DROUGHT FORECASTING USING A HYBRID NEURAL ARCHITECTURE FOR INTEGRATING TIME SERIES AND STATIC DATA
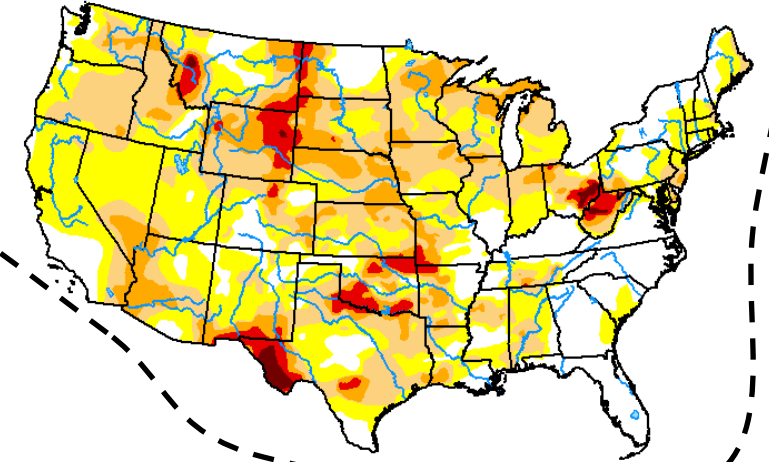
Julian Agudelo [1,2]

Vincent Guigue [1]

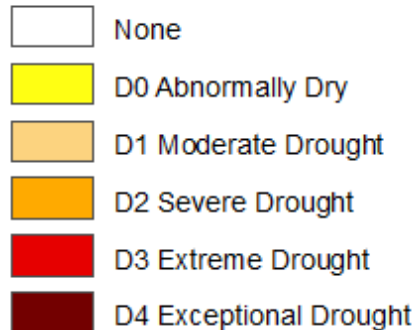Cristina Manfredotti [1]

Hadrien Piot [2]

1. INTRODUCTION

Drought is a natural phenomenon characterized by a prolonged period of below-average precipitation.
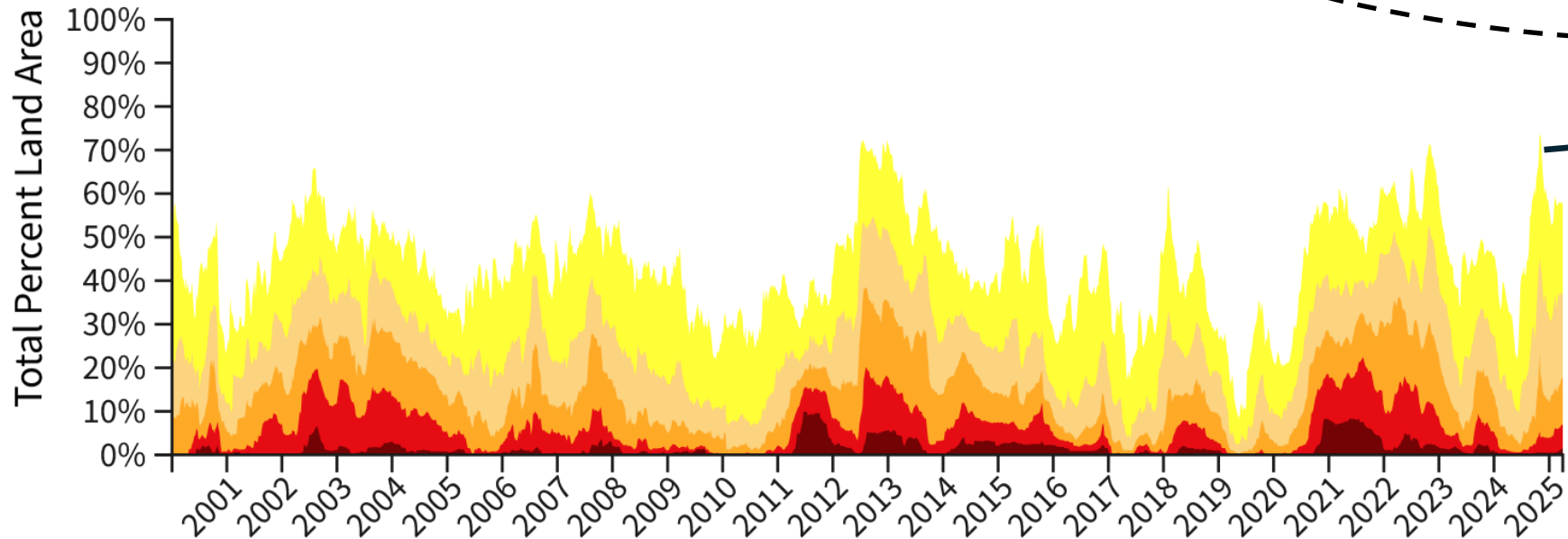
By October 15, 2024, 77 % of the continental US was experiencing drought conditions

Intensity:

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

droughtmonitor.unl.edu

1. INTRODUCTION

- Most previous deep learning approaches target **homogeneous regions** and/or use **single-modality data**.

- **DroughtED [1]:** public large-scale dataset containing **static data, time series, and an expert-informed metric**.

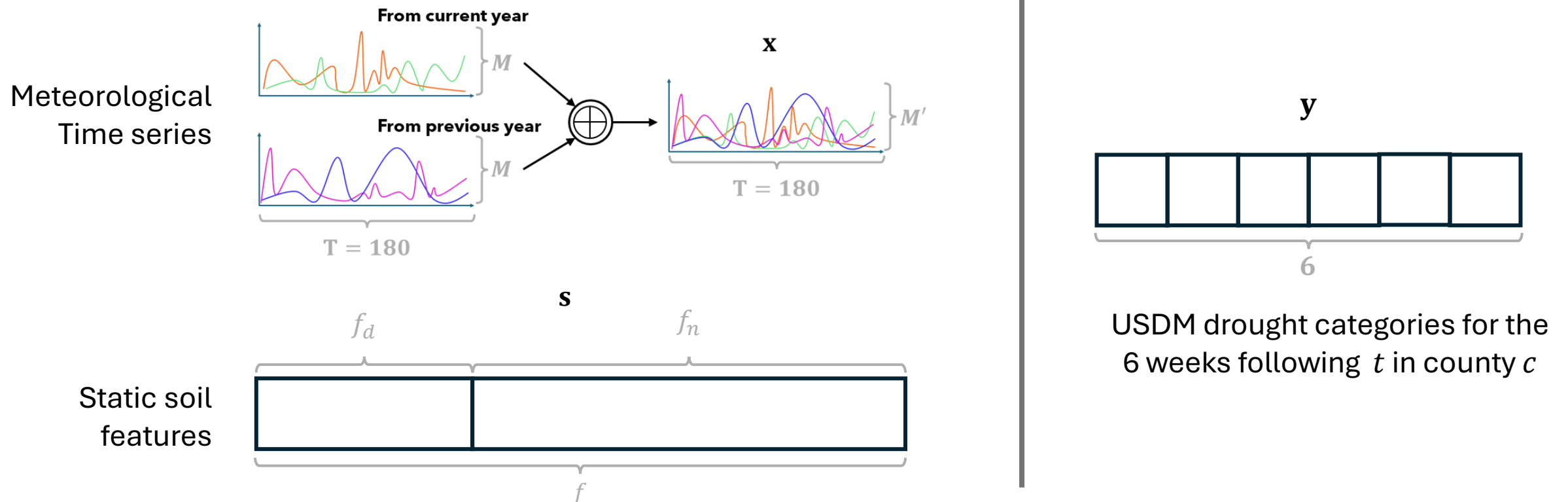[1] Christoph D Minixhofer, Mark Swan, Calum McMeekin, and Pavlos Andreadis. Droughted: A dataset and methodology for drought forecasting spanning multiple climate zones. In ICML 2021 Workshop on Tackling Climate Change with Machine Learning, 2021.

2. THE DATASET : DroughtED [1]

Each observation is described by the tuple (county c, timestamp t) :
So, for each (c, t): $\{\mathbf{x}, \mathbf{s}\} \rightarrow \mathbf{y}$

Inputs	**Target**

Meteorological Time series

From current year

From previous year

$\mathbf{x}$

$T = 180$

$\mathbf{s}$

f_d f_n

Static soil features

f

$\mathbf{y}$

6

USDM drought categories for the 6 weeks following t in county c

[1] Christoph D Minixhofer, Mark Swan, Calum McMeekin, and Pavlos Andreadis. Droughted: A dataset and methodology for drought forecasting spanning multiple climate zones. In ICML 2021 Workshop on Tackling Climate Change with Machine Learning, 2021.
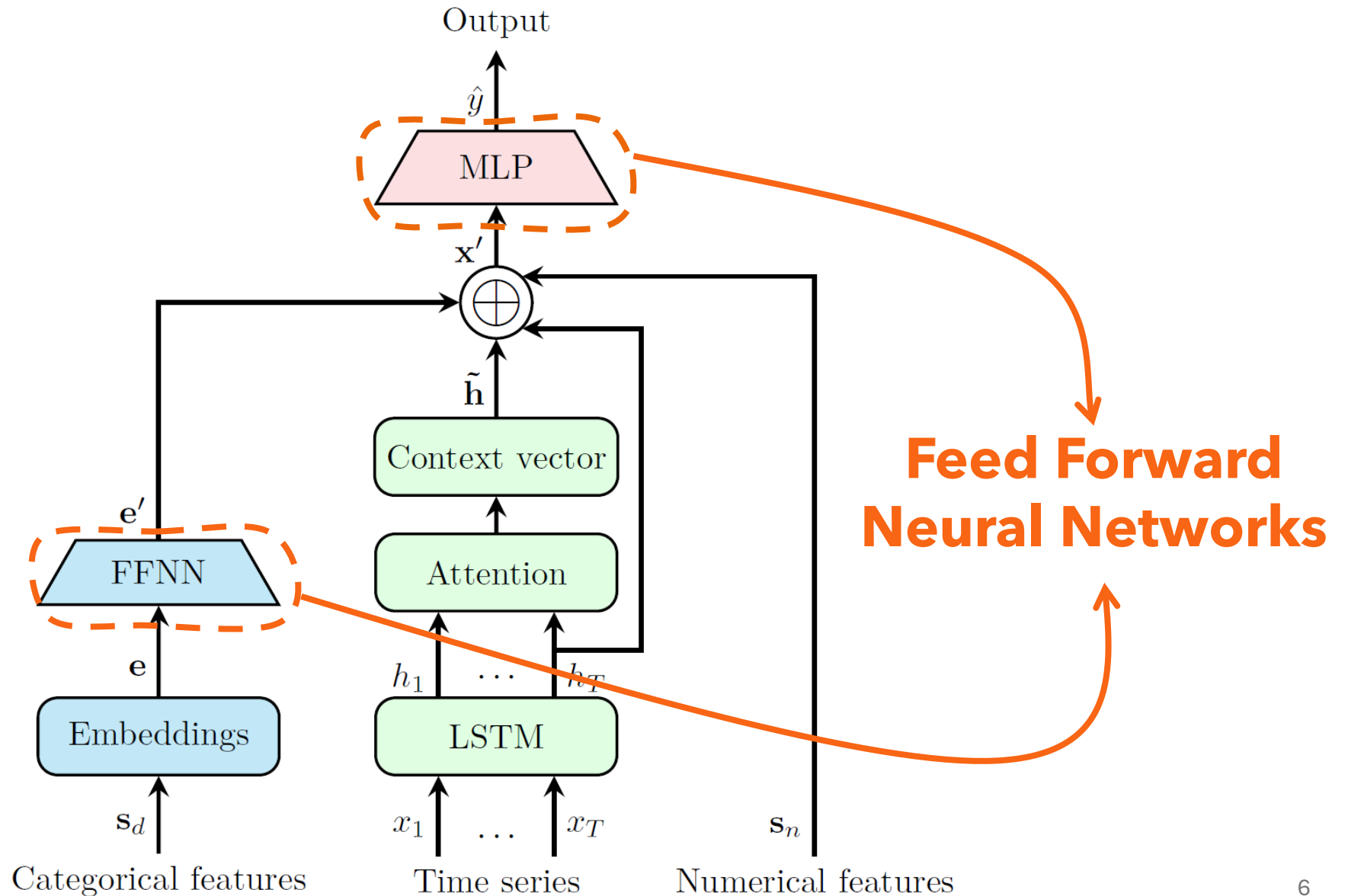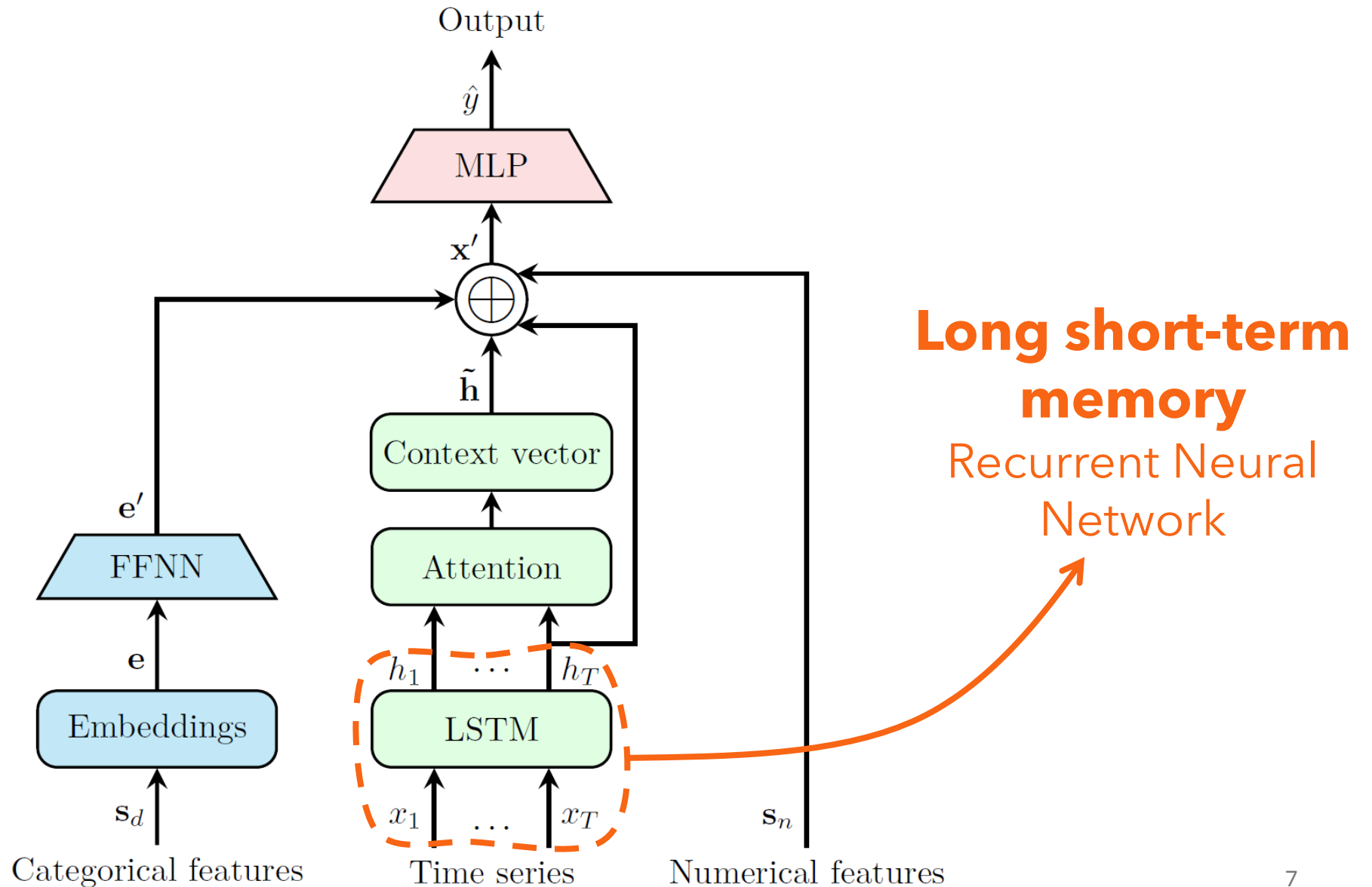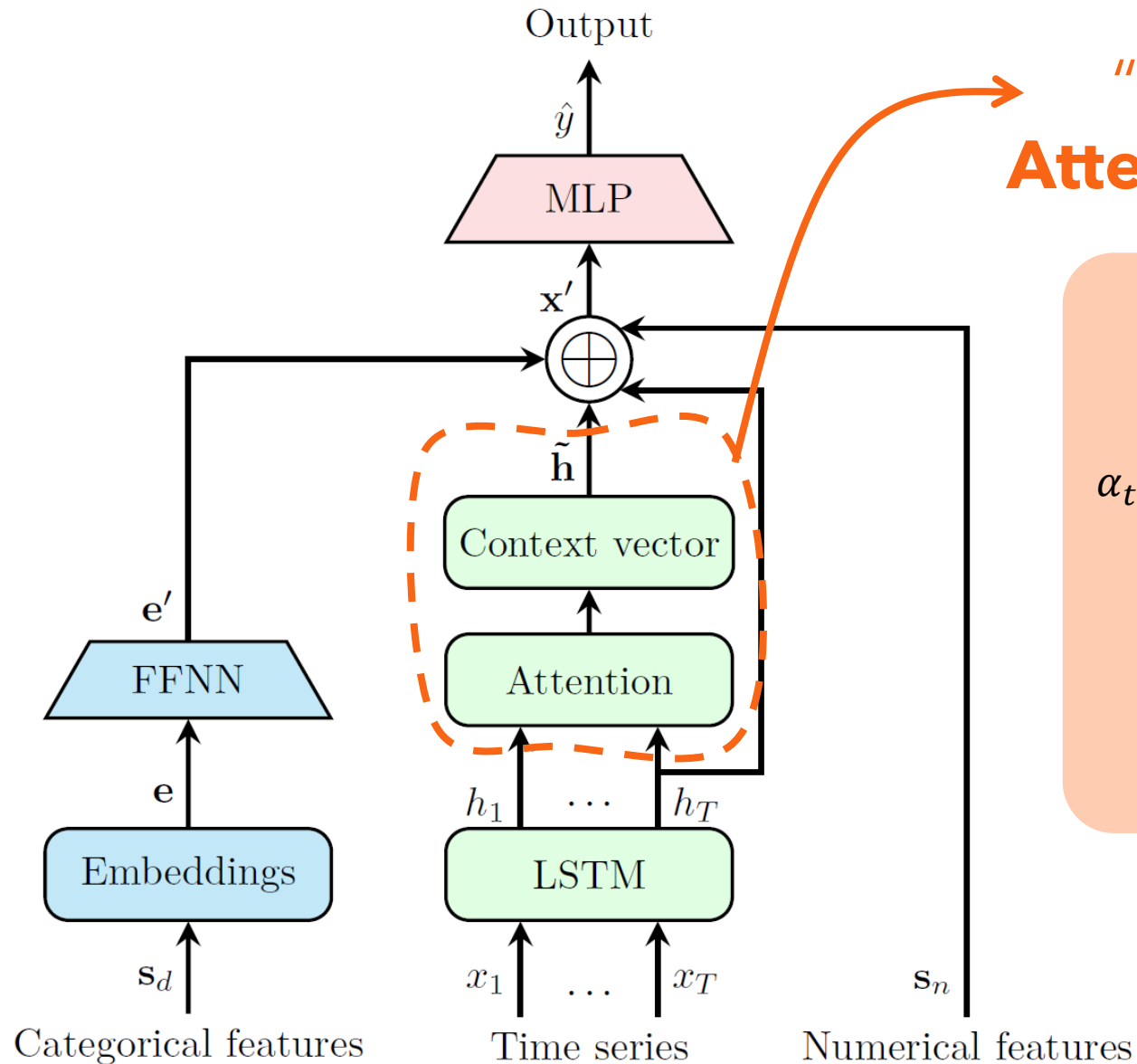
3. THE PROPOSED MODEL
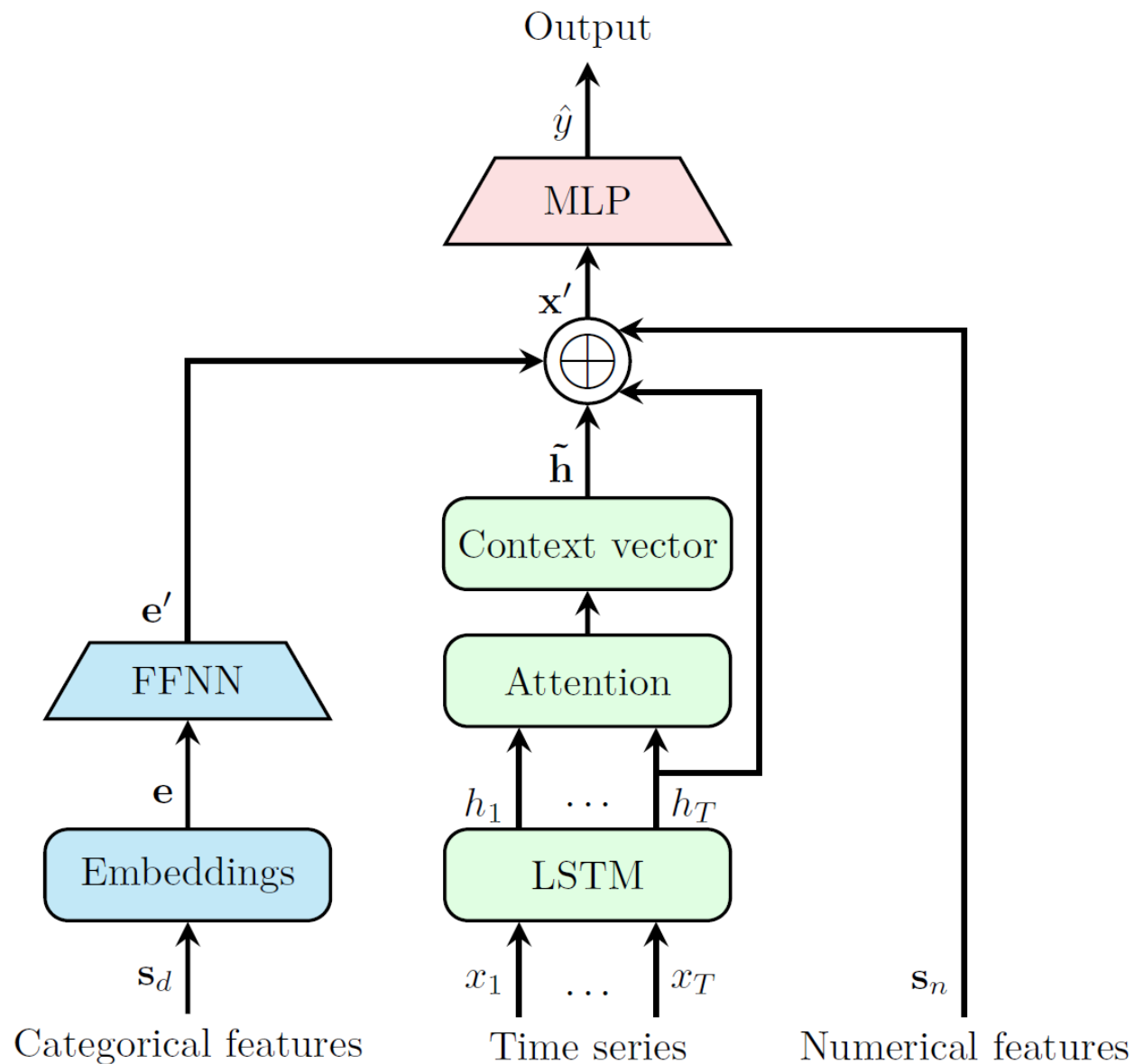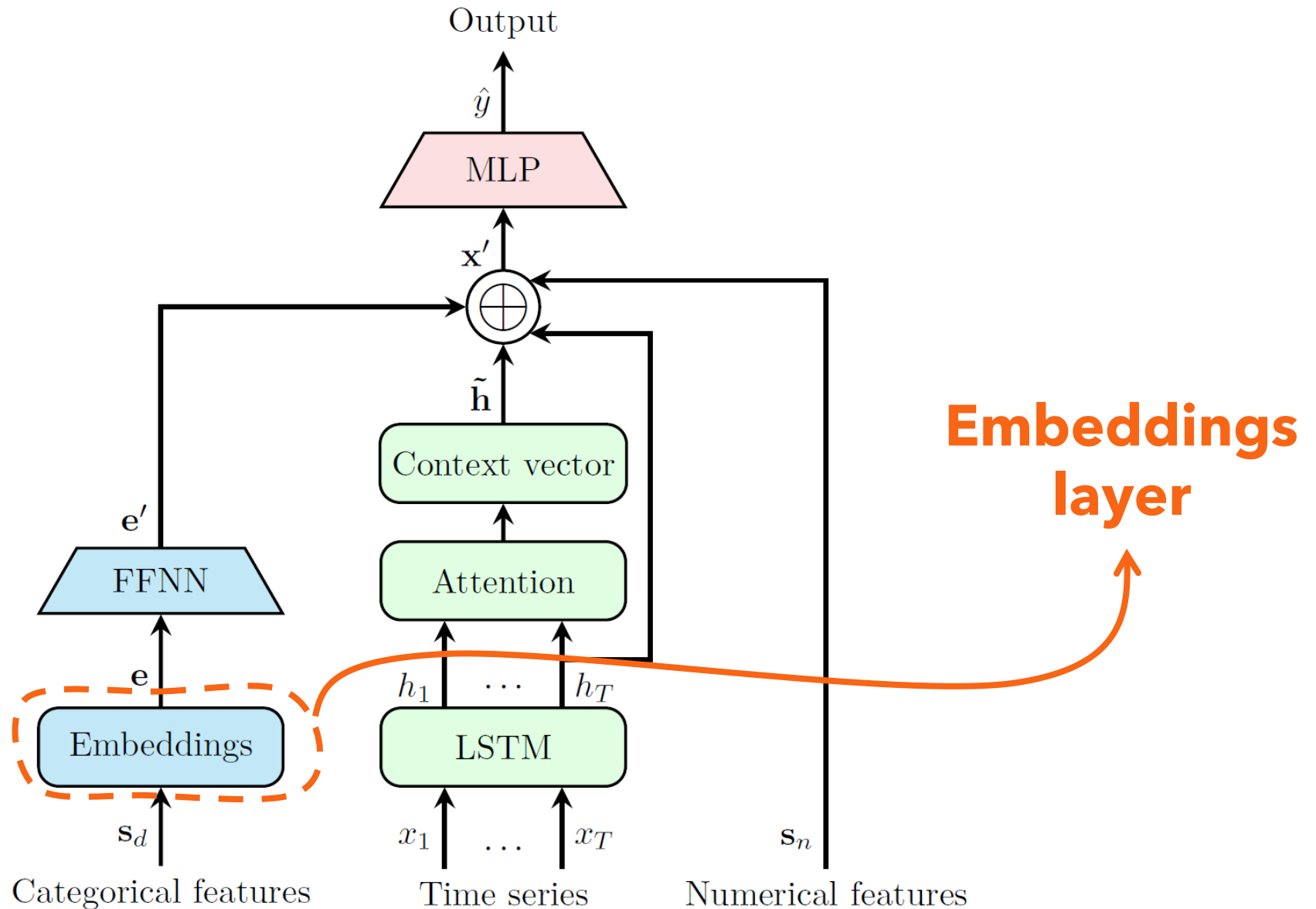
3. THE PROPOSED MODEL

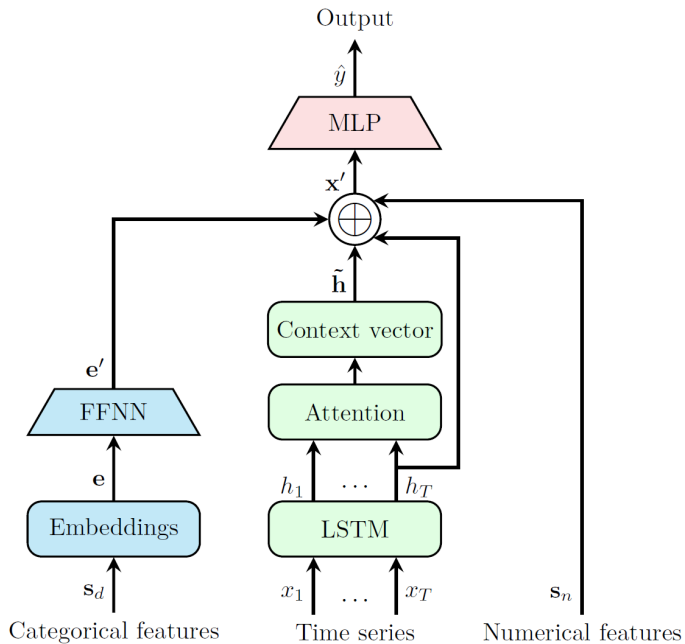# 3. THE PROPOSED MODEL

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"Bahdanau like"
Attention mechanism

$$s_t = Wh_t + b$$

$$\alpha_t = softmax(s_t) = \frac{e^{s_t}}{\sum_{i=1}^{T} e^{s_t}}$$

$$\widetilde{h} = \sum_{t=1}^{T} \alpha_t h_t$$

3. THE PROPOSED MODEL

4. MAIN EXPERIMENTS

1. Predictive performance and generalization.

- Hyperparameter optimization and direct comparison over the test set.
- 5-fold cross-validation and paired t-test.

2. Ablation study.

3. Model introspection.

- t-SNE.
- Attention curves.

5. RESULTS

1. Predictive performance and generalization

- MAE ⬇30%
- F1 ⬆9%
- Multi-class weighted ROC-AUC ⬆7%

2. Ablation study

Ablation settings					
Static features	Time series	Attention mech.	MAE	RMSE	F1
✓	✓	✓	**0.217**	**0.377**	**66.3**
	✓	✓	0.267	0.419	56.2
	✓		0.271	0.420	56.6
✓	✓		0.280	0.427	57.1
✓			0.755	0.920	21.2

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Most of knowledge sources from time series !

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5. RESULTS

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In all setups, attention mechanism improves performance.

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5. RESULTS

3. Model introspection
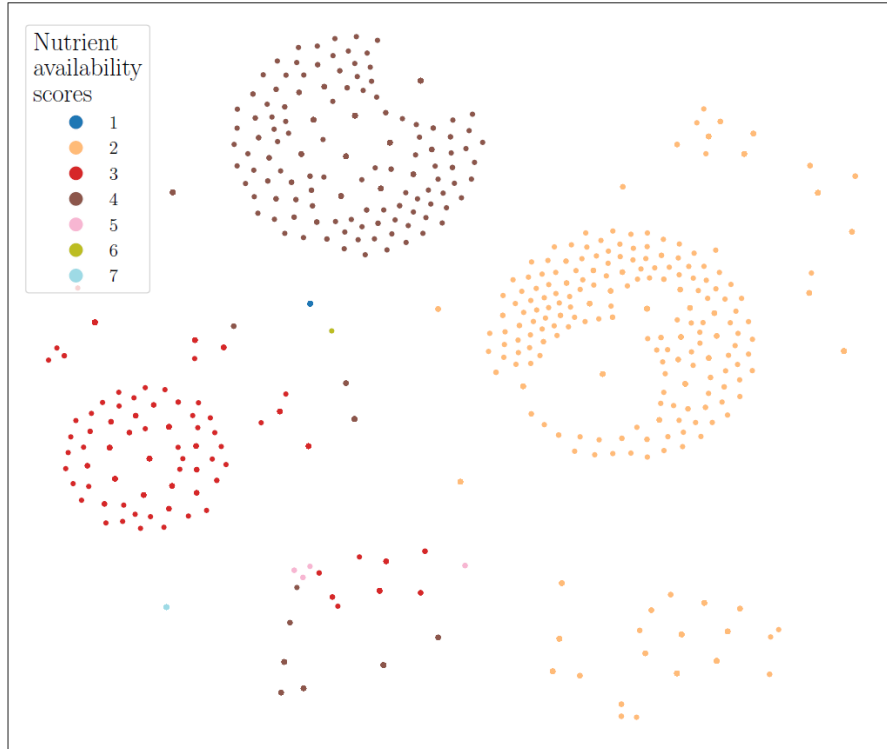
t-SNE colored by "Nutrient availability".
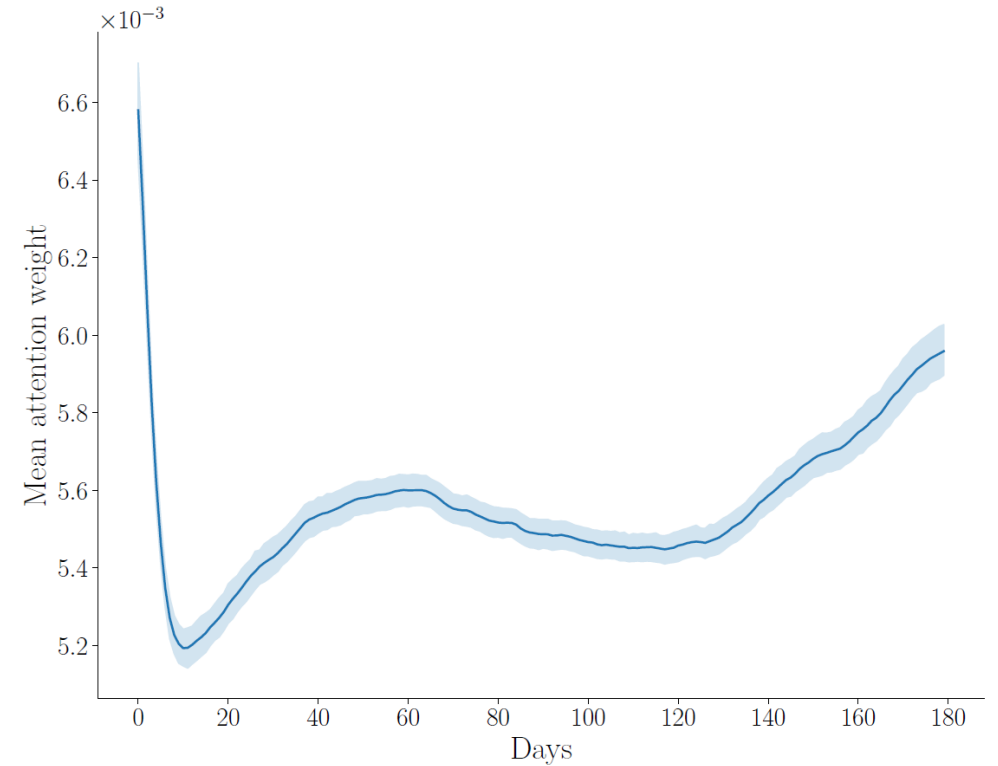
Mean attention weights on the test set
(95% confidence interval)

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