**Spatiotemporal Models for Ecologists**

**Homework #3 – Temporal Models**

Goal: Practice and demonstrate ability to (1) estimate parameters for a linear model with an autoregressive structure, (2) use a simulation experiment to evaluate the ability to estimate the level of autocorrelation and the measurement error and (3) modify the process portion of the state space model to incorporate non-linear dynamics.

Files to turn in:

1. Please submit a written description of your results (approximately 2 pages).
2. Please also submit a single R script, and TMB Template files that can replicate the analysis.

**Simulation experiment**

State-space models are composed of dynamics that describe the evolution of the state equations. In the Week 3 Lab we used one of the simpler state-space model formulations, a dynamic linear model (DLM). Dynamic linear models assume linear dynamics in the state equations and linear dynamics in the observation process, and normal errors.

Build a simulation exercise to explore the estimation performance of the DLM model. Specifically, compile estimates from 100 replicates for 3 values of AR (*a* = -0.5,0,0.5), process error of 0.4, and three levels of measurement error (50% of process error, 100% of process error, 200% of process error). Use the R script and TMB file from Week 3 Lab to complete this analysis.

Please run a simulation experiment involving the following steps:

1. Generate a simulated data set using “DLM\_sim”
2. Use the “dlm.cpp” TMB code to estimate *a*, , and
3. Save the estimates
4. Compute the following statistics on the estimates:
   1. Mean
   2. Standard Deviation
   3. (2.5%, 97.5%) quantiles

Provide a short write-up of the simulation and estimation experiment including a table with the statistics. Please describe how the ability to estimate the underlying AR(1) term changes as a function of the parameter value and the measurement error.

**Gompertz model**

A Gompertz density-dependent state-space model can be described as:



Please simulate a time series of 100 observations under these dynamics with values of the parameters: , and an initial value of *S1* = 4. Please plot your time series of the states and observations in a figure. Modify the dlm.cpp file to construct a Gompertz model, estimate the four parameters of the model and report your estimates in a table (parameter, mean, sd).

Gompertz – simplest model for density dependence

* Density dependence changes per capita productivity to meet target, on average
* Simulated data – seems to stay around the area it’s starting at – this is a property of density dependence – if you start near equilibrium, will tend to stay near equilibrium
* Can start model at different starting values
* Could do analytics to determine equilibrium – accidentally, 4 is the equilibrium
* MLE – should get back true values if you are fitting with models used to generate the data – simulations meant to prove that