R code for Application 3.1

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Load required R packages

```
require(tidyverse)
require(patchwork)
require(sf)
require(foieGras)
```

Fit `rw` and `crw` SSM's with 12-h `time.step` to southern elephant seal example data

```
## access data from foieGras
data(sese2, package = "foieGras")

## use only 1 seal track
sese2 <- subset(sese2, id == "ct36-E-09")

fit.rw <- fit_ssm(sese2, model = "rw", time.step = 12)
fit.crw <- fit_ssm(sese2, model = "crw", time.step = 12)
```

Calculate One-Step-Ahead (Prediction) residuals for both model fits

```
res.rw <- osar(fit.rw)
res.crw <- osar(fit.crw)
```

Create Figure 1

Panel A - model fits to observed locations

```
## Use sf package to project locations & convert SSM-estimated locations to lines
dat <- grab(fit.rw[1,], "d", as_sf = TRUE) %>%
  st_transform("+proj=stere +lon_0=90 +units=km")

loc.rw <- grab(fit.rw[1,], "f", as_sf = TRUE) %>%
  st_transform("+proj=stere +lon_0=90 +units=km")

line.rw <- loc.rw %>%
  group_by(id) %>%
  summarise(do_union = FALSE, .groups = "drop") %>%
  st_cast("MULTILINESTRING")

loc.crw <- grab(fit.crw[1,], "f", as_sf = TRUE) %>%
  st_transform("+proj=stere +lon_0=90 +units=km")
```

```r
line.crw <- loc.crw %>%
  group_by(id) %>%
  summarise(do_union = FALSE, .groups = "drop") %>%
  st_cast("MULTILINESTRING")

line.ssm <- bind_rows(line.rw, line.crw) %>%
  mutate(SSM = c("rw","crw")) %>%
  select(id, SSM, geometry)

## Plot SSM fits to observed locations
pA <- ggplot() +
  geom_sf(data = dat,
              col = "dodgerblue",
              size = 1.5) +
  geom_sf(data = line.ssm,
            aes(colour = SSM)) +
  scale_colour_manual(values = c("orange", "firebrick")) +
  labs(x = element_blank(), y = element_blank()) +
  theme_minimal() +
  theme(axis.text = element_text(size = 6),
        legend.key.size = unit(c(5, 4), "mm"),
        legend.title = element_text(size = 7),
        legend.text = element_text(size = 6),
        legend.position = c(0.25,0.2))
```

Panel B - plot time-series of prediction residuals for `rw` model

```r
## use `foieGras::plot.osar()`; modify with additional ggplot2 functions
pB <- plot(res.rw, "ts") +
  xlab(element_blank()) +
  ylab("Residuals") +
  theme(axis.text.x = element_text(size=6, angle=45),
        axis.title.y = element_text(size = 8),
        strip.text.y = element_blank(),
        axis.title.x = element_blank())
```

Panel C - plot autocorrelation functions of prediction residuals for `rw` model

```r
## use `foieGras::plot.osar()`; modify with additional ggplot2 functions
pC <- plot(res.rw, "acf") +
  theme(strip.text.y = element_blank(),
        axis.text = element_text(size = 6),
        axis.title = element_text(size = 8))
```

Panel D - plot time-series of prediction residuals for `crw` model

```r
## use `foieGras::plot.osar()`; modify with additional ggplot2 functions
pD <- plot(res.crw, "ts") +
  xlab(element_blank()) +
  ylab("Residuals") +
  theme(axis.text.x = element_text(size=6, angle=45),
        axis.title.y = element_text(size = 8),
```

```
        strip.text.y = element_blank(),
        axis.title.x = element_blank())
```

Panel E - plot autocorrelation functions of prediction residuals for `crw` model

```
## use `foieGras::plot.osar()`; modify with additional ggplot2 functions
pE <- plot(res.crw, "acf") +
  theme(strip.text.y = element_blank(),
        axis.text = element_text(size = 6),
        axis.title = element_text(size = 8))
```

Arrange panels & render figure 1 using the `patchwork` package

```
pA / (pB | pD) / (pC | pE) +
  plot_layout(widths = c(2,3,3),
              heights = c(2,1,1)) +
  plot_annotation(tag_levels = "a") &
  theme(plot.tag = element_text(size = 9))
```