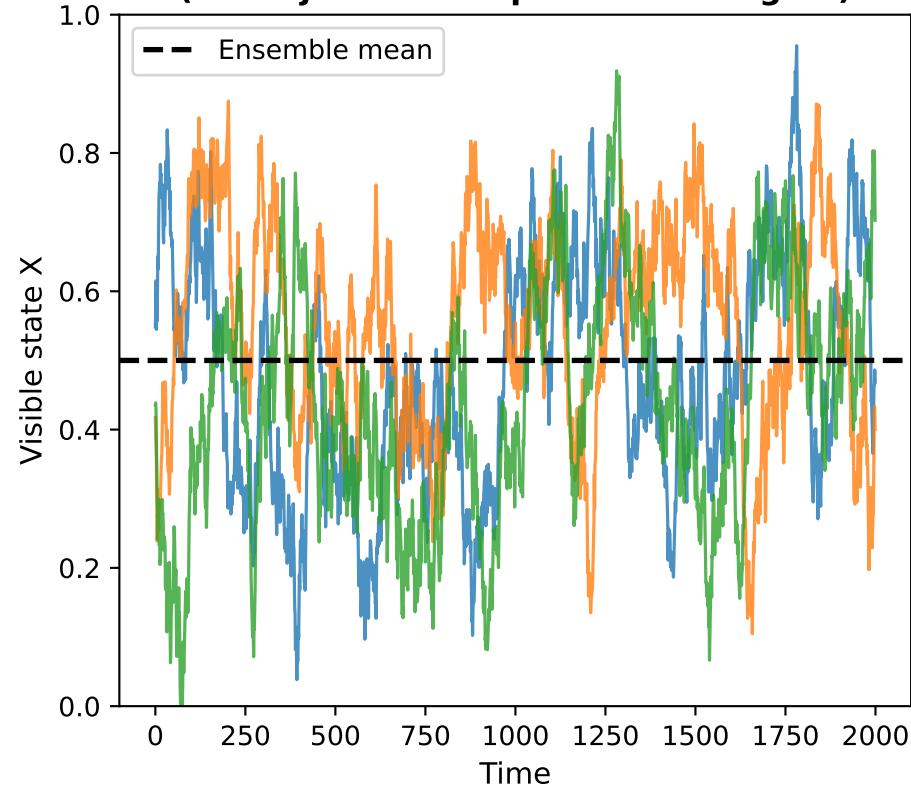
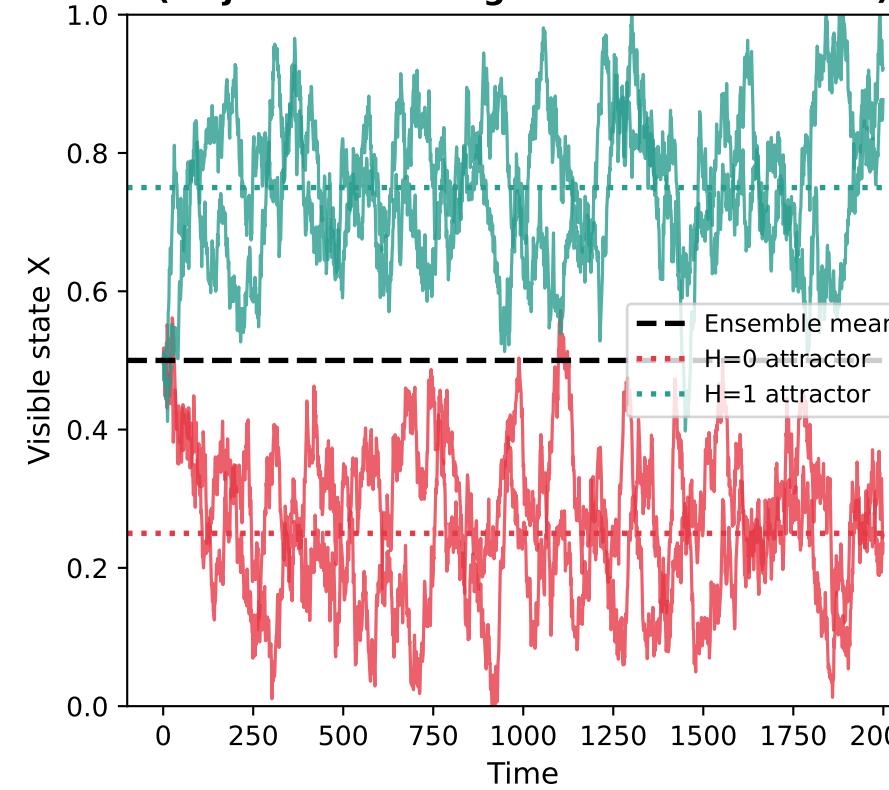


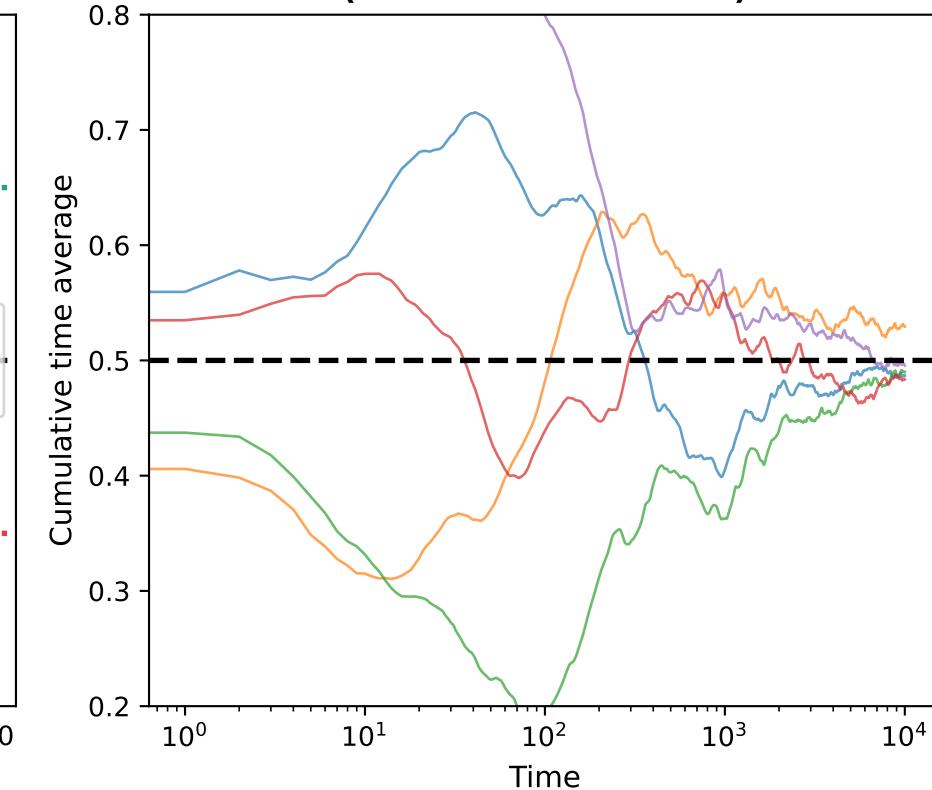
A. Ergodic System
(all trajectories explore same region)



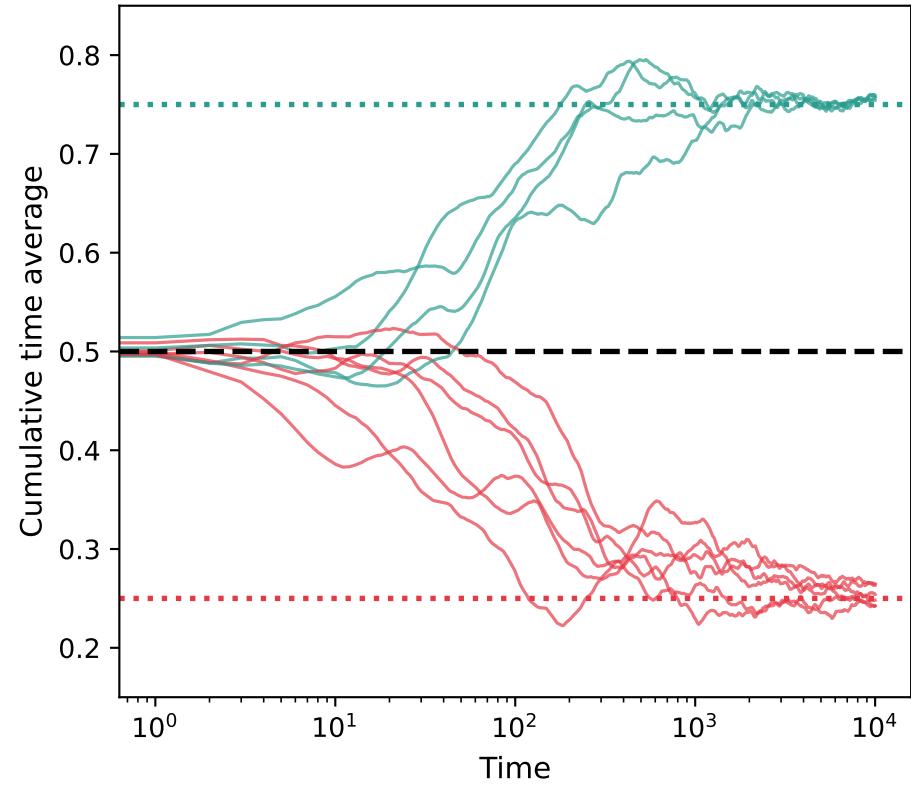
B. Non-Ergodic System
(trajectories diverge based on hidden H)



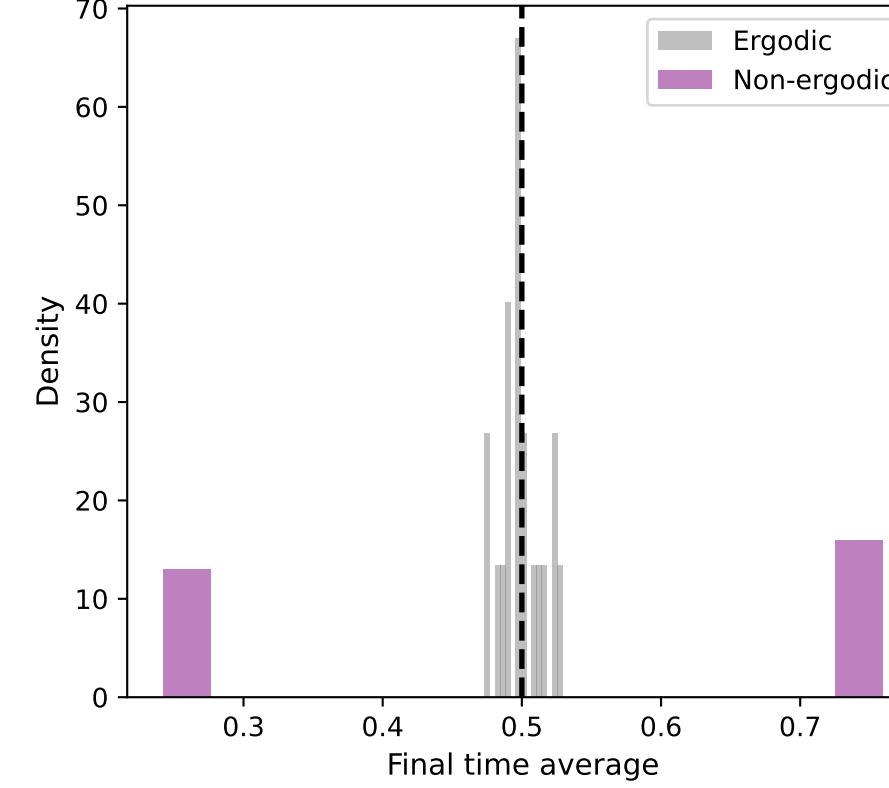
C. Ergodic: Time Averages Converge
(all \rightarrow ensemble mean)



D. Non-Ergodic: Time Averages DIVERGE
(depend on hidden H)



E. Distribution of Time Averages
(ergodic=tight, non-ergodic=bimodal)



F. The Epistemological Point

WHY TIME AVERAGING FAILS

ERGODIC SYSTEM:

- No hidden memory
- All trajectories explore same states
- Time avg \rightarrow Ensemble avg as $T \rightarrow \infty$
- Inference: just measure longer

NON-ERGODIC SYSTEM:

- Hidden state H carries memory
- H constrains which states are visited
- Time avg \rightarrow H -dependent value
- Inference: measuring longer doesn't help!

THE BIOLOGICAL CASE:

If sub-Landauer structure (epigenetic marks, conformational states, developmental history) encodes memory that you cannot observe:

- Your time averages are BIASED
- The bias depends on HISTORY
- You cannot detect the bias
- "Just collect more data" doesn't fix it

This is why non-ergodicity breaks the classical inference toolkit.