Evaluation of SSMIS Upper Atmosphere Sounding Channels for High-Altitude Data Assimilation

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Middle atmosphere temperature observations

Current Operational
Future operational (JPSS/DWSS)
NASA research instruments

Available Temperature Observations

- AMSU-A
- AIRS
- GPS-RO
- SSMIS (UAS)
- CrIMSS
- MIS-UAS
- MLS
- SABER

Temperature range:
- Troposphere
- Stratosphere
- Mesosphere
- Thermosphere
SSMIS-UAS weighting functions with Zeeman splitting

- Weighting function shifts in altitude when B field changes
- For channel 19, shift corresponds to ~10 K change

Zeeman splitting illustration:
- Weak B field (equatorial)
- Strong B field (polar)

For this talk, “UAS” refers
Only to ch 19, 20, 21

Normal Channels
SSMIS, SABER, and MLS Coverage

- Looking for spatial coincidences
- Figure also illustrates the coverage for a 6hr analysis cycle

Measurement locations for MLS, SABER and SSMIS on F16, F17 and F18; 10 June 2010 for the 1200 UTC analysis.
Local time at equatorial crossing

- No close MLS time coincidences (except near pole).
- Saber coincidences periodic in time.
- Ascending and descending coincidences at different local times

Measurement times (HHMM):
- SABER (thin black),
- MLS (red dash)
- DMSP F16, F17, and F18
SABER-UAS comparison methodology

• Coincidence criteria:
  • +/- 3 Hours, 1 degree (~111 km) separation.
  • Data from the 15\textsuperscript{th} day of each month, Apr 2010 to Mar 2011
  • ~35000 total coincidences per SSMIS instrument

• Simulated brightness temperatures (T\textsubscript{b})
  • SABER Temperatures from 10 hPa to 0.001 hPa
  • GEOS-5 temperatures from surface to 10 hPa.
  • Geomagnetic field and observation geometry from NRL-UAS preprocessor
  • CRTMv2 calculates simulated UAS T\textsubscript{b}

Results: \( T\textsubscript{b}(\text{SABER+CRTM}) - T\textsubscript{b}(\text{UAS}) \)
SABER–UAS comparison results

- Std Dev. is reasonable, given the Ch 19 random error of ~1.2 K
- Global mean bias should be removed by bias correction schemes.
- No explanation for meridional variations, but they are generally < ~2K
- Uncorrected 2K errors are less than typical model biases in mesosphere
SABER–UAS comparison results

Ascending pass
Descending pass
All orbit

Standard Deviation

Mean

Dates: 20100415-20110416
Chan=20 Sat=F16

Dates: 20100415-20110316
Chan=20 Sat=F17

Dates: 20100415-20110316
Chan=20 Sat=F18

Chan=19 Sat=F16

Chan=19 Sat=F17

Chan=19 Sat=F18

Chan=21 Sat=F16

Chan=21 Sat=F17

Chan=21 Sat=F18

Tb(SABER+CRTM) - Tb(UAS)

Ascending pass only
Mean
Descending pass only
StdDev

Latitude

Tb(SABER+CRTM) - Tb(UAS)

-90 -60 -30 0 30 60 90

-90 -60 -30 0 30 60 90

-90 -60 -30 0 30 60 90
Navy Global Environment Model (NAVGEM) experiments

- NAVGEM: Navy’s operational 4DVar NWP system.

- Modifications for this study:
  - Model top raised to 0.005 hPa (with ~2 km resolution in middle atmosphere)
  - Horizontal resolution of 0.75° (T239)
  - Non-orographic Gravity Wave Drag parameterization added
  - Ozone climatology used by RRTMG modified
  - Limited tuning of GWD to produce “reasonable” mesosphere

- Mesospheric physics not sufficiently developed; assimilation needed to correct biases.

- 4 analysis experiments for July 2010 with different mesospheric observations:
  1. **MLS+SABER** assimilation
  2. **MLS+SABER+UAS** assimilation
  3. **UAS** assimilation
  4. No Mesospheric Observations (**NoMesoObs**)
Zonal mean analysis temperature, 14 July 2010, 1200 UT

Mesosphere

T(K)
300.0
288.8
277.5
266.2
255.0
243.8
232.5
221.2
210.0
198.8
187.5
176.2
165.0
153.8
142.5
131.2
120.0
Observation-Forecast (O-F) for July 2010

Global O-F StdDev

- Panel a: SABER T StdDev (K)
- Panel b: MLS T StdDev (K)
- Panel c: UAS-F18 bT StdDev (K)

Legend:
- MLS+SABER+UAS Assimilation: 20100705-20100731
- MLS+SABER Assimilation: 20100705-20100731
- UAS Assimilation: 20100705-20100731
- No Meso. Obs: 20100705-20100719
Comparison of dominant waves in the mesosphere

Peak Temperature amplitude at 0.02 hPa (~76 km) for:

(a) **DW1**; diurnal migrating tide

(b) **SW2**; semidiurnal migrating tide

(c) **Q2DW3**; quasi-2-day wave
Zonal-mean winds during 1-14 July 2010

- Amplitude (K) of Q2DW3
- Zonal Wind
- 2-day, wave-3 critical line
- Zero line of meridional gradient of quasi-geostrophic PV

![Diagram showing zonal-mean winds with various assimilation scenarios]
Conclusions/Discussion

- UAS comparisons with coincident SABER+CRTMv2 simulated Tb compare well; StdDev < ~2K.
- UAS assimilation improves mesospheric analysis.
- UAS assimilation is valuable for quantifying forecast model biases.
- Future UAS-like measurements (beyond SSMIS) are important, but not planned.