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)

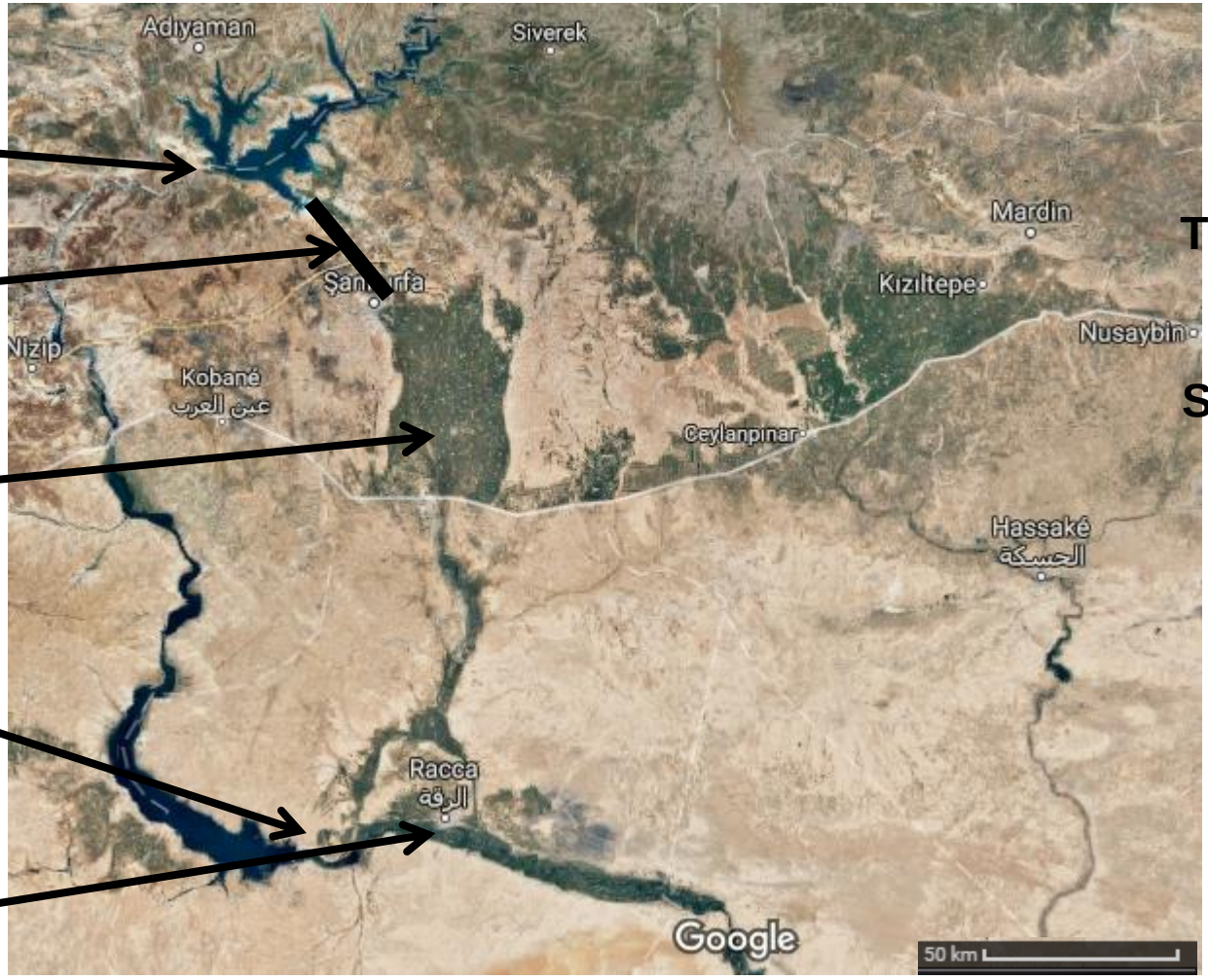


Image credits: Google maps

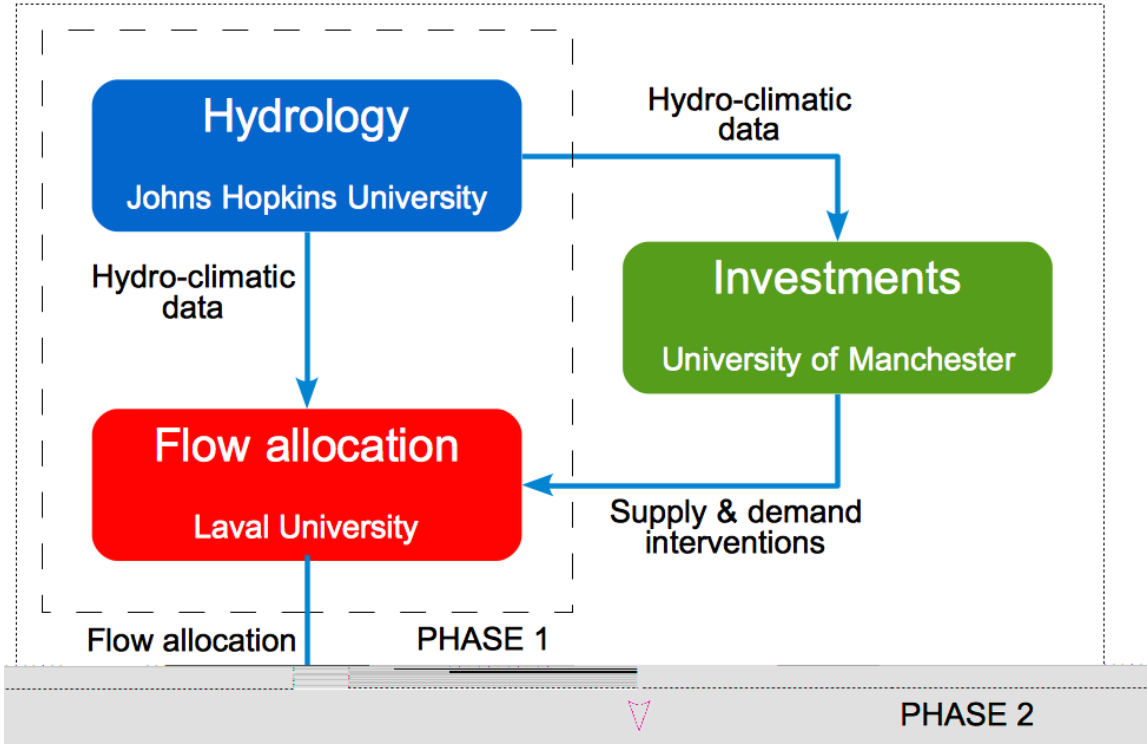
Outline

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

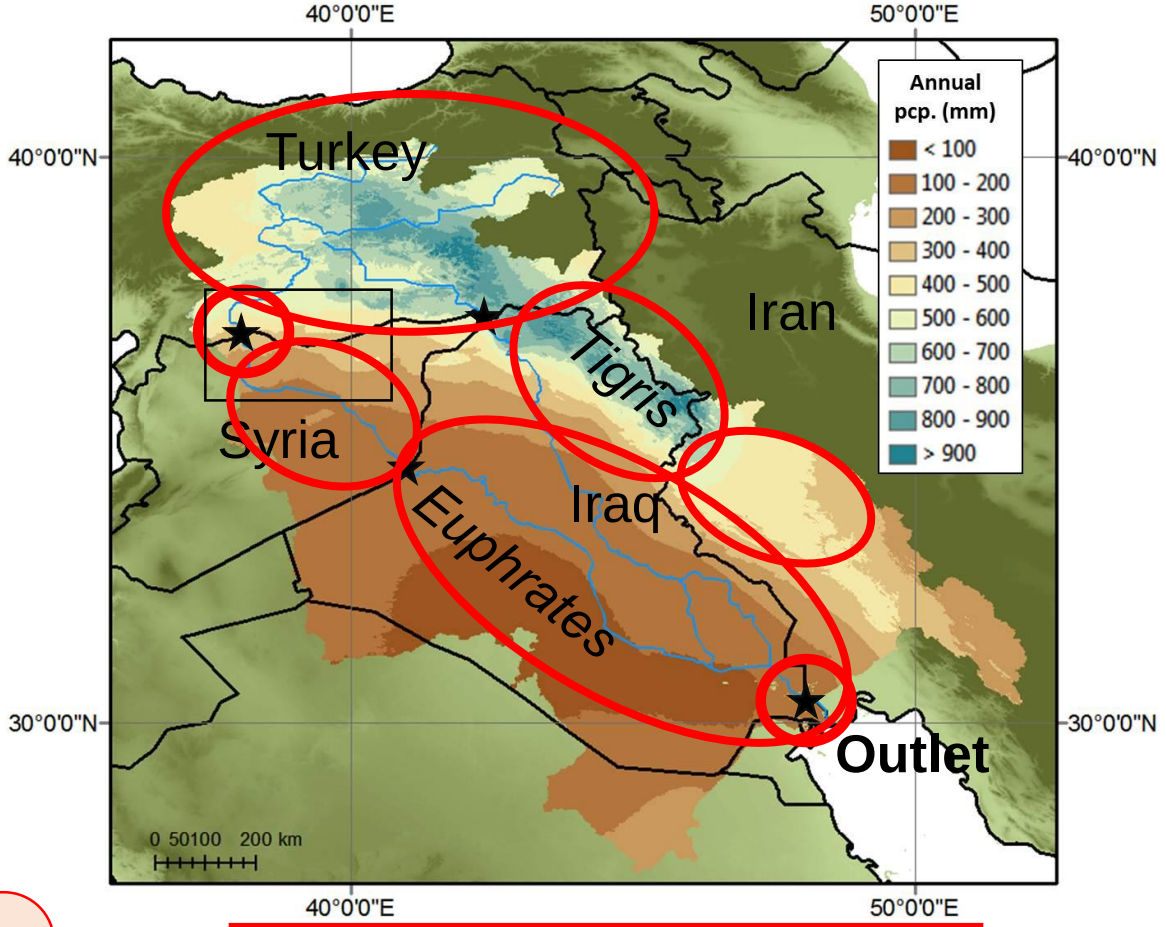
Current situation?

1) Hydropower, irrigation benefits (per country)

2) Vulnerabilities, risks.

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

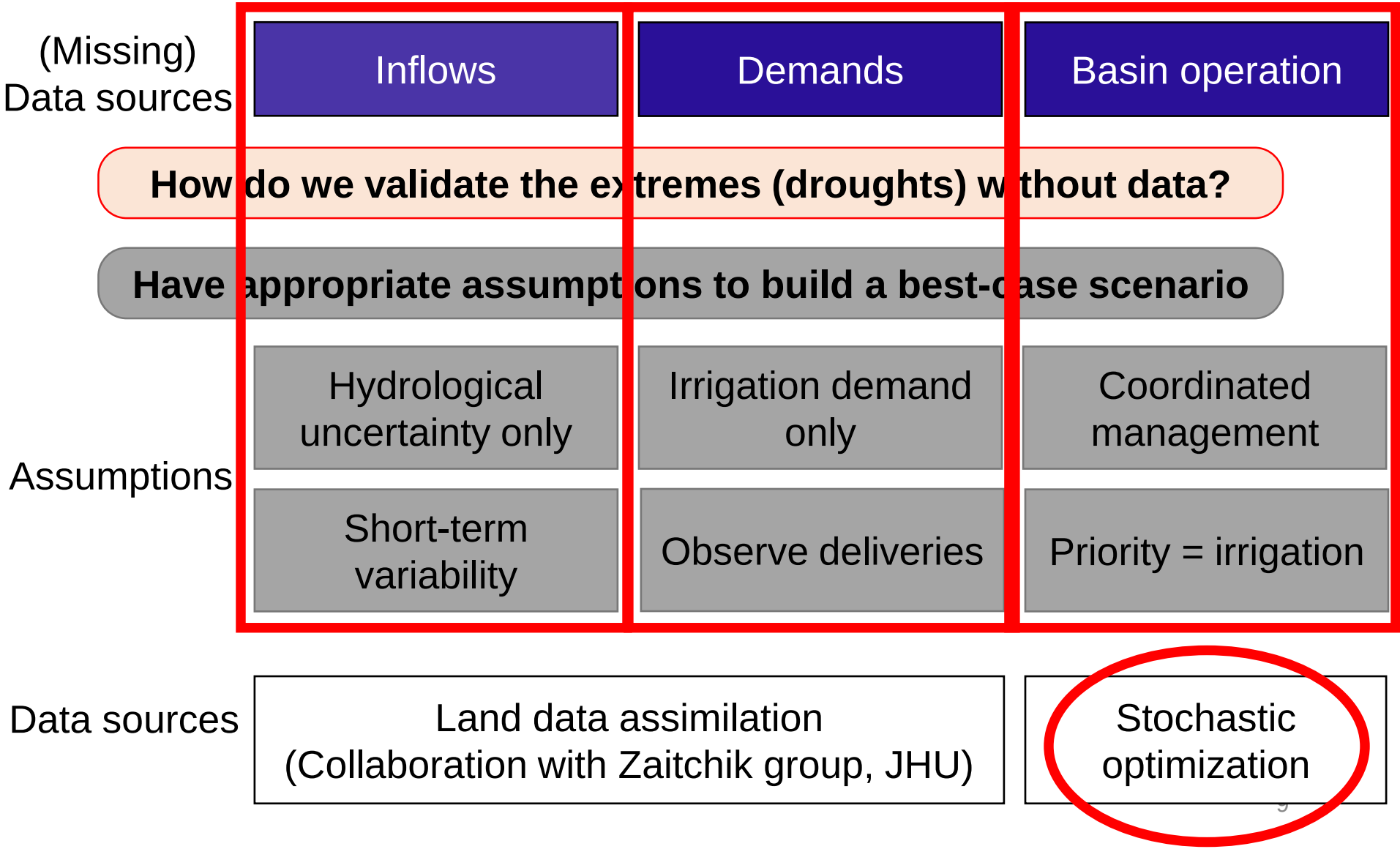
Uncoordinated development (+ conflict)
- **Limited data availability**



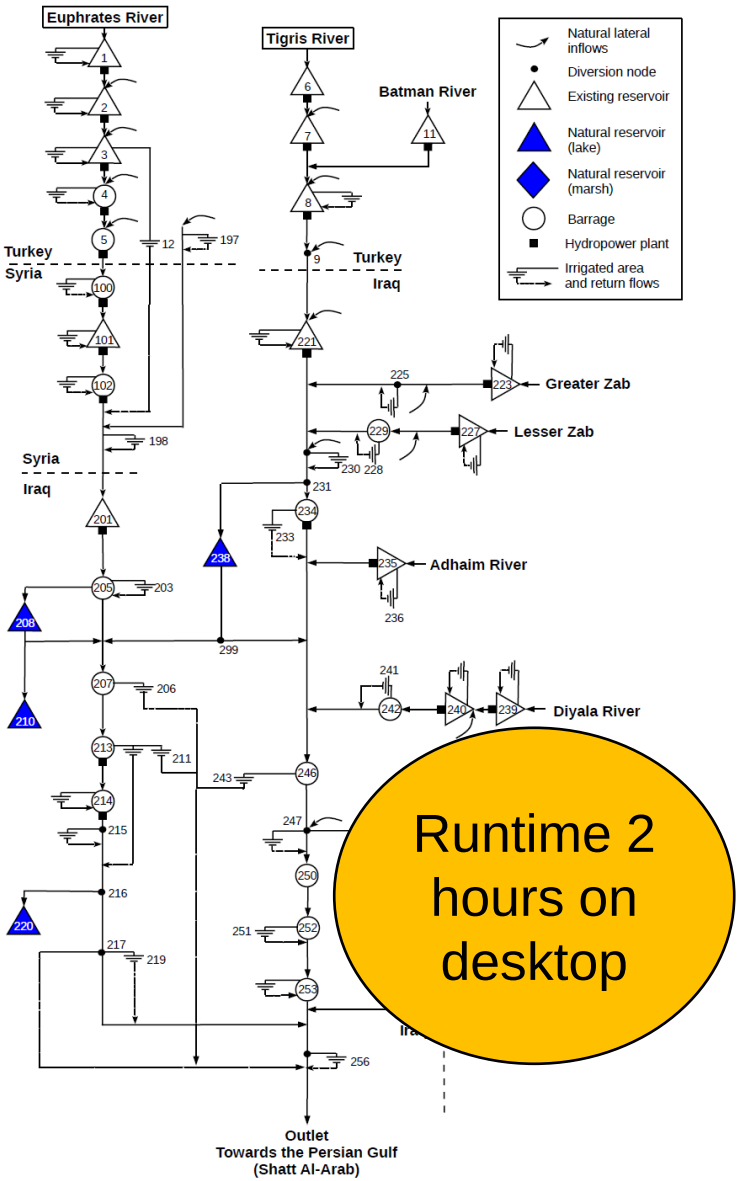
Monthly flow allocation

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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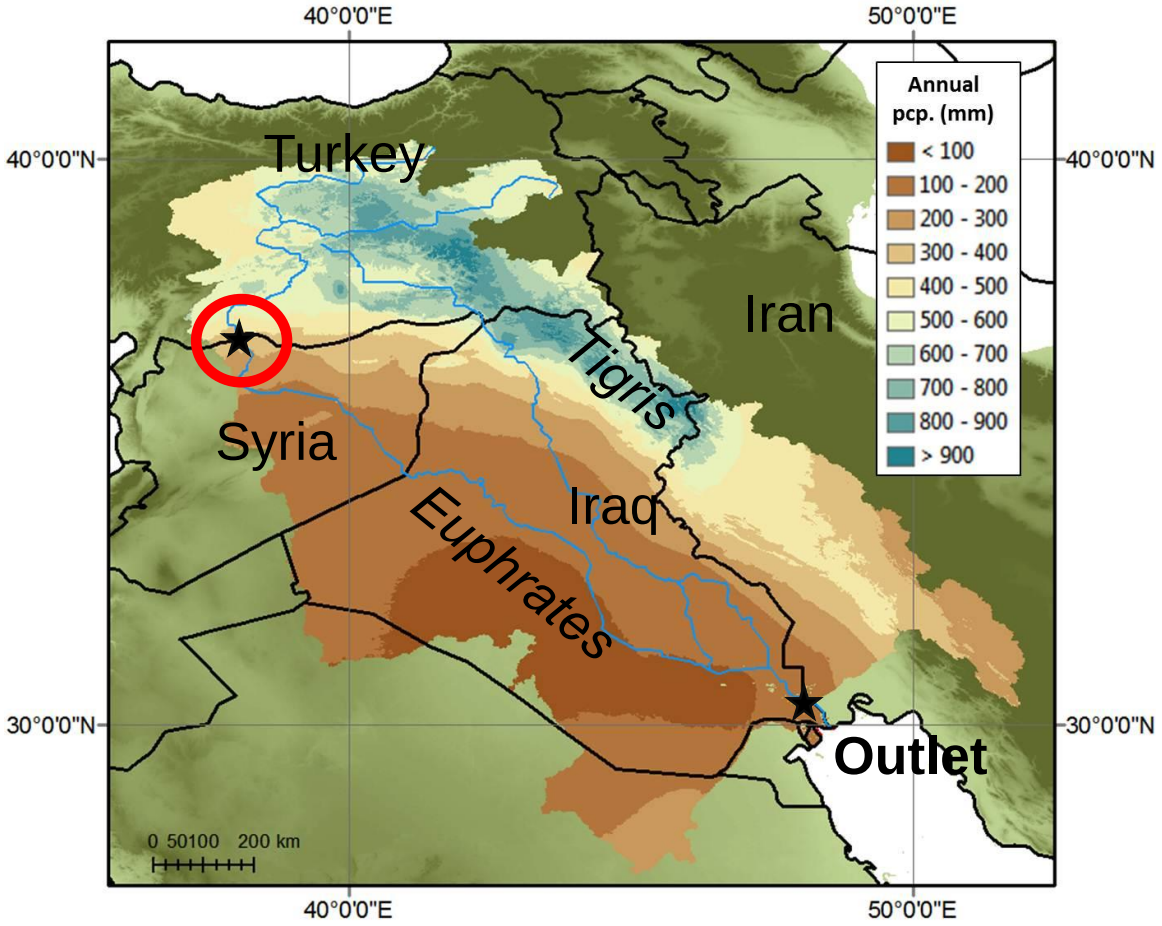
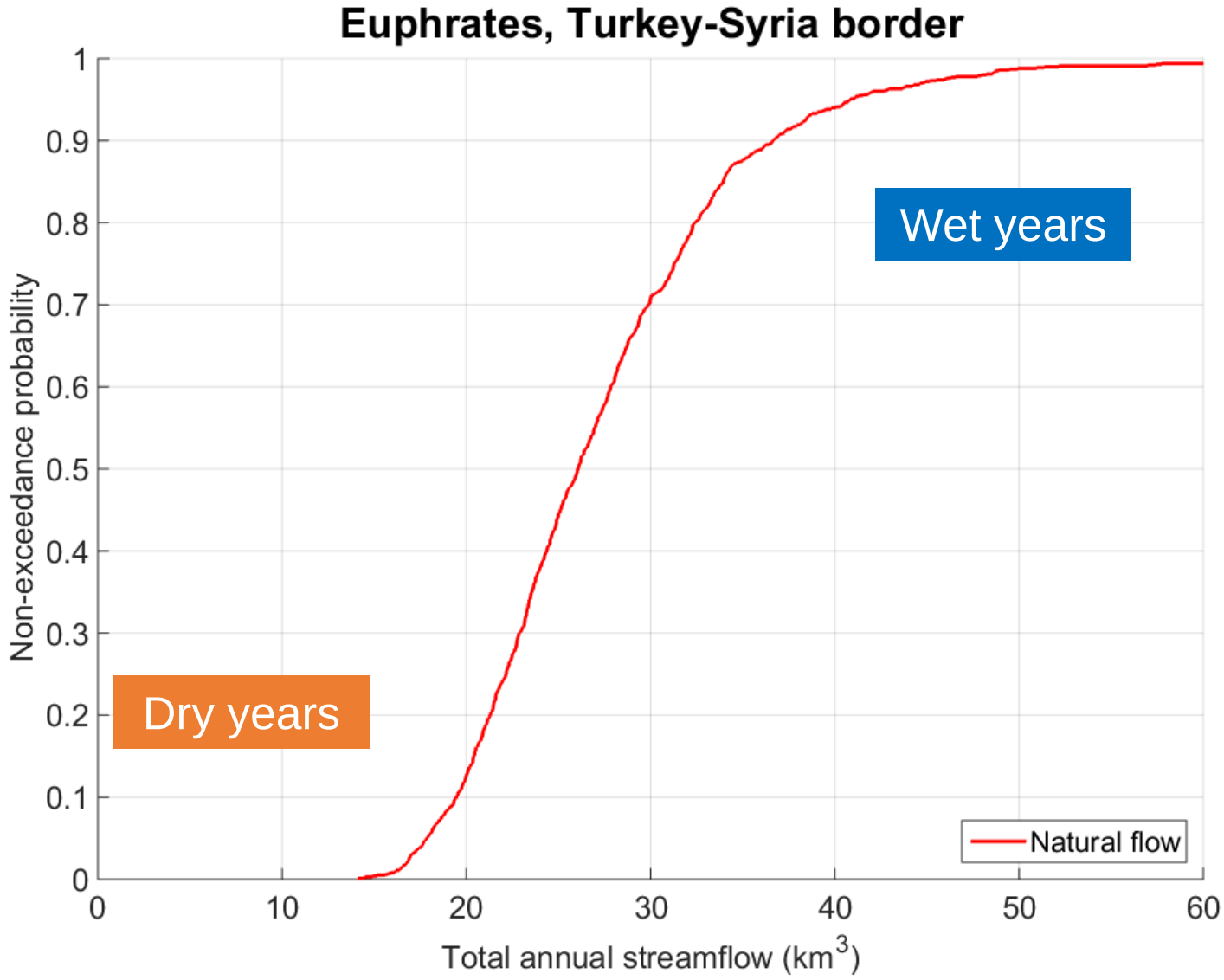
Results from 1,000 simulations

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

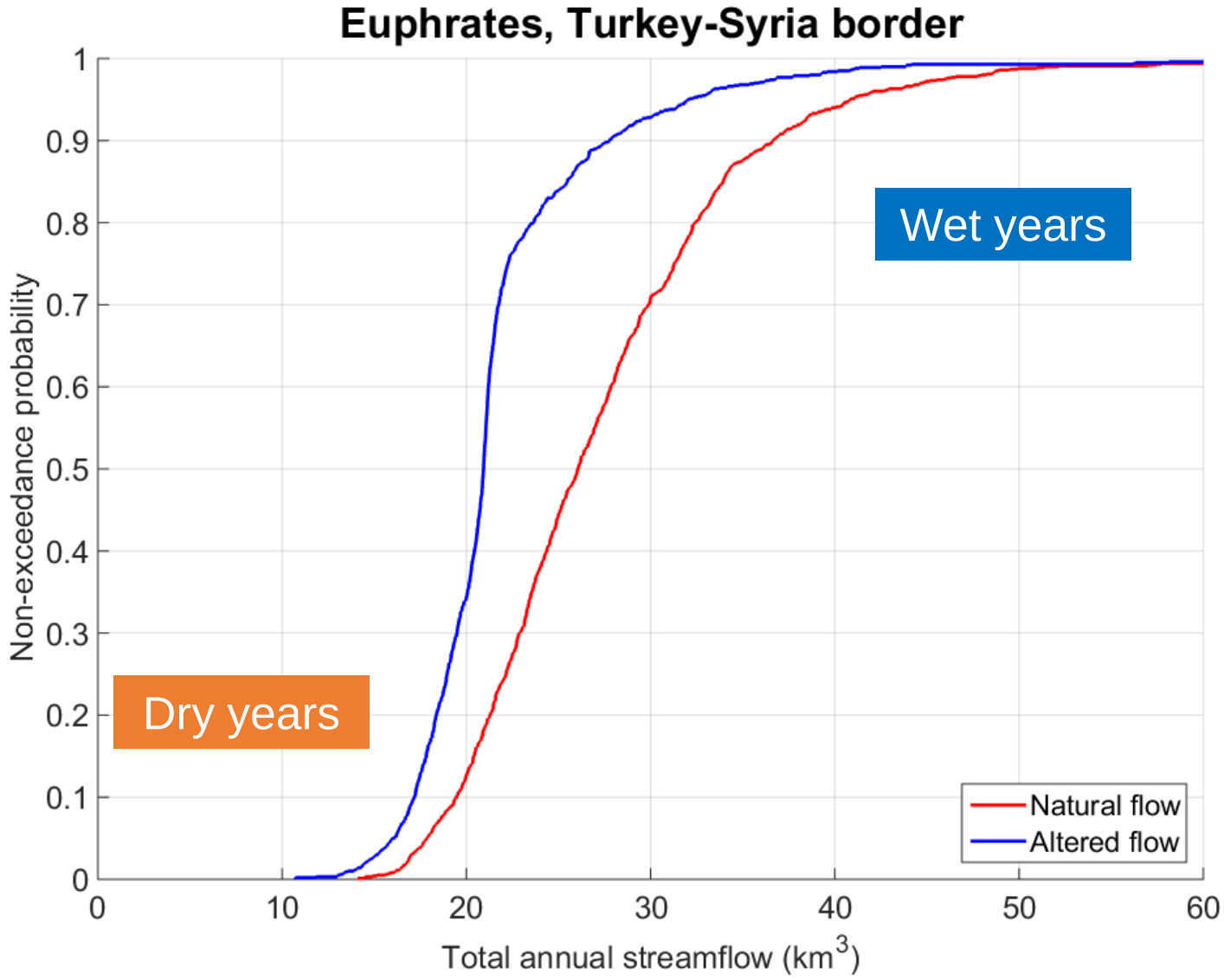
"Best-case" scenario: Reliability >99% for irrigation demand



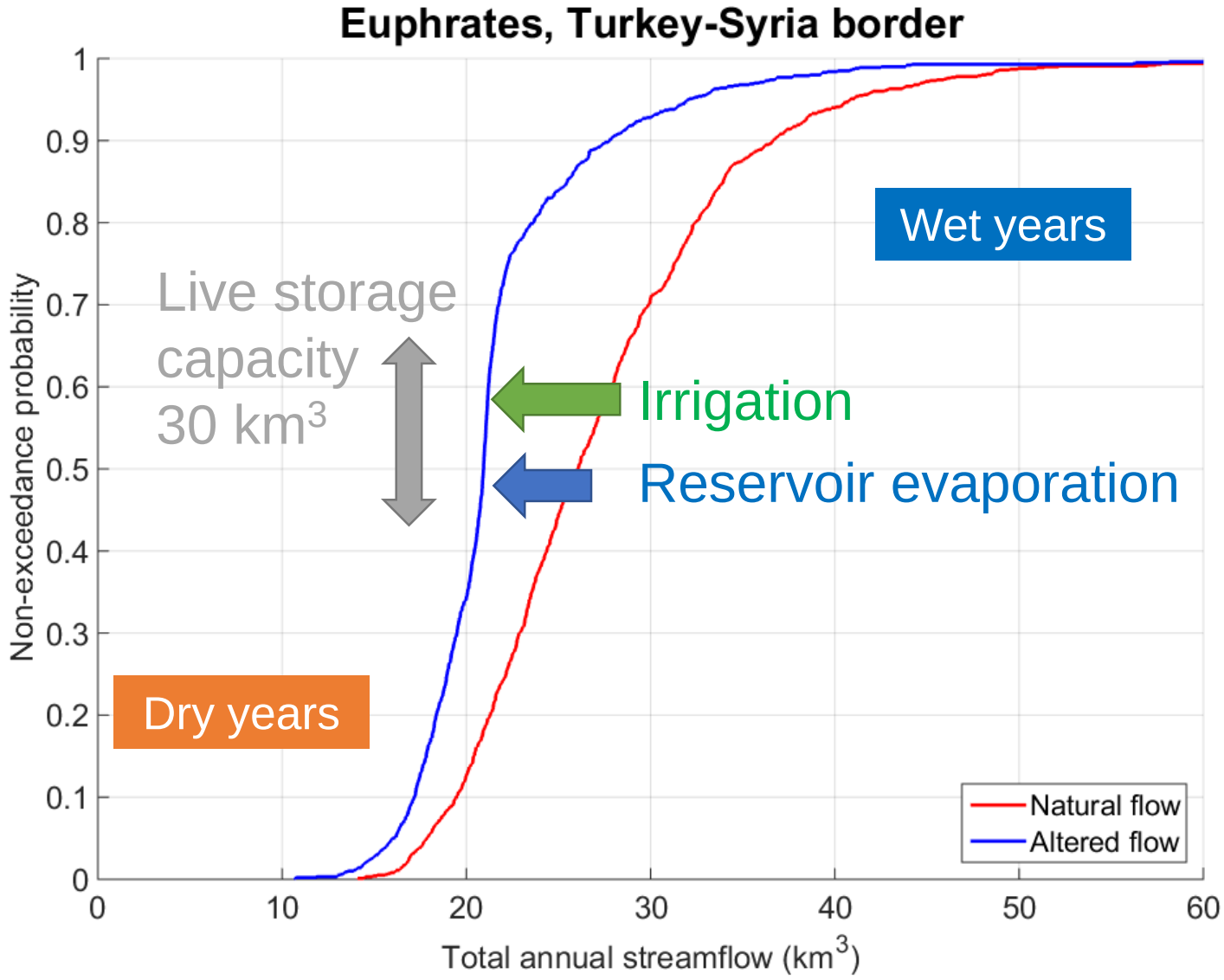
From natural flows…



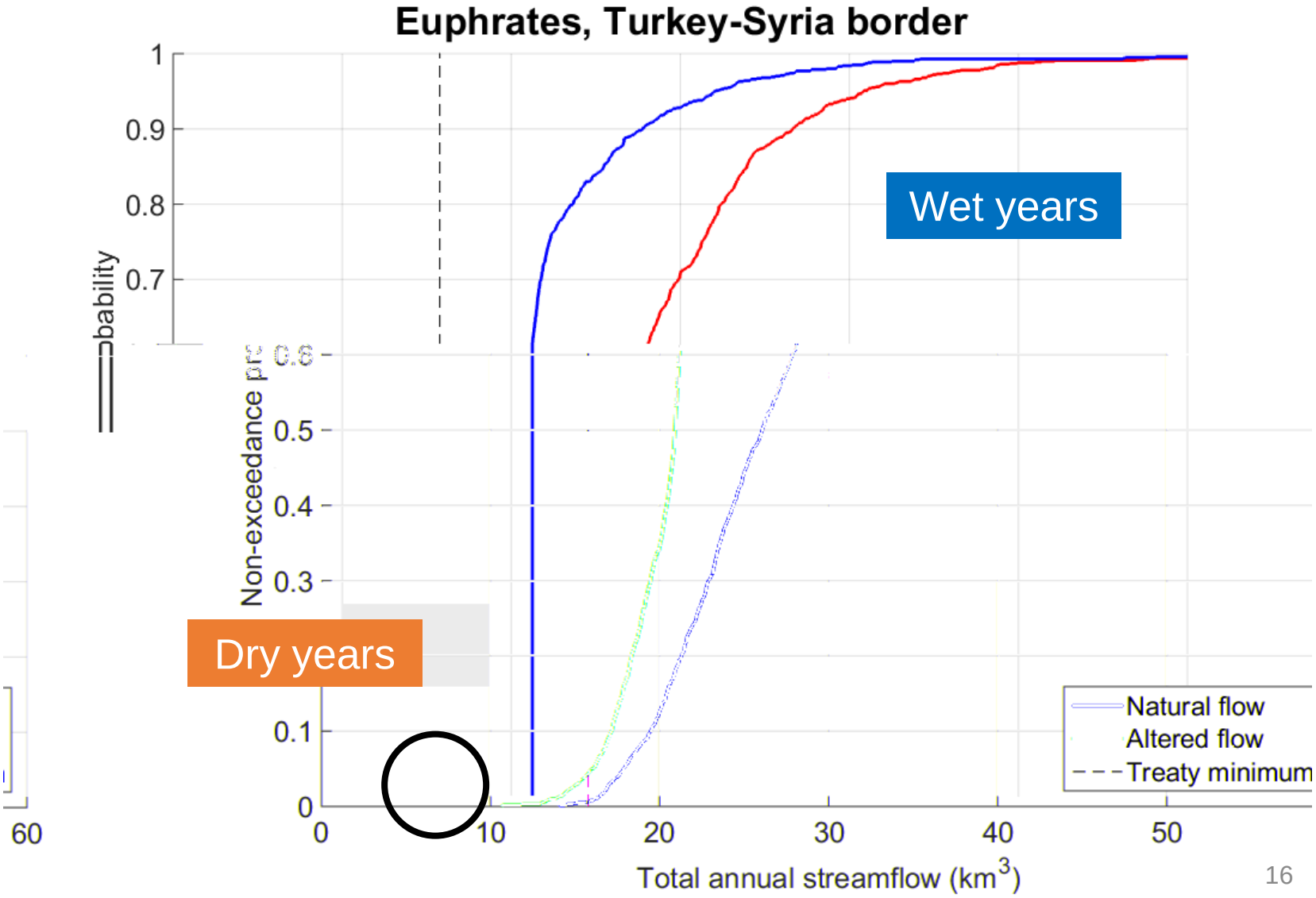
… to altered flows



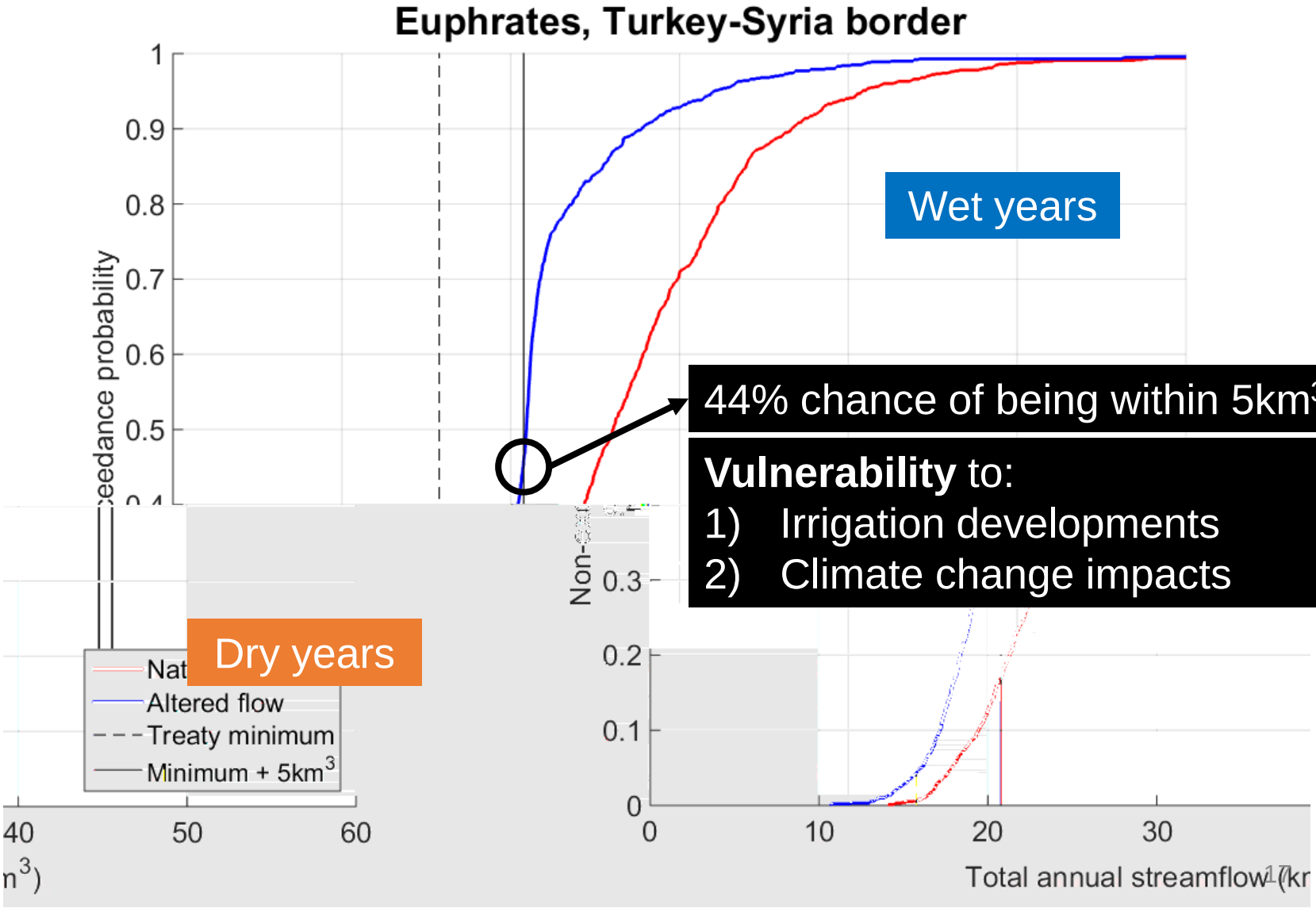
Infrastructure impacts on flow?



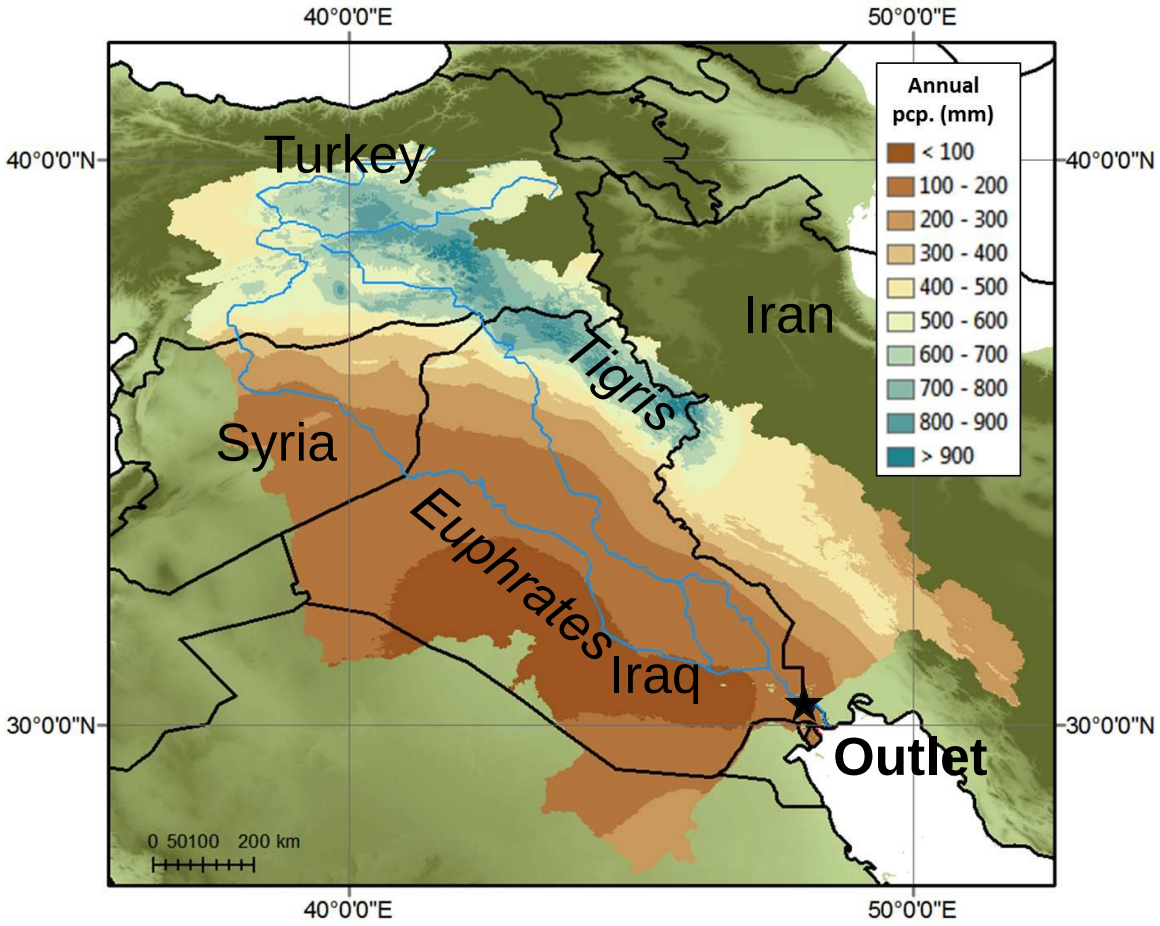
Respect of 1987 agreement?



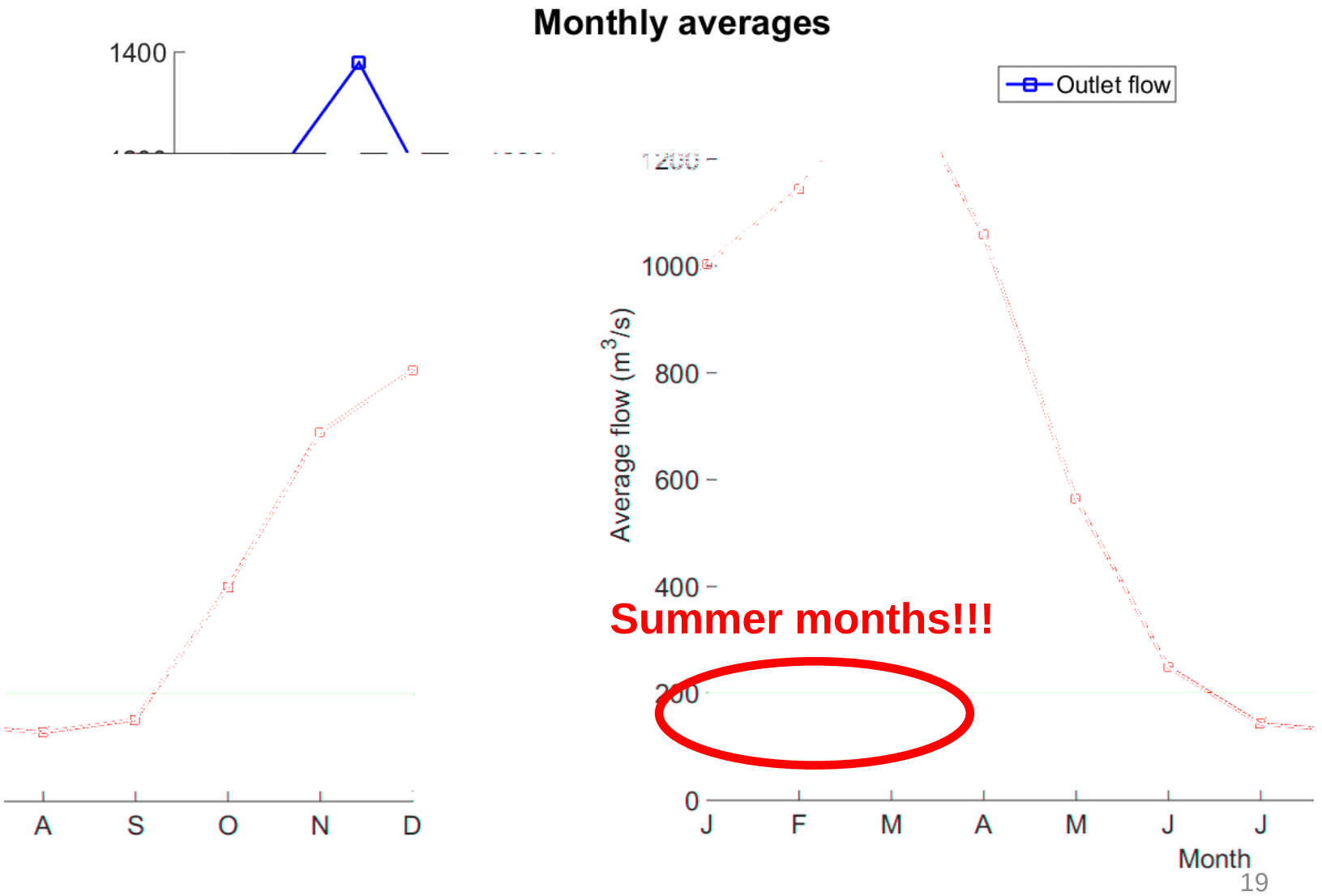
Vulnerability of treaty respect!



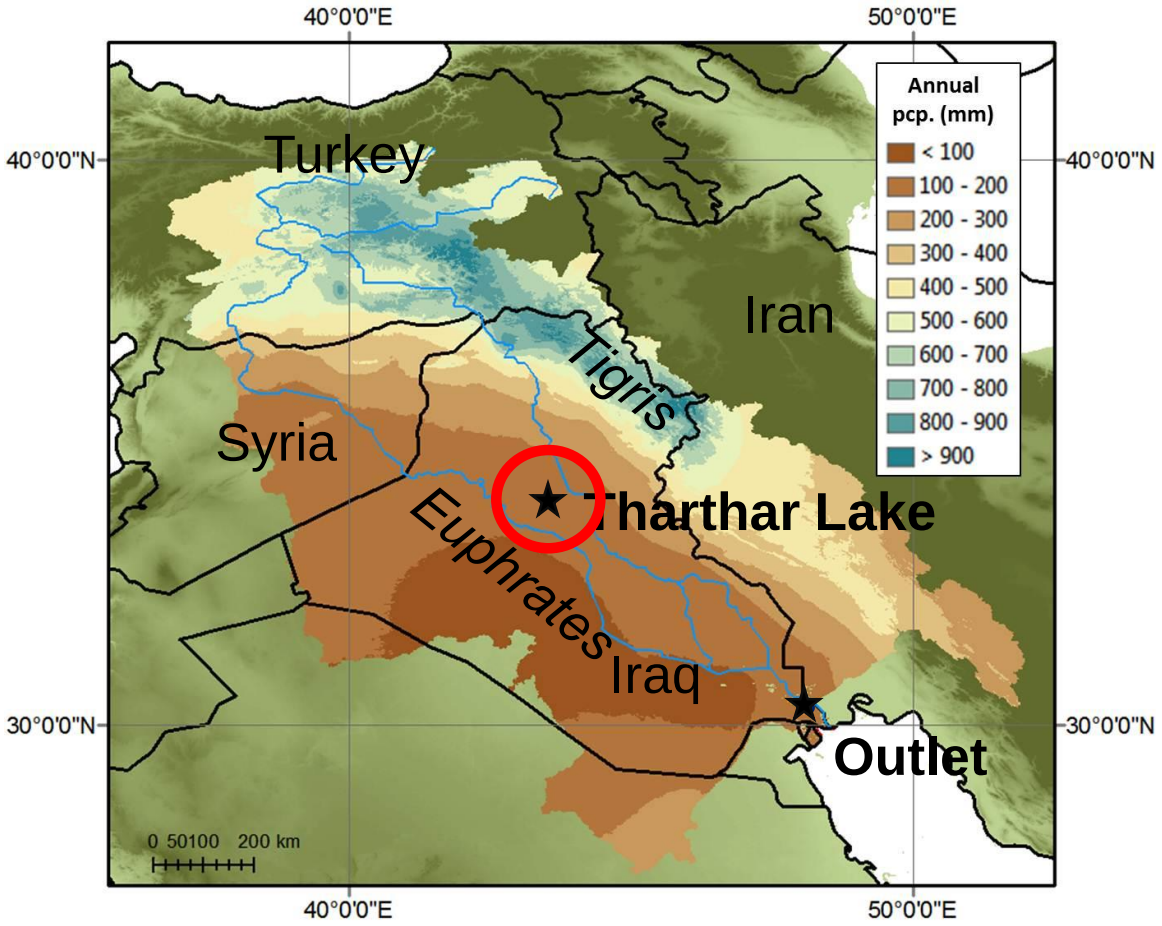
Outlet flows



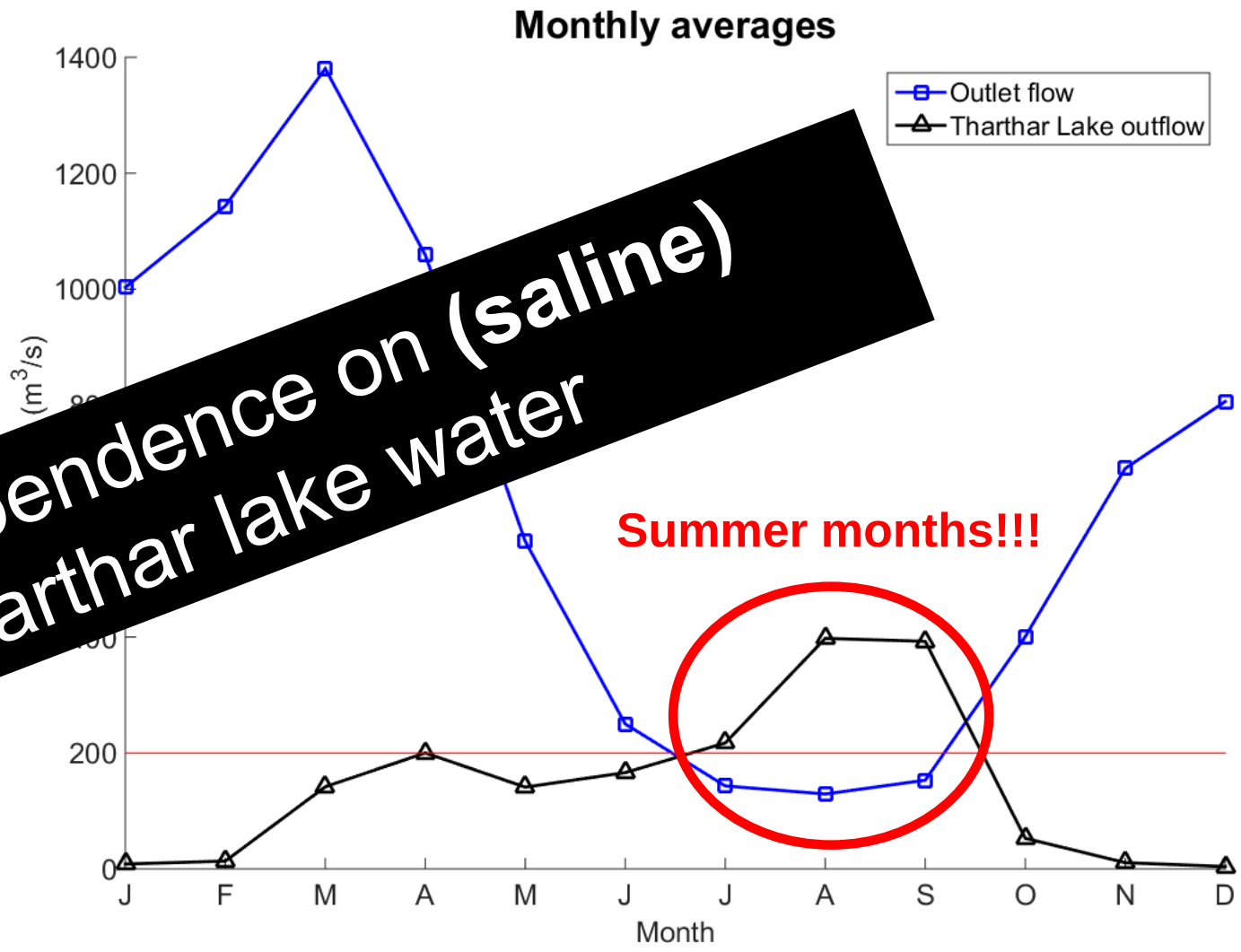
Outlet flows



A comparison



Outlet vs. Tharthar Lake flows



Dependence on (saline) Tharthar lake water

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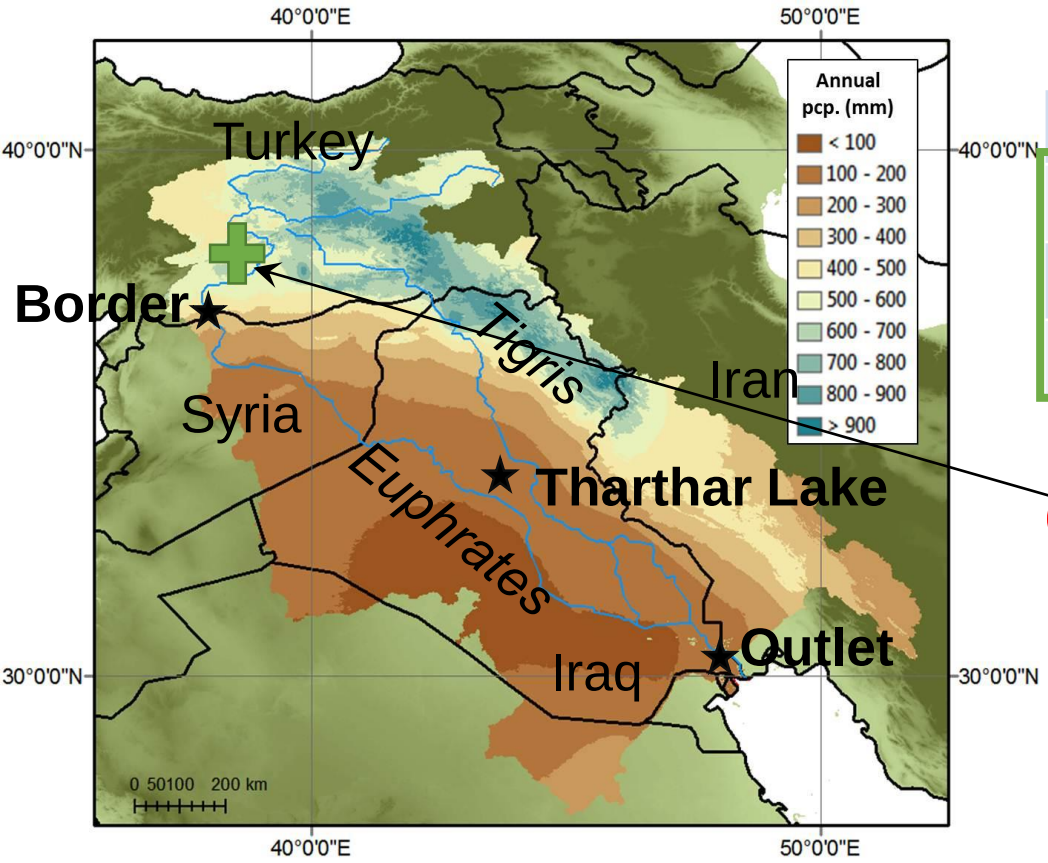
Key vulnerabilities & scenarios



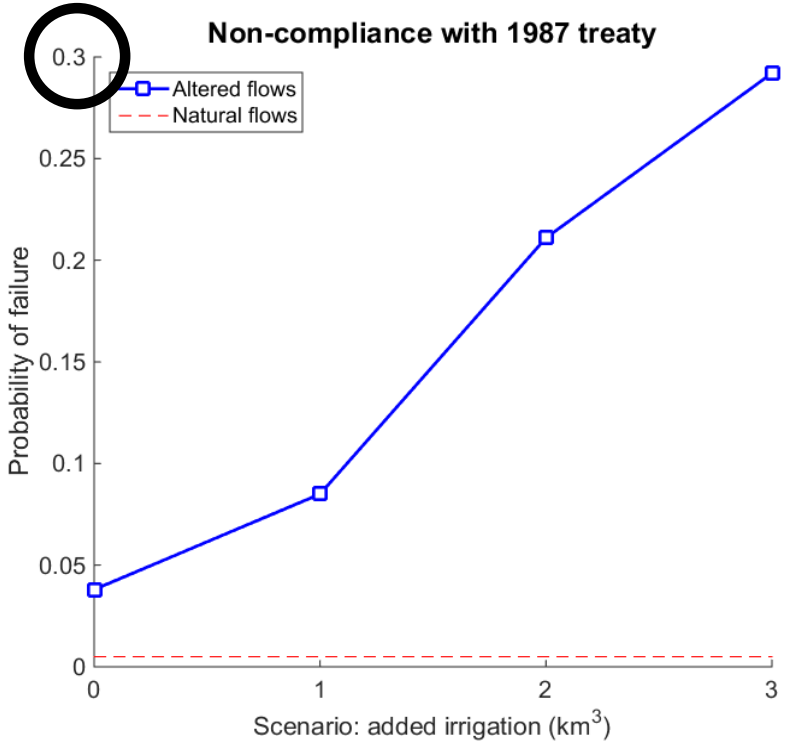
- Scenarios

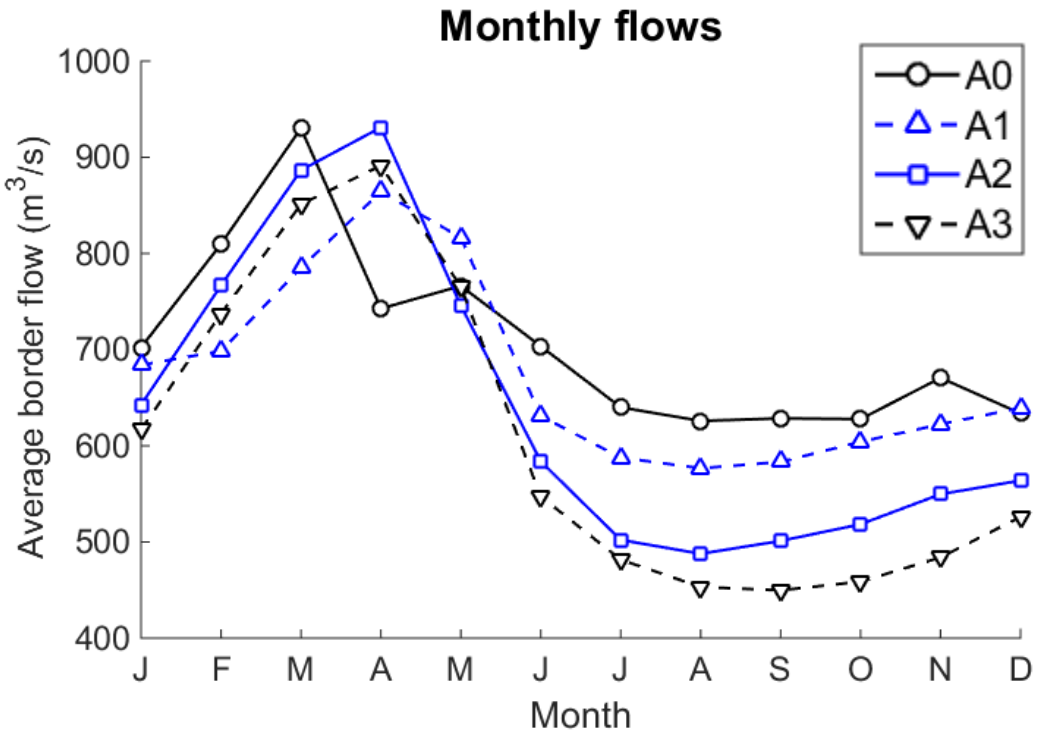
	Baseline network
Baseline irr.	A0
Irr. +1 km^3	A1
Irr. +2 km^3	A2
Irr. +3 km^3	A3

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

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

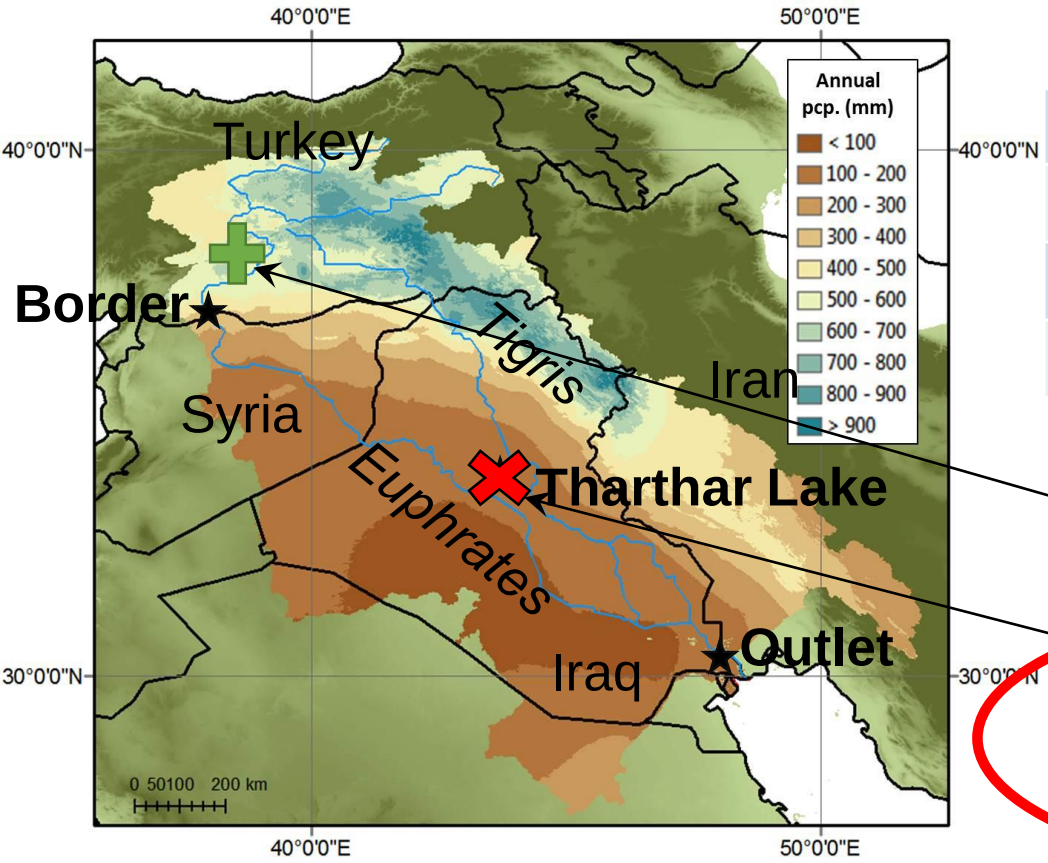
Scenarios A: Border flows





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

Key vulnerabilities & scenarios



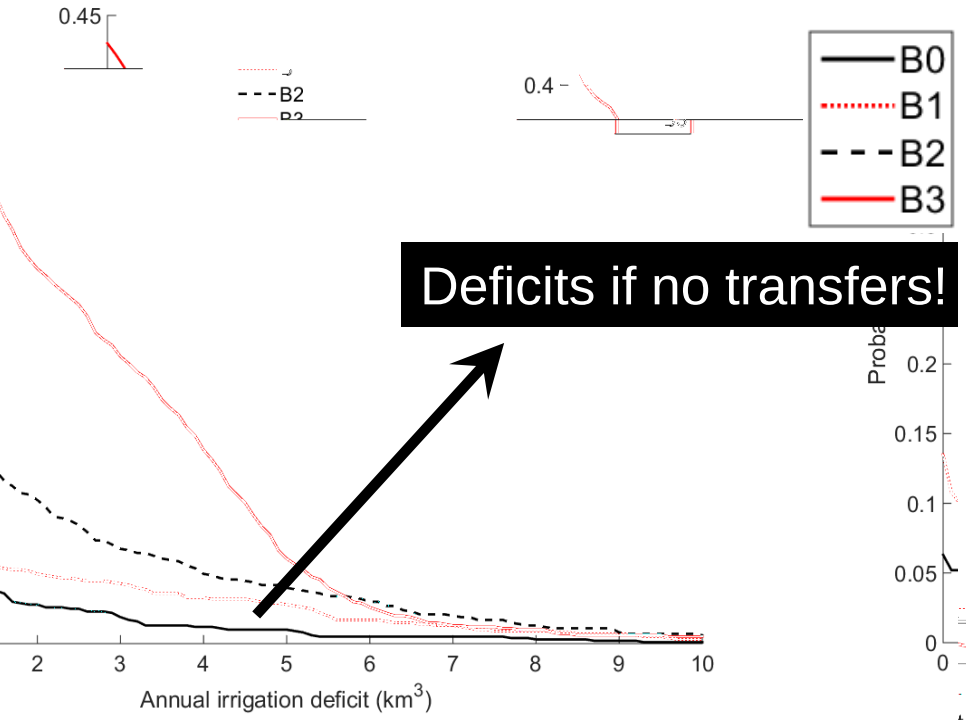
- Scenarios

	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

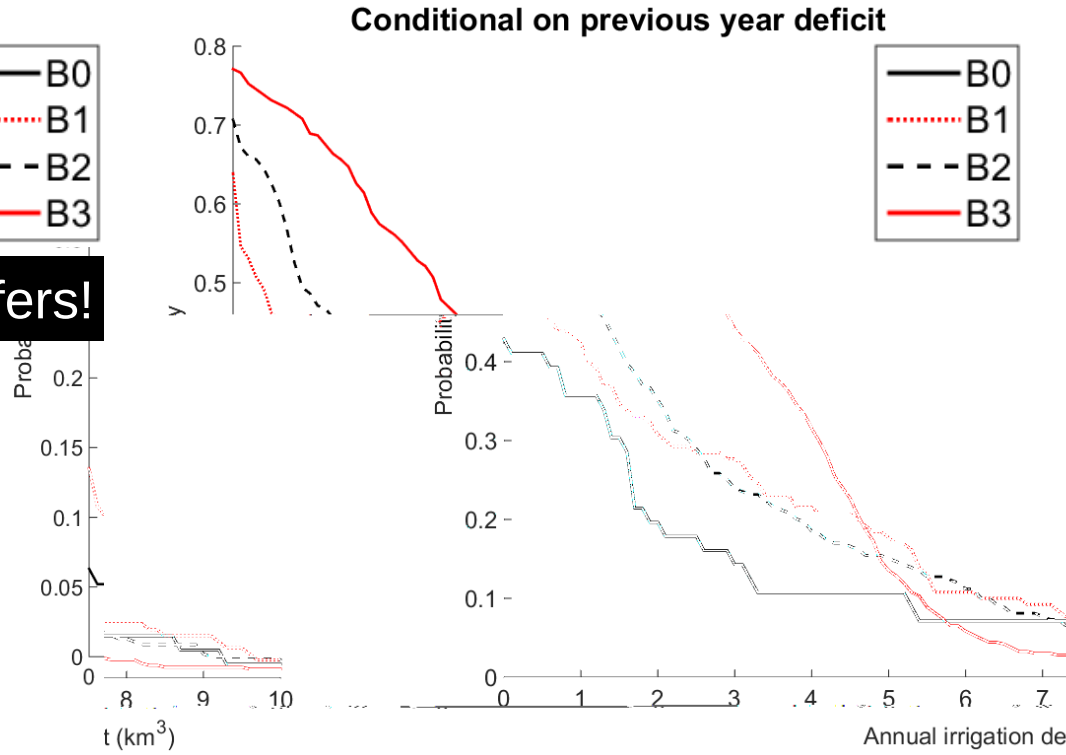
1) Vulnerability of border flows to supply-demand change?

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

Scenarios B: Euphrates irrigation

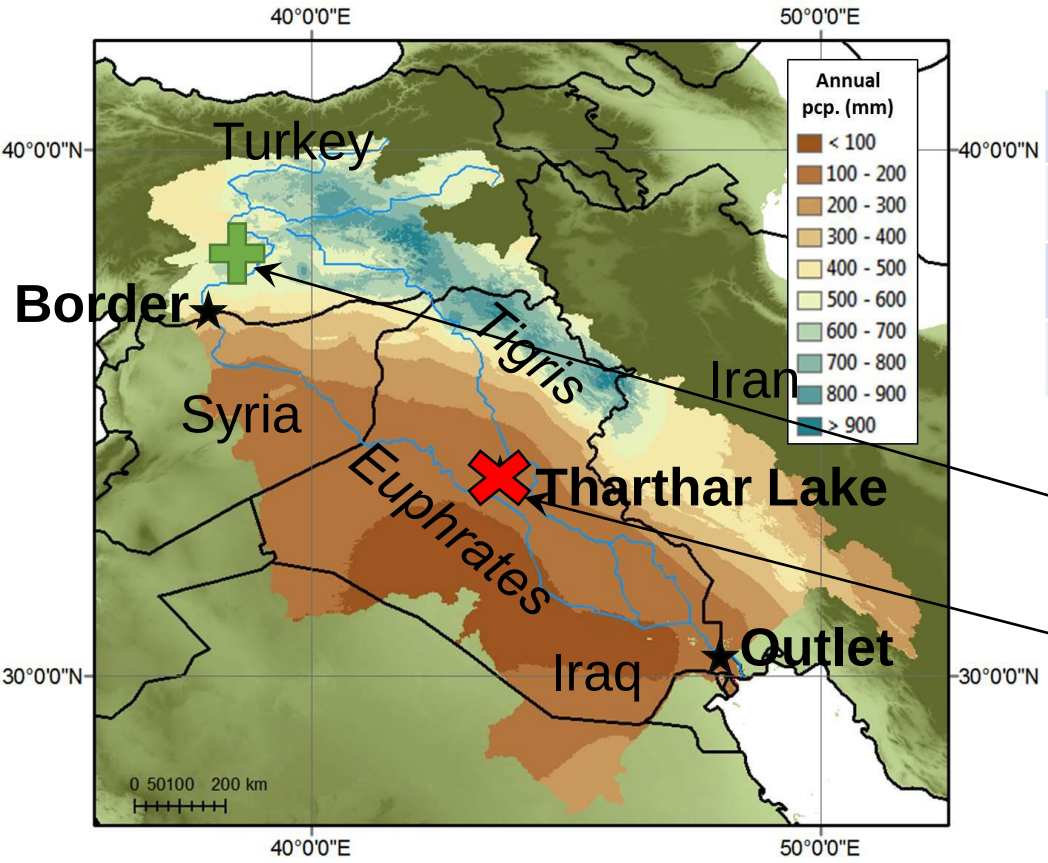


Deficits if no transfers!



Large storage capacity means risks are correlated over multiple years!

Key vulnerabilities & scenarios



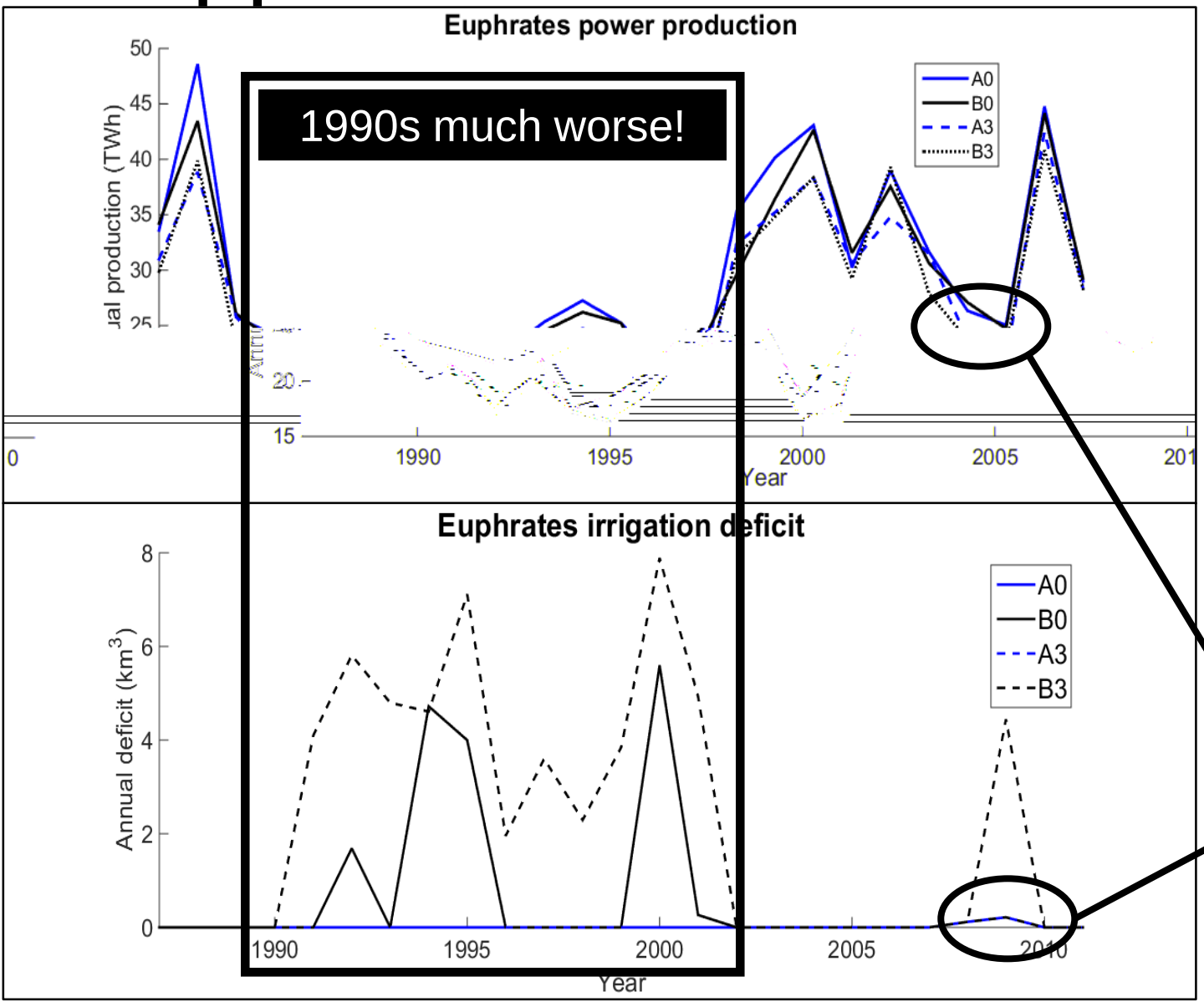
- Scenarios

	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?

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