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Adventures in Bayesian Structural Time Series

Part 4: Analyzing SST Data With Regression

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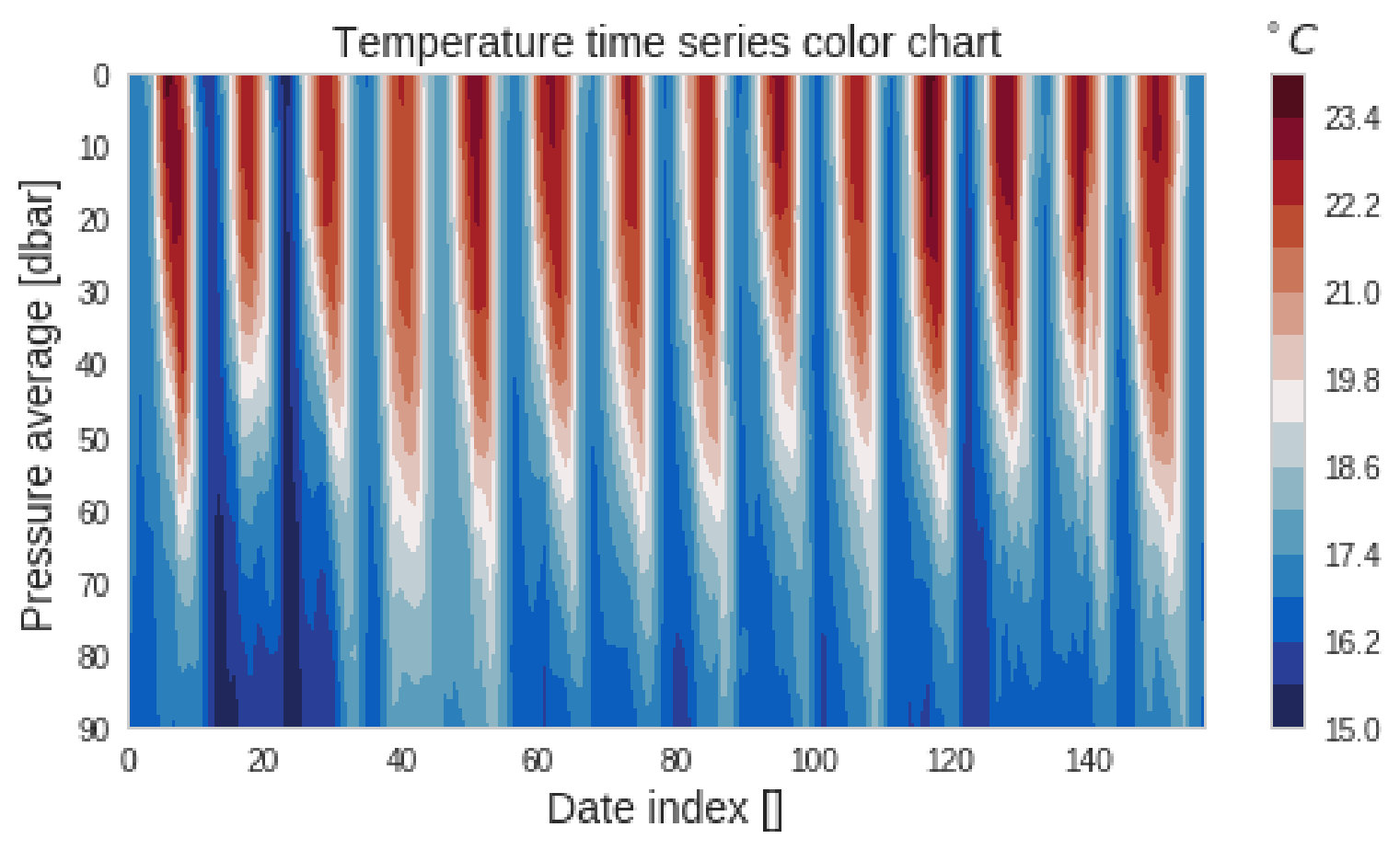
Temperature time series color chart
°C
Pressure average [dbar]
0
10
20
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40
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120
140
Date index []
23.4
22.2
21.0
19.8
18.6
17.4
16.2
15.0

Outline

- SST data with covariates
- Use `bsts` to
  - Fit structural model with regression
  - Forecast
  - Custom regresson prior

SST Data

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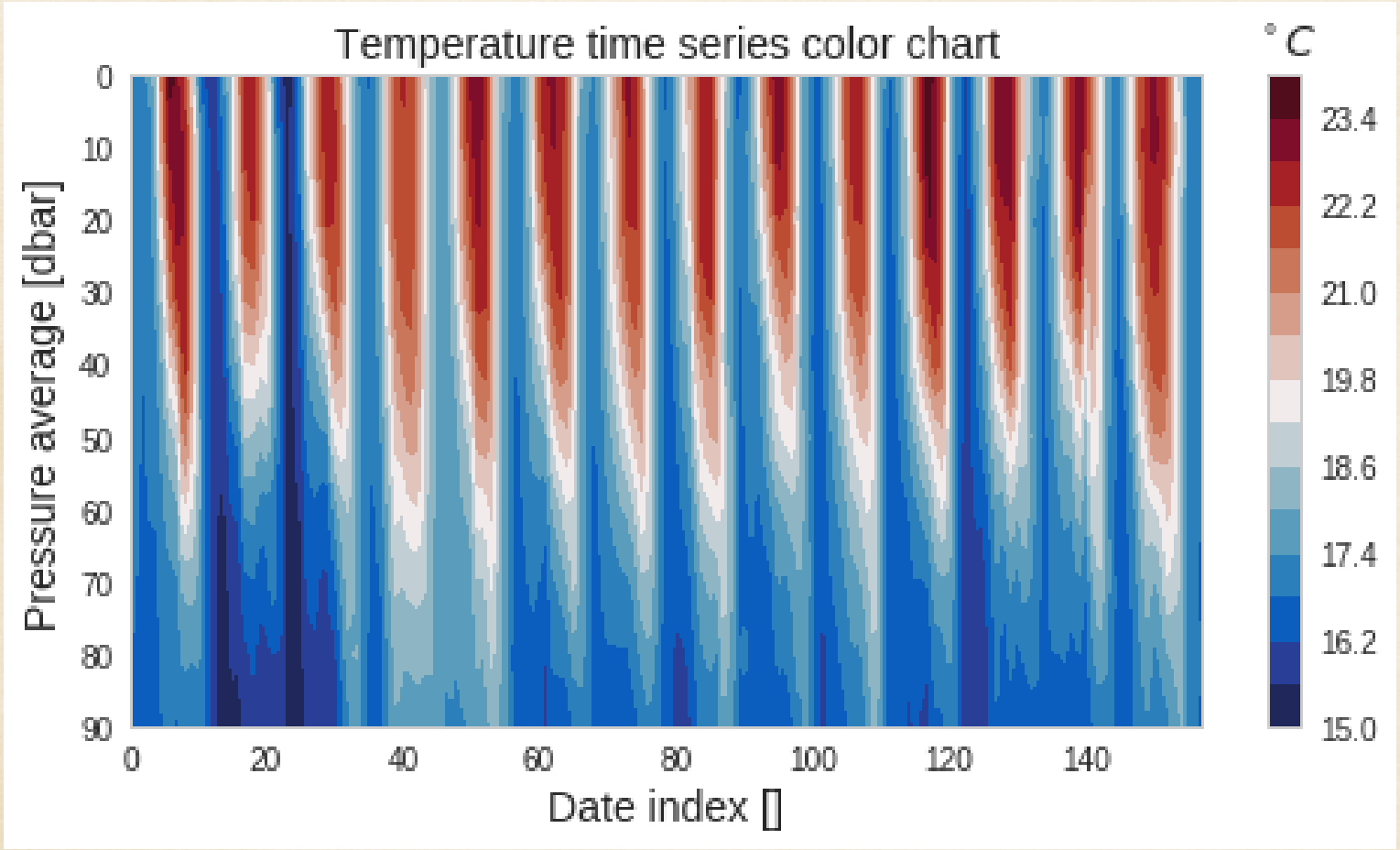
- Sea Surface Temperature near Gibraltar
- Aggregated monthly
- January 2004 to November 2017
- Covariates: 10 meter thick water layers at 10, 20, . . . ,90 meters

SST Data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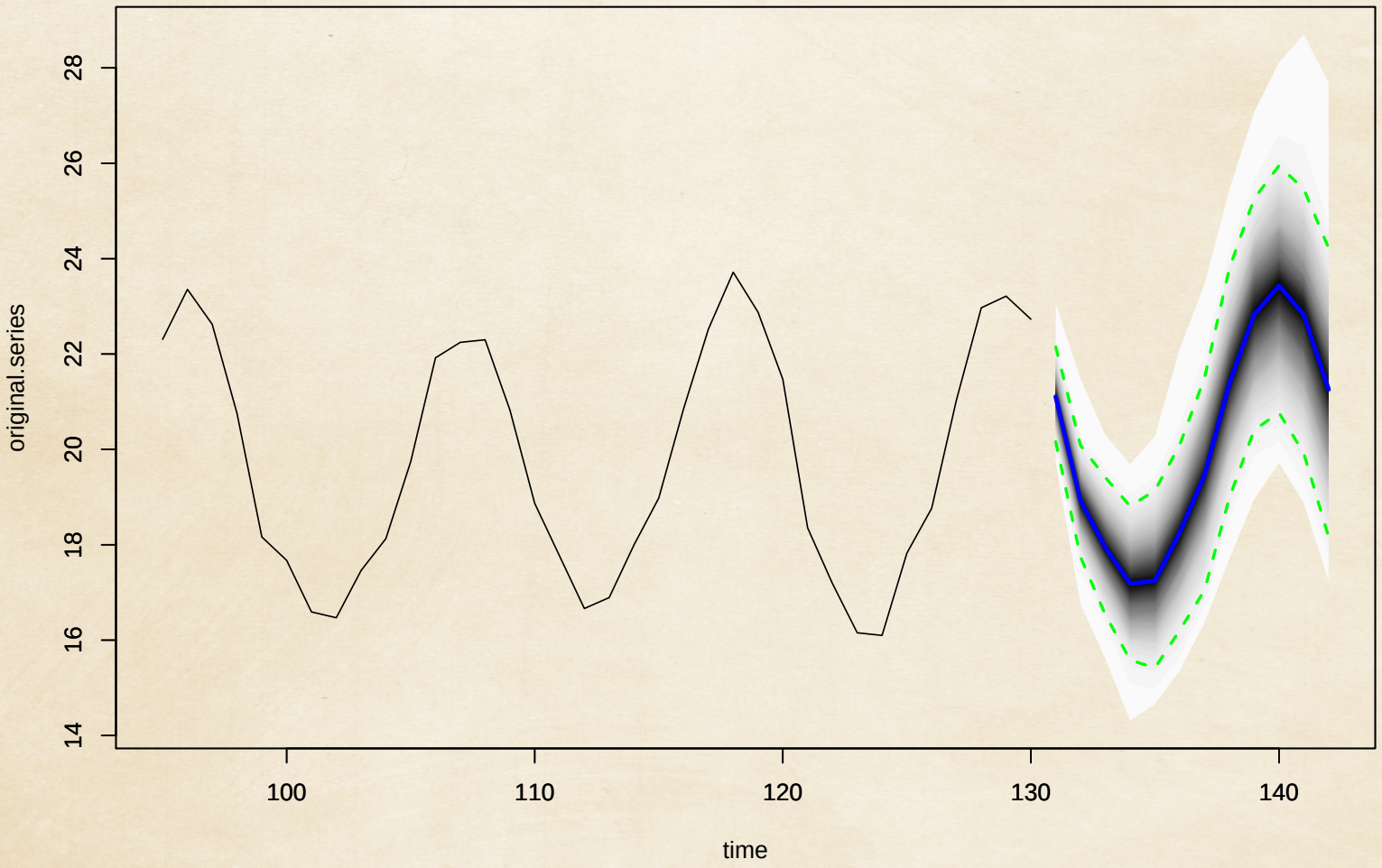
SST Data



Setup


```
library(readr)
library(bsts)
gib <- read_csv("./data/gilbralter_ts_reg.csv")
gib = gib[,-c(1,3)]
names(gib) = c("SST", "10m", "20m", "30m",
               "40m", "50m", "60m", "70m",
               "80m", "90m")
```

Local Trend With Seasonality and Regression

μ_t: local linear trend τ_t: seasonal component $\beta^T x_t$: regression component

$$y_t = \mu_t + \tau_t + \beta^T x_t + \varepsilon_t \qquad \varepsilon_t \sim N(0, \sigma_\varepsilon^2)$$

SST Data

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```
## # A tibble: 5 x 5
##       SST    `10m`    `20m`    `30m`    `40m`
##     <dbl>    <dbl>    <dbl>    <dbl>    <dbl>
## 1 17.16350 17.13767 17.12700 17.12233 17.11667
## 2 17.15525 17.03225 17.00650 16.96175 16.91225
## 3 17.30200 17.12400 17.02533 16.92900 16.78975
## 4 17.50700 17.12456 17.10000 17.04656 16.98300
## 5 18.60500 18.38300 17.91400 17.56489 17.29556
```

Forecasting Data


```
gib_train = gib[1:130,]
gib_test = gib[131:158,-1]
```

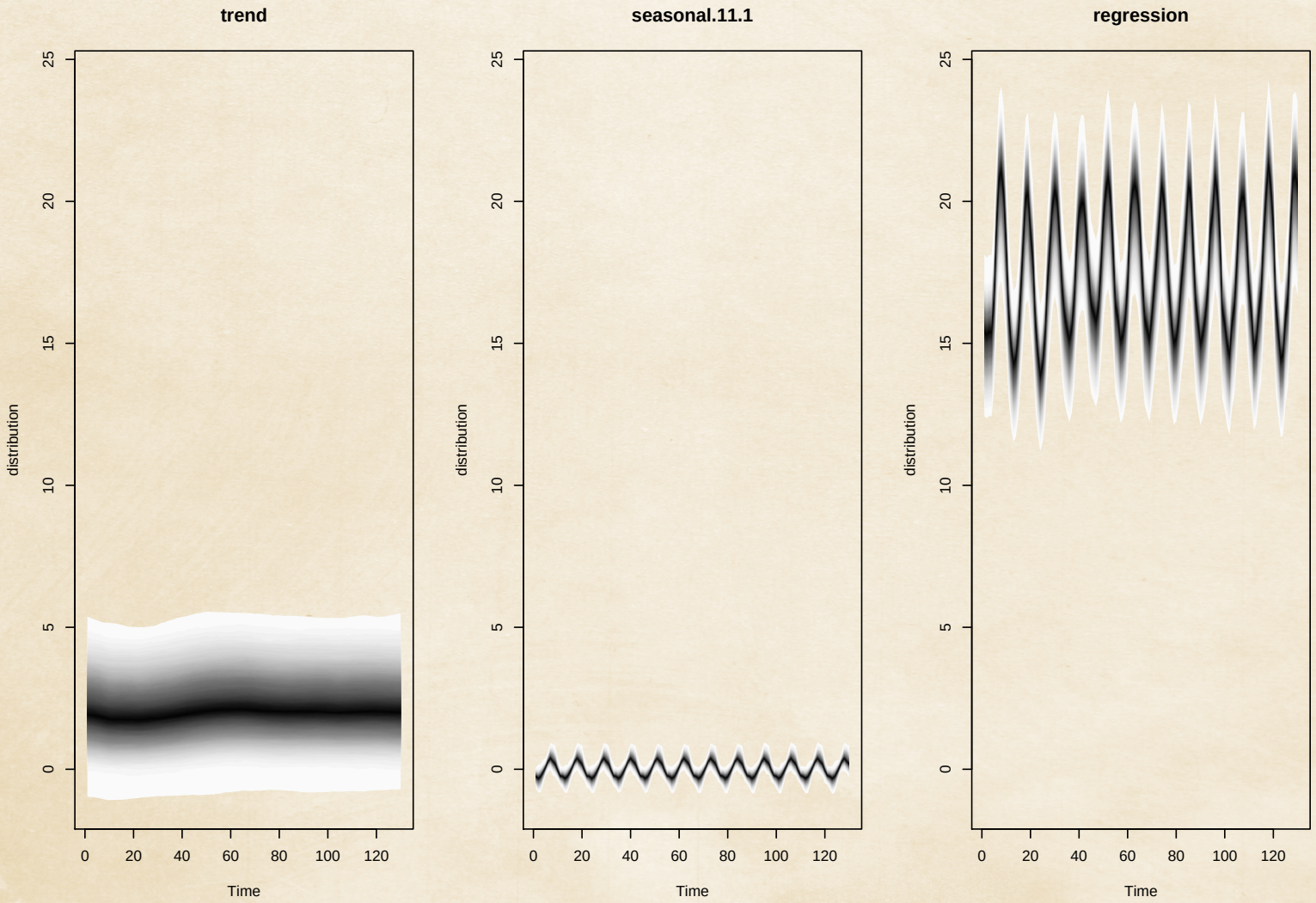
Model 1

Local linear, seasonal, and one linear component

```
nseasons = 11
ss <- list()
ss = AddLocalLinearTrend(ss, y=gib_train$SST)
ss = AddSeasonal(ss, gib_train$SST, nseasons=nseasons)
rlls_model = bsts(SST ~ ., state.specification=ss,
                  data=gib_train, niter=1000, ping=0,
                  expected.model.size=1)
```

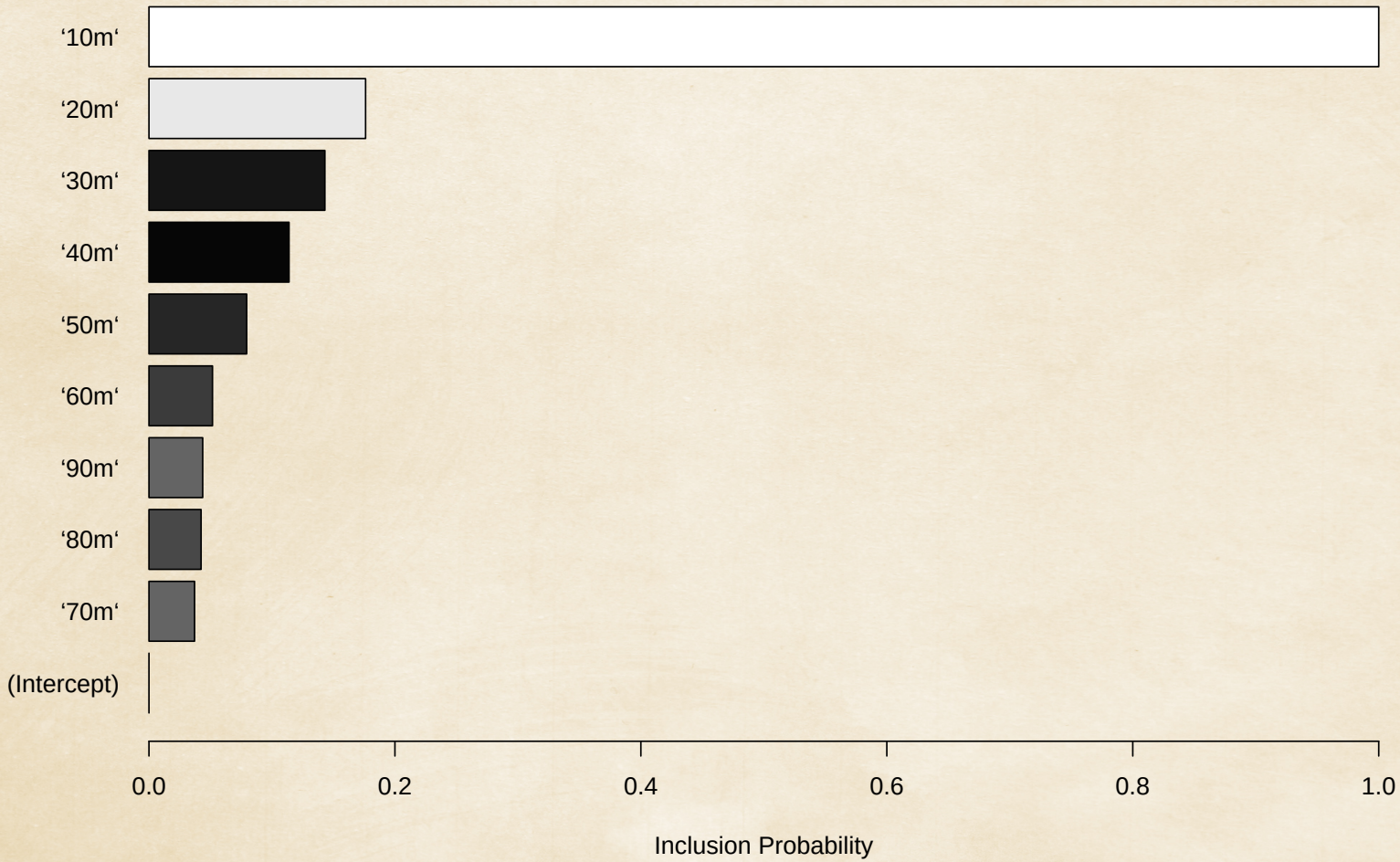
Component Plotting


```
plot(rlls_model, 'components')
```



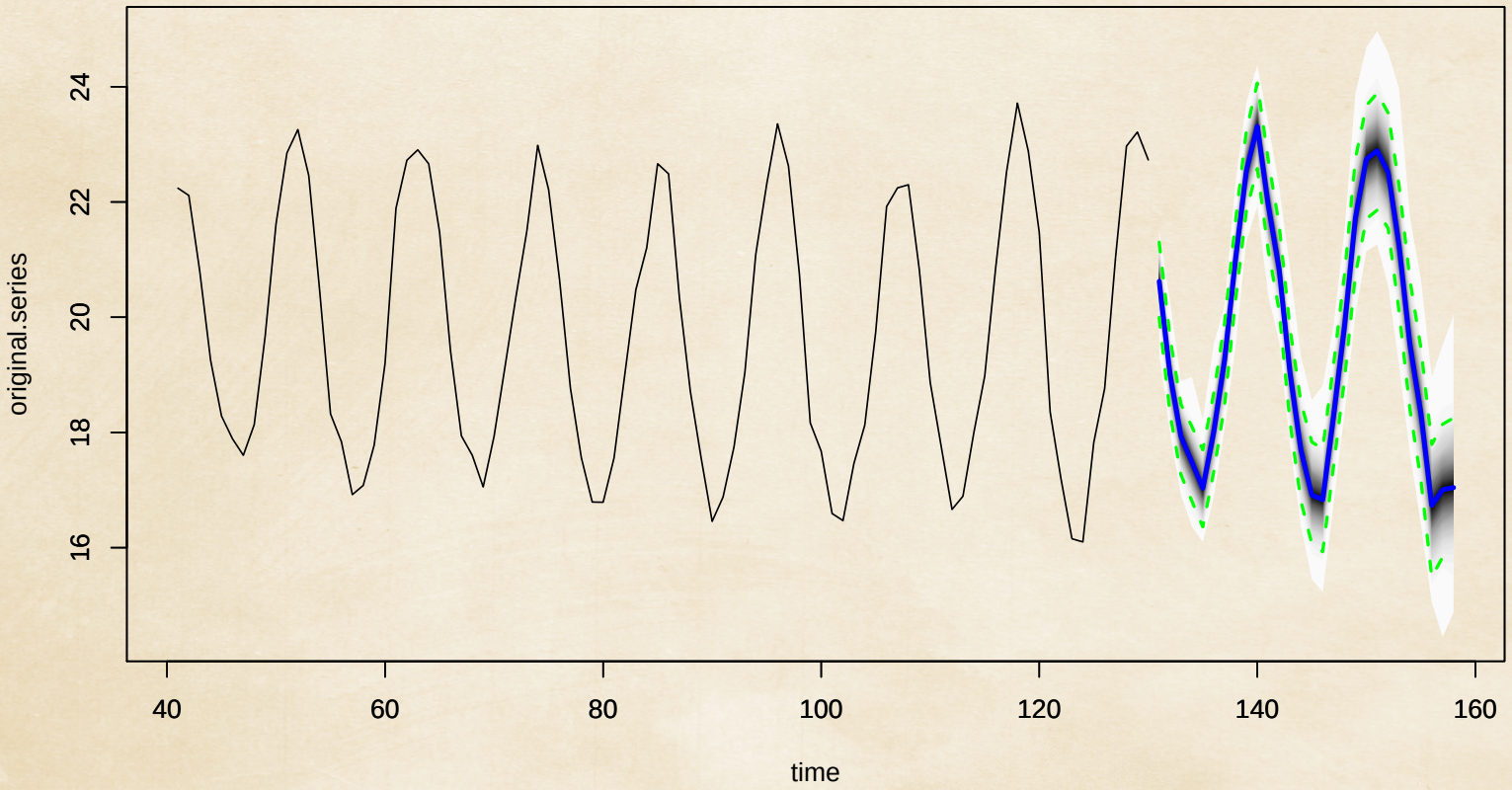
Covariate Significance


```
plot(rlls_model, 'coefficients')
```



Forcasting


```
rlls_model_pred = predict(rlls_model,
                          newdata=gib_test,
                          horizon = 28)
plot(rlls_model_pred, plot.original = 90)
```



Model 2

Local linear, seasonal and two linear component model

```
r2lls_model = bsts(SST ~ ., state.specification=ss,
                   data=gib_train, niter=1000, ping=0,
                   expected.model.size=2)
```

Model 3

Specifying inclusion probabilities

```
bp = c(.6,.3,.3,.3,.1,.1,.1,.1,.1,.1)
bp_model = bsts(SST ~ ., state.specification=ss,
                data=gib_train, niter=1000, ping=0,
                expected.model.size=2,
                prior.inclusion.probabilities=bp)
```

Model Comparisons

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```
CompareBstsModels(lwd = 4,
model.list = list("No reg." = lls_model,
"Model 1" = rlls_model, "Model 2" = r2lls_model,
"Model 3" = bp_model),
  colors = c("forestgreen","firebrick",
             "blue4", "black"))
```