# The NOAA Unique CrIS/ATMS Processing System (NUCAPS): First Light Results

**Antonia Gambacorta (1), Chris Barnet (2),**

**Walter Wolf (2), Mitch Goldberg(2), Thomas King (1), Nicholas Nalli (3), Xiaozhen Xiong (1), Eric Maddy (1), Murty Divakarla (3)**

Presented by Mitch Goldberg
Contacts: antonia.gambacorta@noaa.gov

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(1) NOAA/NESDIS/STAR – Riverside Technology
(2) NOAA/NESDIS/STAR
(3) NOAA/NESDIS/STAR - IMSG

# Introduction

- The JPSS advanced infrared and microwave sounders (CrIS and ATMS) and the advanced imager (VIIRS) will provide critical data to improve forecast skill of NWP end user applications.
- The NOAA Unique CrIS ATMS Processing System (NUCAPS) is the NOAA version of the AIRS Science Team Algorithm, a well established and thoroughly validated algorithm, already operational for the Aqua AIRS/AMSU and Metop IASI/AMSU/MHS instruments.
- NUCAPS has the unique option to compare every step and iteration to a “truth” data set and can provide extensive diagnostic information for specific scenes. NUCAPS ability of reprocessing is also key to evaluate algorithm performance and make improvements.
- Funded efforts are already in action under the JPSS cal/val activities to run a unique and never implemented experiment, consisting in comparing side by side two hyper spectral retrieval algorithms, the NGAS and NUCAPS, on the same instrument suite, the NPP CrIS/ATMS/VIIRS.
- We  will use a well established and heritage algorithm, NUCAPS, to cross-validate the NGAS system and perform improvements to the NGAS algorithm that will be transitioned into operations for JPSS.
- NUCAPS is a physical least squares minimization algorithm; NGAS is an optimal estimation retrieval algorithm. Lessons learned from this experiment will ultimately lead to a final single improved merged algorithm for hyper spectral sounding applications.

# Scope of this talk

- This talk focuses on NUCAPS first light retrieval results of Atmospheric Vertical Temperature and Moisture Profiles (AVTP, AVMP), which represent NPP/JPSS mission key performance parameters (KPPs).

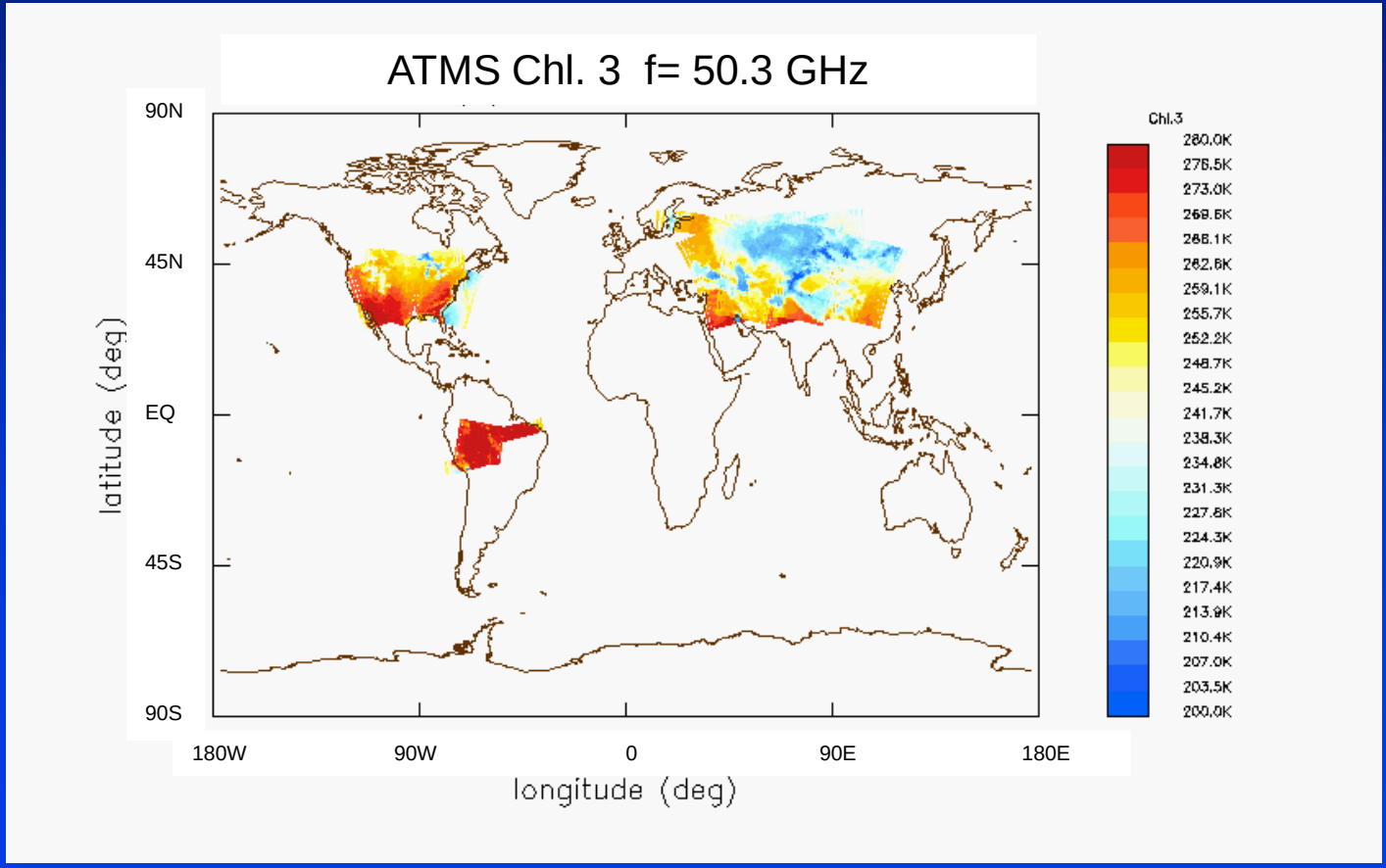
- Part I: We study 2 extended statistical ensembles: ocean, land/coastal.
- Part II: We compare CrIS/ATMS results to AIRS/AMSU results over ocean.

- Collocated ECMWF analysis profiles are used as truth reference.

- We show BIAS and SDV statistics of ATMS-ONLY and ATMS+CrIS retrievals.
  - » Note: ATMS + CrIS retrievals are obtained from a selection of 399 CrIS IR channels + all ATMS MW channels. ATMS MW channels are used in the cloud clearing step and in the temperature and water vapor retrieval. ATMS ONLY retrievals are used as first guess for the physical least square minimization.

- **Summary: NUCAPS first light retrieval results show good stability over both ocean & land regions. Results are comparable to equivalent first light results of the AIRS and IASI missions and to AIRS operational results. Overall results fall in the bulk of system specs.**

# Land/coastal Ensemble (~17000 cases)

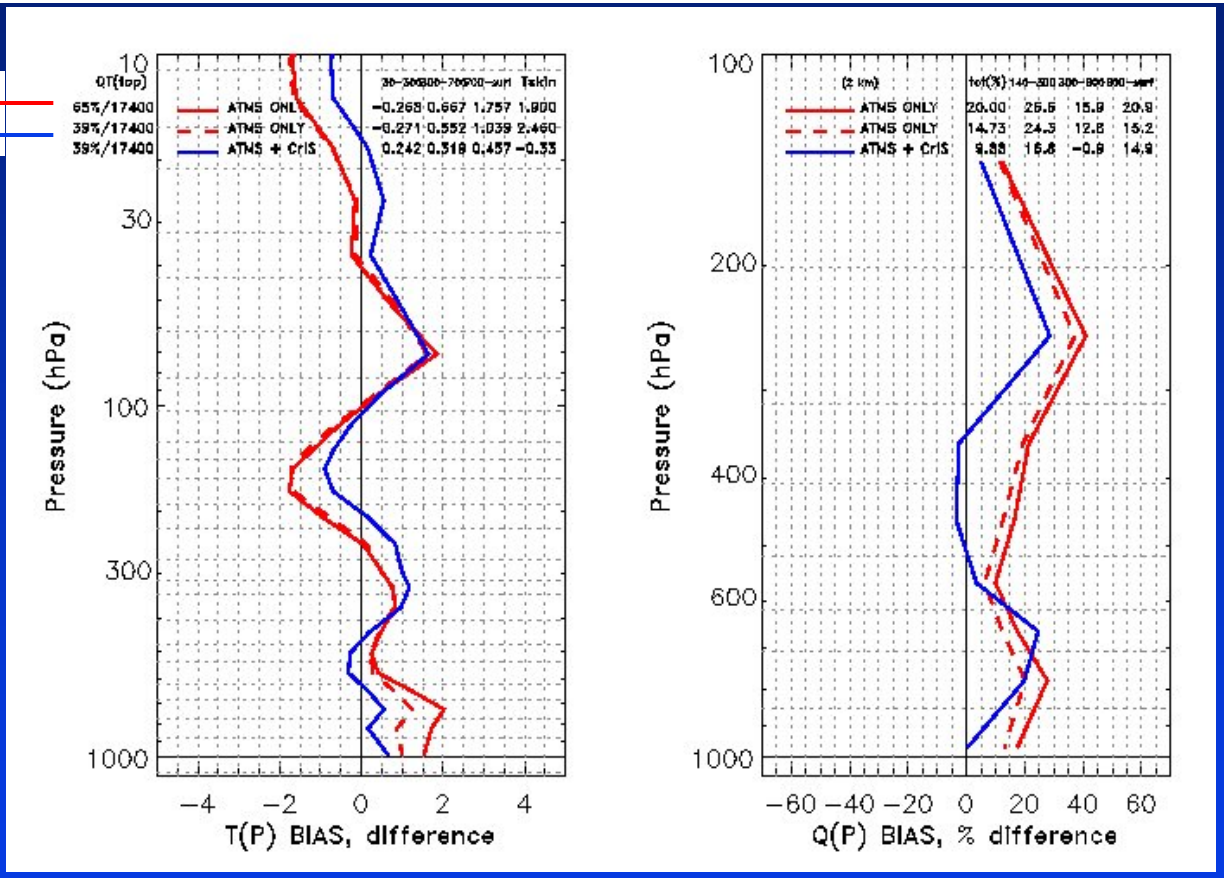


# NUCAPS Temperature (left) and Water Vapor (right) BIAS statistics (ECMWF as truth reference)

—ATMS ONLY; — ATMS+CrIS; (- - -ATMS ONLY on ATMS+CrIS QA ensemble);

Acceptance yield

65% ←
39% ←




Top right: Coarse Layer Statistics
T: 20-300mb; 300-700mb; 700mb-surf
TPW: total; 140-300mb; 300-800mb; 800mb-surf

- **First light retrieval results show good stability over land/coastal regions.**
- **CrIS + ATMS retrievals improve the ATMS ONLY results of:**
  - **up to ~1K in the temperature bias statistics.**
  - **up to ~20% in the water vapor bias statistics.**
- **CrIS SDRs are not fully stable yet. CrIS +ATMS are preliminary. *See caveats below.***

**CAVEATS:**

- CrIS radiances still untuned: ~ 1k bias in the water vapor band (equivalent to ~15% SDV error). ATMS radiances are tuned.
- CrIS radiance local angle correction not computed yet.
- No regression first guess used yet ("ATMS only" retrievals are being used as first guess here)
- ICT (blackbody) emissivity issue is likely to affect the vapor UT region.
- Sweep calibration issues are likely to introduce +/-0.2K differences in the water vapor band.

# NUCAPS Temperature (left) and Water Vapor (right) SDV statistics (ECMWF as truth reference)

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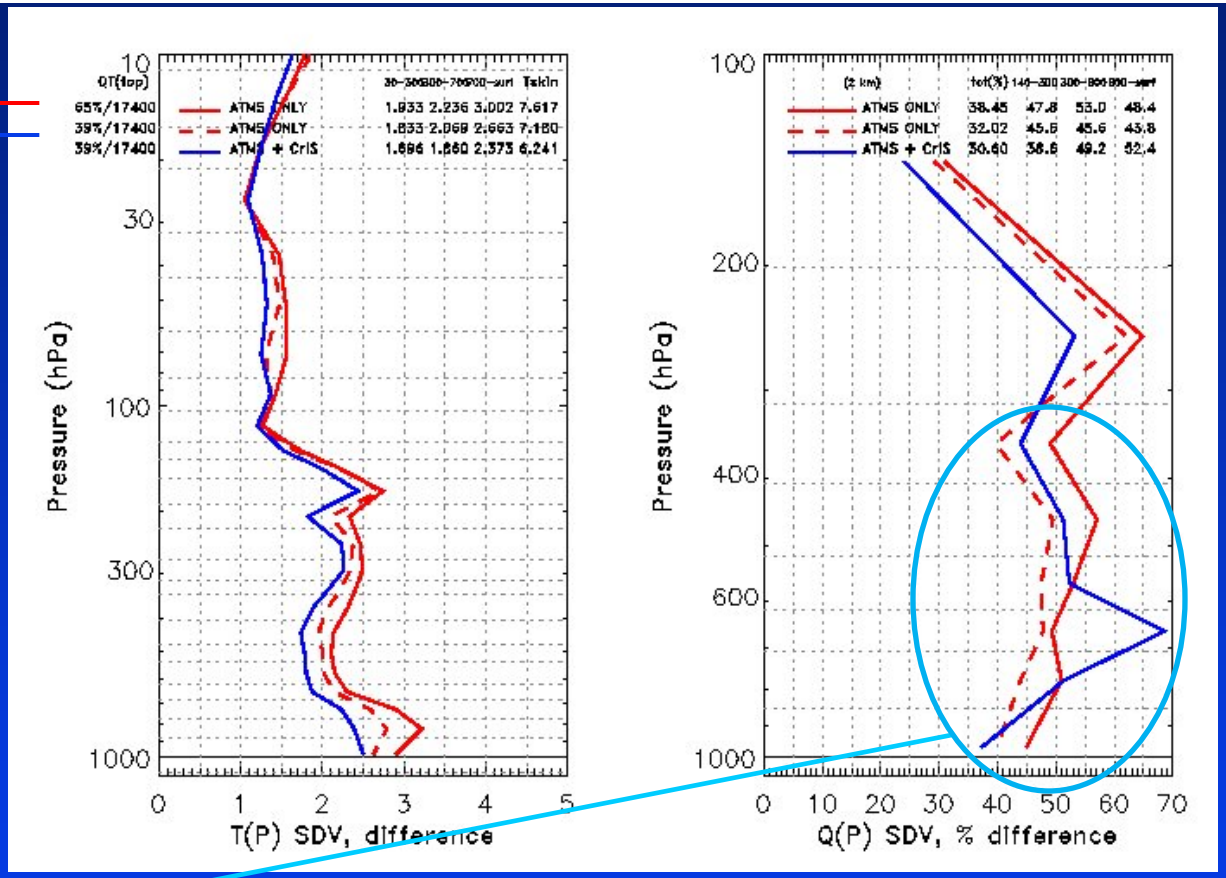
Acceptance yield

65%

39%

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- **First light retrieval results show good stability over land/coastal regions.**
- **CrIS + ATMS retrievals improve the ATMS ONLY results of:**
  - **up to ~0.5K in the temperature sdv statistics.**
  - **up to ~15% in the UT water vapor sdv statistics.**
- **CrIS SDRs are not fully stable yet. CrIS +ATMS results are preliminary.** ***See caveats below.***

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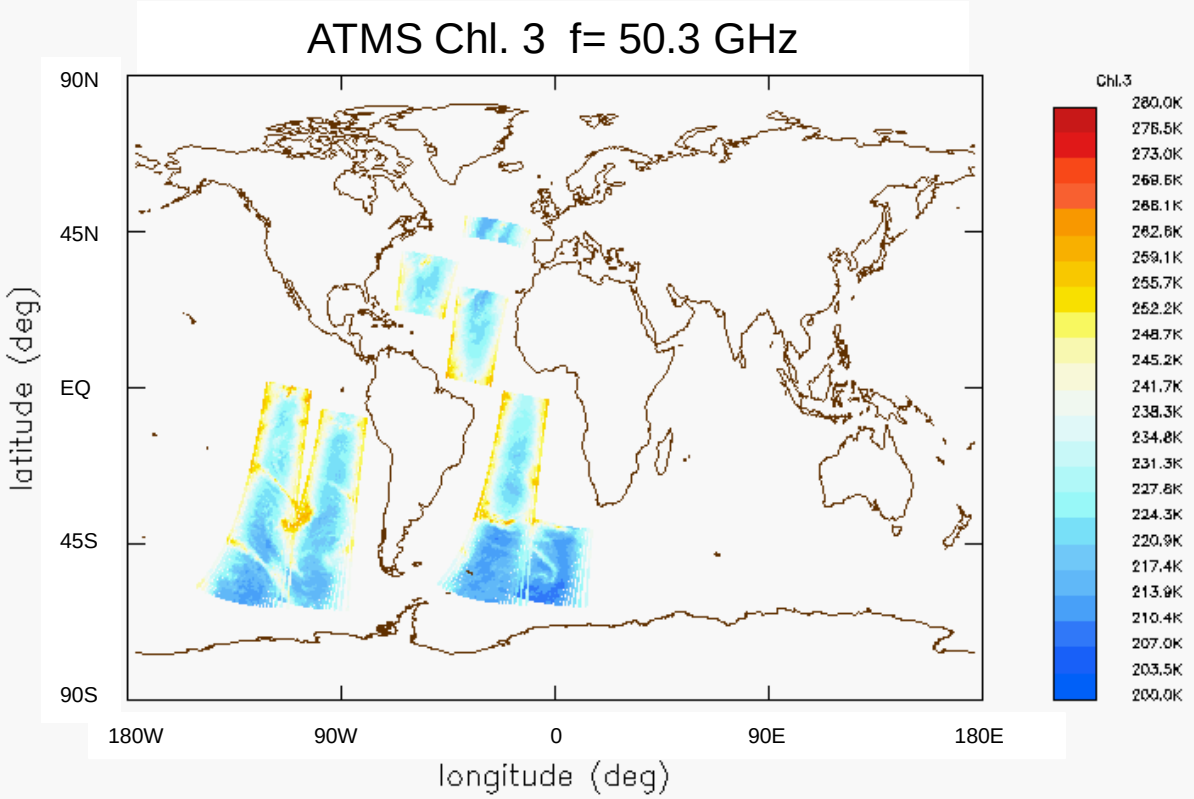
# Ocean Night Ensemble (~16000 cases)



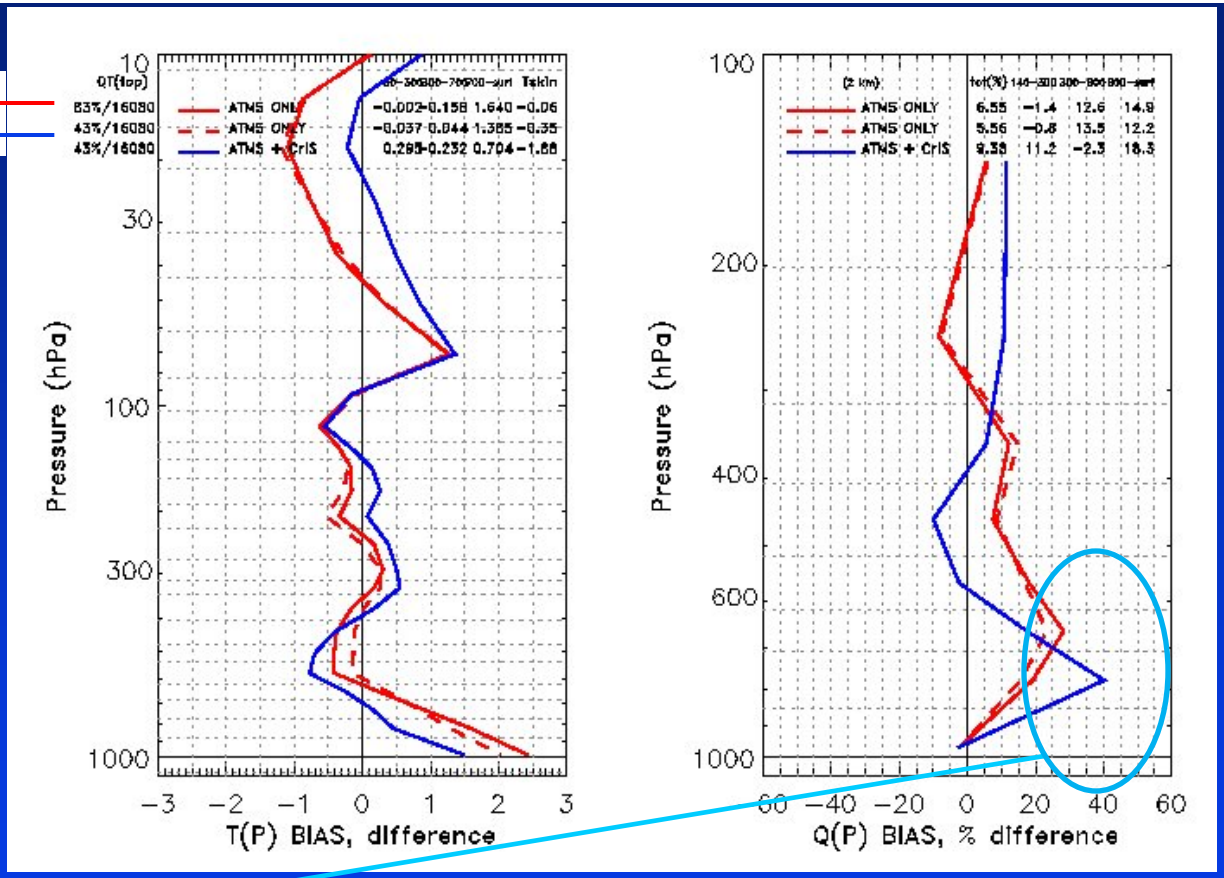
# NUCAPS Temperature (left) and Water Vapor (right) BIAS statistics (ECMWF as truth reference)

—ATMS ONLY; — ATMS+CrIS; (- - - ATMS ONLY on ATMS+CrIS QA ensemble);

Acceptance yield

83%

43%




Top right: Coarse Layer Statistics

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- **First light retrieval results show good stability over ocean night regions.**
- **CrIS + ATMS retrievals improve the ATMS ONLY results of:**
  - **up to ~1K in the temperature bias statistics.**
  - **up to ~10% in the UT water vapor bias statistics.**
- **CrIS SDRs are not fully stable yet. CrIS +ATMS are preliminary. *See caveats below*.**

**CAVEATS:**

- CrIS radiances still untuned: ~ 1k bias in the water vapor band (ATMS radiances are tuned)
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# NUCAPS Temperature (left) and Water Vapor (right) SDV statistics (ECMWF as truth reference)

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Acceptance yield

83% ←
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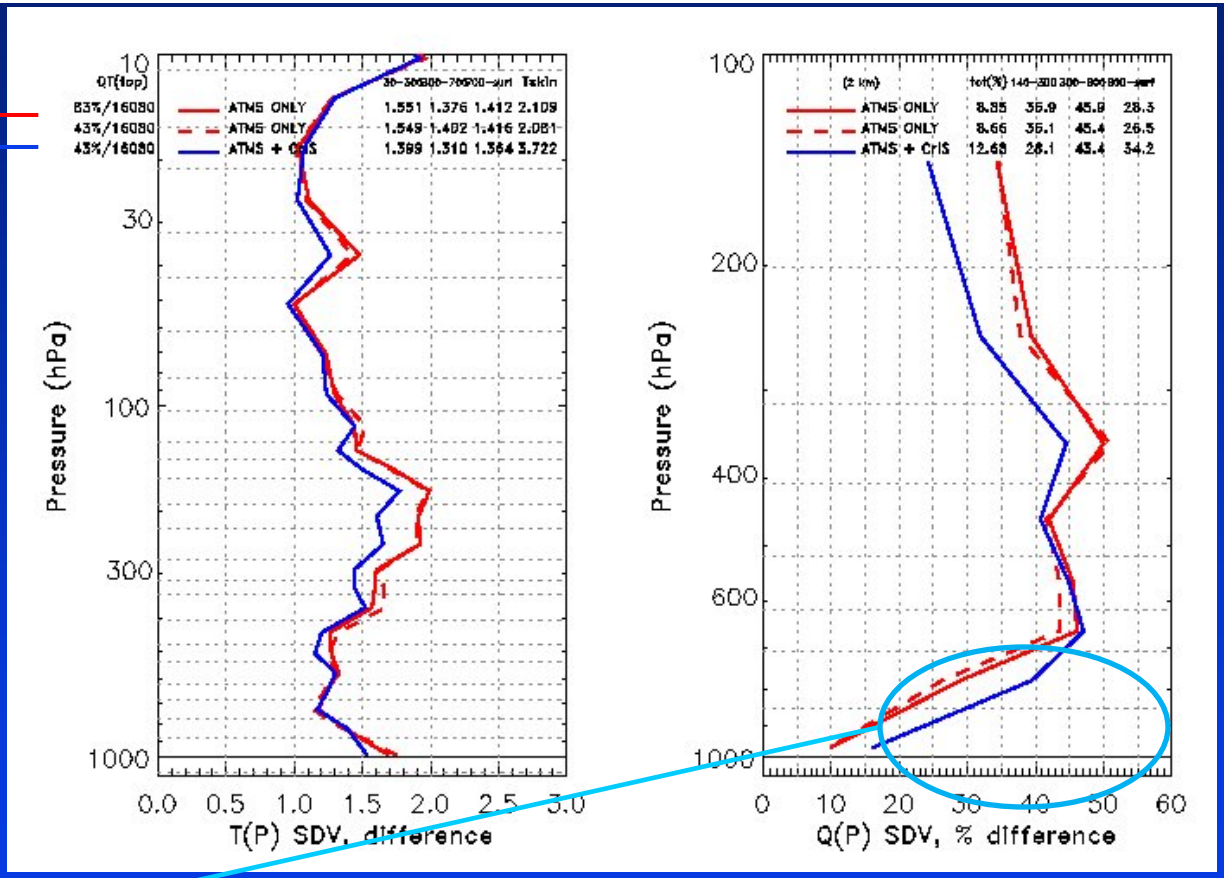


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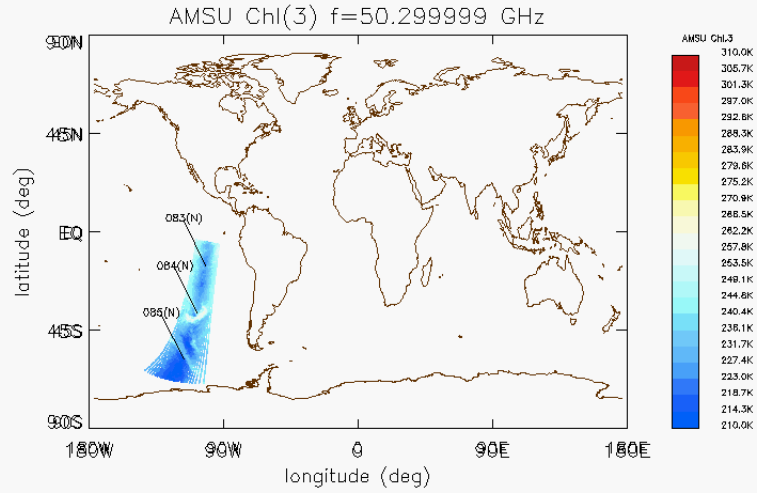
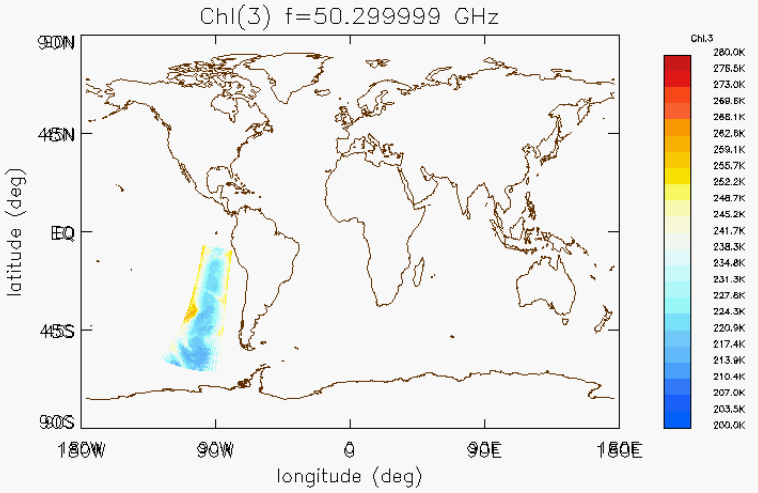
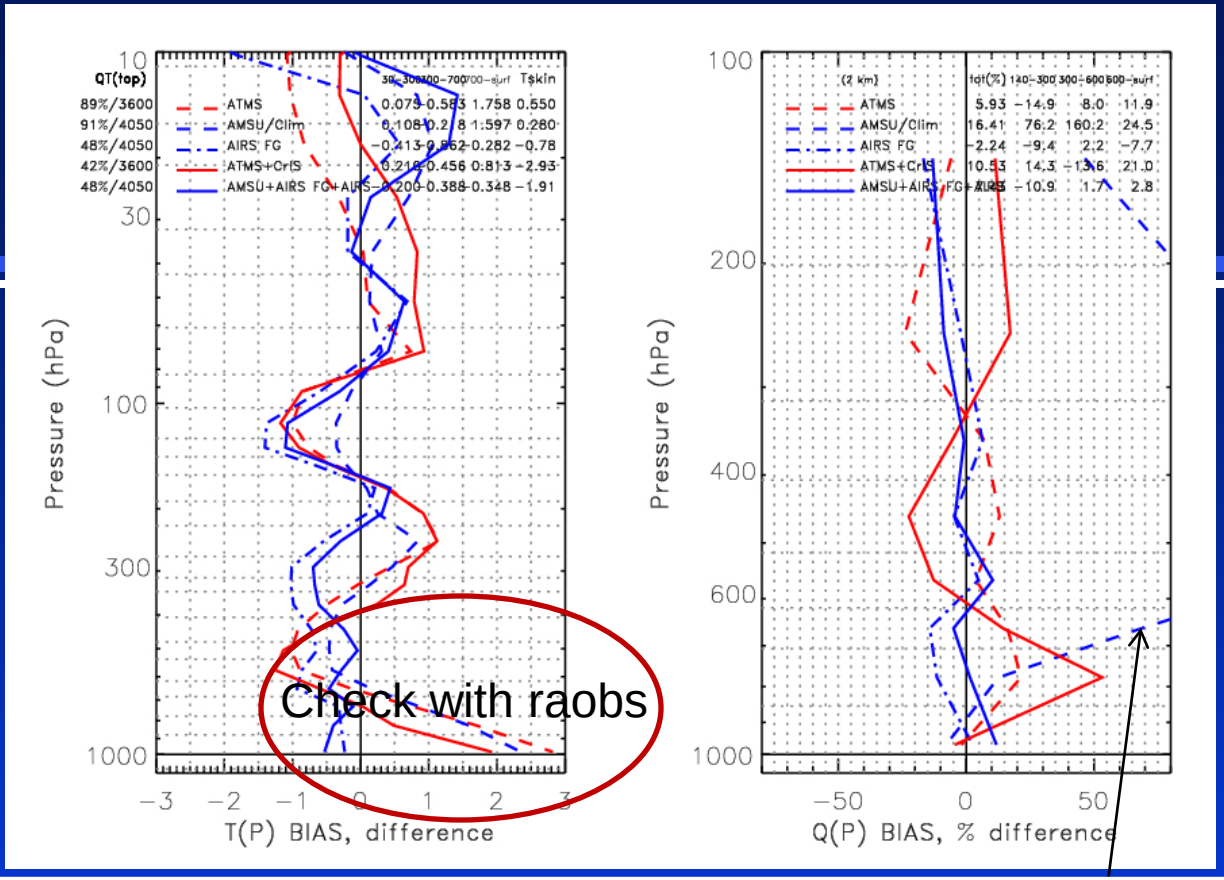
# AIRS/AMSU & CrIS/ATMS NUCAPS comparisons (2012-02-24)

3 AIRS/AMSU granules




30 CrIS/ATMS granules






-- - ATMS ONLY: accepts ~89% of cases. Yield is comparable to AMSU ONLY (91%). Used as first guess input for ATMS+CrIS retrieval.

-- - AMSU temperature retrieval; Climatology water vapor retrieval (exceeds 150% sdv error, not plotted for clarity)

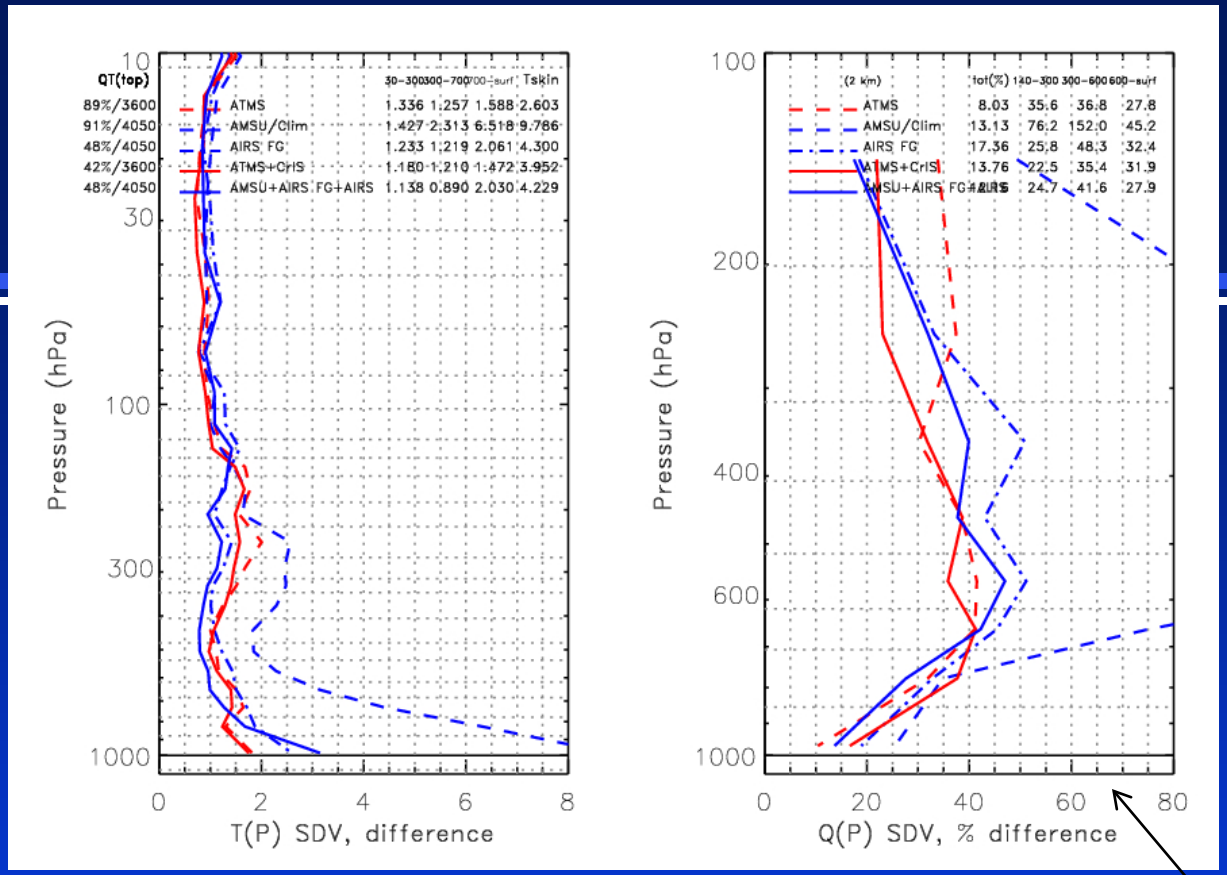
-.-.- AIRS FG: first guess input to the final AIRS retrieval (stand alone ECMWF trained, used in operations)

___ ATMS +CrIS final retrieval (CrIS's caveats from previous slides still hold true (no CrIS tuning, "ATMS only" first guess, SDRs cal. issues)

___AMSU +AIRS FG +AIRS: AIRS final retrieval. Yield (48%) is comparable with ATMS+CrIS (42%)

**Conclusions:**

- ATMS and AMSU temperature retrieval are comparable. AMSU generally better
- ATMS +CrIS temperature and water vapor bias comparable to AIRS final solution

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___**AMSU +AIRS FG +AIRS: AIRS final retrieval. Yield (48%) is comparable with ATMS+CrIS (42%)**

**Conclusions:**

- **ATMS temperature sdv outperforms AMSU temperature sdv; ATMS water vapor sdv outperforms AIRS FG sdv (up to300mb)**
- **ATMS +CrIS temperature sdv outperforms AIRS temperature sdv in the lower trop and stratosphere**
- **ATMS +CrIS water vapor sdv outperforms AIRS vater vapor sdv in the mid and upper troposphere**

# Summary on NUCAPS first light retrieval results

- NUCAPS first light retrieval results show good stability over both ocean & land regions. Results are comparable to equivalent first light results of the AIRS and IASI missions and to AIRS operational results. Overall results fall in the bulk of system specs.

- CrIS + ATMS retrievals improve the ATMS ONLY results of up to ~1K (~0.5K) in the bias (sdv) temperature statistics and of up to ~20% (~15%) in the water vapor bias (sdv) statistics.

- Comparisons with AMSU/AIRS:
  - ATMS ONLY and ATMS +CrIS temperature bias is comparable to AMSU ONLY and AMSU+AIRS FG+ AIRS final solution
  - ATMS ONLY temperature sdv outperforms AMSU temperature sdv; ATMS water vapor sdv outperforms AIRS FG sdv (up to300mb)
  - ATMS +CrIS temperature sdv outperforms AIRS temperature sdv in the lower trop and stratosphere
  - ATMS +CrIS water vapor sdv outperforms AIRS vater vapor sdv in the mid and upper troposphere

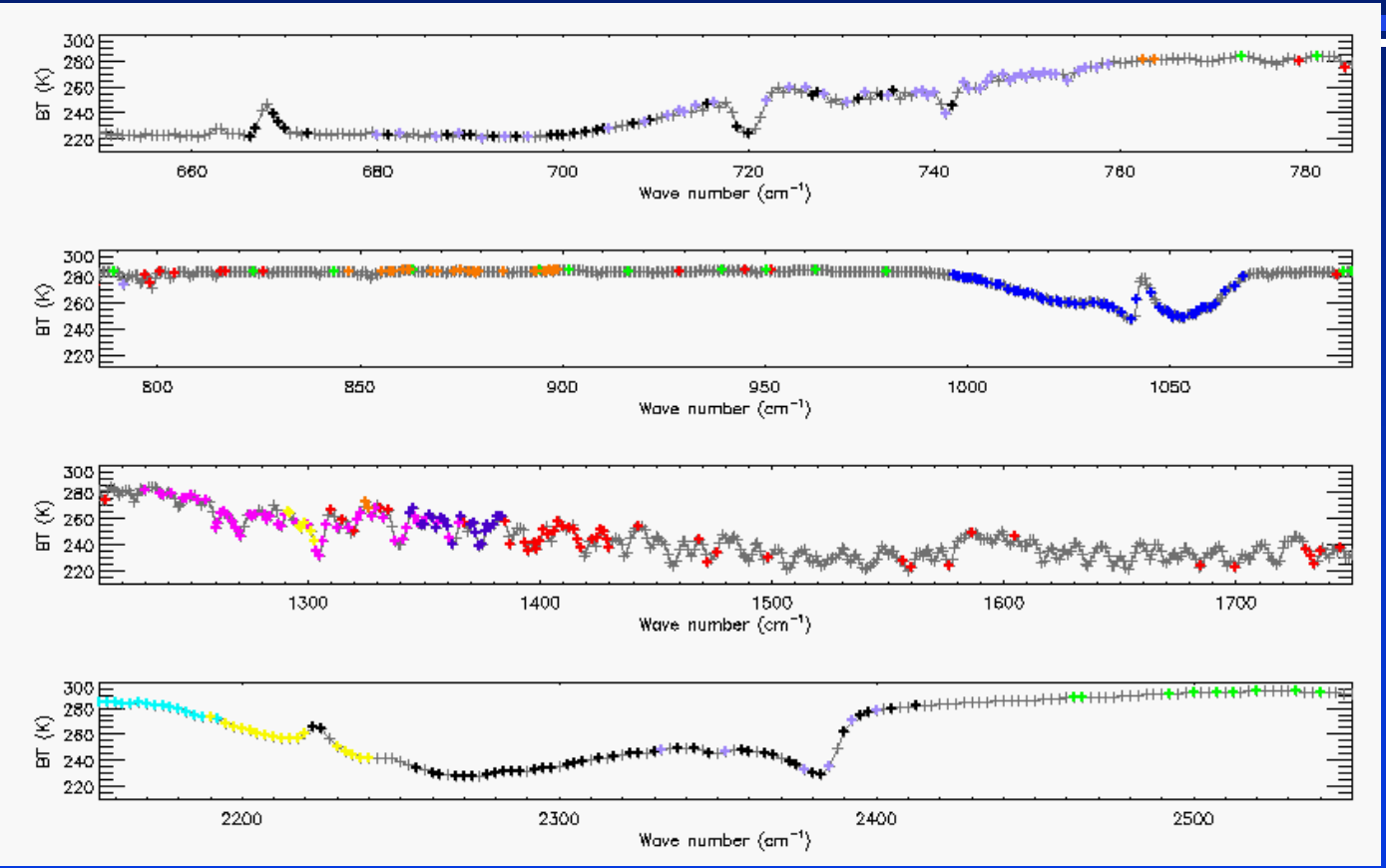
- Results are preliminary. See next slide on “ongoing work”.

# Ongoing work

- Once CrIS SDRs become stable (ICT emissivity and sweep calibration issues are solved), we will:
  - » Compute radiance bias tuning. An improvement of up to ~1.5 K in the temperature and ~15% in water vapor sdv statistics is expected.
  - » Compute local angle correction.
  - » Collect a global ensemble and train regression coefficients to derive robust cloudy and clear first guess solutions used as input for the CrIS+ATMS final solution.
  - » Perform extended cross-comparisons of collocated AIRS, IASI and CrIS data sets.
  - » Cross-compare NUCAPS and NGAS: understand pros and cons, make improvements and transition them into operations.

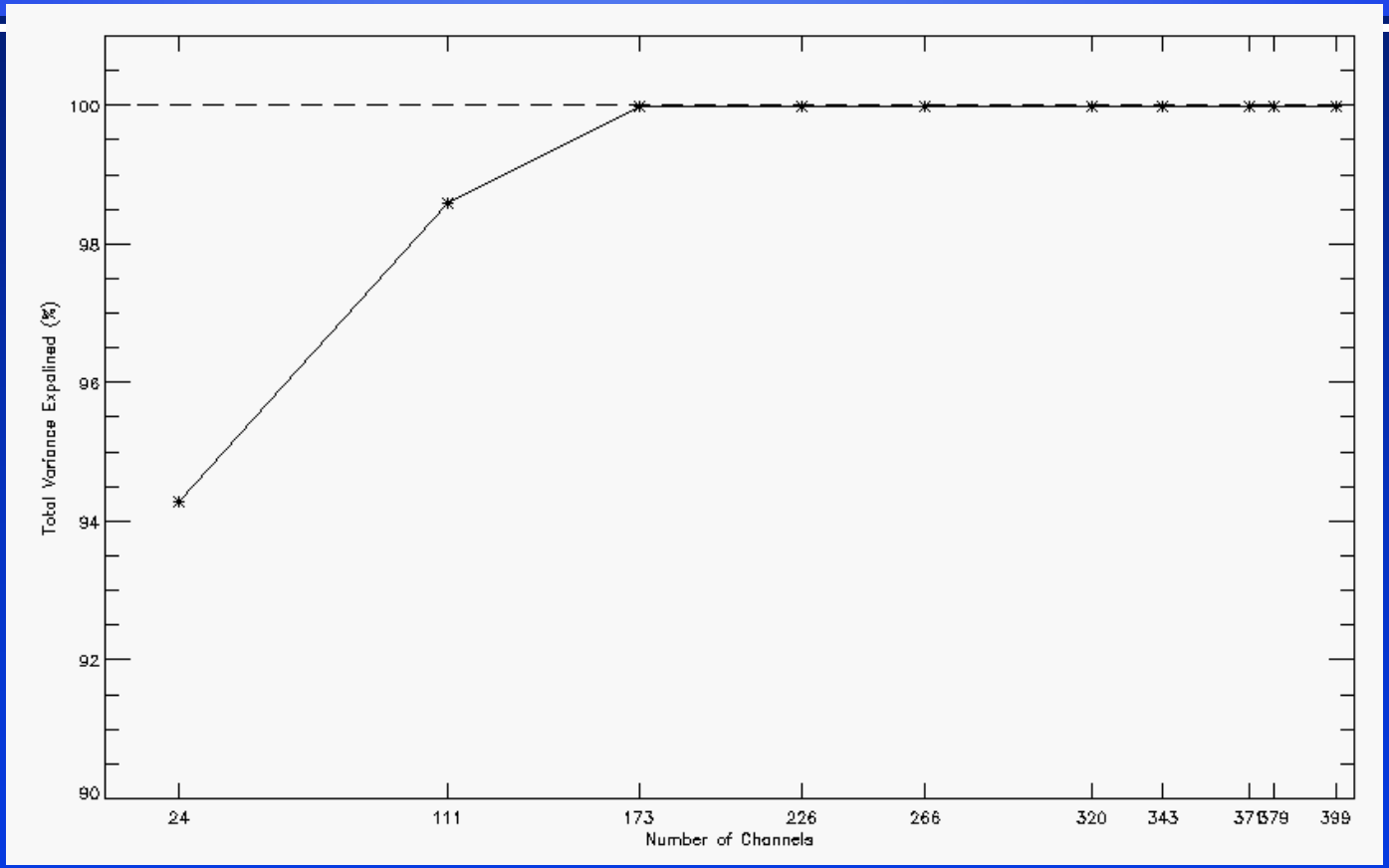
# Back up slides

# CrIS opertional Channel Selection (Total # of Channels: 399)




**Black crosses: temperature sounding channels;** Light Purple: CO2 sounding channels; **Red crosses: Water vapor sounding channels;** Green crosses= surface temperature and emissivity sounding channels; orange crosses= NHO3 sounding channels; Blue crosses = ozone sounding channels; magenta cross symbols= CH4 sounding channels; Cyan crosses= CO sounding channels; Yellow crosses = N2O sounding channels; Dark Purple=SO2 sounding channels; Grey = all remaining channels.

# Total Variance Explained




- The total explained atmospheric variance increases asymptotically by incrementally adding unique channels. The full list of 399 selected channels explains ~99.9% of the total atmospheric variance.
- First 173 channels (window, temperature and water vapor channels) already explain ~99% of the total atmospheric variance.