bias_variance_QNJL

In [738]:

```
# imports
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import mean_squared_error
from sklearn.pipeline import make_pipeline
from sklearn.preprocessing import PolynomialFeatures
from sklearn.linear_model import Ridge
from sklearn.linear_model import LinearRegression
from sklearn.metrics import r2_score, mean_absolute_error
from sklearn.model_selection import cross_val_score
```

In [739]:

```
# dataset phat

DATA_PHAT = '../dataset/'
DATA_PATH_TRUE = 'DS-5-1-GAP-0-1-N-0_v2.csv'
DATA_PATH_NOISE1 = 'DS-5-1-GAP-1-1-N-1_v2.csv'
DATA_PATH_NOISE2 = 'DS-5-1-GAP-5-1-N-3_v2.csv'
```

In [740]:

```
df_true = pd.read_csv(DATA_PHAT + DATA_PATH_TRUE, header=None)
df_noise1 = pd.read_csv(DATA_PHAT + DATA_PATH_NOISE1,header=None)
df_noise2 = pd.read_csv(DATA_PHAT + DATA_PATH_NOISE2,header=None)
```

In [741]:

```
df_true.head(5)
```

Out[741]:

	0	1	2
0	0.00	17.49	17.04
1	2.12	17.65	17.17
2	3.06	17.70	17.24

	0	1	2
3	4.16	17.73	17.33
4	4.93	17.75	17.39

In [742]:

```
df_noise1.head(5)
```

Out[742]:

	0	1	2	3	4	5	6	7	8	9	...	191	192	193
0	0.00	17.49	17.50	17.49	17.49	17.50	17.49	17.50	17.49	17.49	...	17.04	17.04	17.05
1	2.12	17.65	17.65	17.64	17.64	17.65	17.65	17.65	17.64	17.65	...	17.16	17.17	17.18
2	3.06	17.69	17.70	17.70	17.69	17.69	17.70	17.69	17.69	17.70	...	17.25	17.24	17.24
3	4.16	17.74	17.73	17.74	17.73	17.74	17.74	17.74	17.74	17.73	...	17.33	17.32	17.33
4	4.93	17.75	17.74	17.73	17.74	17.74	17.75	17.75	17.75	17.74	...	17.38	17.39	17.39

5 rows × 201 columns

In [743]:

```
df_noise2.head(5)
```

Out[743]:

	0	1	2	3	4	5	6	7	8	9	...	191	192	193
0	0.00	17.61	17.55	17.48	17.46	17.43	17.53	17.35	17.66	17.60	...	17.16	17.03	17.12
1	2.12	17.71	17.55	17.70	17.52	17.67	17.62	17.76	17.73	17.63	...	17.24	17.17	17.24
2	3.06	17.68	17.77	17.61	17.72	17.73	17.78	17.80	17.81	17.68	...	17.42	17.27	17.22
3	4.16	17.62	17.72	17.66	17.69	17.75	17.65	17.82	17.78	17.86	...	17.32	17.28	17.25
4	4.93	17.80	17.54	17.66	17.71	17.82	17.69	17.70	17.81	17.82	...	17.33	17.46	17.39

5 rows × 201 columns

Test Data 1¶

In [744]:

```
#DATA_PATH_NOISE1 = 'DS-5-1-GAP-1-1-N-1_v2.csv'
X = df_noise1[0]  #time
x = X.to_numpy()[:, np.newaxis]

Y = df_noise1.iloc[:,1:101]
y = Y.to_numpy()
```

```
#true is test
x_test = df_true[0].to_numpy()[:,np.newaxis]
y_test = df_true[1].to_numpy()[:, np.newaxis]

degrees = list(range(1,20))

mean_bias = np.zeros(len(degrees))
mean_variance = np.zeros(len(degrees))

for j, degree in enumerate(degrees):
    bias = []
    y_pred_all = []

    for i in range(0, 100):
        y_i = y[:, i]
        y_i = y_i[:, np.newaxis]

        # create model
        model = make_pipeline(PolynomialFeatures(degree), LinearRegression())
        # training
        model.fit(x, y_i)

        #predictions
        y_pred_all.append(model.predict(x_test))

        bias.append(abs(y_test - y_pred_all[i]))

    # bias
    pred_mean = np.mean(bias, axis=0)
    mean_bias[j] = np.mean(pred_mean)

    # variance
    pred_variance = np.std(y_pred_all, axis=0)
    mean_variance[j] = np.mean(pred_variance)

print("Mean Bias:")
print(mean_bias)
print()
print("Mean Variance:")
print(mean_variance)
```

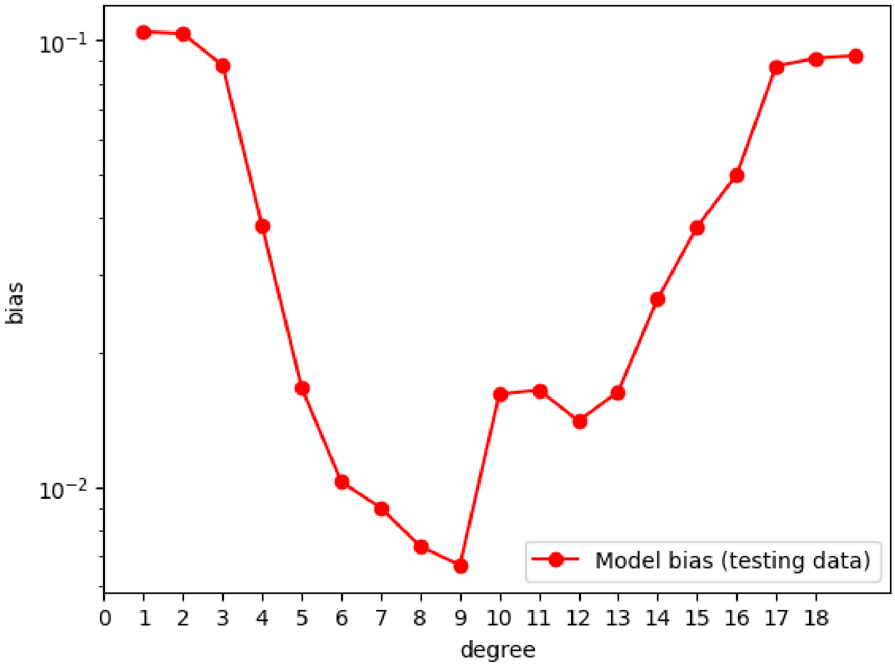
```
Mean Bias:
[0.1046119  0.10361983 0.08780442 0.03847091 0.01668811 0.0102933
 0.00898785 0.00737389 0.00669004 0.01615585 0.01651086 0.01407579
 0.01633646 0.0263673  0.03827158 0.05005268 0.08763278 0.09121493
 0.09245241]

Mean Variance:
[0.00118132 0.00147208 0.00171471 0.00189878 0.00203802 0.00223529
 0.00238363 0.00254565 0.00394676 0.0026084  0.00242827 0.00238885
 0.00235898 0.00234475 0.00243909 0.00241474 0.00212611 0.00210574
 0.0020848 ]
```

In [745]:

```
plt.xlabel('degree')
plt.ylabel('bias')
plt.plot(degrees, mean_bias,'-ro', label = 'Model bias (testing data)')
plt.legend(loc='best')
plt.yscale('log')
plt.xticks(range(0,len(degrees)))
plt.show
```

Out[745]:

```
<function matplotlib.pyplot.show(close=None, block=None)>
```

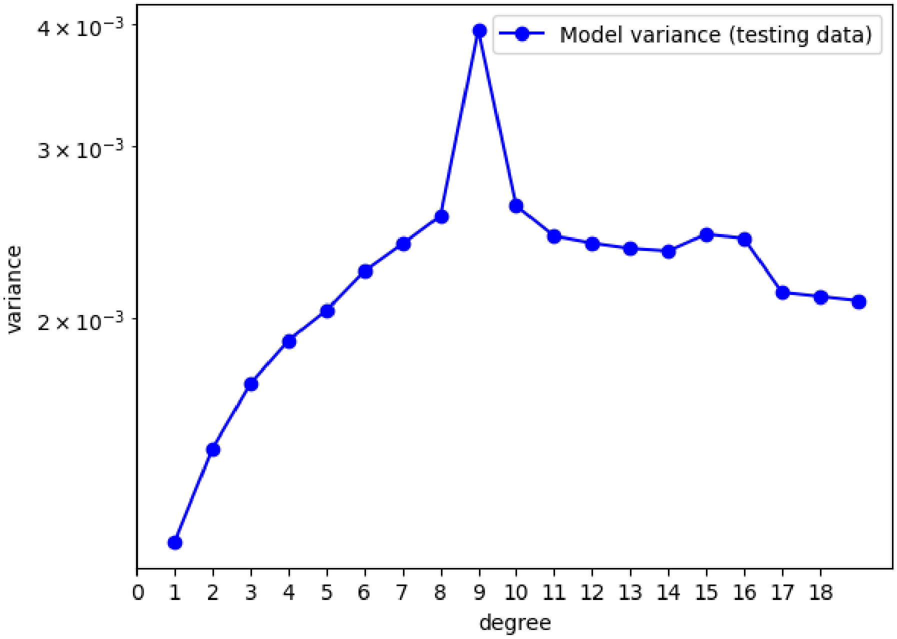


In [746]:

```
plt.xlabel('degree')
plt.ylabel('variance')
plt.plot(degrees, mean_variance,'-bo', label = 'Model variance (testing data)')
plt.legend(loc='best')
plt.yscale('log')
plt.xticks(range(0,len(degrees)))
plt.show
```

Out[746]:

```
<function matplotlib.pyplot.show(close=None, block=None)>
```



In [747]:

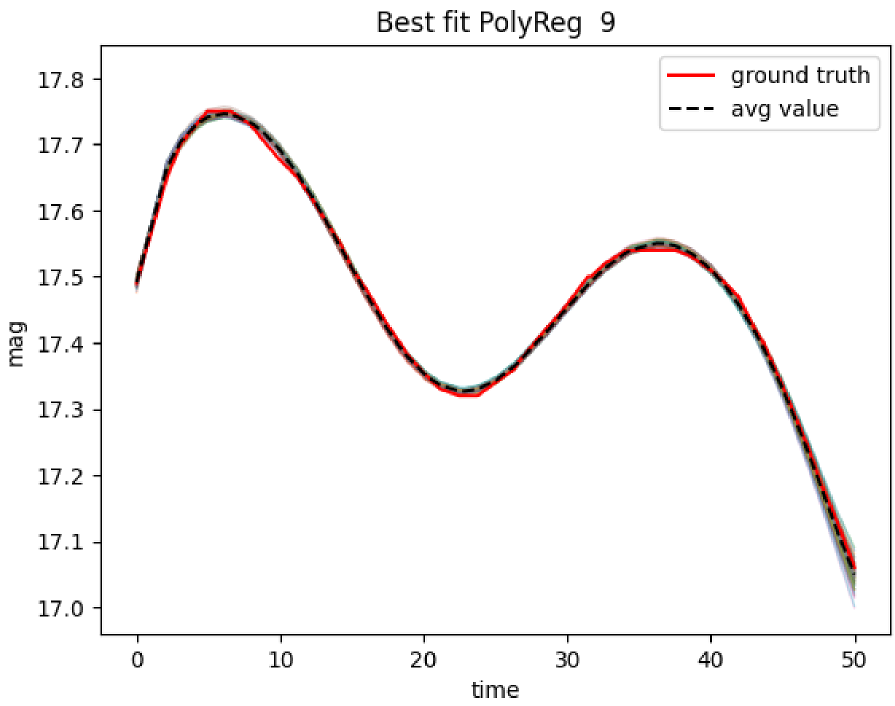
```
best_degree = degrees[np.argmin(mean_bias)]
best_degree
```

Out[747]:

```
9
```

In [748]:

```
plt.title( f'Best fit PolyReg  {best_degree}')
plt.ylim(y_test.min() - 0.1, y_test.max() + 0.1)

y_pred_all = []
for i in range(0, 100):
        y_i = y[:, i]
        y_i = y_i[:, np.newaxis]
        # create model
        model = make_pipeline(PolynomialFeatures(best_degree), LinearRegression())
        # training
        model.fit(x, y_i)

        #Testing
        y_pred_train = model.predict(x)
        y_pred_test = model.predict(x_test)
        y_pred_all.append(y_pred_test)
        plt.plot(x_test,y_pred_test,linewidth = 1, alpha = 0.3)

pred_mean = np.mean(y_pred_all, axis=0)
pred_variance = np.std(y_pred_all, axis=0)



plt.plot(x_test, y_test, 'r', label = 'ground truth')

plt.plot(x_test, pred_mean, '--k', label = 'avg value')
plt.xlabel('time')
plt.ylabel('mag')
plt.legend(loc="best")
plt.show()

print('bias: ', mean_bias[best_degree - 1])
print('variance', mean_variance[best_degree - 1])
```



```
bias:  0.006690036291529672
variance 0.003946759748134829
```

Test Data 2¶

In [749]:

```
#DATA_PATH_NOISE3 = 'DS-5-1-GAP-5-1-N-3_v2.csv'
X = df_noise2[0]  #time
x = X.to_numpy()[:, np.newaxis]

Y = df_noise2.iloc[:,1:101]
y = Y.to_numpy()

#true is test
x_test = df_true[0].to_numpy()[:,np.newaxis]
y_test = df_true[1].to_numpy()[:, np.newaxis]

degrees = list(range(1,20))

mean_bias = np.zeros(len(degrees))
mean_variance = np.zeros(len(degrees))
```

```
for j, degree in enumerate(degrees):
    bias = []
    y_pred_all = []

    for i in range(0, 100):
        y_i = y[:, i]
        y_i = y_i[:, np.newaxis]

        # create model
        model = make_pipeline(PolynomialFeatures(degree), LinearRegression())
        # training
        model.fit(x, y_i)


        y_pred_all.append(model.predict(x_test))

        bias.append(abs(y_test - y_pred_all[i]))

    # bias
    pred_mean = np.mean(bias, axis=0)
    mean_bias[j] = np.mean(pred_mean)

    # variance
    pred_variance = np.std(y_pred_all, axis=0)
    mean_variance[j] = np.mean(pred_variance)

print("Mean Bias:")
print(mean_bias)
print()
print("Mean Variance:")
print(mean_variance)
```

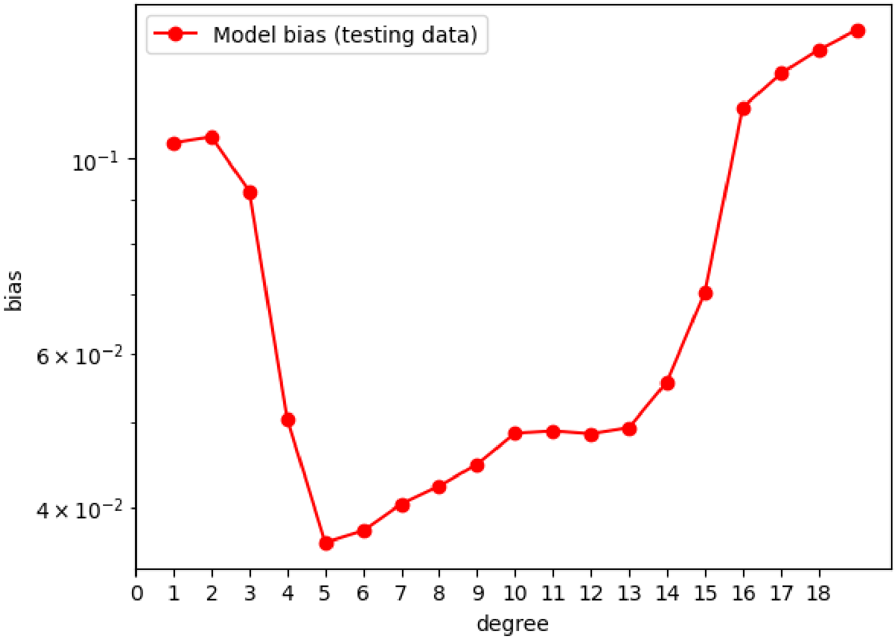
```
Mean Bias:
[0.10436904 0.10607181 0.09187968 0.05050545 0.03643462 0.03758568
 0.04032173 0.04228031 0.04477442 0.0485861  0.04888251 0.04851896
 0.04930965 0.05563294 0.0704391  0.11455676 0.12518624 0.13329452
 0.14040393]

Mean Variance:
[0.02113256 0.02560118 0.03167672 0.03527781 0.0402986  0.04559276
 0.04941269 0.0526682  0.05583096 0.05445432 0.04969405 0.04968259
 0.05091983 0.05372675 0.05759329 0.04780424 0.0507615  0.05431813
 0.05835109]
```

In [750]:

```
plt.xlabel('degree')
plt.ylabel('bias')
plt.plot(degrees, mean_bias,'-ro', label = 'Model bias (testing data)')
plt.legend(loc='best')
plt.yscale('log')
plt.xticks(range(0,len(degrees)))
plt.show
```

Out[750]:

```
<function matplotlib.pyplot.show(close=None, block=None)>
```

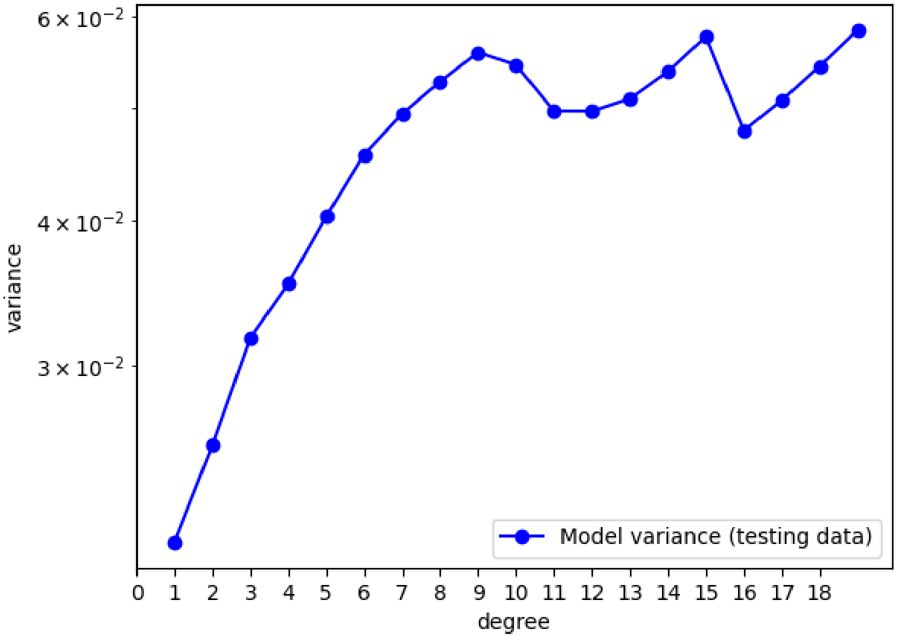


In [751]:

```
plt.xlabel('degree')
plt.ylabel('variance')
plt.plot(degrees, mean_variance,'-bo', label = 'Model variance (testing data)')
plt.legend(loc='best')
plt.yscale('log')
plt.xticks(range(0,len(degrees)))
plt.show
```

Out[751]:

```
<function matplotlib.pyplot.show(close=None, block=None)>
```



In [752]:

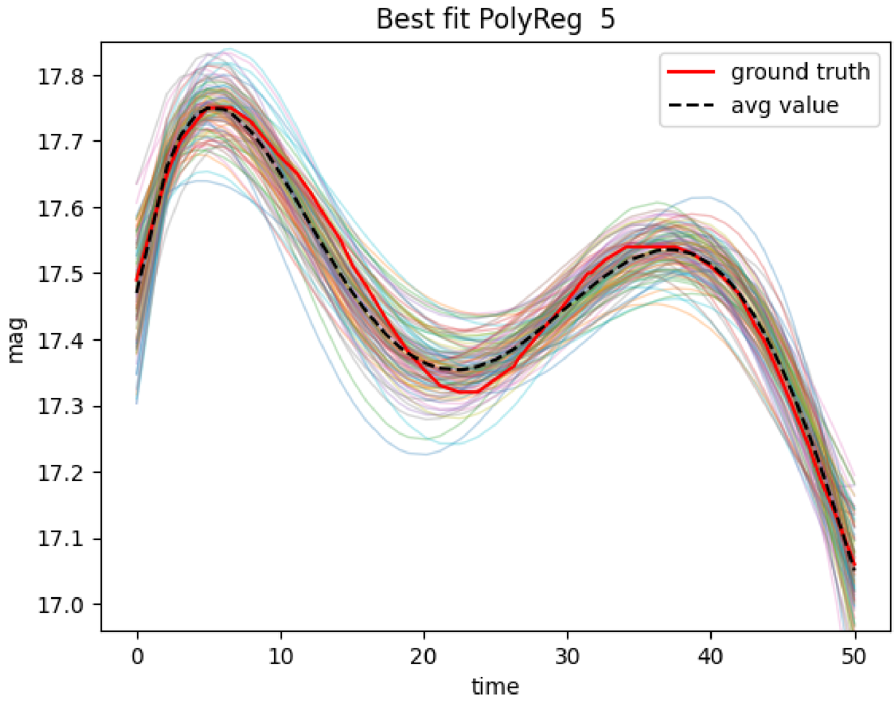
```
best_degree = degrees[np.argmin(mean_bias)]

best_degree
```

Out[752]:

```
5
```

In [753]:

```
plt.title( f'Best fit PolyReg  {best_degree}')
plt.ylim(y_test.min() - 0.1, y_test.max() + 0.1)

y_pred_all = []
for i in range(0, 100):
        y_i = y[:, i]
        y_i = y_i[:, np.newaxis]

        # create model
        model = make_pipeline(PolynomialFeatures(best_degree), LinearRegression())
        # training
        model.fit(x, y_i)

        #Testing
        y_pred_train = model.predict(x)
        y_pred_test = model.predict(x_test)
        y_pred_all.append(y_pred_test)
        plt.plot(x_test,y_pred_test,linewidth = 1, alpha = 0.3)

pred_mean = np.mean(y_pred_all, axis=0)
pred_variance = np.std(y_pred_all, axis=0)



plt.plot(x_test, y_test, 'r', label = 'ground truth')

plt.plot(x_test, pred_mean, '--k', label = 'avg value')
plt.xlabel('time')
plt.ylabel('mag')
plt.legend(loc="best")
plt.show()

print('bias: ', mean_bias[best_degree - 1])
print('variance', mean_variance[best_degree - 1])
```



```
bias:  0.036434619162285936
variance 0.04029860246793506
```

In [ ]: