A Framework of Multi-objective Optimization for Monthly Water Resources Allocation from Multiple Supply Sources

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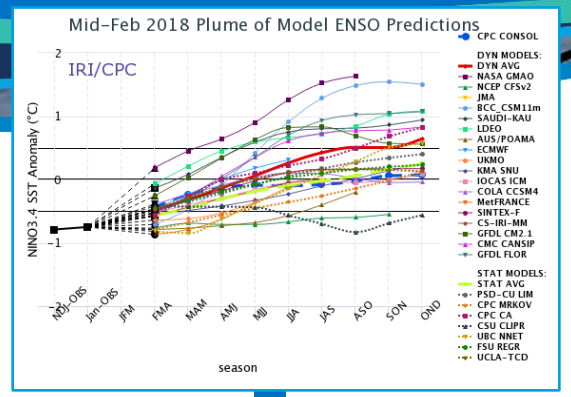
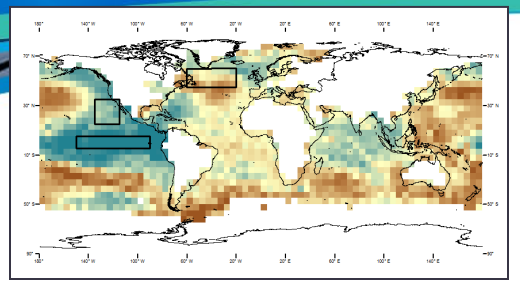
Multi-time Step Decision Process

- Long-term water master planning (10-20 years)
- Annual (1 to 5 years), budgeting and member government rate advice
- Seasonal source allocation
  - Source allocation, seasonal outlook
  - Agency wide cross functional team
- Weekly Operational Decision Support
  - Optimized Regional Operations Plan (OROP): optimizes wellfield pumpage to maximize environmental value
  - Weekly coordination among departments of the agency

Tampa Bay Water Models: Seasonal Flow Outlook



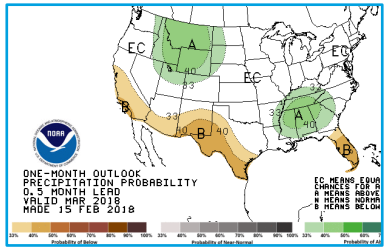


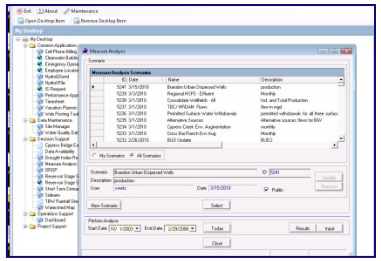
Climate Outlook & Observation

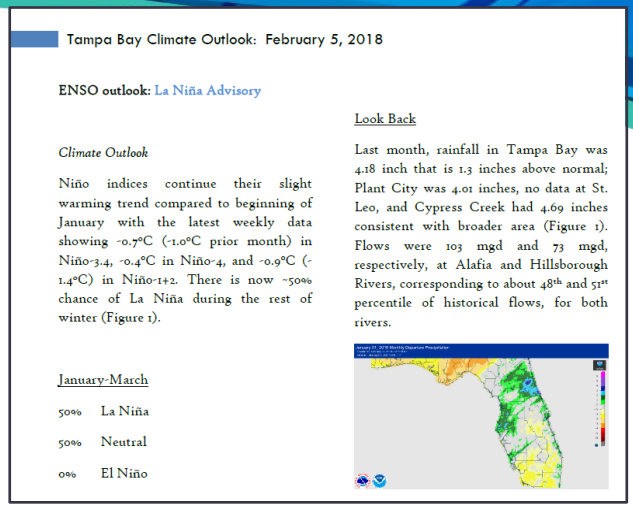
Contingency Table

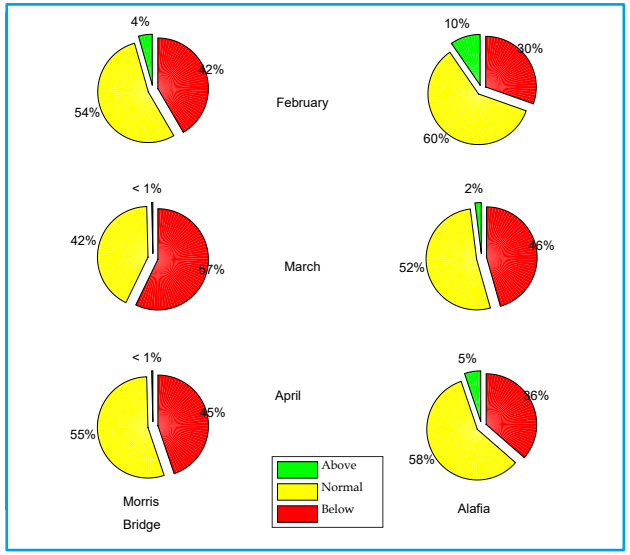
Weather-based Rainfall Model

Rainfall/Runoff Model



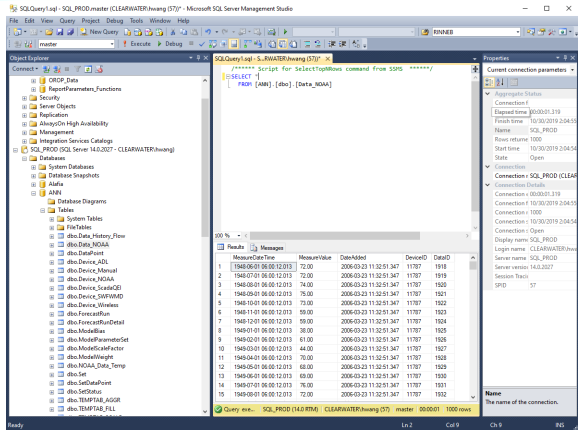




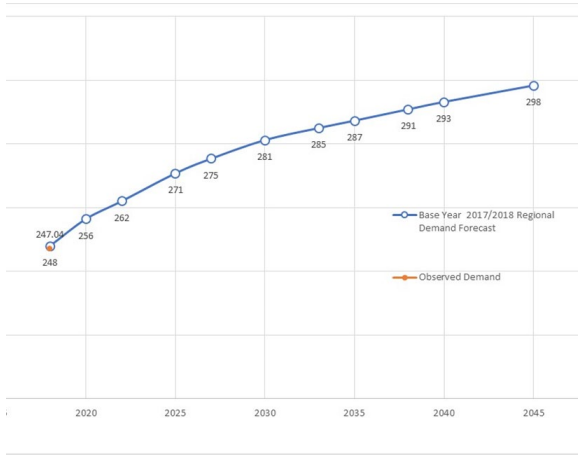


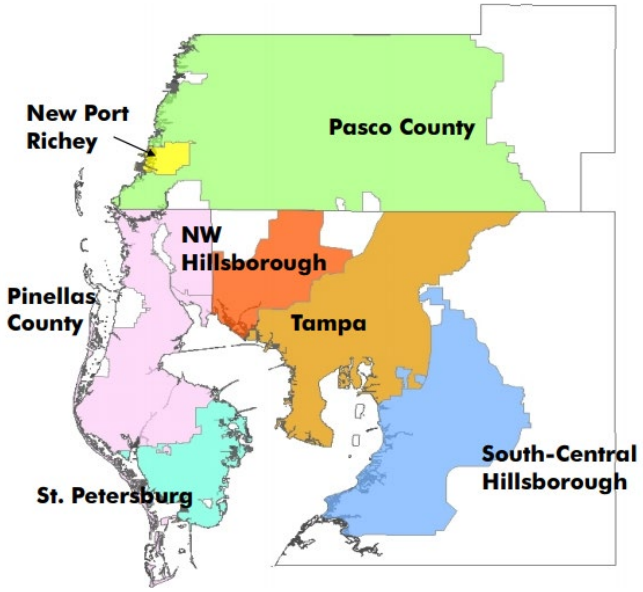
Tampa Bay Water Models: Seasonal Demand Forecasts

Weather observations & Forecasts

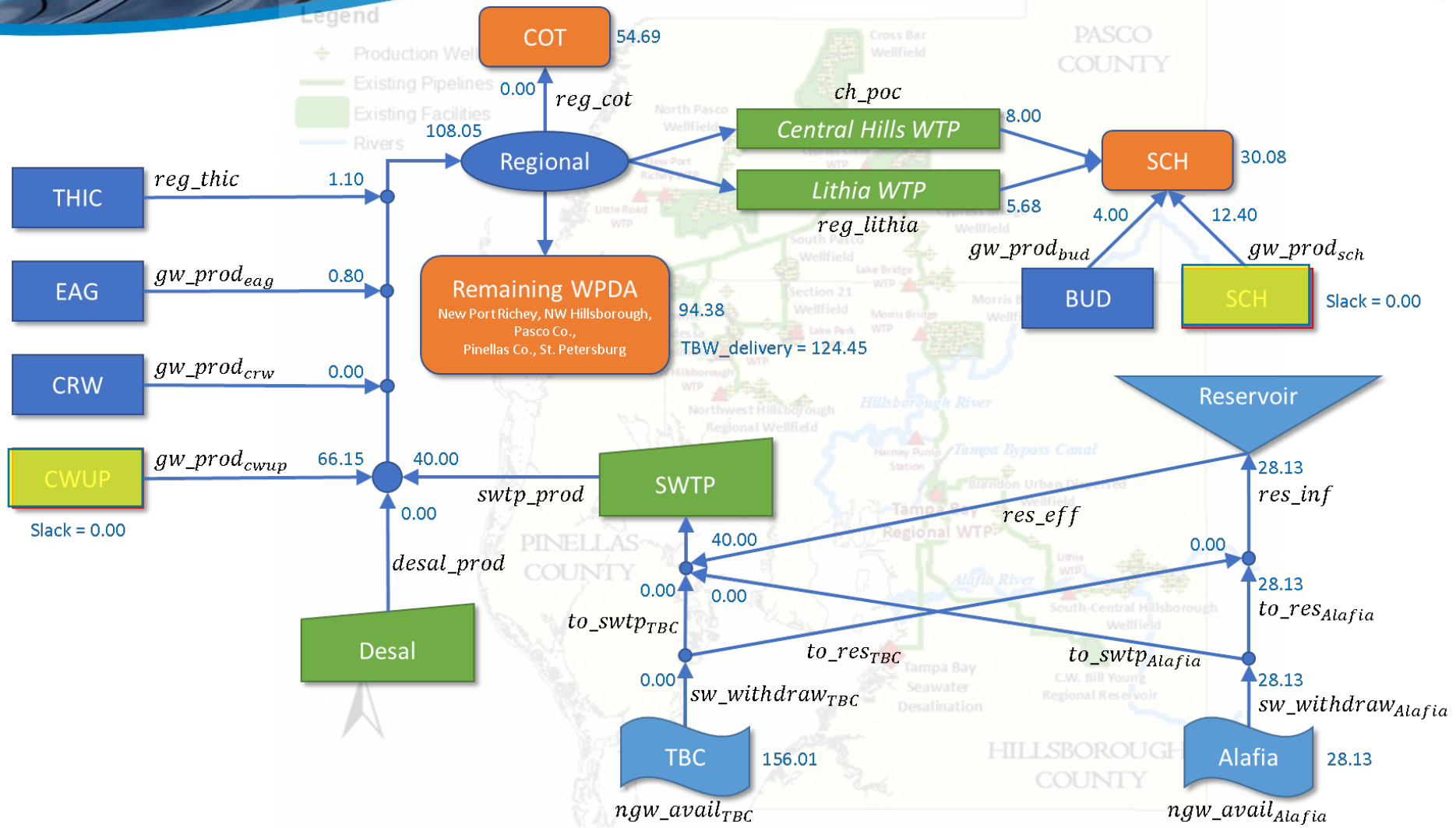


Long-term demand projections (social-economic factor)





Simplified TBW water supply system



Input and output of the Model

Streamflow projections

Regional demand projections

Monthly water production from different supply sources

MOEA-assisted Seasonal Allocation: Retrospective analysis

Objectives of the Seasonal Allocation Model

Minimize:

- deviation from annual budget (in mgd)
- total cost of water production (in relative monetary values)
- Under-Utilization of groundwater use
- Over-Utilization of groundwater use

Examples of Operating Constraints:

- Keep reservoir storage full at the end of water year
- surface water treatment operation efficiency

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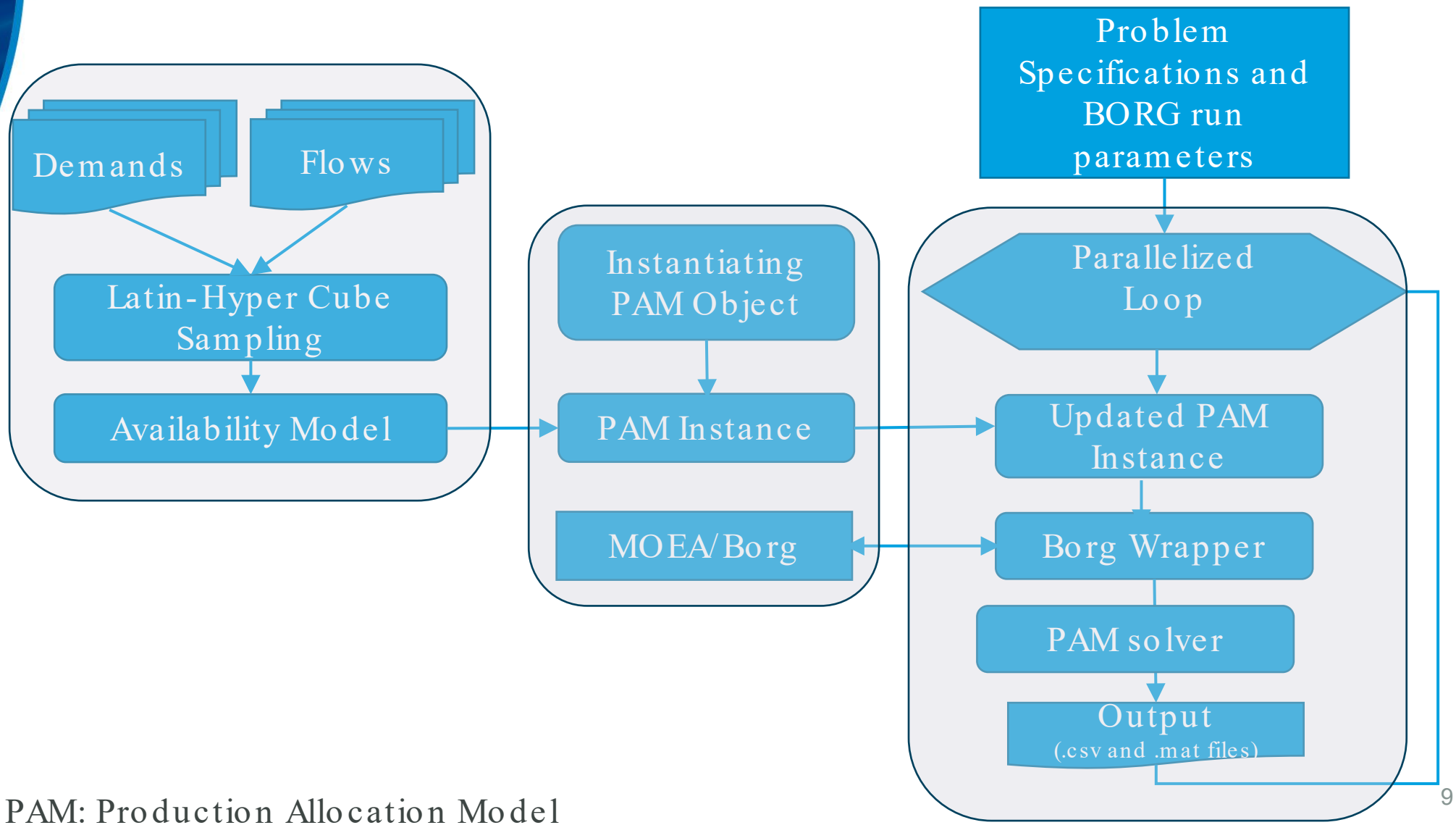
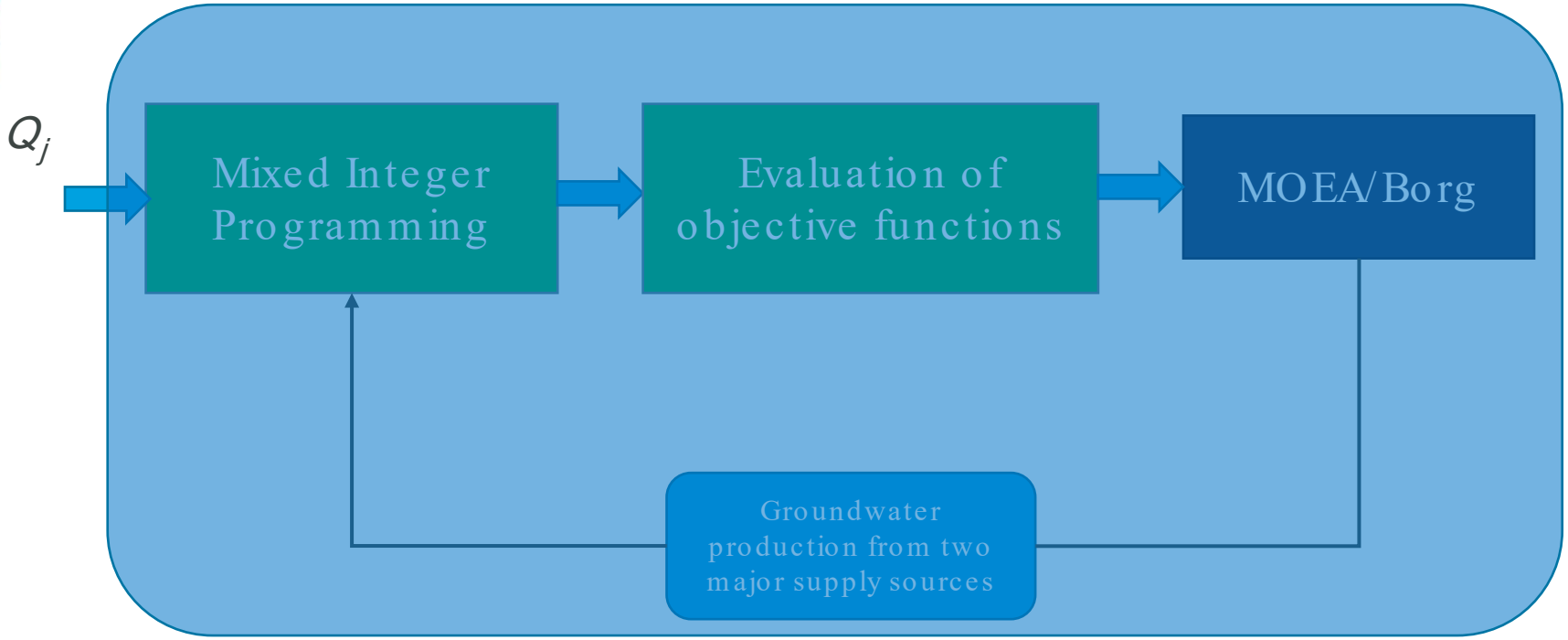
Configuration of the model: Framework



PAM: Production Allocation Model

Configuration of the model: Interaction between PAM and BORG



PAM fixed variables – MOEA/Borg decision variables (groundwater production from two major supply sources)

PAM decision variables – allocation from other sources

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Setup PAM in AMPL as Simulation

- PAM problem – 24-month source allocation to satisfy monthly demands for a given water availability (to be withdrawn from TBC and Alafia river)
- PAM objective as optimizing preferential operation via penalty functions
- PAM constraints – operating rules, facility capacity, water distribution balance, etc.
- PAM equality constraints – evaluation of multi-objectives for MOEA/Borg

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Retrospective analysis using MOEA

- Water year 2017 with an extreme dry spring
- Retrospective forecast of demand and flow at beginning of each month
- Define data set by "RunDate" for each month
- Interim criteria to select one Pareto solution per realization

Overarching question: For each month in WY2017, how much improvement in source allocation if MOEA was used?

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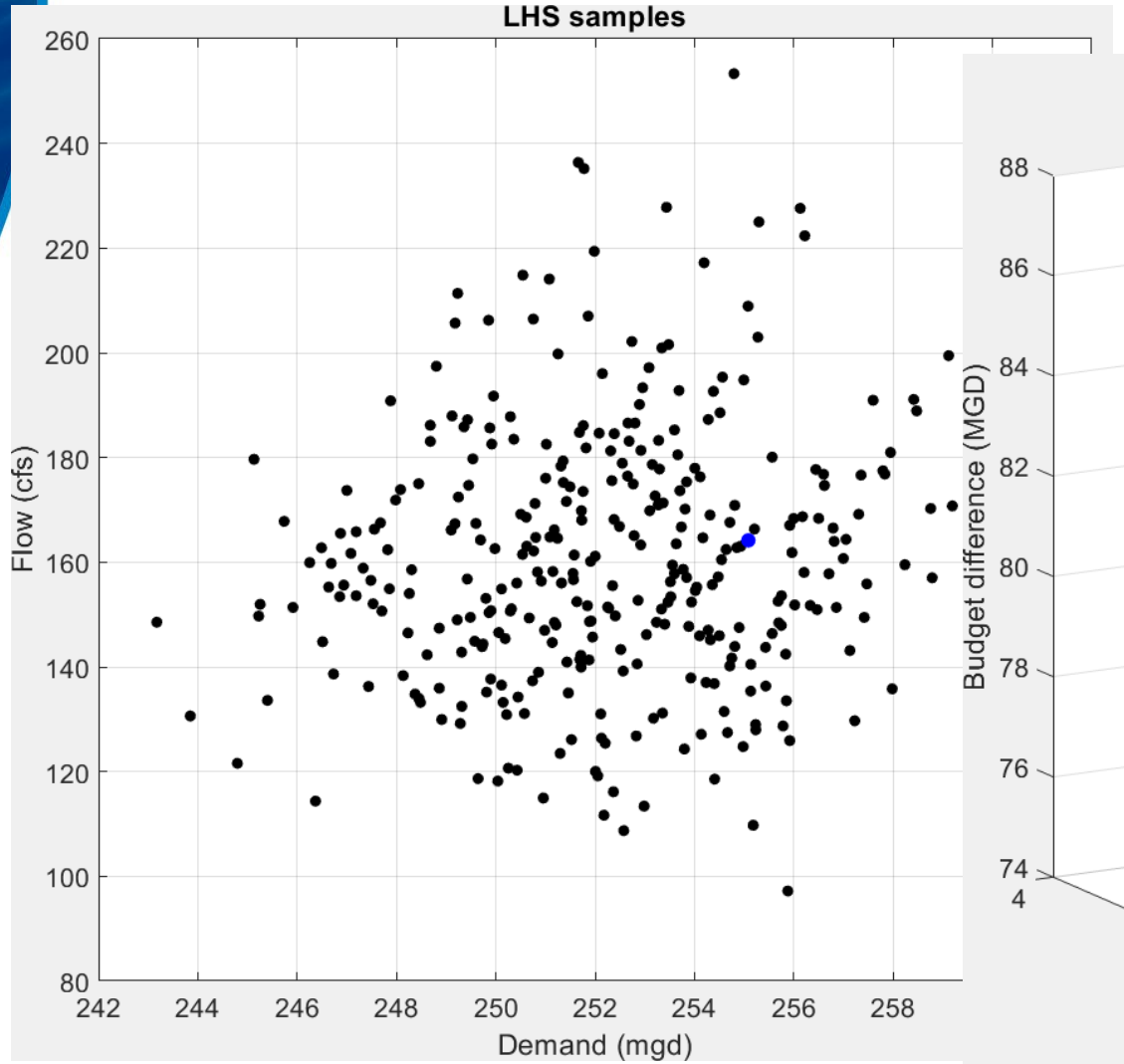
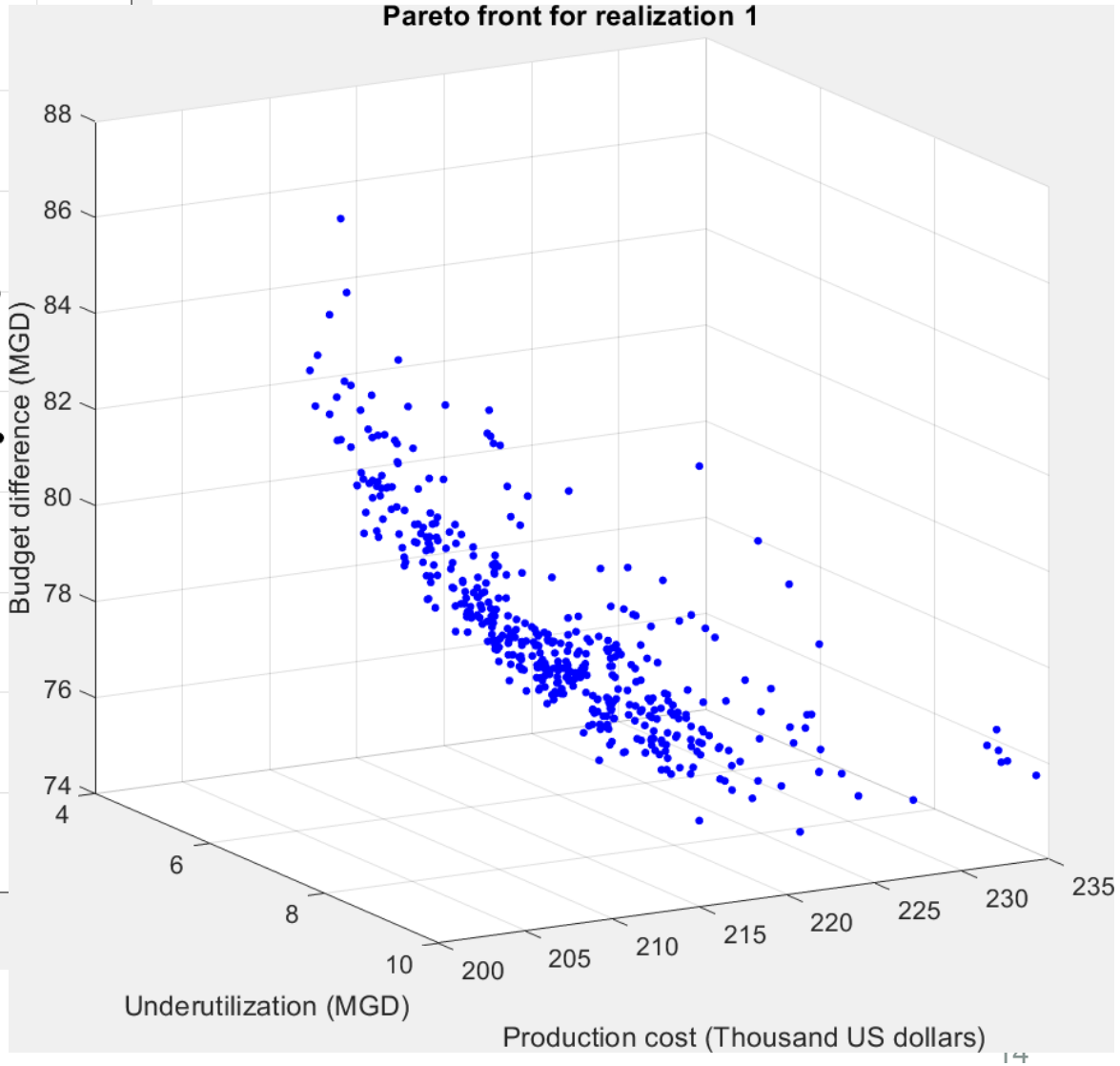
Results of MOEA for Tampa Bay Water's Seasonal Source Allocation: Model run October 2016





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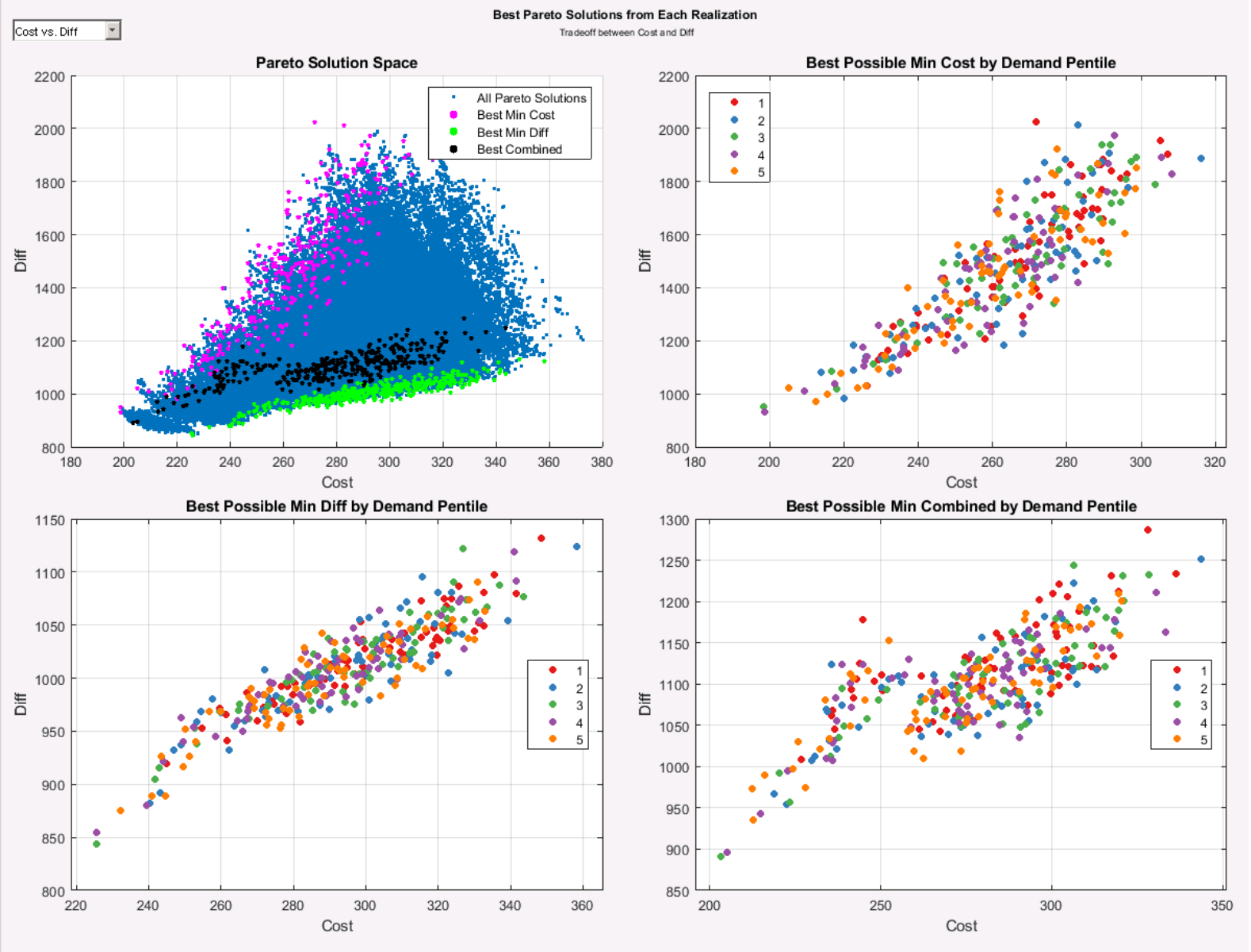
Results of MOEA for Tampa Bay Water's Seasonal Source Allocation: Pareto optimal solutions



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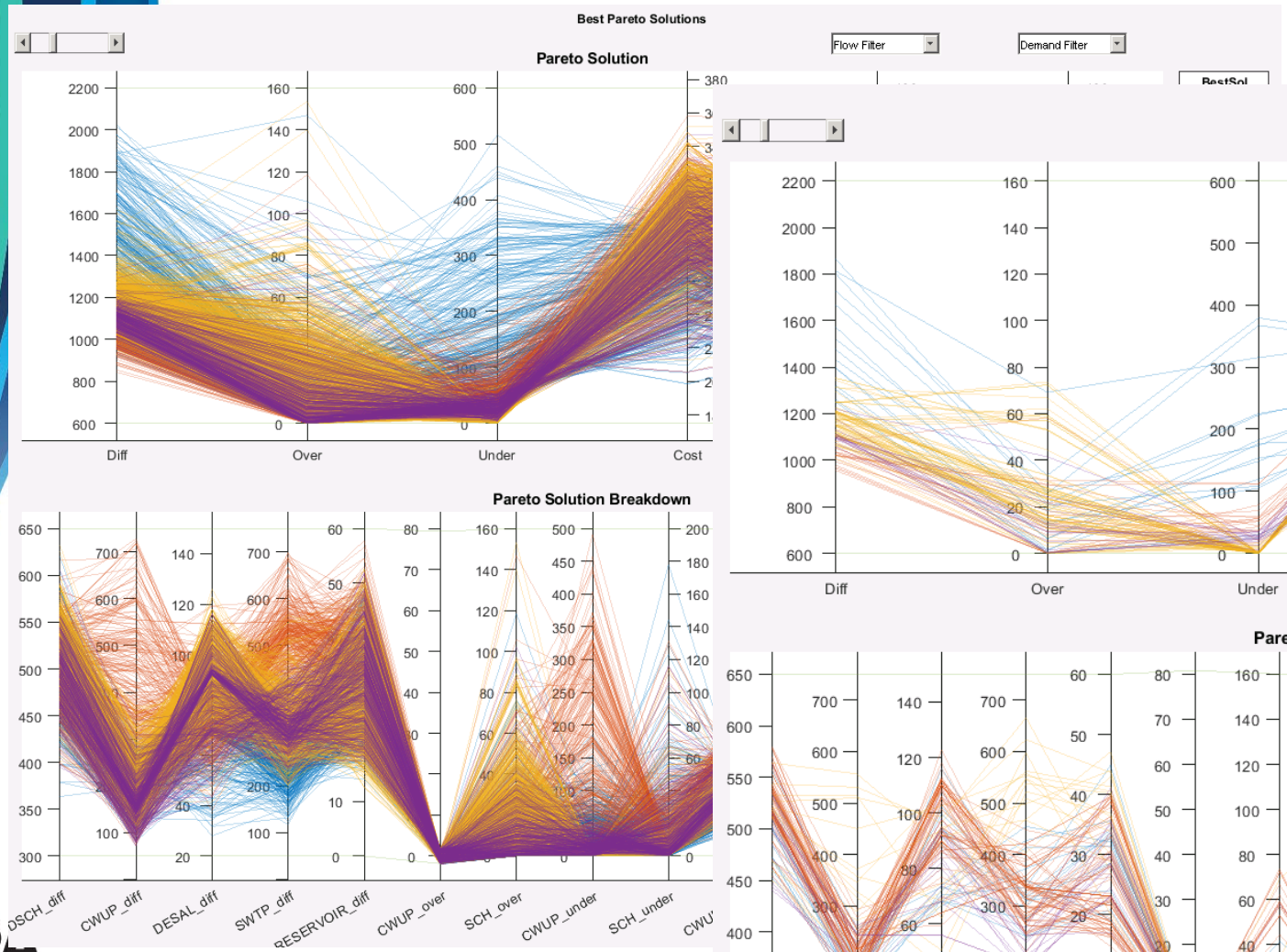
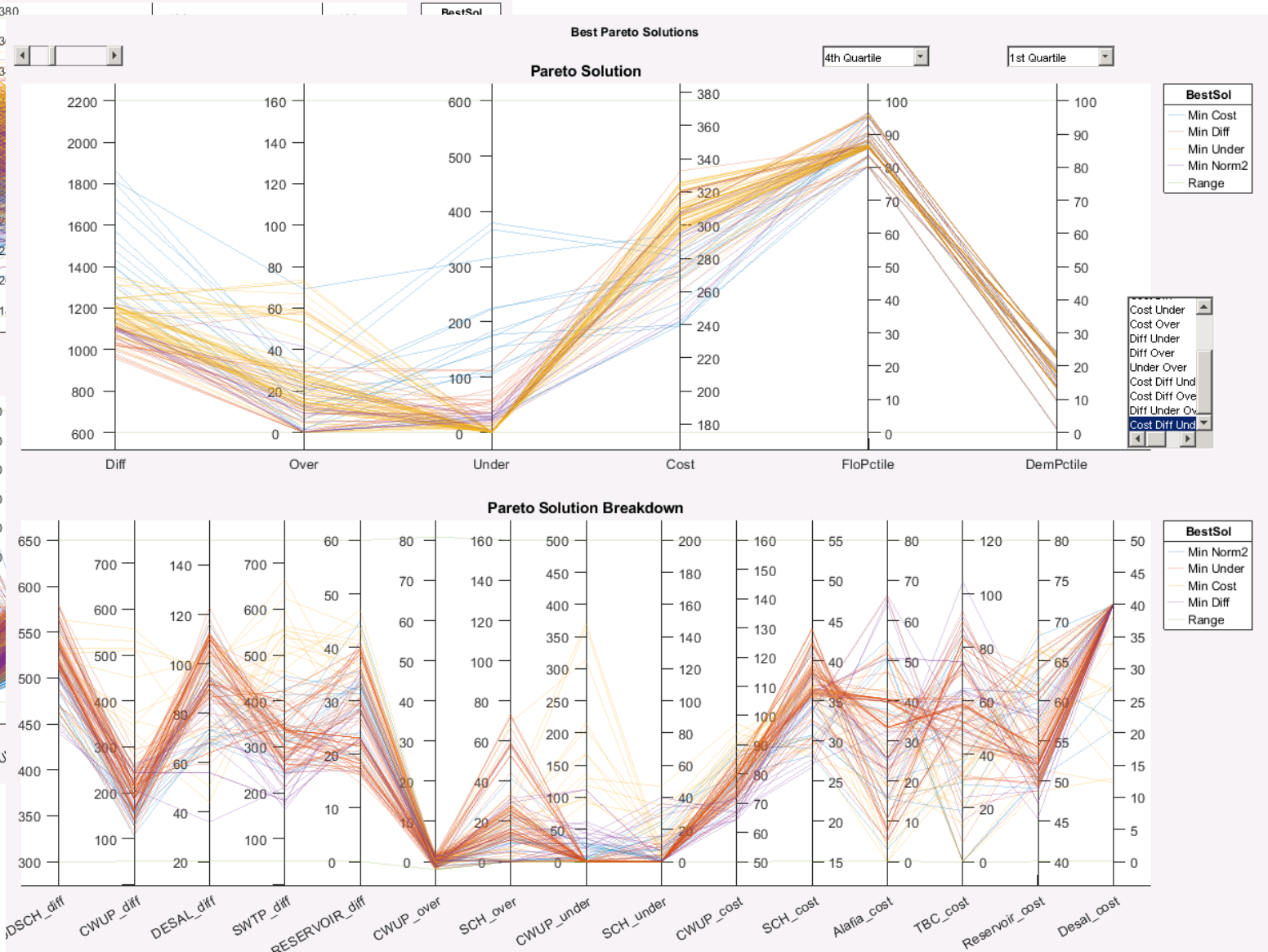
Results of MOEA: Filtering of Pareto Solutions





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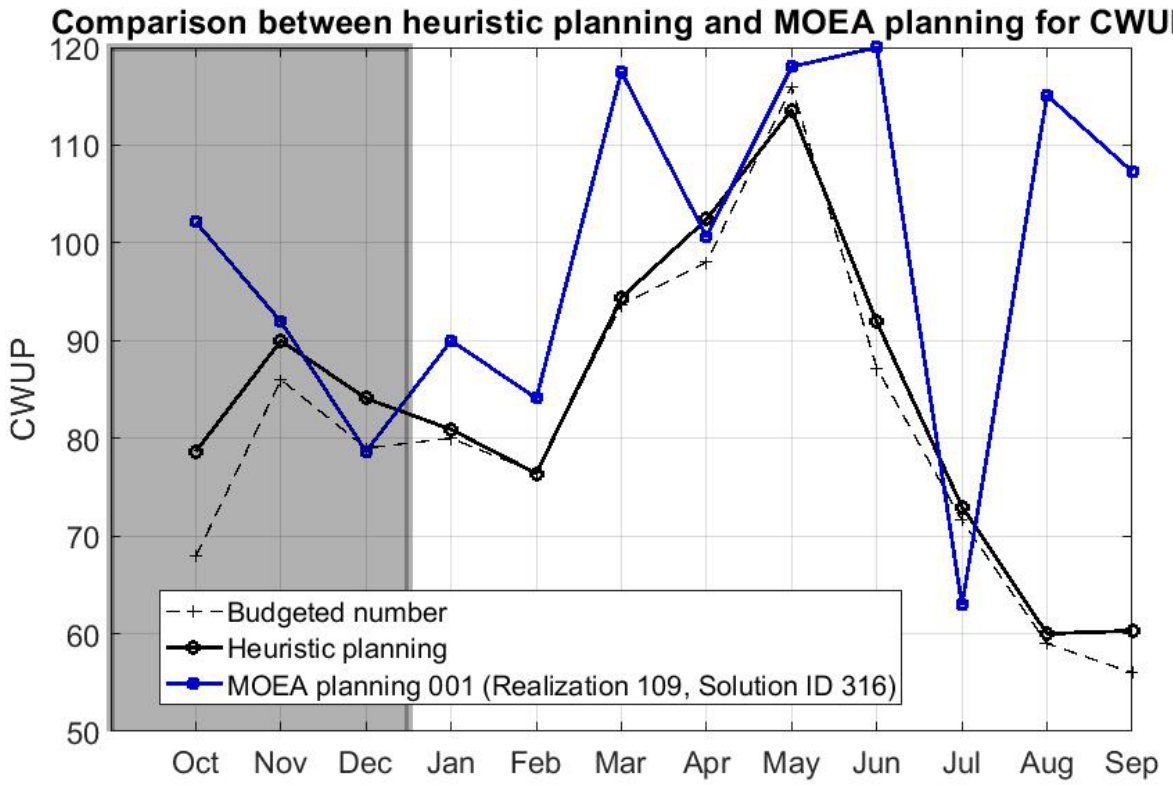
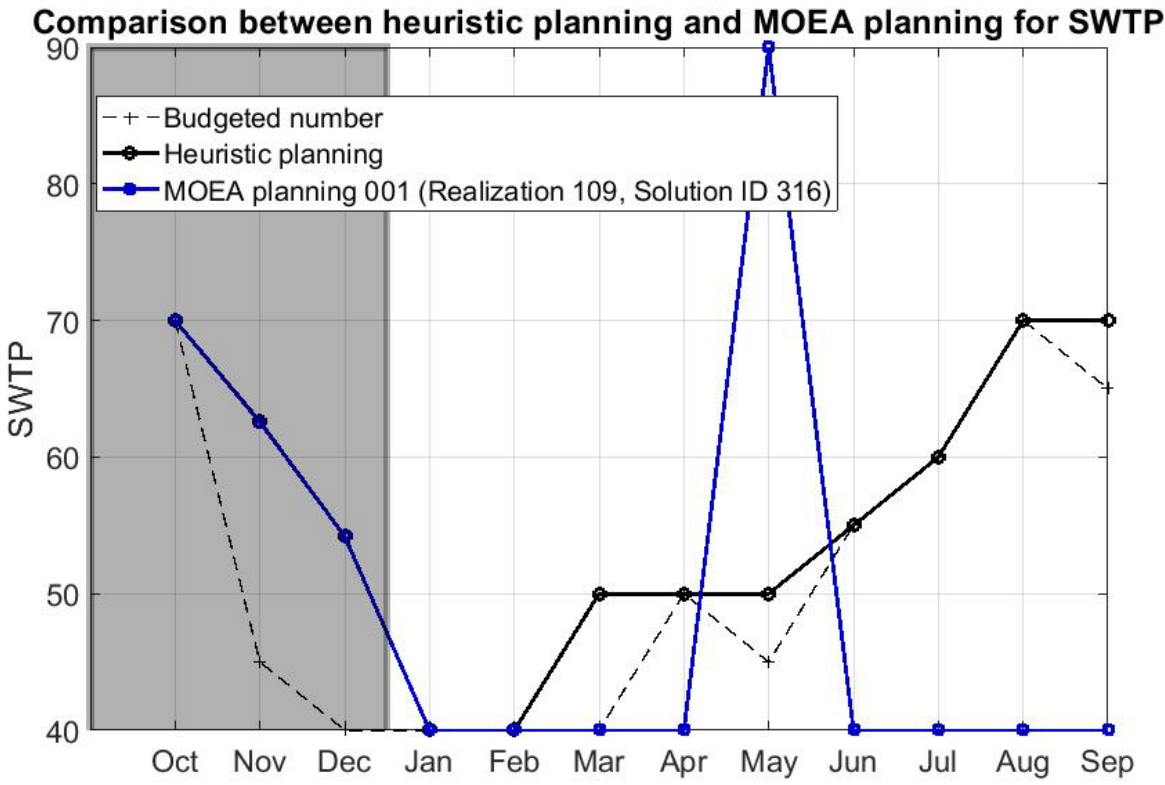
Comparison between heuristic-planning and MOEA-assisted planning: operational differences





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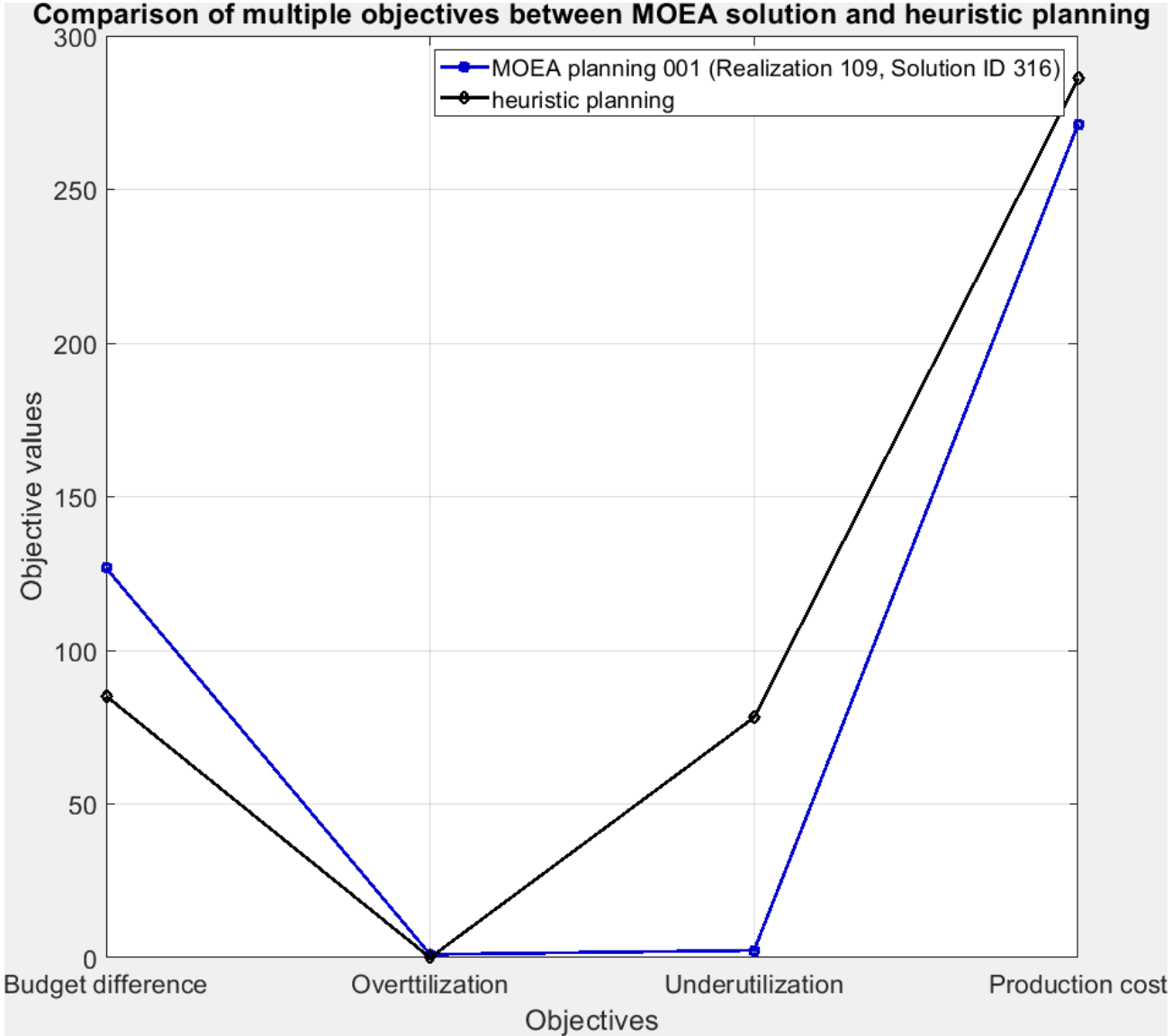
Comparison between heuristic-planning and MOEA-assisted planning: objective differences



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MOEA-assisted Seasonal Allocation: Real-time Implementation

Real-time implementation of MOEA-assisted source allocation

- Different inputs of the model run, e.g., seasonal demand forecasts and water availability forecasts, prepared at the beginning of the month
- Model run: ~6 hours
- Postprocessing: test use of Power BI

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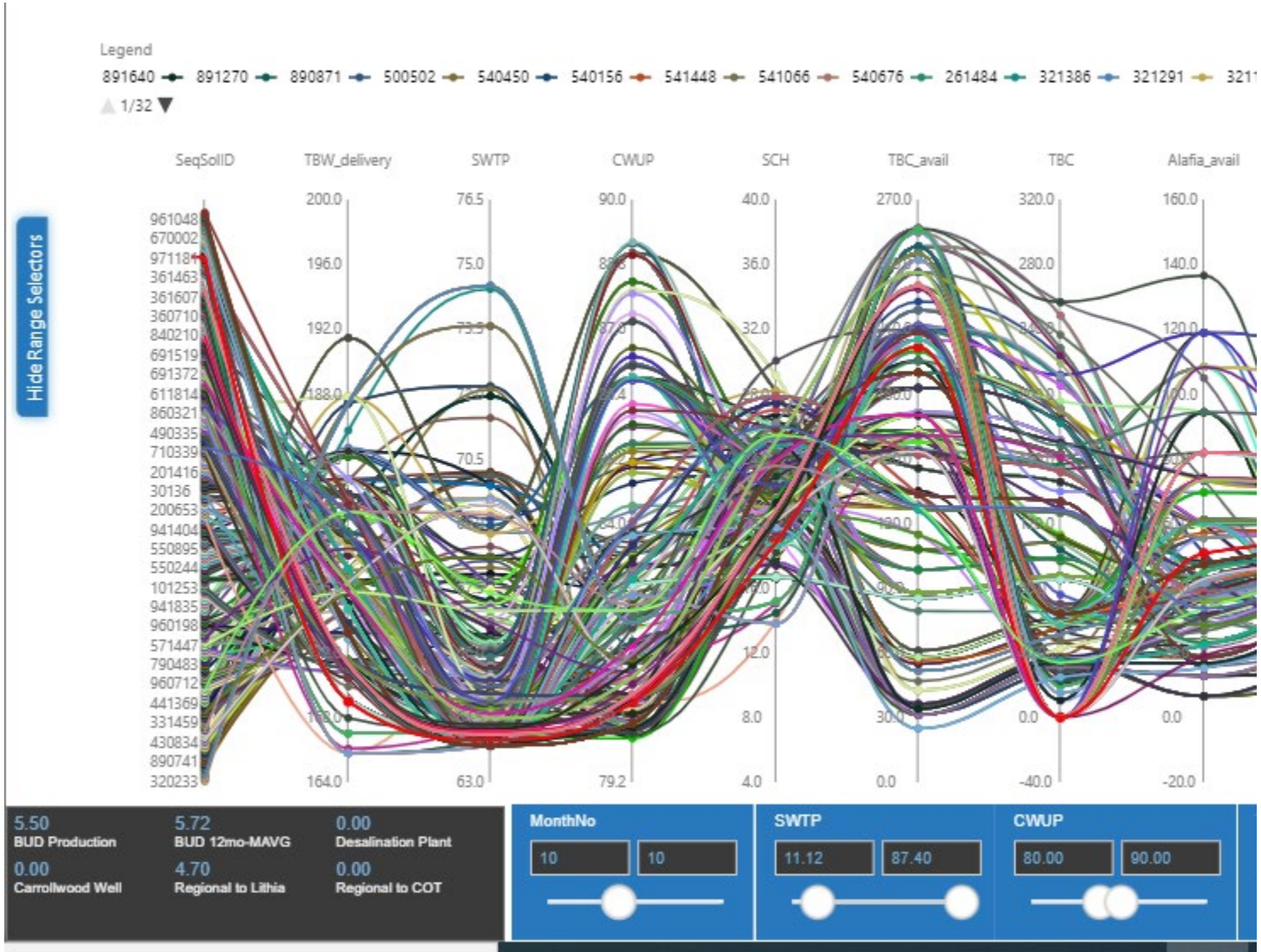
Real-time implementation of MOEA-assisted source allocation: postprocessing



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Application of MOEA Results: Challenges

- Distilling the huge amount of output information to determine final decisions on allocation
- Communicating uncertainty/risk
- How to incorporate feedback to inform decision processes

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Conclusions

- Collaborative research among Water Research Foundation, Universities and Water Utilities helps to develop tailed decision tools (WRF project #4941)

- MOEA provides a framework for Tampa Bay Water to formulate its seasonal source allocation in a rigid model

- Challenges exists in using enormous amount of information to develop on-ground decisions

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Questions

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