**Spatiotemporal Models for Ecologists**

**Homework #4 – 1D spatial models using TMB**

Goal: Practice and demonstrate ability to (1) estimate parameters for nonlinear mixed-effects models involving a 1-dimensional spatial process and (2) use a simulation experiment to demonstrate that benefit of including covariates to reduce uncertainty in spatial models.

Files to turn in:

1. Please submit a written description of your results. The whole thing should be less than 3 pages (and could easily be 1 page).
2. Please also submit a single R script, and a single TMB Template file that can replicate the analysis.

**Simulation experiment**

Many species show latitudinal clines in individual growth rates. I include an R function (“Sim\_Fn” in “Homework\_Week\_5\_simulator.R”) which simulates 1000 age and length samples for fish following a von Bertalanffy growth curve:

but where the asymptotic maximum size varies spatially along a coastline (e.g., from 32°N to 49°N, like on the US West Coast). Asymptotic size specifically includes both a trend (with increasing size northward) and a random component (representing unmodeled biological variation in catabolism). Please run a simulation experiment involving the following steps:

1. Generate a simulated data set using “Sim\_Fn”.
2. Build TMB code to estimate , , and , where follows a 1D random process:

where and are estimated parameters, and where is derived from two parameters (pointwise variance, and geostatistical range, see Week 5 lecture and lab for details). After fitting this model, extract estimates of for each sample, and compare these with the true value for each sample (Linf\_i from “Sim\_Fn”).

1. Compare the root-mean-squared error (RMSE) in estimates of for each sample when either estimating the spatial trend (estimating ) or ignoring the spatial trend (fixing ):

where is the true asymptotic maximum length for sample *i*, and is its estimate from the spatial model.

1. Repeat steps 1-3 one-hundred times, to generate 100 replicates of the simulation experiment. Calculate the average RMSE for either including or ignoring the spatial trend.