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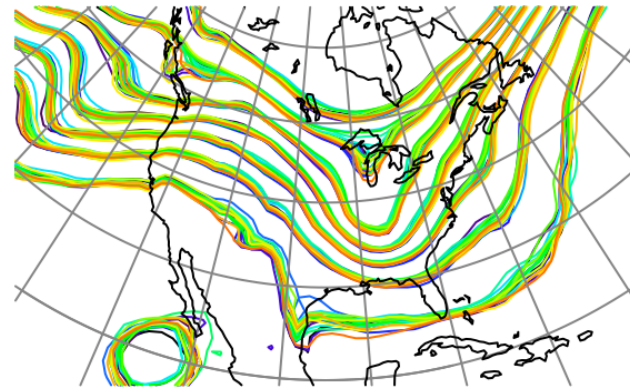
©UCAR

Some Error Sources in Ensemble Filters

2. h errors; Representativeness

3. 'Gross' Obs. Error

4. Sampling Error; Gaussian Assumption

t_k

t_{k+1}

t_{k+2}

h

h

h

1. Model Error

5. Sampling Error; Assuming Linear Statistical Relation
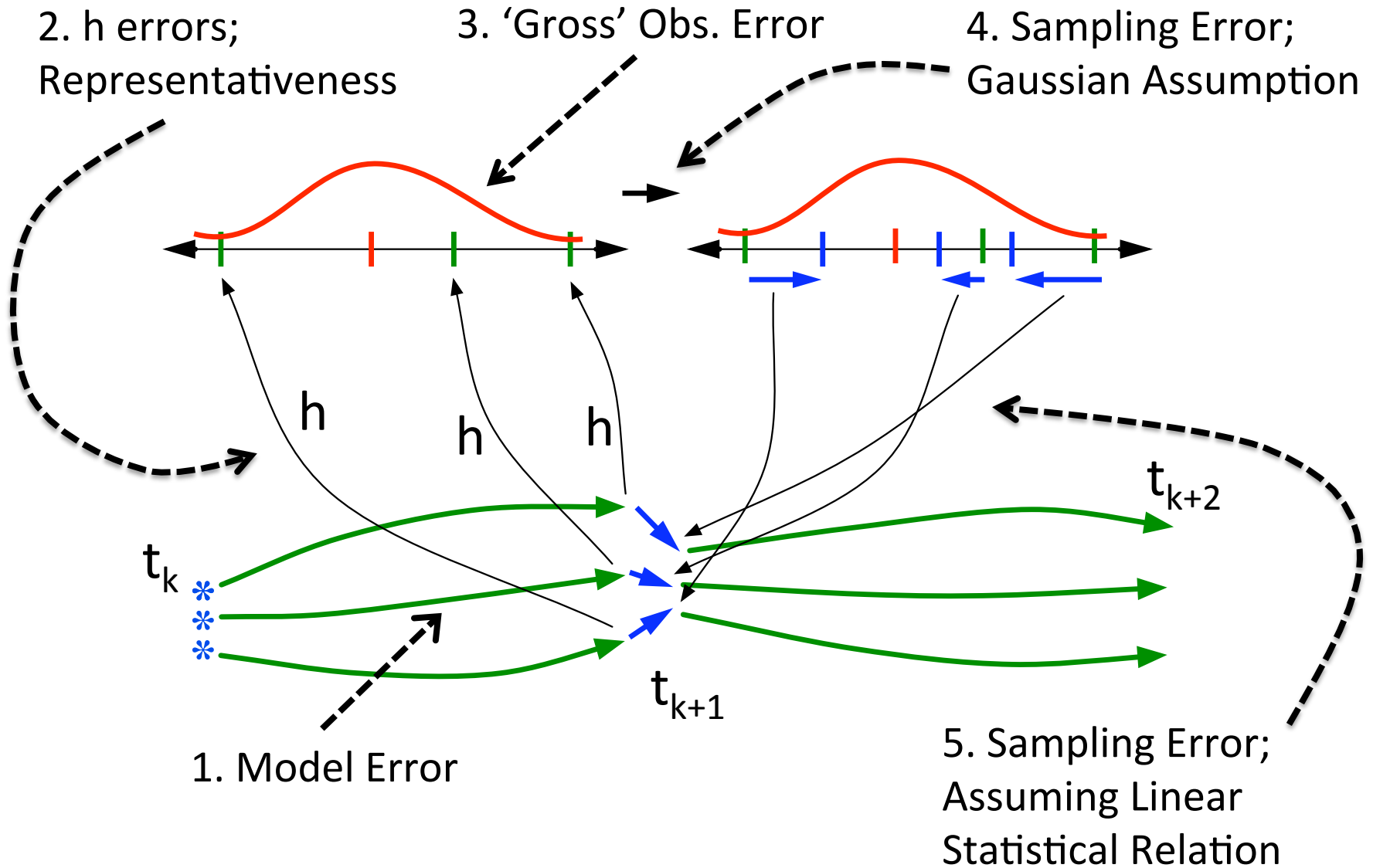
Dealing with Ensemble Filter Errors
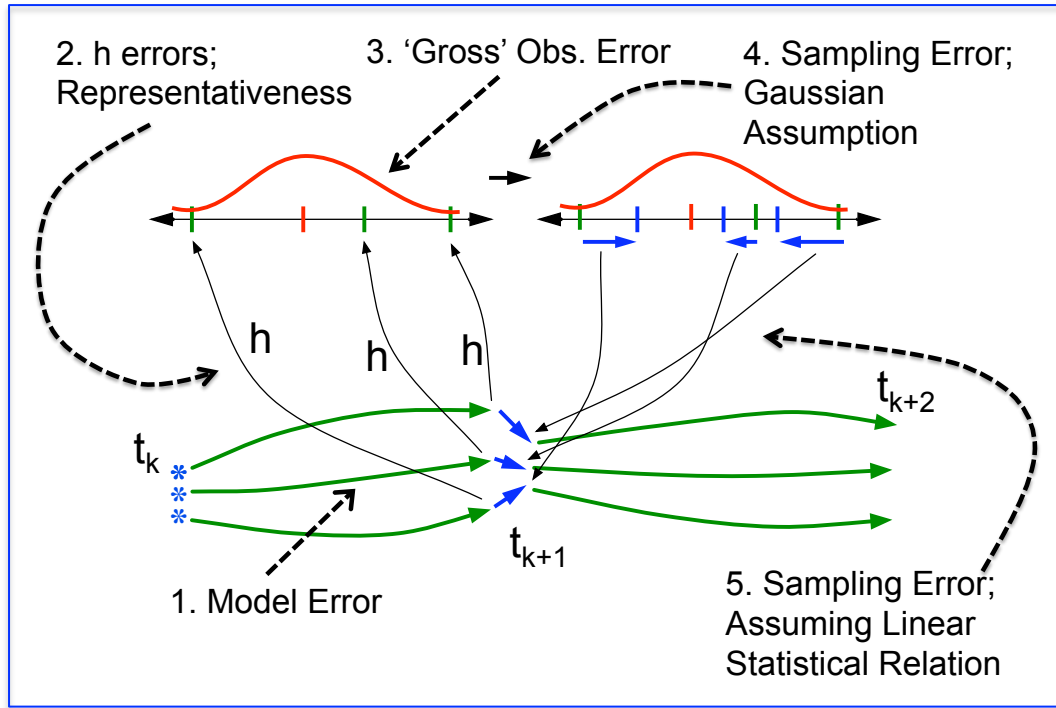
Fix 1, 2, 3 independently, HARD but ongoing.
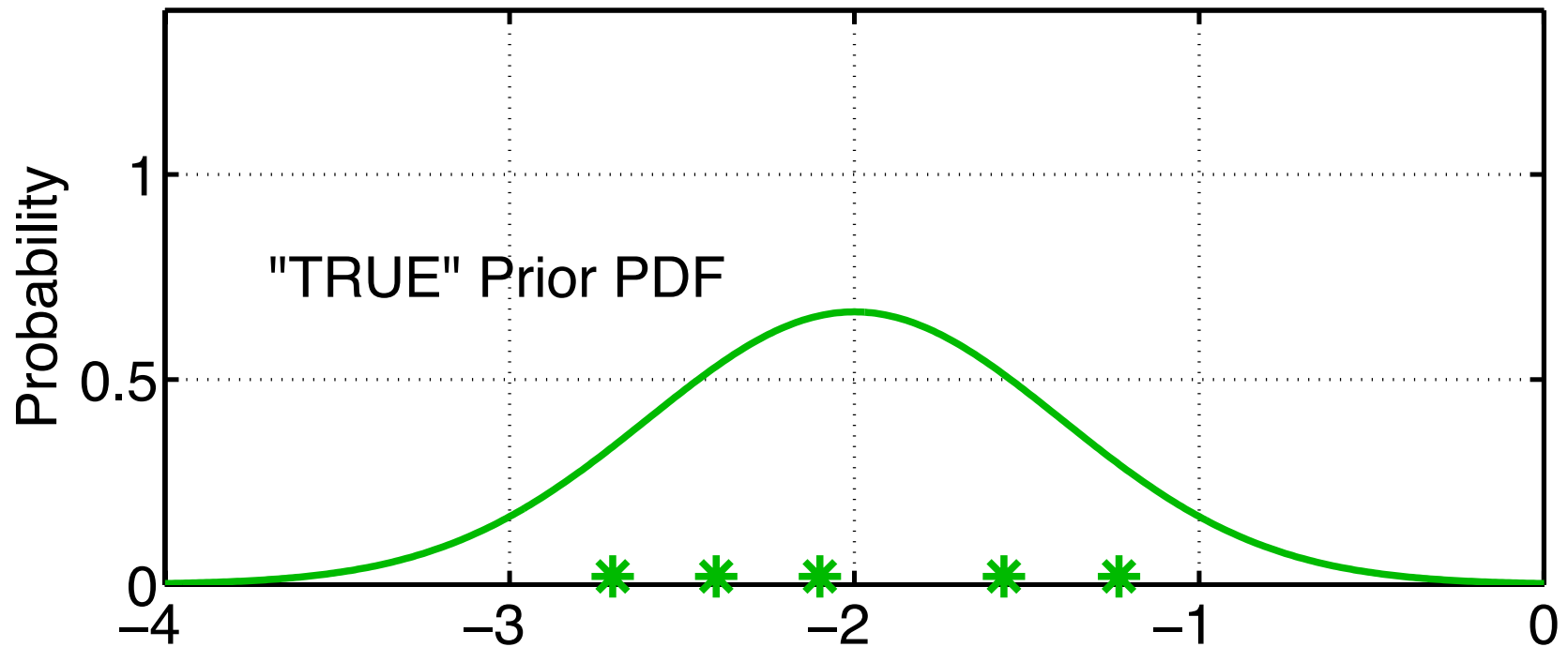
Often, ensemble filters...

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

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

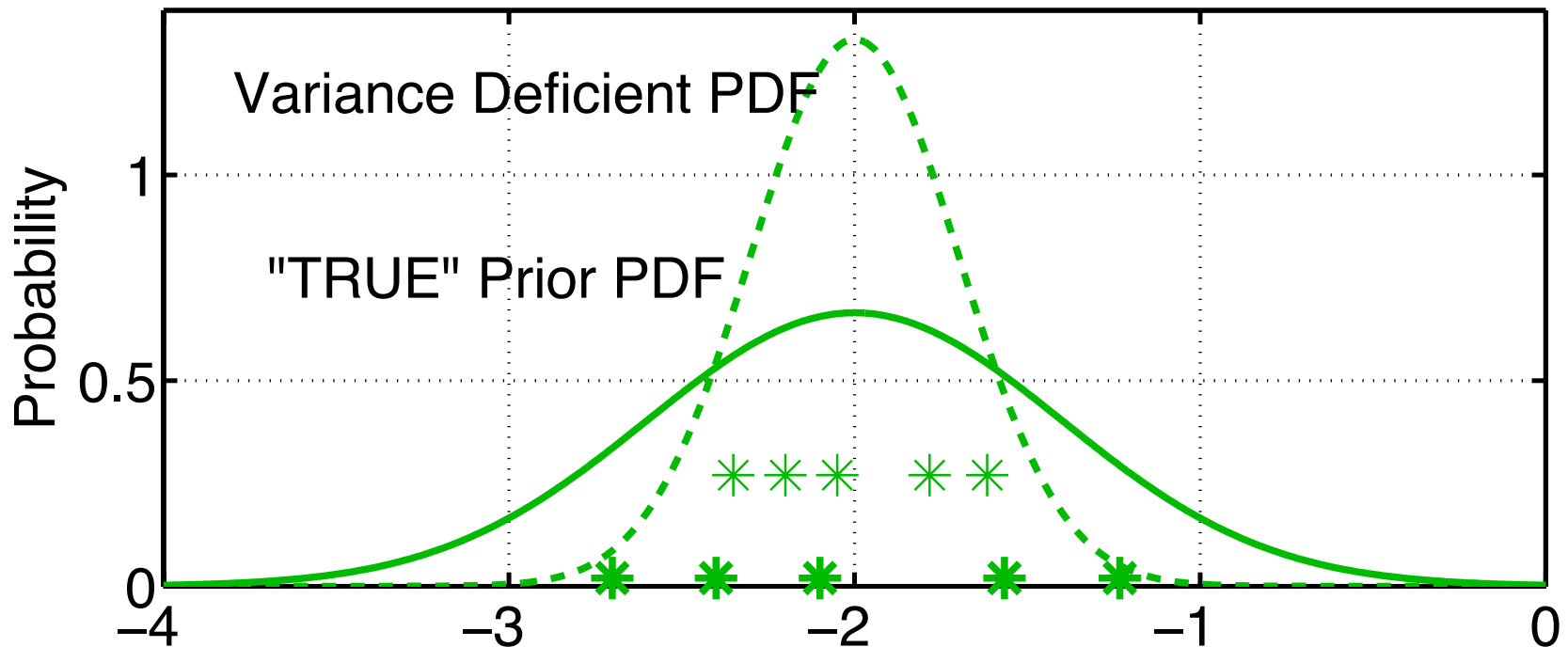Often smoothly decrease impact to 0 as function of distance.

Model/Filter Error: Filter Divergence and Variance Inflation

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Model/Filter Error: Filter Divergence and Variance Inflation

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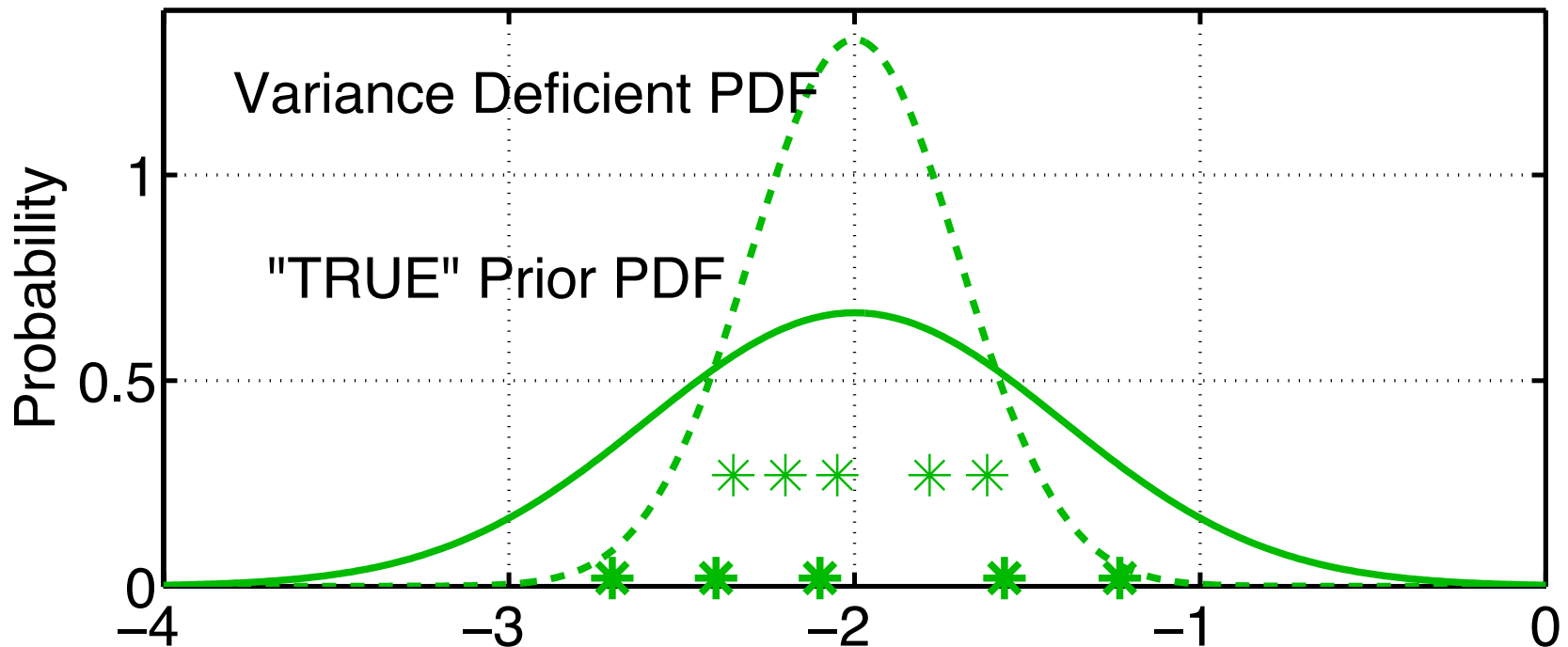3. Can lead to 'filter divergence': prior is too confident, obs. Ignored.

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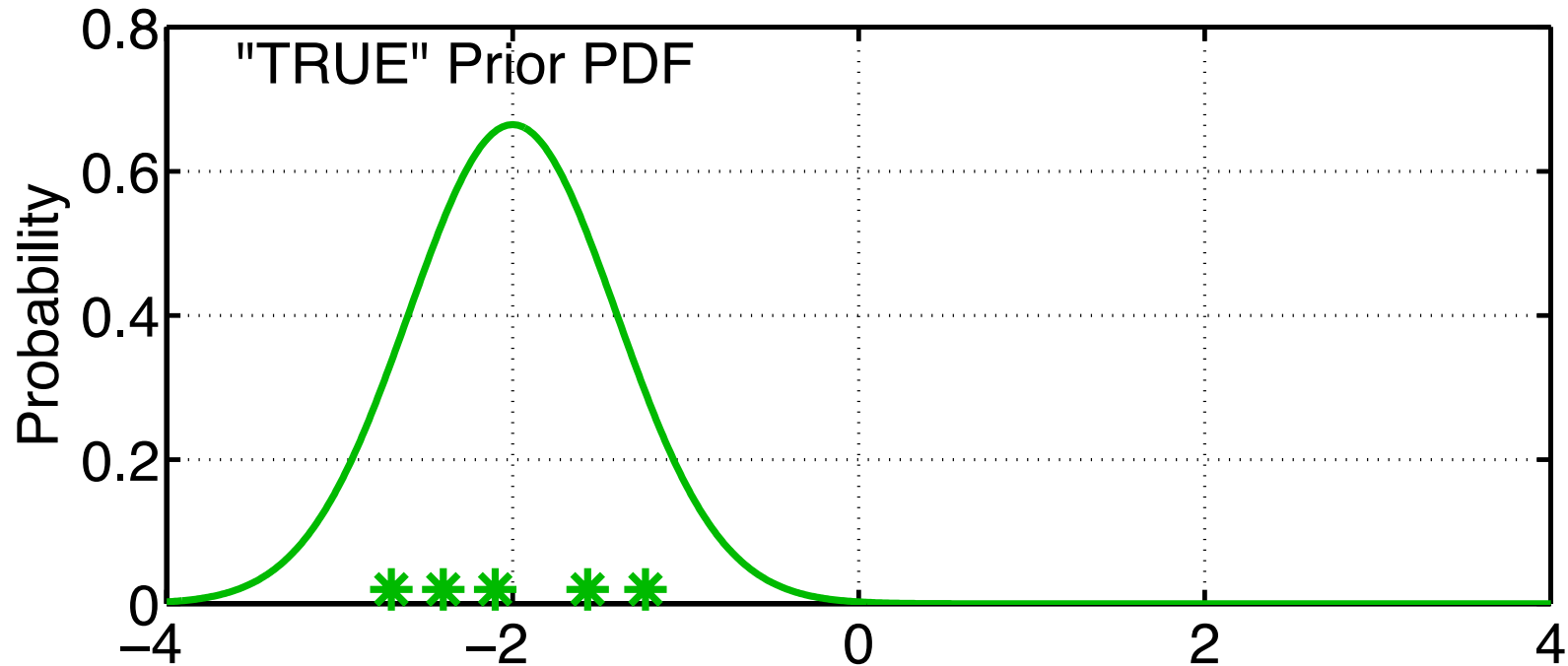3. Can lead to 'filter divergence': prior is too confident, obs. Ignored.

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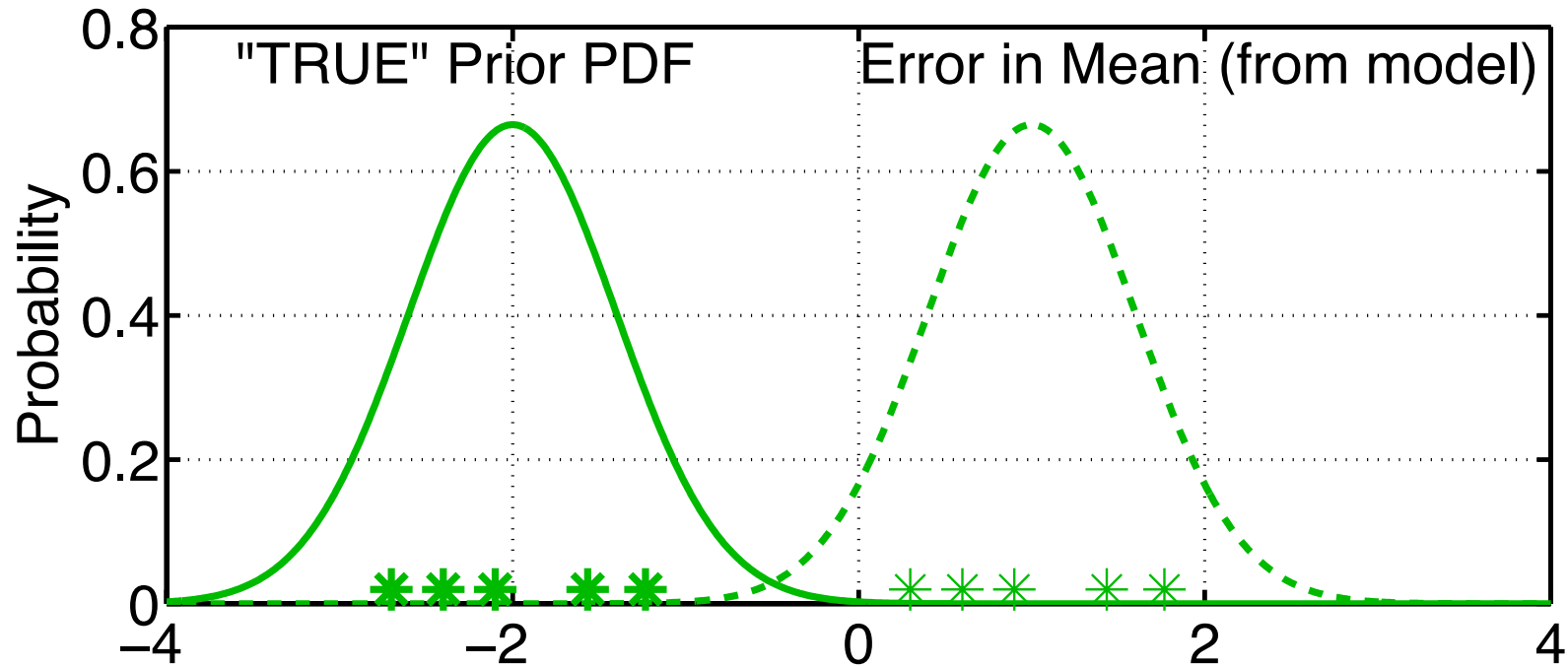For ensemble member i, $inflate(x_i) = \sqrt{\lambda}(x_i - \bar{x}) + \bar{x}$

Model/Filter Error: Filter Divergence and Variance Inflation

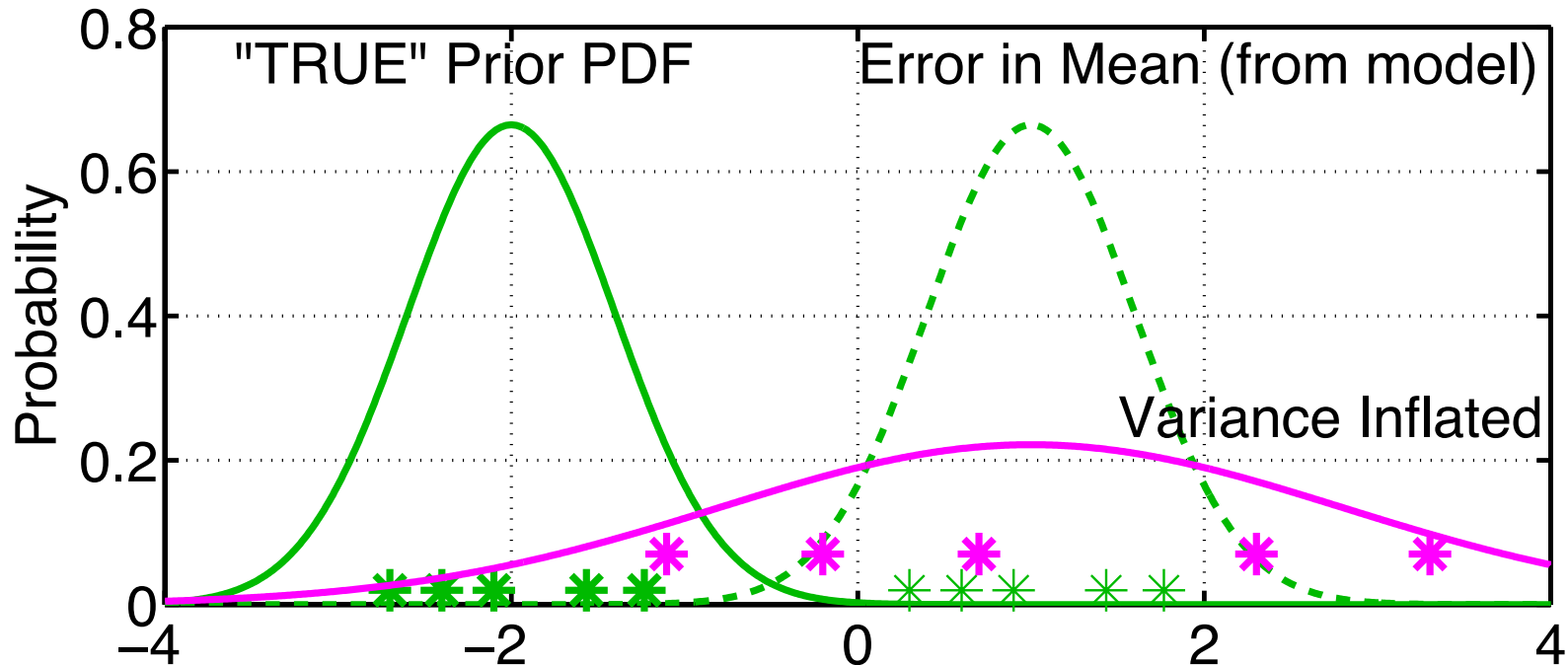1. History of observations and physical system => 'true' distribution.

Model/Filter Error: Filter Divergence and Variance Inflation

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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.

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.
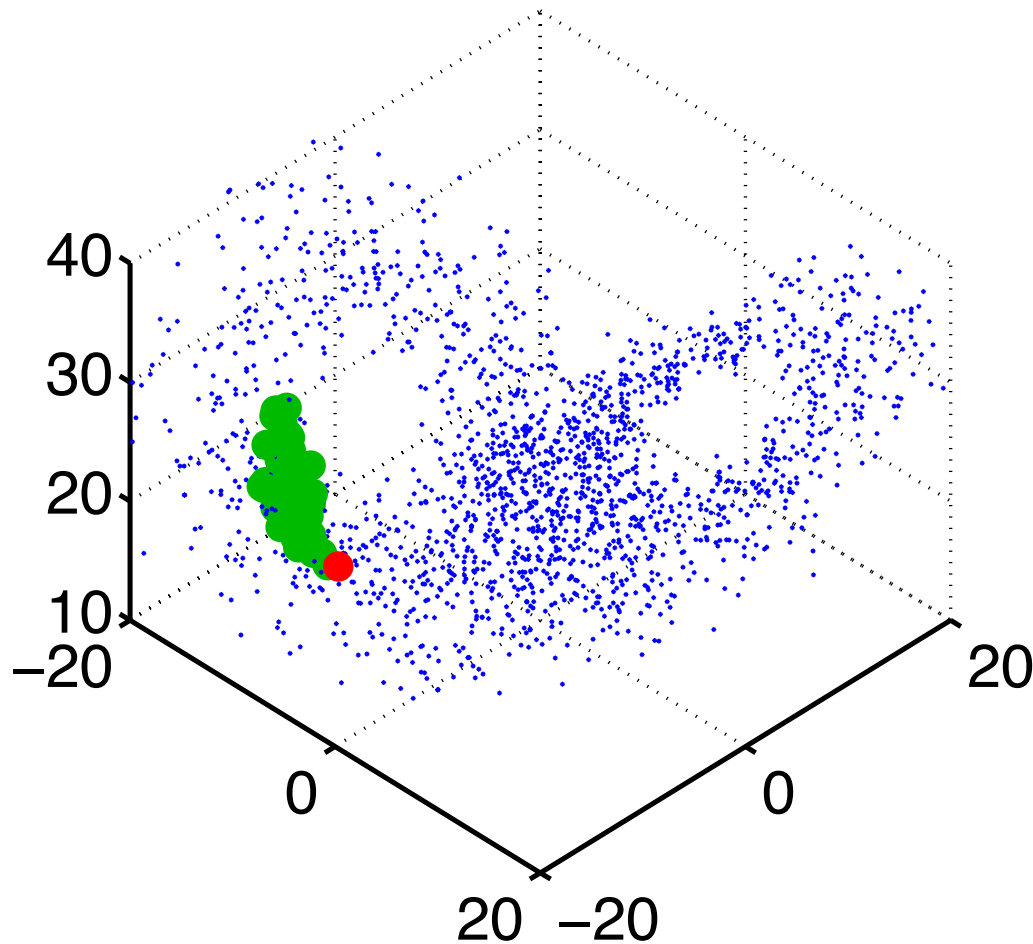
Capabilities:

1. Can be effective for a variety of models.

2. Can maintain linear balances.

3. Stays on local flat manifolds.

4. Simple and cheap.

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.

Observation outside prior: danger of filter divergence.

Observation in red.

Prior ensemble in green.

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

Observation in red.

Prior ensemble in green.

Inflated ensemble in magenta.

Prior distribution is significantly 'curved'.

Observation in red.

Prior ensemble in green.

Inflated prior outside attractor. Posterior will also be off attractor.
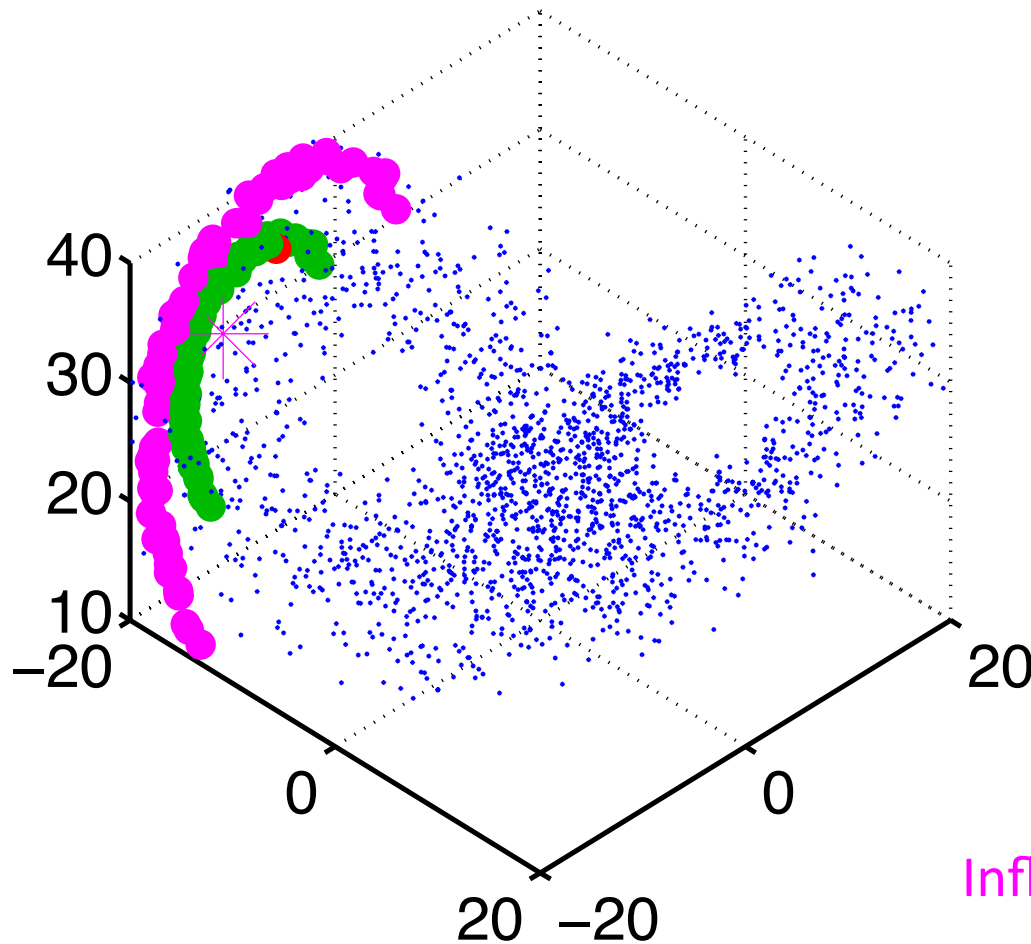
Can lead to transient off-attractor behavior or...

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,
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,

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

Inflation Value

prior inflation column   posterior inflation column

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
```
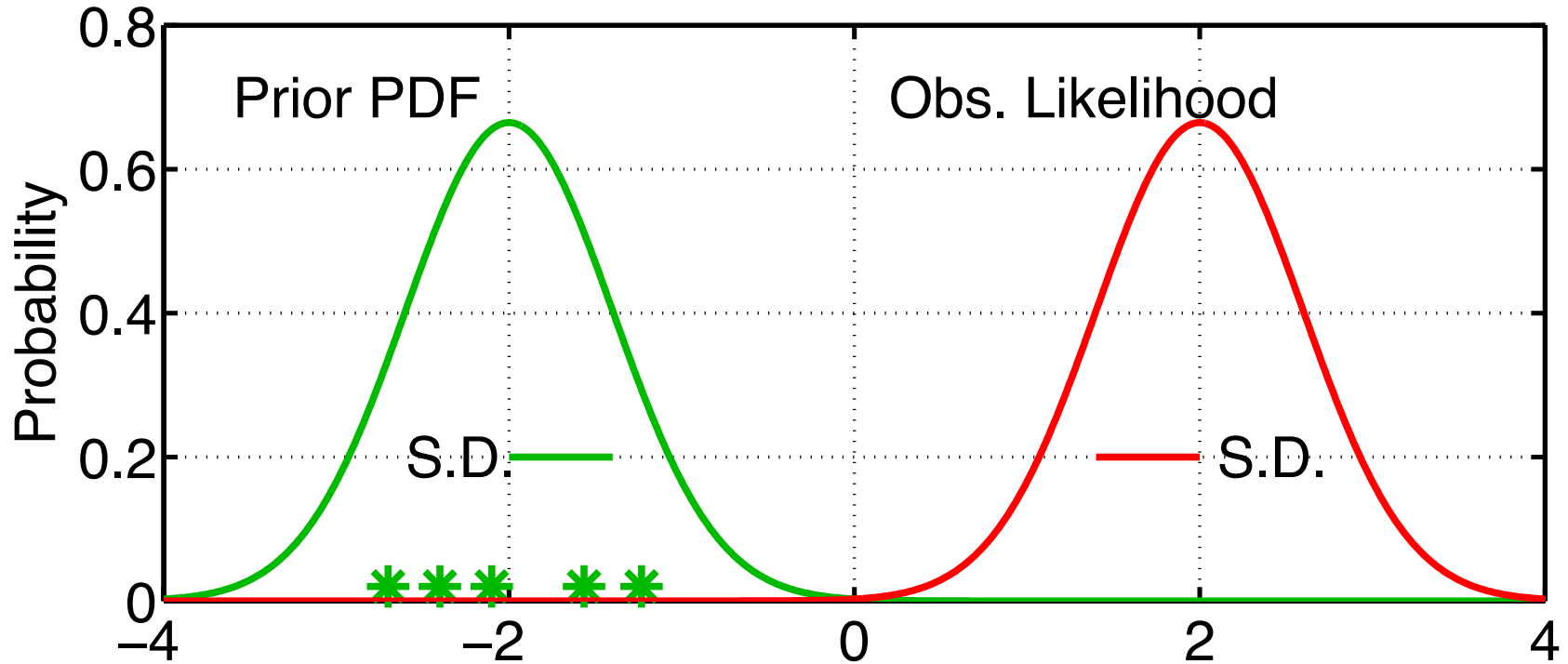
These were the settings that diverged without inflation.

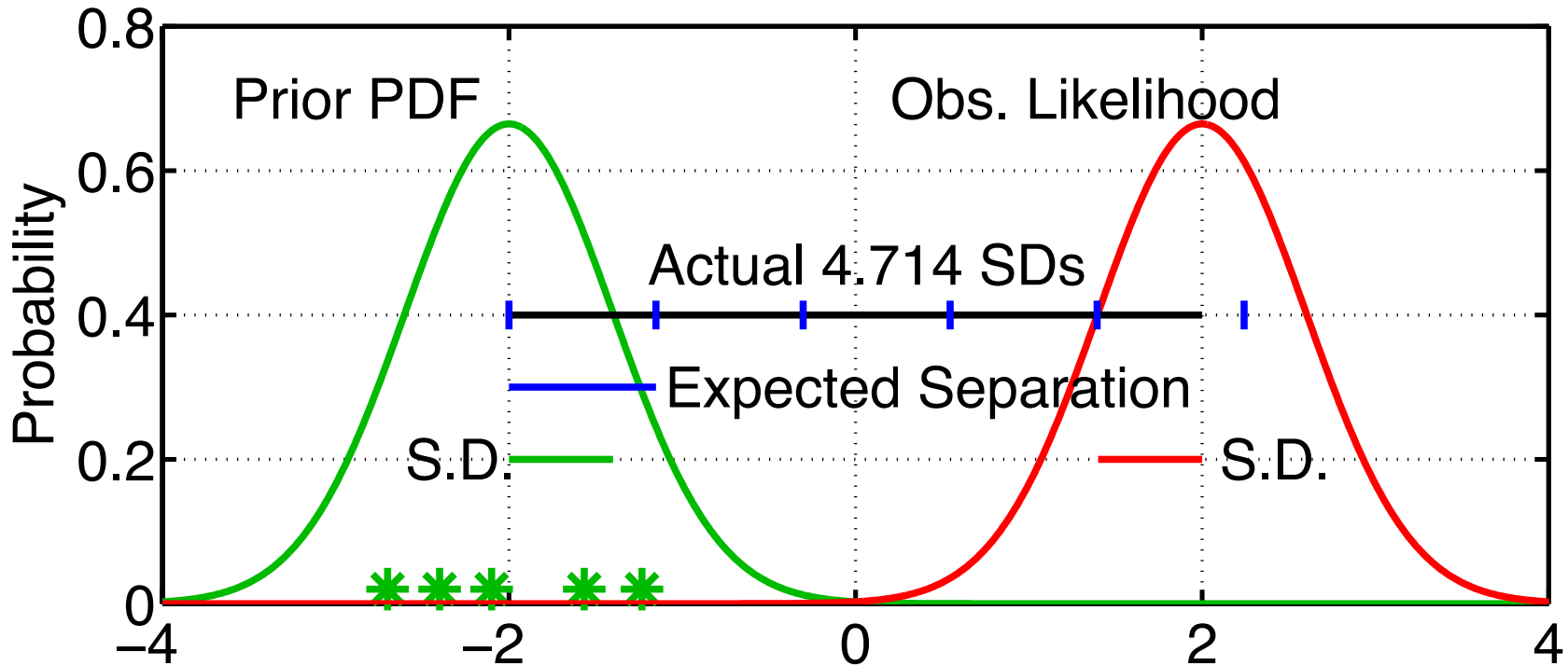3 = state space inflation

Explore with this!

Not currently supported in DART Manhattan.

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

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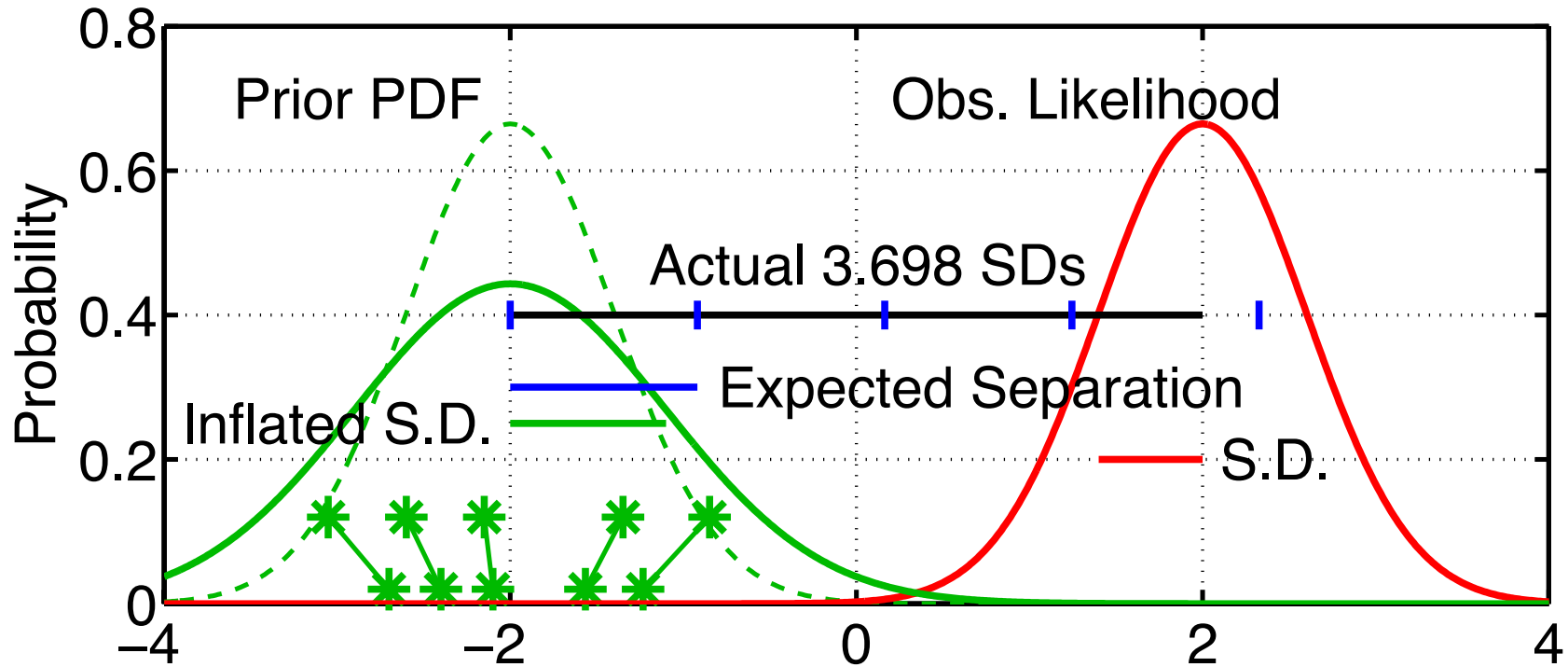
1. For observed variable, have estimate of prior-observed inconsistency.
2. Expected (prior_mean − observation) = $\sqrt{\sigma_{prior}^2 + \sigma_{obs}^2}$
3. Inflating increases expected separation.

   Increases 'apparent' consistency between prior and observation.

Variance inflation in observation space: Lorenz 96

Variance inflation in observation space not currently supported.

Try some values and see what happens to Lorenz 96 assimilation.
    Set *inf_flavor=1*, observation space inflation in first column.

Try some values and see what happens to Lorenz 96 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)

DART Tutorial Index to Sections