
MAX PLANCK INSTITUTE
FOR DYNAMICS OF COMPLEX
TECHNICAL SYSTEMS
MAGDEBURG
CSC
COMPUTATIONAL METHODS IN
SYSTEMS AND CONTROL THEORY
morgen – Model Order Reduction for Gas and Energy Networks
(MathEnergy Model Reduction Sub-Project @ MPI Magdeburg)
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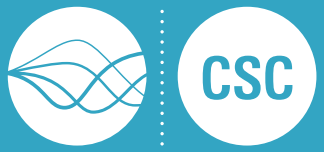


Model Reduction Sub-Project

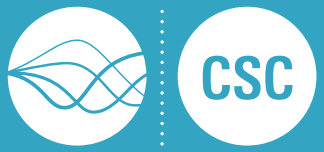
Goals:

- Adapt Model Reduction Methods to Gas Transport Models
- Implement Model Reduction Algorithms
- Perform Scenario Analysis
- Provide Software Library
- Parallelize Implementation*

Enhancements

Outcomes:

- Contributed to modeling and discretization.
- Extended dominant subspaces methods.
- Improved training for hyperbolic systems.
- Found unstructured model reduction methods to be unsuitable.
- Working structured variants formulated.
- Created short training, long testing.
- Collected and tested various network topologies.



Implementation (morgen)

Features:

- **2** Discretizations, **4** Integrators, **12** Reductors, **24** Networks
- Comparison & Benchmarking
- Modular & Extensible
- Open & Accessible

Notes:

- Reads GasLib XML, MathEnergy JSON, (SciGrid_gas CSV).
- Compatible with MATLAB and OCTAVE.
- Licensed under BSD-2-Clause license.
- Approximately 4500 Lines of Code.

Sample Analysis (GasLib-134)

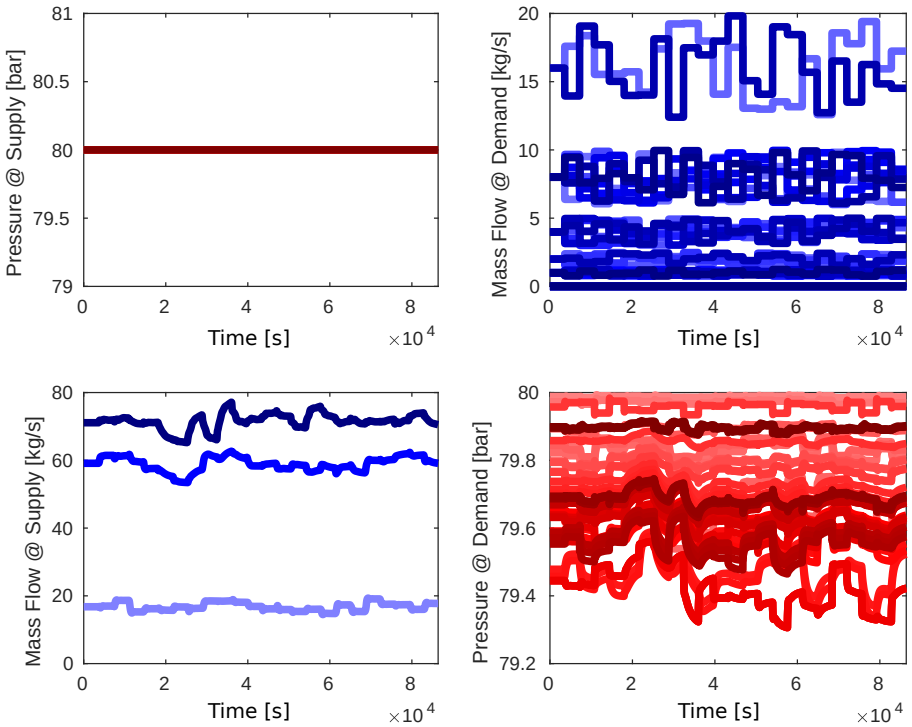


Figure: 24h input-output scenario simulation with stochastics.

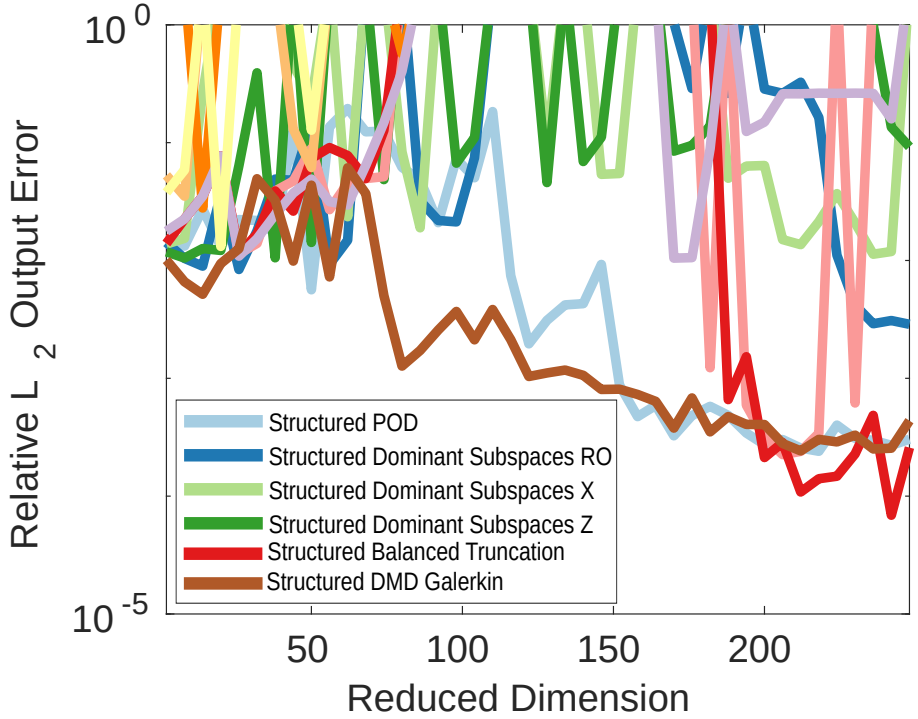


Figure: Averaged scenario simulation error of tested reduced order models.

For details see: https://arxiv.org/abs/2002.12226

Our Conclusions

- Best model:
  → **Endpoint discretization of isothermal Euler equations**
- Best integrator:
  → **First-Order Implicit-Explicit**
- Most accurate MOR method:
  → **Structured Empirical Dominant Subspaces**
- Most efficient MOR method:
  → **Structured Dynamic Mode Decomposition Galerkin**
- MOR stability preservation:
  → Prefer **Galerkin** over **Petrov-Galerkin**

Further Results

- **Power2Gas:**
  $\rightarrow$ Works similar to standard supply nodes due to buffer storage.
- **Modeling:**
  $\rightarrow$ New and improved discretization proposed.
- **Hyperbolicity:**
  $\rightarrow$ Alternative reduction method proposed.
- **Decoupling:**
  $\rightarrow$ Alternative nonlinear models derivable.
- **Parallelization:**
  $\rightarrow$ Core algorithm (SVD) flexibly parallelizable via **HAPOD**.

Summary

- ✓ Accelerate gas network simulation with model reduction.
- ✓ Enhance modeling and model reduction.
- ✓ Open-source implementation.

`morgen` – **Model Order Reduction for Gas and Energy Networks**

https://git.io/morgen

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Selected References

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