

Water Resources in Cities Around the World and Their Simulation

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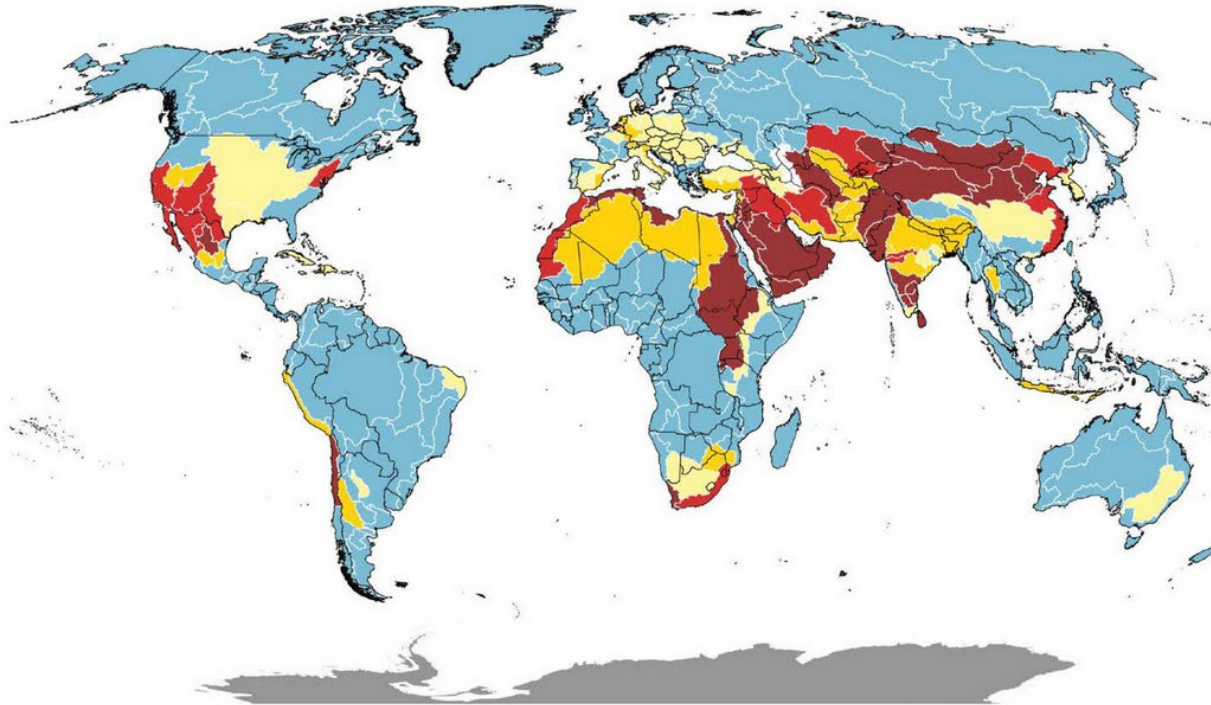
Basis 1: Water scarcity in the world

Water resources are scarce in many regions worldwide.

Water scarcity is considered a direct threat to the global economy and others.

Water scarcity atlas (2018)

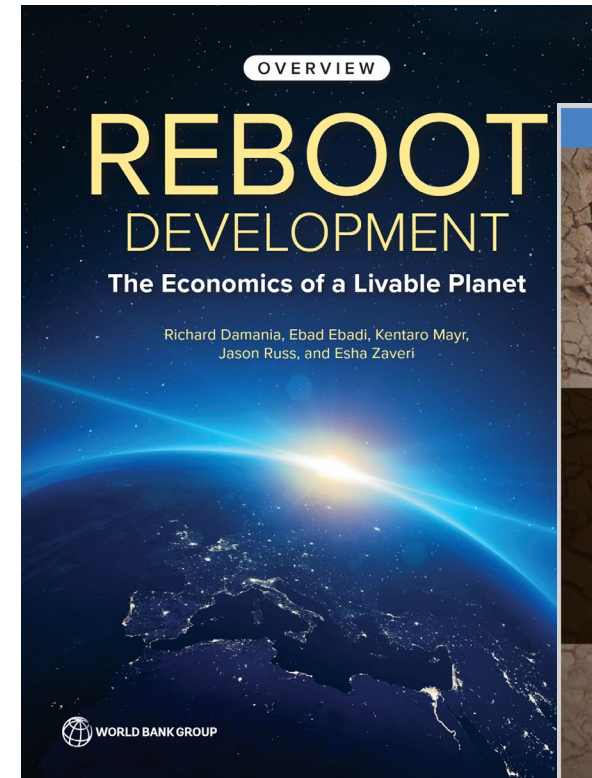
■ No stress (0 - 25%) ■ Low (25% - 50%) ■ Medium (50% - 75%) ■ High (75% - 100%) ■ Critical (>100%)



Source: FAO and UN-Water, 2021, modified to comply with UN, 2021.

FAO, 2021

Two World Bank reports published in 2025



WB 2025a

WB 2025b

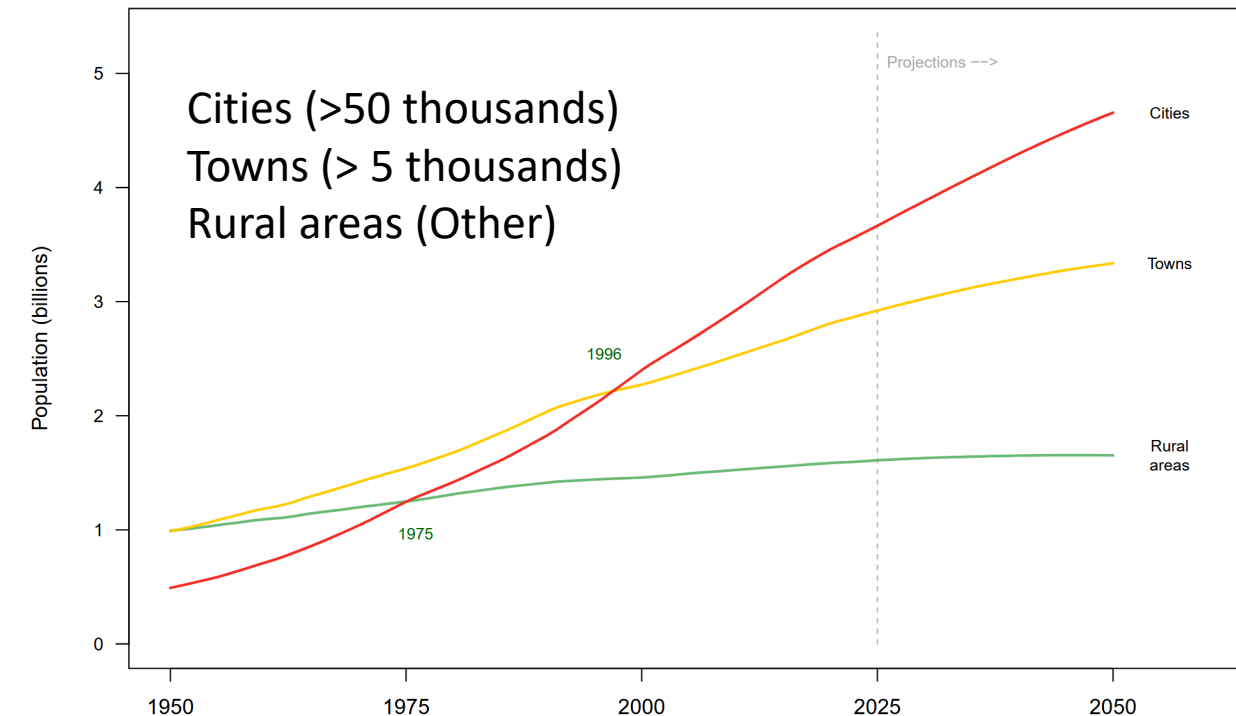


Basis 2: Urbanization in the world

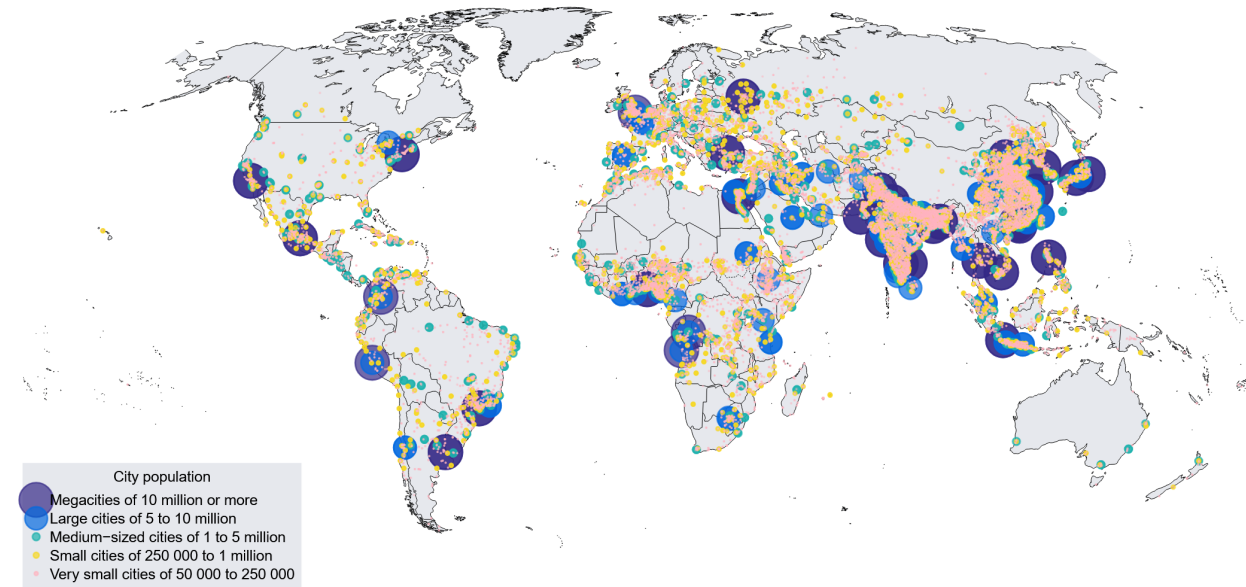
**45% of the world's population lives in cities, and megacities continue to grow.
There are 33 megacities (with populations of 10 million or more) in the world.**

World population living in cities, towns and rural areas, estimates, 1950–2025, and projections, 2025–2050

World

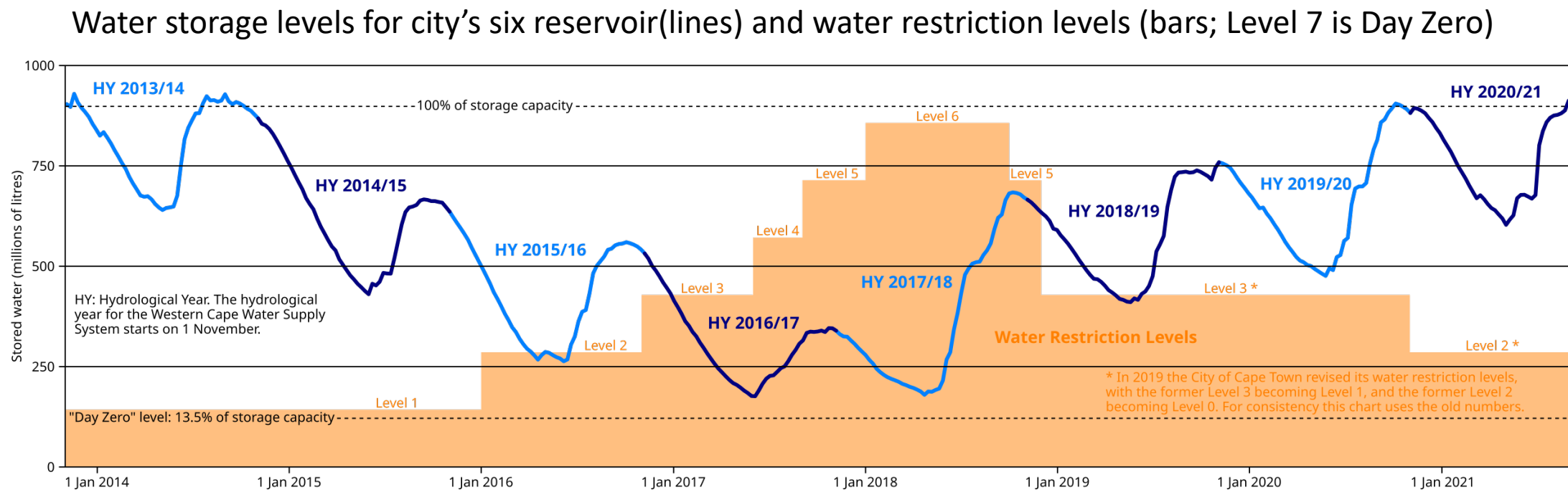


The world's cities in 2025



Basis 3: Water crisis in cities (Day Zero)

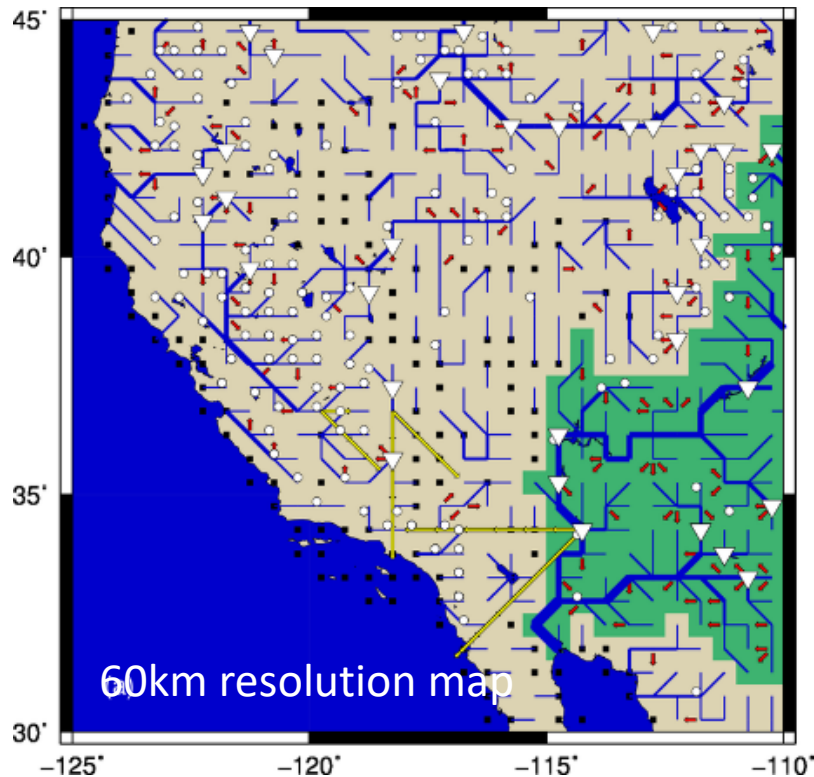
In 2017–2018, the City of Cape Town (South Africa) experienced a severe water shortage. It came close to “Day Zero”—the water level at which the water supply would be completely cut off. Similar cases have since emerged in various parts of the world.



https://en.wikipedia.org/wiki/Cape_Town_water_crisis

Basis 4: Global water scarcity simulation

Simulations using the “Global Water Resources Model” can estimate water scarcity.
(Assessing water supply and demand balance + geographic and temporal disparities)

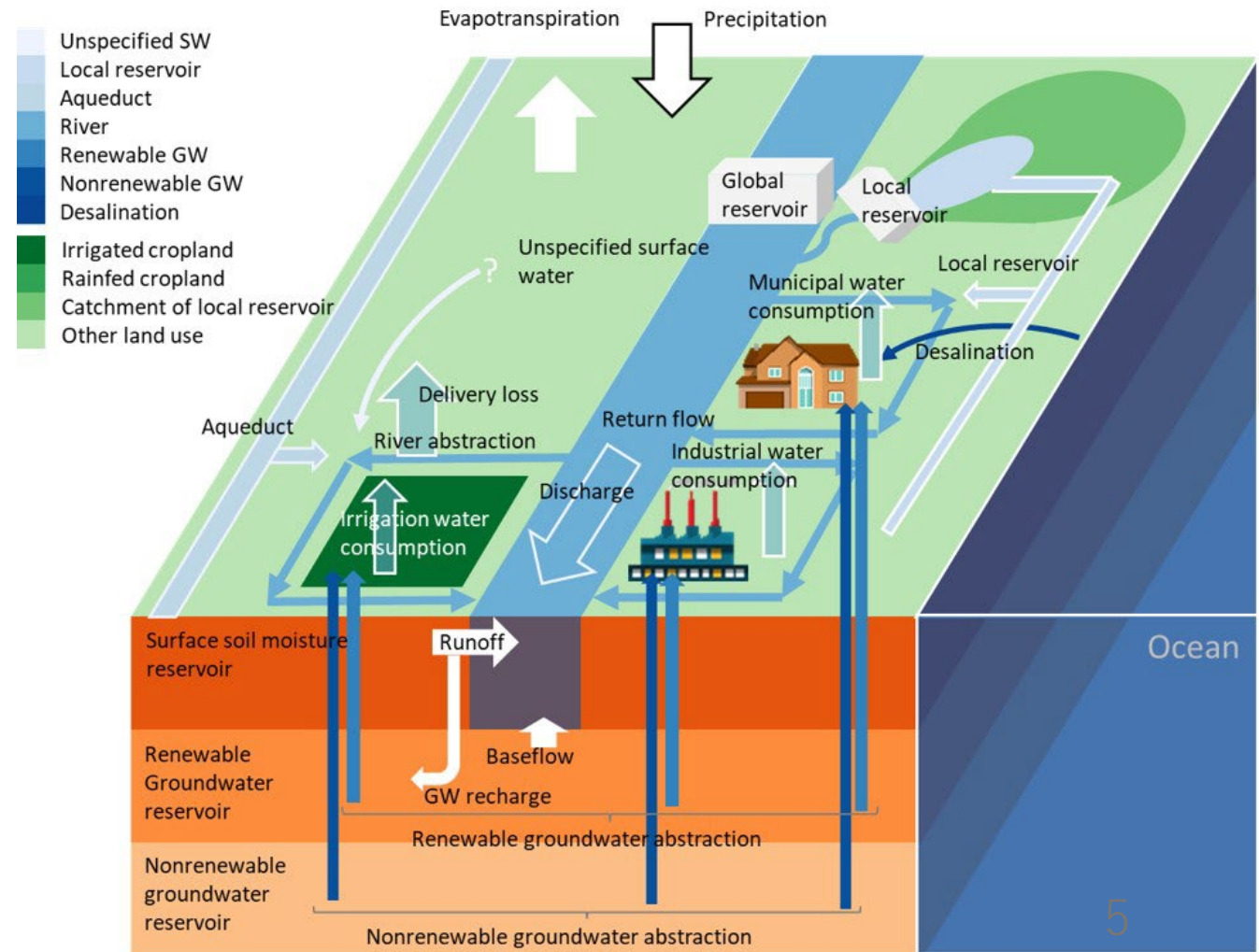


Spatial resolution: 10km x 10km

Temporal resolution: Daily

[H08 Website](#)

Hanasaki et al. 2018, Hydrol Earth Syst. Sci.

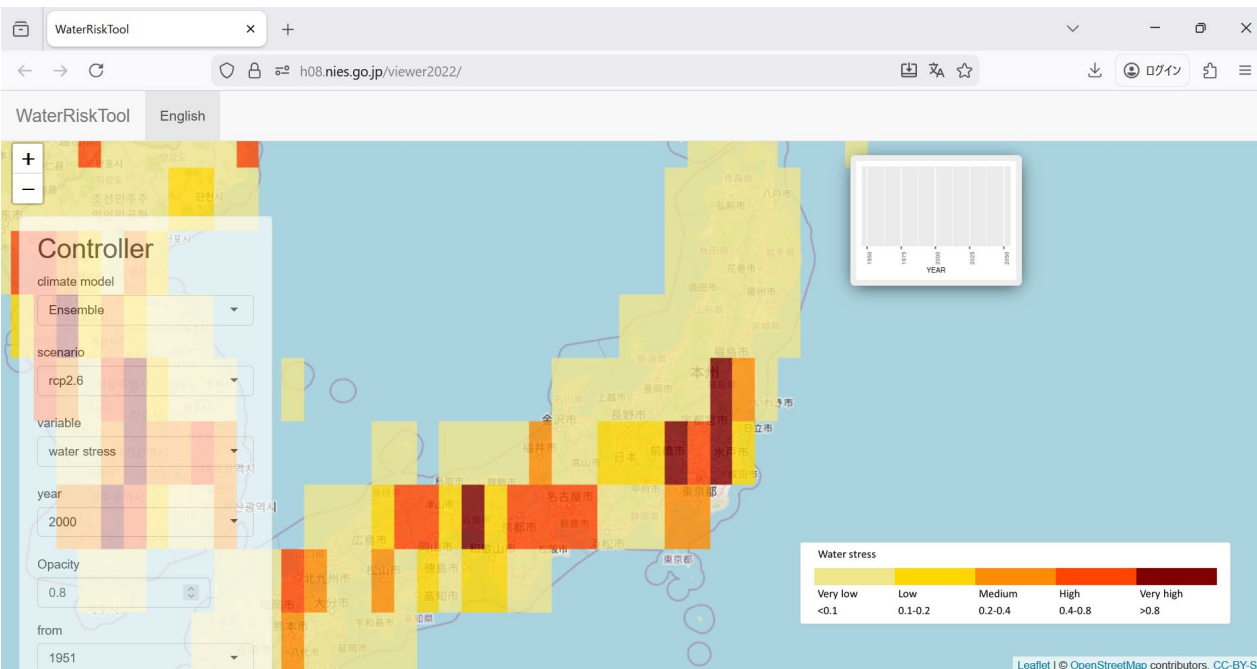


Basis 5: Spatial resolution of models

So far, global water resources simulations have been conducted at a resolution of 60 km. Recently, a 10 km resolution has become common, enabling us to resolve individual cities.

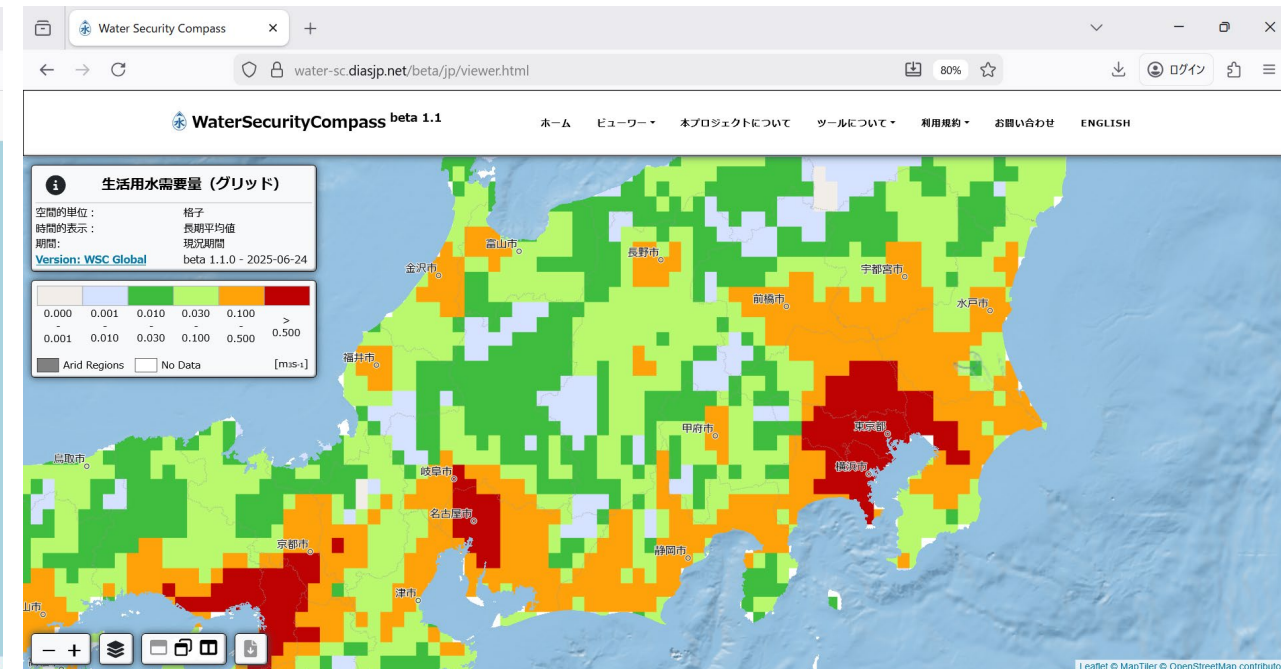
Research Topic: Assessing Global Water Scarcity at the City Level

60km resolution (traditional)



<https://h08.nies.go.jp/h08/viewer.html>

10km resolution (recent)



<https://water-sc.org>

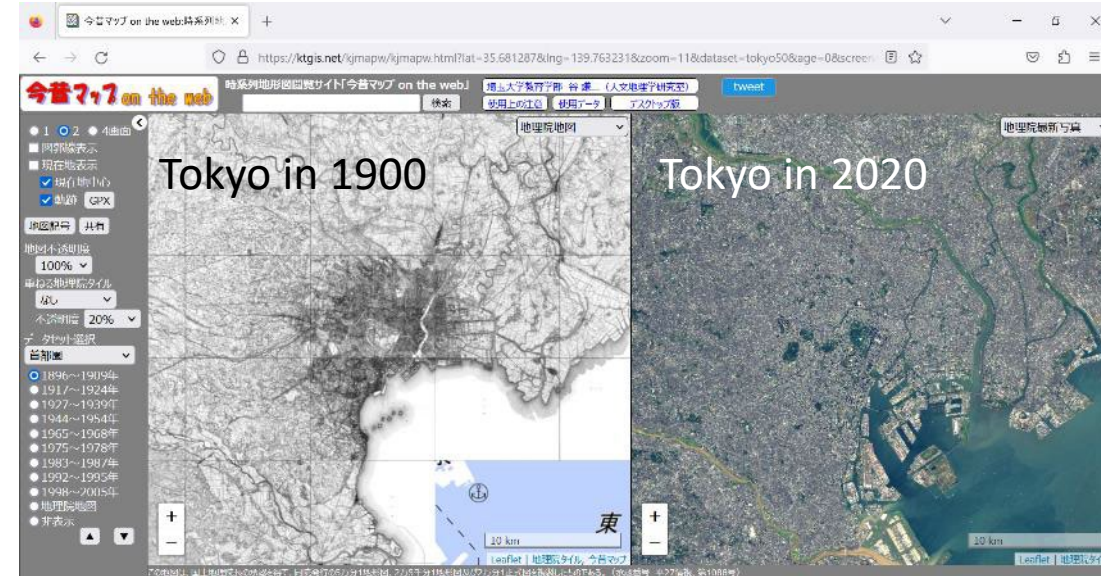
A method for representing cities in global hydrological models

Hanasaki, N., Kajiyama, K., Takahashi, Y., Yabu, K., Maniwa, Y., and Kanae, S.:
A method for representing cities in global hydrological models,
EGUsphere, 2026, 1-27, [10.5194/egusphere-2026-5322](https://doi.org/10.5194/egusphere-2026-5322), 2026.

This study was supported by the Environment Research and Technology Development Fund of the ERCA (JPMEERF23S21120) funded by the Ministry of the Environment.

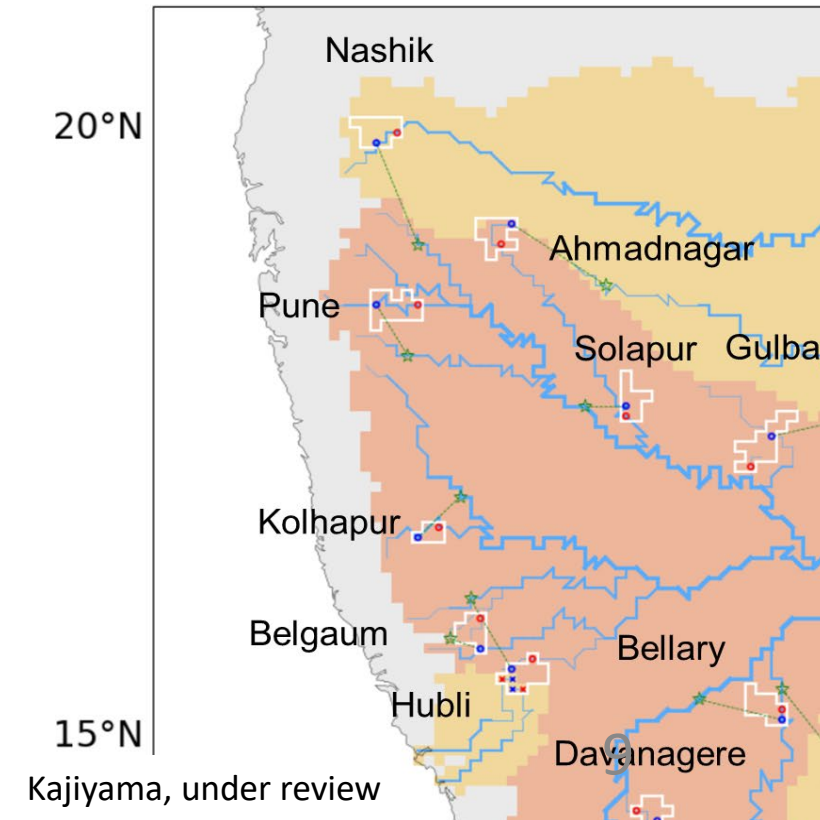
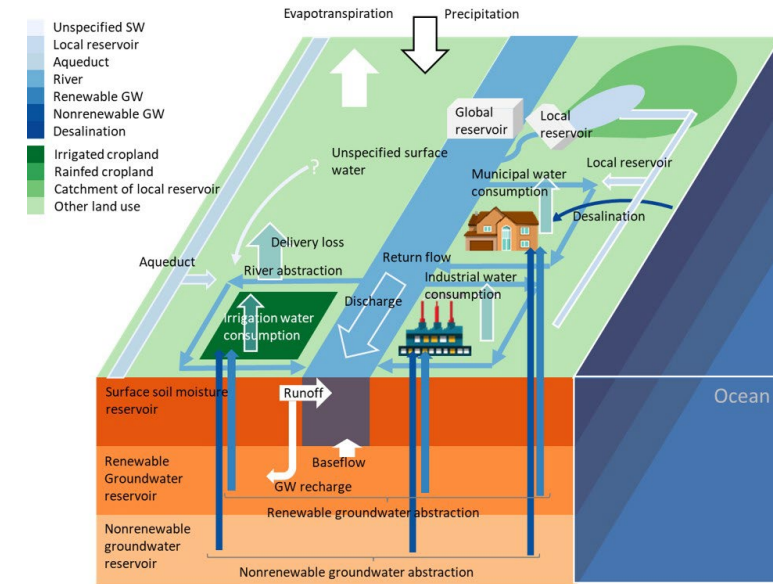
Introduction

- Background
 - Water is scarce around the world.
 - Cities are growing around the world.
- Earlier studies
 - High-resolution Global Hydrological Models (GHMs)
 - Wada et al. (2016): First global 6 arcmin simulation
 - They identified water scarcity in large cities, but lacked inter-grid water exchange representation.
 - Florke et al. (2018): Water balance at 482 cities
 - They succeeded in city-level water scarcity assessment, but relied on the coverage of their city infrastructure inventory.
- Research questions
 - Can we represent “cities” in GHMs by a generic model?
 - Can we conduct a global city-level water scarcity assessment?



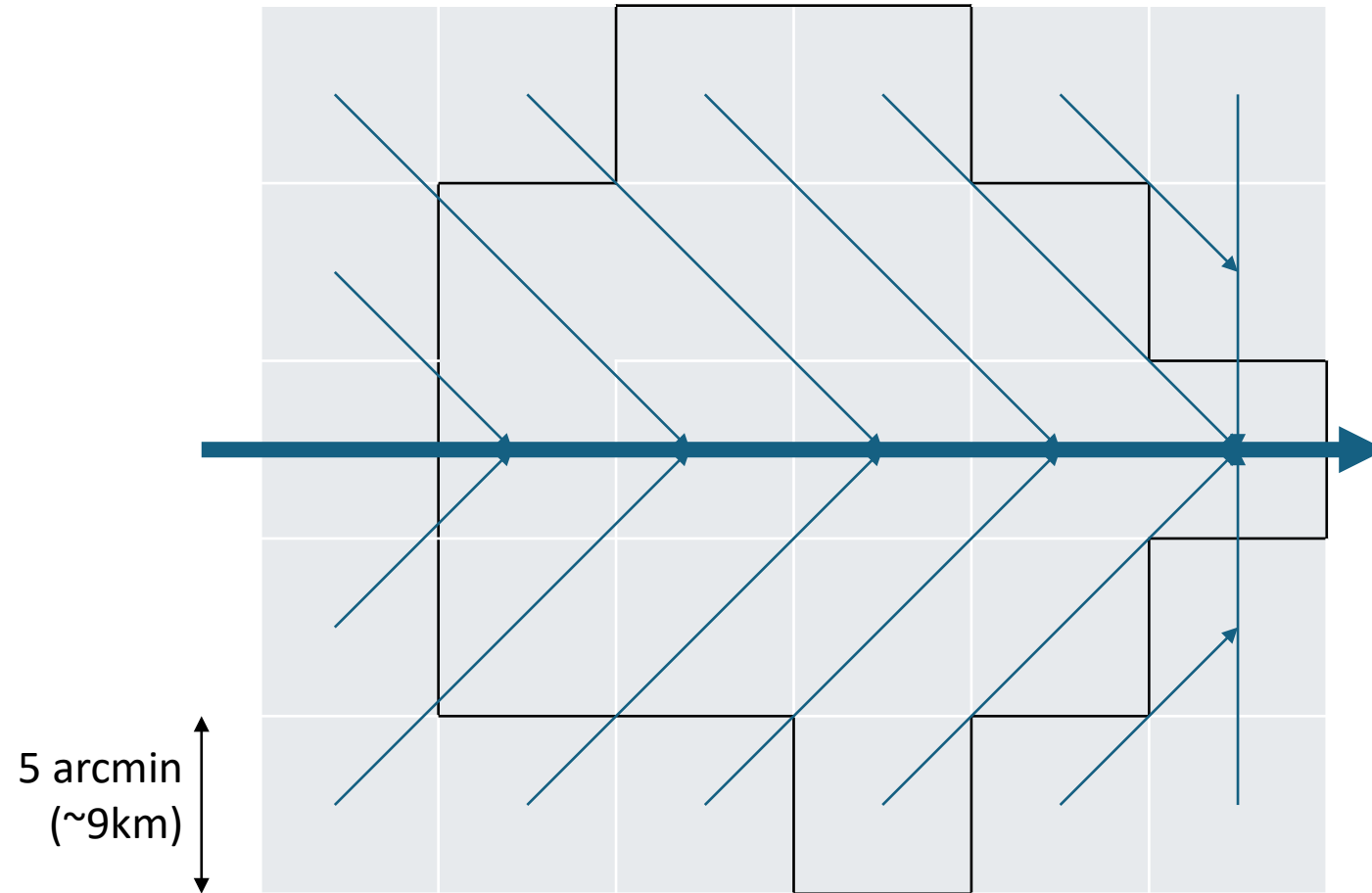
Methods

- Model
 - The H08 global water resources model
 - 5 arc-min resolution
 - +**City sub-model**
- Data
 - Standard H08 boundary conditions
 - **The city boundary data**
 - Densely populated continuous grid cells for ~1800 cities (UN WUP 2018) in the world (Kajiyama et al., 2026)
 - **City boundary, river inlet, and outlet**



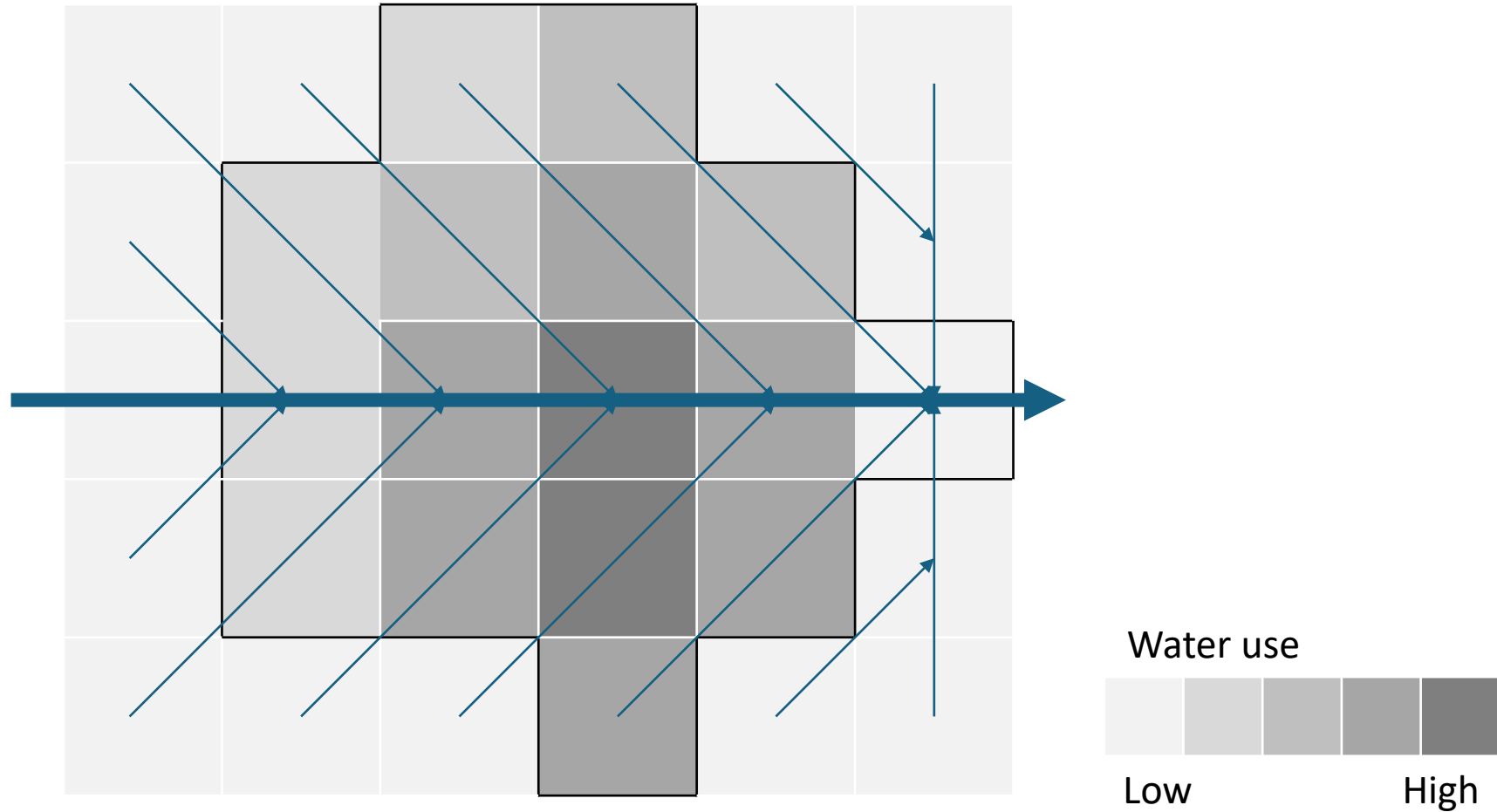
The urban sub-model

a) River and city boundary



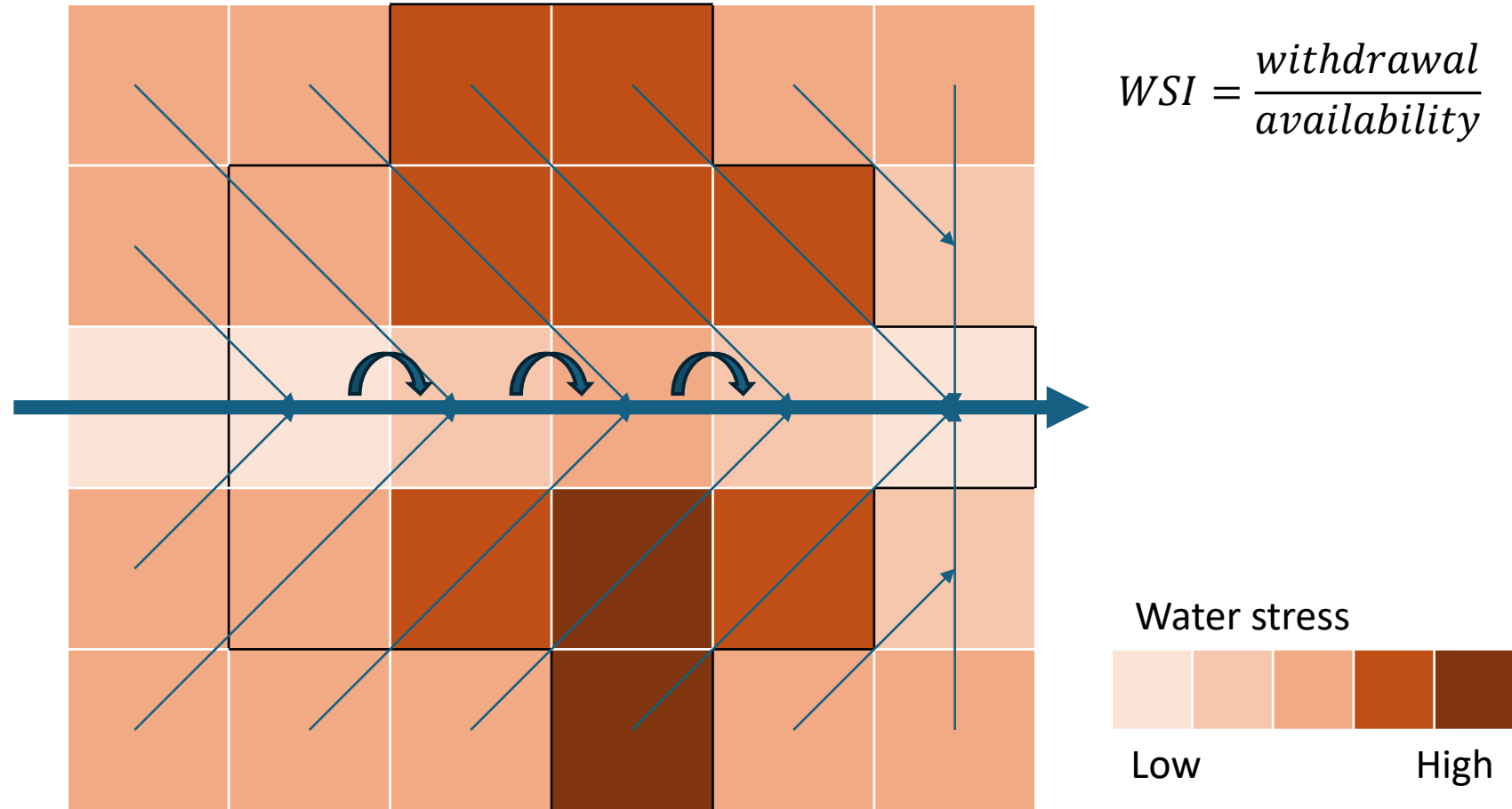
The urban sub-model

b) Urban water use



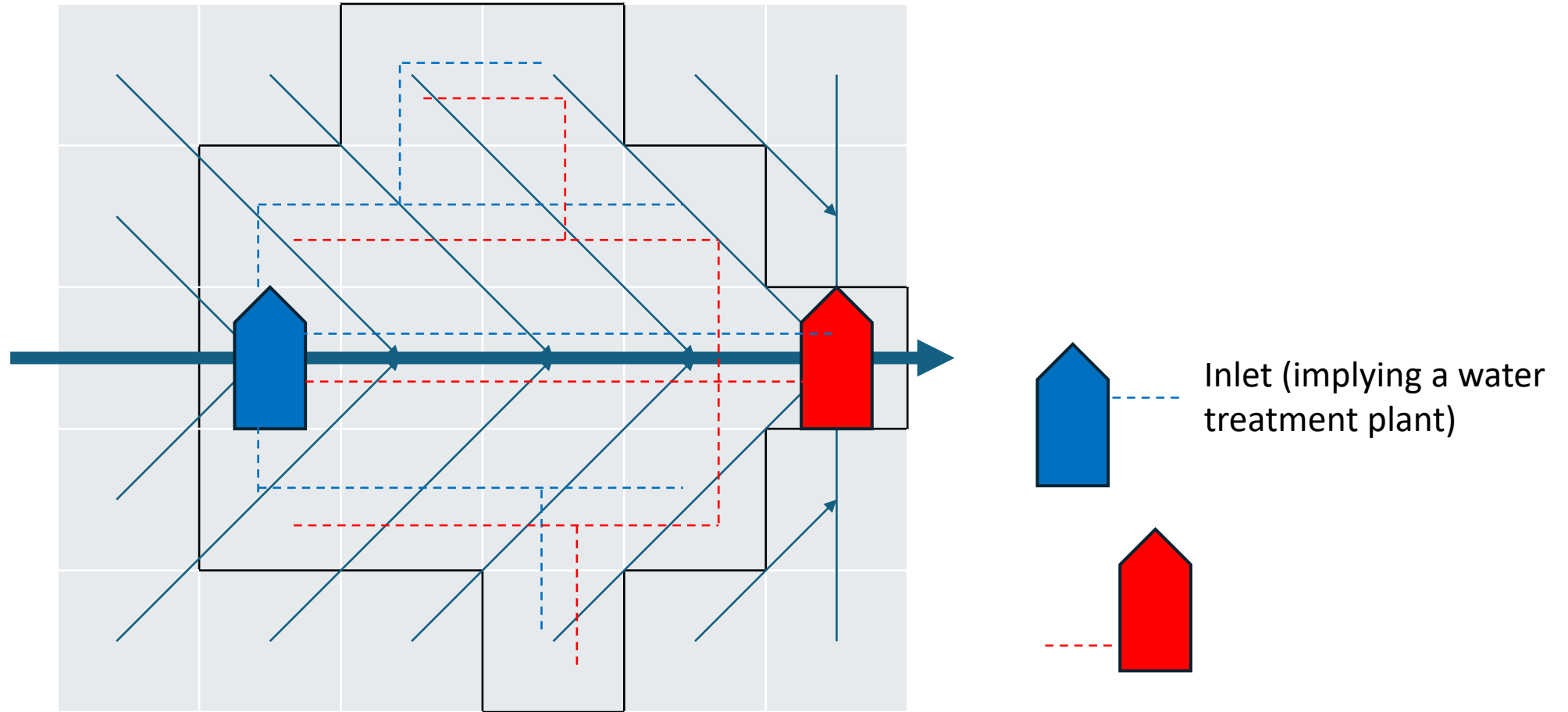
The urban sub-model

c) Grid-based water scarcity assessment



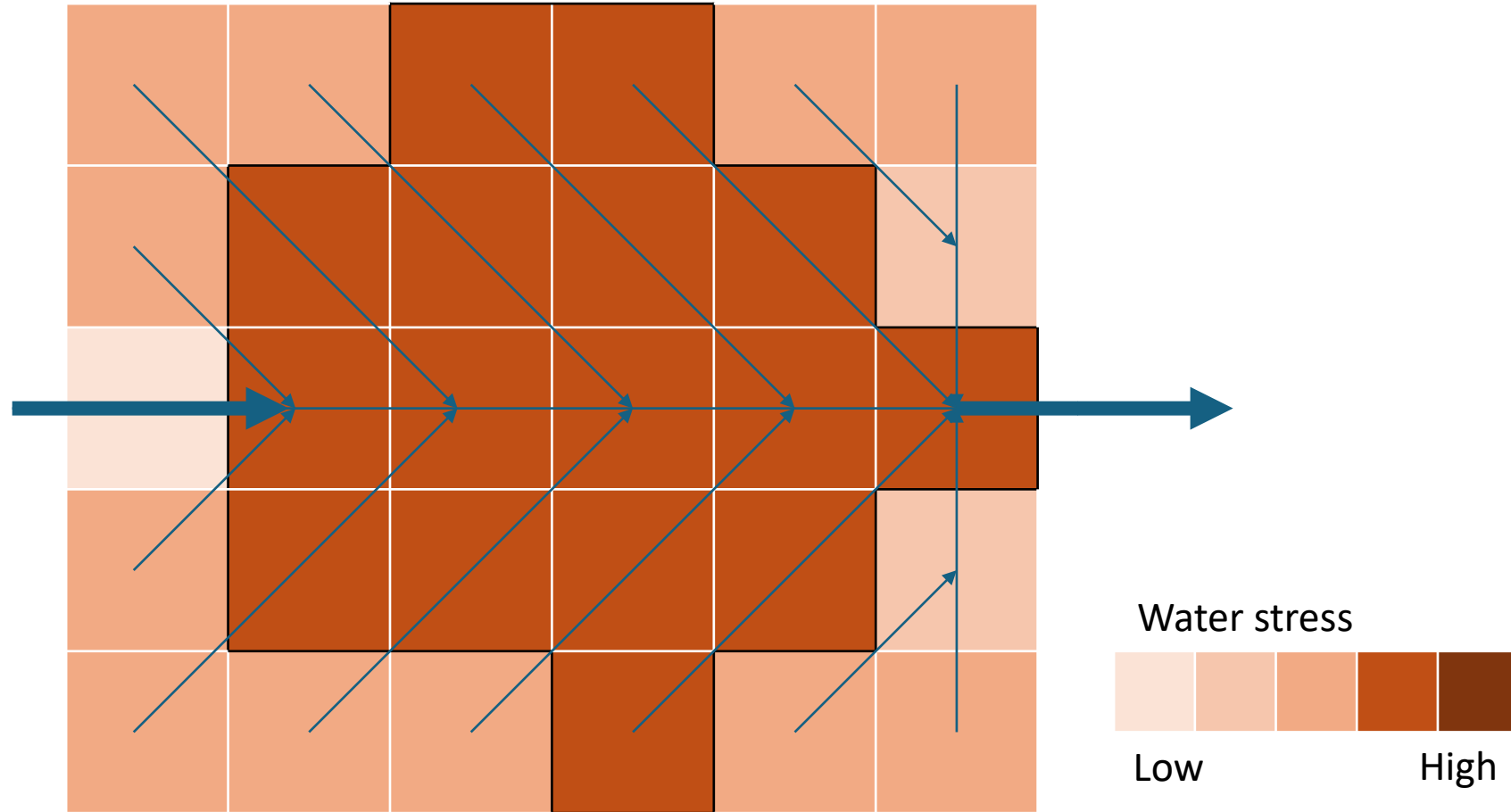
The urban sub-model

d) The city sub-model



The urban sub-model

e) City-level water scarcity assessment



Methods

- **Simulation** (NB: not yet global; still in the model development stage)
 - Selected cities: the largest cities of 12 regions
 - Without city sub-model (CTR)
 - With city sub-model (CTY)
- **Validation**
 - Discharge: From GRDC and local agencies
 - Water sources, water purification, and sewage treatment plants: Local agencies
 - Water withdrawal: Local agencies
- **Assessment**
 - CAD (Hanasaki et al. 2008, 2018)
 - Grid-level (city center grid), basin-level vs city-level

$$\text{CAD} = \frac{\text{Abstraction from sustainable sources}}{\text{Water demand}}$$

Cities

Cape Town

Los Angeles

Mexico City

São Paulo

Tokyo

Bangkok

Chennai

Istanbul

Moscow

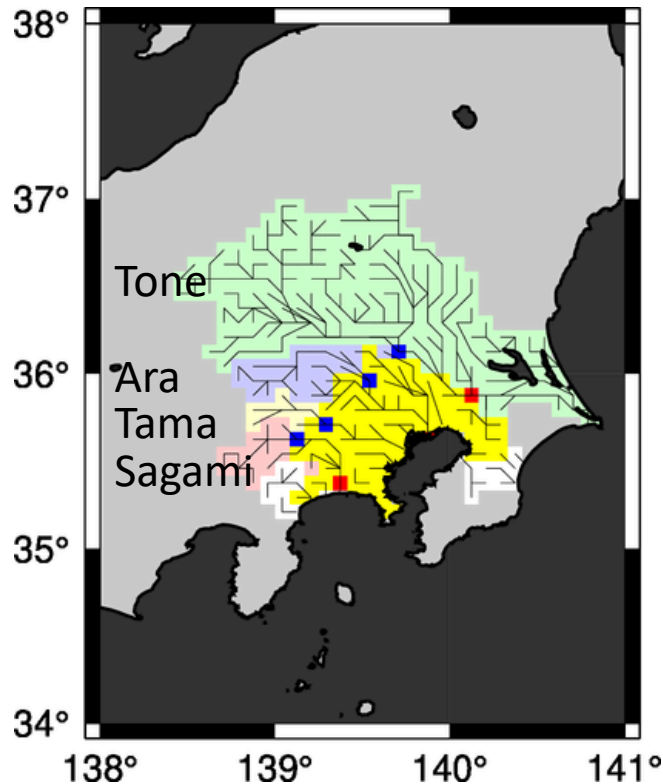
Paris

Sydney

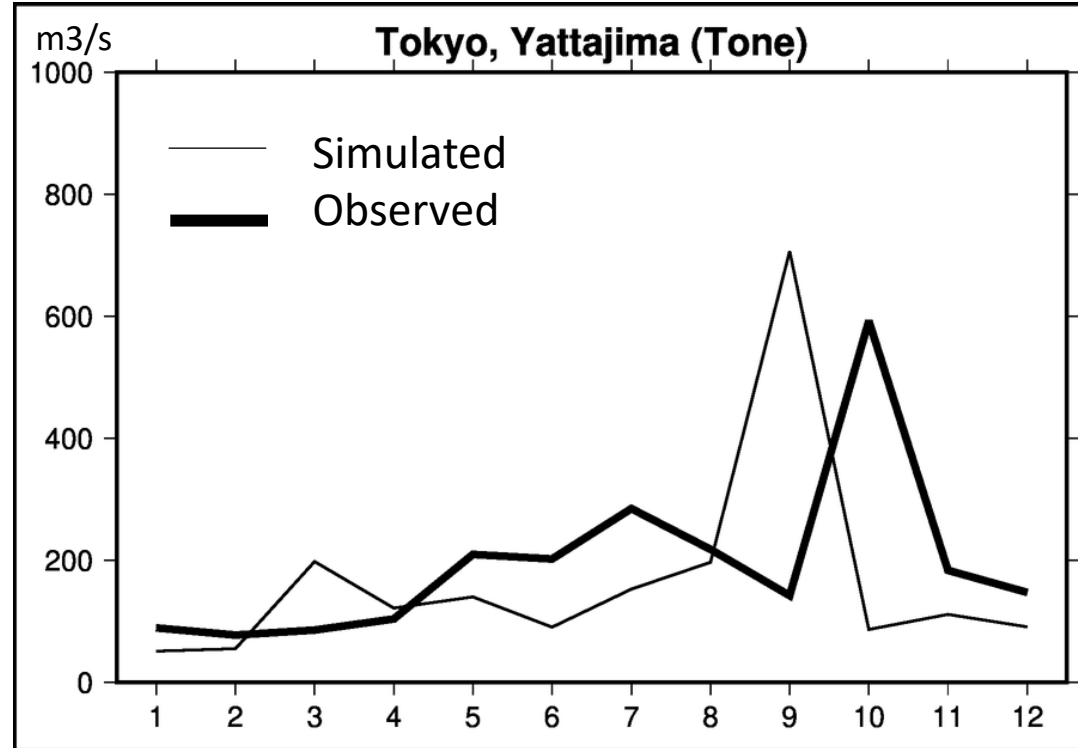
Results (City sub-model)

Can we represent “cities” in GHMs by a generic model?

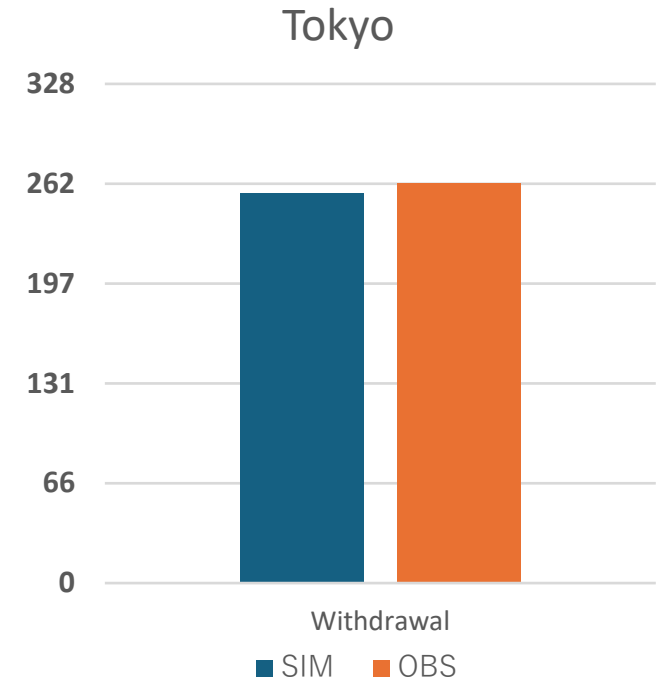
City: Tokyo



Discharge



Water withdrawal



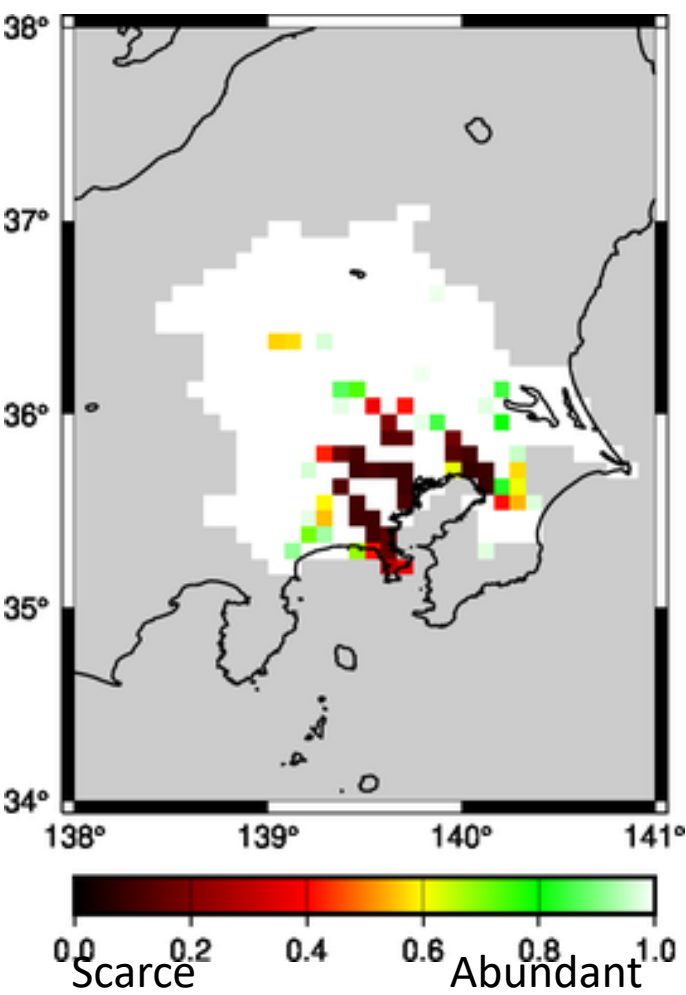
A: Yes, but river discharge and water withdrawal may not be very accurate.

Results (Assessment)

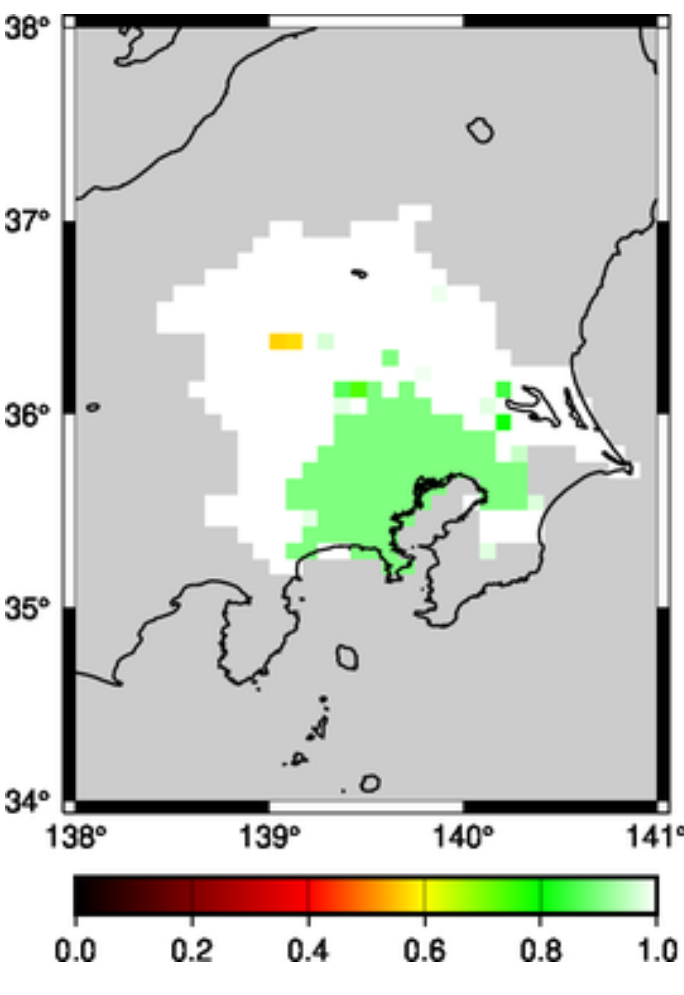
Can we conduct a global city-scale water scarcity assessment?

Water scarcity (index=CAD)

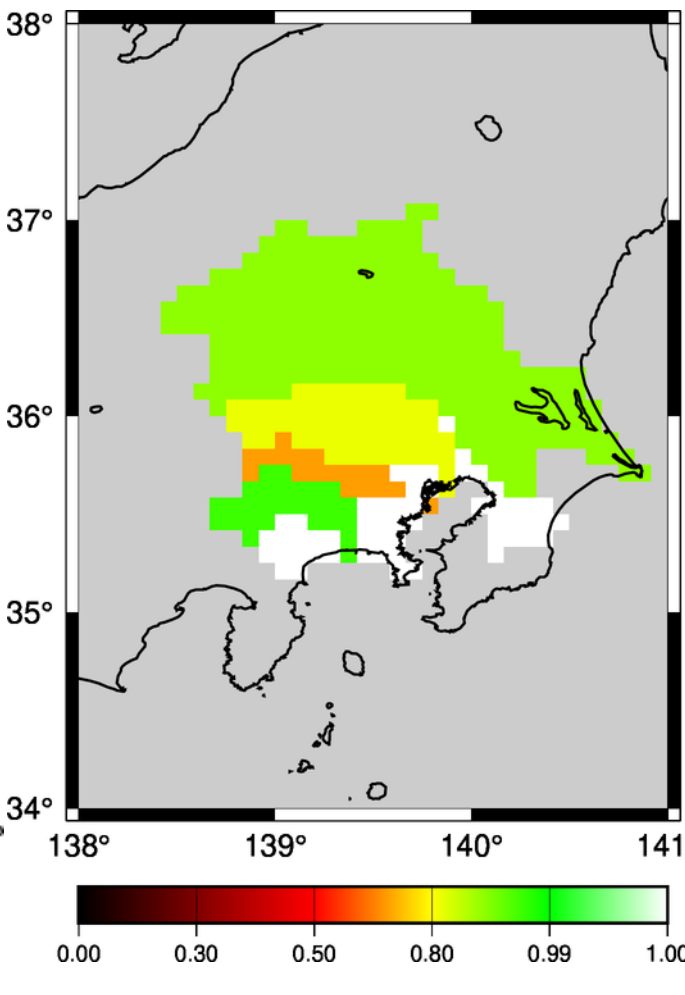
Grid-level



City-level



Basin-level



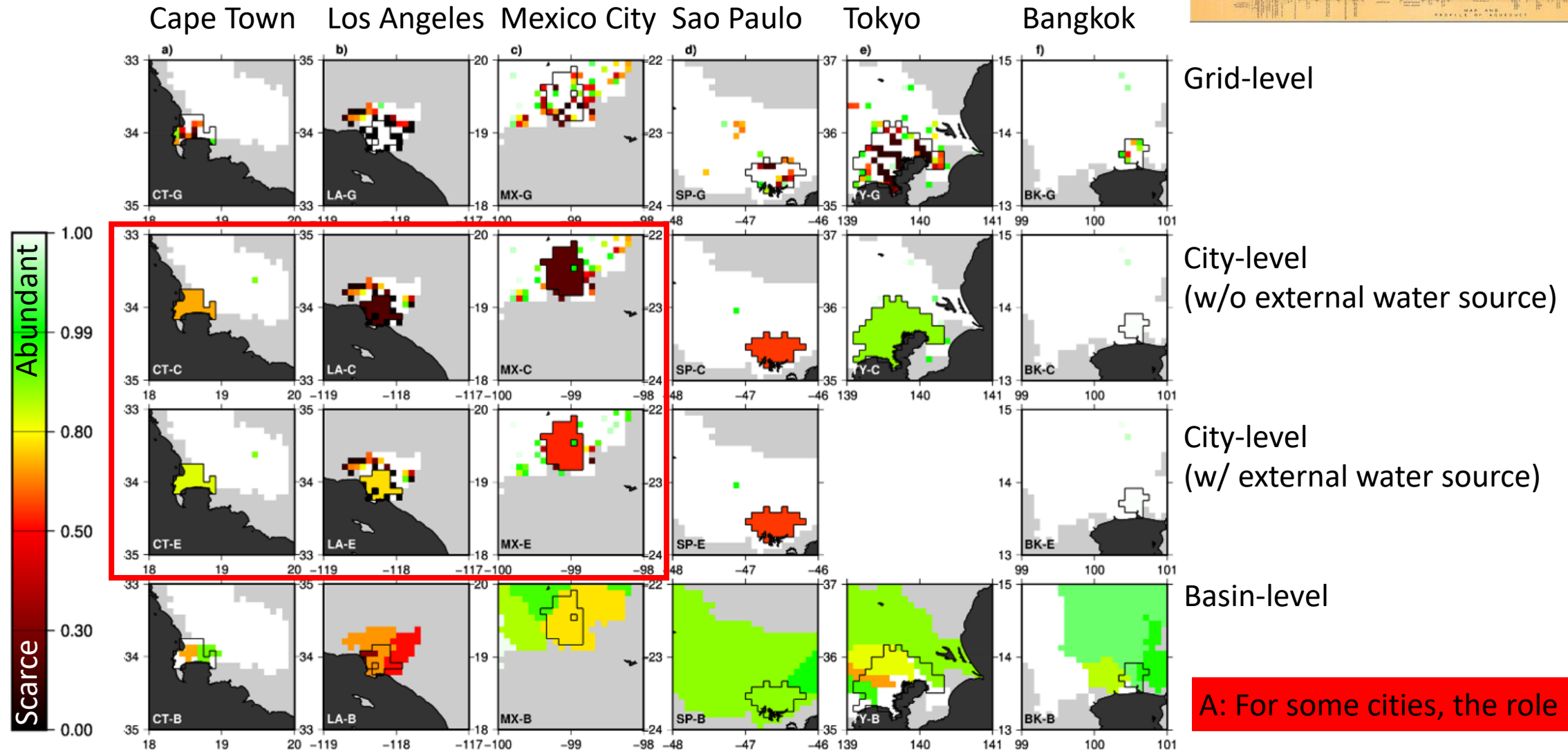
List

	CAD
Grid-wise	0.08-1.00
City-wise	0.88
Basin-wise	0.69-0.88

A: Yes. 1/7

Results (External water sources)

What is the role of the external (outside the basin) water sources?



Conclusions

- Conclusions
 - Can we represent “cities” in GHMs by a generic model?
A: Yes, but river discharge and water withdrawal may not be very accurate.
 - Can we conduct a city-level global water scarcity assessment?
A: Yes. City-level assessment is more informative than grid- or basin-level assessments.
 - For some cities, the role of external water sources is substantial.
- Significance
 - City sub-model: Simple and easy to implement
 - City boundary data: Flexibly applicable to future population/water-use scenarios
- Implications
 - Moving forward towards global water resources assessments resolving major cities.
 - Highlighting the importance of a database of city-level water resources and use.

References

- Research paper
 - <https://egusphere.copernicus.org/preprints/2026/egusphere-2026-5322/>
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- Reboot development
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 - <https://jp.reuters.com/markets/commodities/VY3HUP6SSFLFVHRWVHOTTOZPKM-2025-09-02/>
- Continental drying
 - <https://www.worldbank.org/en/publication/continental-drying-a-threat-to-our-common-future>
- World urbanization prospects
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