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science for global insight

IIASA

Improving water resources management on global and region scales

Evaluating strategies for water futures with the IIASA's Community Water Model

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AGU Fall Meeting, 15th Dec. 2017, New Orleans

Increasing Water Demands, Increasing Challenges

Human needs

Ecological Health

Food

Agricultural water requirements in Africa increase by **240%** due to irrigated land expansion and climate change

Domestic

Domestic water withdrawals in Africa increase by **400%**

Energy & Industry

Industrial water withdrawals in Africa increase by **350%**

Ecology

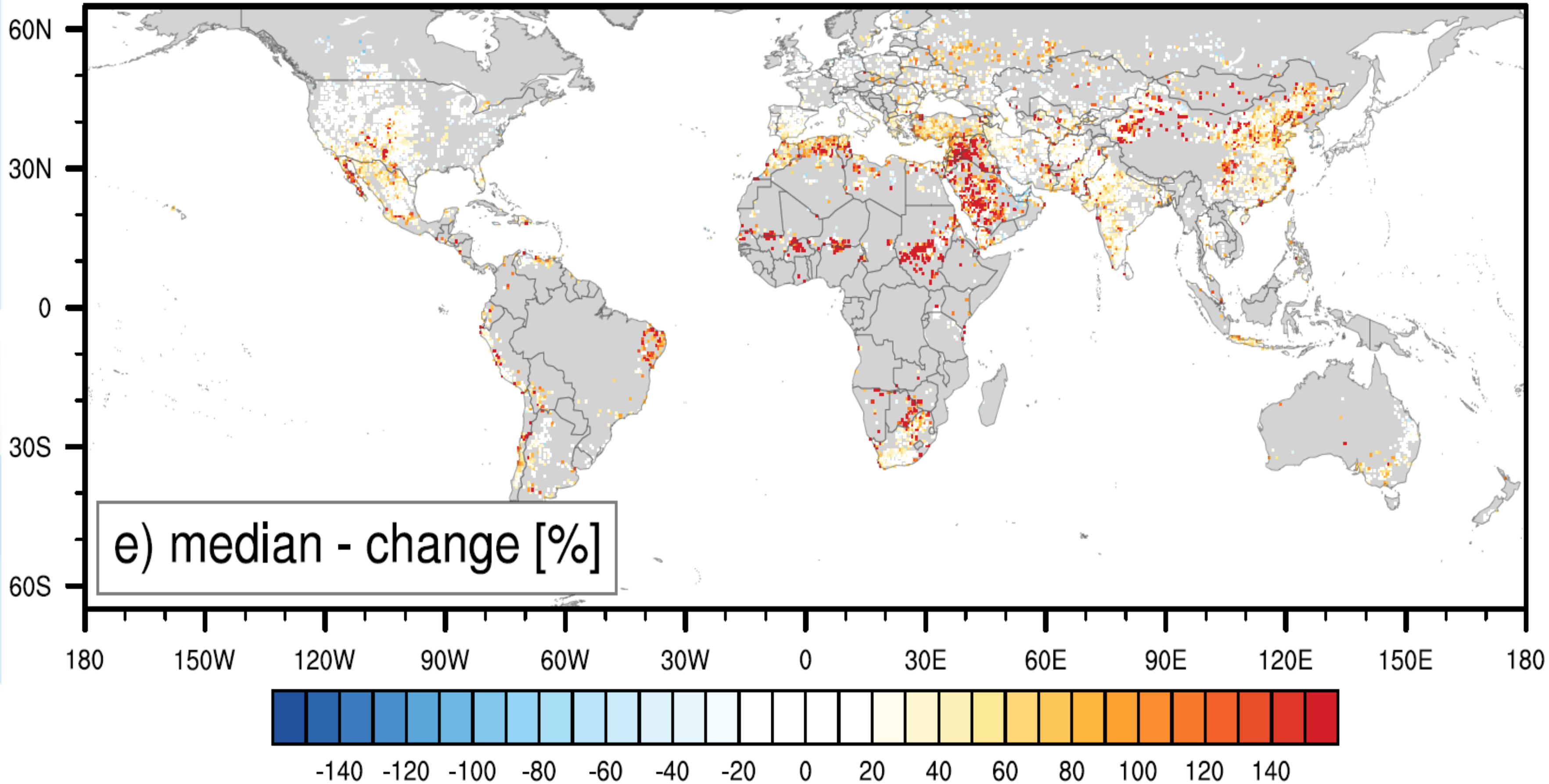
Lost of wetlands and biodiversity

River do not reach the sea

Concept of environmental flow

By 2050, under SSP2, RCP6.0 Scenario
Using 3 GHM, 5 GCM model ensemble

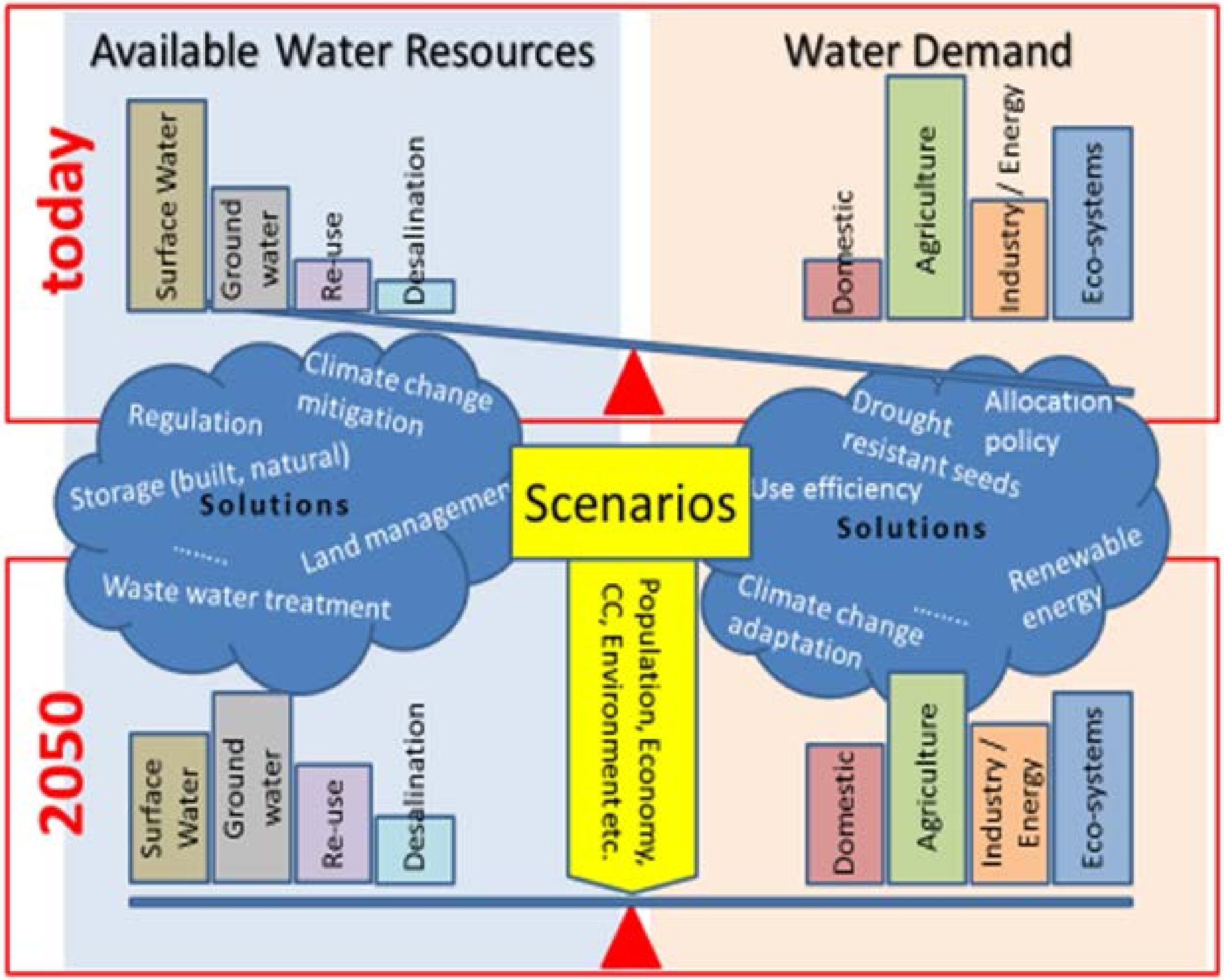
Change in water scarcity conditions between 2010 and 2050



Ensemble of 45 global estimates of both water supply and water demand
3 GHMs, 5 GCM under 3 scenarios (SSP and RCP combinations)
(Points with WSI < 0.1 and points with very low average water demand are masked)

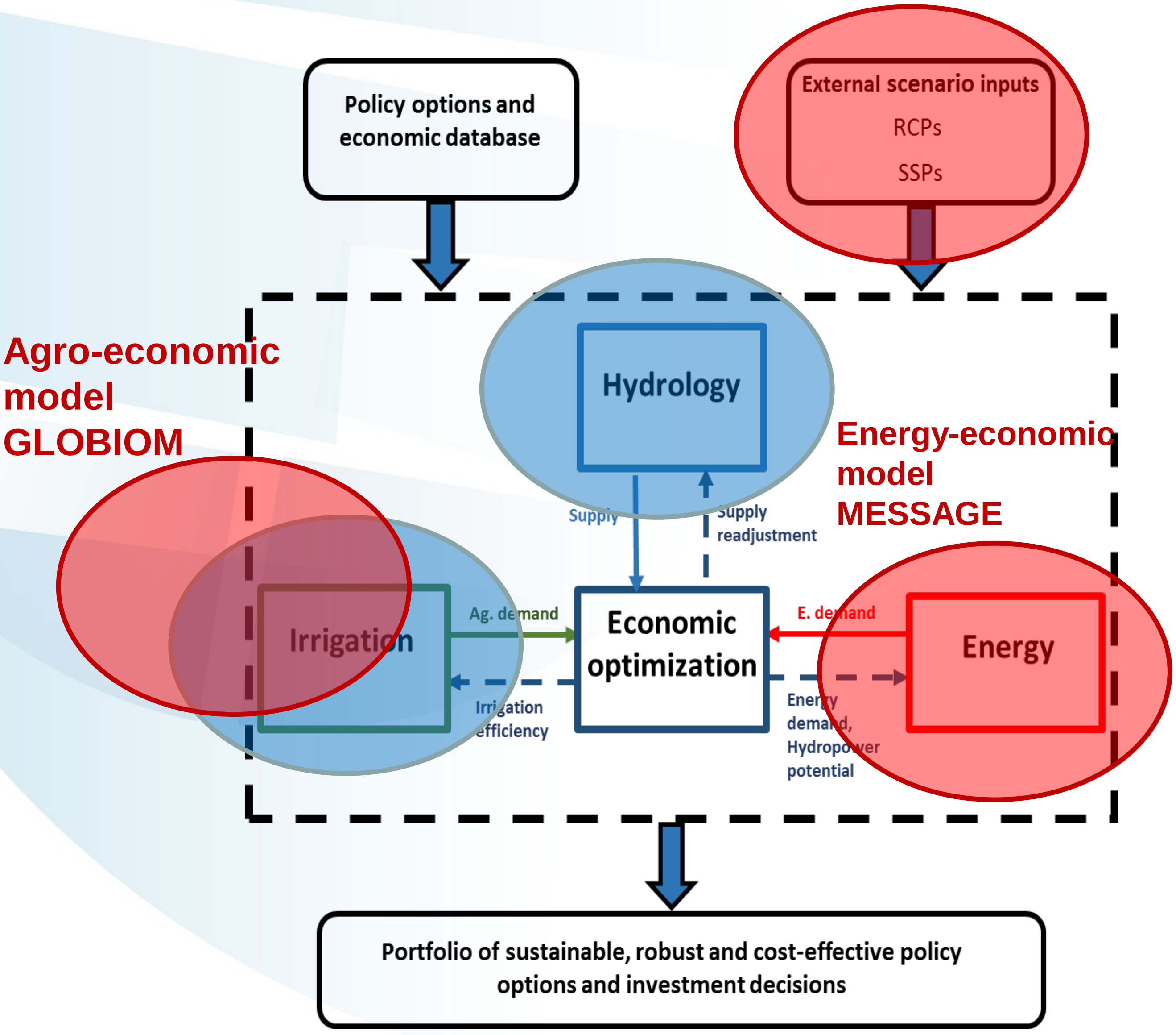
Source: Greve et al. Forthcoming

Reducing risks of water stress



What strategy is best to implement where and when? How much will it cost? How will this impact land and energy use?

Hydro-economic modeling framework



Key features represented in the model:

Drivers: Demand growth; Resource availability; Climate change; etc.

Processes: Reservoir management; Irrigation use; Electricity generation; Water pumping; End-use efficiency; Wastewater treatment; etc.

Impacts: Prices; Demands; Environmental flow; Groundwater depletion; Resource security; etc.

Hydrological model CWATM

Global discharge demo

Contact

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Community Water Model

Feat

Com

Well

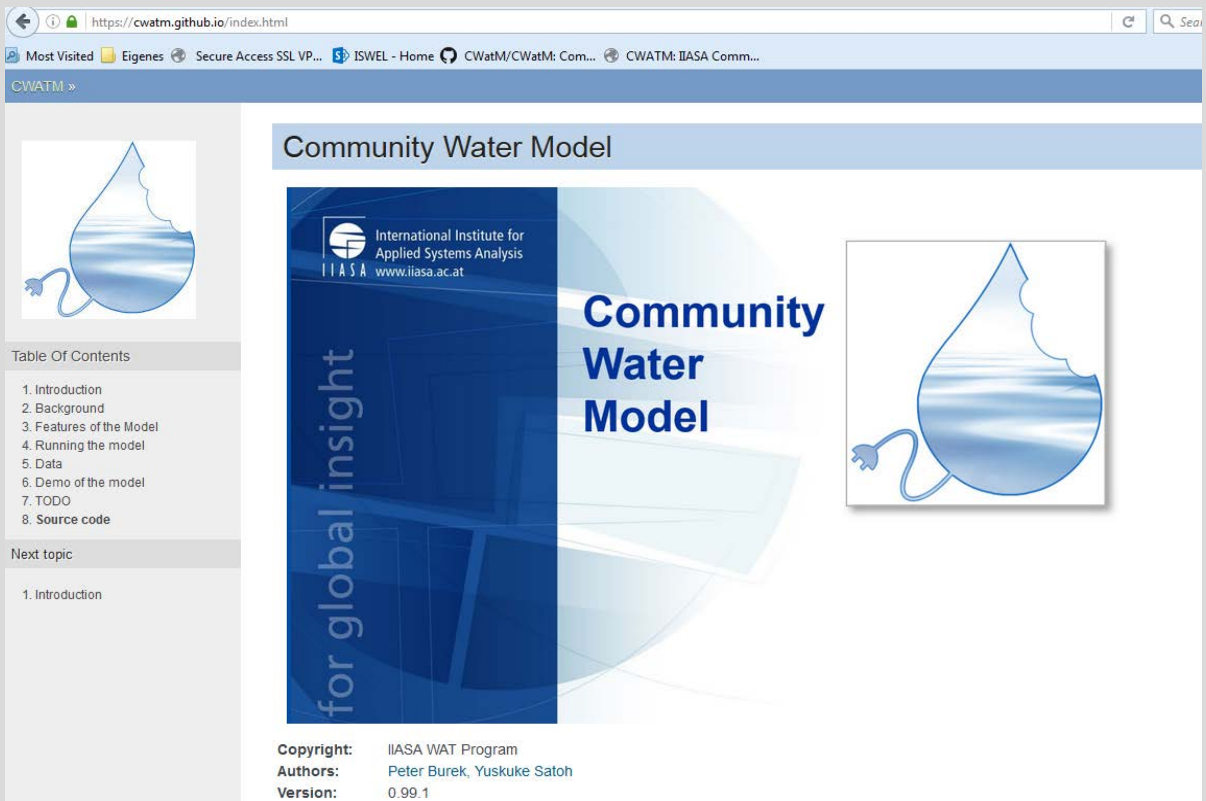
Easy

Mult

Mod

Community Model on the web

https://cwatm.github.io/

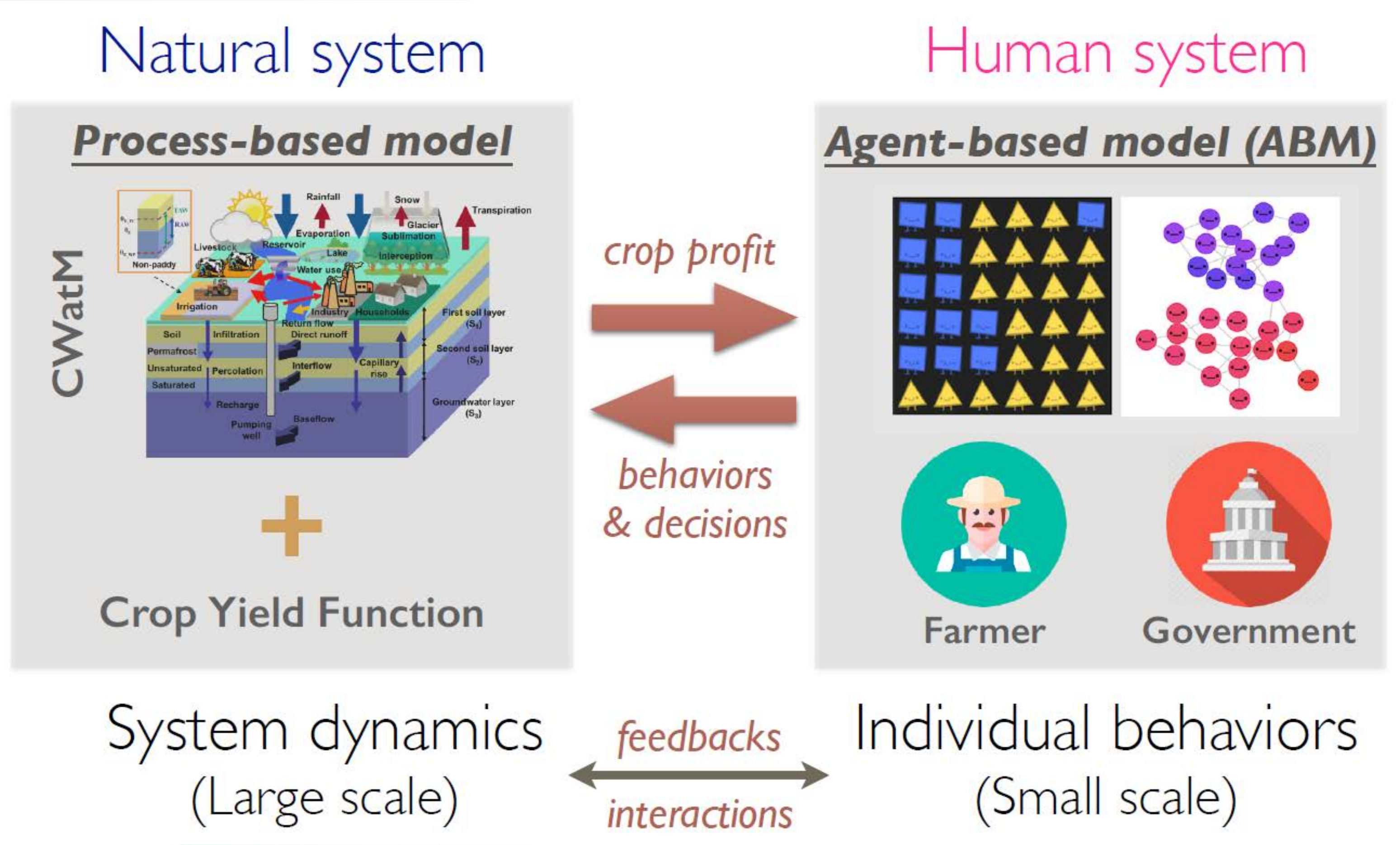


Community Water Model

Feature	Description
Flexible	different resolution, different processes for different needs, links to other models, across sectors and across scales Resolution: global: 0.5°, daily, working on global 5´, daily; regional 5km
Adjustable	to be tailored to the needs at IIASA i.e. collaboration with other programs/models, including solutions and option as part of the model
Multi-disciplinary	including economics, environmental needs, social science perspectives etc.
Sensitive	Sensitive to measures / options
Fast	Global to regional modeling – a mixture between conceptional and physical modeling – as complex as necessary but not more
Comparable and exchangeable	Planned to be part of the ISI-MIP community, part of capacity development

Examples of application

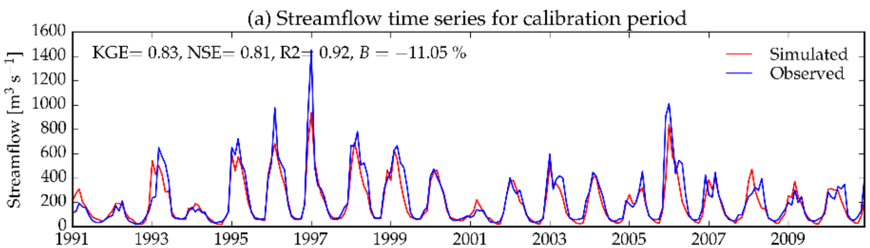
Example 1:
Coupling with an agent-based model

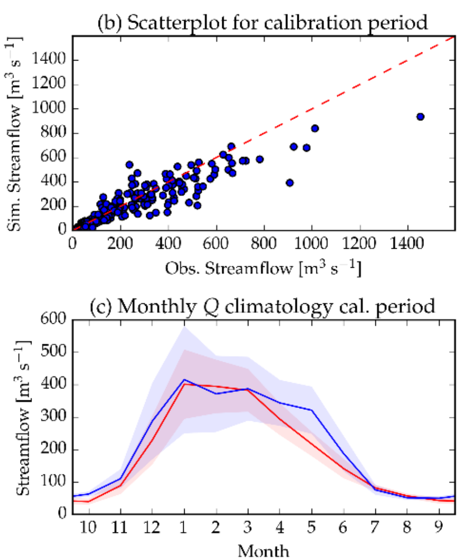


From: Xiaogang He, Princeton:
Presentation AGU 12/14/17 yesterday

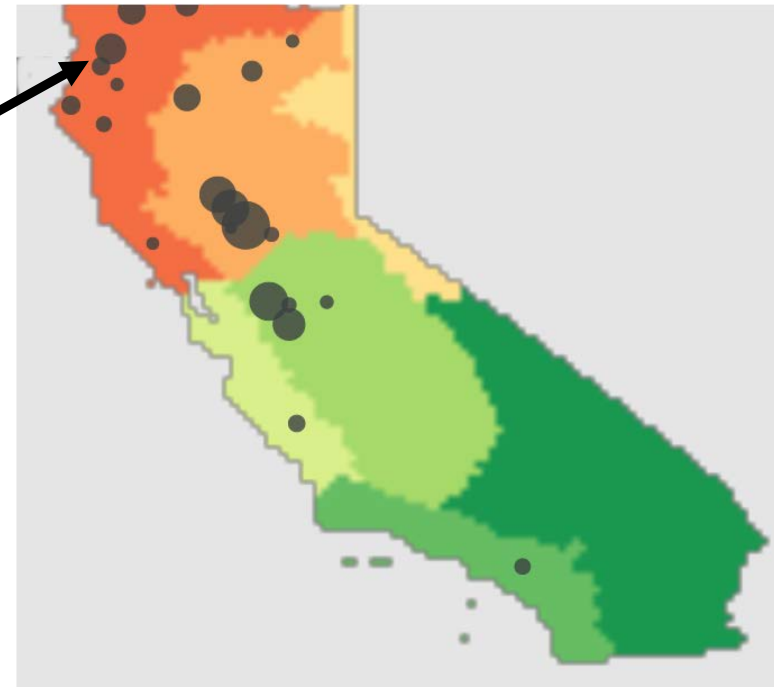
Calibration of river discharge with human interaction Klamath / Orleans, CA, USA

River: Klamath, Station: USGS 11523000 - Orleans, CA





	Obs.	Sim.
KGE		0.832
NS		0.814
NSlog		0.841
R2		0.916
Bias		-11.05%
RMSE		93
MAE		55
Mean	222	198
Min	20	18
5 %	38	26
50 %	132	131
95 %	649	550
99 %	956	691
Max	1452	937



Calibration:

- Daily run of 20 years
- Compared to monthly observed discharge
- Objective function: KGE’

KGE’: modified Kling-Gupta efficiency 0.83
NSE: Nash-Sutcliffe Efficiency 0.81
R2: Correlation coefficient 0.92
B: Bias -11%

Example 2: Integrated Solutions for Water, Energy and Land (IIASA/UNIDO/GEF)

GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET

Zambezi Basin

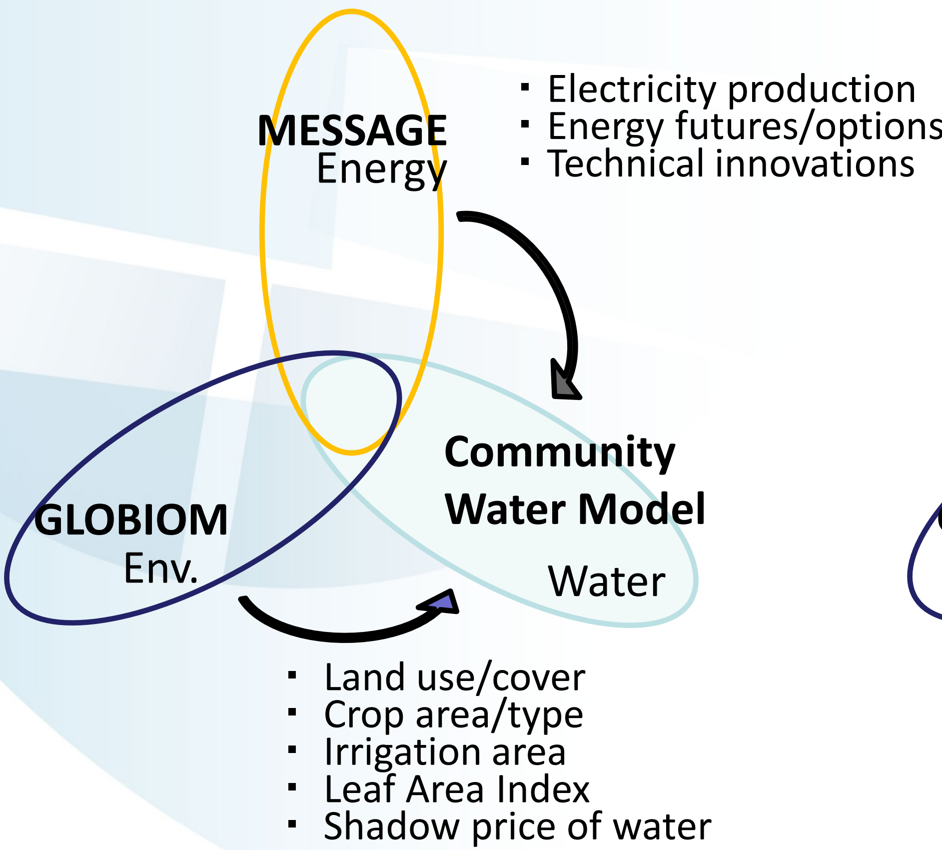
Area: 1.332.000 km^2

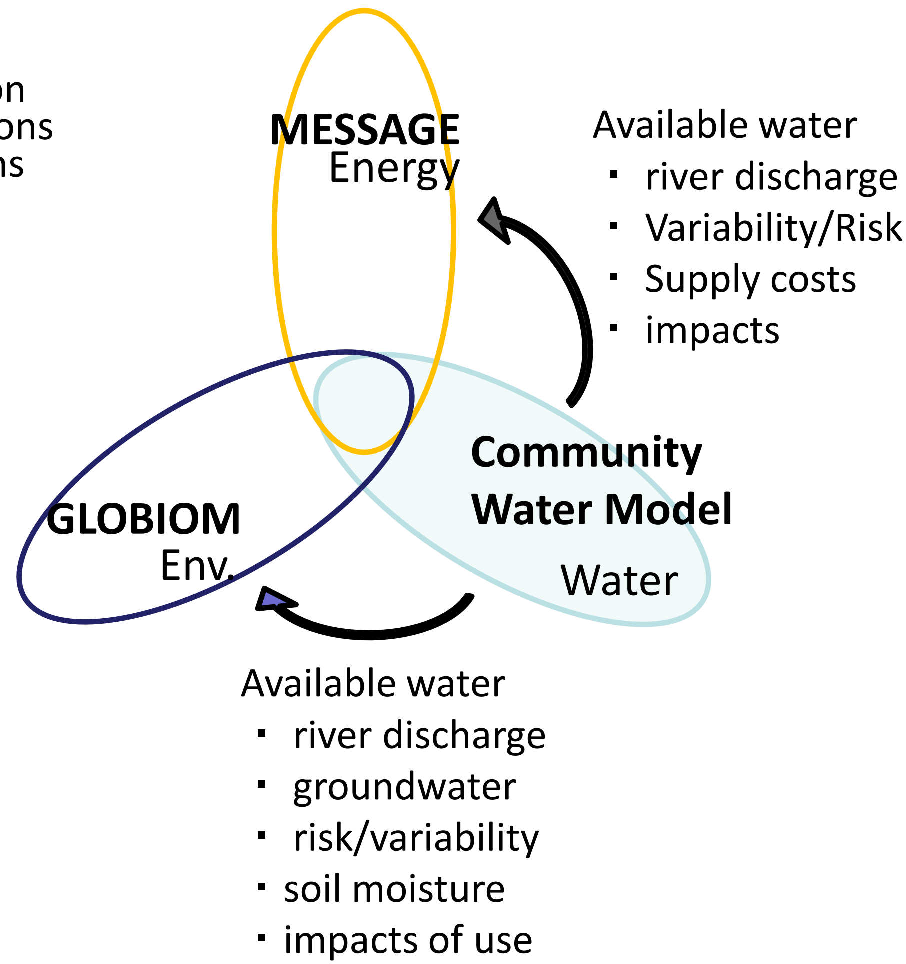
Countries:
Zambia, Angola, Zimbabwe, Mozambique, Malawi, Tanzania, Botswana, Namibia

Population 2010:
38 Mio. people
Projection 2050 (SSP1-5):
70-95 Mio. people

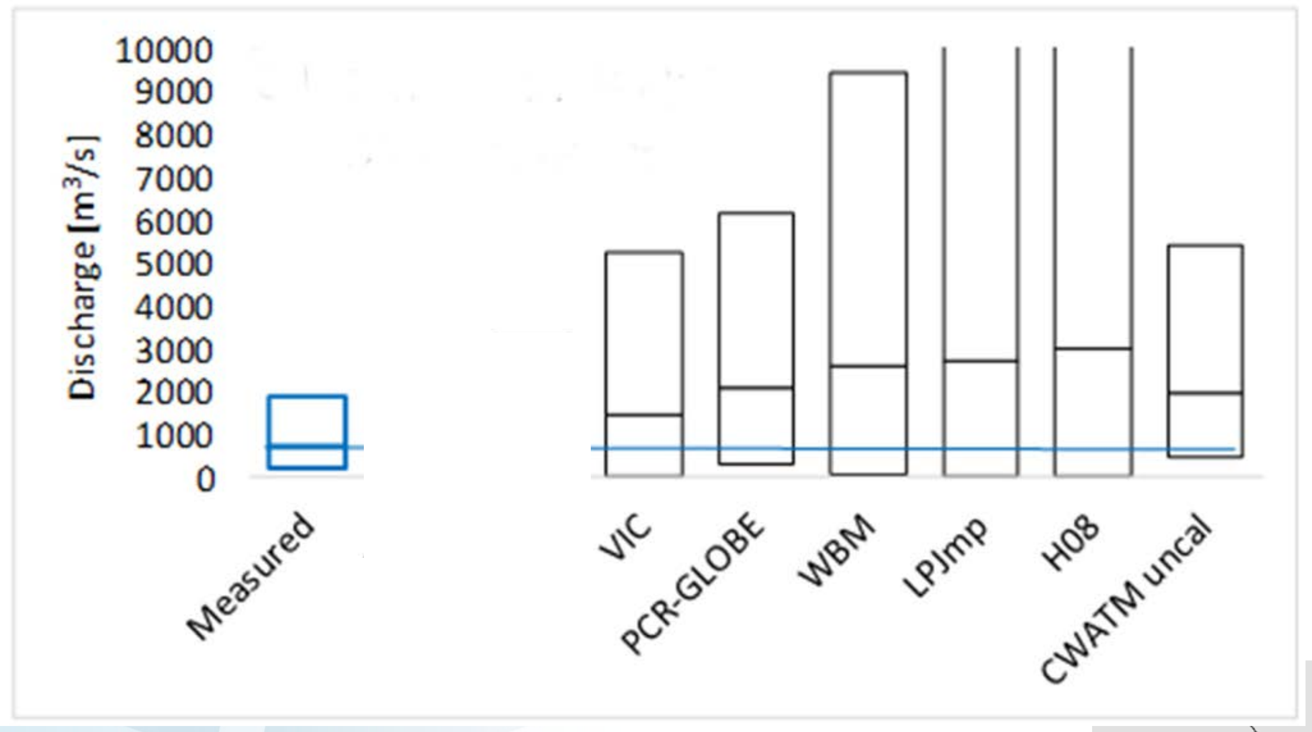
Nexus Integration towards SDGs

Enhanced water assessments - Improved analysis feedbacks



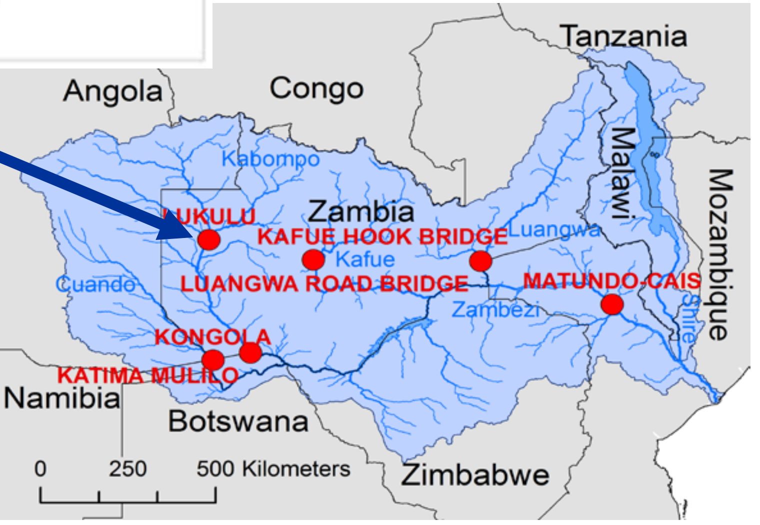


Comparison of discharge simulation
Same GCM (HadGEM2-ES), different GHM



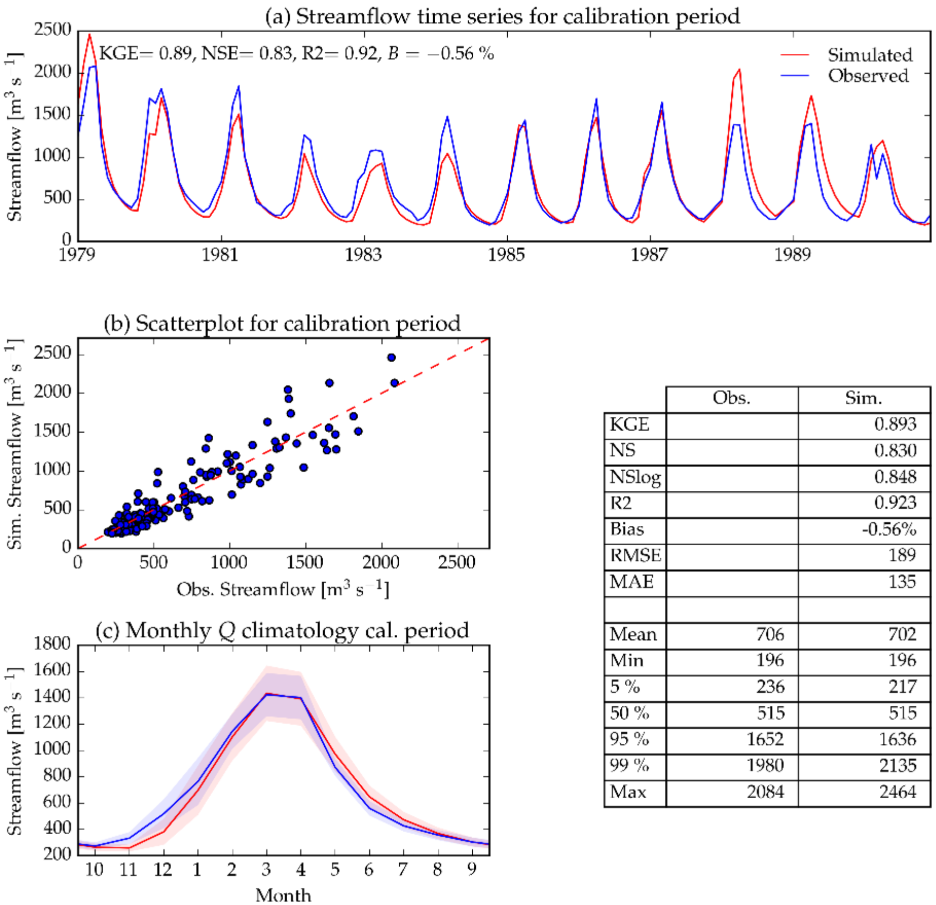
Discharge Lukuku / Zambia
(5% percentile, average, 95% percentile)

Climate Forcing:
ISI-MIP Fast track
Historical run from
HadGEM2-ES climate model from 1971-2004

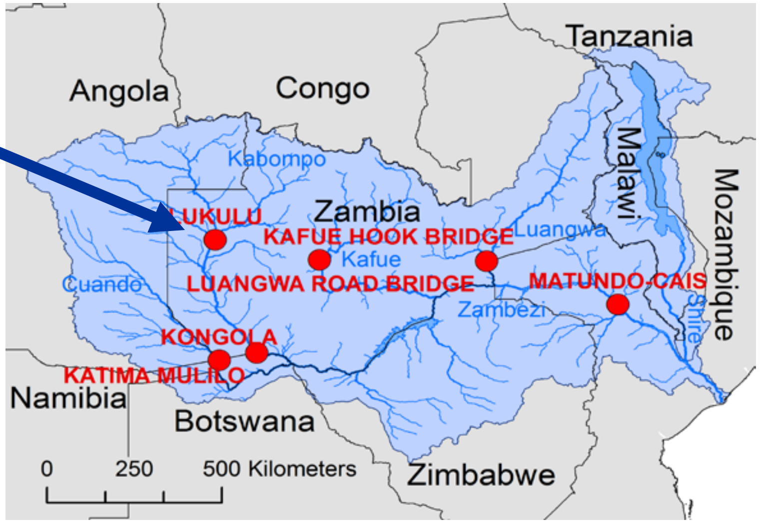


Calibration of river discharge Zambezi / Lukulu, Zambia

Station: Lukulu / Zambezi



	Obs.	Sim.
KGE		0.893
NS		0.830
NSlog		0.848
R2		0.923
Bias		-0.56%
RMSE		189
MAE		135
Mean	706	702
Min	196	196
5 %	236	217
50 %	515	515
95 %	1652	1636
99 %	1980	2135
Max	2084	2464

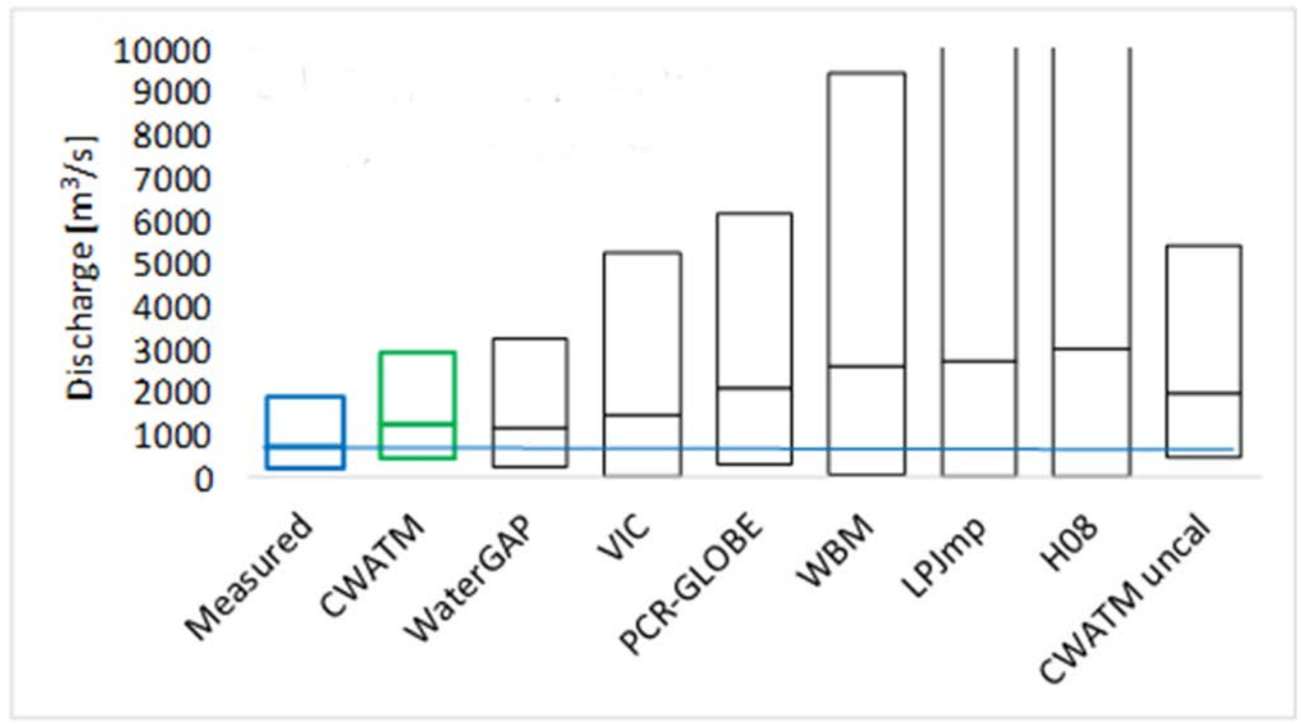


Calibration:
- Daily run of 12 years
- Compared to monthly observed discharge
- Objective function: KGE’

KGE’: modified Kling-Gupta efficiency	0.89
NSE: Nash-Sutcliffe Efficiency	0.83
R^2: Correlation coefficient	0.92
B: Bias	-0.6%

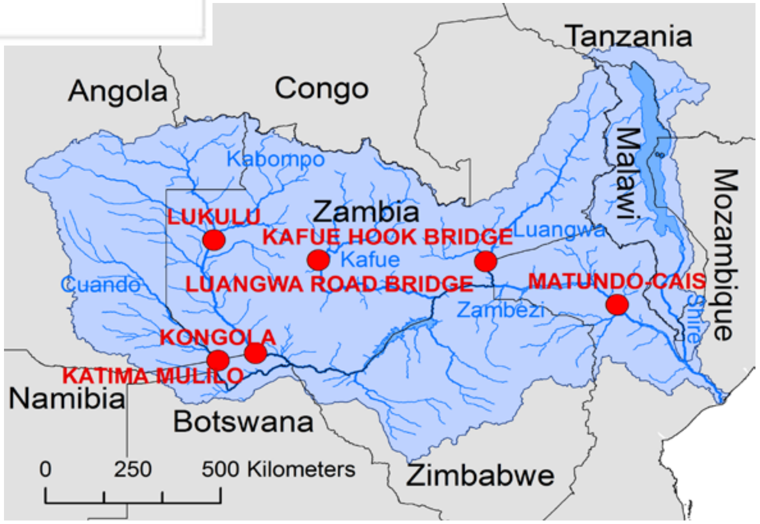
Climate Forcing: Watch WFDEI (Weedon et al. 2014)

Comparison of discharge simulation
Same GCM (HadGEM2-ES), different GHM

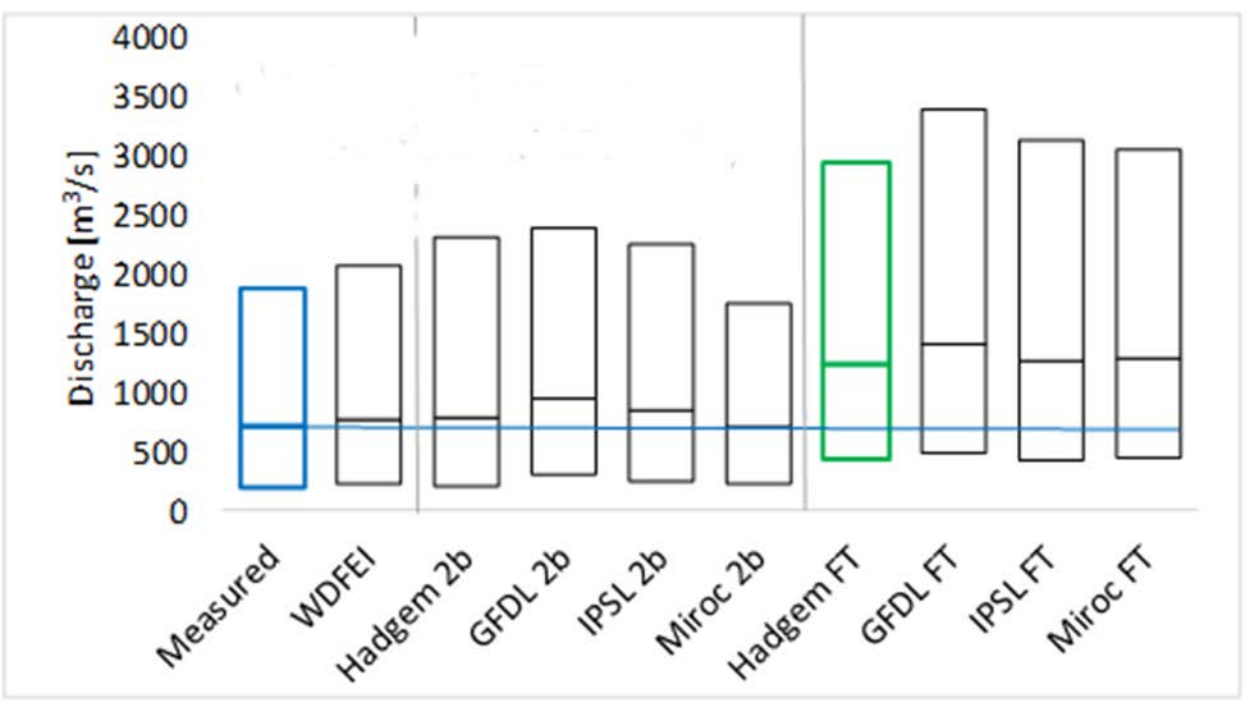


Discharge Lukuku / Zambia
(5%, average, 95%)

Climate Forcing:
ISI-MIP Fast track
Historical run from
HadGEM2-ES climate model from 1971-2004

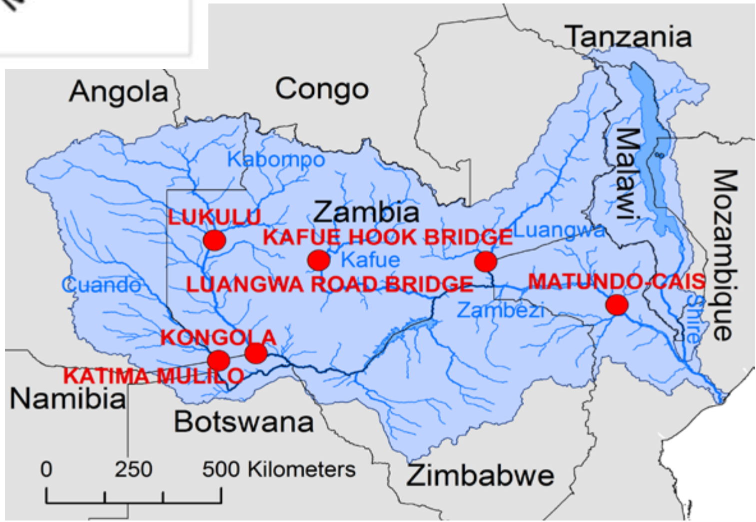


Comparison of discharge simulation Different GCM, same GHM (CWATM)

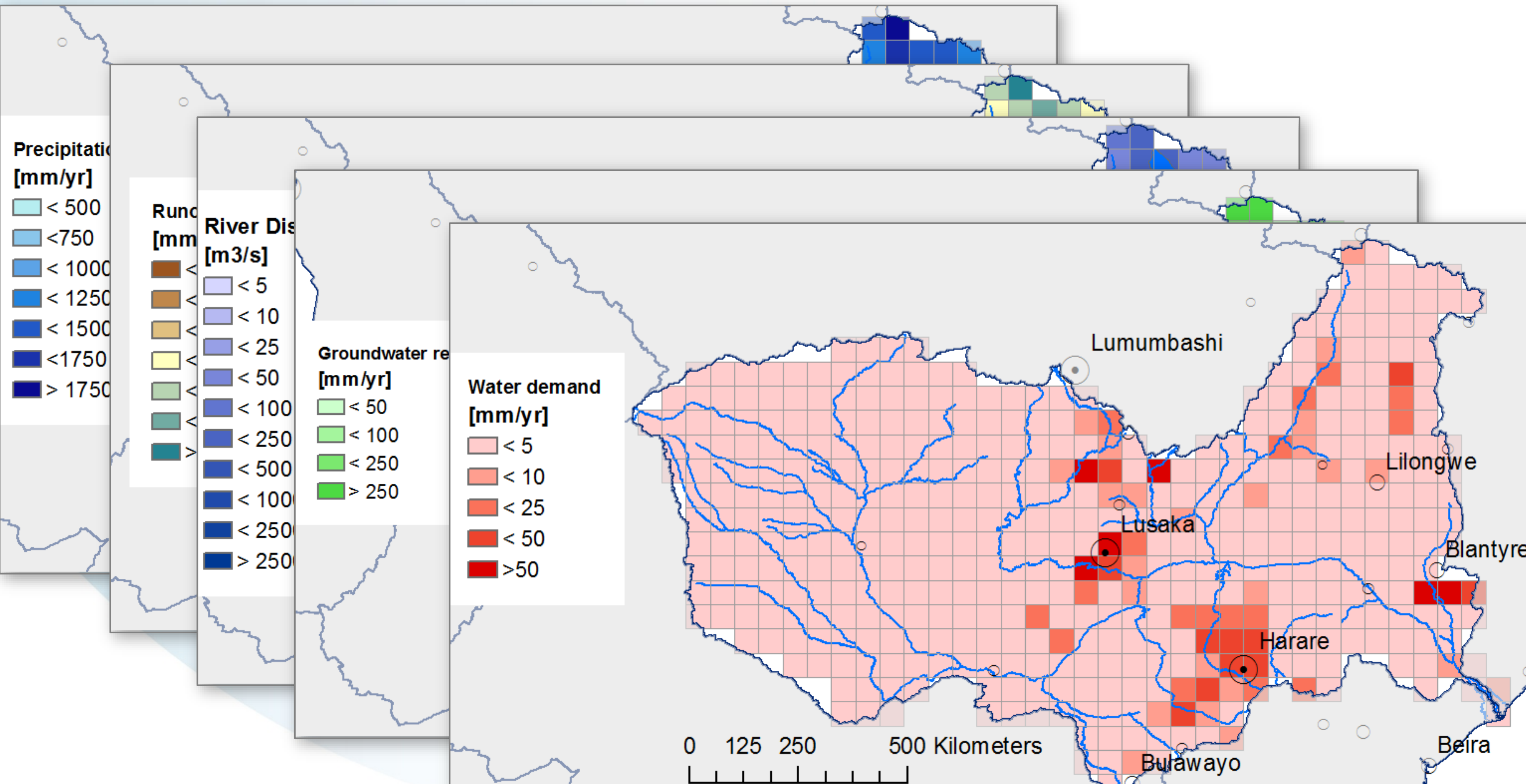


Discharge Lukuku / Zambia
(5%, average, 95%)

Climate Forcing:
Watch WFDEI, ISI-MIP 2b, ISI-MIP Fast track 1971-2004

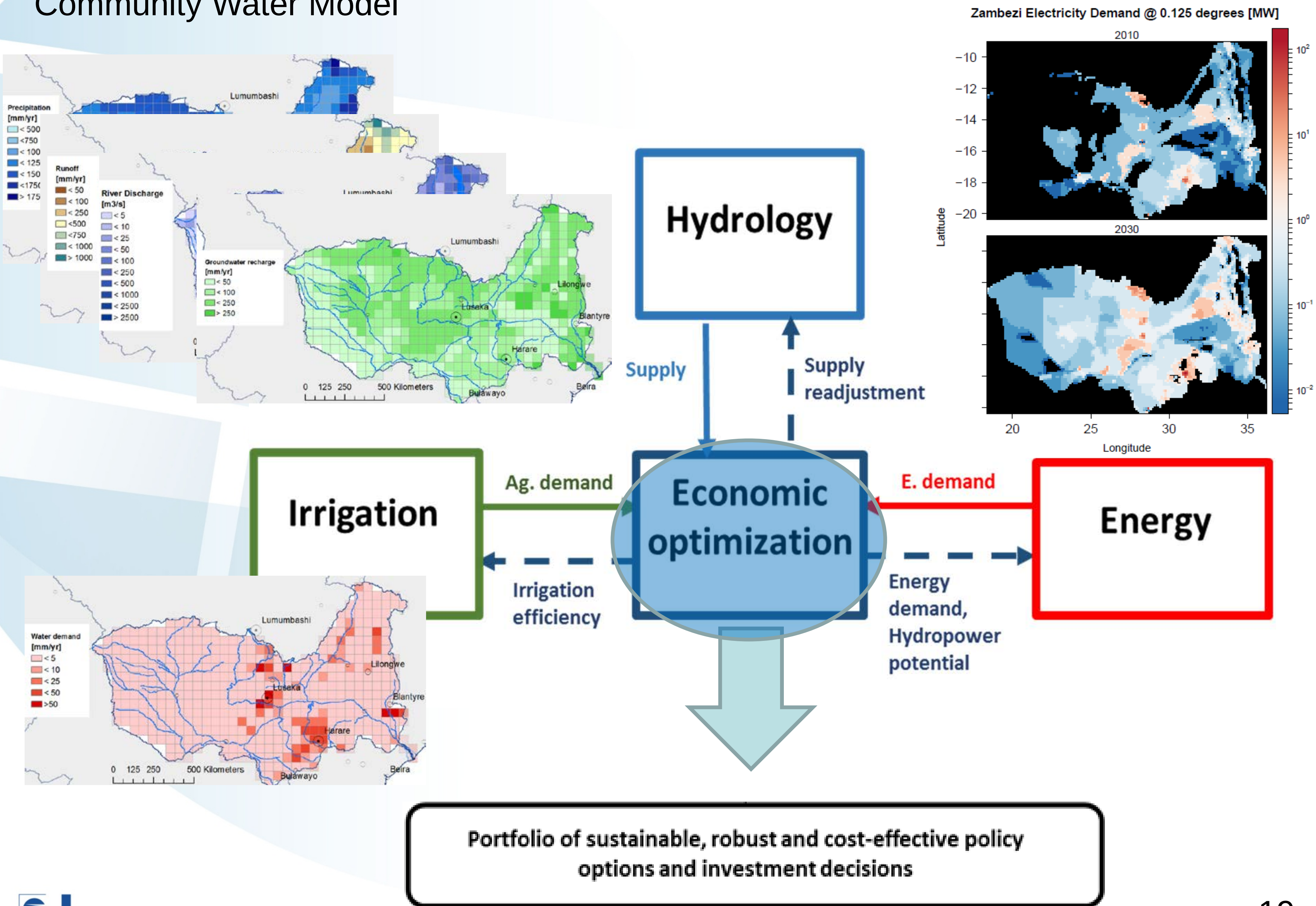


Using the calibrated hydrological model to calculate input data for the hydro-economic model



Community Water Model

Message Model



Conclusion and findings

1. We need to model hydrological processes and relate them to socio-economic developments and the environment

- Building evidence base for solid policy, sustainable water management and investment decisions.
- “water proofing” future development pathways

2. There is a new kid on the block for “Global hydrological modeling” called CWATM

- State of the art hydrological modelling (including groundwater, human interactions, etc.)
- Open source on github https://github.com/CWatM

3. For Africa we need to look at the results our global models