Ensemble Kalman Filters for Data Assimilation in WRF

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1. Filters have been mostly successful in regional anelastic model

2. Ensemble filter has been run in WRF configuration

3. Initial results promising, but problems remain

4. Research continues to investigate if filter can work in WRF

Advantages of Ensemble Filters

1. Basic update algorithms require only 10's of lines of code

2. Require no auxiliary information about model like an adjoint

3. Produce information about complete probability distribution

4. Provide initial conditions for ensemble forecasts

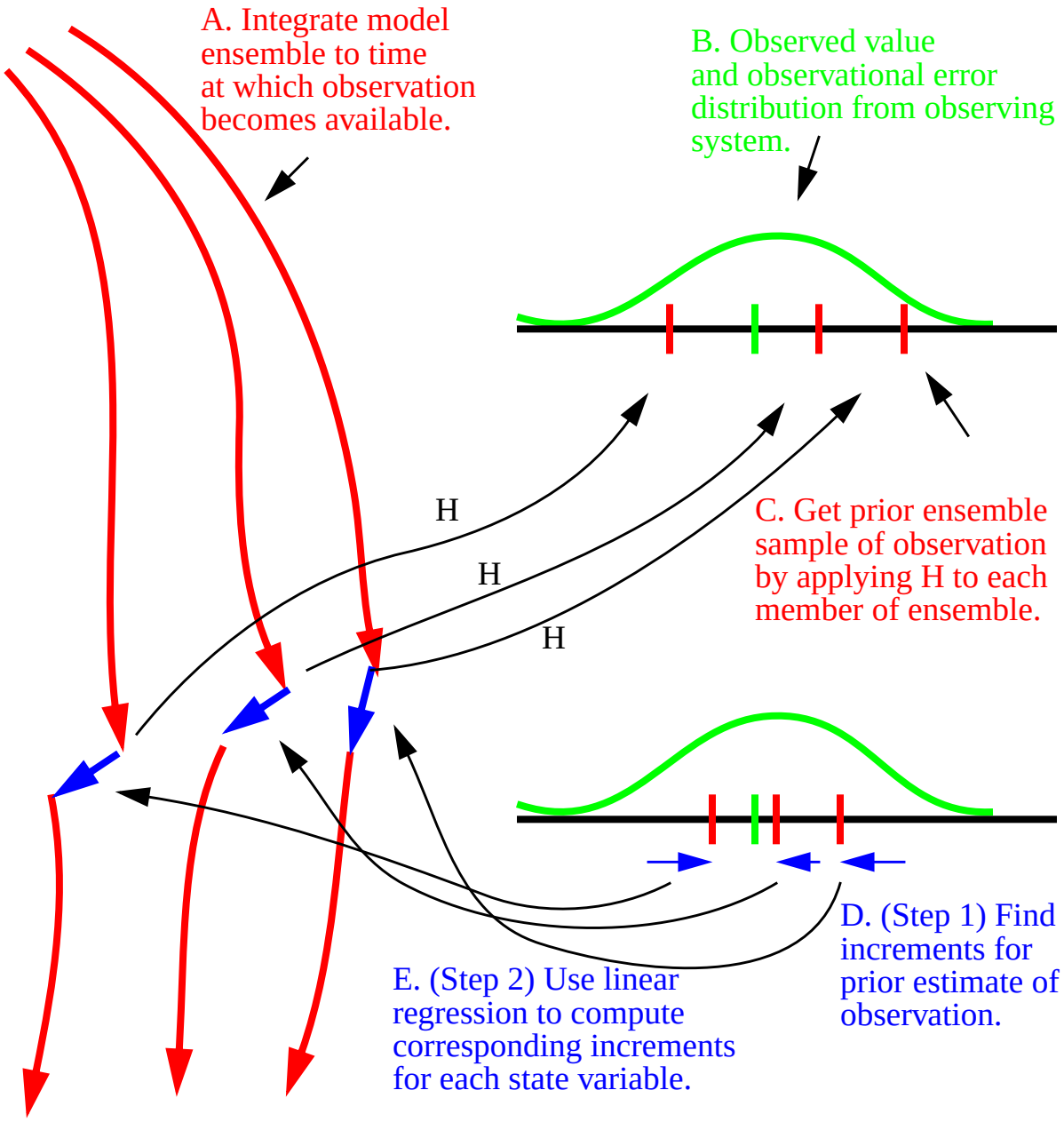
5. Estimated costs comparable to 4D-variational
(may not be true with many low information observations)

6. Efficient use of observation information with time-varying
'covariances'

How an Ensemble Filter Works

Theory: Impact of observations can be handled sequentially

Impact of observation on each state variable can be handled sequentially



Technical Difficulties Remain

Problem 1. Sampling error impacts estimates of increments

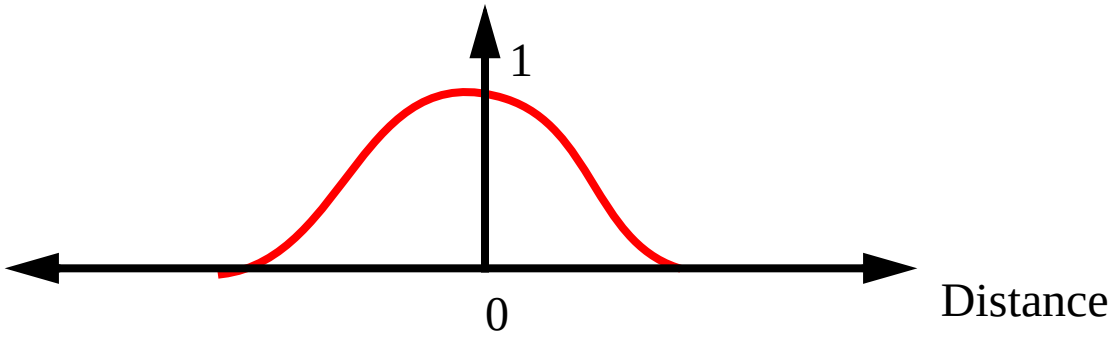
Key: estimates of correlations for regression have errors

Many obs. with small expected correlations => error build-up

Solution: Reduce impact of observations as function of ensemble size, sample correlation, and prior knowledge of expected distribution of correlation

But...need this prior estimate (may be mostly unknown?)

For now, use distance dependent envelope to reduce impact of remote observations



Even picking this envelope still tricky for now

Problem 2. Initial conditions for ensembles

Key: Bayesian, assumes initial ensembles are magically available

Solution: For ergodic models (many global GCMs) spin-up by running ensemble a very long time from arbitrary initial perturbations, slowly ‘turn on’ observations

But... this may be impossible for WRF regional applications

Given prior knowledge of expected correlations (see problem 1) should be able to generate appropriate ensemble ICs

Still a topic for ongoing research

Problem 3. Assimilation of variableswith discrete distributions

Key: ensemble prior may indicate zero probability of an event that is occurring

I.E. All ensemble members say no rain but rain is observed

Directly related to existence of discrete convective cells

Solutions: Apply methods for accounting for model error

Redefine state variables to avoid discrete probability densities

Research on this problem is in its infancy

Summary

1. Research on ensemble filters underway in WRF

2. Some initial results encouraging, but many unknowns

3. Many technical problems remain

4. Solutions for these problems appear to exist

5. Successes in global models are encouraging

6. Research to continue: we'll keep you posted