Assimilation of Satellite Microwave Water Vapor Sounding Channel Data in NCEP Global Forecast System (GFS)

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Outline

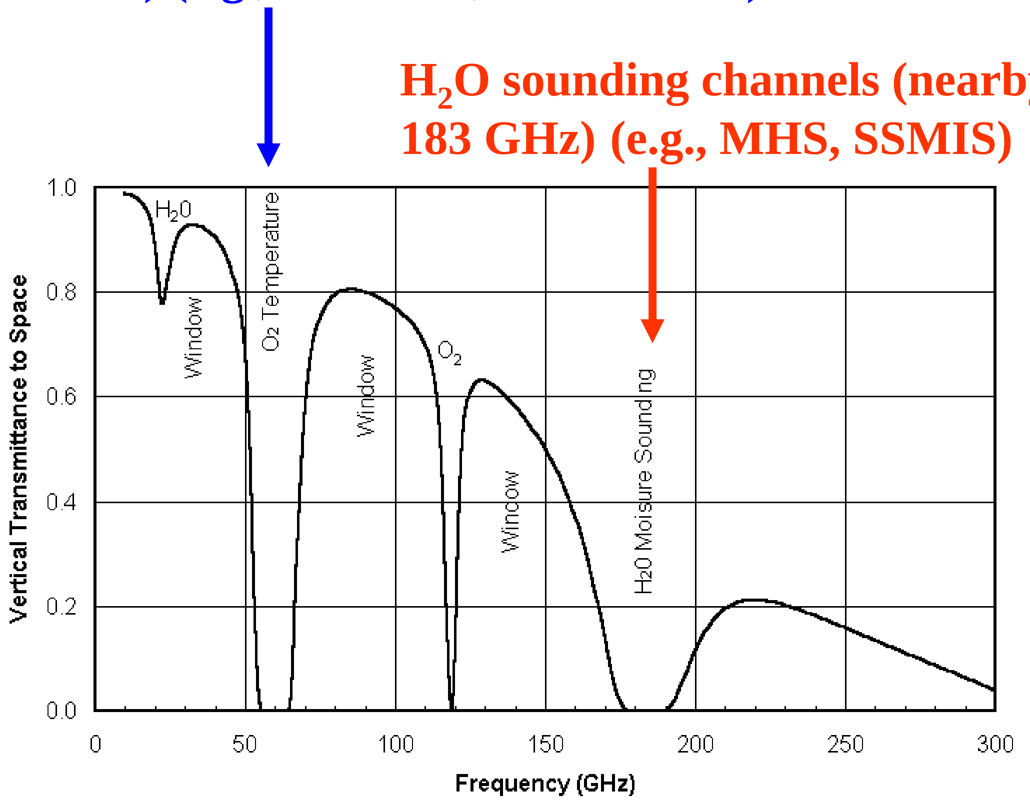
- Introduction
- Assimilation of MHS and (F16) SSMIS water vapor sounding channel data
- Preliminary assessment of F18 SSMIS data
- Summary

Satellite Microwave Sounding Channels

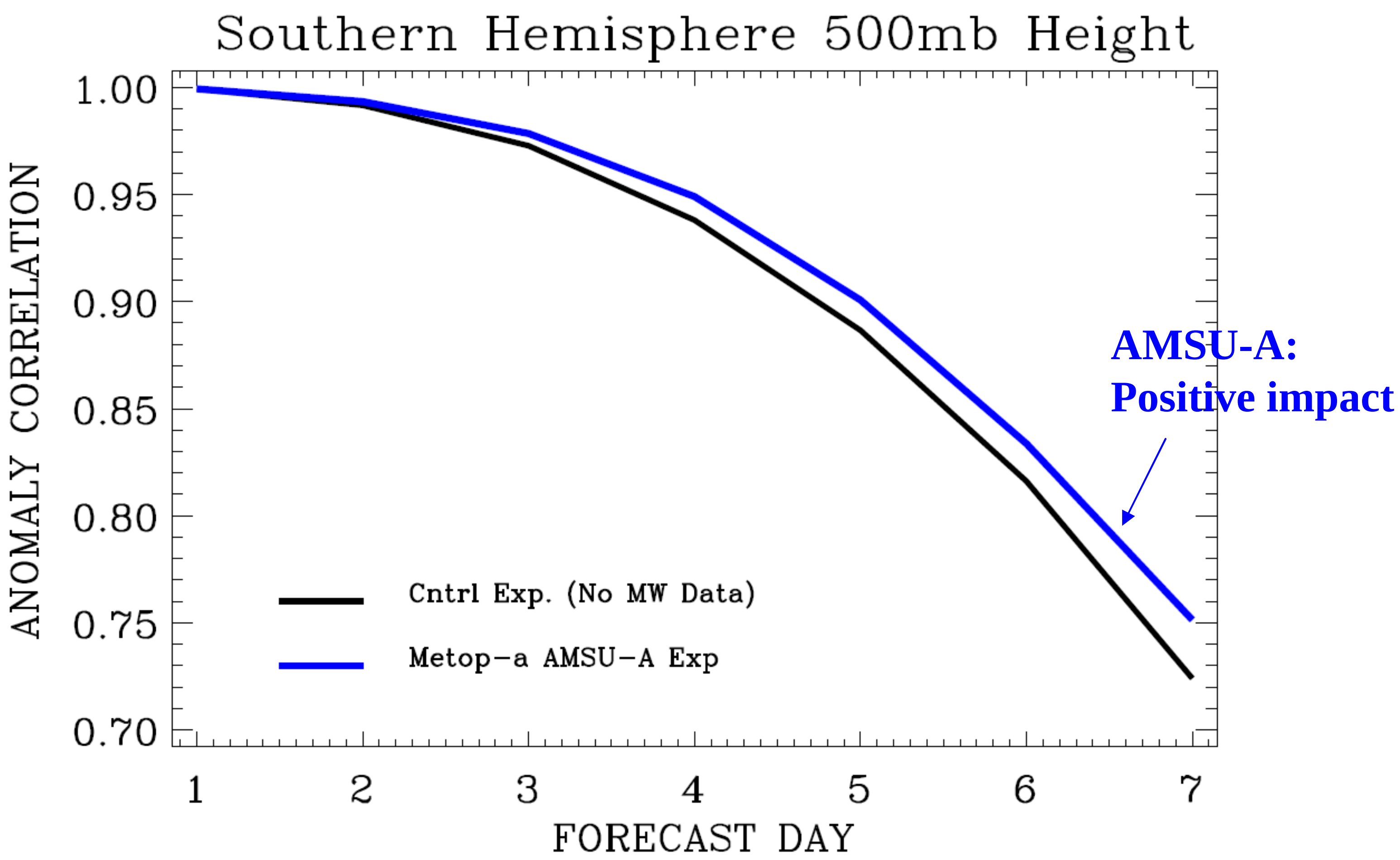
- Two groups of microwave sounding channels: one is temperature sounding channels which are between 50 and 60 GHz; other one is water vapor sounding channels nearby 183 GHz provide rich sounding information of water vapor
- Those channel measurements are mostly available from NOAA, Metop, DMSP, and Fengyun-3 satellites

Temperature sounding channels (50 ~ 60 GHz) (e.g., AMSU-A, SSMIS LAS)

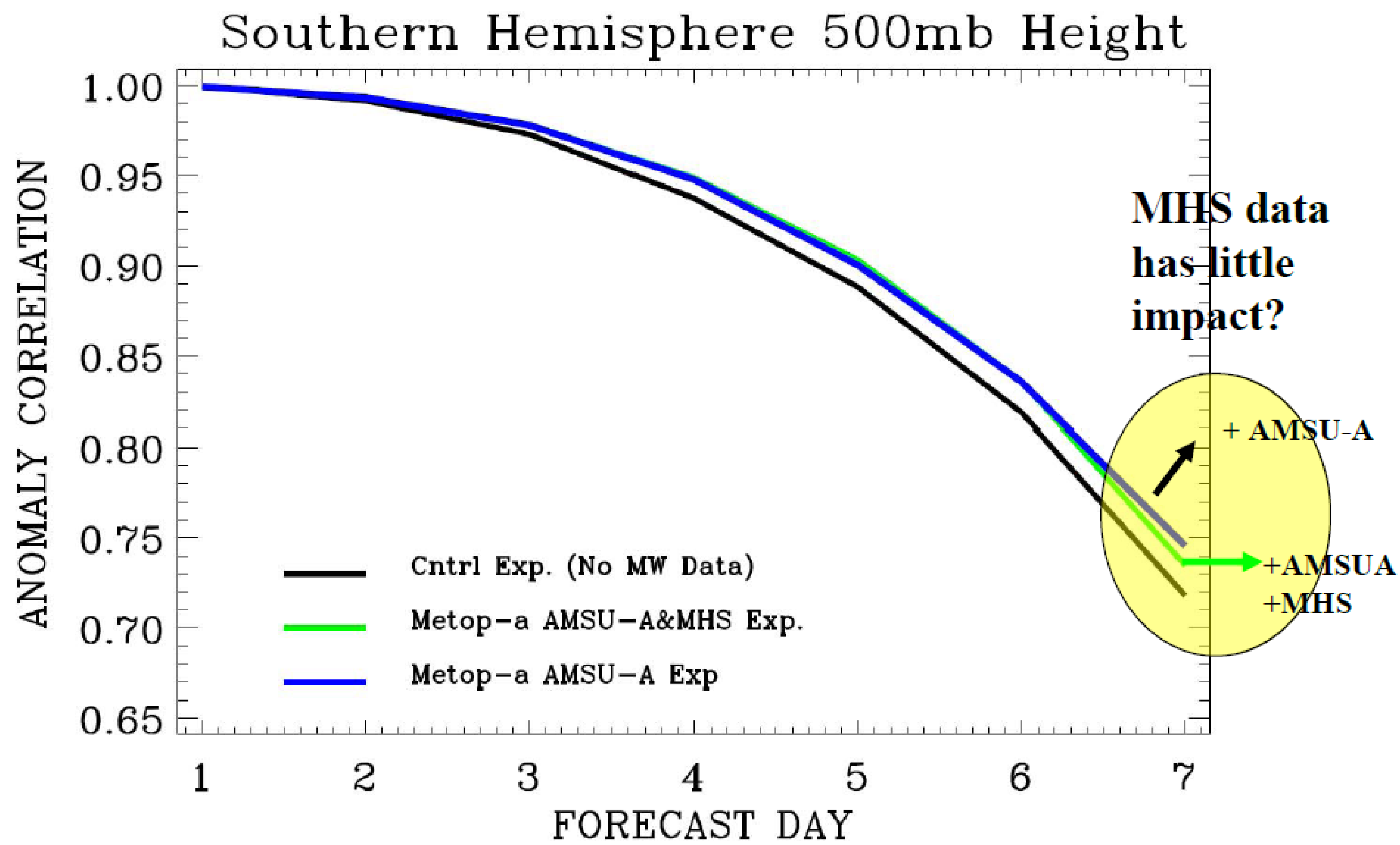
H_2O sounding channels (nearby 183 GHz) (e.g., MHS, SSMIS)



Assimilation Impact of METOP-A AMSU-A Data



Assimilation Impact of METOP-A MHS Data (Current Quality Control)



- Little impacts in GFS are observed from assimilation of water vapor sounding channels

Requirements in Satellite Data Assimilation

- Observations have no bias after better calibration and bias correction

- Radiative Transfer Model (RTM) associated with surface emissivity model is physically consistent with what data represents

- Data passing **quality control** is 1) not affected by clouds and 2) can also be well simulated by RTM

(which are due to limited capabilities in RTM, Global Data Assimilation System, and GFS)

Current Quality Control Scheme for Satellite Microwave Water Vapor Channels

$T_{B,iCH}$ (i=1~5) after bias correction, $\Delta T_{B,ich}$, T_S, ε, etc.

1ST Criterion: Reasonability check of the data

2nd Criterion: Check of cloud-affected data using $\Delta T_{B,CH.1}$ & $\Delta T_{B,CH.2}$ **(?)**

$$factor = [0.1(\Delta T_{B,CH1} - 7.5\, dsi)]^2 + dsi^2$$

sea, ice, snow :

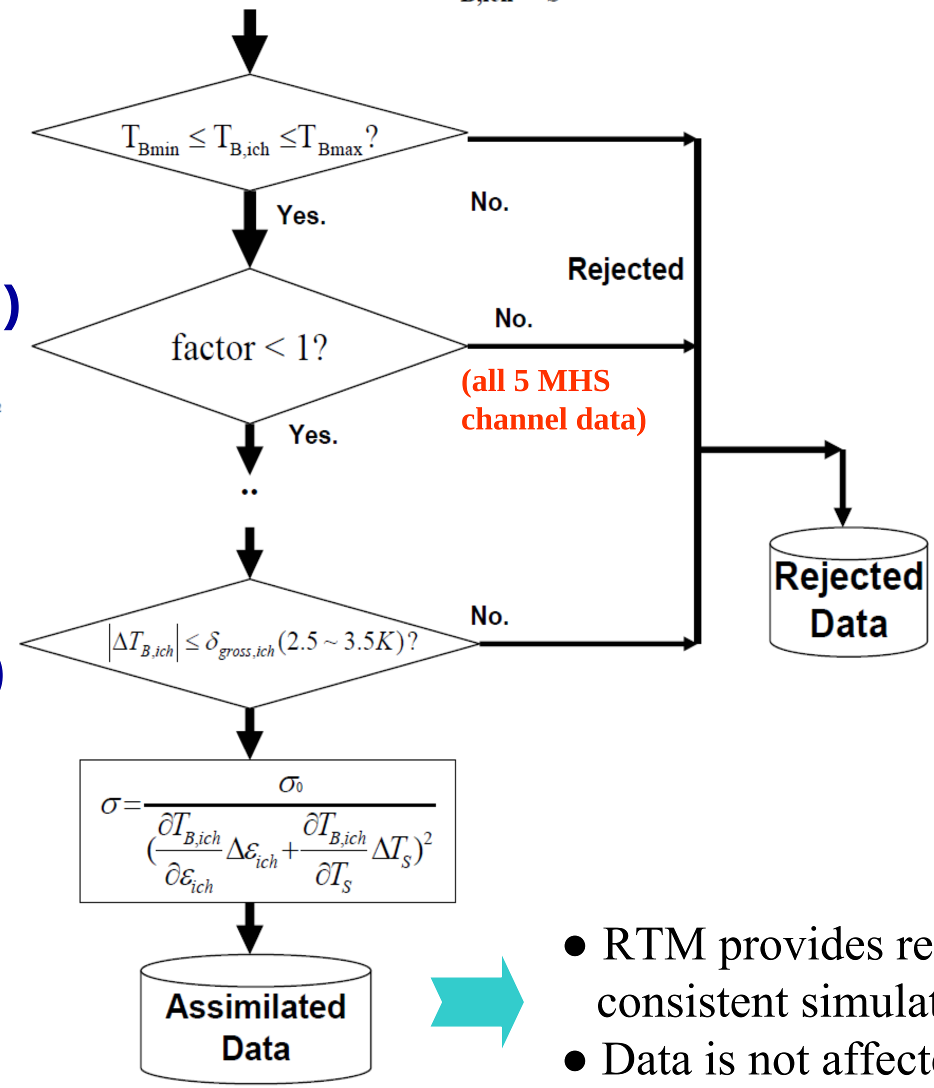
$$dsi = 0.13\left(\frac{\Delta T_{B,CH1} - 33.58\,\Delta T_{B,CH2}}{300. - \Delta T_{B,CH2}}\right)$$

otherwise :

$$dsi = 0.85\,\Delta T_{B,CH1} - \Delta T_{B,CH2}$$

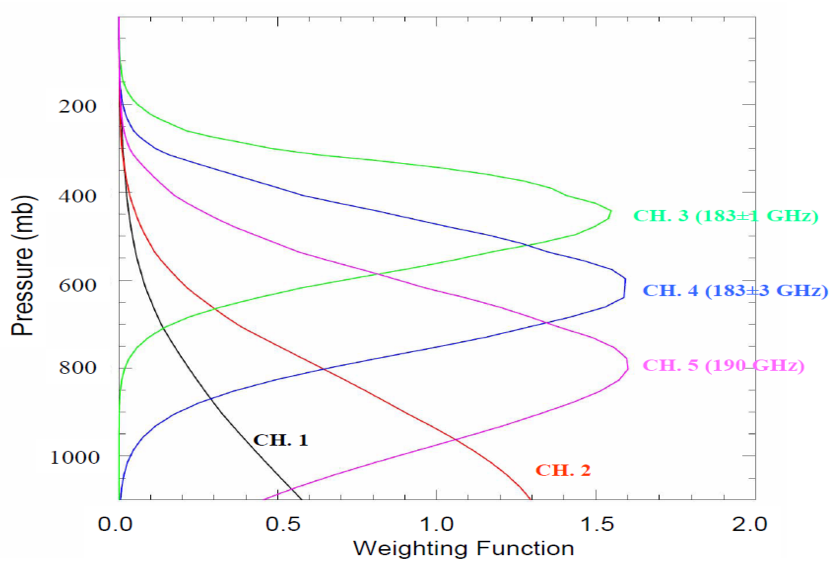
3rd Criterion: Gross error check of the data (2.5 ~ 3.5 K) **(?)**

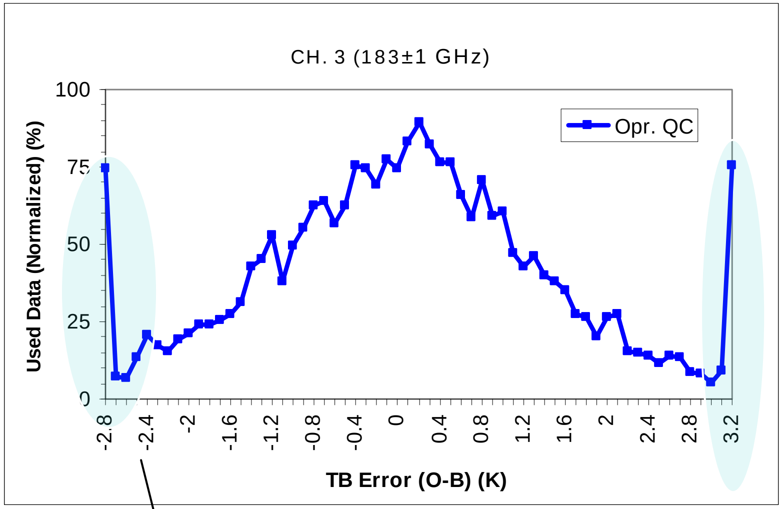
4th Criterion: Determination of weighting factor (σ) of the data



- RTM provides relatively consistent simulation for data
- Data is not affected by clouds

Major Problems in Current Quality Control Scheme for MHS (AMSU-B) Water Vapor Channels





(gross error check threshold: about 3 K)

Residual cloud contamination?

e.g., when $\Delta\varepsilon = 0.04$,

ΔT_B: around 8 K (89 and 157 GHz)

ΔT_B: around 6 K (183±7 GHz)

ΔT_B: around 3 K (183±3 GHz)

ΔT_B: around 1 K (183±1 GHz)

Problems: 1) High quality sounding channel data might be removed

2) Some cloud-detected data might remain

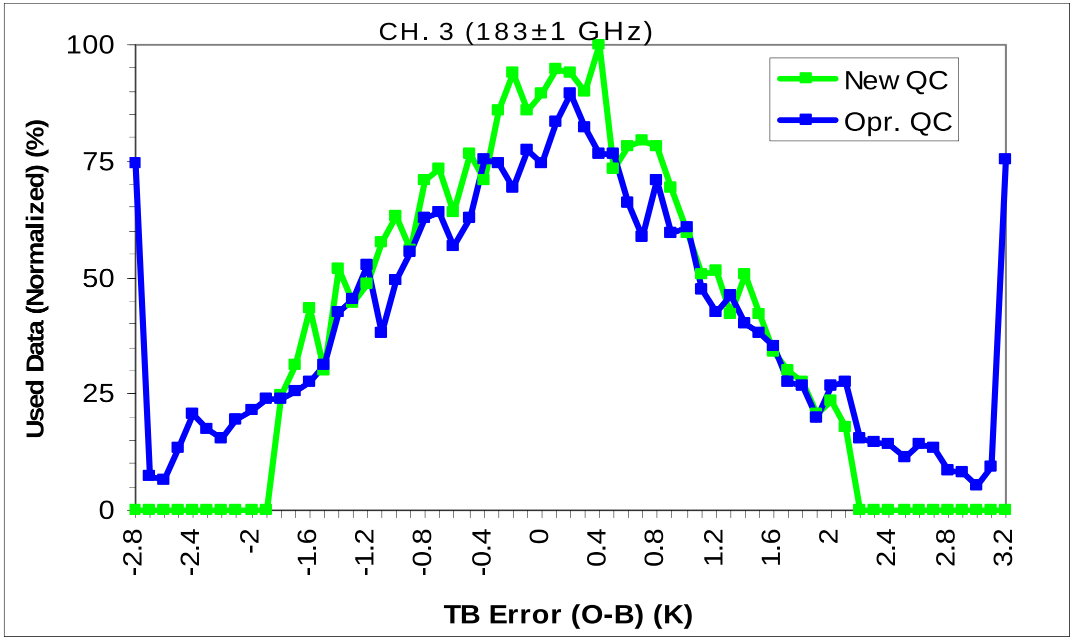
Improved Cloud Detection for MHS (AMSU-B) Quality Control

- QC criteria from two window channels are not applied to three water vapor channels

- Gross error check threshold is set to 2 K

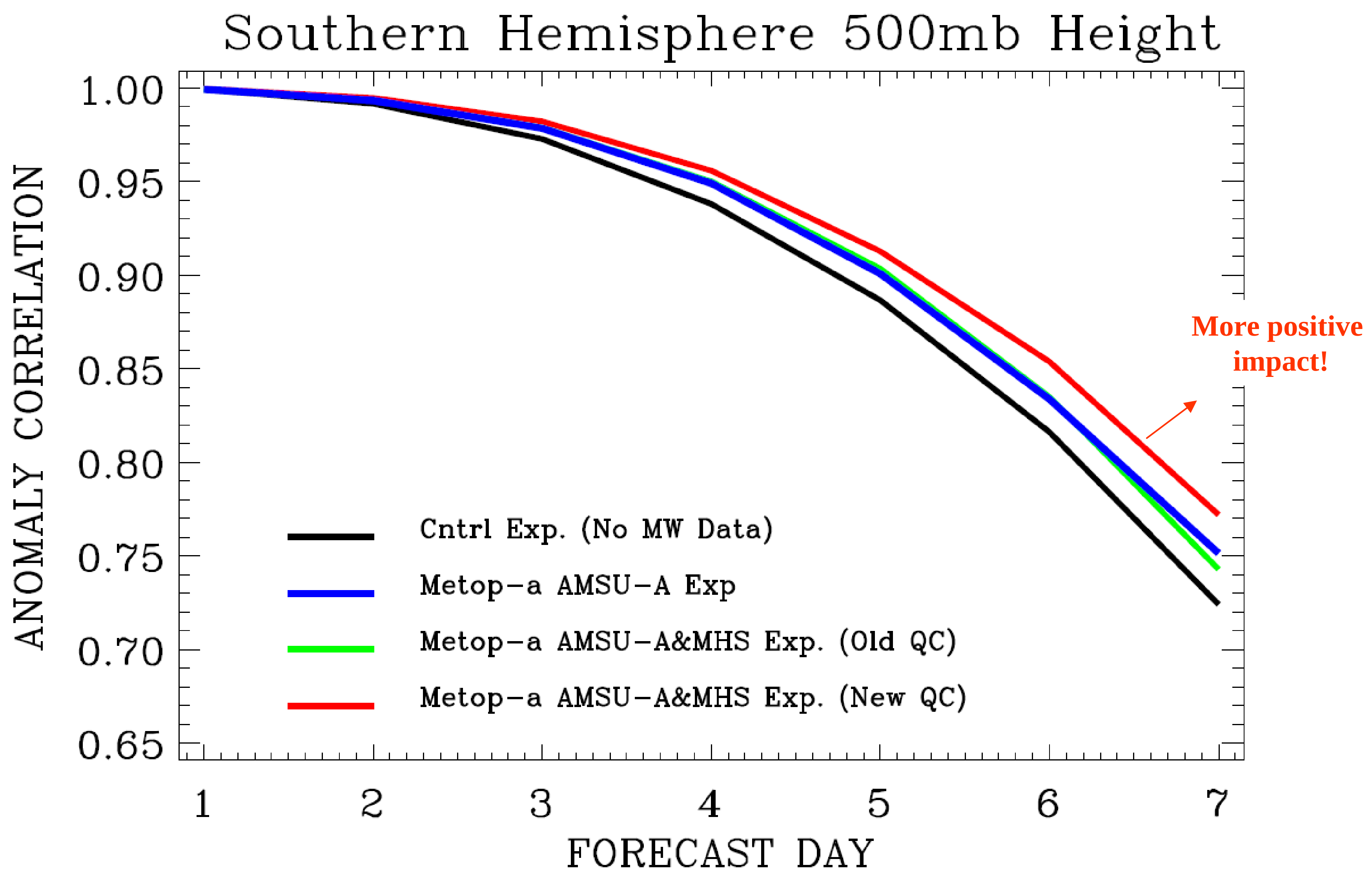
- More high quality is used and less cloud-contaminated data remain using new QC criteria

TB departure histograms (new/old QCs)



Impacts of METOP-A MHS Data (New/Old QCs)

(Exp. Period: Sept. 1 – Oct. 30, 2009)



Cloud Detection Algorithm for SSMIS Water Vapor Channel Data

- Introduce a ratio (r) of two scattering parameters at 91.655 V-POL and 150 H-POL (Ω_{91}, Ω_{150})

$$r = \frac{\Omega_{91}}{\Omega_{150}}$$

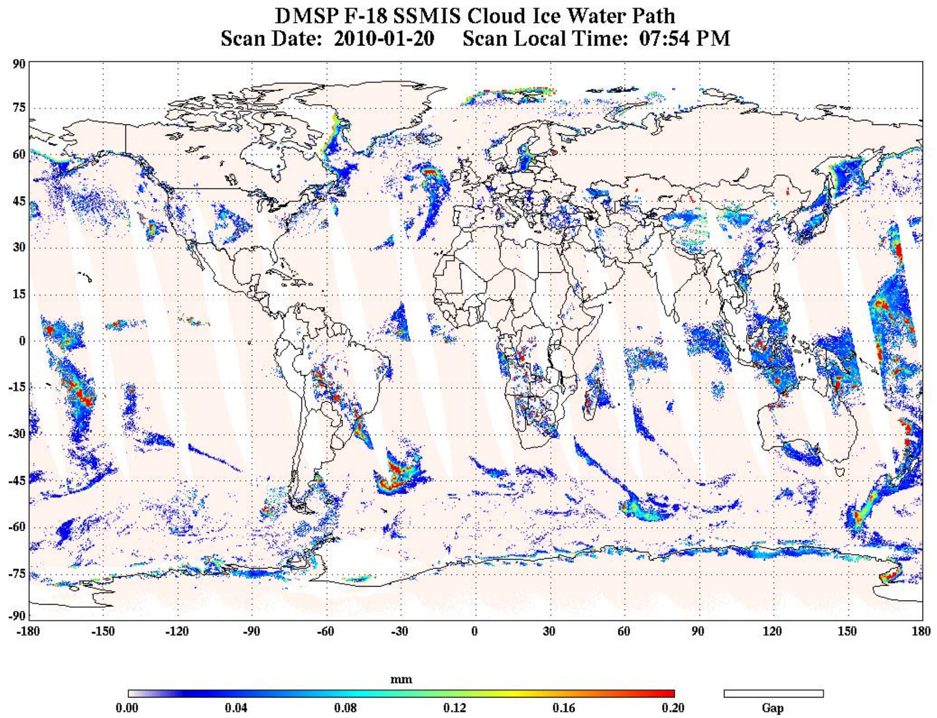
- Effective diameter of ice particles (De) is determined by r

$$D_e = \exp[a_0 + a_1 \ln(r) + a_2 \ln^2(r)]$$

- Ice water path (IWP) is determined by Ω_{91} and De)

$$IWP = \frac{\Omega_{91v} * De * COS(53.2^o) * \rho_{ice}}{\Omega_N}$$

$$\Omega_N = \exp[b_0 + b_1 \ln(D_e) + b_2 \ln^2(D_e)]$$



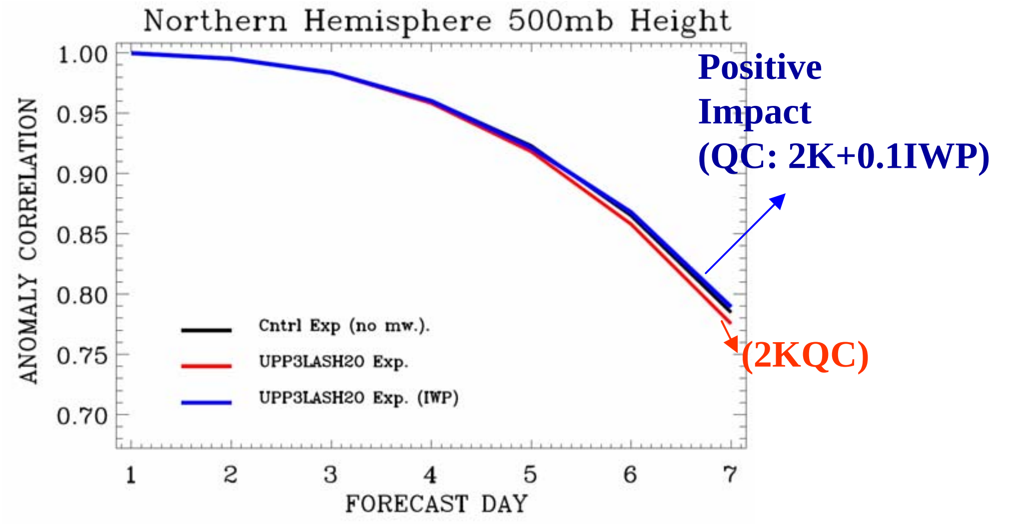
(Reference: Sun and Weng, JAMC, 2010)

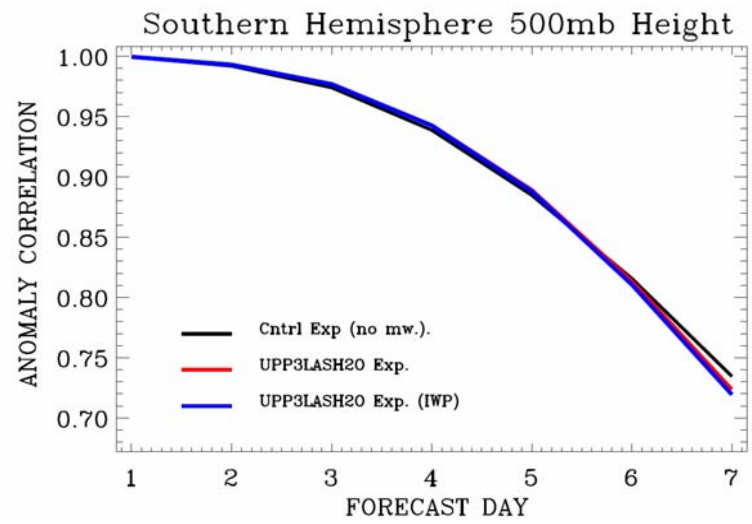
Impacts of F16 SSMIS UPP Water Vapor Sounding Data

- Positive impacts of F16 SSMIS UPP water vapor sounding data in NH (IWP-cloud detection of 0.1 mm)

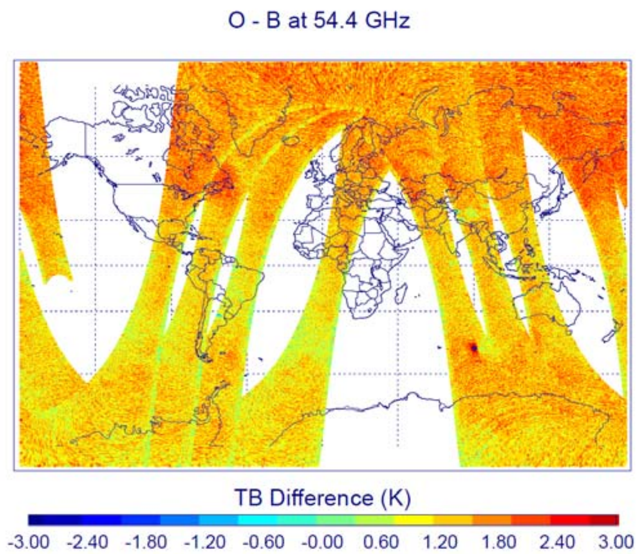
- Little impact of F16 water vapor sounding data in SH

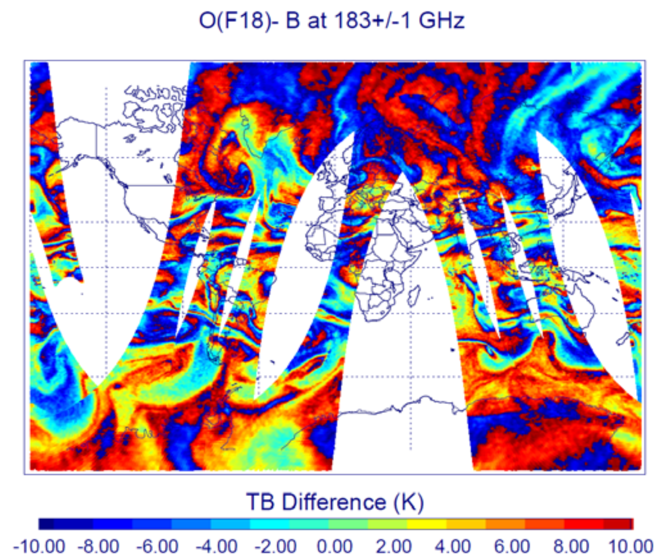
- A remaining issue: F16 UPP water vapor sounding data has some residual calibration bias?

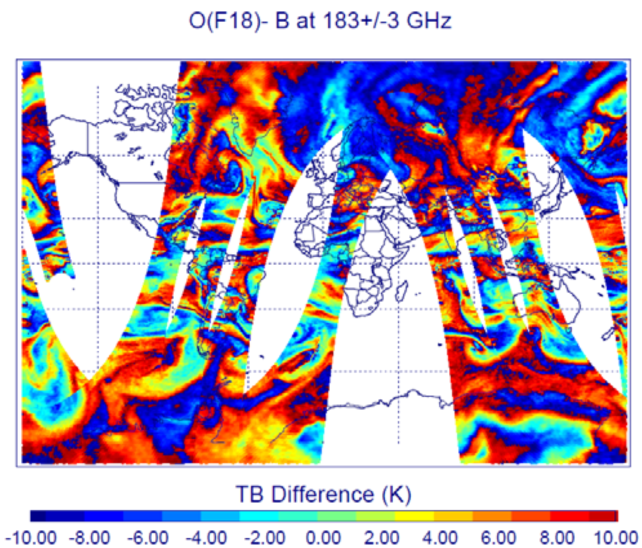


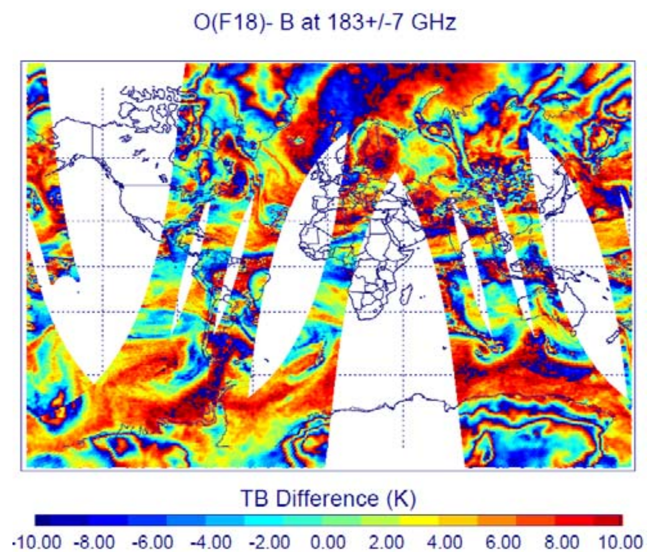


Preliminary Assessment of F18 SSMIS Data



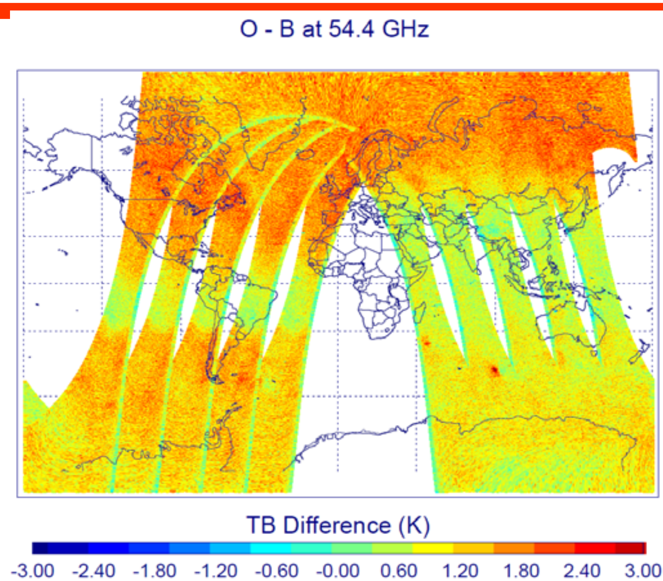




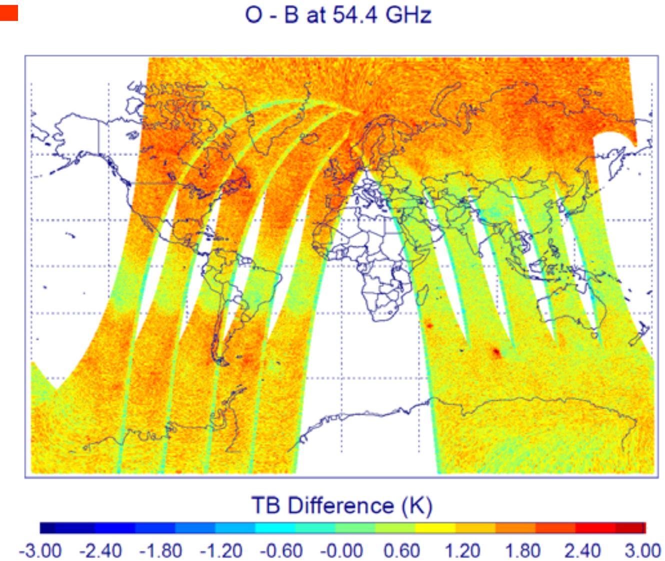


O –B (3 SSMIS & N19 AMSU-A): 54.4 GHz

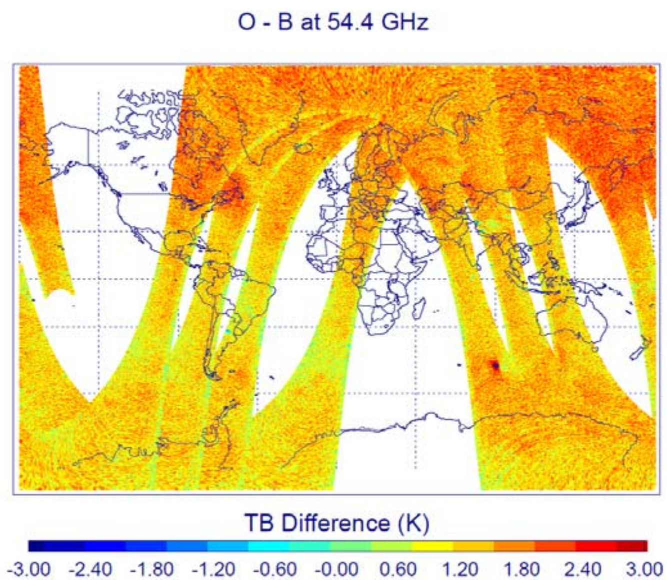
F16



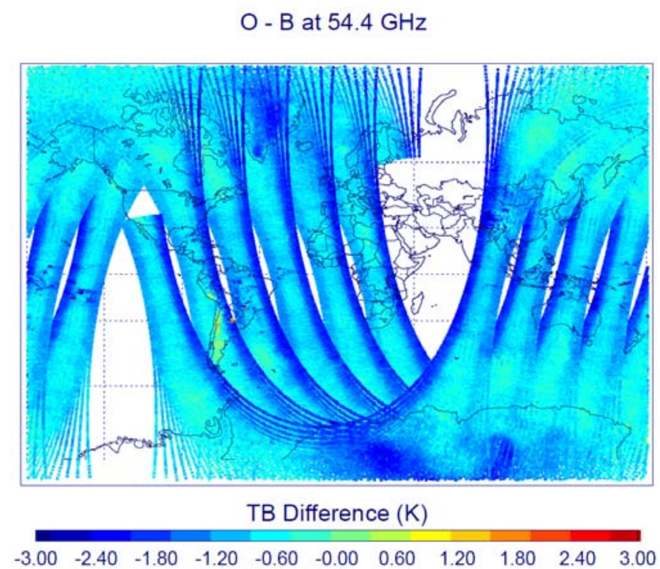
F17



F18



N19



Summary

- **Assimilation of MHS water vapor sounding channel data**
  - *An improved QC scheme is developed for MHS water vapor sounding channels*
  - *This improved QC results in more positive impacts of Metop-a MHS water vapor data in GFS*

- **Assimilation of SSMIS water vapor sounding channel data**
  - *An ice water path algorithm developed by Sun and Weng (2010) is applied to check (ice) cloud-contaminated data in F16 UPP*
  - *A positive impact is observed over NH from F16 SSMIS UPP water vapor data, but little impact over SH*

- **Preliminary assessment of F18 SSMIS data**
  - *Preliminary results show that F18 SSMIS data has an excellent performance compared to F16 & F17 data*
  - *Assimilation impact of F18 is yet to be completed*