EDS230: Assignment 4

Carlo Broderick, Erika Egg, Ruth Enriquez

```
# packages
library(sensitivity)
```

```
## Warning: package 'sensitivity' was built under R version 4.2.3
```

```
## Registered S3 method overwritten by 'sensitivity':
##   method    from
##   print.src dplyr
```

```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.2 --
```

```
## v ggplot2 3.4.0      v purrr   1.0.1
## v tibble  3.1.8      v dplyr   1.0.10
## v tidyr   1.2.1      v stringr 1.5.0
## v readr   2.1.3      v forcats 0.5.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x tidyr::extract() masks sensitivity::extract()
## x dplyr::filter()  masks stats::filter()
## x dplyr::lag()     masks stats::lag()
## x dplyr::src()     masks sensitivity::src()
```

```
library(lhs)
library(purrr)
```

Your task
For a given forest, you will perform a sensitivity analysis of model predictions of conductance. Consider the sensitivity of your estimate to uncertainty in the following parameters and inputs

- height
- kd
- k0
- v

Windspeeds v are normally distributed with a mean of 250 cm/s with a standard deviation of 30 cm/s
For vegetation height assume that height is somewhere between 9.5 and 10.5 m (but any value in that range is equally likely)
For the kd and k0 parameters you can assume that they are normally distributed with standard deviation of 1% of their default values

a) Use the Latin hypercube approach to generate parameter values for the 4 parameters
b) Run the atmospheric conductance model for these parameters

c) Plot conductance estimates in a way that accounts for parameter uncertainty 1
d) Plot conductance estimates against each of your parameters
e) Estimate the Partial Rank Correlation Coefficients
f) Discuss what your results tell you about how aerodynamic conductance? What does it suggest about what you should focus on if you want to reduce uncertainty in aerodynamic conductance estimates? Does this tell you anything about the sensitivity of plant water use to climate change?

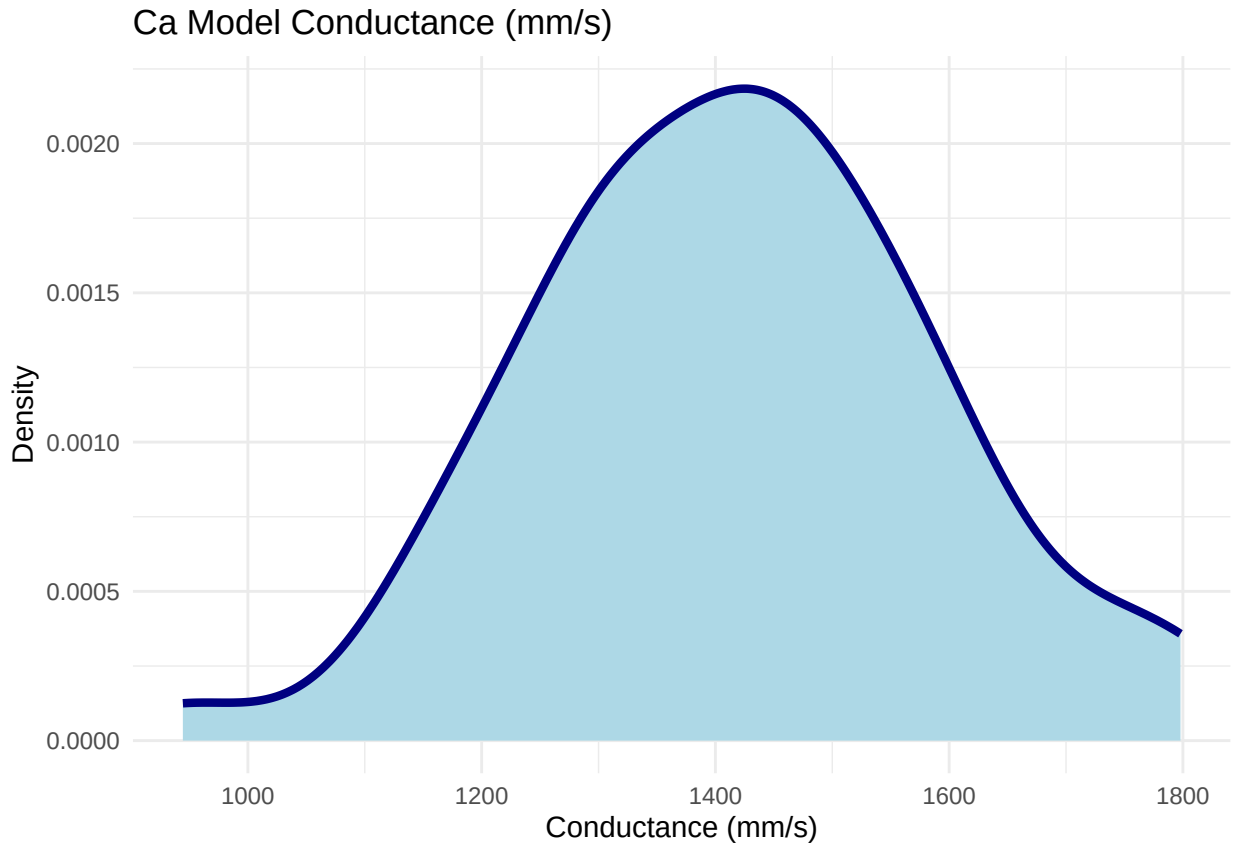
We suggest to reduce uncertainty that we look at wind speed and height, as they are the two most important values and are most sensitive to change. This can be seen in the partial correlation graph which shows them as the highest values and in the obvious positive correlations seen in the output by parameter plot. Since wind speed and height seem to be most sensitive to change, uncertainty in these parameters may be more likely to create an underestimate or overestimate of plant water use under climate change.

```
# source the function
source("Catm-1.R")

# set a random seed to make things 'random'
set.seed(2)

# specify parameters
pnames = c("v", "height","k_o", "k_d")

# how many parameters
npar =  length(pnames)

# how many samples
nsample = 50

# create the random values array matrix using LHS for the parameters
parm_quant = randomLHS(nsample, npar)

# assign the parameter names columns
colnames(parm_quant)=pnames

# make a data frame
parm = as.data.frame(matrix(nrow=nrow(parm_quant), ncol=ncol(parm_quant)))

# name columns
colnames(parm) = pnames

# create the samples for the different parameters

# to create the 1% sdeviation
pvar = 100

# normal
parm[,"v"] = qnorm(parm_quant[,"v"], mean=250, sd=30)
parm[,"k_d"] = qnorm(parm_quant[,"k_d"], mean=0.7, sd=0.7/pvar)
parm[,"k_o"] = qnorm(parm_quant[,"k_o"], mean=0.1, sd=0.1/pvar)

# uniform
parm[,"height"] = qunif(parm_quant[,"height"], min = 9.5, max = 10.5)
```

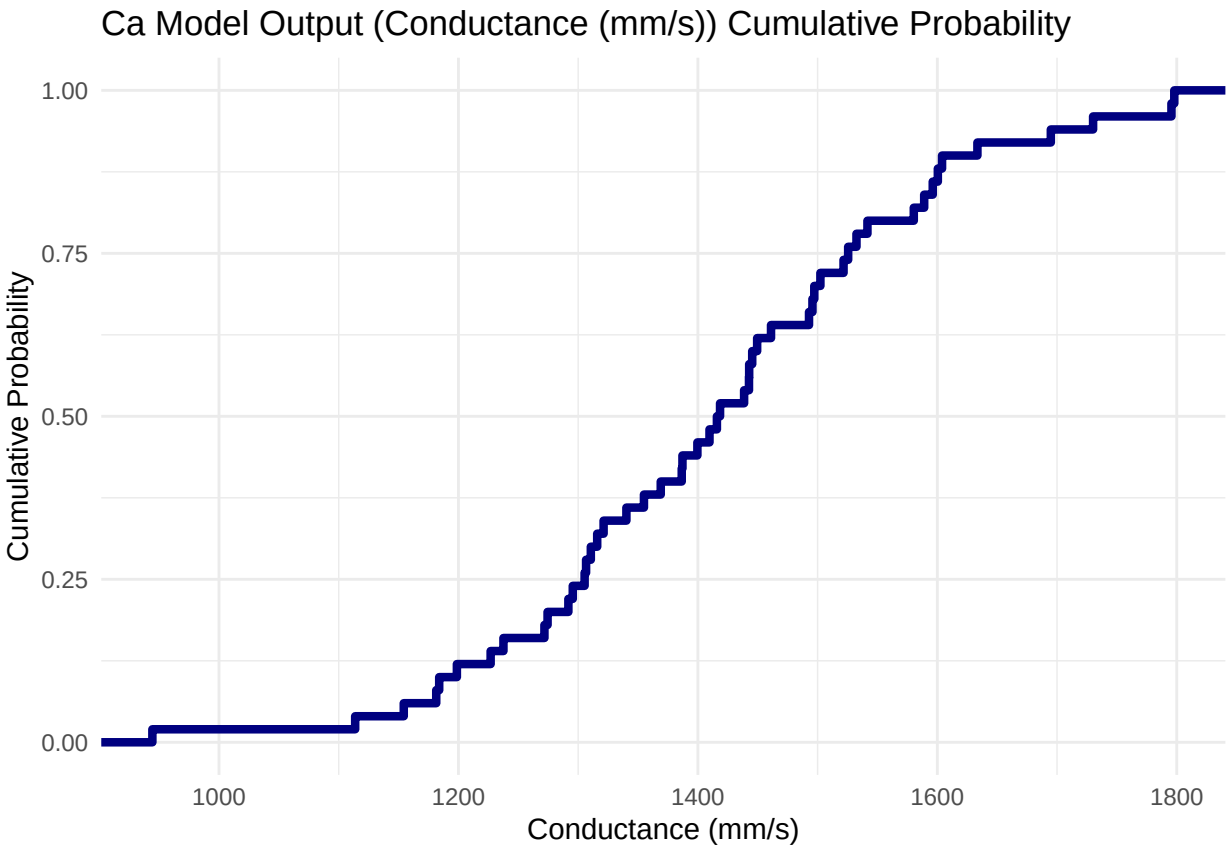
```
# run the hypercube through the model
Ca_outputs = pmap(parm, Catm)

# turn results in to a array for easy display/analysis
Cas = unlist(Ca_outputs)

# put the outputs in the same df as the parameters
param_outputs <- parm |>
  mutate(output = Cas)
```

```
# plot predicted Ca for each parameter combo
ggplot(param_outputs, aes(x = output)) +
  geom_density(color = "navy", size = 1.5, fill = "lightblue") +
  theme_minimal() +
  labs(x = "Conductance (mm/s)", y = "Density", title = "Ca Model Conductance (mm/s)")
```

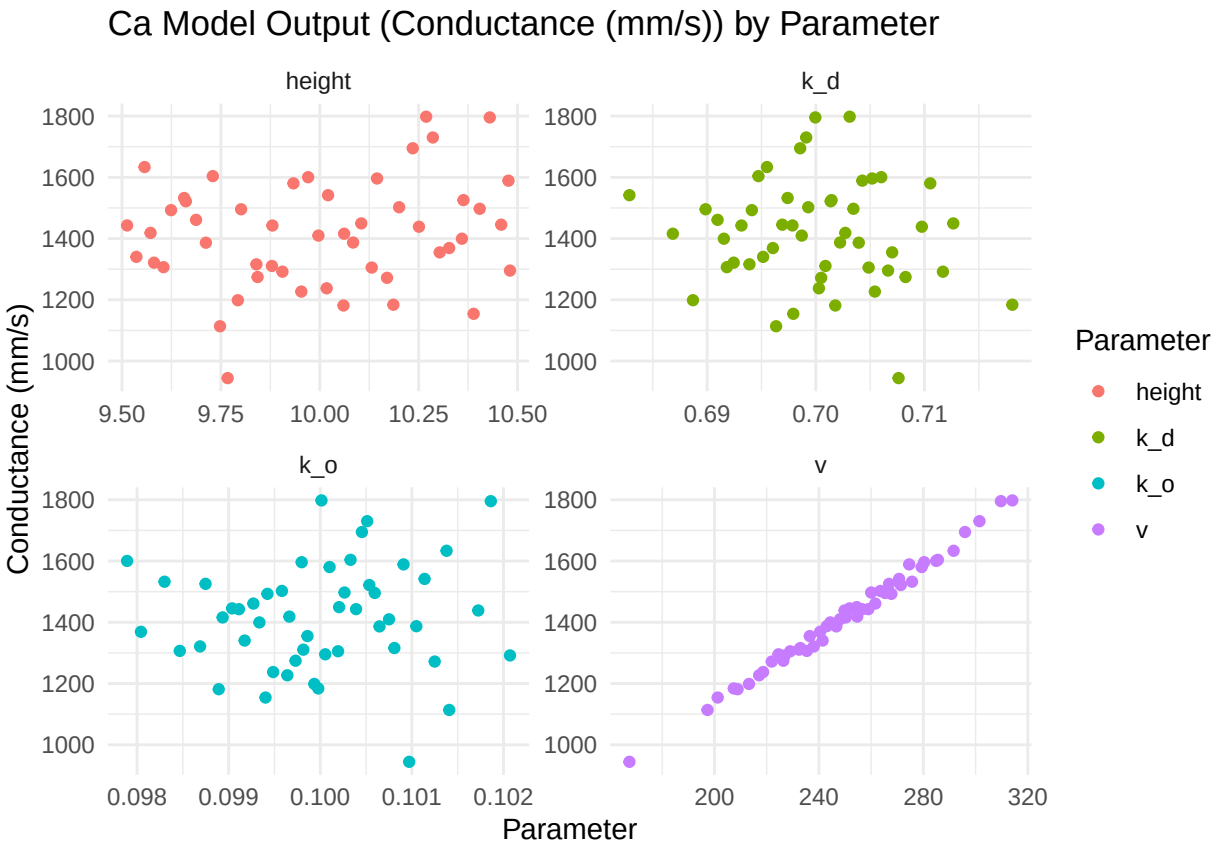
```
## Warning: Using 'size' aesthetic for lines was deprecated in ggplot2 3.4.0.
## i Please use 'linewidth' instead.
```



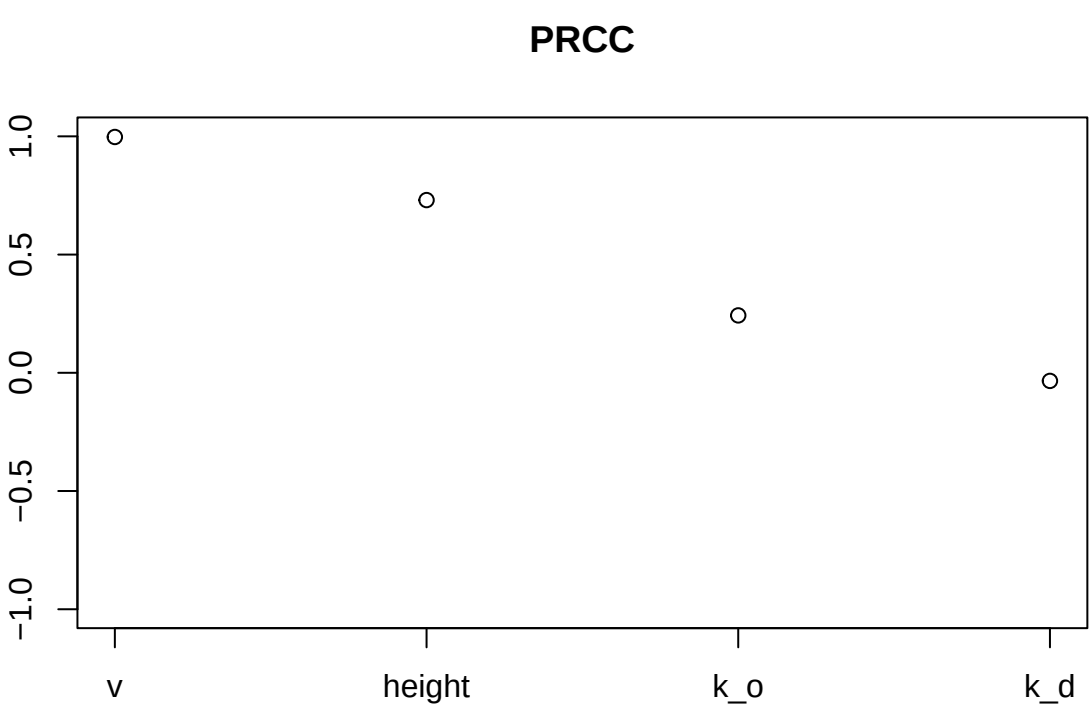

```
# cumulative distribution
ggplot(param_outputs, aes(x = output)) +
  stat_ecdf(color = "navy", size = 1.5) +
  theme_minimal() +
  labs(x = "Conductance (mm/s)", y = "Cumulative Probability", title = "Ca Model Output (Conductance (mm
```




```
# make a df for the outputs pivot longer for graphs
df_long <- param_outputs %>%
  pivot_longer(cols = v:k_d, names_to = "parm", values_to = "value")

# Create plots for parameters effect on output
ggplot(df_long, aes(x = value, y = output, col = parm)) +
  geom_point(size = 1.5) +
  facet_wrap(~ parm, ncol = 2, scales = "free") +
  theme_minimal() +
  labs(x = "Parameter", y = "Conductance (mm/s)", color = "Parameter", title = "Ca Model Output (Conduc
```




```
# calculate partial correlations
partial_correlation = pcc(parm, param_outputs$output, rank = TRUE)

plot(partial_correlation)
```


PRCC
1.0
0.5
0.0
−0.5
−1.0
v
height
k_o
k_d