GENERATING WATER VALUE FUNCTIONS WITH A STOCHASTIC SHORT-TERM MODEL

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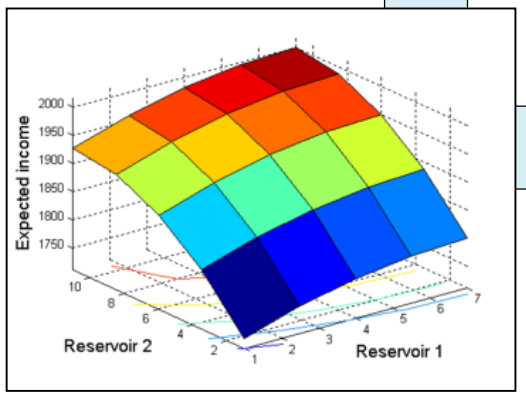
SINTEF Energi, MultiSharm project

Background

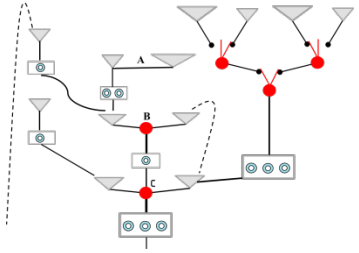
Long-term & seasonal planning



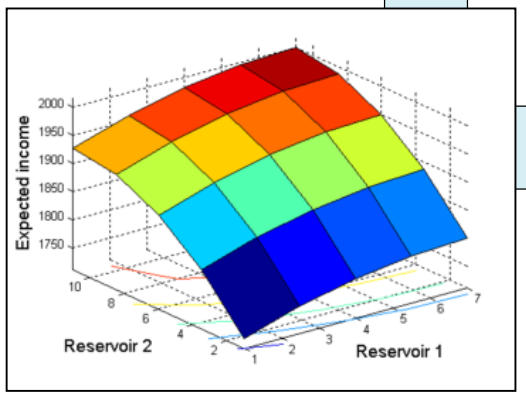
Short-term scheduling

Background

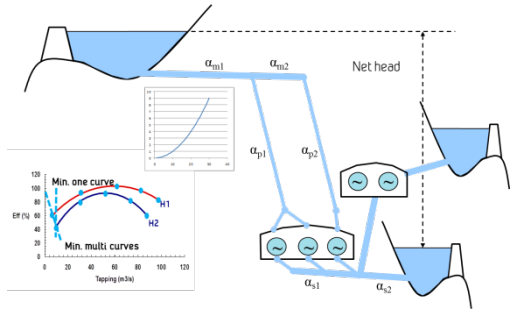
Long-term & seasonal planning



- SDDP/SDP
- Weekly resolution of water values/cuts
- ProdRisk, VanSimTap



Short-term scheduling



- Nonconvex, MILP
- Deterministic (stochastic)
- Hourly/quarterly resolution
- SHOP / SHARM

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Why water values from a short-term model?

1. Computation time
2. Water values for mid-week days
3. Water values from a more detailed model

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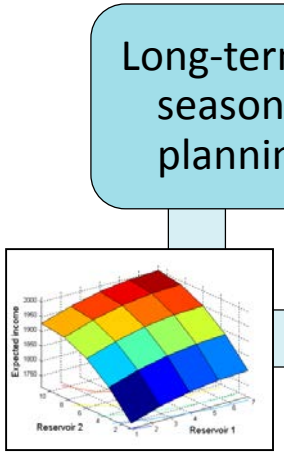
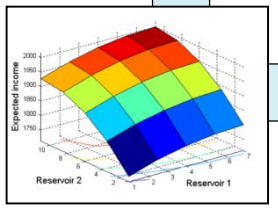
1. Computation time



Long-term & seasonal planning

Short-term water value generation

- ~2 week horizon
- Run at night
- Stochastic
- SHARM



Short-term scheduling

- Reduced horizon
- Run close to decision
- Stochastic/deterministic
- SHARM / SHOP

2. Water values for mid-week days

3. Water values from a more detailed model

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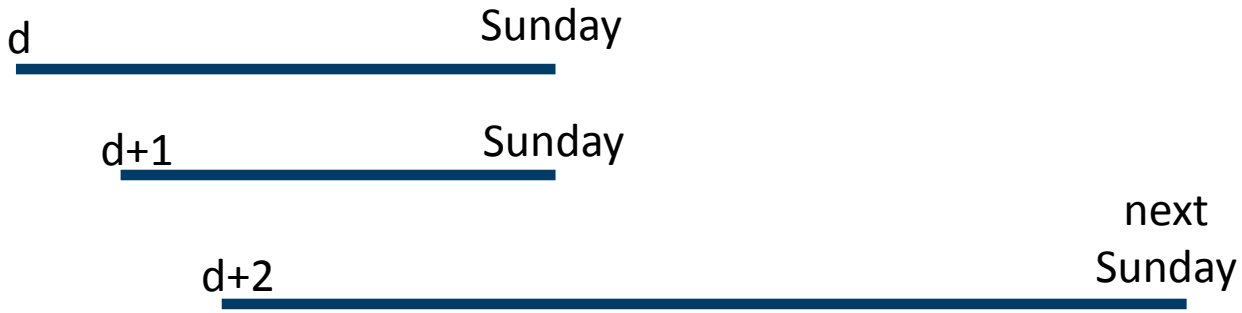

3. Water values from a more detailed model

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Why water values from a short-term model?

1. Computation time
2. Water values for mid-week days
3. Water values from a more detailed model
   - Small reservoirs
   - Long cascades with strong dependencies between plants
   - Large head effects

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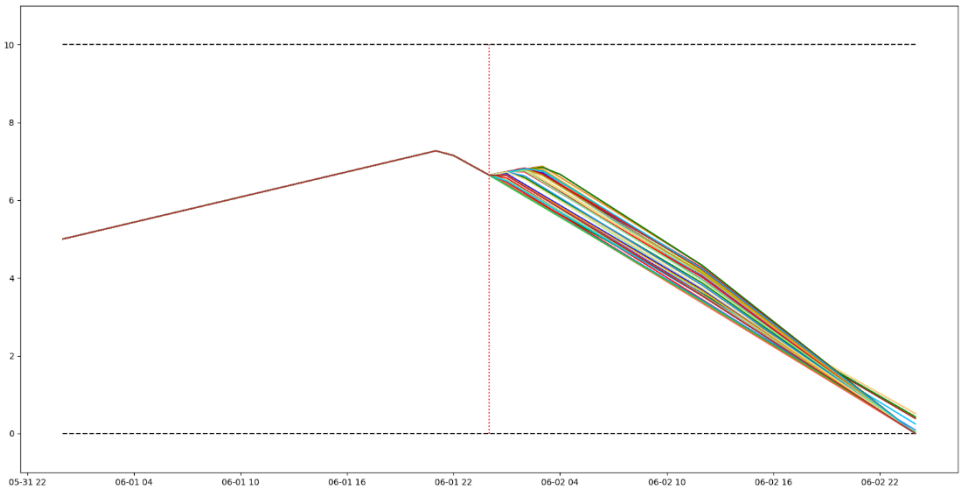
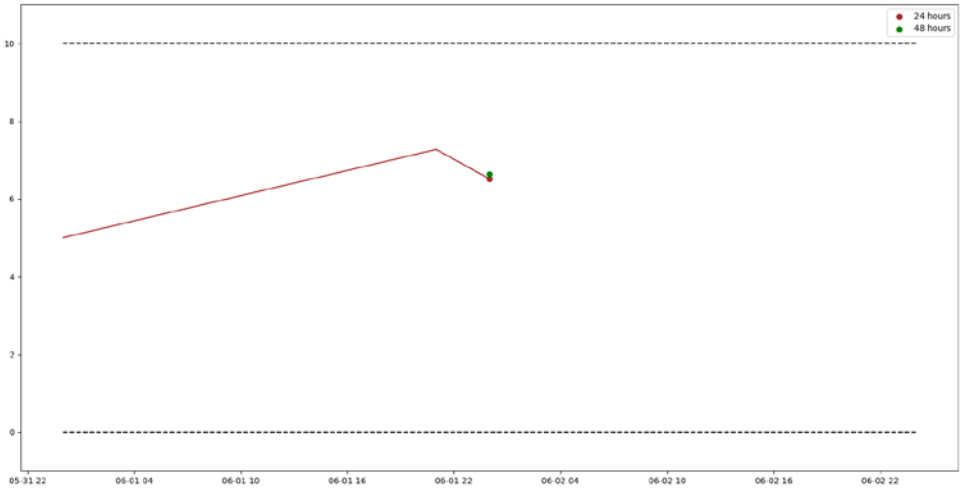
48h integrated

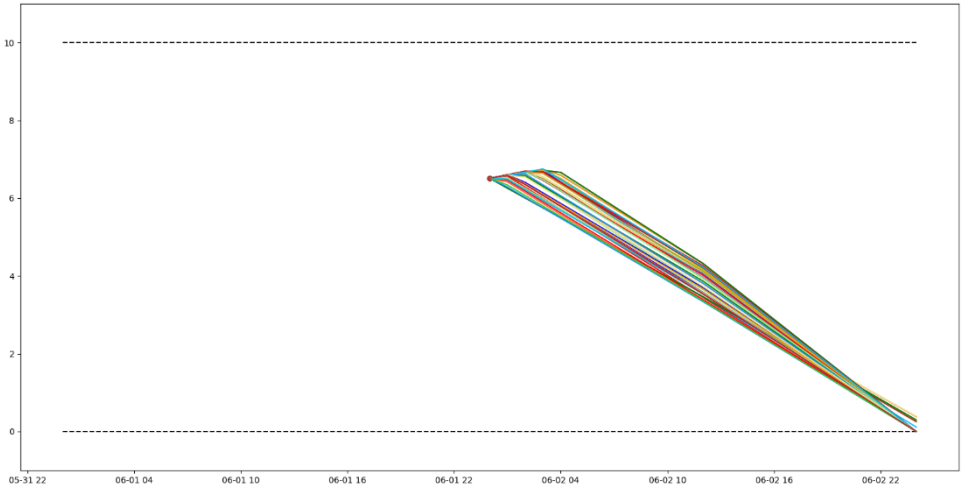


Water value at end day 1

Sequential



End reservoir level day 1



1. Run 2-days model to generate water values at end of day 1
2. Run day 1 with generated water values for end reservoir valuation
3. Run day 2 with start reservoir level given from previous 1-day run

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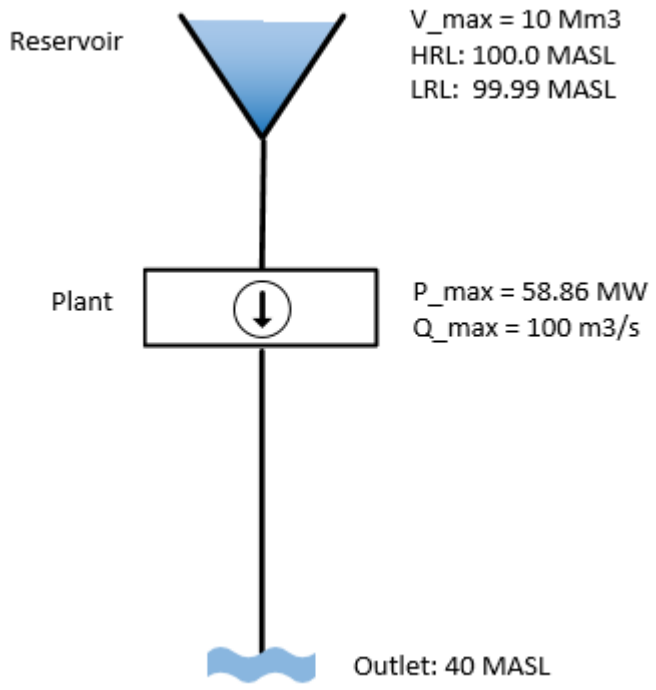
Topology



- Flat reservoir
- No head loss
- 100% generator efficiency
- 100% turbine efficiency
- P_min at 0 MW
- P_max estimated at Q_max
- No start- nor stop costs

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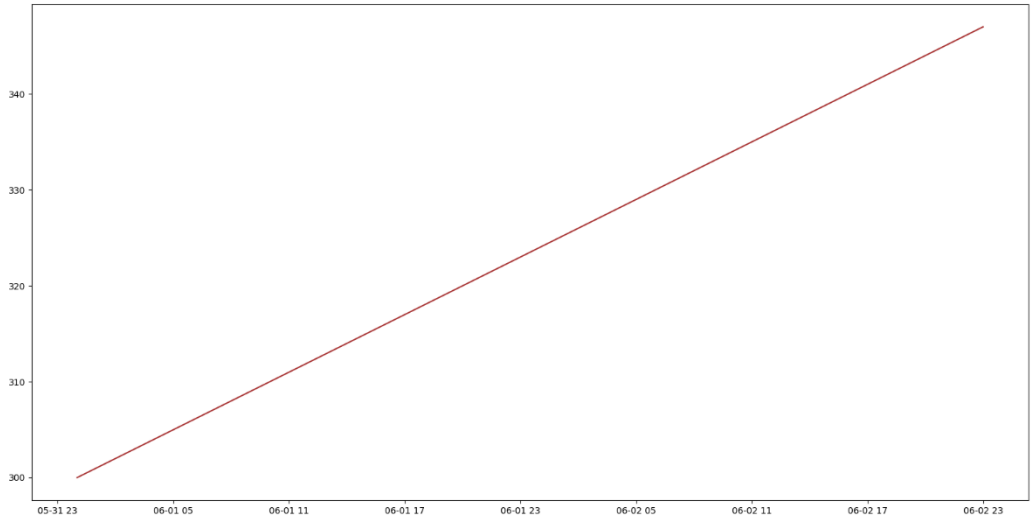
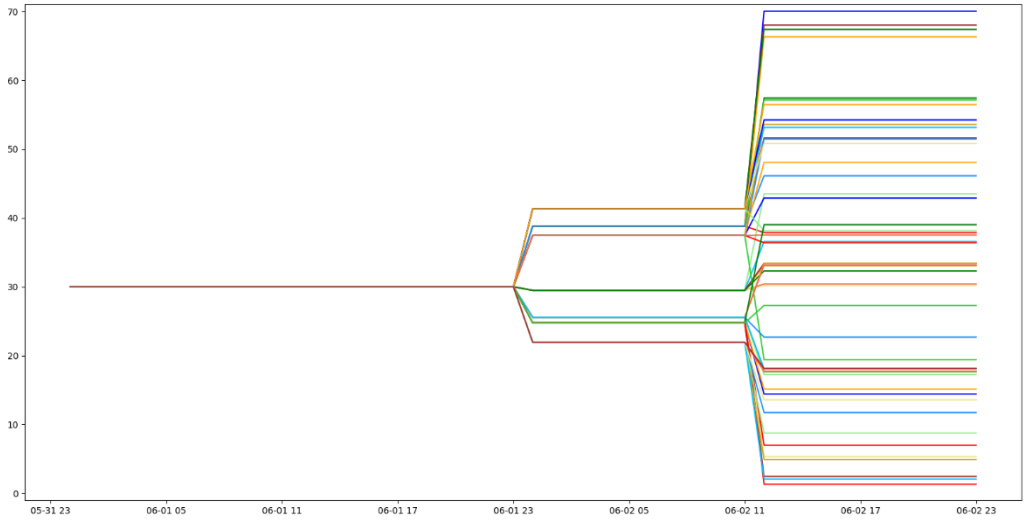
Price and inflow

Price



time

Inflow



time

Water value at the end of day 2 < price

Mean inflow h1-h24: 30 m^3/s

Random deviation from mean

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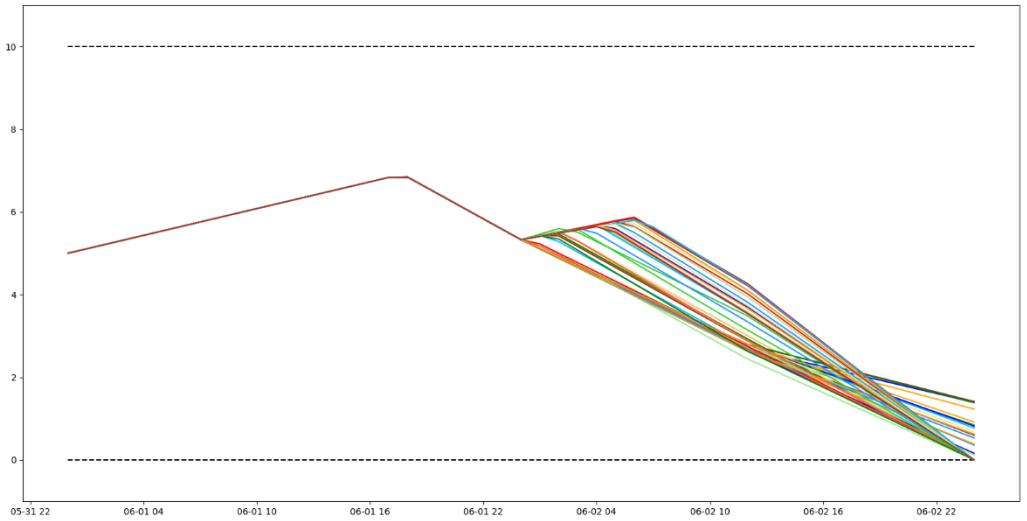
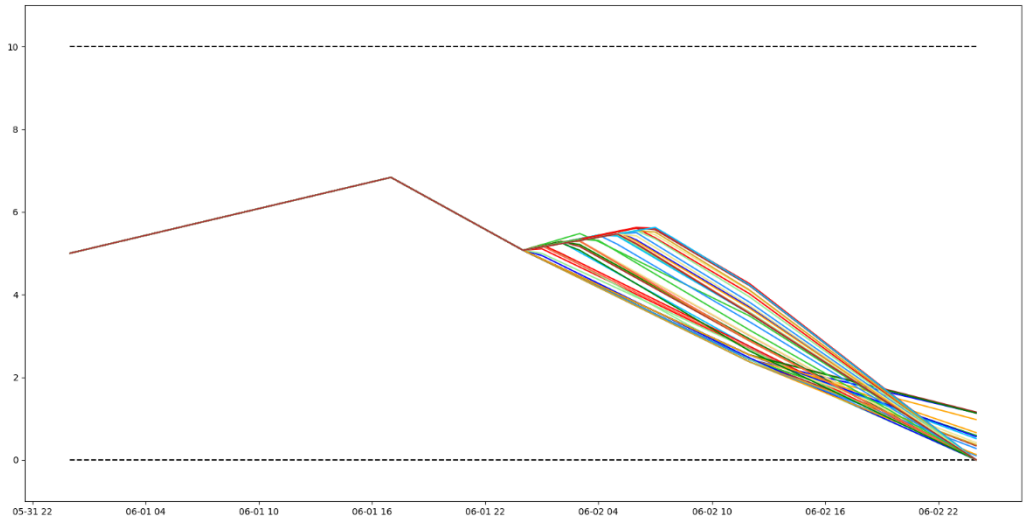
Results - Reservoir trajectories



48h integrated



Sequential

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Results

2-day stochastic model run – represents the target solution

Model	End volume day 1		Expected profit
48h stochastic	5.327		563 273

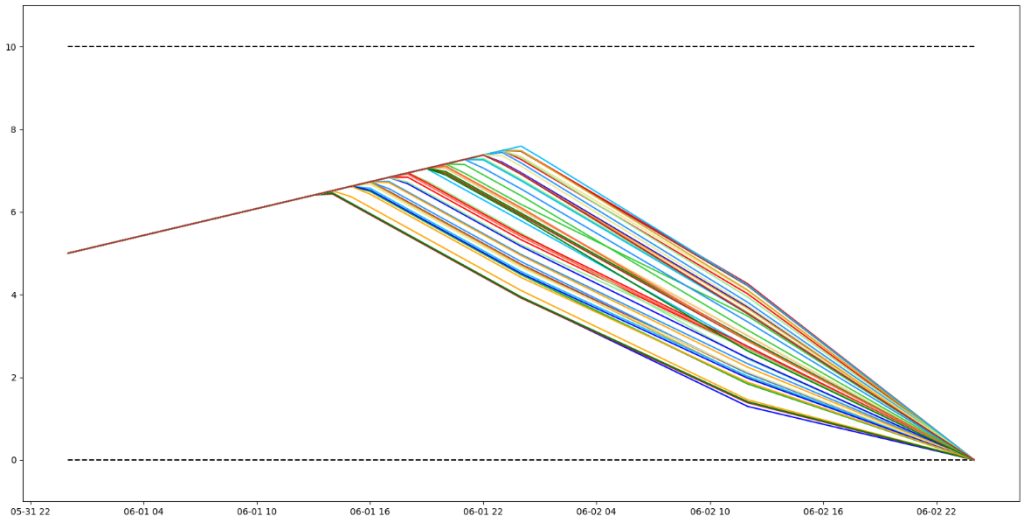
Sequential model run for day 1 and day 2 using water values

Model	End volume day 1	Water value day 1	Expected profit
Single cut, stochastic	5.072	51 802.1	563 222

Benchmark – alternative mode

- **Multi-deterministic** model runs to generate water values
- Reduced computation time, easy to parallelize
- Use expected water value

Results – Multi-deterministic



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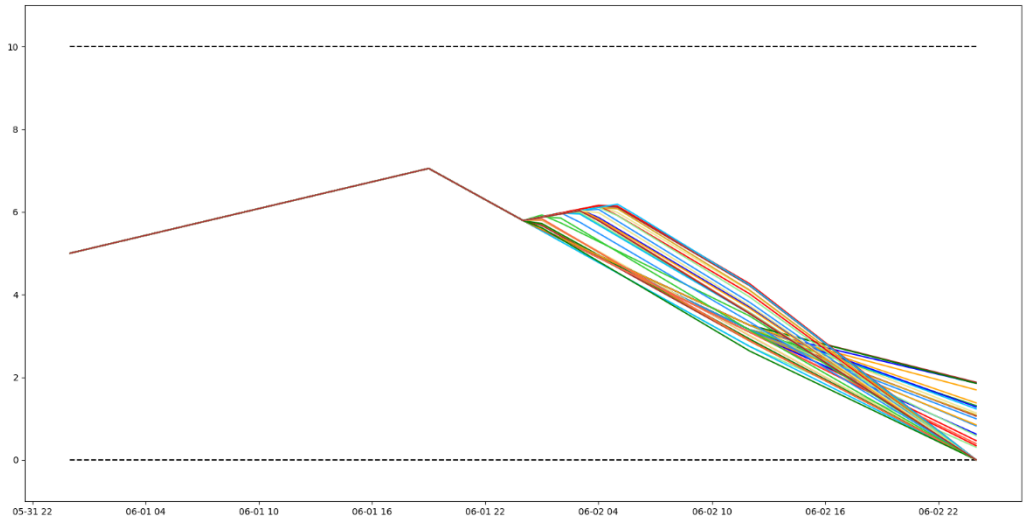

Sequential

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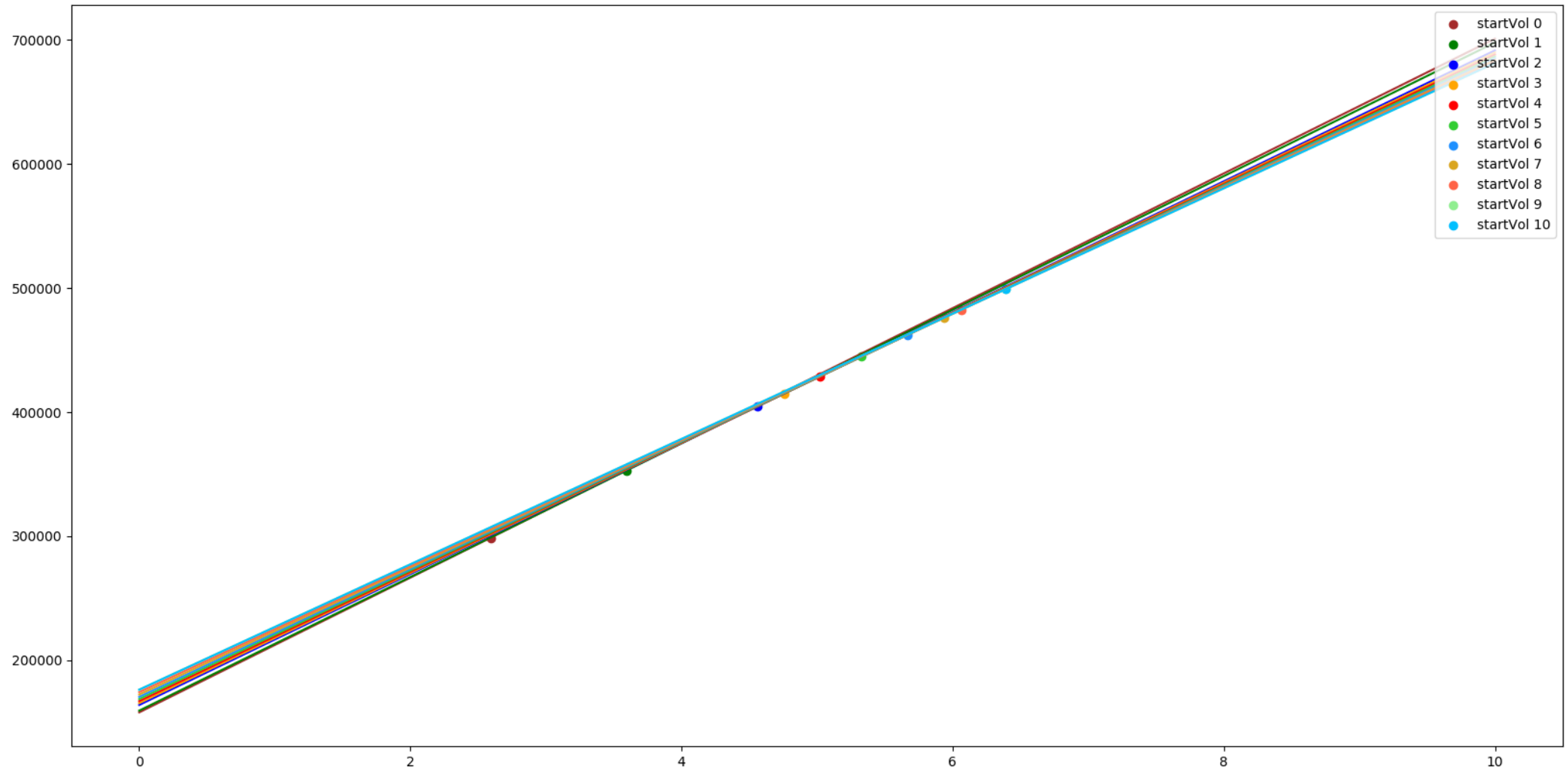
Multi-deterministic	5.792	52 073.8	563 122

*Coefficient from binding cut

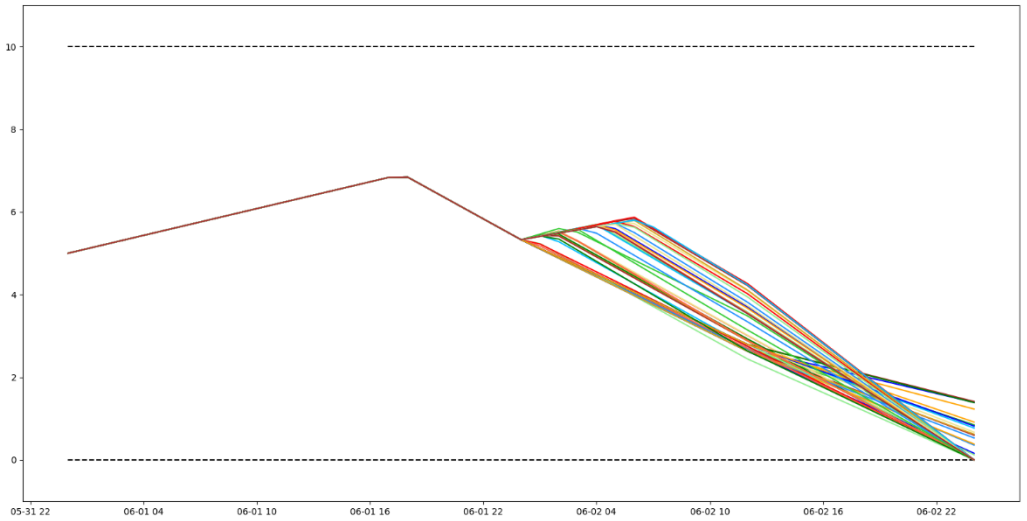
Benchmark – alternative modes

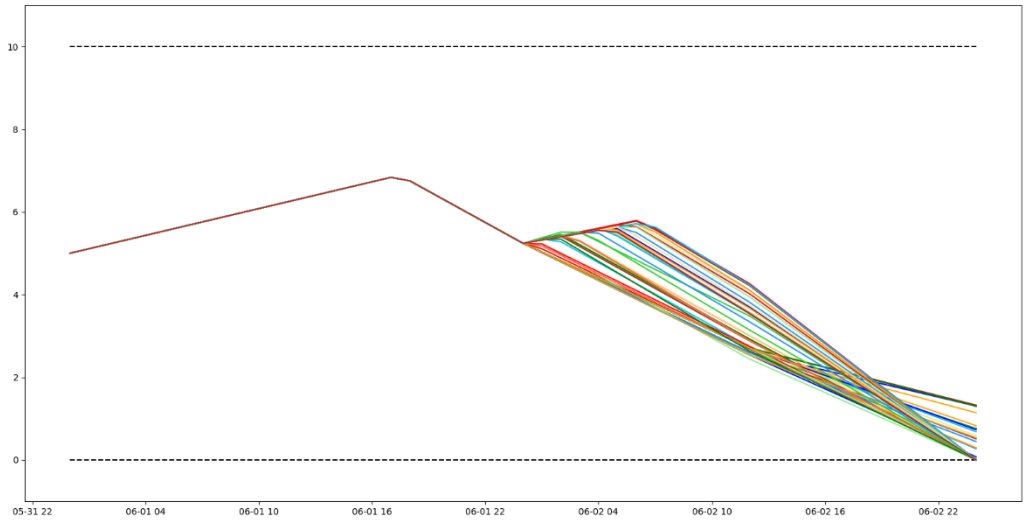
- **Multi-deterministic** model runs to generate water values
- Reduced computation time, easy to parallelize
- Use expected water value

- **Multiple cuts** by starting the stochastic model with different start reservoir levels
- Improved water value approximation


700000
600000
500000
400000
300000
200000
0
2
4
6
8
10
startVol 0
startVol 1
startVol 2
startVol 3
startVol 4
startVol 5
startVol 6
startVol 7
startVol 8
startVol 9
startVol 10

Results - Multiple cuts





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Sequential model run for day 1 and day 2 using water values

Model	End volume day 1	Water value day 1	Expected profit	Delta from 48h
Single cut, stochastic	5.072	51 802.1	563 222	-51 / -0.009%
Multi-deterministic	5.792	52 073.8	563 122	-151 / -0.027%
Multi-cut, stochastic	5.240	51 802.1*	563 264	-9 / -0.002%

*Coefficient from binding cut

Summary

- Water values from a stochastic short-term scheduling model, SHARM
- Simplified 2-day test setup
- Observations (from single case!)
  - Water values captures that value of day 2 exceeds water value beyond day 2
    - Indicates that weekday correction might be possible
  - Stochasticity adds value relative to multi-deterministic
    - No single obvious way to define the water value from the multi-deterministic approach
  - Multiple cuts improves result
- More testing to be done

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Technology for a better society