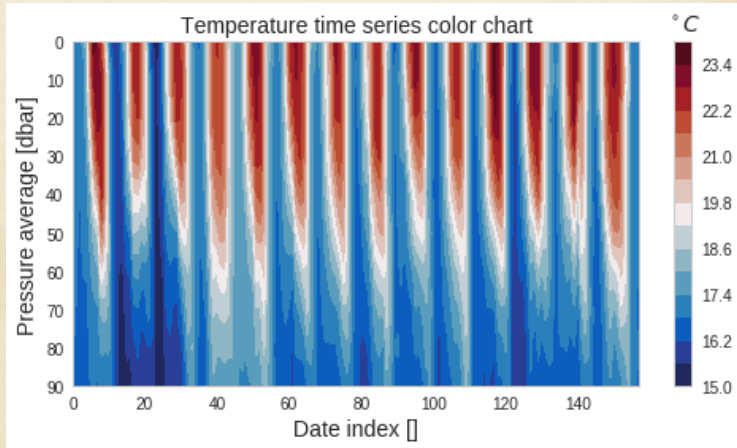




# Adventures in Bayesian Structural Time Series

## *Part 4: Analyzing SST Data With Regression*

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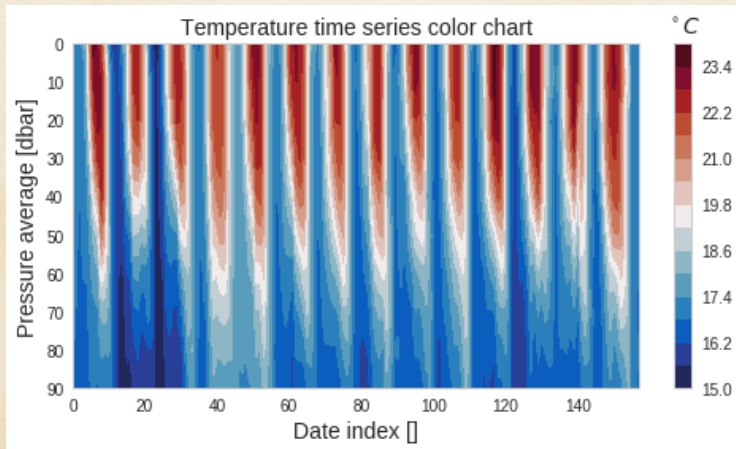




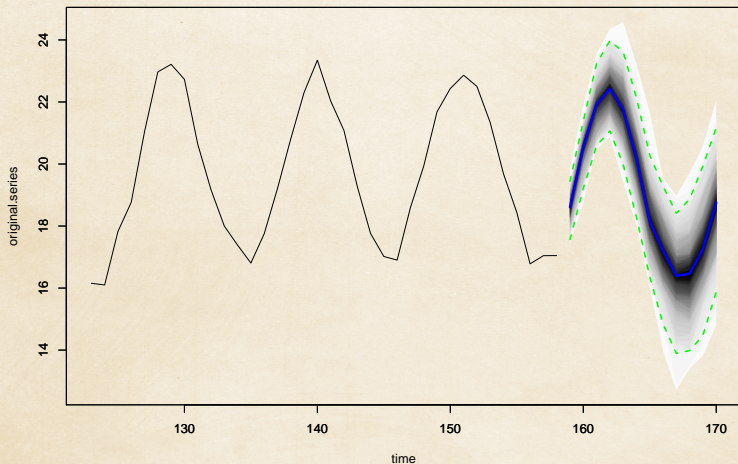
- ⊠ SST data with covariates
- ⊠ Use **bsts** to
  - ⊠ Fit structural model with regression
  - ⊠ Forecast
  - ⊠ Custom regresson prior



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









# Setup

```
library(readr)
library(bsts)

gib <- read_csv("data/gilbralter_ts_reg.csv",
               col_types=cols(startDate=col_skip(),
                             timeIdx=col_skip()))
names(gib) <- c('SST', '10', '20', '30', '40',
               '50', '60', '70', '80', '90')
gib <- zooreg(gib)
```



## Local Trend With Seasonality and Regression

$\mu_t$ : local linear trend  $\tau_t$ : seasonal component  $\beta_t^T x_t$ : regression component

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





##	SST	10	20	30	40
## 1	17.163	17.138	17.127	17.122	17.117
## 2	17.155	17.032	17.006	16.962	16.912
## 3	17.302	17.124	17.025	16.929	16.790
## 4	17.507	17.125	17.100	17.047	16.983
## 5	18.605	18.383	17.914	17.565	17.296



# Forecasting Data

```
newdata <- matrix(0, ncol=9, nrow=12)
newdata[1, ] <- colMeans(gib[, 2:10])
gib_sd <- apply(gib, 2, sd)
for(i in 2:12){
  for(j in 2:9){
    newdata[i, ] <- newdata[1, ] + rnorm(1, sd=gib_sd[j])}}
```



## Model 1

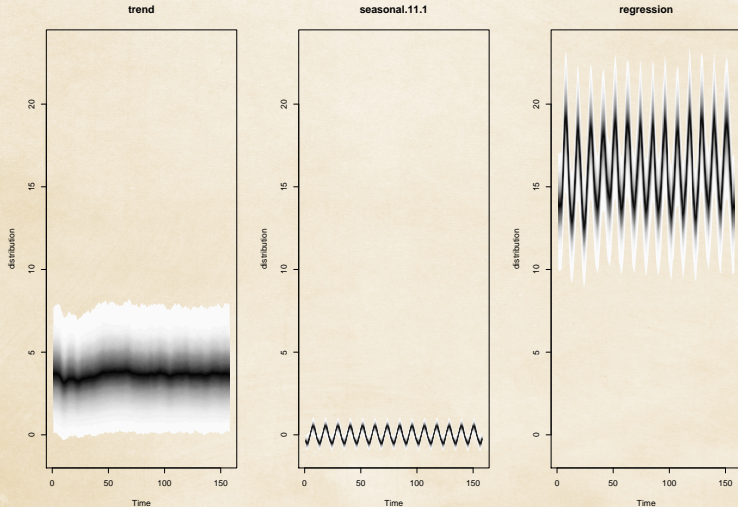
---

Local linear, seasonal, and one linear component

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

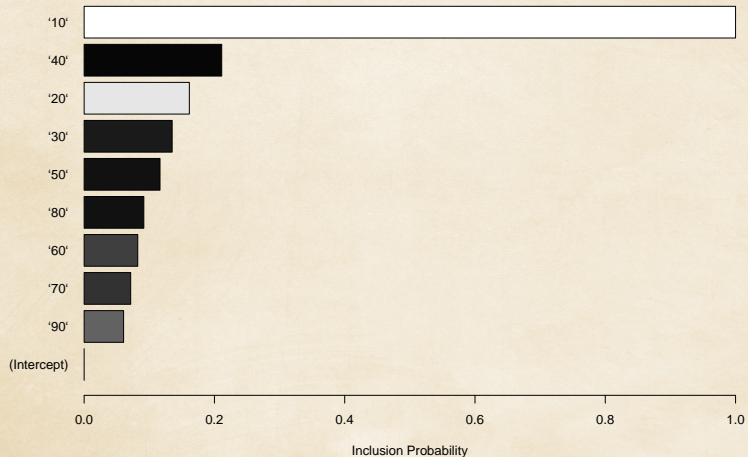


```
plot(rlls_model, 'components')
```





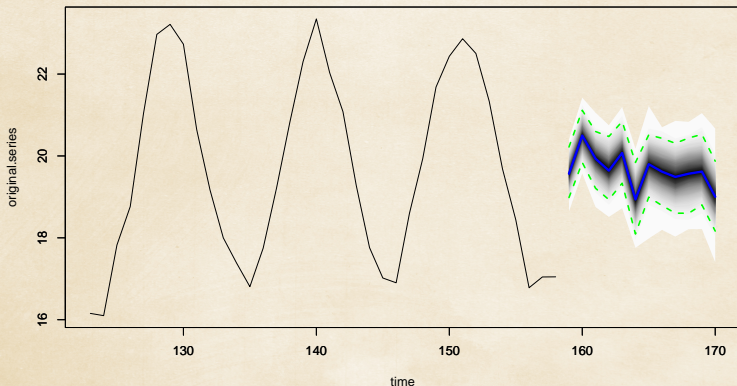
```
plot(rlls_model, 'coefficients')
```







```
rlls_model_pred <- predict(rlls_model,  
                           newdata=newdata, horizon=12)  
plot(rlls_model_pred, plot.original=36)
```







## Model 2

---

Local linear, and one linear component model

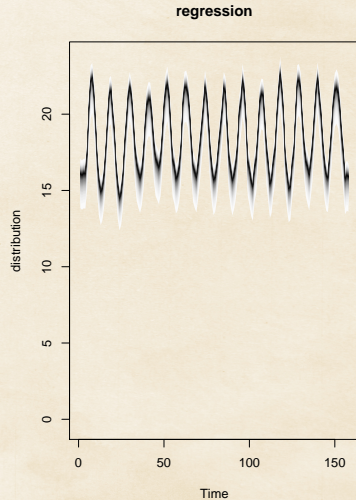
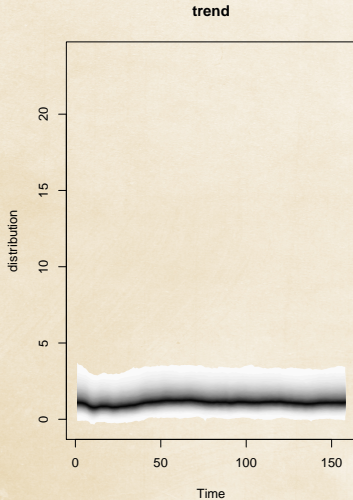
```
ss <- list()
ss <- AddLocalLinearTrend(ss, gib$SST)
rll_model <- bstts(SST ~., state.specification = ss,
                  data=gib, niter=1000, ping=0,
                  expected.model.size=1)
```

# Component Plotting



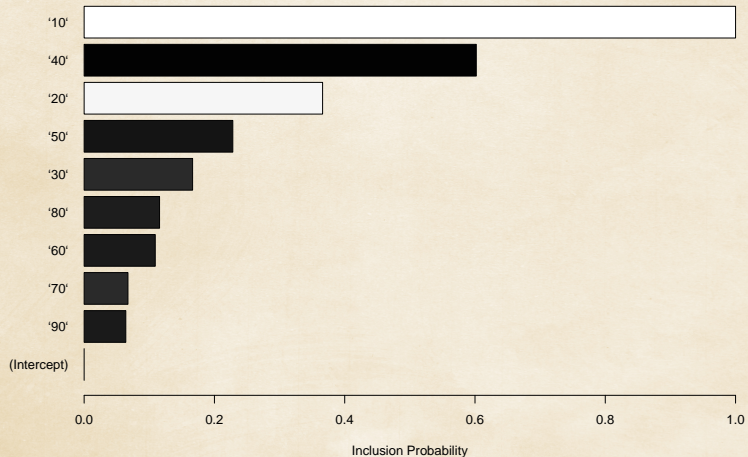
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```
plot(rll_model, 'components')
```



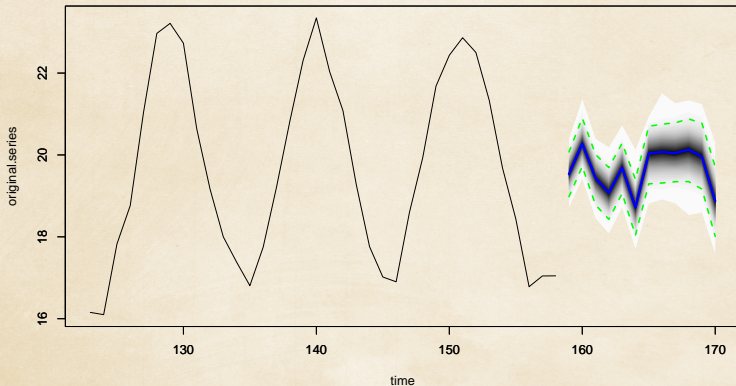


```
plot(rll_model, 'coefficients')
```





```
rll_model_pred <- predict(rll_model,  
                           newdata=newdata, horizon=12)  
plot(rll_model_pred, plot.original=36)
```





## Model 3

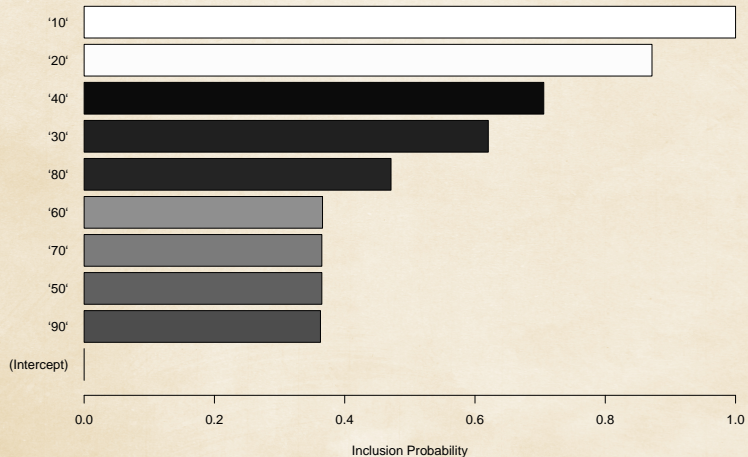
Local linear, and five linear component model

```
ss <- list()
ss <- AddLocalLinearTrend(ss, gib$SST)
r5ll_model <- bsts(SST ~., state.specification = ss,
                  data=gib, niter=1000, ping=0,
                  expected.model.size=5)
```





```
plot(r5ll_model, 'coefficients')
```







```
r5ll_model_pred <- predict(r5ll_model,  
                           newdata=newdata, horizon=12)  
plot(r5ll_model_pred, plot.original=36)
```

