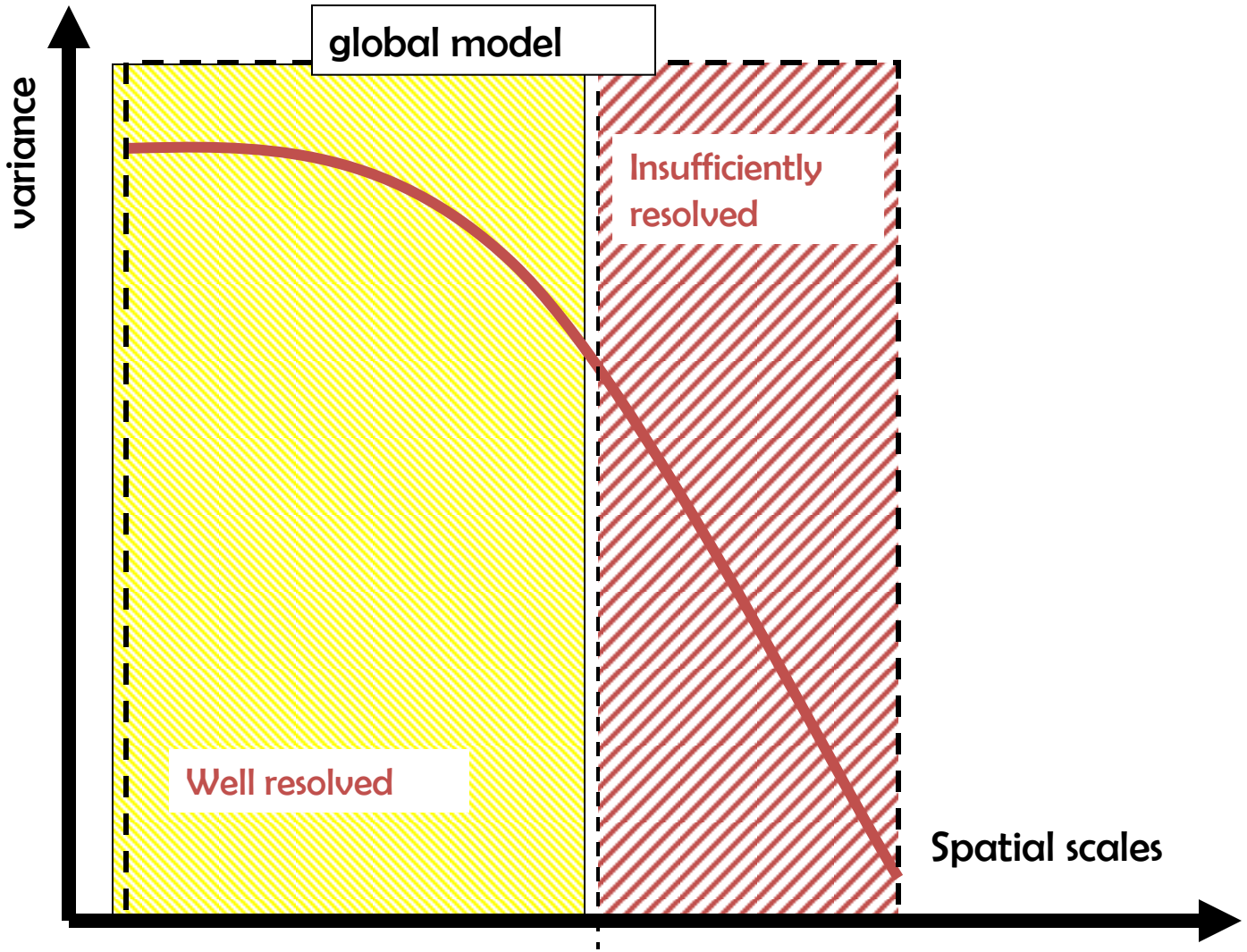
Predictability of RCM

Spectral Nudging for Dynamical Downscaling Studies

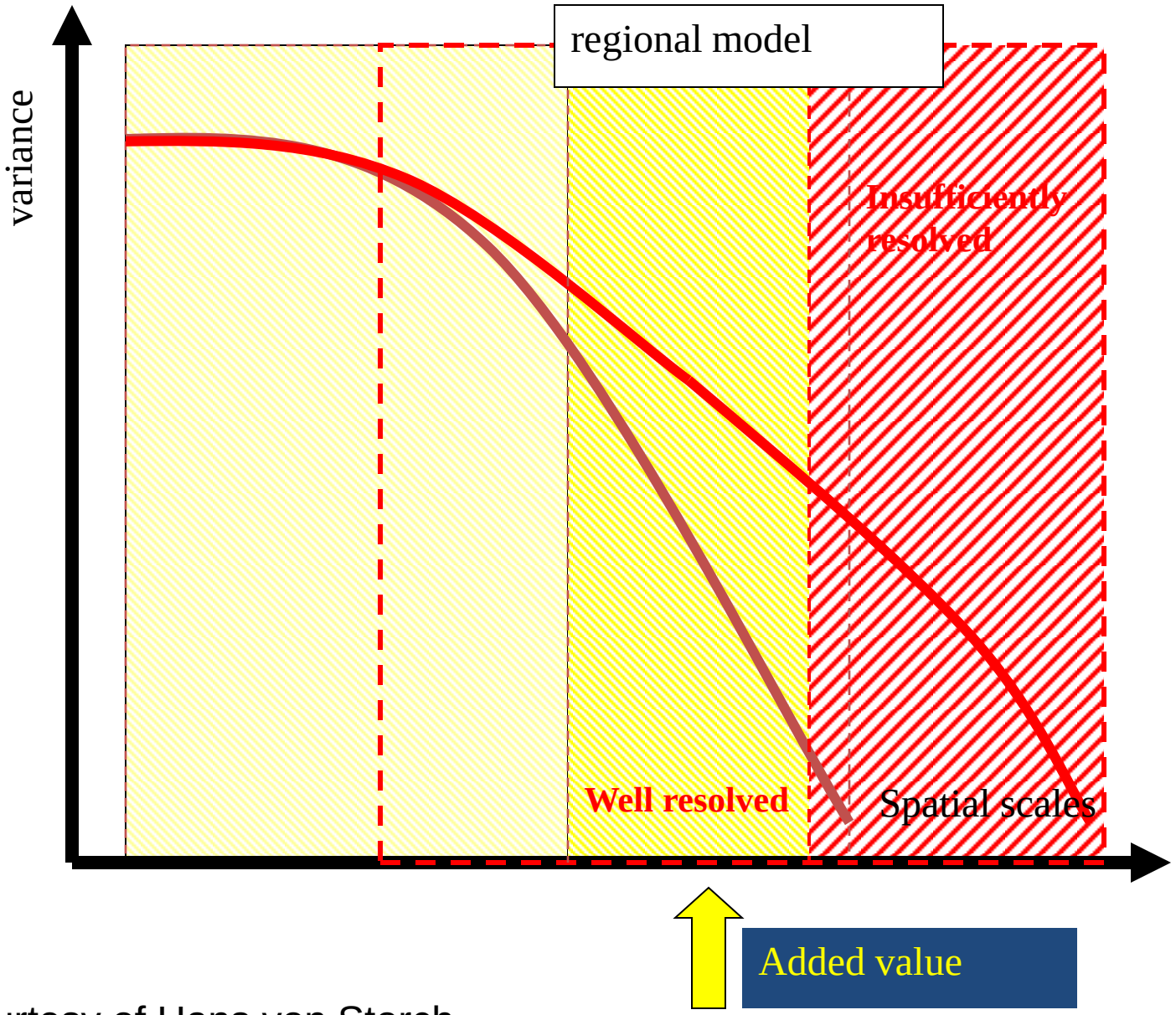
Kei Yoshimura

AORI, Univ. Tokyo

Concept of Dynamical Downscaling



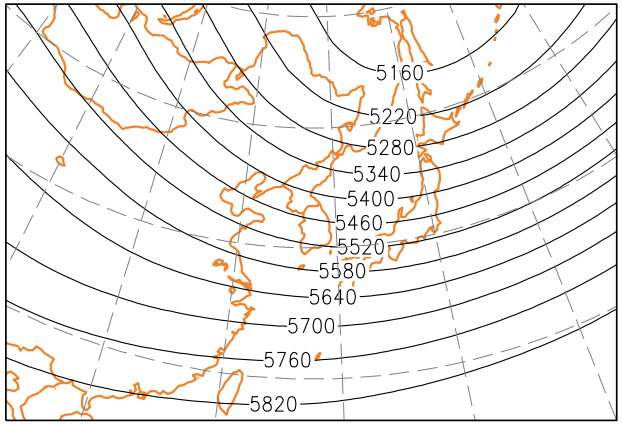
Courtesy of Hans von Storch



Courtesy of Hans von Storch

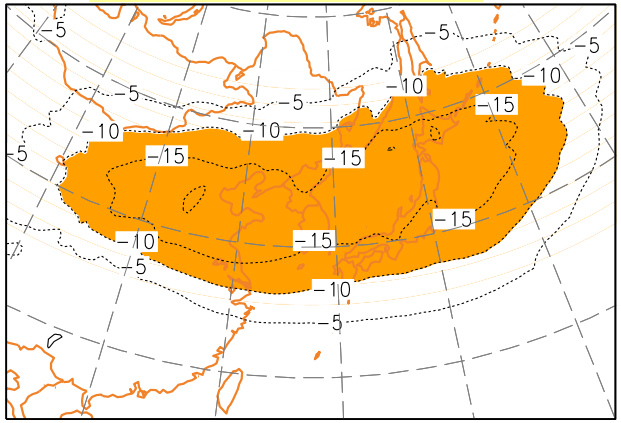
Advantages of Spectral Nudging
1. Smaller large scale bias

R2



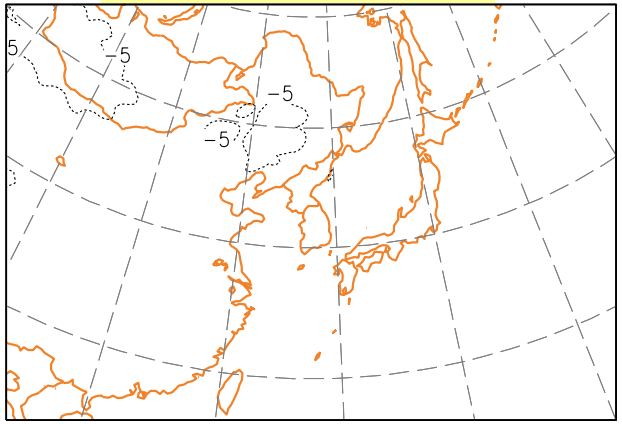
DJF 25-year 500-hPa height climatology and error (m)

NOSSBC-R2



conventional lateral boundary nudging

NEWSSBC-R2



spectral nudging

Kanamitsu et al, 2010

Advantages of Spectral Nudging
2. No dependency on domain size

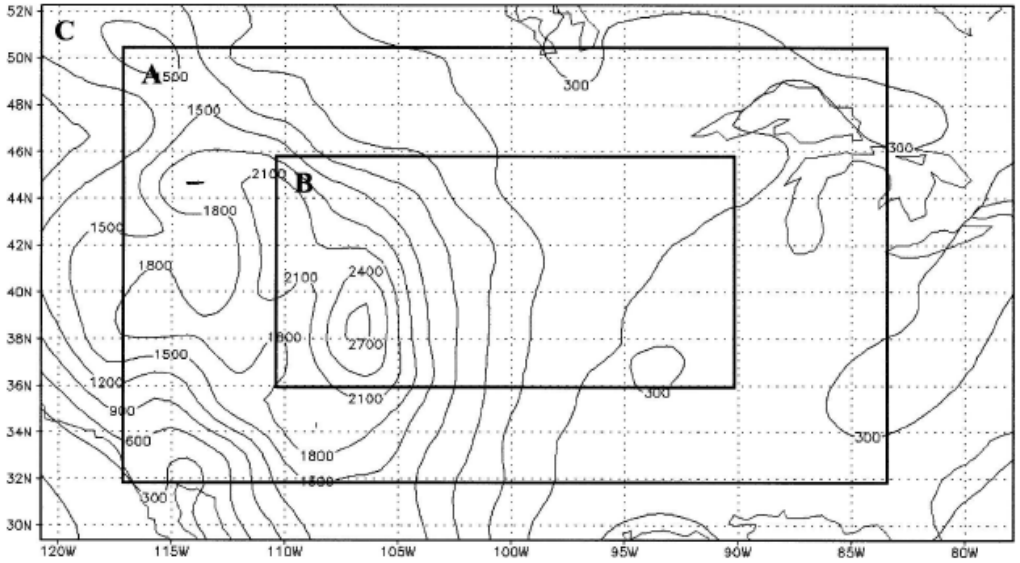


FIG. 3. Three domain sizes for the domain size sensitivity experiment (Fig. 4 and Table 2): (a) 48 × 35 grids, 2880 km × 2100 km; (b) 24 × 17 grids, 1440 km × 1020 km; and (c) 60 × 43 grids, 3600 km × 2580 km.

TABLE 2. RMSD of 500-hPa height (m) between the regional model and the reanalysis field in winter of 2000/01 calculated for the common area (domain B). The model was run for the different domain sizes shown in Fig. 3.

	A	B	C
Control	5.9	15.1	7.6
SSBC	2.9	2.4	2.5

LB Nudging

Spectral Nudging

Kanamaru and Kanamitsu, 2007

Ideal Role of Spectral Nudging

- Faithfully reproduces spatial detail by;
  - Assuming large scale constrain as truth, and
  - Ignoring influence from the small scale to the large scale (if exists).

→From this stand point, Type 3&4 downscaling with SN provides a result which would have been given if the GCM was in high resolution.

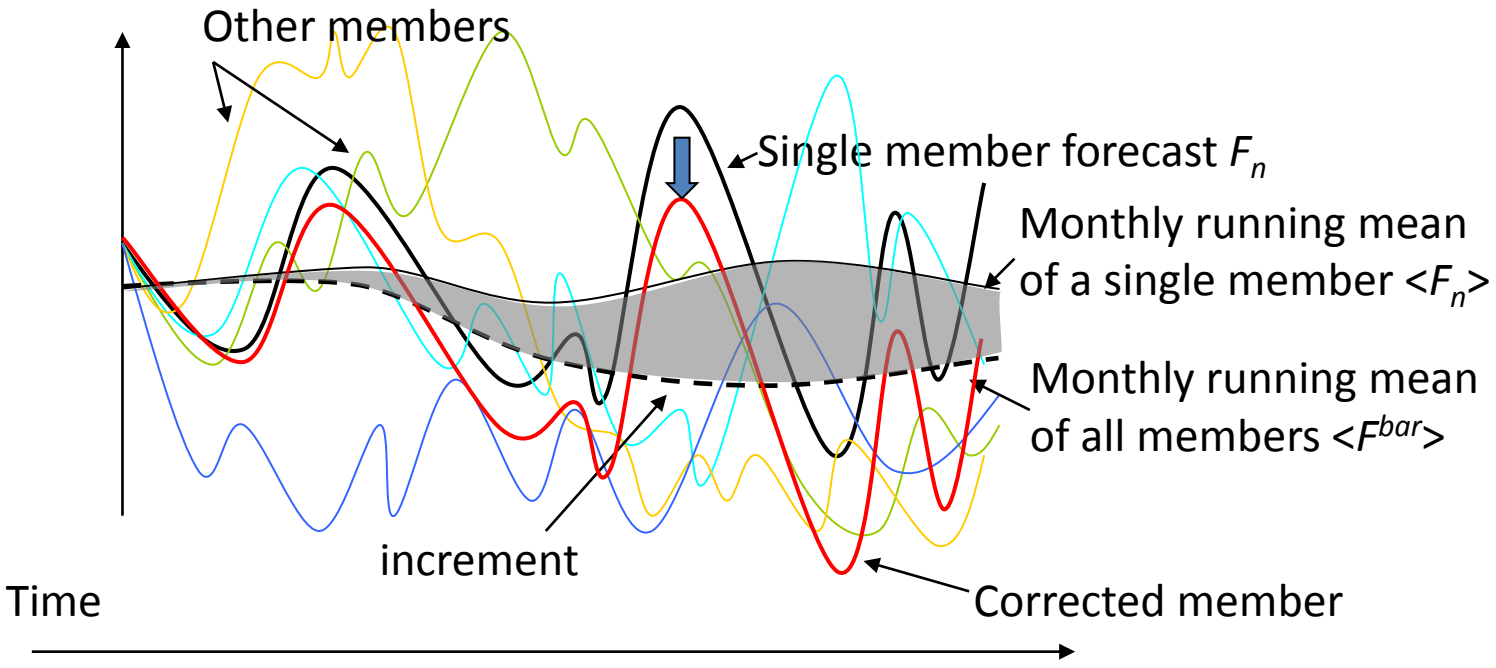
→SN should be regarded as a “diagnostic tool.”

What else can we do for Type 3&4 DS?

- Making Ensemble Mean field (EM) usable as large scale forcing for SN might give a better predictability because EM is generally better than a single member field.
- Downscaling of each ensemble member and creating ensemble mean regional field are straightforward, but very costly.

$$F_n^{new} = F_n + \left\langle \overline{F} \right\rangle - \left\langle F_n \right\rangle$$

- where F is full field of physical variable, n is an ensemble member, bar indicates ensemble mean, and <> indicates running mean (e.g. one-month).
- The downscaling will be performed using F_n^{new} as a lateral boundary forcing.



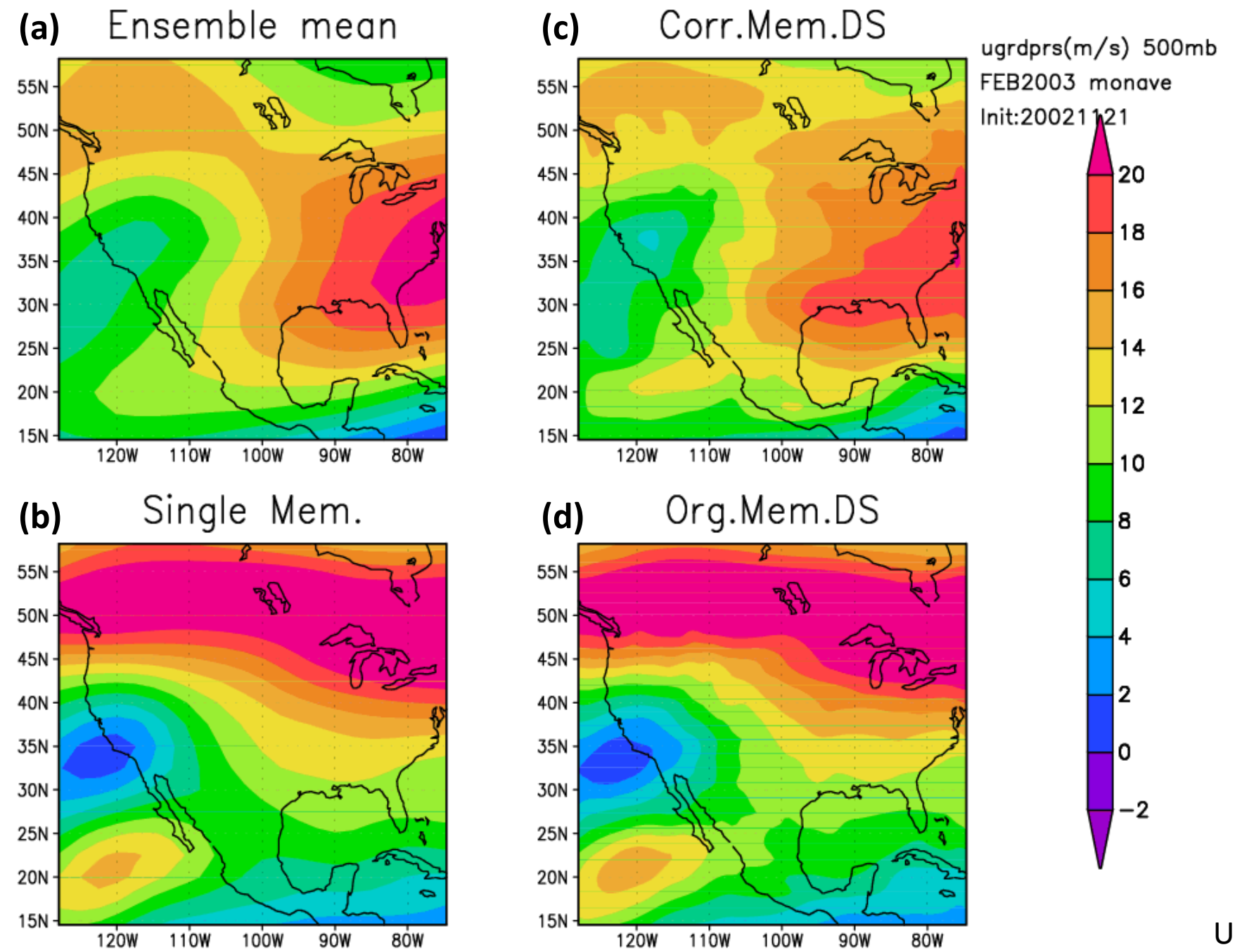
Type 3 DS Experiment
(also applicable to Type 4)

- 5-member Ensemble global forecast
- Initials: 2002/11/21 0Z, 11/22 0Z ~ 11/25 0Z
- CTL-DS:
  - DS for 3-month forecast with original base
- COR-DS:
  - DS for 3-month forecast with corrected base

Global data

Downscaled

3rd month



U500

Global data

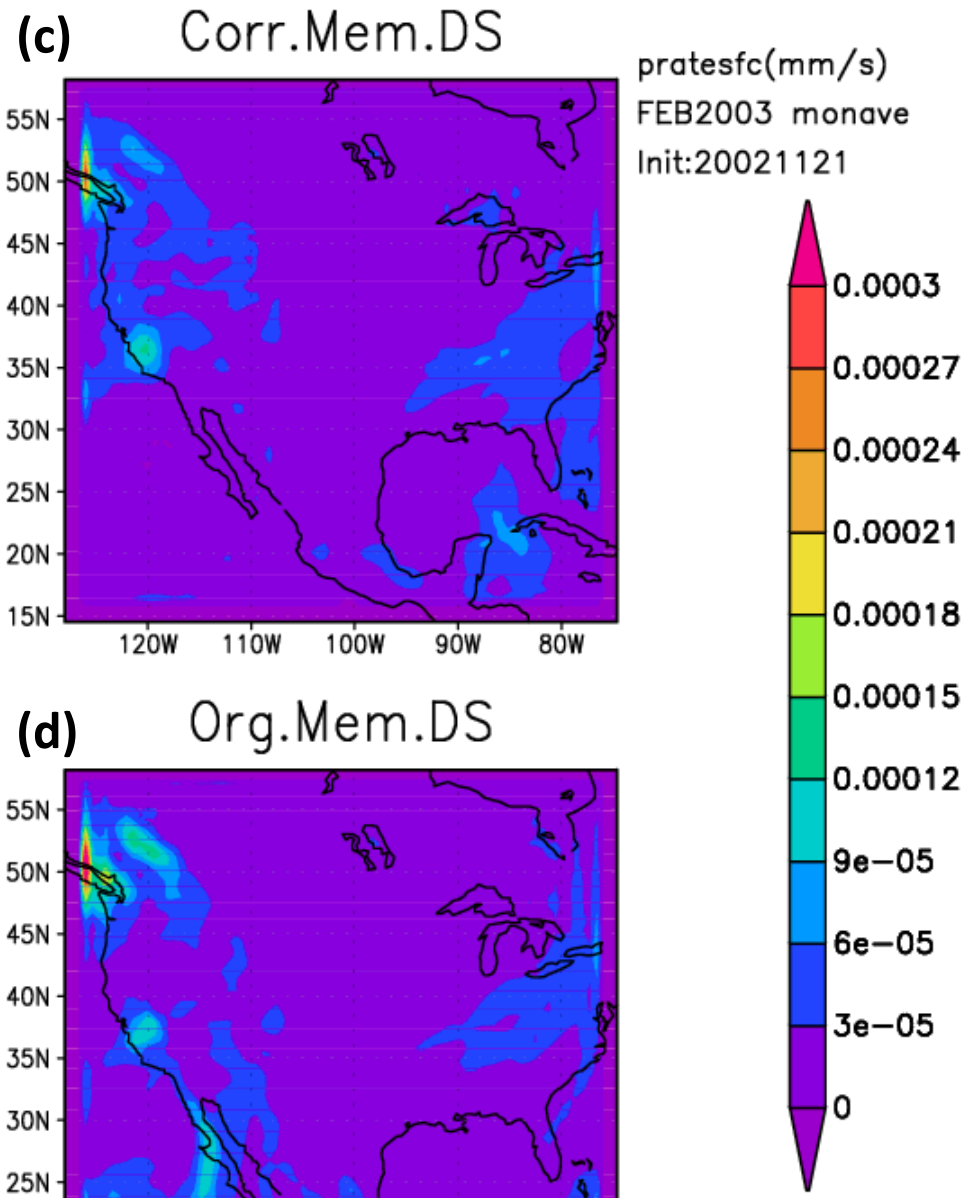
Downscaled

3rd month

(a)

N/A

(c)



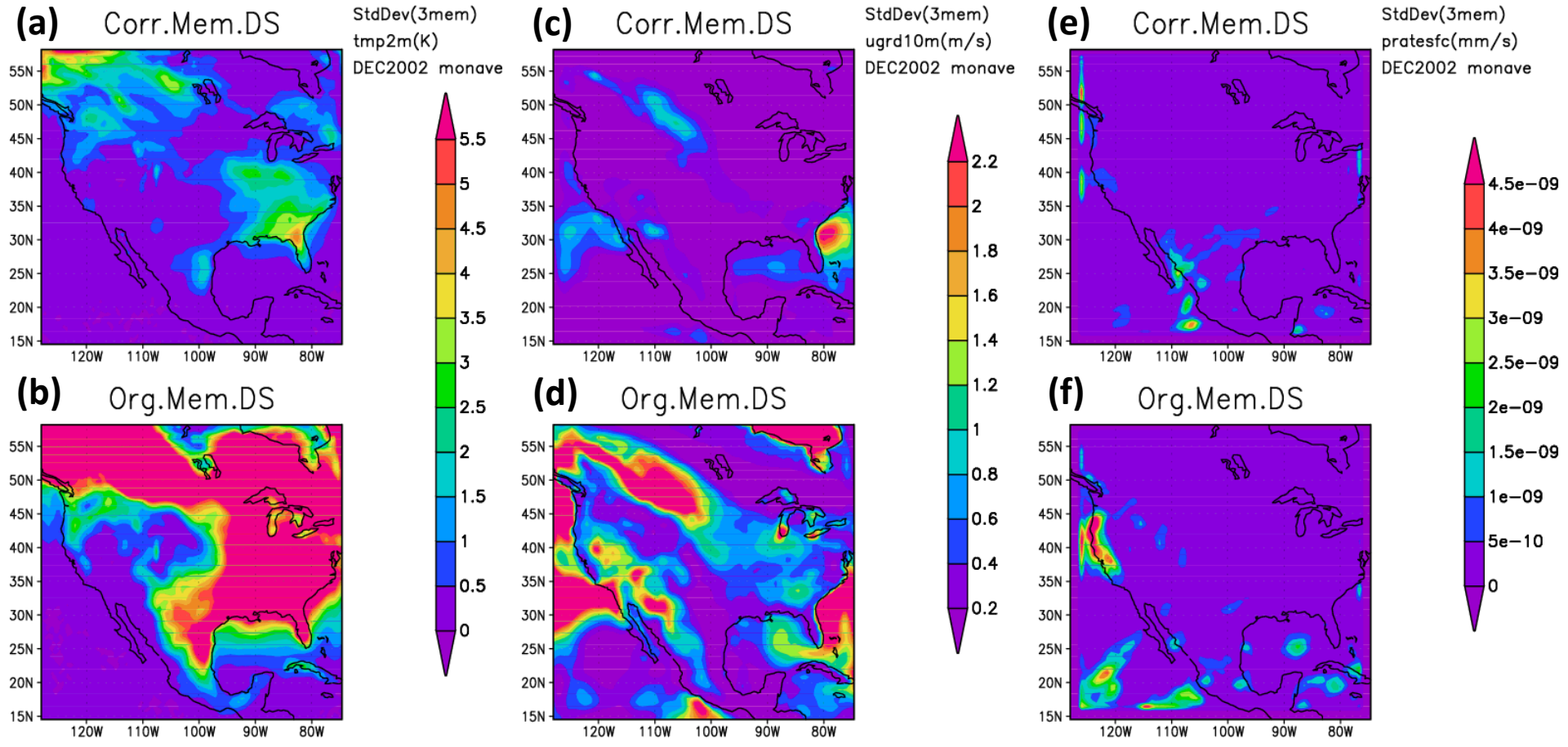
(b)

N/A

(d)

Precip

Standard Deviation between ensemble members for T2m, U10m & P



Summary of my talk

- Use of spectral nudging (SN) improves general skill of dynamical downscaling for Type 1 and Type 2 comparing to lateral boundary nudging.
- SN never improves the predictability skill of RCM from its concept. Therefore, SN does not help for Type 3 and Type 4.
- Downscaling of ensemble mean may provide better predictability skill than simple Type 3 & 4 DS. Developing an efficient way of doing so would be useful and challenging.

Open Questions

- What is physical justification of spectral nudging specification?
- What should we do for decrease of internal variability of RCM when using SN?
- Is the downscaling of ensemble mean field valid? What else can we do?
  - What is behind dynamics of making ensemble mean field?
  - How should we downscale variables that are controlled by high frequency variability (transient components), like precipitation?