S-NPP EDR Validation at ARM (GRUAN) Sites

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JPSS Radiosonde Program

Who is involved?

- Coordinated effort involving:

What is being done?

- Radiosondes launched from ARM sites coincident with S-NPP overpasses

Goals:

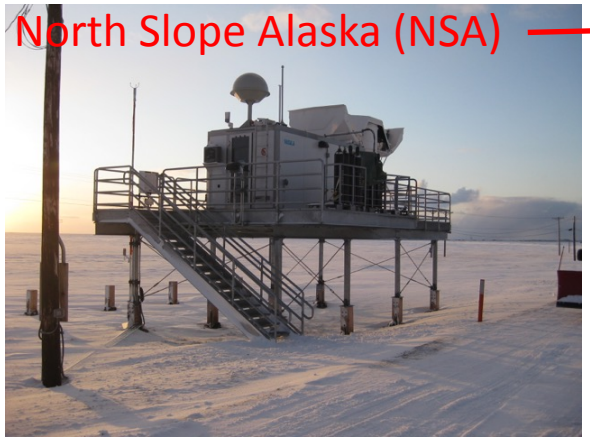
- Assessment of S-NPP soundings
- Accurate & on-going validation data

Heritage:

- Follows efforts by Tobin et. al., 2006 in the assessments of AIRS temperature and water vapor soundings

JPSS Radiosonde Program

North Slope Alaska (NSA)



Southern Great Plains (SGP)

Eastern North Atlantic (ENA)

- S-NPP launches started Feb 2015

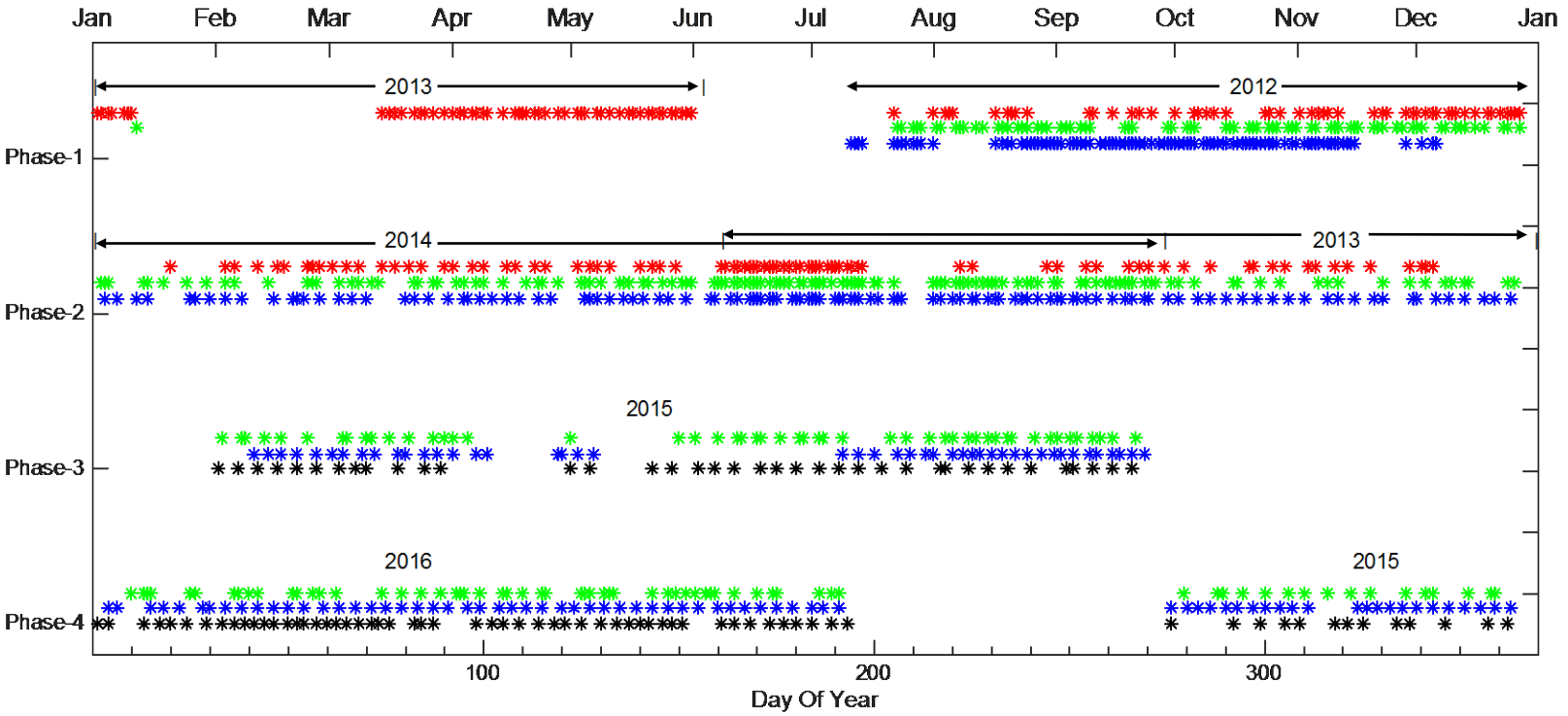
Tropical Western Pacific (TWP)

- site closed May 2014

JPSS Radiosonde Program

Logistics:

- S-NPP radiosonde launches began in July 2012 and are ongoing …



- Radiosondes launched across seasons to sample a range of atmospheres

- Phase-5 begins October 1, 2016 & will run ~1-year

JPSS Radiosonde Program

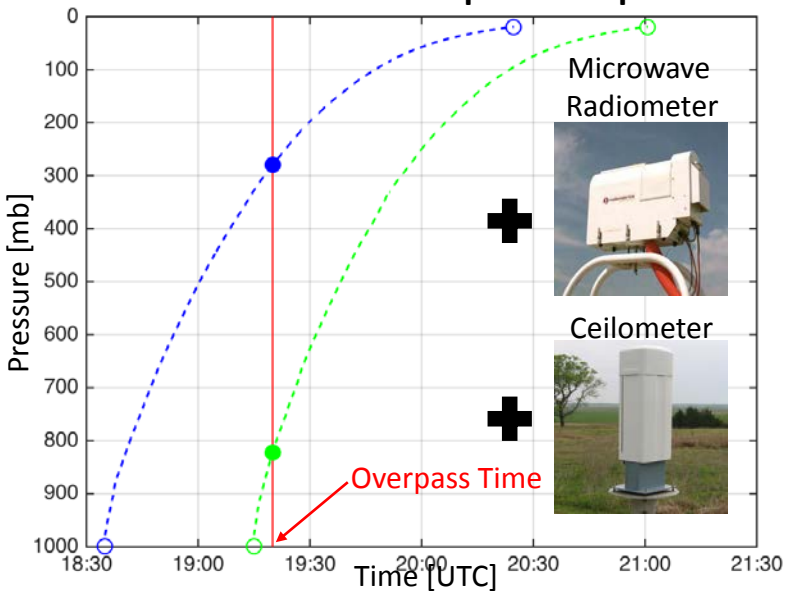
Logistics:

- Launching for ‘acceptable’ overpasses at each site:
- Launches occurring every ~4 days at each site

- view angle criteria (<=30 deg)
- not fully overcast
- not heavily precipitating

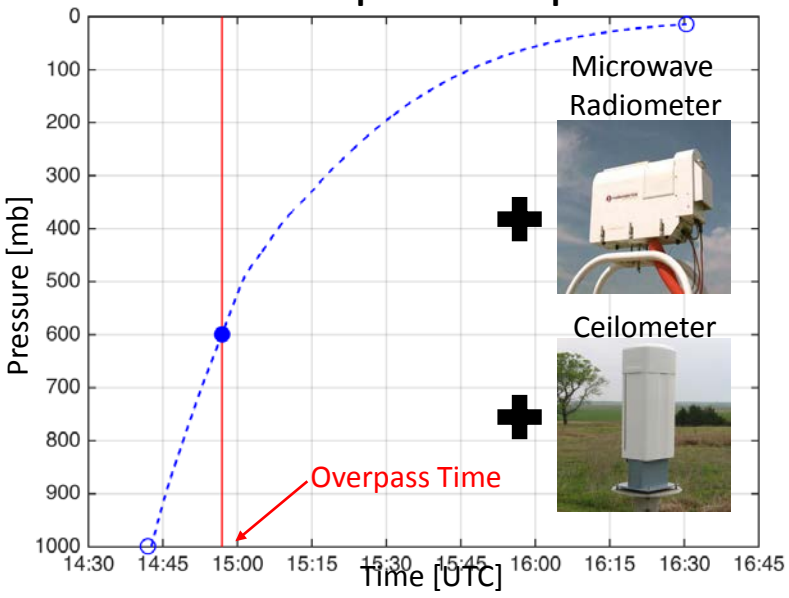
Dual Launch Strategy: NSA & SGP

~45 min and ~5 min prior overpass



Single Launch Strategy: ENA & TWP

~15 min prior to overpass



Best Estimate of Atmospheric State (BE)

JPSS Radiosonde Program

Logistics:

- **Many issues:**
  - Helium shortages, gasoline shortages
  - Autosonde failures at NSA & SGP
  - Communications & hardware failures at TWP

ARM
CLIMATE RESEARCH FACILITY

- **ARM extremely supportive of this effort. Thank You!**

Special Thanks to …

Donna Holdridge (ANL)
Sonde Instrument Mentor

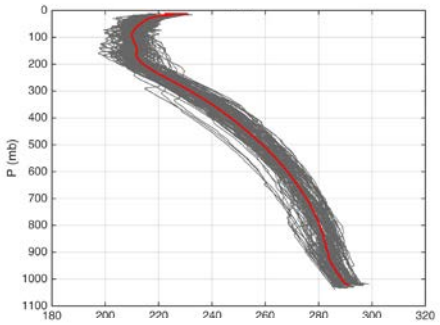
&

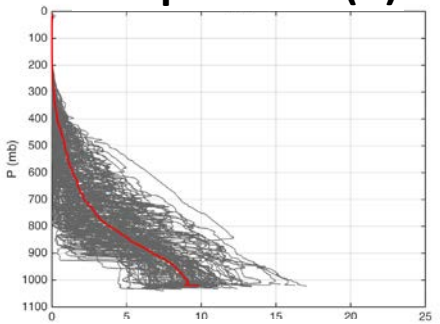
Jim Mather (PNNL)

Radiosonde Temperature & WV Profile Distributions

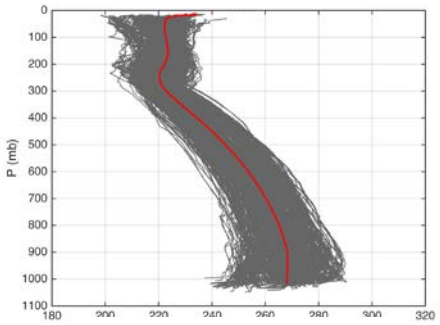
- While the collection sites are limited in number, the profiles consist of highly accurate measurements of a wide range of climatic conditions

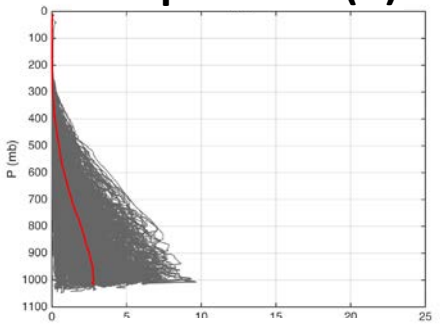
ENA

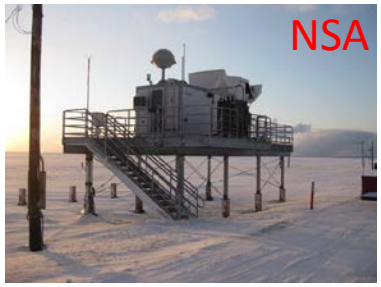




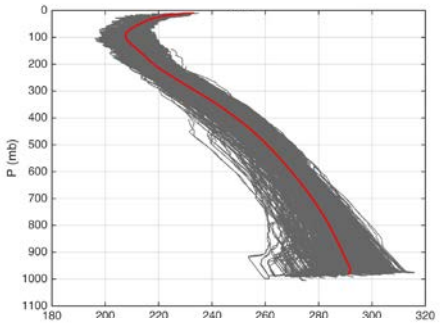
NSA

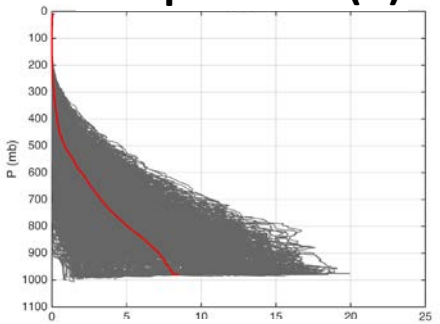




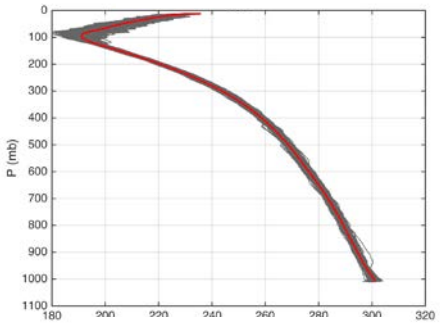


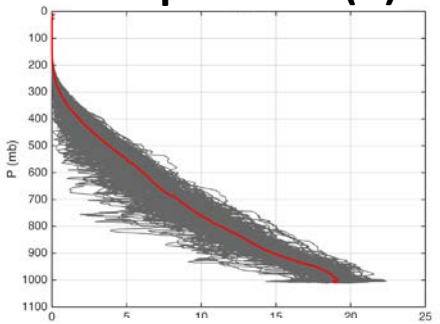
SGP





TWP

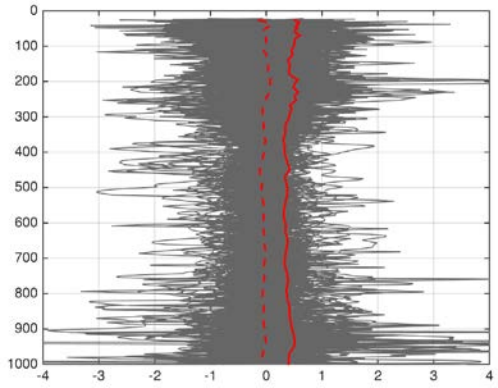


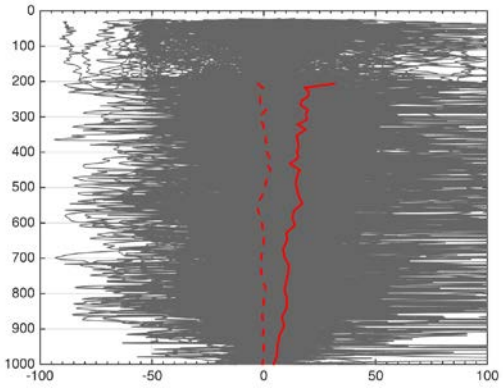


Short Term Variability at NSA & SGP

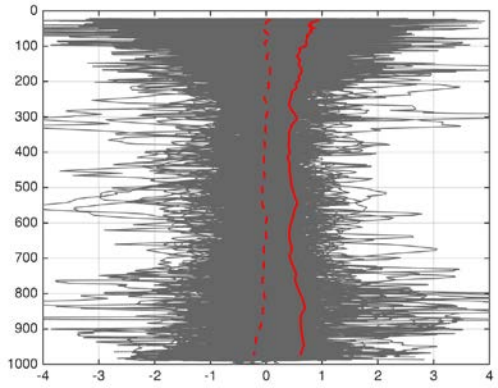
- Differences between sonde pairs are shown
- mean (dashed) & RMS (solid) differences shown in red for 1km (temp) & 2km (h2o) layers
- The variability in temperature that occurs within ~40 minutes is 3/4°K
- The water vapor RMS percent differences range from 5-30%

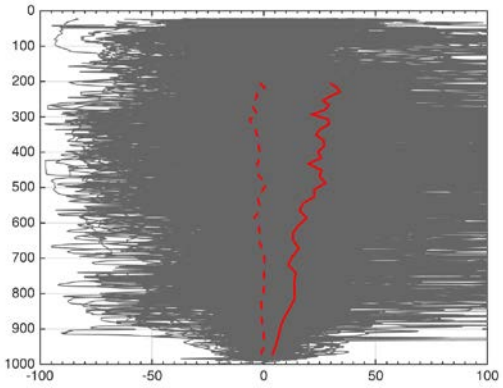
NSA





SGP



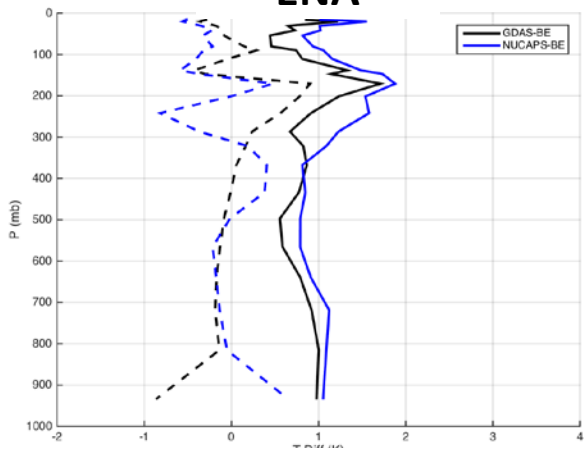


Temperature (K) **H2O (%)**

Validation of NUCAPS Temperature Retrievals

- 1km layer differences shown for each ARM site for ALLSky conditions
- mean (dashed) & RMS (solid) differences shown

ENA



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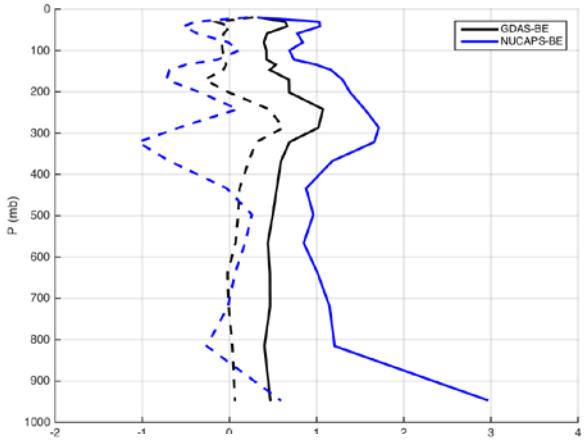

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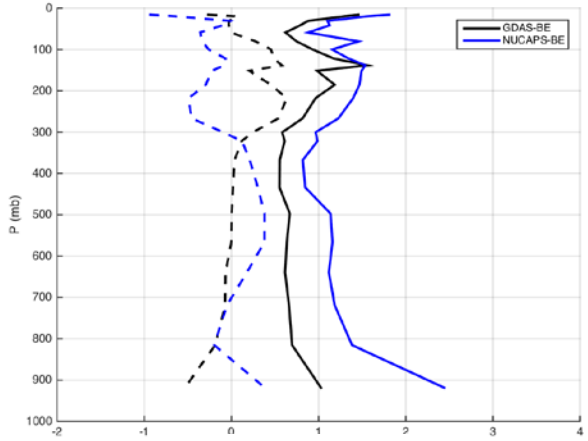
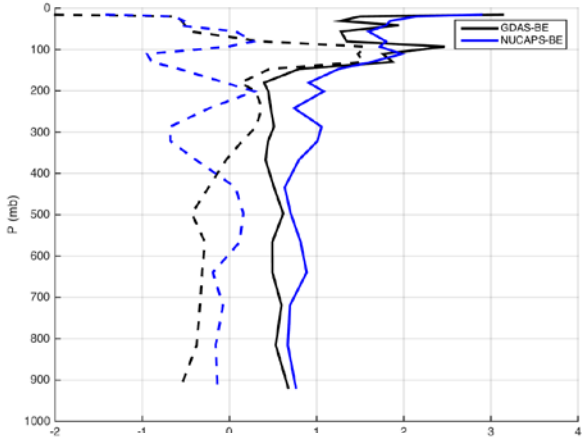


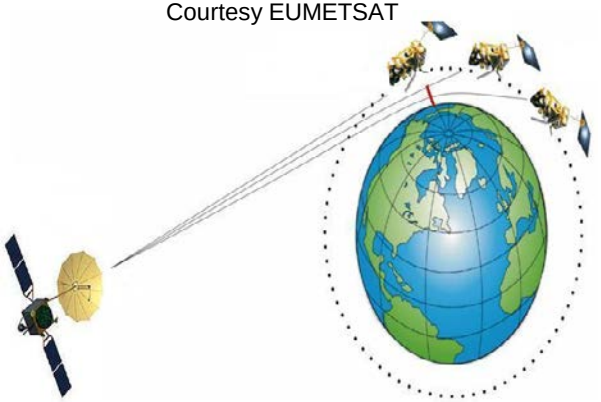
TWP

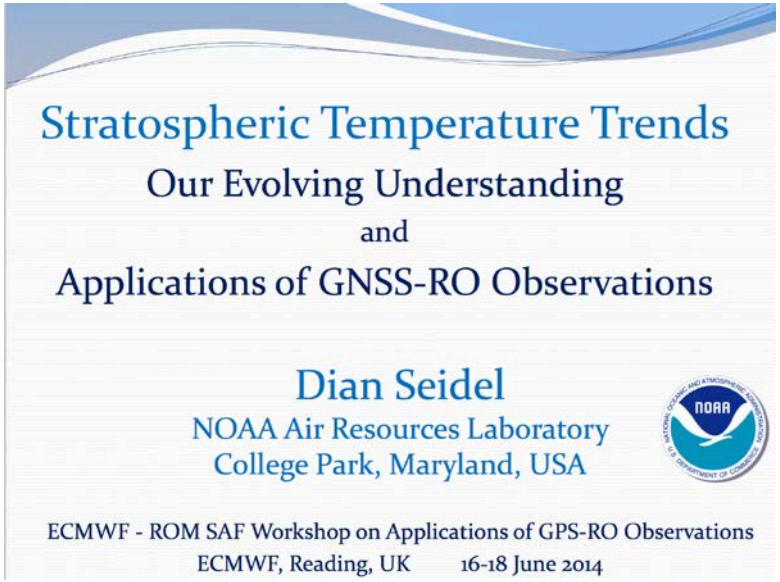


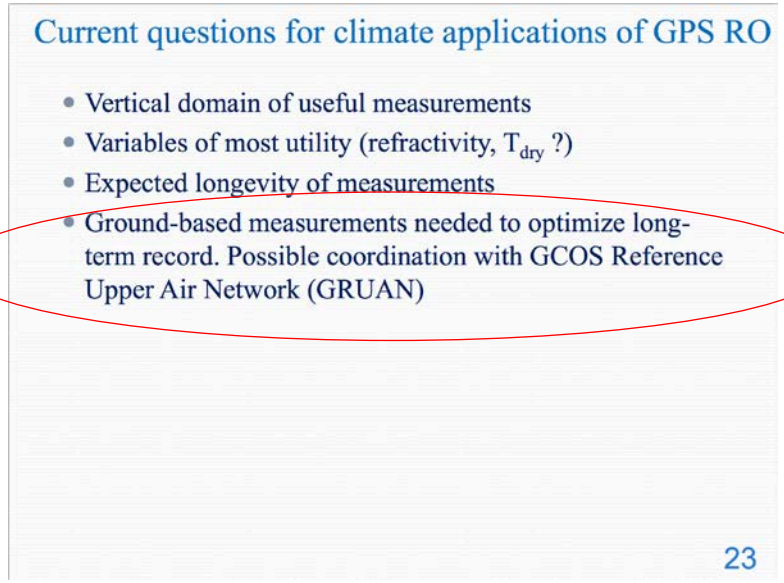
UTLS Temperature Validation using GPS RO

- Radiosondes often not best suited in measuring UTLS temperatures
- GPS RO offers potential produce climate quality measurements w/SI traceability

GRAS RO Measurement Depiction
Courtesy EUMETSAT







- **Lack of reference-quality observations a major problem**
- **GPS RO & GRUAN can help resolve trends & ambiguities in stratospheric temperature**

The Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN)

What is GRUAN?

- International reference observing network
- Currently consisting handful ground sites but envisaged contain 30-40 sites
  - NSA & SGP becoming GRUAN certified

Goals:

- provide long-term climate records from surface, through troposphere, and into stratosphere
- Focus efforts on characterizing observational biases
- Ensure long-term stability by managing instrumental changes
- Tie measurements to internationally accepted standards
- Ensure that potential gaps in satellite programs do not invalidate long-term climate record, thus leading to improved satellite data products

ARM – GRUAN – JPSS Collaboration

GRUAN ICM-8, April 2016 Boulder, CO

- Many overlapping goals
- Proposal of ARM Intensive Operational Period (IOP)

Radiosonde Intercomparison & VALidation (RIVAL) IOP

- **Primary focus:** RS-92 to RS-41 radiosonde transition
- JPSS sondes launched w/both RS-92 and RS-41 for 1-2 years at SGP (ENA & NSA)
- GRUAN interested in radiosonde comparison statistics
- JPSS project gets targeted overpasses with more instrumentation
- **I**n discussions with Vaisala to loan necessary ground stations to ARM program

UTLS Temperature Validation using GPS RO

How often GPS RO & JPSS radiosonde matchups?

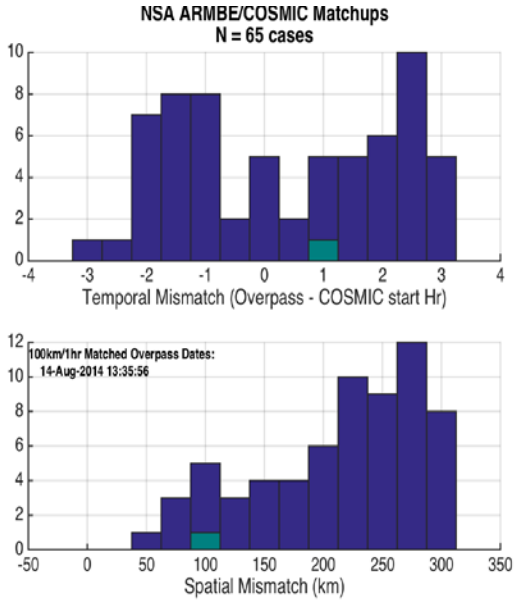
- Depends on matchup criteria
- Not often

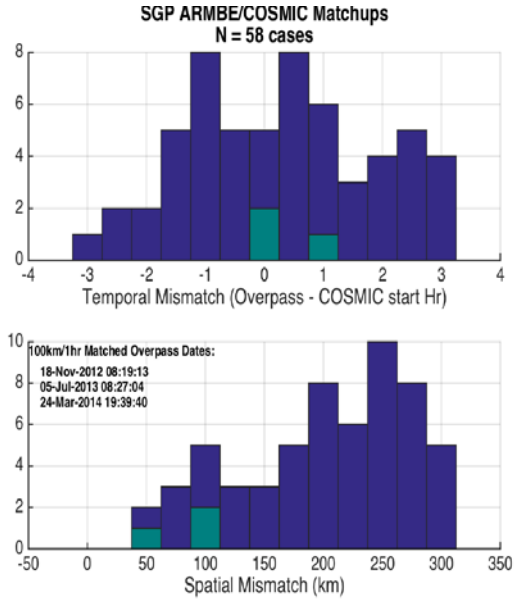
Need ability to predict GPS RO occultations:

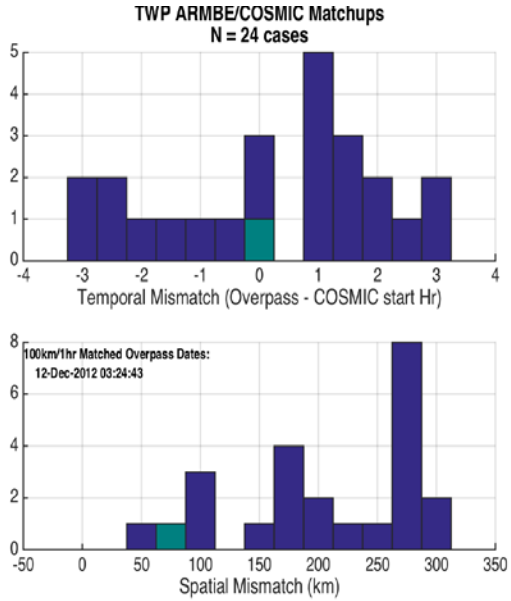
- Currently working with EUMETSAT to establish this capability with METOP-A/B (Axel Von Engeln) & with UCAR for COSMIC

Matchup Criteria:

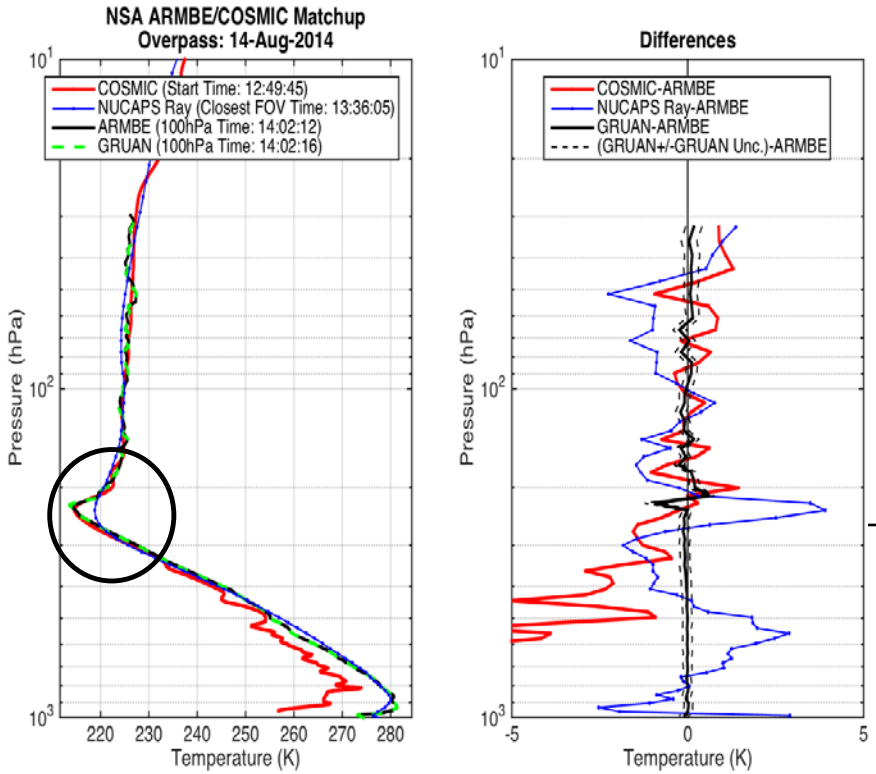
- **300km/3hr**
- **100km/1hr**







S-NPP Validation: GPS RO (COSMIC) Case Study at NSA



Matchup Criteria:

- **100km/1hr**

Oscillation (blue line) is seen in NUCAPS statistics

- This is an example showing benefit of RO & sonde over IR sounder
- RO & sonde pick up coldest layer at tropopause
- NUCAPS captures general structure well, but not able to pick up finer vertical structures

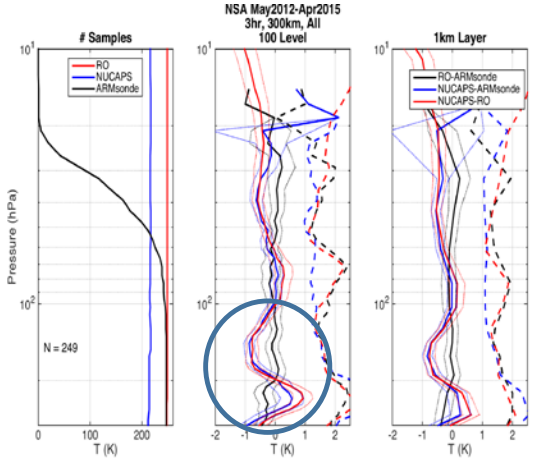
courtesy of Michelle Feltz

S-NPP Validation: COSMIC Matchups w/Routine Launches at NSA

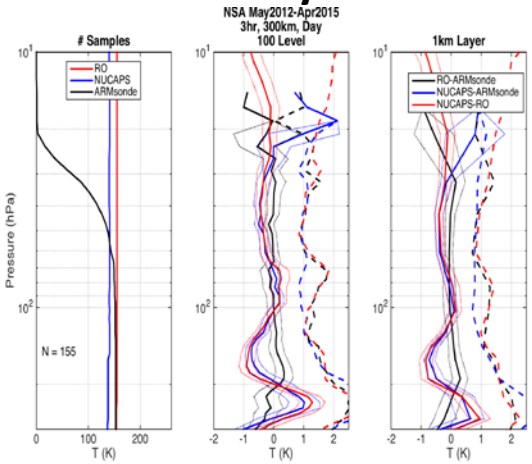
- May 2012 thru April 2015
- Criteria: 3hrs, 300km
- Small sample numbers
- Average over all seasons

LEGEND:
Solid: bias
Dashed: RMS
Dotted: bias +/- 2*(bias uncertainty)

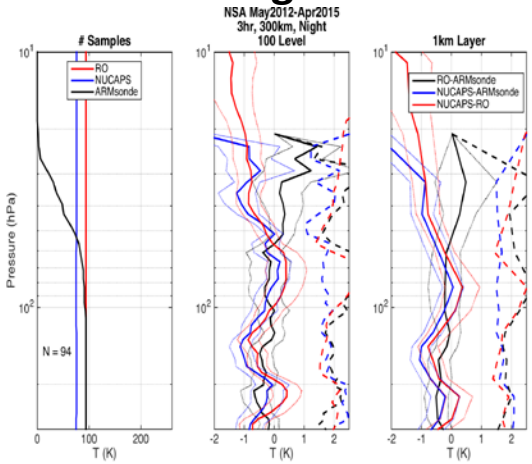
All



Day



Night

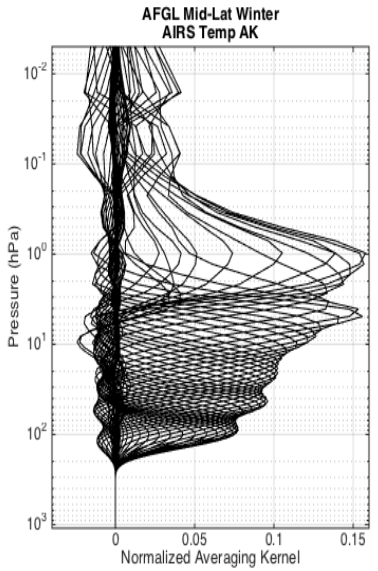


- NUCAPS has a ~1K cold/warm bias at ~150hPa/250hPa respectively
- Bias btwn RO and sonde less than 0.5K where there's more samples and no water vapor contamination. Also true at SGP (not shown).

courtesy of Michelle Feltz

COSMIC & Operational Sounders Matchups

- **Comparisons of:**
  - COSMIC2013 vs. EUMETSAT **IASI B** v6 — 1 yr: May 2013-April 2014
  - COSMIC2013 vs. **AIRS v6** — 3 yr: May 2012-April 2015
  - COSMIC2013 vs. **NUCAPS** — 3 yrs: May 2012-April 2015
  - Updated COSMIC version 2013.3520 (climate and post processed versions) is used
- **Matchup Method**
  - IR raypath technique accounts for estimated RO horizontal resolution & geometry
  - 1 hr time criterion
- **Averaging Kernel (AK) Calculation**
  - AKs calculated for each matchup case for 15um region channels



courtesy of Michelle Feltz

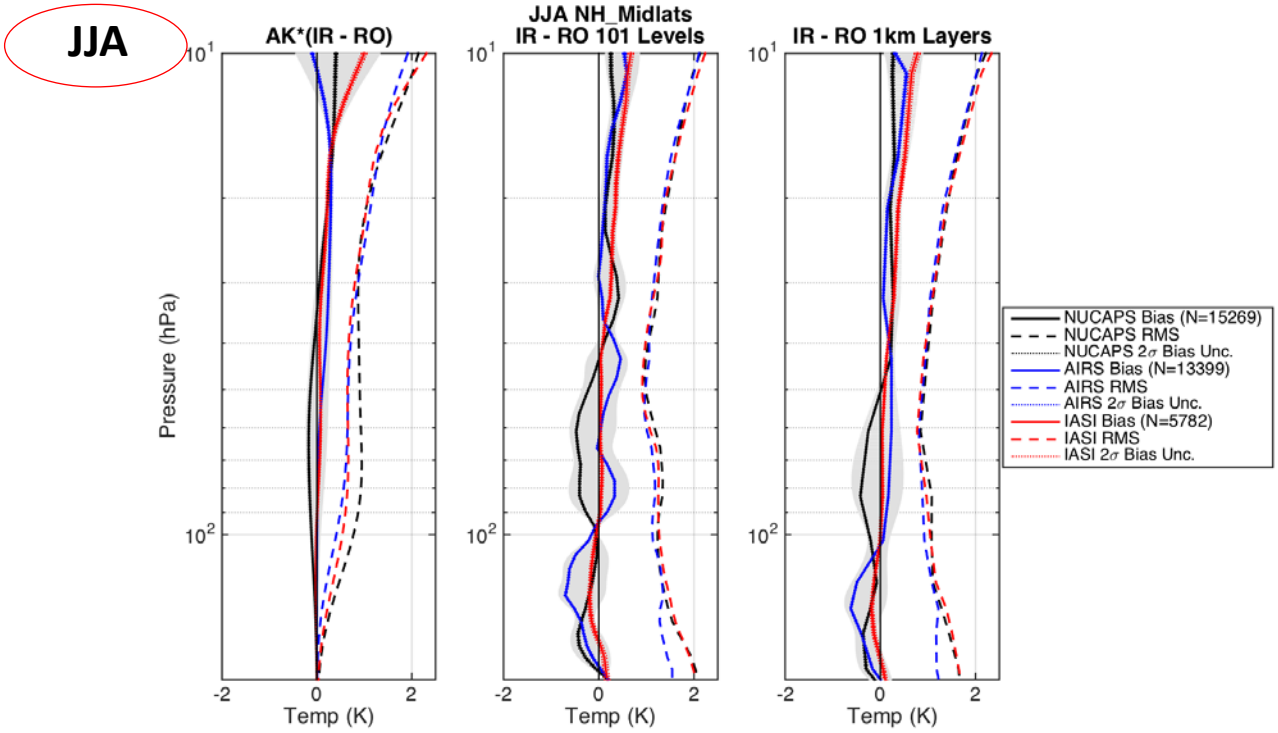
COSMIC & Operational Sounders Matchups

NUCAPS

AIRS

IASI

IR-RO profiles



- Seasonal zonal IR-RO bias (solid), RMS (dashed)
- **NUCAPS, AIRS, IASI**
- 200-10 hPa region bounding where COSMIC & RO processing most accurate
- grey shading marks +/-2 stnd dev from mean of 3 different sounder biases
- averaging kernels applied (left), 101 levels (middle), 1km layers (right)

courtesy of Michelle Feltz

COSMIC & Operational Sounders Matchups

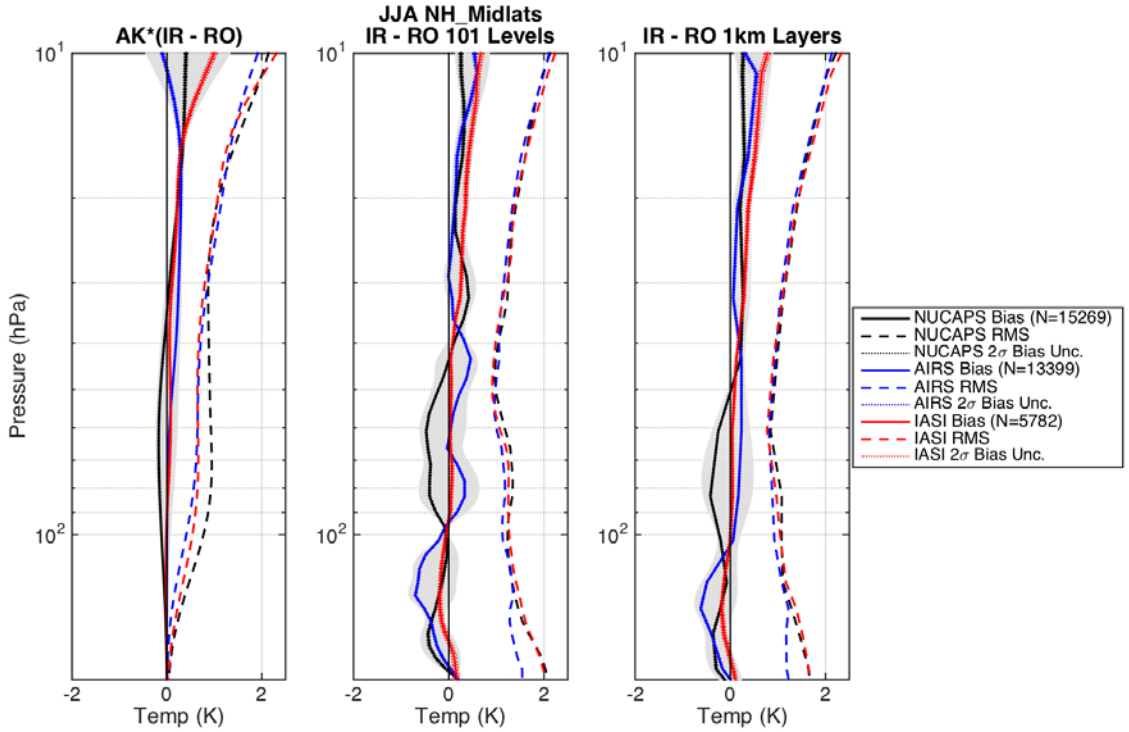
NUCAPS

AIRS

IASI

IR-RO profiles

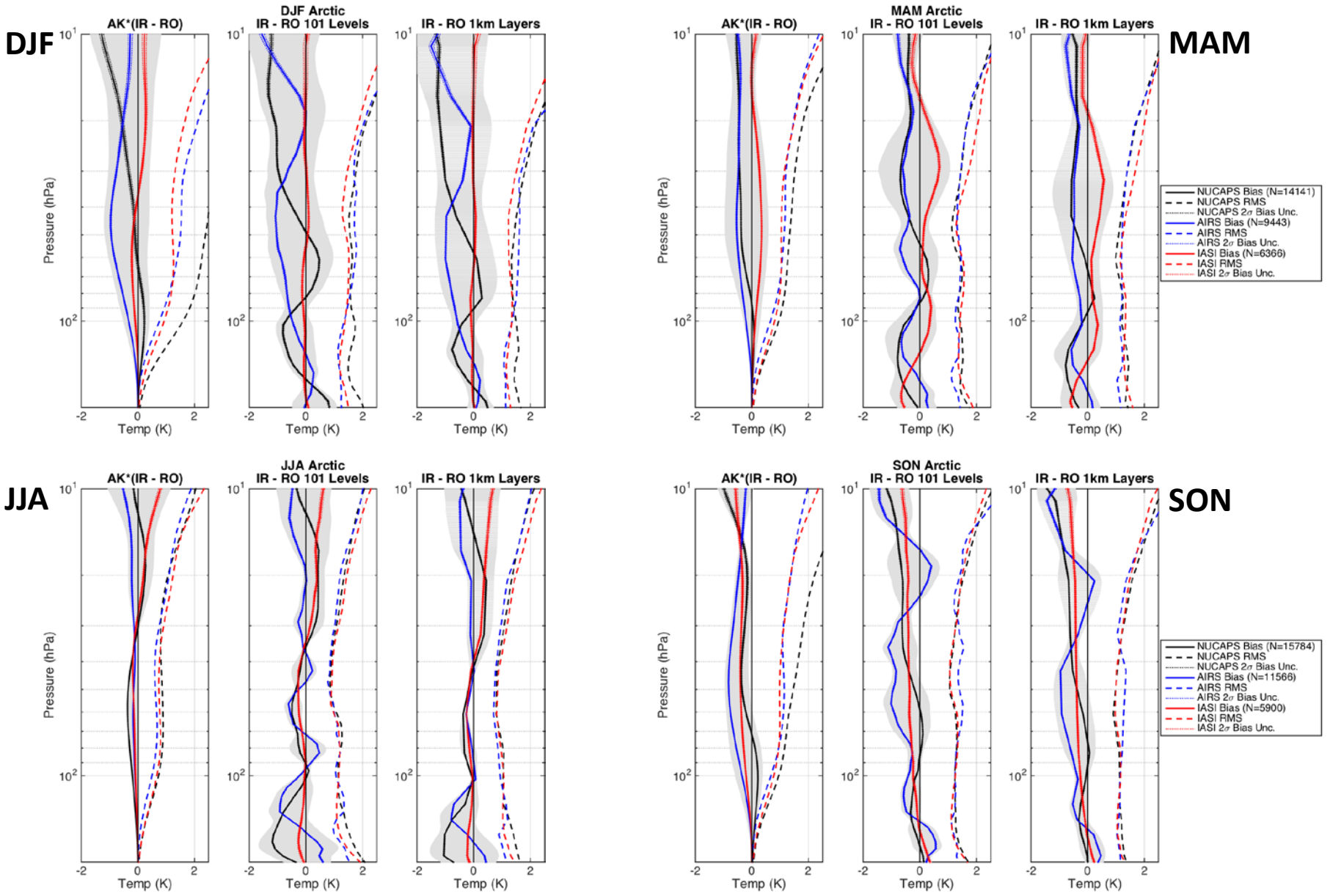
JJA



- AK reduces biases (solid) to within ~ 0.5K
  - True for most zones and seasons (excluding JJA & MAM Antarctic & DJF Arctic)
- AK RMS similar to those at 101 levels & are under ~2K and often below 1.5K below ~30hPa
- 1km layering reduces RMS (dashed) within 40-150 hPa region by over 0.25K
- 1km layering removes smaller magnitude vertical oscillations

courtesy of Michelle Feltz

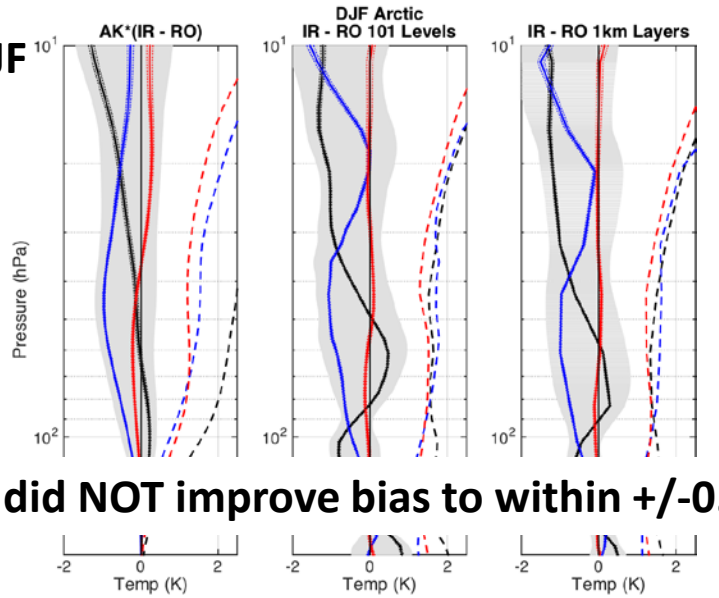
COSMIC & Operational Sounders Matchups: Arctic



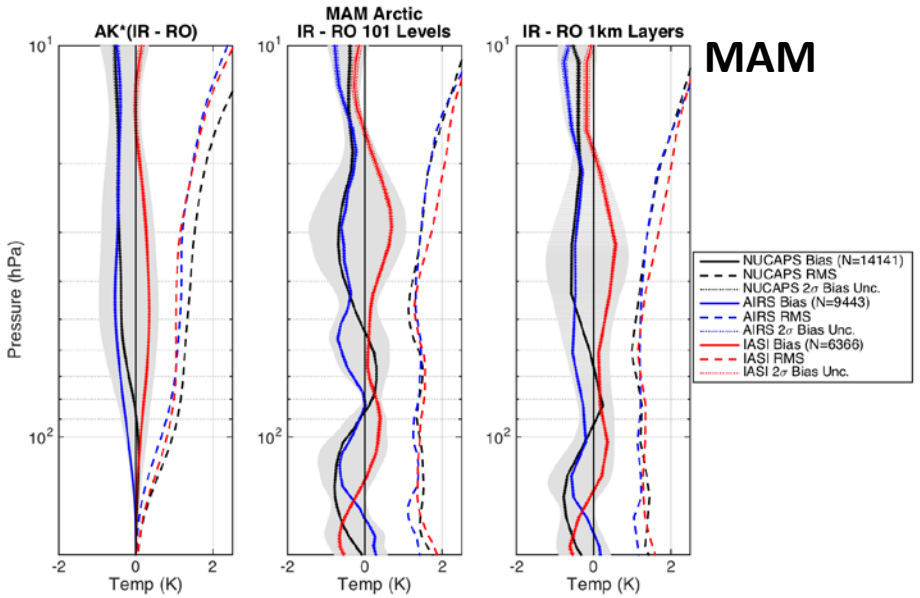
courtesy of Michelle Feltz

COSMIC & Operational Sounders Matchups: Arctic

DJF

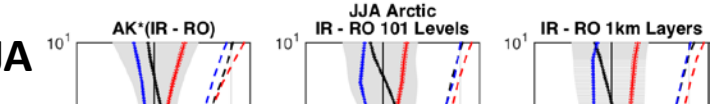


MAM

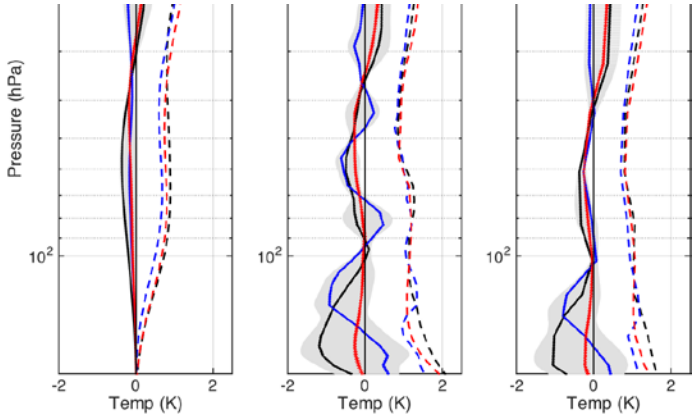


AK did NOT improve bias to within +/-0.5K

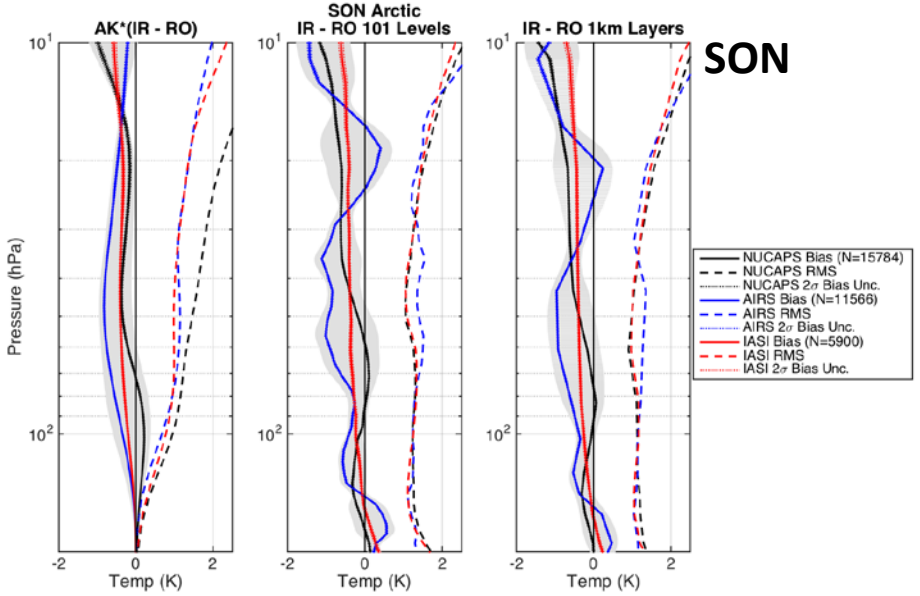
JJA



1km layering removes vertical oscillations

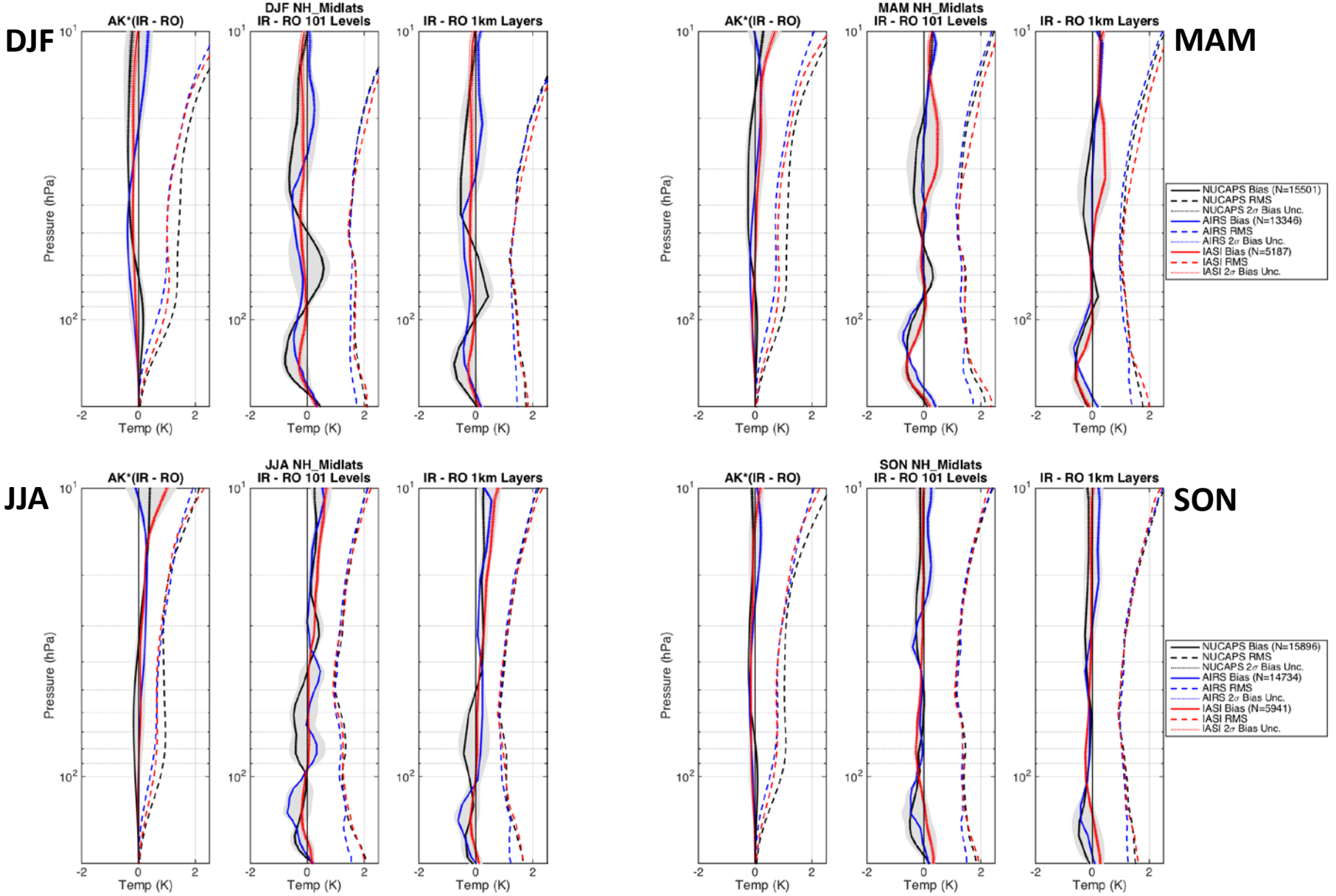


SON



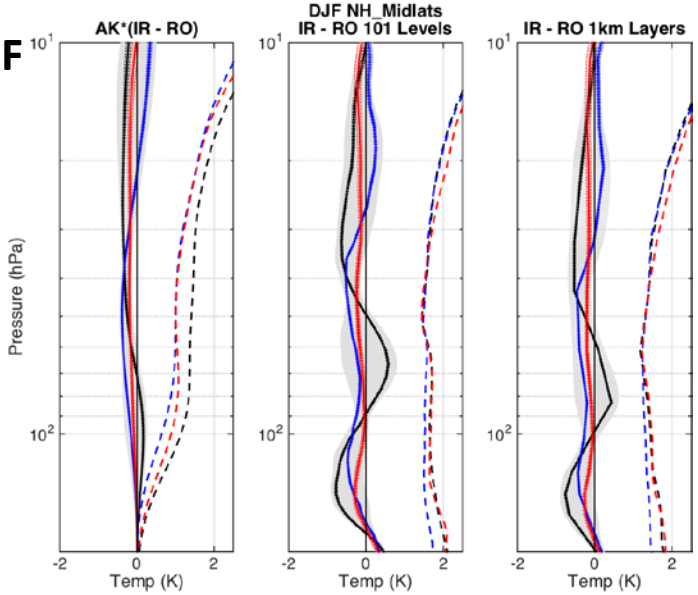
courtesy of Michelle Feltz

COSMIC & Operational Sounders Matchups: NH-Midlat



COSMIC & Operational Sounders Matchups: NH-Midlat

DJF



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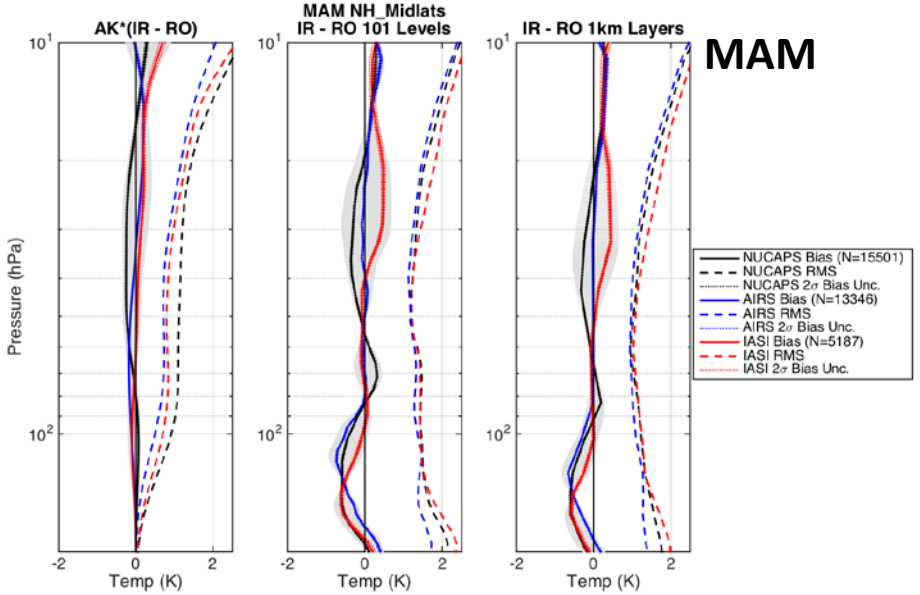

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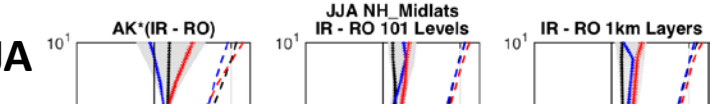
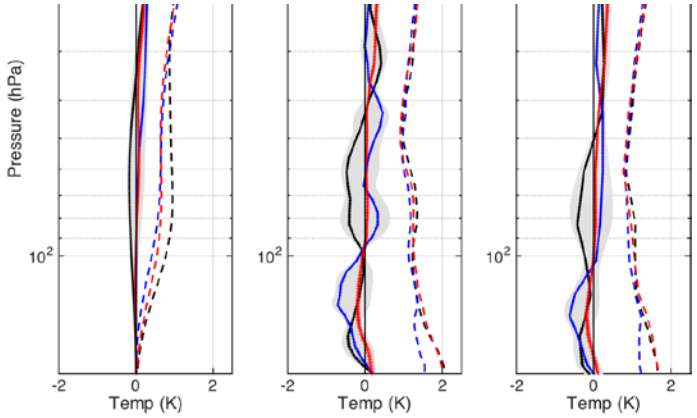


1km layering removes vertical oscillations



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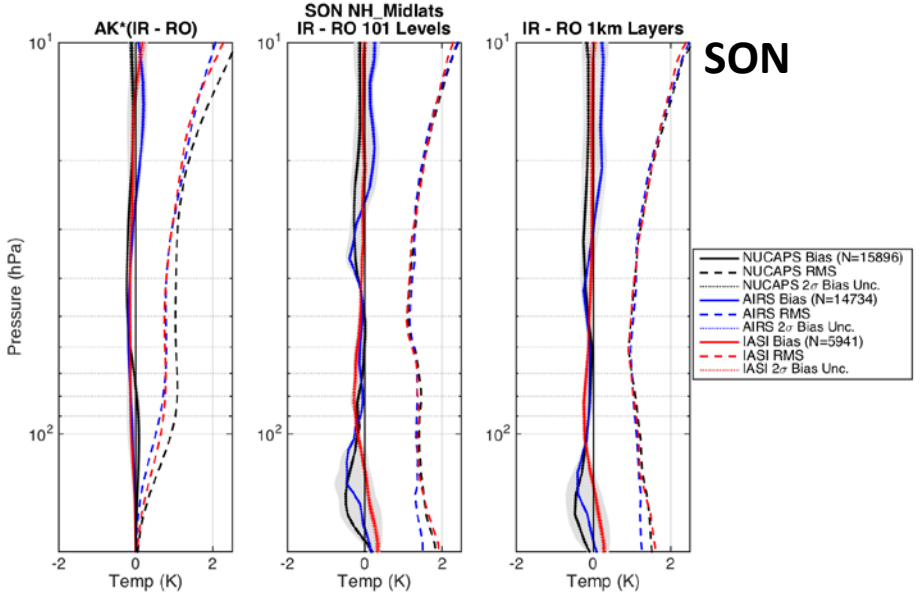
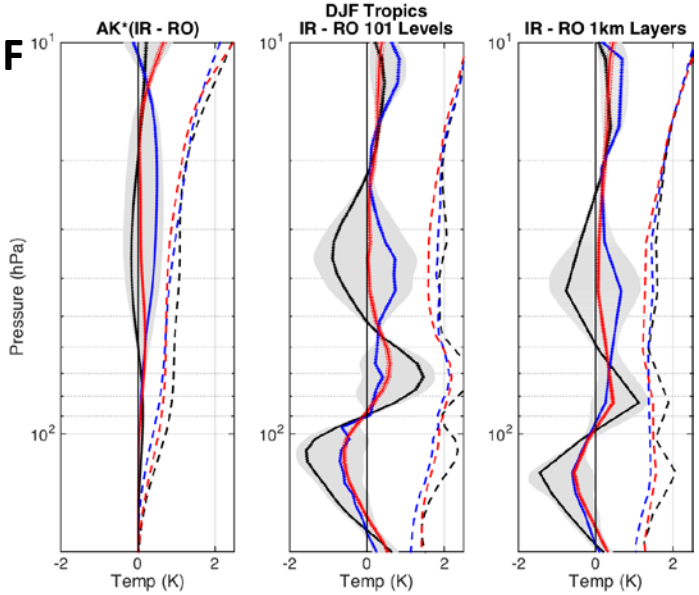


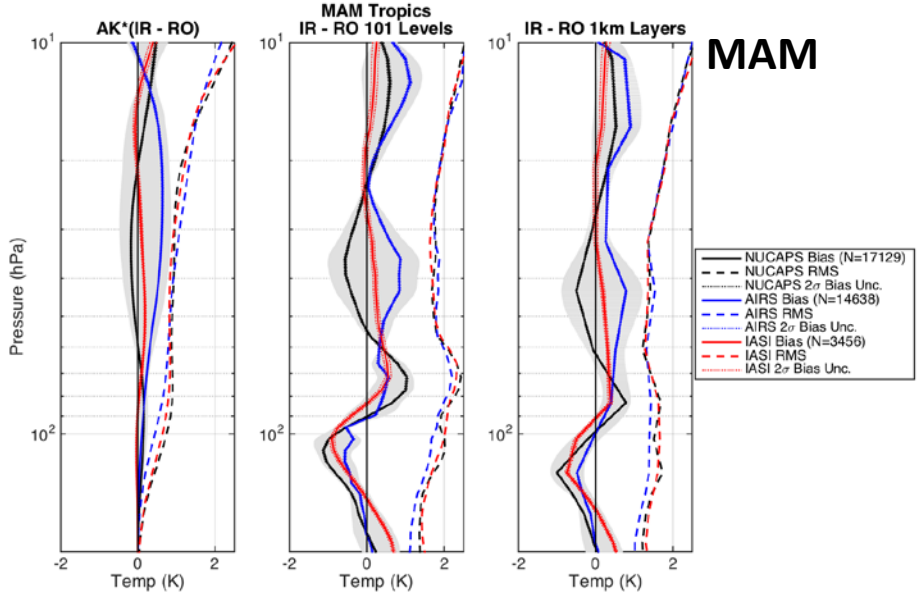
courtesy of Michelle Feltz

COSMIC & Operational Sounders Matchups: Tropics

DJF



MAM



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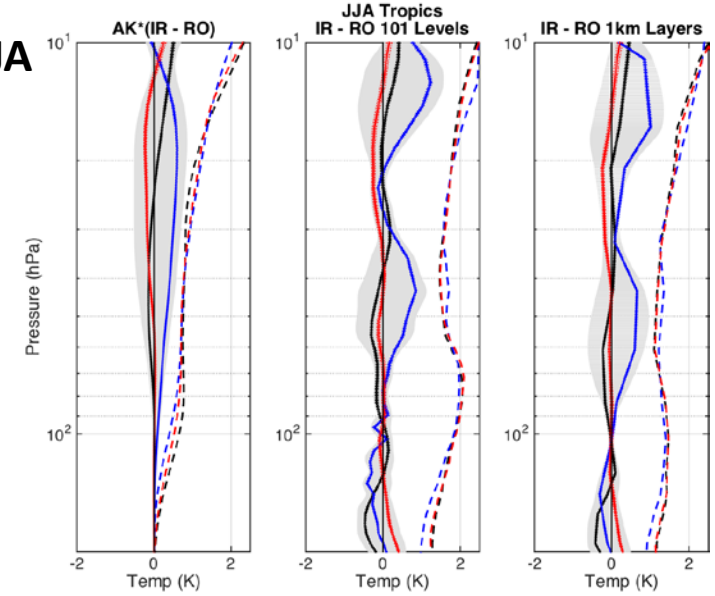

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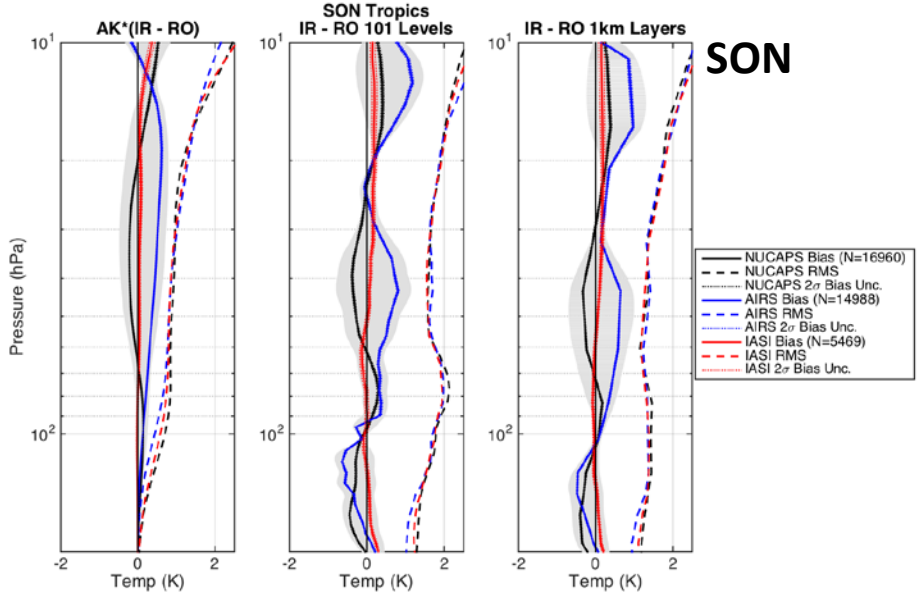
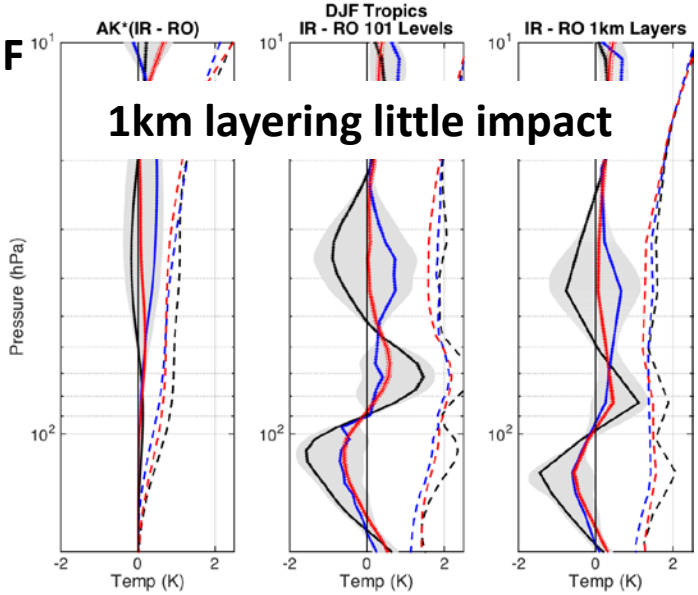


courtesy of Michelle Feltz

COSMIC & Operational Sounders Matchups: Tropics

DJF



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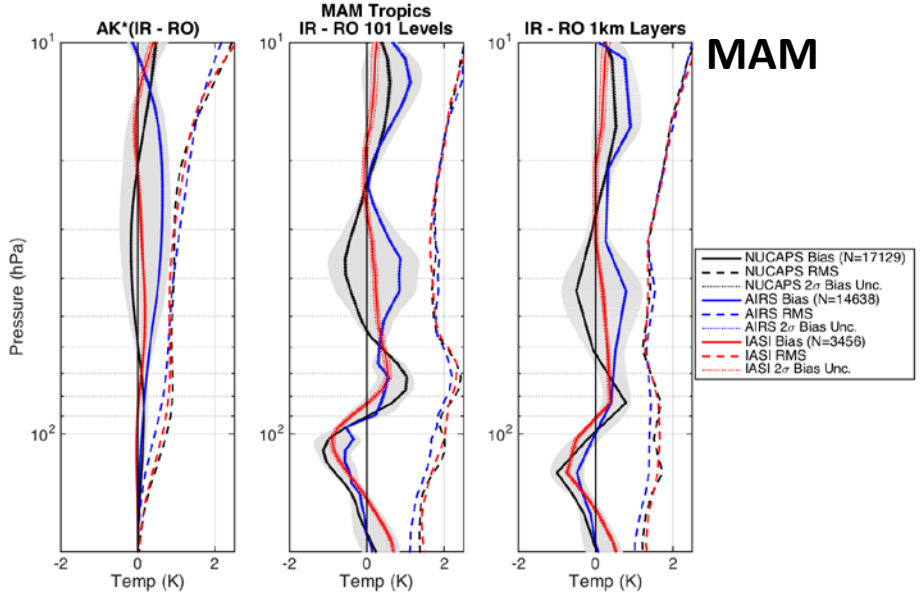

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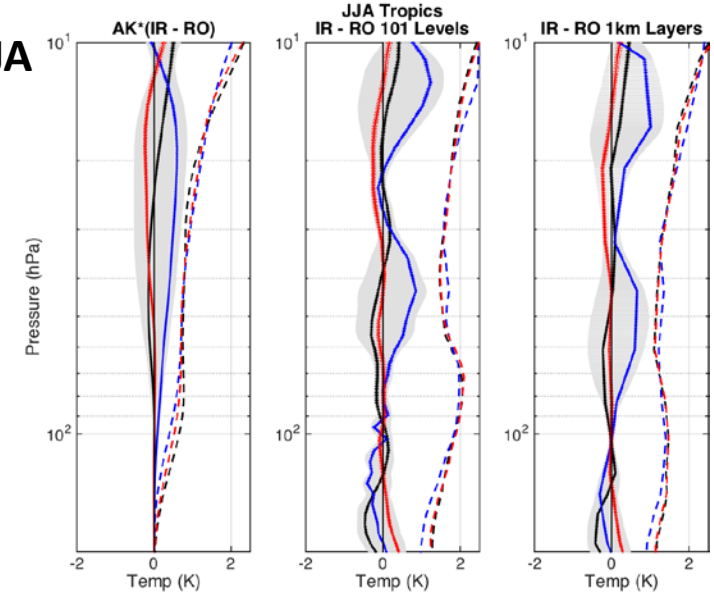

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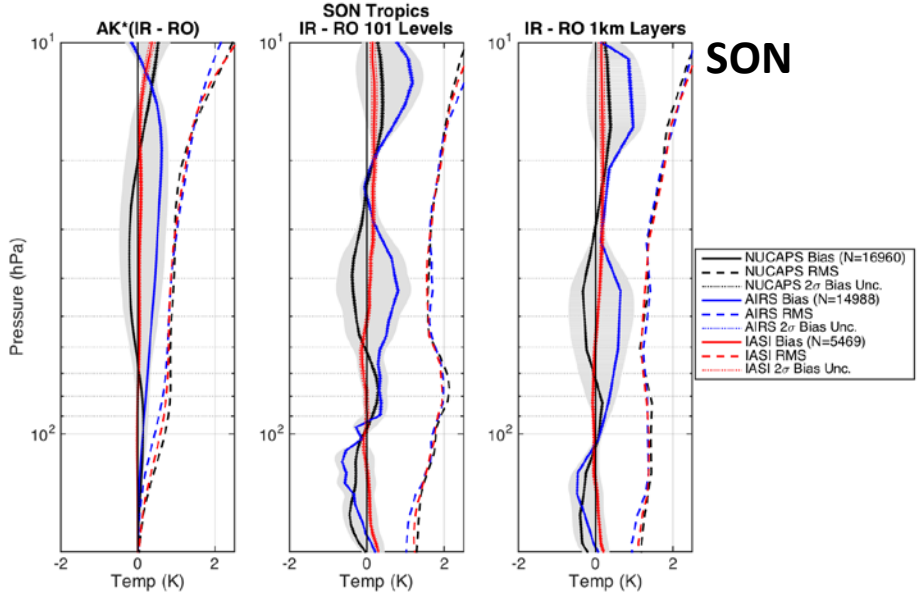
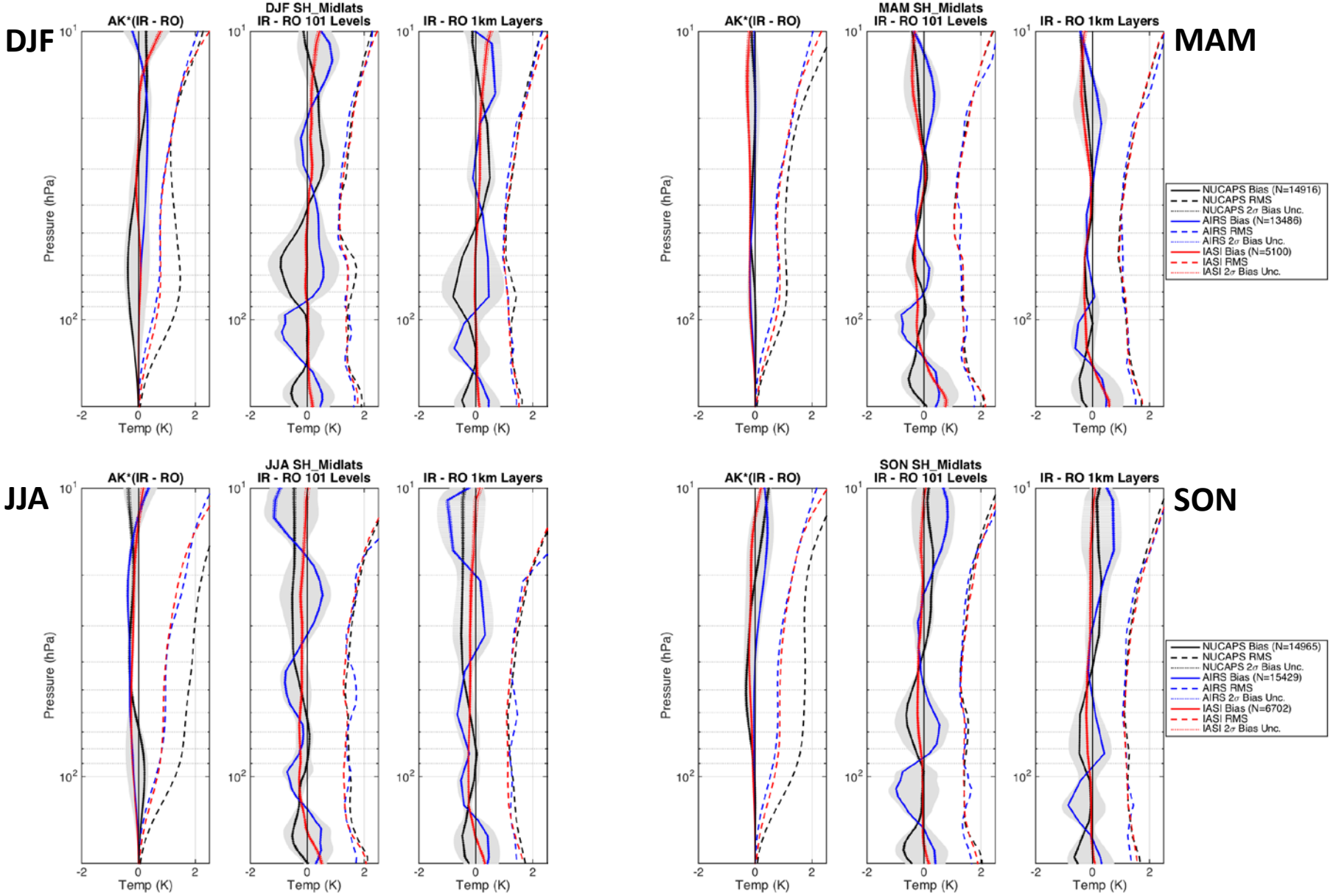


courtesy of Michelle Feltz

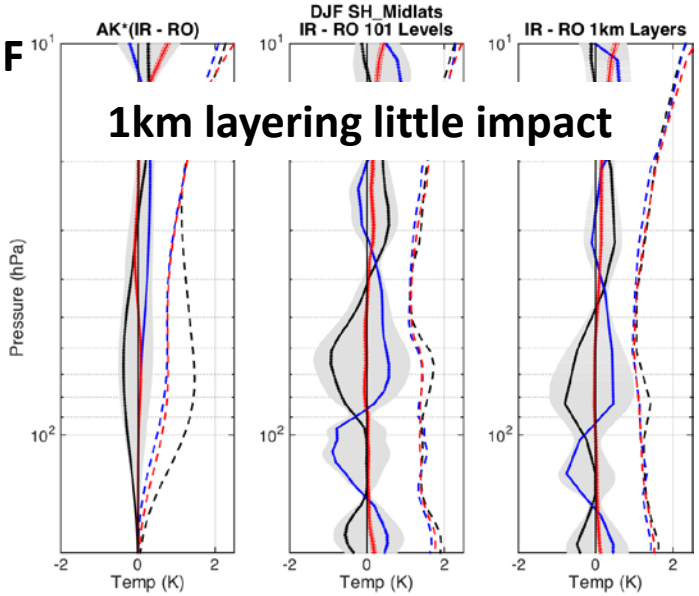
COSMIC & Operational Sounders Matchups: SH-Midlat



courtesy of Michelle Feltz

COSMIC & Operational Sounders Matchups: SH-Midlat

DJF



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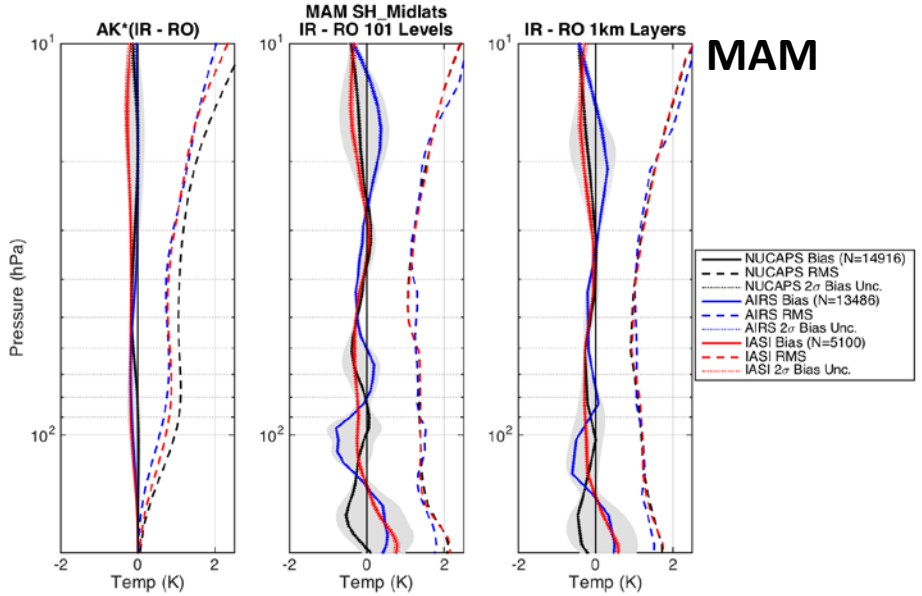

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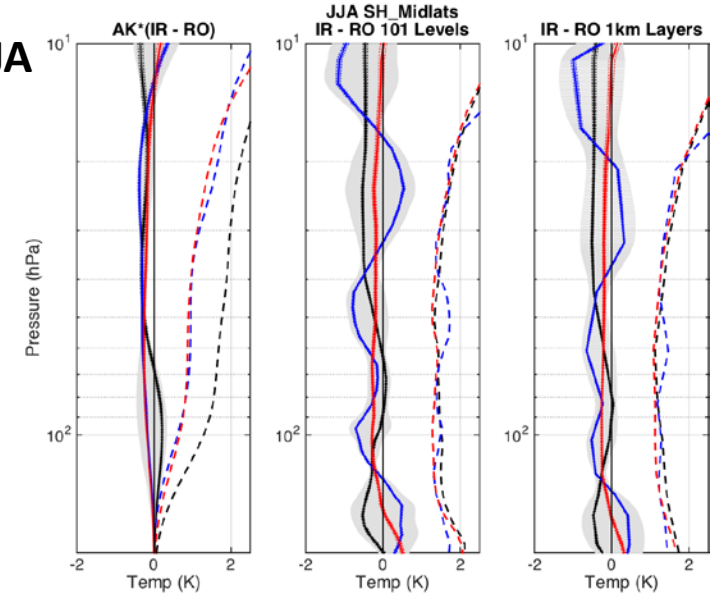

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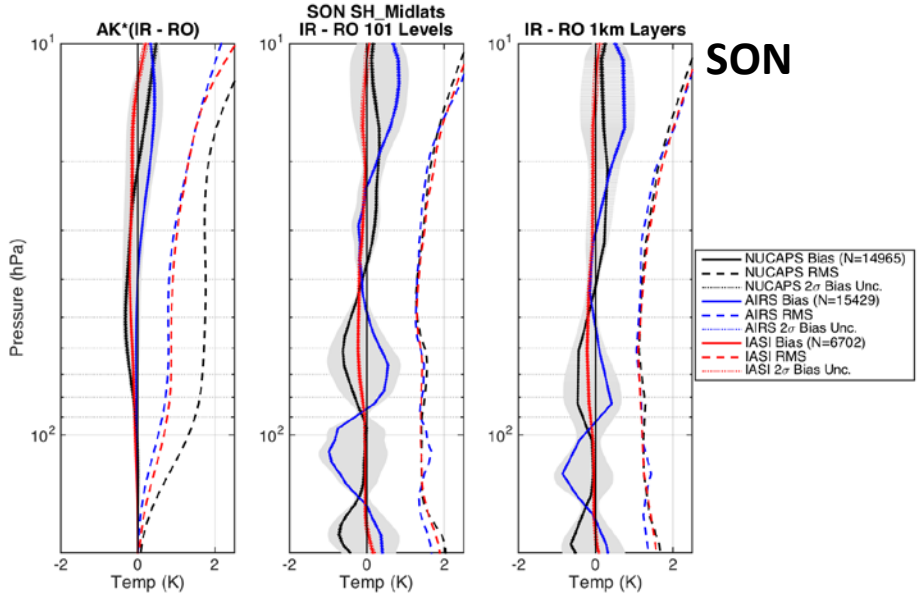
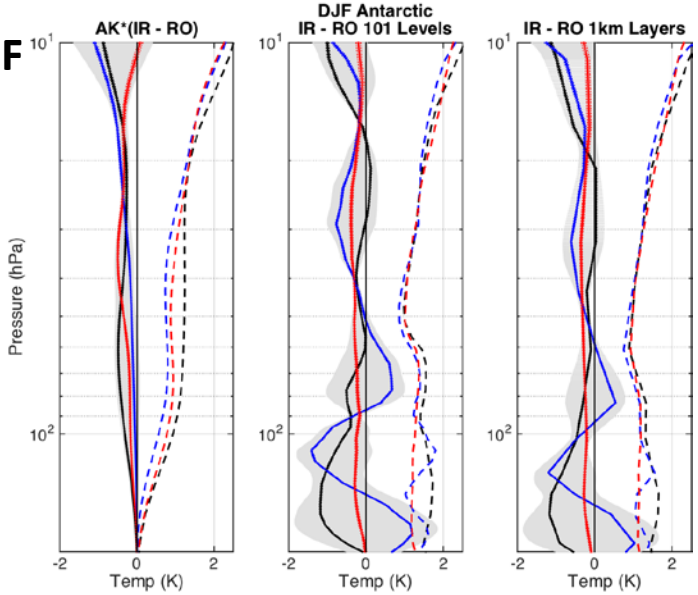


courtesy of Michelle Feltz

COSMIC & Operational Sounders Matchups: Antarctic

DJF



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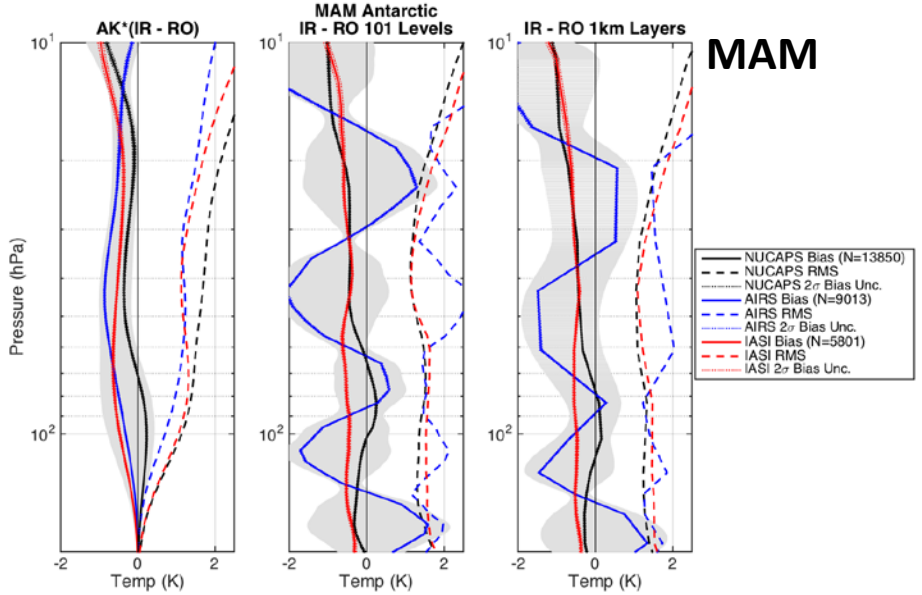

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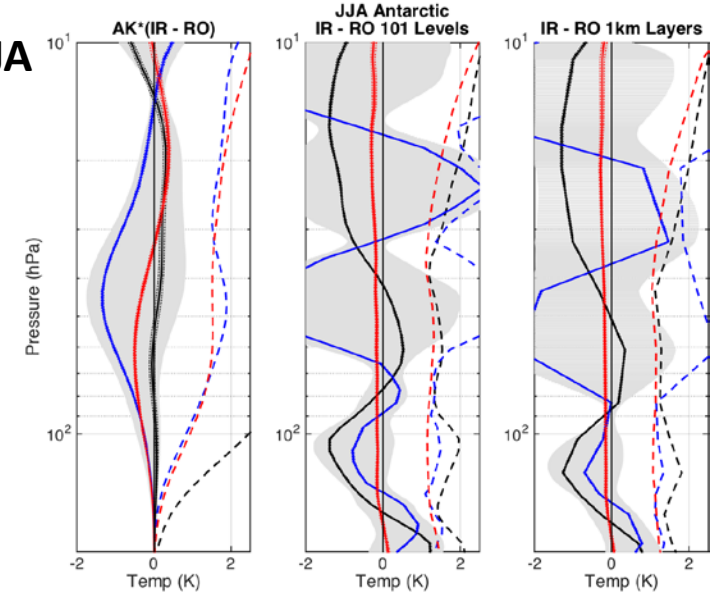

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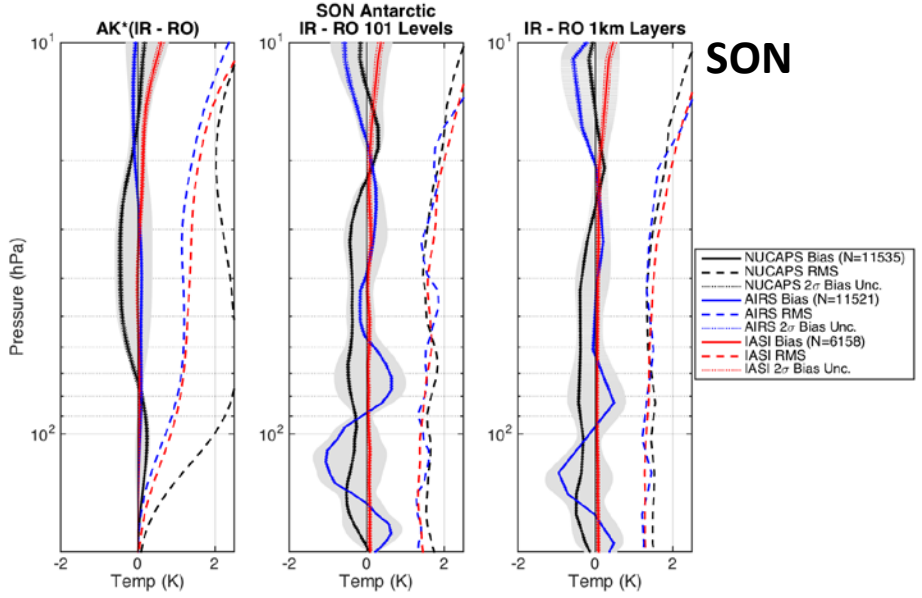
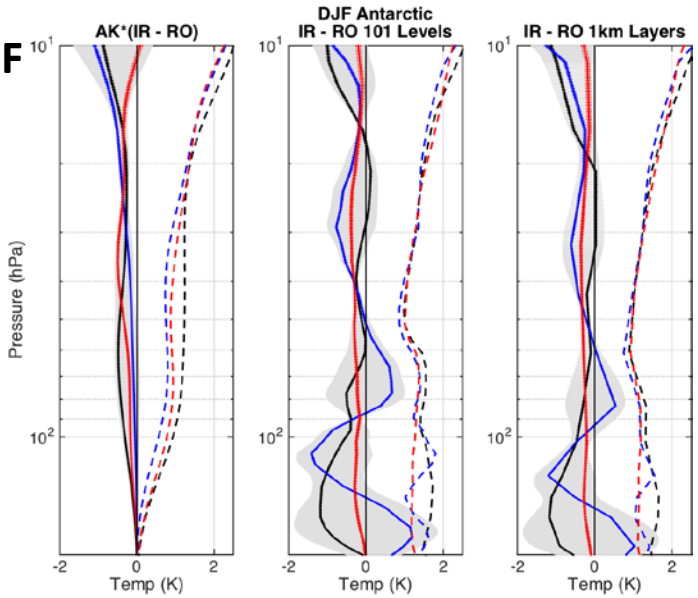


courtesy of Michelle Feltz

COSMIC & Operational Sounders Matchups: Antarctic

DJF



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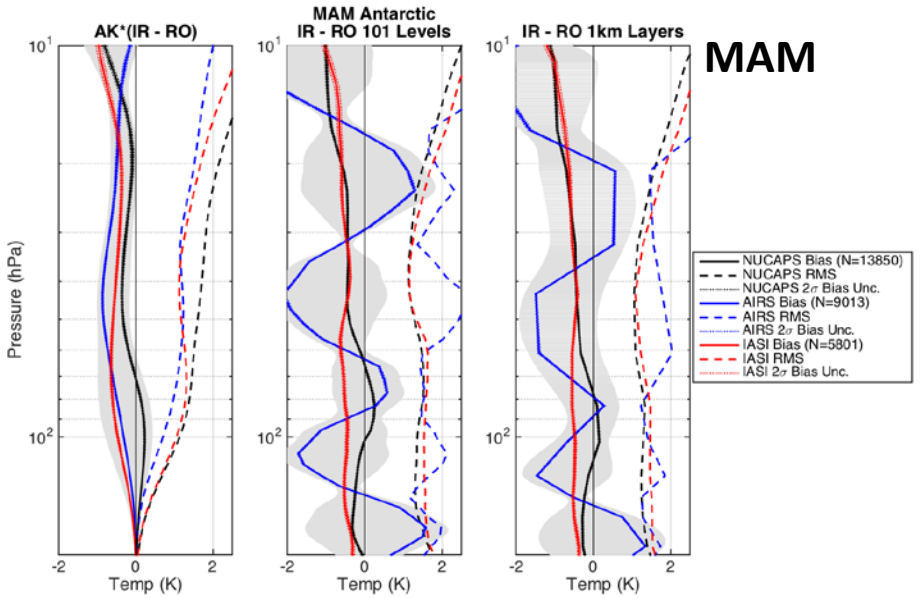

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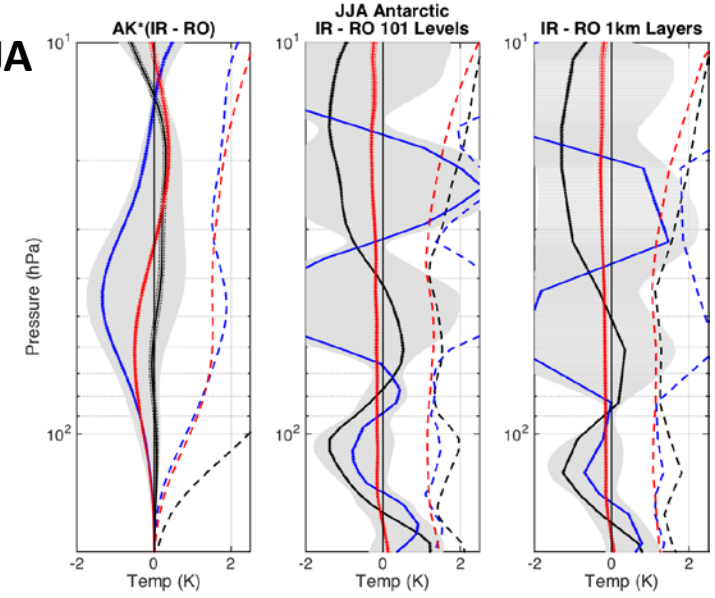


MAM & JJA:

- 1km layering little impact
- AK did NOT improve bias to within +/-0.5K
- AIRS (blue) non degraded results (center subplots) point to unphysical large vertical oscillation in AIRS temperature profiles

courtesy of Michelle Feltz

COSMIC & Operational Sounders Matchups

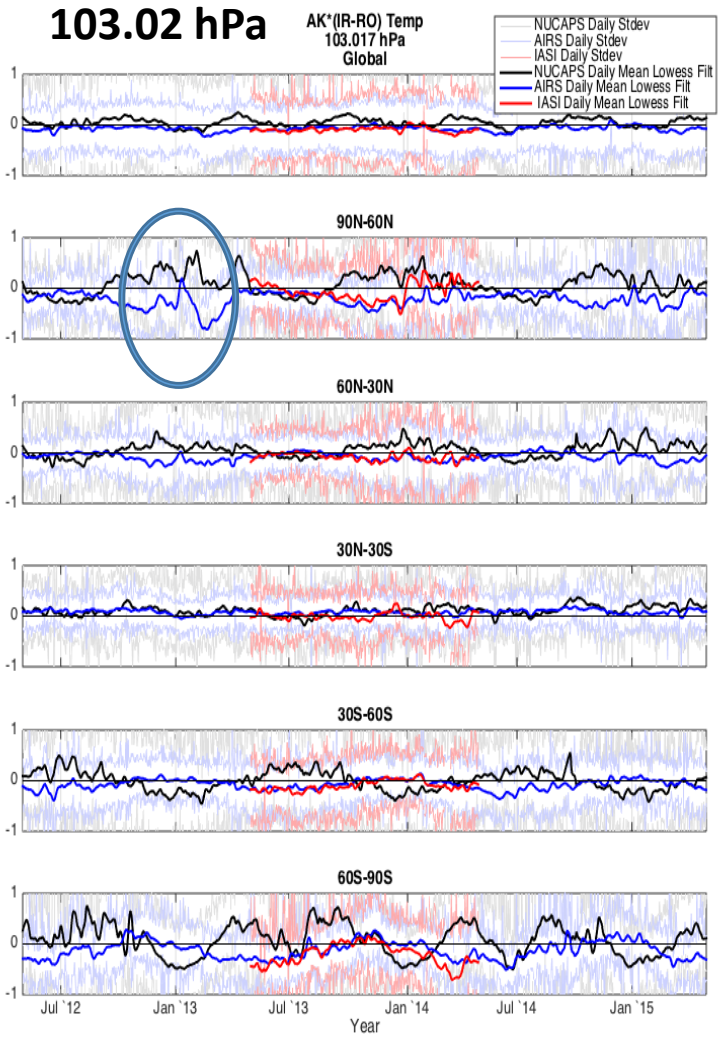
NUCAPS AIRS IASI

Results:

- Largest biases occur in the polar zones
- IASI in general has smaller biases then AIRS & NUCAPS
- For all zones the AK smoothed differences are within ~1K except for the JJA Antarctic
- RO and IR sounders on zonal scales are agreeing to within 1K. In some zones (e.g. Mid-lats) this agreement is even better (within ~0.5K)
- AK smoothed NUCAPS bias is well behaved and not far from ~0.25K below 30 hPa.
- For NUCAPS, the 1km DJF & MAM tropics region of largest differences

COSMIC/Operational Sounders Matchups:

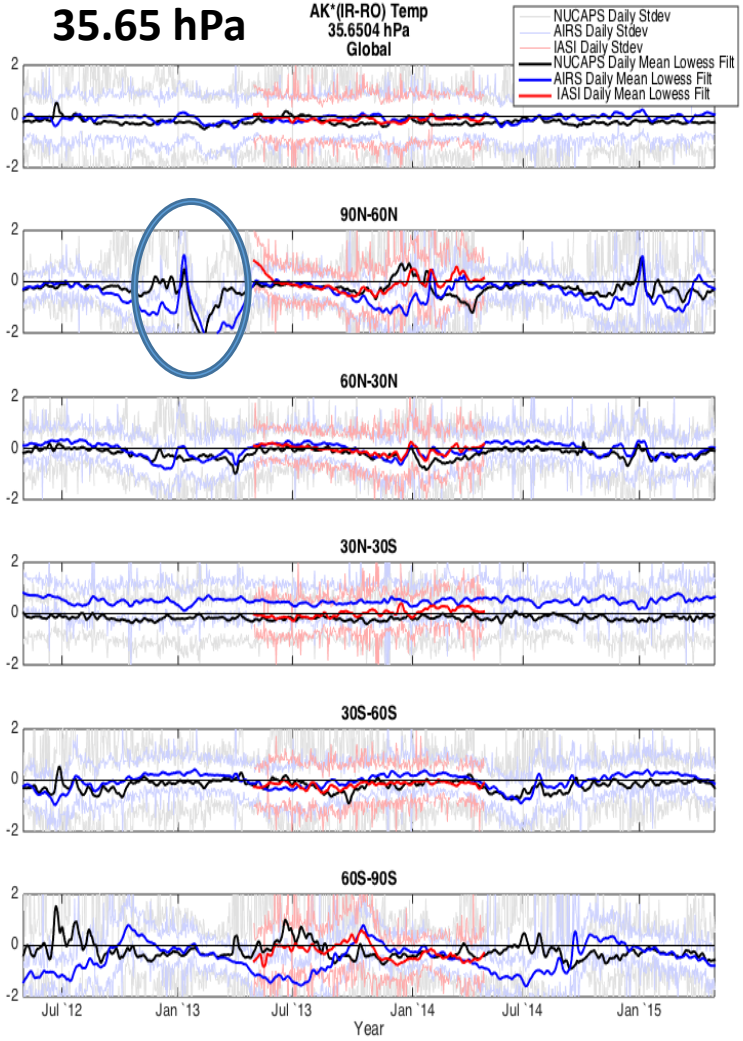
- **Daily Mean Lowess Filter (AK smoothed temp biases)**



COSMIC is known to have a warm bias in polar winters, but nucaps is often warmer than cosmic in those locations

global and tropical panels show good (less than 0.3K?) agreement btwn RO and IR sounders

Polar zones reveal larger differences and some seasonal dependences of bias



courtesy of Michelle Feltz

Future Work:

- Phase-5 of radiosonde launches begins October 1, 2016
- Work towards synchronizing sonde launches w/COSGPS RO
- Continue working with GRUAN and ARM IOP
- Use NPROVS+ as repository for Best Estimates
- A Better Best Estimate
  - AERI OS
  - VIIRS cloud mask
  - OBS-CALCs using LBLRTM