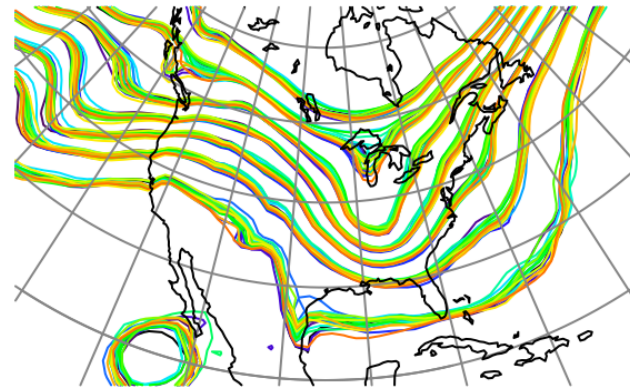


Data
Assimilation
Research
Testbed



DART Tutorial Section 7: Some Additional Low-Order Models



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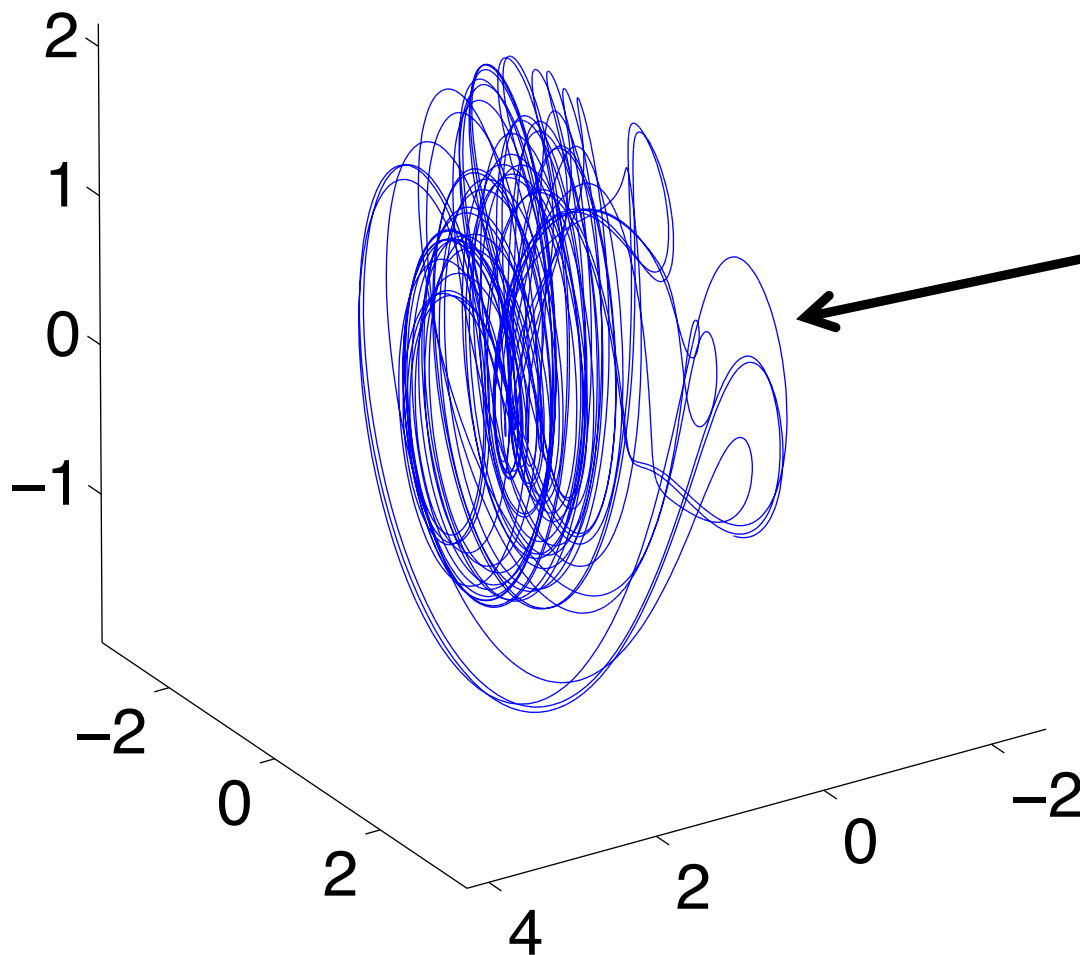
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Low Order Models in DART

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



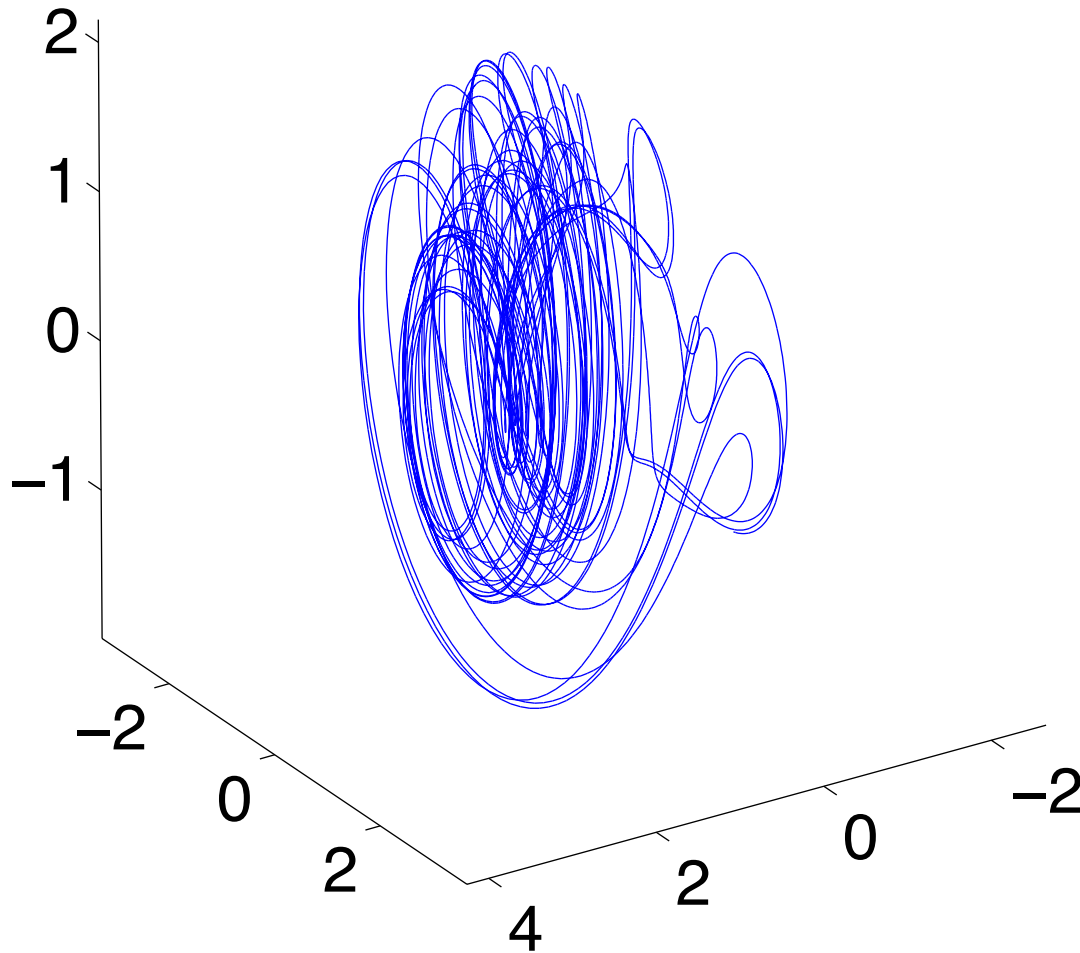
Attractor not sheet-like.

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.

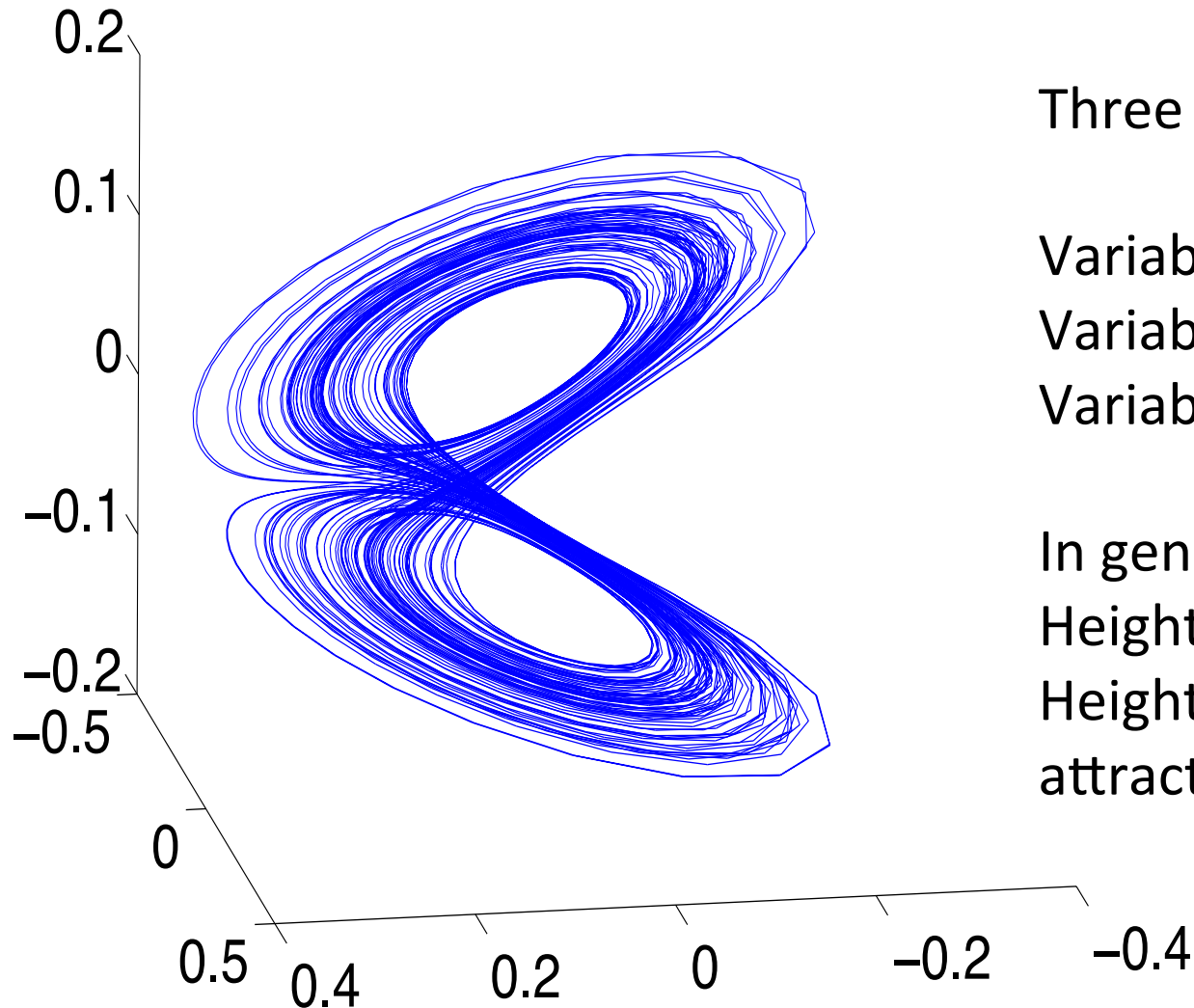
Use matlab to examine the output.

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

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

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

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

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

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

$$X_i = -a_i x_i$$

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

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.

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

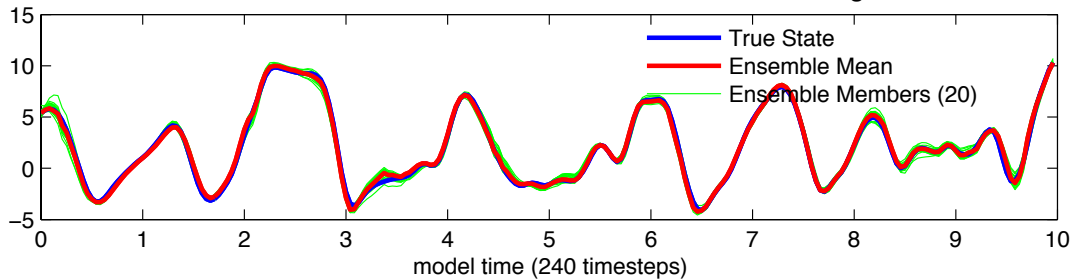
Y1, Y2, Y3 (the 'vorticity' variables) are observed once every 6 hours
Observational error variance is 0.4.

Use matlab to examine the output.

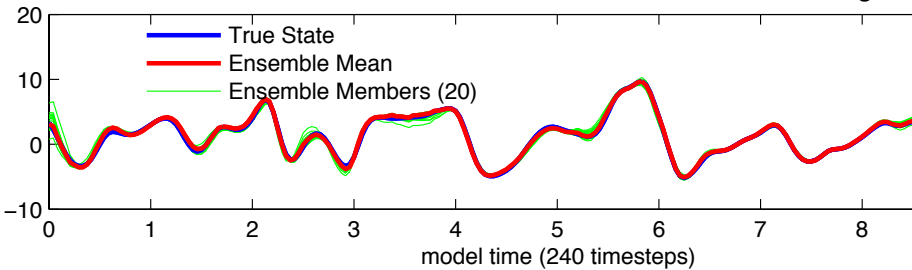
How do different filter kinds interact with 'gravity' waves?

Lorenz 96 (40-variable) Model

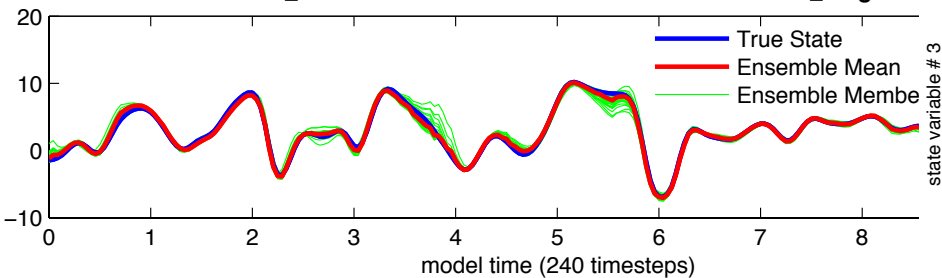
Lorenz_96 state varnum 1 Ensemble Members of ./Prior_Diag.nc



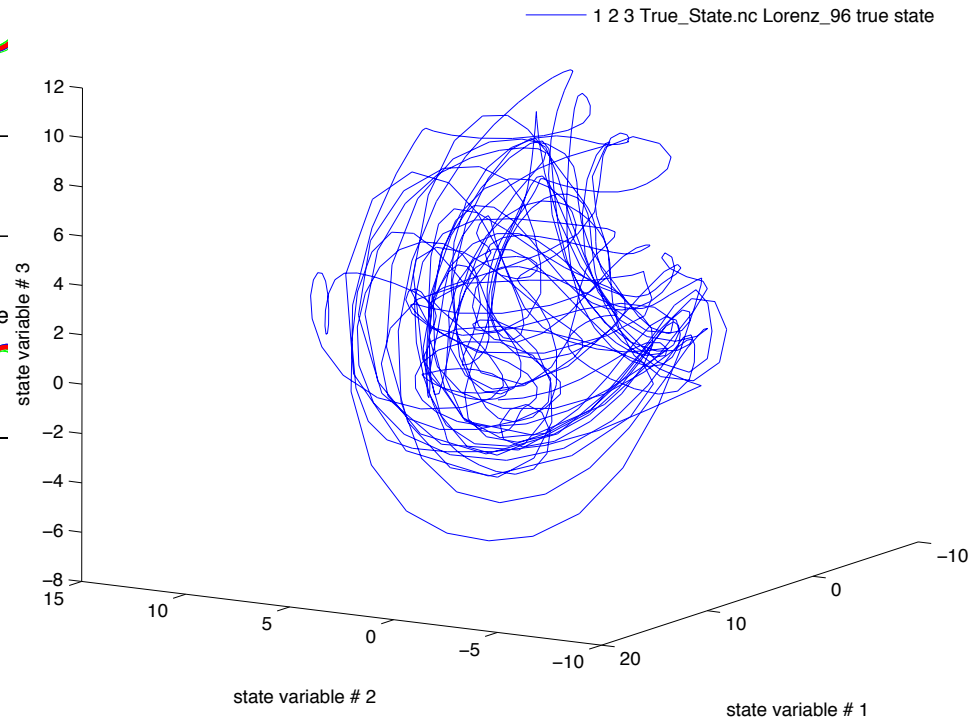
Lorenz_96 state varnum 2 Ensemble Members of ./Prior_Diag.nc



Lorenz_96 state varnum 3 Ensemble Members of ./Prior_Diag.nc



The Attractor



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 *ssh 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

1. Filtering For a One Variable System
2. The DART Directory Tree
3. DART Runtime Control and Documentation
4. How should observations of a state variable impact an unobserved state variable?
Multivariate assimilation.
5. Comprehensive Filtering Theory: Non-Identity Observations and the Joint Phase Space
6. Other Updates for An Observed Variable
7. Some Additional Low-Order Models
8. Dealing with Sampling Error
9. More on Dealing with Error; Inflation
10. Regression and Nonlinear Effects
11. Creating DART Executables
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13. Hierarchical Group Filters and Localization
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16. Diagnostic Output
17. Creating Observation Sequences
18. Lost in Phase Space: The Challenge of Not Knowing the Truth
19. DART-Compliant Models and Making Models Compliant
20. Model Parameter Estimation
21. Observation Types and Observing System Design
22. Parallel Algorithm Implementation
23. Location module design (not available)
24. Fixed lag smoother (not available)