A Variational Approach to NWP Preprocessing and Quality Control

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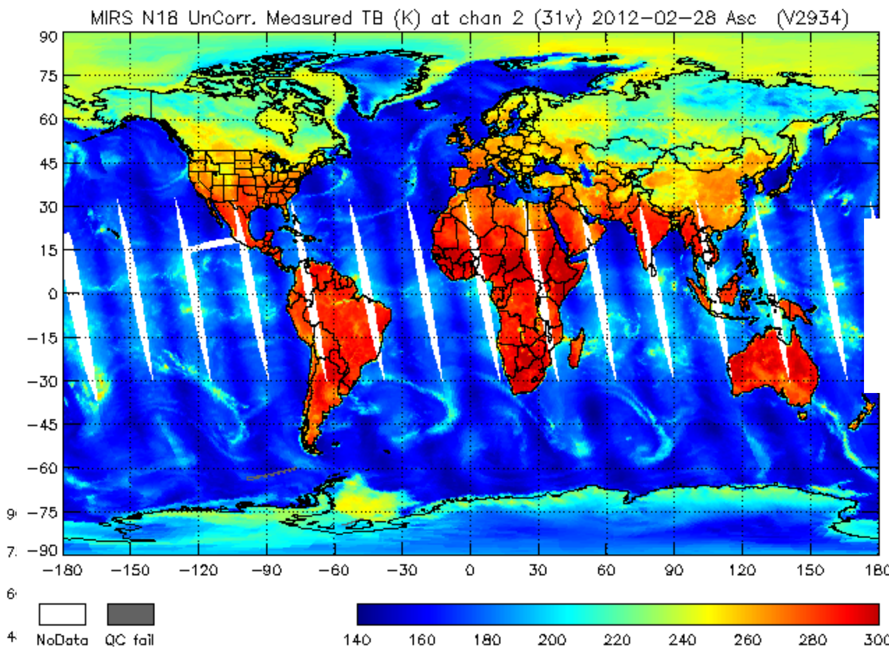
Motivation



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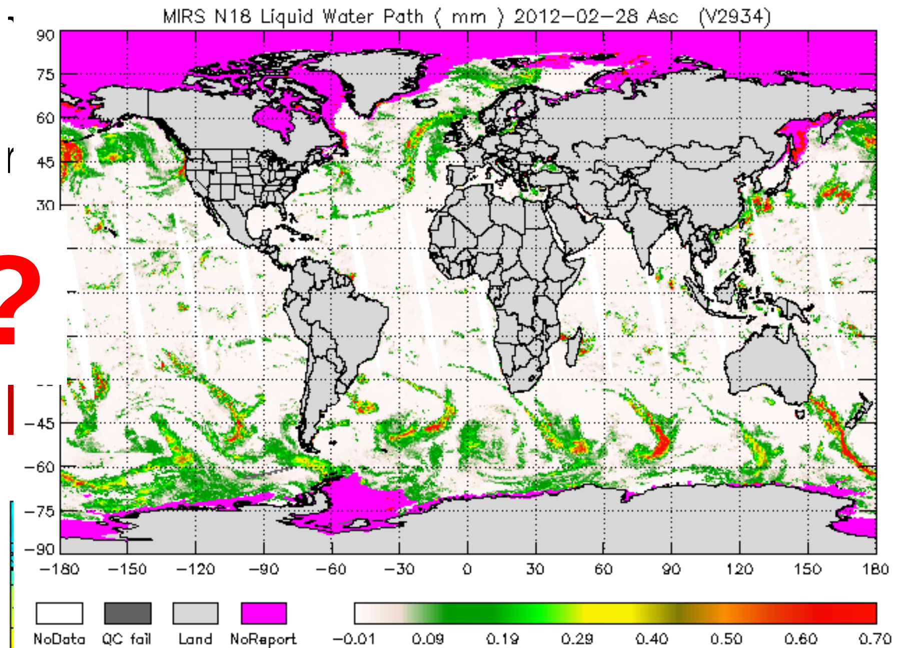

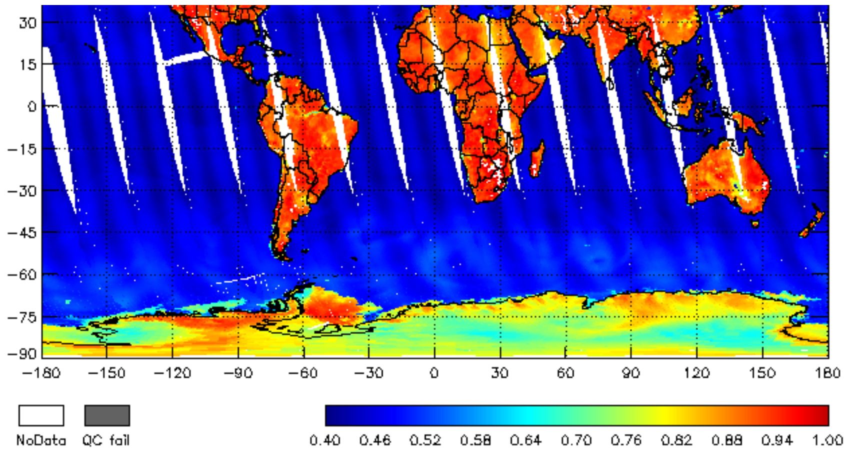

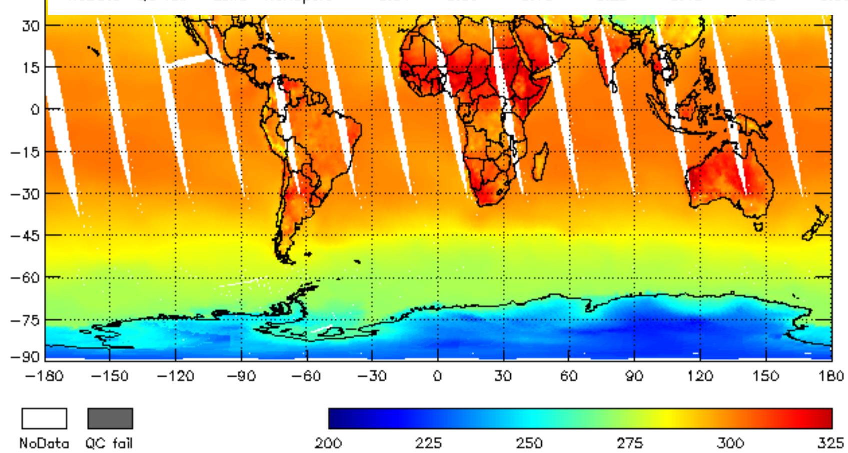

GDAS Analysis 23 GHz Emissivity and Tskin

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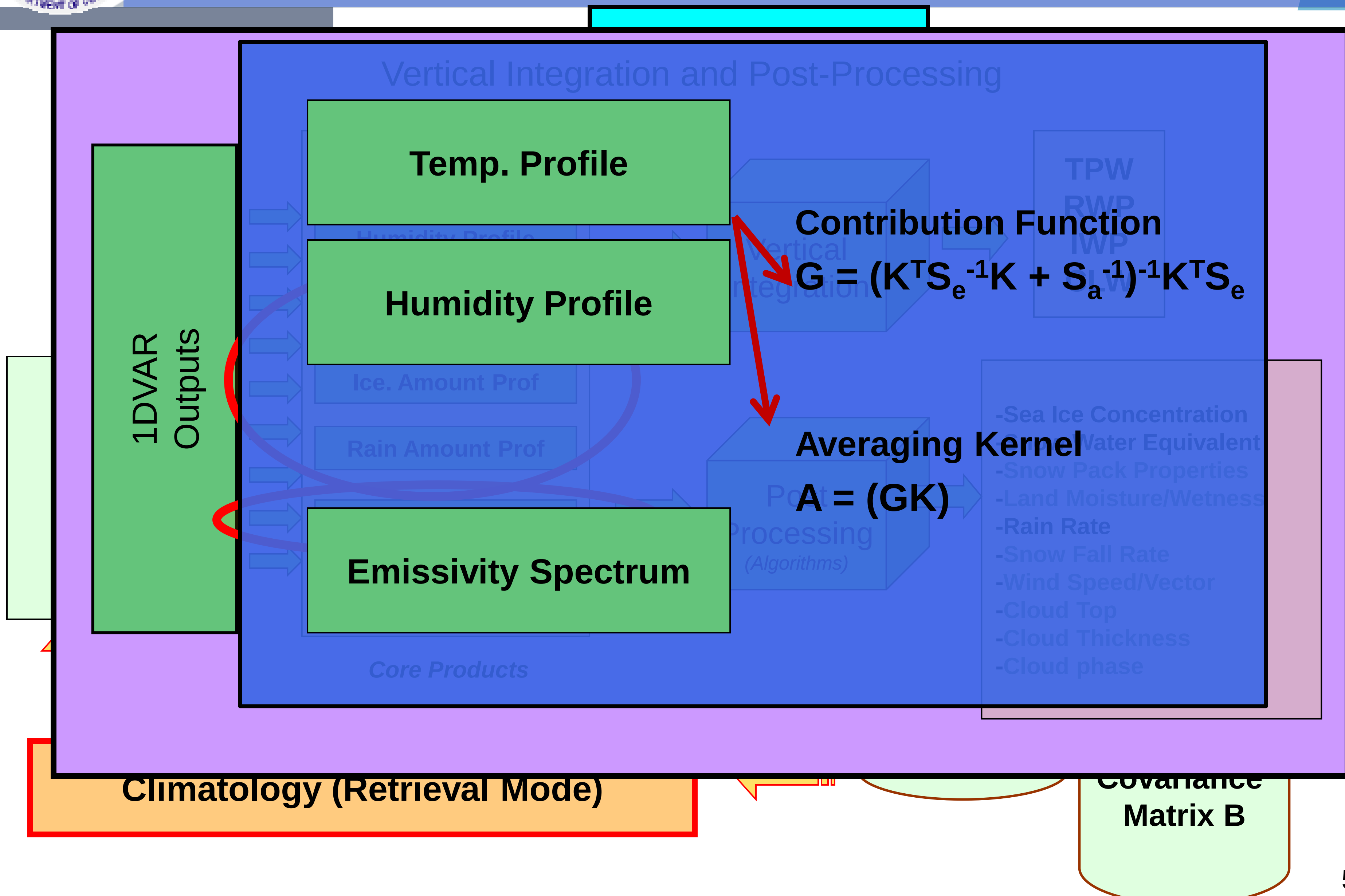
Outline

Overview

- Physical algorithm (1DVAR) for microwave sensors (MiRS)
- MiRS applies to imagers, sounders, combination
- Cost to extend to new sensors greatly reduced
- MiRS uses the CRTM as forward operator (leverage)
- Applicable on all surfaces and in all-weather conditions
- Operational for N18, N19, Metop-A and F16/F18 SSMI/S
- **On-going / Future:**
  - Extension operations to Metop-B, NPP/ATMS and Megha-Tropiques (MADRAS and SAPHIR)
  - Get ready for the JPSS and GPM sensors.
  - **Extend MiRS to Infrared Remote Sensing (CRTM is already valid)**

The 1DVAR Algorithm



Contribution Function

$$G = (K^T S_e^{-1} K + S_a^{-1})^{-1} K^T S_e$$

Averaging Kernel

$$A = (GK)$$

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1 The 1DVAR Algorithm

2 **Preprocessor – QC/Geophysical Fields**

3 Radiance Assimilation Impact

4 Summary

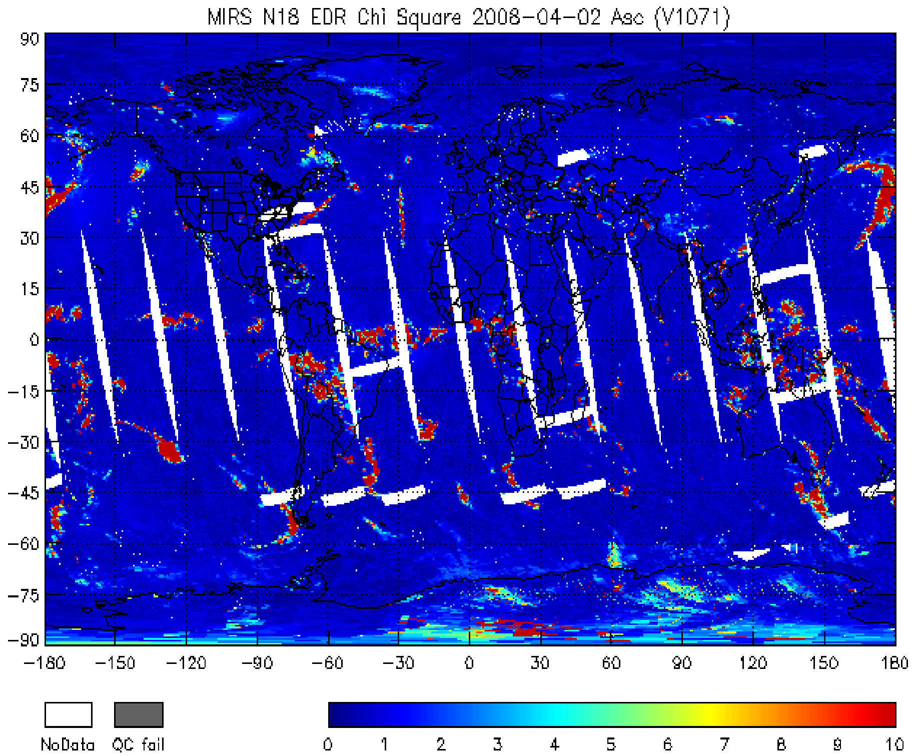
Preprocessor QC

- Convergence is reached everywhere: all surfaces, all weather conditions including precipitating, icy conditions
- A radiometric solution (whole state vector) is found even when precip/ice present. With CRTM physical constraints.

$$\varphi^2 = \left(Y^m - Y(X)\right)^T \times E^{-1} \times \left(Y^m - Y(X)\right)$$

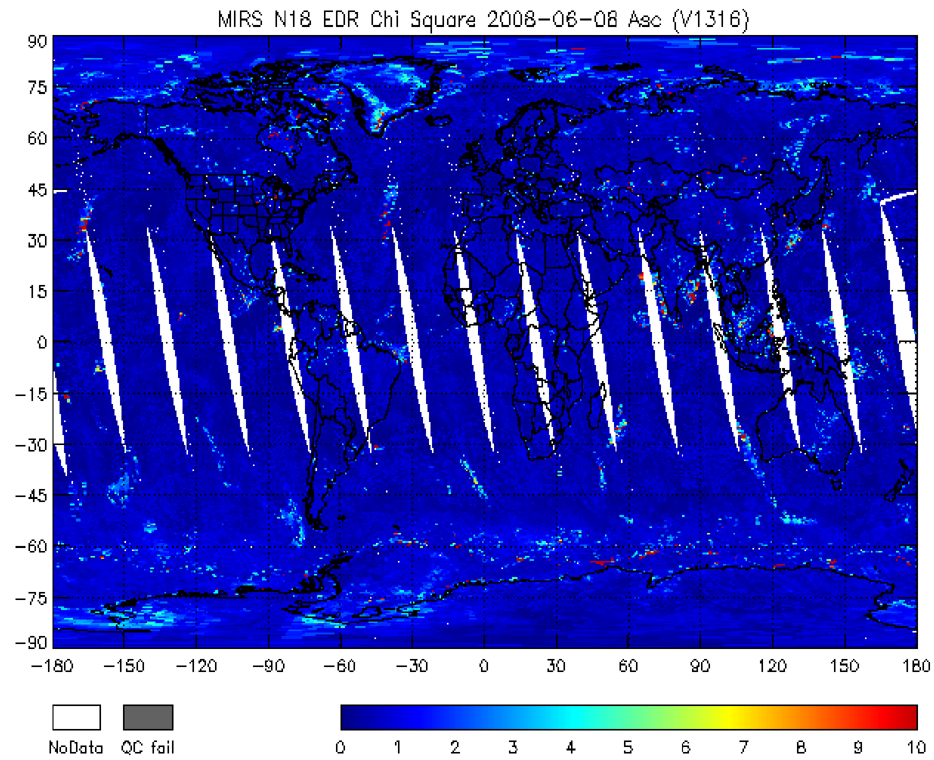
Previous version (1 attempt)

(assume non-scattering atmosphere)



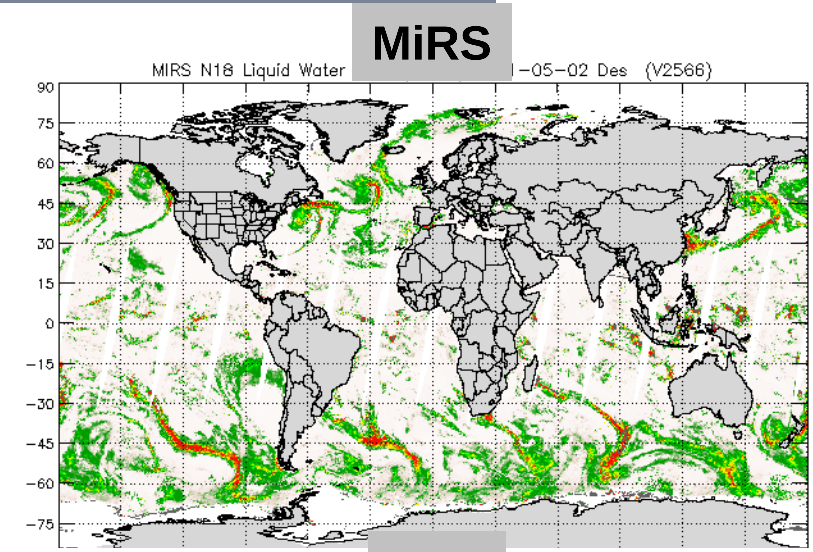
Current version (2 attempts)

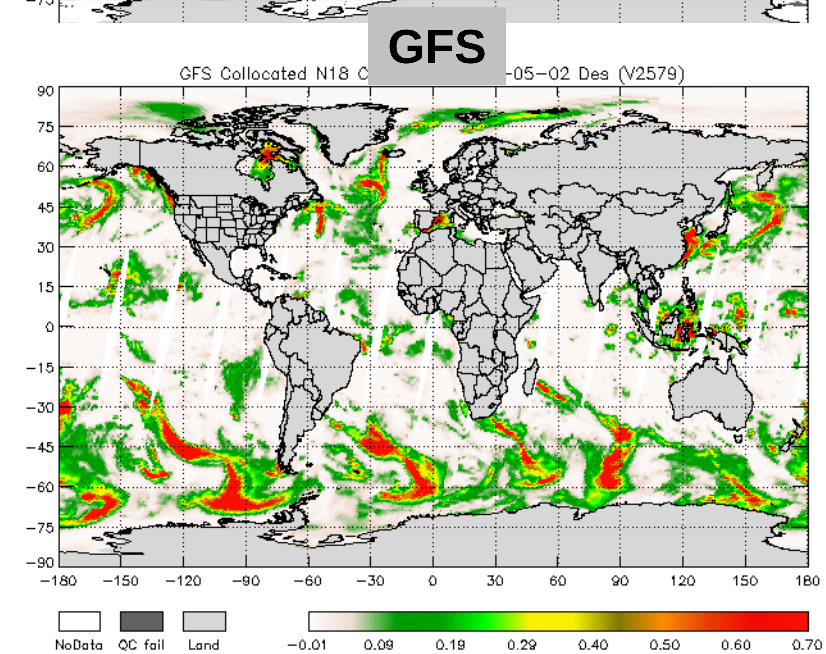
(assume scattering from precip)

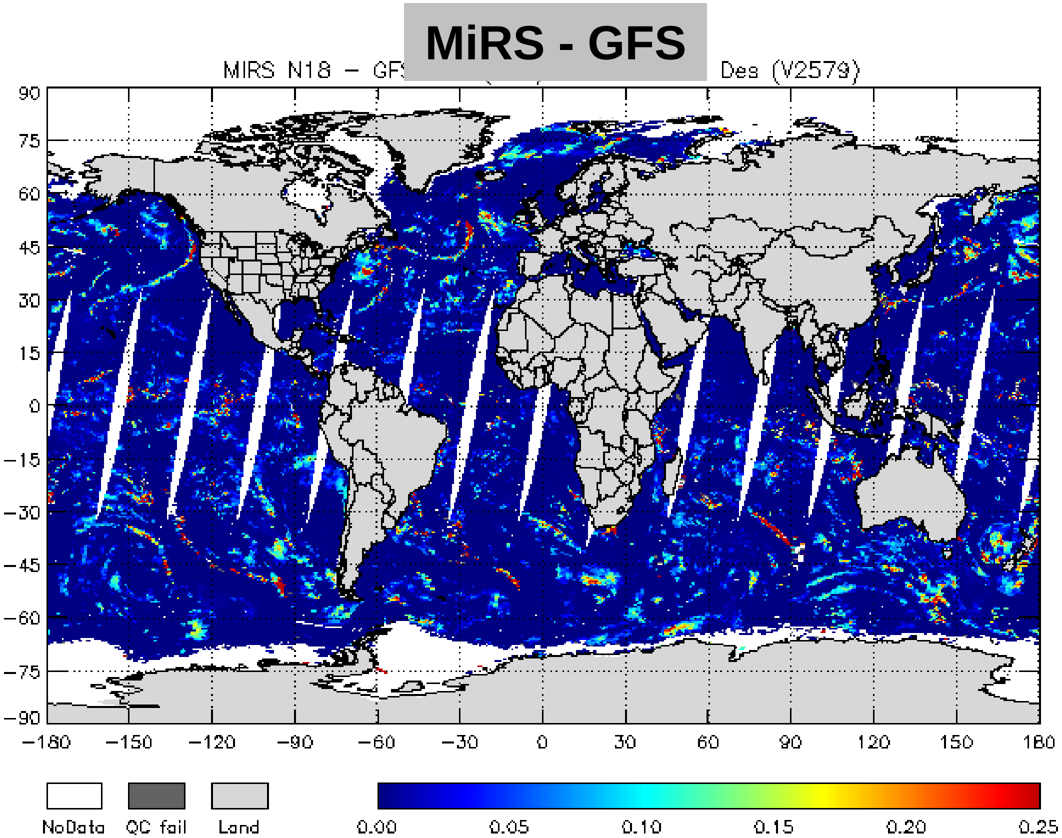


Preprocessor-CLW

Cloud Liquid Water

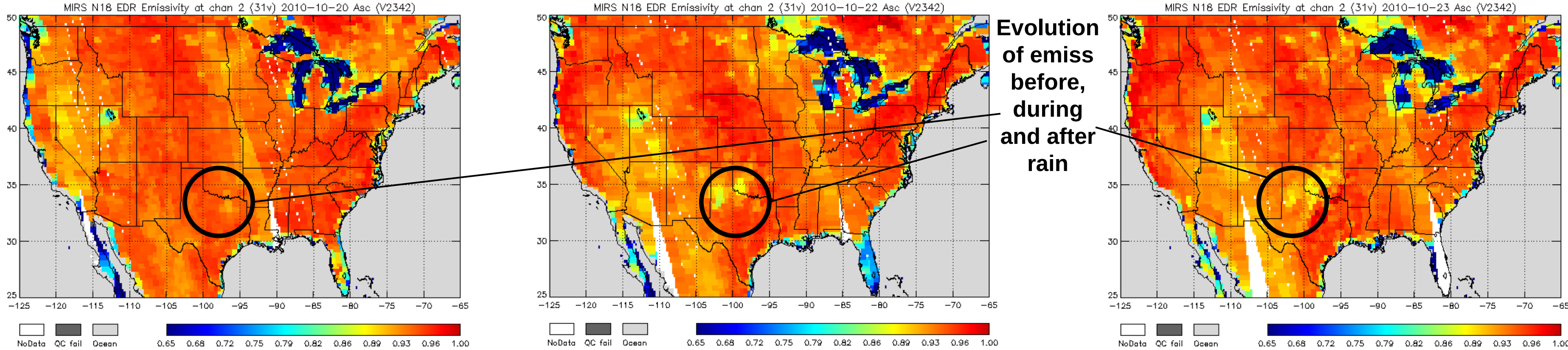




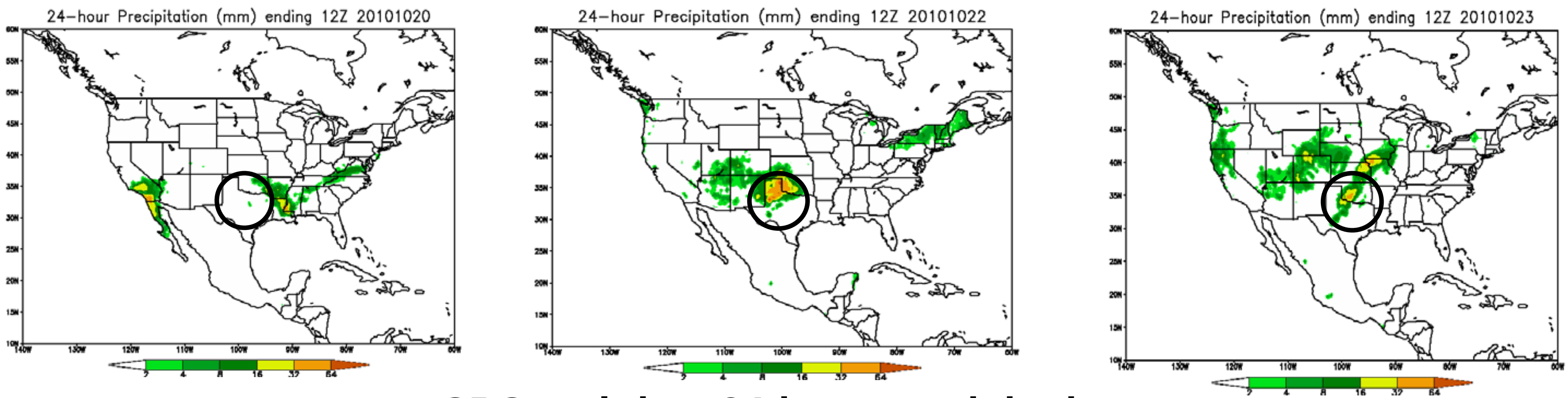


Preprocessor-Emissivity

MiRS N18 retrieved emissivity at 31 GHz ascending node



2010-10-20 **2010-10-21** **2010-10-22**



CPC real-time 24-hour precipitation

CPC Figures courtesy http://www.cpc.necp.noaa.gov

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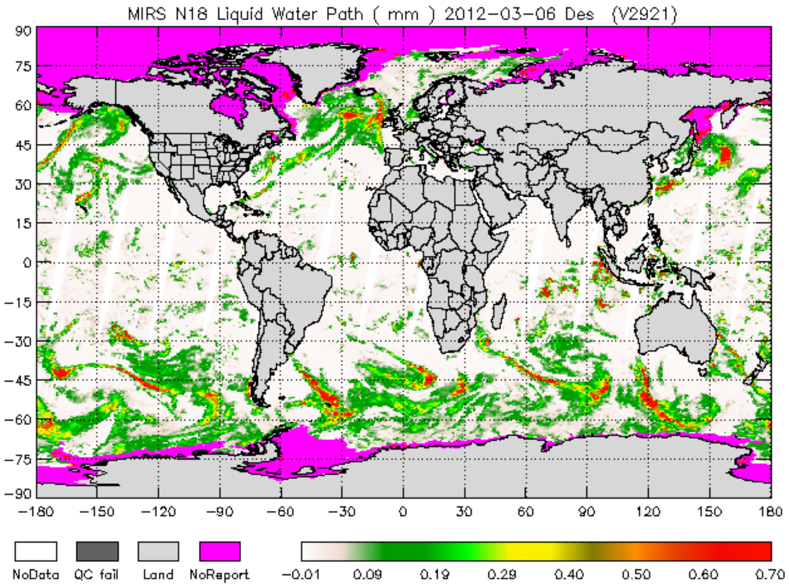
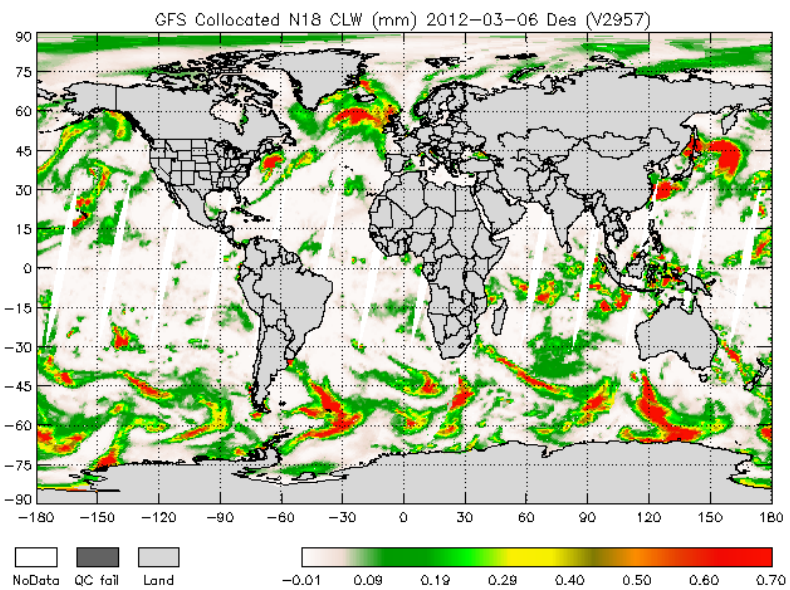
3 **Radiance Assimilation Impact**

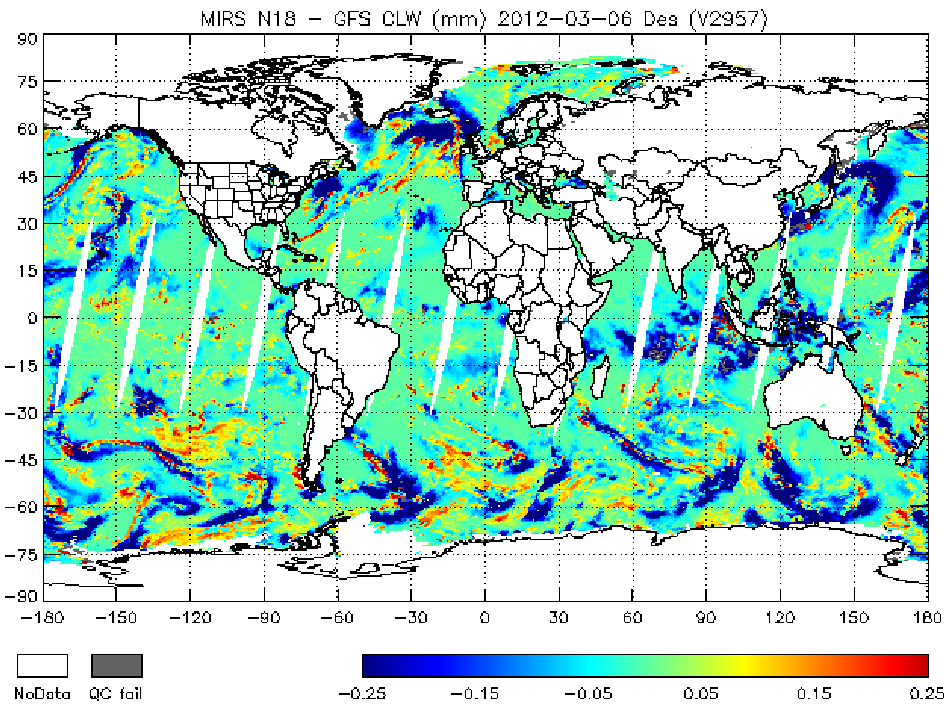
4 Summary

Assimilation Impact

…sing MiRS retrieved CLW

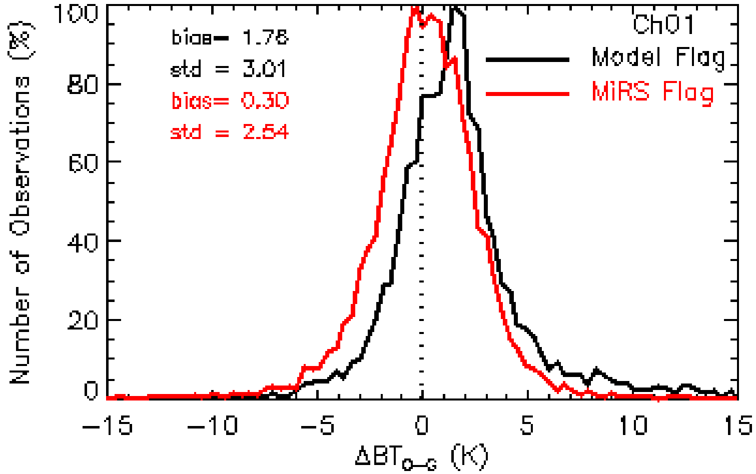




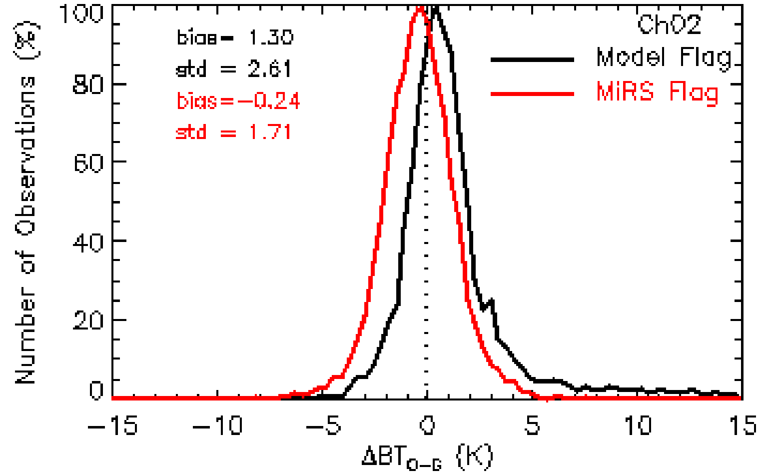


Assimilation Impact (O-B)

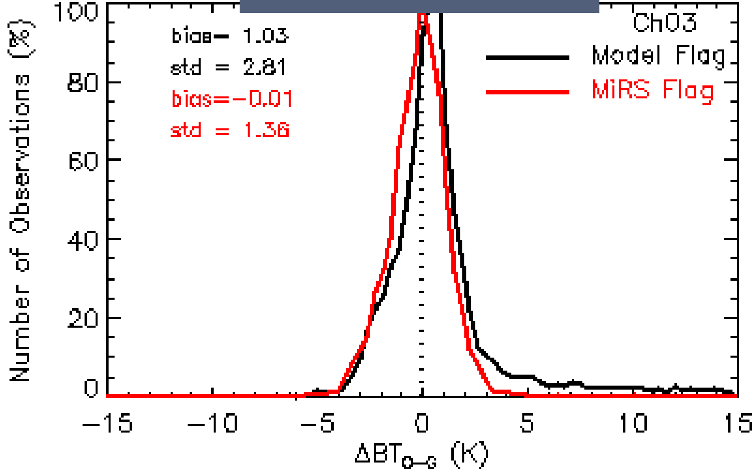
AMSU 23 GHz



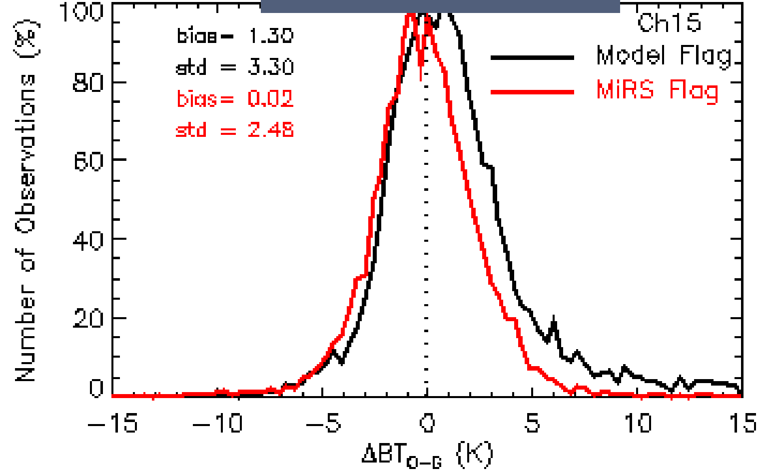
AMSU 31 GHz



AMSU 50 GHz

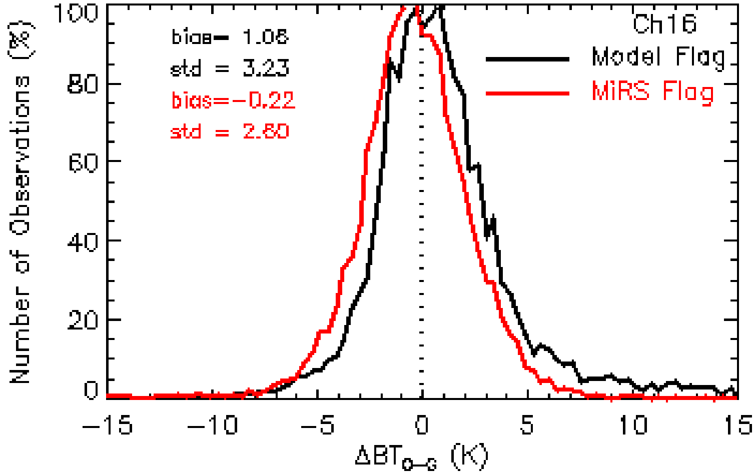


AMSU 89 GHz

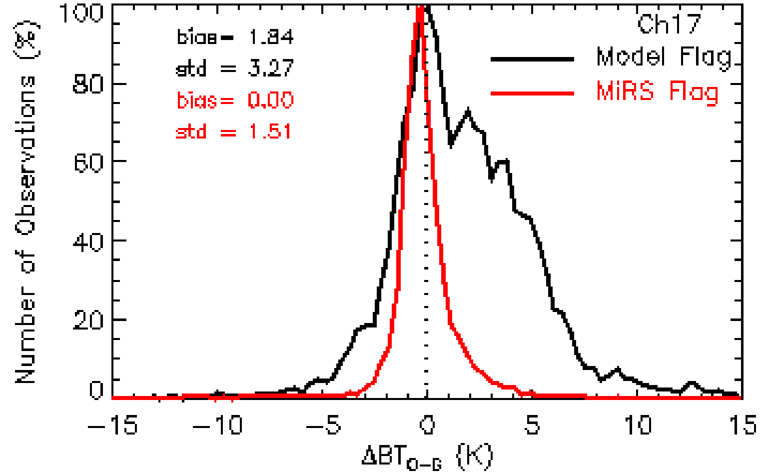


Assimilation Impact (O-B)

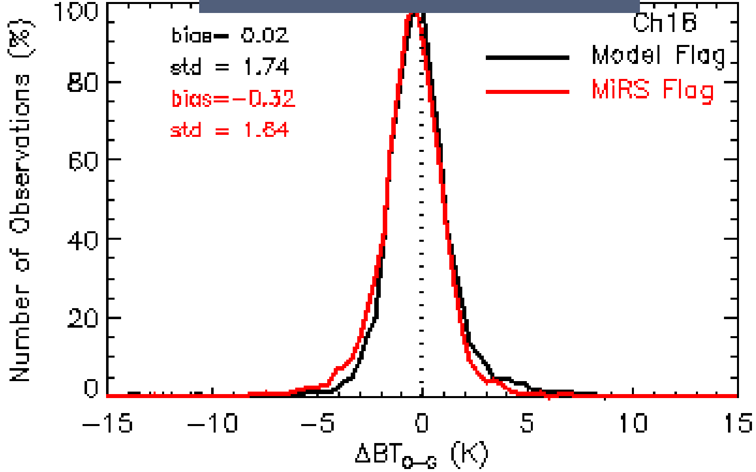
MHS 89 GHz



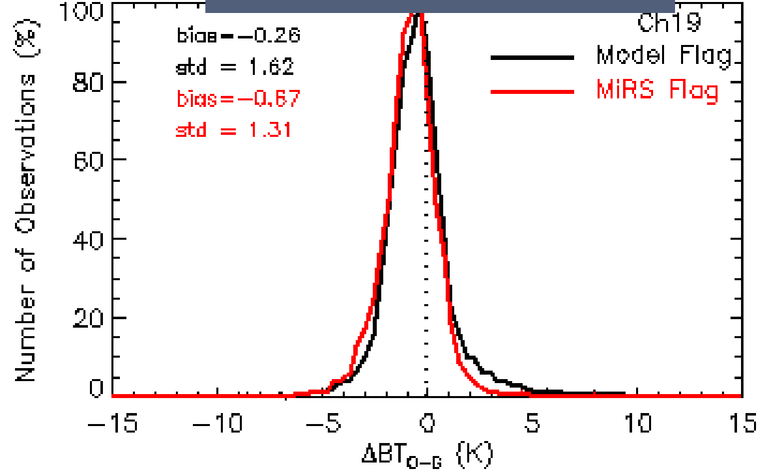
MHS 157 GHz



MHS 183 ±1 GHz



AMSU 183 ±3 GHz



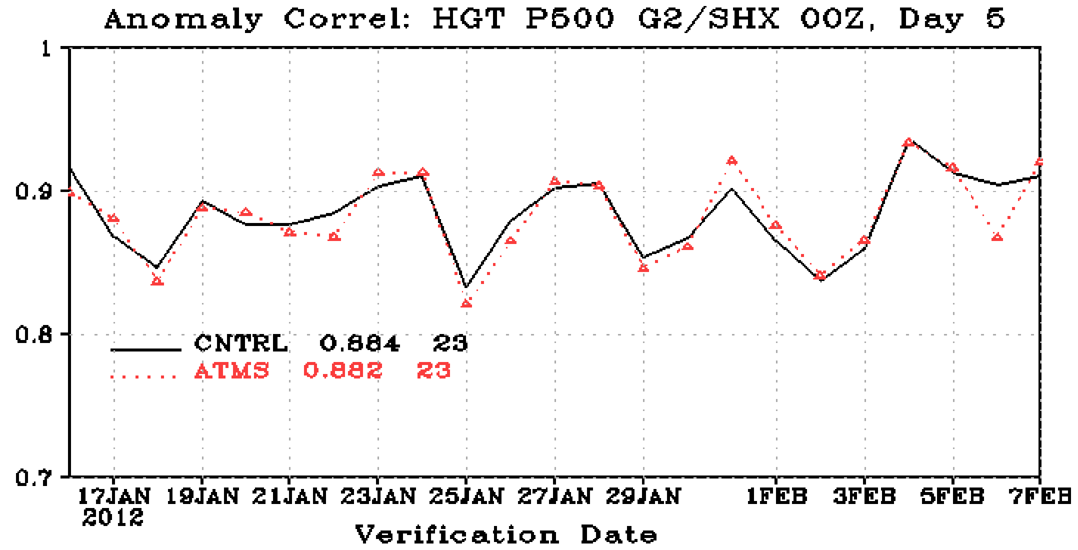
Summary

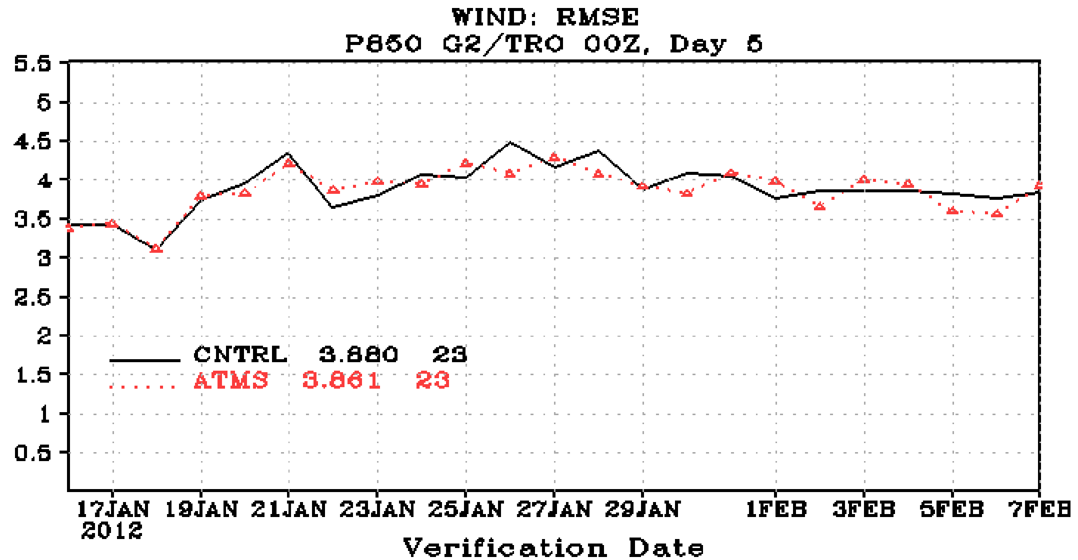
- MiRS is a generic retrieval/assimilation system (N18, N19, Metop-A, DMSP F16/18 SSMIS)
- In retrieval mode, MiRS can be used as an NWP (assimilation) preprocessor
- MiRS LWP has shown to produce reasonable O-B (improvement over using guess fields)
- Future work will include investigating the use of other QC metrics and retrieved fields to filter/parameterize DA
- For more detailed information about the MiRS project, visit: mirs.nesdis.noaa.gov *(more validation data, publication list and software package)*

BACKUP SLIDES

ATMS Impact Experiment

GDAS (Hybrid ENKF)
high resolution
ATMS experiment





<u>Acknowledgements:</u>

A. Collard

J. Jung

E. M. Devaliere

The 1DVAR Algorithm

- Cost Function to Minimize:

$$J(X) = \left[\frac{1}{2}(X - X_0)^T \times B^{-1} \times (X - X_0)\right] + \left[\ \ldots\ \right]$$

Jacobians & Radiance Simulation from Forward Operator: CRTM

- To find the optimal solution, solve for: $\frac{\partial J(X)}{\partial X} = J'(X) = 0$
- Assuming Linearity $y(x) = y(x_0) + K[x - x_0]$
- This leads to iterative solution:

$$\Delta X_{n+1} = \left\{\left(B^{-1} + K_n^T E^{-1} K_n\right)^{-1} K_n^T E^{-1}\right\}\left[\left(Y^m - Y(X_n)\right) + K_n \Delta X_n\right]$$

$$\Delta X_{n+1} = \left\{B K_n^T \left(K_n B K_n^T + E\right)^{-1}\right\}\left[\left(Y^m - Y(X_n)\right) + K_n \Delta X_n\right]$$

More efficient (1 inversion)

Preferred when nChan << nParams (MW)