LHS Sensitivity Analysis

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```r
# for formal sensitivity analysis it is useful to describe output in
# several summary statistics - how about mean, max and min yield
source(here("R/crop_water_use.R"))
```

```r
# You are estimating the atmospheric conductance for a forest that is
# 10 m high (the accuracy of that measurement is +/- 0.5 m )
# Windspeeds v in this region are normally distributed with a mean of 250 cm/s
# with a standard deviation of 30 cm/s
crop_water_use(v_m=250, h=1000)
```

```
## $conductance
## [1] 15.44228
```

Part A. Use LHS to generate parameter values for the 4 parameters

```r
# consider 4 parameters
factors = c("v_m", "k_d", "k_0", "h")

# calculate number of sets
nsets = 100

# choose distribution of parameters
q = c("qnorm", "qnorm", "qnorm", "qunif")
q.arg = list(list(mean=250, sd=30),
             list(mean=0.7, sd=0.007),
             list(mean=0.1, sd=0.001),
             list(min=950, max=1050))

# generate samples for LHS
sens_crop_water = LHS(NULL, factors, nsets, q, q.arg)
sens_params = get.data(sens_crop_water)
head(sens_params)
```

```
##        v_m       k_d        k_0      h
## 1 224.2115 0.6937247 0.09960114  968.5
## 2 257.2128 0.6983170 0.10075542 1019.5
## 3 244.3264 0.6951678 0.09954624 1047.5
## 4 229.2907 0.6912250 0.10137220 1023.5
## 5 245.0902 0.7151906 0.09898478  978.5
## 6 275.7885 0.7111874 0.09862780  997.5
```

Part B. Run atmospheric conductance model for these parameters and return aerodynamic conductances

```r
# lets now run our model for all of the parameters generated by LHS
crop_water = sens_params %>%
  pmap(crop_water_use, z_m=200) %>%
  bind_rows() # turn results in to a dataframe for easy display/analysis

head(crop_water)
```

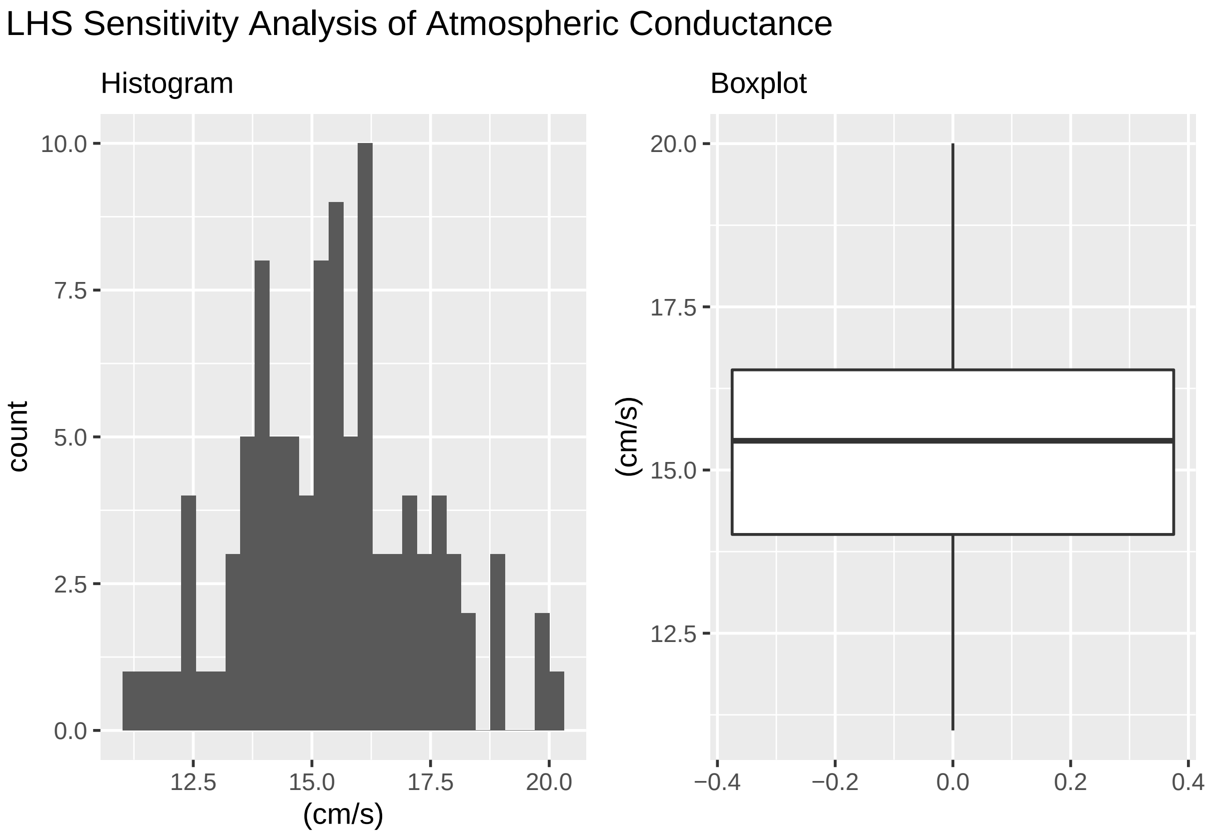
```
## # A tibble: 6 x 1
##   conductance
##         <dbl>
## 1        13.4
## 2        16.1
## 3        15.2
## 4        14.3
## 5        15.4
## 6        17.2
```

```r
# tell is what links output to original LHS object
sens_conductance <- pse::tell(sens_crop_water, t(as.matrix(crop_water)),
                        res.names=c("conductance"))
```

Part C. Plot conductance estimates in a way that accounts for parameter uncertainty

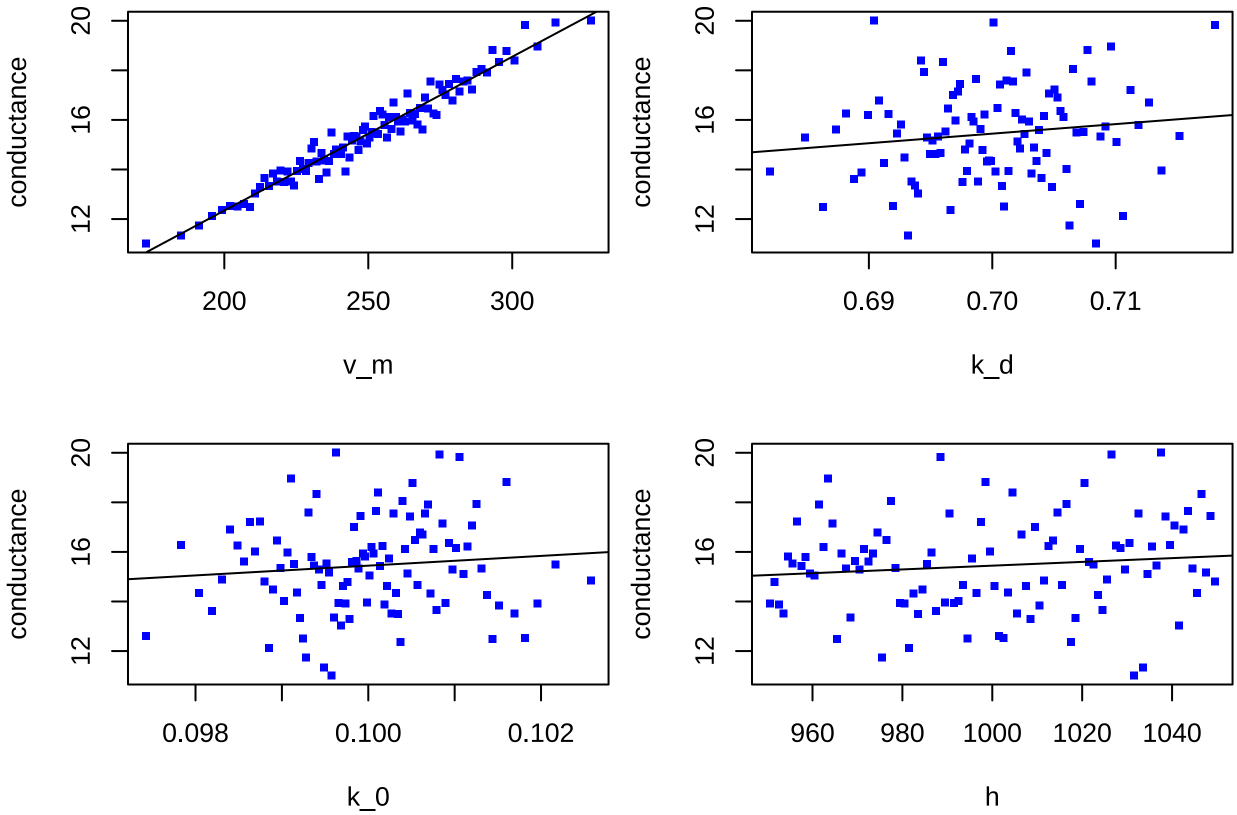
```r
hist <- ggplot(crop_water, aes(conductance)) +
  geom_histogram() +
  labs(subtitle = "Histogram",
       x = "(cm/s)")
box <- ggplot(crop_water, aes(conductance)) +
  geom_boxplot() +
  labs(subtitle = "Boxplot",
       x = "(cm/s)") +
  coord_flip()

(hist + box) + plot_annotation(title = "LHS Sensitivity Analysis of Atmospheric Conductance")
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



Part D. Plot conductance estimates against each of your parameters

```
# now we use built in LHS functions to analyze parameter sensitivity
pse::plotscatter(sens_conductance, col="blue", cex=5)
```



Part E. Est. PRCC

```
# partial rankk correlation coefficients
sens_conductance$prcc
```

```
## [[1]]
##
## Call:
## pcc.default(X = L, y = r, rank = T, nboot = nboot)
##
## Partial Rank Correlation Coefficients (PRCC):
##      original
## v_m 0.9957844
## k_d 0.8456651
## k_0 0.7286138
## h   0.8219793
```

Part F. Discussion

Discuss what your results tell you about how aerodynamic conductance varies with the different parameters? 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?

Our model tells us that aerodynamic conductance is the most sensitive to wind speed (v_m). It suggests that we should focus on wind speed if we want to reduce uncertainty in aerodynamic conductance estimates. We can infer from previous knowledge about climate change and how it is effecting average wind speeds, that plant water use can be sensitive to climate change.