IASI channel selection
for the Unified Model data assimilation

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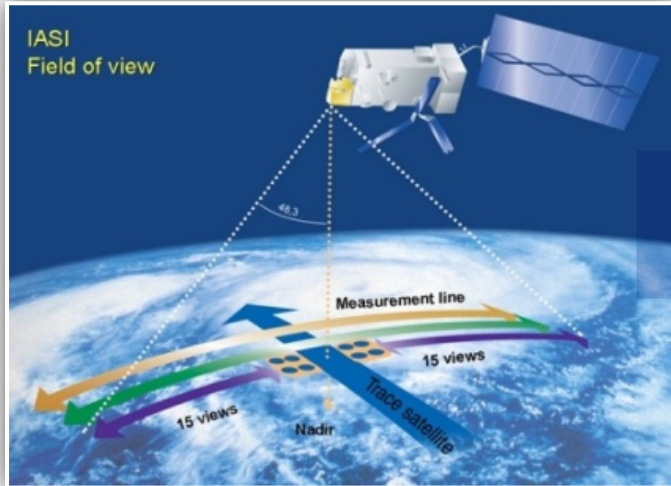
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Necessity of IASI channel selection

IASI observations

Unified Model


(Development agency)

IASI channel selection

Huge volume of observations from 8461 channels
Insufficient ability of RTM (i.e. SW IR)
Degradation of some specific channels

- **Only 314 channels of the total 8461 are recommended for the data assimilation purpose, and 183 channels are used in UM model assimilation system.**

- **Since 2007 a subset of selected 314 IASI channels has been operationally used in UM DA. In the mean time, skills of NWP model and RTM have been improved, and it would be beneficial to re-examine the performance.**

Collard (2007)

IASI 300 channels
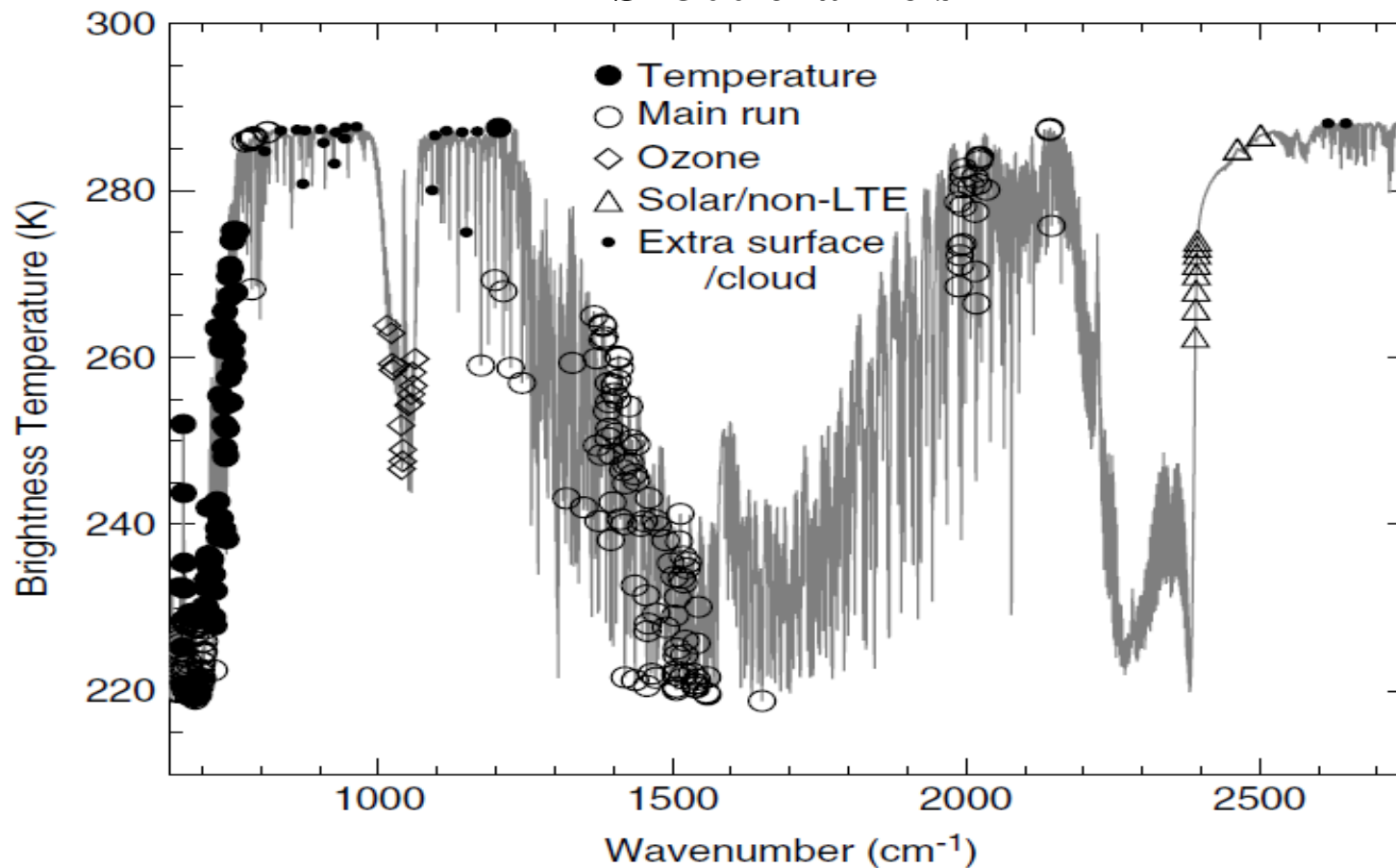
- **Removing channels with large forward-model uncertainty**

    - **Channels dominated by trace gases (i.e. CH$_4$)**

    - **Channels in the spectrum where the RT calculations are problematic**

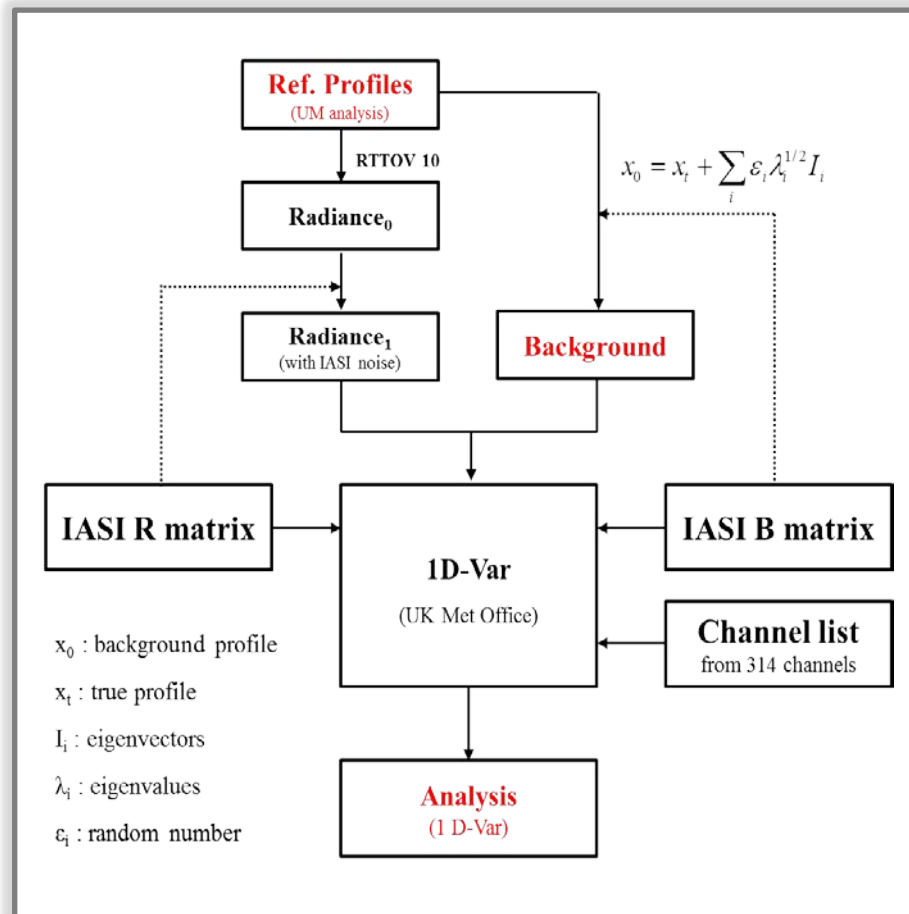# Method of IASI channel selection

Basic framework of 1 D-Var

$$x_0 = x_t + \sum_i \varepsilon_i \lambda_i^{1/2} I_i$$

Ref. Profiles (UM analysis)

RTTOV 10

Radiance$_0$

Radiance$_1$ (with IASI noise)

Background

IASI R matrix

1D-Var (UK Met Office)

IASI B matrix

Channel list from 314 channels

x_0 : background profile
x_t : true profile
I_i : eigenvectors
λ_i : eigenvalues
ε_i : random number

Analysis (1 D-Var)

Figure of merit

$$CSI_i = \sum_{j=1}^{N} [1 - \frac{RMSE(A)_{i,j}}{RMSE(B)_j}] w_j$$

$$RMSE(A)_{i,j} = \sqrt{\frac{\sum_{k=1}^{M} \left(X_{i,j,k}^a - X_{j,k}^t\right)^2}{M}}$$

$$RMSE(B)_j = \sqrt{\frac{\sum_{K=1}^{M} \left(X_{j,k}^b - X_{j,k}^t\right)^2}{M}}$$

X^a : state vector of **Analysis**

X^b : state vector of **Background**

X^t : state vector of **Reference**

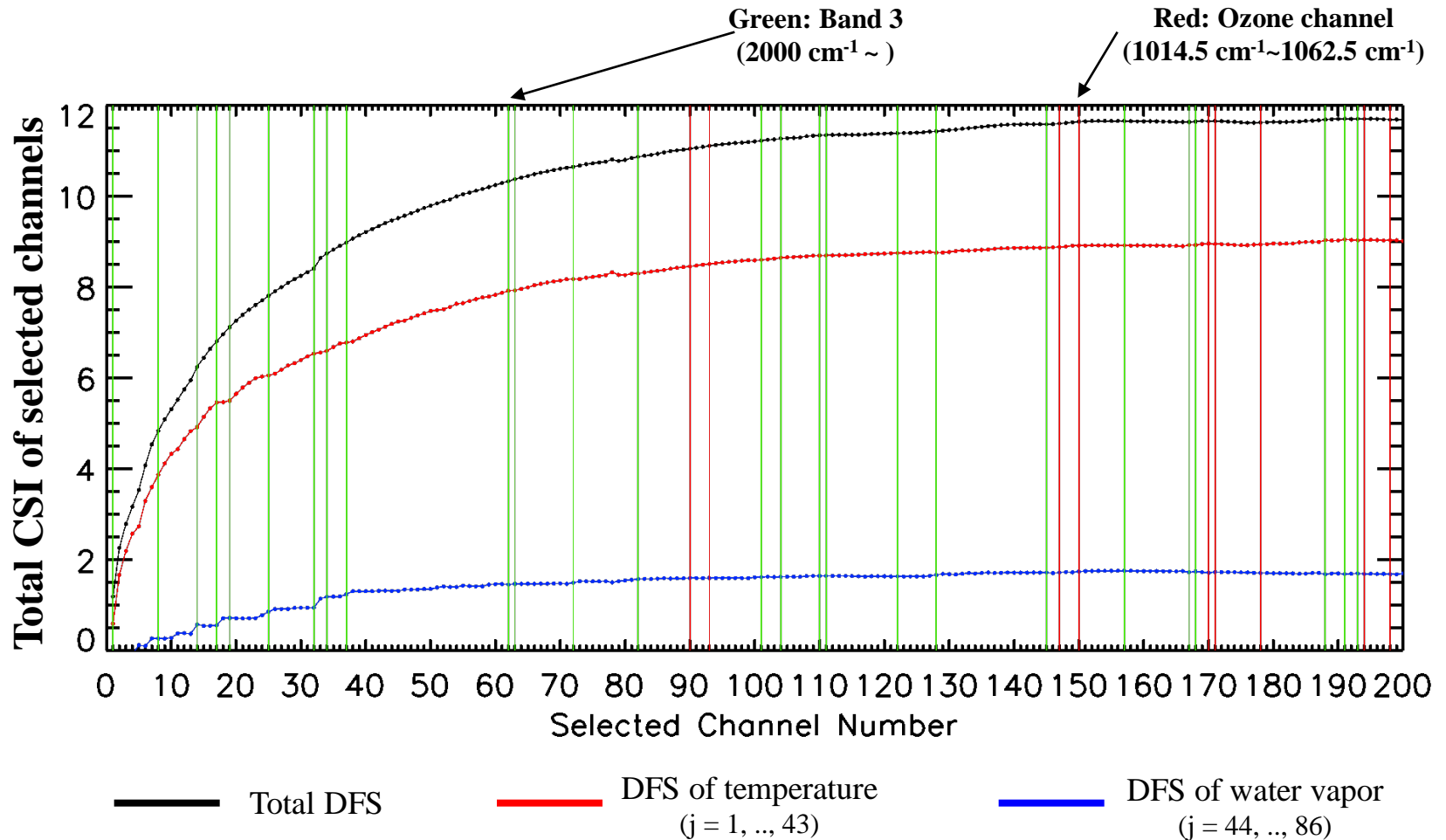*** Channel Score Index (CSI)**

CSI ≤ 0 (no improvement)

CSI ≥ 0 (improvement)

Cumulative CSI by selected 200 channels

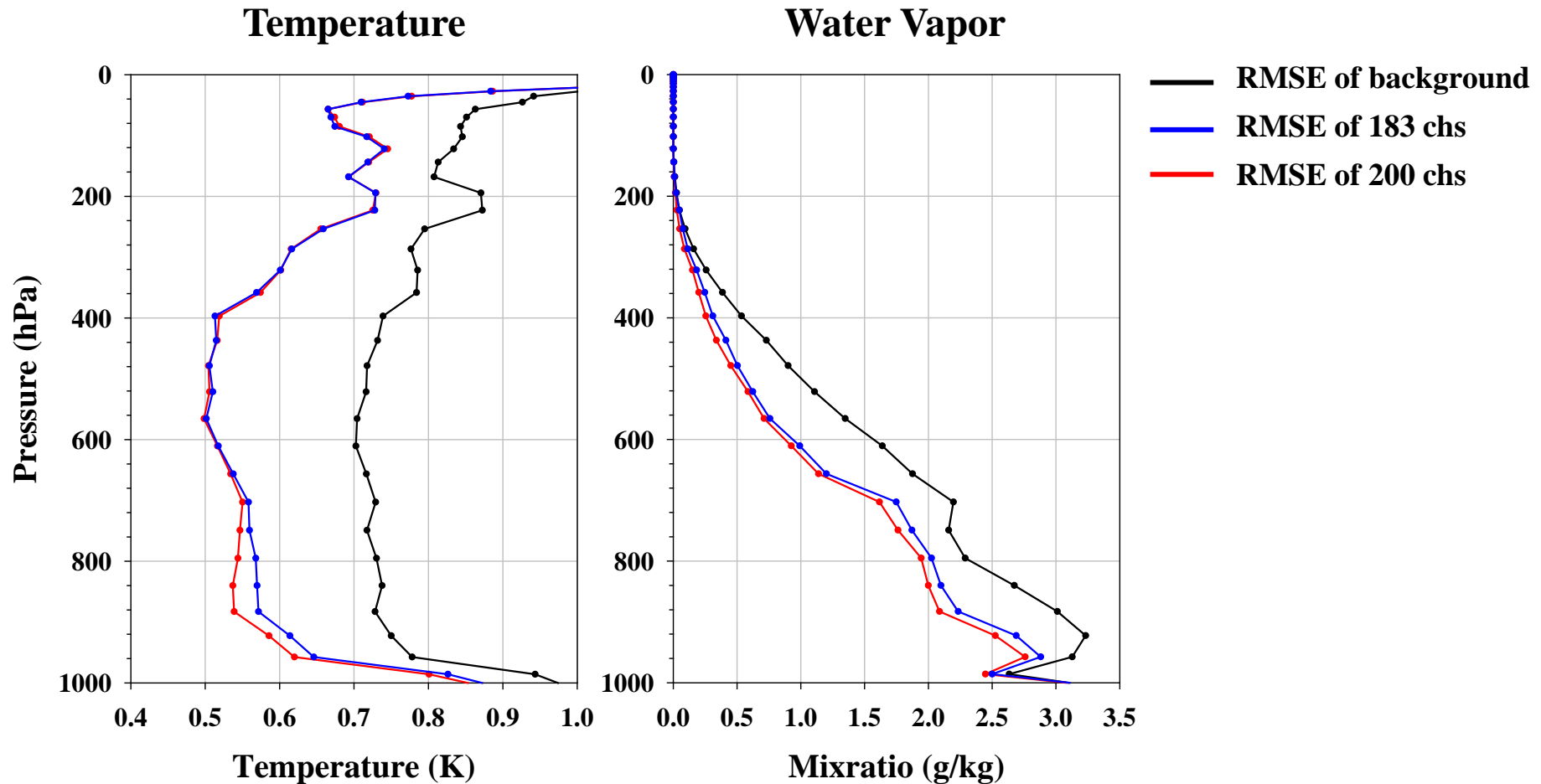$$CSI_i = \sum_{j=1}^{N}[1 - \frac{RMSE(A)_{i,j}}{RMSE(B)_j}]\, w_j$$

- Most of information is from CO_2 channels.

- Band 3 and ozone channels are not included in operational 183 channels

Green: Band 3
($2000\ cm^{-1} \sim$)

Red: Ozone channel
($1014.5\ cm^{-1} \sim 1062.5\ cm^{-1}$)

| Total DFS | DFS of temperature (j = 1, .., 43) | DFS of water vapor (j = 44, .., 86) |

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Little impact is made beyond first 150 channels.

Impact of different channel selections on T, q profiles

Experiment 1 - 183 channels use in 1 D-Var (**operational IASI channels**)

Experiment 2 - 200 channels use in 1 D-Var (**new IASI channels**)

Selected 200 channels vs. Operational 183 channels

New IASI 200 channels

Operational IASI 183 channels
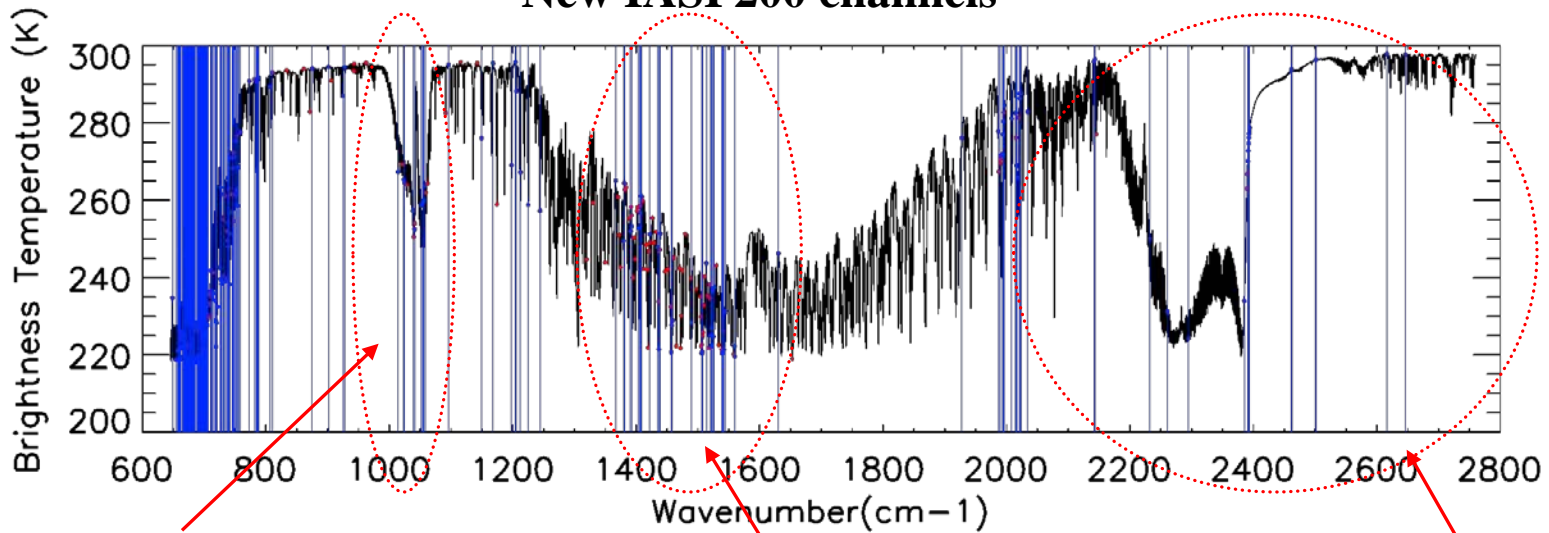
Ozone channel
(1014.5 ~ 1062.5 cm⁻¹)

Water vapor channel
(1300 cm⁻¹ ~ 1600 cm⁻¹)
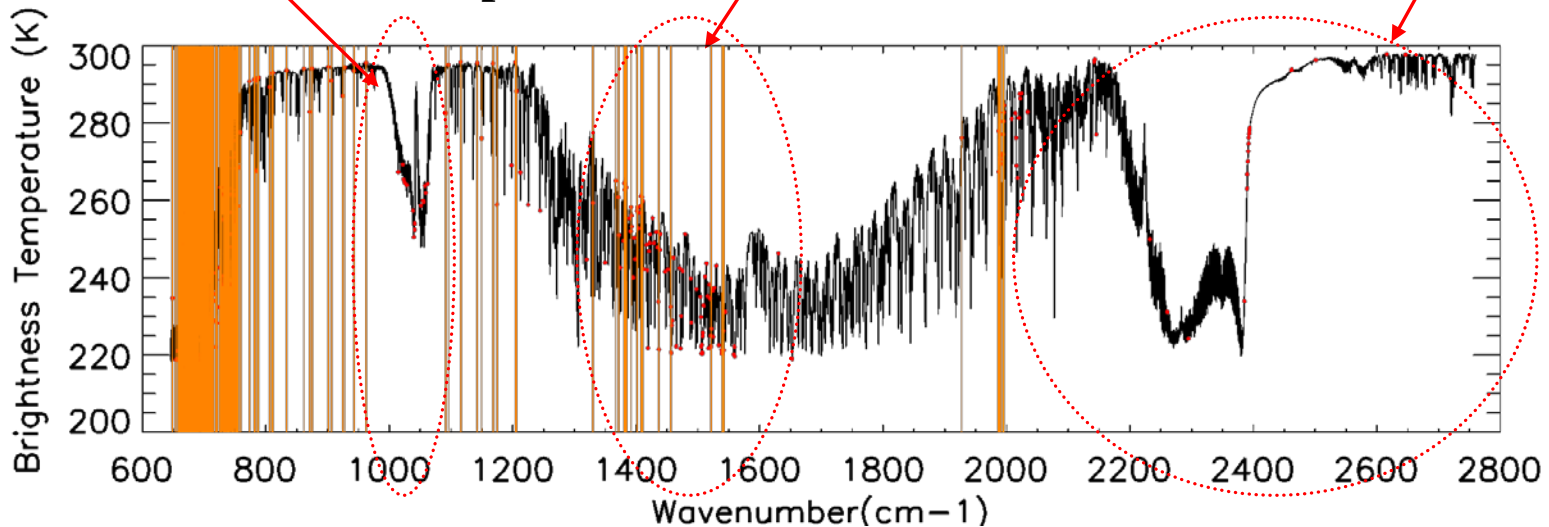
Band 3
(2000 cm⁻¹ ~)

Impact of ozone, water vapor, and Band 3 channels
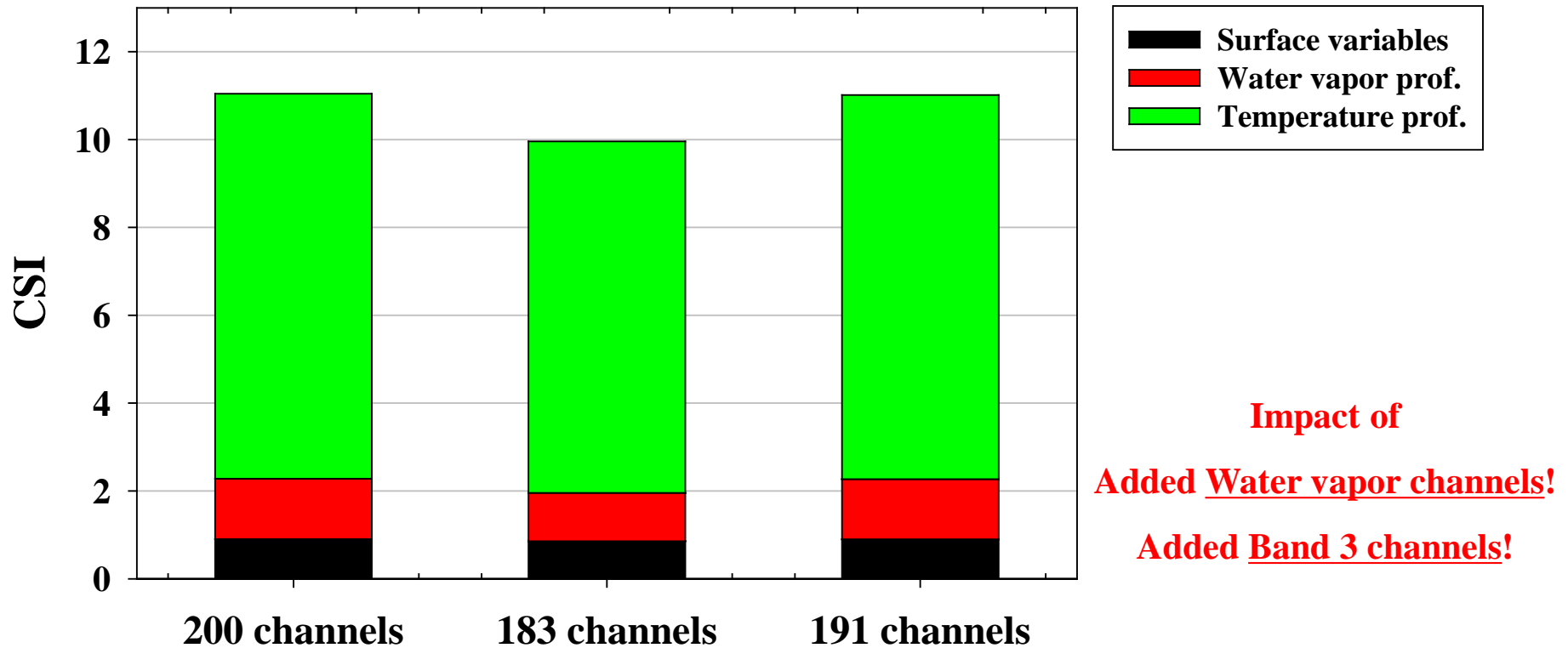
Experiment 1 – 200 channels (new IASI channels)

Experiment 2 – 183 channels (operational IASI channels)

Experiment 3 – 191 channels (200 channels – ozone channel(9))

Impact of selected IASI channels on OPS

- **Period: 1st May 12 UTC (1 cycles)**

| **Control** (183 channels) | → | **OPS** | → | - Retrieved BTs
- Retrieved T, q profiles
(T_{con}, q_{con}) |

Comparison

| **Exp 4** (191 channels, No O3, No daytime Band 3) | → | **OPS** | → | - Retrieved BTs
- Retrieved T, q profiles
$(T_{exp}4, q_{exp}4)$ |
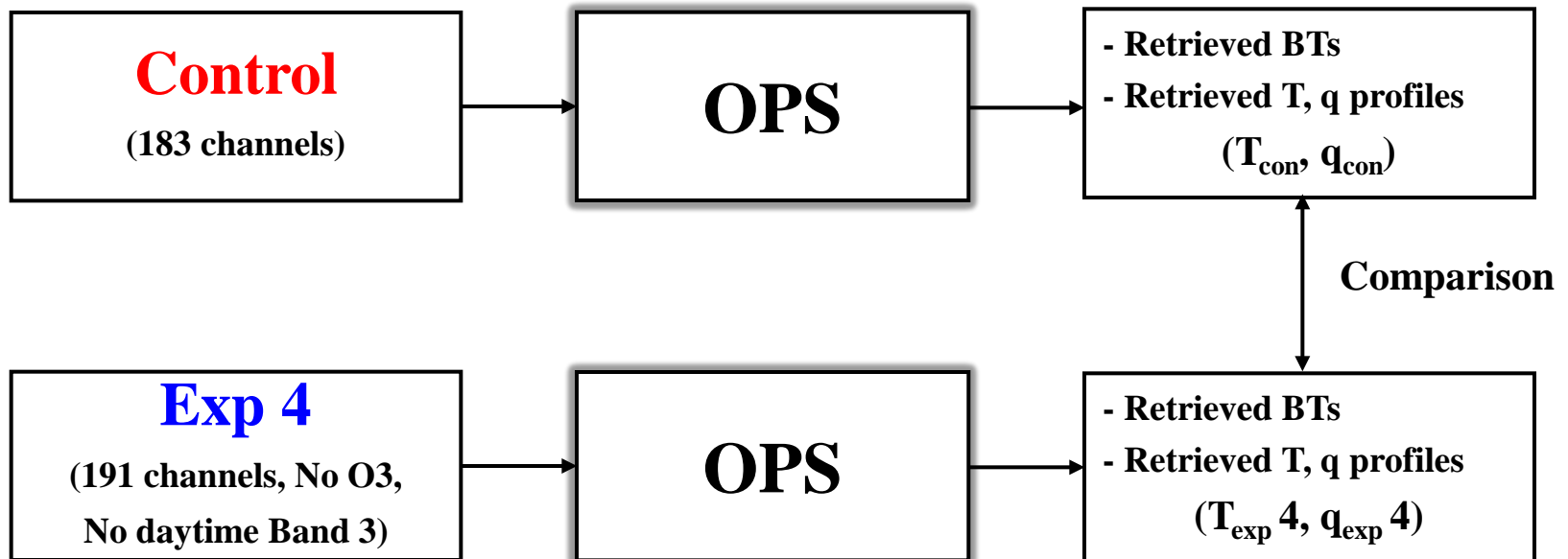
12 UTC 1 May 2013

Total IASI observation
(total # 168411)
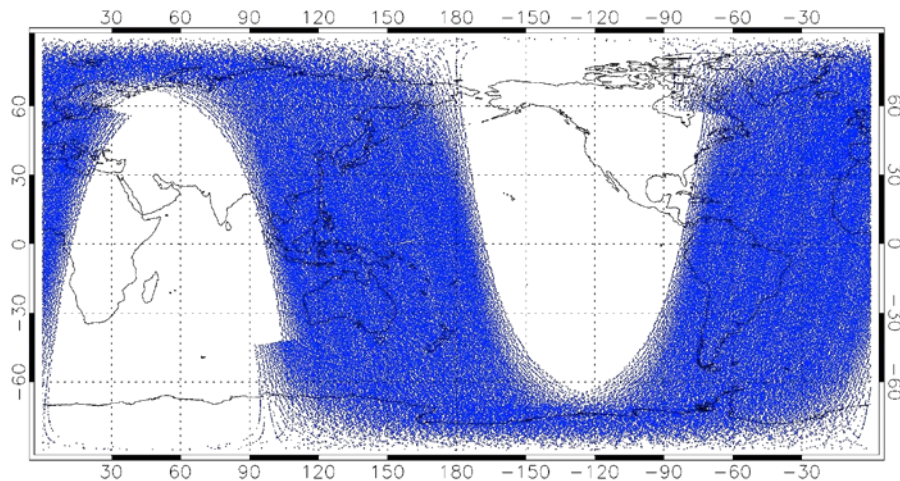
After thinning process
(total # 72628)
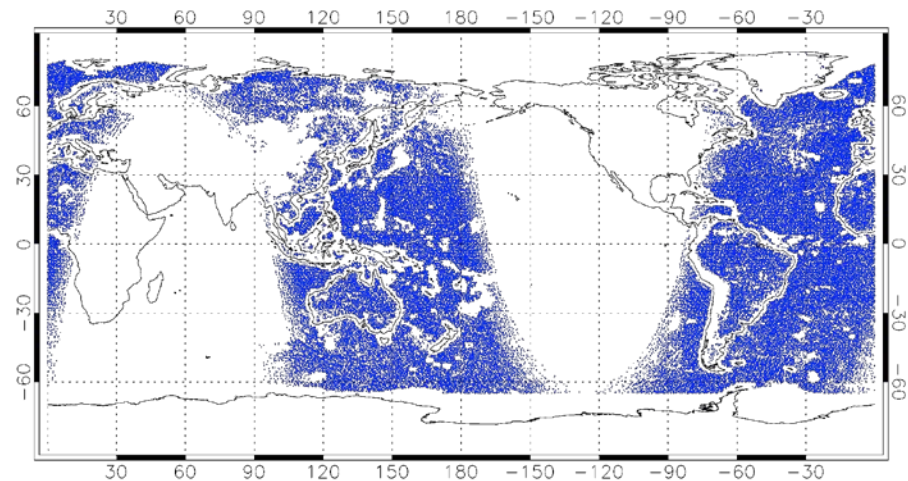
Solar zenith angle
(total # 72628)

S. zenith > 90 º
(nighttime)

S. zenith < 90 º
(daytime)
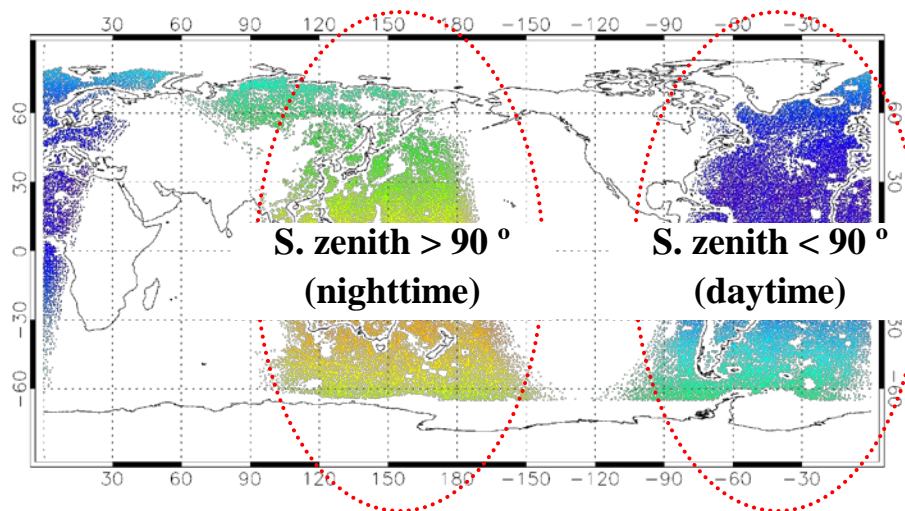
B3 solar channels are
excluded if it is daytime.

Results will be displayed
day and night separately

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Daytime Exp 4 result over ocean (12UTC 1 May 2013)

- # of used IASI observation: 10000
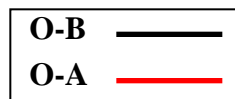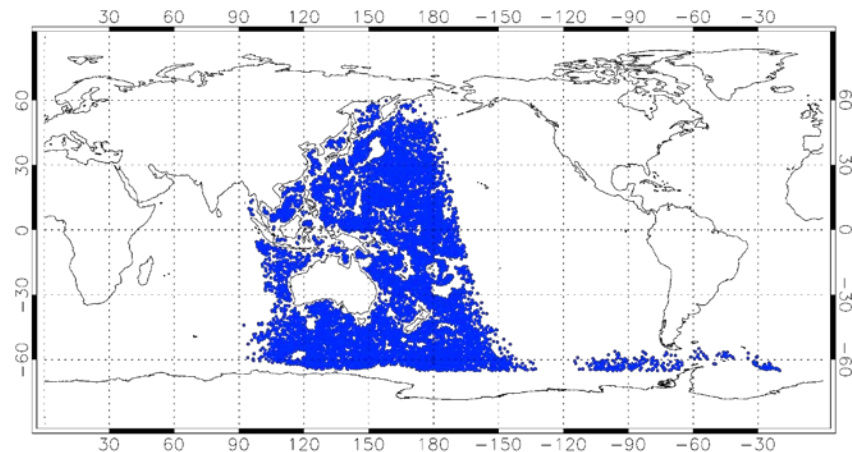
- Surface type: ocean

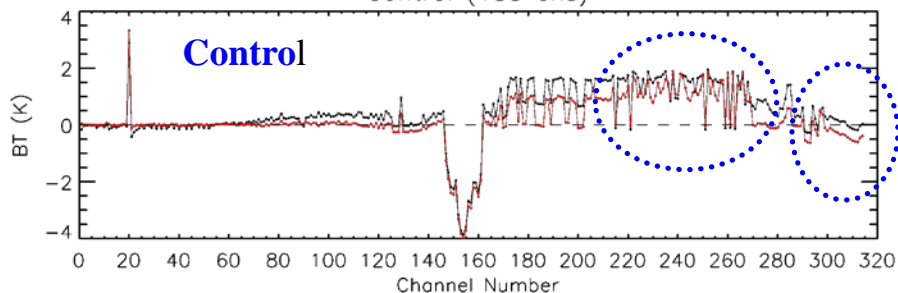- Threshold for collocation:

$$|CTP_{cntl} - CTP_{exp4}| < 20 \text{ hPa}$$

$$|CF_{cntl} - CF_{exp4}| < 0.1$$

(to minimize the effects of discrepancy of cloud parameters)

| O-B | ———— |
| O-A | ———— |

Bias

RMSE

- **# of used IASI observation: 10000**

- **Surface type: ocean**

- **Threshold for collocation:**

$$|CTP_{cntl} - CTP_{exp4}| < 20$$

$$|CF_{cntl} - CF_{exp4}| < 0.1$$

(to minimize the effects of discrepancy of cloud parameters)

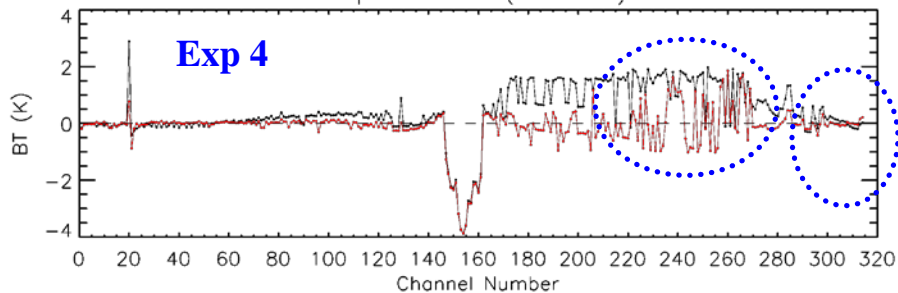| O-B | ——— |
| O-A | ——— |

Bias

RMSE
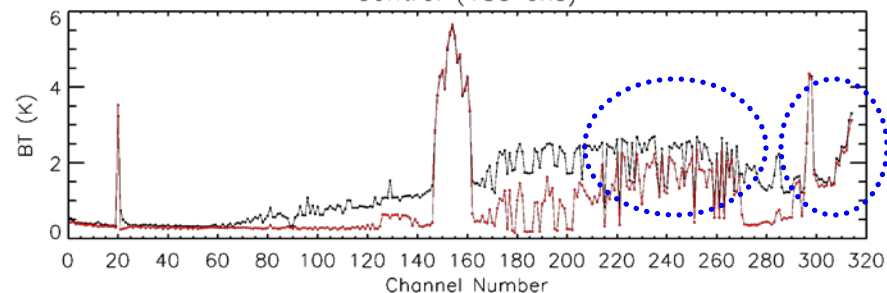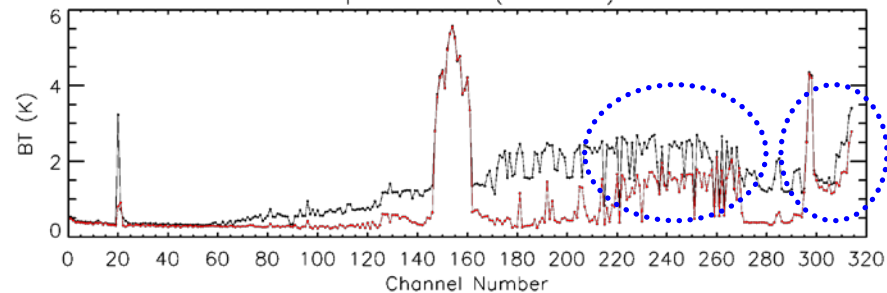
Results shown in IASI/AMSU TBs
(New Selection - UM 183 channels, total 40 cycles over the globe)

IASI (650 cm^{-1} - 2800 cm^{-1})

AMSU-A

AMSU-B
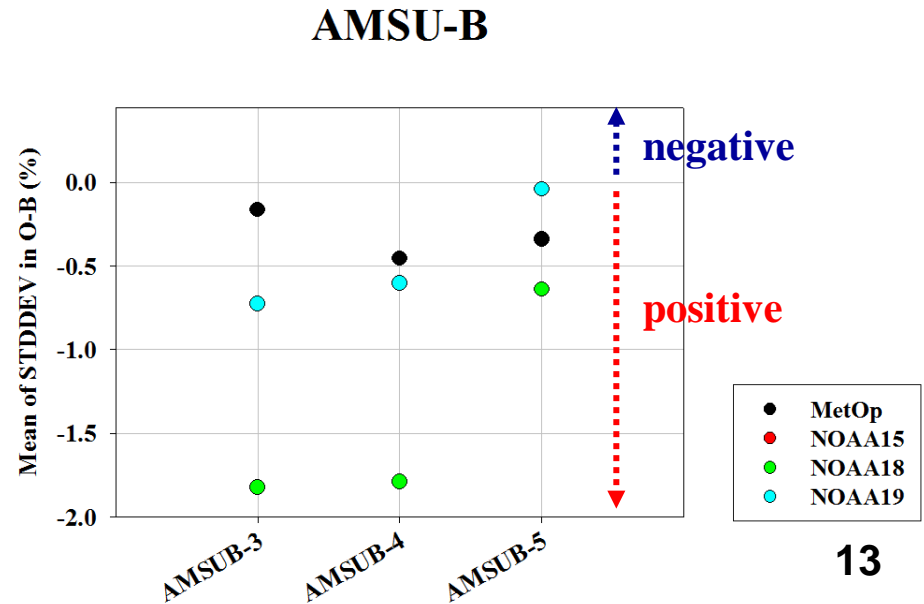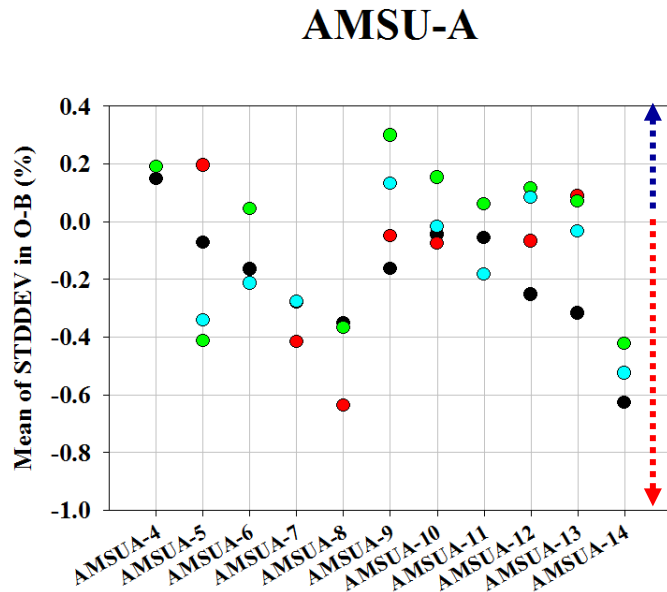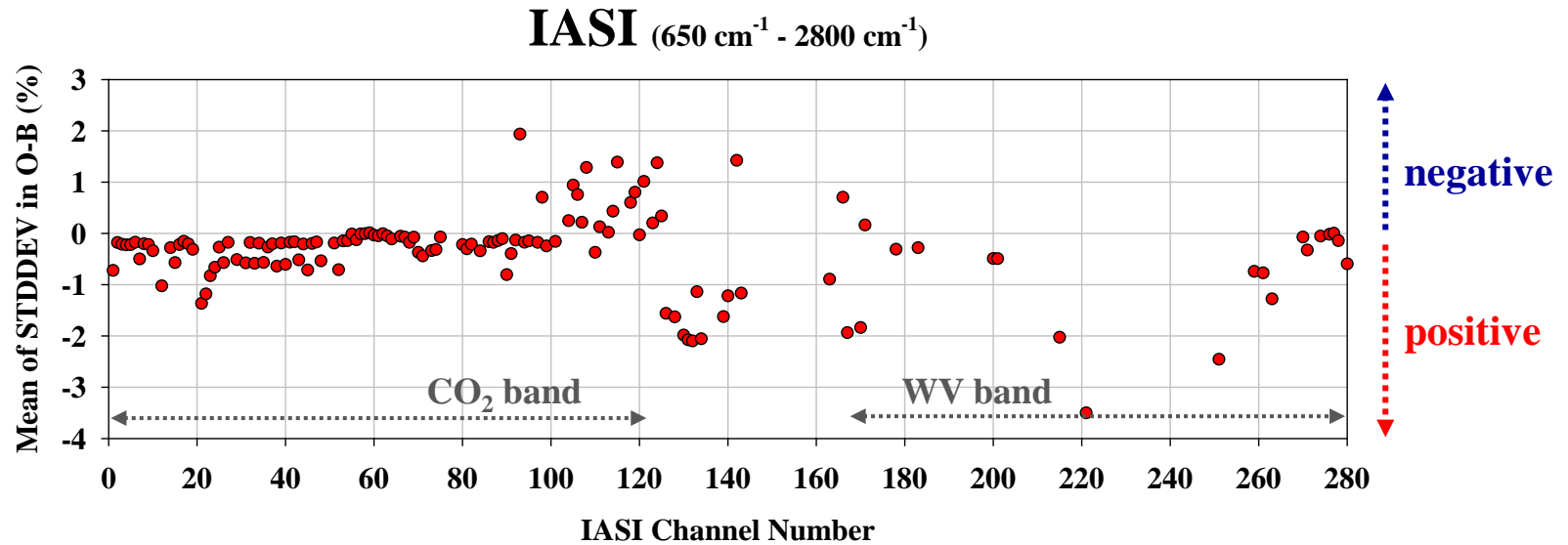
Summary

- IASI 200 channels were selected by 1D-Var simulation approach.

- Majority channels are from CO_2 absorption band ($\sim$ 15 μm).

- Some water vapor, ozone, and SW IR channels were included in the new selection, which are not used in the current UM data assimilation system.

- From 1D-Var validation study, new selected IASI channels showed positive impact on low-tropospheric temperature and low/middle tropospheric humidity.

- O-B analysis showed that both temperature and moisture fields were improved in background (based on the comparison against IASI, AMSU-A, and AMSU-B TBs)

- Future works: Impact assessment will be made using UM model experiments for a longer term.