What I used:  
X\_jma shape: (85325, 10, 10)

y\_jma shape: (85325, 1)  
  
def build\_optimized\_cnn\_gru\_model(input\_shape):  
 model = Sequential()  
  
 # CNN layers with residual connections  
 model.add(Conv1D(filters=64, kernel\_size=3, activation='relu', input\_shape=input\_shape))  
 model.add(BatchNormalization())  
 model.add(MaxPooling1D(pool\_size=2))  
  
 model.add(Conv1D(filters=128, kernel\_size=3, activation='relu'))  
 model.add(BatchNormalization())  
 model.add(MaxPooling1D(pool\_size=2))  
  
 # GRU layers with regularization  
 model.add(GRU(units=256, return\_sequences=True, kernel\_regularizer=l2(0.001)))  
 model.add(Dropout(0.2))  
 model.add(GRU(units=128, return\_sequences=True, kernel\_regularizer=l2(0.001)))  
  
 # Fully connected layers  
 model.add(Dense(units=64, activation='relu', kernel\_regularizer=l2(0.001)))  
 model.add(Dropout(0.2))  
 model.add(Dense(units=1, activation='linear'))  
  
 # Compile model  
 model.compile(optimizer=Adam(learning\_rate=0.9),  
 loss='mse', metrics=['mae'])  
 return model

from tensorflow.keras.callbacks import LearningRateScheduler  
# Define Callbacks  
early\_stopping = EarlyStopping(  
 monitor='val\_loss',  
 patience=10, # Stop if no improvement after 10 epochs  
 restore\_best\_weights=True  
)  
reduce\_lr = ReduceLROnPlateau(  
 monitor='val\_loss',  
 factor=0.5, # Reduce learning rate by half  
 patience=5, # After 5 epochs of no improvement  
 min\_lr=1e-6 # Minimum learning rate  
)  
# Define the learning rate scheduler function  
def lr\_schedule(epoch, lr):  
 if epoch % 5 == 0 and epoch != 0: # Decay every 5 epochs, excluding the first epoch  
 return lr \* 0.9 # Multiply the current learning rate by 0.9  
 return lr  
  
# Create the LearningRateScheduler callback  
lr\_scheduler = LearningRateScheduler(lr\_schedule, verbose=1)

input\_shape = (X\_jma.shape[1], X\_jma.shape[2]) # (10, 10)  
  
# Build the model  
model = build\_optimized\_cnn\_gru\_model(input\_shape)  
model.summary()

Model: "sequential\_10"

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Layer (type) Output Shape Param #

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conv1d\_21 (Conv1D) (None, 8, 64) 1984

batch\_normalization\_20 (Ba (None, 8, 64) 256

tchNormalization)

max\_pooling1d\_20 (MaxPooli (None, 4, 64) 0

ng1D)

conv1d\_22 (Conv1D) (None, 2, 128) 24704

batch\_normalization\_21 (Ba (None, 2, 128) 512

tchNormalization)

max\_pooling1d\_21 (MaxPooli (None, 1, 128) 0

ng1D)

gru\_18 (GRU) (None, 1, 256) 296448

dropout\_20 (Dropout) (None, 1, 256) 0

gru\_19 (GRU) (None, 1, 128) 148224

dense\_14 (Dense) (None, 1, 64) 8256

dropout\_21 (Dropout) (None, 1, 64) 0

dense\_15 (Dense) (None, 1, 1) 65

=================================================================

Total params: 480449 (1.83 MB)

Trainable params: 480065 (1.83 MB)

Non-trainable params: 384 (1.50 KB)

# Train the model  
history = model.fit(  
 X\_jma, y\_jma,  
 validation\_split=0.2,  
 epochs=50, # Increased to 100 to allow for more learning  
 batch\_size=64,  
 callbacks=[early\_stopping, reduce\_lr, lr\_scheduler],  
)

I got this:

Epoch 1: LearningRateScheduler setting learning rate to 0.0010000000474974513.

Epoch 1/50

1067/1067 [==============================] - 12s 9ms/step - loss: 1.3928 - mae: 0.8187 - val\_loss: 0.8906 - val\_mae: 0.6930 - lr: 0.0010

Epoch 2: LearningRateScheduler setting learning rate to 0.0010000000474974513.

Epoch 2/50

1067/1067 [==============================] - 8s 8ms/step - loss: 1.0175 - mae: 0.7580 - val\_loss: 0.8236 - val\_mae: 0.7104 - lr: 0.0010

Epoch 3: LearningRateScheduler setting learning rate to 0.0010000000474974513.

Epoch 3/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.9434 - mae: 0.7444 - val\_loss: 0.7995 - val\_mae: 0.6961 - lr: 0.0010

Epoch 4: LearningRateScheduler setting learning rate to 0.0010000000474974513.

Epoch 4/50

1067/1067 [==============================] - 9s 8ms/step - loss: 0.9046 - mae: 0.7320 - val\_loss: 0.7619 - val\_mae: 0.6736 - lr: 0.0010

Epoch 5: LearningRateScheduler setting learning rate to 0.0010000000474974513.

Epoch 5/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.8736 - mae: 0.7187 - val\_loss: 0.7763 - val\_mae: 0.6919 - lr: 0.0010

Epoch 6: LearningRateScheduler setting learning rate to 0.0009000000427477062.

Epoch 6/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.8561 - mae: 0.7117 - val\_loss: 0.7819 - val\_mae: 0.7001 - lr: 9.0000e-04

Epoch 7: LearningRateScheduler setting learning rate to 0.0009000000427477062.

Epoch 7/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.8387 - mae: 0.7041 - val\_loss: 0.7562 - val\_mae: 0.6863 - lr: 9.0000e-04

Epoch 8: LearningRateScheduler setting learning rate to 0.0009000000427477062.

Epoch 8/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.8239 - mae: 0.6981 - val\_loss: 0.8664 - val\_mae: 0.7594 - lr: 9.0000e-04

Epoch 9: LearningRateScheduler setting learning rate to 0.0009000000427477062.

Epoch 9/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.8099 - mae: 0.6909 - val\_loss: 0.7760 - val\_mae: 0.7063 - lr: 9.0000e-04

Epoch 10: LearningRateScheduler setting learning rate to 0.0009000000427477062.

Epoch 10/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.8066 - mae: 0.6899 - val\_loss: 0.7616 - val\_mae: 0.6918 - lr: 9.0000e-04

Epoch 11: LearningRateScheduler setting learning rate to 0.0008100000384729356.

Epoch 11/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.7869 - mae: 0.6796 - val\_loss: 0.7831 - val\_mae: 0.7119 - lr: 8.1000e-04

Epoch 12: LearningRateScheduler setting learning rate to 0.0008100000559352338.

Epoch 12/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.7858 - mae: 0.6794 - val\_loss: 0.7915 - val\_mae: 0.7188 - lr: 4.0500e-04

Epoch 13: LearningRateScheduler setting learning rate to 0.0004050000279676169.

Epoch 13/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.7561 - mae: 0.6653 - val\_loss: 0.7432 - val\_mae: 0.6910 - lr: 4.0500e-04

Epoch 14: LearningRateScheduler setting learning rate to 0.0004050000279676169.

Epoch 14/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.7461 - mae: 0.6608 - val\_loss: 0.7437 - val\_mae: 0.6899 - lr: 4.0500e-04

Epoch 15: LearningRateScheduler setting learning rate to 0.0004050000279676169.

Epoch 15/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.7446 - mae: 0.6599 - val\_loss: 0.7393 - val\_mae: 0.6896 - lr: 4.0500e-04

Epoch 16: LearningRateScheduler setting learning rate to 0.0003645000251708552.

Epoch 16/50

1067/1067 [==============================] - 9s 8ms/step - loss: 0.7373 - mae: 0.6562 - val\_loss: 0.7378 - val\_mae: 0.6898 - lr: 3.6450e-04

Epoch 17: LearningRateScheduler setting learning rate to 0.00036450003972277045.

Epoch 17/50

1067/1067 [==============================] - 9s 8ms/step - loss: 0.7264 - mae: 0.6508 - val\_loss: 0.7866 - val\_mae: 0.7167 - lr: 3.6450e-04

Epoch 18: LearningRateScheduler setting learning rate to 0.00036450003972277045.

Epoch 18/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.7210 - mae: 0.6470 - val\_loss: 0.7795 - val\_mae: 0.7148 - lr: 3.6450e-04

Epoch 19: LearningRateScheduler setting learning rate to 0.00036450003972277045.

Epoch 19/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.7164 - mae: 0.6459 - val\_loss: 0.7654 - val\_mae: 0.7065 - lr: 3.6450e-04

Epoch 20: LearningRateScheduler setting learning rate to 0.00036450003972277045.

Epoch 20/50

1067/1067 [==============================] - 9s 8ms/step - loss: 0.7166 - mae: 0.6450 - val\_loss: 0.7938 - val\_mae: 0.7209 - lr: 3.6450e-04

Epoch 21: LearningRateScheduler setting learning rate to 0.0003280500357504934.

Epoch 21/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.7112 - mae: 0.6419 - val\_loss: 0.7559 - val\_mae: 0.7004 - lr: 1.6403e-04

Epoch 22: LearningRateScheduler setting learning rate to 0.0001640250120544806.

Epoch 22/50

1067/1067 [==============================] - 9s 8ms/step - loss: 0.6980 - mae: 0.6359 - val\_loss: 0.6871 - val\_mae: 0.6594 - lr: 1.6403e-04

Epoch 23: LearningRateScheduler setting learning rate to 0.0001640250120544806.

Epoch 23/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6916 - mae: 0.6319 - val\_loss: 0.6938 - val\_mae: 0.6648 - lr: 1.6403e-04

Epoch 24: LearningRateScheduler setting learning rate to 0.0001640250120544806.

Epoch 24/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6900 - mae: 0.6314 - val\_loss: 0.7613 - val\_mae: 0.7030 - lr: 1.6403e-04

Epoch 25: LearningRateScheduler setting learning rate to 0.0001640250120544806.

Epoch 25/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6845 - mae: 0.6282 - val\_loss: 0.6886 - val\_mae: 0.6613 - lr: 1.6403e-04

Epoch 26: LearningRateScheduler setting learning rate to 0.00014762251084903257.

Epoch 26/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6816 - mae: 0.6266 - val\_loss: 0.6880 - val\_mae: 0.6616 - lr: 1.4762e-04

Epoch 27: LearningRateScheduler setting learning rate to 0.00014762251521460712.

Epoch 27/50

1067/1067 [==============================] - 9s 8ms/step - loss: 0.6770 - mae: 0.6236 - val\_loss: 0.6703 - val\_mae: 0.6510 - lr: 1.4762e-04

Epoch 28: LearningRateScheduler setting learning rate to 0.00014762251521460712.

Epoch 28/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6840 - mae: 0.6284 - val\_loss: 0.6829 - val\_mae: 0.6554 - lr: 1.4762e-04

Epoch 29: LearningRateScheduler setting learning rate to 0.00014762251521460712.

Epoch 29/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6781 - mae: 0.6247 - val\_loss: 0.7007 - val\_mae: 0.6683 - lr: 1.4762e-04

Epoch 30: LearningRateScheduler setting learning rate to 0.00014762251521460712.

Epoch 30/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6813 - mae: 0.6264 - val\_loss: 0.7625 - val\_mae: 0.7046 - lr: 1.4762e-04

Epoch 31: LearningRateScheduler setting learning rate to 0.00013286026369314642.

Epoch 31/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6719 - mae: 0.6212 - val\_loss: 0.6582 - val\_mae: 0.6430 - lr: 1.3286e-04

Epoch 32: LearningRateScheduler setting learning rate to 0.00013286026660352945.

Epoch 32/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6694 - mae: 0.6209 - val\_loss: 0.6601 - val\_mae: 0.6444 - lr: 1.3286e-04

Epoch 33: LearningRateScheduler setting learning rate to 0.00013286026660352945.

Epoch 33/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6743 - mae: 0.6225 - val\_loss: 0.6922 - val\_mae: 0.6673 - lr: 1.3286e-04

Epoch 34: LearningRateScheduler setting learning rate to 0.00013286026660352945.

Epoch 34/50

1067/1067 [==============================] - 9s 8ms/step - loss: 0.6730 - mae: 0.6218 - val\_loss: 0.7462 - val\_mae: 0.6962 - lr: 1.3286e-04

Epoch 35: LearningRateScheduler setting learning rate to 0.00013286026660352945.

Epoch 35/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6667 - mae: 0.6184 - val\_loss: 0.6462 - val\_mae: 0.6334 - lr: 1.3286e-04

Epoch 36: LearningRateScheduler setting learning rate to 0.00011957423994317651.

Epoch 36/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6653 - mae: 0.6178 - val\_loss: 0.6749 - val\_mae: 0.6535 - lr: 1.1957e-04

Epoch 37: LearningRateScheduler setting learning rate to 0.00011957423703279346.

Epoch 37/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6636 - mae: 0.6158 - val\_loss: 0.7538 - val\_mae: 0.7007 - lr: 1.1957e-04

Epoch 38: LearningRateScheduler setting learning rate to 0.00011957423703279346.

Epoch 38/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6639 - mae: 0.6164 - val\_loss: 0.6985 - val\_mae: 0.6681 - lr: 1.1957e-04

Epoch 39: LearningRateScheduler setting learning rate to 0.00011957423703279346.

Epoch 39/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6603 - mae: 0.6147 - val\_loss: 0.7201 - val\_mae: 0.6818 - lr: 1.1957e-04

Epoch 40: LearningRateScheduler setting learning rate to 0.00011957423703279346.

Epoch 40/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6587 - mae: 0.6136 - val\_loss: 0.6344 - val\_mae: 0.6275 - lr: 1.1957e-04

Epoch 41: LearningRateScheduler setting learning rate to 0.00010761681332951412.

Epoch 41/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6553 - mae: 0.6124 - val\_loss: 0.6551 - val\_mae: 0.6424 - lr: 1.0762e-04

Epoch 42: LearningRateScheduler setting learning rate to 0.00010761681187432259.

Epoch 42/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6557 - mae: 0.6117 - val\_loss: 0.6940 - val\_mae: 0.6668 - lr: 1.0762e-04

Epoch 43: LearningRateScheduler setting learning rate to 0.00010761681187432259.

Epoch 43/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6563 - mae: 0.6125 - val\_loss: 0.6729 - val\_mae: 0.6539 - lr: 1.0762e-04

Epoch 44: LearningRateScheduler setting learning rate to 0.00010761681187432259.

Epoch 44/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6556 - mae: 0.6119 - val\_loss: 0.6775 - val\_mae: 0.6556 - lr: 1.0762e-04

Epoch 45: LearningRateScheduler setting learning rate to 0.00010761681187432259.

Epoch 45/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6511 - mae: 0.6097 - val\_loss: 0.7383 - val\_mae: 0.6911 - lr: 5.3808e-05

Epoch 46: LearningRateScheduler setting learning rate to 4.842756534344517e-05.

Epoch 46/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6481 - mae: 0.6088 - val\_loss: 0.6319 - val\_mae: 0.6280 - lr: 4.8428e-05

Epoch 47: LearningRateScheduler setting learning rate to 4.842756607104093e-05.

Epoch 47/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6446 - mae: 0.6060 - val\_loss: 0.5641 - val\_mae: 0.5776 - lr: 4.8428e-05

Epoch 48: LearningRateScheduler setting learning rate to 4.842756607104093e-05.

Epoch 48/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6446 - mae: 0.6060 - val\_loss: 0.6234 - val\_mae: 0.6190 - lr: 4.8428e-05

Epoch 49: LearningRateScheduler setting learning rate to 4.842756607104093e-05.

Epoch 49/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6445 - mae: 0.6065 - val\_loss: 0.6181 - val\_mae: 0.6184 - lr: 4.8428e-05

Epoch 50: LearningRateScheduler setting learning rate to 4.842756607104093e-05.

Epoch 50/50

1067/1067 [==============================] - 8s 8ms/step - loss: 0.6421 - mae: 0.6054 - val\_loss: 0.5856 - val\_mae: 0.5941 - lr: 4.8428e-05

Training Loss: 0.6509

Training MAE: 0.6181

