Recent Enhancements to the NOAA Unique CrIS ATMS Processing System (NUCAPS)

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JPSS meeting, August 26, 2015

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2. NOAA JPSS Science Lead
3. NOAA NESDIS STAR
4. IM System Group (IMSG)

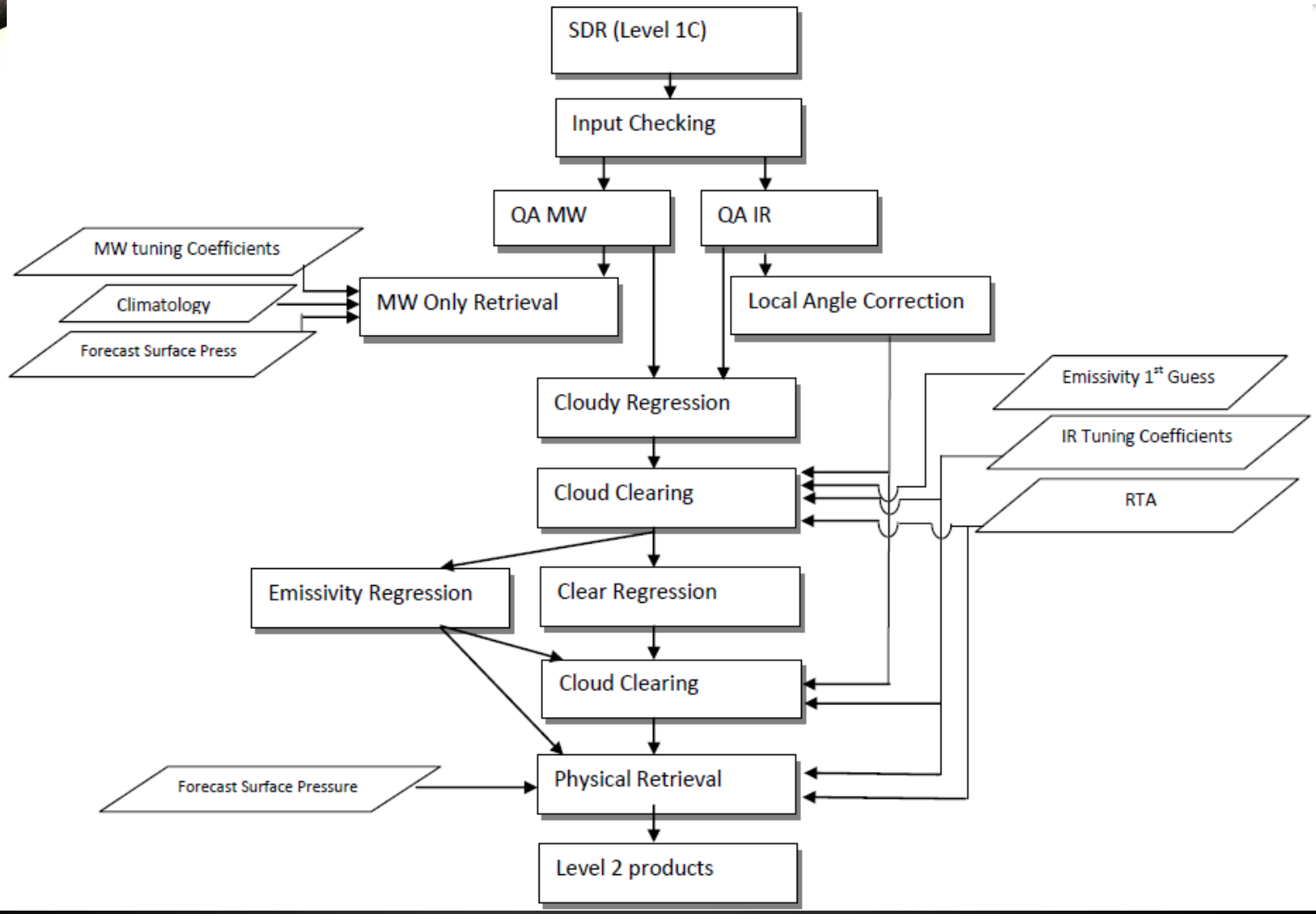
Objectives

- **Introduction on the NUCAPS System**
  - General outline, algorithm characteristics
- **Recent enhancements to the system**
  - MW-only retrieval module
  - MW+IR retrieval module
  - New system has been delivered to NOAA on July 8th 2015 and is currently running in operations.
- **Ongoing research**
- **Future work**

The NOAA Unique CrIS ATMS Processing System (NUCAPS)

- **A multi-step retrieval algorithm, heritage of the AIRS Science Team Retrieval Algorithm**
- **Current operational system (same retrieval code, same spectroscopy) run by NOAA to process:**
  - AIRS/AMSU (since 2003); IASI/AMSU/MHS (since 2006); CrIS/ATMS (since 2011)
- **Retrieval Steps**
  - 1) a microwave retrieval module which computes Temperature, water vapor and cloud liquid water (Rosenkranz, 2000)
  - 2) a fast eigenvector regression retrieval that is trained against the European Center for Medium-Range Weather Forecasts (ECMWF) analysis and CrIS all sky radiances which computes temperature and water vapor (Goldberg et al., 2003)
  - 3) a cloud clearing module (Chahine, 1974)
  - 4) a second fast eigenvector regression retrieval that is trained against ECMWF analysis and CrIS cloud cleared radiances (Temperature and water vapor)
  - 5) the final infrared physical retrieval based on a regularized iterated least square minimization: temperature, water vapor, trace gases (O3, CO, CH4, CO2, SO2, HNO3, N2O) (Susskind, Barnet, Blaisdell, 2003)

The NOAA Unique CrIS ATMS Processing System (NUCAPS)



What's Unique about NUCAPS?

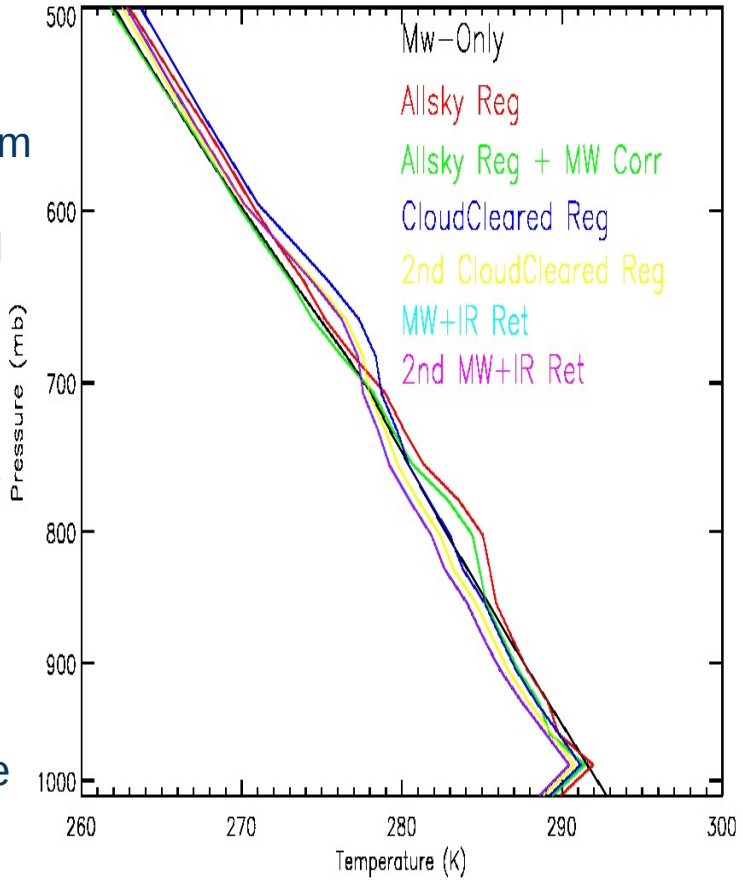
Designed to use all available *sounding* instruments.

- Climatological startup.
- Only ancillary information used is surface pressure from GFS model
- Microwave radiances used in microwave-only physical retrieval, "allsky" regression solution, "cloud cleared" regression and downstream physical T(p) and q(p) steps.

Uses a comparison of 4 independent retrieval steps for quality control (QC) in addition to traditional QC (residuals, etc.).

Utilizes the high-information content of the hyper-spectral infrared – both radiances and physics.

- All channels used in linear regression first guesses.
- Utilizes forward model derivatives to help constrain the solution.
  - Physical steps use full off-diagonal covariance of (obs-calc) errors.
  - Minimizes arbitrary *a-priori* constraints.



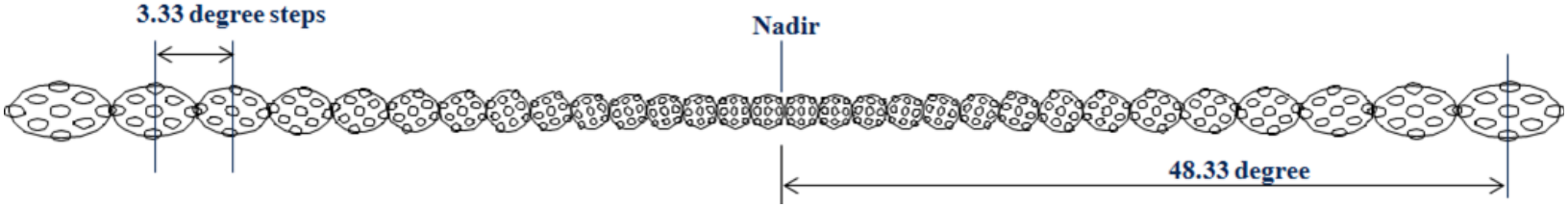
Goal of NUCAPS is to sound as close to surface as possible

We use a cluster of 9 infrared footprints and co-located microwave to eliminate the effects of clouds

- Cloud clearing sacrifices spatial resolution for coverage
- Cloud clearing works in ~70% of cases (~225,000 / 324,000 per day)

For all 3 hyperspectral infrared instruments (AIRS, IASI, and CrIS) we have 30 retrieval fields-of-regard per 2200 km-wide swath (a “scan-set”)

- Nadir retrieval field of regard is ~50 km, Edge of scan is ~70x135 km
- At this scale ~95% of all retrievals are impacted by clouds

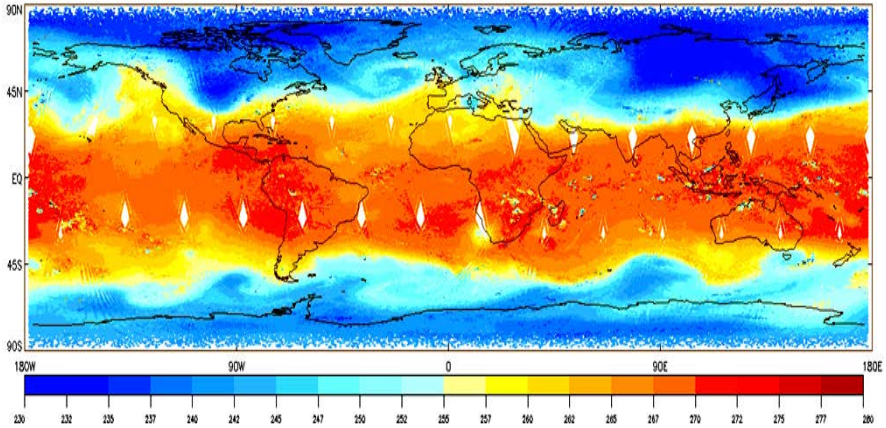


List of operational retrieval products

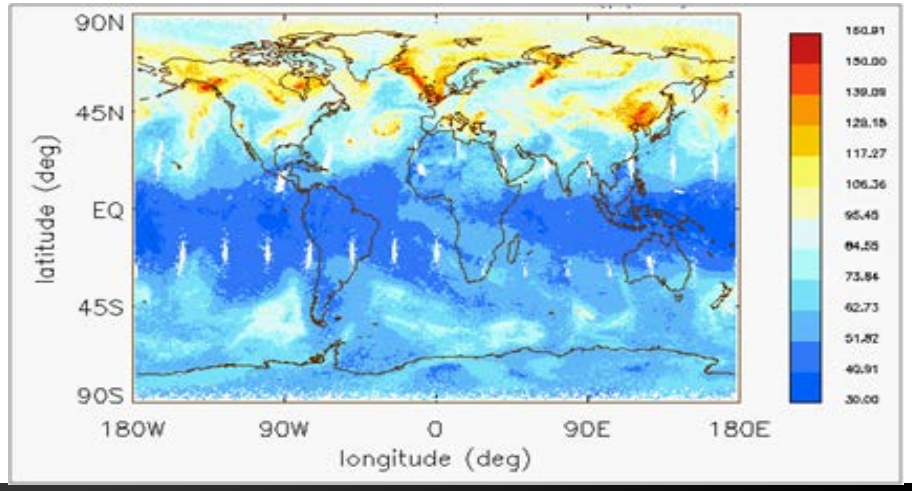
Retrieval Products

Cloud Cleared Radiances	660-750 cm-1 2200-2400 cm-1
Cloud fraction and Top Pressure	660-750 cm-1
Surface temperature	window
Temperature	660-750 cm-1 2200-2400 cm-1
Water Vapor	780 – 1090 cm-1 1200-1750 cm-1
O3	990 – 1070 cm-1
CO	2155 – 2220 cm-1
CH4	1220-1350 cm-1
CO2	660-760 cm-1
N2O	1290-1300cm-1 2190-2240cm-1
HNO3	760-1320cm-1
SO2	1343-1383cm-1

NUCAPS Temperature retrieval @ 500mb



NUCAPS Ozone retrieval @ 500mb



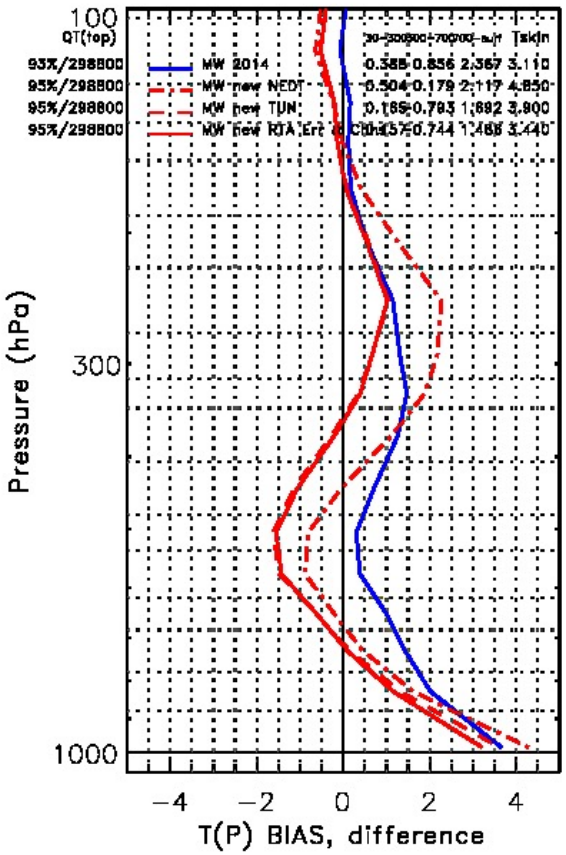
Recent Algorithm Enhancements - MW Only Retrieval

MW-Only Module

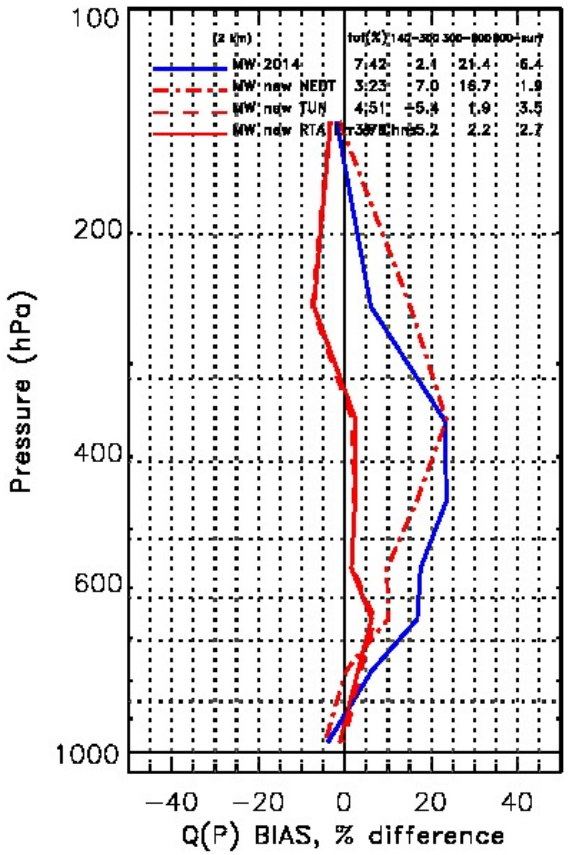
- 2014 MW Only System
- Updated Instrument NEDT file (dash dot red)
- New Forward Model Bias Tuning (dash ret)
- and Error file and optimized Channel Selection (solid ret)
- Bug fixes

FOCUS DAY 2015-02-17 GLOBAL BIAS

Temperature



Water vapor



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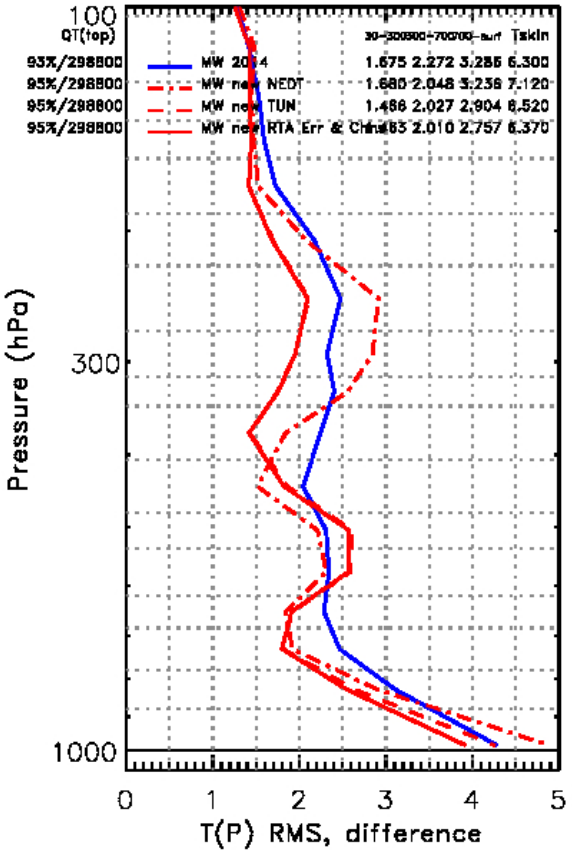
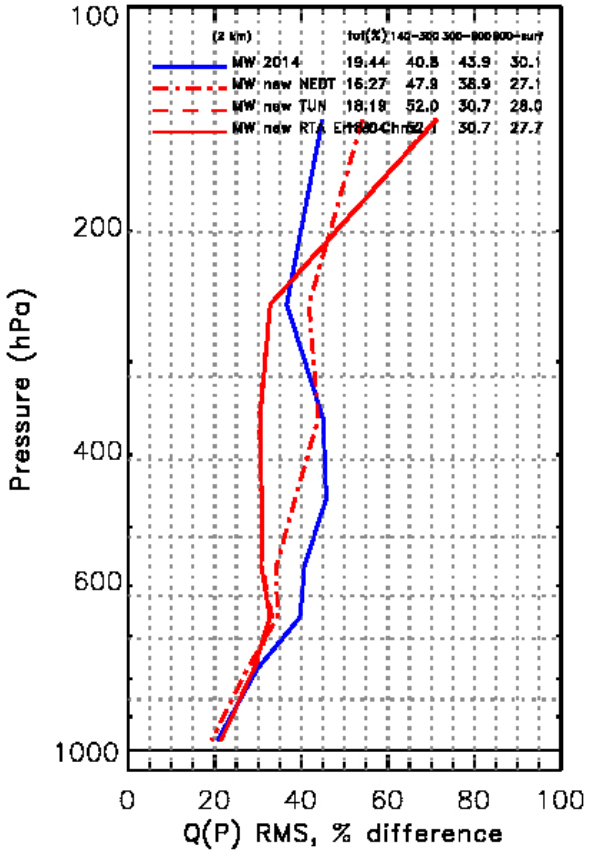
FOCUS DAY 2015-02-17 GLOBAL RMS

Temperature



Water vapor



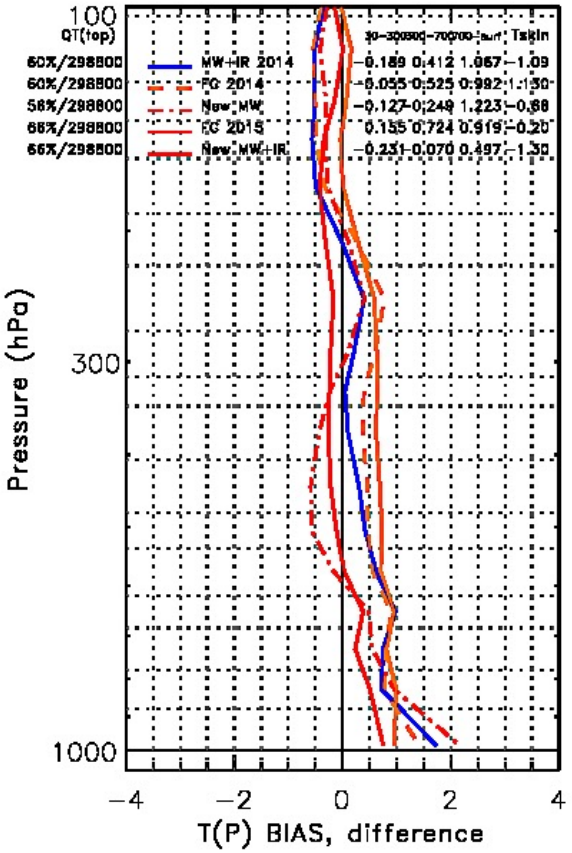
Recent Algorithm Enhancements - MW+IR Retrieval

MW+IR Module

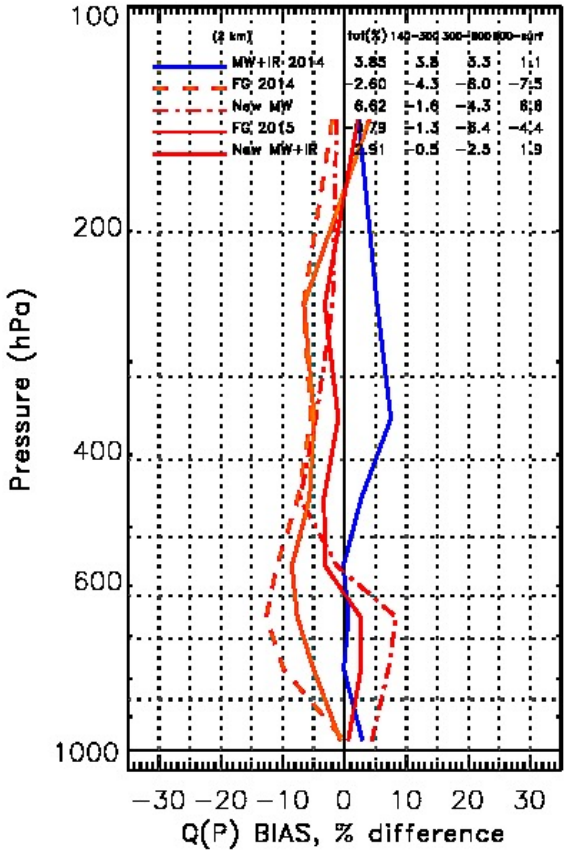
- 2014 MW+IR System
- OLD FG (dash blue)
- New MW-Only System
- New first guess (STAR)
- Optimized QC (on going)
- New first guess experiment (on going)

FOCUS DAY 2015-02-17 GLOBAL BIAS

Temperature



Water vapor



Recent Algorithm Enhancements - MW+IR Retrieval

MW+IR Module

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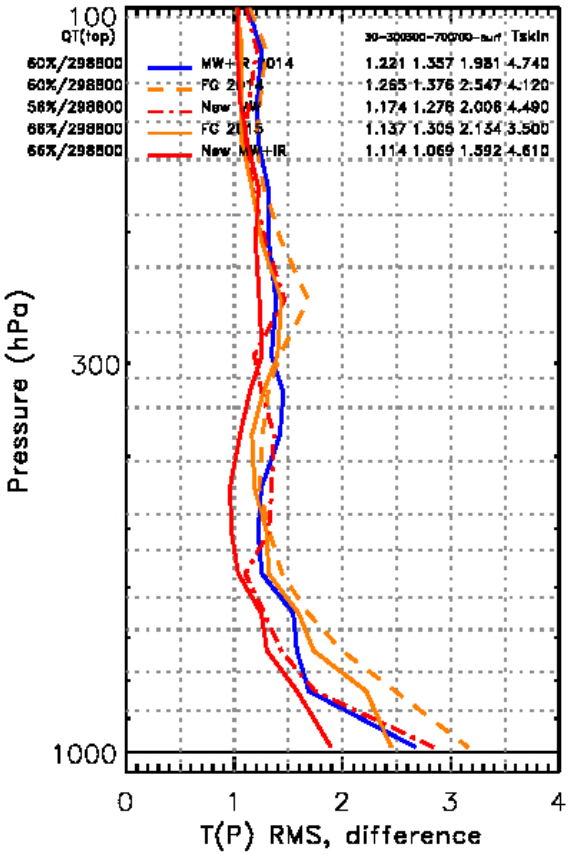
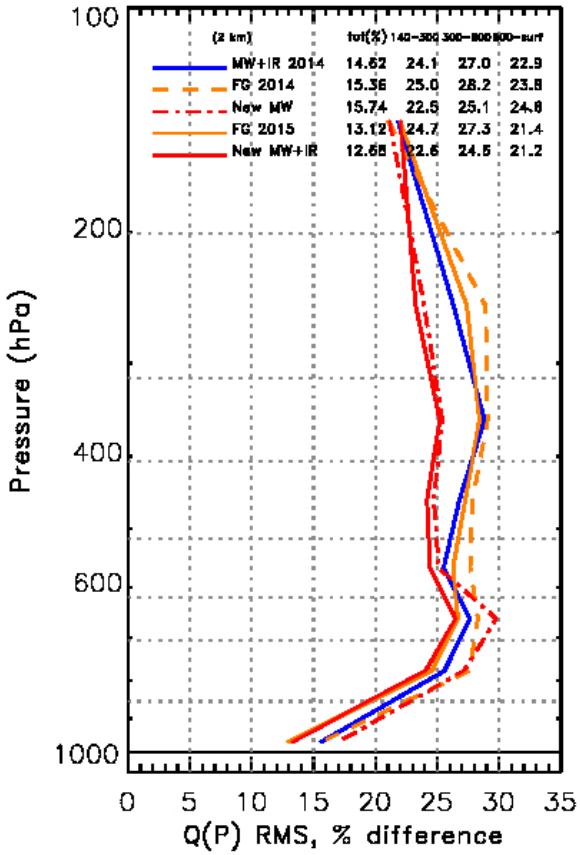


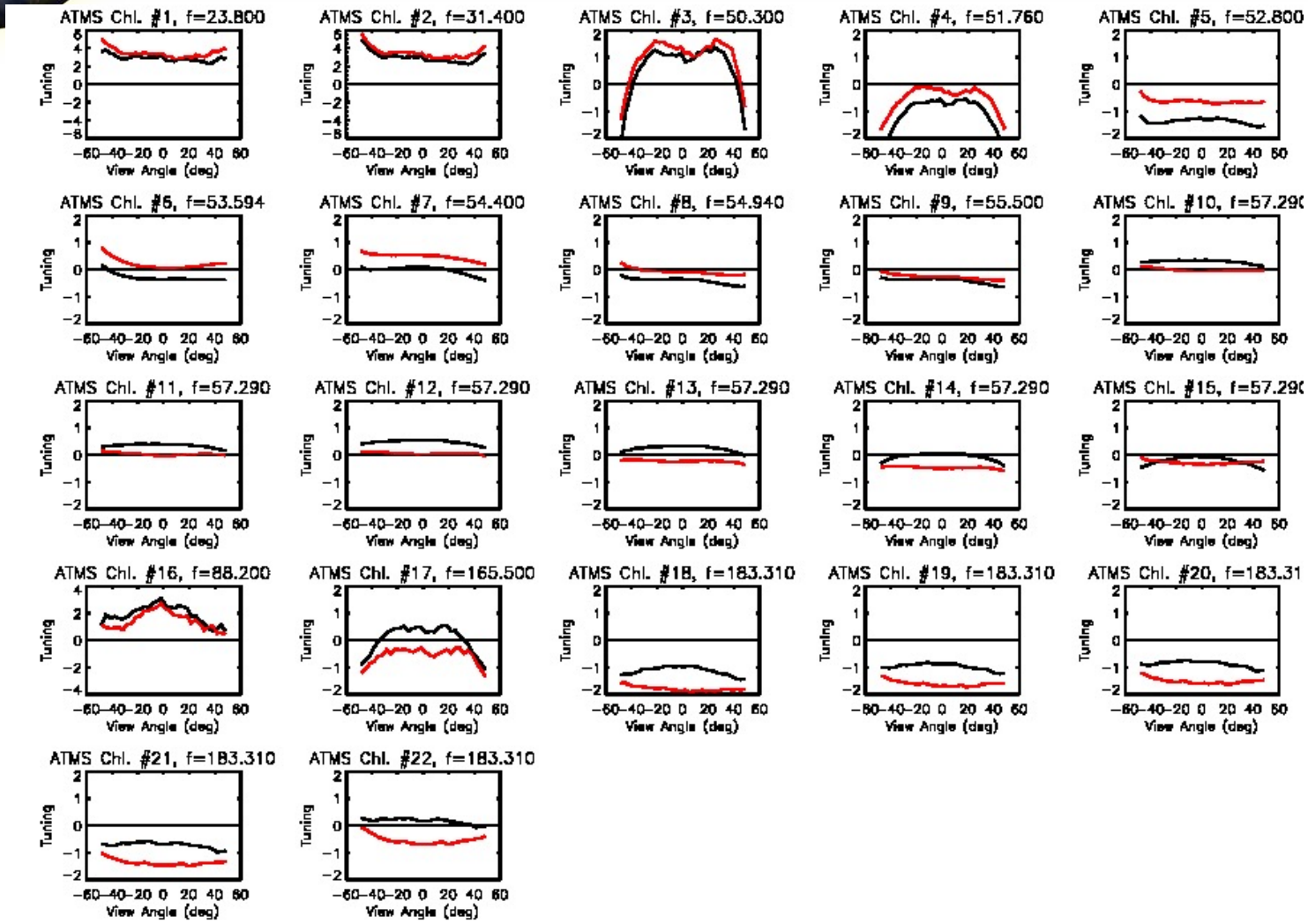
Water vapor



Ongoing research

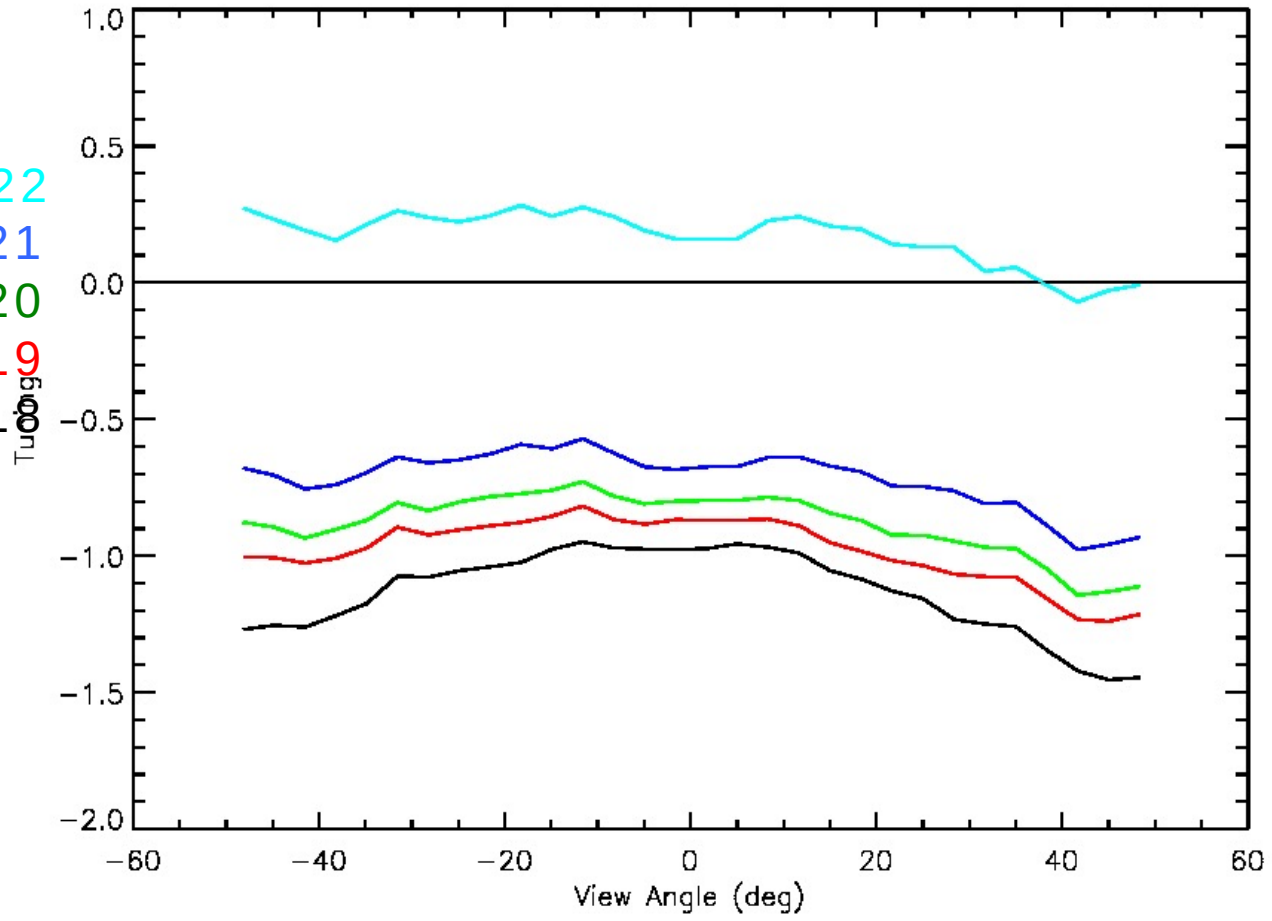
- **Ongoing discussion on the sensitivity peak height dependent bias in the 183GHz band**
  - OBS-CALC bias computation is observed to increase with lower peaking 183GHz channels
  - Problem is observed across all current forward models and MW instruments (AMSU, SAPHIR, ATMS)
  - Problem is observed on both ATMS TDR and SDR files (next 2 slides)
  - June 2015: a dedicated workshop to study the issue
  - Possible sources: surface, precipitation contamination, water vapor continuum. Workshop outcome summary is going to be distrubuted soon.
  - We are in contact with Phil Rosenkranz who has an updated forward model with improved water vapor transmittance.

ATMS tuning
TDR (black) & SDR (red)



183 GHz bias (OBS-CALC): TDR cases

ATMS Chn. 22
ATMS chn. 21
ATMS chn. 20
ATMS chn. 19
ATMS chn. 18



183 GHz bias (OBS-CALC): SDR cases

ATMS Chn. 22
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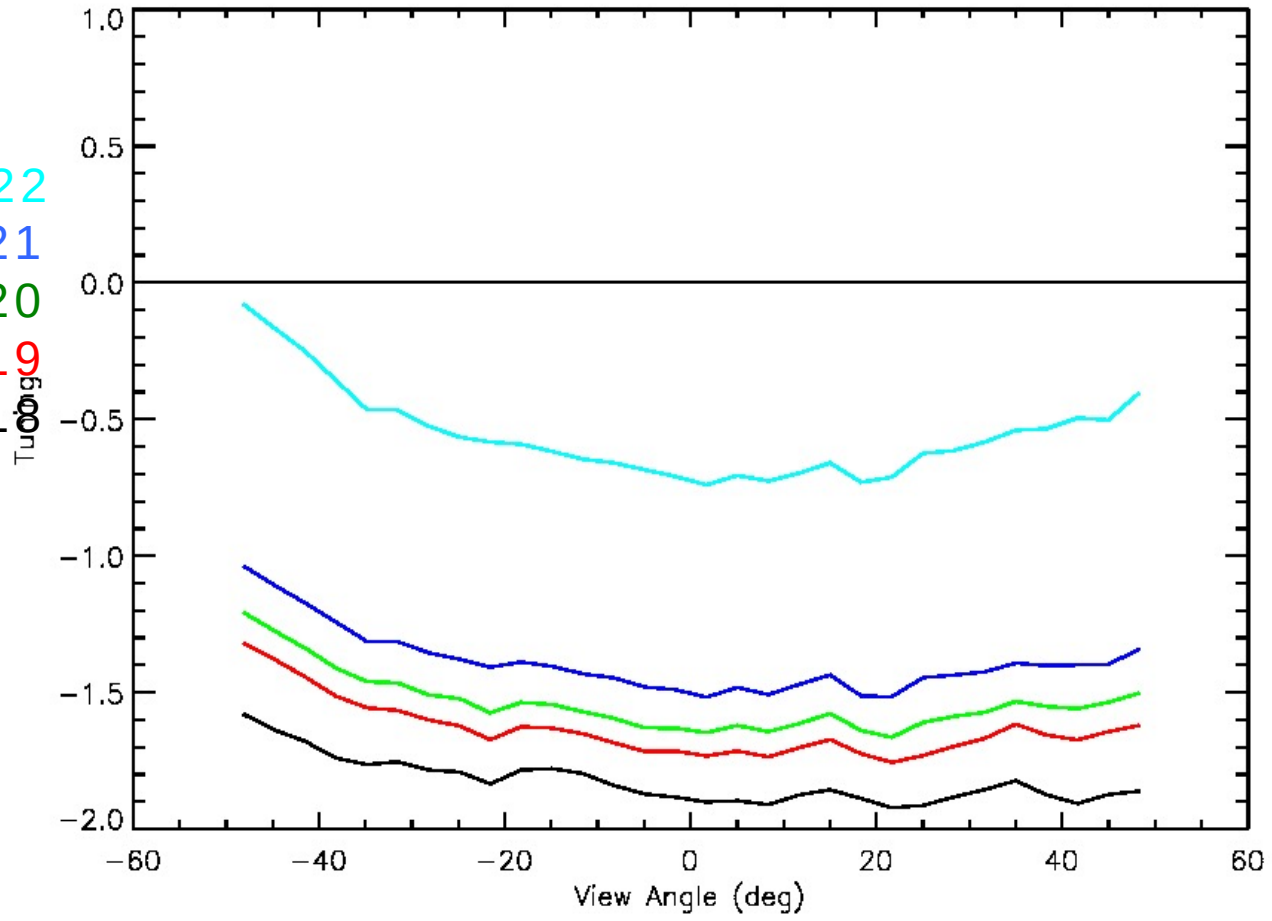
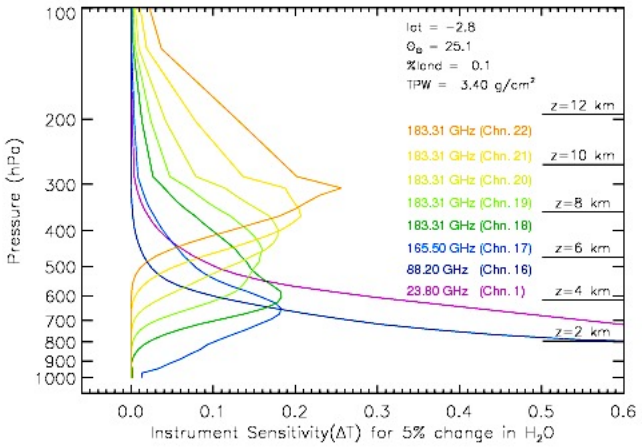
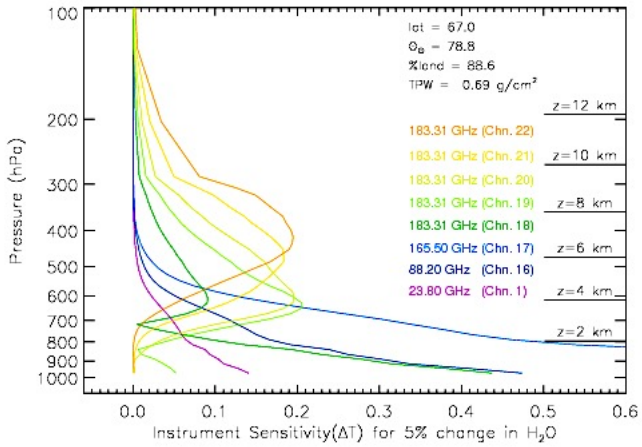
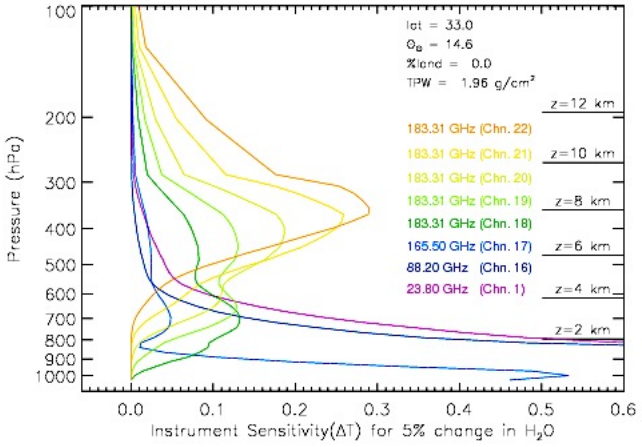
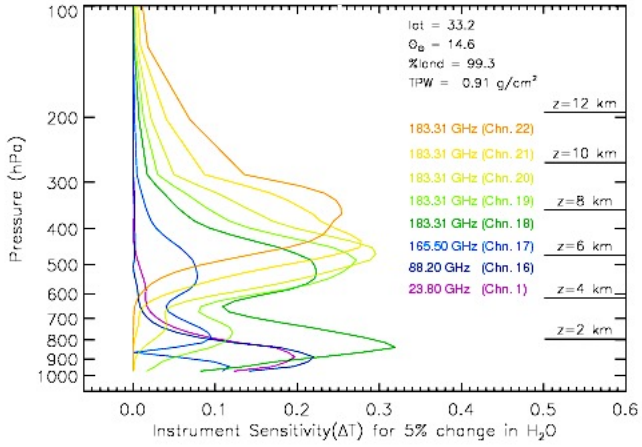


Summary and future work

- **NUCAPS is showing an improved accuracy, yield and stability.**
  - Upgrades shown have been delivered to NOAA on July 8th 2015 and is currently running in operations.
- **Ongoing research towards solving existing issues in both MW and MW+IR retrieval module**
  - 183GHz bias issue
  - Experimenting with alternative first guess and improved QC
- **Approved 2014 PSDI project plan has the SARTA CrIS full-spectral resolution delivery scheduled early next year.**
  - We are currently funded to compute high res CrIS channel selection and IR bias tuning. Delivery is scheduled for April 2016.

Back-Up Slides

ATMS q(p) Sensitivity