13th International Winds Workshop: 29 June 2016

Impacts of Spatial Observation Error Correlation in AMVs on Data Assimilation

KIAPS
KOREA INSTITUTE OF ATMOSPHERIC PREDICTION SYSTEMS

Sihye Lee and Hyo-Jong Song

Korea Institute of Atmospheric Prediction Systems (KIAPS)

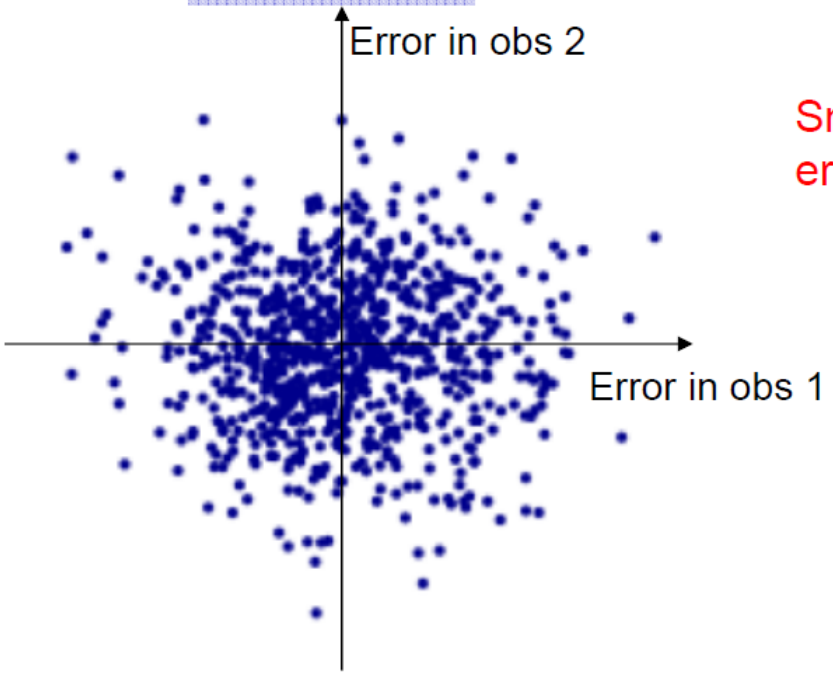
www.kiaps.org

Error Correlation

$$J(\mathbf{x}) = \frac{1}{2}(\mathbf{x}-\mathbf{x}_b)^T \mathbf{B}^{-1}(\mathbf{x}-\mathbf{x}_b) + \frac{1}{2}(\mathbf{y}-\mathbf{H}[\mathbf{x}])^T \mathbf{R}^{-1}(\mathbf{y}-\mathbf{H}[\mathbf{x}])$$

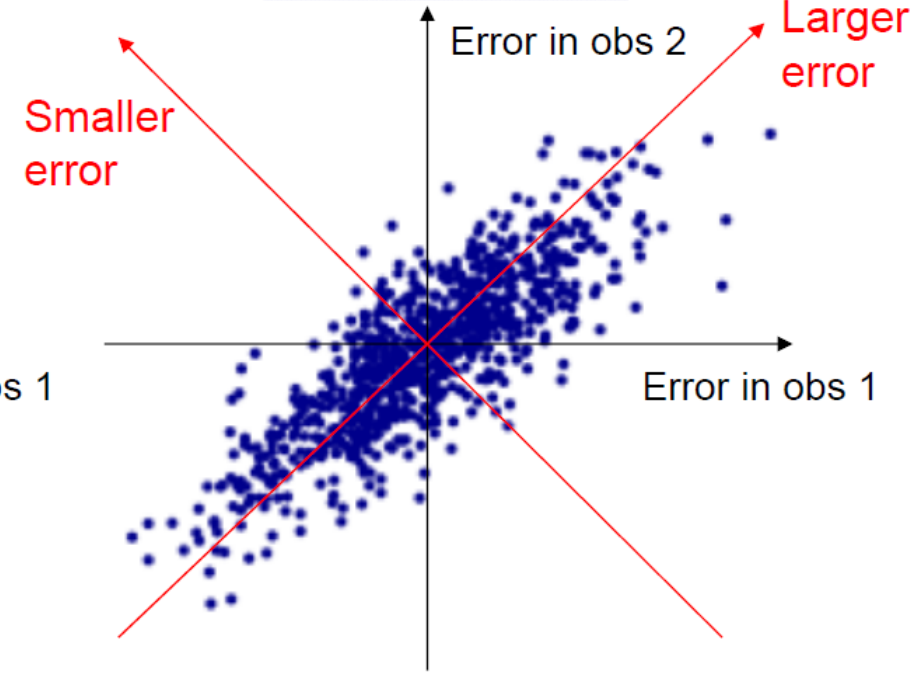
Uncorrelated error

$$\mathbf{R} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$



Correlated error

$$\mathbf{R} = \begin{pmatrix} 1 & 0.8 \\ 0.8 & 1 \end{pmatrix}$$



Niels Bormann (2015) NWP SAF training course: Observation errors

Objective & Methodology

Objective : **To characterize the spatial error correlation of COMS and MTSAT AMVs**

Method :

1. **Pairs of collocations with sonde and AMVs :**
   horizontal < 150 km, vertical < 25 hPa, vector difference < 18 m/s

2. **AMV-sonde departure correlation (R) =** $0.5(< \Delta u, \Delta u > + < \Delta v, \Delta v >)$

3. **Correlation function:** $R(r) = R_0 (1 + r/L) e^{-r/L}$

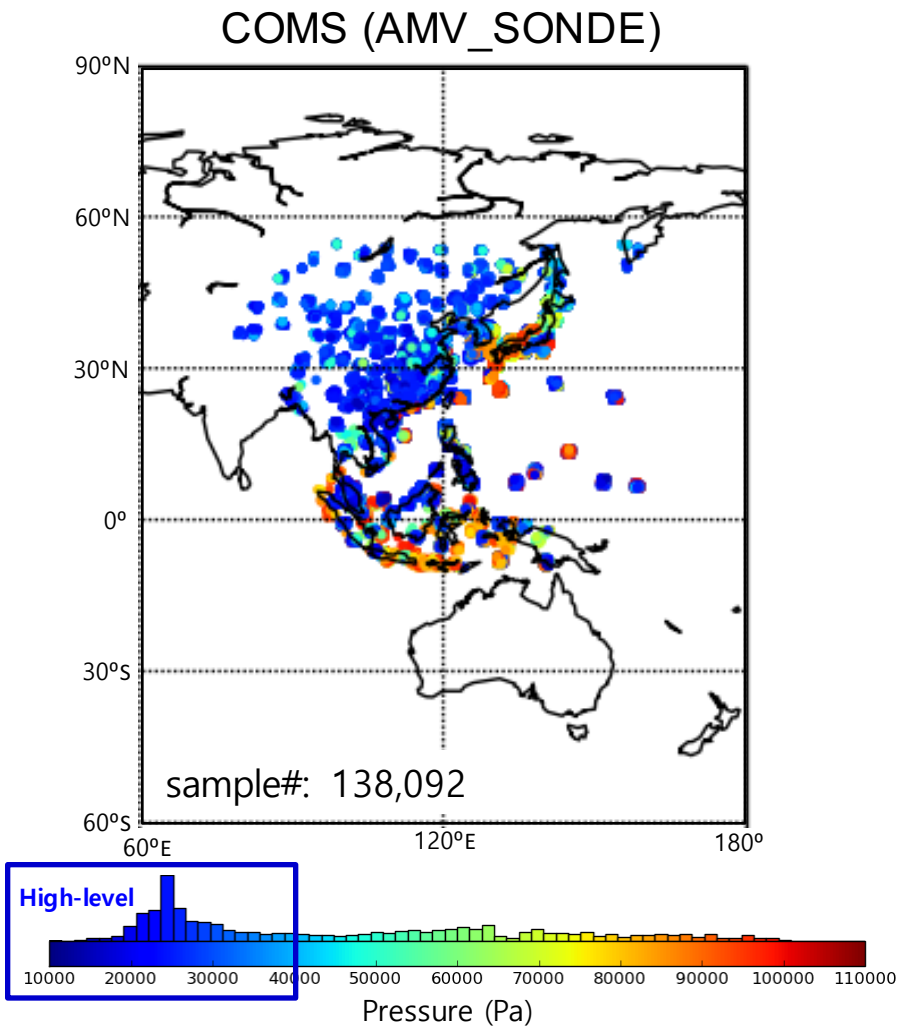
4. **Covariance matrix with spatial error correlation**

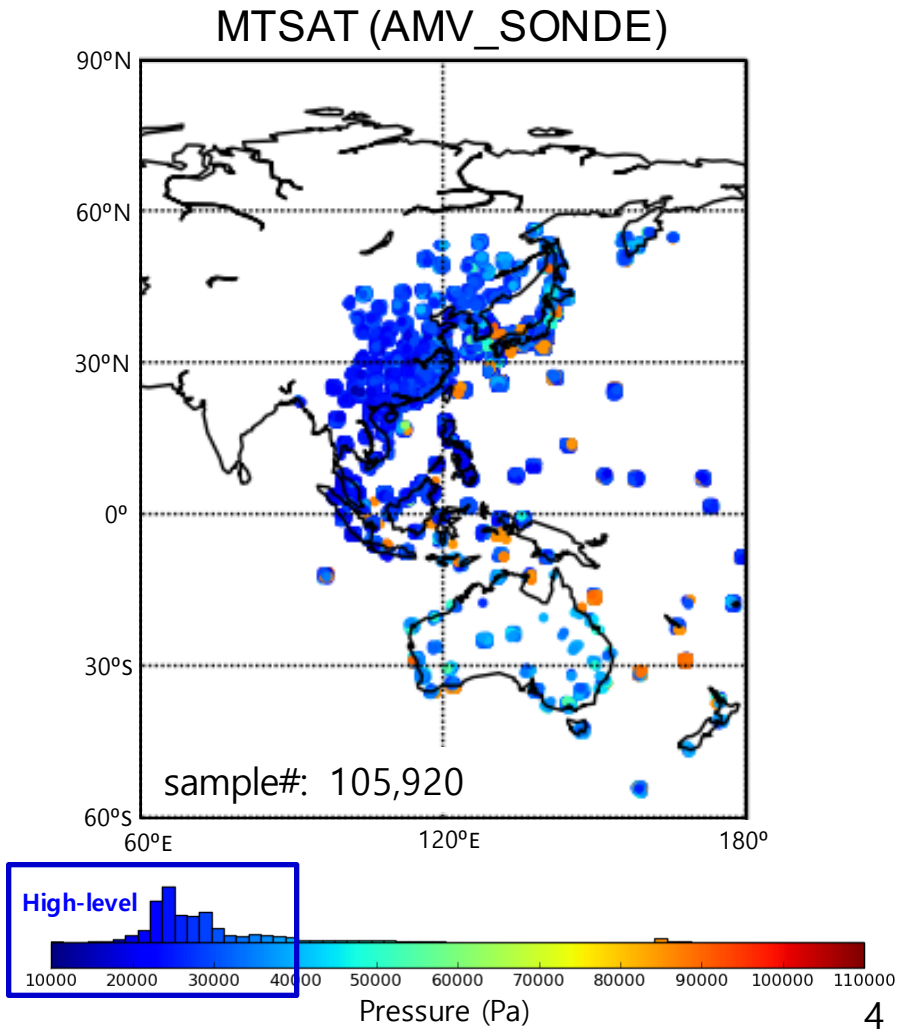
5. **Comparison of variances in eigen mode and observation space**

6. **Same steps with sonde and background**

Collocated Sonde and AMVs

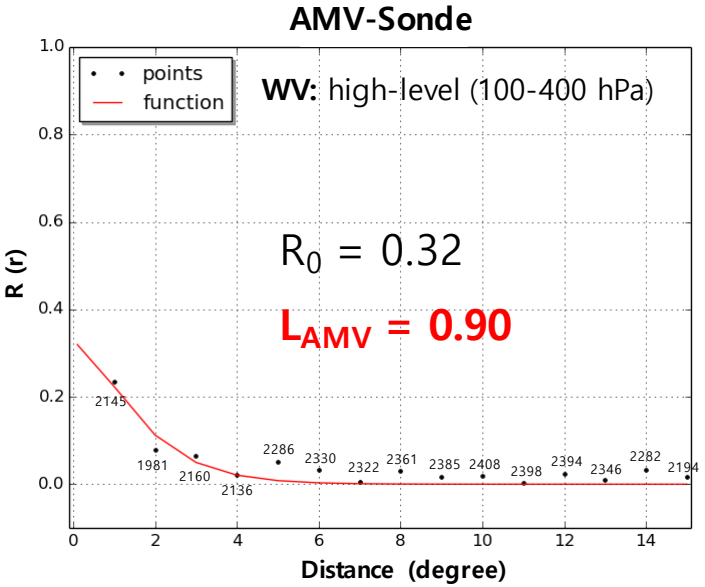
- **Period:** 2015070100-2015073118
- **Sonde** (w/ windprofiler), **COMS AMVs** (QI80_fc: IR, WV & VIS), and **MTSAT AMVs** (QI80_fc: IR & WV)

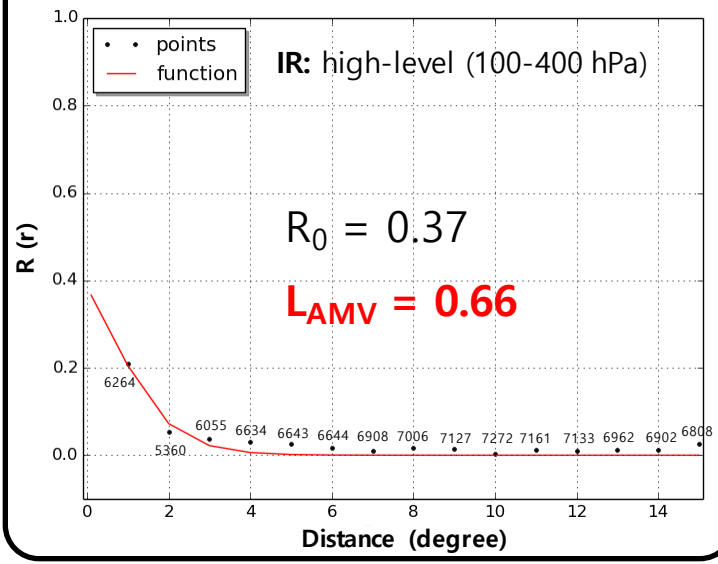




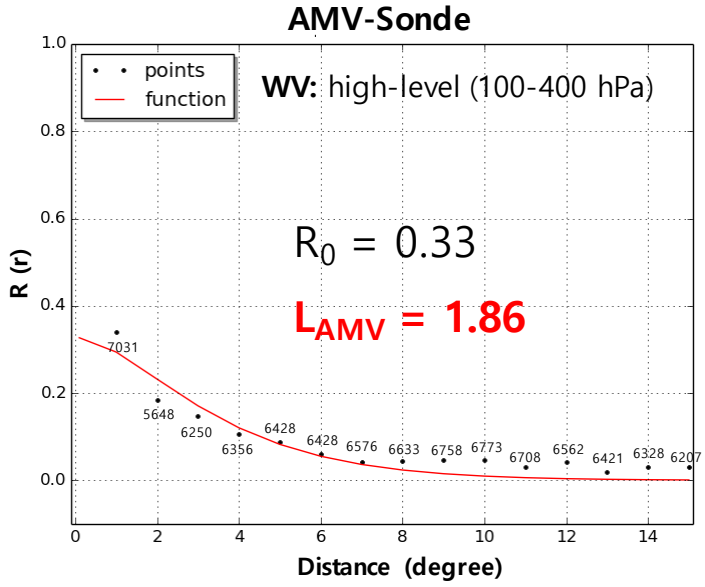
Departure Correlation (I)

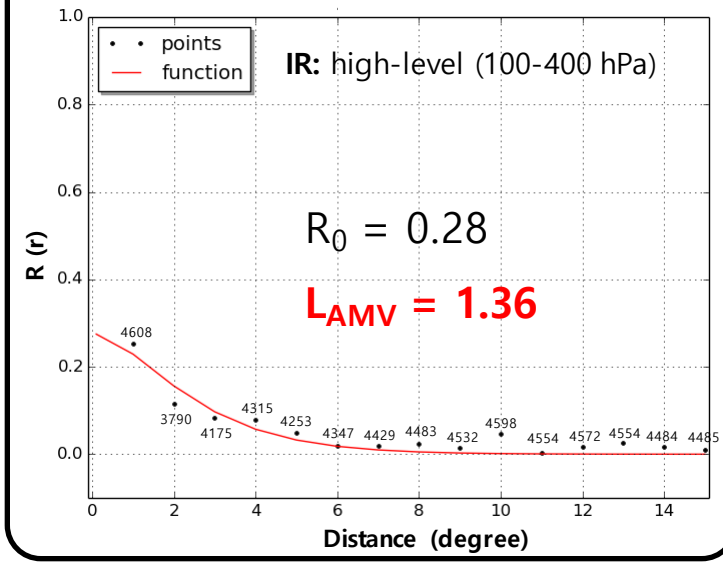
COMS





MTSAT





$R(r) = R_0 (1 + r/L) e^{-r/L}$

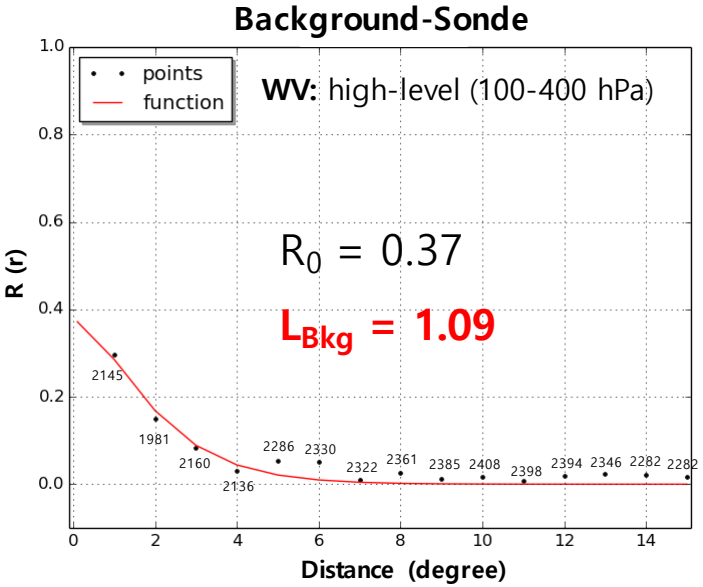
Assume sondes are spatially uncorrelated.

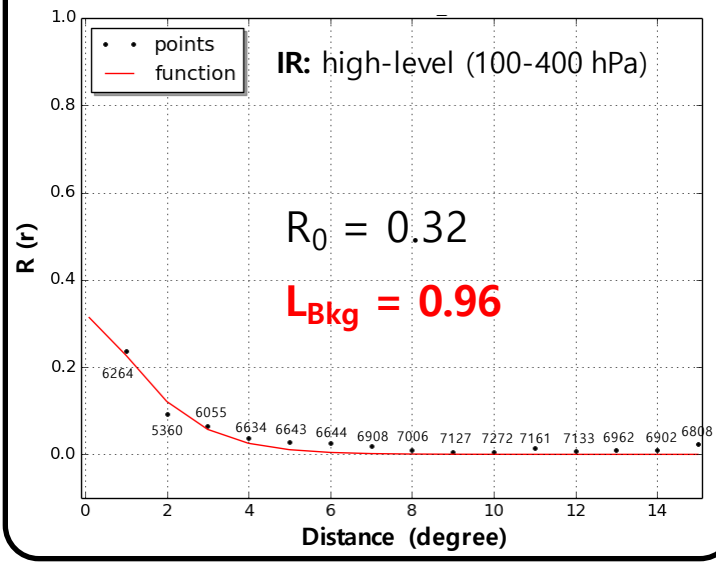
The correlation length scales (L) of **MTSAT AMVs** are longer than those of COMS AMVs. This fitting parameter shows larger spatially correlated error in MTSAT AMVs.

In both satellites, the correlations of the AMV-sonde differences tend to be larger for **WV AMVs** compared to IR AMVs.

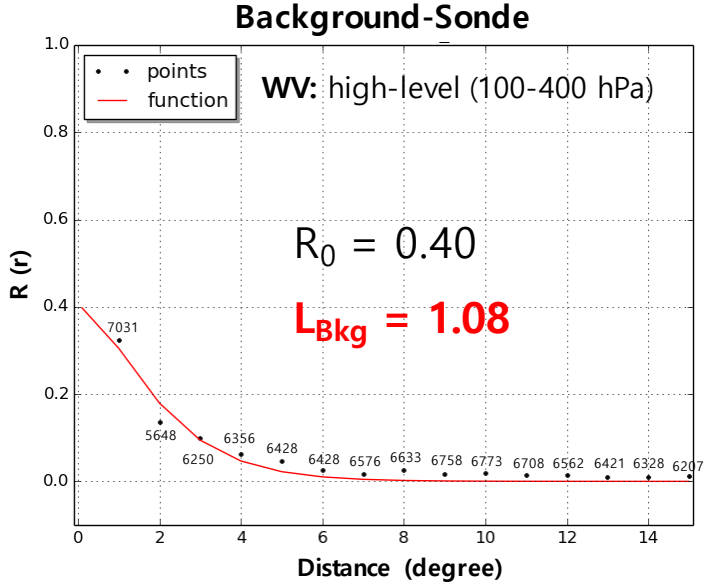
Background-Sonde Departure Correlation (II)

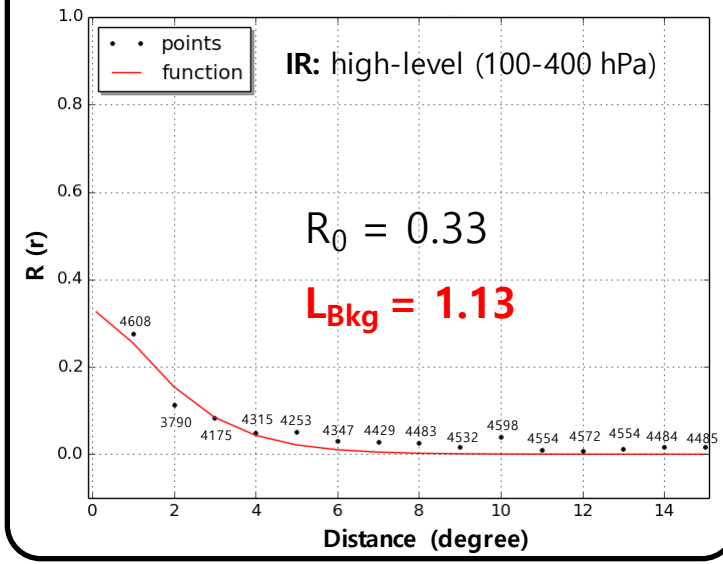
COMS





MTSAT





$$R(r) = R_0 \left(1 + r/L \right) e^{-r/L}$$

Assume sondes are spatially uncorrelated.

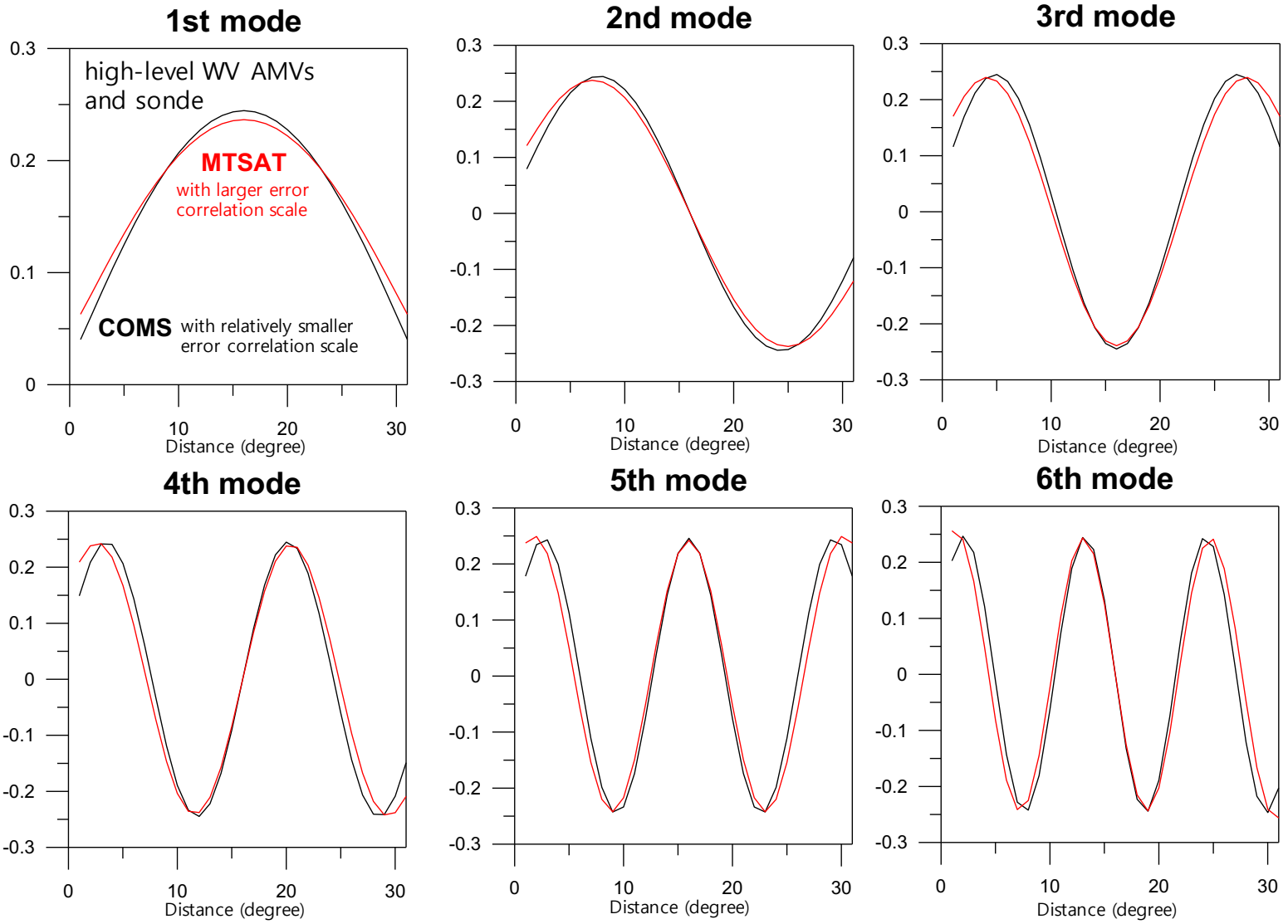
Background:
KIAPS Integrated Model (KIM) v2.3

The background winds in collocated COMS and MTSAT AMVs give similar error correlations with length scale of 0.96 to 1.13.

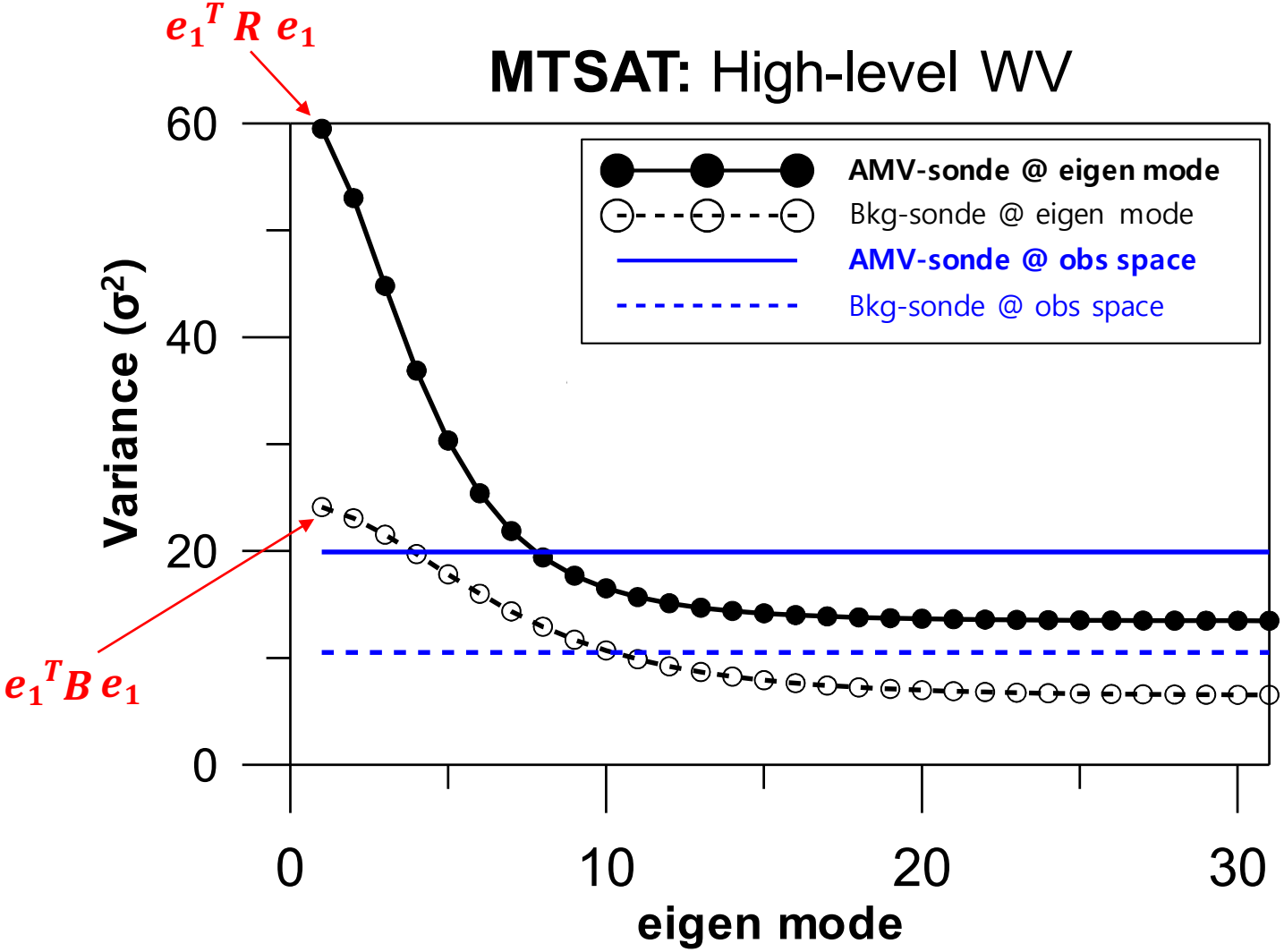
- **COMS:** $L_{AMV} < L_{Bkg}$
- **MTSAT:** $L_{AMV} > L_{Bkg}$

Eigen vectors

Eigenvectors of the error correlation matrix



Spatial Error Correlation

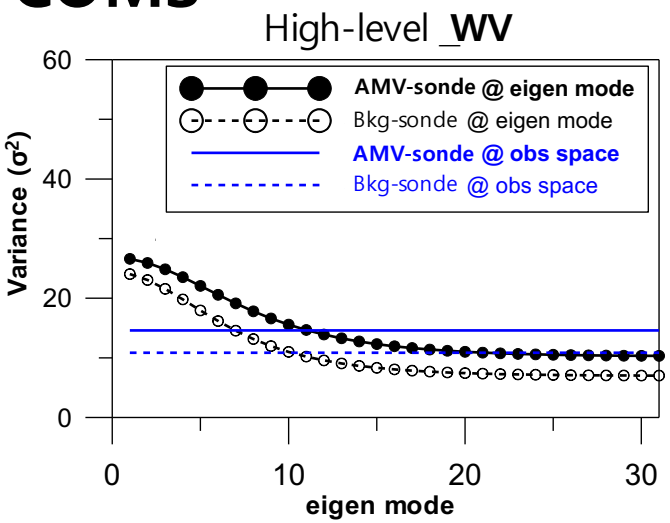


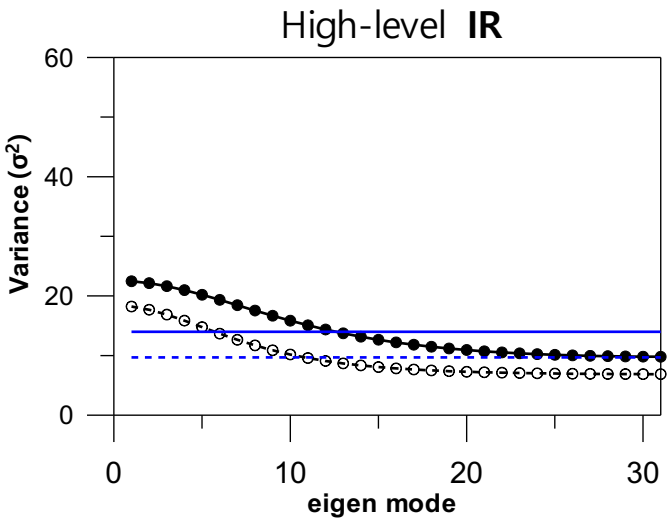
Error variance concentrated on governing eigen-mode is attributed to longer length scale of error correlation of MTSAT AMV.
On the other hand, relatively background error does not much intrude to large-scale pattern with its smaller correlation radius.

Compared to observation space, the variance ratio of AMV-sonde differences and bkg-sonde differences is amplified when the spatial error correlation error is reflected in eigen mode.

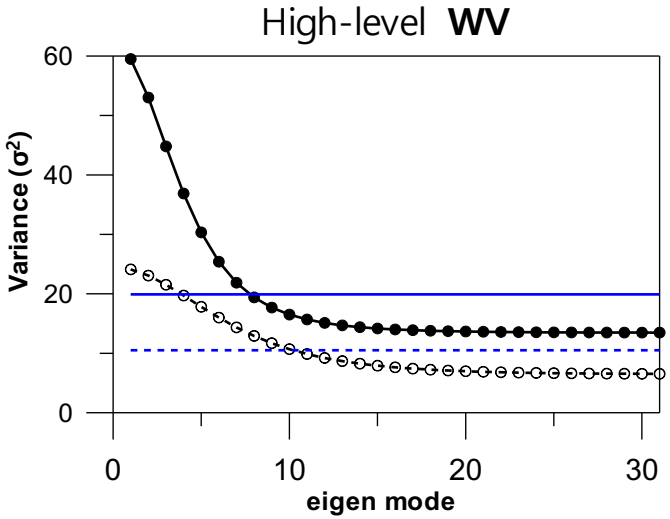
Spatial Error Correlation

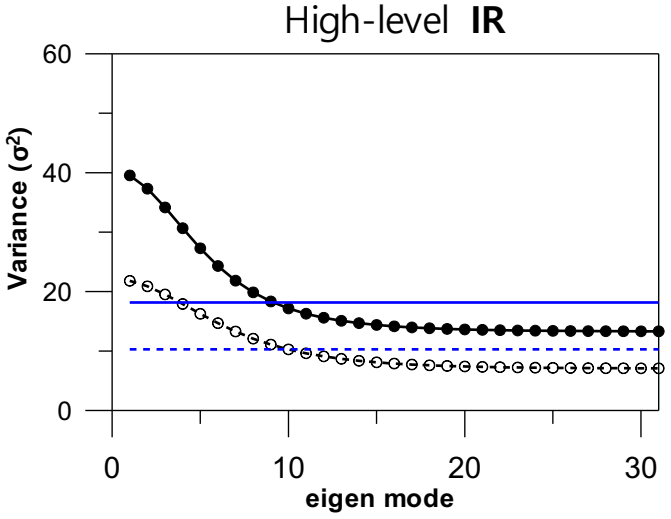
COMS





MTSAT

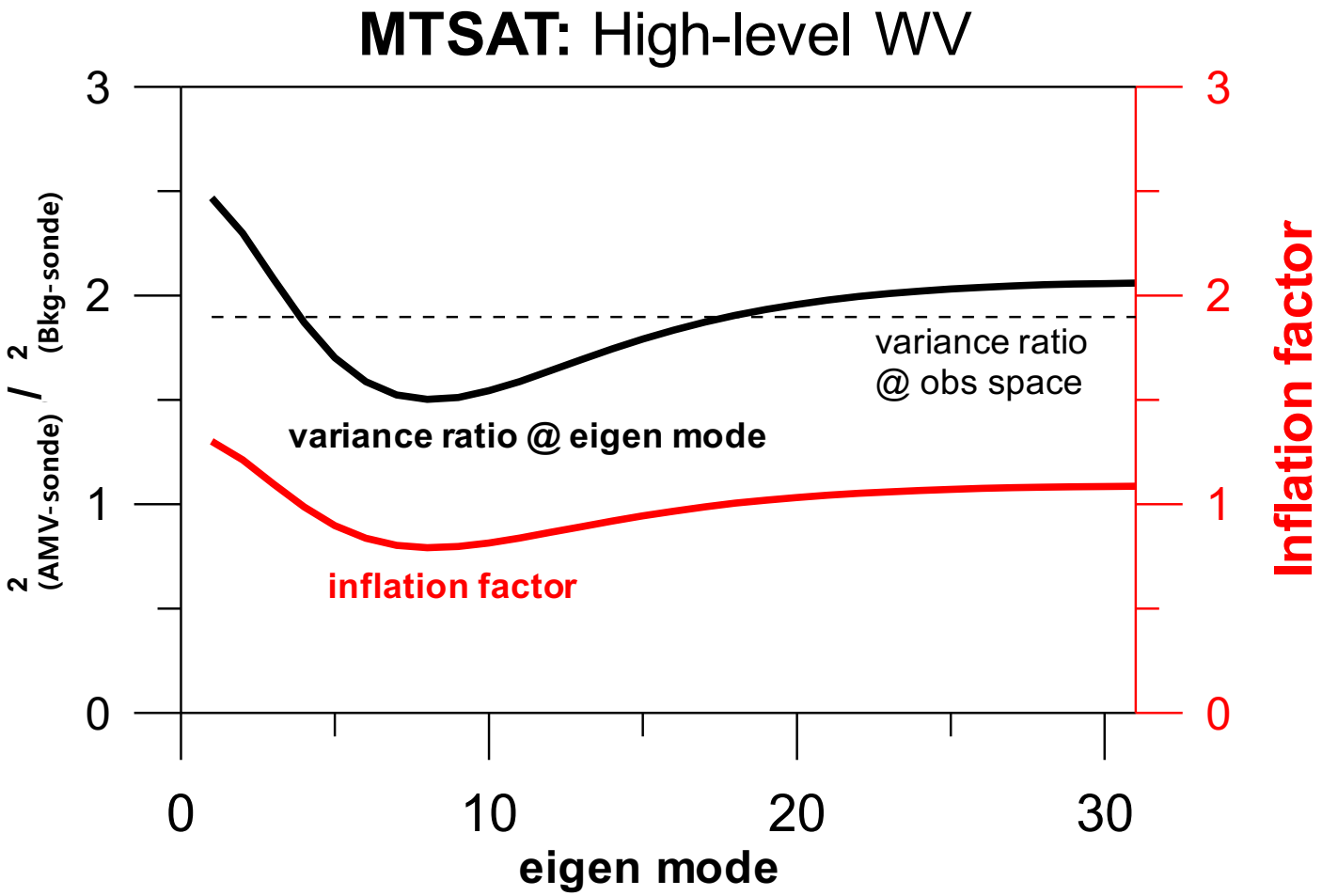




In high-level, the variance of the AMV-sonde differences is larger than that of background-sonde differences.

Especially, the variance ratio of spatially correlated MTSAT AMVs to background winds is 3 times larger in the governing eigen mode, compared to observation space with considering spatial error correlation.

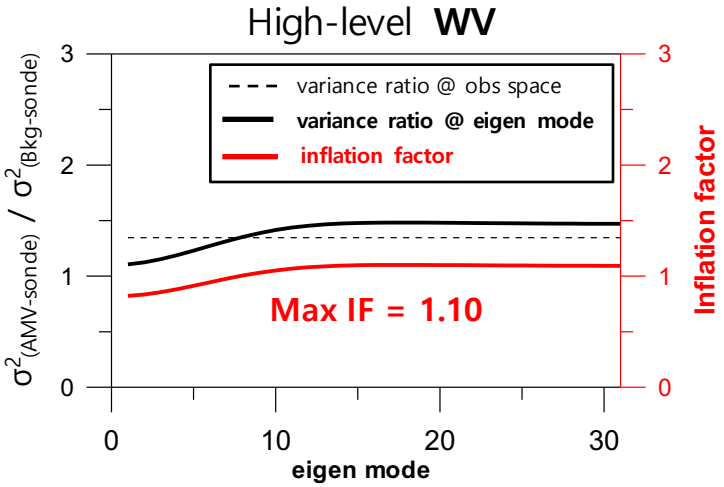
Inflation Factor

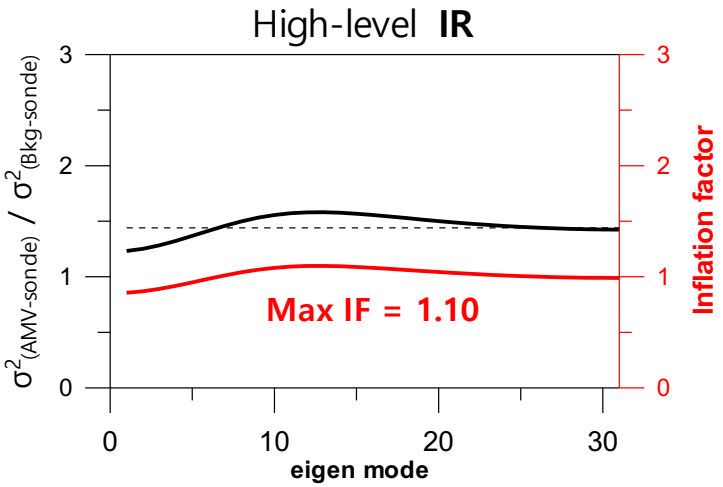


The spatial correlations of the AMV errors account for inflation of observation error variation:
Inflation factor = variance ratio @ eigen mode / variance ratio @ obs space

Inflation Factor

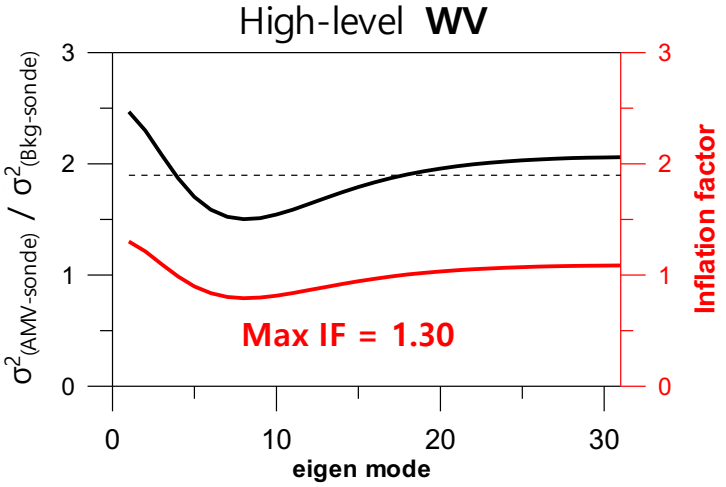
COMS

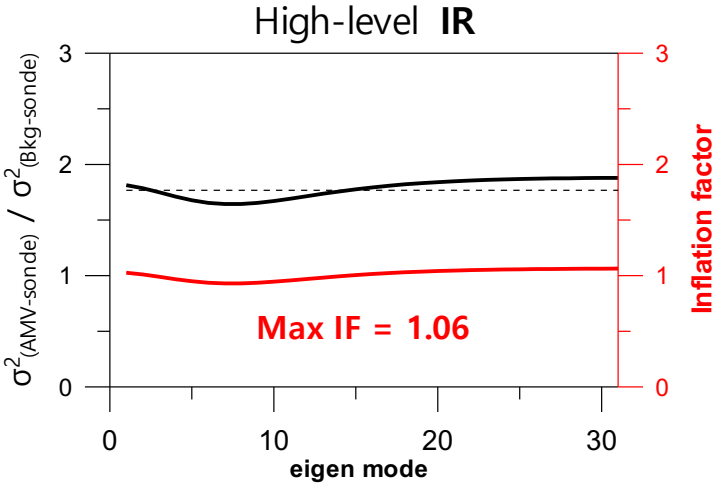




To consider spatial error correlations, observation error of high-level AMVs should be inflated about 1.10 ~ 1.30 times.

MTSAT

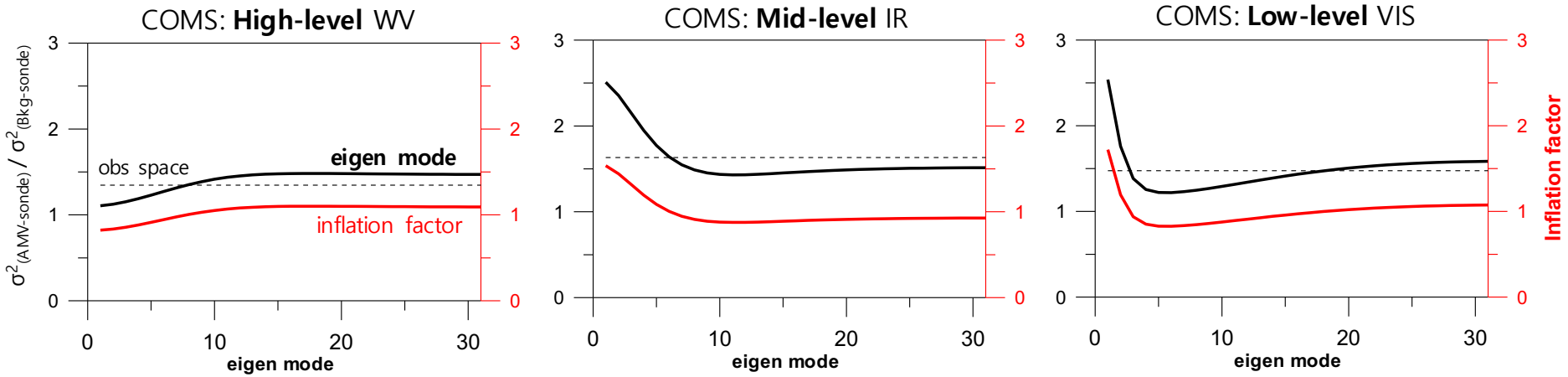




MTSAT AMVs show the maximum inflation factor in the governing mode, but maximum inflation factor of COMS AMVs shows smaller eigen mode.

COMS AMVs: Inflation Factor

COMS AMVs	Sample #	L_{AMV}	L_{Bkg}	Maximum inflation factor
High-level WV	34,128	0.90	1.09	1.10
Mid-level IR	56,639	**1.71**	0.89	**1.54**
Low-level VIS	17,978	**6.33**	0.56	**1.72**



In the **low-level,** the inflation factor of COMS AMVs from spatial error correlation is the highest up to 1.72. It is associated to larger length scale (of 6.33 degree) involving a dramatic integration of error variance on governing mode

Summary

- The ratio of AMV-sonde difference and background-sonde difference variances is amplified in eigen mode space where considering the spatial error correlation error.

- COMS and MTSAT AMVs show statistically significant spatial error correlations. In high-level, the correlation length scales of MTSAT AMVs are longer than those of COMS AMVs. It reflects advantage of COMS in retrieval algorithm, and so on…

- Spatial error correlations motivate to inflate observation error variance of MTSAT high-level-WV channel 1.3 times, while high-level COMS WV 1.1 times.

- Along vertical levels of COMS AMV, the inflation factor increases up to 1.72 responding to longer correlation length scale, 6.33 degree.

Korea Institute of Atmospheric Prediction Systems

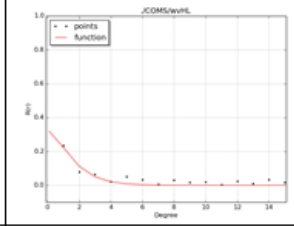
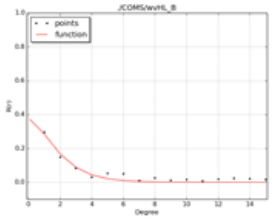
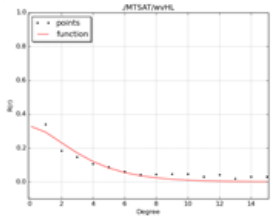
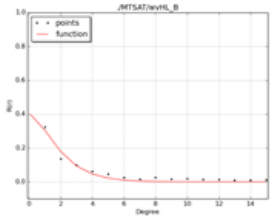
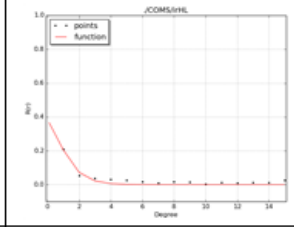
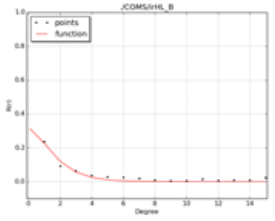
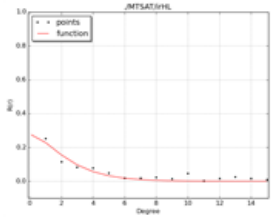
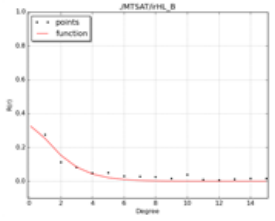
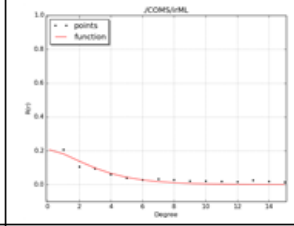
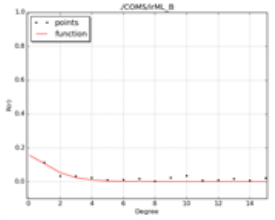
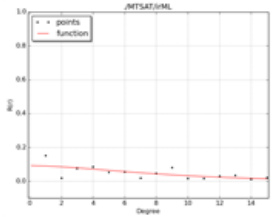
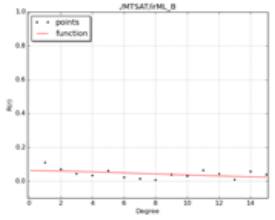
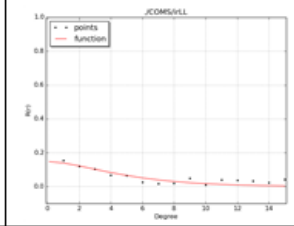
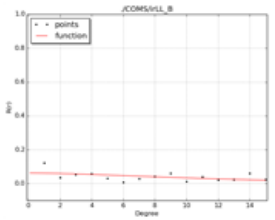
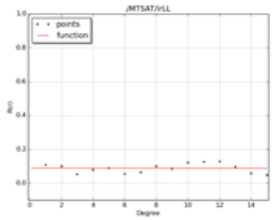
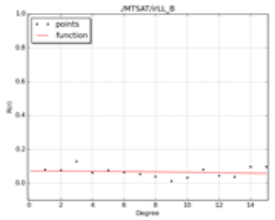
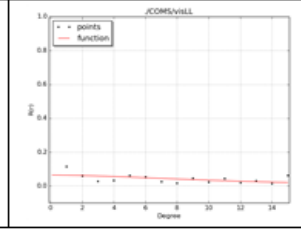
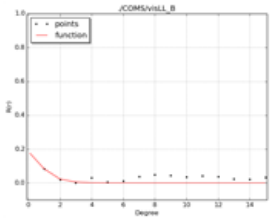
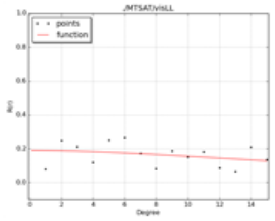
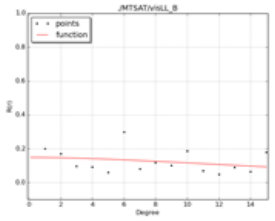
:Beyond the limit of the modern science and technology

Thank you

KIAPS

KOREA INSTITUTE OF ATMOSPHERIC PREDICTION SYSTEMS

Back-up

Satellite	COMS		MTSAT	
	AMV_sonde	Bkg_sonde	AMV_sonde	Bkg_sonde
WV_HL				
IR_HL				
IR_ML				
IR_LL				
VIS_LL				

Back-up

❖ Fitting parameters of correlation function

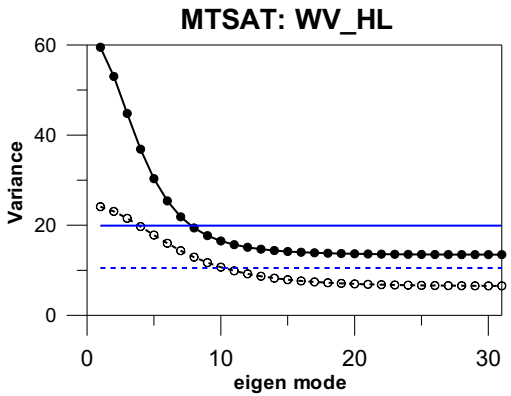
(1) AMV_Sonde

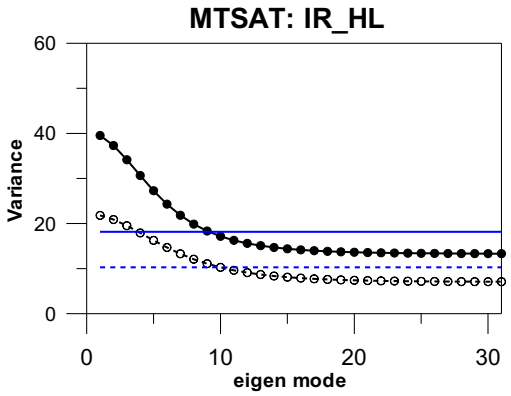
Satellite	COMS		MTSAT	
	R0	L	R0	L
WV_HL	0.32	0.90	0.33	1.86
IR_HL	0.37	0.66	0.28	1.36
IR_ML	0.21	1.71	-	-
IR_LL	0.15	2.69	-	-
VIS_LL	0.06	6.33	-	-

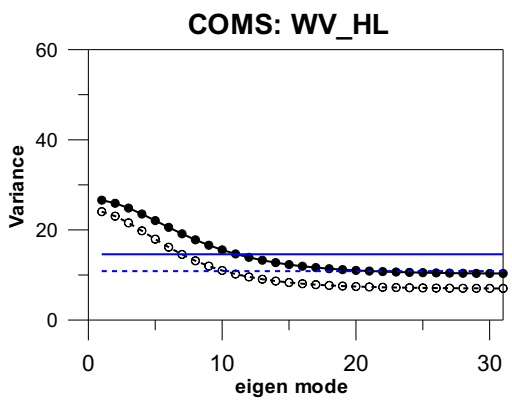
(2) Background_Sonde

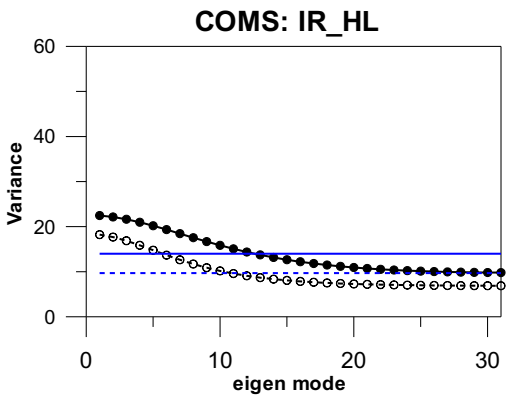
Satellite	COMS		MTSAT	
	R0	L	R0	L
WV_HL	0.37	1.09	0.40	1.08
IR_HL	0.32	0.96	0.33	1.13
IR_ML	0.15	0.89	-	-
IR_LL	0.06	6.43	-	-
VIS_LL	0.18	0.56	-	-

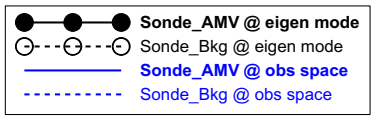
Back-up

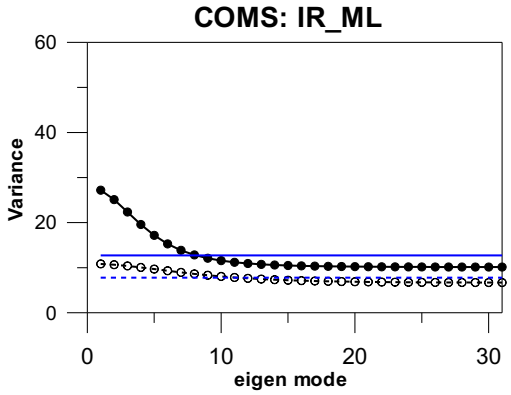

MTSAT: WV_HL
Variance
eigen mode
0
20
40
60
0
10
20
30

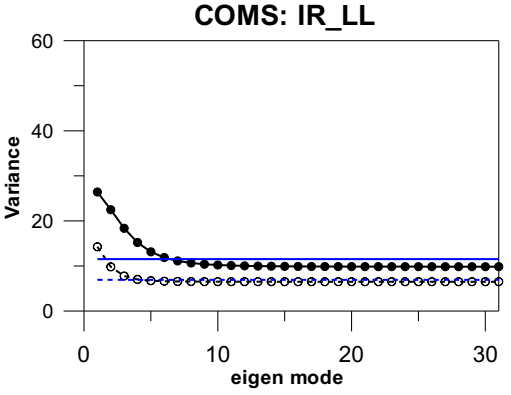

MTSAT: IR_HL
Variance
eigen mode
0
20
40
60
0
10
20
30

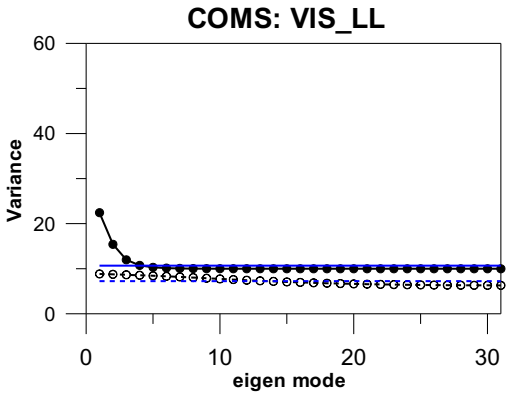

COMS: WV_HL
Variance
eigen mode
0
20
40
60
0
10
20
30


COMS: IR_HL
Variance
eigen mode
0
20
40
60
0
10
20
30

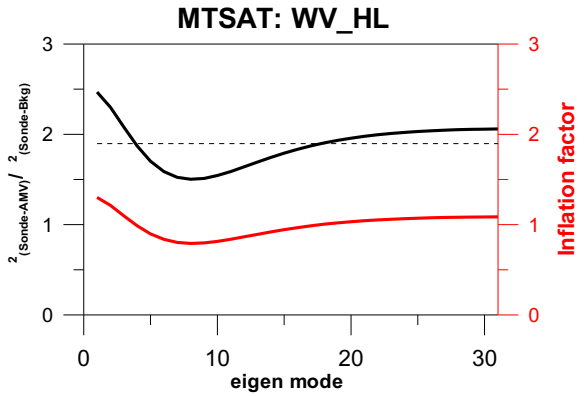

Sonde_AMV @ eigen mode
Sonde_Bkg @ eigen mode
Sonde_AMV @ obs space
Sonde_Bkg @ obs space

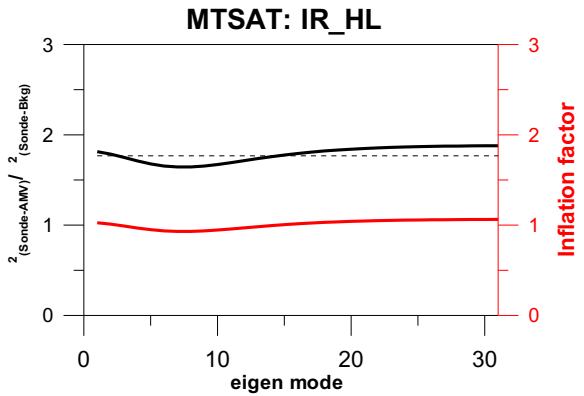

COMS: IR_ML
Variance
eigen mode
0
20
40
60
0
10
20
30

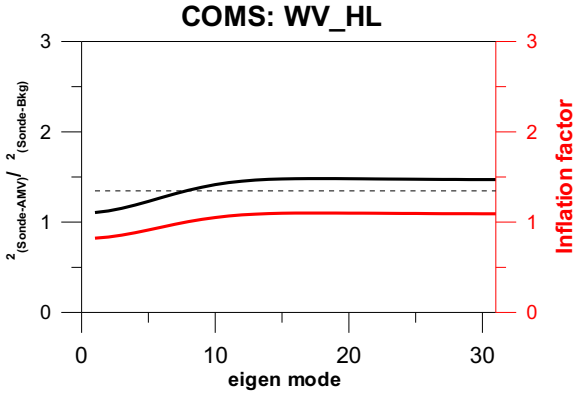

COMS: IR_LL
Variance
eigen mode
0
20
40
60
0
10
20
30

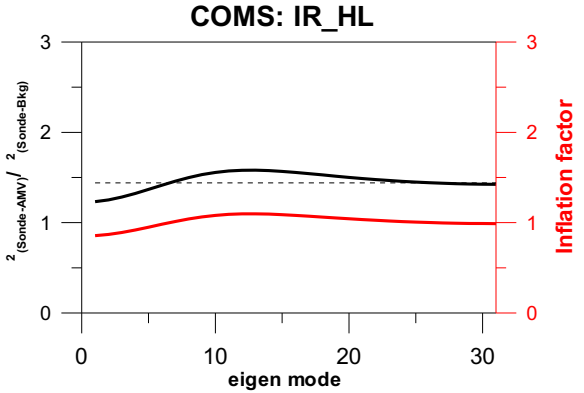

COMS: VIS_LL
Variance
eigen mode
0
20
40
60
0
10
20
30

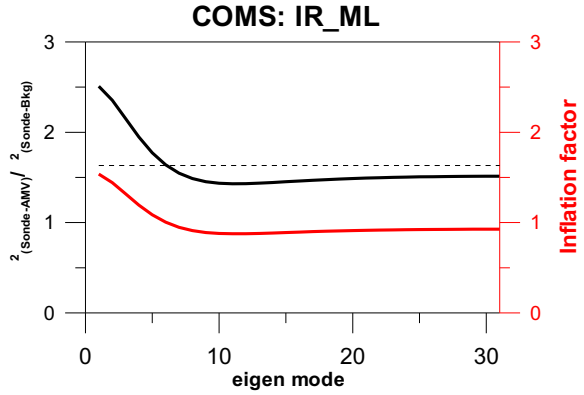
Back-up

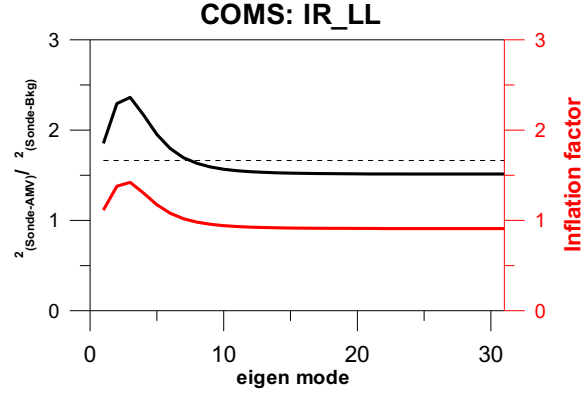

MTSAT: WV_HL
$^2_{(Sonde-AMV)}$ / $^2_{(Sonde-Bkg)}$
Inflation factor
eigen mode

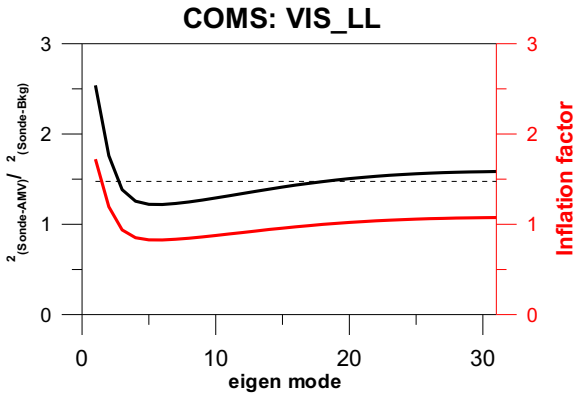

MTSAT: IR_HL
$^2_{(Sonde-AMV)}$ / $^2_{(Sonde-Bkg)}$
Inflation factor
eigen mode


COMS: WV_HL
$^2_{(Sonde-AMV)}$ / $^2_{(Sonde-Bkg)}$
Inflation factor
eigen mode


COMS: IR_HL
$^2_{(Sonde-AMV)}$ / $^2_{(Sonde-Bkg)}$
Inflation factor
eigen mode


COMS: IR_ML
$^2_{(Sonde-AMV)}$ / $^2_{(Sonde-Bkg)}$
Inflation factor
eigen mode


COMS: IR_LL
$^2_{(Sonde-AMV)}$ / $^2_{(Sonde-Bkg)}$
Inflation factor
eigen mode


COMS: VIS_LL
$^2_{(Sonde-AMV)}$ / $^2_{(Sonde-Bkg)}$
Inflation factor
eigen mode