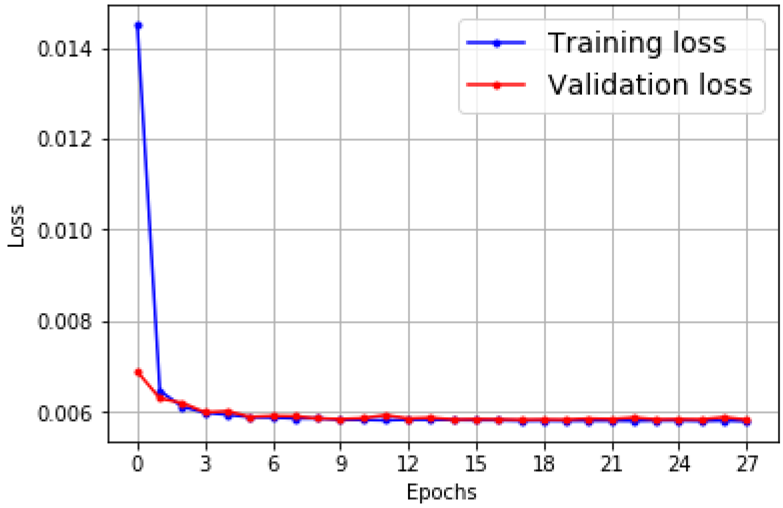
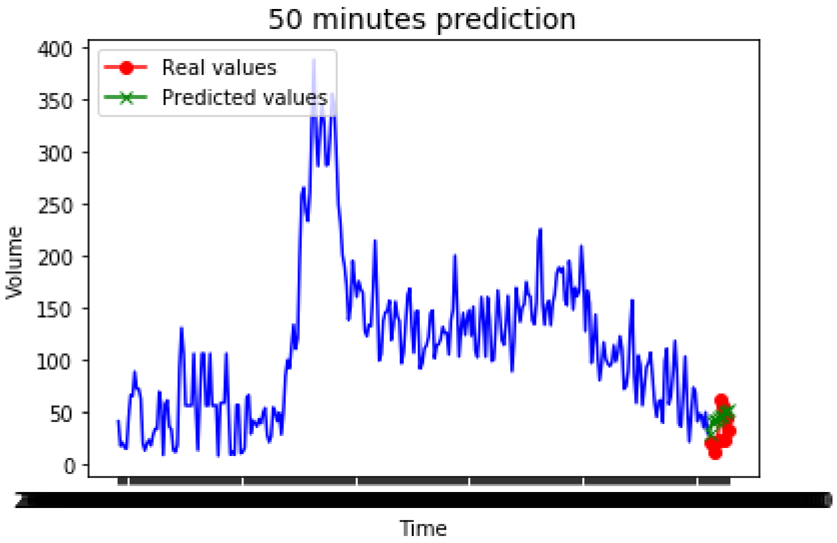
```
import matplotlib as mpl
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
from sklearn.preprocessing import MinMaxScaler
from scipy import stats
import seaborn as sns
import tensorflow as tf
from tensorflow import keras
import sklearn
import sys
import io

n_steps = 50
forecast = 10

def plot_learning_curves(loss, val_loss):
    plt.figure()
    plt.plot(np.arange(len(loss)), loss, "b.-", label="Training loss")
    plt.plot(np.arange(len(val_loss)), val_loss, "r.-", label="Validation loss")
    plt.gca().xaxis.set_major_locator(mpl.ticker.MaxNLocator(integer=True))
    plt.legend(fontsize=14)
    plt.xlabel("Epochs")
    plt.ylabel("Loss")
    plt.grid(True)

#LOAD DATA
data_west = pd.read_csv('denoised_data_1016_east.csv')
data_west_o = np.array(data_west.FLOW)
# #EXRTEND DATA
array_to_concatinate = data_west_o[288:]
for iter in range (35):
    data_west_o = np.concatenate([data_west_o,array_to_concatinate])

# #SCALE AND RESHAPE DATA
scaler = MinMaxScaler()
array = data_west_o.reshape(-1, 1)
array_scaled = scaler.fit_transform(array)
flow_reshaped = array_scaled[:(len(array_scaled) - (len(array_scaled) % (n_steps+forecast
print(flow_reshaped.shape)

# #TRAIN SET, VALIDATION SET, TEST SET
test = int(0.7 * flow_reshaped.shape[0])
valid = int(0.9 * flow_reshaped.shape[0])

X_train= flow_reshaped[:test, :n_steps] #first 50, last 10
X_valid = flow_reshaped[test:valid, :n_steps]
X_test = flow_reshaped[valid:, :n_steps]

#prepare targets
Y = np.empty((flow_reshaped.shape[0], n_steps, forecast))
for step_ahead in range(1, forecast + 1):
    Y[:, :, step_ahead - 1] = flow_reshaped[:, step_ahead:step_ahead + n_steps, 0]

y_train = Y[:test]
y_valid = Y[test:valid]
y_test = Y[valid:]

# # NEW MODEL TO FIT HYPERPARAMETERS
model = keras.models.Sequential([
    keras.layers.SimpleRNN(20, return_sequences=True, input_shape=[None, 1]),
    keras.layers.SimpleRNN(20, return_sequences=True),
    keras.layers.TimeDistributed(keras.layers.Dense(forecast))
])

def last_time_step_mse(Y_true, Y_pred):
    return keras.metrics.mean_squared_error(Y_true[:, -1], Y_pred[:, -1])

model.compile(loss="mse", optimizer="adam",  metrics=[last_time_step_mse])
```

```
early_stopping_cb = keras.callbacks.EarlyStopping(patience=10, restore_best_weights=True
history = model.fit(X_train, y_train, epochs=700,
                    validation_data=(X_valid, y_valid), callbacks=[early_stopping_cb])

model.save("rnn_1016_west.h5")
plot_learning_curves(history.history["loss"], history.history["val_loss"])


#50 minutes forecast
flow_unscaled = array[:(len(array) - (len(array) % (n_steps + forecast)))].reshape(-1, (
y_test_unscaled = flow_unscaled[valid:, n_steps:, 0]
y_real_rescaled = y_test_unscaled[-1, :].reshape(-1, 1)
print(y_real_rescaled.shape)

flow_not_reshaped = array[:(len(array) - (len(array) % (n_steps+forecast)))]

#flow prediction
y_pred = model.predict(X_test[-1, :].reshape(-1, n_steps, 1)) #shape (1, 50, 10)
y_pred = y_pred[-1,-1,:].reshape(-1,1)
y_pred_rescaled = scaler.inverse_transform(y_pred).reshape(-1, 1) #shape (10, 1)
print(y_pred_rescaled.shape)

#time
time_not_reshaped = np.array(data_west['TIME'][:(len(data_west['TIME']) - (len(data_west[
time_reshaped = np.array(data_west['TIME'][:(len(data_west['TIME']) - (len(data_west['TIM
    reshape(-1, (n_steps+forecast), 1)

valid_time = int(0.9 * time_reshaped.shape[0])
y_time_test = time_reshaped[valid_time:, n_steps:, 0]
print(y_time_test[-1, :].shape)

def plot_prediction(y_real_resacled, y_pred_rescaled, flow_not_reshaped, time_not_reshape
    plt.figure()
    plt.title("50 minutes prediction", fontsize=14)
    plt.plot(time_not_reshaped[-300:-forecast], flow_not_reshaped[-300:-forecast], 'b-')
    plt.plot(y_time_test[-1, :], y_real_resacled, 'ro-', label = 'Real values')
    plt.plot(y_time_test[-1, :], y_pred_rescaled, 'gx-', label = 'Predicted values')
    plt.legend(loc="upper left")
    plt.xlabel("Time")
    plt.ylabel('Volume')

plot_prediction(y_real_rescaled, y_pred_rescaled, flow_not_reshaped, time_not_reshaped, y

plt.show()
```

```
7381/7381 [==============================] - 3s 470us/sample - loss: 0.0058 -
Epoch 18/700
7381/7381 [==============================] - 3s 472us/sample - loss: 0.0058 -
Epoch 19/700
7381/7381 [==============================] - 3s 464us/sample - loss: 0.0058 -
Epoch 20/700
7381/7381 [==============================] - 3s 460us/sample - loss: 0.0058 -
Epoch 21/700
7381/7381 [==============================] - 3s 447us/sample - loss: 0.0058 -
Epoch 22/700
7381/7381 [==============================] - 3s 453us/sample - loss: 0.0058 -
Epoch 23/700
7381/7381 [==============================] - 3s 465us/sample - loss: 0.0058 -
Epoch 24/700
7381/7381 [==============================] - 3s 438us/sample - loss: 0.0058 -
Epoch 25/700
7381/7381 [==============================] - 3s 464us/sample - loss: 0.0058 -
Epoch 26/700
7381/7381 [==============================] - 3s 424us/sample - loss: 0.0058 -
Epoch 27/700
7381/7381 [==============================] - 3s 435us/sample - loss: 0.0058 -
Epoch 28/700
7381/7381 [==============================] - 3s 457us/sample - loss: 0.0058 -
(10, 1)
(10, 1)
(10,)
```


Training loss
Validation loss
Loss
Epochs


50 minutes prediction
Real values
Predicted values
Volume
Time