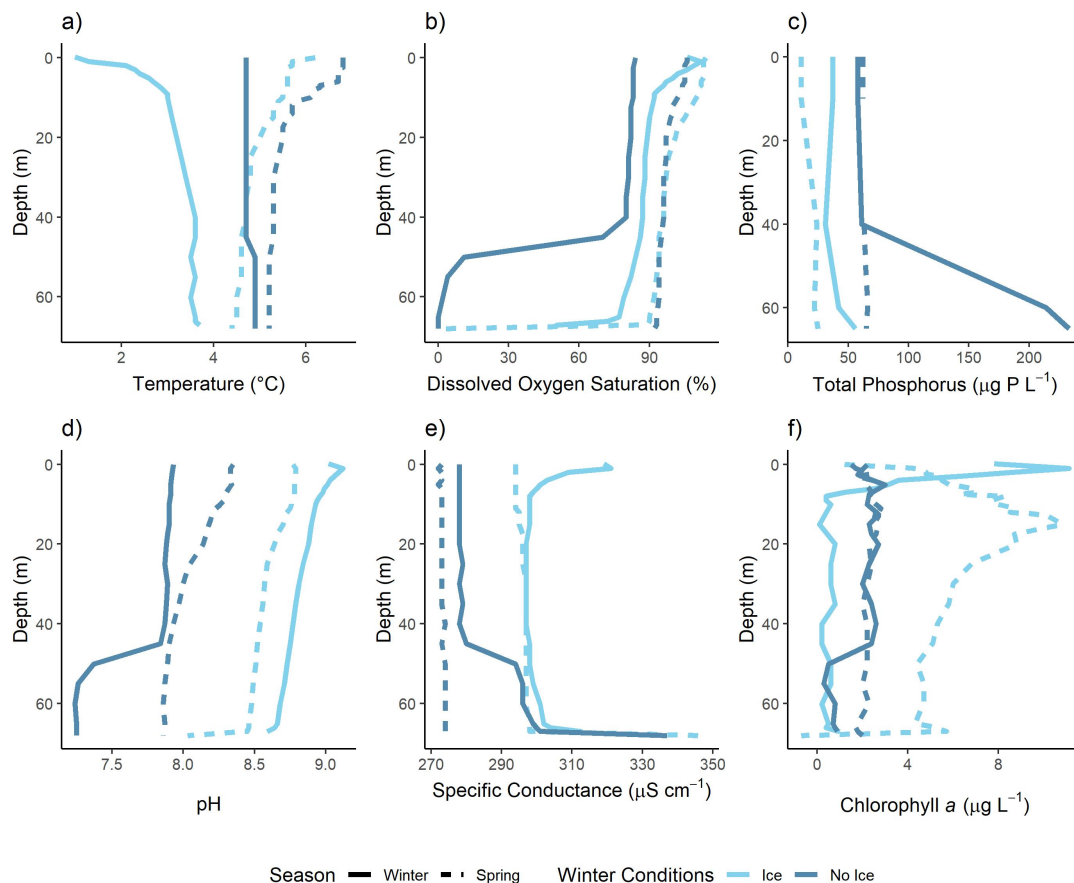


# Lake Stechlin winter and spring water column profiles addressing cross-seasonal linkages in cold and warm years 2012 and 2020 (The Lake Ice Continuum Concept)

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This dataset complements the case study of Lake Stechlin presented in *The Lake Ice Continuum Concept: Influence of Winter Conditions on Ecosystem Dynamics* published in the Journal of Geophysical Research - Biogeosciences.

Data was collected from Lake Stechlin, Germany, at the deepest point of the lake (53°09'20"N 13°02'52"E). The lake was ice covered in winter 2012 (15 cm) and ice-free in spring 2012, winter 2020, and spring 2020 during the measurement. Vertical profiles of temperature, dissolved oxygen saturation, pH, specific conductivity and chlorophyll-a were measured in 0.5-1 m intervals by multi-parameter probes YSI 6000 in 2012 and YSI EXO in 2020 (YSI, Yellow Springs, OH, USA). Water samples in discrete depths (5 m intervals) were used to determine total phosphorus (TP) concentrations, measured by flow injection analysis (FIA Foss FIAstar 5000 Analyzer, Foss Analytical AB, Höganäs, Sweden, ISO 15681-1:2003). Water clarity was measured by Secchi disc readings (white disc 25 cm diameter) using a bathyscope to reduce the impact of refraction and glittering.



## R-Script

```
#Packages:-----
library(tidyverse)
library(ggpubr)
library(lubridate)
library(patchwork)
library(gridExtra)
library(grid)
library(scales)

#winter and spring stechlin plots:----
stech<-read.csv("./Stechlin Data_Stella and Isabelle/Lake_Stechlin_case_study.csv",
header=T)

#remove non-column name rows rows:----
colnames(stech) <- as.character(unlist(stech[1,]))
summary(stech)
head(stech)

stech =stech[-c(1:4), ]
tail(stech)
#rename columns:----
names(stech)
colnames(stech)[2]<-"Depth"
colnames(stech)[3]<-"temp"
colnames(stech)[4]<-"DO_percent"
colnames(stech)[5]<-"pH"
colnames(stech)[6]<-"cond"
colnames(stech)[7]<-"chla"
colnames(stech)[8]<-"tp"

#other cleaning:----
summary(stech)
names(stech)

df <- data.frame(apply(stech[c(2:8)], 2, function(x) as.numeric(as.character(x))))
date<-as.Date(stech$date, format="%Y-%m-%d")
stech<-cbind(date,df)
summary(stech)

stech<-subset(stech, Depth <68)

#add season factor----
stech$Season<-NULL

stech$Season<-ifelse(stech$date %in% c(as.Date("2012-02-15"),as.Date("2020-02-
05")), "Winter", "Spring")
```

```
stech$Season = factor(stech$Season,levels=c("Winter","Spring"))
levels(stech$Season) <-c("Winter", "Spring")
```

```
stech$year<-year(stech$date)
summary(stech$year)
stech$winter.conditions = NULL
stech$winter.conditions<-ifelse(stech$year==2012, "Ice","No Ice")
levels(as.factor(stech$winter.conditions))
stech$winter.conditions<-as.factor(as.character(stech$winter.conditions))
stech<-droplevels(subset(stech,!is.na(winter.conditions)))
```

```
#colors:----
#open-water: #5389ac rgb(83,137,172)
#clear ice: #82d2ee rgb(130, 210, 238)
#snow and ice: #b8c6c9 rgb(184, 198, 201)
#vendy changed:
#grey60, #5CCBEF, and #005889
```

```
#plots:----
summary(stech$winter.conditions)
temp<-ggplot(stech)+
  geom_path(aes(y=Depth, x=temp, color=winter.conditions, linetype=Season),
size=1.5)+
  #geom_point(aes(y=Depth, x=temp, color=winter.conditions), size=1.5)+
  scale_color_manual(values = c('#82d2ee','#5389ac')) +
  #geom_point(aes(x=Depth, y=Light_lum_ft2, color=season_yr))+
  # ylab("Depth (m)")+
  # xlab("Analyte measurement")+
  labs( x = "Temperature (°C)", y = "Depth (m)", color = "Winter Conditions") +
  scale_y_continuous(trans = "reverse")+
  ggtitle("a")+
  #theme(legend.position="none")+
  #facet_wrap(~analyte, scales="free_x")+
  theme_classic2()
temp
names(stech)
```

```
xtitle <- expression(atop(paste("Specific Conductance", " (",mu, "S ", cm^-1,")"))
cond<-ggplot(stech)+
  geom_path(aes(y=Depth, x=cond, color=winter.conditions, linetype=Season),
size=1.5)+
  #geom_point(aes(x=Depth, y=Light_lum_ft2, color=season_yr))+
  # ylab("Depth (m)")+
  # xlab("Analyte measurement")+
  labs( y = "Depth (m)", color = "Winter Conditions") +
  # xlab(bquote('Specific Conductance (*mu~'S' ~ cm^-1*')))+
```

```

xlab(xtitle)+
scale_y_continuous(trans = "reverse")+
ggtitle("e")+
scale_color_manual(values = c('#82d2ee','#5389ac')) +
theme_classic2()+theme(legend.position="none")
# theme(legend.position="top",legend.box = "horizontal",
#   legend.title = element_text(color = "black", size = 20),
#   legend.text = element_text(color = "black", size = 18),
#   legend.key.size = unit(3,"cm"))

cond

#dev.off()
names(stech)
ph<-ggplot(stech)+
  geom_path(aes(y=Depth, x=pH, color=winter.conditions, linetype=Season),
size=1.5)+
  #geom_point(aes(x=Depth, y=Light_lum_ft2, color=season_yr))+
  # ylab("Depth (m)")+
  # xlab("Analyte measurement")+
  labs( y = "Depth (m)", color = "Winter Conditions") +
  xlab("pH")+
  ggtitle("d")+
  scale_y_continuous(trans = "reverse")+
  scale_color_manual(values = c('#82d2ee','#5389ac')) +
  #theme(legend.position="none")+ #facet_wrap(~analyte, scales="free_x")+
  theme_classic2()+theme(legend.position="none")
ph
levels(as.factor(stech$date))
names(stech)
chl<-ggplot(stech)+
  # annotate("rect",xmin=-Inf, xmax=Inf, ymin=0,ymax=10.5, alpha=0.3,
fill='lightgoldenrod3')+
  # annotate("rect",xmin=-Inf, xmax=Inf, ymin=10.5,ymax=15.9, alpha=0.3,
fill='lightgoldenrod1')+
  geom_path(aes(y=Depth, x=chl, color=winter.conditions, linetype=Season),
size=1.5)+
  #geom_point(aes(x=Depth, y=Light_lum_ft2, color=season_yr))+
  # ylab("Depth (m)")+
  # xlab("Analyte measurement")+
  labs( y = "Depth (m)", color = "Winter Conditions") +
  ggtitle("f")+
  xlab(bquote(paste('Chlorophyll ',italic("a"), ' ( ' *mu,'g ', L^-1*')')))+
  scale_y_continuous(trans = "reverse")+
  scale_color_manual(values = c('#82d2ee','#5389ac')) +
  # annotate("text", x=0.4, y=2.5, label= bquote(paste('No Ice ', Z[eu], "= 10.5 m")))+
  # annotate("text", x = 0.5, y=12, label = bquote(paste('Clear Ice ', Z[eu], "=15.9
m")))+
  xlim(0, max(stech$chl, na.rm = T))+
  #theme(legend.position="none")+

```

```
#facet_wrap(~analyte, scales="free_x")+  
theme_classic2()+theme(legend.position="none")  
chl
```

```
#Zeu winter ice cover: 2020: 10.5m (no ice); 2012: 15.9 m (ice)
```

```
dosat<-ggplot(stech)+  
  geom_path(aes(y=Depth, x=DO_percent, color=winter.conditions,linetype=Season),  
size=1.5)+  
  #geom_point(aes(x=Depth, y=Light_lum_ft2, color=season_yr))+  
  # ylab("Depth (m)")+  
  # xlab("Analyte measurement")+  
  labs( y = "Depth (m)", color = "Winter Conditions") +  
  ggtitle("b")+  
  xlab("Dissolved Oxygen Saturation (%)")+  
  scale_y_continuous(trans = "reverse")+  
  scale_color_manual(values = c('#82d2ee','#5389ac')) +  
  #facet_wrap(~analyte, scales="free_x")+  
  theme_classic2()+theme(legend.position="none")  
dosat
```

```
#nutrients:
```

```
#tp:
```

```
tapply(stech$tp *1000, stech$Depth, median, na.rm=T)  
names(stech)  
names(stech)  
tp<-ggplot(na.omit(stech))+  
  geom_path(aes(y=Depth, x=tp*1000, color=winter.conditions, linetype=Season),  
size=1.5)+  
  #geom_point(aes(x=Depth, y=Light_lum_ft2, color=season_yr))+  
  # ylab("Depth (m)")+  
  # xlab("Analyte measurement")+  
  labs( y = "Depth (m)", color = "Winter Conditions") +  
  ggtitle("c")+  
  xlab(bquote(paste('Total Phosphorus (' *mu,'g P ', L^-1*'))))+  
  scale_y_continuous(trans = "reverse")+  
  scale_color_manual(values = c('#82d2ee','#5389ac'), guide=F) +  
  #theme(legend.position="none")+  
  #facet_wrap(~analyte, scales="free_x")+  
  theme_classic2()+theme(legend.position="none");tp
```

```
summary(na.omit(stech))
```

```
#combine plots:----
```

```
combined <-temp+dosat+tp+ph+cond+chl& theme(legend.position = "bottom",  
legend.direction = "horizontal")  
stech_plot<-combined + plot_layout(guides = "collect")  
stech_plot
```

```
jpeg(filename = "20210117 stechlin_winter_spring.jpeg", res=300, unit="cm", width =  
24, height=20)  
stech_plot  
dev.off()
```

Photo from Lake Stechlin 11<sup>th</sup> of April 2020 (Stella A. Berger)

