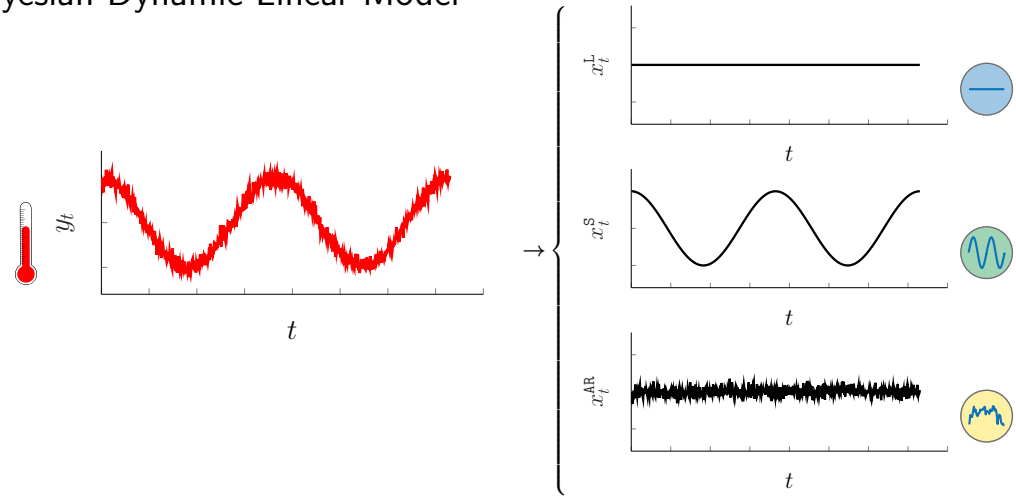
State-Based Regression for Modeling Nonlinear Relationship

Bhargob Deka, PhD Student
James-A. Goulet, Professor

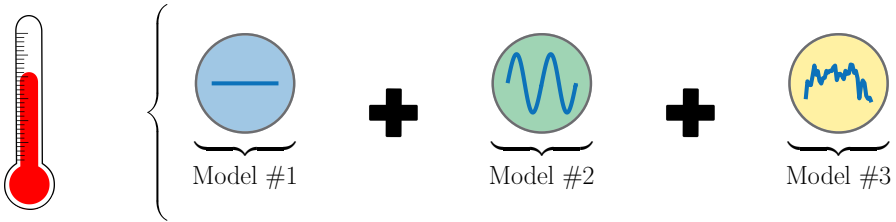
Polytechnique Montreal, Canada
Civil Engineering Department

August 5, 2022

Bayesian Dynamic Linear Model

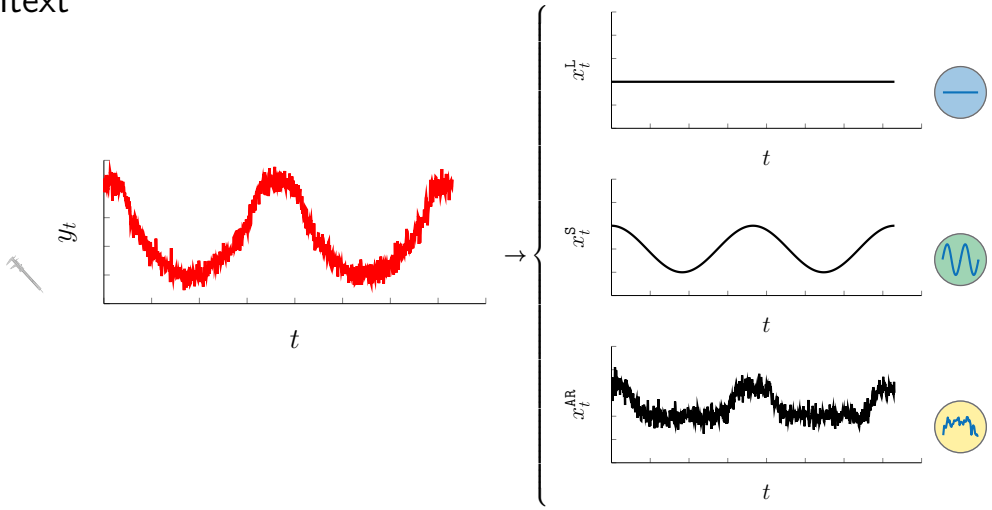


Bayesian Dynamic Linear Model

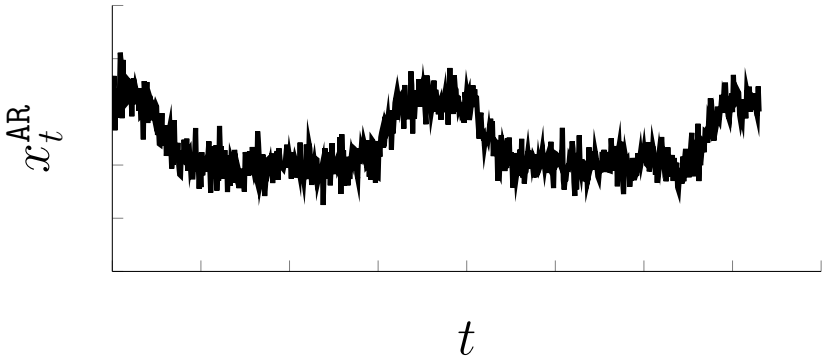


Probabilistic

Context

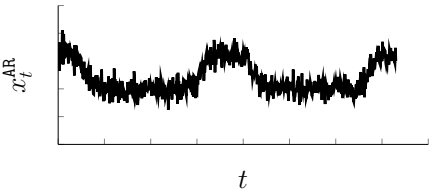


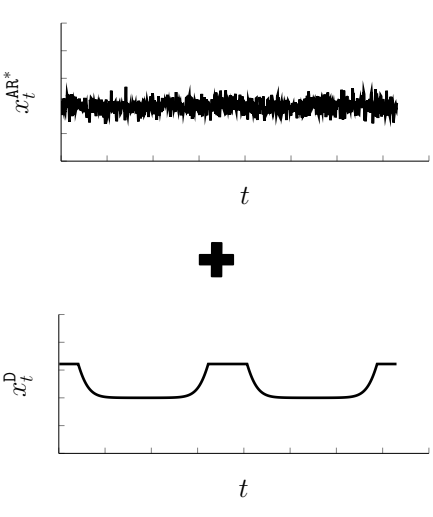
Context



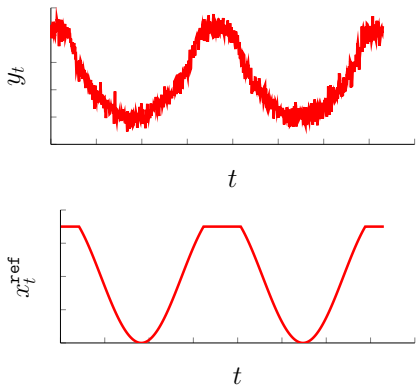
Patterns still exist

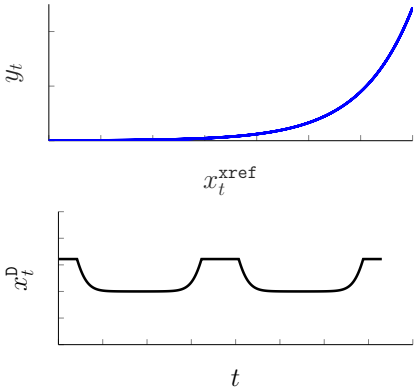
Context



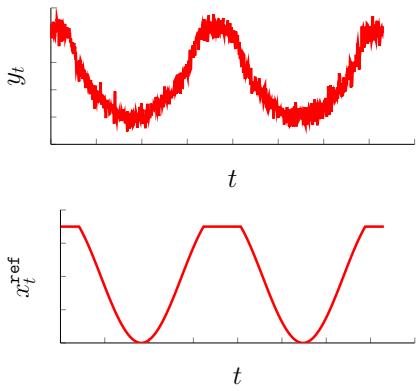


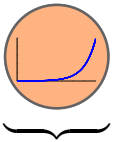
Nonlinear Dependency



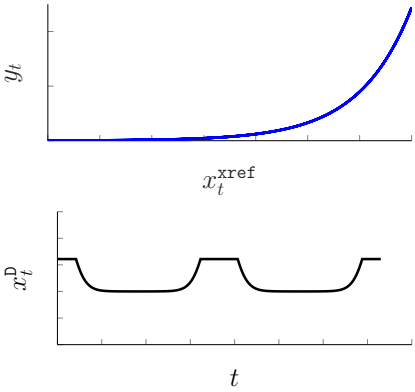


Nonlinear Dependency

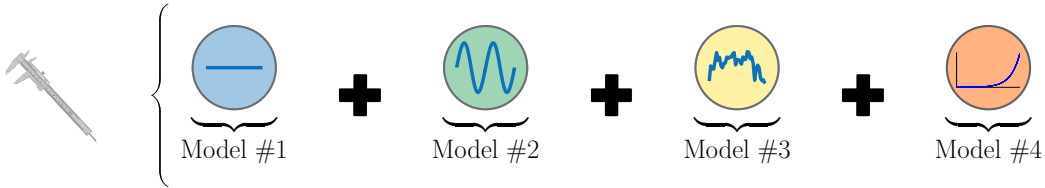




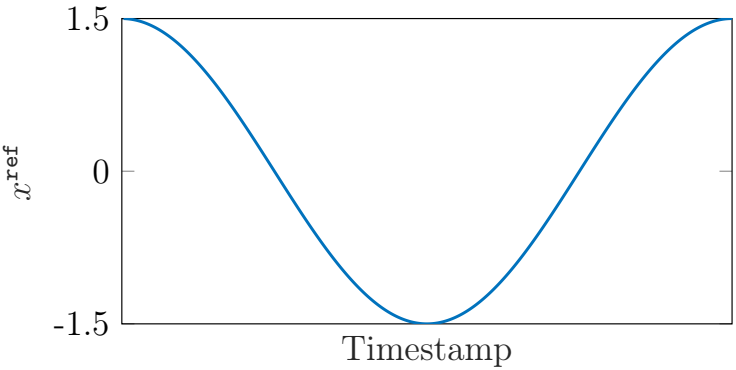
State Regression



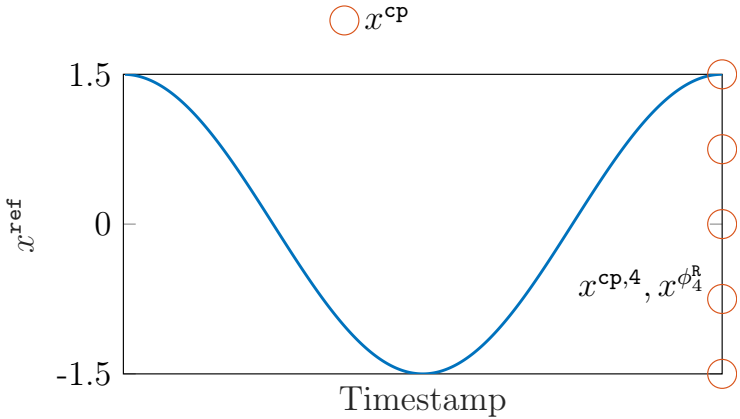
Nonlinear Dependency



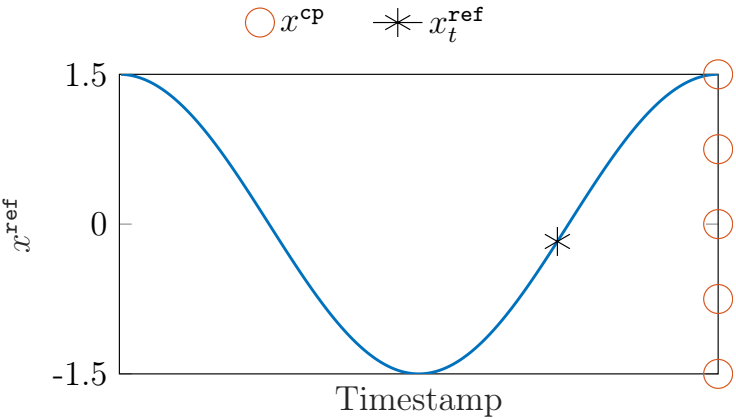
State Regression – Kernel Method



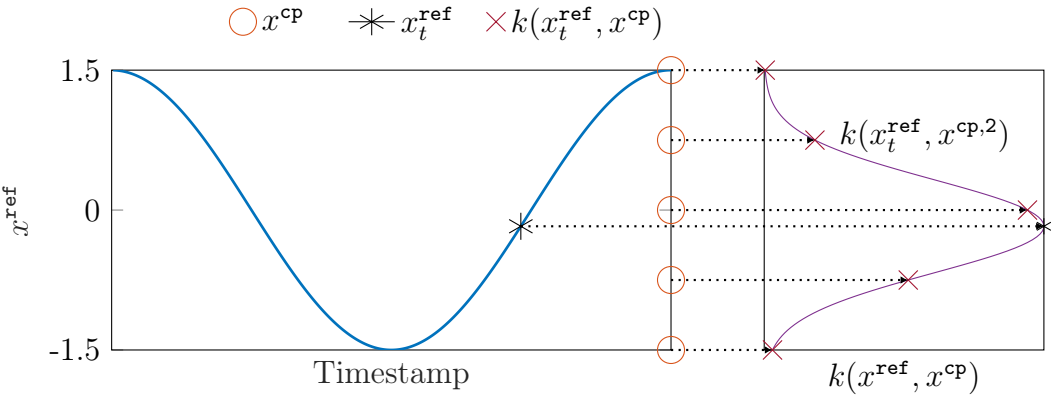
State Regression – Kernel Method



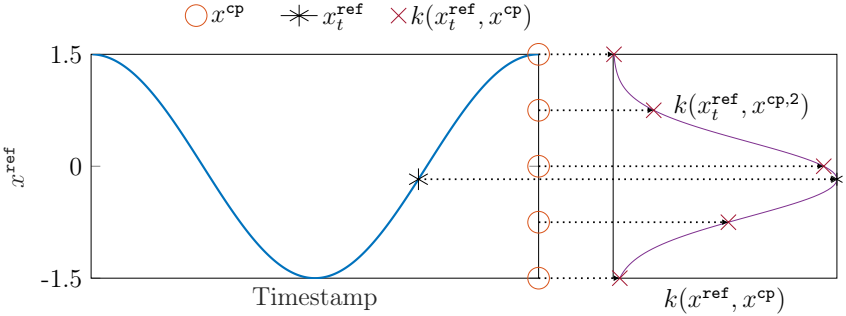
State Regression – Kernel Method



State Regression – Kernel Method



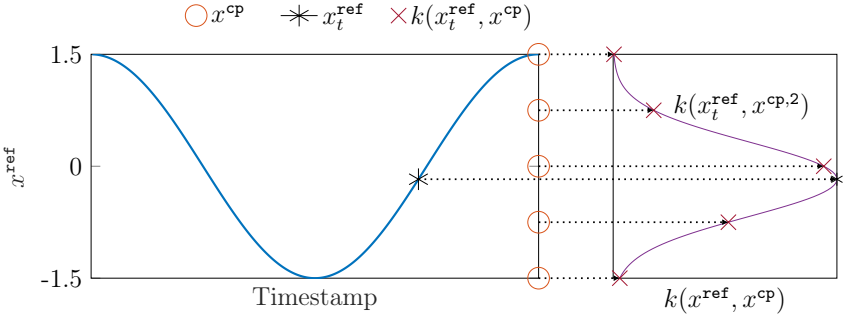
State Regression – Kernel Method



$$\left.\begin{aligned} x^{\phi_0^{\mathtt{R}}} &= \sum k_i \cdot x^{\phi_i^{\mathtt{R}}} \\ x^{\mathtt{D}} &= x^{\phi_0^{\mathtt{R}}} \cdot x^{\mathtt{ref}} \end{aligned}\right\}$$

[Goulet et al. 2020, Deka et al. 2021]

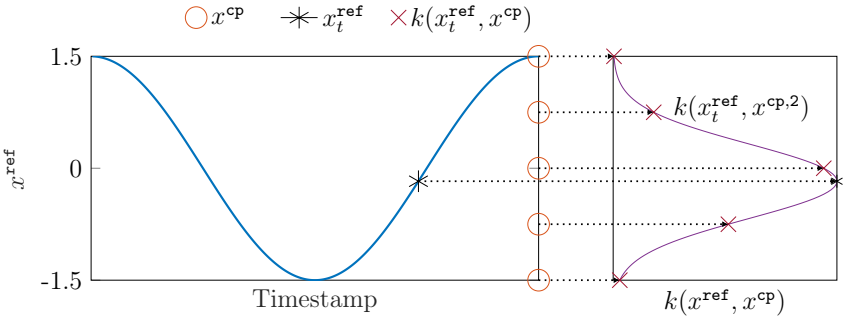
State Regression – Kernel Method



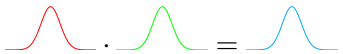
$$\left.\begin{aligned} x^{\phi_0^{\mathtt{R}}} &= \sum k_i \cdot x^{\phi_i^{\mathtt{R}}} \\ x^{\mathtt{D}} &= x^{\phi_0^{\mathtt{R}}} \cdot x^{\mathtt{ref}} \end{aligned}\right\} \longrightarrow \textbf{GMA}$$

[Goulet et al. 2020, Deka et al. 2021]

State Regression – Kernel Method



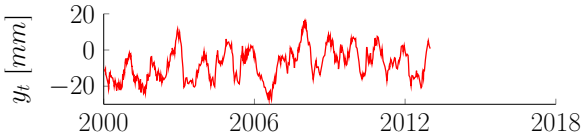
$$\left.\begin{aligned} x^{\phi_0^{\mathtt{R}}} &= \sum k_i \cdot x^{\phi_i^{\mathtt{R}}} \\ x^{\mathtt{D}} &= x^{\phi_0^{\mathtt{R}}} \cdot x^{\mathtt{ref}} \end{aligned}\right\} \longrightarrow \textbf{GMA}$$



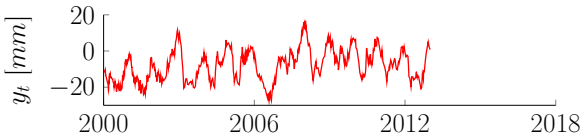
Analytically Tractable

[Goulet et al. 2020, Deka et al. 2021]

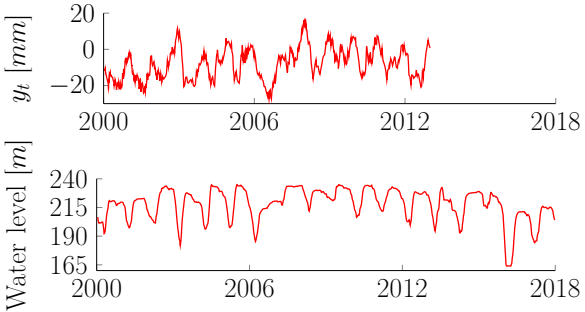
Datasets & Forecast



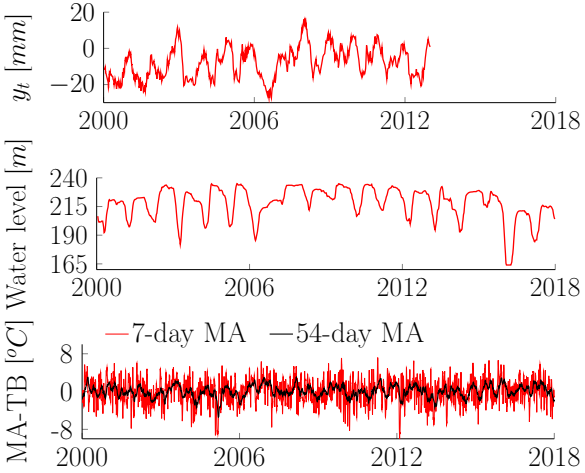
Datasets & Forecast

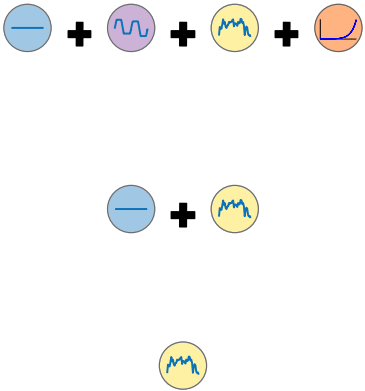


Datasets & Forecast

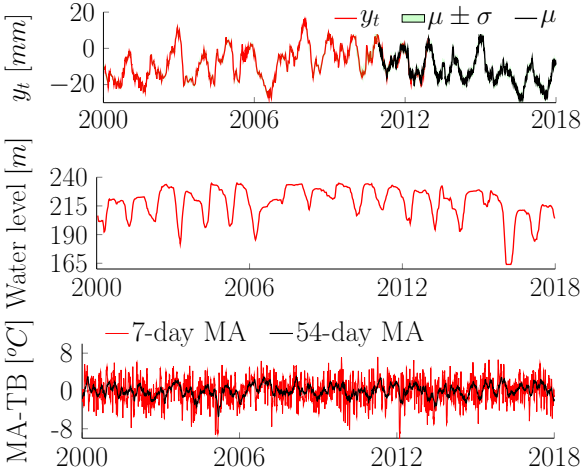


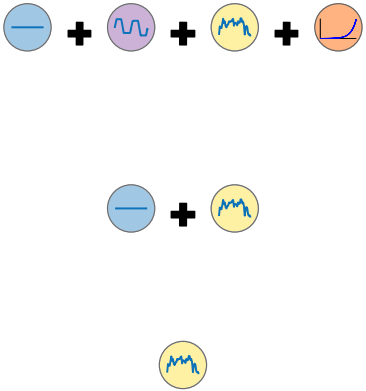
Datasets & Forecast



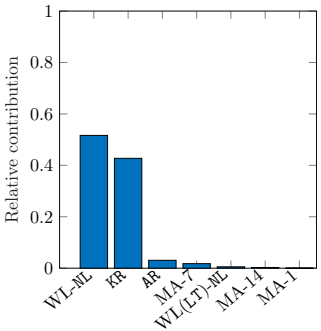


Datasets & Forecast

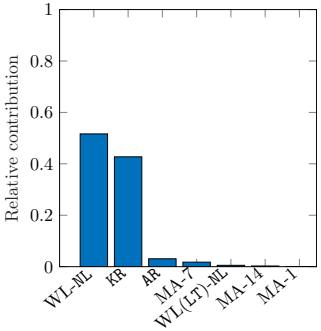


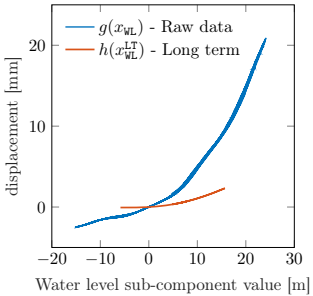


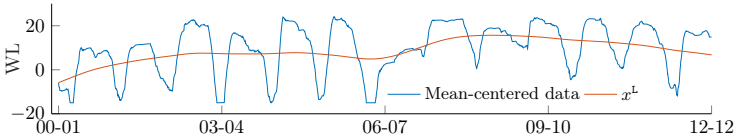
BDLM's model structure & interpretation



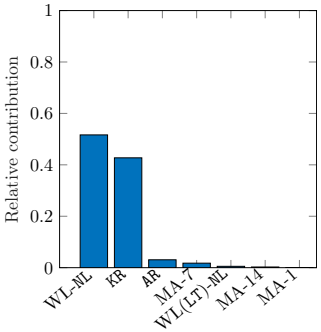
BDLM's model structure & interpretation

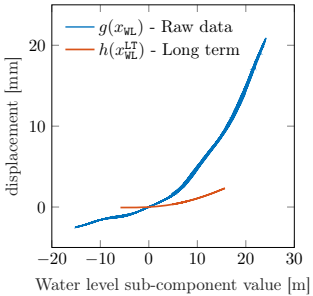


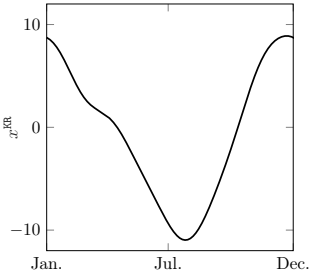


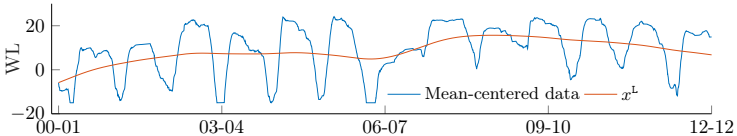


BDLM's model structure & interpretation



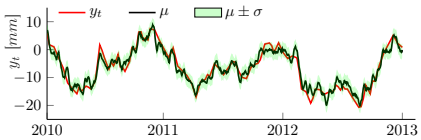






Conclusion

Displacement

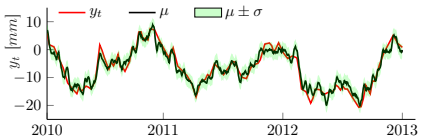


Strengths

- Combine state regression & BDLM
- Fully probabilistic
- Interpretable components

Conclusion

Displacement

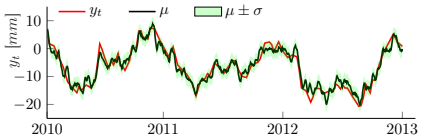


Strengths

- Combine state regression & BDLM
- Fully probabilistic
- Interpretable components
- Good accuracy

Conclusion

Displacement



Strengths

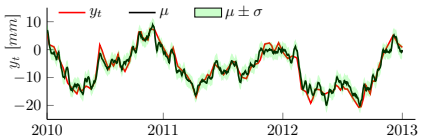
- Combine state regression & BDLM
- Fully probabilistic
- Interpretable components
- Good accuracy

Limitations

- Requires manual setup and feature engineering

Conclusion

Displacement



Strengths

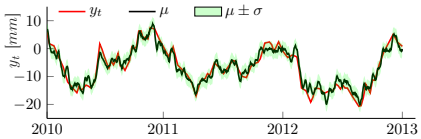
- Combine state regression & BDLM
- Fully probabilistic
- Interpretable components
- Good accuracy

Limitations

- Requires manual setup and feature engineering
- Multiple dependency modeling 

Conclusion

Displacement



Strengths

- Combine state regression & BDLM
- Fully probabilistic
- Interpretable components
- Good accuracy

Limitations

- Requires manual setup and feature engineering
- Multiple dependency modeling

OpenBDLM `https://github.com/CivML-PolyMtl/OpenBDLM/tree/ICOLD_benchmark`