Krigging (and IDW) example - Meuse river sediments

We shall be predicting zinc-sediment levels. Exampble is based on the Meuse dataset:

```
glimpse(meuse)
```

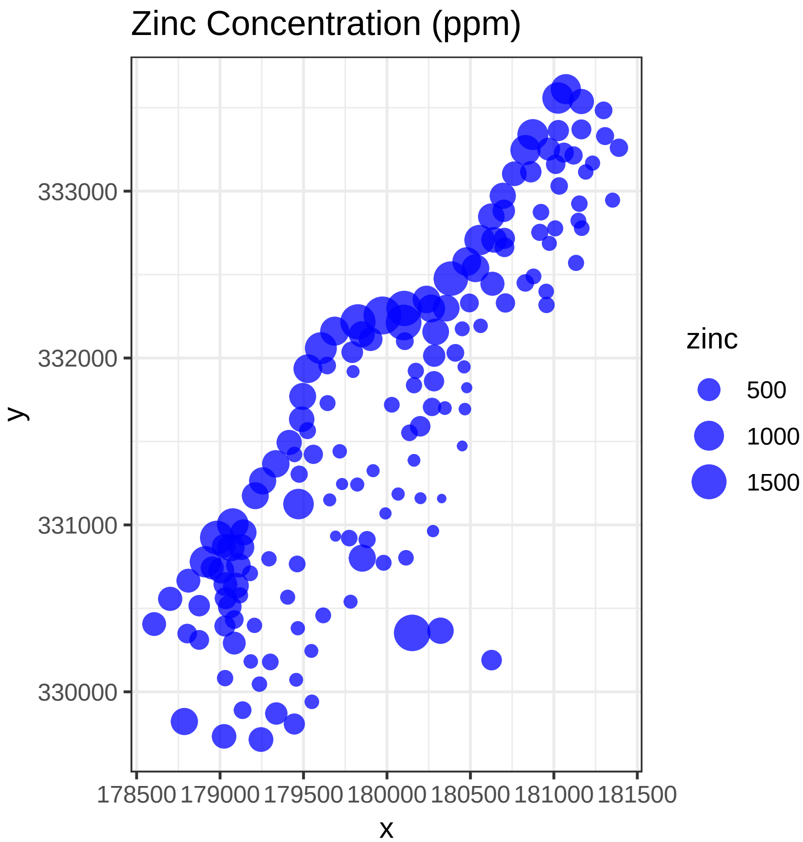
```
## Observations: 155
## Variables: 14
## $ x       <dbl> 181072, 181025, 181165, 181298, 181307, 181390, 181165...
## $ y       <dbl> 333611, 333558, 333537, 333484, 333330, 333260, 333370...
## $ cadmium <dbl> 11.7, 8.6, 6.5, 2.6, 2.8, 3.0, 3.2, 2.8, 2.4, 1.6, 1.4...
## $ copper  <dbl> 85, 81, 68, 81, 48, 61, 31, 29, 37, 24, 25, 25, 93, 31...
## $ lead    <dbl> 299, 277, 199, 116, 117, 137, 132, 150, 133, 80, 86, 9...
## $ zinc    <dbl> 1022, 1141, 640, 257, 269, 281, 346, 406, 347, 183, 18...
## $ elev    <dbl> 7.909, 6.983, 7.800, 7.655, 7.480, 7.791, 8.217, 8.490...
## $ dist    <dbl> 0.00135803, 0.01222430, 0.10302900, 0.19009400, 0.2770...
## $ om      <dbl> 13.6, 14.0, 13.0, 8.0, 8.7, 7.8, 9.2, 9.5, 10.6, 6.3, ...
## $ ffreq   <fct> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, ...
## $ soil    <fct> 1, 1, 1, 2, 2, 2, 2, 1, 1, 2, 2, 1, 1, 1, 1, 1, 1, 1, ...
## $ lime    <fct> 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 1, ...
## $ landuse <fct> Ah, Ah, Ah, Ga, Ah, Ga, Ah, Ab, Ab, W, Fh, Ag, W, Ah, ...
## $ dist.m  <dbl> 50, 30, 150, 270, 380, 470, 240, 120, 240, 420, 400, 3...
```

```
glimpse(meuse.grid) # empty grid - zinc levels will be predicted here
```

```
## Observations: 3,103
## Variables: 7
## $ x      <dbl> 181180, 181140, 181180, 181220, 181100, 181140, 181180,...
## $ y      <dbl> 333740, 333700, 333700, 333700, 333660, 333660, 333660,...
## $ part.a <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1...
## $ part.b <dbl> 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0...
## $ dist   <dbl> 0.00000000, 0.00000000, 0.01222430, 0.04346780, 0.00000...
## $ soil   <fct> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1...
## $ ffreq  <fct> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1...
```

We can use `ggplot2` to visually inspect how zinc varies over the domain of interest where we map concentration to point size:

```
meuse %>% as.data.frame %>%
  ggplot(aes(x, y)) + geom_point(aes(size=zinc), color="blue", alpha=3/4) +
  ggtitle("Zinc Concentration (ppm)") + coord_equal() + theme_bw()
```



Prepare data for spatia analysis (IDW, krigging)

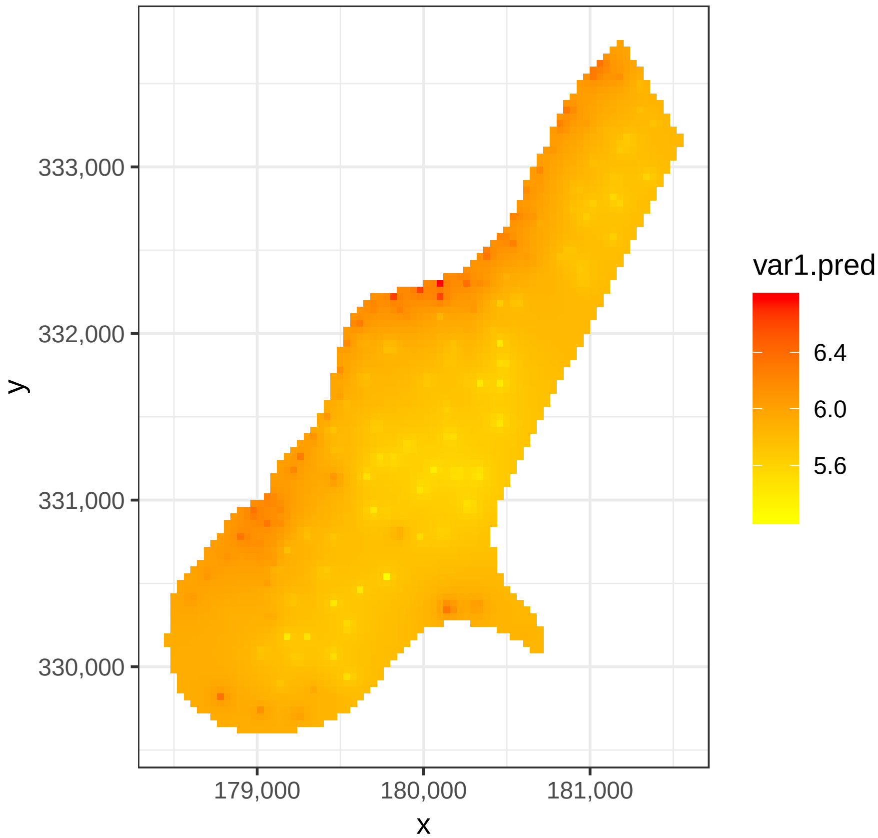
```
coordinates(meuse) = ~x+y
coordinates(meuse.grid) = ~x+y
```

IDW

```
idwmodel <- idw(log(zinc) ~1, meuse,meuse.grid,
               maxdist = Inf, idp = 1)
```

```
## [inverse distance weighted interpolation]
```

```
idwmodel %>% as.data.frame %>%
  ggplot(aes(x=x, y=y)) + geom_tile(aes(fill=var1.pred)) + coord_equal() +
  scale_fill_gradient(low = "yellow", high="red") +
  scale_x_continuous(labels=comma) + scale_y_continuous(labels=comma) +
  theme_bw()
```

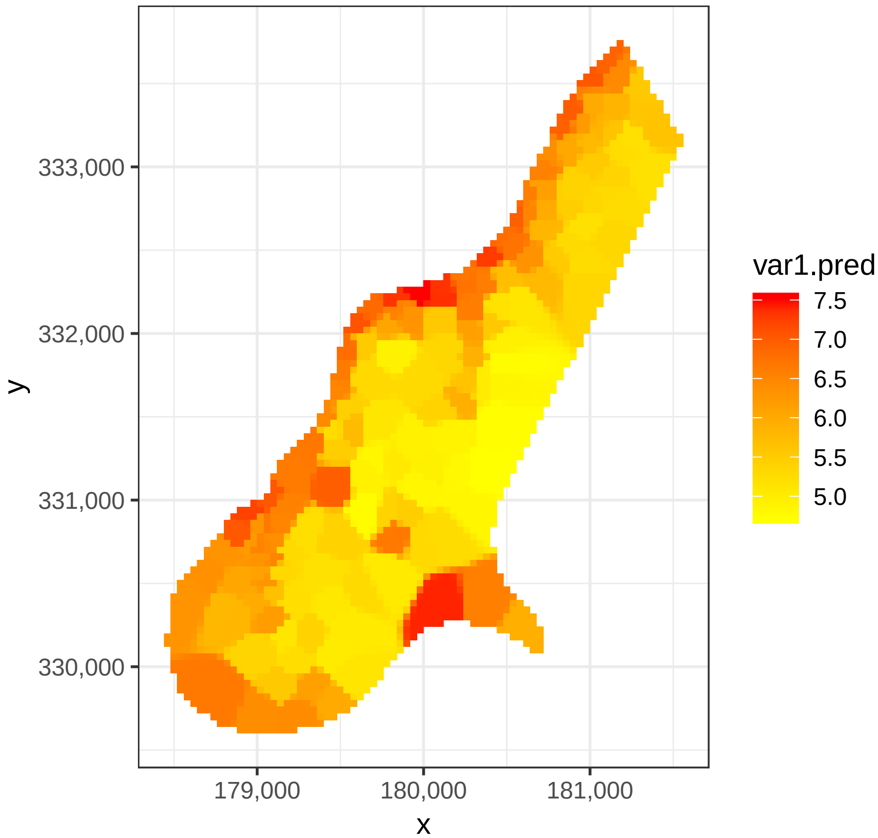


- Voronoi-type diagram

```
idwmodel2 <- idw(log(zinc) ~1, meuse,meuse.grid,
                 maxdist = Inf, idp = 20)
```

```
## [inverse distance weighted interpolation]
```

```
idwmodel2 %>% as.data.frame %>%
  ggplot(aes(x=x, y=y)) + geom_tile(aes(fill=var1.pred)) + coord_equal() +
  scale_fill_gradient(low = "yellow", high="red") +
  scale_x_continuous(labels=comma) + scale_y_continuous(labels=comma) +
  theme_bw()
```



Kriging

- 1) Calculate the sample variogram. This is done with the `variogram()` function.
- 2) Fit a model to the sample variogram using `fit.variogram()` function.
- 3) Use the fitted variogram for krigging - bassed on the λ_i weights - using `krige()` function
- 4) Plot the krigged data using `ggplot()`

```r
# 1
lzn.vgm <- variogram(log(zinc)~1, meuse) # calculates sample variogram values
# 2
lzn.fit <- fit.variogram(lzn.vgm, model=vgm(psill=NA, "Sph", range=900, nugget=1))
# 3
lzn.kriged <- krige(log(zinc) ~ 1, meuse, meuse.grid, model=lzn.fit)
```

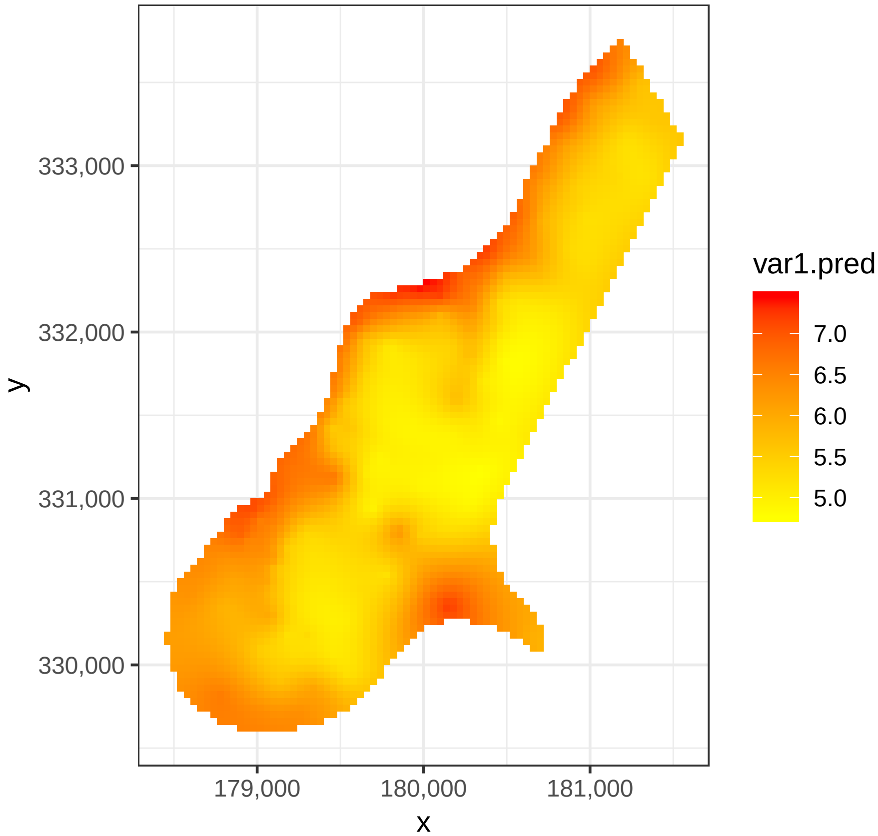
```
## [using ordinary kriging]
```

```r
head(lzn.kriged)
```

```
##         coordinates var1.pred  var1.var
## 1 (181180, 333740)  6.499632 0.3198086
## 2 (181140, 333700)  6.622361 0.2520219
## 3 (181180, 333700)  6.505172 0.2729863
## 4 (181220, 333700)  6.387597 0.2955293
```

```
## 5 (181100, 333660)  6.764493 0.1779457
## 6 (181140, 333660)  6.635516 0.2022069
```

```r
# 4
lzn.kriged %>% as.data.frame %>%
  ggplot(aes(x=x, y=y)) + geom_tile(aes(fill=var1.pred)) + coord_equal() +
  scale_fill_gradient(low = "yellow", high="red") +
  scale_x_continuous(labels=comma) + scale_y_continuous(labels=comma) +
  theme_bw()
```



Quick exercise:

- Repeat the krigging process (including plotting) while fitting the empirical semivariogram to a Gaussian curve.

```r
# 1

# 2

# 3

# 4
```

For application to London's house prices, see example here