

Supplemental material 3 - Statistical analysis and plots

Lucas Krüger

2024-02-08

```
library(ggplot2)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##   filter, lag
```

```
## The following objects are masked from 'package:base':
##
##   intersect, setdiff, setequal, union
```

```
library(patchwork)
library(car)
```

```
## Loading required package: carData
```

```
##
## Attaching package: 'car'
```

```
## The following object is masked from 'package:dplyr':
##
##   recode
```

```
library(lmerTest)
```

```
## Loading required package: lme4
```

```
## Loading required package: Matrix
```

```
##
## Attaching package: 'lmerTest'
```

```
## The following object is masked from 'package:lme4':
##
##   lmer
```

```
## The following object is masked from 'package:stats':  
##  
##      step
```

```
library(sjPlot)
```

```
## #refugeeswelcome
```

load previously processed GPS data and summarise to have all variables at the day scale

```
dfS<-readRDS("C:/GiantSuperModel/WindUse/GiantsOnIce/GiantPetrels_processed_trips.Rds")  
  
daydf<-plyr::ddply(dfS, c("daystamp", "tripID", "Ring", "Trip", "beh.state", "head.tails"), summarise,  
  MCD=max(ColDist), # maximum colony distance for the day, trip, and state  
  MTD=max(total_dist), #maximum trip distance  
  Tdur=mean(as.numeric(return-departure)), #trip duration # does not vary between states or days if the trip  
  # has more than one day  
  Tdir=mean(direction), # trip direction, does not vary between states or days if the trip has more than on  
  # e day  
  speed=mean(speed.ms), # mean bird ground speed  
  dist=sum(dist), #accumulated distance covered in one day per trip per state  
  abs.dir=mean(abs.dir), # mean direction between consecutive points  
  windspeed=mean(windspeed),  
  head.tail=mean(na.omit(heaedtailN)),  
  SIC=mean(na.omit(SIC)), CHL=mean(na.omit(CHL)),  
  N=length(ColDist),  
  perc=(N/max(n_locs))*100) # percentage of fixes  
  
body<-read.csv("C:/GiantSuperModel/body_measures.csv") # body measures  
  
body$sexo<-ifelse(body$bill.mm>90, "M", "F")  
  
ids<-na.omit(merge(daydf, body, by="Ring", all=F))  
  
# variable transformation  
ids$speedZ<-scale(sqrt(ids$speed))  
  
ids$distT<-sqrt((log10(ids$dist+1))) # consecutive transformations to reduce over-dispersion  
  
#subset  
transit<-subset(ids, beh.state=="Transit") # transit points  
  
forag<-subset(ids, beh.state!="Transit") # foraging, scavenging and resting points
```

Statistical analysis. Please see supplemental material 2 for variables transformation procedure, a priori and a posteriori diagnostics

```
transit<-subset(ids,beh.state=="Transit")
lmm1<-lmer(speedZ~(windspeed)+(windspeed|Ring),data=transit)
summary(lmm1)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: speedZ ~ (windspeed) + (windspeed | Ring)
## Data: transit
##
## REML criterion at convergence: 1771.2
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.4760 -0.5563  0.1082  0.6756  2.8076
##
## Random effects:
## Groups Name Variance Std.Dev. Corr
## Ring (Intercept) 0.1118436 0.33443
## windspeed 0.0008695 0.02949 -0.37
## Residual 0.3424771 0.58522
## Number of obs: 950, groups: Ring, 31
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 1.13439 0.07727 27.78678 14.68 1.28e-14 ***
## windspeed 0.01761 0.00859 31.25360 2.05 0.0488 *
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
## (Intr)
## windspeed -0.619
```

```
anova(lmm1, type=1, ddf="Satterthwaite")
```

```
## Type I Analysis of Variance Table with Satterthwaite's method
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## windspeed 1.4397 1.4397 1 31.254 4.2036 0.0488 *
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
ranova(lmm1)
```

```
## ANOVA-like table for random-effects: Single term deletions
##
## Model:
## speedZ ~ windspeed + (windspeed | Ring)
##          npar  logLik   AIC    LRT Df Pr(>Chisq)
## <none>          6 -885.59 1783.2
## windspeed in (windspeed | Ring)    4 -890.33 1788.7 9.4721  2   0.008773 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
lmm2<-lmer(speedZ~head.tail+(head.tail|Ring),data=subset(transit,head.tails=="Tail"))
```

```
## boundary (singular) fit: see help('isSingular')
```

```
summary(lmm2)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: speedZ ~ head.tail + (head.tail | Ring)
## Data: subset(transit, head.tails == "Tail")
##
## REML criterion at convergence: 787.2
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.2349 -0.5972  0.1074  0.7244  2.7186
##
## Random effects:
##  Groups   Name                Variance Std.Dev. Corr
##  Ring     (Intercept)  0.0691468  0.26296
##           head.tail    0.0001572  0.01254   1.00
## Residual                0.3634918  0.60290
## Number of obs: 404, groups: Ring, 30
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)   1.15642    0.07411  38.91408  15.605   <2e-16 ***
## head.tail     0.04318    0.01780 206.60923   2.426   0.0161 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr)
## head.tail -0.534
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see help('isSingular')
```

```
anova(lmm2, type=1, ddf="Satterthwaite")
```

```
## Type I Analysis of Variance Table with Satterthwaite's method
##      Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## head.tail 2.1387  2.1387    1 206.61  5.8838 0.01614 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
ranova(lmm2)
```

```
## ANOVA-like table for random-effects: Single term deletions
##
## Model:
## speedZ ~ head.tail + (head.tail | Ring)
##      npar  logLik   AIC    LRT Df Pr(>Chisq)
## <none>          6 -393.62 799.23
## head.tail in (head.tail | Ring)  4 -393.87 795.74 0.51422  2    0.7733
```

```
lmm3<-lmer(speedZ~head.tail+(head.tail|Ring),data=subset(transit,head.tails=="Head"))
summary(lmm3)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: speedZ ~ head.tail + (head.tail | Ring)
## Data: subset(transit, head.tails == "Head")
##
## REML criterion at convergence: 1024.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.14961 -0.56864  0.05095  0.61424  3.08700
##
## Random effects:
## Groups Name Variance Std.Dev. Corr
## Ring (Intercept) 0.107334 0.32762
## head.tail 0.001625 0.04031 -0.29
## Residual 0.330782 0.57514
## Number of obs: 546, groups: Ring, 31
##
## Fixed effects:
##      Estimate Std. Error    df t value Pr(>|t|)
## (Intercept)  1.20416    0.07707 27.67662  15.625 2.94e-15 ***
## head.tail    0.00663    0.01196 28.45211   0.554  0.584
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##      (Intr)
## head.tail -0.559
```

```
anova(lmm3, type=1, ddf="Satterthwaite")
```

```
## Type I Analysis of Variance Table with Satterthwaite's method
##          Sum Sq Mean Sq NumDF   DenDF F value Pr(>F)
## head.tail 0.10164 0.10164     1 28.452  0.3073 0.5837
```

```
ranova(lmm3)
```

```
## ANOVA-like table for random-effects: Single term deletions
##
## Model:
## speedZ ~ head.tail + (head.tail | Ring)
##          npar  logLik    AIC    LRT Df Pr(>Chisq)
## <none>              6 -512.31 1036.6
## head.tail in (head.tail | Ring)  4 -516.48 1041.0 8.3415  2    0.01544 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
lmm4<-lmer(distT~windspeed+(windspeed|Ring),data=transit)
summary(lmm4)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: distT ~ windspeed + (windspeed | Ring)
## Data: transit
##
## REML criterion at convergence: -107.3
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.2246 -0.7208 -0.0557  0.6568  3.4784
##
## Random effects:
## Groups Name Variance Std.Dev. Corr
## Ring (Intercept) 0.0126611 0.11252
## windspeed 0.0001399 0.01183 -0.42
## Residual 0.0474100 0.21774
## Number of obs: 950, groups: Ring, 31
##
## Fixed effects:
##              Estimate Std. Error    df t value Pr(>|t|)
## (Intercept)  0.321646   0.027108 25.781314  11.87 6.04e-12 ***
## windspeed    0.011459   0.003303 36.911230   3.47 0.00134 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr)
## windspeed -0.655
```

```
anova(lmm4, type=1, ddf="Satterthwaite")
```

```
## Type I Analysis of Variance Table with Satterthwaite's method
##           Sum Sq Mean Sq NumDF  DenDF F value    Pr(>F)
## windspeed 0.57077 0.57077      1 36.911  12.039 0.001343 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
ranova(lmm4)
```

```
## ANOVA-like table for random-effects: Single term deletions
##
## Model:
## distT ~ windspeed + (windspeed | Ring)
##           npar logLik      AIC    LRT Df Pr(>Chisq)
## <none>           6 53.669 -95.337
## windspeed in (windspeed | Ring)  4 46.075 -84.150 15.187  2 0.0005037 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
lmm5<-lmer(distT~head.tail+(head.tail|Ring),data=subset(transit,head.tails=="Tail"))
```

```
## boundary (singular) fit: see help('isSingular')
```

```
summary(lmm5)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: distT ~ head.tail + (head.tail | Ring)
## Data: subset(transit, head.tails == "Tail")
##
## REML criterion at convergence: -58.3
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.20237 -0.63474 -0.08947  0.55360  3.07503
##
## Random effects:
## Groups Name Variance Std.Dev. Corr
## Ring (Intercept) 6.758e-03 0.0822051
## head.tail 5.452e-07 0.0007384 -1.00
## Residual 4.556e-02 0.2134397
## Number of obs: 404, groups: Ring, 30
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 2.802e-01 2.493e-02 1.968e+01 11.240 5.18e-10 ***
## head.tail 3.344e-02 6.174e-03 3.657e+02 5.417 1.10e-07 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
## (Intr)
## head.tail -0.668
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see help('isSingular')
```

```
anova(lmm5, type=1, ddf="Satterthwaite")
```

```
## Type I Analysis of Variance Table with Satterthwaite's method
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## head.tail 1.3367 1.3367 1 365.75 29.343 1.102e-07 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
ranova(lmm5)
```

```
## ANOVA-like table for random-effects: Single term deletions
##
## Model:
## distT ~ head.tail + (head.tail | Ring)
## npar logLik AIC LRT Df Pr(>Chisq)
## <none> 6 29.127 -46.253
## head.tail in (head.tail | Ring) 4 29.124 -50.249 0.0047703 2 0.9976
```

```
lmm6<-lmer(distT~head.tail+(head.tail|Ring),data=subset(transit,head.tails=="Head"))
summary(lmm6)
```



```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: distT ~ head.tail + (head.tail | Ring)
## Data: subset(transit, head.tails == "Head")
##
## REML criterion at convergence: -40.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.2650 -0.7142 -0.0040  0.6694  3.3650
##
## Random effects:
##      Groups      Name      Variance Std.Dev. Corr
##      Ring      (Intercept) 0.0083652 0.09146
##      head.tail 0.0001997 0.01413  -0.09
##      Residual      0.0475831 0.21814
## Number of obs: 546, groups: Ring, 31
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)  0.344499   0.024695 28.787080  13.950 2.44e-14 ***
## head.tail    0.014907   0.004368 40.252126   3.413 0.00148 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr)
## head.tail -0.536
```

```
anova(lmm6, type=1, ddf="Satterthwaite")
```

```
## Type I Analysis of Variance Table with Satterthwaite's method
##              Sum Sq Mean Sq NumDF  DenDF F value    Pr(>F)
## head.tail 0.55416 0.55416     1 40.252  11.646 0.001478 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
ranova(lmm6)
```

```
## ANOVA-like table for random-effects: Single term deletions
##
## Model:
## distT ~ head.tail + (head.tail | Ring)
##              npar logLik      AIC      LRT Df Pr(>Chisq)
## <none>              6 20.277 -28.554
## head.tail in (head.tail | Ring)  4 13.713 -19.426 13.127  2  0.001411 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
### extract significant random effects
```

```
ranef1<-data.frame(ranef(lmm1))  
ranef3<-data.frame(ranef(lmm3))  
ranef4<-data.frame(ranef(lmm4))  
ranef5<-data.frame(ranef(lmm5))  
ranef6<-data.frame(ranef(lmm6))
```

```
ranef1$Ring<-ranef1$grp  
ranef3$Ring<-ranef3$grp  
ranef4$Ring<-ranef4$grp  
ranef5$Ring<-ranef5$grp  
ranef6$Ring<-ranef6$grp
```

```
r1<-merge(ranef1,body)  
r3<-merge(ranef3,body)  
r4<-merge(ranef4,body)  
r5<-merge(ranef5,body)  
r6<-merge(ranef6,body)
```

```
### foraging variables
```

```
ids$sicbin<-ifelse(ids$SIC>0,1,0)  
forag<-subset(ids,beh.state!="Transit")
```

```
lmm8<-lmer(distT~CHL+(CHL|Ring),data=forag)  
summary(lmm8)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: distT ~ CHL + (CHL | Ring)
## Data: forag
##
## REML criterion at convergence: -424.8
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.4317 -0.7326 -0.0955  0.5858  3.4116
##
## Random effects:
## Groups Name Variance Std.Dev. Corr
## Ring (Intercept) 0.02308 0.1519
## CHL 0.00549 0.0741 -0.87
## Residual 0.04260 0.2064
## Number of obs: 1696, groups: Ring, 31
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.25160 0.03195 29.24573 7.875 1.04e-08 ***
## CHL 0.01910 0.01601 25.64235 1.192 0.244
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
## (Intr)
## CHL -0.881
```

```
anova(lmm8, type=1, ddf="Satterthwaite")
```

```
## Type I Analysis of Variance Table with Satterthwaite's method
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## CHL 0.060579 0.060579 1 25.642 1.422 0.244
```

```
ranova(lmm8)
```

```
## ANOVA-like table for random-effects: Single term deletions
##
## Model:
## distT ~ CHL + (CHL | Ring)
## npar logLik AIC LRT Df Pr(>Chisq)
## <none> 6 212.4 -412.79
## CHL in (CHL | Ring) 4 189.1 -370.21 46.586 2 7.654e-11 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
lmm9<-lmer(distT~SIC+(SIC|Ring),data=forag)
summary(lmm9)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: distT ~ SIC + (SIC | Ring)
## Data: forag
##
## REML criterion at convergence: -506.2
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0401 -0.7338 -0.1098  0.5729  3.8318
##
## Random effects:
## Groups Name Variance Std.Dev. Corr
## Ring (Intercept) 0.006526 0.08078
## SIC 0.077843 0.27900 0.21
## Residual 0.041064 0.20264
## Number of obs: 1696, groups: Ring, 31
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.27874 0.01575 28.92454 17.701 < 2e-16 ***
## SIC 0.30618 0.09142 12.09496 3.349 0.00573 **
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
## (Intr)
## SIC 0.027
```

```
anova(lmm9, type=1, ddf="Satterthwaite")
```

```
## Type I Analysis of Variance Table with Satterthwaite's method
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## SIC 0.46066 0.46066 1 12.095 11.218 0.005729 **
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
ranova(lmm9)
```

```
## ANOVA-like table for random-effects: Single term deletions
##
## Model:
## distT ~ SIC + (SIC | Ring)
##      npar logLik AIC LRT Df Pr(>Chisq)
## <none> 6 253.12 -494.25
## SIC in (SIC | Ring) 4 228.34 -448.69 49.559 2 1.731e-11 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```

ranef8<-data.frame(ranef(lmm8))
ranef9<-data.frame(ranef(lmm9))

ranef8$Ring<-ranef8$grp
ranef9$Ring<-ranef9$grp

r8<-merge(ranef8,body)
r9<-merge(ranef9,body)

# figure 3

(ggplot(data=subset(r1,term=="windspeed"),aes(tarsus.mm,condval,
                                                colour=sexo,shape=sexo,linetype=sexo))+
  geom_smooth(method="lm",se=F)+
  geom_errorbar(aes(ymin=condval-condsd,ymax=condval+condsd))+geom_point()+
  theme_bw()+
  scale_colour_manual(values=c("red","blue"))+
  xlab("Tarsus (mm)") + ylab("Slope")+
  ggtitle(label="a. [bird ground speed ~ wind speed]"))+

  ggplot(data=subset(r3,term=="head.tail"),aes(tarsus.mm,condval,
                                                colour=sexo,shape=sexo,linetype=sexo))+
  geom_smooth(method="lm",se=F)+
  geom_errorbar(aes(ymin=condval-condsd,ymax=condval+condsd))+geom_point()+
  theme_bw()+
  scale_colour_manual(values=c("red","blue"))+
  xlab("Tarsus (mm)") + ylab("Slope")+
  ggtitle(label="b. [bird ground speed ~ head wind]")))/

( ggplot(data=subset(r4,term=="windspeed"),aes(tarsus.mm,condval,
                                                colour=sexo,shape=sexo,linetype=sexo))+
  geom_smooth(method="lm",se=F)+
  geom_errorbar(aes(ymin=condval-condsd,ymax=condval+condsd))+geom_point()+
  theme_bw()+
  scale_colour_manual(values=c("red","blue"))+
  xlab("Tarsus (mm)") + ylab("Slope")+
  ggtitle(label="c. [covered distance ~ wind speed]"))+

  ggplot(data=subset(r6,term=="head.tail"),aes(tarsus.mm,condval,
                                                colour=sexo,shape=sexo,linetype=sexo))+
  geom_smooth(method="lm",se=F)+
  geom_errorbar(aes(ymin=condval-condsd,ymax=condval+condsd))+geom_point()+
  theme_bw()+
  scale_colour_manual(values=c("red","blue"))+
  xlab("Tarsus (mm)") + ylab("Slope")+
  ggtitle(label="d. [covered distance ~ head wind]")))/

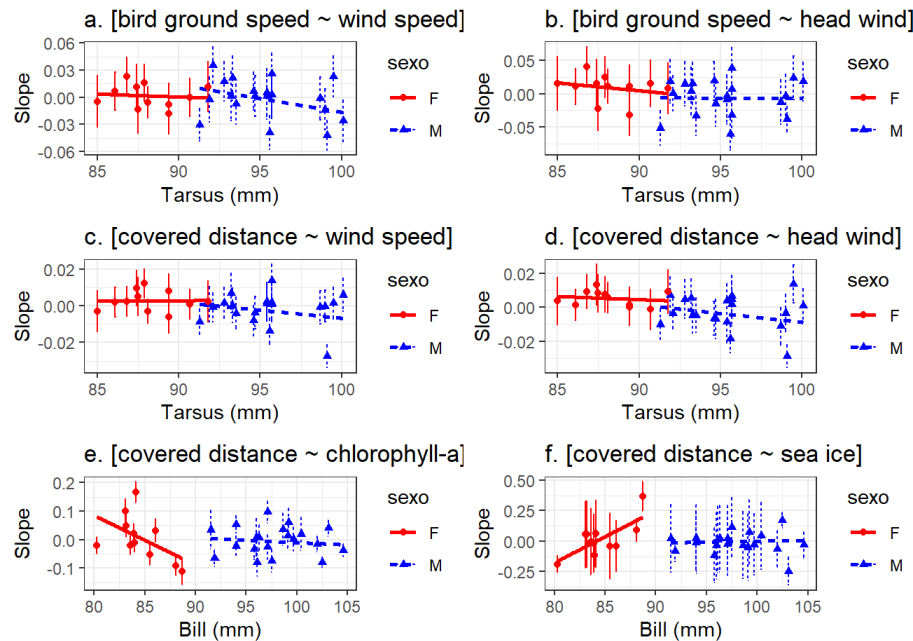
```

```
(ggplot(data=subset(r8,term=="CHL"),aes(bill.mm,condval,
                                         colour=sexo,shape=sexo,linetype=sexo))+
  geom_smooth(method="lm",se=F)+
  geom_errorbar(aes(ymin=condval-condsd,ymax=condval+condsd))+geom_point()+
  theme_bw()+
  scale_colour_manual(values=c("red","blue"))+
  xlab("Bill (mm)")+ ylab("Slope")+
  ggtitle(label="e. [covered distance ~ chlorophyll-a]")+

  ggplot(data=subset(r9,term=="SIC"),aes(bill.mm,condval/1.457322,
                                         colour=sexo,shape=sexo,linetype=sexo))+
  geom_smooth(method="lm",se=F)+
  geom_errorbar(aes(ymin=(condval/1.457322)-condsd,ymax=(condval/1.457322)+condsd))+geom_point()+
  theme_bw()+
  scale_colour_manual(values=c("red","blue"))+
  xlab("Bill (mm)")+ ylab("Slope")+
  ggtitle(label="f. [covered distance ~ sea ice]"))
```

```
## `geom_smooth()` using formula = 'y ~ x'
```

```
## `geom_smooth()` using formula = 'y ~ x'
## `geom_smooth()` using formula = 'y ~ x'
## `geom_smooth()` using formula = 'y ~ x'
## `geom_smooth()` using formula = 'y ~ x'
## `geom_smooth()` using formula = 'y ~ x'
```



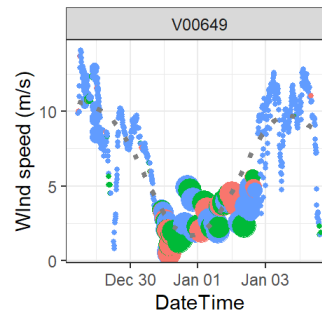
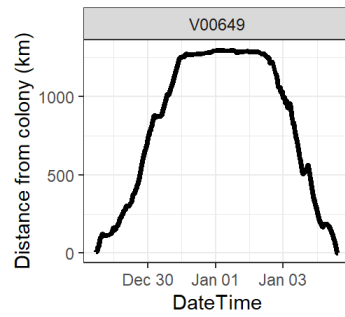
finally, two examples of trips, a long one, targeting sea ice, and a short one, foraging on productive sites along the trip

```
ggplot(subset(dfs,tripID=="V00649 21/22_01" & speed.ms>0),
  aes(DateTime,ColDist/1000))+
  geom_line(colour="black",linewidth=1.4)+
  facet_wrap(ID~.)+scale_colour_distiller(palette="Spectral")
ylab("Distance from colony (km)")+facet_wrap(Ring~.)+
theme_bw()+

ggplot(data=subset(dfs,tripID=="V00649 21/22_01" & speed.ms>0))+
  geom_point(aes(DateTime,windspeed, colour=beh.state,size=SIC))+
  geom_smooth(aes(DateTime,windspeed), linetype="dotted",method="gam",
    formula=y~s(x,k=5),
    se=F,colour="grey50",linewidth=1.4)+
  facet_wrap(ID~.)+scale_colour_distiller(palette="Spectral")
ylab("WInd speed (m/s)")+facet_wrap(Ring~.)+
theme_bw()+

ggplot(subset(dfs,tripID=="V00634 22/23_01" & speed.ms>0),
  aes(DateTime,ColDist/1000))+
  geom_line(colour="black",linewidth=1.4)+
  facet_wrap(ID~.)+scale_colour_distiller(palette="Spectral")
ylab("Distance from colony (km)")+facet_wrap(Ring~.)+
theme_bw()+

ggplot(data=subset(dfs,tripID=="V00634 22/23_01" & speed.ms>0))+
  geom_point(aes(DateTime,windspeed, colour=beh.state,size=CHL))+
  geom_smooth(aes(DateTime,windspeed), linetype="dotted",method="gam",
    formula=y~s(x,k=5),
    se=F,colour="grey50",linewidth=1.4)+
  facet_wrap(ID~.)+scale_colour_distiller(palette="Spectral")
ylab("WInd speed (m/s)")+facet_wrap(Ring~.)+
scale_size_continuous(breaks=c(0.25,1,1.5,2))+theme_bw()
```



SIC

- 0.0
- 0.1
- 0.2
- 0.3

beh.state

- Foraging
- Scavenging/Resting
- Transit

CHL

- 0.25
- 1.00
- 1.50
- 2.00

beh.state

- Foraging
- Scavenging/Resting
- Transit

