Sea level

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Evidence for coherent the local sea level rise based on PCA. Relate the local response to the global, expecting a physical connection

R Markdown

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.

```
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
```

```
library(RgoogleMaps)
```

```
dm <- function(x) {
  if (!is.null(dim(x))) y <- zoo(t(t(coredata(x)) -                    colMeans(coredata(x),na.rm=TRU
                        y <- zoo(x - mean(x,na.rm=TRUE), order.by=index(x))
  y <- attrcp(x,y)
  class(y) <- class(x)
  y
}
```

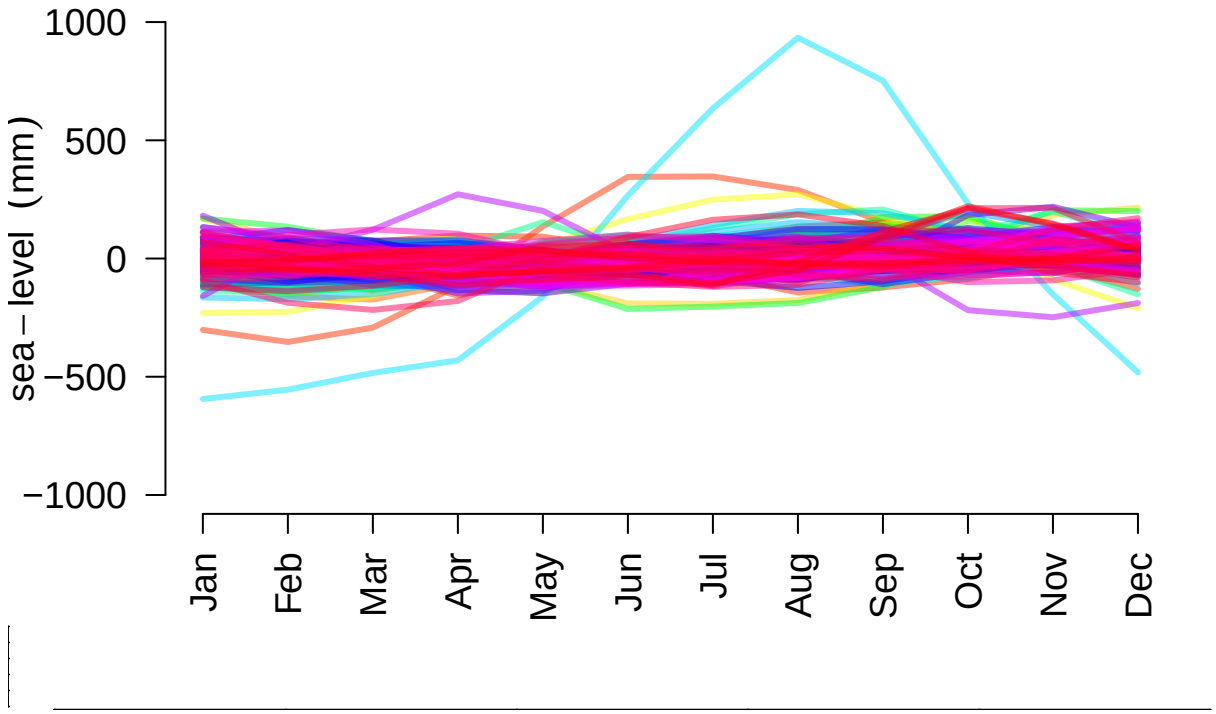
Analysis

You can also embed plots, for example:

```
gsl <- GSL()
gloss <- station.gloss()
sonel <- station.sonel()
#newlyn <- station.newlyn()
```

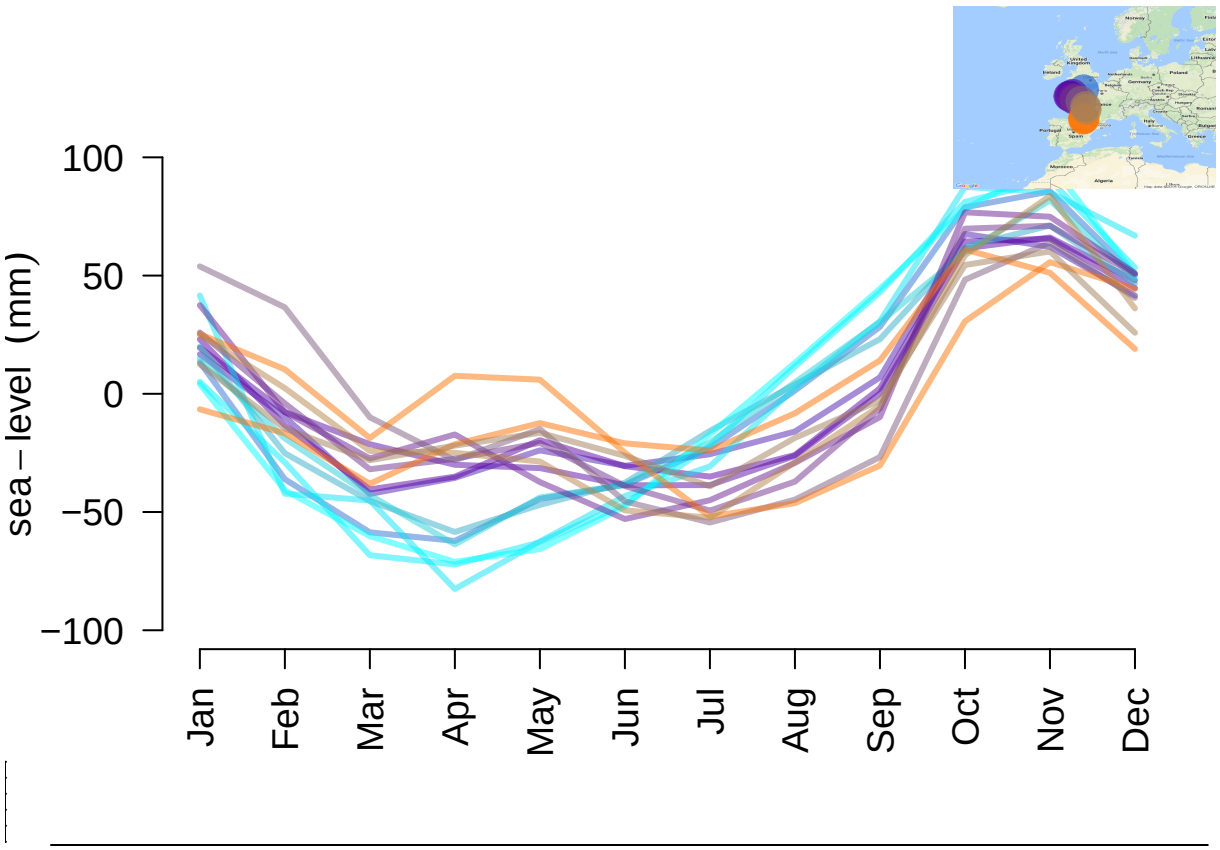
Examine the mean seasonal cycle in the tide gauge records:

```
plot(aggregate(dm(gloss),month,'mean'),map.show=FALSE,new=FALSE)
lines(aggregate(dm(gsl),month,'mean'))
```




```
plot(aggregate(dm(sonel),month,'mean'),new=FALSE)
```

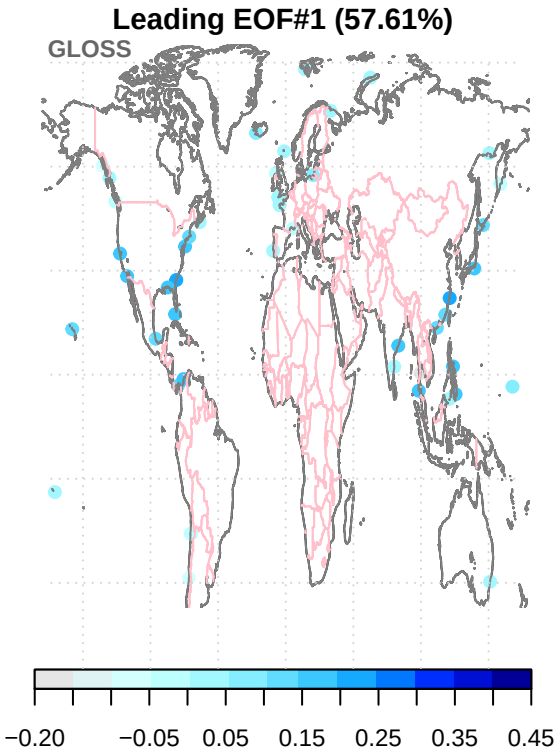
```
## Warning in plotmap(lat(x), lon(x), bgmap, pch = 19, col = col, cex = 2):
## NAs introduced by coercion
```

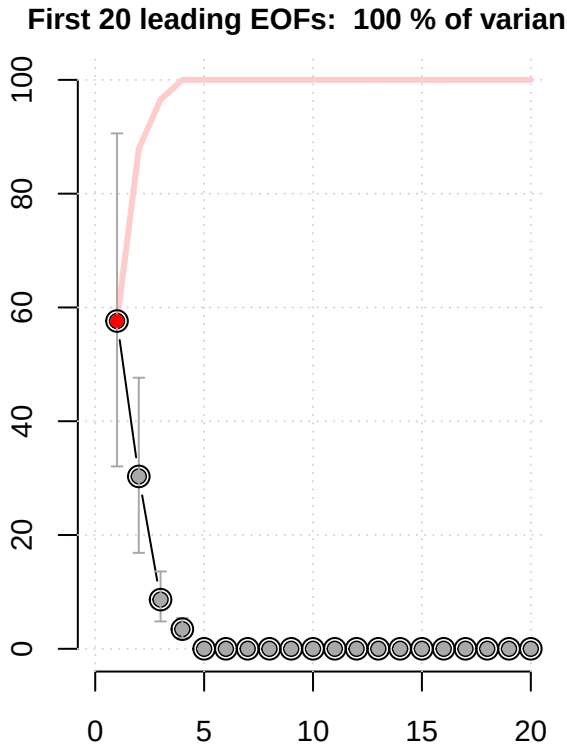


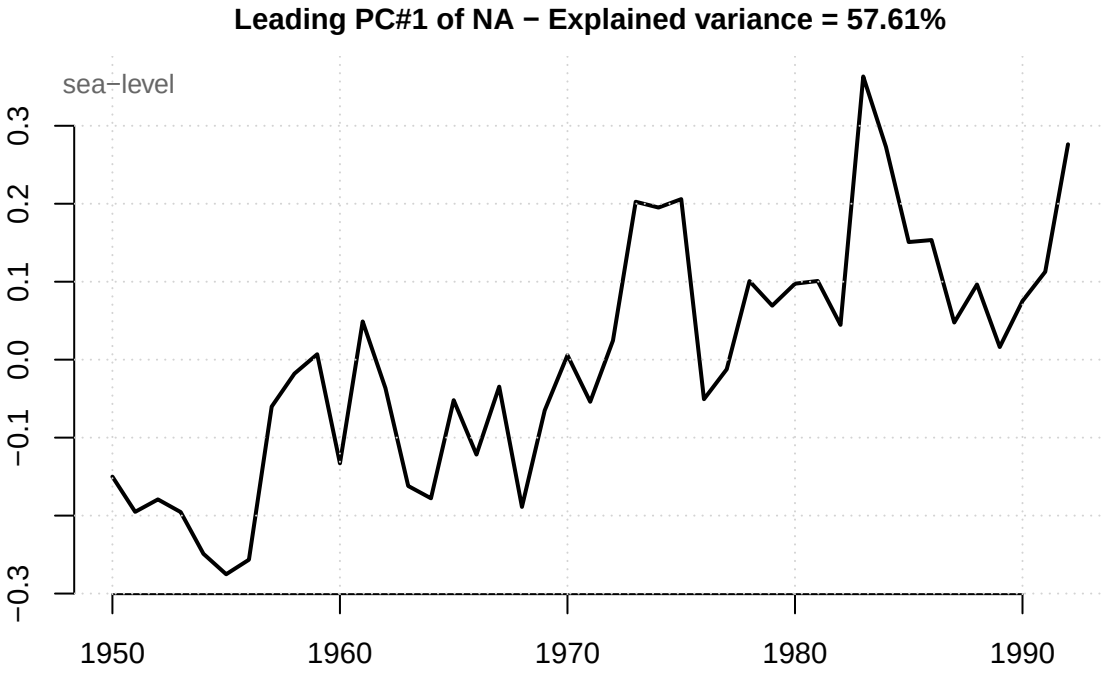
Examine globally distributed tide gauge data.

```
gloss <- subset(gloss,it=c(1950,1992))
nv <- apply(coredata(gloss),2,'nv')
gloss <- subset(gloss,is=nv > 400)
gloss <- pcafill(gloss)
pca <- PCA(annual(gloss))
plot(pca,new=FALSE)
```

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





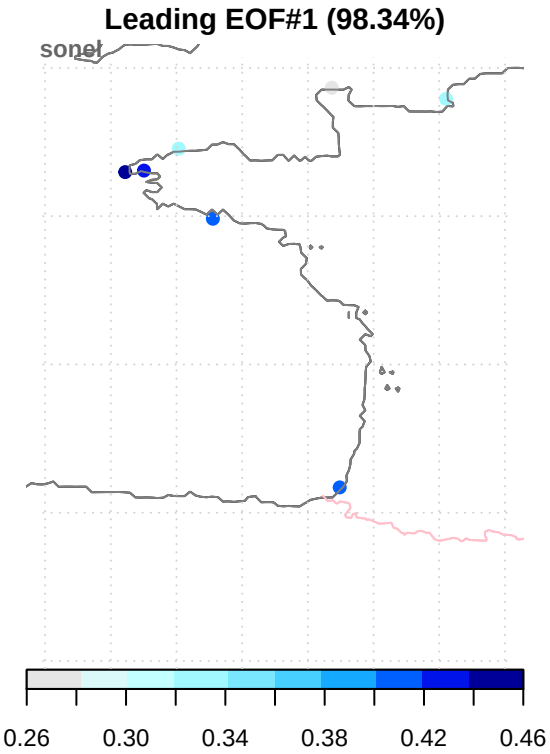


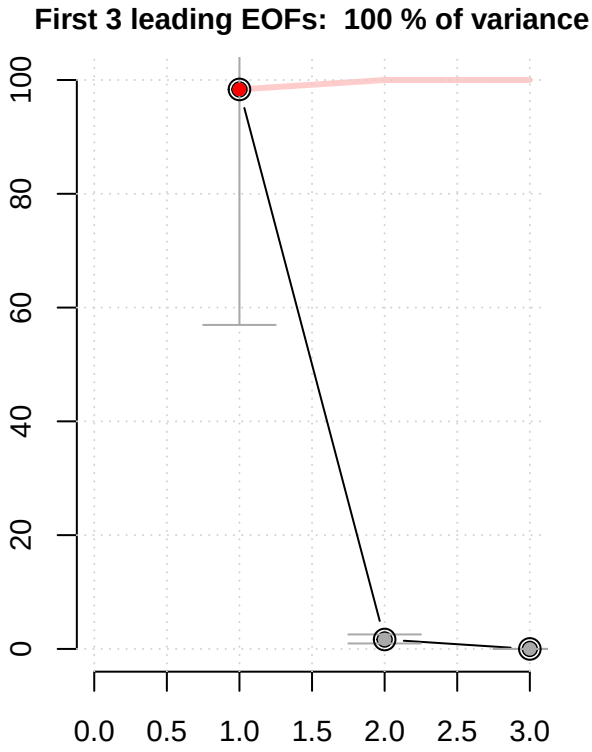
Tide gauge data from the coast of northern France. There are some missing data gaps, but ignore those.

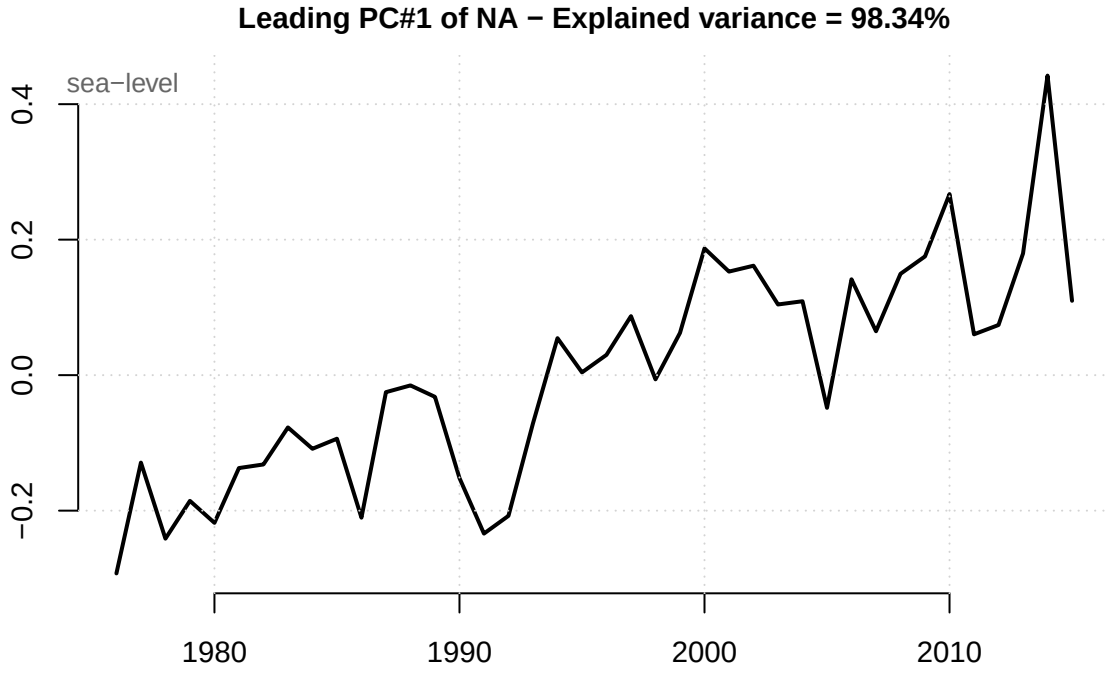
```
sonel <- annual(sonel,nmin=275)
sonel <- subset(sonel,it=c(1976,2015))
nv <- apply(coredata(sonel),2,'nv')
sonel <- subset(sonel,is=nv > 30)
sonel <- pcafill(sonel)
pca <- PCA(annual(sonel),n=3)
```

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

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







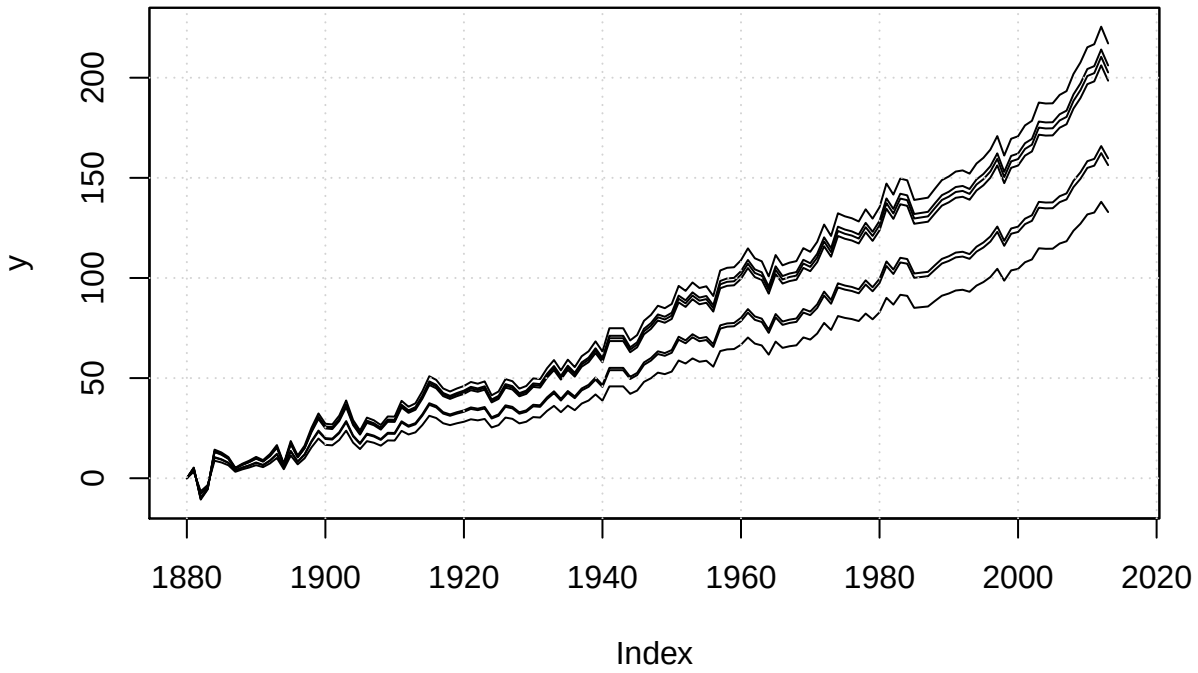
Connect to the global mean sea level

```
gsl <- annual(gsl); index(gsl) <- year(gsl)
xy <- merge(zoo(annual(gsl)),zoo(pca),all=TRUE)
cal.sl <- data.frame(y = xy[,2],x=xy[,1])
slfit <- lm(y ~ x, data=cal.sl)
print(summary(slfit))
```

```
##
## Call:
## lm(formula = y ~ x, data = cal.sl)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.16561 -0.06583  0.01367  0.05373  0.18129
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.712457   0.087909  -8.104 1.24e-09 ***
## x            0.040037   0.004976   8.047 1.46e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.08824 on 36 degrees of freedom
##   (98 observations deleted due to missingness)
## Multiple R-squared:  0.6427, Adjusted R-squared:  0.6327
## F-statistic: 64.75 on 1 and 36 DF,  p-value: 1.465e-09
```

Construct the effect of a global sea level rise on the local tide levels using the leading PC only:

```
z <- gsl; dim(z) <- c(length(z),1)
U <- attr(pca,'pattern')[,1]; dim(U) <- c(1,length(U))
## Need to apply the matrix product to recover the original data.
y <- zoo((attr(pca,'eigenvalues')[1] * slfit$coefficient[2]) * (z %*% U),order.by=index(gsl))
plot(y,plot.type='single')
grid()
```



This regression model can now be applied to projected global mean sea levels from e.g. CMIP. Need to use the `slfit$coefficient[2]` together with `U`, `attr(pca,'eigenvalues')[1]` and the global sea level.