Data-Driven of Spatio-temporal Prediction: Earthquakes Case

Group : 14 (HZL) – Dataset 1

Members : Zhang Yumeng Luo Wenjun Huang Yi

Instructors: Prof. Gianmarco Mengaldo & Dr. Adriano Gualandi

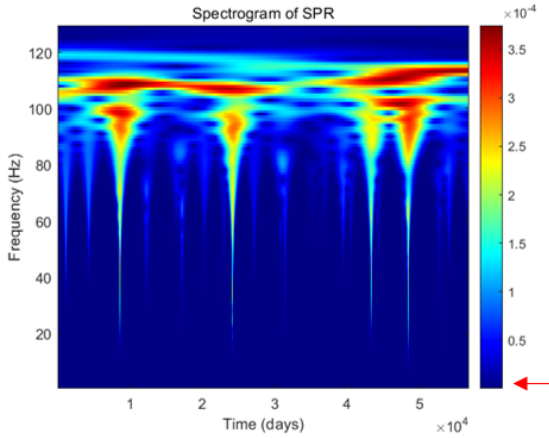
10/04/2023 presentation for 6 mins

CONTENT

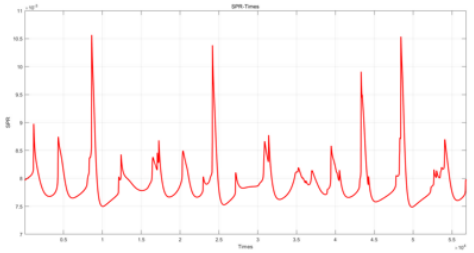
System Analysis

- System is dynamic spatio-temporal.

Temporal Analysis

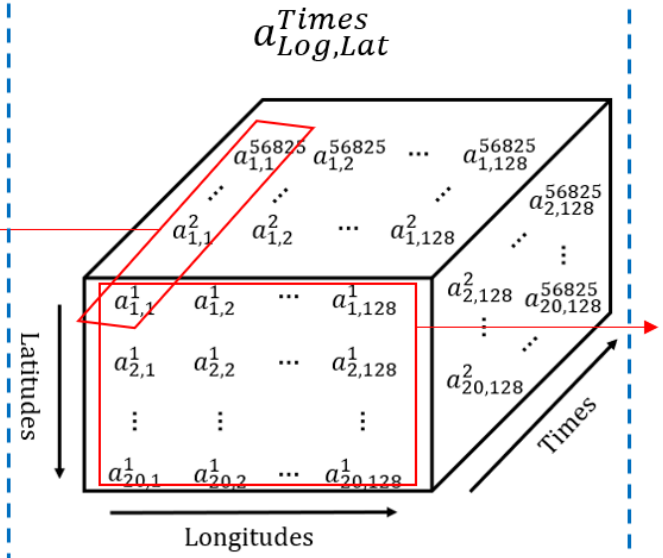


SPR Spectrogram

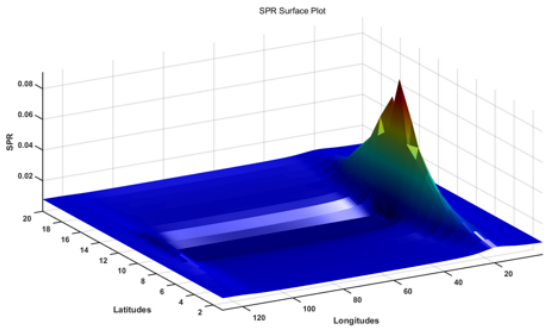


SPR Time Domain

Spatio-temporal Dataset



Spatio Analysis



SPR Surface

SPR Heatmap

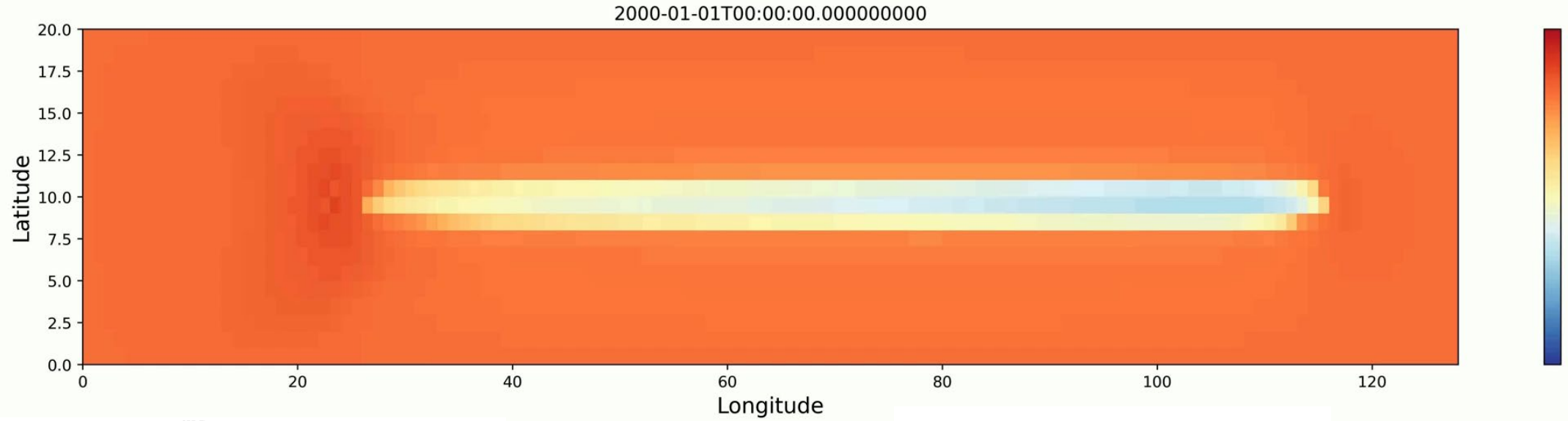
Conclusions

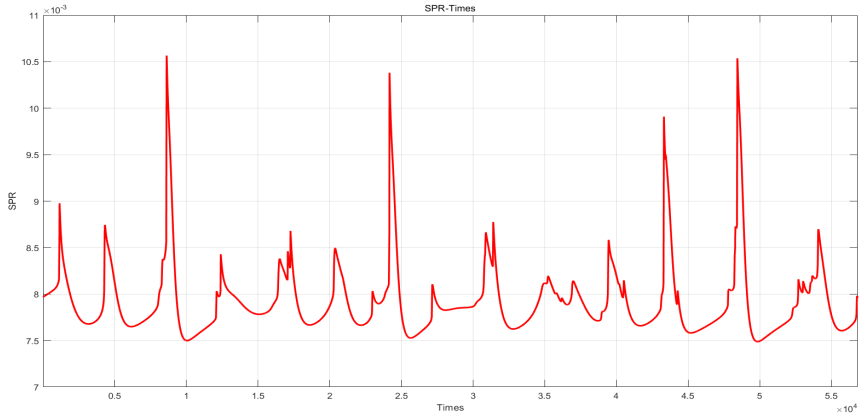
- Three dimensions.
- Spatial peaks exist.
- Variation with time periods.
- Energy concentration at 80-120Hz

System Analysis

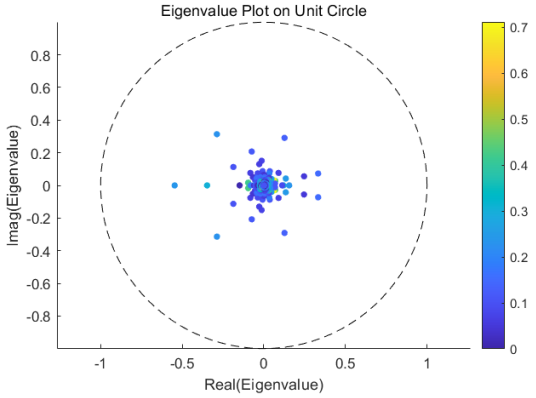
➢ System is predictable.

Dataset Visualization





- A point in space has periodicity in the time dimension.



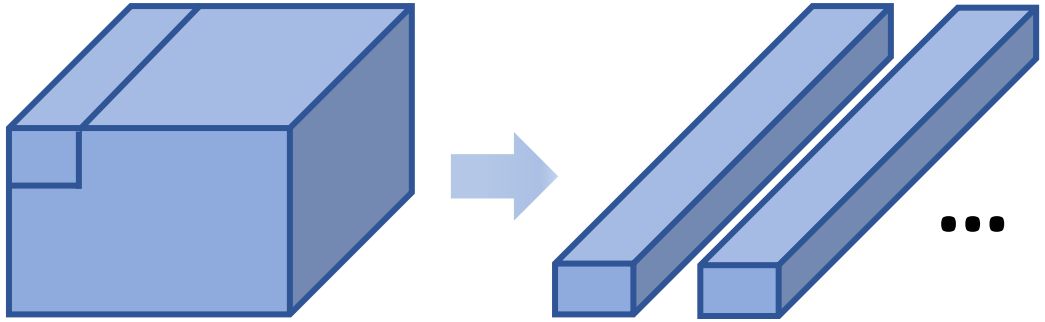
- The system is non-chaotic and decaying.

CONTENT

Time Series Prediction

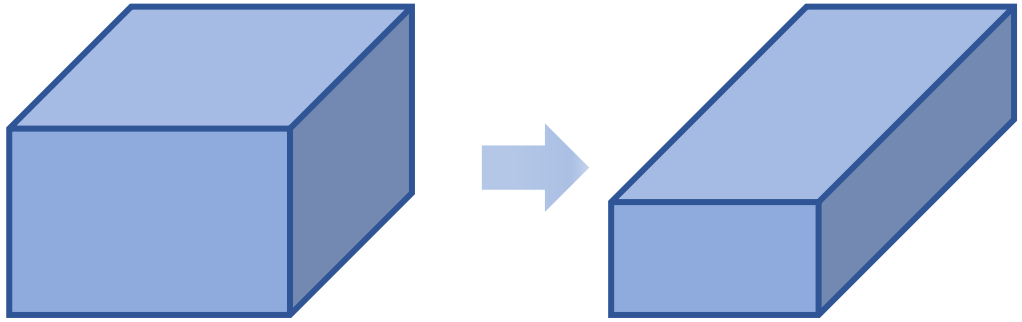
➢ Two prediction strategies for high-dimensional system.

System segment



- Divide the system into a series of small subsystems to improve prediction accuracy.

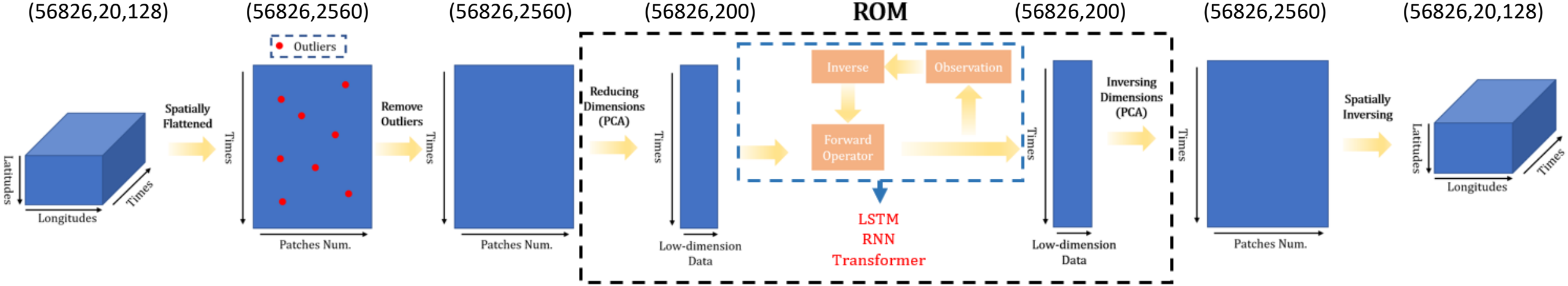
Reduce system order

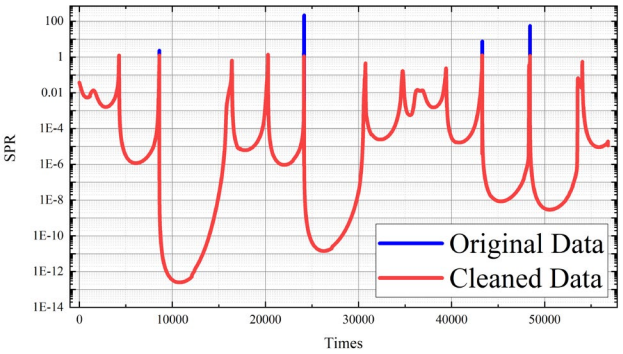


- Reduce the dimensions of system in space to reduce system complexity and computation.

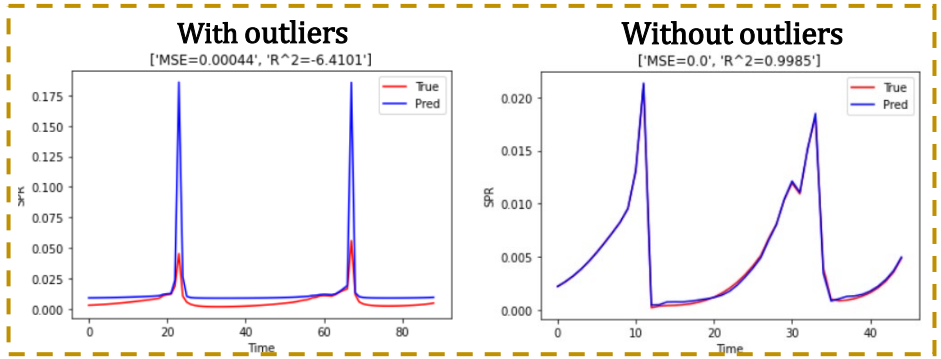
Reduced Order Model (ROM)

➢ Two prediction strategies for high-dimensional system.

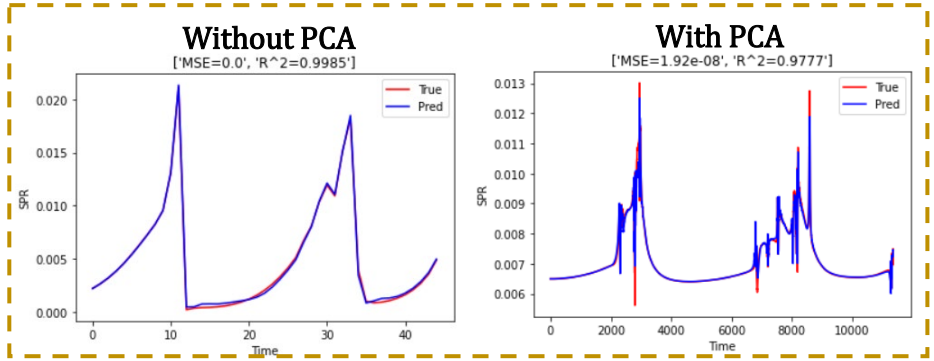




Data comparison of preprocessing



Pred. comparison of with/without outliers



Pred. comparison of with/without PCA

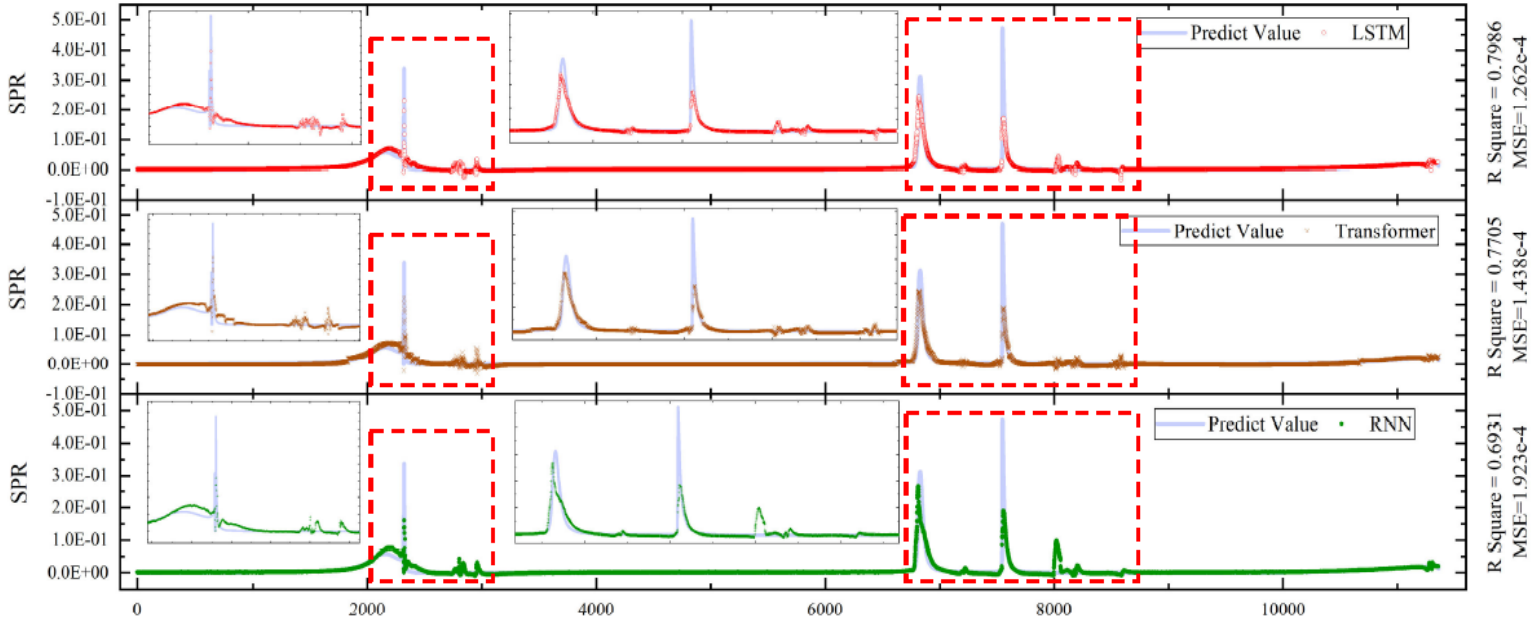
Reduced Order Model (ROM)

➢ Prediction using LSTM with PCA and preprocessing.

LSTM

Transformer

RNN



Name	R Square	MSE	Note
LSTM –With outliers – Without PCA	0.0183	0.0646	
LSTM –Without outliers – Without PCA	**0.9819**	**1.104e-5**	
LSTM – Without outliers – With PCA	0.8268	4.906e-5	**Time: 199.27 s**
LSTM – Without outliers – Without PCA	**0.9819**	**1.104e-5**	Time: 11873.31 s
LSTM – Without outliers – With PCA	**0.8268**	**4.906e-5**	
RNN – Without outliers – With PCA	0.4108	0.63143	
Transformer – Without outliers – With PCA	0.7989	6.750e-5	

Seen in SPR-Time fig:

- LSTM has best performance among RNN and Transformer.
- All of them cannot fit well in peak region.

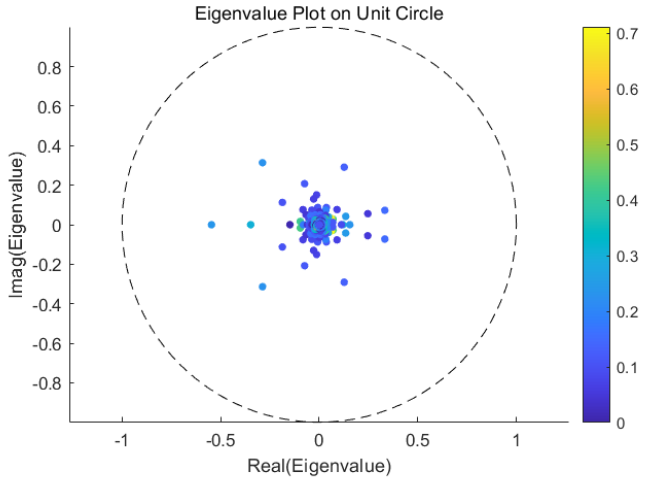
Summary:

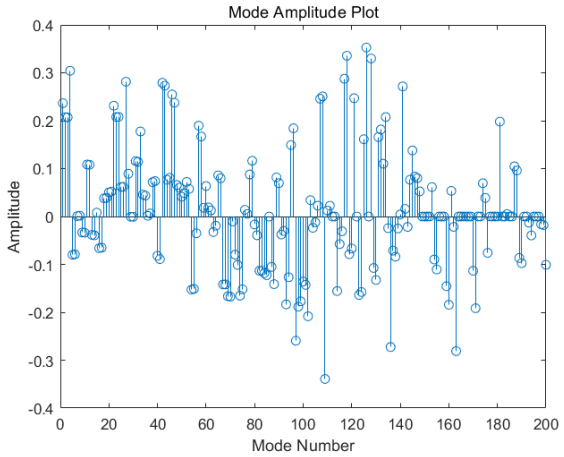
- LSTM with PCA predicts well, has fast response and short training cost.
- PCA-based reduction loses a lot of system information.

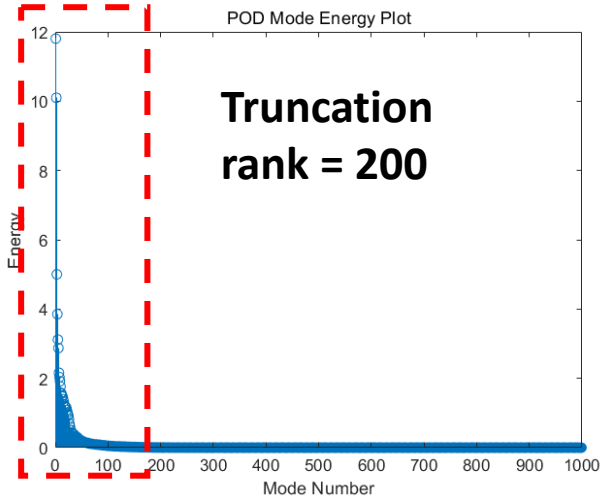
Content

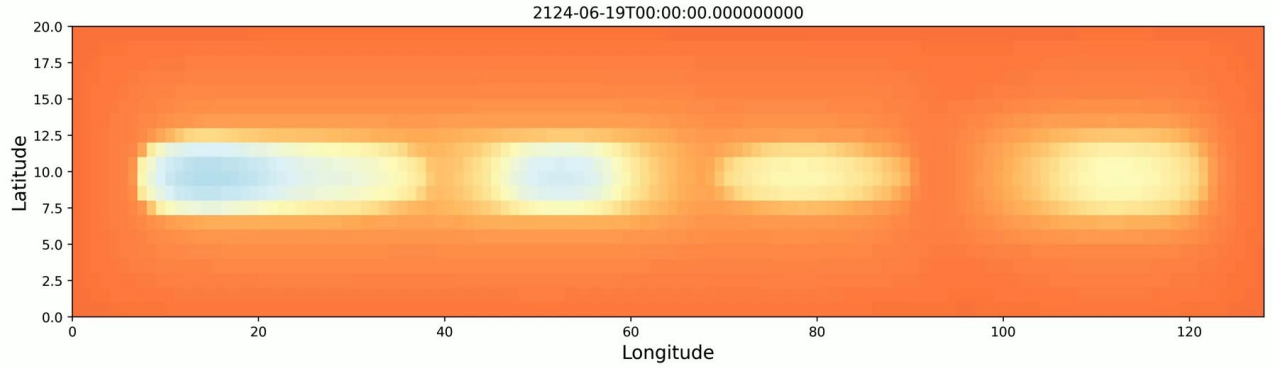
Dynamic Mode Decomposition (DMD)

➢ Prediction using DMD - Koopman.

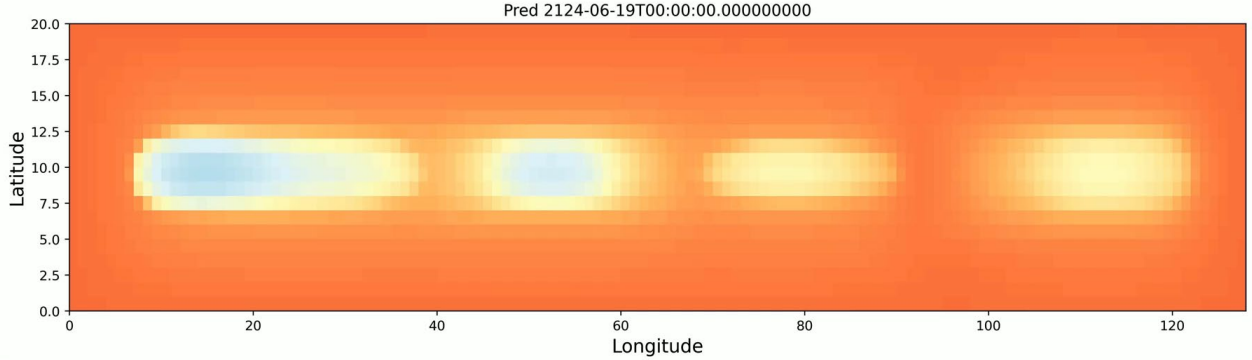








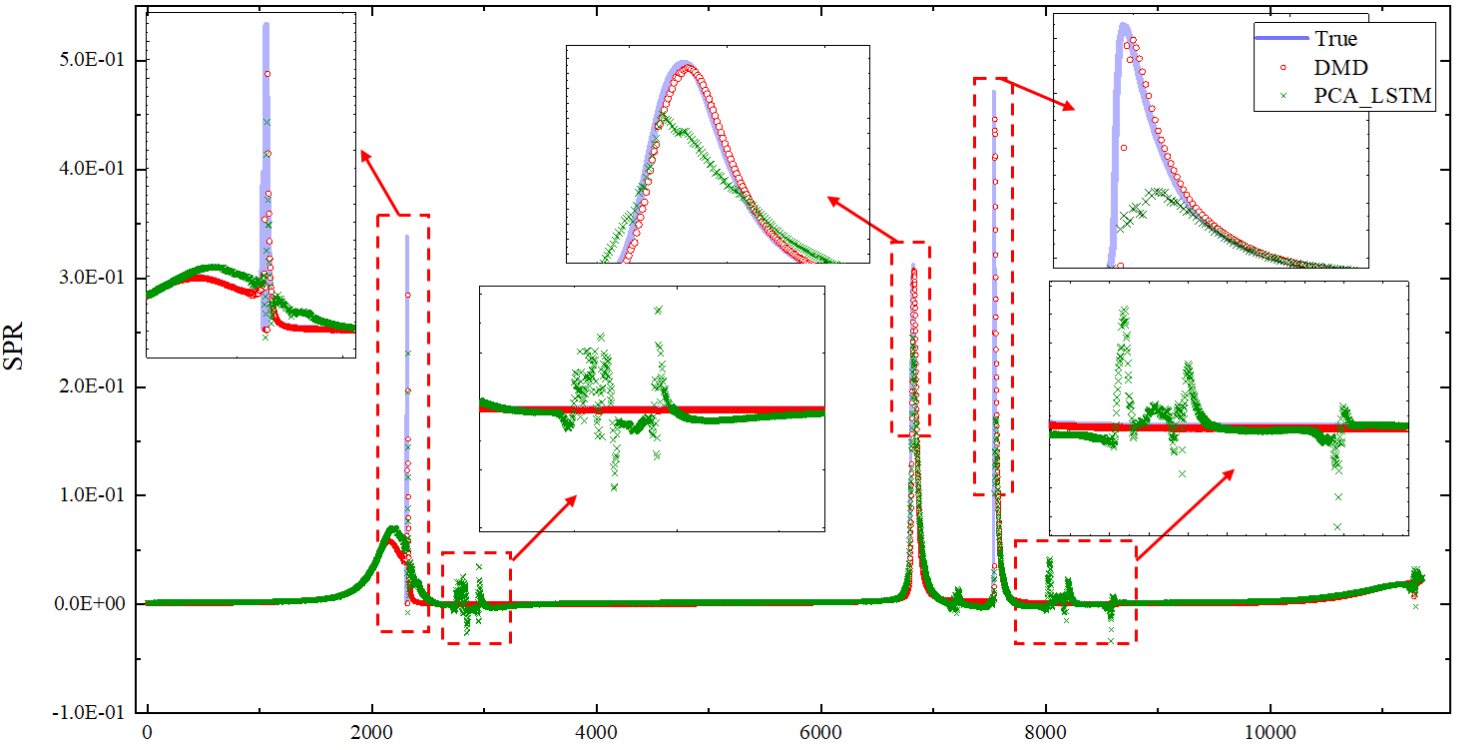
True



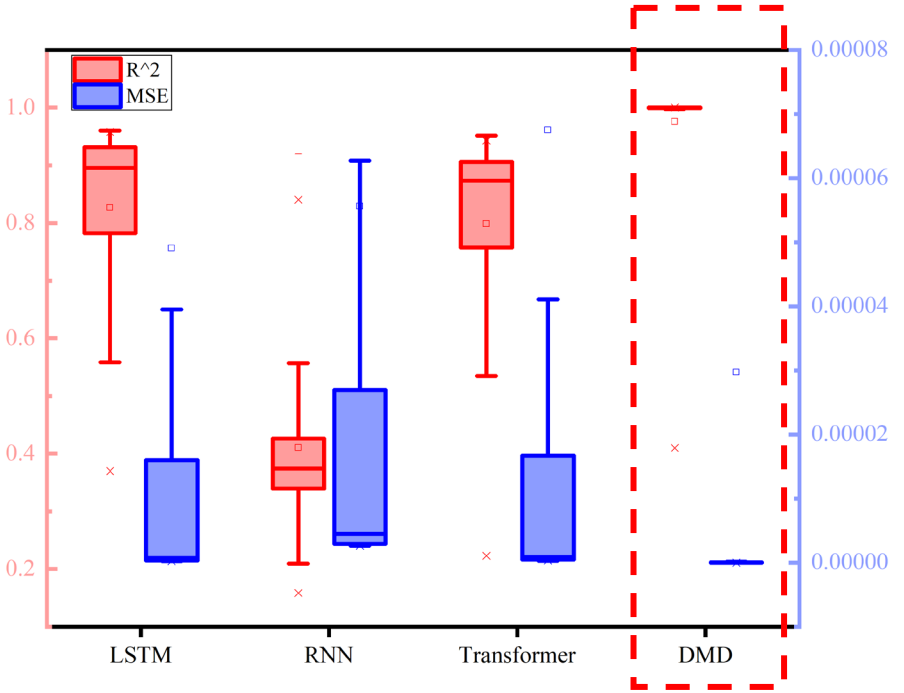
DMD Pred

Dynamic Mode Decomposition (DMD)

➢ Prediction using DMD - Koopman.



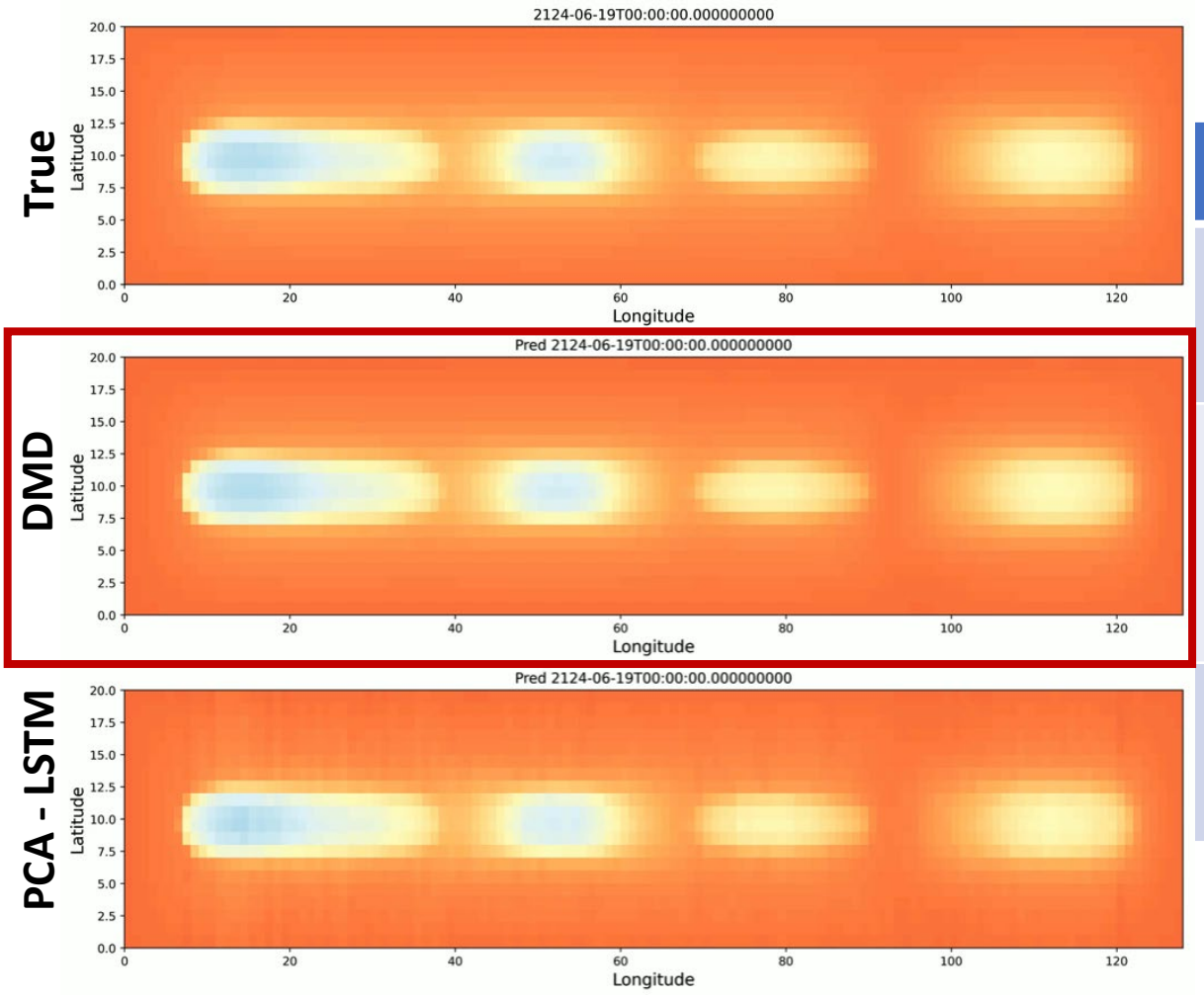
DMD: R Square = 0.9191, MSE = 5.069E-5
PCA_LSTM: R Square = 0.7986, MSE = 1.262E-4



- Compared with PCA-LSTM, DMD can fit well both in peak region and smooth region.
- DMD has the best prediction accuracy and stability among other models in ROM.

CONTENT

Summary



Summary

Perform time, space, frequency and modes analysis of systems.

Based on PCA reduce the system's order and apply three main-stream models to predict system status. (PCA-LSTM best)

Apply DMD-Koopman to predict the system and compare with PCA-LSTM. (DMD-Koopman better)

Thanks for listening!

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