

# Working with geo-spatial data in R

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## Intro

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- Rapid fire overview of geo-spatial miscellany in R
- If you're not familiar with R, don't worry about the code
- The code/data necessary to reproduce anything in this talk is all on [github!](#)

# Intro

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## My goal

Show you enough relatively cool things in 15min to entice you to give R a shot!

# Using ggmap to get lat/lon coordinates

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- Just type what you would type into Google Maps

```
# install.packages("ggmap")
library(ggmap)
geocode("St. Paul, MN")

      lon      lat
1 -93.08996 44.9537

geocode("2115 Summit Ave., St. Paul, MN")

      lon      lat
1 -93.18971 44.94412

geocode("University of St. Thomas, MN")

      lon      lat
1 -93.18975 44.94192
```

# Grabbing maps

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## Methods

- Lat/lon + zoom level
- Bounding box

## Sources

- Google
- Stamen
- Cloudmade
- OpenStreetMap

## Using lat/lon + zoom

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```
loc <- geocode("2115 Summit Ave, St. Paul, MN")
ust <- get_map(location = c(lon = loc$lon, lat = loc$lat),
               zoom = 15, source = "google",
               maptype = "hybrid", crop = T)

ggmap(ust)
```

# Using lat/lon + zoom

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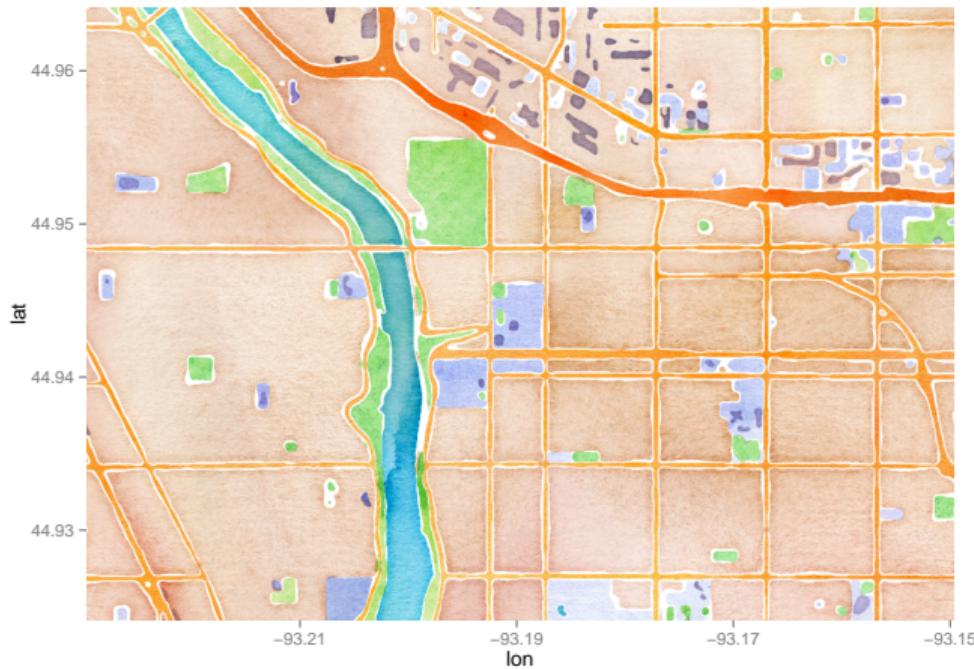
## Using lat/lon + bounding box

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```
loc <- geocode("2115 Summit Ave, St. Paul, MN")  
  
box <- c(left = loc$lon - 0.04, bottom = loc$lat - 0.02,  
        right = loc$lon + 0.04, top = loc$lat + 0.02)  
  
ust_box <- get_map(location = box, source = "stamen",  
                     maptype = "watercolor", crop = T)  
  
ggmap(ust_box)
```

# Using lat/lon + bounding box

---



# Overplotting maps

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- `ggmap()` adds onto existing `ggplot2` functionality
- Thus, layering standard `ggplot2` graphics on top of maps is easy!

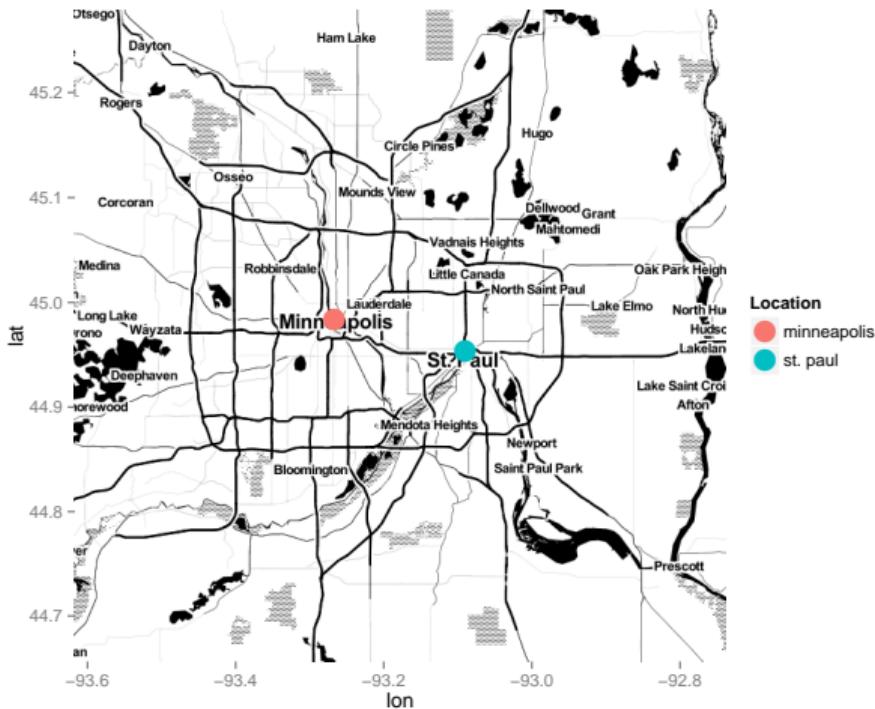
```
locs <- data.frame(names = c("st. paul", "minneapolis"))                      # grab locations
locs <- cbind(locs, geocode(as.character(locs$names)))

mid <- get_map(location = c(lon = mean(locs$lon), lat = mean(locs$lat)),    # get a map
                zoom = 10, source = "stamen", maptype = "toner", crop = T)

p <- ggmap(mid)                                                               # plot map
p <- p + geom_point(aes(x = lon, y = lat, colour = factor(names)),           # overplot w/ points
                     dat = locs, size = 6)
p <- p + scale_colour_discrete("Location")
```

# Overplotting ggmaps

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# Working with world/country maps

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- `get_map()` limited by allowable zoom levels (e.g.  $0 < \text{zoom} < 21$ )
- For larger scale data, the `maps` package is necessary
- Various maps available; see the [documentation](#)

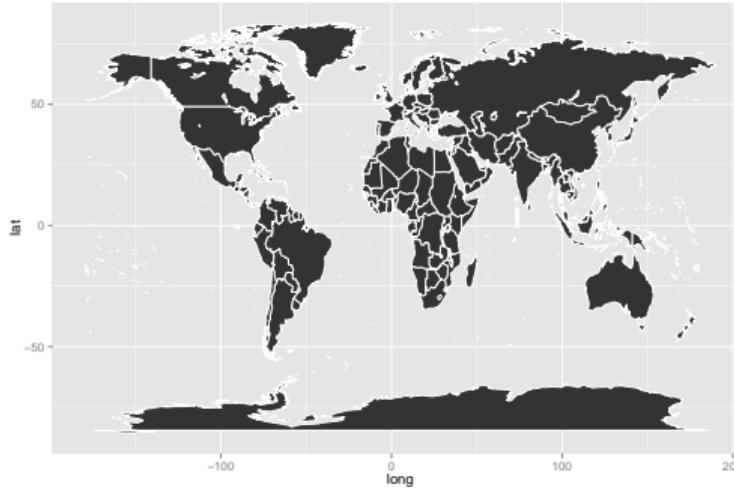
```
library(maps)
world <- map_data("world")
head(world, 5)

  long      lat group order region subregion
1 -133.3664 58.42416     1    1 Canada      <NA>
2 -132.2681 57.16308     1    2 Canada      <NA>
3 -132.0498 56.98610     1    3 Canada      <NA>
4 -131.8797 56.74001     1    4 Canada      <NA>
5 -130.2492 56.09945     1    5 Canada      <NA>
```

# World map example

---

```
# pay attention to column names (long vs. lon!)
p <- ggplot(world, aes(x = long, y = lat, group = group))
p <- p + geom_polygon(colour = "white")
p
```



# United States example

---

```
usa <- map_data("state")
p <- ggplot(usa, aes(x = long, y = lat, group = group))
p <- p + geom_polygon(colour = "white")
p
```



# Subsetting areas

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```
states <- c("minnesota", "wisconsin", "illinois", "indiana",
          "iowa", "missouri", "michigan")

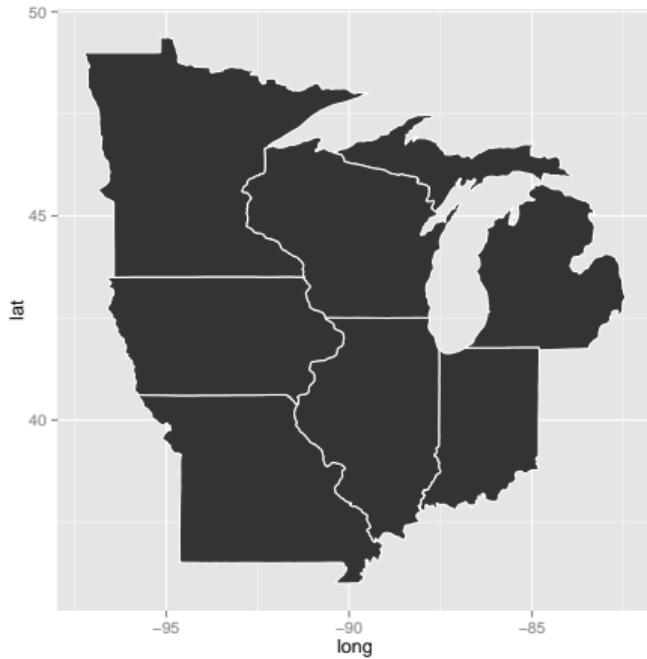
states_map <- map_data("state")

states_map <- states_map[states_map$region %in% states, ]

p <- ggplot(states_map, aes(x = long, y = lat, group = group))
p <- p + geom_polygon(colour = "white")
p
```

# Subsetting areas

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# A hobby project

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- Internal talks at 3M typically given live to US audience; recorded for int'l
- Organized two "reverse talks" to reach a wider global audience
- Attendance records shattered
- Wanted to visualize impact/reach!

# The inspiration

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# Calculating great circle arcs

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- `gcIntermediate()` function from `geosphere` package

```
library(geosphere)
arc <- gcIntermediate(c(lon_1, lat_1), c(lon_2, lat_2),
                      n = steps, addStartEnd = T)
```

## Crossing the Date Line

```

# draw great circles from St. Paul to everywhere else
gcircles <- lapply(1:nrow(end), function(i) {                                # arc for each set
  temp <- gcIntermediate(start[, c("lon", "lat")],
                         end[i, c("lon", "lat")],
                         n = 50, addStartEnd = T,
                         breakAtDateLine = T)

  if(is.list(temp) == T) {                                                     # were two half-paths returned?
    ids <- c(rep(paste0("i", i), nrow(temp[[1]])),
             rep(paste0("j", i), nrow(temp[[2]])))
    temp <- as.data.frame(rbind(temp[[1]], temp[[2]]))                      # if so, make id's for both halves
    temp$id <- ids
  }
  ...
}

```

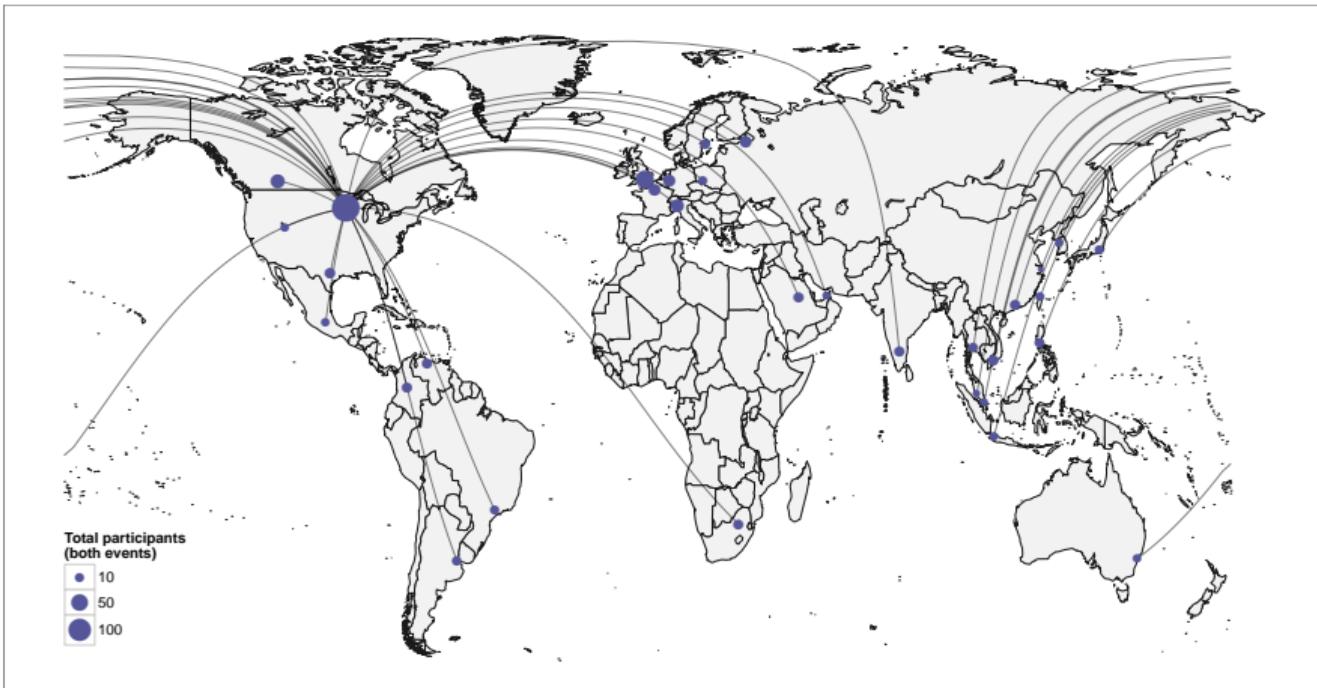
# The plot

---

```
p <- ggplot()  
p <- p + geom_polygon(aes(x = long, y = lat, group = group),  
                      data = world, colour = "gray10", fill = "gray95")  
p <- p + geom_line(aes(x = lon, y = lat, group = id),  
                    dat = gcircles, lwd = 0.4, alpha = 0.5)  
p <- p + geom_point(aes(x = lon, y = lat, size = sqrt(total/pi)),  
                     dat = talks_agg, colour = "#555599")  
p <- p + scale_size("Total participants\n(both events)",  
                     limits = c(0, max(sqrt(talks_agg$total / pi)) + 1),  
                     breaks = sqrt(c(10, 50, 100) / pi),  
                     labels = c(10, 50, 100), range = c(1, 10))  
p <- p + theme_bw()  
p <- p + theme(axis.text = element_blank(), axis.title = element_blank(),  
               axis.ticks = element_blank(), panel.grid = element_blank(),  
               legend.position = c(0.092, 0.15))
```

# The result

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# Infographic

## Crazy Technology Group

2 live broadcasts

Awesome Talk 1  
Presented  
Some Day 2012

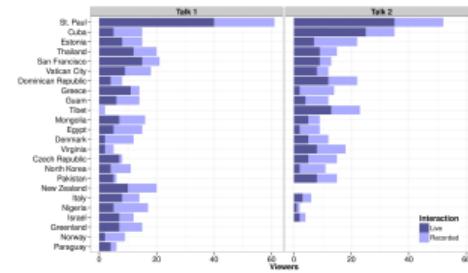
Awesome Talk 2  
Name & Name  
Some Day 2012

100 participating countries

300 time zones

100,000 registrants

50,000 total viewers



Plots by John Henderson via R and ggplot2

# Creating .kml files for Google Earth

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- Pretty easy! (Follow along with [this](#), [this](#), [this](#), and [this](#))

```
talks_agg$size <- 100 * talks_agg$total

talks_sp <- talks_agg
coordinates(talks_sp) <- c("lon", "lat")                      # converts to spatial object
proj4string(talks_sp) <- CRS("+init=epsg:4238")                # G Earth coordinate system
talks_ll <- spTransform(talks_sp,
                        CRS("+proj=longlat +datum=WGS84")) # Something else G Earth wants

# open a file connection and write the data with custom icon/size/label
kml_open("./data/talks-w-gcircles.kml")
kml_layer.SpatialPoints(talks_ll, colour = "white", labels = city, size = total,
                        shape="http://upload.wikimedia.org/wikipedia/commons/a/af/Tux.png")
kml_close("./data/talks-w-gcircles.kml")
```

# Adding great circles

---

- A bit hackish, but manually writing the kml code works, too!

```
# for each point set, generate the following kml syntax
gcircs <- lapply(1:nrow(end), function(i) {
  paste0("<Placemark><LineString><tesselate>1</tesselate><coordinates>",
         start$lon, ",",
         start$lat, " ",
         end[i, "lon"], ",",
         end[i, "lat"],
         "</coordinates></LineString></Placemark>") })
}

# combine the results into a single table
gcircs <- do.call(rbind, gcircs)

# print out each line of the above table
# result can simply be pasted after last <Placemark> in .kml file
write.table(gcircs, row.names = F)
```

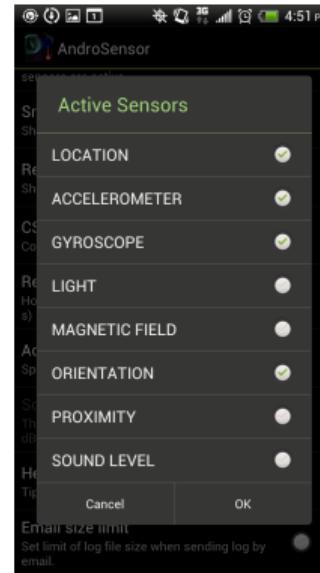
# .kml file in Google Earth

---



# Getting some GPS data

## AndroSensor



# Reading/cleaning the data

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```
gps <- read.csv("./data/gps-data.csv", sep = ";")  
  
# subset to columns we're interested in  
gps <- gps[, c(10, 11, 13, 18)]  
  
# give the columns sensical names  
names(gps) <- c("lat", "lon", "speed", "time")  
head(gps, 5)  
  
      lat      lon speed time  
1 44.92633 -93.09771    NA     5  
2 44.92633 -93.09771    NA   505  
3 44.92633 -93.09771    NA  1011  
4 44.92633 -93.09771    NA  1532  
5 44.92626 -93.09747    0  2032
```

# Plot path and speed over a map

```
p <- ggmap(gps_map)  
p <- p + geom_point(aes(x = lon, y = lat, colour = speed), data = gps, size = 3)  
p <- p + scale_colour_continuous(low = "black", high = "red", na.value = NA)
```



# Public transportation efficiency

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- Background information can be found [here](#)

```
transpo <- read.csv("./data/public-transpo.csv")

transpo_agg <- ddply(transpo, .(city, state), summarize,
                      btus_pmile_ave = mean(btus_pmile),
                      density = mean(population) / mean(service_area_sq_mi))
transpo_agg$lookup <- paste0(transpo_agg$city, ", ", transpo_agg$state)

coords <- geocode(transpo_agg$lookup)                                # city/state string

transpo_agg <- cbind(transpo_agg, coords)                            # get lat/lon

# let's not run that again...
write.table(transpo_agg, file = "./data/transpo-agg-geocoded.csv", row.names = F, sep = ",")
```

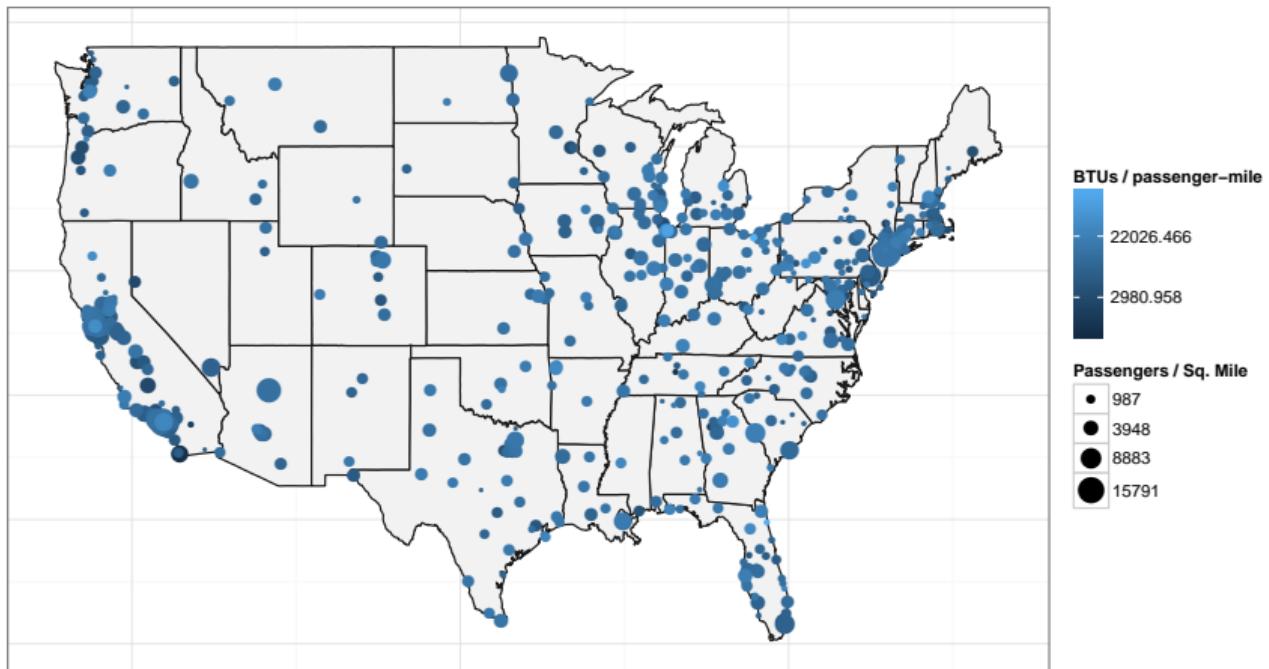
# Efficiency visualized

---

```
plot <- read.csv("./data/transpo-agg-geocoded.csv")
plot <- plot[plot$state != "AK" & plot$state != "HI", ]
usa <- map_data("state")
plot <- plot[order(plot$btus_pmile_ave), ]
p <- ggplot() + geom_polygon(aes(x = long, y = lat, group = group),
                               data = usa, fill = "gray95", colour = "gray10")
p <- p + geom_point(aes(x = lon, y = lat, colour = btus_pmile_ave,
                         size = sqrt(density)/pi), data = plot)
p <- p + scale_colour_gradient("BTUs / passenger-mile", trans = "log")
p <- p + scale_x_continuous("") + scale_y_continuous("")
p <- p + scale_size_continuous("Passengers / Sq. Mile", breaks = c(10, 20, 30, 40),
                                labels = round((c(10, 20, 30, 40)*pi)^2, 0),
                                range = c(1, 8))
p <- p + theme_bw() + theme(axis.text = element_blank(), axis.ticks = element_blank())
```

# Efficiency visualized

---



# Converting data to .json for d3

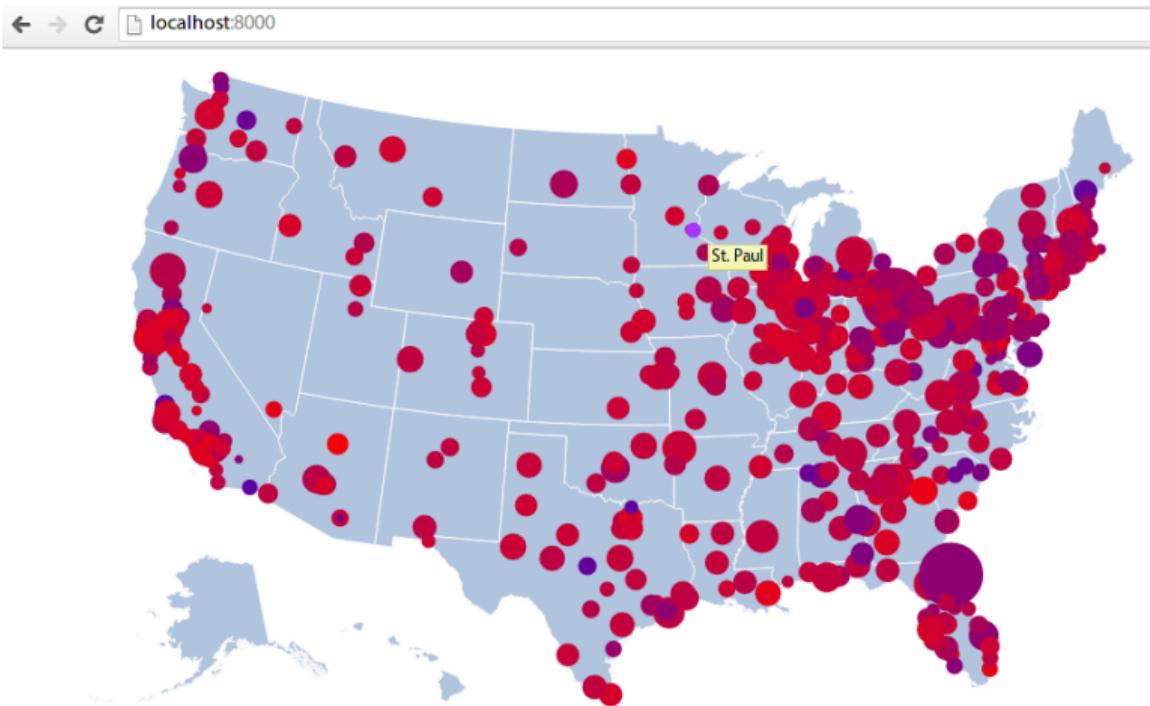
---

- R is excellent for working with data
  - Reshape (wide ↔ long)
  - Calculate columns
  - Summarize, e.g. with ddply
- Manipulate in R, then output to .json, d3's friend
- Helpful function found [here](#), toJSONArray()

```
plot_json <- toJSONArray(plot)          # function defined in link above
file_con <- file("./d3/transpo.json")   # create file
writeLines(plot_json, file_con)         # write results to file
close(file_con)
```

# And voila, a d3 version!

---



# Visualizing work activity

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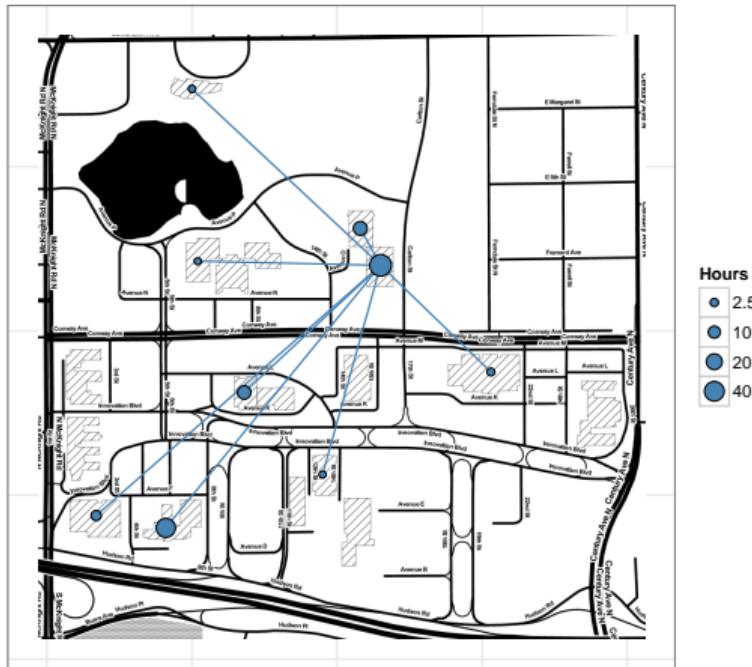
- Tracked work projects with [Timesheet](#) (projects, tags, location)

```
time <- read.csv("./data/timesheet.csv")                      # read data
time <- time[!is.na(time$Location), ]                          # remove entries w/ no loc
mmm_box <- c(left = -93.0053, bottom = 44.9485,             # bounding box
             right = -92.9844, top = 44.9632)
mmm <- get_map(location = mmm_box, source = "stamen", # get map
               maptype = "toner", crop = T)

time <- ddply(time, .(Location), summarize,                  # total time per loc
              total = sum(Duration))

# figure out building coords and merge with timesheet data
bldgs <- data.frame(loc = time$Location))
bldgs$lat <- c(44.9515, 44.9576, 44.9525, 44.9545, 44.9577, 44.955, 44.9512, 44.9619, 44.9585)
bldgs$lon <- -c
```

# Visualizing work activity



## R packages used

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- Getting coordinates/working with Google: `ggmap`
- Great circle paths: `geosphere`
- Larger scale maps: `maps`
- Projection conversion/KML output: `rgdal`, `maptools`, `sp`, and `plotKML`
- Summary computations on data: `ddply()` function from `plyr`
- Reshaping data (wide ↔ long): `reshape2`
- Plotting: `ggplot2`

## References

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- [ggmap: Spatial Visualization with ggplot2](#), Kahle & Wickham
- [How to draw good looking maps in R](#), uchicagoconsulting
- [Great circles on a recentered worldmap](#), AnthroSpace
- [How to map connections with great circles](#), FlowingData
- [SO question on creating .kml files](#)
- For any given package, find the documentation on [CRAN](#)

Code and files from this presentation are on [github](#)!

# Tools

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Presentation made entirely with open source software!



- Emacs and Org-mode for reproducible code environment
- L<sup>A</sup>T<sub>E</sub>X / Beamer for typesetting
- Torino Beamer theme so that it wasn't obvious I was using Beamer