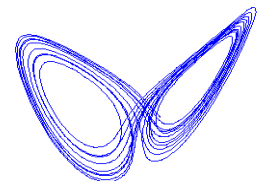# What is a reasonable ensemble size for operational GEFS?

Juhui (Jessie) Ma

Acknowledgment: Yuejian Zhu, Dingchen Hou, Mozheng Wei, Malaquias Pena
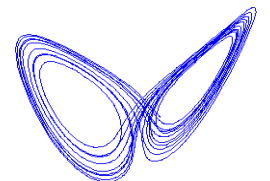
10/08/2010

Outline

- Impact of ensemble size on ensemble skill with Lorenz 96 model

- Impact of ensemble size on ensemble skill with NCEP GEFS model

- The relative impact of increasing model resolution and increasing ensemble size with NCEP GEFS model

- Model: Lorenz 96 model $\dfrac{dX_i}{dt} = (X_{i+1} - X_{i-2})X_{i-1} - X_i + F$

  -The magnitude of the forcing $F = 8$

  - $\Delta t = 0.05$ (corresponds to approximately 6h in the atmosphere)

  -Fourth-order Runge-Kutta integration scheme

  -Cyclic boundary condition

- Analysis: Kalman Filter method $x^a = x^b + P^b H^T (HP^b H^T + R)^{-1}(y - Hx^b)$

  It provides analysis-error covariance to ETR perturbation.

  $$P^a = P^b - P^b H^T (HP^b H^T + R)^{-1} HP^b$$

- Initial perturbations :

  1) Monte Carlo perturbation

  2) ETR based perturbation

- Ensemble size: 10, 20, 40, 60, 80, 100, 200

- Verification:

  1)RMS error of ensemble mean and Spread
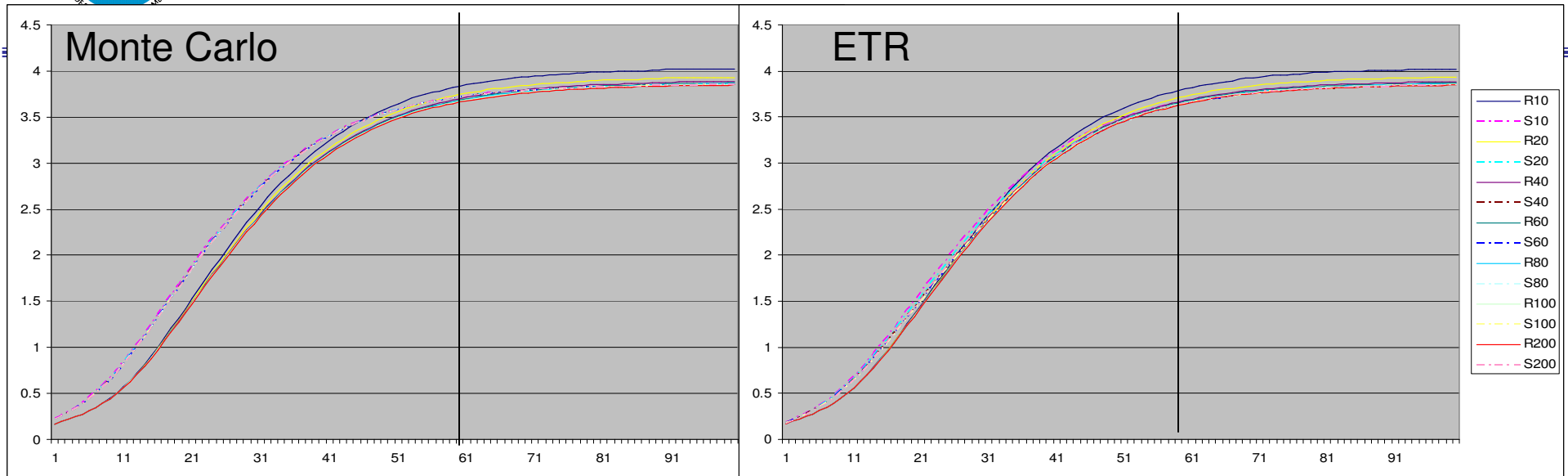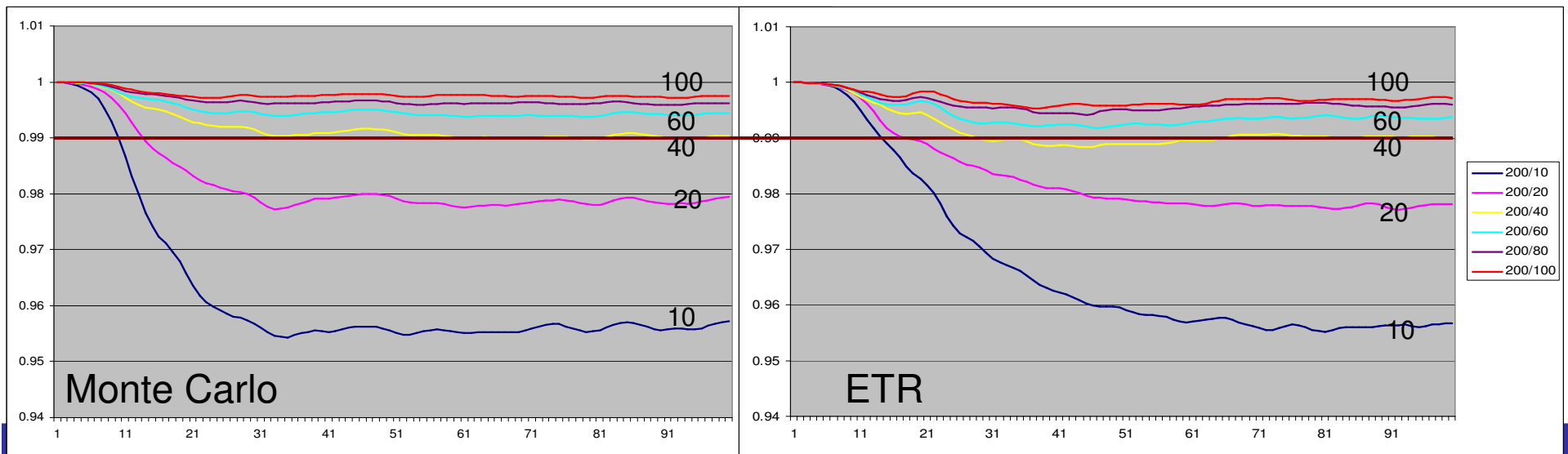
  2)CRPS
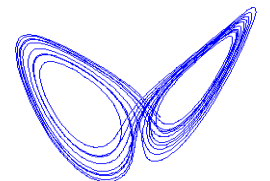
RMSE and SPREAD

FIG.1 RMS error of ensemble mean and SPREAD for different ensemble members

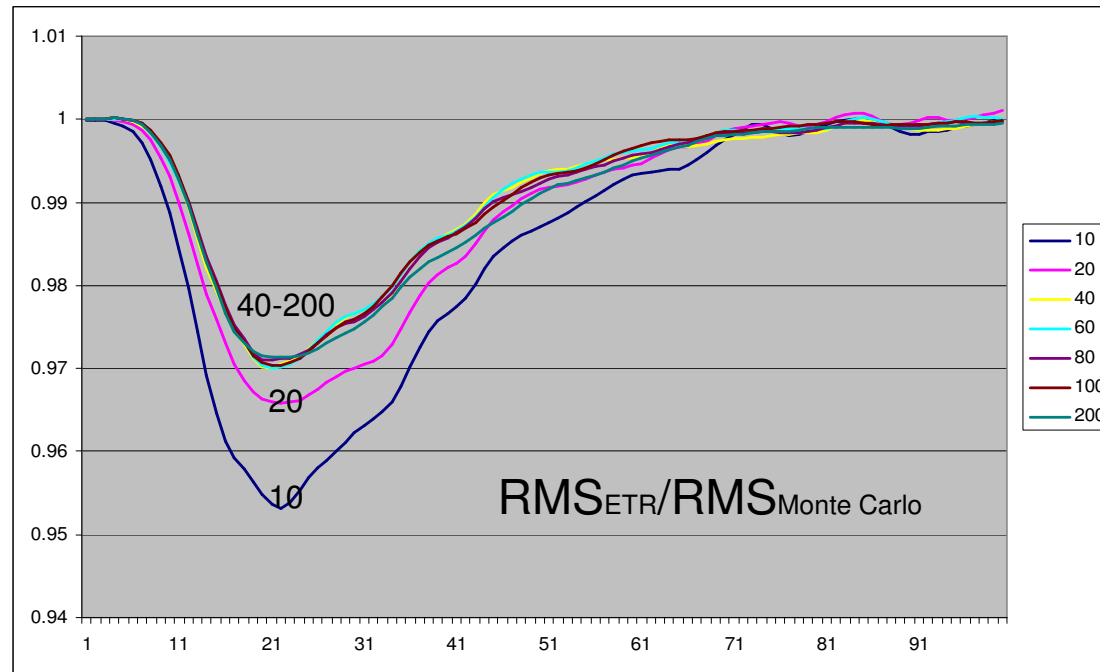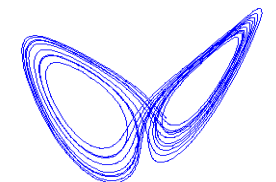FIG.2 RMS error ratios of 200-member ensemble mean to others

FIG.3 RMS error ratios of ETR to Monte Carlo perturbation
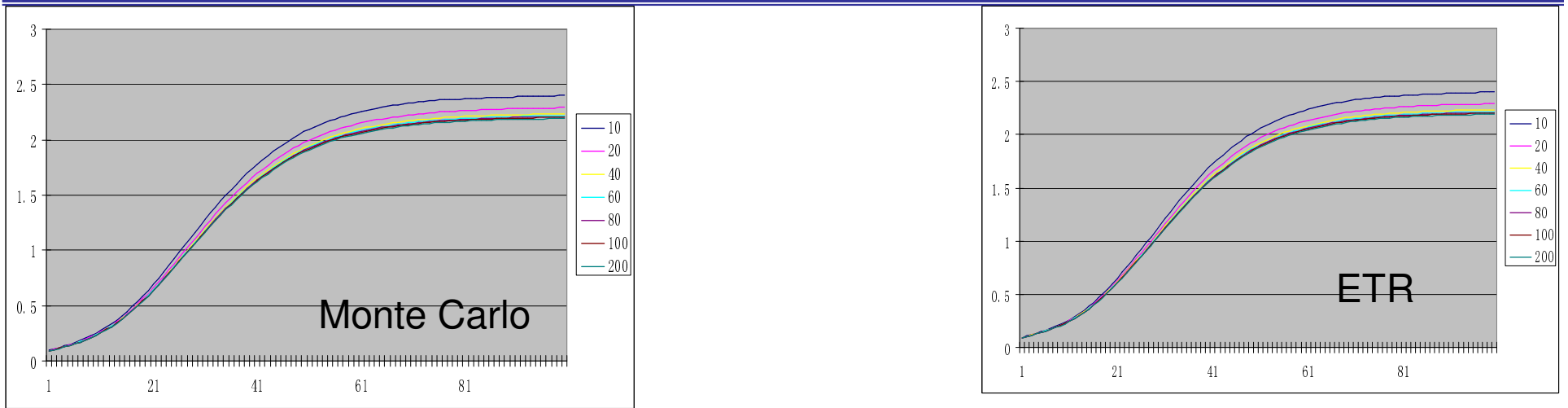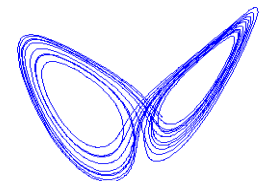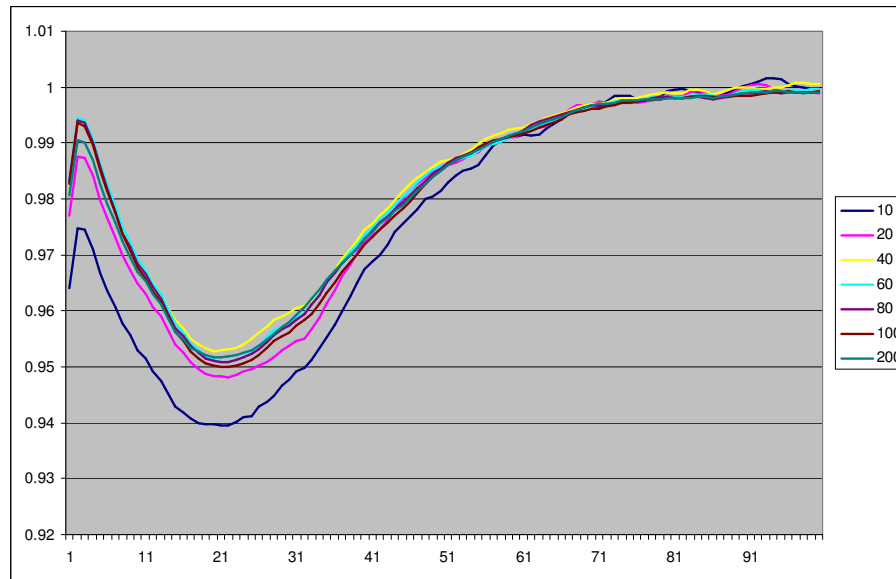for different ensemble members.

CRPS

FIG.4 CRPS for different ensemble members. a, Monte Carlo perturbation; b, ETR perturbation.
FIG.5 CRPS ratios of ETR to Monte Carlo perturbation for different ensemble members.

Plan
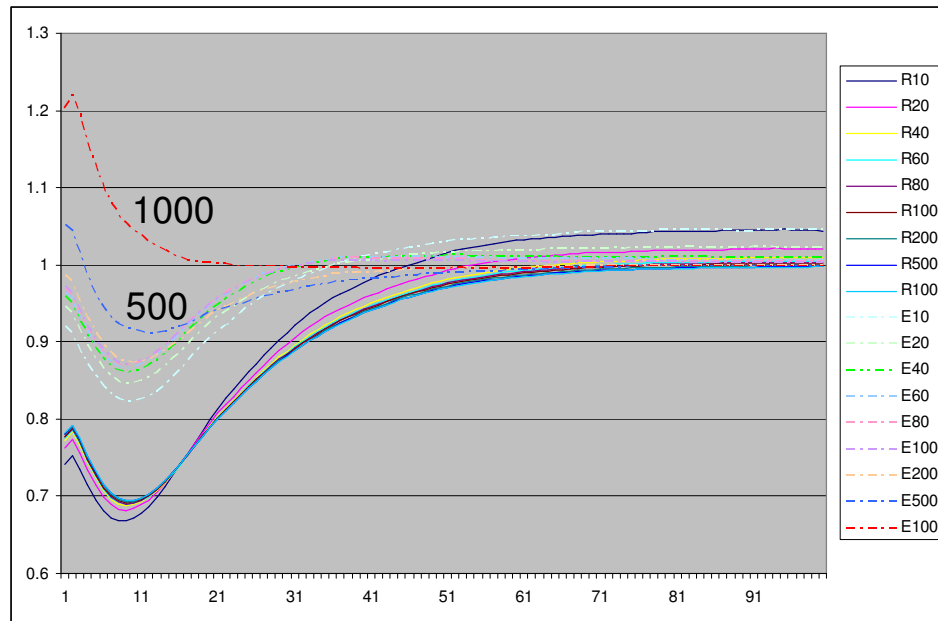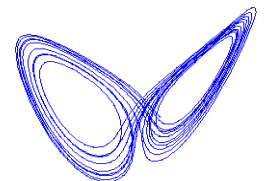# - increase ensemble size to 1000

FIG.6 Ratio of RMS to SPREAD for different ensemble members.
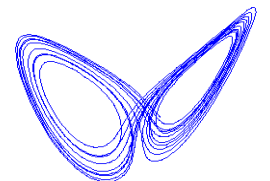Solid lines are Monte Carlo perturbation; dot lines are ETR perturbation.

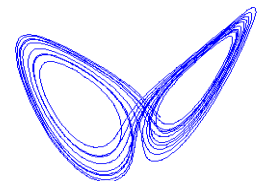$$\frac{dX_i}{dt} = (X_{i+1} - X_{i-2})X_{i-1} - X_i + F \qquad i=1000$$

Outline and Summary

➡️ Impact of **ensemble size** on ensemble skill with **Lorenz 96** model

- RMS error of 40 members can almost represent 99% of 200 members, but 10 members only represent less than 96%.
- ETR scheme outperforms Monte Carlo method for all lead time, especially around 4-7d.

➡️ Impact of **ensemble size** on ensemble skill with **NCEP GEFS** model

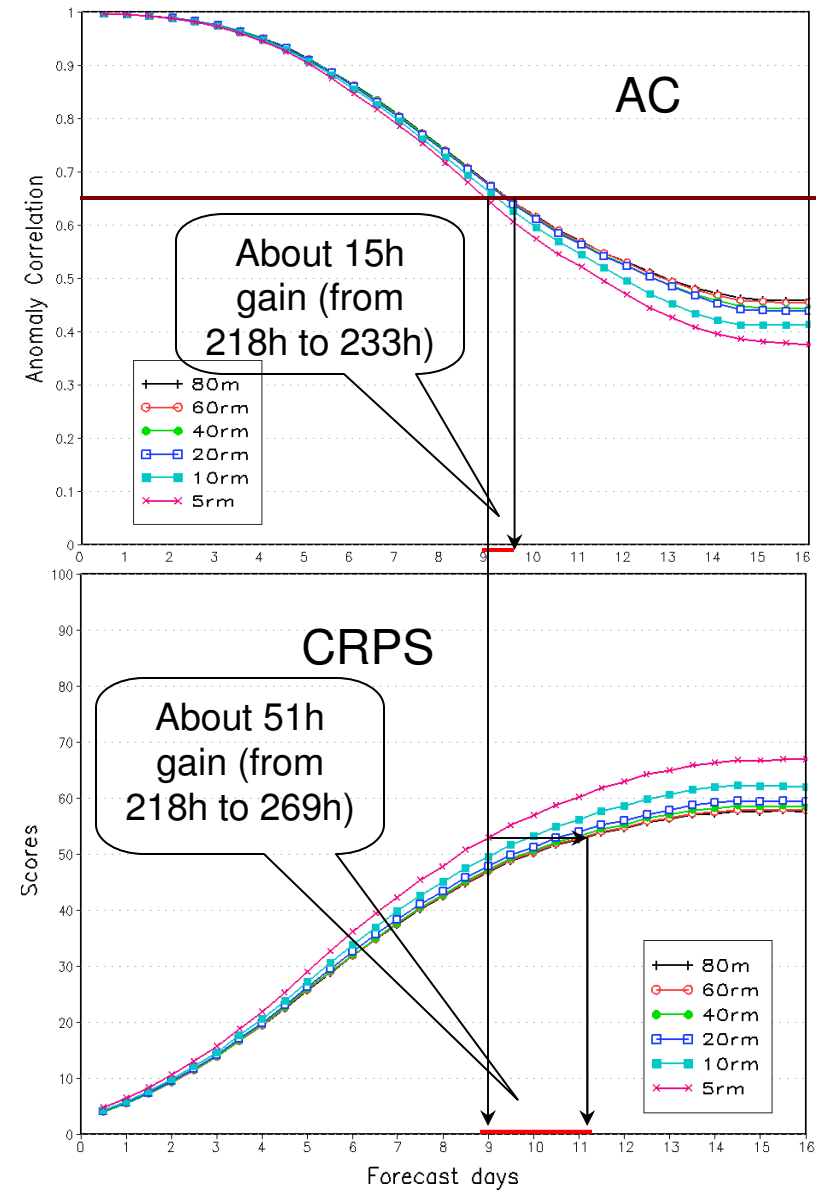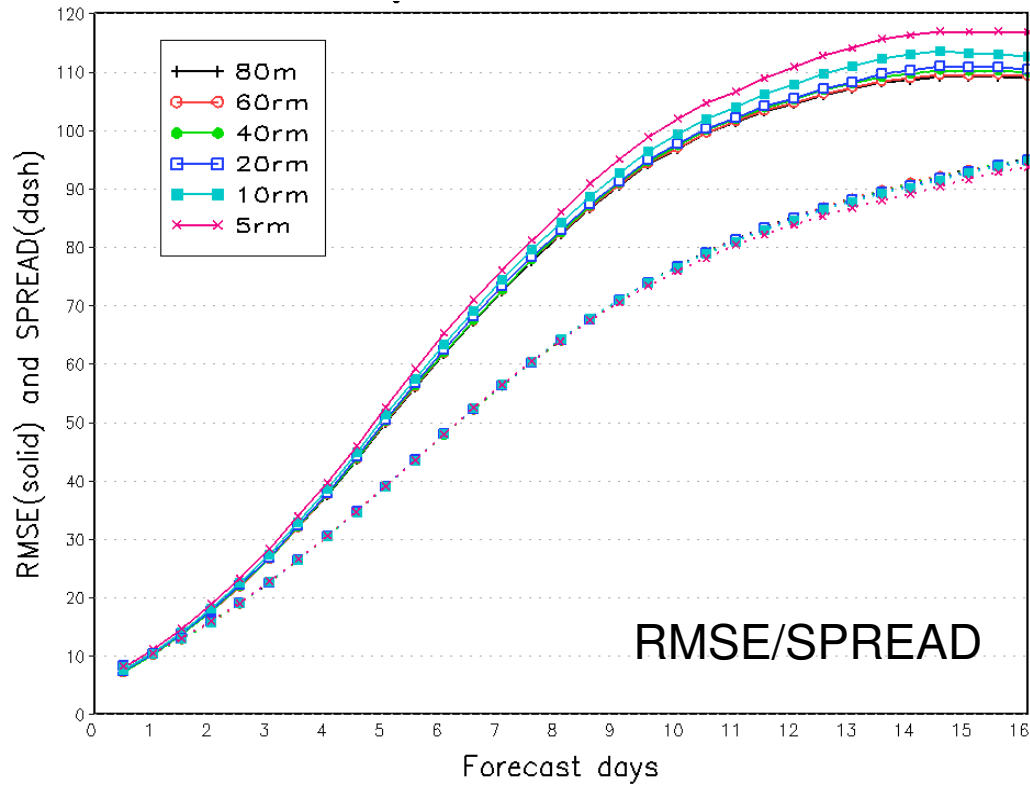➡️ The relative impact of increasing **model resolution** and increasing **ensemble size** with **NCEP GEFS** model

- **Model:** The current operational GEFS bases on GFS v8.0 model at resolution T126L28.

- **Forecast length:** 384 forecast hours from 00UTC

- **Initial uncertainty:** ETR

- **Ensemble sizes:** 80, 60, 40, 20, 10 and 5

- From December 1st, 2009 to January 31st, 2010
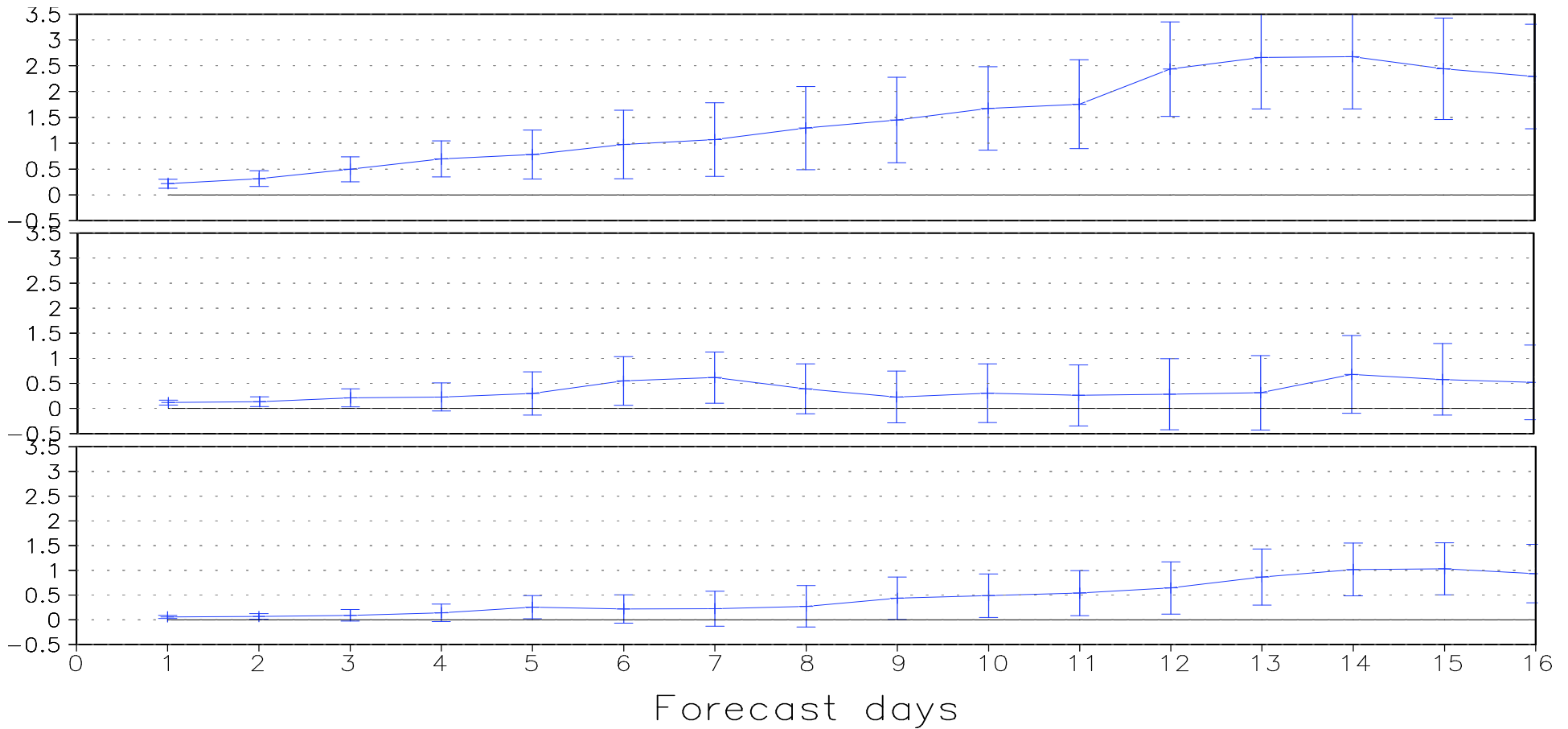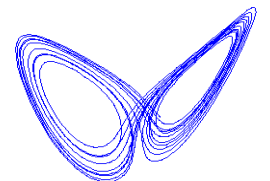
NH z500

RMSE

FIG. The differences of RMSE between 10-20, 20-40 and 40-80 ensemble members respectively. The Blue bars around the difference (blue line) are 95% confidence intervals.
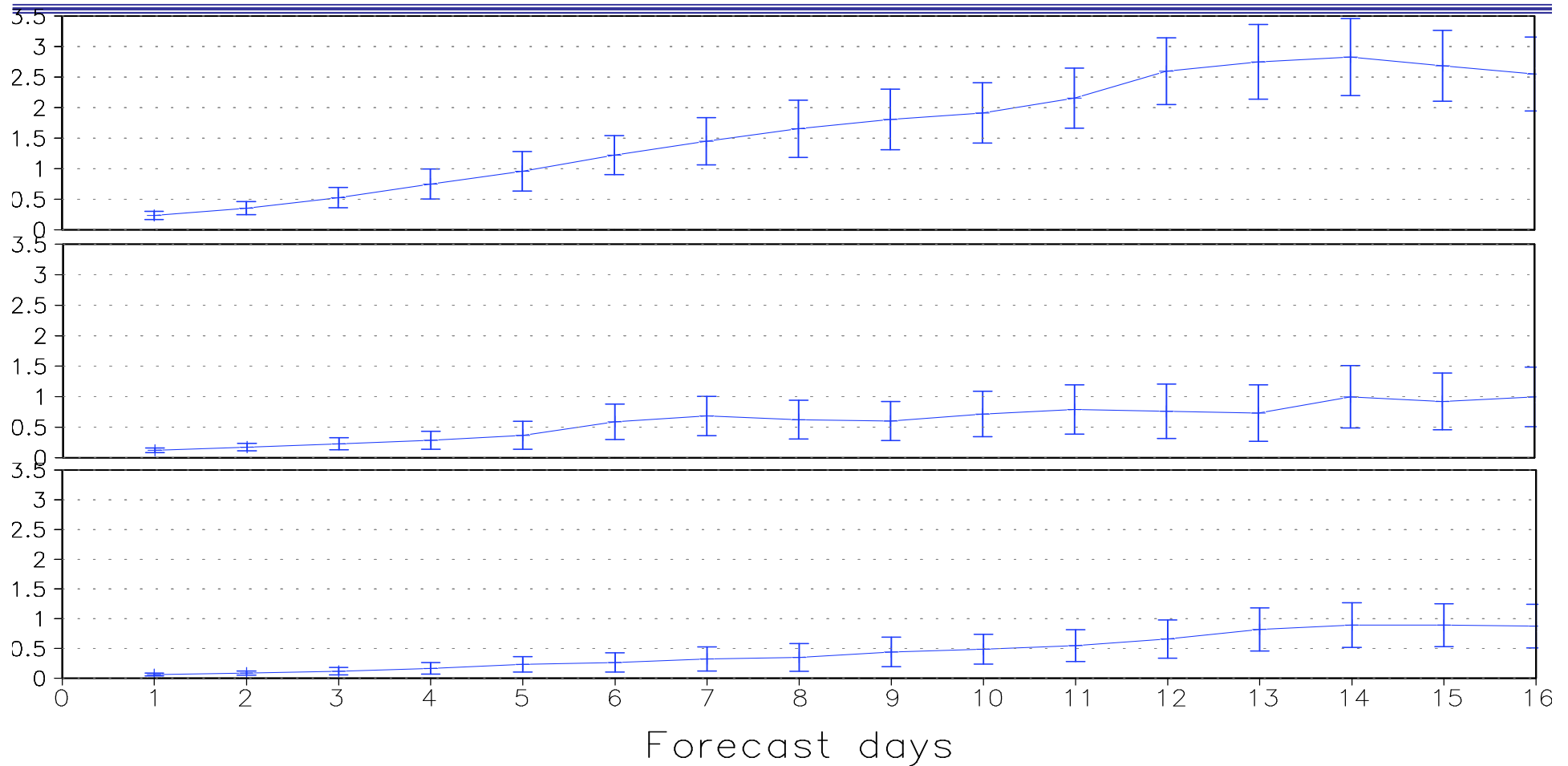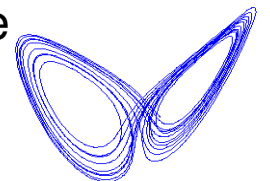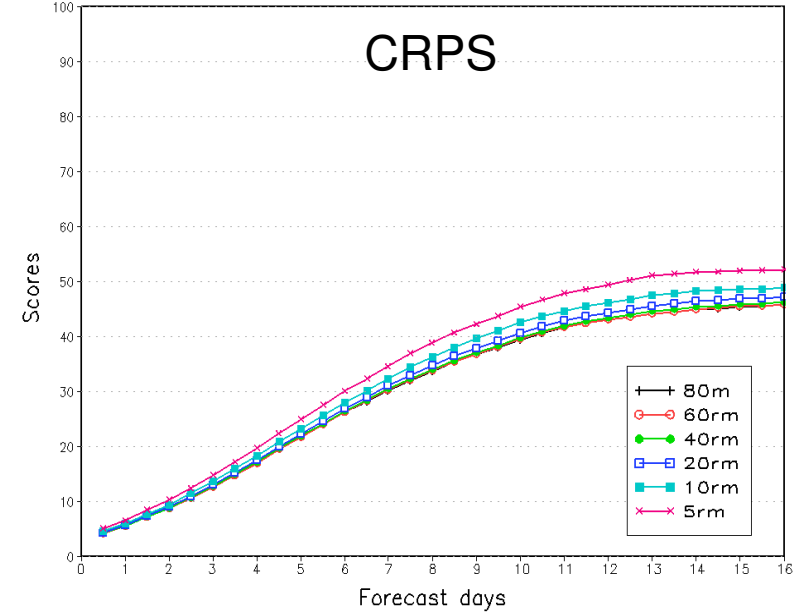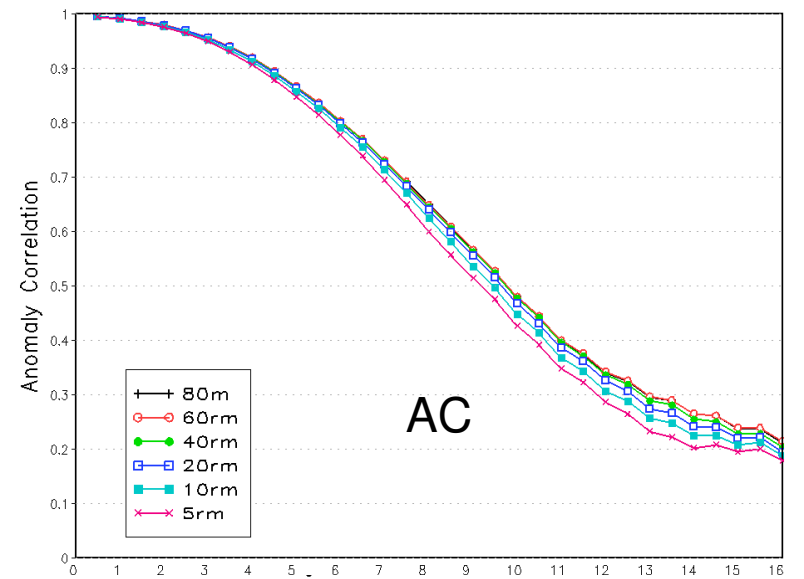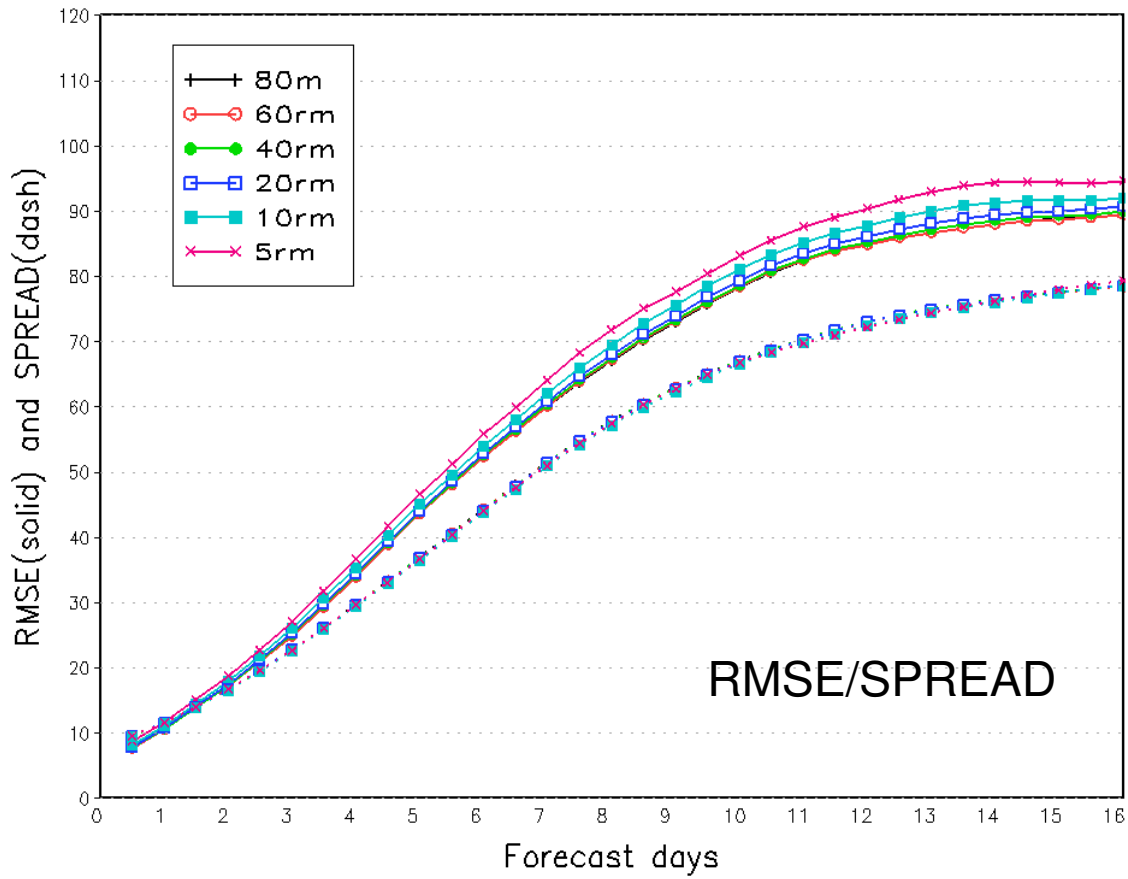
CRPS

FIG. The differences of CRPS between 10-20, 20-40 and 40-80 ensemble members respectively. The Blue bars around the difference (blue line) are 95% confidence intervals.
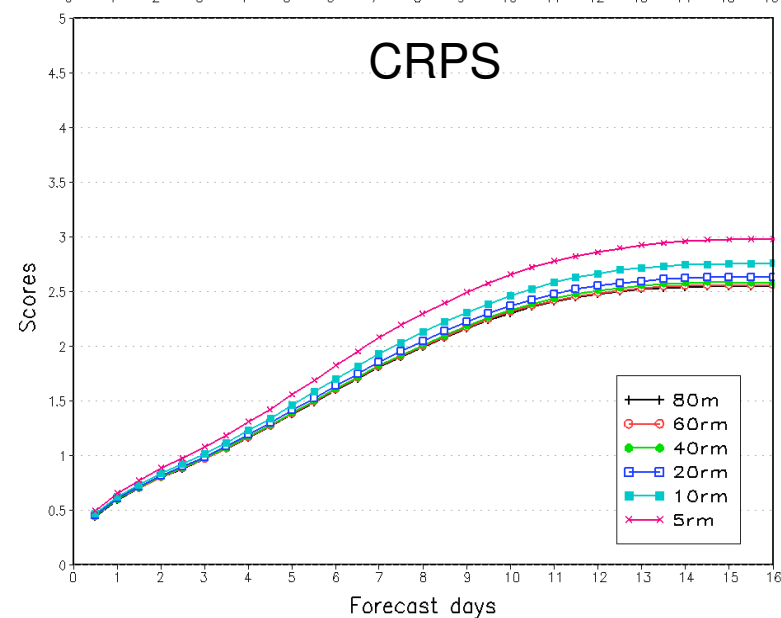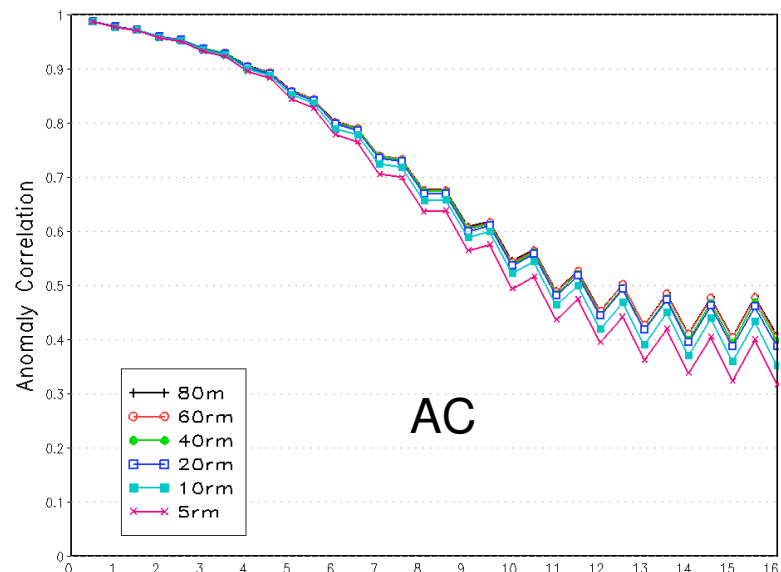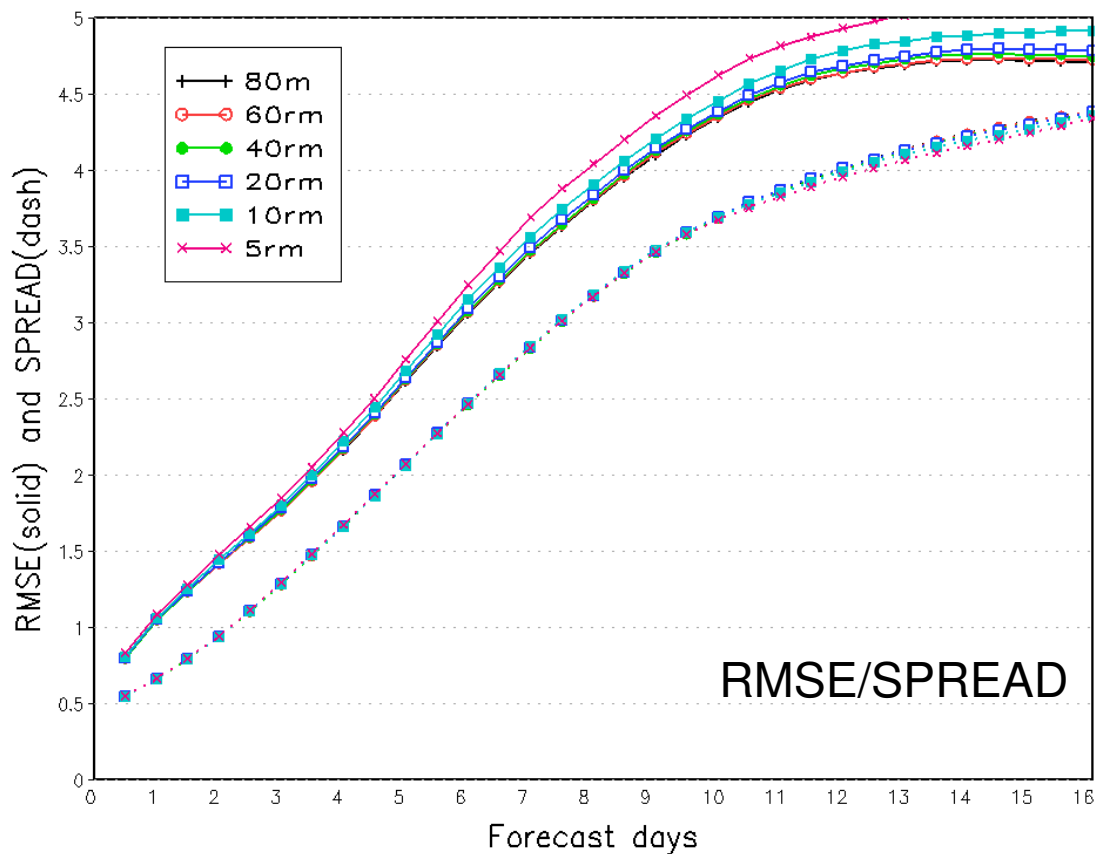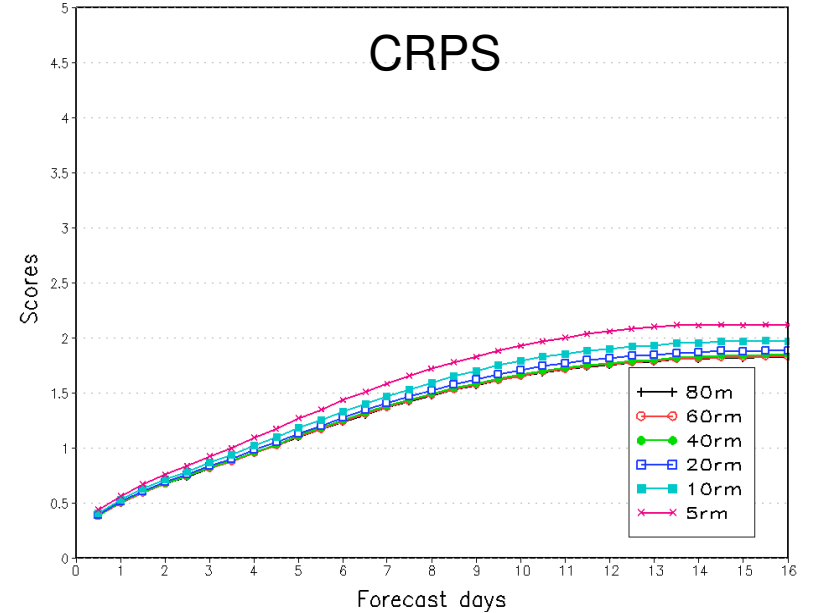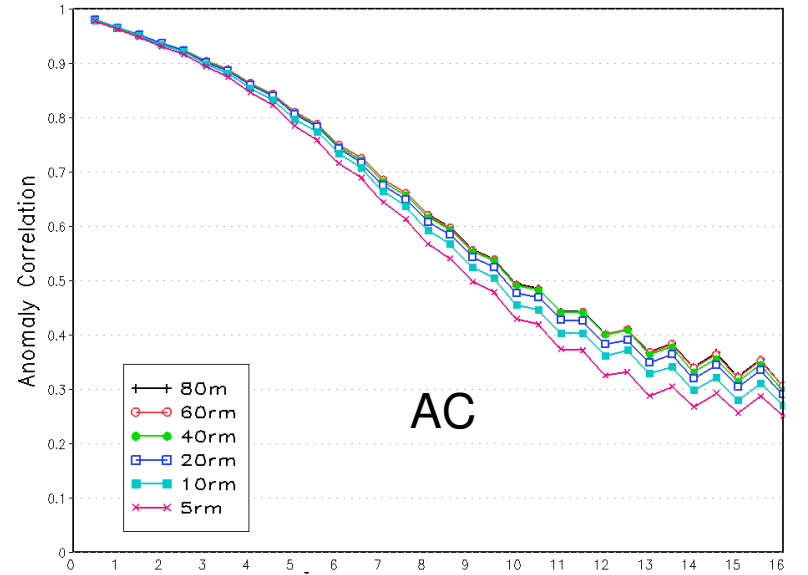
SH z500

NH t850

SH t850

Outline and Summary

➡️ **Impact of ensemble size on ensemble skill with Lorenz 96 model**

- RMS error of 40 members can almost represent 99% of 200 members, but 10 members only represent less than 96%.

- ETR scheme outperforms Monte Carlo method for all lead time, especially around 4-7d.

➡️ **Impact of ensemble size on ensemble skill with NCEP GEFS model**

- The performance of ensemble forecast is affected by ensemble size, especially from 10-member increasing to 20-member.

➡️ **The relative impact of increasing model resolution and increasing ensemble size with NCEP GEFS model**

T126L28 with 80 members

VS

T190L28 with 20 members

They have equivalent computational costs,
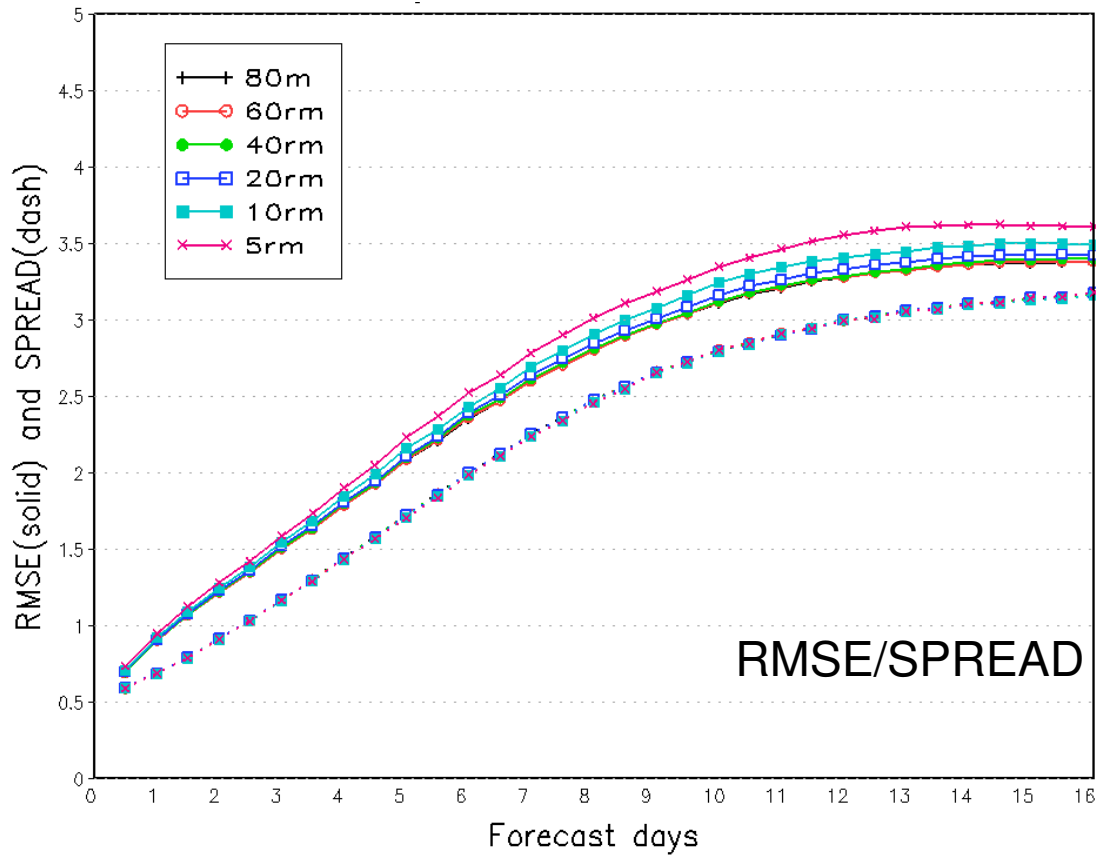so it's necessary to compare their relative benefits.

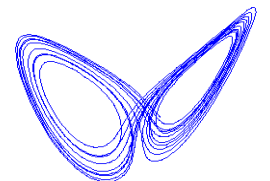# NH z500

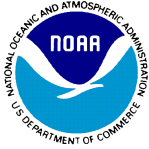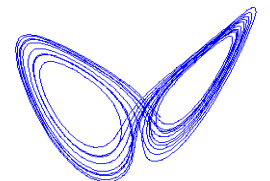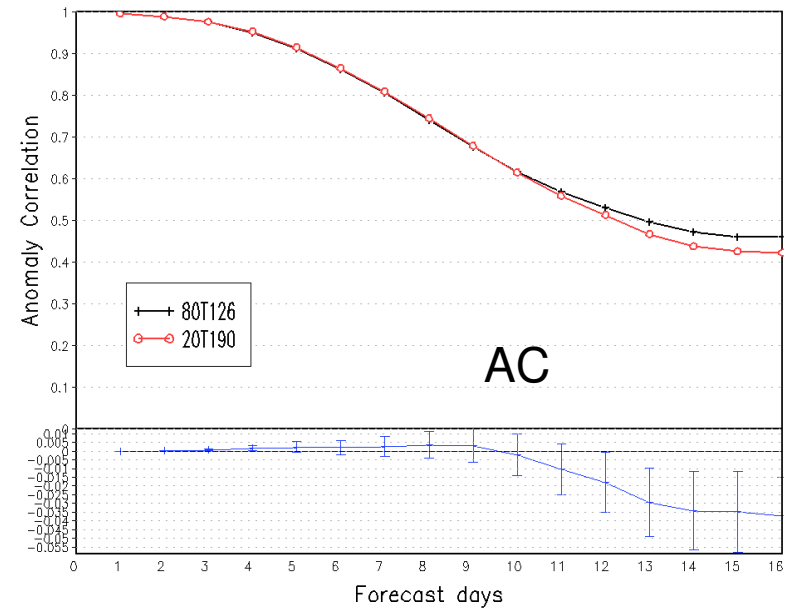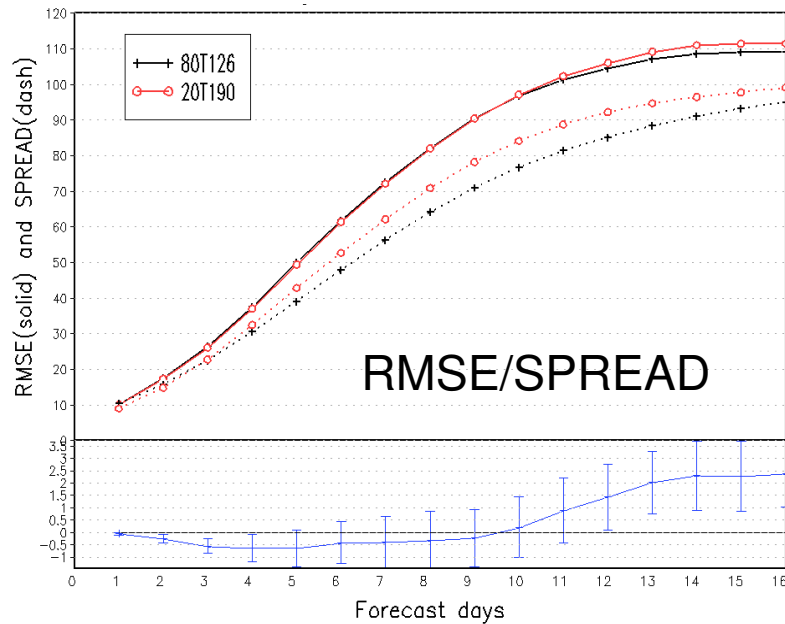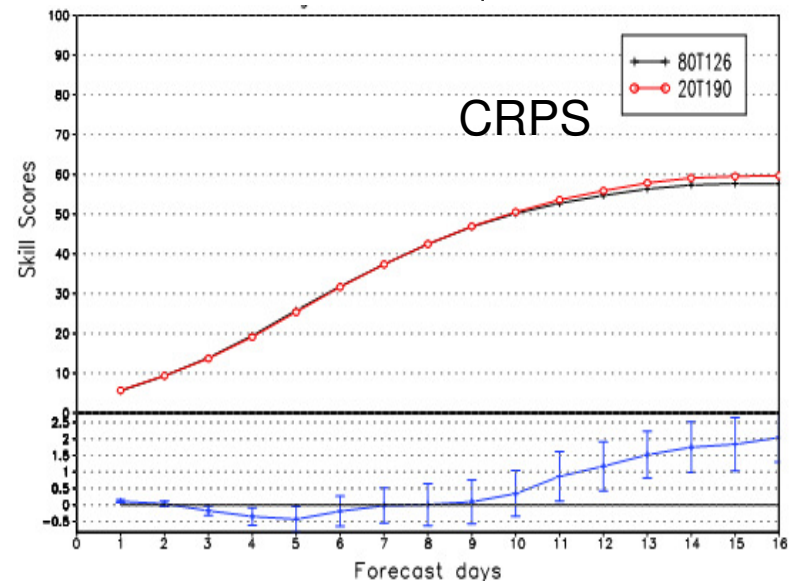# Outline and Summary

➡️ Impact of ensemble size on ensemble skill with Lorenz 96 model

- RMS error of 40 members can almost represent 99% of 200 members, but 10 members only represent less than 96%.
- ETR scheme outperforms Monte Carlo method for all lead time, especially around 4-7d.

➡️ Impact of ensemble size on ensemble skill with NCEP GEFS model

- The performance of ensemble forecast is affected by ensemble size, especially from 10-member increasing to 20-member.

➡️ The relative impact of increasing model resolution and increasing ensemble size with NCEP GEFS model

- Increasing model resolution is more (less) beneficial than increasing ensemble size for short (long) lead times.
- More ensemble members will benefit the extend forecast.