# Spatial Toolbox Session

## Code:

src/spatial.cpp: spatial Poisson model in TMB

R/simdata.R

* sim.omega(): function simulates spatial field
* sim.covariate(): function simulates covariates
* sim.spatial.dat(): function simulates Poisson data based on covariates and spatial field
* samp.dat(): function generates a sample from the simulated data

spatialTutorial.R

1. Lines 1-34: Tutorial setup (install packages from CRAN, set up TMB, compile source code)
2. Lines 38-44: Load libraries and source external R code
3. Lines 51-65: Simulate data and create sample
4. Lines 68-72: Setup INLA SPDE components
5. Lines 75-84: Setup data and parameter list
6. Lines 89-90: Setup TMB model
7. Line 95: Optimize model
8. Lines 98-107: View results
9. Lines 110-119: Create spatial maps
10. Lines 123-124: Run model using tmbstan

## Suggested Exercises

1. Add Covariates. This can be done by increasing the size of the beta vector (Line 54). This will trigger the sim.spatial.dat() function to simulate uniformly distributed covariates. The cov.mod argument can be changed from ‘non-spatial’ to ‘spatial’, in which case, the covariate will be normally distributed with spatial structure. Compare models with and without the spatial covariate. Make sure the dimensions of Dat$x and Par$beta match so matrix multiplication does not fail (ncol(x) = length(beta)). If dimensions are incorrect, the .cpp code will throw an error that oftentimes crashes RStudio.
2. Change mesh settings. Line 69 defines the settings for the INLA mesh. The max.edge argument sets the maximum triangle edge lengths for the inner and outer boundaries. The offset argument extends the inner and outer boundaries around locations. How does the estimate of the range parameter change if you only supply one max.edge value and remove the offset term (ie. remove the boundary)? What is the optimal boundary for the mesh? As you decrease the max.edge, the resolution of the spatial model increases, which also increases runtime. Is there a better max.edge setting than what is used currently in the model?

## Advanced Exercises

1. Modify the spatial likelihood. Replace Line 36-41 in the spatial.cpp with a definition for the matern covariance function using TMB’s matern() function and the multivariate normal likelihood using TMB’s MVNORM() function. See the TMB matern example as a guide. <https://kaskr.github.io/adcomp/matern_8cpp-example.html>. You will need to change data input from the INLA sparse matrices to a distance matrix generated in R (see line 58 in simdata.R for an example). How does this new likelihood definition affect parameter estimation and runtime?
2. Add the projection matrix to TMB. Lines 110-119 of the spatial tutorial define a projection matrix, P$A from the inla.mesh.project() function. This projection matrix can be read into TMB as a SPARSE\_DATA\_MATRIX. Matrix algebra can be used in the .cpp file to calculate the projections for omega and lambda. These projections can be reported using the ADREPORT() function, which will return the projection along with standard errors.
3. Play with tmbstan. \*warning: this code will take a long time to run.