EU-Circle Case study 5

Rasmus Benestad

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Rapid Winter Flooding (melting ice, narrow mountain streams, flooding) around Dresden, Germany

Dresden is the largest city in the Eastern part of Germany, Saxony, near the Czech border. It is crossed by the large river Elbe (its width is around 110m in Dresden) which comes from the Czech Republic and flows through Magdeburg and Hamburg into the North Sea. The region between Dresden and the Czech border, but also in the near surroundings in the Eastern and South-Western directions, is quite hilly with mountains up to ca. 1200 m. In the recent past (especially notable are the big floodings in 2002 and 2013) there has been quite some floodings caused by intense and long rain which led to floods of the Elbe.However, there is another threat which is happening more often and hence causing more damage because of the currently ongoing climate changes. In the mountains are lots of small mountain streams which are really small on a normal day (a typical one has a width of 1.5m and a depth of 0.5m). But in cases of heavy rains these small streams rapidly grow quite large (1-2h is not uncommon), especially compared to their normal size (sometimes they grow to their hundredfold size in respect of the amount of water they carry). This causes a lot of damage, especially as prediction and short-term prevention mechanisms are not really possible because of the small timescale. The damages caused by such events are quite local and often not related to the flooding of big rivers. In these regions there are often roads going through valley which are vital in a sense that if they are not available any more, quite long bypasses have to be taken. Additionally railways, especially railway bridges, are often effected as well. These two aspects show the impacts on the transport network.

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see http://rmarkdown.rstudio.com.

Analysis: precipitation

Data from ECA&D: precipitation. Snow depth?

```
library(esd)
```

```
## Loading required package: ncdf4
```

```
## Loading required package: zoo
```

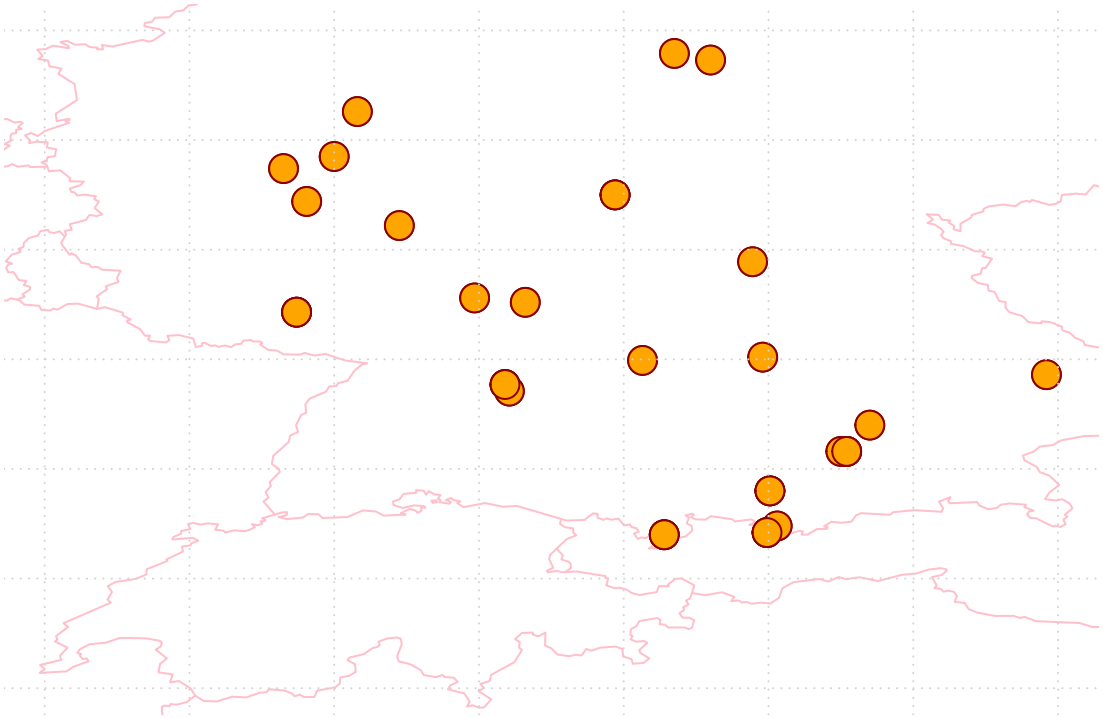
```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
##
## Attaching package: 'esd'
```

```
## The following object is masked from 'package:base':
##
##     subset.matrix
```

```
ss <- select.station(param='precip',cntr='Germany',alt=250,nmin=75)
map(ss,new=FALSE)
```

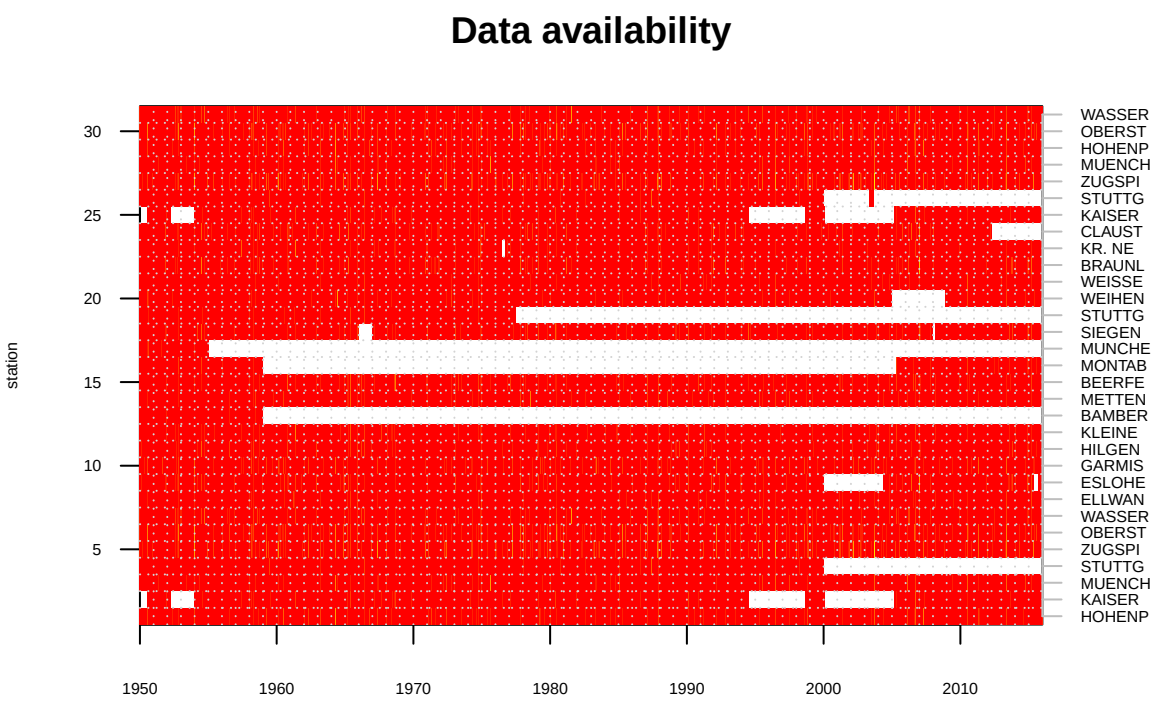


```
Y <- station(ss)
```

```
## [1] "Retrieving data from 31 records ..."
## [1] "1 PRECIP 100169 HOHENPEISSENBERG GERMANY ECAD"
## [1] "2 PRECIP 100179 KAISERSLAUTERN GERMANY ECAD"
## [1] "3 PRECIP 100189 MUENCHEN GERMANY ECAD"
## [1] "4 PRECIP 100209 STUTTGART GERMANY ECAD"
## [1] "5 PRECIP 100219 ZUGSPITZE GERMANY ECAD"
## [1] "6 PRECIP 121114 OBERSTDORF GERMANY ECAD"
## [1] "7 PRECIP 121174 WASSERKUPPE GERMANY ECAD"
## [1] "8 PRECIP 121654 ELLWANGEN-RINDELBACH GERMANY ECAD"
## [1] "9 PRECIP 121966 ESLOHE GERMANY ECAD"
## [1] "10 PRECIP 122662 GARMISCH-PARTENKIRCHEN GERMANY ECAD"
## [1] "11 PRECIP 123778 HILGENROTH GERMANY ECAD"
## [1] "12 PRECIP 124546 KLEINER FELDBERG/TAUNUS GERMANY ECAD"
## [1] "13 PRECIP 125014 BAMBERG (STERNWARTE) GERMANY ECAD"
## [1] "14 PRECIP 126010 METTEN GERMANY ECAD"
## [1] "15 PRECIP 126118 BEERFELDEN GERMANY ECAD"
## [1] "16 PRECIP 126178 MONTABAUR GERMANY ECAD"
## [1] "17 PRECIP 126274 MUNCHEN-BOTANISCHER GARTEN GERMANY ECAD"
## [1] "18 PRECIP 128794 SIEGEN (KLARANLAGE) GERMANY ECAD"
## [1] "19 PRECIP 129142 STUTTGART-HOHENHEIM GERMANY ECAD"
## [1] "20 PRECIP 129982 WEIHENSTEPHAN-DURNAST GERMANY ECAD"
## [1] "21 PRECIP 130090 WEISSENBURG GERMANY ECAD"
## [1] "22 PRECIP 131638 BRAUNLAGE GERMANY ECAD"
## [1] "23 PRECIP 132334 KR. NECKAR-ODENWALD BUCHEN GERMANY ECAD"
## [1] "24 PRECIP 132562 CLAUSTHAL-ZELLERFELD GERMANY ECAD"
## [1] "25 PRECIP GM000002288 KAISERSLAUTERN GERMANY GHCND"
## [1] "26 PRECIP GM000002716 STUTTGART  GERMANY GHCND"
## [1] "27 PRECIP GM000004155 ZUGSPITZE  GERMANY GHCND"
## [1] "28 PRECIP GM000004199 MUENCHEN GERMANY GHCND"
```

```
## [1] "29 PRECIP GM000010962 HOHENPEISSENBERG GERMANY GHCND"
## [1] "30 PRECIP GME00121114 OBERSTDORF GERMANY GHCND"
## [1] "31 PRECIP GME00121174 WASSERKUPPE  GERMANY GHCND"
```

```
Y <- subset(Y,it=c(1950,2015))
diagnose(Y)
```



GHCND

```
nv <- apply(coredata(Y),2,'nv')
Y <- subset(Y,is=nv > 24000)
```

```
y <- subset(Y,is=1)
coredata(y) <- rowMeans(coredata(Y))
attr(y,'location') <- 'German higher elevation'
attr(y,'longitude') <- mean(lon(Y))
attr(y,'latitude') <- mean(lat(Y))
attr(y,'altitude') <- min(alt(Y))
plot(y)
```

```
## Loading required package: RgoogleMaps
```

```
## Warning in plotmap(lat(x), lon(x), bgmap, pch = 19, col = col, cex = 2):
## NAs introduced by coercion
```

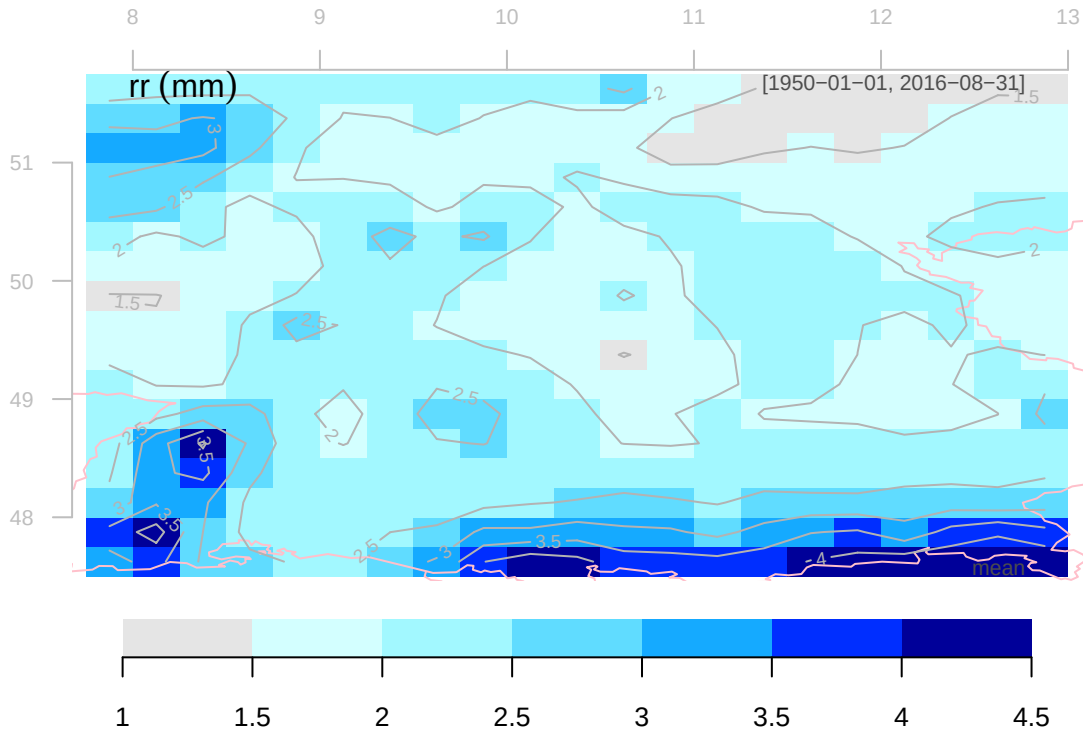
```
lines(trend(y),lty=2)
grid()
```

Area total precipitation from gridded EOBS.

```
rr <- retrieve('data.ECAD/rr_0.25deg_reg.nc',lon=range(lon(Y)),lat=range(lat(Y)))
```

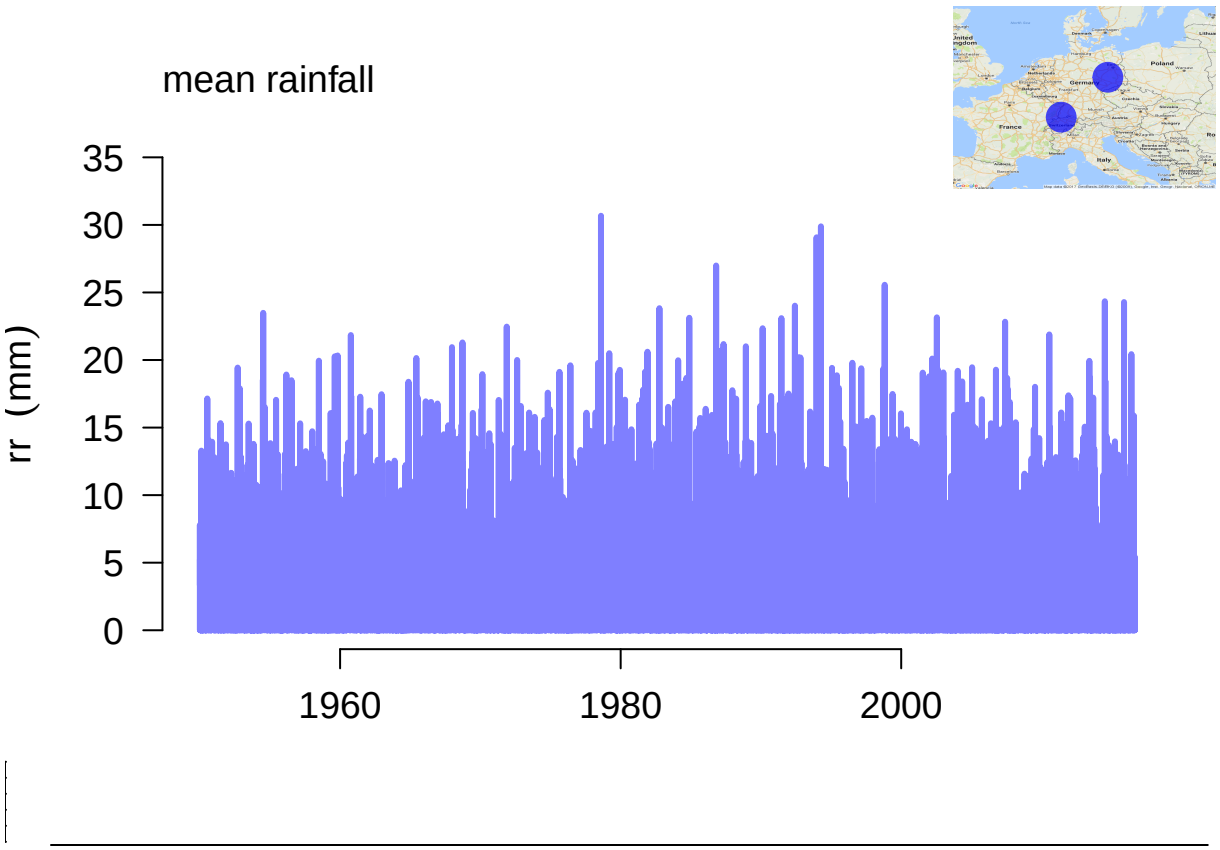
```
## [1] "Warning : Calendar attribute has not been found in the meta data and will be set automatically.
```

```
map(rr,new=FALSE)
```




```
Arr <- aggregate.area(rr)
plot(rr,new=FALSE)
```

```
## Warning in plotmap(lat(x), lon(x), bgmap, pch = 19, col = col, cex = 2):
## NAs introduced by coercion
```

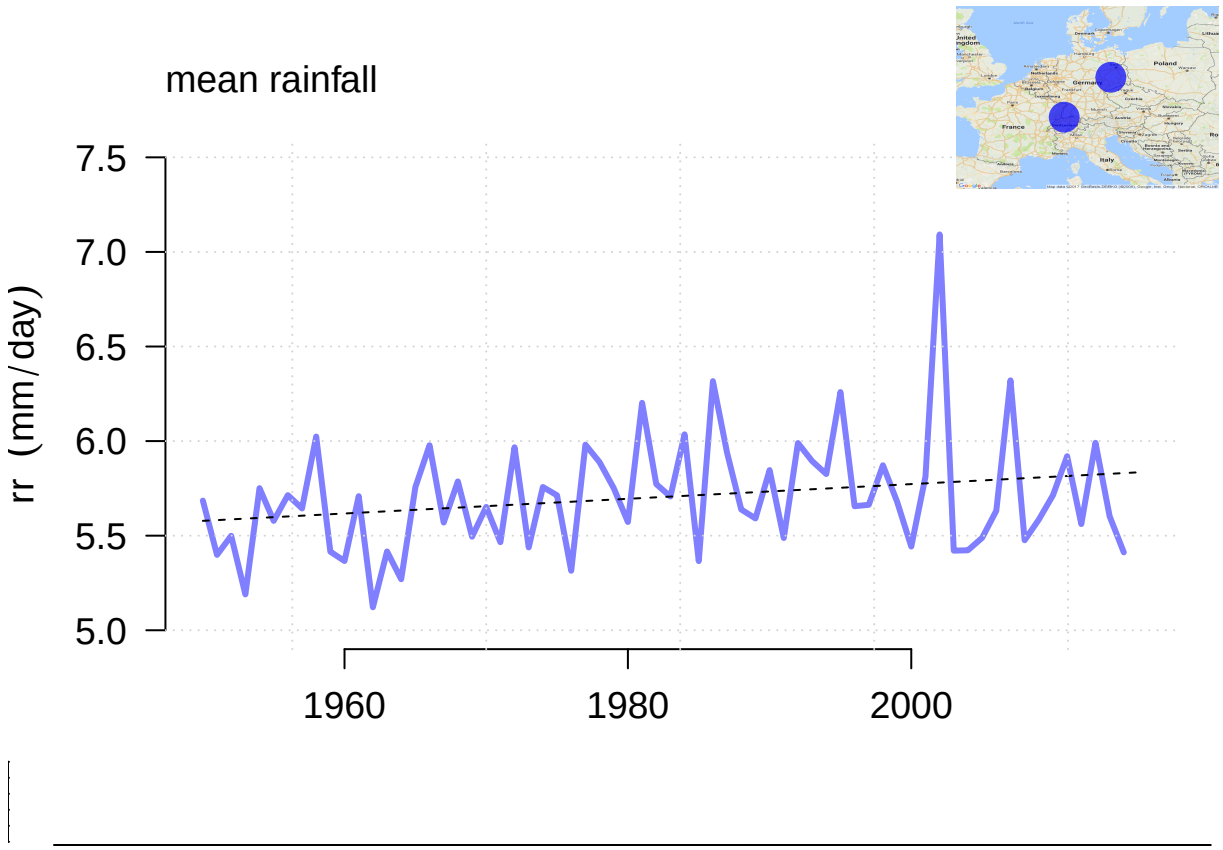


Wet day mean and frequency

```
mu <- annual(rr,FUN='wetmean')
fw <- annual(rr,FUN='wetfreq')
MU <- aggregate.area(mu,FUN='mean')
FW <- aggregate.area(fw,FUN='mean')
plot(MU,new=FALSE)
```

```
## Warning in plotmap(lat(x), lon(x), bgmap, pch = 19, col = col, cex = 2):
## NAs introduced by coercion
```

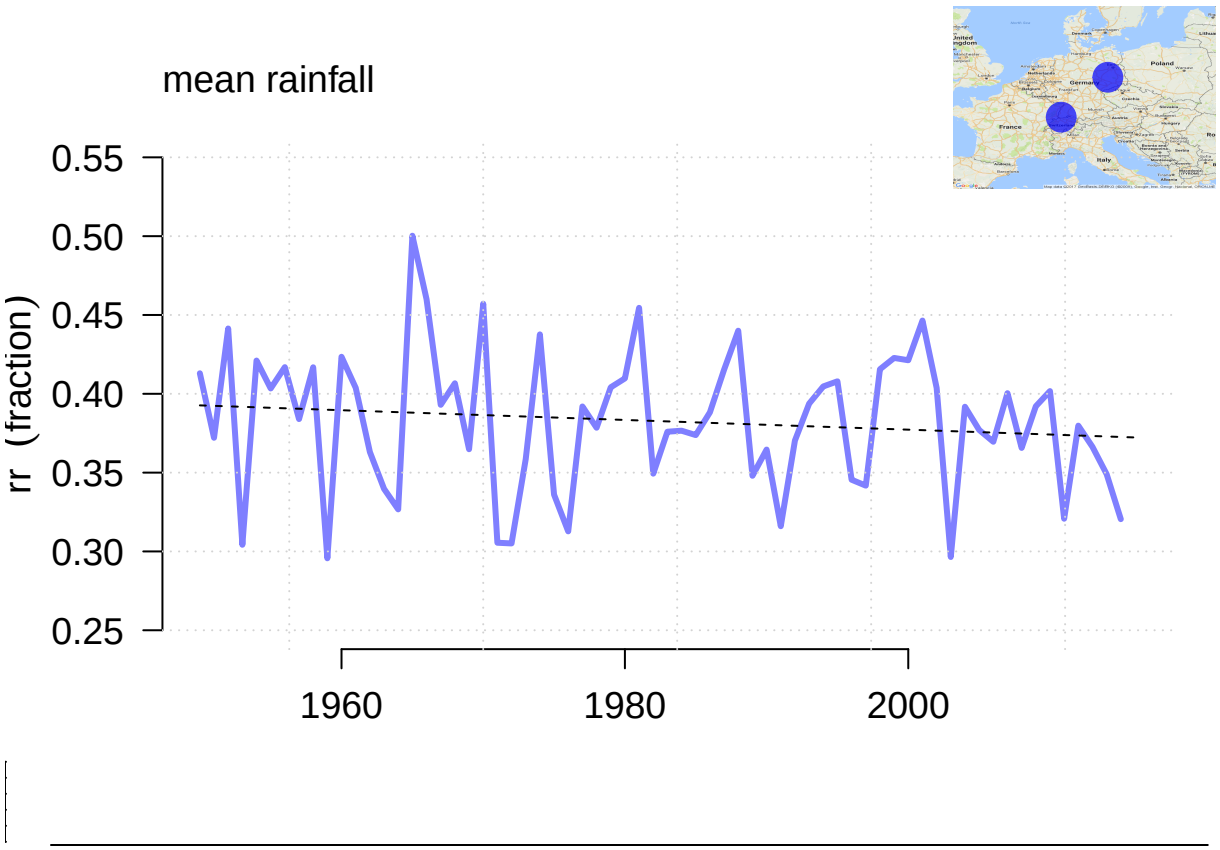
```
lines(trend(MU),lty=2)
grid()
```




```
plot(FW,new=FALSE)
```

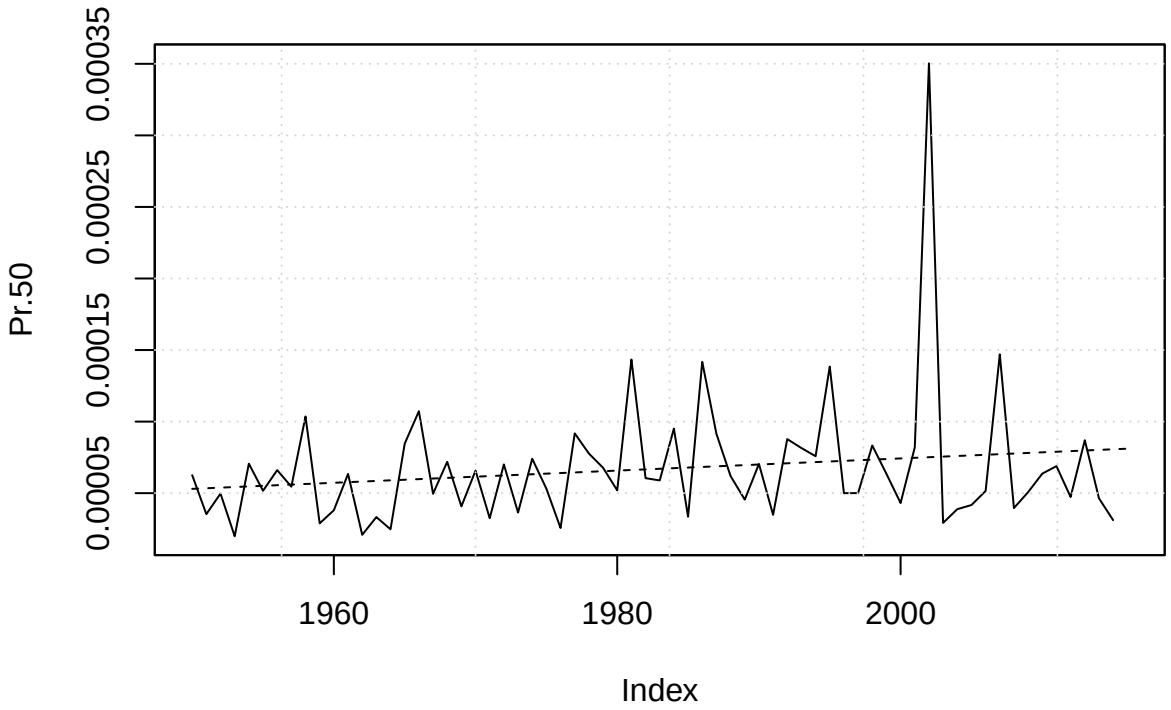
```
## Warning in plotmap(lat(x), lon(x), bgmap, pch = 19, col = col, cex = 2):
## NAs introduced by coercion
```

```
grid()
lines(trend(FW),lty=2)
```



Plot the probability of more than 50mm/day

```
Pr.50 <- FW*exp(-50/MU)
plot(Pr.50)
lines(trend(Pr.50),lty=2)
grid()
```



Test to see if the long-wave outgoing radiation (OLR) can be used as a predictor for the winter-time wet-day mean precipitation over Germany. It contains information about cloud tops, and the hypothesis is that heavy precipitation comes from clouds with high (and cold) cloud tops.

```
olr <- retrieve('~/Downloads/ERAINT-OLR-mon.nc', lon=c(-50,40),lat=c(40,70))
olr <- subset(as.4seasons(olr),it='djf')
```

```
## Warning in zoo(coredata(x), order.by = tshifted): some methods for "zoo"
## objects do not work if the index entries in 'order.by' are not unique
```

```
eof.olr<- EOF(olr,n=5)
class(eof.olr)[3] <- "season"
mu.djf <- subset(as.4seasons(Y,FUN='wetmean'),it='djf')
pca.mu <- PCA(pcafill(mu.djf),n=5)
ds.mu.orl <- DS(pca.mu,eof.olr)
```

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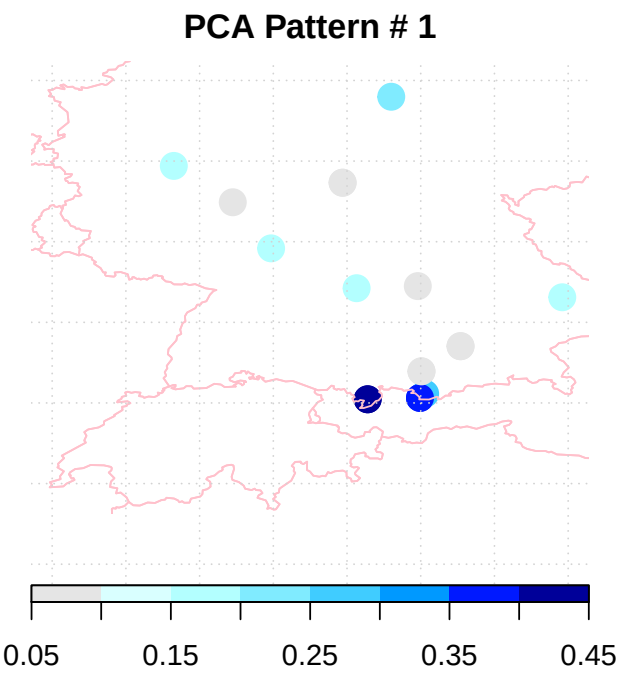
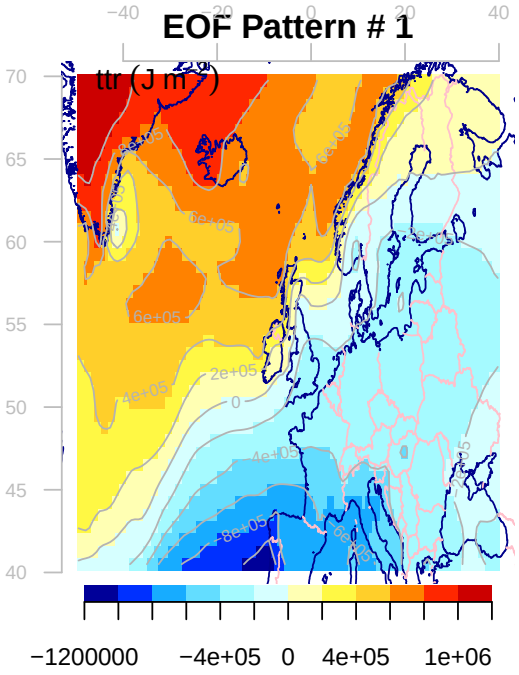
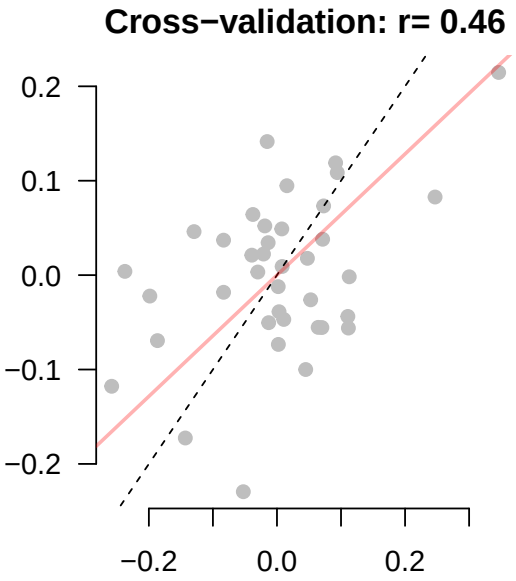
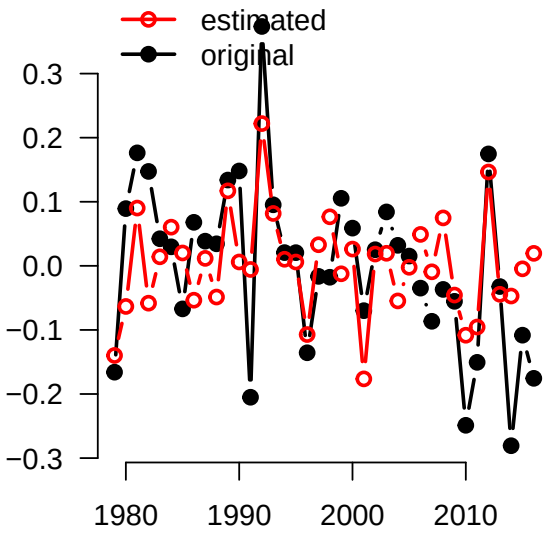
```
plot(ds.mu.orl,new=FALSE)
```

```
## Warning in plot.xy(xy.coords(x, y), type = type, ...): "plot" is not a
## graphical parameter
```







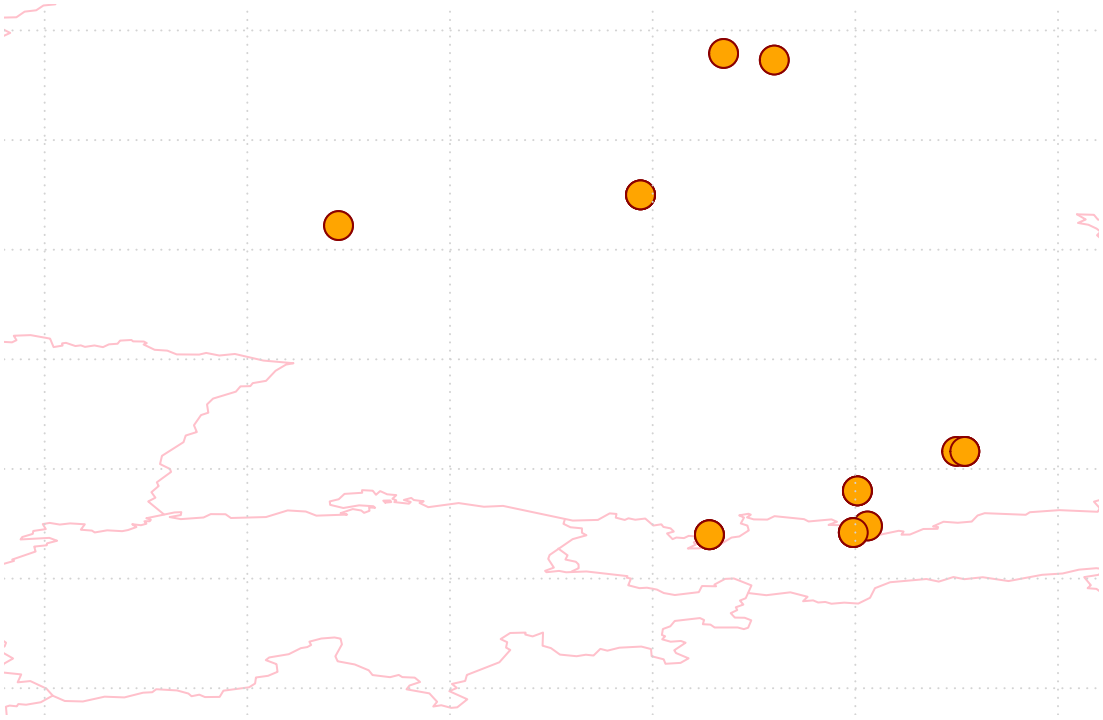



```
## NULL
```

Analysis: temperature

Check for melting.

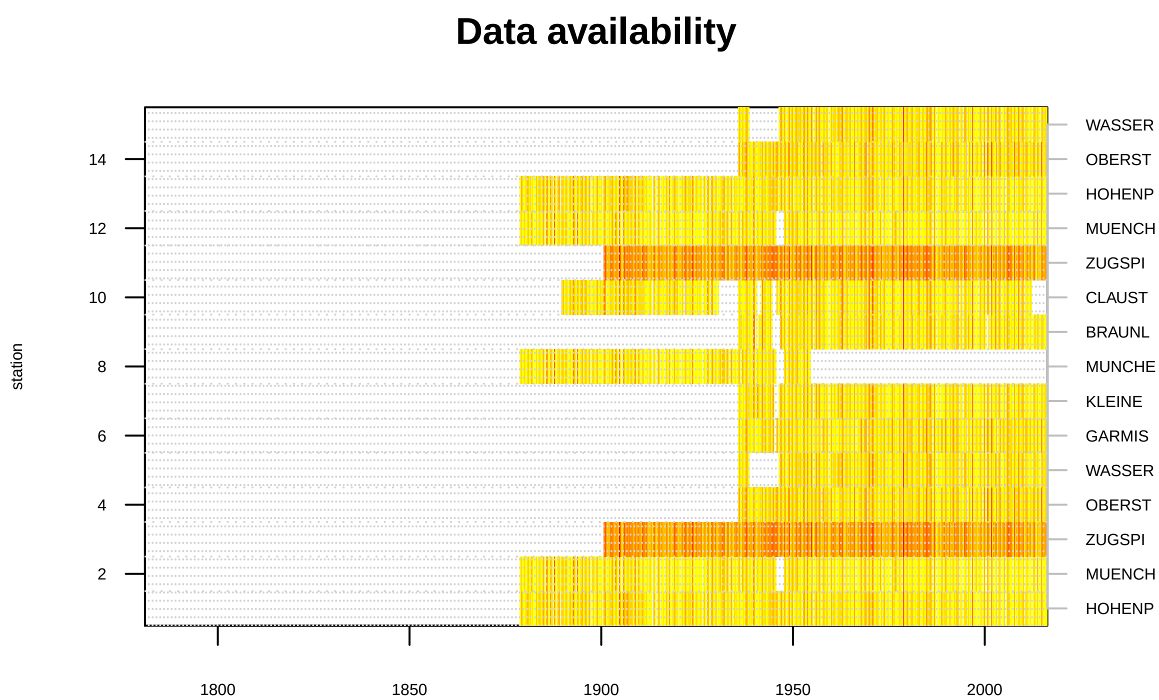
```
ss <- select.station(param='tn',cntr='Germany',alt=500,nmin=75)
map(ss)
```



```
X <- subset(station(ss),it=month.abb[1:4])
```

```
## [1] "Retrieving data from 15 records ..."
## [1] "1 TMIN 100166 HOHENPEISSENBERG GERMANY ECAD"
## [1] "2 TMIN 100186 MUENCHEN GERMANY ECAD"
## [1] "3 TMIN 100216 ZUGSPITZE GERMANY ECAD"
## [1] "4 TMIN 121117 OBERSTDORF GERMANY ECAD"
## [1] "5 TMIN 121177 WASSERKUPPE GERMANY ECAD"
## [1] "6 TMIN 122665 GARMISCH-PARTENKIRCHEN GERMANY ECAD"
## [1] "7 TMIN 124549 KLEINER FELDBERG/TAUNUS GERMANY ECAD"
## [1] "8 TMIN 126277 MUNCHEN-BOTANISCHER GARTEN GERMANY ECAD"
## [1] "9 TMIN 131641 BRAUNLAGE GERMANY ECAD"
## [1] "10 TMIN 132565 CLAUSTHAL-ZELLERFELD GERMANY ECAD"
## [1] "11 TMIN GM000004155 ZUGSPITZE  GERMANY GHCND"
## [1] "12 TMIN GM000004199 MUENCHEN GERMANY GHCND"
## [1] "13 TMIN GM000010962 HOHENPEISSENBERG GERMANY GHCND"
## [1] "14 TMIN GME00121114 OBERSTDORF GERMANY GHCND"
## [1] "15 TMIN GME00121174 WASSERKUPPE  GERMANY GHCND"
```

```
diagnose(X)
```



GHCND

```
X <- subset(X,it=c(1940,2015))
```

```
tnx <- annual(X,FUN='max',nmin=100)
```

```
## Warning in FUN(X[[i]], ...): no non-missing arguments to max; returning -
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```

```
plot(tnx,new=FALSE)
```

```
## Warning in plotmap(lat(x), lon(x), bgmap, pch = 19, col = col, cex = 2):
## NAs introduced by coercion
```

```
grid()
```