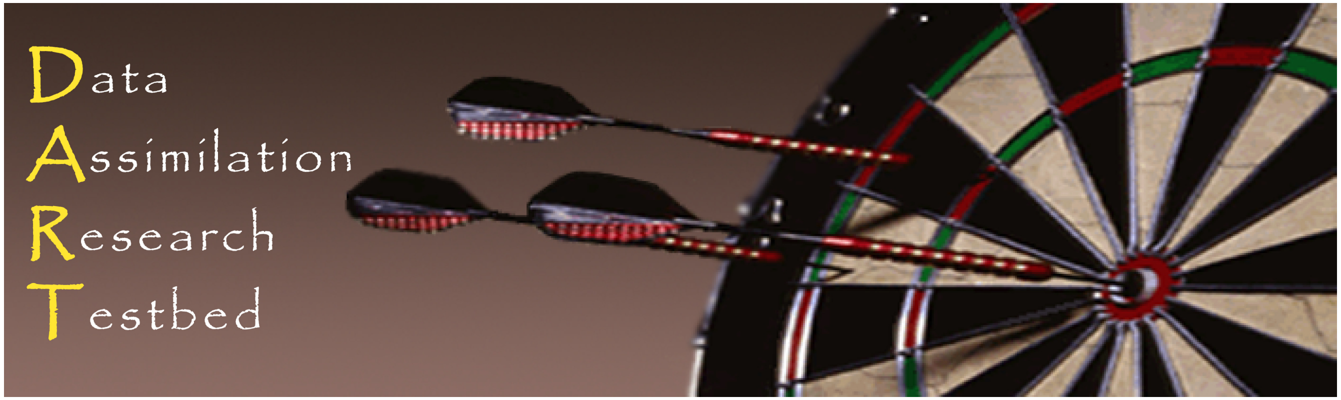
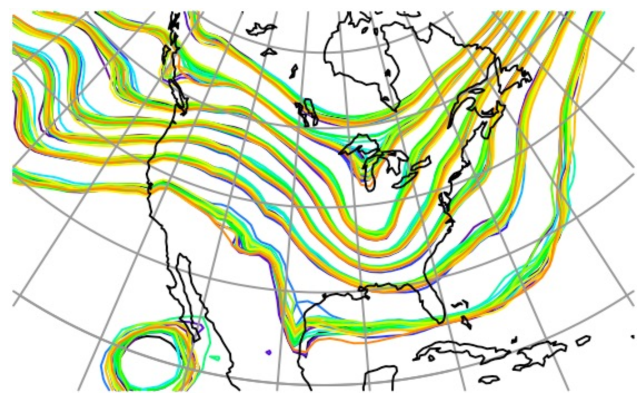


DART Tutorial Section 9: More on Dealing with Error: Inflation



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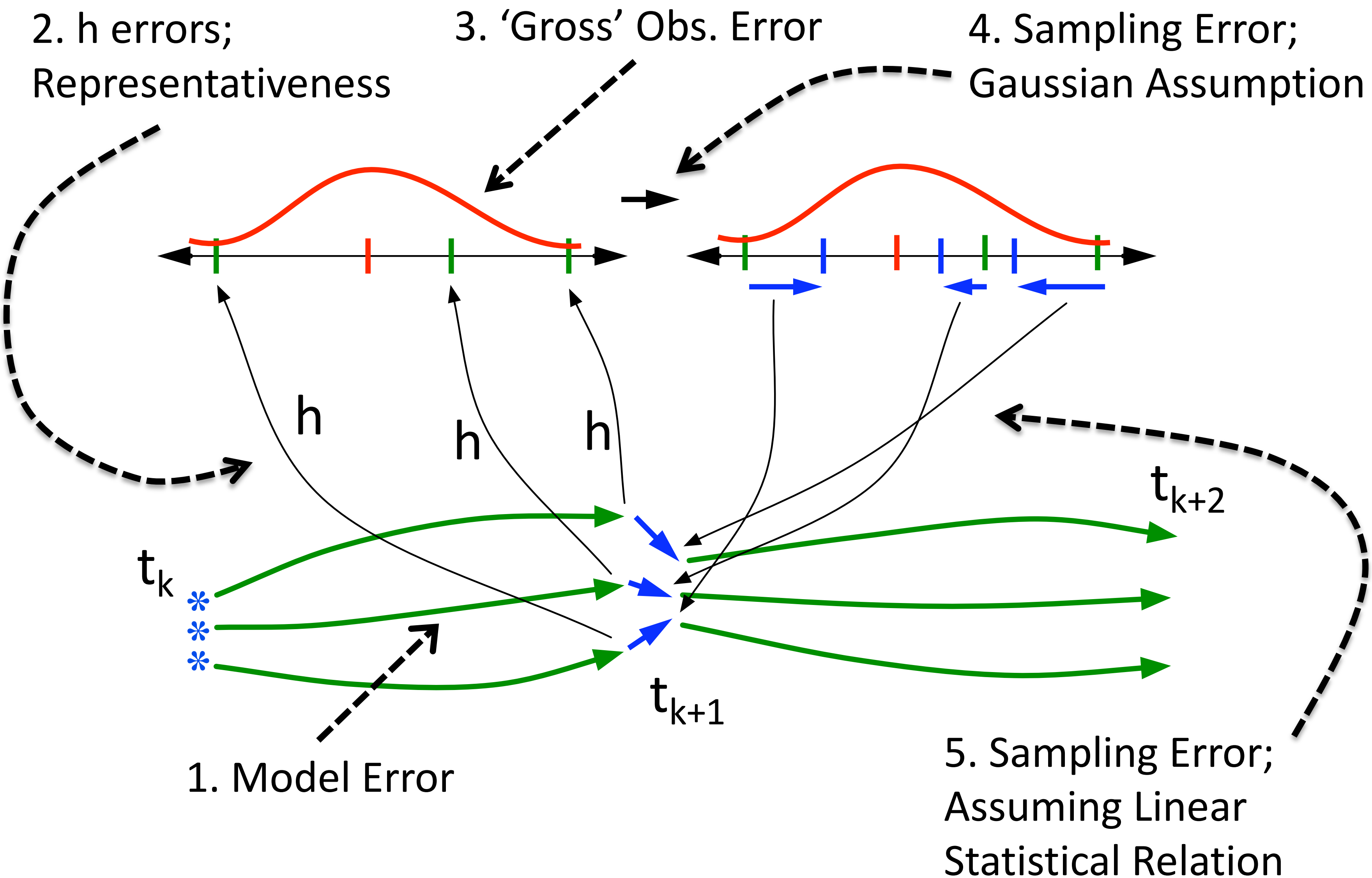
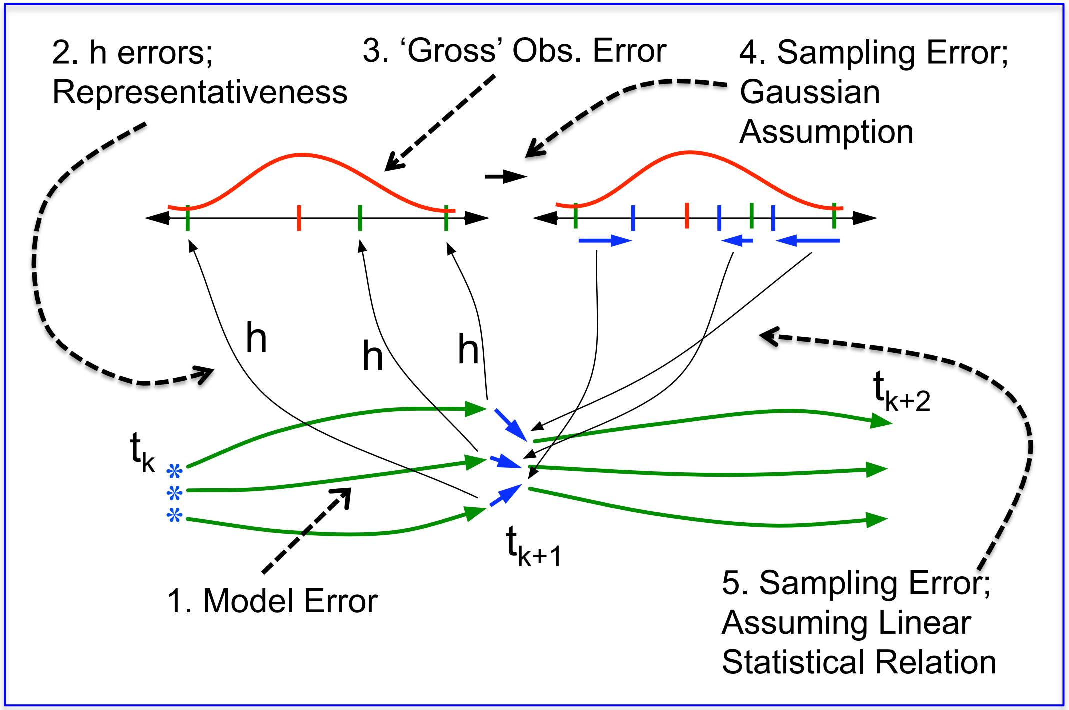
Some Error Sources in Ensemble Filters



Dealing with Ensemble Filter Errors



Fix 1, 2, 3 independently, HARD but ongoing.

Often, ensemble filters...

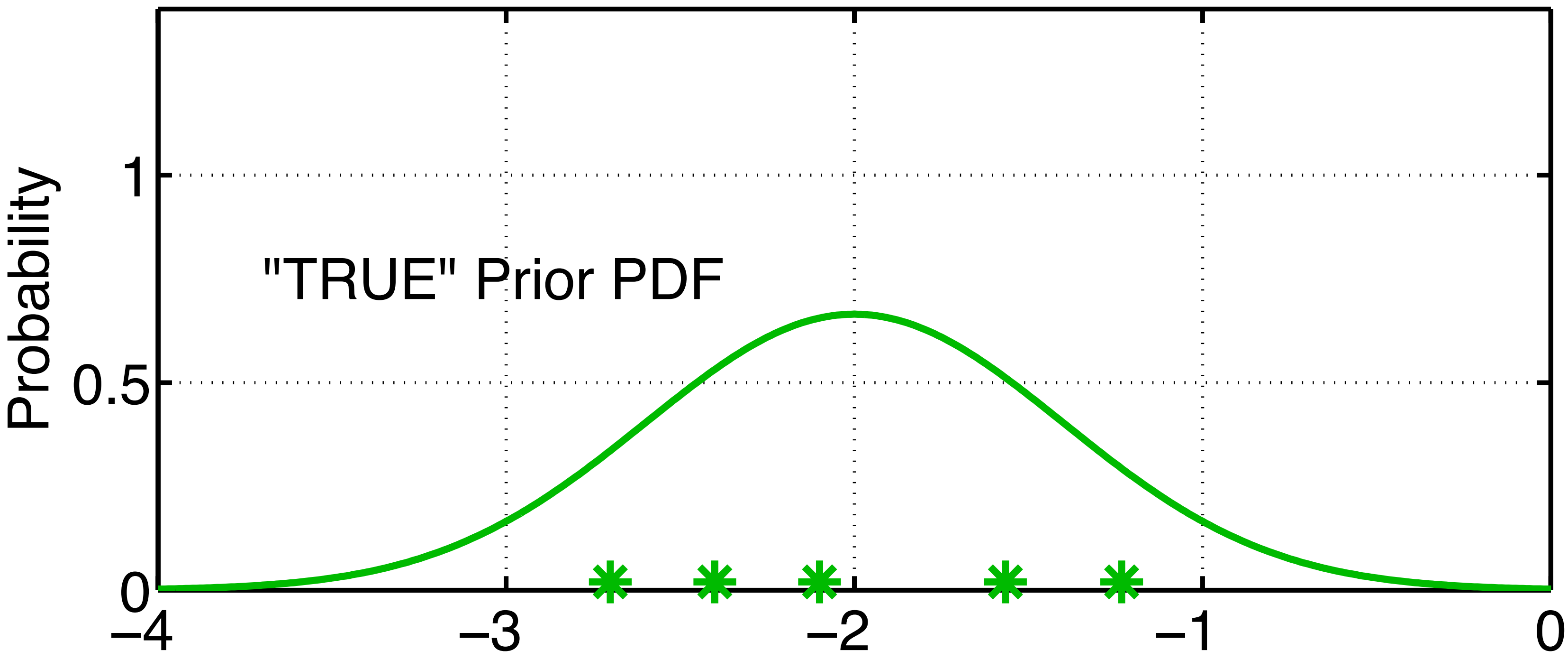
1-4: Variance inflation, Increase prior uncertainty to give obs more impact.

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

Often smoothly decrease impact to 0 as function of distance.

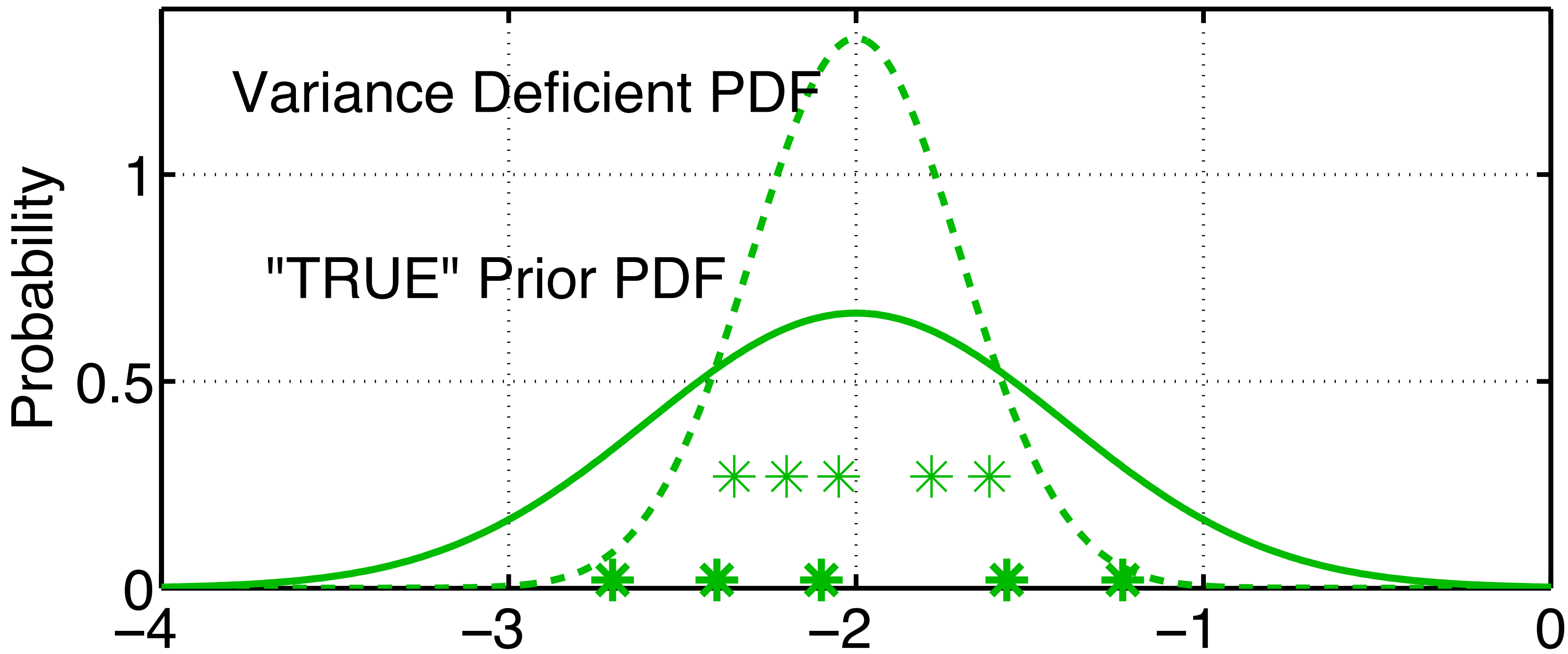
Model/Filter Error: Filter Divergence and Variance Inflation

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.



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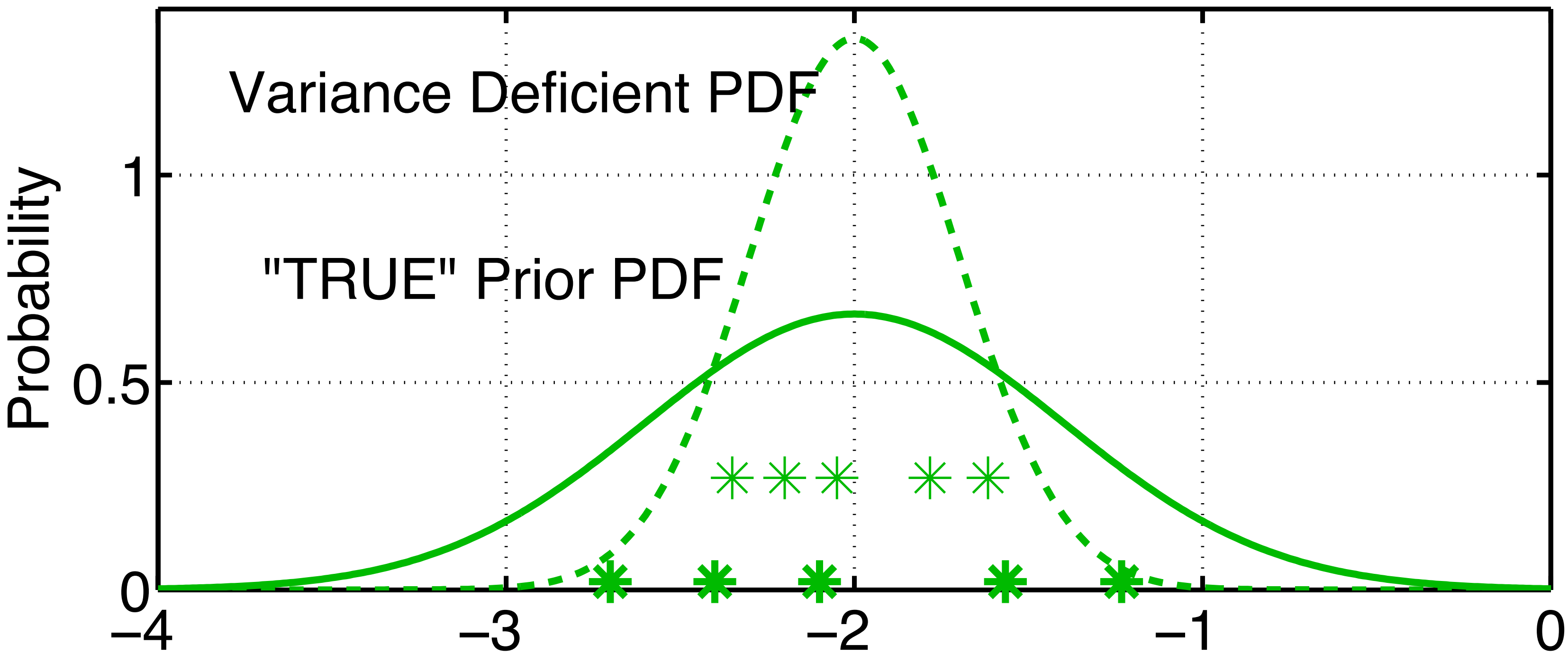

Naïve solution is variance inflation: just increase spread of prior.
For ensemble member i, $inflate\left(x_i\right)=\sqrt{\lambda}\left(x_i-\overline{x}\right)+\overline{x}$

Model/Filter Error: Filter Divergence and Variance Inflation

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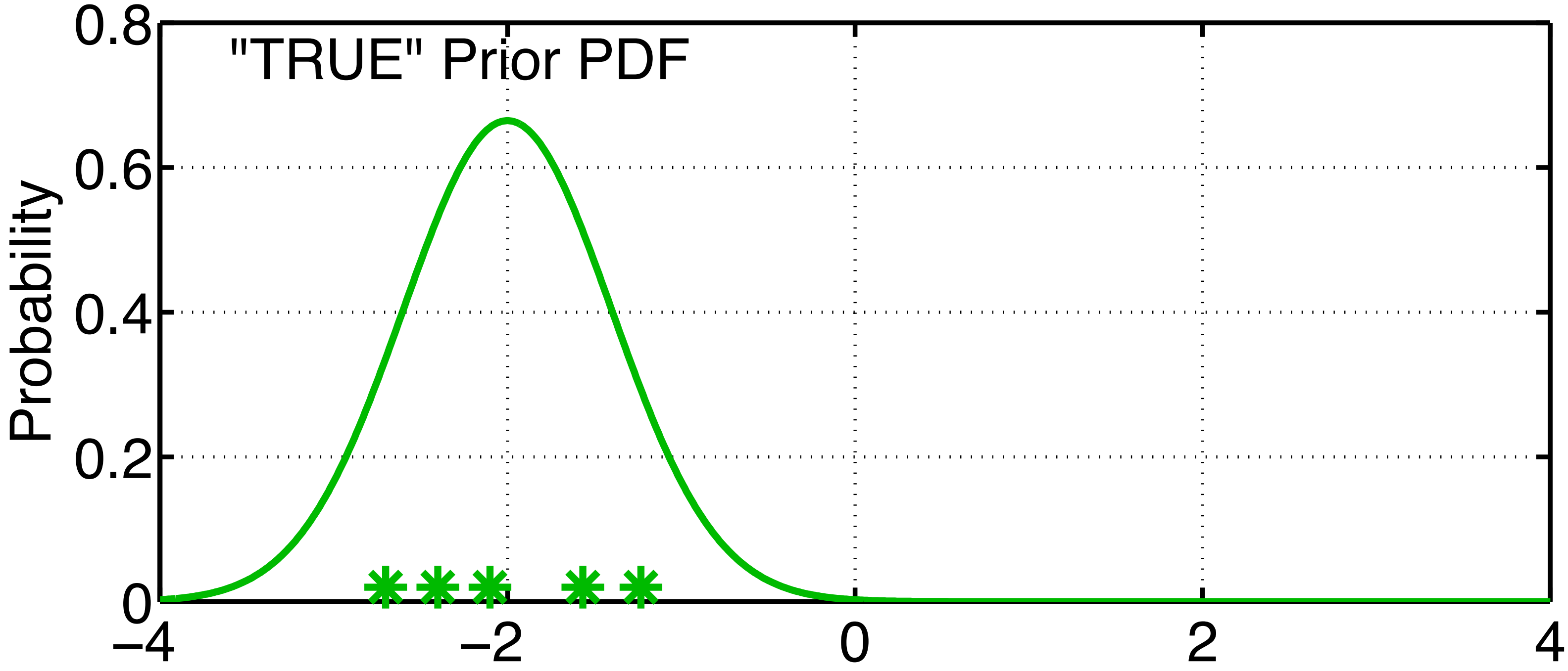
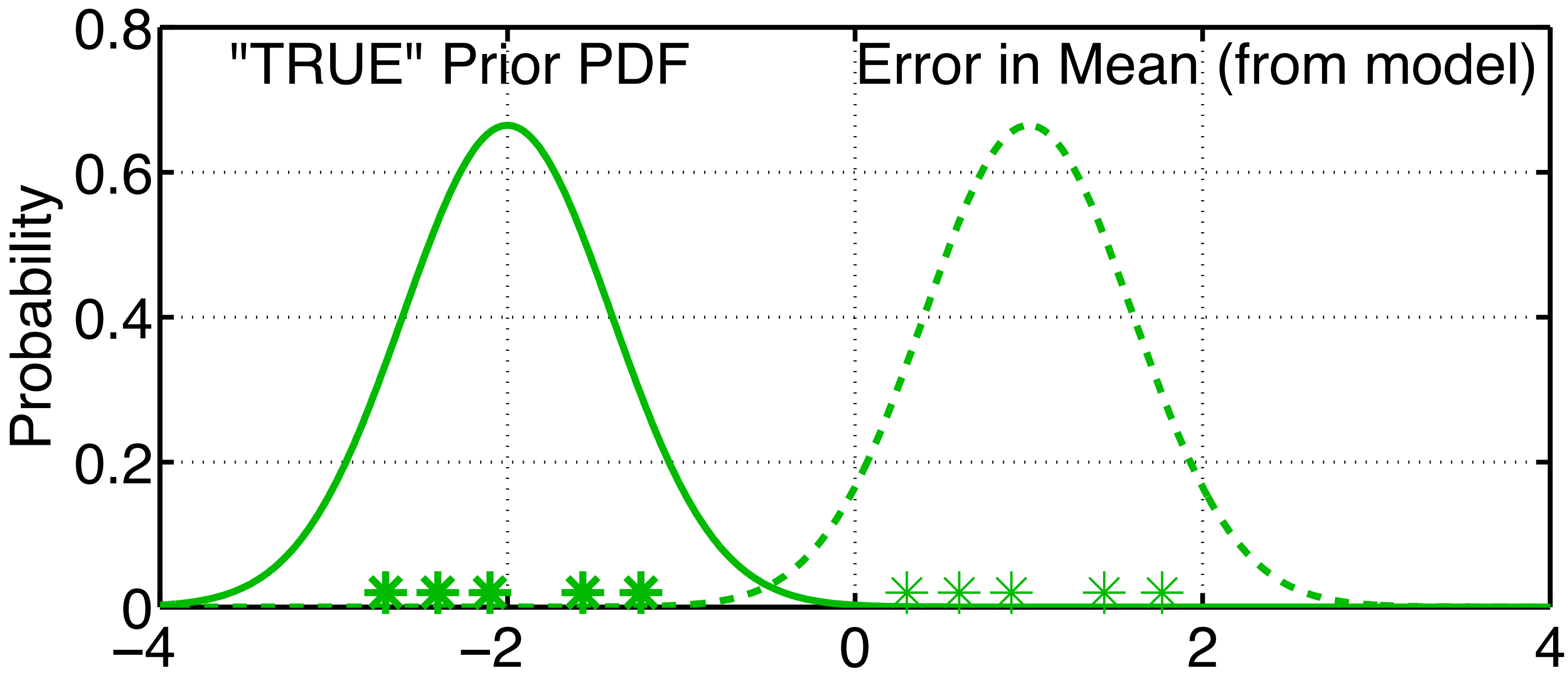


Model/Filter Error: Filter Divergence and Variance Inflation

1. History of observations and physical system => ‘true’ distribution.
2. Most model errors also lead to erroneous shift in entire distribution.
3. Again, prior can be viewed as being TOO CERTAIN.



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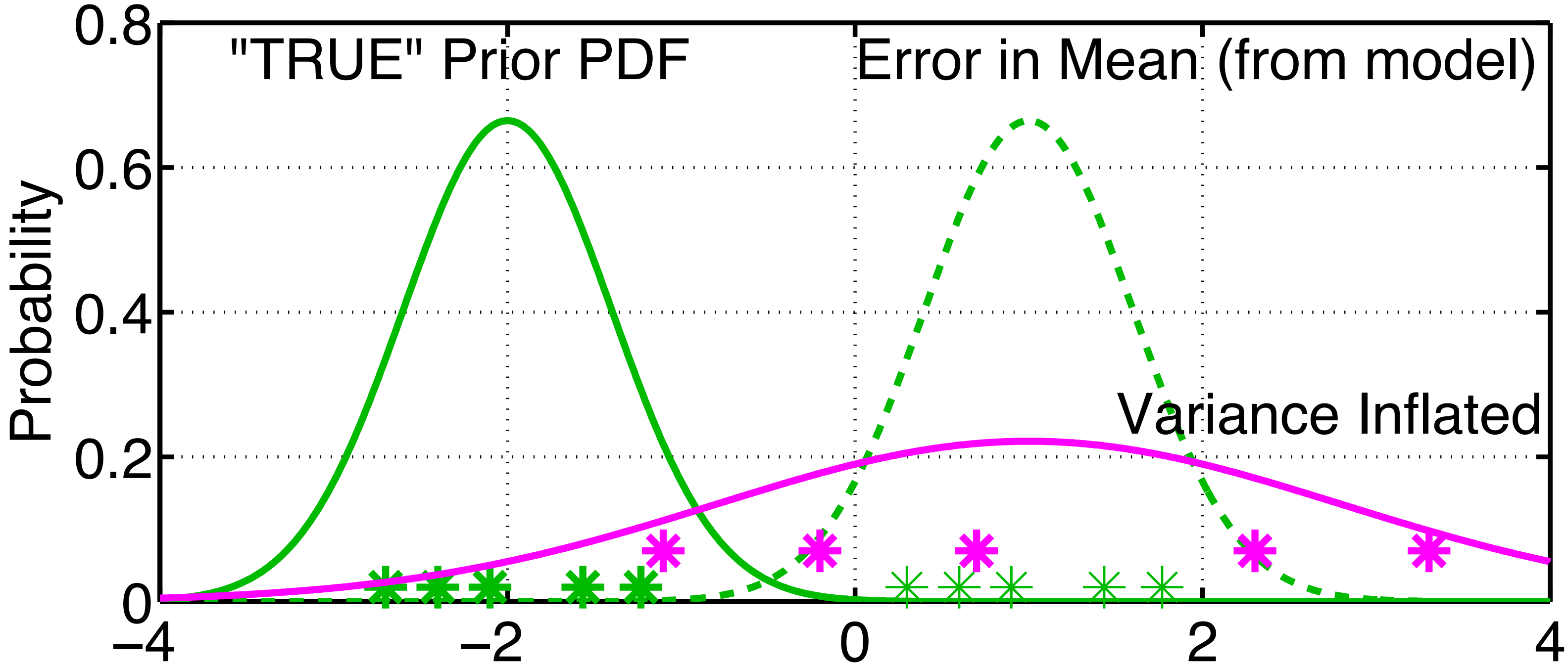


Inflating can ameliorate this.
Obviously, if we knew E(error), we'd correct for it directly.

Physical Space Variance Inflation

Inflate all state variables by same amount before assimilation.

<u>Capabilities:</u>

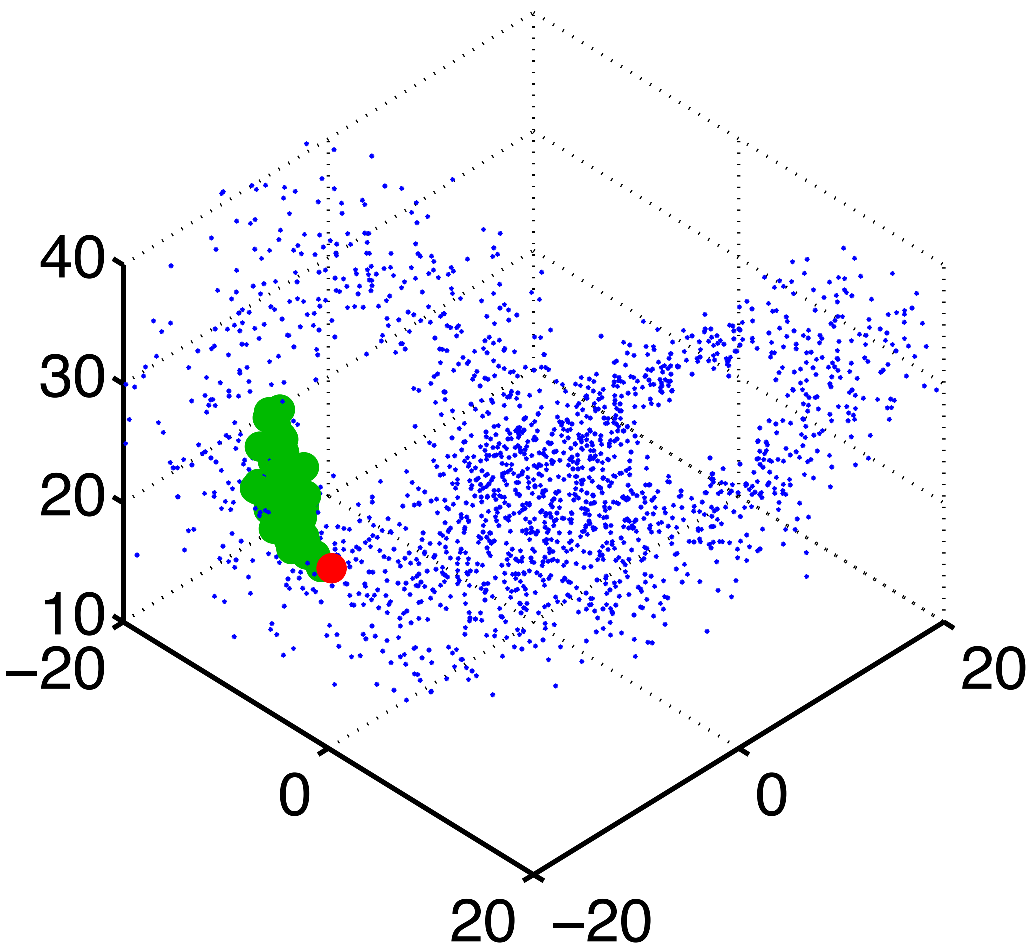
1. Can be effective for a variety of models.
2. Can maintain linear balances.
3. Stays on local flat manifolds.
4. Simple and cheap.

<u>Liabilities:</u>

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 Variance Inflation in Lorenz 63

Observation outside prior: danger of filter divergence.

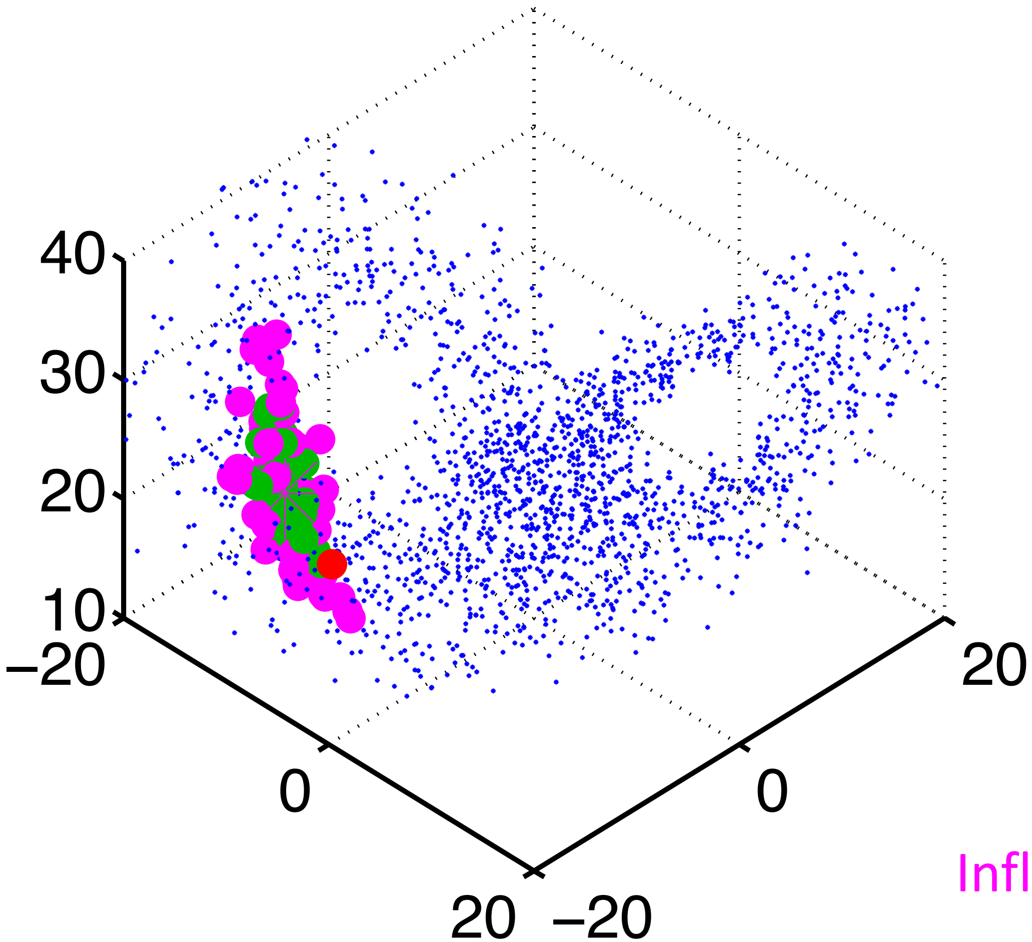


Observation in red.

Prior ensemble in green.

Physical Space Variance Inflation in Lorenz 63

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



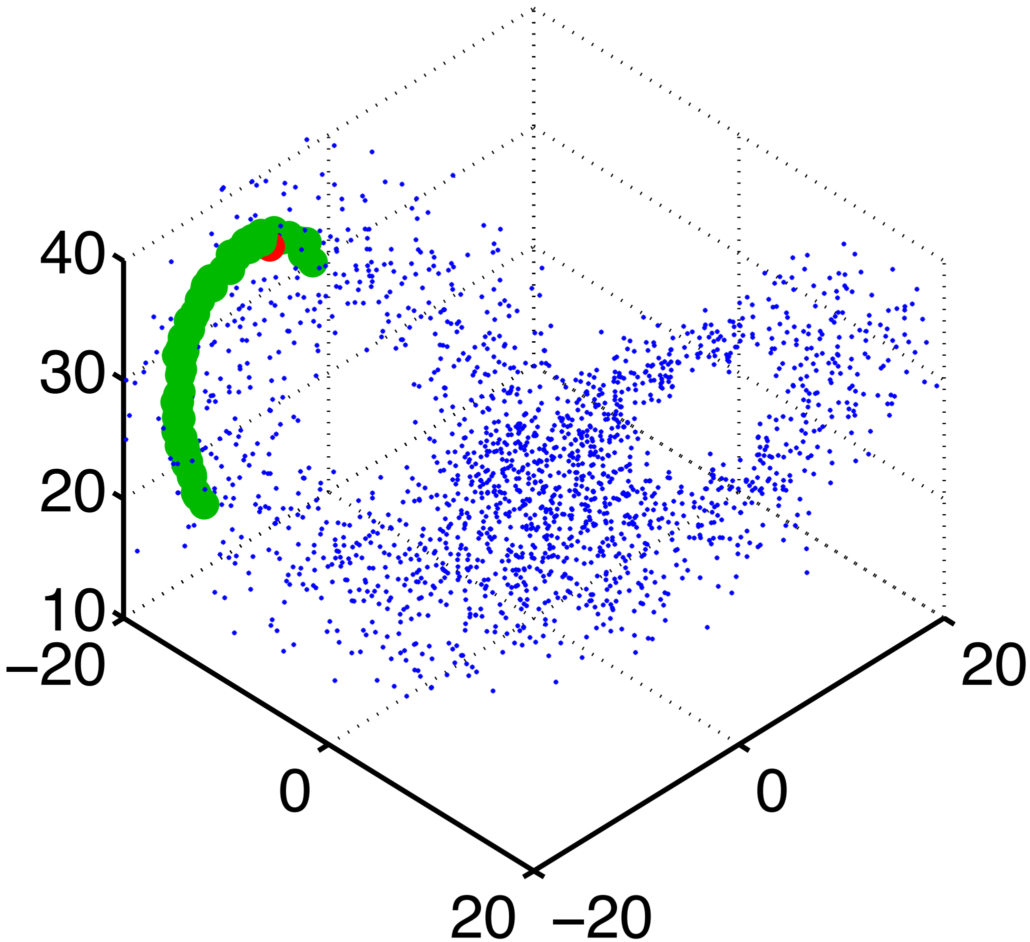
Observation in red.

Prior ensemble in green.

Inflated ensemble in magenta.

Physical Space Variance Inflation in Lorenz 63

Prior distribution is significantly ‘curved’.

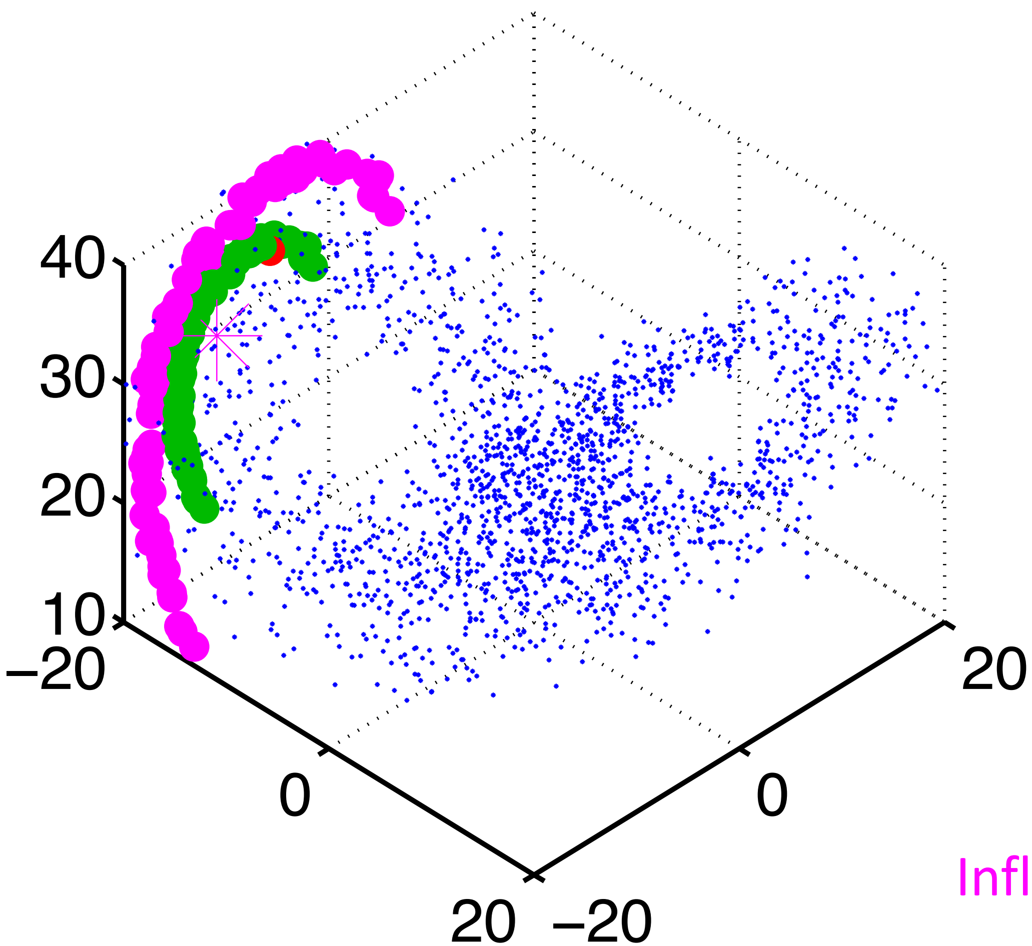


Observation in red.

Prior ensemble in green.

Physical Space Variance Inflation in Lorenz 63

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,
inf_initial_from_restart	= .false.,	.false.,
inf_sd_initial_from_restart	= .false.,	.false.,
inf_deterministic	= .true.,	.true.,
inf_initial	= 1.0,	1.0,
inf_sd_initial	= 0.0,	0.0,
inf_damping	= 1.0,	1.0,
inf_lower_bound	= 1.0,	1.0,
inf_upper_bound	= 1000000.0,	1000000.0,
inf_sd_lower_bound	= 0.0,	0.0,
	prior inflation column	posterior inflation column

Flavor: 0 => NONE
1 => deprecated
2,3 => physical space

Inflation Value

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

Physical space variance inflation in Lorenz 96

models/lorenz_96/work/

Try some values and see what happens to assimilations with Lorenz 96.

Set ***inf_flavor*** to 3 to use state space inflation.
In the first column, set ***inf_initial*** to values like 1.05, 1.08, 1.10

```
&assim_tools_nml
   filter_kind                 = 1
   cutoff                      = 1000000.0
   spread_restoration          = .false.
   sampling_error_correction = .false.
   …
&filter_nml
   ens_size = 20
   perturb_from_single_instance = .false.
   …
   inf_flavor                 = 3,           0
   inf_initial_from_restart   = .false.,    .false.
   inf_sd_initial_from_restart = .false.,   .false.
   inf_initial                = 1.0,         1.0
   inf_sd_initial             = 0.0,         0.0
   inf_damping                = 1.0,         1.0
   inf_lower_bound            = 1.0,         1.0
   inf_upper_bound            = 1000000.0,    1000000.0
   inf_sd_lower_bound         = 0.0,         0.0
```

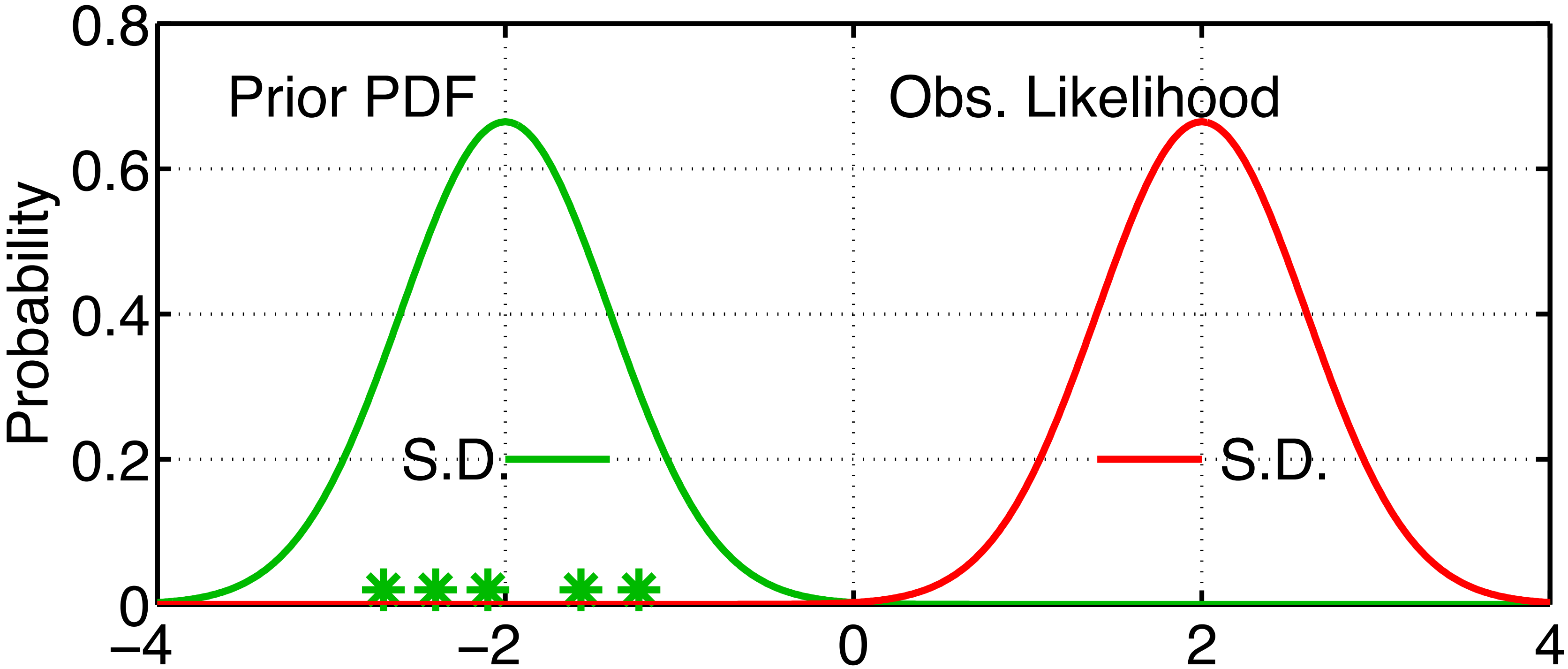
These were the settings that diverged without inflation.

3 = state space inflation

Explore with this!

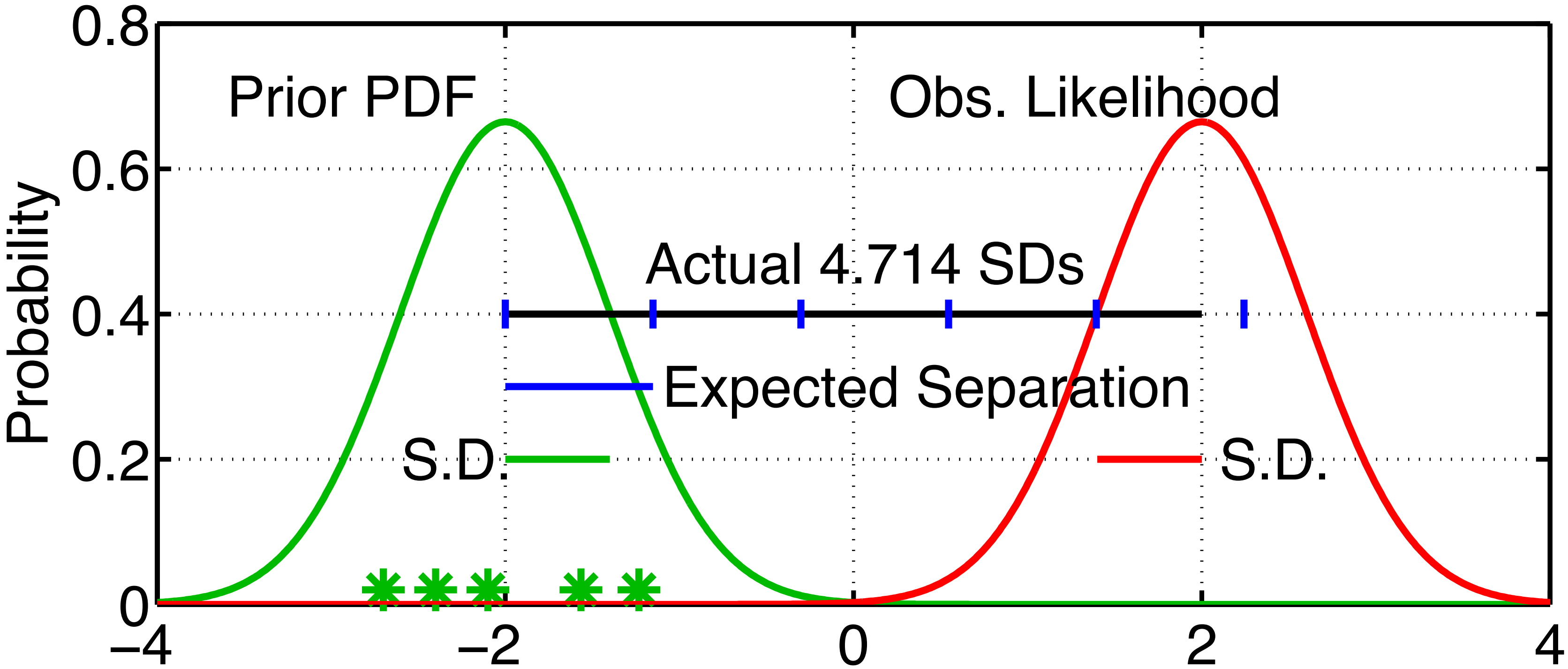
Variance inflation in observation space

Not currently supported in DART Manhattan.



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

Variance inflation in observation space

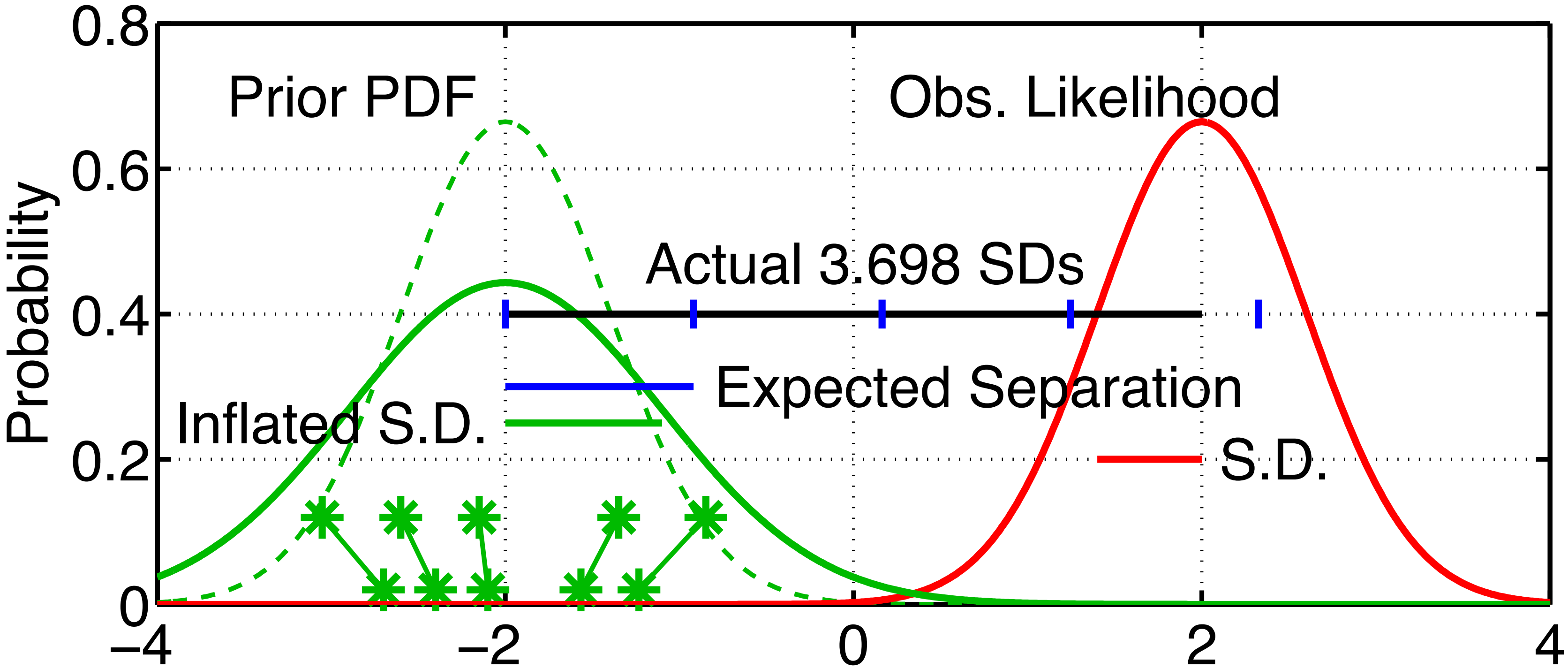


1. For observed variable, have estimate of prior-observed inconsistency.
2. Expected (prior_mean – observation) = $\sqrt{\sigma_{prior}^2 + \sigma_{obs}^2}$

   Assumes that prior and observation are supposed to be unbiased.

Is it model error or random chance?

Variance inflation in observation space



1. For observed variable, have estimate of prior-observed inconsistency.
2. Expected (prior_mean – observation) = $\sqrt{\sigma_{prior}^2 + \sigma_{obs}^2}$
3. Inflating increases expected separation.

Increases 'apparent' consistency between prior and observation.

DART Tutorial Index to Sections