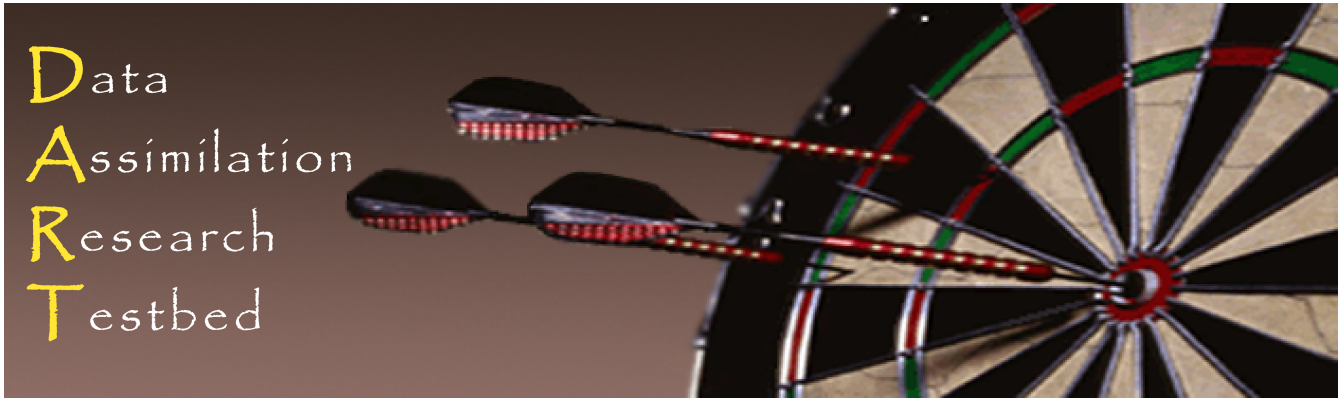
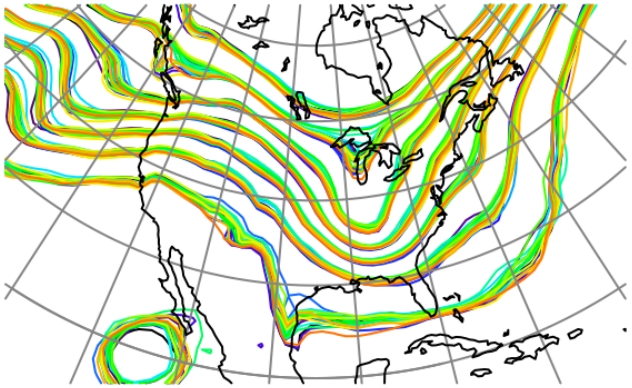


DART Tutorial Section 7: Some Additional Low-Order Models



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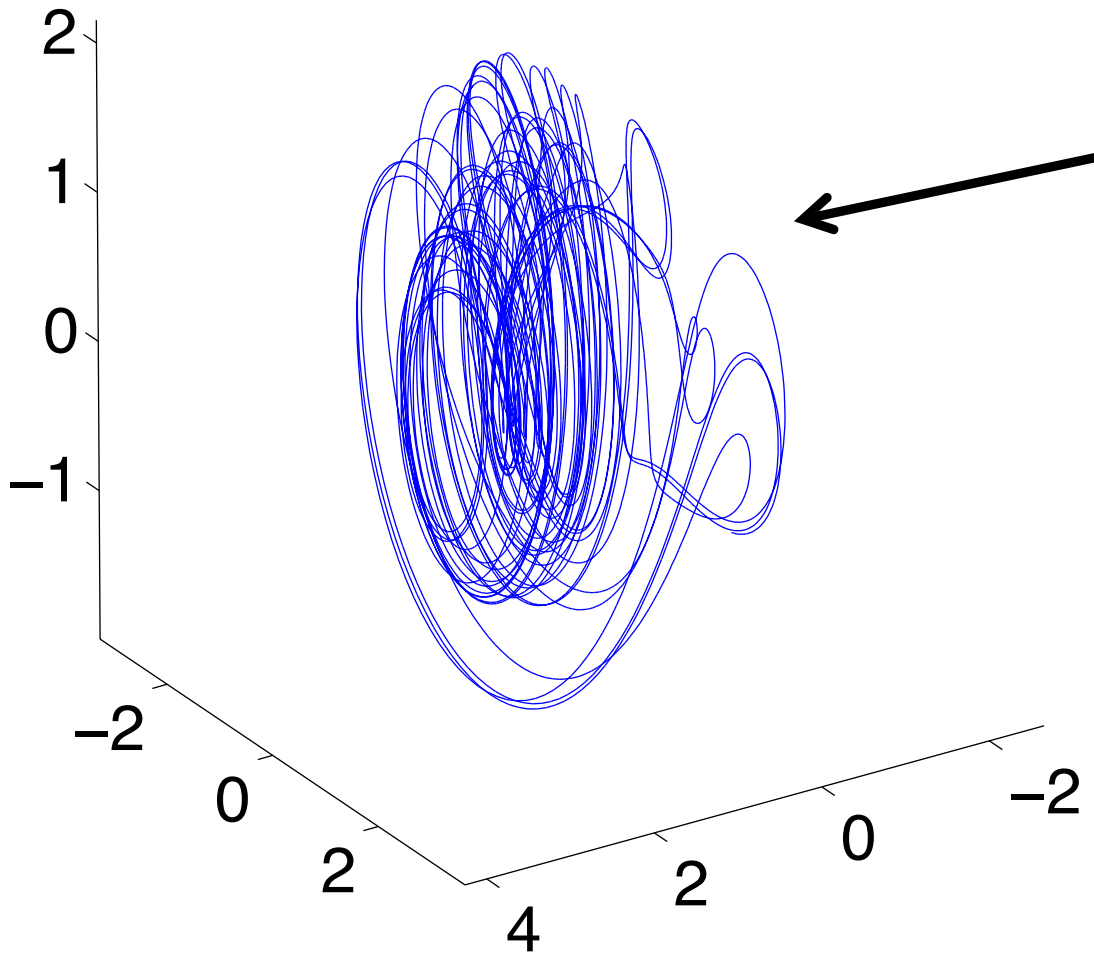
Low Order Models in DART

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 with 40 variables and standard forcing.
forced_lorenz_96	80 (variable)	Allows assimilation of model parameter (see Section 20)
lorenz_96_2scale	396 (variable)	Two primary interacting spatial/temporal scales
lorenz_04	variable	Multiscale dynamics

Lorenz 84 Model

models/lorenz_84/work/



Attractor not sheet-like.

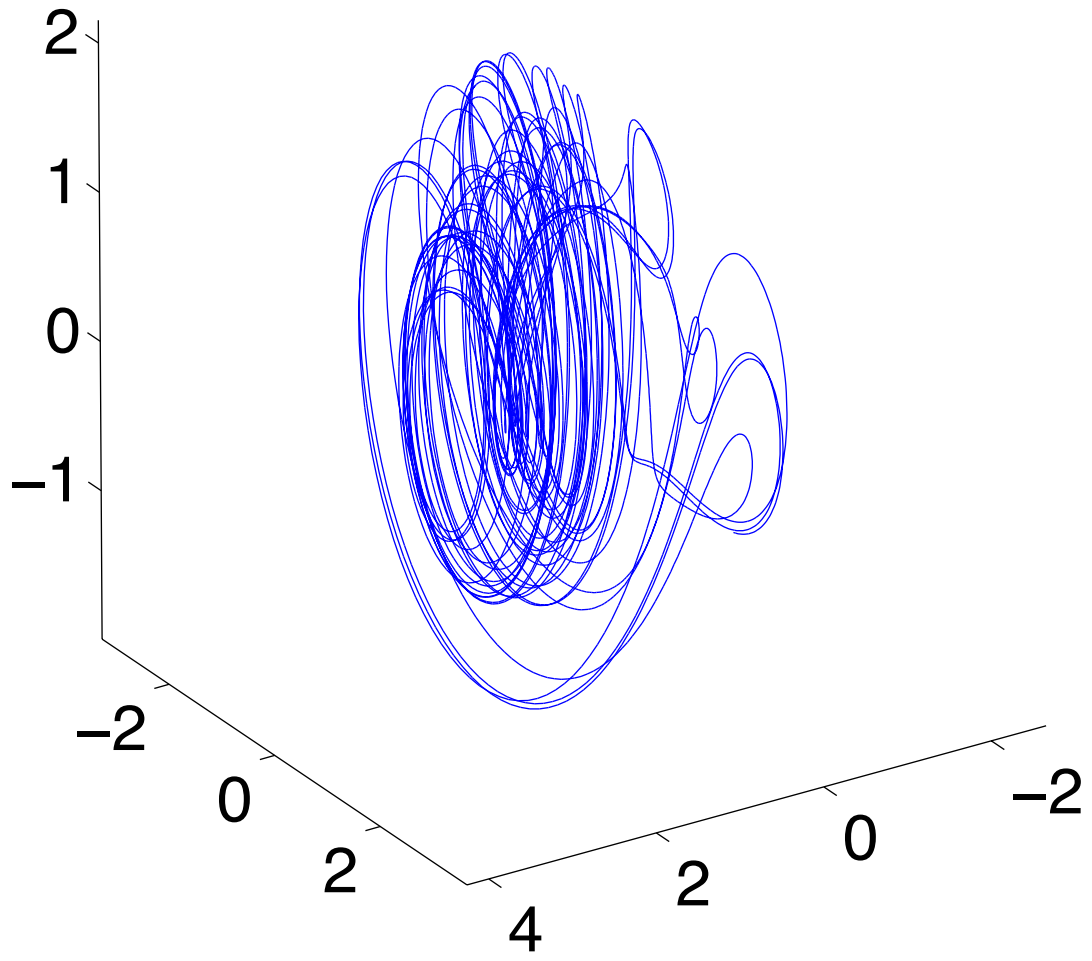
Rare significant deviations.

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

models/lorenz_84/work/



3-variables:

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

$$\frac{dx_2}{dt} = x_1 x_2 - b x_1 x_3 - x_2 + g$$

$$\frac{dx_3}{dt} = b x_1 x_2 + x_1 x_3 - x_3$$

Parameters

a= 0.25,

b = 4,

f = 8,

g = 1.25

can set from model_nml

Lorenz 84 Model

Exercise:

```
cd models/lorenz_84/work
csh workshop_setup.csh
```

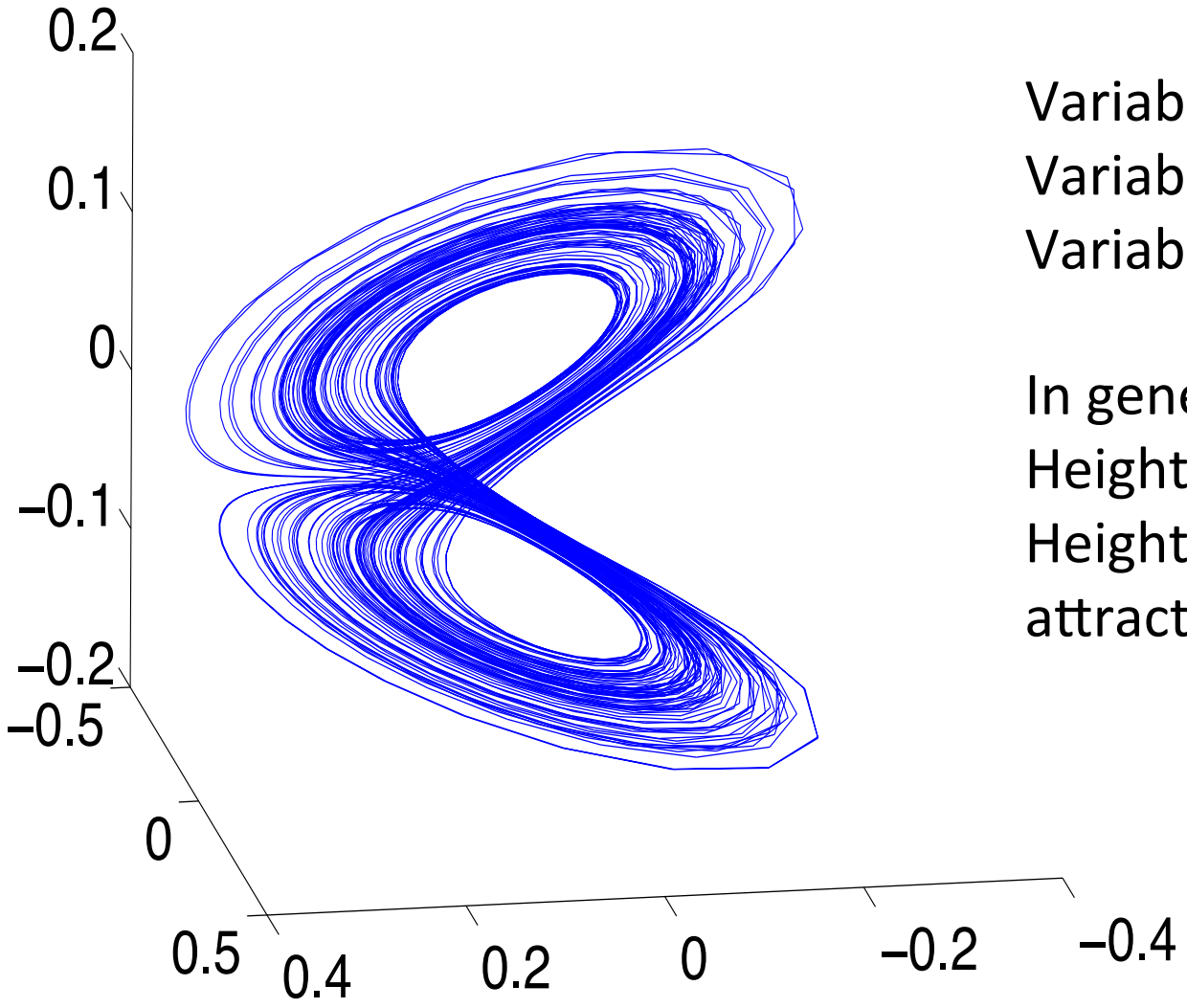
Each state variable is observed every once every hour.
Observational error variance is 1.

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

models/9var/work/



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 parameters 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.

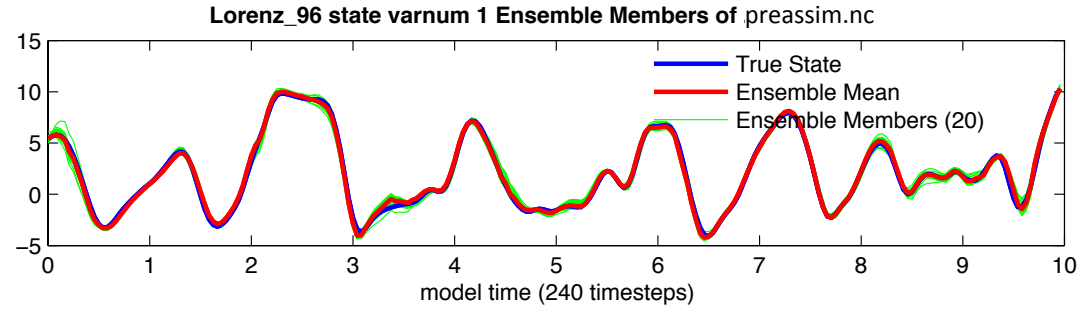
```
cd models/9var/work
csh workshop_setup.csh
```

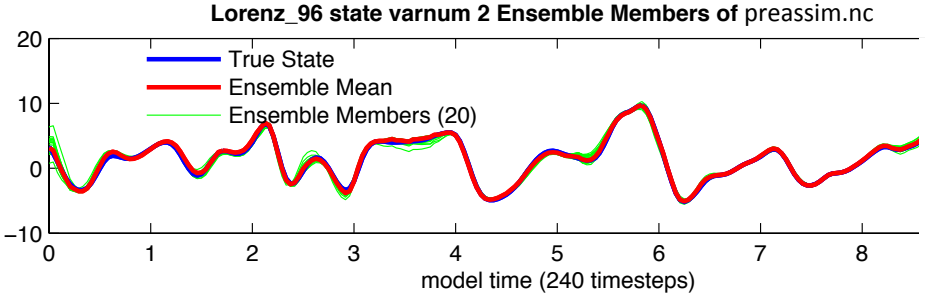
Y1, Y2, Y3 (the ‘vorticity’ variables) are observed once every 6 hours
Observational error variance is 0.4.

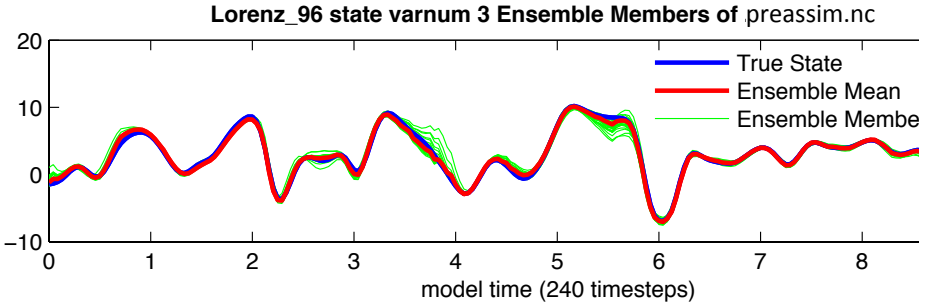
Use Matlab to examine the output.

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

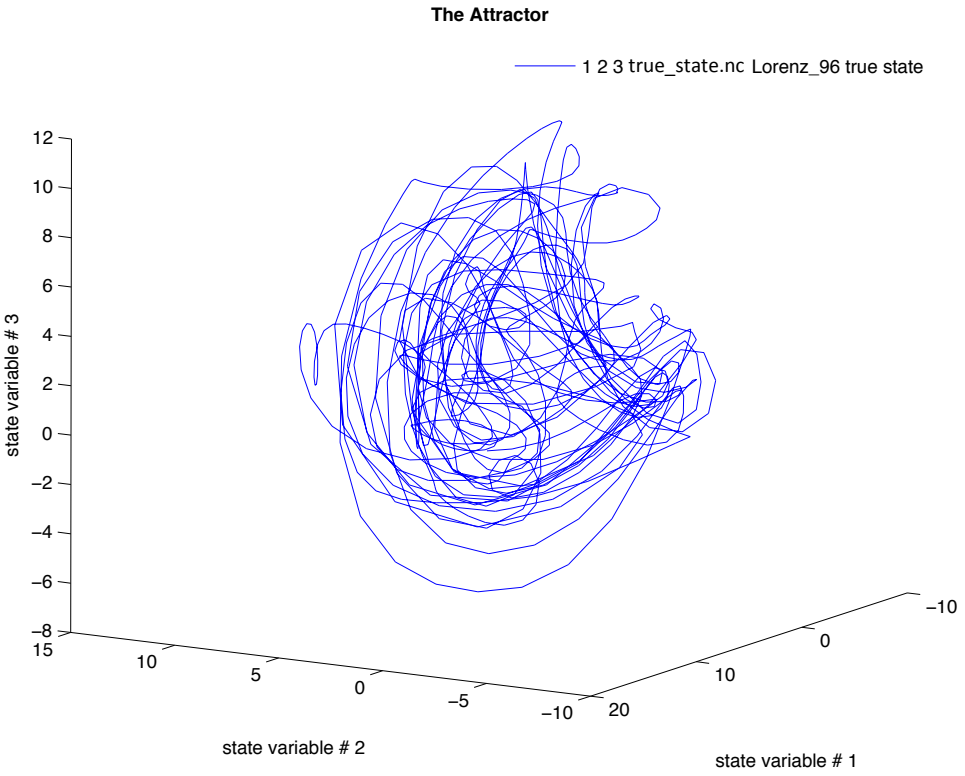
Lorenz 96 (40-variable) Model







models/lorenz_96/work/



Lorenz 96 (40-variable) Model

Attractor dimension 13 by some measures with 40 variables and standard forcing (*forcing* = 8.00 in `&model_nml`).

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

```
cd models/lorenz_96/work
csh workshop_setup.csh
```

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 problem seen here.

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