Using R for oceanography

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Investigating Argo and animal-borne observations in the Southern Ocean using R

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The Southern Ocean

- connects major oceans and redistributes ocean properties
- crucial to global ocean and climate system
- problems with data collection (logistics, ice, rough weather)

(Lumpkin & Speer 2007)
Autonomous sampling devices: Argo

- Argo floats play important role
- Argo limitations south of 60°S (ice and advection)
Conductivity-temperature-depth satellite relay data loggers (CTD-SRDL’s)
Mapping with oce

- [https://github.com/dankelley/oce](https://github.com/dankelley/oce) [thanks & credit to Dan Kelley & Clark Richards]
- oce code to go from lon/lat space to x/y space

```r
b <- binCount2D(rlon, rlat, seq(-180, 180, 1), seq(-90, 90, 1))
dims <- dim(b$number)
llon <- b$xmids
llat <- b$ymids
R <- 6371
deg2rad <- pi/180
dlon <- diff(llon)[1]
dlat <- diff(llat)[1]
LON <- array(expand.grid(llon, llat)[,1], dim=dims)
LON1 <- LON - dlon/2
LON2 <- LON + dlon/2
LAT <- array(expand.grid(llon, llat)[,2], dim=dims)
LAT1 <- LAT - dlat/2
LAT2 <- LAT + dlat/2
A <- 2*pi*R^2 * abs(sin(LAT1*deg2rad) - sin(LAT2*deg2rad) ) * abs(LON1 - LON2)/360
normalizedCounts <- log10(b$number/A)
normalizedCounts[is.infinite(normalizedCounts)] <- NA
..."
Mapping with oce: all data (2004 - 2016)

Argo

Seal
Mapping with oce: all data (2004 - 2016)
Latitudinal comparison with `ggplot2`

- Overlaid histogram

```r
> ggplot(dat, aes(x = Lat, fill = Type)) +
  geom_histogram(binwidth = 0.5, alpha = 0.5, position = "identity") +
  theme(...) + xlab(...) + ylab(...)
```
Overlaid histogram

```r
> d_bg <- dat[, -4]  # Background Data - full without the 4th column (Type)
> ggplot(dat, aes(x = Lat, fill = Type)) +
  geom_histogram(data = d_bg, fill = "lightgrey", binwidth = 0.5, alpha = 0.5) +
  geom_histogram(...) + theme(...) + xlab(...) + ylab(...)
```

Latitudinal comparison with `ggplot2`
Kernel density distribution of seasonal profiles

- `density()` in `stats` package
Closer look at the data with oce

```r
> d <- read.argo("ct33-OO418-07_prof.nc")  # 1 seal track
> data(coastlineWorld)
> plot(d, ...)
```
> summary(d)

Argo Summary
------------
* Source: `/Volumes/AnnePortable2T/aaSealCTDdata/SealData/MEOP-CTD_2016-07-12/SOUTH-AFRICA/ncARGO/ct33-OO418-07_prof.nc`
* id: "00013668"
* Profiles: 300 delayed; 0 adjusted; 0 realtime
* Time ranges from 2008-02-22 16:40:00 to 2008-05-29 01:19:59 with 300 samples and mean step 7.734671 hours

* Statistics of data

<table>
<thead>
<tr>
<th></th>
<th>Min.</th>
<th>Mean</th>
<th>Max.</th>
<th>Dim.</th>
<th>OriginalName</th>
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</thead>
<tbody>
<tr>
<td>time</td>
<td>2008-02-22 18:40:00</td>
<td>2008-04-10 18:23:25</td>
<td>2008-05-29 03:19:59</td>
<td>300</td>
<td>-</td>
</tr>
<tr>
<td>latitude [\302\260N]</td>
<td>-62.231</td>
<td>-57.044</td>
<td>-46.777</td>
<td>300</td>
<td>-</td>
</tr>
<tr>
<td>longitude [\302\260E]</td>
<td>-13.476</td>
<td>2.8135</td>
<td>37.653</td>
<td>300</td>
<td>-</td>
</tr>
<tr>
<td>pressure [dbar]</td>
<td>6</td>
<td>186.88</td>
<td>1096</td>
<td>17x300</td>
<td>-</td>
</tr>
<tr>
<td>pressureAdjusted [dbar]</td>
<td>6</td>
<td>186.88</td>
<td>1096</td>
<td>17x300</td>
<td>-</td>
</tr>
<tr>
<td>pressureAdjustedError [dbar]</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>17x300</td>
<td>-</td>
</tr>
<tr>
<td>temperature [\302\260C, ITS-90]</td>
<td>-1.769</td>
<td>0.49298</td>
<td>7.235</td>
<td>17x300</td>
<td>-</td>
</tr>
<tr>
<td>temperatureAdjusted [\302\260C, ITS-90]</td>
<td>-1.769</td>
<td>0.49298</td>
<td>7.235</td>
<td>17x300</td>
<td>-</td>
</tr>
<tr>
<td>temperatureAdjustedError [\302\260C, ITS-90]</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>17x300</td>
<td>-</td>
</tr>
<tr>
<td>salinity [PSS-78]</td>
<td>33.728</td>
<td>34.354</td>
<td>34.752</td>
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<tr>
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<td>0.05</td>
<td>0.05</td>
<td>17x300</td>
<td>-</td>
</tr>
</tbody>
</table>

* Processing Log
- 2017-01-27 11:59:59 UTC: `create 'argo' object`
Closer look at the data with **oce**

```r
> argo <- argoGrid(handleFlags(d))  # remove bad data, and grid to regular pressure levels
> Tcm <- colormap(argo[['temperature']], col=oceColorsTemperature)
> imagep(argo[['latitude']], argo[['pressure']][,1], t(argo[['temperature']]), colormap=Tcm, flipy=TRUE, ...)
```
• Identify properties and characteristics of fronts using Argo and seal CTD data: comparisons

(constable et al. 2014)
Acknowledgments

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