10p.07

Development of AMSU-A Pre-processing and Quality Control Modules at KIAPS Observation Processing System

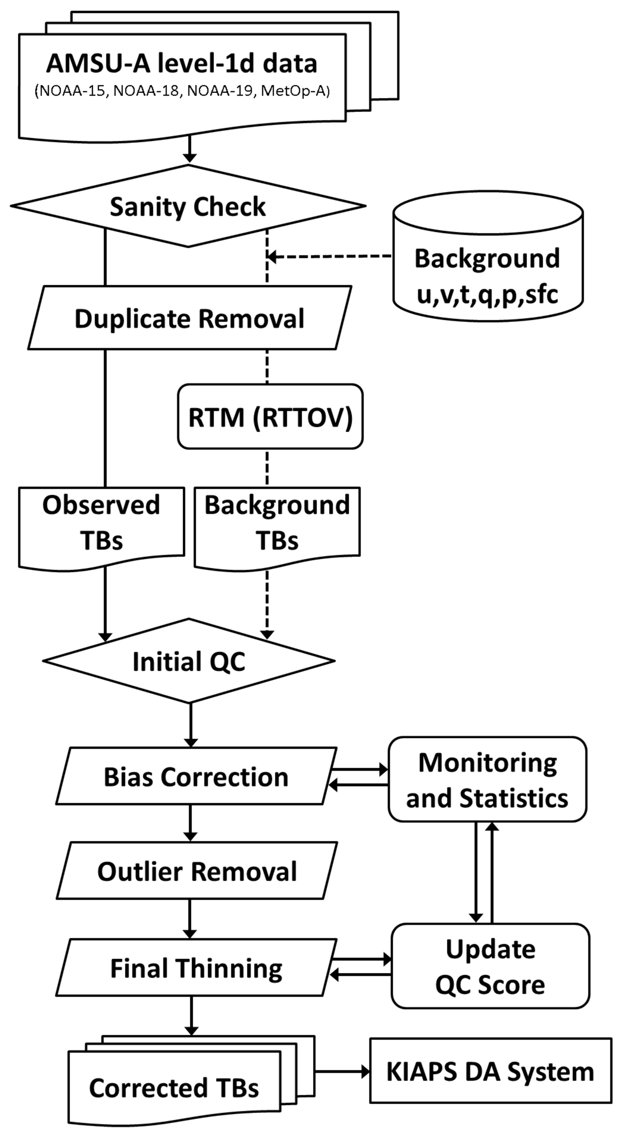
Sihye Lee, Ju-Hye Kim, Jeon-Ho Kang, and Hyoung-Wook Chun

Korea Institute of Atmospheric Prediction Systems (KIAPS), Seoul, South Korea

INTRODUCTION

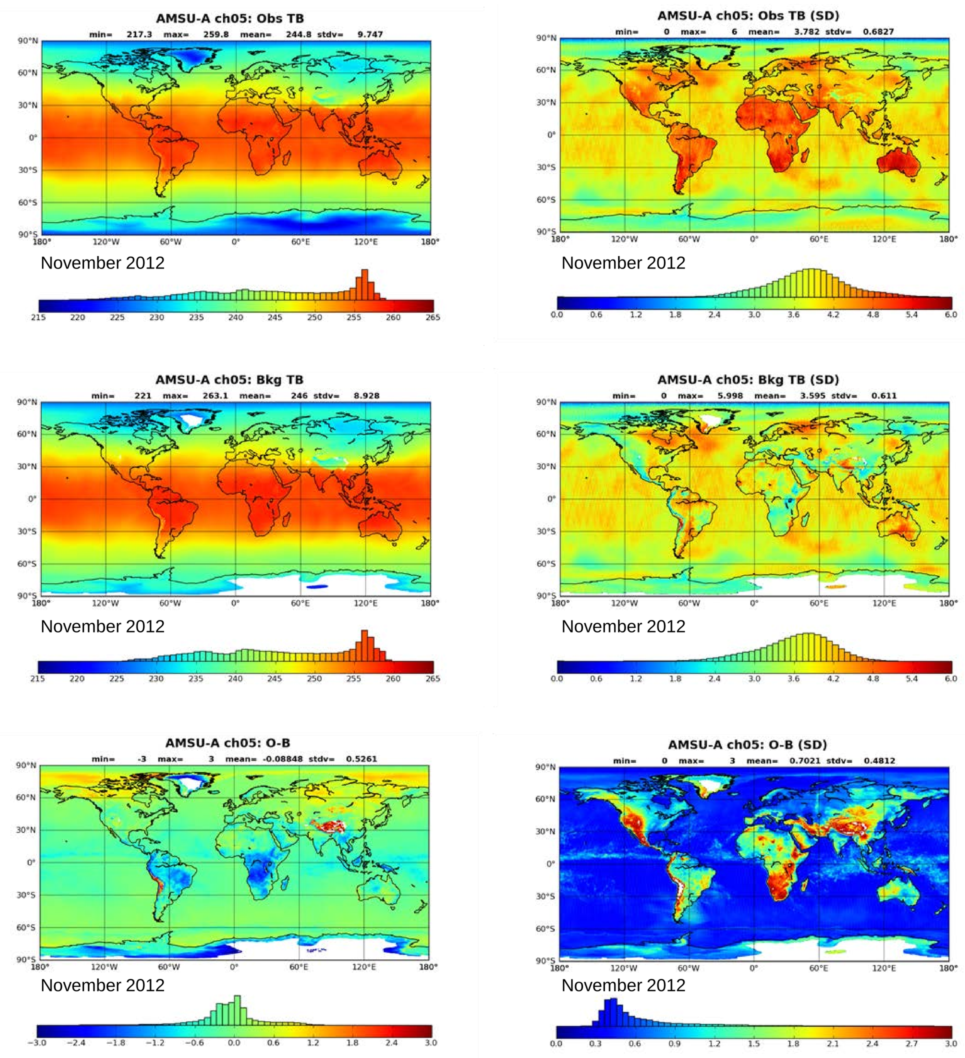
- Microwave radiometers onboard satellites have been used to measure a wide variety of atmospheric and surface parameters. The Advanced Microwave Sounding Unit-A (AMSU-A) is one of the satellites with the largest impact to reduce forecast errors in data assimilation.
- All data assimilation systems are affected by biases, caused by problems with the data, by approximations in the observation operators used to simulate the data, by limitations of the assimilating model, or by the assimilation methodology itself. A clear symptom of bias in the assimilation is the presence of systematic features in the analysis increments (Dee, 2005).
- The objective of this study is to introduce the AMSU-A radiance pre-processing and quality control modules including bias correction at the KIAPS observation processing system.

KIAPS AMSU-A Processing System



- **Observation Extraction:** AMSU-A level-1d radiance data have been extracted using the ECMWF BUFR decoder.
- **Sanity Check:** Physical reality checks on geolocation and observation, blacklisting of broken channels, and QC flagging for clear-sky radiance assimilation.
- **Background Ingest:** Atmospheric variables of model background have been matched to the observation state with space interpolation.
- **First Thinning:** Duplicate observations in a defined grid box have been eliminated using the removal scores.
- **Observation Operator:** The RTTOV_10.2 fast RTM have been implemented to convert the atmospheric variables of model state to the radiance of observation state, and to calculate the Jacobian matrices of model state.
- **Initial Quality Control:** The pixels contaminated by cloud, precipitation, and sea ice have been removed and assimilation channels have been selected, with considering surface type and topography.
- **Bias Correction:** Scan and airmass bias correction modules have been developed in two steps based on 30-day innovation statistics.
- **Outlier Removal:** The expected standard deviation of first guess (FG) departure has been estimated from assigned observation errors to eliminate outliers.
- **Final Thinning:** Final thinning have been performed with considering the assimilation resolutions, and then survived radiance data have been prepared to pass KIAPS data assimilation system.
- **Monitoring and Statistics:** Bias correction coefficients and observation errors have been updated by off-line monitoring codes of statistics and QC scores.

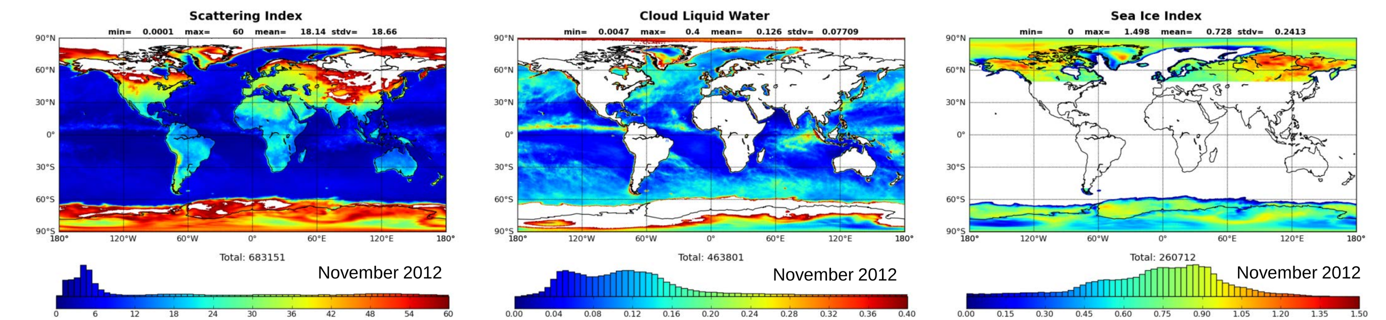
❖ Extracted AMSU-A radiance data (TB) monitoring



- **Observed TB (0.35° x 0.23°)**
  In channel 5, monthly mean of observed TB is high at low latitude for November 2012, but it decreases at high latitude. The land variability (i.e., standard deviation) is more than ~4.5 K.
- **Background TB (0.35° x 0.23°)**
  Monthly mean of background (Unified Model output: e.g., qwqu00.pp_006) is similar to observed TB but land variation of background TB is less than that of observation.
- **O-B (innovation)**
  Both monthly mean and standard deviation of innovation are high in land, especially for high topography such as the Andes mountains and desert area.

Quality Control and Bias Correction

❖ QC flags: Scattering index, Cloud liquid water, Sea ice index [Grody et al., 1999, 2001]



Threshold for initial QC
- Scatt Index > 40
- CLW > 0.2
- Sea-ice index > 50

$$Scatt\_indx = -113.2 + (2.41 - 0.0049 T_{B(CH1)}) T_{B(CH1)} + 0.454 T_{B(CH2)} - T_{B(CH15)}$$

$$CLW = \mu[D_0 + 0.754 \ln(285.0 - T_{B(CH1)}) - 2.265 \ln(285.0 - T_{B(CH2)})]$$

$$D_0 = 8.240 - (2.622 - 1.846\mu)\mu$$

$$\mu = \cos(sat\_zenith)$$

For latitudes beyond 50 degrees of the equator,

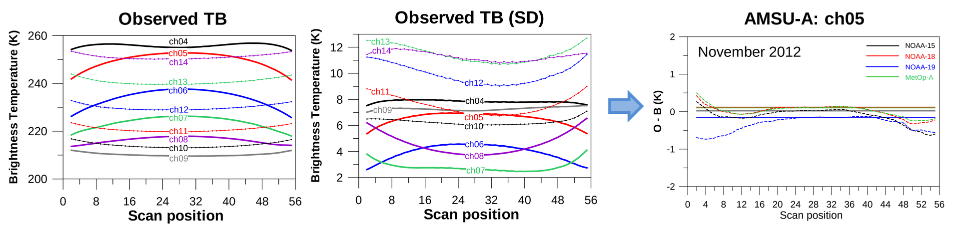
$$Seaice\_indx = 2.85 + 0.20 T_{B(CH1)} - 0.028 T_{B(CH3)}$$

❖ Bias correction

(1) Step 1: mean innovation at each scan angle to equal to the mean innovation at the center scan angle

$$b_{j,s}^{scan}(\theta) = (O-B)_{j,s}(\theta) - (O-B)_{j,s}(\theta = 0)$$

b^{scan}: scan bias j: channel s: satellite θ: scan angle



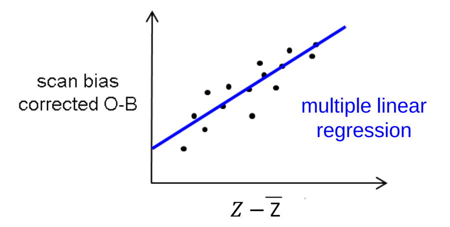
Similar patterns for observed and background TBs

(2) Step 2: global multiple linear regression of the scan-corrected innovations against 4 predictors (thickness 850-300, 200-50, 50-5, 10-1 hPa) to correct the airmass bias

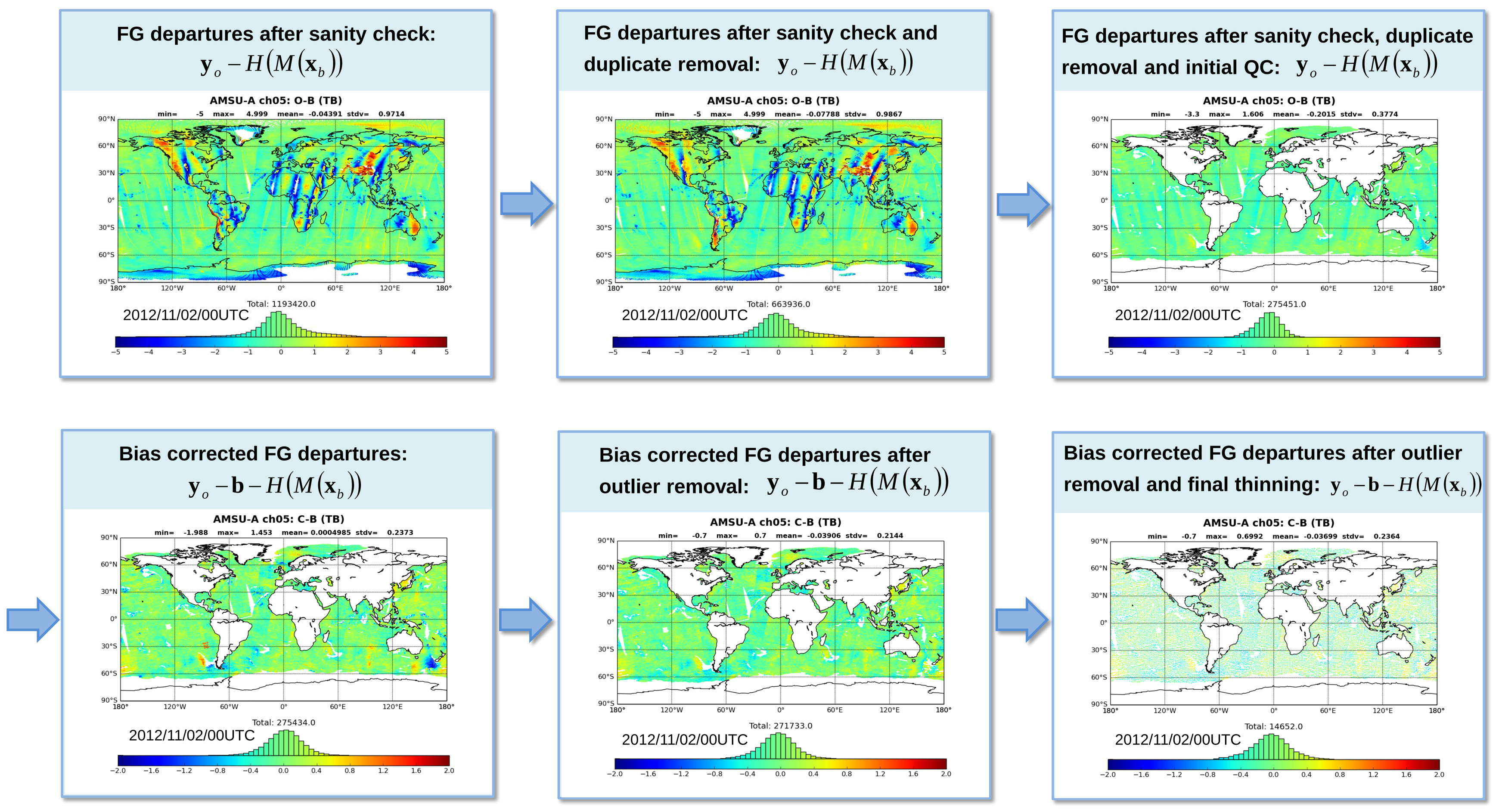
$$b_{j,s}^{air} = a_{j,s}(Z_{850} - \overline{Z}_{850}) + b_{j,s}(Z_{200} - \overline{Z}_{200}) + c_{j,s}(Z_{50} - \overline{Z}_{50}) + d_{j,s}(Z_{10} - \overline{Z}_{10}) + e_{j,s}$$

b^{air}: airmass bias j: channel s: satellite a, b, c, d, e: airmass coefficients

Z_{850}: $Thickness_{850-300}$ Z_{200}: $Thickness_{200-50}$ Z_{50}: $Thickness_{50-10}$ Z_{10}: $Thickness_{10-1}$

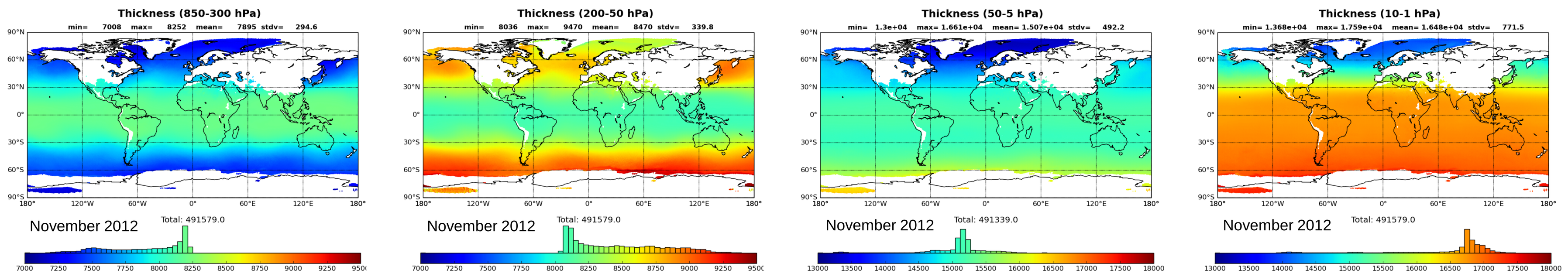


❖ Global distributions for quality control and bias correction



Multicollinearity of Airmass Predictors

❖ Spatial distributions of airmass predictors



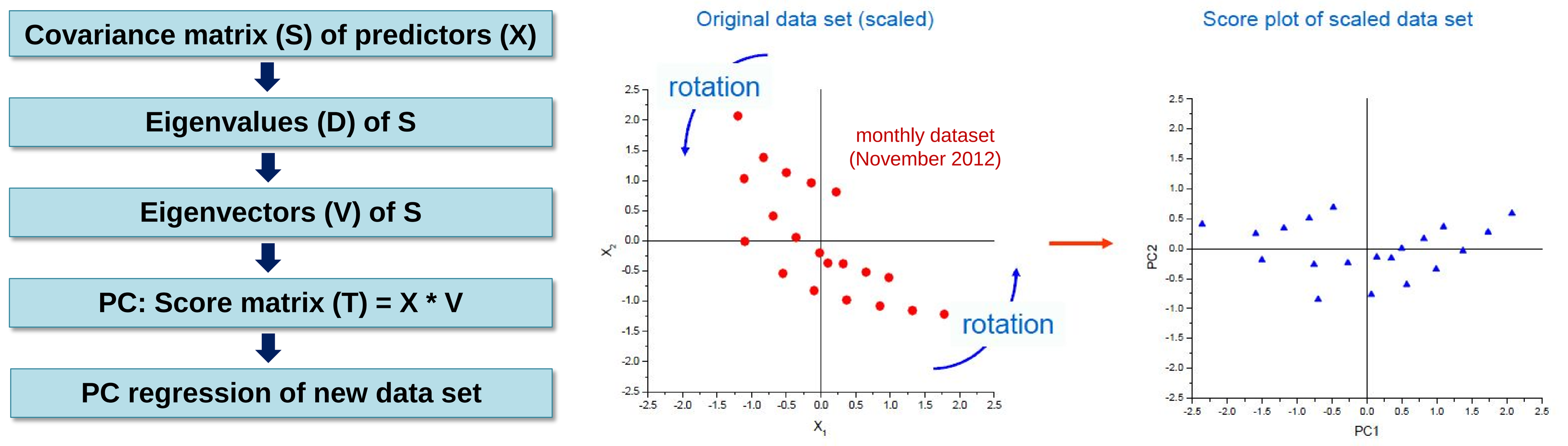
✓ **Problems in multiple linear regression**
- Multicollinearity is a statistical phenomenon in which two or more predictor variables are highly correlated.
- In this situation the coefficient of the multiple regression may change erratically in response to small changes, and it may not give valid results about estimation of parameters.
- Variance Inflation Factor (VIF)

$$VIF_j = \frac{1}{1 - R_j^2}$$

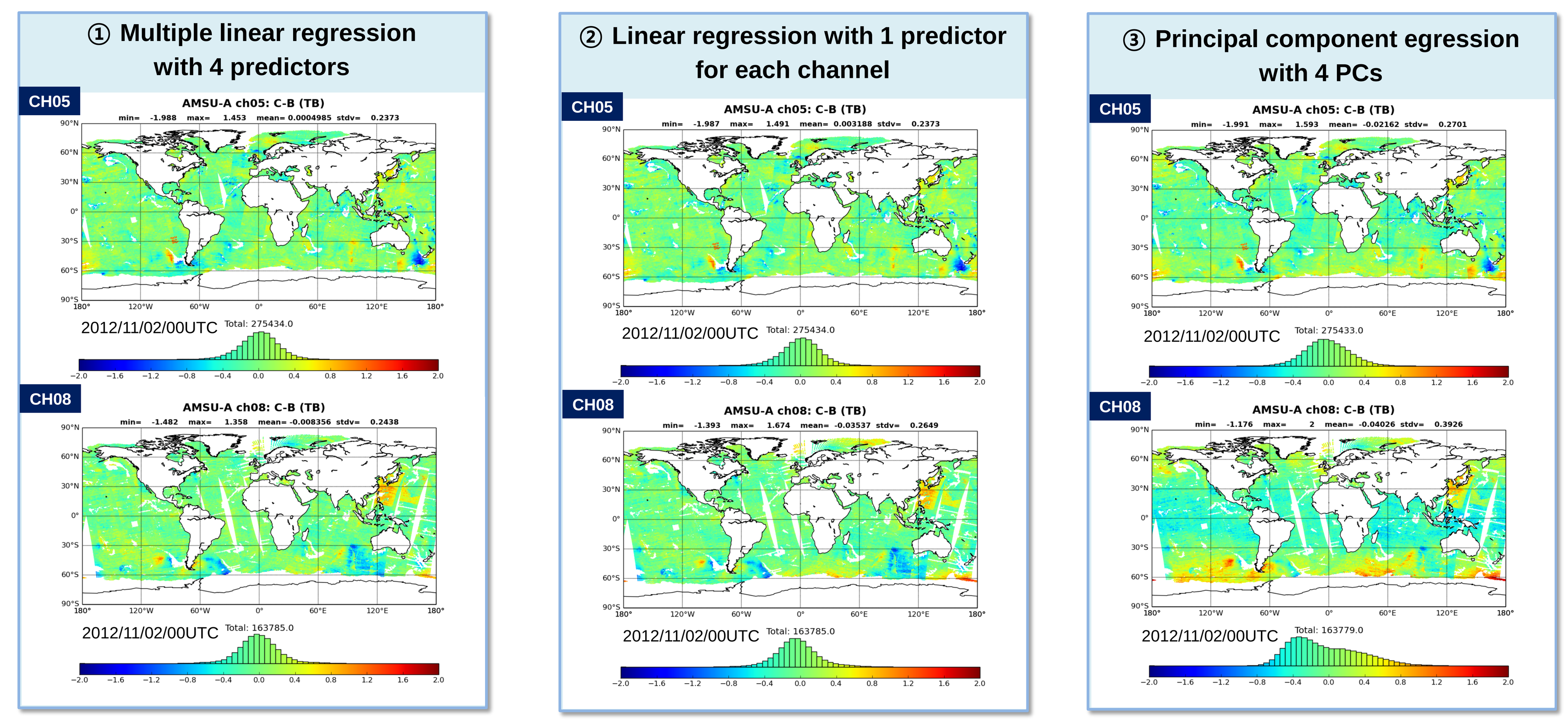
$Thick_{850-300}$	$Thick_{200-50}$	$Thick_{50-5}$	$Thick_{10-1}$
1.04	1.04	10.42	1.24

✓ **Remedies for multicollinearity of airmass predictors**
- Selection of different airmass predictors or one predictor
- Ridge regression or principle component regression (PCR) with 4 atmospheric thickness predictors

❖ Step of PCR to calculate new airmass bias coefficients



❖ Experiments to remedy multicollinearity



SUMMARY

- We have developed the AMSU-A data pre-processing and quality control system to provide the well-qualified radiance data for KIAPS data assimilation system.
- It appears to be successful in controlling the scan and airmass bias in the crucial channels which sound tropospheric and stratospheric temperature below 50 km altitude.
- However, multicollinearity is observed when 4 thickness predictors are highly correlated among themselves. We have tried to find a small set of linear combinations of the covariates which are uncorrelated with each other. As a result, multicollinearity of predictors are resolved with PCR of 4 PCs, the bias correction performance at lower stratospheric channels is not shown improved much, though.