Buddy check for radiance with analysis error variance

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KIAPS
KOREA INSTITUTE OF
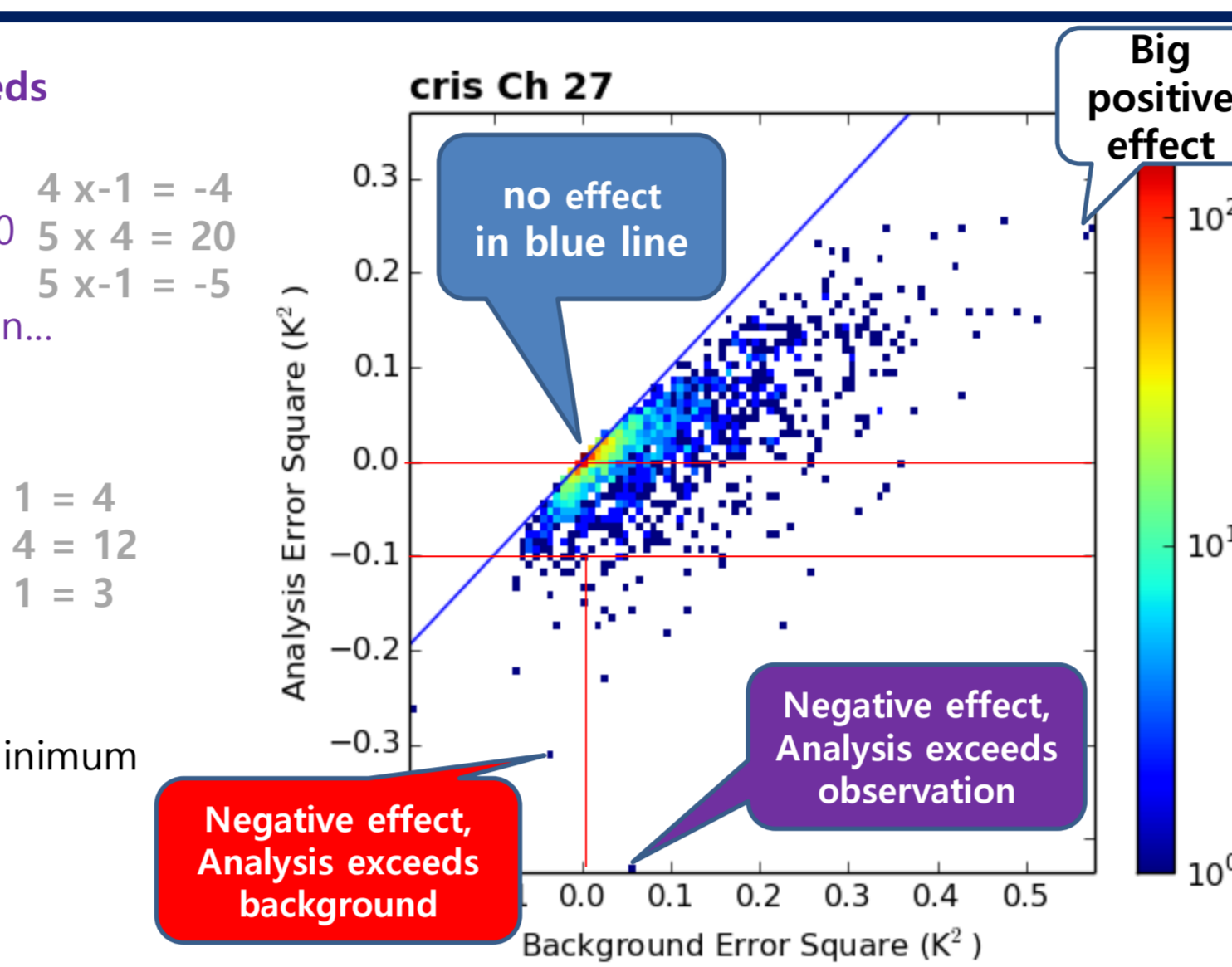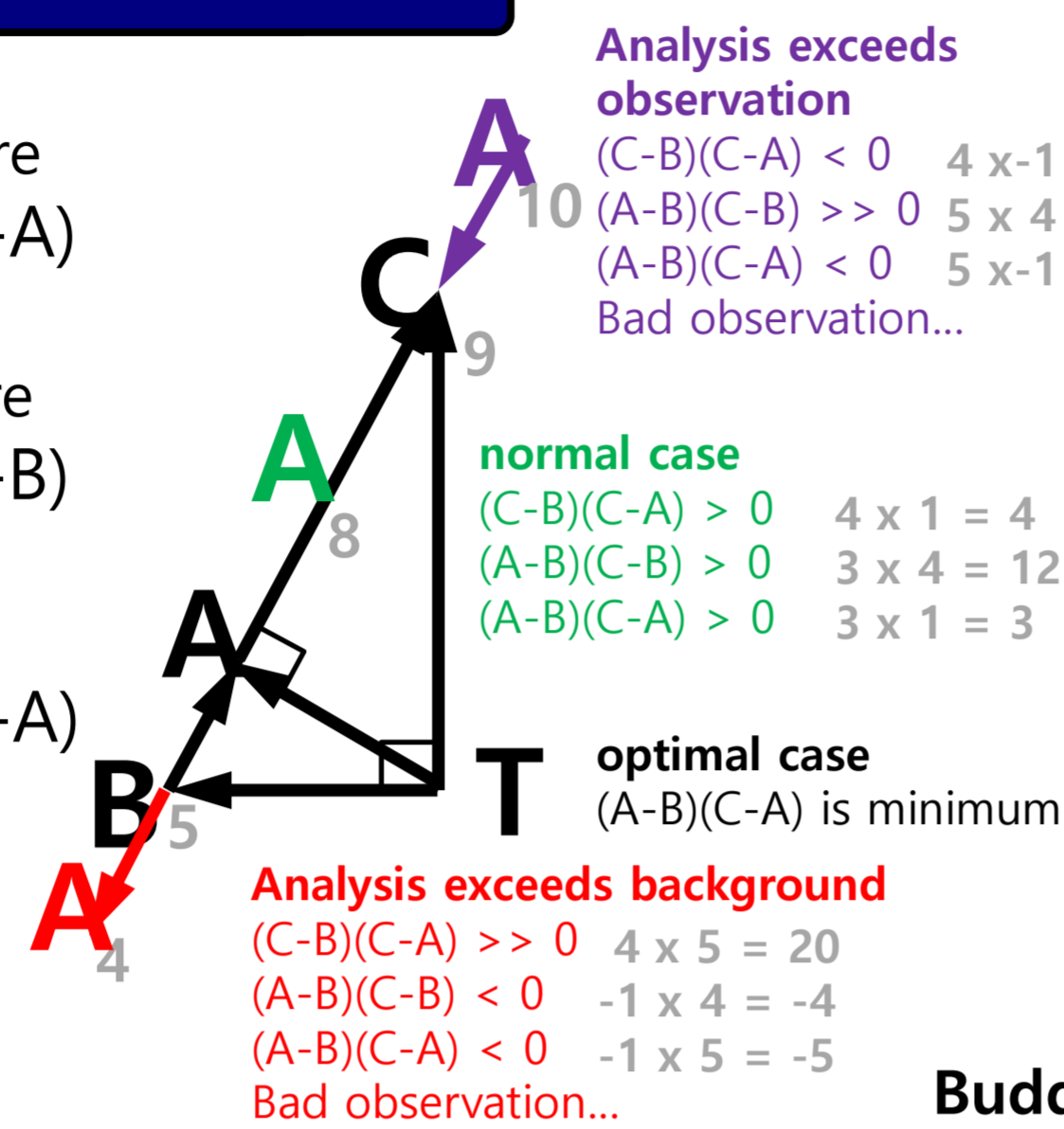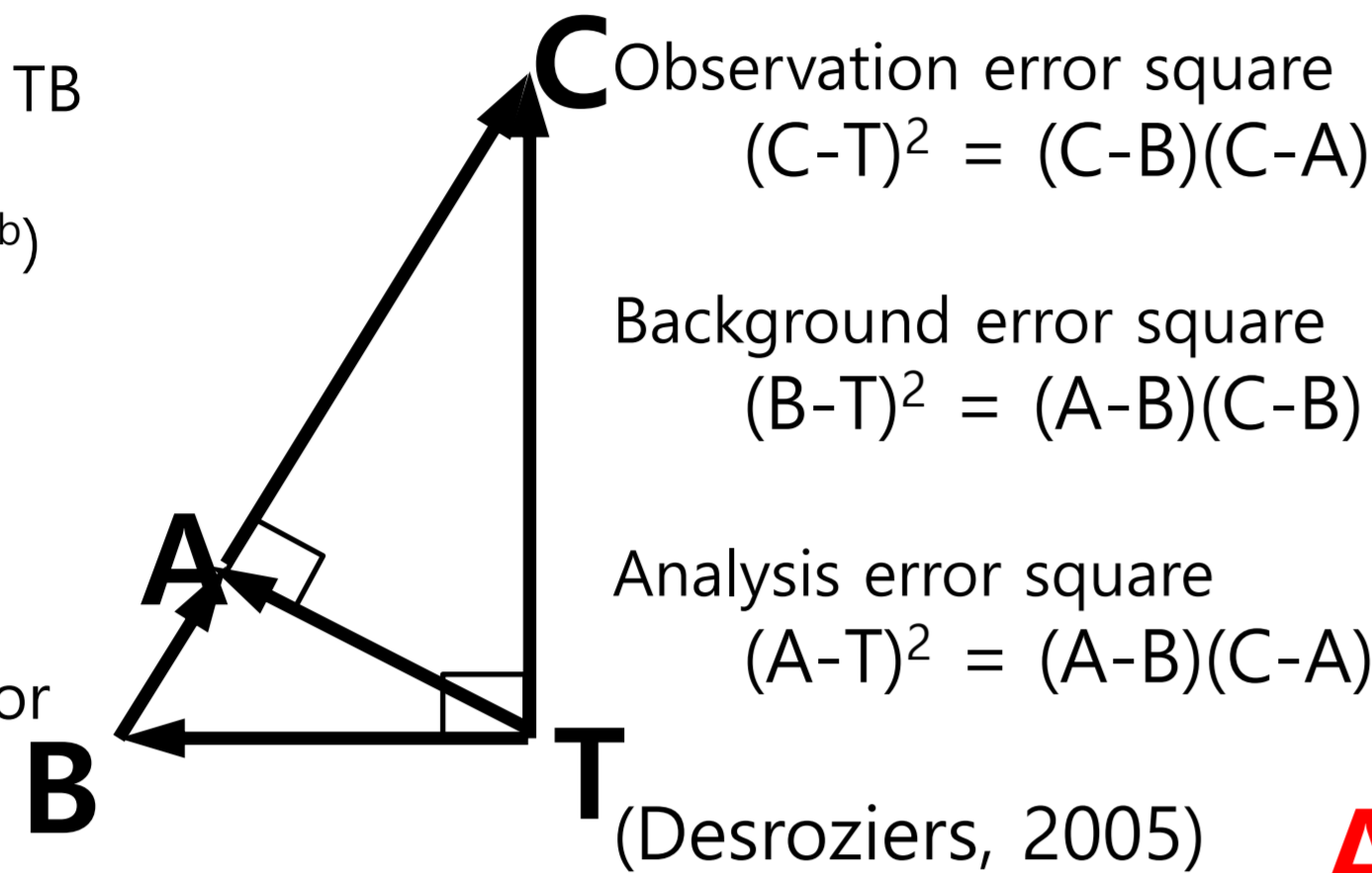ATMOSPHERIC PREDICTION SYSTEMS

Introduction

The analysis error variances are calculated as the product of increment and analysis departure, so they should normally be positive value at each observation point. But the analysis error variances are negative when the given observation has different signal from other observations in the vicinity because the analysis does not exist between the background and the observation.

The process of eliminating observation with large negative analysis error variance is defined as buddy check in this study. The buddy check is adapted for satellite radiance data such as IASI, CrIS, AMSUA, ATMS, and MHS, after first outer loop in data assimilation process of Korea Institute of Atmospheric Prediction Systems (KIAPS)

Buddy check method

C: corrected observed TB

B: background TB, $H(x^b)$

A: analysis TB, $H(x^a)$

T: true TB, $H(x^t)$

H: observation operator

x: model space

TB: brightness temperature, observation space

Observation error square
$$(C-T)^2 = (C-B)(C-A)$$

Background error square
$$(B-T)^2 = (A-B)(C-B)$$

Analysis error square
$$(A-T)^2 = (A-B)(C-A)$$

(Desroziers, 2005)

Analysis exceeds observation
(C-B)(C-A) < 0   4 x-1 = -4
(A-B)(C-B) >> 0   5 x 4 = 20
(A-B)(C-A) < 0   5 x-1 = -5
Bad observation...

normal case
(C-B)(C-A) > 0   4 x 1 = 4
(A-B)(C-B) > 0   3 x 4 = 12
(A-B)(C-A) > 0   3 x 1 = 3

optimal case
(A-B)(C-A) is minimum

Analysis exceeds background
(C-B)(C-A) >> 0   4 x 5 = 20
(A-B)(C-B) < 0   -1 x 4 = -4
(A-B)(C-A) < 0   -1 x 5 = -5
Bad observation...

cris Ch 27

no effect in blue line

Big positive effect

Negative effect, Analysis exceeds observation

Negative effect, Analysis exceeds background

Buddy check: Each observation is rejected when
(A-B)(C-A) < c* obs.err

Bkg TB
Outer Loop 1
ObsPosition1, AnITB1
Buddy check
Outer Loop 2
ObsPosition2, AnITB2
Buddy check
Outer Loop 3
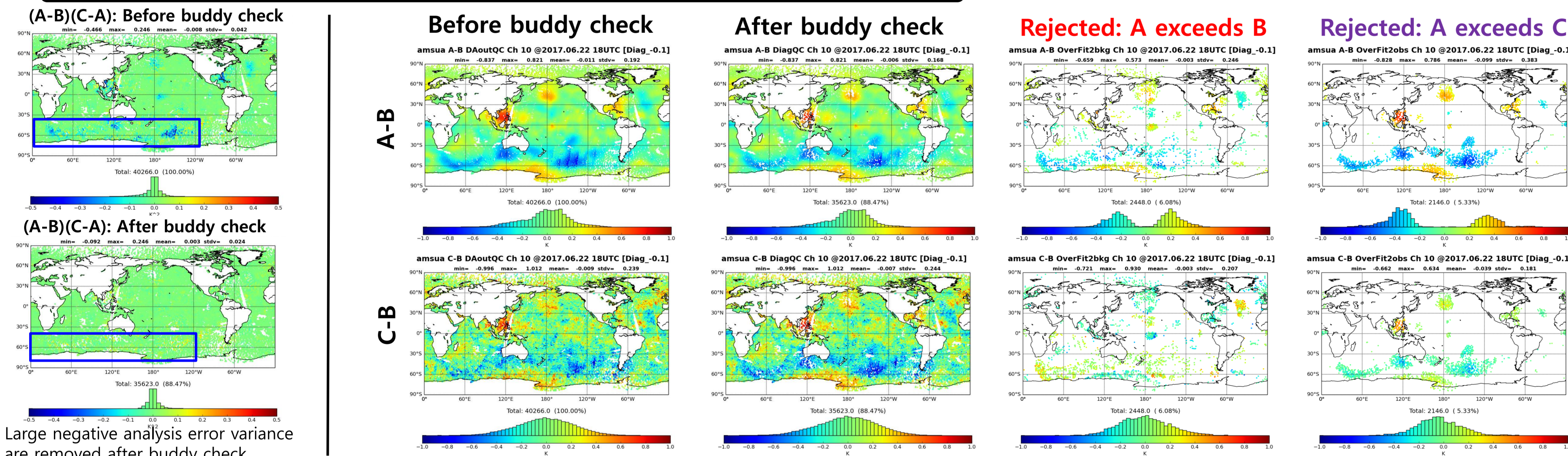ObsPosition3, AnITB3
Buddy check
Outer Loop 4

Settings
- Model: KIM 91L ne120 (~25 km)
- DA: HybDA ne60 (~50 km) without ensemble loop
- Used data: Sonde, Aircraft, Surface, GPSRO, AMV, SCATWIND, IASI, CrIS, ASMUA, ATMS, MHS, COMS
- Period: 2017.06.22-07.31
- 6hour forecast cycle run

Experiments
- Diag_off: No buddy check (CTRL)
- Diag_-3.0: Buddy check as follows
  (A-B)(C-A) <-3.0 *obs.err
- AexB_-3.0: reject only A exceeds B
 (A-B)(C-A) <-3.0 *obs.err
  (A-B)(C-B) < 0

Application Buddy check to AMSUA ch. 10

Date: 2017.06.22 18UTC, Buddy check: (A-B)(C-A) < -0.1 * obs.err   We applied a strict buddy check to clearly identify the effect.

(A-B)(C-A): Before buddy check

(A-B)(C-A): After buddy check

Large negative analysis error variance are removed after buddy check

Before buddy check

After buddy check
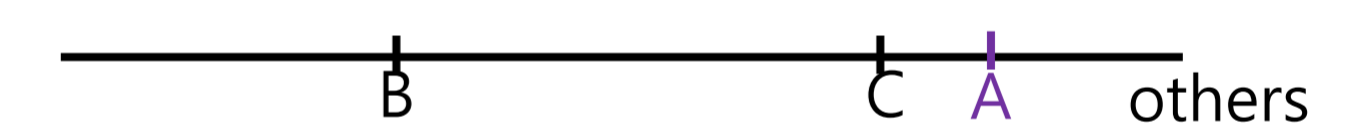
Rejected: A exceeds B

Rejected: A exceeds C

Buddy check is not the outlier rejection on C-B. So the standard deviation of C-B is not reduce after buddy check.
- Before buddy check: stddev of C-B = 0.239
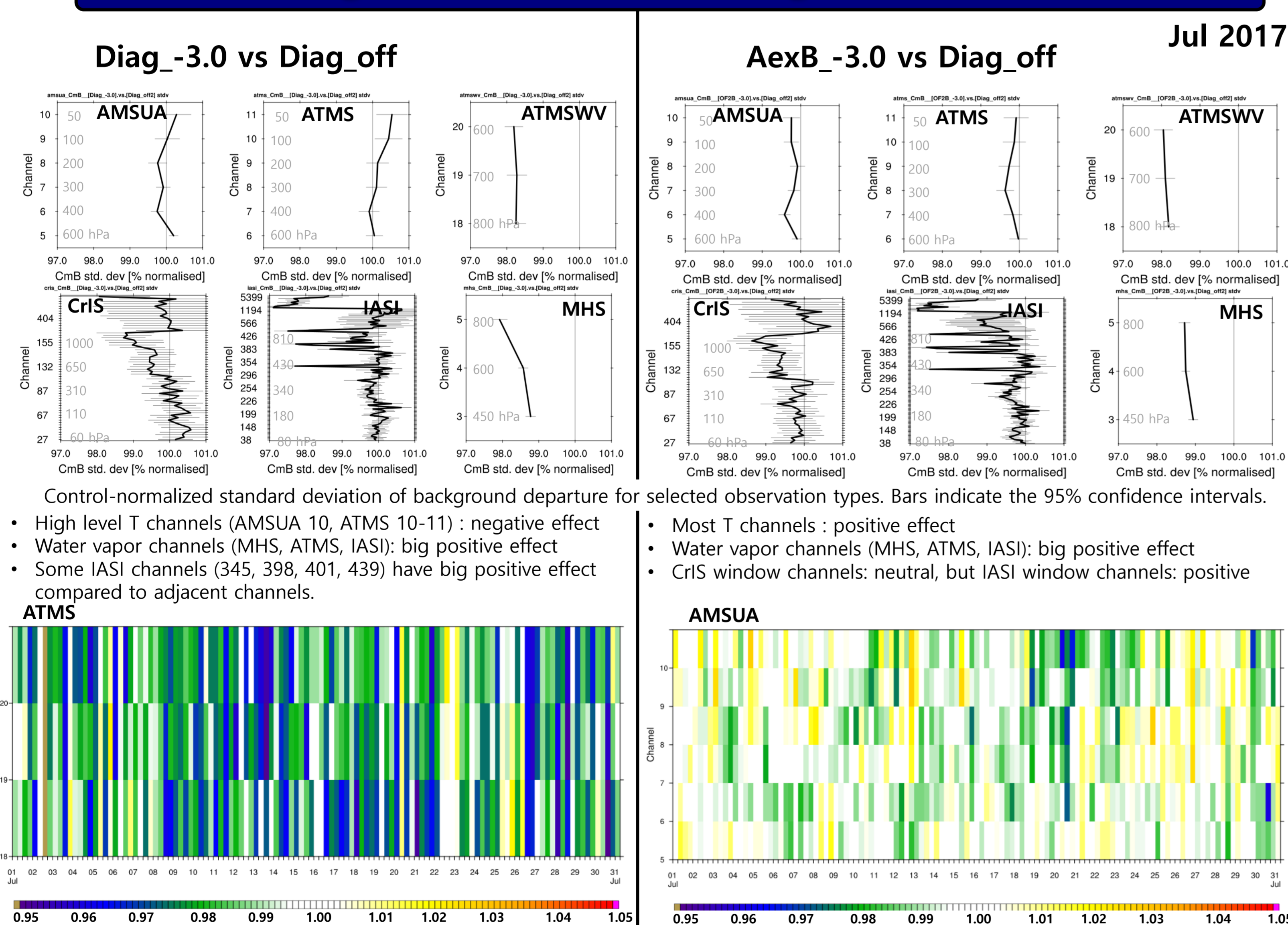- After buddy check: stddev of C-B = 0.244

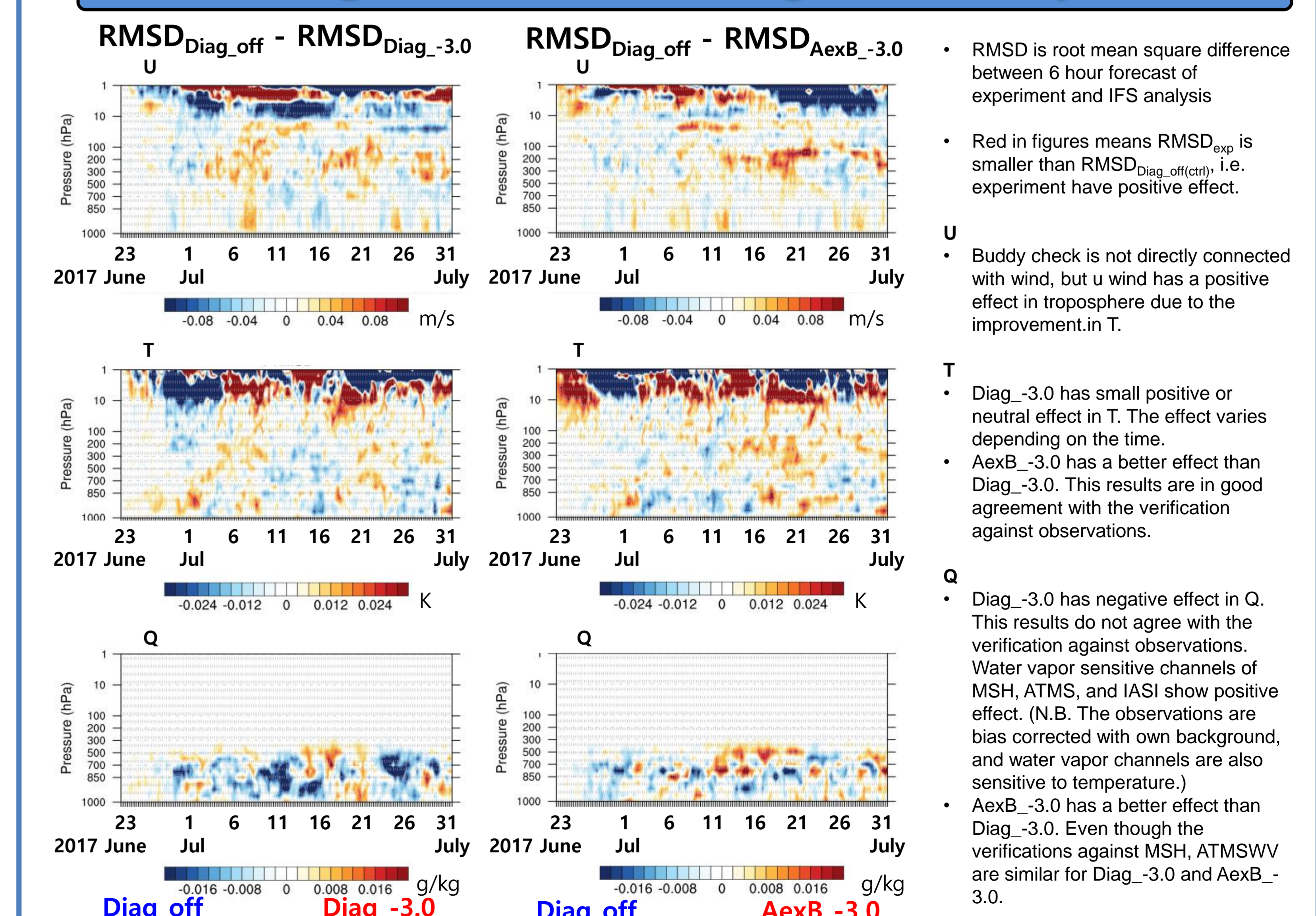Buddy check reject the observation when its C-B is opposite the sign of many others
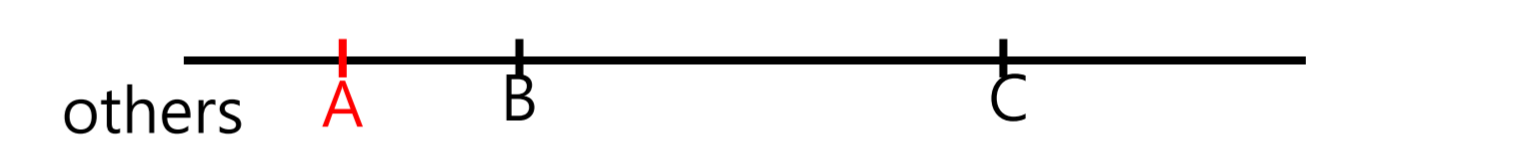
And also buddy check reject the observation when its C-B is smaller than the magnitude of many others

Short range forecast verification against Observations

Diag_-3.0 vs Diag_off

AexB_-3.0 vs Diag_off

Jul 2017

AMSUA   ATMS   ATMSWV

CrIS   IASI   MHS

Control-normalized standard deviation of background departure for selected observation types. Bars indicate the 95% confidence intervals.

- High level T channels (AMSUA 10, ATMS 10-11) : negative effect
- Water vapor channels (MHS, ATMS, IASI): big positive effect
- Some IASI channels (345, 398, 401, 439) have big positive effect compared to adjacent channels.

- Most T channels : positive effect
- Water vapor channels (MHS, ATMS, IASI): big positive effect
- CrIS window channels: neutral, but IASI window channels: positive

ATMS

AMSUA

Short range forecast verification against IFS analysis

RMSD_Diag_off - RMSD_Diag_-3.0

RMSD_Diag_off - RMSD_AexB_-3.0

- RMSD is root mean square difference between 6 hour forecast of experiment and IFS analysis

- Red in figures means RMSD_exp is smaller than RMSD_Diag_off(ctrl), i.e. experiment have positive effect.

U
- Buddy check is not directly connected with wind, but u wind has a positive effect in troposphere due to the improvement in T.

T
- Diag_-3.0 has small positive or neutral effect in T. The effect varies depending on the time.
- AexB_-3.0 has a better effect than Diag_-3.0. This results are in good agreement with the verification against observations.

Q
- Diag_-3.0 has negative effect in Q. This results do not agree with the verification against observations. Water vapor sensitive channels of MSH, ATMS, and IASI show positive effect. (N.B. The observations are bias corrected with own background, and water vapor channels are also sensitive to temperature.)
- AexB_-3.0 has a better effect than Diag_-3.0. Even though the verifications against MSH, ATMSWV are similar for Diag_-3.0 and AexB_-3.0.

Diag_off   Diag_-3.0   Diag_off   AexB_-3.0

Summary

- Buddy check works well to remove the observations which have a different effect from most other observations.
- We have verified how removing the data with buddy check had an effect on short rage forecast.

- There was a positive effect on temperature in the verification against observation and IFS analysis, especially AexB_-3.0 which reject only the observation when its C-B is opposite the sign of many others.

- Water vapor was strongly positive for the verification against MHS, ATMS and IASI. On the other hand, the verification against IFS analysis showed negative or neutral effect.

Future Works
- Fitting the threshold for each observation
- Investigation of removal data with buddy check to improve QC or blacklisting
- Setting large observation errors instead of removing the data