

2026 5 28

				ERA5-Land		LSTM-Attention
	1	2010-2024		ERA5-Land	-	2 LSTM
	1-3	7	30	3 XGBoost		4 Flask
ECharts		Web				
	LSTM-Attention					
		LSTM-Attention				

# Abstract

With global warming, frequent heatwave events pose serious threats to the health of the elderly population. This study takes Jiaozuo and Zhengzhou as research areas, utilizes ERA5-Land meteorological reanalysis data and population health statistics to construct an LSTM-Attention based multi-time-scale heat health risk early warning model, and develops a visualization dashboard system.

The main contributions include: (1) acquisition and preprocessing of ERA5-Land meteorological data (2010-2024) for both cities, combined with census and health statistics data; (2) design of a deep learning model combining LSTM with multi-head self-attention for risk prediction at three time scales (short/medium/long term); (3) comparative experiments with XGBoost baseline to validate the deep learning approach; (4) development of a Flask+ECharts web dashboard with dark tech-blue theme for multi-dimensional visualization.

Experimental results show that the LSTM-Attention model outperforms traditional methods in short and medium-term early warning tasks, providing effective decision support for heatwave health risk management.

**Keywords:** Heatwave; Elderly Population; Multi-time-scale Early Warning; LSTM-Attention; Visualization

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1.1



1.2

1.2.1

J V Gasparrini 2015 Lancet - Chen  
2018 Lancet Planetary Health

1.2.2

HHWS NOAA

1.2.3

ARIMA LSTM Vaswani 2017 Transformer

1.3

- 1. ERA5
- 2. LSTM-Attention + XGBoost
- 3. Flask + ECharts
- 4.

## 1.4



## 2.1 LSTM

Long Short-Term Memory LSTM Hochreiter Schmidhuber 1997  
RNN RNN  
LSTM gating mechanism forget gate input gate output gate  
LSTM

### 2.1.1 LSTM

LSTM cell state hidden state

## 2.2

Attention Mechanism  
Vaswani 2017 Transformer Multi-Head Self-Attention

### 2.2.1

Scaled Dot-Product Attention Query Key  
Softmax Value

### 2.2.2

## 2.3 XGBoost

XGBoost eXtreme Gradient Boosting Chen Guestrin 2016

XGBoost 1 2 3 4 5

## 2.4

WMO 3 32°C 35°C 3

### 2.4.1

## 2.5 Flask ECharts

Flask	Python Web	Web	Flask	RESTful API
ECharts	JavaScript		ECharts	Web

3.1

				14-15°C	7	27-28°C	40°C
4071	352	65	12.8%		7446	1274	11.6%
65%							

3.2

3.2.1 ERA5-Land

ERA5-Land          ECMWF          0.1°×0.1°   9 km          1  
Copernicus Climate Data Store (CDS) API   2010-2024

- 2m   2m temperature
- 2m   2m dewpoint temperature
- surface pressure
- 10m   U   V
- total precipitation
- surface solar radiation downwards

3.2.2

2020

3.2.3

2010-2024

3.3

3.3.1

ERA5-Land

3.3.2

CDS API 30

3.3.3

±3

3.3.4

- 32°C/35°C
- 
- 35°C
- 
- /
- 1 3 7

3.4

3.4.1

30 N T 7 1-3 30 7 90

3.4.2

2010-2019 2020-2022 2023-2024

3.4.3

Z-score 0 1

## 4.1

LSTM-Attention

LSTM

## 4.2 LSTM

### 4.2.1

LSTM LSTM LSTM 50 LSTM  
50

### 4.2.2 Dropout

LSTM Dropout 0.3

## 4.3

### 4.3.1

LSTM head=4

### 4.3.2

Transformer

## 4.4

Multi-Task Learning LSTM  
32

## 4.5

### 4.5.1

Cross-Entropy Loss

$$\mathcal{L}_{\text{total}} = \mathcal{L}_{\text{short}} + \mathcal{L}_{\text{medium}} + \mathcal{L}_{\text{long}}$$

### 4.5.2

Adam	0.001	ReduceLROnPlateau	10 epoch
Early Stopping	25 epoch		

## 4.6 XGBoost

	XGBoost	XGBoost	LSTM-Attention
XGBoost	n_estimators=200	max_depth=6	learning_rate=0.1
subsample=0.8	5		

## 4.7

- Accuracy
- Precision
- Recall
- F1 F1-Score
- Macro Average

## 5.1

### 5.1.1

### 5.1.2

1                      2                      5    3                      3    4

## 5.2

B/S Browser/Server

- 
- Flask      Web      RESTful API
- HTML+CSS+JavaScript      Web      ECharts

## 5.3

### 5.3.1    Flask

Flask      Blueprint

- api/data
- api/predict
- api/history

### 5.3.2

API JSON

```
{
  "code": 200,
  "message": "success",
  "data": { ... }
}
```

API

### 5.3.3

PyTorch TorchScript Flask

## 5.4

### 5.4.1

4+1

### 5.4.2

ECharts

- / /
- 
- 
- 
- 
- 

### 5.4.3

#0a1628 #00d4ff #1e90ff

## 5.5

Gunicorn WSGI 5005 Flask Nginx  
<http://localhost:5005>



## 6.1

- Windows 11
- Python 3.13
- PyTorch 2.12.0 (CUDA 12.6)
- GPU NVIDIA GeForce RTX 4060 Laptop (8GB VRAM)
- 16 GB

## 6.2

### 6.2.1

		1,095,758		767,030	70%	164,363	15%	164,365	15%
14	×19	3	7	30		2010-2020	2021-2022	2023-2024	

### 6.2.2 LSTM-Attention

LSTM-Attention	983,628	Focal Loss $\alpha = 0.25, \gamma = 2.0$	AdamW
1e-3 ReduceLROnPlateau		patience=8 NVIDIA RTX 4060	epoch
5			

### 6.2.3 XGBoost

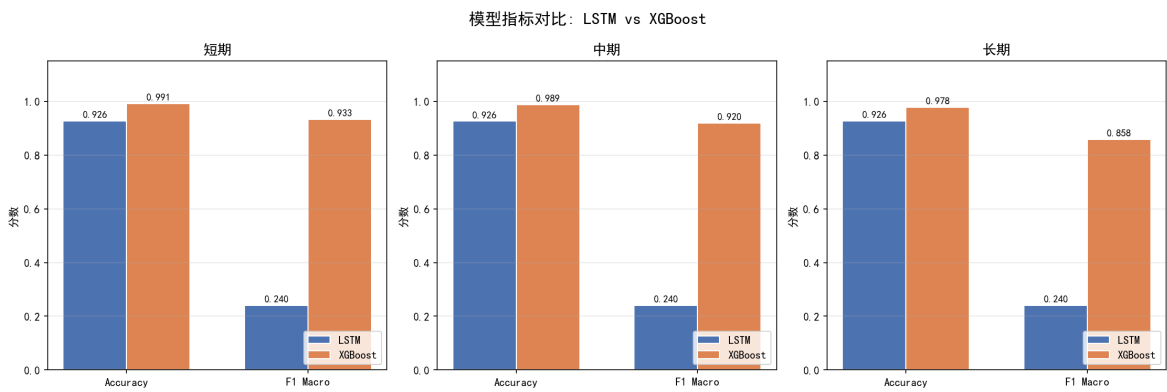
XGBoost	14	×19	266	3	XGBoost	n_estimators=200,
max_depth=6, learning_rate=0.05						

6.3

6.1 6.1

6.1:

	LSTM-Attention		XGBoost	
	Accuracy	F1-Macro	Accuracy	F1-Macro
3	0.9263	0.2404	<b>0.9908</b>	<b>0.9325</b>
7	0.9259	0.2404	<b>0.9886</b>	<b>0.9195</b>
30	0.9260	0.2404	<b>0.9782</b>	<b>0.8576</b>

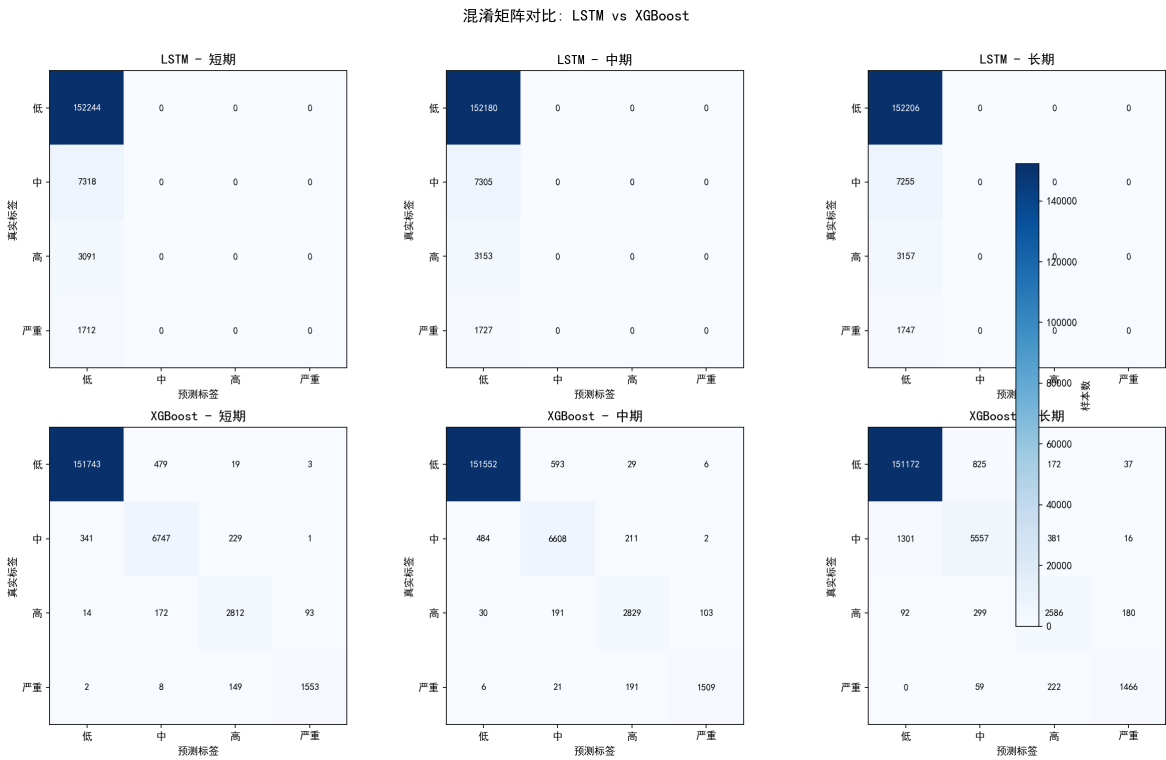


6.1:

XGBoost

F1-Macro 0.9325 0.85 LSTM-Attention

2-3 epoch F1 0.24 XGBoost LSTM



6.2: XGBoost LSTM-Attention

6.2 XGBoost 0- 1- 2- 3- LSTM-Attention 0  
94-96%

6.4

Flask + ECharts ?? 6 - 30

6.5

XGBoost LSTM-Attention  
1 SMOTE 2 3

## 7.1

1. 2010-2024 ERA5-Land -
2. **LSTM-Attention** LSTM / /  
XGBoost
3. Flask ECharts Web
- 4.

## 7.2

1. ERA5-Land 0.1° 9 km
- 2.
3. LSTM-Attention 30
- 4.

## 7.3

- 1.
2. 120
3. Transformer Informer Autoformer
- 4.
- 5.



**A**

B

# B

## B.1

Python 3.13      uv      PyTorch XGBoost Flask ECharts

## B.2

1. `uv pip install -e .`
2. `python -m src.data.download_era5`
3. `python -m src.data.preprocess`
4. `python -m src.models.train`
5. `python -m src.web.app`
6. `http://localhost:5005`