

Impact study of DMSP F-16 SSMIS radiances in NCEP global data assimilation system

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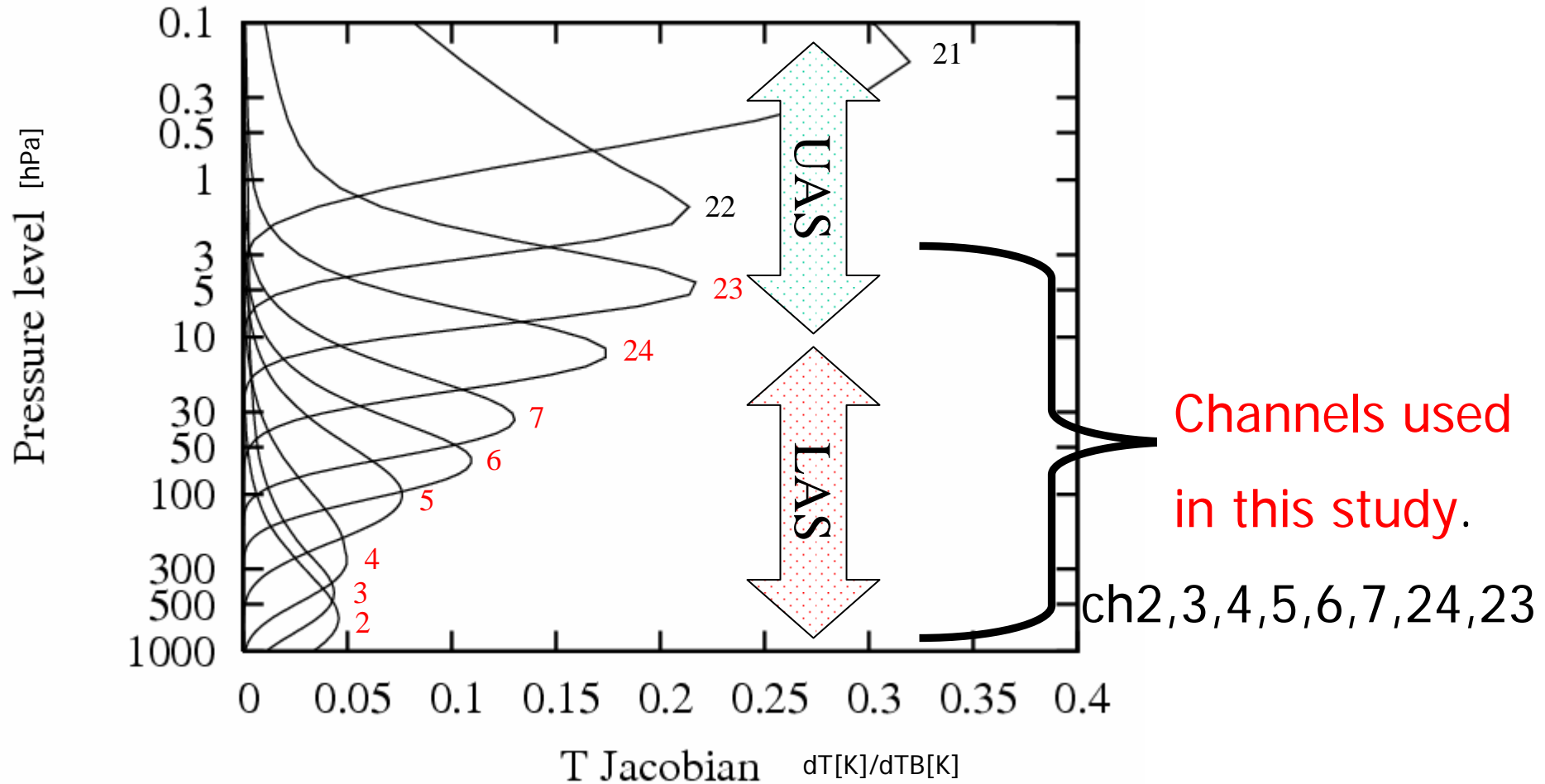
SSMIS

- Conical scanning instrument and successor of SSMI
- Four components of SSMIS instrument
 - Lower atmospheric temperature sounding channels (**LAS**)
 - (Freq. 50-60GHz, ch1-7,24)
 - Imager channels (**IMG**)
 - (Freq. 90-183GHz, ch8-11,17 and 18)
 - Environmental channels (**ENV**)
 - (Freq. 19-23GHz, ch12-16)
 - Upper atmospheric temperature sounding channels (**UAS**)
 - (Freq. 60-63GHz, ch19-23)

SSMIS has temperature sounding channels (LAS) along with window channels (ENV). ENV can be used for cloud detection.

But, as each component has different observation locations. Collocation (re-mapping) is necessary to use these components together.

SSMIS Temperature Jacobian for US Standard Atmosphere



SSMIS provides atmospheric temperature information in stratosphere and troposphere.

However...

- Since the launch, F-16 SSMIS has been suffering from calibration problems.
- The largest problems are solar contamination in the warm calibration target and an emissive antenna


Therefore,

- Pre-processed (re-calibrated) SSMIS radiance data are produced and distributed to several NWP centers by UKMO and NESDIS.

The purpose of this study is to investigate the quality of pre-processed (re-calibrated) SSMIS data and their impacts on analyses and forecasts in NCEP global data assimilation system.

Quality of SSMIS data

- F-16 SSMIS data available at NCEP (Mar. 2007)
 - **FNMOCC data** (Original data, no collocation)
 - Distributed to Public via Internet (NOAA CLASS Server)

FNMOCC Ta  FNMOCC Tb

- **UKMO preprocessed data** (collocated on LAS)

- Distributed to several NWP centers (ECMWF, NCEP, the Italian Met Agency and the Danish Met Service) pre- operationally.
- UKMO assimilate the data in their operational system since Sep. 2006

preprocess

FNMOCC Ta  UKMO Tb

- **NESDIS recalibrated data** (collocated on LAS)

- Under development and evaluation at NCEP.

recalibrate

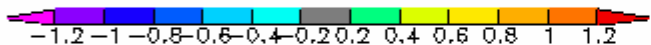
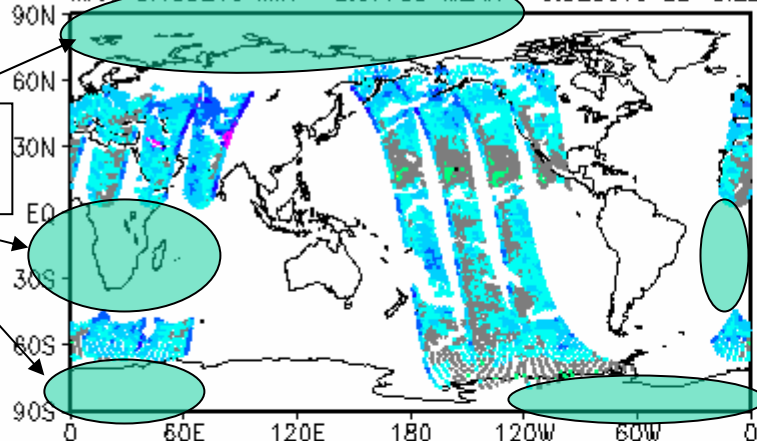
FNMOCC Ta  NESDIS Tb

Comparison of SSMIS data (ch4, brightness temperature O-B, w/o BC)

UKMO

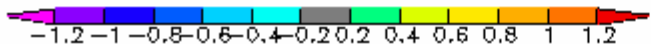
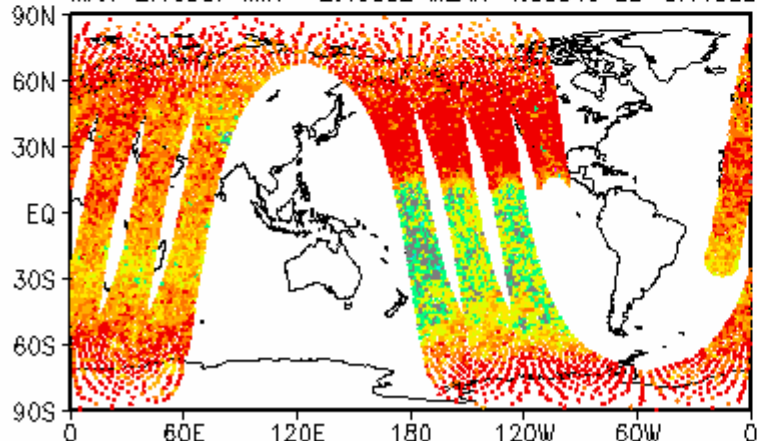
UKMO SSMIS CH4 06Z09AUG2006

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NRL SSMIS CH4 06Z09AUG2006

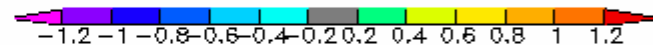
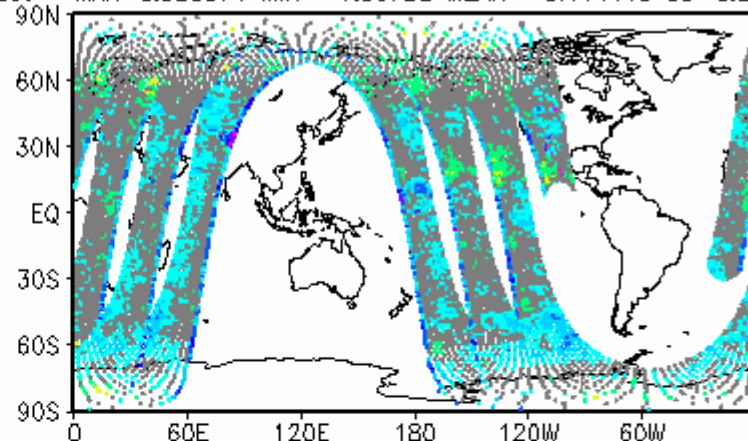
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NESDIS

NESDIS SSMIS CH4 06Z09AUG2006

NUM=8827
MAX=0.580574 MIN=-1.90758 MEAN=-0.114113 SD=0.226311



Original

FNMOOC

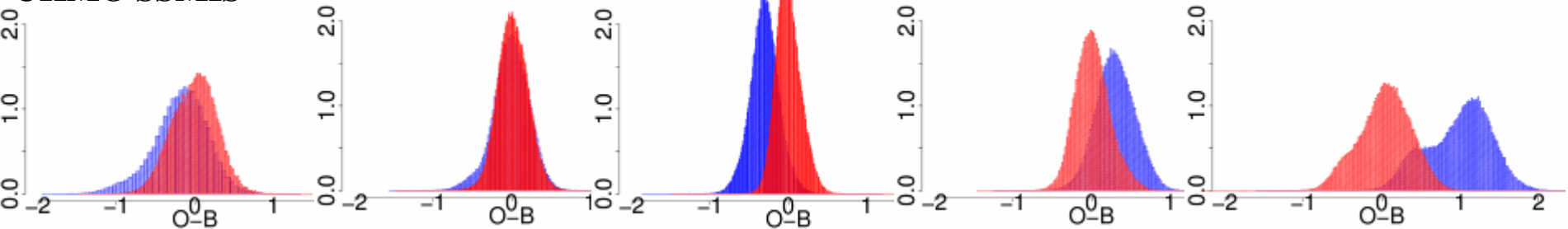
O-B histograms for QC passed data (global ocean data only)

Red: w BC

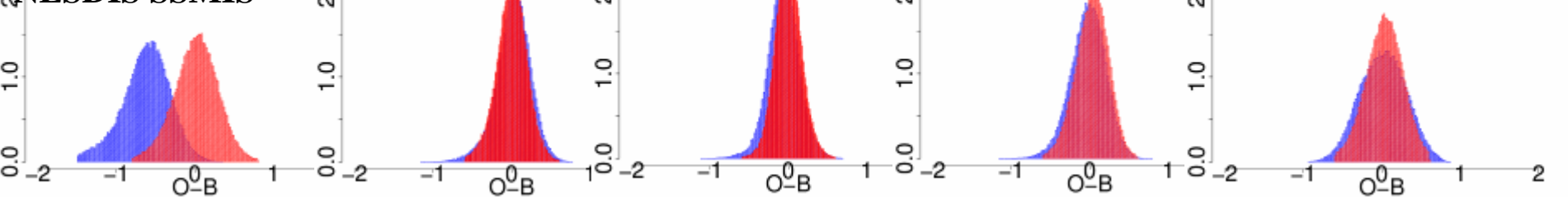
Blue: w/o BC

Statistics: Aug.2 – 12, 2006

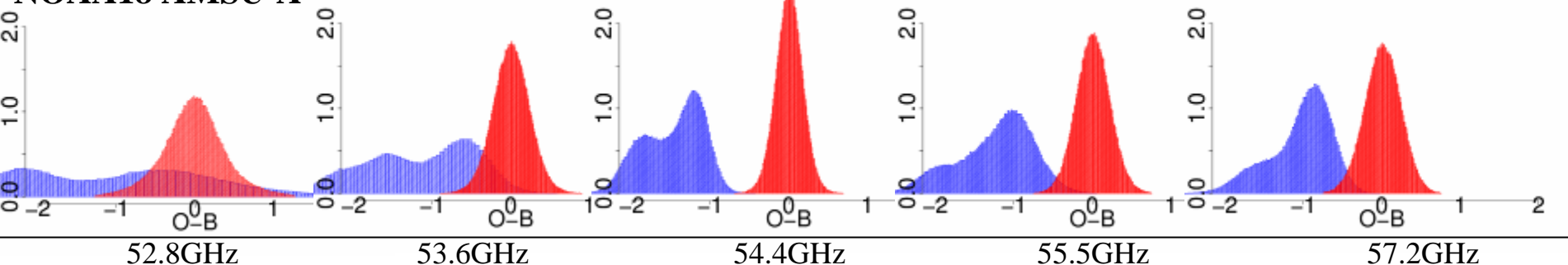
UKMO SSMIS



NESDIS SSMIS



NOAA18 AMSU-A



Weighting function Peak

700hPa

400hPa

300hPa

100hPa

70hPa

Current AMSU-A bias correction scheme can be used for SSMIS. 8

Assimilation experiments

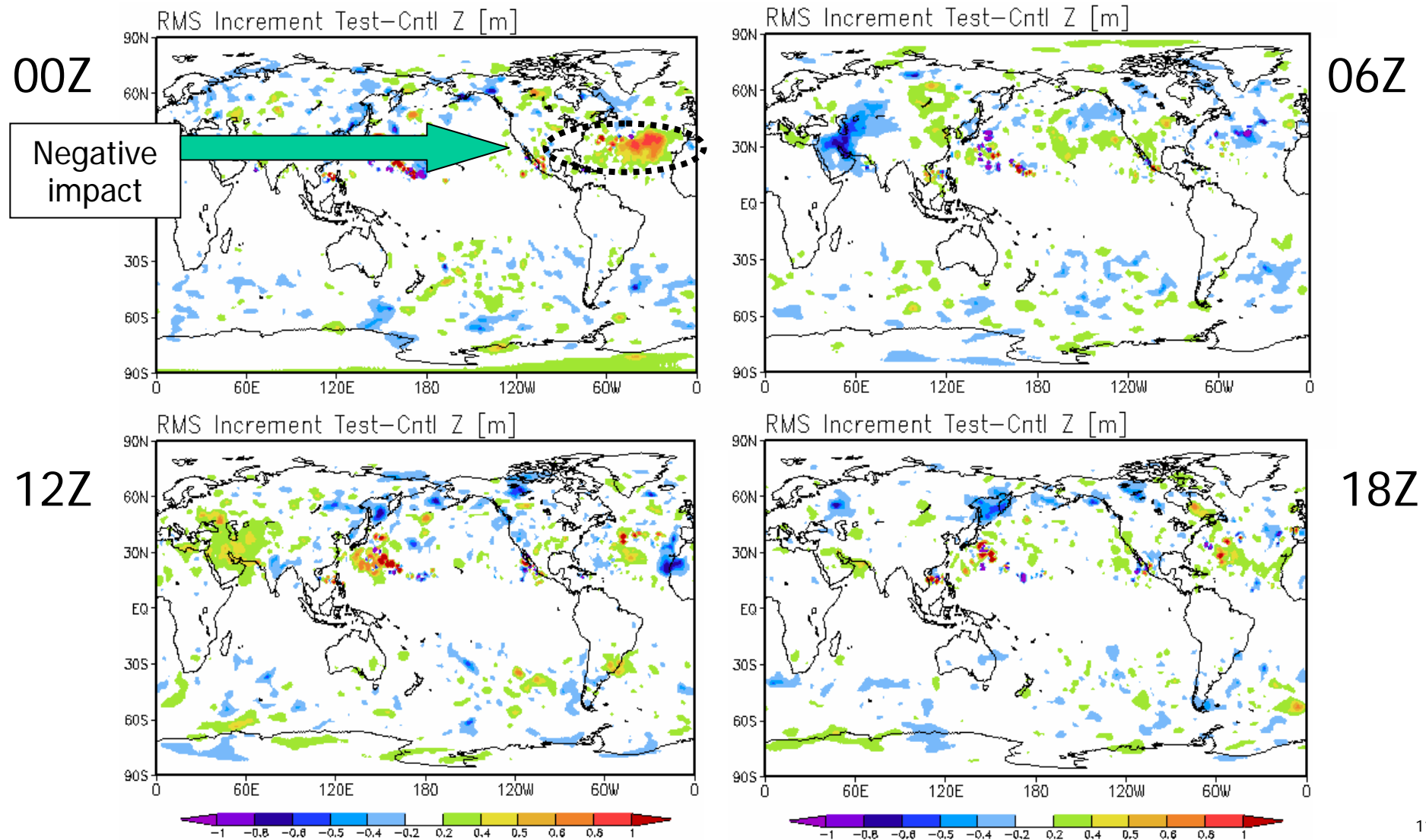
- **Experiment with UKMO SSMIS data**
August 2 – October 7, 2006
(December 2, 2006 – February 10, 2007)
- **Experiment with NESDIS SSMIS data**
August 2 – October 7, 2006

Design of experiments

- Analysis: **GSI** 3D-Var (Sep. 2006).
- Forecast model: NCEP global forecast model (Dec. 2006).
- Resolution: **T382L64**.
- Added new data: SSMIS brightness temperature (T sounding channels 2,3,4,5,6,7,23,24)
- Assimilation period: Aug. 2 – Oct. 7, 2006
- Forecast: every day 00Z initial, 168 hour forecast
- Experiment name
 - Prd: control
 - **Pre: Test with UKMO SSMIS**
 - **Prg: Test with NESDIS SSMIS**
- Each experiment uses NCEP operational data set.
- Only Cloud-Clear data were used. 160km thinning.
- Operational radiance bias correction scheme was used.

Impacts on analysis

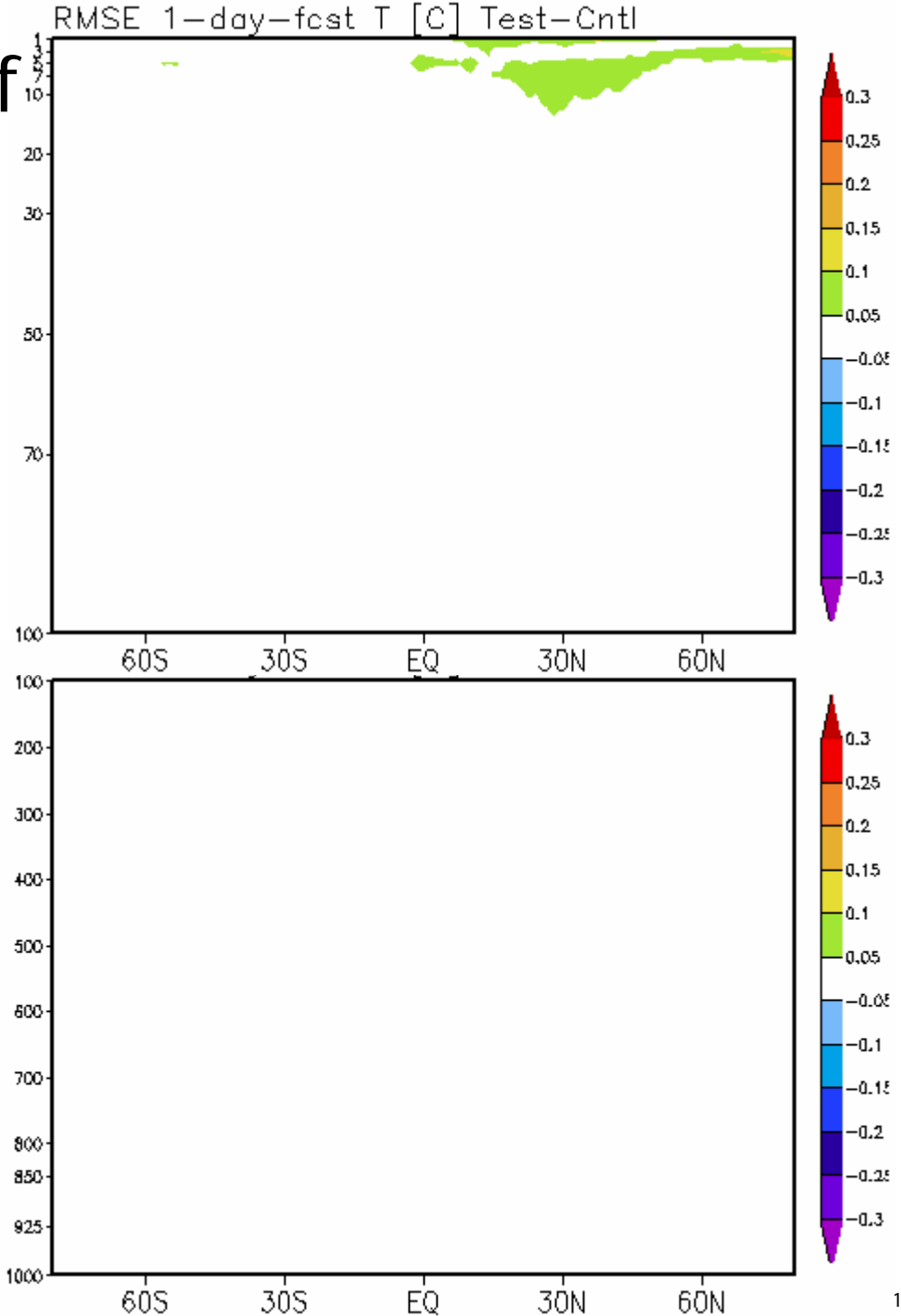
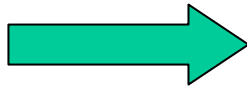
- Difference of RMS of Z500 analysis increment
Test – Cntl (52 cases average, Aug.10-Sep.30)



Zonal mean of RMSE of Temperature forecast (Test-Cntl)

- 1-day forecast
- From Aug. 2 –
- 66 cases average

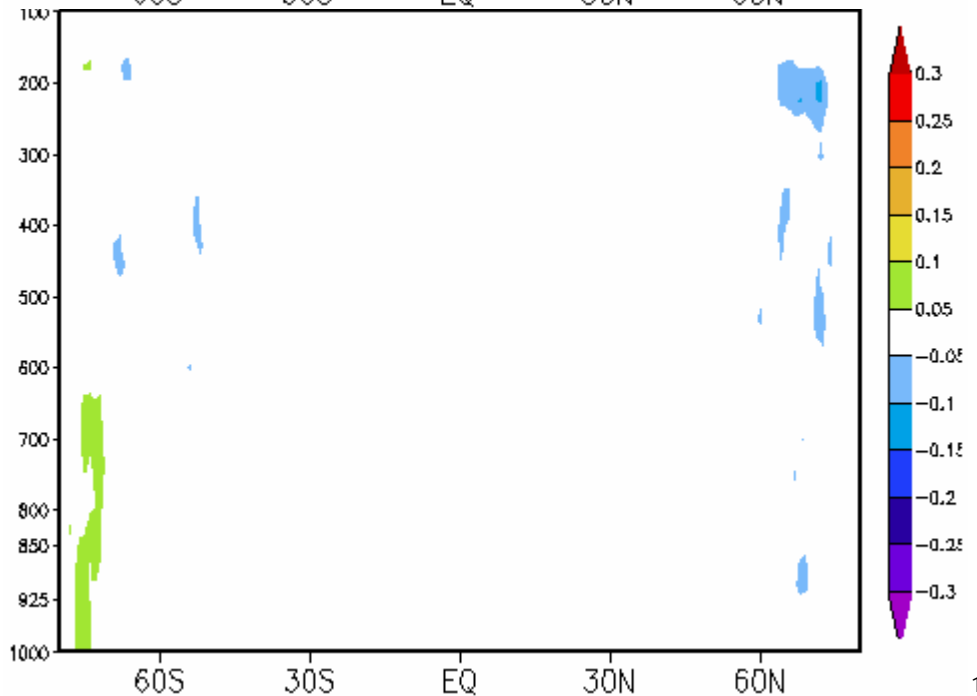
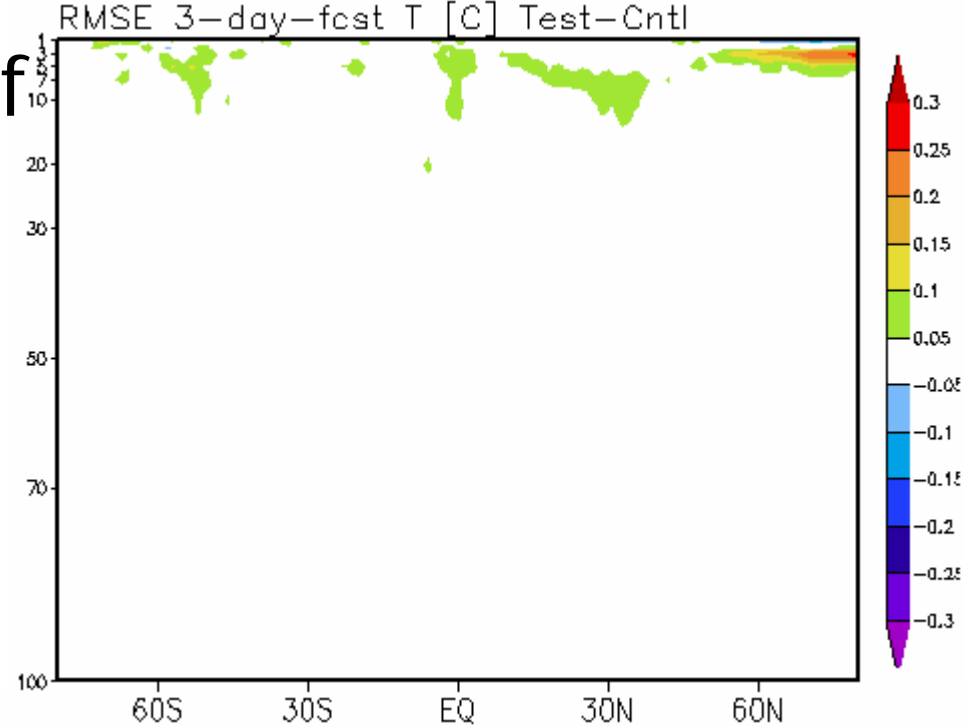
Blue color means improvement



Zonal mean of RMSE of Temperature forecast (Test-Cntl)

- 3-day forecast
- From Aug. 4 –
- 64 cases average

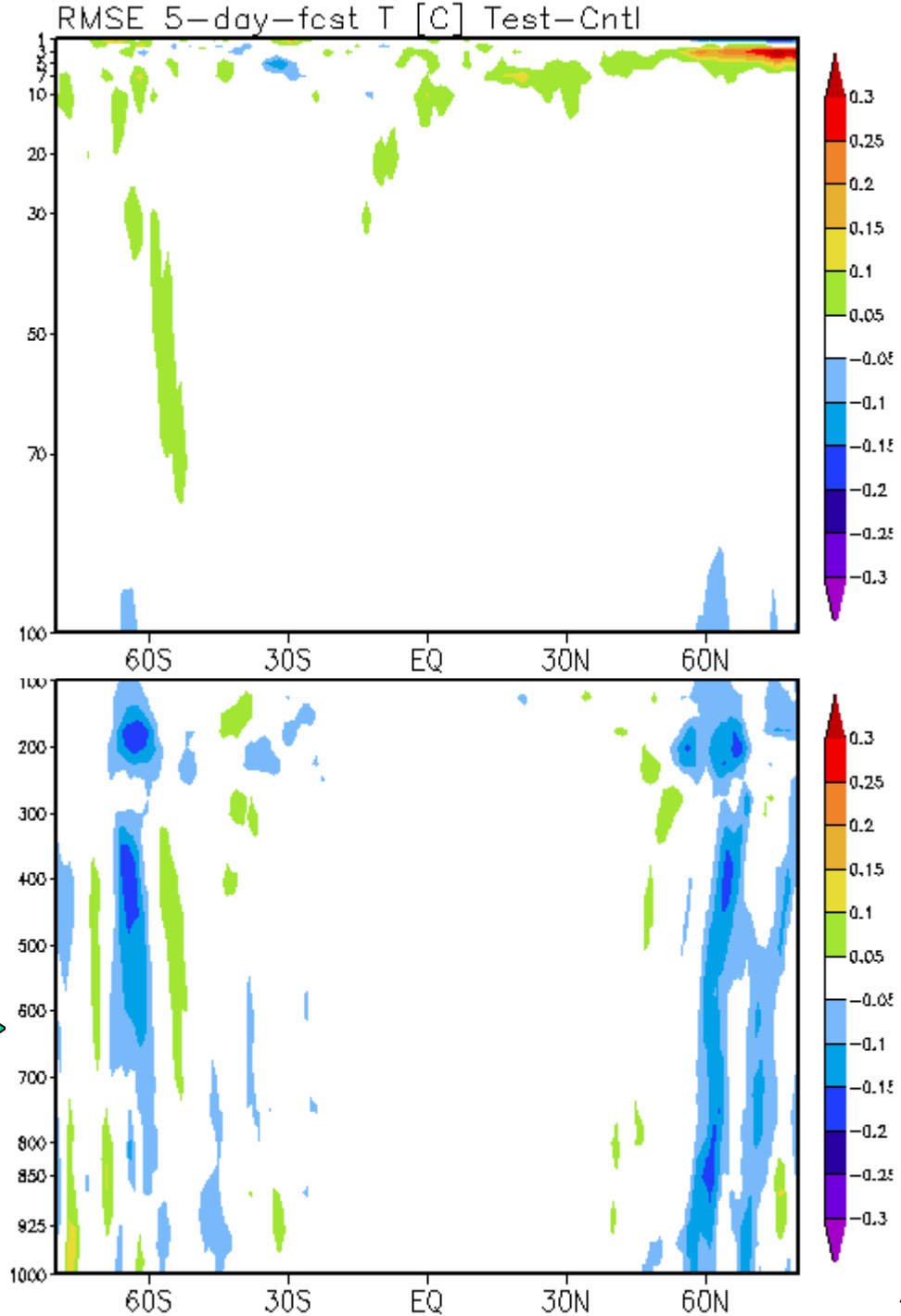
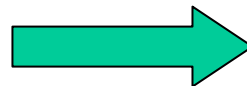
Blue color means improvement



Zonal mean of RMSE of Temperature forecast (Test-Cntl)

- 5-day forecast
- From Aug. 6 –
- 62 cases average

Blue color means improvement

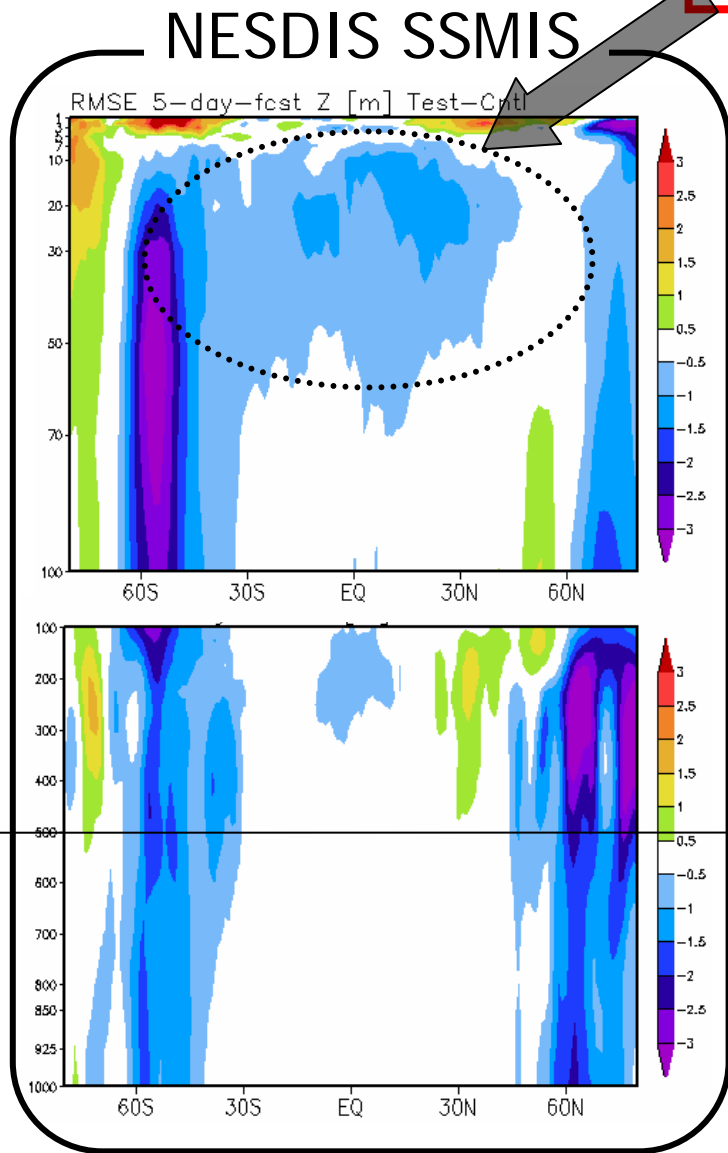
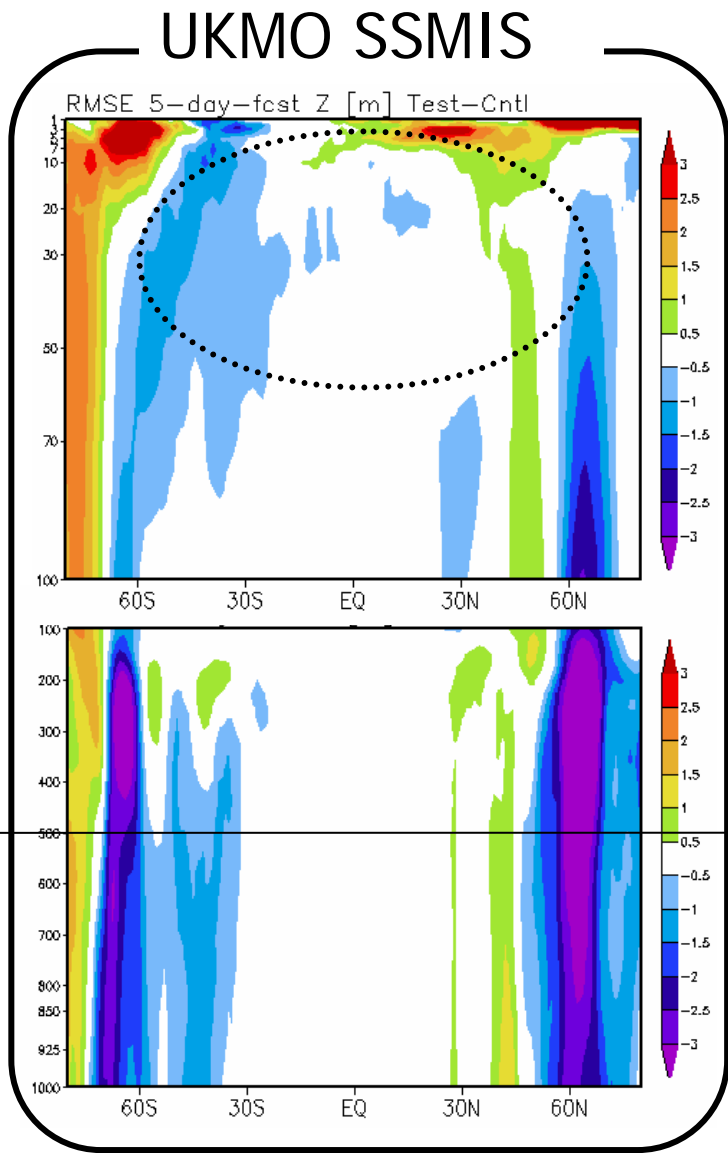


5day Z forecast zonal averaged RMSE difference

Blue color means improvement.

(Test-Cntl)

Much improvement in the stratosphere



10hPa

100hPa

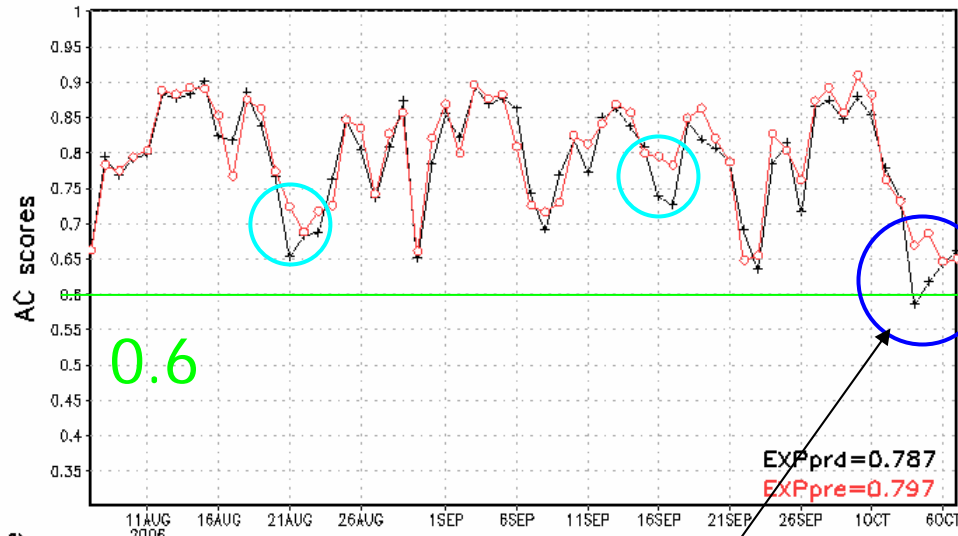
500hPa

1000hPa

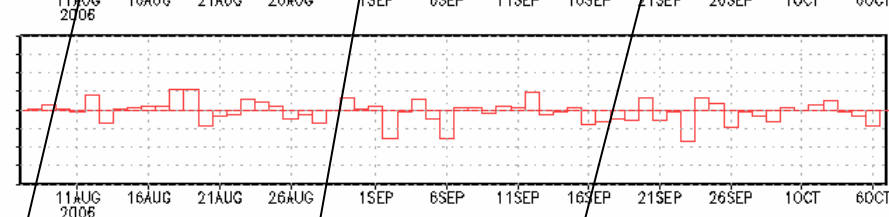
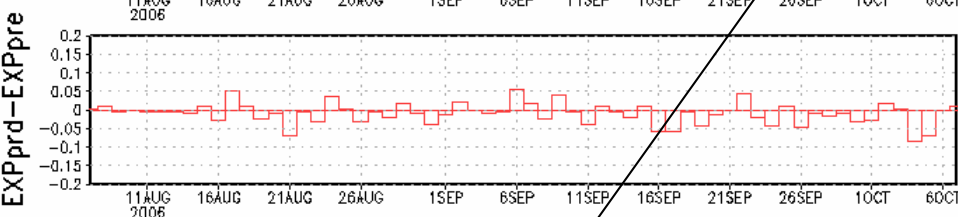
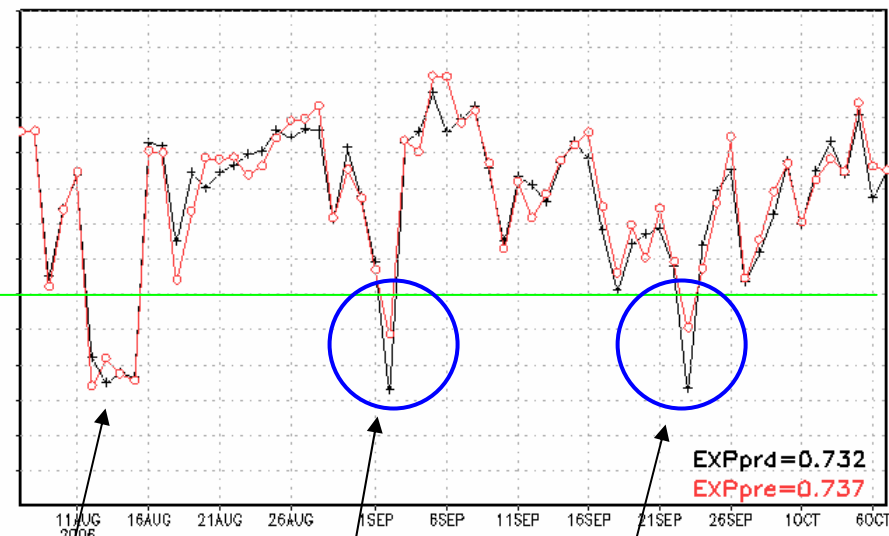
Time sequences of Z500 5 day forecast A.C.

“Forecast bust : A.C. dropping below 0.6 in 5day forecast”

NH 500 mb Geopotential Height at day 5
for 00Z07AUG2006 – 00Z07OCT2006



SH 500 mb Geopotential Height at day 5
for 00Z07AUG2006 – 00Z07OCT2006



Case1
Forecast bust

Case2

Case3

Conclusions

- Preprocessed UKMO SSMIS data and recalibrated NESDIS SSMIS data have comparable quality with AMSU-A data
- Assimilation experiments with cloud cleared SSMIS radiances (UKMO and NESDIS) in GSI were carried out.
- Impacts on analysis
 - Neutral in average fields. The data around 30N in ascending orbit make negative impacts on 500hPa height analysis increment. But it does not affect forecast accuracy so much. Negative above 10hPa due to unbalance bias in stratosphere channels. (UKMO SSMIS)
- Impacts on forecast
 - **Positive**: A.C. of Z500,Z1000(not shown), T200 A.C. for both hemisphere, RMSE of T,Z (1000-10hPa)
 - **Neutral**: Vector Wind(Trop. not shown), Fits to RAOB (most of element, 1day, 2day), TPW
 - **Negative**: Above 10hPa, T, Z (UKMO SSMIS)
- Precipitation (In 60-84hr forecast, slightly positive on North America)
- Small improvements for hurricane track prediction after 48hour forecasts (about 50km improvement in 96-hour forecast).
- **In NCEP GDAS, assimilation of preprocessed (recalibrated) SSMIS data can improve forecast accuracy especially in medium range forecasts.**

Final comments

- Assimilations of corrected SSMIS radiances data show positive impacts on 500hPa height forecast score whichever SSMIS data is used (UKMO or NESDIS).
- In the stratosphere, improvement was found from NESDIS SSMIS data.
- Correction algorithm should be merged
 - Promised by fall 2007
- Operational NWP center desire **one well-calibrated SSMIS data in real time data base.**
- Clean SSMIS data (F17-F20) must be valuable for NWP in the next decade.

Supplementaries

QC of SSMIS data

- Selected channels (ch2,3,4,5,6,7,24,23)
- Thinning with 160 km distance
- Removal of flagged data (bad data and rain data) for UKMO SSMIS data
- Removal of cloud affected data by using a retrieval of cloud liquid water
- Gross error check

Usage

Ch2: ocean only, $clw < 0.2 \text{ kg/m}^2$

Ch3: ocean or land (alt. < 2000m), $clw < 0.6 \text{ kg/m}^2$

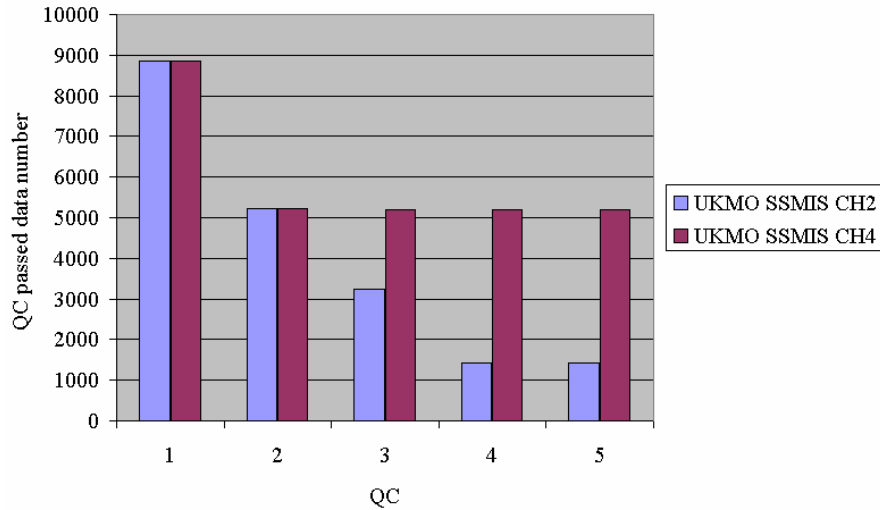
Ch4: ocean or land (alt. < 4000m), $clw < 0.6 \text{ kg/m}^2$

CH5,6,7,24,23: all qc passed data

QC passed data

UKMO

06UTC August 9, 2006



CH2: 15% data were used after QC
CH4: 60% data were used after QC

QC1: After thinning

QC2: Solar contamination and rain flag

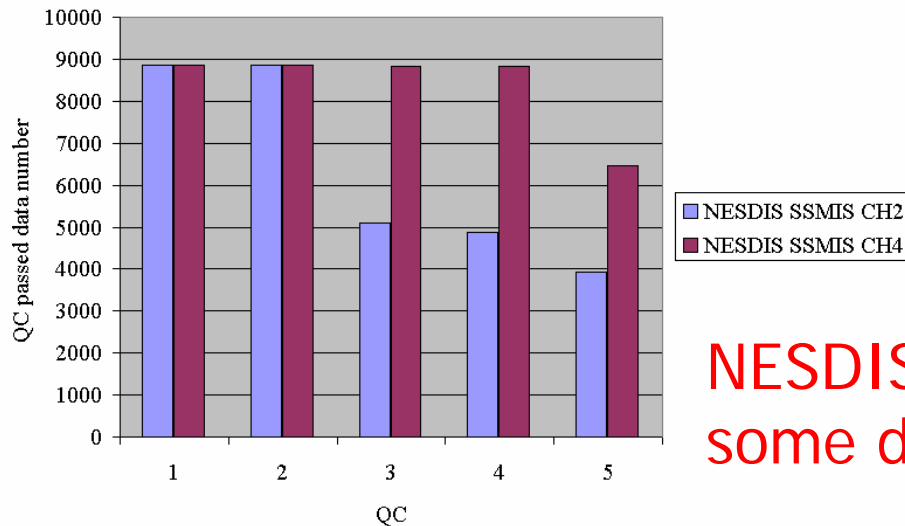
QC3: land ice QC

QC4: Cloud QC

QC5: gloss error check

NESDIS

06UTC August 9, 2006

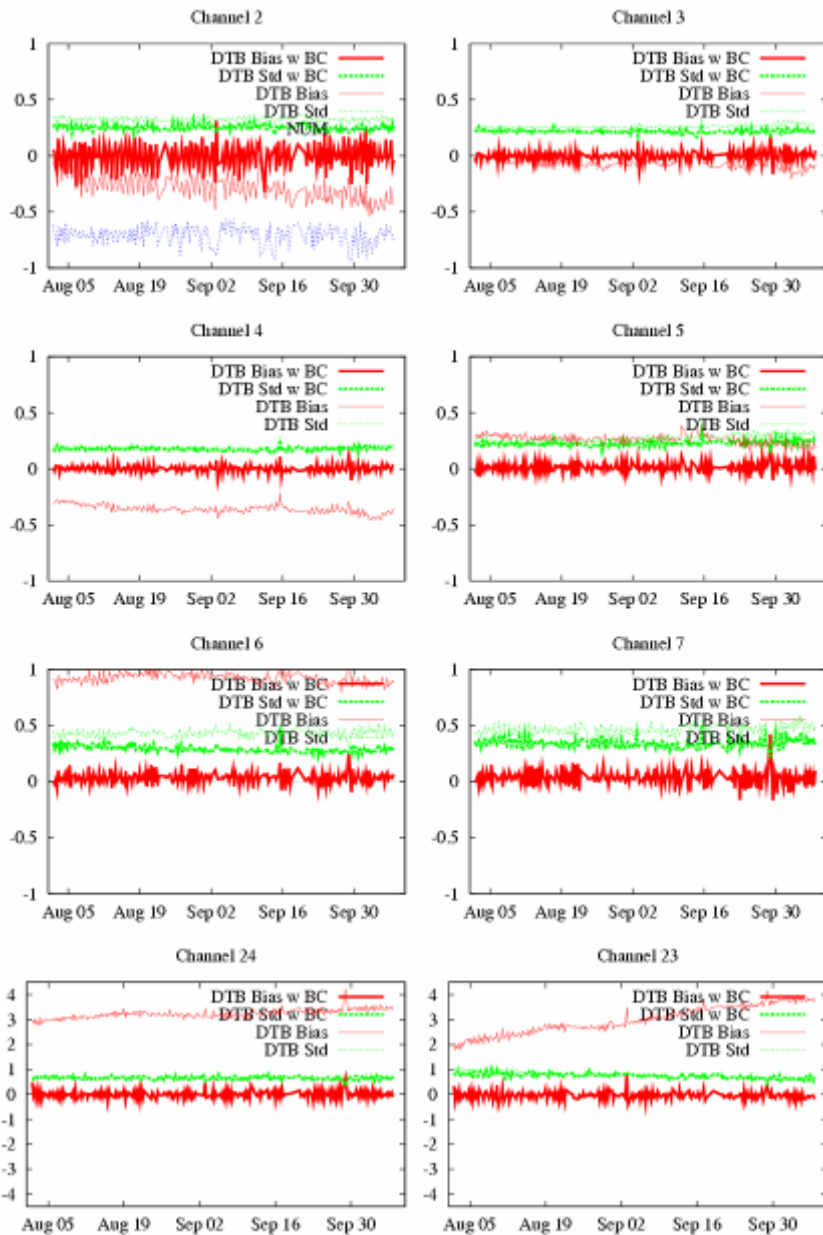


CH2: 44% data were used after QC
CH4: 72% data were used after QC

NESDIS correction algorithm can save some data from the solar contamination.

Bias correction

Time sequence of O-B (UKMO SSMIS)



- Same formula as other radiance data (AMSU-A)

Scan dependent + air-mass dependent

5 predictors for linear regression of air-mass dependent part

Constant, Scan angle (=0 for SSMIS), Cloud liquid water, Weighted laps late $(dt \cdot d\tau)$, $(dt \cdot d\tau)^2$

Coefficients are optimized as analysis variables in GSI.

In general, SSMIS radiance bias correction works properly.

Assigned observation error

Ch2-7: 0.5K, Ch24,23: 1.0K

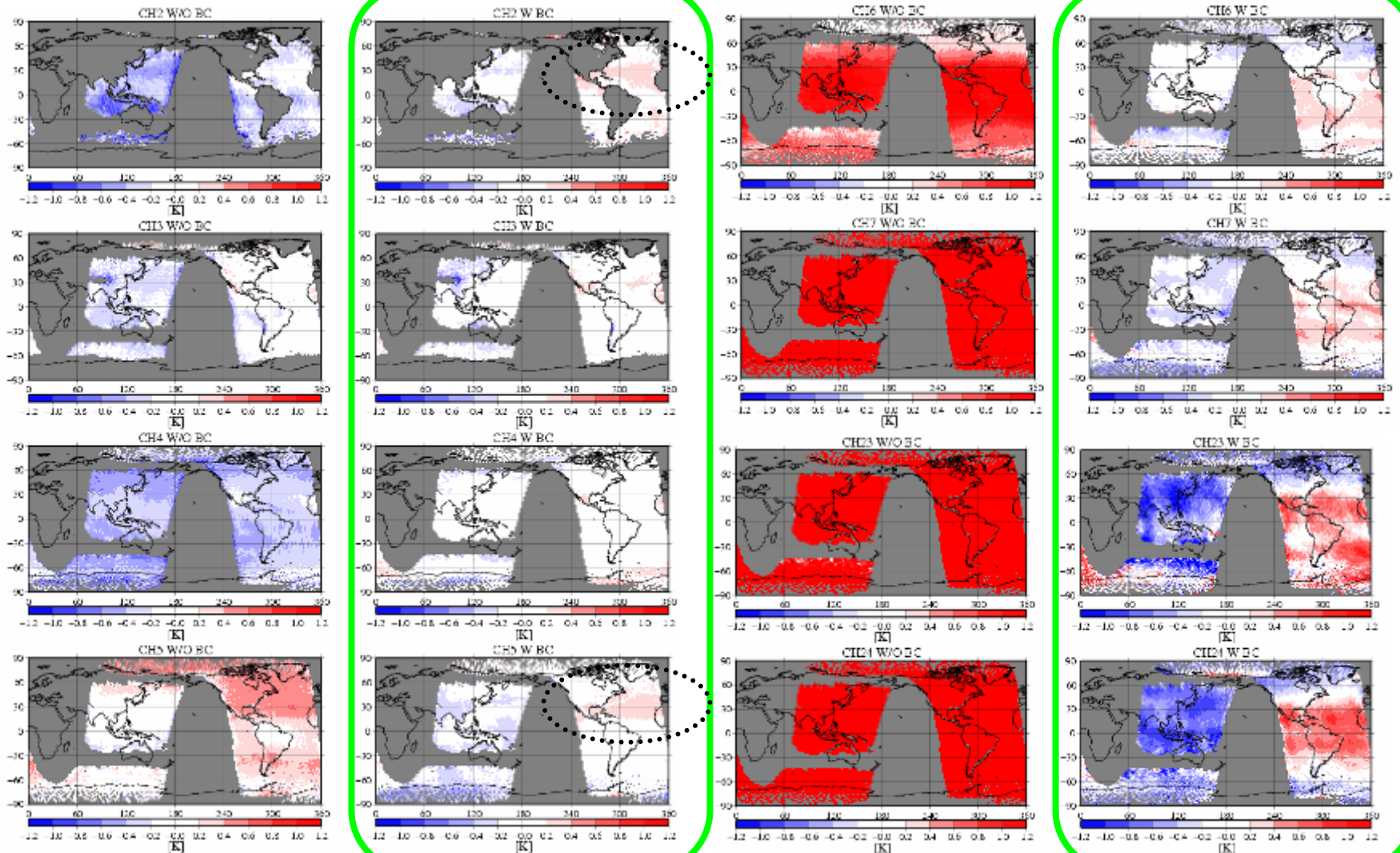
Red: Bias

Green: Standard deviation

Mean O-B distribution for 00UTC analysis

With BC

With BC



Ch2 and 5 have remaining bias around 30N in ascending orbit.

CH6,7,23 and 24 have unbalanced bias between ascending and descending.

Bias corrected O-B (2month average) 00Z analysis time

UKMO

NESDIS

