

# CixPAG-IMD-Tx

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*August 3, 2016*

## 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'
```

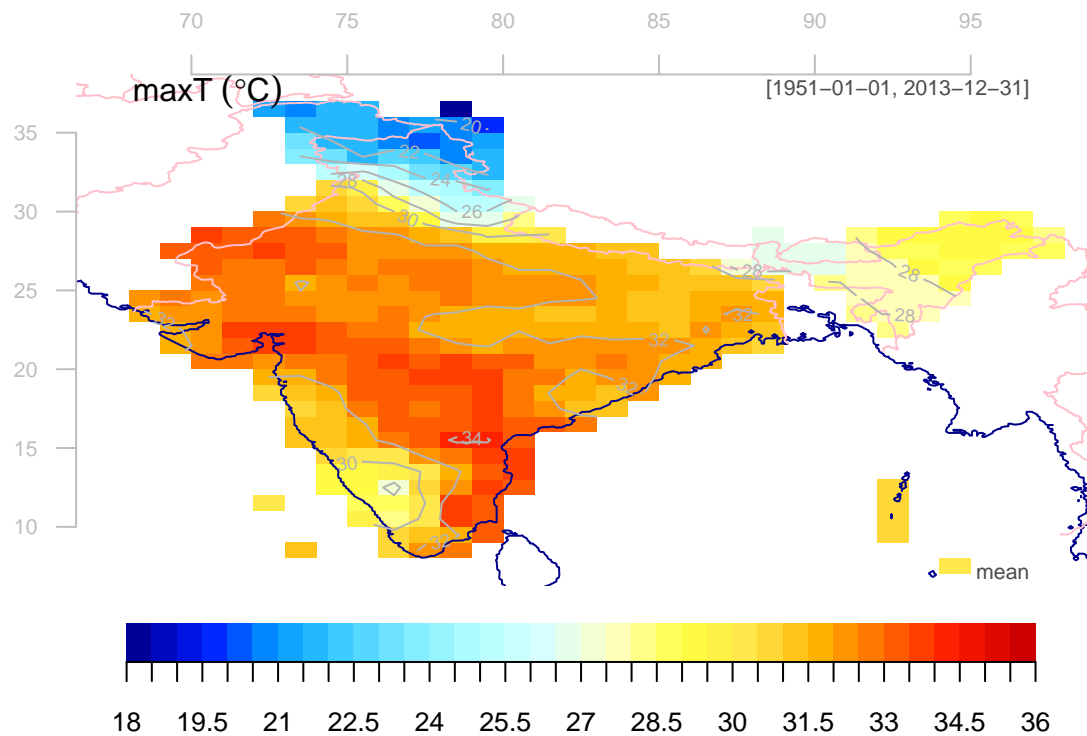
```
## The following object is masked from 'package:base':
```

```
##
```

```
##      subset.matrix
```

## Reading data predictand: maximum temperature

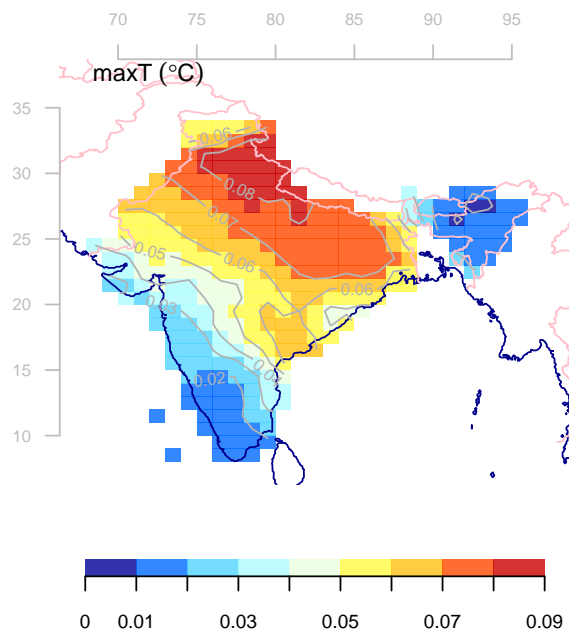
```
tx <- retrieve('data/IMD/maxT_IMD.1951-2013.nc')  
attr(tx, 'unit') <- 'degC'  
map(tx, colbar=list(breaks=seq(18, 36, 0.5)))
```



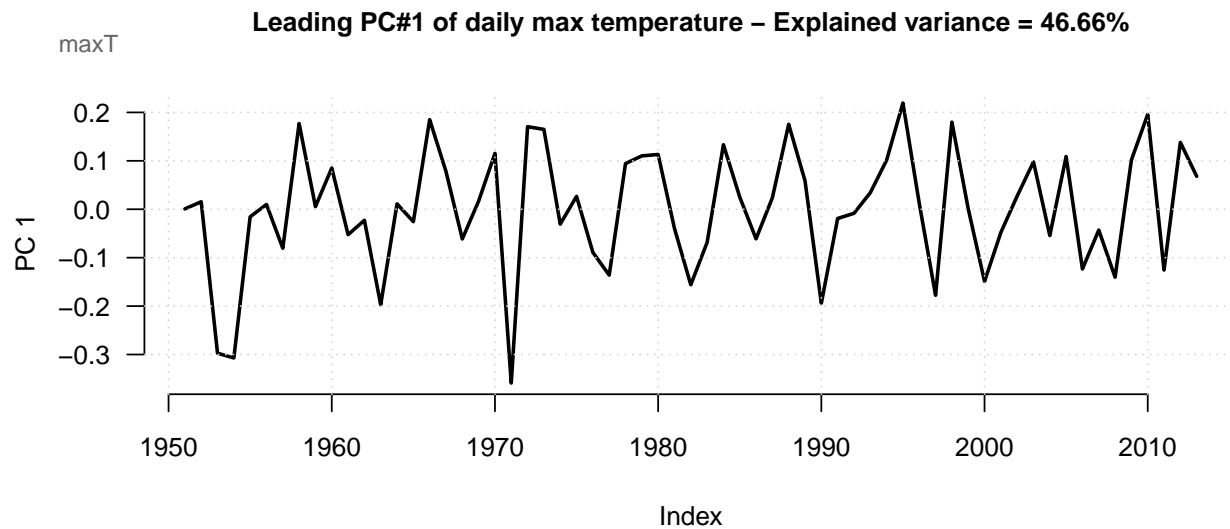
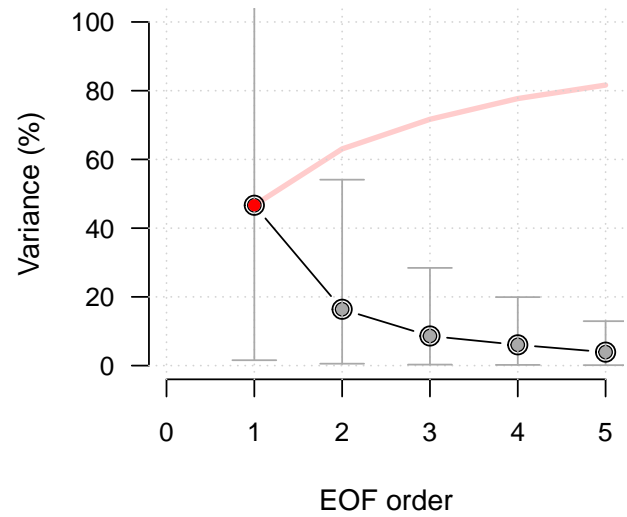
The annual mean daily maximum temperature ranges between 18C in the higher elevations of northwestern India to 36C in parts of the interior of southern India

An initial exploration of the the annual 98-percentile of daily maximum temperature was carried out through an EOF analysis, for which the gravest mode accounted for 46.7% of the variance. It's principal component (PC) did not reveal any obvious long-term trend, however, the greatest covariance (geographical weights) were found over the central parts of India with diminishing weights in the south and the far eastern parts. The second mode (16.4% - not shown) was associated with a longitudinal tripole/wave pattern and the PC had a non-zero long-term trend.

```
q98 <- function(x) quantile(x,probs=0.98,na.rm=TRUE)
Tx.max <- annual(tx,FUN="q98")
index(Tx.max) <- year(Tx.max)
eof.Y <- EOF(Tx.max,n=5)
plot(eof.Y,new=FALSE)
```

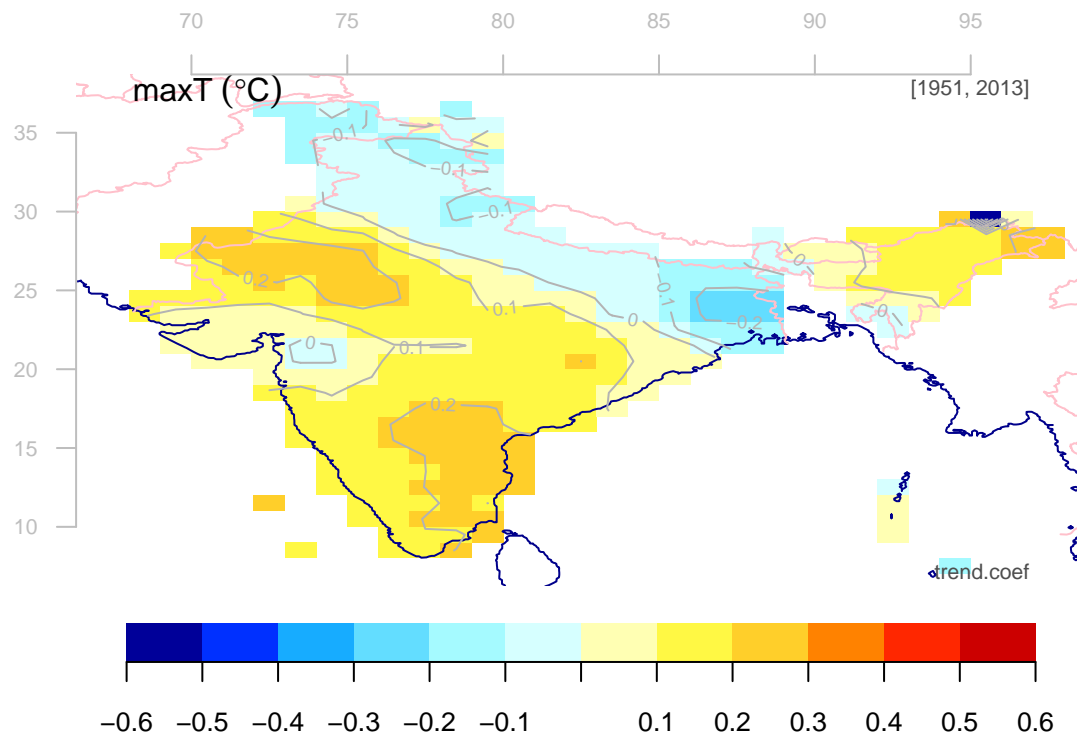


**First 5 leading EOFs: 81.6 % of variance**



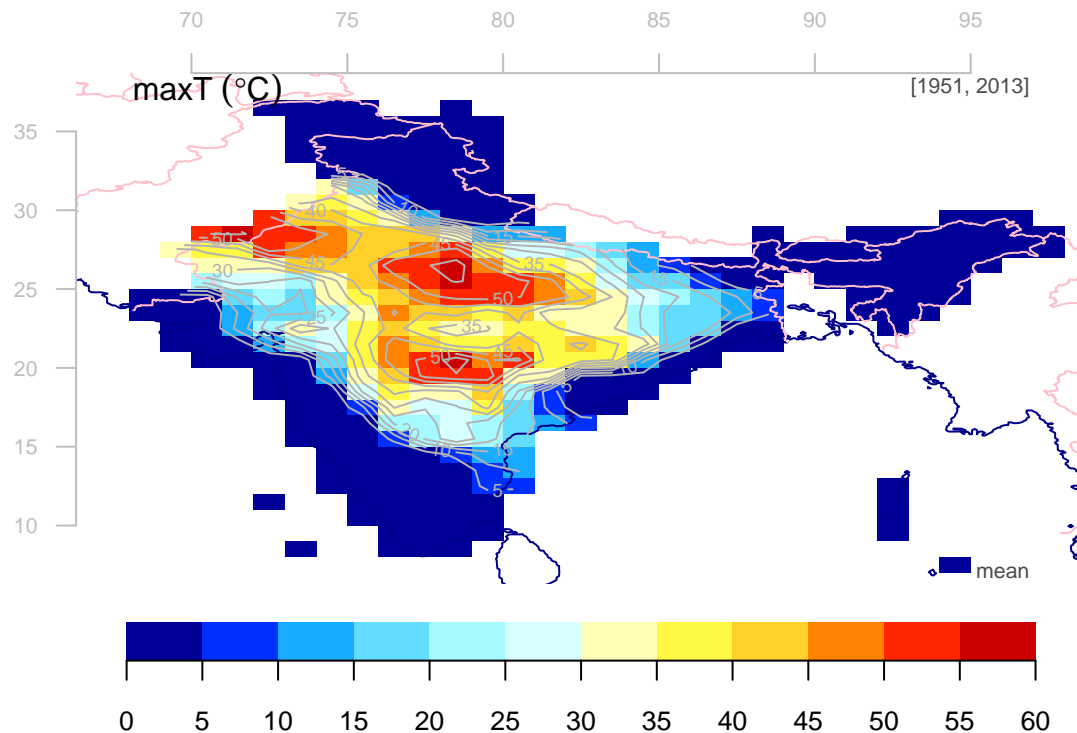
Trend in the annual 98-percentile of the daily maximum temperature over 1951–2013 suggested increases over most of the western parts of India but decreases in a zone along the northern border that includes Kolkata and Delhi.

```
map(Tx.max,FUN='trend',new=FALSE,colbar=list(breaks=seq(-0.6,0.6,by=0.1)))
```



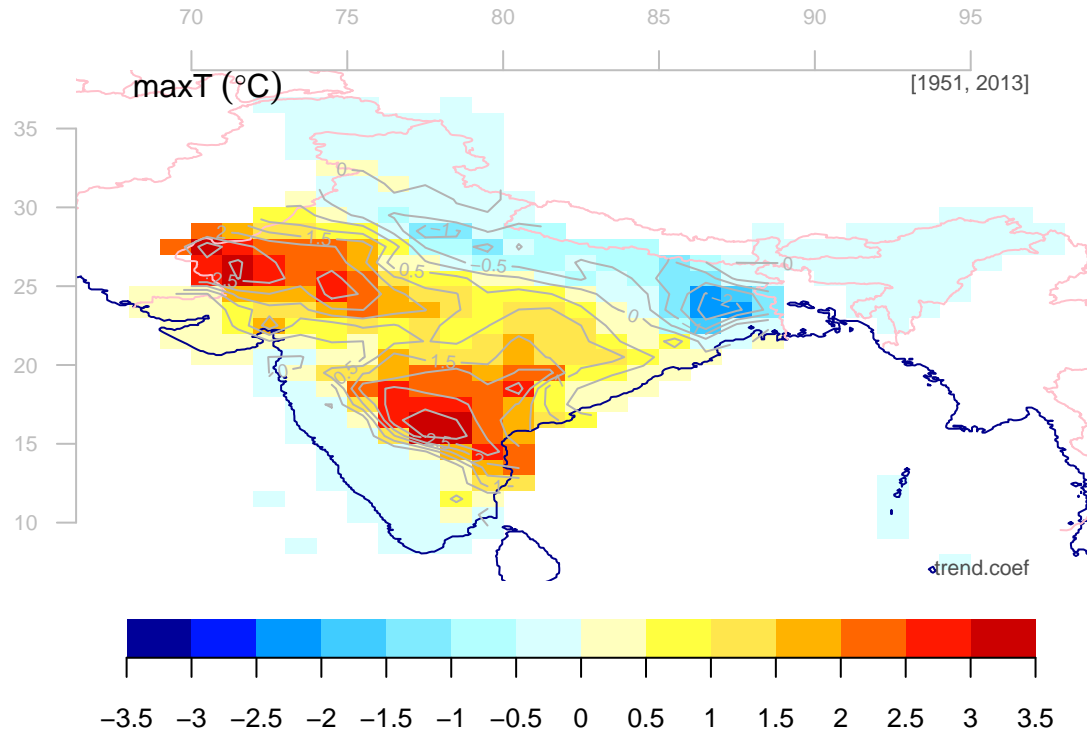
An analysis of the mean number of days with daily maximum temperature exceeding 40°C suggested that this threshold only has been exceeded in the interior parts of India. In some parts, there are up to 60 days per year hotter than 40°C on average.

```
Tx.nhd40 <- annual(tx,FUN='count',threshold=40)
map(Tx.nhd40,new=FALSE)
```



The number of hot days has increased over 1951-2013 with up to 3.5 days/decade in the interior parts of India.

```
map(Tx.nhd40,new=FALSE,FUN='trend',colbar=list(breaks=seq(-3.5,3.5,by=0.5)))
```



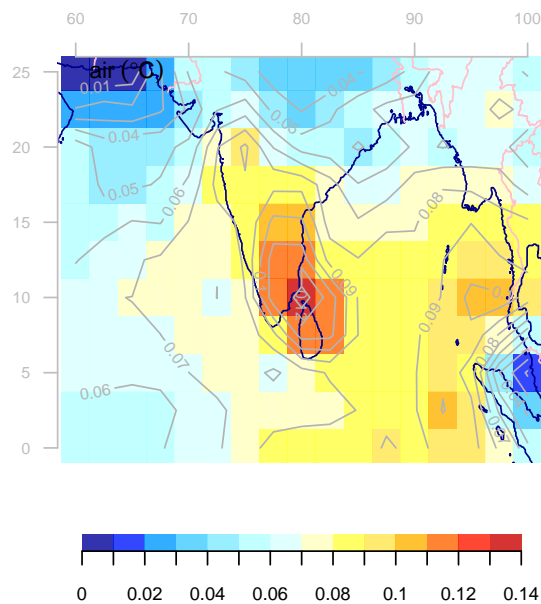
## Preparing for downscaling

Get the predictor - large-scale surface temperatures from NCEP/NCAR 1 reanalysis.

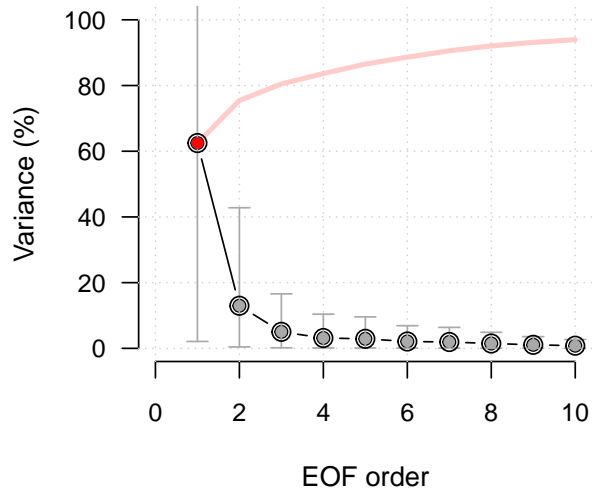
```
predictor <- retrieve('air.mon.mean.nc',lon=c(60,100),lat=c(0,25))
```

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

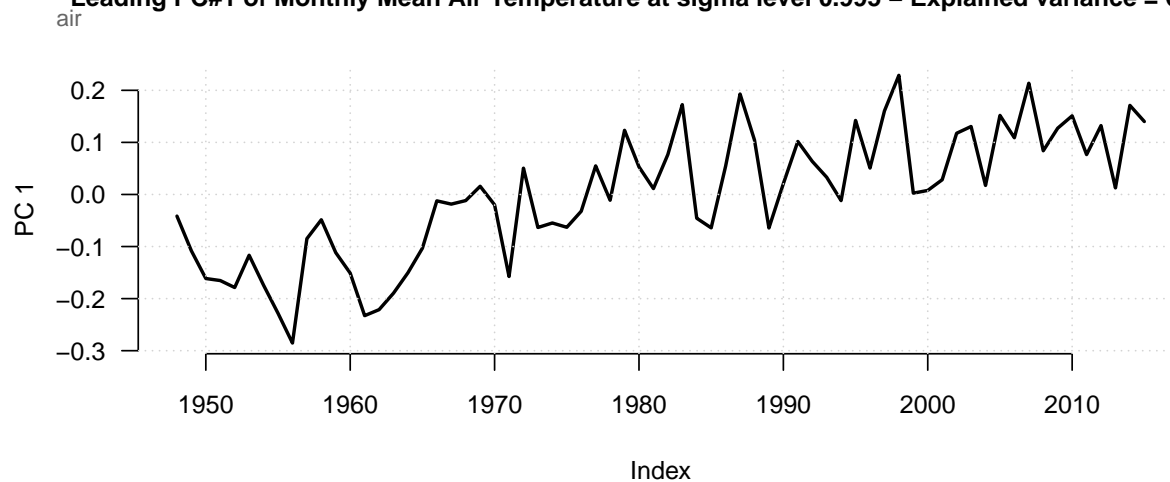
```
predictor <- annual(subset(predictor,it='jja'),nmin=3)
eof.X <- EOF(predictor,n=10)
plot(eof.X,new=FALSE)
```



First 10 leading EOFs: 93.9 % of variance



Leading PC#1 of Monthly Mean Air Temperature at sigma level 0.995 – Explained variance = 62.49%



Check the link between large and small scales

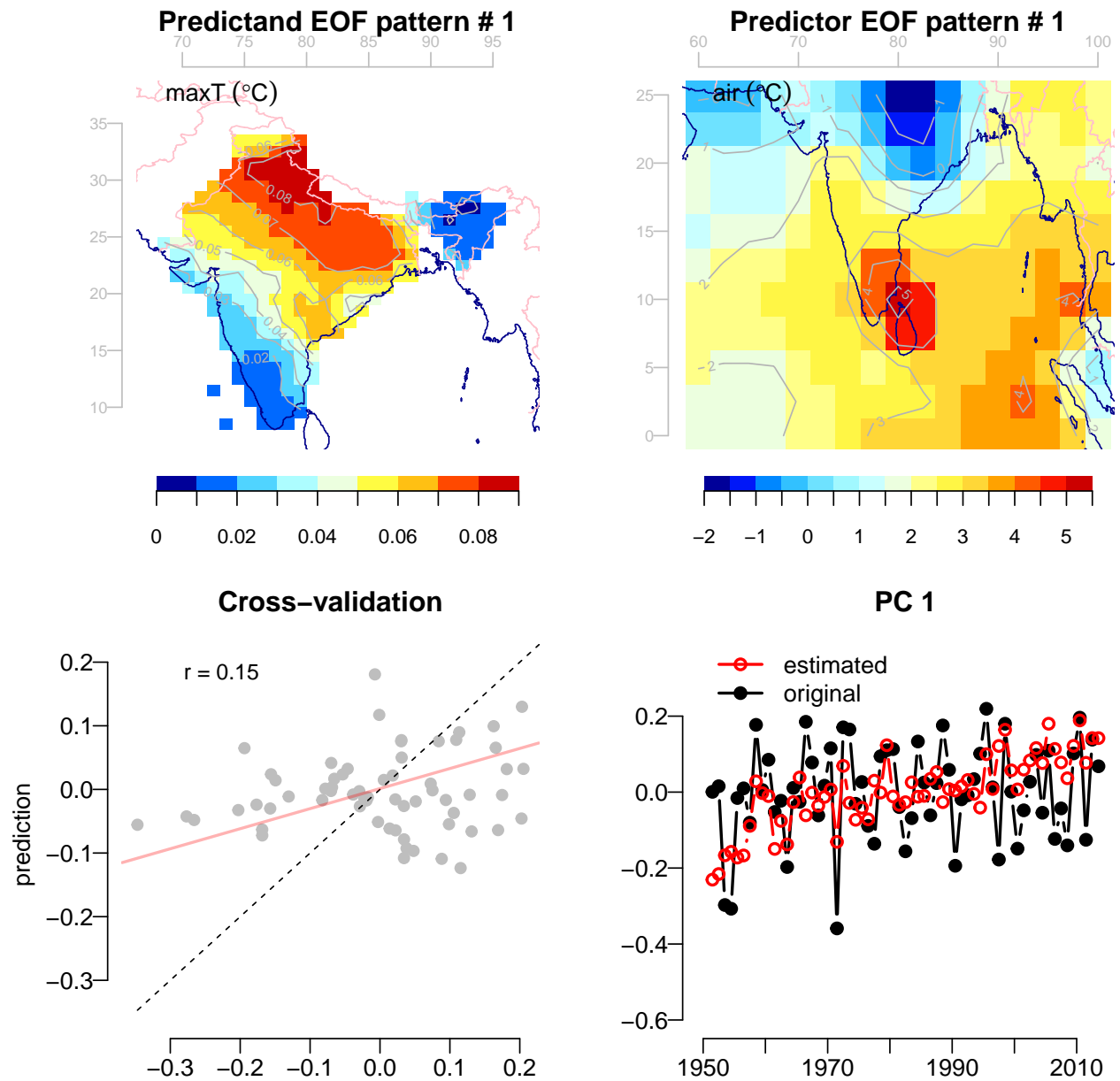
```
class(eof.Y) <- c("eof", "field", "season", "zoo") # Fix some incorrect settings
class(eof.X) <- c("eof", "field", "season", "zoo") # Fix some incorrect settings
index(eof.Y) <- as.Date(paste(year(eof.Y), '-07-01', sep=''))
index(eof.X) <- as.Date(paste(year(eof.X), '-07-01', sep=''))
ds.test <- DS(eof.Y, eof.X, ip=1:6)
```

```
##
|
|
|
|=====
|
|=====
|
|
```

0%  
20%  
40%

```
=====| 60%
=====| 80%
=====| 100%
```

```
plot(ds.test,new=FALSE)
```



## NULL

Apply the downscaling to the CMIP5 ensemble RCP4.5

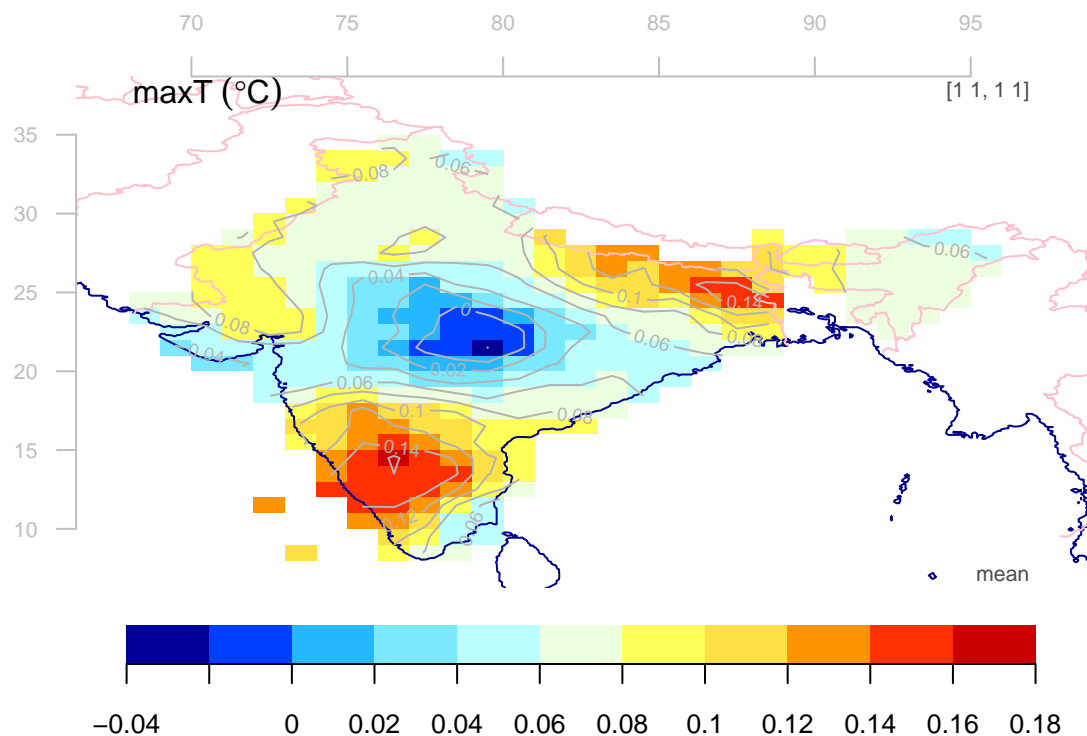
Carry out the downscaling once and save the results.

```

if (!file.exists('dse.Tx.jja.cixpag.rda')) {
  dse.Tx <- DSensemble.eof(eof.Y,eof.X,ip=1:6,it='jja',
    predictor='air.mon.mean.nc',verbose=FALSE)
  save(dse.Tx,file='dse.Tx.jja.cixpag.rda')
} else load('dse.Tx.jja.cixpag.rda')

## Present annual maximum daily maximum temperature from RCP4.5 ensemble mean
z0 <- map(dse.Tx,it=2010,new=FALSE,plot=FALSE)
## annual maximum daily maximum temperature for 2050 based on RCP4.5 ensemble mean
z1 <- map(dse.Tx,it=2050,new=FALSE,plot=FALSE)
## Projected change in annual maximum daily maximum temperature
dz <- z1-z0
dz <- attrcp(z1,dz)
attr(dz,'dimensions') <- attr(z1,'dimensions')
class(dz) <- class(z1)
map(dz,new=FALSE)

```



Plot the area mean temperature for the IMD grid

```

plot(dse.Tx,new=FALSE,zoom=5)

```

## Loading required package: RgoogleMaps

```

grid()

```



