Code Used:

```
setwd("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis")
#install.packages("ncdf4")
library(ncdf4)
ERA5_F_2013_14_cdf<- nc_open("ERA5_F_2013_14.nc")
print(ERA5_F_2013_14_cdf)
names(ERA5_F_2013_14_cdf$var)
ncvar_get(ERA5_F_2013_14_cdf, varid="t2m")
attributes(ERA5_F_2013_14_cdf)
attributes(ERA5_F_2013_14_cdf$var)
attributes(ERA5_F_2013_14_cdf$dim)
lat<- ncvar_get(ERA5_F_2013_14_cdf, "latitude")
dim(lat)
lon<- ncvar_get(ERA5_F_2013_14_cdf, "longitude")
dim(lon)
print(c(dim(lon), dim(lat)))
tim<- ncvar_get(ERA5_F_2013_14_cdf, "time")
head(tim)
dim(tim)
t2m_array<- ncvar_get(ERA5_F_2013_14_cdf,"t2m")
fillvalue<- ncatt_get(ERA5_F_2013_14_cdf,"t2m","_FillValue")
dim(t2m_array)
t2m_array[t2m_array==fillvalue$value]<- NA
t2m_array
#install.packages("anytime")
library(anytime)
mins<-tim*60
secs<-mins*60
time_units2<- as.POSIXct(secs, origin = "1900-01-01 00:00:00.0", tz ="GMT")
dim(time_units2)
range(time_units2)
lonlattime <- as.matrix(expand.grid(lon,lat,time_units2))
head(lonlattime)
t2m_vector<- as.vector(t2m_array)
length(t2m_vector)
head(t2m_vector)
t2m_df<- data.frame(cbind(lonlattime, t2m_vector))
colnames(t2m_df)<-c("longitude", "latitude", "time", "tempK")
head(t2m_df)
write.csv(t2m_df, "ERA5_F_2013_14.csv", row.names=T)
#################################################################################
ERA5_F_2013_14<-read.csv("ERA5_F_2013_14.csv")
table(ERA5_F_2013_14[,2])
long_coords<-c(8, 8.25, 8.5, 8.75, 9)
table(ERA5_F_2013_14[,3]) #switched log/lat by accident (no effect on output)
lat_coords<-c(49, 49.25, 49.5, 49.75, 50)
E<-ERA5_F_2013_14
```

```
station_coords = NULL
for (i in long_coords) { for (j in lat_coords) {
  station = E[(E$longitude==i) & (E$latitude==j), 1:3]
  station_row = c(station[,1])
  station_lat = c(station[,2])
  station_lon = c(station[,3])
  station_coords0 = data.frame(station_row, station_lat, station_lon)
  station_coords = rbind(station_coords, station_coords0)}}
colnames(station_coords)<-c("row","latitude","longitude")
head(station_coords)
station_coords<-data.frame(station_coords)
S<- station_coords
row_num = c()
for (i in long_coords) { for(j in lat_coords){
  row_sample = S[(S[,2]==i) & (S[,3]==j), 1]
  row_sample0 = data.frame(rep("row",6),row_sample)
  row_num = cbind(row_num, row_sample0[,2])}}
head(row_num)
location_01<-E[(E$longitude==8) & (E$latitude==50), ]
location_02<-E[(E$longitude==8.25) & (E$latitude==50), ]
location_03<-E[(E$longitude==8.5) & (E$latitude==50), ]
location_04<-E[(E$longitude==8.75) & (E$latitude==50), ]
location_05<-E[(E$longitude==9) & (E$latitude==50), ]
location_06<-E[(E$longitude==8) & (E$latitude==49.75), ]
location_07<-E[(E$longitude==8.25) & (E$latitude==49.75), ]
location_08<-E[(E$longitude==8.5) & (E$latitude==49.75), ]
location_09<-E[(E$longitude==8.75) & (E$latitude==49.75), ]
location_10<-E[(E$longitude==9) & (E$latitude==49.75), ]
location_11<-E[(E$longitude==8) & (E$latitude==49.5), ]
location_12<-E[(E$longitude==8.25) & (E$latitude==49.5), ]
location_13<-E[(E$longitude==8.5) & (E$latitude==49.5), ]
location_14<-E[(E$longitude==8.75) & (E$latitude==49.5), ]
location_15<-E[(E$longitude==9) & (E$latitude==49.5), ]
location_16<-E[(E$longitude==8) & (E$latitude==49.25), ]
location_17<-E[(E$longitude==8.25) & (E$latitude==49.25), ]
location_18<-E[(E$longitude==8.5) & (E$latitude==49.25), ]
location_19<-E[(E$longitude==8.75) & (E$latitude==49.25), ]
location_20<-E[(E$longitude==9) & (E$latitude==49.25), ]
location_21<-E[(E$longitude==8) & (E$latitude==49), ]
location_22<-E[(E$longitude==8.25) & (E$latitude==49), ]
location_23<-E[(E$longitude==8.5) & (E$latitude==49), ]
location_24<-E[(E$longitude==8.75) & (E$latitude==49), ]
location_25<-E[(E$longitude==9) & (E$latitude==49), ]
station_sums = c()
for (i in long_coords) { for (j in lat_coords) {
  station_sum0 = E[(E$longitude==i) & (E$latitude==j), 5]
  station_sum = c(i,j,summary(station_sum0))
  station_sums = rbind(station_sums, station_sum)}}
station_sums<- data.frame(station_sums)
onetwentyfive<-seq(from = 1, to = 25, length.out =25)
```

```
station_summaries<-cbind(onetwentyfive, station_sums)
colnames(station_summaries)<- c("station", "longitude", "latitude", "Min", "Q1",
"Med", "Mean", "Q3", "Max")
rownames(station_summaries)<-NULL
station_summaries
location_list <-
list(location_01,location_02,location_03,location_04,location_05,location_06,
                location_07,location_08,location_09,location_10,location_11,
location_12,
                location_13, location_14, location_15, location_16, location_17,
location_18,
                location_19, location_20, location_21, location_22, location_23,
location_24, location_25)
location_shapiro<- c()
for (i in location_list) {result = shapiro.test(i[,5])
result = c(i[1,1],result)
location_shapiro = rbind(location_shapiro, result)}
location_shapiroW<-location_shapiro[,1:3]
row.names(location_shapiroW)<- NULL
colnames(location_shapiroW)<- c("location", "SW-statistic", "p-value")
location_shapiroW
location_IQR<- c()
for (i in location_list) {result = IQR(i[,5])
result = c(i[1,1],result)
location_IQR = rbind(location_IQR, result)}
colnames(location_IQR)<-c("location","IQR")
row.names(location_IQR)<-NULL
location_IQR
location_stats<-cbind(location_shapiroW, location_IQR[,2])
colnames(location_stats)<- c("location", "SW-statistic", "p-value", "IQR")
location_stats
loc_cor00 = NULL
loc_cor0 = NULL
loc_cor = NULL
for (i in location_list) {for(j in location_list){
  loc_cor00 = c(cor(i[,5],j[,5]),i[1,1],j[1,1])
  loc_cor0 = rbind(loc_cor0,loc_cor00)}}
loc_cor000<-loc_cor0[order(loc_cor0[,3]),]
loc_cor<- matrix(data = loc_cor000[,1], nrow = 25, ncol = 25, byrow = TRUE)
colnames(loc_cor)<-c("1":"25")
location_stats<-cbind(location_stats, loc_cor)
head(location_stats)
head(E)
#install.packages("sf")
library(sf)
#install.packages("rjson")
library(rjson)
europe<-st_read("europe.geo.json")
EJSON<- st_as_sf(x = E, coords = c("longitude", "latitude"), crs = st_crs(europe))
#install.packages("tmap")
```

```
library(tmap)
tmap_mode('view')
base_map <-leaflet::providers$CartoDB.Positron
tm_basemap(base_map)+ tm_shape(EJSON) + tm_bubbles(col = "pink4", size =
0.01) +
  tm_shape(europe[europe$sov_a3=="DEU",]) + tm_borders()
kelvin<- c(E[,5])
kelvin -273.15 ->celcius
celcius
E.C<- cbind(E, celcius)
location_07.stats<- location_stats[7,]
location_07.stats
summary(location_07)
mock_07d<-rnonnorm(1440, mean = 288.5 , sd = 3.913184, skew = 0.55883625, kurt
= 0.72209601)
mock_07<-data.frame(mock_07d)
plot(location_07[,5])
plot(mock_07[,1])
cor(location_07[,5],mock_07[,1])
mock_n_07<-rnorm(location_07[,5])
plot(mock_n_07)
cor(location_07[,5], mock_n_07)
mock_iqr_07d<-rnonnorm(1440, mean = 288.5 , sd = 4.771247, skew = 0.55883625,
kurt = 0.72209601)
mock_iqr_07d<-data.frame(mock_iqr_07d)
plot(mock_iqr_07d[,1])
cor(location_07[,5], mock_iqr_07d[,1])
t2m_07<-location_07[,5]
mock_07dd<-rnonnorm(1440, mean = 288.5 , sd = 3.913184, skew = 0.55883625,
kurt = 0.72209601)$t2m_07
#install.packages("mnonr")
library(mnonr)
location_07m<-data.matrix(location_07[,5])
mardia_07<-mardia(location_07m, na.rm = TRUE)
mardia_07
#install.packages("fitdistrplus")
library(fitdistrplus)
t2m_07<-location_07[,5]
descdist(t2m_07)
descdist(t2m_07, boot= 1440)
#install.packages("MASS")
library(MASS)
fitdistr(t2m_07,"weibull")
fitdistr(t2m_07,"gamma")
fitdistr(t2m_07,"lognormal")
fitdistr(t2m_07,"normal")
hist(t2m_07)
set.seed(00)
sample1_07<-rnorm(1440, 288.5, 3.9)
head(sample1_07)
```

```
summary(sample1_07)
sd(sample1_07)
cor(t2m_07,sample1_07)
plot(sample1_07)
plot(t2m_07)
set.seed(01)
sample2_07<-rnorm(1440, 288.5, 3.5)
summary(sample2_07)
sd(sample2_07)
cor(t2m_07,sample2_07)
plot(sample2_07)
barplot(sample2_07)
barplot(t2m_07)
dens_07a = density(t2m_07, adjust=0.8)
set.seed(03)
sample2a_07 = sample(dens_07a$x, 1440, replace=TRUE, prob=dens_07a$y)
summary(sample2a_07)
sd(sample2a_07)
cor(sample2a_07, t2m_07)
par()
plot(sample2a_07)
plot_sept_loc=function(x){
  par(mfrow=c(5,5), mar = c(1, 1, 1, 1))
  plot_draw=lapply(x, function(x)  plot(x[,5], cex=0.2))}
plot_sept_loc(location_list)
#install.packages("devtools")
library(devtools)
#install_github("ProcessMiner/nlcor")
library(nlcor)
cor(t2m_07, sample1_07)
cor(t2m_07, sample2_07)
cor(t2m_07, sample2a_07)
nlcor(t2m_07, sample1_07, plt = T)
nlcor(t2m_07, sample2_07, plt = T)
nlcor(t2m_07, sample2a_07, plt = T)
set.seed(NULL)
dens_07.1 = density(t2m_07, adjust=1)
set.seed(1)
sample_07.1 = sample(dens_07.1$x, 1440, replace=TRUE, prob=dens_07.1$y)
nlcor(t2m_07, sample_07.1, plt = T)
summary(t2m_07)
individual_07t<- seq(278.3,302.7, by=0.1)
rounded_07.1<- round(t2m_07, digits = 1)
rounded_07.2<- round(t2m_07, digits = 2)
#install.packages("plyr")
library(plyr)
count(rounded_07.1)
freq_mat_07<- as.matrix(count(rounded_07.2))
nlcor(t2m_07, sample_07.1, refine = 0.95, plt = T)
set.seed(NULL)
```

```
set.seed(01)
noise_07.1<-jitter(t2m_07, factor=0.01)
nlcor(t2m_07, noise_07.1, refine = 0.95, plt = T)
noise_factor<-seq(0.01, 1, by= 0.01)
noise_07 = NULL
for (i in noise_factor) {
  a = jitter(t2m_07, factor=i)
  b = nlcor(t2m_07, a, refine = 0.95, plt = T)
  c = b$cor.estimate
  d = b$adjusted.p.value
  e = c(i,c,d)
  noise_07 = rbind(noise_07, e)}
tail(noise_07)
noise_factor2<-seq(3, 6, by= 0.01)
noise_07.2 = NULL
for (i in noise_factor2) {
  a = jitter(t2m_07, factor=i)
  b = nlcor(t2m_07, a, refine = 0.95, plt = T)
  c = b$cor.estimate
  d = b$adjusted.p.value
  e = c(i,c,d)
  noise_07.2 = rbind(noise_07.2, e)}
tail(noise_07.2)
noise_factor2<-seq(3, 6, by= 0.01)
noise_07.2 = NULL
for (i in noise_factor2) {
  a = jitter(t2m_07, amount = i)
  b = nlcor(t2m_07, a, refine = 0.95, plt = T)
  c = b$cor.estimate
  d = b$adjusted.p.value
  e = c(i,c,d)
  noise_07.2 = rbind(noise_07.2, e)}
tail(noise_07.2)
head(noise_07.2)
noise_factor<-seq(0.01, 3, by= 0.01)
noise_07 = NULL
set.seed(300)
for (i in noise_factor) {
  a = jitter(t2m_07, amount = i)
  b = nlcor(t2m_07, a, refine = 0.95, plt = T)
  c = b$cor.estimate
  d = b$adjusted.p.value
  e = c(i,c,d)
  noise_07 = rbind(noise_07, e)}
noise_07<- data.frame(noise_07)
colnames(noise_07)<- c("noise factor", "correlation", "p-value") #analyse then in tab?
rownames(noise_07)<-NULL
set.seed(NULL)
set.seed(42)
noise_07.42<-jitter(t2m_07, amount =0.42)
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```
noise_07.42_cor<-nlcor(t2m_07, noise_07.42, refine = 0.95, plt = T)
print(noise_07.42_cor$cor.estimate, digits = 9)
print(nlcor(location_08[,5], noise_07.42, refine = 0.95, plt = T), digits = 9)
par()
plot(noise_07.42)
plot(t2m_07)
noise_factor_small<-seq(0.01, 1.5, by= 0.01)
loc_noise_cor = NULL
for (j in location_list) { for(i in noise_factor_small){
  a = jitter(t2m_07, amount = i)
  b = nlcor(j[,5], a, refine = 0.95, plt = T)
  c = b$cor.estimate
  d = b$adjusted.p.value
  e = c(i,j[1,1],c,d)
  loc_noise_cor = rbind(loc_noise_cor, e)}}
head(loc_noise_cor) #19mins
loc_noise_cor<- loc_noise_cor[,1:3]
rownames(loc_noise_cor)<- NULL
noise_cor_list<-loc_noise_cor[,3]
loc_noise_cor0<- matrix(data = noise_cor_list,ncol = 25, byrow = F)
colnames(loc_noise_cor0)<-c("1":"25")
rownames(loc_noise_cor0)<-seq(0.01, 1.50, by = 0.01)
noise_cor_w_loc<- data.frame(loc_noise_cor0)
head(noise_cor_w_loc)
write.csv(noise_cor_w_loc, "noise_cor_w_loc.csv", row.names=T)
max_cor_w_07 = NULL
for (i in 1:150) {
  m = max(noise_cor_w_loc[i,])
  col_plus_max = c(i, m)
  max_cor_w_07 = rbind(max_cor_w_07, col_plus_max)}
colnames(max_cor_w_07)<-c("factor","max cor per f.")
rownames(max_cor_w_07)<-seq(0.01, 1.50, by = 0.01)
max_cor_w_07
noise_factor_med<-seq(1.51, 4, by= 0.01) #15.42 to 16.20
loc_noise_cor2 = NULL
for (j in location_list) { for(i in noise_factor_med){
  a = jitter(t2m_07, amount = i)
  b = nlcor(j[,5], a, refine = 0.95, plt = T)
  c = b$cor.estimate
  d = b$adjusted.p.value
  e = c(i,j[1,1],c,d)
  loc_noise_cor2 = rbind(loc_noise_cor2, e)}}
head(loc_noise_cor2)
loc_noise_cor2<- loc_noise_cor2[,1:3]
rownames(loc_noise_cor2)<- NULL
noise_cor_list2<-loc_noise_cor2[,3]
loc_noise_cor02<- matrix(data = noise_cor_list2,ncol = 25, byrow = F)
colnames(loc_noise_cor02)<-c("1":"25")
rownames(loc_noise_cor02)<-seq(1.51, 4, by = 0.01)
noise_cor_w_loc2<- data.frame(loc_noise_cor02)
```

```
head(noise_cor_w_loc2)
write.csv(noise_cor_w_loc2, "noise_cor_w_loc2.csv", row.names=T)
max_cor2_w_07 = NULL
for (i in 1:250) {
  m = max(noise_cor_w_loc2[i,])
  col_plus_max = c(i, m)
  max_cor2_w_07 = rbind(max_cor2_w_07, col_plus_max)}
colnames(max_cor2_w_07)<-c("factor","max cor per f.")
rownames(max_cor2_w_07)<-seq(1.51, 4, by = 0.01)
max_cor2_w_07
n2<-noise_cor_w_loc2
cor_point = NULL
for (i in noise_cor_list2){
  indice = which(n2==i,arr.ind=TRUE)
  cor_point = rbind(cor_point, indice)}
head(cor_point )
noise_cor_w_loc3<- rbind(noise_cor_w_loc,noise_cor_w_loc2) #now shows corrs for
stats 0.01 to 4.00
max_cor3_w_07<- rbind(max_cor_w_07, max_cor2_w_07)
head(max_cor3_w_07)
tail(max_cor3_w_07)
n3<-noise_cor_w_loc3
cor_point = NULL
for (i in max_cor3_w_07){
  indice = which(n3==i,arr.ind=TRUE)
  cor_point = rbind(cor_point, indice)}
head(cor_point)
tail(cor_point)
cor_point<-data.frame(cor_point)
write.csv(noise_cor_w_loc3, "noise_cor_w_loc3.csv", row.names=T)
############################Reproducible#################################
#######################
E <- read.csv("ERA5_F_2013_14.csv") #a) tell R to read this file in (it has to be in
# your working directory first)

#b) group the temperature information per station:
location_01<-E[(E$longitude==8) & (E$latitude==50), ]
location_02<-E[(E$longitude==8.25) & (E$latitude==50), ]
location_03<-E[(E$longitude==8.5) & (E$latitude==50), ]
location_04<-E[(E$longitude==8.75) & (E$latitude==50), ]
location_05<-E[(E$longitude==9) & (E$latitude==50), ]
location_06<-E[(E$longitude==8) & (E$latitude==49.75), ]
location_07<-E[(E$longitude==8.25) & (E$latitude==49.75), ]
location_08<-E[(E$longitude==8.5) & (E$latitude==49.75), ]
location_09<-E[(E$longitude==8.75) & (E$latitude==49.75), ]
location_10<-E[(E$longitude==9) & (E$latitude==49.75), ]
location_11<-E[(E$longitude==8) & (E$latitude==49.5), ]
location_12<-E[(E$longitude==8.25) & (E$latitude==49.5), ]
location_13<-E[(E$longitude==8.5) & (E$latitude==49.5), ]
location_14<-E[(E$longitude==8.75) & (E$latitude==49.5), ]
```

```
location_15<-E[(E$longitude==9) & (E$latitude==49.5), ]
location_16<-E[(E$longitude==8) & (E$latitude==49.25), ]
location_17<-E[(E$longitude==8.25) & (E$latitude==49.25), ]
location_18<-E[(E$longitude==8.5) & (E$latitude==49.25), ]
location_19<-E[(E$longitude==8.75) & (E$latitude==49.25), ]
location_20<-E[(E$longitude==9) & (E$latitude==49.25), ]
location_21<-E[(E$longitude==8) & (E$latitude==49), ]
location_22<-E[(E$longitude==8.25) & (E$latitude==49), ]
location_23<-E[(E$longitude==8.5) & (E$latitude==49), ]
location_24<-E[(E$longitude==8.75) & (E$latitude==49), ]
location_25<-E[(E$longitude==9) & (E$latitude==49), ]

#c) list each location to be accessible under one function:
location_list <- list(location_01,location_02,location_03,location_04,location_05,
                      location_06,location_07,location_08,location_09,location_10,
                      location_11, location_12,location_13, location_14, location_15,
                      location_16, location_17, location_18,location_19, location_20,
                      location_21, location_22, location_23, location_24, location_25)

t2m_0<-location_07[,5] #d) extract only the temperature information

# (do this for your chosen location only, i.e. location 7 is used in this example,
# but if you are working on e.g. location 25, change this to: t2m_0<-location_25[,5]
etc.)
# (don't forget to change any names in the code below if they were changed in this
section)

noise_factor <- seq(0.01, 4, by= 0.01) #e) create a vector of the range of noise added

################ 2: Correlate Generated Noise to all Location Co-ords
############

#f) print all the correlations per location whene correlated with the noise added
# to our chosen location:
loc_noise_cor1 = NULL
for (j in location_list) { for(i in noise_factor){
  a1 = jitter(t2m_0, amount = i)
  b1 = nlcor(j[,5], a1, refine = 0.95, plt = T)
  c1 = b1$cor.estimate
  d1 = b1$adjusted.p.value
  e1 = c(i,j[1,1],c1,d1) #11.48:12.39
  loc_noise_cor1 = rbind(loc_noise_cor1, e1)}}
head(loc_noise_cor1) # view the first six lines to make sure you have 4 columns:
# noise factor, location, correlation, p-value (p-value will be 0)

#g) give these columns names and remove p-value (as is 0)
loc_noise_cor1<- loc_noise_cor1[,1:3]
rownames(loc_noise_cor1)<- NULL
noise_cor_list1<-loc_noise_cor1[,3]
loc_noise_cor_01<- matrix(data = noise_cor_list1, ncol = 25, byrow = F)
```

```
colnames(loc_noise_cor_01)<-c("1":"25")
rownames(loc_noise_cor_01)<-seq(0.01, 4, by = 0.01)

#h) make this data into an extractable dataframe and save as a csv to your computer:
noise_cor_w_loc1<- data.frame(loc_noise_cor_01)
write.csv(noise_cor_w_loc1, "noise_cor_w_loc_7_2.csv", row.names=T)
head(noise_cor_w_loc1)

trial07_2<- read.csv("noise_cor_w_loc_7_2.csv")
trial07_2<- data.frame(trial07_2[,2:26])
max_cor_trial07_2 = NULL
for (i in 1:400) {
  m = max(trial07_2[i,])
  col_plus_max = c(i, m)
  max_cor_trial07_2 = rbind(max_cor_trial07_2, col_plus_max)}
colnames(max_cor_trial07_2)<-c("factor","max cor per f.") # name the rows and cols
rownames(max_cor_trial07_2)<-seq(0.01, 4, by = 0.01)
head(max_cor_trial07_2)
tail(max_cor_trial07_2)
max_cor_trial07_2<- max_cor_trial07_2[,2]
cor_point_t2 = NULL
#for i in the list of max value per row:
for (i in max_cor_trial07_2){
  indice = which(trial07_2==i, arr.ind=TRUE)
  cor_point_t2 = rbind(cor_point_t2, indice)}
head(cor_point_t2)
write.csv(cor_point_t2, "cor_point_7_1.csv", row.names=T)

setwd("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA
5_Analysis/trials/7")
y<-read.csv("cor_point_7_1.csv")
x<- read.csv("noise_cor_w_loc_7_1.csv")
x<- data.frame(x[,2:26])
max_cors = NULL
for (i in 1:400) {
  m = max(x[i,])
  col_plus_max = c(i, m)
  max_cors = rbind(max_cors, col_plus_max)}
colnames(max_cors)<-c("factor","corr")
rownames(max_cors)<-seq(0.01, 4, by = 0.01)
max_cors<-data.frame(max_cors)
cor_w_max<-cbind(y,max_cors$corr)
colnames(cor_w_max)<-c("noise","row","location","max_corr_per_row")
E2<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_E
RA5_Analysis/ERA5_F_2013_14.csv")
Elong<-E2[c(1:25),2]
Elat<-E2[c(1:25),3]
long<- NULL
for (i in cor_w_max$location) {
```

```
  z <- Elong[i]
  long<- rbind(long,z)}
cor_w_max$long<-long
lat<- NULL
for (i in cor_w_max$location) {
  z <- Elat[i]
  lat<- rbind(lat,z)}
cor_w_max$lat<-lat
head(cor_w_max)
write.csv(cor_w_max, "cor_w_max_7_2.csv", row.names=T)

max_1<-read.csv("cor_w_max_7_2.csv")
freq_0= NULL
for (i in c(1:400)) {
  x = max_1[i,4]
  y = nrow(max_1[max_1$location== x,])
  z = c(x,y)
  freq_0<- rbind(freq_0, z)}
freq_0<-data.frame(freq_0)
max_1$freq<- freq_0[,2]
head(max_1)
write.csv(max_7,
"/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Anal
ysis/trials/7/cor_w_max_7_2.csv", row.names=T)

setwd("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA
5_Analysis")
CORR<- read.csv("CORR.csv")
c_7<-CORR[CORR$Location==7,]
c_8<-CORR[CORR$Location==8,]
c_9<-CORR[CORR$Location==9,]
c_12<-CORR[CORR$Location==12,]
c_13<-CORR[CORR$Location==13,]
c_14<-CORR[CORR$Location==14,]
c_17<-CORR[CORR$Location==17,]
c_18<-CORR[CORR$Location==18,]
c_19<-CORR[CORR$Location==19,]
summary(CORR$Correlation)
sd(CORR$Correlation)
summary(CORR$Noise)
sd(CORR$Noise)
summary(c_7$Correlation) #0.9677  0.9678  0.9693  0.9694  0.9699  0.9724
sd(c_7$Correlation) #0.001927486
summary(c_8$Correlation) #0.9611  0.9676  0.9720  0.9696  0.9726  0.9745
sd(c_8$Correlation) #0.005359999
summary(c_9$Correlation) #0.9554  0.9569  0.9587  0.9595  0.9623  0.9642
sd(c_9$Correlation) #0.003667868
summary(c_12$Correlation) #0.9600  0.9604  0.9655  0.9646  0.9656  0.9715
sd(c_12$Correlation) #0.004715054
summary(c_13$Correlation) #0.9528  0.9552  0.9567  0.9590  0.9616  0.9686
```

```
sd(c_13$Correlation) #0.006251089
summary(c_14$Correlation) #0.9376  0.9442  0.9505  0.9489  0.9521  0.9603
sd(c_14$Correlation) #0.008546863
summary(c_17$Correlation) #0.9524  0.9541  0.9586  0.9594  0.9607  0.9710
sd(c_17$Correlation) #0.007308597
summary(c_18$Correlation) #0.9483  0.9530  0.9599  0.9595  0.9672  0.9691
sd(c_18$Correlation) #0.00893114
summary(c_19$Correlation) #0.9573  0.9655  0.9660  0.9655  0.9686  0.9700
sd(c_19$Correlation) #0.00492992
m_iCorr<-c(mean(c_7$Correlation), mean(c_8$Correlation), mean(c_9$Correlation),
          mean(c_12$Correlation), mean(c_13$Correlation), mean(c_14$Correlation),
          mean(c_17$Correlation), mean(c_18$Correlation), mean(c_19$Correlation))
mean(m_iCorr)
sd(m_iCorr)
sd_iCorr<-c(sd(c_7$Correlation), sd(c_8$Correlation), sd(c_9$Correlation),
sd(c_12$Correlation),
           sd(c_13$Correlation), sd(c_14$Correlation), sd(c_17$Correlation),
sd(c_18$Correlation),
           sd(c_19$Correlation))
mean(sd_iCorr)
sd(sd_iCorr)
summary(c_7$Noise) #  1.62    1.71    1.71    1.71    1.75    1.76
sd(c_7$Noise) #0.05522681
summary(c_8$Noise) #  1.530   1.590   1.620   1.678   1.710   1.940
sd(c_8$Noise) #0.1602186
summary(c_9$Noise) #  1.870   1.930   2.050   2.002   2.070   2.090
sd(c_9$Noise) #0.09654015
summary(c_12$Noise) # 1.640   1.810   1.840   1.846   1.960   1.980
sd(c_12$Noise) #0.1366748
summary(c_13$Noise) #   1.73    1.92    2.09    2.00    2.09    2.17
sd(c_13$Noise) #0.1763519
summary(c_14$Noise) #  2.020   2.180   2.210   2.278   2.410   2.570
sd(c_14$Noise) #0.2141728
summary(c_17$Noise) #  1.680   2.000   2.050   2.024   2.170   2.220
sd(c_17$Noise) #0.211731
summary(c_18$Noise) #  1.760   1.820   2.010   2.028   2.220   2.330
sd(c_18$Noise) #0.2467185
summary(c_19$Noise) #  1.760   1.790   1.850   1.892   1.930   2.130
sd(c_19$Noise) #0.148054
m_iNoise<-c(mean(c_7$Noise), mean(c_8$Noise), mean(c_9$Noise),
mean(c_12$Noise), mean(c_13$Noise),
           mean(c_14$Noise), mean(c_17$Noise), mean(c_18$Noise),
mean(c_19$Noise))
mean(m_iNoise)
sd(m_iNoise)
sd_iNoise<-c(sd(c_7$Noise), sd(c_8$Noise), sd(c_9$Noise), sd(c_12$Noise),
sd(c_13$Noise),
            sd(c_14$Noise), sd(c_17$Noise), sd(c_18$Noise), sd(c_19$Noise))
mean(sd_iNoise)
sd(sd_iNoise)
```

```
set.seed(1)
sample_Corr<- rnorm(1000, 0.96170, 0.008261583)
set.seed(2)
sample_Noise<- rnorm(1000, 1.94, 0.2331161)
t.test(sample_Corr, CORR$Correlation)
t.test(m_iCorr, CORR$Correlation)
t.test(sample_Noise, CORR$Noise)
t.test(m_iNoise, CORR$Noise)
hist(CORR$Correlation)
hist(CORR$Noise)
hist(sample_Noise)
sd(CORR$Correlation)/sqrt(length(CORR$Correlation))
sd(CORR$Noise)/sqrt(length(CORR$Noise))
qt(p=0.05/2, df=(length(CORR$Correlation)-1),lower.tail=F)
ME_Corr<-2.015368*0.001231564
ME_Noise<-2.015368*0.0347509
CI_Corr<- c(mean(CORR$Correlation)-ME_Corr, mean(CORR$Correlation) +
ME_Corr)
CI_Noise<- c(mean(CORR$Correlation)-ME_Noise, mean(CORR$Correlation) +
ME_Noise)
shapiro.test(CORR$Correlation)
shapiro.test(CORR$Noise)
hist(CORR$Noise, xlim = c(1,3), ylim = c(0,15),
    main= "Noise Degree of Alternate Location Correlation",
    xlab= "Degree of Noise")
abline(v=mean(CORR$Noise),col='red', lwd=2)
text(x=1.97, y=7,'mean', col='red', srt=90)
abline(v=mean(CORR$Noise)-(2*sd(CORR$Noise)), col='lightblue4', lwd=2)
text(x=1.44, y=7,'-2*SD', col='darkgrey', srt=90)
abline(v=mean(CORR$Noise)+(2*sd(CORR$Noise)), col='lightblue4', lwd=2)
text(x=2.44, y=7,'+2*SD', col='darkgrey', srt=90)
text(x=1.94, y=15,'<----95% Confidence Interval---->', col='black')
abline(v=1.53, col='darkblue', lwd=2)
text(x=1.27, y=4,'threshold value--->', col='black')
hist(sample_Noise, xlim = c(1,3),
    main= "Sample Noise Degree of Alternate Location Correlation",
    xlab= "Degree of Noise")
abline(v=mean(sample_Noise),col='red', lwd=2)
text(x=1.98, y=75,'mean', col='red', srt=90)
abline(v=mean(sample_Noise)-(2*sd(sample_Noise)), col='lightblue4', lwd=2)
text(x=1.45, y=75,'-2*SD', col='darkgrey', srt=90)
abline(v=mean(sample_Noise)+(2*sd(sample_Noise)), col='lightblue4', lwd=2)
text(x=2.46, y=75,'+2*SD', col='darkgrey', srt=90)
text(x=1.95, y=125,'<----95% Confidence Interval---->', col='black')
abline(v=1.53, col='darkblue', lwd=2)
text(x=1.27, y=50,'threshold value--->', col='black')
setwd("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA
5_Analysis")
noise_1.53<- read.csv("1_53corrs.csv")
summary(noise_1.53$max_corr_per_row)
```

```
sd(noise_1.53$max_corr_per_row)
hist(noise_1.53$max_corr_per_row)
wo_outliers_153<- noise_1.53[c(1:85,87:125),6]
hist(wo_outliers_153, breaks = 124, ylim = c(0,6),
     main = "Correlations at 1.53 degrees of Noise", xlab = "correlation")
abline(v=mean(wo_outliers_153),col='red', lwd=2)
text(x=0.976325, y=4.5,'mean', col='red', srt=90)
abline(v=0.9744667, col='darkblue', lwd=2)
text(x=0.9751, y=4.5,'<----threshold value', col='black')
abline(v=mean(wo_outliers_153)-(2*sd(wo_outliers_153)), col='lightblue4', lwd=2)
text(x=0.97455, y=3.5,'-2*SD', col='darkgrey', srt=90)
abline(v=mean(wo_outliers_153)+(2*sd(wo_outliers_153)), col='lightblue4', lwd=2)
text(x=0.9782, y=3.5,'+2*SD', col='darkgrey', srt=90)
text(x=mean(wo_outliers_153), y=6,'<---------95% Confidence Interval--------->',
     col='black')
mean(sample_Noise)-(2*sd(sample_Noise)) #1.481252 vs##1.53
mean(sample_Noise)+(2*sd(sample_Noise)) #2.427654
mean(wo_outliers_153)-(2*sd(wo_outliers_153)) #0.9744052 vs##0.9744667
mean(wo_outliers_153)+(2*sd(wo_outliers_153)) #0.9781093
setwd("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA
5_Analysis")
library(sf)
#install.packages("rjson")
library(rjson)
#install.packages("tmap")
library(tmap)
#install.packages("geojson")
library(geojson)
E<-read.csv("ERA5_F_2013_14.csv")
europe<-st_read("europe.geo.json")
germany<-europe[europe$sovereignt== "Germany",]
EJSON<- st_as_sf(x = E, coords = c("longitude", "latitude"), crs = st_crs(europe))
tmap_mode('view')
base_map <-leaflet::providers$CartoDB.Positron
tm_basemap(base_map)+ tm_shape(EJSON) + tm_bubbles(col = "pink4", size =
0.01) +
  tm_shape(europe[europe$sov_a3=="DEU",]) + tm_borders()
tmap_mode('plot')
tm_shape(germany) + tm_borders() + tm_shape(EJSON) + tm_bubbles(col = "pink4",
size = 0.01)
st_bbox(EJSON) #find bounding box coordinates: (x-min: 8, y-min: 49, x-max: 9, y-
max: 50)
bbox_new<- st_bbox(EJSON)
bbox_new[1] <- bbox_new[1] - 0.25
bbox_new[2] <- bbox_new[2] - 0.25
bbox_new[3] <- bbox_new[3] + 0.25
bbox_new[4] <- bbox_new[4] + 0.25
tmap_mode('plot')
tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "pink4", size = 0.1) +
  tm_shape(germany) + tm_borders()
```

```
long_coords<-c(8, 8.25, 8.5, 8.75, 9)
lat_coords<-c(49, 49.25, 49.5, 49.75, 50)
station_coords = NULL
for (i in long_coords) { for (j in lat_coords) {
  station = E[(E$longitude==i) & (E$latitude==j), 1:3]
  station_row = c(station[,1])
  station_lat = c(station[,2])
  station_lon = c(station[,3])
  station_coords0 = data.frame(station_row, station_lat, station_lon)
  station_coords = rbind(station_coords, station_coords0)}}
colnames(station_coords)<-c("row","latitude","longitude")
head(station_coords)
station_coords<-data.frame(station_coords)
S<- station_coords
row_num0 = c()
for (i in long_coords) { for(j in lat_coords){
  row_sample = S[(S[,2]==i) & (S[,3]==j), 1]
  row_sample0 = data.frame(rep("row",6),row_sample)
  row_num0 = cbind(row_num0, row_sample0[,2])}}
head(row_num0)
row_num<-
row_num0[,c(5,10,15,20,25,4,9,14,19,24,3,8,13,18,23,2,7,12,17,22,1,6,11,16,21)]
head(row_num)
EJSON$loc<- EJSON$X
for (i in c(1:25)) {for (j in row_num[,i]) {
  EJSON$loc[EJSON$loc == j] <- i}}
tmap_mode('view')
base_map <-leaflet::providers$CartoDB.Positron
tm_basemap(base_map)+ tm_shape(EJSON[c(1:25),], bbox = bbox_new) +
  tm_bubbles(col = "white", size = 0.75) +
  tm_text("loc", size = 1, col = "black", shadow = TRUE) +
  tm_shape(germany) + tm_borders()
tmap_mode('plot')
tm_shape(EJSON[c(1:25),], bbox = bbox_new) +
  tm_text("loc", size = 1, col = "black", shadow = TRUE) +
  tm_shape(germany) + tm_borders()
max_1<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_E
RA5_Analysis/trials/1/cor_w_max_1_2.csv")
head(max_1)
max_2<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_E
RA5_Analysis/trials/2/cor_w_max_2_5.csv")
head(max_2)
max_3<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_E
RA5_Analysis/trials/3/cor_w_max_3_1.csv")
head(max_3)
```

```
max_4<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/4/cor_w_max_4_2.csv")
head(max_4)
max_5<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/5/cor_w_max_5_3.csv")
head(max_5)
max_6<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/6/cor_w_max_6_4.csv")
head(max_6)
max_7<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/7/cor_w_max_07_5.csv")
head(max_7)
max_8<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/8/cor_w_max_8_4.csv")
head(max_8)
max_9<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/9/cor_w_max_9_2.csv")
head(max_9)
max_10<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/10/cor_w_max_10_3.csv")
head(max_10)
max_11<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/11/cor_w_max_11_5.csv")
head(max_11)
max_12<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/12/cor_w_max_12_3.csv")
head(max_12)
max_13<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/13/cor_w_max_13_5.csv")
head(max_13)
max_14<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/14/cor_w_max_14_3.csv")
head(max_14)
max_15<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/15/cor_w_max_15_1.csv")
head(max_15)
```

```
max_16<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/16/cor_w_max_16_3.csv")
head(max_16)
max_17<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/17/cor_w_max_17_4.csv")
head(max_17)
max_18<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/18/cor_w_max_18_4.csv")
head(max_18)
max_19<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/19/cor_w_max_19_4.csv")
head(max_19)
max_20<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/20/cor_w_max_20_2.csv")
head(max_20)
max_21<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/21/cor_w_max_21_1.csv")
head(max_21)
max_22<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/22/cor_w_max_22_4.csv")
head(max_22)
max_23<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/23/cor_w_max_23_2.csv")
head(max_23)
max_24<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/24/cor_w_max_24_3.csv")
head(max_24)
max_25<-
read.csv("/Users/elizabeth/Documents/GY652_Applied_Climate_Sciences/Group_ERA5_Analysis/trials/25/cor_w_max_25_3.csv")
head(max_25)
l_1<- st_as_sf(x = max_1, coords = c("long", "lat"), crs = st_crs(europe))
l_2<- st_as_sf(x = max_2, coords = c("long", "lat"), crs = st_crs(europe))
l_3<- st_as_sf(x = max_3, coords = c("long", "lat"), crs = st_crs(europe))
l_4<- st_as_sf(x = max_4, coords = c("long", "lat"), crs = st_crs(europe))
l_5<- st_as_sf(x = max_5, coords = c("long", "lat"), crs = st_crs(europe))
l_6<- st_as_sf(x = max_6, coords = c("long", "lat"), crs = st_crs(europe))
l_7<- st_as_sf(x = max_7, coords = c("long", "lat"), crs = st_crs(europe))
l_8<- st_as_sf(x = max_8, coords = c("long", "lat"), crs = st_crs(europe))
l_9<- st_as_sf(x = max_9, coords = c("long", "lat"), crs = st_crs(europe))
l_10<- st_as_sf(x = max_10, coords = c("long", "lat"), crs = st_crs(europe))
```

```
l_11<- st_as_sf(x = max_11, coords = c("long", "lat"), crs = st_crs(europe))
l_12<- st_as_sf(x = max_12, coords = c("long", "lat"), crs = st_crs(europe))
l_13<- st_as_sf(x = max_13, coords = c("long", "lat"), crs = st_crs(europe))
l_14<- st_as_sf(x = max_14, coords = c("long", "lat"), crs = st_crs(europe))
l_15<- st_as_sf(x = max_15, coords = c("long", "lat"), crs = st_crs(europe))
l_16<- st_as_sf(x = max_16, coords = c("long", "lat"), crs = st_crs(europe))
l_17<- st_as_sf(x = max_17, coords = c("long", "lat"), crs = st_crs(europe))
l_18<- st_as_sf(x = max_18, coords = c("long", "lat"), crs = st_crs(europe))
l_19<- st_as_sf(x = max_19, coords = c("long", "lat"), crs = st_crs(europe))
l_20<- st_as_sf(x = max_20, coords = c("long", "lat"), crs = st_crs(europe))
l_21<- st_as_sf(x = max_21, coords = c("long", "lat"), crs = st_crs(europe))
l_22<- st_as_sf(x = max_22, coords = c("long", "lat"), crs = st_crs(europe))
l_23<- st_as_sf(x = max_23, coords = c("long", "lat"), crs = st_crs(europe))
l_24<- st_as_sf(x = max_24, coords = c("long", "lat"), crs = st_crs(europe))
l_25<- st_as_sf(x = max_25, coords = c("long", "lat"), crs = st_crs(europe))
tmap_mode('plot')
p1<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1) +
  tm_shape(l_1, bbox = bbox_new) + tm_bubbles(col = "freq",
                                              size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 1", main.title.position = "center")
p2<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1) +
  tm_shape(l_2, bbox = bbox_new) + tm_bubbles(col = "freq",
                                              size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 2", main.title.position = "center")
p3<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1) +
  tm_shape(l_3, bbox = bbox_new) + tm_bubbles(col = "freq",
                                              size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 3", main.title.position = "center")
p4<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1) +
  tm_shape(l_4, bbox = bbox_new) + tm_bubbles(col = "freq",
                                              size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 4", main.title.position = "center")
p5<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1) +
  tm_shape(l_5, bbox = bbox_new) + tm_bubbles(col = "freq",
                                              size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 5", main.title.position = "center")
p6<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1) +
  tm_shape(l_6, bbox = bbox_new) + tm_bubbles(col = "freq",
                                              size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 6", main.title.position = "center")
p7<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1) +
  tm_shape(l_7, bbox = bbox_new) + tm_bubbles(col = "freq",
                                              size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
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  tm_layout(legend.show = F, main.title = "Location 7", main.title.position = "center")
p8<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1) +
  tm_shape(l_8, bbox = bbox_new) + tm_bubbles(col = "freq",
                                      size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 8", main.title.position = "center")
p9<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1) +
  tm_shape(l_9, bbox = bbox_new) + tm_bubbles(col = "freq",
                                      size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 9", main.title.position = "center")
p10<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_10, bbox = bbox_new) + tm_bubbles(col = "freq",
                                       size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 10", main.title.position = "center")
p11<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_11, bbox = bbox_new) + tm_bubbles(col = "freq",
                                       size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 11", main.title.position = "center")
p12<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_12, bbox = bbox_new) + tm_bubbles(col = "freq",
                                       size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 12", main.title.position = "center")
p13<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_13, bbox = bbox_new) + tm_bubbles(col = "freq",
                                       size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 13", main.title.position = "center")
p14<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_14, bbox = bbox_new) + tm_bubbles(col = "freq",
                                       size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 14", main.title.position = "center")
p15<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_15, bbox = bbox_new) + tm_bubbles(col = "freq",
                                       size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 15", main.title.position = "center")
p16<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_16, bbox = bbox_new) + tm_bubbles(col = "freq",
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                                    size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 16", main.title.position = "center")
p17<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_17, bbox = bbox_new) + tm_bubbles(col = "freq",
                                    size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 17", main.title.position = "center")
p18<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_18, bbox = bbox_new) + tm_bubbles(col = "freq",
                                    size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 18", main.title.position = "center")
p19<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_19, bbox = bbox_new) + tm_bubbles(col = "freq",
                                    size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 19", main.title.position = "center")
p20<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_20, bbox = bbox_new) + tm_bubbles(col = "freq",
                                    size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 20", main.title.position = "center")
p21<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_21, bbox = bbox_new) + tm_bubbles(col = "freq",
                                    size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 21", main.title.position = "center")
p22<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_22, bbox = bbox_new) + tm_bubbles(col = "freq",
                                    size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 22", main.title.position = "center")
p23<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_23, bbox = bbox_new) + tm_bubbles(col = "freq",
                                    size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 23", main.title.position = "center")
p24<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_24, bbox = bbox_new) + tm_bubbles(col = "freq",
                                    size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
```

```
  tm_layout(legend.show = F, main.title = "Location 24", main.title.position = "center")
p25<- tm_shape(EJSON, bbox = bbox_new) + tm_bubbles(col = "white", size = 0.1)
+
  tm_shape(l_25, bbox = bbox_new) + tm_bubbles(col = "freq",
                                       size = 1.25, style = "cont", palette = "Reds") +
tm_shape(germany) + tm_borders() +
  tm_layout(legend.show = F, main.title = "Location 25", main.title.position = "center")
tmap_mode('plot')
tmap_arrange(p1,p2,p3,p4,p5, nrow=1)
tmap_arrange(p6,p7,p8,p9,p10, nrow=1)
tmap_arrange(p11,p12,p13,p14,p15, nrow=1)
tmap_arrange(p16,p17,p18,p19,p20, nrow=1)
tmap_arrange(p21,p22,p23,p24,p25, nrow=1)
plot_sept_loc=function(x){
  par(mfrow=c(5,5), mar = c(2, 1, 1.5, 1))
  plot_draw=lapply(x, function(x)  plot(x[,5], cex=0.2, main= x[1,1], yaxt="n",
xaxt="n"))}
plot_sept_loc(location_list)
```