Subsetting of Spatio-Temporal Objects

ifgi
Institute for Geoinformatics
University of Münster

52north
exploring horizons

Benedikt Gräler

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Abstract

This vignette briefly describes how the subsetting of ST... classes works and mentions some of the underlying assumptions and pitfalls to be aware of.

Contents

1 Introduction

The design of the spatio-temporal classes in `spacetime` tries to follow the usual *look-and-feel* of a standard `R` structure such as matrices and data frames. However, the two indices used in the representation referring to space and time do have some implicit meaning to be taken care of. The following examples will use small toy data set to illustrate the differences in subsetting among different notations and classes. All presented code can be used for both structures with and without data slot.

```
R> library(sp)
R> library(xts)
R> library(spacetime)
R> # spatial component
```

```
R> spObj <- data.frame(x=c(0,2,1,0,2), y=c(2,2,1,0,0))
R> coordinates(spObj) <- ~x+y
R> row.names(spObj) <- c("A","B","C","D","E")
R> # temporal component
R> timeObj = as.POSIXct("2010-08-05")+3600*24*(0:1)
R> # data slot
R> m = 1:5*10 # means for each of the 5 point locations
R> mydata = data.frame(smpl1=rnorm(10, mean=rep(m, 2)),
+                       smpl2=rnorm(10, mean=rep(m, 2)))
R> mydata[c(2, 4, 6, 7),] <- NA
R> STFDFobj <- STFDF(spObj, timeObj, mydata)
R> STSDFobj <- as(STFDFobj, "STSDF")
R> STIDFobj <- as(STFDFobj, "STIDF")
R> STFobj <- geometry(STFDFobj)
R> STSobj <- geometry(STSDFobj)
R> STIobj <- geometry(STIDFobj)
```

2 Selection over space

Subsetting over space can be done in different ways. This includes indices of class `numeric` where we refer to each actual index of the spatial location, `logical` that must be of the same length as the spatial component, `character` referring to row names of the spatial object and `Spatial` initiating an overlay to retrieve selection indices.

2.1 Indices of class `numeric`

Spatio-temporal objects with a *full* outline represent the complete structure of $3 \times 2 = 6$ spatio-temporal locations:

```
R> STFobj[1:3,]

An object of class "STF"
Slot "sp":
SpatialPoints:
  x y
A 0 2
B 2 2
C 1 1
Coordinate Reference System (CRS) arguments: NA

Slot "time":
            timeIndex
2010-08-05          1
2010-08-06          2

Slot "endTime":
[1] "2010-08-06 CEST" "2010-08-07 CEST"
```

In case of the *sparse* structure, only the observed locations are stored leading to an index of only 3 rows.

```
R> STSobj[1:3,]

An object of class "STS"
Slot "index":
     [,1] [,2]
[1,]    1    1
[2,]    2    1
[3,]    2    2

Slot "sp":
SpatialPoints:
  x y
A 0 2
C 1 1
Coordinate Reference System (CRS) arguments: NA

Slot "time":
           timeIndex
2010-08-05         1
2010-08-06         2

Slot "endTime":
[1] "2010-08-06 CEST" "2010-08-07 CEST"
```

The *irregular* case stores for each spatio-temporal location a separate spatial and temporal entity with an own spatial and temporal index. Hence the same selection as above returns the first three entries, i.e. the first three locations at the same moment in time. Note that the spatial locations "B" and "D" are not observed at the first moment in time.

```
R> STIobj[1:3,]

An object of class "STI"
Slot "sp":
SpatialPoints:
  x y
A 0 2
C 1 1
E 2 0
Coordinate Reference System (CRS) arguments: NA

Slot "time":
           timeIndex
2010-08-05         1
2010-08-05         1
2010-08-05         1

Slot "endTime":
[1] "2010-08-06 CEST" "2010-08-06 CEST" "2010-08-06 CEST"
```

Like-wise one might select the same station repeatedly,

```
R> STSobj[rep(3,3),]

An object of class "STS"
Slot "index":
    [,1] [,2]
[1,]    1    1
[2,]    1    1
[3,]    1    1
[4,]    1    2
[5,]    1    2
[6,]    1    2


Slot "sp":
SpatialPoints:
  x y
C 1 1
Coordinate Reference System (CRS) arguments: NA

Slot "time":
           timeIndex
2010-08-05         1
2010-08-06         2


Slot "endTime":
[1] "2010-08-06 CEST" "2010-08-07 CEST"
```

or stations in a different order:

```
R> STFobj[3:1,]

An object of class "STF"
Slot "sp":
SpatialPoints:
  x y
C 1 1
B 2 2
A 0 2
Coordinate Reference System (CRS) arguments: NA

Slot "time":
           timeIndex
2010-08-05         1
2010-08-06         2


Slot "endTime":
[1] "2010-08-06 CEST" "2010-08-07 CEST"
```

This applies to all three structures.

2.2 Indices of class `logical`

Spatio-temporal objects with a *full* and *sparse* structure require a vector of the same length as the slot `sp`. The vector will be recycled if necessary. The *full*

structure refers to $3 \times 2 = 6$ spatio-temporal locations

```
R> STFobj[c(TRUE,TRUE,FALSE,FALSE,TRUE),]

An object of class "STF"
Slot "sp":
SpatialPoints:
  x y
A 0 2
B 2 2
E 2 0
Coordinate Reference System (CRS) arguments: NA

Slot "time":
          timeIndex
2010-08-05        1
2010-08-06        2

Slot "endTime":
[1] "2010-08-06 CEST" "2010-08-07 CEST"
```

where the *sparse* structure only provides an index with 3 rows:

```
R> STSobj[c(TRUE,TRUE,FALSE,FALSE,TRUE),]

An object of class "STS"
Slot "index":
     [,1] [,2]
[1,]    1    1
[2,]    2    1
[3,]    2    2

Slot "sp":
SpatialPoints:
  x y
A 0 2
E 2 0
Coordinate Reference System (CRS) arguments: NA

Slot "time":
          timeIndex
2010-08-05        1
2010-08-06        2

Slot "endTime":
[1] "2010-08-06 CEST" "2010-08-07 CEST"
```

The *irregular* case will again provide the exact matches with observation, but needs a longer vector of size 6, as each observation has its own spatial entity in the slot sp.

```
R> STSobj[c(TRUE,TRUE,FALSE,FALSE,TRUE,FALSE),]
```

```
An object of class "STS"
Slot "index":
     [,1] [,2]
[1,]    1    1
[2,]    2    1
[3,]    2    2

Slot "sp":
SpatialPoints:
  x y
A 0 2
E 2 0
Coordinate Reference System (CRS) arguments: NA

Slot "time":
           timeIndex
2010-08-05         1
2010-08-06         2

Slot "endTime":
[1] "2010-08-06 CEST" "2010-08-07 CEST"
```

A repeated selection or changing the order is not possible for `logical` indices.

2.3 Indices of class `character`

The character provided as first argument in the subsetting brackets is matched against the row names of the spatial object. Objects of type *full* represent the complete structure of $2 \times 2 = 4$ spatio-temporal locations:

```
R> STFobj[c("A","B"),]
```

```
An object of class "STF"
Slot "sp":
SpatialPoints:
  x y
A 0 2
B 2 2
Coordinate Reference System (CRS) arguments: NA

Slot "time":
           timeIndex
2010-08-05         1
2010-08-06         2

Slot "endTime":
[1] "2010-08-06 CEST" "2010-08-07 CEST"
```

In case of the *sparse* structure, only a single spatio-temporal locations is returned, as B has actually never been observed:

```
R> STSobj[c("A","B"),]
```

```
An object of class "STS"
Slot "index":
     [,1] [,2]
[1,]    1    1

Slot "sp":
SpatialPoints:
  x y
A 0 2
Coordinate Reference System (CRS) arguments: NA

Slot "time":
           timeIndex
2010-08-05         1

Slot "endTime":
[1] "2010-08-06 CEST"
```

The *irregular* case might have the same location several times and will return all occurrences:

```
R> STIobj[c("C"),]
```

```
An object of class "STI"
Slot "sp":
SpatialPoints:
  x y
C 1 1
Coordinate Reference System (CRS) arguments: NA

Slot "time":
           timeIndex
2010-08-05         1

Slot "endTime":
[1] "2010-08-06 CEST"
```

Like-wise one might select the same station repeatedly

```
R> STIobj[c("C","C"),]
```

```
An object of class "STI"
Slot "sp":
SpatialPoints:
  x y
C 1 1
C 1 1
Coordinate Reference System (CRS) arguments: NA

Slot "time":
           timeIndex
```

```
2010-08-05           1
2010-08-05           1

Slot "endTime":
[1] "2010-08-06 CEST" "2010-08-06 CEST"
```

or stations in a different order:

```
R> STFobj[c("E","A"),]

An object of class "STF"
Slot "sp":
SpatialPoints:
  x y
E 2 0
A 0 2
Coordinate Reference System (CRS) arguments: NA

Slot "time":
          timeIndex
2010-08-05           1
2010-08-06           2

Slot "endTime":
[1] "2010-08-06 CEST" "2010-08-07 CEST"
```

This applies to all three structures.

2.4   Indices of class `Spatial`

In this case, the function `over` is called to determine the spatial relationship. See the documentation `?over` for further details.

3   Selection over time

The temporal dimension is realised as an `xts` object and subsetting along time is completely left to the routines in the `xts` package. Please see the corresponding documentation for further details. A special property of the temporal domain is its natural order. Hence, no reordering takes place even if explicitly asked for in the subsetting index. This is especially evident for the `STI...` classes, as these have only identical indices for space and time and a spatial reordering would involve a temporal one as well. In these cases, the natural order of time is given preference.

4   Selection over space and time

Selection over space and time can be done in two general ways. Either providing two separate vectors or as a two-column matrix. Just as for simple matrices, these two possibilities imply two distinct metaphors. The vectors will return all selected spatial entities combined with all temporal ones (where possible)

respecting the ordering of the spatial index. The matrix notation selects pairs of indices. The vector notation accepts all formats indicated above while the matrix only supports `numeric` values.

As this type of selection is typically done to select a sparse subset from the data, the object returned from a `STF...` object will be of type `STS....` Typically, the provided matrix reflects the `index` slot:

```
R> STFobj[cbind(1:3,c(1,2,2)),]
```

```
An object of class "STS"
Slot "index":
     [,1] [,2]
[1,]    1    1
[2,]    2    2
[3,]    3    2

Slot "sp":
SpatialPoints:
  x y
A 0 2
B 2 2
C 1 1
Coordinate Reference System (CRS) arguments: NA

Slot "time":
           timeIndex
2010-08-05         1
2010-08-06         2

Slot "endTime":
[1] "2010-08-06 CEST" "2010-08-07 CEST"
```

A *sparse* structure will remain *sparse*, but only existing pairs from the index will be returned.

```
R> STSobj[cbind(1:3,c(1,1,1))]
```

```
An object of class "STS"
Slot "index":
     [,1] [,2]
[1,]    1    1
[2,]    2    1

Slot "sp":
SpatialPoints:
  x y
A 0 2
C 1 1
Coordinate Reference System (CRS) arguments: NA

Slot "time":
```

```
          timeIndex
2010-08-05        1

Slot "endTime":
[1] "2010-08-06 CEST"
```

The *irregular* structure only provides data for identical spatial and temporal indices:

```
R> STIobj[cbind(1:5,5:1)]

An object of class "STI"
Slot "sp":
SpatialPoints:
  x y
E 2 0
Coordinate Reference System (CRS) arguments: NA

Slot "time":
          timeIndex
2010-08-05        1

Slot "endTime":
[1] "2010-08-06 CEST"
```

Multiple selection over space and time is in general possible, but re-ordering is only possible for the spatial domain.