

Non-Gaussian statistics and data assimilation in the global atmospheric dynamics with 10240-member ensemble Kalman filter



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Introduction

• Miyoshi et al. (2014) successfully implemented 10,240member LETKF with the SPEEDY model.

Auto-correlations for Q from 4 at 00 UTC 17 January. Specific humidity [g/kg] at a single grid point



Experimental settings

\circ Settings

Experiment	M20	M80	M320	NOLOC
Ensemble size	20	80	320	10240
Radius of Influence (Localization scale)	2550 km (700 km)	5100 km (1400 km)	7303 km (2000 km)	∞ km (-)

- The experimental period: 60 days (Jan. 1 Mar. 1)
 SPEEDY model (T30/L7)
- Perfect model experiments



Time series of analysis RMSEs (U \sim 500 hPa)

Analysis RMSEs (U, Lev = 4)



- \circ NOLOC greatly improves.
- \odot The improvement from M20 to M80 is large.
- \circ The improvement is saturated from M80.

Definitions of Non-Gaussianity & Outlier



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• Outlier (Anderson 2010, Amezcua et al. 2012)



Definitions of Non-Gaussianity & Outlier



• **Outlier** (Anderson 2010, Amezcua et al. 2012)



Non-Gaussianity



Non-Gaussianity & Outlier

1982 02 22 06 UTC (M10240, T [K])



Frequency of Non-Gaussianity (21 Jan.~01 Mar.)



T at 4th model level (\sim 500 hPa)





Frequency of Outliers (21 Jan.~01 Mar.)





RMSE ⇔ Non-Gaussianity

Surface-pressure RMSE (hPa)



RMSE ⇔ Non-Gaussianity

Surface-pressure RMSE (hPa)



Non-Gaussianity based on 10240 members



Skewness, Ps, 1982/02/01 06Z



Kurtosis, Ps, 1982/02/01 06Z



Non-Gaussianity(KLD), Ps, 1982/02/01 06Z



 $0.01 \quad 0.02 \quad 0.04 \quad 0.07 \quad 0.10 \quad 0.15 \quad 0.20 \quad 0.30 \quad 0.50$

NICAM-LETKF (Terasaki et al. 2015)

NICAM: Icosahedral grid arrangements

Grid division level 0 is the original Icosahedron.

The horizontal resolution can be increased by splitting one triangle into four triangles.

Grid division level	Horizontal resolution	
6	112 km	
7	56 km	
8	28 km	
9	14 km	
10	7 km	
11	3.5 km	
12	1.7 km	
13	0.87 km	



NICAM-LETKF with 10240 members is performed.

Non-Gaussianity (KLD) in real case



0.01 0.02 0.04 0.07 0.10 0.15 0.20 0.30 0.50

Summary

- Non-Gaussianity investigated
 - >1000 members necessary for capturing Non-Gaussianity
 - The distribution of non-Gaussianity ⇔ analysis RMSE
 Import Non-Gaussian data assimilation helps ?
 - Outliers are randomly generated.
 - More non-Gaussian in the real case



Summary (Non-Gaussianity)

$\,\circ\,$ Non-Gaussianity and outlier

- Frequency distributions are almost similar.
- 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. But after some analysis steps, the outliers come back.

• Future works

- Multi-localization method (Miyoshi and Kondo 2013, Kondo et al. 2013)
- Real observations and realistic model (NICAM).
 - 10240-member NICAM-LETKF (Miyoshi et al. 2015)

Histogram, Q, lev=1, 1982/02/01 06Z



1.856N, 120.000E

Histogram, Q, lev=1, 1982/02/01 06Z



1.856N, 176.25E

Non-Gaussianity in real case





NICAM (T, 9th level \sim 850 hPa)

Skewness





Ps



Improvement

