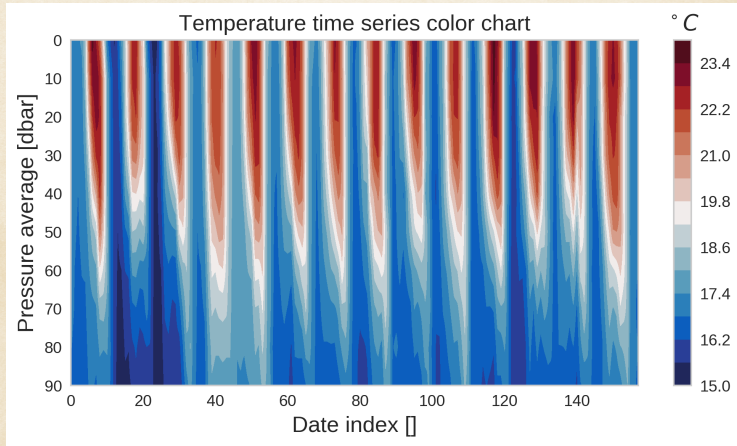




Adventures in Bayesian Structural Time Series

Part 4: Analyzing SST Data With Regression

Andrew Bates, Josh Gloyd, Tyler Tucker

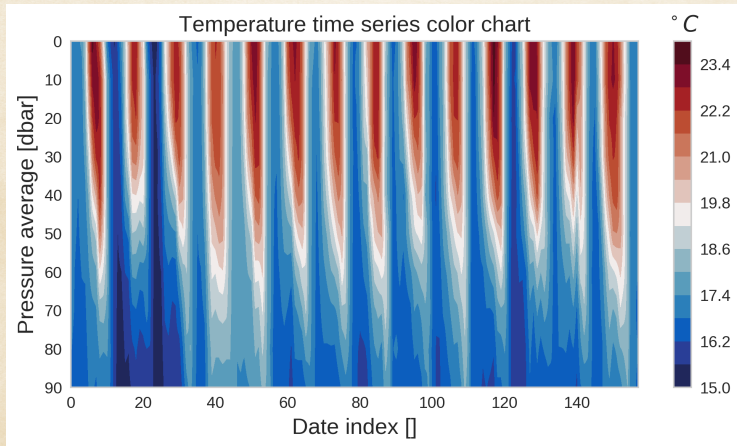




- ⊠ SST data with covariates
- ⊠ Use **bsts** to
 - ⊠ Fit structural model with regression
 - ⊠ Forecast
 - ⊠ Custom regresson prior

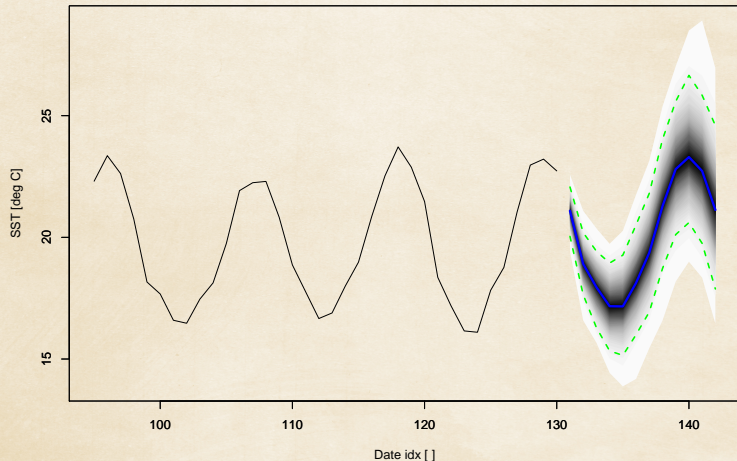


- ⊠ Sea Surface Temperature near Gibraltar
- ⊠ Aggregated monthly
- ⊠ January 2004 to November 2017
- ⊠ Covariates: 10 meter thick water layers at 10, 20, ..., 90 meters





Seasonal local linear trend forecasts





```
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

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



```
## # 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
```



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



Model 1

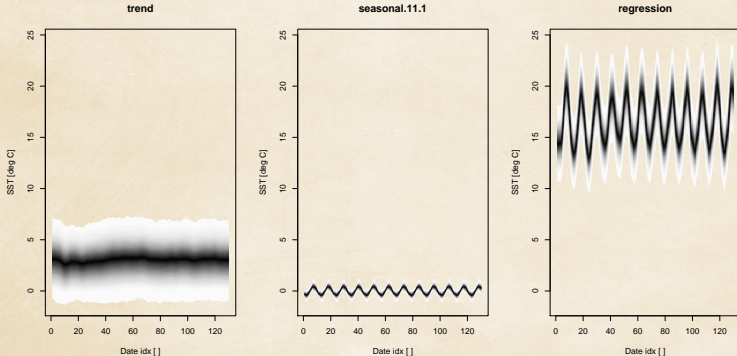
Local linear, seasonal, and one linear component

```
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)
```



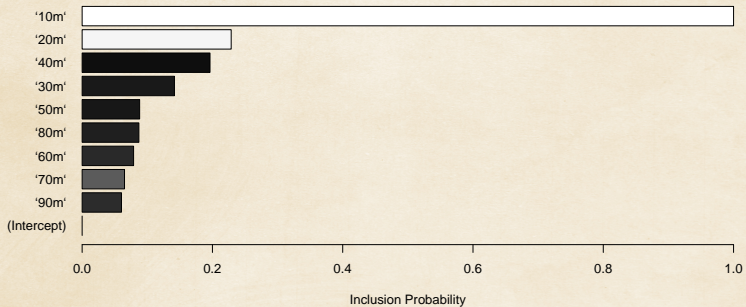
Component Plotting

```
plot(rlls_model, 'components',  
     xlab='Date idx [ ]',  
     ylab='SST [deg C]')
```





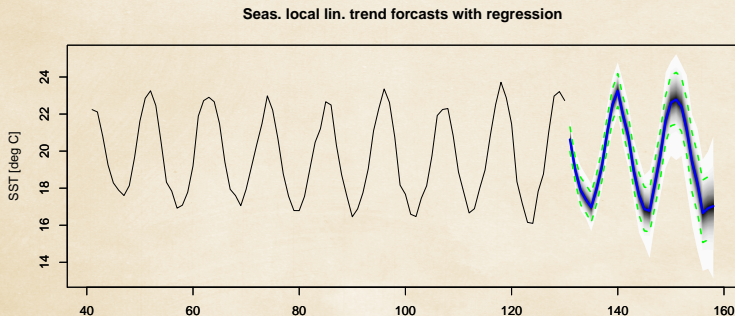
```
plot(rlls_model, 'coefficients')
```





Forecasting

```
rlls_model_pred = predict(rlls_model,newdata=gib_test,  
                           horizon = 28)  
plot(rlls_model_pred, plot.original = 90,  
     main='Seas. local lin. trend forecasts with regression  
     xlab='Date idx [ ]',  
     ylab='SST [deg C]')
```





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

```
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",  
                                "darkblue","black"),  
xlab='Date idx [ ]')
```

