Using R for oceanography

Anne Treasure and Katrin Tirok

(http://kiwi.psnc.pl)

(https://samspostgrads.wordpress.com)

(http://www.polemermediterranee.com)

(http://meop.net/meop-portal/pictures)

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

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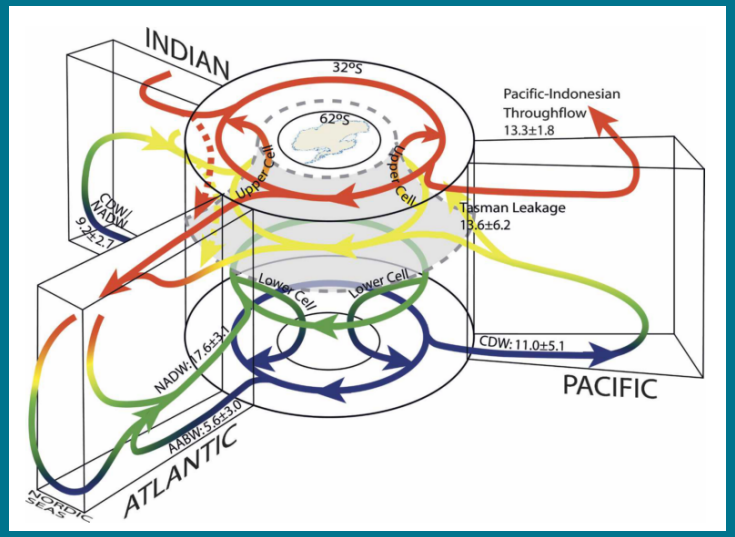
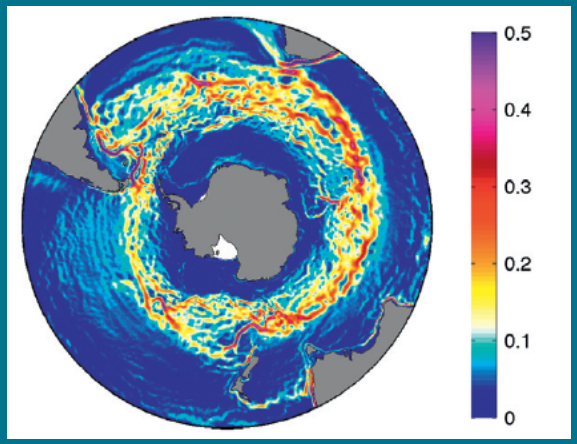
The Southern Ocean

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



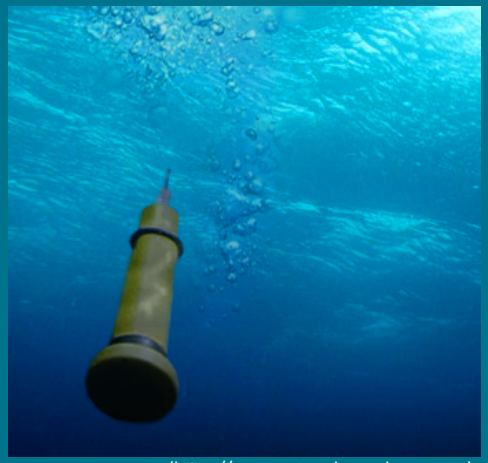
(Lumpkin & Speer 2007)



(Rintoul et al. 2013)

Autonomous sampling devices: Argo

- Argo floats play important role
- Argo limitations south of 60°S (ice and advection)



(https://samspostgrads.wordpress.com)

(http://www.argo.ucsd.edu/pictures.html)

(A. Treasure)

Conductivity-temperature-depth satellite relay data loggers (CTD-SRDL's)

(http://meop.net/meop-portal/pictures)

(http://meop.net/meop-portal/pictures)

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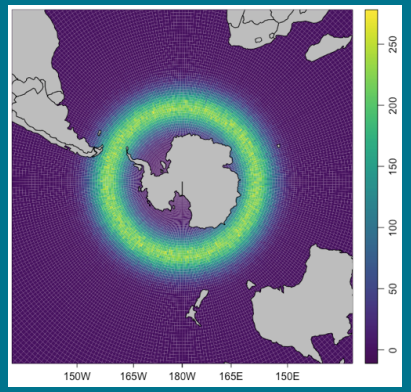
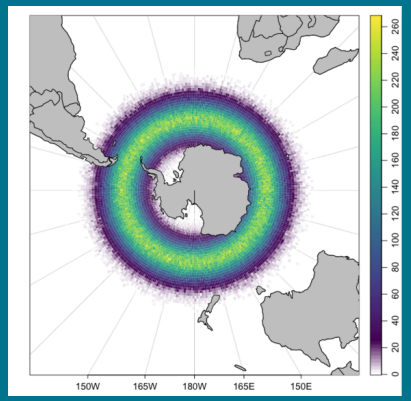
Mapping with *oce*

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

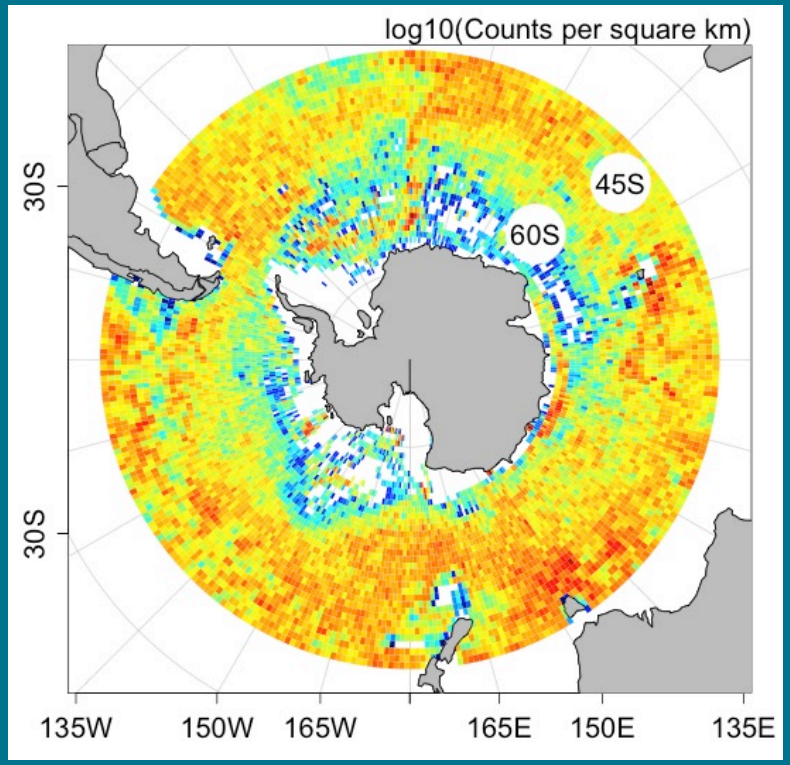
```
> b <- binCount2D(rlon, rlat, seq(-180, 180, 1), seq(-90, 90, 1))
> dims <- dim(b$number)
> llon <- b$xmids
> llat <- b$ymids
> R <- 6371
> deg2rad <- pi/180
> dlon <- diff(llon)[1]
> dlat <- diff(llat)[1]
> LON <- array(expand.grid(llon, llat)[,1], dim=dims)
> LON1 <- LON - dlon/2
> LON2 <- LON + 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$number/A)
> normalizedCounts[is.infinite(normalizedCounts)] <- NA
...
> cm <- colormap(normalizedCounts, col=oce.colorsJet, missingColor=NA, zlim = c(-4.0, -1.5))
> mapPlot(coastlineWorld, projection="+proj=stere +lat_0=-90", longitudelim=c(-180,180), latitudelim=c(-90,-39),col="lightgray")
> mapImage(b$xmids, b$ymids, normalizedCounts, colormap=cm)
> mapPolygon(coastlineWorld, col='lightgray', border = NA)
> drawPalette(colormap=cm, fullpage=TRUE, col=oce.colorsJet, zlim = c(-4.0, -1.5))
...
```

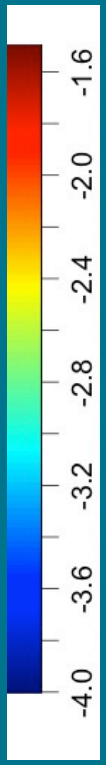




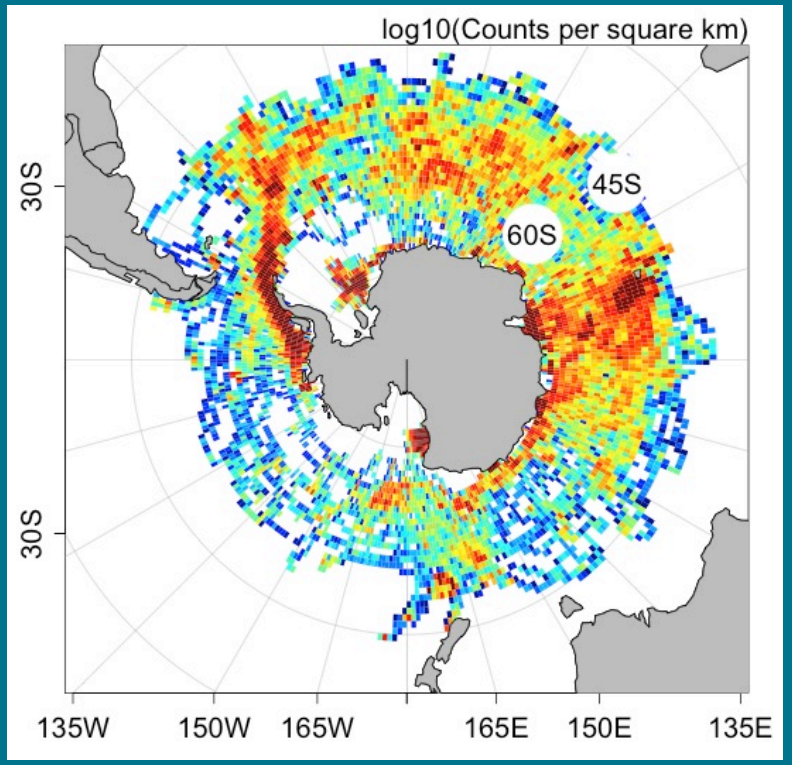
Mapping with *oce*: all data (2004 - 2016)

Argo



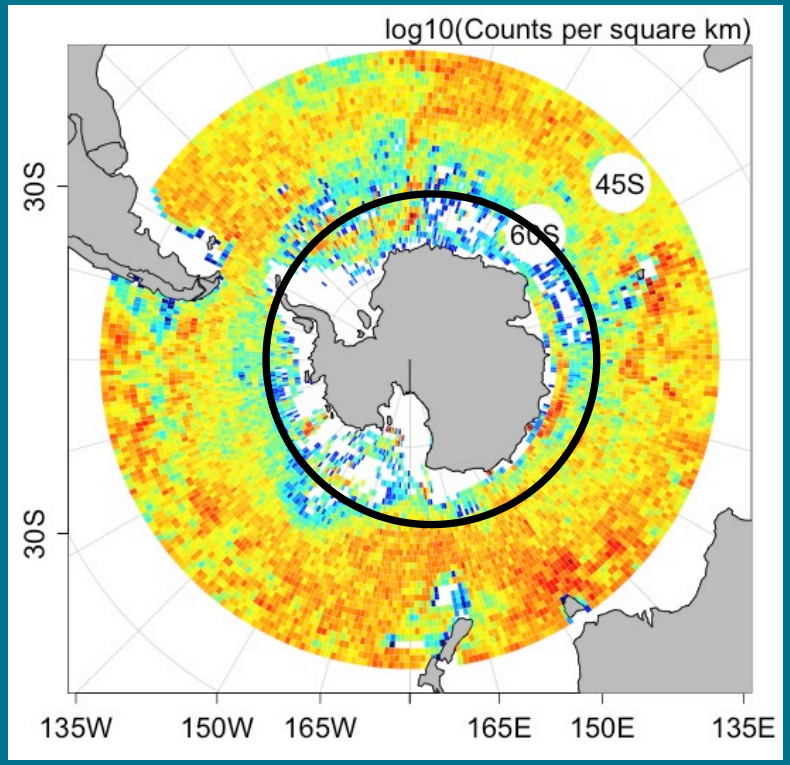


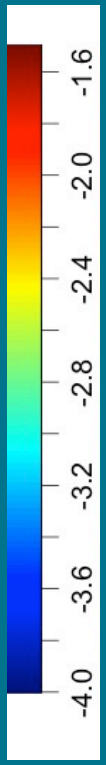
Seal



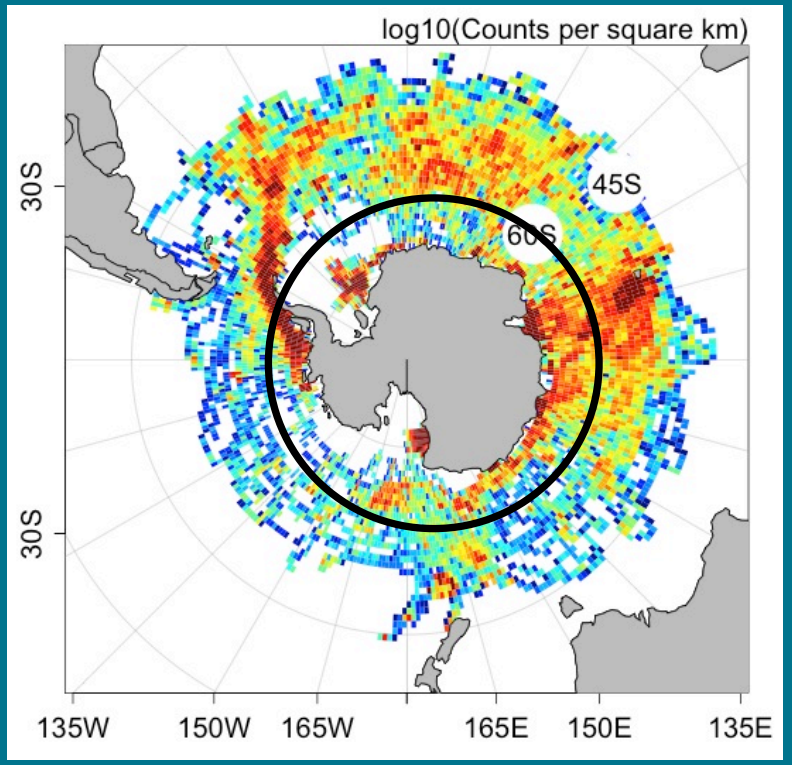
Mapping with *oce*: all data (2004 - 2016)

Argo





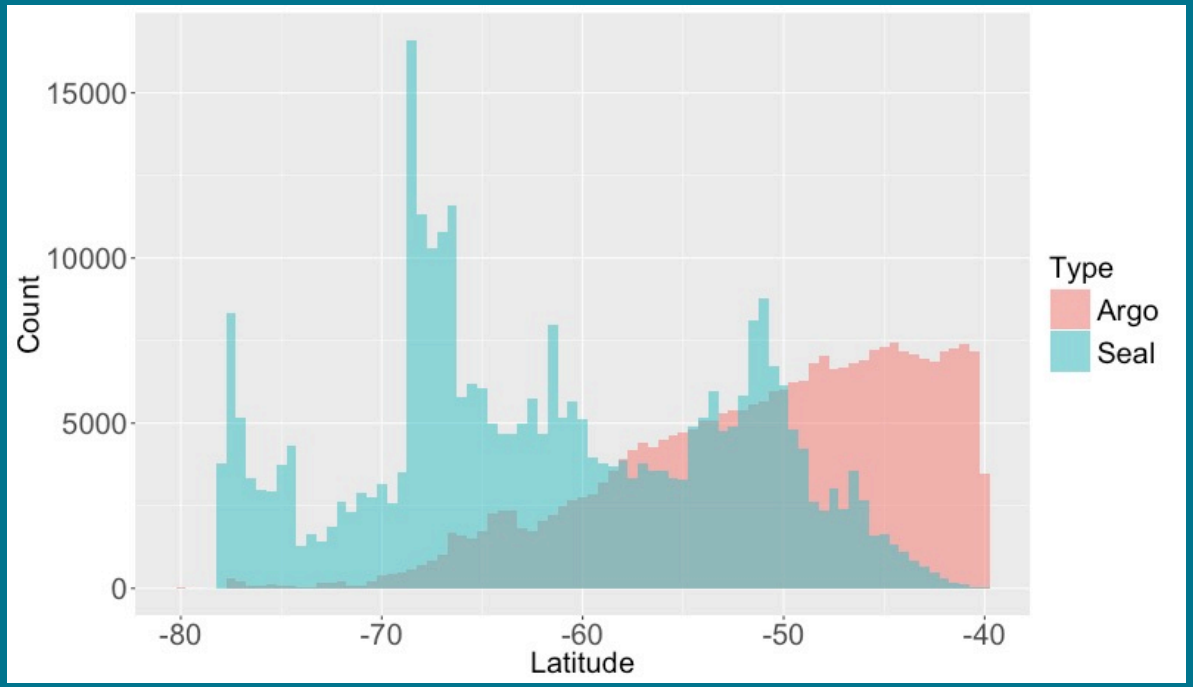
Seal



Latitudinal comparison with *ggplot2*

- Overlaid histogram

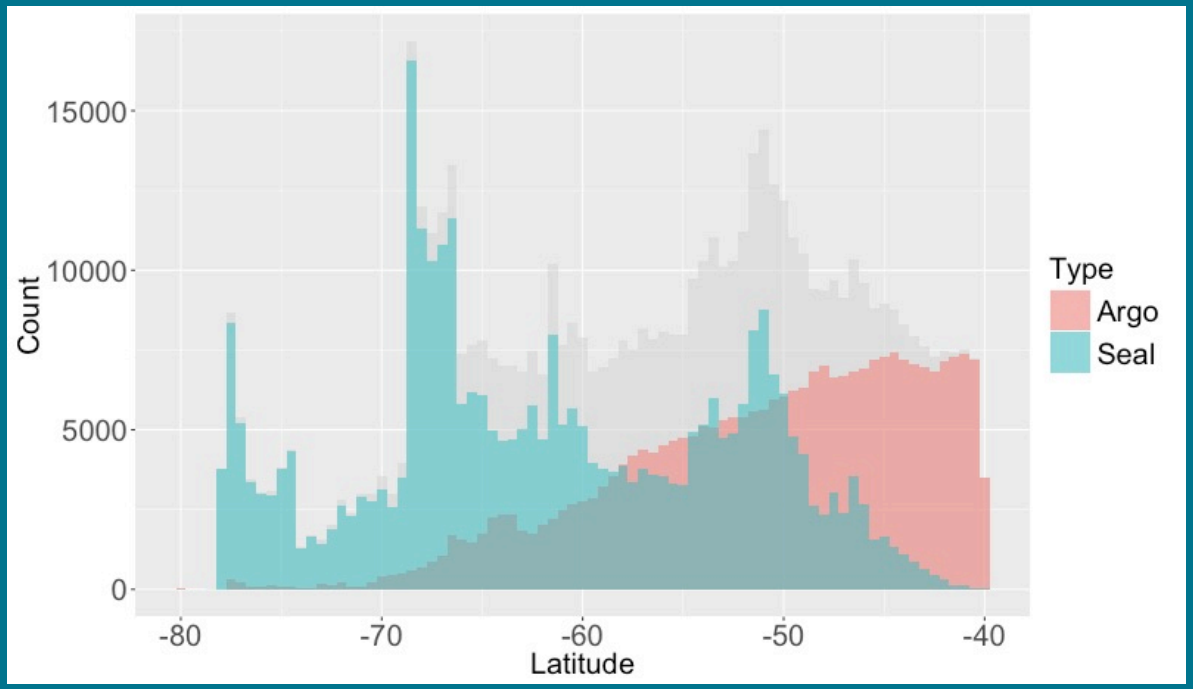
```
> ggplot(dat, aes(x = Lat, fill = Type)) +
        geom_histogram(binwidth = 0.5, alpha = 0.5, position = "identity") +
        theme(...) + xlab(...) + ylab(...)
```



Latitudinal comparison with *ggplot2*

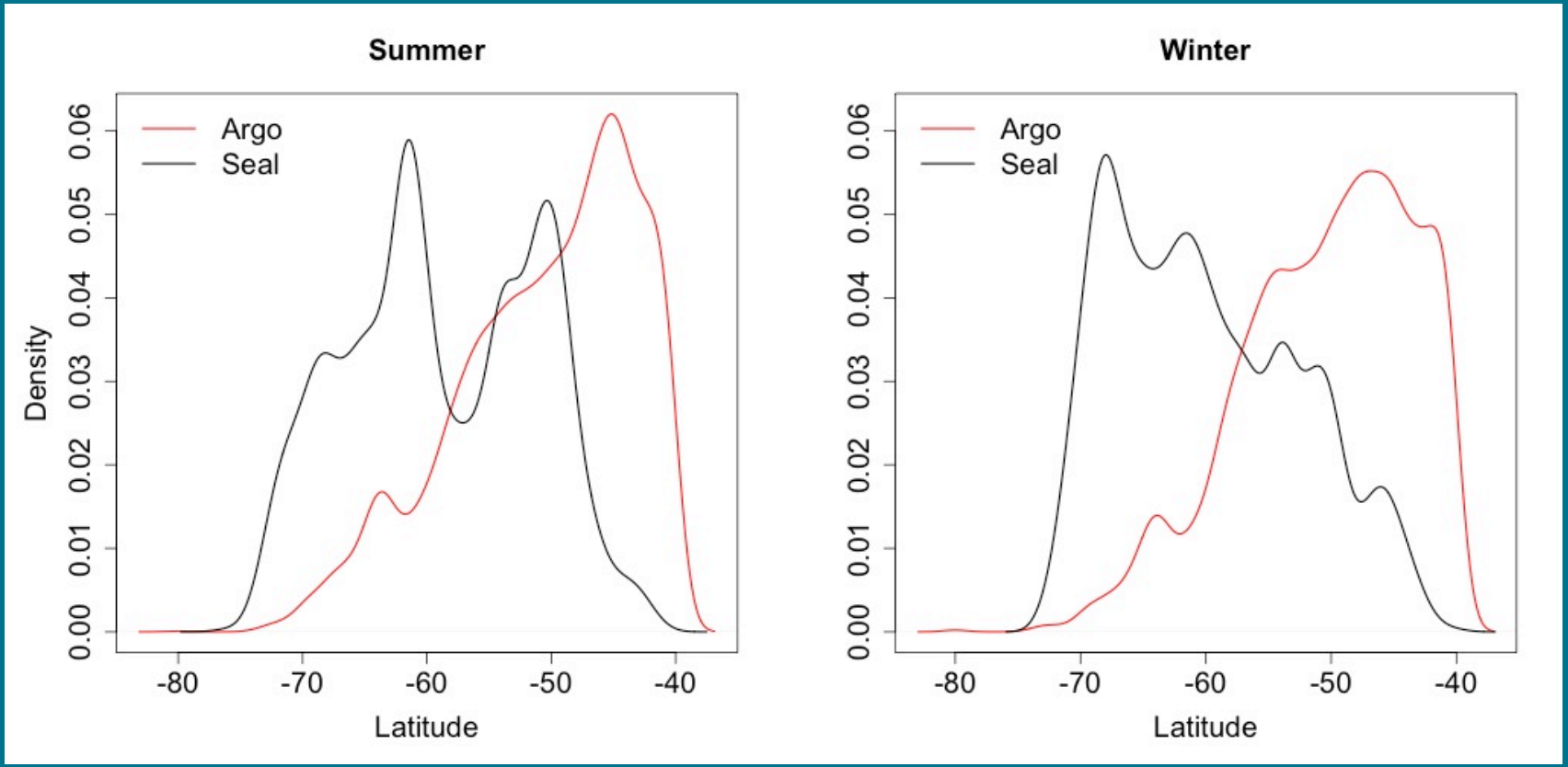
- Overlaid histogram

```
> 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(...)
```



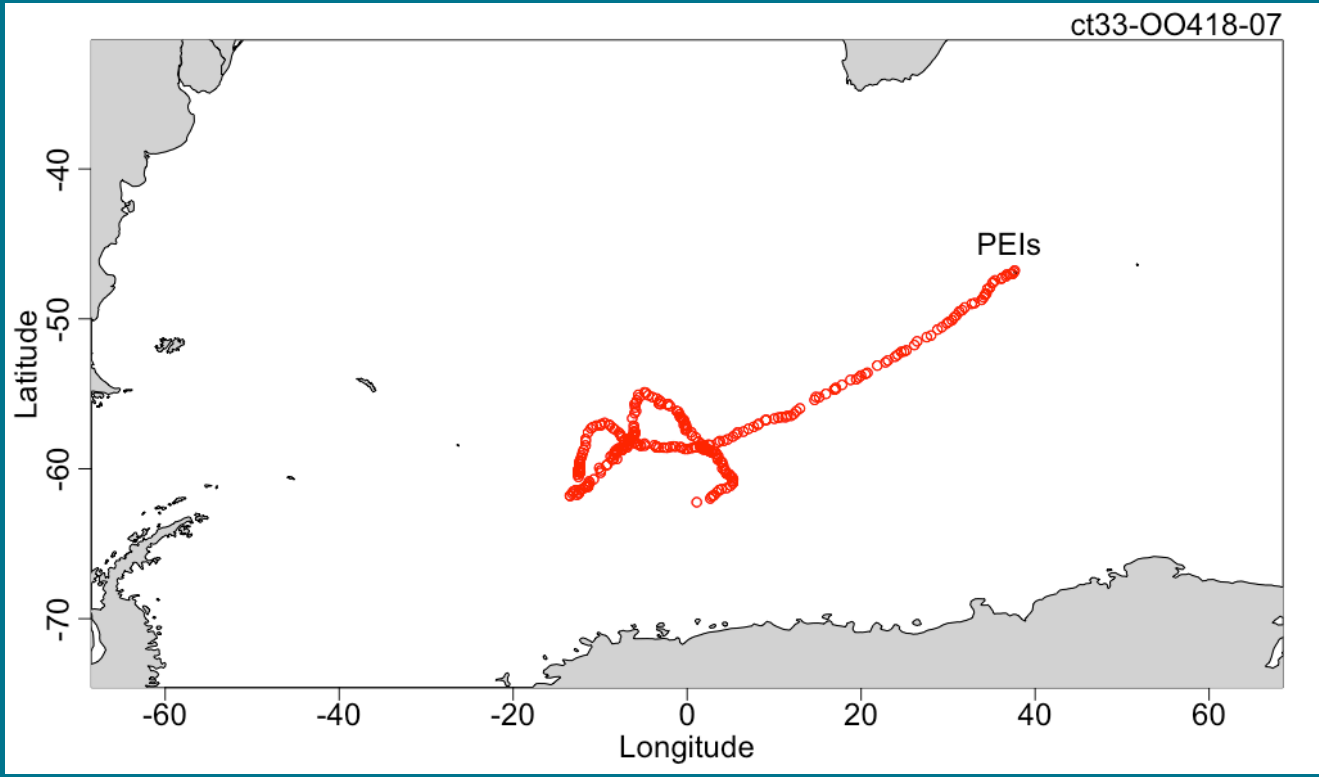
Kernel density distribution of seasonal profiles

- *density()* in *stats* package



Closer look at the data with *oce*

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



Closer look at the data with *oce*

> summary(d)

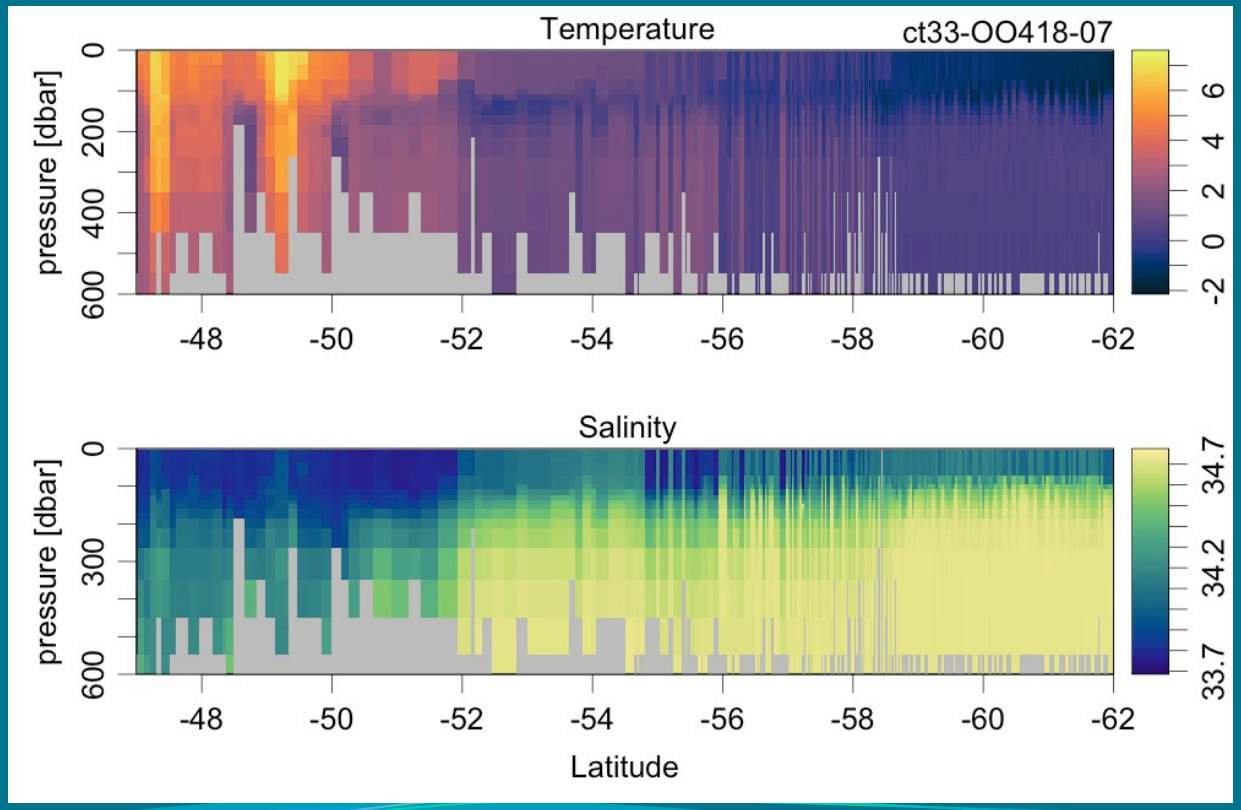
Argo Summary
---
* Source: `"/Volumes/AnnePortable2T/aaSealCTDdata/SealData/MEOP-CTD_2016-07-12/SOUTH-AFRICA/ncARGO/ct33-OO418-07_prof.nc"`
* id: "00013668"
* Profiles: 300 delayed; 0 adjusted; 0 realtime
* Time ranges from 2008-02-22 16:40:00 to 2008-05-29 01:19:59 with 300 samples and mean step 7.734671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

	Min.	Mean	Max.	Dim.	OriginalName
time	2008-02-22 18:40:00	2008-04-10 18:23:25	2008-05-29 03:19:59	300	-
latitude [\302\260N]	-62.231	-57.044	-46.777	300	-
longitude [\302\260E]	-13.476	2.8135	37.653	300	-
pressure [dbar]	6	186.88	1096	17x300	-
pressureAdjusted [dbar]	6	186.88	1096	17x300	-
pressureAdjustedError [dbar]	NA	NA	NA	17x300	-
temperature [\302\260C, ITS-90]	-1.769	0.49298	7.235	17x300	-
temperatureAdjusted [\302\260C, ITS-90]	-1.769	0.49298	7.235	17x300	-
temperatureAdjustedError [\302\260C, ITS-90]	0.05	0.05	0.05	17x300	-
salinity [PSS-78]	33.728	34.354	34.752	17x300	-
salinityAdjusted [PSS-78]	33.698	34.324	34.722	17x300	-
salinityAdjustedError [PSS-78]	0.05	0.05	0.05	17x300	-

```
* Processing Log
  - 2017-01-27 11:59:59 UTC: ``create 'argo' object``
  - 2017-01-27 11:59:59 UTC: ``read.argo(file = "ct33-OO418-07_prof.nc")``
```

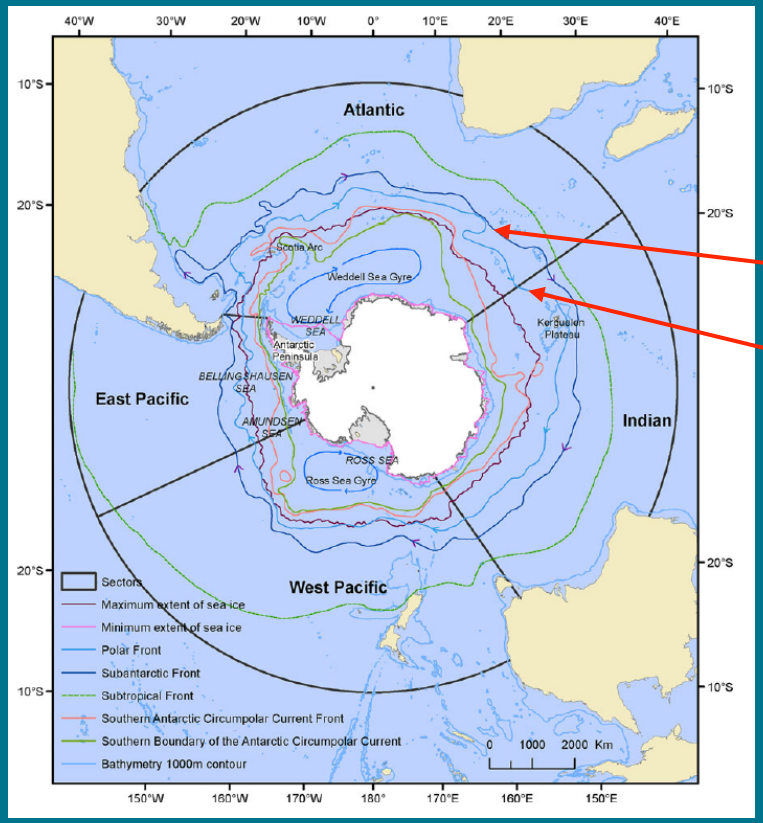
Closer look at the data with *oce*

```
> 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, ...)
```



Work in progress ...

- Identify properties and characteristics of fronts using Argo and seal CTD data: comparisons



Sub-Antarctic front

Polar front

(Constable et al. 2014)

Acknowledgments

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