# HEM for identifying water resources vulnerabilities in data-scarce basins

## The case of the Tigris-Euphrates River Basin

ICID Meeting

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# Outline

1. Context of the Tigris-Euphrates river basin
2. The FAO project: objectives and challenges
3. Results: vulnerability identification
4. Further vulnerability evaluations
5. Conclusions and recommendations

# Outline

1. Context of the Tigris-Euphrates river basin

# The Tigris-Euphrates


Image credits: Google maps

# Tigris-Euphrates context

Ataturk dam

Sanliurfa tunnel

Harran plain
(150k ha)

Tabqa dam

Raqqa
(ISIS ex-capital)

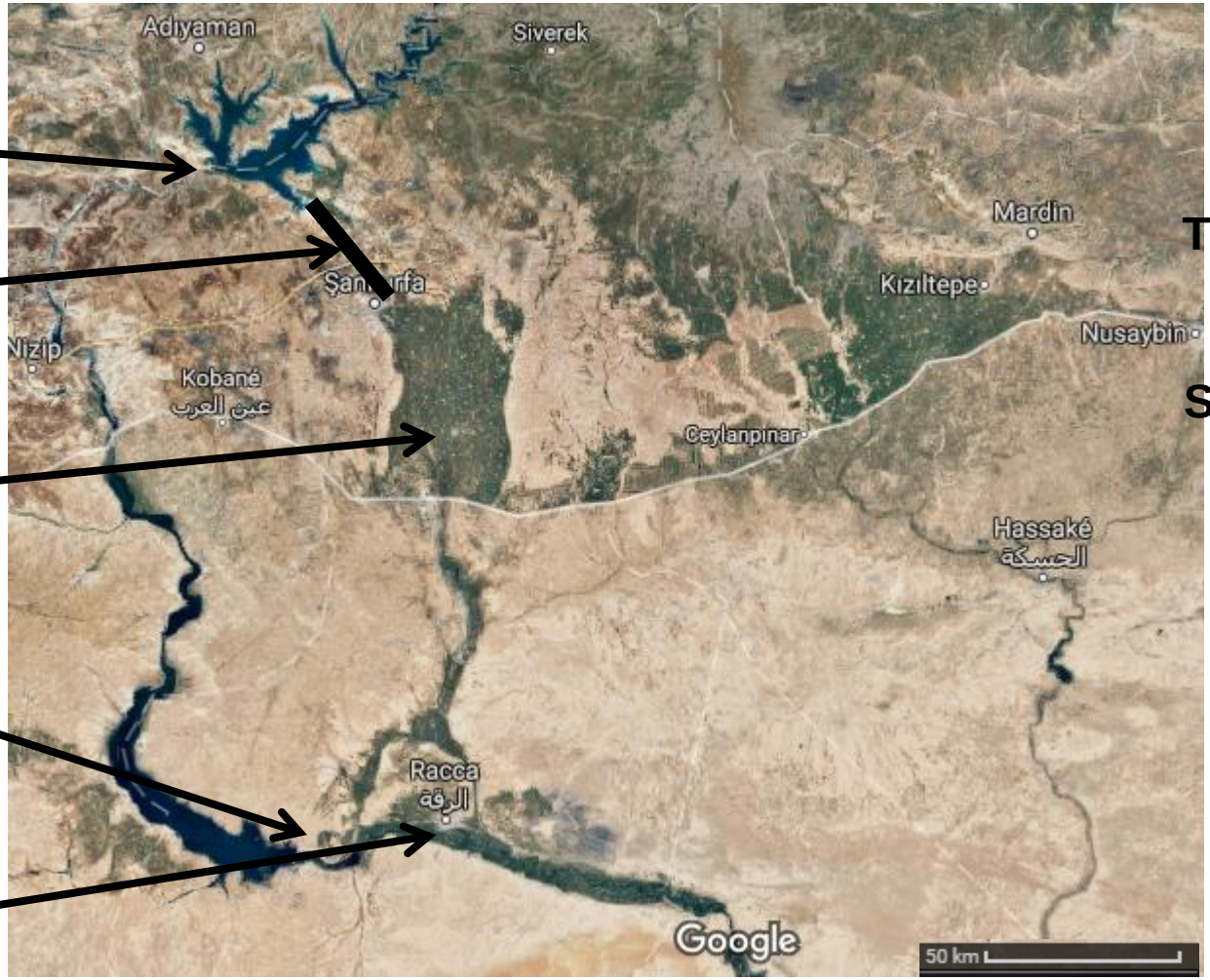



Image credits: Google maps

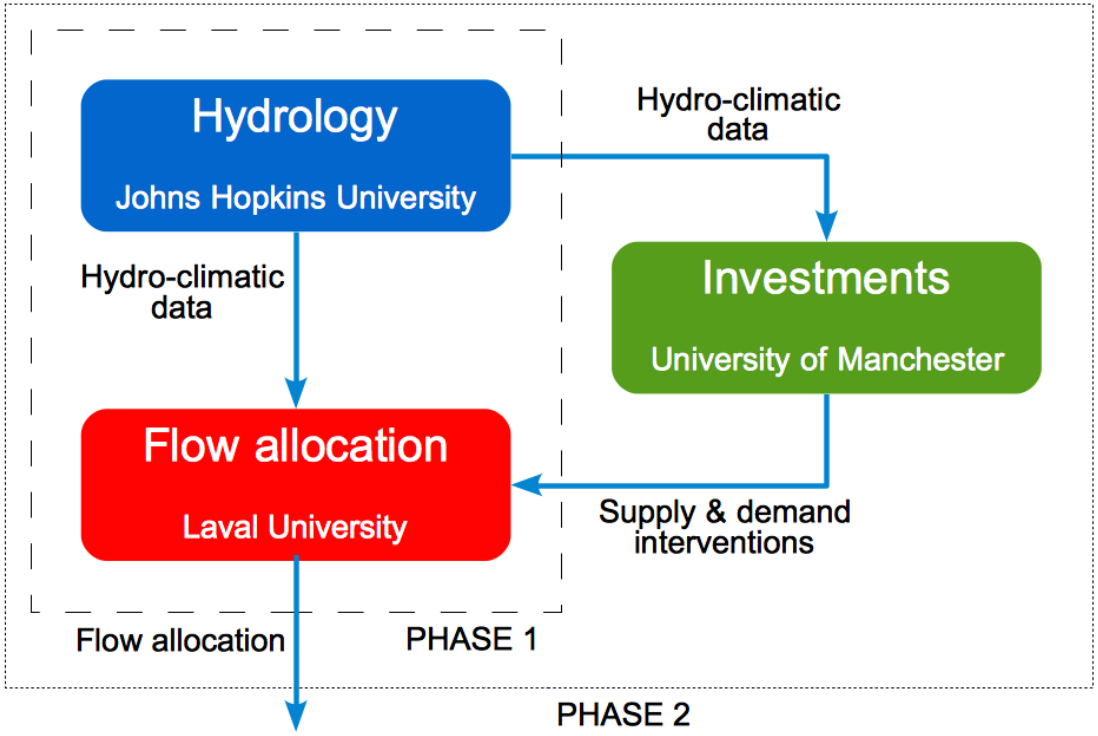
# Outline

1. Context of the Tigris-Euphrates river basin
2. The FAO project: objectives and challenges

# The FAO project

- The project has several phases and components including the development of a detailed hydro-economic model of the basin

- Phase 1 = current situation in the basin in terms of supplies and demands




Phase 2 = scenarios of future demands and supplies

Climate change
Irrigation projects
Hydropower projects

**BUT: ISIS-related conflicts!**

# Project goals: phase 1

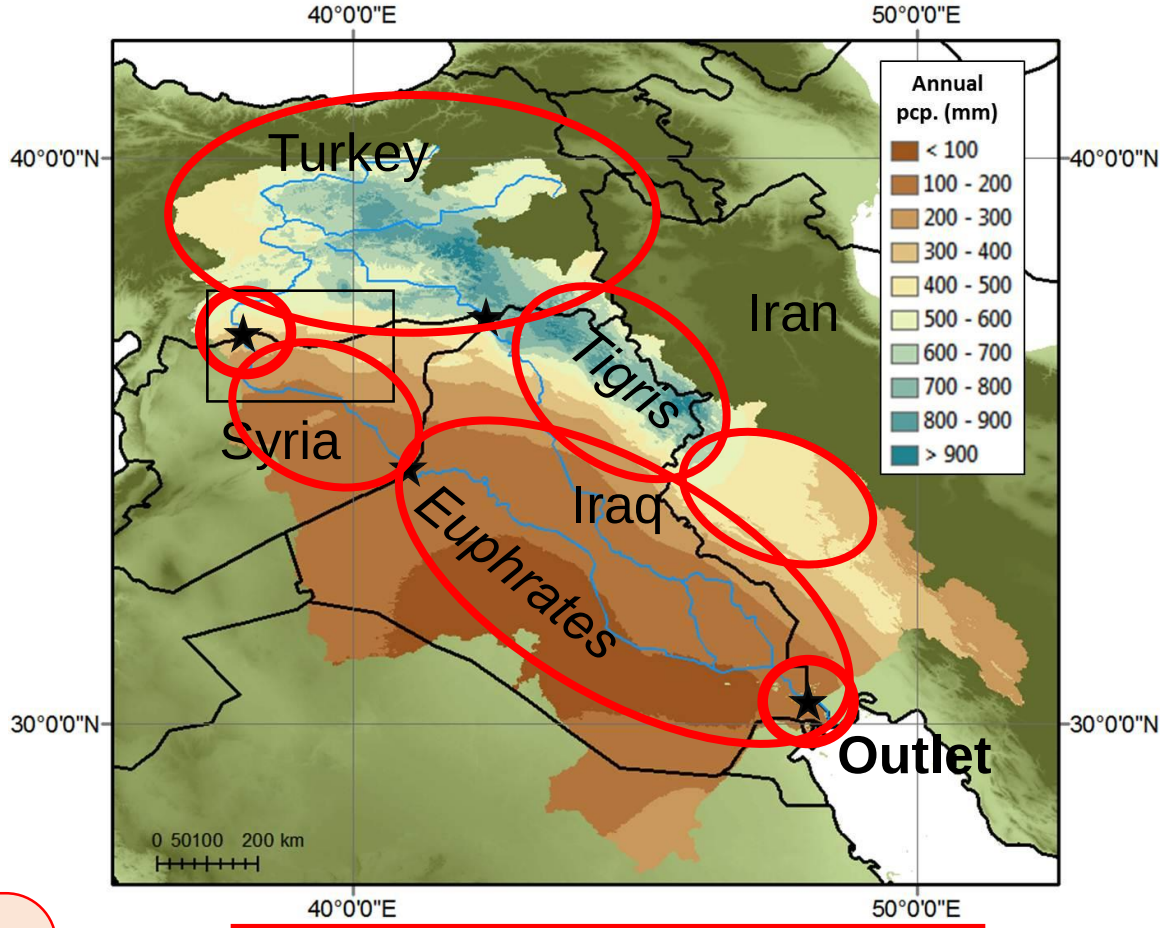
Current situation?

1) Hydropower, irrigation benefits (per country)

2) Vulnerabilities, risks.

- Irrigation shortages?
- Border flows?
- Outlet flows?

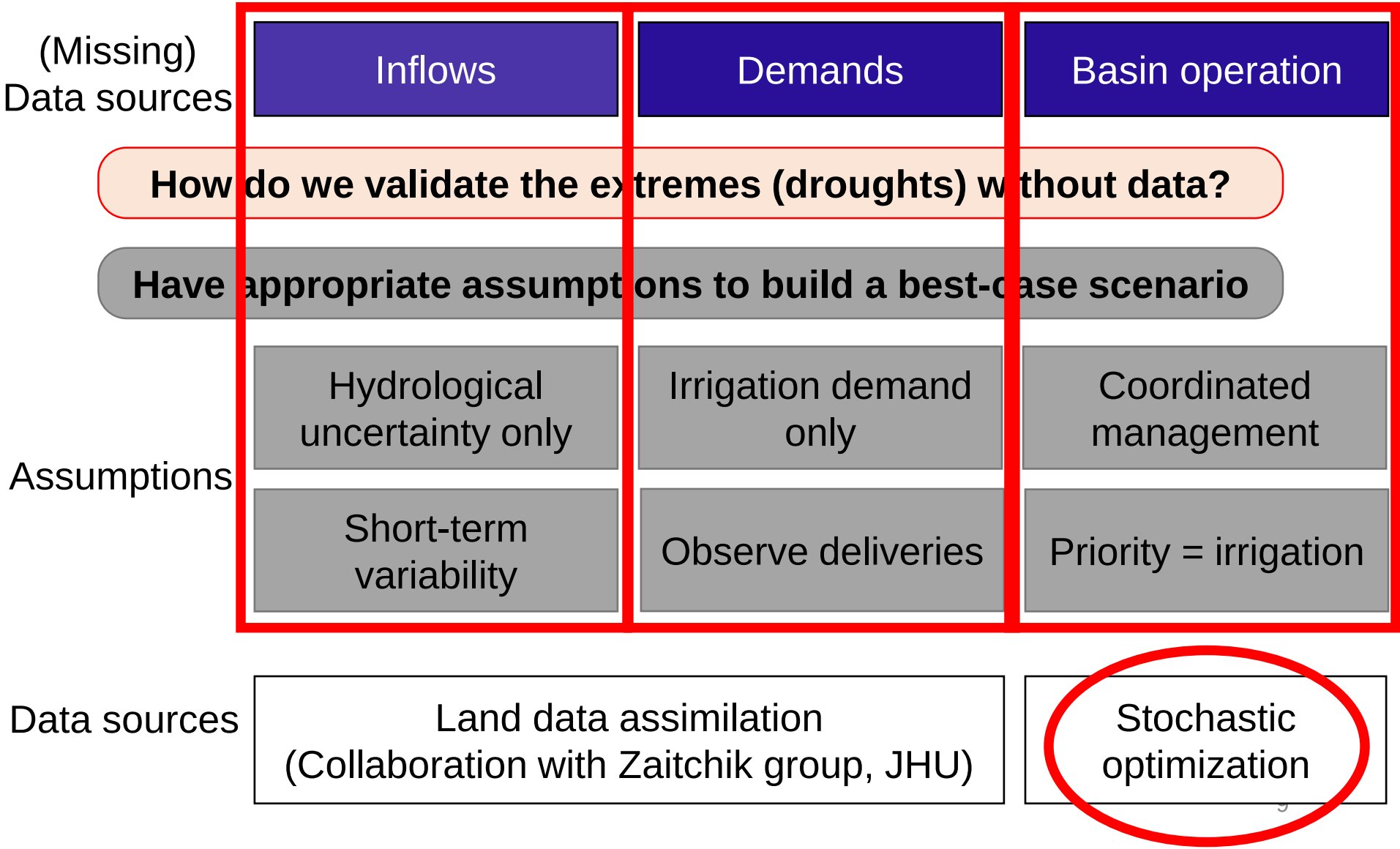
**Uncoordinated development (+ conflict)**
- **Limited data availability**



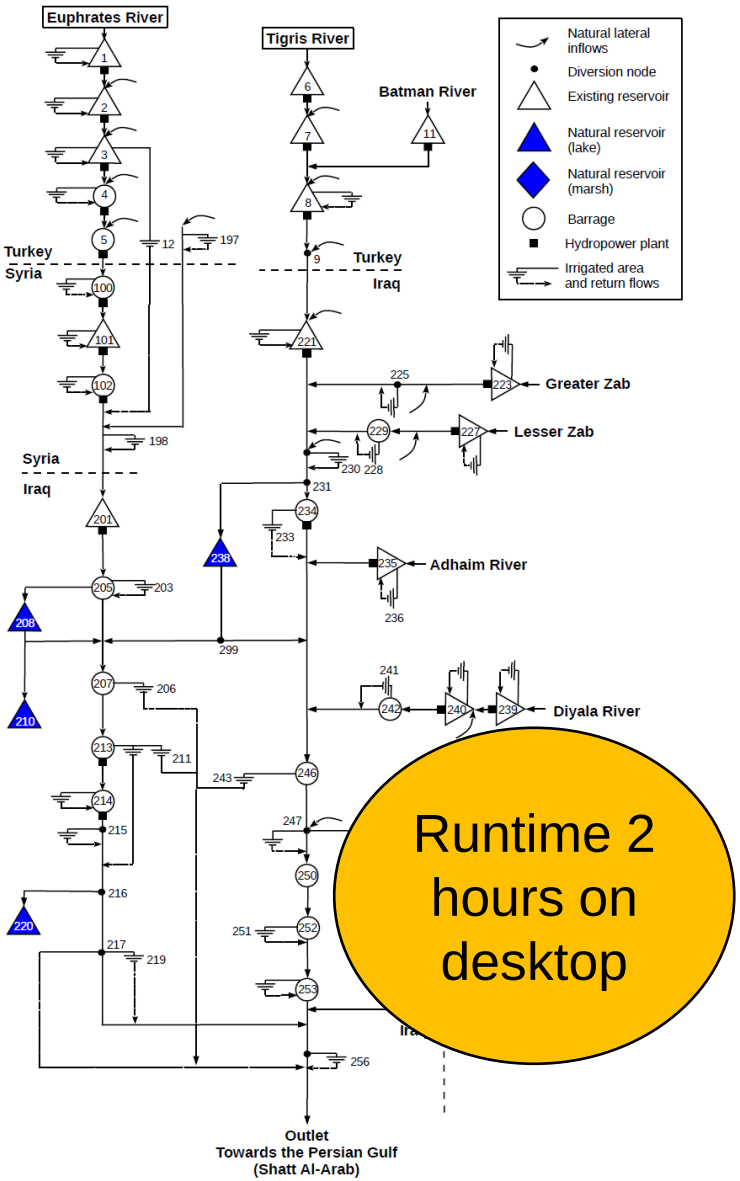

Monthly flow allocation

Represent variability

# The modelling challenge



# A large multi-reservoir system




Inflows at 28 nodes

Irrigation demands at 51 sites

Operation of 17 reservoirs

**Curse of dimensionality?**

## SDDP-YPRE

- SDDP invented in 1980s (Brazil) for stochastic multireservoir optimisation.
- YPRE: extension I developed for data-limited cases (WRR, 2016)

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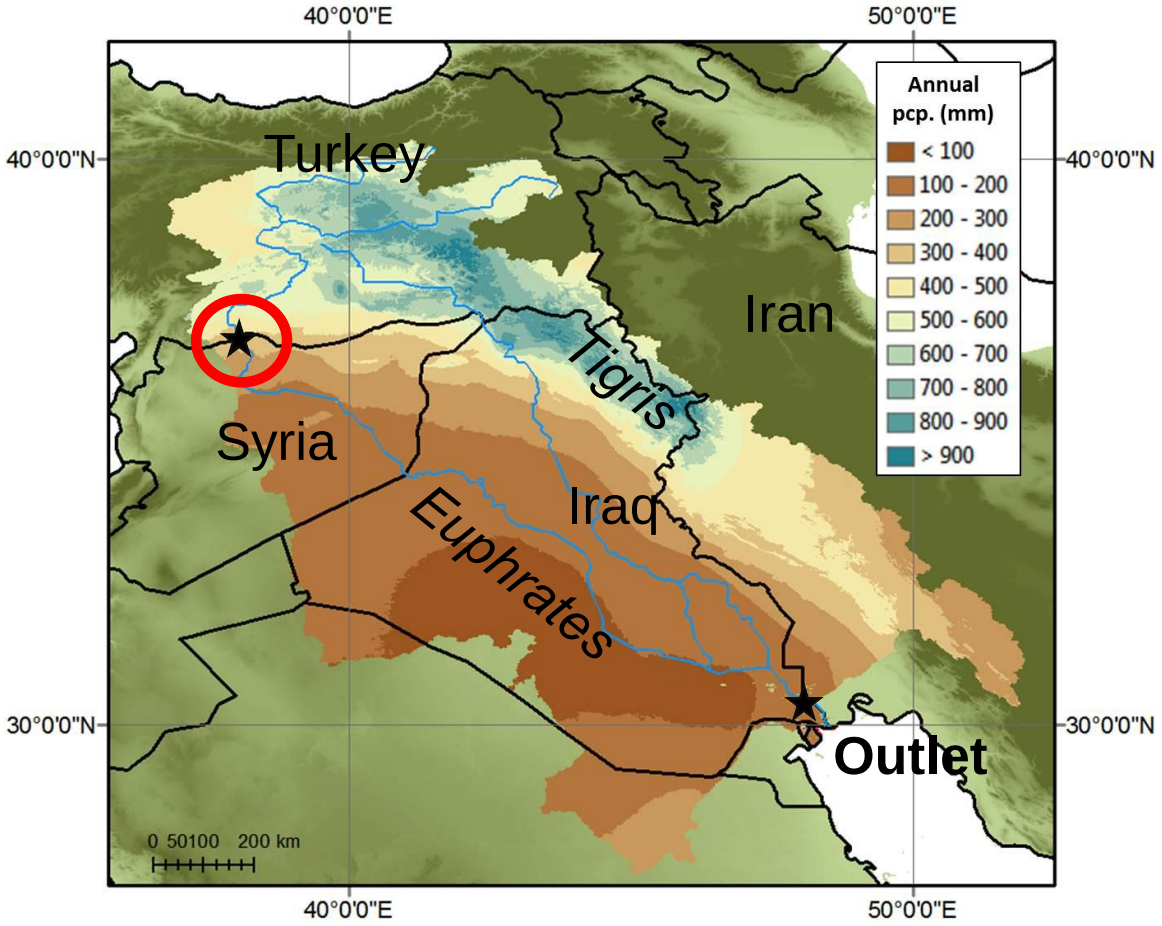
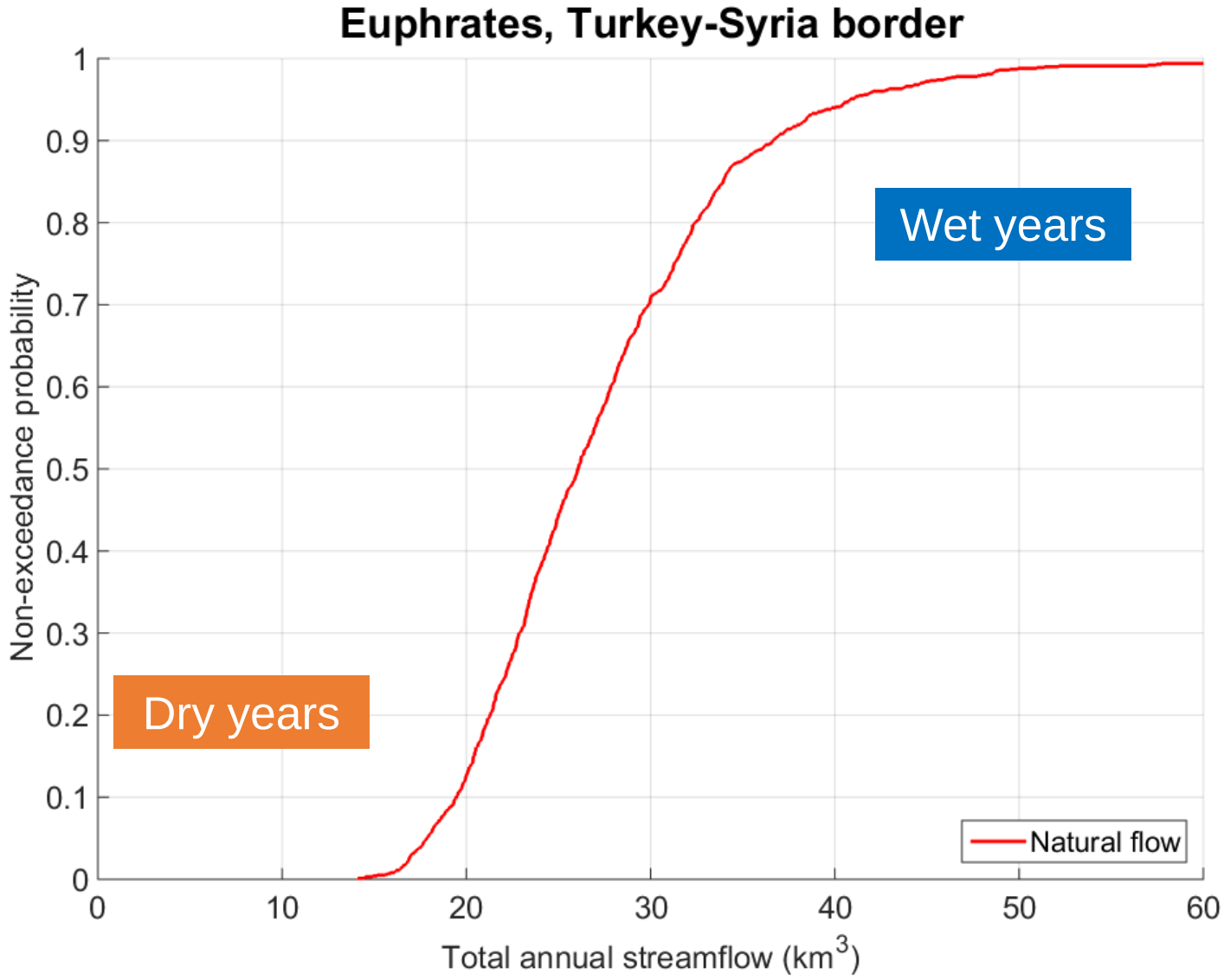
# Results from 1,000 simulations

1,000 data points
✓ for all 12 months
✓ anywhere

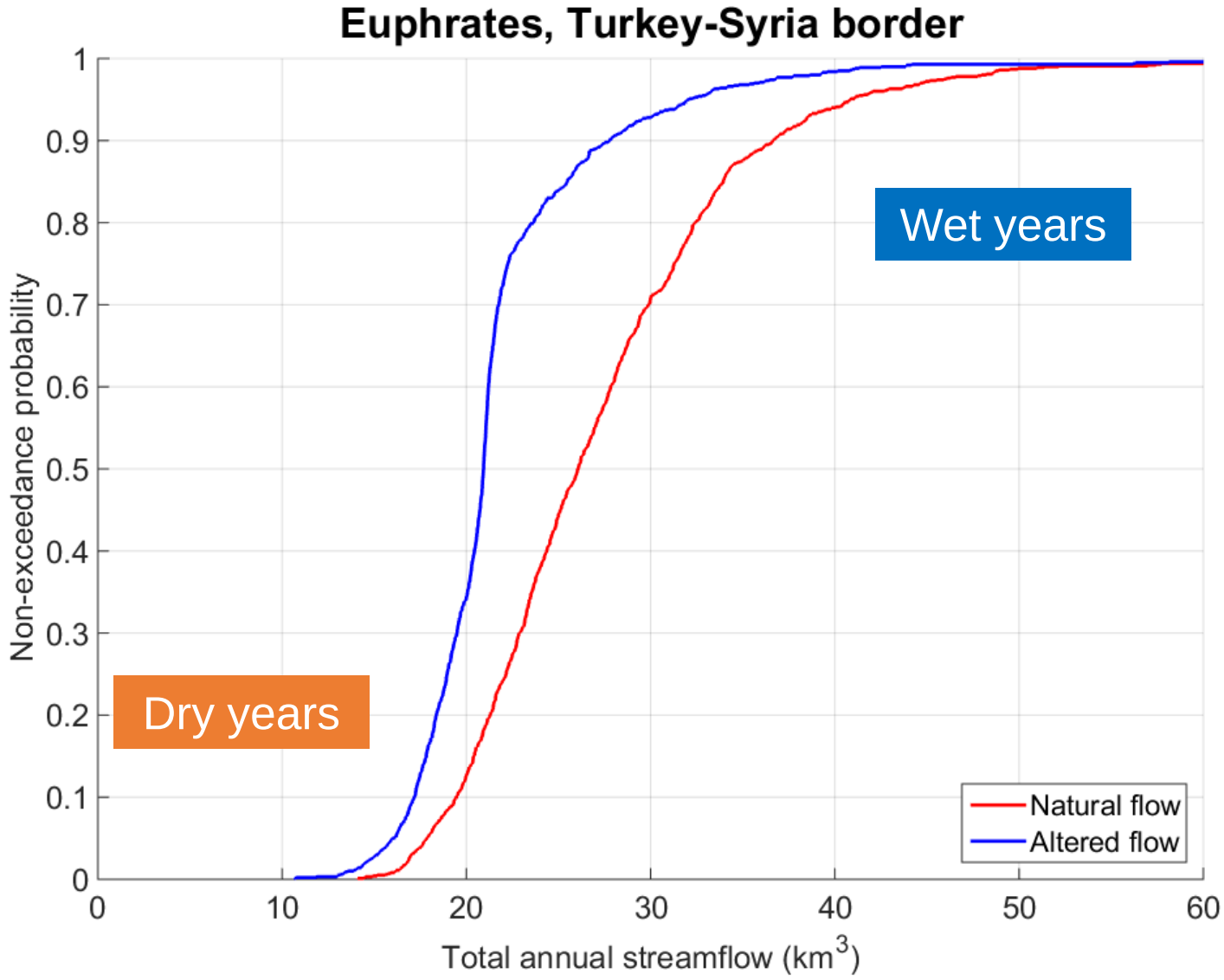
"Best-case" scenario: Reliability >99% for irrigation demand



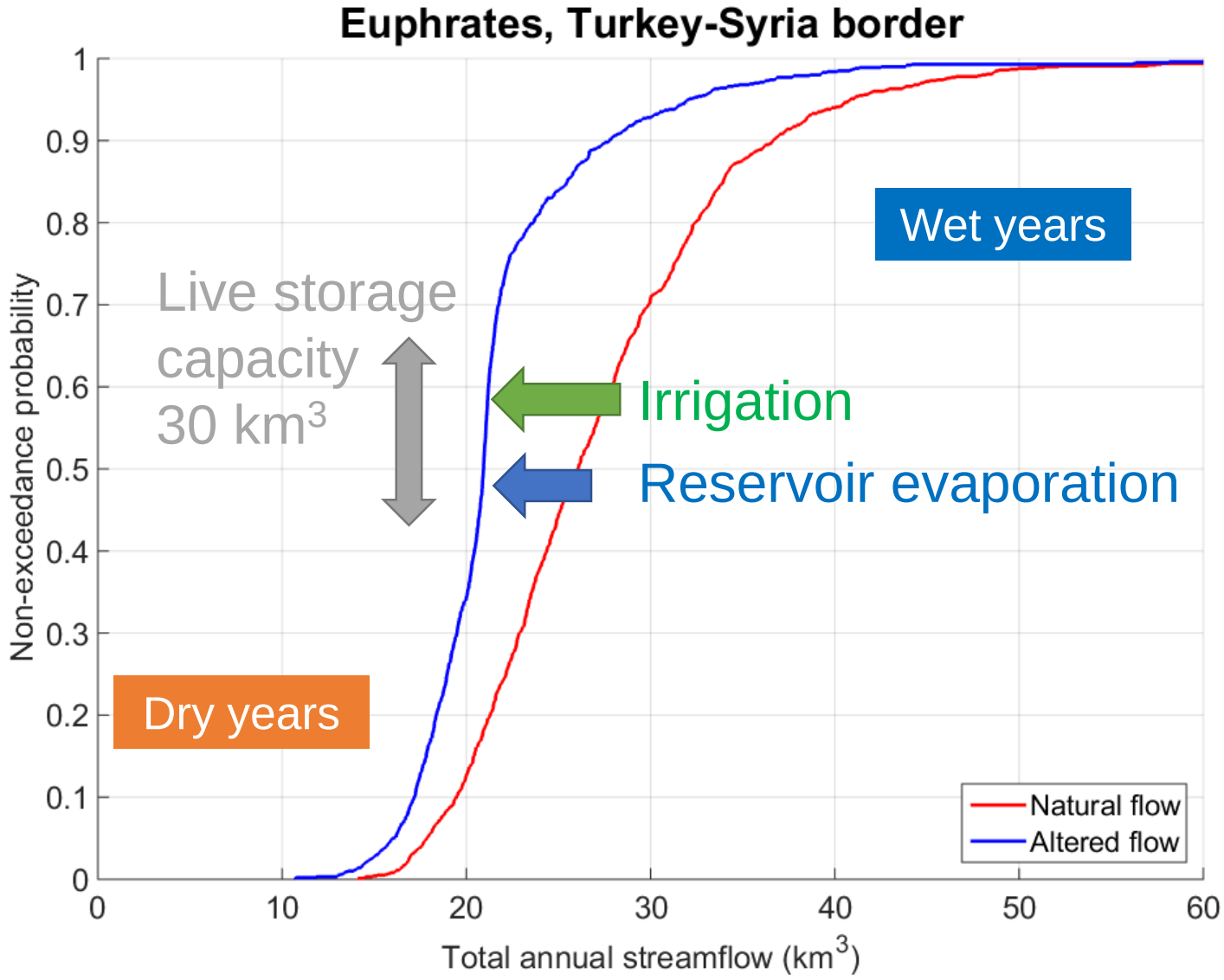
# From natural flows…



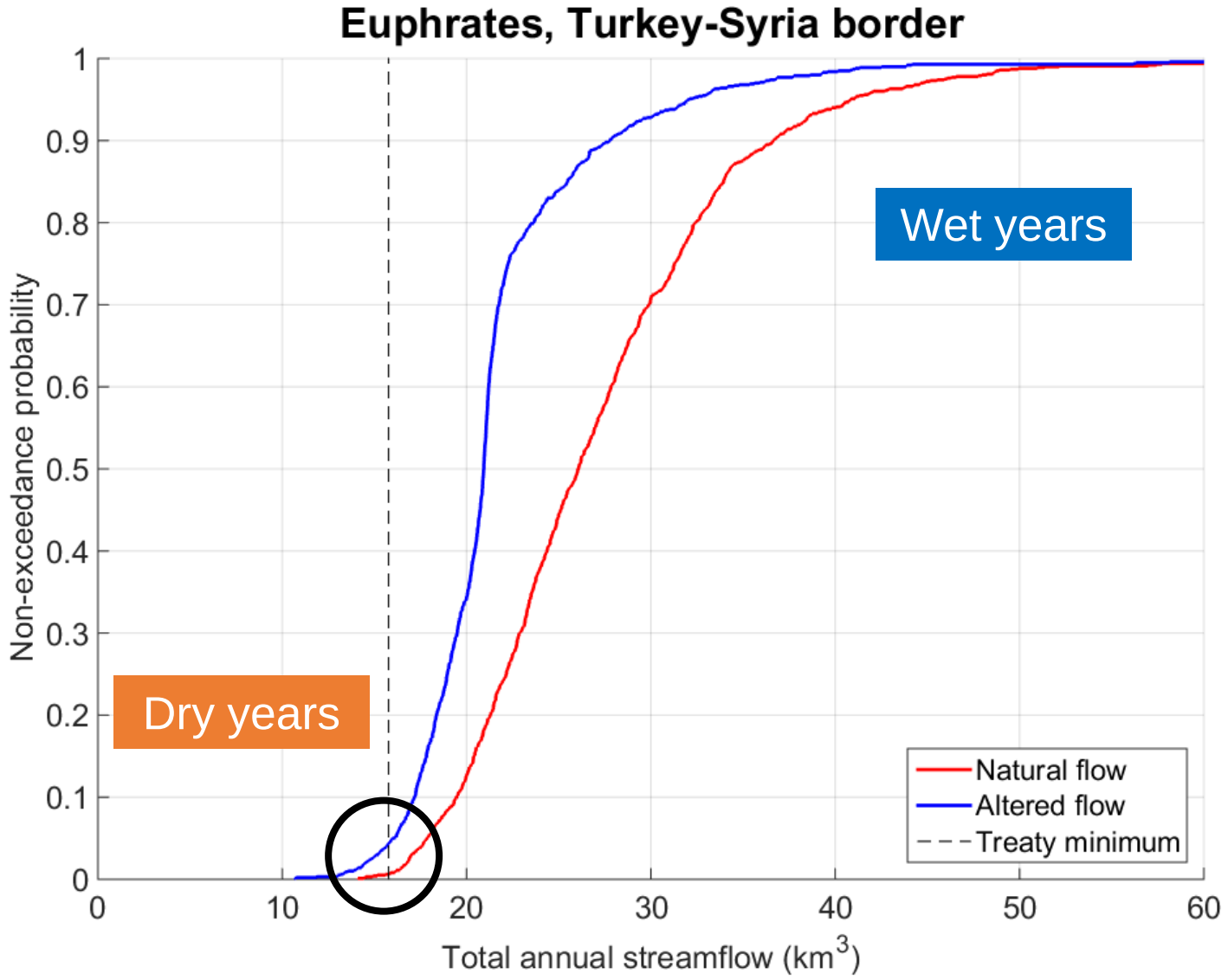
# … to altered flows



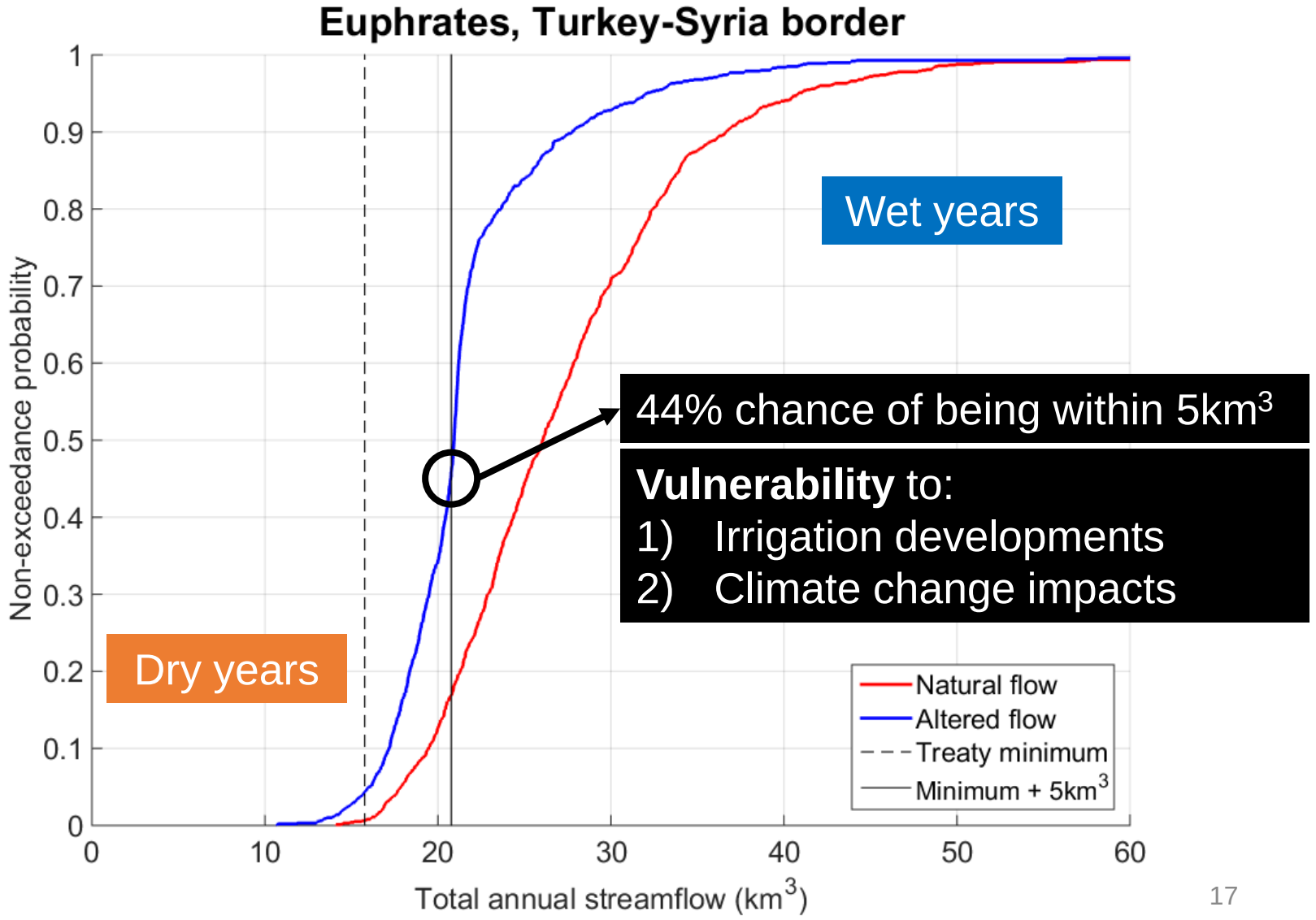
# Infrastructure impacts on flow?



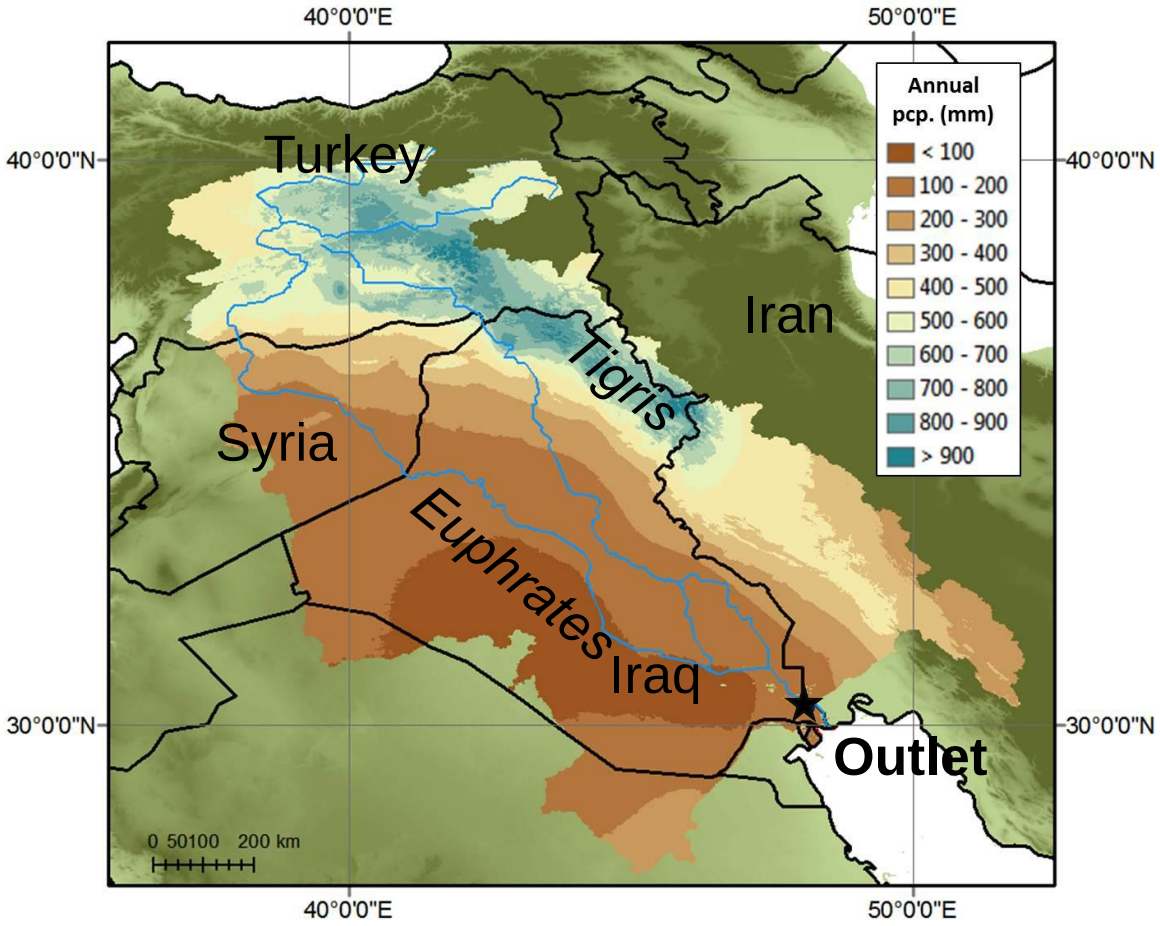
# Respect of 1987 agreement?



# Vulnerability of treaty respect!



# Outlet flows



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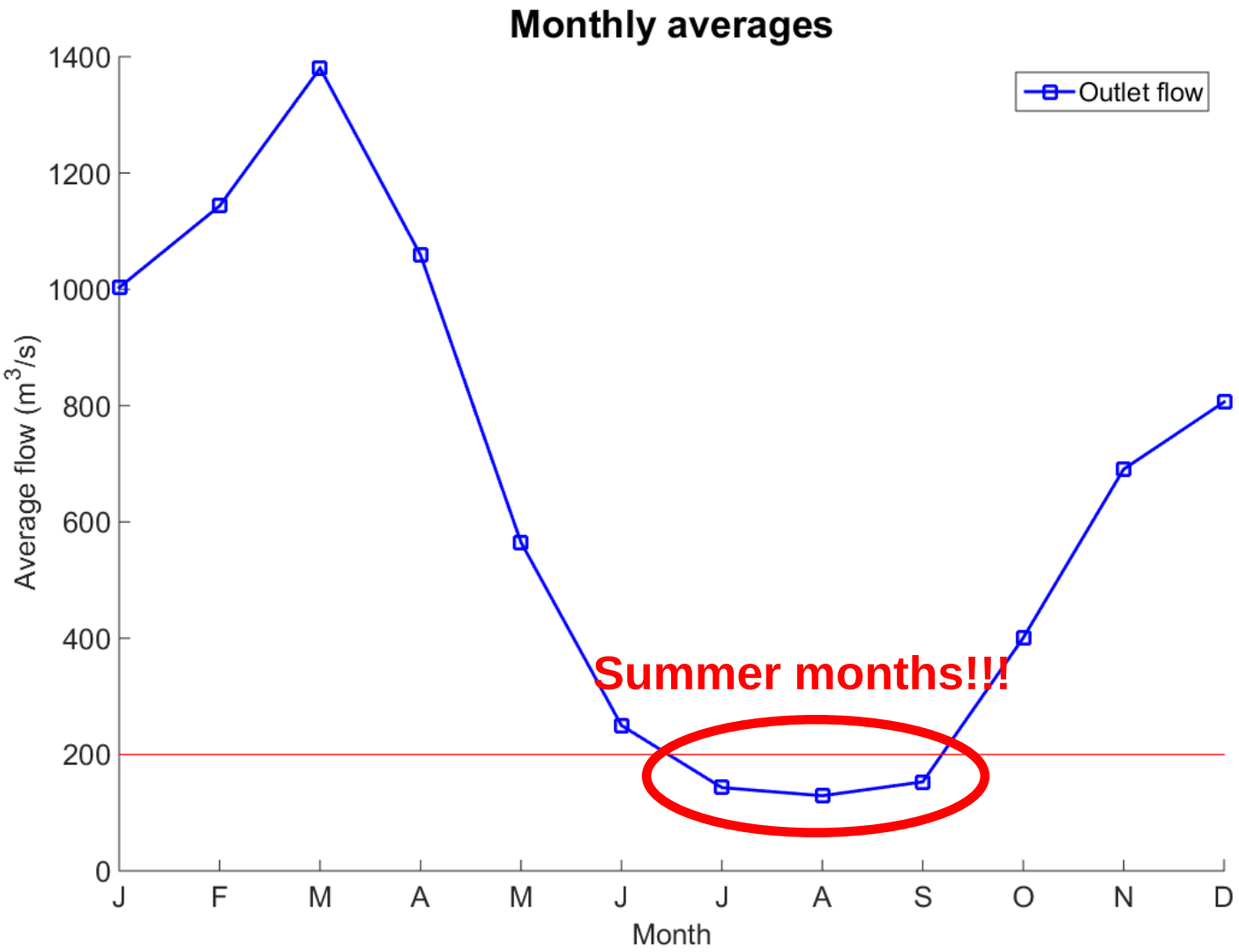
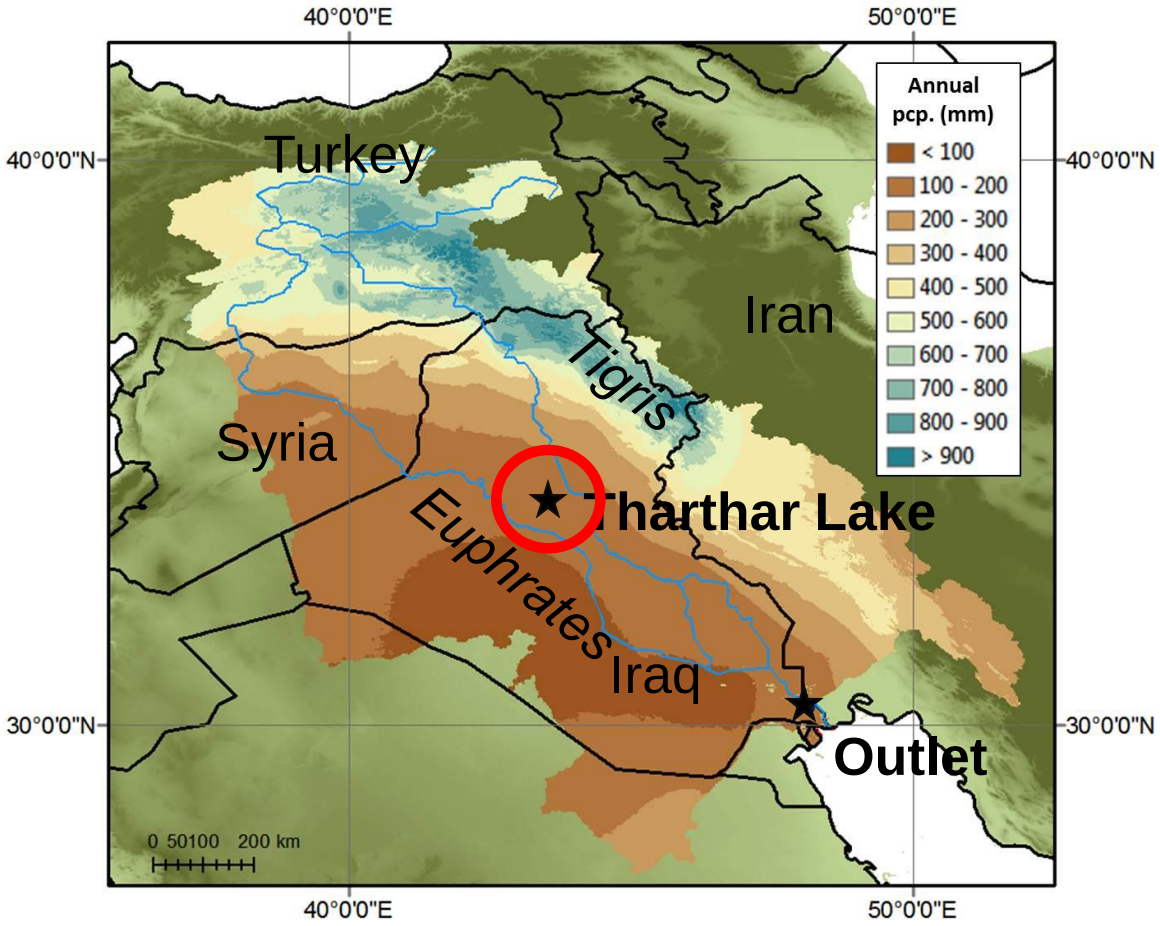
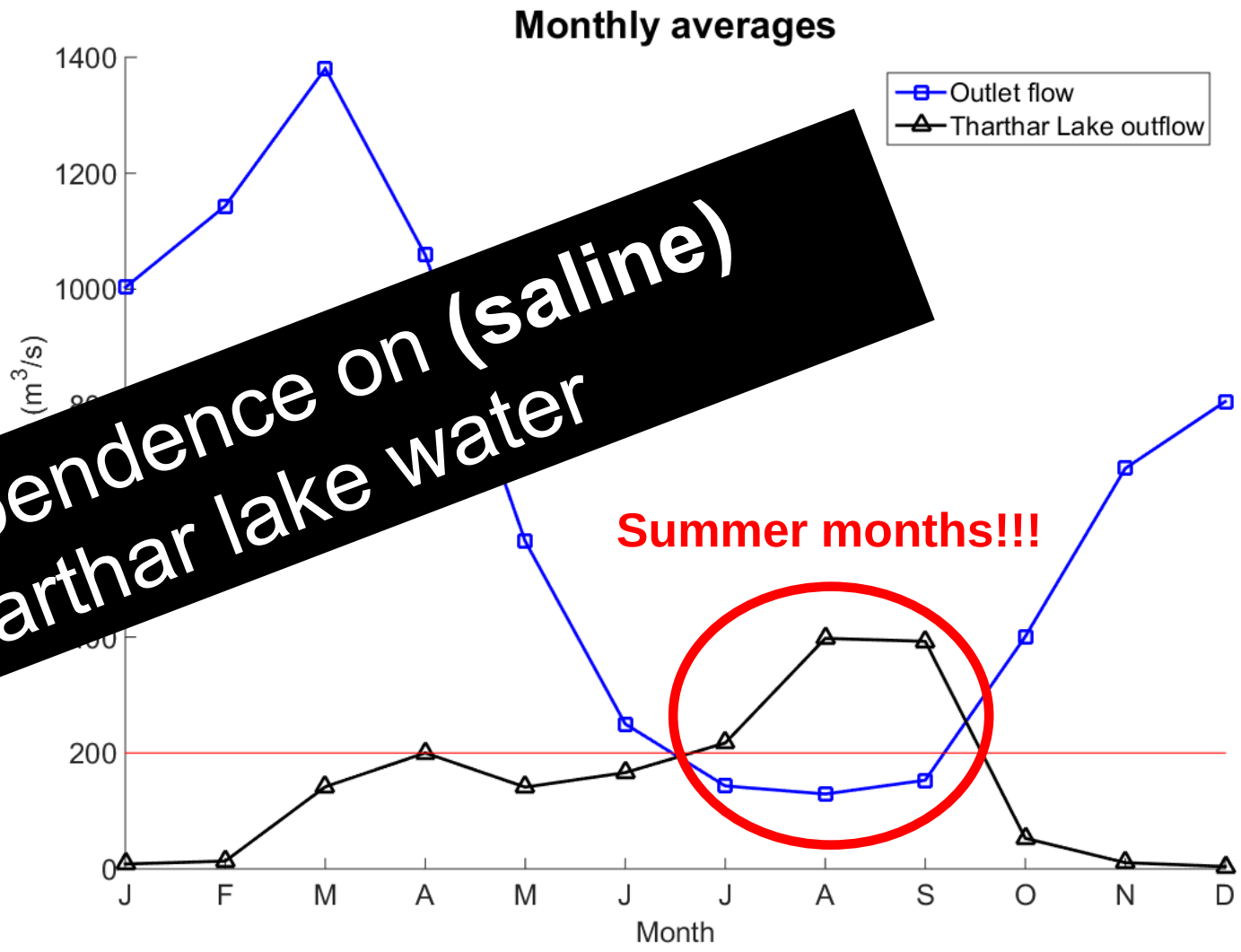


# A comparison



# Outlet vs. Tharthar Lake flows




**Dependence on (saline) Tharthar lake water**

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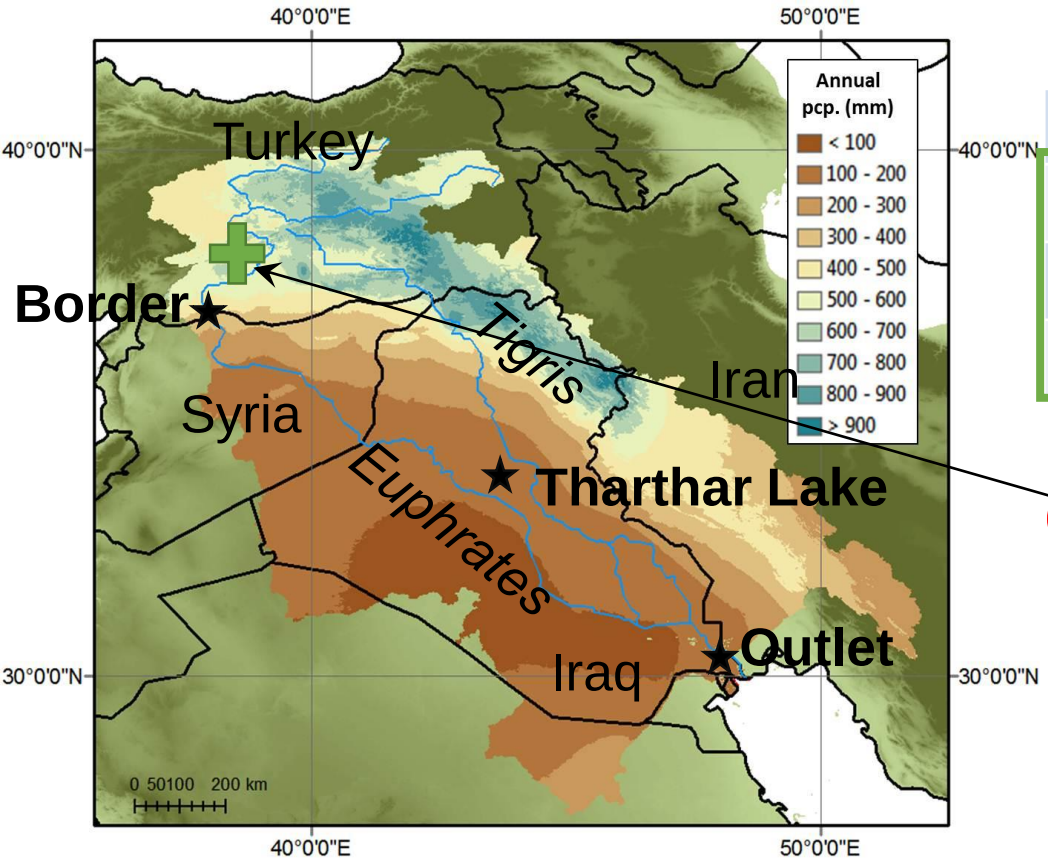
# Key vulnerabilities & scenarios



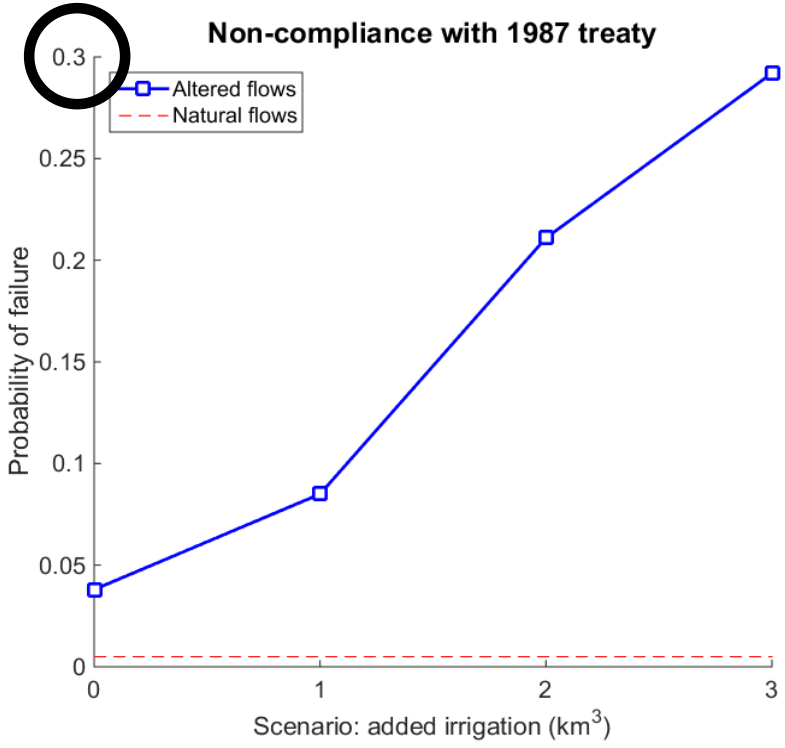

- Scenarios

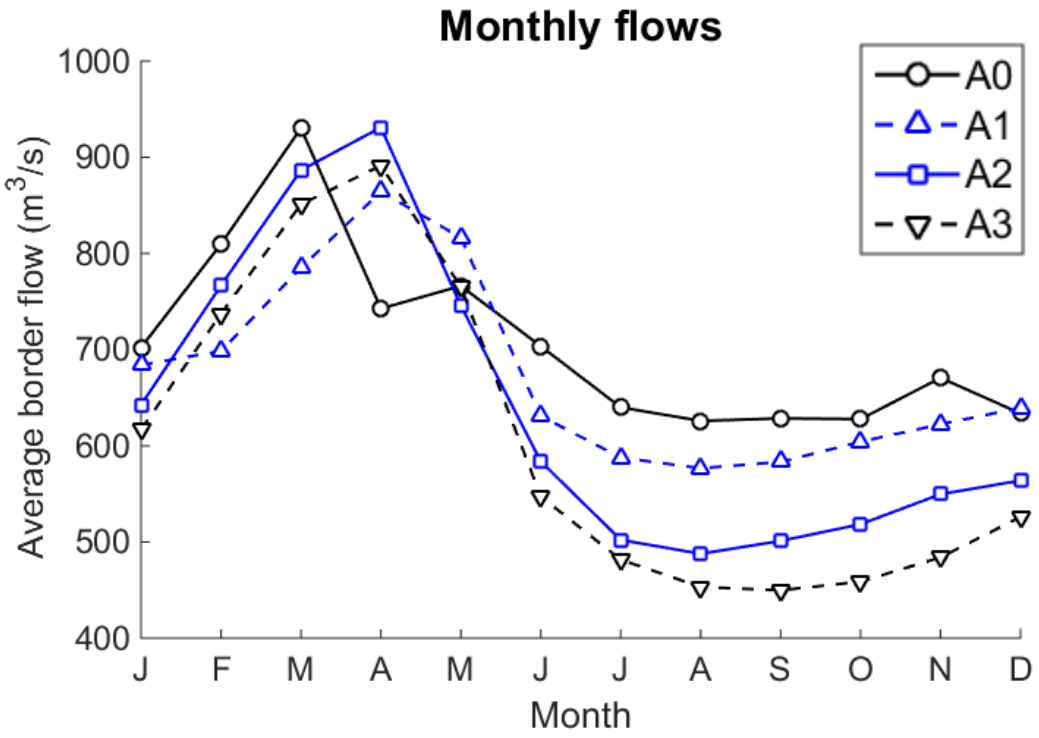
| | Baseline network |
|---|---|
| Baseline irr. | A0 |
| Irr. +1 km$^3$ | A1 |
| Irr. +2 km$^3$ | A2 |
| Irr. +3 km$^3$ | A3 |

1) Vulnerability of border flows to supply-demand change?

2) Dependence of (Euphrates) flow on outside transfers of saline water?

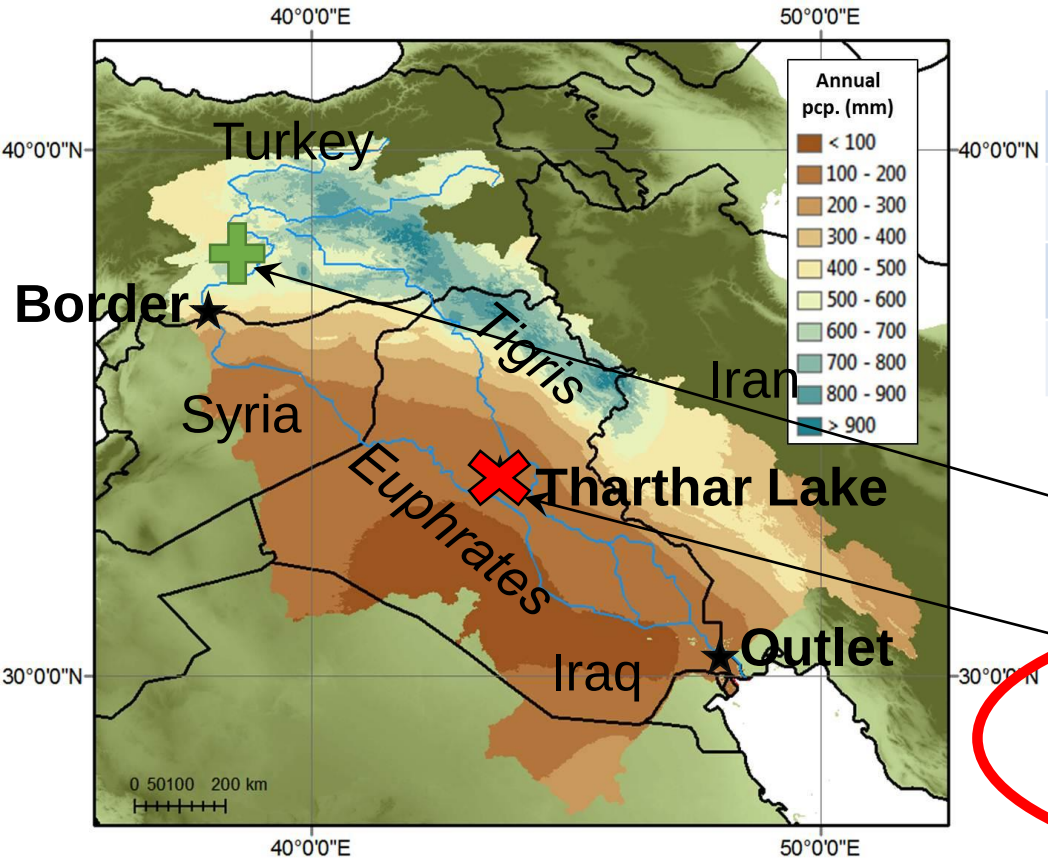
# Scenarios A: Border flows




Increases dependence of downstream irrigation on **(saline)** water transfers

# Key vulnerabilities & scenarios




- Scenarios

| | Baseline network | No Tharthar outlet |
|---|---|---|
| Baseline irr. | A0 | B0 |
| Irr. +1 km$^3$ | A1 | B1 |
| Irr. +2 km$^3$ | A2 | B2 |
| Irr. +3 km$^3$ | A3 | B3 |

1) Vulnerability of border flows to supply-demand change?

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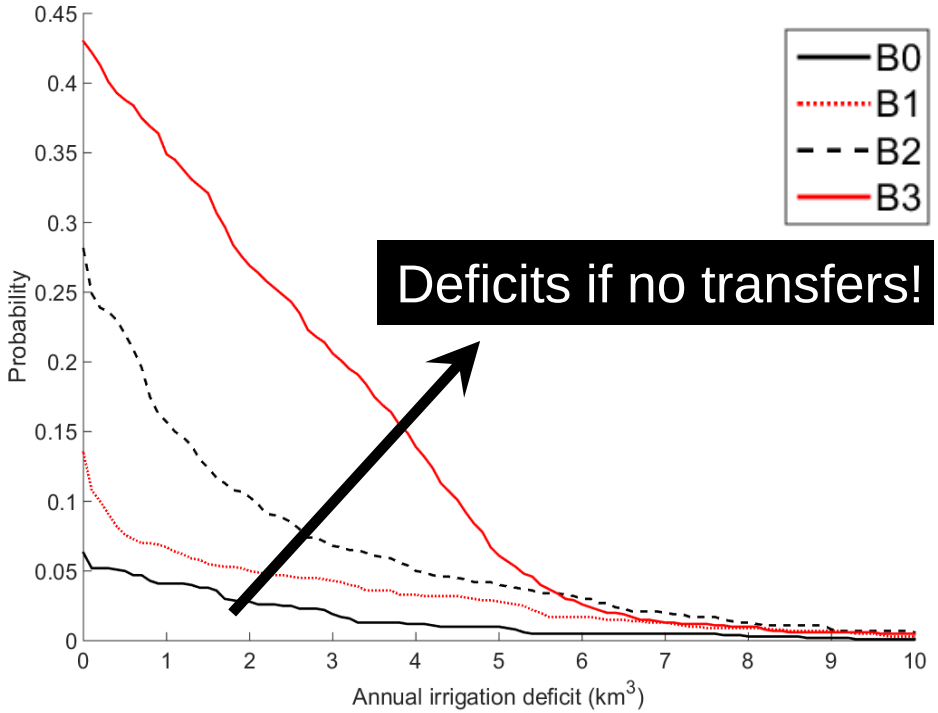
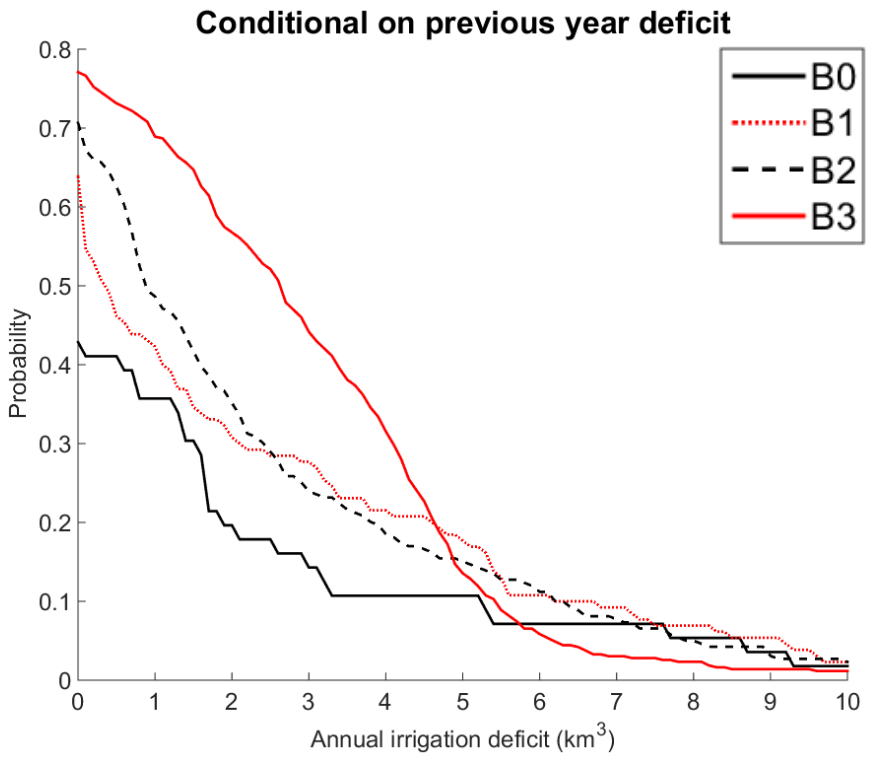
# Scenarios B: Euphrates irrigation

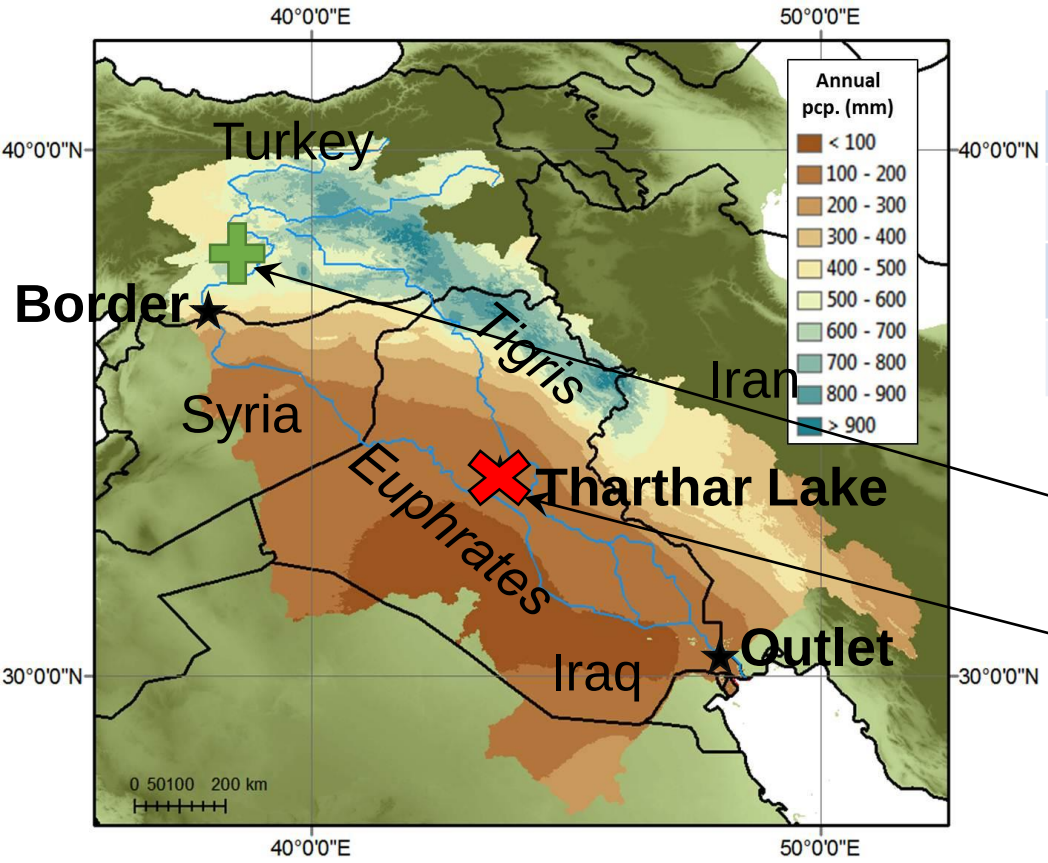



Deficits if no transfers!




Large storage capacity means risks are correlated over multiple years!

# Key vulnerabilities & scenarios




- Scenarios

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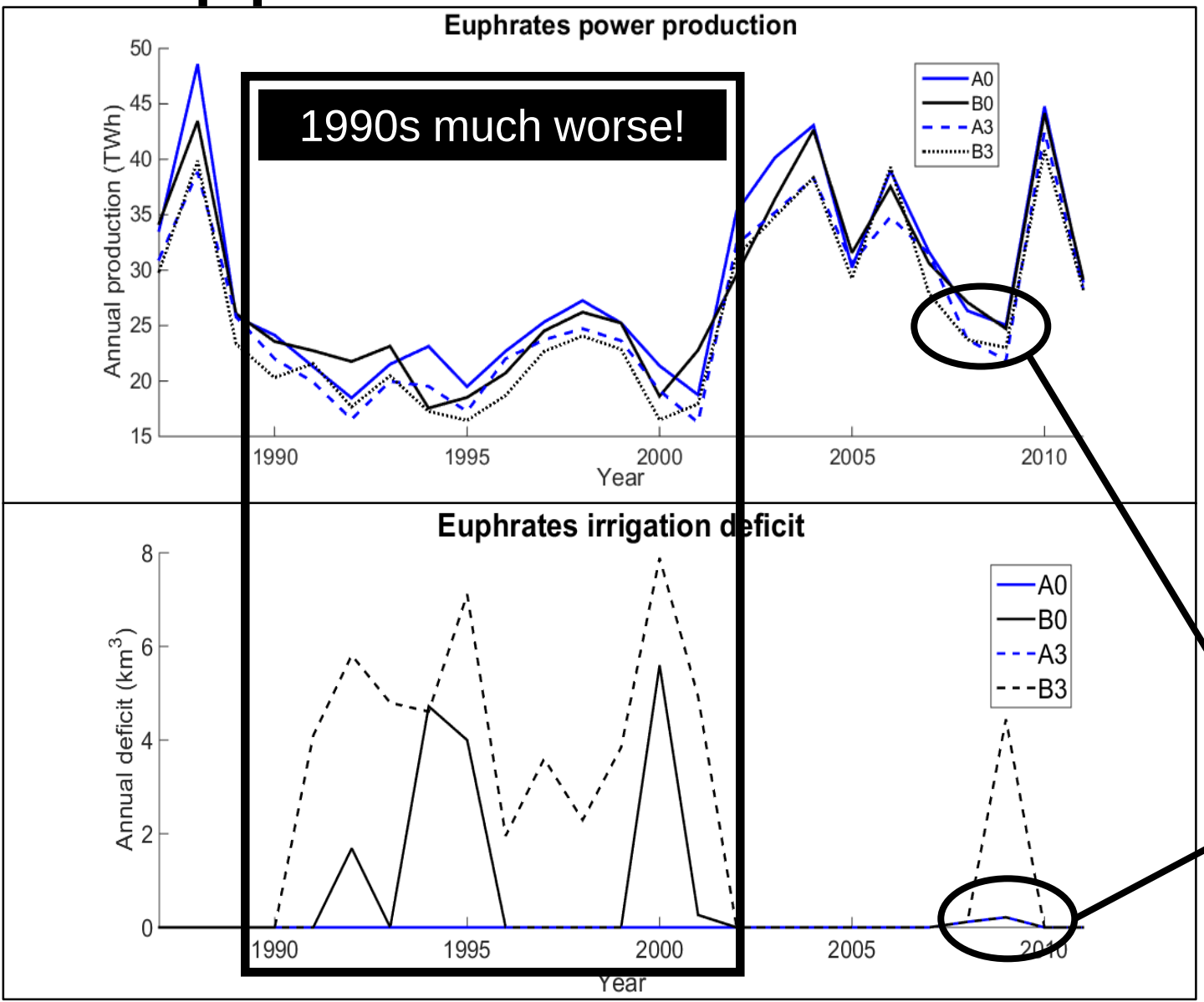
1) Vulnerability of border flows to supply-demand change?

2) Dependence of (Euphrates) flow on outside transfers of saline water?

# Application to historic flows




Inter-annual Variability

2007-2009 Syria drought

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# Key takeaways

- **Best-case scenario built to overcome lack of data**
  - Monthly time-step, accounts for variability.
  - Drought vulnerability assessment

**Unsustainable development :**

- Iraq dependence on saline water
- Sensitivity to additional (planned) irrigation developments

- **Quantitative evaluation of competing claims**
  - Vulnerabilities likely to be present in practice
  - Approach translatable to other transboundary basins

# Next steps


The University Of Sheffield.

**Starting 1 September:**

**Lecturer at the University of Sheffield**

**Interests: water resilience**

**Hydro-economic modeling**

**Trade-off analysis (multiple criteria)**

**Diagnostics of complex coupled models**

Example: hydrological model WBM, featured in Nature & Science