Outline of how circ\_lorenz2005 Matlab code works with the ode45 solver:

Ref: Lorenz 2005, Designing Chaotic Model

1. Circ\_lorenz2005.m is a (hopefully) transparent implementation of Lorenz 2005 models 1, 2, and 3. When you are reading the paper, it will be helpful to browse this code and see how it matches up. We will start with Model 3 (includes spatial correlation and scale interaction), using the same set up as shown in Fig 6 of Lorenz (2005). N=960, K=32, J=12, F=15, b=10 and c=2.5
2. First generate a “nature run” (aka “truth run”) using nature\_run.m. The output will be a .mat file with a name like ‘L05M3\_N\_960\_K32\_F15.00\_I12\_b10.00\_c2.50\_tf0.05\_spinup100\_tsteps1000\_seed4921760.mat’ . The interpretation of the filename is Lorenz 2005 Model 3, 960 points, with parameters K=32,I=12,b=10,c=2.5, a time step of 0.05, first 100 values discarded as spinup, 1000 total steps retained, using the specified random number seed. This is a model run only, no data assimilation is happening yet.
   1. The “nature” run is a long model integration which we will treat as “truth” for our experiments
   2. The model code that the ODE solver calls is in circ\_lorenz2005 (fairly straightforward to match up the code to the equations in Lorenz 2005)
   3. You will need to update the directory names for location of code and location of where data should be written (line 10)
   4. The version of the L96 model (1, 2, or 3) is automatically determined from parameters
   5. The correct parameters should be set as default – 1000 cycles takes ~7 seconds on my older work laptop.
   6. Make sure you can get the code running with just a few time steps and then run a longer nature run (~100,000 cycles, should take 10 minutes or so)
3. Now that you have a nature run, you can create observations by drawing obs form your nature run and perturbing them with a specified observation error. For starters, we treat observation error variance as uncorrelated and all give all the observations the same error variance.
   1. Use draw\_obs.m to select your nature run (via a file picker dialog), choose your parameters (you can start with the default values), and create an obs file
   2. Again make sure to update the directory path for the output.
   3. tseed for the obs file will match seed for the nature run, while oseed should be independent
   4. You obs file will have a name like “obs\_tf0.05\_nc1000\_R1.00\_N960\_K32\_F15.00\_I12\_b10.00\_c2.50\_tseed4921760\_oseed4207416.mat” (R is the observation error variance, 1.0 in this example)

1. Data Assimilation
   1. Now that you have a nature run (“truth”) and some observations created with a known observation error, you can start the assimilation
   2. parLorGKSQ calls parDA\_GKSQ, which uses circ\_lorenz2005, and calls KSQ
   3. KSQ runs a global ensemble based square root filter (Ensemble Transform Kalman Filter, following Bishop et al. 2000)
   4. The code is currently set to run on 1 processor (see parLorGKSQ line 103), but supports multiple processors if you are able to run on multiple processors and have the matlab parallel toolbox installed
   5. To see graphics for the obs and ensemble integrated in time, uncomment lines 57-74 of KSQ.m
   6. Localization is supported, but you can start without localization
   7. Plot results will plot the mean error as a function of cycles (you should see the error reduce and stabilize). Text output should show the “posterior” (after DA) error variance reduced from the “prior” (forecast background before DA)
   8. Truth stored in Xt
   9. Obs stored in y
   10. Initial ensemble XIC drawn from climatology (equispaced in time)
2. circ\_lorenz2005 args:
   1. Z=posterior ensemble member from previous time step
   2. F=forcing term
   3. Kparm=correlation length for models II and III (if Kparm > 1)
   4. Iparm=small scale correlation length for model III (if Iparm > 1)
   5. b=small scale damping parameter for model III
   6. c=scale coupling parameter for model III
3. Additional plotting routines
   1. Par5\_plots
   2. Plot\_profile (covariance and fig 6 of Lorenz 2005)