The 10,240-member ensemble Kalman filtering with an intermediate AGCM without localization

Keiichi KONDO and Takemasa MIYOSHI

RIKEN AICS
Data Assimilation Research Team

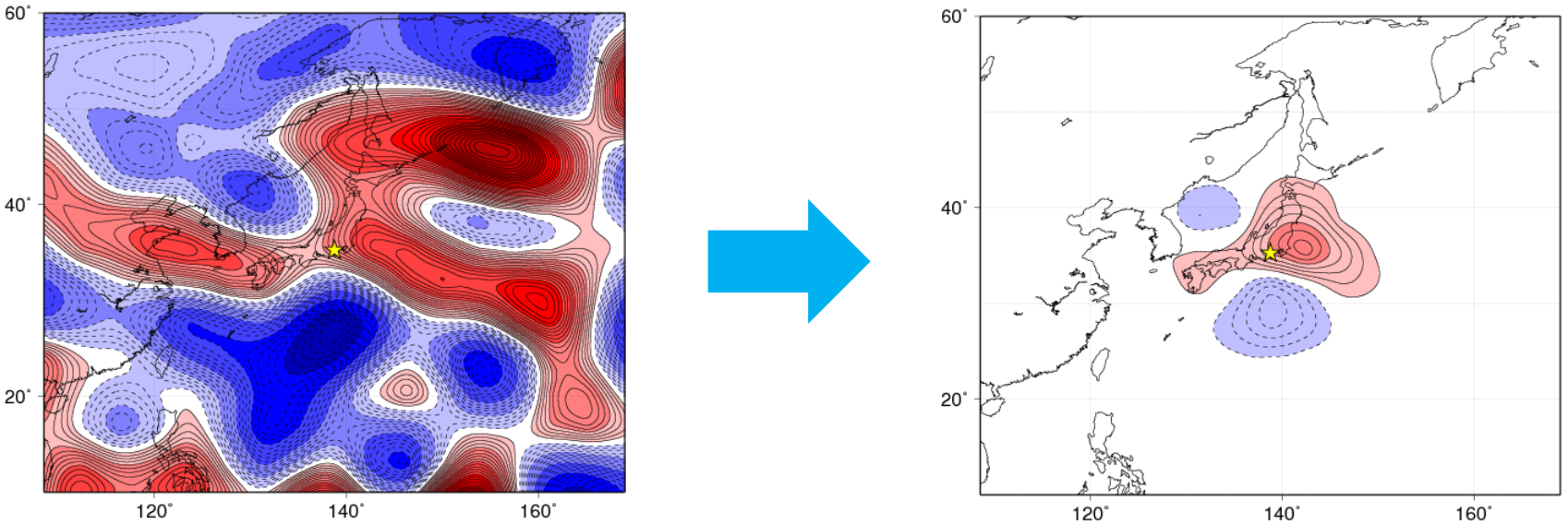
Introduction

- Dual localization method
- Impact of a large ensemble

Introduction

- Spurious sampling error may be problematic.
  - Localization plays an essential role.

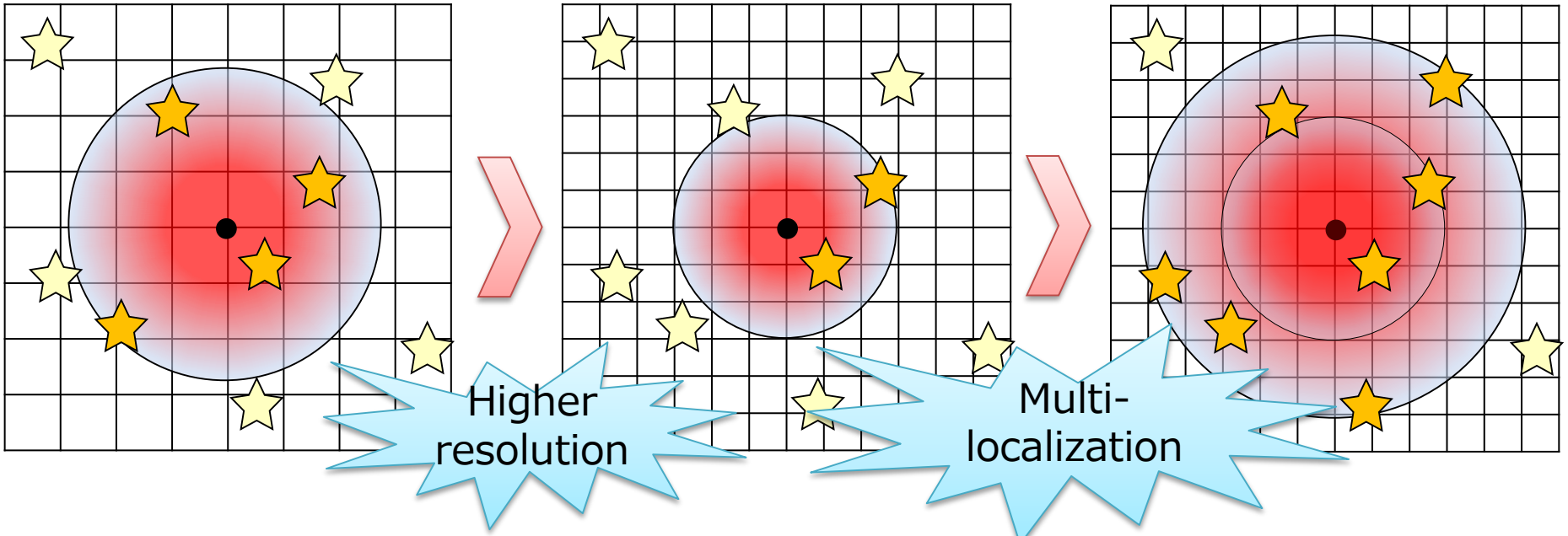
No localization | **Localized**



Analysis increments from a single profile observation (20 members)

Introduction

- Model resolution and localization



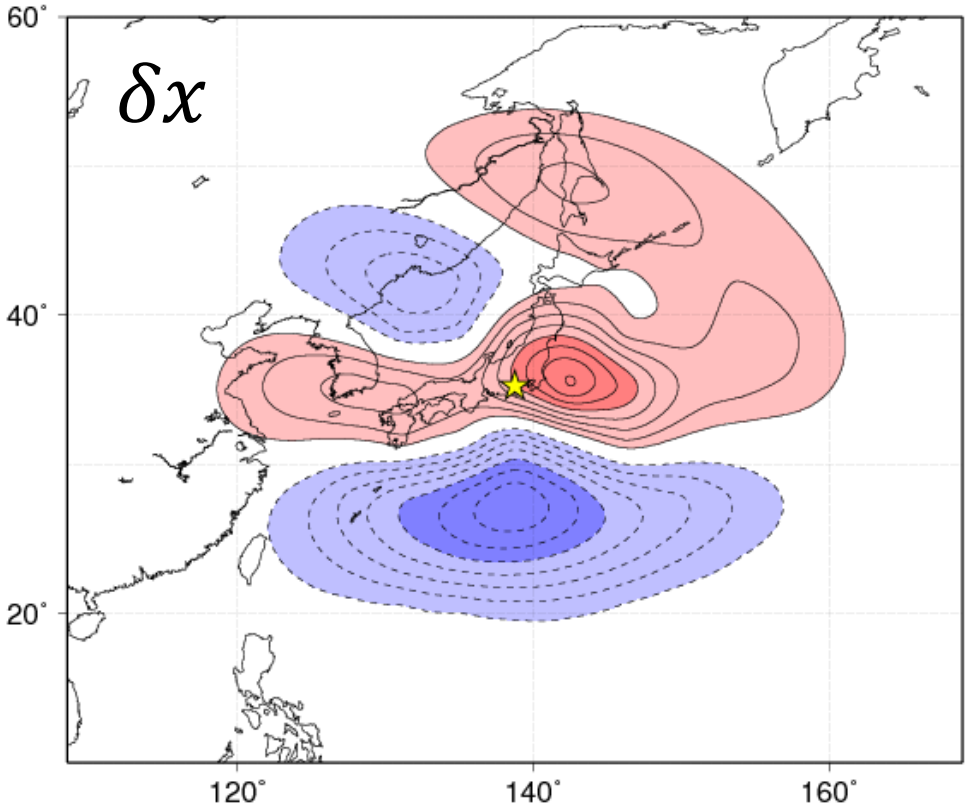
- Higher resolution models require narrower localization which limits the influence of observations.

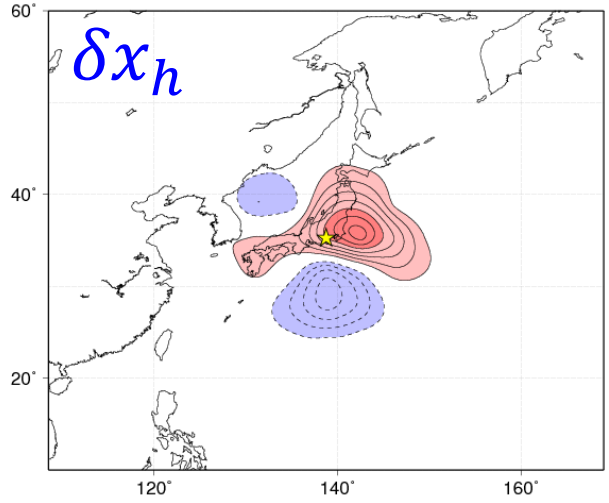
- Miyoshi and Kondo (2013) and Kondo et al. (2013) proposed “multi-scale localization method”.

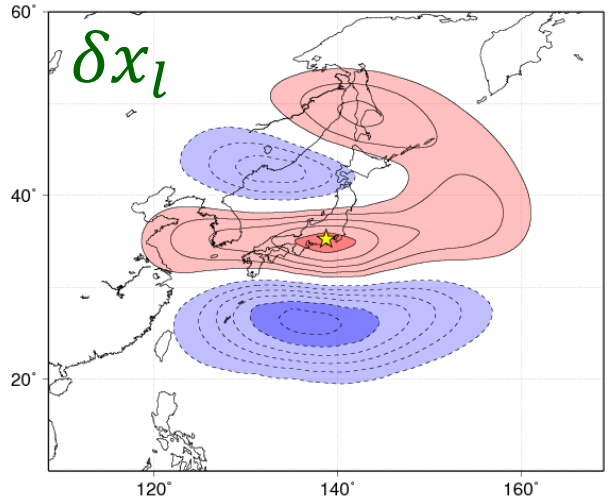
Dual-Localization Method

- We construct analysis increments as a sum of high- and low- resolution components.

$$\delta x = \delta x_h + \delta x_l$$





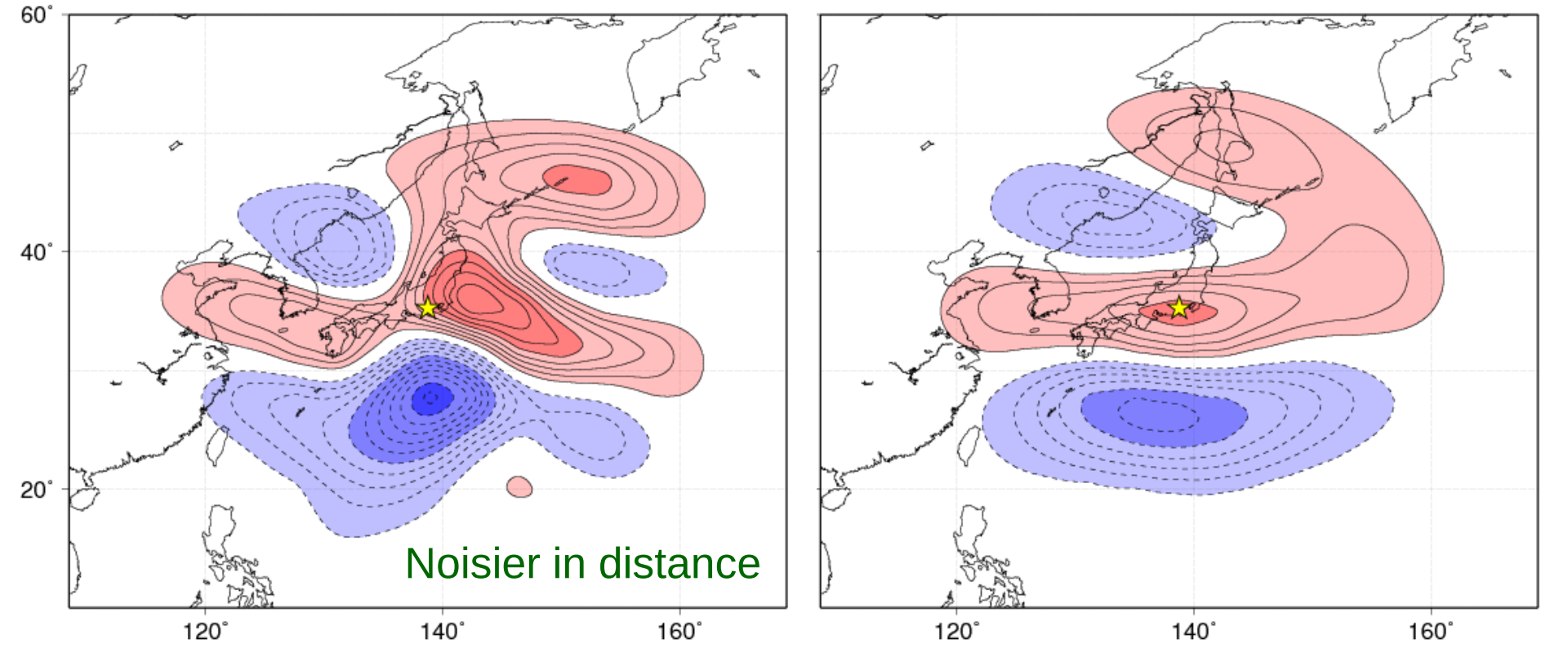


Larger-scale structure

○ Applying a larger scale localization.

Full-resolution analysis increment

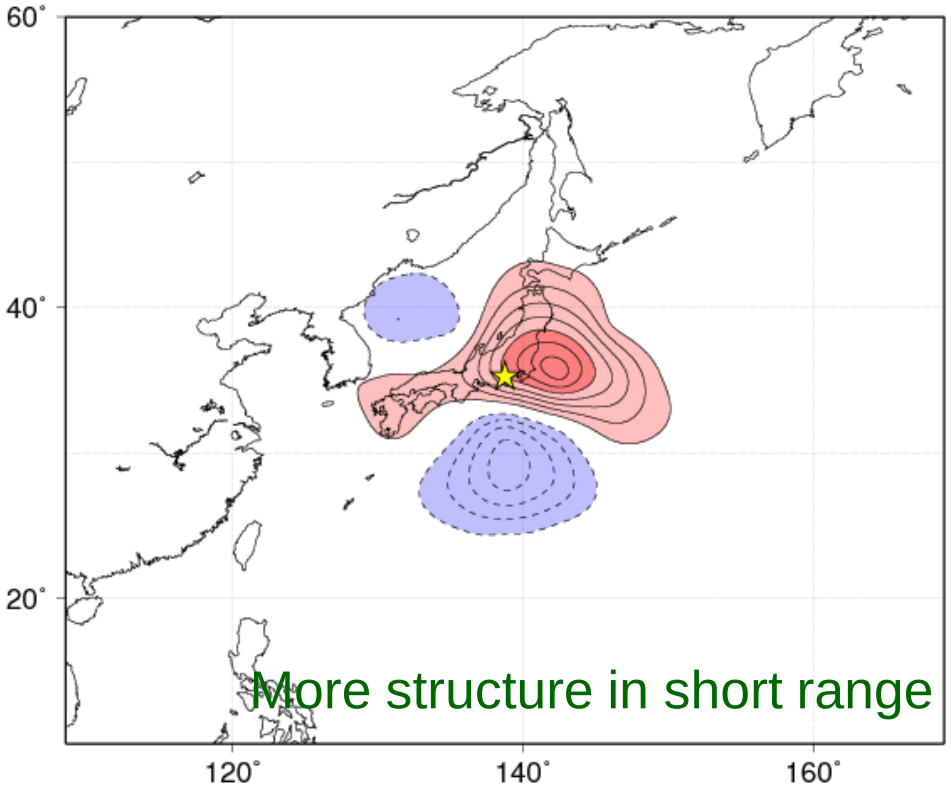
Reduced-resolution analysis increment



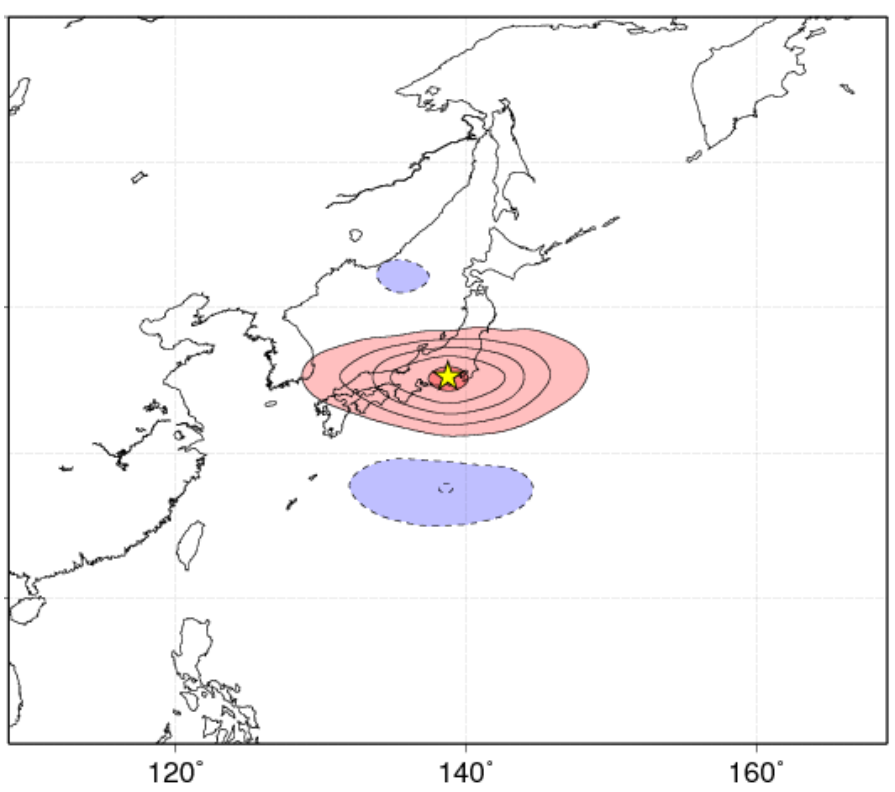
Smaller-scale structure

○ Applying a smaller scale localization.

Full-resolution analysis increment

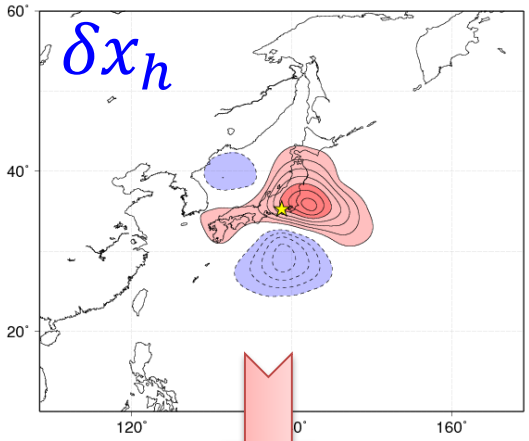


Reduced-resolution analysis increment

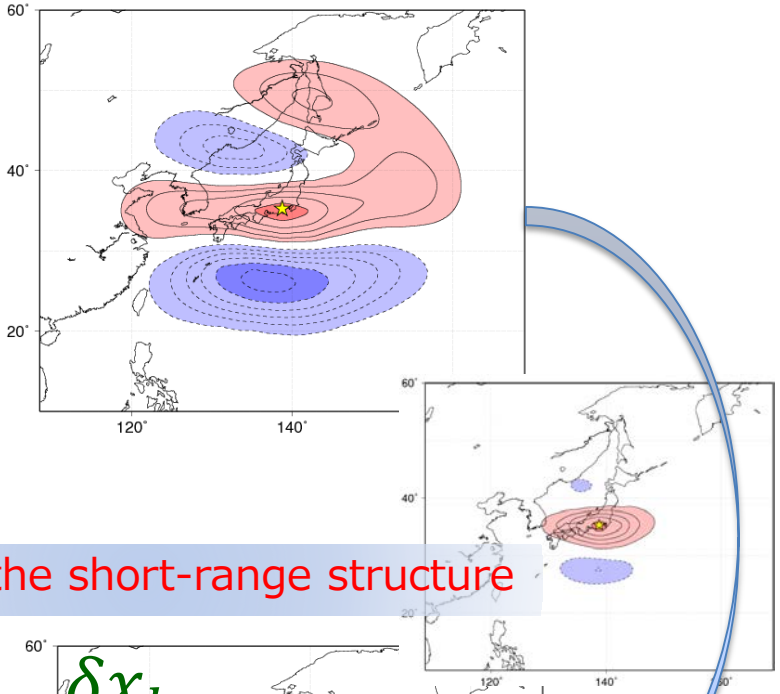


Merging the two scales

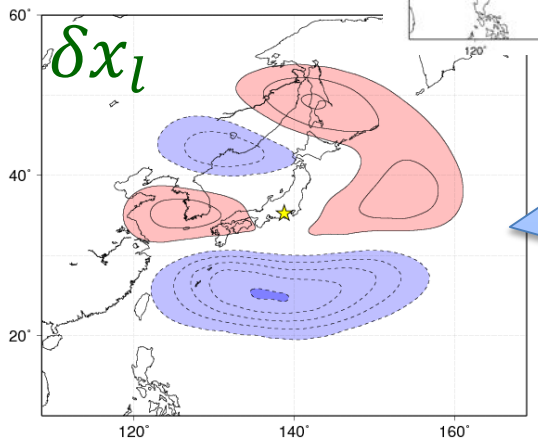
Full-resolution and short-range analysis increment

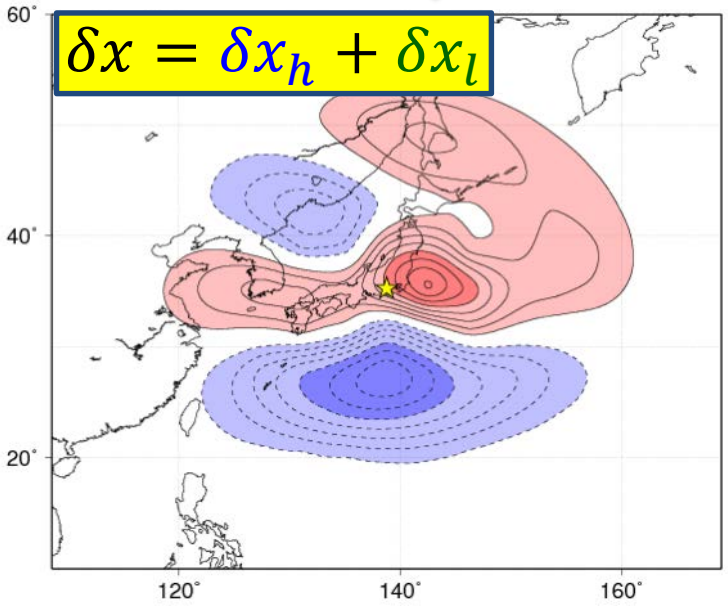


Reduced-resolution and long-range analysis increment

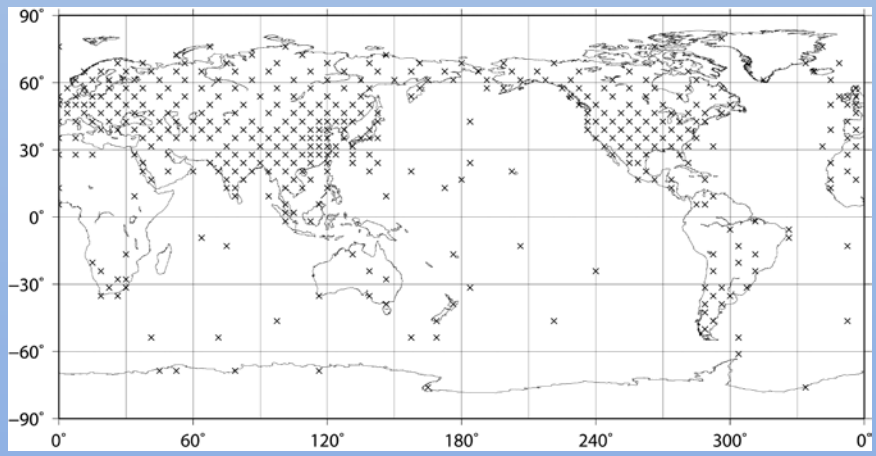


Removing the short-range structure





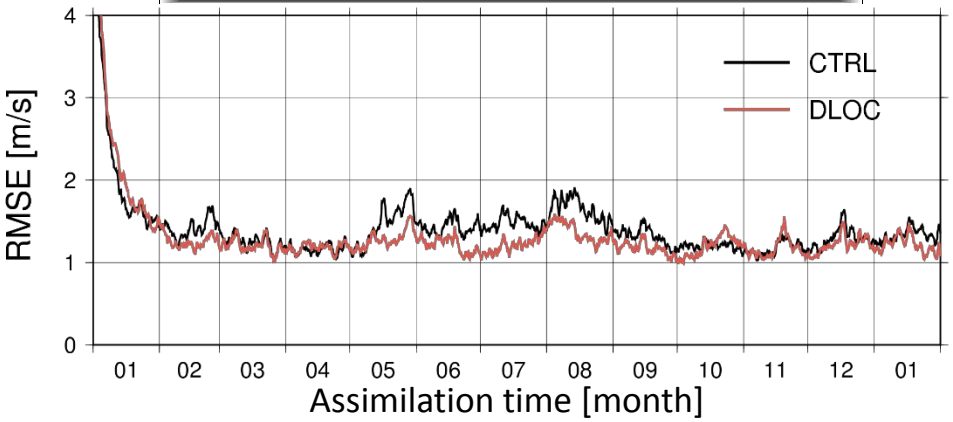
Settings of perfect model experiments

	CTRL (single localization)	**DLOC** (dual localization)
Model	SPEEDY, T30L7 (Molteni 2003)	
Observation network	Radiosonde-like  Observation elements: U, V, T, Q, Ps	
Ensemble size	20	
Localization scale	**700 km**	**600 km** **900 km**

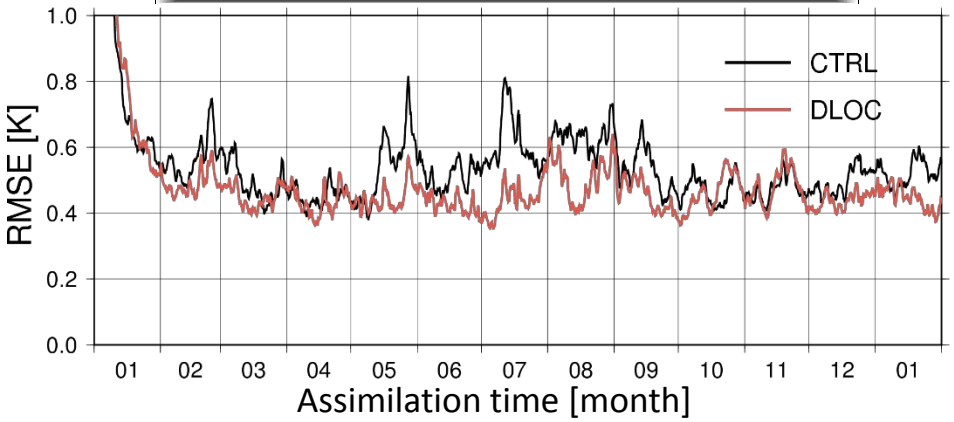
- Experiment period : 01/01/1982 – 02/01/1982
- DLOC: Dual-Localization method with Lanczos filter as a smoothing function.

CTRL vs. DLOC: Analysis RMSE

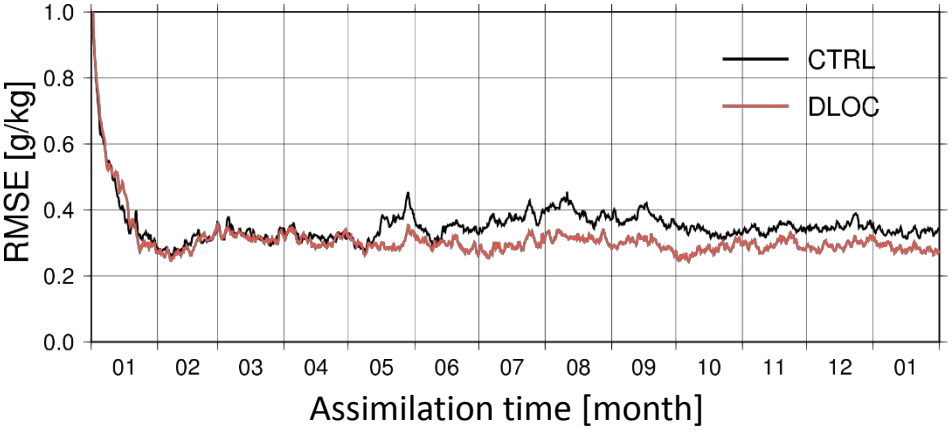
U (4th model level)



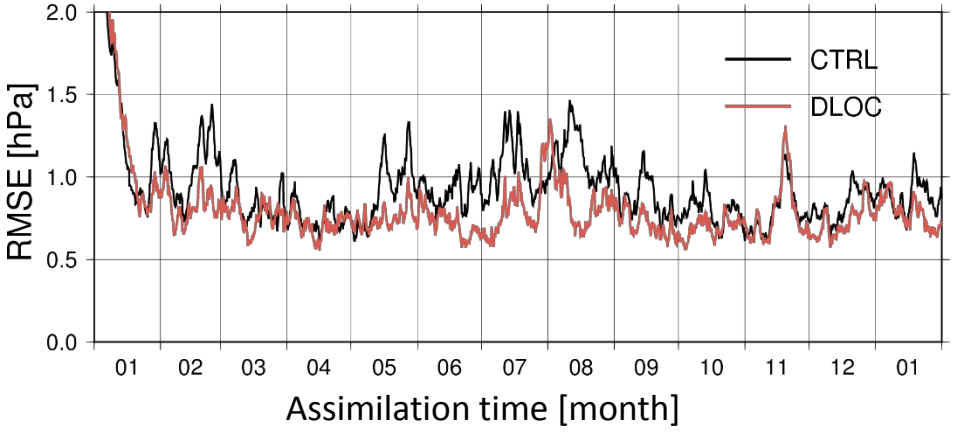
T (2nd model level)



Q (1st model level)

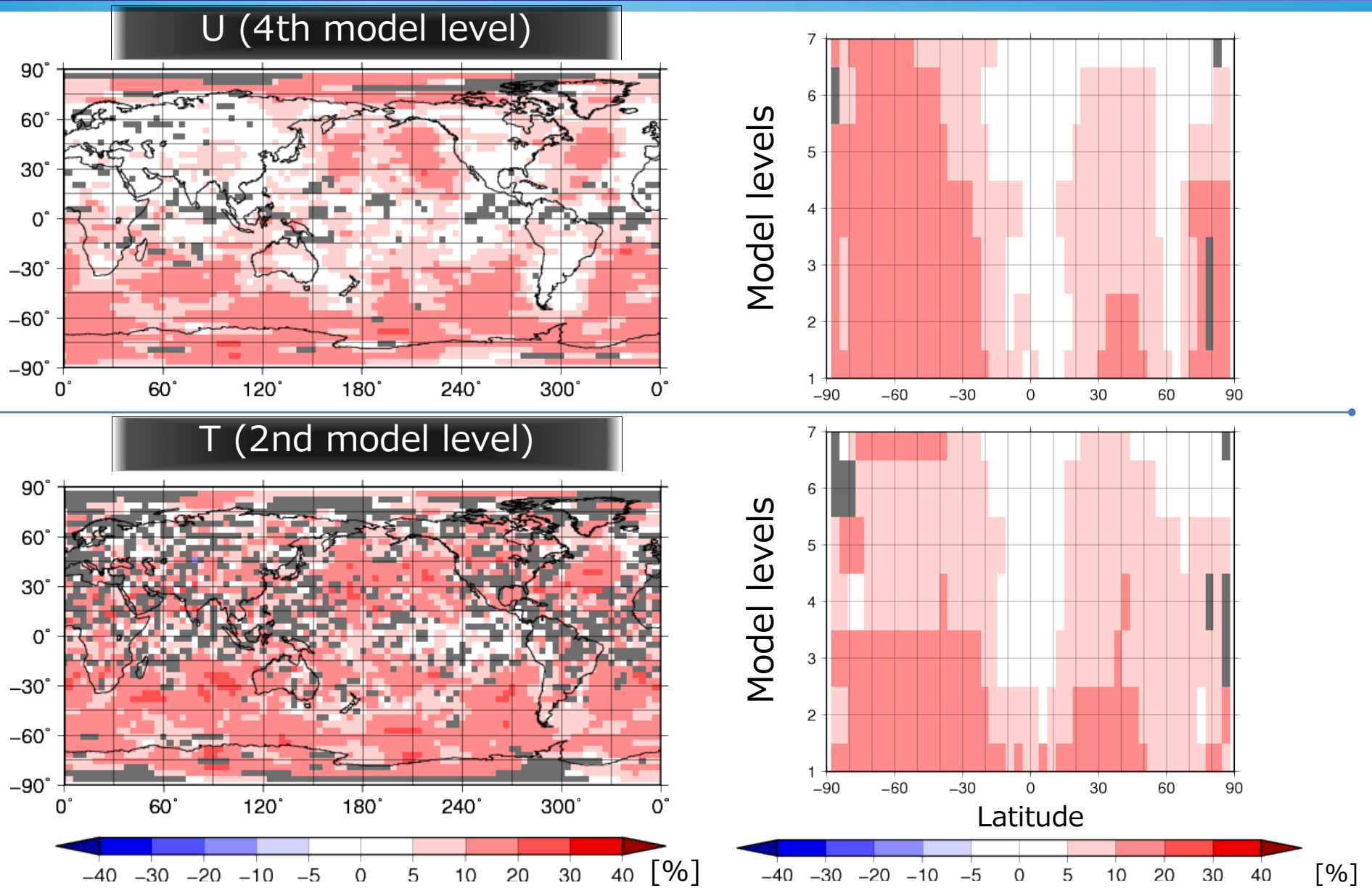


Ps



- General improvements everywhere for all variables.
  - Especially, Q !

Improvements of an annual averaged RMSE

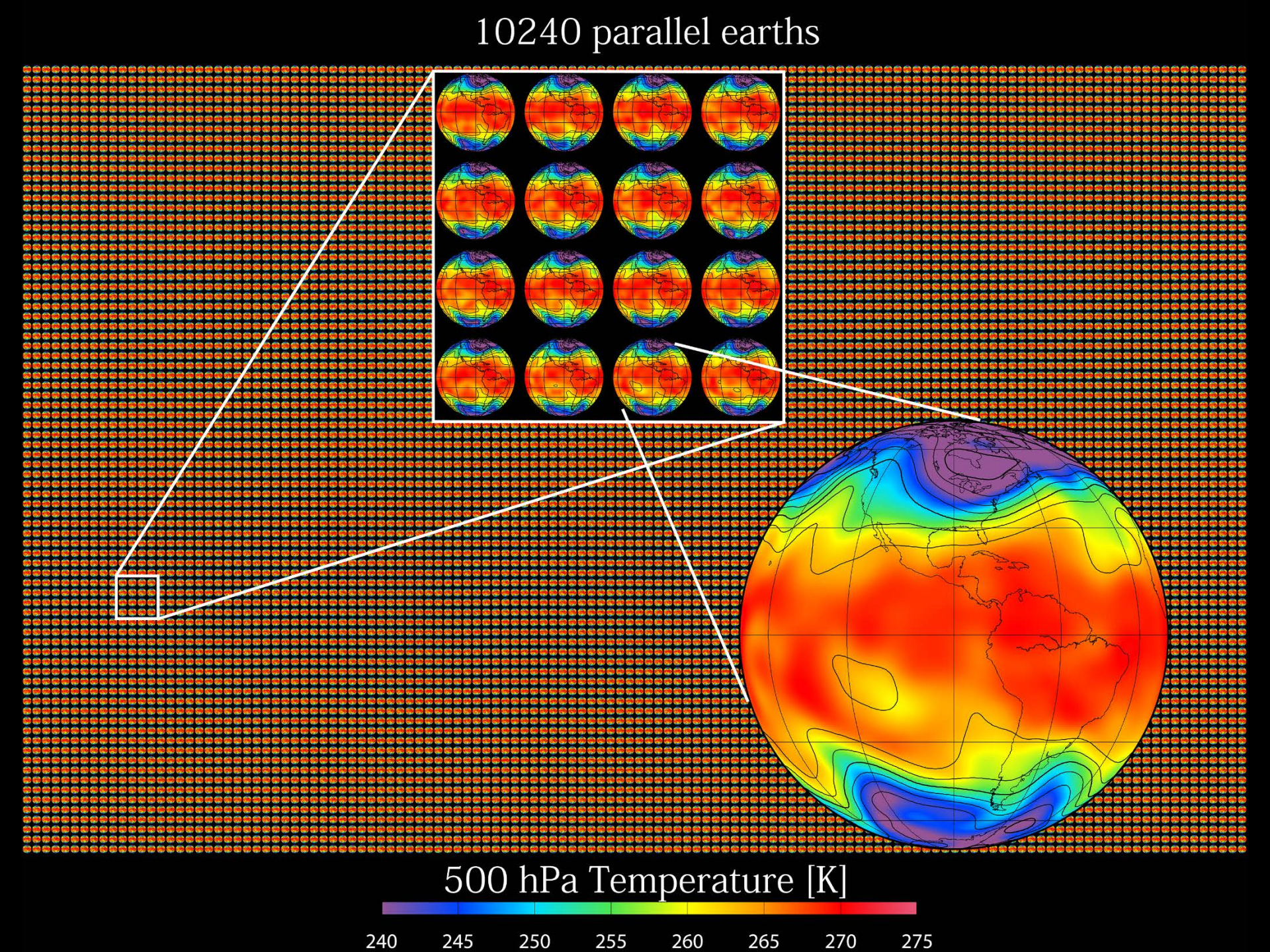


※ Gray : non-significant areas in which any one of the four parallel experiments disagrees.

Summary

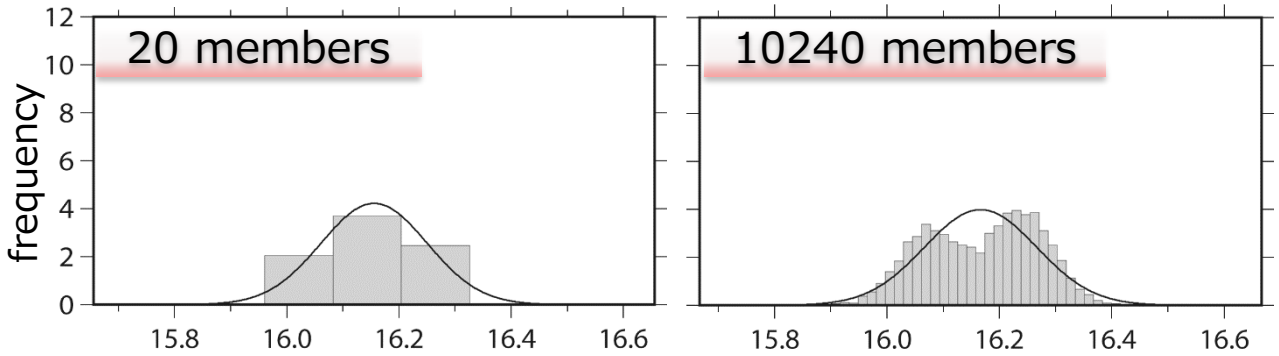
- Dual-localization showed promising results.
  - General improvements everywhere for all variables.
  - But computations of the dual-localization are tripled.

- Triple-localization did not improve analysis in the SPEEDY model (not shown).


10240 parallel earths
500 hPa Temperature [K]
240
245
250
255
260
265
270
275

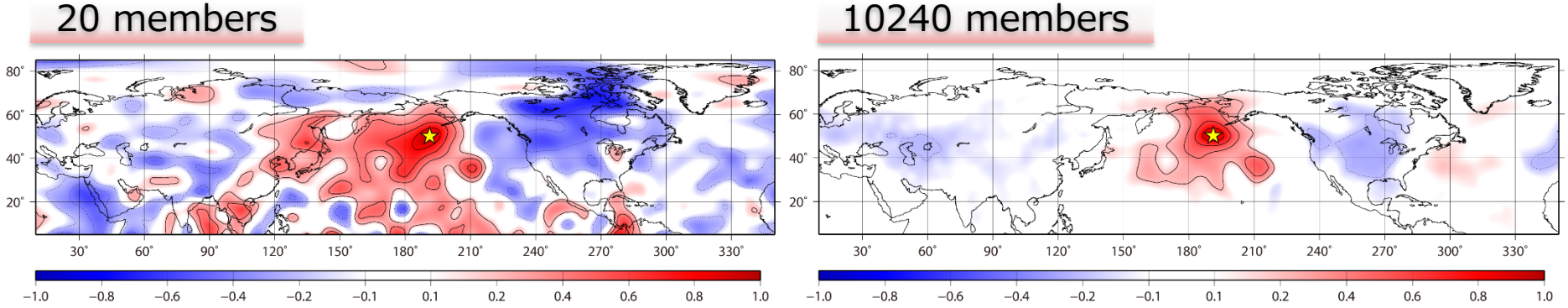
Introduction

- Miyoshi et al. (2014) successfully implemented 10,240-member LETKF with the SPEEDY model.
  - It is difficult to discuss the PDFs with 20 members.



Specific humidity [g/kg] at a single grid point (16.7N, 150.0E)

  - Long range correlations



Auto-correlations for Ps from ★ at 00 UTC 17 January.

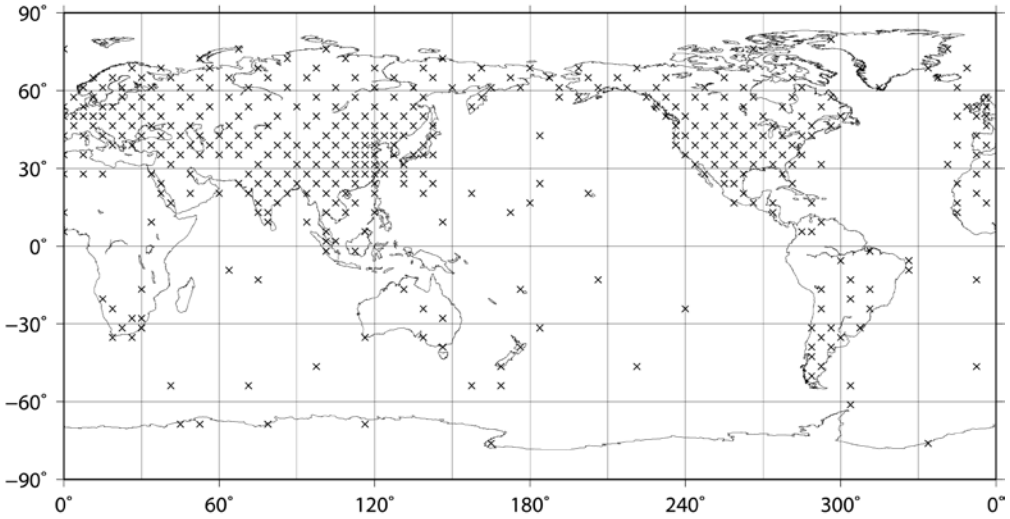
Motivation

- Localization is removed to investigate
  - the impact of far-away observations
  - non-Gaussianity

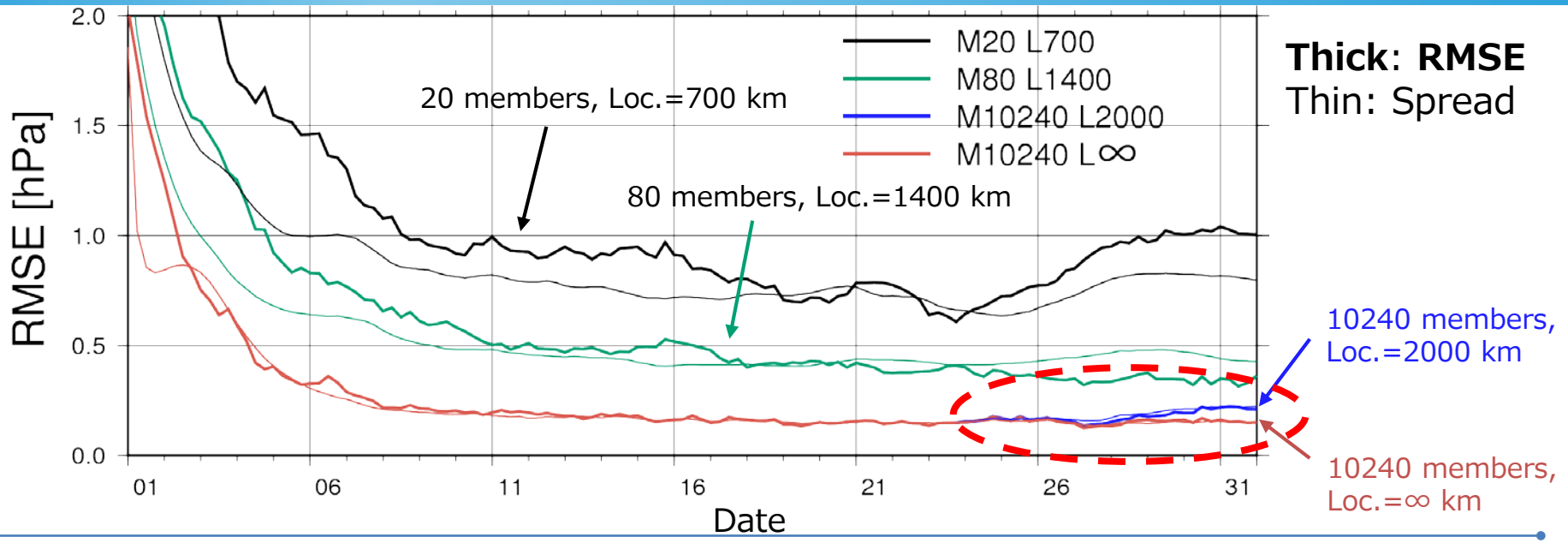
Experimental settings

Ensemble size	20	80	10240	**10240**
Localization scale (Radius of Loc.)	700 km (2550 km)	1400 km (5100 km)	2000 km (7300 km)	∞ km (∞ km)

- The experimental period: 1 month
- Observation network



Analysis RMSE (Ps)



Thick: **RMSE**
Thin: Spread

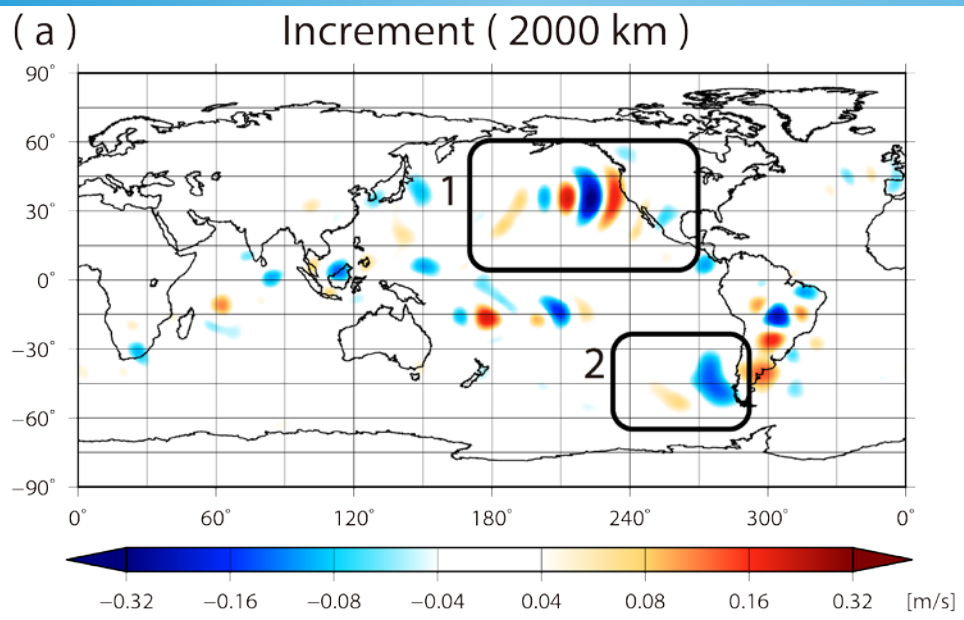
Spatial distribution of analysis RMSE (01/24/1982 ~ 02/01/1982)

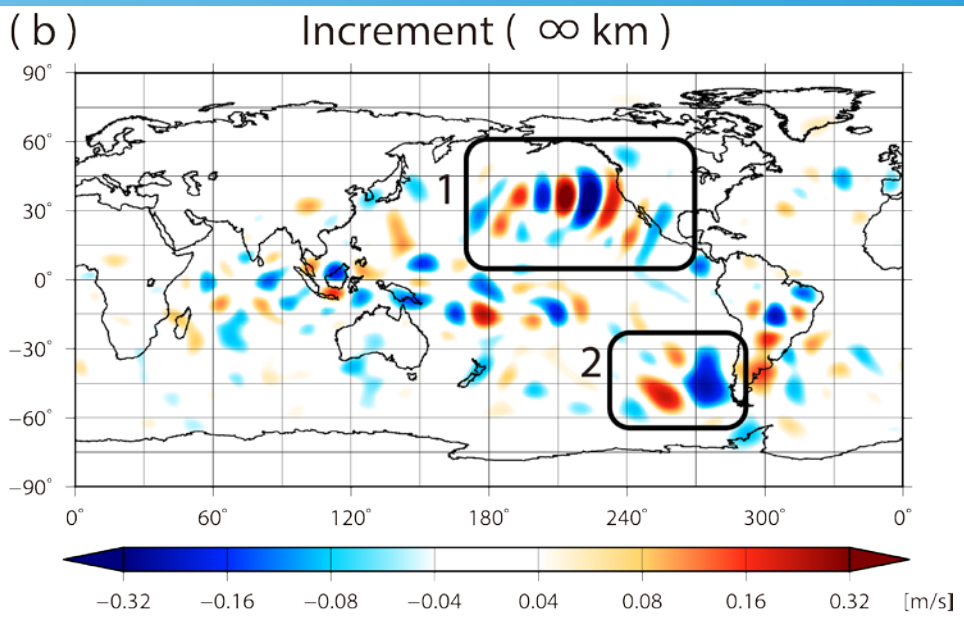
20 members (Loc.=700 km)

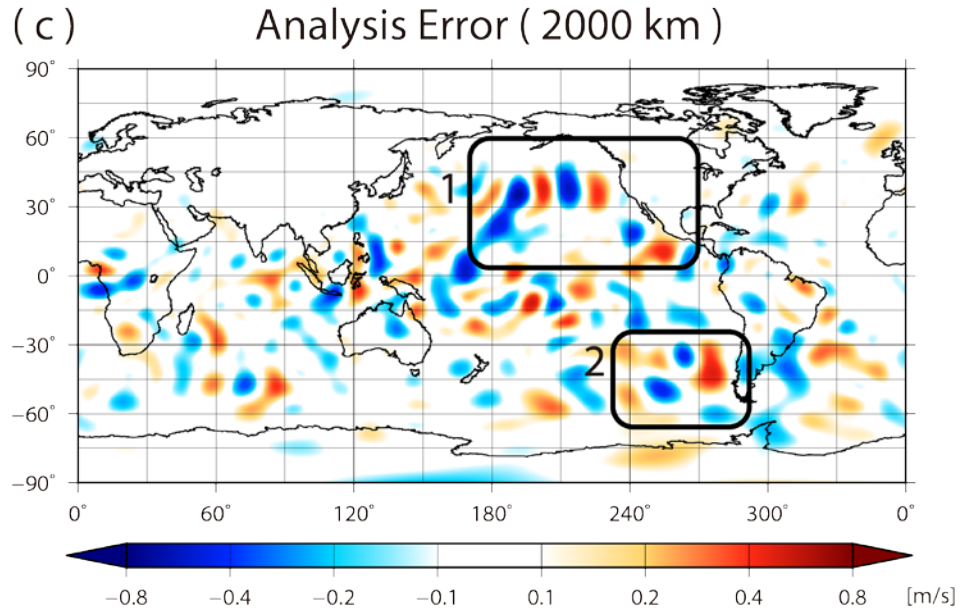
10240 members (Loc.=2000 km)

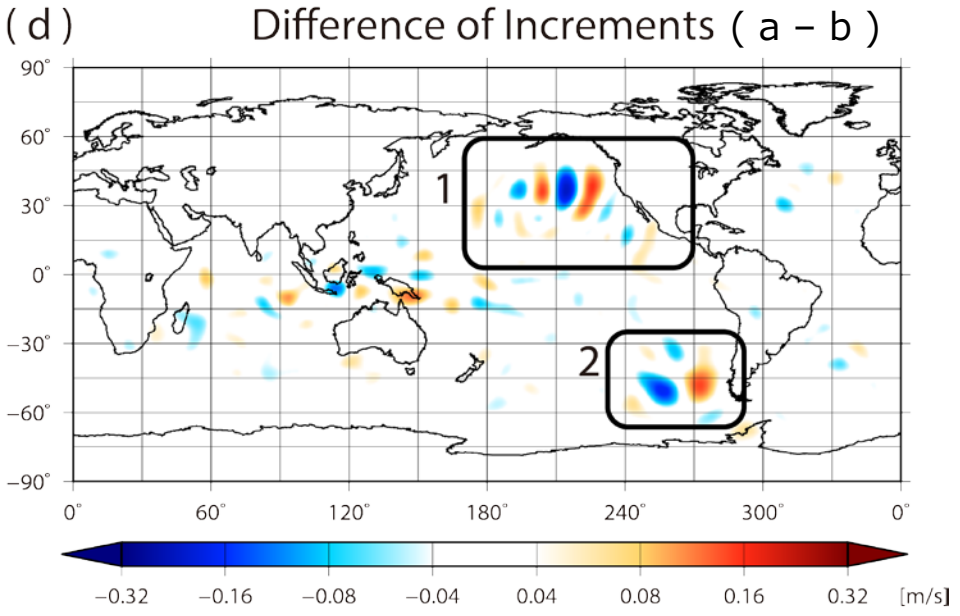
10240 members (Loc. = ∞ km)

Analysis Increments (V at 1st level at 00 UTC 24 Jan.)







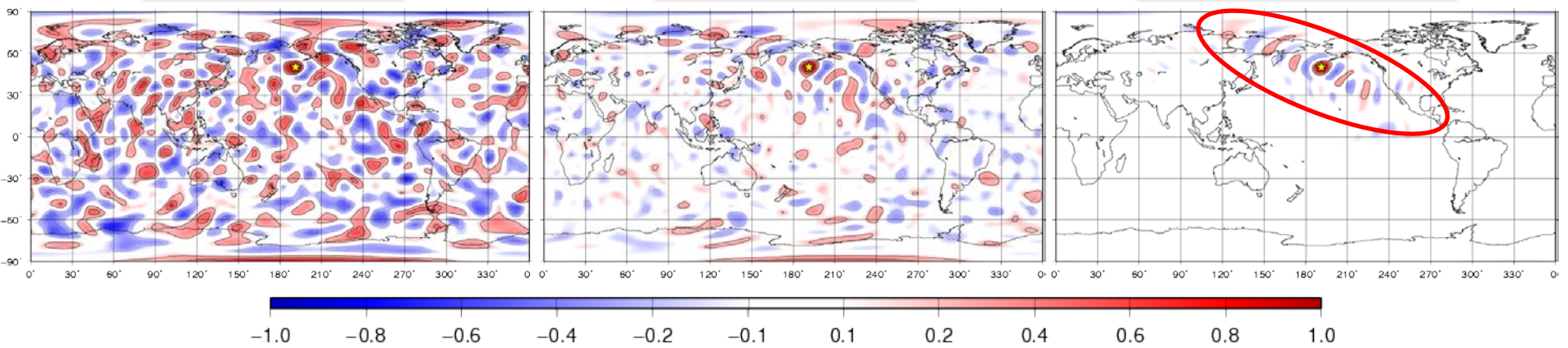


Auto-correlations, Q (4th level: ~500 hPa)

20 members

80 members

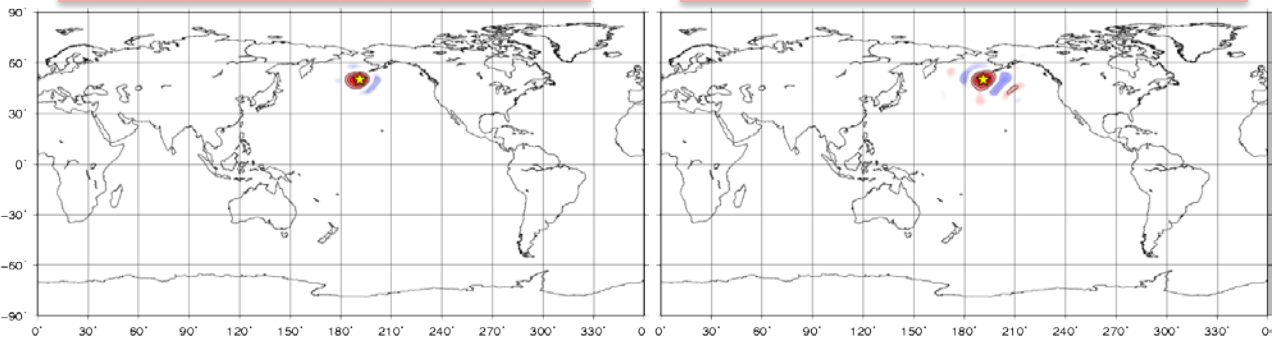
10240 members



−1.0 −0.8 −0.6 −0.4 −0.2 −0.1 0.1 0.2 0.4 0.6 0.8 1.0

Localization = 700 km

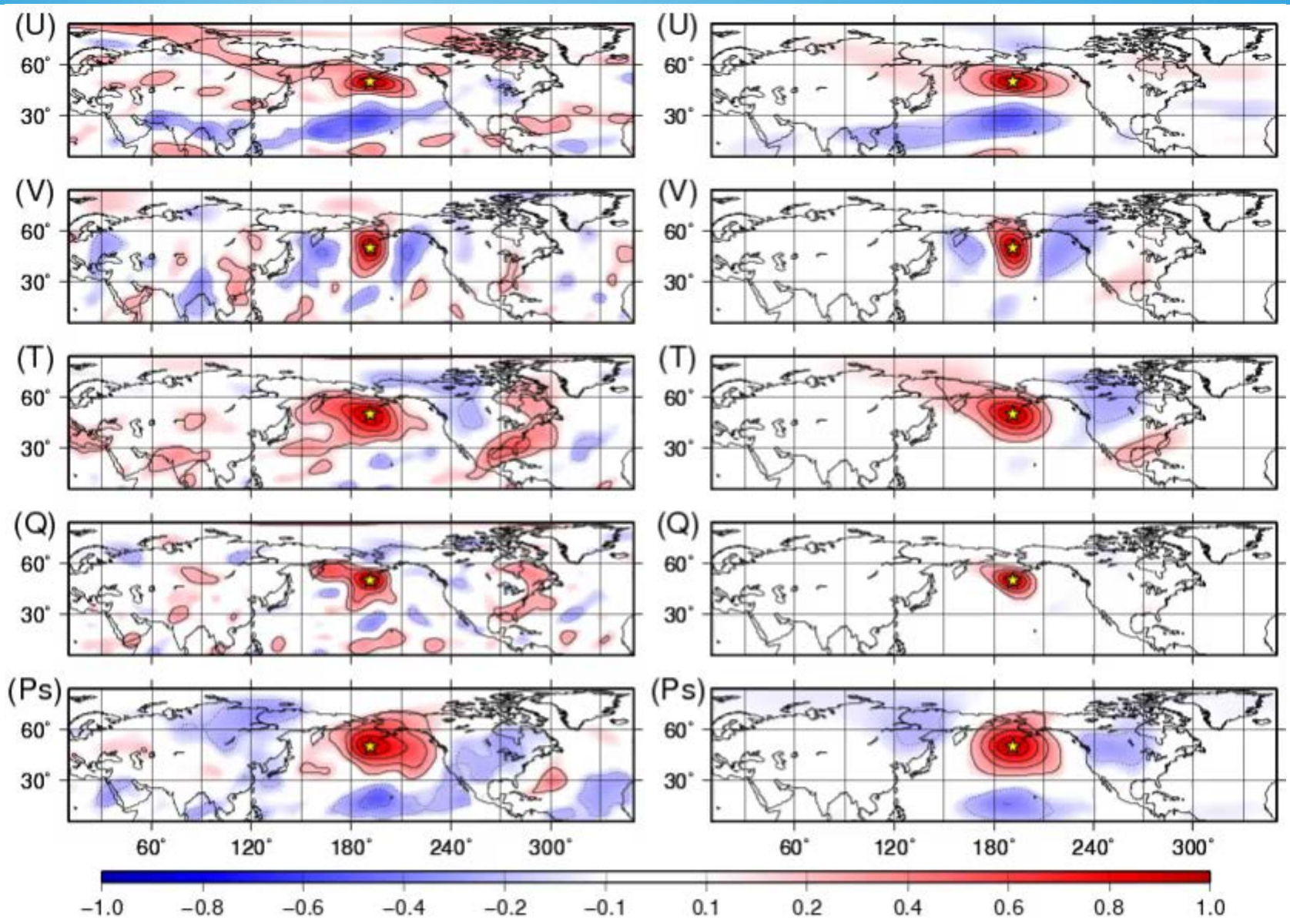
Localization = 1400 km



- Far-away observations are included with 10,240 members.

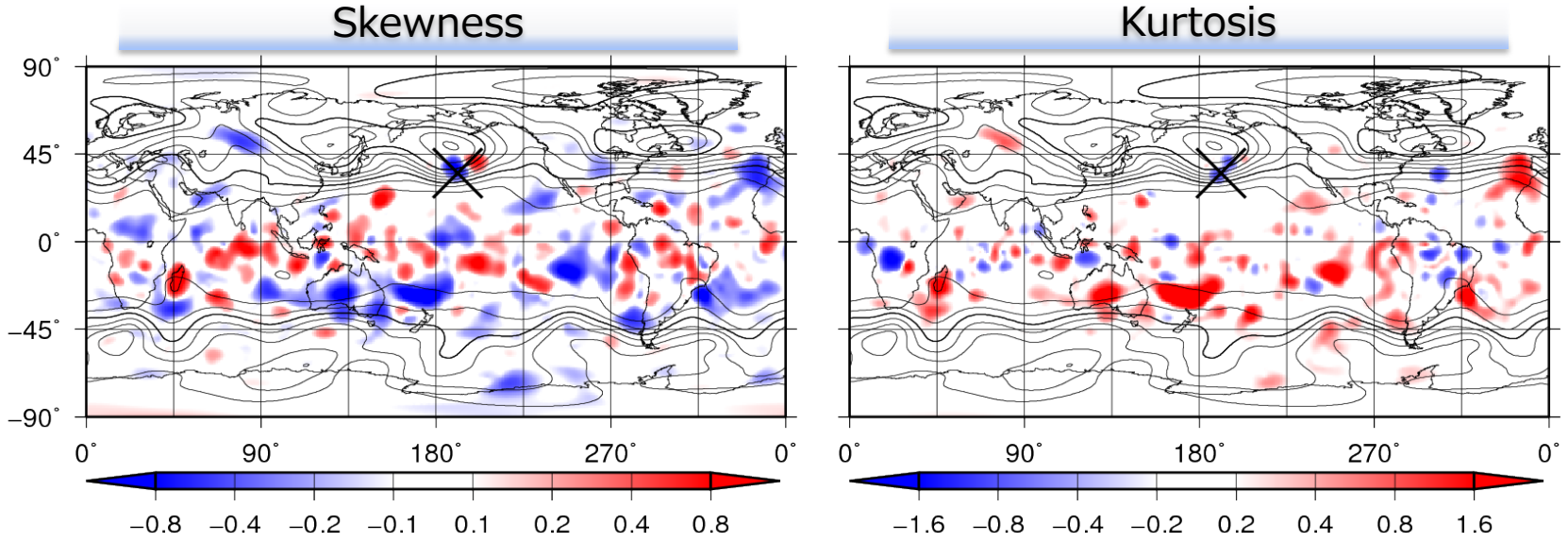
⇒ Reducing the analysis errors

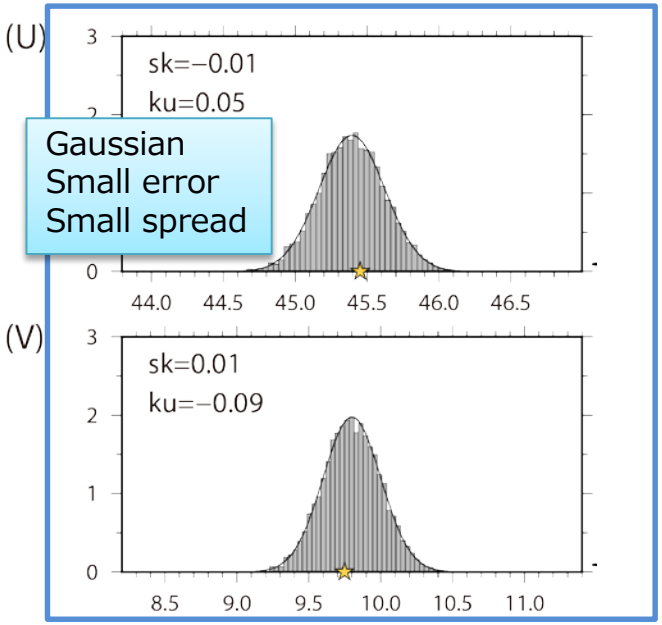
Auto-correlations (animation)

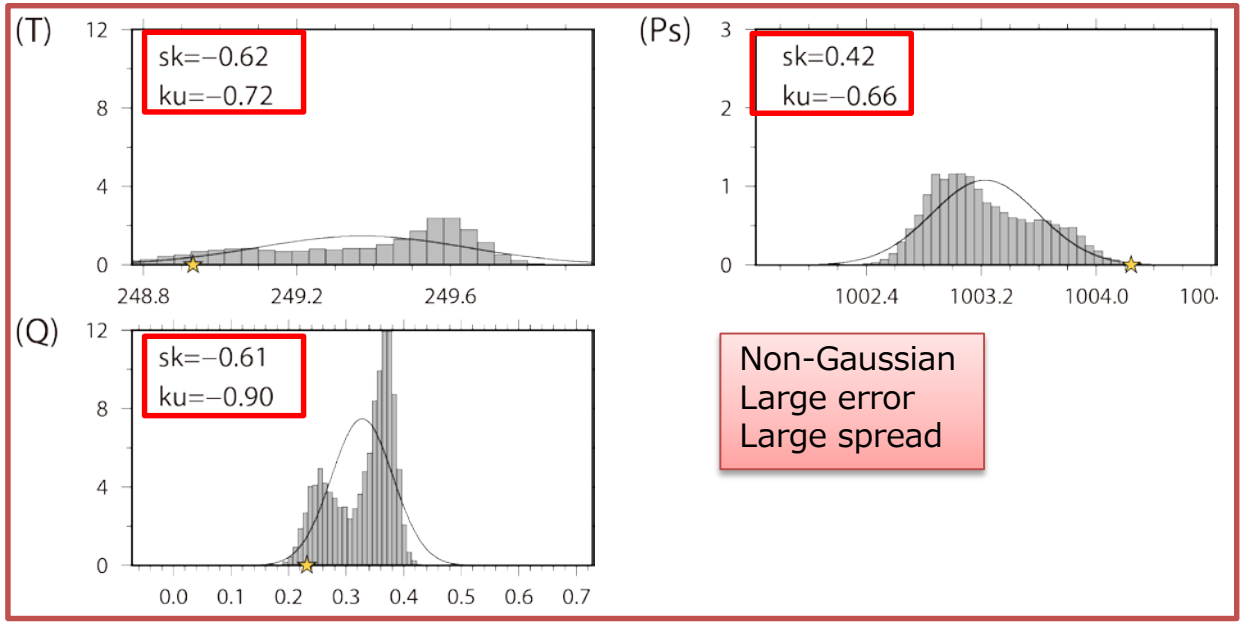


Non-Gaussianity①

○ **T at 4th level (00 UTC, 01/13/1982)**

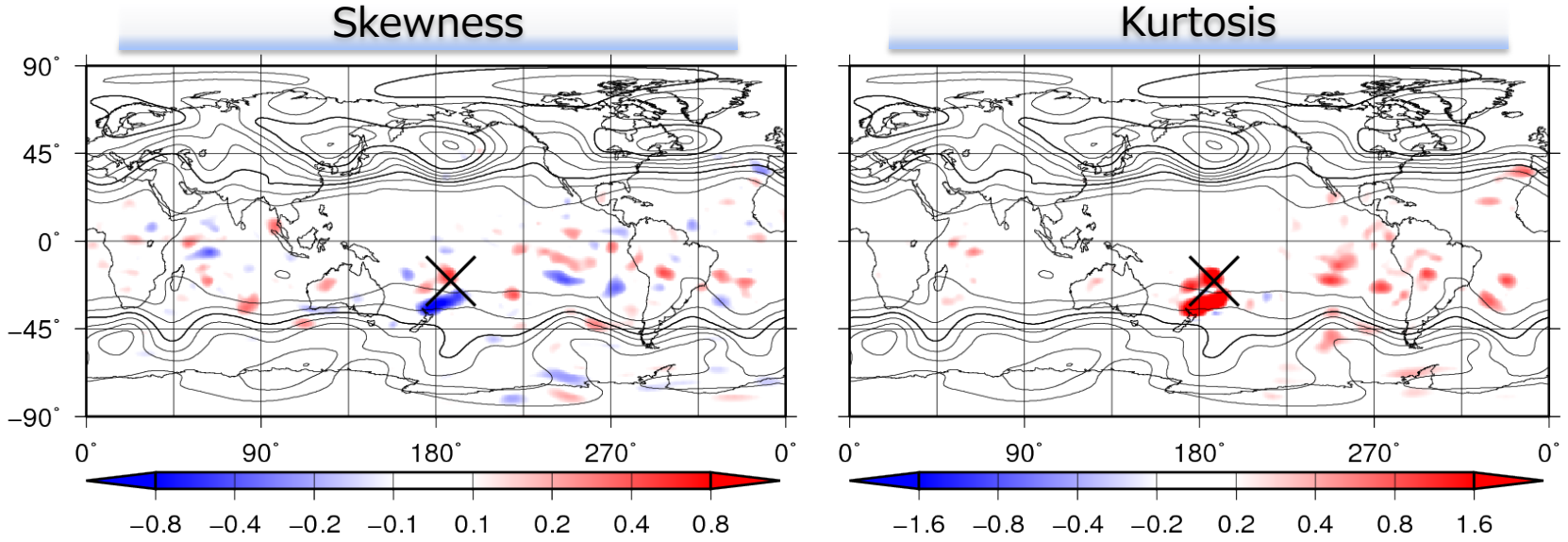


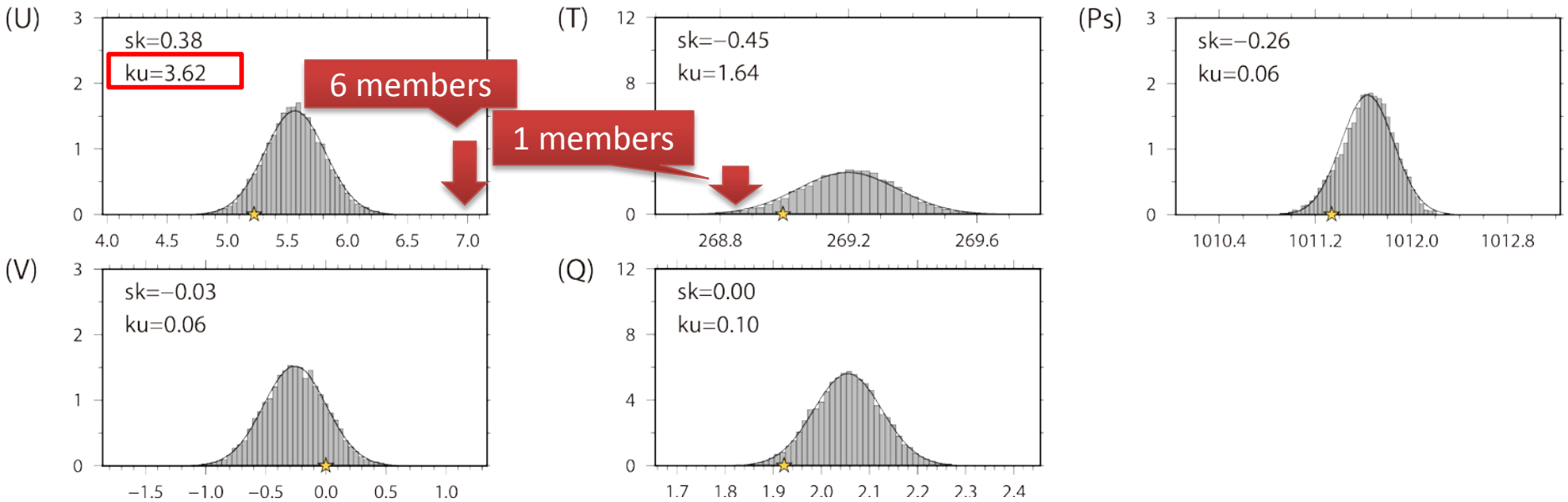




Non-Gaussianity②

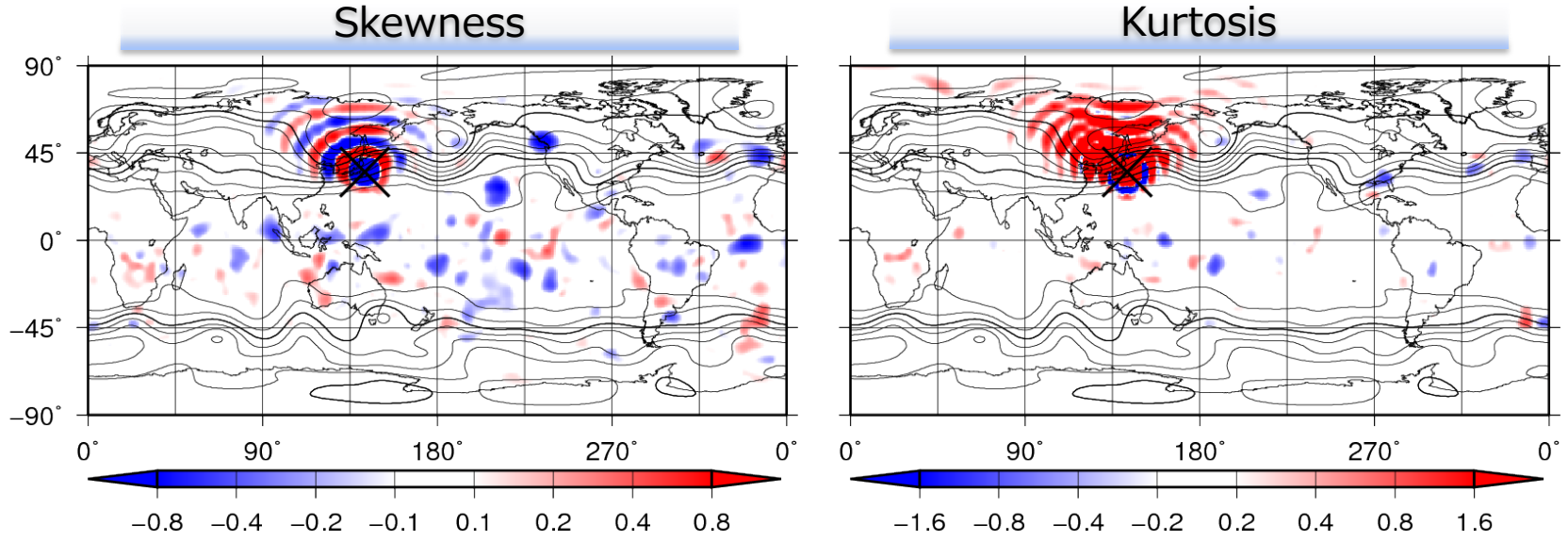
○ **U at 4th level (00 UTC, 01/13/1982)**

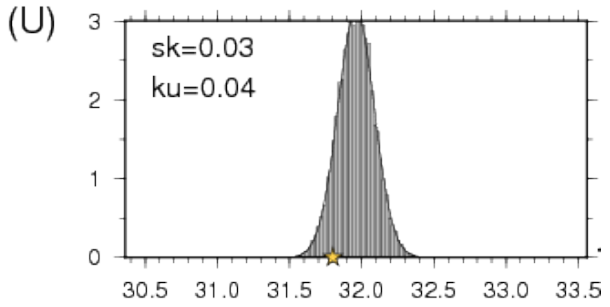


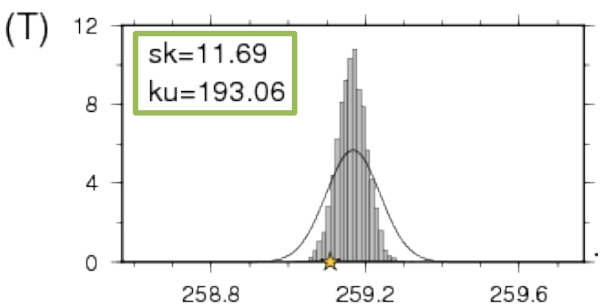


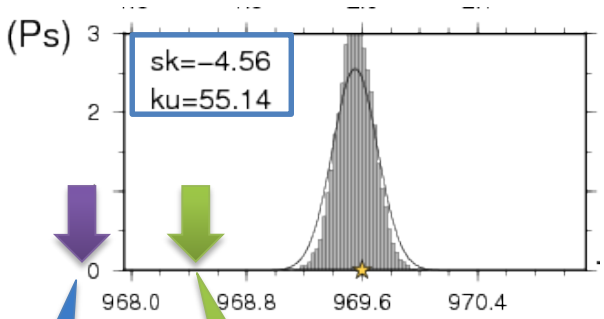
Non-Gaussianity③

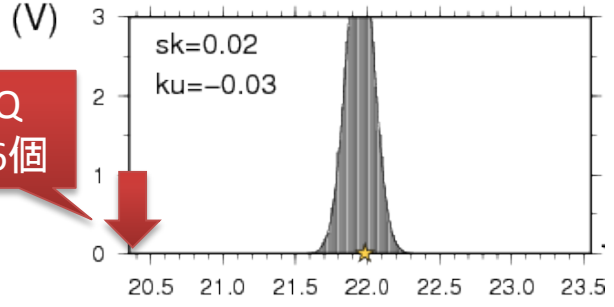
○ **Q at 4th level (00 UTC, 01/31/1982)**

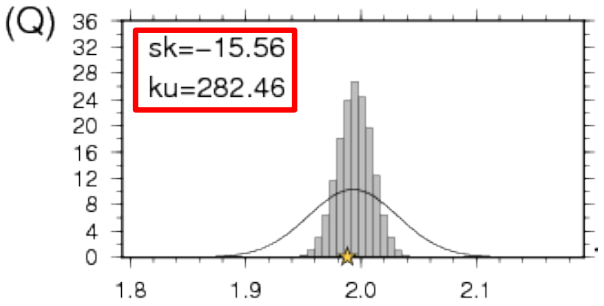




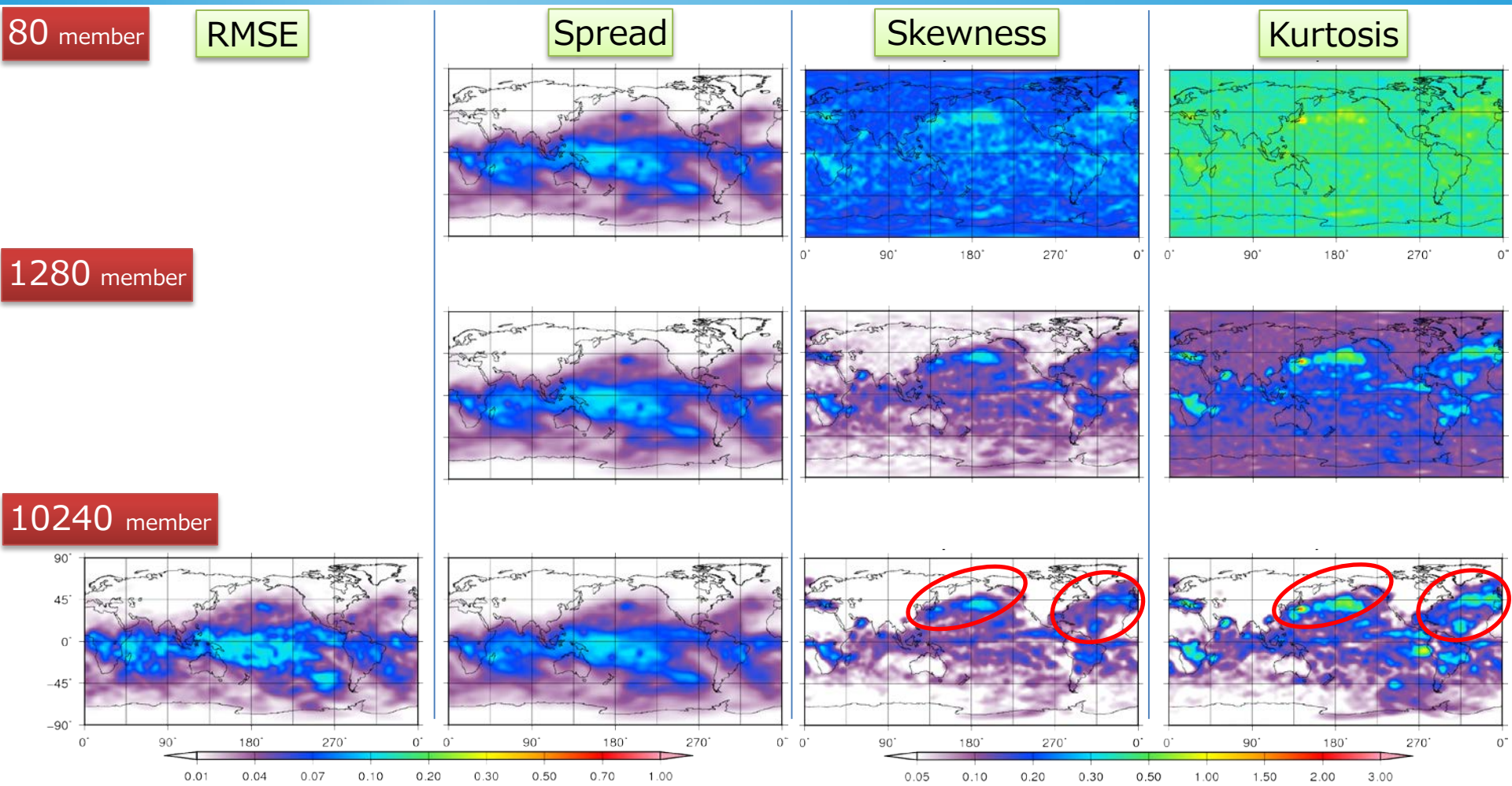








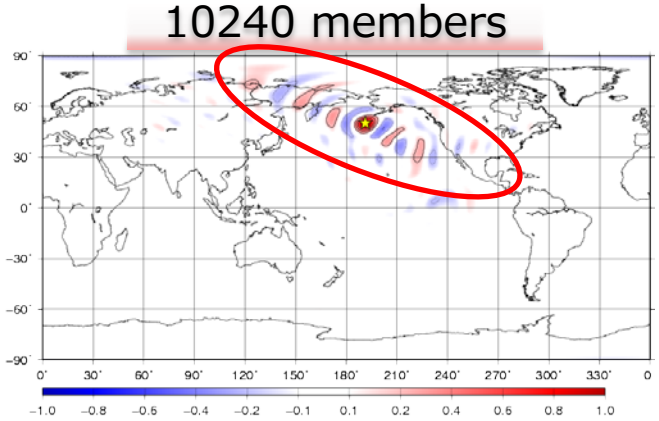
Skewness & Kurtosis (21 days average, for **Q** at 2nd level)



- Skewness, Kurtosis are large in the storm track.
- The shape of Skewness and Kurtosis are similar to the RMSE and spread.

Summary

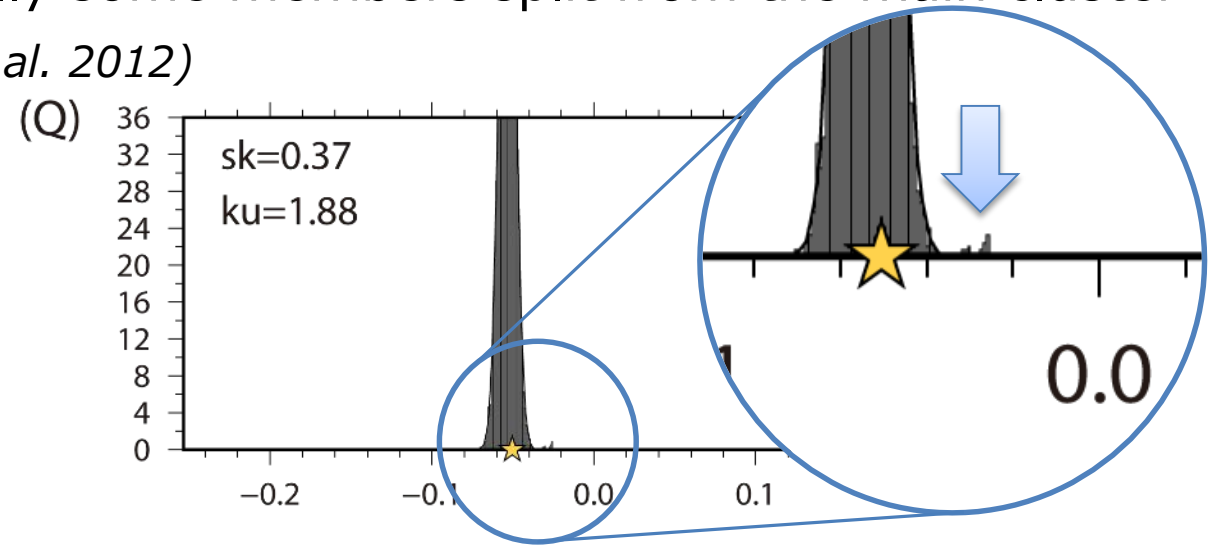
- Analysis is improved by including far-away observations.
  - No localization with a large ensemble



- Non-Gaussianity
  - Large in the storm-track and tropical regions.
  - Skewness, Kurtosis ⇔ RMSE, Spread

    ⇨ Non-Gaussian data assimilation helps ?
  - Occasionally some members split from the main cluster

(Amezcua et al. 2012)



Thank you!