# Enhancing the assimilation of microwave water vapor channels

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# Outline

# Variational Bias Correction

## Variational Bias Correction

Cost function for 3D-Var Data Assimilation:

$$J(\vec{x}) = \overbrace{\frac{1}{2}(\vec{x} - \vec{x_b})^T \vec{B}^{-1}(\vec{x} - \vec{x_b})}^{J_b} + \overbrace{\frac{1}{2}(H(\vec{x}) - \vec{y})^T \vec{R}^{-1}(H(\vec{x}) - \vec{y})}^{J_o}$$
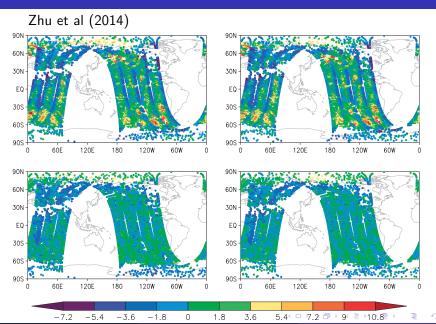
$y = Tb + \epsilon_r + \epsilon_s$

$\epsilon_s$ is the random error (R) and $\epsilon_s$ is known as observation bias or representativeness error that is taken into account using the variational bias correction:
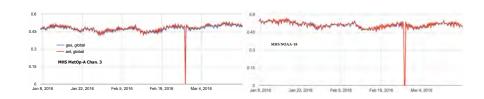
$$\epsilon_s = \sum_{k=1}^{N} \beta_k p_k + b^{angle}$$

The control variables ($p_k$) include cloud liquid water (CLW); temperature lapse rate; and the square of the temperature lapse rate.
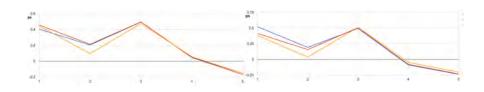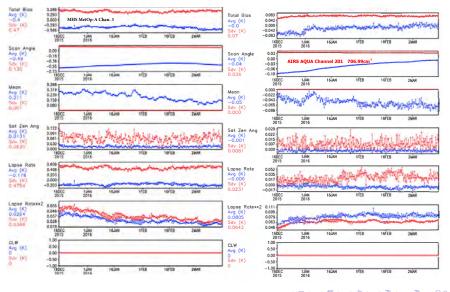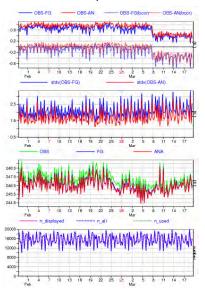
# Variational Bias Correction

Zhu et al (2014)

# NASA GMAO
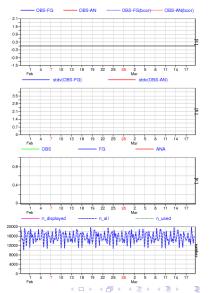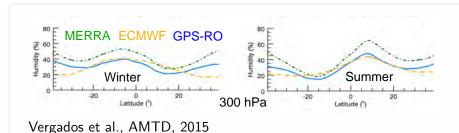
# ECMWF

## All MHS MetOp-A Observations

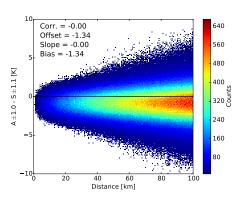## Assimilated MHS MetOp-A

# Issues in Variational Bias Correction?

$\epsilon_s = Obs_e + RT_e + Col_e$

- variational bias correction does not distinguish between the model error and the observations error
- in variational bias correction, the RT and collocation errors are counted as observations error
- biased NWP fields or some biased observations could lead to the over-correction of good observations
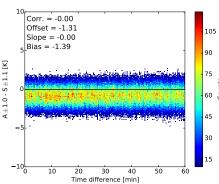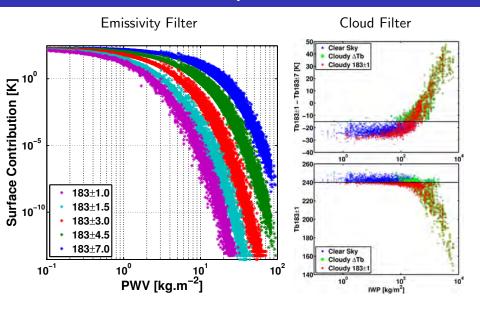


Vergados et al., AMTD, 2015

# Collocation Error

## Collocation error as a function of distance
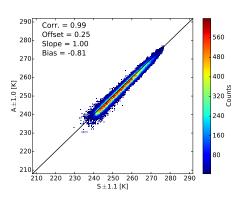
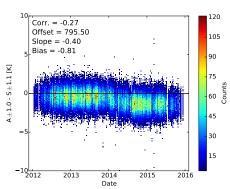## Collocation Error vs. the time difference

# Clouds and Surface Emissivity

# Radiometric Error
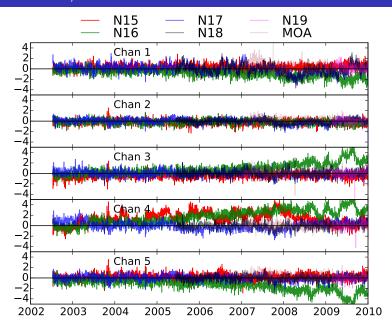
# Quantifying Radiometric Error
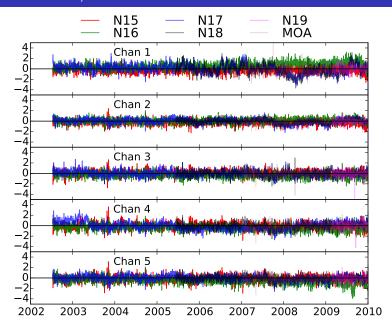


Collocated observations from similar channels

Time series of the difference between the observations
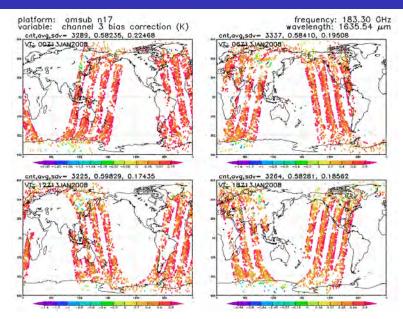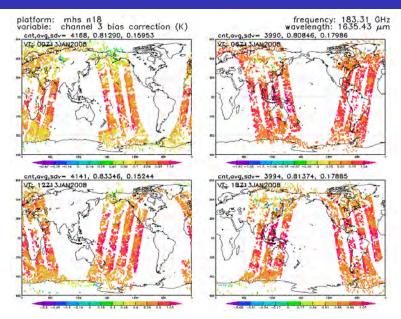
# Level 1b MHS/AMSU-B

# Corrected MHS/AMSU-B

# Validation
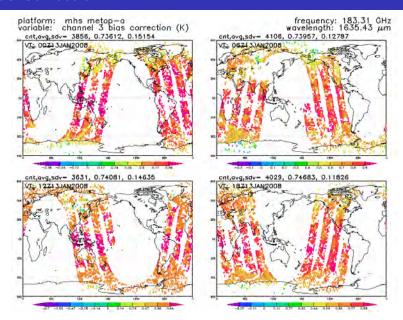
# L1b Bias Correction

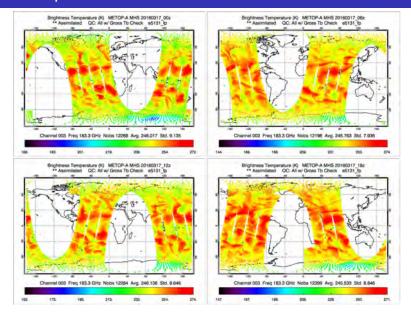# L1b Bias Correction

# L1b Bias Correction



platform: mhs metop-a
variable: channel 3 bias correction (K)

frequency: 183.31 GHz
wavelength: 1635.43 $\mu m$
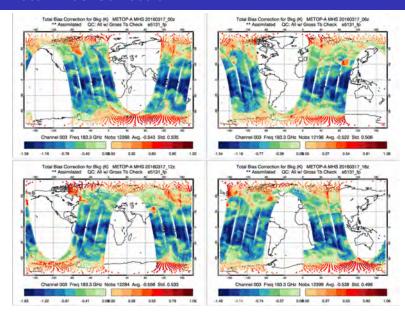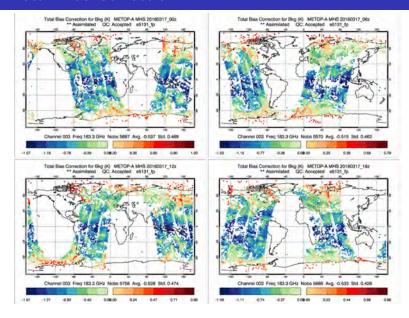
# GMAO MetOp-A MHS Tb's

# GMAO Total Bias Correction
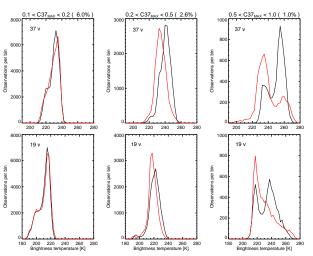
# GMAO Total Bias Correction

# Assimilation of All-Weather MW

Black: observed, Red: bias-corrected FG for AMSR-E 37v. C37 is the cloud index derived from polarization difference (one minus v-h all sky divided by v-h clear) C37 varies from 0 for clear-sky to 1 for opaque clouds (Geer and Bauer, 2010).

**Conclusions**

# Conclusions

- variational bias correction technique does not distinguish between error sources - errors may compensate for each other

- variational bias correction does not especially work for water vapor channels because of large error in the NWP water vapor fields

- more robust and physical bias correction techniques are available that can quantify different components of the representativeness error

- some preliminary results are presented but more work is required to properly validate the impact of bias corrected observations on the system

# Thank you for your attention!