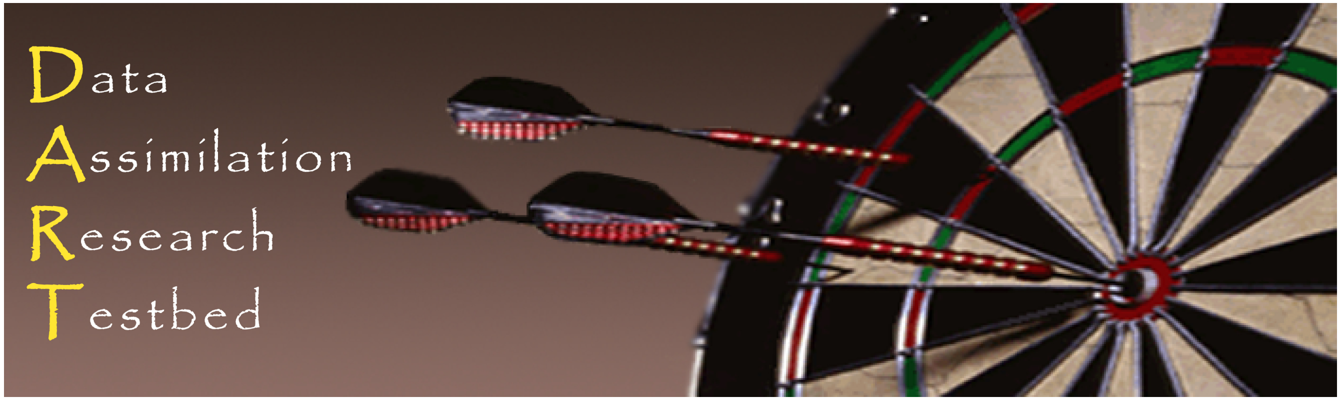
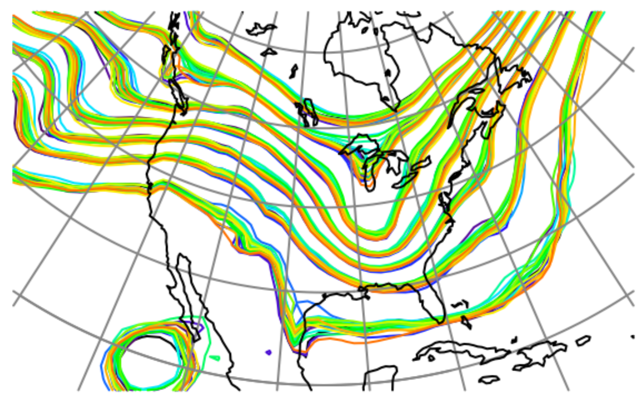


DART Tutorial Section 10: Regression and Non-linear Effects



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Updating additional prior state variables

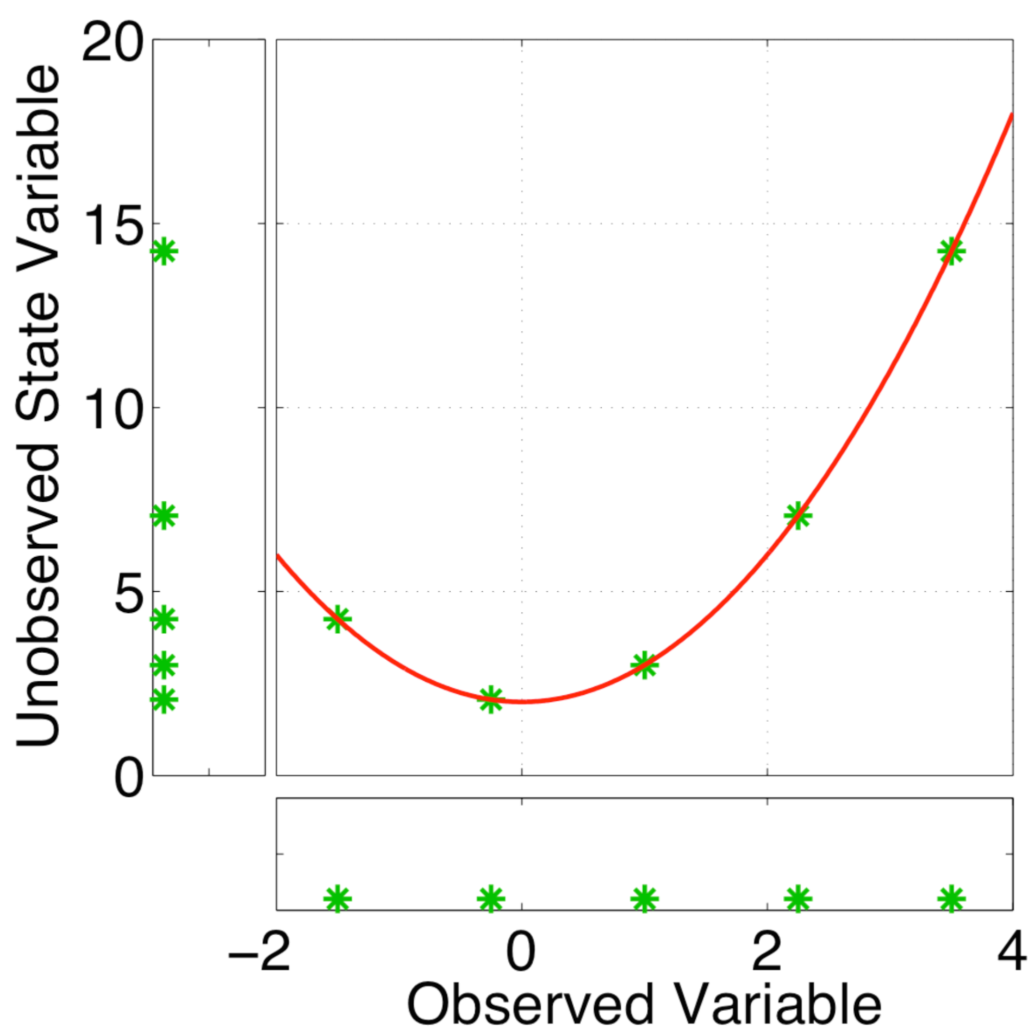
Two primary error sources:

1. Linear approximation is invalid.
   Substantial nonlinearity in ‘true’ relation over range of prior.

2. Sampling error due to noise (we’ve already looked at this).
   Even if linear relation, sample regression coefficient imprecise.

May need to address both issues for good performance.

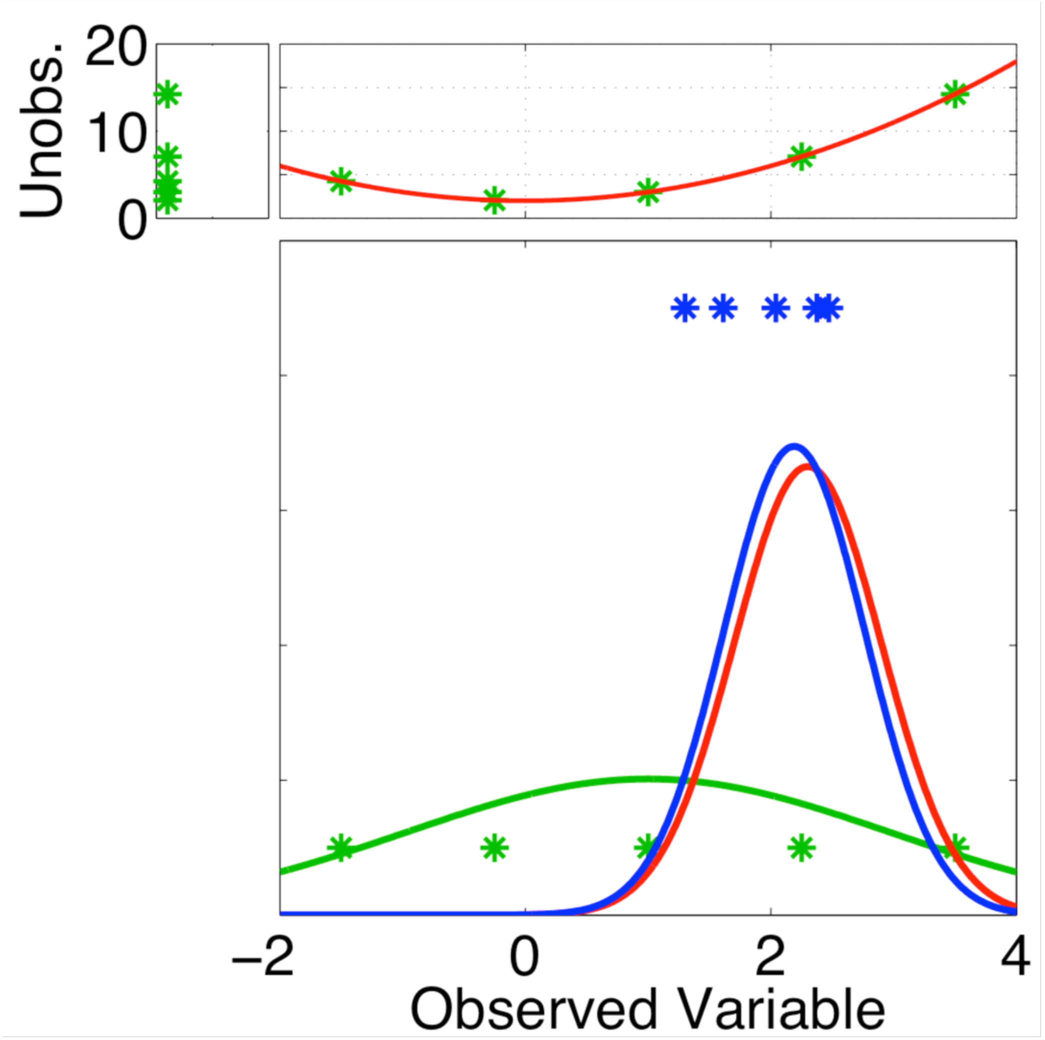
Nonlinear relations between variables: Sorting increments



Suppose prior sample has NO noise.

But, relation between un/observed variables is non-linear.

Nonlinear relations between variables: Sorting increments

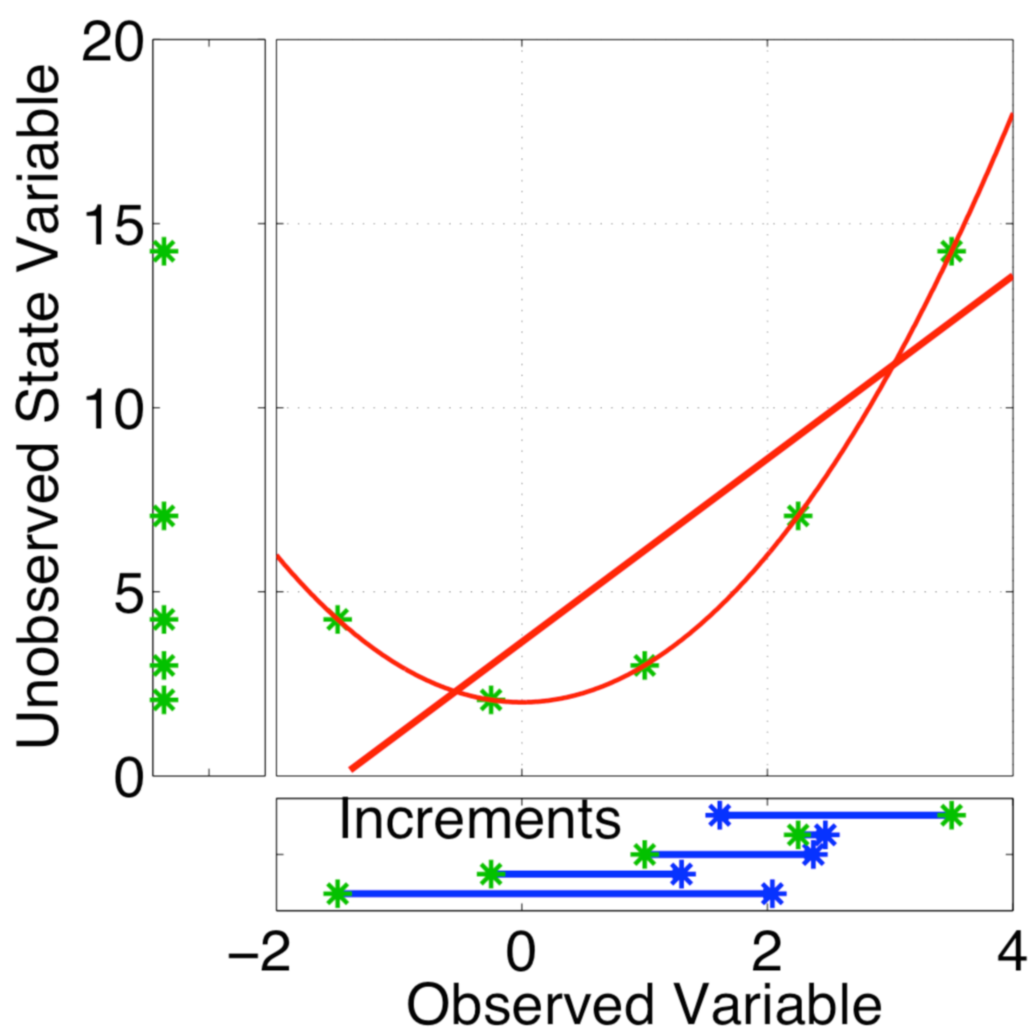


Suppose prior sample has NO noise.

But, relation between un/observed variables is non-linear.

Update observed sample and compute increments.

Nonlinear relations between variables: Sorting increments

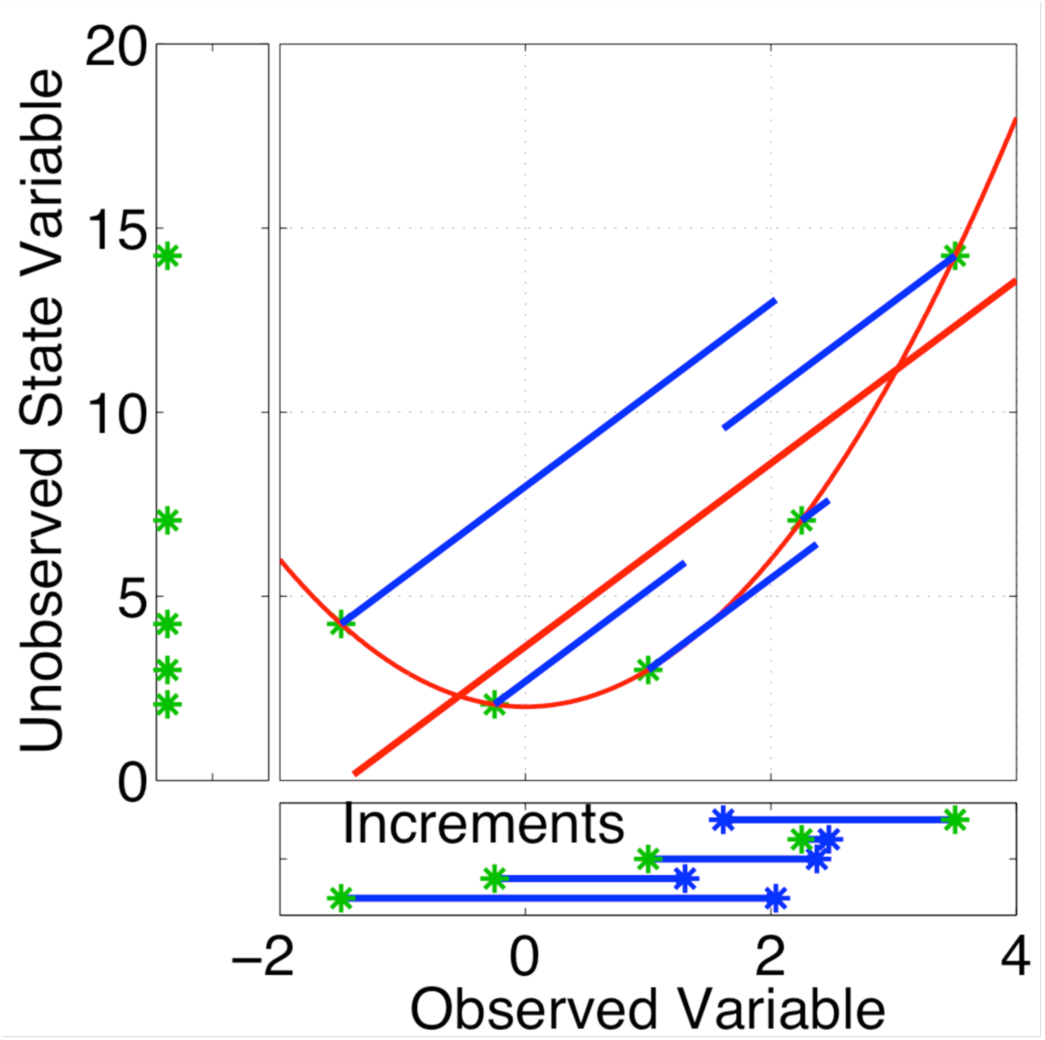


Suppose prior sample has NO noise.

But, relation between un/observed variables is non-linear.

Regression error varies with value of observed variable.

Nonlinear relations between variables: Sorting increments



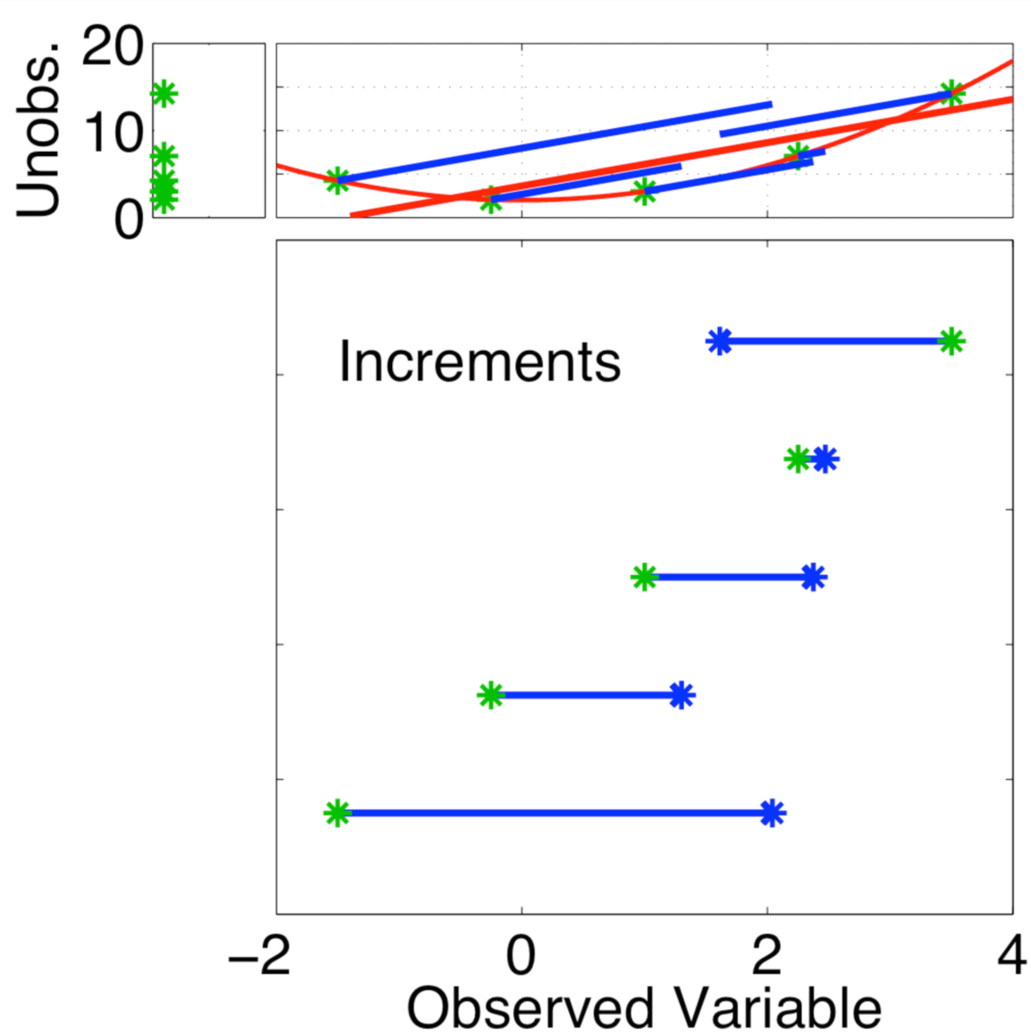
Suppose prior sample has NO noise.

But, relation between un/observed variables is non-linear.

Regression error varies with value of observed variable.

Smaller increments have smaller expected errors.

Nonlinear relations between variables: Sorting increments



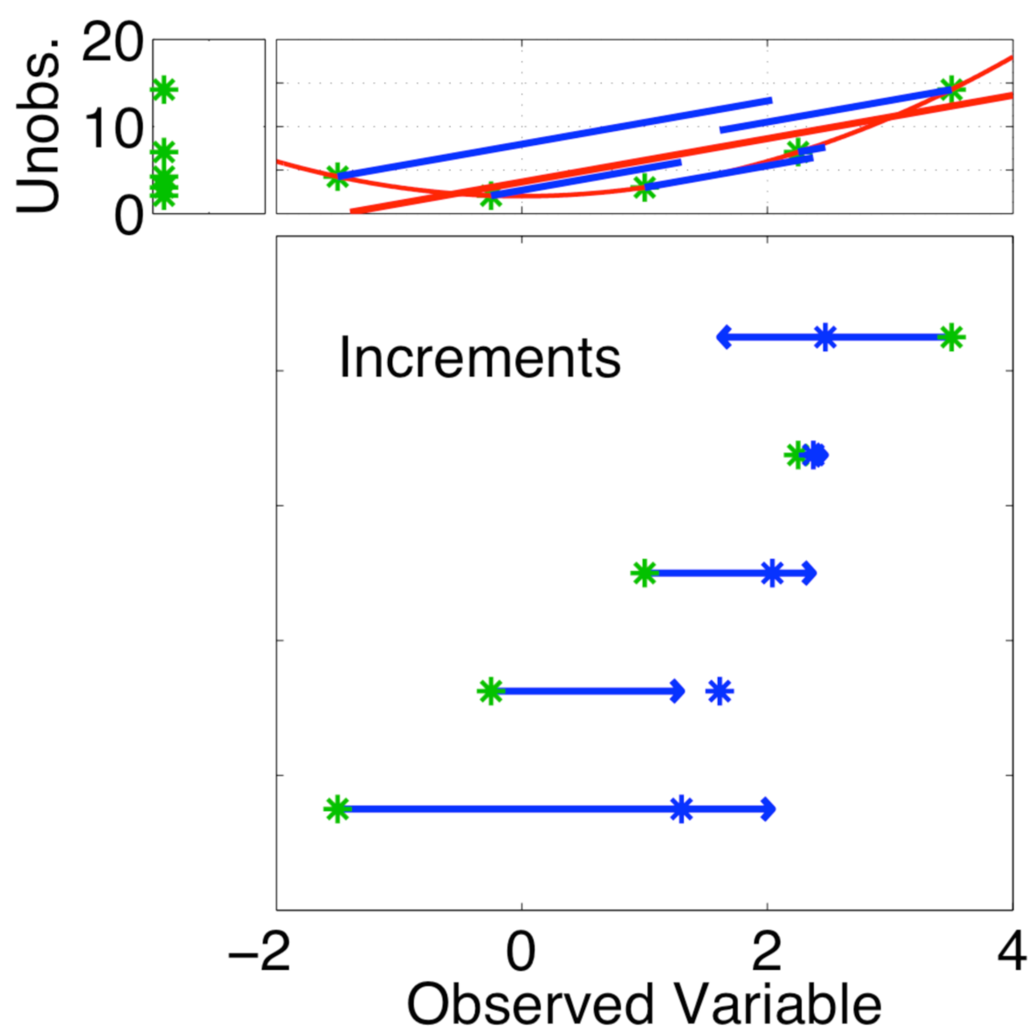
Suppose prior sample has NO noise.

But, relation between un/observed variables is non-linear.

Pairing between prior and posterior sample of observed variable can be viewed as arbitrary.

Posterior is same sample however it's paired.

Nonlinear relations between variables: Sorting increments



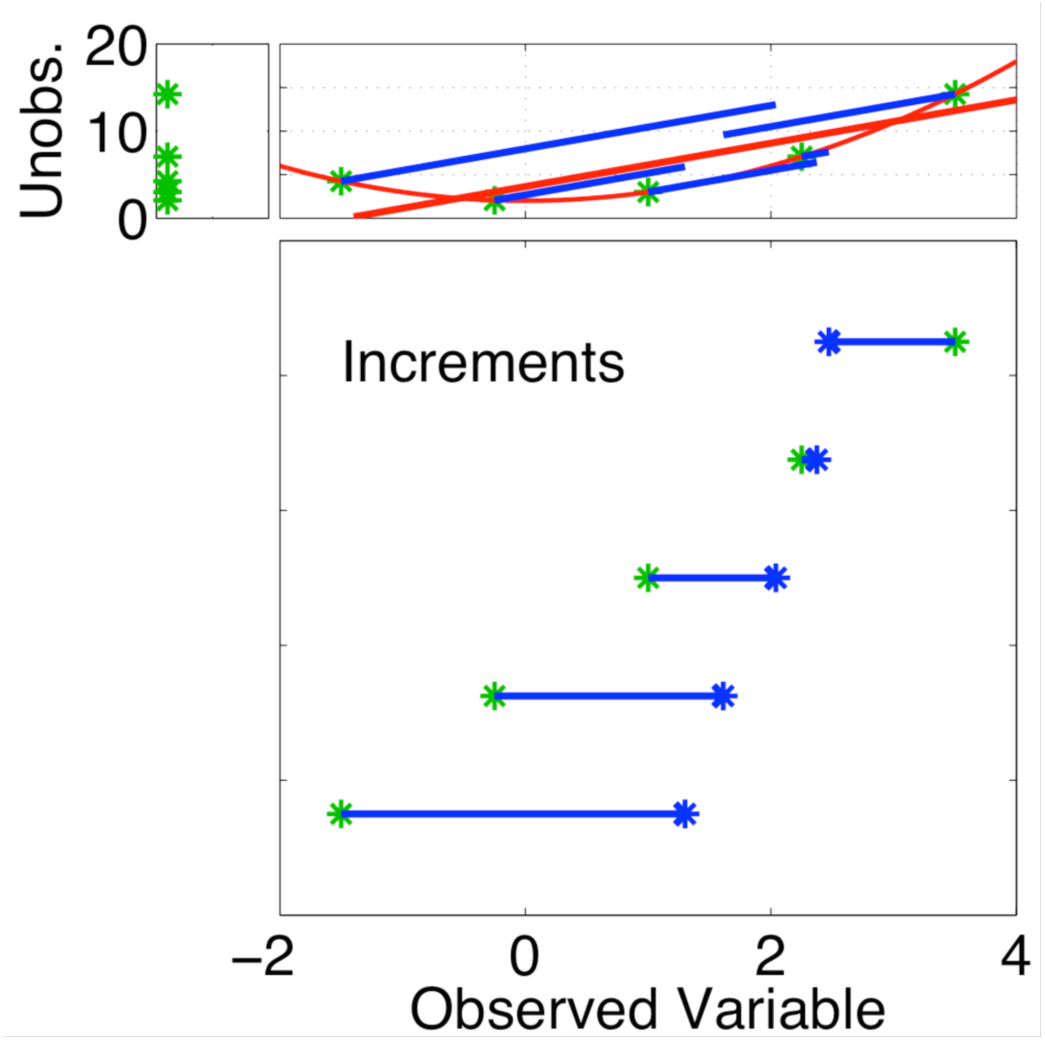
Suppose prior sample has NO noise.

But, relation between un/observed variables is non-linear.

Can minimize increments by changing pairing.

Sorting prior and posterior and pairing samples minimizes one norm of increment size (could do other methods)

Nonlinear relations between variables: Sorting increments



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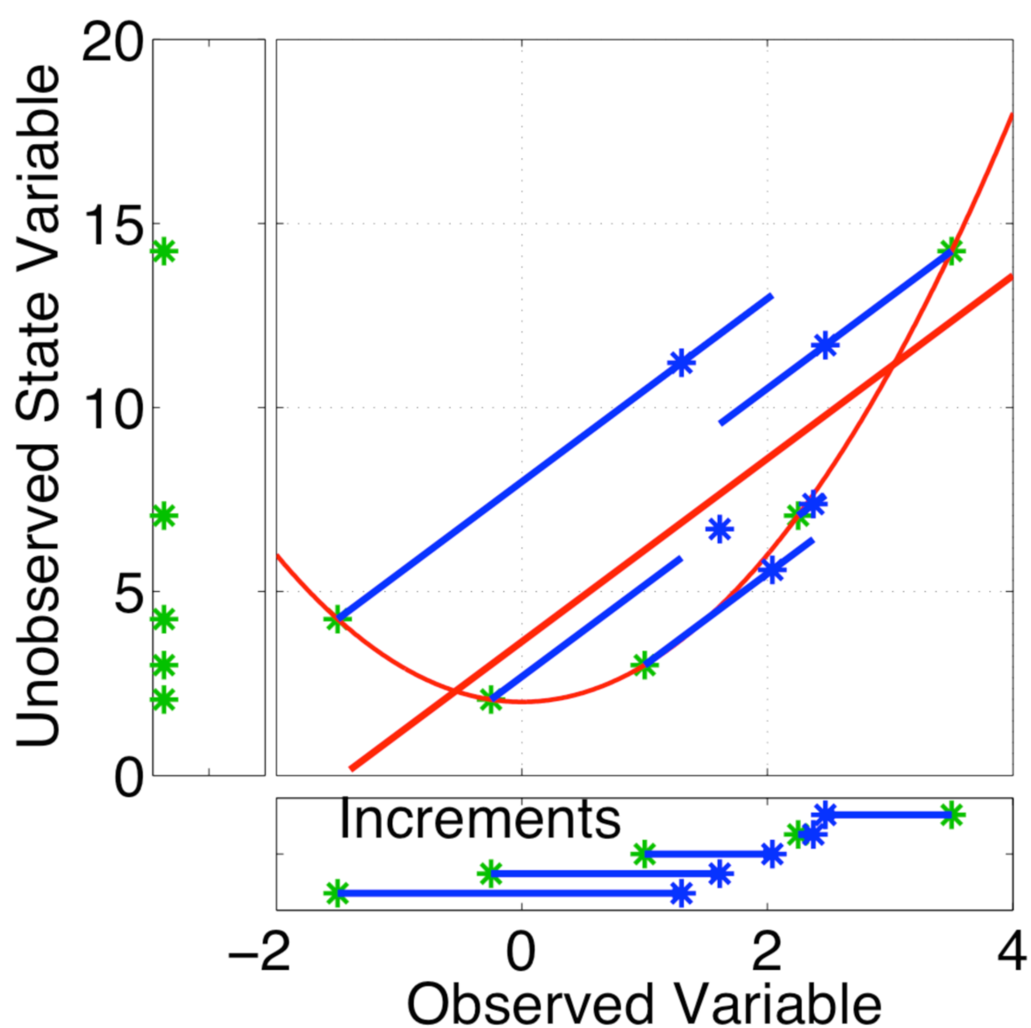
Nonlinear relations between variables: Sorting increments



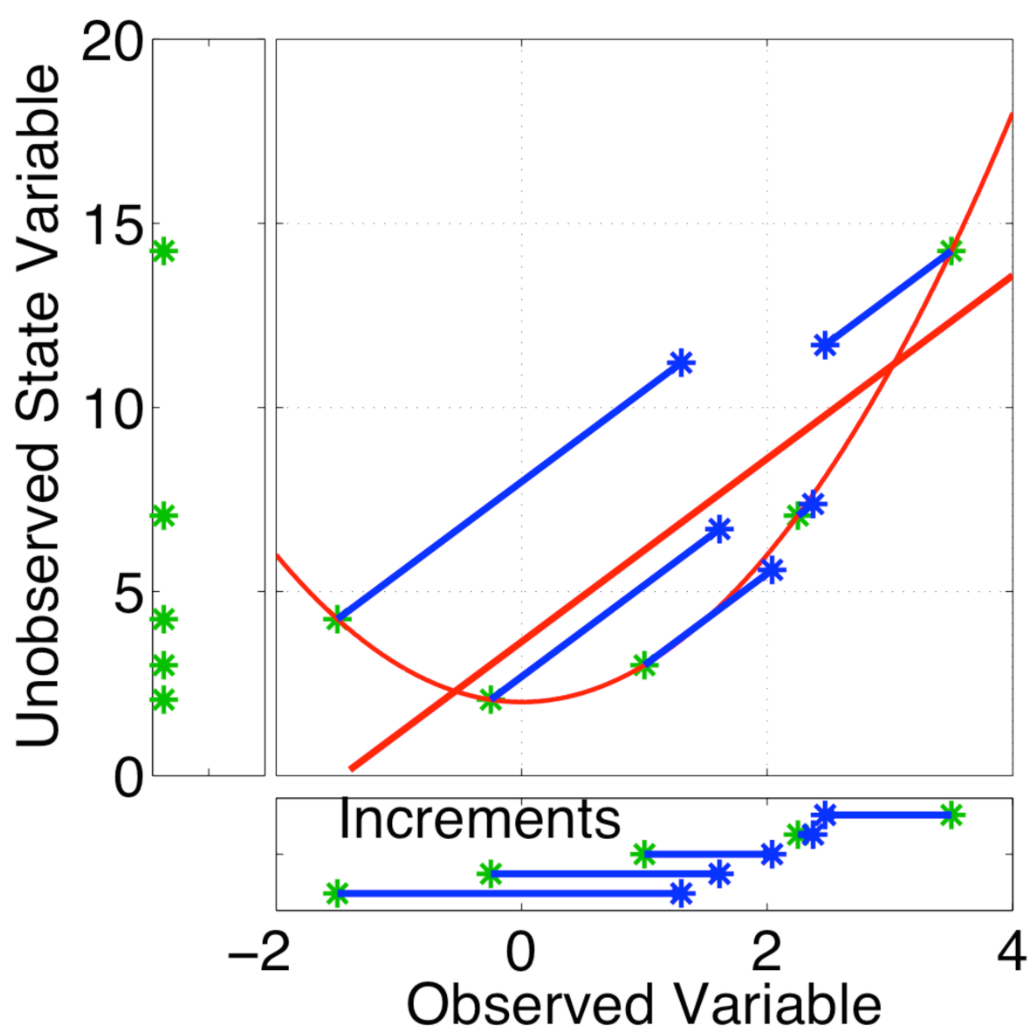
Suppose prior sample has NO noise.

But, relation between un/observed variables is non-linear.

Resulting regression error is minimized.

Impact of sorting can be very large when posterior selected by 'random' algorithms.

Nonlinear relations between variables: Sorting increments



Suppose prior sample has NO noise.

But, relation between un/observed variables is non-linear.

Resulting regression error is minimized.

Impact of sorting can be very large when posterior selected by 'random' algorithms.

Nonlinear relations between variables: Sorting increments

Can see this impact nicely in 9var model.

models/9var/work/

Try *filter_kind = 2* in *assim_tools_nml* with:

sort_obs_inc = .true. (increments minimized) and

sort_obs_inc = .false.

```
&assim_tools_nml
   filter_kind                = 2
   sort_obs_inc               = .false.
   …
```

change between .true. and .false., record results

Examine the amount of noise in different time series.

Impact on RMS may not be what was expected.

There may be surprises in other low-order models when trying this.

Nonlinear relations between variables: Sorting increments

models/lorenz_96/work/

Also can examine in Lorenz 96.

Try *filter_kind = 2* in *assim_tools_nml* with:

sort_obs_inc = .true. (increments minimized) and

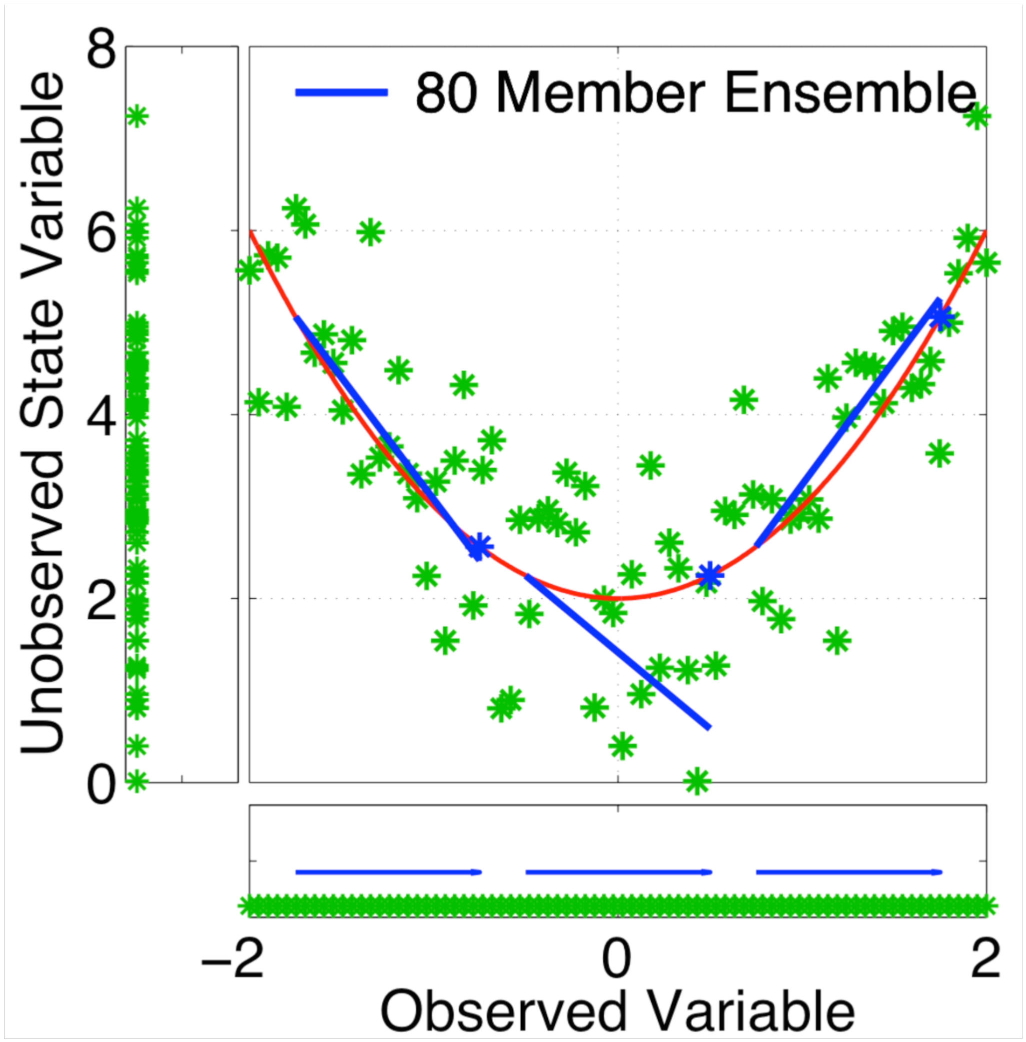
sort_obs_inc = .false.

Try a case with no localization (large cutoff)

Vary inflation with and without the sorting.

```
&assim_tools_nml
   filter_kind             = 2
   sort_obs_inc            = .true.
   cutoff                  = 1000000.0
   …
```

Nonlinear relations between variables: Local regression



Prior sample is noisy.

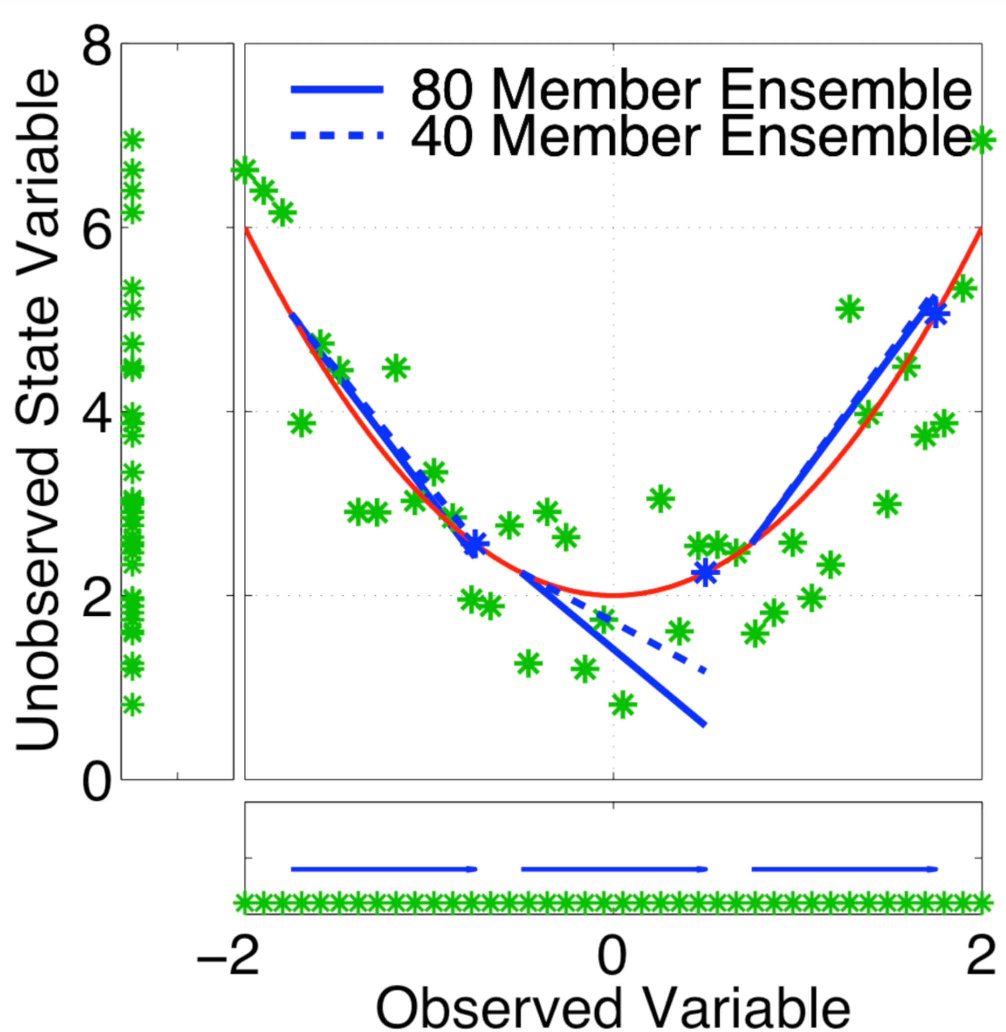
Un/observed relation is non-linear.

Doing global regression would be BAD here.

Can do regression only for points that lie in range of update increment.

Could also pick local sets in other ways.

Nonlinear relations between variables: Local regression



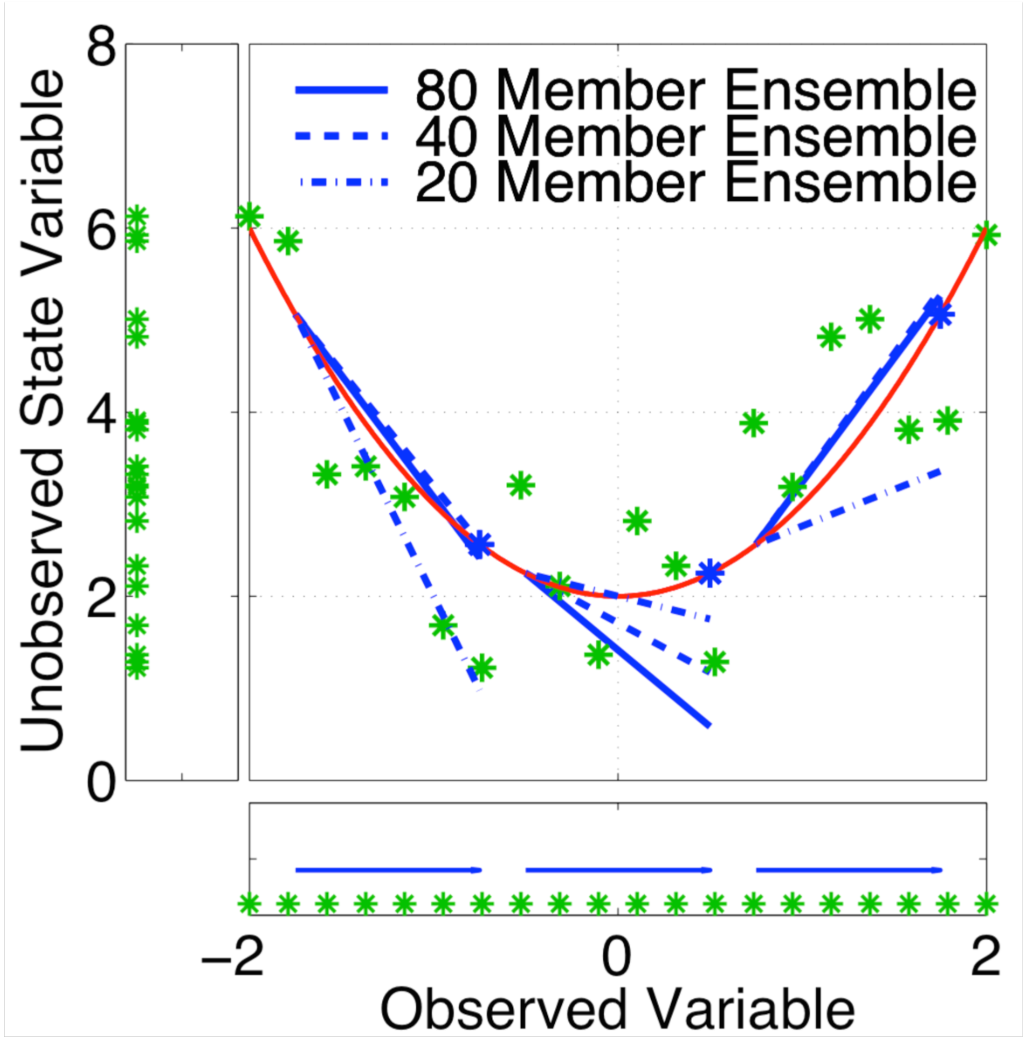
Prior sample is noisy.

Un/observed relation is non-linear.

For larger ensembles, local regressions can work well.

Error is largest where signal is weakest (near bottom of parabola here).

Nonlinear relations between variables: Local regression



Prior sample is noisy.

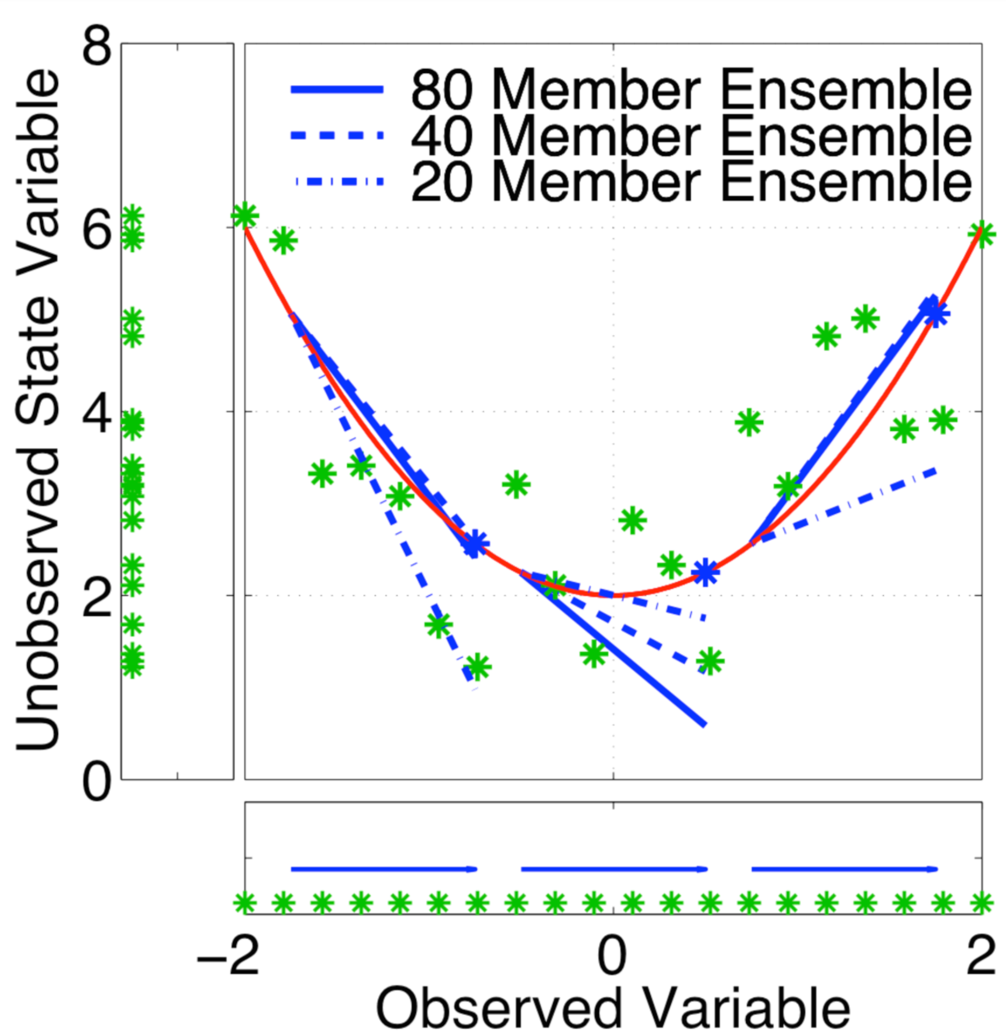
Un/observed relation is non-linear.

As sample size decreases, error grows.

(Except where it was rotten to start).

Applications where local regression is useful are unknown to me.

Nonlinear relations between variables: Local regression



DART does not currently support local regression without code modification.

DART Tutorial Index to Sections