Hybrid CNN-LSTM Framework for Predicting Subsurface Energy Production

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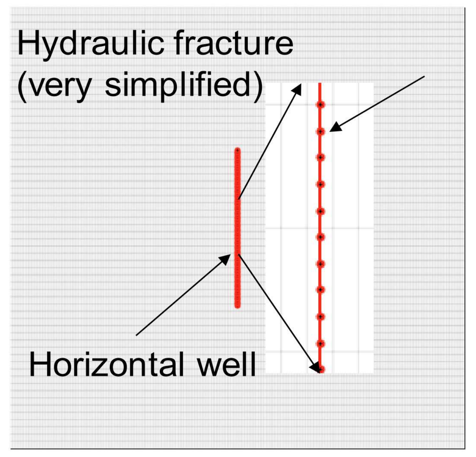
Introduction

Accurate prediction of subsurface energy production necessitates the modeling of complex, multi-scale processes. However, current modeling methods of these processes are often computationally expensive and inflexible.

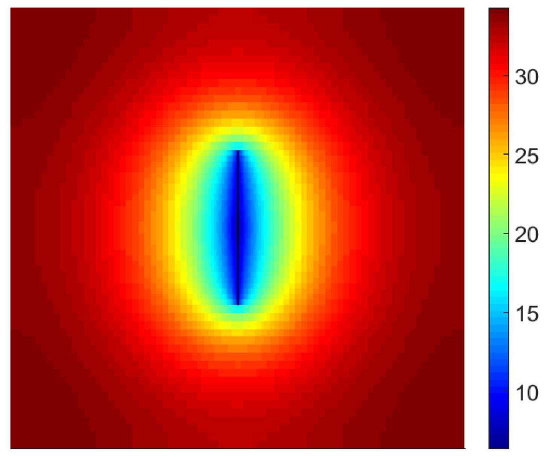
Proposal – This work aims to augment current development of a predictive data-driven platform (PDDP) for subsurface energy systems by researching the effectiveness of a CNN-LSTM Hybrid model architecture towards tackling this spatio-temporal problem.

Dataset

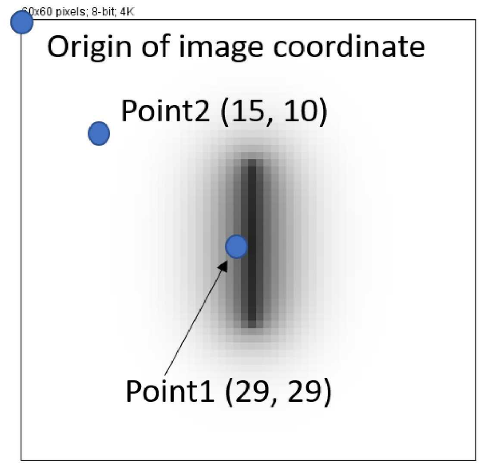
- Data used to model subsurface energy production was obtained using the MRST-Shale simulator.
- The goal of this work is to predict cumulative energy production (*temporal* data) and pressure distribution over time (*spatio-temporal* data)



Horizontal well with hydraulic fractures



Pressure distribution



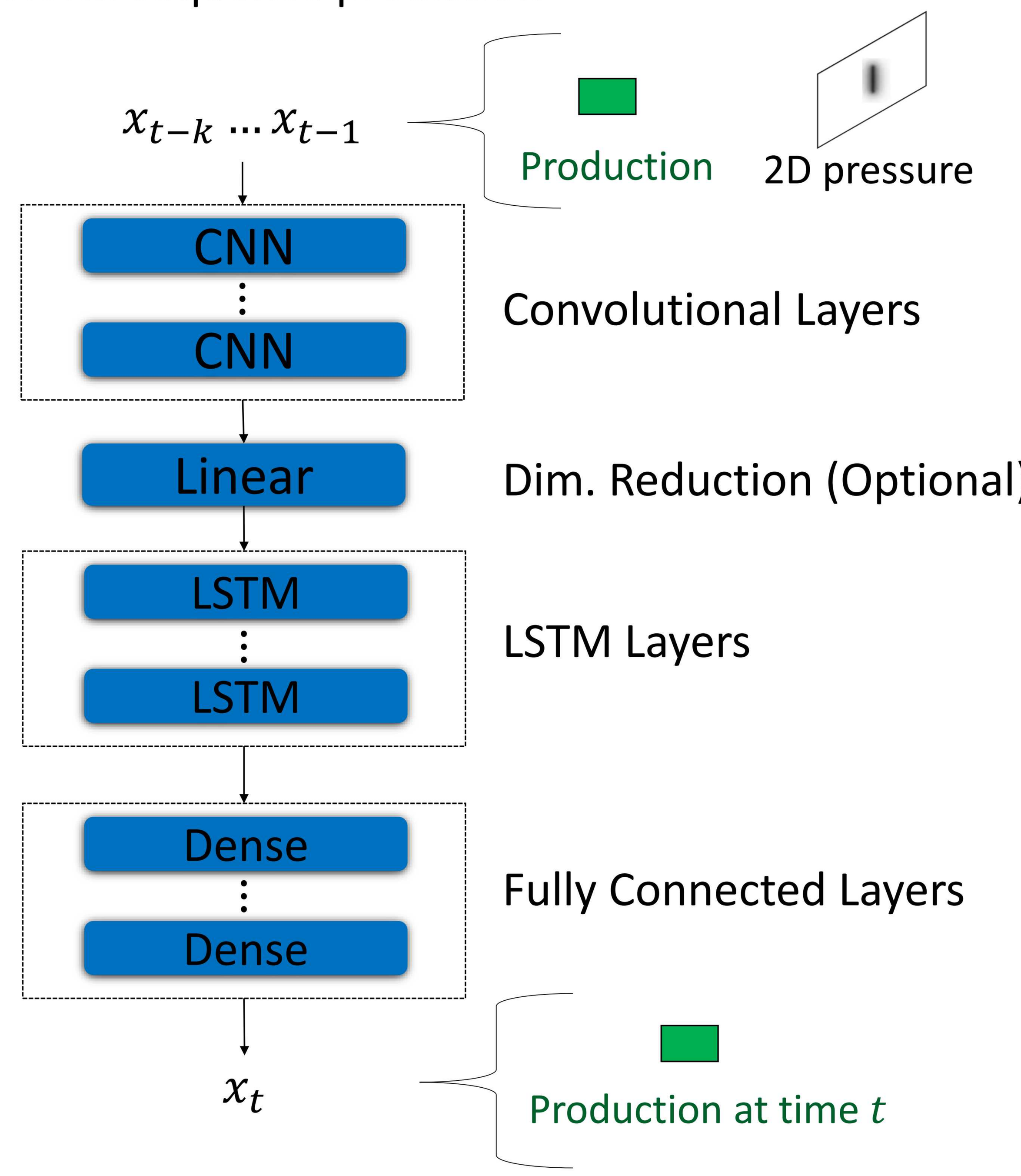
Normalized Pressure dist.

- The dataset contains five features:
  - *Permeability* – measure of interconnectivity
  - *Porosity* – measure of the void spaces
  - *Hydraulic conductivity* – ease with which media can move through fractures
  - *Bottom hole pressure* – pressure acting on the walls of the fracture
  - *Fracture aperture* – perpendicular width of the open fracture
- The dataset contains samples at 30 different time points across 28 total cases
  - Training and validation set – 25 cases
  - Test set – 3 cases

Methodology: CNN-LSTM

The CNN-LSTM hybrid model is an architecture specifically designed to tackle problems where the input data has both spatial and temporal structure

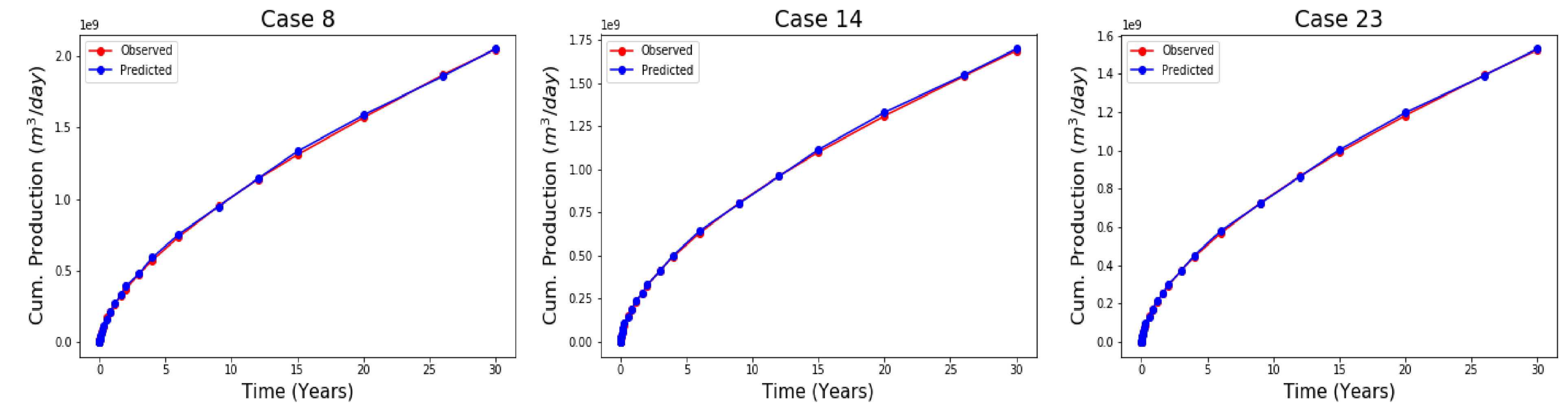
- The CNN Layers perform feature extraction on the multi-dimensional input data
- The LSTM layers interpret these features across time in order to perform sequence prediction



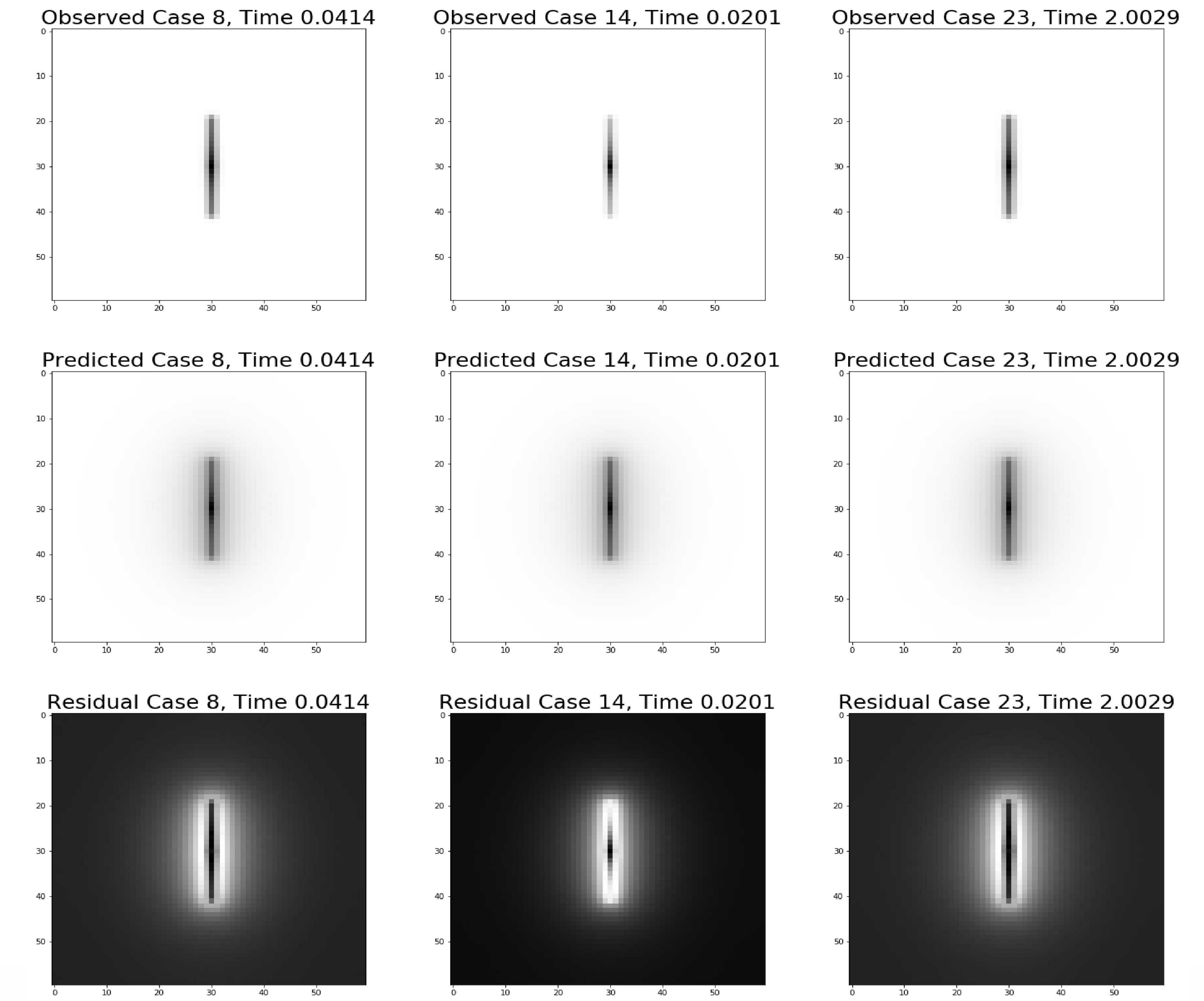
Model Parameters		Models	
		Cum. Energy Production	Pressure Distribution
CNN	# of layers	3	4
	# of hidden units	128, 64, 128	256, 128, 256, 128
	Kernel Size	3x3, 1x1, 3x3	3x3, 1x1, 3x3, 1x1
LSTM	# of layers	2	2
	# of hidden units	128, 64	128, 64
Dim. Reduction Layer		Y	N
Optimizer		Adam	NAdam

Results

Cumulative Energy Production



Pressure Distribution



Discussion

Cumulative Energy Production – Model obtained accurate performance, despite 'lightweight' implementation

Pressure Distribution – Model obtained promising initial results, despite lack of optimization

Future work

- Investigate effect of different model considerations on accuracy, e.g. multi-scale additions for short- and long-term contexts.
- Investigate additional promising model architectures, e.g. Bidirectional LSTMs, etc.

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