Evolving Reference Networks and Integrated Satellite Data (Product) Validation

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Outline

• Evolving GCOS Atmospheric Reference Observations Network (GARON)

• Construction of Historical (TOVS) Psuedo-Reference Database (SEARCH)

• ATOVS Operational Data and Integrated Validation

• Expanded Integrated (Operational) Validation … in preparation for NPOESS via NOAA IPO award
GCOS Atmospheric Reference Observations Network (GARON):
Justification, Requirements, Siting and Instrumentation Options
Report (comments by Oct 15)
(http://hadobs.metoffice.com/aopc_wg_aro)

• Scientific Requirement
  – Climate record vs Measurement (uncertainty) record …
  – Measurement Requirement Tables (Appendix-A)

• Network Operating Principles
  – Training, site (network) management, data management … user

• Data and Instruments
  – Pressure, temperature, humidity and wind … Priority 1
  – Srfc Radiation, microwave / infrared (AERI) sounder, clouds, trace gas, aerosol … Priority 2

• Candidate Networks and Sites

• Sampling
  – Spatial … global robustness ?
  – Temporal … synoptic vs satellite coincident (“still an active area of ongoing debate”)

• Cal / Val
• “Sensor” and “calibration source” data uncertainty traceable to International System of Units standards.

• Residual uncertainty evaluated as a function of time.
  – Simultaneous measurement by independent sensors.
  – In the laboratory when the sensor can be retrieved.
  – In the operational environment when the sensor cannot be retrieved.

• Extended uncertainty computed and documented for every sensor and system.
Candidate Networks…

- Baseline Surface Radiation Network (http://bsrn.ethz.ch/)

- Network for Detection of Atmospheric Composition Change (http://www.ndacc.org/)

- Aeronet (http://aeronet.gsfc.nasa.gov/)

- Global Atmospheric Watch ozone network

- International GNSS (Global Navigation Satellite Systems) Service (IGS) (see http://igscb.jpl.nasa.gov/)

- WMO Global Observing System

- The Atmospheric Radiation Measurement (ARM) Program (see http://www.arm.gov/)

- A number of individual national observatories

- The network of surface GPS total column water vapour instruments
... Initial Candidate Sites

- ARM sites (Tropical Western Pacific, Southern Great Plains, North Slope of Alaska) (http://www.arm.gov/, Ackerman and Stokes, 2003)
- Lindenberg, Germany (http://www.dwd.de/en/FundE/Observator/MOL/MOL.htm)
- Camborne, U.K., Payerne, Switzerland,
- Cabauw, Netherlands (http://www.cesar-observatory.nl/)
- Sodankylä, Finland (http://www.sgo.fi/)
- Heredia, Costa Rica
- Lauder, New Zealand
- Boulder / Denver, U.S,
Radiance Validation at Reference Sites using RTM

Satellite Observations

Improving RTM

Validating Calibration

RTM Forward Calculations
Referencing The Past … TOVS
Collocated TOVS and Radiosonde Database compiled in support of
NOAA Study Of Environmental ARctic CHange Program (SEARCH)

• “Complete” 1b-level records for TOVS HIRS and MSU

• 1b-level readers (Schweiger, Univ Wash…)

• WMO and Special radiosondes 1979-2003

• Collocated Observations (poleward 45N)
  – referenced to sounder measurements

• Data Management
  – relational file structures

• Users and Access
  – Francis and Schweiger … compile RT bias (RTTOVS) and reprocess TOVS (ITPP-3I)
  – Plans for FTP and Web
“Global Climate Change” Proposal Submitted … 3-years (follow-up to SEARCH work)

• Baseline SEARCH Expansion
  – Global
  – TOVS SSU, operational soundings
  – DMSP, other?
  – TOVS N14 to 2006
  – ATOVS (1998-onward)
    • Special (simultaneous) TOVS and ATOVS (1998-2006) record
    – In-situ, Research,

• Implement into ATOVS Product Operation …

• Serve as Baseline for NPOESS … Reference Network

• User Access
  – FTP and Web
Orient Operational Product Environment to Provide Integrated Validation Datasets and Analysis
ATOVS Processing Diagram … Orbital, Daily, Weekly

Product Generation

Validation (tuning)
ATOVS Surface / Sounding Products

- **Incorporate MHS**

- **Integrate Microwave Integrated Retrieval (MIR) Products**
  - TPW, CLW, Emissivity … (Weng, Boukabara; talk 11.6)

- Regression Guess replaces Library Search
  - Calculate First Guess Radiance (CRTM)

- Measurement (Radiance) Bias Adjustment
  - AMSU-A
  - MHS
  - HIRS

- **Integrate MIR Retrieval Solution (CRTM) per sounding** (Paul Van Delst, Fuzhong Weng, Yong Han)
  - based on Guess Temp and Moisture

- **Baseline for NPOESS** (… AIRS and IASI… Thomas King talk 12.3)

- Peripheral Upgrades
  - Limb-adjustment
  - Complete NWP Profile (Srfc data, +/- 90 minutes, 3hr fcst …)
Red areas are moister, blue areas drier (–10 to +10 mm):

a) NVAP blended minus AIRS TPW.

b) ATOVS (NOAA-15 and -16) minus AIRS.

c) SSM/I (F-13 and F-14) minus AIRS

d) TMI minus AIRS.

... ATOVS sounding product use in climate studies ...???
ATOVS Integrated (to 1000mb) TPW

ATOVS - MIR

MIR TPW (to Srfc)

NWP Srfc Pressure >1000mb
ATOVS Oper WVMR @1000mb

ATOVS Test WVMR @1000mb

ATOVS - NWP

NWP WVMR @ 1000mb
Orient to Integrated Data (Product) Validation

(Part-1)

• **Collocation DataBase Generation**
  – Reference to *Satellite Measurement (not Sounding)*

  – Expand Radiosonde Data stored
    • rad correction, drift parameters, updated instrument type
    • appended NWP, QC
    • *Moisture Profile QC*

  – Expand data platforms to include
    • AIRS, GOES, COSMIC,
    • In-situ (ie from ARM), …
    • Research Experiment data

  – Relational Data Management (…*baseline SEARCH*)
Operational Procedures to Process, Screen and Collocate Radiosondes with NOAA Polar Satellite Observations

Reale and Tilley
2006

Examples of Radiosonde Moisture QC …
Orient to Integrated Data (Product) Validation

(Part-2)

• Collocation DataBase Analysis
  – Product vs Product
  – Radiance (Obs) vs Radiance (Obs)
  – Radiance (RTM) vs radiance (Obs)
  – Convergence studies,
  – Other …
Environmental Data Graphic and Evaluation System (EDGES)

- Three (3) Major Sub-systems:
  - *EDGEIS*: Horizontal Fields of Orbital Products data
  - *Profile Display (PDISP)*: Collocated Multiple Platforms of Ground Truth vs Satellite Obs … see SSSP web site
  - *Vertical Statistics (VSTAT)*: Multiple Platform inter-Validation

- **Vehicle for EUMETSAT/NOAA Collaboration for METOP**

- Cornerstone for NPOESS Validation Protocols …
  (also see Lihang Zhou Poster B-17)
Multi-platform Product Comparison

Multi-channel Radiance Comparison
... the independent nature of radio occultation soundings make them highly complementary to other atmospheric sounding systems, such as infrared and microwave sounders ...

Eva Borbas (SSEC), Christian Rocken (UCAR), Jim Yoe (NOAA)
In-situ Observations

Measurements

The Atmospheric Radiation Measurement (ARM) Program gathers a wide variety of measurements from many different sources. Each day, the Data Archive stores and distributes large quantities of data collected from these sources. Scientists then use these data to research atmospheric radiation balance and cloud feedback processes, which are critical elements of global climate change.

- **Atmospheric Profiling and Clouds**
  - Microwave Radiometer (Column Integrated H2O)
  - Microwave Radiometer Profiler (T, H2O and CLW profiles @ 20-30 and 50-60 GHz)
  - GVR (183 +/- 1,3,7,14 GHz)
  - Raman Lidar (H2O Vapor, Cloud, Aerosol)
  - Radiosonde (Vaisala RS-92, dual humicap)
  - AERI (RT, Clouds, T, H2O and Trace Gas @ 3-20 (25) Microns)
Initiatives for Satellite Coincident Radiosonde Launches (RS-90) at ARM Site(s)

- continued NASA support for ARM (SGP, NSA, TWP) site radiosonde launches coincident with AIRS … (Tobin, Revercomb SSEC, Wisconsin)

- pending agreement for to launch “144 extra sondes at SGP” coincident with polar ATOVS … (Barry Lesht (ARM), Reale)

- studies to quantify impact of coincidence for GARON … (Menzel, Goldberg, Thorne and most recently Goodrich, Peterson) … possible funding opportunity
  - results from EOS-Aqua-AIRS
  - user community
  - other
Spatial gradient in RS 90 radiosonde-retrieval RMS Comparison (ARM-SGP ... 97W, 36N)

Antonia Gambacorta (a), Chris Barnet (b), Dave Tobin ©, Leslie Moy ©, Scott Hannon (a), Larrabee Strow (a), Dave Whiteman (d)
AIRS Science Meeting, 9-27-2006
Temporal Gradient in Dropsonde – AMSU/MHS retrieval (MIR) Comparison

(Weng, Boukabara, Ferraro, Zhao; MIR, 9-30-2006)

- Dropping time ~ 12 minutes
- Case of July 6th 2005

H2O Vapor Profiles

[Graphs showing H2O vapor profiles with time differences indicated: closest in time at 0.65, closest in time at 0.95, furthest apart in time at 1.32, and furthest apart in time at 1.67.]
NOAA POES Simultaneous Nadir Overpasses (SNO)
(... Cheng-Zhi Zhou)
Integrated Cal/Val System
(Weng, Cao ... Goldberg)

http://www.orbit.nesdis.noaa.gov/smcd/spb/calibration/icvs/
Integrated Operational Product Data Validation
(NPOESS IPO Award)
EXTRAS
Potential Ground Sites

- ARM NSA
- ARM SGP
- ARM TWP
- Dunhuang Desert
- Qinghai Lake
- Libyan desert
- Dome C
- Greenland
The NVAP dataset is a widely-used, global, daily, 1-degree resolution blended product suitable for studies of water vapor in the climate system (Randel et al, 1996; Simpson et al, 2001). NVAP contains layered water vapor fields as well as TPW fields. NVAP has layered precipitable water at 1000-700, 700 – 500, 500 – 300 and above 300 hPa.

NVAP was constructed by blending observations from radiosondes, satellite sounder instruments (NOAA TIROS Operational Vertical Sounder (TOVS, or ATOVS after 1998)), and passive microwave radiometers (Special Sensor Microwave / Imager (SSM/I)). The TRMM Microwave Imager (TMI) was used for 2000-2001. Retrievals are performed on each dataset, and the results are then blended together to create a global merged field. NVAP currently covers the time period 1988 – 2001. Our goal in the creation of the global NVAP dataset to compare with AIRS is to achieve a product which mimics a withdrawal of the NVAP data from the NASA DAAC, as if it existed in 2003-2004.

NVAP data for 1988-2001 is available from the NASA Langley DAAC at:

The comparison of TPW indicates that the ATOVS TPW field is an outlier from the other datasets. These results make it questionable whether the ATOVS sounding product should be used in climate studies. The ATOVS sounding product has historically been used in NVAP production, in particular to provide soundings over land and provide vertical structure.

AIRS validation and reprocessing is an ongoing process, so results from this study must be viewed in that light. As AIRS validation increases in maturity, it can be used in scientific data stewardship studies with greater confidence in the AIRS products.
Compare individual profiles from **Radiosonde, Satellite** and **NWP** platforms (PDISP)
The slide illustrates the multiple profiles from different satellite product systems, for example, operational and test systems for NOAA-16, NOAA-15 and various NWP profiles that were appended to the satellite products data record during orbital processing, capable of being collocated with and evaluated against radiosonde observations.

Solid curves indicate temperature and dashed curves moisture profiles respectively.

Each profile source is color coded based on the legend on the right.

The file contains over 6700 collocations compiled over an approximate 30 day period, and available for statistical evaluations as shown in the next slide.

ORA, 12/14/2004
ARM Site Satellite Overpass Dedicated Radiosondes for FY2007
Draft recommendation letter, 3 August 2006

In the past several years, NASA has funded DoE’s Atmospheric Radiation Measurement (ARM) program to provide special radiosonde launches which are coincident with EOS Aqua overpasses of the primary ARM sites (SGP, TWP and NSA). This has been a scientifically productive interagency cooperation. Due to the high accuracy requirements of atmospheric soundings from AIRS, such data is required for detailed and critical assessments of the satellite products. Examples of resulting work include the use of clear sky ensembles for radiative transfer model development and validation (Strow et al. 2006), assessment of upper level water vapor measurement accuracy (Miloshevich et al. 2006; Whiteman et al., 2006), and temperature and water vapor retrieval validation (Tobin et al. 2006). Making use of the ARM site facilities, previous studies to characterize the ARM measurements, and routine, on-going operations, the ARM site efforts are a cost effective and fundamental part of the EOS validation program. While other validation datasets provide complimentary information for satellite validation studies, the ARM site products are considered the “gold standard” for this work. The level of coincidence achieved markedly exceeds past efforts at this scale and quality. In addition to AIRS, the ARM site radiosondes have also been useful for Aqua MODIS and Aura TES studies.

To enable the development of long term and well-characterized Earth Science Data Records, we recommend that NASA support for these ARM site efforts continue. Specifically, we recommend that the same level of effort from the previous two years (i.e. 2 phases of radiosonde launches from each of the three primary ARM sites) be continued for FY2007. Considering inputs from all interested parties, a consensus plan will be developed in the near future detailing the timing and level of effort at each ARM site. In the future, we also recommend that these efforts be extended to include the advanced sounders IASI on METOP and CrIS on NPP and NPOESS; discussions with the NPP and IPO programs should be pursued to facilitate this.

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George Aumann, JPL
Tony Clough, AER (representing TES)
Hi Jimmy,

Dan Rusk, Luci Walker, and I have been tracking down the source of 144 'extra' radiosondes that are at SGP. Luci has discovered that these were ordered for last year's AIRS experiment, but not delivered until afterwards. Because they were marked 'For AIRS' they were not included in our estimates of sondes needed for operations next year. Apparently we supported AIRS with sondes we already had in stock so, in a sense, these are extras. We could use them to offset future operational needs, but I was thinking that perhaps a better use might be to start a 'pilot' IOP to help Tony Reale at NOAA. As you certainly know by now, Rick Wegener has decided that the added cost of processing the NOAA satellite data that Tony has found for us would not offset the savings of cutting the SeaSpace contract and doing the extra soundings that Tony had requested.

Maybe we could use a few of these extra sondes and start a one-per-day extra sounding to match Tony's needs at the SGP only as a kind of demonstration. If he is happy with the result, perhaps we could then get support for a wider program. As you will recall, Tony was one of the more vocal ACRF supporters at the Seattle GCOS workshop.

Anyway, I don't have a personal stake, I just think it might be good for the program and wanted to mention it. Whatever you guys decide is of course fine with me. It seems that this would be less of a cold and complete turn down to Tony - that's all.

Best, Barry
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NPOESS

VIIRS - vis/IR imager
CMIS - μwave imager
CrIS - IR sounder
ATMS - μwave sounder
SESS - space environment
OMPS - ozone
ADCS - data collection
SARSAT - search & rescue
APS - aerosol polarimeter
ERBS - Earth radiation budget
SS - laser sensor
ALT - altimeter
TSIS - solar irradiance
## NPOESS EDR-to-Sensor Mapping

55 Product Sets [EDR, RDR, SDR]

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🌟 Environmental Data Records (EDRs) with Key Performance Parameters

- **VIIRS (23)**
- **CMIS (19)**
- **CrIS/ATMS (3)**
- **OMPS (1)**
- **SES (13)**
- **ERBS (5)**
- **TSIS (1)**
- **ALTIMETER (3)**
- **APS (4)**
NPOESS Certified Program – Demanifested EDRs

**MISSION AREAS**
- Atmosphere
- Climate
- Land
- Ocean
- Space Environment

**CMIS** (1)
- SOIL MOISTURE (DEG)

**SESS** (8)
- Auroral Imagery
- Electric Fields
- Electron Density Profile
- Geomagnetic Field
- In-situ Plasma Fluctuation
- In-situ Plasma Temp
- Ionospheric Scintillation
- Neutral Density Profile

**APS** (4)
- AEROSOL OPTICAL THICKNESS
- AEROSOL PARTICLE SIZE
- Aerosol Refractive Index
- Single Scatter Albedo, Shape
- Cloud Particle Size/Distrib

**TSIS** (1)
- Solar Irradiance

**ERBS** (4)
- Down LW Radiance (Sfc)
- Down SW Radiance (Sfc)
- Net Solar Radiation (TOA)
- Outgoing LW Rad (TOA)

**ALT** (2)
- OCEAN WAVE CHARACTERISTICS
- Sea Surface Height

**KEY**
- = NPOESS Key Performance Parameters
- BOLD CAPS = LRD Environmental Data Records

(Dog indicates degraded performance)

19 September 2006
DOC, NOAA, NESDIS
Integrated Program Office
M. Borjesson, M. Haas
J. Whicomb
International TOVS Study Conference, 15th, ITSC-15, Maratea, Italy, 4-10 October 2006
Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,