Data Assimilation Studies

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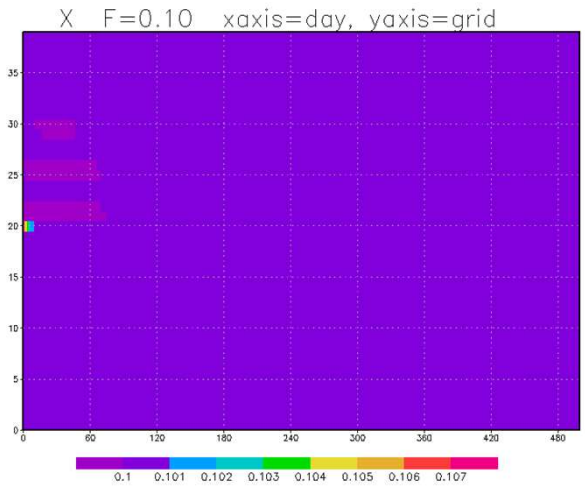
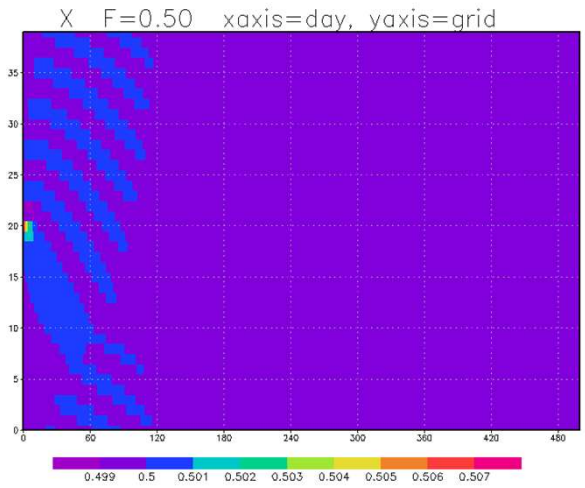
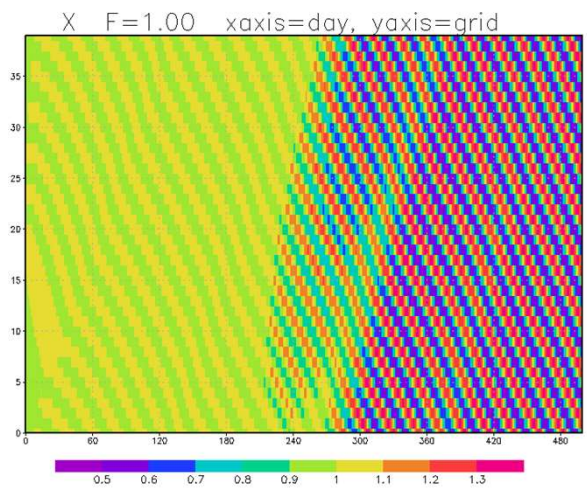
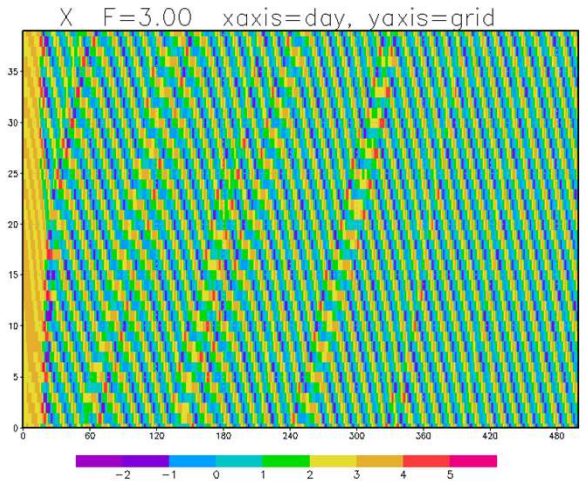
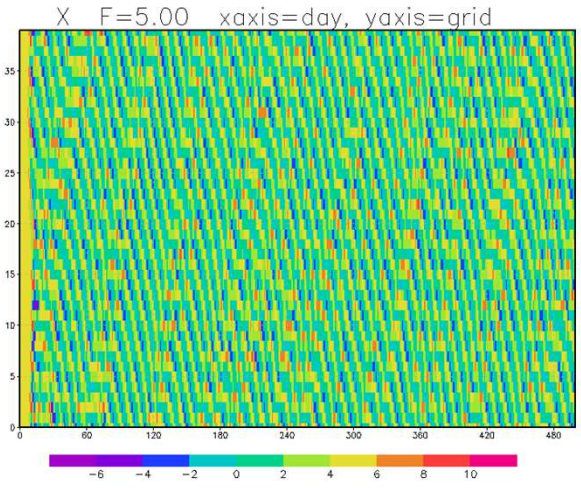
Stable or chaotic ?

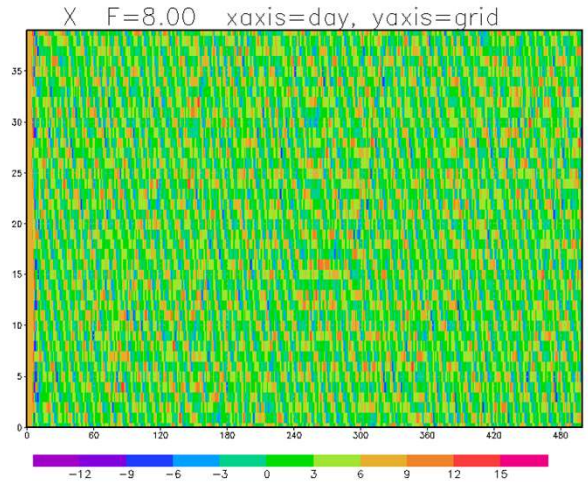




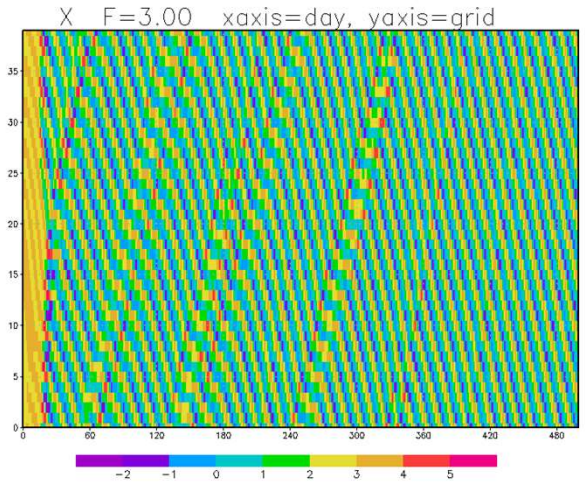


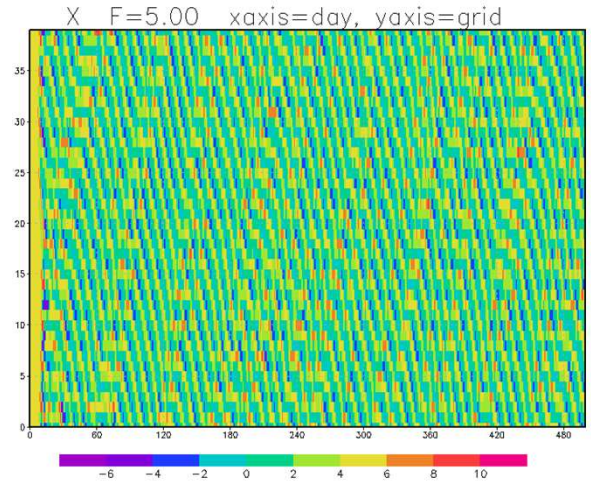


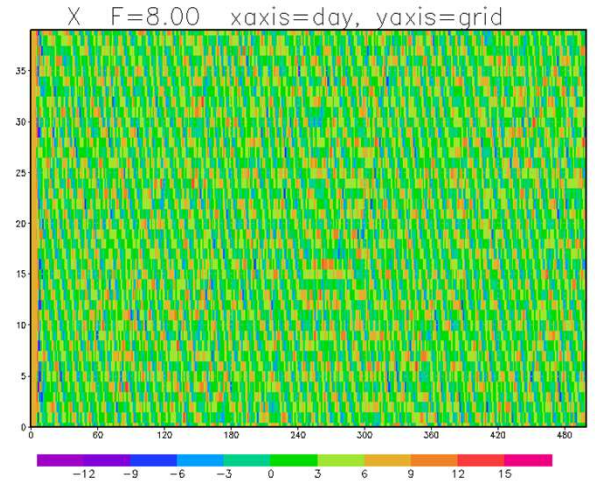


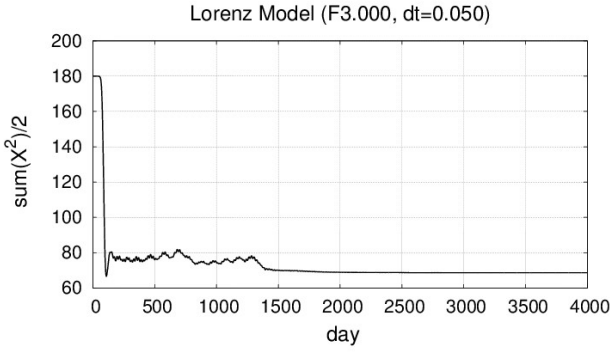


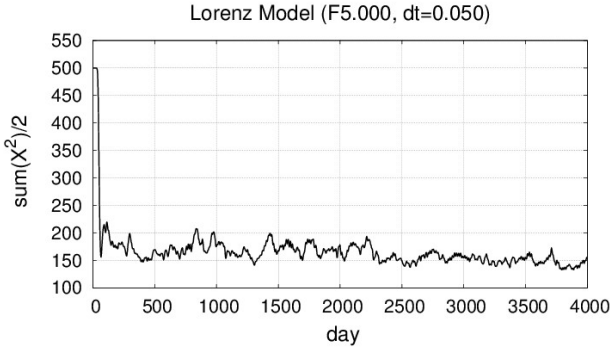
Stable or chaotic ?

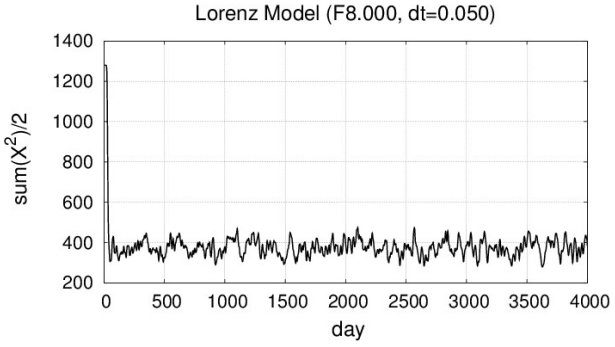












$$dX_j / dt = \left(X_{j+1} - X_{j-2} \right) X_{j-1} - X_j + F$$ For j=1,…,J, $X_j = X_{j+J}$

Advection term Dissipation term Forcing term

Advection term conserve the total energy defined as $\sum \left(X_j^2 \right) / 2$

EnKF

(1) $X_t^{f(l)} = Mx_{t-1}^{a(l)}$

(2) $P_t^{f(l)} = E_t^f \left(E_t^f\right)^T = M' E_{i-1}^a \left(M' E_{i-1}^a\right)^T$

$$M' E_{t-1}^a \approx \frac{1}{\sqrt{m-1}} \left[Mx_{t-1}^{f(1)} - \bar{x}_{t-1}^f, \cdots, Mx_{t-1}^{f(\mathrm{m})} - \bar{x}_{t-1}^f \right]$$

(3) $K_t^f = E_t^f \left(HE_t^f\right)^T \left[HE_t^f \left(HE_t^f\right)^T + R \right]^{-1}$

$$K_t^f = E_t^f \left[I + \left(HE_t^f\right)^T R^{-1} HE_t^f \right]^{-1} \left(HE_t^f\right)^T R^{-1}$$

(4) $\bar{x}_t^a = \bar{x}_t^f + K_t^f \left(y - H\bar{x}_t^f \right)$

(5) Update Pa (Ea)

(6) Update ensemble members

$$E_t^a \approx \frac{1}{\sqrt{m-1}} \left[x_t^{a(1)} - \bar{x}_t^a, \cdots, x_t^{a(m)} - \bar{x}_t^a \right]$$

Serial EnSRF

Localization

$$r = \frac{d}{\sqrt{10/3}\sigma}$$

Schur product length scale

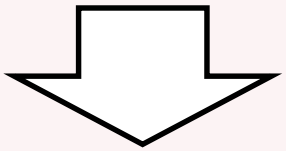
$$K \leftarrow S(r) \circ K$$

Fifth-order piecewise rational function
(The Gaussian-like weighting function)

Multiplicative covariance inflation

$$P^f \leftarrow P^f (1+\delta)$$

$$P^f = E^f (E^f)^{\mathrm{T}}$$

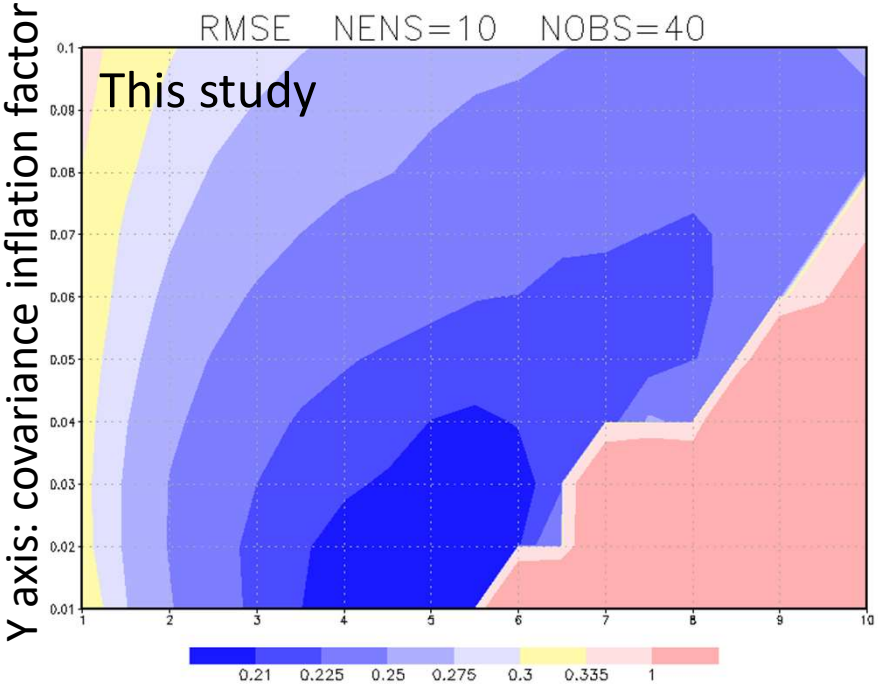


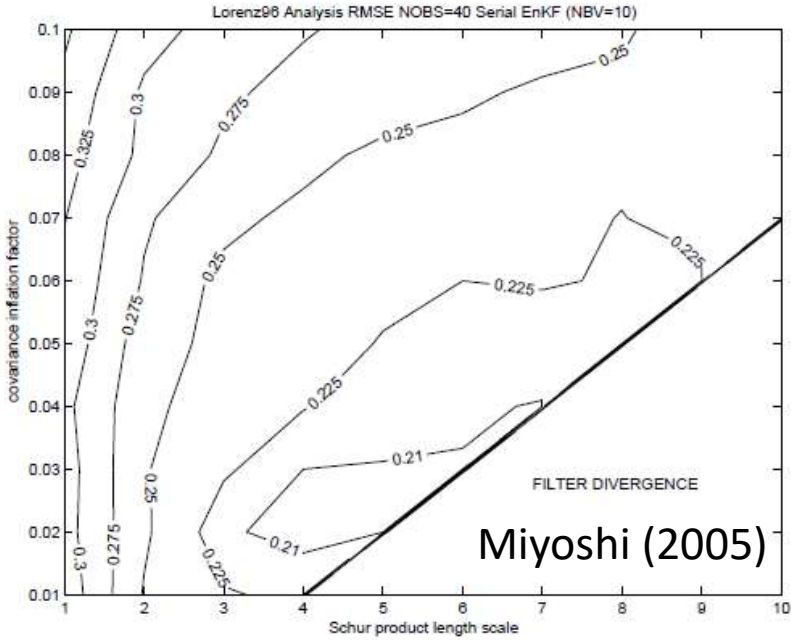
$$E^f \leftarrow E^f \sqrt{1+\delta}$$

Only once for the first observation of the serial filtering loops.

Serial EnSRF has been applied to the Lorenz-96 model.

Serial EnSRF



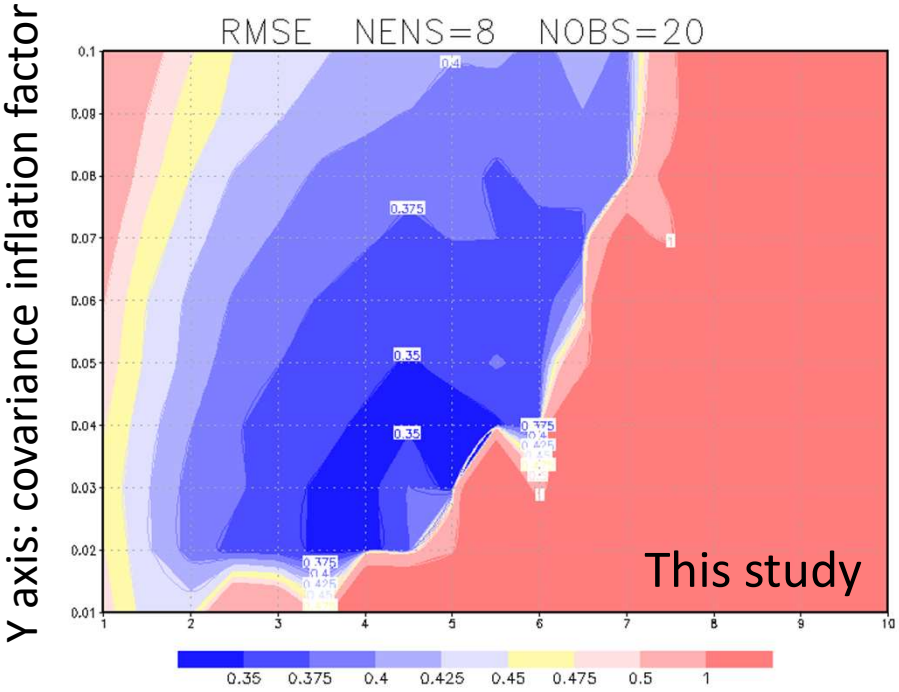


X axis: Schur product length scale

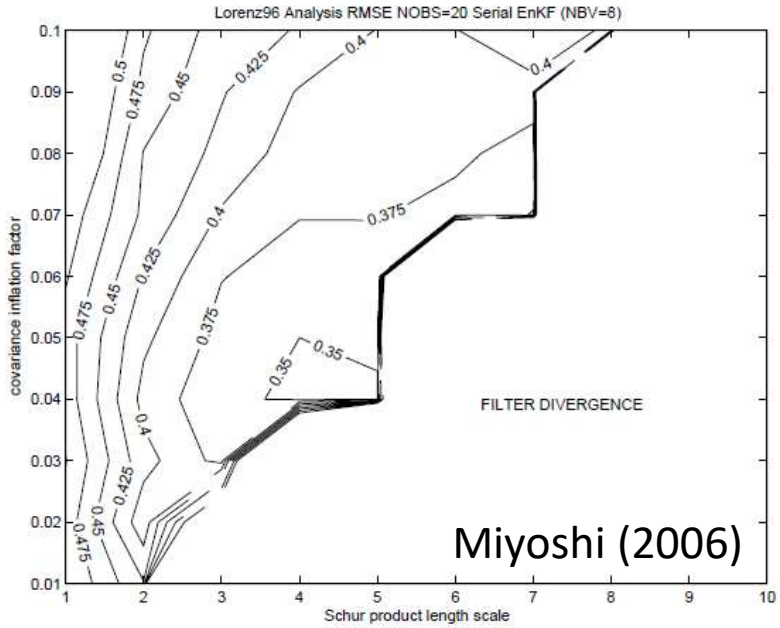
※ Note: Single simulation result

Figure 2.3: Parameter dependence of the analysis RMSE of serial EnSRF with 10 ensemble members on the Lorenz-96 model when the number of observations is 40, cf. Fig.3(b) of Whitaker and Hamill (2002). The horizontal and vertical axes show the localization length scale σ and the covariance inflation paramter δ, respectively. The minimum error 0.20 is observed when $\sigma = 5$ and $\delta = 0.02$. "FILTER DIVERGENCE" denotes the region with RMSE of more than 1.0.

Serial EnSRF



X axis: Schur product length scale

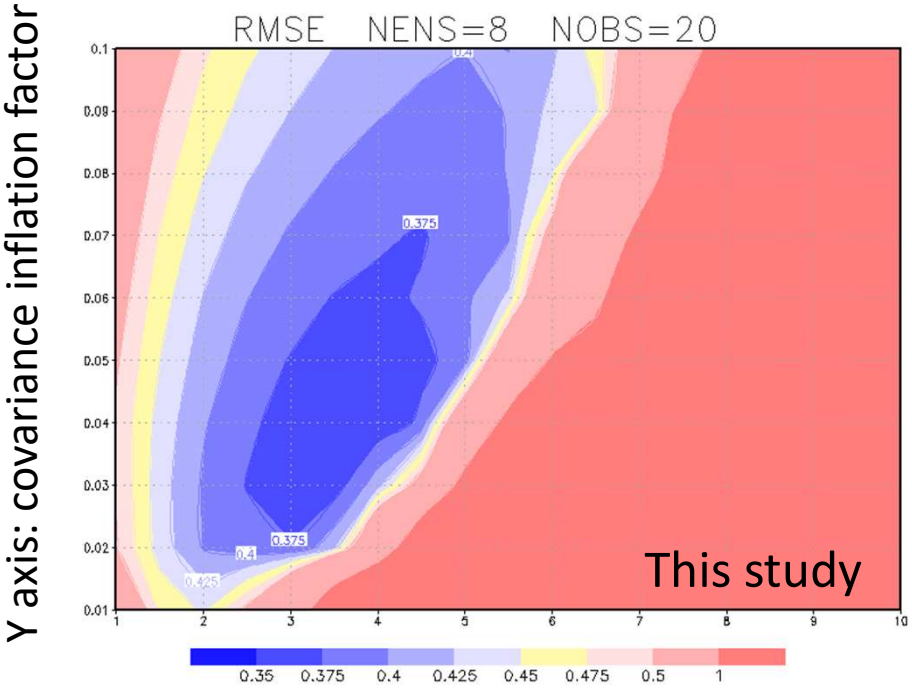


The differences of the figures
may derive from following reasons.

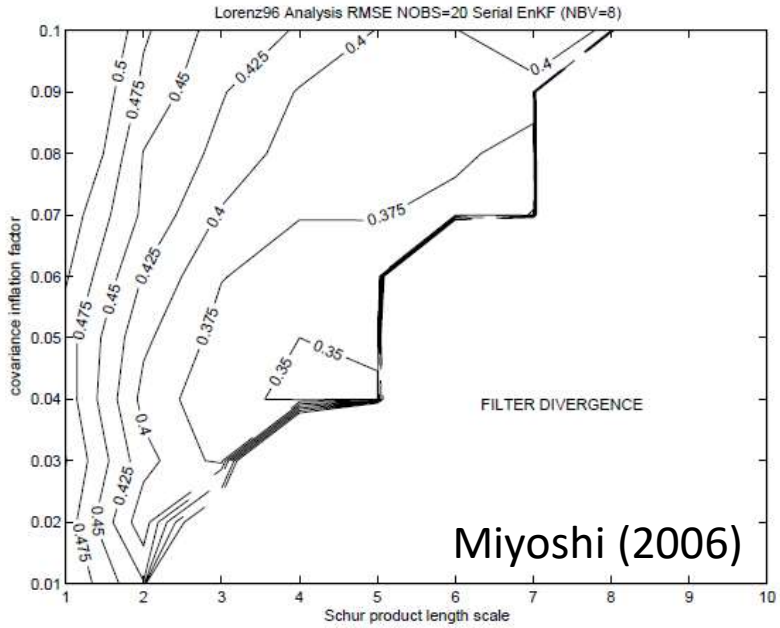
1. The number of simulations
2. Intervals of X and Y axis.

※ Note: Single simulation result

Serial EnSRF



X axis: Schur product length scale



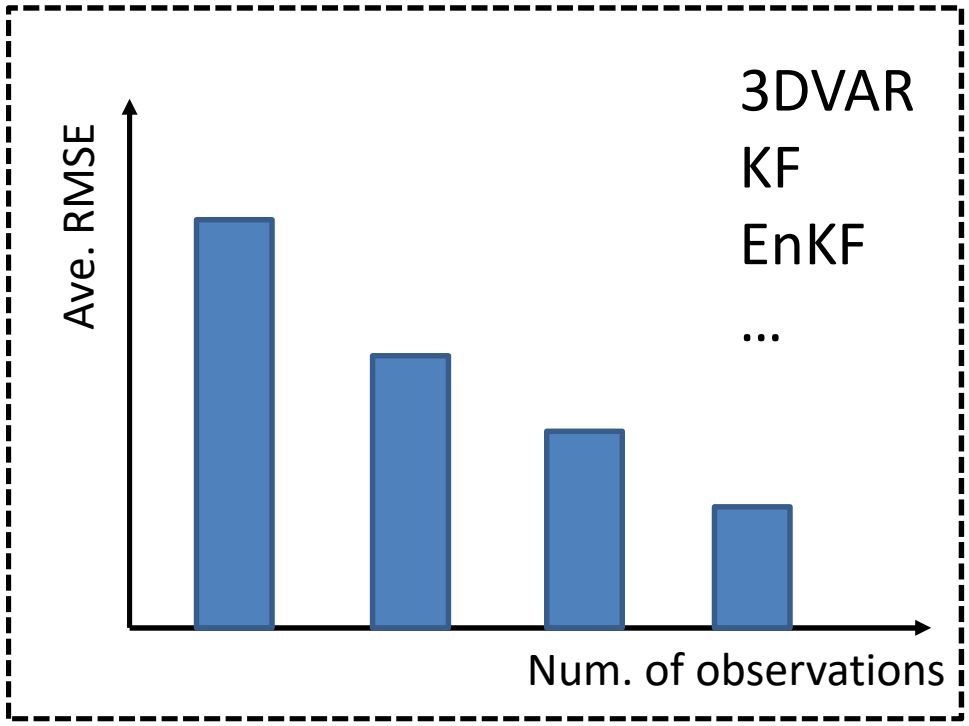
The differences of the figures
may derive from following reasons.

1. The number of simulations
2. Intervals of X and Y axis.

※ Note: ave. 50 simulations

Next step

- Remaining homework
  - To re-run KF with breeding method
  - To investigate dependency of filtering methods on observation density with KF, 3DVAR, and EnKFs.



- Code development
  - LEKF, LETKF