Visualizing Results Notebook

## Visualizing Results from the Original Reynolds-number range

Grid Study with Original Parameter Ranges

```
column_names <- c("Re", "alpha", "camber")
params_grid_nolog <- read.csv("./data/bad_parameters/grid_Params_noLogRe.csv",
                              header = FALSE)
colnames(params_grid_nolog) <- column_names

grid_nolog_results <- read.csv("./results/bad_results/grid_noLogRe_results.csv")
grid_nolog_results <- grid_nolog_results[order(grid_nolog_results$sim),]
grid_nolog_results$CLCD <- grid_nolog_results$CL/grid_nolog_results$CD
complete_grid_nolog <- cbind(params_grid_nolog, grid_nolog_results)
```
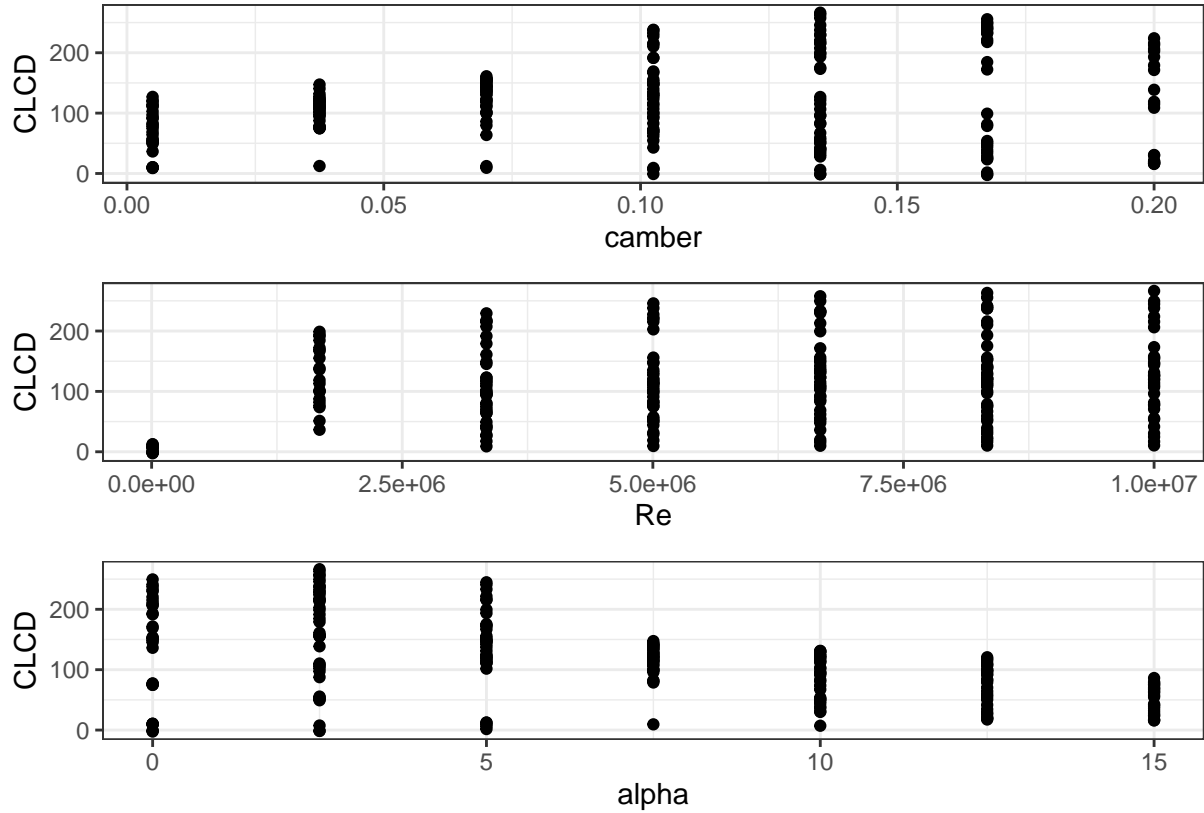
Convergence rate: 65%.

Plotting parameters for gPC (Re no log) showing where simulations did not converge:
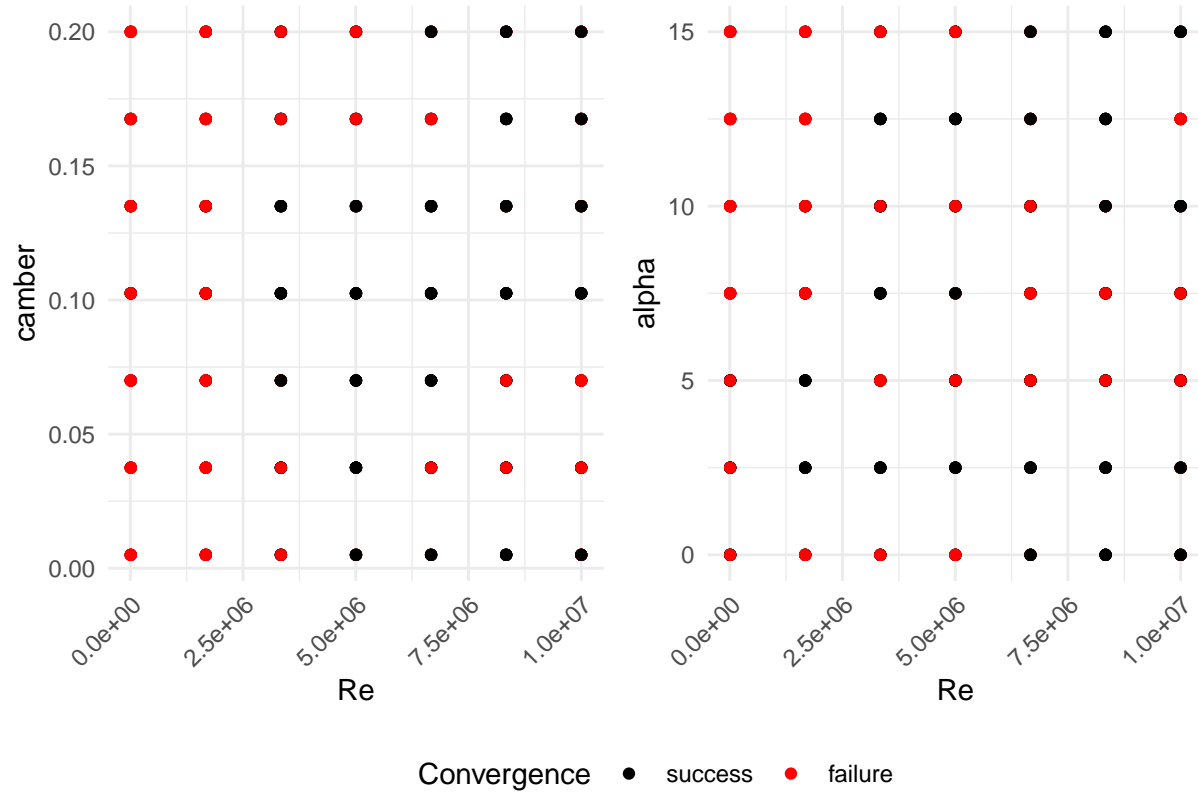
CL/CD results:

gPC Studies with Original Parameter Ranges

These results reflect the original gPC results study that includes a range of Reynolds number (Re) and angle of attack (aoa) that created a large area in the parameter space of unstable simulations which did not converge (marked as failure points). We include these to demonstrate how important intrinsic validation is to the conclusions that one is able to draw from simulation studies.

Originally, we wanted to know if applying a log transform to the Re range was appropriate since it covered several orders of magnitude.
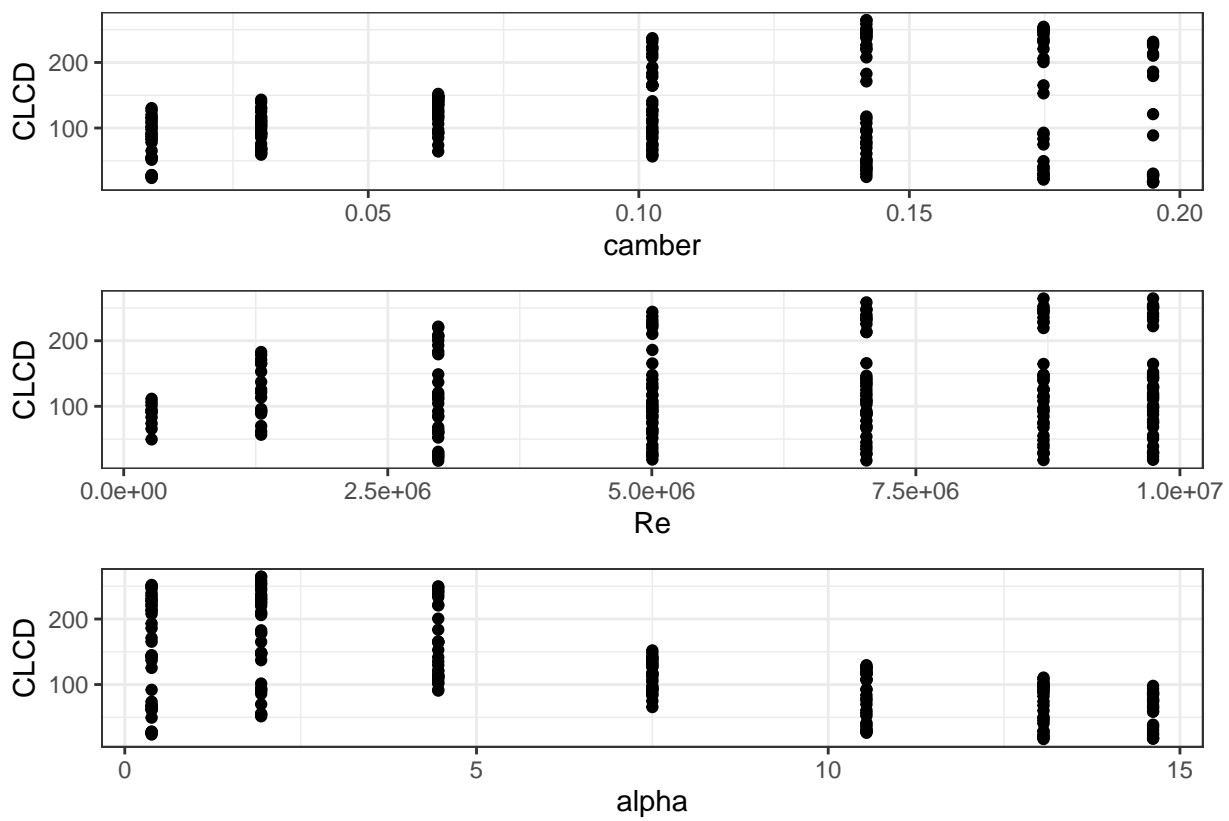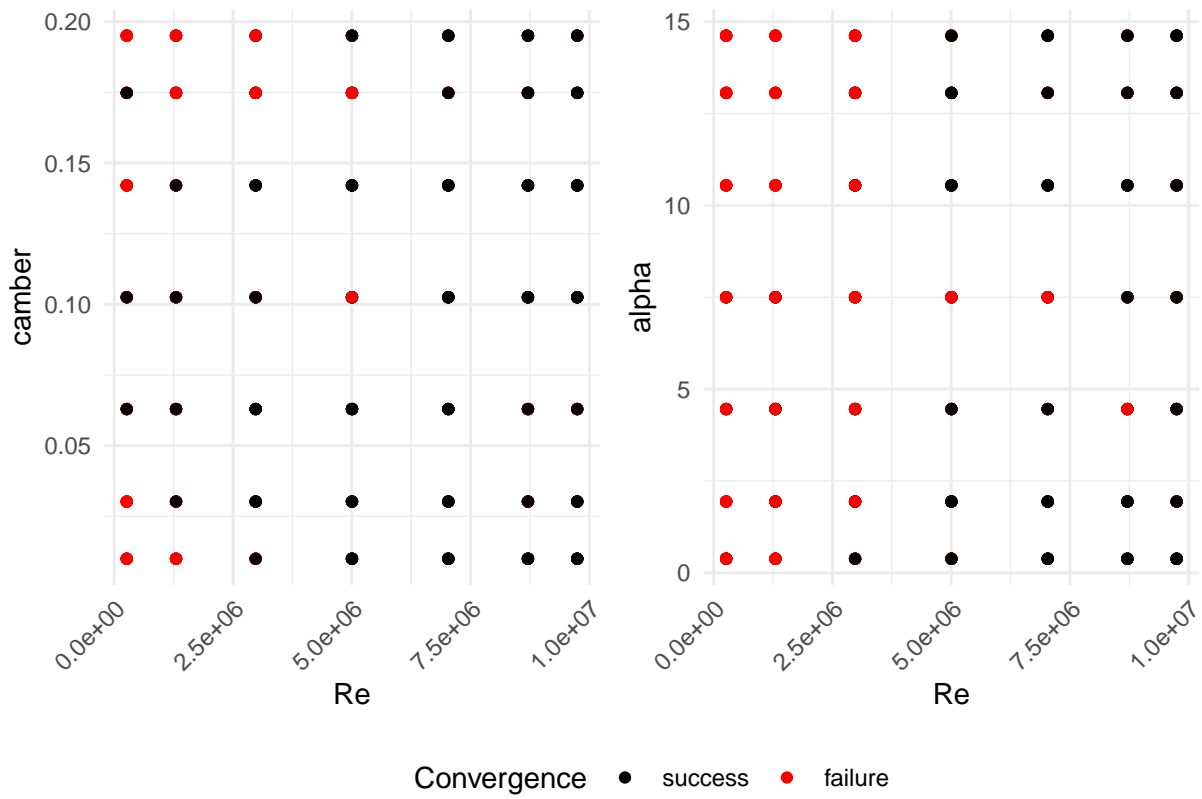
gPC with non-log transformed Re

Loading results for gPC non-log transformed Re:

```
column_names <- c("Re", "alpha", "camber")
params_gpc_nolog <- read.csv("./data/bad_parameters/gPC_Params_noLogRe.csv",
                             header = FALSE)
colnames(params_gpc_nolog) <- column_names

gpc_nolog_results <- read.csv("./results/bad_results/gPC_noLogRe_results.csv")
gpc_nolog_results <- gpc_nolog_results[order(gpc_nolog_results$sim),]
gpc_nolog_results$CLCD <- gpc_nolog_results$CL/gpc_nolog_results$CD
complete_gpc_nolog <- cbind(params_gpc_nolog, gpc_nolog_results)
```

Convergence rate: 64%.

Plotting parameters for gPC (Re no log) showing where simulations did not converge:

Convergence ● success ● failure

CL/CD results:

gPC with log-transformed Re range

Loading results for log-transformed *Re* study:

```r
params_gpc_log <- read.csv("./data/bad_parameters/gPC_Params_LogRe.csv",
                           header = FALSE)
colnames(params_gpc_log) <- column_names
gpc_log_results <- read.csv("./results/bad_results/gPC_LogRe_results.csv")
gpc_log_results <- gpc_log_results[order(gpc_log_results$sim),]
gpc_log_results$CLCD <- gpc_log_results$CL/gpc_log_results$CD
complete_gpc_log <- cbind(params_gpc_log, gpc_log_results)
```

Convergence rate: 38%.

Plotting parameters for gPC (*Re* log) showing where simulations did not converge:

Convergence ● success ● failure
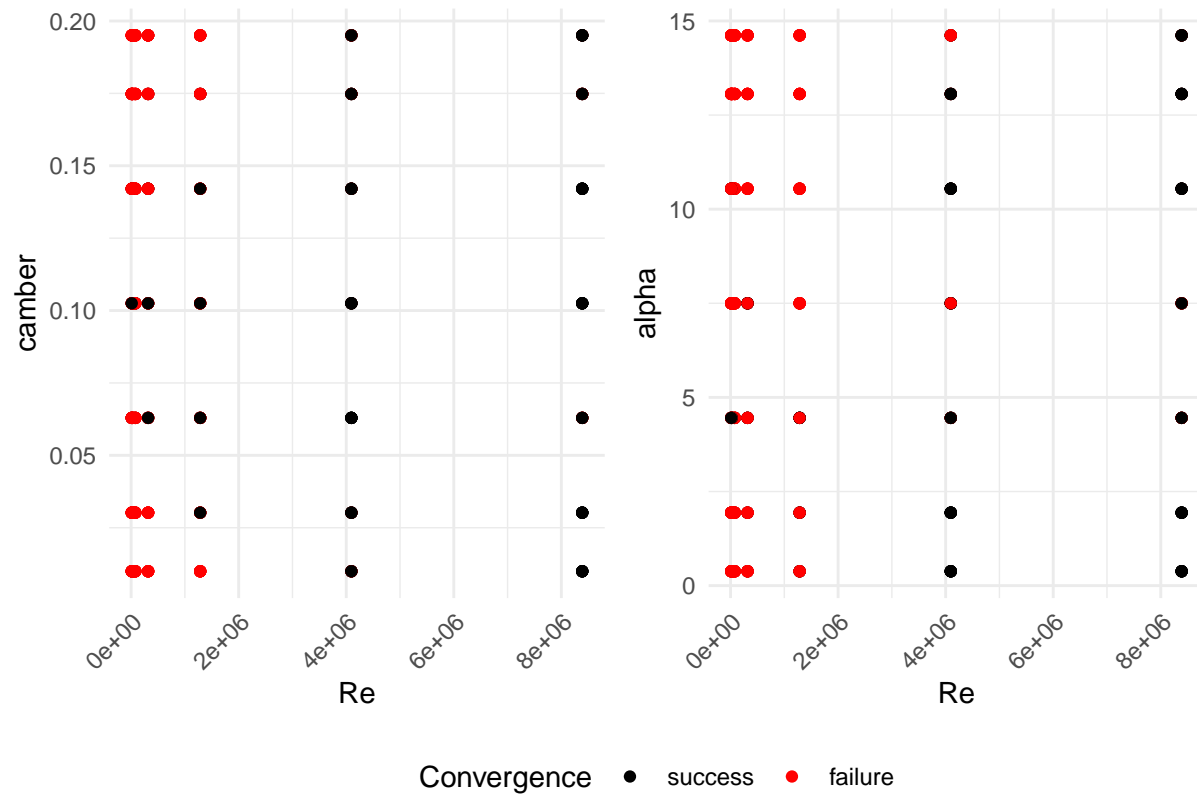
CL/CD results:
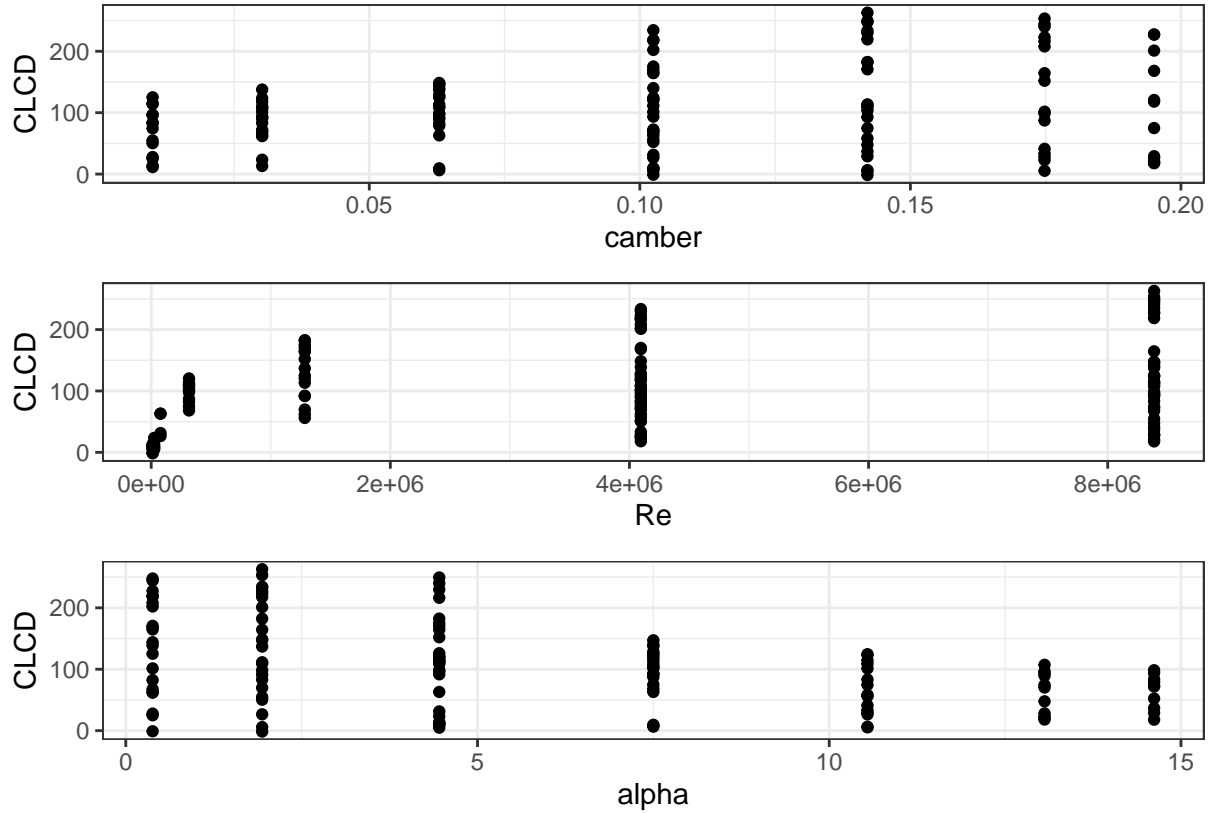
The results show that there is an area of high *aoa* and low *Re* that resulted in many unconverged simulations (show in red). This will affect the final gPC surrogate because the values at these unconverged simulations is NaN. This is very problematic for the final conclusions.

Since the effect is relatively more severe because of the log-transformation, we are choosing to proceed with non-log transformed *Re* range.

Neural Network studies

Our third method involved training an artificial neural network (NN) to create a surrogate function that would cover the entire parameter space. To generate the data set to train this NN, we ran a set of simulations. Like the gPC space, we chose to run two sets: one set where the *Re* range was log transformed and one set where it was not.
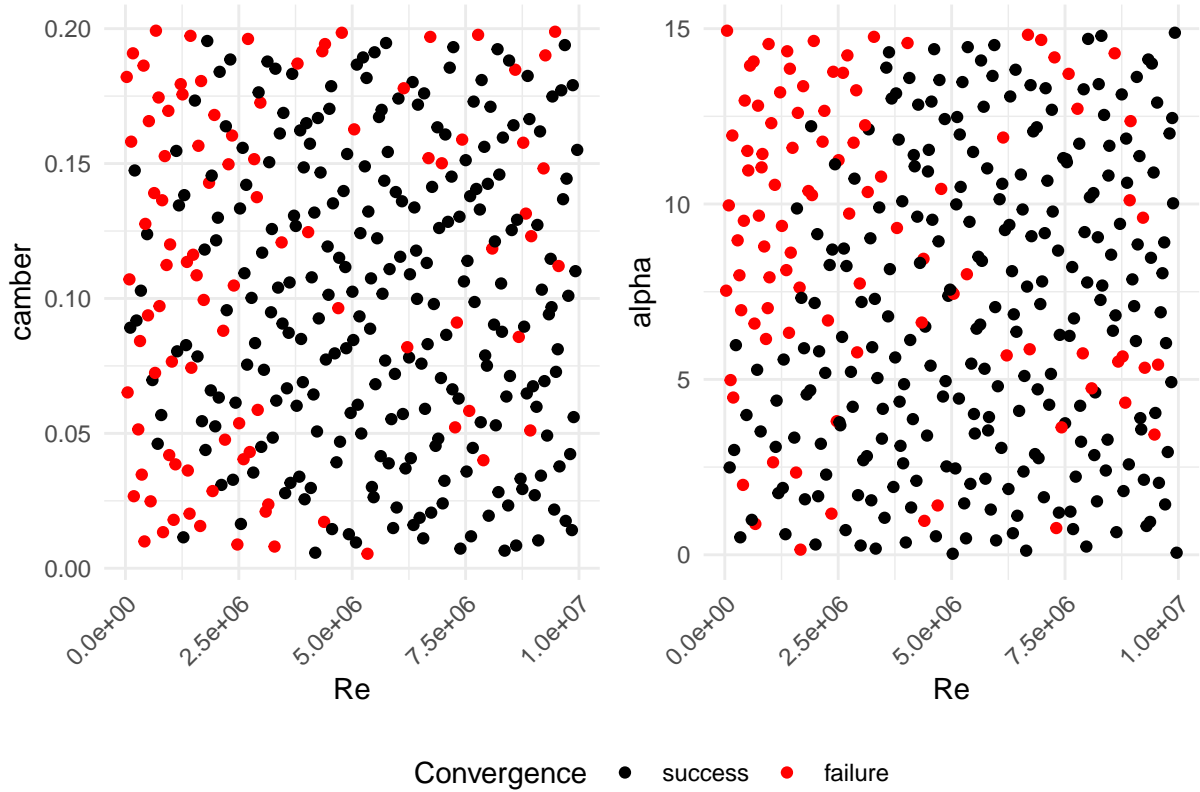
NN with non-log transformed Re

Loading data for NN study with non-log transformed *Re*:

```
params_nn_nolog <- read.csv("./data/bad_parameters/NN_Params_noLogRe.csv",
                            header = FALSE)
colnames(params_nn_nolog) <- column_names
nn_nolog_results <- read.csv("./results/bad_results/NN_noLogRe_results.csv")
nn_nolog_results <- nn_nolog_results[order(nn_nolog_results$sim),]
complete_nn_nolog <- cbind(params_nn_nolog, nn_nolog_results)
complete_nn_nolog$CLCD <- complete_nn_nolog$CL/complete_nn_nolog$CD
```
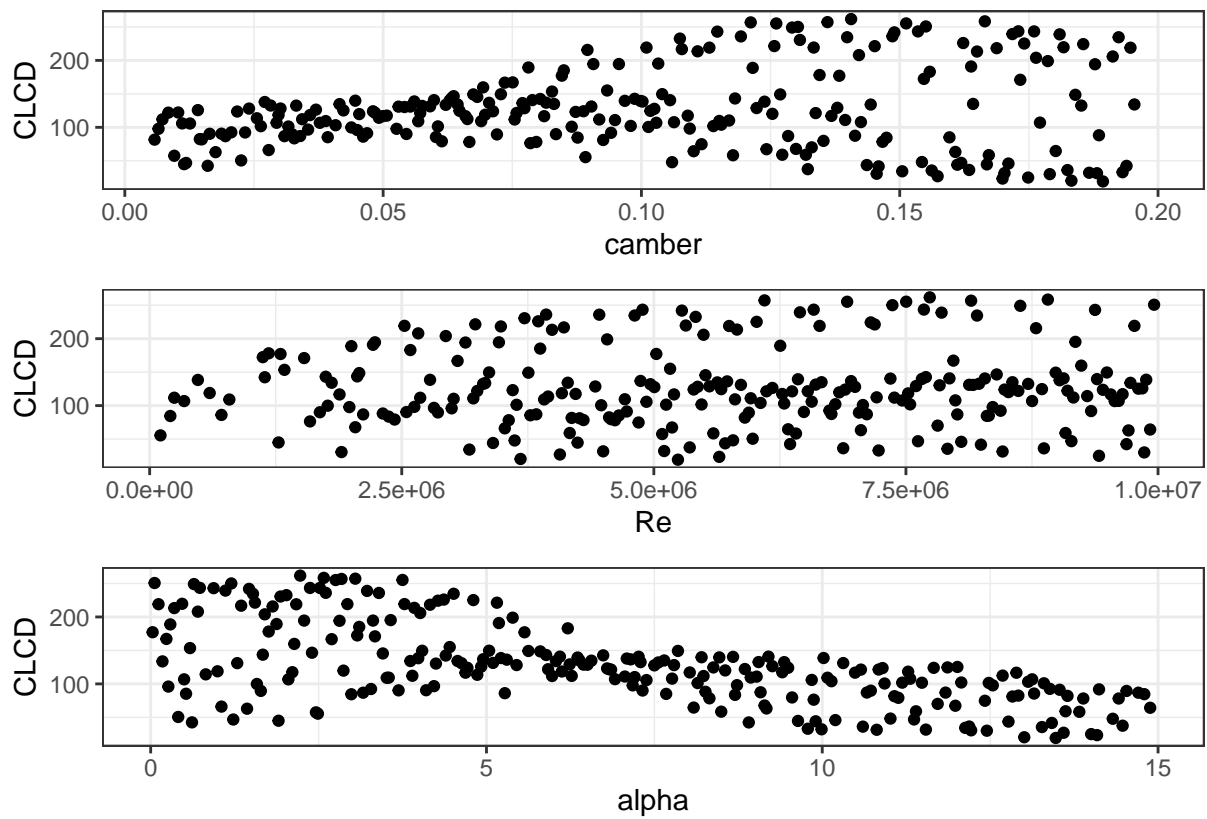
Convergence rate: 72%.

Plotting parameters for NN (*Re* no log) showing where simulations did not converge:

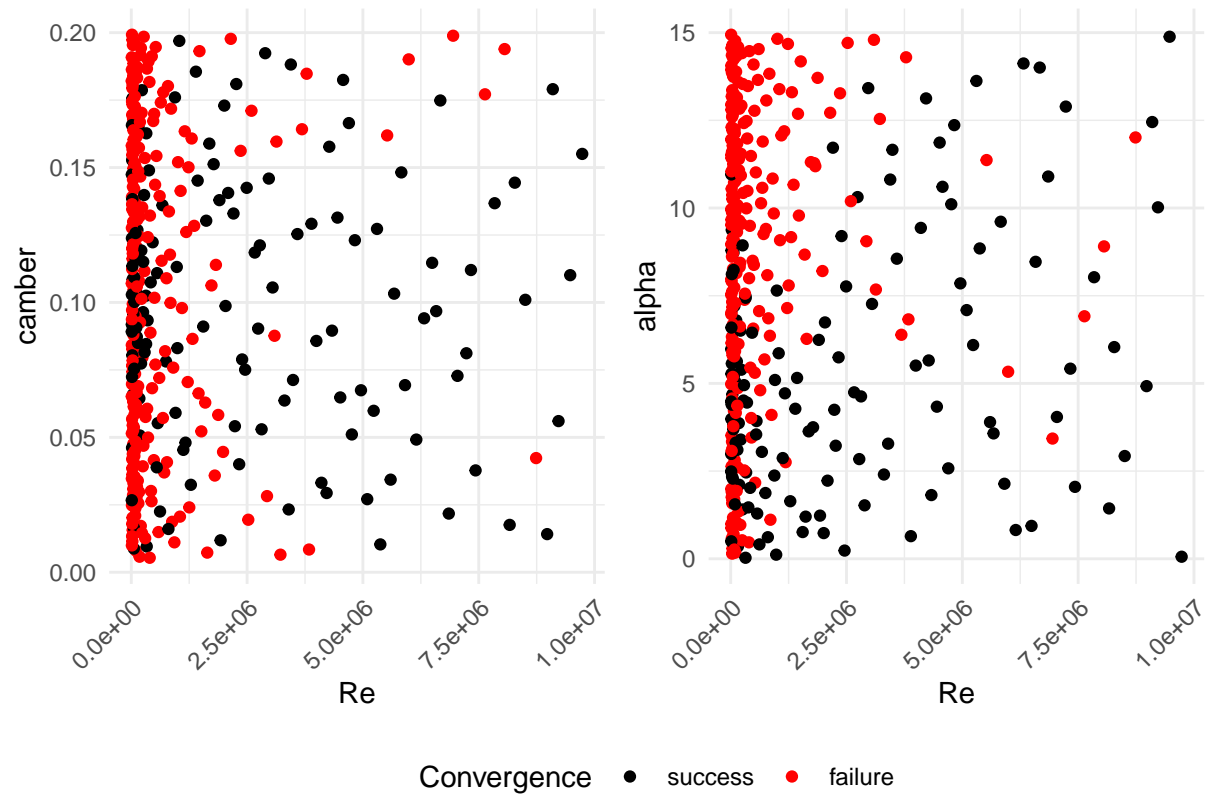Convergence ● success ● failure

CL/CD results:

NN with log-transformed Re range

Loading data for NN study with log-transformed Re:

```
params_nn_log <- read.csv("./data/bad_parameters/NN_Params_LogRe.csv",
                           header = FALSE)
colnames(params_nn_log) <- column_names
nn_log_results <- read.csv("./results/bad_results/NN_LogRe_results.csv")
nn_log_results <- nn_log_results[order(nn_log_results$sim),]
complete_nn_log <- cbind(params_nn_log, nn_log_results)
complete_nn_log$CLCD <- complete_nn_log$CL/complete_nn_log$CD
```

Convergence rate: 38%.

Plotting parameters for NN (Re no log) showing where simulations did not converge:

Convergence ● success ● failure

CL/CD results:
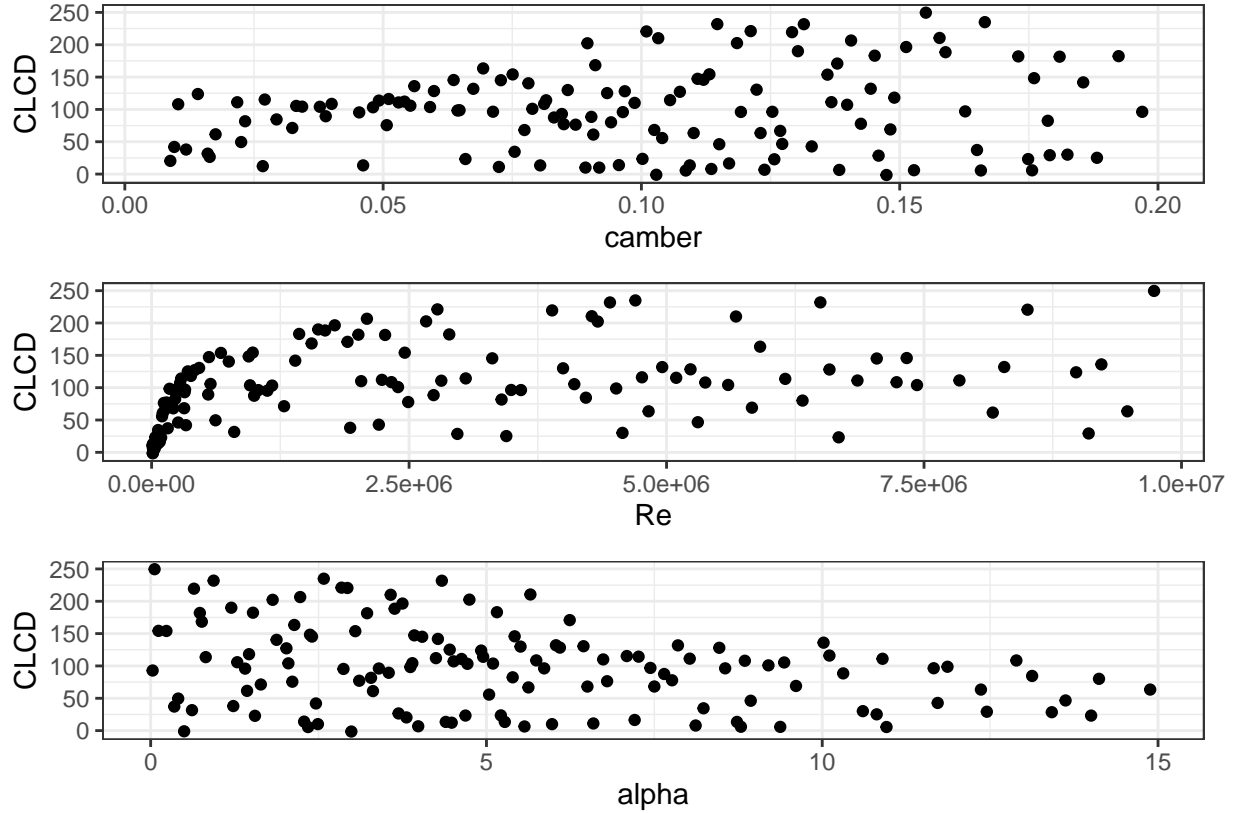
For the log-transformed *Re* range, the convergence of simulations was particular bad, only 38% ran successfully, leaving not many simulations with which we could train the NN.

Assesssing the success of the original Reynolds number range

Visualizing Results from the Modified Reynolds-number range

Due to the low convergence of the the original range of *Re*, we modified the range to be $1e6 < Re < 1e9$. We also used both log-transformed and non-log-transformed ranges.
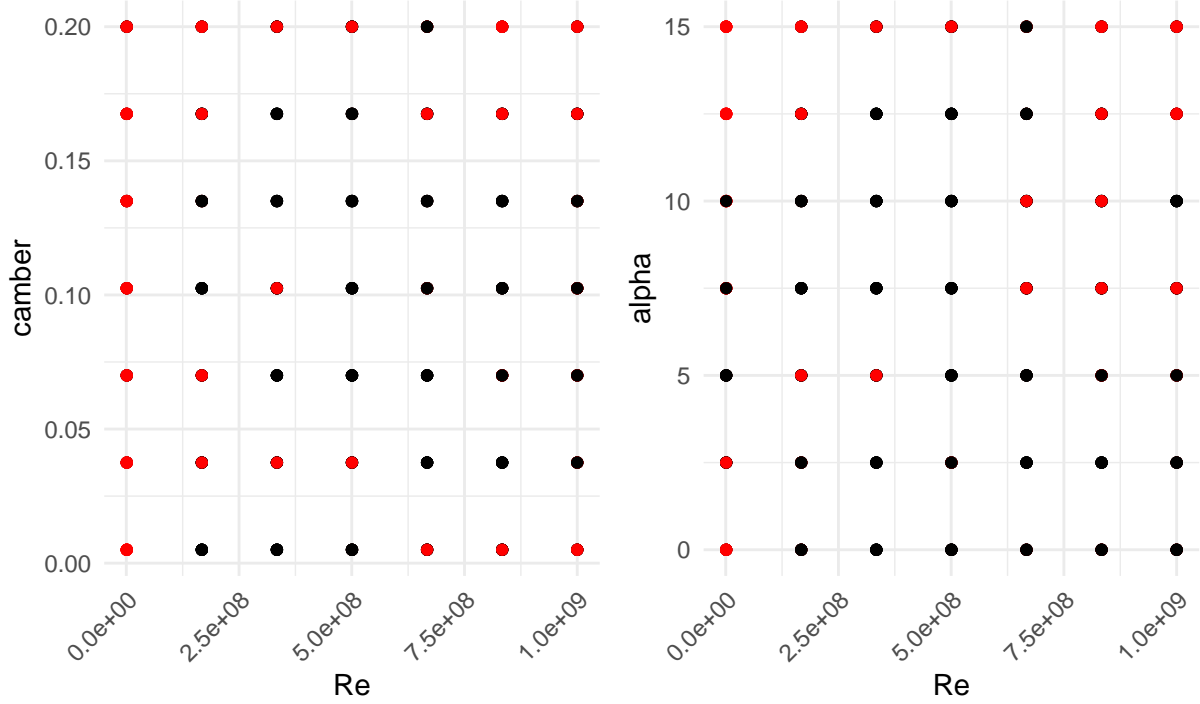
Grid Study with Original Parameter Ranges

```
column_names <- c("Re", "alpha", "camber")
params_grid_nolog <- read.csv("./data/parameters/grid_Params_noLogRe.csv",
                              header = FALSE)
colnames(params_grid_nolog) <- column_names

grid_nolog_results <- read.csv("./results/grid_noLogRe_results.csv")
grid_nolog_results <- grid_nolog_results[order(grid_nolog_results$sim),]
grid_nolog_results$CLCD <- grid_nolog_results$CL/grid_nolog_results$CD
complete_grid_nolog <- cbind(params_grid_nolog, grid_nolog_results)
```

Convergence rate: 75%.

Plotting parameters for gPC (*Re* no log) showing where simulations did not converge:

CL/CD results: