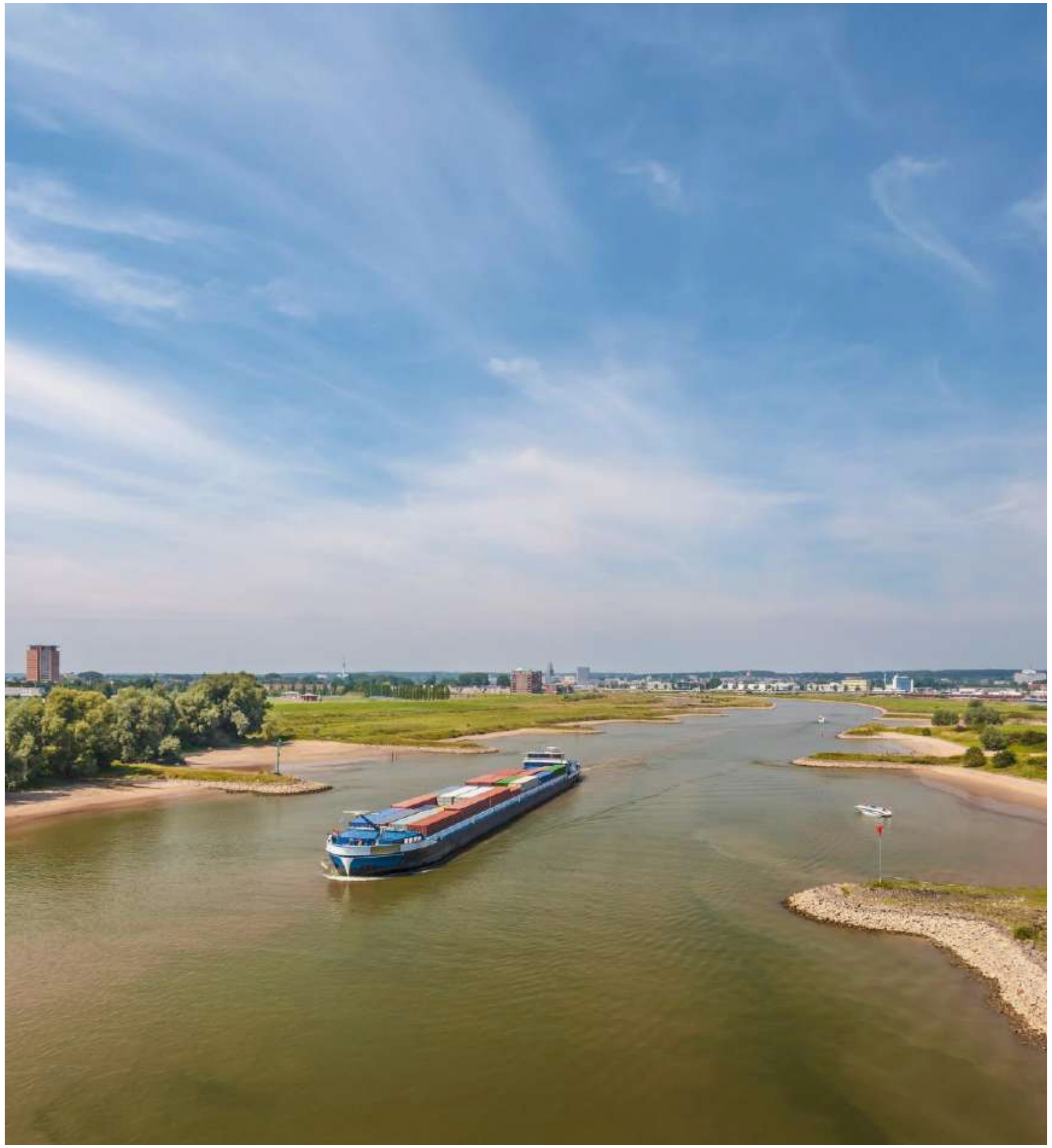
Digishape Online Technical Sessions

Bed Level Predictions Waal with spatio-temporal networks

29 may 2024



Content

- Introduction
- Model
- Challenges
- Data processing
- Discussion

Introduction
Timeline

Digishape Seedmoney
June 2022


Nieuws

DigiShape-project gaat met machine learning waterdiepte van de Waal voorspellen

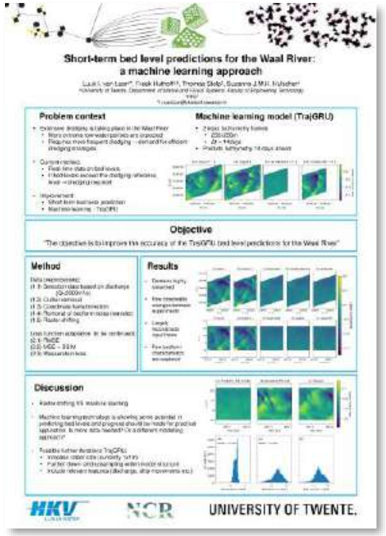
Is het mogelijk om via machine learning de waterdiepte van de rivier de Waal te voorspellen? Zodat er efficiënter gebaggerd of slimmer beladen kan worden? Deze vraag gaat HKV verkennen met 10.000 euro seedmoney van DigiShape. We spraken projectleider Andries Paarlberg van HKV: wat gaan ze precies doen? En wat hopen ze hiermee te bereiken?

Wat ging er aan jullie innovatie vooraf?

Wat is daarvan het voordeel?

TrajGRU model
Jan 2023

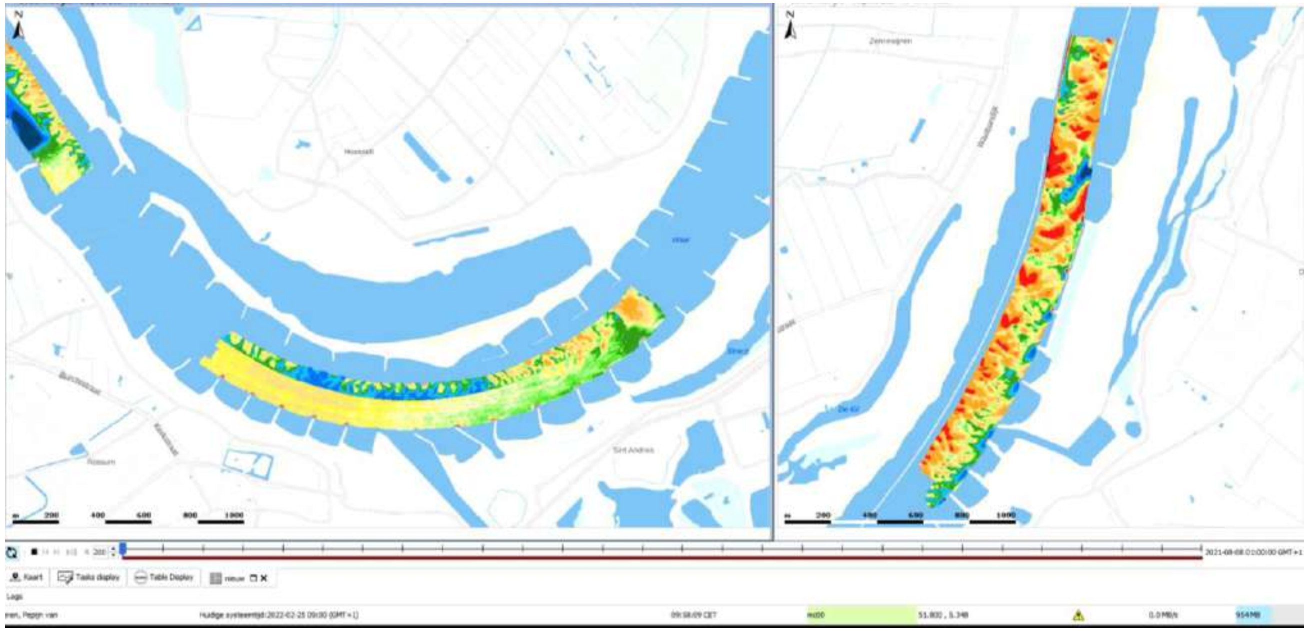
NCR poster
Nov 2023



Luuk I. van Laar, Freek Huthoff, Thomas Stolp, Suzanne J.M.H. Hulscher

Introduction
Bed level in the Waal

- Digital Twin of the Waal river
- Integration of bi-weekly multibeam measurements
- Monitoring of MGD and dredging operations
- Questions around forecasting



Introduction

Spatio-temporal networks

- Forecasting algorithms for sequential raster data

Spatio-temporal networks

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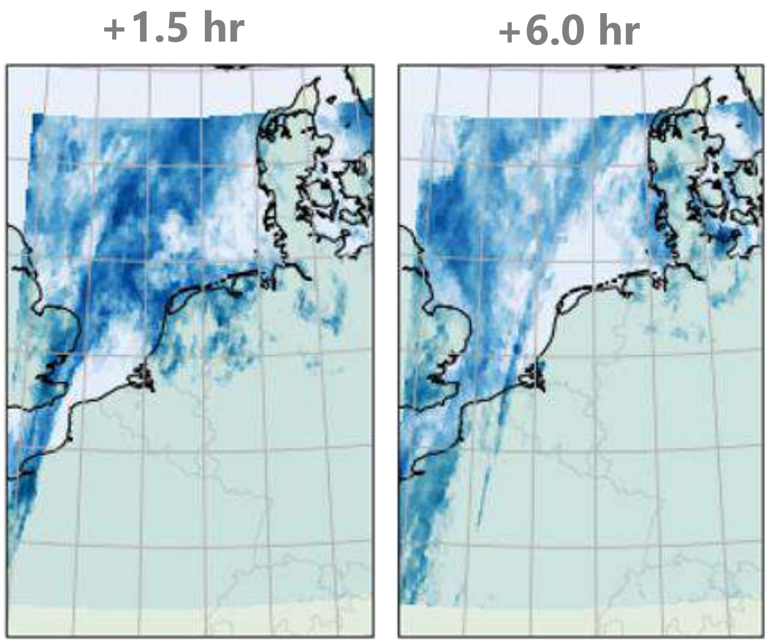
- Use cases:
  - Solar radiation
  - Extreme precipitation



PYTHIA
ENERGY INTELLIGENCE

Introduction
Spatio-temporal networks

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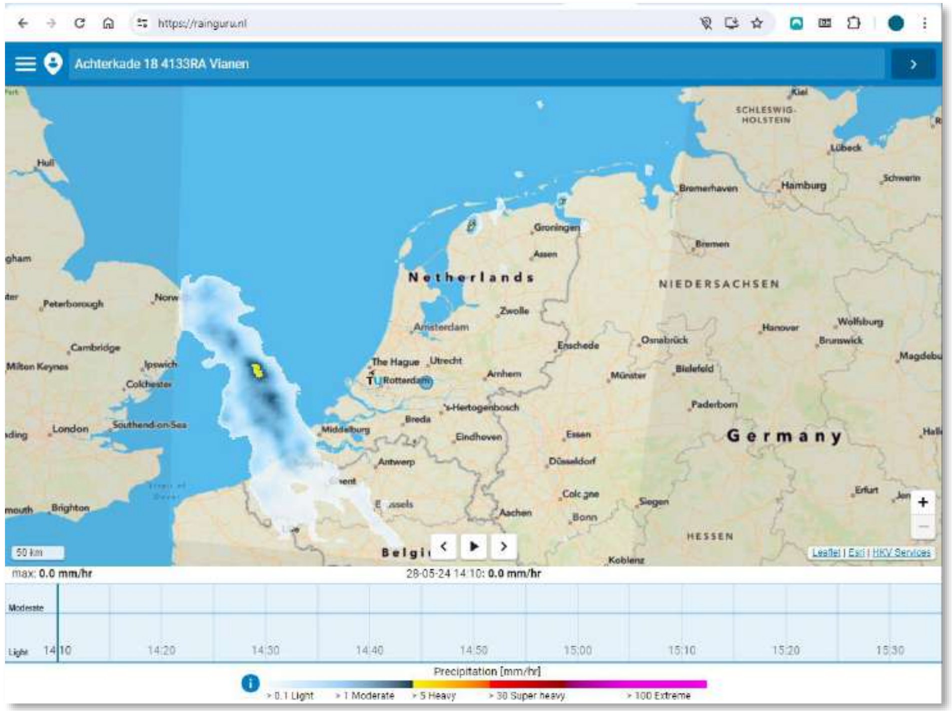
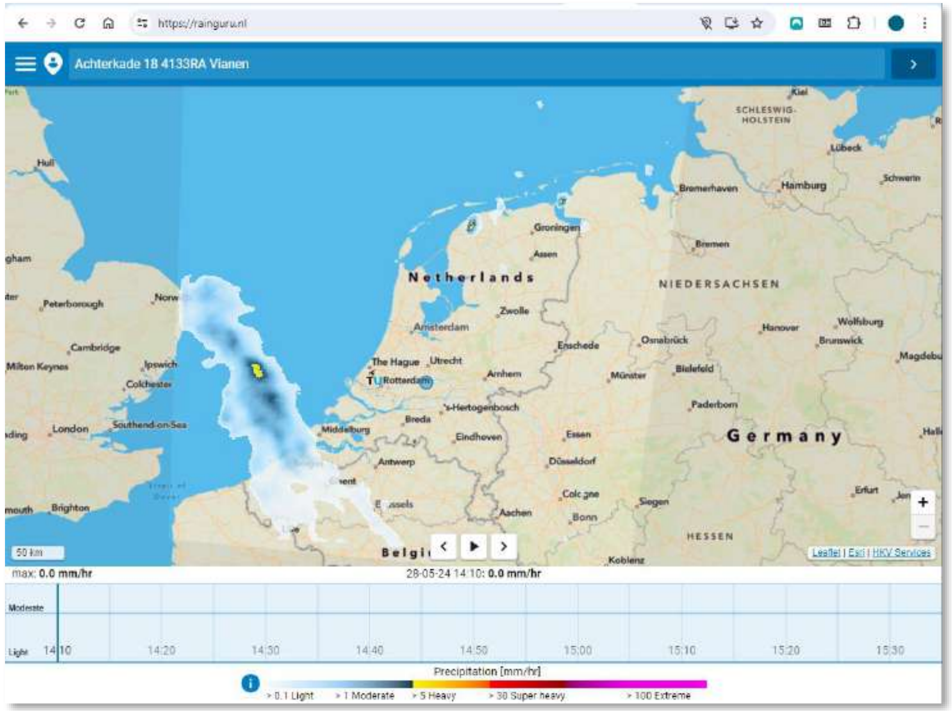


Introduction

Spatio-temporal networks

- Forecasting algorithms for sequential raster data
- Use cases:
  - Solar radiation **(GAN)**
  - Extreme precipitation **(TrajGRU)**

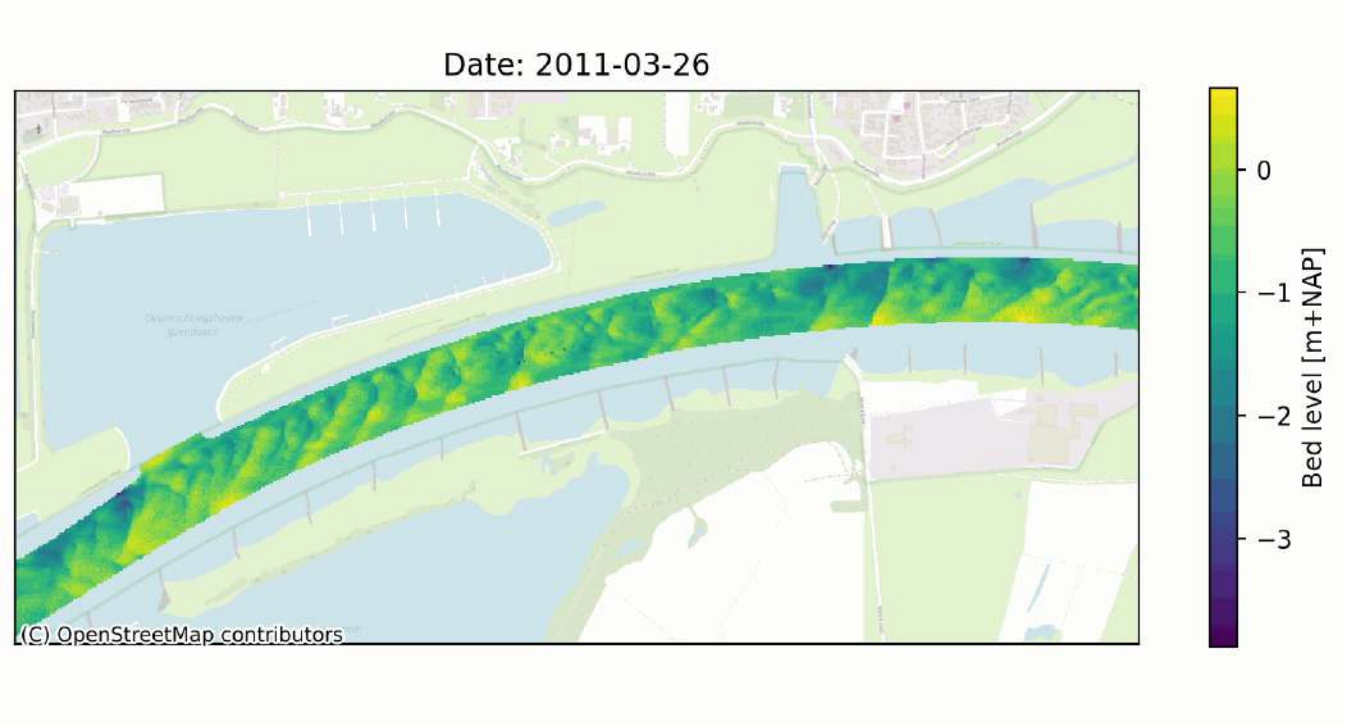


Introduction
Research question

- *Is it possible to train a spatio-temporal model for forecasting of bed levels in the Waal River?*

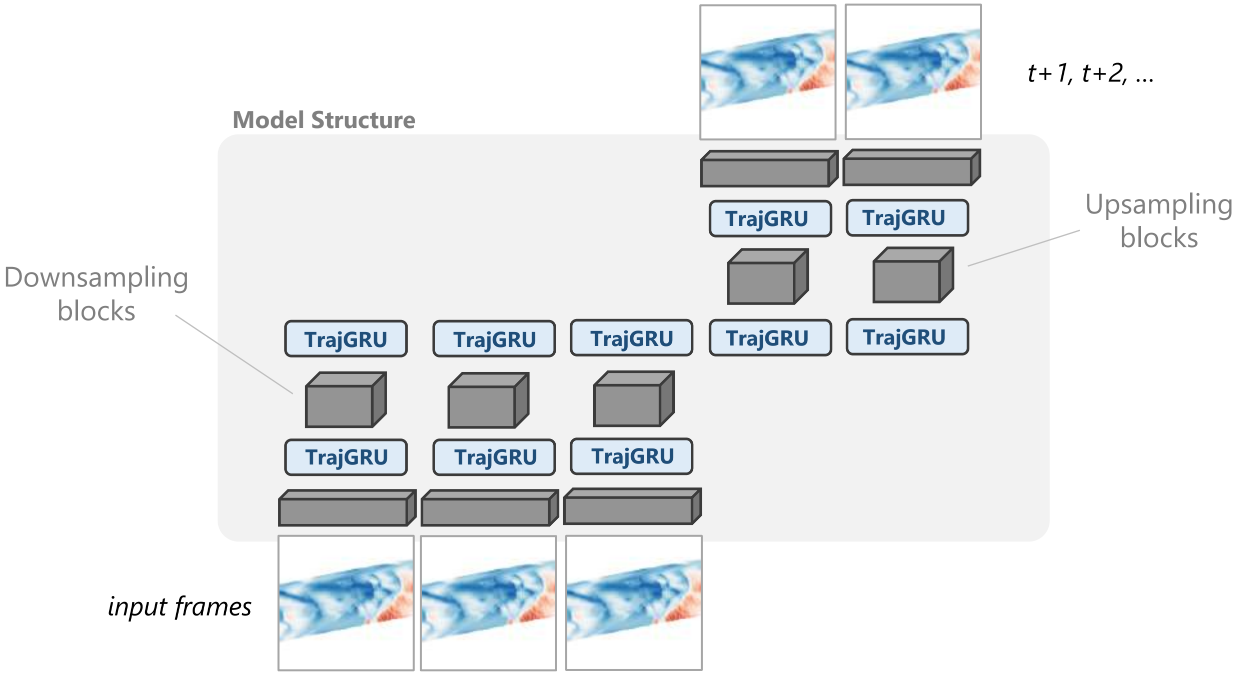
Model selection

- Large dataset, entire length of Waal and collected over many years
- High resolution in temp. dimension (multibeam)



Model
TrajGRU

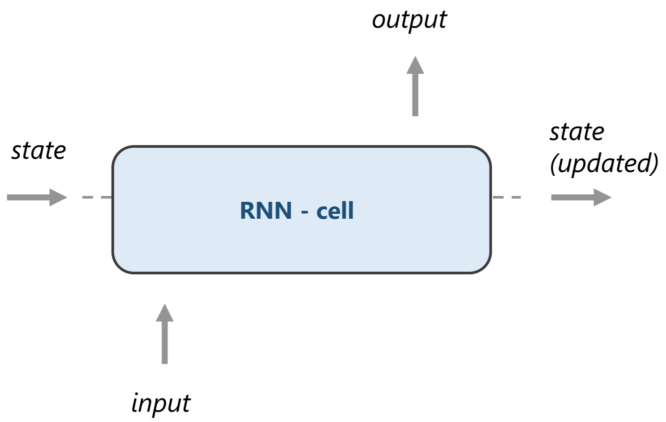
- Encoder-decoder structure
- Extract important features
- Recurrent cells (with convolution), the state or "memory"



Model

TrajGRU

- Input and state interaction
- Gates for updating, resetting
- Extensions with convolution (ConvLSTM)
- TrajGRU uses extra warp function



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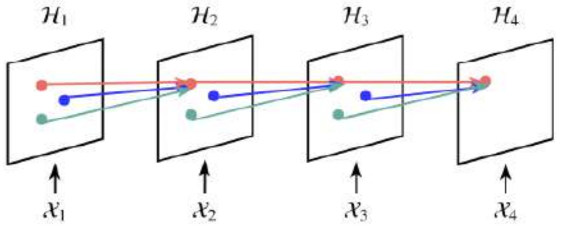
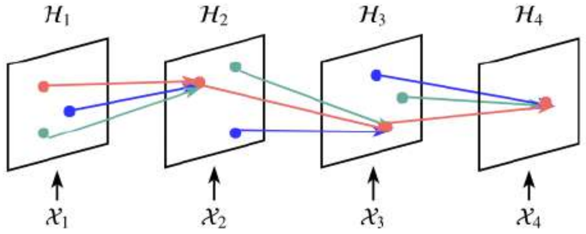


(a) For convolutional RNN, the recurrent connections are fixed over time.

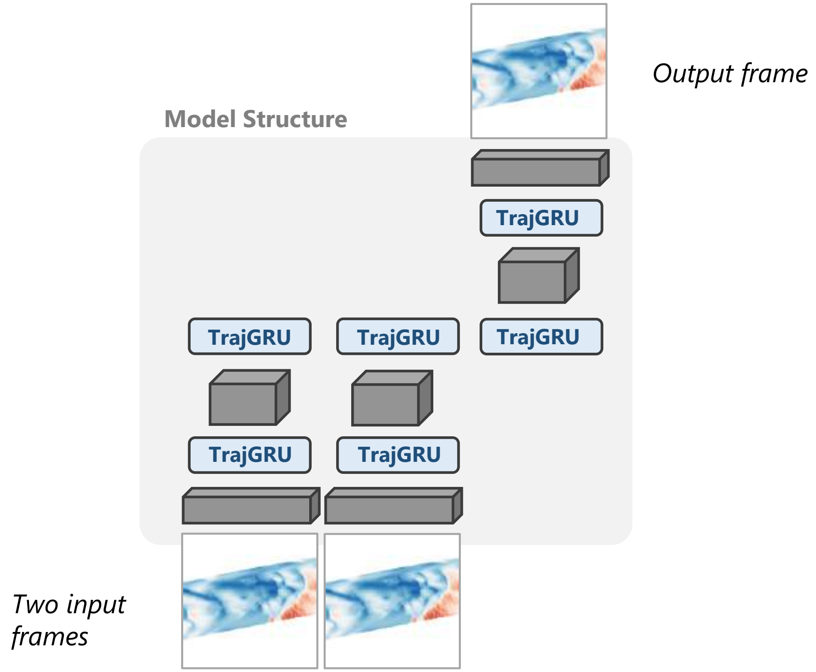


(b) For trajectory RNN, the recurrent connections are dynamically determined.

{1} Shi, X., Gao, Z., Lausen, L., Wang, H., Yeung, D. Y., Wong, W. K., & Woo, W. C. (2017). Deep learning for precipitation nowcasting: A benchmark and a new model. *Advances in neural information processing systems*, *30*.

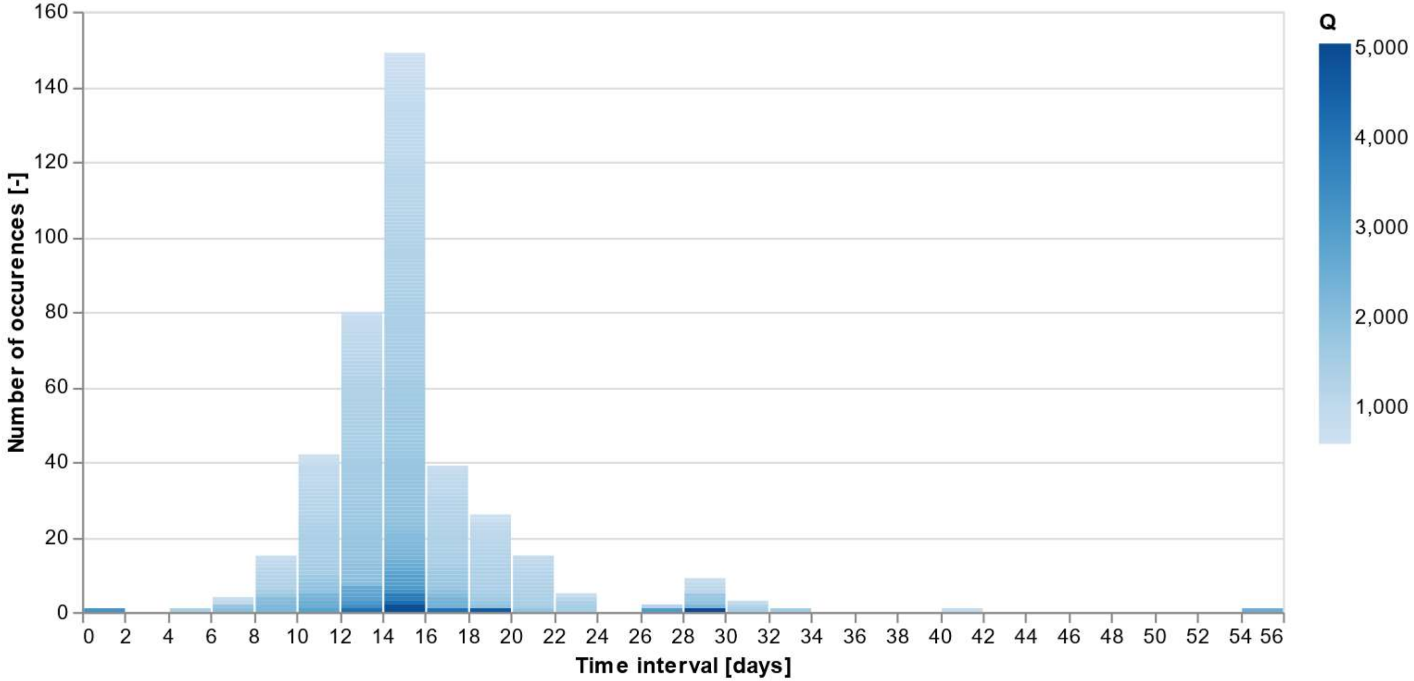
Model
TrajGRU

- Modified architecture, reduced size
- Two input frames, one output



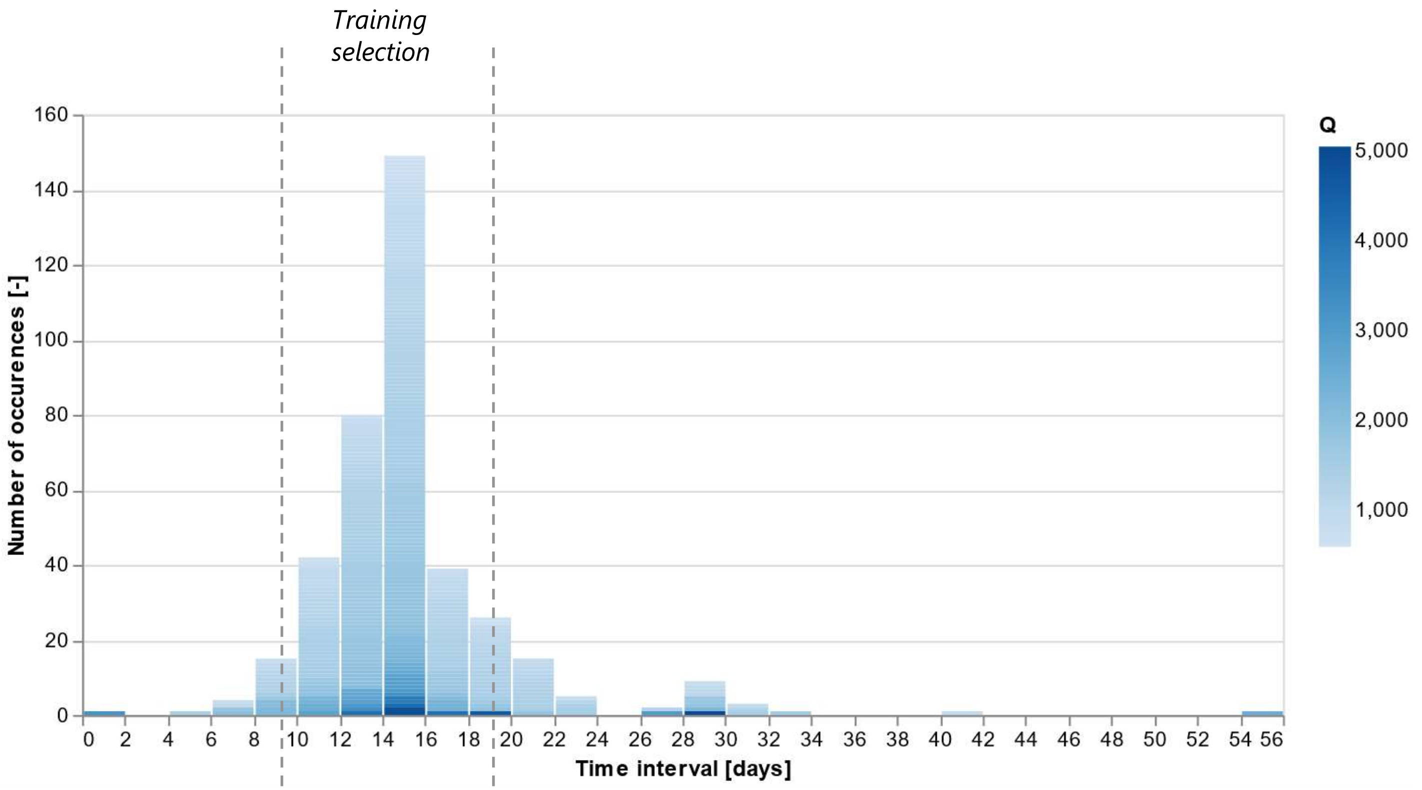
Challenges
Irregular time intervals

- Time between two measurements varies
- Increased complexity in training



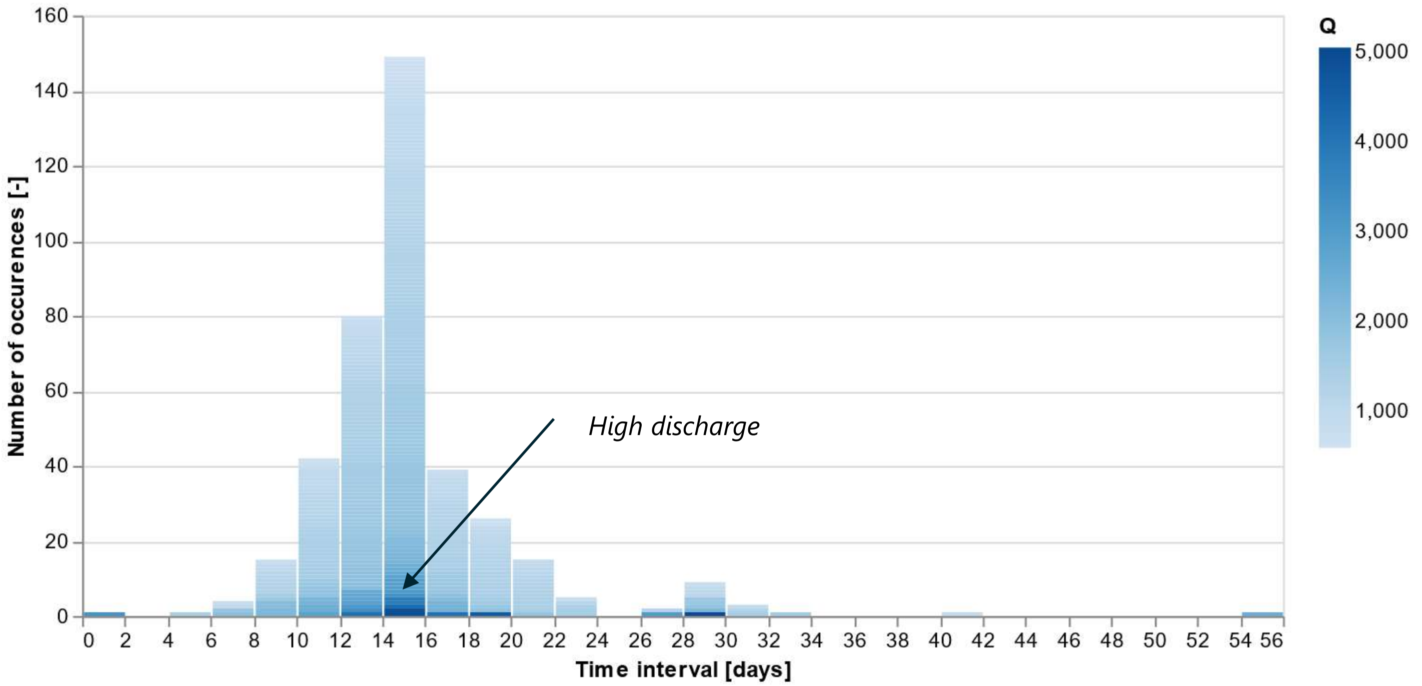
Challenges
Irregular time intervals

- Regularization of time series



Flow regimes

- Discharge regimes
- The dune length λ, and 14-day dune celerity *14c*.
- Exclude high discharge regime (>2000m3/s)



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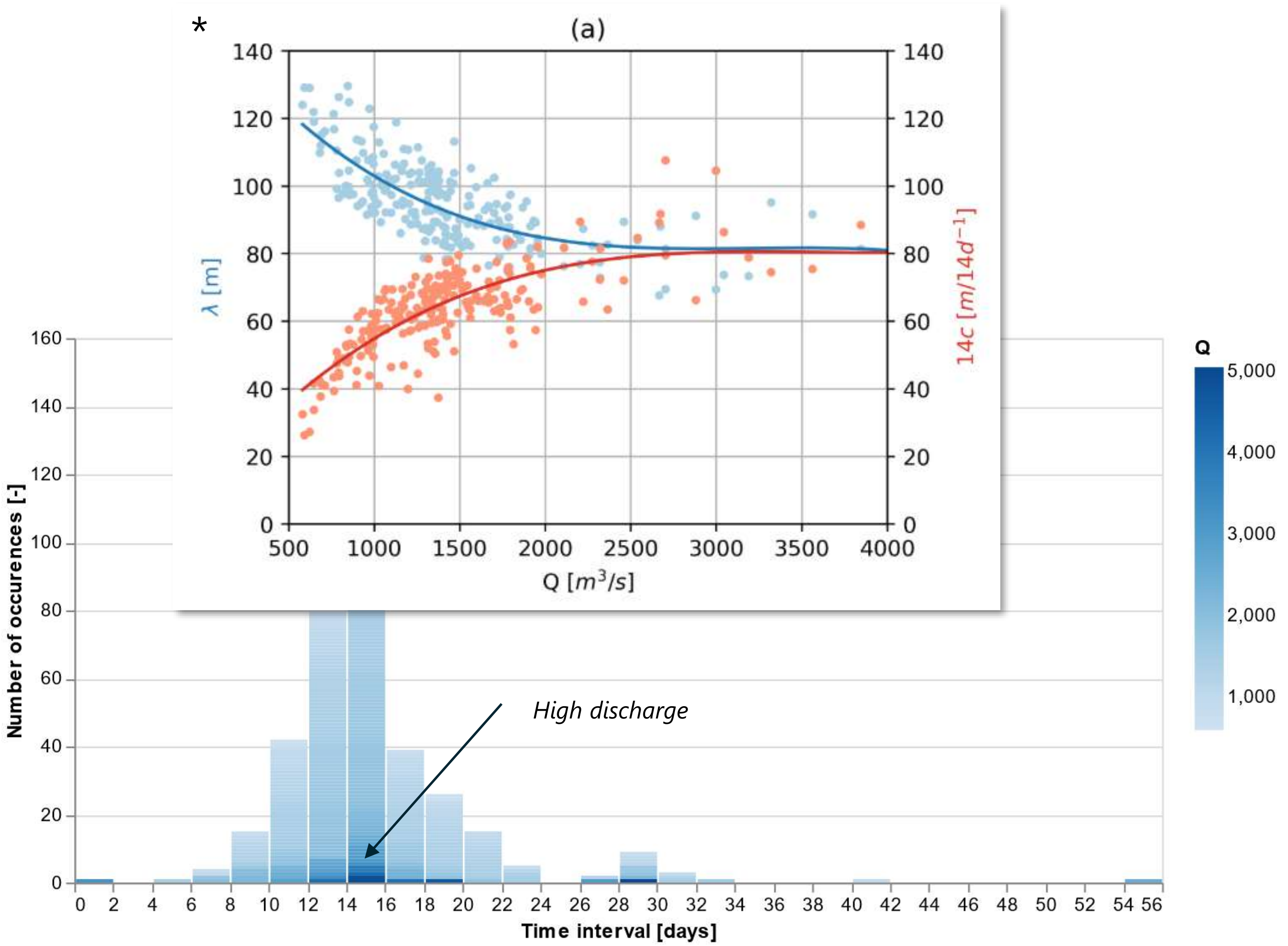

* Laar, L. I. (2024). *Two data-driven approaches for predicting bed levels in 3D for the Waal River* (Master's thesis, University of Twente).

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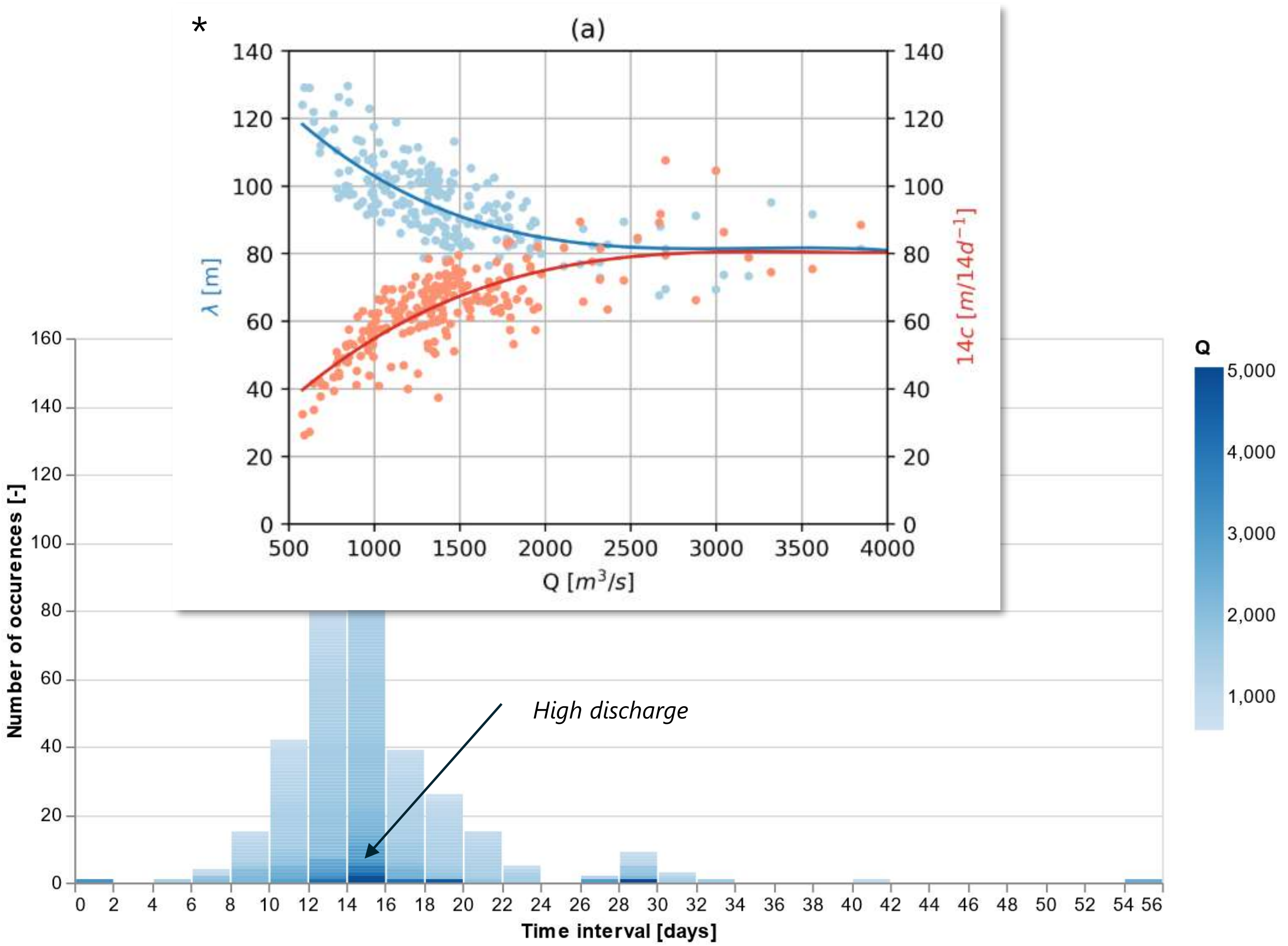

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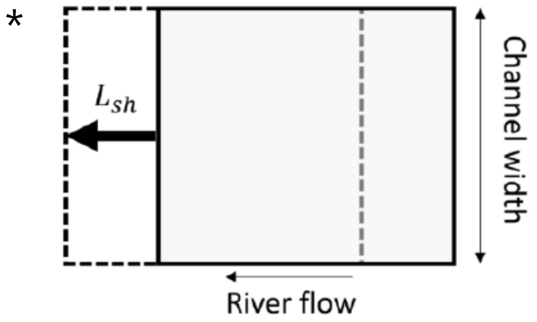
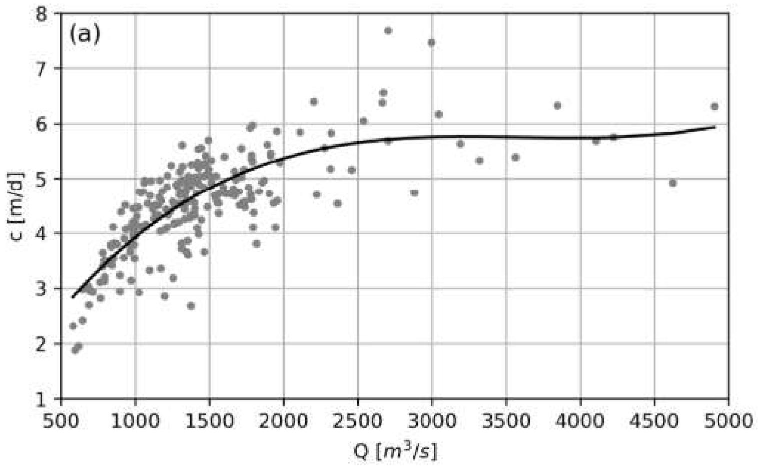
Challenges

Irregular time intervals

- Feature engineering with dune celerity
- Make time intervals more consistent (14 days)





Lokin, L. R., Warmink, J. J., Bomers, A., & Hulscher, S. J. M. H. (2022). River Dune Dynamics During Low Flows. Geophysical Research Letters, 49 (8)

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Data preprocessing
Three techniques

- Improved the removing of outliers in training data
- Stream coordinate transformation
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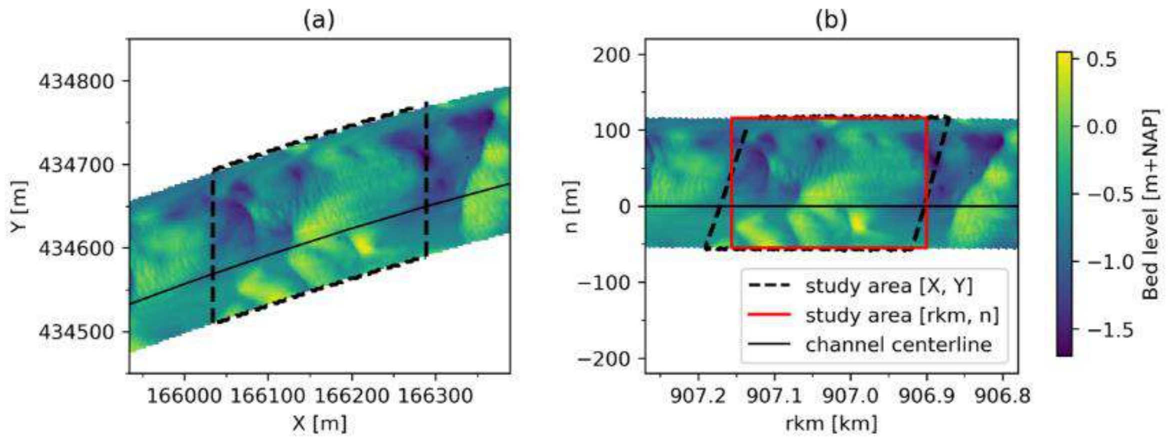

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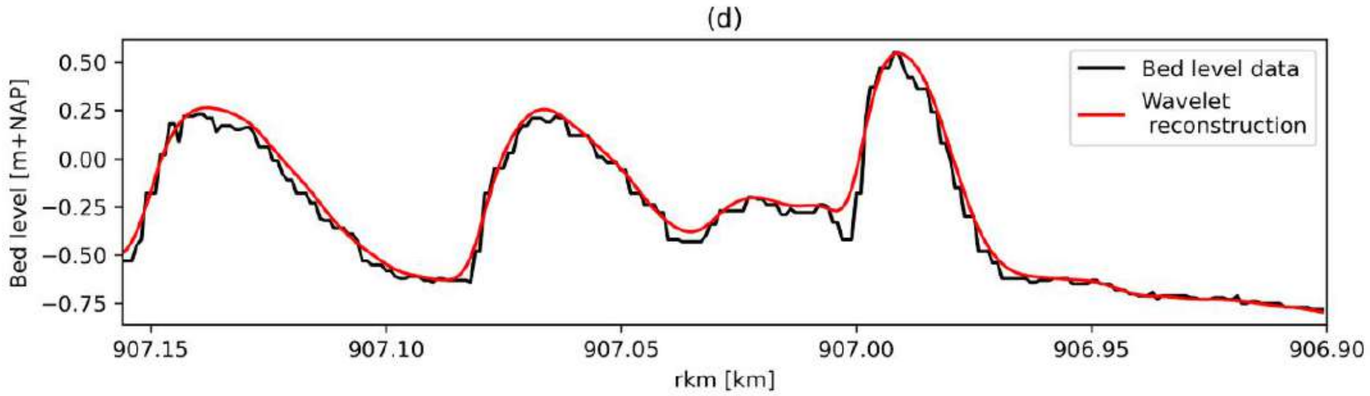

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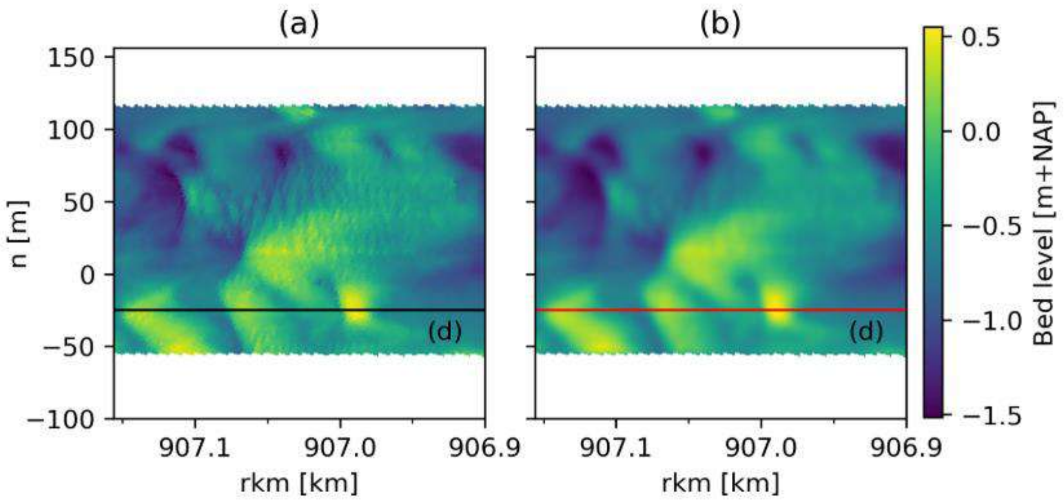

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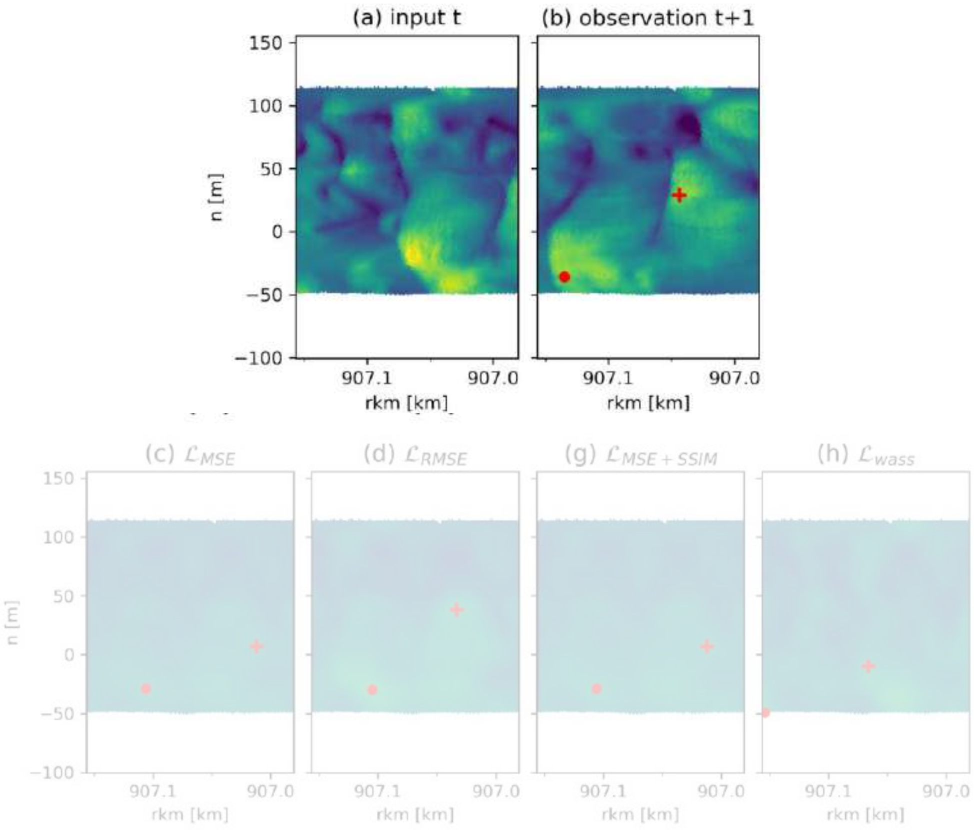
Discussion
Results

- Testing different loss functions
- Smooth output, also some fading



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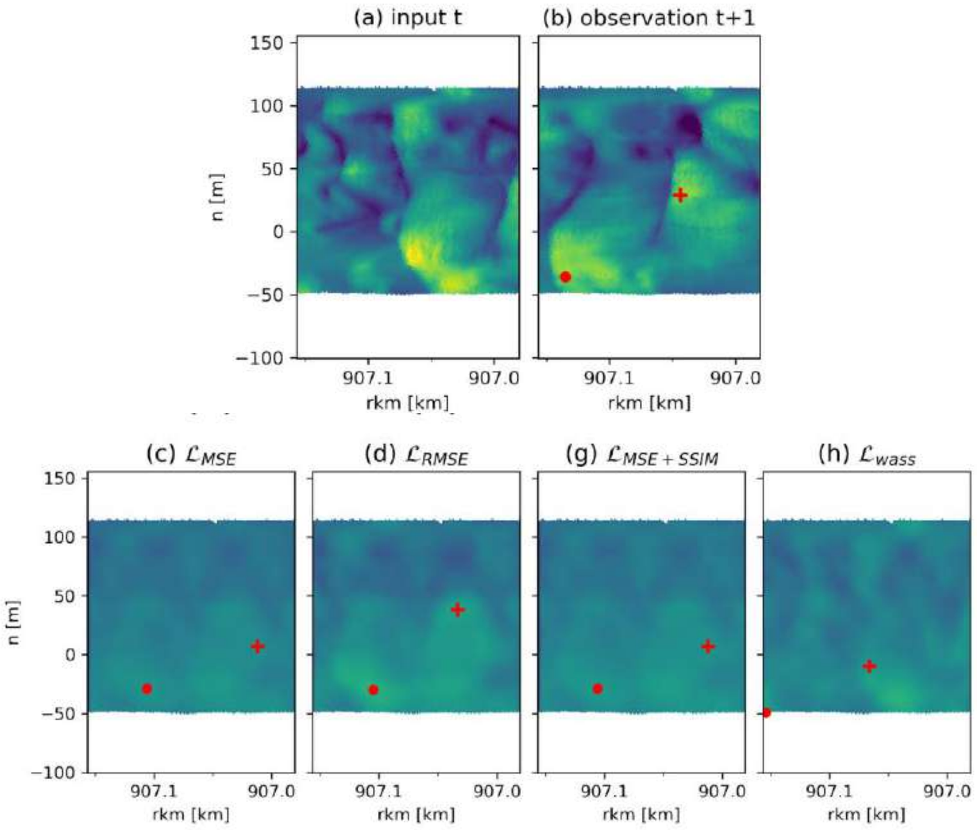

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Discussion

Questions

Thanks for your attention

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