NPROVS Utility in a Variety of Meterological and Cal/Val Scenarios

Tony Reale
STAR

(Bomin Sun, Frank Tilley, Mike Pettey and Nick Nalli)
(IMSG)
June 2015

STAR /JPSS
2015 Annual Science Team Meeting
24-28 August 2015
NCWCP, College Park, Md.
Outline

- About NPROVS
- Long Term Monitoring (LTM-NARCS)
- 10-day Collocation datasets (PDISP)
- AWIPS-2 Coordination
  - Cold Core
  - CALWATER
- Uncertainty
NPROVS/NPROVS+ Data Management Schematic

**INPUTS**
- Conv Radiosondes + GFS
- NUCAPS (S-NPP)
- NUCAPS Parallel (STAR)
- NOAA IASI MetOp-A (OSPO) MetOp-B (STAR FTP)
- MIRS NPP (Op, v.11) NOAA-18,19 MetOP-A,B DMSP F18 (STAR FTP, OSAPO)
- AIRS v.6 (NASA)
- EUMETSAT IASI MetOp-A,B (OSPO)
- GRUAN & DOE/ARM Radiosondes

**PROCESSING**
- 3 day delay
- FTP
- Visualization Tools: ODS PDISP NARCS
- NPROVS
- NPROVS+ 14 day delay
- FTP

**OUTPUTS**
- Algorithm Development
- FTP
- NPROVS Collocation Archive
- NPROVS+ Collocation Archive
- VALAR
NOAA Products Validation System (NPROVS)

Centralized RAOB and Satellite Product Collocation

S-NPP
NUCAPS, test
MIRS, test

MetOp-B
ATOVs, MIRS,
IASI, IASI (EU)
GRAS

MetOp-A
ATOVs, MIRS,
IASI, IASI (EU)
GRAS

NOAA-18, 19
ATOVs, (19)
MIRS (18,19)

GOES
IR Soundings

DMSP F-16,18,19
MIRS

FORMOSAT-3
COSMIC (UCAR)

NASA-EOS-Aqua
AIRS v.6

Conv RAOB
DropSonde
and
NWP

6-hour

250km

NWP:
• GFS
• CFSR
• ECMWF

Every Day since April 2008

Collocation DataSet

"single closest"

... over 2 million stored

https://www.star.nesdis.noaa.gov/smcd/opdb/nprovs
EDGE Analytical Interface ...

... routine monitoring to deep dive
Typical NPROVS Global Collocation Dataset
(1000 collocation records per day)
GRUAN and JPSS funded Dedicated (S-NPP) RAOB Sites
Over 10,000 RAOBS (1000 Dedicated) available since July 2013
Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN)

NOAA/GRUAN Coordination Committee

JPSS Funded Dedicated RAOB

• DOE ARM (SGP, NSA, ENA)
  ✓ CIMSS
  ✓ (2) per week
  ✓ GRUAN processed
  ✓ dual vs single, etc

• AEROSE
• CALWATER
• PMRF …

Request coordination with “other” intensive field experiments particularly is synchronized with S-NPP
Independent (Enterprise) Validation of Sounding Products at STAR
EDGE Analytical Interface ...

Seasonal

NARCS

Daily Weekly

PDISP

Orbital

ODS

... routine monitoring to deep dive
NOAA Archive Summary (NARCS)  
(Long Term Monitoring (LTM) of SAT-minus-RAOB  
2008-present)

**optimal sample per system**

- 2013 to present
- Maritime vs Continental … Global
- NUCAPS, IASI (NOAA and EU), AIRS v.6, MiRS, NWP
- IR vs MW
- QC’d products
- Weekly average differences
- RMS
- 650 hPa
- T and H2O vapor fraction (W2)
Temperature 649.99 mb Layer Statistics

- 0.3K improvement; less for AIRS

Water Vapor Percent Error 649.8 mb Layer Statistics

- < 10%
Temperature 649.99 mb Layer Statistics

0.4K improvement; less for AIRS

Water Vapor Percent Error 649.8 mb Layer Statistics

>10% improvement; more for AIRS

Maritime MW
Temperature 649.99 mb Layer Statistics

0.5K improvement including AIRS

Water Vapor Percent Error 649.8 mb Layer Statistics

< 10%
Monthly Global Collocation Sample Size Yields Reflect Global Product Yields
STAR / SMCD / OPDB - NOAA Products Validation System (NPROVS)

NPROVS Overview
NPROVS routinely (daily) compiles datasets of collocated radiosonde, dropsonde and numerical weather prediction (NWP) collocated with the following satellites and sounding product suites:
- Suomi-NPP (S-NPP)
  - NOAA Unique CrIS and ATMS Processing System (NUCAPS)
  - Microwave Integrated Retrieval System (MIRS)
- MetOp A and B
  - Infrared Atmospheric Sounder Interferometer (IASI)
  - IASI from EUMETSAT
- ATOVS
- NOAA-15, 19
  - MIRS
  - ATOVS
- Defense Meteorological Satellite Program (DMSP) F-13, F-15, F-18
  - MIRS
- NASA-Earth Observing System (EOS)-Aqua
  - Advanced InfraRed Sounder (AIRS) (NASA v6 beginning April, 2013)
  - GOES 11 and 13 (clear sky only)
- Constellation Observing System for Meteorology Ionosphere and Climate (COSMIC) Global Positioning System Radio Occultation (GPSRO) from University Corporation for Atmospheric Research (UCAR) Infrared Atmospheric Sounding Interferometer (IASI)

Collocation datasets are used for product monitoring and support of scientific algorithm development.

The website is broken into 3 major sections:
- Summary Plots of product monitoring for selected product suite combinations
- Graphical Interface (JAVA applications) for user analysis of collocation datasets (i.e., weekly) and longer term trends (seasonal) are available.
- Daily Data Monitoring images on this page show 24 hour data coverage for each system that is input into NPROVS.

EDGE Analytical Interface ... 

Daily Weekly

PDISP

Seasonal

NARCS

Orbital

ODS

... routine monitoring to deep dive
**Profile Display (PDISP):**
(Monitoring/Analysis of (10-day) NPROVS collocation datasets)

**Common Samples**

**Analytical options:**
- Collocated profile display and statistics
- Sampling options (space / time windows, region, weather, satellites, instruments, day/nite, qc …)

**Assessments:**
- NUCAPS upgrade (oper vs parallel test)
- MiRS upgrade (oper vs parallel test)
- Retrieval vs First Guess Convergence
- Moisture Statistics Weighting
10-day sample of collocations containing NUCAPS test and Oper IR+MW soundings which pass QC
NOAA Products Validation System (NPROVS)

Baseline: Radiosonde Radiosonde

NUCAPS NUCAPS Test
QC flags ... red means MiRS (upper) and both NUCAPS (lower) failed
10-day sample of collocations containing:

1) NUCAPS Test  2) AIRS  3) IASI-EU ... all pass respective QC  
4) ECMWF

179 (158) available out of 12919
Product performance generally rooted in first guess
NOAA Products Validation System (NPROVS)

August 3, 2015 to August 13, 2015

Baseline: Radiosonde Radiosonde

Radiosonde GFS 6 Hour
NUCAPS Test

AIRS AQUA
EUMETSAT IASI MetOp-B

Retrieval Temp
NARCS LTM of NUCAPS (Oper) retrieval vs 1st guess:

(NUCAPS IR+MW show seasonal (summer) non-convergence vicinity 500 hPa mainly continental cases; not evident at 650 hPa)
Moisture weighting makes a difference
AWIPS-2 WG Cold Core Analysis
(fuel freezes below -60C)
Radiosonde
GFS 6 Hour
ECMWF Analysis
MIRS NPP
NUCAP NPP
MIT

Canada (S)
IR+MW pass QC
Radiosonde
GFS 6 Hour
ECMWF Analysis
MIRS NPP
NUCAP NPP
MIT

NOAA Products Validation System (NPROVS)

Temperature (deg K)

Pressure (hPa)

200 hPa

NSA
IR+MW pass QC
Radiosonde
GFS 6 Hour
ECMWF Analysis
MIRS NPP
NUCAP NPP
MIT

NSA
IR+MW pass QC
SAT-minus-RAOB Statistics

1. Case Study Day Jan 9 (Alaska Region)
2. Case Study Period Jan 5-15 (Alaska Region)
3. Case Study Period Jan 5-15 (CONUS)
Baseline: Radiosonde

Radiosonde GFS 6 Hour
NUCAPS NPP

ECMWF Analysis
NUCAPS NPP MIT

MIRS NPP *

SAT-minus-RAOB for Jan 9, 2015: Alaska Region
(NUCAPS IR+MW and MiRS pass QC)
Baseline: Radiosonde

<table>
<thead>
<tr>
<th>Radiosonde GFS 6 Hour</th>
<th>ECMWF Analysis</th>
<th>MIRS NPP *</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUCAPS NPP</td>
<td>NUCAPS NPP MIT</td>
<td></td>
</tr>
</tbody>
</table>

**SAT-minus-RAOB for Jan 5-15, 2015: Alaska Region**

(NUCAPS IR+MW and MiRS pass QC)
SAT-minus-RAOB for Jan 5-15, 2015: CONUS
(NUCAPS IR+MW and MiRS pass QC)
CalWater 2/ACAPEX
Field Campaign

- Interagency Campaign:
  - Scripps (Marty Ralph, Kim Prather)
  - NOAA (Allen White, Ryan Spackman)
  - DOE (PI: L. Ruby Leung) ACAPEX = ARM Cloud Aerosol Precipitation Experiment

- White paper at
  - [http://esrl.noaa.gov/psd/calwater](http://esrl.noaa.gov/psd/calwater)

<table>
<thead>
<tr>
<th>Platform</th>
<th>Range of Obs</th>
<th>Duration</th>
<th>Types of sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR Observatories and Hydro-Met Testbed</td>
<td>ARO sites: CA(4), OR(2), WA(1)</td>
<td>Full campaign</td>
<td>Snow level radar (S-band), 449 MHz wind profilers, soil moisture, 10 meter surface tower</td>
</tr>
<tr>
<td>NOAA WP-3D</td>
<td>1-22 kft, 4000 km range</td>
<td>80h over 4 weeks</td>
<td>~150 dropsondes, W-band radar (clouds), IWRAP Radar, Tail Doppler Radar, Cloud Probes, SFMR</td>
</tr>
<tr>
<td>NOAA G-IV</td>
<td>1-45 kft</td>
<td>90h over 6 weeks</td>
<td>~300 dropsondes, Tail Doppler Radar, NOAA O3, SFMR</td>
</tr>
<tr>
<td>DOE G-1 with ~40 instruments</td>
<td>1-23 kft</td>
<td>120h over 8 weeks</td>
<td>Cloud properties (Liq/water content, size), aerosol properties (concentration, size, CCN), trace gases (H2O, O3, CO)</td>
</tr>
<tr>
<td>NOAA R.H. Brown</td>
<td>Can move ≤ 5 deg/day to stay within AR</td>
<td>30 days</td>
<td>AMF2: Aerosol Observing System, Ka ,X, W-Band Cloud Radars, DOE, Micropulse LiDAR, Wind Speed, Rain Guages, RS-92 Sondes: ~260 (~half dedicated overpass time)</td>
</tr>
</tbody>
</table>

9/1/2015  Gambacorta et al.  43
GRUAN and JPSS funded Dedicated (S-NPP) RAOB Sites
Over 10,000 RAOBS (1000 dedicated) available since July 2013
CALWATER RAOB collocated with NUCAPS

All collocated with NUCAPS
All collocated with NUCAPS 
+/- 1 hour, 50km 

IR+MW pass QC 

CALWATER RAOB collocated with NUCAPS
Baseline: Reference Sonde GRUAN RAOB

ECMWF Analysis  MIRS NPP Test  NUCAPS NPP

Sample of NUCAPS IR which pass QC
NOAA Products Validation System (NPROVS)

Baseline: Reference Sonde GRUAN RAOB

ECMWF Analysis  MIRS NPP Test  NUCAPS NPP

Sample of NUCAPS IR which pass QC
ECMWF 12Z (Feb 7th) to 6Z (Feb 8th)
NOAA Products Validation System (NPROVS)

Temperature (deg K)

Pressure (hPa)

<table>
<thead>
<tr>
<th>Source</th>
<th>Date/Time</th>
<th>Latitude/Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRUAN Sonde ACAPEX (80)</td>
<td>2/07/2015 10:00</td>
<td>37.00 N / 127.17 W</td>
</tr>
<tr>
<td>ECMWF ANALYSIS</td>
<td>2/07/2015 12:00:00 (2 hours)</td>
<td>37.00 N / 127.25 W (6.2 km)</td>
</tr>
<tr>
<td>MIRS NPP TEST (0.9)</td>
<td>2/07/2015 10:03:12 (0.1 hours)</td>
<td>36.92 N / 127.23 W (9.2 km)</td>
</tr>
<tr>
<td>NUCAPS NPP</td>
<td>2/07/2015 10:02:54 (0 hours)</td>
<td>36.86 N / 127.24 W (15.8 km)</td>
</tr>
</tbody>
</table>

Reference Sonde
ECMWF Analysis
MIRS NPP Test
NUCAPS NPP

SAT @ 1003Z … ECMWF @ 12Z … RAOB @ 1000Z
Reference Sonde
ECMWF Analysis
MIRS NPP Test
NUCAPS NPP
Reference Sonde
ECMWF Analysis
Reference Sonde

ECMWF Analysis

SAT @ 0435Z

ECMWF @ 06Z

RAOB @ 0435Z
650 hPa H20 Vapor

NUCAPS

Retrieved Water Vapor (650 hPa) [g/kg]

NUCAPS IR+MW

ECMWF

ANL

MiRS NPP

Absorption Layer H20 (650.1 mb)

ECMWF NPP

ANL

 Retrieved Water Vapor (650.1 hPa) [g/kg]

ECMWF 18Z Analysis

Retrieved Water Vapor (650.1 hPa) [g/kg]

ECMWF ANL

SAT @ 21Z Feb 7th … ECMWF @ 18Z
Special session on users

featuring

ongoing AWIPS-2 activities

top utilize NUCAPS (etc) sounding

at

at NWS field office

Thursday

10:30
GRUAN Reference Measurement Principles
(see Poster)

Given two measurement \((m_1, m_2)\), their uncertainty \((u_1, u_2)\) and variability \((\sigma)\), then two observations are consistent if \(k \leq 2\):

\[ |m_1 - m_2| < k \sqrt{\sigma^2 + u_1^2 + u_2^2} \]

... in following plots:

\[ K = \text{ABS}(X - \text{GRUAN}) / u \]

where \(u\) is GRUAN or NASA v6 uncertainty

“need uncertainty estimates for EDR” !!
GRUAN and JPSS funded Dedicated (S-NPP) RAOB Sites
Over 10,000 RAOBS (1000 Dedicated) available since July 2013
Baseline: GRUAN Radiosonde

| AIRS AQUA | ECMWF | NUCAPS NPP |
Baseline: GRUAN Radiosonde

AIRS AQUA  ECMWF  NUCAPS NPP
Baseline: AIRS AQUA

GRUAN Radiosonde
ECMWF
NUCAPS NPP

“k” based on AIRS v.6 (Uncertainty?)
SUMMARY

• Independent validation of multiple product system performance provided by NPROVS/NPROVS+ (see Poster; Pettey)

• LTM tracks overall characteristic performance and targets areas of improvement for respective systems

• Analysis of collocations with conventional and reference/dedicated RAOB provides more detailed assessments down to “deep dive” (see Poster; Sun)

• NUCAPS and MiRS test products appear better than respective operations

• Product performance generally rooted in first guess; moisture weighting

• Performance in unique weather environments (Cold core and CALWATER) justifies ongoing AWIPS-2 efforts to disseminate (NUCAPS) soundings to NWS field offices (See Poster; Sounding user session Thursday)

• Providing uncertainty estimates for soundings opens door to more robust validation against GRUAN RAOB (see Poster)
10-day sample of collocations containing MiRS v.11 and Oper MW soundings which pass QC