ATS421/521 *Climate Modeling*

Homework 6 due 05-20-2013

1. Implement the Lorenz model in a fortran program using a time step of $\Delta t=0.012$, the following classical parameter set ($\sigma=10$, b=8/3, r=28), and initial conditions (X=2, Y=2, Z=10).
   ATS421 students: Use the Euler forward scheme.
   ATS521 students: Use the Runge-Kutta method, which is more accurate (to 4th order) than the Euler forward scheme. The Runge-Kutta scheme is based on a weighted average of estimates of the slope at t_n, $t_n+\Delta t/2$, and $t_n+\Delta t$. The ordinary differential equation

   $$\frac{dy}{dt}=f(t,y)$$

   is discretized according to

   $y_{n+1}=y_n+\Delta t\cdot F(t_n,y_n)$, where

   $F(t_n,y_n)=\frac{1}{6}(K_1+2K_2+2K_3+K_4)$, and

   $K_1=f(t_n,y_n)$

   $K_2=f(t_n+\frac{\Delta t}{2},y_n+\frac{\Delta t}{2}K_1)$

   $K_3=f(t_n+\frac{\Delta t}{2},y_n+\frac{\Delta t}{2}K_2)$

   $K_4=f(t_n+\Delta t,y_n+\Delta t\cdot K_3)$.

   More weight is given to the evaluation of the slope at $t_n+\Delta t/2$.
   Print your code. (2)
2. Plot a time series of 3000 time steps of X, Y and Z. (2)
3. Plot the model trajectories in the X-Y, X-Z, and Y-Z planes. (2)
4. Use slightly different initial conditions and re-plot some of the time series and trajectories. (2)