Relative information content of the Advanced Technology Microwave Sounder, and the Advanced Microwave Sounding Unit and the Microwave Humidity Sounder

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Motivation

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THE USE OF TOVS/ATOVS IN DATA ASSIMILATION/ NUMERICAL WEATHER PREDICTION (DA/NWP)

The WG is concerned that the instrument specification for ATMS channel noise exceeds current AMSU performance and that the choice of polarisations may not be optimal for sounding the lower troposphere.
The WG were keen to do more scientific studies to provide good evidence for the impact of different choices in microwave sounder design on microwave sounder impact in NWP. When these studies are complete, the WG will be in a stronger position to formulate a recommendation to satellite agencies concerning future microwave sounding missions.

Action DA/NWP-19
Tom Kleespies to repeat Kleespies & Watts MHS study for ATMS compared to AMSU-A.
Reference:
"Comparison of Simulated Radiances, Jacobians and Linear Error Analysis for the Microwave Humidity Sounder and the Advanced Microwave Sounding Unit–B."
Accepted, Quarterly Journal of the Royal Meteorological Society

Conclusions

- Some kind of footprint matching or footprint averaging will be necessary for the ATMS to yield similar performance to the current AMSU/MHS.
- ***********This will be airmass dependent.
- **********Experience has shown that on-orbit measured NEDT is somewhat better than that measured pre-launch, so the retrieval improvement estimates presented here may be an slight underestimate. This favors the AMSU/MHS in this study.

Caveats
1) This study assumes averaging to the largest footprint
2) Polarization differences were not examined

Channel Characteristics

AMSU/MHS Channel	AMSU/MHS Frequency	ATMS Channel	ATMS Frequency
1	23800	1	23800
2	31399	2	31400
3	50299	3	50300
		4	51760
4	52800	5	52800
5	53595 ±115	6	53596±115
6	54400	7	54400
7	54940	8	54940
8	55500	9	55500
9	f0=57290.344	10	f$_2$=57290.344
10	f0±217	11	f$_2$ ± 217
11	f0±322.2±48	12	f$_2$ ±322.2±48
12	f0±322.2±22	13	f$_2$ ±322.2±22
13	f0±322.2±10	14	f$_2$ ±322.2±10
14	f0±322.2±4.5	15	f$_2$ ±322.2±4.5
15	89000		
16	89000	16	88200
17	157000	17	165500
18	183310± 1000	18	183310± 7000
19	183310± 3000	19	183310± 4500
20	191310	20	183310± 3000
		21	183310± 1800
		22	183310± 1000

Radiative Transfer
JCSDA Community Radiative Transfer Model v1.4.2.2 2005/10/20
ECMWF 52 profile-100 layer set
Surface emissivity set to 0.6, 0.9, variable with surface
Nadir view
Cloud free
No terrain variations

Information Content

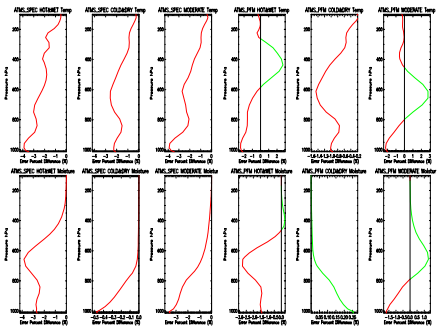
• Error covariance defined by Rogers (1976)

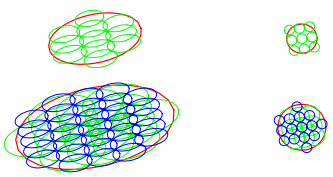
$$\mathbf{S} = \left(\mathbf{B}^{-1} + \mathbf{K}(\mathbf{x})^{\mathrm{T}}\left(\mathbf{O}+\mathbf{F}\right)^{-1}\mathbf{K}(\mathbf{x})\right)^{-1}$$

• B – background covariance, courtesy Tony McNally *
• O - On-orbit NEDT for NOAA18 (Tsan Mo),
- Thermal Vac for ATMS EDU and PFU (see below)
• F – set to 0.2K (Fourrié and Thépaut (2003))
• K(x) Jacobians, derivative of brightness temperatures wrt state vector

*This matrix was computed from an ensemble of data assimilation experiments where the members differed because of random perturbations to the observations

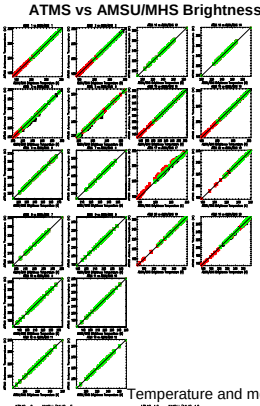
Single Field of View Performance
Green=ATMS better, Red=AMSU/MHS better
Expressed as percent improvement over ECMWF covariance





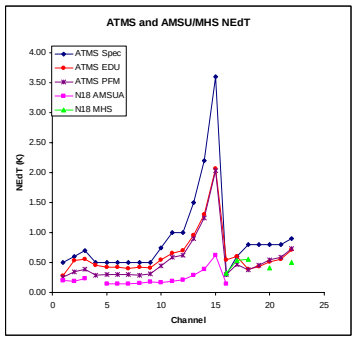
Layout of composite fields of view for AMSU/MHS (top) and ATMS (bottom). AMSU is red and MHS is green. For ATMS, red is 5.2° , green is 2.2° and blue is 1.1° fields of view. Left pair is for near edge of scan, and right pair is near nadir.

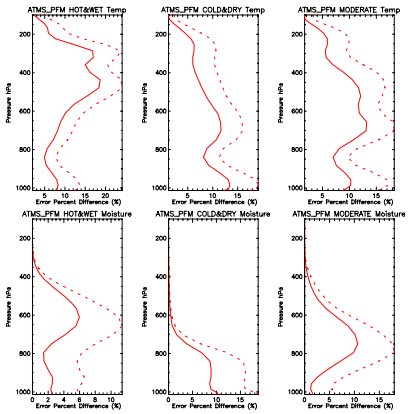
ATMS vs AMSU/MHS Brightness temperatures and difference statistics



AMSU Channel	ATMS Channel	Mean Difference	Std Deviation
1	1	-0.0157	0.1306
2	2	-0.0531	0.1041
3	3	0.3069	1.0698
4	5	0.2172	0.7327
5	6	0.0112	0.0155
6	7	-0.0233	0.0225
7	8	-0.0287	0.0340
8	9	-0.0175	0.0278
9	10	0.0049	0.0249
10	11	-0.0019	0.0041
11	12	-0.0003	0.0070
12	13	0.0295	0.0316
13	14	0.0255	0.0418
14	15	0.0056	0.0647
15	16	0.0204	0.2767
16	16	0.0005	0.3052
17	17	-1.2654	3.7747
18	22	-0.0588	0.1002
19	20	-0.0270	0.0541
20	18	0.2202	1.0355

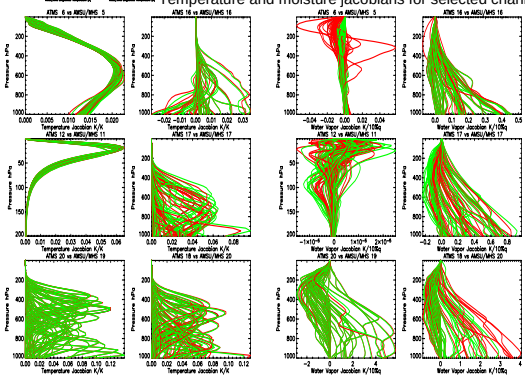
ATMS and AMSU/MHS NEdT





Percent improvement over ECMWF covariance of ATMS over AMSU/MHS when all fields of view within the largest are used. Solid is for near nadir, dashed is for near edge of scan. Top is temperature improvement, bottom is moisture improvement. Left to right is for a hot and wet, cold and dry, and moderate atmosphere respectively. The improvement near edge of scan is due to the increase in the number of fields of view in the averaging process.

Temperature and moisture jacobians for selected channels



Temperature and moisture jacobians difference statistics for selected channels