```
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```

```
import tensorflow as tf
print(tf.__version__)
```

```
2.3.0
```

```
import numpy as np
import matplotlib.pyplot as plt
def plot_series(time, series, format="-", start=0, end=None):
    plt.plot(time[start:end], series[start:end], format)
    plt.xlabel("Time")
    plt.ylabel("Value")
    plt.grid(True)
```

```
!wget --no-check-certificate \
    https://raw.githubusercontent.com/jbrownlee/Datasets/master/daily-min-temperatures.csv \
    -O /tmp/daily-min-temperatures.csv
```

```
--2020-10-07 00:52:07--  https://raw.githubusercontent.com/jbrownlee/Datasets/master/daily-min-
temperatures.csv
Resolving raw.githubusercontent.com (raw.githubusercontent.com)... 151.101.0.133, 151.101.64.133,
151.101.128.133, ...
Connecting to raw.githubusercontent.com (raw.githubusercontent.com)|151.101.0.133|:443...
connected.
HTTP request sent, awaiting response... 200 OK
Length: 67921 (66K) [text/plain]
Saving to: '/tmp/daily-min-temperatures.csv'

/tmp/daily-min-temp 100%[===================>]  66.33K  --.-KB/s    in 0.02s

2020-10-07 00:52:07 (3.95 MB/s) - '/tmp/daily-min-temperatures.csv' saved [67921/67921]
```

```
import csv
time_step = []
temps = []

with open('/tmp/daily-min-temperatures.csv') as csvfile:
  reader = csv.reader(csvfile, delimiter=',')
  next(reader)
  step=0
  for row in reader:
    temps.append(float(row[1]))
    time_step.append(step)
    step = step + 1

series = np.array(temps)
time = np.array(time_step)
```

```
plt.figure(figsize=(10, 6))
plot_series(time, series)
```
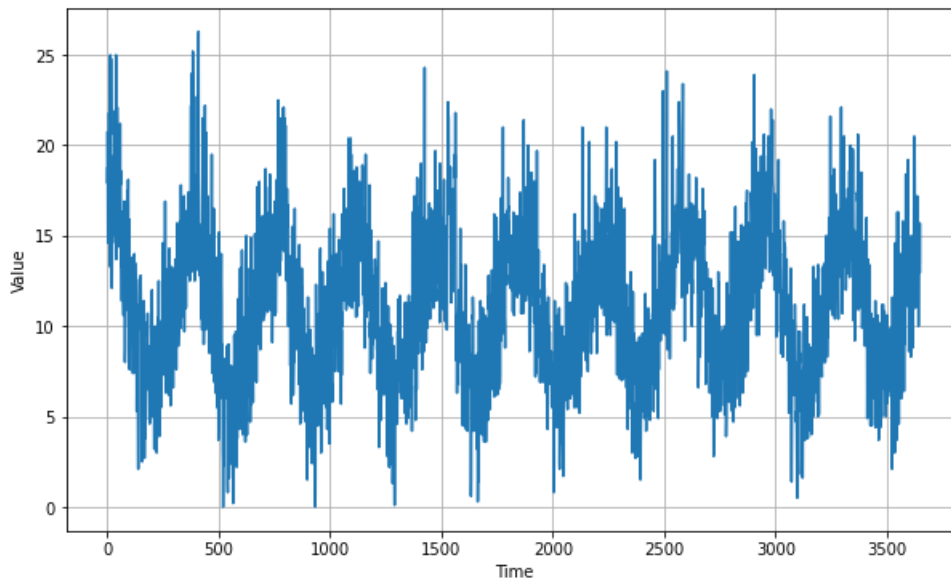
```
split_time = 2500
time_train = time[:split_time]
x_train = series[:split_time]
time_valid = time[split_time:]
x_valid = series[split_time:]

window_size = 30
batch_size = 32
shuffle_buffer_size = 1000
```

In [7]:

```
def windowed_dataset(series, window_size, batch_size, shuffle_buffer):
    series = tf.expand_dims(series, axis=-1)
    ds = tf.data.Dataset.from_tensor_slices(series)
    ds = ds.window(window_size + 1, shift=1, drop_remainder=True)
    ds = ds.flat_map(lambda w: w.batch(window_size + 1))
    ds = ds.shuffle(shuffle_buffer)
    ds = ds.map(lambda w: (w[:-1], w[1:]))
    return ds.batch(batch_size).prefetch(1)
```

In [8]:

```
def model_forecast(model, series, window_size):
    ds = tf.data.Dataset.from_tensor_slices(series)
    ds = ds.window(window_size, shift=1, drop_remainder=True)
    ds = ds.flat_map(lambda w: w.batch(window_size))
    ds = ds.batch(32).prefetch(1)
    forecast = model.predict(ds)
    return forecast
```

In [9]:

```
tf.keras.backend.clear_session()
tf.random.set_seed(51)
np.random.seed(51)
window_size = 64
batch_size = 256
train_set = windowed_dataset(x_train, window_size, batch_size, shuffle_buffer_size)
print(train_set)
print(x_train.shape)

model = tf.keras.models.Sequential([
  tf.keras.layers.Conv1D(filters=32, kernel_size=5,
                         strides=1, padding="causal",
```

```python
                        strides=1, padding="causal",
                        activation="relu",
                        input_shape=[None, 1]),
  tf.keras.layers.LSTM(64, return_sequences=True),
  tf.keras.layers.LSTM(64, return_sequences=True),
  tf.keras.layers.Dense(30, activation="relu"),
  tf.keras.layers.Dense(10, activation="relu"),
  tf.keras.layers.Dense(1),
  tf.keras.layers.Lambda(lambda x: x * 400)
])

lr_schedule = tf.keras.callbacks.LearningRateScheduler(
    lambda epoch: 1e-8 * 10**(epoch / 20))
optimizer = tf.keras.optimizers.SGD(lr=1e-8, momentum=0.9)
model.compile(loss=tf.keras.losses.Huber(),
              optimizer=optimizer,
              metrics=["mae"])
history = model.fit(train_set, epochs=100, callbacks=[lr_schedule])
```

```
<PrefetchDataset shapes: ((None, None, 1), (None, None, 1)), types: (tf.float64, tf.float64)>
(2500,)
Epoch 1/100
10/10 [==============================] - 0s 27ms/step - loss: 31.1571 - mae: 31.6550
Epoch 2/100
10/10 [==============================] - 0s 23ms/step - loss: 30.5778 - mae: 31.0756
Epoch 3/100
10/10 [==============================] - 0s 25ms/step - loss: 29.6825 - mae: 30.1801
Epoch 4/100
10/10 [==============================] - 0s 23ms/step - loss: 28.5613 - mae: 29.0586
Epoch 5/100
10/10 [==============================] - 0s 24ms/step - loss: 27.1974 - mae: 27.6945
Epoch 6/100
10/10 [==============================] - 0s 26ms/step - loss: 25.5017 - mae: 25.9986
Epoch 7/100
10/10 [==============================] - 0s 26ms/step - loss: 23.3464 - mae: 23.8429
Epoch 8/100
10/10 [==============================] - 0s 28ms/step - loss: 20.6148 - mae: 21.1108
Epoch 9/100
10/10 [==============================] - 0s 25ms/step - loss: 17.3142 - mae: 17.8091
Epoch 10/100
10/10 [==============================] - 0s 28ms/step - loss: 13.6449 - mae: 14.1371
Epoch 11/100
10/10 [==============================] - 0s 27ms/step - loss: 10.1273 - mae: 10.6152
Epoch 12/100
10/10 [==============================] - 0s 26ms/step - loss: 7.6175 - mae: 8.1025
Epoch 13/100
10/10 [==============================] - 0s 27ms/step - loss: 6.2869 - mae: 6.7711
Epoch 14/100
10/10 [==============================] - 0s 26ms/step - loss: 5.7015 - mae: 6.1856
Epoch 15/100
10/10 [==============================] - 0s 25ms/step - loss: 5.3344 - mae: 5.8166
Epoch 16/100
10/10 [==============================] - 0s 26ms/step - loss: 4.9409 - mae: 5.4206
Epoch 17/100
10/10 [==============================] - 0s 26ms/step - loss: 4.5578 - mae: 5.0338
Epoch 18/100
10/10 [==============================] - 0s 26ms/step - loss: 4.2340 - mae: 4.7085
Epoch 19/100
10/10 [==============================] - 0s 26ms/step - loss: 3.9611 - mae: 4.4360
Epoch 20/100
10/10 [==============================] - 0s 26ms/step - loss: 3.7448 - mae: 4.2177
Epoch 21/100
10/10 [==============================] - 0s 26ms/step - loss: 3.5855 - mae: 4.0566
Epoch 22/100
10/10 [==============================] - 0s 25ms/step - loss: 3.4641 - mae: 3.9344
Epoch 23/100
10/10 [==============================] - 0s 26ms/step - loss: 3.3711 - mae: 3.8414
Epoch 24/100
10/10 [==============================] - 0s 28ms/step - loss: 3.2948 - mae: 3.7645
Epoch 25/100
10/10 [==============================] - 0s 27ms/step - loss: 3.2288 - mae: 3.6978
Epoch 26/100
10/10 [==============================] - 0s 25ms/step - loss: 3.1662 - mae: 3.6346
Epoch 27/100
10/10 [==============================] - 0s 25ms/step - loss: 3.1014 - mae: 3.5693
Epoch 28/100
10/10 [==============================] - 0s 24ms/step - loss: 3.0380 - mae: 3.5053
```

```
10/10 [                                     ] - 0s 24ms/step - loss: 3.0000 - mae: 3.0000
Epoch 29/100
10/10 [==============================] - 0s 27ms/step - loss: 2.9716 - mae: 3.4379
Epoch 30/100
10/10 [==============================] - 0s 26ms/step - loss: 2.9063 - mae: 3.3712
Epoch 31/100
10/10 [==============================] - 0s 27ms/step - loss: 2.8452 - mae: 3.3098
Epoch 32/100
10/10 [==============================] - 0s 27ms/step - loss: 2.7842 - mae: 3.2479
Epoch 33/100
10/10 [==============================] - 0s 27ms/step - loss: 2.7256 - mae: 3.1891
Epoch 34/100
10/10 [==============================] - 0s 25ms/step - loss: 2.6740 - mae: 3.1379
Epoch 35/100
10/10 [==============================] - 0s 26ms/step - loss: 2.6212 - mae: 3.0848
Epoch 36/100
10/10 [==============================] - 0s 27ms/step - loss: 2.5728 - mae: 3.0357
Epoch 37/100
10/10 [==============================] - 0s 25ms/step - loss: 2.5254 - mae: 2.9877
Epoch 38/100
10/10 [==============================] - 0s 27ms/step - loss: 2.4800 - mae: 2.9415
Epoch 39/100
10/10 [==============================] - 0s 25ms/step - loss: 2.4355 - mae: 2.8968
Epoch 40/100
10/10 [==============================] - 0s 25ms/step - loss: 2.3933 - mae: 2.8541
Epoch 41/100
10/10 [==============================] - 0s 26ms/step - loss: 2.3523 - mae: 2.8124
Epoch 42/100
10/10 [==============================] - 0s 26ms/step - loss: 2.3124 - mae: 2.7718
Epoch 43/100
10/10 [==============================] - 0s 25ms/step - loss: 2.2730 - mae: 2.7314
Epoch 44/100
10/10 [==============================] - 0s 25ms/step - loss: 2.2338 - mae: 2.6913
Epoch 45/100
10/10 [==============================] - 0s 27ms/step - loss: 2.1954 - mae: 2.6523
Epoch 46/100
10/10 [==============================] - 0s 27ms/step - loss: 2.1622 - mae: 2.6190
Epoch 47/100
10/10 [==============================] - 0s 25ms/step - loss: 2.1313 - mae: 2.5877
Epoch 48/100
10/10 [==============================] - 0s 27ms/step - loss: 2.1047 - mae: 2.5607
Epoch 49/100
10/10 [==============================] - 0s 27ms/step - loss: 2.0740 - mae: 2.5300
Epoch 50/100
10/10 [==============================] - 0s 25ms/step - loss: 2.0481 - mae: 2.5040
Epoch 51/100
10/10 [==============================] - 0s 26ms/step - loss: 2.0263 - mae: 2.4818
Epoch 52/100
10/10 [==============================] - 0s 25ms/step - loss: 2.0048 - mae: 2.4598
Epoch 53/100
10/10 [==============================] - 0s 25ms/step - loss: 1.9897 - mae: 2.4444
Epoch 54/100
10/10 [==============================] - 0s 26ms/step - loss: 1.9650 - mae: 2.4193
Epoch 55/100
10/10 [==============================] - 0s 27ms/step - loss: 1.9469 - mae: 2.4008
Epoch 56/100
10/10 [==============================] - 0s 27ms/step - loss: 1.9247 - mae: 2.3783
Epoch 57/100
10/10 [==============================] - 0s 29ms/step - loss: 1.9090 - mae: 2.3620
Epoch 58/100
10/10 [==============================] - 0s 26ms/step - loss: 1.8863 - mae: 2.3394
Epoch 59/100
10/10 [==============================] - 0s 24ms/step - loss: 1.8594 - mae: 2.3121
Epoch 60/100
10/10 [==============================] - 0s 26ms/step - loss: 2.1962 - mae: 2.6561
Epoch 61/100
10/10 [==============================] - 0s 26ms/step - loss: 2.6844 - mae: 3.1553
Epoch 62/100
10/10 [==============================] - 0s 28ms/step - loss: 3.0853 - mae: 3.5612
Epoch 63/100
10/10 [==============================] - 0s 28ms/step - loss: 3.5161 - mae: 3.9953
Epoch 64/100
10/10 [==============================] - 0s 24ms/step - loss: 3.6601 - mae: 4.1412
Epoch 65/100
10/10 [==============================] - 0s 25ms/step - loss: 4.2058 - mae: 4.6924
Epoch 66/100
10/10 [==============================] - 0s 25ms/step - loss: 4.3838 - mae: 4.8702
Epoch 67/100
```

```
Epoch 67/100
10/10 [==============================] - 0s 28ms/step - loss: 4.6310 - mae: 5.1187
Epoch 68/100
10/10 [==============================] - 0s 27ms/step - loss: 4.7004 - mae: 5.1866
Epoch 69/100
10/10 [==============================] - 0s 28ms/step - loss: 4.9989 - mae: 5.4863
Epoch 70/100
10/10 [==============================] - 0s 28ms/step - loss: 5.0512 - mae: 5.5357
Epoch 71/100
10/10 [==============================] - 0s 26ms/step - loss: 5.2422 - mae: 5.7261
Epoch 72/100
10/10 [==============================] - 0s 27ms/step - loss: 5.4587 - mae: 5.9484
Epoch 73/100
10/10 [==============================] - 0s 26ms/step - loss: 4.7423 - mae: 5.2251
Epoch 74/100
10/10 [==============================] - 0s 28ms/step - loss: 4.2564 - mae: 4.7379
Epoch 75/100
10/10 [==============================] - 0s 28ms/step - loss: 3.6927 - mae: 4.1683
Epoch 76/100
10/10 [==============================] - 0s 27ms/step - loss: 3.7762 - mae: 4.2532
Epoch 77/100
10/10 [==============================] - 0s 26ms/step - loss: 4.5301 - mae: 5.0170
Epoch 78/100
10/10 [==============================] - 0s 26ms/step - loss: 6.1094 - mae: 6.5934
Epoch 79/100
10/10 [==============================] - 0s 26ms/step - loss: 2.9695 - mae: 3.4385
Epoch 80/100
10/10 [==============================] - 0s 26ms/step - loss: 2.8934 - mae: 3.3623
Epoch 81/100
10/10 [==============================] - 0s 29ms/step - loss: 4.7226 - mae: 5.2042
Epoch 82/100
10/10 [==============================] - 0s 26ms/step - loss: 5.3774 - mae: 5.8639
Epoch 83/100
10/10 [==============================] - 0s 26ms/step - loss: 3.1506 - mae: 3.6217
Epoch 84/100
10/10 [==============================] - 0s 27ms/step - loss: 4.1580 - mae: 4.6369
Epoch 85/100
10/10 [==============================] - 0s 25ms/step - loss: 5.8540 - mae: 6.3460
Epoch 86/100
10/10 [==============================] - 0s 26ms/step - loss: 6.4447 - mae: 6.9360
Epoch 87/100
10/10 [==============================] - 0s 25ms/step - loss: 6.9261 - mae: 7.4152
Epoch 88/100
10/10 [==============================] - 0s 26ms/step - loss: 18.2498 - mae: 18.7448
Epoch 89/100
10/10 [==============================] - 0s 24ms/step - loss: 38.9727 - mae: 39.4701
Epoch 90/100
10/10 [==============================] - 0s 25ms/step - loss: 28.5342 - mae: 29.0282
Epoch 91/100
10/10 [==============================] - 0s 25ms/step - loss: 85.6631 - mae: 86.1599
Epoch 92/100
10/10 [==============================] - 0s 25ms/step - loss: 83.9756 - mae: 84.4721
Epoch 93/100
10/10 [==============================] - 0s 25ms/step - loss: 25.2830 - mae: 25.7762
Epoch 94/100
10/10 [==============================] - 0s 28ms/step - loss: 17.9940 - mae: 18.4931
Epoch 95/100
10/10 [==============================] - 0s 27ms/step - loss: 20.2531 - mae: 20.7504
Epoch 96/100
10/10 [==============================] - 0s 27ms/step - loss: 48.1390 - mae: 48.6361
Epoch 97/100
10/10 [==============================] - 0s 27ms/step - loss: 107.0428 - mae: 107.5428
Epoch 98/100
10/10 [==============================] - 0s 29ms/step - loss: 158.6773 - mae: 159.1741
Epoch 99/100
10/10 [==============================] - 0s 27ms/step - loss: 113.6728 - mae: 114.1728
Epoch 100/100
10/10 [==============================] - 0s 26ms/step - loss: 141.0664 - mae: 141.5664
```
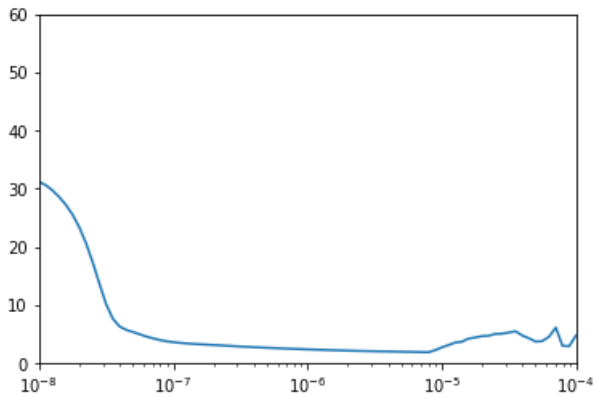
In [10]:

```python
plt.semilogx(history.history["lr"], history.history["loss"])
plt.axis([1e-8, 1e-4, 0, 60])
```

Out[10]:

```
(1e-08, 0.0001, 0.0, 60.0)
```

```python
tf.keras.backend.clear_session()
tf.random.set_seed(51)
np.random.seed(51)
train_set = windowed_dataset(x_train, window_size=60, batch_size=100, shuffle_buffer=shuffle_buffer
_size)
model = tf.keras.models.Sequential([
  tf.keras.layers.Conv1D(filters=60, kernel_size=5,
                      strides=1, padding="causal",
                      activation="relu",
                      input_shape=[None, 1]),
  tf.keras.layers.LSTM(60, return_sequences=True),
  tf.keras.layers.LSTM(60, return_sequences=True),
  tf.keras.layers.Dense(30, activation="relu"),
  tf.keras.layers.Dense(10, activation="relu"),
  tf.keras.layers.Dense(1),
  tf.keras.layers.Lambda(lambda x: x * 400)
])


optimizer = tf.keras.optimizers.SGD(lr=1e-5, momentum=0.9)
model.compile(loss=tf.keras.losses.Huber(),
             optimizer=optimizer,
             metrics=["mae"])
history = model.fit(train_set,epochs=150)
```

```
Epoch 1/150
25/25 [==============================] - 0s 16ms/step - loss: 9.9814 - mae: 10.4694
Epoch 2/150
25/25 [==============================] - 0s 14ms/step - loss: 2.5295 - mae: 2.9922
Epoch 3/150
25/25 [==============================] - 0s 15ms/step - loss: 1.9502 - mae: 2.4047
Epoch 4/150
25/25 [==============================] - 0s 15ms/step - loss: 1.8619 - mae: 2.3151
Epoch 5/150
25/25 [==============================] - 0s 15ms/step - loss: 1.8215 - mae: 2.2733
Epoch 6/150
25/25 [==============================] - 0s 14ms/step - loss: 1.7909 - mae: 2.2418
Epoch 7/150
25/25 [==============================] - 0s 15ms/step - loss: 1.7686 - mae: 2.2186
Epoch 8/150
25/25 [==============================] - 0s 14ms/step - loss: 1.7413 - mae: 2.1906
Epoch 9/150
25/25 [==============================] - 0s 15ms/step - loss: 1.7193 - mae: 2.1681
Epoch 10/150
25/25 [==============================] - 0s 14ms/step - loss: 1.7000 - mae: 2.1482
Epoch 11/150
25/25 [==============================] - 0s 16ms/step - loss: 1.6811 - mae: 2.1287
Epoch 12/150
25/25 [==============================] - 0s 14ms/step - loss: 1.6688 - mae: 2.1159
Epoch 13/150
25/25 [==============================] - 0s 15ms/step - loss: 1.6566 - mae: 2.1030
Epoch 14/150
25/25 [==============================] - 0s 14ms/step - loss: 1.6434 - mae: 2.0891
Epoch 15/150
25/25 [==============================] - 0s 16ms/step - loss: 1.6354 - mae: 2.0803
```

```
Epoch 16/150
25/25 [==============================] - 0s 15ms/step - loss: 1.6264 - mae: 2.0710
Epoch 17/150
25/25 [==============================] - 0s 15ms/step - loss: 1.6140 - mae: 2.0581
Epoch 18/150
25/25 [==============================] - 0s 15ms/step - loss: 1.6114 - mae: 2.0553
Epoch 19/150
25/25 [==============================] - 0s 15ms/step - loss: 1.6011 - mae: 2.0444
Epoch 20/150
25/25 [==============================] - 0s 14ms/step - loss: 1.5933 - mae: 2.0365
Epoch 21/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5917 - mae: 2.0348
Epoch 22/150
25/25 [==============================] - 0s 14ms/step - loss: 1.5849 - mae: 2.0276
Epoch 23/150
25/25 [==============================] - 0s 16ms/step - loss: 1.5806 - mae: 2.0232
Epoch 24/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5797 - mae: 2.0222
Epoch 25/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5701 - mae: 2.0121
Epoch 26/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5665 - mae: 2.0085
Epoch 27/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5639 - mae: 2.0057
Epoch 28/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5596 - mae: 2.0014
Epoch 29/150
25/25 [==============================] - 0s 16ms/step - loss: 1.5573 - mae: 1.9991
Epoch 30/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5552 - mae: 1.9972
Epoch 31/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5546 - mae: 1.9966
Epoch 32/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5520 - mae: 1.9936
Epoch 33/150
25/25 [==============================] - 0s 16ms/step - loss: 1.5480 - mae: 1.9897
Epoch 34/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5520 - mae: 1.9939
Epoch 35/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5489 - mae: 1.9909
Epoch 36/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5430 - mae: 1.9846
Epoch 37/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5422 - mae: 1.9836
Epoch 38/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5403 - mae: 1.9817
Epoch 39/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5404 - mae: 1.9822
Epoch 40/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5411 - mae: 1.9829
Epoch 41/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5354 - mae: 1.9769
Epoch 42/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5354 - mae: 1.9770
Epoch 43/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5351 - mae: 1.9768
Epoch 44/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5360 - mae: 1.9781
Epoch 45/150
25/25 [==============================] - 0s 16ms/step - loss: 1.5308 - mae: 1.9723
Epoch 46/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5330 - mae: 1.9748
Epoch 47/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5285 - mae: 1.9699
Epoch 48/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5312 - mae: 1.9730
Epoch 49/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5306 - mae: 1.9724
Epoch 50/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5262 - mae: 1.9678
Epoch 51/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5291 - mae: 1.9708
Epoch 52/150
25/25 [==============================] - 0s 14ms/step - loss: 1.5274 - mae: 1.9692
Epoch 53/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5288 - mae: 1.9708
Epoch 54/150
```

```
25/25 [==============================] - 0s 15ms/step - loss: 1.5239 - mae: 1.9656
Epoch 55/150
25/25 [==============================] - 0s 16ms/step - loss: 1.5236 - mae: 1.9654
Epoch 56/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5214 - mae: 1.9629
Epoch 57/150
25/25 [==============================] - 0s 16ms/step - loss: 1.5219 - mae: 1.9635
Epoch 58/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5347 - mae: 1.9776
Epoch 59/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5251 - mae: 1.9669
Epoch 60/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5221 - mae: 1.9638
Epoch 61/150
25/25 [==============================] - 0s 14ms/step - loss: 1.5185 - mae: 1.9600
Epoch 62/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5197 - mae: 1.9612
Epoch 63/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5170 - mae: 1.9584
Epoch 64/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5174 - mae: 1.9589
Epoch 65/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5167 - mae: 1.9581
Epoch 66/150
25/25 [==============================] - 0s 16ms/step - loss: 1.5169 - mae: 1.9585
Epoch 67/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5219 - mae: 1.9636
Epoch 68/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5163 - mae: 1.9579
Epoch 69/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5146 - mae: 1.9561
Epoch 70/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5145 - mae: 1.9559
Epoch 71/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5129 - mae: 1.9542
Epoch 72/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5123 - mae: 1.9537
Epoch 73/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5153 - mae: 1.9569
Epoch 74/150
25/25 [==============================] - 0s 16ms/step - loss: 1.5112 - mae: 1.9527
Epoch 75/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5127 - mae: 1.9542
Epoch 76/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5114 - mae: 1.9527
Epoch 77/150
25/25 [==============================] - 0s 16ms/step - loss: 1.5104 - mae: 1.9520
Epoch 78/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5143 - mae: 1.9559
Epoch 79/150
25/25 [==============================] - 0s 17ms/step - loss: 1.5090 - mae: 1.9505
Epoch 80/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5104 - mae: 1.9520
Epoch 81/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5148 - mae: 1.9565
Epoch 82/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5075 - mae: 1.9490
Epoch 83/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5081 - mae: 1.9495
Epoch 84/150
25/25 [==============================] - 0s 14ms/step - loss: 1.5085 - mae: 1.9501
Epoch 85/150
25/25 [==============================] - 0s 16ms/step - loss: 1.5070 - mae: 1.9484
Epoch 86/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5061 - mae: 1.9476
Epoch 87/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5075 - mae: 1.9489
Epoch 88/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5054 - mae: 1.9468
Epoch 89/150
25/25 [==============================] - 0s 16ms/step - loss: 1.5050 - mae: 1.9463
Epoch 90/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5064 - mae: 1.9479
Epoch 91/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5056 - mae: 1.9468
Epoch 92/150
25/25 [==============================] - 0s 14ms/step - loss: 1.5046 - mae: 1.9459
```

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Epoch 93/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5033 - mae: 1.9446
Epoch 94/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5023 - mae: 1.9438
Epoch 95/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5110 - mae: 1.9529
Epoch 96/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5034 - mae: 1.9449
Epoch 97/150
25/25 [==============================] - 0s 14ms/step - loss: 1.5052 - mae: 1.9469
Epoch 98/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5057 - mae: 1.9469
Epoch 99/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5013 - mae: 1.9426
Epoch 100/150
25/25 [==============================] - 0s 14ms/step - loss: 1.5012 - mae: 1.9425
Epoch 101/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5014 - mae: 1.9428
Epoch 102/150
25/25 [==============================] - 0s 14ms/step - loss: 1.4997 - mae: 1.9411
Epoch 103/150
25/25 [==============================] - 0s 16ms/step - loss: 1.5000 - mae: 1.9412
Epoch 104/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5006 - mae: 1.9419
Epoch 105/150
25/25 [==============================] - 0s 16ms/step - loss: 1.4999 - mae: 1.9411
Epoch 106/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4998 - mae: 1.9412
Epoch 107/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5016 - mae: 1.9430
Epoch 108/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5003 - mae: 1.9415
Epoch 109/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5001 - mae: 1.9413
Epoch 110/150
25/25 [==============================] - 0s 16ms/step - loss: 1.5015 - mae: 1.9428
Epoch 111/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4988 - mae: 1.9401
Epoch 112/150
25/25 [==============================] - 0s 16ms/step - loss: 1.4977 - mae: 1.9388
Epoch 113/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4966 - mae: 1.9378
Epoch 114/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4968 - mae: 1.9380
Epoch 115/150
25/25 [==============================] - 0s 16ms/step - loss: 1.4967 - mae: 1.9378
Epoch 116/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4979 - mae: 1.9391
Epoch 117/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4966 - mae: 1.9377
Epoch 118/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4973 - mae: 1.9384
Epoch 119/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4960 - mae: 1.9370
Epoch 120/150
25/25 [==============================] - 0s 17ms/step - loss: 1.4971 - mae: 1.9382
Epoch 121/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5011 - mae: 1.9427
Epoch 122/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4966 - mae: 1.9375
Epoch 123/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5012 - mae: 1.9424
Epoch 124/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4959 - mae: 1.9370
Epoch 125/150
25/25 [==============================] - 0s 14ms/step - loss: 1.4955 - mae: 1.9367
Epoch 126/150
25/25 [==============================] - 0s 16ms/step - loss: 1.4952 - mae: 1.9360
Epoch 127/150
25/25 [==============================] - 0s 14ms/step - loss: 1.4945 - mae: 1.9354
Epoch 128/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4942 - mae: 1.9350
Epoch 129/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4928 - mae: 1.9337
Epoch 130/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4962 - mae: 1.9374
Epoch 131/150
```

```
25/25 [==============================] - 0s 14ms/step - loss: 1.4926 - mae: 1.9336
Epoch 132/150
25/25 [==============================] - 0s 15ms/step - loss: 1.5004 - mae: 1.9415
Epoch 133/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4971 - mae: 1.9380
Epoch 134/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4968 - mae: 1.9382
Epoch 135/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4917 - mae: 1.9323
Epoch 136/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4927 - mae: 1.9334
Epoch 137/150
25/25 [==============================] - 0s 14ms/step - loss: 1.4957 - mae: 1.9365
Epoch 138/150
25/25 [==============================] - 0s 16ms/step - loss: 1.4922 - mae: 1.9330
Epoch 139/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4915 - mae: 1.9322
Epoch 140/150
25/25 [==============================] - 0s 17ms/step - loss: 1.4917 - mae: 1.9325
Epoch 141/150
25/25 [==============================] - 0s 16ms/step - loss: 1.4905 - mae: 1.9312
Epoch 142/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4897 - mae: 1.9305
Epoch 143/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4924 - mae: 1.9334
Epoch 144/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4920 - mae: 1.9326
Epoch 145/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4894 - mae: 1.9300
Epoch 146/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4957 - mae: 1.9365
Epoch 147/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4901 - mae: 1.9307
Epoch 148/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4893 - mae: 1.9301
Epoch 149/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4900 - mae: 1.9307
Epoch 150/150
25/25 [==============================] - 0s 15ms/step - loss: 1.4889 - mae: 1.9293
```

In [12]:

```
rnn_forecast = model_forecast(model, series[..., np.newaxis], window_size)
rnn_forecast = rnn_forecast[split_time - window_size:-1, -1, 0]
```
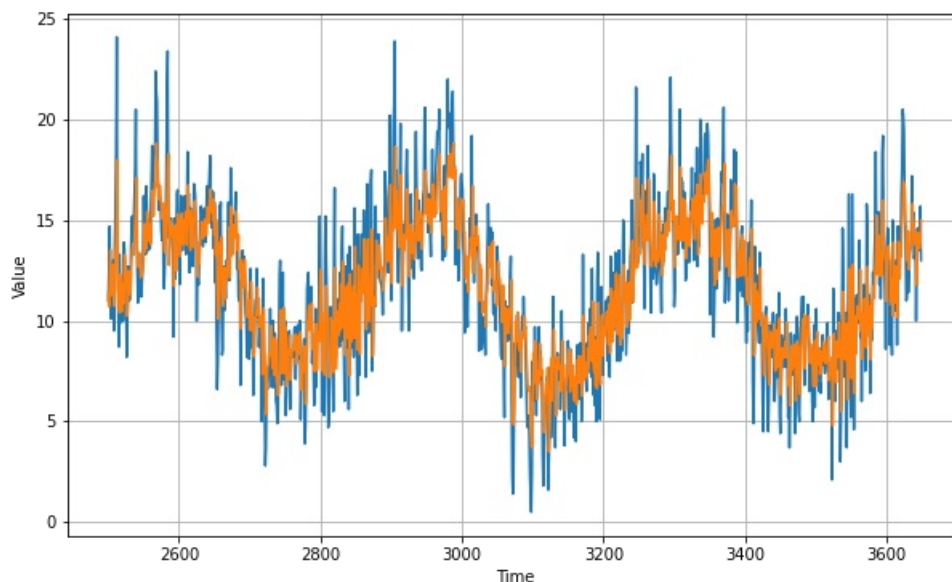
In [13]:

```
plt.figure(figsize=(10, 6))
plot_series(time_valid, x_valid)
plot_series(time_valid, rnn_forecast)
```

In [14]:

```python
tf.keras.metrics.mean_absolute_error(x_valid, rnn_forecast).numpy()
```

Out[14]:

1.7797372

In [15]:

```python
print(rnn_forecast)
```

[11.327622 10.703384 12.1217165 ... 13.602117 13.794539 15.006724]

In [ ]: