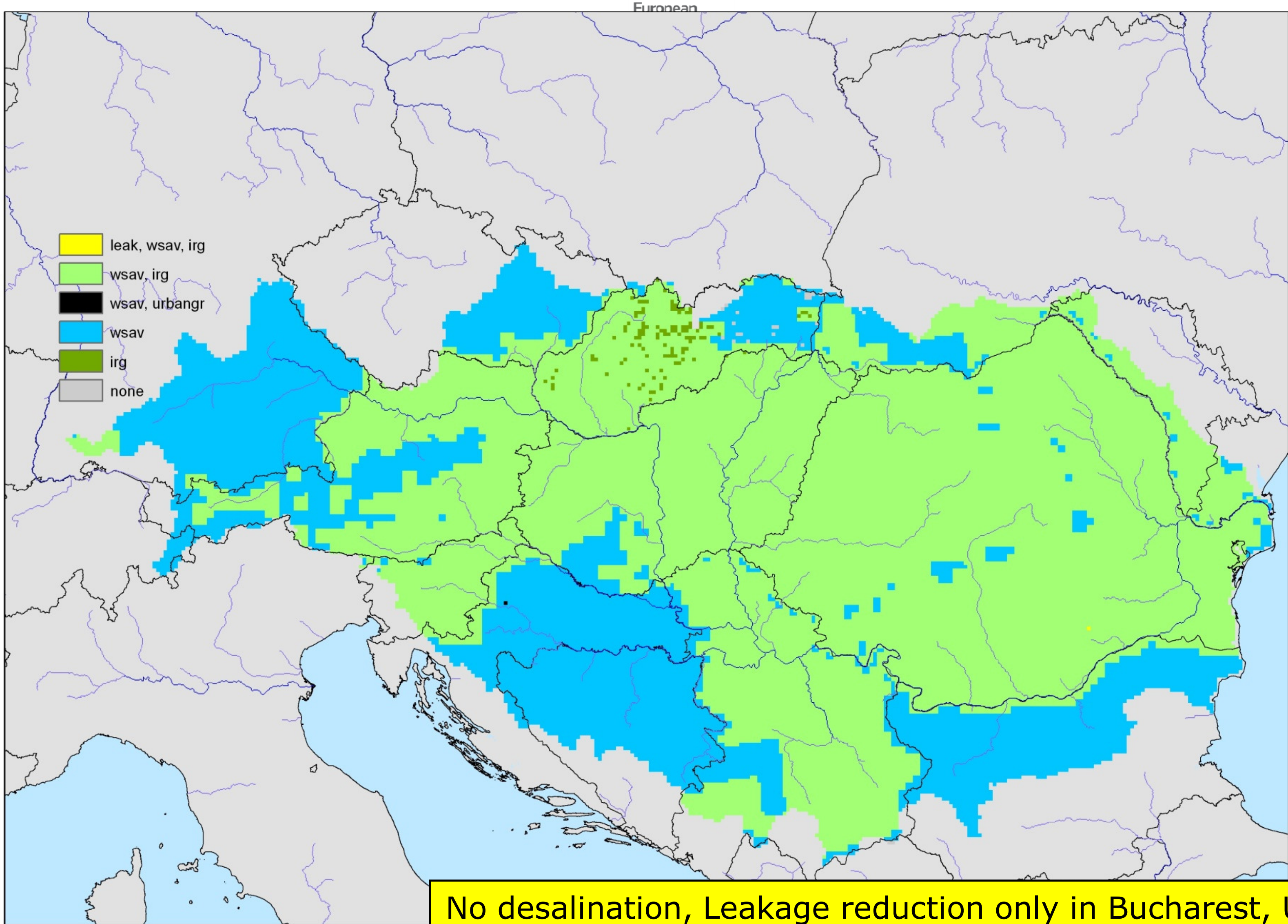
1. Point A is better choice compare with points B-C-D-E
2. The situation is less clear when you are looking to the point A and A'. A is lower Cost, but A' is better ENVIRONMENTAL quality…both options are valid choices.

Danube: scenario-combination C47



Leakage reduction, Desalination (Black Sea), Urban Greening in Zagreb and Belgrade, Re-Use of Water in Industry in Bulgaria, irrigation water use efficiency, and water savings in households

Danube: scenario-combination C71



No desalination, Leakage reduction only in Bucharest, Urban Greening only in Zagreb, no water-re-use in industry in Bulgaria

Danube Water Nexus Meeting

16 & 17 January 2014

JRC Ispra

Aim of project

The project Danube Water-Agriculture-Energy-Ecosystems Nexus (Danube Water Nexus) aims to provide input to decision makers (EC DG's: ENV, REGIO, CLIMA, AGRI) and managers in the region about ***sustainable futures*** *of water resources usage.*

Agenda 16 January

09:30	*Start & Welcome; Tour De Table*
09:45	*Giovanni Bidoglio (JRC): Update of the Danube Nexus*
10:10	*Ad De Roo (JRC): Update of the technical work: case studies and expert studies*
10:30	***Coffee break***
11:00	*Faycal Bouraoui (JRC): Water quality modelling in the Danube with SWAT*
11:30	*Arnaud Renaud (JRC): Economic Analysis of Residential Water Use in the Danube: Data, Methods and Preliminary Results*
12:00	*Andrej Ceglar, Faycal Bouraoui (JRC): Agriculture and Irrigation water requirements*
12:30	***Lunch***
14:15	*Ad de Roo (JRC): Overview of current data availability at JRC to support the Danube Nexus work*
14:30	*Past & current modelling studies Danube*
15:00	*Scenarios*
15:30	***Coffee Break***
16:00	*Sediment*
16:30	*Case Study: Prut/Siret*
17:00	*Groundwater*

Agenda 17 January

09:00	*Water Quality (Exp: Lea Mrafkova)*
09:30	*Navigation (Exp: Anja Scholten)*
10:00	*Case Study: Tisza (Exp: Miodrag Milovanovic)*
10:30	***Coffee break***
11:00	*Case Study: Sava (Exp: Ales Bizjak)*
11:30	*Way Forward*
12:30	***Lunch***
14:00	***End of meeting / Travel to airport***

Multi-criteria hydro-economic optimisation of water resources in Europe

supporting the EU Blueprint to safeguard Europe's waters & the Danube Strategy

Prof. Dr. Ad de Roo[1,2], Dr. Giovanni Bidoglio[1], et al.

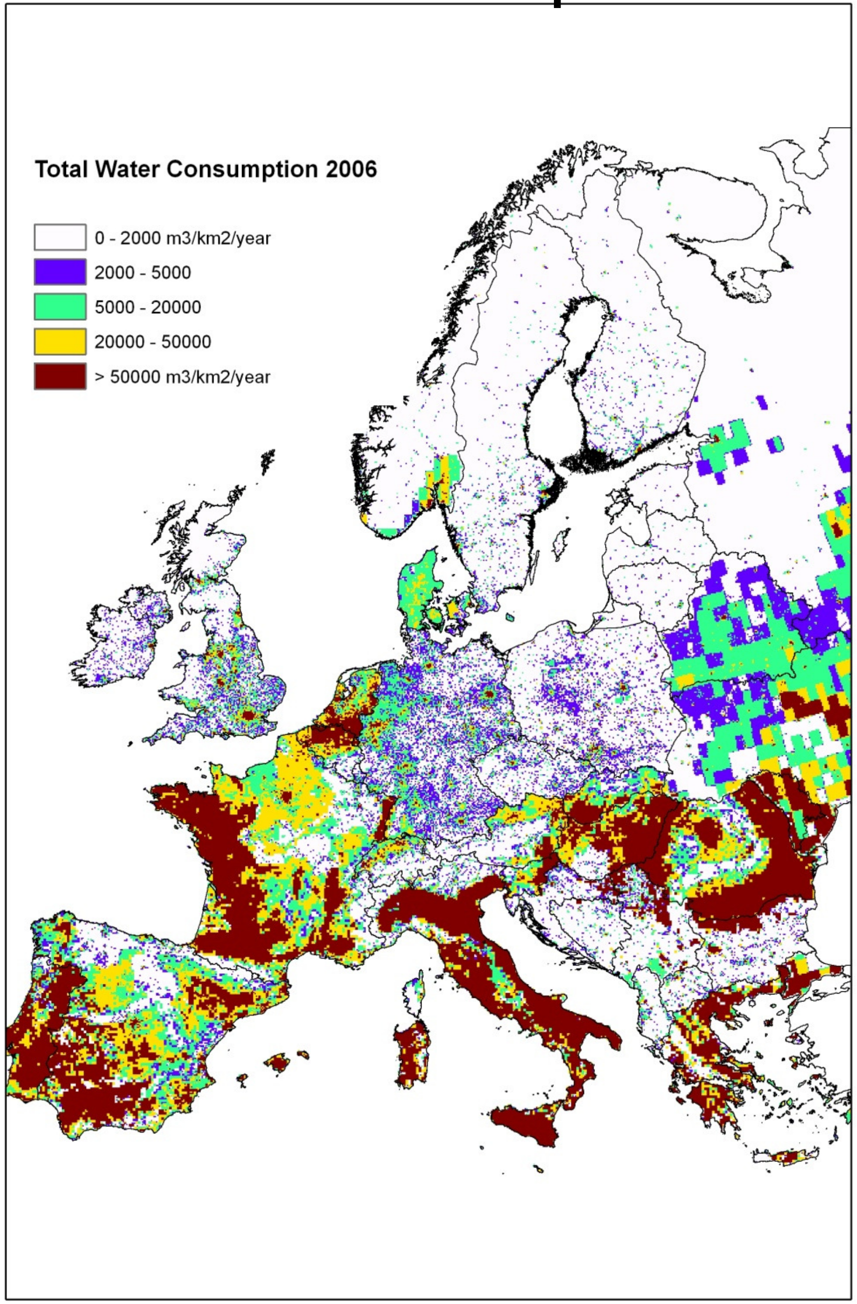
[1]European Commission, Joint Research Centre
[2]Faculty of Earth Sciences, Utrecht University

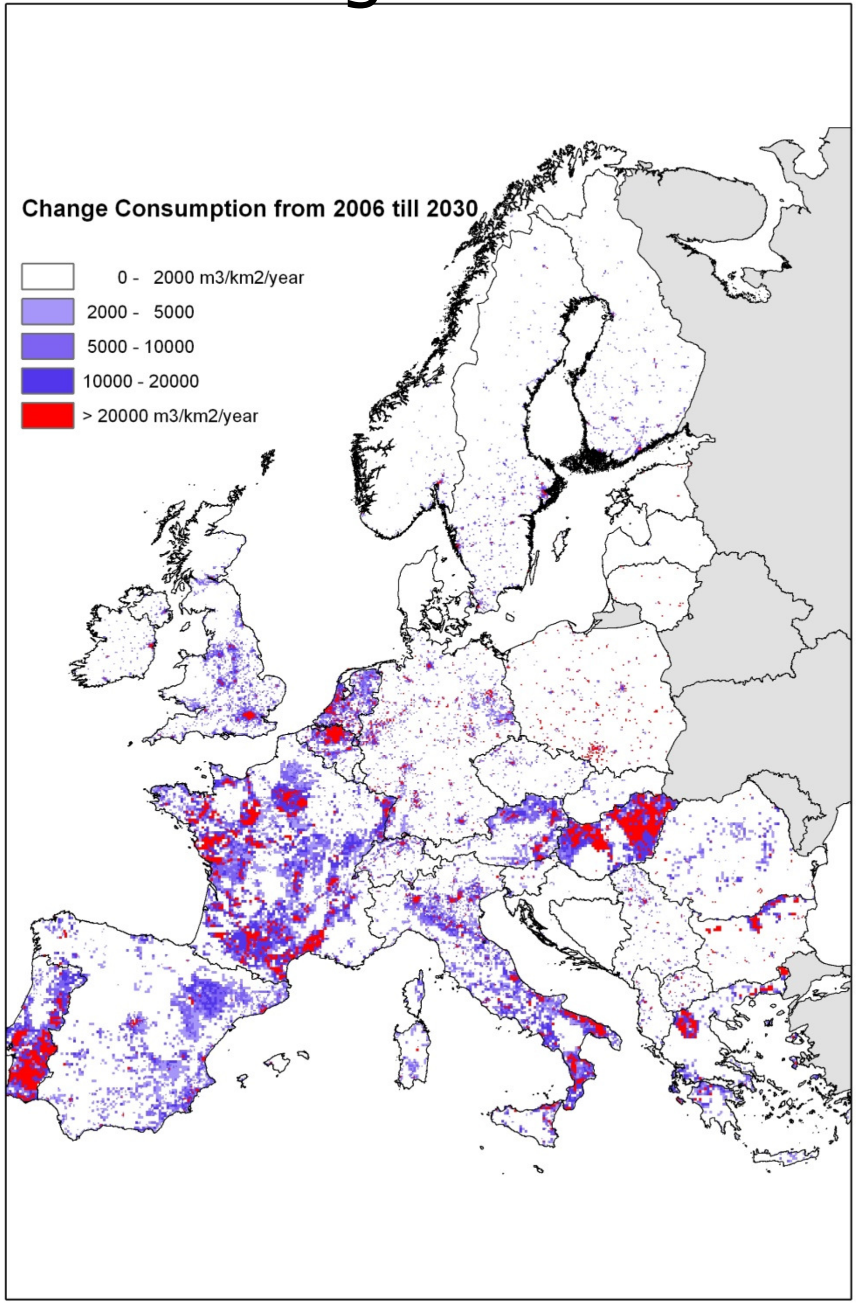
European Commission

Grand challenge:

Match water demand with supply

Water consumption 2006 and changes until 2030

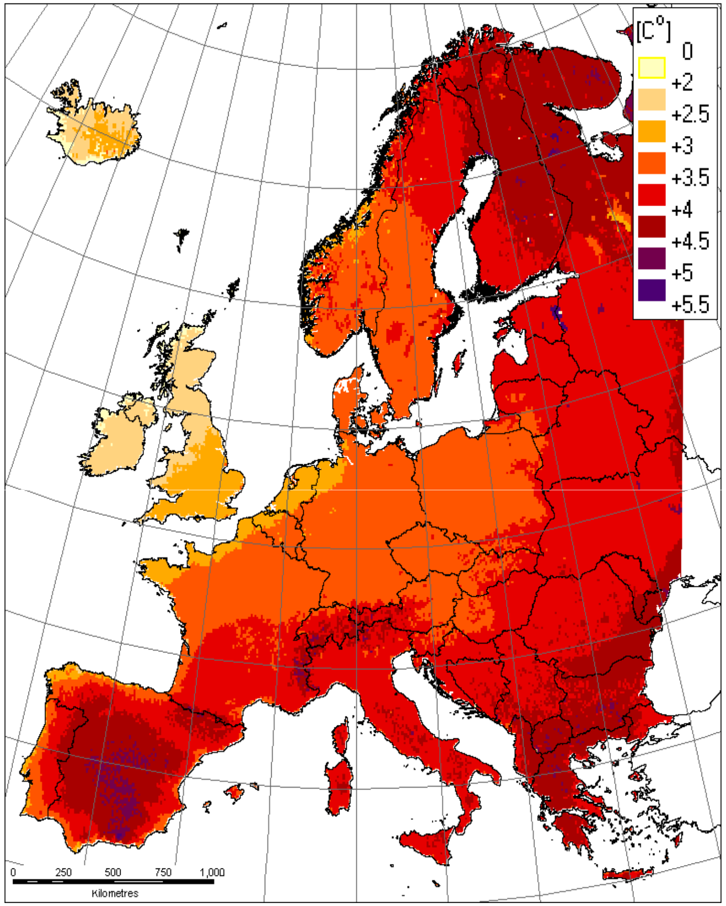




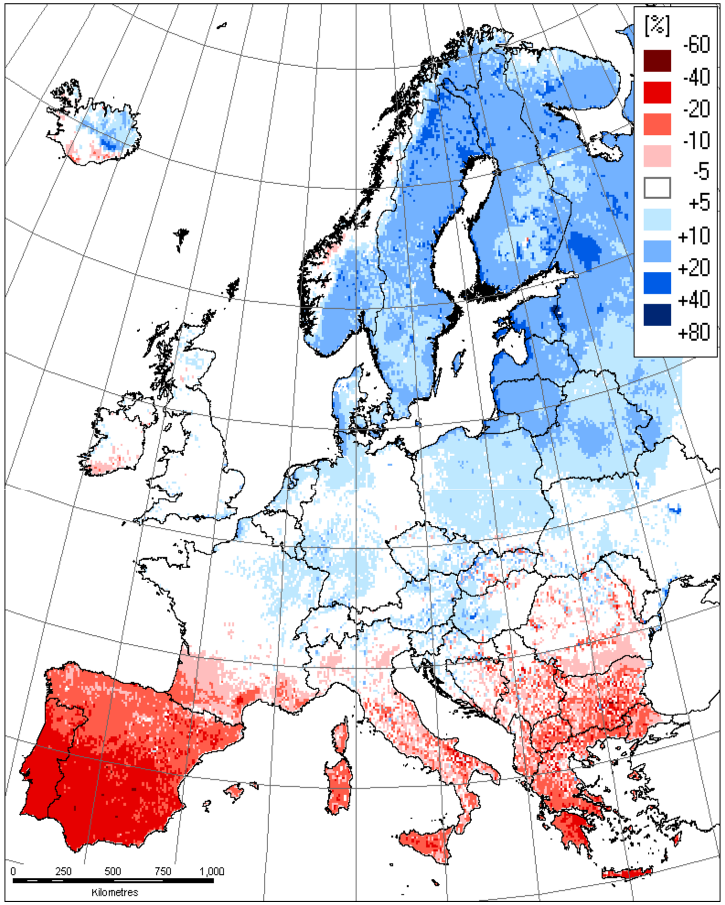
Not only society changes, but the climate changes as well….

European Commission

Temperature: change in mean annual temperature [C°]

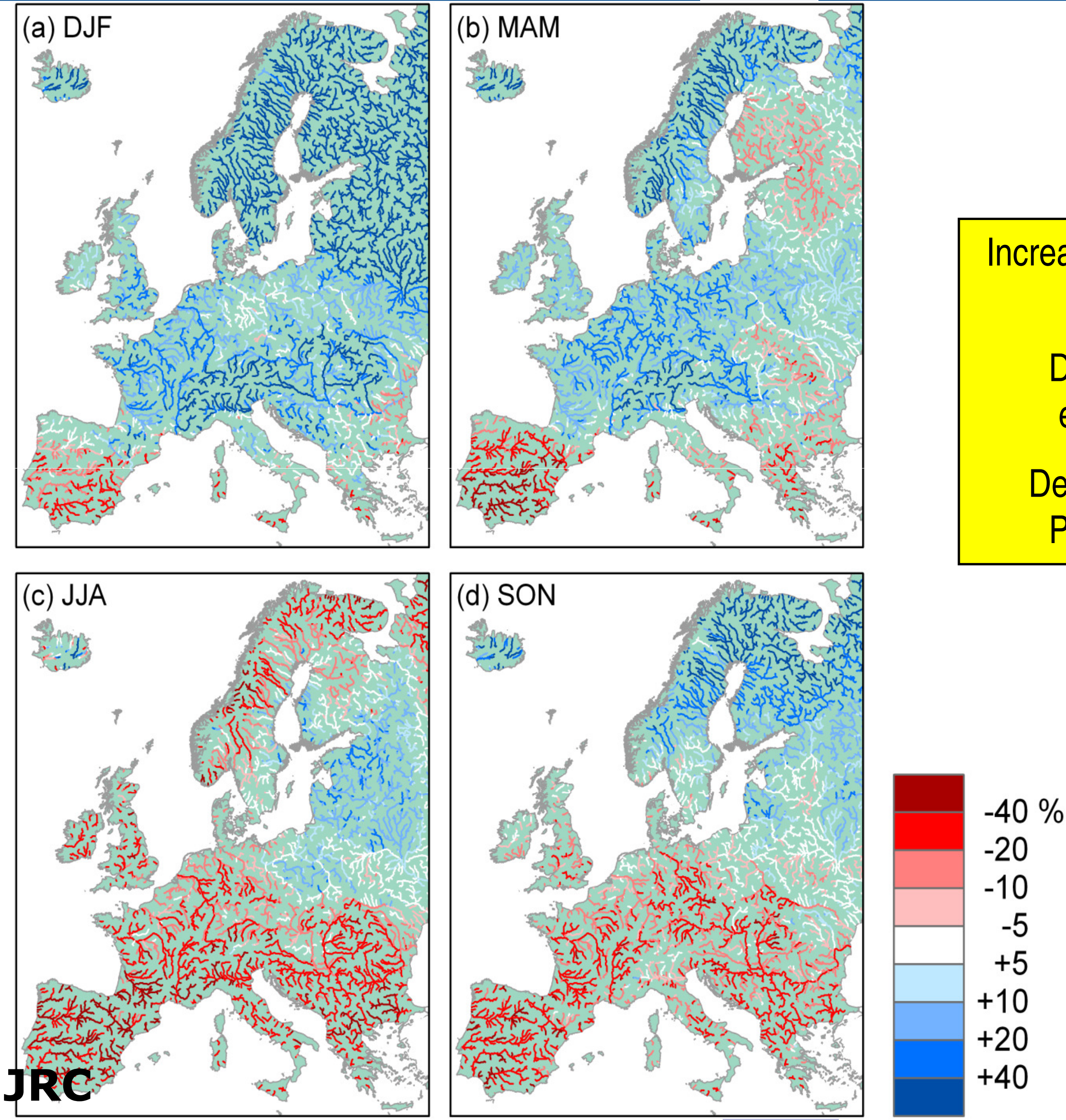


Precipitation: change in annual amount [%]



Expected changes in average temperature and annual precipitation 2070-2100 as compared to 1960-1990

Climate change effects on river flow:
hydrological model simulations with bias-corrected climate scenarios forcing



changing amounts of available water, with regional and seasonal variations

Increase of river flow in winter and spring in Central and N-NE Europe

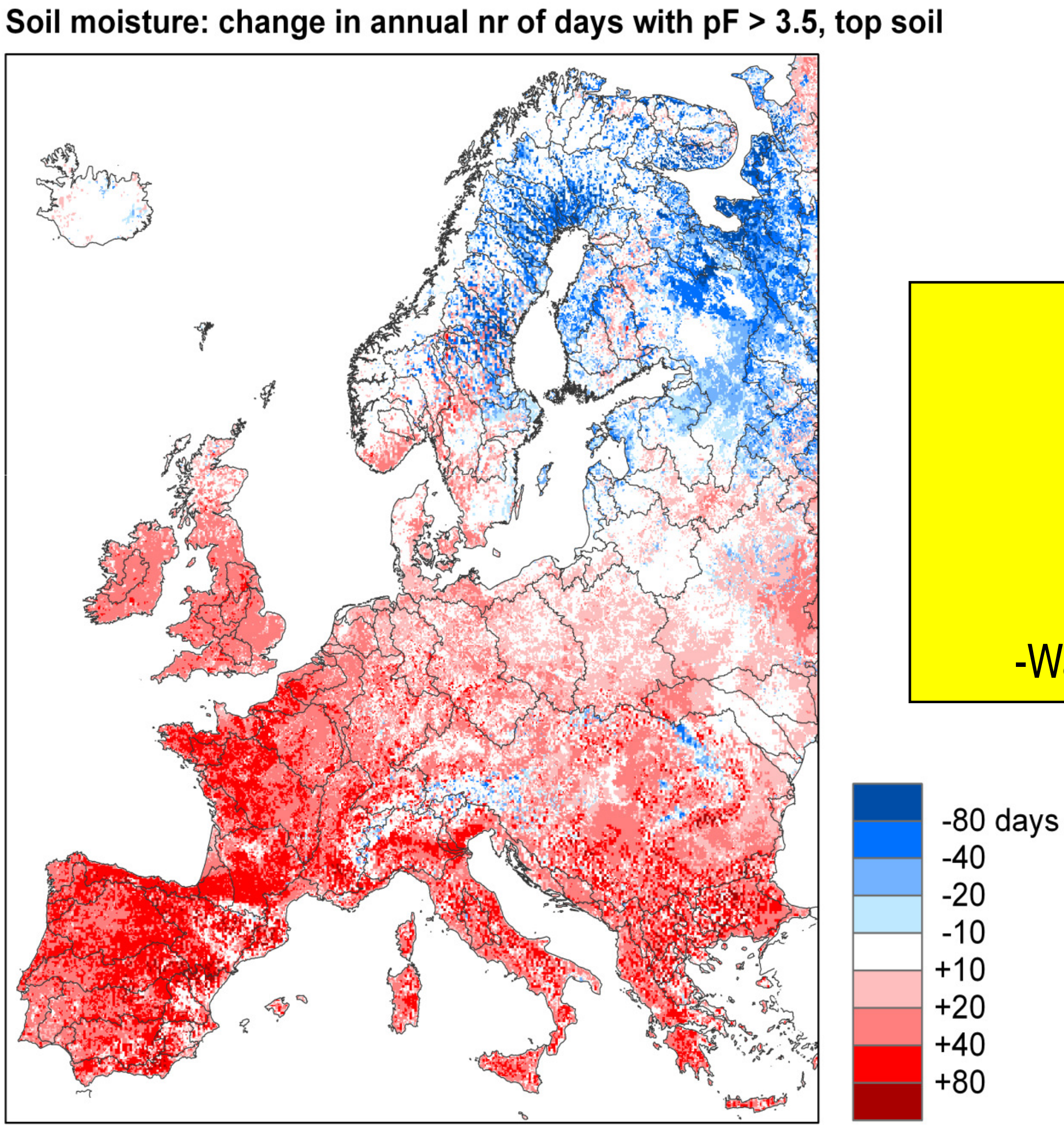
Decrease of summer discharge, everywhere except NE Europe

Decrease in ALL seasons in Spain, Portugal, Southern Italy, Greece

Consequences:

- Flood Hazard
- River Transport (low flows)
- Hydropower (energy production)

Climate change effects on soil moisture: changing # of days/year with extreme dry soils (pF >3.5)



Consequences:

-Agriculture

-Forest Fire Hazard

- Environment

-Water Availability (scarcity)

Added to Water Framework Directive & Floods Directive:

European Commission

2012 EU Water Blueprint:
The water milestone in the 2020 Roadmap to a Resource Efficient Europe

EUROPEAN COMMISSION

Brussels, 14.11.2012
SWD(2012) 381 final

COMMISSION STAFF WORKING DOCUMENT

EXECUTIVE SUMMARY OF THE IMPACT ASSESSMENT

Accompanying the document

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

A Blueprint to Safeguard Europe's Water Resources

Ensure sufficient availability of good quality water for sustainable and equitable water use

- Efficient water use
- Resilience to extreme events
- Good Ecological Status

- Integration
- Economic instruments
- Governance
- Knowledge base

https://dl.dropbox.com/u/21190688/EUR25551EN_JRC_Blueprint_NWRM.pdf

https://dl.dropbox.com/u/21190688/EUR25552EN_JRC_Blueprint_Optimisation_Study.pdf

European Commission

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JRC SCIENTIFIC AND POLICY REPORTS

Evaluation of the effectiveness of Natural Water Retention Measures

Support to the EU Blueprint to Safeguard Europe's Waters

Peter Burek, Sarah Mubareka, Rodrigo Rojas, Ad de Roo, Alessandra Bianchi, Claudia Baranzelli, Carlo Lavalle, Ine Vandecasteele

2012

Report EUR 25551 EN

Joint Research Centre

European Commission

JRC SCIENTIFIC AND POLICY REPORTS

A multi-criteria optimisation of scenarios for the protection of water resources in Europe

Support to the EU Blueprint to Safeguard Europe's Waters

Ad de Roo, Peter Burek, Alessandro Gentile, Angel Udias, Faycal Bouraoui, Alberto Aloe, Alessandra Bianchi, Alessandra La Notte, Onno Kuik, Javier Elorza Tenreiro, Ine Vandecasteele, Sarah Mubareka, Claudia Baranzelli, Marcel Van Der Perk, Carlo Lavalle, Giovanni Bidoglio

2012

Report EUR 25552 EN

Joint Research Centre

Aim of EC/JRC studies:

Aim is to stimulate EU countries to increase the efficiency of water use by 2020/2030, e.g:

- **Increasing irrigation water efficiency**
- **Increasing water savings in households**
- **Water re-use in industry/agriculture, etc**

& explore pro's and con's of other options:

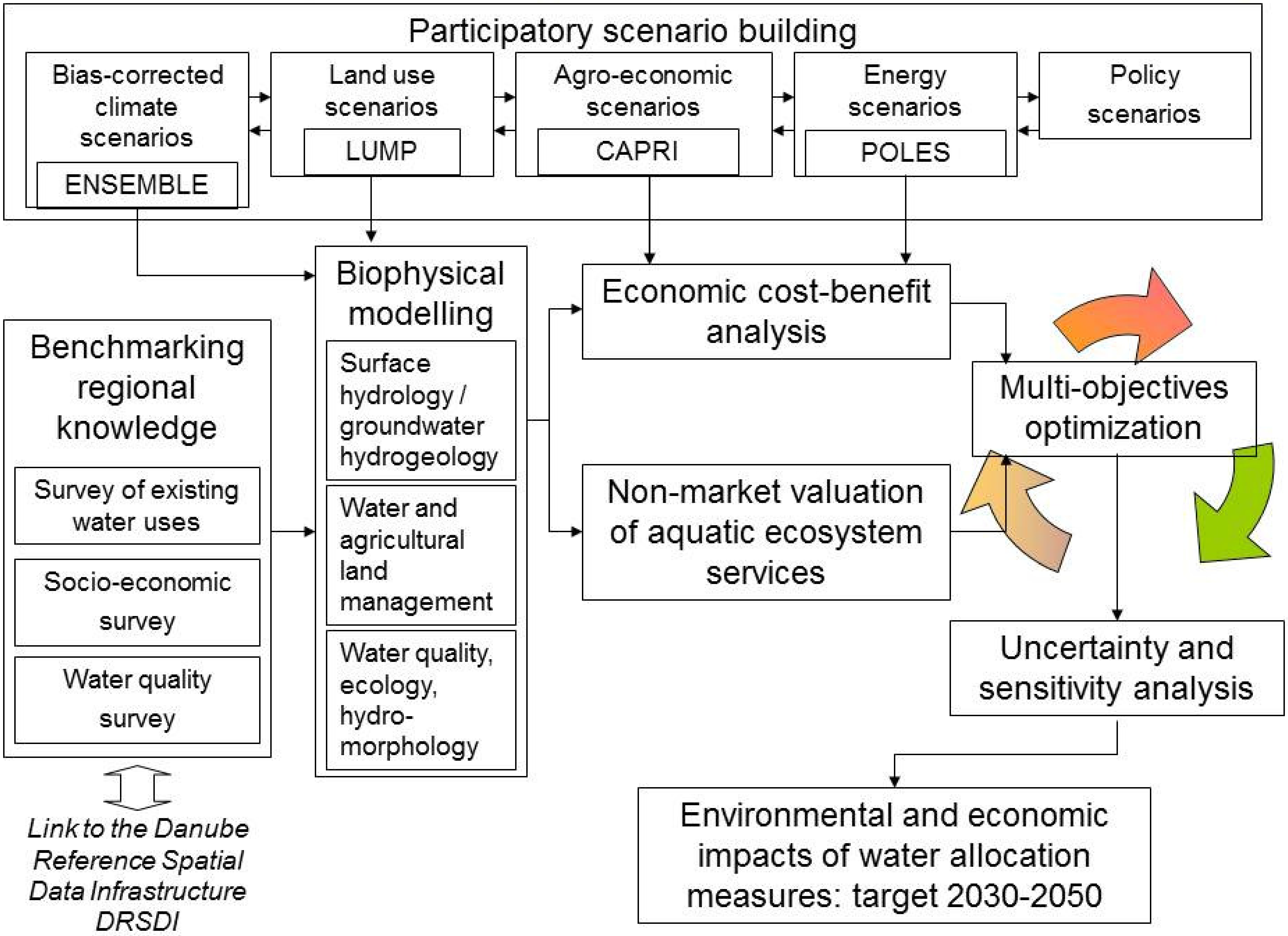
- **Desalination**
- **Reducing leakage from water supply**
- **Large distance water transfers between basins**
- **Water pricing**

& and at the same time:

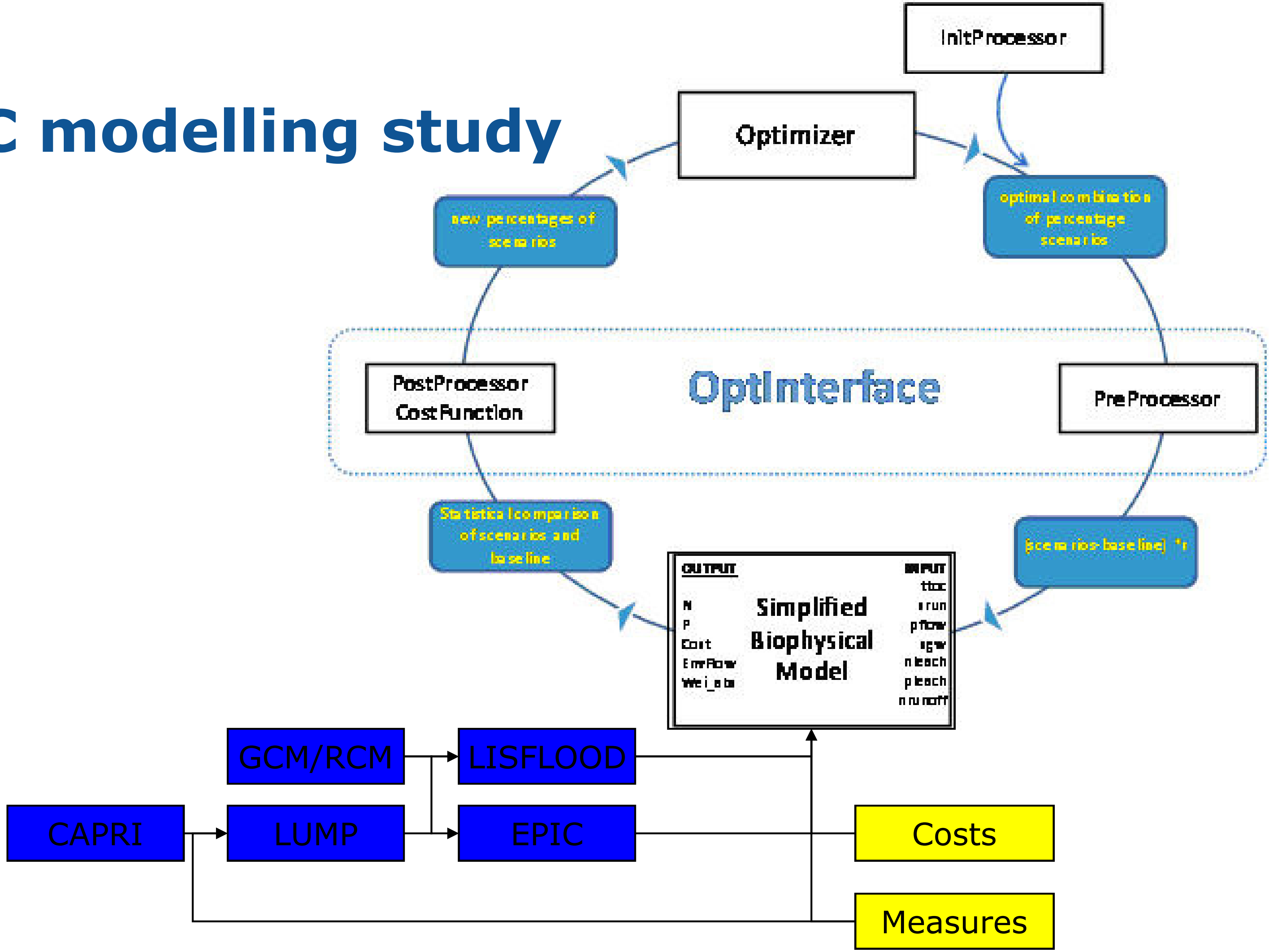
- **Reduce flood risk, if possible through natural water retention measures**
- **Have sufficient water for all economic sectors**
- **Respect 'environmental flow' conditions**
- **Maintain 'good ecological status' (WFD)**
- **Take into account costs & benefits**

& while respecting & taking into account:

- **Common Agricultural Policy & crop yield targets (CAPRI)**
- **Expected population growth [redacted] and economic growth (LUMP)**


Participatory scenario building
Bias-corrected climate scenarios
ENSEMBLE
Land use scenarios
LUMP
Agro-economic scenarios
CAPRI
Energy scenarios
POLES
Policy scenarios
Biophysical modelling
Surface hydrology / groundwater hydrogeology
Water and agricultural land management
Water quality, ecology, hydro-morphology
Benchmarking regional knowledge
Survey of existing water uses
Socio-economic survey
Water quality survey
Link to the Danube Reference Spatial Data Infrastructure DRSDI
Economic cost-benefit analysis
Non-market valuation of aquatic ecosystem services
Multi-objectives optimization
Uncertainty and sensitivity analysis
Environmental and economic impacts of water allocation measures: target 2030-2050

JRC modelling study



JRC LUMP Land Use Modelling Platform

European
Commission

using the land use model
Eu-ClueScanner (JRC)

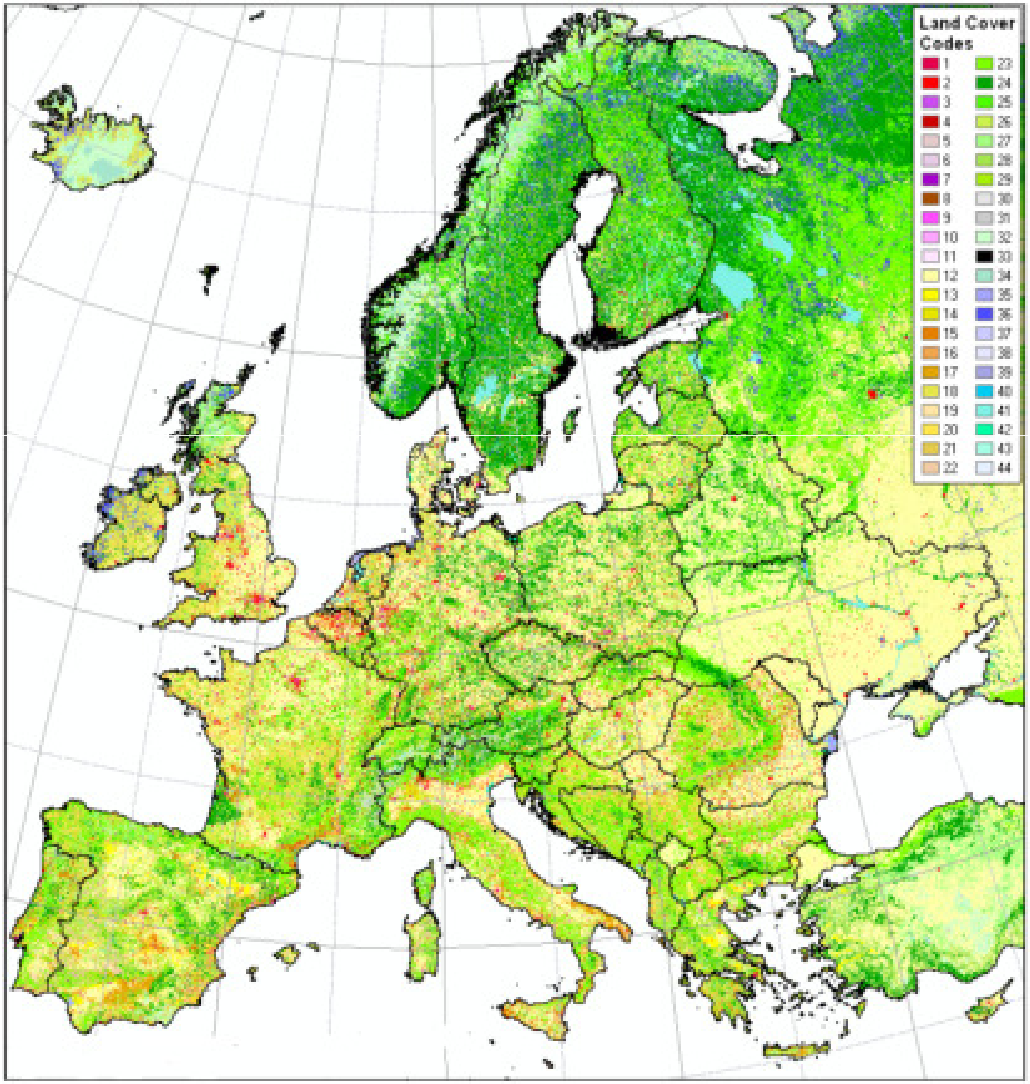
Land use / land cover change
scenarios until 2030

Common Agricultural Policy (CAP)
consistent (using CAPRI boundary
conditions for 2030)

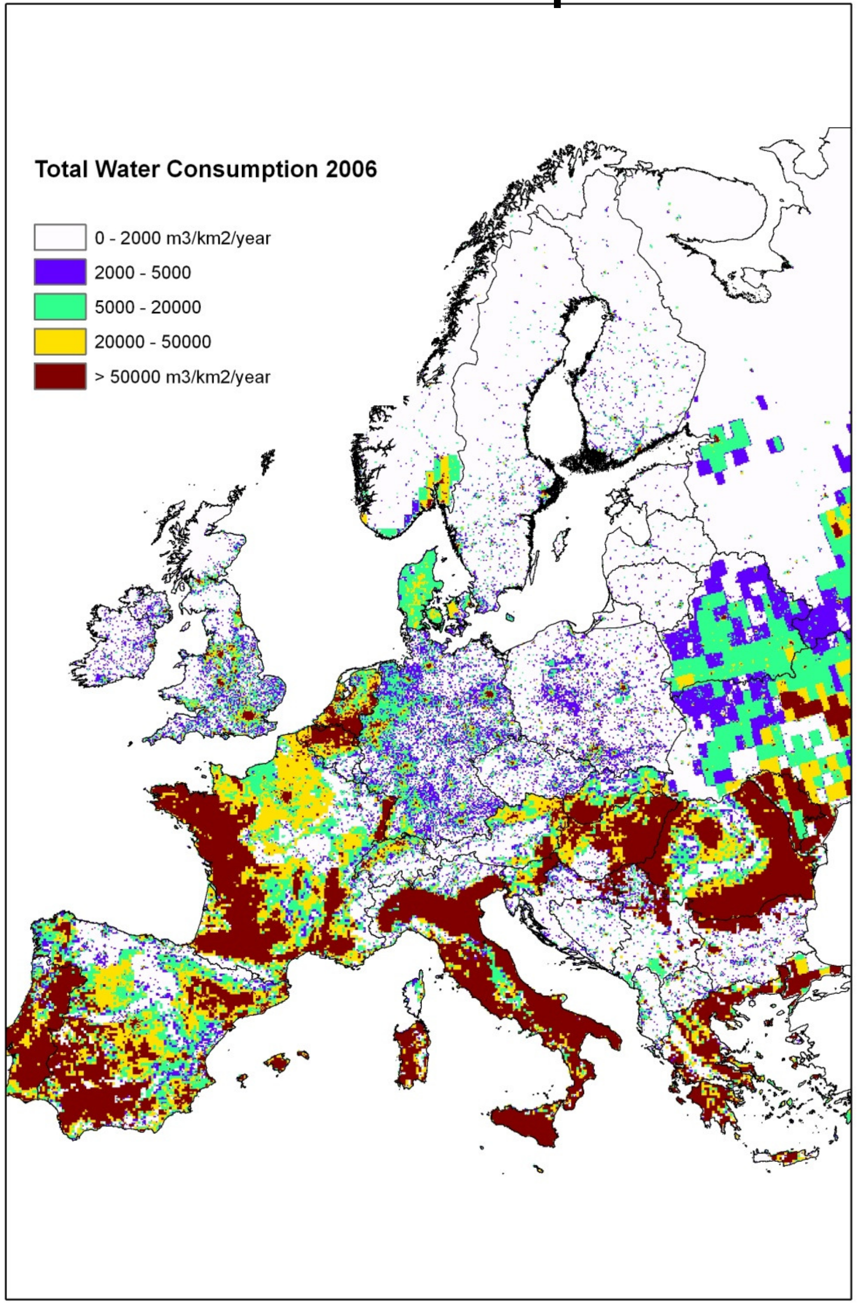
Socio-Economic data used from
Eurostat

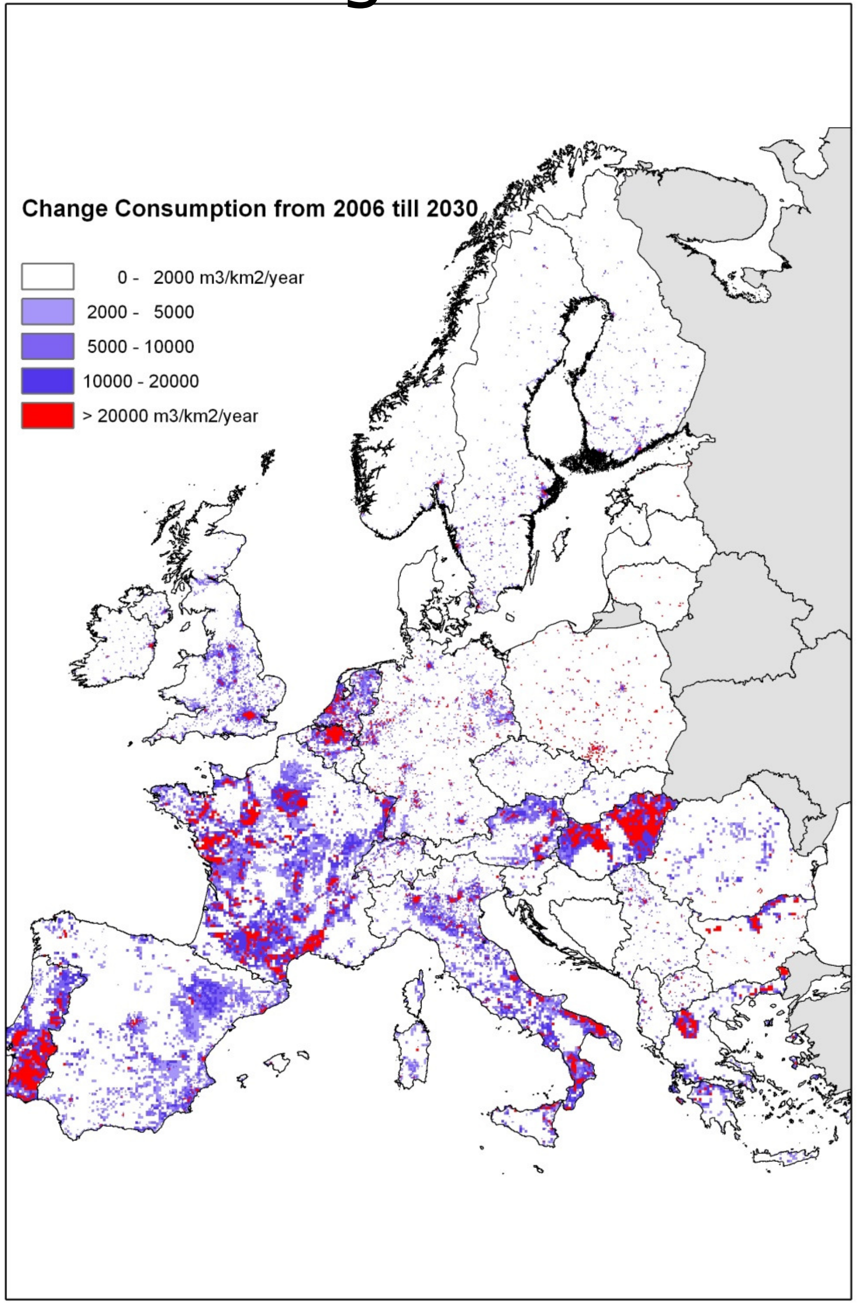
100m spatial resolution

Pan-European



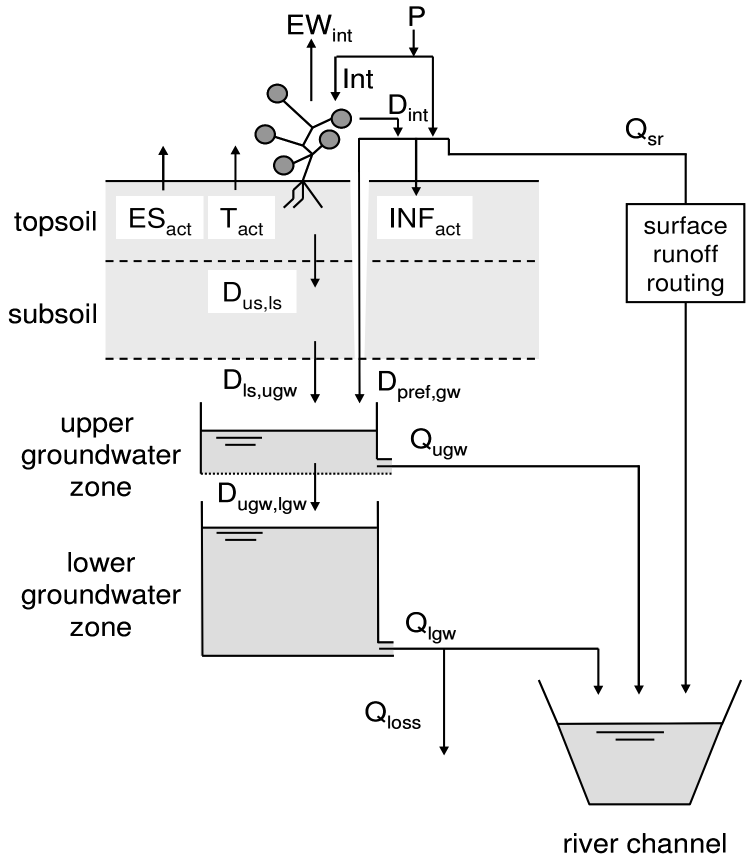
Water consumption 2006 and changes until 2030





European Commission

Hydrological model LISFLOOD

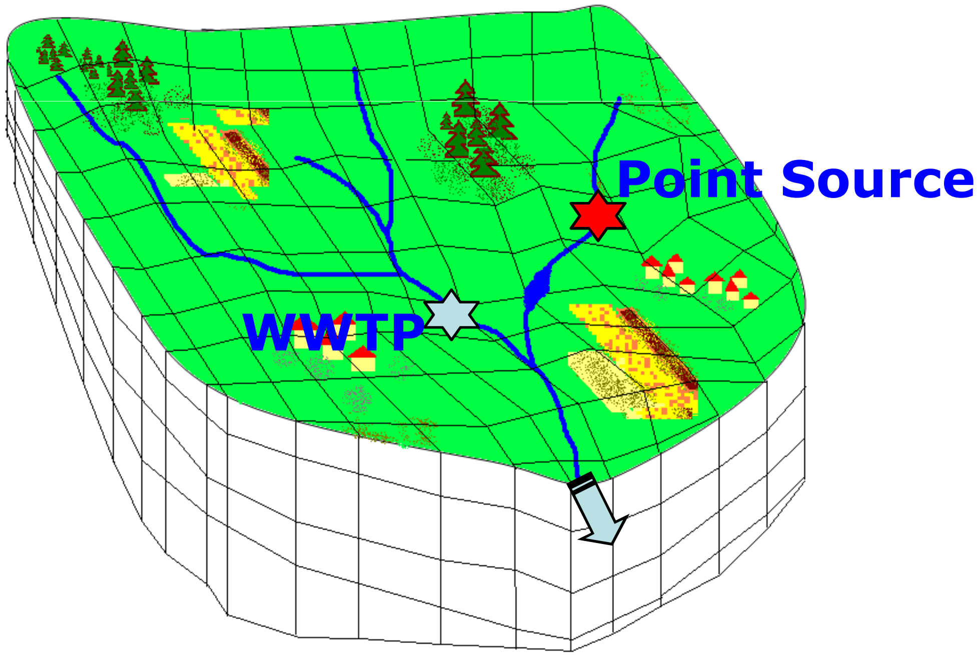


The LISQUAL model

European Commission

distributed routing model for Q, N and P, with decay functions and point sources, water scarcity indicators, and including functions to estimate monetary loss due to water scarcity

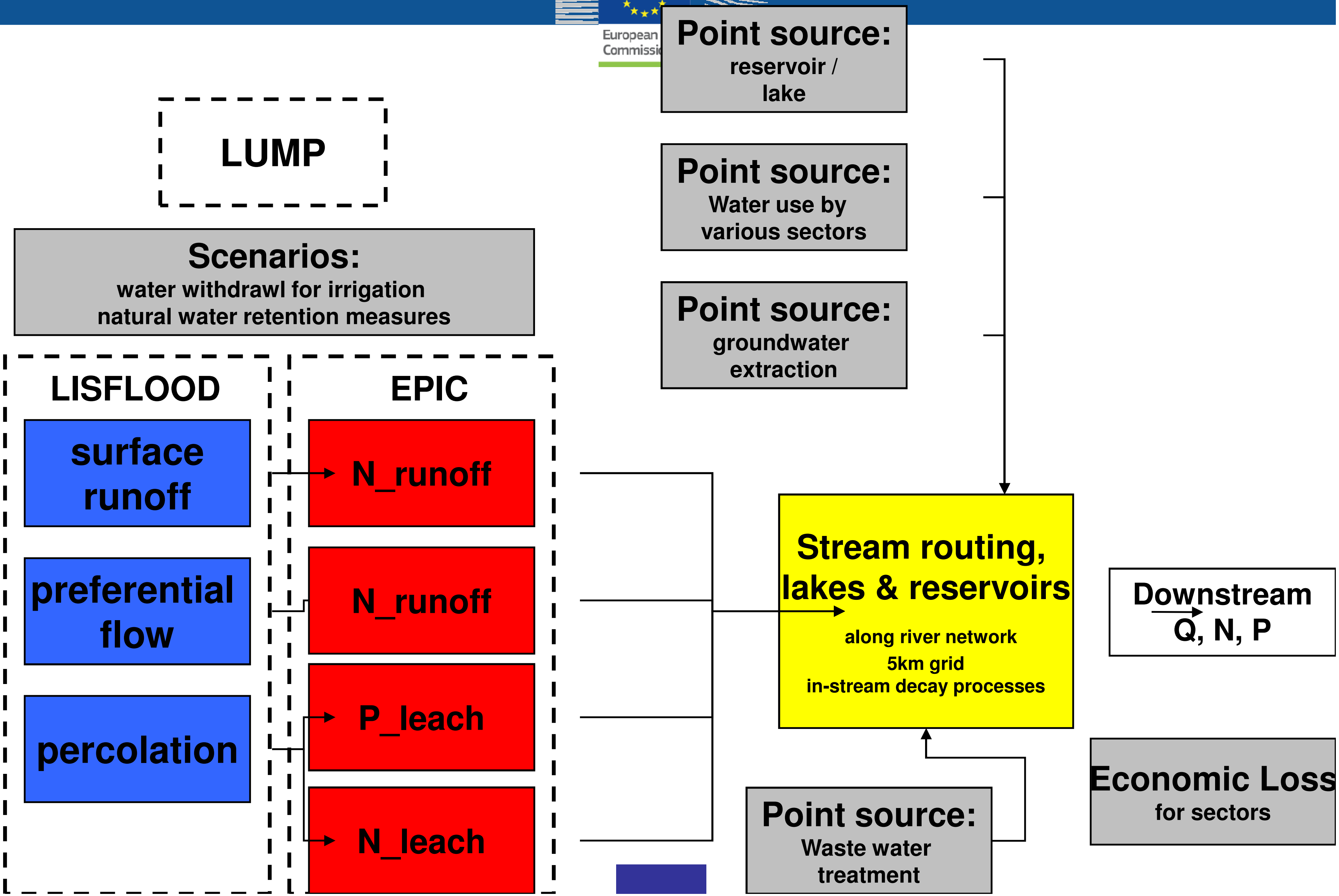
Q, N, P daily local fluxes from LISFLOOD & EPIC



Spatial resolution : 5 x 5 km for Europe (with sub-grid info)

Calibration parameters are uniform over each sub-basin

LISQUAL bio-physical model



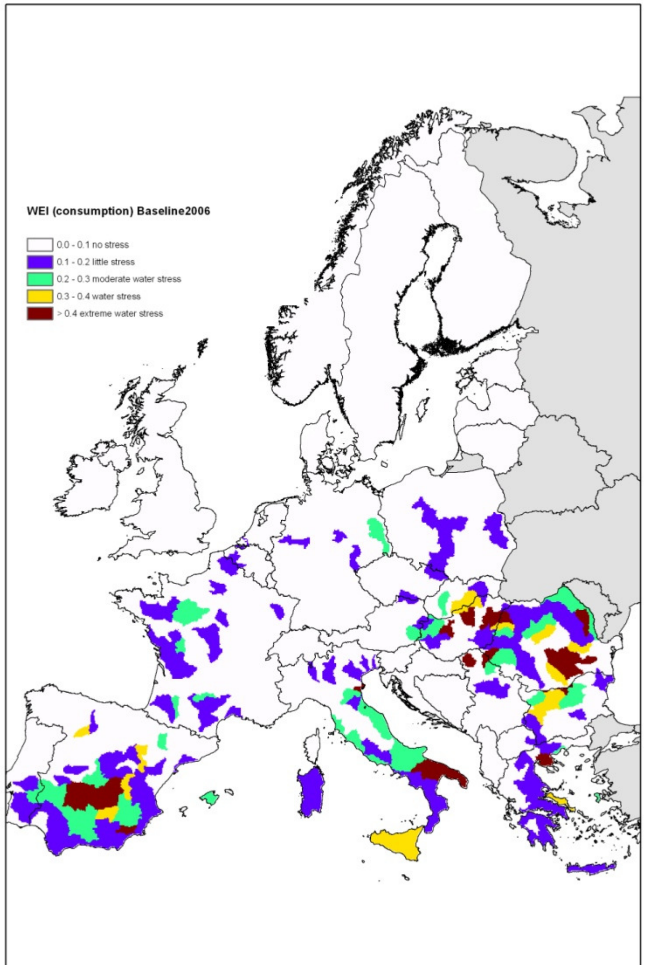
Example LISQUAL outputs

- **River discharge (daily, m3/s, spatial)**
  - flood damage (using 100m SRTM & landuse in post-processing)
- **Nitrate concentration (daily, mg/l, spatial)**
- **Phosphorous concentration (daily, mg/l, spatial)**
- **Environmental Flow indicator (daily, spatial)**
  - 10^{th} percentile monthly flows (spatial)
  - 25^{th} percentile monthly flows (spatial)
- **Water Exploitation Index (1 Oct – 1 Oct) (annual, regions)**
  - abstraction / available water
  - consumption / available water
- **Economic Loss (annual, million Euros, regions)**
  - domestic sector
  - industry/manufacturing sector
  - energy sector
  - irrigation

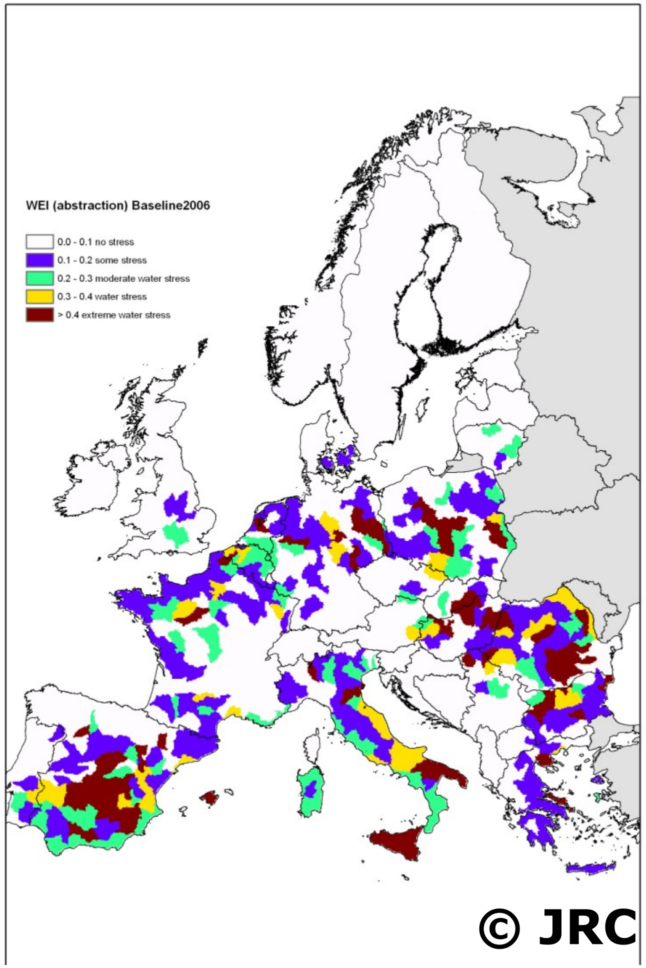
LISQUAL output: Water Exploitation Index

WEIcns= (Abstraction – ReturnFlow) / (Local runoff + Incoming runoff)

WEIcns (WEI+, consumption only)



WEIabs (abstraction only)



Scenarios (1)

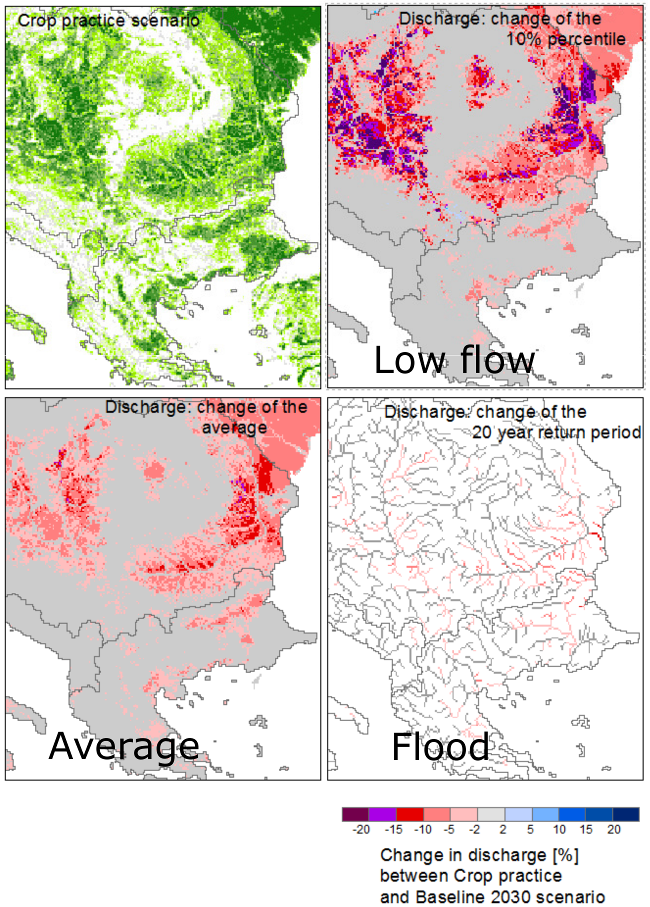
Category	Scenario	Description
BASELINE2030	0.0 Baseline 2030	LUMP 2030, 2010 fertilisation application, 2010 point sources
BASELINE2006	0.1 Baseline 2006	As Baseline 2030, but with Landuse 2006
1-FOREST	1.1 Riparian Afforestation, CAP consistent	Afforest areas from LUMP-CAP scenarios
	1.2 Afforestation in mountainous areas	Afforest areas in mountainous areas (LUMP)
2-URBAN	2.1 50% Green	Green infrastucture, Green roofs, Rain Gardens, Park Depressions; For all urban areas: Direct Runoff Fraction << 50%, Evapotanspiration >> 50%
	2.2 25% Green	Green infrastucture, Green roofs, Rain Gardens, Park Depressions; For all urban areas: Direct Runoff Fraction << 25%, Evapotanspiration >> 25%
3-AGRICULTURE	3.1 Grassland	Convert areas from LUMP-CAP scenarios to grassland
	3.2 Buffer strips	5m wide grass buffer strips within arable fields, on slopes < 10%, every 200m; 2.5% of arable land converted to grassland, only on slopes < 10%
	3.3 Grassed waterways	10m wide grass-covered areas in valley-bottom; 1% of arable land converted to grassland, in valley-bottoms > 5%
	3.4 Crop practicies	Reverse OM decline and increase mulching; increased infiltration, porosity, modified hydraulic parameters
4-NATURAL RETENTION	4.1 Wetlands	Riparian wetlands along rivers; Change cross section
	4.2 Polders	Introduce flood retention polders along rivers
	4.3 Re-meandering	
	4.4 Buffer ponds in headwater areas 1	natural retention ponds in headwater areas with 5000 m3 storage per 25km2
	4.5 Buffer ponds in headwater areas 2	natural retention ponds in headwater areas with 10000 m3 storage per 25km2
5-NUTRIENTS	5.1 N-fixing winter crops	updated N & P fluxes
	5.2 optimum fertilisation application	updated N & P fluxes

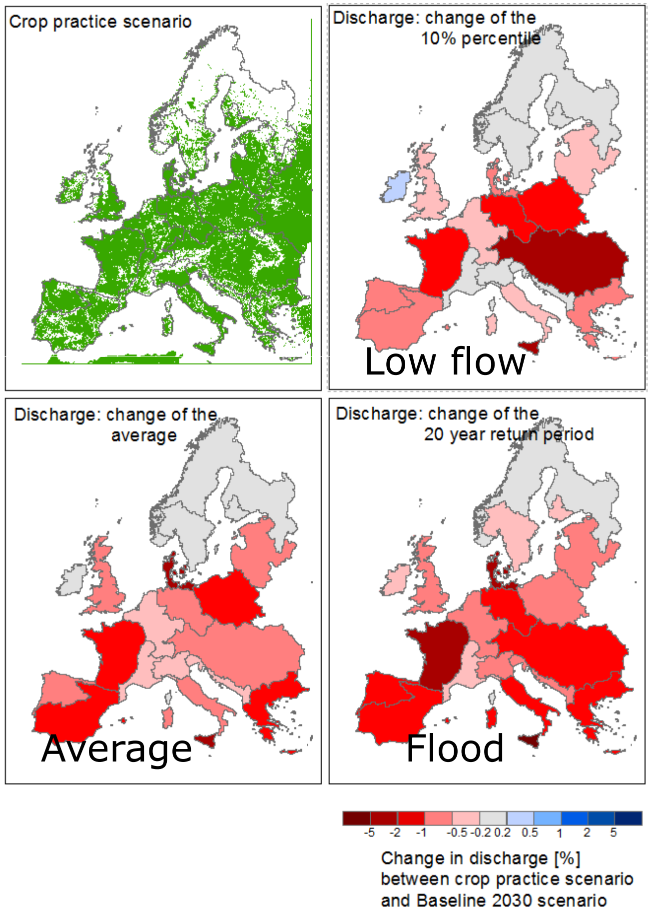
Scenarios (2)

Category	Scenario	Description
6-POINT SOURCES	6.1 New wastewater treatment plants (WWTP)	updated point information
	6.2 Changing type of WWTP	updated point information
7. WATER SUPPLY	7.1 groundwater extraction	updated point water availability
	7.2 desalination	updated point water availability
	7.3 large-scale water-transfer infrastructures	transfer of water between river basins
8. TECHNICAL RETENTION	8.1 constructing dams and reservoirs	new dams/resoirvoir to temporarily store water
	8.2 hard infrastructure for flood risk	
9. EFFICIENCY	9.1 Irrigation management	optimizing crop water requirements
	9.2 Water efficiency in power generation	Save water in power generation, as compared to current use
	9.3 Water efficiency in industrial processes	Save water in industry, as compared to current use
	9.4 Water efficiency in Buildings/households	Save water in households, as compared to current use
	9.5 Leakage reduction 9.6 Wastewater reuse for irrigation	Fix all leakages 90% or 100% (reduce water abstraction) Reduce deep groundwater use for irrigation and replace by treated wastewater

Scenario: changing crop practices

Reducing organic matter decline / mulching / tillage methods

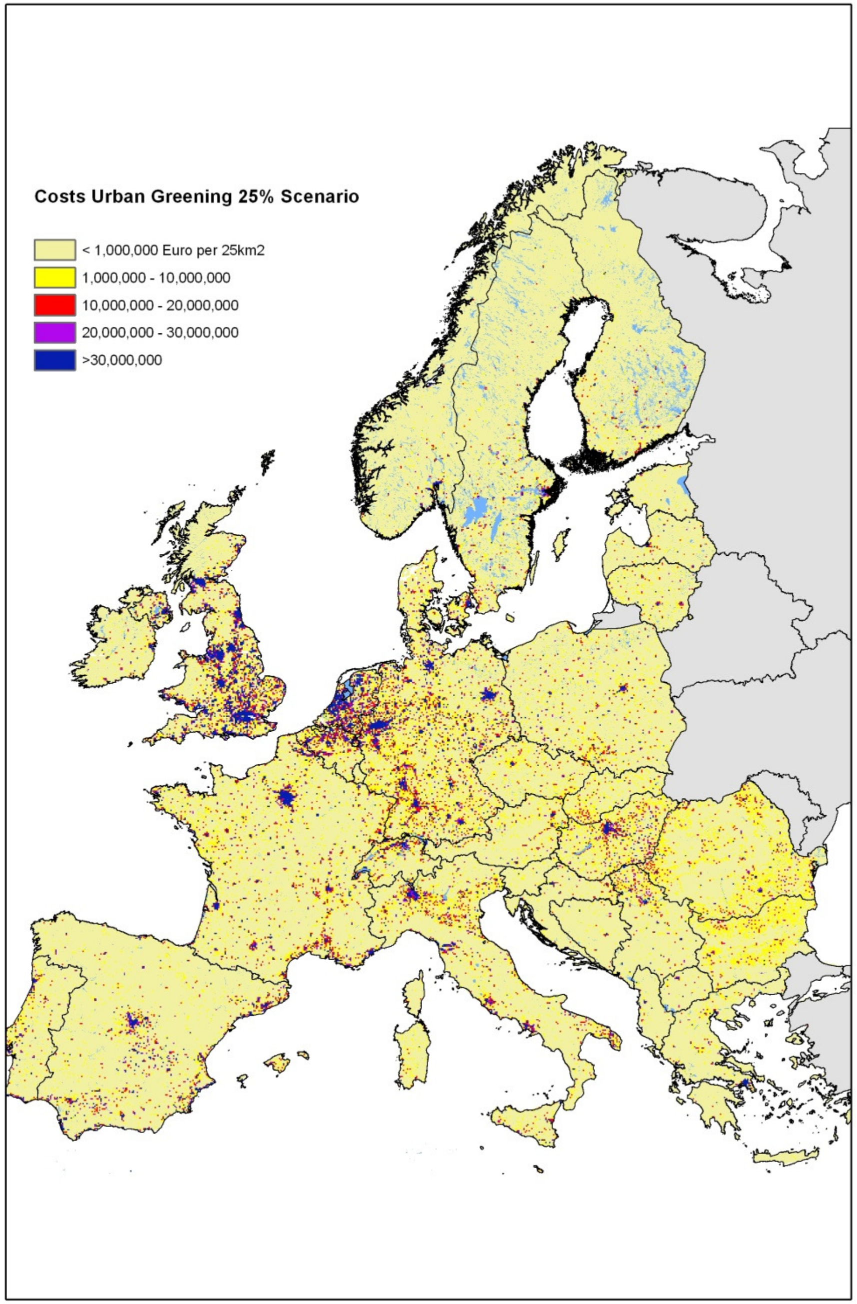


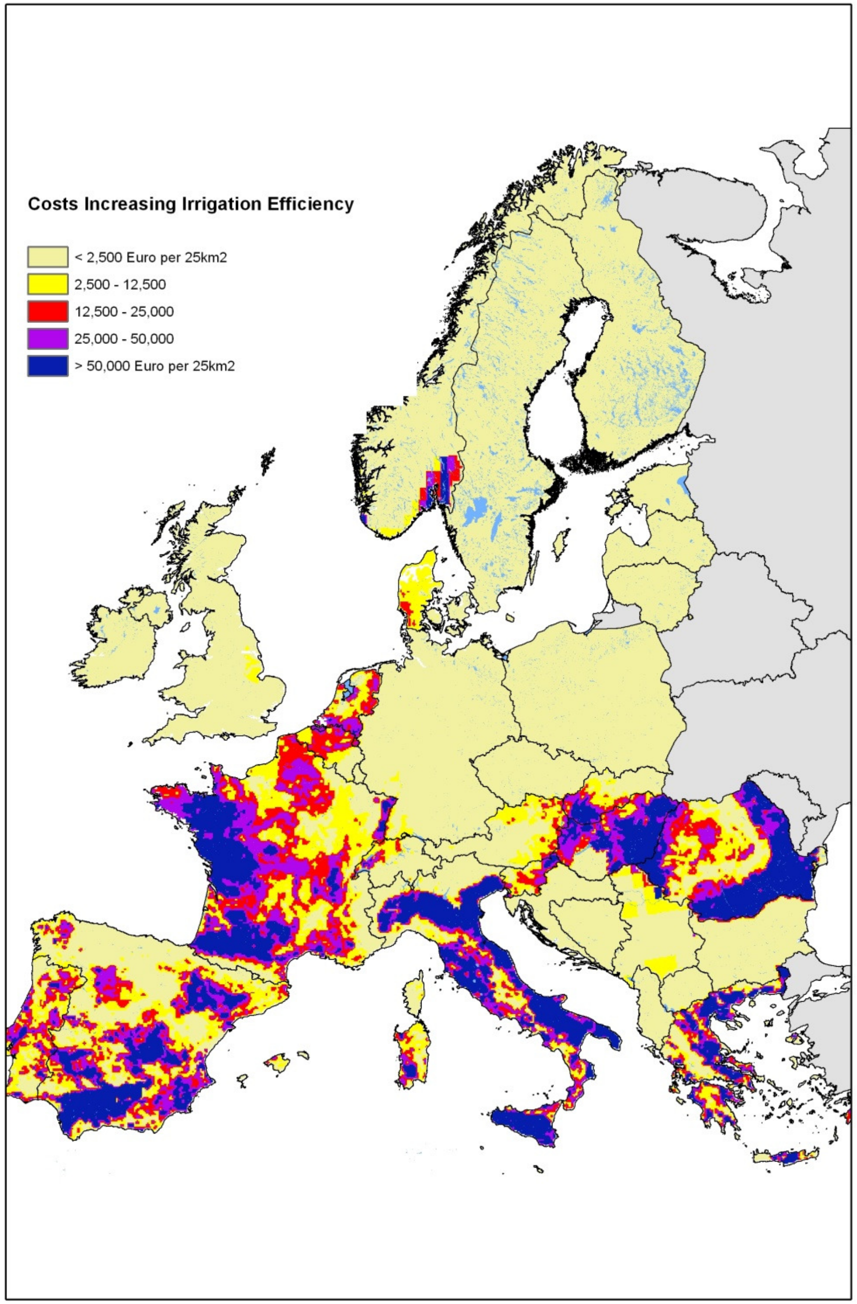


Low flows are reduced up to 40%
Floods are reduced up to 20%

On average discharge is reduced up to 5%

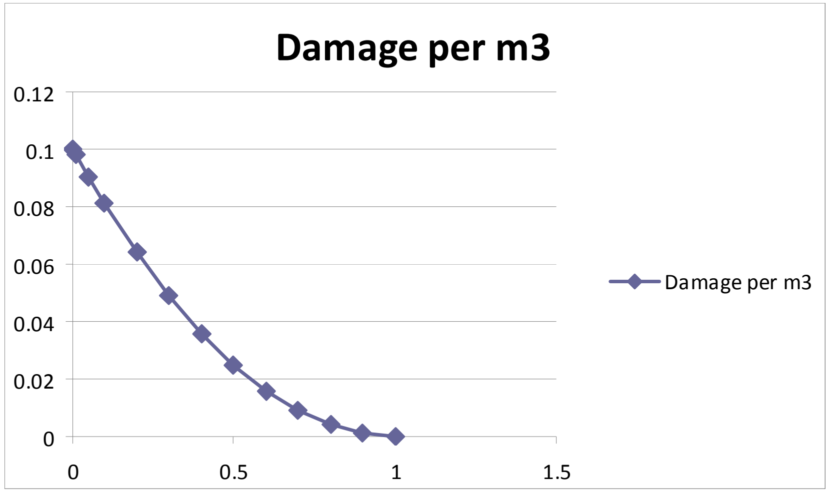
Cost of scenarios





Economic Loss model irrigation

Total water delivered	2.00E+06	m3	based on page 13 of (	
Total damage	200000	Euro		
Ratio	1.00E-01	Euro/m3	RealW	2.00E+06
Water delivered Fr	Damage per m3		Water(m3)	Damage(E
0	0.1		0.00E+00	2.00E+05
0.001	0.0998001		2.00E+03	2.00E+05
0.01	0.09801		2.00E+04	1.96E+05
0.05	0.09025		1.00E+05	1.81E+05
0.1	0.081		2.00E+05	1.62E+05
0.2	0.064		4.00E+05	1.28E+05
0.3	0.049		6.00E+05	9.80E+04
0.4	0.036		8.00E+05	7.20E+04
0.5	0.025		1.00E+06	5.00E+04
0.6	0.016		1.20E+06	3.20E+04
0.7	0.009		1.40E+06	1.80E+04
0.8	0.004		1.60E+06	8.00E+03
0.9	0.001		1.80E+06	2.00E+03
1	0		2.00E+06	0.00E+00



Assumptions:
- Ratio delivered water <> value is taken as 0.1
- Quadratic function

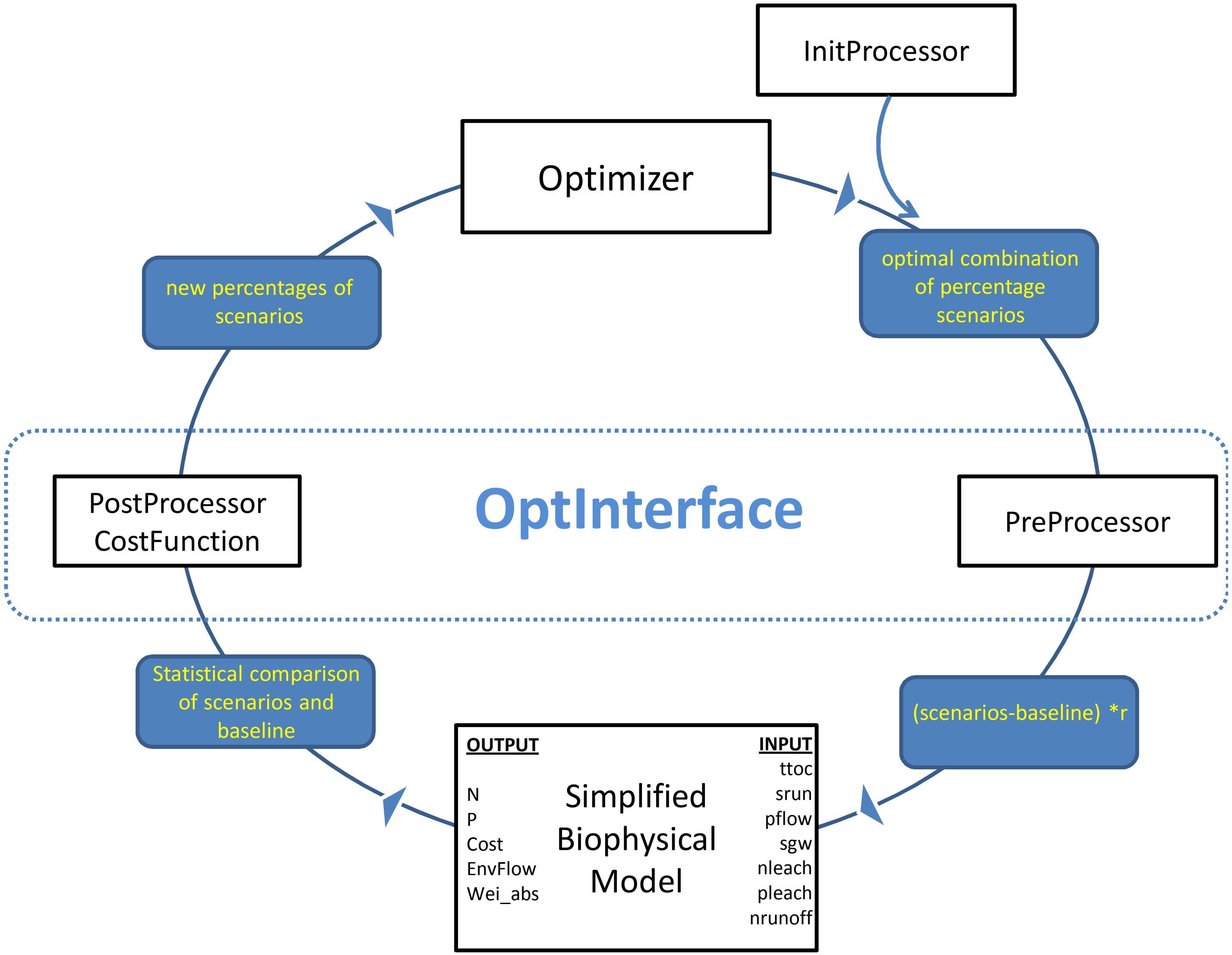
This results in that for every m3 water that is not available for irrigation, the damage is maximally the ***<u>choke price</u>*** *(0.1 euro in this example)*

So, e.g, if the required amount of water for irrigation area is 1 Mm3, and

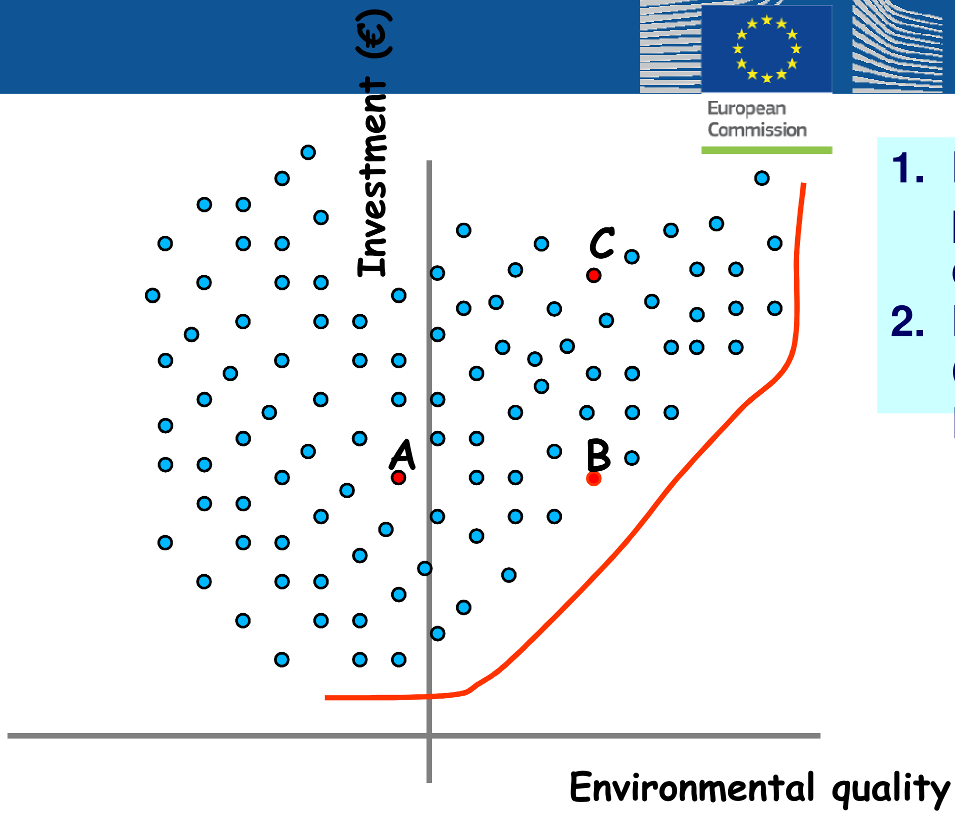
Available water (Mm3)	***Loss (MEuro)***
1.0	*0.0 MEuro*
0.5	*0.025 MEuro*
0.1	*0.081 MEuro*
0	*0.1 MEuro*

Choke price:
0.35 Euro/m3 (low value crops)
1.25 Euro/m3 (high value crops)

Optimization

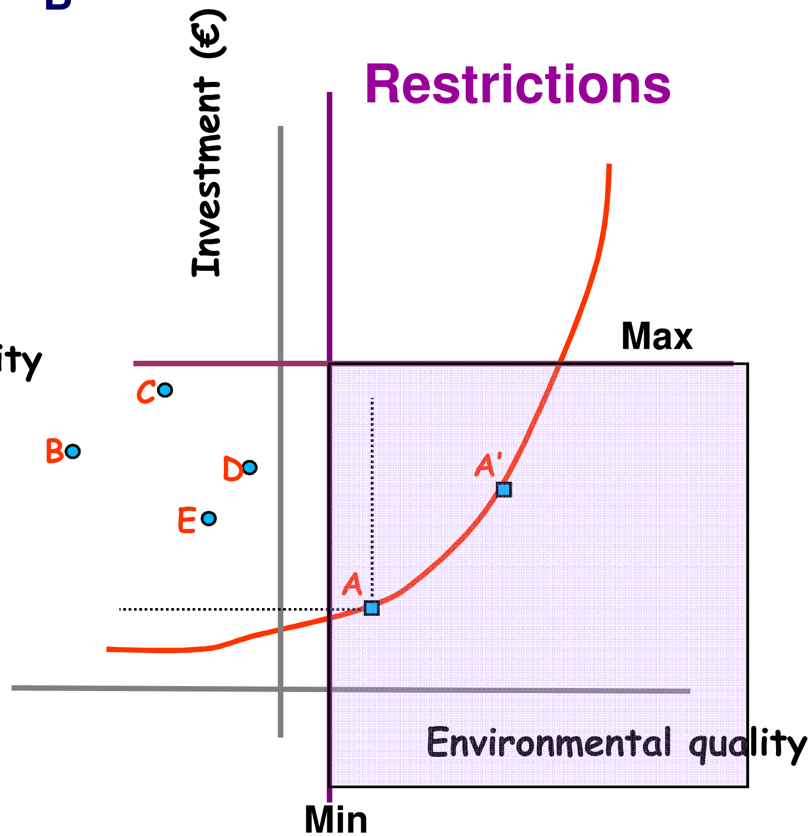


Multicriteria Optimization



1. Point A and B same investment but point B has better Env. quality – I chose B
2. Point C and B same Env. quality but C needs higher investment – I chose B

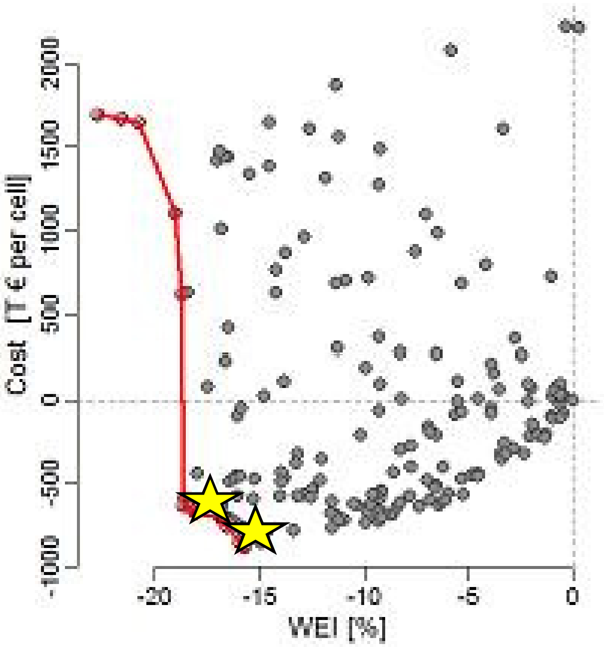
1. Point A is better choice compare with points B-C-D-E
2. The situation is less clear when you are looking to the point A and A'. A is lower Cost, but A' is better ENVIRONMENTAL quality…both options are valid choices.

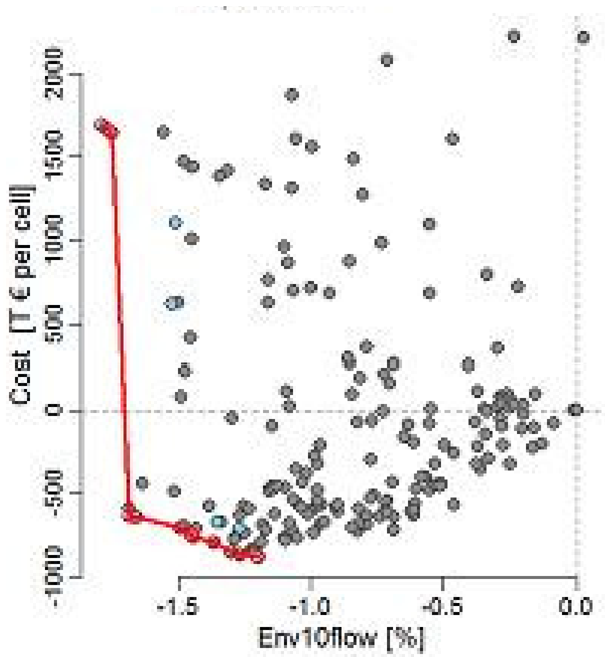


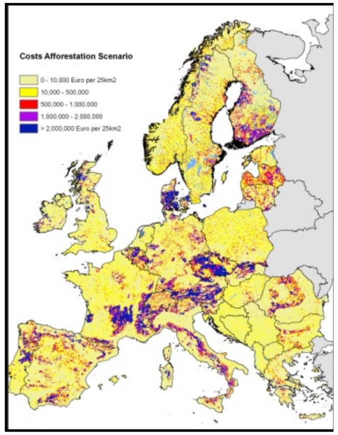
Example optimisation

European Commission

FLOOD	CROP	WATER SAVING
12afforestation	51Nfixing	71Desalination
21urban25 34crop	52OptFertilization 53Combined	91Irrigation 93Reuse
43meander	91Irrigation	94WaterSaving
31grassland	34crop 93Reuse	95Leakage 21urban25







Region 11 "Water saving" Scenario combination	Scenario combination 21_UG	71_DS	91_IE	93_WRI	94_WSH	95_LR	Objective functions Cost [T Euro per cell]	EnvFlow [per cell]	WEI [per cell]
C7	100	100	100	100	100	100	1696	-2	-23
C16	13	0	100	1	100	1	-877	-1	-16
C47	27	94	100	70	100	100	-635	-2	-19
C59	100	100	100	98	100	100	1643	-2	-21
C66	13	4	98	70	100	100	-639	-2	-18
C68	100	100	100	99	100	100	1673	-2	-22
C71	13	0	100	0	100	1	-879	-1	-16
C77	13	5	98	70	100	99	-706	-1	-17
C90	28	92	100	73	100	96	-762	-1	-17
C110	13	4	98	38	100	98	-743	-1	-16
C136	13	2	98	70	100	37	-865	-1	-16
C148	0	2	97	43	100	91	-790	-1	-16
C158	34	4	100	71	100	59	-847	-1	-16
C159	13	5	98	70	100	98	-740	-1	-16
C165	14	0	100	1	100	2	-871	-1	-16
C174	11	3	98	72	100	35	-865	-1	-16

Example optimisation: Danube

European Commission

Region 11 "Water saving" Scenario combination	Scenario combination 21_UG	71_DS	91_IE	93_WRI	94_WSH	95_LR	Objective functions Cost [T Euro per cell]	EnvFlow [per cell]	WEI [per cell]
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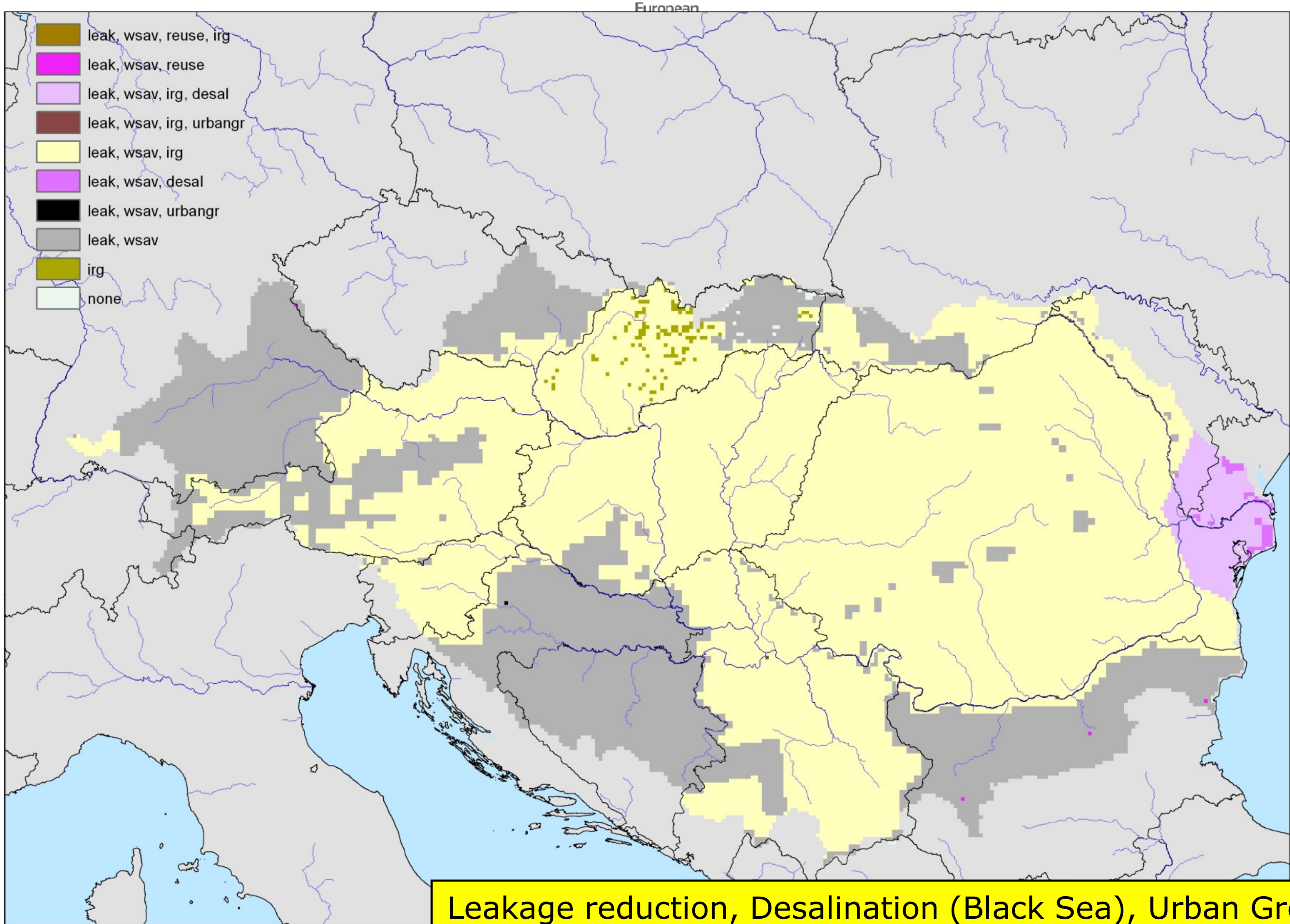
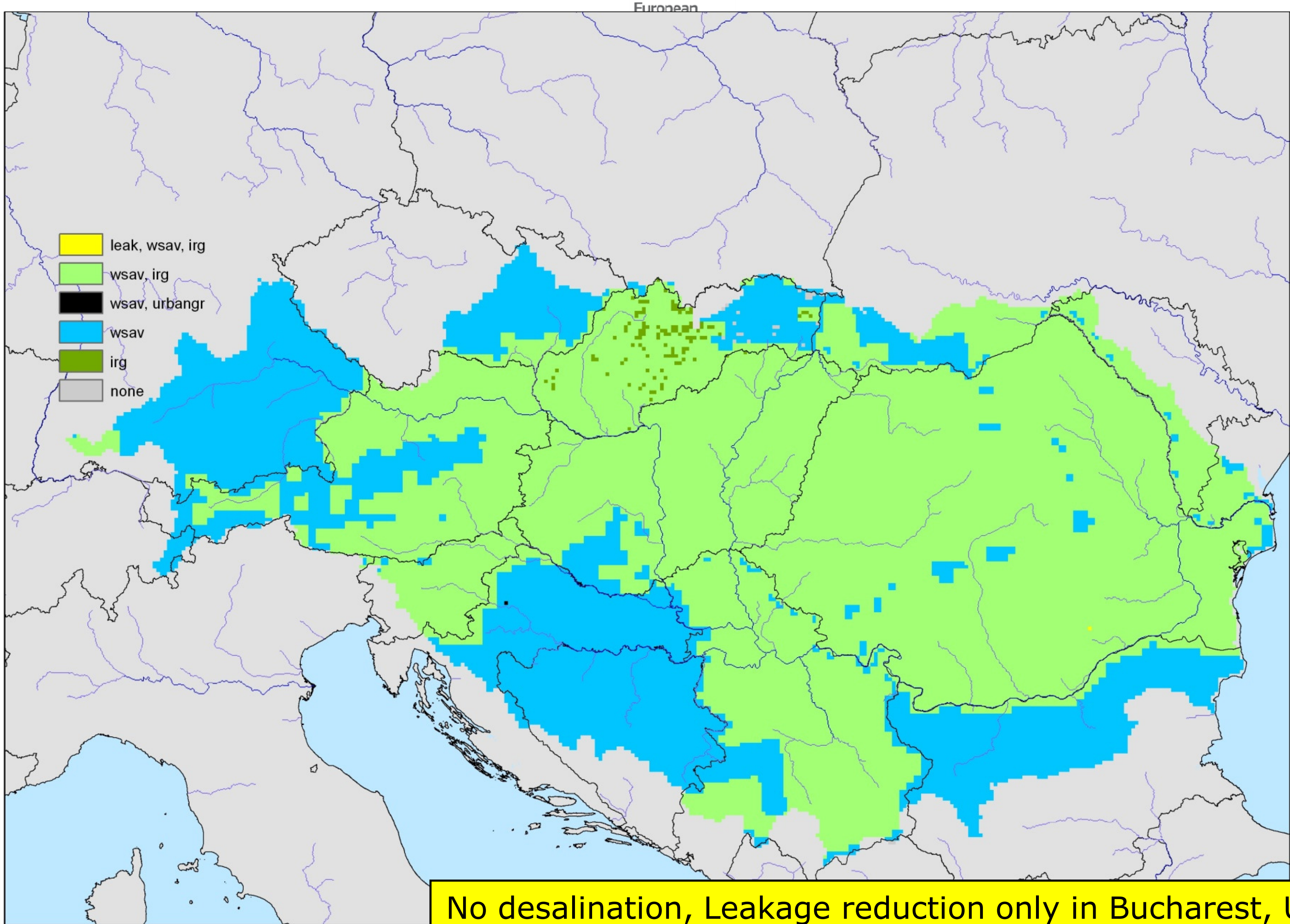
C159	13	5	98	70	100	98	-740	-1	-16
C165	14	0	100	1	100	2	-871	-1	-16
C174	11	3	98	72	100	35	-865	-1	-16

Danube: scenario-combination C47



Leakage reduction, Desalination (Black Sea), Urban Greening in Zagreb and Belgrade, Re-Use of Water in Industry in Bulgaria, irrigation water use efficiency, and water savings in households

Danube: scenario-combination C71



No desalination, Leakage reduction only in Bucharest, Urban Greening only in Zagreb, no water-re-use in industry in Bulgaria

Further work

European Commission

- **The tool is further improved for Europe:**
  - **<u>Include groundwater modelling in relevant areas in Europe</u>** (linking LISFLOOD/LISQUAL/MODFLOW, SWAT/MODFLOW, or conceptual)
  - Economic Loss functions for Water Scarcity for all sectors (based on factual direct damage)
  - Selection of water regions that fit water supply areas
  - Water transfers between river basins
  - Improve underlying data: discharge (neg. WMO/ENV/JRC/EEA), precipitation, wastewater fluxes, <u>groundwater use (for irrigation, drinking water) etc..</u>
  - Costing other benefits, e.g. ecosystem services
  - Costs of measures from national and regional projects
  - Data on water price (industry, irrigation)
- **Specific case study started for the Danube, to support the Danube Strategy**
  - Two technical meetings already took place with Danube stakeholders
  - Budget available now for collaborating studies

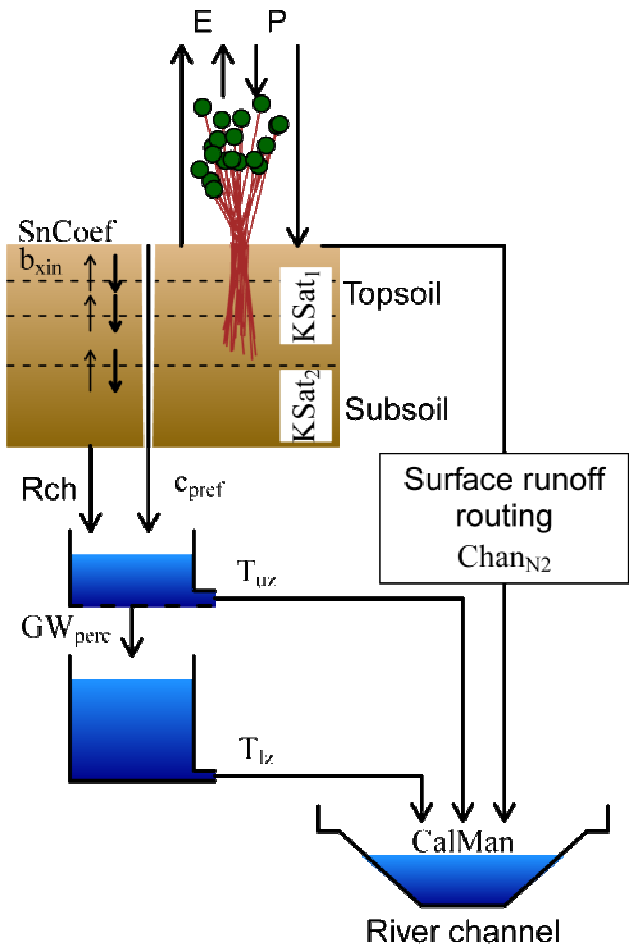
LISFLOOD model update

Calibration & Data assimilation

in the Upper Danube

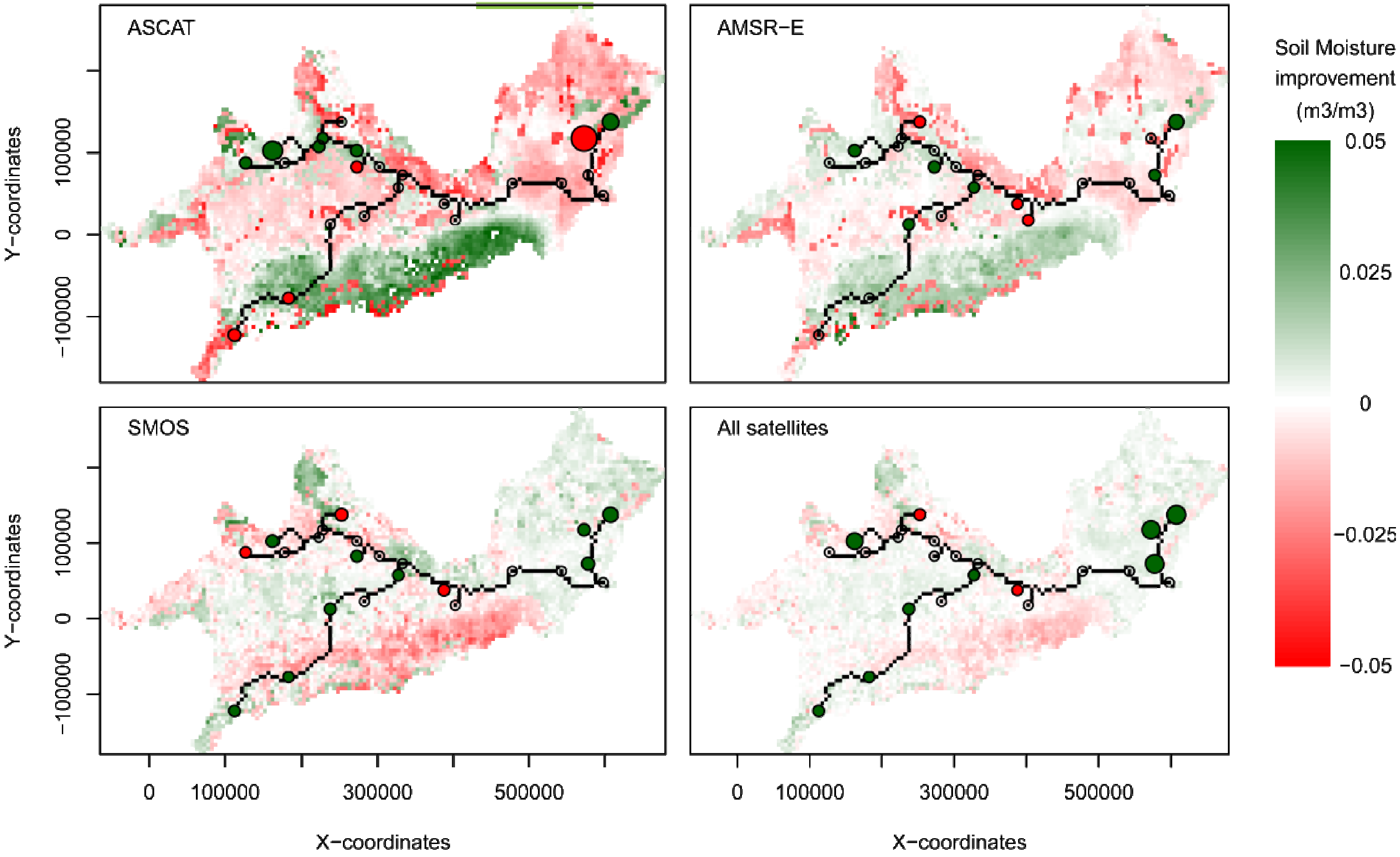
scenarios:

- **Discharge (0, 1, 7 locations)**
- **Satellites (0, 1, 3 sensors)**
  - ASCAT
  - AMSR-E
  - SMOS



Soil moisture updating (Ensemble Kalman Filtering)

European Commission

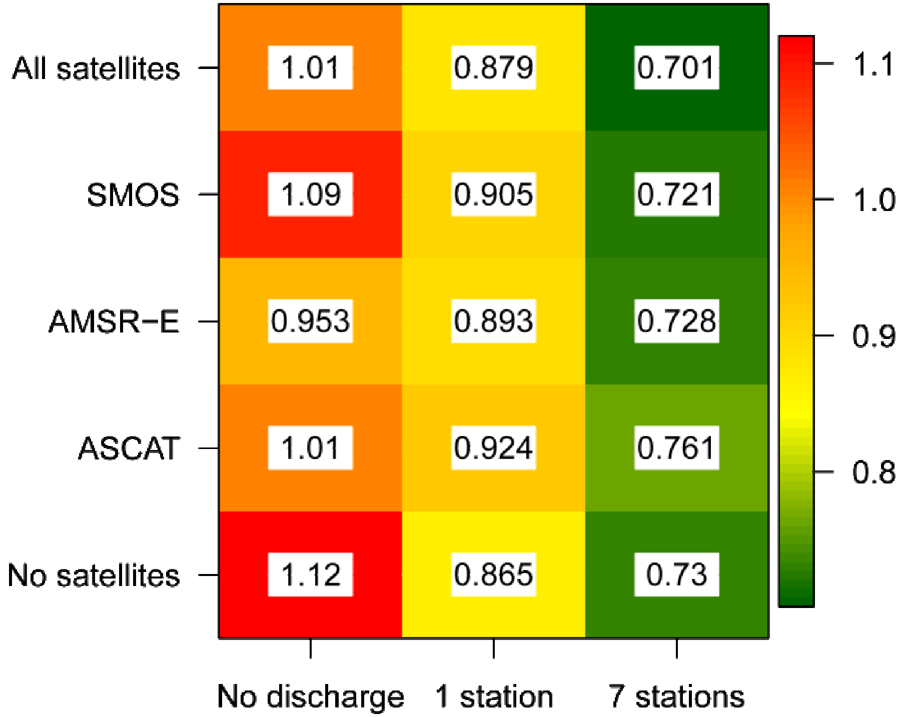


Improvements due to data assimilation

European Commission

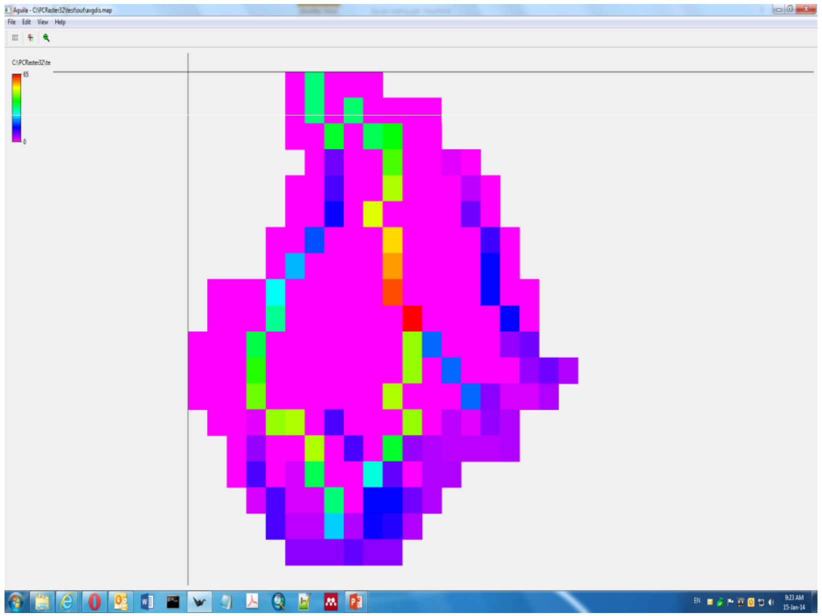
- Calibration on discharge improves model calibration
- Calibration on satellite data shows little improvement for model calibration
- More discharge observations results in a better calibration

$$\frac{RMSE}{\overline{Q}}$$

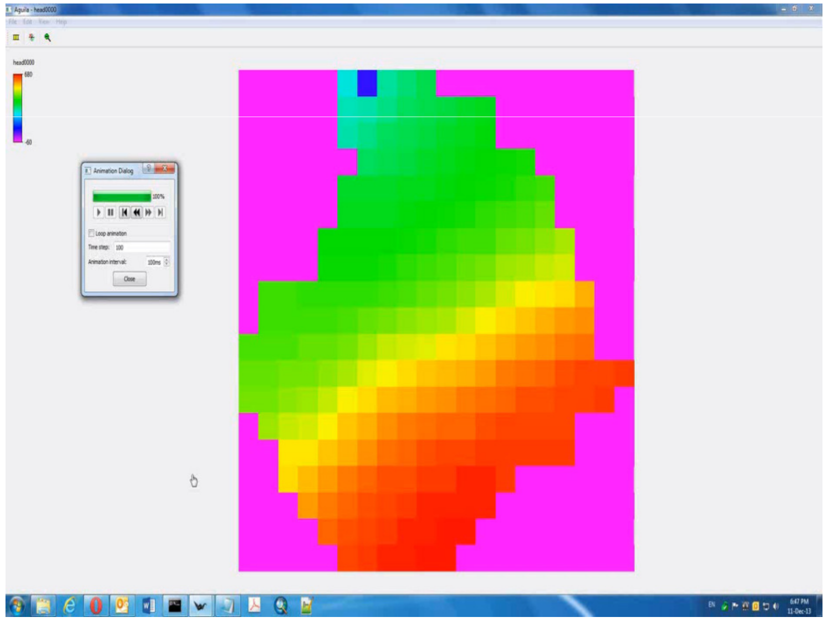


Integrating LISFLOOD & MODFLOW

LIDFLOOD
Average Surface Runoff



MODFLOW
Hydraulic Head



Water Allocation

Built in – user defineable – rules on allocation:

Public water supply (e.g. at least 80%)
Environmental flow
Energy production water demand
Manufactory industry water demand
Livestock water demand
Irrigation water demand

European Commission

Overview of data available at JRC to carry out water resources modelling and optimisation

Current data available

Meteo: MARS, EUFLOODGIS, CARPATCLIM

Hydro: GRDC and NHS data

Soils: European Soils Database

Land use: Corine Land Cover

Waterstats: Eurostat etc (EEA pending)

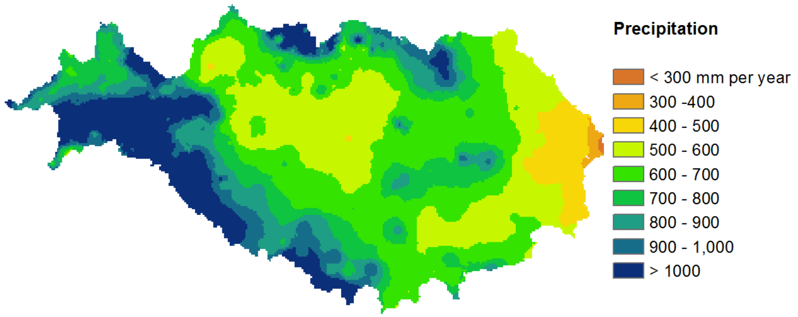
Groundwater: IHME1500

Water Footprint

Meteorological data

Aim:

- Homogenous database for the whole Danube basin
- Joining different sources and providers
- Different spatial resolution for different models (100m to 5km)

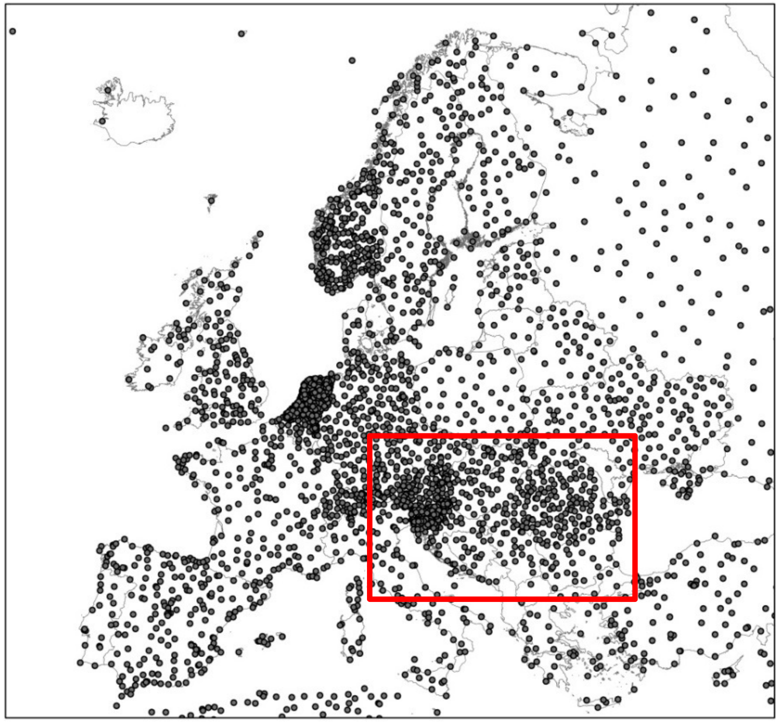


Yearly average precipitation 1990-2013 (Source: EFAS-Meteo)

Meteorological data

Sources:

1.) EFAS-Meteo: A European daily high-resolution gridded meteorological data set for 1990 - 2013



Data Provider	Abbreviation
Joint Research Centre Monitoring and Agricultural Resources	JRC MARS
Deutscher Wetterdienst Climatic	DWD Climatic
Deutscher Wetterdienst SYNOP	DWD Synop
European Climate Assessment & Dataset	ECA
Deutscher Wetterdient AMDA SYNOP	DWD AMDA Synop
Agencija Republike Slovenije za okolje	ARSO
Servizio Idro Meteo, Agenzia Regionale Prevenzione e Ambiente dell'Emilia-Romagna	ArpaSim
Confederacion hydrografica del Ebro (Spain)	SAIH-Ebro
Euro Synop	Euro Synop
Hungarian Meteorological Service	HMS
Institute of Meteorology and Water Management (Poland)	IMGW
Met Éireann	MET EIRE
Meteo Consult	MeteoConsult
Meteo Suisse	MeteoSwiss
Norwegian Meteorological Institute (Norway)	NMI
Slovak Hydro Meteorological Institute (Slovakia)	SHMU


Firefox
Benjamin VAN DOORSLAER
CARPATCLIM - Climate of the Carpat...
www.carpatclim-eu.org/pages/home/
CARPATCLIM
Climate of the Carpathian Region
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European Commission

CARPATCLIM

Timeframe

- **1961-2010**

Spatial range

- **Climatological grids cover the area between latitudes 44°N and 50°N, and longitudes 17°E and 27°E**

Temporal resolution:

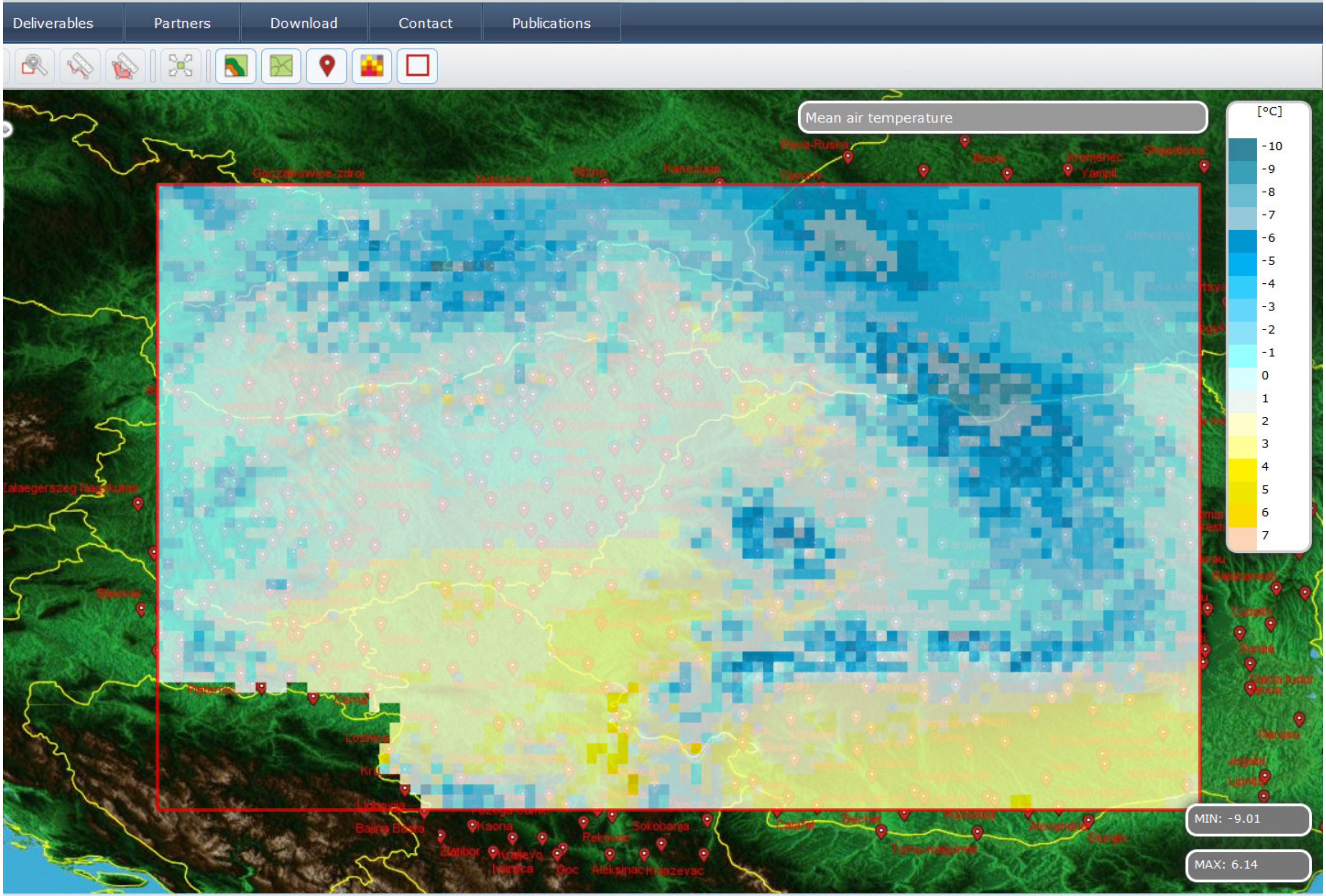
- **1 day**

Spatial resolution

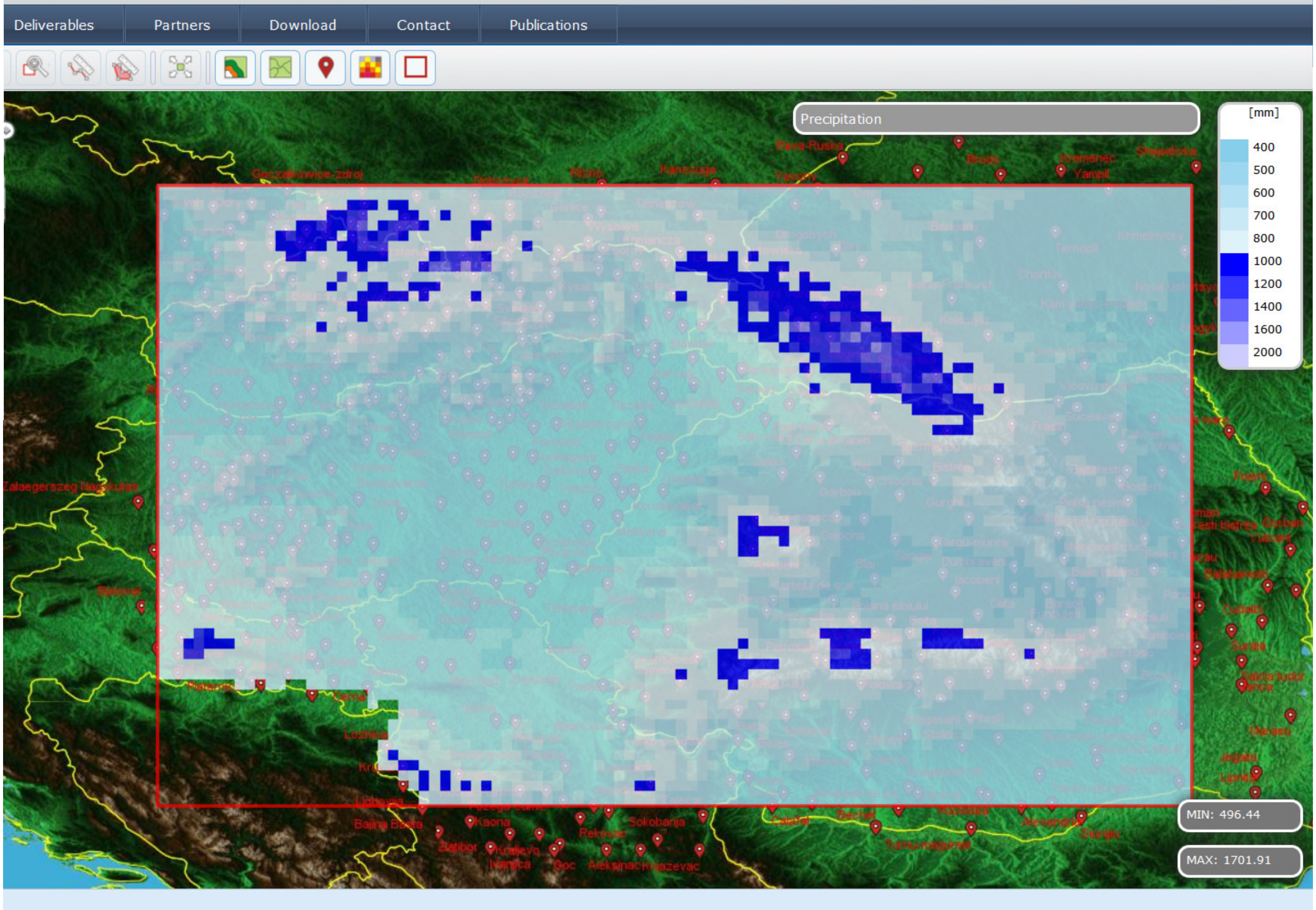
- **0.1° x 0.1°**

http://www.carpatclim-eu.org/pages/home/

Daily Temperature

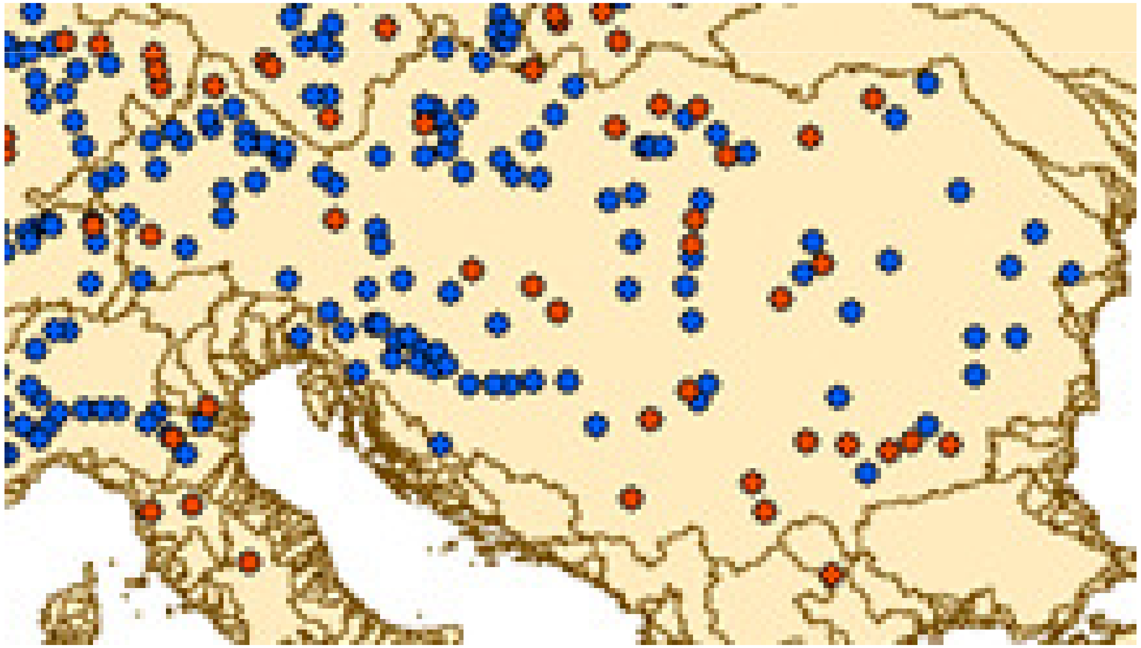


Daily Precipitation

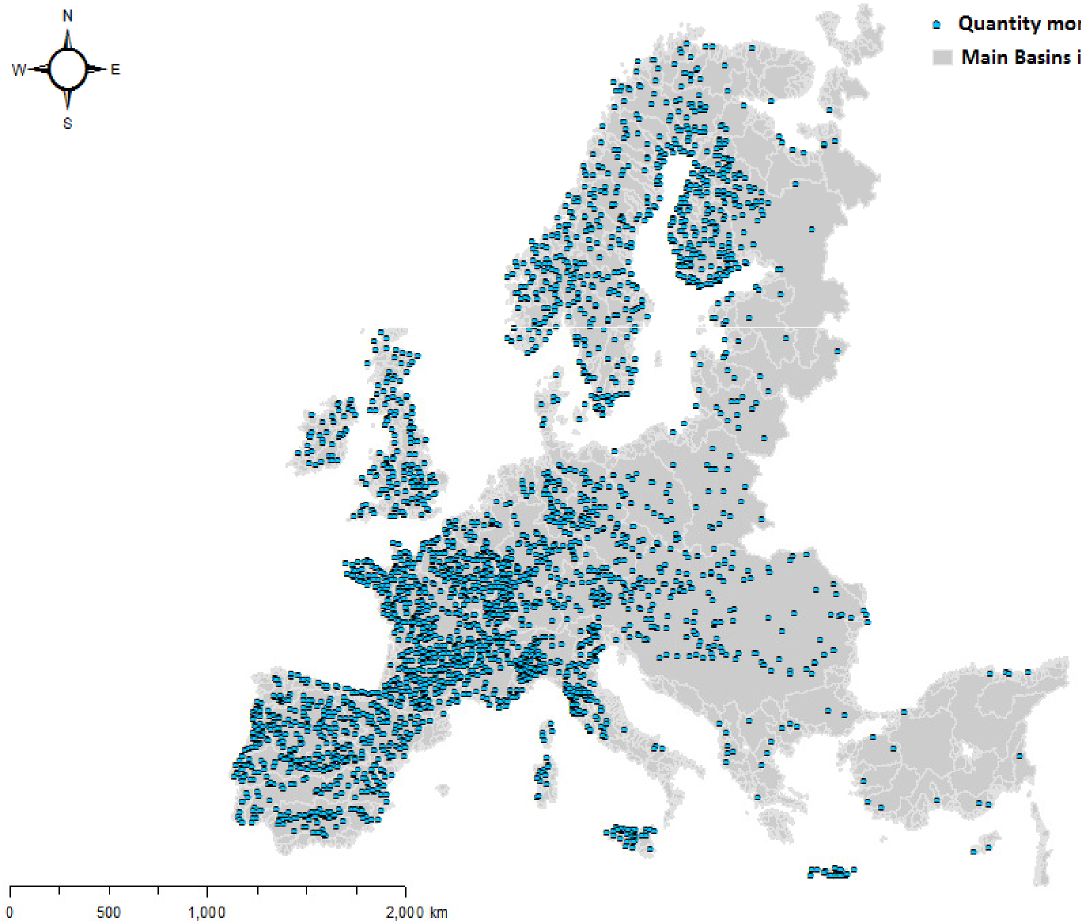


Discharge data

152 selected Danube stations for calibration Lisflood with a catchment area ≥ 1000 km^2 (source: GRDC and NHS's)



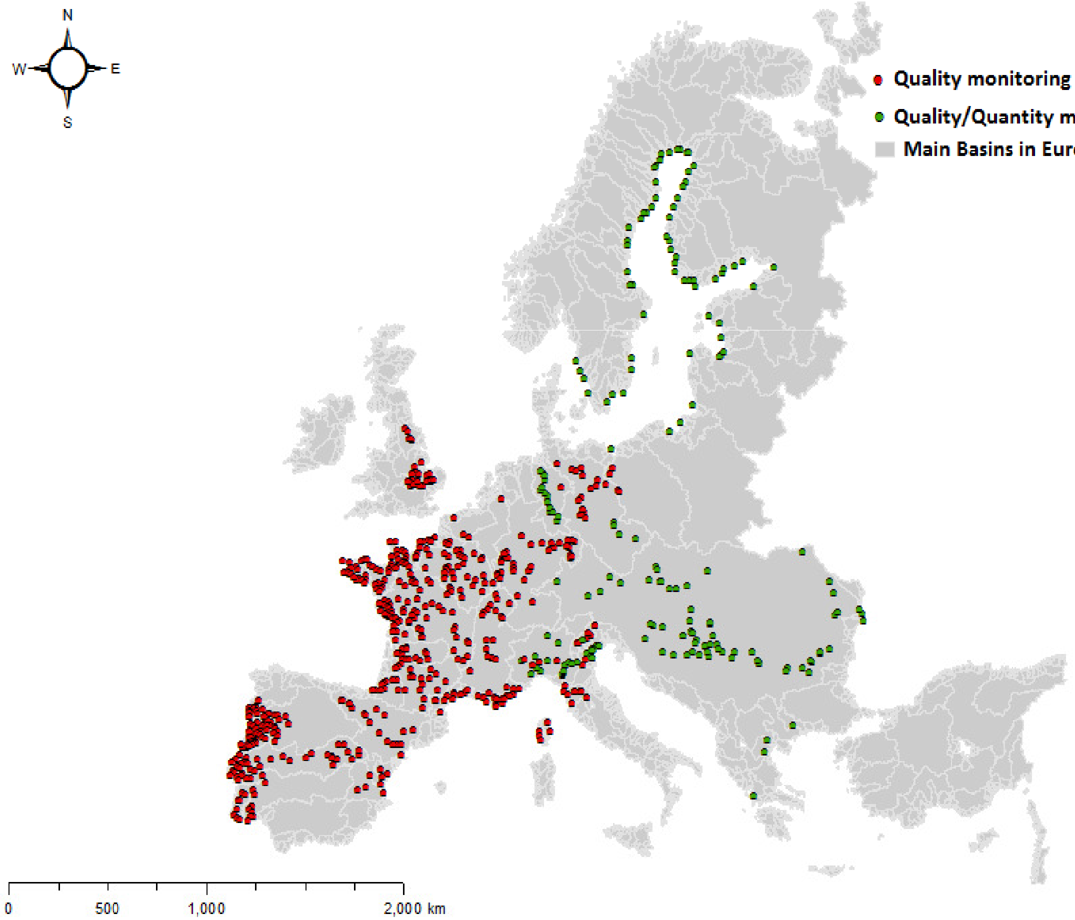
Water Quantity database (in general from 1985 – 2010)



- 3034 points of discharge data

Being merged

Water Quality database (in general from 1985 – 2010)



- 723 points
- Not always associated to water quantity data
- N, P, Sediments etc (not all constituents in all points)

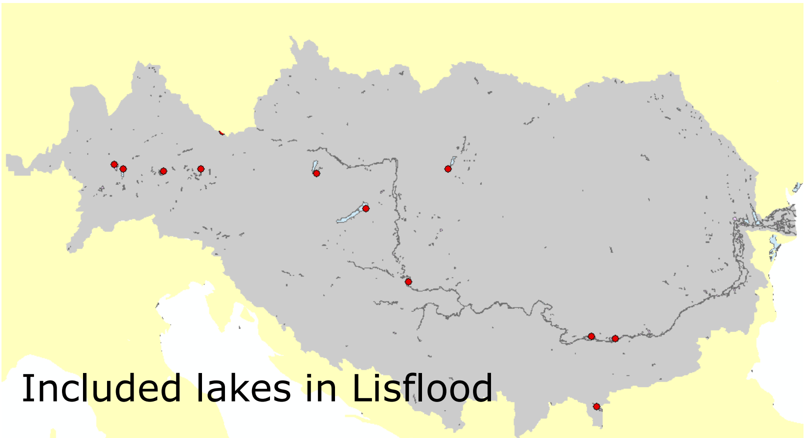
Lakes and reservoirs

Included lakes in Lisflood:

- 181 lakes in Europe
-   11 lakes in the Danube catchment with an area ≥ 50 km^2

Included reservoirs:

- 67 in Europe
-   - in the Danube catchment

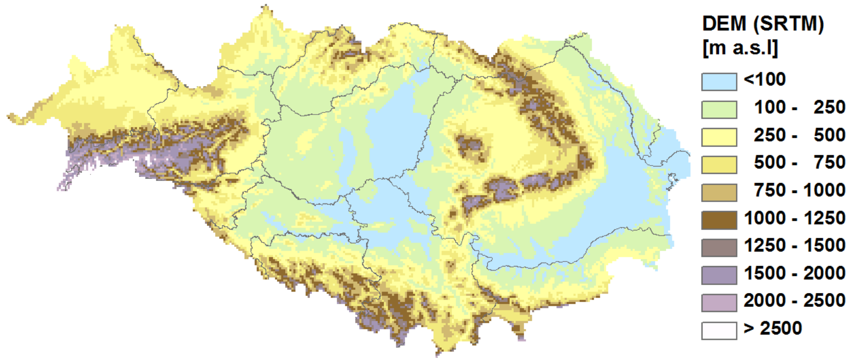


Source: Global Lakes and Wetlands Database GLWD
Lehner, B. and Döll, P. (2004): Development and validation of a global database of lakes, reservoirs and wetlands. Journal of Hydrology 296/1-4: 1-22.

Digital elevation data

Source data: SRTM (100m spatial resolution)

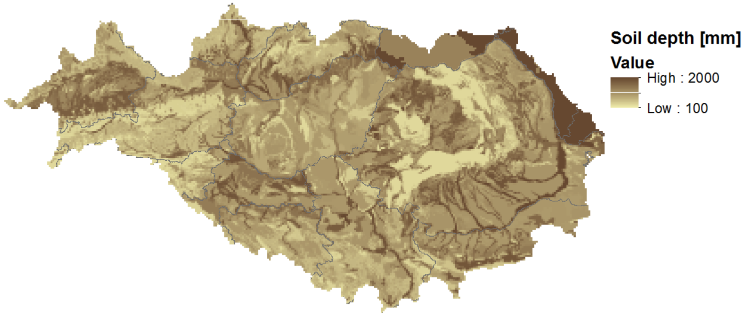
Upscaled for hydrological modelling to 5x5km (and 1x1km)
100m subgrid information maintained for snowmelt processing

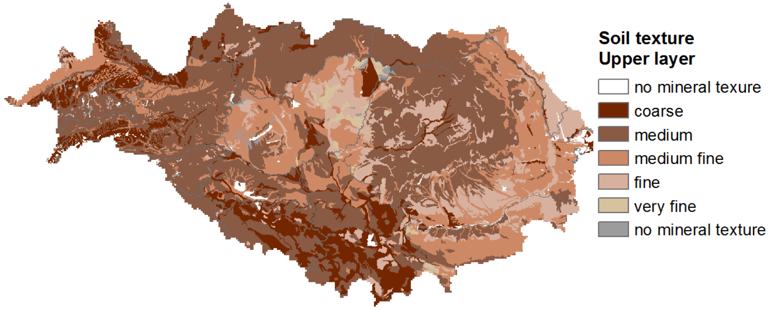


used for calculating potential inundation areas
(revision with new 25m EU Copernicus DEM is envisaged)

Soil

Source:
European Soil Database v2.0
JRC - IES





JRC LUMP Land Use Modelling Platform

using the land use model Eu-ClueScanner (JRC)

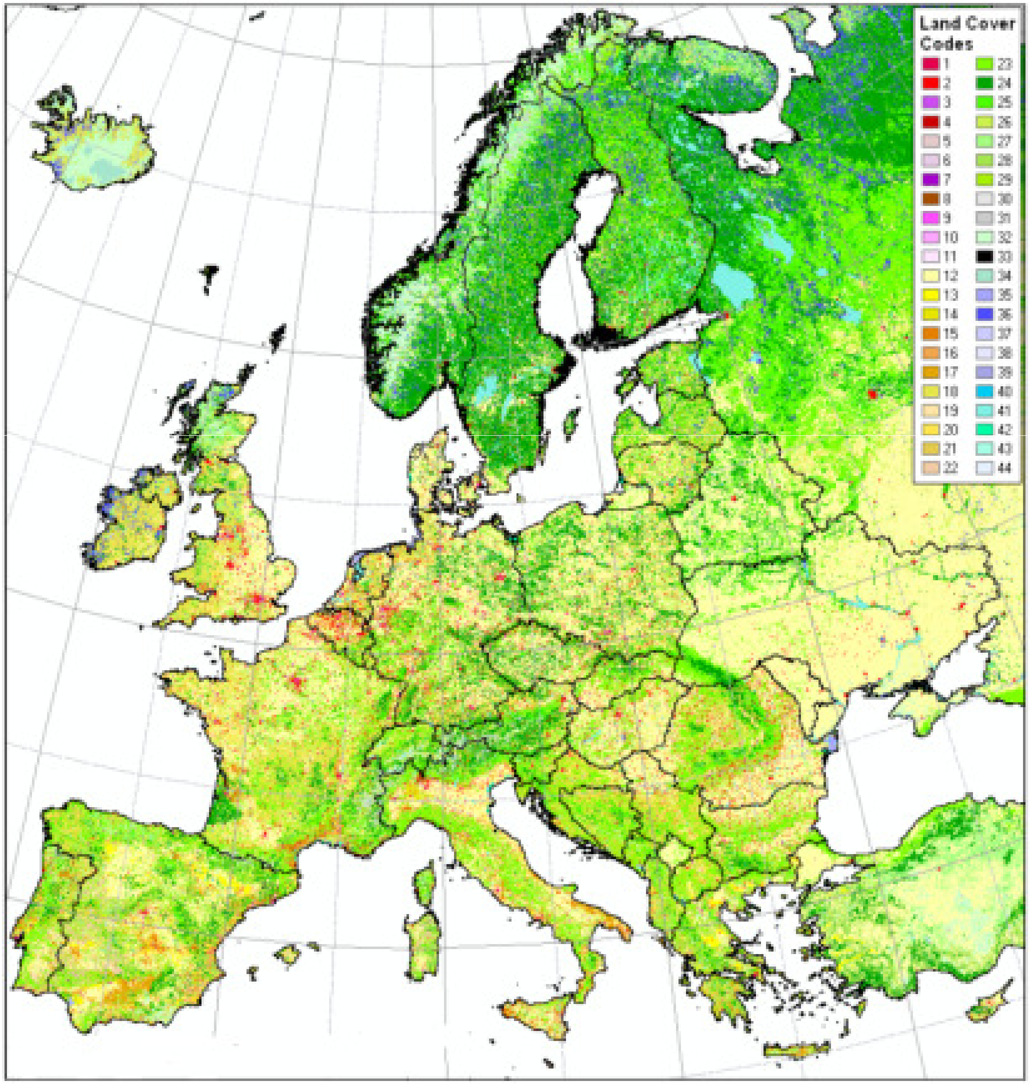
Land use / land cover change scenarios until 2030

Common Agricultural Policy (CAP) consistent (using CAPRI boundary conditions for 2030)

Socio-Economic data used from Eurostat

100m spatial resolution

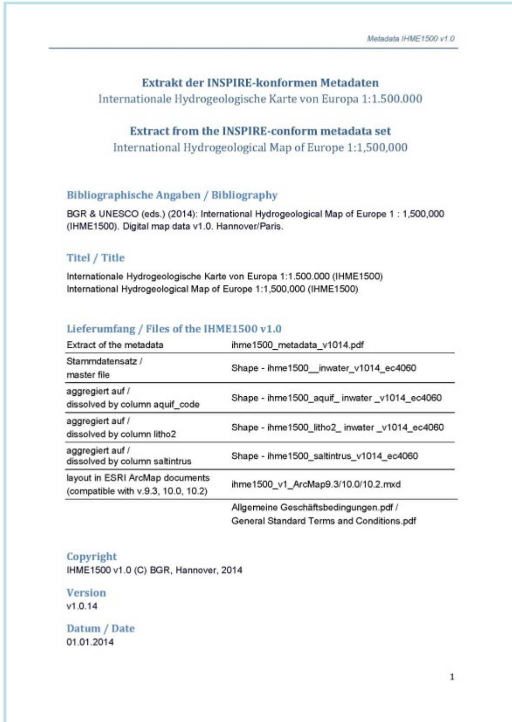
Pan-European



Groundwater

BGR & UNESCO (eds.) (2014): International Hydrogeological Map of Europe 1 : 1,500,000 (IHME1500)

- Main aquifers
- Lithology



Metadata IHME1500 v1.0

Extrakt der INSPIRE-konformen Metadaten
Internationale Hydrogeologische Karte von Europa 1:1.500.000

Extract from the INSPIRE-conform metadata set
International Hydrogeological Map of Europe 1:1,500,000

Bibliographische Angaben / Bibliography

BGR & UNESCO (eds.) (2014): International Hydrogeological Map of Europe 1 : 1,500,000 (IHME1500). Digital map data v1.0. Hannover/Paris.

Titel / Title

Internationale Hydrogeologische Karte von Europa 1:1.500.000 (IHME1500)
International Hydrogeological Map of Europe 1:1,500,000 (IHME1500)

Lieferumfang / Files of the IHME1500 v1.0

Extract of the metadata	ihme1500_metadata_v1014.pdf
Stammdatensatz / master file	Shape - ihme1500__inwater_v1014_ec4060
aggregiert auf / dissolved by column aquif_code	Shape - ihme1500_aquif_ inwater _v1014_ec4060
aggregiert auf / dissolved by column litho2	Shape - ihme1500_litho2_ inwater _v1014_ec4060
aggregiert auf / dissolved by column saltintrus	Shape - ihme1500_saltintrus_v1014_ec4060
layout in ESRI ArcMap documents (compatible with v.9.3, 10.0, 10.2)	ihme1500_v1_ArcMap9.3/10.0/10.2.mxd
	Allgemeine Geschäftsbedingungen.pdf / General Standard Terms and Conditions.pdf

Copyright
IHME1500 v1.0 (C) BGR, Hannover, 2014

Version
v1.0.14

Datum / Date
01.01.2014

1

Water use

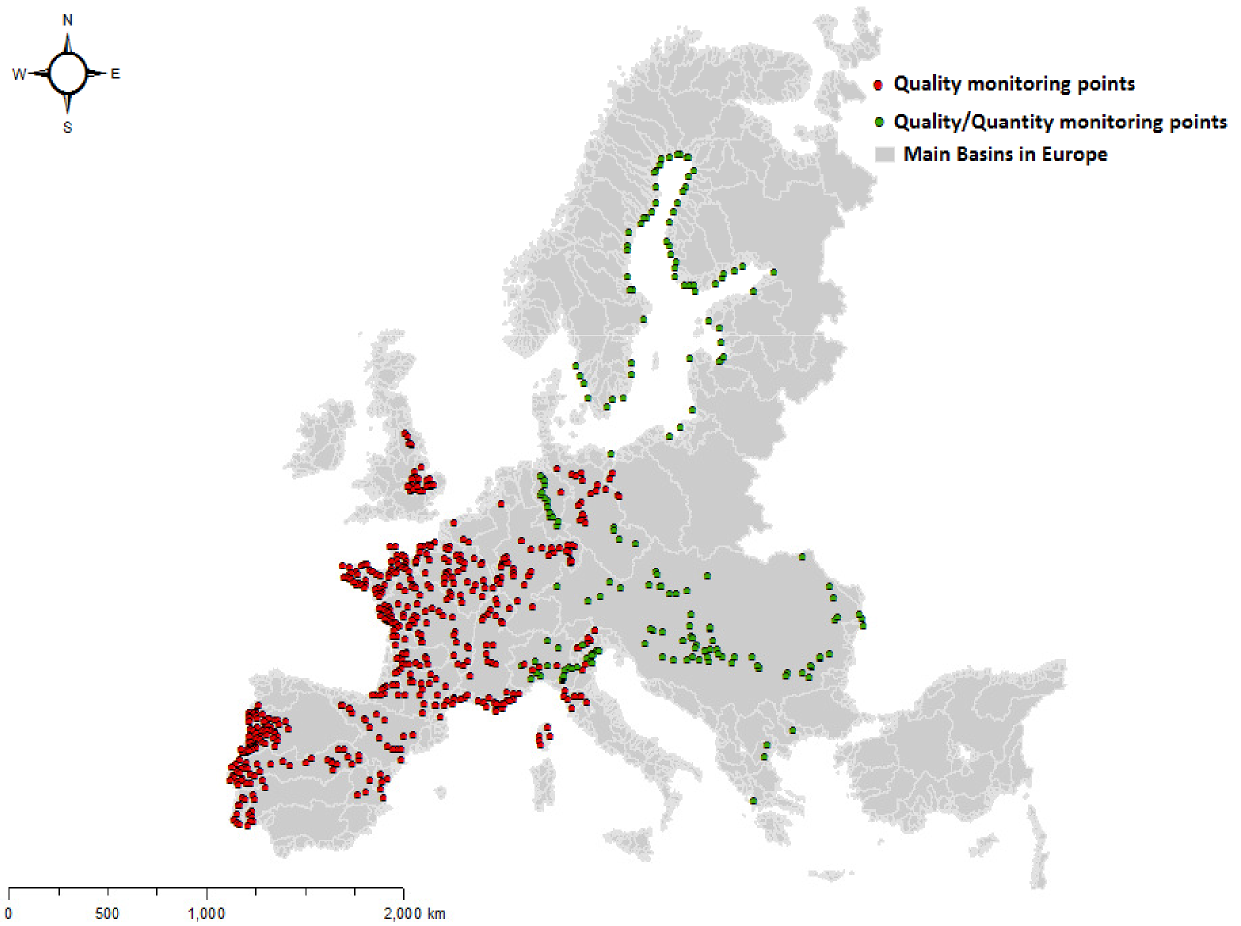
Public, Industrial & Energy production, Livestock water demand & use:

Eurostat and other sources statistical data, downscaled with Corine land use and population data, extrapolations using land use scenarios (LUMP), GDP and population forecasts

Irrigation water demand and use:

FAO and Eurostat national totals, downscaled with EPIC model to 10x10 km

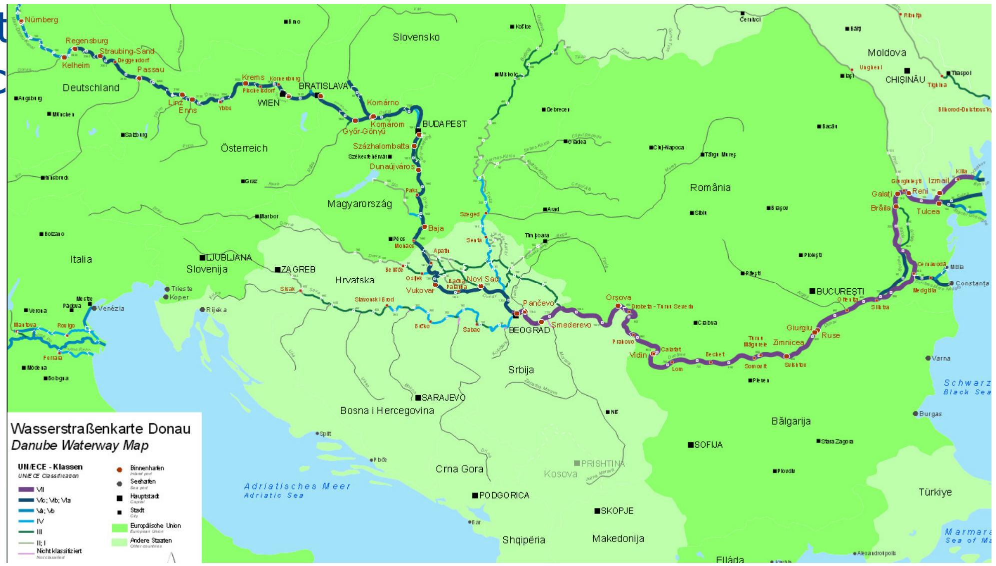
Water Quality database (in general from 1985 – 2010)



- 723 points
- Not always associated to water quantity data
- N, P, Sediments etc (not all constituents in all points)

Navigation

1. Overview of executed and ongoing studies on Danube navigation (e.g. KLIWAS, EUSDR PAC1a)
2. Overview of possible scenarios to overcome problems of navigation
3. Location of bottleneck area for shipping (e.g. Straubing – Vilshofen, Vienna – Bratislava)
4. Metadata and data of the main bottlenecks and along the Danube related to navigation
5. Economic pot
6. Economic



Establishment of a collection of scenario definitions that are essential within the Sava region

TASKS

- What are the most preferred scenario calculations to be carried out within the Danube Nexus project, e.g. desalination, irrigation efficiency increase, water re-use by industry, treated urban waste water re-use for irrigation, increase of mini-hydropower, increase of large hydropower facilities, and what is the motivation for this; Assessments based on regional criteria included in the ICPDR "Guiding Principles on Sustainable Hydropower Development in the Danube Basin" (http://www.icpdr.org/main/sites/default/files/nodes/documents/icpdr_hydropower_final.pdf)
- Scenarios for improving shipping or cost/benefit estimation of shipping vs. other means of transport
- Which (environmental, economical and water related) indicators need ideally to be included in the analysis of these scenarios: e.g. water exploitation index, environmental flow (in line with E-flow Guidance currently developed in the WFD CIS process), economic loss for specific sectors, areas of water scarcity, other ..
- Overview of previous scenario studies in Danube, listing area, purpose, summary, year, point of contact, website of that study

DELIVERABLES:

- Catalog of previous studies done in the Danube (Word Document or Excel Sheet)
- Catalog of new scenarios (Word Document or Excel Sheet)
- Catalog of indicators (Word D[redacted]ent or Excel Sheet).

Data collection for the Sava basin

TASKS

- **Overview of points of contacts, contact persons and possible available data for the Sava basin in Slovenia, Croatia, Bosnia Herzegovina, Serbia and Montenegro and trans-catchment organizations (e.g. Sava river commission)**
- **Collection of metadata and data on:**
  - Hydrology and hydraulics
  - Groundwater
  - Water abstraction and water use

Note: for deliverables 2-6 we realize that not all collection might be feasible within the duration of this project. As an alternative, aggregated datasets are an option for some of the data requested. In any case, a metadata description, the conditions under which the data can be shared, and the organisation where to request official authorisation of the use of the data, are required.

We understand, from the Ispra meeting in January, that some data are available from the Sava Commission website

Data collection for the Sava basin

European Commission

DELIVERABLES:

- **A database of organization, persons related to available data for different regions**
- **A database of hydrological data (water level, discharge, water level – discharge relation):**
  - Metadata (location (lat/lon),name of the catchment, river and station, name of the provider, IDs of the station (e.g. national, GRDC), catchment area, start end date of the time series
  - Data (time series, water level-discharge relation)
- **A database of hydraulic data (cross section at specific points, spatial data)**
  - Metadata (location of the cross section (lat/lon), name of the provider, ID of the location
  - Data (cross section data)
  - Spatial distributed data on river length, width, slope, roughness
- **A database on dams and lakes**
  - Metadata on lakes and reservoirs (location (lat/lon), name, catchment, river, provider of data, responsible authority for managing the lake/reservoir)
  - Data on lakes (size, average depth, volume ,width of the outlet)
  - Data on reservoirs (size, storage capacity, controlling rules (e.g. flood storage limit, normal storage limit, conservative storage limit, non-damaging outflow, normal outflow, minimum outflow))
- **A database of groundwater data (groundwater level, spatial data)**
  - Metadata (location (lat/lon),name of the station, name of the provider, IDs of the station (e.g. national), start end date of the time series
  - Data (time series, water level-discharge relation)
  - Spatial distributed data on groundwater levels conductivity, porosity, groundwater recharge, geology
- **A database on water use and abstraction. Data on water use divided into classes energy, industry, agriculture and population**
  - Spatial data on irrigation
  - Spatial data on water use of household / livestock
  - Spatial and point data on industry water use and consumption
  - Spatial and point data on energy water use and consumption

Envisaged results

- **Modelling toolbox, useful at Commission and Sava region level**
- **Can be made available to regional stakeholders**
- **Training workshops**
- **Further research collaborations:**
  - PhD subtopics, invite PhD's to work with JRC at JRC (e.g. navigation)
  - Joint publications