Rhine Level Data

Christoph Smoch and Yannick Burchart

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Data Set


Siegen
Bonn
Oberwinter
Andernach
Koblenz(up)
Kalkofen (Lahn)
Kaub
Oestrich
Frankfurt (Main)
FRANKFURT AM MAIN
Raunheim (Main)
Bingen
Mainz
Worms
Rockenau (Neckar)
MANNHEIM
Kaiserslautern
Heidelberg
Speyer

Inflowing rivers

Inflowing rivers

- Training data from 28.07.1992 to 30.06.2013

Inflowing rivers

- Training data from 28.07.1992 to 30.06.2013
- Delay = 36 h

Inflowing rivers

- Training data from 28.07.1992 to 30.06.2013
- Delay = 36 h
- Optimizer: Adam

Inflowing rivers

- Training data from 28.07.1992 to 30.06.2013
- Delay = 36 h
- Optimizer: Adam

Layer (type)	Output Shape	Param #
dense_96 (Dense)	(None, 1536)	7680
dense_97 (Dense)	(None, 1536)	2360832
dense_98 (Dense)	(None, 768)	1180416
dense_99 (Dense)	(None, 1)	769

Total params: 3,549,697
Trainable params: 3,549,697
Non-trainable params: 0

Inflowing rivers

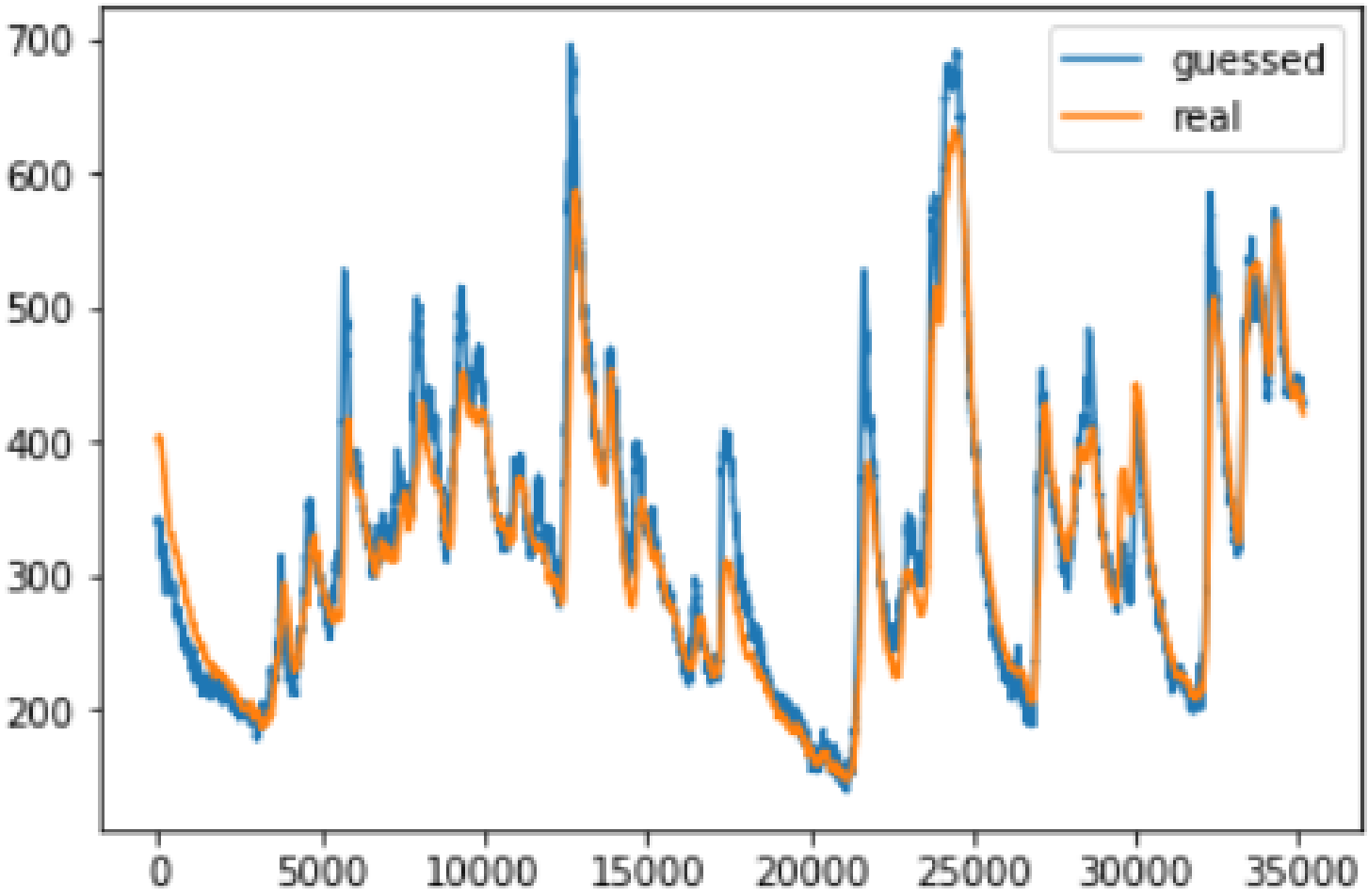
- Training data from 28.07.1992 to 30.06.2013
- Delay = 36 h
- Optimizer: Adam

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_96 (Dense)             (None, 1536)              7680
_________________________________________________________________
dense_97 (Dense)             (None, 1536)              2360832
_________________________________________________________________
dense_98 (Dense)             (None, 768)               1180416
_________________________________________________________________
dense_99 (Dense)             (None, 1)                 769
=================================================================
Total params: 3,549,697
Trainable params: 3,549,697
Non-trainable params: 0
_________________________________________________________________
```

```
Train on 550116 samples, validate on 183372 samples
Epoch 1/3
550116/550116 [==============================] - 767s 1ms/step - loss: 1317.8855 - val_loss: 1109.0031
Epoch 2/3
550116/550116 [==============================] - 753s 1ms/step - loss: 921.7284 - val_loss: 845.6725
Epoch 3/3
550116/550116 [==============================] - 751s 1ms/step - loss: 861.3388 - val_loss: 832.7554
```

Inflowing rivers

- From 31.03.2007 to 31.03.2008
- MSE: 1181,8



Middle Citys

Middle Citys

- Training data from 31.05.1997 to 31.03.2007

Middle Citys

- Training data from 31.05.1997 to 31.03.2007
- Delay Features = 12 h -15 h in 15 min intervals

Middle Citys

- Training data from 31.05.1997 to 31.03.2007
- Delay Features = 12 h -15 h in 15 min intervals
- Optimizer: Adam

Middle Citys

- Training data from 31.05.1997 to 31.03.2007
- Delay Features = 12 h -15 h in 15 min intervals
- Optimizer: Adam

Layer (type)	Output Shape	Param #
dense_3 (Dense)	(None, 1536)	93696
dense_4 (Dense)	(None, 1536)	2360832
dense_5 (Dense)	(None, 768)	1180416
dense_6 (Dense)	(None, 1)	769

Total params: 3,635,713
Trainable params: 3,635,713
Non-trainable params: 0

Middle Citys

- Training data from 31.05.1997 to 31.03.2007
- Delay Features = 12 h -15 h in 15 min intervals
- Optimizer: Adam

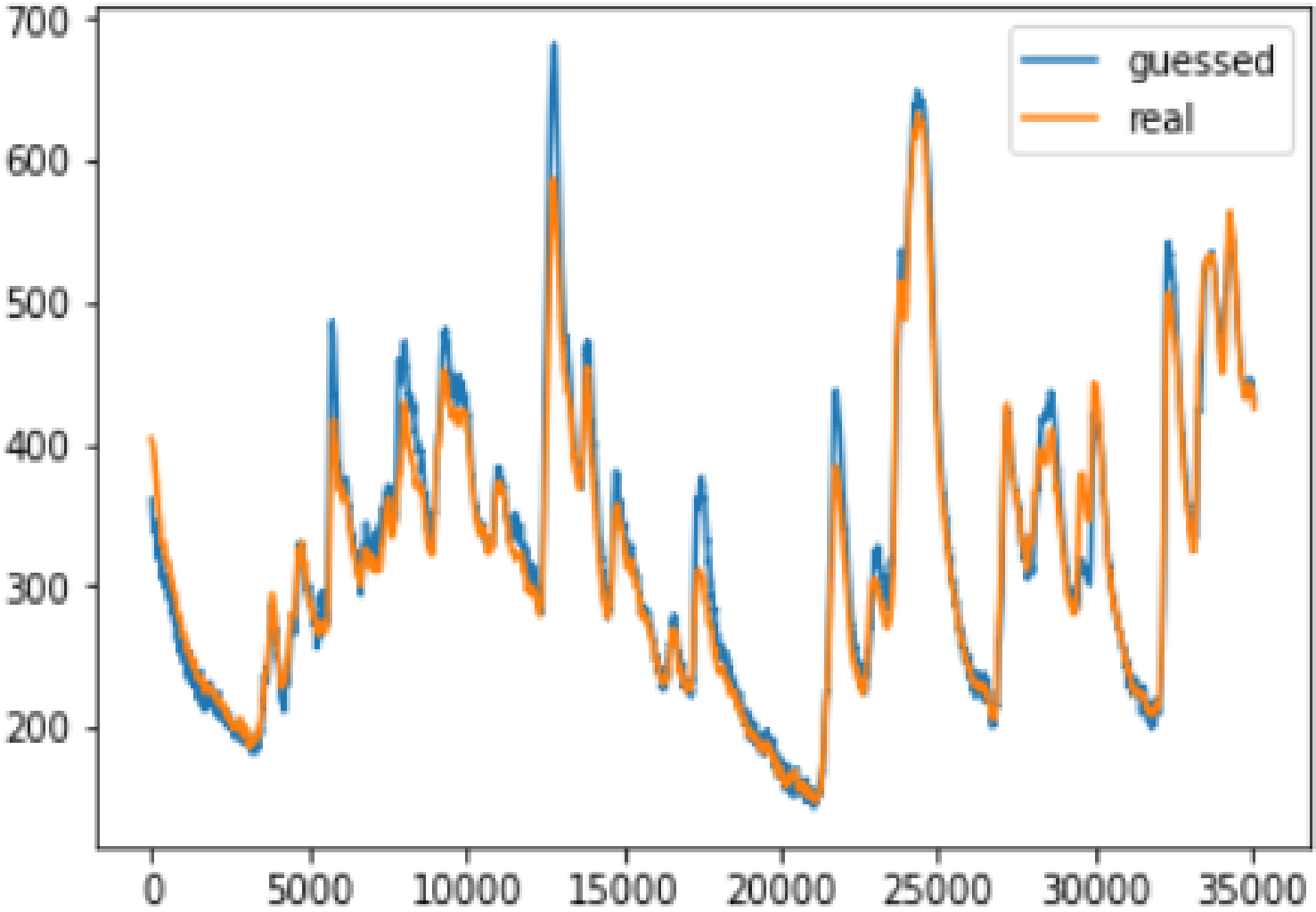
Layer (type)	Output Shape	Param #
dense_3 (Dense)	(None, 1536)	93696
dense_4 (Dense)	(None, 1536)	2360832
dense_5 (Dense)	(None, 768)	1180416
dense_6 (Dense)	(None, 1)	769

Total params: 3,635,713
Trainable params: 3,635,713
Non-trainable params: 0

```
Train on 258479 samples, validate on 86160 samples
Epoch 1/3
258479/258479 [==============================] - 337s 1ms/step - loss: 519.4644 - val_loss: 457.1992
Epoch 2/3
258479/258479 [==============================] - 345s 1ms/step - loss: 383.6351 - val_loss: 397.9228
Epoch 3/3
258479/258479 [==============================] - 342s 1ms/step - loss: 359.2963 - val_loss: 354.5216
```

Middle Citys

- From 31.03.2007 to 31.03.2008
- MSE: 460,6

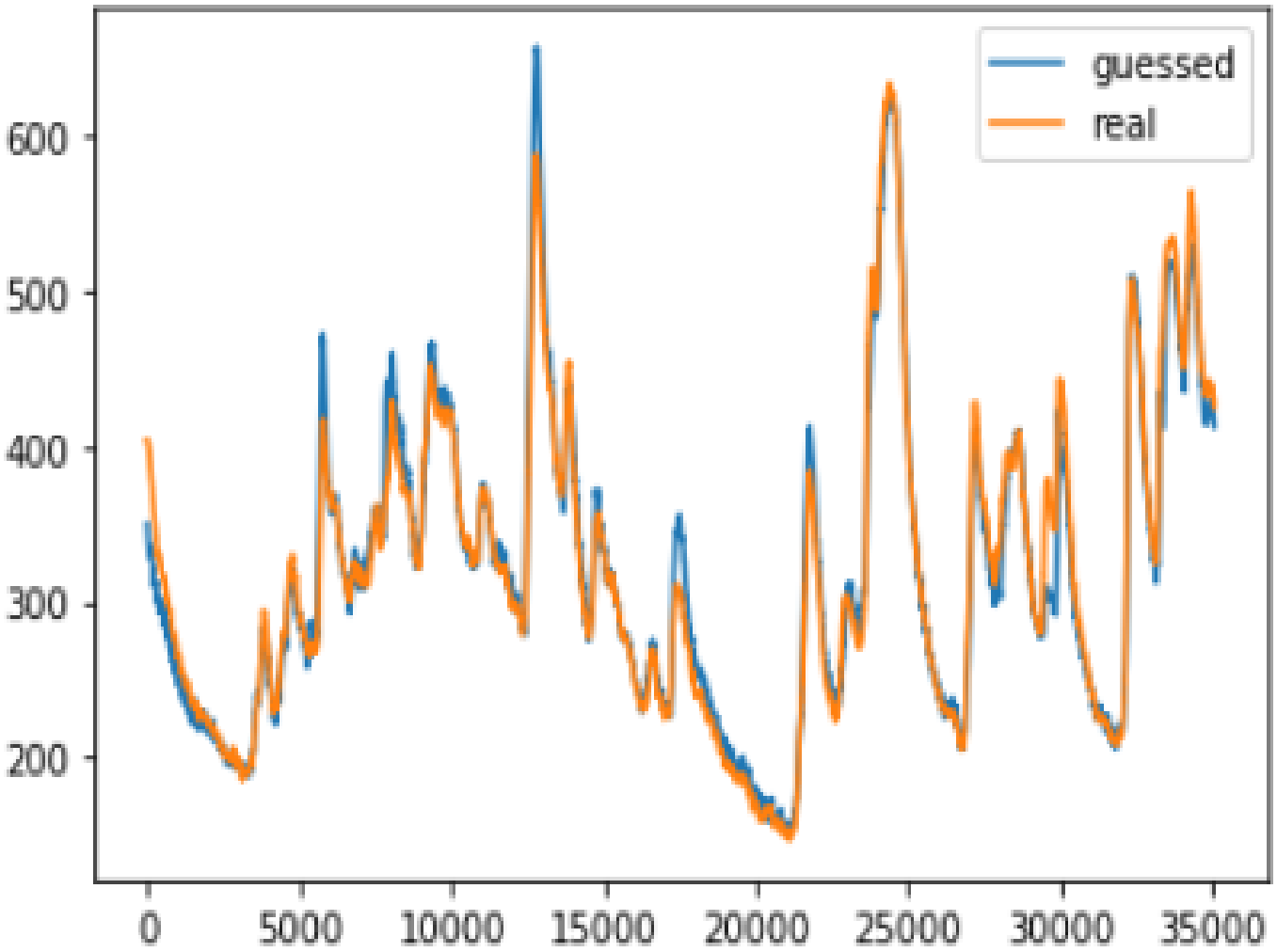


Middle Citys

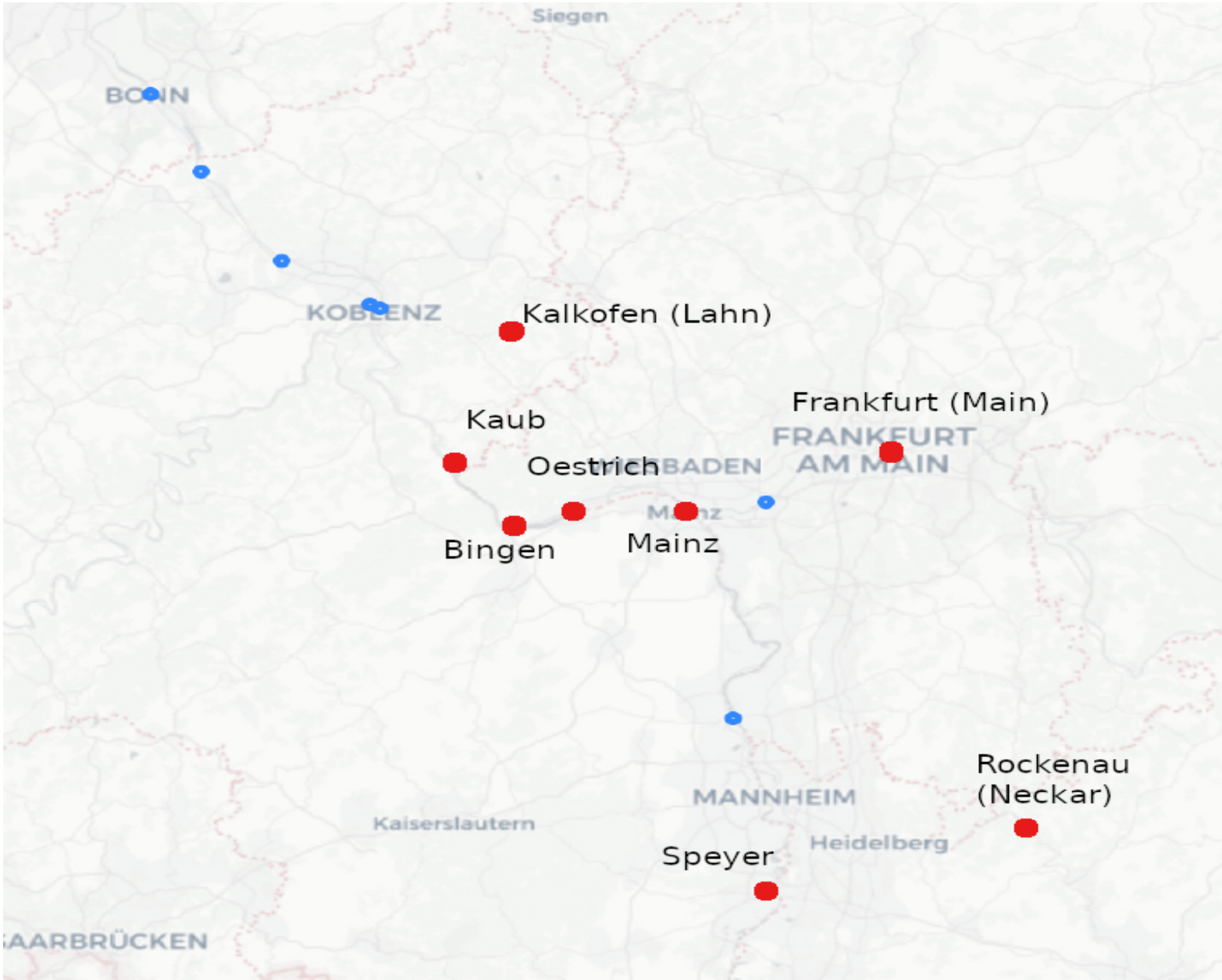
```
Train on 258479 samples, validate on 86160 samples
Epoch 1/10
258479/258479 [==============================] - 317s 1ms/step - loss: 577.7630 - val_loss: 362.9495
Epoch 2/10
258479/258479 [==============================] - 314s 1ms/step - loss: 376.8651 - val_loss: 471.1167
Epoch 3/10
258479/258479 [==============================] - 314s 1ms/step - loss: 355.5362 - val_loss: 462.2183
Epoch 4/10
258479/258479 [==============================] - 305s 1ms/step - loss: 336.8638 - val_loss: 319.9021
Epoch 5/10
258479/258479 [==============================] - 310s 1ms/step - loss: 320.9154 - val_loss: 308.5900
Epoch 6/10
258479/258479 [==============================] - 303s 1ms/step - loss: 307.2807 - val_loss: 289.8575
Epoch 7/10
258479/258479 [==============================] - 302s 1ms/step - loss: 301.3183 - val_loss: 400.4257
Epoch 8/10
258479/258479 [==============================] - 309s 1ms/step - loss: 294.8623 - val_loss: 287.2317
Epoch 9/10
258479/258479 [==============================] - 311s 1ms/step - loss: 294.0019 - val_loss: 291.2982
Epoch 10/10
258479/258479 [==============================] - 267s 1ms/step - loss: 292.0886 - val_loss: 277.6455
```

Middle Citys

- From 31.03.2007 to 31.03.2008
- MSE: 295,3



Combined


Siegen
KOBLENZ
Kalkofen (Lahn)
Kaub
Oestrich
Frankfurt (Main)
FRANKFURT
AM MAIN
Bingen
Mainz
Rockenau
(Neckar)
MANNHEIM
Kaiserslautern
Heidelberg
Speyer

Combined

- Training data from 31.05.1997 to 31.03.2007

Combined

- Training data from 31.05.1997 to 31.03.2007
- Optimizer: Adam

Combined

- Training data from 31.05.1997 to 31.03.2007
- Optimizer: Adam

Layer (type)	Output Shape	Param #
dense_9 (Dense)	(None, 1536)	98304
dense_10 (Dense)	(None, 1536)	2360832
dense_11 (Dense)	(None, 768)	1180416
dense_12 (Dense)	(None, 1)	769

Total params: 3,640,321
Trainable params: 3,640,321
Non-trainable params: 0

Combined

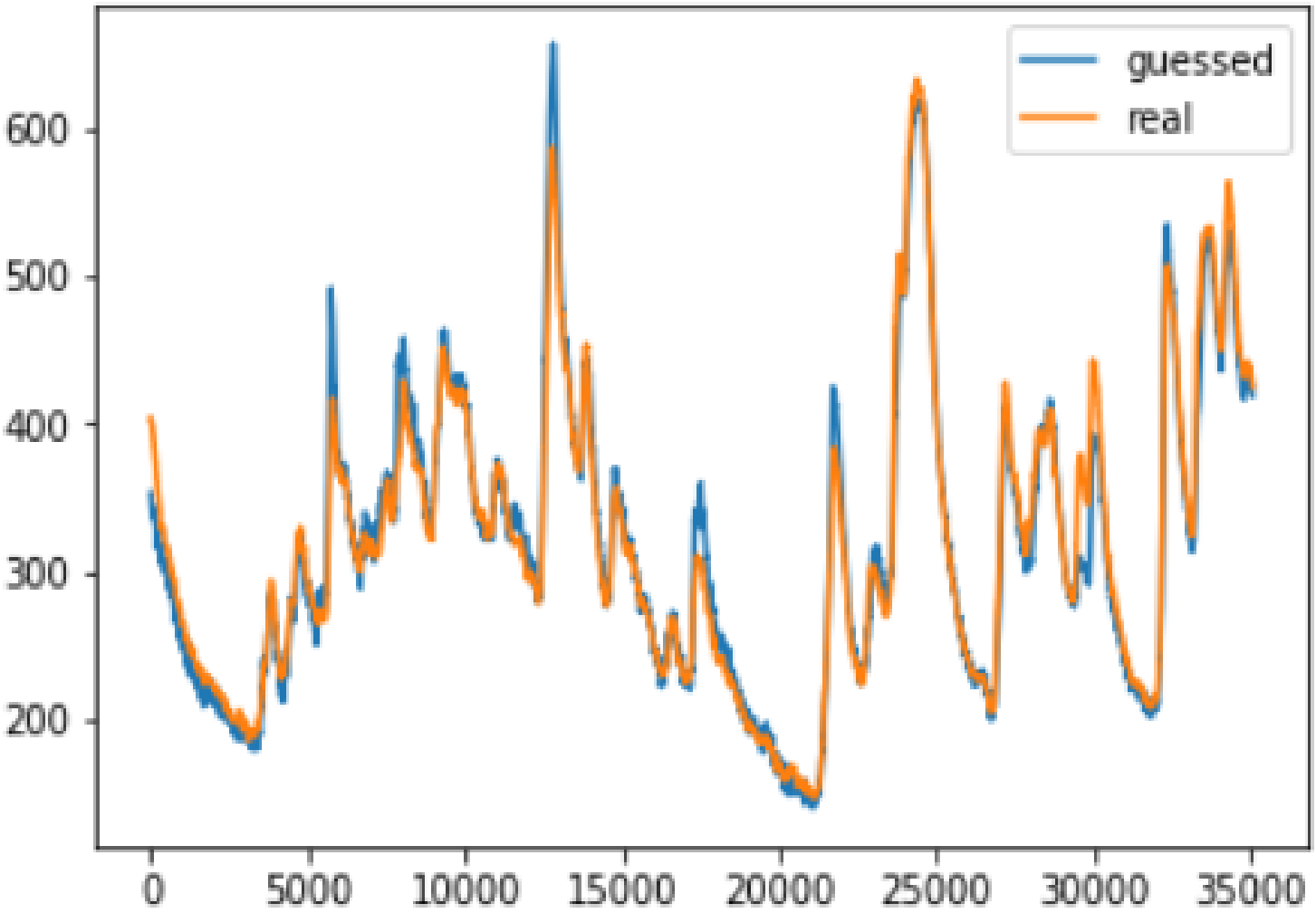
- Training data from 31.05.1997 to 31.03.2007
- Optimizer: Adam

```
Layer (type)                 Output Shape              Param #
=================================================================
dense_9 (Dense)              (None, 1536)              98304
_________________________________________________________________
dense_10 (Dense)             (None, 1536)              2360832
_________________________________________________________________
dense_11 (Dense)             (None, 768)               1180416
_________________________________________________________________
dense_12 (Dense)             (None, 1)                 769
=================================================================
Total params: 3,640,321
Trainable params: 3,640,321
Non-trainable params: 0
_________________________________________________________________
```

```
Train on 258479 samples, validate on 86160 samples
Epoch 1/3
258479/258479 [==============================] - 340s 1ms/step - loss: 504.7584 - val_loss: 341.5425
Epoch 2/3
258479/258479 [==============================] - 342s 1ms/step - loss: 361.1113 - val_loss: 400.0493
Epoch 3/3
258479/258479 [==============================] - 340s 1ms/step - loss: 339.2705 - val_loss: 296.5153
```

Combined

- From 31.03.2007 to 31.03.2008
- MSE: 329,5



Combined

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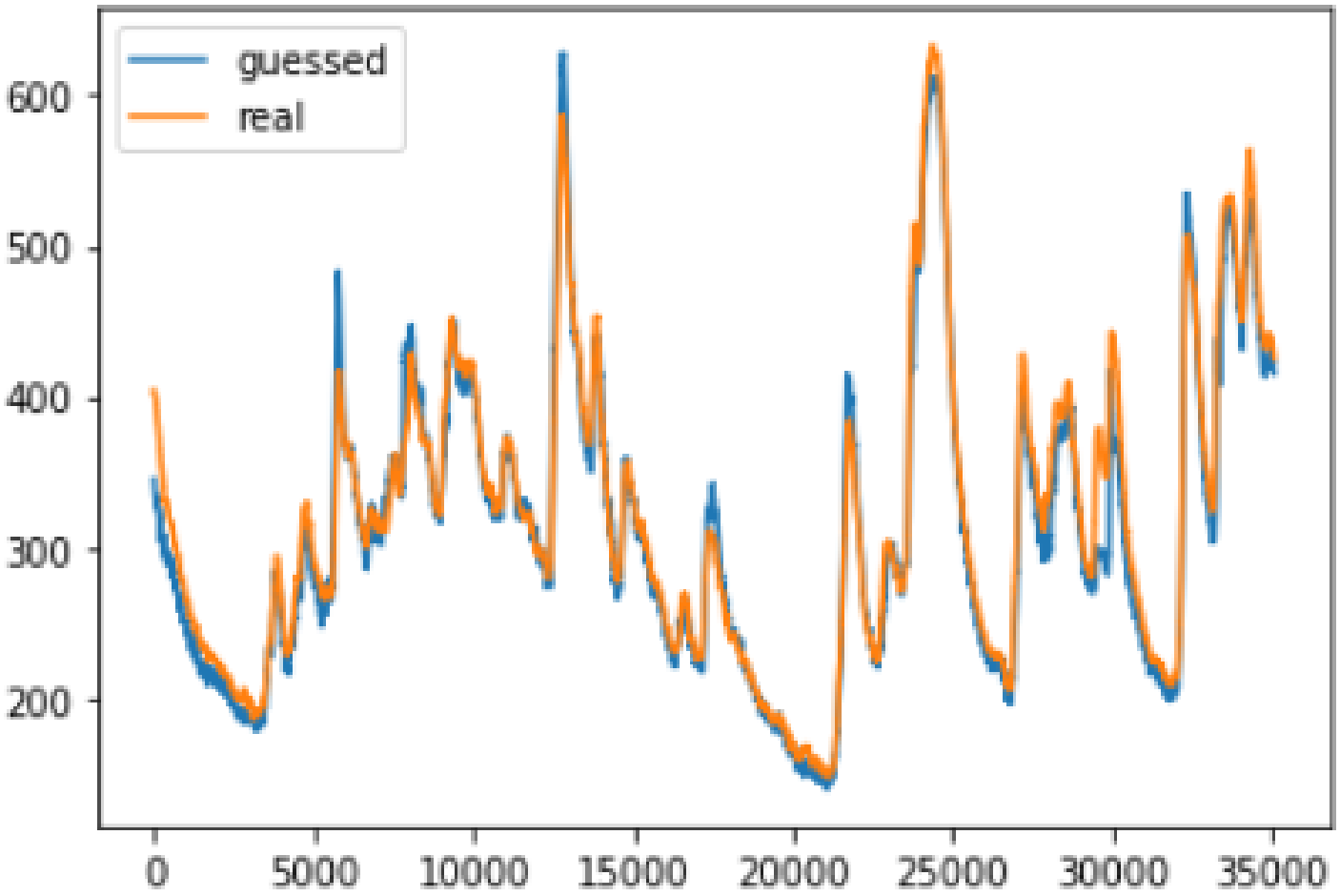
Epoch 1/10
258479/258479 [==============================] - 235s 908us/step - loss: 483.2609 - val_loss: 331.0151
Epoch 2/10
258479/258479 [==============================] - 240s 930us/step - loss: 355.9876 - val_loss: 312.2569
Epoch 3/10
258479/258479 [==============================] - 245s 946us/step - loss: 329.5866 - val_loss: 309.3313
Epoch 4/10
258479/258479 [==============================] - 248s 961us/step - loss: 311.6672 - val_loss: 323.3539
Epoch 5/10
258479/258479 [==============================] - 249s 964us/step - loss: 297.5114 - val_loss: 307.0521
Epoch 6/10
258479/258479 [==============================] - 253s 980us/step - loss: 288.6783 - val_loss: 272.2609
Epoch 7/10
258479/258479 [==============================] - 243s 942us/step - loss: 281.1152 - val_loss: 277.6102
Epoch 8/10
258479/258479 [==============================] - 247s 957us/step - loss: 275.0219 - val_loss: 268.8025
Epoch 9/10
258479/258479 [==============================] - 251s 971us/step - loss: 269.4939 - val_loss: 299.3749
Epoch 10/10
258479/258479 [==============================] - 255s 988us/step - loss: 265.2712 - val_loss: 278.9041
```

Combined

- From 31.03.2007 to 31.03.2008
- MSE: 346,9



LSTM


Siegen
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Bingen
Mainz
MANNHEIM
Kaiserslautern
Heidelberg

LSTM

- Training data from 31.05.1997 to 31.03.2007

LSTM

- Training data from 31.05.1997 to 31.03.2007
- Delay Features = 12 h -15 h in 15 min intervals

LSTM

- Training data from 31.05.1997 to 31.03.2007
- Delay Features = 12 h -15 h in 15 min intervals
- Optimizer: Adam

LSTM

- Training data from 31.05.1997 to 31.03.2007
- Delay Features = 12 h -15 h in 15 min intervals
- Optimizer: Adam

Layer (type)	Output Shape	Param #
lstm_11 (LSTM)	(None, 1, 192)	194304
lstm_12 (LSTM)	(None, 192)	295680
dense_36 (Dense)	(None, 1)	193

Total params: 490,177
Trainable params: 490,177
Non-trainable params: 0

LSTM

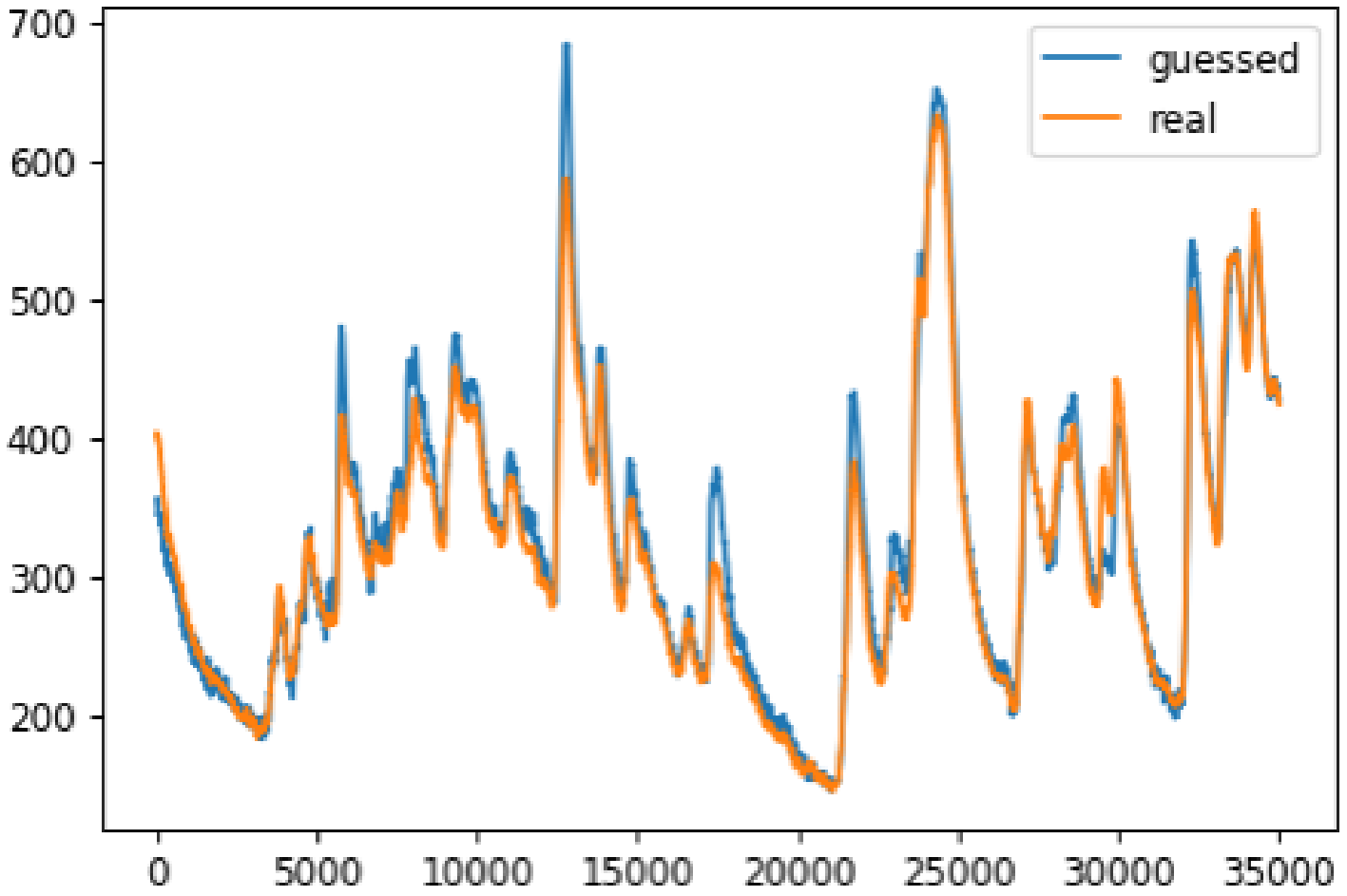
- Training data from 31.05.1997 to 31.03.2007
- Delay Features = 12 h -15 h in 15 min intervals
- Optimizer: Adam

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_11 (LSTM)               (None, 1, 192)            194304
_________________________________________________________________
lstm_12 (LSTM)               (None, 192)               295680
_________________________________________________________________
dense_36 (Dense)             (None, 1)                 193
=================================================================
Total params: 490,177
Trainable params: 490,177
Non-trainable params: 0
_________________________________________________________________
```

```
Train on 258479 samples, validate on 86160 samples
Epoch 1/3
258479/258479 [==============================] - 97s 374us/step - loss: 521.2406 - val_loss: 368.6379
Epoch 2/3
258479/258479 [==============================] - 99s 384us/step - loss: 375.3672 - val_loss: 396.2590
Epoch 3/3
258479/258479 [==============================] - 103s 400us/step - loss: 355.9427 - val_loss: 381.2970
```

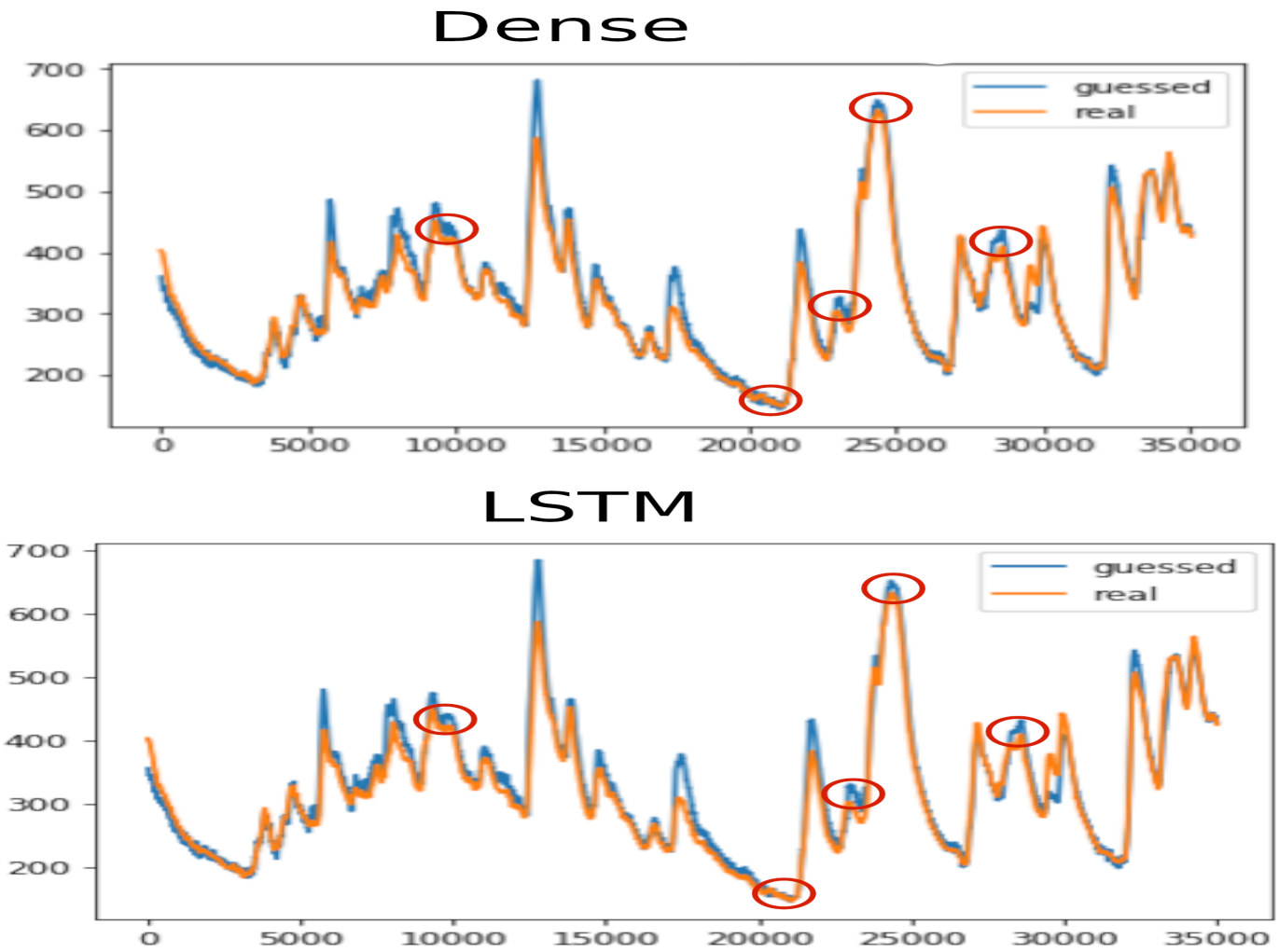
LSTM

- From 31.03.2007 to 31.03.2008
- MSE: 462,1



Dense vs. LSTM

- From 31.03.2007 to 31.03.2008



Mistake