Stream network models

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```
library(sf)
library(sfnetworks)
library(tinyVAST)
set.seed(101)
```

tinyVAST is an R package for fitting vector autoregressive spatio-temporal (VAST) models using a minimal and user-friendly interface. We here show how it can fit a stream network model, where spatial correlations arise from stream distances along a network.

First, we load a shapefile representing a stream network, and convert it to *sfnetwork* format

```
stream <- st_read( file.path(system.file("stream_network",package="tinyVAST"),
                    "East_Fork_Lewis_basin.shp"), quiet=TRUE )
stream = as_sfnetwork(stream)
plot(stream)
```
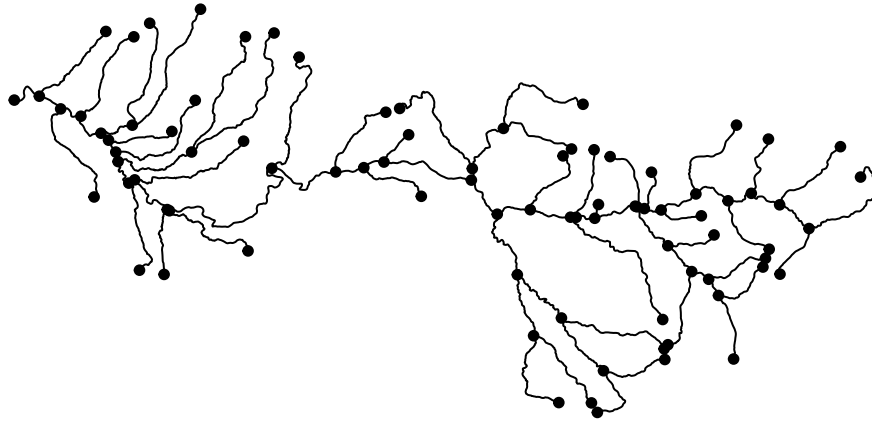
We then convert it to an S3 class defined by *tinyVAST* for stream networks, and rescale distances to 1000 ft (to ensure that distances are 0.01 to 100, avoiding issues of numerical under or overflow).

```
# Rescale
graph = sfnetwork_mesh( stream )
graph$table$dist = graph$table$dist / 1000  # Convert distance scale
```

Next, we'll simulate data at stream vertices, project to evenly spaced locations, and simulate data at those locations:

```
# Parameters
alpha = 2
kappa = 1

# simulate
omega_s = simulate_sfnetwork( n=1, sfnetwork_mesh=graph, theta=kappa)[,1]
```

```r
# sample locations along network
extrap = st_union( st_line_sample( activate(stream,"edges"), density=1/10000))
extrap = st_cast( extrap, "POINT" )

# Project to sampled locations
A_is = sfnetwork_evaluator( stream = graph$stream,
                            loc = st_coordinates(extrap) )
omega_i = (A_is %*% omega_s)[,1]

# Simulate sampling
#Count = rpois( n=graph$n, lambda=exp(alpha + omega) )
Count_i = rnorm( n=length(omega_i), mean=alpha + omega_i, sd=0.5 )

# Format into long-form data frame
Data = data.frame( Count = Count_i,
                   st_coordinates(extrap),
                   var = "species",
                   time = "2020",
                   dist = "obs" )
```
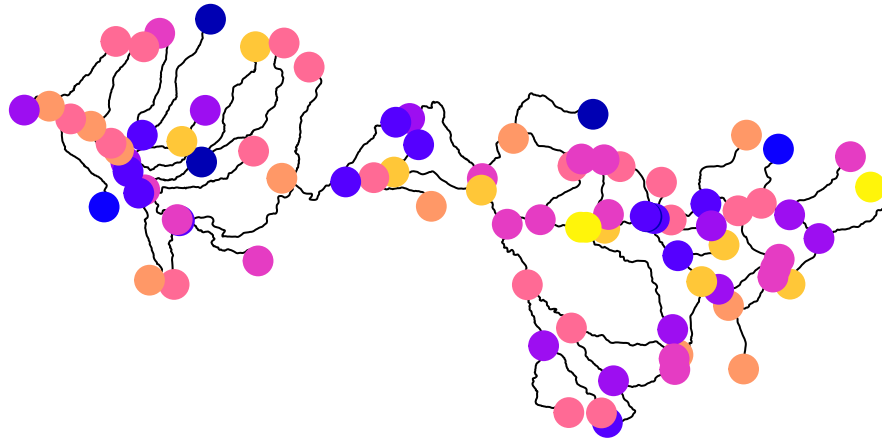
We can visualize the GMRF at those locations using *sfnetwork*

```r
Nodes = st_as_sf(activate(stream,"nodes"))
Nodes$omega = omega_s
stream = sfnetwork( nodes = Nodes,
                    edges = st_as_sf(activate(stream,"edges")),
                    directed = FALSE )
plot(stream)
plot(Nodes, add=TRUE, pch=19, cex=2)
```

Finally, we can fit the model and plot output

```r
# fit model
out = fit( data = Data,
           formula = Count ~ 1,
           spatial_graph = graph,
           #family_link = rbind( "obs"=c(3,1) ),
           family_link = rbind( "obs"=c(0,0) ),
           data_colnames = list("spatial"=c("X","Y"), "variable"="var", "time"="time", "distribution"="
           control = tinyVASTcontrol(trace=0, quiet=TRUE),
           sem = "" )

# Plot true GMRF at sampled locations
plot(stream, main="omega_i")
plot( st_sf(extrap,"omega"=omega_i), add=TRUE, pch=19, cex=2 )
```
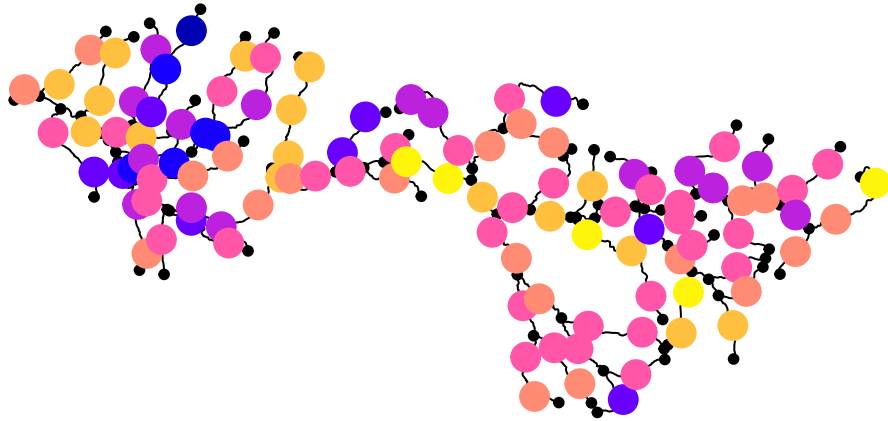
omega_i


```r
# Plot estimated GMRF at sampled locations
parhat = out$obj$env$parList()
omegahat_i = (A_is %*% parhat$omega_sc[,1])[,1]
plot(stream, main="omegahat_i")
plot( st_sf(extrap,"omega"=omegahat_i), add=TRUE, pch=19, cex=2 )
```

omegahat_i