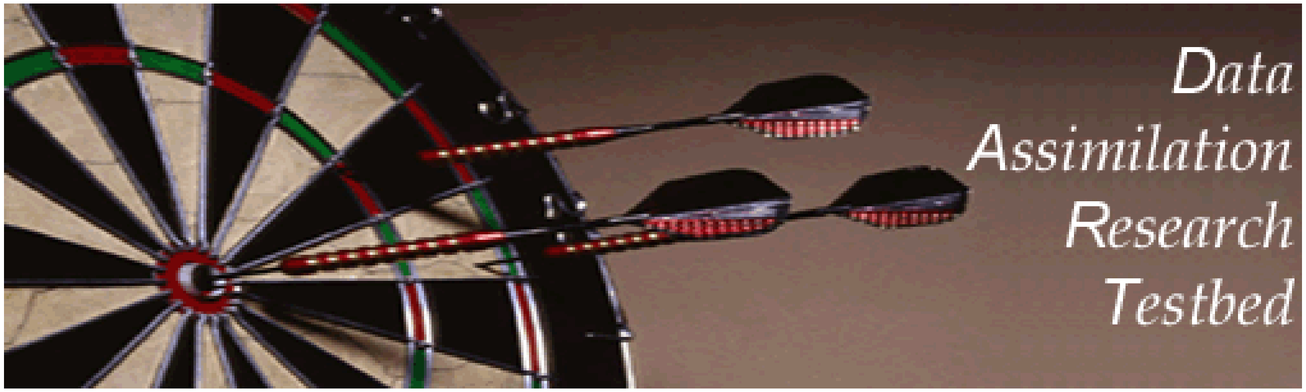
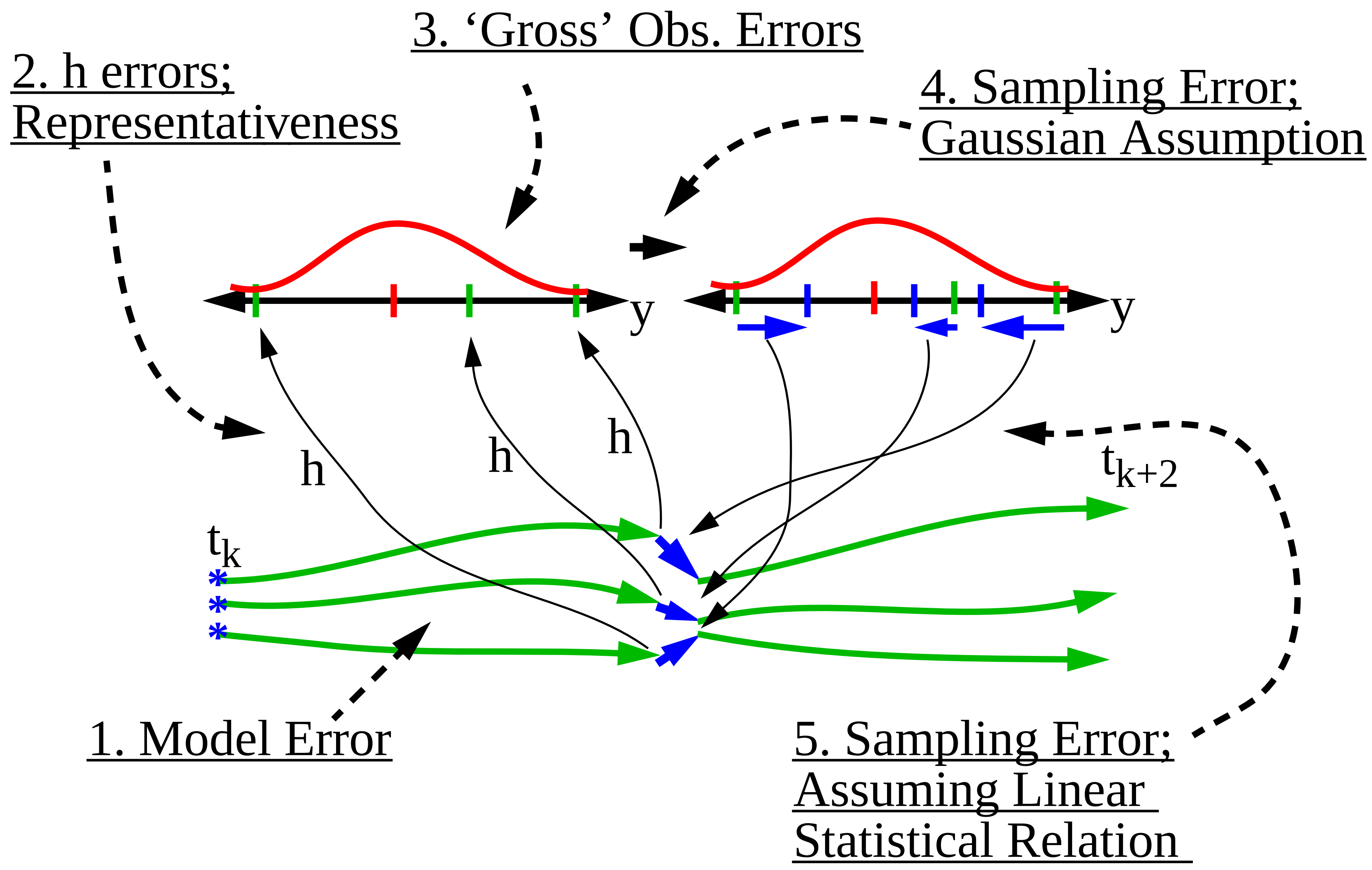
Data Assimilation Research Testbed Tutorial



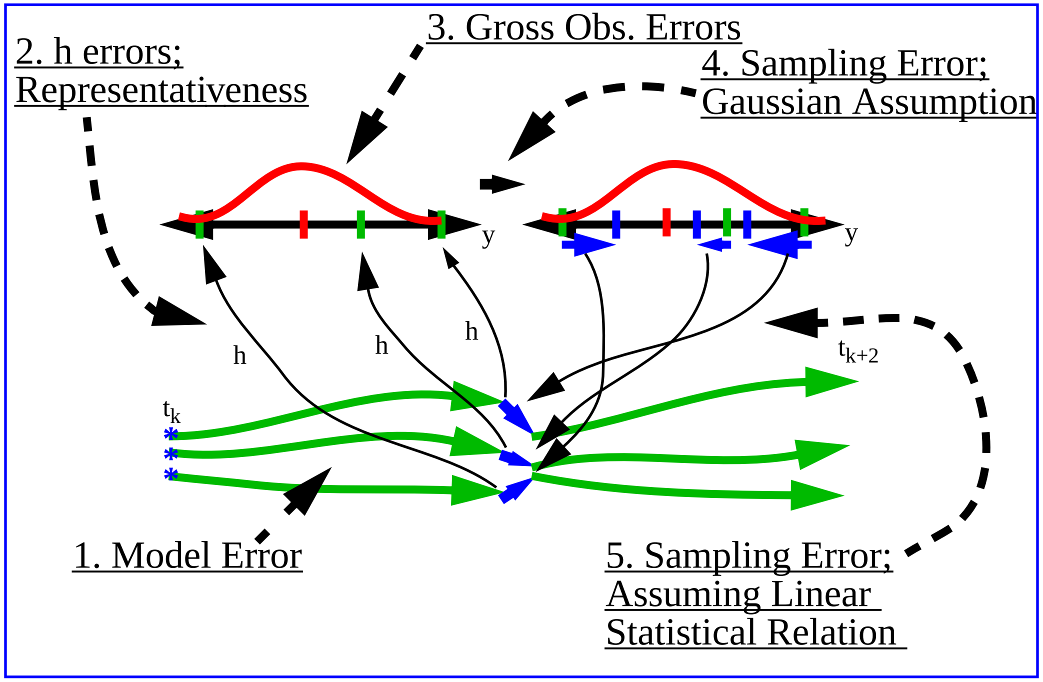
Section 9: More on Dealing with Error; Inflation

Version 2.0: September, 2006

Some Error Sources in Ensemble Filters



Dealing With Ensemble Filter Errors



Fix 1, 2, 3 independently HARD but ongoing.

Often, ensemble filters...

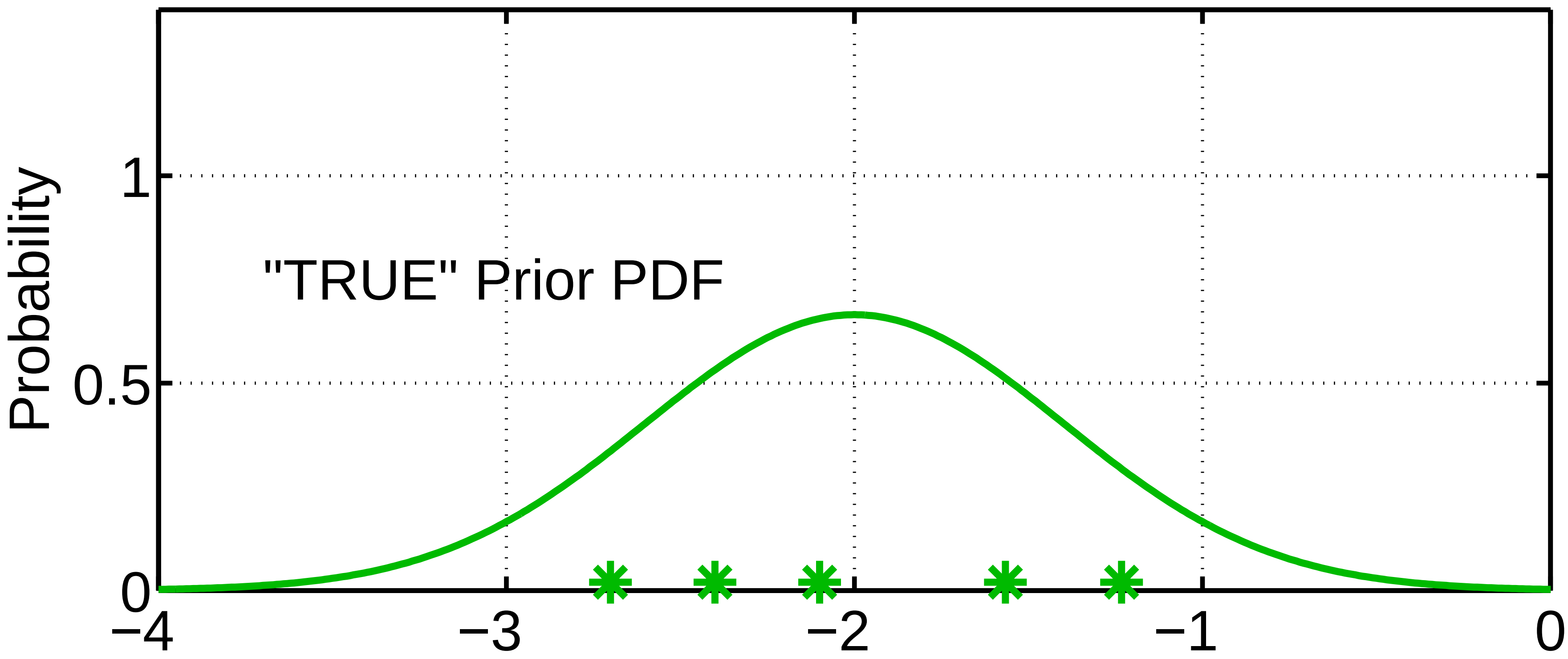
1-4: Covariance inflation, Increase prior uncertainty to give obs more impact.

5. ‘Localization’: only let obs. impact a set of ‘nearby’ state variables.

Often smoothly decrease impact to 0 as function of distance.

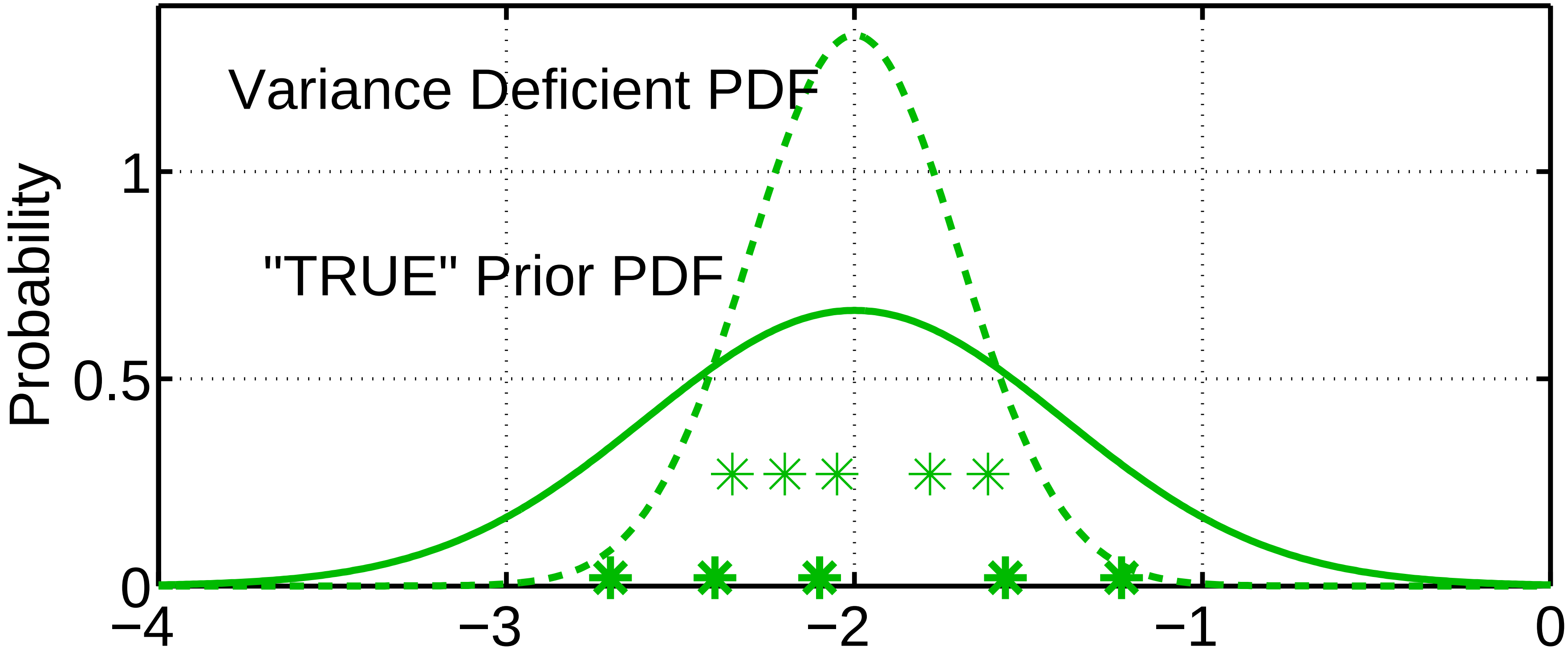
Model/Filter Error; Filter Divergence and Variance Inflation

1. History of observations and physical system => ‘true’ distribution.



Model/Filter Error; Filter Divergence and Variance Inflation

1. History of observations and physical system => ‘true’ distribution.
2. Sampling error, some model errors lead to insufficient prior variance.



3. Can lead to ‘filter divergence’: prior is too confident, obs. ignored

Model/Filter Error; Filter Divergence and Variance Inflation

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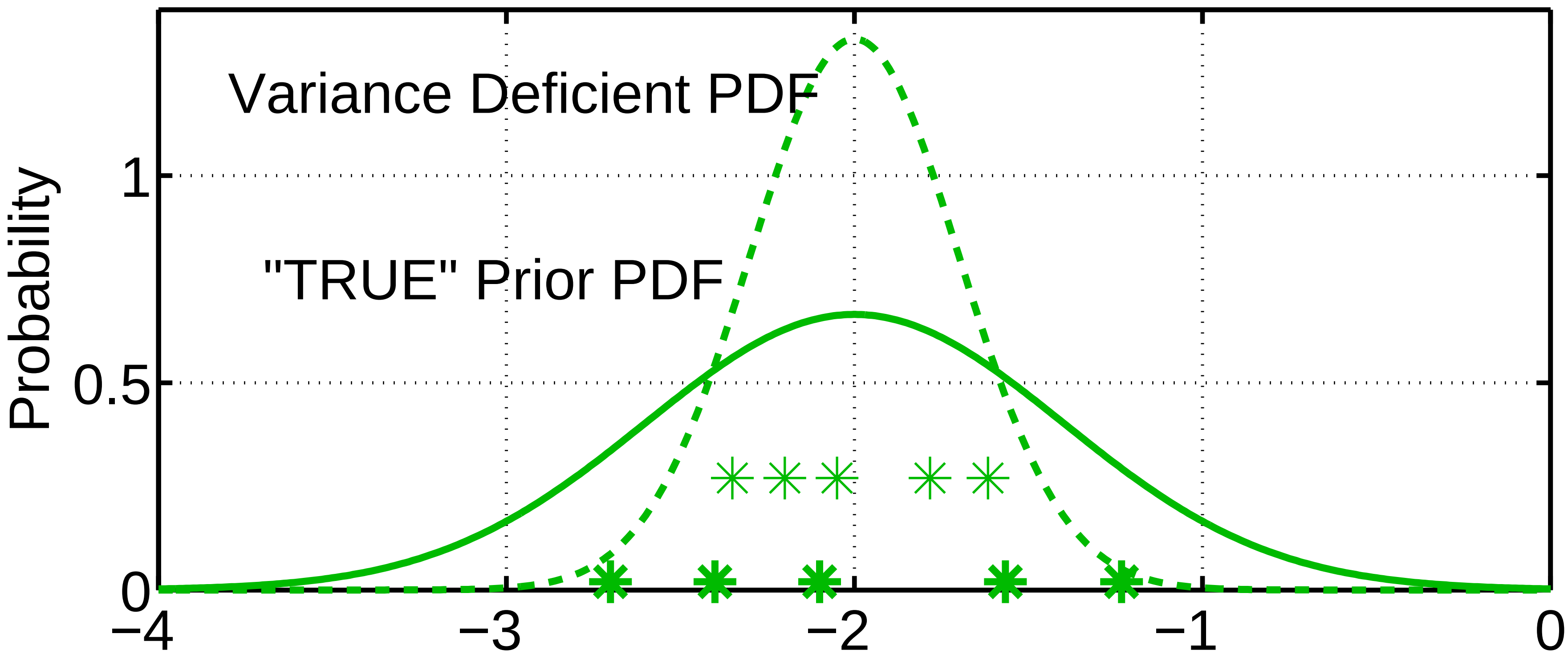

3. Naive solution is Variance inflation: just increase spread of prior

4. For ensemble member i, $inflate(x_i) = \sqrt{\lambda}(x_i - \bar{x}) + \bar{x}$.

Model/Filter Error; Filter Divergence and Variance Inflation

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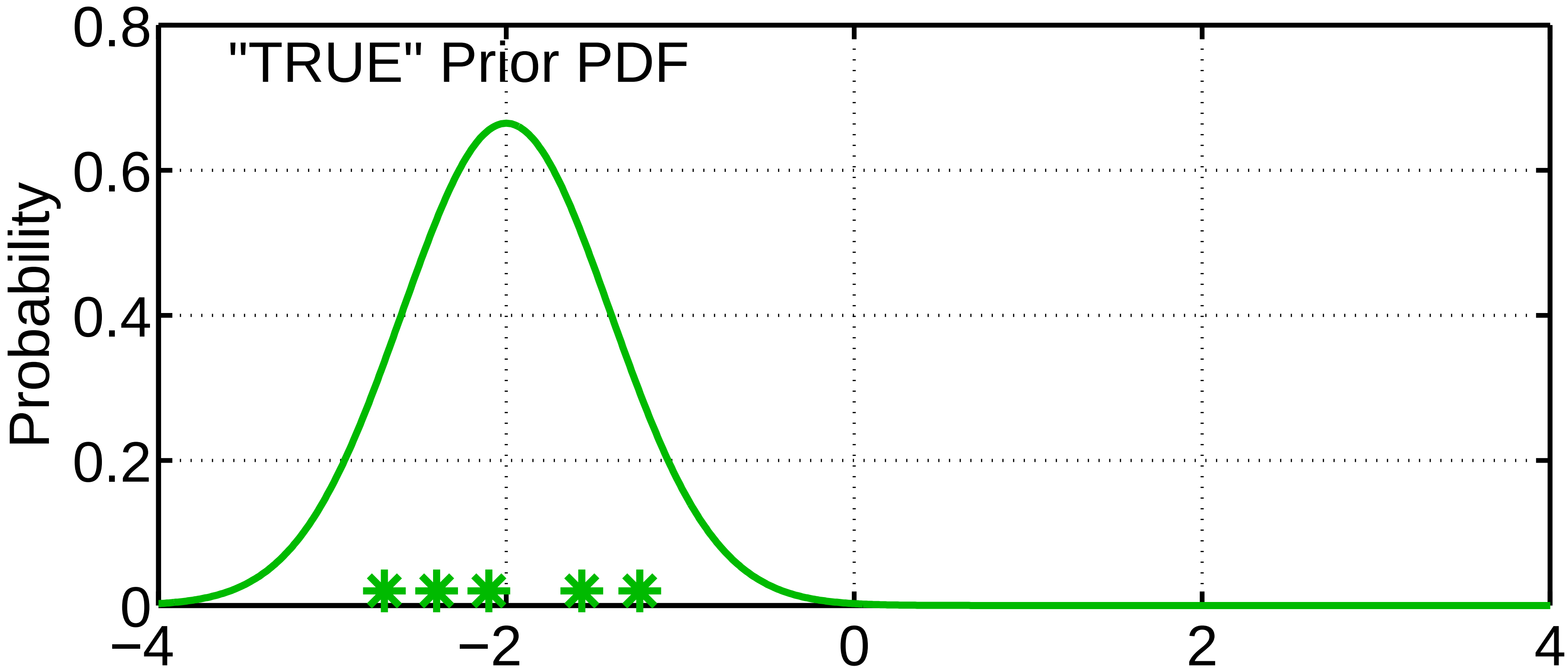
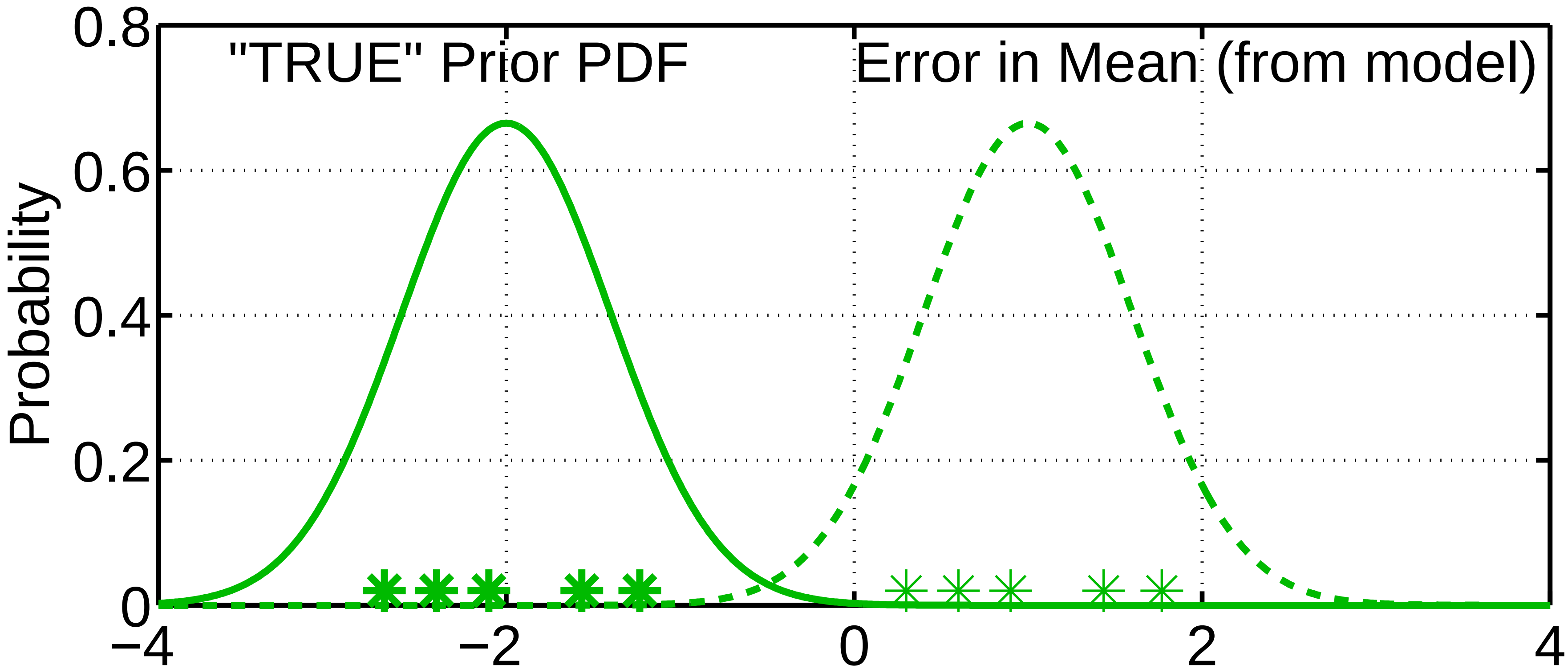


Model/Filter Error; Filter Divergence and Variance Inflation

1. History of observations and physical system => ‘true’ distribution.
2. Most model errors also lead to erroneous shift in entire distribution.



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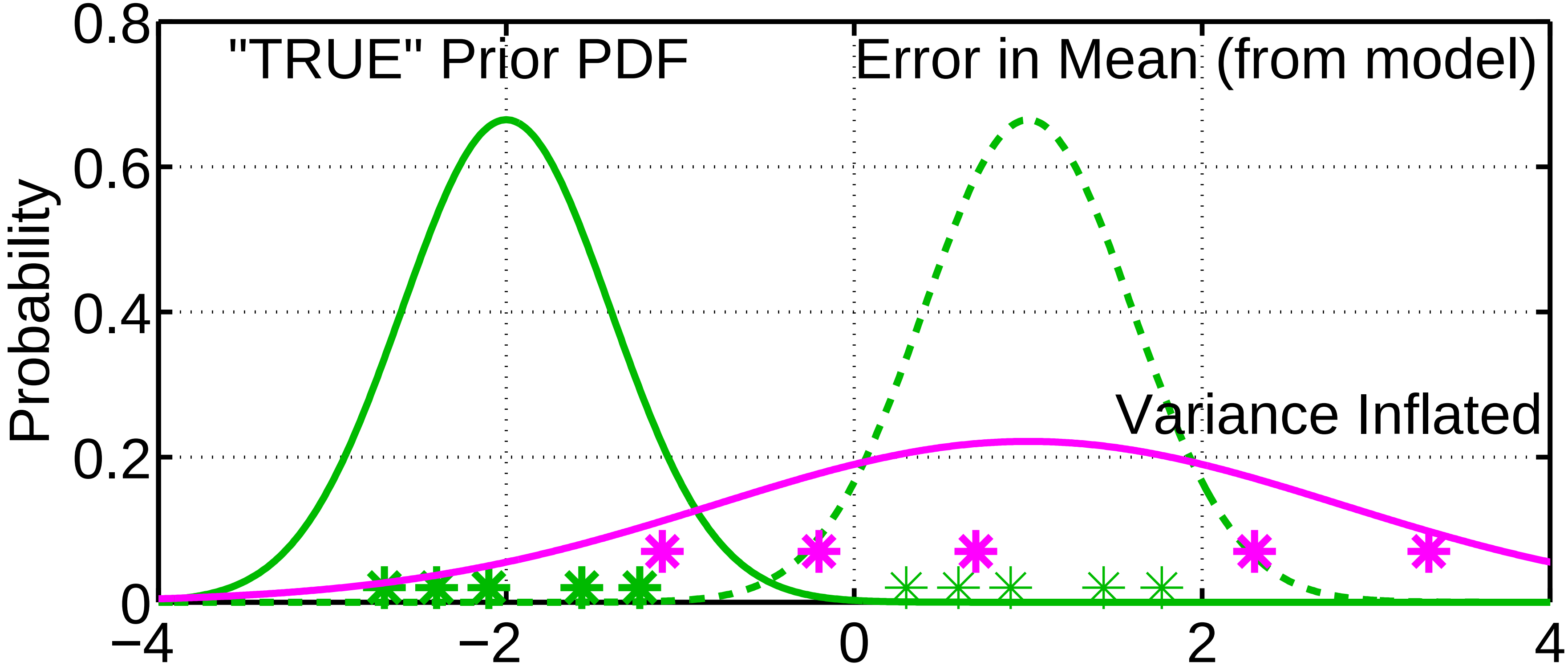


3. Again, prior can be viewed as being TOO CERTAIN
4. Inflating can ameliorate this
5. Obviously, if we knew E(error), we’d correct for it directly

Physical Space Variance Inflation

Inflate all state variables by same amount before assimilation

Capabilities:

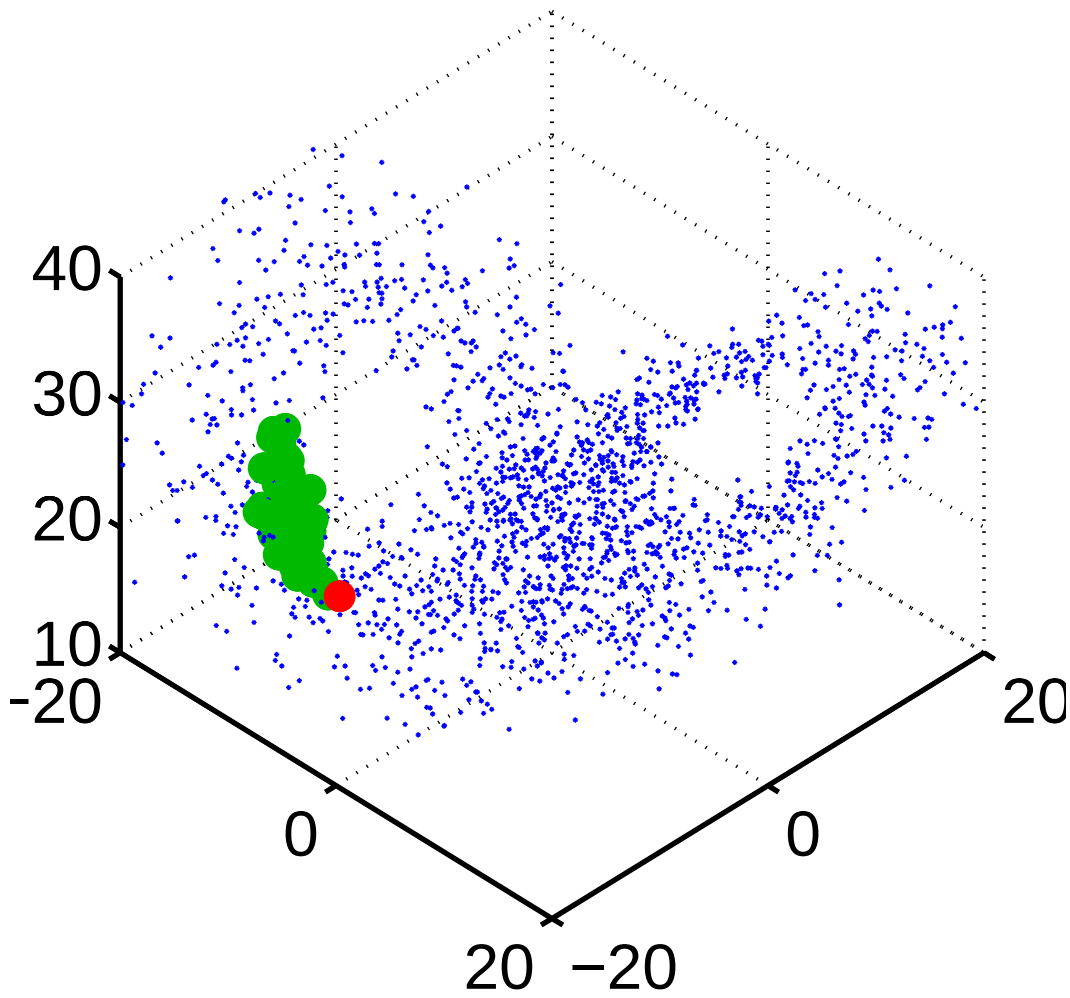
1. Can be very effective for a variety of models.
2. Can maintain linear balances.
3. Stays on local flat manifolds.
4. Simple and inexpensive.

Liabilities:

1. State variables not constrained by observations can 'blow up'.
   For instance unobserved regions near the top of AGCMs.
2. Magnitude of λ normally selected by trial and error.

Physical space covariance inflation in Lorenz_63

Observation outside prior: danger of filter divergence

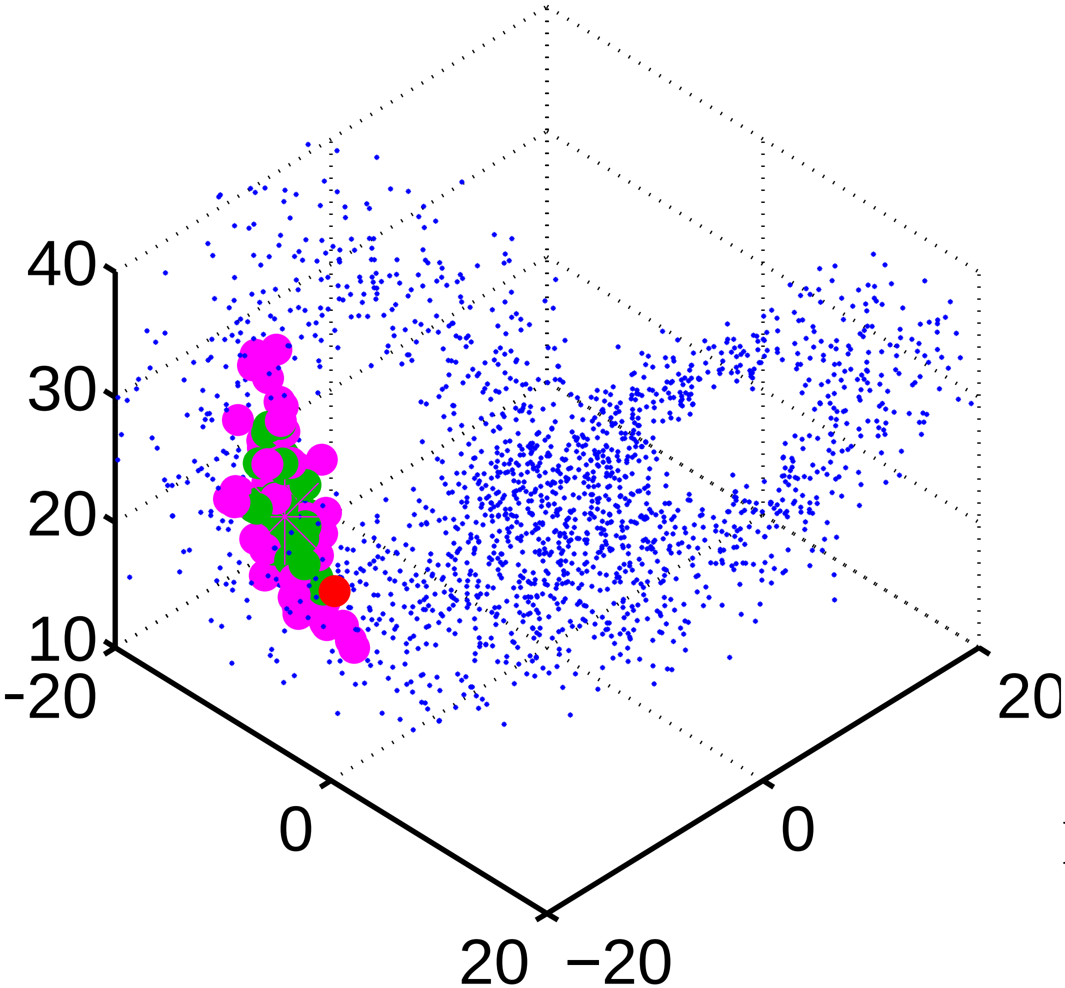


Observation in red.

Prior ensemble in green.

Physical space covariance inflation in Lorenz_63

After inflating, observation is in prior cloud: filter divergence avoided



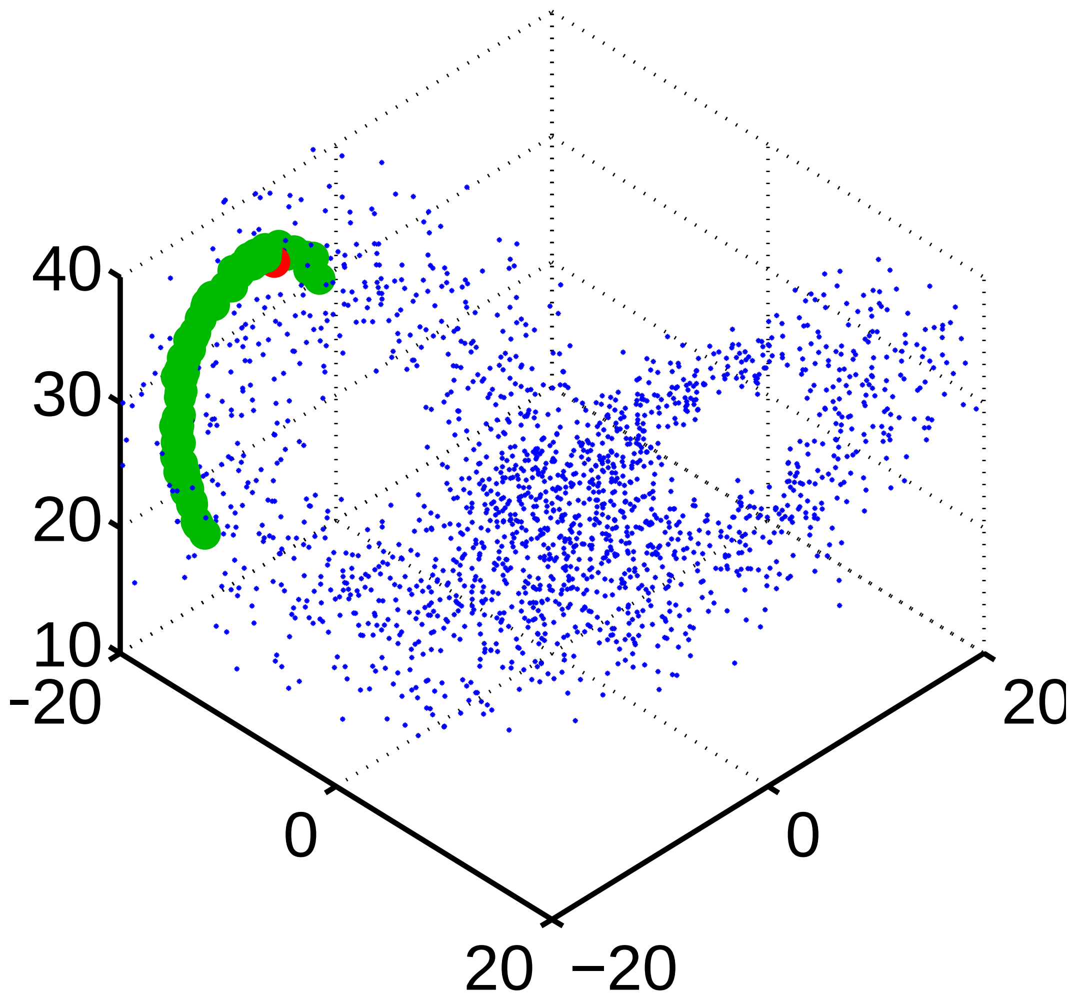
Observation in red.

Prior ensemble in green.

Inflated ensemble in magenta.

Physical space covariance inflation in Lorenz_63

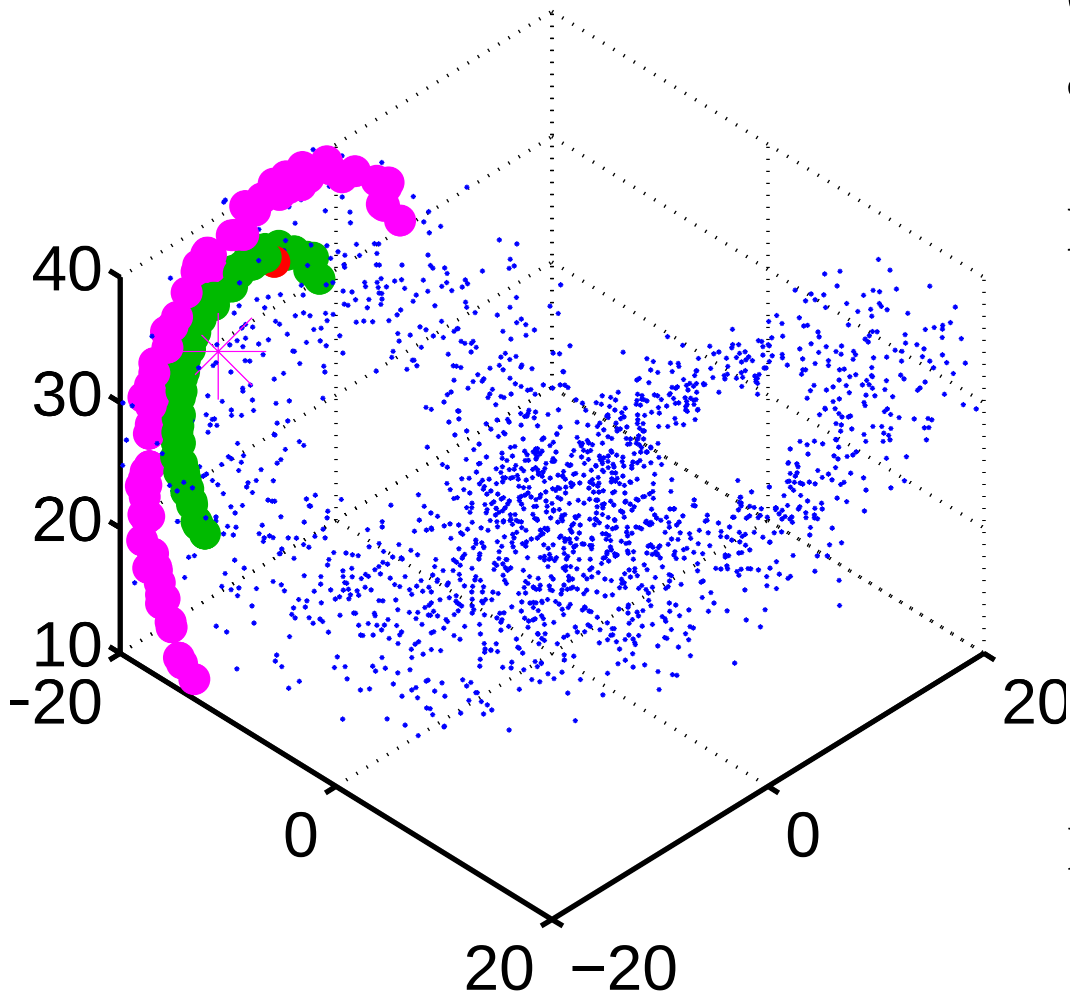
Prior distribution is significantly 'curved'



Observation in red.

Prior ensemble in green.

Inflated prior outside attractor. Posterior will also be off attractor.



Can lead to transient off attractor behavior or...

Model ‘blow-up’.

Observation in red.

Prior ensemble in green.

Inflated ensemble in magenta.

Basic control of Inflation in DART is in filter.nml

	Before Assimilation	After Assimilation		
inf_flavor	= 0,	0,	Flavor:	1=> obs. space
inf_start_from_restart	= .false.,	.false.,		3=>physical space
inf_output_restart	= .true.,	.true.,		0=>NONE
inf_deterministic	= .true.,	.true.,		
inf_in_file_name	= 'prior_inflate_ics',	'prior_inflate_ics',		
inf_out_file_name	= 'prior_inflate_restart',	'prior_inflate_restart',		
inf_diag_file_name	= 'prior_inflate_diag',	'prior_inflate_diag',		
inf_initial	= 1.00,	1.00,	Inflation value	
inf_sd_initial	= 0.0,	0.0,		
inf_lower_bound	= 1.0,	1.0,		
inf_upper_bound	= 1000000.0,	1000000.0,		
inf_sd_lower_bound	= 0.0,	0.0		

Initially, we'll change *inf_flavor* and *inf_initial* in first column

Physical space covariance inflation in Lorenz_96

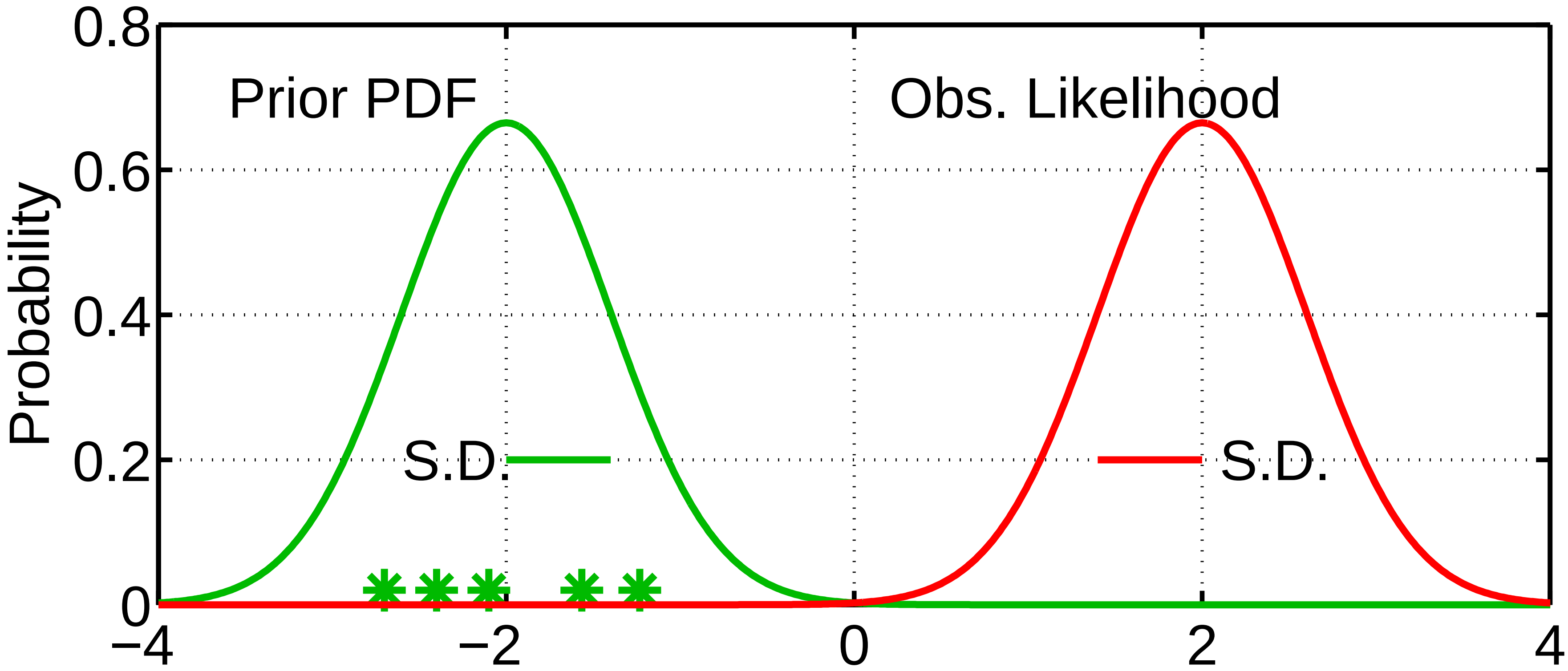
Set *inf_flavor=3*, state space inflation, in the first column.

Try some values and see what happens to L96 assimilation.
Set *inf_initial* to values like 1.05, 1.08, 1.10 in the first column.

Make sure that *cutoff=10000000* and *ens_size=20*
(These were settings that diverged without inflation)

Variance inflation in Observation Space:

1. For observed variable, have estimate of prior-observed inconsistency



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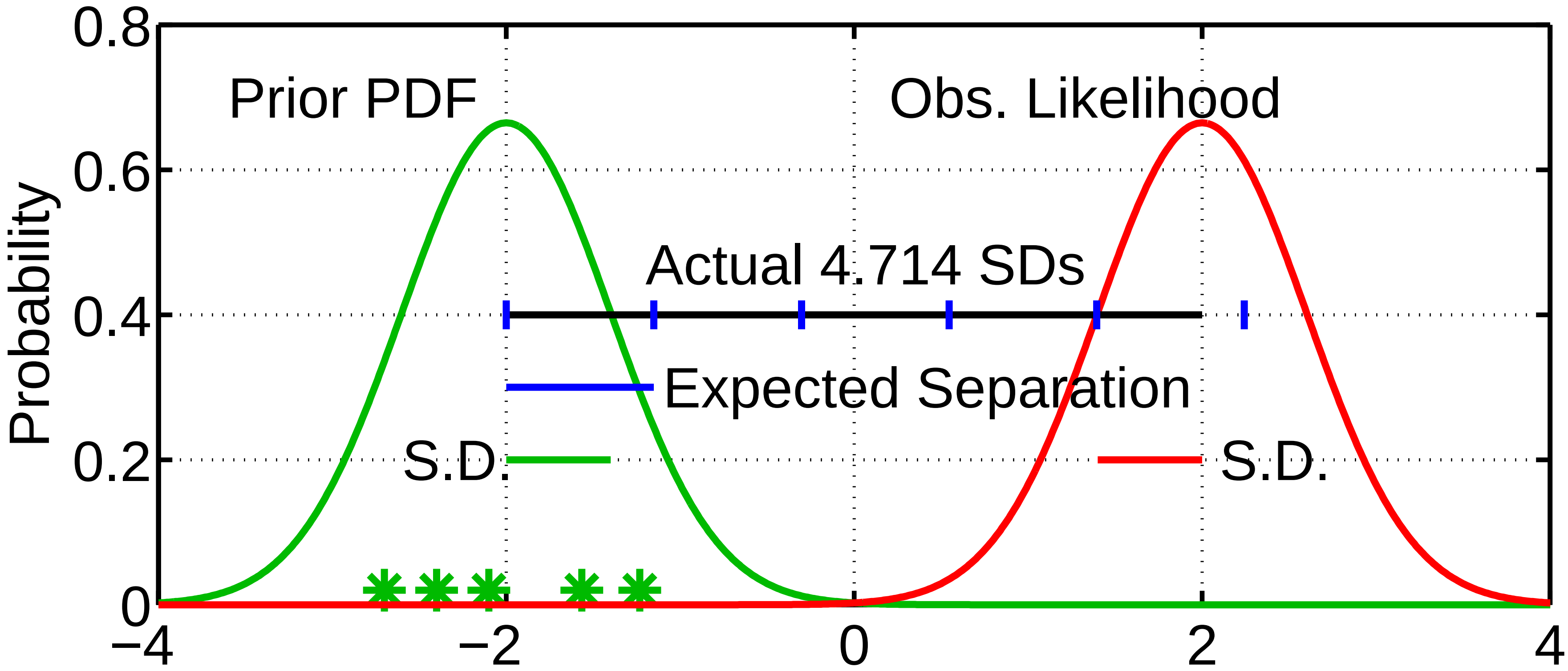

2. Expected(prior mean - observation) = $\sqrt{\sigma^2_{prior} + \sigma^2_{obs}}$.

Assumes that prior and observation are supposed to be unbiased.

Is it model error or random chance?

Variance inflation in Observation Space:

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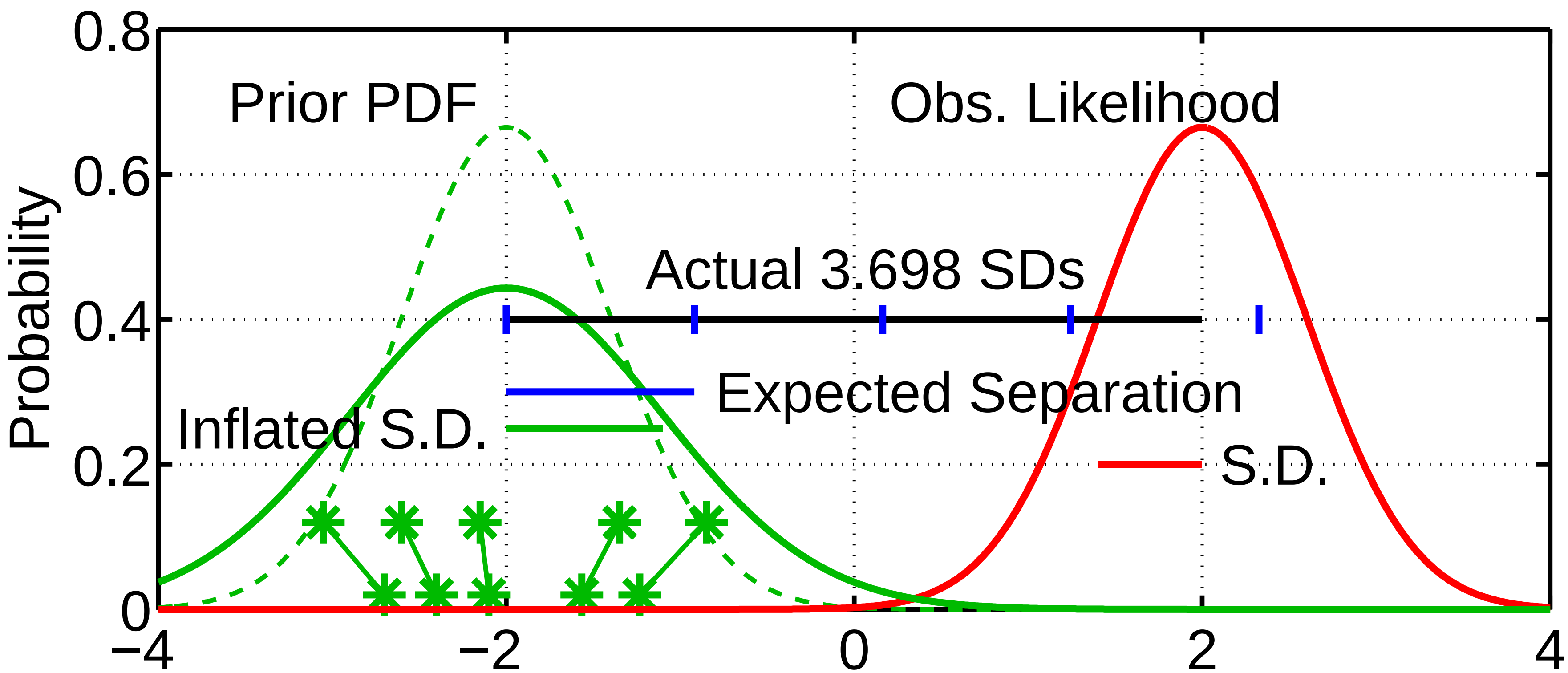

2. Expected(prior mean - observation) = $\sqrt{\sigma^2_{prior} + \sigma^2_{obs}}$.

3. Inflating increases expected separation.

Increases 'apparent' consistency between prior and observation.

Variance inflation in Observation Space: Lorenz_96 Example.

Try some values and see what happens to L96 assimilation.
Set *inf_flavor=1*, observation space inflation in first column.

Try some values and see what happens to L96 assimilation.
Set *inf_initial* to values like 1.05, 1.08, 1.10 in first column.

Make sure that *cutoff=10000000* and *ens_size=20*
(These were settings that diverged without inflation)