Slim waterbeheer 2.0

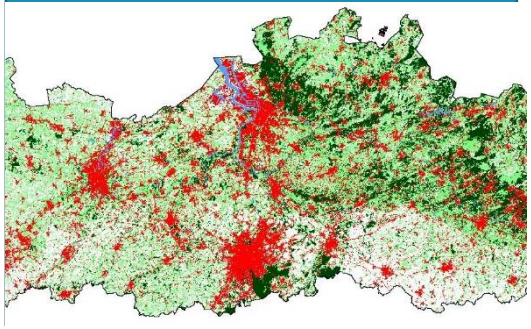
Prof. dr. ir. Patrick WILLEMS

KU Leuven, Departement Burgerlijke Bouwkunde, Afdeling Hydraulica

Uitdagingen

Klimaatverandering

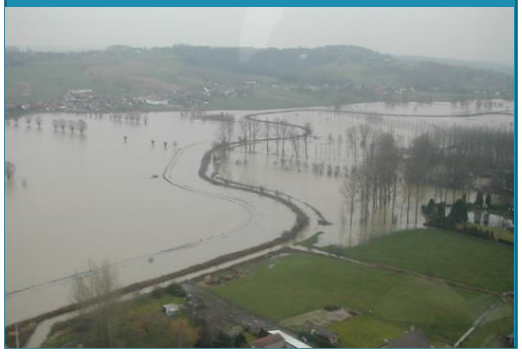
Urbanisatie



Droogte

Pluviale overstromingen

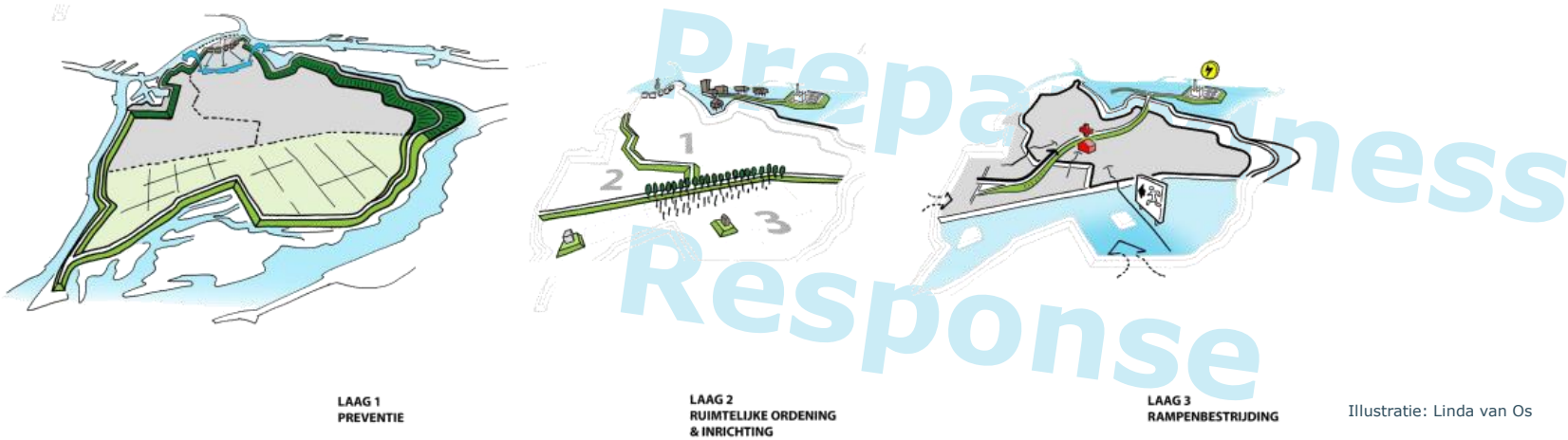
Fluviale overstromingen



Zeespiegelstijging

Inzetten op combinatie van “slimme” oplossingen

- slimme technologie
- robuuste infrastructuur
- doordacht (multi-functioneel, creatief) ruimtegebruik
- gedrag (<- sensibiliseren, gedeelde verantwoordelijkheid)



LAAG 1
PREVENTIE

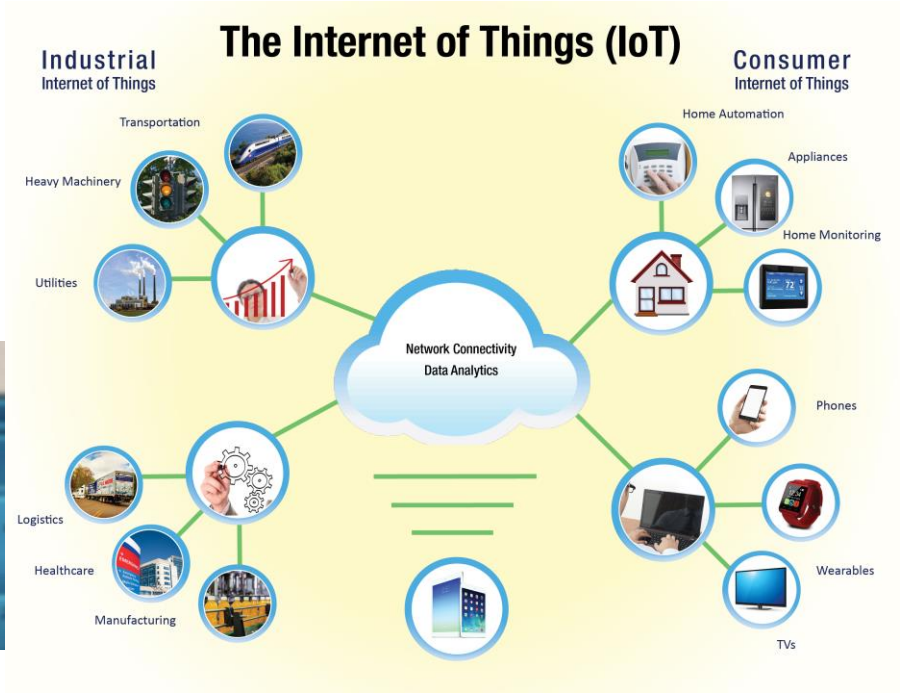
LAAG 2
RUIMTELIJKE ORDENING
& INRICHTING

LAAG 3
RAMPENBESTRIJDING

Illustratie: Linda van Os

Informatiseren vh waterbeheer !

Uitgelezen opportuniteiten:



Voorbeelden hierna vanuit lopende projecten

EU-innovatieprojecten:

HORIZON 2020

BRIGAID

BRIDGING THE GAP FOR INNOVATIONS IN DISASTER RESILIENCE

KU Leuven - VLAIO innovatiemandaat:

Sumaqua

PLURISK

belspo

Innovatieve studieprojecten voor Vlaamse partners:

Aquafin

RMI

Climate-fit.city

Experience the benefits of climate services

VLAAMSE MILIEUMAATSCHAPPIJ

gent: klimaatstad

VLARIO

OVERLEGPLATFORM

De Watergroep

WATER. VANDAAG EN MORGEN.

waterbouwkundig LABORATORIUM

FloodCitiSense

JPI Urban Europe

ERA-NET Smart Urban Futures

RainGain

antwerpen stadslab 2050

VENECO

provincie Oost-Vlaanderen

BRUGGE

Interreg

2 Seas Mers Zeeën

Water Resilient Cities

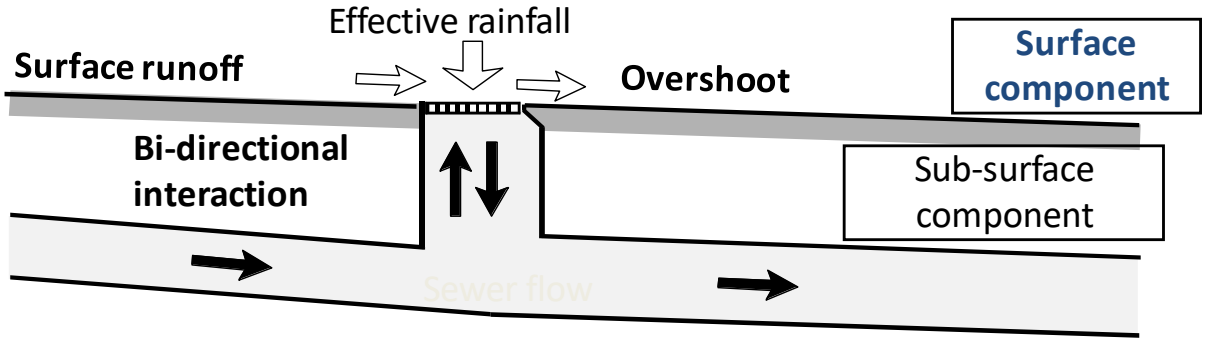
European Regional Development Fund

KU LEUVEN

Kwantificering & voorspelling stedelijke overstromingsrisico's

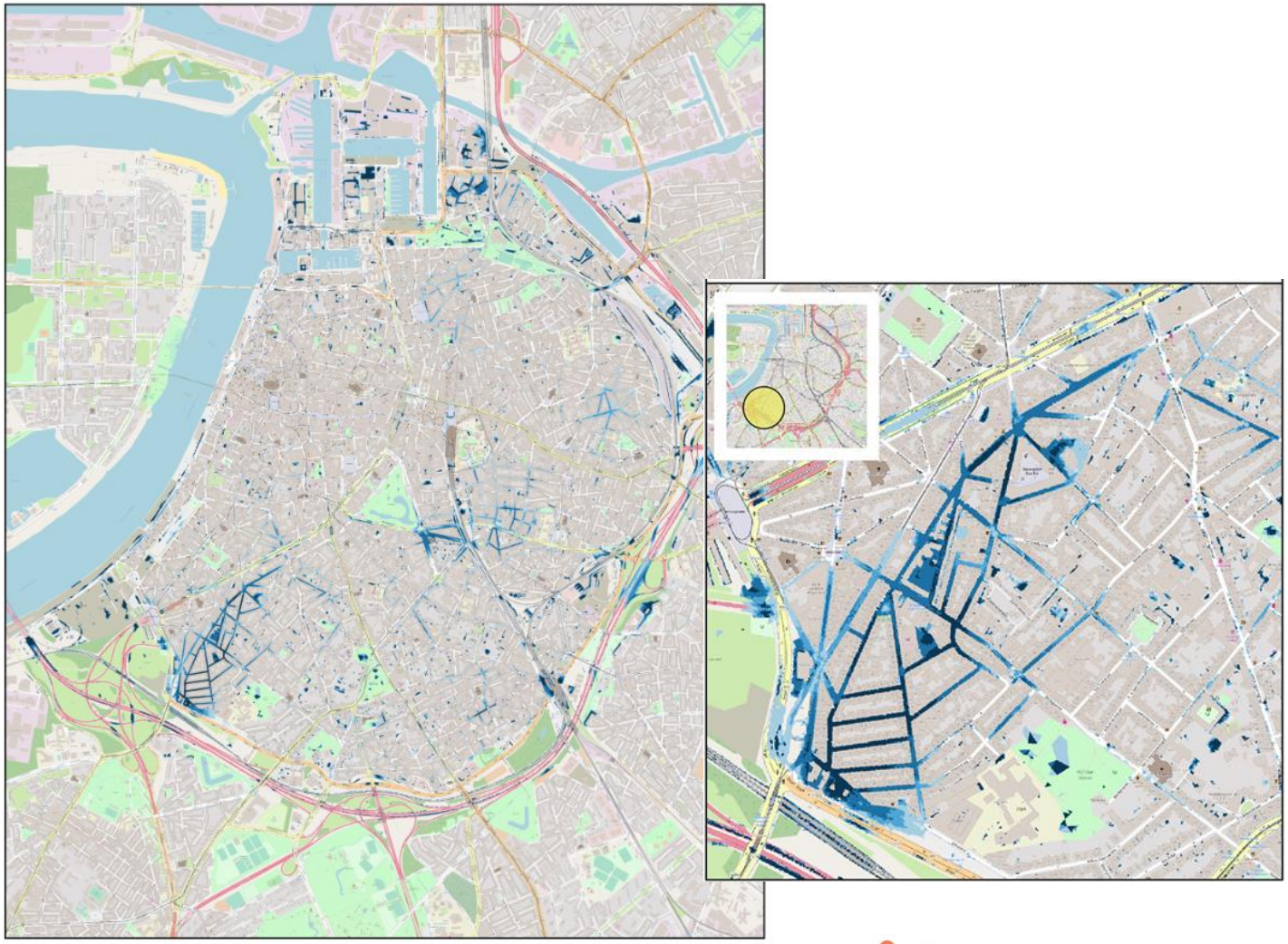
2D stedelijke pluviale overstromingsmodellering

1D ondergronds – 2D bovengronds hydraulisch:



Stad Antwerpen: pluviale overstromingsrisico's

Huidig klimaat:

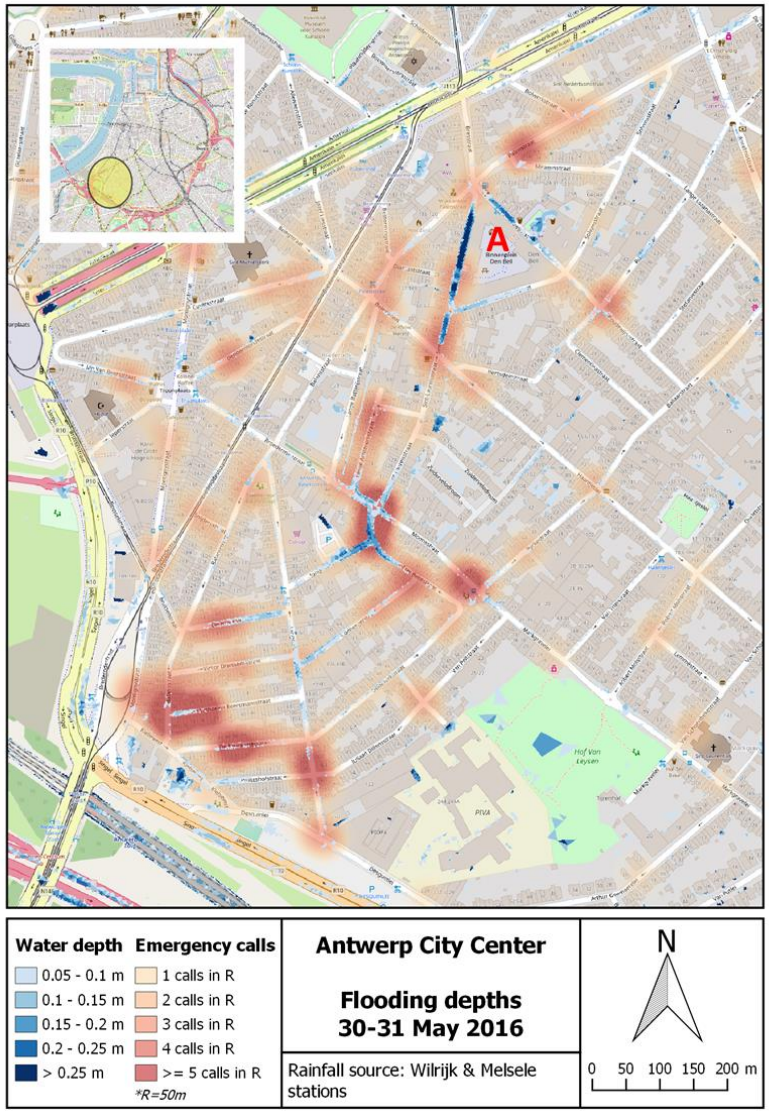


Climate-fit.city
Experience the benefits of climate services

KU LEUVEN

Validatie o.b.v. crowd-sourced data

Aantal brandweerinterventies:



(Sociale) media:

A

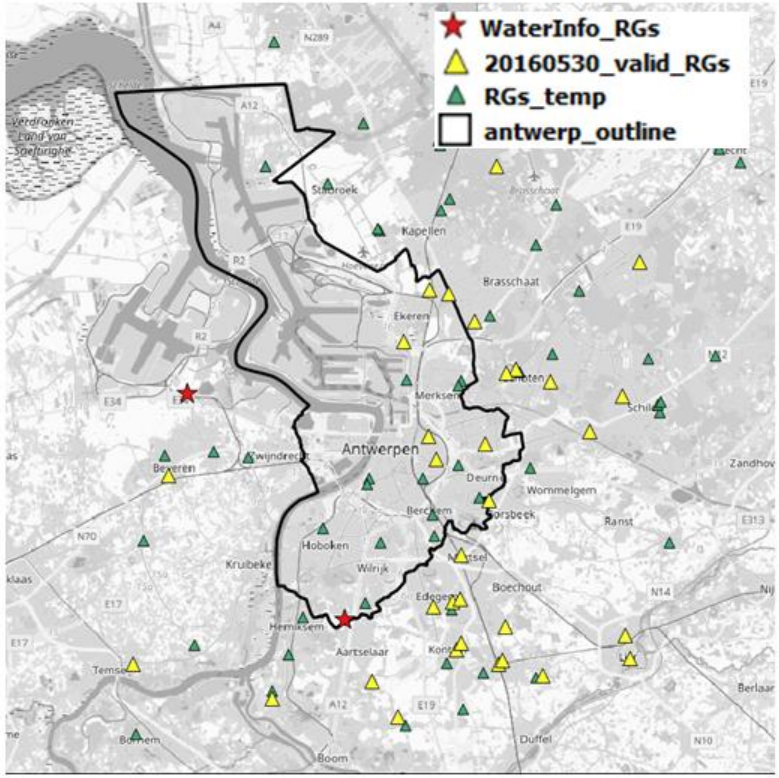
Source: GVA

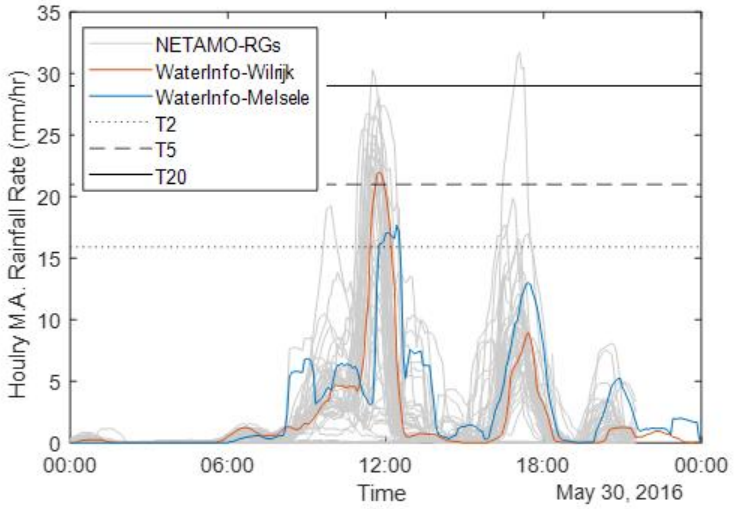
BRANDWEER IN ANTWERPEN

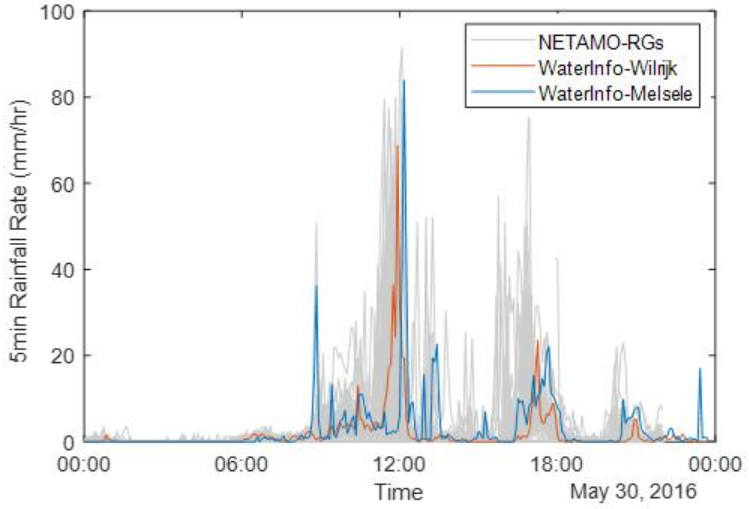
KU LEUVEN

Burgerwetenschap

NETAMO RAIN GAUGES (ANTWERP REGION)





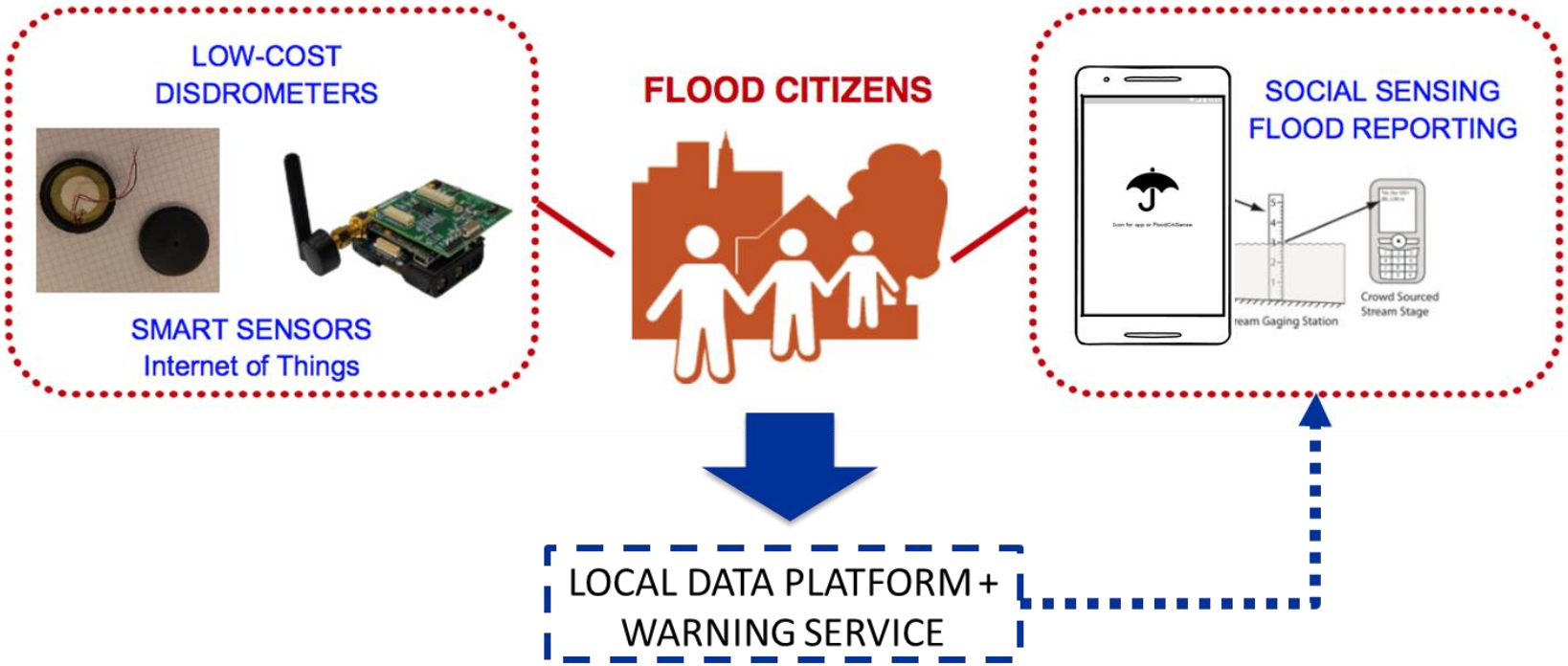


* RGs_temp: the rain gauges are now in place but was not installed during 30th may 2016

KU LEUVEN

Burgerwetenschap

Burgerobservatoria (co-creatieaanpak !):



FloodCitiSense

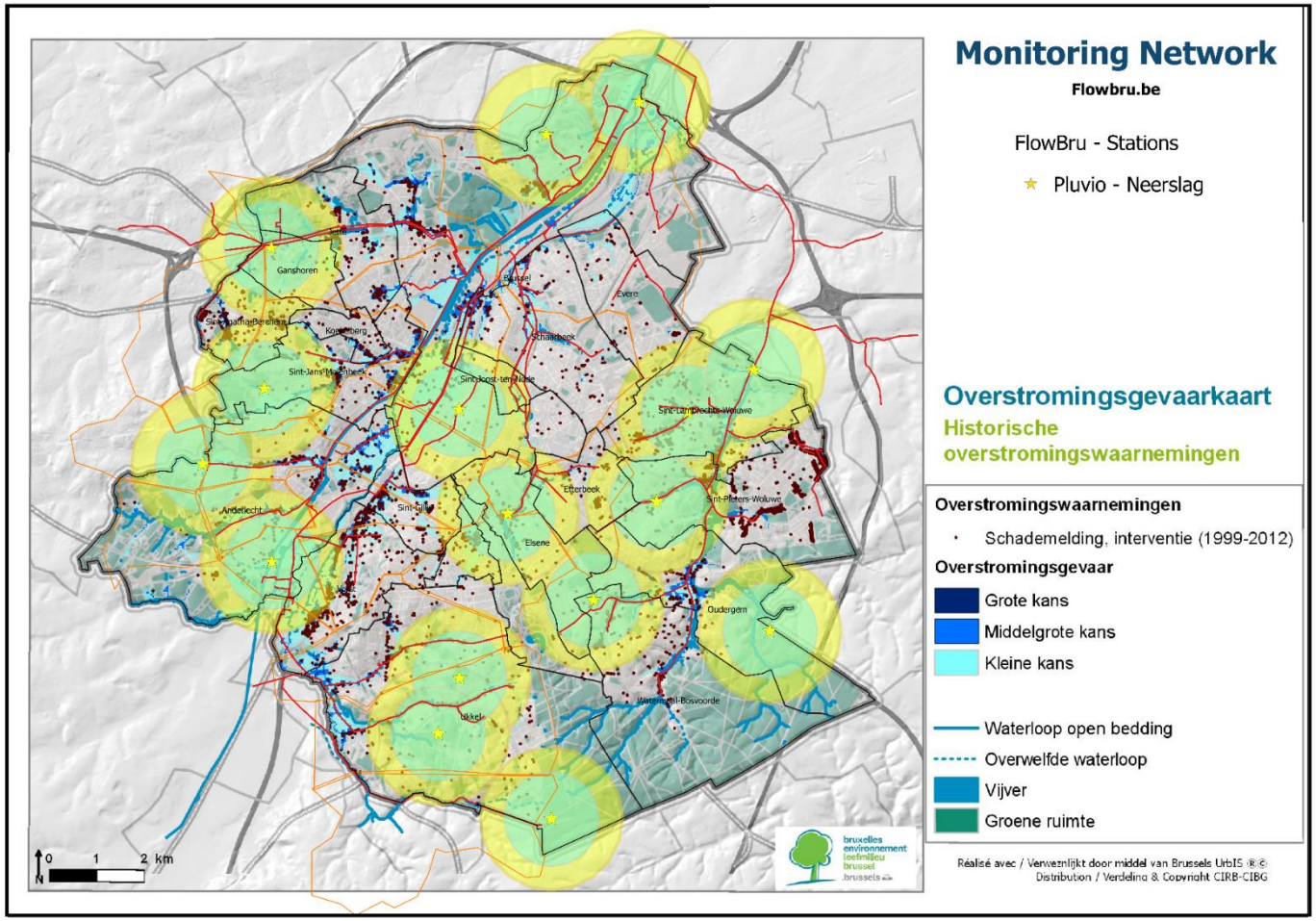
JPI Urban Europe
ERA-NET Smart Urban Futures

VUB VRIJE UNIVERSITEIT BRUSSEL

KU LEUVEN

Burgerwetenschap

Ruimtelijke gaten in pluviograafmetingen:



FloodCitiSense

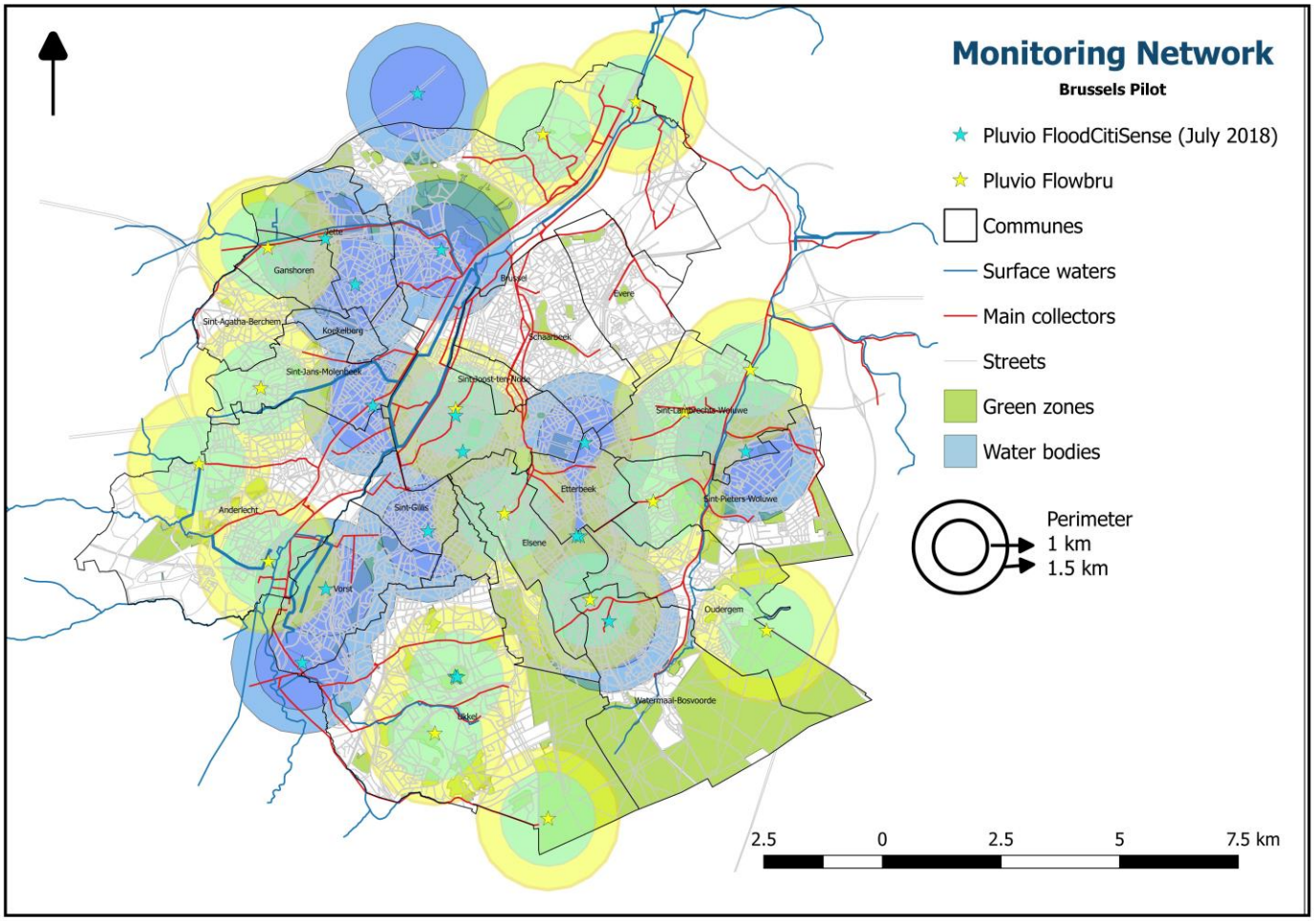
BRUSSELS

VUB VRIJE UNIVERSITEIT BRUSSEL

KU LEUVEN

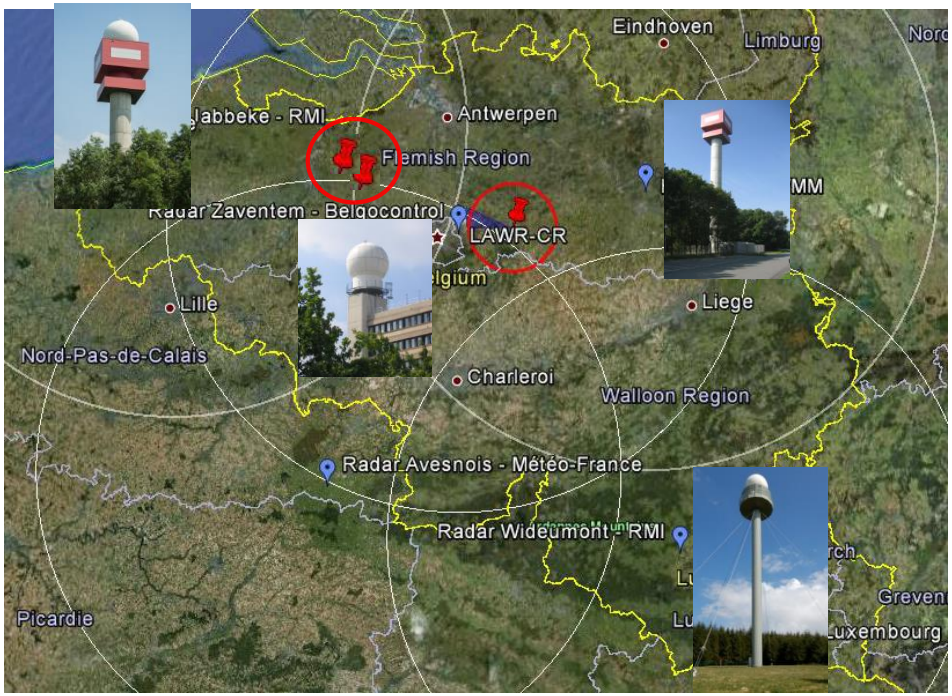
Burgerwetenschap

Bijkomende neerslagsensoren:



Lokale neerslagmeting met X-band radar

C-band radars KMI & VMM (500 m, 5 min):

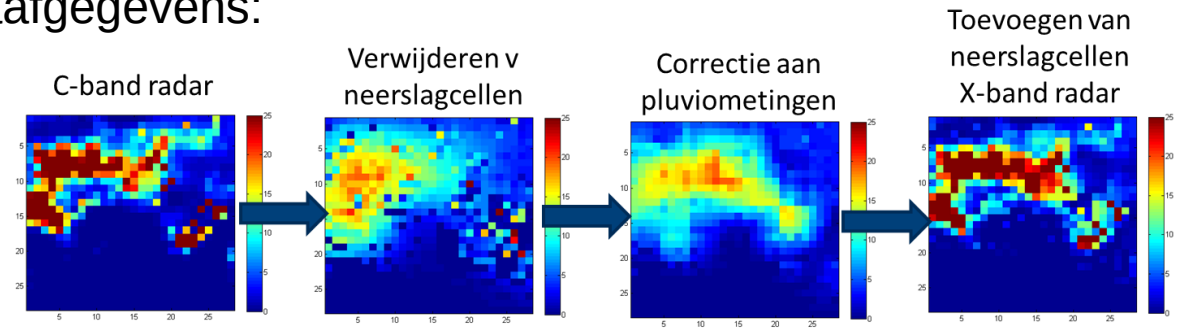


Local low-cost (X-band) radars

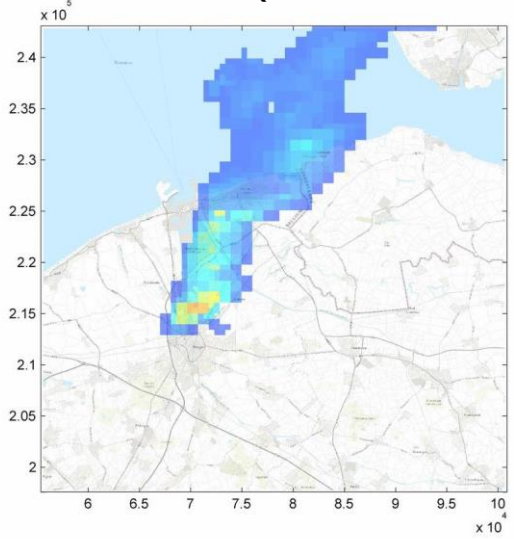
FURUNO WR-2100, high resolution (50m - 100m, 1 min):

Lokale neerslagschatting

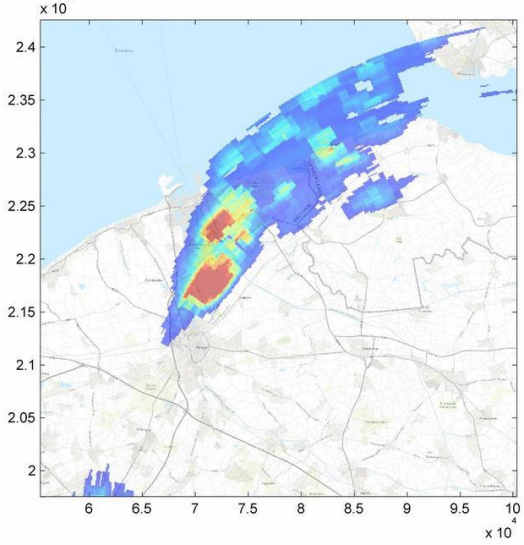
Beste lokale neerslagschatting door combineren C-band, X-band & pluviograafgegevens:



C-band radar (500m, 5min):



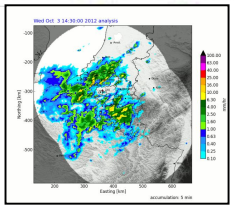
Gecombineerd met X-band radar (100m, 1min):



Wang, L-P., Ochoa-Rodriguez, S., Onof, C., Willems, P. (2015), 'Singularity-sensitive gauge-based radar rainfall adjustment methods for urban hydrological applications', Hydrology and Earth System Sciences, 19, 4001–4021

Voorspelling stedelijke wateroverlast

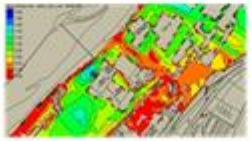
1 Nowcasting of extreme local rainfall intensities



Prototype system for Belgium

2 Nowcasting of pluvial flash floods

3 Nowcasting of socio-economic risks



4 Risk communication and warning

Demonstration for selected Belgian cities

RainGain

PLURISK

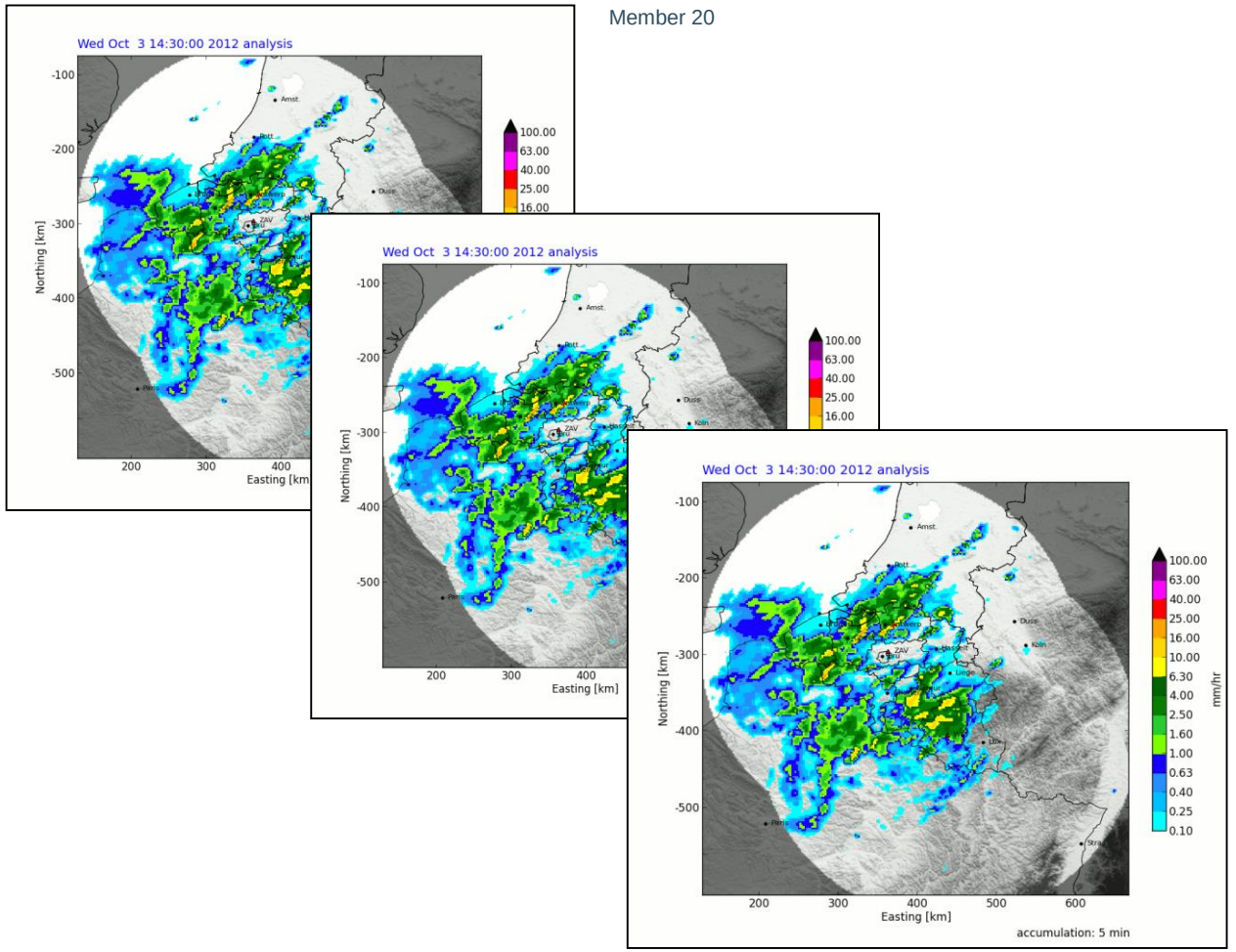
belspo

FloodCitiSense

KU LEUVEN

Lokale neerslagvoorspelling + onzekerheid

Neerslagtracking + stochastische modelextrapolatie:



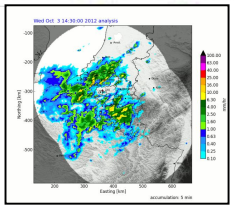
Member 20

Member 1

20 members

Voorspelling stedelijke wateroverlast

1 Nowcasting of extreme local rainfall intensities



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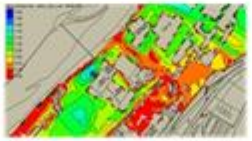


4 Risk communication and warning

Demonstration for selected Belgian cities

RainGain

PLURISK

belspo

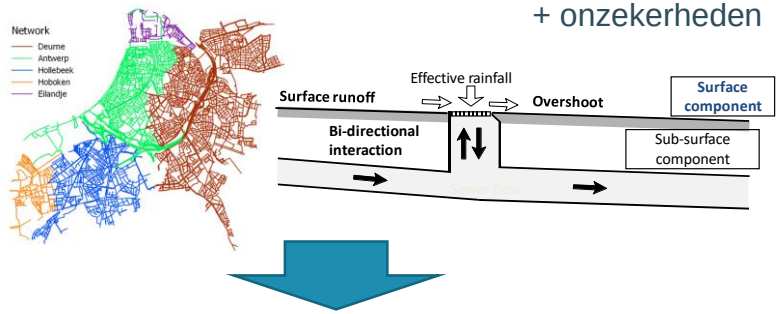
FloodCitiSense

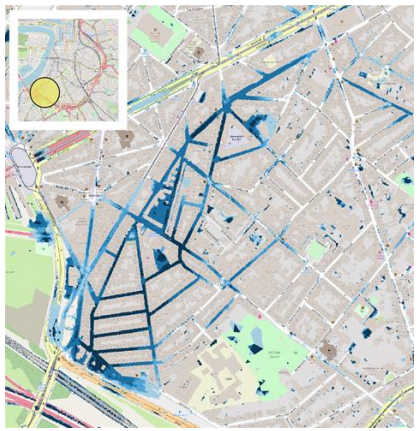
KU LEUVEN

Zelflerende modellen

Modellen (fysische systeemkennis)

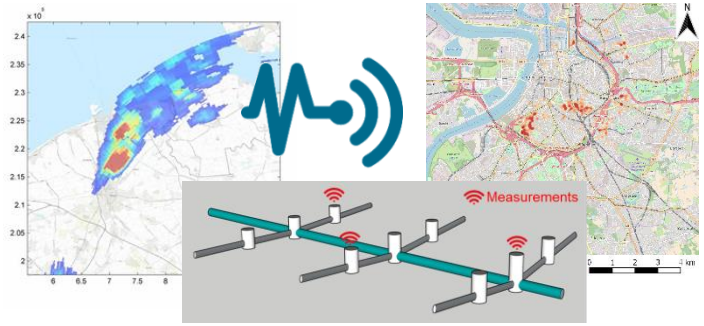
+ onzekerheden

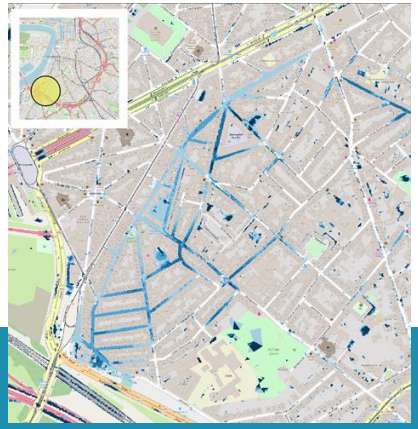




Waarnemingen (empirische informatie)

+ onzekerheden

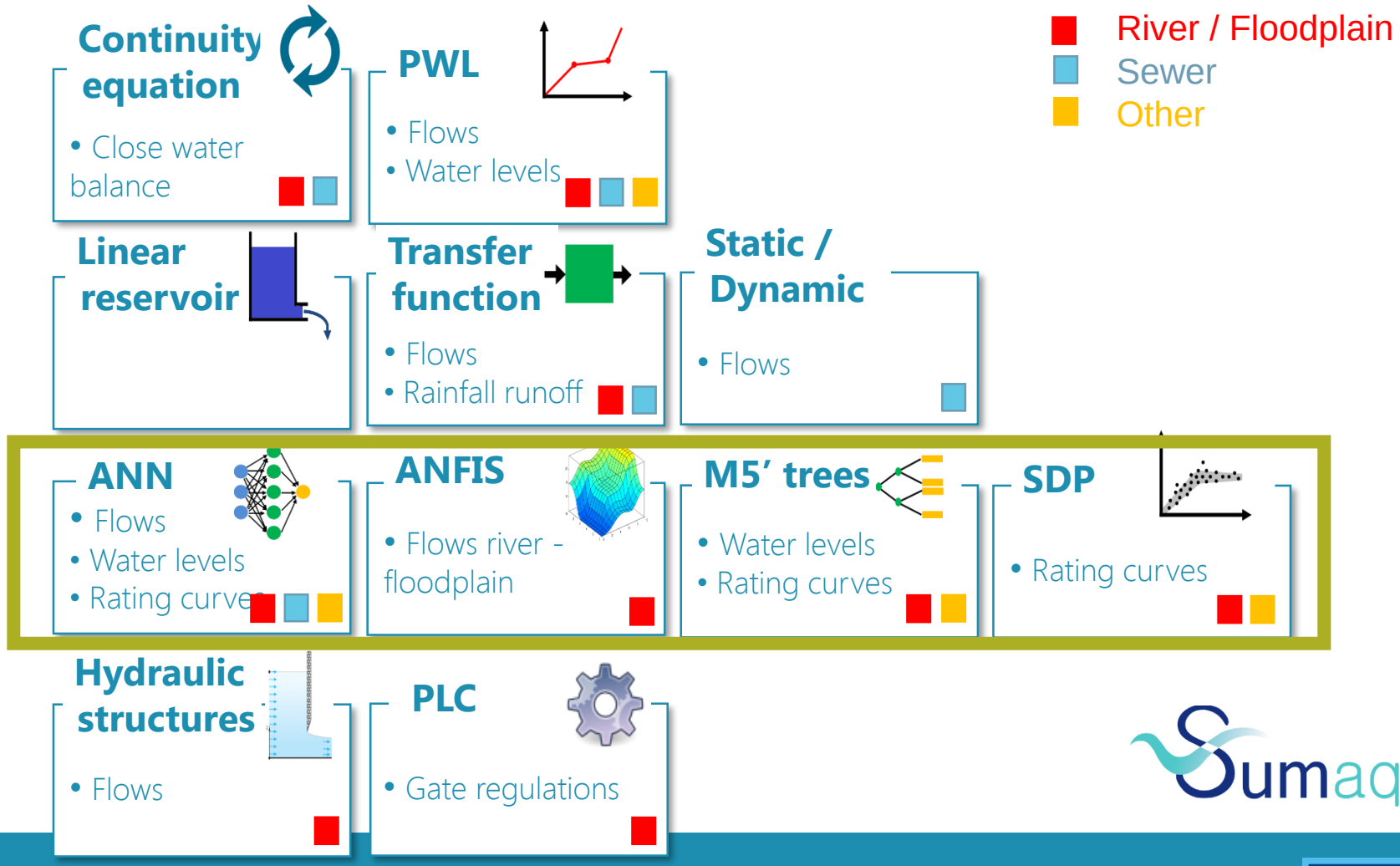




Sumaqua

KU LEUVEN

Zelflerende modellen: via Artificiële Intelligentie



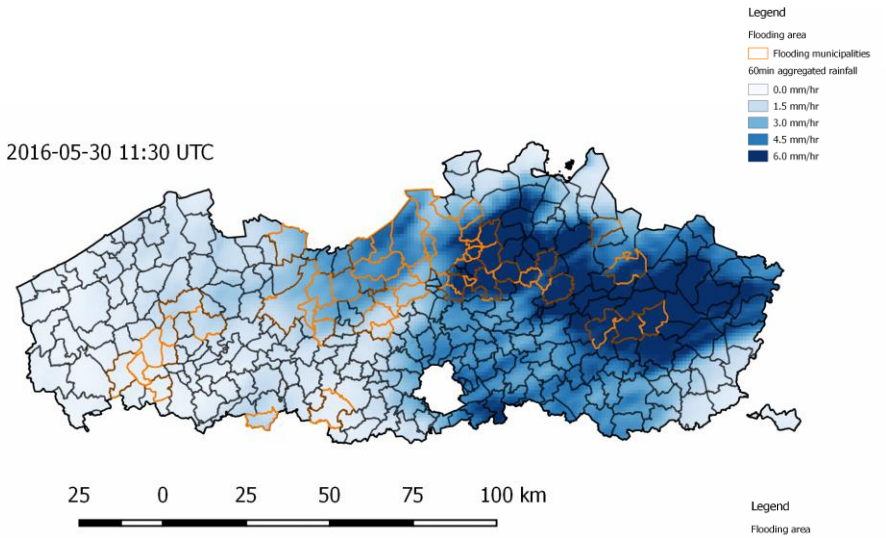
Sumaqua

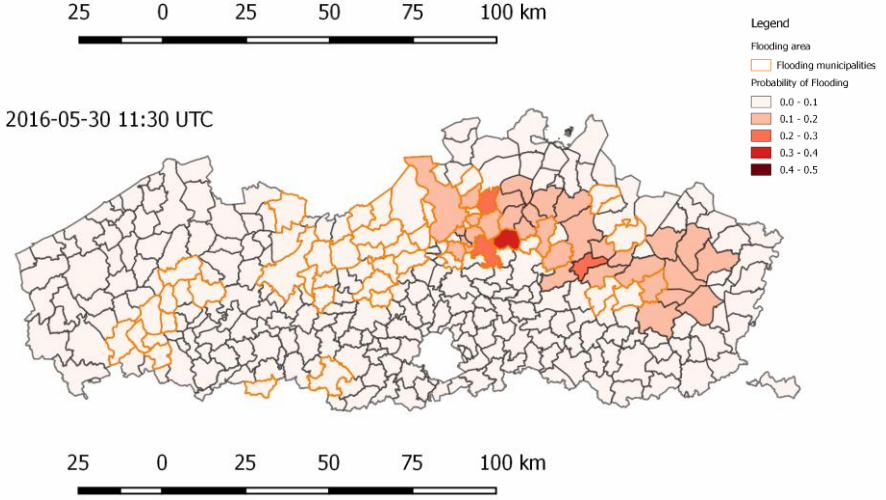
Wolfs, V., Meert, P., Willems, P., 2015. Modular conceptual modelling approach and software for river hydraulic simulations. Environmental Modelling & Software 71, 60-77

KU LEUVEN

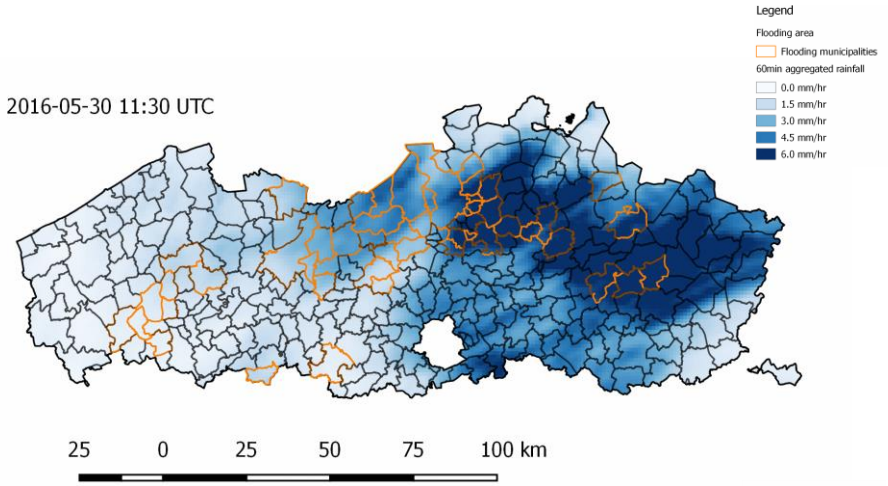
Probabilistisch voorspellingsmodel vr stedelijke overstromingen

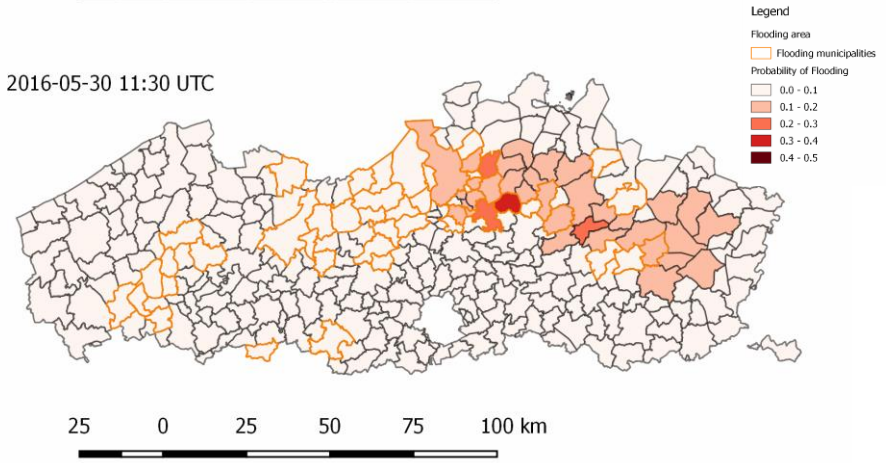
Observatie:



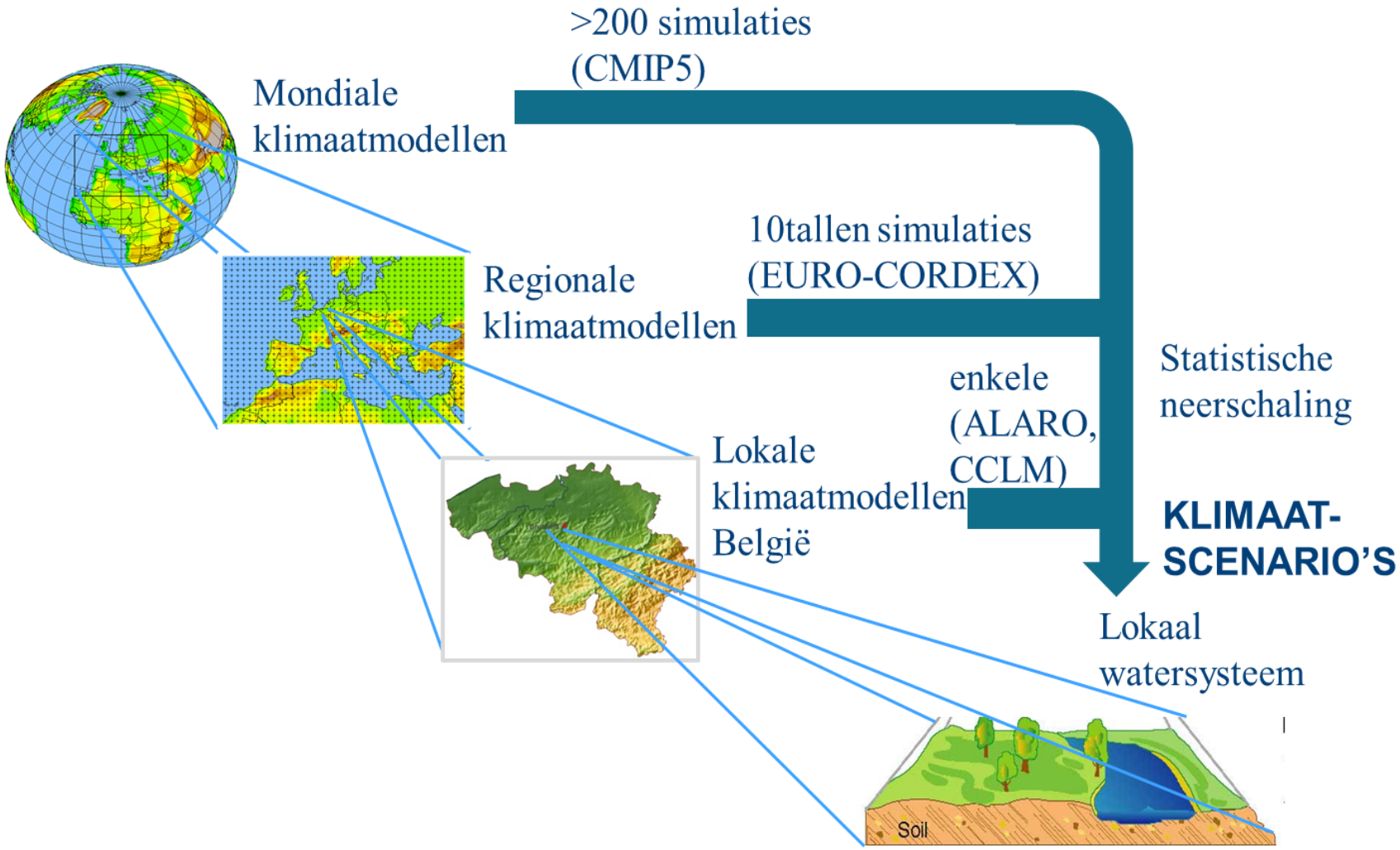


Observatie + nowcast:





Impactanalyse klimaatverandering



Tabari, H., Taye, M.T., Willems, P. (2014), 'Bijsturing van de Vlaamse klimaatscenario's voor hydrologische en hydrodynamische impactanalyse inclusief hydrologische extremen', KU Leuven voor VMM & MIRA2015 Klimaatrapport

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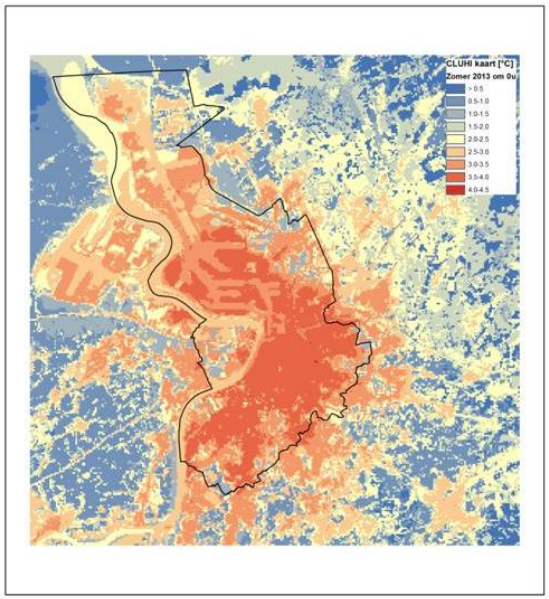
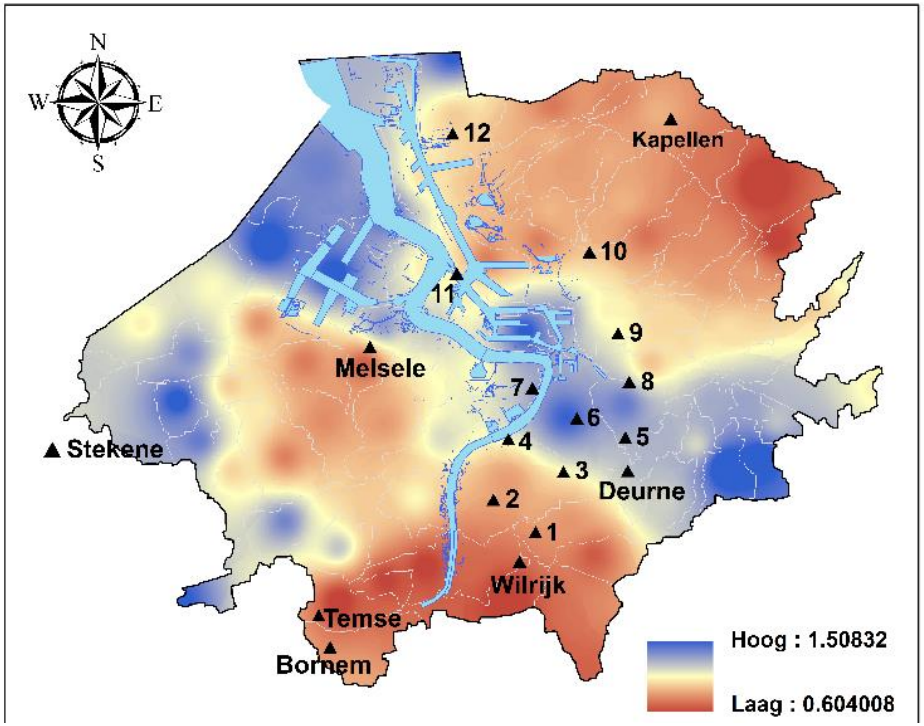
Lokaal microklimaat



Stad Antwerpen, VITO 2014



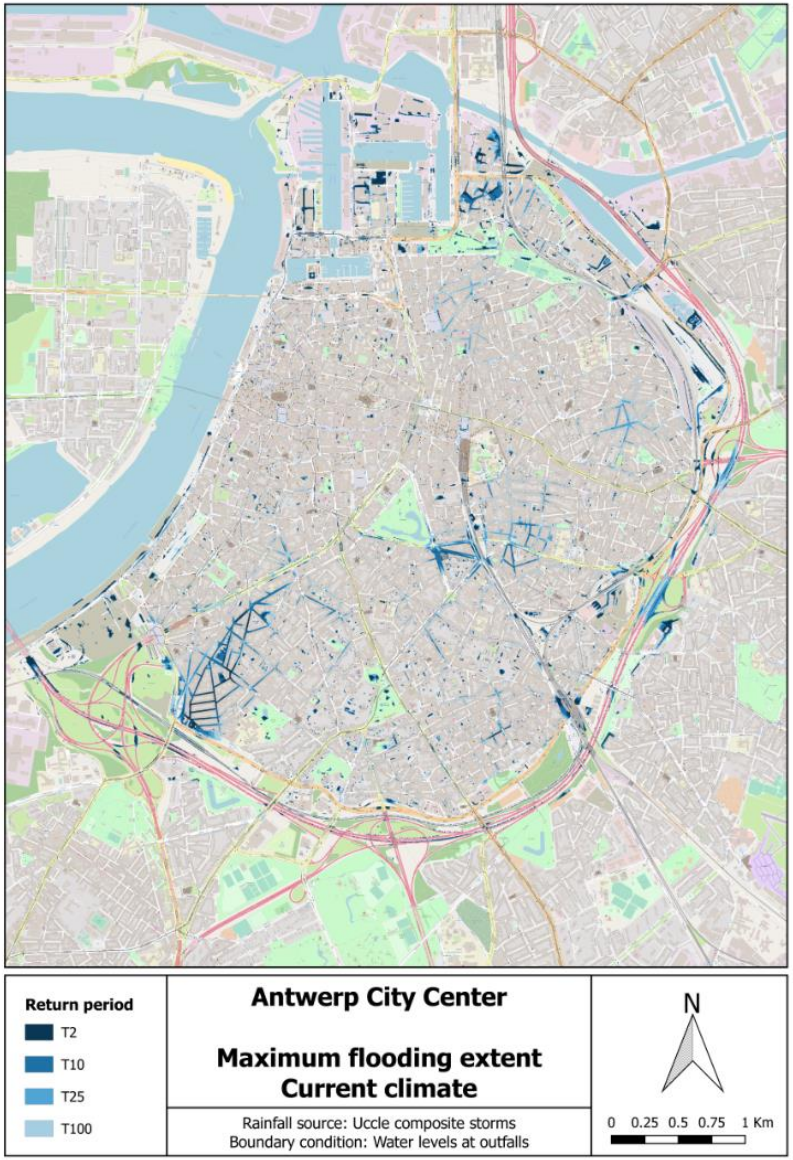
Stad Antwerpen, KU Leuven 2015-2016

Willems, P., De Niel, J., Tabari, H. (2016), 'Modellering en beleidsaanbevelingen ten aanzien van neerslag in Antwerpen', KU Leuven voor Stad Antwerpen

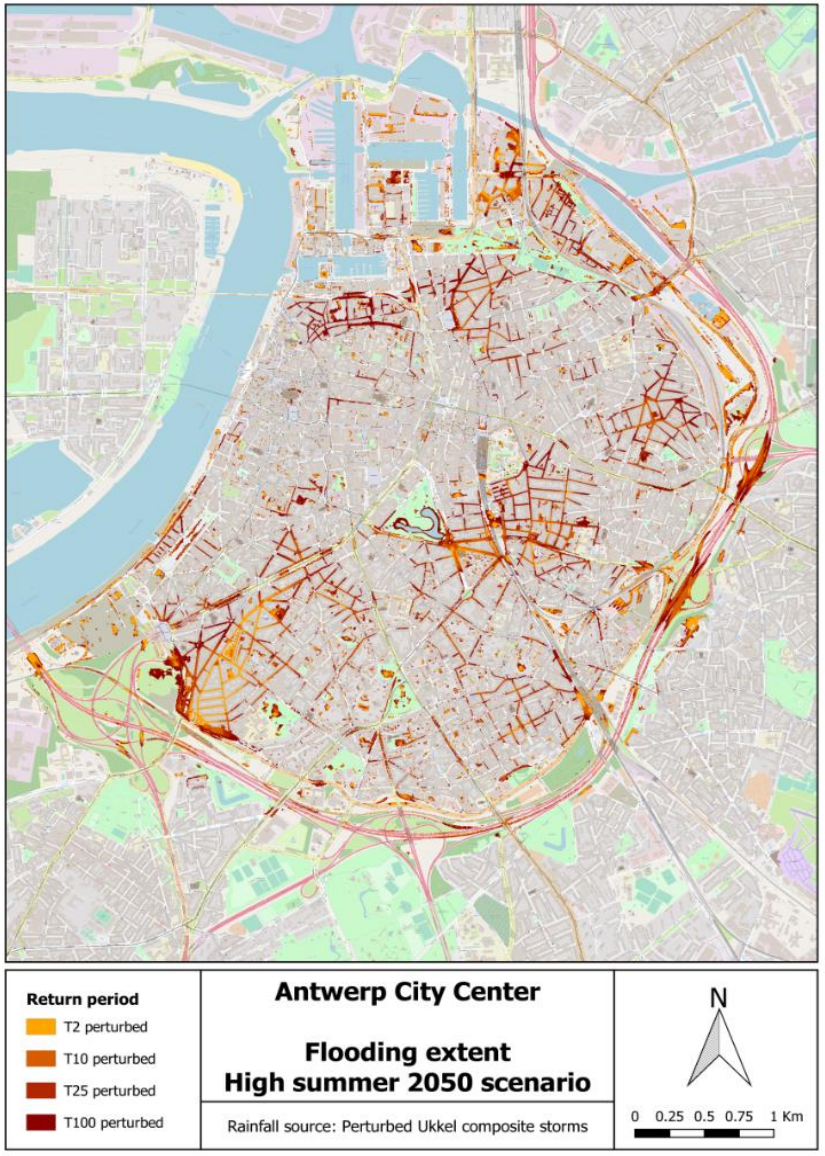
KU LEUVEN

Stad Antwerpen: pluviale overstromingsrisico's

Huidig klimaat:



Toekomstig klimaat, hoogzomer 2050:



Slimme adaptatiestrategieën

Climate adaptation & improving disaster resilience

BRIGAID

BRIDGING THE GAP FOR INNOVATIONS IN DISASTER RESILIENCE

HORIZON 2020

FROM PROTOTYPE TO MARKET READY INNOVATION

ADAPTING TO: FLOODS, DROUGHTS & EXTREME WEATHER

INNOVATION PROCESS

PROTOTYPE
STOCKTAKING OF INNOVATIONS
INNOVATOR INCUBATOR

END USERS
MARKET READY INNOVATIONS
LARGE SCALE MARKET UPTAKE

VALLEY OF DEATH

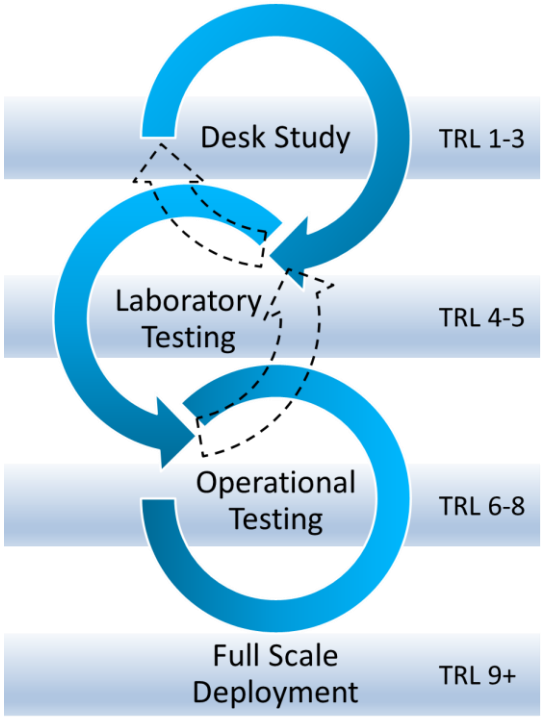
Climate adaptation & improving disaster resilience

BRIGAID

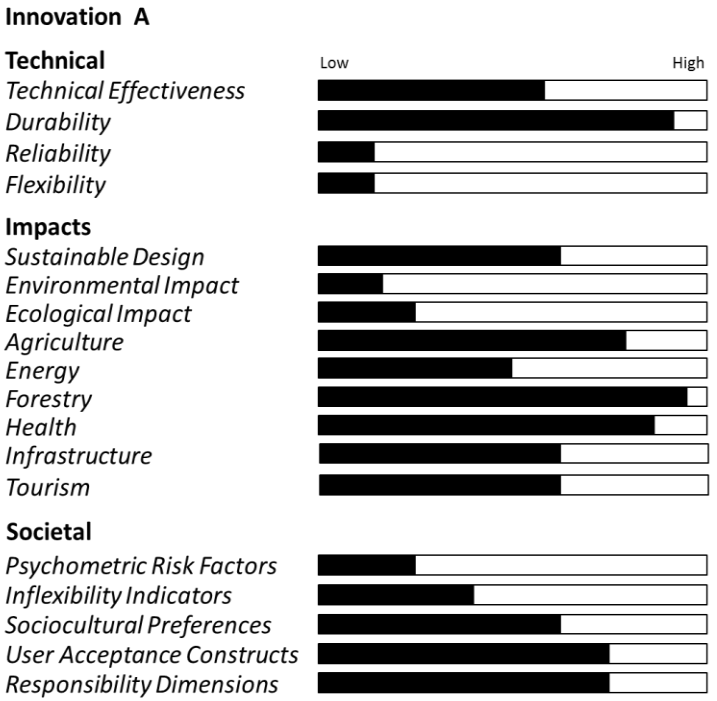
BRIDGING THE GAP FOR INNOVATIONS IN DISASTER RESILIENCE

Testing of innovations:

Testing Framework



Technical, Societal & Market Readiness



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Stad Antwerpen: living lab Sint-Andries

BRIGAID

antwerpen stadslab 2050

WE EXPERIMENTEREN EEN TOEKOMST

beweging.net

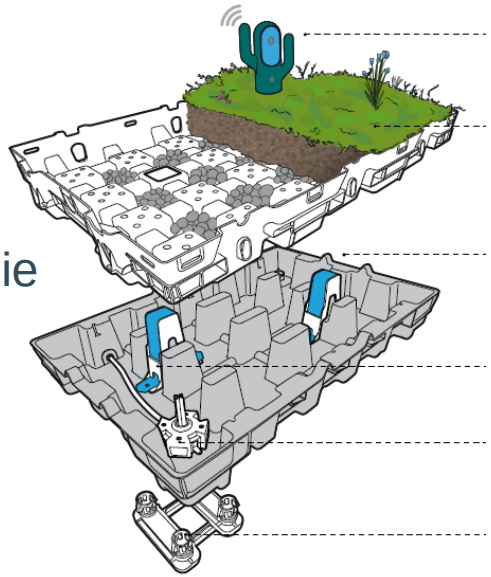
Green innovation for smart cities

vegetal.ID

KU LEUVEN

Intelligent groendak

Impact op afstroming, afkoeling,
tegengaan droogteimpact, stadsecologie

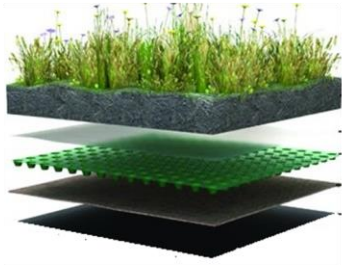


Installatie op 6-10 nov. 2017:

KU LEUVEN

Intelligent groendak

Conventioneel
Tafel 1



✓6 cm substraat
✓Filterdoek
✓Uitlaat en overstort

Hydroventiv (HVV)
Tafel 2

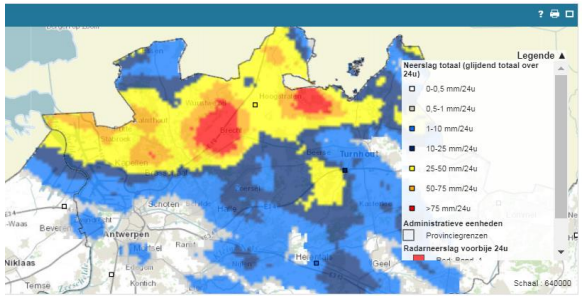
✓8 cm substraat
✓8 cm waterberging
✓Uitlaat en overstort

OASIS
Tafel 3

✓20 cm substraat
✓8 cm waterberging
✓Geen uitlaat (wel overstort)

KU LEUVEN

Intelligent groendak



STAP 1: Het “weerbericht” van het komende uur lezen: komt er een hevig onweer?

STAP 2: Kan het dak deze bui opvangen? Moet de berging geledigd worden?

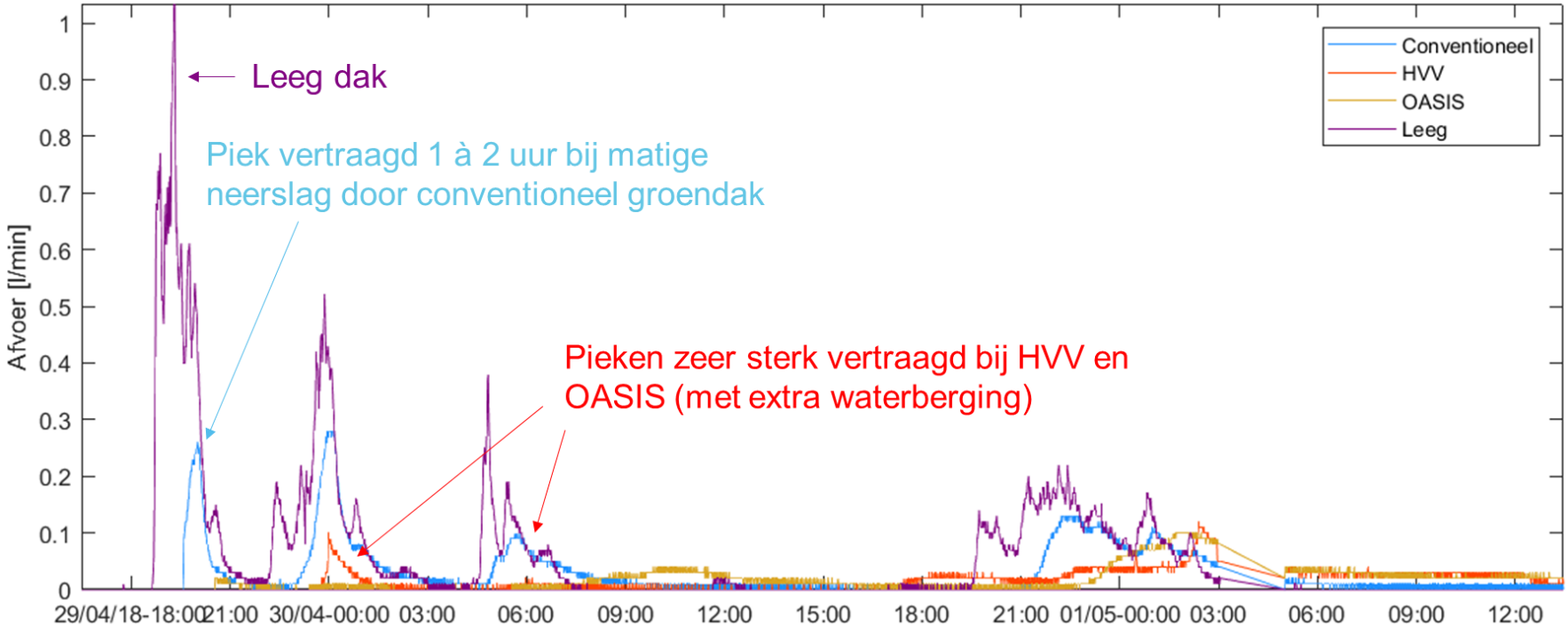
STAP 3: Kunnen we nog lozen, of is de riolering nu reeds overbelast?

Intelligent groendak

Omgekeerd bij droogte: water vasthouden en beschikbaar stellen aan planten!

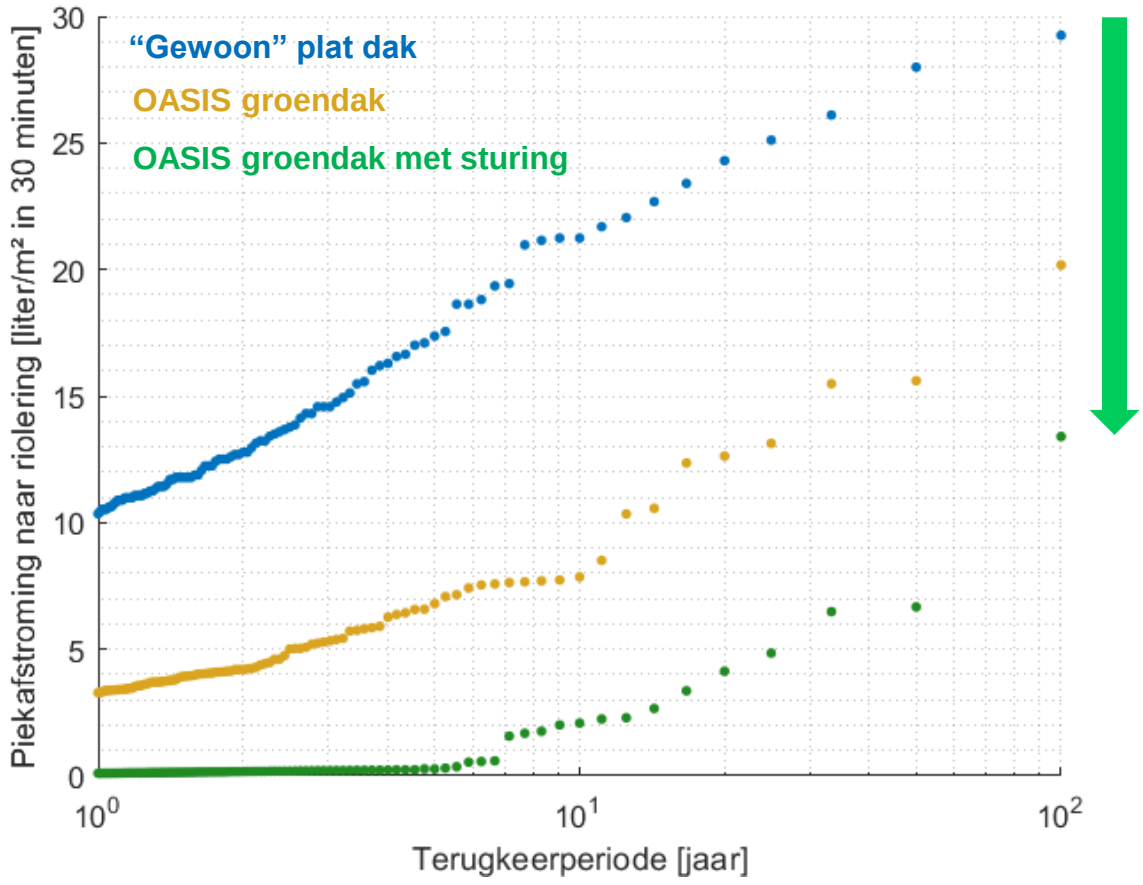
Intelligent groendak

Impact op neerslagafstroming:



Intelligent groendak

Reductie afvoer naar riolering:



Zeer grote reductie (tot 80%) van kritieke stormafvoer

Sirio

Sumaqua

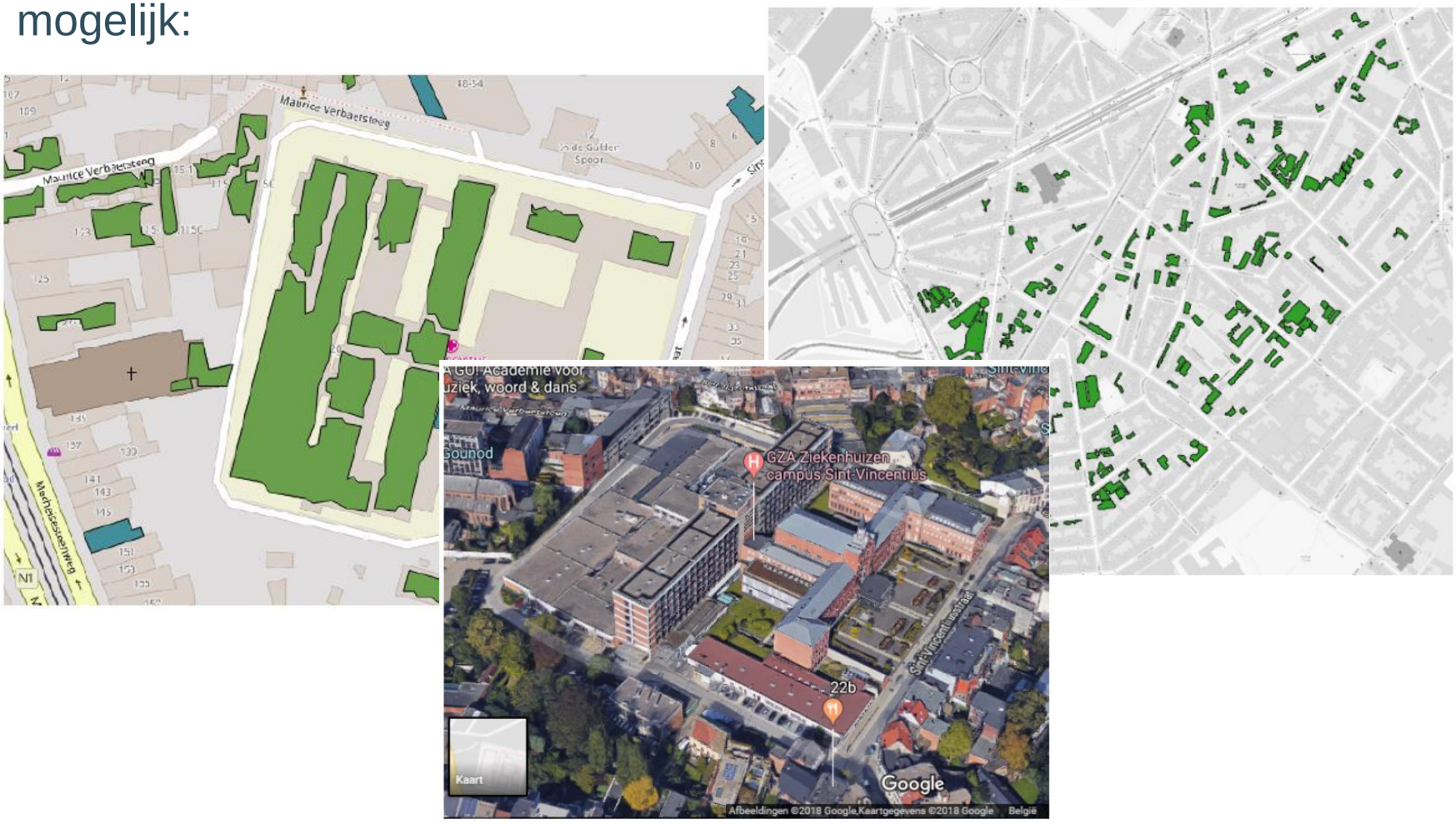
KU LEUVEN

Opschaling

Sumaqua

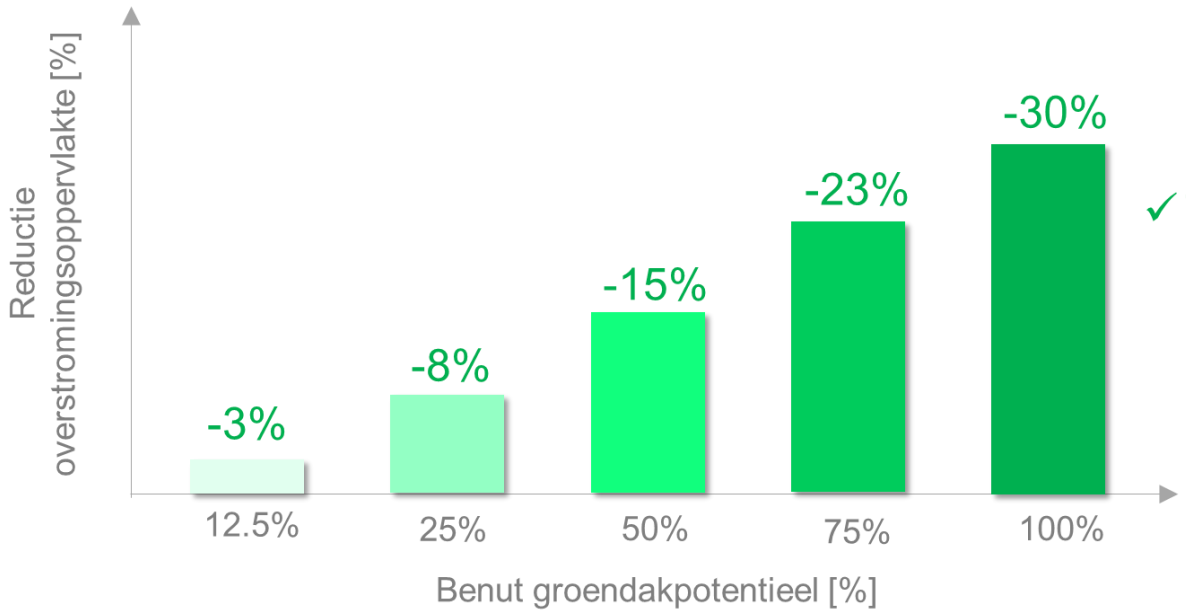
Intelligent groendak

Antwerpen “historisch centrum”: circa 750 000 m² aan groendaken mogelijk:



Intelligent groendak

Opschaling naar gans historisch stadscentrum (30 mei 2016):



✓ Tot 30% minder overstromingsoppervlakte

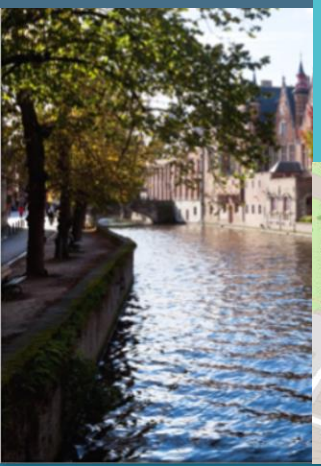
Waterplan (Klimaat- en waterrobuuste inrichting stedelijke ruimtes)

01 RIOLERING 2.0
- ✓ Afkoppeling naar de reien, parken, …

02 INRICHTING BEBOUWDE KERN
- ✓ Opvangen en hergebruiken van hemelwater
- ✓ Groenblauwe inrichting van de open ruimte
- ✓ Waterrobuuste straatinrichting

03 KLIMAATROBUUSTE REIEN
- ✓ Verhogen van overstortdrempels
- ✓ Vergroten van de waterbeschikbaarheid van de reien
- ✓ Intelligente sturing

Afkoppeling naar reien



Hergebruik regenw

Groenblauwe inrichting

Gans

Voorste dakdelen (565 m²)

Dakdelen rond speelplaats (1944 m²)

Waterrobuuste straten

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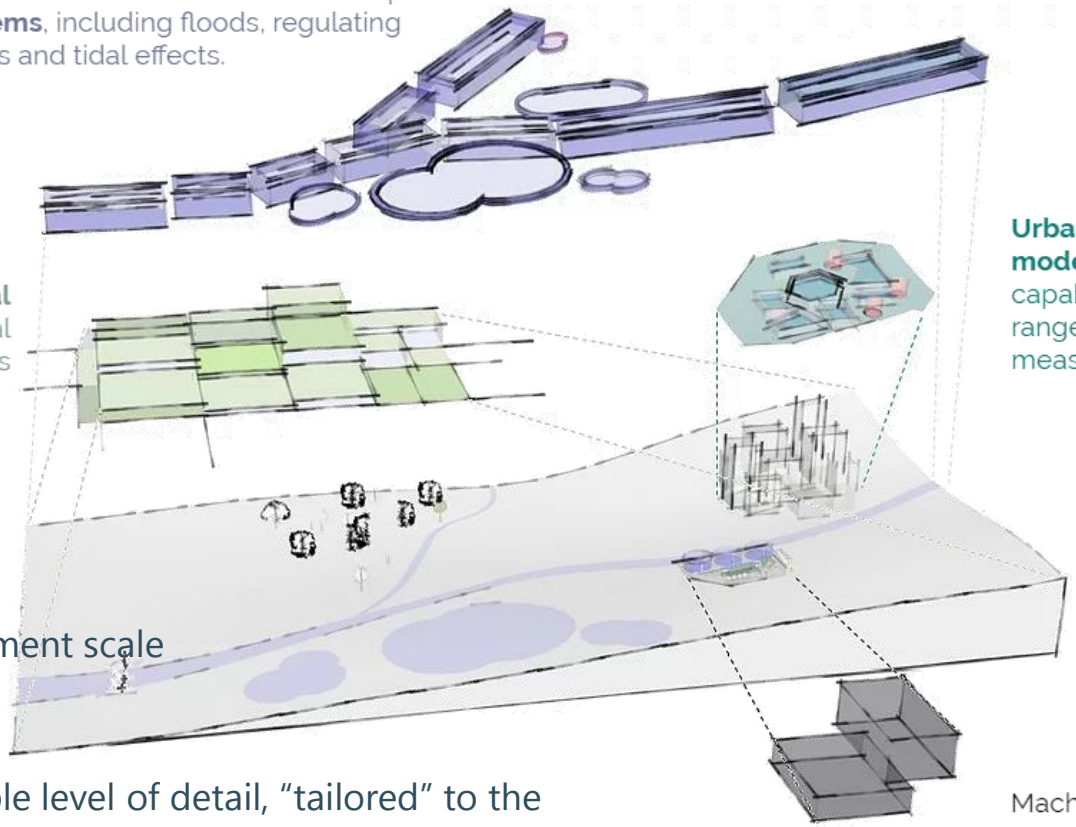
Opschaling -> waterplan

Sumaqua

Conceptuele modellen

Conceptual reservoir-type models that can emulate complex dynamics of **river systems**, including floods, regulating structures and tidal effects.

State-of-the-art **hydrological models** suitable for spatial scenario analyses

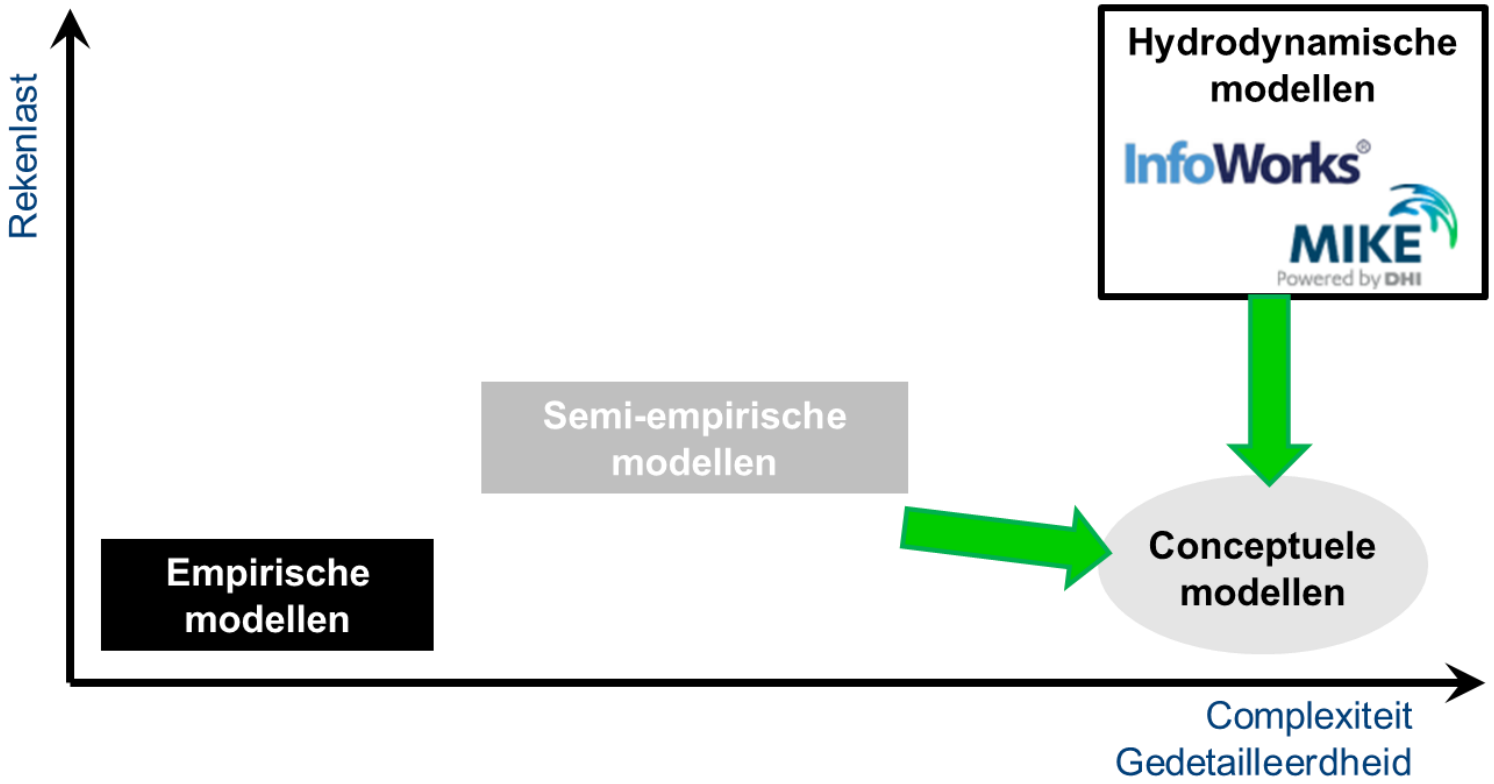


Urban drainage and flood models using radar data, and capable of simulating a vast range of source control measures

Machine learning techniques to **turn process data from various sources in powerful predictive models**

- ✓ Integrated catchment scale
- ✓ Super fast
- ✓ Flexible: adjustable level of detail, “tailored” to the application
- ✓ Accurate (if well calibrated)

Snelle, zelflerende modellen



Wolfs V, Meert P, Willems P (2015), 'Modular conceptual modelling approach and software for river hydraulic simulations', Environmental Modelling and Software, 71, 60-77

Meert P, Pereira F, Willems P (2016). 'Computationally efficient modeling of tidal rivers using conceptual reservoir-type models', Environmental Modelling and Software, 77, 19-31

Wolfs V, Willems P (2017), 'Modular conceptual modelling approach and software for sewer hydraulic computations', Water Resources Management, 31(1), 283–298

Keupers I, Willems P (2017), 'Development and testing of a fast Conceptual River Water Quality model', Water Research, 113, 62-71

waterbouwkundig LABORATORIUM

VLAAMSE MILIEUMAATSCHAPPIJ

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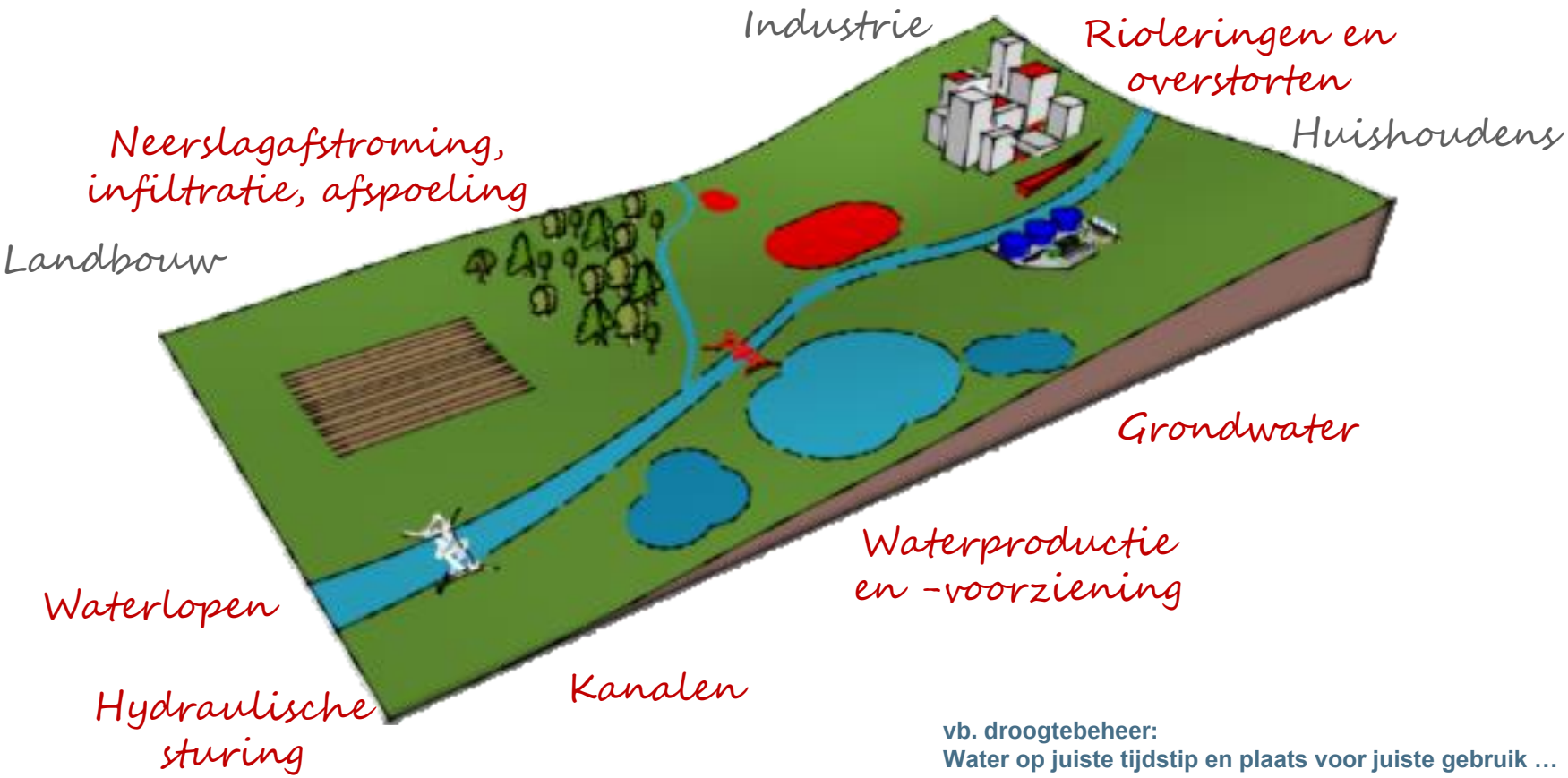
Integrale aanpak = systeemdenken

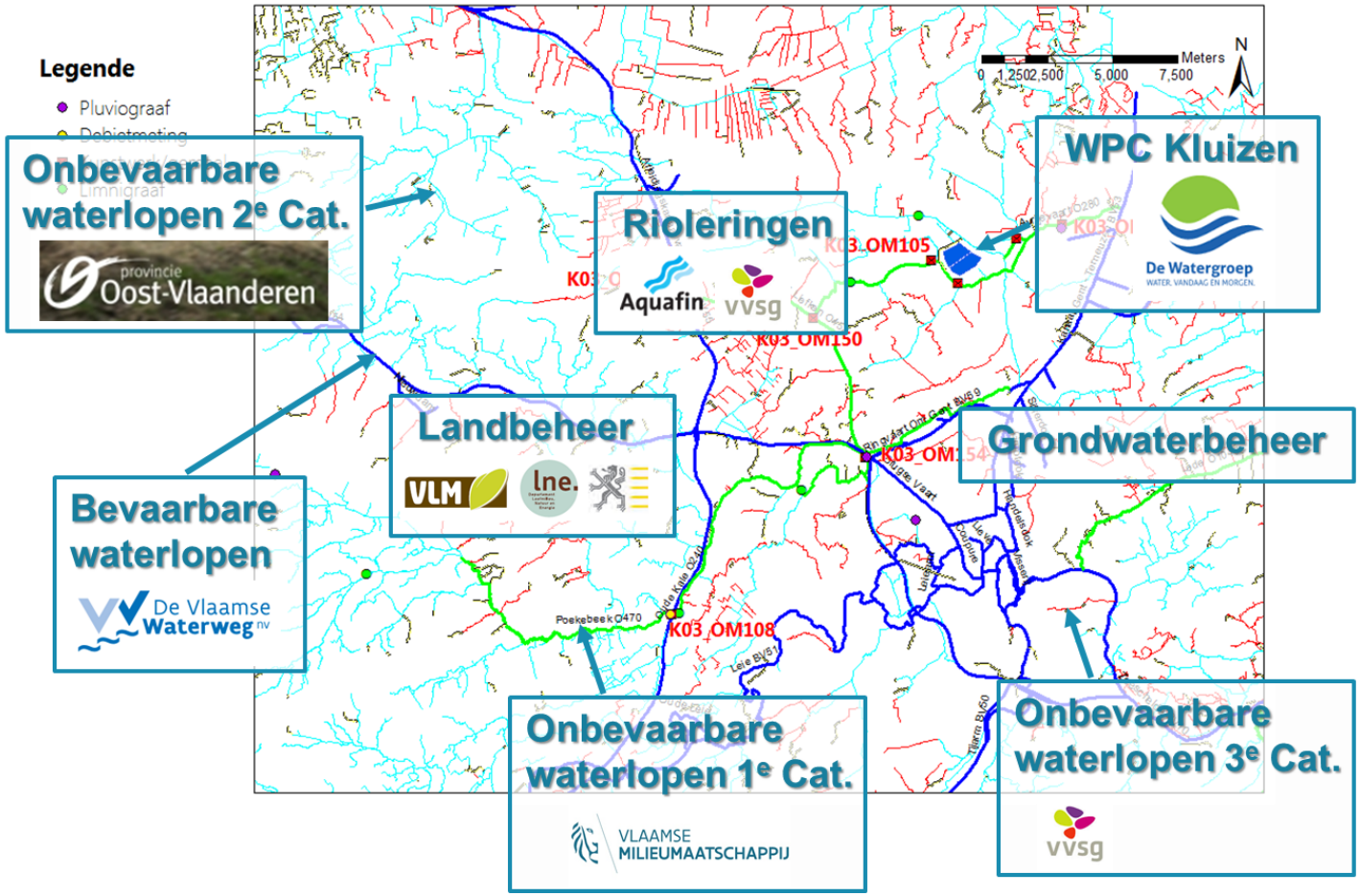
Geïntegreerde analyse vh groot aantal deelcomponenten van het integrale watersysteem + interacties -> **OPTIMALISATIE !**



vb. droogtebeheer:
Water op juiste tijdstip en plaats voor juiste gebruik …

Integrale aanpak = systeemdenken

Voorbeeld: WPC Kluizen



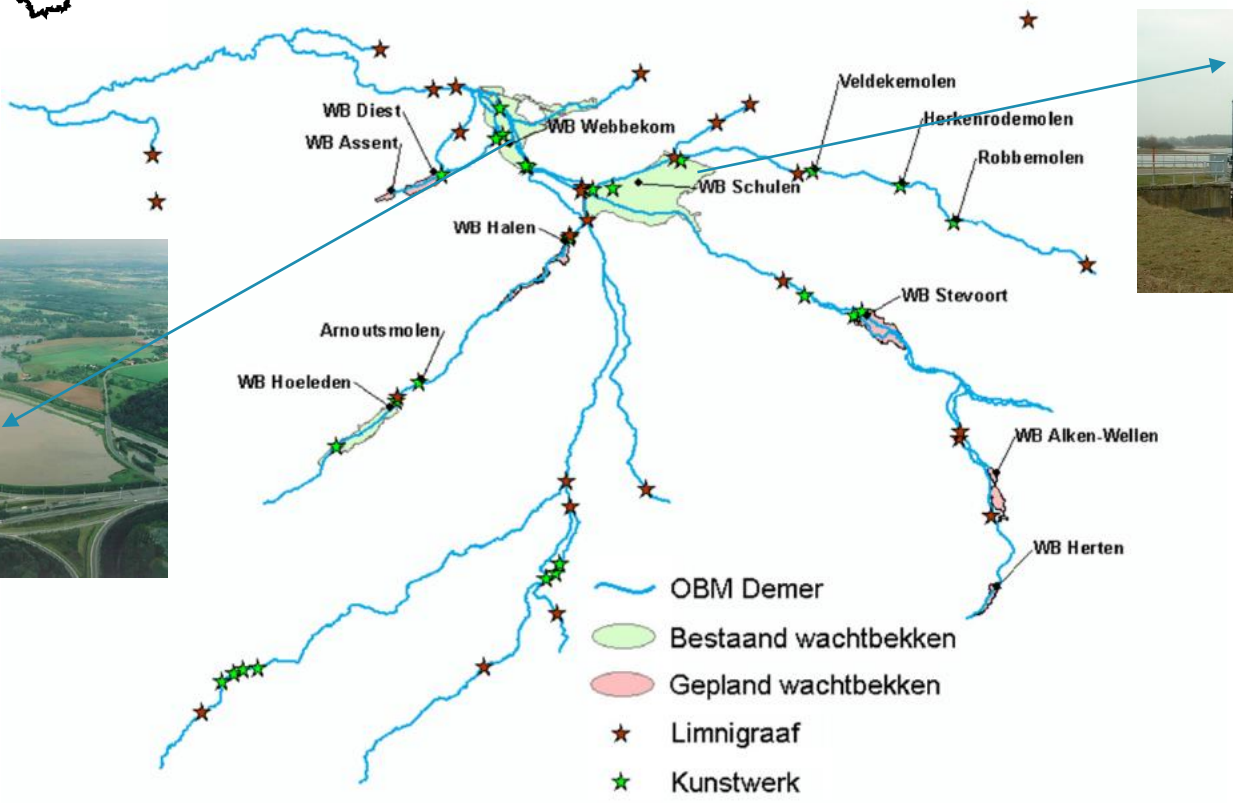
Intelligente sturing wachtbekkens

Demerbekken:

Model Predictive Control

anticiperend op voorspelde neerslag & bovendebieten

VLAAMSE MILIEUMAATSCHAPPIJ



Chiang, P., Willems, P. (2015). 'Combine evolutionary optimization with Model Predictive Control in real-time flood control of a river system', *Water Resources Management*, 29(8), 2527-2542

Vermuyten, E., Meert, P., Wolfs, V, Willems, P. (2018), 'Combining model predictive control with a reduced genetic algorithm for real-time flood control', *ASCE Journal of Water Resources Planning and Management*, 144(2), 04017083

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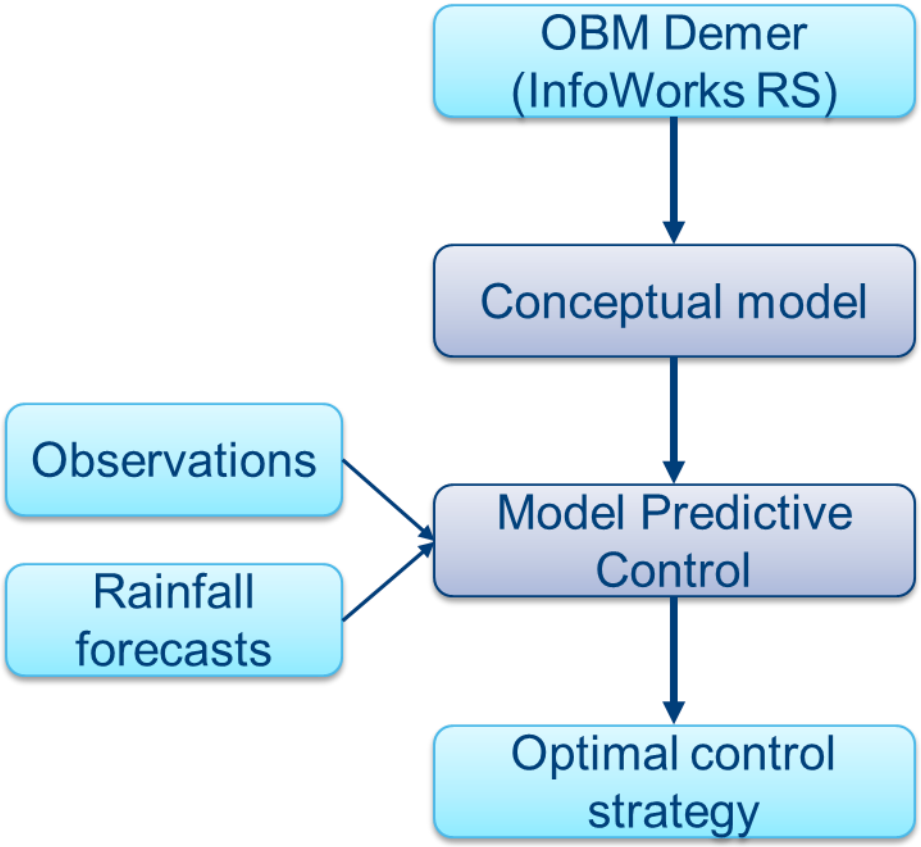
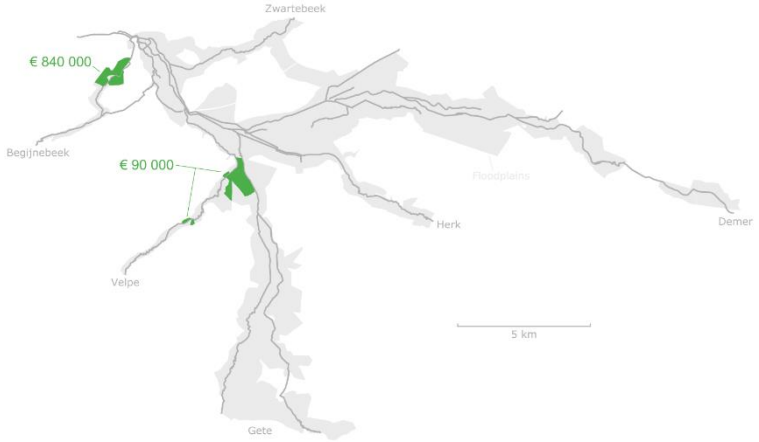
Snelle modellen + MPC



Event	Economic damage cost [€]		Damage reduction [%]
	PLC	MPC	
Sept1998	3.0M	2.1M	30
Aug2003	0	0	/
Dec1999	0	0	/
Jan1995	0	0	/
Jan2002	0	0	/
Nov2010	300	100	(67)
VMM	4.7M	3.5M	26
T1000	2.0M	1.7M	15
Sept1998x1.3	28.0M	26.8M	4
2xSept1998	28.1M	27.5M	2



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VLAAMSE MILIEUMAATSCHAPPIJ

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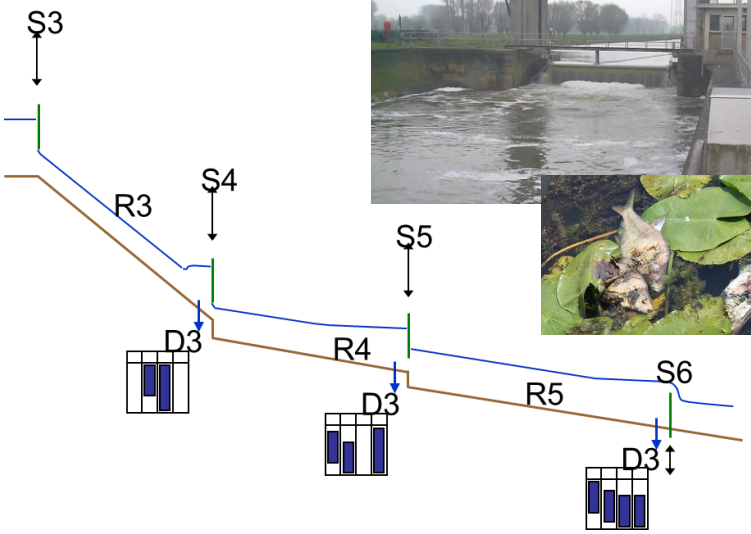
Intelligent peilbeheer



Wachtbekkens

Pompen tegen lekverliezen

Bovendebieten / spoeling tegen zoutbezwaar

Buffer- & spaarbekkens


industry 4.0
intelligent
high-tech
revolution
computer
smart
automation
work
cyber
robot
factory
machine
production
cloud
strategy
process
future
IoT
business
facilities
global
manufacturing
industrial
augmented
customization
autonomously
technical
fourth
logistics
tech
tasks
virtual
systems
engineering
chain
reliability
connectivity
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skills
resources
interoperability
society
project
strategic computing

Slim waterbeheer 2.0

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