

Data Assimilation Research Testbed Tutorial

Section 7: Some additional low-order models and their purpose

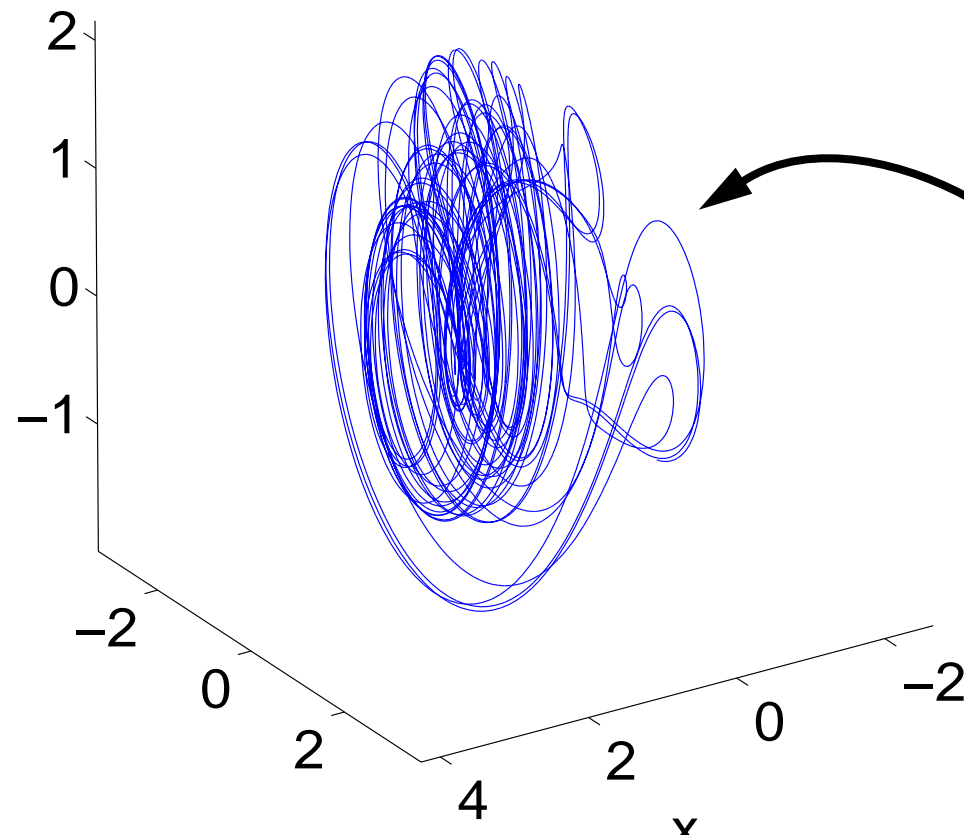
Version 1.0: June, 2005

Low-order models in DART:

Table 1:

| Model | Size | Features |
|------------------|-------------------|--|
| lorenz_63 | 3 | Chaotic, nearly integral attractor, bifurcations |
| lorenz_84 | 3 | More complex attractor, not as periodic |
| 9var | 9 | Transient off-attractor dynamics |
| lorenz_96 | 40 (variable) | Higher dimensional system. Attractor dimension 13. |
| forced_lorenz_96 | 80 (variable) | Allows assimilation of model parameter (see Section 20). |
| lorenz_96_2scale | 440 (variable) | Two primary interacting spatial/temporal scales. |
| lorenz_04 | variable | Multiscale dynamics. |

Lorenz 84 model:



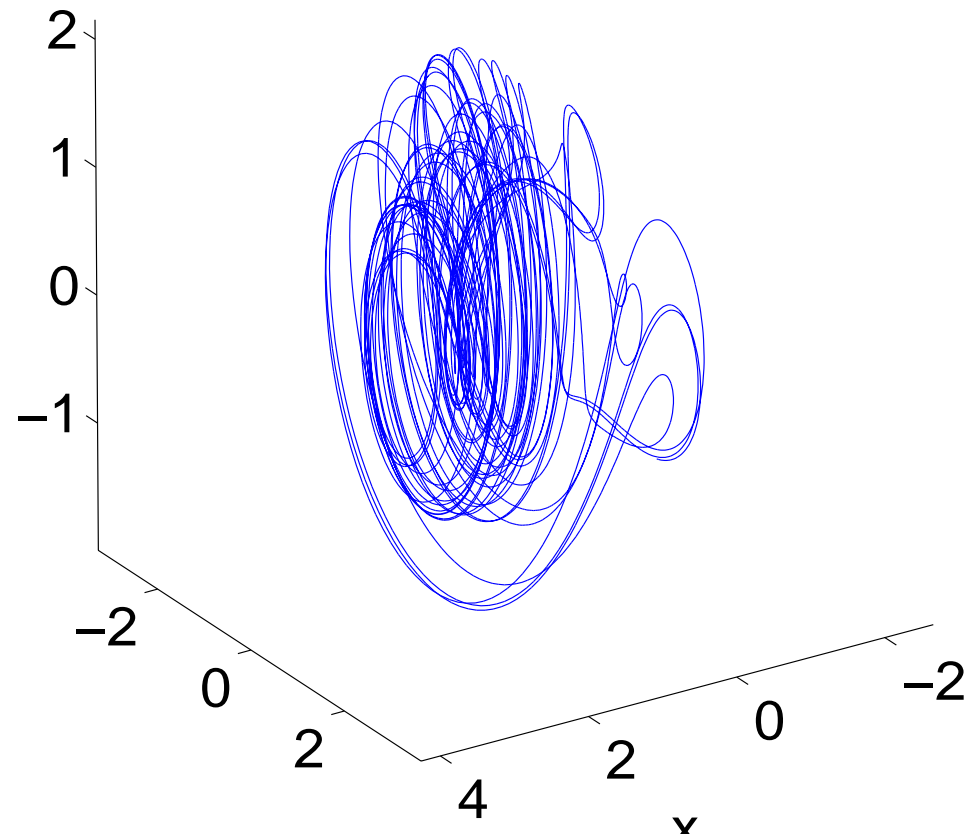
Attractor not sheet-like.

Rare significant deviations.

Trajectories along deviations
don't 'mesh' back up with rest of
attractor.

This behavior can be challenging
for certain filter variants.

Lorenz 84 model:



3-variables:

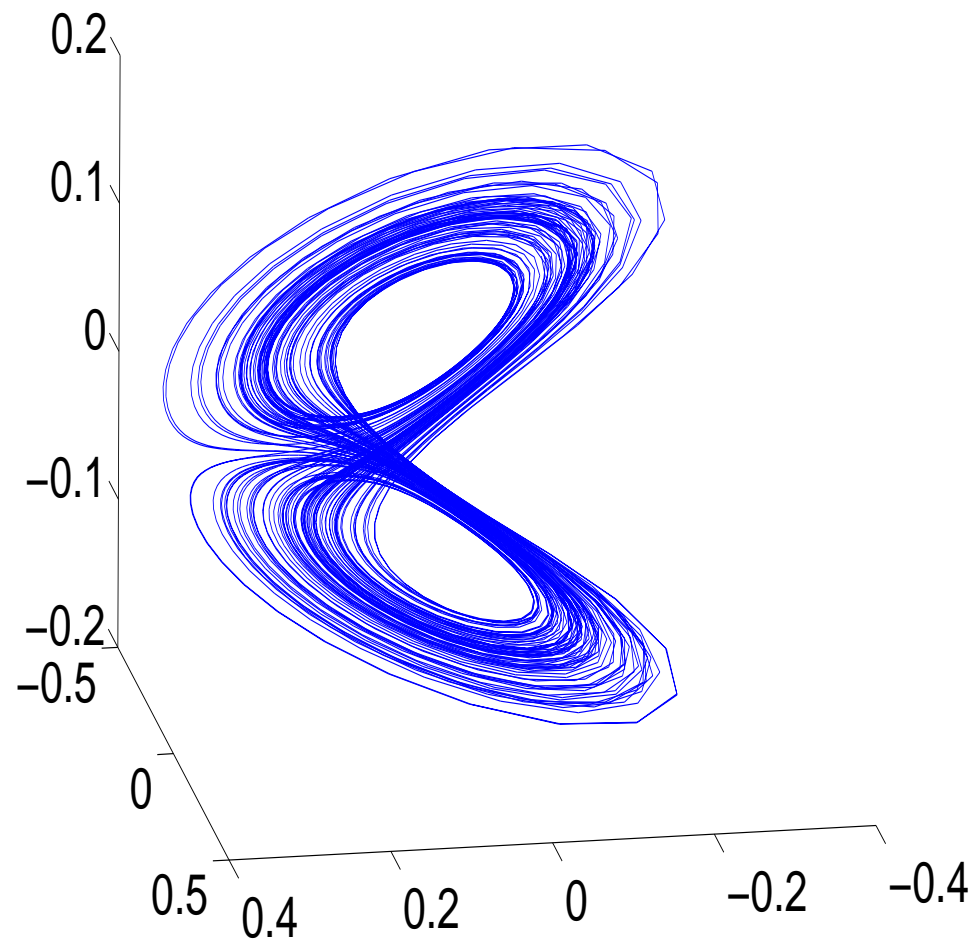
$$\frac{dx_1}{dt} = -x_2^2 - x_3^2 - ax_1 + af$$

$$\frac{dx_2}{dt} = x_1x_2 - bx_1x_3 - x_2 + g$$

$$\frac{dx_3}{dt} = bx_1x_2 + x_1x_3 - x_3$$

Parameters: $a = 0.25$, $b = 4$,
 $f = 8$, $g = 1.25$
can be set from model_nml.

9 Variable model:



Three groups of variables

Variables 1-3: Divergence

Variables 4-6: Vorticity.

Variables 7-9: Height.

In general, divergence is small.

Height and pressure similar.

Height and pressure have
attractor similar to Lorenz-63.

9 Variable model:

$$\dot{X}_i = U_j U_k + V_j V_k - v_0 a_i X_i + Y_i + a_i z_i \quad (1)$$

$$\dot{Y}_i = U_j Y_k + Y_j V_k - X_i - v_0 a_i Y_i \quad (2)$$

$$\dot{z}_i = U_j (z_k - h_k) + (z_j - h_j) V_k - g_0 X_i - K_0 a_i z_i + F_i \quad (3)$$

$$U_i = -b_j x_i + c y_i \quad (4)$$

$$V_i = -b_k x_i - c y_i \quad (5)$$

$$X_i = -a_i x_i \quad (6)$$

$$Y_i = -a_i y_i \quad (7)$$

X=> Divergence, Y=>Vorticity, z=> height

Parameters can be adjusted from model_nml.

9 Variable model:

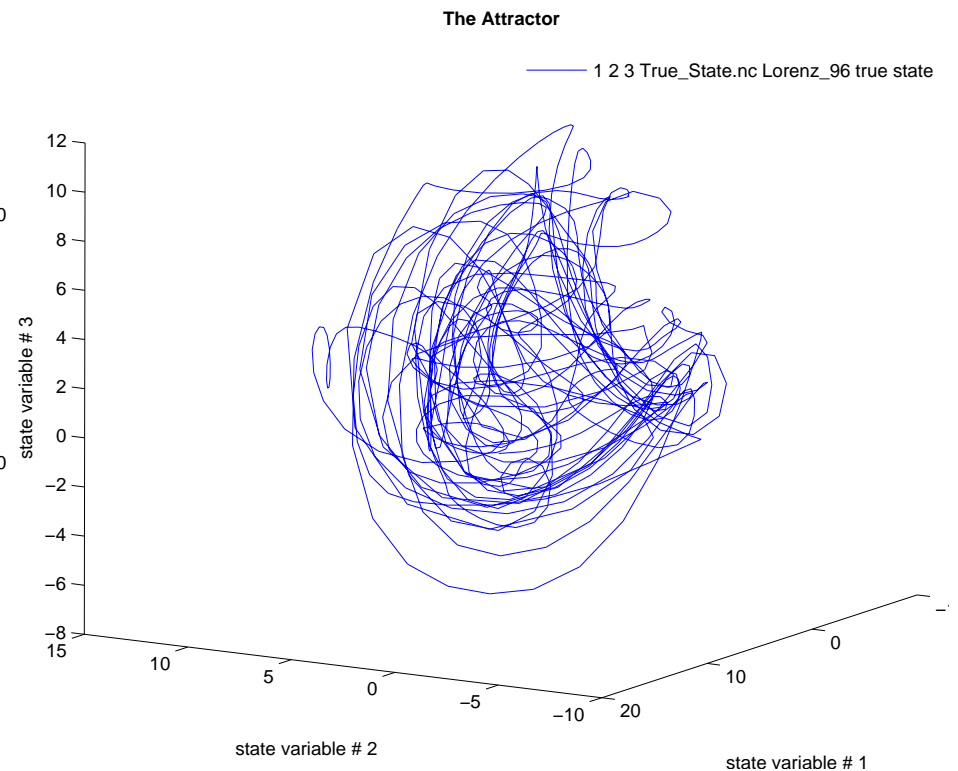
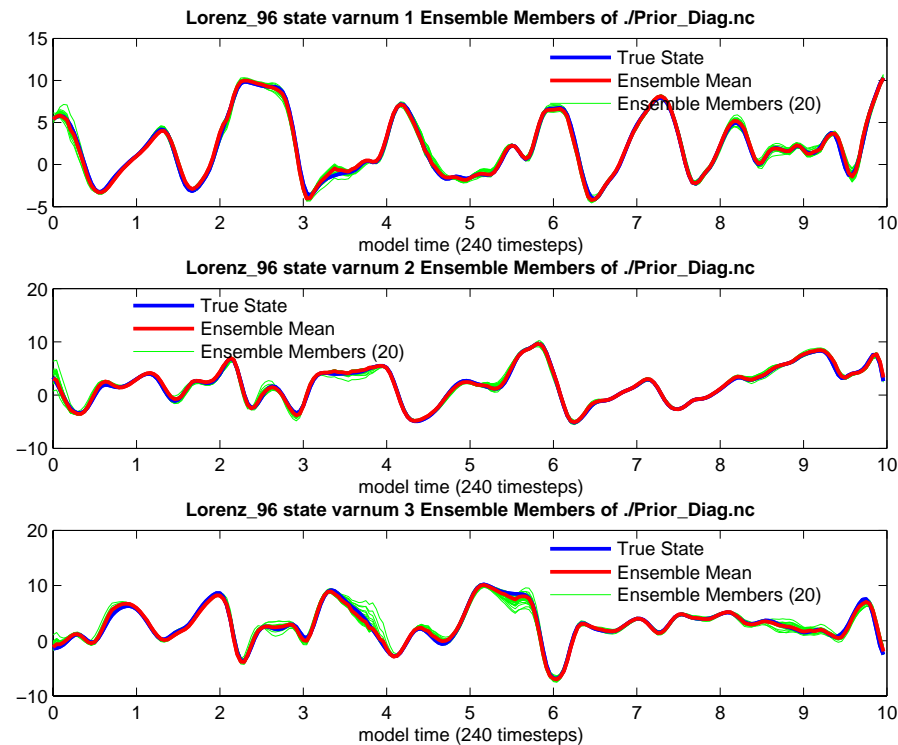
When perturbed off the attractor, mimics ‘gravity waves’.
Transient, high frequency oscillations dominate divergence variables.
Can also appear in height and pressure variables.

Set up experiments to confirm this....

Lorenz-96 (40-variable) model:

One dimensional cyclic domain.

Acts something like synoptic scale weather around mid-latitude circle.



Lorenz-96 (40-variable) model:

Attractor dimension 13 by some measures.

Start to explore model sizes close to ensemble size.

Can examine possible degeneracy issues with sample covariance.

Naive application of small ensembles diverges in many cases.