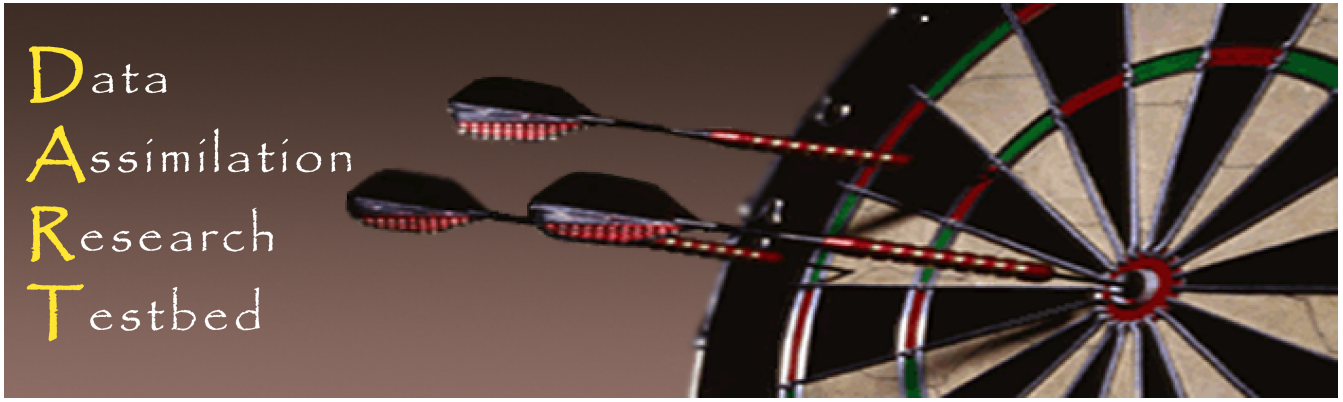
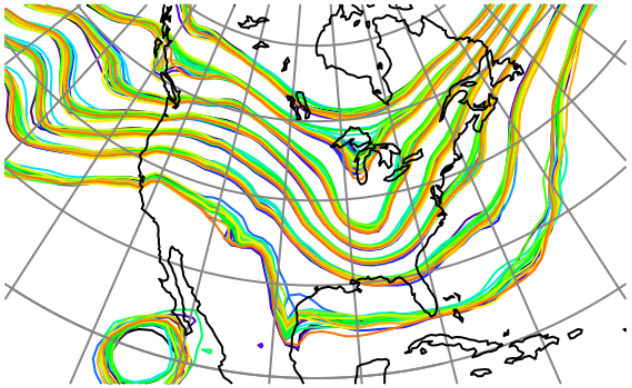



# DART Tutorial Section 7: Some Additional Low-Order Models





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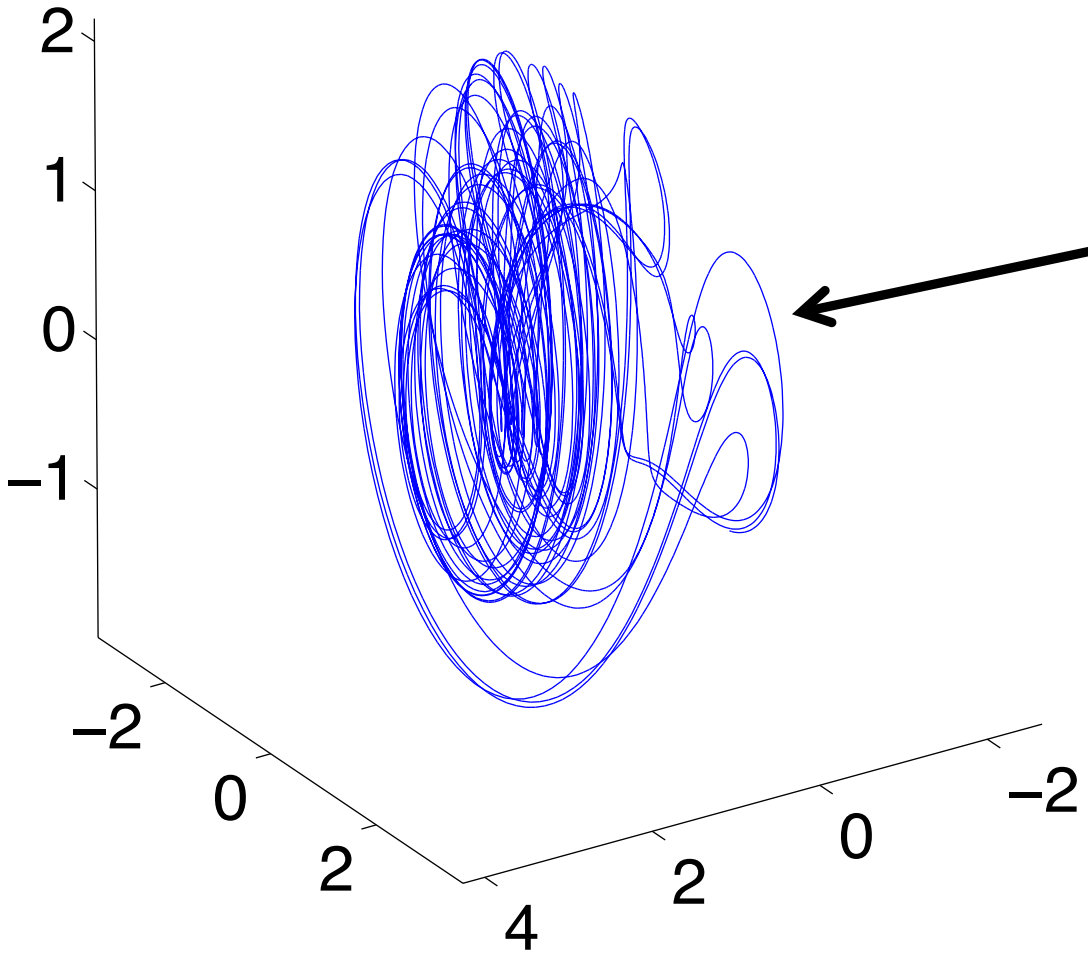
# Low Order Models in DART

| 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 NOT CURRENTLY SUPPORTED. COMING SOON. |
| lorenz_04 | variable | Multiscale dynamics |

# Lorenz 84 Model



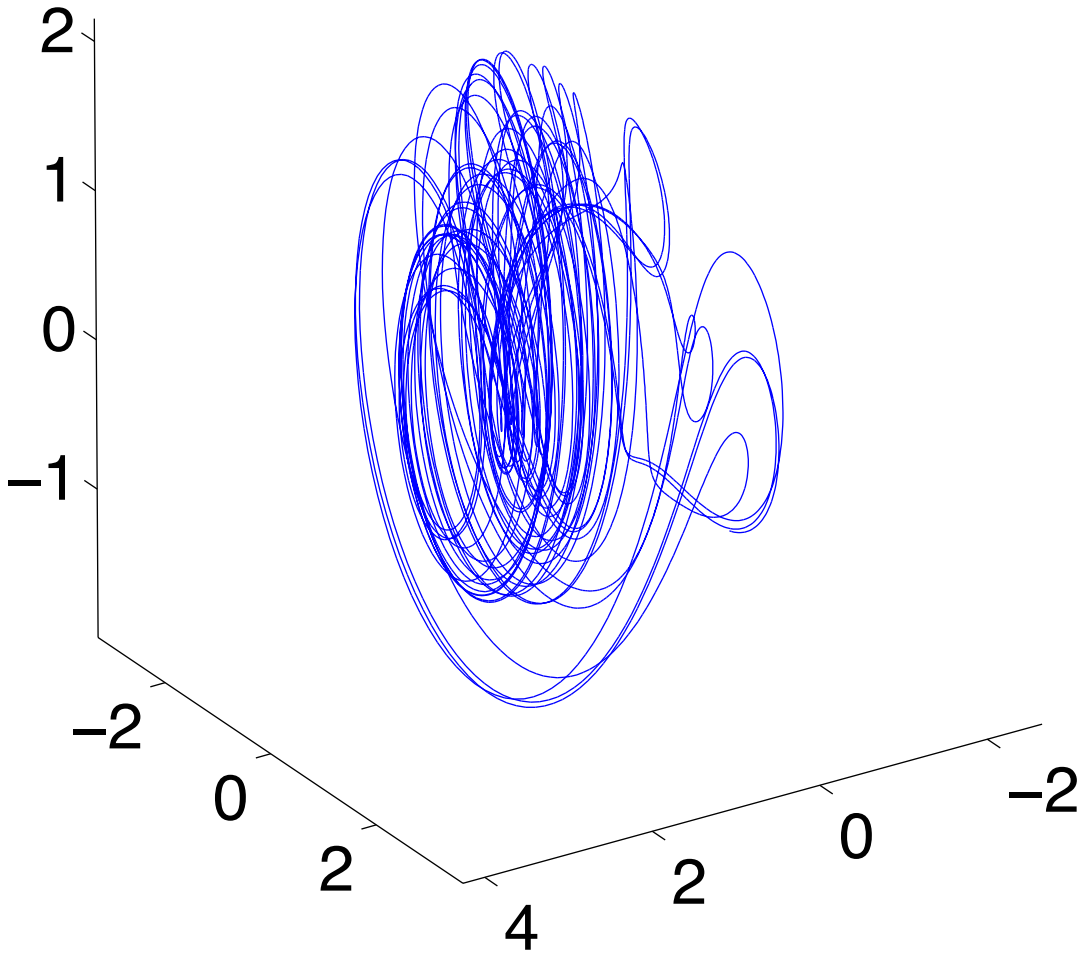

Attractor not sheet-like.

Rare significant deviations.

Trajectories along deviations don't 'mesh' back up with the rest of the 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 set from model_nml

# Lorenz 84 Model

Exercise:

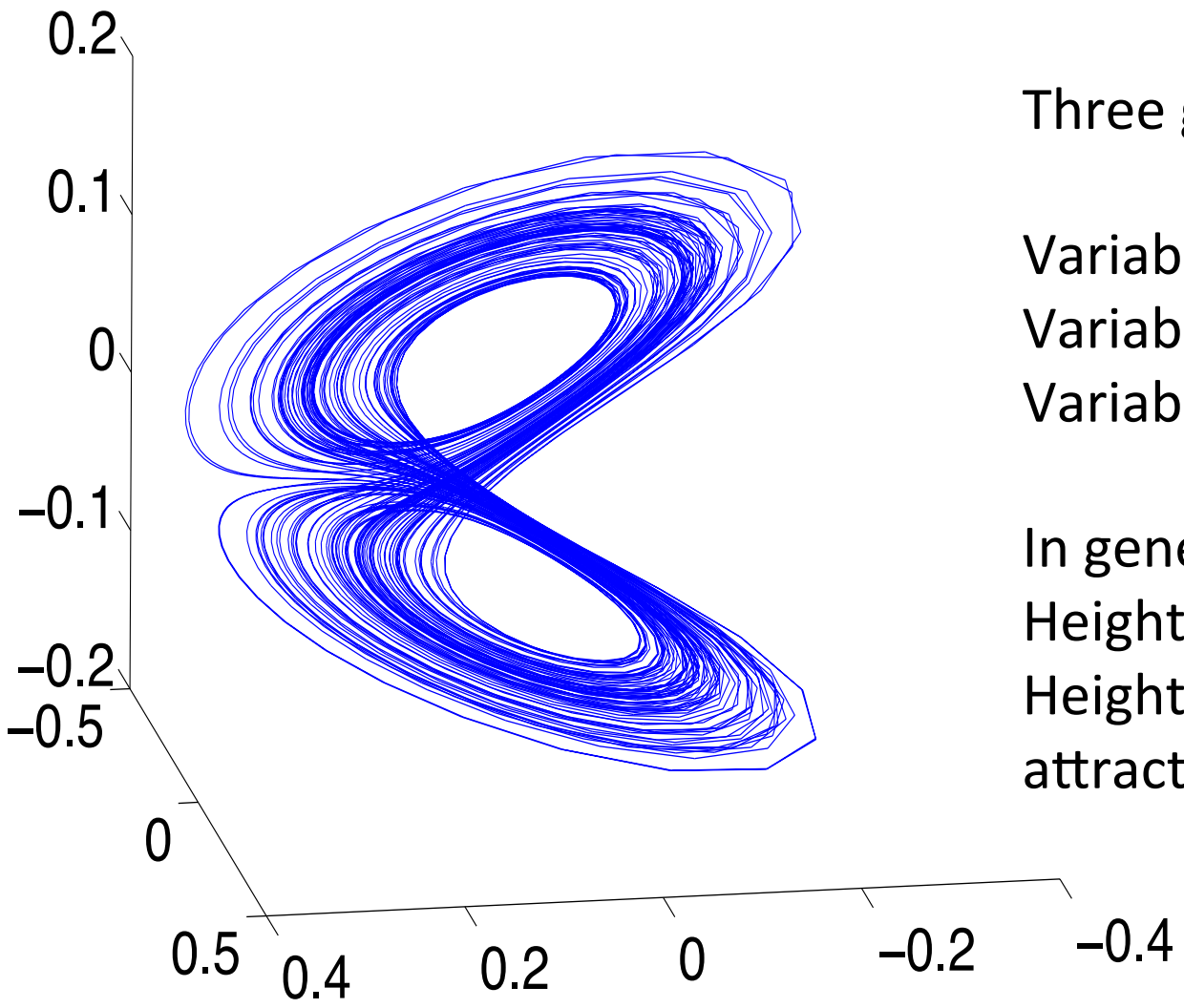
Run *csh workshop_setup.csh* in directory *models/lorenz_84/work*.

Each state variable is observed every once every hour.
Observational error variance is 1.

Use matlab to examine the output.

There's a new type of filter challenge represented here.
Can you identify it?
Can you propose ways to address it with techniques learned to date?

# 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

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

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

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

$$U_i = -b_j x_i + c y_i$$

$$V_i = -b_k x_i - c y_i$$

$$X_i = -a_i x_i$$

$$Y_i = -a_i y_i \qquad i = 1,2,3 \quad j = \mathrm{mod}(i,3)+1 \quad k = \mathrm{mod}(i+1,3)+1$$

X is divergence, Y is vorticity, Z is height

All paremeters can be adjusted from model_mod.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.

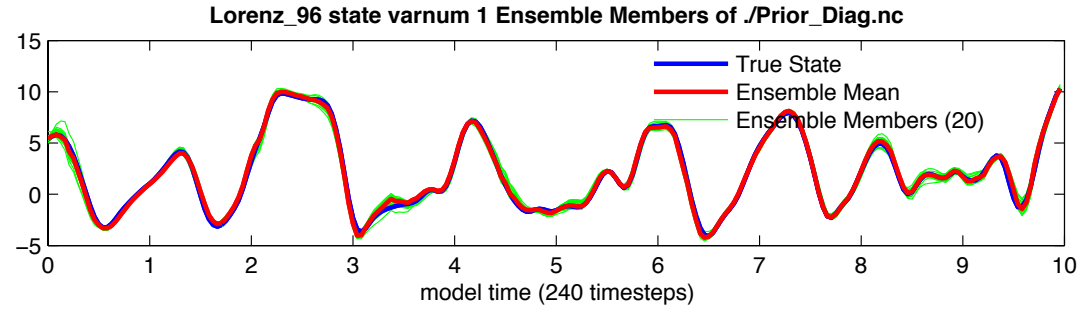
Run *csh workshop_setup.csh* in directory *models/9var/work*.

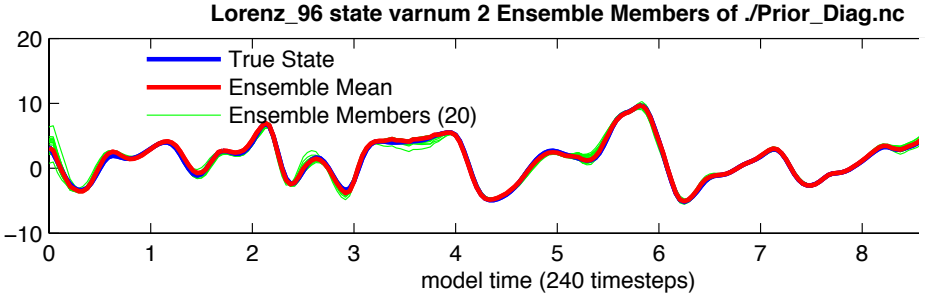
Y1, Y2, Y3 (the ‘vorticity’ variables) are observed once every 6 hours
Observational error variance is 0.4.

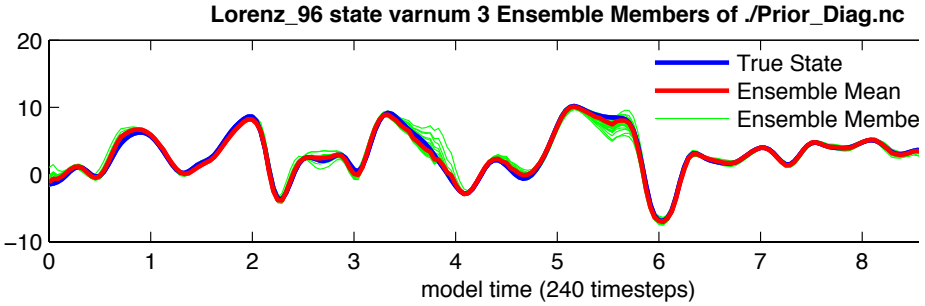
Use matlab to examine the output.

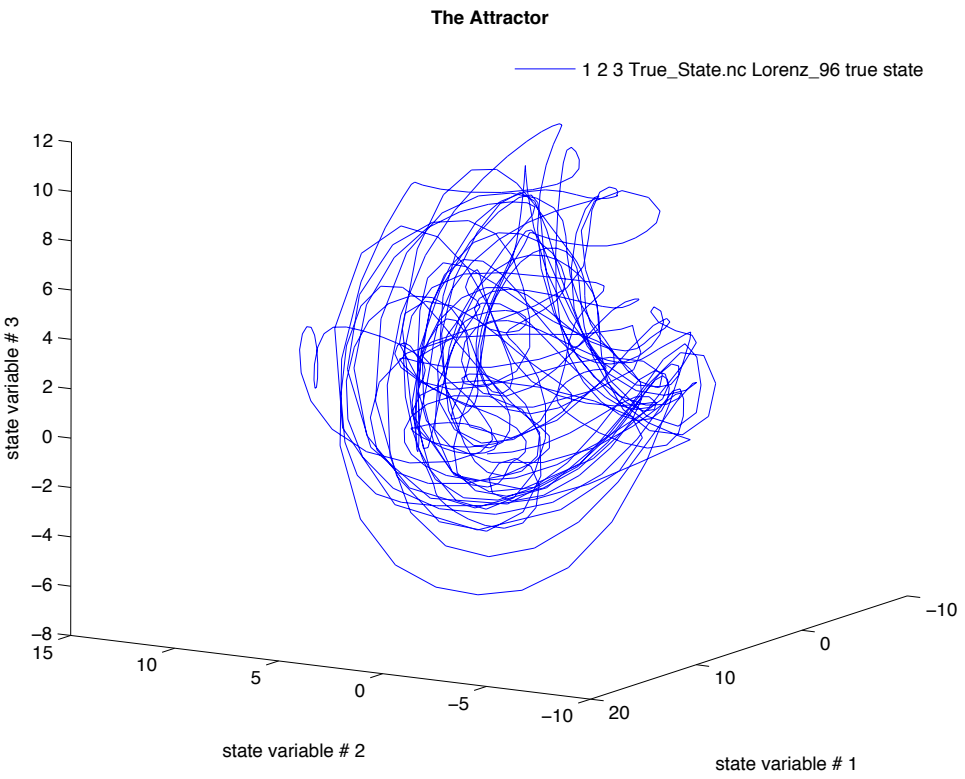
How do different filter kinds interact with ‘gravity’ waves?

# Lorenz 96 (40-variable) Model



# Lorenz 96 (40-variable) Model

Attractor dimension 13 by some measures.

Start to explore model sizes closer to ensemble size.

Can examine possible degeneracy issues with sample covariance.

Naive application of small ensembles diverges in many cases.

# Lorenz 96 (40-variable) Model

Run *csh workshop_setup.csh* in directory *models/lorenz_96/work*.

40 observations, randomly located in space, equally spaced in time.
Observed once an hour; Observational error variance is 1.0.

Use matlab to examine the output.
Need new techniques to fix this.

For *plot_ens_time_series*, *plot_ens_mean_time_series*:

- Can select subset of variables to plot,
- Default selection of variables 1, 13, and 27 are approximately equally spaced around the cyclic domain.

# DART Tutorial Index to Sections