JPSS Radiosonde Program

Validation of NUCAPS at ARM 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:

• Obtain accurate & on-going validation data for assessment of S-NPP soundings

Heritage:

• Follows efforts by Tobin et. al., 2006 in the assessments of AIRS temperature and water vapor soundings
North Slope Alaska (NSA)

Southern Great Plains (SGP)

Eastern North Atlantic (ENA)

Tropical Western Pacific (TWP)

- S-NPP launches started Feb 2015
- Site closed May 2014
Radiosonde Launches

- S-NPP radiosonde launches began in July 2012 and are ongoing
- Radiosonde launches have occurred across seasons and have sampled a range of atmospheres at each site
- Phase-5 (black) began October 1, 2016 & runs through September 2017
- Phase-6 funding will target JPSS-1
1. JPSS project provides funds for radiosondes to ARM

2. UW provides ARM with launch schedules for ‘acceptable’ overpasses at each site
   - meets view angle criteria (<=30 deg)
   - not fully overcast and/or heavily precipitating as judged by site operator

3. ARM launches radiosondes

   ARM Sondes are Valuable!
While the collection sites are limited in number, the profiles consist of highly accurate measurements of a wide range of climatic conditions.
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**ARM Sondes are Valuable!**

- Sondes are accurate and traceable to calibrated reference
- ARM providing:
  - Supplies & equipment
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   **ARM Sondes are Valuable!**

- Sondes are accurate and traceable to calibrated reference
- ARM providing:
  - Supplies & equipment
  - Expertise to launch sondes consistently at various sites
  - Suite ancillary measurements
    - Microwave radiometers
    - Ceilometers
    - AERI
JPSS Radiosonde Program

Best Estimate of Atmospheric State (BE)

- Sondes interpolated to common pressure grid
- MWR PWV scaling applied to sonde RH & WVMR
- Sondes interpolated to overpass time (dual launch)

Dual Launch Strategy: NSA & SGP
~45 min and ~5 min prior overpass

Single Launch Strategy: ENA & TWP
~15 min prior to overpass
• 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%
Validation of NUCAPS Temperature Retrievals Using BE

- 1km layer Temp Differences (NU-BE) shown for each site and ALLSky conditions
- BIAS (left) & RMS (right)
Validation of NUCAPS H2O Retrievals Using BE

- 2km layer H2O_MR differences (NU-BE) shown for each site and ALLSky conditions
- BIAS (left) & RMS (right)
Validation of NUCAPS

Using a multi-year BE product to validate NUCAPS can be difficult ...

- Requires consistently processed NUCAPS dataset
- Which in turn requires consistently processed set of CrIS & ATMS SDRs

Accomplished using Community Satellite Processing Package (CSPP)
CSPP Overview

The Community Satellite Processing Package (CSPP) is a collection of freely available software for processing data from LEO and GEO meteorological satellites.

CSPP supports the creation of calibrated observational data, geophysical derived products, and mapped images from visible, infrared, and microwave sensors.

The CSPP project is based at the Space Science and Engineering Center at the University of Wisconsin-Madison and is funded by NOAA JPSS Program Office.
Satellites supported by CSPP

CSPP LEO supports processing of data from these satellites in low earth orbit:

*Suomi NPP, Metop-A/B, NOAA-18/19, Terra, Aqua, GCOM-W1, and FY-3B/C.*

Data source is usually Direct Broadcast (DB) from the spacecraft. However, archived data are also supported (e.g., NOAA CLASS, NASA DAAC).
Validation of NUCAPS

Using a multi-year BE product to validate NUCAPS is somewhat of a moving target...

- Requires consistently processed NUCAPS dataset
- Which in turn requires consistently processed set of CrIS & ATMS SDRs

Accomplished using Community Satellite Processing Package (CSPP)

Previous analysis is a validation of CSPP NUCAPS

- CrIS RDRs edited to contain consistent set of NL coefs
- CSPP v2.2.4 (equivalent to IDPS Mx8.11) used produce CrIS & ATMS NSR SDRs
- CSPP NUCAPS v1_1 used produce NUCAPS retrievals

Future of CSPP:

- Block2 build of CSPP is currently being tested
- Block2 version of CSPP will be capable of producing both NSR & FSR CrIS SDRs
COSMIC Case Study at NSA

- 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

Matchup Criteria:
- 100km/1hr

Oscillation (blue line) is seen in NUCAPS statistics

courtesy of Michelle Feltz
Validation of NUCAPS Stratospheric Temperature Profiles

Tropical Zone: 30S – 30N

DJF

## ARM Radiosonde, COSMIC, and NUCAPS Matchup Statistics

<table>
<thead>
<tr>
<th></th>
<th>AK*(NUCAPS-RO)</th>
<th>AK*(NUCAPS-Sonde)</th>
<th>RO-Sonde</th>
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<tbody>
<tr>
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<td>Bias 2*Unc. RMS</td>
<td>Bias 2*Unc. RMS</td>
<td>Bias 2*Unc. RMS</td>
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<tr>
<td>NSA Annual</td>
<td>-0.144 0.151 1.10</td>
<td>-0.203 0.0926 0.70</td>
<td>-0.130 0.258 1.78</td>
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<td>SGP Summer</td>
<td>-0.291 0.199 0.796</td>
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<td>0.229 0.576 2.00</td>
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<td>SGP Winter</td>
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<td>-0.145 0.293 0.95</td>
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<tr>
<td>TWP Annual</td>
<td>-0.174 0.189 0.405</td>
<td>-0.171 0.176 0.371</td>
<td>-0.068 0.764 1.41</td>
</tr>
</tbody>
</table>

### Table.
ARM site radiosonde, COSMIC, and NUCAPS matchup statistics averaged over the 40 to 100 hPa vertical range for the 3 year time period April 2012 through May 2015. Uncertainties are 2 times the uncertainty of the mean (k=2). Collocation criteria require the matchups to occur less than 300 km away from the ARM site and that the time of the radiosonde is within 3 hrs of the RO and NUCAPS matchup time (see text for details).
Validation of NUCAPS Stratospheric Temperature Profiles


- Radio occultation (RO) has highest temperature accuracy in the upper-troposphere, lower-stratosphere. Focus on UCAR COSMIC and EUMETSAT MetOp GRAS RO dry temperature.

- Comparison of NUCAPS retrievals with RO profiles offers a common reference point for comparison of NUCAPS with other IR/MW retrievals. This study compares NOAA NUCAPS (ATMS/CrIS) soundings with NASA AIRS v6, and EUMETSAT IASI v6 operational products.

- Analysis of the NUCAPS difference statistics should include vertical smoothing to degrade products to a common vertical resolution. Calculated vertical averaging kernels (AKs) lead to excellent agreement (< 0.3K) for NUCAPS and (<0.5K for AIRS & IASI, not shown).
JPSS Radiosonde Program will be collaborating with GRUAN in the RIVAL field campaign at ARM

What is RIVAL?
- ARM field campaign starting ~Oct 2017
- Vaisala will stop producing RS92 radiosondes this month
- RS92 sondes will be replaced by RS41 model
- RIVAL is motivated by the need for a sustained intercomparison and validation campaign to fully quantify the RS92-RS41 sonde differences

Benefits of RIVAL to JPSS Radiosonde Program:
- Twin soundings (RS92 & RS41 on same balloon) will occur weekly at ENA, NSA, and SGP coordinated with SNPP & J1 overpasses
  - JPSS provides RS41 & ARM provides RS92
- RRS92/RS41 differences will be assessed ensuring continuity of radiosonde dataset
- Better Best Estimate (BE) of atmospheric state

What is GRUAN?
The Global Climate Observing System (GCOS) Reference Upper-Air Network
https://www.gruan.org/
Conclusions & Future Work

Conclusions:

• JPSS radiosonde program is ongoing and will target J1 after launch
• NUCAPS Temperature and H2O_MR validations look good relative to BE, further analysis needed to determine what is happening at SFC at NSA & SGP
• CSPP integral to this analysis providing uniform algorithm for processing SDRs and EDRs
• When comparing NUCAPS/AIRS/IASI with RO vertical smoothing should be used to degrade products to common resolution. Excellent agreement (< 0.3K) between NU-RO & NU-Sonde.

Future Work:

• Refinement of BE
• Synchronize sonde launches with COSMIC (if RO can be predicted)
• Collaborate with RIVAL field campaign in assessing RS92/RS41 differences
• Supporting NUCAPS Validation Team in their Efforts
  • Providing Best Estimates for dedicated launches (& CalWater Cruise 2015)
  • Assessing Block2 CSPP NUCAPS using the BE
JPSS Radiosonde Program

Validation of NUCAPS at ARM Sites

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