A statistical approach to PVA validation: testing quasi-extinction estimation and the IUCN red list criteria

Overview

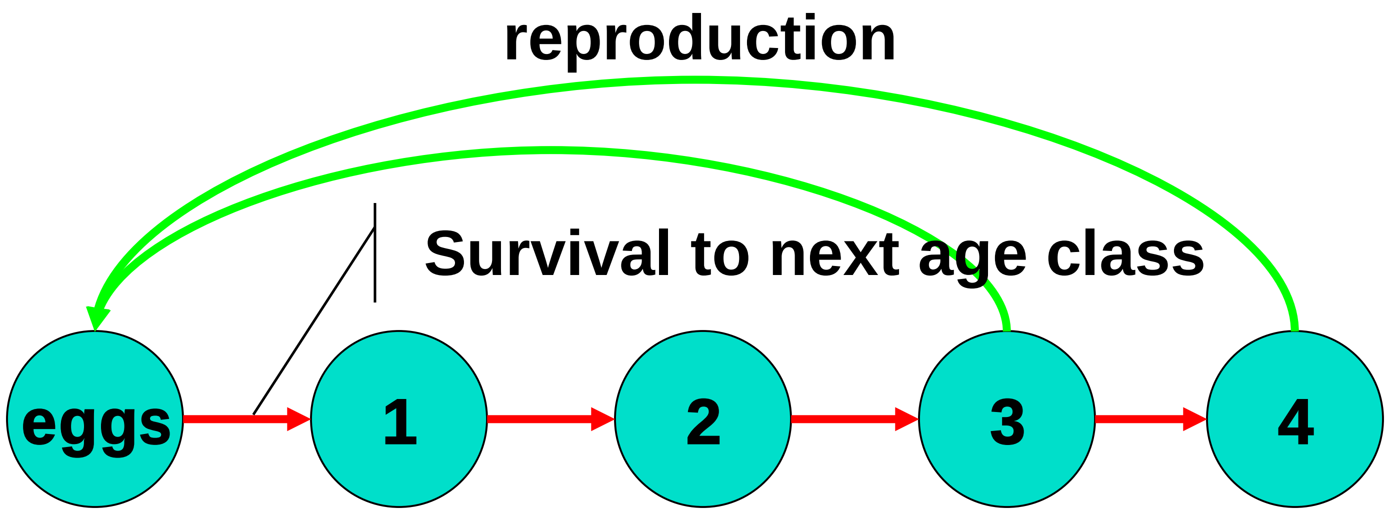
- Different validation approaches
- Example: a cross-validation study of state-space modeling of stochastic populations
- The database
- Some results

Methods for testing PVAs

from McCarthy et al. 2002. "Testing the Accuracy of PVA" Cons. Bio.

Compare mean or median predictions with observations	Subjective, ignores variability, single trajectories unlikely to be similar to mean
Compare observed vs predicted frequency of events	Only assesses average number or frequency of occurrences within a group, ignores variability
Compare probability distributions of population size or parameters	Assesses both the mean and variability, generally requires transformation of data to a standard variate, lots of data

Diffusion approximation PVA

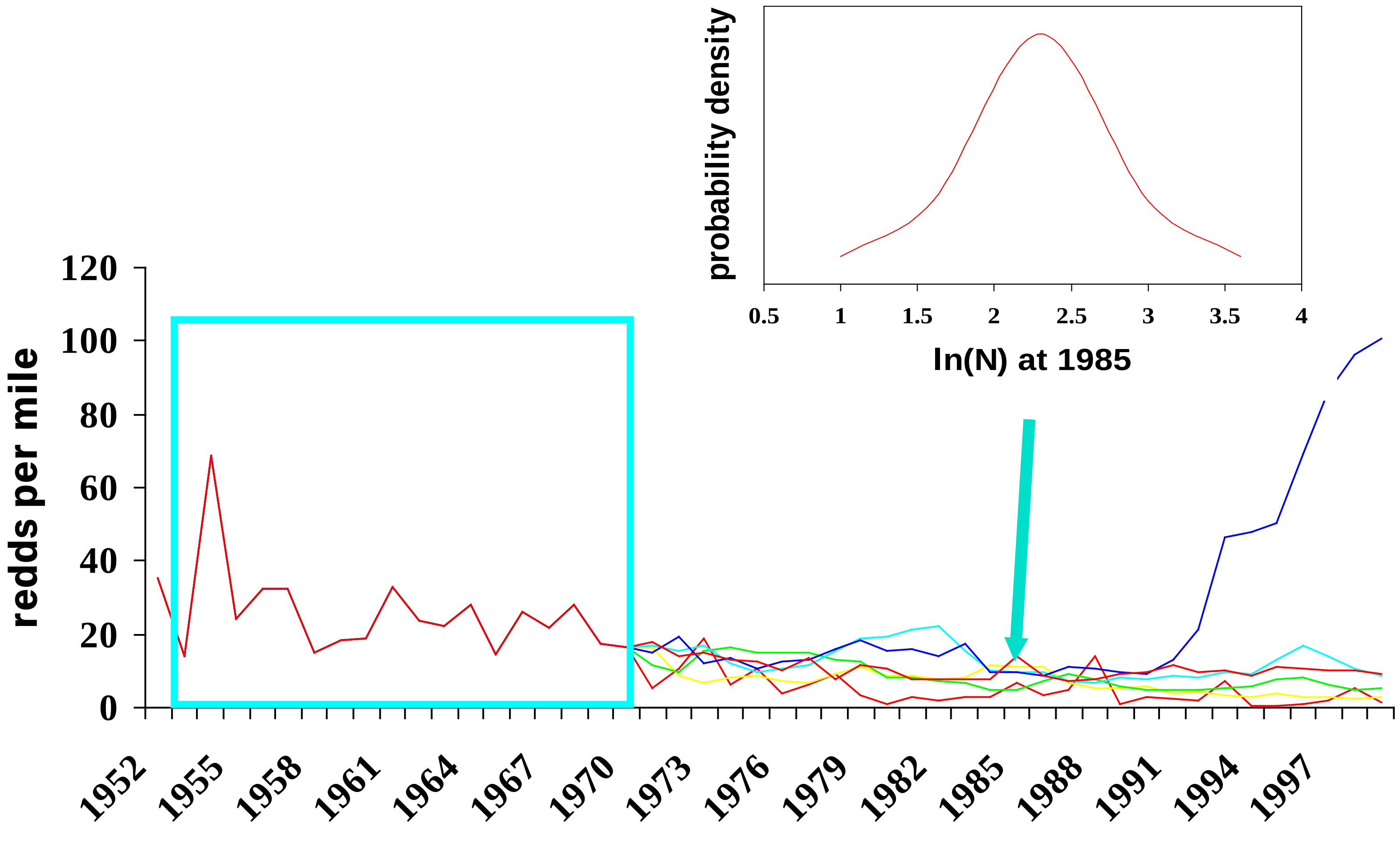


Let reproduction and survival vary yearly

$$N_t = N_0 \exp(\mu t + \varepsilon t)$$

where $\varepsilon \sim \text{Normal}(0, \sigma)$

Basic Idea of DA PVA



Parameters of a corrupted DA model – aka a state-space model

$N_t = N_0 * \exp(\mu t + \varepsilon t)$ where $\varepsilon \sim N(0,\sigma)$

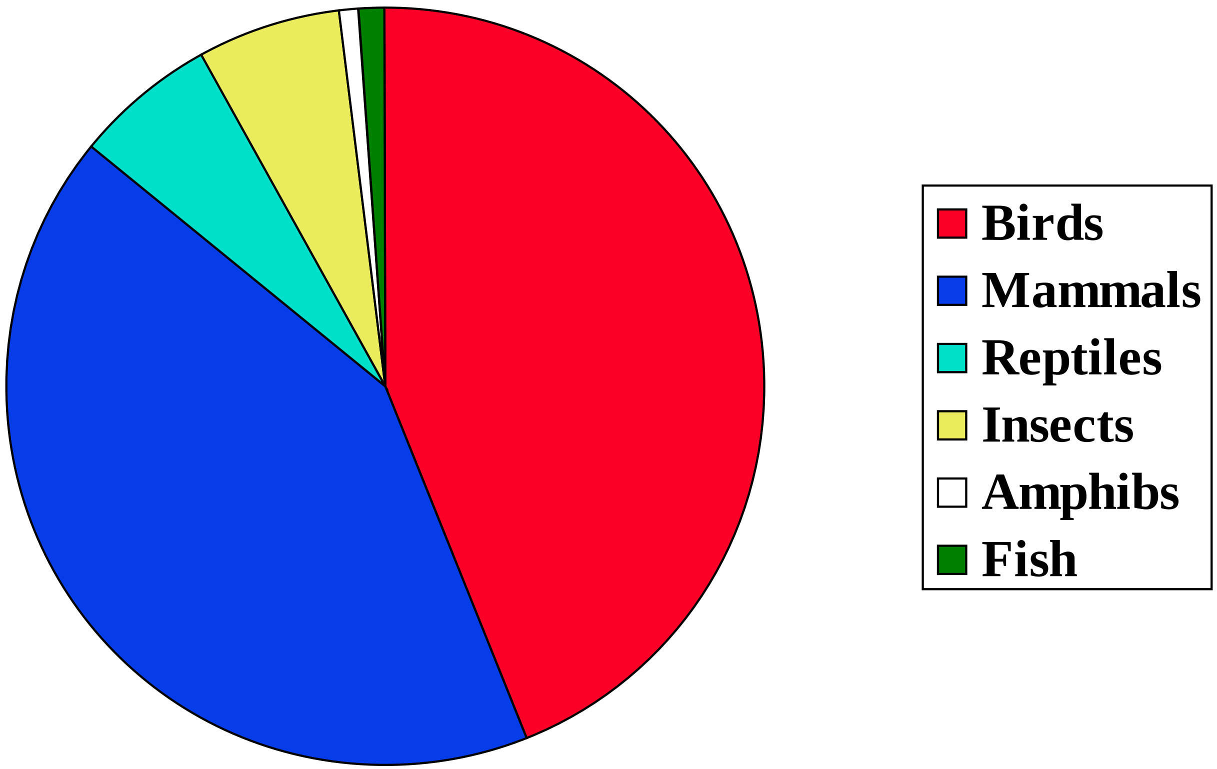
$N_t = N_0 * \exp(\varepsilon_s t)$ where $\varepsilon_s \sim f(0,\sigma_{np})$

Parameter that governs the median rate of decline.

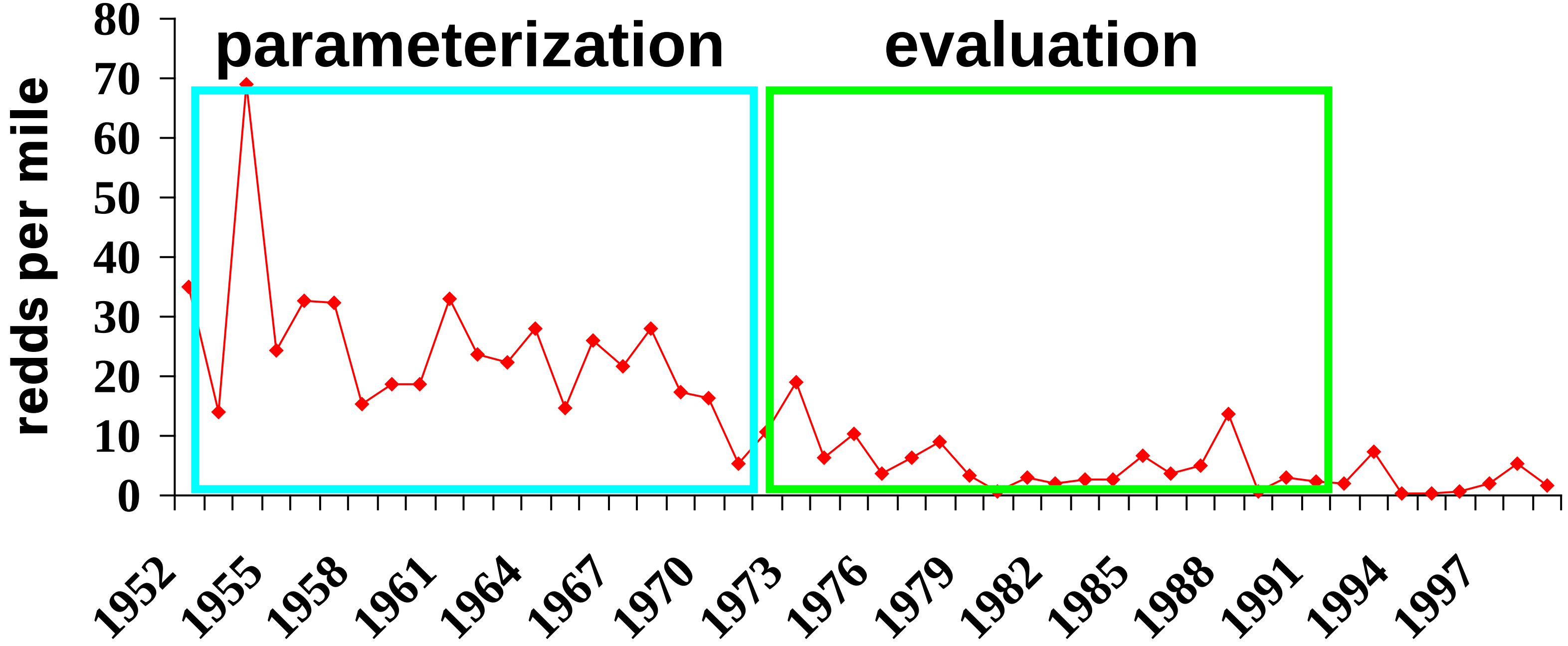
“Non-process error”

“Process error”

117 Time series 20-50 yrs long
72 are listed species

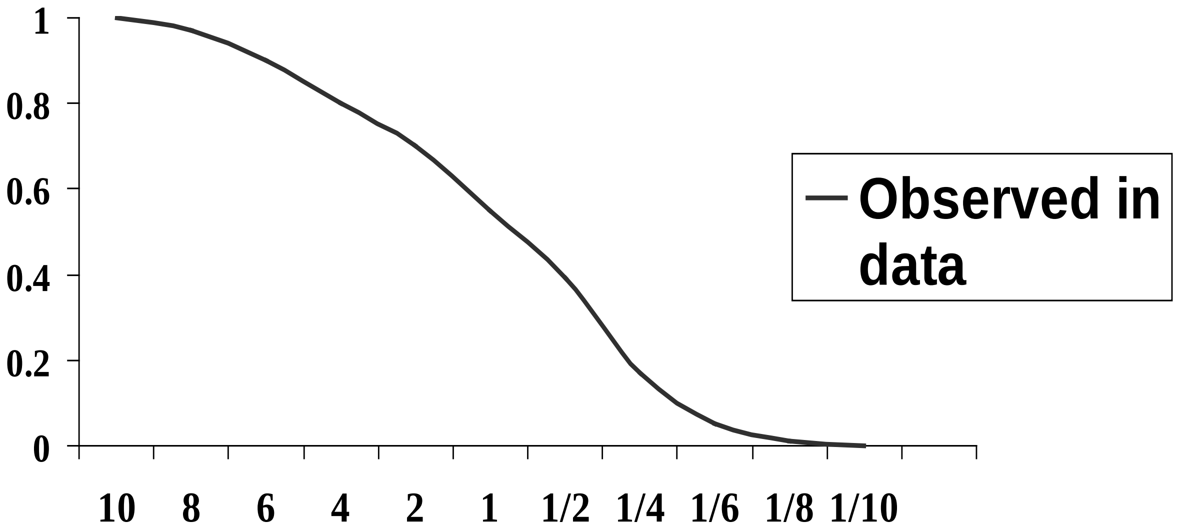


Cross-validation



Does the DA model predict the frequency of actual declines?

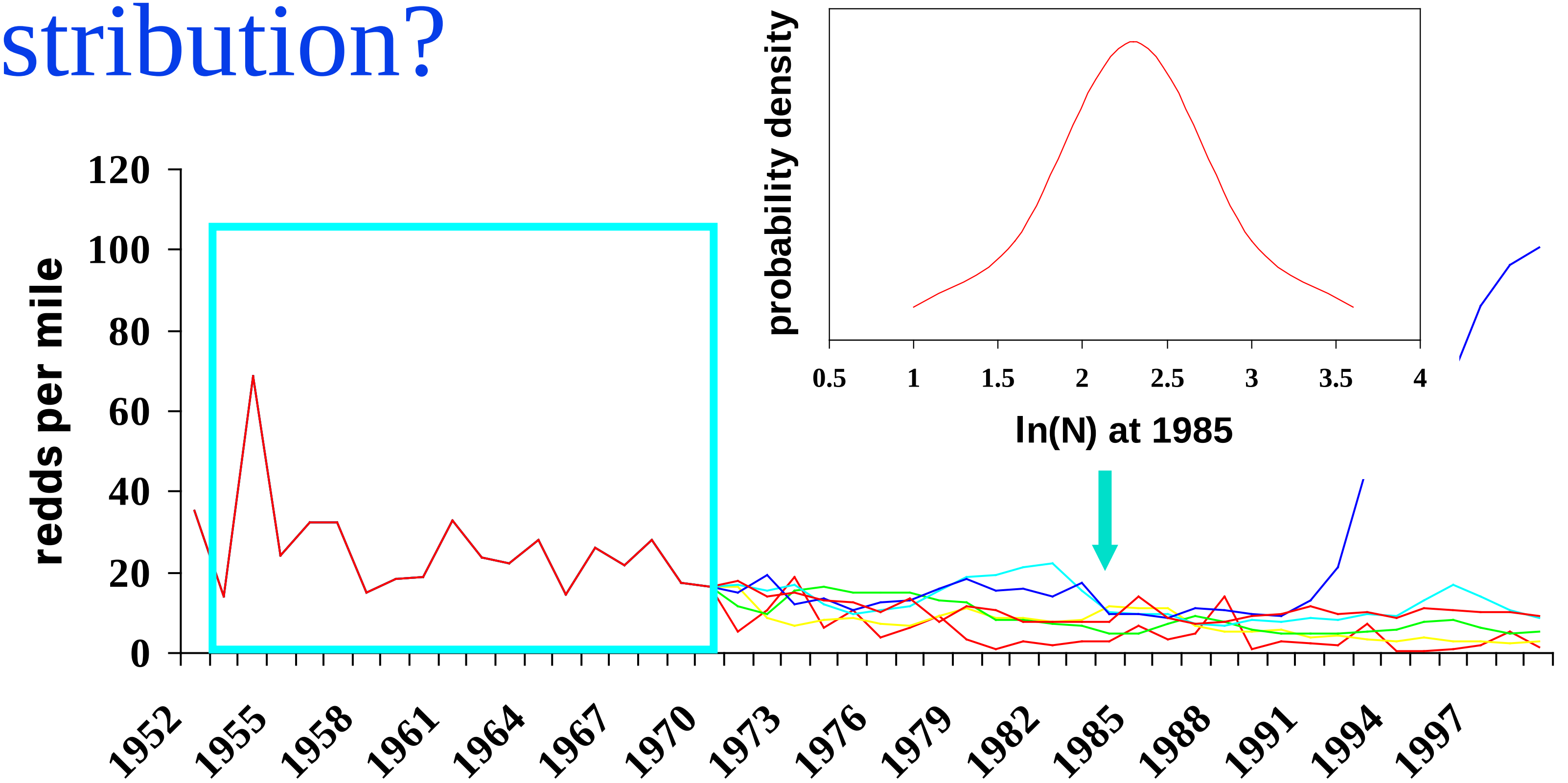
fraction of time series that dip below a threshold



threshold

(rel. to size at the start of the eval. period)

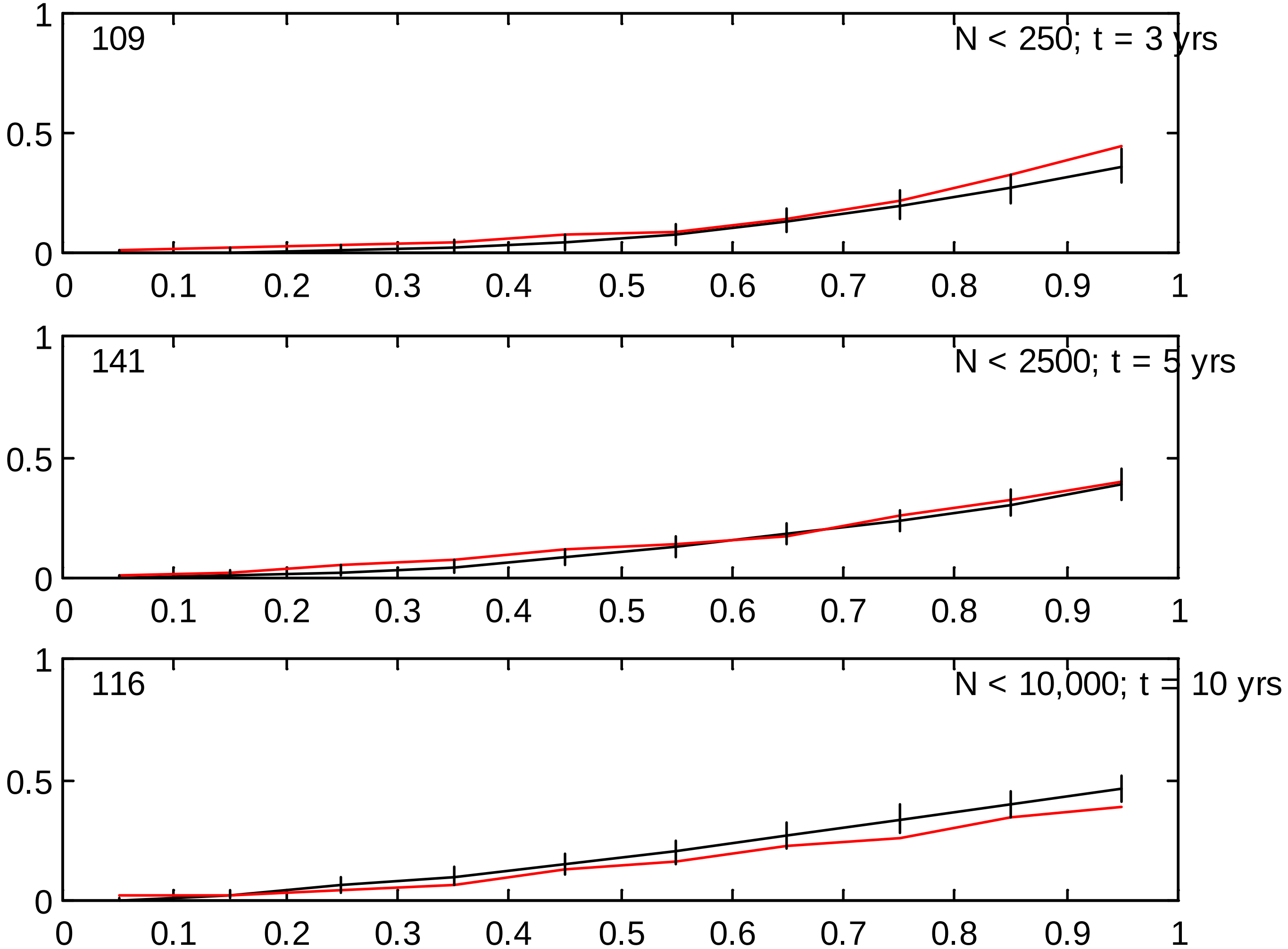
Do the projected population sizes follow the expected theoretical distribution?



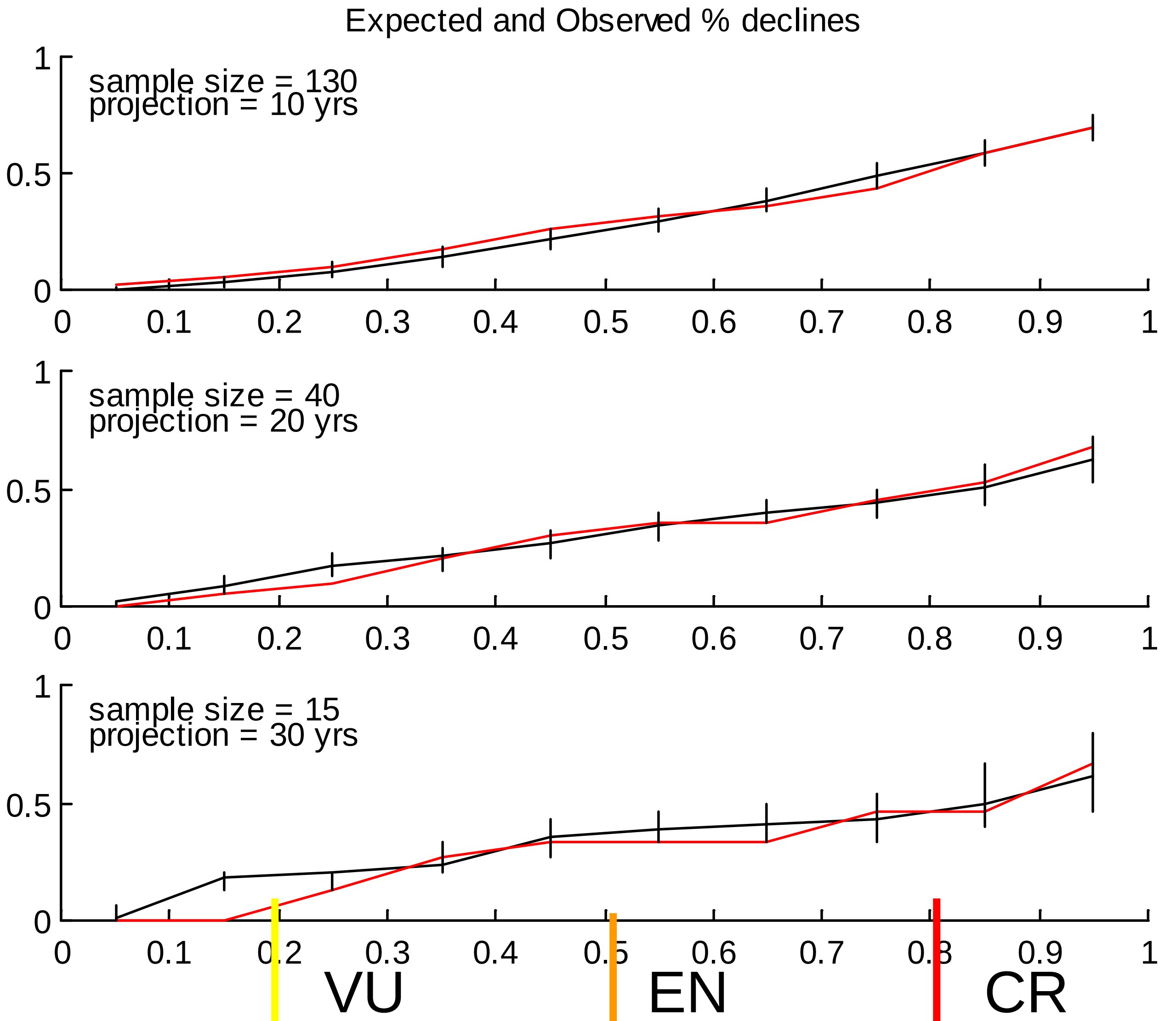
IUCN Red List Criteria

- A: Population reduction in the form of either
  1. Observed X% decline over the last Y yrs
  2. Projected X% decline in next Y yrs or Z g
- B: Pop. fragmented or habitat contracting
- C: Population below some threshold &
  1. Declining and fragmented
  2. Projected X% decline within Y yrs
- D: Less than X mature individuals
- E: Extinction risk greater than X% in Y yrs

Expected versus predicted % declines: criteria C1

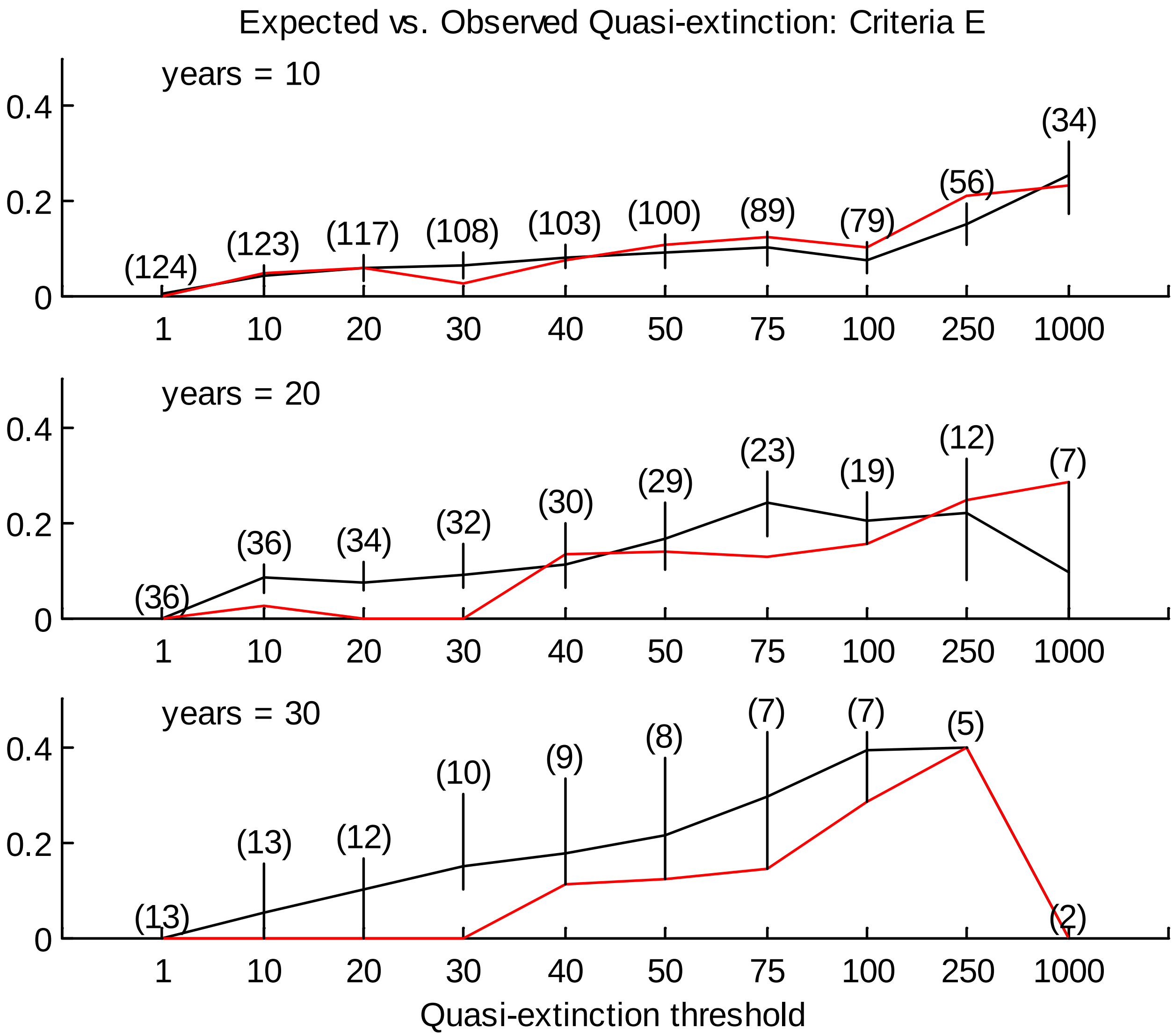


Criteria: A2



Expected and Observed % declines
sample size = 130
projection = 10 yrs
sample size = 40
projection = 20 yrs
sample size = 15
projection = 30 yrs
1
0.5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
VU
EN
CR

Quasi-extinction: Criteria E



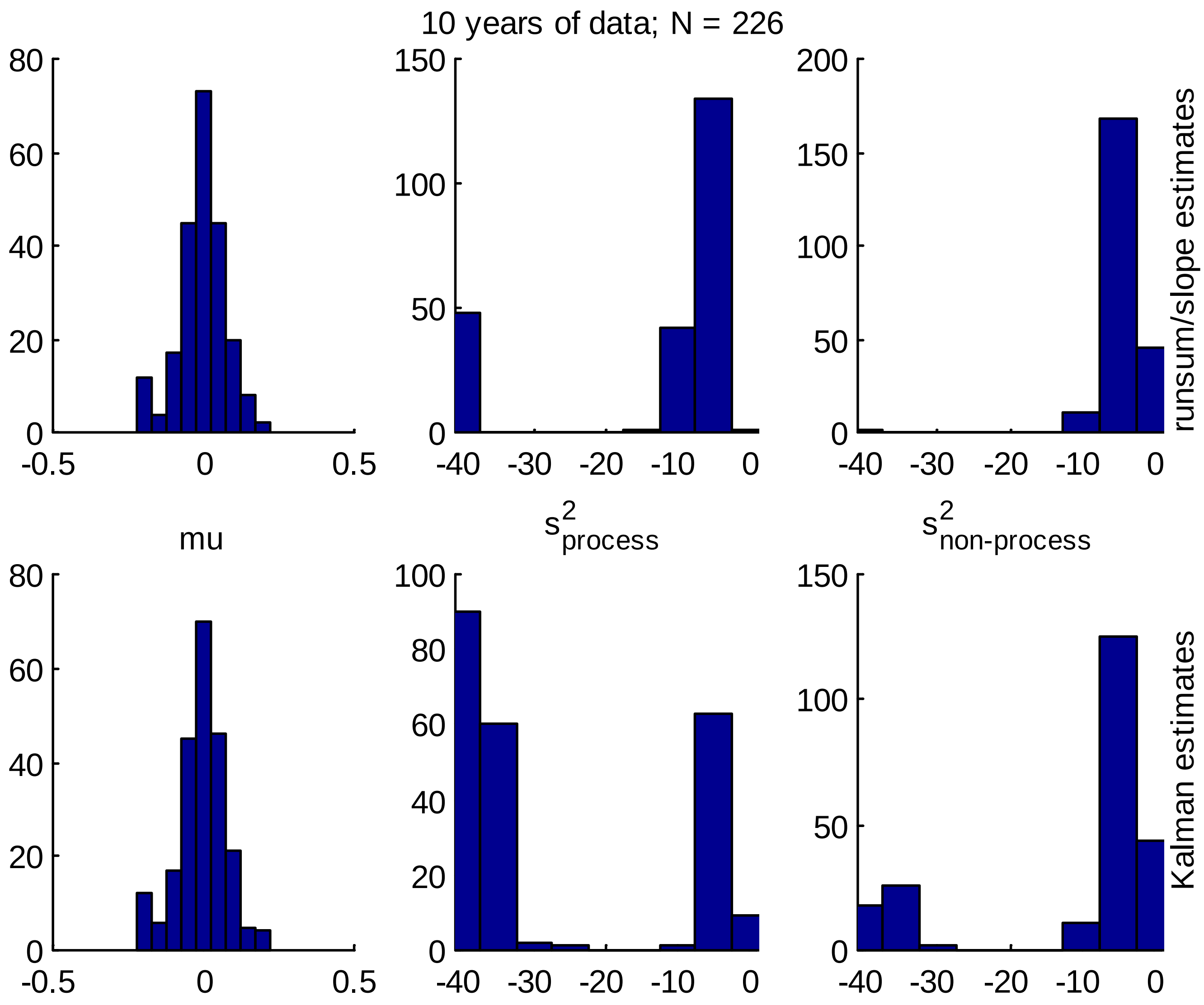
Why does this seem to work?

- Simple model makes many simplifying assumptions
  - density-independence
  - no environmental correlation
  - no trends
  - diffusion approximation of age-structured population

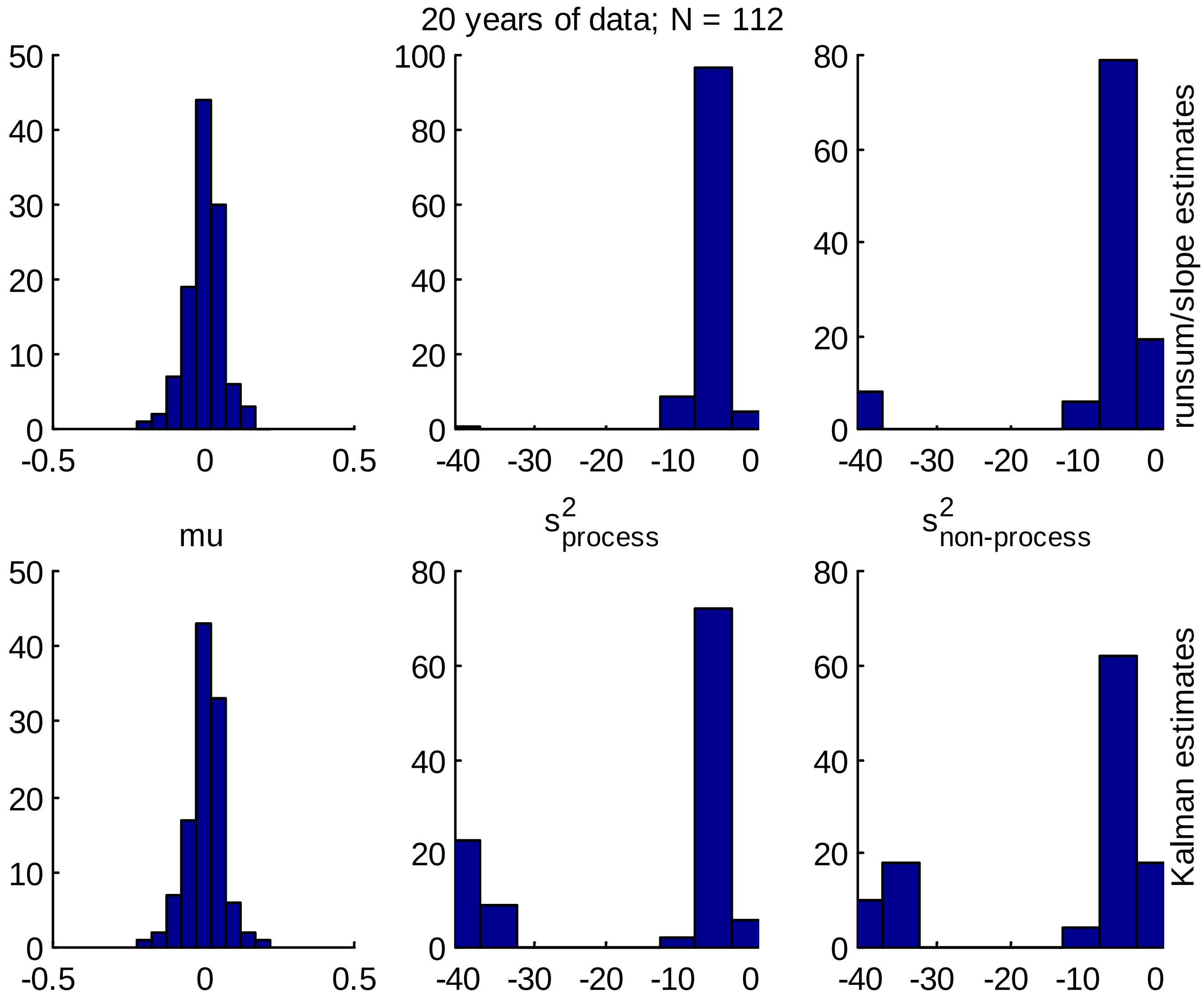
Parameterization performance

- Using a Kalman filter estimator
  - Maximum likelihood estimator for mu, sigma2_p, sigma2_np
  - Using runsum-slope estimator

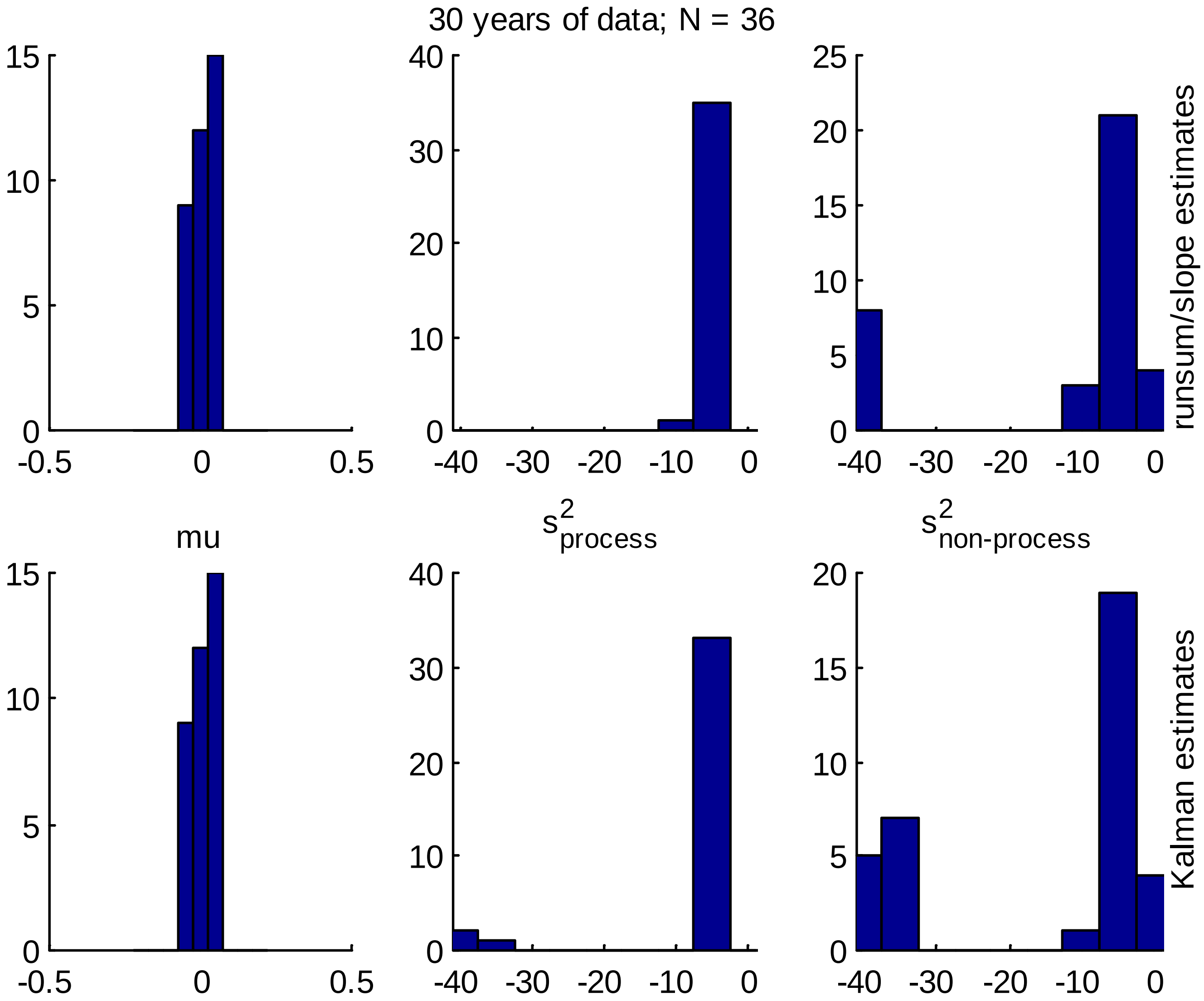
Kalman vs slope 10 years of data



Kalman vs slope with 20 yrs data



Kalman vs slope 30 yrs of data



- Preliminary conclusions
  - State-space model does pretty well for 10-30 year projections
  - Kalman filter estimator does fine since a model with all error attributed to non-process error seems to characterize the 10-30 yr stochastic process pretty well
  - The slope estimator is prone to less errors when estimating the process error from a short time series. This would be important if doing a 100 yr projection from a 10 yr time series – which is probably a bad thing to do, however.

Comparison of Kalman and slope performance

	% 0 process error ests Kalman	% 0 process error ests Slope	Correlation between Kalman and slope
10 yrs	68%	21%	0.72
20 yrs	28%	1%	0.90
30 yrs	8%	0%	0.94