I used this:  
X\_bmkg shape: (92878, 10, 10)

y\_bmkg shape: (92878,)

def build\_optimized\_cnn\_gru\_model(input\_shape):  
 model = Sequential()  
  
 # CNN Layers  
 model.add(Conv1D(filters=64, kernel\_size=3, padding='same', input\_shape=input\_shape))  
 model.add(LeakyReLU(alpha=0.1)) # LeakyReLU for better gradient flow  
 model.add(BatchNormalization())  
 model.add(MaxPooling1D(pool\_size=2))  
  
 model.add(Conv1D(filters=128, kernel\_size=3, padding='same'))  
 model.add(LeakyReLU(alpha=0.1))  
 model.add(BatchNormalization())  
 model.add(MaxPooling1D(pool\_size=2))  
  
 # GRU Layers  
 model.add(GRU(units=192, return\_sequences=True, kernel\_regularizer=l2(0.0001)))  
 model.add(Dropout(0.3))  
 model.add(GRU(units=128, return\_sequences=False, kernel\_regularizer=l2(0.0001)))  
 model.add(Dropout(0.3))  
  
 # Dense Layers  
 model.add(Dense(units=64))  
 model.add(LeakyReLU(alpha=0.1))  
 model.add(Dropout(0.4))  
 model.add(Dense(units=1, activation='linear')) # Regression Output  
  
 # Compile the model  
 model.compile(optimizer=Adam(learning\_rate=0.001), loss='mse', metrics=['mae'])  
  
 return model

# Build the model  
input\_shape = (10, 10) # Adjust based on your data  
model = build\_optimized\_cnn\_gru\_model(input\_shape)

from tensorflow.keras.callbacks import LearningRateScheduler  
# Define Callbacks  
early\_stopping = EarlyStopping(  
 monitor='val\_loss',  
 patience=15, # 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 \* 0.95 # Multiply the current learning rate by 0.9  
 return lr  
  
# Create the LearningRateScheduler callback  
lr\_scheduler = LearningRateScheduler(lr\_schedule, verbose=1)

# Adjust the input shape to match the new data  
input\_shape = (X\_bmkg.shape[1], X\_bmkg.shape[2]) # (10, 10)  
  
# Build the model  
model = build\_optimized\_cnn\_gru\_model(input\_shape)  
model.summary()

Model: "sequential\_3"

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Layer (type) Output Shape Param #

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

conv1d\_5 (Conv1D) (None, 10, 64) 1984

leaky\_re\_lu\_7 (LeakyReLU) (None, 10, 64) 0

batch\_normalization\_5 (Bat (None, 10, 64) 256

chNormalization)

max\_pooling1d\_5 (MaxPoolin (None, 5, 64) 0

g1D)

conv1d\_6 (Conv1D) (None, 5, 128) 24704

leaky\_re\_lu\_8 (LeakyReLU) (None, 5, 128) 0

batch\_normalization\_6 (Bat (None, 5, 128) 512

chNormalization)

max\_pooling1d\_6 (MaxPoolin (None, 2, 128) 0

g1D)

gru\_4 (GRU) (None, 2, 192) 185472

dropout\_6 (Dropout) (None, 2, 192) 0

gru\_5 (GRU) (None, 128) 123648

dropout\_7 (Dropout) (None, 128) 0

dense\_4 (Dense) (None, 64) 8256

leaky\_re\_lu\_9 (LeakyReLU) (None, 64) 0

dropout\_8 (Dropout) (None, 64) 0

dense\_5 (Dense) (None, 1) 65

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

Total params: 344897 (1.32 MB)

Trainable params: 344513 (1.31 MB)

Non-trainable params: 384 (1.50 KB)

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

Training Loss: 0.6030

Training MAE: 0.6163

Epoch 1: LearningRateScheduler setting learning rate to 0.0010000000474974513.

Epoch 1/100

1161/1161 [==============================] - 13s 10ms/step - loss: 1.0422 - mae: 0.7938 - val\_loss: 4.9795 - val\_mae: 1.8339 - lr: 0.0010

Epoch 2: LearningRateScheduler setting learning rate to 0.0010000000474974513.

Epoch 2/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.8601 - mae: 0.7313 - val\_loss: 2.6816 - val\_mae: 1.2480 - lr: 0.0010

Epoch 3: LearningRateScheduler setting learning rate to 0.0010000000474974513.

Epoch 3/100

1161/1161 [==============================] - 11s 10ms/step - loss: 0.8101 - mae: 0.7111 - val\_loss: 0.8677 - val\_mae: 0.7159 - lr: 0.0010

Epoch 4: LearningRateScheduler setting learning rate to 0.0010000000474974513.

Epoch 4/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.7572 - mae: 0.6883 - val\_loss: 1.5000 - val\_mae: 0.8594 - lr: 0.0010

Epoch 5: LearningRateScheduler setting learning rate to 0.0010000000474974513.

Epoch 5/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.7182 - mae: 0.6705 - val\_loss: 0.6828 - val\_mae: 0.6595 - lr: 0.0010

Epoch 6: LearningRateScheduler setting learning rate to 0.0009500000451225787.

Epoch 6/100

1161/1161 [==============================] - 11s 10ms/step - loss: 0.6932 - mae: 0.6601 - val\_loss: 0.6964 - val\_mae: 0.6719 - lr: 9.5000e-04

Epoch 7: LearningRateScheduler setting learning rate to 0.0009500000160187483.

Epoch 7/100

1161/1161 [==============================] - 11s 10ms/step - loss: 0.6787 - mae: 0.6542 - val\_loss: 0.7576 - val\_mae: 0.7093 - lr: 9.5000e-04

Epoch 8: LearningRateScheduler setting learning rate to 0.0009500000160187483.

Epoch 8/100

1161/1161 [==============================] - 11s 10ms/step - loss: 0.6659 - mae: 0.6482 - val\_loss: 0.6501 - val\_mae: 0.6441 - lr: 9.5000e-04

Epoch 9: LearningRateScheduler setting learning rate to 0.0009500000160187483.

Epoch 9/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.6536 - mae: 0.6426 - val\_loss: 0.6938 - val\_mae: 0.6739 - lr: 9.5000e-04

Epoch 10: LearningRateScheduler setting learning rate to 0.0009500000160187483.

Epoch 10/100

1161/1161 [==============================] - 11s 10ms/step - loss: 0.6456 - mae: 0.6402 - val\_loss: 0.6517 - val\_mae: 0.6414 - lr: 9.5000e-04

Epoch 11: LearningRateScheduler setting learning rate to 0.0009025000152178108.

Epoch 11/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.6362 - mae: 0.6338 - val\_loss: 0.6484 - val\_mae: 0.6435 - lr: 9.0250e-04

Epoch 12: LearningRateScheduler setting learning rate to 0.0009025000035762787.

Epoch 12/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.6317 - mae: 0.6328 - val\_loss: 0.6752 - val\_mae: 0.6644 - lr: 9.0250e-04

Epoch 13: LearningRateScheduler setting learning rate to 0.0009025000035762787.

Epoch 13/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.6276 - mae: 0.6311 - val\_loss: 0.7553 - val\_mae: 0.7107 - lr: 9.0250e-04

Epoch 14: LearningRateScheduler setting learning rate to 0.0009025000035762787.

Epoch 14/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.6226 - mae: 0.6282 - val\_loss: 0.6492 - val\_mae: 0.6454 - lr: 9.0250e-04

Epoch 15: LearningRateScheduler setting learning rate to 0.0009025000035762787.

Epoch 15/100

1161/1161 [==============================] - 11s 10ms/step - loss: 0.6207 - mae: 0.6278 - val\_loss: 0.7111 - val\_mae: 0.6840 - lr: 9.0250e-04

Epoch 16: LearningRateScheduler setting learning rate to 0.0008573750033974647.

Epoch 16/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.6155 - mae: 0.6246 - val\_loss: 0.6785 - val\_mae: 0.6647 - lr: 4.2869e-04

Epoch 17: LearningRateScheduler setting learning rate to 0.0004286874900572002.

Epoch 17/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.6065 - mae: 0.6195 - val\_loss: 0.6442 - val\_mae: 0.6403 - lr: 4.2869e-04

Epoch 18: LearningRateScheduler setting learning rate to 0.0004286874900572002.

Epoch 18/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.6016 - mae: 0.6176 - val\_loss: 0.6584 - val\_mae: 0.6549 - lr: 4.2869e-04

Epoch 19: LearningRateScheduler setting learning rate to 0.0004286874900572002.

Epoch 19/100

1161/1161 [==============================] - 11s 10ms/step - loss: 0.6008 - mae: 0.6171 - val\_loss: 0.6496 - val\_mae: 0.6482 - lr: 4.2869e-04

Epoch 20: LearningRateScheduler setting learning rate to 0.0004286874900572002.

Epoch 20/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.6002 - mae: 0.6164 - val\_loss: 0.6494 - val\_mae: 0.6491 - lr: 4.2869e-04

Epoch 21: LearningRateScheduler setting learning rate to 0.0004072531155543402.

Epoch 21/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5974 - mae: 0.6153 - val\_loss: 0.6653 - val\_mae: 0.6578 - lr: 4.0725e-04

Epoch 22: LearningRateScheduler setting learning rate to 0.00040725310100242496.

Epoch 22/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5965 - mae: 0.6146 - val\_loss: 0.6513 - val\_mae: 0.6492 - lr: 2.0363e-04

Epoch 23: LearningRateScheduler setting learning rate to 0.00020362655050121248.

Epoch 23/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5905 - mae: 0.6114 - val\_loss: 0.6447 - val\_mae: 0.6448 - lr: 2.0363e-04

Epoch 24: LearningRateScheduler setting learning rate to 0.00020362655050121248.

Epoch 24/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5885 - mae: 0.6103 - val\_loss: 0.6247 - val\_mae: 0.6310 - lr: 2.0363e-04

Epoch 25: LearningRateScheduler setting learning rate to 0.00020362655050121248.

Epoch 25/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5862 - mae: 0.6091 - val\_loss: 0.6365 - val\_mae: 0.6401 - lr: 2.0363e-04

Epoch 26: LearningRateScheduler setting learning rate to 0.00019344522297615185.

Epoch 26/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5853 - mae: 0.6082 - val\_loss: 0.6454 - val\_mae: 0.6447 - lr: 1.9345e-04

Epoch 27: LearningRateScheduler setting learning rate to 0.00019344521570019424.

Epoch 27/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5843 - mae: 0.6078 - val\_loss: 0.6452 - val\_mae: 0.6466 - lr: 1.9345e-04

Epoch 28: LearningRateScheduler setting learning rate to 0.00019344521570019424.

Epoch 28/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5839 - mae: 0.6074 - val\_loss: 0.6530 - val\_mae: 0.6510 - lr: 1.9345e-04

Epoch 29: LearningRateScheduler setting learning rate to 0.00019344521570019424.

Epoch 29/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5833 - mae: 0.6071 - val\_loss: 0.6390 - val\_mae: 0.6395 - lr: 9.6723e-05

Epoch 30: LearningRateScheduler setting learning rate to 9.672260785009712e-05.

Epoch 30/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5806 - mae: 0.6058 - val\_loss: 0.6309 - val\_mae: 0.6362 - lr: 9.6723e-05

Epoch 31: LearningRateScheduler setting learning rate to 9.188647745759226e-05.

Epoch 31/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5796 - mae: 0.6050 - val\_loss: 0.6435 - val\_mae: 0.6440 - lr: 9.1886e-05

Epoch 32: LearningRateScheduler setting learning rate to 9.188647527480498e-05.

Epoch 32/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5777 - mae: 0.6038 - val\_loss: 0.6461 - val\_mae: 0.6459 - lr: 9.1886e-05

Epoch 33: LearningRateScheduler setting learning rate to 9.188647527480498e-05.

Epoch 33/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5763 - mae: 0.6034 - val\_loss: 0.6310 - val\_mae: 0.6368 - lr: 9.1886e-05

Epoch 34: LearningRateScheduler setting learning rate to 9.188647527480498e-05.

Epoch 34/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5769 - mae: 0.6029 - val\_loss: 0.6298 - val\_mae: 0.6369 - lr: 4.5943e-05

Epoch 35: LearningRateScheduler setting learning rate to 4.594323763740249e-05.

Epoch 35/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5746 - mae: 0.6019 - val\_loss: 0.6334 - val\_mae: 0.6400 - lr: 4.5943e-05

Epoch 36: LearningRateScheduler setting learning rate to 4.364607575553236e-05.

Epoch 36/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5737 - mae: 0.6015 - val\_loss: 0.6296 - val\_mae: 0.6371 - lr: 4.3646e-05

Epoch 37: LearningRateScheduler setting learning rate to 4.3646075937431306e-05.

Epoch 37/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5735 - mae: 0.6013 - val\_loss: 0.6309 - val\_mae: 0.6363 - lr: 4.3646e-05

Epoch 38: LearningRateScheduler setting learning rate to 4.3646075937431306e-05.

Epoch 38/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5730 - mae: 0.6013 - val\_loss: 0.6312 - val\_mae: 0.6363 - lr: 4.3646e-05

Epoch 39: LearningRateScheduler setting learning rate to 4.3646075937431306e-05.

Epoch 39/100

1161/1161 [==============================] - 11s 9ms/step - loss: 0.5723 - mae: 0.6010 - val\_loss: 0.6345 - val\_mae: 0.6386 - lr: 2.1823e-05



