NESDIS ADVANCED-TOVS (ATOVS) SOUNDING PRODUCTS AND A PROPOSED SATELLITE UPPER AIR NETWORK (SUAN)

Tony Reale and Michael Chalfant, NOAA/NESDIS, Washington D.C. (tony.reale@noaa.gov)
Americo S. Allegrino, Frank H. Tilley, Michael P. Ferguson and Michael E. Pettey, Raytheon ITSS, Lanham, Maryland

Measurements and Products

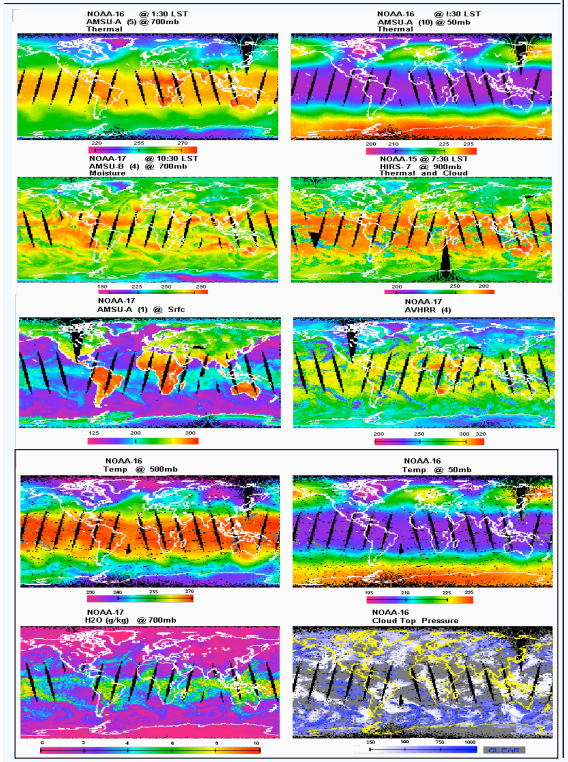
On May 13, 1998, the Advanced TIROS Operational Vertical Sounder (ATOVS) radiometer configuration onboard NOAA-15 was successfully deployed into a morning orbit, replacing TOVS. This was followed by NOAA-16 into an afternoon orbit on September 21, 2000, and NOAA-17 into a mid morning orbit half way between NOAA-16 and NOAA-17 on June 22, 2002. NOAA is currently maintaining this 3-satellite operational configuration.

The ATOVS instrument configuration features:

15 - channel… Advanced Microwave Sounding Unit-A	**AMSU-A**
5 - channel …. Advanced Microwave Sounding Unit -B	**AMSU-B**
20 - channel… High resolution Infrared Radiation Sounder	**HIRS/3**
6 - channel …. Advanced Very High Resolution Radiometer	**AVHRR/3**

AMSU-A and B provide all-weather temperature and moisture data, the HIRS detects clouds and clear-sky temperature and moisture, and the AVHRR is used for cloud-detection.

Examples of the ATOVS measurements (upper 6 panels) and products (bottom 4 panels) from consecutive overpasses of NOAA 16, 17 and 15 are provided below. Each panel shows a 12-hour composite of observations from 04Z to 17Z on January 23, 2003.



Science and Applications

Clouds: ATOVS measurements are combined to determine the global cloud-mask and whether the HIRS can be used in subsequent first guess and retrieval steps; global cloud products are also computed based on derived soundings.

First Guess: The **first guess** is determined for each sounding using a search technique over a library of collocated radiosonde and satellite measurements which seeks to minimize the equation:

$$D = (R - R_k)^t B^{-1} (R - R_k)$$

where the superscript t indicates the matrix transpose, -1 the inverse, and

- D : scalar closeness parameter,
- B : sounding channel radiance covariance matrix of dimension (40 x 40),
- R : adjusted, observed radiance temperature vector of dimension ($N_{A,j}$), and
- R_k : adjusted, library radiance temperature vector of dimension ($N_{A,j}$).

The *first guess* temperature, moisture and radiance temperature profiles are computed by averaging the 10 collocations with the smallest "D"; radiosondes provide temperature and moisture, and satellites the radiance.

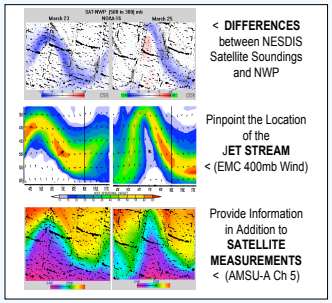
Retrieval: The **retrieval** is done using a Minimum Variance Simultaneous solution which is given by equation (2):

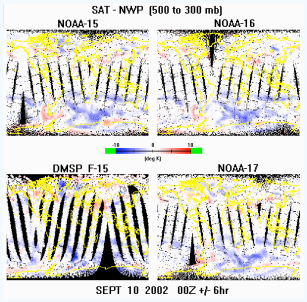
$$T - T_g = S A^t (A S A^t + N)^{-1} (R - R_g) \qquad (2)$$

where the subscript t indicates the matrix transpose, -1 the inverse, and:

- T : final soundings products vector, (133),
- T_g : first guess products vector, (133)
- S : first guess covariance matrix, (133 x 133),
- A : sounder channel weighting matrix, (40 x 133),
- N : measurement uncertainty matrix, (40 x 40),
- R : observed radiance temperature vector, ($M_{A,j}$), and
- R : first guess radiance temperature vector, ($M_{A,j}$).

The S, A and N matrices are pre-computed and updated weekly; nine separate "retrieval operators" are computed.





The two upper **left-side panels** illustrate differences between NOAA-16 (SAT) and Environmental Modeling Center (EMC) numerical weather prediction (NWP) layer temperature in the middle troposphere for observations within +/- 1.5 hours. *Blue* indicates relatively cold SAT temperatures, *Red* are relatively warm, and *White* within +/- 1 deg K. The left panel is a snapshot on March 23, 2002, and the right panel is 48-hours later on March 25th; the region is the remote Indian Ocean. The two middle panels show corresponding EMC analyzed wind (*Red* is high), and the bottom panels the satellite measurements for AMSU channel 5 (*Red* is warm) sensitive in the middle troposphere.

There is high correlation among the SAT-NWP difference, the 400 mb wind, and the satellite thermal patterns over the two day period, each denoting the location of the jet-stream and advancing frontal zone, and together the additional information available from derived soundings in the context of NWP (which assimilate radiance).

The **right side panels** show typical global fields of (SAT - NWP) differences as routinely analyzed by NESDIS during operational monitoring. The high correlation of the patterns evident among the four independently operated derived product systems is an important diagnostic tool. Further studies of these "signature" patterns are needed.

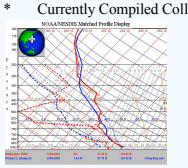
Future Science … ATOVS System 2004+

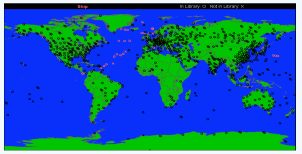
- Incorporate AMSU-B into ATOVS (integrate with AMSU-A and HIRS).
- Replace the search technique to compute the first guess with a statistical regression technique based on AMSU.
- Re-structure the product derivation and validation systems to better assure measurement and product consistency.
- Provide a dual set of *well-behaved* products which satisfy the greatest common denominator for NWP and Climate.

Satellite Upper Air Network (SUAN)

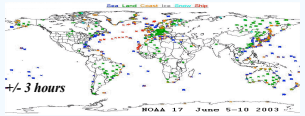
The Problem:

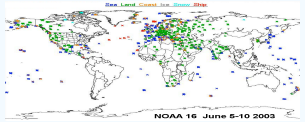
- Polar Satellite *Radiometers, Derived Products* and Associated *Science* Lack Scientific **CALVAL**
- Global **Radiosondes** *"Can"* provide the necessary ground truth data
- Currently Compiled Collocations of Radiosonde and Satellite Observations are **Not Adequate**





SHIPS needed! *(RHB)*





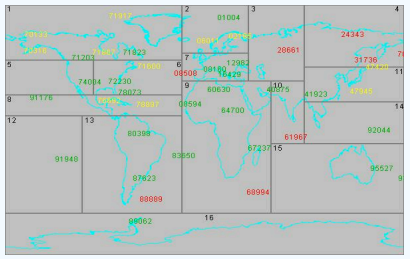
Solution: SUAN … Network of ***Reference Radiosondes*** Coincident with Satellite Overpass

Problem: **Changing** launch schedules and/or **Adding** launches is **Prohibitive**

Solution: Determine viable SUAN candidates through "**Scoring System**" *… P Thorne, UKMO*

	4	4	2	1	NMC		
WMO id	GUAN	Lanz	[illegible]	[illegible]	[illegible]	Radiosonde	Alternate
04018	1	1	1	1	11	61 VRS80G	
04202			1	1	3	61 RS80	
04220			1	1	3	71 RS90-AG	
04270	1		1	1	7	71 RS90-AG	
04320			1	1	1	71 VRS90L	RS80-AL RS80-AG
04339			1	1	3	71 RS90-AL	RS80-L (+ Ozone)
04360		1	1	1	7	71 VRS90L	
05011			1	1	3	61 RS90-AL	
05060					0	9 VIZ II	
05161					0	71 RS90-AL	RS90-AG
05260			1	1	3	71 RS90-AL	RS90-AG
05447				1	1	61 VRS80L	
05476			1	1	3	61 VRS80L	
05496					0	9	
05610			1	1	3	26 ML-SRS	
07110			1	1	3	74 VRS90L	
07145			1	1	3	74 VRS90L	
07180				1	1	74 VRS90L	
07481				1	1	74 VRS90L	
07510			1	1	3	61 VRS90L	
07645			1	1	3	74 VRS90L	

SUAN Candidates



Green: Score 1 or 0 and Acceptable Rasb
Yellow: Score 2 or 3 and Acceptable Rasb
Red: Score 4 or more or Unacceptable Rasb
23 - Sea
20 - Land

Acceptable Instrument Types

Mesei RS2-91 VIZ-MARK II VIZ-B2 Vaisala RS80 … RS90

Perspective

Question of tradeoffs: What is potential impact of these sites in current *Synoptic* versus proposed *SUAN* platform?

In current Synoptic platform Raobs provide independent single point impacts for NWP

In proposed SUAN platform Raobs provide integrated global impact on all Satellite Data, Science, and the Radiosondes … *Past, Present, and Future*

Conclusions:

Since satellite data are a primary input for NWP (and Climate) the benefits of *SUAN* are across the board … ***a transfer standard!***

It *seems* that a proposed *SUAN* platform makes sense … ***adds (much) more than it subtracts!***

PROBLEM: **How To Implement *SUAN* (ITSC, … WMO …)?**