The UW SSEC/CIMSS
Global Clear Sky IR Moisture Products
derived from HIRS data

University of Wisconsin-Madison
Space Science and Engineering Center (SSEC)

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Recalibrating HIRS Sensors to Produce a 30 year Record of Radiance Measurements Useful for Moisture Trend Analysis

Recalibrating HIRS
Accommodating Orbit Drift
TPW and UTH Trends

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HIRS Recalibration

Mitigating sensor to sensor differences

Recalibrating Metop HIRS using IASI

Recalibrating all prior HIRS using Metop HIRS or IASI as a reference

(at Simultaneous Nadir Overpasses adjust for radiance differences beyond those caused by known SRF differences)
16 HIRS sensors used for 35+ year moisture study

morning (8 am Desc Node)    night (2 am Desc Node)
NOAA 10 HIRS/2 – 9/1986       NOAA 9 HIRS/2 – 12/1984

Split window change: HIRS & HIRS/2 ch 10 is 8.6 um and HIRS/2I, /3, & /4 is 12.5 um.
Orbit Drift: Asterisk (*) indicates drift from 14 to 18 UTC over 5 years of operational use.
S/N improved in HIRS/3. FOV improved to 10 km FOV for HIRS/4 (previously 20 km FOV).
HIRS coverage: More than 100 satellite years in HIRS data set.
The length of time required to detect a climate trend caused by human activities is determined by:

- Natural variability
- The magnitude of human driven climate change
- The accuracy of the observing system
SRF of water vapor channel for NOAA/MetOp satellites

- SRF of HIRS ch12 for NOAA/MetOp satellites (left axis), an IASI spectra (right axis)
- Differences can be seen between HIRS/2, HIRS/3, and HIRS/4
BT Bias Change with SRF shift

METOP-B 08/01/2013

HIRS BT minus IASI BT

After optimal SRF shifting

Original BT difference

Color represents different wavenumber shifting

Scan line number

Optimal shift not clear
Between -5 and 5 wavenumber shifting, the orbital variance does not decrease significantly for channel 12.
Toward an Integrated System for Intersatellite Calibration of POES using the SNO Method

N15 & N16 (+) and N16 & N17 (X) SNO locations from 2000 to 2003

SNO: Simultaneous Nadir Overpass
Using Metop-A IASI-HIRS data to estimate SRF shifts implied by HIRS-HIRS SNOs

Impact of spectral shift on inter-satellite radiance (or BT) difference depends on atmospheric state at time of measurements

IASI-simulated HIRS data are used to develop linear models to estimate impacts of SRF shifts (and differences) on inter-satellite radiance differences for various atmospheric conditions;

For channel $i$ and satellite $m$ a shift of $\Delta SRF$ will produce a radiance change $\Delta R_{im} = \Delta SRF \left[ \sum_j a_{ijm} R_{jm} + c_{im} \right]$ where $j$ sums the HIRS CO2 channels 2 – 7, IRW channel 8, and H2O channel 12 (these are used to estimate the atmospheric state for a given SNO)
## CO2 and H2O HIRS spectral shifts

<table>
<thead>
<tr>
<th></th>
<th>Ch4(14.2)</th>
<th>Ch5(13.9)</th>
<th>Ch7(13.3)</th>
<th>Ch12(6.7)</th>
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<td>-0.43</td>
<td>-0.54</td>
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</tr>
</tbody>
</table>

V indicates intercal with VAS, H with later HIRS, and I with IASI directly.
Accommodating Orbit Drift

Dividing the day into four segments
(with sunlight before and after noon; without sunlight before and after midnight)
Equatorial Crossing Times / Operational Transfer Dates for NOAA

Operational Transfer Dates
19Aug81  25Feb85  8Nov88  11Apr95  20Mar01  30Aug05  02Jun09
27Jun79  20Jun83  17Nov86  14May91  15Dec98  16Oct02  21May07  24Apr13

Updated on 12/03/2013 09:49
Dividing the Day into 4 Time Periods

Morning $\text{SZA} \leq 85^\circ$ and Local Time Before Noon
Afternoon $\text{SZA} \leq 85^\circ$ and Local Time After Noon
Evening $\text{SZA} > 85^\circ$ and Local Time Before Midnight
Night $\text{SZA} > 85^\circ$ and Local Time After Midnight

Accounting for and taking advantage of orbit drift
NOAA CDR of monthly mean TPW; 2009 January, morning (0–12h)
NOAA CDR of monthly mean TPW; 2009 January, afternoon (12–24h)
NOAA CDR of monthly mean TPW; 2009 January, night (0–12h)

Total Precipitable Water [mm]

Data Min = 0.0, Max = 103.9, Mean = 23.2
HIRS TPW and UTH Trends

Comparing with Aqua MODIS
HIRS TPW and UTH

HIRS TPW and UTH is a statistical regression developed from the SeeBor data base (Borbas et al. 2005) that consists of geographically and seasonally distributed radiosonde, ozonesonde, and ECMWF ReAnalysis data. TPW are determined for clear sky radiances measured by HIRS over land and ocean both day and night. The retrieval approach is borrowed from MODIS (Seemann et al. 2003, Seemann et al. 2008). There is strong reliance on radiances from 6.5, 11, 12 \( \mu \text{m} \). The PATMOS-x cloud mask is used to characterize HIRS sub-pixel cloud cover.
Time series of N17/HIRS IWV high, middle and low over Daytime

HIRS IWV high over Daytime

HIRS IWV middle over Daytime

HIRS IWV low over Daytime

- HIRS 30-60 S Latitude
- HIRS 30-60 N Latitude
- HIRS -30-+30 Latitude
Time series of MYD07 IWV high, middle and low over Daytime

MYD07 IWV high over Daytime

MYD07 IWV middle over Daytime

MYD07 IWV low over Daytime


Conclusions

Regarding Recalibration
* Metop HIRS recalibration using IASI offers best HIRS reference
* Recalibration against reference HIRS mitigates but does not eliminate sensor to sensor differences
* Dividing the day into 4 time periods mitigates but does not eliminate effects of orbit drift

Regarding H2O Trends
* Seasonal TPW cycle is strongest in northern mid-latitudes and weakest in tropics
* Seasonal TPW cycle is stronger in the afternoon than at night
* La Nina decrease in tropical TPW is evident
* Recalibrating IR split window needed to mitigate sensor to sensor TPW issues
* TPW decrease from 2002 to 2008 and increase after 2008 is suggested

Overall
* Reprocessing whole HIRS record will reveal trends better
Timeline

HIRS Northern Mid latitude (30N-60N)

Aqua/MODIS Northern Mid latitude (30N-60N - green)

S-NPP/VIIRS