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RISK BASED DETERMINATION OF SERVICE LEVELS FOR FRESH WATER SUPPLY IN THE NETHERLANDS

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Outline

- Background
- Methodology
- Example

Water shortage due to climate change

- Situation in The Netherlands
  - At downstream end of Rhine and Meuse
  - Highly dependent on rivers for water supply
  - Fresh water supply
    - for water level management, drinking water supply and irrigation
    - priorities from law-based 'Verdringingsreeks' (≈ water consumption hierarchy)
- Climate change
  - More frequent droughts expected
    - Lower water supply?
    - Impacts on fresh water supply?
  - Possible solution
    - Agreements on regional supply levels

Methodology

- Purpose
  - Knowledge of fresh water availability for users
    - which part of risk for authorities?
    - which risk / investment remains for users?
- Future
  - *What is extreme now, will be normal in the future*
  - Regional agreements on fresh water availability
    - under normal conditions and during dry periods
- Method
  - Study of water availability
    - only interesting when compared with demand
    - availability depends on local situation at intake
    - classification of intake locations
    - different climate scenarios

Available data

- Derived from nation-wide hydrological model (NHI)
  - Area of NL divided in 244 districts
  - State of the art coupled models
    - Groundwater
    - Unsaturated zone
    - Surface water
- Model results
  - Calculated on 10-day basis for 30-year period
    - Water demand of districts
    - River discharges in network

Intake locations

- Availabilty of fresh water depends on local situation at intake
  - 5 types of locations distinguished in system
    - **A** → supply from main water system of NL
    - **B** → supply from main water system **+** storage downstream (but not available upstream)
    - **C** → supply from main water system **+** storage upstream (and available downstream)
    - **D** → supply from main water system **+** limitations due to Cl concentration
    - **E** → supply from main water system **+** limitations due to Cl concentration **+** alternative intake available

Climate scenarios

- Impact of climate change on water shortages
  - 4 Delta scenarios for NL compared with base line
    - **G 2050** → moderate, target year 2050
    - **G 2100** → moderate, target year 2100
    - **W+ 2050** → warm, target year 2050
    - **W+ 2100** → warm, target year 2100

Calculation method

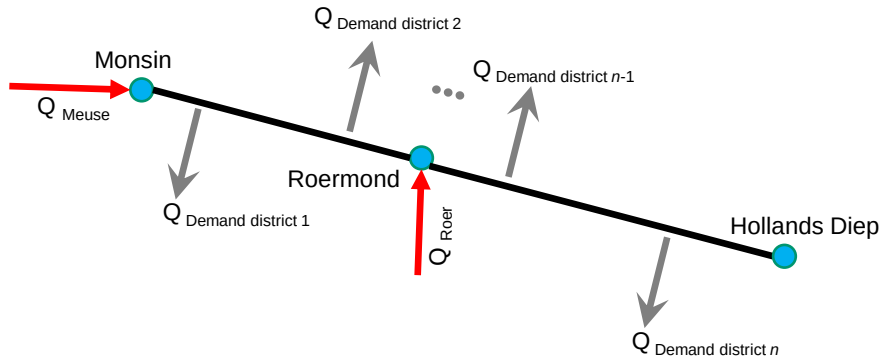
- Significant correlation of water demand and discharge
  - Joint distribution function used
    - Bivariate normal distribution
- Water demand and discharge not Gaussian distributed
  - Transformation of data needed
    - Box-Cox transformation
- Preferably estimation of probability of exceedance
  - Discharge deficit used
    - instead of actual discharge

Calculation method (2)

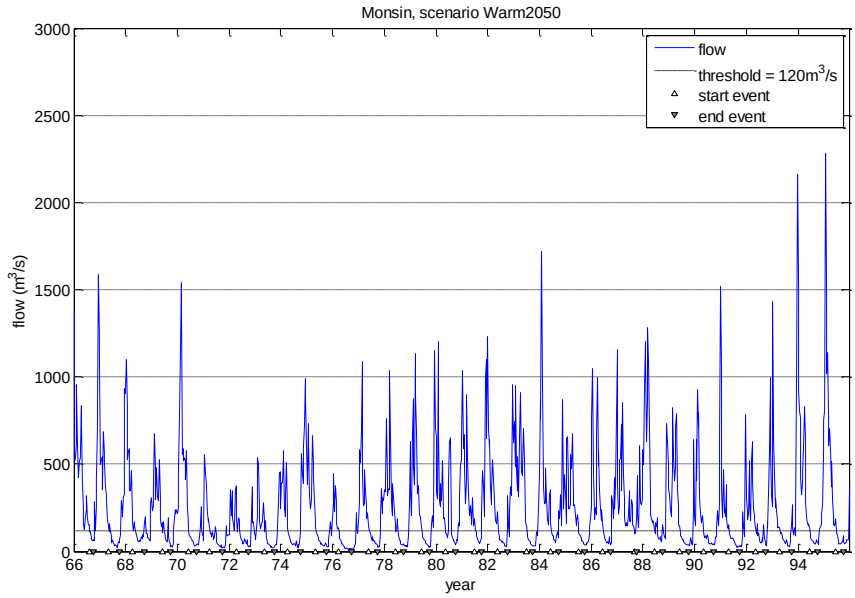
- Parameters of Bivariate normal distribution
  - Estimation method
    - maximum likelihood
  - Data censored at threshold above zero
    - to avoid impact of very small values
  - Expectation maximization algorithm
    - because of censoring of data above threshold

- Return period of water shortages
  - Based on failure region
    - estimated using Monte Carlo simulation
  - Sensitivity analysis
    - maximum demand + average deficit
    - maximum demand + maximum deficit

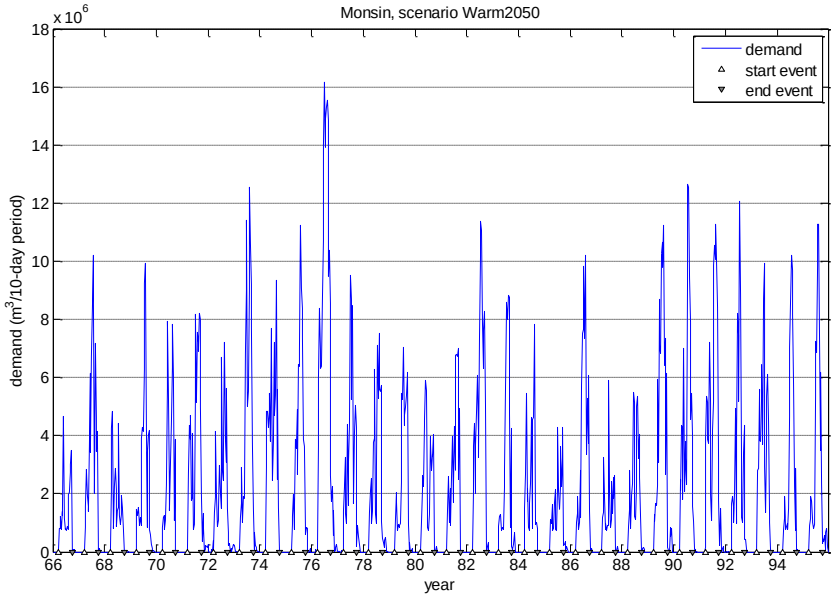
Location´Monsin´ = type A

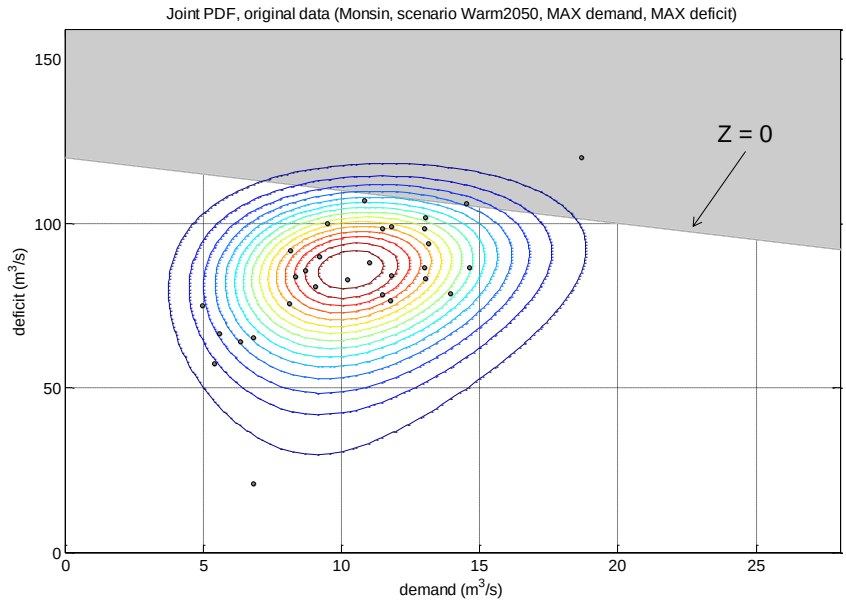


River discharge



Water demand





Return period of water shortage

scenario	demand	deficit	return period
reference	maximum	average	> 1,000
	maximum	maximum	50
G 2050	maximum	average	> 1,000
	maximum	maximum	55
G 2100	maximum	average	> 1,000
	maximum	maximum	60
W+ 2050	maximum	average	> 1,000
	maximum	maximum	20
W+ 2100	maximum	average	> 1,000
	maximum	maximum	5

Key findings

- Availability of fresh water depends on local situation
  - to account for local situation 5 types of intake locations defined
- Discussion of calculation results
  - maximum demand combined with average deficit not in accordance with experience of farmers
  - maximum demand combined with maximum deficit might overestimate probability of water shortage
- Limitations due to available data
  - room for improvement if other data would be available
- Future development of methodology
  - improve calculation method in terms of statistics, and calculation of supply and demand

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